TECHNICAL STUDIES

CENTRAL RADAR SYSTEM
OVER-THE-HORIZON BACKSCATTER

OTH

OVER-THE-HORIZON RADAR

MARCH 9, 1990

METCALF & EDDY, INC. / HOLMES & NARVER, INC.
10 HARVARD MILL SQUARE
WAKEFIELD, MASSACHUSETTS 01880

PREPARED FOR:
ACQUISITION CIVIL ENGINEERING (ESD/DE-2)
OVER-THE-HORIZON BACKSCATTER RADAR SYSTEM
PROGRAM OFFICE
HANSCOM AFB, MASSACHUSETTS 01730

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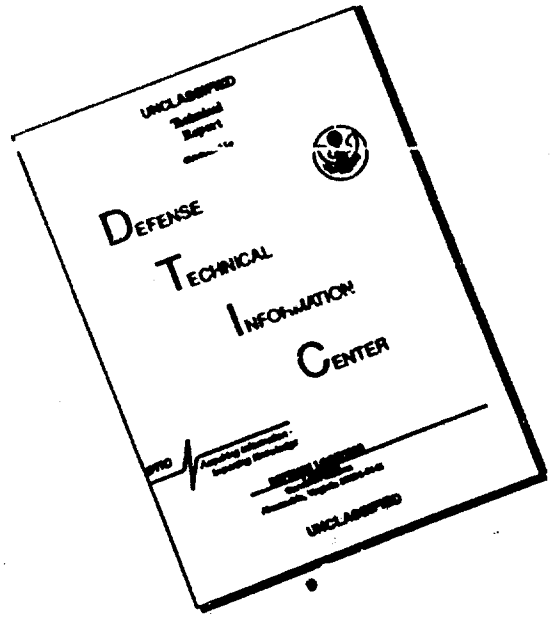

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TECHNICAL STUDIES

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OVER-THE-HORIZON BACKSCATTER RADAR PROGRAM

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1.1 INTRODUCTION

The U.S. Air Force (USAF) proposes to construct an Over-the-Horizon Backscatter (OTH-B) radar facility in the north central region of the United States. This system, to be known as the Central Radar System (CRS), will be comprised of a transmit site, a receive site, and an operations center.

This study provides an overview of the USAF's Environmental Impact Analysis Process (EIAP). The overview begins with the site selection process that occurred during the preparation of initial Draft and Final Environmental Impact Statements (USAF, 1986; 1987), which led to the selection of the transmit and receive study areas in a 1988 Record of Decision (ROD) (USAF, 1988). In the Final Environmental Impact Statement (FEIS) and the ROD, the USAF made a commitment to prepare a site-specific environmental document and to conduct a number of site-specific studies in order to further define potential impacts from the proposed facilities. This report describes the process used to select specific siting areas within the two selected study areas.

As stated in the ROD (USAF, 1988), the transmit facilities will be located within the Amherst, South Dakota study area, the receive facilities will be located within the Thief River Falls, Minnesota study area, and the Operations center will be located at Grand Forks Air Force Base, North Dakota (Figures 1-1 through 1-3). The potential impacts associated with construction of the Operations Center were fully addressed in the 1986 EIS and will not be examined further in this document.

The facilities proposed to be constructed at both the transmit and receive sites include four antenna sectors facing east, southeast, southwest, and west. The transmit antenna sectors will require approximately 2,100 acres of land, while the receive sectors will require approximately 470 acres.

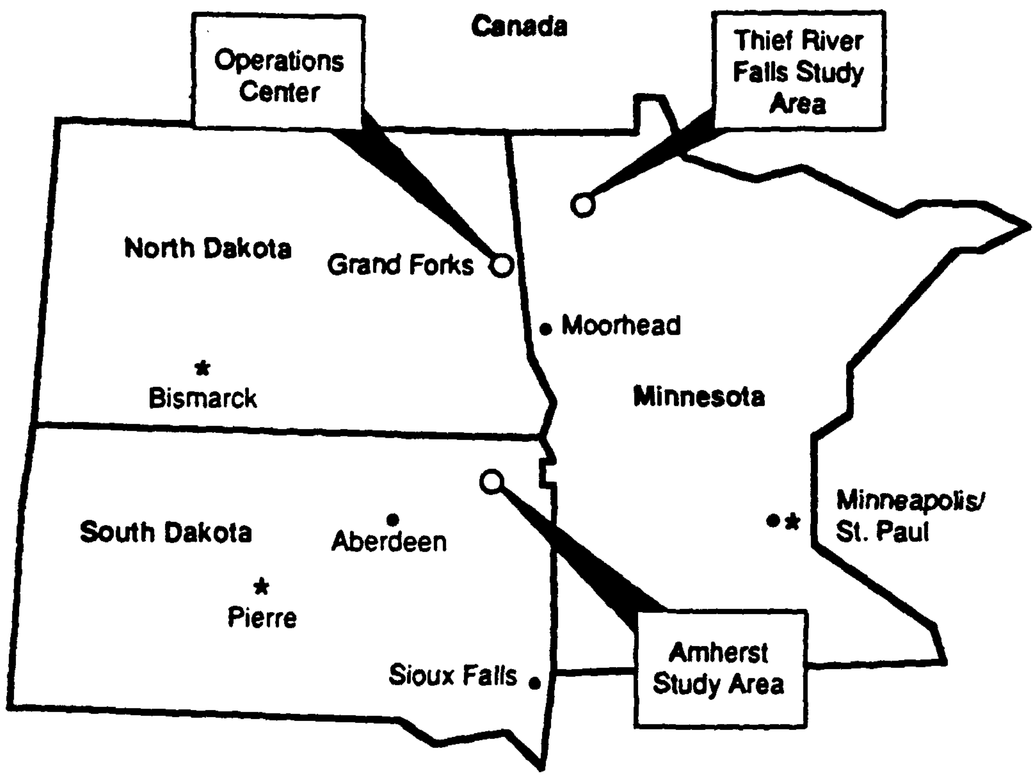


FIGURE 1-1. LOCATION OF THE CENTRAL RADAR SYSTEM TRANSMIT AND RECEIVE STUDY AREAS AND THE OPERATIONS CENTER

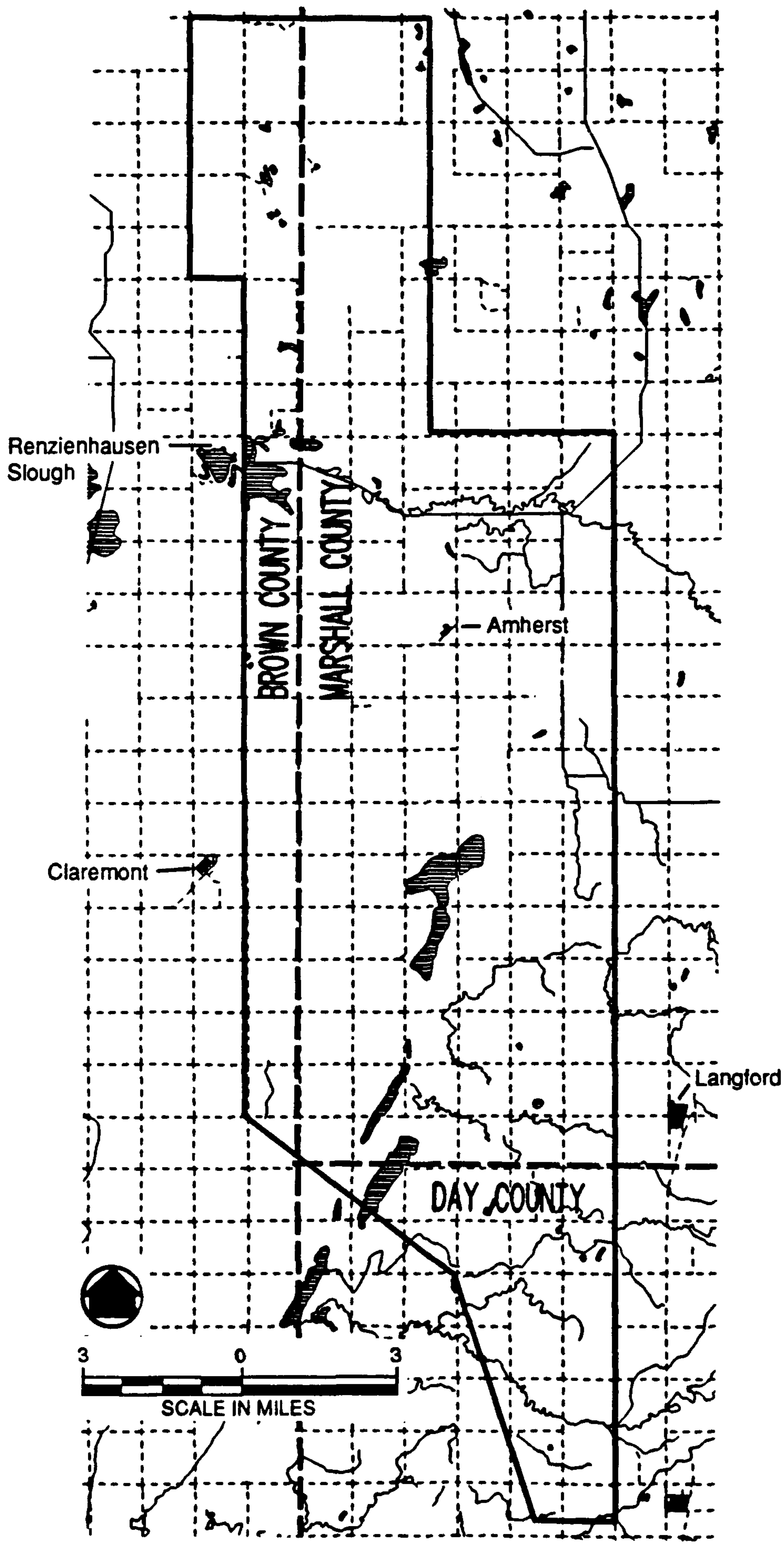


FIGURE 1-2. AMHERST, SD TRANSMIT STUDY AREA

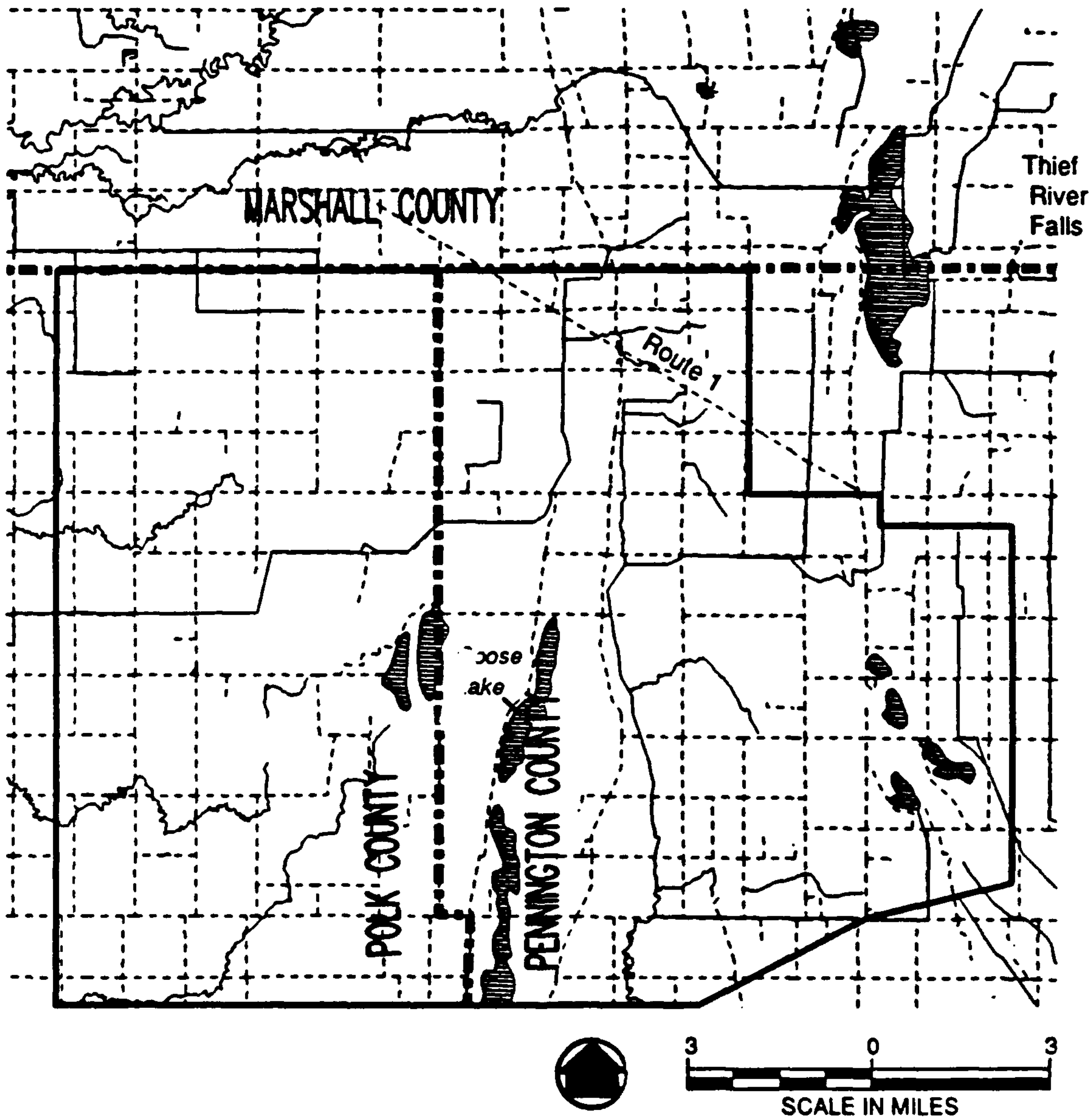


FIGURE 1-3. THIEF RIVER FALLS, MN RECEIVE STUDY AREA

Each of the four transmit antenna sectors contains an antenna array and groundscreen, two sounder antennas, an exclusion area, an electronics and facilities support building, an exclusion fence, and a perimeter security road (Figure 1-4). Each transmit antenna will be approximately 4,200 feet long (including one in-coverage sounder antenna). The antenna towers and backscreen will vary in height from 35 to 135 feet. The sounder antennas consist of two, 150-foot high vertical truss towers with radiating elements spanning to a third 50-foot high monopole. The groundscreen will extend 750 feet in front of each antenna array and an exclusion area will extend about 3250 feet beyond the groundscreen.

The transmit site will require two 115-KV power transmission lines. The power lines will be constructed by the U.S. Department of Energy, Western Area Power Administration (Western). The power lines will be routed to the selected antenna site from Western's substations in Forman, ND and Groton, SD. A summary of the EIAP for the power lines will be included in Technical Study 10.

Each of the four receive antenna sectors will be generally comprised of an antenna array and groundscreen, an electronics building, an exclusion fence, and a perimeter security road (Figure 1-5). The receive antennas and backscreen will be approximately 5,000 feet long and 65 feet high. The groundscreen will extend 750 feet in front of each antenna array. The receive site will require one 12.5-KV power transmission line, which will be routed from the nearest substation by the local electric cooperative in whose franchise area the facilities are sited.

Communications between the transmit site or the receive site and the Operations Center can be accomplished in several ways: microwave, tropo-scatter, or satellite. The system used will be determined by the system contractor. Descriptions of these systems can be found in Technical Study 2, Facilities. The antenna sectors and other associated facilities are also discussed in detail in Technical Study 2.

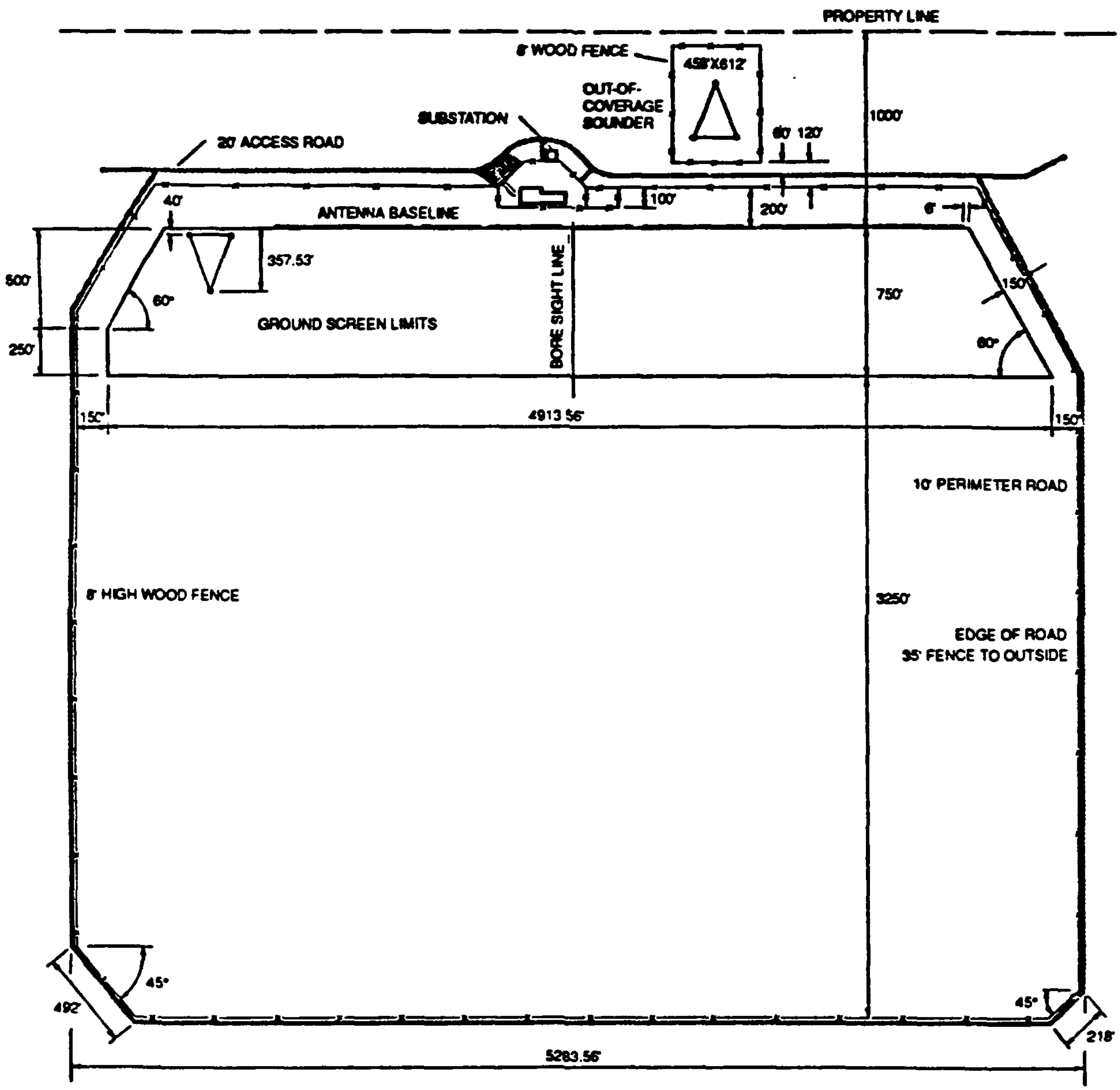


FIGURE 1-4. TRANSMIT SECTOR CONCEPTUAL DESIGN

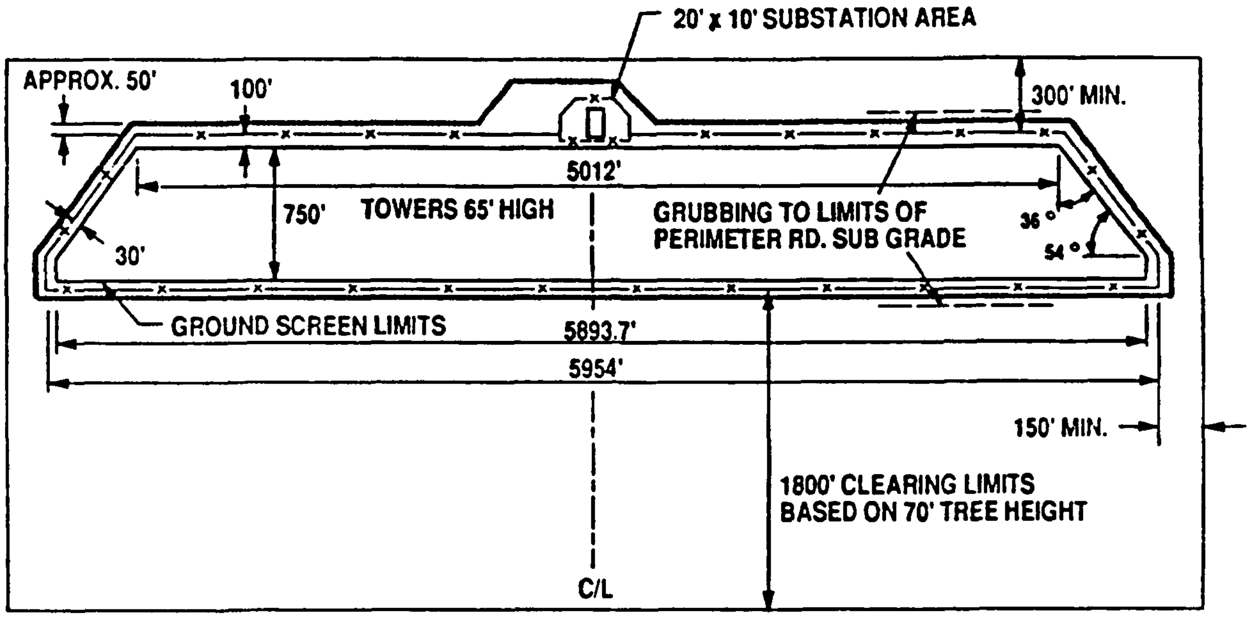


FIGURE 1-5. RECEIVE SECTOR CONCEPTUAL DESIGN

1.2 STUDY AREA SELECTION

The USAF Electronic Systems Division (ESD), Hanscom Air Force Base, Massachusetts, and Tactical Air Command (TAC), Langley Air Force Base, Virginia, initiated the CRS study area selection process in 1985 in accordance with the National Environmental Policy Act (NEPA) guidelines and Air Force Regulation 19-2. Air Force Regulation 19-2, "Environmental Impact Analysis Process," provides specific procedural requirements for USAF implementation of NEPA.

The chronology of the EIAP for the CRS study area up to issuance of the ROD is outlined below, and summarized in Figure 1-6.

Fall, 1985

The CRS search area (Figure 1-7) was defined by radar coverage requirements (Figure 1-8). The CRS facilities must be located within the search area to achieve the required radar coverage of the near-shore areas of the east and west coasts which are not covered by the East and West Coast Radar Systems, and to provide the required coverage of the southern border of the country. The U.S. Army Corps of Engineers (COE), conducted the original study area survey. Within the search area, application of system operational requirements led the COE, on the USAF's behalf, to identify nine candidate sites in Minnesota, South Dakota, and North Dakota (COE, no date) The nine potential study areas were located near: Dahlen, North Dakota; Goose River, North Dakota; Galesburg, North Dakota; Blanchard, North Dakota; Amherst, South Dakota; Wheaton Southwest, Minnesota; Wheaton North, Minnesota; Wheaton Southeast, Minnesota; and Thief River Falls, Minnesota (USAF, 1986).

February - March, 1986

The USAF conducted a total of ten scoping meetings near the proposed study areas and in the state capitols of Minnesota and North and South Dakota.

August, 1986

The Draft Environmental Impact Statement (DEIS) for the CRS (USAF, 1986) was released to the public on 15 August 1986. This document described the potential environmental impacts which might occur within each of the proposed study areas as a result of construction and operation of the CRS.

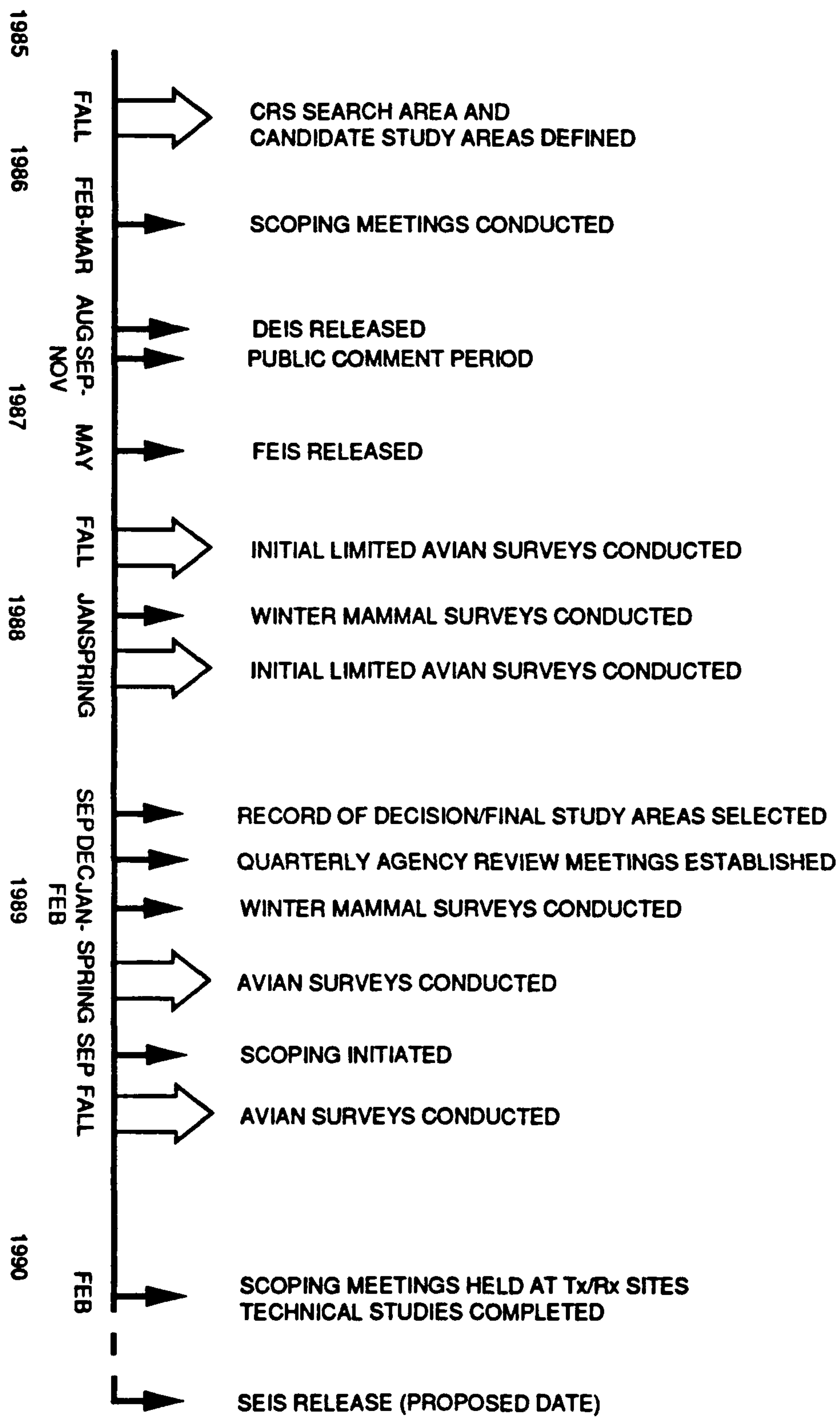


FIGURE 1-6. CENTRAL RADAR SYSTEM EIAP CHRONOLOGY

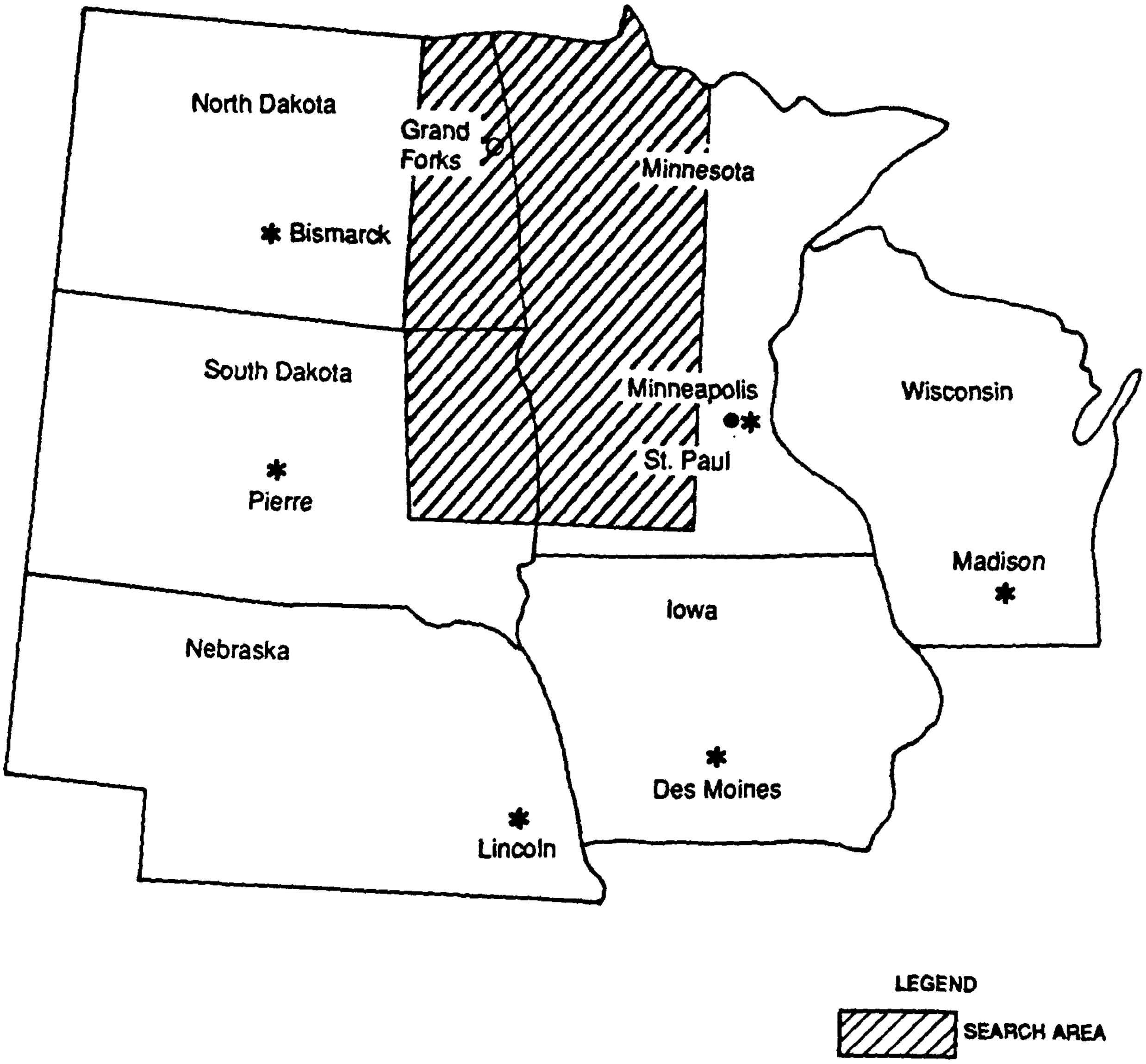


FIGURE 1-7. CENTRAL RADAR SYSTEM SEARCH AREA

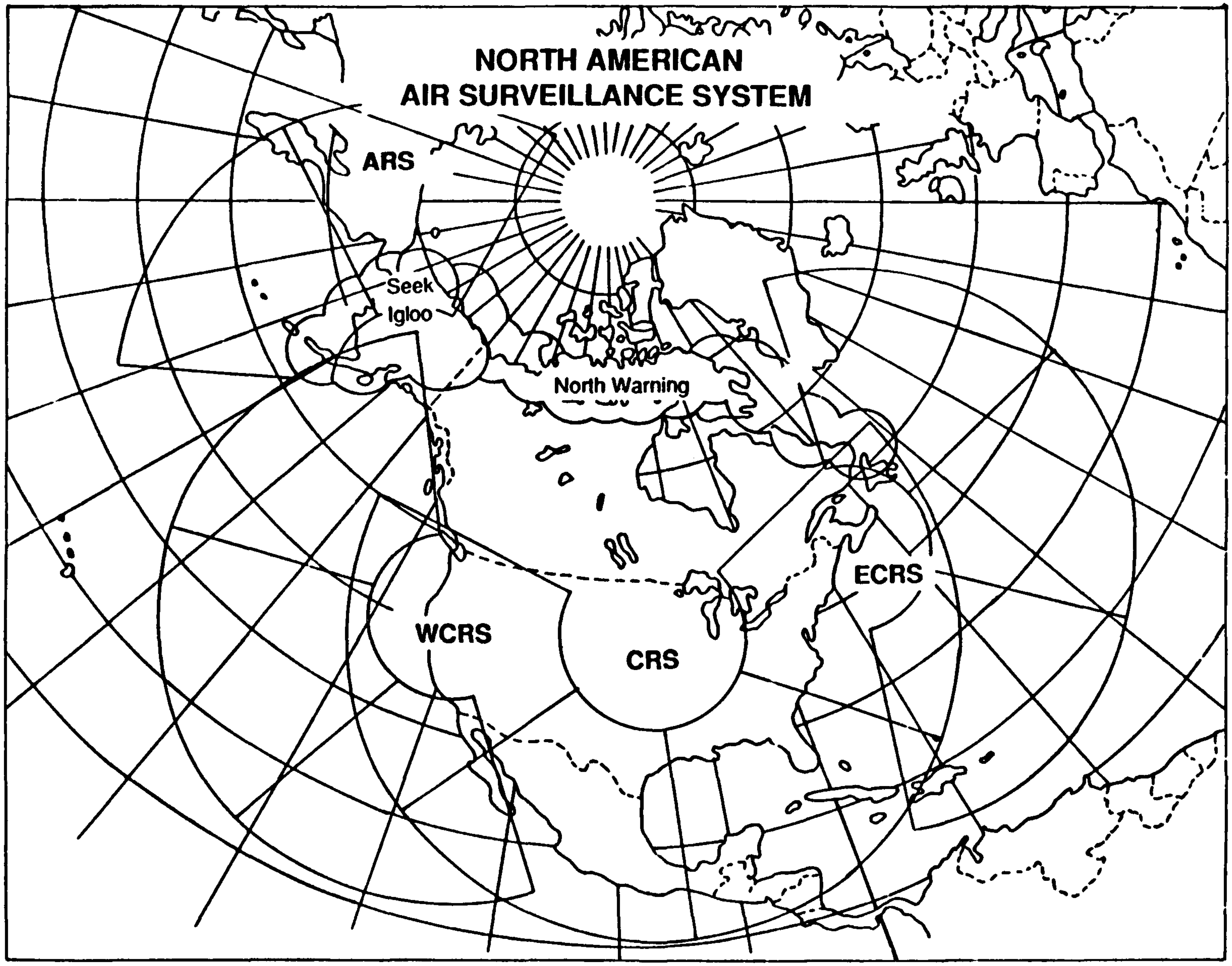


FIGURE 1-8. OTH-B RADAR COVERAGE AREA

Each of the nine study areas was evaluated as either a transmit site or a receive site, based upon operational restrictions. Because of the operational requirements which limit distances between transmit and receive site pairs, the final sites would have to be selected based upon the pairings shown in Table 1-1:

TABLE 1-1. TRANSMIT AND RECEIVE STUDY AREA PAIRINGS

Receive Areas	Transmit Areas Amherst	Wheaton N	Wheaton SW	Wheaton SE
Dahlen	*	*	No.......	No
Goose River	Yes	Yes	Yes	Yes
Blanchard	Yes	Yes	Yes	Yes
Galesburg	Yes	Yes	Yes	Yes
Thief River	*	Yes	Yes	Yes

Source USAF (1986)

* These pairs are at maximum acceptable distance and portions of the study areas may be too far apart.

September-November, 1986

During the public review period, the USAF held public hearings on the DEIS in Grand Forks, North Dakota; Wheaton, Minnesota; and Langford, South Dakota. As a result of public concerns, the USAF extended the public comment period and held additional public hearings in November 1986. The additional hearings were held in Thief River Falls, Minnesota; Hillsboro, North Dakota; and Langford, South Dakota.

May, 1987

The FEIS was released on 22 May 1987 (USAF, 1987). The FEIS included an extension to the Amherst, South Dakota study area boundary to include a parcel of land which was offered for sale to the USAF. This area was investigated and found to be environmentally similar to land within the original study area (USAF, 1987).

In the FEIS, the Amherst, South Dakota and Wheaton North, Minnesota study areas were determined to be the environmentally preferred transmit study areas. Specifically, the FEIS states that "siting within either area would create relatively few biolocal and physical impacts, most of which could be minimized by selecting a site removed from the infrequent wet areas and wildlife habitats" (USAF, 1987). Of the receive study areas, Thief River Falls, Minnesota and Blanchard, North Dakota were determined to be environmentally preferred. These areas were flatter and had fewer surface water bodies than the others, which would result in fewer biological and physical impacts.

In the FEIS, the USAF further designated the Amherst, SD and Thief River Falls, MN study areas as the preferred sites, based upon biological, physical, socioeconomic and constructability factors. Also, the two preferred study areas were larger than the Blanchard and Wheaton study areas, allowing for greater flexibility in siting of the antenna sectors.

September, 1988

The ROD for the Central Radar System study area selection was released on 9 September 1988 (USAF, 1988). The ROD selected the Amherst, South Dakota study area for the transmit site and the Thief River Falls, Minnesota study area for the receive site. The ROD directed the USAF to conduct further environmental assessments to aid in siting the individual system facility locations within the two selected study areas, and to aid in determining specific measures to mitigate for project impacts. The ROD also directed the USAF to consult with local, state and federal environmental agencies during the course of performing the environmental assessments.

1.3 EIAP COORDINATION

In keeping with the ROD, the USAF established quarterly environmental agency review meetings in December, 1988. In addition to the state agencies, the U.S. Fish and Wildlife Service (USFWS) and the U.S. Army Corps of Engineers (COE) participated in these meetings. The USAF also held two coordination meetings with the Environmental Protection Agency (EPA) regional offices responsible for the two study areas; Region V for the receive site in Minnesota, and Region VIII for the transmit site in South Dakota.

The USAF also held periodic meetings in both states with the USFWS and the Minnesota Department of Natural Resources or South Dakota Game, Fish, and Parks Department (SD) to discuss the CRS avian field studies. Agency personnel were invited to observe the field studies during the Spring 1989 field season.

At the public's request, the USAF conducted a public meeting in Langford, South Dakota, in February, 1989, after selection of the preferred siting areas. The USAF also held public meetings in September, 1989 in Langford, South Dakota and Thief River Falls, Minnesota. The Federal Register publication of the Notice of Intent to prepare an Environmental Impact Statement for the CRS project occurred on 19 January 1990 (55 FR 1863). Public scoping meetings were held in February, 1990 in Britton, South Dakota and Warren, Minnesota. Agency scoping meetings were also held in February, 1990 in St. Paul, Minnesota, and Pierre, South Dakota. Additional requests for scoping comments were sent to the two EPA regional offices, and the state and federal agencies in North Dakota (for comments on the transmit site power lines that will be routed through North Dakota).

Also as directed by the ROD, the USAF conducted additional environmental assessment studies. Prior to these field studies, the USAF solicited federal and state environmental agency review comments on the draft scope-of-work (SOW) for each study. The draft SOW's reviewed included vegetation and wetland mapping, mammal surveys, and avian surveys. Agency comments were incorporated to the maximum extent possible into the final SOW's.

In addition, the results of limited avian surveys conducted in fall 1987 and spring 1988 (prior to release of the ROD) were summarized into a preliminary data report for agency review. These early studies were designed to characterize the study areas in order to determine which areas would be most suitable for siting of the facilities. After initiating the field studies, the USAF elected to use these individual environmental assessment studies in preparing a Supplemental EIS.

1.4 FACILITIES REDESIGN

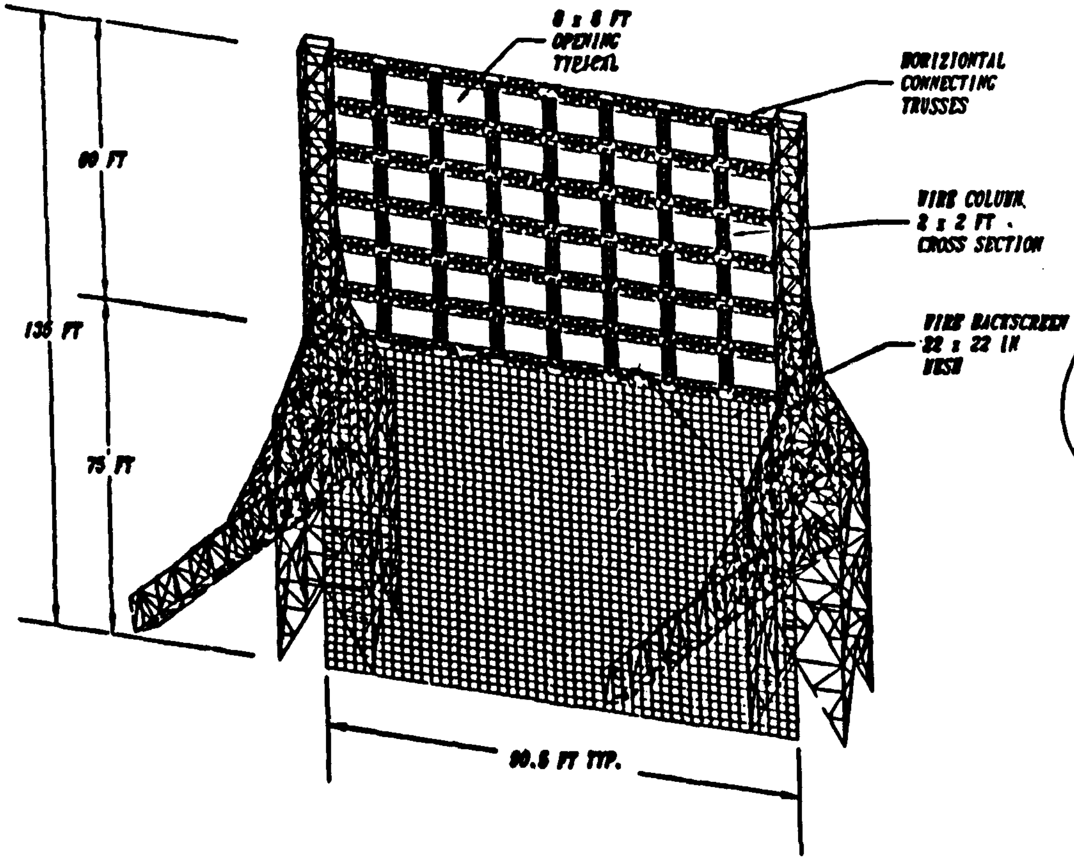
During the site selection process, the USAF decided to construct receive antennas with similar dimensions to those being used for the East Coast Radar System. This redesign reduced the proposed receive antenna length from 8,000 feet (as stated in the 1986 EIS) to 5,000 feet. Also, as a result of environmental agency concerns over potential bird collision impacts, the USAF agreed to use a modified antenna backscreen design based upon the antenna redesigned for the Alaskan Radar System. This design uses a more open and visible structure, which is intended to reduce the possibility of bird collisions.

The original backscreen design consisted of a 22-inch by 22-inch wire mesh, ranging from 35 to 135-feet high at the transmit site, and a uniform 65-feet high at the receive site. At the transmit site, the redesigned backscreen will be used for the two tallest antenna bands, the A and B bands. Below 75 feet, the backscreen will still consist of the wire mesh, but from 75 to 135 feet (A band) or 75 to 100 feet (B band), the backscreen will consist of 2-foot by 2-foot wire columns spaced every ten feet both horizontally and vertically (Fig. 1-9). At the receive site, the wire pole structure will replace the wire mesh above 35 feet for the entire antenna length (Fig. 1-10). The wire column structure, which is both more visible (because the columns are wider than the mesh) and more open (because of the greater spacing between the columns), should significantly reduce the potential for bird collisions.

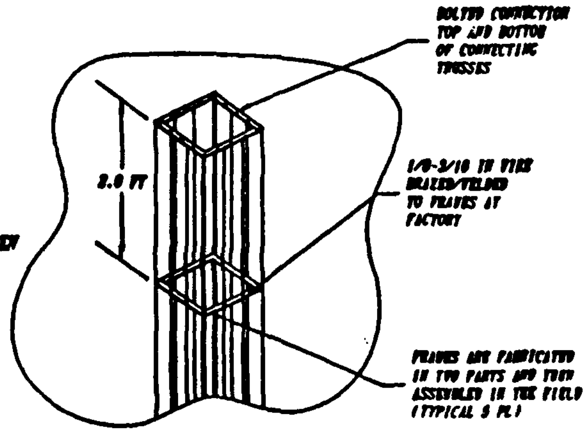
1.5 FACILITY SITING WITHIN THE SELECTED STUDY AREAS

Facility siting within the selected study areas was achieved in three phases. Because the initial study areas contained a large area to be examined (approximately 150 sq. miles for the Amherst study area and 170 sq. miles for the Thief River Falls study area), detailed analysis was not practical at that level. Therefore, in each successive phase of the site selection process, increasingly detailed site investigations were completed, which allowed for more thorough analysis of impacts. The guidelines used for site evaluation focused on operational requirements, environmental issues of concern, and socioeconomic constraints.

During the first phase, selection of preferred siting areas, general siting criteria were applied to the entire study areas. Once the first phase was completed and preferred siting areas were selected, more site-specific field studies were conducted. The results of the early site-specific field studies were used to evaluate the preferred siting areas and refine them to concentrated study areas. The third phase of the site selection process consisted of selecting preliminary site layouts within the concentrated



TYPICAL BAY OF A-BAND TRANSMIT ANTENNA
NOT TO SCALE

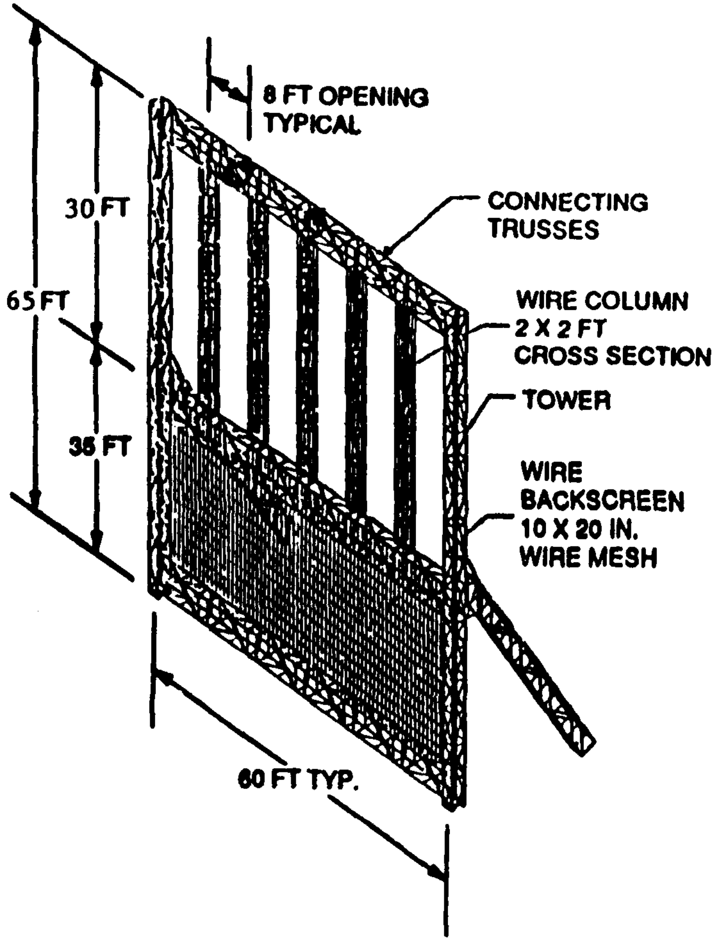


TYPICAL WIRE COLUMN
CONSTRUCTION

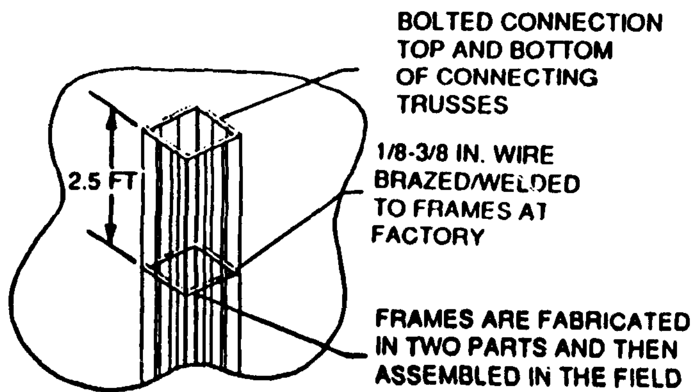
A band = 135' height

B band = 100' height

FIGURE 1-9. REDESIGNED TRANSMIT ANTENNA BACKSCREEN
CONCEPTUAL PLAN



TYPICAL BAY OF 5000 FT RECEIVE ANTENNA
NOT TO SCALE



TYPICAL WIRE COLUMN CONSTRUCTION
NOT TO SCALE

FIGURE 1-10. REDESIGNED RECEIVE ANTENNA BACKSCREEN CONCEPTUAL PLAN study areas. The selected preliminary site layout within each concentrated study area constitutes one alternative for the SEIS analysis. A flow diagram of the site selection process is included in Figure 1-11. A description of the site selection process used during the three phases of site selection is provided below.

1.5.1 Selection of Preferred Siting Areas

Initial preferred siting areas for the CRS facilities within the Amherst and Thief River Falls study areas (Figures 1-12 and 1-13) were developed based upon application of general operational, environmental and socioeconomic siting guidelines. The guidelines represent optimum conditions which the USAF would like to achieve, not strict criteria.

At this stage of the site selection process, socioeconomics were given primary consideration due to the continued concerns expressed by landowners in the study area about the land required to site the facilities. Throughout the EIAP, the USAF has maintained three land acquisition policies: 1) land can be purchased or leased depending upon the wishes of the owner; 2) purchase or lease through direct negotiation is preferred over condemnation; and 3) land acquisition from willing owners will be maximized. The ROD restated these policies, and indicated that the presence of willing sellers was a factor in the selection of the Thief River Falls and Amherst study areas (USAF, 1988).

At the time the preferred siting areas were selected, the USAF had not solicited land offers, however, many land owners had indicated their willingness to sell at public meetings, in writing, or during Right-of-Entry negotiations with the COE. In selecting the preferred siting areas, the information on presence of willing sellers was limited to those voluntary offers. The presence of willing landowners led to the selection of one socioeconomically-preferred siting area within each study area; the northern area at Amherst and the eastern area at Thief River Falls.

In addition to selecting a socioeconomically-preferred siting area at each study area, the USAF applied the site selection guidelines listed below to

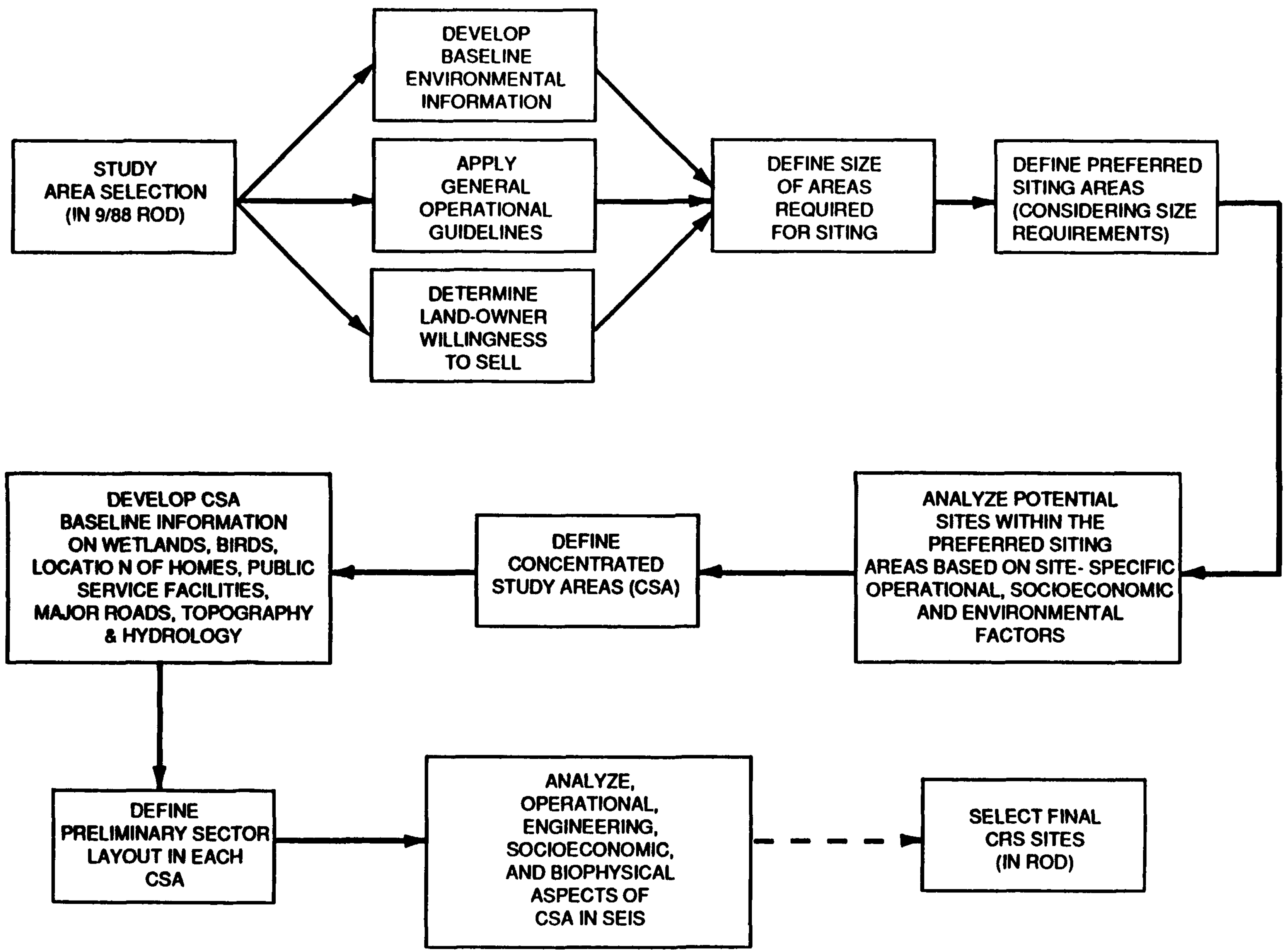


FIGURE 1-11. FLOW DIAGRAM OF CRS SITE SELECTION PROCESS

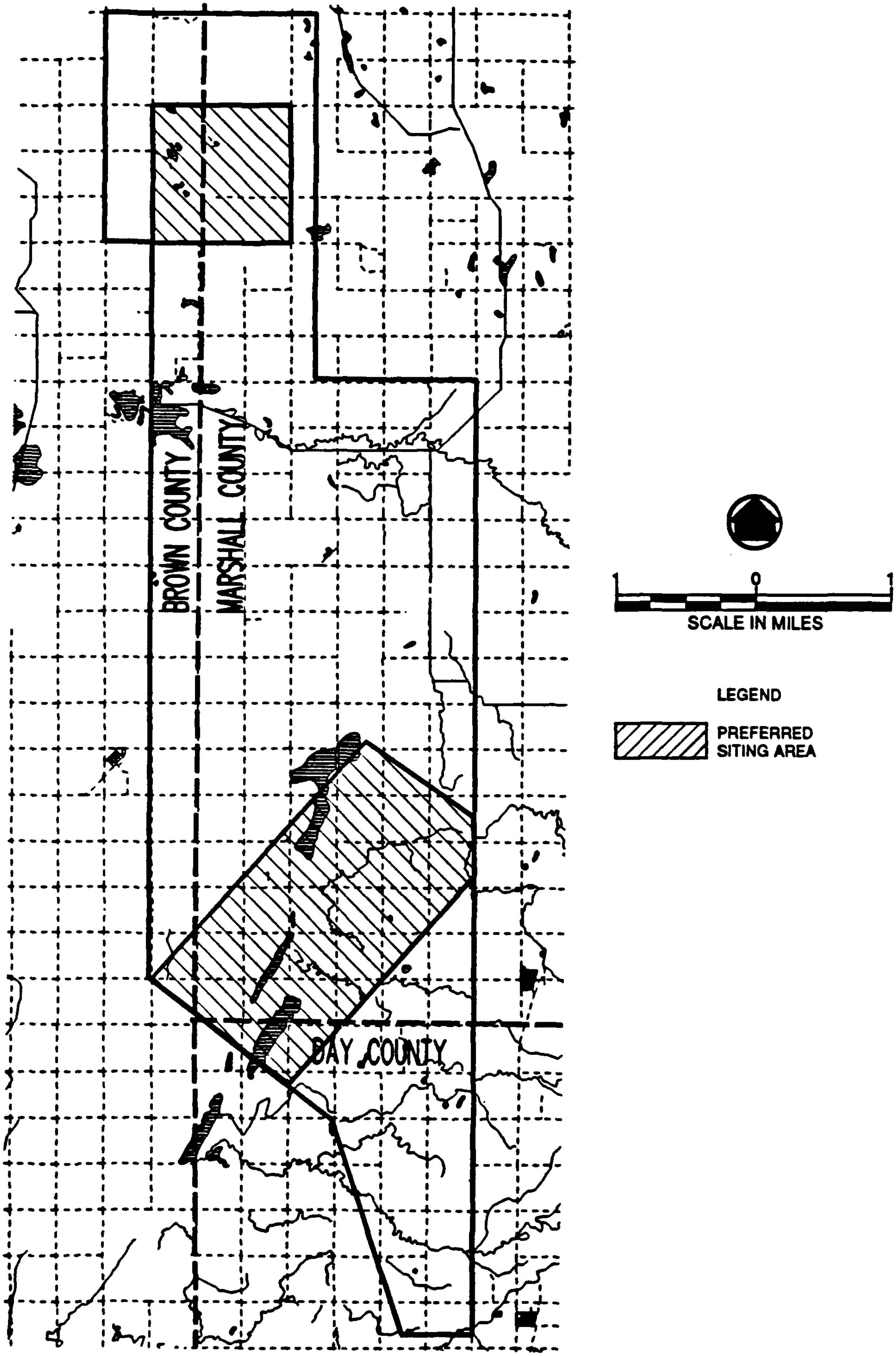


FIGURE 1-12. AMHERST, SD TRANSMIT STUDY AREA PREFERRED SITING AREA LOCATIONS

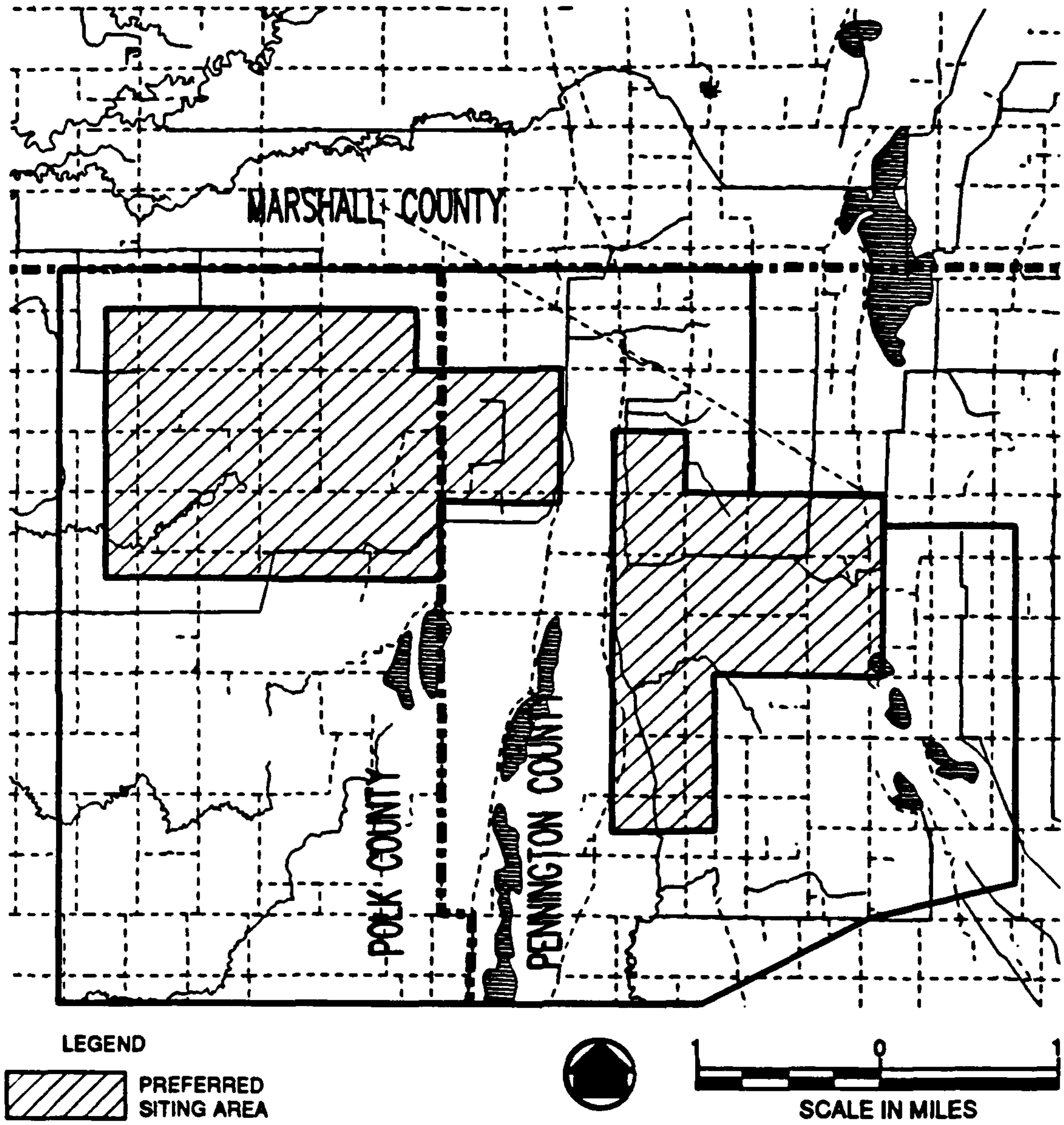


FIGURE 1-13. THIEF RIVER FALLS, MN RECEIVE STUDY AREA PREFERRED SITING AREA LOCATIONS

select environmentally-preferred siting areas. Application of the guidelines resulted in the areas of lowest operational and environmental suitability being excluded from additional study. Then, remaining areas which were too small for siting of the four sector system were also excluded. The remaining portions of the study areas were considered preferred siting areas. A discussion of the application of the site selection guidelines in the siting process is presented in sections 1.5.2.1 and 1.5.2.2.

OPERATIONAL GUIDELINES

a) Maintain ten mile buffer zone around towns with population over 1,000

b) Maintain five mile buffer zone around active railroads

c) Maintain five mile buffer zone around transmitting towers

d) Maintain five mile buffer zone around active airways

e) Parcel must be large enough for siting of four sector system

ENVIRONMENTAL GUIDELINES

a) Minimize impact to water bodies and areas of high wetland concentration

b) Minimize impact to important wildlife habitats and wildlife concentration areas.

1.5.2.1 Transmit Study Area

1.5.2.1.1 Operational Guidelines. The following operational guidelines were used in selecting preferred siting areas. These guidelines represent optimum siting conditions which are recommended to avoid or minimize impacts to and from the CRS facilities.

- Population Center Buffer Zone

In order to minimize electronic interference from the CRS system to other electronic devices within residences and businesses, a buffer zone of 10 miles should be maintained if possible from towns with a population of over 1,000. The USAF can economically provide devices to eliminate electronic interference to less populated areas. The town of

Britton, South Dakota (population 1,467; U.S. Census, 1986); is five miles from the nearest point of the Amherst study area. The area within the ten mile buffer (Figure 1-14) was considered less desirable, and therefore excluded from further study.

- Railroad Buffer Zone

A five mile buffer zone should be maintained, where possible, around railroads to avoid the CRS system interfering with communications devices being used on the trains. An active railroad crosses through the study area, which eliminated much of the middle section of the study area from further consideration (Fig. 1-14).

- Electronic Transmitter Buffer Zones

There are no electronic transmitters in close proximity to the Amherst study area. This criteria did not further reduce the area to be considered for the CRS facilities.

- Airway Buffer Zones

A five mile buffer zone should be maintained around airways at the transmit site to avoid interference to electronic devices used for communications and navigation. As stated above, there is an active low-level airway over the Amherst study area, running from Aberdeen, SD to Fargo, ND. Although this was initially considered to be a significant constraint for facility siting, in later USAF consultation with the Federal Aviation Administration (FAA), the FAA indicated that they can reroute this particular airway if necessary. This airway buffer zone was therefore not considered critical, and did not limit siting of the CRS facilities.

1.5.2.1.2 Environmental Guidelines. During this phase of the site selection process, site specific environmental data consisted of preliminary results from avian field studies conducted in fall 1987 and spring 1988 and preliminary results of large mammal surveys conducted in winter 1988. Other information was taken from U.S. Fish and Wildlife Service (USFWS) National Wetland Inventory (NWI) maps and U.S. Geological Survey (USGS) topographic maps.

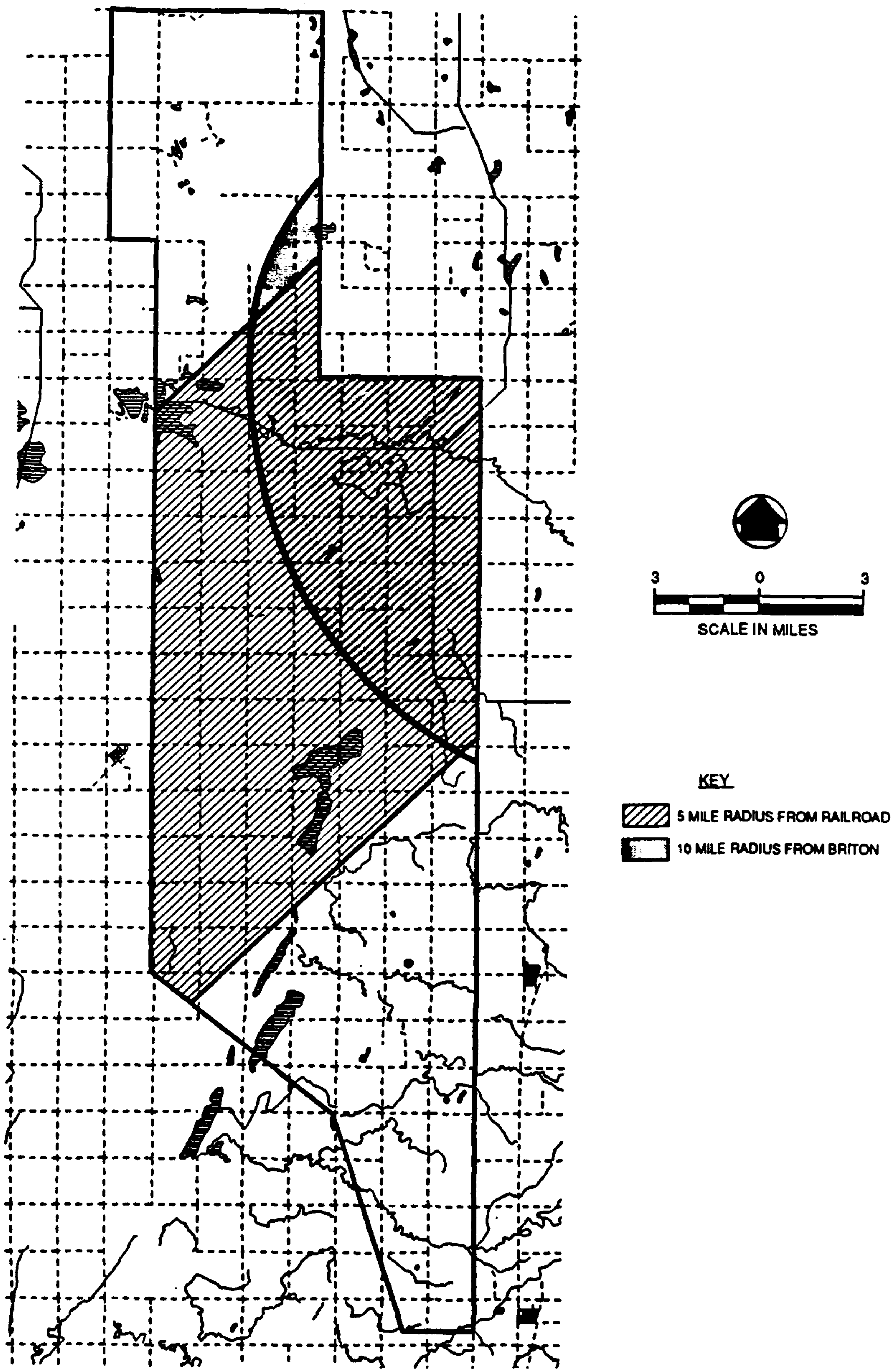


FIGURE 1-14. AMHERST, SD TRANSMIT STUDY AREA OPERATIONAL SITING GUIDELINES

- Wetlands and Surface Water Bodies

Areas of high wetland concentrations were avoided, where possible; areas with low concentrations of wetlands were preferred. Wetland concentrations were determined by totaling the acreage of all wetland types shown on the NWI maps for each square mile section within the study area. Each section was determined to be of high (> 50 acres/section), medium (10 to 50 acres/section), or low (<10 acres/section) wetland concentration (Fig. 1-15).

Areas with high concentrations of surface water bodies were also avoided due to their expected hydrologic and wildlife habitat values. At the Amherst study area, this included the southern-most portion of the study area (Fig. 1-16).

- Wildlife Habitat and Concentration Areas

Known waterfowl production areas and other waterfowl concentration areas (e.g. wetlands and surface water bodies) were avoided. USGS topographic maps were used to determine areas of sizeable woodlots that are known to provide important mammal and other wildlife habitat. These areas were avoided, where possible. The 1988 large mammal surveys showed the area surrounding Renzienhausen Slough, which is on the western border of the study area, to be an important white-tailed deer (*Odocoileus virginianus)* winter habitat. The area around this slough was not considered for siting.

1.5.2.2 Receive Study Area

1.5.2.2.1 Operational Guidelines. The following operational guidelines were used in selection of the preferred siting areas for the receive site. The operational guidelines for the receive site differ somewhat from those used for the transmit site. Whereas the transmit facility signal can cause interference to other electronic devices, the receive facilities are passive listening stations which are designed to detect weak incoming radar signals. Thus, the primary operational concerns at the receive site are impacts to the CRS facility operations from surrounding land use activities.

- Population Center Buffer Zone

In order to minimize electronic interference to the CRS receive facility from other electronic noise sources, a buffer zone of

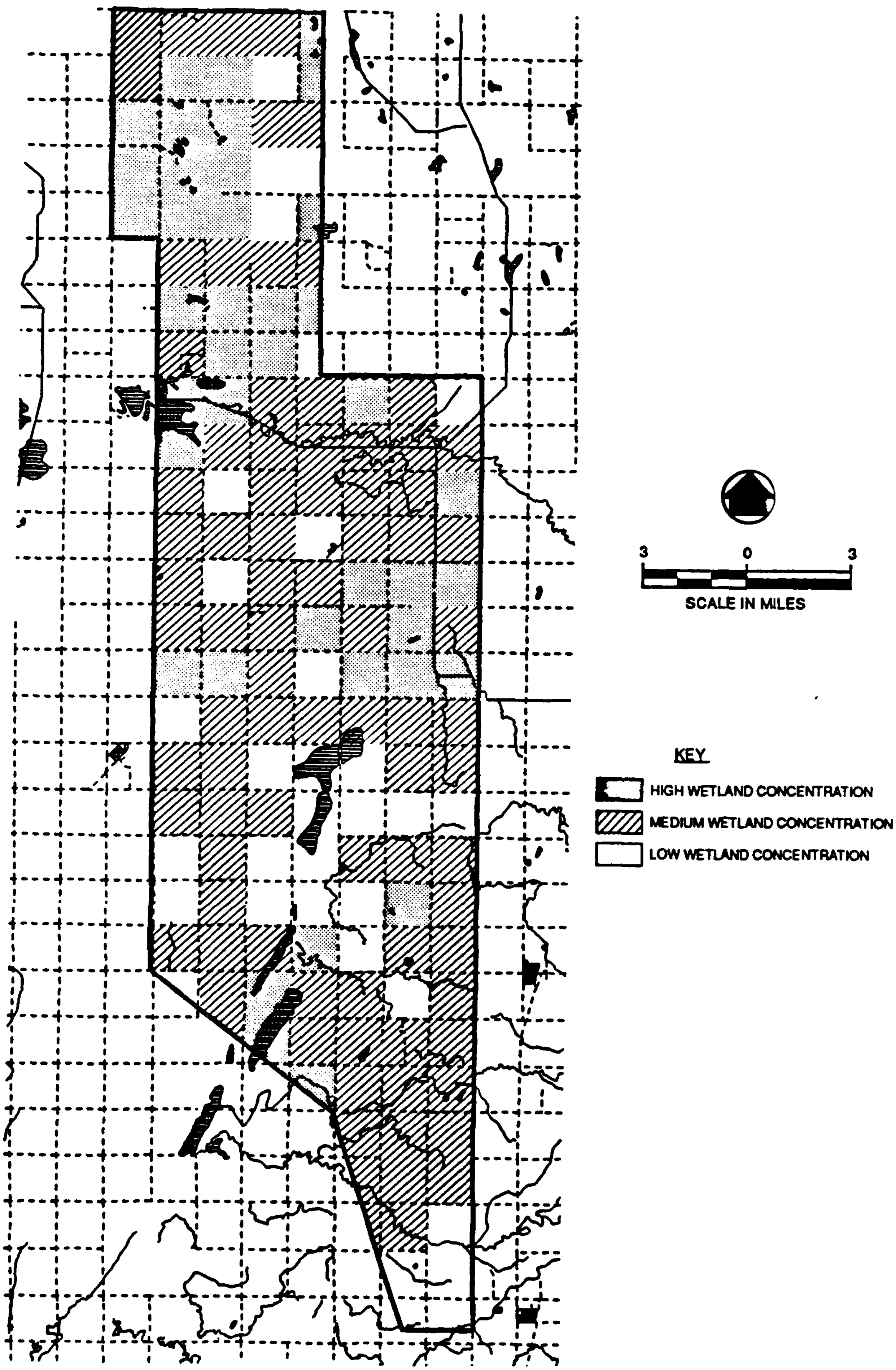


FIGURE 1-15. AMHERST, SD TRANSMIT STUDY AREA WETLAND CONCENTRATION AREAS

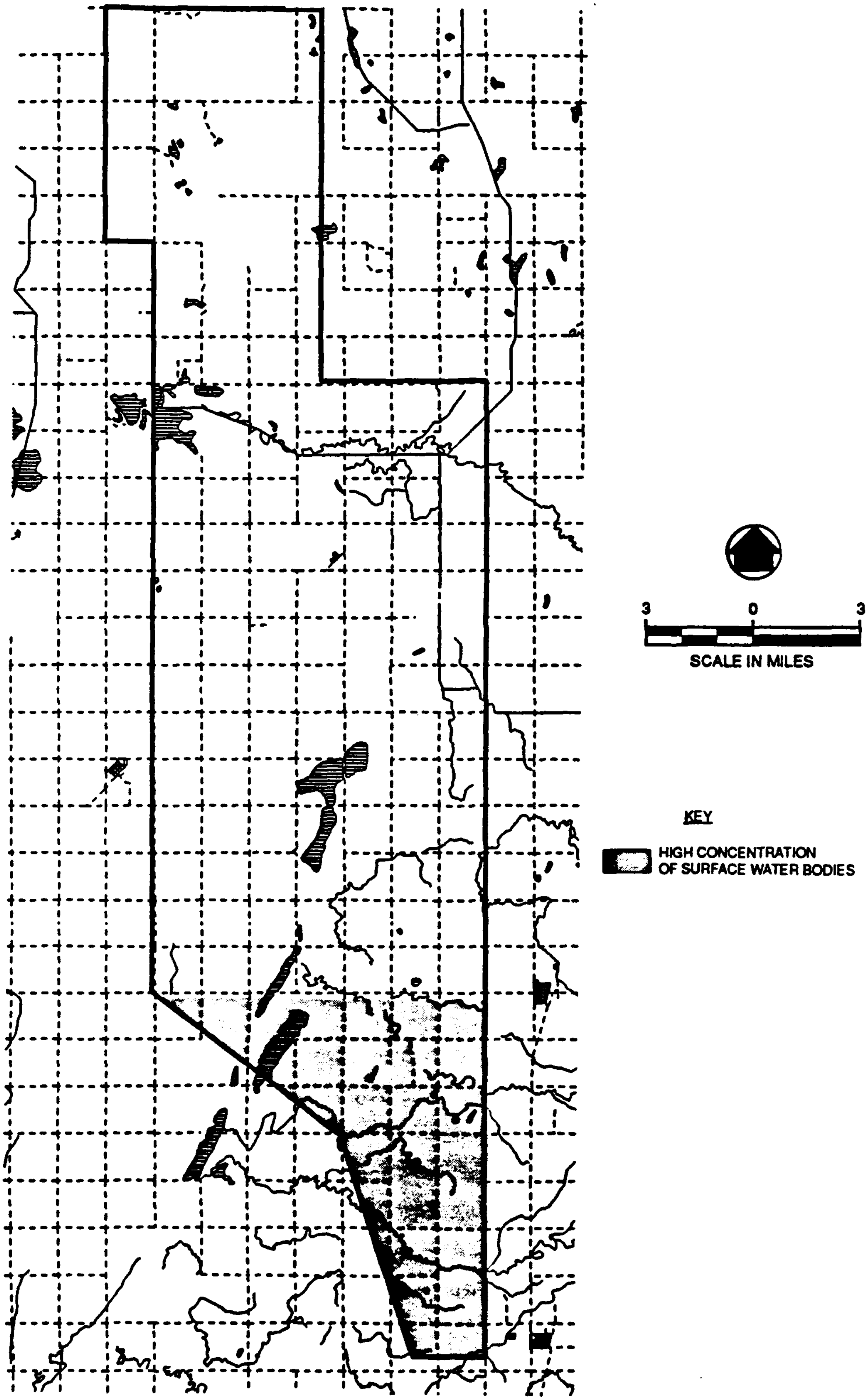


FIGURE 1-16. AMHERST, SD TRANSMIT STUDY AREA SURFACE WATER CONCENTRATION AREA

10 miles from towns with a population of over 1,000 is operationally preferred. Towns of this size are likely to generate electronic noise at levels high enough to interfere with the operation of the receive facility. The area within the buffer zone of the city of Thief River Falls (population 9,105; U.S. Census, 1986) was therefore excluded (Fig. 1-17).

- Railroad Buffer Zone

This criteria does not apply at the receive site, as the receive facilities will not interfere with railroad communication systems.

- Electronic Transmitter Buffer Zones

Because the CRS receive facility is intended to detect distant reflected radar signals, electronic signals generated by nearby transmitting towers can cause electronic interference at the receive site. The CRS facilities should therefore be located away from transmitting towers. A television transmitting tower is located in the southeast portion of the study area and an optimal buffer zone of five miles was established around this tower (Fig. 1-17).

- Airway Buffer Zones

As there is no interference between the receive facility and electronic navigational equipment, this did not limit siting at the receive study area.

1.5.2.2.2 Environmental Guidelines. During this phase of the site selection process, site specific environmental data consisted of preliminary results from avian field studies conducted in fall 1987 and spring 1988, and preliminary results of large mammal surveys conducted in winter 1988. Other information was taken from NWI and USGS maps.

- Wetlands and Surface Water Bodies

Areas of high wetland concentrations were avoided, where possible, and use of areas of low concentrations was maximized. Wetland concentrations were determined by totaling the acreage of all wetland types shown on the USFWS NWI maps for each square mile section within the study area. Each section was determined to be of high (> 50 acres/section), medium (10 to 50 acres/section), or low (<10 acres/section) wetland concentration (Fig. 1-18).

Areas with a high concentration of surface water bodies (primarily small drainage channels) were also avoided (Fig. 1-19). In the Thief River Falls study area, this included much of the southern and central portions of the study area.

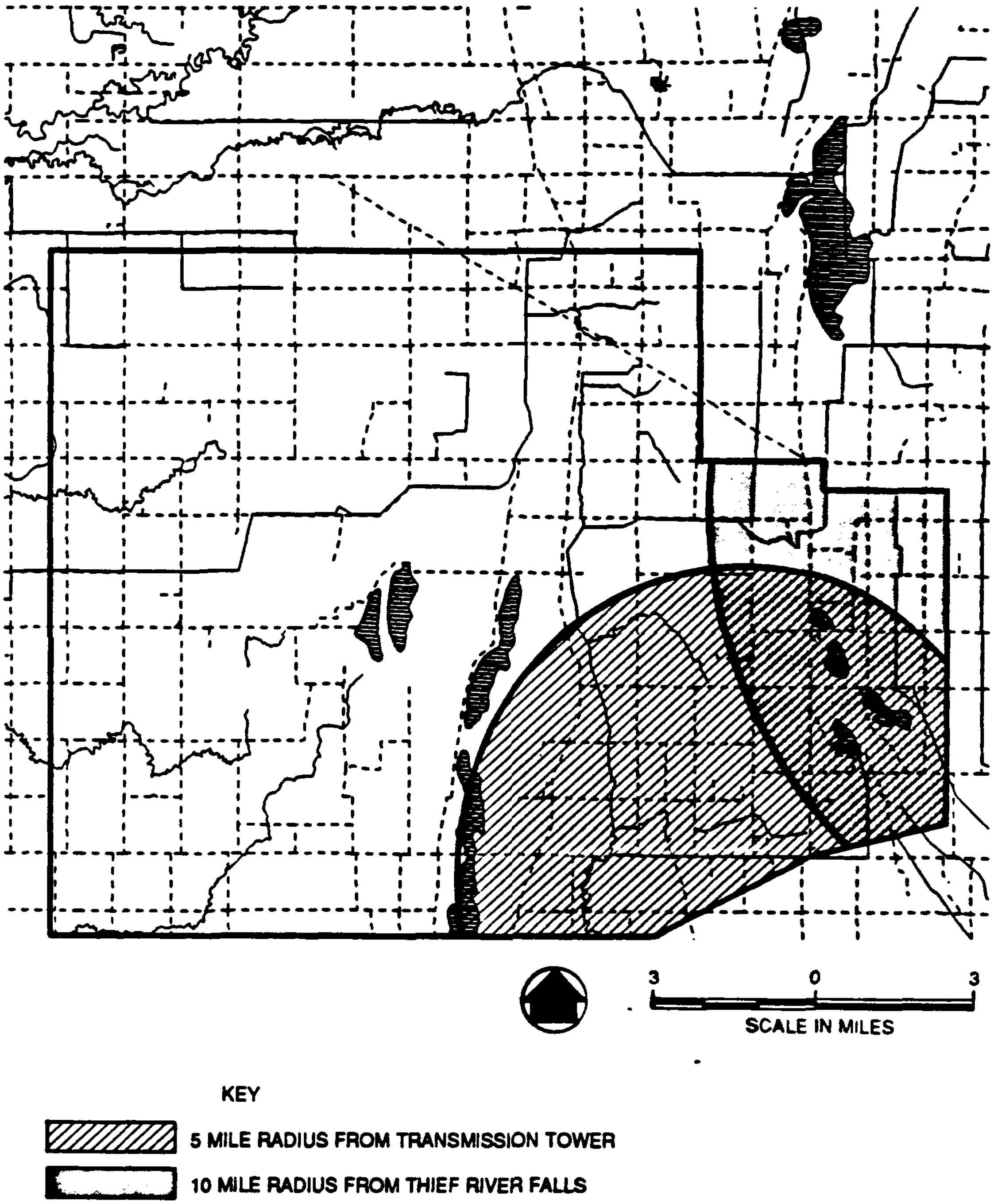


FIGURE 1-17. THIEF RIVER FALLS, MN RECEIVE STUDY AREA OPERATIONAL SITING GUIDELINES

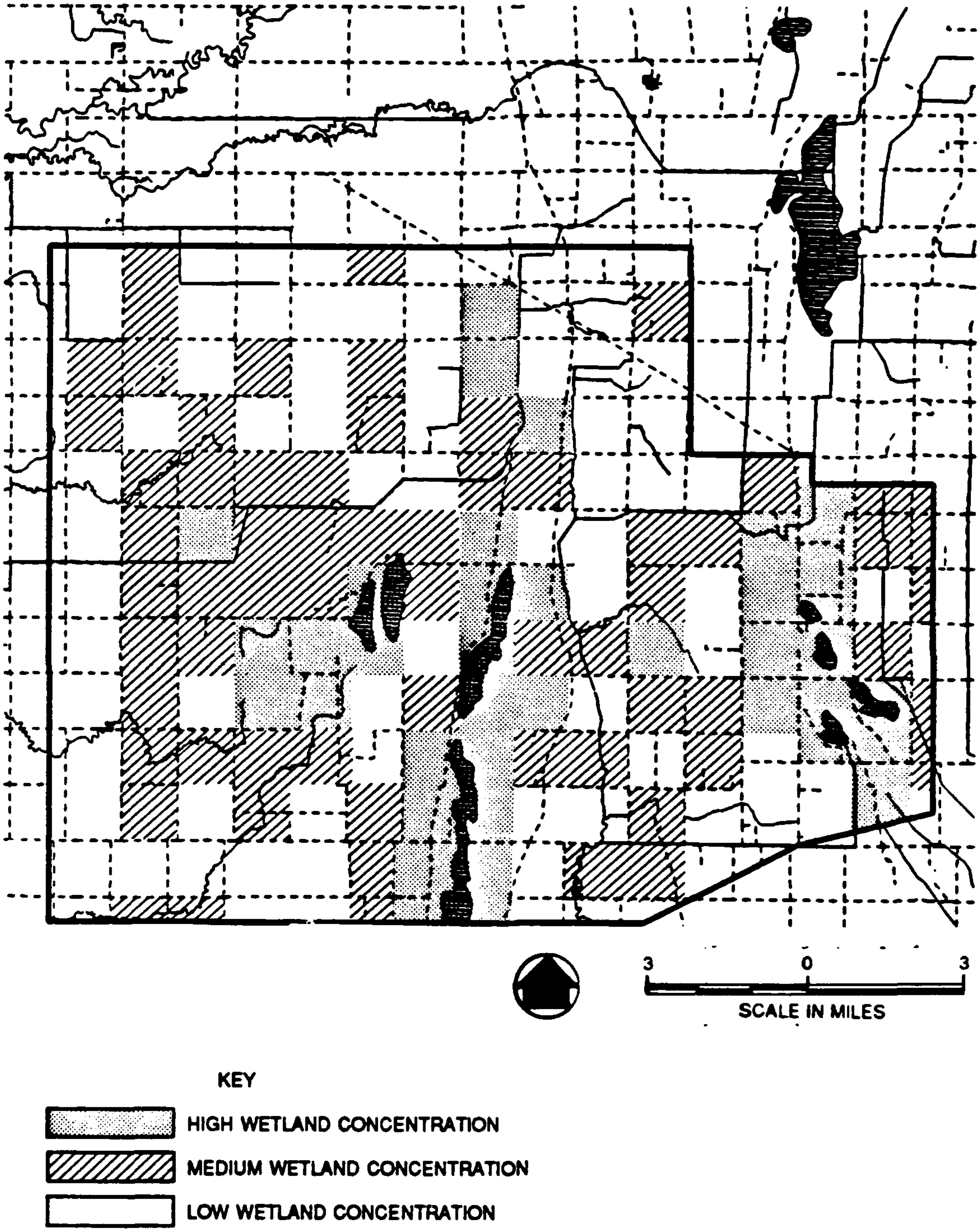
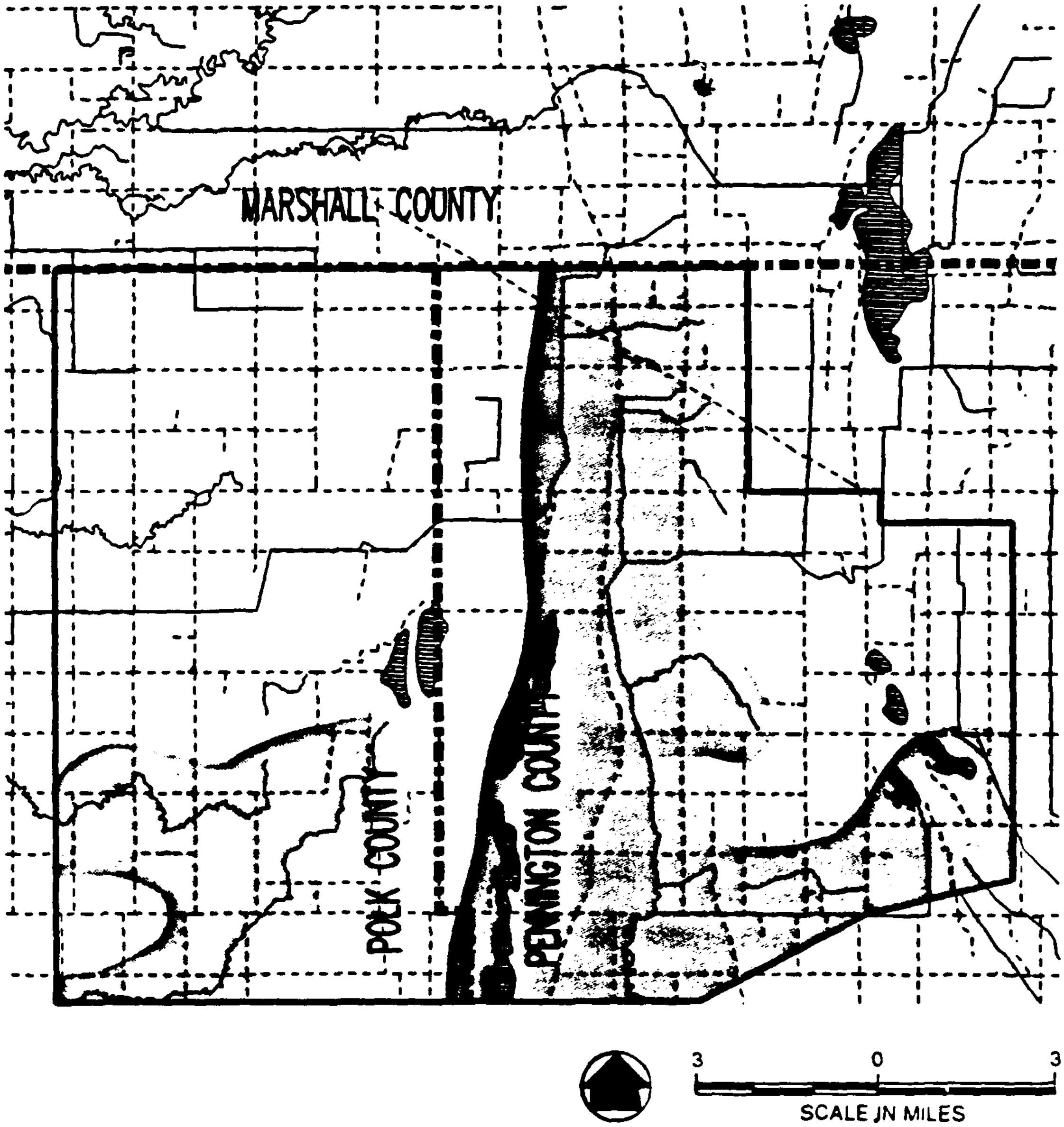


FIGURE 1-18. THIEF RIVER FALLS, MN RECEIVE STUDY AREA WETLAND CONCENTRATION AREAS



KEY

HIGH CONCENTRATION OF SURFACE WATER BODIES

FIGURE 1-19. THIEF RIVER FALLS, MN RECEIVE STUDY AREA SURFACE WATER CONCENTRATION AREAS

- Wildlife Habitat and Concentration Areas

  Known waterfowl production areas and other waterfowl concentration areas (e.g., major wetlands and surface water bodies) were avoided. State and federal wildlife agencies asked that the Goose Lake Wildlife area be avoided as it is a waterfowl and wildlife concentration area. They also asked, during agency consultation meetings, that beach ridge areas be avoided since they serve as bird migration corridors. Woodlots and wildlife concentration areas were avoided where possible.

1.5.3 Selection of Concentrated Study Areas

Once preferred siting areas were established, the USAF focused on selecting concentrated study areas for more detailed impact analysis. To determine the location of the concentrated study areas, a screening process was used to eliminate areas with the highest potential for adverse impacts from the preferred siting areas. The concentrated study areas define an affected area for the SEIS analysis, while allowing for acceptable siting flexibility for the system contractor.

To aid in this phase of the site selection process, additional environmental analyses were conducted, including large mammal and avian surveys. Also, in early 1989 the COE, on behalf of the USAF, conducted a survey of landowners within the study area to update the socioeconomic information. The landowners were asked to complete a form indicating whether they would sell, lease, give easements, or not sell their land. Further operational information was also gathered, as the USAF conducted electromagnetic noise testing within the receive study area. The additional information gathered during this phase of the process enabled the USAF to screen the environmentally preferred siting areas to concentrated study areas.

Potential site-specific operational constraints evaluated during the concentrated study area selection included horizon obstructions (obstruction of the returning signal from tall objects obscuring the area directly in front of the receive antennas), access to commercial power, and proximity to electromagnetic noise sources (at the receive site only). No horizon obstructions or constraints to access of commercial power were present in any of the preferred siting areas. Therefore those site-specific operational guidelines were not factors in selection of the concentrated study areas.

Another operational guideline, array configuration, was a major factor in selection of the concentrated study areas. The operationally-preferred transmit sector array configuration includes all four sectors in one group, each facing in the direction of transmission, with no transmit beams crossing (Fig. 1-20). For the receive sectors, the operationally-preferred array configurations have all four sectors in one group with no antenna obstructing another. This allows for two operationally-preferred configurations for the receive sectors (Fig. 1-21). The concentrated study areas had to be large enough to allow sufficient movement (and hence alternative locations) for the operationally-preferred array configuration.

The socioeconomic constraints included land availability and impacts to public facilities and major roads. During earlier stages of the EIAP, the USAF had made commitments to avoid the taking of public facilities (such as churches, schools, and township buildings) and to avoid the taking of major paved roads. Use of offered land was again maximized.

The environmental factors analyzed at this stage of the site selection process included potential impacts to birds, wetlands, and wildlife habitat (e.g. shelterbelt and woodlots). The potential impacts were determined based upon field studies conducted by the USAF.

In many cases, the operational, socioeconomic, and environmental constraints were nonexistent at a particular preferred siting area, or were equally minor throughout the preferred siting area. Only those constraints that were a factor in determining the concentrated study area locations are included in the discussion below.

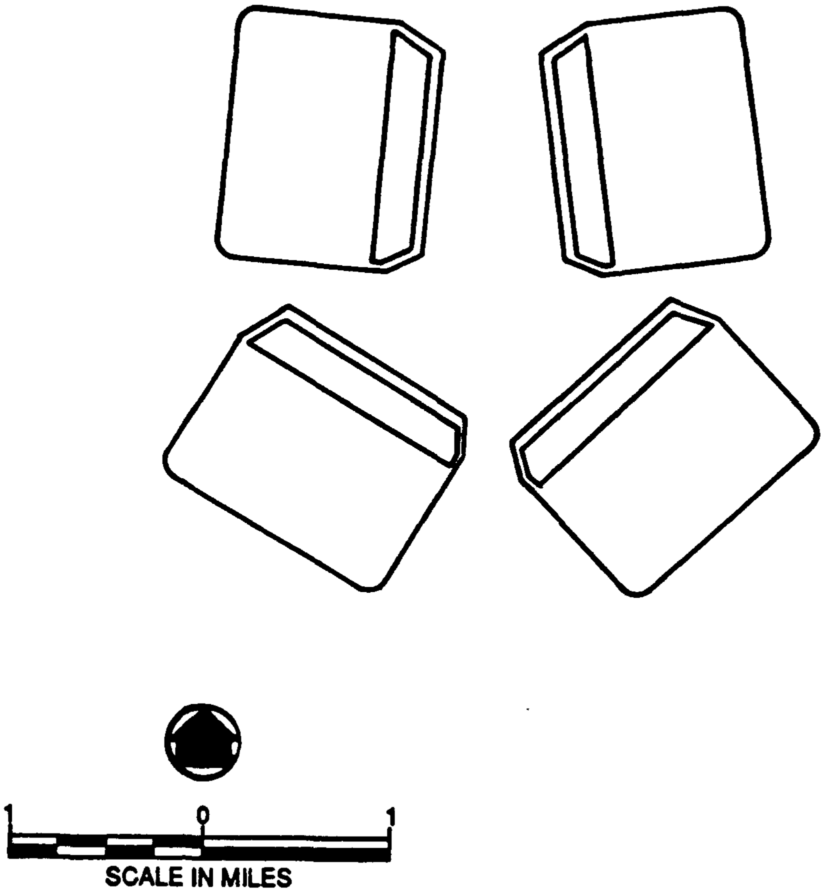


FIGURE 1-20. PREFERRED TRANSMIT SECTOR ARRAY CONFIGURATION

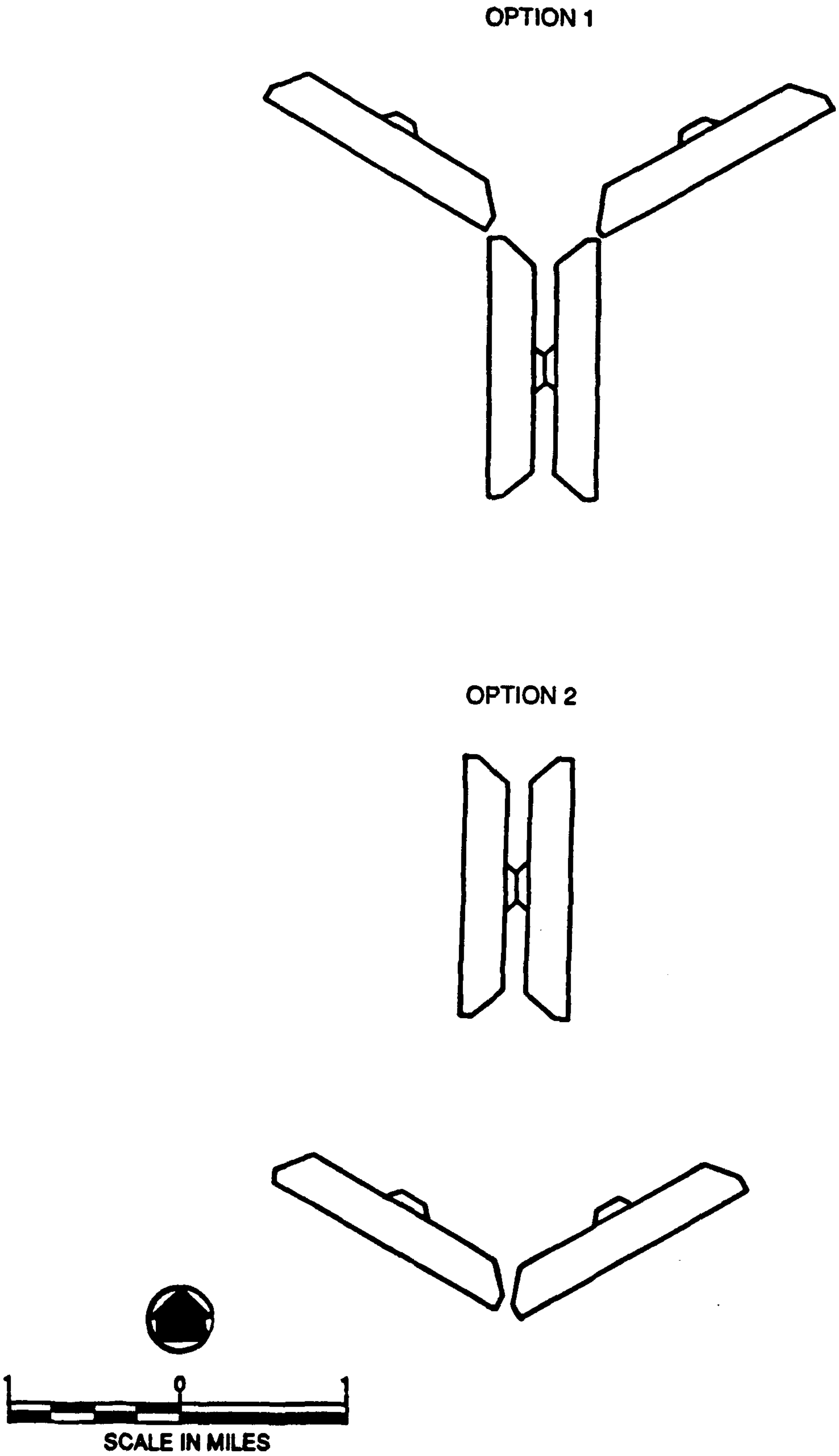


FIGURE 1-21. PREFERRED RECEIVE SECTOR ARRAY CONFIGURATION

The transmit (Tx) site concentrated study areas (CSA) were labelled Tx-North (Tx-N) and Tx-South (Tx-S). The receive (Rx) site CSA's were labelled Rx-East (Rx-E) and Rx-West (Rx-W). The locations of the CSA's are shown in Figures 1-22 and 1-23.

1.5.3.1 Transmit Study Area

1.5.3.1.1 Tx-North. Reevaluation of the operationally-preferred array configuration requirements and the area's environmental features led to the northern transmit concentrated study area being larger than the preferred siting area. The additional area (three square miles on the western edge of the preferred siting area) allowed for greater flexibility in siting of the antennas in the preferred array configuration. It may also allow for minimization of wetland and natural area impacts during siting of the facilities. This area, plus two square mile sections to the north (for a total of 5 square miles) also constituted an addition to the size of the general study area.

1.5.3.1.2 Tx-South. The Tx-South concentrated study area consists of the central portion of the preferred siting area. The southwestern portion was excluded for socioeconomic and environmental reasons. This area encompassed the Augustana Cemetery, and the USAF had made prior commitments not to take any such public facilities. Also, this area lies in a depression that is periodically flooded (as in the spring of 1989), and contains numerous wetlands. Because of the wetlands, many birds were found to use this area during the spring 1989 avian studies and the area was thus considered to have higher potential for impacts due to bird collisions.

Use of the center portion of the concentrated study area maximized use of low wetland concentration areas. In order to avoid or minimize wetland (and hence, wildlife) impacts, the center portion of the preferred siting area was selected.

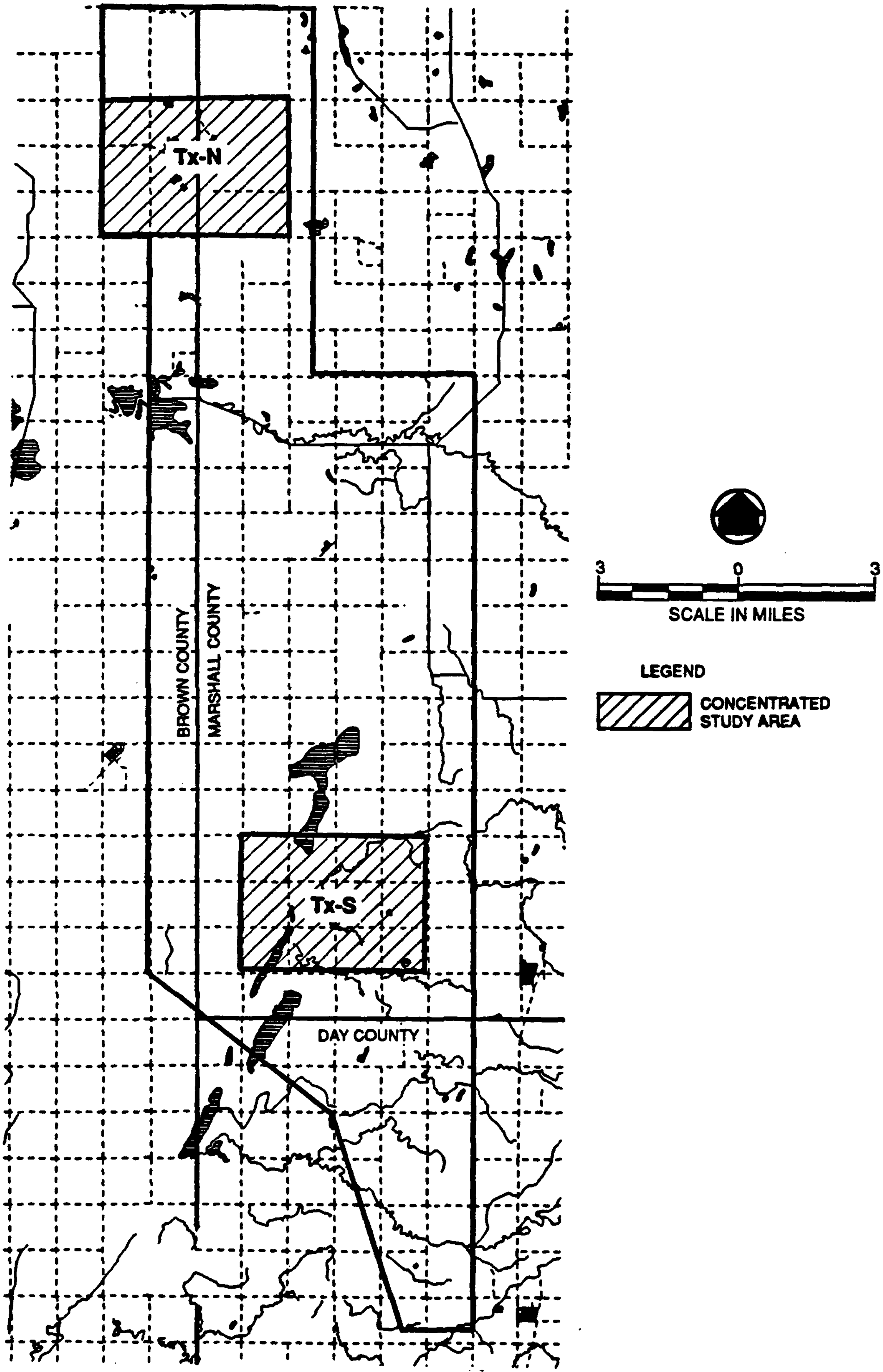


FIGURE 1-22. AMHERST, SD TRANSMIT STUDY AREA CONCENTRATED STUDY AREA LOCATIONS

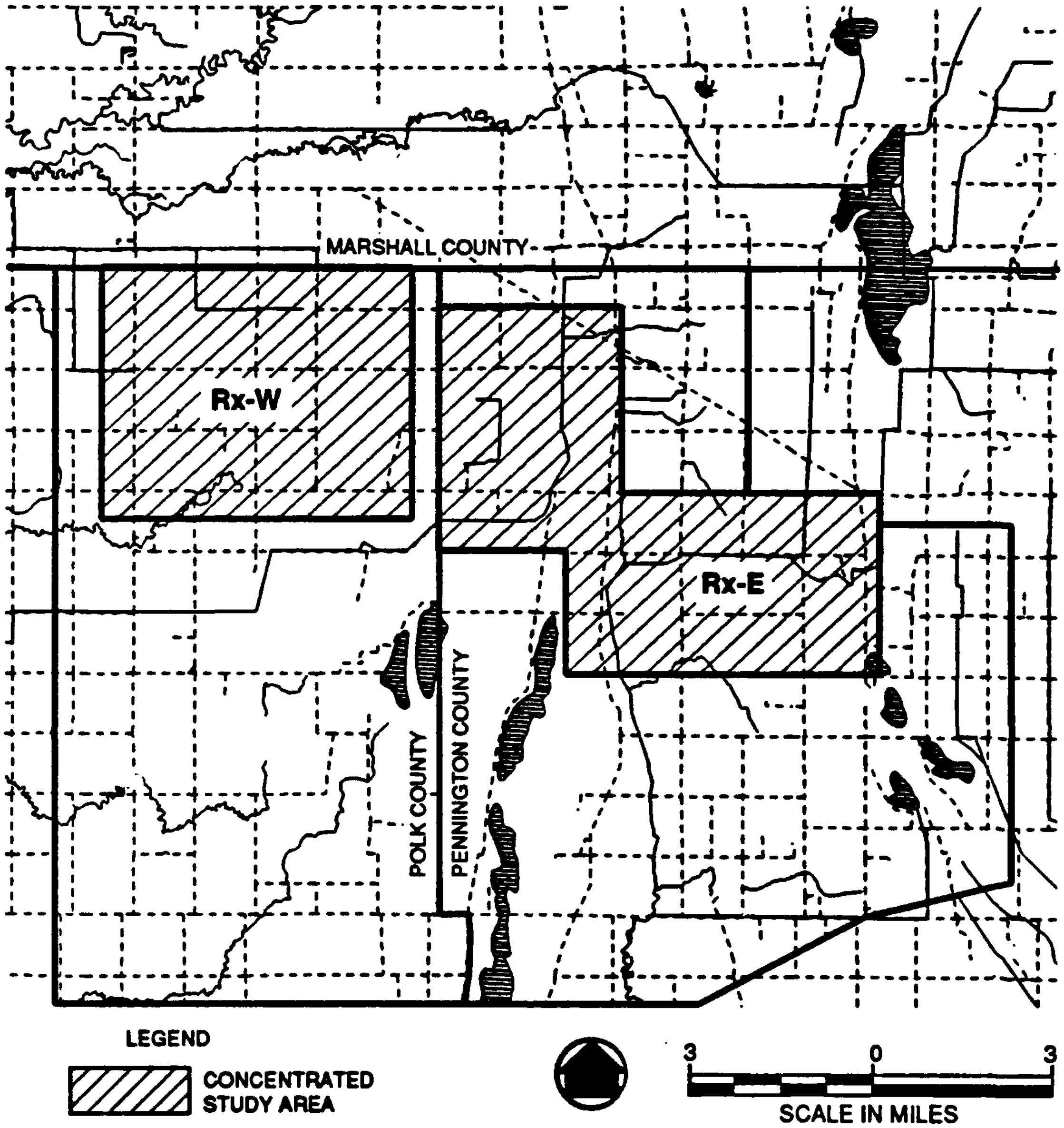


FIGURE 1-23. THIEF RIVER FALLS, MN RECEIVE STUDY AREA CONCENTRATED STUDY AREA LOCATIONS

1.5.3.2 Receive Study Area

1.5.3.2.1 Rx-East. Results of the COE land survey led to the receive site eastern preferred siting area being enlarged to include several square miles in the northeast corner of Pennington County where land was offered for sale. In addition, the southern portion of this preferred siting area was deleted because of its proximity to the transmitting tower to the south.

1.5.3.2.2 Rx-West. There were no major new constraints identified for siting within the western preferred siting area, therefore the size of the preferred siting area was not altered for the concentrated study area.

1.5.4 Selection of Preliminary Site Layouts

The third phase of the site selection process consisted of development of preliminary facility layouts and locations within each CSA. Each preliminary layout includes a buffer zone of 1,000 feet on all sides of the antennas. This buffer is the land the USAF is likely to purchase in order to provide sufficient flexibility for final facility design. The layouts shown are conceptual, as the system contractor will decide during final design the ultimate location of the facilities within the buffer zone. The USAF will consider leasing back portions of the buffer zones for farming, grazing, or other suitable uses following facility design.

The USAF selected the preliminary site layouts and locations based upon review and evaluation of detailed resource map overlays prepared for the CSA's. These detailed resource overlays included a base map of the CSA's with locations of roads and homes shown, and overlays of drainage and hydrology, land ownership, wetlands, avian concentration areas, and topography. The resource overlays were created based upon existing information and site-specific surveys conducted by the USAF. The road locations were determined from county highway maps. Topography information was taken from USGS topographic maps, and the locations of homes were taken from USGS topographic maps and 1989 aerial photographs of the study area. Drainage studies were conducted by the USAF, from which the drainage and hydrology maps were prepared. Land ownership maps were developed based upon results of the most recent COE land surveys. The USAF prepared detailed wetland mapping for the CSA's from USFWS NWI maps, 1989 aerial photography, and field verification (where possible, with landowner permission). Lastly, avian concentration areas were determined based upon the results of fall 1987, spring 1988, and spring 1989 avian field studies.

During this phase of the site selection process, the USAF used the following guidelines, which were given equal weight in the site selection process:

a) Maximize use of offered land.

b) Avoid or minimize impacts to threatened, endangered, or special concern species.

c) Avoid or minimize wetland impacts.

d) Avoid or minimize impacts to natural areas, such as native prairies and large woodlots.

e) Avoid or minimize impacts to bird flight paths.

f) Avoid or minimize impacts to paved roads and major gravel roads.

The following sections discuss the impact of these guidelines on facility siting within the CSA's. The SEIS for the CRS project will examine the selected facility site within each CSA, therefore each selected site constitutes one alternative location. The preliminary site layouts have been labelled Tx-N, Tx-S, Rx-E and Rx-W to correspond with the CSA they fall within. The locations of the alternatives are shown in Figures 1-24 through 1-27.

1.5.4.1 Transmit Site

1.5.4.1.1 Tx-North. The major factors affecting the siting of the Tx-N preliminary site layout within the Tx-N CSA were avoidance or minimization of impacts to threatened, endangered and special concern species natural areas, and wetlands.

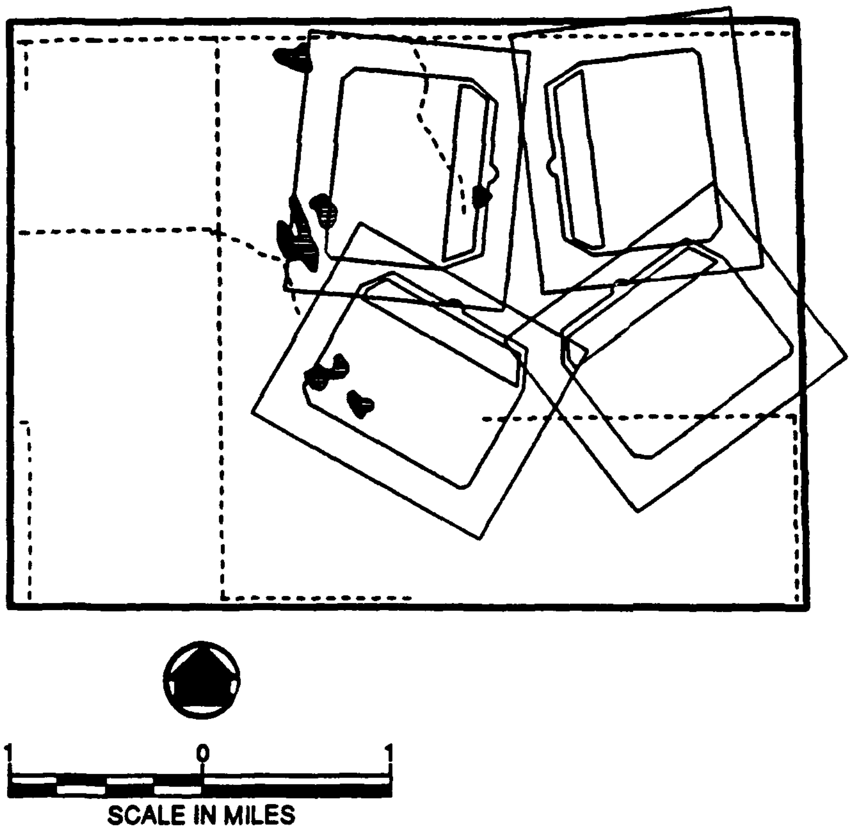


FIGURE 1-24. TX-NORTH PRELIMINARY SITE LAYOUT

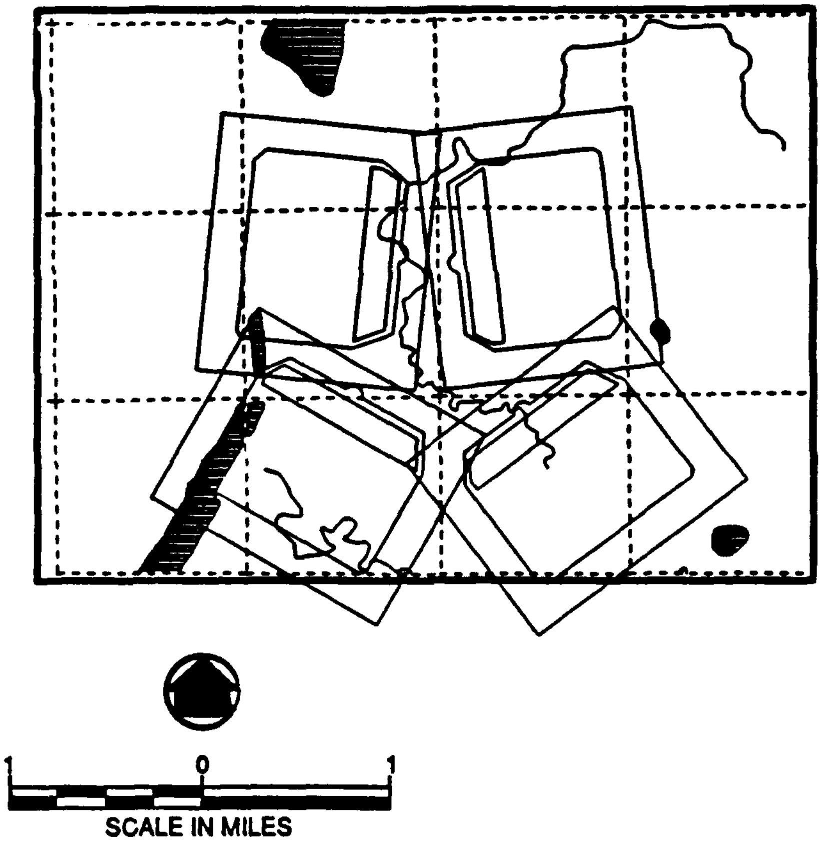


FIGURE 1-25. TX-SOUTH PRELIMINARY SITE LAYOUT

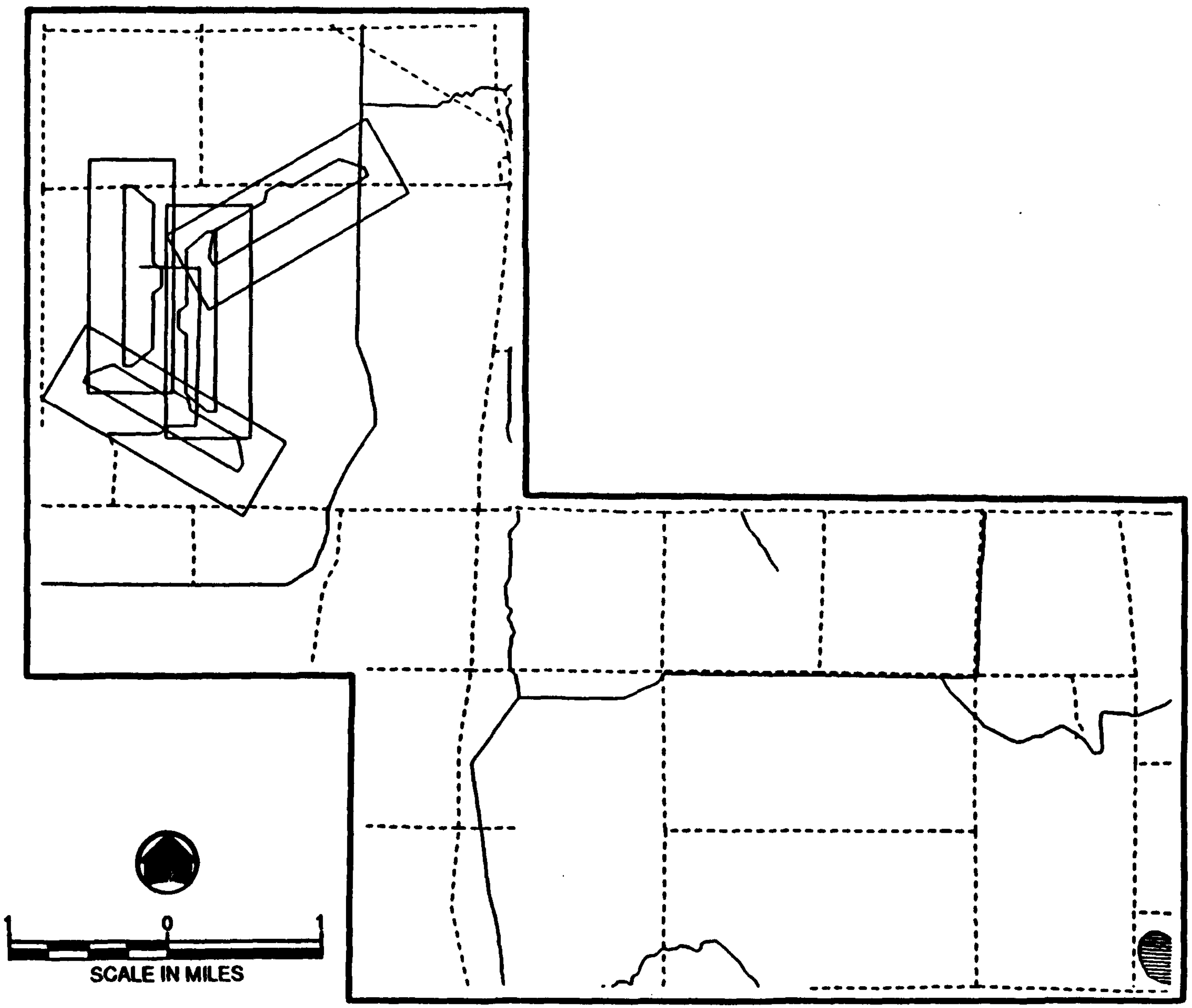


FIGURE 1-26. RX-EAST PRELIMINARY SITE LAYOUT

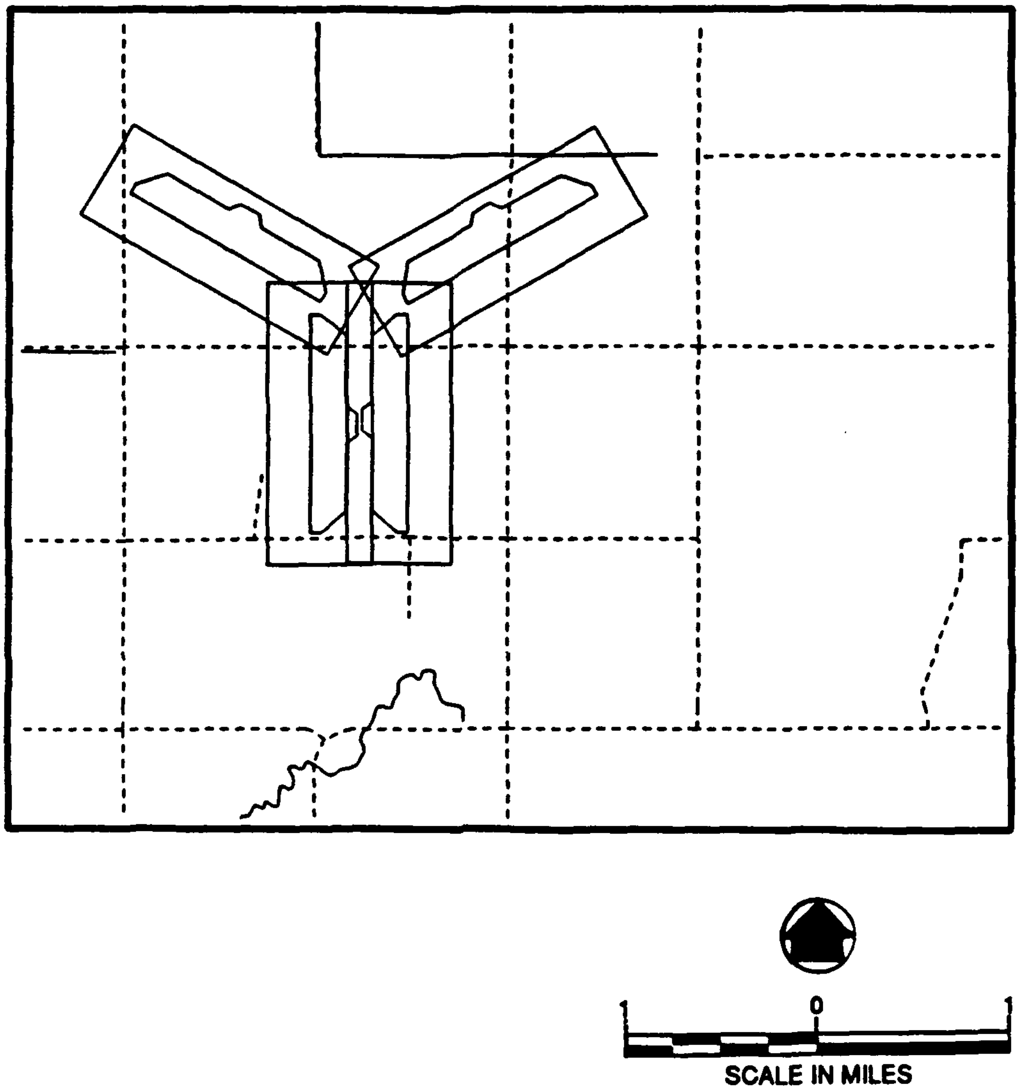


FIGURE 1-27. RX-WEST PRELIMINARY SITE LAYOUT

The western portion of the Tx-N CSA contained the lowest concentration of wetlands, so the alternative site was located as far west as possible, in the preferred array configuration.

Placement of the Tx-N alternative in the western portion of the CSA also allowed for avoidance of direct impacts to breeding habitat (leks) for a species of special concern, the greater prairie-chicken. While one prairie-chicken lek is within the fenced area, there should be no disturbance to the lek itself. The other lek was avoided completely. A tract of native prairie was also avoided in selection of the proposed facility site, as it contains potential critical habitat for several rare and endangered prairie plant species (see Technical Study 9, Threatened and Endangered Species).

Potential impacts to birds were determined to be equal at all areas within the CSA. There are no major roads in this CSA. These two factors did not influence siting of the preliminary layout within the CSA.

1.5.4.1.2 Tx-South. The major factors affecting the siting of the preliminary site layout within the Tx-S CSA were avoidance or minimization of impacts to major roads and wetlands.

Although there were few land offers in this CSA, use of offered parcels was maximized, where possible, given the preferred array configuration and the constraints of the paved roads. Avoidance of major roads was a prime factor in selecting the preliminary site layout within the Tx-S CSA. The two paved roads in the study area were avoided, which necessitated placing two antenna sectors on either side of the north-south road, Marshall County 11, and all four sectors north of the east-west road, Marshall County 16. The final locations of the four sectors on either side of Route 11 were then determined mainly by the location of wetlands.

To avoid wetland impacts, the four sectors were located as close together as possible, which could allow for common access roads and construction staging areas, resulting in less fill area. In addition, the sectors were placed where filled areas, such as the groundscreen, had fewest wetland impacts.

This CSA has no known critical habitat for threatened, endangered or special concern species. Also, there are no major woodlots or natural areas within the Tx-S CSA. As with the Tx-N CSA, potential impacts to bird flight paths were determined to be equal at all areas within the Tx-S CSA. Therefore these guidelines were not factors in the siting of the preliminary layout within the Tx-S CSA.

1.5.4.2 Receive Study Area

1.5.4.2.1 Rx-East. The major factors determining the preliminary site layout within the Rx-E CSA were maximizing the use of offered land, minimizing impacts to woodlots, and minimizing potential impacts to bird flight paths.

The use of offered land at this CSA was maximized by placing the four antennas in the western part of the study area and in the close configuration that was specifically developed for this alternative. During consultation with the federal and state environmental agencies, the agencies stated their preference for placing the CRS facilities to the west of the beach ridge in Pennington County, as the ridge serves as a bird migration corridor and the area east of it is a wildlife concentration area. The beach ridge runs in a north-south direction through the center of the CSA. The antennas were located to the west of the beach ridge to avoid potential wildlife and bird collision impacts.

The largest natural areas in this CSA consist of native tree stands, mostly in the easternmost portion of the CSA. Stands of native trees were avoided in the alternative site selection. Impacts to wetlands were minimized by use of the close array configuration which could allow for common access and perimeter roads and construction staging areas, thereby reducing fill areas.

To avoid Pennington County Route 10 (a major gravel road), however, the preliminary site had to be located to the extreme western part of the CSA. As a result, this guideline, in combination with land offers and minimization of wetland and bird collision impacts led to placement of the preliminary site layout in the western portion of the CSA.

As there is no known critical habitat for threatened, endangered, or special concern species within the Rx-E CSA, this guideline was not a factor in the preliminary site layout selection.

1.5.4.2.2 Rx-West. The major factors determining the preliminary site layout within the RX-W CSA were avoidance of wetlands and woodlots.

This CSA has no known critical habitat for threatened, endangered or special concern species, therefore this guideline was not a factor in the facilities site selection. To avoid wetland impacts, the four sectors were located as close together as possible, allowing the possibility of having common access roads and construction staging areas, causing less fill area. In addition, the sectors were placed where filled areas, such as the groundscreen would have fewest wetland impacts. There is one large woodlot within the Rx-W CSA which was avoided in the siting of the alternative location of the CSA. Two major gravel roads, Routes 68 and 23, were also avoided.

Potential impacts to bird flight paths were determined to be equal at all areas within the Rx-W CSA. Therefore this guideline was not a factor in the siting of the preferred alternative within the Rx-W CSA.

1.6 PERMITTING

Based upon the facilities described in Technical Study 2 and the permitting information available to date, a list of potential federal environmental permits has been developed as shown in Table 1-2. Additional consultation between the USAF and state and local agencies to determine other permitting requirements is ongoing. Although several different contractors are expected to be utilized for site construction, the USAF and its system contractor will oversee all permitting activities and adherence to permit requirements relating to the facilities. The power companies may obtain permits specifically related to power line construction.

1.7 MITIGATION

1.7.1 Draft Mitigation Plan

The USAF has begun to develop a draft project mitigation document in conjunction with the project SEIS. The intent of the plan is to provide mitigation measures for unavoidable environmental impacts identified in the SEIS in accordance with NEPA, AFR 19-2, and recommendations received from agency representatives during the quarterly review meetings. The draft mitigation plan will be released in conjunction with the final SEIS. Although containing complete mitigation concepts, the document will continue to evolve as the system design process proceeds and detailed mitigation measures are developed.

1.7.2 Mitigation Action Plan

A CRS Mitigation Action Plan will also be prepared to specify individual actions that must be implemented to achieve the goals of the mitigation plan and comply with environmental agency requirements. The plan will designate the party responsible for the action and an anticipated date of execution. Like the mitigation plan, the action plan will be an evolving compilation of activities to address environmental issues as they surface. As with the mitigation plan, the system contractor will be provided with the most recent versions of the Action Plan and will be required to comply with mitigation measures adopted by the USAF.

TABLE 1-2. POTENTIAL FEDERAL ENVIRONMENTAL PERMITS FOR THE CONSTRUCTION AND OPERATION OF THE CENTRAL RADAR SYSTEM

Agency	Permit/Approval Authority
Advisory Council on Historic Preservation	Section 106 Review Process
Army Corps of Engineers	Section 404/10 (Wetlands Dredge/ Fill Permit)
South Dakota Department Water and Natural Resources/Minnesota Pollution Control Agency/Environmental Protection Agency	NPDES Permit (Federal Permit Delegated to States)
Environmental Protection Agency	SPCC Plans
Fish & Wildlife Service	Section 7 Consultation
Minnesota Department Water and Natural Resources (MN); Environmental Protection Agency (SD)	Water Quality Certification Section 401 (Federal Permit Delegated to State of Minnesota)
Federal Aviation Administration	Notice of Proposed Construction or Alteration
Environmental Protection Agency	Notification for Underground Storage Tanks

REFERENCES

United States Air Force (USAF), 1986. Draft Environmental Impact Statement: Proposed Central Radar System, Over-the-Horizon Backscatter Program.

United States Air Force (USAF), 1987. Final Environmental Impact Statement: Proposed Central Radar System, Over-the-Horizon Backscatter Program.

United States Air Force (USAF), 1988. Record of Decision Central Radar System Environmental Impact Statement. Over-the-Horizon Backscatter Radar Program.

United States Air Force, 1990. Notice of Intent to Prepare an Environmental Impact Statement. Federal Register. Volume 55.

United States Army Corps of Engineers, no date. Preliminary Site Survey No. 2. Over-the-Horizon Backscatter Central Radar System.

United States Census, 1986. 1986 Population and 1985 Per Capita Income Estimates for Counties and Incorporated Places. US Department of Commerce, Bureau of the Census.

TECHNICAL STUDY 2

CENTRAL RADAR SYSTEM
OVER-THE-HORIZON BACKSCATTER RADAR PROGRAM

FACILITIES

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TECHNICAL STUDY 2
FACILITIES

2.1 INTRODUCTION

The U.S. Air Force (USAF) has proposed to construct an Over-the-Horizon Backscatter (OTH-B) radar in the north central United States. This system will be called the Central Radar System (CRS). In the Record of Decision (USAF, 1988) for the project, the USAF selected a study area near Amherst, South Dakota for the transmit facilities and a study area near Thief River Falls, Minnesota, for the receive facilities (Fig. 2-1). As described in Technical Study 1, EIAP Overview, the USAF has narrowed the proposed location of the facilities to two concentrated study areas (CSA) within each general study area.

This report will address approximate size and location of structures, clearing requirements, utility requirements, and anticipated construction methods for the proposed facilities. The information contained herein provides the baseline for addressing potential impacts for the Supplemental Environmental Impact Statement (SEIS) and supporting technical studies. Since detailed design information will not be available until after system contract award, this facility concept establishes the features to be considered during facility design. Much of the information utilized has been extracted from Air Force programming and planning documents, and from the OTH-B West Coast Radar System (WCRS) design documents, since site design of the Central Radar System is expected to be modeled after the WCRS recently constructed in Oregon and California.

2.1.1 Program Description

The OTH-B Radar System is a long-range, wide-area surveillance radar which can detect and track aircraft at all altitudes at a range of 500 to 1,800 nautical miles.

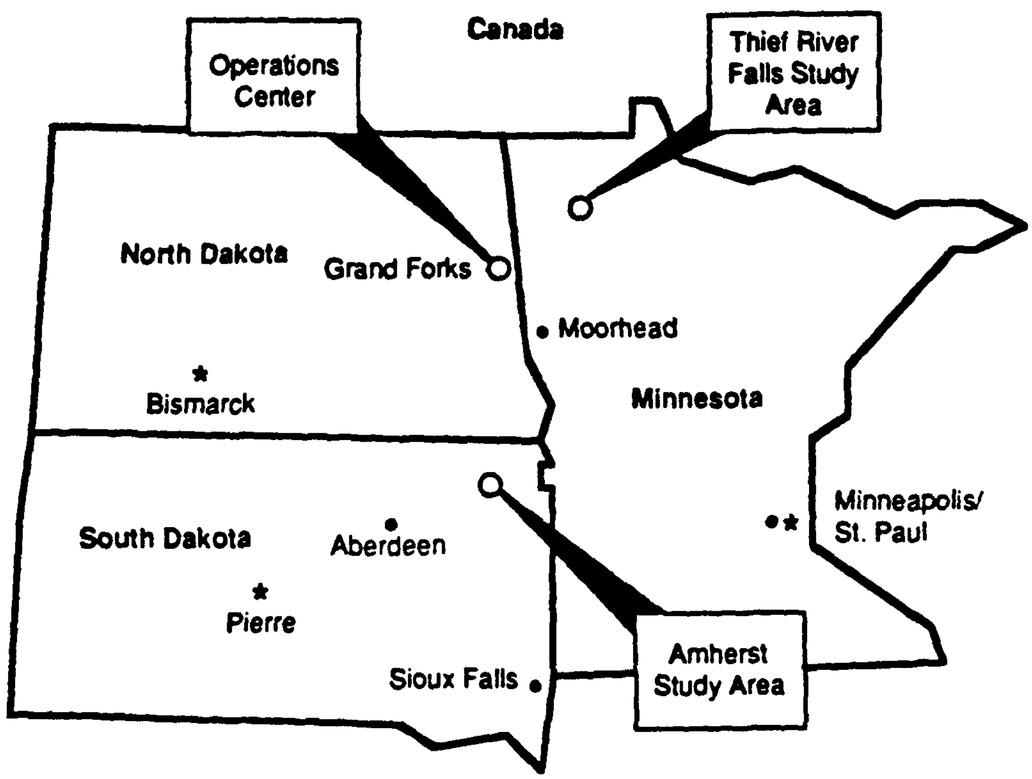


FIGURE 2-1. LOCATION OF THE CENTRAL RADAR SYSTEM TRANSMIT AND RECEIVE STUDY AREAS

Four OTH-B radar systems are planned to provide surveillance and warning of aircraft and cruise missiles approaching the North American continent from eastern, southern, western and northwestern directions. The four systems are referred to as the East Coast Radar System (ECRS), the West Coast Radar System (WCRS), the Alaskan Radar System (ARS) and the Central Radar System (Fig. 2-2).

Limited operation has begun on all three sectors of the 3-sector East Coast Radar System. The West Coast Radar System construction is complete; testing has started and the facility is expected to be operational by 1991. The Alaskan Radar System is currently in the planning and design stages of system development.

The Central Radar System will consist of a transmit site in northeastern South Dakota, a receive site in northwestern Minnesota, and an operations center located at Grand Forks Air Force Base, North Dakota (Fig. 2-1). The transmit and receive facilities each consist of four antenna arrays, each covering a 60° azimuth. The CRS will span a 240° arc, from an azimuth of about 60° (northeast), clockwise, to approximately 300° (northwest). Detailed information regarding the transmit antenna facility and receive antenna facility can be found in Sections 2.2 and 2.3, respectively. The operations center consists of a 33,000 sq. ft. building.

2.1.2 Program Schedule

The major tasks required to be completed for the OTH-B Central Radar System are:

- Environmental Impact Analysis Process (EIAP)
- Land Acquisition
- Permit Acquisition
- Prime System Contract
- Electric Power Supply Design and Construction
- Operations Center Construction

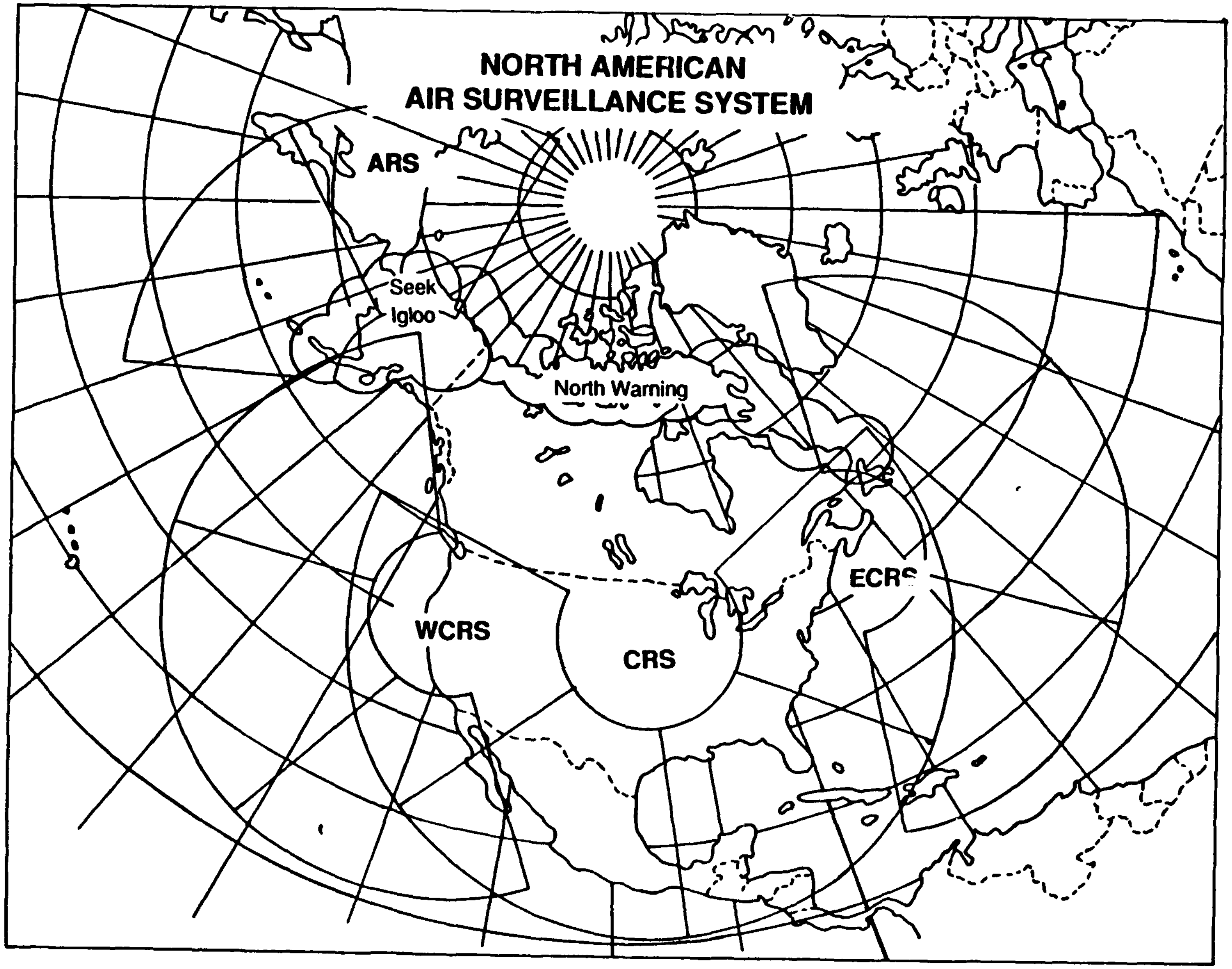


FIGURE 2-2. OTH-B RADAR COVERAGE AREA

The current CRS master schedule is shown on Figure 2-3.

The EIAP is ongoing; a final system EIS was prepared in 1987 (USAF, 1987) and a Record of Decision issued in 1988 (USAF, 1988). An SEIS will continue the EIAP, and is intended to define site-specific environmental impacts. Once the SEIS is completed, the permitting process will begin to enable the start of design, construction and operation of the CRS. Development of a detailed mitigation plan is ongoing. The mitigation plan will be released with the Final SEIS, and will continue to be modified at least through 1996, when the CRS is expected to be operational.

The USAF is currently planning to award the prime system contract for design and construction of the antennas and associated facilities in the winter or spring of 1991. Once begun, system design, construction, equipment installation and operational check-out is expected to last 4 to 6 years. The design of the operations center at Grand Forks AFB, North Dakota is currently being performed as a part of the Military Construction Program (MCP). Construction is scheduled to begin in spring of 1991, and be completed in fall of 1992.

2.2 TRANSMIT SITE

The transmit site is proposed to be located within the Amherst, South Dakota study area. The study area is located approximately 37 miles east of Aberdeen, South Dakota (Fig. 2-4). Within the Amherst Study area, there are two concentrated study areas (CSA) currently being considered for the transmit facility location (Fig. 2-4). The Tx-North (Tx-N) CSA is located in Marshall and Brown Counties, 8.5 miles north of Amherst, South Dakota. The Tx-South (Tx-S) CSA is located in southern Marshall County near the border of Day County, 4.5 miles west of Langford, South Dakota, and 8.0 miles south of Amherst, South Dakota.

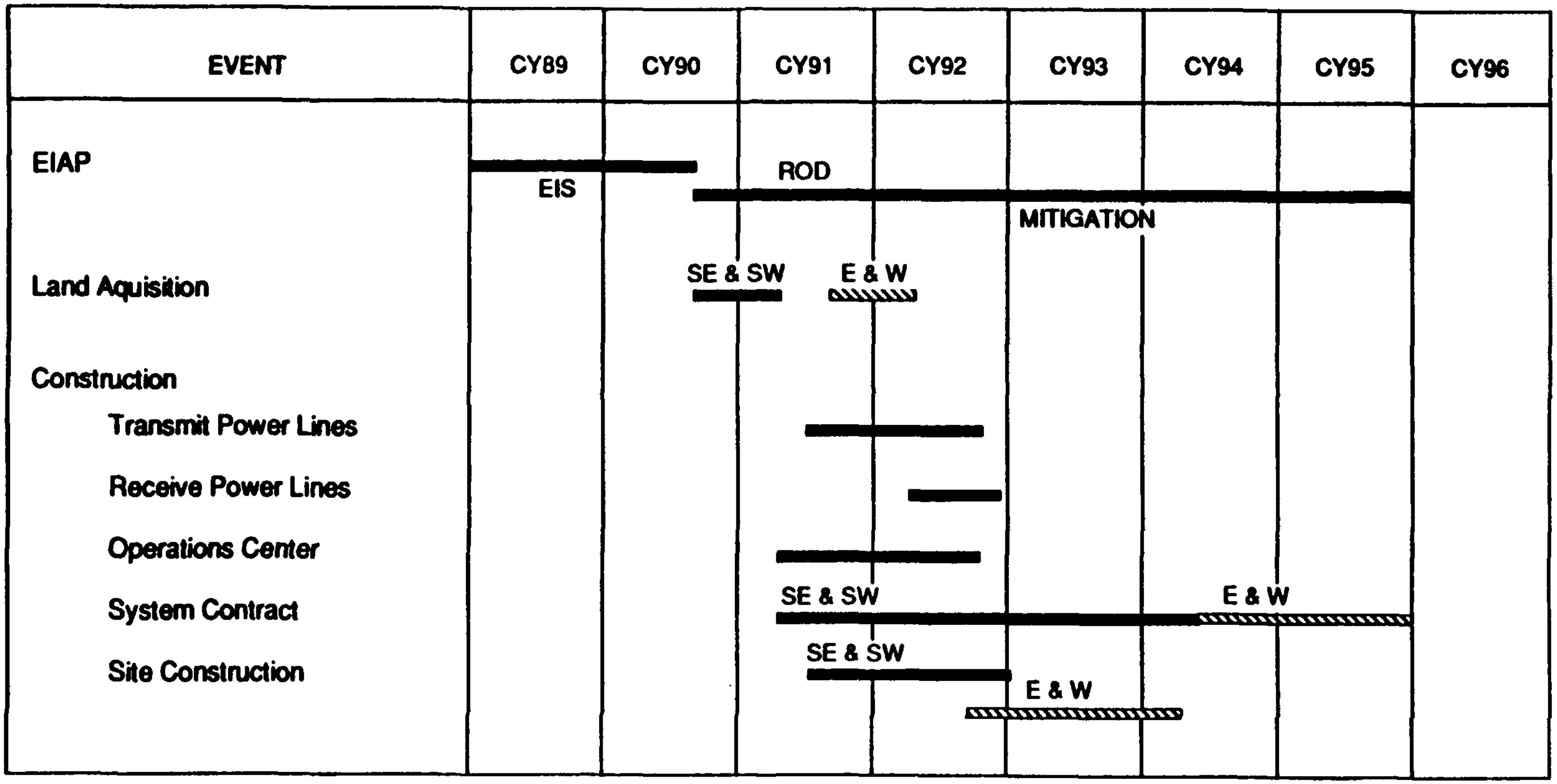


FIGURE 2-3. CENTRAL RADAR SYSTEM MASTER SCHEDULE

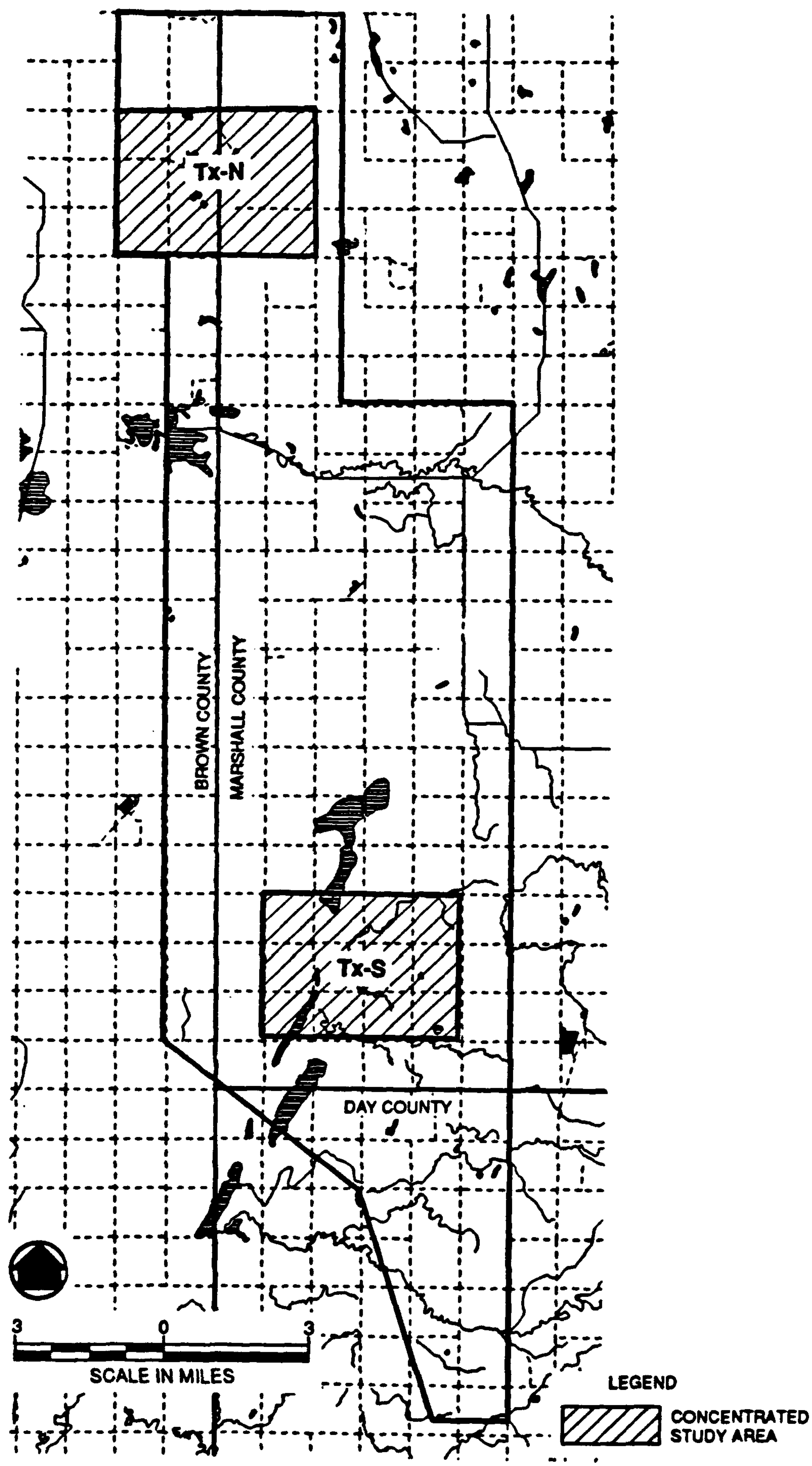


FIGURE 2-4. AMHERST, SD TRANSMIT STUDY AREA

2.2.1 Site Description

The CSA's are generally agricultural and are crossed by a few intermittent streams and creeks which are considered tributaries to the James River (see Technical Study 4, Hydrology and Water Quality). The creeks, except for low-lying emergent wetlands, are dry or stagnant during most late summers (see Technical Study 6, Wetlands and Aquatics). They are characterized by poorly defined channels with numerous pools and meanders. Woody vegetation is generally limited to scattered willows although there is also green ash and American Elm (see Technical Study 5, Vegetation). Tree breaks or shelter belts are present and they often extend entirely across a section, usually in an east-west direction (U.S. Geological Survey, 1986a; 1986b).

2.2.1.1 Topography and Drainage. The topography in the CSA's is flat to gently rolling with shallow depressions. The Tx-N CSA has site elevations varying from 1,350 ft. in the east to 1,295 ft. in the west. The surface has low topographic relief, sloping generally downward from the northeast to the southwest at a rate of less than one percent. The Tx-S CSA has site elevations varying from 1,325 ft. in the east to 1,295 ft. in the west. The surface has low topographic relief, sloping generally downward to the west northwest at a rate of less than one percent.

The higher areas are moderately well drained, the depressions are poorly drained, and drainage features are not well developed. Drainage ditches adjacent to the section roads plus isolated culverts help to control drainage flow. Sheet flow appears to be the predominant means of drainage over much of the CSA's. Maximum flow will probably occur during spring rains and thawing conditions. Surface grading for the proposed site will be designed to allow surface water to flow back into the sites' existing and/or natural drainage system and will be accomplished by a combination of culverts, swales and ditches.

2.2.1.2 Subsurface Conditions. The general area, encompassing the two concentrated study areas is located on the Lake Dakota Plain physiographic division. The surficial geology of this area is a product of sediment deposition in lakes formed from glacial meltwaters. Lake Dakota occupied a significant area where deposition and accumulation of sediment left deposits of silt and clay 100 ft. thick.

Underlying the glacial soil deposits are successive layers of fine grained sands, silts, and marine clays. Underlying these strata are bedrock formations that include sedimentary, granite and schist type rock. No rock outcrops have been observed. The depth to bedrock is unknown and is expected to be too deep to affect the proposed construction. Groundwater depth varies, although a general range is considered to be 4 to 10 feet.

South Dakota is mapped as seismic risk zone 1, corresponding to a maximum earthquake intensity of VI on the Modified Mercalli Intensity Rating Scale. A VI intensity earthquake is defined as causing slight damage to poorly built structures. No earthquakes have been recorded nearer than central South Dakota and west central Minnesota (Soil Conservation Service, 1975). The low intensity earthquakes recorded, together with the attenuation that will occur with distance, reduces seismic forces to the extent that they are not considered to be a governing factor in foundation design.

2.2.2 Existing Infrastructure

2.2.2.1 Power. Existing electrical lines within the Tx-N CSA are single phase 7200 volt lines operated by East River Electric Power Cooperative (East River, 1989). The Tx-S CSA has similar lines, which are operated by Lake Region Electric Association. Power provided by these electric lines serve all existing private dwellings (Lake Region Electric Association, Inc., 1989).

2.2.2.2 Water Supply. There are no public water services in the Tx-N and Tx-S CSAs. Homes draw on private wells for potable water and irrigation. Well depths range from 150 feet to 350 feet, with yields ranging from 2 gallons per minute (gpm) to 25 gpm. The James Aquifer is the closest major aquifer to the two CSA's (see Technical Study 4, Hydrology and Water Quality). Water in the James Aquifer is predominantly of sodium, calcium, bicarbonate, sulfate types with specific conductance ranging from 400 to 700 umhos per centimeter. Hardness ranges from 205 to 702 mg/l (U.S. Dept. of Interior, 1989).

2.2.2.3 Wastewater Disposal. There are no public sewer services in the Tx-N and Tx-S CSAs. Homes have individual septic tanks and drain fields since local soil conditions allow the installation and operation of septic tanks (City of Britton, 1989a).

2.2.2.4 Solid/Hazardous/Industrial Materials. Existing solid waste generators in the Tx-N and Tx-S CSA's are homes and farms. Hazardous materials are likely limited to household cleaning solvents, paints, and waste oil. There are no public solid waste collection services in the Tx-N and Tx-S CSA's, however, there are two private firms that provide solid waste collection services. Solid waste is disposed of in the Brown county landfill and the Marshall county landfill; both landfills are licensed (City of Britton, 1989b).

2.2.3 Proposed Facilities Description

2.2.3.1 Transmit Antenna and Groundscreen. Four transmit antenna sectors are planned as part of the OTH-B Central Radar System. Each transmit antenna consists of a 4,191 ft. linear array of 72 radiating elements mounted on vertical steel towers plus one in-coverage sounder antenna. This antenna array is comprised of six frequency bands of differing width with antenna height varying from 35 ft. to 135 ft. A conceptual transmit sector plan is provided in Figure 2-5, and shows clearing and grubbing limits and fencing limits. Figure 2-6 shows the dimensions of the six antenna bands. The preliminary site layouts for the Tx-N and Tx-S CSA's are shown in Figures 2-7 and 2-8, respectively.

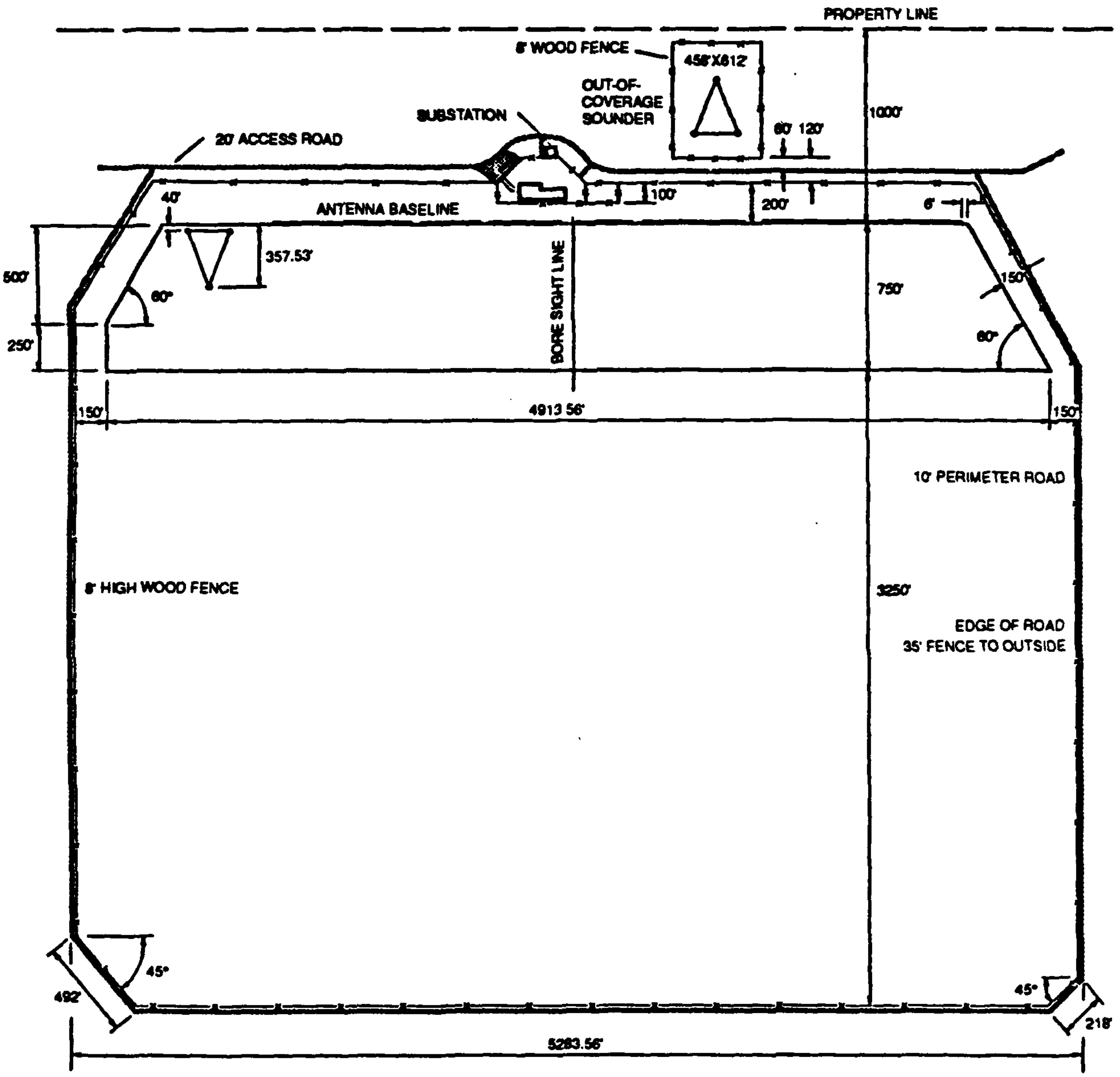
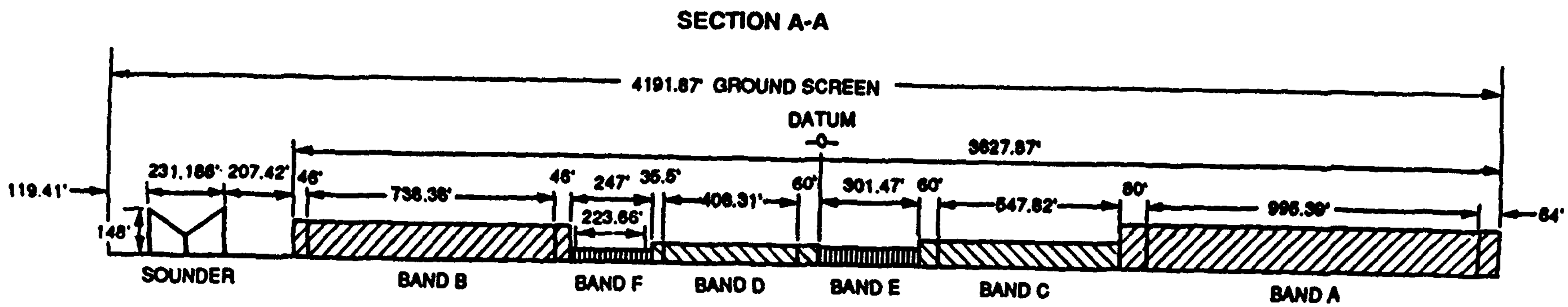
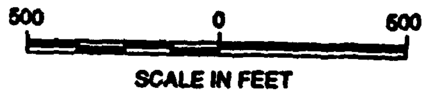
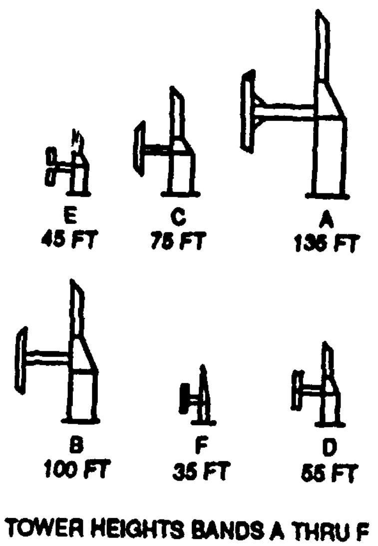


FIGURE 2-5. TRANSMIT SECTOR CONCEPTUAL PLAN







BAND	ANTENNA SPACING
A	90.49'
B	67.125'
C	49.802'
D	36.938'
E	27.406'
F	20.33'

FIGURE 2-6. TRANSMIT ANTENNA PLAN VIEW

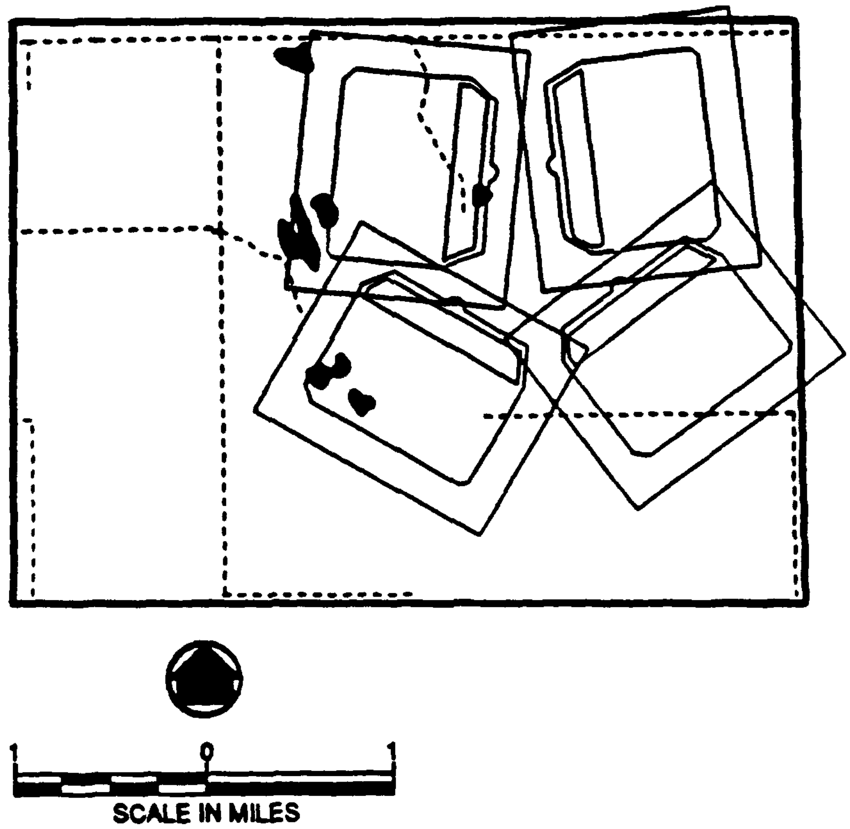


FIGURE 2-7. TX-NORTH PRELIMINARY SECTOR LAYOUT

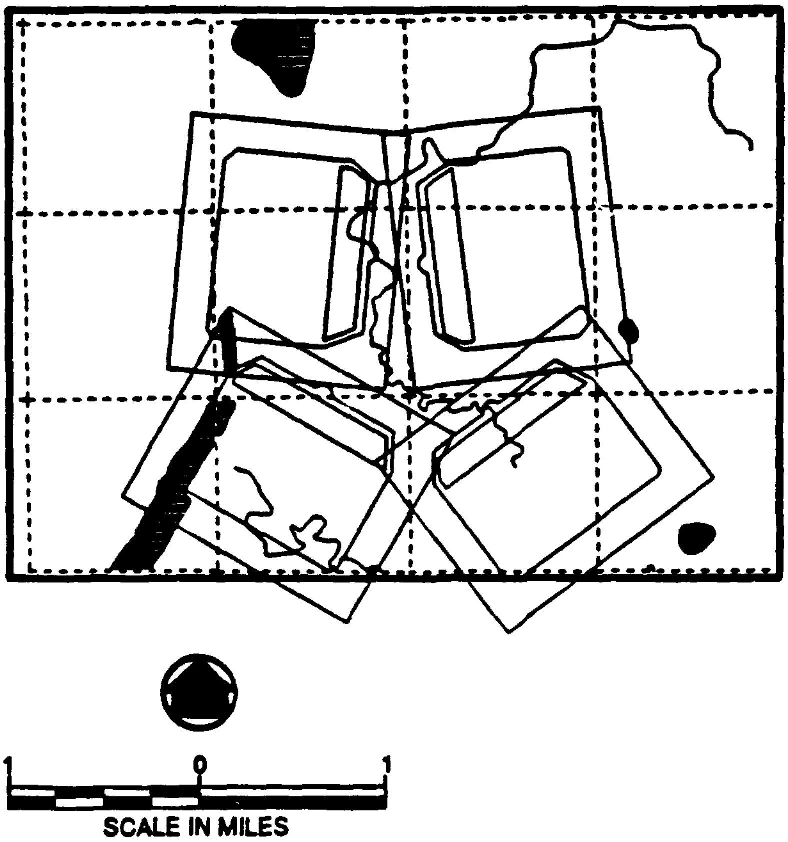


FIGURE 2-8. TX-SOUTH PRELIMINARY SECTOR LAYOUT

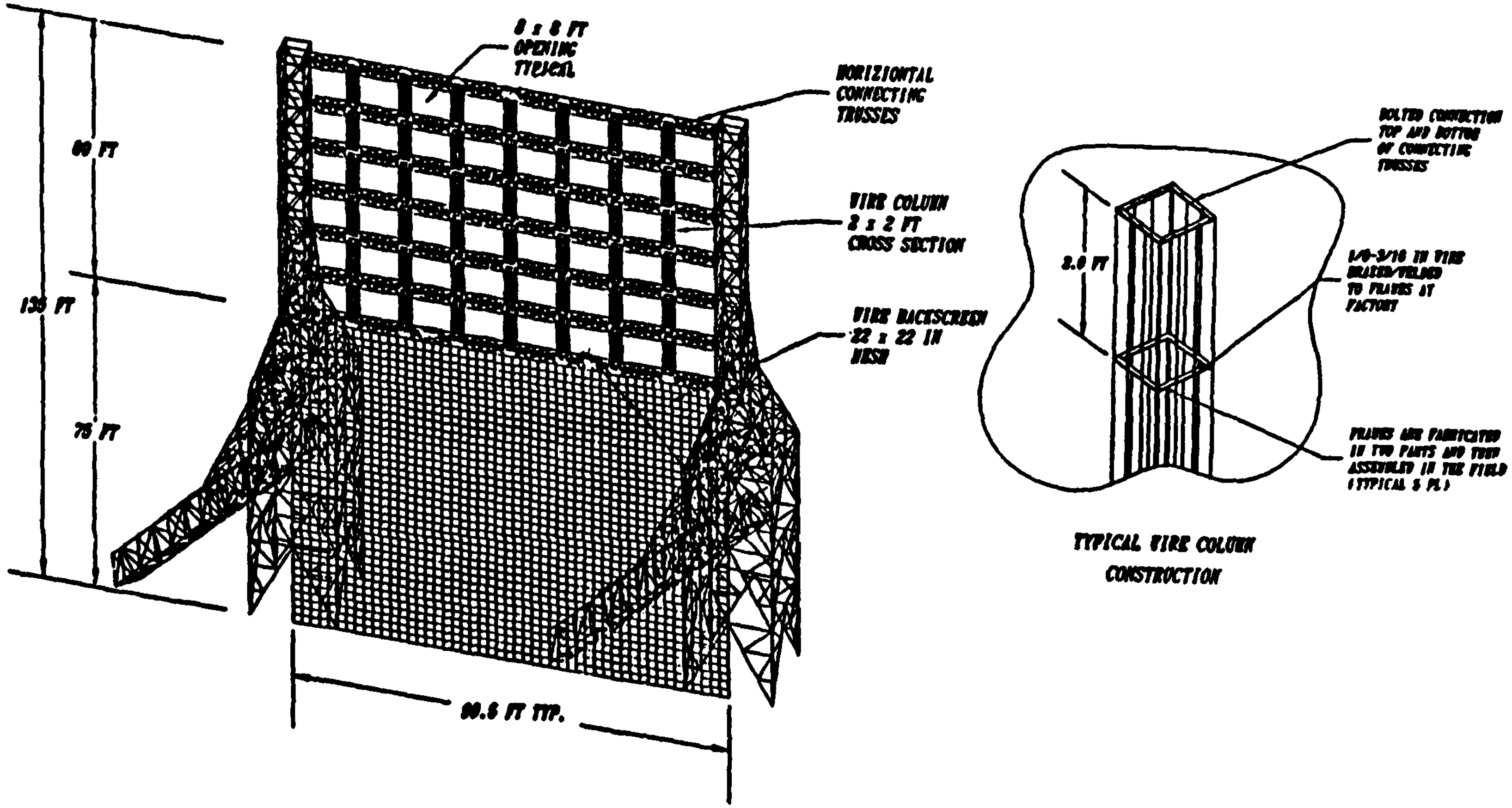
The transmit antenna superstructure consists of vertical towers supporting a rigid frame cantilevered radiating element and a backscreen. Except for band A and band B, the backscreen consists of a 22 in. by 22 in. wire mesh.

For bands A and B, the backscreen consists of wire mesh to 75 feet. The remaining backscreen structure above 75 feet (band A is 135 ft. high and band B is 100 ft. high) consists of a 2 ft. by 2 ft. square cross section, rigid frame lattice and wire columns, spaced 10 ft. center to center, resulting in 8-foot by 8-foot openings (Fig. 2-9).

An additional structure, an integral part of the transmit array, is the in-coverage sounder antenna (Figs. 2-10 and 2-11). The radiating elements for this antenna are supported by two 150-ft. tall vertical truss towers and a 50 ft. monopole all anchored by 3/4-in. diameter guy wires (Fig. 2-12). This structure is situated next to band B (100 ft. tall) subarray and extends out into the antenna groundscreen (Fig. 2-5).

The antenna groundscreen, also an integral part of the transmit antenna, consists of a 6 in. by 6 in. aluminum-coated steel wire mesh plane extending 750 ft. in front of the antenna over its entire length. This wire mesh plane must remain level with the base of the antenna structure and will be supported on a gravel surface to meet design tolerances. Fill thickness over the antenna and groundscreen field is expected to vary from 0 to 6 ft. due to topographic features and design criteria for the groundscreen (see Section 2.2.3.13).

2.2.3.2 Out-of-Coverage Sounder Antennas. In addition to the antenna structures described in Section 2.2.3.1, an out-of-coverage sounder antenna is required at each antenna sector. This additional sounder antenna is of similar design to the in-coverage sounder (Figs. 2-10 through 2-12). Construction will require clearing of vegetation and installation of a gravel-supported groundscreen and exclusion fence. The required exclusion area will be approximately 625 feet by 460 feet. Figure 2-5 shows the location of the out-of-coverage sounder antenna in relation to the other facility components.



TYPICAL BAY OF A-BAND TRANSMIT ANTENNA
NOT TO SCALE

TYPICAL WIRE COLUMN
CONSTRUCTION

A band = 135' height

B band = 100' height

FIGURE 2-9. TRANSMIT ANTENNA BACKSCREEN DESIGN CONCEPT

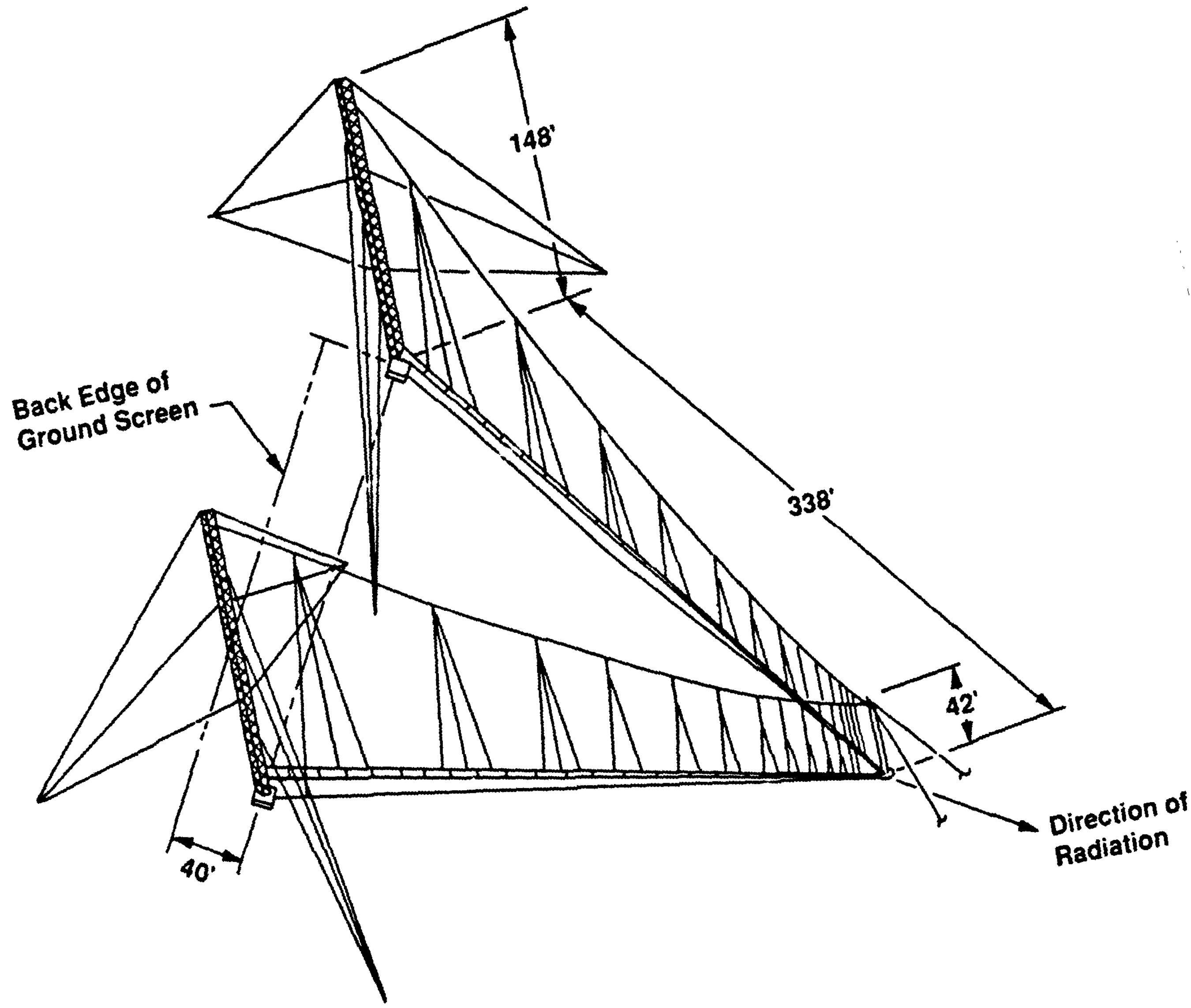


FIGURE 2-10. SOUNDER ANTENNA CONCEPTUAL PLAN

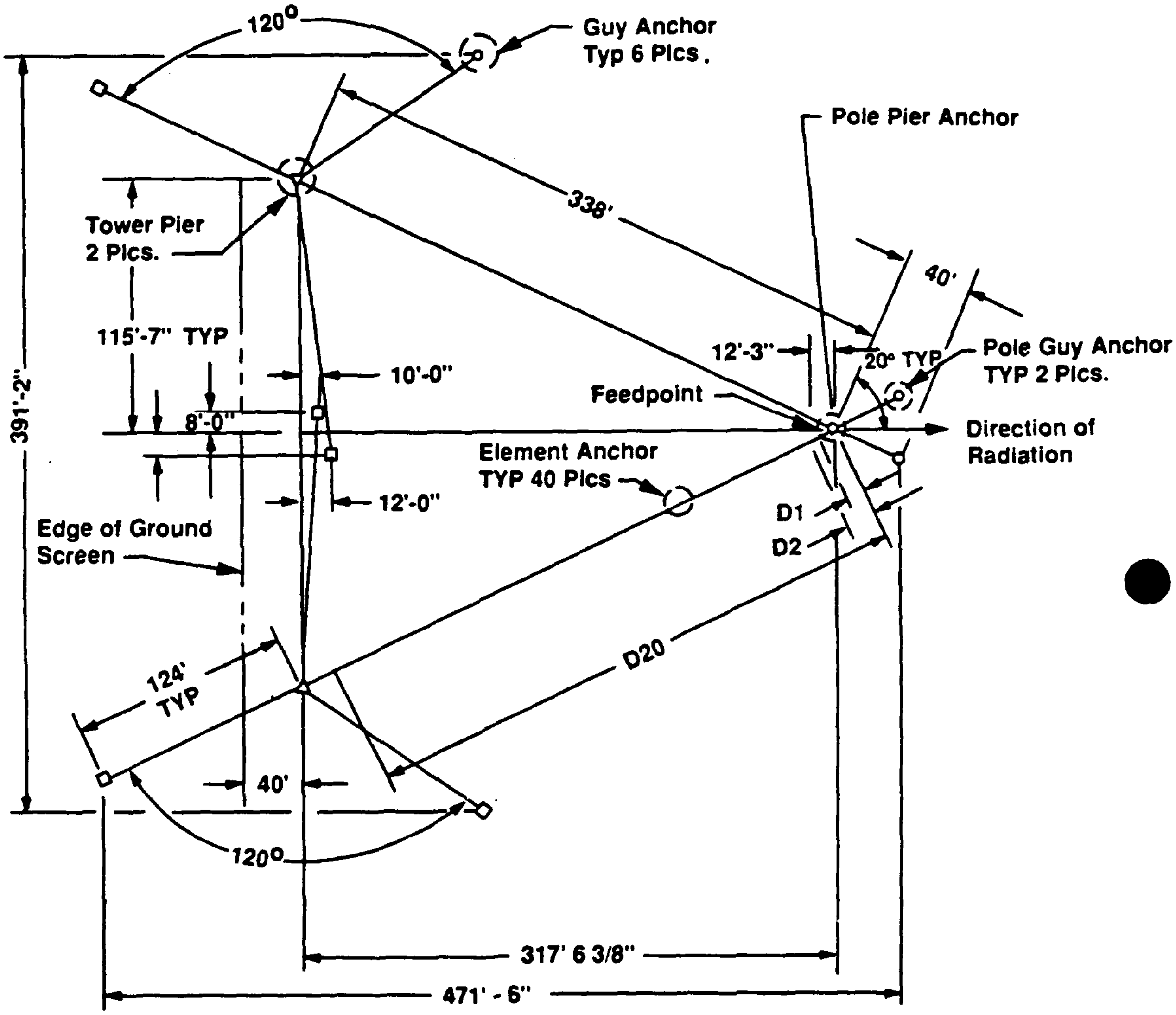


FIGURE 2-11. SOUNDER ANTENNA - PLAN VIEW

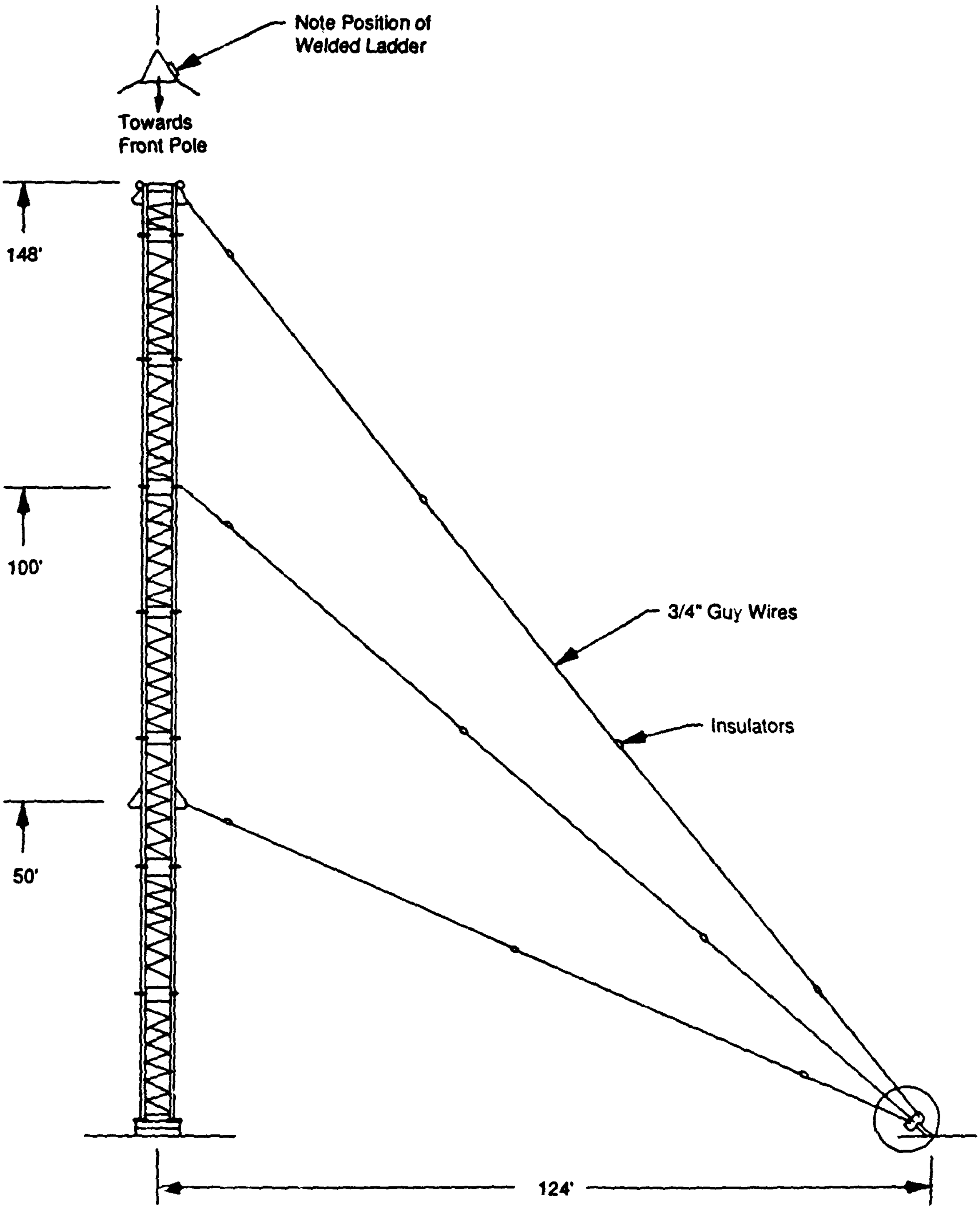


FIGURE 2-12. SOUNDER ANTENNA - SECTIONAL VIEW

2.2.3.3 Equipment Buildings. Each transmit sector will require a transmitter building to house electronics equipment. One sector will be the staffed operating sector, requiring a building approximately 16,290 sq. ft. in size. The three unstaffed sector transmitter buildings will be approximately 14,130 sq. ft. in area.

The staffed sector will also require an approximately 900 sq. ft. warm storage garage to provide enclosed protection for two security vehicles. The garage will also provide storage for spare tires and minor maintenance items such as oil and filters. The floor drains of the garage shall be connected to an oil separator. On-site fuel storage to support these vehicles may be required and would consist of an above ground tank, located near the vehicle garage.

Each transmitter building will contain the following facilities: buried fuel storage tanks, an emergency generator, a 12.4 kv substation, water storage and distribution facilities, parking and vehicle turnaround areas, a holding tank or septic system for domestic sewage, and a trash dumpster. The fuel tanks will hold approximately 6,000 gallons, and the USAF or the system contractor will obtain the required permits for underground storage tanks. An approximately 75,000-gallon water storage tank will be required at each sector for fire protection purposes. These facilities, except the parking areas, will be enclosed within a wooden compound fence as shown in Figure 2-5.

2.2.3.4 Exclusion Fence and Lighting. An 8-ft. high wood (or equivalent non-metallic) fence will be installed around each antenna sector to delineate the radio-frequency (RF) hazard zone and exclude wildlife and humans from this zone. The fence will be placed at a distance far enough from the antenna to ensure that the RF standards are not exceeded outside of the fenced area. This will consist of the installation of an all-wood (or equivalent non-metallic) rail and slat fence together with all fence appurtenances. A total of approximately 21,000 linear ft. of perimeter fence and 1,200 linear ft. of compound fence will be required for each antenna sector. The fence will be installed on relatively level or sloped grades.

Security flood lighting will be provided at all facilities and over the length of each antenna. However, this lighting would only be activated to assist security officers in the event of an emergency. No lighting will be installed on that portion of the exclusion fence beyond the groundscreen limits. Figure 2-5 illustrates the sector fencing boundary. All lighting shall be designed to minimize the potential for "night sky" or other visual impacts. Obstruction marking and lighting may be required for the transmit antenna structure. The criteria for obstruction marking and lighting are provided in the Federal Aviation Administration (FAA) Advisory Circular 70/7460-1G, dated October 1985, titled "Obstruction Marking and Lighting". The FAA by use of the advisory circular has reserved the right to review and comment on other projects as they pertain to aviation safety. Marking and lighting may also be designed as a potential mitigation measure for birds (see Technical Study 9, Avian Resources). Although the transmit antenna at its highest point shall be 135 ft., and therefore below the FAA specified height standard, the length of the antenna may cause concern to the FAA.

FAA Form 7460-1, Notice of Proposed Construction or Alteration, will be submitted by the USAF to the Air Traffic Division of the FAA Regional Office. The FAA will then determine the necessity of marking and/or lighting the antenna structures.

2.2.3.5 Communications Facilities. The data communications between the transmit site and the Operations Center are planned to be accomplished by troposcatter, microwave, and/or satellite systems. If off-site repeater stations are required, the USAF will reinitiate the EIAP for siting of those facilities. Use of a microwave system would require at least one parabolic dish mounted on an approximately 100-foot tall self-supporting tower. The troposcatter and satellite alternatives would use standard parabolic dishes mounted on approximately 60-foot tall steel towers. Where feasible, all towers would be located within the perimeter fence and compound area.

For calibration of the system, switch reflector towers may be required. The switch reflector facilities consist of a 100-foot-high guyed antenna, and parking area. The antenna occupies approximately 110,000 sq. ft., and consists of 2 monopole elements connected by a grid pattern of wire antenna elements and guy wires. A small concrete slab (approximately 300 sq. ft.) will be needed to park an electronic trailer for the antenna. A total of 3 to 4 acres will be required for the antenna and associated facilities. The USAF will seek to site the switch reflector on existing military base property, and will reinitiate the EIAP for these facilities once final locations and requirements are known.

2.2.3.6 Power. The transmit site power requirements will be provided by a commercial utility company. Transmission access (i.e. power line and transformer design and construction) will be provided by Western Area Power Administration (Western). All utilities operate Supervisory Control and Data Acquisition (SCADA) systems and have nearby maintenance crews that can provide reliable electric service to the site.

The projected power requirement for the transmit site at full operation is 3000 KW per sector at a 74 percent load factor. Total power requirements are 14,400 KW peak demand and 93.3 gigawatt hour (GWH) annual energy requirement. Limited actual metered load data from the East Coast Radar System (ECRS) transmit site indicates that peak demands may be reduced. Power will be delivered by overhead 115 KV dual feeds in order to achieve the required 99.999 percent power availability. According to Western, the poles will be wooden H-frame poles, approximately 40 feet high. Six to eight poles are to be placed every mile. Required right-of-way will be approximately 125 feet wide (Western, 1990).

Approximately 60 miles of dedicated lines will have to be built from Western's nearest existing substations at Groton, South Dakota, and Forman, North Dakota. Several alternative corridors have been selected for the transmit site power line routing. The Air Force will attempt to have power lines follow section lines and existing power line corridors, where possible. Technical Study 10 will address the potential impact to biotic resources from the proposed power lines.

2.2.3.7 Emergency Power Generation. Emergency power shall be provided through the use of a single diesel engine generator per sector. The generator will provide power for physical security equipment and the fire pump within one minute of the loss of primary power.

2.2.3.9 Water Supply. A permanent water supply will be developed for the transmit facility. Current projections are that this system must be designed to meet a peak demand of approximately 50,000 to 100,000 gallons per day (gpd) during construction (including dust control and compaction), and 3,000 gpd peak during facility operations. A conventional water well is planned at the transmit building behind each antenna sector. Anticipated well depths are between 150 feet and 300 feet. The USAF or the system contractor will coordinate water appropriations with the South Dakota Department of Water and Natural Resources. It is anticipated that water yields will be sufficient and treatment will not be necessary. If the demand for water during construction is higher than practical well yields, alternate forms of dust control or water sources will be used. If treatment is required, it will be in accordance with all applicable State, Federal and Air Force regulations. During construction all wells situated within the area to be fenced will be closed, unless they are utilized for project water requirements.

2.2.3.10 Wastewater Disposal. The CRS transmit site will generate peak loads of 3,000 gpd of domestic wastewater. The wastewater disposal system will be designed by the system contractor. Due to existing soil conditions, it is likely that the disposal system will consist of either a septic system with a leach field (as at the West Coast Radar System) or a sanitary holding tank, which could be unloaded weekly or biweekly and transported to a local waste treatment facility. The system will be designed in conformance with applicable regulations so that groundwater in the area would not be adversely impacted. If a leach field is chosen, its location will be specified based upon additional site-specific engineering analyses and the need to avoid or minimize impacts to important environmental resources (e.g. wetlands, prairie habitat, or potable water supplies).

2.2.3.11 Solid/Hazardous/Industrial Materials. Each on-site facility will have a fenced enclosure for a trash dumpster. Solid waste generated during construction and operation will be disposed of by a private solid waste collector. Although the exact composition and volume of materials for the CRS is not yet known, Table 2-1 provides a summary of the types of materials typically encountered during construction of the OTH-B West Coast Radar System (USAF, 1989). CRS waste composition is expected to be similar, though volumes will be slightly higher due to the higher number of sectors (4 vs. 3).

It is anticipated that a majority of the site hazardous materials will be generated in vehicle maintenance areas. These materials are likely to include contaminated lube oils, cleaning fluids, antifreeze and paints. Hazardous materials will be temporarily stored on-site in Environmental Protection Agency (EPA) approved containers. These materials will be hauled off-site and disposed by an EPA-approved hazardous materials contractor.

TABLE 2-1. OTH-B WEST COAST RADAR SYSTEM SOLID WASTE COMPOSITION

Activity	Type of Waste
Antenna Tower Foundations	Sonotubes, banding, waste concrete
Antenna Tower Erection	Blockage and donnage
Site Work	Oil drums
Electronics Building	Packing materials, banding, waste concrete

Source: (USAF, 1989)

2.2.3.12 Access Roads. The CRS access road design criteria will require construction of a two-lane, gravel surfaced road, consisting of two 10 foot wide travel lanes plus 4 foot wide shoulders (Fig. 2-13) for site access. Based upon the preliminary site layout's proximity to existing roads, it is estimated that the Tx-N site will require construction of approximately two miles of new gravel surfaced access roads. The Tx-S CSA will require construction of one mile of new gravel surfaced access roads.

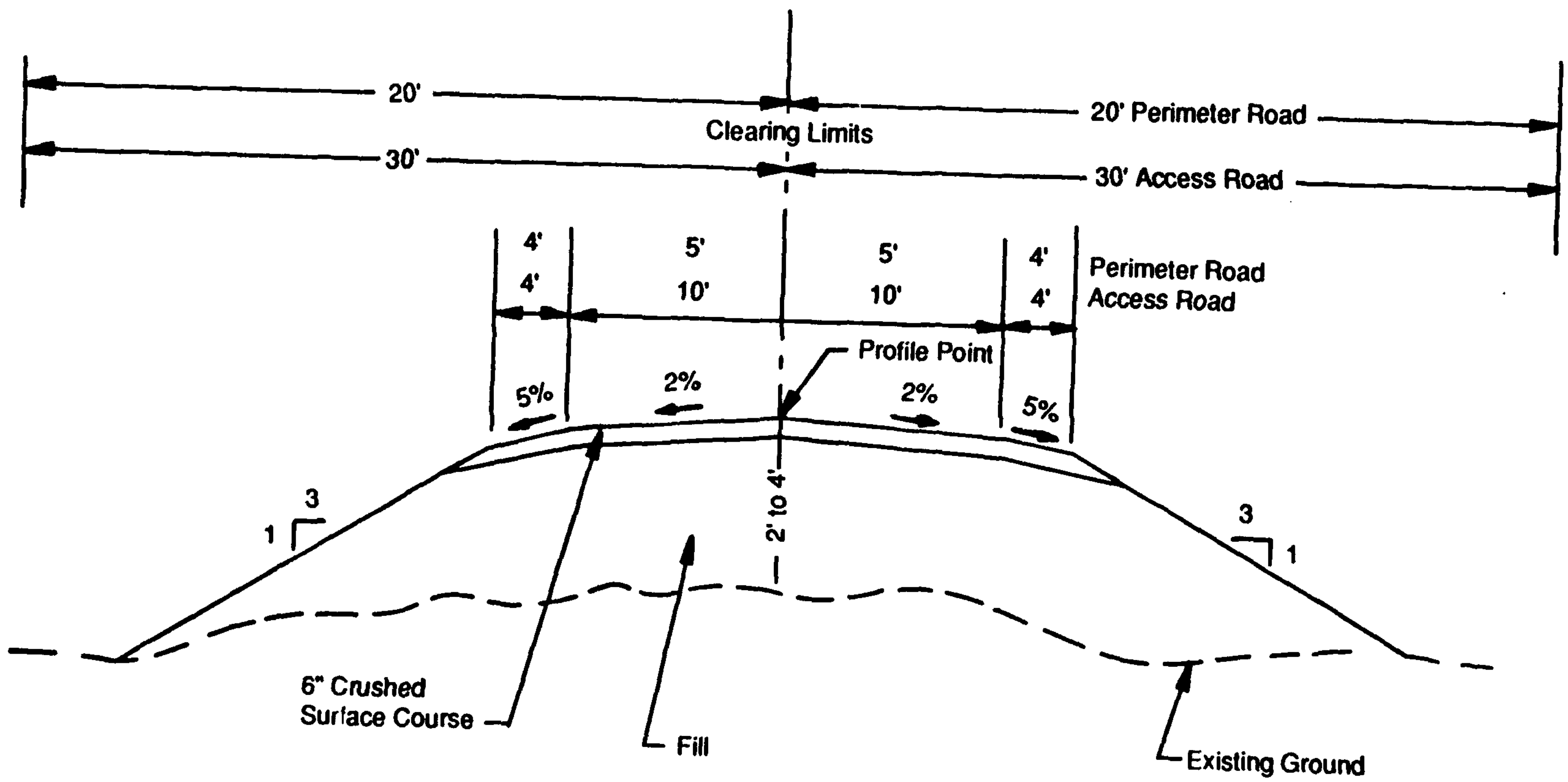


FIGURE 2-13. TYPICAL ACCESS/PERIMETER ROAD CROSS SECTION

Proposed access road alignments will be prepared following site selection; alternative routes will be developed to avoid or minimize impacts to wetlands, drainage channels and other important resource areas.

2.2.3.13 **Parking.** Gravel surfaced parking areas will be provided at each transmit building; approximately 4,500 sq. ft. at each sector except 7,500 sq. ft. at the southwest operating sector. An additional 4,000 sq. ft. of gravel surfaced area will be provided at the southwest operating sector for maintenance and security vehicle unloading and turnaround.

2.2.3.14 Perimeter Roads

A gravel surfaced site perimeter/security road will be constructed outside of the antenna exclusion fence. The location of the roadway and fence is as delineated on Figure 2-5. At each CSA, construction of approximately 16 miles of perimeter road will be required. Perimeter roads will be 10 ft. wide with 4 ft. shoulders; all road and parking areas will require fill sections 3 to 4 ft. in compacted thickness, including a 6-in. thick crushed gravel surface. Figure 2-13 provides a typical perimeter road cross section.

2.2.3.15 **Clearing.** Approximately 2,200 acres of land must be cleared (cutting of vegetation above ground surface) for the four antennas, ancillary structures and facilities, security fencing, and perimeter road. Of that total, approximately 500 acres will require grubbing (removal of vegetation below ground surface) for the Tx-N preliminary layout, and 600 acres for the Tx-S preliminary layout. A total area of approximately 500 acres will be filled for either alternative. Approximately 2,100 acres will be enclosed by the facility perimeter fence. Table 2-1 shows the estimated construction requirements for the two alternative preliminary site layouts.

2.2.3.16 **Site Earthwork Requirements.** The site earthwork quantities for the antenna, groundscreen and support facilities are based upon the minimum slope criteria (0.5 percent to allow for drainage) and the balance or difference between cut and fill volumes. The site earthwork requirements are summarized in Table 2-2. Computations were based upon existing elevations taken from USGS topographic maps (scale 1:24,000) and preliminary hydrologic data. The quantities developed at this concept stage will be refined during the design

TABLE 2-2. APPROXIMATE TRANSMIT SITE CONSTRUCTION REQUIREMENTS

Activity		Estimated Requirements Tx-North	Tx-South
ROAD CONSTRUCTION (MILES)			
Access Road[1]		2	1
Perimeter Road		16	16
	Total miles	18	17
CLEARING (ACRES)			
Access Road		14	7
Perimeter Road and Fence		70	70
Transmit Sectors and Support Facilities[2]		2,100	2,100
Out-of-Coverage Sounder Antenna		7	7
	Total acres	2,191	2,184
GRUBBING AREA (ACRES)			
Access Road		14	7
Perimeter Road and Fence		70	70
Groundscreen and Support Facilities		420	420
Out-of-Coverage Sounder Antenna		7	7
	Total acres	511	504
FILL AREA (ACRES)			
Access Road		14	7
Perimeter Road and Fence		70	70
Groundscreen and Support Facilities		420	420
Out-of-Coverage Sounder Antenna		7	7
	Total acres	511	504
FILL VOLUME (CUBIC YARDS)			
New Access Road[3]		45,000	22,500
Perimeter Road and Fence[3]		225,000	225,000
Groundscreen and Support Facilities[4]		570,000	1,165,000
Out-of-Coverage Sounder Antenna[3]		23,000	23,000
	Total cu. yd.	863,000	1,435,500
TOTAL FENCED AREA (ACRES)			
Antenna Field		2,100	2,100
Out-of-Coverage Sounder Antenna		7	7
	Total acres	2,107	2,107

1. Estimated length of road based on proximity of preliminary layout to existing roads.
2. No clearing of exclusion areas will be necessary if existing vegetation is prairie or grassland.
3. Assumes constant fill depth of approximately 2 feet. Additional depth will require additional fill.
4. Based on minimum depth required to maintain positive site drainage based on 25-year storm event (Technical Study 4, Hydrology and Water Quality).

process using more detailed topographic, hydrologic and geotechnical data. The detailed information is required to specify earthwork requirements, determine borrow quantities, and optimize the facility configuration.

The major features in this quantity determination are the antenna baseline and the groundscreen elevation. Although the USAF intends to use a balanced cut and fill approach, preliminary data indicate that in some instances the cut and fill balance may not be achievable. This imbalance (usually more fill required than cut available) is apparent in lower elevation areas particularly at the Tx-S CSA where it may be necessary to elevate the groundscreen area to ensure positive site drainage. Depending upon the actual groundscreen elevation, which will be determined during final design, the Tx-N CSA may require up to 570,000 cu yds of borrow, and the Tx-S CSA may require up to 1,165,000 cu yds of borrow to construct the antenna and groundscreen. The estimated 100,000 cubic yards of crushed gravel surfacing (6 in. thick) for the groundscreen, roads, parking and building areas can be obtained from commercial sources near the construction site. If required, additional borrow will be obtained from newly-opened pits developed under the environmental criteria specified in Section 2.2.3.17, or from commercial sources.

2.2.3.17 Borrow Requirements. Borrow requirements for the transmit site will be minimized, through maximizing the use of a balanced cut and fill approach for grading within the final facility footprint. Additional borrow may be required to (1) ensure positive site drainage; (2) avoid prolonged flooding or ponding on the groundscreen; (3) construct the final road and groundscreen surfaces; and (4) provide select fill material where needed. Exact borrow requirements (including the required types and quantities of fill) are dependent upon site specific conditions and the precise groundscreen location and will therefore be defined during final design.

Although final borrow quantities are not yet known, the additional fill (beyond the material available within the facility footprint) required varies significantly between the alternative sites under consideration. Final quantities will be determined by the potential for flooding impacts (and hence, the need for elevation of facilities and roads) and the existing site slope in front of the antenna baseline (which defines the amount of grading required to meet system specifications). However, a preliminary engineering analysis indicates that potential borrow requirements are higher for construction within the Tx-S CSA, as compared to the Tx-N CSA, due to the lower elevations (resulting in a higher flood frequency) and site topography.

Borrow volumes will be minimized to reduce both system costs and environmental impacts. Material will be acquired either from commercially available sources, or at new borrow sites, depending upon the availability of the required types of fill. If new borrow sites are required, the USAF, through its system contractor, will adhere to the following criteria for borrow site selection:

1. Avoid or minimize impacts to known wetland areas and establish appropriate buffer zones from adjacent wetlands
2. Avoid or minimize impacts to known cultural resource sites and historic properties
3. Maximize distance between borrow areas and the backscreen
4. Avoid or minimize impacts to known wildlife concentration areas or critical habitats (e.g. nesting, breeding, feeding areas)
5. Avoid or minimize impacts to areas containing known populations of special-status plant species, including native prairie habitats
6. Avoid or minimize impacts to areas subject to frequent flooding or ponding (to minimize erosion and sedimentation impacts)
7. Minimize haul distance to sites (to avoid or reduce impacts to public roads from hauling operations)

New borrow pit design and operation will employ Best Management Practices (BMPs) for erosion and sedimentation control and avoidance or reduction or water quality, wildlife and visual impacts. These BMPs will be outlined in the project mitigation plan and finalized in consultation with the appropriate federal, state and local agencies and landowners following final facility site selection. Any new borrow sites will be selected, to the maximum extent feasible, so as to provide additional mitigation opportunities (e.g. compensatory flood storage, wildlife habitat or recreational usage) for project impacts following removal of the required borrow material.

2.3 RECEIVE SITE

The receive (Rx) site is proposed to be located within the Thief River Falls, Minnesota, study area (Figure 2-14). The study area is located in northwestern Minnesota, approximately 10 miles west of Thief River Falls, Minnesota, and 35 miles northeast of Grand Forks, North Dakota. Within the Thief River Falls study area, there are two concentrated study areas being considered for the receive antenna location. The eastern CSA (Rx-East) is located entirely in Pennington County, and the other CSA (Rx-West) is located entirely in Polk County, as shown on Figure 2-14.

2.3.1 Site Description

The CSA's are generally agricultural with occasional low-lying emergent wetlands, which are dry or stagnant during summers (See Technical Study 6, Wetlands and Aquatics). Some areas of deciduous trees occur in the study area, predominantly in the east (see Technical Study 5, Vegetation). There are no well-developed drainage patterns and no major streams. Ditches and poorly defined channels and meanders make up the area's natural drainage (see Technical Study 4, Hydrology and Water Quality). A large, elongated wetland, Goose Lake Swamp, extends in a north-south direction through the center the study area, but outside the CSA's.

2.3.1.1 Topography and Drainage. The topography in the study area is flat to gently rolling with shallow depressions. The Rx-E CSA has site elevations varying from 1,075 ft. in the east to 975 ft. in the west. This CSA has low topographic relief, sloping downward to the west at a rate of less than one-half of one percent. The Rx-W CSA has site elevations varying from 970 ft. in the east to 920 ft. in the west. The area is extremely flat and has low topographic relief, sloping generally downward to the west at a rate of less than one-half of one percent.

Major portions of the study area are moderately well drained and the depressions are poorly drained. Some natural patterns are well developed. Deep drainage ditches adjacent to the section roads, plus culverts, help

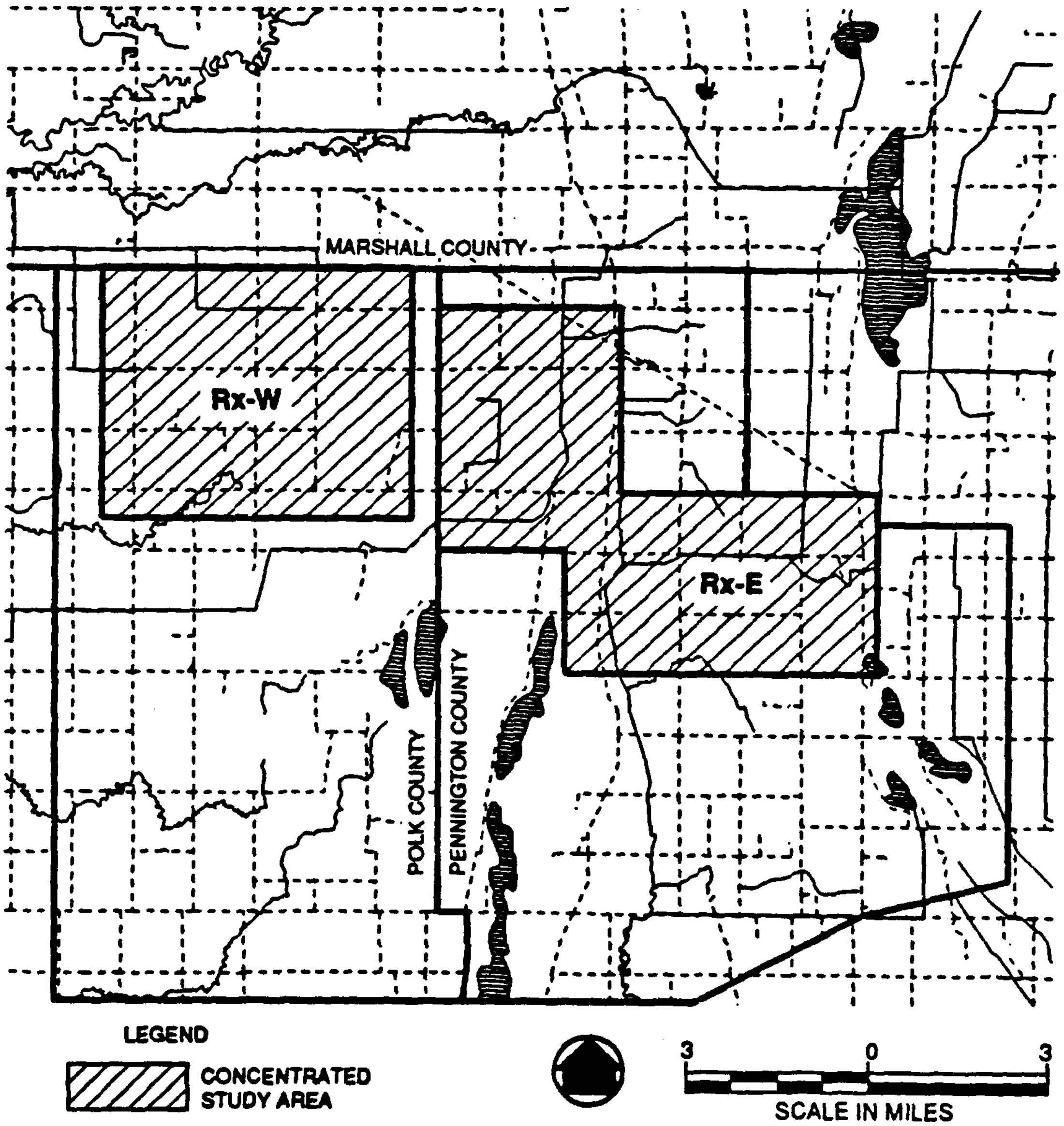


FIGURE 2-14. THIEF RIVER FALLS, MN RECEIVE STUDY AREA

control the overland drainage flows. Sheet flow appears to be the predominant means of drainage over much of the CSA's. Maximum flow will probably occur during spring rains and thawing conditions. Surface grading for the proposed site features will be designed to allow surface water to flow back into the sites' existing and/or natural drainage system and will be accomplished by a combination of culverts, swales and ditches.

2.3.1.2 Subsurface Conditions. The general area encompassing the two concentrated study areas is located on the glacial Lake Agassiz Plain physiographic division. The surficial geology of this area is lacustrine sediments deposited in the lake and overlying glacial till. Such deposits can be up to 300 ft. thick, but are expected to be either much thinner, nonexistent, or significantly altered. Depth to bedrock is probably too deep to be a factor in foundation design or in construction. The glacial till, where present, may allow higher soil-bearing values and reduce the potential for any embankment settlement. Groundwater depth varies from near surface to depths generally in excess of 6 feet and a general range is considered to be 2.5 feet to 8 feet.

Minnesota and all abutting states are classified as seismic risk zone 1. This corresponds to a maximum earthquake intensity of VI on the Modified Mercalli Intensity Rating Scale. A VI intensity earthquake is defined as one causing slight damage to poorly constructed buildings. Only two VI intensity earthquakes are mapped for Minnesota and none for adjacent North Dakota. The peak horizontal ground acceleration from a VI intensity earthquake ranges from 0.035 g to 0.070 g and is normally taken as 0.1 g for design purposes. This is less than the one-third allowable soil bearing value for transient foundation forces; therefore, seismic forces will not be a factor in the design of the foundations (Soil Conservation Service, 1975).

2.3.2 Existing Infrastructure

2.3.2.1 Power. The existing power provider for the Rx-E CSA is Red Lake Electric Cooperative. The existing electrical lines within the Rx-E CSA are single phase overhead lines (Red Lake Electric Cooperative, 1989).

The existing power provider for the Rx-W CSA is PKM Electric Cooperative. The Rx-W CSA also has single phase overhead lines. Power provided by these electric lines serves existing homes and farms (PKM Electric Cooperative, 1989).

2.3.2.2 Water Supply. There is no public water supply system in Rx-E CSA. Private wells are used for potable water and irrigation. Yields ranging from 10 gpm to 150 gpm and well depths ranging from 50 feet to 170 feet are common (Marshall and Polk Rural Water System, 1989b).

Houses in the Rx-W CSA draw water from public and private wells. There are two public wells immediately north of the Rx-W CSA, which are capable of yielding a total of 300 gpm. The public well system is subject to USEPA and Minnesota Department of Health & Safety drinking water regulations and services domestic and other uses, excluding agricultural irrigation, on a continuous basis (Marshall and Polk Rural Water System, 1989a; 1989b). Nearby large industries, such as power generating plants and sugar and potato processing plants, rely on rivers for their water supply (Red Lake Watershed District, 1988).

2.3.2.3 Wastewater Disposal. There are no sewer services in the Rx-E and Rx-W CSA's. Homes have individual septic tanks and drain fields since local soil conditions allow the installation and operation of septic tanks. Septic tanks are cleaned and their waste disposed of at the Thief River Falls stabilization plant (City of Thief River Falls, 1989a).

2.3.2.4 Solid/Hazardous/Industrial Materials. Solid waste generators in the Rx-E and Rx-W CSA's are homes and farms. Hazardous materials are likely limited to household cleaning solvents, paints, and waste oil. There are no public solid waste collection services in the concentrated study area, but there is one private solid waste collection service contractor.

Solid waste generated in the Rx-W CSA is taken to the Polk county incinerator in Fosston. The ashes and remaining waste go to the Polk county landfill (City of Thief River Falls, 1989b). Solid waste generated in the Rx-E CSA is taken to a private solid waste processing company (City of Thief River Falls, 1989b).

2.3.3 Proposed Facilities Descriptions

2.3.3.1 Receive Antenna and Groundscreen. Four receive antenna sectors will be constructed as a part of the OTH-B Central Radar System. Each receive antenna consists of a row of 19 ft. tall antenna receiving elements with a 65 ft. tall backscreen/wire truss structure running parallel and behind the entire 5,000 ft. antenna length. The receive antennas have been reduced in length from the 8,000 feet described in the 1986 Environmental Impact Statement to 5,000 feet in length. Figure 2-15 provides a conceptual plan of a typical receive sector. This site plan gives clearing and grubbing limits, fencing limits, and provides the relative site orientation of the key components that comprise a receive sector. The preliminary site layouts for the Tx-N and Tx-S CSA's are shown in Figures 2-16 and 2-17, respectively.

The 19 foot high receiver element is a self supporting monopole structure. The receive antenna backscreen structure consists of 65 foot high vertical steel truss towers, spaced 60 feet apart, supporting a 10 inch x 20 inch wire mesh backscreen to a height of 35 feet. The remaining backscreen structure from 35 feet to 65 feet height, consists of 2 foot by 2 foot square cross section, rigid frame lattice and wire columns, spaced 10 feet center to center, resulting in openings 8 feet by 28 feet wide. Figures 2-18 and 2-19 illustrate the design concept for this antenna. All structures will be supported on concrete footings.

The receive antenna groundscreen is identical to that of the transmitter, extending 750 ft. in front of the antenna over its entire length. This wire mesh groundscreen plane must remain level with the base of the antenna structure and will be supported on a gravel surface to meet design tolerances (see Section 2.3.3.13).

2.3.3.2 Equipment Buildings. Each receive sector will require a receiver building to house electronics equipment. The one staffed operating sector

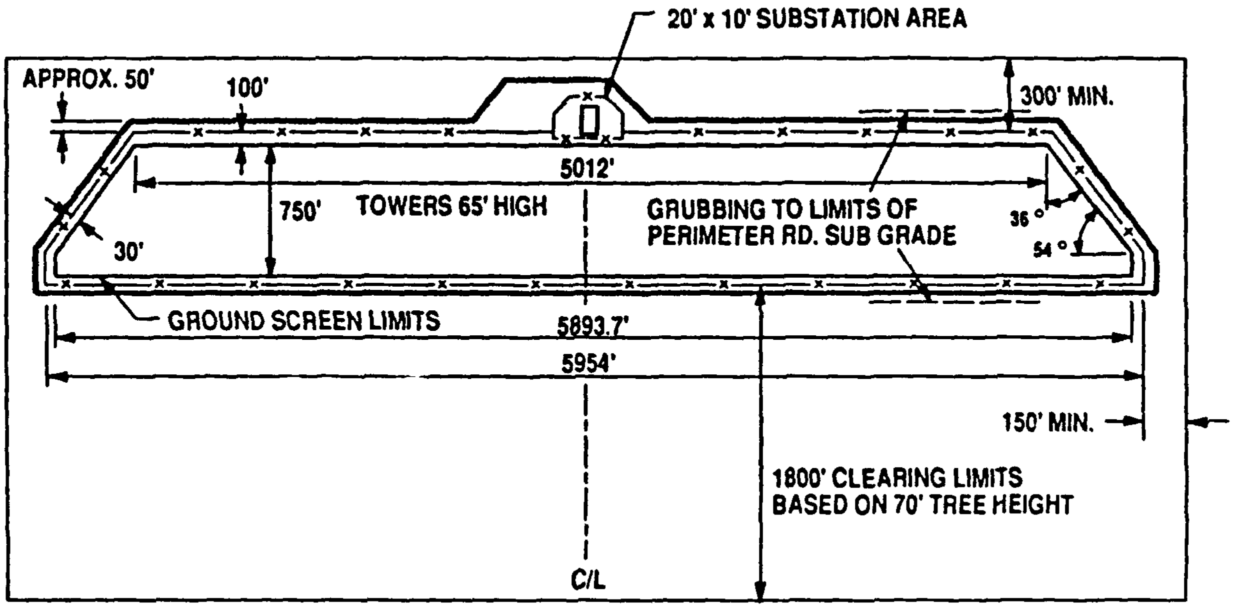


FIGURE 2-15. RECEIVE ANTENNA SECTOR CONCEPTUAL PLAN

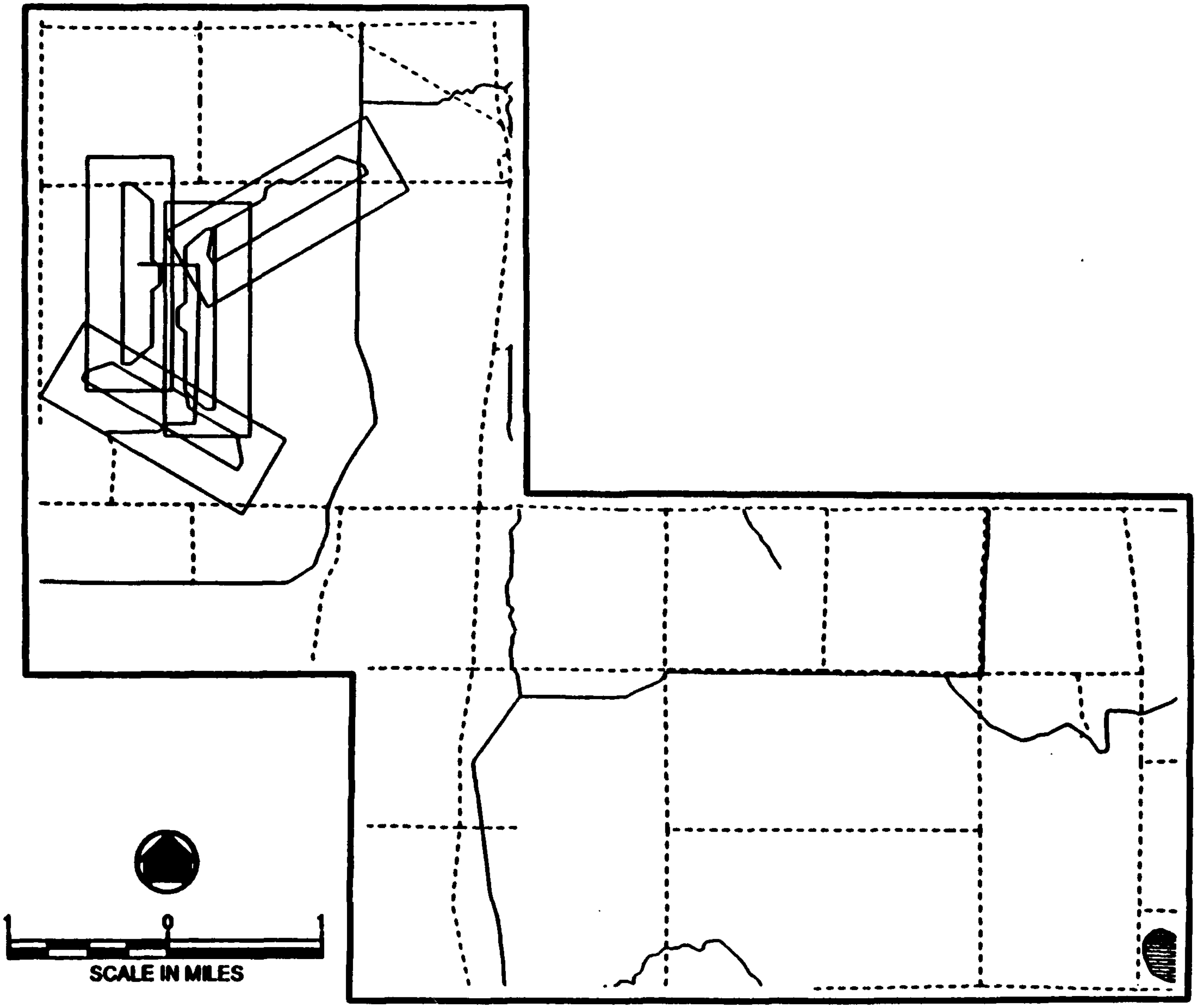


FIGURE 2-16. RX-EAST PRELIMINARY SITE LAYOUT

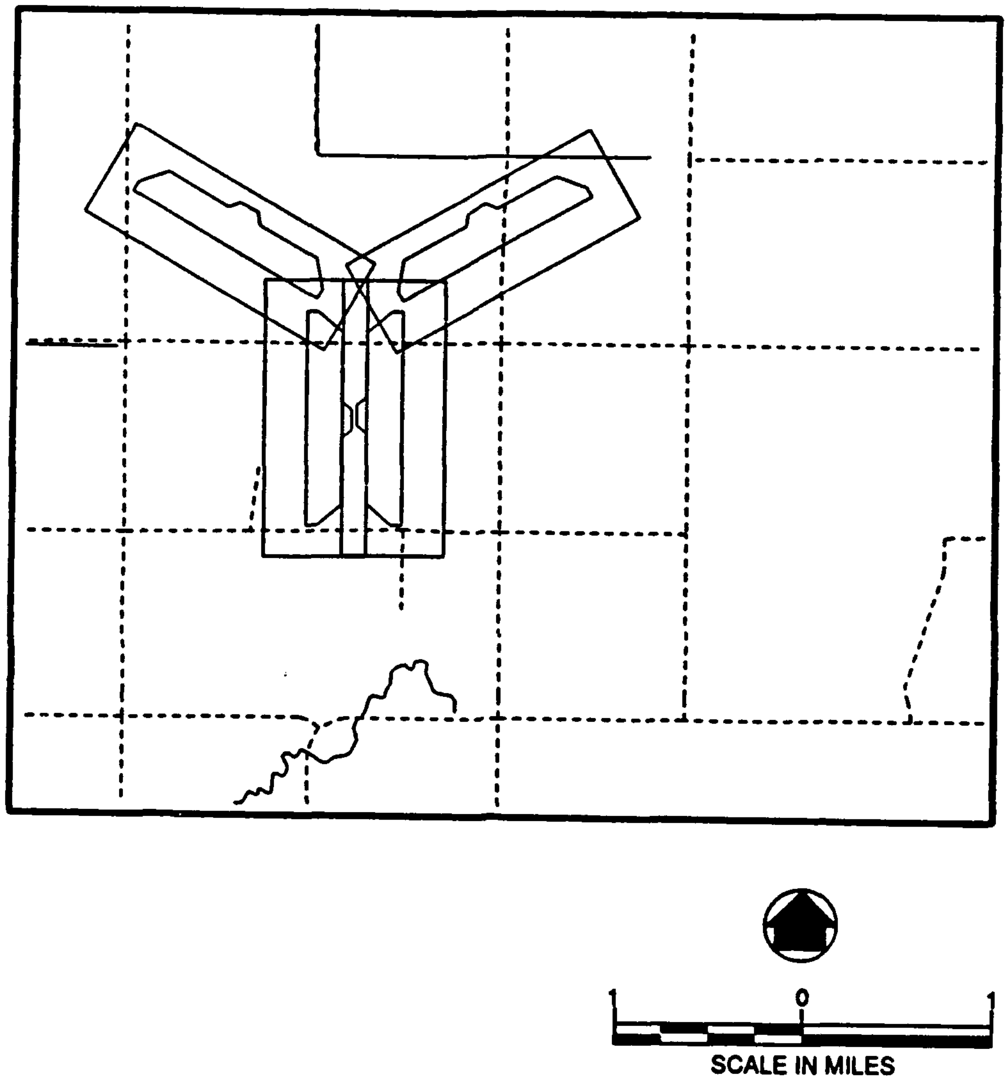


FIGURE 2-17. RX-WEST PRELIMINARY SITE LAYOUT

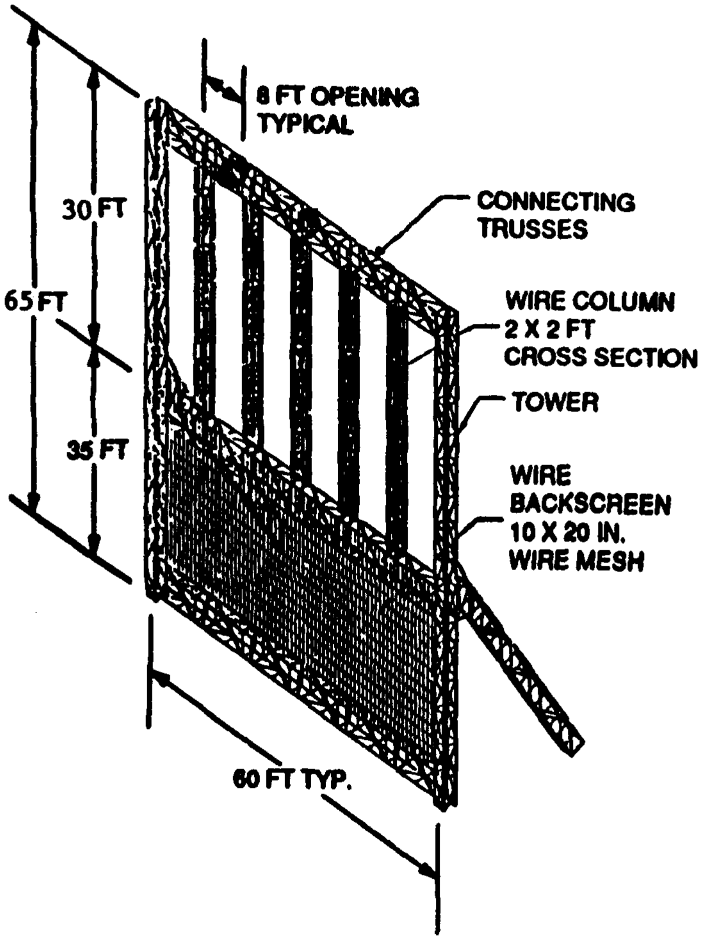
will require a building approximately 7,920 square feet in size. The three unstaffed sector receiver buildings will be approximately 4,160 sq. ft. in size.

The operating sector will require a vehicle storage garage of approximately 900 sq. ft. The garage will provide storage for spare tires and minor maintenance items such as oil and filters. The floor drains of the garage shall be connected to an oil separator. On-site fuel storage to support these vehicles may be required and would consist of an above ground tank, located near the vehicle garage.

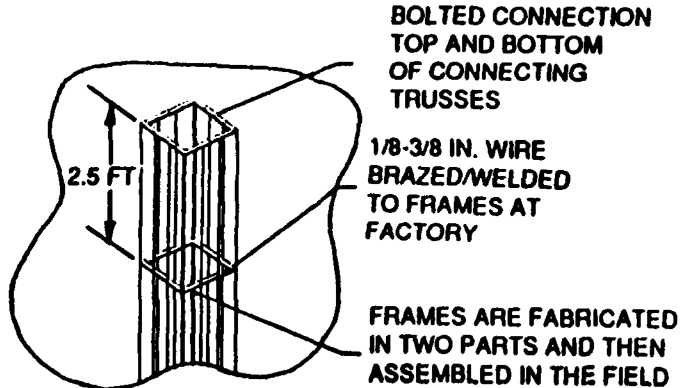
Each receiver building will also contain the following facilities: buried fuel storage tanks, two emergency generators, water storage and distribution facilities, parking and vehicle turnaround areas, a holding tank or septic system for domestic sewage and a trash dumpster. Water storage tanks will be approximately 75,000 gallons each. The fuel tanks will hold approximately 10,000 gallons, and the USAF or the system contractor will obtain the required permits for underground storage tanks. All these facilities, except the parking areas, will be enclosed within a wooden compound fence as shown in Figure 2-5.

2.3.3.3 Exclusion Fence and Lighting. An 8 foot high wood (or equivalent non-metallic) fence will be installed around each antenna sector to delineate the exclusion zone. Security flood lighting will be provided at all facilities and over the length of each antenna. This lighting would only be activated to assist security officers in the event of an emergency. All lighting shall be designed to minimize the potential for "night sky" or other visual impacts. Figure 2-5 illustrates the sector fencing boundary. A total of approximately 13,000 linear feet of perimeter fence, 2,200 linear feet of out-of-coverage sounder antenna perimeter fence and 1,200 linear feet of compound fence will be installed per sector. The fence will be installed on relatively level or sloped grades.

Obstruction marking and lighting may be required for the receive antenna structure. The criteria for obstruction marking and lighting are provided in the October 1985 Federal Aviation Administration (FAA) Advisory Circular

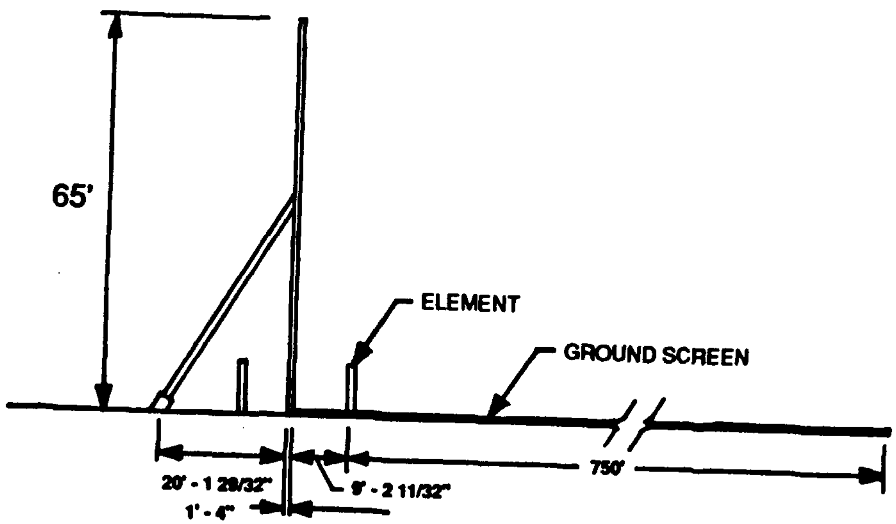


TYPICAL BAY OF 5000 FT RECEIVE ANTENNA
NOT TO SCALE



TYPICAL WIRE COLUMN CONSTRUCTION
NOT TO SCALE

FIGURE 2-18. RECEIVE ANTENNA BACKSCREEN DESIGN CONCEPT



SECTION A-A

NOT TO SCALE

FIGURE 2-19. RECEIVE ANTENNA PROFILE VIEW

70/7460-1G, "Obstruction Marking and Lighting." The FAA by use of this circular has reserved the right to review and comment on each project as it pertains to aviation safety. Although the receive antenna at its highest point shall be 65 feet AGL, and therefore below the FAA specified height standard, the length of the antenna may cause concern to the FAA. The USAF will submit an FAA Form 7460-1, Notice of Proposed Construction or Alteration, to the Air Traffic Division of the FAA Regional office. The FAA will then determine the necessity of marking and/or lighting the antenna structures. Marking and lighting will also be coordinated with the federal and state environmental agencies as a potential mitigation measure for birds. (See Technical Study 8, Avian Resources).

2.3.3.4 Communications Facilities. The data communication between the receive site and the Operations Center at Grand Forks AFB is planned to be accomplished by troposcatter, microwave, and/or satellite systems without the need for off site repeater stations. A description of the towers for each of these systems is contained in Section 2.2.3.5.

2.2.3.5 Power. Power for the receive site must be purchased from the utility cooperative in whose franchised territory the site will be located, since competitive acquisition is not possible. The Rx-E CSA is in Red Lake Electric Cooperative's franchise area, while the Rx-W CSA is in PKM Electric Cooperative's franchise area. The two distribution service cooperatives are both Class A members of the Minnkota Power Cooperative and purchase all of their wholesale power requirements from Minnkota.

The projected power requirement at full operation for the receive site is 500 KW per sector at a 74% load factor. Total power requirements are 2000 KW peak demand and 13 GWH annual energy requirements. The power for the receive site may be a single 12.47 KV phase to phase line, although the USAF requires only 480 V lines. Underground lines require burial to at least 36 inches, although the two electric cooperatives typically bury their lines 48 inches deep. A junction box measuring approximately 5 feet by 3 feet by 2 feet is required at each section boundary, for underground lines only.

The USAF will request that overhead lines be placed along section lines and existing power line corridors, where possible. The power companies have stated that if there is an existing power line in the corridor, either the USAF line or the existing line would have to be buried. (PKM Electric Cooperative, 1989; Red Lake Electric Cooperative, 1989). The power line to the receive site will have to be buried within one-half mile of the site.

For the Rx-E CSA, Red Lake Electric Cooperative would likely route the power lines from their Dakota Junction substation north of Thief River Falls. A second alternative would be to use the Morris-Owen substation, which is in Thief River Falls (Red Lake Electric Cooperative, 1990). The electric cooperative, in conjunction with the USAF, will prepare a Borrower's Environmental Report (BER) prior to constructing the USAF power lines. Either substation would require approximately 12 miles of new lines (Red Lake Electric Cooperative, 1989).

For the Rx-W CSA, PKM would provide service from their Radium substation, located immediately north of the town of Radium. The power line would run directly south from the substation, following an existing corridor, and turn east at the CSA (PKM Electric Cooperative, 1989). This will require approximately six miles of new lines. The electric cooperative, in conjunction with the USAF, will prepare a BER prior to constructing the USAF lines.

The pole height for 12.4 KV service is usually 30 to 45 feet and the right-of-way width required is 55 feet or 6.67 acres per mile. Pole spacing will depend upon pole height, but will be at least 270 feet. Impacts will be minimized by using existing right-of-ways where possible.

2.3.3.6 Emergency Power Generation. Standby electric power for full load operation of the receive site shall be provided by diesel engine-generators. Each of the four receive site electronic support buildings will be equipped with two-300 KW standby generators to provide back-up power.

2.3.3.8 Water Supply. A permanent water supply will be developed at each of the receive sectors. Current projections are that these supplies must be designed to meet a peak demand of approximately 50,000 to 100,000 gallons per day (gpd) during construction (including dust control and compaction) and 3000 gpd during facility operations. A conventional water well is planned at the receiver building behind each antenna sector. Anticipated well depths are between 150 feet and 350 feet. The USAF or the system contractor will coordinate water appropriations with the Minnesota Department of Natural Resources. It is anticipated that water yields will be sufficient and treatment will not be necessary. If the demand for water during construction is higher than practical well yields, alternate forms of dust control or water sources will be used. If treatment is required, it will be in accordance with all applicable State, Federal and Air Force regulations. During construction all wells situated within the area to be fenced will be closed unless they are utilized for project water requirements.

2.3.3.9 Wastewater Disposal. The CRS receive site will generate peak loads of 3000 gpd of domestic wastewater. The wastewater disposal system will be designed by the system contractor. Due to existing soil conditions, it is likely that the disposal system will consist of either a septic system with a leach field (as at the West Coast Radar System) or a sanitary holding tank, which could be unloaded weekly or biweekly and transported to a local waste treatment facility. The system will be designed so that groundwater in the area would not be affected. All applicable state and federal guidelines for waste disposal systems will be met.

If a leach field is chosen, its location will be selected based upon additional site-specific engineering analysis, and the need to avoid or minimize impacts to important environmental resources (e.g. wetlands, drainage channels) or potable water supplies.

2.3.3.10 Solid/Hazardous/Industrial Materials. Each on-site facility will have a fenced closure for a trash dumpster. Solid waste generated during construction and operation will be disposed of by a private solid waste collector. Although the exact composition and volume of waste for the CRS is not yet known, Table 2-1 provides a summary of the types of materials typically encountered during construction of the OTH-B West Coast Radar System (WCRS). As discussed in Section 2.2.3.1.1, CRS solid waste will be similar in composition but slightly higher in volume than the WCRS.

It is anticipated that a majority of the site hazardous materials will be generated in vehicle maintenance areas. These materials are likely to include contaminated lube oils, cleaning fluids, antifreeze and paints. Hazardous materials will be temporarily stored on-site in EPA-approved containers. These materials will then be hauled off-site and disposed of an EPA-approved hazardous materials contractor.

Permitting is not required for facilities that generate hazardous materials at rates less than 100 kg per month and have less than 1,000 kg total in storage. If hazardous materials are stored on site for more than 90 days, permitting is required and a Part A and Part B application must be filed with the Director of the Hazardous Waste Division, Minnesota Pollution Control Agency (PCA). The Minnesota PCA recommends that hazardous materials be shipped more frequently than every 90 days. *Grand Forks AFB is a federally permitted facility, which could accept materials from the OTH-B CRS sites if their existing permit is revised (MNPCA, 1989).*

2.3.3.11 Access Roads. The CRS access road design criteria will require construction of a two-lane, gravel surfaced road, consisting of two 10-foot wide travel lanes plus 4-foot wide shoulders for site access. Based upon the location of the sectors and existing roads, the four sector configuration developed for the Rx-E CSA will require construction of approximately one-half mile of new gravel surfaced road for site access. The Rx-W CSA will require construction of approximately one mile of new gravel surfaced road for site access.

2.3.3.12 Parking. Gravel surfaced parking will be provided at each receiver building; approximately 4,500 square feet at each sector except 7,500 square feet at the SW operating sector. An additional 4,000 square feet of gravel surfaced area will be provided at the SW operating sector for maintenance and security vehicle unloading and turnaround.

2.3.3.13 Perimeter Roads. A gravel surfaced, ten foot wide, perimeter/security road will be constructed outside of the antenna exclusion fence. The location of the roadway and fence is as delineated on Figure 2-15. For either CSA, the four sector configuration of the site will require construction of approximately 10 miles of perimeter road. Access and perimeter road design criteria and a typical road cross section are described in paragraph 2.2.3.8 and shown on Figure 2-13.

2.3.3.14 Clearing. Approximately 525 acres of land must be cleared (cutting of vegetation above ground surface) and grubbed (removal of vegetation below ground surface) for the four antennas, ancillary structures and facilities, security fencing, and perimeter road. A total area of approximately 525 acres will also be filled, while a total of 470 acres will be enclosed by the perimeter fence.

2.3.3.15 Site Earthwork Requirement. The site earthwork quantities (Table 2-3) for the antenna, the groundscreen and support facilities are based upon the minimum slope criteria (½ percent to allow for drainage) and the balance or difference between cut and fill volumes. Computations were based upon existing elevations taken from USGS topographic maps (scale 1:24,000) and preliminary hydrologic data. The quantities developed at this concept stage will be refined during the design process using more detailed topographic, hydrologic and geotechnical data that is required to specify earthwork requirements, determine borrow quantities, and optimize the facilities configuration.

The major features in this quantity determination are the antenna baseline and the groundscreen elevation. Although the USAF intends to achieve a balance of cut and fill, preliminary data indicate that in many instances, cut and fill balance may not be achievable. This imbalance (usually more fill required than cut available) is apparent in lower elevation areas where it may be necessary to elevate the groundscreen to ensure positive site drainage. Depending upon the actual groundscreen elevation, which will be determined during final design, the Rx-E may may require up to 948,000 cu yds. of borrow to construct the antenna and groundscreen. The Rx-W CSA will require

TABLE 2-3. APPROXIMATE RECEIVE SITE CONSTRUCTION REQUIREMENTS

Activity Study Area - Four (4) sectors each		Estimated Requirements Rx-East	 Rx-West
ROAD CONSTRUCTION			
Perimeter Road		10	10
Access Road[1]		1	1
Total Miles		11	11
CLEARING			
Perimeter Road & Fence		50	50
Access Road		7	7
Receive Sectors and Support Facilities		470	470
	Total Acres	527	527
GRUBBING AREA			
Perimeter Road		50	50
Access Road		7	7
Groundscreen and Support Facilities		470	470
	Total Acres	527	527
FILL AREA			
Perimeter Road and Fence		50	50
New Access Road		7	7
Groundscreen and Support Facilities		470	470
	Total Acres	527	527
FILL VOLUME			
Perimeter Road and Fence[2]		162,000	162,000
Access Road[2]		12,000	24,000
Groundscreen and Support Facilities[3]		948,000	1,520,000
	Total cu. yd.	1,122,000	1,706,000
TOTAL FENCED AREA			
Antenna Field	Total acres	470	470

1. Estimated length of road based on proximity of preliminary layout to existing roads.

2. Assumes constant fill depth of approximately 2 feet. Additional depth will require additional fill.

3. Based on minimum fill volume required to maintain positive site drainage during 25-year storm event (Technical Study 4, Hydrology and Water Quality).

approximately 1,520,000 cu yds. of borrow. The estimated 100,000 cubic yards of crushed gravel surfacing (6" thick) for the groundscreen, roads, parking and building areas can be obtained from commercial sources near the construction site. Additional borrow (if required) will be secured at newly-opened pits developed under the environmental criteria specified in Section 2.3.3.13, or from commercial sources.

2.3.3.16 Borrow Requirements. Borrow requirements for the receive sites will be reduced by maximizing the use of a balanced cut and fill approach for grading within the final facility footprint. Additional borrow may be required to (1) ensure positive site drainage; (2) avoid prolonged flooding or ponding on the groundscreen; (3) construct the final road and groundscreen surfaces; and (4) provide select fill material where needed. Exact borrow requirements (including the required types and quantities of fill) are dependent upon site specific conditions and the precise groundscreen location selected, and groundscreen elevation, and cannot therefore be defined prior to final design.

Although final borrow quantities are not yet known, the additional fill (beyond the material available within the facility footprint) required varies significantly between the alternative sites under consideration. Final quantities will be determined by the potential for flooding impacts (and hence, the need for elevation of facilities and roads); and the existing site slope in front of the antenna baseline (which defines the amount of grading required to meet system specifications). However, a preliminary engineering analysis indicates that potential borrow requirements for the Rx-W CSA are expected to exceed those for the Rx-E CSA, due primarily to existing site topography.

Borrow volumes will be minimized to reduce both system costs and environmental impacts. Material will be acquired either from commercially available sources, or at new borrow sites, depending upon the availability of the required types of fill. If new borrow sites are required, the USAF, through its system contractor, will adhere to the following criteria for borrow site selection:

1. Avoid or minimize impacts to known wetland areas and establish appropriate buffer zones from adjacent wetlands

2. Avoid or minimize impacts to known cultural resource sites and historic properties

3. Avoid or minimize impacts to known wildlife concentration areas or critical habitats (e.g. nesting, breeding, feeding areas)

4. Avoid or minimize impacts to areas containing known populations of special-status plant species, including native prairie habitats

5. Avoid or minimize impacts to areas subject to frequent flooding or ponding (to minimize erosion and sedimentation impacts)

6. Minimize haul distance to sites (to avoid or reduce impacts to public roads from hauling operations)

New borrow pit design and operation will employ Best Management Practices (BMPs) for erosion and sedimentation control and avoidance or reduction or water quality, wildlife and visual impacts. These BMPs will be outlined in the project mitigation plan and finalized in consultation with the appropriate federal, state and local agencies and landowners following final facility site selection. Any new borrow sites will be selected, to the maximum extent feasible, so as to provide additional mitigation opportunities (e.g. compensatory flood storage, wildlife habitat or recreational usage) for project impacts following removal of the required borrow material.

REFERENCES

City of Britton, South Dakota. 1989a. D. 'Iillgers (General Superintendent), Personal Communication.

City of Britton, South Dakota. 1989b. Public Works Department. L. Mitzel (Public Works Superintendent), Personal Communication.

City of Thief River Falls, Minnesota. 1989a. R. Lindbergh (City Engineer), Personal Communication. September 20.

City of Thief River Falls, Minnesota. 1989b. B. Jablinski (Sanitation Commissioner), Personal Communication. September 20.

East River Electric Power Cooperative, 1989. Letter from D. Thorson, Manager Engineering Services, to P. Bealieu, Metcalf & Eddy, Inc./Holmes & Narver, Inc. August 22.

Lake Region Electric Association, Inc., 1989. Key Map for the Lake Region Electric Association, Inc. Webster, South Dakota

Marshall and Polk Rural Water System. 1989a. L.L. Murphy (Manager), Letter to C. Ferreira, Metcalf & Eddy, Inc./Holmes & Narver, Inc. October 3.

Marshall and Polk Rural Water System. 1989b. L.L. Murphy (Manager), Personal Communication. Warren, Minnesota. September 20.

Minnesota Pollution Control Agency. 1989. T. Townsend, Personal Communication. September 20.

PKM Electric Cooperative, 1989. C. Riesen (General Manager) Personal Communication. November 15.

Red Lake Electric Cooperative, Inc. 1989. R.M. Kennedy (General Manager), Personal Communication. Red Lake Falls, Minnesota. November 15.

Red Lake Electric Cooperative, 1990. R.M. Kennedy (General Manager), Personal Communication. February 6.

Red Lake Watershed District. 1988. Ten Year Updated Overall Plan, May 1988. Thief River Falls, Minnesota.

Soil Conservation Service, 1975. Soil Survey of Marshall County, South Dakota. U.S. Department of Agriculture.

South Dakota Department of Water & Natural Resources. 1989. C. Jacobson, Personal Communication. Pierre, South Dakota. September 21.

United States Air Force (USAF), 1987. Final Environmental Impact Statement: Proposed Central Radar System, Over-the-Horizon Backscatter Radar Program.

United States Air Force (USAF), 1988. Record of Decision Central Radar System Environmental Impact Statement, Over-the-Horizon Backscatter Radar Program.

United States Air Force (USAF), 1989. Technical Studies, Over the Horizon Backscatter Radar Program Alaska Radar System. Prepared by Metcalf & Eddy, Inc./Holmes & Narver, Inc. Wakefield, Massachusetts.

U.S. Geological Survey, 1976a. Geology and Water Resources of Marshall County, South Dakota. Bulletins No. 23.

U.S. Geological Survey, 1976b. Geology and Water Resources of Brown County, South Dakota. Bulletin No. 25.

United States Department of Interior. 1989. L. Howells (Hydrologist), Personal Communication. Huron, South Dakota.

Western Area Power Administration, 1990. R. D. Heleckson, Personal Communication. January 22.

TECHNICAL STUDY 3

CENTRAL RADAR SYSTEM
OVER THE HORIZON BACKSCATTER RADAR PROGRAM

TRANSPORTATION

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3.0 TRANSPORTATION

3.1 INTRODUCTION

The U.S. Air Force (USAF) has proposed to construct an Over-the-Horizon Backscatter (OTH-B) Central Radar System (CRS) in the north central portion of the United States (USAF, 1987). In the Record-of-Decision (ROD) the USAF selected a study area near Amherst, South Dakota for the transmit sectors, and a study area near Thief River Falls, Minnesota for the receive sectors (USAF, 1988). Within each study area the USAF has identified two concentrated study areas (CSA's) for detailed examination (Figs. 3-1 and 3-2). The transmit (Tx) study area CSA's are called Tx-North (Tx-N) and Tx-South (Tx-S); at the receive (Rx) study area they are called Rx-East (Rx-E) and Rx-West (Rx-W). The CSAs have been selected through a screening process involving environmental, operational, and socioeconomic considerations (Technical Study 1, EIAP Overview).

This section describes existing roadway and traffic conditions and future baseline conditions in the study areas, and evaluates the potential impacts that may occur from construction and operation of the OTH-B CRS. The potentially affected environment for transportation is defined as the existing network of roadways in and near the CSA's. Each roadway is described in terms of its surface characteristics (paved, gravel or dirt), maintenance jurisdiction (state, county or local), funding aid eligibility (federal, state or county), and the destinations served (localities or regional centers). Where available, average daily traffic (ADT) counts are presented as well. Potential transportation impacts are described as either regional (affecting the transportation network between major regional centers or between a locality and a major regional center) or local (affecting the network between localities). Impacts to the local and regional transportation networks may be caused by project-related traffic, or by the siting of the CRS resulting in roadway closures or realignments.

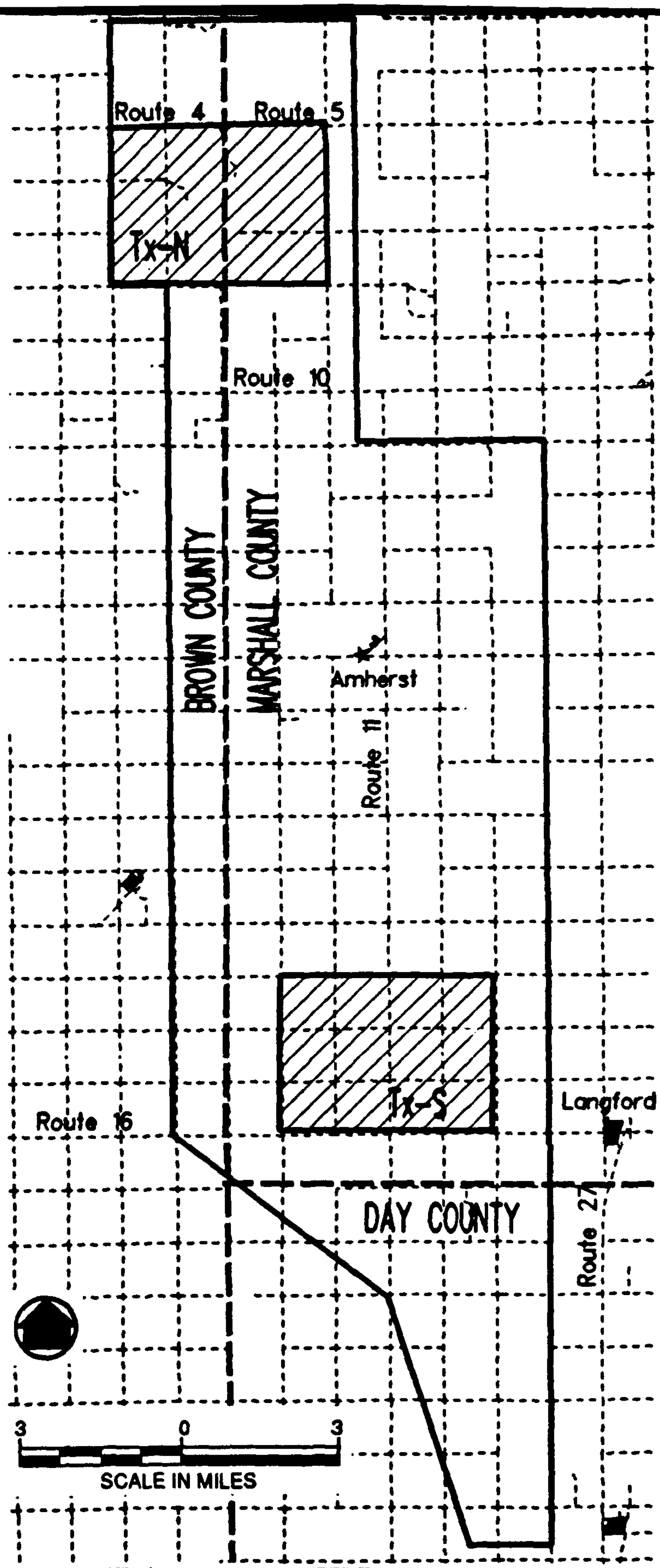


FIGURE 3-1. AMHERST, SD TRANSMIT STUDY AREA EXISTING ROADS

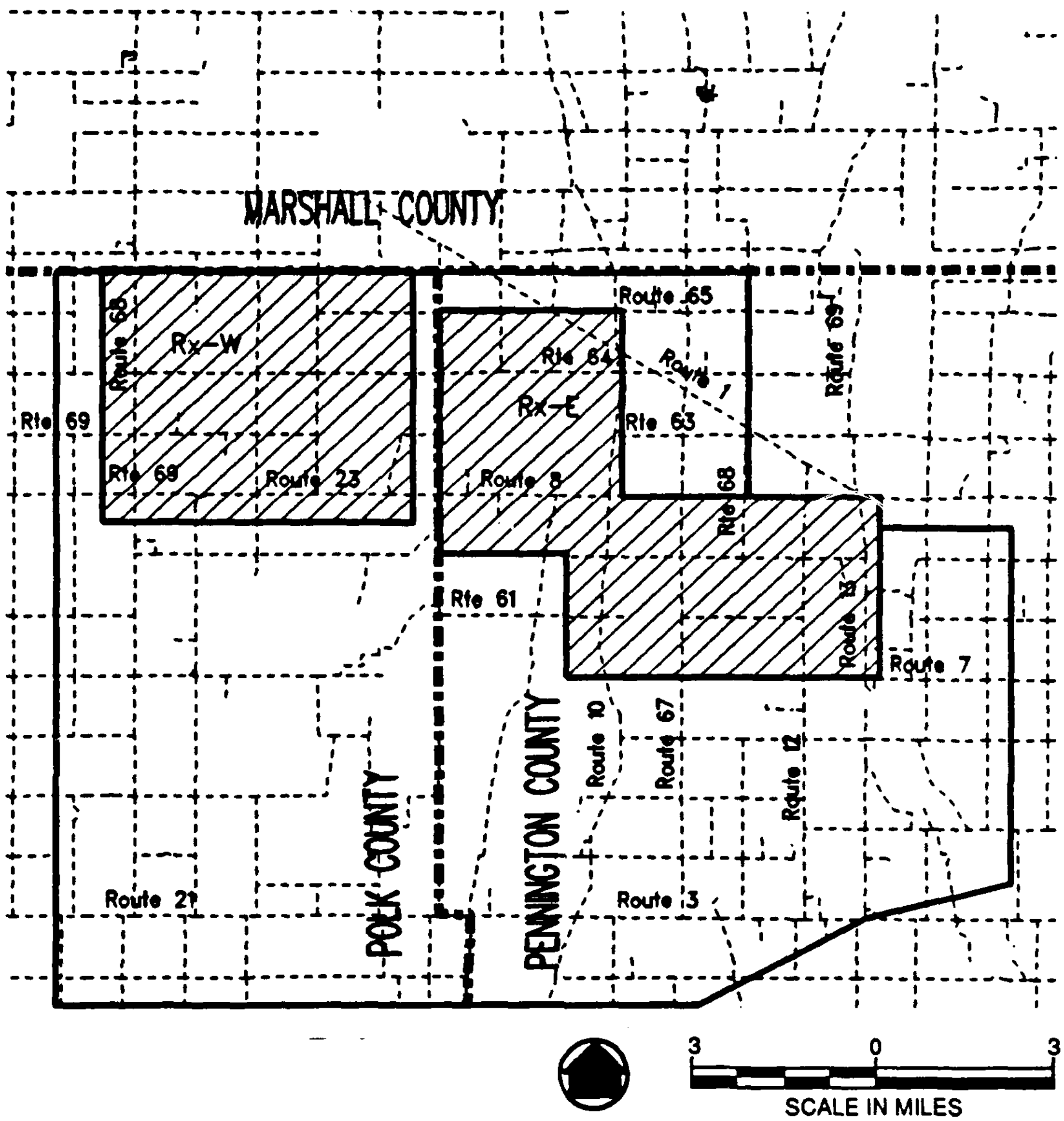


FIGURE 3-2. THIEF RIVER FALLS, MN RECEIVE STUDY AREA EXISTING ROADS

3.2 TRANSPORTATION REGULATIONS

3.2.1 Federal Regulations

Federal transportation regulations do not have direct applicability to the study areas as there are no federal jurisdiction highways which traverse or are in close proximity to the CSA's. The closest CSA to a U.S. Highway is Rx-W in Polk County, Minnesota, which lies approximately seven miles from U.S. 75, a paved, north-south, undivided, two-lane roadway with shoulder.

3.2.2 Transmit Study Area

3.2.2.1 South Dakota Regulations. On state-numbered roads, the South Dakota Department of Transportation (SDDOT) requires an Approach Permit for construction of access drives and ways (private and public). For most rural accesses the permit application must include a sketch-level drawing; for more intensive uses or larger approaches design drawings are sometimes required (SDDOT, 1989).

3.2.2.2 County and Local Regulations. In Brown and Marshall Counties there are no permit or other regulatory requirements for county-maintained roads or township roads.

3.2.3 Receive Study Area

3.2.3.1 Minnesota Regulations. A State Entrance Permit is required from the Minnesota Department of Transportation (MNDOT) where access roads or driveways intersect state highways (a permit is not required on county state-aid roads). Intersection plans and driveway layouts showing sight distance, drainage patterns and drive width must be submitted with the permit application, in accordance with the MNDOT rules and regulations (MNDOT Rules).

3.2.3.2 County and Local Regulations. Both Polk and Pennington Counties have weight-bearing limitations for county-maintained roads during the spring. County roads are designated as either seven-ton-per-axle routes or as nine-ton-per-axle routes. Movement of vehicles or equipment exceeding these weight restrictions would require a permit from the appropriate county. In addition, the party responsible for movement of heavy equipment may be required to assist in roadway maintenance (Pennington County, 1989).

In Polk County any work along a county road, including a new access intersecting a county road (both county and state-aid county roads), requires authorization from the Polk County Highway Department. Plans for both temporary and permanent roadways must be submitted for review to the Polk County Highway Engineer (Polk County, 1989). Although there is no specific schedule for doing so, submissions must be provided reasonably in advance of construction of the access. In addition, if the proposed new roadway or any site construction work will cross a regional watershed ditch or a county drainage ditch, approval is needed from the Watershed District Engineer or the County Ditch Engineer (Polk County, 1989). There are no formal permits or approvals required for an access off a county road in Pennington County, however, the County Highway Department should be notified of scheduled work (Pennington County, 1989). Township roads, which are unpaved and carry low volumes, are not regulated, however, local counties recommend that townships be notified regarding alterations to local roads (Polk County, 1989).

3.3 ROADWAY CLASSIFICATIONS

3.3.1 Roadway Surface and Design

In both Minnesota and South Dakota, the roads in the study areas can be characterized in several broad design categories:

a) Paved - medium-duty, typically with two 12-foot wide bituminous lanes, sometimes with one or more unpaved shoulders if route is a state-numbered highway or on the Federal Aid Primary or Secondary system (Section 3.3.2).

b) Compacted gravel - hardpacked stone and soil surface; width varies but is typically between 16 and 24 feet in total.

c) Dirt, minimal or no improvements - ranges from one lane graded and drained dirt surface to unimproved dirt lane that accommodates mainly farm vehicles. These roads often run along township section lines and are maintained by private vendors under contract to the township. Some of the less improved lanes receive little actual maintenance; the term "primitive road" is sometimes used to describe such roads on county base maps.

3.3.2 Maintenance Jurisdiction and Funding Aid Eligibility

In Marshall and Brown Counties, South Dakota the roads are categorized by the following maintenance jurisdiction and aid classifications:

- Federal Aid Secondary (FAS) - paved medium duty or compacted gravel; surfacing of FAS roads is primarily pavement in the vicinity of the two concentrated study areas. The FAS roads connect to gravel and dirt segments in some instances.
- County-maintained gravel and gravel and dirt roads, no outside funding.
- Local gravel roads/local dirt roads - township and private contractor maintenance, no outside funding.

In Polk and Pennington Counties, Minnesota the following categories are used to describe jurisdictional and aid classifications:

- State Trunk Highway/Federal Aid Primary System - two or more lane paved road with shoulder(s), which connect regional, intrastate or interstate destinations and generally carry higher traffic volumes than other roads in the vicinity.
- County State Aid/Federal Aid Secondary road - medium-duty paved or compacted gravel road; surfacing is a combination of paving and compacted gravel in Pennington County and gravel in Polk County.
- County road - primarily compacted gravel with some segments of dirt; maintained with county funds.
- Township and section line roads - predominantly dirt roads; maintenance, when conducted, is usually done by a private contractor, or in limited instances, by the County Highway Department.

3.4 AFFECTED ENVIRONMENT

For transportation purposes, the affected environment is larger than the CSA because travel to and from the CSA's and alternative routes that may be used due to program-generated road closures are likely to involve roadways outside the CSA's. Thus, the potentially affected transportation environment for each CSA includes the following:

- Roadway segments wholly encompassed by the CSA;
- Roadways that traverse and extend beyond the CSA;
- Roadways that abut or are relatively close to the CSA (typically within approximately one mile from the closest point of the CSA);
- Roadways that provide a regional travel function, i.e. connecting to a regional center which is clearly situated outside of the CSA, but to which the CSA has some ties (housing for personnel, commercial facilities and services, construction supplies, etc.).

Tables 3-1 and 3-2 provide an inventory of the potentially affected highways and roads in the Amherst and Thief River Falls study areas respectively. The tables summarize key information such as roadway surface and design, maintenance jurisdiction, funding eligibility, regional and local significance, average daily traffic and relationship to the CSA. Although traffic counts (ADT) are available on some of the roads in the study areas, their rural nature precludes use of conventional quantitative traffic engineering evaluation methods, commonly referred to as capacity analysis. Likewise, due to low traffic volumes, prospects for intersection failure or deterioration and segmental impedances to flow or safety do not approach minimum levels of concern. Thus although traffic counts are presented in this baseline assessment, capacity analysis has not been conducted by the county or state transportation departments with jurisdiction in the study areas.

3.4.1 Transmit Study Area

The transmit study area is located in Brown, Marshall and Day Counties, South Dakota; the Tx CSA's are located in the townships of Portage, Dayton Newport

TABLE 3-1. AMHERST, SOUTH DAKOTA STUDY AREA EXISTING ROADS

Concentrated Study Area	Road	County Township Location	Road Description (Surface/Direction/Other)	Jurisdiction and Status	Local/Regional Highway Status and Connections	Relationship or Proximity of Road to the Concentrated Study Area (CSA)	Available Traffic Counts
Tx-N	County Rt. 4 – Brown Co. Rt. 5 – Marshall Co.	Brown and Marshall Co. Portage and Dayton TWP	Bituminous Paved, East-West (E-W)	Federal Aid Secondary	Local access to Towns of Kidder and Hecla. 6 miles north of State Highway 10	Passes along the northern boundary of Tx-N	ADT = 54[1,2]
Tx-N	Local Unnamed	Marshall Co. Portage TWP	Dirt Unimproved E-W	Privately contracted by township	Local access 4 miles north of State Highway 10	Passes one mile north of the southern boundary of Tx-N and traverses CSA for 2 miles (E-W)	
Tx-N	Local Unnamed	Brown Co. Stena TWP	Light-duty E-W	Privately contracted by township	Local access 3 miles north of State Highway 10; connects two unimproved dirt roads (N-S), which are located south and west of the CSA	Runs along the southern boundary of Tx-N CSA for one mile	
Tx-N	Local Unnamed	Marshall and Brown Co. Stena Twp.	Dirt Unimproved E-W	Privately contracted by township	Local access 1 mile north of State Highway 10	Passes two miles south of the southern boundary of Tx-N	
Tx-N	Route 10	Marshall and Brown Co. Stena Twp.	Paved E-W	State and Federal Aid Secondary	Connects to U.S. 281 (N-S) approximately 25 miles east of Tx-N; leads to the Town of Britton approximately ten miles southeast of Tx-N CSA	Three miles south of Tx-N CSA	ADT = 735 Total[3] Commercial = 85[3]
Tx-N	Local Unnamed	Brown Co. Portage and Stena TWP	Compacted gravel; the surface of 3 miles of the roadway, which runs parallel to the western boundary of Tx-N CSA and is located 3 miles north of Route 10 has a dirt surface N-S	Privately Contracted by Townships	Intersects Route 10 3 miles south of the Tx-N CSA	Runs one mile east of the western boundary; bisects Tx-N CSA for 3 miles	
Tx-N	Local Unnamed	Marshall and Brown Co. Stena TWP	Dirt Unimproved N-S	Privately contracted by township	Local access Runs along the section line between Marshall and Brown Co. for a mile and a half	Traverses south edge of Tx-N CSA	
Tx-N	Local Unnamed	Marshall Co. Stena TWP	Dirt Unimproved N-S	Privately contracted by township	Local access Intersects Route 10, three miles south of the Tx-N CSA	Originates half mile south of Tx-N CSA Southern boundary and runs (N-S) for two and half miles, until it intersects Route 10	
Tx-N	Local Unnamed	Marshall Co. Stena and Dayton TWP	Dirt A mile of the road located two miles north of Tx-N CSA has a gravel surface N-S	Privately contracted by township	Local access on section line, intersects the FAS highway (E-W)	Runs for one mile and a half on the eastern boundary of Tx-N CSA	

TABLE 3-1 (Continued). AMHERST, SOUTH DAKOTA STUDY AREA EXISTING ROADS

Concentrated Study Area	Road	County Township Location	Road Description (Surface/Direction/Other)	Jurisdiction and Status	Local/Regional Highway Status and Connections	Relationship or Proximity of Road to the Concentrated Study Area (CSA)	Available Traffic Counts
Tx-N	Local Unnamed	Marshall Co.	Dirt Unimproved N-S	Privately contracted by township	Local access on section line, intersects the FAS (E-W)	Is located one mile east of the eastern boundary of Tx-N CSA	
Tx-S	Local Unnamed	Marshall and Brown Co. Newport TWP	Compacted gravel; dirt, for one mile immediately west of the paved FAS highway which bisects the CSA E-W	Privately contracted by township	Local access Intersects the FAS highway which bisects the Tx-S CSA	Passes one mile south of the northern boundary; bisects Tx-S CSA for four miles	
Tx-S	Local Unnamed	Marshall and Brown Co. Newport TWP	Compacted gravel E-W	Privately contracted by township	Local access Intersects the FAS highway which bisects the Tx-S	Passes two miles south of the northern boundary; bisects Tx-S for four miles	
Tx-S	Rt. 16 - Marshall County	Marshall and Brown Co. Newport TWP	Bituminous Paved E-W	Federal Aid Secondary	Intersects Route 37, 10 miles west of the site; leads to the town of Langford approximately two and one half miles southeast of Tx-S CSA	Runs on the southern boundary of Tx-S CSA for four miles	ADT = 184-237 (2)
Tx-S	Local Unnamed	Day and Brown Co. Newport TWP	Compacted gravel; two sections of the road, located southeast and south of the site have dirt surfaces which each run for a mile E-W	Private Contracted by township	Local access Intersects the FAS highway which bisects the Tx-S CSA, one miles south of the site	Passes one and a half mile south of the southern boundary of Tx-S CSA	
Tx-S	Local Unnamed	Day Co. Newport TWP	Compacted Gravel; E-W	Privately Contracted by Township	Local access Bisects State Highway 25 two and a half miles southwest of the CSA	Runs parallel to the southern boundary of Tx-S; located two and a half miles south of the CSA	
Tx-S	Local Unnamed	Marshall and Day Co. Newport TWP	Compacted gravel; dirt for three miles immediately south of the FAS highway which runs (E-W) parallel to southern boarder of Tx-S CSA N-S	Privately contracted by township	Local access on section line	Runs along western boundary of Tx-S CSA	
Tx-S	Local Unnamed	Marshal Co. Newport TWP	Compacted gravel; dirt for three miles north of the FAS highway which runs (E-W) parallel to the southern boarder of Tx-S CSA N-S	Privately contracted by township	Local access on section line	Runs one mile east of the western boundary; bisects Tx-S CSA for three and a half miles	

TABLE 3-1 (Continued). AMHERST, SOUTH DAKOTA STUDY AREA EXISTING ROADS

Concentrated Study Area	Road	County Township Location	Road Description (Surface/Direction/Other)	Jurisdiction and Status	Local/Regional Highway Status and Connections	Relationship or Proximity of Road to the Concentrated Study Area (CSA)	Available Traffic Counts
Tx-S	Route 11 - Marshall County	Marshall and Day Co. Newport TWP	Bituminous paved; gravel for three miles south of the section line separating Marshall and Day Co. N-S	Federal Aid Secondary	Intersects Route 10, approximately 13 miles north of the CSA; leads to the Town of Amherst approximately 10 miles north of the CSA	Bisects the Tx-S CSA site	ADT = 76-78(1)
Tx-S	Local Unnamed	Marshall Co. Newport TWP	Compacted gravel N-S	Privately contracted by township	Local access, intersects the FAS highway which runs parallel to the southern boundary of the Tx-S CSA	Passes one mile west of the eastern boundary of the Tx-S CSA	
Tx-S	Local Unnamed	Marshall and Day Co. Newport TWP	Compacted gravel; two sections of the road located 2 miles north and 2 miles south of the section line separating Marshall and Day Co., have a dirt surface N-S	Privately Contracted by Township	Local Access, Intersects the FAS highway which runs parallel to the southern boundary of the Tx-S CSA	Runs on the eastern boundary of the Tx-S CSA	

Sources:
(1) SDDOT, 1984a.
(2) SDDOT, 1984b.
(3) SDDOT, 1988.

TABLE 3-2. THIEF RIVER FALLS, MINNESOTA RECEIVE SITES STUDY AREA EXISTING ROADS

Concentrated Study Area	Road	County Township Location	Road Description (Surface/Direction/Other)	Jurisdiction and Status	Local/Regional Highway Status and Connections	Relationship or Proximity of Road to the Concentrated Study Area (CSA)	Available Traffic Counts
Rx-W	Route 66	Polk Co. Helgeland TWP	Compacted gravel North-South (N-S)	County State Aid	Local Access Only	Abuts Northwestern Edge of Rx-W	ADT=70-75 (1987)
Rx-W	Route 69	Polk Co. Helgeland TWP	Compacted gravel both E-W and N-S; coterminous with a portion of Route 23	County State Aid	Local road going toward Thief River Falls Area	Traverse (bisects Rx-W) CSA for 1.2 miles, E-W	Routes 69/23=ADT 95 in CSA (1987)
Rx-W	Route 23	Polk Co. Helgeland TWP	Compacted gravel points East and South with a portion or Route 69	County Federal Aid Secondary	Regional E-W Route, to points East and South	Runs along south end of Rx-W CSA for 1.2 miles, E-W	Routes 69/23=ADT 95 in CSA (1987)
Rx-W	Local Generic	Polk Co. Helgeland TWP E-W	Dirt Unimproved	Privately contracted by townships	Essentially a farm road on a section line	Traverses upper portion of Rx-W CSA for 2.25 miles	None
Rx-W	Local Generic	Polk Co. Helgeland TWP	Compacted Gravel N-S	Privately contracted by Townships	Local access, on section	Traverses Rx-W CSA for .6 miles	None
Rx-E	Route 8	Pennington Co. Numedal Bray and Sanders TWPs	Paved 1989 E-W 2 lanes	County State Aid	Regional E-W route to Thief River Falls	Traverses Rx-E Connects to Route 23 in Polk County, to W	ADT = 40-75 in CSA(2)
Rx-E	Route 1 Trunk Highway	Pennington Co. Numedal Bray TWPs Marshall Co.	Paved SE-NW	State highway on federal aid primary system	Major road in vicinity of CSA; connection to U.S. 75 at Warren, MN 17 miles from RxW West	Lies approximately 2 mi. from Rx-E CSA	ADT = 630-690 at CSA(2)
Rx-E	Route 62	Pennington Co. Numedal Bray and Sanders TWPs	Primarily compacted gravel E-W	County road	Secondary road to Thief River Falls	Bisects Rx-E CSA for .85 mi. and connects to route 10	None
Rx-E	Route 61	Pennington Co. Numedal Bray and Sanders TWPs	Compacted gravel west of Rx-E dirt within Rx-E E-W	County road	Secondary road to Thief River Falls	Runs just south of Rx-E CSA	ADT = 5-10 at CSA(2)
Rx-E	Route 63	Pennington Co. Numedal TWP	Dirt lane on Rx-E site; compacted gravel east of Rx-E E-W	County road	Connects to U.S. 59 nr Thief River Falls	Bisects Rx-E CSA for .75 mi.	ADT = 30 east of CSA(2)
Rx-E	Route 65	Pennington Co. Numedal TWP	Dirt abutting north side Rx-E E-W	County road	Connects to Rt. 10 and State one, although it is an unimproved road	Runs along northern boundary of Rx-E CSA	ADT = 10-20 east of CSA(2)
Rx-E	Route 7	Pennington Co. Numedal Bray and Sanders TWPs	Dirt and compacted gravel Nr sites E-W	County State and Federal Aid Secondary	Runs for Rx-E eastward, passing south of Thief River Falls, for 20 miles to center of County	Passes 1-1/4 miles south of Rx-E CSA's closest bound	ADT = 35-70 at CSA(2)

TABLE 3-2 (Continued). THIEF RIVER FALLS, MINNESOTA RECEIVE SITES STUDY AREA EXISTING ROADS

Concentrated Study Area	Road	County Township Location	Road Description (Surface/Direction/Other)	Jurisdiction and Status	Local/Regional Highway Status and Connections	Relationship or Proximity of Road to the Concentrated Study Area (CSA)	Available Traffic Counts
Rx-E	Route 10	Pennington Co. Numedal and Bray TWPs	Compacted gravel N-S	County State Aid Federal Aid Secondary	Runs from State One on north (above that it becomes rte. 11) to southern bound of county and beyond. Major regional N-S route in western corner of Pennington Co.	Traverses Rx-E CSA	ADT = 40-60 in CSA(2)
Rx-E	Route 12	Pennington Co. Numedal and Bray TWPs	Compacted gravel N-S	County State Aid Federal Aid Secondary nr site	Secondary N-S access between County 64 on North and Red Lake Falls south of Pennington County	Passes along eastern bound of Rx-E CSA	ADT = 20 south of CSA(2)
Rx-E	Route 13	Pennington Co. Numedal Bray Norden and Sanders TWPs	Compacted gravel N-S	County State Aid Federal Aid Secondary nr site	Connects to State One on North and Route 7 (1/2 mile South of Rx-E)	Passes one mile east of Rx-E CSA	ADT = 45-85 in CSA(2)
Rx-E	Route 70	Pennington Co. Norden and Sanders TWPs	Compacted gravel N-S	County Road between Route 8 on North and Route 7 on South	Local access only, between Routes 7/8	Passes two miles east of Rx-E CSA	ADT = 60-75 east of CSA(1)
Rx-E	Route 68	Pennington Co. Numedal Bray and Sanders TWPs	Dirt and compacted gravel on-site N-S	County Road	Connects to State One on North	Traverse east edge of Rx-E CSA	ADT = 20-30 N.E. of CSA(2)
Rx-E	Route 67	Pennington Co. Numedal and Bray TWPs	Dirt and compacted gravel on-site N-S	County Road	Connects to State One on North	Traverses Rx-E CSA one mile east of Route 68	ADT = 20 N.E. of CSA(2)

Sources: (1) MNDOT, 1985.
(2) MNDOT, 1987.

and Stena. There are no federal interstates or U.S. highways in the study area (Fig. 3-1). Route 10, a state FAS paved road that travels east-west across the two counties, lies three miles to the south of the Tx-N CSA and ten miles north of the Tx-S CSA. Routes 27 and 37 are also state FAS paved roads; Route 27 is situated approximately two (Tx-S) to fifteen (Tx-N) miles east of the CSA's and intersects Route 10 in the town of Britton (Table 3-1). Route 37 lies six miles west of the CSA's.

3.4.1.1 Tx-North Existing Roadways and Traffic. The Tx-N CSA is located in the northern part of the study area. There is one paved and several dirt roads in and abutting the Tx-N CSA (Fig. 3-3). Route 4 (Brown County)/5 (Marshall County) is a paved road located along the northern boundary of the CSA, which intersects Route 37 six miles west of the Tx-N CSA. Local dirt section roads abut the eastern and western boundaries of the CSA for a distance of one mile each. Dirt roads that terminate one to two miles inside the CSA enter Tx-N from the north, east and west. Table 3-1 provides a technical description of all the roads in and around the Tx-N CSA. Average daily traffic at locations on Routes 4/5 and 10 are shown in Table 3-3. Traffic counts are not available for other roadways in the Tx-N CSA.

3.4.1.2 Tx-South Existing Roadways and Traffic. The Tx-S CSA is located in the south central portion of the study area (Fig. 3-1). The town of Langford is two miles east of the eastern boundary of the CSA and Amherst is seven miles north of the northern boundary. Two paved and several dirt and gravel roads are located in or abut the Tx-S CSA (Fig. 3-4). The two paved county roads are Route 11, which bisects the CSA from the north and Route 16, which lies on the southern boundary of the CSA (Table 3-1). Route 16 intersects Route 27 in Langford two miles east of the CSA. Gravel roads parallel Routes 11 and 16 one mile to the east and one mile to the north, respectively. With the exception of the northern two-thirds of the eastern boundary of the Tx-S CSA, dirt and gravel roads abut and bisect the site on each section line (Fig. 3-4). Table 3-1 provides a physical and jurisdictional description of each roadway in the CSA. Average daily traffic counts available for Routes 11 and 16 are provided in Table 3-3. ADT is not available for other roads in the Tx-S area.

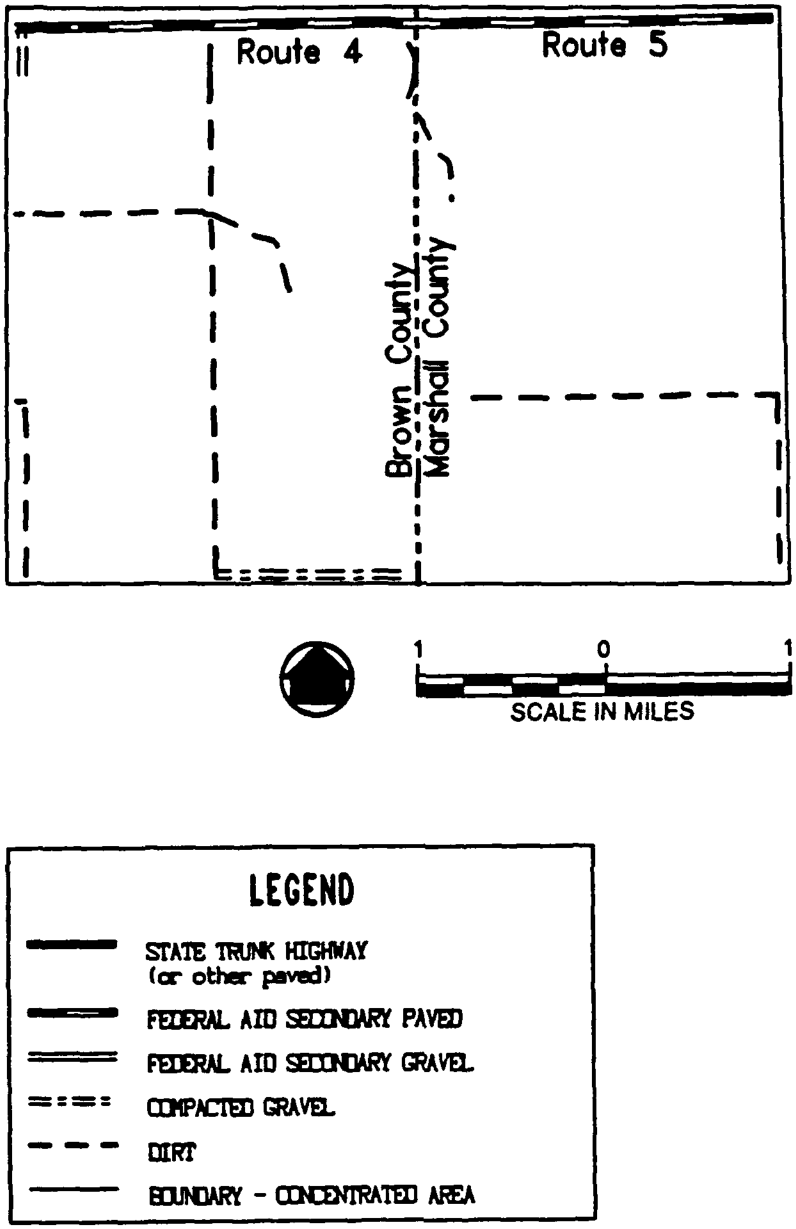


FIGURE 3-3. TX-NORTH CONCENTRATED STUDY AREA EXISTING ROADS

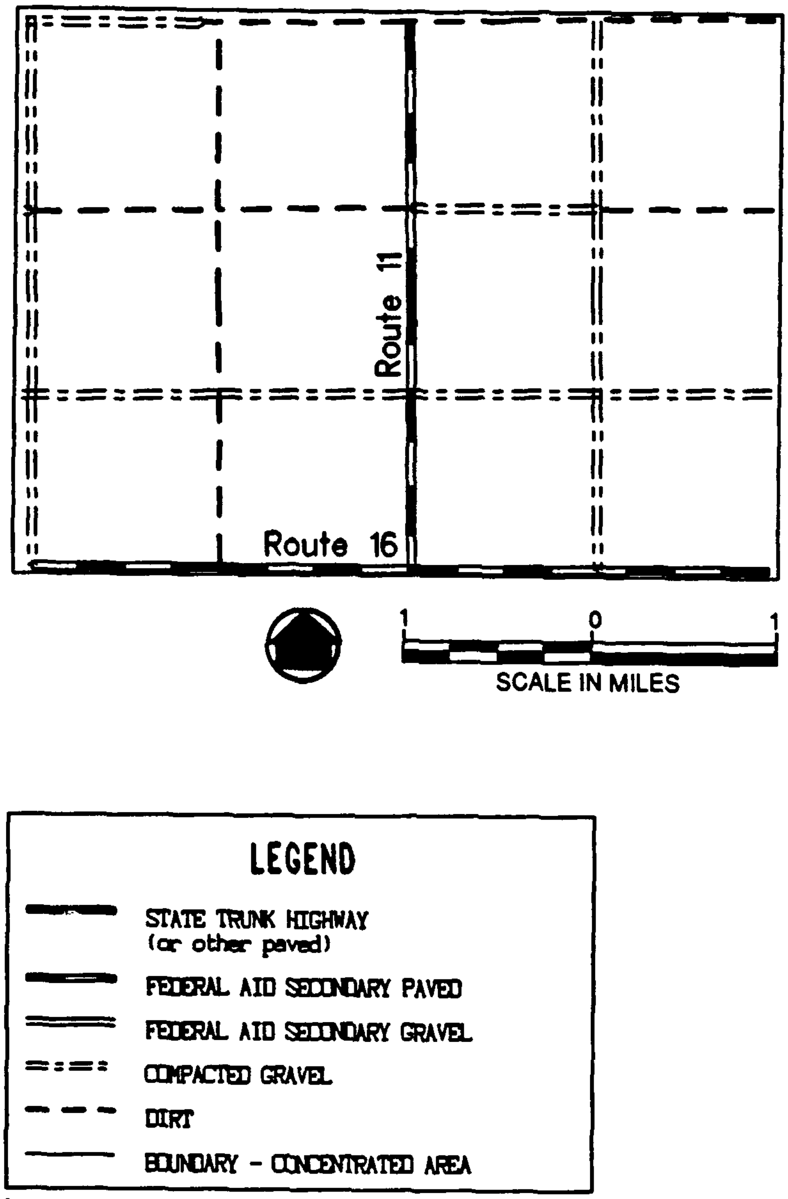


FIGURE 3-4. TX-SOUTH CONCENTRATED STUDY AREA EXISTING ROADS

TABLE 3-3. AMHERST, SD TRANSMIT STUDY AREA EXISTING AVERAGE DAILY TRAFFIC

Roadway Segment	Location of Count	ADT
Route 4/5	Tx-N CSA & county line	54
	west of Route 27, 9 m. east of Tx-N CSA	170-227
	East of Route 37, 6 m. west of Tx-N CSA	238-456
Route 10	Brown/Marshall County Line	735
	West of Route 27	1165
	East of Route 37	350
Route 11	Tx-S CSA	54
	6 m. north of Tx-S CSA	170-227
	South of Route 10 (10 m. north of CSA)	238-456
Route 16	Tx-S CSA, west of Route 11	184-190
	Tx-S CSA, east of Route 11	237-240
	West of Route 27 and Langford	260

Sources: SDDOT, 1984a; SDDOT, 1984b; SDDOT, 1988.

3.4.1.3 Transmit Study Area Projected Traffic. Traffic has not increased significantly in the Amherst, South Dakota study area since the South Dakota Department of Transportation (SDDOT) conducted traffic counts on county roads five years ago (SDDOT, 1989). Generally over the next twenty years, traffic in the study area is not expected to change significantly (SDDOT, 1989).

3.4.2 Receive Study Area. The receive study area is located in northeastern Polk County in Hegeland, Brandt and Belgium Townships and in northwestern Pennington County in Numedal, Bray, Sanders, Norden and Polk Centre Townships (Fig. 3-2). No federal interstates or U.S. highways are located in the study area. U.S. 75 and 59 (both running north-south) lie outside the study area, approximately five miles to the west and five miles to the east, respectively. Route 1, a paved, state trunk highway lies less than two miles north of the Rx-W CSA in Marshall County. It crosses into the study area at the northeastern corner of the Rx-E CSA and continues east through Pennington County (Fig. 3-2). An east-west paved road, Route 21/3 is located in the southern portion of the study area.

3.4.2.1 Rx-East Existing Roadways and Traffic. The Rx-E CSA is located in the northeastern corner of Pennington County in the northeastern part of the Thief River Falls Study area (Fig. 3-2). Two paved roads lie within the Rx-E CSA; state Route 1 passes diagonally through the northeast corner of the CSA and county Route 8 bisects the site from east to west (Fig. 3-5). Route 10 (gravel) passes through the CSA from Route 1 south through Pennington County. Other county and local roads which pass through the Rx-E CSA terminate in or near the CSA, including County Routes 12, 13 and 65 (gravel), 64, 67 and 68 (dirt and gravel). Table 3-2 provides a physical and jurisdictional description of each roadway in the vicinity of the Rx-E CSA. Available ADT counts on roadways in the Rx-E CSA area are in Table 3-4.

3.4.2.2 Rx-West Existing Roadways and Traffic. The Rx-W CSA is located in the northwestern corner of the study area one-half mile west of the Rx-E CSA; thus the major roadway in the vicinity of Rx-W is also Route 1 (described in Section 3.4.4.1) (Fig. 3.2). Route 1 travels east-west approximately two miles north of the Rx-W CSA in Marshall County, before turning southeast and then east to Thief River Falls (Fig. 3-4). Gravel Routes 68, 69 and 23 lie just inside the western and southern boundaries of the CSA (Fig. 3-6). Route 23 turns south, then west from the CSA to intersect U.S. 75 at a distance of approximately five miles from the CSA. Transverse roadways composed of dirt and gravel intersect at the approximate center of the Rx-W CSA; shorter gravel roads extend east from the western portion of Route 69 and north from Route 23 (Fig. 3-6). Several shorter dirt roads terminate in the CSA. Traffic counts for Route 1 and other roadways east of the Rx-W CSA are described above in Section 3.4.4.1; ADT for the other roadways described in this section is presented in Table 3-4.

3.4.2.3 Receive Study Area Projected Traffic. In the vicinity of the receive study area, the Minnesota Department of Transportation has projected an annual growth in ADT of no more than one percent (MNDOT, 1989).

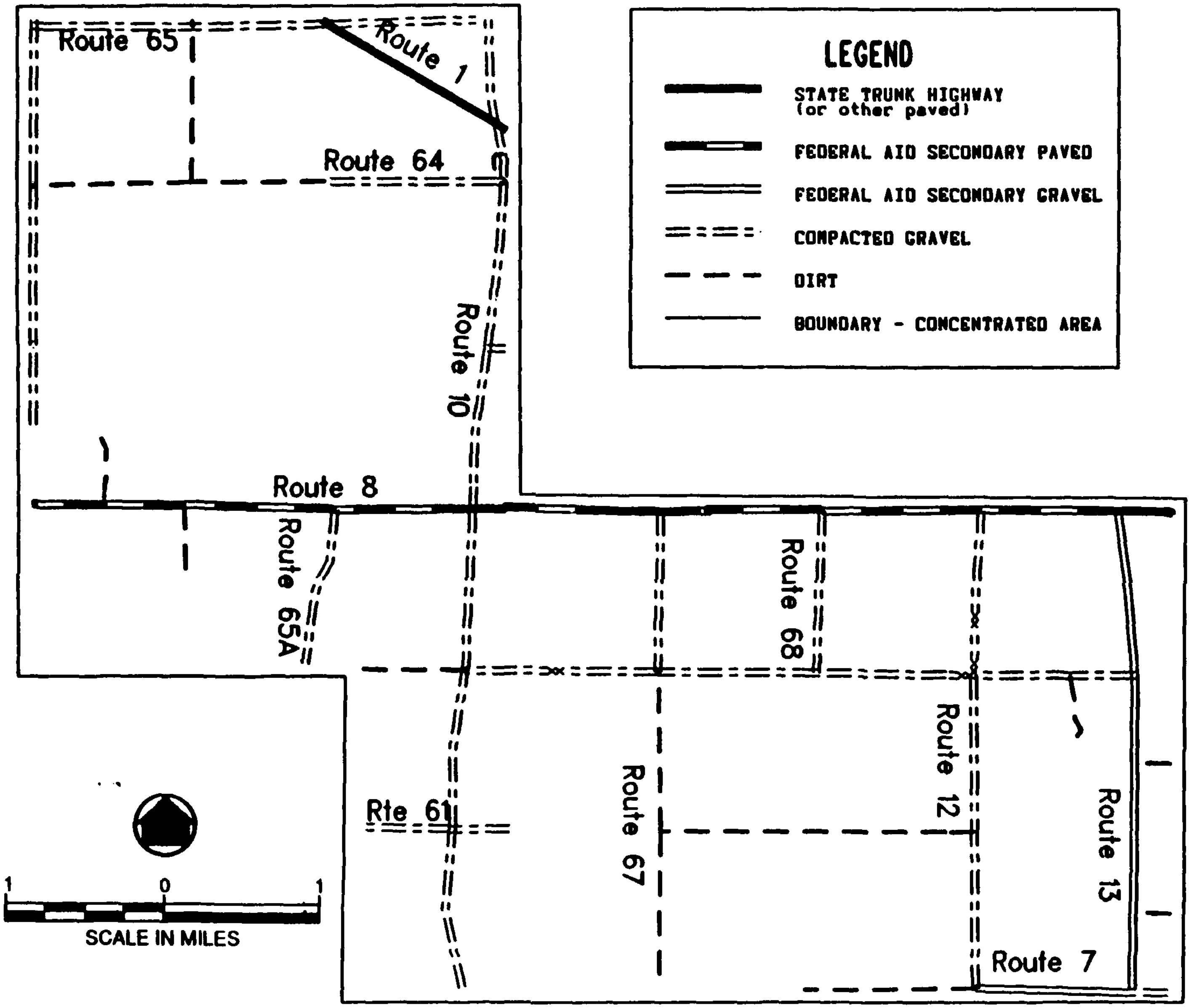


FIGURE 3-5. RX-EAST CONCENTRATED STUDY AREA EXISTING ROADS

TABLE 3-4. THIEF RIVER FALLS, MN RECEIVE STUDY AREA
EXISTING AVERAGE DAILY TRAFFIC

Roadway Segment	Location of Count	ADT
Route 1	Rx-E CSA	630
	North of Rx-E CSA	600
	Directly east of Rx-E CSA	1000
	Thief River Falls	1800
Route 3	Near Route 10 south of the CSA	930
	Near Route 32 (at St. Hilaire)	1460
Route 8	West of Route 10	40-60
	East of Route 10	60-70
	Near Route 1	75
Route 10	Between Route 1 and Route 3	45-65
Route 12	Between Tx-E CSA and Route 3	50-75
Route 13	Between Tx-E CSA and Route 3	45-85
Route 64	East of Rx-E CSA	70
Route 65	Northern border of Rx-E CSA	10-20
Route 67	North and south of Rx-E CSA	5-20
Route 68	North of Rx-E CSA	20-30
Route 69	North of Route 3	5-85
Route 23	East-west segment south of Rx-W CSA	80-90
	Near Route 69	100
	North-south segment	75-90
	Near U.S. 75	150
Route 69	Between Rx-W CSA and U.S. 75	65-70
	North-south segment	105
	Near Route 23	85
Route 68	North of Route 69	70-75
Route 21	7 miles south of Rx-W CSA	800-840
	Near U.S. 75	920

Source: MNDOT, 1985; MNDOT, 1987.

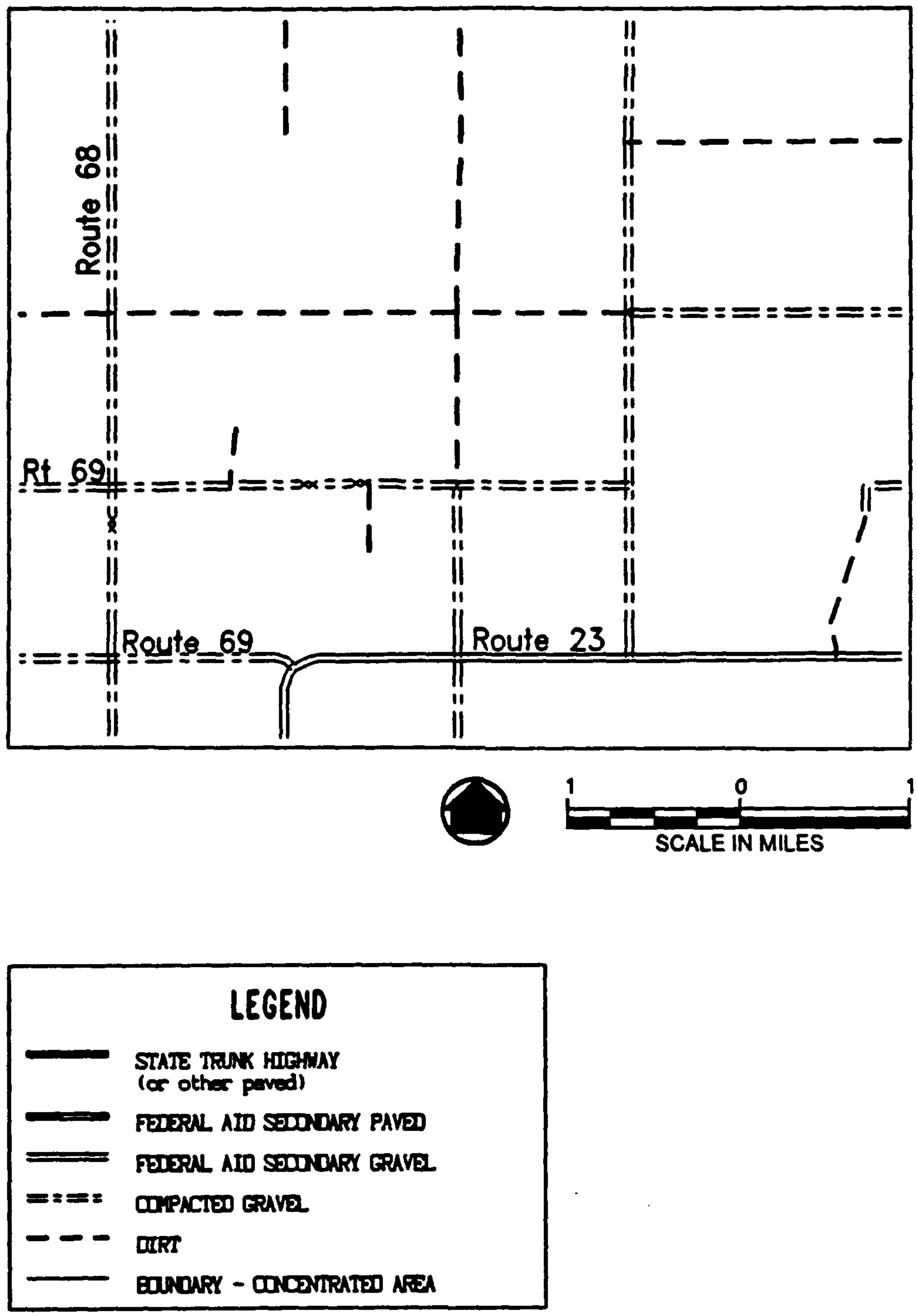


FIGURE 3-6. RX-WEST CONCENTRATED STUDY AREA EXISTING ROADS

3.5 ENVIRONMENTAL CONSEQUENCES

This section evaluates the impacts to transportation routes and traffic that would result from construction and operation of the OTH-B facilities. Program traffic and activities proposed for the implementation of the OTH-B program, such as roadway closures, realignments, and rerouting, may cause impacts such as increased travel distance or time for motorists, detours to less developed roadways and additional traffic on alternative routes. Traffic from construction (materials and personnel) and operation (personnel) of the facilities and from rerouting may affect operating conditions on the roads. The magnitude of impact is dependent upon the level of existing traffic, roadway conditions and the size of the increase. The impact of traffic generated during both construction and operation of the CRS facilities is evaluated below.

Roadway closure impacts are evaluated for the USAF's preliminary site layout, buffer zone and best- and worst-case scenarios in each CSA. The preliminary site layouts are the proposed locations of the CRS facilities, however, the USAF established a buffer zone around each sector in the preliminary site layout in order to provide the system contractor some flexibility during final design of the system. The USAF has committed to not interrupting paved roads in any circumstances. Therefore, there are no paved roads within the preliminary site layouts. Paved roads which fall in the buffer zones will also not be interrupted. For transportation and traffic purposes, the best-case scenario is that which closes the smallest portion of paved and gravel roadways (as measured in miles); the worst-case scenario affects the largest portion of paved and gravel roadways. Traffic impacts are evaluated at the CSA level.

3.5.1 Methods of Analyses

Roadway closure and realignment impacts for each alternative are evaluated by identifying the closures or realignments and the change in distance and roadway surface (as classified in Section 3.3) that must be travelled. Such impacts are classified as either regional (affecting travel between regional centers or between one or more localities and a regional center) or local (affecting travel between localities).

In order to evaluate traffic operations, Level of Service (LOS) analyses were performed on segments of the paved roadways that would likely be used for access to each CSA. LOS for two-lane highway segments is defined according to percent time delay. Percent time delay is defined as the average percent of time that all vehicles are delayed while travelling in "platoons" due to the inability to pass (i.e., travelling behind a lead car at speeds less than desired). Table 3-5 summarizes the LOS criteria for two-lane, level-terrain highway segments. In addition, the quality of traffic operations along a roadway segment is defined by LOS analysis, which measures "driver comfort" in terms of the stability of traffic flow, delays and maneuverability (Table 3-5). The LOS of each highway segment is defined in terms of LOS A through LOS F, where A represents the highest quality operations with free flow, no delays, and good maneuverability. LOS F represents the lowest quality operations with forced flow, long delays and/or sporadic movement and little maneuverability. Generally, LOS C (stable flow; maneuverability and speed beginning to be restricted) or better is considered acceptable. Although in some urban situations, LOS D may be acceptable, it would not be considered acceptable in the rural areas evaluated here. The upper limit of LOS E is defined as the capacity of a particular segment.

Operational analyses were performed on roadway segments at each location evaluated using the most recent available existing traffic volumes; the short-term, maximum, construction-period volumes; and the average, construction-period volumes. Intersection analyses was not performed because turning movement data was not available. Also, no analyses were performed on dirt or gravel roads because the calculations are not appropriate. Any impacts described below for paved roads would be at lease equalled on gravel roads. Traffic during operation of the CRS is expected to be so minimal (25 vehicles or 50 trips per day) as to preclude use of LOS analysis. All analyses are based on existing geometric conditions with no roadway changes, using the 1985 Highway Capacity Manual software developed by the Federal Highway Administration.

TABLE 3-5. LEVEL OF SERVICE DESIGNATIONS FOR LEVEL, TWO-LANE HIGHWAYS

Category/Description	Percent Time Delay	Volume to Capacity Ration (V/C)
LOS A: Describes a condition of free flow, with low volumes and relatively high speeds. There is little or no reduction in maneuverbility due to the presence of other vehicles, and drivers can maintain their desired speeds. Little or no delays result for side street motorists.	≤ 30	.15
LOS B: Describes a condition of stable flow, with desired operating speeds relatively unaffected, but with a slight deterioration of maneuverability within the traffic stream. Side street motorists experience short delays.	≤ 45	.27
LOS C: Describes a condition still representing stable flow, but speeds and maneuverability begin to be restricted. The general level of comfort begins to deteriorate noticeably at this level. Motorists entering from side streets experience average delays.	≤ 60	.43
LOS D: Describes a high-density traffic condition approaching unstable flow. Speeds and maneuverability become more seriously restricted, and the driver experiences a poor level of comfort. Side street motorists may experience long delays.	≤ 75	.64
LOS E: Represents conditions at or near the capacity of the intersection. Flow is usually unstable, and freedom to maneuver within the traffic stream becomes extremely difficult. Very long delays may result for side street motorists.	> 75	1.0
LOS F: Describes forced flow or breakdown conditions with queuing along critical approaches. Operating conditions are highly unstable as characterized by erratic vehicle movements along each approach.	100	--

Source: Highway Capacity Manual, 1985

Because the only available traffic information was daily (ADT), rather than hourly traffic, it was assumed that ten percent of the ADT occurred during the peak CRS traffic hour, the hour during which CRS construction personnel will be travelling to the site. In addition, a ten-hour work day is assumed for CRS truck traffic which overlaps the peak hour. Finally, it is assumed that CRS truck traffic is evenly spaced over the work day. Thus the peak hour traffic includes ten percent of existing ADT, all CRS construction commuters and one-tenth of CRS daily truck traffic.

3.5.2 General Assumptions

The following assumptions were made regarding alternative transportation routes and traffic generated by the CRS. Assumptions regarding the number of program-generated vehicles present a worst-case scenario.

- Where roads are interrupted and it is necessary to use an alternative route, motorists will seek the alternative route with an equal or better surface, provided the additional distance is not excessive. If such an alternative is not available, the motorist will seek the route with the best available surface, if the additional distance is not excessive. If no equal or better surfaced alternative route is available, the motorist will use the shortest alterative route, including the USAF's 10-foot wide dirt perimeter roads.

- During the peak period of the construction phase (Table 3-6) the total number of construction personnel working at the site will be approximately 200, including security personnel. During the construction phase at times wher. ɔrk is not occurring (e.g. when it is too cold to work), only security personnel will be present.

- Up to 25 personnel will be required at each antenna site during operation of the CRS; a maximum of three of those would be military personnel, with the remainder civilian. More than one-half of the total personnel would be assigned to operations and maintenance, with the remainder assigned to site security (USAF, 1989).

- During the peak construction period, (Table 3-6) a maximum of 100 trucks will each make a maximum of 15 trips per day to the site for a maximum total of 1,500 round trips daily, adding a maximum of 3,000 ADT or one-way trips to traffic on the roads used for access to the CSA. This number includes transport of all anticipated borrow requirements, however, a portion of the borrow may be taken from within the CSA, substantially reducing this number. On

TABLE 3-6. TYPICAL OTH-B CONSTRUCTION SCHEDULE

Construction Activity	CONSTRUCTION MONTH 0 1 2	3 4	5 6	7 8	9 10	11 12	13 14	15 16	17 18	19 20
Site Preparation	xxxxxxxx	xxxxxx	xxxxxx	xxxxxx	xxxxxx					
Access Road		xxxxx	xxxxxx	xx						
Antenna/Building Foundation			xxxxxx	xxxxxx	xx					
Metal Building Erection			xx	xxxxxx	xxxxxx					
Equipment Installation					xx	xxxxxx	xxxxxx	xxxxxx	xx	
Antenna Erection						xxxxxx	xxxxxx	xx		
Antenna Lighting						xx	xxxxxx			
Ground Screen Installation								xx	xxxxxx	xx

Peak Constr-uction

Source: USAF, 1989.

average, however, no more than 30 trucks per day will make 15 trips each to the site adding 450 round trips (or 900 ADT) to existing traffic.

- Each worker (construction or operation) will drive his or her own vehicle to the construction site each day. In addition, some traffic will be generated by the families of workers who relocate to the area; however, these vehicle trips will be so dispersed (by the location of their residences and the purpose of their trips) that traffic generation from such is not measurable.

- Some steel antenna components will be assembled offsite, substantially limiting the duration and number of vehicle trips associated with delivery of the components.

Assumptions regarding workers' place of residence are made in the sections below for each CSA.

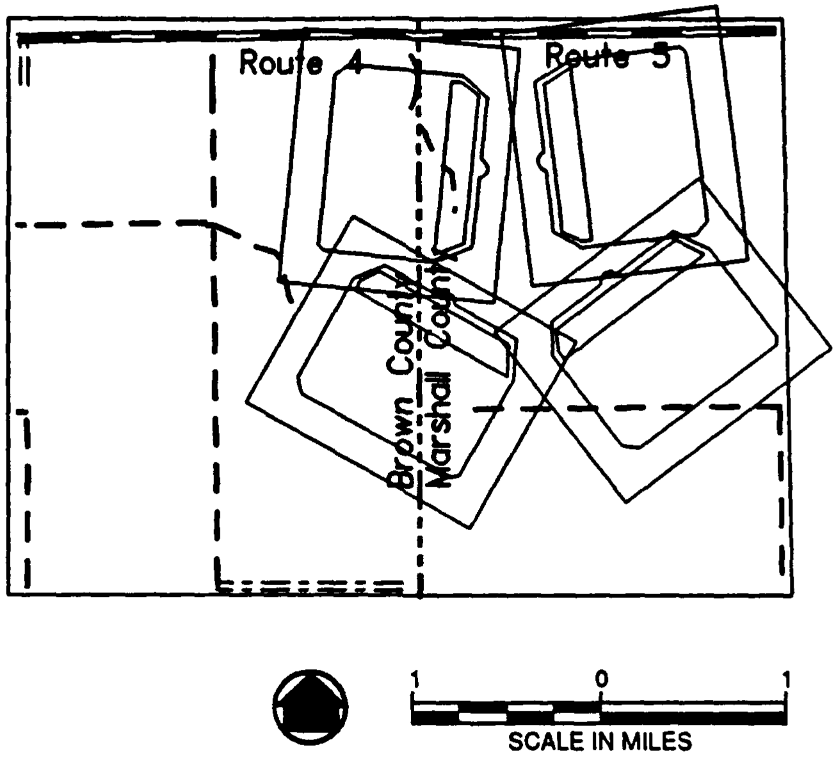
3.5.3 Transmit Study Area (Tx) - Amherst, South Dakota

3.5.3.1 Tx-North. The preliminary site layout and buffer in the Tx-N CSA are shown in Fig. 3-7.

3.5.3.1.1 Road Closings and Realignments. No motorists would be inconvenienced by the preliminary site layout or by the best-case scenario (Table 3-7). The preliminary site layout would close parts of each of the dirt roads that access the CSA from the north, east, and west, all of which terminate in the CSA; the best-case scenario has similar effects (Fig. 3-7). Segments of Route 4, Route 5, and each of the dirt roads that terminate in the CSA lie within the buffer. Interruption of any of the dirt roads would not affect transportation in the area. Routes 4 and 5, although they are in the buffer zone, would not be affected because the USAF will not alter paved roads. The worst-case scenario interrupts Route 4/5 and would require local motorists to travel approximately 0.3 miles on the USAF's dirt perimeter road rather than 0.2 miles on a paved road. This could affect local transportation between the northern parts of Brown and Marshall counties, particularly between the towns of Hecla and Kidder.

TABLE 3-7. TX-NORTH ROADWAY CLOSURES, REALIGNMENTS AND REROUTING

Roadway Description and Location	Closure/Impacts	Alternative Route
Preliminary Site Layout		
Dirt roads from north, east and west which terminate in the CSA	Closed/no impact	
Buffer Zone		
Dirt roads from north, east and west which terminate in the CSA	Closed/no impact	
Route 4/5	Will not be closed/ no impact	
Best-Case Scenario		
Dirt roads from north and east, which terminate in CSA	Closed/no impact	
Worst-Case Scenario		
Route 4/5	0.1 m. closed each in 2 locations/local impact, between Hecla and Kidder	0.3 m. total on USAF dirt perimeter road
Dirt roads from north, east and west which terminate in CSA	Closed/no impact	
North-south dirt transverse	0.2 closed/no impact	Paved road 3 m. east



LEGEND

- STATE TRUNK HIGHWAY (or other paved)
- FEDERAL AID SECONDARY PAVED
- FEDERAL AID SECONDARY GRAVEL
- COMPACTED GRAVEL
- DIRT
- BOUNDARY - CONCENTRATED AREA

FIGURE 3-7. TX-NORTH CONCENTRATED STUDY AREA PRELIMINARY SITE LAYOUT

3.5.3.1.2 Traffic Impacts. There are two sources of traffic generation associated with construction of the CRS facilities, materials deliveries (trucks) and commuting personnel (automobiles and other small vehicles). During the peak construction period, a maximum of 200 construction personnel would travel to the site each day, adding a maximum of 400 trips per day (or ADT). During this period, delivery trucks would add a maximum of 1,500 round trips or 3,000 ADT (one way trips) to local traffic (Table 3-7). Peak construction traffic would total 1,700 round trips, which is equal to 3,400 ADT or 340 vehicles epr hour (VPH). During most of the construction period, the average number of delivery round trips will be 450 per day (one way trips totalling 900), or 90 one-way trips per hour.

Several assumptions have been made in order to estimate local traffic distribution. Aberdeen, the closest large community (population 25,670; U.S. Census, 1986) is located approximately 60 miles from the Tx-N CSA. Due to this distance, it is likely that many of the construction and operations personnel will reside in the small communities near the CSA, with a small portion traveling from as far as Aberdeen. At a distance of 17 miles from the CSA, Britton (population 1,465; U.S. Census, 1986) is the largest community within 40 miles and is likely to house a larger portion of personnel than other communities. It is likely that project traffic will access the CSA via Route 4/5 and that the paved roads east and west of the CSA and Route 10 will carry project traffic as well (Fig. 3-7). It is not expected, however, that personnel will travel from any one direction in numbers that would create a measurable traffic impact.

It is anticipated that construction traffic totalling no more than 1,700 round trips or 3,400 ADT would access the site from either U.S. 281 to Route 10 east or from Interstate 29 to Route 10 west, to the roads that parallel the eastern and western boundaries of the CSA and then to Route 4/5. The existing service level on Route 4/5, the primary access to Tx-N is LOS A, which is freeflowing (Table 3-5). The addition of CRS maximum, peak period construction traffic is a minor impact; it reduces the peak hour service level to LOS C, at which speed and maneuverability begin to be restricted, although the flow of traffic remains stable. The transport of slow-moving farm vehicles from one field to another may be inhibited during the ten-hour trucking operation period each day, by the speed and frequency of the truck traffic. Each of these is a minor, short-term impact, as they occur only during the peak construction period. Because the construction traffic would consist primarily of heavy trucks, the condition of the roadway surface on which the trucks travel may deteriorate on Route 10, Route 4/5, and the paved roads which connect them on either side of the Tx-N CSA. Depending on the existing quality of the surfaces, this could be a minor to moderate impact.

Average construction traffic, which will occur during the majority of the construction period, does not generate a change in the LOS, although roadway surface and farm equipment impacts may occur to a lesser degree than during the peak period (Table 3-8). CRS-related traffic during the operations period, which is equal to approximately three percent of the average construction traffic, is negligible (25 vehicles per day or 50 ADT).

3.5.3.2 Tx-South. The roads, preliminary site layout and buffer in the Tx-S CSA are shown in Fig. 3-8.

3.5.3.2.1 Road Closings and Realignments. Local and regional travel would not be affected by the preliminary site layout in the Tx-S CSA or by the best-case scenario, because similar or better-surfaced roads parallel each interrupted roadway within a few miles (Table 3-8). The USAF's preliminary site layout would interrupt approximately 0.75 miles of the dirt road paralleling Route 11 to the west and 0.75 miles of the gravel road paralleling it to the east (Fig. 3-8). The gravel road just north of Route 16 would be interrupted by the layout twice for approximately 0.3 miles in each case. Also interrupted would be the central two miles of the east-west dirt and gravel road that transverses the CSA. The best-case scenario would have similar impacts on the east-west roads (Table 3-8).

One or more segments of each of the interior roadways and Route 16 lie within the CRS buffer in the Tx-S CSA (Fig. 3-8). Two segments of Route 16 (0.6 miles each) and two segments of Route 11 (0.5 and 0.9 miles) are located in the buffer. Due to the USAF's commitments, however, Routes 11 and 16 would

TABLE 3-8. AMHERST, SD TRANSMIT STUDY AREA CONSTRUCTION TRAFFIC AND LEVEL OF SERVICE

	Existing Traffic		W/Max. Constr. Traffic		W/Av. Constr. Traffic	
Road/Location	VPH	LOS	VPH	LOS	VPH	LOS
Tx-N						
Route 4/5 at Tx-N	6	A	345	C	96	A
Route 10 at Brown/Marshall County Line	74	A	414	C	163	A
Tx-S						
Route 11 at Tx-S	10	A	350	C	100	A
Route 16 at Tx-S	24	A	364	C	114	A

Sources: SDDOT, 1984a; SDDOT, 1984b; and SDDOT, 1986.
VPH = Vehicles per hour
LOS = Level of Service

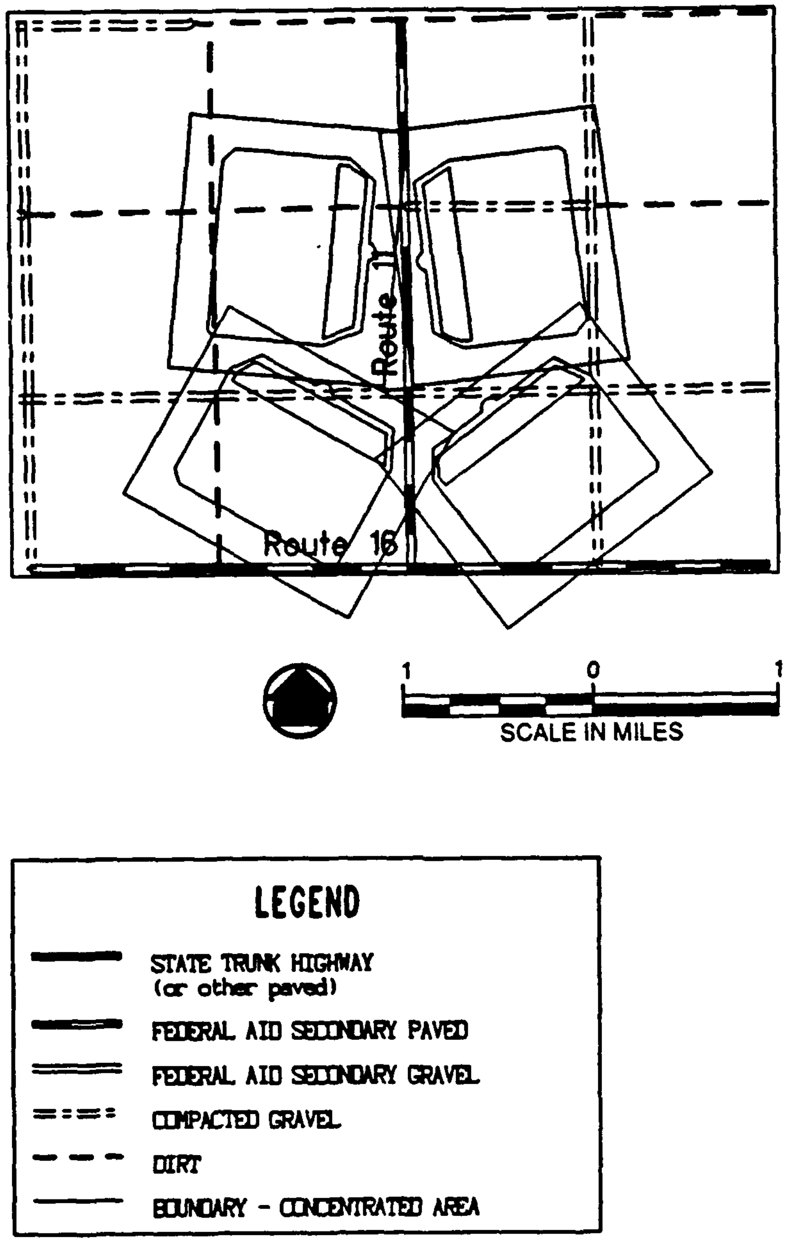


FIGURE 3-8. TX-SOUTH CONCENTRATED STUDY AREA PRELIMINARY SITE LAYOUT

not be interrupted by the CRS facilities even though they lie within the buffer zones. Approximately 2.5 miles of each of the north-south transverses and 2.25 miles of the dirt east-west transverse lie in the buffer. Two segments of the gravel east-west transverse (0.9 miles each) are also situated within the buffer. Interruption of the dirt or gravel roads located in the buffer could occur if the facilities were shifted within the buffer area. Impacts to these roads can be mitigated as described above for the preliminary site layout, by use of nearby roads with equal or better surfaces.

The worst-case scenario would have the same effects as the preliminary site layout; it would also interrupt Routes 11 and 16, requiring that seven of the thirteen miles between Amherst and Langford be travelled on gravel rather than paved roads (Table 3-9). The relatively heavy use of these roads indicates that this closure would result in a significant level of impact to the local population, if not mitigated. No regional impacts would occur since Route 11 is paralleled by paved roads five miles west and two miles east (Route 27), and Route 16 is paralleled seven miles to the south and ten miles to the north (Route 10).

3.5.3.2.2 Traffic Impacts. The number of personnel and delivery vehicles would be the same for Tx-S as for Tx-N (Section 3.5.3.1.2 and Table 3-8). It is likely that a large portion of the construction and operations personnel would reside in Aberdeen and its environs because the Tx-S CSA is approximately 35 miles from Aberdeen, which is 25 miles closer to Aberdeen than the Tx-N CSA. Routes 11 and 16 are expected to provide access to and into the CSA. With personnel distributed among Aberdeen and the small communities immediately around the CSA, no measurable traffic generation is expected beyond Routes 11 and 16. It is anticipated that construction-related trucks and equipment would travel to the site via Routes 16 and 11, as well. Table 3-8 illustrates the worst-case construction traffic scenario for truck traffic on Routes 11 and 16 (all trucks on each road). The impacts on Routes 11 and 16 would be the same as described for the roads at the Tx-N CSA in Section 3.5.3.1.2 (Table 3-8).

TABLE 3-9. TX-SOUTH CSA ROADWAY CLOSURES, REALIGNMENTS AND REROUTING

Roadway Description and Location	Closure/Impacts	Alternative Route
<u>Preliminary Site Layout</u>		
Dirt Road parallel to and 1 m. west of Route 11	0.75 m. closed/no impact	Route 11
Gravel Road parallel to and 1 m. east of Route 11	0.75 m. closed/no impact	Route 11
Gravel east-west transverse 1 m. north of Route 16	2 - 0.6 m. segments closed/no impact	Route 16
Dirt/gravel east-west transfer 2 m. north of Route 16	2 m. closed/no impact	Route 16
<u>Buffer Zone</u>		
Paved Route 11 and Route 16	Will not be closed/no impact	
Dirt road parallel to and 1 m. west of Route 11	2.5 m. closed/no impact	Route 11
Gravel road parallel to and 1 m. east of Route 11	2.5 m. closed/no impact	Route 11
Gravel east-west transverse 1 m. north of Route 16	2-1 m. segments closed/no impact	Route 16
Dirt/gravel east-west transverse 2 m. north of Route 16	2.5 miles closed/no impact	Route 16

TABLE 3-9 (Continued). TX-SOUTH CSA ROADWAY CLOSURES, REALIGNMENTS AND REROUTING

Roadway Description and Location	Closure/Impacts	Alternative Route
<u>Best-Case Scenario</u>		
Gravel east-west transverse 1 m. north of Route 16	2 m. closed/no impact	Route 16
Dirt/gravel east-west transverse 2 m. north of Route 16	2.25 m. closed/no impact	Route 16
<u>Worst-Case Scenario</u>		
Route 11 and Route 16 (paved)	1.5 m. closed/local impact only	7 m. on gravel between Langford and Amherst
Dirt Road parallel to and 1 m. west of Route 11	0.75 m. closed/no impact	Route 11
Gravel Road parallel to and 1 m. east of Route 11	0.75 m. closed/no impact	Route 11
Gravel east-west transverse 1 m. north of Route 16	2 - 0.6 m. segments closed/no impact	Route 16
Dirt/gravel east-west transfer 2 m. north of Route 16	2 m. closed/no impact	Route 16

3.5.4 Receive Sites (Rx) - Thief River Falls, Minnesota

3.5.4.1 Rx-East. Roadways on and abutting the Rx-E CSA, the preliminary site layout and the buffer are shown in Fig. 3-9. Route 65A, in the western portion of the site is a historic trail (Fig. 3-9).

3.5.4.1.1 Road Closings and Realignments. There are no major roadway interruptions in the Rx-E CSA due to the USAF's preliminary site layout or the best-case scenario (Fig. 3-9 and Table 3-10). The USAF's layout interrupts a small portion of Pennington County 64, a dirt and gravel road one mile south and parallel to the state trunk highway, Route 1 (Table 3-10). The southwest sector buffer zone crosses Route 8 but since it is paved, it will not be affected.

The best-case scenario does not interrupt any roads in the CSA. Two segments of Route 64 (of 0.5 miles and 1 mile) and one each of Route 8 (0.3 miles) and the gravel road just inside the western boundary of the CSA (0.2 miles) lie within the designated buffer. Route 64 lies less than one mile south of the state trunk highway, Route 1 and Route 8 parallels Route 1 and joins it just east of the CSA. Thus Route 1, the primary east-west road in the area, is an alternative of better or equal surface to both of these roads. The worst-case scenario interrupts a number of minor gravel roads, Route 10 and most importantly, the state trunk road, Route 1. Route 1 is the major east-west route through northern Marshall and Pennington Counties and Route 10 is the secondary route; thus local and minor regional impacts, particularly access to Thief River Falls from the west, occur as a result of the worst-case combined closure.

3.5.4.1.2 Traffic Impacts. The maximum number of personnel at the Rx-E CSA during the operating and peak construction periods would be the same as described in Section 3.5.3.1.2 (25 and 200, respectively), generating 50 and 400 ADT, respectively. The maximum daily number of truck round trips would be 1,500, or 3,000 ADT (one way trips). Thus, the peak construction period daily traffic generated by the CRS program would be 3,400 trips, or 340 trips per hour (Table 3-11). The average number of truck trips during construction would be 450 per day or 90 per hour.

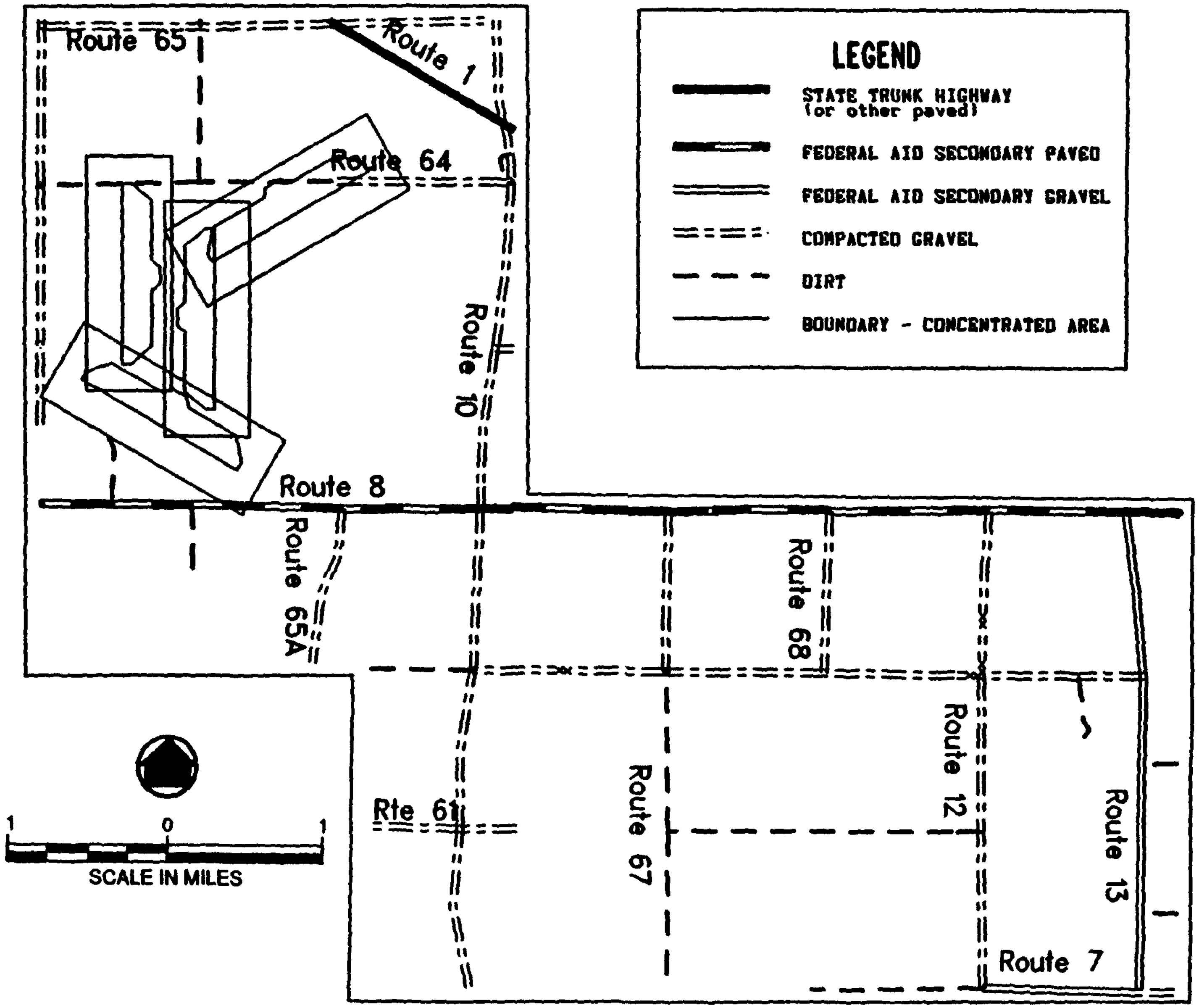


FIGURE 3-9. RX-EAST CONCENTRATED STUDY AREA PRELIMINARY SITE LAYOUT

TABLE 3-10. RX-EAST CSA ROADWAY CLOSURES, REALIGNMENTS AND REROUTING

Roadway Description and Location	Closure/Impacts	Alternative Route
Preliminary Site Layout		
Route 64 (dirt and gravel)	0.3 m. and 0.1 m. segments closed/no impact	paved Route 1, 1 m. north
Buffer Zone		
Route 64 (dirt and gravel)	0.5 m. and 0.75 m. segments closed/no impact	Route 1, 1 m. north
Route 8 (paved)	Will not be closed/no impact	Route 1, approximately 3 m. north.
Best-Case Scenario		
No closures		
Worst-Case Scenario		
State trunk highway Route 1 and Route 10	0.5 m. of each closed/local and some regional impacts from west to Thief River Falls	U.S. highways approximately 45 m. to north and south
Routes 12, 13, 68 (gravel)	0.25 m. of each closed/no impact	paved trunk Route 32, 7 m. east
Route 64 (dirt and gravel)	0.3 m. closed/no impact	Route 1, 1 m. north

TABLE 3-11. THIEF RIVER FALLS, MINNESOTA STUDY AREA CONSTRUCTION TRAFFIC AND LEVEL OF SERVICE

Road/Location	Existing Traffic		W/Max. Constr. Traffic		W/Av. Constr. Traffic	
	VPH	LOS	VPH	LOS	VPH	LOS
Rx-E and Rx-W						
Route 8 in Rx-E	63	A	403	C	153	A
Route 1 east of Rx-E	100	A	440	C	190	A
Route 10 in Rx-E						
Rx-W						
Route 23 at Rx-W	100	*	440	*	290	*
Route 68 at Rx-W	75	*	415	*	165	*
Route 69 at Rx-W	105	*	445	*	195	*

Sources: MHDOT, 1987 and MNDOT, 1985.
*LOS analysis cannot be performed on dirt or gravel roads.
VPH = Vehicles per Hour.
LOS - Level of Service.

In order to estimate local traffic distribution, the following assumptions have been made regarding the place of residence of CRS construction and operations personnel. Thief River Falls (population 9,105; U.S. Census, 1986), less than 15 miles from the Rx-E CSA and the only sizeable community within approximately 50 miles, would likely house a substantial portion of the construction and operations personnel. Some workers however, particularly those already residing there, may come from the small communities surrounding the CSA and from Crookston, Minnesota and Grand Forks, North Dakota, which are approximately 30 and 35 miles from the CSA, respectively. Because these communities lie to the southwest of the Rx-E CSA and Thief River Falls and its environs lie to the east, is not expected that the number of personnel traveling from any one direction would generate a significant traffic impact beyond the immediate area of the Rx-E CSA. It is expected that delivery trucks would travel to the site via the state and federal highways in these communities and access the site via Route 1 to Route 8 or to Route 10, depending upon the final facility location and the origin of the traffic. The peak and average construction period impacts would be the same as described for the Tx-N CSA in Section 3.5.3.1.2, with no impacts resulting from operation of the CRS (Table 3-11). In addition, because gravel roads would be used to reach the construction site (Routes 10 and 64), the generation of dust by 300 trucks per hour in the maximum construction period is a minor impact as well.

3.5.4.2 Rx-West. Roadways in the Rx-W CSA and the preliminary site layout and buffer are shown in Fig. 3-10.

3.5.4.2.1 Road Closings and Realignments. There would be no local or regional impacts resulting from siting the CRS facilities at the preliminary site layout location, the best- or worst-case scenario site or anywhere in the buffer because parallel roads of equal or better surfaces lie within approximately five miles of each potentially-interrupted roadway (Table 3-12 and Fig. 3-10). The preliminary site layout interrupts Route 68, the north-south bisector and the roadway two miles north of Route 23/69; larger segments of the same roads fall within the designated buffer (Table 3-12).

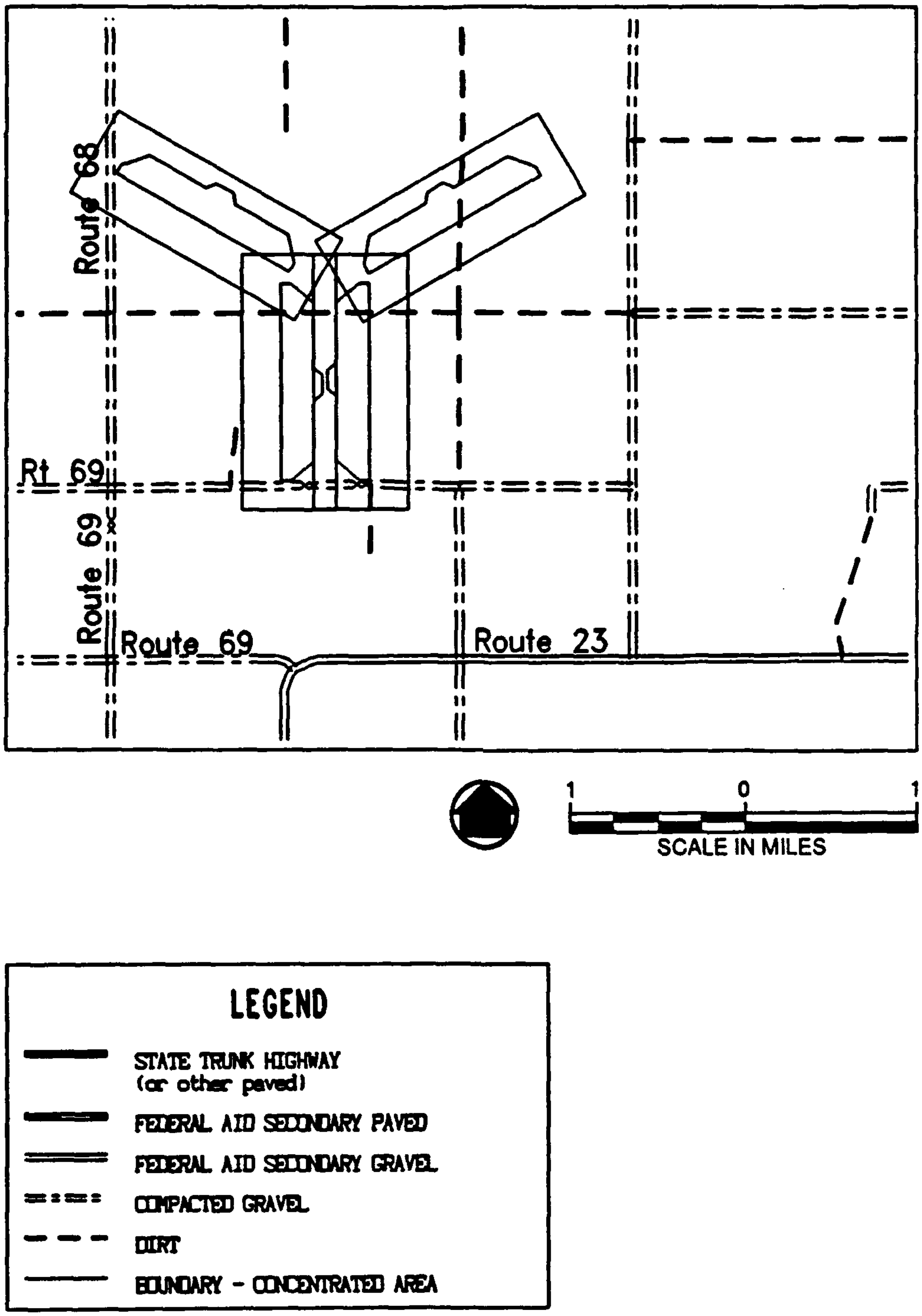


FIGURE 3-10. RX-WEST CONCENTRATED STUDY AREA PRELIMINARY SITE LAYOUT

TABLE 3-12. RX-WEST CSA ROADWAY CLOSURES, REALIGNMENTS AND REROUTING

Roadway Description and Location	Closure/Impacts	Alternative Route
Preliminary Site Layout		
North-south dirt and gravel bisector	0.25 m. closed/no impact	gravel roads 2 m. west and 1 m. east
East-west dirt and gravel transverse	2 - 0.25 m. segments closed/no impact	Route 1, 4 m. north
Gravel Road east of Route 69	2 - 0.1 m. segments closed/no impact	Route 1, 5 m. north
Buffer Zone		
North-south dirt and gravel bisector	0.75 m. closed/no impact	gravel roads 2 m. west and 1 m. east; U.S. 75, 8 m. west
East-west dirt and gravel transverse	1 m. closed/no impact	Route 1, 2 m. north
Gravel road east of Route 69	1 m. closed/no impact	Route 1, 3 m. north
Route 68 (gravel)	0.75 m. closed/ no impact	gravel roads 2 m. west and U.S. 75, 6 m. west
Best-Case Scenario		
East-west dirt and gravel transverse	0.5 m./no impact	gravel road 2 m. south

TABLE 3-12 (Continued). RX-WEST CSA ROADWAY CLOSURES, REALIGNMENTS AND REROUTING

Roadway Description and Location	Closure/Impacts	Alternative Route
<u>Worst-Case Scenario</u>		
Route 23 (gravel)	0.3 m. closed/no impact	Route 1 (paved)
Route 68 (gravel)	0.25 m. closed/no impact	gravel road 2 m. west
Route 69 (gravel)	0.25 m. closed/no impact	gravel road 2 m. south

3.5.4.2.2 Traffic Impacts. Rx-W is one-half mile west of the northern portion of Rx-E; therefore it is anticipated that construction and operations personnel would commute to the site from the same dispersed locations, generating no significant increase in traffic (Section 3.5.4.1.2). Both vehicles and trucks are expected to reach the site primarily via Route 1, using either Route 68 or Route 10 to Route 8/23 to enter the CSA, depending upon the direction of origin. Impacts on these roads during the peak construction period would be the same as described in Section 3.5.3.1.2 (Table 3-11). As at the Rx-E CSA, dust generation would result from traffic on dirt Routes 68, 10, and 23.

In summary, no significant traffic impacts would be created by construction and operation of the CRS facilities at the preliminary site layouts in the Rx-E and Rx-W CSAs. The preliminary site layout at the Rx-E CSA causes no local or regional transportation inconveniences. The layout would interrupt only Route 64, a dirt road parallel to and between two paved roads (Fig. 3-9). Thus the town paved roads, Route 1 (one mile to the north) and Route 8 (two miles to the south) and the USAF perimeter roads provide better-surfaced alternatives to Route 64. In the Rx-W CSA, several dirt and gravel roads would be interrupted by the preliminary site layout, but each interruption can be accommodated by use of either the USAF perimeter roads or one of two parallel roads with equal or better surfaces. The east-west roadways are paralleled by Route 1, (1.5 miles north of the CSA) and by Route 23/69 in the southern part of the CSA; the north-south roads are paralleled by a gravel road and U.S. 75 two and six miles to the west of the CSA, respectively and by Route 10 three miles east of the CSA.

3.5.5 Mitigation

As a result of the (1) alternatives available for re-routing traffic (either on USAF perimeter roads or re-aligned existing roads) and (2) alternative routes which can be used to bypass the USAF facility, no additional mitigation for roadway closure impacts is considered necessary.

A potentially significant minor to moderate impact at each CSA includes roadway surface deterioration during the entire construction period. The frequency and speed of the CRS-related construction traffic may also inhibit the movement of slow-moving farm vehicles during this period. In addition, during the short duration of the peak construction period, on roadways leading to the CSAs major access the level of service would deteriorate from LOS A (freeflow) to LOS C (stable with restricted speed and maneuverability); this minor impact is short-term and would not occur during the remainder of the construction period. In the Thief River Falls, Minnesota receive study area, the use of dirt roads within the CSAs may generate substantial dust during the construction period. No transportation impacts are expected to result from the operation of the CRS.

All of these impacts can be mitigated by a reduction in the CRS-related construction truck traffic. The peak and average construction traffic scenarios examined here are the worst-cases, in which all borrow is supplied from off-site; the majority of the truck traffic is associated with the transport of borrow. Thus, off-site traffic could be substantially reduced by the use of on-site borrow where it is available. It may be possible to mitigate all impacts to insignificance by such action. Where such mitigation is not possible, other mitigation measures that could be implemented include: 1) wetting or other dust reduction methods on the gravel and dirt roads; 2) contributions to roadway maintenance by the systems contractor; and 3) education of CRS truck drivers to alert them to the presence of and difficulty in moving farm vehicles.

REFERENCES

Highway Capacity Manual, 1985. Highway Capacity Manual Special Report 209. National Research Council, Transportation Research Board, Washington, DC.

MNDOT, 1985. 1985 Traffic Map, Polk County, Minnesota. Minnesota Department of Transportation, Technical Services Division in cooperation with the U.S. Department of Transportation, Federal Highway Administration.

MNDOT, 1987. General Highway Map, Pennington County, Minnesota. Minnesota Department of Transportation, Technical Services Division in cooperation with the U.S. Department of Transportation, Federal Highway Administration.

MNDOT Rules, No Date. Minnesota Department of Transportation Rules and Regulations. Rule Hwy-36, Rules and Regulations Establishing Design Specifications for Driveways Along the Trunk Highway System of Minnesota.

MNDOT, 1989. Letter from M. Cepress (State Forecast Traffic Engineer) to B. Shreve-Gibb, (Metcalf & Eddy/Holmes & Narver, Inc.). August 16.

Pennington County, 1989. Personal Communication. T. Kozojed (Pennington County Engineer). July 11.

Polk County, 1989. Personal Communication. M. Reardon, (Polk County Engineer). July 17.

SDDOT, 1984b. 1984 A.D.T. General Highway Map, (North Half) Brown County, South Dakota. South Dakota Department of Transportation in cooperation with the U.S. Department of Transportation.

SDDOT, 1984b. 1984 A.D.T. General Highway Map, Marshall County, South Dakota. South Dakota Department of Transportation in cooperation with the U.S. Department of Transportation.

SDDOT, 1988. 1988 South Dakota Traffic Flow Map. South Dakota Department of Transportation, Division of Planning in cooperation with the U.S. Department of Transportation, Federal Highway Administration.

SDDOT, 1989. Personal Communication. E. Putzier Division of Planning.

United States Air Force (USAF), 1988. Record of Decision for the Proposed Central Radar System.

USAF, 1989. Letter from Major R. Goodner (USAF) to J. Manitakos, Jr. (SRI International). December 7.

U.S. Census, 1986. 1986 Population and 1985 Per Capita Income Estimates for Counties and Incorporated Places. U.S. Department of Commerce, Bureau of the Census.

APPENDIX A
LEVEL OF SERVICE ANALYSIS

1985 HCM:TWO-LANE HIGHWAYS
****

FACILITY LOCATION.... ROUTE 4/5
ANALYST.............
TIME OF ANALYSIS.....
DATE OF ANALYSIS.....
OTHER INFORMATION.... EXISTING TRAFFIC

A) ADJUSTMENT FACTORS

PERCENTAGE OF TRUCKS........................	10
PERCENTAGE OF BUSES..........................	0
PERCENTAGE OF RECREATIONAL VEHICLES.........	0
DESIGN SPEED (MPH)...........................	50
PEAK HOUR FACTOR.............................	1
DIRECTIONAL DISTRIBUTION (UP/DOWN)..........	50 / 50
LANE WIDTH (FT)..............................	12
USABLE SHOULDER WIDTH (AVG. WIDTH IN FT.)...	0
PERCENT NO PASSING ZONES....................	0

B) CORRECTION FACTORS

LEVEL TERRAIN

LOS	E_T	E_B	E_R	f_w	f_d	f_{HV}
A	2	1.8	2.2	.7	1	.91
B	2.2	2	2.5	.7	1	.89
C	2.2	2	2.5	.7	1	.89
D	2	1.6	1.6	.7	1	.91
E	2	1.6	1.6	.88	1	.91

C) LEVEL OF SERVICE RESULTS

INPUT VOLUME(vph): 6
ACTUAL FLOW RATE: 6

LOS	SERVICE FLOW RATE	V/C
A	267	.15
B	473	.27
C	752	.43
D	1140	.64
E	2240	1

LOS FOR GIVEN CONDITIONS: A

1985 HCM:TWO-LANE HIGHWAYS
****

FACILITY LOCATION.... ROUTE 4/5
ANALYST..............
TIME OF ANALYSIS.....
DATE OF ANALYSIS.....
OTHER INFORMATION.... MAX. CONSTRUCTION TRAFFIC

A) ADJUSTMENT FACTORS

PERCENTAGE OF TRUCKS........................	87
PERCENTAGE OF BUSES.........................	0
PERCENTAGE OF RECREATIONAL VEHICLES.........	0
DESIGN SPEED (MPH)..........................	50
PEAK HOUR FACTOR............................	1
DIRECTIONAL DISTRIBUTION (UP/DOWN)..........	50 / 50
LANE WIDTH (FT).............................	12
USABLE SHOULDER WIDTH (AVG. WIDTH IN FT.)...	0
PERCENT NO PASSING ZONES....................	0

B) CORRECTION FACTORS

LEVEL TERRAIN

LOS	E_T	E_B	E_R	f_w	f_d	f_{HV}
A	2	1.8	2.2	.7	1	.53
B	2.2	2	2.5	.7	1	.49
C	2.2	2	2.5	.7	1	.49
D	2	1.6	1.6	.7	1	.53
E	2	1.6	1.6	.88	1	.53

C) LEVEL OF SERVICE RESULTS

INPUT VOLUME(vph): 345
ACTUAL FLOW RATE: 345

LOS	SERVICE FLOW RATE	V/C
A	157	.15
B	259	.27
C	412	.43
D	671	.64
E	1318	1

LOS FOR GIVEN CONDITIONS: C

1985 HCM: TWO-LANE HIGHWAYS

****

FACILITY LOCATION.... ROUTE 4/5
ANALYST..............
TIME OF ANALYSIS.....
DATE OF ANALYSIS.....
OTHER INFORMATION.... AVERAGE CONSTRUCTION TRAFFIC

A) ADJUSTMENT FACTORS

PERCENTAGE OF TRUCKS........................	94
PERCENTAGE OF BUSES.........................	0
PERCENTAGE OF RECREATIONAL VEHICLES.........	0
DESIGN SPEED (MPH)..........................	50
PEAK HOUR FACTOR............................	1
DIRECTIONAL DISTRIBUTION (UP/DOWN)..........	50 / 50
LANE WIDTH (FT).............................	12
USABLE SHOULDER WIDTH (AVG. WIDTH IN FT.)...	0
PERCENT NO PASSING ZONES....................	0

B) CORRECTION FACTORS

LEVEL TERRAIN

LOS	E_T	E_B	E_R	f_w	f_d	f_{HV}
A	2	1.8	2.2	.7	1	.52
B	2.2	2	2.5	.7	1	.47
C	2.2	2	2.5	.7	1	.47
D	2	1.6	1.6	.7	1	.52
E	2	1.6	1.6	.88	1	.52

C) LEVEL OF SERVICE RESULTS

INPUT VOLUME(vph): 96
ACTUAL FLOW RATE: 96

LOS	SERVICE FLOW RATE	V/C
A	152	.15
B	249	.27
C	396	.43
D	647	.64
E	1270	1

LOS FOR GIVEN CONDITIONS: A

1985 HCM: TWO-LANE HIGHWAYS
****

FACILITY LOCATION.... ROUTE 10
ANALYST..............
TIME OF ANALYSIS.....
DATE OF ANALYSIS.....
OTHER INFORMATION.... EXISTING TRAFFIC

A) ADJUSTMENT FACTORS

PERCENTAGE OF TRUCKS.........................	10
PERCENTAGE OF BUSES..........................	0
PERCENTAGE OF RECREATIONAL VEHICLES.........	0
DESIGN SPEED (MPH)...........................	50
PEAK HOUR FACTOR.............................	1
DIRECTIONAL DISTRIBUTION (UP/DOWN)..........	50 / 50
LANE WIDTH (FT)..............................	12
USABLE SHOULDER WIDTH (AVG. WIDTH IN FT.)...	0
PERCENT NO PASSING ZONES.....................	0

B) CORRECTION FACTORS

LEVEL TERRAIN

LOS	E_T	E_B	E_R	f_w	f_d	f_{HV}
A	2	1.8	2.2	.7	1	.91
B	2.2	2	2.5	.7	1	.89
C	2.2	2	2.5	.7	1	.89
D	2	1.6	1.6	.7	1	.91
E	2	1.6	1.6	.88	1	.91

C) LEVEL OF SERVICE RESULTS

INPUT VOLUME(vph): 74
ACTUAL FLOW RATE: 74

LOS	SERVICE FLOW RATE	V/C
A	267	.15
B	473	.27
C	752	.43
D	1140	.64
E	2240	1

LOS FOR GIVEN CONDITIONS: A

1985 HCM:TWO-LANE HIGHWAYS

****

FACILITY LOCATION.... ROUTE 10
ANALYST.............
TIME OF ANALYSIS.....
DATE OF ANALYSIS.....
OTHER INFORMATION.... MAX. CONSTRUCTION TRAFFIC

A) ADJUSTMENT FACTORS

PERCENTAGE OF TRUCKS........................	72
PERCENTAGE OF BUSES.........................	0
PERCENTAGE OF RECREATIONAL VEHICLES.........	0
DESIGN SPEED (MPH)..........................	50
PEAK HOUR FACTOR............................	1
DIRECTIONAL DISTRIBUTION (UP/DOWN)..........	50 / 50
LANE WIDTH (FT).............................	12
USABLE SHOULDER WIDTH (AVG. WIDTH IN FT.)...	0
PERCENT NO PASSING ZONES....................	0

B) CORRECTION FACTORS

LEVEL TERRAIN

LOS	E_T	E_B	E_R	f_w	f_d	f_{HV}
A	2	1.8	2.2	.7	1	.58
B	2.2	2	2.5	.7	1	.54
C	2.2	2	2.5	.7	1	.54
D	2	1.6	1.6	.7	1	.58
E	2	1.6	1.6	.88	1	.58

C) LEVEL OF SERVICE RESULTS

INPUT VOLUME(vph): 414
ACTUAL FLOW RATE: 414

LOS	SERVICE FLOW RATE	V/C
A	171	.15
B	284	.27
C	452	.43
D	729	.64
E	1433	1

LOS FOR GIVEN CONDITIONS: C

1985 HCM:TWO-LANE HIGHWAYS
****

FACILITY LOCATION.... ROUTE 10
ANALYST..............
TIME OF ANALYSIS.....
DATE OF ANALYSIS.....
OTHER INFORMATION.... AVERAGE CONSTRUCTION TRAFFIC

A) ADJUSTMENT FACTORS

PERCENTAGE OF TRUCKS........................	55
PERCENTAGE OF BUSES.........................	0
PERCENTAGE OF RECREATIONAL VEHICLES.........	0
DESIGN SPEED (MPH)..........................	50
PEAK HOUR FACTOR............................	1
DIRECTIONAL DISTRIBUTION (UP/DOWN)..........	50 / 50
LANE WIDTH (FT).............................	12
USABLE SHOULDER WIDTH (AVG. WIDTH IN FT.)...	0
PERCENT NO PASSING ZONES....................	0

B) CORRECTION FACTORS

LEVEL TERRAIN

LOS	E_T	E_B	E_R	f_w	f_d	f_{HV}
A	2	1.8	2.2	.7	1	.65
B	2.2	2	2.5	.7	1	.6
C	2.2	2	2.5	.7	1	.6
D	2	1.6	1.6	.7	1	.65
E	2	1.6	1.6	.88	1	.65

C) LEVEL OF SERVICE RESULTS

INPUT VOLUME(vph): 163
ACTUAL FLOW RATE: 163

LOS	SERVICE FLOW RATE	V/C
A	190	.15
B	319	.27
C	508	.43
D	809	.64
E	1590	1

LOS FOR GIVEN CONDITIONS: A

1985 HCM: TWO-LANE HIGHWAYS

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FACILITY LOCATION.... ROUTE 11
ANALYST..............
TIME OF ANALYSIS.....
DATE OF ANALYSIS.....
OTHER INFORMATION.... EXISTING TRAFFIC

A) ADJUSTMENT FACTORS

PERCENTAGE OF TRUCKS........................	10
PERCENTAGE OF BUSES.........................	0
PERCENTAGE OF RECREATIONAL VEHICLES.........	0
DESIGN SPEED (MPH)..........................	50
PEAK HOUR FACTOR............................	1
DIRECTIONAL DISTRIBUTION (UP/DOWN)..........	50 / 50
LANE WIDTH (FT).............................	12
USABLE SHOULDER WIDTH (AVG. WIDTH IN FT.)...	0
PERCENT NO PASSING ZONES....................	0

B) CORRECTION FACTORS

LEVEL TERRAIN

LOS	E_T	E_B	E_R	f_w	f_d	f_{HV}
A	2	1.8	2.2	.7	1	.91
B	2.2	2	2.5	.7	1	.89
C	2.2	2	2.5	.7	1	.89
D	2	1.6	1.6	.7	1	.91
E	2	1.6	1.6	.88	1	.91

C) LEVEL OF SERVICE RESULTS

INPUT VOLUME(vph): 10
ACTUAL FLOW RATE: 10

LOS	SERVICE FLOW RATE	V/C
A	267	.15
B	473	.27
C	752	.43
D	1140	.64
E	2240	1

LOS FOR GIVEN CONDITIONS: A

1985 HCM:TWO-LANE HIGHWAYS
****

FACILITY LOCATION.... ROUTE 11
ANALYST.............
TIME OF ANALYSIS.....
DATE OF ANALYSIS.....
OTHER INFORMATION.... MAX. CONSTRUCTION TRAFFIC

A) ADJUSTMENT FACTORS

PERCENTAGE OF TRUCKS........................	86
PERCENTAGE OF BUSES.........................	0
PERCENTAGE OF RECREATIONAL VEHICLES.........	0
DESIGN SPEED (MPH)..........................	50
PEAK HOUR FACTOR............................	1
DIRECTIONAL DISTRIBUTION (UP/DOWN)..........	50 / 50
LANE WIDTH (FT).............................	12
USABLE SHOULDER WIDTH (AVG. WIDTH IN FT.)...	0
PERCENT NO PASSING ZONES....................	0

B) CORRECTION FACTORS

LEVEL TERRAIN

LOS	E_T	E_B	E_R	f_w	f_d	f_{HV}
A	2	1.8	2.2	.7	1	.54
B	2.2	2	2.5	.7	1	.49
C	2.2	2	2.5	.7	1	.49
D	2	1.6	1.6	.7	1	.54
E	2	1.6	1.6	.88	1	.54

C) LEVEL OF SERVICE RESULTS

INPUT VOLUME(vph): 350
ACTUAL FLOW RATE: 350

LOS	SERVICE FLOW RATE	V/C
A	158	.15
B	260	.27
C	415	.43
D	674	.64
E	1325	1

LOS FOR GIVEN CONDITIONS: C

1985 HCM: TWO-LANE HIGHWAYS

****

FACILITY LOCATION.... ROUTE 11
ANALYST..............
TIME OF ANALYSIS.....
DATE OF ANALYSIS.....
OTHER INFORMATION.... AVERAGE CONSTRUCTION TRAFFIC

A) ADJUSTMENT FACTORS

PERCENTAGE OF TRUCKS..........................	90
PERCENTAGE OF BUSES...........................	0
PERCENTAGE OF RECREATIONAL VEHICLES.........	0
DESIGN SPEED (MPH)............................	50
PEAK HOUR FACTOR..............................	1
DIRECTIONAL DISTRIBUTION (UP/DOWN)..........	50 / 50
LANE WIDTH (FT)...............................	12
USABLE SHOULDER WIDTH (AVG. WIDTH IN FT.)...	0
PERCENT NO PASSING ZONES.....................	0

B) CORRECTION FACTORS

LEVEL TERRAIN

LOS	E_T	E_B	E_R	f_w	f_d	f_{HV}
A	2	1.8	2.2	.7	1	.53
B	2.2	2	2.5	.7	1	.48
C	2.2	2	2.5	.7	1	.48
D	2	1.6	1.6	.7	1	.53
E	2	1.6	1.6	.88	1	.53

C) LEVEL OF SERVICE RESULTS

INPUT VOLUME(vph): 100
ACTUAL FLOW RATE: 100

LOS	SERVICE FLOW RATE	V/C
A	155	.15
B	254	.27
C	405	.43
D	660	.64
E	1297	1

LOS FOR GIVEN CONDITIONS: A

1985 HCM: TWO-LANE HIGHWAYS
****

FACILITY LOCATION.... ROUTE 16
ANALYST..............
TIME OF ANALYSIS.....
DATE OF ANALYSIS.....
OTHER INFORMATION.... EXISTING TRAFFIC

A) ADJUSTMENT FACTORS

PERCENTAGE OF TRUCKS.........................	10
PERCENTAGE OF BUSES..........................	0
PERCENTAGE OF RECREATIONAL VEHICLES.........	0
DESIGN SPEED (MPH)...........................	50
PEAK HOUR FACTOR.............................	1
DIRECTIONAL DISTRIBUTION (UP/DOWN)..........	50 / 50
LANE WIDTH (FT)..............................	12
USABLE SHOULDER WIDTH (AVG. WIDTH IN FT.)...	0
PERCENT NO PASSING ZONES....................	0

B) CORRECTION FACTORS

LEVEL TERRAIN

LOS	E_T	E_B	E_R	f_w	f_d	f_{HV}
A	2	1.8	2.2	.7	1	.91
B	2.2	2	2.5	.7	1	.89
C	2.2	2	2.5	.7	1	.89
D	2	1.6	1.6	.7	1	.91
E	2	1.6	1.6	.88	1	.91

C) LEVEL OF SERVICE RESULTS

INPUT VOLUME(vph): 24
ACTUAL FLOW RATE: 24

LOS	SERVICE FLOW RATE	V/C
A	267	.15
B	473	.27
C	752	.43
D	1140	.64
E	2240	1

LOS FOR GIVEN CONDITIONS: A

1985 HCM: TWO-LANE HIGHWAYS
****

FACILITY LOCATION.... ROUTE 16
ANALYST..............
TIME OF ANALYSIS.....
DATE OF ANALYSIS.....
OTHER INFORMATION.... MAX. CONSTRUCTION TRAFFIC

A) ADJUSTMENT FACTORS

PERCENTAGE OF TRUCKS.........................	82
PERCENTAGE OF BUSES..........................	0
PERCENTAGE OF RECREATIONAL VEHICLES.........	0
DESIGN SPEED (MPH)...........................	50
PEAK HOUR FACTOR.............................	1
DIRECTIONAL DISTRIBUTION (UP/DOWN)..........	50 / 50
LANE WIDTH (FT)..............................	12
USABLE SHOULDER WIDTH (AVG. WIDTH IN FT.)...	0
PERCENT NO PASSING ZONES.....................	0

B) CORRECTION FACTORS

LEVEL TERRAIN

LOS	E_T	E_B	E_R	f_w	f_d	f_{HV}
A	2	1.8	2.2	.7	1	.55
B	2.2	2	2.5	.7	1	.5
C	2.2	2	2.5	.7	1	.5
D	2	1.6	1.6	.7	1	.55
E	2	1.6	1.6	.88	1	.55

C) LEVEL OF SERVICE RESULTS

INPUT VOLUME(vph): 364
ACTUAL FLOW RATE: 364

LOS	SERVICE FLOW RATE	V/C
A	162	.15
B	267	.27
C	425	.43
D	689	.64
E	1354	1

LOS FOR GIVEN CONDITIONS: C

1985 HCM: TWO-LANE HIGHWAYS

****

FACILITY LOCATION.... ROUTE 16
ANALYST..............
TIME OF ANALYSIS.....
DATE OF ANALYSIS.....
OTHER INFORMATION.... AVERAGE CONSTRUCTION TRAFFIC

A) ADJUSTMENT FACTORS

PERCENTAGE OF TRUCKS........................	79
PERCENTAGE OF BUSES.........................	0
PERCENTAGE OF RECREATIONAL VEHICLES.........	0
DESIGN SPEED (MPH)..........................	50
PEAK HOUR FACTOR............................	1
DIRECTIONAL DISTRIBUTION (UP/DOWN)..........	50 / 50
LANE WIDTH (FT).............................	12
USABLE SHOULDER WIDTH (AVG. WIDTH IN FT.)...	0
PERCENT NO PASSING ZONES....................	0

B) CORRECTION FACTORS

LEVEL TERRAIN

LOS	E_T	E_B	E_R	f_w	f_d	f_{HV}
A	2	1.8	2.2	.7	1	.56
B	2.2	2	2.5	.7	1	.51
C	2.2	2	2.5	.7	1	.51
D	2	1.6	1.6	.7	1	.56
E	2	1.6	1.6	.88	1	.56

C) LEVEL OF SERVICE RESULTS

INPUT VOLUME(vph): 114
ACTUAL FLOW RATE: 114

LOS	SERVICE FLOW RATE	V/C
A	164	.15
B	272	.27
C	433	.43
D	701	.64
E	1377	1

LOS FOR GIVEN CONDITIONS: A

1985 HCM:TWO-LANE HIGHWAYS
****

FACILITY LOCATION.... ROUTE 1
ANALYST.............
TIME OF ANALYSIS.....
DATE OF ANALYSIS.....
OTHER INFORMATION.... EXISTING TRAFFIC

A) ADJUSTMENT FACTORS

PERCENTAGE OF TRUCKS........................	10
PERCENTAGE OF BUSES.........................	0
PERCENTAGE OF RECREATIONAL VEHICLES.........	0
DESIGN SPEED (MPH)..........................	50
PEAK HOUR FACTOR............................	1
DIRECTIONAL DISTRIBUTION (UP/DOWN)..........	50 / 50
LANE WIDTH (FT).............................	14
USABLE SHOULDER WIDTH (AVG. WIDTH IN FT.)...	6
PERCENT NO PASSING ZONES....................	0

B) CORRECTION FACTORS

LEVEL TERRAIN

LOS	E_T	E_B	E_R	f_w	f_d	f_{HV}
A	2	1.8	2.2	1	1	.91
B	2.2	2	2.5	1	1	.89
C	2.2	2	2.5	1	1	.89
D	2	1.6	1.6	1	1	.91
E	2	1.6	1.6	1	1	.91

C) LEVEL OF SERVICE RESULTS

INPUT VOLUME(vph): 100
ACTUAL FLOW RATE: 100

LOS	SERVICE FLOW RATE	V/C
A	382	.15
B	675	.27
C	1075	.43
D	1629	.64
E	2545	1

LOS FOR GIVEN CONDITIONS: A

1985 HCM: TWO-LANE HIGHWAYS
****

FACILITY LOCATION.... ROUTE 1
ANALYST..............
TIME OF ANALYSIS.....
DATE OF ANALYSIS.....
OTHER INFORMATION.... MAX. CONSTRUCTION TRAFFIC

A) ADJUSTMENT FACTORS

PERCENTAGE OF TRUCKS........................	75
PERCENTAGE OF BUSES.........................	0
PERCENTAGE OF RECREATIONAL VEHICLES.........	0
DESIGN SPEED (MPH)..........................	50
PEAK HOUR FACTOR............................	1
DIRECTIONAL DISTRIBUTION (UP/DOWN)..........	50 / 50
LANE WIDTH (FT).............................	14
USABLE SHOULDER WIDTH (AVG. WIDTH IN FT.)...	6
PERCENT NO PASSING ZONES....................	0

B) CORRECTION FACTORS

LEVEL TERRAIN

LOS	E_T	E_B	E_R	f_w	f_d	f_{HV}
A	2	1.8	2.2	1	1	.57
B	2.2	2	2.5	1	1	.53
C	2.2	2	2.5	1	1	.53
D	2	1.6	1.6	1	1	.57
E	2	1.6	1.6	1	1	.57

C) LEVEL OF SERVICE RESULTS

INPUT VOLUME(vph): 440
ACTUAL FLOW RATE: 440

LOS	SERVICE FLOW RATE	V/C
A	240	.15
B	398	.27
C	634	.43
D	1024	.64
E	1600	1

LOS FOR GIVEN CONDITIONS: C

1985 HCM: TWO-LANE HIGHWAYS

****

FACILITY LOCATION.... ROUTE 1
ANALYST..............
TIME OF ANALYSIS.....
DATE OF ANALYSIS.....
OTHER INFORMATION.... AVERAGE CONSTRUCTION TRAFFIC

A) ADJUSTMENT FACTORS

PERCENTAGE OF TRUCKS........................	47
PERCENTAGE OF BUSES.........................	0
PERCENTAGE OF RECREATIONAL VEHICLES.........	0
DESIGN SPEED (MPH)..........................	50
PEAK HOUR FACTOR............................	1
DIRECTIONAL DISTRIBUTION (UP/DOWN)..........	50 / 50
LANE WIDTH (FT).............................	14
USABLE SHOULDER WIDTH (AVG. WIDTH IN FT.)...	6
PERCENT NO PASSING ZONES....................	0

B) CORRECTION FACTORS

LEVEL TERRAIN

LOS	E_T	E_B	E_R	f_w	f_d	f_{HV}
A	2	1.8	2.2	1	1	.68
B	2.2	2	2.5	1	1	.64
C	2.2	2	2.5	1	1	.64
D	2	1.6	1.6	1	1	.68
E	2	1.6	1.6	1	1	.68

C) LEVEL OF SERVICE RESULTS

INPUT VOLUME(vph): 190
ACTUAL FLOW RATE: 190

LOS	SERVICE FLOW RATE	V/C
A	286	.15
B	483	.27
C	770	.43
D	1219	.64
E	1905	1

LOS FOR GIVEN CONDITIONS: A

1985 HCM: TWO-LANE HIGHWAYS
****

FACILITY LOCATION.... ROUTE 8
ANALYST.............
TIME OF ANALYSIS.....
DATE OF ANALYSIS.....
OTHER INFORMATION.... EXISTING TRAFFIC

A) ADJUSTMENT FACTORS

PERCENTAGE OF TRUCKS........................	10
PERCENTAGE OF BUSES.........................	0
PERCENTAGE OF RECREATIONAL VEHICLES.........	0
DESIGN SPEED (MPH)..........................	50
PEAK HOUR FACTOR............................	1
DIRECTIONAL DISTRIBUTION (UP/DOWN)..........	50 / 50
LANE WIDTH (FT).............................	12
USABLE SHOULDER WIDTH (AVG. WIDTH IN FT.)...	0
PERCENT NO PASSING ZONES....................	0

B) CORRECTION FACTORS

LEVEL TERRAIN

LOS	E_T	E_B	E_R	f_w	f_d	f_{HV}
A	2	1.8	2.2	.7	1	.91
B	2.2	2	2.5	.7	1	.89
C	2.2	2	2.5	.7	1	.89
D	2	1.6	1.6	.7	1	.91
E	2	1.6	1.6	.88	1	.91

C) LEVEL OF SERVICE RESULTS

INPUT VOLUME(vph): 63
ACTUAL FLOW RATE: 63

LOS	SERVICE FLOW RATE	V/C
A	267	.15
B	473	.27
C	752	.43
D	1140	.64
E	2240	1

LOS FOR GIVEN CONDITIONS: A

1985 HCM: TWO-LANE HIGHWAYS
****

FACILITY LOCATION.... ROUTE 8
ANALYST..............
TIME OF ANALYSIS.....
DATE OF ANALYSIS.....
OTHER INFORMATION.... MAX. CONSTRUCTION TRAFFIC

A) ADJUSTMENT FACTORS

PERCENTAGE OF TRUCKS.........................	74
PERCENTAGE OF BUSES..........................	0
PERCENTAGE OF RECREATIONAL VEHICLES.........	0
DESIGN SPEED (MPH)...........................	50
PEAK HOUR FACTOR.............................	1
DIRECTIONAL DISTRIBUTION (UP/DOWN)..........	50 / 50
LANE WIDTH (FT)..............................	12
USABLE SHOULDER WIDTH (AVG. WIDTH IN FT.)...	0
PERCENT NO PASSING ZONES.....................	0

B) CORRECTION FACTORS

LEVEL TERRAIN

LOS	E_T	E_B	E_R	f_w	f_d	f_{HV}
A	2	1.8	2.2	.7	1	.57
B	2.2	2	2.5	.7	1	.53
C	2.2	2	2.5	.7	1	.53
D	2	1.6	1.6	.7	1	.57
E	2	1.6	1.6	.88	1	.57

C) LEVEL OF SERVICE RESULTS

INPUT VOLUME(vph): 403
ACTUAL FLOW RATE: 403

LOS	SERVICE FLOW RATE	V/C
A	169	.15
B	280	.27
C	446	.43
D	721	.64
E	1416	1

LOS FOR GIVEN CONDITIONS: C

1985 HCM:TWO-LANE HIGHWAYS

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FACILITY LOCATION.... ROUTE 8
ANALYST..............
TIME OF ANALYSIS.....
DATE OF ANALYSIS.....
OTHER INFORMATION.... AVERAGE CONSTRUCTION TRAFFIC

A) ADJUSTMENT FACTORS

PERCENTAGE OF TRUCKS........................	59
PERCENTAGE OF BUSES.........................	0
PERCENTAGE OF RECREATIONAL VEHICLES.........	0
DESIGN SPEED (MPH)..........................	50
PEAK HOUR FACTOR............................	1
DIRECTIONAL DISTRIBUTION (UP/DOWN)..........	50 / 50
LANE WIDTH (FT).............................	12
USABLE SHOULDER WIDTH (AVG. WIDTH IN FT.)...	0
PERCENT NO PASSING ZONES....................	0

B) CORRECTION FACTORS

LEVEL TERRAIN

LOS	E_T	E_B	E_R	f_w	f_d	f_{HV}
A	2	1.8	2.2	.7	1	.63
B	2.2	2	2.5	.7	1	.59
C	2.2	2	2.5	.7	1	.59
D	2	1.6	1.6	.7	1	.63
E	2	1.6	1.6	.88	1	.63

C) LEVEL OF SERVICE RESULTS

INPUT VOLUME(vph): 153
ACTUAL FLOW RATE: 153

LOS	SERVICE FLOW RATE	V/C
A	185	.15
B	310	.27
C	493	.43
D	789	.64
E	1550	1

LOS FOR GIVEN CONDITIONS: A

TECHNICAL STUDY 4

CENTRAL RADAR SYSTEM

OVER-THE-HORIZON BACKSCATTER RADAR PROGRAM

HYDROLOGY & WATER QUALITY

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4.1 INTRODUCTION

The U.S. Air Force (USAF) has proposed to construct an Over-the-Horizon Backscatter (OTH-B) Radar facility in the north central United States (USAF, 1987). In the Record of Decision (USAF, 1988) the USAF selected a study area near Amherst, South Dakota for the transmit facilities, and a study area near Thief River Falls, Minnesota for the receive facilities (Figure 4-1). The USAF has since identified two concentrated study areas (CSAs) within each general study area, as described in Technical Study 1. The facilities are described in Technical Study 2.

The purpose of this study is to describe the existing hydrologic environment, including a discussion of geology and climatology, and to describe existing surface and groundwater resources that could potentially be affected by the construction of the transmit and receive facilities. This study will also evaluate the impacts of construction and operation of the radar system on existing water quality and the hydrologic environment. In addition, this document outlines possible measures to mitigate potential impacts.

4.2 AFFECTED ENVIRONMENT

4.2.1 Amherst South Dakota Transmit Study Area

The affected environment for the transmit (TX) sites includes the two CSAs, called Tx-North (Tx-N) and Tx-South (Tx-S). The Tx-S CSA is located in the southwest corner of Marshall County, and the Tx-N CSA is located in Marshall and Brown Counties (Figure 4-2). The geology, climatology, flooding, and water quality of the Amherst study area is discussed regionally because there is little variability in these disciplines between the two CSAs. Water resources and site hydrology have been examined individually for each CSA because of the significant variation between the Tx-S and Tx-N CSAs.

4.2.1.1. Geology. The Amherst study area is located at the bottom of the ancient glacial Lake Dakota, now known as the Lake Dakota plains region, a part of the James Valley lowland area (Figure 4-3). The Lake Dakota plain is

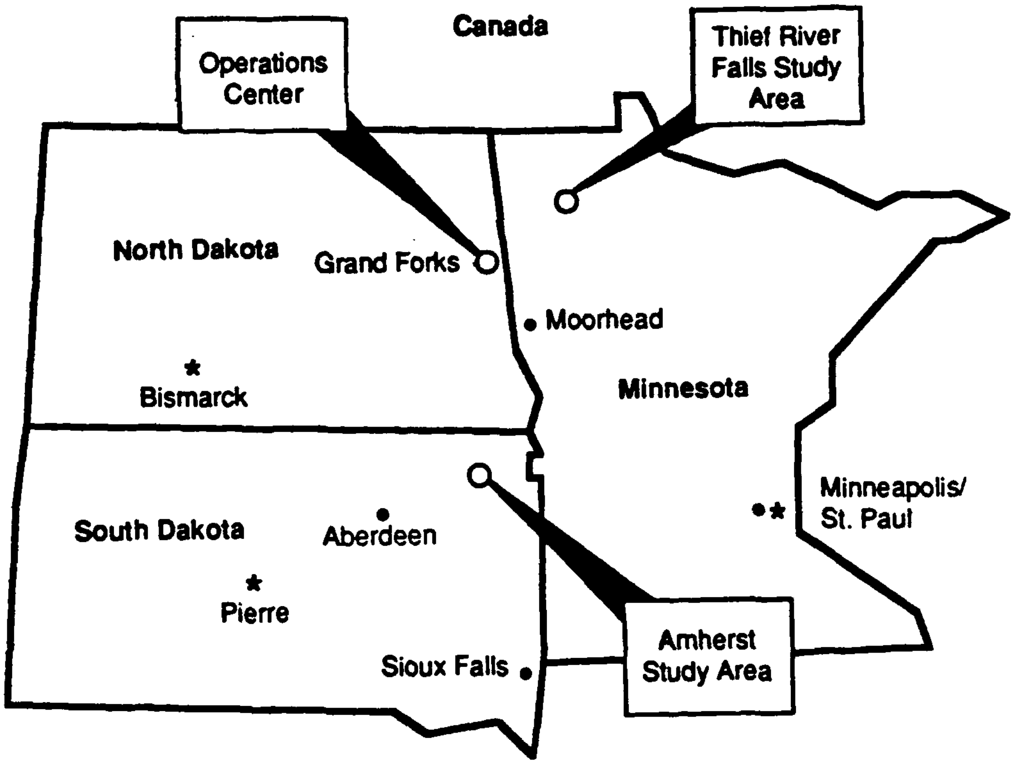


FIGURE 4-1. LOCATION OF THE CENTRAL RADAR SYSTEM TRANSMIT AND RECEIVE STUDY AREAS

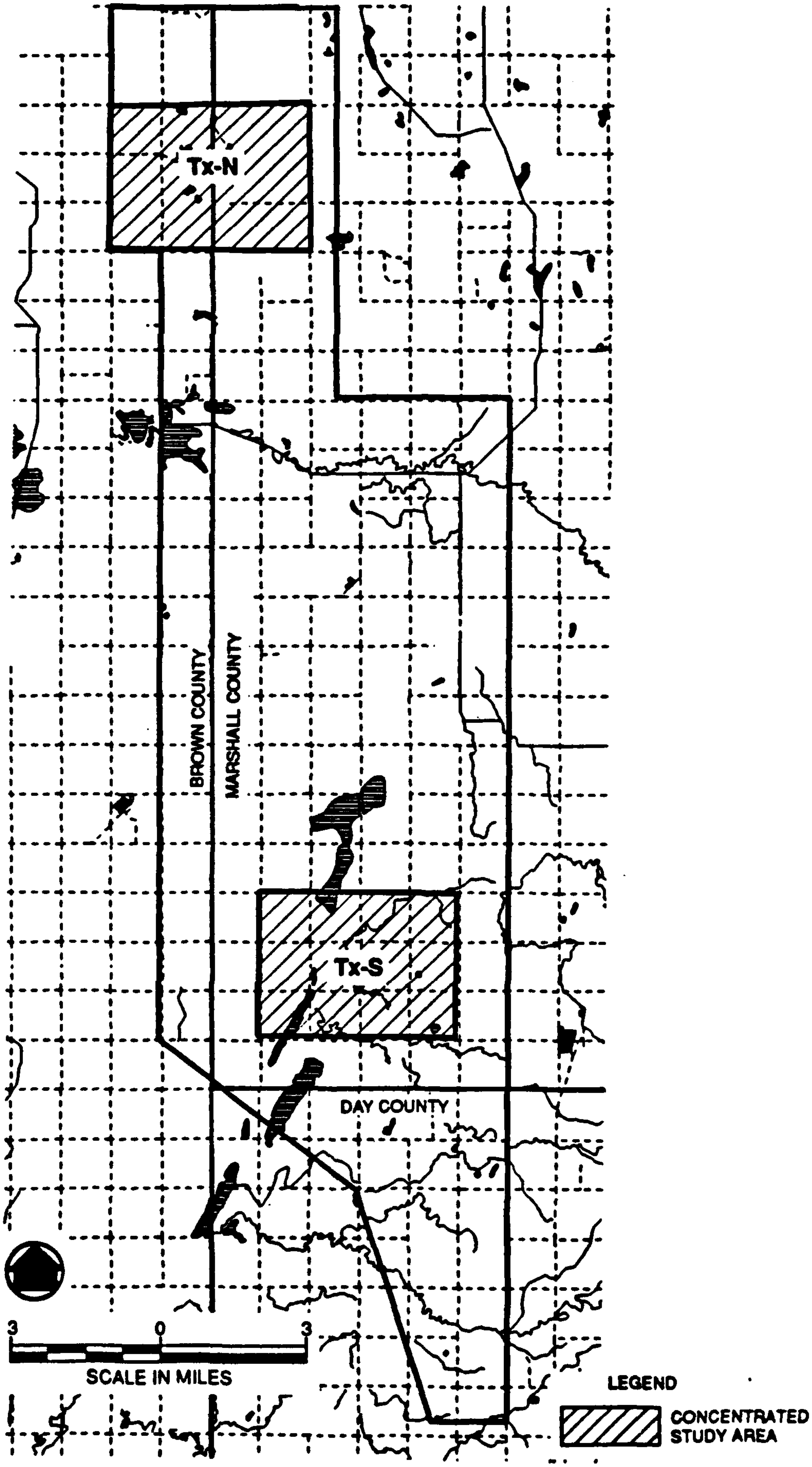


FIGURE 4-2. AMHERST, SD TRANSMIT STUDY AREA AND CONCENTRATED STUDY AREAS

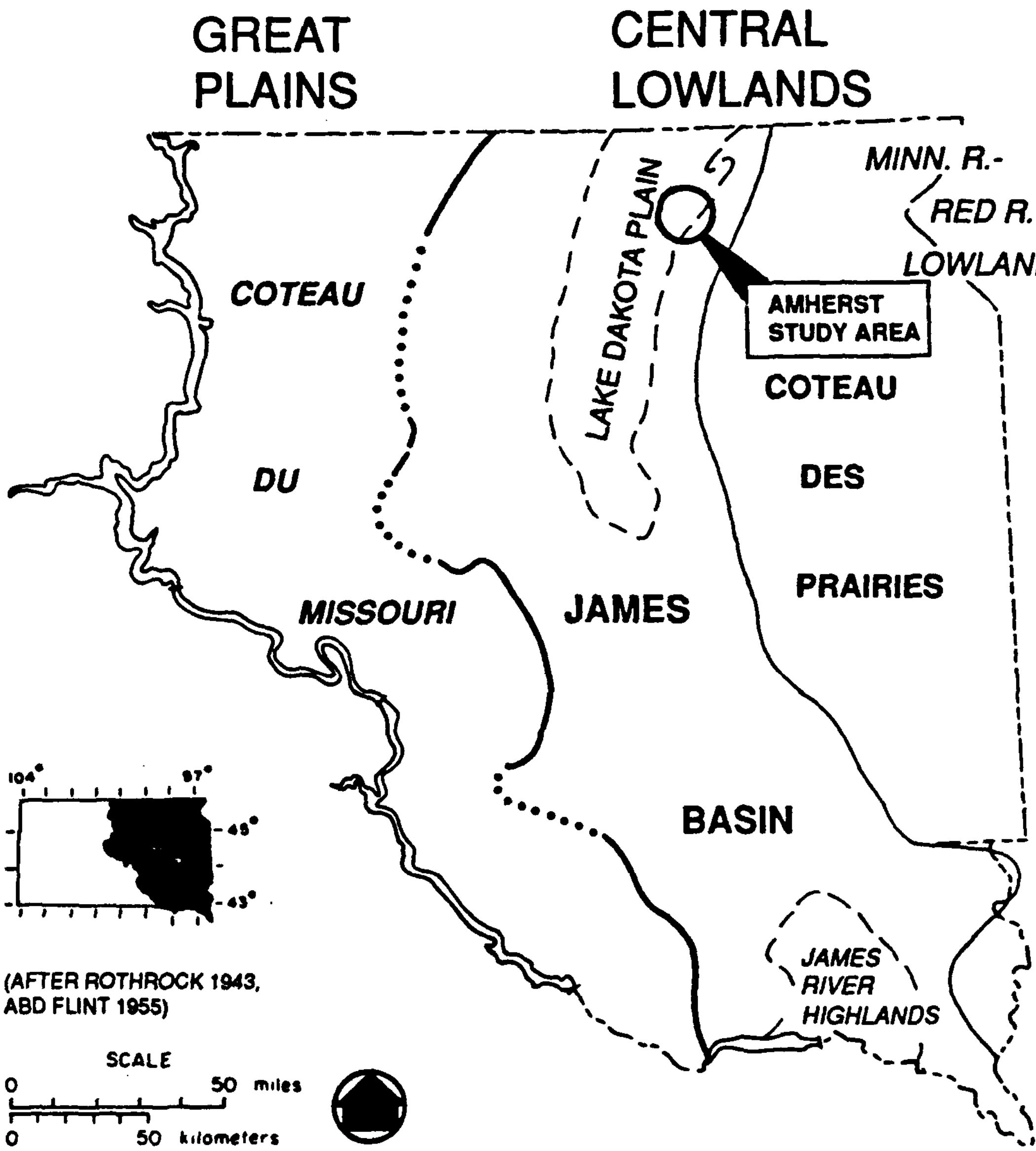


FIGURE 4-3. LOCATION OF MAJOR GEOLOGIC FEATURES NEAR THE AMHERST STUDY AREA

characterized by a very flat surface with local relief rarely exceeding 10 feet. This area consists mainly of Lake Dakota Sediments (lacustrine deposits, dune sand, and loess derived from lacustrine deposits). The glacial sediments in Marshall County are late Wisconsin in age. Ancient lake silt and sand were blown eastward by wind, and coarser material (mostly sand) were deposited against an area known as the Oaks moraine.

The Oaks moraine, located in the northwestern part of Marshall County, was caused by a significant halt of the Late Wisconsin glacier (Figure 4-4). The moraine has a ridged topography and forms a major drainage divide, known as the Continental Divide. This north-south divide separates surface water flow which ultimately discharges to the Hudson Bay in the north, from surface water flow which ultimately discharges to the Gulf of Mexico in the south.

4.2.1.2 **Climatology.** The Amherst study area has a continental climate characterized by cold winters and hot summers. The average annual temperature for the Amherst study area is approximately 43 degrees Fahrenheit, with average January temperatures of approximately 10 degrees Fahrenheit, and average July temperatures of 72 degrees Fahrenheit (SCS, 1975).

Thunderstorms are the main source of rainfall during the growing season. Table 4-1 presents an approximate frequency-duration estimate for a range of rainfall storm events in the Amherst study area. The average annual rainfall for the area is approximately 19 inches (SCS, 1975).

Snowfall in the Amherst area averages approximately 40 inches annually (SCS, 1975). Snow accumulation at depths greater than one inch occurs an average 75 days per year, or approximately 20 percent of the year. Snow accumulation records taken in the city of Britton (approximately 10 miles east of the Amherst Study area) for the winter of 1988-1989 (November-April) showed measurements of snow depths ranging from 0 to 31 inches (SDSU, 1989). Snow drifting is very common in the Amherst study area due to high winds and the flat topography of the area. The drifting creates highly variable snow depth readings.

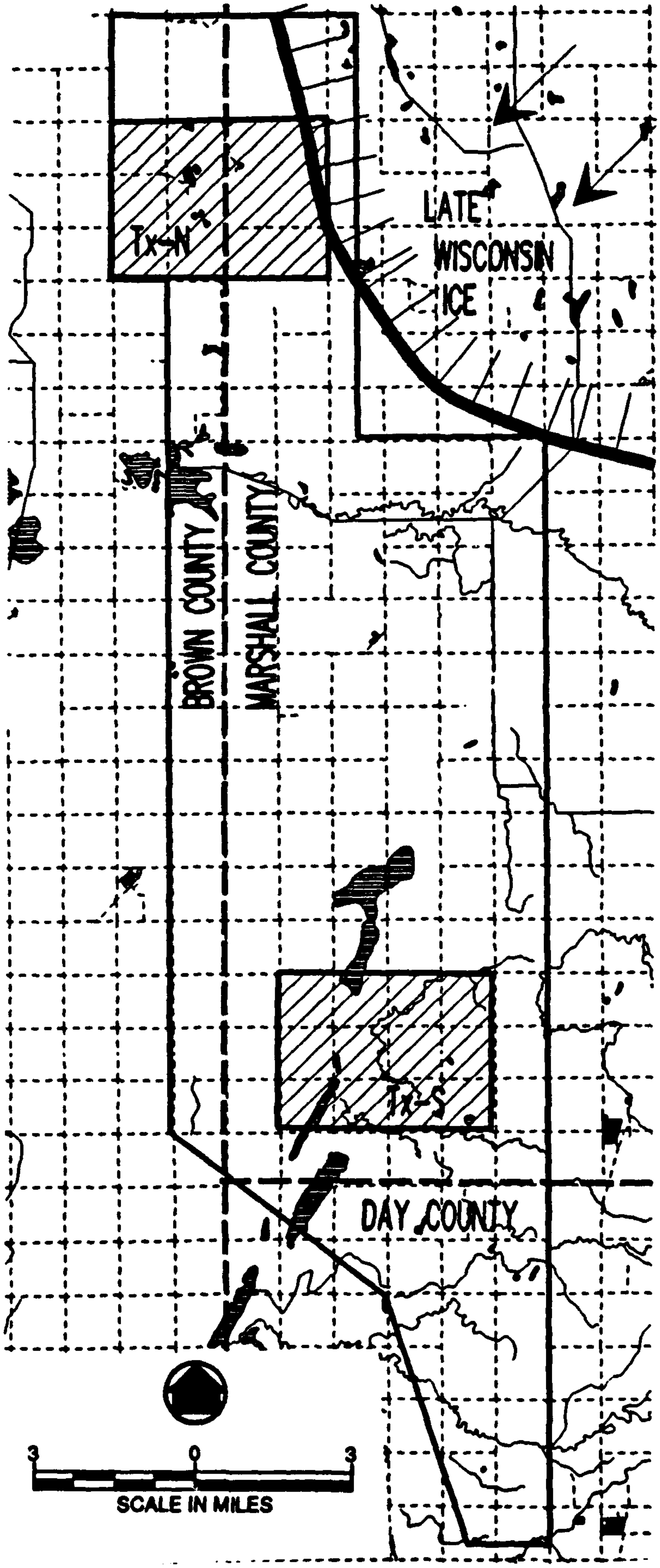


FIGURE 4-4. AMHERST, SD GLACIATION

TABLE 4-1. AVERAGE RAINFALL DISTRIBUTION IN THE VICINITY OF THE AMHERST STUDY AREA

Frequency	Duration	Average Rainfall
1 year	1 hour	1.2 inches
2 years	24 hours	2.0 inches
5 years	1 hour	3.0 inches
10 years	24 hours	3.0 inches
25 years(1)	24 hours	4.2 inches

Source: US SCS, 1982.

(1) Rainfall value used in TR-20 model for Tx-N, and Tx-S.

Soils in the Amherst study area typically remain frozen for approximately 120 days, or one third of the year (SCS, 1975). Flooding impacts from springtime snow melt are often exacerbated by frozen soils. The spring snowmelt of 1989, which occurred in late March, was an example of excessive flooding exacerbated by frozen soils. The early snowmelt of 1989 in the Amherst study area is discussed in more detail in Section 4.2.1.5.

4.2.1.3 Transmit Surface Water Resources and Hydrology. The transmit study area is located within the larger Missouri River Drainage Basin area, while Tx-N and most of Tx-S lie more locally within the Crow Creek Watershed District (Figure 4-5). The southern portion of the Tx-S CSA is located in an un-named watershed area which contributes to the Antelope Creek.

The Sand Lake National Wildlife Refuge, or Mud Lake Reservoir, located approximately 15 miles from the Tx-N CSA, is the largest surface water body near the transmit CSAs. Surface water from precipitation and snowmelt collects at the CSAs in roadside ditches, swales, wetlands, and small stream channels. The Crow Creek Drainage Ditch, a major channel at the Amherst study area travels westward between the Tx-N and Tx-S CSAs. The Portage-Detroit Ditch to the west of the Tx-N CSA discharges to the Crow Creek drainage ditch, which discharges to the James River. To the south of the Tx-S CSA lies Antelope Creek, which contributes to the Mud Creek downstream, which flows to the James River. Figure 4-6 shows water resources at the Amherst study area.

4.2.1.3.1 Tx-North. The topography of the Tx-N CSA slopes generally to the southwest with the exception of one small area to the east which slopes more southerly. The Tx-N CSA is located just southwest of the continental divide. The study area therefore receives very little surface water runoff from upstream contributing areas.

Small depressed "prairie potholes" which collect local surface flow are especially predominant at the Tx-N CSA. These seasonal wetlands are discussed in more detail in Technical Study 6 (Wetlands/Aquatics). Since the Tx-N CSA has very few roads, there are few roadside swales or ditches at this site to channel flow. One large ditch originates in the southwest corner of the

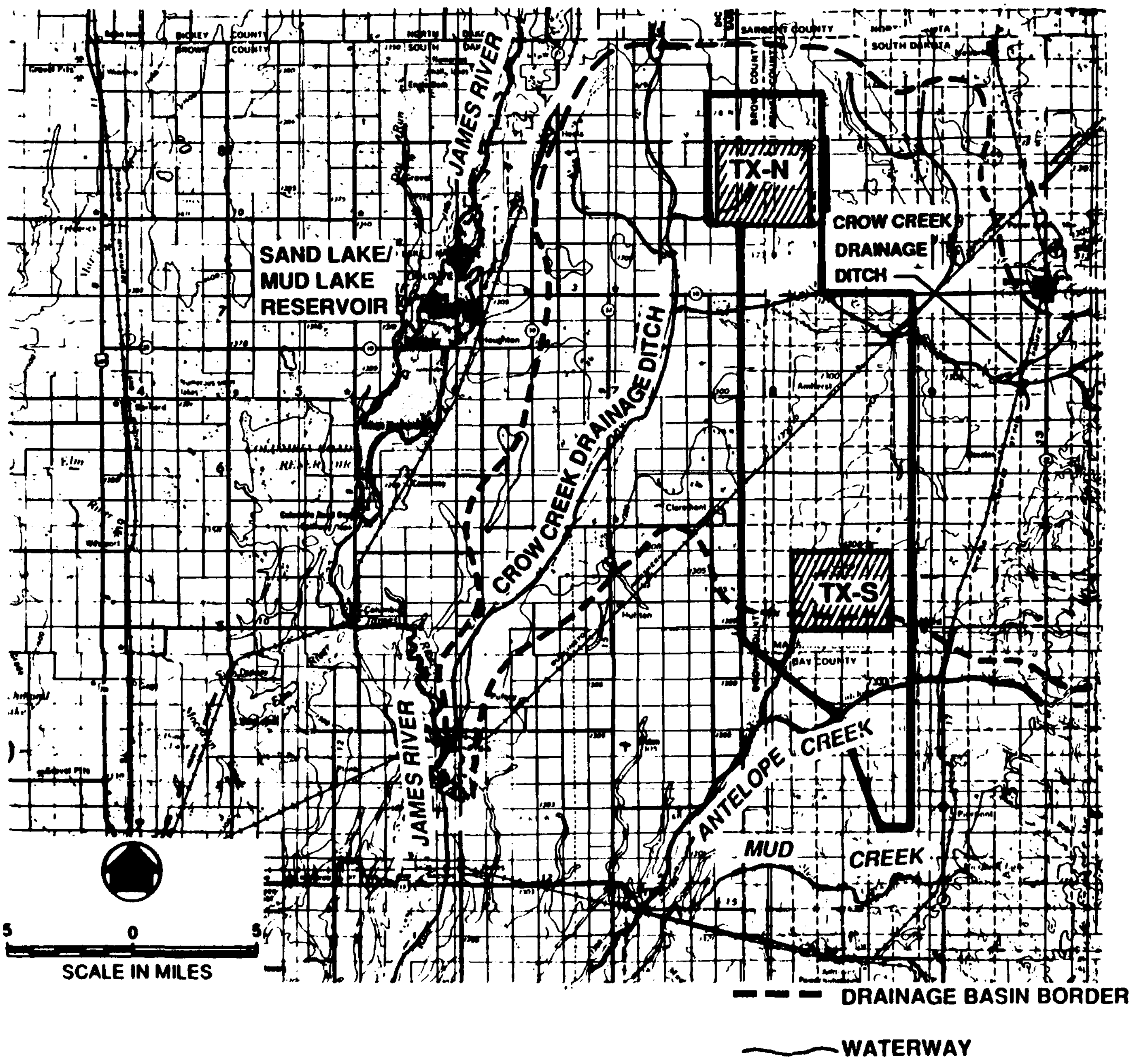


FIGURE 4-5. CROW CREEK WATERSHED DISTRICT

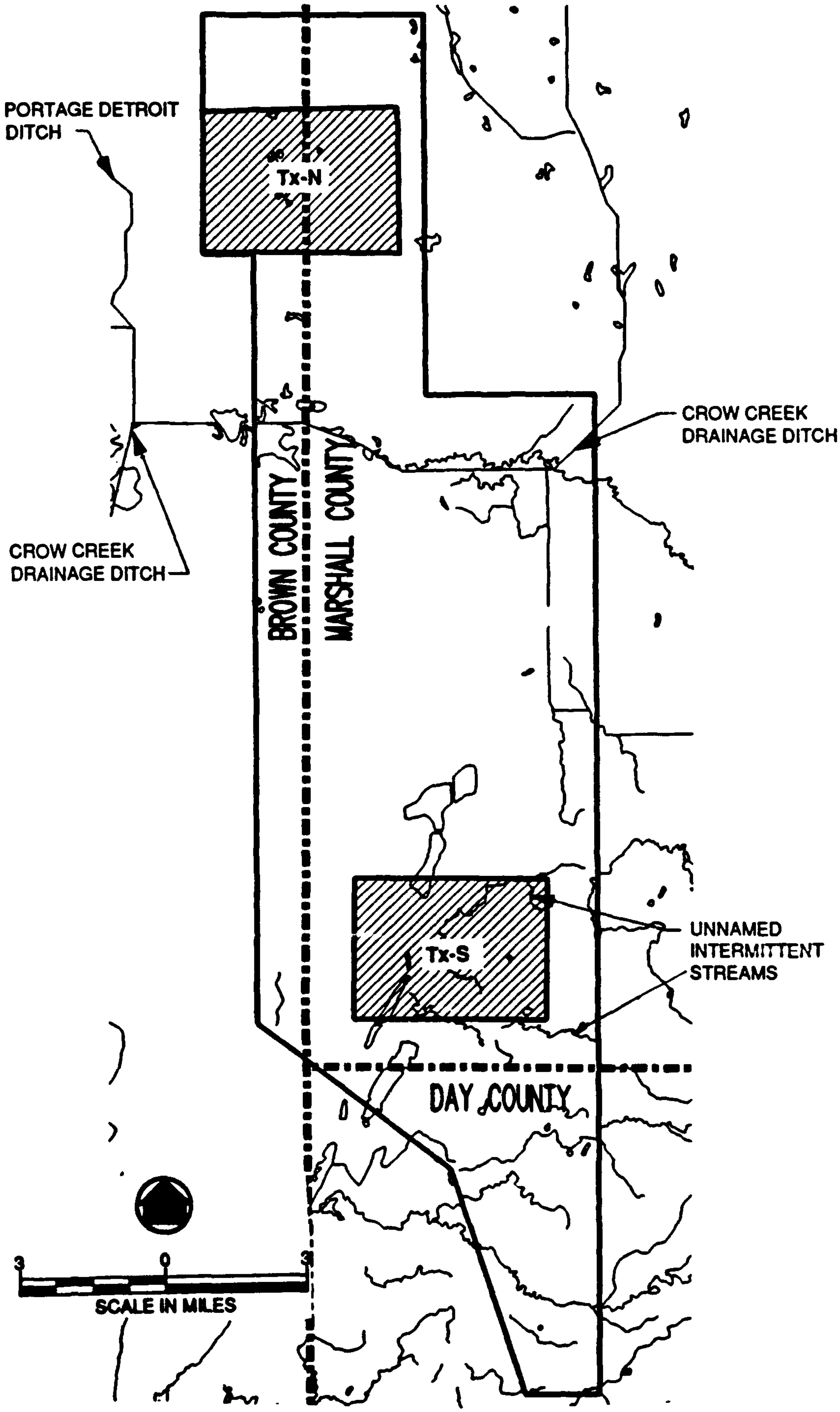


FIGURE 4-6. AMHERST SOUTH DAKOTA TRANSMIT STUDY AREA SURFACE WATER RESOURCES

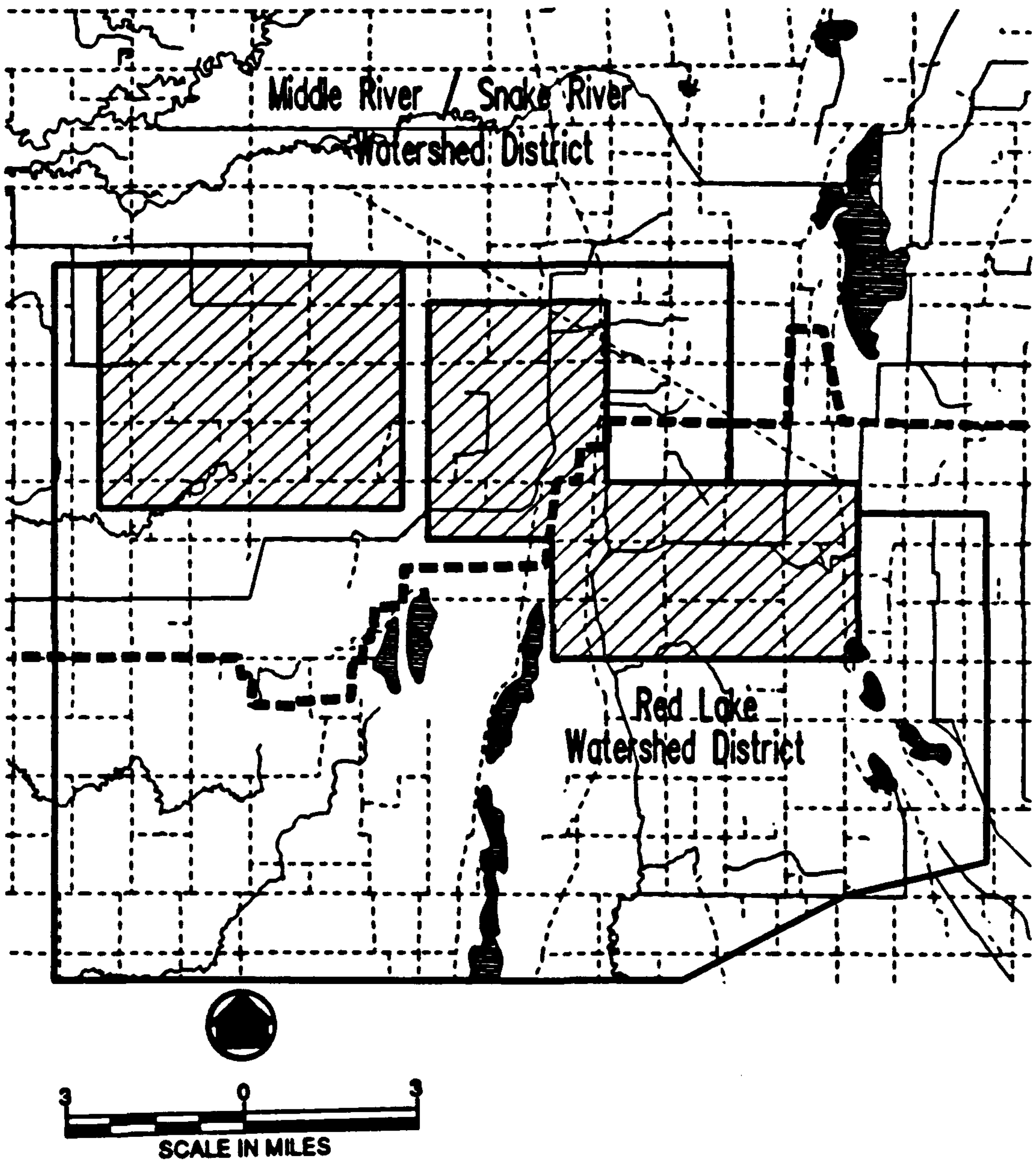


FIGURE 4-15. MIDDLE RIVER/SNAKE RIVER AND RED LAKE RIVER WATERSHED DISTRICTS

Tx-N CSA and carries surface water flow southwest from the site. This drainage ditch flows west to the Crow Creek drainage ditch and subsequently out to the James River. Figure 4-7 shows the direction of overland flow at the Tx-N CSA.

4.2.1.3.2 Tx-South. Surface water flow at the Tx-S CSA is carried primarily through a system of roadside swales and ditches. Several small unnamed intermittent streams exist in the central portion of the CSA. Although field observations conducted by the USAF during the fall of 1989 indicate that there was no standing water in these streams, most channels are culverted under roads. The most significant intermittent stream in the Tx-S CSA, with the widest scoured stream channel, is located in the northeastern corner of the site. This stream receives flows from a contributing watershed area of approximately 60 square miles.

Surface water enters the Tx-S CSA from three different directions. Surface water sheet flow enters the site from the east and follows a northwesterly or westerly direction. Surface water flow from the east is collected through a system of stream channels and road ditches originating at the edge of the Coteau des Prairie highland area. A stream channel in the northeastern portion of the Tx-S study area, which subsequently discharges into the depressed area in the north-central portion of the CSA, provides an outlet for this large upstream drainage area.

Runoff from precipitation in the northwestern corner of the Tx-S CSA also flows into the low area to the north of the CSA. Runoff from the southwest portion of the CSA drains southwesterly through a low channelized area to the Antelope Creek, to the Mud Creek, and ultimately to the James River. Figure 4-8 shows the existing flow paths and the drainage basin divides delineated at the Tx-S site.

4.2.1.3.3 Flooding Potential. The Federal Emergency Management Agency (FEMA), has not developed flood maps for the Amherst study area. Therefore, the 100-year flood zone for the Amherst study area is unknown. However, several areas within the Amherst study area have been known to flood and were observed flooded during the spring of 1989.

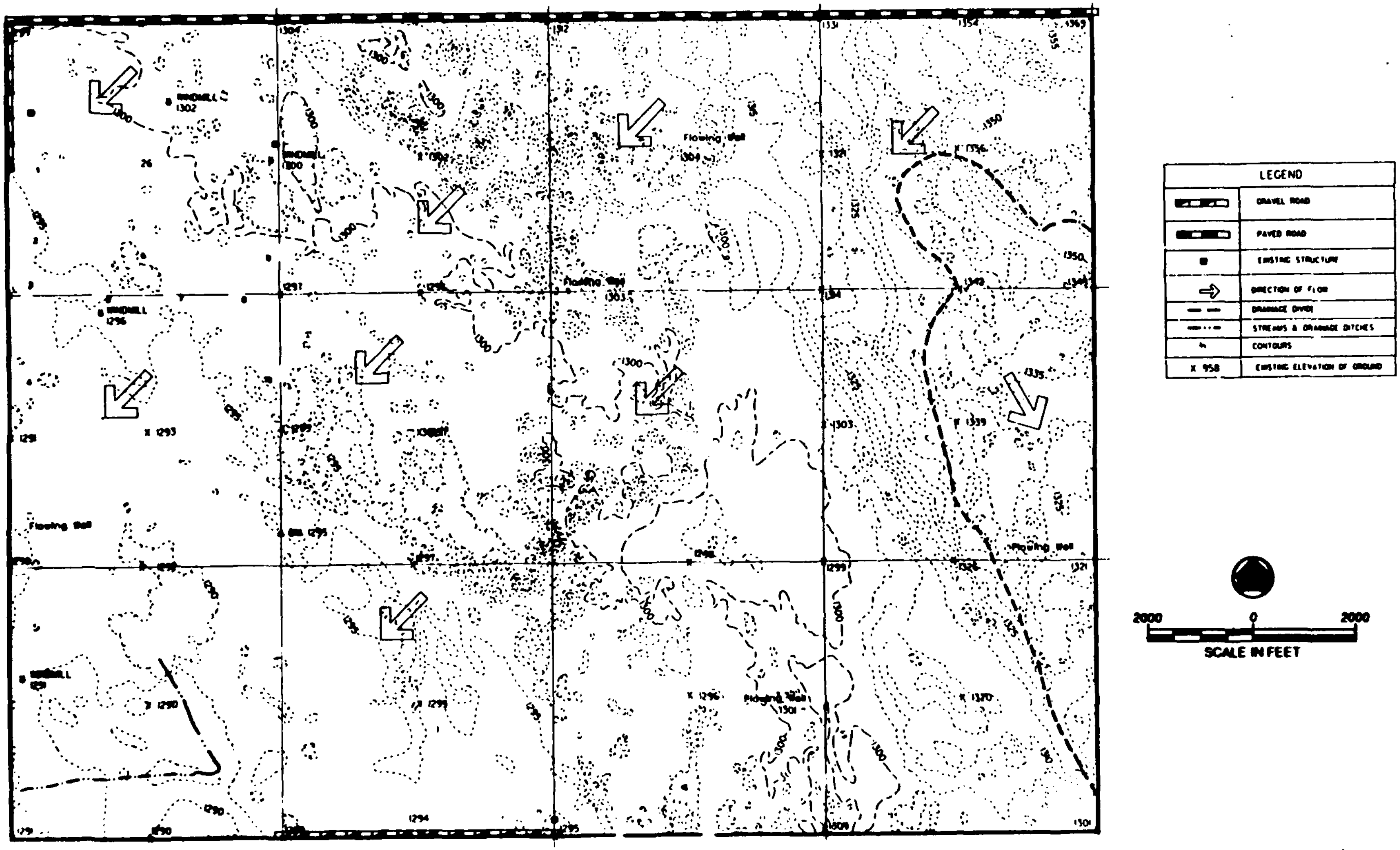


FIGURE 4-7. Tx-NORTH CONCENTRATED STUDY AREA
SURFACE WATER FLOW

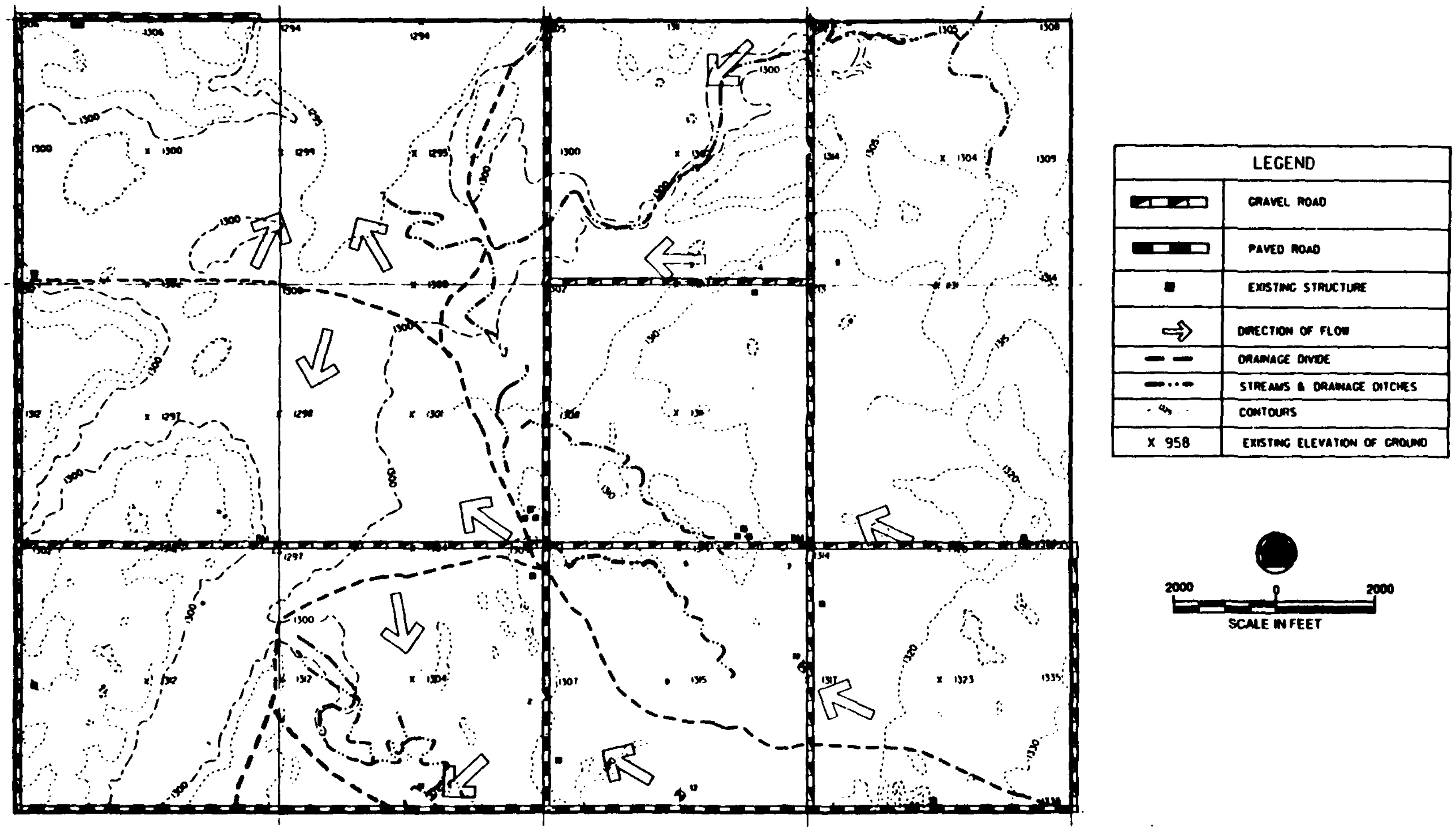


FIGURE 4-8. TX-SOUTH CONCENTRATED STUDY AREA SURFACE WATER FLOW

In March, 1989 the temperatures in the Amherst study area reached unseasonably high levels inducing rapid melting of existing snowpack. The combined effect of frozen ground, frozen channels, blocked ditches, flat topography, and possible frozen downstream river channels created widespread flooding in the area. The Crow Creek drainage ditch overflowed extensively and flooded the areas between Tx-N and Tx-S CSAs (SCS, 1989). The low area that overlaps the northern part of the Tx-S CSA remained flooded through the fall of 1989. Drainage patterns indicate that it is likely this low area also collected upstream flows originating at the Coteau de Prairie. Figure 4-9 shows the extent of the 1989 flood in the study area.

4.2.1.3.4 Surface Water Regulations. The State of South Dakota maintains surface water quality standards (Table 4-2). An application for certification of compliance with water quality standards must be sought by applicants seeking federal permits to conduct any activity including, but not limited to the construction or operation of facilities which may result in discharges into the waters of the state.

4.2.1.3.5 Surface Water Quality. Since no major surface water bodies exist on the Tx-N or Tx-S CSAs, no on-site surface water quality data was available. The best available data was collected during a Marshall County sampling program of 37 lakes and ponds (Petri and Larson, 1969). It is assumed that the water quality of surface waters in channels and wetlands at the CSAs are of a similar quality.

Specific conductance ranged from 460 to 20,000 micromhos/cm (27 of the 37 water bodies had a conductance of less than 1,000 micromhos/cm). Total dissolved solids (TDS) were generally less than 700 mg/l and consisted predominantly of magnesium, calcium, and bicarbonate. The lakes which had total dissolved solids concentration greater than 700 mg/l consisted predominantly of magnesium, calcium, and sulfate. The pH of the water bodies tested ranged from 8.0 to 9.2. Water temperatures ranged from 7.6 to 25.5 degrees Celsius during June sampling, and from 11.4 to 15 degrees Celsius during September sampling. Dissolved oxygen measurements ranged from 1.7 to 14.3 mg/l.

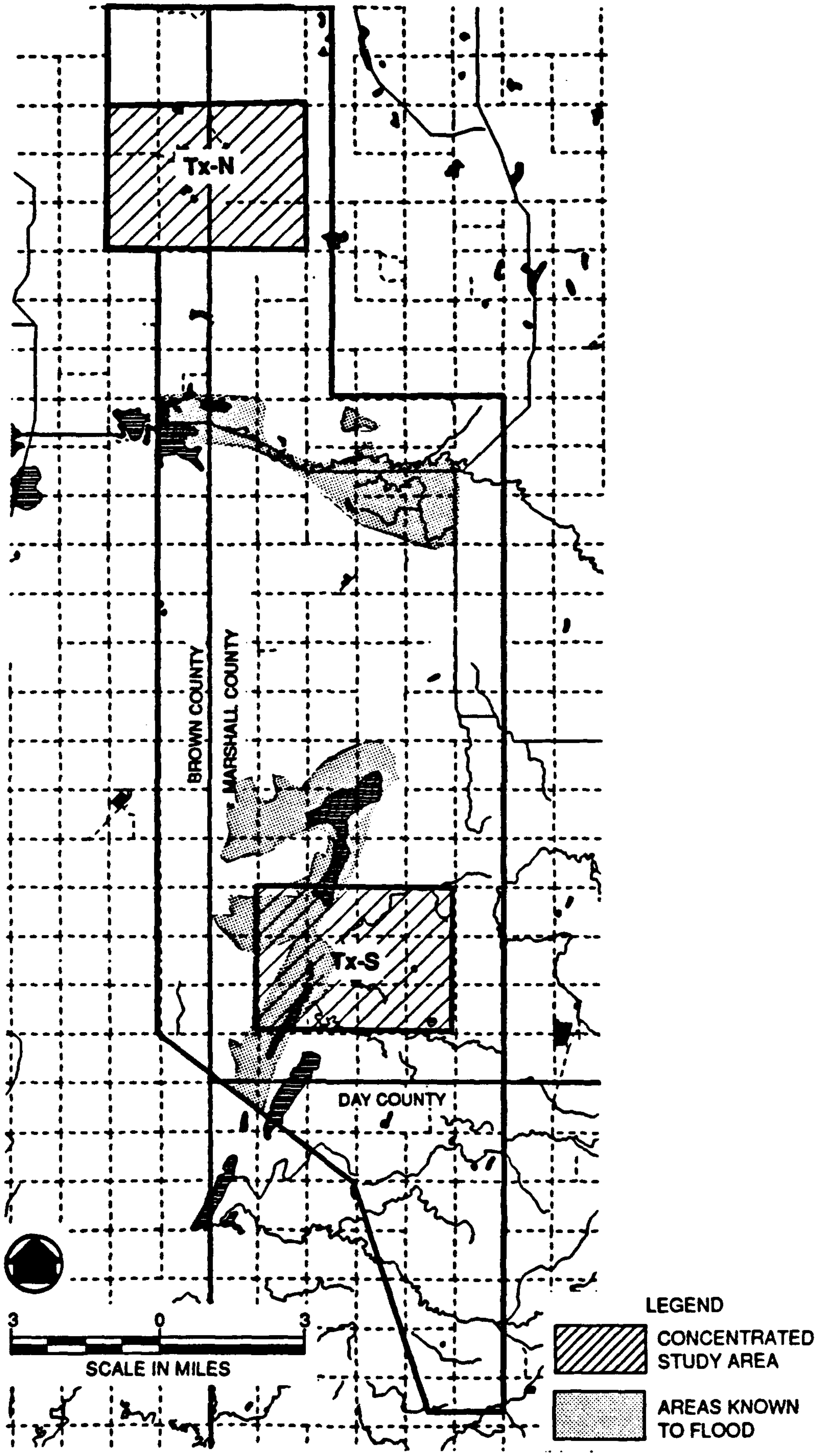


FIGURE 4-9. AREAS KNOWN TO FLOOD AT THE AMHERST SOUTH DAKOTA TRANSMIT STUDY AREA

TABLE 4-2. SURFACE WATER QUALITY STANDARDS OF SOUTH DAKOTA[a]

PARAMETER (mg/l unless noted)	CLASS 1	CLASS 2	CLASS 3	CLASS 4	CLASS 5	CLASS 6	CLASS 7	CLASS 8	CLASS 9	CLASS 10	CLASS 11
Alkalinity (as $CaCO_4$)									750		
Ammonia (un-ionized)		0.02	0.02	0.04	0.04	0.05					
Arsenic	0.05										
Barium	1.0										
Cadmium	0.01										
Chloride	250	100.0									
Chromium	0.05										
Cyanide (total)		0.02	0.02	0.02	0.02	0.02					
(free)		0.005	0.005	0.005	0.005	0.005					
Fluoride	2.4										
Lead	0.05										
Mercury	0.002										
Nitrates as N	10.0								50		
Selenium	0.01										
Silver	0.05										
Sulfate	500										
Fecal Coliforms (May 1 to Sept 30) (#/100ml)							200	1000			
Total coliforms (#/100ml)	5000										
Solids, total dissolved	1000								2500		2000
Solids, suspended		30	90	90	90	150					
Dissolved oxygen		>6.0[a]	>5.0	>5.0[b]	>5.0	>4.0	>5.0	>5.0			
pH	6.5-9.0	6.6-8.6	6.5-9.0	6.5-8.8	6.3-9.0	6.0-9.0	6.5-8.3	6.0-9.0	6.0-9.5		6.0-9.5
Temperature (°F)		65	75	80	90	90					
Total chlorine residual		0.02	0.02	0.02	0.02	0.02					
Hydrogen sulfide		0.002	0.002	0.002	0.002	0.002					
PCBs	0.000001	0.000001	0.000001	0.000001	0.000001						
Conductivity (umhos/cm at 25°C)									4000	2500	
Sodium, absortion ratio (SAR)										10	

Source: Title 74, Chapter 3, SD, 1984
a) In Spawning areas, dissolved oxygen >7.0 mg/l.
b) For Big Stone Lake and Traverse Lake, dissolved >6.0 mg/l in April and May.

4.2.1.4. Groundwater. Groundwater in the Amherst study area is obtained from confined bedrock deposits and from a complicated system of confined and unconfined aquifers in glacial drift (SCS, 1975). Two major aquifers lie below the transmit CSAs; the James Aquifer (closer to the surface) and the Dakota Aquifer (at greater depths). Depths to seasonal high groundwater levels can range from 1 to 3 feet below the ground (USAF, 1986). Groundwater levels in the western portion of Marshall County, where a portion of the Amherst study area lies, can vary from 1 to 40 feet below the ground level (USAF, 1986). Groundwater is the principal source of drinking water for the surrounding townships because of the highly transient nature of most surface water in the area.

4.2.1.4.1. Groundwater Hydrology of the James Aquifer. The James Aquifer is located in the north-central portion of Marshall County (Figure 4-10) and has narrow channels that extend southwest into Brown County. The northern part of the Tx-N CSA overlaps a portion of the James Aquifer. The aquifer is composed mainly of buried outwash deposits and alluvium from an ancient river and consists of sorted and stratified gravel, sand, and silt. Water in the aquifer occurs under artesian conditions and water levels range from 2 to 111 feet below land surface. The James Aquifer was estimated to contain 1.5 million acre-feet of water in storage in 1971. In areas where 40 or more feet of medium or coarser sand occurs, wells can yield up to 500 gpm under artesian pressure.

Recharge to the James Aquifer is primarily through percolation of precipitation and snowmelt through the overlying lake plain sediments and till. The portion of the aquifer which underlies the Tx-N CSA has been identified as an important recharge area because of the tendency of water salinity and water quality to deteriorate with distance from this area, and the higher soil permeability rates in this area (SCS, 1975).

Groundwater flow in the James Aquifer is in an easterly direction. Subsurface recharge to the James Aquifer supplements the surface recharge by inflow from the Middle James Aquifer in Brown County, and possibly additional aquifer areas in Day County (SCS, 1975).

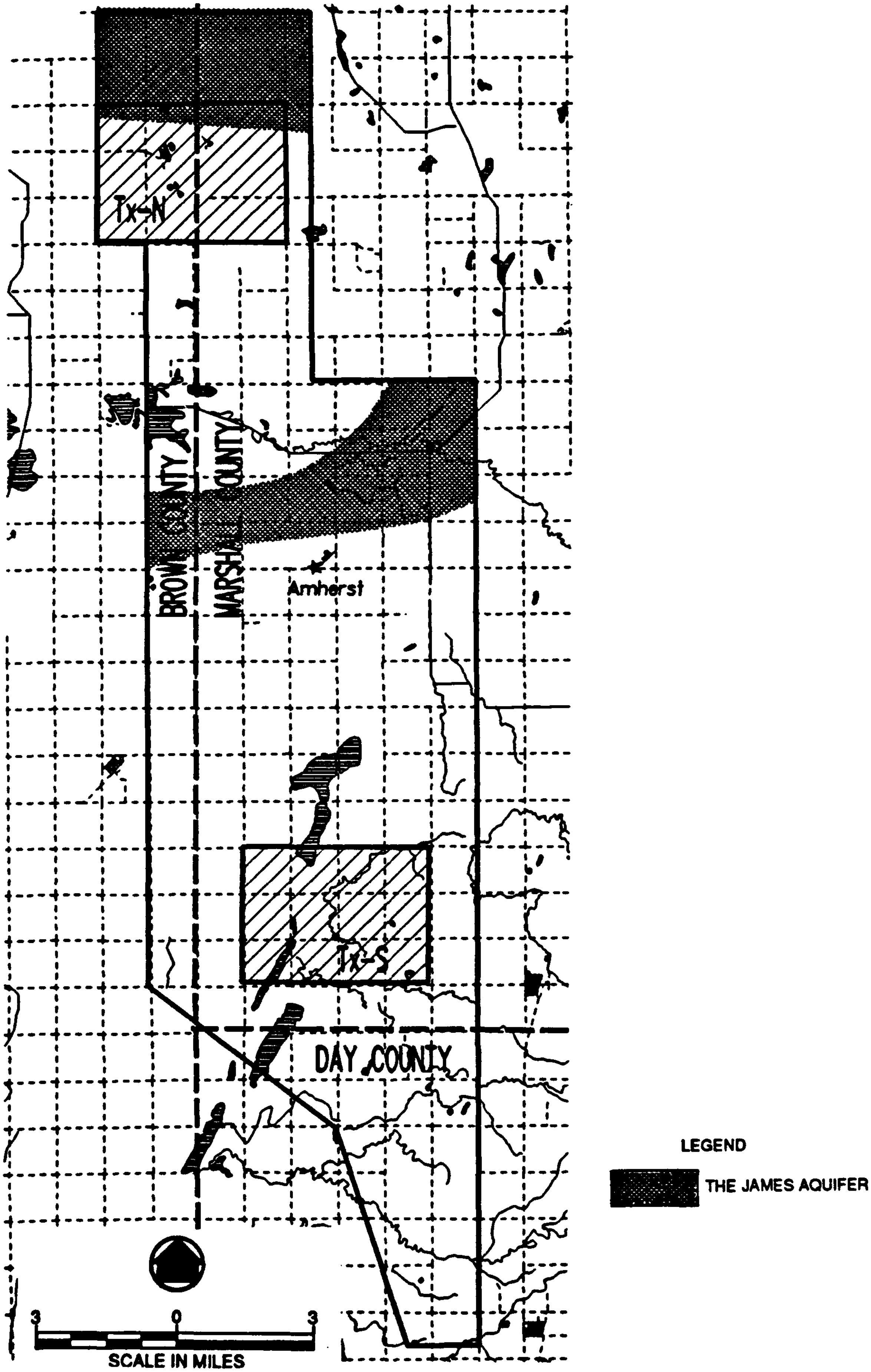


FIGURE 4-10. THE JAMES AQUIFER

4.2.1.4.2. Groundwater Hydrology of The Dakota Aquifer. The Dakota Aquifer is comprised of sandstone inter-bedded with shale. It underlies all of Marshall County at depths ranging from 900 to 1500 feet (Figure 4-11). Water is under artesian pressure and in low-lying areas many wells flow with yields as great as 200 gallons per minute (gpm). The Dakota Aquifer ranges from 100 to 250 feet in thickness.

The source of recharge to the Dakota Aquifer is not agreed upon by geologists and hydrologists who have studied the area, however all agree that local overlying or underlying aquifers are not the source. Recharge is thought to be either from downward leakage from aquifers in the Black Hills or the Rocky Mountains, or upward leakage from underlying aquifers in Central South Dakota (SCS, 1975).

The groundwater flow direction has changed from west-east to east-west since the early 1900's due to development of the aquifer which reduced the artesian pressure by as much as 300 feet The city of Britton provides an example of the impact of development on the Dakota Aquifer. When Britton's drinking water supply changed in 1970 from use of the Dakota Aquifer to White Lake, water levels in the aquifer rose by more than 20 feet in the following two years.

4.2.1.4.3. Groundwater Regulations. South Dakota groundwater quality is protected under Chapter 74:03:15 of the South Dakota State Laws. Groundwater which has an ambient concentration of 10,000 mg/L or less of total dissolved solids (TDS) is considered beneficial for drinking water purposes. Human health standards for drinkable groundwater have been developed and are presented in Table 4-3. No specific standards exist for groundwater exceeding 10,000 mg/L TDS, however a no further degradation policy requires a permit from the state to further degrade these waters.

4.2.1.4.4. Groundwater Quality of the James Aquifer. Water from the James aquifer near the Tx-N CSA is predominantly a sodium, sulfate and bicarbonate type. Hardness ranges from 110 to 260 mg/l. The results of field sampling at 19 wells (SCS, 1975) showed that chloride concentrations are fairly high in

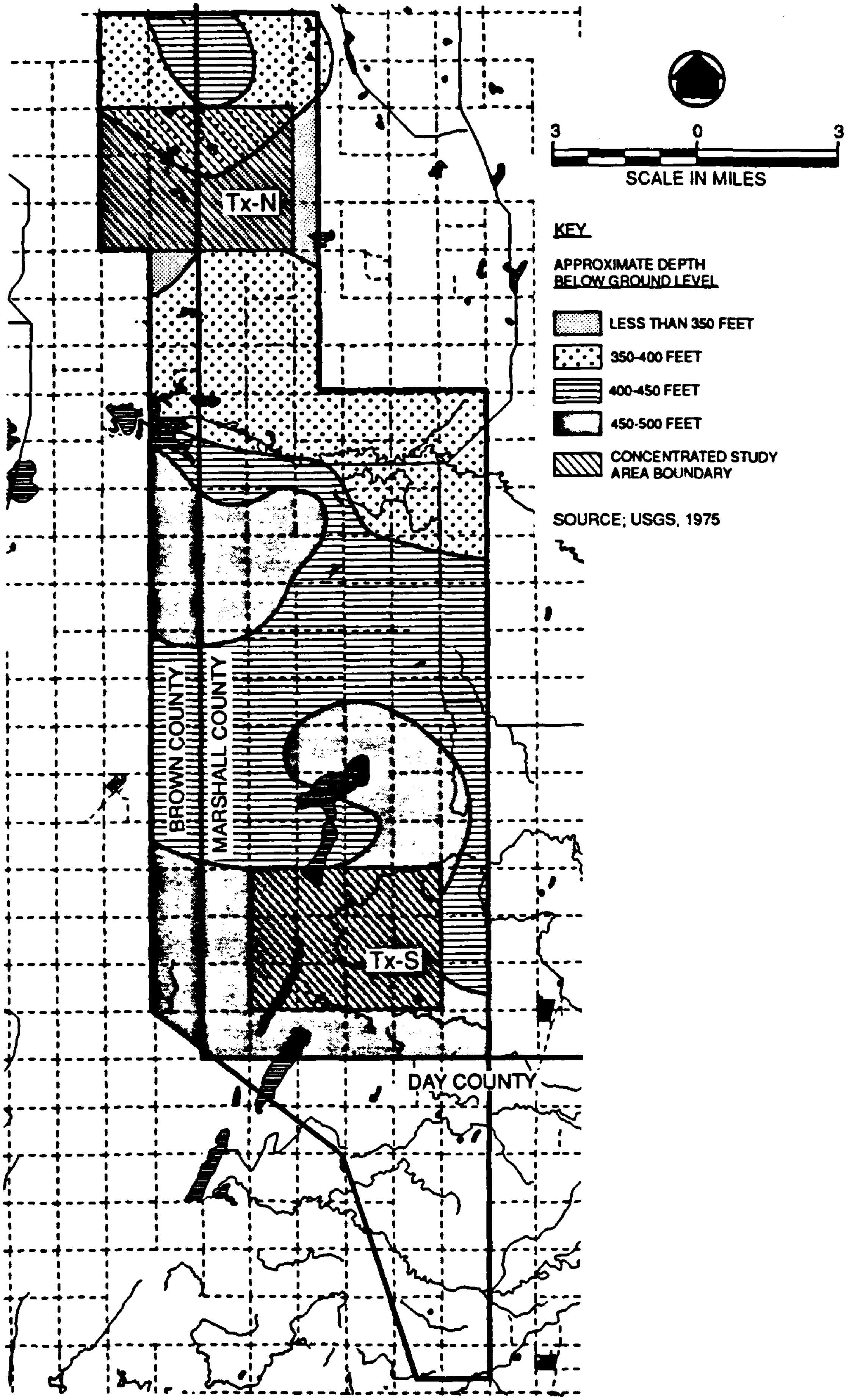


FIGURE 4-11. THE DAKOTA AQUIFER

TABLE 4-3. SOUTH DAKOTA GROUNDWATER STANDARDS

Contaminant	Level (mg/L unless otherwise noted)
Arsenic	0.05
Barium	1.0
Cadmium	0.010
Chromium	0.05
Copper	1.3
Cyanide	0.75
Fluoride	2.4
Lead	0.02
Mercury	0.002
Nitrate as N	10.0
Nitrite	1.0
Selenium	0.01
Silver	0.05
Endrin	0.0002
Lindane	0.004
Methoxychlor	0.1
Toxaphene	0.005
2,4-D	0.1
2,4-5-TP Silvex	0.01
Total Trihalomethanes	0.10
Fecal Coliform Bacteria	< 2.2/100 mL
Radium 226 and Radium 228	5.0 picocurries/L
Gross Alpha (to include Uranium)	15.0 picocurries/L
Trichloroethylene	0.005
Carbon Tetrachloride	0.005
Vinyl Chloride	0.002
1,2-Dichloroethane	0.005
Benzene	0.005
1,1-Dichloroethylene	0.007
1,1,1-Trichloroethane	0.200
para-Dichlorobenzene	0.075
Total Hydrocarbons	0.10
Polychlorinated biphenals	0.000001
Chloride	250.00
pH	6.5-8.5 units
Sulfate	500.0
Total Dissolved Solids	1000.00

Source: South Dakota State Law, Chapter 74:03:15

some areas of the James aquifer and can range from 8 mg/l to 152 mg/l. Specific conductance ranged from 950 to 2,000 micromhos/cm (at 25 degrees Celsius).

4.2.1.4.5. Groundwater Quality of the Dakota Aquifer. Water from the Dakota aquifer is of a sodium sulfate type near the Tx-N and Tx-S CSAs. Specific conductance ranges from 3,480 to 4,050 micromhos/cm and hardness ranges from 48 to 150 mg/l. Chloride concentrations range from 210 to 400 mg/l, while fluoride concentrations range from 2.8 to 9.3 mg/l (USGS, 1975).

4.2.2. Thief River Falls Study Area

The affected environment for the receive (Rx) study area includes two CSAs, Rx-West (Rx-W) and Rx-East (Rx-E) (Figure 4-12). Rx-East lies in the northwestern corner of Polk County, bordering Pennington County to the west and Marshall county to the north. Rx-West lies in the northeastern corner of Pennington County, bordering Marshall County to the north. The geology, climatology, flooding, and water quality of the Thief River Falls study area are discussed regionally because there is little variability between the two receive CSAs. The site hydrology and water resources have been examined individually for each CSA.

4.2.2.1. Geology. The Thief River Falls study area is located within the Red River Valley formed by the ancient glacial Lake Agassiz. Major stabilizations of water levels from Lake Agassiz created beach ridges. The most significant beach, where the water levels stabilized for almost 2,000 years is the Campbell Beach.

The ridges of the Campbell Beach run north-south through the Rx-E CSA as shown in Figure 4-13. The ridges of the beach range between 2 and 15 feet high and consist of sandy, gravelly soils. The inter-beach area, to the west of the beach, is primarily comprised of fine sand, clay, and silt. The inter-beach area is one of the nation's most poorly drained areas, which has prompted intensive ditching (Waters, 1977).

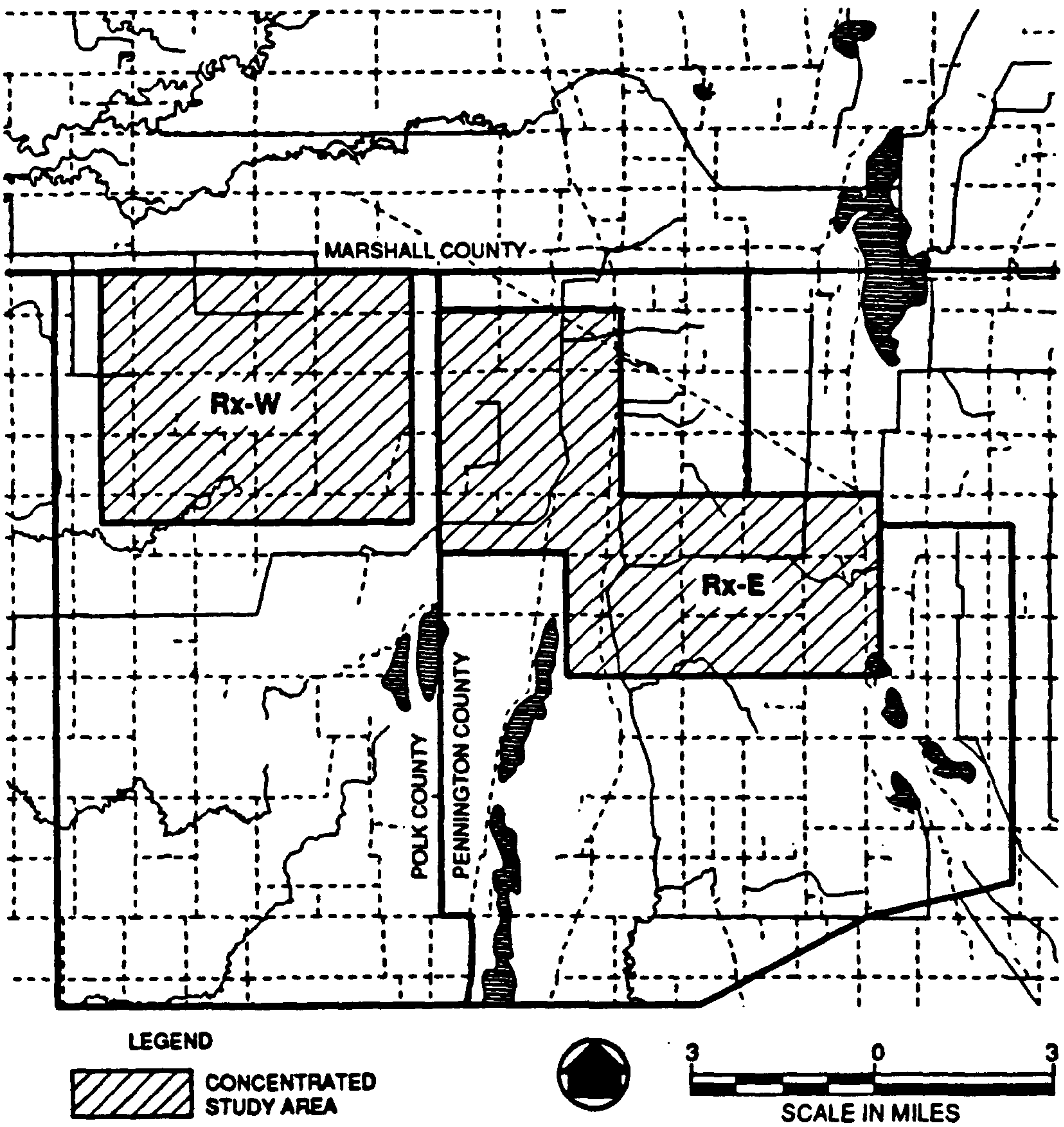


FIGURE 4-12. THIEF RIVER FALLS, MN RECEIVE STUDY AREA AND CONCENTRATED STUDY AREAS

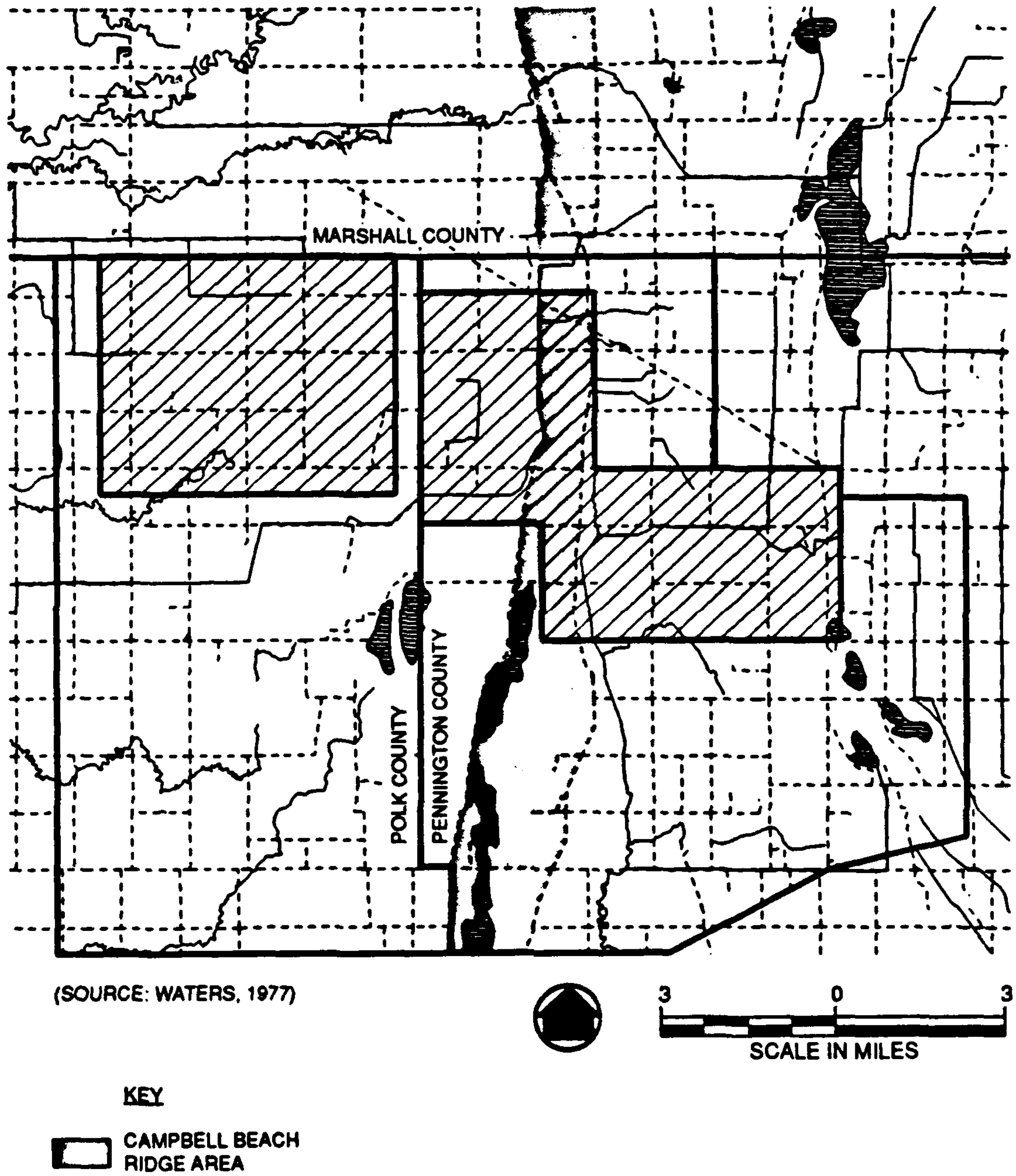


FIGURE 4-13. THIEF RIVER FALLS, MN RECEIVE STUDY AREA AND LOCATION OF CAMPBELL BEACH RIDGE

4.2.2.2. Climate. The Thief River Falls study area has a continental climate characterized by cold arctic winters with numerous winter storms and short summers of moderate temperatures. January and February are the coldest months with mean monthly temperatures of approximately 4 degrees Fahrenheit. The mean monthly temperature between April and September is 59 degrees Fahrenheit, of which July and August, the hottest months, have a mean temperature of 70 degrees Fahrenheit. Temperatures exceeding 100 degrees Fahrenheit have been recorded approximately 15 times in the last 60 years.

Annual precipitation in the Thief River Falls study area is approximately 19 inches. The greatest amount of precipitation, approximately 6.3 inches, occurs during the months of June and July when thunderstorms occur frequently. The least amount of precipitation, approximately 1.75 inches, falls as snow during the months of December, January, and February (Red Lake Watershed District, 1988). Table 4-4 presents an approximate frequency-duration estimate for a range of rainfall storm events in the Thief River Falls study area.

The soils in the Thief River Falls study area remain frozen for approximately two-thirds of the year (Maclay, 1972). Snow drifting is very common in the Thief River Falls area due to the high winds and flat topography. Erratic climatic conditions characterize the Thief River Falls area, which has a long history of severe droughts and flooding.

4.2.2.3. Receive CSA Surface Water Resources and Hydrology. The receive CSAs lie within the larger Red River of the North Watershed Basin (Figure 4-14), and within two more local watershed districts, the Red Lake Watershed District, and the Middle River/Snake River Watershed District (Figure 4-15). The watershed districts carry out the conservation requirements of the Minnesota Watershed Act, and include the regulation of activities affecting water resources, construction and finance of improvement projects, and long range district planning.

TABLE 4-4. AVERAGE RAINFALL DISTRIBUTION IN THE VICINITY OF THE THIEF RIVER FALLS, MN STUDY AREA

Frequency	Duration	Average Rainfall
2 year	24 hours	2.25 inches
5 years	24 hours	3.1 inches
10 years	24 hours	3.5 inches
25 years(1)	24 hours	4.0 inches
100 years	24 hours	6.9 inches

Source: US SCS, 1982.

(1) Rainfall value used in TR-20 model for Rx-E, and Rx-W.

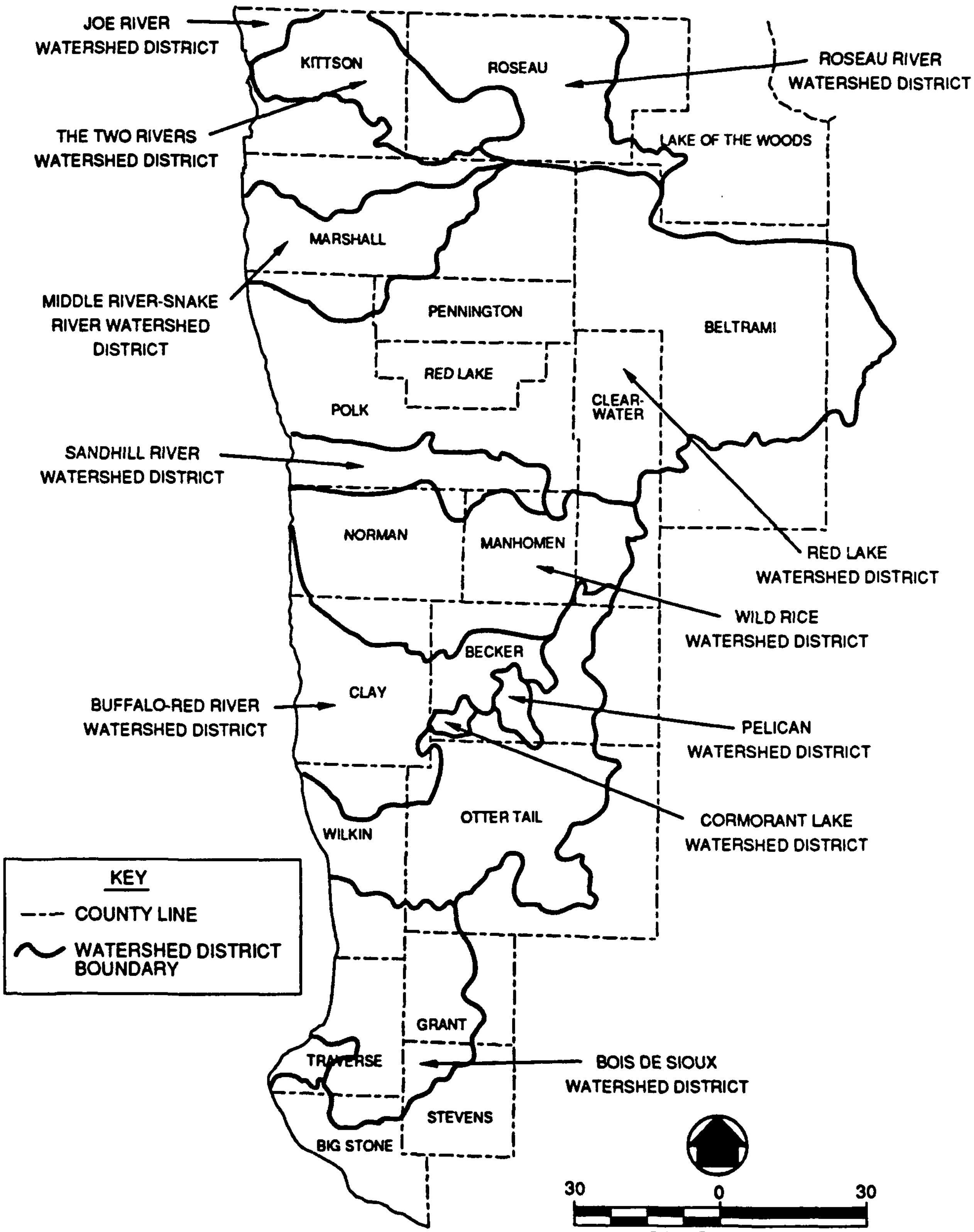


FIGURE 4-14. RED RIVER OF THE NORTH DRAINAGE BASIN

There are no major surface water bodies on either the Rx-E or Rx-W CSA. Goose Lake, a small lake located in the center of the Thief River Falls Study area, is the closest surface water body. This lake and its associated swamp area is designated by the Minnesota Department of Natural Resources (MNDNR) as a protected water of the state.

Several ditches and channels flow through the study areas primarily in a westerly direction. Major ditches in Minnesota are classified as county ditches, judicial ditches, or state ditches. Pennington County maintains judicial ditches located within Pennington County, and the Middle River/Snake River Watershed maintains Judicial Ditches located in Polk county. Several segments of the Judicial Ditch 25 lie within the receive CSAs as shown in Figure 4-16.

4.2.2.3.1. Rx-East. The northern part of the Rx-E CSA has a very flat topography, with the exception of the Campbell Beach area to the east which has a steeper slope (Figure 4-17). Surface water flows in a westerly direction following the natural grade. The eastern border of the CSA follows the watershed boundary at a relatively high elevation of 1010. Surface water flow to the east of the beach collects in Judicial Ditch 25. A small intermittent stream in the center of the CSA flows in a west southwest direction when filled with water.

Overland flow at the southern part of the Rx-E CSA also flows from east to west following the natural grade (Figure 4-18). A segment of Judicial Ditch 25 flows through the center of the area and discharges into the Black River to the west. The area to the north of Judicial Ditch 25 slopes slightly more to the northwest than west and discharges to the upstream reaches of the Black River. The area to the west of the beach ridge flows to the south into the Goose Lake swamp.

4.2.2.3.2 Rx-West. The topography of the Rx-W CSA is very flat and gently slopes to the west (Figure 4-19). Surface water flows from east to west following the natural grade. Surface water runoff collects in a system of roadside swales and ditched channels. A section of the Judicial Ditch 25 in

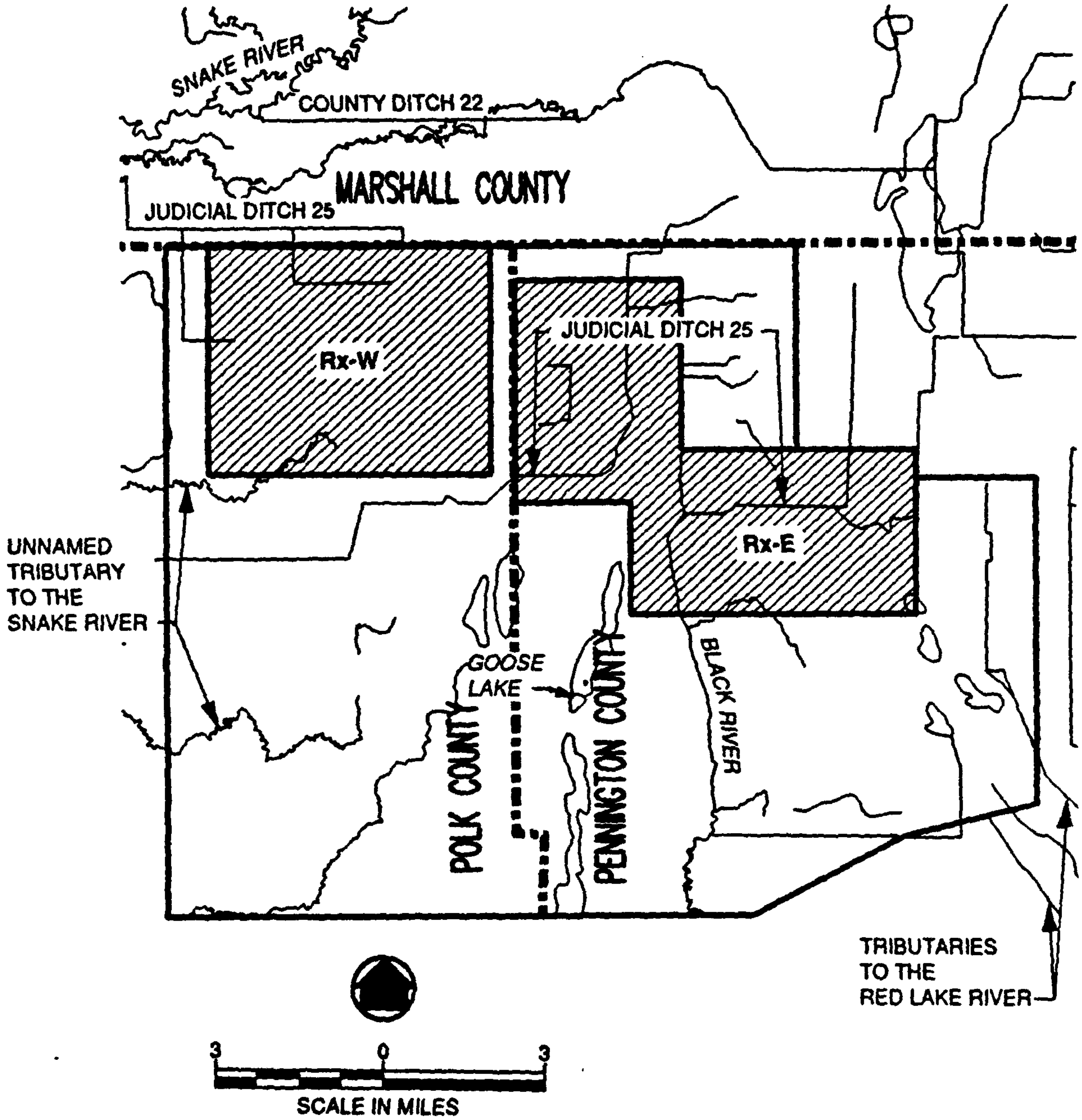


FIGURE 4-16. THIEF RIVER FALLS, MN RECEIVE STUDY AREA SURFACE WATER RESOURCES

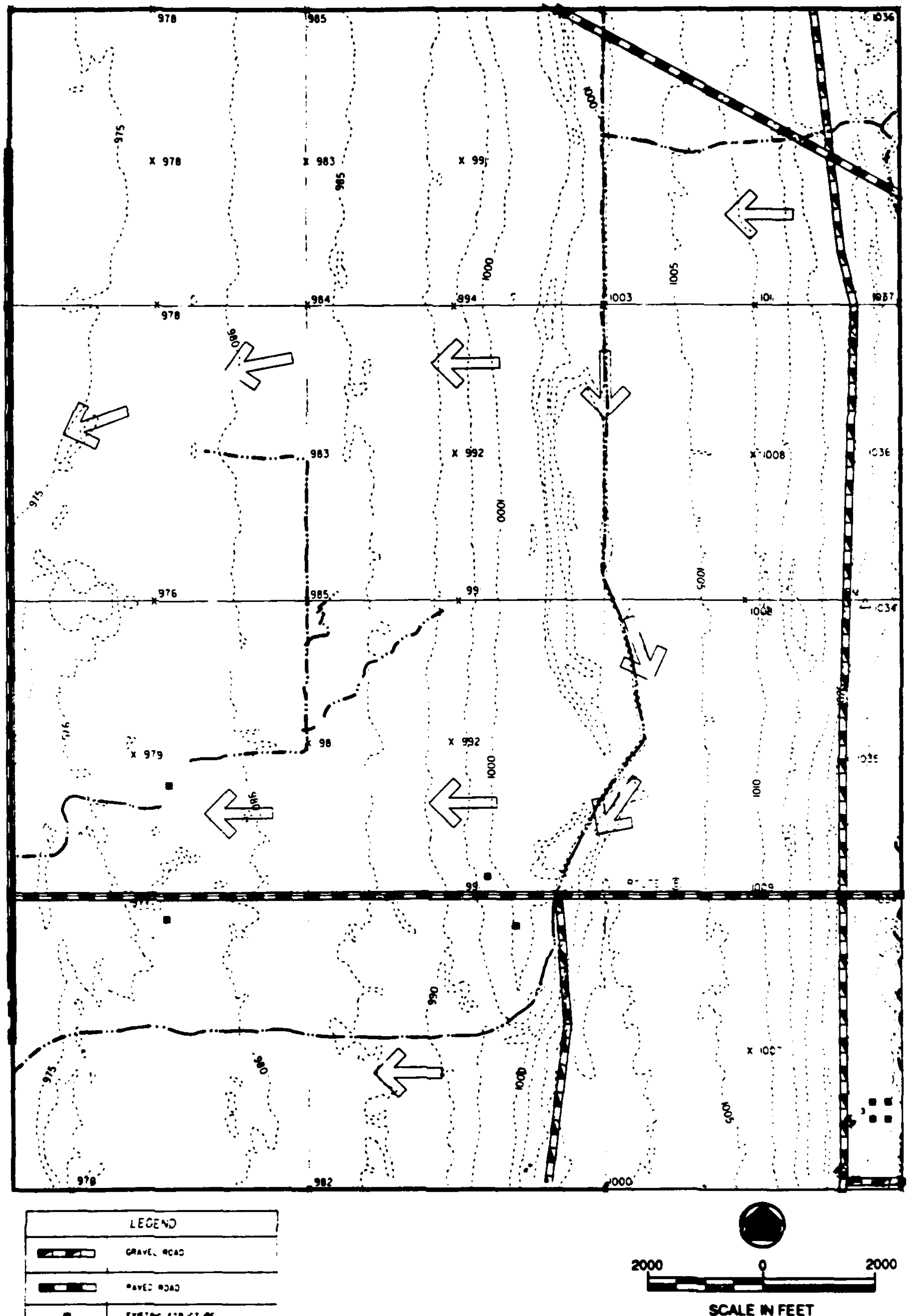


FIGURE 4-17. Rx-EAST CONCENTRATED STUDY AREA (WESTERN SEGMENT) SURFACE WATER FLOW

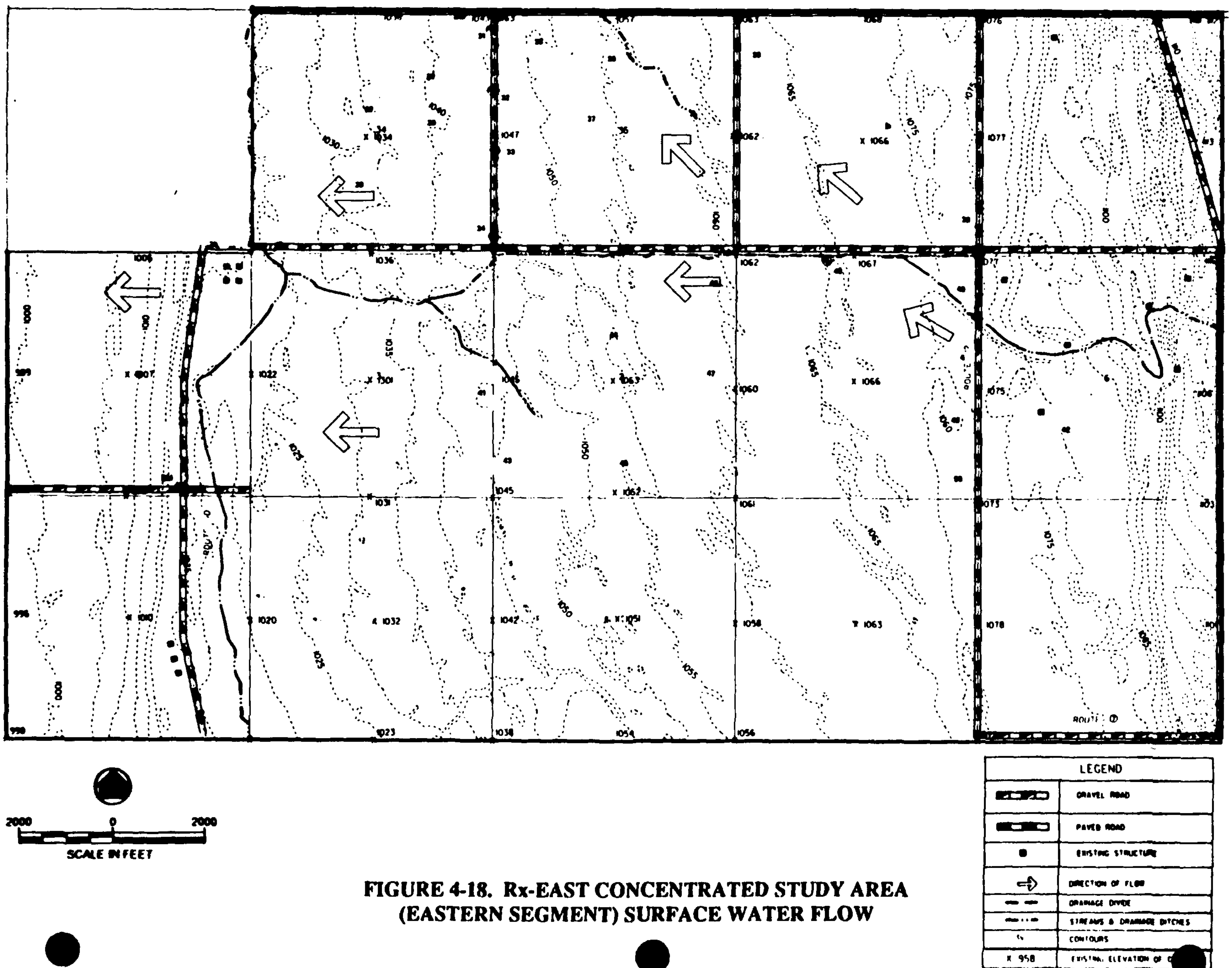


FIGURE 4-18. Rx-EAST CONCENTRATED STUDY AREA (EASTERN SEGMENT) SURFACE WATER FLOW

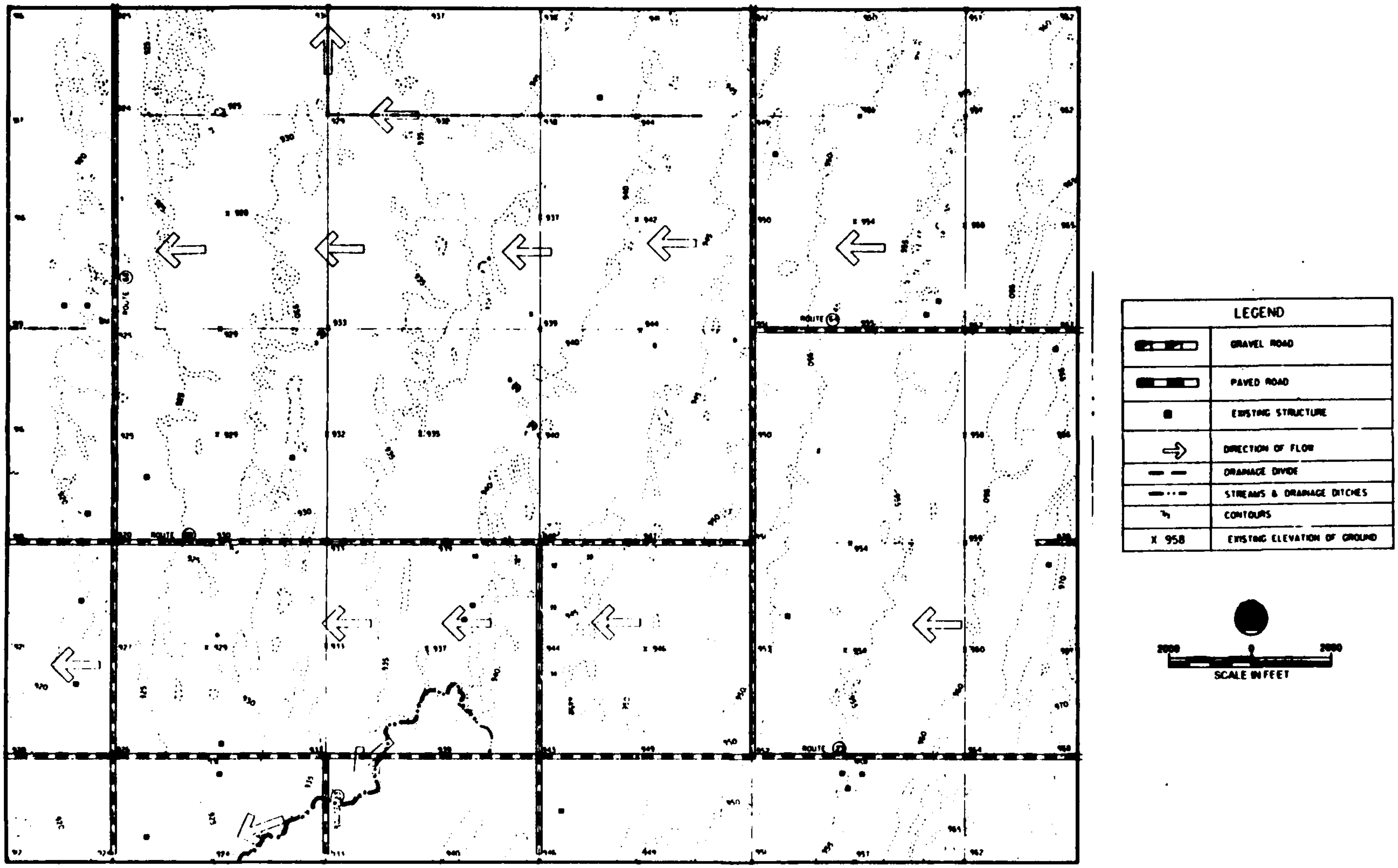


FIGURE 4-19. RX-WEST CONCENTRATED STUDY AREA SURFACE WATER FLOW

the north central portion of the CSA, carries surface flow off the site in a northerly direction, to the Snake River. A second unnamed ditch originates near the western edge of the CSA and carries surface flow to the west. Another segment of Judicial Ditch 25 which lies to the southeast of the CSA collects surface runoff westerly to the Red River of the North. A small intermittent stream channel in the southwest corner of the CSA carries surface flow in a southwesterly direction.

4.2.2.3.3. Flooding Potential. Federal Emergency Management Agency (FEMA, 1983) maps indicate that the two receive CSAs are not located within a 100-year flood zone. The area downstream of the receive CSAs has a long history of flood events particularly due to the flat topography and the northward flow of the Red River. The Red River of the North lies to the west of the receive CSAs and collects channelized flow throughout the Red River of the North Drainage Basin. During the spring snowmelt, the thaw generally begins in the southern reaches of the Red River of the North. The northern reaches of the Red River normally remain frozen longer, and can inhibit flow from southern upstream reaches. This aggravates flooding in upstream areas (Red Lake Watershed District, 1988).

Widespread damage from flooding has occurred in upstream areas of the Red River of the North approximately eight times in the past thirty five years including the years 1950, 1965, 1966, 1968, 1969, 1975, 1978, and 1979. The communities of Oslo, Argyle, Alvarado, and Warren in the Middle River/Snake River Watershed District experienced some of the heaviest flooding. These communities are located downstream of the Rx-W CSA and the northern section of the Rx-E CSA.

The greatest flood in the period of record occurred in 1969, however a greater historical flood in 1897 probably exceeded it (Middle River/Snake River Watershed District, 1971). In April, 1969 an inch of rain fell along with the equivalent of five inches of water from snowmelt, creating six inches of runoff. The peak flow of the Snake River reached 4,300 cfs (which has a channel capacity of about 1,400 cfs). Serious flood losses were experienced along both of the river and its tributaries.

The receive CSAs are believed to be in one of the areas less sensitive to flooding and no known flooding has occurred there (Middle River-Snake River Watershed District, 1989). The 1975 flood, which is said to be approximately equivalent to a 100-year storm, did not flood the CSAs (Middle River-Snake River Watershed District, 1989).

4.2.2.3.4 Surface Water Regulations. Chapter 750 of the Minnesota Rules regulates waters of the state. Both aquatic life and human health criteria are included and are presented in Table 4-5. In addition to standards, the Minnesota Rules classifies surface water bodies into the following seven use categories: aquatic fish and wildlife, domestic water supply, recreation, agricultural, industrial, navigation, and non-degradation. The Snake River and Goose Lake are classified for all of the above uses except for use as a domestic water supply.

4.2.2.3.5 Surface Water Quality. Since no major surface water bodies exist on the Rx-E or Rx-W CSAs, no on-site surface water quality data was available. The most locally available information was reported by the Red Lake Watershed District (Red Lake Watershed District, 1988). It is assumed that water quality of surface waters in channels and wetlands at the CSAs are of similar quality.

Surface water quality in the Thief River Falls area is generally low in total dissolved solids (less than 500 mg/l) and is suitable for domestic and agricultural purposes. The hardness of surface water varies within the watershed district with some surface waters less than 180 mg/l and others greater than 180 mg/l. The hardness of surface waters tends to fluctuate depending on flow levels. Purification would be necessary if surface waters were used for a drinking water supply.

4.2.2.4. Groundwater. Groundwater in the Thief River Falls study area is normally found in buried, confined lenses. Depth to seasonal high groundwater ranges from 1 to 3 feet (USAF, 1986). Surficial aquifers are usually low yielding due to fine aquifer materials. Some coarser textured aquifers along the beach ridges are higher yielding and can be used as sources of water supply.

TABLE 4-5. SURFACE WATER QUALITY STANDARDS FOR THE STATE OF MINNESOTA

PARAMETER (mg/l unless noted)	CLASS 1a, 1b, 1c[a]	CLASS 1d	CLASS 2a	CLASS 2b	CLASS 2c	CLASS 3a	CLASS 3b	CLASS 3c	CLASS 4a	CLASS 4b	CLASS 5	CLASS 7
Ammonia (un-ionized as N)			0.016	0.04	0.04							
Arsenic	0.01	0.05				0.01	0.05					
Barium	1.0	1.0				1.0	1.0					
Bicarbonates meq/l									5			
Boron									0.5			
Cadmium	0.01	0.01				0.01	0.01					
Carbon chloroform extract	0.2					0.2						
Chloride	250		50			50	100	250				
Chromium (hexavalent)	0.05	0.05	0.02	0.05	0.05	0.05	0.05					
Cyanide	0.01	0.02	0.02	0.02	0.02	0.01	0.02					
Copper	1.0		0.01	0.01	0.01	1.0						
Fluoride	1.5	1.5				1.5	1.5					
Hydrogen sulfide												
Iron	0.3					0.3						
Lead	0.05	0.05				0.05	0.05					
Manganese	0.05					0.05					0.02	
Nitrates	45					45						
Sodium									60% as meq/l			
Selenium	0.01	0.01				0.01	0.01					
Silver	0.05	0.05				0.05	0.05					
Sulfate	250					250			10			
Zinc	5					5						
Specific conductance (umhos/cm)									1000			
Total dissolved solids									700			
Total coliforms (MPN/100ml)	1					1						
Fecal coliforms (#/100ml)			200	200								1000[c]
Hardness						50	250	500				
Total residual chlorine			0.005	0.005	0.005							
Turbidity value	5		10	25		5						
Color value	15		30			15						
Odor, threshold number	3					3						
Oil			0.5	0.5	10							
MBAS	0.5					0.5						
Phenols			0.01	0.01	0.1							
Dissolved Oxygen			27	25.0	25.0							
Temperature			no increase	(b)	(b)							
pH			6.5-8.5	6.5-9.0	6.5-9.0	6.5-8.5	6.0-9.0	6.0-9.0	6.0-8.5	6.0-9.0	6.0-9.0	6.0-9.0
Total salinity										1000		

Source: Minnesota Pollution Control Agency, 1985a.
a) Turbidity value for Class 1c limited to 25 turbidity units.
b) 5°F above natural in streams, 3°F above natural in lakes.
c) Applies between May 1 and October 31.

Little is known about the exact locations of groundwater aquifers in the Thief River Falls study area. However, by characterizing general soil conditions, general conclusions on the availability of groundwater can be made. Most of the Thief River Falls study area consists of fine grained lake deposits and beach ridge material. Although fine grain lake deposits are not usually a source of water (USGS, 1970), large diameter wells or cattle ponds in the clay and silt intercept enough permeable material to maintain watering ponds for livestock. Beach ridge areas are usually saturated in their lower half to two-thirds depth. Yields of up to 20 gpm have been reached in these areas (USGS, 1970).

4.2.2.4.1 **Groundwater Regulations.** The state of Minnesota has recommended allowable drinking water limits, which are guidelines for testing when a drinking water well site is being selected. These are human health criteria and are presented in Table 4-6. In July, 1989, Minnesota passed the Minnesota Groundwater Protection Act which included a commitment to create and enforce groundwater standards. The Minnesota Pollution Control Agency and the Minnesota Department of Agriculture are the responsible agencies for implementation and enforcement of the act.

4.2.2.4.2 **Groundwater Quality.** Groundwater in the Thief River Falls study area typically has low chloride concentrations of 50 mg/l, an average hardness of 300 mg/l, and average sulfate concentrations of 200 mg/l (Maclay, 1972). Iron concentrations in the area have been reported as high, and in most areas the concentration exceeds 1 mg/l (Maclay, 1972).

The town of St. Hillaire, approximately 5 miles east of the study area, uses three wells that tap the glacial drift aquifer as a municipal water source (USAF, 1986). Water from these wells is of relatively good quality (MN Department of Public Health, 1985), but exceed the federal drinking water standard for sulfate.

During a study measuring pesticide contamination in groundwaters of Minnesota, eight wells near the concentrated study areas were tested. None of the tested wells indicated contamination from pesticides. Nitrate-nitrogen, which was

TABLE 4-6. MINNESOTA RECOMMENDED ALLOWABLE LIMITS (RAL) FOR DRINKING WATER WELLS

Compound	RAL (ug/l)
Acetone	700.0
Acifluorfen (Acid)	9.00
Acrylamide	0.10
Acrylonotrile	0.70
Alachlor	6.00
Aldicarb	10.00
Aldrin	0.02
Allyl Chloride	0.002
Ametryn	60.0
Ammonium Sulfamate	1500.0
Arsenic	50.0
Asbestos	71000000*
Atrazine	3.0
Barium, Barium Sulfate and Chloride	1500.0
Baygon (Propoxur)	3.0
Bentazon (Basagran)	18.0
Benzene	7.0
Bis (2-chloroethyl) ehter	0.3
Bromacil	80.0
Bromodichloromethane	140.0
Bromoform	140.0
Bromomethane	0.003
Butylate	50.0
Cadmium	5.0
Carbaryl	700.0
Carbofuran	36.0
Carbon Tetrachloride	2.7
Carboxin	700.0
Chloramben	105.0
Chlordane	0.3
Chlorobenzene (Monochlorobenzene)	300.0
Chlorodibromomethane (Dibromochloromethane)	140.0
Chloroform	57.0
Chlorothalonil	15.0
Chromium (Total)	120.0
Copper	1300.0
Cyanazine	9.0
Cyanide	154.0
Dacthal	3500.0
Dalapon	560.0
DDT	1.0
Di(20ethylhexyl)phthalate (bis--) (DEHP)	40.0
Diazinon	0.6
1,4-Dibromobenzene	70.0
1,2-Dibromoethane (Ethylene dibromide, EDB)	0.005
1,2-Dibromo-3-chloropropane (DBCP)	0.3

TABLE 4-6 (Continued). MINNESOTA RECOMMENDED ALLOWABLE LIMITS (RAL) FOR DRINKING WATER WELLS

Compound	RAL (ug/l)
Dicamba	9.0
1,2-Dichlorobenzene (ortho-)	620.0
1,3-Dichlorobenzene (meta-)	620.0
1,4-Dichlorobenzene (para-)	75.0
3,3-Dichlorobenzidine	0.2
Dichlorodifluormethane	1400.0
1,1-Dichloroethane	810.0
1,2-Dichloroethane	3.8
1,1-Dichloroethene	7.0
1,2-Dichloroethene (cis)	70.0
1,2-Dichloroethene (trans)	70.0
2,4-Dichlorophenoxyacetic acid (2,4-D)	70.0
1,2-Dichloropropane	5.6
1,3-Dichloropropene (cis-, trans-, mixture)	2.0
Dieldrin	0.02
Dimethrin	2100.0
2,4-Dinitrophenol	14.0
2,4-Dinitrotoluene	1.1
Dinoseb	3.5
p-Dioxane (1,4-Dioxane)	70.0
Diphenamid	200.0
1,2-Diphenylhydrazine	0.5
Disulfoton	0.3
Diuron	14.0
Endothall	140.0
Endrin	0.3
Epichlorohydrin	35.0
Ethylbenzene	680.0
Ethylene Glycol	14000.0
Ethylene Thiourea (ETU)	2.4
Fenamiphos	1.8
Fluometuron	90.0
Fonofos	14.0
Glyphosate	700.0
Heptachlor	0.08
Heptachlor Epoxide	0.04
Hexachlorobenzene	0.2
Hexachlorobutadiene (1,3-butadiene)	1.4
Hexachlorocyclohexane (HCH, alpha-)	0.06
HCH (beta-)	0.2
HCH (gamma-) (Lindane)	0.3
Hexachlorodibenzo-p-dioxin (HxCDD)	0.00006
Hexachloroethane	0.7
Hexazinone	210.0
Lead	20.0
Maleic Hydrazide	3500.0

TABLE 4-6 (Continued). MINNESOTA RECOMMENDED ALLOWABLE LIMITS (RAL) FOR DRINKING WATER WELLS

Compound	RAL (ug/l)
Mercury, Mercury Chloride or Sulfate	1.1
Methomyl	175.0
Methoxychlor	340.0
Methyl Ethyl Ketone (MEK, 2-butanone)	170.0
Methyl Isobutyl Ketone (MIBK)	350.0
Methyl Parathion	2.0
Methylene Chloride (Dichloromethane)	48.0
(MCPA) (4-Chloro-2-Methylphenoxy)-Acetic Acid	3.6
Metolachlor	10.0
Metribuzin	175.0
Nickel	150.0
Nitrate	10000.0
Nitrite	1000.0
N-Nitrosodimethylamine	0.007
N-Nitrosodiphenylamine	70.0
Oxamyl	175.0
PAH's (total carcinogenic)	0.028
PAH's (total noncarcinogenic)	0.28
Paraquat (dichloride salt)	3.0
Pentachlorophenol (PCP)	220.0
Phenol	280.0
Picloram	490.0
Polychlorinated biphenyls (PCB)	0.05
Prometon	100.0
Pronamide	52.0
Propachlor	92.0
Propazine	14.0
Propham	120.0
Selenium	45.0
Simazine	35.0
Styrene	0.1
Tebuthiuron	35.0
Terbacil	90.0
Terbufos	0.2
2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD)	0.000002
1,1,2,2-Tetrachloroethane	2.0
1,1,2,2-Tetrachloroethene	6.6
Tetrahydrofuran	154.0
Toluene	2420.0
Toxaphene	0.3
1,1,1-Trichloroethane	200.0
1,1,2-Trichloroethane	14.0
1,1,2-Trichloroethene (TCE)	31.0
Trichlorofluoromethane	2100.0
2,4,6-Trichlorophenol	18.0
2,4,5-Trichlorophenoxyacetic Acid (2,4,5-T)	21.0

TABLE 4-6 (Continued). MINNESOTA RECOMMENDED ALLOWABLE LIMITS (RAL) FOR DRINKING WATER WELLS

Compound	RAL (ug/l)
2,4,5-Trichlorophenoxypropionic Acid (Silvex)	52.0
1,1,2-Trichlorotrifluoroethane	210000.0
Trifluralin	2.0
Vinyl Chloride	0.15
Xylene (total m, p and o)	400.0

another pollutant of concern in the area was also tested for but was not detected. The study concluded that the combination of a low aquifer recharge potential and high organic content, fine-textured soil, and fine-textured subsoils resulted in a limited impact of pesticides on the groundwater in this region (MN Department of Public Health and MN Department of Agriculture, 1988).

4.3 METHODS

This section describes the evaluation methods used to analyze the hydrological impacts of the Over-the-Horizon Backscatter Central Radar System. It also discusses the process used to evaluate the USAF's preliminary site layout as well as best and worst case scenarios (from a hydrological perspective) within each CSA.

4.3.1 Evaluation Criteria

The following criteria were applied to preliminary site layouts at all four CSAs to predict impacts of constructing and operating the proposed radar facility.

4.3.1.1 Upstream Flooding. The maximum potential impact from flooding upstream areas due to the construction of the radar facilities was evaluated for each CSA by examining the size and location of upstream contributing drainage areas. The loss of on-site conveyance capacity and flood storage capacity, which can contribute to upstream flooding, was also examined.

A worst-case sector, or sector which had the largest upstream drainage area at each of the four USAF preliminary site layouts was also evaluated. The upstream drainage area for each worst-case sector was delineated and TR-20 was used to estimate upstream contributing flows from this area. The curve number developed for a sector's corresponding CSA was used to characterize runoff in the upstream area, and a time of concentration was computed which accounted for the existing flow patterns and topography. This estimate of upstream flows provides an estimate of the extent of hydrologic design required to re-route or divert upstream flows around the facility.

4.3.1.2 Downstream Flooding. The potential for downstream flooding due to facilities construction was evaluated by examining downstream areas with existing flooding problems, the addition of impervious surface areas by construction of facilities, the change in surface runoff from pre-construction to post-construction conditions, and the need to alter the existing drainage patterns at each CSA. In addition, the loss of any on-site retention capacity and flood storage capacity was examined due to the potential for affecting downstream flooding. These effects are discussed below.

4.3.1.3 Flood Storage Loss. The loss of flood storage, due to the addition of fill in the construction area, has the potential to create both upstream and downstream flooding impacts. The flood storage volume lost in areas known to flood was estimated. This was done only for the Tx-S CSA since it is the only CSA known to flood. This volume is presented for the area within the perimeter roads for the best and worst case scenarios, and the USAF's preliminary site layout. An average depth was estimated to determine the retention capacity of wetland areas.

4.3.1.4 On-site Conveyance Capacity. The amount of conveyance capacity lost due to the addition of fill in the construction area has the potential to create both upstream and downstream flooding impacts. The linear footage of major ditches and channels, roadside swales, and intermittent streams that will be filled at each CSA was evaluated. The total distance of channels and estimated volumes are presented for areas within the perimeter roads for the best and worse case scenarios, and for the USAF's preliminary site layouts.

A typical cross-section of each channel type (ditches, channels, swales, and streams) has been analyzed so that the significance of each channel could be prioritized. The volume of channels was estimated because of the large on-site variation and the dependency of channel conveyance capacity on parameters (slope, roughness, vegetation, material, etc.) found in Manning's Equation which is used to calculate open channel flow. A detailed hydraulic capacity analysis should be performed during the design stage when the facility location is finalized and additional information on channel configurations is available.

4.3.1.5 Surface Water Diversion. Additional impacts such as water deficits or excess created by diversions from existing flow patterns may occur at wetland areas. The potential for these impacts was evaluated by examining areas of the proposed facilities where existing drainage patterns would be difficult to maintain, and identifying wetland areas which are likely to be impacted by flow excess or deficits from these areas.

4.3.1.6 Surface Water Runoff. The U.S. Soil Conservation Service's (SCS) Technical Release Number 20 (1982 version), Project Formulation - Hydrology, (TR-20) was selected to compute surface water runoff at selected facility locations for pre-construction and post-construction scenarios. The change in surface water runoff from pre-construction to post-construction represents the hydrologic impact of site development on downstream areas. TR-20 uses procedures described in the Soil Conservation Service National Engineering Handbook, Section 4, Hydrology.

The State of South Dakota requires development projects to use the SCS Technical Release, Number 55 (TR-55) hydrologic model to evaluate downstream impacts from increased runoff (SCS, 1989). For this study, the SCS Technical Release, Number 20 (TR-20), which is a more sophisticated version of TR-55 was used because TR-55 will not accept a time of concentration (T_c) greater than two hours. The T_c exceeds TR-55's two hour limit for the transmit CSAs primarily because of the large site area. Therefore, TR-20 was used to generate peak discharges so that methods would be consistent and results comparable.

A typical antenna sector for each of the USAF's preliminary site layouts was selected for evaluation to estimate the size of the detention ponds required to attenuate the peak discharge. Although it was assumed that a detention basin or similar mitigating measure would be designed on a sector by sector basis, a variety of mitigation alternatives are discussed in the mitigation section (4.5). Since the selected typical antenna was the sector with the worst case attributes of the four sectors, this assumes a worst case for all other sectors. The results are therefore a conservative estimate of actual required detention basin sizes. A more comprehensive description of the TR-20 model and other constraints which affect the conservative estimate of site runoff are discussed in Appendix A.

4.3.1.7 Groundwater Quality. Potential groundwater quality impacts may result from a number of construction activities including wastewater treatment and disposal and fuel and hazardous materials storage and handling facilities. The recharge potential was also considered because impacts could be greater in areas with higher recharge due to the soil permeability and resultant migration of specific pollutants in recharge areas.

4.3.1.8 Surface Water Quality. Potential surface water quality impacts are possible from wastewater treatment and disposal, fuel and hazardous materials use and storage, and potential corrosion of the facilities groundscreen. The short-term construction and long-term operational impacts of soil erosion on water quality was examined by characterizing existing soils and considering the slopes at which these soils would likely erode or be transported by water. In addition the classification of downstream channels was examined and the potential for alterations of classification due to on-site activities will be described.

4.3.1.9 Groundwater Supply. Impacts to potential drinking water supplies were evaluated by assessing potential loss of existing natural groundwater recharge areas which may be blocked by the facilities construction, plus areas of recharge which may be enhanced by the construction of gravel mats. The recharge potential of the facility after construction, including impervious surface areas, and gravel surface areas is described.

4.3.1.10 Long-term Soil Erosion. The universal soil loss equation (USEPA, 1975) was used to compare the potential for long-term erosion at each of the CSAs. The equation is:

$$A = (R)\ (K)\ (LS)\ (C)\ (P)$$

where: A = average annual soil loss in tons

R = rainfall and runoff erosivity index

K = soil-erodibility factor

LS = site length and steepness factor

C = cover and management factor

P = supporting practices

The rainfall and erosivity index (R) is approximately 100 for both the transmit and receive sites. The K will differ from CSA to CSA depending on local soil properties. The LS and C factors are assumed to be the same for all transmit and receive facilities, and the P factor is assumed to be 1 because no support practices would be used. Since the K factor is the only variable which changes in the equation between CSAs, and all factors have a linear relationship, the K factor was used alone to compare the potential for long-term erosion impacts at alternative CSAs.

An overall K factor for each CSA was developed from the soil associations found at each CSA (Technical Study 6). Since the SCS develops K values for individual soil types, rather than associations, a weighted average of the K values for soils in each association was obtained and this was weighted by the percentage of each association in a CSA.

4.3.2. Facility Site Selection

In this study, the USAF's preliminary site layout is used to assess potential flooding impacts. A best and worst case facility siting scenario was also selected to present the possible range of impacts to hydrologic resource areas at each CSA. The USAF's preliminary site layout at each CSA is compared to best and the worst case scenarios (from a hydrological perspective) based on the presence of hydrological resources such as major channels, known flood areas, wetland flood storage areas, roadside swales, and intermittent streams. The selection of the best and worst case scenarios within the CSAs is described below.

4.3.2.1 Best-Case Scenario. The best-case scenario selected for each CSA minimizes the number of streams, surface water bodies, land within areas known to flood, major drainage ditches, and roadside swales and ditches requiring filling. The best-case scenario was located as close as possible to drainage ditches, roadside swales, or streams so that on-site runoff could be routed directly into these surface water bodies and so that the number of new drainage ditches required would be minimized.

4.3.2.2 Worst-Case Scenario. A worst-case scenario maximized filling of streams, surface water bodies, land within the 100-year floodplain, major drainage ditches, and roadside swales and ditches. If several site alternatives were judged as being equal based upon these criteria, the distance between the site and an existing drainage ditch or outlet was maximized.

4.4 ENVIRONMENTAL CONSEQUENCES

This section discusses the potential effects of the CRS facilities on hydrologic and water quality conditions discussed in Section 4.1 of this report. Potential mitigation measures which could be used to minimize these impacts are addressed in section 4.5. Site-specific mitigation will be more clearly defined in the project mitigation plan being prepared for the project, as described in Technical Study 1.

4.4.1. Transmit Site

Hydrologic and water quality impacts at the transmit sites have been evaluated using the methods and criteria described in section 4.3. The Tx-North preliminary site layout (Figure 4-20) is compared to the Tx-South preliminary site layout (Figure 4-21) for each criterion to establish a basis for further site evaluation.

4.4.1.1 Alteration of Hydrologic Patterns. Three potential causes of impacts in the hydrological environment are the augmentation of flow, loss of flow, and alterations to existing drainage channels on-site. These three impacts are discussed below.

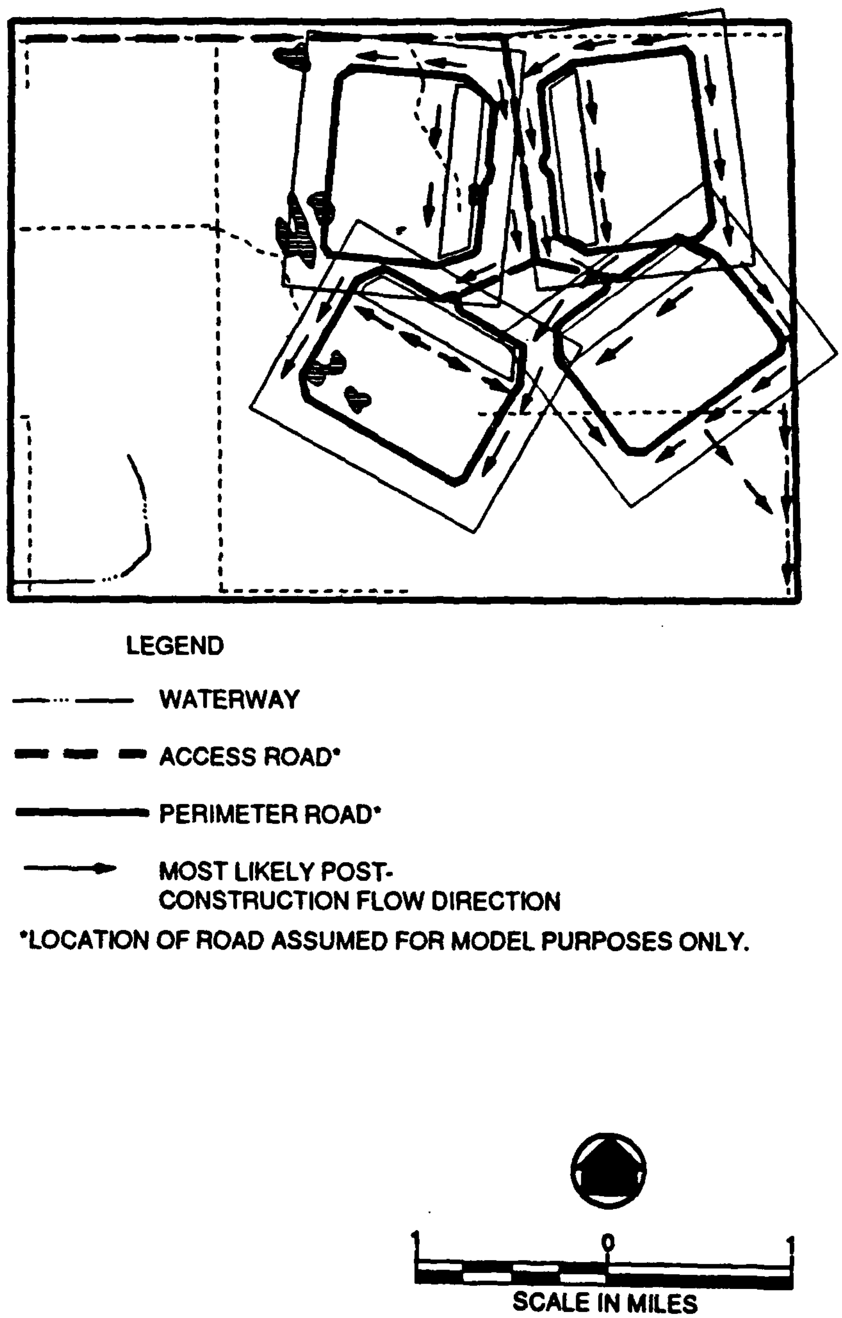
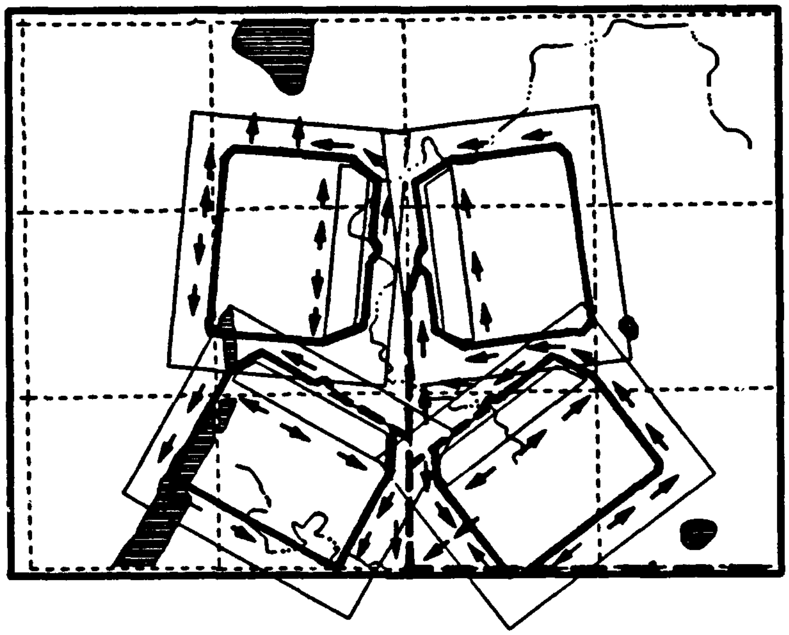


FIGURE 4-20. TX-NORTH PRELIMINARY LAYOUT AND POST-CONSTRUCTION ASSUMED FLOW PATTERNS



LEGEND

WATERWAY

ACCESS ROAD*

PERIMETER ROAD*

MOST LIKELY POST-CONSTRUCTION FLOW DIRECTION

*LOCATION OF ROAD ASSUMED FOR MODEL PURPOSES ONLY.

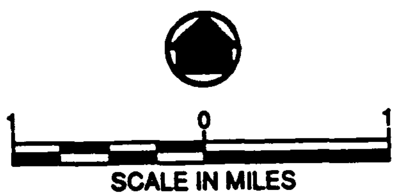


FIGURE 4-21. TX-SOUTH PRELIMINARY LAYOUT AND POST-CONSTRUCTION ASSUMED FLOW PATTERNS

4.4.1.1.1 Augmentation of Flow. The addition or augmentation of flow can occur due to increased runoff, loss of retention or flood storage capacity, or surface water diversion. Impacts from the augmentation of flow can occur in either upstream or downstream areas. Potential impacts created by the augmentation of flow due to the construction or operation of proposed transmit antenna facilities are described below.

4.4.1.1.1.1 Surface Water Runoff. A hydrograph, or description of how discharge of surface water runoff would change with time for a given watershed, was estimated at each of the transmit CSAs for a typical antenna sector during pre-construction and post-construction site conditions. Surface water runoff impacts are assumed to occur from augmented flow in downstream areas if post-construction peak runoff exceeds pre-construction peak runoff. The estimates were projected for a typical 25-year, 24-hour storm event.

A 25-year, 24-hour storm was selected because it is a typical design criteria used for engineering USAF facilities. If a storm event with a recurrence interval greater than 25 years occurred, short-term impacts beyond those identified in this document may occur. However, potential impacts which may be created by storms with a recurrence interval of 25 years or less are identified in this impact analysis. This analysis does not address runoff from snowmelt or frozen ground conditions. If these were included, the problems and differences between CSAs would be exacerbated. Mitigation measures such as those recommended in section 4.5 of this technical study can be incorporated into the final design to alleviate these potential impacts. A typical post-construction layout of drainage ditches and swales was assumed for this analysis. Figures 4-20 and 4-21 shows the locations of these channels for the Tx-North and Tx-South sites respectively.

The TR-20 input variables for the transmit CSAs include rainfall, curve number (which represents the permeability of a given soil and land cover combination) time of concentration, and contributing drainage area (Table 4-7). A more complete description of each of the input variables and how they influence runoff can be found in Appendix A. The time of concentration was the most critical factor in this analysis for distinguishing the pre-construction

TABLE 4-7. TRANSMIT CSA's TR-20 INPUT DATA AND ASSUMPTIONS

CSA/ Scenario	Rainfall (25 yr/24 hr) (inches)	Curve Number	Slope (ft./ft.)	Time of Conc. (hours)	Drainage Area (square miles)
Tx-North					
PRE-CONST.	4.2	83	0.004	2.73	0.8
POST-CONST.	4.2	83	0.005 (1)	2.87	0.8
Tx-South					
PRE-CONST.	4.2	90	0.0019	2.79	0.8
POST-CONST.	4.2	90	0.005 (1)	2.22	0.8

(1) Represents slope under groundscreen.
Assumes other areas will maintain pre-construction slopes.

conditions from the post-construction conditions. Flow tends to dissipate and the peak discharge is reduced as the flow pathway and time to travel through this path increases.

The flow length and slope are the most important parameters used to predict time of concentration. An increase in slope from pre- to post-construction creates a decrease in the time of concentration and thus an increase in peak runoff. The pre-construction and post-construction flow lengths used to develop the typical transmit sector for the Tx-N and Tx-S preliminary site layouts are shown in Figures 4-22 and 4-23.

The northwest sector of the preliminary site layout was assumed to be typical for Tx-N, and the northeast sector of the preliminary layout was assumed for Tx-S. The pre-construction flow path (based upon existing topography) followed a diagonal pattern across the antenna sector. The flow was initiated in different corners depending upon the local topography and direction the sector faces. The post-construction flow path will be directed away from the antenna groundscreen area by grading at an approximately 0.5 percent slope, and the original flow pattern would be resumed as soon as possible following any necessary channeling.

Using the TR-20 model, the peak discharge, or the maximum flow which would occur at the discharge outlet during a storm, was predicted for pre-construction and post-construction conditions. The excess volume of water generated due to post-construction development was also estimated. For the typical antenna sector at the Tx-N CSA, the pre-construction peak discharge was estimated at 315 cubic feet per second (cfs), and the post-construction peak discharge was estimated at 300 cfs. This reduction in flow is due to topographical conditions such as the routing path and changes in slope, which are used to calculate the time of concentration. The time of concentration is longer for post-construction conditions because grading under the groundscreen results in an increase in sheet flow from pre- to post-construction conditions. No storage volume would be required because the post-construction peak flow is lower than pre-construction peak flow. Flooding which occurs under the site's existing condition may even be reduced due to post-construction conditions.

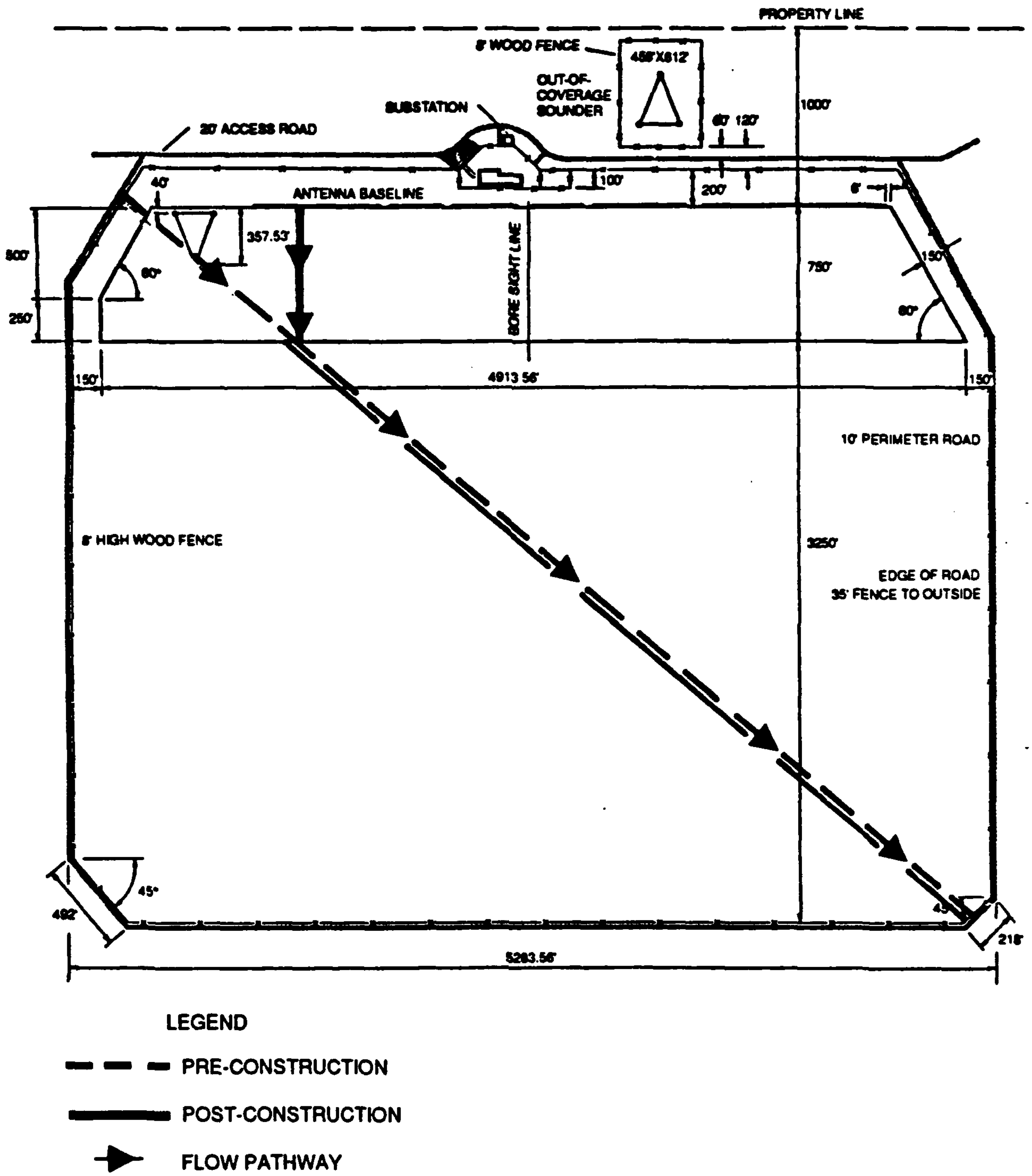


FIGURE 4-22. ASSUMED PRE- AND POST- CONSTRUCTION FLOW AT TYPICAL TX-N SECTOR

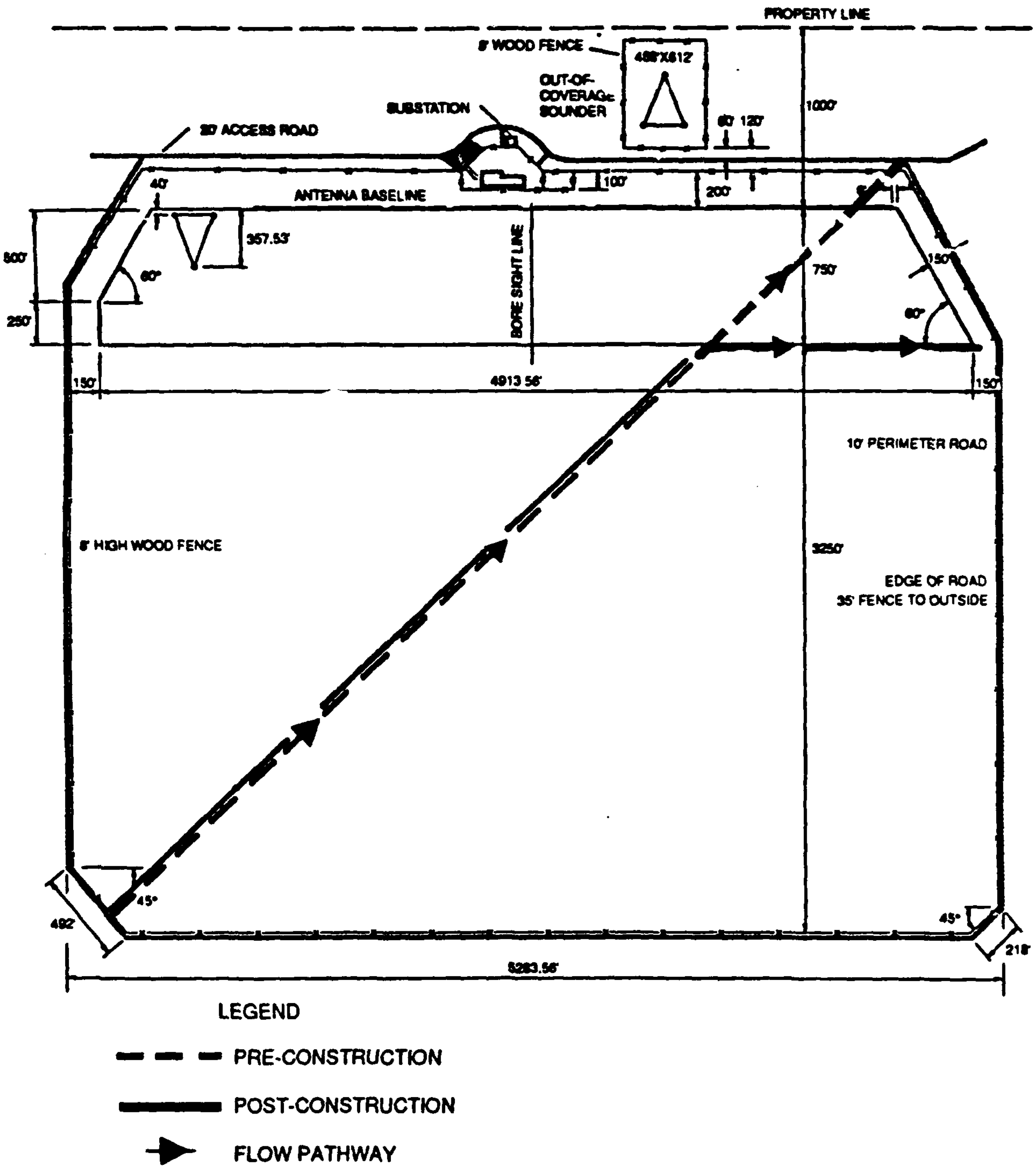


FIGURE 4-23. ASSUMED PRE- AND POST- CONSTRUCTION FLOW AT TYPICAL TX-S SECTOR

At the Tx-S CSA, the pre-construction peak discharge was estimated at 390 cfs, and post-construction peak discharge was estimated at 460 cfs. The storage volume of water which would be required to attenuate the peak post-construction flow was estimated at approximately 15 acre-feet. If this peak runoff occurred at all four sectors, the storage volume of water required to attenuate the peak flow generated from the entire Tx-S facility would be approximately 60 acre-feet.

4.4.1.1.1.2 Flood Storage Loss. The loss of flood storage capacity at the transmit CSAs was estimated by evaluating known flood areas, and estimating the depth of standing water during the wettest season for an average wetland. Although large drainage ditches could also maintain some flood storage capacity, the amount of storage would be minimal and so it is not evaluated here. Most channels (drainage ditches, streams, and roadside swales) act primarily to convey rather than store flow during storms.

Using the USAF's preliminary site layout for Tx-N, the average volume of flood storage capacity that would be filled to create the facility is approximately 670 acre-feet. This estimate only includes flood storage capacity loss due to filling in wetland areas because there are no other known flood areas at the Tx-N CSA.

Using the USAF's preliminary site layout for Tx-S, the average volume of flood storage capacity that would be filled or excluded for water storage is approximately 1700 acre-feet. This estimate includes approximately 265 acre-feet of flood storage capacity in wetlands and approximately 1440 acre-feet of flood storage capacity from known flood areas. Five hundred thirty acre-feet of the known flood area is also considered wetland, but only included in the estimate of known flood area. The Tx-S CSA would require more than twice as much mitigation of flood storage capacity than Tx-N.

4.4.1.1.1.3 Upstream Flooding. Upstream flooding at the transmit sites has the potential to occur if the proposed facilities are not constructed to properly divert pre-construction incoming flow around or through the facility. If existing flows from the upstream contributing drainage area are not considered within the final design, water could back up into upstream channels or over upstream farmlands and create flooding.

The potential for upstream flooding was evaluated by defining the upstream contributing drainage area(s) for each CSA and for a worst-case sector at each of the four preliminary site layouts. The upstream contributing drainage areas for the Tx-N CSA are shown in Figure 4-24. The size of the total contributing drainage area has been estimated as approximately 4.5 square miles. Since the Tx-N CSA is approximately 12 square miles, the total upstream drainage area is only 0.4 times as large as the CSA.

The upstream contributing drainage areas for the Tx-S CSA are shown on Figure 4-25. Flow enters this CSA from three different directions. Flow entering from the east represents the largest upstream drainage area, which originates on the edge of the Coteau de Prairie and extends for approximately 60 square miles. The total contributing drainage area has been estimated as approximately 67.5 square miles. Since the Tx-South CSA is approximately 12 square miles, the total upstream drainage area is approximately 5.5 times as large as the CSA.

The upstream flows were estimated for the worst-case sector at each of the preliminary site layouts. The worst-case sector was defined as the sector with the largest upstream drainage area. Upstream flows for the entire facility may be significantly increased over that projected for the worst-case sector only if incoming flows could travel from several different upstream areas to different sectors. For example, at the Tx-S CSA, total upstream flows to the facility are estimated to be twice the incoming flows at the worst-case sector, due to the contribution of two similarly sized drainage areas to the site layout. The TR-20 input parameters used to estimate upstream flows at the two worst-case transmit sectors are presented in Table 4-8. The upstream drainage area for the worst-case Tx-S sector is 8.25 square miles. This upstream drainage area is significantly smaller than the upstream drainage area for the entire Tx-S CSA because the location of the preliminary site layout as shown on Figure 4-25, avoids intercepting flows from the largest upstream drainage basin.

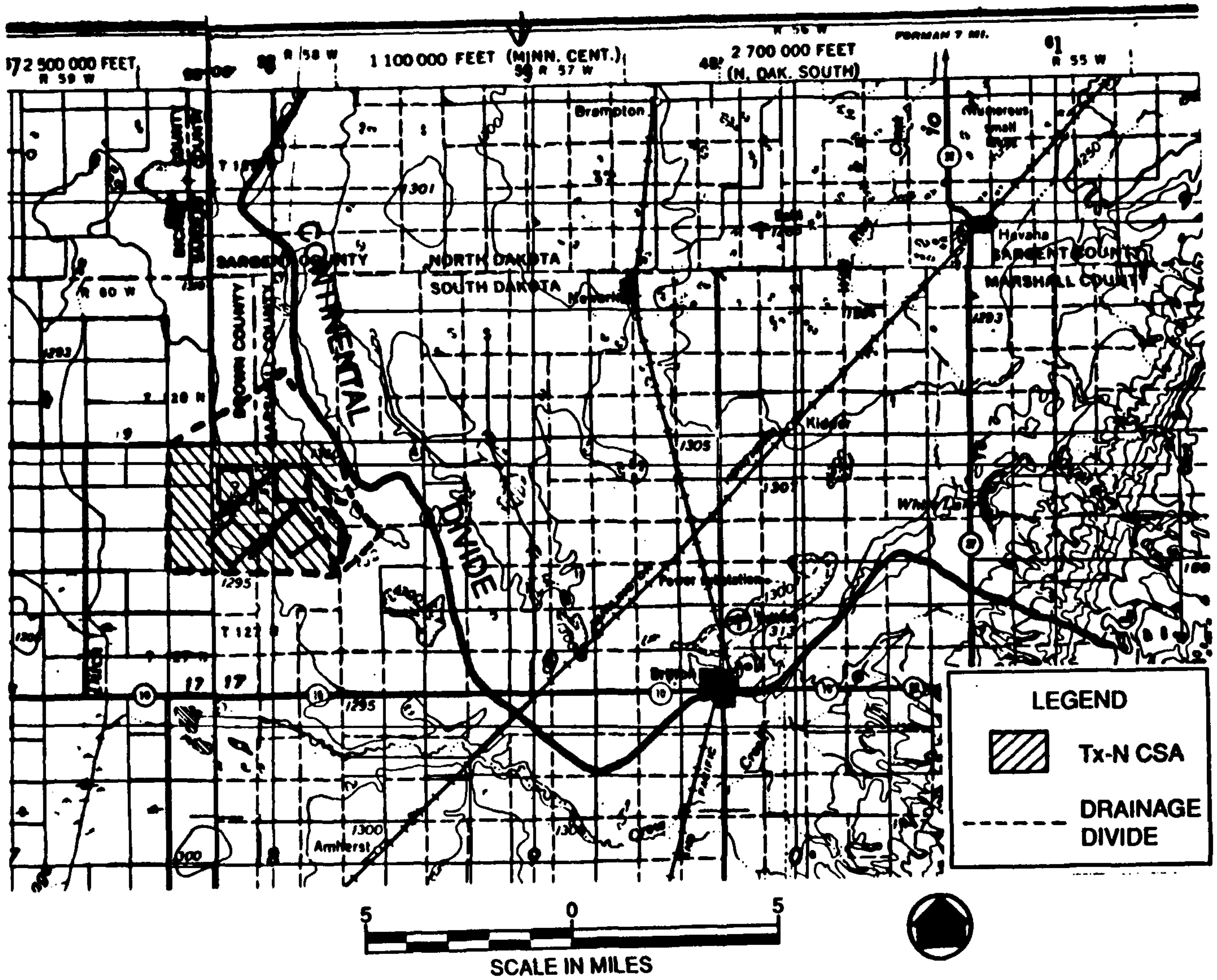


FIGURE 4-24. TX-NORTH UPSTREAM CONTRIBUTING DRAINAGE AREA

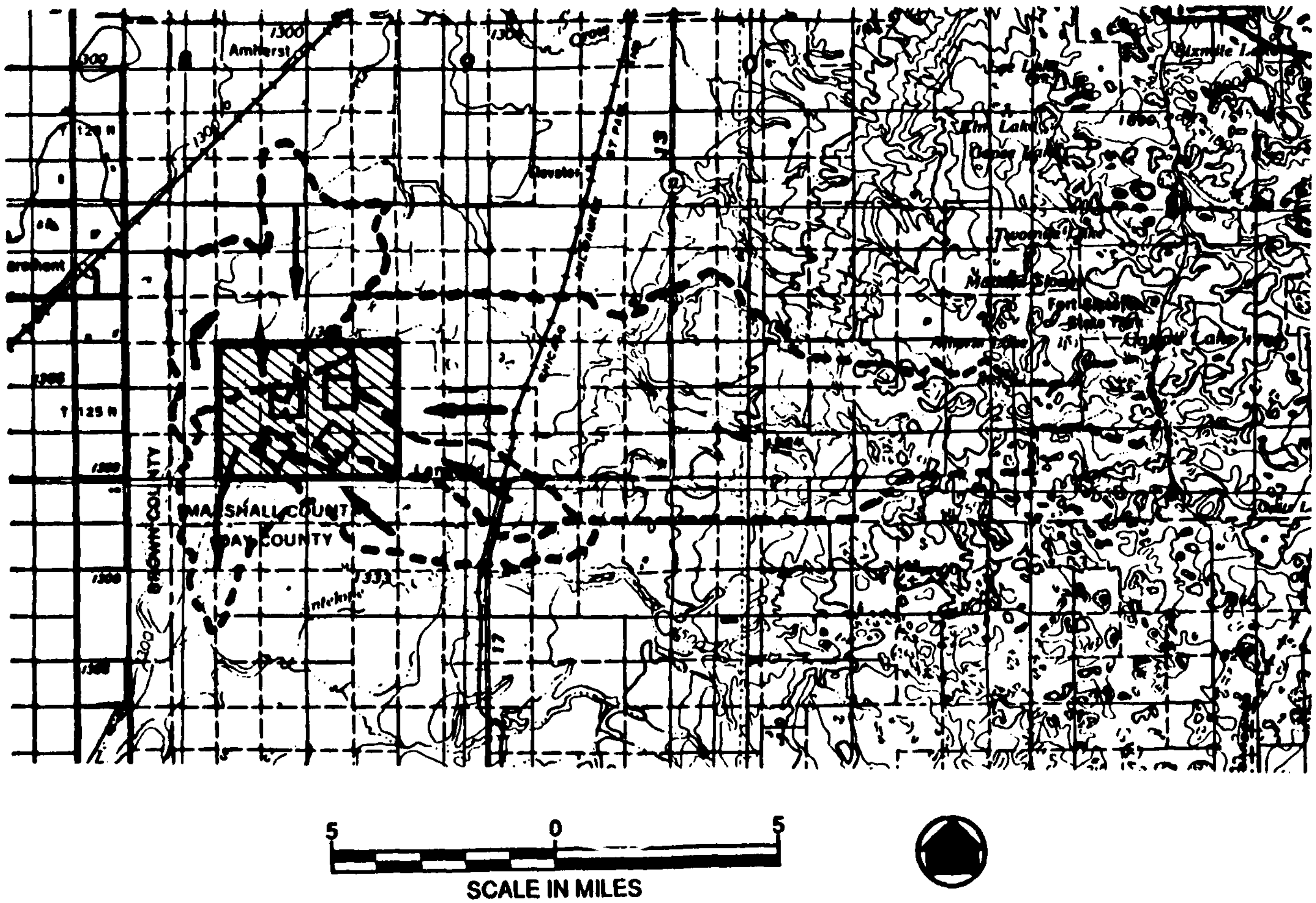


FIGURE 4-25. TX-SOUTH UPSTREAM CONTRIBUTING DRAINAGE AREA

TABLE 4-8. TR-20 ANALYSIS - UPSTREAM AREAS OF WORST-CASE TRANSMIT SECTORS

CSA Worst-Case Sector	Rainfall (24 hr/25 yr) (inches)	Curve Number	Slope (ft./ft.)	Time of Concentration (hours)	Upstream Drainage Area (square miles)	Upstream Flow (cubic feet/second)
Tx-N	4.2	83	.004	5.31	3.0	750
Tx-S	4.2	90	.01 .0024	12.65	8.25	1,220[a]

(a) The total upstream flow for the Tx-S facility is expected to be approximately twice the upstream flow of the worst-case sector because there are two similar upstream drainage areas contributing to the total preliminary site layout.

Although there is not a linear relationship between the size of the upstream drainage area and the amount of flow contributed from the upstream area, a larger upstream area would be expected to contribute higher flows. This flow must be redirected around the facilities and returned to its existing drainage area(s) in order to avoid or minimize upstream flooding impacts. Thus, the potential for upstream impacts from flooding would be much greater at the Tx-South preliminary site layout than at the Tx-North preliminary site layout.

The worst-case sector (southwestern sector) at the USAF preliminary site layout for Tx-N has an upstream drainage area of approximately 3 square miles, originating at the continental divide. The peak upstream flow during a 25-year, 24-hour storm were estimated to be approximately 750 cfs. The worst-case sector (northwestern sector) at the Tx-S CSA has an upstream drainage area of approximately 8.25 square miles. The peak upstream flows were estimated as approximately 1,220 cfs. Therefore, there would be greater flow diversion and re-routing requirements at Tx-S than at Tx-N if this CSA is selected for the facilities.

As an example of the magnitude of these flows, conservative assumptions were used to estimate the channel width necessary to convey these flows around the facility. If a single channel were used to convey these upstream flows around the Tx-N facility, the estimated bottom width of this channel could be as wide as 100 feet with a depth of approximately 1.5 feet. If one channel were used to convey upstream flows around the Tx-S facility, the estimated bottom width of this channel could be as wide as 160 feet with a depth of approximately 1.5 feet. Thus potential drainage impacts at Tx-S are considered to be significantly higher than those at Tx-N.

It should be noted that the bottom widths have been estimated strictly to convert the estimated upstream flow values into more tangible terms and should not be interpreted as actual design requirements. They are provided solely to allow comparison between CSAs.

Final drainage designs will determine the number, depth, and width of the drainage channels for the facility. It is likely that many channels in an overall drainage system for the facility would be developed to convey this flow. Each of the channel widths would be smaller depending on the number of channels and their location.

While conservative, these estimates indicate that extensive drainage mitigation could be required, particularly for the Tx-S CSA. These measures might include one or more of the following: 1) upstream diversionary channels or detention areas; 2) culverts underneath the facility; or 3) periodic use of the groundscreen area to store peak flood flows. The final choice of mitigation measures will be determined following site selection, during the final system design phase. The magnitude of these upstream flows could be a significant criterion for site selection.

4.4.1.1.1.4 **Downstream Flooding.** Flooding impacts downstream of the proposed facility could be caused by several factors including (1) the loss of on-site retention capacity such as floodplain and wetland storage; (2) over-sizing of replacement ditches and roadside swales; (3) an increase in surface water runoff from pre- to post-construction site conditions, and (4) changes in the existing drainage pattern which would re-route flow from one downstream direction and increase flow to another downstream direction.

Areas downstream of Tx-North which are known to flood include along the Crow Creek Drainage Ditch below the Portage-Detroit Ditch, and to the southeast of Tx-N (MC ASCS, 1989). Tx-North could lose as much as 670 acre-feet of on-site retention capacity, as described in section 4.4.1.1.1.2. Increases in surface water runoff from pre-construction to post-construction conditions would be expected to occur, as described in section 4.4.1.1.1.1. If replacement ditches, roadside swales, and culverts installed under roadways are over-sized for the incoming flow, the increased conveyance capacity could add to the flooding of downstream areas.

Tx-North has a fairly low potential for requiring rerouting of existing flow patterns from one downstream area into another because existing drainage patterns follow one general direction, from the northeast to the southwest. Only a small area on the eastern portion of the CSA flows more directly south. However, the USAF preliminary site layout does not overlap this area.

The upstream flows from the contributing drainage areas for both Tx-N and Tx-S are expected to be large, requiring extensive channels to re-route incoming flows around the facility. Although minor flooding impacts are possible at Tx-N, proper site design should be able to minimize these impacts. Tx-S will potentially incur more extensive flooding impacts, requiring a more complex system of drainage structures to attenuate peak flood flows.

The Tx-S preliminary site could lose as much as 1700 acre-feet of on-site retention capacity as was described in section 4.4.1.1.1.2. Increases in surface water runoff from pre-construction to post-construction conditions would be expected to occur as was described in section 4.4.1.1.1.2. If replacement ditches, roadside swales, and culverts installed under roadways are over-sized for the incoming flow, an increased volume of water could travel faster and add to the flooding of downstream areas.

The Tx-S preliminary site has a high potential for requiring rerouting of existing flow patterns from one downstream area into another, because of the complicated system of existing drainage patterns. Pre-construction drainage patterns will be more difficult to maintain after site construction and grading. This becomes even more difficult as the number of upstream and downstream areas increase.

Since the Tx-S CSA has three upstream drainage areas with flows coming from different directions, and two downstream outlets, maintaining pre-construction drainage patterns would be complex. The volume of flow entering the site which would require rerouting would also be much larger than the Tx-N site because the upstream contributing drainage area is so much larger.

4.4.1.1.2 Loss of Flow. Potential impacts could be created by the loss of both surface water and groundwater due to construction and operation (e.g. well drawdown) of the proposed facility. A diversion of flow to a different downstream area would create an excess in one downstream area, and a deficit in the original downstream area. A reduction in groundwater levels could occur if pumping rates for the facility wells were greater than the natural recharge, or groundwater recharge was blocked by the construction of impervious areas such as buildings over high recharge areas.

4.4.1.1.2.1 Wetlands/Surface Water. The Tx-N CSA has a lower potential for downstream water deficits from surface water diversion because there is essentially only one incoming and outgoing flow direction, with the exception of the small area mentioned previously. The Tx-S CSA has a relatively high potential for downstream water deficits from surface water diversion due to the complexity of existing drainage patterns presently coming into the site. Wetlands and surface waters downstream have the potential to be impacted by both surface water deficits and excesses.

As indicated by the results of the wetlands functional analyses (see Technical Study 6) wetlands at Tx-N provide slightly better wildlife habitat values than Tx-S, which would be indirectly affected by the facilities. Tx-S wetlands typically provide slightly higher values for sediment stabilization and retention than those found at Tx-N. These values could be adversely impacted by upstream facility development.

The site drainage plan will be designed, to the maximum event possible, to ensure that water levels in existing wetlands (except for those filled for the project) would remain constant, and that compensatory flows would be provided if site grading alters existing drainage patterns. Therefore, potential off-site impacts to wetlands are not expected to be significant.

4.4.1.1.2.2 Water Supply. The transmit facility will utilize a water supply system which includes a well behind each antenna sector. Each of these wells would be designed with a pumping rate of approximately 0.5 gpm, for a total pumping rate of approximately 2 gpm. During construction, temporary wells with a total pumping rate ranging from 35 to 70 gpm would be utilized. The USAF or their system contractor will coordinate water appropriations needs with the South Dakota Department of Water and Natural Resources.

To determine the impact of the proposed pumping rates on the existing aquifers, the pump rates were compared to any known information on aquifer yields, and the relationship between recharge rates and pump rates. In addition, the potential for impacting important recharge areas was considered.

The Tx-North wells could be pumped from either the Dakota Aquifer or the James Aquifer. The James Aquifer underlies the most northern portion of Tx-N, so only the northernmost one or two antenna sectors would have access to it. This aquifer has been estimated to have a volume of approximately 1.5 million acre-feet of water storage in 1971, lies from 2 to 111 feet below the surface, and extends over approximately 220 square miles. Water is under artesian pressure, yielding as much as 500 gpm, much more than the facility would require.

The Tx-S CSA wells would be pumping from the Dakota Aquifer, located between 900 to 1500 feet below the surface. This aquifer extends over approximately 890 square miles and supports approximately 225 wells in Marshall County alone (SCS, 1975). Water is under artesian pressure, yielding as much as 200 gpm, much more than the facility would require. Because recharge to the aquifer is subsurface from aquifers located far to the east and west, development of the proposed facility would not impact any important recharge areas. No impacts to the Dakota Aquifer would be expected.

4.4.1.1.2.3 **Groundwater Recharge.** Because recharge to the James Aquifer is primarily through percolation of precipitation and snowmelt, development over recharge areas may reduce recharge. The impact of facility construction on groundwater recharge was evaluated by examining the curve numbers, or runoff coefficients used in the TR-20 model.

The TR-55 model was used to generate curve numbers for pre-construction and post-construction conditions. The curve numbers selected using the TR-55 model were the same for pre-construction and post-construction at both of the transmit CSAs, because: 1) the impervious areas to be constructed cover a relatively small percentage of the total facility area; and 2) the curve number which TR-55 uses for gravel areas similar to the CRS facilities was similar to pre-construction curve numbers. These models and inputs to the selection of the curve number are more fully described in Appendix A.

The curve number represents the percentage of precipitation which will run off a given drainage area without considering a time factor (versus the peak discharge which considers time). The remaining amount would either be lost to evaporation, transpiration, or infiltration. It is assumed that no significant alteration of evaporation, transpiration or infiltration would occur with construction of the facility as the gravel and other borrow material used for site preparation will have similar characteristics to the existing soil conditions. Thus, no significant changes are expected to groundwater recharge due to the construction of the proposed facility at the transmit sites.

4.4.1.1.3 **Drainage Channels.** Filling channels to construct the proposed facilities could create significant impacts and cause severe upstream flooding. Improper sizing of replacement channels could also create either upstream or downstream flooding impacts. The predominant channel types found at the transmit sites are major channels and drainage ditches, roadside swales, and intermittent streams.

Major drainage ditches can be as large as 20 feet wide and 10 feet deep. A blockage or diversion in a major drainage ditch has the potential to impact a very large upstream area and alterations to these channels can promote region-wide concerns. The only major ditch at the transmit sites is a ditch in the southwest corner of the Tx-N CSA which flows southwest to the Portage-Detroit Ditch, to the Crow Creek Drainage, and eventually to the James River.

An unnamed drainage swale in the northeast corner of the Tx-S CSA was also considered a major channel for the purposes and definitions of this study. This channel has a large upstream contributing area (approximately 60 square miles) and the potential impacts from filling this could be significant.

The presence of roadside swales was based on field investigations which led to the following assumption for the study areas: dirt roads do not have roadside swales; gravel roads have roadside swales on one side; and paved roads have roadside swales on both sides. Roadside swales are typically smaller than major drainage ditches and can range from 0.5 to 3 feet deep and from 2 to 10 feet wide. Roadside swales can have extensive connections to upstream and downstream areas, especially in the midwest where roadways are constructed in a grid system.

Intermittent streams are usually found in low lying areas where they carry water to seasonal wetlands. The flows carried by intermittent streams are usually very low and only exist during high runoff periods.

Best and worst case scenarios were used to evaluate the range of potential impacts from filling drainage channels. In the selection of the best and worst case scenarios, each of the resources were ranked by hydrologic importance with known flood areas and wetlands ranked equal and first, major drainage ditches ranked second, roadside swales ranked third, and intermittent streams ranked fourth.

The Tx-N CSA does not have any known flood areas, roadside swales, or intermittent streams. The only major ditch at the Tx-N CSA is located in the far southwest corner and can easily be avoided.

At Tx-S, a large trade-off was made between flood storage and major drainage ditches, and roadside swales and intermittent streams. Although the best case scenario was better for the two more important resources (flood storage and major ditches), it was worse than the USAF preliminary site layout for the roadside swales and intermittent streams. In the selection of best and worst-case scenarios it was impossible to avoid known flood areas, roadside swales, and intermittent streams. However, the major drainage channel could be avoided if more of other resources were compromised.

Table 4-9 presents an estimate of the acre-feet of flood storage and wetland areas, and the linear yards of major drainage channels, roadside swales, and intermittent streams affected by construction of the facility for best-case, worst-case, and USAF preliminary site layouts. The table indicates that selection of Tx-S for the facilities will result in significantly higher losses in overall flood storage capacity than Tx-N, although Tx-N wetland storage losses are comparable to Tx-S.

4.4.1.3 Water Quality. The proposed facility activities which could potentially cause surface water or groundwater impacts are erosion, wastewater treatment facilities, hazardous materials stored on site, or impacts from corrosion of facilities.

TABLE 4-9. POTENTIAL RANGE OF IMPACTS TO FLOOD STORAGE CAPACITY AND DRAINAGE CHANNELS AT TRANSMIT CSA'S

Rank of Importance	1A	1B	2	3	4
	Flood Storage (1) (acre-feet)	Wetland Storage (1)(2) (acre-feet)	Major Ditches (linear yards)	Roadside Swales (linear yards)	Intermittent Streams (linear yards)
Tx-North					
Preliminary Site Layout	0	700	0	0	0
Best-Case	0	600	0	0	0
Worst-Case	0	1000	0	0	0
Tx-South					
Preliminary Site Layout	1400	300	500	4000	6000
Best-Case	500	400	0	9000	7000
Worst-Case	500	1200	300	11,000	6500

(1) Assumed an average depth of 3 feet in wetlands and flood areas.

(2) Wetland best- and worst-case volumes were taken from the wetland study (Technical Study 6) best- and worst-case scenarios. All other best- and worst-case volumes and lengths were taken from hydrologic best and worst case scenarios.

4.4.1.3.1 Erosion Impacts. Water quality could be adversely affected from both short-term and long-term erosion (both water and wind) created by construction and operation of the facility. Erosion could create turbidity in downstream waters, and sediment transported by water tends to collect in and block channels thereby reducing the hydraulic capacity of the channel. Short-term erosion impacts would be created during construction because of exposed excavated areas. There is potential for long-term erosion impacts due to the elevated grade at which the facilities would be constructed.

Since there are no major water bodies on any of the CSAs, erosion impacts to downstream drainage ditches, roadside swales, and intermittent streams are the primary concern. Areas constructed with steep slopes would be more susceptible to erosion than areas with flatter slopes and some soils are more susceptible to erosion than others. A variety of standard erosion-control measures are available for use during construction of the facilities to minimize impacts from erosion. These will be specified in the project mitigation plan, and can include silt curtains, sedimentation control basins, vegetative treatments, and dust control measures. Prompt site revegetation and proper maintenance of channels should prevent any significant impacts from wind erosion.

The universal soil loss equation (USEPA, 1975) was used to compare the potential for long-term soil loss due to natural erosion at the transmit CSAs. The only factor in the equation which differs from Tx-N to Tx-S is the K-factor, or soil erodibility factor, which depends upon local soil properties. Soils in the Tx-N CSA were estimated to have a K factor of approximately 0.19, and soils at the Tx-S CSA have been estimated to have a K factor of approximately 0.29. Therefore, the potential for long-term soil erosion in tons/year is estimated to be approximately 50 percent greater at the Tx-S CSA than the Tx-N CSA.

4.4.1.3.2 Wastewater Disposal. Wastewater facilities could include an on-site storage tank or a septic tank with leach fields. Potential impacts to groundwater would be created if leachate contaminates adjacent water supplies, or is unexpectedly spilled from a holding tank. If a septic system is constructed, it will be located and designed in accordance to the criteria for the design of wastewater collection and treatment facilities published by the South Dakota Department of Water and Natural Resources. These criteria require the design to minimize the impacts on the groundwater system. Therefore, no significant impacts would be expected to occur.

If no leach field site at the selected CSA is available which would meet wastewater regulations, alternative wastewater facilities would be constructed. If a wastewater holding tank is constructed, raw sewerage could enter surface or groundwater systems through an accidental spill. If proper handling methods are used, the impact can be prevented.

4.4.1.3.3 Hazardous/Industrial Materials. Potential impacts could occur to surface and groundwater in the event of an accidental spill. Any hazardous materials generated on-site will be stored, transported, and disposed of in accordance with all applicable state and federal regulations. The materials will be stored and transported in containers approved by the U.S. Department of Transportation (DOT) and the U.S. Environmental Protection Agency (EPA), and hauled off-site by an EPA-approved contractor.

Potential water quality impacts due to increased vehicle traffic (and resulting runoff of fuel oils and lubricant) would be highest during the peak construction period. The magnitude of these potential impacts is dependent upon the sites selected, final borrow requirements, and borrow source locations.

All storage facilities and handling areas will be addressed in a site specific Spill Prevention, Containment, and Countermeasure (SPCC) Plan. State and federal resource agencies will review the plan to ensure that spill containment facilities, contingency plans, and preventative maintenance procedures minimize the potential for impact to ground and surface waters.

4.4.2 Receive Site

Hydrologic and water quality impacts at the receive sites have been evaluated using the methods and criteria described in Section 4.3. The Rx-East CSA and preliminary site layout is compared to the Rx-West CSA and preliminary site layout for each criterion to establish a basis for further site evaluation.

4.4.2.1 Alteration of Hydrologic Patterns. As with the transmit site, three potential causes of impacts in the hydrological environment are possible at the receive site. These are augmentation of flow, loss of flow, and alterations to existing drainage channels. These three impacts are discussed below.

4.4.2.1.1 Augmentation of Surface Water. The addition or augmentation of flow can occur due to increased runoff, loss of retention or flood storage capacity, or surface water diversion. Impacts from the augmentation of flow can occur in either upstream or downstream areas. Potential impacts created by the augmentation of flow due to the construction or operation of proposed receive antenna facilities are described below.

4.4.2.1.1.1 Surface Water Runoff. A hydrograph representing surface water runoff was estimated at each of the receive CSAs for the typical case antenna sector during pre-construction and post-construction site conditions. The estimates were projected for a typical 25-year, 24-hour storm event for the same reasons as were described for the transmit CSAs.

A typical post-construction layout of drainage ditches and swales was assumed for this analysis. Figures 4-26 and 4-27 show the locations of these channels for the Rx-East and Rx-West sites respectively.

The TR-20 input variables for the receive CSAs include rainfall, curve number, time of concentration, and drainage area, and are presented in Table 4-10. A more complete description of each of the input variables and how they influence runoff can be found in Appendix A. The time of concentration was

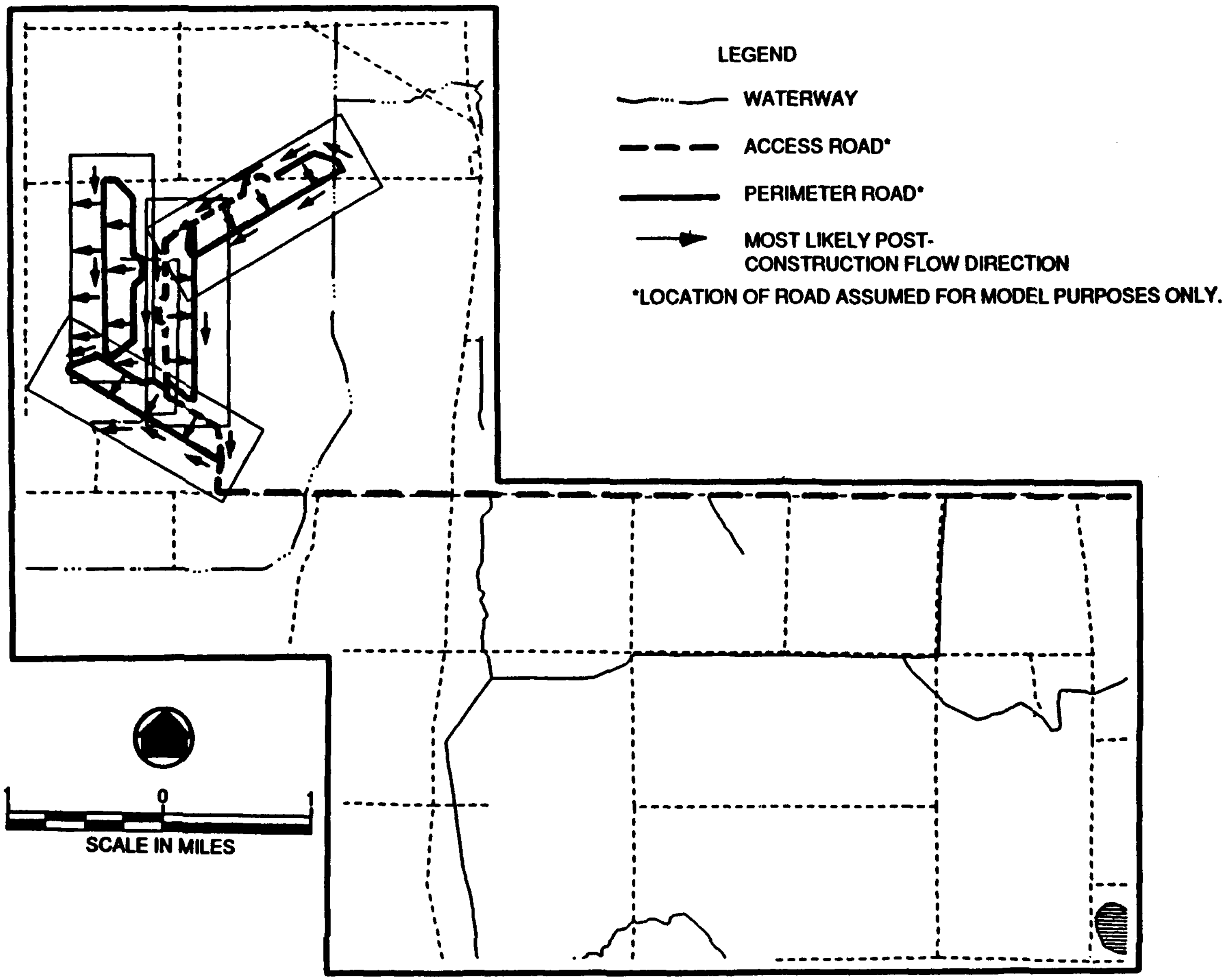


FIGURE 4-26. RX-EAST PRELIMINARY LAYOUT AND ASSUMED POST-CONSTRUCTION FLOW PATTERNS

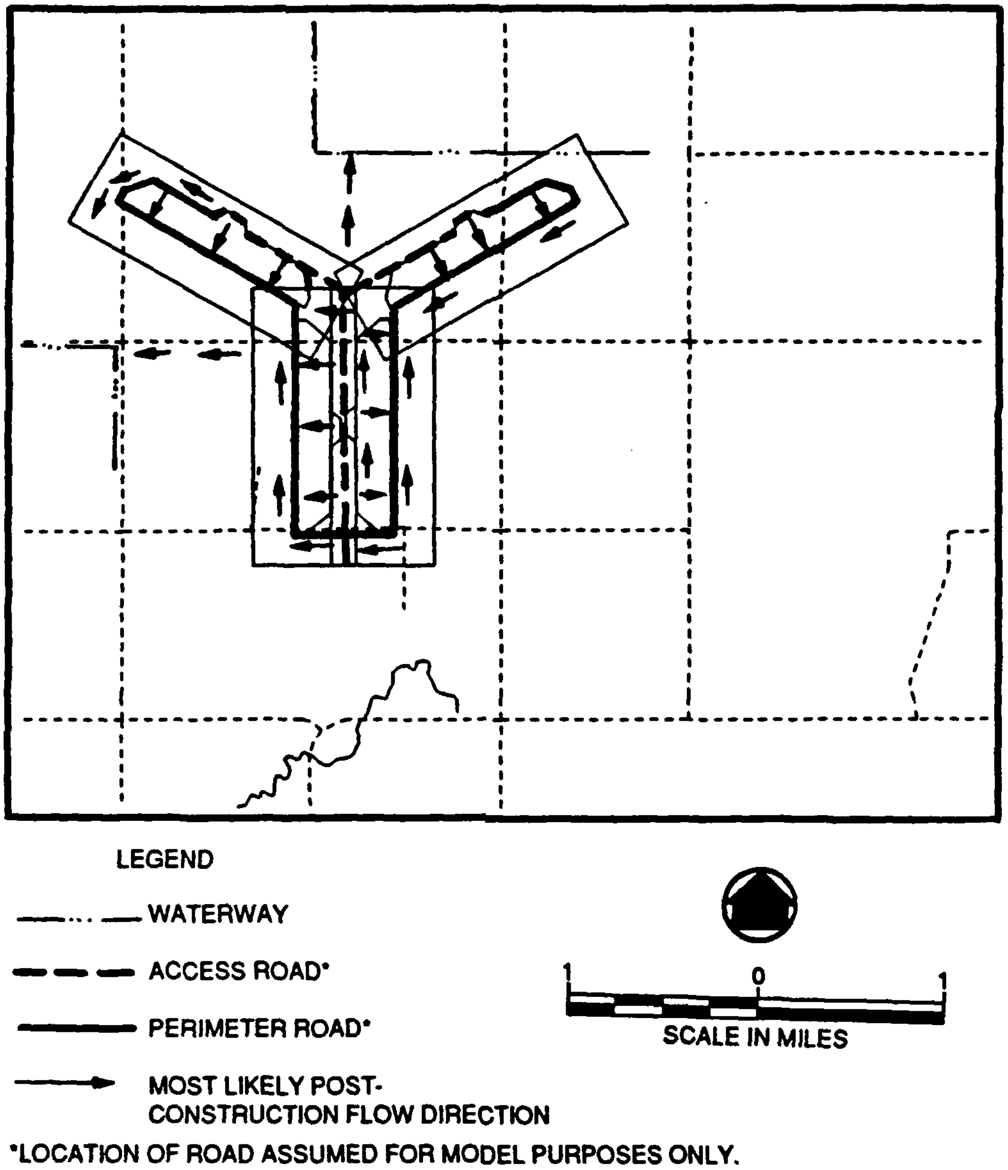


FIGURE 4-27. RX-WEST PRELIMINARY LAYOUT AND ASSUMED POST-CONSTRUCTION FLOW PATTERNS

TABLE 4-10. RECEIVE CSA's TR-20 INPUT DATA AND ASSUMPTIONS

CSA/ Scenario	Rainfall (25 yr/24 hr) (inches)	Curve Number	Slope (ft./ft.)	Time of Conc. (hours)	Drainage Area (square miles)
Rx-East					
PRE-CONST.	4.0	89	0.002	1.4	0.24
POST-CONST.	4.0	89	0.005(1)	0.74	0.24
Rx-West					
PRE-CONST.	4.0	91	0.003	1.33	0.24
POST-CONST.	4.0	91	0.005(1)	0.74	0.24

(1) Represents slope under groundscreen. Assumes other areas will maintain pre-construction slopes.

the most critical factor in this analysis for distinguishing the pre-construction from post-construction conditions for the same reason described for the transmit CSAs.

The flow length and slope are the most important parameters used to predict time of concentration. The pre-construction and post-construction flow lengths used to develop a typical receive sector are shown in Figure 4-28. The northwest sector of the preliminary layout at Rx-West was used to develop assumptions for the typical sector. Only one typical receive sector was selected to represent both the Rx-E and Rx-W preliminary site layouts because overland flow travels from east to west at both CSAs. The pre-construction flow path followed a diagonal pattern across the typical sector. The post-construction flow path will be directed away from the groundscreen by grading at an approximately 0.5 percent slope, and the original flow pattern would be resumed as soon as possible following any necessary channeling.

Using the TR-20 model, the peak discharge, or the maximum flow which would occur at the discharge outlet during a storm was predicted for pre-construction and post-construction conditions, and the excess volume of water generated due to post-construction development was estimated. Using the typical receive sector for the Rx-E preliminary site layout, the pre-construction peak discharge was estimated at 180 cubic feet per second (cfs), and post-construction peak discharge was estimated at 280 cfs. The storage volume required to attenuate the peak flow during post-construction conditions for one sector was estimated at 8 acre-feet. If this runoff occurred at all four sectors, the storage volume required to attenuate the peak from the entire Rx-E preliminary site layout would be approximately 32 acre-feet.

At the Rx-West CSA, the pre-construction peak discharge was estimated at 200 cfs, and the post-construction peak discharge was estimated at 290 cfs. The storage volume required to attenuate post-construction peak flow from one sector was estimated at 9 acre-feet. If this runoff occurred at all four sectors, the storage volume required to attenuate the peak for the entire Rx-W facility could be as great as 36 acre-feet. Conditions at Rx-West and Rx-East produced similar peak discharges and similar storage requirements to attenuate

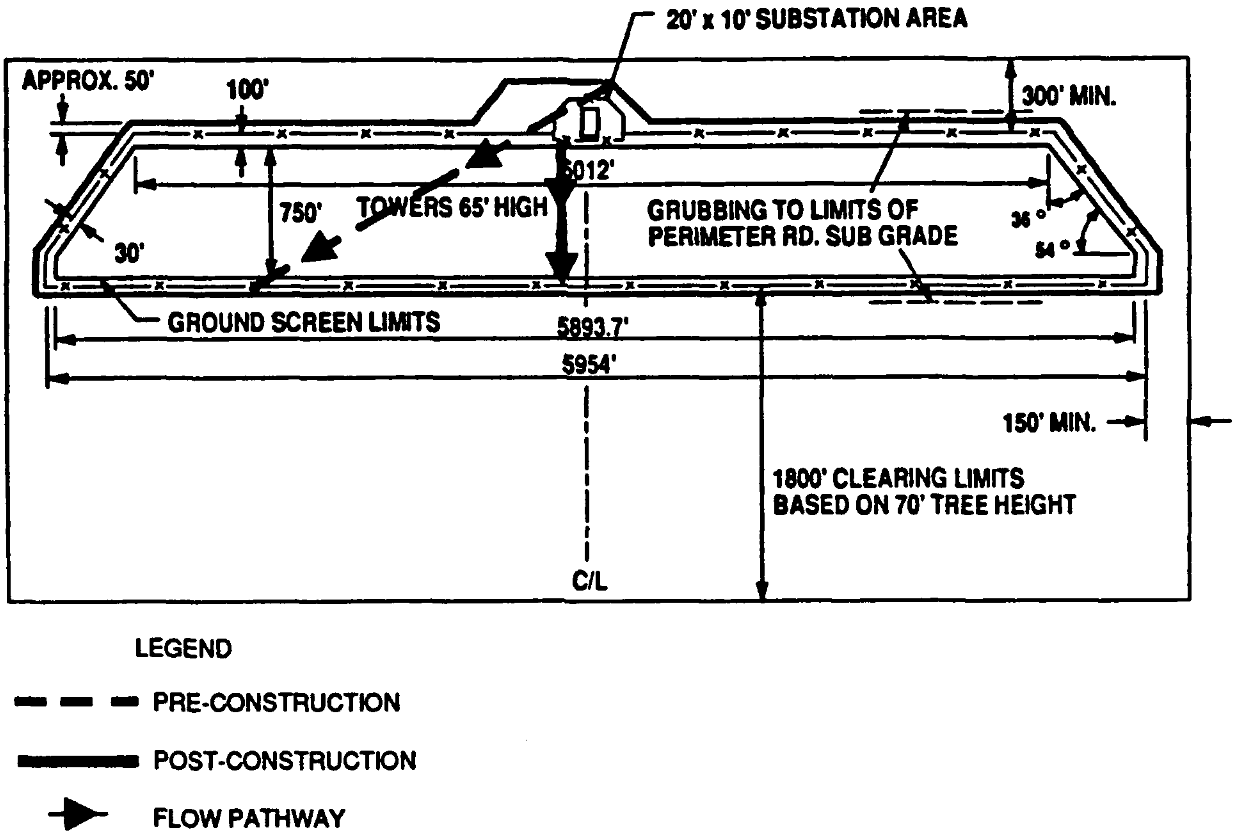


FIGURE 4-28. ASSUMED PRE- AND POST- CONSTRUCTION FLOW AT TYPICAL RECEIVE SECTOR

the peak. Therefore it may be difficult to screen the receive sites based on differences in peak runoff.

4.4.2.1.1.2 **Flood Storage Loss.** The loss of flood storage capacity at the receive CSAs has been estimated using the depth of standing water during the wettest season for an average wetland. Only wetland and flood areas within the proposed facilities' perimeter roads were examined. Since there are no known flood plain areas at the receive site CSAs, loss of floodplain due to filling was not examined. Using the US Air Force's preliminary site layout for Rx-East, the average volume of flood storage capacity lost by filling wetland areas could be as much as 38 acre-feet. Using the preliminary site layout for Rx-West, the average volume of flood storage capacity that would be filled to construct the facility could be as much as 10 acre-feet. Therefore, flood storage loss impacts are considered highest at the Rx-E CSA.

4.4.2.1.1.3 **Upstream Flooding.** Upstream flooding at the receive sites has the potential to occur if the proposed facilities are not constructed to properly divert incoming flow around or through the facility. If existing flows from the upstream drainage area are not considered within the final design, water could back up into upstream channels or over upstream farmlands and create flooding.

The potential for upstream flooding was evaluated by defining the upstream contributing drainage areas for each CSA. The upstream contributing drainage areas for Rx-E are shown on Figure 4-29. Each shaded area on Figure 4-29 represents a separate sub-drainage basin within the entire CSA. These are determined by local drainage divides such as high points, a major drainage ditch, a large highway with roadside ditches, or a river. Figures 4-17 and 4-18 show the direction of flow within these areas. The total contributing drainage area for Rx-E CSA has been estimated as approximately 8 square miles. Since the Rx-East CSA encompasses 28 square miles, the total upstream drainage area is approximately 0.3 times larger than the CSA.

The upstream contributing drainage area for Rx-W is shown on Figure 4-30. The total contributing drainage area for Rx-W has been estimated as approximately

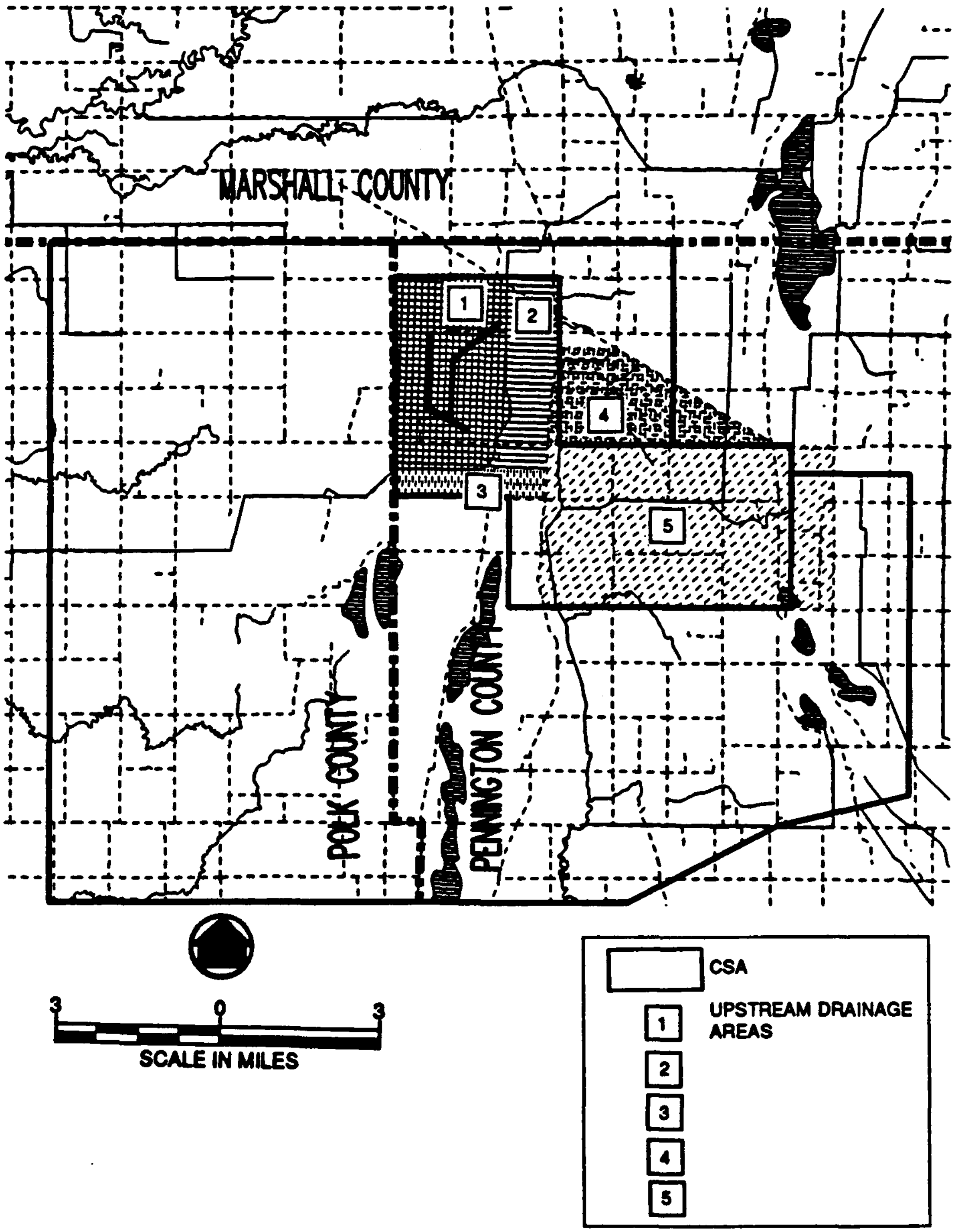


FIGURE 4-29. RX-EAST CONCENTRATED STUDY AREA UPSTREAM CONTRIBUTING DRAINAGE AREA

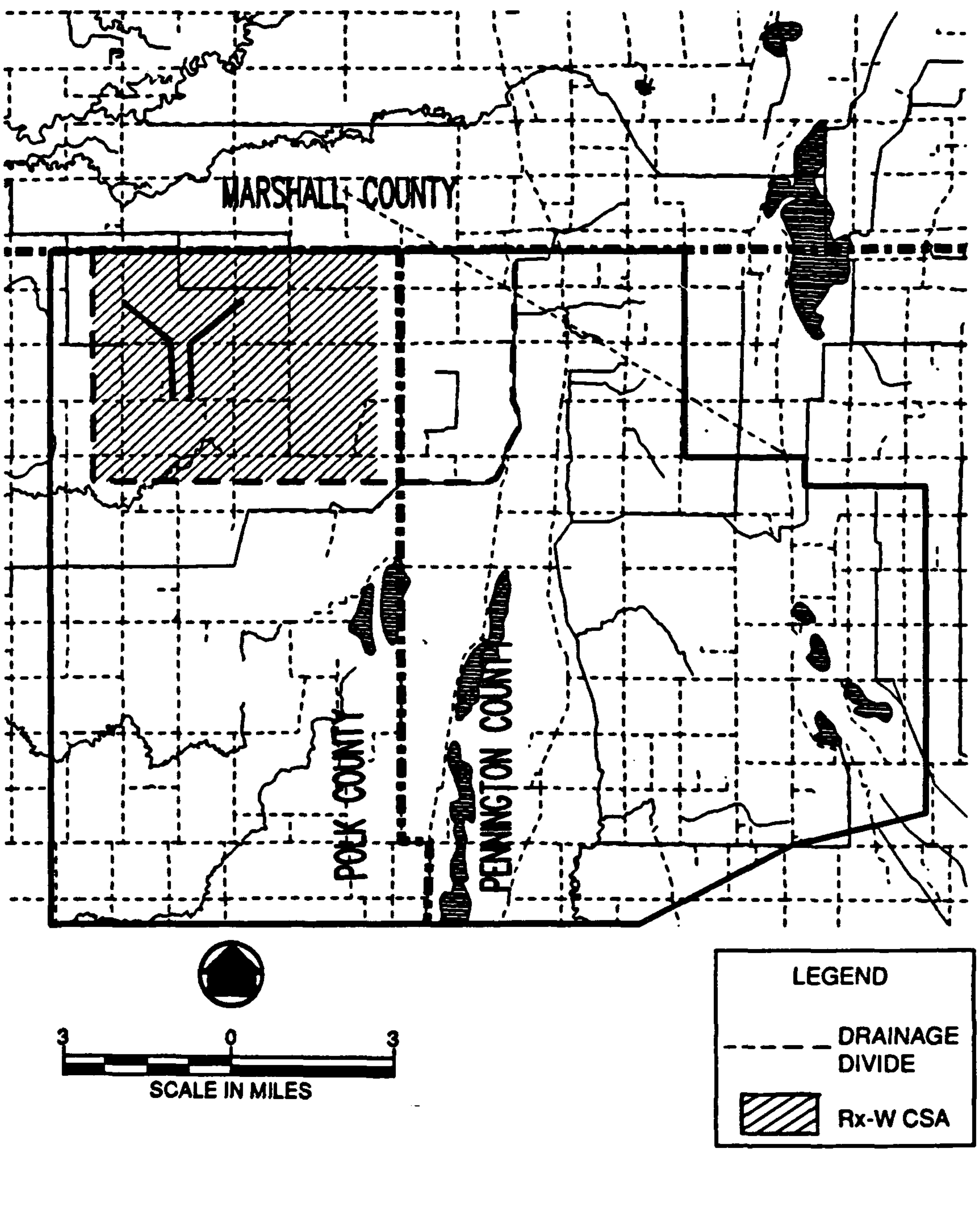


FIGURE 4-30. RX-WEST UPSTREAM CONTRIBUTING DRAINAGE AREA

9.5 square miles. Since the Rx-W CSA encompasses 20 square miles, the total upstream contributing drainage area is approximately 0.45 times larger than the CSA.

The upstream flows were estimated for the worst-case sector at each of the receive preliminary site layouts. The worst-case sectors were selected to maximize the flow to be intercepted by the facility. The TR-20 input parameters used to estimate upstream flows at the two worst case receive sectors are presented in Table 4-11. The USAF preliminary site layout at the Rx-E and Rx-W CSAs lie within the same drainage basin, bordered by a J-shaped segment of Judicial Ditch 25 to the east which acts as the drainage divide.

The Rx-E preliminary site layout lies closest to this drainage divide and therefore the worst-case sector (western sector) has an upstream drainage area of approximately 1.75 square miles. The peak upstream flows during 25-year, 24-hour storm were estimated to be approximately 800 cfs. The Rx-W preliminary site layout lie. further downstream of the drainage divide and the worst-case sector (western sector) has an estimated upstream area of 10.5 square miles (this is larger than the upstream drainage area of the entire CSA because it comprises a significant portion of the CSA). The peak upstream flow during a 25-year, 24-hour storm would be much larger than Rx-E because of the larger upstream area and is estimated at 1,650 cfs.

As an example of these flows, conservative assumptions were used to estimate the channel width necessary to convey these flows around the facility. If a single channel were used to convey these upstream flows around the Rx-E facility, the estimated bottom width of this channel could be as wide as 105 feet with a depth of approximately 1.5 feet. If one channel were used to convey upstream flows around the Rx-W facility, the estimated bottom width of this channel could be as wide as 215 feet with a depth of approximately 1.5 feet. Thus, potential drainage impacts at Rx-W are considered to be significantly higher than those at Rx-E. It should be noted that the bottom widths have been estimated strictly to convert the estimated upstream flow values into more tangible terms and should not be interpreted as actual design requirements. They are provided solely to allow comparison between CSAs.

TABLE 4-11. TR-20 ANALYSIS - UPSTREAM AREAS OF WORST-CASE RECEIVE SECTORS

CSA Worst-Case Sector	Rainfall (24 hr/25 yr) (inches)	Curve Number	Slope (ft./ft.)	Time of Concentration (hours)	Upstream Drainage Area (square miles)	Upstream Flow (cubic feet/second)
Rx-E	4.0	89	.004	2.55	1.75	800[a]
Rx-W	4.0	91	.002	11.56	10.5	1,650[a]

(a) The upstream flows for the worst-case sectors constitute the bulk of the upstream flows to the entire facility due to sector configuration.

As with the transmit site, final drainage designs will determine the number, depth and width of the drainage channels for the facility. It is likely that many channels in an overall drainage system for the facility would be developed to convey this flow. Each of these channel widths would be smaller depending on the number of channels and their location.

While conservative, these estimates indicate that extensive drainage mitigation could be required, particularly for the Rx-W CSA. These measures might include one or more of the following: 1) upstream diversionary channels or detention areas; 2) culverts underneath the facility; or 3) periodic use of the groundscreen area to store peak flood flows. The final choice of mitigation measures will be determined following site selection, during the final system design phase. The magnitude of these upstream flows could be a significant criterion for site selection.

4.4.2.1.1.4 Downstream Flooding. Flooding impacts downstream of the proposed facility could be caused by several factors including (1) the loss of on-site retention capacity such as floodplain and wetland storage; (2) over-sizing of replacement ditches and roadside swales; (3) an increase in surface water runoff from pre- to post-construction site conditions, and (4) changes in the existing drainage pattern which would divert flow from one downstream direction and increase flow to another downstream direction.

Impacts would be exacerbated if downstream flooding problems already exist. Areas downstream of the Rx-W CSA which are known to flood include areas along the Snake River. The Rx-W preliminary site layout could cause as much as 10 acre-feet of on-site retention capacity to be lost as was described in section 4.4.2.1.1.2. Increases in surface water runoff from pre-construction to post-construction conditions would be expected to occur as was described in section 4.4.2.1.1.1.

The preliminary site layout for Rx-E could cause as much as 38 acre-feet of on-site retention capacity to be lost as was described in section 4.4.2.1.1.2. Increases in surface water runoff from pre-construction to post-construction conditions would be expected to occur as was described in section 4.4.2.1.1.1.

The Rx-W preliminary site layout and the Rx-E preliminary site layout have a fairly low potential for requiring rerouting of existing flow patterns from one downstream area into another because existing drainage patterns follow one general direction, from the east to the west.

However, the upstream flows from the contributing drainage areas for both Rx-E and Rx-W are expected to be large, requiring extensive channels to re-route incoming flows around the facility. Although minor flooding impacts are possible at Rx-E, proper site design should be able to minimize these impacts. Rx-W will potentially incur more extensive flooding impacts, requiring a more complex system of drainage structures to attenuate peak flood flows.

4.4.2.1.2 **Loss of Flow.** Potential impacts could be created by the loss of both surface waters and groundwater in certain areas due to construction and operation of the proposed facility. A diversion of flow to a different downstream area would create an excess in one downstream area, and a deficit in the original downstream area. A reduction in groundwater levels could occur if pumping rates for the facilities were greater than the natural recharge, or if groundwater recharge was blocked by the construction of impervious areas such as buildings over high recharge areas. These are discussed below.

4.4.2.1.2.1 **Wetlands/Surface Water.** Both of the receive CSAs have a low potential for downstream water deficits from surface water diversion because there is only one incoming and outgoing flow direction. The site drainage plan will be designed to ensure that water levels in existing wetlands (except those filled for the project) would remain constant, and the compensatory flows would be provided if site grading alters existing drainage patterns.

The potential for off-site indirect impacts to wetlands is expected to be higher at Rx-W, due to the expected need for a larger drainage conveyance structures needed to divert and release flow into the site.

4.4.2.1.2.2 **Water Supply.** The receive facilities are proposed to be constructed with a water supply system which includes a well behind each of the four antenna sectors. Each of these wells would be designed with a pumping rate of approximately 0.5 gpm, for a total pumping rate of approximately 2 gpm. During construction temporary wells with a total pumping rate ranging from 35 to 70 gpm would be utilized.

To determine the impact of the proposed pumping rates on the existing aquifers, the pump rates need to be compared to known information on aquifer yields, and the relationship between recharge rates and pump rates. No known important recharge areas exist at either of the receive CSAs, and little is known about the exact locations or yields of underlying aquifers. Therefore, the USAF will have to study the (potential) groundwater supply to determine if it could support the facility without causing off-site water supply impacts. Consultation will be initiated with the appropriate state and local agencies to conduct this evaluation following site selection. If on-site wells are not feasible, the USAF will obtain water using alternative means such as pumping water from a local water supply or transporting water to the site. Water appropriations will be coordinated with the Minnesota Department of Natural Resources.

4.4.2.1.2.3 **Groundwater Recharge.** The potential impact of the proposed facility on any existing groundwater recharge areas was evaluated by examining the curve numbers, or runoff coefficients used in the TR-20 model. The TR-55 model was used to generate curve numbers for pre-construction and post-construction conditions. The curve numbers selected using the TR-55 model were the same for pre-construction and post-construction at both receive CSAs because the proposed facility's impervious areas (e.g. buildings and antenna foundations) include a small percentage of the total facility. The remaining area will be gravel covered and the curve number which TR-55 uses for gravel was similar to the area's pre-construction curve numbers. These models and inputs to the selection of this number are more fully described in Appendix A. The curve number represents the percentage of precipitation which will run-off a given drainage area without considering a time factor (versus the peak discharge which considers time). The remaining amount would either be lost to evaporation, transpiration, or infiltration. Therefore, no changes are expected to groundwater recharge due to the construction of the proposed facility at the receive sites.

4.4.2.2 Drainage Channels. Filling channels to construct the proposed facilities could create significant impacts and cause severe upstream flooding. Improper sizing of replacement channels could also create either upstream or downstream flooding impacts. The major channel types found at the receive sites are major drainage ditches, roadside swales, and intermittent streams. These three channel types were described in more detail in section 4.4.1.1.3. above.

The best- and worst-case scenarios were used to evaluate the range of potential impacts from filling drainage channels. In the selection of the best- and worst-case scenarios, each of the resources were ranked by hydrologic importance with known flood areas and wetlands ranked equal and first, major drainage ditches ranked second, roadside swales ranked third, and intermittent streams ranked fourth.

Table 4-12 presents an estimate of acre-feet of flood storage and wetland areas, and the linear yards of major drainage channels, roadside swales, and intermittent streams impacted by construction of the facility for best- and worst-case scenarios, and the preliminary site layout. At Rx-W, the best-case scenario was the same as the preliminary site layout. As Table 4-10 indicates, Rx-E would result in higher losses of flood storage (for all cases) due to losses in wetlands, and greater losses of ditches, swales and intermittent streams. Minor amounts of flood storage capacity, ditches, and swales would be lost within the Rx-W CSA.

4.4.2.3 Water Quality. Surface and groundwater could be potentially impacted by erosion, wastewater treatment facilities, or hazardous materials stored on site.

4.4.2.3.1 Erosion Impacts. Water quality could be impacted from both short-term and long-term erosion created by construction and operation of the facility. Erosion could create turbidity in downstream waters, and sediment transported by water tends to collect in and block channels, thereby reducing the hydraulic capacity of the channel. Short-term erosion impacts would be created during construction because of exposed excavated areas. The potential

TABLE 4-12. POTENTIAL RANGE OF IMPACTS TO FLOOD STORAGE CAPACITY AND DRAINAGE CHANNELS AT RECEIVE CSA'S

Rank of Importance	1A	1B	2	3	4
	Flood Storage(1) (acre-feet)	Wetland Storage(1)(2) (acre-feet)	Major Ditches (linear yards)	Roadside Swales (linear yards)	Intermittent Streams (linear yards)
Rx-East					
Preliminary Site Layout	0	38	100	200	3000
Best	0	4	0	0	700
Worst	0	285	700	1000	3200
Rx-West					
Preliminary Site Layout	0	10	0	0	0
Best	0	1	0	0	0
Worst	0	94	400	400	0

(1) Assumed an average depth of 3 feet in wetlands and flood areas.

(2) Wetland best- and worst-case volumes were taken from wetland best- and worst-case scenarios. All other best- and worst-case volumes and lengths were taken from hydrologic best- and worst-case scenarios.

for long-term erosion impacts (from both water and wind) may occur with increased elevation of facilities and roads, but the similarity in terrain and soils of Rx-E and Rx-W indicate that impacts will be similar at either site.

Since there are no major water bodies on any of the CSAs, erosion impacts to downstream drainage ditches, roadside swales, and intermittent streams are the primary concern. Areas constructed with steep slopes would be more susceptible to erosion than areas with flatter slopes and some soils are more susceptible than others to erosion. Standard erosion-control measures would be taken during construction of the facilities to minimize impacts from erosion as was discussed in section 4.4.1.3.1. Wind erosion could also cause the accumulation of sediments in channels. Prompt revegetation and proper maintenance of channels would prevent any significant impacts from wind erosion.

The universal soil loss equation (USEPA, 1975) was used to compare the potential for long-term soil loss due to natural erosion at the receive CSAs. The only factor in the equation which differs from the Rx-E CSA to Rx-W CSA is the K-factor, or soil erodibility factor, which depends upon local soil properties. Soils in the Rx-E CSA were estimated to have a K factor of approximately 0.25, and soils at the Rx-W CSA were estimated to have a K factor of approximately 0.23. Therefore, the potential for long-term soil erosion in tons/year is estimated to be approximately 8 percent greater at the Rx-E CSA than at the Rx-W CSA.

4.4.2.3.2 Wastewater Disposal. Wastewater facilities could include an on-site storage tank, or a septic tank with leach fields. Potential impacts to groundwater would be created if leachate entered the groundwater, or from an unexpected spill of raw sewage from a holding tank. If a septic system is constructed, it will be located in accordance with the Minnesota Pollution Control Rules and Regulations and designed to meet wastewater treatment standards which minimize the potential for leachate entering the groundwater system. Therefore no significant impacts would be expected to occur.

If no acceptable leach field site is available, alternative wastewater facilities would be constructed. If a wastewater holding tank is constructed, raw sewerage could enter surface or groundwater systems through an accidental spill. If proper handling methods are used, the impact can be prevented.

4.4.2.3.3 Hazardous/Industrial Materials. Potential impacts could occur to surface and groundwater in the event of an accidental spill. Any hazardous materials generated on-site will be stored, transported, and disposed of in accordance with all applicable state and federal regulations. The materials will be stored in DOT and EPA-approved containers, and hauled off-site by an EPA-approved contractor.

Potential water quality impacts due to increased vehicle traffic would be highest during the peak construction period. The magnitude of these potential impacts is dependent upon the sites selected, final borrow requirements and borrow area locations.

All storage facilities and handling areas will be addressed in a site specific Spill Prevention, Containment, and Countermeasure (SPCC) Plan. State and federal resource agencies will review the plan to ensure that spill containment facilities, contingency plans, and preventative maintenance procedures minimize the potential for impact to ground and surface waters.

4.4.2.3.4 Corrosion. The soils at the receive CSAs have been cited for their corrosive properties (USAF, 1986). A potential impact to water quality could result from the introduction of ferrous metals into surface or groundwater through the oxidation of the groundscreen. The extent of a potential impact would depend on the actual material selected for the groundscreen and the length of time the groundscreen area would be flooded or the likelihood of ponding in the groundscreen area. Proper design and grading will minimize the extent and duration of ponding (and hence, corrosion) on the groundscreen.

4.4.3 Conclusion

Table 4-13 presents a summary of the hydrologic impacts evaluated for both the transmit and receive CSAs. For the transmit facility, the Tx-N preliminary site layout rates better than the Tx-S site layout on all hydrologic criteria and therefore Tx-N would have fewer impacts from a hydrologic perspective. For the receive facility, the Rx-W preliminary site layout rates only slightly better than the Rx-E site layout for most criteria but could require more extensive mitigation to handle higher upstream flows. Since the differences are not as great as at the transmit CSAs, and could become equal if the locations of the facility were altered, one receive CSA is not clearly preferable over the other based on hydrologic criteria alone. Water quality impacts would also be essentially the same at all transmit and receive CSAs and therefore no CSA is preferred on the basis of the potential for water quality impacts.

4.5 MITIGATION

The following section describes mitigation measures recommended to alleviate impacts identified in section 4.4. Mitigation measures discussed are appropriate for both the transmit and receive facilities; they address upstream flooding, downstream flooding, water supply, and water quality. Specific mitigation measures for particular CSAs are also identified.

4.5.1 Upstream Flooding

Upstream flooding may occur if replacement drainage ditches are under-sized due to an improper estimate of the upstream contributing flows. To prevent upstream flooding, replacement channels must be constructed large enough to handle upstream flows. By minimizing the amount of replacement ditches required in the final site selection, this problem can also be minimized. A larger upstream drainage area contributes higher peak upstream flows (as described in the previous sections). These upstream peak flows would require re-routing around the facility to be discharged at incoming flow rates.

TABLE 4-13. SUMMARY OF HYDROLOGIC IMPACTS

Frame of Reference[4]	Impact	Criteria	Unit of Measure	Transit Sites		Receive Sites	
				Tx-North	Tx-South	Rx-East	Rx-West
PSL	Up and downstream Flooding	Flood storage loss[1]	(acre-feet)	670[2]	1700	40[2]	10[2]
One Sector of PSL	Downstream Flooding	Volume required to attenuate peak runoff per sector	(acre-feet)	0	15	8	9
CSA	Upstream Flooding	Size of drainage area upstream of entire CSA	(square miles)	4.5	67.5	8[3]	9.5
One Sector of PSL	Upstream Flooding	Size of drainage area upstream of worst-case sector	(square miles)	3.0	8.25	1.75	10.5
One Sector of PSL	Upstream Flooding	Upstream Peak Flow	(cubic feet/second)	750	1200	800	1650
PSL	Up and downstream Flooding	Loss of major channel and ditches	(linear yards)	0	500	100	0
PSL	Up and downstream Flooding	Loss of roadside swales	(linear yards)	0	4000	200	0
PSL	Up and downstream Flooding	Loss of intermittent streams	(linear yards)	0	6000	3000	0
PSL	Downstream Flooding	Average increase in slope from pre to post	(factor)	0.8	2.63	2.5	1.67
CSA	Downstream Flooding/Droughts	Number of Incoming Drainage Patterns	-	1	3	1	1
CSA	Water Quality	Soil Erosion Potential	(K-factor)	0.19	0.29	0.25	0.23

(1) Assumes existing wetlands and flood areas have an average depth of 3 feet.
(2) Flood storage from wetlands only. No other flood storage areas known to exist.
(3) Includes upstream areas for both eastern and western portions of Rx-E CSA.
(4) CSA = Concentrated Study Area; PSL = Preliminary Site Layout

Two approaches which could be taken to assure that replacement channels are properly sized are (1) to develop a good estimate of upstream flows through the subsequent use (with better design information) of modeling techniques such as TR-20, or (2) measure and characterize each channel being replaced for its hydraulic capacity. TR-20 has limitations, such as not accounting for runoff from snowmelt, and an exaggerated runoff coefficient as described in Appendix A. Appropriate adjustments should be made to reflect more realistic conditions if this model is used to size channels in the final design.

To measure and characterize the hydraulic capacity of each channel being replaced would also have its limitations, and become more involved as the number of channels increased. Most parameters in Manning's equation for open-channel flow would need to be defined for each channel. The dimensions of each channel would require close surveying, and reaches would be defined based on constant characteristics such as the slope, width, depth, and channel material. This would involve extensive field investigations by a hydrologist or engineer because many parameters used to describe each channel require site-specific study and the use of good engineering judgment.

The Tx-S CSA has greatest potential for upstream flooding impacts because this CSA has the largest upstream peak flow and the most channel resources (ditches, roadside swales, and intermittent streams). Therefore, a more extensive mitigation effort would be required if this CSA were selected to construct the transmit facility. The Tx-N preliminary site layout has a much lower potential for upstream flooding impacts because the upstream peak flow is much smaller and there are few channel resources on-site. The Rx-E preliminary site layout has a lower potential for upstream flooding impacts due to upstream flows than the Rx-W preliminary site layout because the upstream peak flow is significantly smaller for Rx-E than Rx-W. However, Rx-W has fewer channel resources than Rx-E, and more mitigation of drainage channel resources to replace lost conveyance capacity may be required if Rx-E is selected.

4.5.2 Downstream Flooding

Downstream flooding impacts can be created by an increase in surface water runoff, flood storage loss, surface water diversions, or over-sizing replacement drainage channels.

4.5.2.1 Increase in Surface Water Runoff. Increases in surface water runoff from pre-construction conditions to post-construction conditions should be temporarily retained and released at a slower rate than it collects, so that no downstream flooding impacts are generated. A detention basin should be designed to attenuate the peak discharge and would discharge at pre-construction rates. South Dakota SCS engineering standards and Minnesota SCS guidelines should be followed to the maximum extent possible to design these basins.

Detention basins should be designed to be normally dry, in order to minimize the attraction of birds. It is recommended that small and shallow detention basins be constructed at each receive or transmit sector rather than one large detention basin for the entire facility. This should provide more discharge areas to allow flexibility in routing flows to pre-construction patterns. The surface area of each basin should also be minimized when possible to prevent bird attraction. Detention basins and inlet/outlet structures should be inspected and maintained by the USAF on a regular basis to assure that design discharge rates are preserved.

The Tx-S CSA would require more or larger detention basins than the Tx-N CSA if selected for the facilities. Both of the receive CSAs would have similar detention basin requirements.

4.5.2.2 Flood Storage Loss. Compensation for flood storage losses from construction of the facilities can be provided either upstream or downstream of the site. If compensation is provided downstream of the facility, incoming flows which normally utilize flood storage areas at the facility must be rerouted around the facility. If possible, it is recommended that compensation for flood storage space be found upstream to avoid re-routing large volumes of water. If the flood storage volume lost is not compensated, downstream areas could flood. If a constriction or blockage occurs downstream, flood water could back up to the facility or upstream areas.

If downstream flood storage compensation is provided, incoming flows should be controlled with channels which lead to the flood storage area. The channel should be designed to carry the peak flow from the upstream drainage area. Energy dissipation techniques such as baffling, riprap, or the use of special grasses may be required if channel velocities become excessive. Flood storage compensation should be coordinated with wetland replication and mitigation.

Construction of the transmit facilities at either the Tx-N or Tx-S CSA will require a significant amount of compensatory flood storage. Mitigation of flood storage capacity will be coordinated with areas selected for borrow material and wetlands mitigation and addressed concurrently in the project mitigation plan. Since borrow areas, newly created wetlands, and compensatory flood storage may serve similar mitigative purposes, this would likely reduce the amount of mitigation required. Although the amount of filled flood storage at both CSAs is considered large, the compensatory flood storage required for Tx-S would be more than twice as much as the compensatory flood storage requirements at Tx-N. The feasibility of procuring and creating compensatory flood storage areas would be evaluated in more detail and coordinated with appropriate regulatory agencies. The compensatory flood storage requirement for the receive CSAs are more than ten times less than the requirement at the Tx-N CSA and should be easily mitigable. The Rx-W site layout has fewer wetland resources than Rx-E and therefore would require the least amount of compensatory storage of any of the alternatives.

4.5.2.3 Surface Water Diversion. The diversion of surface waters and alteration of existing drainage patterns by re-grading the site can create flow deficits or excesses in downstream areas. Any regrading should be analyzed and flow directions should be compared to pre-construction drainage patterns. Every effort should be made to maintain pre-construction flows in each drainage area. If a significant amount of flow is diverted from one drainage area to another, flows in these drainage area should be compensated through channeling or additional grading. The potential for mitigation due to surface water diversion is greatest at the Tx-S CSA because of the number of contributing drainage basins and the great variation in existing flow patterns. Since surface flow directions at the Tx-N, Rx-E, and Rx-W CSAs are fairly consistent, less mitigation would be required at these CSAs.

4.5.2.4 Replacement Drainage Ditches. Any drainage ditches, roadside swales, or stream channels which are filled to construct the facility should be re-routed or diverted to maintain pre-construction drainage patterns and to carry the peak flow from the upstream drainage area. The mitigation measures discussed in Section 4.5.1 to prevent upstream flooding impacts should be implemented to avoid or minimize these potential impacts.

4.5.3 Water Supply

The extent of groundwater supplies at the receive sites are not known. Therefore, test wells should be developed to determine groundwater supply availability and aquifer recharge characteristics. Test wells should also be installed at the selected transmit site to identify the best locations for the installation of drinking water wells, and determine proper fuel handling and storage facilities design, best management practices for fuel transfer operations, and proper design and siting of wastewater treatment facilities.

4.5.4 Water Quality

Potential impacts to surface water and groundwater can be mitigated through a variety of preventative measures, such as proper fuel handling and storage facilities design, Best Management Practices for vehicle maintenance and fuel transfer operations, and proper design and siting of wastewater treatment facilities.

4.5.4.1 Erosion. Short-term erosion impacts created during construction would be mitigated using appropriate sedimentation and erosion control devices such as silt curtains, sedimentation control basins, hay bales, proper re-vegetation treatments, and dust control techniques. The USAF, in consultation with the appropriate local, state and federal agencies, will direct the contractor to utilize the most appropriate method(s). To minimize short-term erosion impacts, construction should be scheduled during the low flow season (summer-early fall) and avoided during the springtime high-runoff period. Other measures, such as diversionary noise or visual decoys could be used during peak bird migration periods to ensure that temporary sedimentation basins do not attract birds.

Long-term erosion impacts can be reduced by minimizing the slopes of channel banks, and using appropriate vegetation. All channels on-site and downstream should be maintained to prevent the collection of sediments, snow, or debris which could reduce the hydraulic capacity and cause upstream flooding. Native soils at the Tx-S CSA have the highest potential for long-term erosion, while native soils at the Tx-N CSA have the lowest potential for long-term erosion. The potential for long-term erosion at the receive CSAs are similar with Rx-W being slightly lower than Rx-E.

4.5.4.2 **Wastewater.** The installation, maintenance, or operation of a septic tank or wastewater storage facility would be determined by a detailed soils investigation following site selection. Any discharge from these facilities would be in compliance with state wastewater disposal regulations, and would be installed and operated under the review of the Minnesota Pollution Control Agency for the selected receive CSA, and the South Dakota Department of Water and Natural Resources for the selected transmit CSA.

4.5.4.3 **Hazardous Materials.** Any hazardous materials generated on-site will be stored, transported, and disposed of in accordance with all applicable state and federal regulations. The materials will be stored in EPA and DOT-approved containers and hauled off-site by an EPA-approved contractor. Permanent fuel storage will be designed to minimize the risk of spills or leaching of contaminants, through diked tank storage areas, or other approved means of spill containment. Proper vehicles maintenance and fueling procedures should significantly reduce the potential for impacts due to fuel/oil spills or leaks.

All fuel storage facilities and handling areas will be addressed in site specific Spill Prevention, Containment, and Countermeasure (SPCC) Plans for both transmit and receive facilities. State and federal resource agencies will review these plans to ensure that spill containment facilities, contingency plans, and preventative maintenance procedures minimize the potential for impact to ground and surface waters.

4.5.4.4 Corrosion. Native soils at the receive CSAs have been cited for their corrosive properties and therefore special design features may be required for the groundscreen at the Rx-E and Rx-W CSAs. Soils at the transmit CSAs have not been cited for their corrosive properties, and mitigation is not considered necessary at the Tx-N or Tx-S CSA. The potential for corrosion of the groundscreen can be reduced by selecting galvanized materials or other non-corrosive alloys for construction. Elevation of the groundscreen area and grading away from the screen should minimize puddling and flooding of the area. If necessary, corrosion could be controlled or prevented by using an external voltage source or sacrificial anode for cathodic protection. Outside non-corrosive fill material could also be brought in to help minimize any corrosive impacts.

REFERENCES

Federal Emergency Management Agency (FEMA), 1981. Pennington County, Minnesota, Flood Hazard Boundary Map, community panel number 270651 0001-0008, April 10.

Federal Emergency Management Agency (FEMA), 1983. County of Polk Minnesota, Flood Insurance Rate Map, community panel number 270503 0001-0550, August 15.

Maclay, R.W., T.W. Winter, and L.E. Bidwell, 1972. Water Resources of the Red River of the North Drainage Basin in Minnesota, R.W. Maclay, T.C. Winter, and L.E. Bidwell, U.S. Geological Survey, Saint Paul, Minnesota. 129 pp.

Marshall County Agricultural Stabilization and Conservation Service (MC ASCS) 1989. Map indicating known flood areas and watershed boundary for the upper and lower Crow Creek watersheds.

Middle River-Snake River Watershed District, 1971. Overall Plan.

Middle River-Snake River Watershed District, 1989. Personal communication between Adrain and Shepardson of Metcalf & Eddy, Inc., August 15.

Minnesota Pollution Control Agency (MPCA), 1988. Water Years 1986-1987, the 1988 Report to the Congress of the United States.

Minnesota Pollution Control Agency (MPCA), 1989. Personal communication between Maschowitz and Shepardson of Metcalf & Eddy, Inc., October 23.

Minnesota Department of Health (MDPH) and Minnesota Department of Agriculture (MDA), 1988. Pesticides and Groundwater: Surveys of Selected Minnesota Wells, prepared for the Legislative Commission on Minnesota Resources.

Red Lake Watershed District, 1988. Red Lake Watershed District, 10-year Updated Overall Plan.

South Dakota Soil Conservation Service (SD SCS). 1989. Personal communication between Hale and Shepardson of Metcalf & Eddy, Inc., October 20.

South Dakota State University (SDSU), 1989. College of Engineering, Agricultural Engineering Department, Monthly summarized Station and Divisional Data.

United States Air Force (USAF), 1986. Draft Environmental Impact Statement: Proposed Central Radar System Over-the-Horizon Backscatter Radar Program.

United States Environmental Protection Agency (USEPA), 1975. Control of Water Pollution from Cropland, Volume I, A Manual for Guideline Development, Washington D.C., 112 pp.

United States Geologic Survey (USGS), 1965. Water Resources of the Middle River Watershed, Northwestern Minnesota, Hydrologic Atlas Number 201. Prepared in cooperation with Minnesota Department of Conservation (MDC), Division of Waters.

United States Geologic Survey (USGS), 1970. Water Resources of the Red Lake River Watershed, Northwestern Minnesota, Hydrologic Atlas Number 346. Prepared in cooperation with Minnesota Department of Conservation (MDC), Division of Waters, Soils and Minerals.

United States Geologic Survey (USGS), 1975. Geology and Water Resources of Marshall County, South Dakota, Bulletin 23. Prepared in cooperation with the South Dakota Geologic Survey (SDGS), Marshall County and the Oahe Conservancy District.

United States Geologic Survey (USGS), 1976. Geology and Water Resources of Brown County, South Dakota, Bulletin 25. Prepared in cooperation with the South Dakota Geologic Survey, Brown County, and the Oahe Conservancy Sub-District.

United States Soil Conservation Service (US SCS), 1982. TR-20 Computer Program for Project Formulation Hydrology.

Waters, Thomas F., 1977. Pages 106-131 in The Streams and Rivers of Minnesota, University of Minnesota Press, Minneapolis, Minnesota. 373 pp.

APPENDIX A

TR-20
MODEL DESCRIPTION

A.1 Model description

The Soil Conservation Service's (SCS) TR-20 model begins with a rainfall amount uniformly imposed on the watershed over a specified time distribution. Mass rainfall is converted to mass runoff by using a runoff curve number (CN). CN is based on soils, plant cover, amount of impervious area, interception, and surface storage. Runoff is then transformed into a hydrograph, or a description of how discharge of surface water runoff would change with time for a given watershed, by using unit hydrograph theory and routing procedures that depend on runoff travel time through segments of the watershed.

TR-20 develops flood hydrographs from runoff and routes flow through stream channels and reservoirs. It can combine the routed hydrograph with those from tributaries and compute the peak discharges, the time of occurrence, and the water surface elevation at any desired cross-section or structure. TR-20 is primarily used for large watershed areas and complicated flood storage and routing procedures.

In this study, TR-20 was used in one of its simplest applications. A hydrograph was developed from runoff generated during a 25-year, 24-hour storm event for the project site. The model was run for both pre- and post-construction scenarios. The difference in peak flow generated at the discharge point during pre- and post- construction was then used to estimate the size of a retention basin if required.

Surface flow at the Tx-N, Rx-W, and Rx-E sites followed the same general direction, so only one drainage area and discharge point was evaluated for the USAF's preliminary site layout at each of these CSAs. Surface flow at the the Tx-S CSA discharges to three different areas which were evaluated separately.

A.1.1 Curve Number Selection

The percentage of each cover, treatment, and hydrologic condition present with each hydrologic soil group at a CSA was estimated to develop the curve number for the pre-construction condition. The curve number, which can range from 0 to 100, characterizes the drainage area's capacity for absorbing precipitation through infiltration and percolation of stormwater. The TR-20 model is sensitive to the curve number. Major factors which influence the curve number are the hydrologic soil groups on site, land cover material, treatment, the hydrologic condition, and the antecedent runoff condition. A curve number was determined using the TR-55 model for each CSA for both pre-construction and post-construction conditions.

The antecedent runoff condition accounts for variation in the curve number from storm to storm. The curve number selected for TR-20 input uses the antecedent runoff condition for an average storm. Other factors which may influence the curve number are climate (percent of the year which the ground is frozen), or human factors which alter site drainage, such as imported fill material that is different in character than native soils.

A.1.2 Hydrologic Soil Group

All soil types have been classified into four hydrologic soil groups (A,B,C,D) by the United States Soil Conservation Service (SCS) according to their minimum infiltration rate, which is obtained for bare soil after prolonged wetting. Soils classified as hydrologic soil group A have the greatest infiltration rates, while soils classified as hydrologic soil group D have the lowest infiltration rates. The U.S. Soil Conservation Service (SCS) has developed soil maps for almost all counties in the country which identify and characterize the use of soils in that area. The hydrologic soil groups were mapped on the SCS soil maps for each CSA and the percentage of each hydrologic soil group was used to develop the curve number. The most predominant soil group found at all four CSAs studied was group D.

A.1.3 Land Cover

Major parameters influencing land cover are the type of cover, treatment, and hydrologic condition. The type of cover material at each CSA was evaluated through US Air Force field visits during the summer of 1989 and supplemented by input from on-site field personnel during the fall of 1989. The cover categories which were used in this study included: fallow land; row crops; small grain crops; close-seeded or broadcast legumes or rotation meadow; paved, gravel, and dirt roads; pasture, grassland, or range; meadow; woods; and farmsteads. Cover description categories can be further divided into treatment categories such as bare soil and crop residue cover for the fallow land.

The hydrologic condition represents the effects of cover type and treatment on infiltration and runoff and is generally estimated from density of plant and residue cover on sample areas. A good hydrologic condition indicates a low potential for runoff for the specific hydrologic soil group, cover type, and treatment. The hydrologic condition was selected for each cover and treatment type used to develop a curve number.

A.1.4. Time of Concentration and Travel Time

Travel time (T_t) is the time it takes for water to travel from one location to another within a watershed. The time of concentration (T_c) is the time it takes for runoff to travel from the hydraulically most distant point in a watershed to the discharge point being evaluated, and can be comprised of many T_t components in a drainage conveyance system. T_c influences the shape and the peak of the runoff hydrograph.

Several factors which influence the T_c include flow type, travel distance, slope, and channel shape and roughness. Development of a site usually decreases T_c, thereby increasing the peak discharge. T_c can also be increased as a result of ponding behind small or inadequate drainage systems, reduction of land slope through grading, and an increased network of drainage ditches. Several factors which influence the T_c include flow type, travel distance, slope, and channel shape and roughness.

A.1.5 Flow type

Surface water flow at the CSAs was characterized as sheet flow, shallow concentrated flow or open channel flow. Sheet flow is flow over plane surfaces with very shallow depths of about 0.1 foot. The following solution of the Kinematic wave equation (Overton and Meadows, 1976) is used to compute T_t for sheet flow.

$$T_t = \frac{0.007\ (nL)^{0.8}}{(P_2)^{0.5} s^{0.4}}$$

Where:

T_t = travel time (hr.)
n = Manning's roughness coefficient
L = flow length (ft.)
P_2 = 2-year, 24-hour rainfall (in.)
s = slope of hydraulic grade line (land slope ft./ft.)

Manning's n, or the roughness coefficient in the equation is a composite parameter which accounts for the effect of raindrop impacts, drag over the plane surface, obstacles such as rocks and crop ridges, and erosion and transportation of sediment. The model assumes that sheet flow only exists for the first 300 feet within a watershed during pre-construction conditions, and after that the flow would become shallow concentrated flow.

The majority of the flow within the CSAs is characterized as shallow concentrated flow such as flow collected in roadside swales and ditches, intermittent stream channels, and larger county-owned ditches. The following equation, derived from a solution of Manning's equation which uses a roughness coefficient of 0.05 and a hydraulic radius of 0.4 ft., was used to estimate the flow velocity.

$$V = 16.1\ (S)^{0.5}\ \ (ft/sec)$$

Using the flow length L, the T_t is calculated. The T_t's for all flow components are added to get the overall time of concentration.

Open channel flow was used to evaluate runoff at the Tx-S typical sector where the existing topography would require a drainage ditch or swale in front of the antenna groundscreen to direct flow off the facilities. Manning's equation was used to estimate the velocity through the channel.

$$V = \frac{1.49}{n} R^{2/3}\ \ S^{1/2}$$

where: V = Channel velocity (ft/sec)
n = Manning's roughness coefficient
R = Hydraulic radius (ft)
S = Channel slope

It was assumed that the channel slope would be approximately equal to the existing grade, a Manning's n of 0.03 for a grassy or rocked channel was assumed, and a trapezoidal channel with a 3 ft. bottom, and 3 to 1 side slopes was assumed.

A.1.6 Flow Length

The flow length, or the distance surface flow travels from the hydraulically most distant point in a watershed, was estimated for pre-construction and post-construction scenarios for each CSA.

A.1.7. Slope of Hydraulic Grade Line

The slope used for each scenario was derived from USGS topographic maps of the CSAs. An average slope was estimated to characterize the entire CSA. Table A-1 which presents the input parameters for TR-20, includes slope estimates for each CSA. It was assumed that the proposed facilities would be graded with a slope of approximately 0.5 percent.

TABLE A-1. OTH-B CRS TR-20 INPUT DATA AND ASSUMPTIONS

CSA/ Scenario	Sheet Flow (feet)	Shallow Concentrated Flow (feet)	Open Channel Flow (feet)	Rainfall (25 yr/24 hr) (inches)	Curve Number	Slope (ft./ft.)	Time of Conc. (hours)	Drainage Area (sq. miles)
Rx-East								
PRE-CONST.	300	2300	0	4.0	89	0.002	1.4	0.24
POST-CONST.	800	0	0	4.0	89	0.005(1)	0.74	0.24
Rx-West								
PRE-CONST.	300	2300	0	4.0	91	0.003	1.33	0.24
POST-CONST.	800	0	0	4.0	91	0.005(1)	0.74	0.24
Tx-North								
PRE-CONST.	300	6000	0	4.2	83	0.004	2.73	0.8
POST-CONST.	1050	4750	0	4.2	83	0.005(1)	2.87	0.8
Tx-South								
PRE-CONST.	300	5850	0	4.2	90	0.0019	2.79	0.8
POST-CONST.	300	4300	1700	4.2	90	0.005(1)	2.22	0.8

(1) Assumes slope under groundscreen. Assumes other areas will maintain pre-construction slopes.

A.2. Model Constraints

The TR-20 model is being used in this application for planning tool rather than for final design purposes. Therefore generalizations have been made about input parameters such as curve numbers. Although a curve number could vary within a CSA depending upon the exact location of facilities, it is assumed that an average curve number for the CSA can be used for all facility locations within the CSA.

Use of TR-20 in this study does not go to the level of detail necessary to distinguish between various site alternatives within a CSA. It is assumed that parameters such as the curve number will not vary significantly within a CSA. The use of criteria other than the TR-20 model, such as the criteria used in screening to select best and worse case facility site alternatives (described in section 5.3.1) are thought to be more useful for refined site selections.

The selection of the curve number is an important input to the TR-20 model. Therefore it is important to understand all of the constraints associated with the use of this number. The curve number describes average conditions which are useful for design purposes. The curve number does not account for rainfall duration or intensity. The initial abstraction, which is factored into the curve number, consists of variables such as interception, initial infiltration, surface depression storage, evapotranspiration and is estimated as 0.2 times the potential maximum retention after runoff begins. This is based on data from agricultural watersheds. The curve number does not account for runoff from snowmelt or rain on frozen ground. The runoff procedures apply only to direct surface runoff.

A.3 TR-20 Peak Runoff Factor

TR-20 uses a dimensionless hydrograph to estimate runoff. The area under the unit hydrograph is determined by the model inputs, and represents total runoff. A standard Peak runoff factor of 484 is included in the model equation to determine peak runoff, and represents average U.S. conditions.

Selection of the peak runoff factor is related to several characteristics of the watershed including slope. Although this factor is developed into the model, it may be altered to calibrate the model to local conditions. TR-20 documentation states that for mountainous regions the constant could be expected to be closer to 600, and for flat swampy areas the constant may be closer to 300.

Because no documentation was available to select a more appropriate factor for Minnesota and South Dakota, the factor found in the model was used. However, it is likely that a lower peak runoff factor would reflect more realistic results. Therefore, the model results are considered conservative, and it would be necessary to develop a refined factor to determine peak runoff in the final project design.

A.4 Sizing Detention Basins

To estimate the effect of temporary detention on peak discharges, a SCS procedure from TR-55 (Technical Release, version 55) was used. The ratio of the peak outflow to peak inflow (q_o/q_i) was calculated and related to the ratio of storage volume to runoff volume (V_s/V_r) through a pre-derived curve. The unknown variable is Vs, or the storage volume required, which is usually expressed in acre-feet. V_r is derived from the following equation:

$$V_r = 53.33\ Q\ (A_m)$$

where: V_r = runoff volume (acre-feet)
Q = runoff (in)
A_m = drainage area (mi^2)
53.33 = conversion factor from in-mi^2 to acre-feet

Using the computed V_r value, the following equation can be used to derive V_s.

$$V_s = V_r \left(\frac{V_s}{V_r}\right)$$

TECHNICAL STUDY 5

CENTRAL RADAR SYSTEM
OVER-THE-HORIZON-BACKSCATTER RADAR PROGRAM

VEGETATION

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TECHNICAL STUDY 5

VEGETATION

5.1 INTRODUCTION

The U.S. Air Force (USAF) has proposed to construct the Central Radar System (CRS) Over-the-Horizon Backscatter (OTH-B) Radar Facility in the north-central portion of the United States (USAF, 1987). In the Record of Decision (USAF, 1988) for the Environmental Impact Statement (EIS) the USAF selected a study area at Amherst, South Dakota for the transmit sectors, and a study area near Thief River Falls, Minnesota for the receive sectors (Figure 5-1). Within each study area the USAF has identified two concentrated study areas (CSAs) for possible facility locations (Figures 5-2 and 5-3). The CSAs have been selected through a screening process involving environmental, operational, and socioeconomic considerations (Technical Study 1, EIAP Overview).

This document describes the historical and current vegetative conditions within the project areas and evaluates the impacts of the project upon the area's vegetation. It discusses habitat characteristics, vegetation associations, and farmlands at the study area level and the concentrated study area level for both sites. Farmlands are evaluated in accordance with the guidelines of the Farmland Protection Policy Act. Impacts on vegetation and farmlands are evaluated for the USAF's preliminary site layouts and best and worst case locations of the radar facilities.

5.2 REGULATIONS

The Farmland Protection Policy Act of 1981 (FPPA) (7 USC 4209) requires federal agencies to evaluate adverse effects of federal programs on the preservation of farmland and to consider alternative actions that could lessen such effects. Farmland, as defined by the act, includes four categories: prime farmland, unique farmland, farmland of statewide importance, and

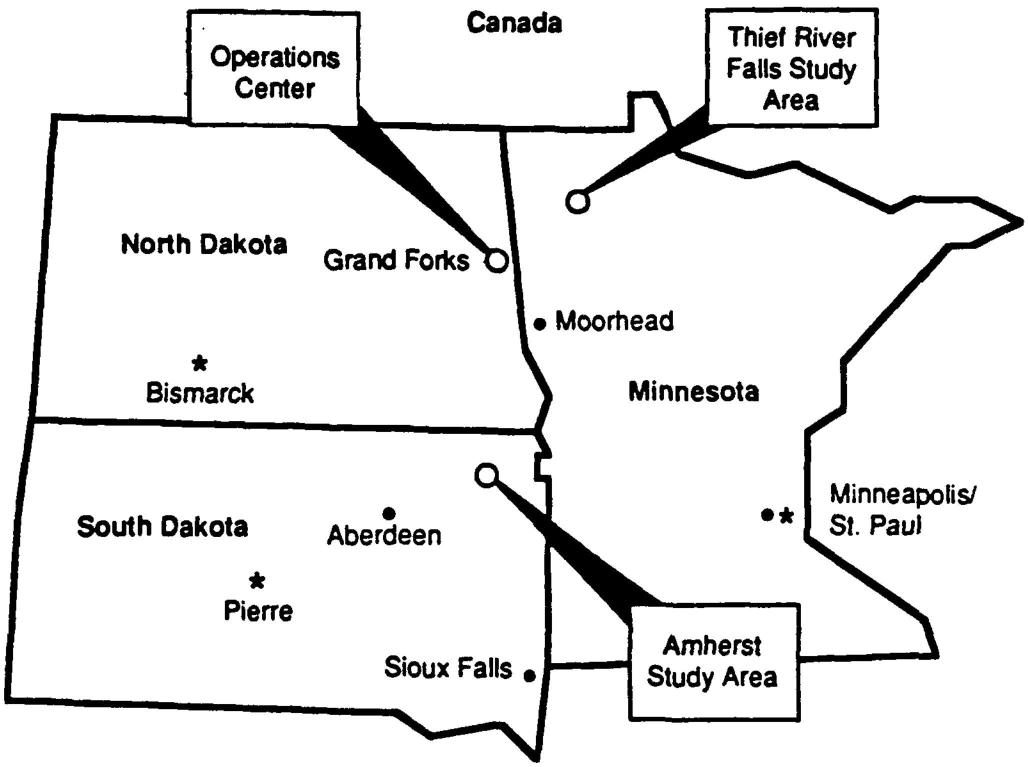


FIGURE 5-1. LOCATION OF THE CENTRAL RADAR SYSTEM TRANSMIT AND RECEIVE STUDY AREAS

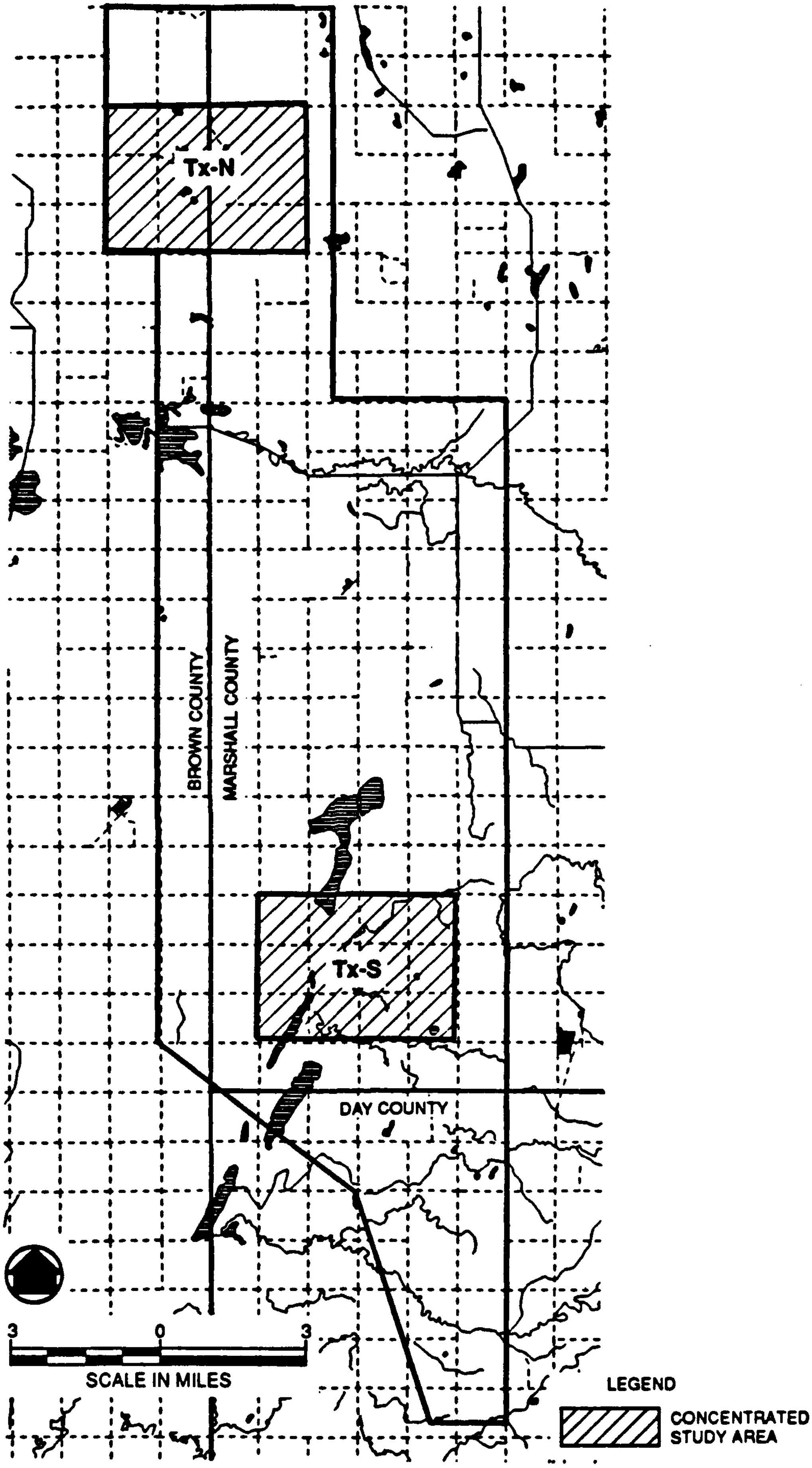


FIGURE 5-2. AMHERST TRANSMIT STUDY AREA AND CONCENTRATED STUDY AREAS

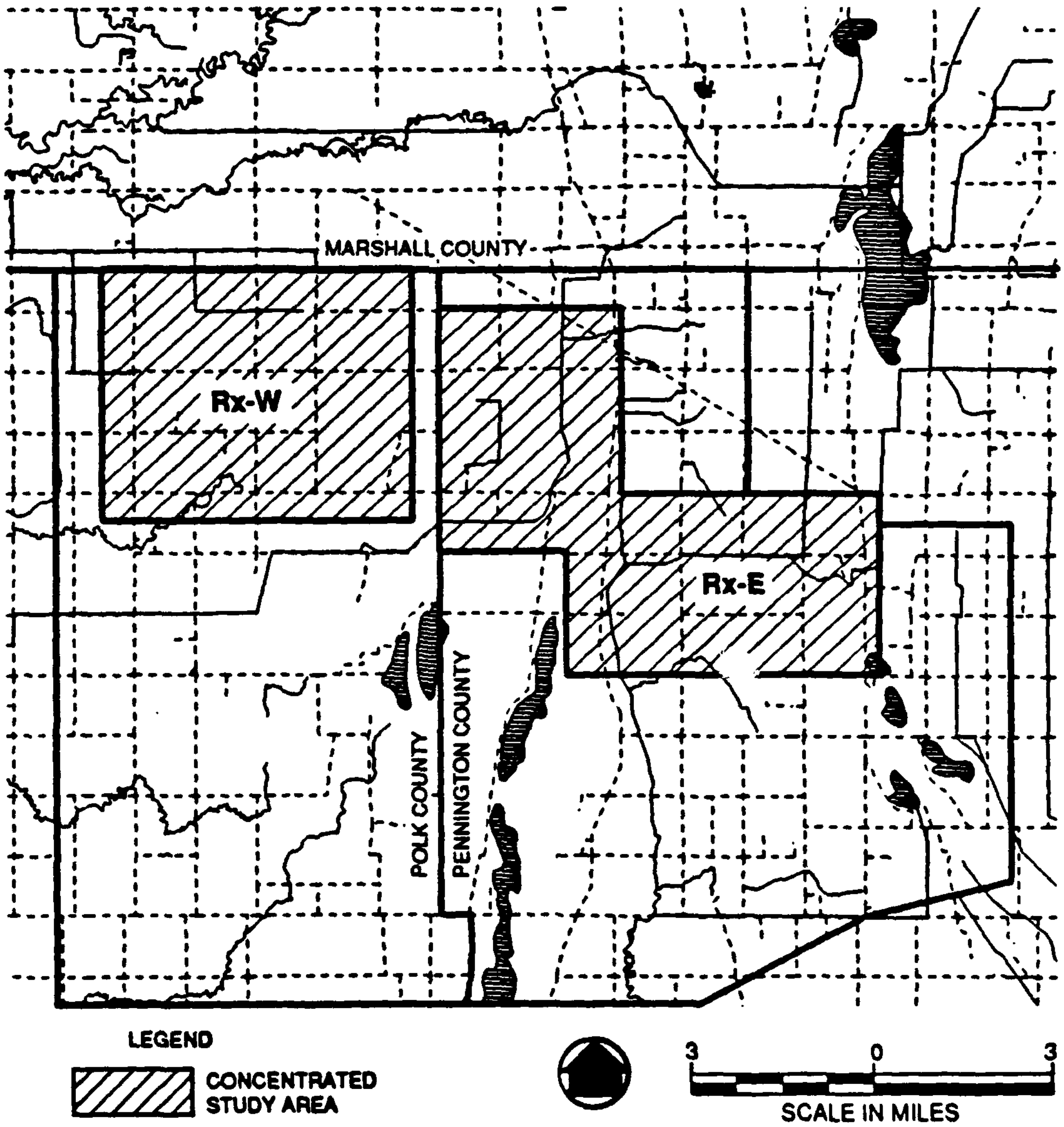


FIGURE 5-3. THIEF RIVER FALLS RECEIVE STUDY AREA AND CONCENTRATED STUDY AREAS

farmland of local importance. Compliance with the act requires the proponent agency to consult with the U.S. Soil Conservation Service (SCS) to identify agricultural lands of importance and to perform a subsequent assessment and evaluation of the direct and indirect impacts associated with the proposed action. Agencies must also consider avoidance or mitigation of any adverse effects to the maximum extent possible. Federal actions which require acquisition of farmland for national defense purposes are exempt from the act. However, the USAF has voluntarily chosen to prepare an evaluation of prime farmland impacts as part of its EIAP.

Although there are no federal or state regulations concerning the disturbance of natural areas such as native prairies or forested areas, these habitats are recognized as important ecological resources. In the site selection process, the USAF has attempted to avoid and minimize impacts to these areas to the maximum extent possible (Technical Study 1).

5.3 AFFECTED ENVIRONMENT

This section discusses habitat characteristics, historical and current vegetation associations, the areal extent and values of vegetation associations, and farmland classifications at the study area and CSA levels. The SCS land evaluation critera for farmlands are presented for the CSAs.

5.3.1 Methods

5.3.1.1 Vegetation Mapping. The following evaluation of the current vegetation status of the transmit and receive study areas is based on land cover and vegetation maps prepared by DPA International Ltd. (DPA) for the USAF (DPA, 1989). DPA prepared maps of the Amherst study area from: 1:12,000 black and white aerial photographs, May 1989; 1:63,000 color infrared photographs, 1984; 35mm color slides from the county Agricultural Stabilization and Conservation Service (ASCS) offices, 1989; 1:24,000 U.S. Fish and Wildlife Service (USFWS) National Wetland Inventory (NWI) preliminary maps; and 1:24,000 US Geological Survey (USGS) 7.5 minute topographic maps. Mapping of the Thief River Falls study area was based on: 35mm color slides from the county ASCS office, 1987; 1:24,000 scale USFWS preliminary NWI maps; LANDSAT Thematic Mapper 1:1,000,000 color composite film projected to 1:24,000, spring 1987; 1:12,000 black and white aerial photographs, May 1989; 1:63,000 color infrared photographs, 1982; and 1:24,000 USGS 7.5 minute topographic maps (DPA, 1989).

The vegetation classification system used was a revision of the classification system developed for Minnesota which is now being used on a statewide basis (DPA, 1989). Figure 5-4 shows the vegetation classification system used. Due to the large size of the study area, cover types were broadly defined at the study area level and further differentiated at the concentrated study area level. Appendix A defines the general characteristics of cover types mapped. Crop type is based on 1989 production and may vary from year to year. It is important to note that DPA's vegetation mapping and the subsequent analysis focuses on upland vegetation. DPA's wetland determination was based on NWI maps. However, more detailed and more accurate wetland maps have been prepared and evaluated by the USAF for the project which is summarized in Technical Study 6, Wetlands and Aquatics. Locations and acreages of wetlands discussed in this study may differ slightly from those in Technical Study 6 due to the variations in methodology, with Technical Study 6 being the more accurate.

Cover types were mapped to a minimum of two acres in the study area and a minimum of one acre in the concentrated study areas, with the exception of cultivated lands periodically flooded, which were mapped to a minimum of 40 acres in the study area and 10 acres in the CSAs. DPA determined areal extent of the cover types in the two study areas and the four CSAs from the vegetation maps.

DPA field verified the vegetation maps on 8 through 12 September 1989 at the Amherst study area and 14 through 16 September 1989 at the Thief River Falls study area. Field verification was done from section roads, where possible. Approximately 6.4 percent of the Amherst study area and 2.6 percent of the Thief River Falls study area was not accessible for field verification (DPA, 1989).

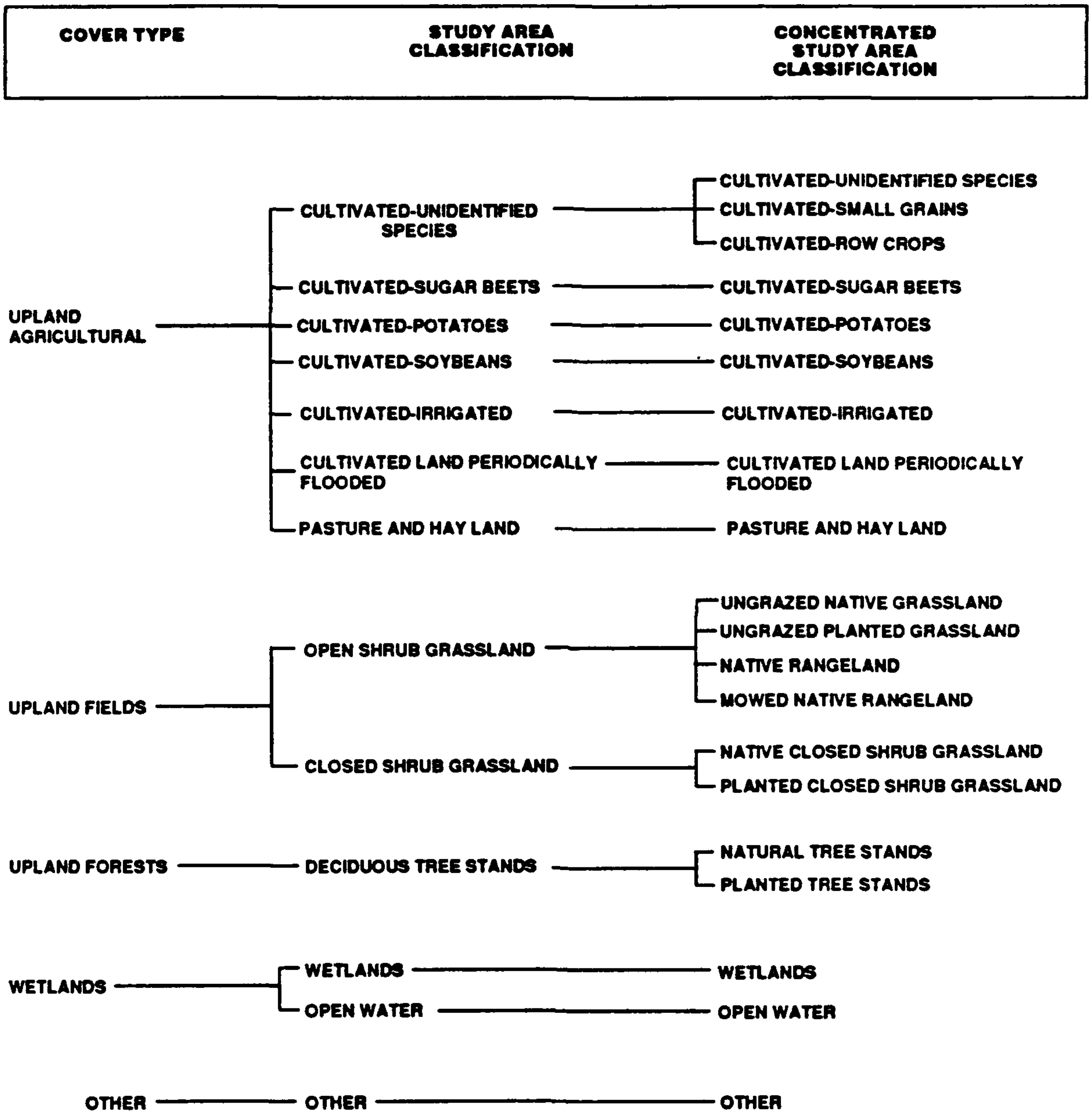


FIGURE 5-4. VEGETATION CLASSIFICATION SYSTEM USED FOR THE CENTRAL RADAR SYSTEM

5.3.1.2 SCS Prime Farmland Classification. Prime farmland identification maps for the Amherst and Thief River Falls CSAs were prepared from published soil survey maps for Marshall County, SD and Pennington County, MN (SCS, 1975; SCS, 1984a) and unpublished draft soil maps for Brown County, SD and Polk County, MN (SCS, No Date; SCS, 1988). Each mapped soil type was identified based on the SCS farmland classifications for Marshall County, SD (SCS, 1984b; SCS, 1984c), Brown County, SD (SCS, 1987), and Pennington County, MN (SCS, 1985). Soil types in Polk County, MN were identified based on the SCS farmland classifications for Pennington County as recommended by the SCS (SCS, 1989a).

Pursuant to the FPPA, the SCS classified soil types as prime farmland, prime farmland if drained, prime farmland if irrigated, and farmland of statewide importance. All other soils were classified as non-prime farmland. According to the SCS classifications, there are no soil types within the CSAs that would be classified as unique farmland or farmland of local importance. Very few prime farmlands if irrigated were found in the study area and were therefore included with prime farmlands. Prime farmland is defined by the SCS as land that has the soil quality, growing season, and moisture supply needed to economically produce sustained high yields of crops when treated and managed. This land must be available for crop production and could include cropland, pastureland, rangeland, forest land, or other land, but excludes developed land or land under water. Farmland of state-wide importance is defined and delineated by appropriate state agencies. The CSA prime farmland identification maps were used to determine acres of prime and prime if drained farmlands, farmlands of statewide importance, and non-prime farmlands.

The area SCS offices provided land evaluation criteria for the concentrated study areas following the guidelines established by 7 CFR 658.5(b) pursuant to the Farmland Protection Policy Act. This criteria describes the relative value of farmland to be affected, as compared to all farmland in the county, on a scale of 0 to 100, with 0 being of no value and 100 being of greatest value.

The following information on general land uses, soil associations, and the percentage composition of prime farmlands in the general study areas was estimated using the general soil maps and information from the published soil surveys for Marshall County, SD (SCS, 1975) and Pennington County, MN (SCS, 1984a), and a published general soil map for Polk County, MN (SCS, 1977). Soil associations and percentage of individual soil types found within the soil associations are presented in these documents. The percentage of the different farmland classifications in the general study area was determined by 1) estimating the percentage of each soil associations within the study area 2) determining the percentage of each soil type within the soil association 3) applying a farmland classification to each soil type, and 4) totalling the percentages of each farmland classification.

5.3.2 Transmit Study Area

The transmit study area (Tx) is located primarily in Marshall County, with portions in Brown and Day Counties. The northern concentrated study area (Tx-N CSA) is located in both Marshall County and Brown County. The southern concentrated study area (Tx-S CSA) is located in Marshall County (Figure 5-2).

5.3.2.1 Habitat Characteristics. The transmit study area is situated on the glacial Lake Dakota Plain physiographic division. In this region, glacial meltwaters have produced soils consisting of sediment deposition of silt and clay 100 feet in depth (USAF, 1986). The major soil types include Maddock-Serden, Embden-Hecla-Ulen, Beotia-Great Bend, and Harmony-Aberdeen-Exline associations (Table 5-1) (SCS, 1975). Topography is generally flat with slopes approximating 1 percent except in localized areas and wetlands occur in localized depressions. Average annual precipitation ranges from 18 to 24 inches (USAF, 1986).

5.3.2.2 Vegetative Associations. Originally, the transmit study area supported bluestem prairie *(Andropogon-Panicum-Sorghastrum)* or tall-grass prairie to the east, wheatgrass-bluestem-needlegrass prairie *(Agropyron-Andropogon-Stipa)* or mixed-grass prairie to the west, and Nebraska Sandhills prairie *(Andropogon-Calamovilfa)* known locally as the "Hecla Sandhills" to the

TABLE 5-1. TRANSMIT STUDY AREA SOIL ASSOCIATION DESCRIPTIONS

Soil Association	% of Study Area(1)	% of Tx-N	% of Tx-S	Soil Type and Classification(2)	Land Use	Description
Marshall County						
Maddock - Serden	10	86	0	45% Maddock - N 25% Serden - N 30% Other - P, N	Mostly native grass pasture, some areas cultivated feed and forage crops	Nearly level to hilly, well drained to excessively drained, sandy soils formed in eolian (wind blown) and lacustrine sands
Embden-Hecla-Ulen	35	14	14	20% Embden - P 20% Hecla - N 20% Ulen - N 40% Other - P, P/D, or N	Crops, hay, and pasture	Nearly level to hilly, well drained to somewhat poorly drained, loamy and sandy soils formed in eolian, lacustrine, and outwash sand
Beotia-Great Bend	35	0	38	45% Beotia - P 10% Great Bend - P 45% Other - P, P/D, S, or N	Crops, small areas of native and tame pasture	Nearly level to sloping, well drained, silty soils formed in lacustrine silt
Harmony-Aberdeen-Exline	20	0	48	35% Harmony - S 30% Aberdeen - S 15% Exline - N 20% Other - P or P/D	Crops, some areas of hay and pasture	Nearly level, moderately well drained to somewhat poorly drained, silty soils formed in lacustrine silt and silty clay

1. Based on Marshall County only.

2. P = Prime Farmland P/D = Prime Farmland if Drained P/I = Prime Farmland if Irrigated
S = Farmland of Statewide Importance N = Non-Prime Farmland

Sources: SCS, 1975; SCS 1984b; SCS, 1984c; SCS, 1987.

north (Figures 5-5 and 5-6). Additionally, wetlands and their associated vegetation were scattered throughout. Over time, most of the native prairies and many of the wetlands have been converted for agricultural uses and shelterbelts and woodlots have been planted where trees did not originally exist.

5.3.2.2.1 Upland Agricultural. Upland agricultural associations occupy 75 percent of the transmit study area (Table 5-2). This is comprised of 71 percent cultivated-unidentified species, 2 percent cultivated-periodically flooded, and 2 percent pasture and hay land. Cultivated-irrigated lands are negligible, comprising less than 1 percent of the study area.

Areas classified as cultivated-unidentified species are extensive and dominate the southern three-fourths of the study area. This is a result of the fertile, stable soils of the Embden-Hecla-Ulen, Beotia-Great Bend, and Harmony-Aberdeen-Exline associations which are able to support extensive agriculture. Among the most common crop species grown are spring wheat, flax, corn, oats, barley, alfalfa, sunflowers, and sorghum, (SCS, 1975; USAF, 1986).

Cultivated-periodically flooded lands are found in the central and southwestern portions of the study area. In years when flooding does not occur, these areas are usually planted with the same species grown in other cultivated lands.

Pasture and hay lands are found in relatively small parcels throughout the study area. Native species commonly associated with pasture and hay lands include tall-grass and mixed-grass prairie species listed in Tables 5-3 and 5-4. These species may also be planted. However, plantings are rare due to the high cost involved (SCS; 1989b).

Cultivated lands provide forage for white-tailed deer, possibly pronghorn antelope, and numerous species of waterfowl. Cultivated-periodically flooded lands are especially important to waterfowl in years of flooding (Technical Studies 7 and 8). If not overgrazed, pasture and hayland can provide habitat for white-tailed deer, ground-dwelling mammals, and ground-nesting birds

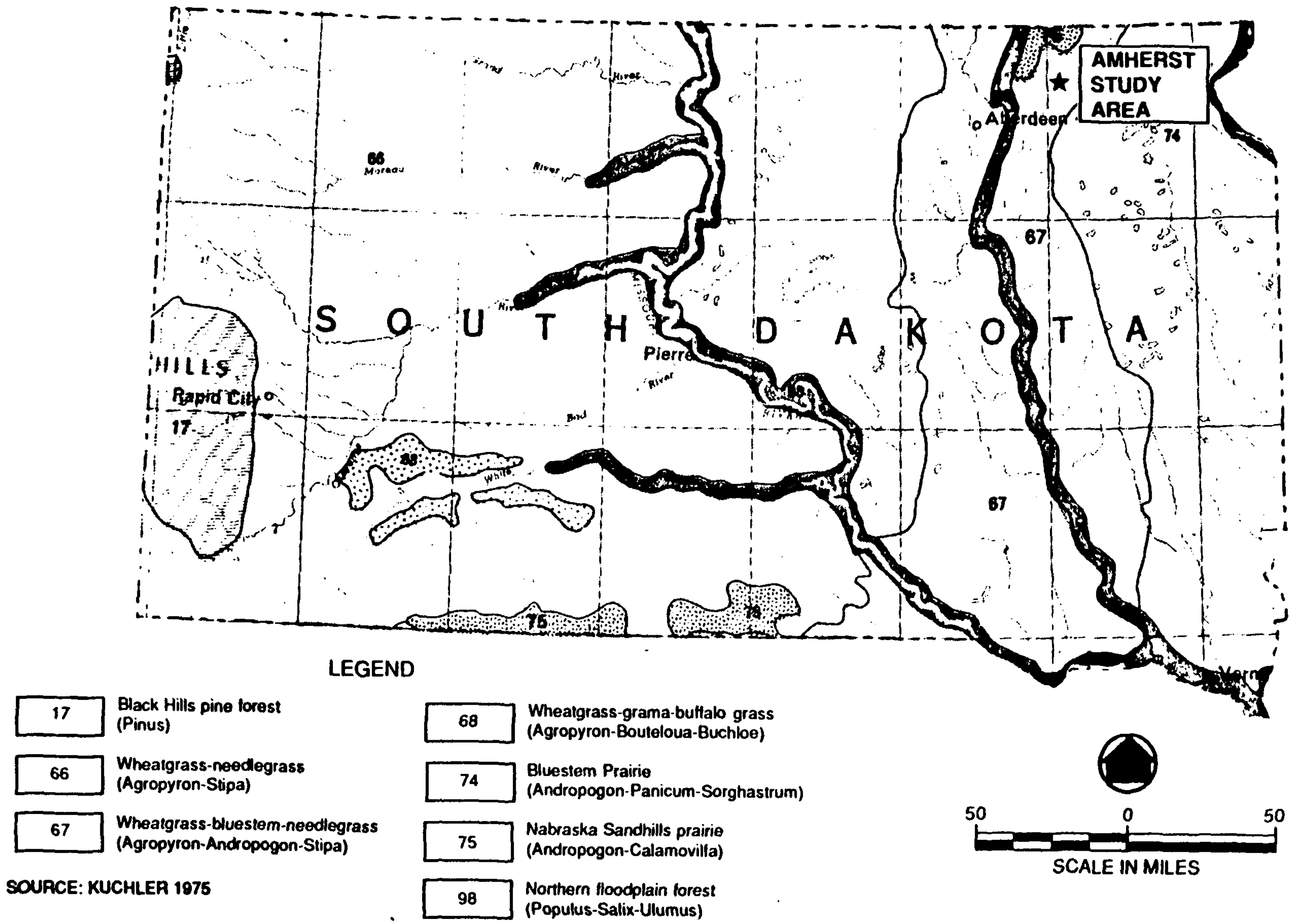


FIGURE 5-5. POTENTIAL NATURAL VEGETATION OF SOUTH DAKOTA

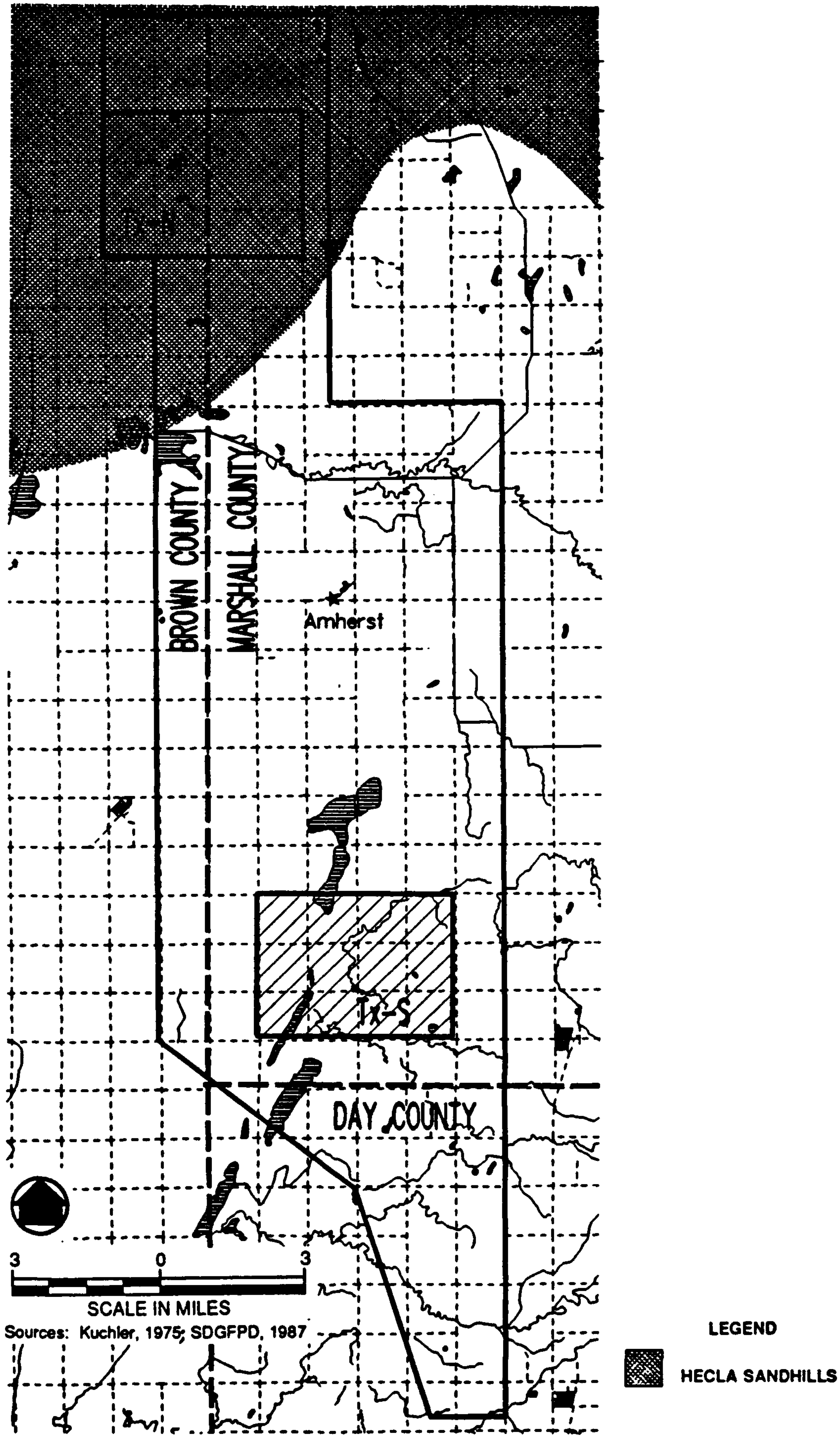


FIGURE 5-6. AMHERST, SD TRANSMIT STUDY AREA GENERAL REGION OF THE HECLA SANDHILLS

TABLE 5-2. PERCENTAGE OF LAND COVER TYPES AT THE TRANSMIT STUDY AREA

Cover Type	Study Area	Tx-N CSA	Tx-S CSA
Upland Agricultural			
Cultivated-Unidentified Species	71	3	7
Cultivated-Small Grains	-	0	43
Cultivated-Row Crops	-	2	30
Cultivated-Sugar Beets	0	0	0
Cultivated-Potatoes	0	0	0
Cultivated-Soybeans	0	0	0
Cultivated-Irrigated	<1	0	0
Cultivated-Periodically Flooded	2	0	7
Pasture and Hay Land	2	4	4
SUBTOTAL	**75**	**9**	**91**
Upland Fields			
Open Shrub Grassland	17	15	<1
Ungrazed Native Grassland	-	0	<1
Ungrazed Planted Grassland	-	0	<1
Native Rangeland	-	61	5
Mowed Native Rangeland	-	1	0
Closed Shrub Grassland	<1	<1	0
Native Closed Shrub Grassland	-	<1	0
Planted Closed Shrub Grassland	-	0	0
SUBTOTAL	**17**	**77**	**5**
Upland Forests			
Deciduous Tree Stands	2	<1	<1
Natural Tree Stands	-	<1	<1
Planted Tree Stands	-	<1	<1
SUBTOTAL	**2**	**1**	**1**
Wetlands(1)			
Wetlands	5	13	3
Open Water	<1	<1	<1
SUBTOTAL	**5**	**13**	**3**
Other	1	0	0
TOTAL	**100**	**100**	**100**

1. Based on DPA, 1989 vegetation mapping. See Technical Study 6 for wetland acreages based on more detailed wetland mapping.

TABLE 5-3. SPECIES COMMONLY ASSOCIATED WITH TALL-GRASS PRAIRIES

	Common Name	Scientific Name
Grasses	Big bluestem	*Andropogon gerardi*
	Bluejoint grass	*Calamagrostis canadensis*
	Canada wild-rye	*Elymus canadensis*
	Indian grass	*Sorghastrum nutans*
	Porcupine grass	*Stipa spartea*
	Prairie cordgrass	*Spartina pectinata*
	Prairie dropseed	*Sporobolus heterolepis*
	Switchgrass	*Panicum vigratum*
Forbs	Bottle gentian	*Gentiana andrewsii*
	Blazing star	*Liatris pycnostachya*
	Canada anemone	*Anemone canadensis*
	New England aster	*Aster novae-angliae*
	Red lily	*Lilium philadelphicum*
	Silky aster	*Aster sericeus*
	Tall goldenrod	*Solidago altissima*
	Yellow star grass	*Hypoxis nirsuta*
	White sage	*Artemisia ludoviciana*
Invaders	Bromegrass	*Bromus spp.*
	Foxtail barley	*Hordeum jabatum*
	Kentucky bluegrass	*Poa pratensis*
	Western wheatgrass	*Agropyron smithii*

Sources: Kannowski, 1979; MNDNR, 1984.

TABLE 5-4. SPECIES COMMONLY ASSOCIATED WITH MIXED-GRASS PRAIRIES

	Common Name	Scientific Name
Grasses	Blue grama	*Bouteloua gracilis*
	Buffalo grass	*Buchloe dactyloides*
	Green needlegrass	*Stipa viridula*
	Junegrass	*Koeleria cristata*
	Little bluestem	*Andropogon scoparius*
	Needle-and-thread	*Stipa comata*
	Side-oats grama	*Bouteloua curtipendula*
Forbs	Narrowleaf blazing star	*Liatris punctata*
	Fringed sage	*Artemisia frigida*
	Pasque-flower	*Anemone patens*
	Prairie rose	*Rosa arkansana*
	Purple coneflower	*Echinacea angustifolia*
	Purple prairie-clover	*Petalostemum purpureum*
	Silverberry	*Elaeagnus commutata*
	Torch flower	*Geum triflorum*
	Wolfberry	*Symphoricarpos occidentalis*

Source: Kannowski, 1979.

(Crawford, et. al., 1979). These lands are also important socioeconomically as they support the area's valuable grazing and agricultural economy (USAF, 1986).

5.3.2.2.2 Upland Fields. Upland field associations occupy 17 percent of the transmit study area (Table 5-2). This is essentially all open shrub grassland with small amounts of closed shrub grassland.

Open shrub grasslands dominate the northern one-fourth of the study area. These grasslands are found primarily within the boundaries of the Hecla Sandhills, a region of undulating sandhills interspersed with subirrigated meadows and wetlands (Figure 5-6). These lands are predominantly native rangeland used mostly for haying or grazing. This area has excessively drained, sandy soils of the Maddock-Serden series which support unique floristic combinations that set them apart from adjacent grassland communities. In the sandhills, common species associated with dry uplands include blue grama, needle-and-thread, bluegrasses, big sandgrass, lead plant, white sage, sweet clover, and a sedge *(Carex heliophila)*; species associated with subirrigated meadows include big bluestem, switchgrass, sweet clover, sedges, a wheatgrass *(Agropyron caninum)*, and a reedgrass *(Agrostis stolonifera)*; and species associated with wetter communities include switchgrass, prairie cordgrass, path rush, and a spikerush *(Eleocharis compressa)*, (SDGFPD, 1985). Additionally, the subirrigated meadows of the sandhills provide suitable habitat for the threatened Western prairie fringed orchid (Technical Study 9, Threatened and Endangered Species), although it has not actually been sighted there (USFWS, 1988). (Common and scientific names of plants discussed in this report are listed in Appendix B).

Open shrub grasslands are also found in small parcels of land in the southern three-fourths of the study area. These may be remnants of the original prairies supporting species of either the tall-grass or mixed-grass prairie types listed in Tables 5-3 and 5-4.

Upland field associations that maintain prairie ecosystems are of national importance due to the extensive conversion of these natural areas for agricultural uses. Prairie ecosystems maintaining grassland and wetland communities provide habitat for white-tailed deer, possibly pronghorn antelope, small mammals, waterfowl, raptors, game birds, and ground-nesting birds (Crawford, et. al., 1979) (Technical Studies 7 and 8).

5.3.2.2.3 Upland Forests. Upland forest associations comprised of deciduous tree stands occupy 2 percent of the transmit study area (Table 5-2). Deciduous tree stands within the study area may be either natural or planted, although this differentiation was made only at the CSA level.

Natural tree stands are found in riparian areas and around wetlands where soil moisture is sufficient. Native tree and shrub species include cottonwoods, ash, American elm, boxelder, oak, willow, chokeberry, plum, and russian olive, an introduced species. (Crawford, et. al., 1979; SCS, 1975). Trees in these stands range from 8 to more than 20m in height and the stands are moderate to open in density. The understory consists of saplings, shrubs, forbs, and woodland grasses and sedges. Ground cover ranges from a leafmat layer to a herbaceous layer of grasses, sedges, and forbs (Crawford, et. al., 1979).

Planted tree stands are in the form of shelterbelts and woodlots throughout the study area. Planted trees and shrubs include native and exotic species such as American elm, boxelder, Siberian elm, green ash, plum, caragna, honeysuckle, Russian olive, red cedar, Ponderosa pine, and blue spruce (Crawford, et. al., 1979). Tree heights based on measurements and observations of 20 year old windbreaks that had been given adequate care ranged from 5 to 40 feet depending on soils and tree species (SCS, 1975).

Upland forest associations provide habitat for white-tailed deer, small mammals, and numerous bird species (Technical Studies 7 and 8). Additional values of natural tree stands include soil erosion control, streambank shade, and recreational uses. Planted tree stands provide soil erosion control, shelter from wind, and maintenance of moisture levels.

5.3.2.3 SCS Prime Farmland Classification. The transmit study area is comprised of approximately 38 percent prime farmland, 8 percent prime farmland if drained, 19 percent farmland of statewide importance, and 38 percent non-prime farmland (Table 5-5). The majority of the prime farmlands, prime farmlands if drained, and farmlands of statewide importance are in the southern three-fourths of the study area where the fertile, stable soils of Embden-Hecla-Ulen, Beotia Great-Bend, and Harmony-Aberdeen-Exline associations predominate. The non-prime farmlands are primarily found in the northern one-fourth of the study area where the droughty, sandy soils of the Maddock-Serden association predominates (Table 5-1).

TABLE 5-5. TRANSMIT STUDY AREA PRIME FARMLAND CLASSIFICATION AND LAND EVALUATION CRITERIA

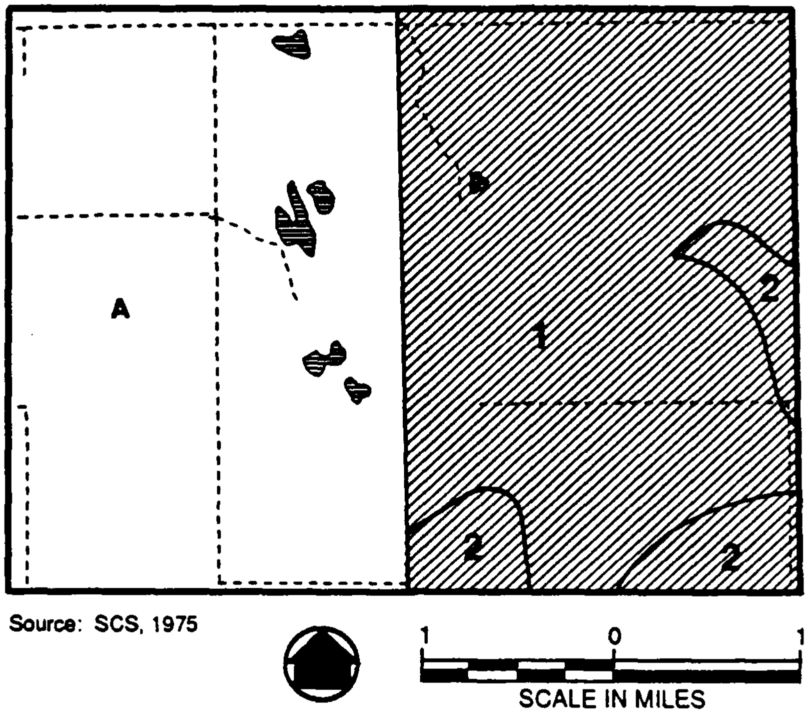
	Study Area(1)(2)	Concentrated Study Area	
		Tx-N(2)	Tx-S(2)
Prime Farmland (%)	38	<1	32
Prime (if Drained) (%)	8	3	8
Statewide Importance (%)	19	0	23
Non-Prime (%)	38	96	37
Land Evaluation Criteria	--	32(Marshall) 42(Brown)	89

1. Based on approximate areas only.
2. Based on Marshall County soil survey only.

Sources: SCS, 1975; SCS, 1989a; SCS, 1989d

5.3.3 Tx-North Concentrated Study Area

5.3.3.1 Habitat Characteristics. The Tx-N CSA is situated within the Hecla Sandhills. The terrain is undulating sandhills with wetlands interspersed in localized depressions. Soils are predominately the excessively drained, sandy soils of the Maddock-Serden association with small portions of the somewhat poorly drained loamy and sandy soils of the Embden-Hecla-Ulen Association (Figure 5-7).



Source: SCS, 1975

LEGEND

SCS GROUP NO.	SOIL ASSOCIATION
1	MADDOCK-SERDEN
2	EMBDEN-HECLA-ULEN
A	UNKNOWN

FIGURE 5-7. TX-NORTH CONCENTRATED STUDY AREA SOIL ASSOCIATIONS

5.3.3.2 Vegetation Associations. The Tx-N CSA consists of large tracts of upland fields with small areas of upland agriculture. Wetlands and their associated vegetative species are abundant in the central portion of the Tx-N CSA with additional wetlands scattered around the perimeters. Upland forests consist primarily of planted tree stands.

5.3.3.2.1. Upland Agricultural. Upland agricultural associations occupy 9 percent of the Tx-N CSA (Table 5-2). This is comprised of 4 percent pasture and hay land, 3 percent cultivated-unidentified species, and 2 percent cultivated-row crops. Upland agricultural associations are generally found as small parcels of land located in the western one-fourth of the Tx-N CSA. The lack of upland agricultural associations is a result of the predominance of the Maddock-Serden associations which preclude extensive agriculture (SCS, 1975).

5.3.3.2.2. Upland Fields. Upland field associations occupy 77 percent of the Tx-N CSA (Table 5-2). This is comprised of 61 percent native rangeland, 15 percent open shrub grassland, and 1 percent mowed native rangeland. Open shrub grassland can be assumed to be native rangeland by its shape and locations within the sandhills. *Closed* shrub grasslands are small parcels of land comprising less than 1 percent of the Tx-N CSA.

Native rangelands and open shrub grasslands are found in large tracts of land throughout the Tx-N CSA. Sandhills prairie and its associated native species dominate the area. The threatened Western prairie fringed orchid could inhabit the subirrigated meadows of this portion of the sandhills (Technical Study 9). Although invasion of exotic species has occurred in this region, it is not extensive. In the past, these lands have been overgrazed, although currently, overgrazing is not as extensive. Range conditions now vary from poor to excellent due to past and present land usage. However, current range evaluations are not available (SDGFPD, 1990).

Mowed native rangeland consists predominantly of an 80 acre parcel designated as a native prairie. It is the only protected community of big bluestem prairie within the Hecla Sandhills and the only known site in South Dakota where prairie loosestrife, a species inhabiting moist and dry upland soils (Gleason and Cronquist, 1963), can be found. It is also one of four or five known sites in South Dakota where alpine rush and meadow sweet, species inhabiting wet meadows (Gleason and Cronquist, 1963), can be found (SDGFPD, 1985).

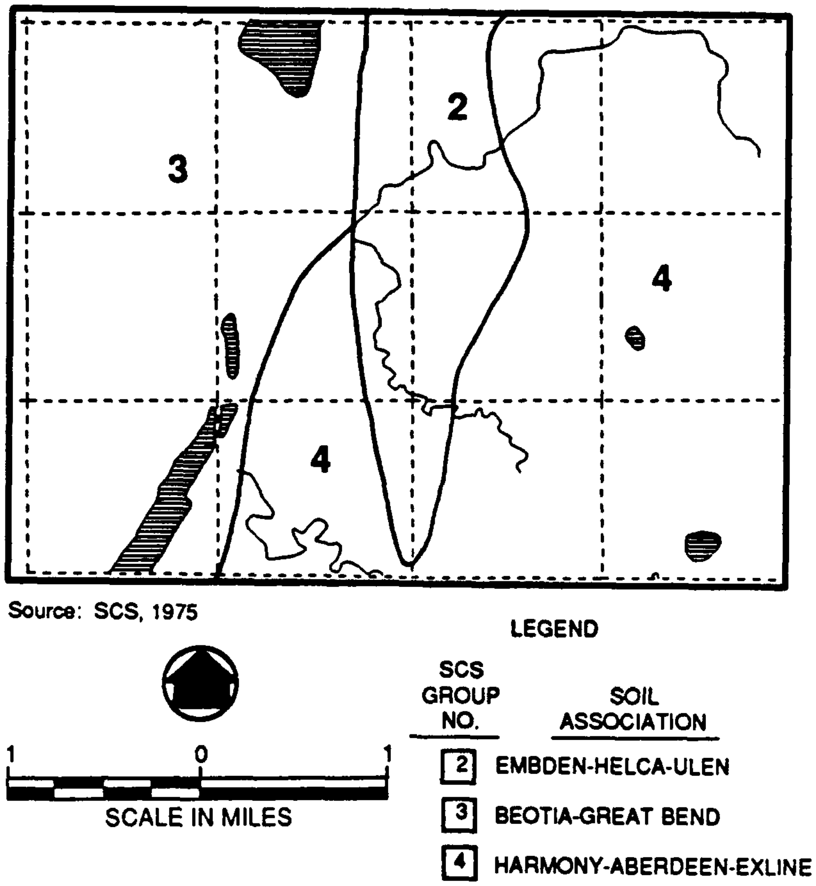
5.3.3.2.3 Upland Forests. Upland forests comprise approximately 1 percent of the Tx-N CSA (Table 5-2). Although there are few forested areas, they are important due to their relative scarcity in the region and their potential as habitat for wildlife species (Technical Studies 7 and 8).

5.3.3.3 SCS Prime Farmland Classification. The Tx-N CSA is comprised of less than 1 percent prime farmland, 3 percent prime farmland if drained, and 96 percent non-prime farmland (Table 5-5). The SCS assigned a land evaluation criterion of 32 for Marshall County and 42 for Brown County lands in the Tx-N CSA (SCS, 1989c; SCS 1989d). The high percentage of non-prime farmlands is a direct result of the predominance of the excessively drained, sandy soils of the Maddock-Serden association which is not conducive to agricultural uses (Table 5-1 and Figure 5-7).

5.3.4 Tx-South Concentrated Study Area

5.3.4.1 Habitat Characteristics. Topographic features and soils of the Tx-S CSA differ from those of the Tx-N CSA. The Tx-S CSA is primarily flat, and the western portion contains periodically-flooded depressed areas with poor drainage capacity. Soils are of the rich Embden-Hecla-Ulen, Beotia-Great Bend, and Harmony-Aberdeen-Exline associations with the Embden-Hecla-Ulen associations being concentrated in the poorly drained, periodically flooded areas (Figure 5-8).

5.3.4.2 Vegetation Associations. Vegetation associations of the Tx-S CSA differ from those of the Tx-N CSA. The Tx-S CSA is dominated by agriculture with small interspersed tracts of upland fields, while the Tx-N CSA is dominated by upland fields with few upland agricultural lands. Wetlands and their associated species are primarily in the east and central portions of the Tx-S CSA. Upland forests are primarily in the form of shelterbelts.



Source: SCS, 1975

FIGURE 5-8. TX-SOUTH CONCENTRATED STUDY AREA
SOIL ASSOCIATIONS

5.3.4.2.1 Upland Agricultural. Upland agricultural associations occupy 91 percent of the Tx-S CSA (Table 5-2). This is comprised of 43 percent cultivated-small grains, 30 percent cultivated-row crops, 7 percent cultivated-periodically flooded, 7 percent cultivated-unidentified species, and 4 percent pasture and hay land.

Cultivated areas are mostly in large tracts of land throughout the Tx-S CSA. A large tract of cultivated-periodically flooded land is located in the west-central portion of the Tx-S CSA. It is cultivated only in years of feasible water levels. Pasture and hay lands are interspersed within the croplands.

5.3.4.2.2 Upland Fields. Upland field associations occupy 5 percent of the Tx-S CSA (Table 5-2). This is primarily native rangeland with small amounts of native and planted ungrazed grasslands and open shrub grassland (undifferentiated). The native rangelands are small parcels of land interspersed between agricultural fields and along wetlands in the eastern portions of the Tx-S CSA.

5.3.4.2.3 Upland Forests. Upland forests comprise approximately 1 percent of the Tx-S CSA (Table 5-2). Forested areas are of ecological importance due to their relative scarcity in the area and they provide valuable habitat for a number of wildlife species (Technical Studies 7 and 8).

5.3.4.3 SCS Prime Farmland Classification. The Tx-S CSA is comprised of 32 percent prime farmland, 8 percent prime farmland if drained, 23 percent farmland of statewide importance, and 37 percent non-prime farmland (Table 5-5). The SCS assigned a land evaluation criterion of 89 to the Tx-S CSA (SCS, 1989e). The high percentage of prime farmland, prime farmland if drained, and farmland of statewide importance is due to the predominance of the fertile, stable soils of the Embden-Hecla-Ulen, Beotia-Great Bend, and Harmony-Aberdeen-Exline associations (Table 5-1 and Figure 5-8).

5.3.5 Receive Study Area

The receive study area (Rx) is located in Pennington and Polk Counties. The eastern concentrated study area (Rx-E CSA) is located in Pennington County and the western concentrated study area (Rx-W CSA) is located in Polk County (Figure 5-3).

5.3.5.1 Habitat Characteristics. The receive study area is situated on the Glacial Lake Agassiz Plain physiographic division. In this region, glacial meltwaters have produced soils consisting of sediment deposition of silt and clay 300 feet in depth (USAF, 1986). A number of soil associations exist in the study area. Major soil types include the Rollis-Vallers, Lohnes-Karlstad, Wheatville-Augsburg, Arveson-Ulen, and Roliss-Kittson-Viking associations (Tables 5-6 and 5-7) (SCS, 1977; SCS, 1984a). Topographic features include ancient beach strands. The strand lines are a series of low linear ridges with numerous wetlands lying in the low areas between the ridges. They are in a north-south orientation and are most evident in the central and eastern portions of the study area. Areas to the west, not closely associated with the strand lines, are flatter and better drained, maintaining unnamed streams. Average annual precipitation is 21 inches and average annual temperature is 38°F (MNDNR, 1984).

5.3.5.2 Vegetation Associations. The Thief River Falls Study Area is located in a transition zone between an area dominated by bluestem prairie (tall-grass prairie) to the west and oak savanna (Quercus-Andropogon) to the east (Figure 5-9). However, like the transmit study area, most of these natural areas have been converted for agricultural purposes. According to the Minnesota Department of Natural Resources (MNDNR), less than 1 percent of Minnesota's tall-grass prairies remain intact (MNDNR, 1984). The tall-grass prairies within the study area may consist of communities of mesic blacksoil prairies or wet blacksoil prairies which are considered threatened by the Minnesota Department of Natural Resources' Natural Heritage Program (MNDNR, 1987b; MNDNR, 1987c). Species commonly associated with mesic and wet blacksoil prairies are listed in Tables 5-8 and 5-9. Although the receive study area supports more forested areas than the transmit study area, many of

TABLE 5-6. RECEIVE STUDY AREA SOIL ASSOCIATION DESCRIPTIONS - PENNINGTON COUNTY

Soil Association	% of Study Area	% of Rx-E	Soil Type and Classification(1)	Land Use	Description
Pennington County					
Rollis-Vallers	44	70	35% Rollis - P/D 20% Vallers - P/D 45% Other - P or P/D	Crops, hay, and pasture	Poorly drained, medium textured soils
Grimstad-Rockwell-Foldahl	12	3	30% Grimstad - P 25% Rockwell - P/D 20% Foldahl - P 25% Other - P, S, or N	Crops, hay and pasture	Moderately well drained and poorly drained, moderately course textured, dominantly calcareous soils
Lohnes-Karlstad	24	25	50% Lohnes - N 15% Karlstad - N 35% Other - N	Crops, hay, and pasture	Well drained and moderately well drained, coarse textured and moderately coarse textured, noncalcareous soils
Rosewood-Ulen-Flaming	7	<1	40% Rosewood - S 20% Ulen - P/I 20% Flaming - N 20% Other - P, P/D, or N	Most of this association has been or is being cleared for farming small grains, sunflowers, hay, and pasture	Poorly drained and moderately well drained, moderately coarse textured and coarse textured, dominantly calcareous soils
Clearwater-Wyandotte-Thiefriver	5	0	50% Clearwater - P/D 15% Wyandotte - S 10% Theifriver - P/D 25% Other - P or P/D	Cultivated small grains, sunflowers, and hay	Poorly drained, fine textured, moderately fine textured, and moderately coarse textured, calcareous soils
Borup-Glyndon-Augsburg	5	0	40% Borup - P/D 30% Glyndon - P 10% Augsburg - P/D 20% Other - P, P/I, or N	Most of this association has been cleared for farming small grains, sunflowers, hay, and pasture	Poorly drained and moderately well drained, medium textured, calcareous soils
Deerwood-Hamre	3	2	35% Deerwood - N 30% Hamre - P/D 35% Other - P/D, S, or N	Mostly not farmed, few areas used for pasture and hay	Very poorly drained, mucky, mineral soils

1. P = Prime Farmland P/D = Prime Farmland if Drained P/I = Prime Farmland if Irrigated
S = Farmland of Statewide Importance N = Non-Prime Farmland

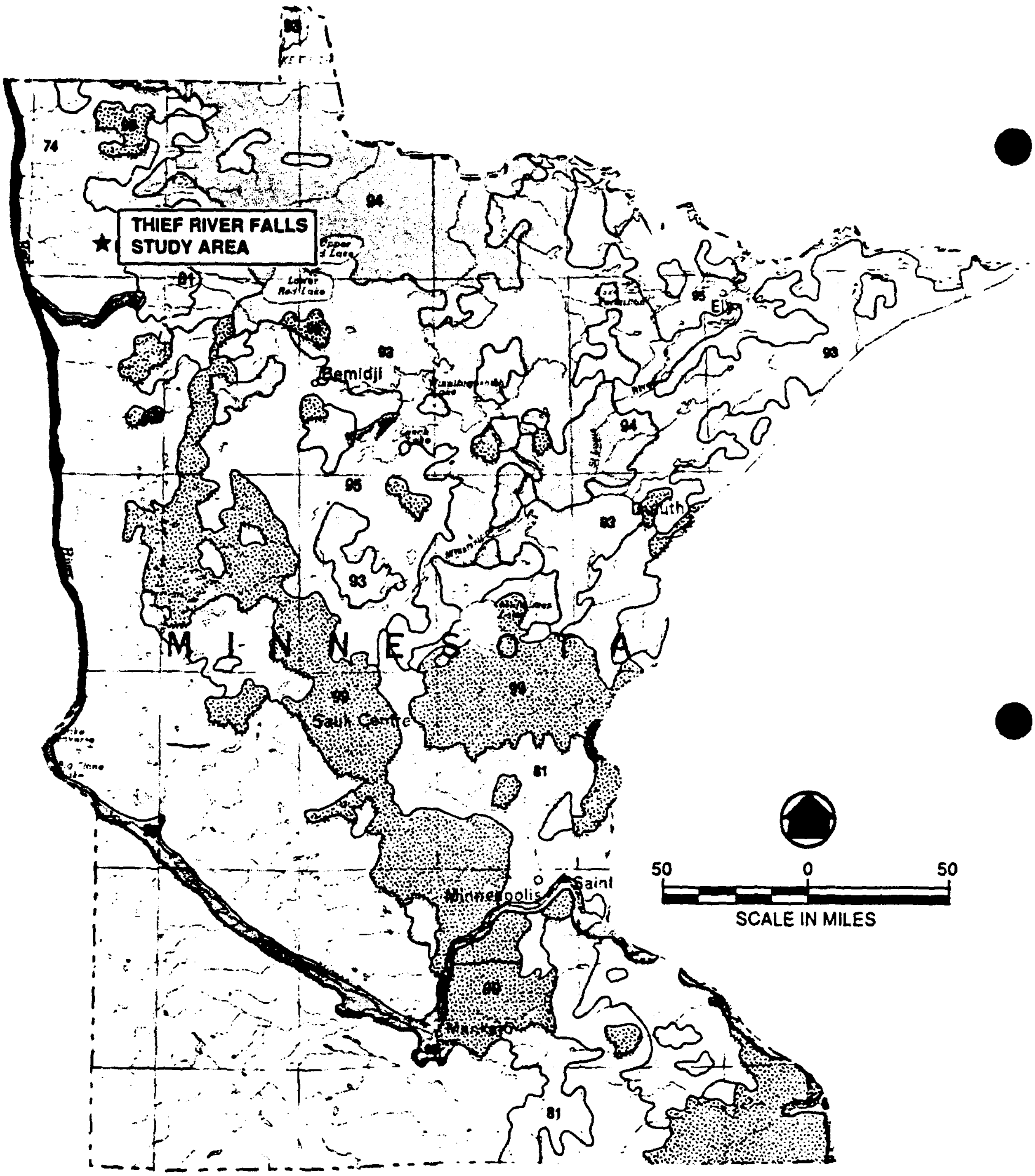
Sources: SCS, 1984a; SCS, 1985.

TABLE 5-7. RECEIVE STUDY AREA SOIL ASSOCIATION DESCRIPTIONS - POLK COUNTY

Soil Association	% of Study Area	% of Rx-W	Soil Type and Classification(1)	Land Use	Description
<u>Polk County</u>					
Wheatville-Augsburg	23	1	50% Wheatville - P 15% Augsburg - P/D 35% Other - P or P/D	Cultivated with small grains, potatoes, and sugar beets being the primary crops	Moderately well to poorly drained, loamy soil underlain by very fine sands over clay
Rockwell-Grimstad	8	0	65% Rockwell - P/D 15% Grimstad - P 20% Other - P, P/D, P/I, or N	Cultivated for small grains and livestock feed, few areas uncultivated	Poorly to moderately well drained, loamy soils underlain by fine sands, over glacial till
Arveson-Ulen	34	72	50% Arveson - N 30% Ulen - P/I 20% Other - P, P/D, or N	Cultivated with small grains, forage, and potatoes being the primary crops	Poorly to moderately well drained, fine sandy soils
Roliss-Kittson-Viking	24	27	50% Roliss - P/D 15% Kittson - P 10% Viking - N 25% Other - P, P/D, or S	Cultivated small grains, hay, and pasture	Poorly to moderately well drained, loamy and clayey soils
Lohnes-Syrene-Hangaard	11	<1	40% Lohnes - N 15% Syrene - N 10% Hangaard - N 35% Other - P/D or N	Cultivated small grains, hay, and pasture	Somewhat excessively drained to poorly drained, sandy or loamy soils, underlain by gravelly sand

1. P = Prime Farmland P/D = Prime Farmland if Drained P/I = Prime Farmland if Irrigated
   S = Farmland of Statewide Importance N = Non-Prime Farmland

Sources: SCS, 1977; SCS, 1985.



LEGEND

74	Bluestem Prairie (Andropogon-Panicum-Sorghastrum)
81	Oak savanna (Quercus-Andropogon)
93	Great Lakes spruce-fir forest (*Picea-Abies*)
94	Conifer bog (Larix-Picea-Thuja)
95	Great Lakes pine forest (Pinus)
98	Northern floodplain forest (Populus-Salix-Ulmus)
99	Maple-basswood forest (Acer-Tilia)

SOURCE: KUCHLER 1975

FIGURE 5-9. POTENTIAL NATURAL VEGETATION TYPES OF MINNESOTA

TABLE 5-8. SPECIES COMMONLY ASSOCIATED WITH MESIC BLACKSOIL PRAIRIES IN NORTHWESTERN MINNESOTA

	Common Name	Scientific Name
Grasses	Big bluestem	*Andorpogon gerardi*
	Cordgrass	*Spartina pectinata*
	Fowl-meadow grass	*Poa palustris*
	Indian grass	*Sorghastrum nutans*
	Little bluestem	*Andropogon scoparius*
	Needle grass	*Stipa spartea*
	Northern dropseed	*Sporobolus heterolepis*
	Northern reedgrass	*Calamagrostic inexpansa*
Forbs	American licorice	*Glycryrrhiza lepidota*
	Blazing star	*Liatris ligulistylis*
	Death camas	*Zygadenus elegans*
	Fragrant false indigo	*Amorpha nana*
	Golden alexanders	*Zizia aptera*
	Green needlegrass	*Stipa viridula*
	Milkweed	*Asclepias ovalifolia*
	Mountain-mint	*Pycnanthemum virginianum*
	Prairie dandelion	*Agoseris glauca*
	Prairie lily	*Lilium philadelphicum*
	Prairie onion	*Allium stellatum*
	Prairie thistle	*Cirsium floodmanii*
	Richardson's muhly	*Muhlenbergia richardsonis*
	Silvery scurf-pea	*Psoralea argophylla*
	Slender wheatgrass	*Agropyron trachycaulum*
	Smooth aster	*Aster laevis*
	Sunflower	*Helianthus maximiliana*
	White lady's slipper	*Cypripedium candidum*

Sources: MNDNR, 1987b.

TABLE 5-9. SPECIES COMMONLY ASSOCIATED WITH WET BLACKSOIL PRAIRIES IN NORTHWESTERN MINNESOTA

	Common Name	Scientific Name
Grasses	Big bluestem	*Andropogon gerardi*
	Bluejoint grass	*Calamagrostis inexpansa*
	Cordgrass	*Spartina pectinata*
	Fowl-meadow grass	*Poa palustris*
	Prairie muhly	*Muhlenbergia richardsonis*
Forbs	Blazing star	*Liatris pycnostachya*
	Bottle gentian	*Gentiana andrewsii*
	Dogbane	*Apocynum sibiricum*
	Golden alexanders	*Zizia aurea*
	Marsh goldenrod	*Solidago gigantea*
	Mountain-mint	*Pycnanthemum virginianum*
	New England aster	*Aster novae-angliae*
	Northern bedstraw	*Galium boreale*
	Prairie milkweed	*Asclepias speciosa*
	White lady's slipper	*Cypripedium candidum*
	Yellow star grass	*Hypoxis hirsuta*
Species Transitional To Wetlands	American bugleweed	*Lycopus americanus*
	American germander	*Teucrium canadense*
	Baltic rush	*Juncus balticus*
	Fen muhly grass	*Muhlenbergia glomerata*
	Fringed gentian	*Gentiana procera*
	Grass of parnasus	*Parnassia glauca*
	Hedge nettle	*Stachys palustris*
	Joe-pye weed	*Eupatorium maculatum*
	Marsh milkweed	*Asclepias incarnata*
	Marsh thistle	*Cirsium muticum*
	Sedge	*Carex tetanica*
	Sedge	*Cares sartwellii*
	Sticky false asphodel	*Tofieldia glutinosa*
	Swamp lousewort	*Pedicularis lanceolota*
	Water hemlock	*Cicuta maculata*
	Yellow twayblade orchid	*Liparis loeselii*

Sources: MNDNR, 1987c.

the forests have also been cleared for agriculture or lumber. Today, only about half of Minnesota's original forested areas remain intact (MNEQB, 1988). Shelterbelts and woodlots have also been planted throughout the study area.

5.3.5.2.1 Upland Agricultural. Upland agricultural associations occupy 79 percent of the receive study area (Table 5-10). This is comprised of 76 percent cultivated-unidentified species and 1 percent cultivated-soybeans. Pasture and hay lands comprise less than 1 percent of the receive study area.

Upland agricultural associations are found throughout the study area where more fertile soils are located. Commonly cultivated plants include wheat, oats, barley, alfalfa, sunflowers, soybeans, sugar beets, potatoes, and small amounts of buckwheat and flax (SCS, 1977; SCS, 1984a; DPA, 1989).

Cultivated lands provide forage for white-tailed deer, moose, and waterfowl (Technical Studies 7 and 8). If not overgrazed, pasture and hay lands can provide habitat for white-tailed deer, ground-dwelling mammals, and ground nesting birds (Crawford, et. al, 1979). These lands are also important socioeconomically as they support the area's valuable grazing and agricultural economy (USAF, 1986).

5.3.5.2.2 Upland Fields. Upland field associations occupy 11 percent of the receive study area (Table 5-10). This is comprised of 9 percent open shrub grassland and 2 percent closed shrub grassland.

Upland field associations are found in small parcels throughout the study area. These may be mesic blacksoil prairies where soils are moderately drained, or wet blacksoil prairies where soils are poorly drained. Of the 95 plant species listed as special concern in Minnesota, 4 are found in or near the study area. These are found in wetter areas and include marsh arrowgrass, sticky false asphodel, white lady's slipper, and a sedge (Carex scirpiformis) (Sayler, et. al., 1988) (Technical Study 9).

TABLE 5-10. PERCENTAGE OF LAND COVER TYPES AT THE RECEIVE STUDY AREA

Cover Type	Study Area	Rx-E CSA	Rx-W CSA
Upland Agricultural			
Cultivated-Unidentified Species	76	35	5
Cultivated-Small Grains	-	29	57
Cultivated-Row Crops	-	5	4
Cultivated-Sugar Beets	<1	0	0
Cultivated-Potatoes	<1	0	0
Cultivated-Soybeans	1	1	8
Cultivated-Irrigated	0	0	0
Cultivated-Periodically Flooded	0	0	0
Pasture and Hay Land	<1	<1	<1
SUBTOTAL	**79**	**70**	**74**
Upland Fields			
Open Shrub Grassland	9	2	0
Ungrazed Native Grassland	-	2	1
Ungrazed Planted Grassland	-	14	19
Native Rangeland	-	0	0
Mowed Native Rangeland	-	0	0
Closed Shrub Grassland	2	1	0
Native Closed Shrub Grassland	-	<1	<1
Planted Closed Shrub Grassland	-	0	0
SUBTOTAL	**11**	**20**	**20**
Upland Forests			
Deciduous Tree Stands	6	2	0
Natural Tree Stands	-	2	2
Planted Tree Stands	-	<1	<1
SUBTOTAL	**6**	**5**	**2**
Wetlands(1)			
Wetlands	4	5	1
Open Water	<1	<1	<1
SUBTOTAL	**4**	**5**	**1**
Other	<1	<1	3
TOTAL	**100**	**100**	**100**

1. Based on DPA, 1989 vegetation mapping. See Technical Study 6 for wetland acreages based on more detailed wetland mapping.

Upland field associations that maintain prairie ecosystems are of national interest due to the extensive conversion of these areas for agricultural uses. Prairie ecosystems provide habitat for white-tailed deer, small mammals, waterfowl, raptors, game birds, and ground-nesting birds (Crawford, et. al., 1979) (Technical Studies 7 and 8).

5.3.5.2.3 Upland Forests. Upland forest associations occupy 6 percent of the receive study area (Table 5-10). Deciduous tree stands within the study area may be either natural or planted, although this differentiation was made only at the concentrated study area level.

Natural tree stands are primarily found in the east where the range of natural forests extends. These forests are Aspen Parkland communities which are fire-maintained mosaics of open prairies, sedge meadows, shrub thickets, and groves of small trees. Shrub species include pussy-willow, hazel-nut, chokecherry, and red osier. Common tree species include trembling aspen, balsam poplar, and bur oak (MNDNR, 1987a).

Planted tree stands are found throughout the study area in the form of shelterbelts and woodlots. Planted species are mostly evergreen (MNDNR, 1989).

Upland forest associations provide habitat for white-tailed deer, small mammals, and numerous bird species (Technical Studies 7 and 8). Additional values of natural tree stands include soil erosion control, streambank shade, and recreational uses. Planted tree stands provide soil erosion control, shelter from the wind, and maintenance of moisture levels.

5.3.5.3 SCS Prime Farmland Classification. The receive study area is comprised of 27 percent prime farmland, 39 percent prime farmland if drained, 3 percent farmland of statewide importance, and 31 percent non-prime farmland (Table 5-11). These percentages are a reflection of the diversity of soil associations found throughout the study area (Tables 5-6 and 5-7).

TABLE 5-11. RECEIVE STUDY AREA PRIME FARMLAND CLASSIFICATION AND LAND EVALUATION CRITERIA

	Concentrated Study Area		
Farmland Classification	Study Area(1)	Rx-W	Rx-E
Prime Farmland (%)	27	44	13
Prime (if Drained) (%)	39	25	57
Statewide Importance (%)	3	1	3
Non-Prime (%)	31	30	27
Land Evaluation Criteria	--	83	80.3

1. Based on approximate areas only.

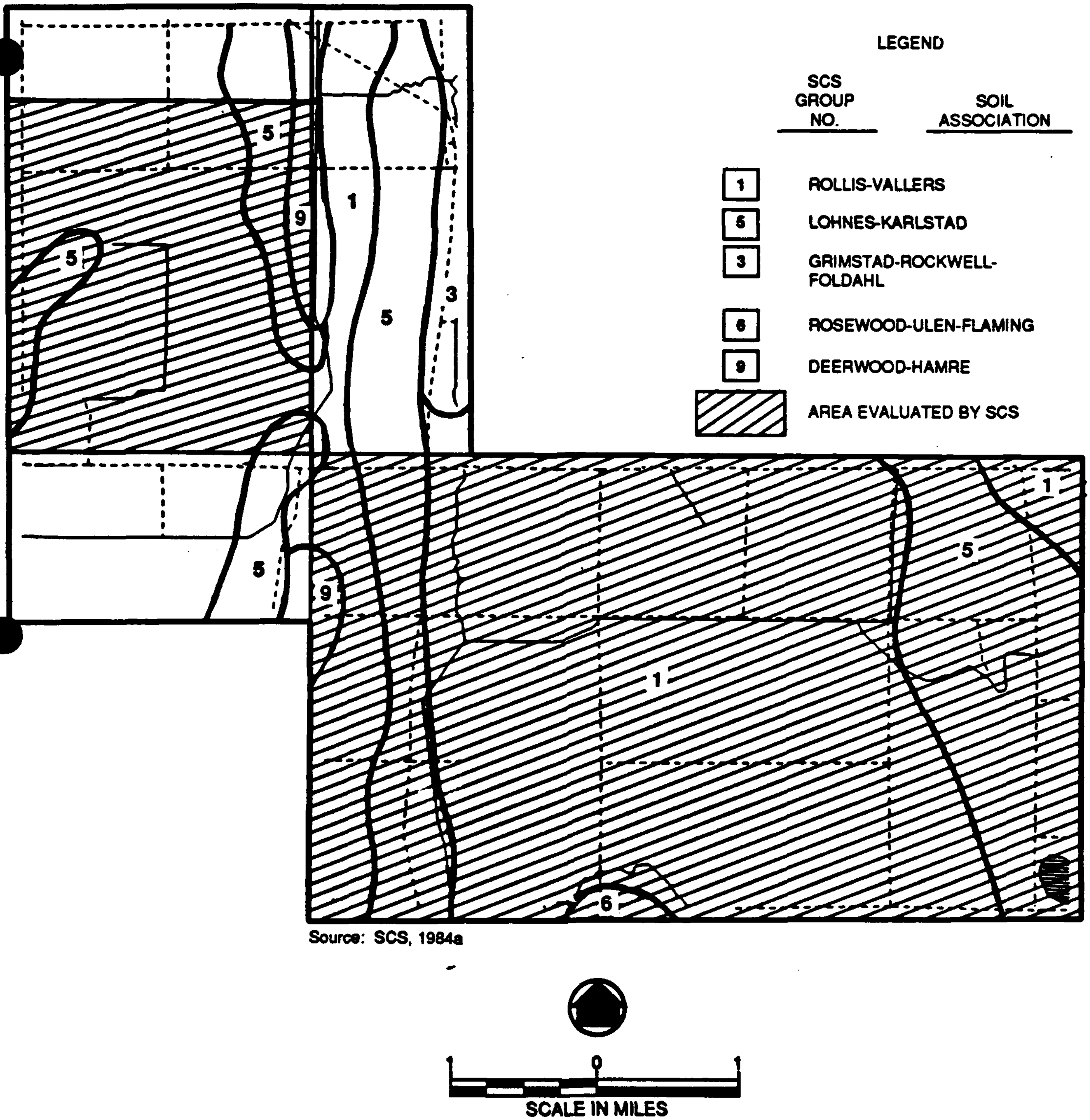
Sources: SCS, 1977; SCS, 1984; SCS, 1989b; SCS, 1989c.

5.3.6 Rx-East Concentrated Study Area

5.3.6.1 Habitat Characteristics. The Rx-E CSA is characterized by beach strands and associated wetlands, which are most evident in the central and western portions of the Rx-E CSA. Soils here include the well to moderately well drained Lohnes-Karlstad association and the very poorly drained, mucky Deerwood-Hamre association (Figure 5-10). Soils in the surrounding flatter areas are the poorly drained Rollis-Vallers association.

5.3.6.2 Vegetation Associations. The Rx-E CSA consists primarily of large tracts of upland agriculture with upland fields interspersed. Relatively large forested areas and wetlands occur in the central and western portions of the Rx-E CSA where the beach strands are found.

5.3.6.2.1 Upland Agricultural. Upland agricultural associations occupy 70 percent of the Rx-E CSA (Table 5-10). This is comprised of 35 percent cultivated-unidentified species, 29 percent cultivated-small grains, 5 percent cultivated-row crops, and 1 percent cultivated-soybeans. Pasture and hay lands comprise less than 1 percent of the Rx-E CSA. Cultivated-unidentified



Source: SCS, 1984a

FIGURE 5-10. RX-EAST CONCENTRATED STUDY ARE SOIL CONDITIONS

species and small grains occupy large tracts of land and row crops and soybeans occupy smaller areas. Soils in these areas are the Rollis-Vallers association.

5.3.6.2.2 Upland Fields. Upland field associations occupy 20 percent of the Rx-E CSA (Table 5-10). This is comprised of 14 percent ungrazed planted grassland, 2 percent ungrazed native grassland, 2 percent open shrub grassland (undifferentiated), and 1 percent closed shrub grassland (undifferentiated). Native closed shrub grassland acreage is small parcels of land comprising less than 1 percent of the Rx-E CSA.

The ungrazed planted grasslands are large tracts of land located in the west-central portions of the Rx-E CSA with small tracts situated on the ridges of the beach strands. The species planted appear to be a mixture of grass species and alfalfa with some non-native species such as ragweed and pigweed (DPA, 1989). The remaining upland field associations are found as small tracts of land on the beach strand ridges or along unnamed streams. Soils are primarily of Lohnes-Karlstad and Deerwood-Hamre Associations.

5.3.6.2.3 Upland Forests. Upland forest associations occupy 5 percent of the Rx-E CSA (Table 5-10). These are comprised of 2 percent natural tree stands, 2 percent undifferentiated deciduous tree stands, and less than 1 percent planted tree stands. Of the tree stands which were not differentiated when mapping, it can be assumed from their shape and location that they are mostly natural tree stands. The tree stands are concentrated in the central and western portions of the study area where the beach strand ridges are most evident.

5.3.6.3 SCS Prime Farmland Classification. The Rx-E CSA is comprised of 13 percent prime farmland, 57 percent prime farmland if drained, 3 percent farmland of statewide importance, and 27 percent non-prime farmland. The SCS assigned a land evaluation criterion of 80.3 to the Rx-E CSA (SCS, 1989e) (Table 5-11). The prime farmlands are primarily found in the Rollis-Vallers soil associations. Prime farmlands if drained and farmlands of statewide importance are found in the Rollis Vallers, Rosewood-Ulen-Fleming, and

Deerwood-Hamre soil associations. Most of the non-prime farmlands are found in the Lohnes-Karlstad and Deerwood-Hamre soil associations (Figure 5-10 and Table 5-6).

5.3.7 Rx - West Concentrated Study Area

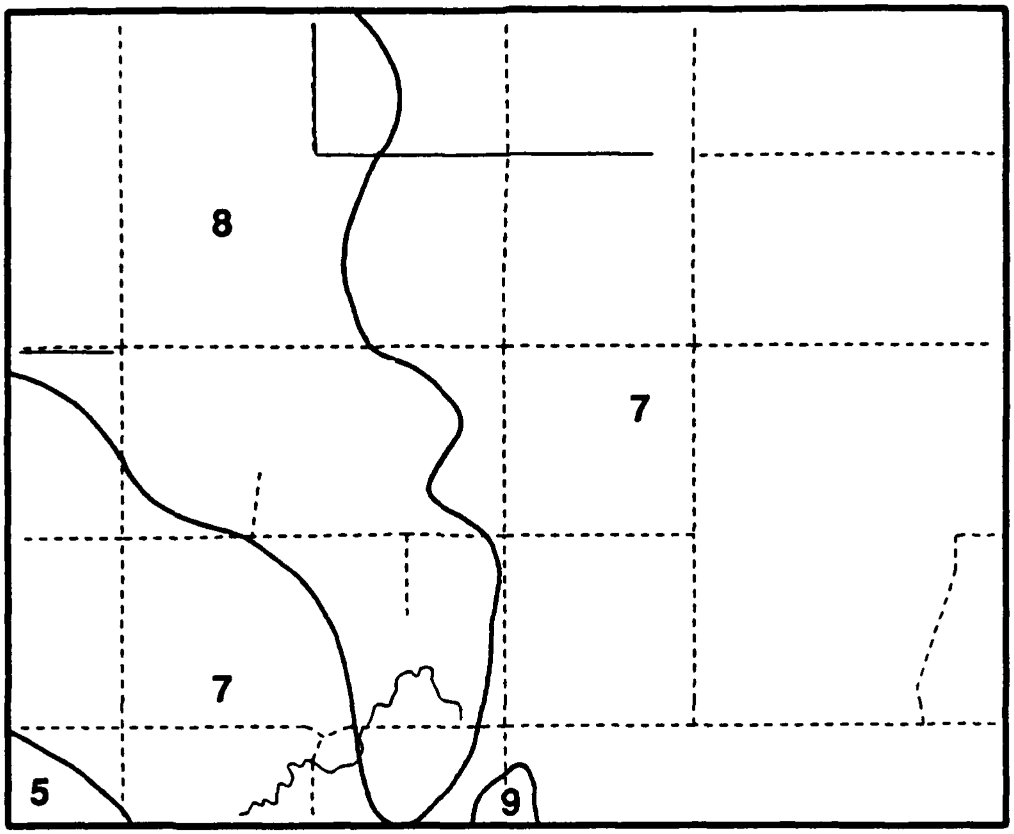
5.3.7.1 Habitat Characteristics. Topographic features and soils of the Rx-W CSA differ from those of the Rx-E CSA. In the Rx-W CSA, beach strands are not evident and the terrain is flat and gently sloping. Soils are primarily the poorly to moderately well drained soils of the Arveson-Ulen and Roliss-Kittson-Viking associations (Figure 5-11).

5.3.7.2 Vegetation Associations. The Rx-E CSA is similar to the Rx-W CSA in that it contains large tracts of upland agriculture with mostly large and some small tracts of upland fields interspersed. Only small sections of forested areas and wetlands are scattered throughout the Rx-W CSA.

5.3.7.2.1 Upland Agricultural. Upland agricultural associations occupy 74 percent of the Rx-W CSA (Table 5-10). This is comprised of 57 percent cultivated-small grains, 8 percent cultivated-soybeans, 5 percent cultivated-unidentified species, and 4 percent cultivated-row crops. Pasture and hay lands comprise less than 1 percent of the CSA.

Areas of cultivated-small grains are usually large tracts of land, while soybeans, row crops, and other unidentified crop species are smaller tracts of land. These extensive agricultural lands coincide with the Arveson-Ulen and Roliss-Kittson-Viking soil associations.

5.3.7.2.2 Upland Fields. Upland field associations occupy 20 percent of the Rx-W CSA (Table 5-10). This is comprised of 19 percent ungrazed planted grassland and 1 percent ungrazed native grassland. Native closed shrub grassland acreages comprise less than 1 percent of the CSA.



Source: SCS, 1977

1 0 1
SCALE IN MILES

LEGEND

SCS GROUP NO.	SOIL ASSOCIATION
5	WHEATVILLE-AUGSBURG
7	ARVESON-ULEN
8	ROLISS-KITTSON-VIKING
9	LOHNES-SYRENE-HANGAARD

FIGURE 5-11. RX-WEST CONCENTRATED STUDY AREA SOIL ASSOCIATIONS

The ungrazed planted grasslands are large tracts of land located in the central portion of the Rx-W CSA. The species planted are similar to those in the Rx-E CSA Section 5.3.6.2.2. Ungrazed native grasslands are small parcels of land scattered throughout.

5.3.7.2.3 Upland Forests. Upland forest associations occupy 2 percent of the Rx-W CSA (Table 5-10). These are primarily natural tree stands with less than 1 percent being planted tree stands. The natural tree stands are concentrated in the southwest portion of the Rx-W CSA with small pockets existing in the remaining areas.

5.3.7.3 SCS Prime Farmland Classification. The Rx-W CSA is comprised of 44 percent prime farmland, 25 percent prime farmland if drained, 1 percent farmland of statewide importance, and 30 percent non-prime farmland (Table 5-11). The SCS assigned a land evaluation criterion of 83 to the Rx-W CSA (SCS, 1989e). The prime farmlands, prime farmlands if drained, and farmlands of statewide importance are found throughout the Rx-W CSA with non-prime farmlands interspersed. The non-prime farmlands are primarily comprised of the Arveson and Viking soil types (Figure 5-11 and Table 5-7).

5.4 ENVIRONMENTAL CONSEQUENCES

This section provides an evaluation of the potential vegetation and farmland impacts of the CRS project. Potential mitigation measures are discussed in Section 5.5.

5.4.1 Methods

The USAF has selected preliminary site layouts for CRS facilities within each of the CSAs (Figures 5-12 through 5-15). The preliminary site layouts of the CRS transmit and receive facilities were evaluated to determine the potential impacts to vegetation and prime farmlands. Impacts to vegetation will occur in disturbed areas and exclusion areas. For the transmit sectors, disturbance will occur in the areas selected for access roads, perimeter roads, buildings, the antenna and groundscreen, the narrow strip of land behind the antenna and

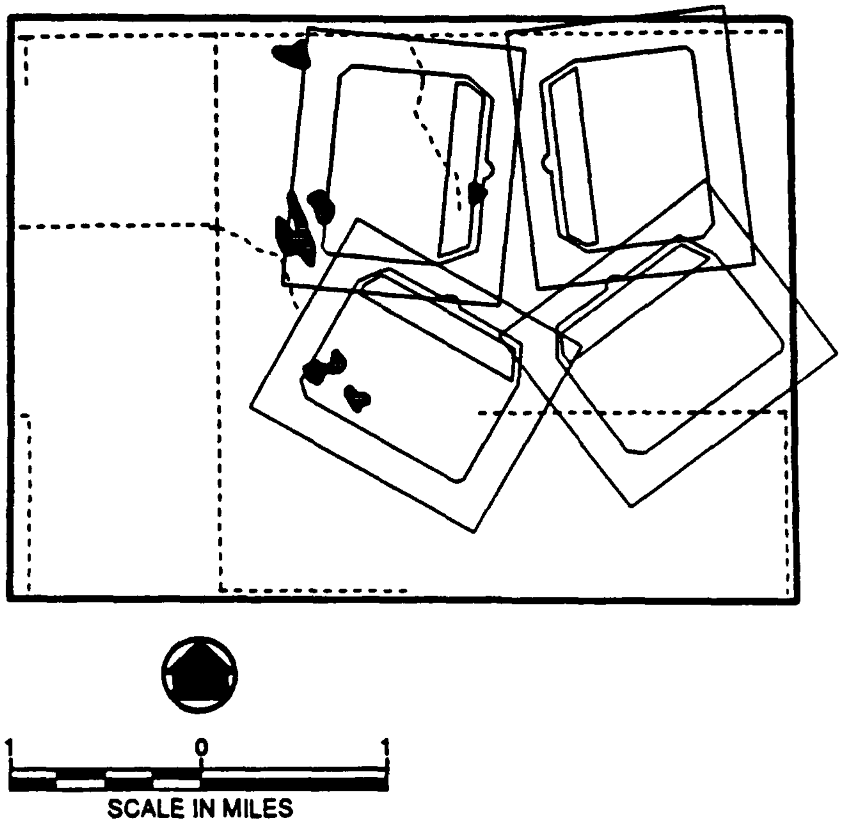


FIGURE 5-12. TX-NORTH PRELIMINARY SITE LAYOUT

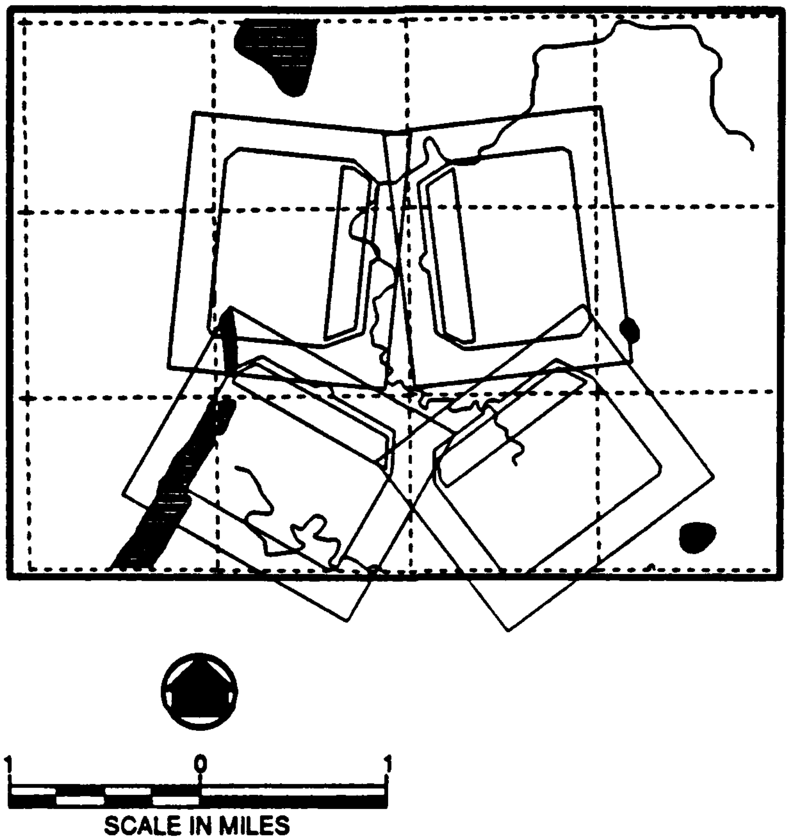


FIGURE 5-13. TX-SOUTH PRELIMINARY SITE LAYOUT

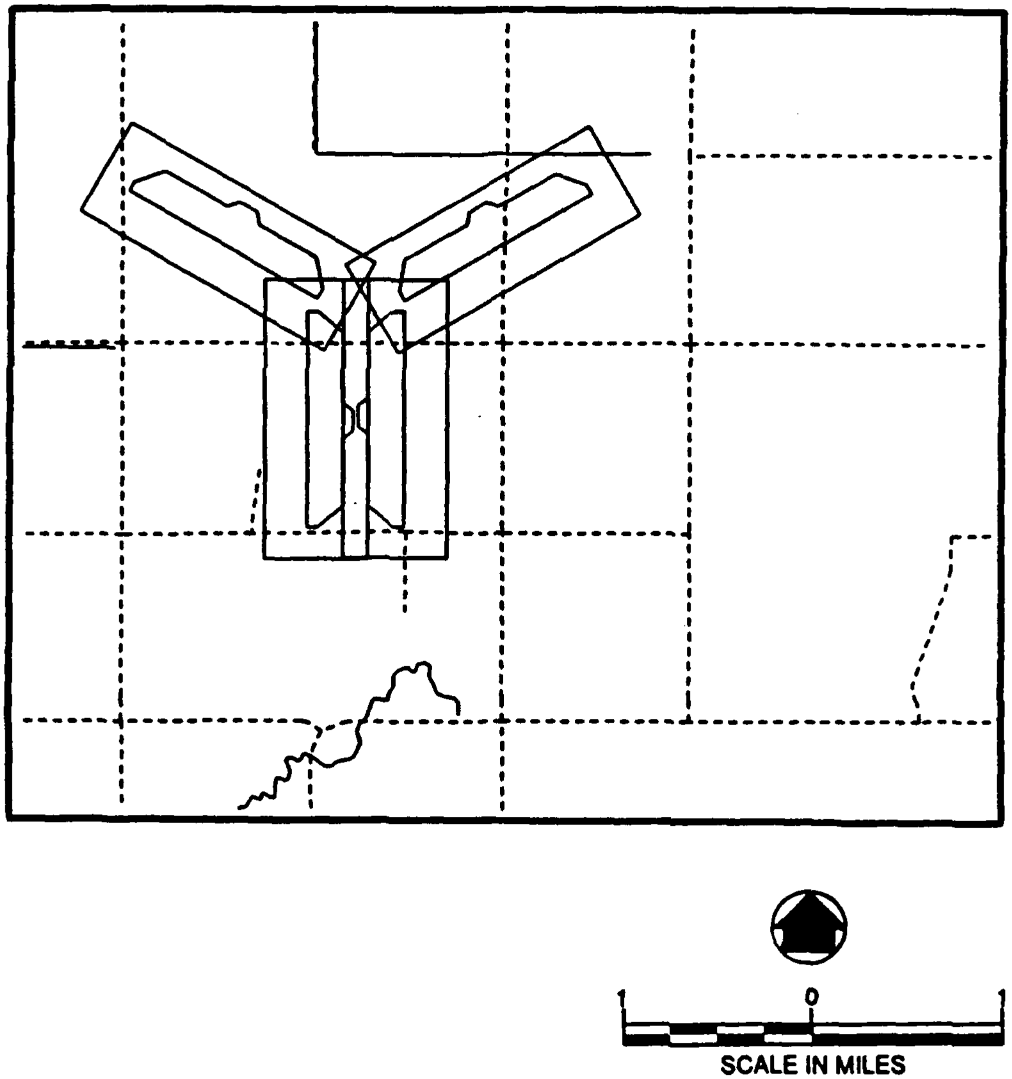


FIGURE 5-15. RX-WEST PRELIMINARY SITE LAYOUT

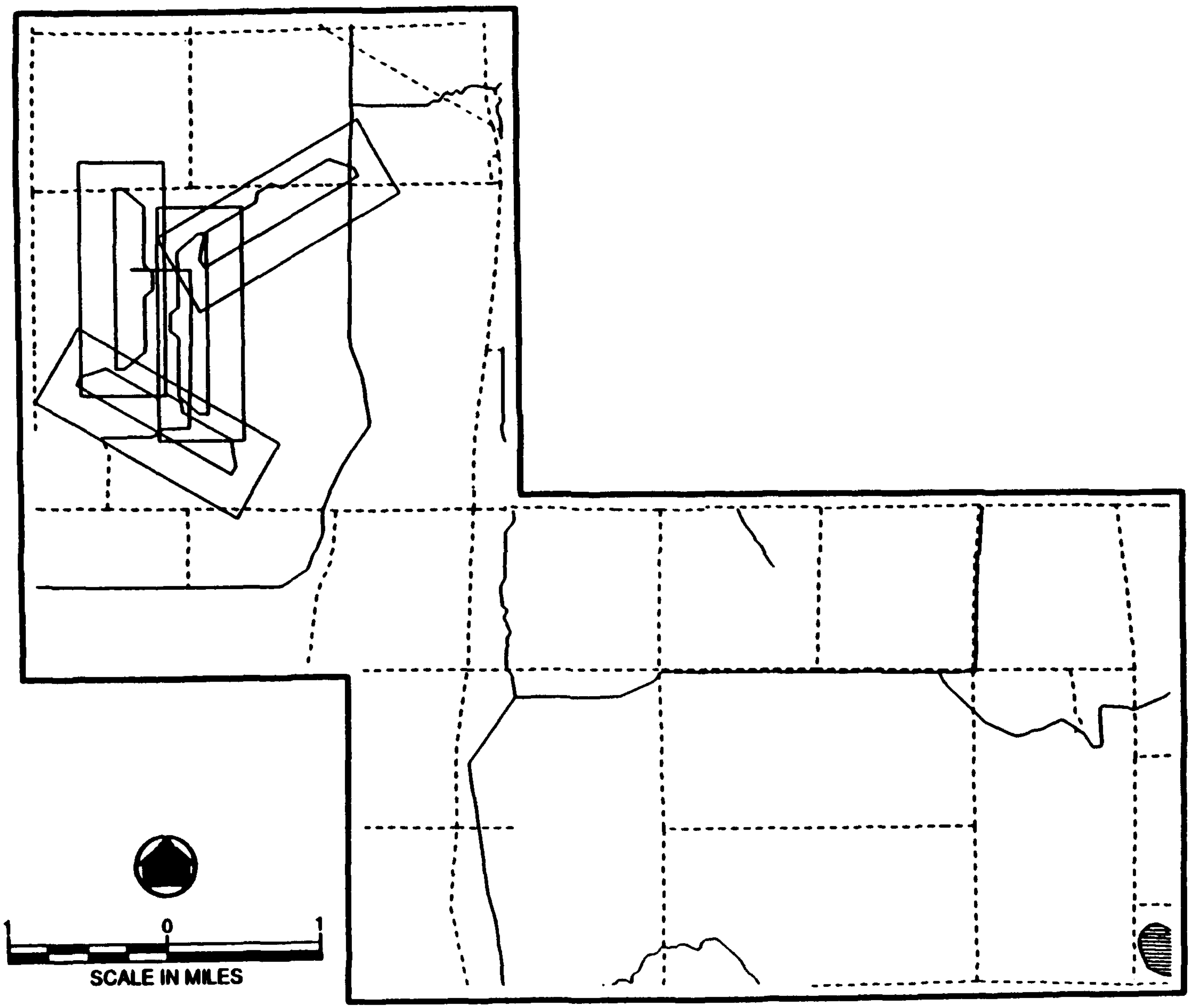


FIGURE 5-14. RX-EAST PRELIMINARY SITE LAYOUT

groundscreen, and the out-of-coverage sounder antenna. Exclusion areas in the transmit sectors are those areas enclosed by the fence but not otherwise disturbed. For the receive sectors, disturbed areas are considered to be those areas enclosed by and including the perimeter road. Exclusion areas are not present at the receive site facilities.

At the transmit site, permanent, primary impacts to prime farmlands will occur in areas selected for access roads, perimeter roads, buildings, the antenna, the narrow strip of land behind the antenna and groundscreen, and the out-of-coverage sounder antenna; partial impacts will occur in the groundscreen areas; and temporary impacts in the exclusion areas. At the receive site, impacts to prime farmlands will all be permanent with the exception of the groundscreen area which will be partially impacted. At both sites, secondary impacts will occur on lands adjacent to the CRS facilities.

The areal extent of the various potential impacts on individual cover types and prime farmlands are presented for the USAF's preliminary site layouts. Affected acreage was determined by digitizing overlays of the proposed facility layouts on vegetation and prime farmland maps. Impacts from perimeter roads at the transmit sectors were determined by measuring the length of the roads intersecting cover types and multiplying by the nominal road width of 40 feet. The alternative locations of access roads have not been selected and are thus not included in these calculations.

To allow for modifications of the sector locations during final design, a 1000 foot buffer zone is included around each sector. The areal extent of buffer zones is not equal for each sector because of overlaps in individual sector zones. Overlapping areas were considered independently of any one sector, and are included in final calculations. Acreage of buffer zones was also calculated by digitizing overlays of the proposed facility layouts on vegetation and prime farmland maps.

Best and worst case scenarios for vegetation impacts were chosen and evaluated against the USAF's preliminary site layouts. Best case scenarios were selected to minimize impacts to natural areas found in upland field and upland forest associations. Worst case scenarios were selected to maximize impacts to these associations. For the transmit sectors, disturbed areas were considered to have greater impacts on vegetation than exclusion areas and best and worst case scenarios were determined accordingly.

Best and worst case scenarios were not determined for prime farmlands due to the consistency of farmland classifications throughout the CSAs. Farmland compositions are consistent throughout the Tx-N and Rx-W CSAs. The western and eastern portions of the Tx-S CSA vary in farmland composition. However, only the eastern portion of this CSA was considered during final site selection for the CRS facilities in order to avoid the cultivated-periodically flooded lands; and farmland composition within the eastern portion is consistent. The Rx-E CSA also varies in farmland composition. However, large portions of non-prime farmlands occurring along the ecologically unique beach ridges were avoided. Areas feasible for construction of facilities within the Rx-E CSA are primarily prime farmlands or prime farmlands if drained.

5.4.2 General Vegetation Impacts

During the selection of preliminary site layouts within the concentrated study areas, the USAF attempted to avoid or minimize vegetative impacts to natural areas such as native prairies and large woodlots (Technical Study 1). From a biological perspective, the loss of agricultural associations was considered to be of less ecological importance due to their regional abundance and relatively limited wildlife values. The following analysis of vegetation impacts reflects this by focusing on the loss of natural areas, whereas the prime farmland sections focus on the loss of farmlands.

Maximum impacts to vegetation will occur in and around disturbed areas where vegetation will be removed and subsequent vegetative growth will be precluded by construction of facilities. Lesser impacts will occur in the exclusion areas of transmit sectors where agricultural practices will be discontinued and all tree stands will be removed. At the receive sectors, all trees above 70 feet in height will be removed within 1,800 feet of the perimeter road at the base of the ground screen. Indirect impacts in the transmit site exclusion areas may result from the elimination of grazing and prevention of present management practices within these areas. Historically, grassland species were maintained by fire and grazing of bison or other native animals. Presently, they are maintained by fire, mowing, and grazing of cattle. If these activities cease, a thick layer of mulch could accumulate over a period of time, which will in turn shorten the growing season by insulating the soil. With this, native species lose their vigor and exotic and woody species may begin to invade the area, creating different vegetative compositions. Time frames for the accumulation of mulch and invasion by exotic and woody species depend on the productivity of the area. Productive wet sites are invaded in a relatively short period of time, whereas drier sites may take much longer (SDGFPD, 1990). The time frame and extent of change in vegetative composition which may occur within the exclusion areas is dependent upon the current vegetative condition and productivity of the site.

Indirect impacts in buffer zones could result from the construction of facilities or slight modifications in final sector locations. The extent and degree of these impacts is dependent on the final site selection and management of land purchased or leased by the USAF around the facilities. Any significant potential indirect impacts to vegetation will be addressed in the project mitigation plan.

5.4.3 General Farmland Impacts

Possible impacts to prime farmlands have been determined using procedures developed under the Farmland Protection Policy Act of 1981. Farmland impacts were classified as primary, where farmland will be directly impacted by radar facilities, and secondary, where adjacent farmland will be impacted by radar facilities. Additionally, these impacts may be permanent, existing after decommissioning of the facilities; partial, where productivity will be impaired after decommissioning; or temporary, having no impacts after decommissioning.

Primary-permanent farmland impacts will result from the construction of structures (buildings and antennas) that, even if removed after decommissioning, will leave foundations which cannot be farmed. Also, the new access roads and the perimeter roads will cause permanent damage to the soils from compaction and continual useage. These facilities may also affect existing drainage patterns in the area (Technical Study 4, Hydrology and Water Quality).

Primary-partial farmland impacts will result from the construction of the groundscreen at the base of the antenna. Here, a minimum of approximately 6 inches of gravel will be placed underneath the groundscreen. The addition of gravel will reduce soil fertility by diminishing the soil's cation exchange capacity which is the soils' ability to attract and hold electrically-charged nutrients and is related to soil particle size.

Primary-temporary impacts are limited to the exclusion area of the transmit site. The major impact in these areas will be the loss of farmland production throughout the extent of facility operations. Impacts to soils will be minimal in exclusion areas, and agricultural practices could be resumed after decommmissioning of facilities, although access to these areas may be limited by the remaining structures.

Secondary farmland impacts to lands adjacent to CRS facilities may include limiting access to farmlands and subdividing farmlands into plots too small for farming. The permanency of these impacts will depend on the activities that cause them. They would be considered permanent if associated with buildings, the antenna, or roads; partial if caused by the groundscreen; or temporary if associated with the exclusion area.

Indirect impacts in buffer zones could result from the construction of facilities or slight modifications in final sector locations. As stated above, the extent and degree of these impacts is dependent on the final site selection and management of land purchased or leased by the USAF around the facilities. If significant, they will be addressed in the project mitigation plan.

This analysis of farmland impacts grouped prime farmland if drained and prime farmland if irrigated with prime farmland under the assumption that these lands would be farmed if at all possible. Also, it should be noted that farmland classification is independent of land use or cover types. Acreages presented encompass the total facilities area and not only the agricultural lands discussed in the vegetation sections.

5.4.4 Transmit Site

The transmit facilities will affect a total of about 2,000 acres. This is comprised of approximately 500 acres of disturbed areas and 1500 acres of exclusion areas.

5.4.4.1 Tx-North Preliminary Site Layout

5.4.4.1.1 Vegetation Impacts

5.4.4.1.1.1 Disturbed areas. The area disturbed by the Tx-N preliminary site layout is comprised of 403 acres of native rangelands and 90 acres of wetland associations (Table 5-12). The Tx-N preliminary site layout is located entirely within the boundaries of the Hecla sandhills region.

Percentages of native rangelands and wetlands disturbed by the Tx-N preliminary site are much greater than in the overall study area (Table 5-12). This suggests that construction of the CRS facilities within the Tx-N CSA would impact a relatively high proportion of the sandhills' native rangelands and wetlands within the overall study area. The ecological significance of disturbing this area is not well understood, as a thorough investigation of this region of South Dakota has not been conducted (SDGFPD, 1990). However, this region is one of the few remaining areas maintaining native prairie species and potential habitat for the threatened Western prairie fringed orchid and other uncommon species in South Dakota. Additionally, this area provides habitat for a variety of terrestrial and avian wildlife species (Technical Studies 7 and 8).

TABLE 5-12. COVER TYPE ACREAGES FOR THE Tx-N PRELIMINARY SITE LAYOUT AND BEST AND WORST CASE SCENARIOS

Cover Type	% of Study Area	% of Tx-N CSA	Preliminary Site Disturbed Acres (% of Total)	Preliminary Site Exclusion Acres (% of Total)	Preliminary Site Buffer	Best Case Disturbed Acres (% of Total)	Best Case Exclusion Acres (% of Total)	Worst Case Disturbed Acres (% of Total)	Worst Case Exclusion Acres (% of Total)
Upland Agricultural									
Cultivated-Unidentified Species	71	3	0	0	0	0	0	12	4
Cultivated-Small Grains	-	0	0	0	0	0	0	0	0
Cultivated-Row Crops	-	2	0	0	0	2	14	0	0
Cultivated-Sugar Beets	0	0	0	0	0	0	0	0	0
Cultivated-Potatoes	0	0	0	0	0	0	0	0	0
Cultivated-Soybeans	0	0	0	0	0	0	0	0	0
Cultivated-Irrigated	<1	0	0	0	0	0	0	0	0
Cultivated-Periodically Flooded	2	0	0	0	0	0	0	0	0
Pasture and Hay Land	2	4	0	0	0	0	0	10	29
SUBTOTAL	75%	9%	0 (0%)	0(0%)	0(0%)	2 (<1%)	14 (1%)	22 (4%)	33 (2%)
Upland Fields									
Open Shrub Grassland	17	15	0	0	0	0	0	46	530
Ungrazed Native Grassland	-	0	0	0	0	0	0	0	0
Ungrazed Planted Grassland	-	0	0	0	0	0	0	0	0
Native Rangeland	-	61	403	1354	1484	426	1393	328	731
Mowed Native Rangeland	-	1	0	0	8	0	0	32	7
Closed Shrub Grassland	<1	<1	0	0	0	0	0	0	0
Native Closed Shrub Grassland	-	<1	0	0	0	0	5	0	0
Planted Closed Shrub Grassland	-	0	0	0	0	0	0	0	0
SUBTOTAL	17%	77%	403 (80%)	1354 (88%)	1492 (88%)	426 (85%)	1398 (92%)	406 (81%)	1268 (83%)
Upland Forests									
Deciduous Tree Stands	2	<1	0	0	0	0	0	0	1
Natural Tree Stands	-	<1	0	6	<1	5	1	0	1
Planted Tree Stands	-	<1	0	12	3	0	4	0	0
SUBTOTAL	2%	1%	0 (0%)	18 (1%)	3 (<1%)	5 (1%)	5 (<1%)	0 (0%)	2 (<1%)
Wetlands[(1)]									
Wetlands	5	13	90	161	203	65	111	55	222
Open Water	<1	<1	0	0	0	5	0	21	3
SUBTOTAL	5%	13%	90 (18%)	161 (11%)	203 (12%)	70 (14%)	111 (7%)	76 (15%)	225 (15%)
Other	1%	<1%	10 (2%)	0 (0%)	4 (0%)	1 (<1%)	0 (0%)	0(0%)	0(0%)
TOTAL	100%	100%	504	1533	1702	504	1528	504	1528

1. Based on DPA, 1989 vegetation mapping. See Technical Study 6 for wetland acreages based on more detailed wetland mapping.

Although vegetative impacts to the sandhills region are unavoidable in the Tx-N CSA, the Tx-N preliminary site layout has been positioned to exclude the designated native prairie from direct disturbance. However, the prairie habitat does lie within the buffer zone. The USAF has attempted to avoid this area since it is the only protected area of big bluestem prairie within the Hecla Sandhills, and it maintains species uncommon in South Dakota.

Vegetation associations in the Tx-N buffer zones are proportionally similar to those in the Tx-N disturbed areas (Table 5-12). This indicates that acreages of vegetation associations impacted by disturbed areas will not vary greatly with modifications in facility locations within buffer zones. However, the designated prairie is located within the buffer zone and modifications to this layout could cause a portion of the west sector perimeter road to be positioned within the boundaries of the designated native prairie at the Tx-N CSA.

In the selection of best and worst case scenarios, the complete avoidance (disturbed areas, exclusion areas, and buffer zones) of the designated native prairie was considered optimal while the avoidance of wetlands was considered to the greatest extent possible. The analysis of the best and worst case scenarios illustrates that the designated prairie could be completely avoided while disturbing fewer wetlands (Table 5-12). However, avoiding this prairie will impact even more native rangeland than the preliminary site layout. Since the designated prairie is only in the buffer zone of the preliminary site layout and the percentage of wetlands disturbed does not differ greatly between sites, this indicates that the location of the preliminary site layout within the CSA is comparable to the best case layout. However, as stated above, a thorough investigation of this area's value to special status plant species has not been completed to date and the area disturbed could actually be equally as important as the designated native prairie. These studies will confirm if this is actually the "best" case scenario within the area and determine the overall significance of this disturbance to the region.

5.4.4.1.1.2 Exclusion Areas. The exclusion areas for the Tx-N preliminary site layout are comprised of 1,354 acres of native rangeland, 12 acres of planted tree stands, 6 acres of natural tree stands, and 161 acres of wetlands (Table 5-12).

As in the disturbed areas of the Tx-N preliminary site layout, the exclusion areas will impact a relatively high proportion of native rangelands and wetlands in comparison to the overall study area (Table 5-12). Impacts to forested areas in the exclusion area are comparable to those in the Tx-N CSA and the overall study area.

Vegetation associations in the Tx-N buffer zones are proportionally similar to those in the Tx-N exclusion areas (Table 5-12). This indicates that acreages of vegetation associations impacted by exclusion areas will not vary greatly with modifications in facility locations in buffer zones. However, location modifications may cause a portion of the west sector exclusion area to be positioned within the boundaries of the designated native prairie.

Analysis of best and worst case scenarios indicates that acreage of upland fields and wetlands in exclusion areas are comparable for all layouts (Table 5-12). A relatively high percent of forested areas will be affected by exclusion areas in the preliminary site. However, the loss of planted tree stands is not considered as ecologically important as the loss of upland fields or wetlands in this region.

5.4.4.1.2 **Farmland Impacts.** Prime farmlands and farmlands of statewide importance comprise only 100 acres of the Tx-N preliminary site layout (Table 5-13). The percentages of farmlands affected are comparable to those in the Tx-N CSA and the buffer zones. This indicates that impacts to prime farmlands and farmlands of statewide importance are not significant in this site when compared to other portions of the study area. In addition, impacts will not vary greatly due to alterations in facility locations or indirect impacts from construction of the CRS.

TABLE 5-13. PRIME FARMLAND IMPACT ACREAGE FOR THE TX-N AND TX-S PRELIMINARY SITE LAYOUTS

Farmland Classification	% of Study Area	% of Tx-N	TX-N Preliminary Site Acres (%)			
			Permanent	Partial	Temporary	Buffer
Prime Farmland (and Prime if Drained)	46%	3%	19 (10)	34 (11)	38 (2)	107 (6)
Statewide Importance	19%	<1%	0	0	9 (1)	0
Non-Prime	38%	96%	167 (90)	284 (89)	1,481 (97)	1,594 (94)
Total	100%	100%	186	318	1,528	1,701

Farmland Classification	% of Study Area	% of Tx-S	TX-S Preliminary Site Acres (%)			
			Permanent	Partial	Temporary	Buffer
Prime Farmland (and Prime if Drained)	46%	40%	11 (6)	20 (6)	279 (18)	363 (23)
Statewide Importance	19%	23%	40 (21)	69 (22)	415 (27)	345 (22)
Non-Prime	38%	37%	135 (73)	229 (72)	834 (55)	867 (55)
Total	100%	100%	186	318	1,528	1,575

5.4.4.2. Tx-South Preliminary Site Layout

5.4.4.2.1 Vegetation Impacts

5.4.4.2.1.1 Disturbed Areas. The area disturbed by the Tx-S preliminary site layout is comprised of 456 acres of upland agricultural associations, 34 acres of upland fields, and 5 acres of upland forests (Table 5-14). The upland fields are primarily small parcels of native grasslands or rangelands and the upland forests are all planted tree stands.

The Tx-S preliminary site layout will disturb a much lower percentage of upland fields than is found throughout the study area and in disturbed areas of the Tx-N preliminary site. This suggests that construction of the CRS facilities in the Tx-S preliminary site layout would have less impacts on the region's native prairie ecosystems than the Tx-N preliminary site layout. Although the Tx-S preliminary site layout would result in a higher percentage of upland agricultural associations being disturbed, these associations are considered less ecologically important than natural areas due to their regional abundance and relatively low value to wildlife species.

Vegetation associations in the Tx-S buffer zones are proportionally similar to those in the Tx-S disturbed areas (Table 5-14). This indicates that acreages of vegetation associations impacted by the disturbed areas will not vary greatly with modifications in location of radar facilities within buffer zones.

Analysis of the best and worst case scenarios and the preliminary site layout indicates that any site within the CSA would disturb minimal acreages of natural areas (Table 5-14). This is a result of the low percentages of these areas found throughout the CSA.

5.4.4.2.1.2 Exclusion Areas. The exclusion areas for the Tx-S preliminary site layout are comprised of 1,441 acres of upland agricultural associations, 49 acres of upland fields, and 8 acres of upland forests (Table 5-14). As in disturbed areas of the Tx-S preliminary site layout, the upland fields are

TABLE 5-14. COVER TYPE ACREAGES FOR THE Tx-S PRELIMINARY SITE LAYOUT AND BEST AND WORST CASE SCENARIOS

Cover Type	% of Study Area	% of Tx-S CSA	Preliminary Site: Disturbed	Preliminary Site: Exclusion	Preliminary Site: Buffer	Best Case: Disturbed	Best Case: Exclusion	Worst Case: Disturbed	Worst Case: Exclusion
			Acres (% of Total)			Acres (% of Total)		Acres (% of Total)	
Upland Agricultural									
Cultivated-Unidentified Species	71	7	37	136	42	3	80	33	141
Cultivated-Small Grains	-	43	230	659	763	215	557	214	751
Cultivated-Row Crops	-	30	145	489	353	123	680	142	355
Cultivated-Sugar Beets	0	0	0	0	<1	0	0	0	0
Cultivated-Potatoes	0	0	0	0	0	0	0	0	0
Cultivated-Soybeans	0	0	0	0	0	0	0	0	0
Cultivated-Irrigated	<1	0	0	0	0	0	0	0	0
Cultivated-Periodically Flooded	2	7	<1	106	161	134	81	0	0
Pasture and Hay Land	2	4	44	45	65	19	26	23	61
SUBTOTAL	75%	91%	456 (91%)	1441 (94%)	1384 (88%)	494 (98%)	1424 (93%)	412 (82%)	1308 (86%)
Upland Fields									
Open Shrub Grassland	17	<1	10	0	9	0	0	0	0
Ungrazed Native Grassland	-	<1	4	4	11	0	9	0	26
Ungrazed Planted Grassland	-	<1	0	0	0	0	0	0	0
Native Rangeland	-	5	21	45	81	3	56	57	123
Mowed Native Rangeland	-	0	0	0	0	0	0	0	0
Closed Shrub Grassland	<1	0	0	0	0	0	0	0	0
Native Closed Shrub Grassland	-	0	0	0	0	0	0	0	0
Planted Closed Shrub Grassland	-	0	0	0	0	0	0	0	0
SUBTOTAL	17%	5%	34(7%)	49 (3%)	101 (6%)	3 (1%)	65 (4%)	57 (11%)	149 (10%)
Upland Forests									
Deciduous Tree Stands	2	<1	0	0	0	0	0	0	0
Natural Tree Stands	-	<1	0	0	0	0	1	0	0
Planted Tree Stands	-	<1	5	8	20	0	27	3	17
SUBTOTAL	2%	1%	5 (1%)	8 (1%)	20 (1%)	0 (0%)	28 (2%)	3 (1%)	17 (1%)
Wetlands[1]									
Wetlands	5	3	8	22	59	7	11	19	46
Open Water	<1	<1	0	0	0	0	0	0	0
SUBTOTAL	5%	3%	8 (2%)	22 (1%)	59 (4%)	7 (1%)	11 (1%)	19 (4%)	46 (3%)
Other	1	0	2 (<1%)	8 (1%)	<1 (1%)	0 (0%)	0 (0%)	13 (2%)	8 (<1%)
TOTAL	100%	100%	504	1528	1563	504	1528	504	1528

1. Based on DPA, 1989 vegetation mapping. See Technical Study 6 for wetland acreages based on more detailed wetland mapping.

primarily small parcels of native grasslands and rangelands and the upland forests are all planted tree stands in the exclusion areas of this layout.

Like the Tx-S disturbed areas, a much lower percentage of upland fields will be impacted by exclusion areas in the Tx-S preliminary site layout than are found throughout the study area and in exclusion areas of the Tx-N preliminary site layout. This also suggests that the Tx-S preliminary site layout would have lower impacts on the region's native prairie systems at the expense of the ubiquitous upland agricultural associations.

Vegetation associations in the buffer zones are proportionally similar to those in the Tx-S exclusion areas (Table 5-14). This indicates that acreages of vegetative associations impacted by exclusion areas will not vary greatly with modifications in locations of radar facilities within buffer zones.

As with the disturbed areas, analysis of the exclusion areas in the best and worst case scenarios and the preliminary site layout shows that minimal acres of natural areas will be impacted (Table 5-14). This is a result of the low percentage of these areas found throughout the CSA.

5.4.4.2.2 **Farmland Impacts.** Prime farmlands and farmlands of statewide importance comprise 834 acres of the Tx-S preliminary site layout (Table 5-13). However, only 140 acres will be permanently or partially impacted, and the remaining 694 acres will only be temporarily unavailable for agricultural uses. In relation to the overall study area and the Tx-N preliminary site layout, the Tx-S preliminary site layout will have minimal permanent and partial impacts to prime farmlands and prime farmlands if drained.

Temporary impacts in the Tx-S preliminary site layout will be greater than in the Tx-N preliminary. However, temporary impacts in the Tx-S preliminary site layout are proportionally less than in the Tx-S CSA and the overall study area.

Prime farmlands and farmlands of statewide importance in the buffer zones are proportionally greater than the permanent and partial impacts in the Tx-S preliminary site layout (Table 5-13). This suggests that a higher number of acres may be permanently or partially affected with modifications in locations of radar facilities within the buffer zones. Proportions of buffer zones and temporarily impacted areas are comparable.

5.4.5 Receive Site

The receive facilities will affect a total of about 500 acres. All of the 500 acres will be directly disturbed by construction of facilities or roads because there is no fenced exclusion area at the receive site.

5.4.5.1 Rx-East - Preliminary Site Layout

5.4.5.1.1 Vegetation Impacts - Disturbed Areas. Rx-E disturbed areas are comprised of 264 acres of upland agricultural associations and 245 acres of upland field associations (Table 5-15). The upland field associations are comprised entirely of ungrazed planted grasslands.

In comparison to the overall study area, the Rx-E preliminary site layout will disturb a relatively high percentage of ungrazed planted grasslands. However, these grasslands are primarily comprised of alfalfa and other non-native species and are not considered as ecologically important as native prairie ecosystems. No upland forests are impacted by the Rx-E preliminary site layout, as a result of the USAF's efforts to avoid a large natural tree stand in the eastern portion of the Rx-E CSA.

Vegetation associations in the buffer zones are proportionally similar to those in the Rx-E disturbed areas (Table 5-15). This indicates that acreages of vegetation associations impacted by the disturbed areas will not vary greatly with modifications in location of radar facilities within these zones.

In the selection of best and worst case scenarios for the Rx-E CSA, the avoidance of large woodlots was considered primary and the avoidance of upland

TABLE 5-15. COVER TYPE ACREAGES FOR THE Rx-E PRELIMINARY SITE LAYOUT AND BEST AND WORST CASE SCENARIOS

Cover Type	% of Study Area	% of Rx-E CSA	Preliminary Site Disturbed Acres (% of Total)	Preliminary Site Buffer Acres (% of Total)	Best Case Disturbed Acres (% of Total)	Worst Case Disturbed Acres (% of Total)
Upland Agricultural						
Cultivated-Unidentified Species	76	35	7	96	42	105
Cultivated-Small Grains	-	29	124	376	299	67
Cultivated-Row Crops	-	5	106	73	78	19
Cultivated-Sugar Beets	<1	0	0	0	0	0
Cultivated-Potatoes	<1	0	0	0	0	0
Cultivated-Soybeans	1	1	27	73	49	0
Cultivated-Irrigated	0	0	0	0	0	0
Cultivated-Periodically Flooded	0	0	0	0	0	0
Pasture and Hay Land	<1	<1	0	0	0	9
SUBTOTAL	79%	70%	264 (50%)	618 (53%)	468 (90%)	200 (38%)
Upland Fields						
Open Shrub Grassland	9	2	0	2	0	18
Ungrazed Native Grassland	-	2	0	1	0	14
Ungrazed Planted Grassland	-	14	245	458	40	185
Native Rangeland	-	0	0	0	0	0
Mowed Native Rangeland	-	0	0	0	0	0
Closed Shrub Grassland	2	1	0	7	0	10
Native Closed Shrub Grassland	-	<1	0	2	0	0
Planted Closed Shrub Grassland	-	0	0	0	0	0
SUBTOTAL	11%	20%	245 (48%)	470 (42%)	40 (8%)	227 (44%)
Upland Forests						
Deciduous Tree Stands	6	2	0	14	5	0
Natural Tree Stands	-	2	0	0	0	52
Planted Tree Stands	-	<1	0	1	1	0
SUBTOTAL	6%	5%	0 (0%)	15 (1%)	6 (1%)	52 (10%)
Wetlands(1)						
Wetlands	4	5	11	46	6	38
Open Water	<1	<1	0	0	0	0
SUBTOTAL	4%	5%	11 (2%)	46 (4%)	6 (1%)	38 (7%)
Other	<1%	<1%	0 (0%)	0 (0%)	0 (0%)	3 (1%)
TOTAL	100%	100%	520	1149	520	520

1. Based on DPA, 1989 vegetation mapping. See Technical Study 6 for wetland acreages based on more detailed wetland mapping.

field associations secondary. The best case scenario would have negligible impacts to both forested areas and upland fields, whereas the preliminary site layout would impact 245 acres of upland field associations (Table 5-15). However, as stated above the ungrazed planted grasslands are of less ecological importance than the more natural areas. The worst case scenario would impact a relatively high percentage of forested areas, consisting primarily of natural tree stands. Thus, the preliminary site layout is expected to have moderate impacts in comparison to the best and worst case scenarios.

5.4.5.1.2 Farmland Impacts. Prime farmlands and farmlands of statewide importance comprise 453 acres of the Rx-E preliminary site layout (Table 5-16). This is a relatively high percentage compared to the Rx-E CSA and the overall study area. However, most of the non-prime farmlands are concentrated near the beach ridges areas which were avoided due to their environmental sensitivity and the difficulty of facility construction on the beach areas.

Prime farmlands and farmlands of statewide importance in the buffer zones are proportionally similar to the impacts in the Rx-E preliminary site layout (Table 5-16). This indicates that acreages of vegetative associations impacted by exclusion areas will not vary greatly with modifications in locations of facilities.

5.4.5.2 Rx-West Preliminary Site Layout

5.4.5.2.1 Vegetation Impacts - Disturbed Areas. The Rx-W preliminary site layout disturbed areas are comprised of 442 acres of upland agricultural associations, 75 acres of upland field associations, and 1 acre of upland forest associations (Table 5-17). The upland field associations consist entirely of ungrazed planted grasslands and the 1 acre of upland forest is a planted tree stand.

TABLE 5-16. PRIME FARMLAND IMPACT ACREAGE FOR THE RX-E AND RX-W PRELIMINARY SITES LAYOUTS

Farmland Classification	% of Study Area	% of Rx-E	RX-E Preliminary Site Acres (%)		
			Permanent	Partial	Buffer
Prime Farmland (and Prime if Drained)	66%	70%	123 (88)	331 (87)	989 (86)
Statewide Importance	3%	3%	2 (1)	7 (2)	15 (1)
Non-Prime	31%	27%	15 (11)	42 (11)	145 (13)
Total	100%	100%	140	380	1,149

Farmland Classification	% of Study Area	% of Rx-W	RX-W Preliminary Site Acres (%)		
			Permanent	Partial	Buffer
Prime Farmland (and Prime if Drained)	66%	69%	85 (61)	232 (61)	846 (73)
Statewide Importance	3%	1%	0	0	0
Non-Prime	31%	30%	55 (39)	148 (39)	306 (27)
Total	100%	100%	140	380	1,152

TABLE 5-17. COVER TYPE ACREAGES FOR Rx-W PRELIMINARY SITE LAYOUT AND BEST AND WORST CASE SCENARIOS

Cover Type	% of Study Area	% of Rx-W CSA	Preliminary Site Disturbed Acres (% of Total)	Preliminary Site Buffer Acres (% of Total)	Best Case Disturbed Acres (% of Total)	Worst Case Disturbed Acres (% of Total)
Upland Agricultural						
Cultivated-Unidentified Species	76	5	0	15	1	0
Cultivated-Small Grains	-	57	414	926	453	216
Cultivated-Row Crops	-	4	28	21	0	0
Cultivated-Sugar Beets	<1	0	0	0	0	0
Cultivated-Potatoes	<1	0	0	0	0	0
Cultivated-Soybeans	1	8	0	55	59	28
Cultivated-Irrigated	0	0	0	0	0	0
Cultivated-Periodically Flooded	0	0	0	0	0	0
Pasture and Hay Land	<1	<1	0	0	0	0
SUBTOTAL	79%	74%	442 (85%)	1017 (88%)	513 (99%)	244 (47%)
Upland Fields						
Open Shrub Grassland	9	0	0	0	0	0
Ungrazed Native Grassland	-	1	0	2	3	3
Ungrazed Planted Grassland	-	19	75	123	0	189
Native Rangeland	-	0	0	0	0	0
Mowed Native Rangeland	-	0	0	0	0	0
Closed Shrub Grassland	2	0	0	0	0	0
Native Closed Shrub Grassland	-	<1	0	0	0	26
Planted Closed Shrub Grassland	-	0	0	0	0	0
SUBTOTAL	11%	20%	75 (14%)	125 (11%)	3 (1%)	218 (42%)
Upland Forests						
Deciduous Tree Stands	6	0	0	0	0	0
Natural Tree Stands	-	2	0	1	2	43
Planted Tree Stands	-	<1	1	5	0	0
SUBTOTAL	6%	2%	1 (<1%)	6 (1%)	2 (<1%)	43 (8%)
Wetlands(1)						
Wetlands	4	1	2	3	2	10
Open Water	<1	<1	0	0	0	0
SUBTOTAL	4%	1%	2 (1%)	3 (<1%)	2 (<1%)	10 (2%)
Other	<1%	3%	0 (0%)	1 (<1%)	0 (0%)	5 (1%)
TOTAL	100%	100%	520	1152	520	520

1. Based on DPA, 1989 vegetation mapping. See Technical Study 6 for wetland acreages based on more detailed wetland mapping.

The percentages of vegetation associations in the Rx-W preliminary site layout are comparable to the Rx-W CSA and the overall study area (Table 5-17). However, in comparison to the Rx-E preliminary site layout, the Rx-W preliminary site layout will impact a much lower percentage of ungrazed planted grasslands. This will result in a higher percentage of upland agricultural associations being impacted, but these are not considered ecologically important, due to their regional abundance.

Vegetation associations in the buffer zones are proportionally similar to those in the Rx-W disturbed areas (Table 5-17). This indicates that acreages of vegetation associations impacted by the disturbed areas will not vary greatly with modifications in location of radar facilities within buffer zones.

As in the Rx-E CSA, the best and worst case scenarios for the Rx-W CSA considered avoidance of large woodlots primary and avoidance of upland field associations secondary. The best case scenario would have minimal disturbance to these areas whereas the worst case scenario would disturb 218 acres of upland field associations and 43 acres of natural tree stands (Table 5-17). In comparison to these cases, the preliminary site would have moderate impacts to upland field associations and minimal impacts to forested areas.

5.4.5.2.2 **Farmland Impacts.** Approximately 317 acres of prime farmland will be permanently or partially impacted at the Rx-W preliminary site layout (Table 5-16). This site will affect fewer acres of prime farmland and farmland of statewide importance than the Rx-E layout. However, the buffer zones contain a relatively high percent of these farmlands in comparison to the Rx-E preliminary site layout, indicating that a higher percentage of farmlands could be affected if facility location is shifted within this CSA.

5.5 MITIGATION

5.5.1 Vegetation Mitigation

5.5.1.1 Upland Agricultural. The negative effect of the loss of agricultural lands on the region's or total U.S. agricultural production is considered to be minor due to the regional abundance of agricultural lands in production. The socioeconomic effects of the loss of these lands is discussed in the previous project environmental impact statement (USAF, 1986). Accordingly, no mitigation is necessary for this impact.

5.5.1.2 Upland Fields. There are no federal or state regulations concerning the disturbance of native prairies. However, mitigation measures may be appropriate for the loss of these areas to radar facilities due to their relative scarcity and potential importance to special status plants and wildlife species.

In disturbed areas, potential mitigation for the loss of ecologically important and extensive acreages of upland field associations may include the maintenance or restoration of native prairies on the lands acquired by the USAF and not utilized for facilities. If adjacent agricultural acreage is purchased or leased, it could be seeded with native prairie species. Subsequent intermittent management practices, such as mowing or grazing, should be conducted on lands being maintained as native prairies depending on their current condition and productivity (Section 5.4.2.1.2). The USAF will also implement management practices to prevent the encroachment of native species and other noxious weeds on the nearby agricultural lands. In addition, on-site surveys should be conducted to determine the presence or absence of the threatened Western prairie fringed orchid and other native prairie species. The results of these surveys will be used to determine the need for additional mitigation measures for these species (Technical Study 9).

In exclusion areas, agricultural lands and other areas temporarily disturbed by construction activities should be replanted with native species. This will prevent soil erosion and help to create a native prairie regime, although native species may eventually be invaded by exotic and woody species (Section 5.4.2.1.2).

5.5.1.3 Upland Forests. There are no federal or state regulations concerning the disturbance of upland forests. However, additional mitigation measures beyond the avoidance of large woodlots and shelterbelts are recommended for the loss of these areas to radar facilities due to their relative scarcity and ecological importance such as providing diversity in these predominantly agricultural regions.

Mitigation for the loss of forested areas in disturbed areas and exclusion areas could involve planting trees on lands acquired by the USAF and not utilized by the facilities. However, trees should be planted on the perimeters of these lands to avoid facility disturbances to wildlife species. It can be assumed that regeneration of natural tree stands is inherent to wetland mitigation measures since natural tree stands of this region are generally found in these habitat types. Therefore, this mitigation could be conducted as part of any wetland replication or enhancement program (Technical Study 6).

5.5.2 Farmland Mitigation

The evaluation of prime farmland impacts, in accordance with the Farmland Protection Policy Act of 1981, shows that impacts to prime farmlands are not expected to be significant. The following mitigation measures, which are likely to be used to preserve other resources, will also assist in prime farmlands protection.

These include placement of construction staging areas in areas to be permanently disturbed and the layout of construction roads along existing fencelines or roads to preserve existing fields in their present configuration. During decommissioning, mitigation of permanently affected areas may include complete (below-ground) removal or destruction of all installations which could interfere with the movement of farm machinery.

In partially affected areas, mitigation measures could include restoring, to the extent possible, the former condition of the farmlands. This may include the removal and stockpiling of topsoil from cut and fill areas to be replaced after decommissioning, as well as the removal of gravel in the groundscreen area. In addition, tile or surface drainage systems may be restored.

In exclusion areas, mitigation efforts should include seeding and maintenance of permanent vegetative cover to minimize soil erosion. After decommissioning, these areas could then be returned to use as productive farmland.

5.6 CONCLUSIONS

5.6.1 Vegetation

The transmit facilities will affect a total of approximately 2,000 acres, including about 500 acres of disturbed areas and 1,500 acres in exclusion areas. Construction of the CRS facilities of the USAF's proposed preliminary site layout in the Tx-N CSA would impact a total of approximately 1,750 acres of the environmentally sensitive Hecla Sandhills' native rangelands and 250 acres of wetland associations. Although the USAF layout attempted to minimize impacts to these natural areas, the construction of CRS facilities anywhere within the Tx-N CSA would affect a relatively high proportion of the native rangelands and associated wetlands in comparison to the Tx-S preliminary site layout and the overall study area.

The proposed Tx-S CRS facility location would have fewer impacts to the region's natural areas in comparison to the Tx-N preliminary site layout. Only about 80 acres of upland field associations and 5 acres of planted trees would be impacted by the Tx-S preliminary site layout. However, the remaining acres are predominantly agricultural associations. Thus, the Tx-S preliminary site layout would have greater impacts on upland agricultural associations than the Tx-N preliminary site layout.

The receive site will affect a total of about 500 acres, all of which will be directly disturbed. The Rx-E preliminary site layout will impact approximately 250 acres of upland field associations and 250 acres of agricultural associations. Although a relatively high percentage of upland fields will be affected, the selection of this layout successfully avoided all forested areas, resulting in minimal overall impacts to the area ecological values.

The proposed Rx-W CRS facility location would affect fewer acres of upland field associations than the Rx-E preliminary site layout, with only 75 acres being disturbed. The selection of the Rx-W preliminary site layout was also successful in avoiding forested area, and only 1 acre of planted tree stands would be impacted.

5.6.2 Farmlands

The transmit facilities will permanently affect approximately 190 acres, partially affect 320 acres, and temporarily affect 1,530 acres. The Tx-N preliminary site layout will affect only about 90 acres of prime farmlands and 10 acres of farmland of statewide importance. The remaining 1,940 acres are non-prime farmlands.

The Tx-S preliminary site layout would impact more acres of prime farmlands and farmlands of statewide importance than the Tx-N layout. However, the majority of these impacts will be only temporary.

The Rx-E preliminary site layout would have a relatively high percentage of all three types of impacts to prime farmlands and farmlands of statewide importance in comparison to the overall study area. However, most of the non-prime farmlands are concentrated in the beach strand areas where construction of CRS facilities is not feasible.

The Rx-W preliminary site layout would also impact a relatively high percentage of prime farmlands and the farmlands of statewide importance compared to the Rx-W CSA and the overall study area. However, fewer total acres would be impacted in this layout than the Rx-E layout.

5.6.3 Mitigation

Mitigation for unavoidable losses of the native prairie habitats at Tx-N may be appropriate, depending upon the results of site-specific surveys for special-status plant species. Mitigation is not considered necessary for loss of farmland (including prime farmland) due to the extensive amount of farmland in the area. However, mitigation measures to avoid or minimize impacts to other environmental resources will also benefit farmlands.

REFERENCES

Crawford, R.D., J.B. Owen and N.R. Seabloom. 1979. Ecosystems - Existing Characteristics and Significance. Chapter 3, p. 1-52 in P.B. Kannowski, ed., Fish and Wildlife Resources Technical Paper, James River Basin, North and South Dakota. Institute for Ecological Studies, University of North Dakota. Research Report No. 29.

DPA International Ltd. (DPA). 1989. Land Cover/Land Use Mapping for the Proposed Over-the-Horizon Backscatter Radar Sites in Northwestern Minnesota and Northeastern South Dakota. Prepared for the U.S. Air Force, Hanscom Air Force Base, MA and the U.S. Army Corps of Engineers, Omaha, NE.

Gleason, H.A. and A. Cronquist. 1963. Manual of Vascular Plants of Northeastern United States and Adjacent Canada. D. Van Nostrand Company, New York, N.Y.

Küchler, A.W. 1975. Potential Natural Vegetation of the Coterminous U.S. American Geographical Society, New York, N.Y. Special Publication No. 36.

Minnesota Department of Natural Resources (MNDNR). 1984. A Guide to Minnesota Prairies. Prepared by K.M. Wendt. The Natural Heritage Program, St. Paul, MN.

Minnesota Department of Natural Resources (MNDNR). 1987a. A Preliminary Classification and Description of Natural Communities in Minnesota. Draft, Unpublished Report. The Natural Heritage Program, St. Paul, MN.

Minnesota Department of Natural Resources (MNDNR). 1987b. Mesic Blacksoil Prairie (NW) Element Abstract. Unpublished Report, Prepared by K.M. Wendt. The Natural Heritage Program, St. Paul, MN.

Minnesota Department of Natural Resources (MNDNR). 1987c. Wet Blacksoil Prairie (NW) Element Abstract. Unpublished Report, Prepared by K.M. Wendt. The Natural Heritage Program, St. Paul, MN.

Minnesota Department of Natural Resources (MNDNR). 1989. J. Nelson. Personal Communication. Forestry Division, St. Paul, MN. December 7.

Minnesota Environmental Quality Board (MNEQB). 1988. Minnesota's Land Resources, p. 119-127. in Minnesota Environmental Quality: Trends In Resource Conditions and Current Issues.

Sayler, R.D., M.A. Willms and N.R. Seabloom. 1988. Wildlife Resources and Avian Migration Chronology in Northwestern Minnesota and Northeastern South Dakota. Institute for Ecological Studies, University of North Dakota. Research Report No. 38.

Soil Conservation Service (SCS). No Date. Unpublished Draft Soil Maps of Brown County, South Dakota. U.S. Department of Agriculture.

REFERENCES (Continued)

Soil Conservation Service (SCS). 1975. Soil Survey of Marshall County, South Dakota. U.S. Department of Agriculture.

Soil Conservation Service (SCS). 1977. General Soils Map of Polk County, Minnesota. U.S. Department of Agriculture.

Soil Conservation Service (SCS). 1984a. Soil Survey of Pennington County, Minnesota. U.S. Department of Agriculture.

Soil Conservation Service (SCS). 1984b. Prime Farmland: Marshall County, South Dakota. U.S. Department of Agriculture.

Soil Conservation Service (SCS). 1984c. Additional Farmland of Statewide Importance: Marshall County, South Dakota. U.S. Department of Agriculture.

Soil Conservation Service (SCS). 1985. Minnesota Technical Guide Notice No. 46. U.S. Department of Agriculture.

Soil Conservation Service (SCS). 1987. Unpublished Soil Survey of Brown County, South Dakota. U.S. Department of Agriculture.

Soil Conservation Service (SCS). 1988. Unpublished Draft Soil Maps of Polk County, Minnesota. U.S. Department of Agriculture.

Soil Conservation Service (SCS). 1989a. R.B. Heschke. Personal Communication. U.S. Department of Agriculture. October 12.

Soil Conservation Service (SCS). 1989b. Wayne Bachman. Personal Communication. U.S. Department of Agriculture. December [illegible].

Soil Conservation Service (SCS). 1989c. Farmland Conversion Impact Rating for the Over-the-Horizon Backscatter Program in Marshall County, South Dakota. U.S. Department of Agriculture.

Soil Conservation Service (SCS). 1989d. Farmland Conversion Impact Rating for the Over-the-Horizon Backscatter Program in Brown County, South Dakota. U.S. Department of Agriculture.

Soil Conservation Service (SCS). 1989e. Farmland Conversion Impact Rating for the Over-the-Horizon Backscatter Program in Pennington County, Minnesota. U.S. Department of Agriculture.

Soil Conservation Service (SCS). 1989f. Farmland Conversion Impact Rating for the Over-the-Horizon Backscatter Program in Polk County, Minnesota. U.S. Department of Agriculture.

REFERENCES (Continued)

South Dakota Game, Fish and Parks Department (SDGFPD). 1985. Unpublished Field Survey File Document, Prepared by D.J. Ode. Natural Heritage Program, Pierre, S.D.

South Dakota Game, Fish and Parks Department (SDGFPD). 1990a. D.J. Ode. Personal Communication. The Natural Heritage Program, Pierre, South Dakota. January 12.

South Dakota Game, Fish and Parks Department (SDGFPD). 1990b. D.J. Ode. Personal Communication. The Natural Heritage Program, Pierre, South Dakota. February 6.

U.S. Air Force (USAF). 1986. Draft Environmental Impact Statement: Proposed Central Radar System, Over-the-Horizon Backscatter Program.

U.S. Air Force (USAF). 1987. Final Environmental Impact Statement: Proposed Central Radar System, Over-the-Horizon Backscatter Program.

U.S. Air Force (USAF). 1988. Record of Decision. Central Radar System Environmental Impact Statement, Over-the-Horizon Backscatter Program.

U.S. Fish and Wildlife Service (USFWS). 1989. Letter From M.S. Zschomler (State Supervisor) to Interested Party (USAF). October 12.

APPENDIX A

DESCRIPTION OF COVER TYPES MAPPED IN STUDY AREAS AND CONCENTRATED STUDY AREAS

UPLAND AGRICULTURAL(1)

Cultivated-Unidentified Species

- Those areas under intensive cropping or rotation including fallow periods. Crops may include those planted for commercial or forage purposes but exclude those specified below.

  Cultivated-Small Grains(2)

  Cultivated-Row Crops(2)

Cultivated-Sugar Beets

Cultivated-Potatoes

Cultivated-Soybeans

Cultivated-Irrigated

- Cultivated land which has been irrigated.

Cultivated Land Periodically Flooded

- Those areas which may be submerged for longer periods of time than that associated with spring melt and subsequent runoff, and/or periods of above average precipitation. They are found in areas with extensive depressions having poor drainage capabilities. During flooded periods the fields are left fallow. However, when flooding has not occurred the same species as grown in cultivated lands may be planted in these areas.

Pasture and Hay Land

- These areas experience heavy grazing and/or mowing for hay and are generally found in close proximity to farmsteads. They are dominated by planted grass which may have native species present or pastures dominated primarily by native species devoid of woody species.

UPLAND FIELDS

Open Shrub Grassland

- These areas maintain herbaceous understories dominated by grasses and may contain from 0 to 25 percent woody crown cover of bushes and/or trees. Essentially, open shrub grasslands exist where soils are not feasible for agriculture and can be found between agricultural fields and heavily wooded areas, along right-of-ways and drainage ditches, in so-called waste areas, and on former fields.

Ungrazed Native Grassland(2)

- Grasslands containing native species which are not grazed.

Ungrazed Planted Grassland(2)

- Grasslands containing planted species which are not grazed.

Native Rangeland(2)

- Areas dominated by native species managed exclusively for grazing but not as intensively as for pasture and hay land.

Mowed Native Rangeland(2)

- Native rangelands which are mowed.

Closed Shrub Grassland

- Closed shrub grasslands are similar to open shrub grasslands except closed shrub grasslands maintain woody covers from 25 to 75 percent crown cover. This cover type also includes short, dense stands of woody vegetation lacking apparent crowns as in the brushy willow stands in wet habitats.

Native Closed Shrub Grassland(2)

- Closed shrub grasslands primarily comprised of native species.

Planted Closed Shrub Grassland(2)

- Closed shrub grasslands primarily comprised of planted species.

UPLAND FORESTS

Deciduous Tree Stands

- These stands maintain canopy covers of at least 75 percent deciduous species and less than 25 percent coniferous species.

Natural Tree Stands(2)

- These are naturally growing stands but may consist of native or exotic species. They are usually found along riparian areas and wetlands where the soils' moisture and nutrients are replenished through periodic flooding. They are generally not found in the dry upland communities where moisture is insufficient to support tree growth.

DESCRIPTION OF COVER TYPES MAPPED IN STUDY AREAS AND CONCENTRATED STUDY AREAS (Continued)

Planted Tree Stands[2]

- These stands are comprised of planted native and/or exotic species. They are generally found in the form of woodlots (usually regular in shape) located near farmsteads, or shelterbelts (long, narrow strips of trees) near farmsteads or between agricultural fields.

WETLANDS

Wetlands

- All types of wetlands are represented with boundaries determined by U.S. Fish and Wildlife Services National Inventory Maps.

Open Water

- Lakes, rivers, reservoirs, and permanent or semi-permanent areas of open water.

OTHER

- Urban areas and areas lacking vegetation

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1. Crop type is based on 1989 production and may vary from year to year.
2. Differentiated only at the concentrated study area level.

Source: DPA International Ltd., 1989.

TECHNICAL STUDY 6

OVER-THE-HORIZON-BACKSCATTER RADAR PROGRAM
CENTRAL RADAR SYSTEM

WETLANDS AND AQUATICS

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TECHNICAL STUDY 6
WETLANDS AND AQUATICS

6.1 INTRODUCTION

The U.S. Air Force (USAF) proposes to construct the Over-the-Horizon Backscatter (OTH-B) Central Radar System (CRS) in northeastern South Dakota and northwestern Minnesota (USAF, 1987). As stated in the Record of Decision (USAF, 1988), the proposed transmit facility will be located near Amherst, South Dakota, and the proposed receive facility will be located near Thief River Falls, Minnesota (Figure 6-1). The USAF has since selected two concentrated study areas (CSAs) within each study area. The CSA's have been selected through a screening process involving environmental, operational, and socioeconomic considerations (Technical Study 1, EIAP Overview). A complete description of these facilities can be found in Technical Study 2 (Facilities).

This technical study presents information on the existing wetland and aquatic habitats and resources within the study areas, and evaluates the potential impacts of construction and operation of the transmit and receive facilities on these wetland and aquatic environments. Proposed mitigation measures for potential impacts to the wetland and aquatic environments are also presented.

6.2 GENERAL DESCRIPTION OF PRAIRIE WETLANDS

The area in which the proposed radar facilities will be located is dominated by many shallow depressions called prairie potholes, and is consequently known as the Prairie Pothole Region (PPR). Some of these basins are larger than ten acres in size, however, many are relatively small (less than one acre) and less than two feet deep (USFWS, 1987; Tiner, 1984). The prairie pothole region, which formed as a result of glaciation, extends from south-central Canada into the north-central United States (Figure 6-2), and covers approximately 300,000 square miles, one third of which is in the United States (Tiner, 1984).

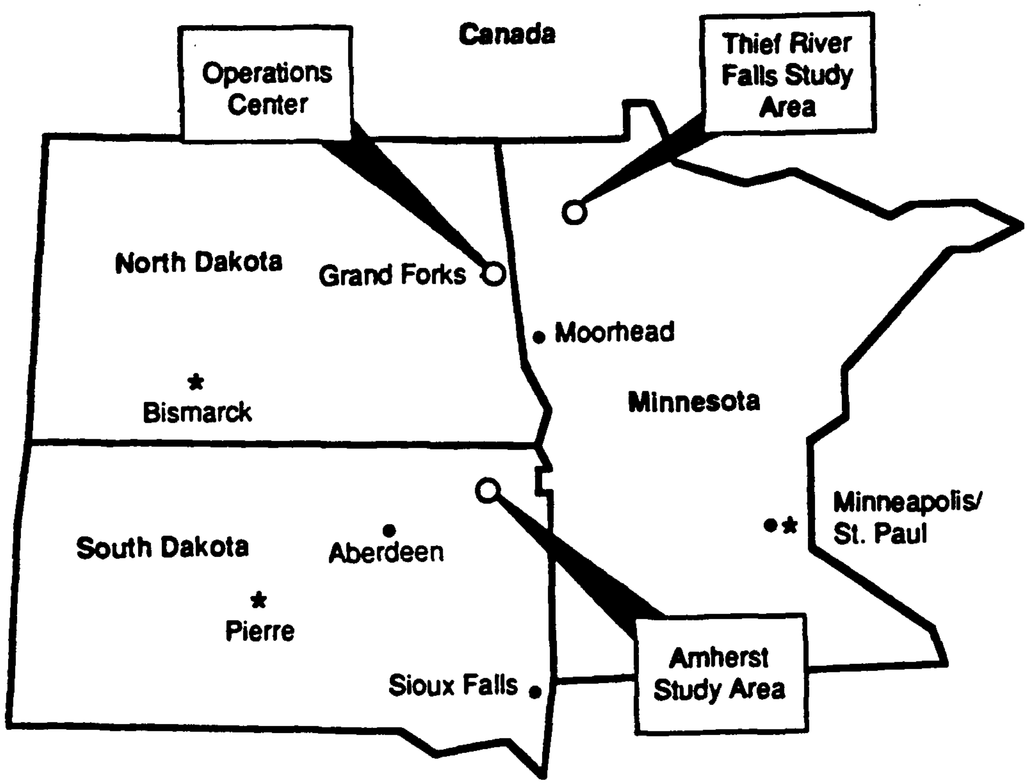

FIGURE 6-1. LOCATION OF THE CENTRAL RADAR SYSTEM TRANSMIT AND RECEIVE STUDY AREAS

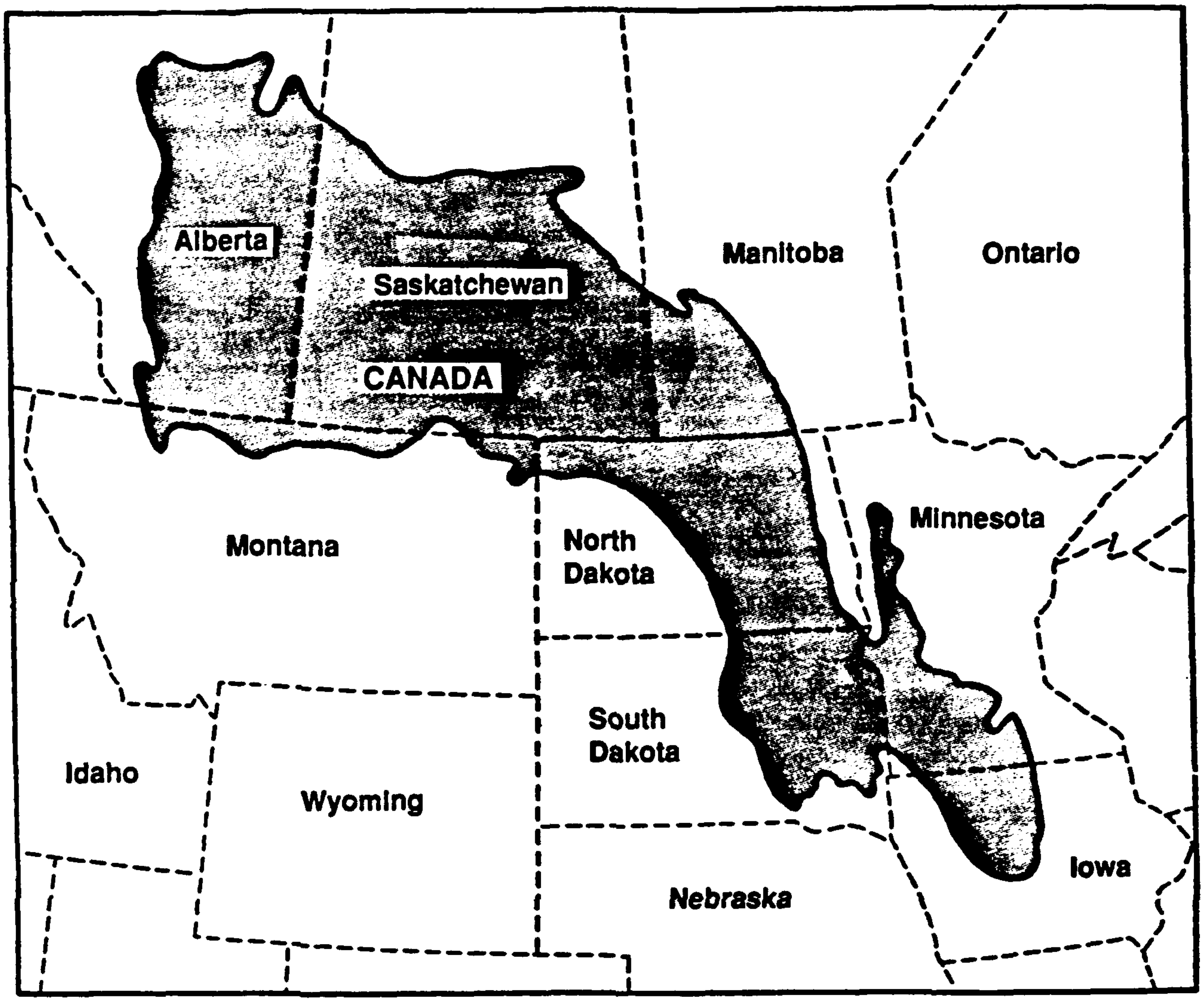

FIGURE 6-2. PRAIRIE POTHOLE REGION OF NORTH AMERICA

No large bodies of open water exist at either the transmit or receive study areas (USAF, 1987), however, some drainage ditches are present. Discussions of aquatic habitats will therefore be limited to an evaluation of the potential impacts to these drainage ditches.

The majority of the wetlands in the study areas are located in depressions (i.e. prairie potholes). Nondepressional wetlands in the study area include rivers and streams, but they represent a small percentage of the total wetland acreage (approximately 2% each at both the transmit and receive study areas). This is consistent with estimates from studies in North and South Dakota, where nondepressional wetlands (such as rivers and streams) comprised 7% and 10%, respectively (Hubbard, 1988).

Wetlands are a valuable resource because they provide several ecological, social and economic benefits (Linder and Hubbard, 1982; Burke et al., 1988). Wetlands furnish water and habitat to waterfowl and other forms of wildlife, and provide water for livestock and crops. They also supply flood damage protection and replenish groundwater supplies, thereby moderating regional drought and flood impacts. Wetlands maintain water quality by filtering nutrients, wastes, and sediments from flooding waters.

In recent years, increasing national attention has focused on the future of wetlands in general, and prairie pothole wetlands in particular. As the draining of wetlands in the prairies for agricultural development, industrial expansion, and other purposes intensifies, the effort to preserve existing wetlands for future wildlife populations also increases. Efforts to resolve these conflicting goals have resulted in programs such as the North American Waterfowl Management Plan being developed by the U.S. Fish and Wildlife Service (USFWS) and the Canadian Wildlife Service (CWS) (USFWS/CWS, 1986).

Wetlands are characterized by hydrophytic vegetation, hydrologic patterns (duration of ponding) and saturated (hydric) soils. The following sections discuss the primary features which characterize the hydrology, vegetation, and soils of wetlands in the PPR. Included also is a discussion of the various hydrologic, recreational, and wildlife support functions for which these wetlands are recognized. A discussion of the impacts of draining wetlands is also included as it pertains to the agricultural activities which are common in the study areas.

6.1.1 Wetland Hydrology

Wetlands generally receive their water from several sources: direct precipitation, meltwater from early spring snowmelt, runoff from surrounding uplands, and groundwater discharge (Hubbard, 1988). The main source of water to a wetland in the prairies is direct precipitation, and runoff is the next most important source of inflow (Sloan, 1972). Precipitation varies annually and determines the duration of ponding, which ranges from brief ponding to seasonal inundation. The amount of meltwater also varies annually depending on the amount of snowfall. Runoff from precipitation or snowmelt can occur either while the soil is still frozen in the early spring and cannot absorb water, or later in the season when precipitation rates exceed the soil's infiltration capacity. The amount of runoff can vary from year to year in either case.

Groundwater discharge is defined as the movement of water from the water table into the wetland basin. Groundwater discharge wetlands are more common in lower elevations where the water table is frequently at or just below the surface. This source of water, however, depends on several factors including soil permeability, configuration of the local water table, and direction and magnitude of the hydraulic gradient around the wetland (Sloan, 1972).

Water loss from wetlands occurs as a result of evapotranspiration, groundwater recharge, overflow out of the basin during periods of high water levels, or a combination of all three methods (Hubbard, 1988). Evapotranspiration is the primary source of water loss from wetlands in the prairies, and consists of evaporation from water and soil surfaces, and transpiration from plant surfaces. Transpiration is believed to be a major component of water loss (60 to 80 percent) in wetlands less than one acre in size. It is a minor component in the water budget of large open water wetlands (Hubbard, 1988). In small wetlands the amount of shoreline vegetation causing transpiration is large relative to the amount of open water, but as wetland size increases, the amount of shoreline vegetation decreases relative to the amount of open water.

Overflow out of wetlands is infrequent or nonexistent in most prairie potholes. Groundwater recharge is therefore also a significant method of water loss, depending on basin configuration (Sloan, 1972). Groundwater recharge is defined as the downward flow of water out of a wetland to the water table. Groundwater recharge relies primarily on soil permeability, local topography, and location of the underlying water table. Depending on fluctuations in the water table, a pothole may temporarily change from a recharge wetland to a discharge wetland and vice versa (Sloan, 1972; Hubbard, 1988). Wetlands exhibiting groundwater recharge tend to be more common in higher elevations where the water table is located deep underground, resulting in consistent downward movement of water from the wetland (Sloan, 1972).

The salinity of water in prairie pothole wetlands is extremely variable (Sloan, 1972). In general, groundwater recharge wetlands tend to contain fresher waters with lower salinities (e.g., under 3000 mg/l of total dissolved salts), because the downward flow of water carries dissolved solids out of the wetland. Conversely, groundwater discharge wetlands concentrate salts during the upward movement of water through the soil and during subsequent evapotranspiration. They therefore tend to exhibit higher salinities (e.g. over 10,000 mg/l). Some wetlands, however, perform both of these functions when the water table slopes into one side of the basin and away from it on the other side (Sloan, 1972; Hubbard, 1988). These wetlands are called flowthrough wetlands and salinities can vary from 3,000 to 10,000 mg/l (Stewart and Kantrud, 1972). Figure 6-3 illustrates these three mechanisms of groundwater movement.

In summary, the overall water regime in prairie pothole wetlands is regulated by the rate of evaporation, because average annual precipitation in the PPR is always less than the average annual evaporation (Hubbard, 1988). Annual and seasonal climatic variations determine water level fluctuations in wetlands in

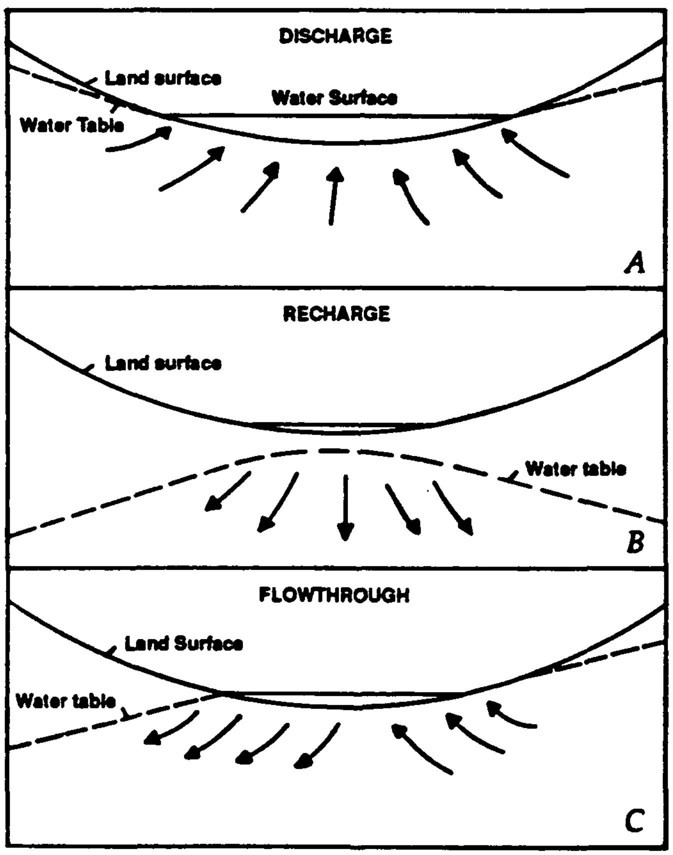

FIGURE 6-3. GROUNDWATER FLOW DIRECTIONS AND WATER TABLE CONFIGURATIONS

the PPR, and climatic variations tend to be cyclical in nature and reflect 10 to 20-year wet-dry cycles common to this region. (Kantrud et al., 1989).

Water regime modifiers are used by the USFWS to describe the duration of ponding in wetlands, and are illustrated in Figure 6-4. These modifiers are defined in terms of the growing season, which is defined as the frost-free period (Cowardin, et al., 1979). Temporarily flooded (temporary) wetlands contain surface water for brief periods during the growing season. Seasonally flooded (seasonal) wetlands hold surface water for extended periods, especially early in the growing season, but not for the entire growing season. Semipermanently flooded (semipermanent) wetlands are characterized by standing water throughout the growing season in most years. When no standing water is present, the water table is usually at or very near the surface. Intermittently exposed wetlands contain open water throughout the year except during years of extreme drought. Permanently flooded (permanent) wetlands have open water zones throughout the year. Finally, saturated wetlands are characterized by substrates which are saturated to the surface for extended periods throughout the growing season, but where standing water is seldom present.

The most common wetlands found in South Dakota are temporary, seasonal, and semipermanent types (Hubbard, 1988). Hydrologic regimes vary within a wetland, with the zone of longest ponding duration located centrally in the wetland, with outer concentric zones of decreasing ponding duration (Kantrud, et al., 1989). Local differences in the water table may, however, result in patchy distributions of these zones within an individual wetland.

The water regime, based on the modifiers described above, is roughly related to local groundwater flow patterns. Based on several studies, Hubbard (1988) concluded that recharge wetlands are typically temporarily and seasonally flooded; discharge wetlands are typically semipermanent, intermittently exposed, permanent, and saturated; and flowthrough wetlands are typically semipermanently flooded. There are some exceptions, however, where flowthrough wetlands are also seasonal, intermittently exposed, and permanently flooded.

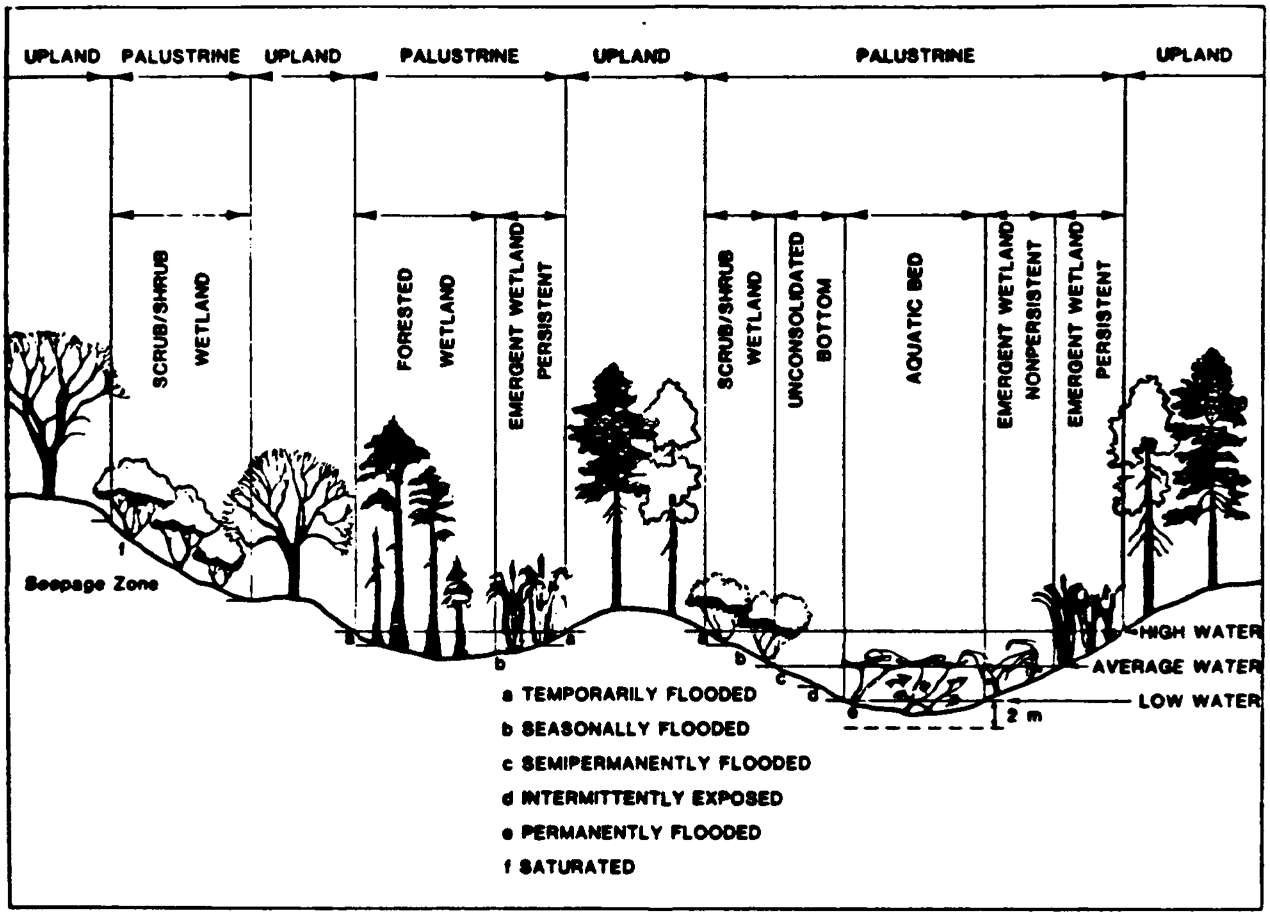

FIGURE 6-4. USFWS WETLAND CLASSIFICATION SYSTEM WATER REGIME MODIFIERS

In summary, the hydrologic functions of prairie pothole wetlands depend upon several variables which characterize the water regime and groundwater flow systems in each wetland. These variables include size of the wetland, soil permeability and hydraulic gradient, local topography, water table configurations, annual and seasonal climatic variations, and abundance of plant cover. The specific hydrology of the proposed sites is described in detail in Technical Study 4.

6.1.2 Wetland Vegetation

Wetlands are identified in part by the presence of hydrophytic vegetation, which is defined as plant life adapted to growing in water, soil, or on a substrate that is at least periodically deficient in oxygen as a result of extended periods of saturation (Federal Interagency Committee for Wetland Delineation, 1989). The USFWS has divided hydrophytic vegetation into four wetland indicator groups. These groups are based on a plant species' frequency of occurrence in wetlands, and are described as follows: (1) obligate wetland plants (OBL) occur almost always in wetlands (estimated probability >99%); (2) facultative wetlands plants (FACW) usually occur in wetlands (estimated probability 67-99%) but occasionally are found in nonwetlands; (3) facultative plants (FAC) are equally likely to occur in wetlands or nonwetlands (estimated probability 34-66%); and (4) facultative upland plants (FACU) usually occur in nonwetlands (estimated probability 67-99%) but occasionally are found in wetlands (estimated probability 1-33%) (Reed, 1988; Federal Interagency Committee for Wetland Delineation, 1989).

The USFWS wetland classification system characterizes wetland habitats using several substrate and vegetation classes (Figure 6-5). Wetlands which develop in channels are classified as riverine systems, while wetlands located in depressions larger than 20 acres with water depths greater than 6.6 feet are classified as lacustrine systems (Cowardin et al., 1979). The wetlands found in the CRS study areas are typically less than 20 acres in size and are classified as palustrine systems. Vegetation common to wetlands in the PPR is presented in Table 6-1 and is summarized below. Appendix A contains a list of common and scientific names of wetland vegetation in the prairie pothole region, and includes each species' wetland indicator status. Description of upland vegetation found at the proposed study areas is contained in Technical Study 5.

Palustrine emergent wetlands in the prairies are typically dominated by rooted herbaceous (non-woody) plants, including certain grasses, cattails, bulrushes, and sedges (Table 6-1). These wetlands frequently occur along margins of rivers and lakes as well as in prairie potholes, and are commonly known as marshes, meadows, fens, prairie potholes, and sloughs (Cowardin et al., 1979).

Duration of flooding can range from a couple of weeks in the early growing season to permanent flooding (Burke et al, 1988). Typical vegetation in temporary emergent wetlands includes prairie cordgrass, northern reedgrass, switchgrass, and sedges. Seasonally-flooded emergent wetland plants include whitetop, slough sedge, water smartweed, and giant burreed. Vegetation common to semipermanently flooded emergent wetlands includes cattails and bulrushes (Stewart and Kantrud, 1972).

Palustrine scrub-shrub wetlands are dominated by woody vegetation less than 20 feet tall (Cowardin et al., 1979). Both deciduous or evergreen plants are common to these wetlands and include low shrubs, young trees, and sedges (Table 6-1). These wetlands are rarely flooded, although the water table is usually very close to the surface for most of the year. Scrub-shrub wetlands are frequently called bogs, pocosins, or shrub swamps, depending on the region of the country (Burke et al, 1988).

Palustrine forested wetlands are typically dominated by woody vegetation at least 20 feet tall (Cowardin et al., 1979), including red maple, black spruce, and willows (Table 6-1). Flooding regimes are variable and depend on regional climate, hydrology, and topography (Burke et al, 1988).

Palustrine aquatic bed wetlands are typically dominated by rooted and floating vascular plants that grow on or below the water surface for most of the growing season (Cowardin et al., 1979). Although water regimes are variable, aauatic beds attain their best development in permanently flooded conditions.

TABLE 6-1. VEGETATION COMMON TO PRAIRIE WETLANDS[1]

Type of Wetland	Vegetation[2]
Emergent Wetlands:	
Persistent	Cattails, dock, sedges, rushes, bulrushes, spikerushes, giant burreed, slough grass, saltgrass, giant reed, prairie cordgrass, smartweeds, tall mannagrass, asters, goldenrods
Nonpersistent	Wild rice, pickerelweeds, arrowheads
Scrub/Shrub Wetlands:	
Broadleaf Deciduous	Alders, buttonbush, red-osier dogwood, honeycup, willows, sedges, bog birch, spirea, red maple saplings, silky dogwood, black spruce saplings, hawthorne,
Broadleaf Evergreen	Labrador tea, bog rosemary, bog laurel, leatherleaf
Needleleaf Evergreen	Young or stunted black spruce or pond pine
Forested Wetlands:	
Broadleaf Deciduous	Red maple, green ash, aspens, American elm, box elder, willows
Broadleaf Evergreen	Cottonwood, sweet bay, red bay, loblolly bay
Needleleaf Evergreen	Black spruce, Northern white cedar
Aquatic Bed Wetlands:	
Aquatic Moss	Mosses
Rooted Vascular	Pondweeds, water smartweed, ditch grasses, waterweed, white water-crowfoot, common bladderwort
Floating Vascular	Water lettuce, water hyacinth, water nut, duckweeds, water ferns
Unconsolidated Bottom Wetlands[3]:	
Cobble-gravel	Periphytic algae
Sand	Periphytic algae
Mud	Periphytic algae
Organic	Periphytic algae

1. Sources: Cowardin et al, 1979 and Stewart and Kantrud, 1972.
2. A listing of scientific names can be found in Appendix A.
3. Substrate does not permit the attachment of larger plants. Macroinvertebrates are used to classify wetland subclasses.

Plants characteristic of these wetlands include mosses, pondweeds, and duckweeds (Table 6-1).

Unconsolidated bottom wetlands are not characterized by existing plant species because they lack large stable surfaces for plant attachment (Cowardin et al., 1979). Therefore, algal communities are the dominant non-animal component of these habitats. Substrates typical of this wetland class include cobble-gravel, sand, mud, and organic debris.

6.1.3 Soils

One of the characteristics which defines a wetland is the presence of periodically saturated or flooded soils, called hydric soils. Hydric soils are defined by the U.S. Department of Agriculture Soil Conservation Service (SCS) as soils that are saturated, flooded, or ponded long enough during the growing season to develop anaerobic conditions (SCS, 1987b).

Prolonged periods of saturation are caused primarily by high water tables and poor soil drainage (SCS, 1987b). The type and amount of plant cover will also affect the duration of ponding and soil saturation (Federal Interagency Committee for Wetlands Delineation, 1989). Anaerobic conditions (the lack of free oxygen) develop because the saturation hinders aerobic decomposition of existing organic matter. Consequently, accumulation of organic matter is common in most hydric soils. Anaerobic conditions are stressful to most plants since a primary function of the root system is to obtain oxygen from the surrounding soil. Therefore, plants which do germinate and grow on these soils must be able to adapt to saturated, anaerobic conditions (Burke et al., 1988).

Soils are separated into two major types on the basis of material composition: organic and mineral (Federal Interagency Committee for Wetland Delineation, 1989). Organic soils include soils with at least 18 inches of organic matter in the upper part, and soils with organic matter resting on bedrock. Mineral soils are largely composed of sand, silt, and clay. Nearly all organic soils are hydric, while most mineral soils are not. Hydric organic soils are characterized as either muck, peat, or mucky peat/peaty muck, depending on the ratio of decomposed organic matter to identifiable organic matter. The organic matter in muck is mostly decomposed, whereas it is mostly identifiable in peat. Hydric mineral soils are recognized by the presence of thick dark surface layers, grayish subsurface layers, and brown or yellow mottles.

Hydric soils in the prairie pothole region are generally fine-textured, and consist primarily of clays and silts which have formed from the shales, sandstones, and siltstones common to the region. The high clay content typical of these soils causes extreme expansion when the soils get wet. This expansion is the reason for the low soil permeabilities (Sloan, 1972; Hubbard, 1988). The soils are therefore dense and do not permit rapid infiltration of water (Winter, 1989). Once wet, however, hydric soils in the prairies have high water retention capacities and can potentially support large quantities of lush vegetation (Winter, 1989).

Hydric soils vary in lime and salt content. Based on several studies, in which hydric soils from wetlands in the PPR were sampled, Hubbard (1988) summarized these characteristics in term of groundwater flow systems. Groundwater recharge wetlands are generally characterized by hydric soils which are nonsaline and noncalcareous (non-carbonated). These soils contain well-leached (eluvial) layers which are relatively free of salts, and well-developed clay (argillic) layers. The presence of these distinct soil layers denotes a well-developed soil profile. Together with the low lime and salt content, these soils indicate a consistent downward flow of water. In contrast, groundwater discharge wetlands are typically saline and calcareous to the surface. These soils are the least developed of soils found in prairie pothole wetlands, and they lack eluvial and argillic layers. These features indicate the overall upward movement of groundwater into the wetland. Flowthrough wetlands have soils typically intermediate in salinity between recharge and discharge wetlands, but they tend to be calcareous like the discharge wetlands (Hubbard, 1988). Further description of the soils of the proposed study area is contained in Technical Study 5, Vegetation.

6.1.4 Functions and Values of Natural Wetlands

Numerous waterfowl species depend heavily on wetlands in the PPR during overwintering, spring migration, breeding, and molting seasons (Hubbard, 1988). Figure 6-6 illustrates the primary waterfowl habitat regions of North America. Although the PPR accounts for only 10 percent of the total waterfowl breeding area in the continental United States, it is estimated that half of all ducklings are raised in the PPR each year (Tiner, 1984). At least 41 percent of the North American population of dabbling ducks alone rely on these wetlands for breeding habitat (Hubbard, 1988), because they are often the only source of open water available during the early spring (Welford, 1987). Appendix B contains a list of common and scientific names of waterfowl species associated with wetlands in the PPR.

Studies have indicated that dabbling ducks such as the mallard and pintail prefer temporarily and seasonally flooded wetlands because they are usually the earliest to thaw and warm up. The wetlands may provide sufficient breeding pair isolation and abundant high-protein invertebrate food sources (Hubbard, 1988). Other species such as the diving ducks tend to utilize the semipermanent and permanent wetlands to coincide with their later arrival and the wetlands' later availability of invertebrate food sources (Kantrud and Stewart, 1977). In addition, diving ducks, including the canvasback and redhead, nest over open water, therefore the larger wetlands are more suitable for their needs (Linder and Hubbard, 1982).

Prairie pothole wetlands also provide food, shelter, and protection to other forms of wildlife. Muskrats and beavers use cattails for food and shelter. White-tailed deer use wetland habitats for winter shelter (Burke et al., 1988). Pheasants in South Dakota roost in the emergent plants and use them for winter cover (Sather-Blair and Linder, 1979). In addition, predators including the red fox, mink, and raccoon rely on prairie pothole wetlands for food sources (Hubbard, 1988). For more information on the wildlife of the study areas, refer to Technical Study 7, Mammals. See Appendix B for a list of common and scientific names of the wildlife species mentioned here. In addition to these functional wildlife benefits, wetland plants are actively

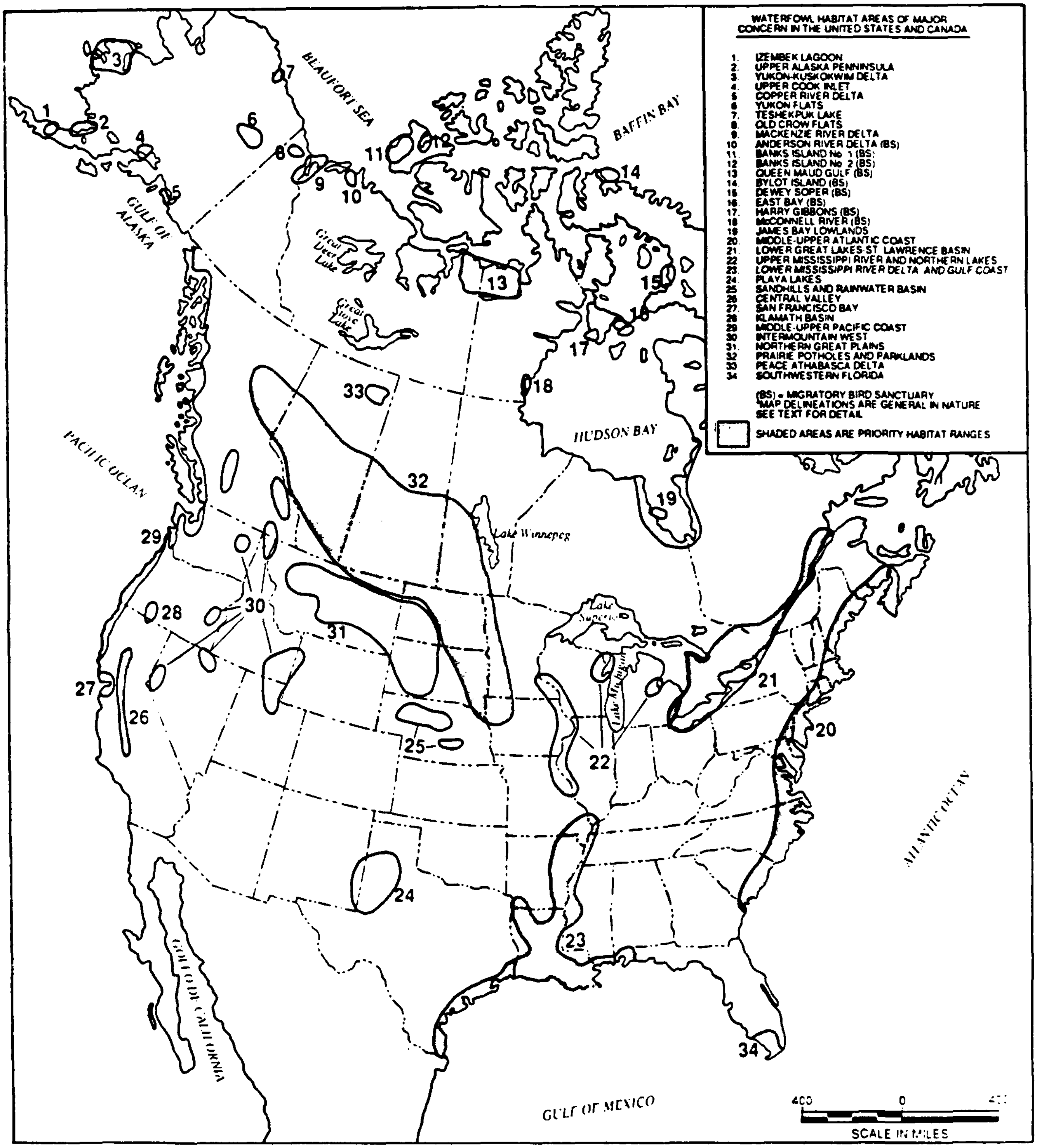

FIGURE 6-6. WATERFOWL HABITAT AREAS IN NORTH AMERICA

grazed upon by livestock. Wetland grasses are also frequently harvested for winter hay food sources (Burke et al., 1988).

In addition to providing habitat for wildlife, wetlands perform several important hydrological functions (Hubbard, 1988; Burke et al., 1986). Wetlands act as potential floodwater storage reservoirs by temporarily collecting and storing meltwaters and runoff, and slowly releasing the waters later. This slows floodwaters and reduces the extent of soil erosion caused by high runoff (USFWS, 1987; Hubbard, 1988). Wetlands also purify incoming water by removing sediments and taking up nutrients like nitrates, phosphates, and sulfates. This tends to reduce siltation and turbidity in the water, and helps to reduce nutrient enrichment (eutrophication) of lowland waters (Burke et al, 1988). Wetlands also provide important water storage reservoirs for wildlife, livestock, and irrigation during drought periods. In addition, wetlands help to maintain groundwater levels by replenishing aquifers, but this function varies depending on soil permeability, local topography, and water table configurations (Hubbard, 1988).

There are economic and recreational benefits of prairie pothole wetlands. These benefits include 1) commercial harvesting of minnows, frogs, leeches, crayfish, and salamanders for the baitfish industry and scientific purposes, 2) recreational sport fishing, and 3) recreational hunting of game and non-game wildlife, especially waterfowl (Hubbard, 1988). Although recreational fishing may be common in the PPR as a whole, this function probably does not apply to the wetlands located in the CRS study areas. Wetlands located in the study areas do not contain standing water year-round, and are not part of a local drainage network, therefore fisheries resources are minimal. Commercial harvesting of aquatic organisms may be a functional benefit of wetlands in the CRS study areas, however, quantitative information for the area was not available.

The value of prairie pothole wetlands to hunters is well known. According to Hubbard (1988), farmers in Minnesota leasing their wetlands to hunters get a return equivalent to their cropland per acre, and their wetlands can also be leased to bait dealers. In South Dakota, a one year study of the use of six public wetlands estimated that over 9,000 people made over 5,000 trips to the wetlands for hunting purposes. In 1982 alone, direct expenditures by hunters in South Dakota for wetland-related hunting was estimated at over $24 million (Hubbard, 1988). Hunting is likely to be the primary recreational benefit of wetlands in the proposed study areas. Quantitative information on hunting expenditures in the area, however, is not available.

6.1.5 Farmed Wetlands

Many thousands of acres of wetlands in the PPR have been drained, primarily to create additional cropland (Tiner, 1984; USFWS/CWS, 1986). Since their introduction in 1849, 1859, and 1860, the Swamp Land Acts turned over 65 million acres of federally-owned inland wetlands to 15 states for reclamation and farming (Burke et al, 1988; Linder and Hubbard, 1982). Millions of acres were similarly drained during the 1930's through the Works Project Administration. In addition, during the 1960's, the Soil Conservation Service assisted farmers in draining their wetlands for agricultural purposes. In the PPR, about half of all wetlands were drained before 1950 (Linder and Hubbard, 1982).

Historically in North and South Dakota, prairie pothole wetlands covered seven million acres (Tiner, 1984). As of 1984, however, approximately three million acres remained intact. Minnesota has lost over nine million of its original 18.5 million acres of natural wetlands (Tiner, 1984). Recent estimates conclude that, overall, 35 and 53 percent of the original wetlands have been drained in South Dakota and Minnesota, respectively (Hubbard, 1988).

Major environmental problems are now being documented throughout the prairie region as a result of wetland drainage, intensified agricultural activities, irrigation, and flood control programs (USFWS/CWS, 1986). These problems include accelerated soil erosion and salinization, water quality degradation, chemical contamination, and reduction in the quality and quantity of waterfowl habitat. As a result, decreased productivity of the land is now being observed for both agriculture and wildlife.

Draining wetlands reduces the availability of invertebrate food sources which are important to breeding ducks such as the pintail and blue-winged teal (Tiner, 1984). In addition, agricultural activities on grasslands bordering wetlands have destroyed valuable nesting areas used by mallards and other dabbling ducks. Consequently, wetland drainage and agricultural conversion of adjacent grasslands is resulting in further concentration of waterfowl populations on fewer available wetlands (USFWS/CWS, 1986; Tiner, 1984). Such overcrowded breeding conditions are lowering productivities (i.e. populations of return breeders) (USFWS/CWS, 1986). The success of breeding waterfowl populations also directly affects populations of mink, red fox, and other predators which rely on waterfowl.

Hydrologic impacts from artificial drainage of wetlands in the PPR have been suggested from several models and simulations (Hubbard, 1988). The conclusions of these modelling studies, however, have not been verified with actual experimental data, because the extensive size of most watersheds in the PPR prohibits undertaking such a study. Based on models, potential impacts may include (1) elimination of dug-outs for livestock and irrigation; (2) reduction in the amount of water replenishing aquifers; and (3) an increase in the net drainage area of watersheds which would result in higher probabilities of flood runoff events (i.e. higher flooding frequencies) (Tiner, 1984; Hubbard, 1988). It should be noted, however, that these projected impacts are a subject of debate and require further examination (Hubbard, 1988).

Agricultural development of prairie pothole wetlands alters the existing plant communities (Hubbard, 1988; Kantrud et al, 1989). Table 6-2 lists some of the changes in vegetation common to palustrine emergent wetlands under various regimes including grazed, idle, hayed, and farmed. In general, the intensity of the disturbance is more important than the nature of the disturbance (Walker and Coupland, 1970). Kantrud et al (1989) summarized the results of several studies that examined the impacts of grazing, mowing, and burning on wetland plant communities as follows: grazing typically stimulates higher species diversity, more complex species distribution patterns within a wetland, and sharper boundaries between zones. Overgrazing may decrease

TABLE 6-2. COMMON DOMINANT EMERGENT VEGETATION IN PALUSTRINE WETLANDS OF THE PRAIRIE POTHOLE REGION[1]

		Land Use			
Water Regime	Burned	Grazed	Idle	Hayed	Farmed
Temporarily Flooded - Fresh		Foxtail barley Baltic rush Prairie cordgrass Lowland white aster	Fowl bluegrass Bluejoint reedgrass Prairie cordgrass Sartwell sedge	Baltic rush Bluejoint reedgrass Wooly sedge Clustered field sedge	Quackgrass Barnyard grass Nodding smartweed Foxtail barley
Seasonally Flooded - Fresh	Water Smartweed	Tall mannagrass American slough grass Giant burreed Common water parsnip Common water plantain Spike rushes Bulrushes	Slough sedge Giant burreed Reed canarygrass Marsh smartweed Whitetop	Slough sedge Reed canarygrass	American slough grass Common water plantain Shortawn foxtail Water smartweed
Semipermanently Flooded - Fresh		Slender bulrush Softstem bulrush River bulrush	Broadleaf cattail Narrowleaf cattail Hybrid cattail	unknown	River bulrush Softstem bulrush

Sources: Kantrud et al, 1989, and Stewart & Kantrud, 1972

(1) All species are persistent with the exception of common water plantain which is nonpersistent.

primary productivity and increase turbidity in the water. Extreme grazing may even eliminate all vegetation. In cases where overgrazing occurs, trampling by livestock may actually have more impact on the wetland than the overgrazing by reducing the height and density of the vegetation. Mowing appears to particularly favor the growth of the pla-t whitetop. Burning wetland vegetation, particularly during the spr - and fall, usually improves the quality of foraged hay by reducing acc ated litter. By removing litter, however, burning exposes the soil to a erated erosion. Furthermore, burning accumulated litter often has a nificant impact on the water regime of wetlands in the prairies. The remov of vegetation reduces the wetland's ability to trap snow during the winter, and therefore reduces a source of water which is important to many wetlands. Chronic burning can ultimately alter production and species composition. Kantrud et al. (1989) concluded, however, that the impacts of burning are quite variable and depend on the amount of existing vegetation, time of year, and species involved.

Artificial drops in prairie wetland water levels (ie. drawdowns) lead to accelerated soil erosion and sa ization, and reduced nutrient sink functions (Hubbard, 1988; Tiner, 1986). Soil erosion is most commonly observed in the temporary and seasonal wetlands. Salinization, or the upward movement of dissolved salts into topsoil layers, tends to be intensified in wetlands where either groundwater discharge or flowthrough conditions exist (Kantrud et al., 1989; Hubbard, 1988). Accelerated salinization will eventually change species composition of the wetland. In terms of functioning as a nutrient sink, the added fertilizers and livestock waste create additional loads on a system accustomed to filtering out lower volumes of nitrates and phosphates (Tiner, 1984).

6.3 METHODS

The following methods were used to gather baseline information on the existing wetlands in each area and to evaluate potential impacts resulting from project construction and operation. The proposed transmit (Tx) study area near Amherst, South Dakota contains two concentrated study areas (CSA) which have been termed Tx-North (Tx-N) and Tx-South (Tx-S). The proposed receive (Rx) study area near Thief River Falls, Minnesota, also contains two CSAs called Rx-East (Rx-E) and Rx-West (Rx-W).

6.3.1 Hydric Soil Mapping

Where available, SCS soil surveys and U.S. Army Corps of Engineers (COE) state hydric soil lists were obtained (SCS, 1988a; COE, 1987b; 1988a;). Completed soil surveys were obtained for Pennington County, Minnesota and Marshall County, South Dakota (SCS, 1984; 1975). Although soil surveys have not been completed for Brown County, South Dakota and Polk County, Minnesota, draft data and maps were available (SCS, 1987; 1988b). Hydric soil maps were produced for each CSA from 1:20,000 scale soil survey maps. At the transmit study areas, some soil associations consisted of two or more soil types, not all of which were defined as hydric. In order to map hydric soils conservatively, these soil groups as a whole were mapped as being hydric. Therefore, the actual extent of hydric soils in the study areas is somewhat less than indicated. The area of soils was then digitized to obtain total acreage estimates for each CSA.

6.3.2 Wetlands Mapping

Wetlands were classified according to the classification system used on USFWS National Wetlands Inventory (NWI) maps, and according to Cowardin et al. (1979). Using NWI maps, acreage estimates for each wetland type were obtained for the Tx and Rx study areas, in order to compare the variety of wetland habitats to those found in the concentrated study areas. Wetlands maps were produced for each of the four concentrated study areas. This section describes the methodology used in producing these maps.

The primary source of information used was black and white aerial stereo pair photographs (scale 1:1,000) taken by the COE for the USAF (COE, 1989). All photographs were taken on 6 May 1989. The photographs were taken several weeks after snowmelt and were assumed to depict the 1989 maximum extent of wetland acreage. An 8X stereoscope was used to analyze the photographs. Additional information used in compiling the wetland maps included field investigat.ons, preliminary NWI maps (USFWS, 1980; 1983), SCS soil surveys and wetland maps (SCS, 1975; 1984; 1987a), and climate information (MN State Climatology Office, 1989; National Weather Service, 1989).

Field investigations were conducted during the final two weeks of August 1989 on all four concentrated study areas. Field investigations consisted of vegetation identification, soil sampling, and aerial surveys. The purpose of the field investigations was twofold: to field verify wetlands mapped from photographs and to characterize the vegetation and soils of the typical wetland classes (e.g. PEMA, PEMC, PFO1B). Investigations were limited to areas for which the USAF had permission to enter.

The USFWS compiled draft NWI maps from aerial photographs taken in April 1980 for the transmit sites and in May 1983 for the receive sites . The USFWS verified a small proportion of the wetland maps by field investigations (USFWS, 1989). For both sites, NWI maps were used as a baseline; all wetland areas shown on NWI maps have been included on the wetland maps. Wetlands sometimes appeared more extensive in the USAF's 1989 aerial photographs than on the NWI maps. In such cases, the CSA wetland maps reflect this larger acreage. In other instances, the 1989 aerial photographs indicate small, temporary wetlands that are not shown on NWI maps. These additional wetlands are also included on the wetland maps. In summary, the CSA wetland maps include at a minimum all wetlands indicated on the NWI maps.

Where possible, the 1989 aerial photographs were used to more specifically classify wetlands than indicated on NWI maps. The most notable difference was for farmed wetlands; the NWI maps usually labelled these wetlands as temporarily flooded emergent (PEMA) wetlands, however, when it was clear from the photographs that the wetlands were farmed ($PEMA_f$), this is indicated on the wetland maps. When the 1989 photographs indicated that the water regime was different from that shown on the NWI maps, the CSA wetland maps reflect the water regime of the photographs, assuming average wetland conditions at the time the photographs were taken. This assumption appears valid for all concentrated study areas except the Tx-S CSA, where extensive flooding occurred. In this case, wet conditions were assumed from the photographs.

On all four concentrated study areas, hydric soils are generally more extensive and do not strictly overlap with wetlands. Therefore, the use of hydric soils as the predominant criterion in delineating wetlands would result in an inaccurate depiction of actual wetland acreage. The recent multi-agency wetlands delineation manual (Federal Interagency Committee for Wetland Delineation, 1989) mandates that a three-parameter approach (soils, vegetation, and hydrology) be adopted for wetland delineations. While the hydric soil information served to confirm the wetland delineations, the combination of hydrologic and vegetation criteria took precedence in the final determinations.

SCS wetlands maps were obtained from the county offices (SCS, 1989). These maps have been developed at the county level in accordance with the Swampbuster provision of the 1985 Federal Farm Bill. This provision denies federal cost-sharing assistance to any landowner who drains a wetland. The wetland maps are based on aerial photographs taken during the spring of five or more years. Any area appearing wet in at least three of the five years is labeled a wetland. The SCS is currently re-evaluating the accuracy of these maps (SCS, 1989); therefore, the SCS maps served only as supplemental information where other information was conflicting or inadequate.

At both study areas, winter and spring 1988 precipitation was slightly above average (Minnesota State Climatology Office, 1989). Rapid warming in late March, however, created abnormal snowmelt and runoff conditions at the Tx CSA, in which surface water could not percolate because of frozen subsoils. This condition presumably caused the extensive and persistent flooding in 1989, which consequently resulted in the classification of a large flooded wetland in the Tx-S CSA.

Best estimate wetland maps were developed for each CSA using all of the above information, and then plotted using a computer-aided drafting and design (CADD) software package. Each of the wetlands was then digitized to obtain acreage estimates for each class of wetland.

6.3.3 Wetland Functions and Values Assessment

The Wetlands Evaluations Technique (WET) version 2.0 (COE, 1987) was used to derive quantitative estimates of functions and values for typical wetland types at each of the four concentrated study areas. Wetland functions consist of the physical, chemical, and biological characteristics of a wetland, while values are those characteristics that are beneficial to society. Functions and values which were evaluated by WET included groundwater recharge and discharge, floodflow alteration, sediment stabilization, nutrient removal/transformation, sediment/toxicant retention, wildlife diversity/abundance, aquatic diversity/abundance, uniqueness/heritage, and recreation.

WET evaluates functions and values in terms of social significance, effectiveness, and opportunity. The social significance of a wetland is that wetland's value to society. Effectiveness is a wetland's capability to perform a specific function, and opportunity is the opportunity of a wetland to perform a function at its level of capability (COE, 1987). Functions and values were evaluated in the relative terms "high," "moderate," and "low."

The use of WET in this technical study was not intended to provide detailed information on specific wetlands. Rather, WET was used to provide supplemental information about the wetlands in the study areas. Because of the large area of the project and considerable number of wetlands involved, this analysis focused primarily on "typical" rather than specific wetlands. Limitations of the model regarding the use of a representative wetland rather than a specific wetland resulted in an incomplete assessment of most wetland opportunities. Opportunity was evaluated only for flood flow alteration, nutrient removal/transformation, and sediment/toxicant retention.

Four wetland types were selected to represent each of the four CSA's. Three of these representative wetlands were selected on the basis of their abundance at each site and were derived by aggregating the predominant characteristics of wetlands on each CSA. The fourth wetland type was selected because it occupied a large portion of the study area. Representative size was obtained from an average of the most common size group. These typical wetlands included a small, temporarily-flooded palustrine emergent (PEMA) wetland; a small sized seasonally-flooded palustrine emergent (PEMC) wetland, a medium sized saturated palustrine forested (PFO1B) wetland, and a large PEMA wetland. Although these wetlands were selected to represent wetlands in a specific CSA, they generally occur in each study area. The functional analysis for the small PEMA wetland, for instance, is generally applicable to PEMA wetlands on all four CSAs.

WET includes options for assessing wetlands under average, wet, and dry conditions. Wetlands were evaluated based upon the presence of "average" conditions, with the exception of the large $PEMA_f$ wetland at the Tx-S CSA, which remained flooded throughout the summer and fall of 1989. The large $PEMA_f$ at the Tx-S CSA was therefore evaluated under the "wet" conditions that were apparent during the spring and summer of 1989.

6.4 AFFECTED ENVIRONMENT

6.4.1 Transmit Study Area

The Amherst study area is located primarily in Marshall County, South Dakota. The Tx-N CSA is located in both Brown and Marshall Counties, while the Tx-N CSA is located entirely in Marshall County (Figure 6-7).

Wetlands occupy approximately 5,790 acres or 6% of the general study area (Table 6-3). Of these wetlands, palustrine emergent (PEM) habitats are the most common (91%) and they are dominated by wetlands with temporary (PEMA) and seasonal (PEMC) regimes. Some semipermanent (PEMF) wetlands are also present. Palustrine aquatic bed (PAB) wetlands, palustrine scrub-scrub (PSS) wetlands, palustrine unconsolidated bottom (PUB) wetlands, and palustrine forested (PFO) wetlands are relatively uncommon in the general study area, each representing less than one percent of total wetland habitat. However, some wetlands containing vegetation characteristics of two vegetations classes are present in the general study area. These wetlands include PEM/PAB

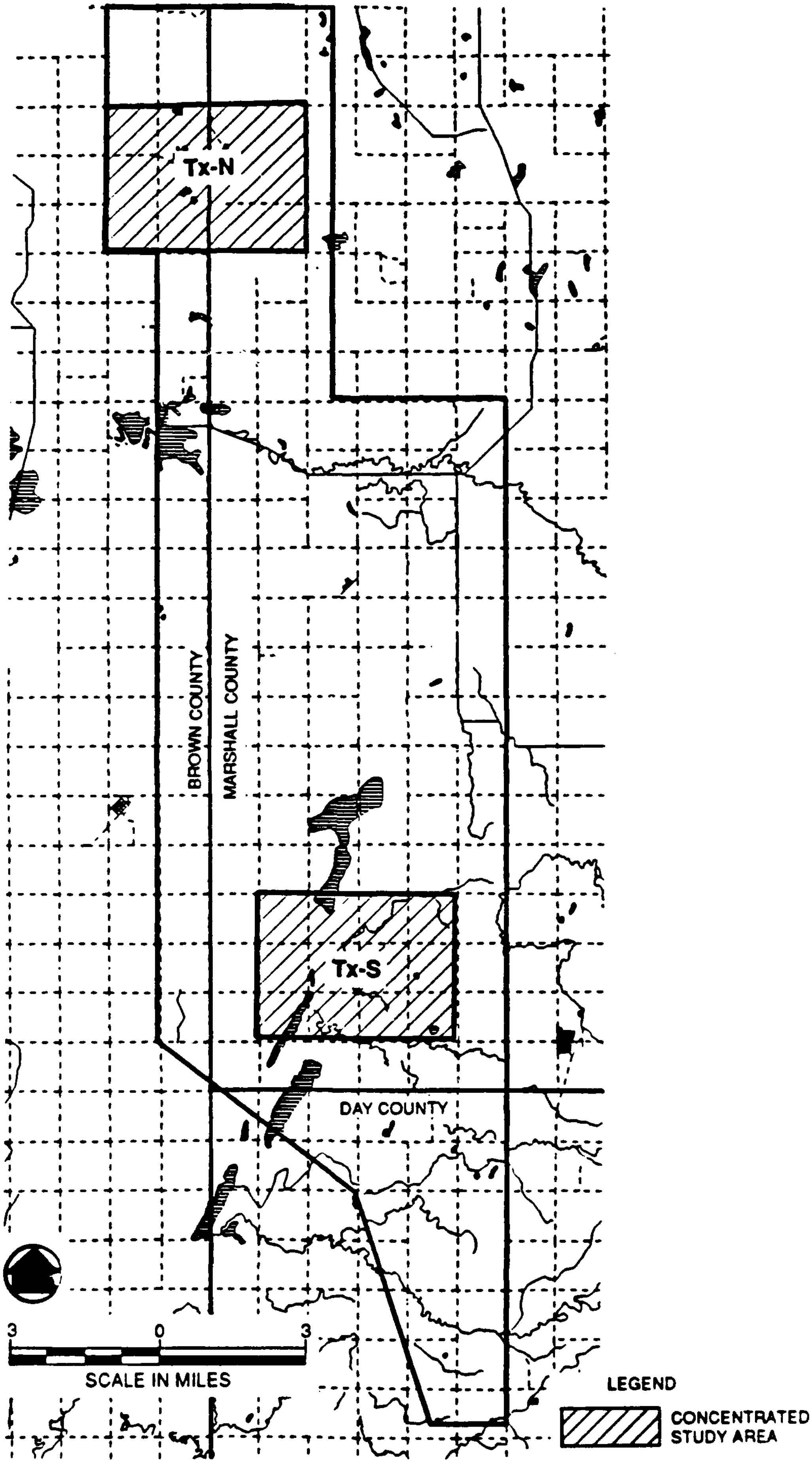

FIGURE 6-7. AMHERST, SD TRANSMIT STUDY AREA AND CONCENTRATED STUDY AREAS

TABLE 6-3. ACREAGE AND PERCENT COVERAGE OF WETLANDS IN THE AMHERST, SD TRANSMIT STUDY AREAS

Wetland Type	Wetland Code[1]	General Study Area		Tx-South		Tx-North	
		Acres	% Total Wetlands	Acres	% Total Wetlands	Acres	% Total Wetlands
Palustrine Emergent							
- Temporary	PEMA	2,794		1,051		172	
- Saturated	PEMB	1				1	
- Seasonal	PEMC	1,827		114		785	
- Semipermanent	PEMF	634				79	
- Unknown	PEM	25					
TOTAL		5,281	91	1,165	98	1,037	97
Palustrine Emergent/ Aquatic Bed TOTAL	PEM/PAB	265	5				
Palustrine Emergent/ Scrub-Shrub TOTAL	PEM/PSS	1	<0.1				
Palustrine Emergent/ Forested TOTAL	PEM/PFO	48	1	10	<1		
Palustrine Unconsolidated Bottom							
- Semipermanent	PUBF	29		11		19	
TOTAL		29	<1	11	<1	19	2
Palustrine Aquatic Bed							
- Semipermanent	PABF	27				12	
TOTAL		27	<1			12	1
Palustrine Scrub-Shrub							
- Broadleaf Deciduous							
Unknown	PSS1	5		5			
TOTAL		5	<1	5	<1		

TABLE 6-3 (Continued). ACREAGE AND PERCENT COVERAGE OF WETLANDS IN THE AMHERST, SD TRANSMIT STUDY AREAS

Wetland Type	Wetland Code[1]	General Study Area		Tx-South		Tx-North	
		Acres	% Total Wetlands	Acres	% Total Wetlands	Acres	% Total Wetlands
Palustrine Forested							
- Unknown temporary	PFOA	16					
- Unknown seasonal	PFOC	6					
- Broadleaf Deciduous							
- Temporary	PF01A	1					
TOTAL		23	<1				
Palustrine Forested/ Scrub-Shrub TOTAL	PFO/PSS	13	<1				
Riverine-Intermittent Streambed							
- Semipermanent	R4SBF	42					
TOTAL		42	<1				
Lacustrine-Littoral Aquatic Bed							
- Semipermanent	L2ABF	57					
TOTAL		57	1				
TOTAL WETLANDS and % Overall		5,792	6	1,191	16	1,068	14
TOTAL STUDY AREA (Approximate)		96,000		7,680		7,680	

1. Wetland codes are defined in Figure 6-5.

habitats (265 acres), PEM/PSS habitats (one acre), PEM/PFO habitats (48 acres), and PFO/PSS wetlands (13 acres). These mixed wetland habitats combined represent 6% of total wetland acerage. Riverine and lacustrine wetlands each represent one percent or less of the total wetlands, and are not found in either of the CSAs.

Aquatic resources in the general study area consist of a few surface drainage ditches and a large waterfowl protection area (WPA). The drainage ditches are typically narrow, intermittent channels that receive most of their water from spring runoff, meltwaters, and occassional summer showers (SDGFPD, 1990). In addition to these ditches, a large waterfowl protection area called Renzienhausen Slough is located in the north central region of the study area to the south of the Tx-N CSA. This large wetland receives water from Crow Creek, which flows from the east of the Tx-N CSA. Crow Creek is not classified as a fisheries resource, and is a tributary of the James River which lies to the west of the study area. Mud Creek, located southwest of the study area, is classified as a warmwater, marginal semipermanent habitat (SDWNRD, 1990), and is also a tributary of the James River.

The larger streams may support benthic invertebrates and such fish species as northern pike, walleye, crappies and bass. The smaller drainage ditches probably do not support any fish other than minnows, however, benthic invertebrates may be supported during spring breeding season (SDGFPD, 1990). Appendix B contains a list of common and scientific names of fishes referred to in this report.

6.4.1.1 Tx-North Concentrated Study Area. Wetlands occupy approximately 1,035 acres (14%) of the total 7,680 acres in the Tx-N CSA (Table 6-3). Palustrine emergent (PEM) wetlands comprise the majority (1,000 acres, or 97%) of these wetlands, and consist of PEMC, PEMA, and PEMF wetland regimes. The more abundant PEMC and PEMA wetlands average approximately two acres and one acre in size, respectively. The remaining 3 percent of wetlands consist of PUB and PAB wetland habitat. No PSS or PFO wetlands are found in this study area.

There are virtually no aquatic resources in the Tx-N CSA. An intermittent drainage ditch is located in the extreme southwest corner of the study area, however, it does not support fisheries. It may support breeding aquatic invertebrate organisms throughout the period of standing water, but no studies on the typical fauna are available.

6.4.1.1.1 Hydrology. The majority of the wetlands at the Tx-N CSA are seasonally flooded. Standing water is therefore usually present for extended periods during the growing season, but does not remain through the entire season (Cowardin *et al*, 1979). These wetlands generally recharge the groundwater below as a result of their partially sandy soils, and because they are above the water table. In late spring, however, groundwater discharge usually occurs when seasonal high water tables caused by runoff reach the surface (USGS, 1975). Very little surface drainage occurs between wetlands as they do not contain permanent outlets and drainage ditches are scarce.

6.4.1.1.2 Soils. Total acreage of hydric soils located in this study area is listed in Table 6-4 below. Soil descriptions are contained in Table 6-5 . The Tx-N CSA is dominated by two soil associations: Hecla-Hamar (Hha) sandy loams and Serden-Venlo (SeB) sandy loams. According to the SCS (1975), hydric soils occupy approximately 4,510 acres, the majority of which (3,535 acres) is comprised of partially hydric soils mapped as hydric (see Section 6.3.1).

TABLE 6-4. ACREAGE OF HYDRIC SOILS OF THE TRANSMIT AND RECEIVE STUDY AREAS

	Transmit Study Area		Receive Study Area	
Soil Type (Code)	Tx-South	Tx-North	Rx-East	Rx-West
Hydric Soil Acreage	1,710	975	9,005	7,390
Partially Hydric Soils Acreage	53	3,535	0	0
Total Hydric Soil Acreage	1,763	4,510	9,005	7,390
Total Study Area Acreage	7,680	7,680	17,280	12,800

Hydric soils at the Tx-N CSA are deep and level or nearly level, and have formed either from eolian (wind blown) or lacustrine deposits or from alluvium (Table 6-5). The soils typically formed in depressions or upland blowouts

TABLE 6-5. CHARACTERISTICS OF HYDRIC SOILS AT THE TRANSMIT STUDY AREAS

Soil Type (Code)	Texture	Depth	Level	Soil Features	Drainage	Perm.	Runoff	Avail. Water Capacity	Water Table (Feet)	Remarks
Arveson (Ar)	Loam	deep	level	mottles in subsoil	very poorly drained	moderately rapid	very slow	moderate	at/near surface	low to moderate fertility
Hamar (Hd)	Fine sandy loam	deep	nearly level	mottles in subsoil	poorly to somewhat poorly drained	moderately rapid	slow	moderate	0-3 below	moderate fertility
Hamar (Ha)	Loamy fine sand	deep	nearly level	mottles in subsoil	poorly to somewhat poorly drained	moderately rapid	very slow or ponded	low to moderate	1-3 below	tendency to blow when dry, moderate fertility
Fossum (Fo)[1]										
Hecla-Venlo (HvB2)[2](5)	Sandy loam Matrix	deep	neary level	mottles in subsoil, non-calcareous in upper layers	very poorly drained	rapid above	no information	low	0-3 below	low to moderate fertility, tendency to blow when dry
Colvin (Co)	Silt	deep	level	highly calcareous, mottles and gypsum crystals in subsoil	poorly drained	moderately slow	no inform-ation	moderate to high	1-5 below	moderate fertility
Dovray (Do)	Clay	deep	level	calcareous throughout, gypsum crystals in subsoil	poorly drained	very slow	very slow	moderate	1-4 below	moderate to high fertility

TABLE 6-5 (CONTINUED). CHARACTERISTICS OF HYDRIC SOILS AT THE TRANSMIT STUDY AREAS

Soil Type (Code)	Texture	Depth	Level	Soil Features	Drainage	Perm.	Runoff	Avail. Water Capacity	Water Table (Feet)	Remarks
Ludden (Lu)	Clay	deep	level	gypsum crystals in subsoil	poorly drained	very slow	very slow or ponded	moderate	2-3 below	tendency for flooding, moderate fertility
Lamoure (La)	Silty clay loam	deep	nearly level	mottled and highly calcareous in subsoil	poorly or somewhat poorly drained	moderate	very slow	high	2-5 below	tendency for flooding, tendency to blow when dry, moderate to high fertility
Parnell (Pa)	Silty clay loam	deep	level	occasional organic matter layer on top, mottles in subsoil	poorly or very poorly drained	slow	very slow	moderate to high	0-4 below	tendency for flooding, high fertility
Tonka (To)	Silty loam	deep	level	mottles occasionally in subsoil	poorly drained	slow to moderately slow	slow	no information	0-4 below	tendency for ponding
Hecla-Hamar (Hha)(3)(5)	Loamy fine sand	deep	nearly level	mottles in subsoil	poorly to somewhat poorly drained	moderately rapid	very slow or ponded	low to moderate	1-3 below	tendency to blow when dry, moderate fertility
Serden-Venlo (SeB)(4)(6)	Sandy loam	deep	nearly level	mottles in subsoil, noncalcareous in upper layers	very poorly drained	rapid above water table	no information	low	0-3 below	low to moderate fertility, tendency to blow when dry

TABLE 6-5 (CONTINUED). CHARACTERISTICS OF HYDRIC SOILS AT THE TRANSMIT STUDY AREAS

Soil Type (Code)	Texture	Depth	Level	Soil Features	Drainage	Perm.	Runoff	Avail. Water Capacity	Water Table (Feet)	Remarks
Stirum (Su)[7]	Fine Sandy load	deep	nearly level	highly calcareous and mottles in subsoil	poorly drained	moderately slow to moderately rapid	no information	low to moderate	0-3 below	low to moderate, fertility, tendency to blow when dry

(1) Soil characteristics not known.
(2) Venlo soils represent 25% of this soil type and are hydric.
(3) Hamar soils represent 40% of this soil type and are hydric.
(4) Venlo soils represent 45% of this soil type and are hydric.
(5) For purposes of this table, description of the non-hydric Hecla soil has been omitted.
(6) For purposes of this table, description of the non-hydric Serden soil has been omitted.
(7) Stirum soils represent 70% of this soil type and are hydric.

Source: SCS, 1975.

(SCS, 1975). Soil texture is predominantly loam and sandy loam, with fine sand present in subsoil layers. Mottles are present in most of the subsoils, and gypsum crystals are present only in the Ludden soils. Drainage varies from somewhat poorly to very poorly drained, and permeability is very slow to moderately rapid. Runoff tends to be slow to very slow or ponded. Available water capacity ranges from low to moderate, and the water table varies from near the surface to three feet below.

6.4.1.1.3 Vegetation. Wetland vegetation found in this CSA is listed in Table 6-6, and consists primarily of emergent species including sedges and cattails. PAB wetlands were not observed during the period of field investigations, partially as a result of inaccessibility of the land to the USAF. Therefore, data on common PAB wetland plant species could not be obtained.

6.4.1.1.4 Wetland Functions and Values. A seasonally-flooded palustrine emergent (PEMC) wetland, containing primarily emergent vegetation, and less than five acres in size, was selected for functional analysis as a typical wetland of the Tx-N CSA, because it was the dominant wetland type in that CSA. This type of wetland typically exists in an isolated watershed which is dominated by grazed native prairie.

A typical PEMC wetland of this size range is socially significant at the Tx-N CSA as a result of its uniqueness, and because of its ability to discharge groundwater, and support wildlife (Table 6-7). Groundwater discharge, which likely occurs with higher water tables in late spring, is important because it extends the duration of ponding and helps to provide habitat for migrating waterfowl and raptors, including the endangered bald eagle. This typical wetland received a high uniqueness/heritage rating not only for its ability to support an endangered species, but also because of its proximity to a tract of native prairie and the 320-acre Hayes Waterfowl Production Area. The wetland received a moderate rating for its social significance of all other values except recreation, which was rated low because of its typical distance to urban areas.

TABLE 6-6. COMMON PALUSTRINE WETLAND VEGETATION AT THE TRANSMIT CONCENTRATED STUDY AREAS

Wetland Type	At Tx-N	At Tx-S	Vegetation[1]
Palustrine Unconsolidated Bottom (PUB)[2]	X	X	narrowleaf cattail, broadleaf cattail, dock, river bulrush, giant burreed, giant goldenrod, pond weed, prairie cordgrass
Palustrine Aquatic Bed (PAB)	X		no data available
Palustrine Emergent (PEM)	X	X	sedges, rushes, hummock sedge, asters, big bluestem, narrowleaf cattail, broadleaf cattail, river bulrush, giant burreed, giant goldenrod, pond weed, prairie cordgrass
Palustrine Scrub-Shrub (PSS)		X	willows, green ash, rushes, sedges
Palustrine Forested (PFO)		X	willows, green ash, sedges, rushes, cottonwood, American elm

1. A list of scientific names can be found in Appendix A.
2. Palustrine unconsolidated bottom (PUB) wetlands do not by definition contain any vascular, herbaceous, or woody plants, therefore the plants listed in Table 6-6 refer to those found on the shoreline of these wetlands.

TABLE 6-7. WETLAND FUNCTIONS AND VALUES ASSESSMENT FOR A TYPICAL SEASONALLY-FLOODED PALUSTRINE EMERGENT (PEMC) WETLAND AT THE TX-NORTH CSA[1]

	Social Significance[2]	Effectiveness[2]	Opportunity[2]
Ground Water Recharge	M	H	*
Ground Water Discharge	H	L	*
Floodflow Alteration	M	H	H
Sediment Stabilization	M	L	*
Sediment/Toxicant Retention	M	H	L
Nutrient Removal/Transformation	M	H	H
Production Export	*	L	*
Wildlife Diversity/Abundance	H	*	*
Wildlife D/A Breeding	*	M	*
Wildlife D/A Migration	*	H	*
Wildlife D/A Wintering	*	L	*
Aquatic Diversity/Abundance	M	M	*
Uniqueness/Heritage	H	*	*
Recreation	L	*	*

1. Ratings derived from Wetlands Evaluations Technique (WET) version 2.0 (COE, 1987).
2. H = High; M = Moderate; L = Low; U = Uncertain; * = Not Evaluated

Given the opportunity, a typical PEMC wetland at the Tx-N CSA would be highly effective at recharging groundwater, altering floodflows, retaining sediments, removing nutrients, and supporting migrating waterfowl (Table 6-7). Wetlands at the Tx-N CSA effectively recharge groundwater during summer and fall when the water table drops. This typical PEMC wetland also retains sediments, filters out nutrients from runoff, and retards floodwaters (because of the lack of a surface outlet). The interspersion of emergent vegetation and open water provides important habitat for migrating waterfowl during the spring.

The typical PEMC wetland does not effectively discharge water, stabilize sediments, export organic products, or support wintering wildlife. The relatively sandy soils at the Tx-N CSA permit the occurrence of groundwater recharge throughout most of the year, except during late spring, when the water table rises to the surface and causes discharge to occur. The seasonally elevated water table is primarily due to meltwater percolating into the groundwater system rather than artesian pressure (Technical Study 4). A typical PEMC wetland at the Tx-N CSA cannot effectively stabilize sediments because surrounding soils are already stabilized by vegetation. Therefore surface runoff does not carry significant amounts of sediments into the wetlands. The typical PEMC wetland cannot export organic products because it has no permanent outlet. The lack of open water and frozen state of soils at the Tx-N CSA explain its low rating for supporting wintering wildlife.

A typical PEMC wetland at the Tx-N CSA has a high opportunity to perform flood flows alteration and nutrient removal or transformation. The lack of a surface outlet provides the means to effectively perform these functions. A low opportunity rating for sediment/toxicant retention indicates that however effective the wetland is, it will not likely perform this function adequately.

Wetlands in general may be effective at providing certain functions, however, if opportunity is lacking, they will be unable to perform the functions adequately. Opportunity is therefore an important element in the overall functional value of a particular wetland. The typical wetland received high ratings for its opportunity to perform floodflow alteration and nutrient removal/transformation. The absence of a permanent outlet and the gentle slopes surrounding it provide the vicinity with a settling basin for floodwaters and associated sediments. The only difference in opportunity ratings between the two typical wetlands analyzed was the higher rating for the $PEMA_f$ wetland (at Tx-S) in sediment retention. Based on the WET functional analysis, these two representative wetlands have the opportunity and are capable of altering floodflows and removing or transforming nutrients.

6.4.1.2 Tx-South Concentrated Study Area. Wetlands occupy approximately 1,190 acres (16%) of the total 7,680 acres in the Tx-S CSA (Table 6-3). Palustrine emergent (PEM) wetlands are the most abundant type present, (1,163 acres or 98% of total wetlands) and are primarily temporarily-flooded (PEMA). Most of these PEMA wetlands are classified as farmed ($PEMA_f$) because the are typically cultivated when conditions permit. A large portion of the Tx-S CSA is dominated by a single, large PEMAF wetland which ordinarily would be cultivated land, but was inundated with water during the spring and summer of 1989. Mixed PEM/PFO wetlands represent less than one percent of total wetland acreage. PUB and PSS wetlands are both present in this study area and represent less than one percent each of the total wetlands.

A few drainage ditches are present in the Tx-S CSA, and are intermittent in nature and do not persist through the entire growing season. They may support breeding populations of benthic macroinvertebrates during the spring, however they are not adequate to support fisheries habitat. No studies were found that examine the fauna of these ditches. The closest aquatic resources to the CSA are Mud Creek and Antelope Creek, located approximately 4-6 miles south of the Tx-S CSA.

6.4.1.2.1 Hydrology. The majority of the wetlands at the Tx-S CSA are temporarily flooded. Standing water is therefore present for only a brief period early in the growing season. In general, the wetlands do not have outlets, however, the large $PEMA_f$ wetland has an inlet. Groundwater recharge is slow due to the relatively impermeable soils (USGS, 1975). More drainage ditches exist at this CSA than at the Tx-N CSA, therefore surface drainage may be more efficient at this CSA.

6.4.1.2.2 Soils. According to the SCS maps (1975), several different hydric soil associations are found at the Tx-S CSA, including two partially hydric soils which were mapped as hydric for this study (see Section 6.3.1). Table 6-4 contains total hydric soil acreage for this CSA. Hydric and partially hydric soils combined occupy approximately 1,763 acres (1,710 and 53 acres, respectively), and are dominated by Ludden (Lu) clay, Colvin (Co) silt, and Hamar (Hd) sandy loam soils.

The hydric soils at the Tx-S CSA as a group are generally deep and level or nearly level (Table 6-5). They have formed either from alluvial (flowing water) deposits or lacustrine (glacial lake) deposits, and are located primarily in shallow depressions and bottom lands (SCS, 1975). Soil texture is predominantly clay, silty loam, or sandy loam. Mottling and the formation of gypsum crystals are common subsoil features of these soils. Soil drainage ranges from somewhat poorly to very poorly drained. Permeability is very slow to moderately rapid, and runoff is slow to very slow or ponded. The location of local water tables ranges from near the surface to five feet below, and available water capacity ranges from low to high.

6.4.1.2.3 Vegetation. Vegetation found in wetlands at the Tx-S CSA was similar to vegetation found at the Tx-N CSA, and is summarized in Table 6-6. The PEM wetlands and PUB shorelines are dominated by cattails, sedges and rushes. The scrub-shrub wetlands typically contain willows and green ash, and the forested wetlands consist of willows, green ash, cottonwood, and elm. The large number of farmed PEMA wetlands are cultivated with a variety of agricultural crops (Technical Study 5).

6.4.1.2.4 Wetland Functions and Value. A large $PEMA_f$ wetland (640 acres lies within the CSA) at the Tx-S CSA was selected for an analysis of functions and values. The evaluation was conducted assuming wet conditions which occur when the wetland is flooded to its maximum extent. In this respect, the evaluation for this wetland represents maximum value. The wetland evaluated contains at least one inlet but no permanent outlet, it has no channel or directional flow, it exists on poorly drained soils, and it contains typical emergent vegetation.

The highest social significance functions of the large $PEMA_f$ wetland are its groundwater benefits, uniqueness, and its ability to provide wildlife diversity and abundance (Table 6-8). The wetland is both unique and beneficial to wildlife because of its large size and ability to discharge and store water. When surface water is present the wetland supports considerable numbers of migrating birds, including the endangered bald eagle (Technical Study 9). The social significance of other functions and values is moderate except for recreation, which received a rating of low because of the limited public access and distance of the wetland from urban areas.

Given the opportunity, this large $PEMA_f$ wetland can be most effective at floodflow alteration, sediment stabilization and retention, nutrient removal and transformation, and supporting migrating waterfowl (Table 6-8). Two features of the wetland allow it to perform these functions well: the gradual slopes of the surrounding watershed and the absence of a real outlet. The gentle slopes surrounding the wetland allow it to retain a large amount of water and protect areas downstream from floodwaters. The wetland, therefore, acts as a settling basin for sediment and nutrient runoff from the surrounding agricultural lands.

The wetland would be least effective at performing groundwater recharge and providing production export, wildlife breeding and wintering habitat, and aquatic diversity/abundance. The high clay content and low permeability of the soils explain the low groundwater recharge effectiveness. The wetland is unable to export organic products because it has no surface outlet. Wildlife breeding and wintering received low ratings because the wetland contains little cover, and when water is present throughout the year it freezes during the winter months. Aquatic diversity and abundance were rated low because the wetland is usually only present for a few weeks during the growing season.

TABLE 6-8. WETLAND FUNCTIONS AND VALUES ASSESSMENT FOR A TYPICAL FARMED TEMPORARILY-FLOODED PALUSTRINE EMERGENT ($PEMA_f$) WETLAND AT THE TX-SOUTH CSA[1]

	Social Significance[2]	Effectiveness[2]	Opportunity[2]
Ground Water Recharge	M	L	*
Ground Water Discharge	H	M	*
Floodflow Alteration	M	H	H
Sediment Stabilization	M	H	*
Sediment/Toxicant Retention	M	H	H
Nutrient Removal/Transformation	M	H	H
Production Export	*	L	*
Wildlife Diversity/Abundance	H	*	*
Wildlife D/A Breeding	*	L	*
Wildlife D/A Migration	*	H	*
Wildlife D/A Wintering	*	L	*
Aquatic Diversity/Abundance	M	L	*
Uniqueness/Heritage	H	*	*
Recreation	L	*	*

1. Ratings derived from Wetlands Evaluations Technique (WET) version 2.0 (COE, 1987).
2. H = High; M = Moderate; L = Low; U = Uncertain; * = Not Evaluated

High ratings were given for the opportunity of this typical wetland to perform flood flood alteration, sediment/toxicant retention and nutrient removal or transformation, and the gentle slopes and lack of a surface outlet provide the means to effectively perform these functions.

6.4.1.3 Summary of Functional Analysis of Wetlands at the Tx CSAs. The two representative wetlands provide similar functions and values. The social significance of the selected values for these typical wetlands was found to be similar, with high ratings received by both wetlands for the functions of groundwater discharge, wildlife diversity and abundance and uniqueness. The large $PEMA_f$ wetland at the Tx-S CSA and the seasonal PEMC wetlands at the Tx-N CSA were rated equally high for their effectiveness to remove nutrients, retain sediments, reduce floodwaters, and provide habitat for migrating waterfowl. The large $PEMA_f$ wetland at the Tx-S CSA was rated more effective at groundwater discharge and sediment stabilization, however, the PEMC at the Tx-N CSA wetland was rated as being more effective at providing wildlife breeding habitat and aquatic diversity and abundance.

6.4.2 Receive Study Area

The Thief River Falls, Minnesota study area is located in Polk and Pennington Counties. The Rx-E CSA is located entirely in Pennington County, while the Rx-W CSA is located entirely in Polk County (Figure 6-8).

Wetlands occupy approximately 6,126 acres or 6% of the general study area (Table 6-9). Of these wetlands, palustrine emergent (PEM) types are the most common and represent approximately 59% of total wetland acreage. These PEM wetlands consist primarily of saturated (PEMB) and semipermanent (PEMF) wetlands, however, PEMA and PEMC wetlands are also present in this study area. Mixed palustrine emergent/scrub-shrub (PEM/PSS) wetlands are the next most common type of wetland found (17%). PUB wetlands, PSS wetlands, and PFO wetlands are all found in lesser amounts in the general study area. Riverine wetlands are uncommon, and lacustrine wetlands do not exist in this study area.

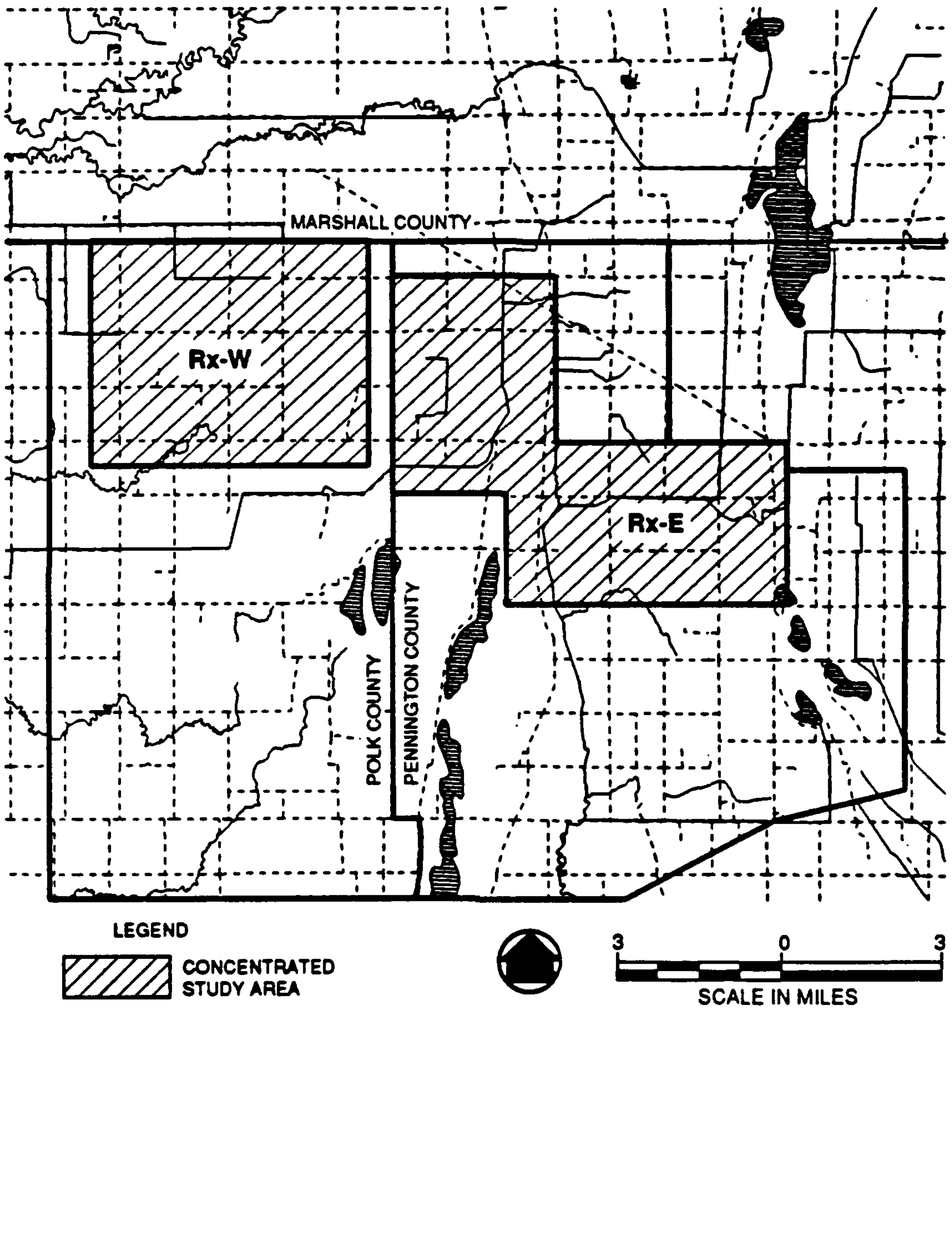

FIGURE 6-8. THIEF RIVER FALLS, MN RECEIVE STUDY AREA AND CONCENTRATED STUDY AREAS

TABLE 6-9. ACREAGE AND PERCENT COVERAGE OF WETLANDS IN THE THIEF RIVER FALLS, MN RECEIVE STUDY AREA

Wetland Type	Wetland Code[(1)]	General Study Area		Rx-West		Rx-East	
		Acres	% Total Wetlands	Acres	% Total Wetlands	Acres	% Total Wetlands
Palustrine Emergent							
- Unknown	PEM	4					
- Temporary	PEMA	381		232		143	
- Saturated	PEMB	2,037				116	
- Seasonal	PEMC	445		121		117	
- Semipermanent	PEMF	705		6		29	
- Intermittently exposed	PEMG	11					
TOTAL		3,581	59	359	75	405	39
Palustrine Emergent/ Scrub-Shrub TOTAL	PEM/PSS	1,053	17			236	23
Palustrine Emergent/ Forested TOTAL	PEM/PFO	205	3			109	11
Palustrine Unconsolidated Bottom							
- Seasonal	PUBC	<1					
- Semipermanent	PUBF	15		2		4	
- Intermittently exposed	PUBG	62		7		4	
TOTAL		77	1	9	2	8	<1
Palustrine Scrub-Shrub-Broadleaf Deciduous							
- Temporary	PSS1A	<1				<1	
- Saturated	PSS1B	462				112	
- Seasonal	PSS1C	43		18		68	
- Unknown	PSS1			4		5	
TOTAL		505	8	22	5	185	18
Palustrine Forested-							
- Unknown	PFO			13			

TABLE 6-9 (Continued). ACREAGE AND PERCENT COVERAGE OF WETLANDS IN THE THIEF RIVER FALLS, MN RECEIVE STUDY AREA

Wetland Type	Wetland Code[1]	General Study Area		Rx-West		Rx-East	
		Acres	% Total Wetlands	Acres	% Total Wetlands	Acres	% Total Wetlands
Broadleaf Deciduous							
- Temporary	PF01A	10					
- Saturated	PF01B	216		65		49	
- Seasonal	PF01C	39		4		22	
- Unknown	PF01					2	
TOTAL		265	4	81	17	73	7
Palustrine Forested/ Scrub-Shrub TOTAL	PFO/PSS	297	5	7	2	12	1
Riverine-Intermittent Streambed							
- Semipermanent	R4SBF	138				18	
TOTAL		137	2			17	2
TOTAL WETLANDS and % overall		6,126	6	479	4	1,046	6
TOTAL STUDY AREA (Approximate)		108,800		12,800		17,280	

1. Wetland codes are defined in Figure 6-5.

Aquatic resources in the Thief River Falls general study area consists of a network of drainage ditches, and Goose Lake, which lies in the south-central region of the study area. The drainage ditches are not considered resources for fisheries, especially in dry years of low spring runoff (MNDNR, 1990a). If standing water persists, brook sticklebacks and fathead minnows may occasionally be found (MNDNR, 1990b). Appendix B contains common and scientific names of fish species referred to in this report. No studies were found, however, to elaborate on the aquatic communities of these ditches. Goose Lake has been designated as a wildlife management area (WMA) and is also considered a protected water resource (MNDNR, 1990c). Its location within a larger wetland area which provides habitat to local wildlife. The CRS receive facility, however, is not in the immediate vicinity of this aquatic environment, and drainage from site activities is not expected to reach it. To the north of the study area lies the Snake River which is a tributary of the Red River of the North. Minimal aquatic impacts are expected to occur to this river as flow at the study area is towards the southwest not the north.

6.4.2.1 **Rx-East Concentrated Study Area.** Wetlands cover approximately 1,046 acres (6%) of the 17,280 acres of this CSA (Table 6-9). These wetlands are represented by several types including PEM wetlands (39%), mixed PEM/PSS wetlands (23%), and PSS wetlands (18%). PFO wetlands comprise 7% overall and mixed PEM/PFO wetlands represent 11% of total wetland habitat. The majority of the PEM wetlands are PEMA, PEMB, and PEMC wetlands. Average size of these wetlands is approximately one acre, seven acres, and two acres, respectively. Average size of the PSS and PFO wetlands is 2.5 acres and 8 acres, respectively. Riverine wetlands are uncommon in this CSA and represent 2% overall.

Two large drainage ditches are present in the Rx-E CSA both of which flow from north to south. One flows south and west into the Red River of the North, which lies to the west of the study area, and the other flows south into the Black River. These unnamed ditches possibly support such fish species as northern pike and minnows (MNDNR, 1990a).

6.4.2.1.1 Hydrology. Although standing water is generally not present in wetlands in the Rx-E CSA through the growing season, temporarily-flooded wetlands retain water briefly early in the growing season. The relatively impermeable soils inhibit groundwater recharge or discharge, and surface drainage tends to be poor, despite the presence of numerous drainage ditches (Maclay et al, 1972).

6.4.2.1.2 Soils. According to SCS maps (1984) hydric soils found in this CSA occupy approximately 9,005 acres (Table 6-4), and are described in Table 6-10. The Rx-E CSA is dominated by three soil types: Rockwell sandy loam, Vallers loam and Roliss loam. There are no partially hydric soils in this CSA.

The hydric soils are deep and level or nearly level, and have formed from lacustrine deposits (SCS, 1984). They are located mainly in closed depressions, and consist primarily of sandy loams and muck. High lime concentrations and mottles are common in the subsoil layers, and mucky surface layers are present in some of the soils. Permeability is moderately slow to moderately rapid, and the soils are poorly to very poorly drained. Runoff is slow to very slow or ponded and available water capacity is generally moderate to high. The water table ranges from one foot above to three feet below the surface. Development of wetland habitat would be possible on both the Kratka fine sandy loam and Hamre muck.

6.4.2.1.3 Vegetation. Vegetation found in wetlands located at the Rx-E CSA is summarized in Table 6-11. The emergent vegetation found in the PEM wetlands and on the shorelines of the PUB wetlands is predominantly cattails, rushes, and sedges, while the PSS wetlands are dominated by dogwoods, hawthorne, and chokecherry. The PFO wetlands contain dogwoods and hawthorne plus quaking aspen, box elder, and other trees common to the Tx CSAs.

TABLE 6-10. CHARACTERISTICS OF HYDRIC SOILS AT THE RECEIVE STUDY AREAS

Soil Type (Code)	Texture	Depth	Level	Soil Features	Drainage	Perm.	Runoff	Avail. Water Capacity	Water Table (Feet)	Remarks
Rockwell (439)	Sandy loam	deep	nearly level	calcareous to highly calcareous and mottled in loam layers	poorly drained	mod. rapid in sand layers, mod. in loam layers	very slow	moderate	1-3 below	moderate-high organic matter, tendency to blow when dry
Kratka (481)	Fine sandy loam	deep	nearly level	occasional sand layer on top calcareous and mottled in in subsoil	poorly drained	mod. rapid in sand layers mod. in loam layers	slow	moderate	1-3 below	high organic matter, tendency to blow when dry, tendency for ponding, good for wetland development
Vallers (236)	Loam	deep	nearly level	highly calcareous and mottled in subsoil	poorly drained	moderately slow	slow	high	1-2.5 below	high fertility and organic matter, tendency to blow when dry
Percy (383)[1]										
Hamre (1878)	Muck	deep	level	calcareous and mottled in sub-soil, black muck top 13 inches	very poorly drained	moderate	very slow or ponded	high	1 above to 1 below	low fertility and high organic matter, tendency to blow when dry, good for wetland development, tendency for ponding
Rosewood (712)	Fine sandy loam	deep	level	calcareous to highly calcareous in all layers, mot-tled throughout	poorly drained	moderately rapid	slow	low	1-3 below	low to moderate fertility, moderate to high organic matter, tendency to to blow when dry

TABLE 6-10 (CONTINUED). CHARACTERISTICS OF HYDRIC SOILS AT THE RECEIVE STUDY AREAS

Soil Type (Code)	Texture	Depth	Level	Soil Features	Drainage	Perm.	Runoff	Avail. Water Capacity	Water Table (Feet)	Remarks
Rockwell/ Kratka (987)	Fine sandy loam	deep	nearly level	calcareous and mottled	poorly drained	moderately rapid in sand layers, moderate below	slow to very slow	moderate	1-3 below	moderate fertility, moderate to high organic matter
Roliss (582)	Loam	deep	level	Calcareous and mottled in all layers, occasional sand layer at surface	poorly drained	moderate	very slow	high	1-3 below	high fertility and organic matter, tendency to blow when dry
Roliss (387)	Loam	deep	level	Calcareous in subsoil, mottles throughout occasional thin organic matter layer on top	very poorly drained	moderate	very slow or ponded	high	0.5 above to 3 below	high organic matter, tendency to blow when dry, tendency for ponding
Rosewood (1882)	Fine sandy loam	deep	gently sloping	highly calcareous and mottled in subsoil occasional mucky layer at surface	very poorly	moderately rapid	very slow	low	0-3 below	high organic matter, low to moderate fertility, good for wetland development
Deerwood (547	Muck	deep	level	Mottles in subsoil, black muck top 9 inches	very poorly	moderately rapid in organic layers rapid below	very slow	moderate	1 above to 1 below	low fertility and high organic matter, tendency for ponding good for wetland development

(1) Soil characteristics not known

Source SCS, 1984.

TABLE 6-11. COMMON PALUSTRINE WETLAND VEGETATION AT THE RECEIVE STUDY AREAS

Wetland Type	At Rx-E	At Rx-W	Vegetation[1]
Palustrine Unconsolidated Bottom (PUB)[2]	X	X	narrowleaf cattail, broadleaf cattail, dock, river bulrush, giant burreed, giant goldenrod pondweed, prairie cordgrass
Palustrine Emergent (PEM)	X	X	sedges, rushes, hummock sedge, roses, asters, big bluestem, dock, rubus, narrowleaf cattail, broadleaf cattail, river bulrush, giant burreed, giant goldenrod, poison ivy, pondweed, prairie cordgrass, milkweed
Palustrine Scrub-Shrub (PSS)	X	X	poison ivy, dogwoods, milkweed, roses, chokecherry, hawthorne
Palustrine Forested (PFO)	X	X	Willows, green ash, sedges, asters, rushes, cottonwood, box elder, quaking aspen, rubus, hawthorne, chokecherry, dogwoods, grapevine

1. A list of scientific names can be found in Appendix A.
2. PUB wetlands do not by definition contain any vascular, herbaceous, or woody plants, therefore the plants listed in Table 6-11 refer to those found on the shoreline of these wetlands.

6.4.2.1.4 Wetland Functions and Values. A forested wetland dominated by broad-leaved decideous vegetation (PFO1B) and ranging in size from five to forty acres size class (specified in the WET model) was selected for functional analysis of a typical wetland habitat for Rx-E, because it is more prevalent in this study area than at any of the other CSAs. Although other wetland types are more abundant at the Rx-E CSA (e.g. PEM), they have been evaluated for the other CSAs. This typical wetland contains saturated soils with little or no standing water throughout the year, and is surrounded by a small, predominantly agricultural watershed.

Analysis of the functions and values of a typical wetland of this type and size indicated high social significance in terms of its uniqueness and ability to support wildlife (Table 6-12). The wetland's high uniqueness rating is primarily a result of its ability to support the endangered bald eagle. The high wildlife rating is due to the location of this wetland in the PPR and in a migratory bird flyway (see Technical Study 8). In addition, the wetland provides food and cover for both small and large mammals (see Technical Study 7 for more information).

Low ratings for social significance were determined for groundwater recharge, floodflow alteration, sediment and nutrient removal and transformation, and recreation. Although some of these functions can be performed well, the functions are not highly valued by society because of the distance to an urban area and the local abundance of wetlands which perform similar functions.

Given the opportunity, a typical PFO1B wetland in this size range would be highly effective at altering floodflow and stabilizing and retaining sediments and nutrients (Table 6-12). The gentle slopes surrounding the wetland allow it to retain large amounts of water and prevent downstream flooding. In addition, the location of a typical forested wetland in a local depression allows the wetland to retain, store, and transform sediment and nutrient runoff from surrounding agricultural lands. Nutrients are efficiently assimilated into the vegetation of a PFO1B wetland, which often includes emergent and shrub-scrub vegetation in addition to trees.

TABLE 6-12. WETLAND FUNCTIONS AND VALUES ASSESSMENT FOR A TYPICAL SATURATED, BROAD-LEAVED DECIDUOUS FORESTED (PF01B) WETLAND AT THE RX-EAST CSA(1)

	Social Significance(2)	Effectiveness(2)	Opportunity(2)
Ground Water Recharge	L	L	*
Ground Water Discharge	M	L	*
Floodflow Alteration	L	H	H
Sediment Stabilization	M	H	*
Sediment/Toxicant Retention	L	H	H
Nutrient Removal/Transformation	L	H	H
Production Export	*	L	*
Wildlife Diversity/Abundance	H	*	*
Wildlife D/A Breeding	*	M	*
Wildlife D/A Migration	*	M	*
Wildlife D/A Wintering	*	L	*
Aquatic Diversity/Abundance	M	M	*
Uniqueness/Heritage	H	*	*
Recreation	L	*	*

1. Ratings derived from Wetlands Evaluations Techniques (WET) version 2.0 (COE, 1987).
2. H = High; M = Moderate; L = Low; U = Uncertain; * = Not Evaluated

The wetland would be least effective at groundwater recharge and discharge, production export, and support of wintering wildlife. A typical PFO1B wetland in this study area does not significantly recharge groundwater or receive groundwater discharge because it is permanently saturated and underlain by soils that are relatively impervious. The typical forested wetland does not export organic nutrients (production export) because it has no permanent outlet. This typical PFO1B wetland received a low rating for wintering wildlife because of the absence of open water, particularly during the winter months when standing water and saturated soils are frozen.

High ratings were given for the opportunity of this typical wetland to perform flood flood alteration, sediment/toxicant retention, and nutrient removal or transformation. The gentle slopes and varied vegetation provide the means to effectively perform these functions.

6.4.2.2 Rx-West Concentrated Study Area. Wetlands occupy approximately 479 acres (4%) of the 12,800 acres in this CSA (Table 6-9). The most common wetlands found here are palustrine emergent (PEM) wetlands (74%) and PFO wetlands (18%). The PEM wetlands are primarily temporarily flooded (PEMA) and seasonally (PEMC) flooded, each averaging approximately one acre in size. PSS wetlands and PUB wetlands are relatively uncommon and comprise 5% and 2% of the total wetlands, respectively. No riverine wetlands are found in this CSA.

With the exception of one drainage ditch located in the northern portion of the CSA, no aquatic habitats or resources are located in this CSA. This drainage ditch does not provide suitable fisheries habitat since it is intermittent in nature, however, should standing water persist, sticklebacks and minnows may be supported in addition to benthic invertebrates (MNDNR, 1990b).

6.4.2.2.1 Hydrology. The majority of the wetlands at the Rx-W CSA are temporarily flooded, so standing water does not generally persist beyond the first few weeks of the growing season. The impermeable soils do not permit significant groundwater recharge (Maclay et al, 1972). Only one drainage ditch exists in the study area, and the wetlands do not contain outlets, therefore, surface drainage networks are pooly developed at the Rx-W CSA.

6.4.2.2.2 Soils. Hydric soils located in this CSA occupy approximately 7,390 acres (Table 6-4 and Table 6-10). The Rx-W CSA is dominated by two soil associations: Rockwell sandy loam and Roliss loam. No partially hydric soils are present at this CSA.

The hydric soils at the Rx-W CSA are deep and level or nearly level, and have formed primarily from lacustrine deposits (SCS, 1984). They are located mainly in closed depressions, and range in texture from sandy loam to muck. The majority of the soils are calcareous, and mottles are common throughout the subsoil layers. A thick organic muck surface layer is common to most of the soils. Gypsum crystals are not present in these soils. Permeability varies from moderately slow to moderately rapid, and runoff is slow to very slow or ponded. The soils are poorly to very poorly drained, and available water capacity varies from low to high. Some of the soil types have ideal conditions for the development of wetland habitat (e.g. Rosewood fine sandy loam and the Hamre and Deerwood mucks).

6.4.2.2.3 Vegetation. Vegetation surveyed at the Rx-W CSA was similar to vegetation found at the Rx-E CSA, and is listed in Table 6-11. Emergent vegetation such as cattails and bulrushes are common to the PUB wetland shorelines and PEM wetlands. Scrub-shrub wetlands contain some of these emergent species plus dogwoods and chokecherry. The forested wetlands contain cottonwood and such plants as rubus, hawthorne and willows.

6.4.2.2.4 Wetland Functions and Values. A temporarily-flooded palustrine emergent (PEMA) wetland dominated by emergent vegetation and less than five acres in size was selected as a typical wetland for functional analysis, as it was the dominant form of wetland found at the Rx-W CSA. The soils underlying this wetland are clay-enriched and relatively impermeable and the wetland is typically surrounded by a gently sloping, predominantly agricultural watershed.

The results of the WET analysis indicated that a small temporary wetland such as this rates as highly socially significant in terms of its uniqueness and its ability to support a diversity of wildlife (Table 6-13). The wetland's uniqueness is a reflection of its ability to provide habitat for endangered species such as the bald eagle. The high rating for wildlife diversity is due to its location in the PPR and proximity to the central flyway (see Technical Study 8). The wetland was given a rating of low social significance for groundwater recharge, floodflow alteration, sediment and nutrient removal, and recreation. Although the wetland is effective at performing some of these functions, the functions are not socially significant because of the small size of the wetland, its closeness to wetlands which provide similar functions, and its significant distance from an urban area.

Given the opportunity, this typical wetland would be highly effective at floodflow alteration, sediment stabilization and retention, and nutrient removal and transformation (Table 6-13). The gradual slopes surrounding the wetland, the locations of each wetland at the bottom of an isolated watershed, and the lack of a permanent outlet all allow the typical wetland to act as a detention basin for nutrient-laden agricultural runoff and to prevent downstream flooding.

The typical wetland would be least effective at groundwater recharge, organic products export, support of breeding and wintering wildlife and aquatic life. The wetland's small size and the presence of impermeable soils explain the wetland's ineffectiveness to perform groundwater recharge. Furthermore, small PEMA wetlands such as this can be ineffective at exporting organic products because they have no real surface outlets. Low effectiveness ratings for wildlife and aquatics are a result of the wetland's size, homogeneous pattern of vegetation distribution, and temporary water regime.

TABLE 6-13. WETLAND FUNCTIONS AND VALUES ASSESSMENT FOR A TYPICAL TEMPORARILY FLOODED PALUSTRINE EMERGENT (PEMA) WETLAND AT THE RX-WEST CSA[1]

	Social Significance[2]	Effectiveness[2]	Opportunity[2]
Ground Water Recharge	L	L	*
Ground Water Discharge	M	M	*
Floodflow Alteration	L	H	H
Sediment Stabilization	M	H	*
Sediment/Toxicant Retention	L	H	H
Nutrient Removal/Transformation	L	H	H
Production Export	*	L	*
Wildlife Diversity/Abundance	H	*	*
Wildlife D/A Breeding	*	L	*
Wildlife D/A Migration	*	M	*
Wildlife D/A Wintering	*	L	*
Aquatic Diversity/Abundance	M	L	*
Uniqueness/Heritage	M	*	*
Recreation	L	*	*

1. Ratings derived from Wetlands Evaluations Technique (WET) version 2.0 (COE, 1987).
2. H = High; M = Moderate; L = Low; U = Uncertain; * = Not Evaluated

High ratings were given for the opportunity of this typical PEMA wetland to perform flood flow alteration, sediment/toxicant retention, and nutrient removal or transformation. The gradual slopes and lack of a surface outlet provide the wetland with the means to perform these functions effectively.

6.4.2.3 Summary of Functional Analysis of Wetlands at the Rx CSA's. The two representative wetlands provide similar functions and values. The most notable function common to both concentrated study areas is their opportunity and effectiveness to serve as detention basins. The representative wetlands have the opportunity and are therefore effective at retaining sediments, removing nutrients and preventing floodflows. Although these functions are performed effectively, the social significance of the functions is moderate or low because of distance from urban areas and the proximity of other wetlands which provide similar functions.

The function receiving the highest significance in the two typical wetlands relates to the wetlands' abilities to support migrating waterfowl and endangered species such as the bald eagle. The social significance of wildlife diversity and abundance at both representative wetlands was rated high. Typical wetlands at the receive site are moderately effective at providing wildlife habitat and aquatic diversity and abundance. Opportunity was not, however, evaluated for these functions. The Rx-W CSA was rated as more effective at groundwater discharge, while the Rx-E CSA is more effective at providing wildlife habitat, perhaps because forested wetlands are less common and provide more suitable shelter for wildlife than do PEMA wetlands.

6.5 ENVIRONMENTAL CONSEQUENCES

This section discusses potential impacts to the wetland and aquatic environments of construction and operation of the OTH-B radar facilities. Recommended mitigation measures for unavoidable impacts to these environments are presented in Section 6.6. A complete description of the radar facilities is contained in Technical Study 2. A discussion of hydrology and upland vegetation impacts is found in Technical Studies 4 and 5, respectively.

6.5.1 Methods

The USAF's four preliminary site layouts (one in each concentrated study area) were evaluated to identify and assess the magnitude of potential impacts to the wetland and aquatic environments. Potential impacts were characterized (1) as loss or alteration of existing wetlands or aquatic habitats as a direct result of facility construction and operation, or (2) indirect alteration of functions and benefits. Activities which may result in impacts to the wetlands and aquatic habitats include (1) filling areas for construction of access roads and radar facilities, (2) clearing and fencing areas for operational or safety requirements, (3) disposing of wastewater, and (4) developing available water supplies. Direct impacts to wetlands are expected to occur in all filled areas, which include roads, fences, the groundscreen area and facility buildings. Indirect impacts are expected to occur in exclusion areas at the transmit study areas.

For each CSA, the preliminary site layout was placed on the wetland map. Affected wetlands in the filled and exclusion area were then digitized and summed by habitat type. Areal extent of impacts caused by the construction of perimeter roads and adjacent fences, however, was determined by linear measurement of road segments which intersected wetland habitat, assuming an average road width of 40 feet.

Each antenna sector in the preliminary site layout is surrounded by a 1,000 foot buffer zone. The buffer zones were designed to permit modifications of sector locations during final design. The areal extent of buffer zones is not equal for each sector because in some cases adjacent buffer zones overlap. Wetlands found in the buffer zone overlap areas have been totaled independently of each sector's buffer zone. During final design, the location of the antenna sectors could be shifted anywhere within the buffer zone, therefore some wetlands within the buffer could be affected. Therefore, wetland impacts are only estimates until the final layout locations are decided upon.

The USAF's preliminary site layouts at each CSA were compared with best and worst case scenarios to evaluate the extent of wetland impacts. Using operationally-preferred facility configurations and the wetland maps for each CSA, best case scenarios were selected to minimize wetland impacts, while worst case scenarios were selected to maximize wetland impacts. Locations of the best and worst case scenarios are described below.

6.5.1.1 Location of Best-Case Scenarios. A best-case scenario of facilities was selected for each CSA using operationally-preferred facility configurations and each CSA wetland map. At the transmit sites, the best-case scenario was selected to minimize total impacts; both direct impacts in filled areas and indirect impacts in exclusion areas. At the receive sites, all impacts are a result of filling, therefore filling of wetland areas was minimized.

The best-case scenario for the Tx-N CSA was placed in the eastern portion of the study area so that the east and southeast sectors contained very few wetlands. The best-case scenario for the Tx-S CSA was located in the northeast corner of the study area, to the east of the large flooded $PEMA_f$ wetland. In both scenarios, the number of wetlands to be directly disturbed (i.e. filled) is greater than the numbers presented in the worst case scenarios. Despite this apparent contradiction, overall wetland impacts (both direct fill and indirect impacts in the exclusion areas) were minimized.

For the Rx-E CSA best-case scenario, the east and west facing sectors were located in the northwest portion of the CSA and the southwest and southeast sectors were located at the extreme southern border of the CSA. The Rx-W best-case scenario was located at the northwest portion of the CSA so that very few wetlands were affected by location of all sectors.

6.5.1.2 Location of Worst-Case Scenarios. A worst-case scenario of facilities was also selected for each CSA using operationally-preferred facility configurations and each CSA wetland map. The worst-case layouts were placed in areas of highest wetland concentration in order to maximize the amount of wetland habitat to be affected by facility construction. For the transmit sites, total impacts (including filled and exclusion areas) were maximized. Buffer zones were excluded from these wetland acreage summaries.

The worst-case scenario for the Tx-N CSA was placed in the central region of the CSA to maximize impacts to the large number of wetlands located there. The worst-case scenario for the Tx-S CSA was also located in that study area's central portion in order to maximize total wetland impacts.

The worst-case scenario for the Rx-E CSA was located in the extreme eastern portion of the CSA. The worst-case scenario for the Rx-W CSA included the southwest corner of the CSA.

6.5.2 General Wetland & Aquatic Impacts

Impacts to wetlands will occur in both the filled areas and exclusion areas. At the transmit sectors, the filled areas include the access roads, perimeter roads and fences, buildings and the groundscreens. The exclusion areas include all other areas contained within the fence. At the receive sectors, all areas within the fence will be considered as filled areas.

Direct loss of wetland habitat will occur where wetlands are filled. Associated floodwater storage benefits will also be lost. Soil erosion, soil sedimentation, and turbidity will increase from the removal of stabilizing vegetation. Reduction in wetland size from partial filling will alter the hydrologic regime of the remaining basin. A reduction in the duration of ponding will equally reduce waterfowl diversity/abundance benefits.

Wetland impacts in the exclusion areas may also occur. Construction of perimeter roads will create a barrier to the downstream progress of runoff and floodwaters and could result in altered stream channelization, and potential soil erosion and sedimentation in existing channels. However, the site drainage will be designed to maintain current water levels in on-site wetlands. Removal of upstream flood waters may alter hydrologic regimes in wetlands contained in the exclusion areas. Clearing of wetland trees may reduce wildlife habitat benefits. All trees within the exclusion areas at the transmit study areas will be removed, and any trees over 70 feet tall within 1800 feet from the groundscreens at the receive study area will be removed. Perimeter fence construction will exclude some resident wildlife from wetlands and may adversely affect predator populations.

6.5.3 Transmit Site

6.5.3.1 Tx-North Preliminary Site Layout. The location of the USAF's preliminary site layout for the Tx-N CSA is illustrated in Figure 6-9. This preliminary site layout will not be located in the vicinity of aquatic habitats or resources, therefore minimal aquatic impacts are expected.

Estimated fill and clearing requirements for transmit site construction are approximately 598 acres and 2,191 acres, respectively (Technical Study 2). These estimates include areas required to build access and perimeter roads, fences, and the four sectors. Location of the Tx-N preliminary site layout will result in approximately 62 acres of wetlands being directly filled; consisting of 46 acres of seasonal (PEMC) wetlands, 9 acres of temporary (PEMA) wetlands and 6 acres of semipermanent (PEMF) wetlands (Table 6-14). An additional 179 acres of wetlands located in the exclusion areas will be indirectly affected. The majority of these wetlands (154 acres) are PEMC wetlands. Appendix C contains a list of wetland impacts by sector for this CSA.

Total affected wetlands, consisting of the 62 acres filled and 179 acres isolated within the exclusion areas, represent 11 percent of the area occupied by the Tx-N preliminary site layout. Wetlands occupy approximately 14 percent of the CSA, and only 6 percent of the general Tx study area. PEMC wetlands are the most common type of wetland to be found in both the preliminary site layout and the Tx-N CSA. The estimated 334 acres of wetlands located in all buffer zones combined represent approximately 19 percent of the total buffer

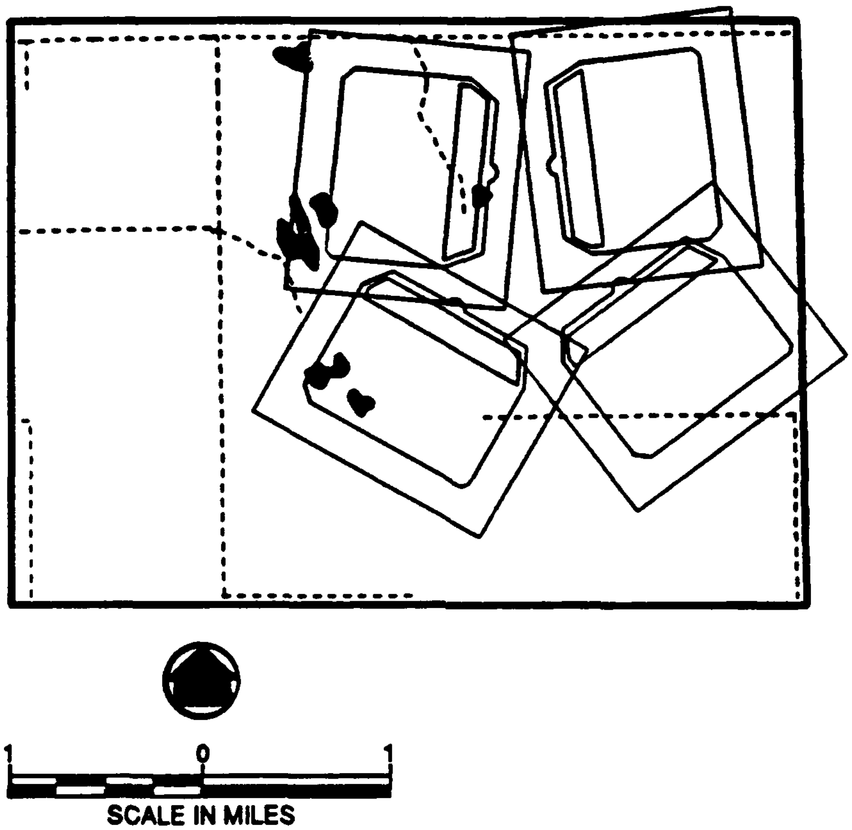

FIGURE 6-9. TX-NORTH PRELIMINARY SITE LAYOUT

TABLE 6-14. ACREAGE OF AFFECTED WETLANDS FOR THE TX-NORTH PRELIMINARY SITE LAYOUT

Wetland Type	Code	Preliminary Site Layout			Best Case		Worst Case	
		Filled	Exclusion	Buffer	Filled	Exclusion	Filled	Exclusion
Palustrine Unconsolidated Bottom								
- Semipermanent, excavated	PUBFx		1	9	10	3		2
Palustrine Emergent								
- Temporary	PEMA	9	15	12		21	8	19
- Temporary, farmed	PEMAf					2		
- Temporary, farmed	PEMAbf			3		3		
- Saturated	PEMB		1				1	
- Seasonal	PEMC	46	154	298	52	78	39	294
- Semipermanent	PEMF	6	3	10	11	9	12	8
- Semipermanent excavated	PEMFx	1	5	<1	<1	4		3
TOTAL WETLANDS		62	179	334	73	120	59	327

area (1,701 acres). This rate is slightly higher than the 11 percent observed for the preliminary site, however, it is not enough to result in significantly higher or lower impact estimates, should final design modifications require a shift in sector locations within the buffer zones.

Loss or alteration of PEMC wetland habitat will affect associated PEMC functional values, in addition to the expected wetland impacts discussed in Section 6.5.2. Based on the WET model, primary functional values which would be affected include floodwater alteration, groundwater recharge, nutrient removal/transformation, sediment/toxicant retention, and migratory waterfowl habitat.

Minimizing both direct (i.e. filled) impacts and total (filled and exclusion) impacts concurrently was difficult in this CSA due to the heavy concentration of wetlands. The best-case scenario therefore minimized total wetland impacts and not direct impacts. With the best-case scenario, a minimum of 73 acres of wetlands would be filled, with an additional 120 acres isolated in the exclusion areas (Table 6-14). PEMC wetlands would be the most abundant affected wetland in this scenario. The worst-case scenario maximized total impacts rather than direct impacts from filling, and would cause 59 acres to be filled and 327 acres to be isolated in the exclusion areas. The majority of these wetlands would also be PEMC wetlands. In comparison with these two alternatives, the USAF's preliminary site layout appears to be in the best possible location, in terms of wetland impacts, within the Tx-N CSA.

Impacts to wetlands as a result of wastewater disposal are expected to be minimal. The wastewater disposal system will consist of either a septic tank and leach field or holding tanks (Technical Study 2). Location of the wastewater disposal system is expected to be in the vicinity of the facility buildings and should not affect additional wetlands. Impacts to wetlands as a result of developing a water supply are not expected to occur, as location of an on-site well will similarly be in the vicinity of facility buildings. No additional wetlands are therefore expected to be affected.

6.5.3.2 Tx-South Alternative. Location of the USAF's preliminary site layout for the Tx-S CSA is illustrated in Figure 6-10. The intermittent streams and drainage ditches that are found in this CSA are not expected to be affected by construction of the OTH-B transmit facility. They are not considered fisheries habitat, and any streams downstream of the CSA are sufficiently far enough away to avoid any discharge impacts.

The area required to be filled and cleared for site construction will be approximately 590 acres and 2191 acres respectively (Technical Study 2). These estimates involve the construction of access roads, perimeter roads and fences, and the four sectors. The Tx-S preliminary site layout will cause approximately 23 acres of wetlands to be filled, the majority of which are $PEMA_f$ wetlands (Table 6-15). An additional 257 acres of wetlands, (primarily $PEMA_f$) in the exclusion areas may be indirectly affected. Appendix C shows wetland impacts by sector for this preliminary site layout.

Total affected wetlands (280 acres), consisting of the 23 acres filled and 257 acres located in the exclusion areas, represent 14 percent of the preliminary site layout area. In comparison, the Tx-S CSA contains 16 percent wetlands, and the general Tx study area contains 6 percent total wetlands. $PEMA_f$ wetlands are the most abundant type of wetland in both the preliminary site layout and the Tx-S CSA. The estimated 241 acres of wetlands found in all of the buffer zones combined represent approximately 15 percent of the total buffer area (1,575 acres). This rate is equivalent to the 14 percent rate observed for the preliminary site layout. Final design modifications in sector locations should not significantly affect more wetland habitats if facilities are moved within existing buffer zones.

Loss or alteration of $PEMA_f$ wetland habitat will affect associated $PEMA_f$ functional values, in addition to the expected wetland impacts discussed in Section 6.5.2. Based on the WET model, major functional values which would be affected include floodflow alteration and storage benefits, sediment stabilization, nutrient transformation and removal from adjacent croplands, and sediment retention. Migratory waterfowl habitat may be significantly altered as well. Loss of agricultural benefits of the $PEMA_f$ wetlants would also occur, since wetland cultivation during dry years would no longer be possible.

Minimizing both direct (i.e. filled) impacts and total (filled and exclusion) impacts concurrently was difficult in the CSA. The best-case scenario minimized total wetland impacts by avoiding the large $PEMA_f$ wetland as much as possible, however, by doing so, direct impacts were not minimized. With the best-case scenario, a minimum of 41 acres of wetlands would be filled, with an additional 95 acres isolated in the exclusion areas (Table 6-15). $PEMA_f$ wetlands would be the most abundant affected wetland using this scenario. The worst-case scenario maximized overall impacts rather than direct impacts from filling, and would cause 17 acres to be filled and 399 acres to be isolated in the exclusion ares. The majority of these wetlands would also be $PEMA_f$ wetlands. In comparison with these two alternative scenarios, the USAF's preliminary site layout affects fewer wetlands overall than the worst-case scenario does, and will fill less wetlands than indicated in the best-case scenario, and is therefore the best alternative of the three.

Impacts to wetlands as a result of wastewater disposal are expected to be minimal. The wastewater disposal system will consist of either a septic tank and leach field or above-ground storage tanks. The wastewater disposal system will be located in previously disturbed areas near the facility buildings. Developing a water supply for the facilities is not expected to affect additional wetlands as location of the water supply will also be in previously disturbed areas near the facility buildings.

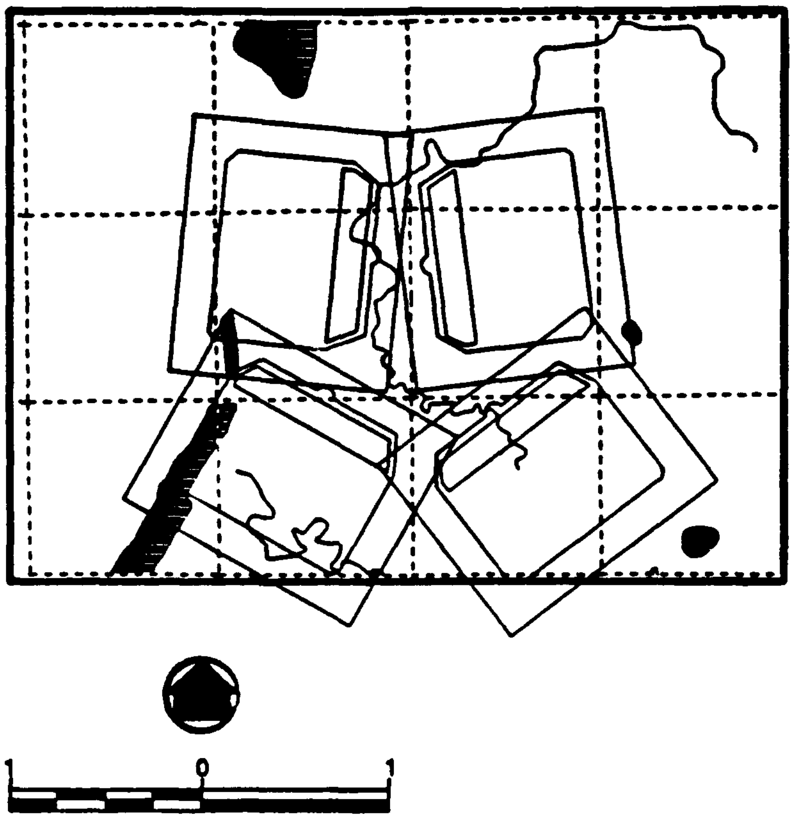

FIGURE 6-10. TX-SOUTH PRELIMINARY SITE LAYOUT

TABLE 6-15. ACREAGE OF AFFECTED PALUSTRINE WETLANDS FOR THE TX-SOUTH PRELIMINARY SITE LAYOUT

Wetland Type	Code	Preliminary Site Layout			Best Case		Worst Case	
		Filled	Exclusion	Buffer	Filled	Exclusion	Filled	Exclusion
Palustrine Unconsolidated Bottom								
- Semipermanent, excavated	PUBFx	<1	2	2		<1		<1
Palustrine Emergent								
- Temporary	PEMA	<1	4	4	<1	28		
- Temporary, farmed	PEMAf	22	216	225	17	51	13	320
- Seasonal	PEMC			10	7	4		72
- Seasonal, farmed	PEMCf	<1	35	12	16	6		5
Palustrine Emergent/Forested								
- Seasonal	PEM/PFOC			3	<1	5	4	1
TOTAL WETLANDS		23	257	256	41	95	17	399

6.5.4 Receive Site

All areas within the receive antenna sector boundaries will be disturbed. All wetland impacts at the receive sites are therefore considered direct impacts.

6.5.4.1 Rx-East Alternative. Location of the USAF's preliminary site layout for the Rx-E CSA is illustrated in Figure 6-11. Construction and operation of the OTH-B receive facility in this study area may cause accelerated soil erosion and subsequently raise turbidity and sediment deposition in the larger drainage ditches located at the Rx-E CSA. Alteration of stream channels is possible (see Technical Study 4). Increased turbidity could adversely affect the benthic community in these streams, however no data is available to provide baseline information prior to construction. These impacts can be mitigated through the use of Best Management Practices for erosion and sediment control.

Estimated fill and clearing requirements for receive site construction are approximately 523 acres for both activities (Technical Study 2). Construction of the receive facility in this CSA will result in approximately 15 acres of wetlands being filled, consisting primarily of 8 acres of PEMAf wetlands and 6 acres of mixed PEM/PSSIBg wetlands (Table 6-16). The total 15 acres of affected wetlands represent three percent of the total preliminary site layout area. In comparison, wetlands in the Rx-E CSA occupy 6 percent of the total area, which is consistent with total wetland acreage observed in the general Rx study area (6 percent). The estimated 80 acres which lie in the buffer zones represent approximately six percent of total buffer area. This density, in comparison with the three percent found in the preliminary site layout is not significantly different, therefore final modifications in sector locations should not result in significantly higher or lower wetland impact than presently anticipated. Loss of approximately 15 acres of palustrine wetlands, eight of which are comprised of PEMAf habitats, could result in moderate impacts to local wetland functional benefits. In addition to specific impacts described in Section 6.5.2, the eight acres of lost PEMAf habitat would be accompanied by decreased flood flows storage abilities, decreased sediment

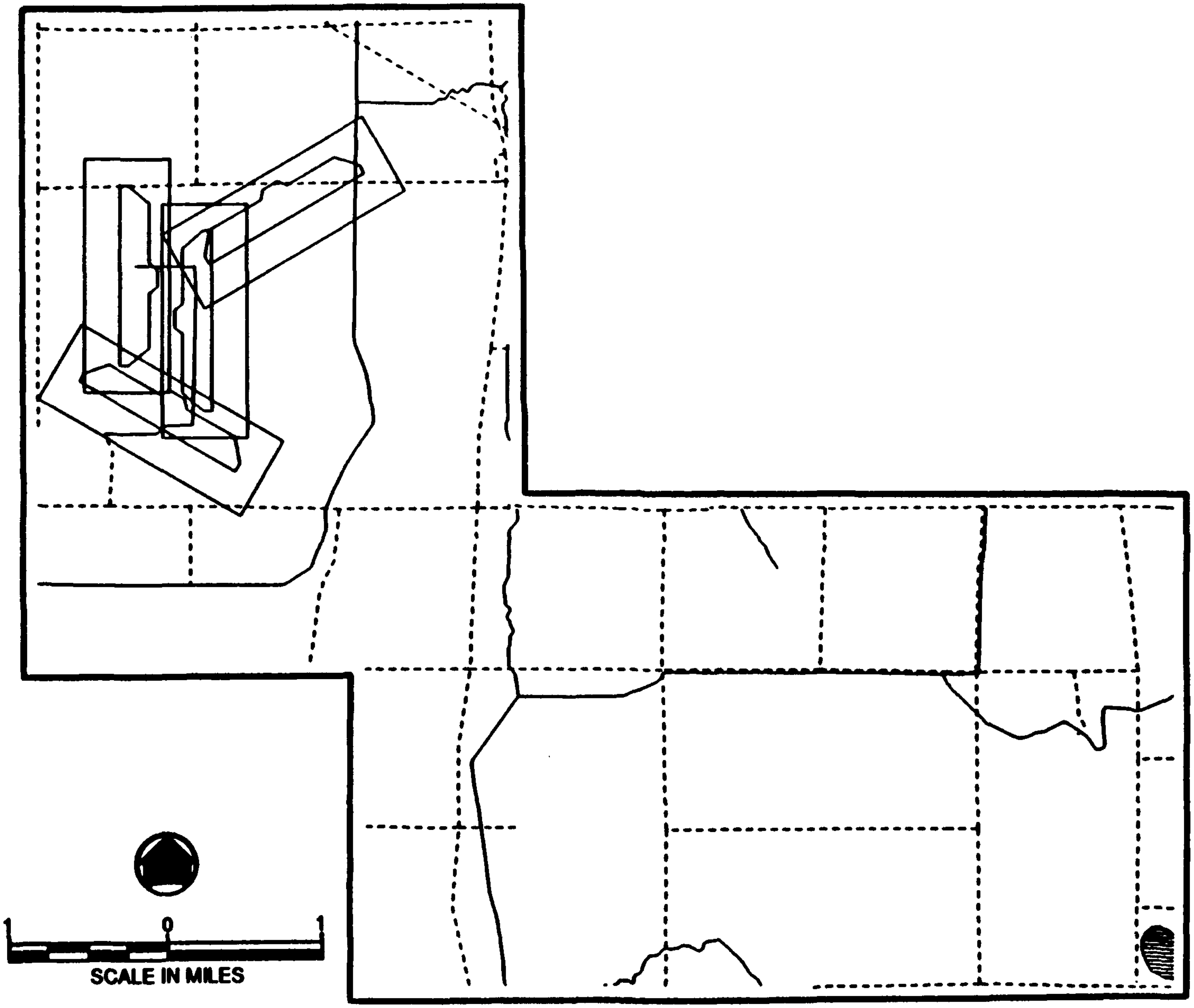

FIGURE 6-11. RX-EAST PRELIMINARY SITE LAYOUT

TABLE 6-16. ACREAGE OF AFFECTED PALUSTRINE WETLANDS FOR THE RX-EAST PRELIMINARY SITE LAYOUT

Wetland Type	Code	Preliminary Site Layout Filled	Preliminary Site Layout Buffer	Best Case Filled	Worst Case Filled
Palustrine Unconsolidated Bottom					
- Semipermanent	PUBF				3
- Intermittently Exposed, excavated	PUBGx		<1		
Palustrine Emergent					
- Temporary	PEMA		<1		
- Temporary, drained	PEMAd	<1	1	<1	
- Temporary, farmed	PEMAf	8	23		3
- Saturated	PEMB				36
- Saturated, organic	PEMBg		11		4
- Seasonal	PEMC		<1		10
- Seasonal, farmed	PEMCf		2		
Palustrine Scrub-Shrub Broadleaf	PSS1		<1		
- temporary	PSS1A	<1			
- saturated	PSS1B				16
- seasonal	PSS1C	<1	8		22
Palustrine Foreseted Broadleaf					
- Saturated	PFO1B				8
Palustrine Emergent/ Scrub/Shrub					
- Seasonal, drained	PEM/PSSICd			1	

TABLE 6-16 (Continued). ACREAGE OF AFFECTED PALUSTRINE WETLANDS FOR THE RX-EAST PRELIMINARY SITE LAYOUT

Wetland Type	Code	Preliminary Site Layout Filled	Preliminary Site Layout Buffer	Best Case Filled	Worst Case Filled
Palustrine Emergent/ Scrub-Shrub					
- Saturated, organic	PEM/PSS1Bg	6	16		
Palustrine Emergent/ Forested Broadleaf					
- Saturated	PEM/PFO1B		16		
TOTAL WETLANDS		15	80	1	103

retention, nutrient removal from surrounding croplands,and loss of agricultural productivity benefits of these wetlands.

With the best-case scenario, wetland impacts were minimized. In this scenario, approximately one acre of mixed PEM/PSS1 wetland habitat would be filled. The worst-case scenario maximized impacts, and would result in a total of 103 acres of wetlands being filled. These wetlands would primarily be PEMB and PSS1C types. In comparison with these two alternatives, the USAF's preliminary site layout, wetland impacts are somewhat worse than the best-case scenario, but they are considerably better than the worst-case scenario.

The location of an onsite wastewater disposal system, comprised of a septic tank and leachfield or a holding tank, is not expected to affect any additional wetlands. The system will be sited in previously disturbed areas and should not cause additional wetlands habitat loss. Location of an onsite water supply system is not expected to affect additional wetlands. A well will be situated in the vicinity of facility buildings in order to avoid further wetland impact.

6.5.4.2 Rx-West Alternative. The location of the USAF's preliminary site layout for the Rx-W CSA is illustrated in Figure 6-12. This preliminary site layout is not located in the vicinity of significant aquatic habitats or resources. With the exception of one drainage ditch in the northern part of the CSA, no aquatic habitats are found here. No significant aquatic impacts are therefore expected.

Estimated fill and clearing requirements for construction at this CSA are approximately 527 acres for both activities (Technical Study 2). Construction of the receive facility in this CSA will cause a total of approximately four acres of wetlands to be directly filled (Table 6-17), consisting of two acres or less of both PEMA and PEMC wetlands. The acreage of affected wetlands in the preliminary site layout comprises one-half of one percent of the total area. This is lower than the four percent observed in the Rx-W CSA, and the six percent observed for the general study area. The estimated

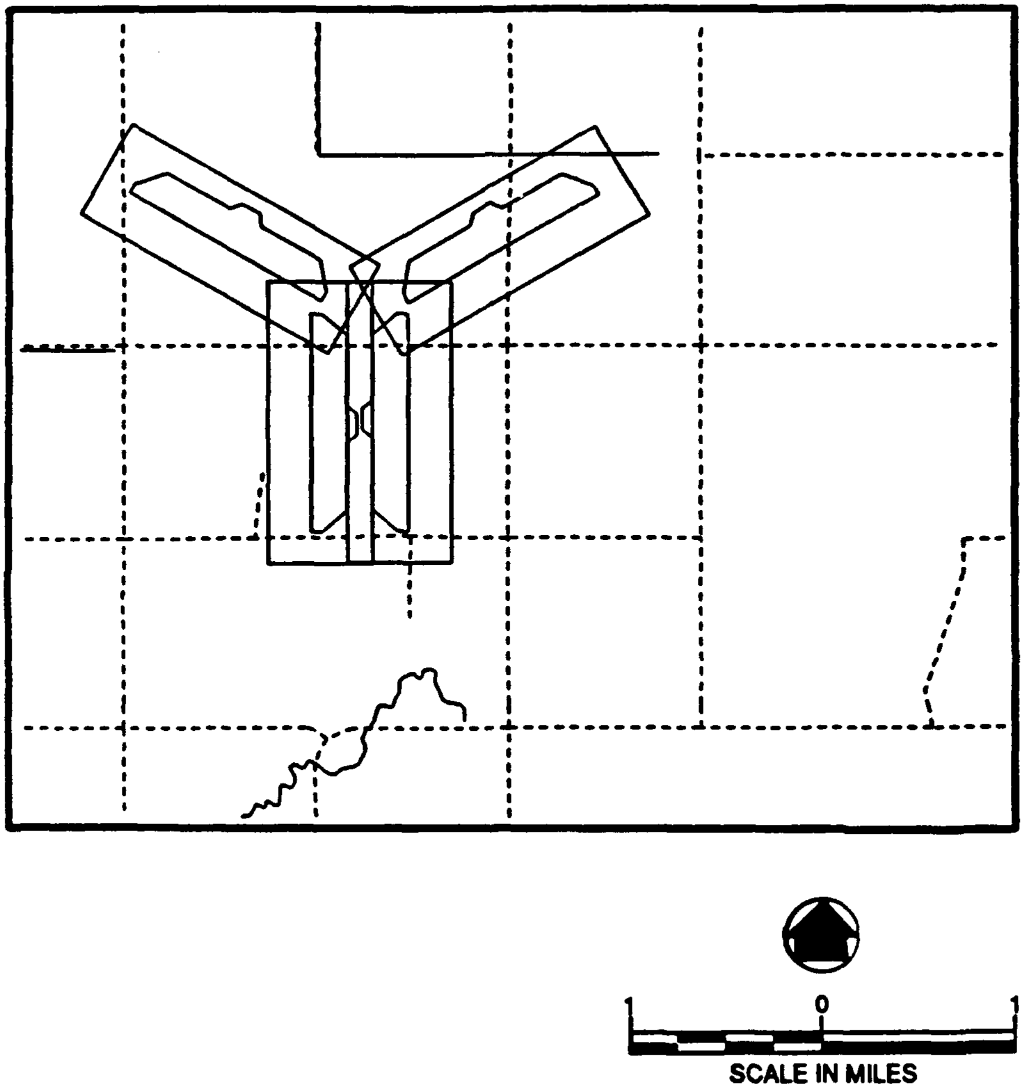

FIGURE 6-12. RX-WEST PRELIMINARY SITE LAYOUT

TABLE 6-17. ACREAGE OF AFFECTED PALUSTRINE WETLANDS FOR THE RX-WEST PRELIMINARY SITE LAYOUT

Wetland Type	Code	Preliminary Site Layout Filled	Preliminary Site Layout Buffer	Best Case Filled	Worst Case Filled
Palustrine Unconsolidated Bottom					
- Semipermanent, excavated	PUBF		<1		2
Palustrine Emergent					
- Temporary	PEMA	<1	1	<1	
- Temporary, drained	PEMAd	<1	<1	<1	
- Temporary, farmed	PEMAf	1	12		10
- Seasonal	PEMC	<1	<1		<1
- Seasonal, farmed	PEMCf	1	4		5
Palustrine Scrub-Shrub Breadloaf					
Saturated	PSS1B		<1		
Palustrine Forested					
- Unknown	PFO		2		
Palustrine Forested Broadleaf					
- Saturated	PFO1B				14
Palustrine Scrub-Shrub Forested					
- Saturated	PSS1/PFO1B				<1
TOTAL WETLANDS		4	19	<1	31

19 acres of wetlands which are located in the buffer zones combined represent approximately two percent of total buffer area. These estimates are not expected to produce significantly higher or lower acreage estimates should final sector locations change within buffer zones. Loss of approximately four acres is not expected to cause significant impacts to local hydrologic and biological functional values, based upon availability of similar habitats in the region. Impacts are therefore expected to be minimal.

The USAF preliminary site layout was compared in terms of wetland impacts to the best and worst case scenarios. The best-case scenario would result in less than one acre of PEMA wetland being filled, while the worst-case scenario would directly fill about 31 acres of wetlands, most of which would be PFO1B and $PEMA_f$ habitat. In comparison to these two alternative scenarios, the 4 acres of wetlands filled in the preliminary site layout is only marginally worse than the best-case scenario and is considerably better than the worst-case scenario.

The location of an on-site wastewater disposal system is not expected to affect additional wetland habitat. Location of a septic tank and leachfield or a holding tank will be near facility buildings in previously disturbed areas, in order to minimize further wetland impacts. Similarly, water supply facilities will not affect additional wetlands, as a well will be located near facility buildings in previously disturbed areas.

6.6 MITIGATION

The USAF is currently preparing a detailed mitigation plan, which will include specific mitigation actions (Technical Study 1). This section will present general mitigation measures, which will be the basis for the mitigation plan.

Mitigation for the loss of wetland habitat may include a variety of measures. The preferred means of mitigating potential impacts is to avoid as many wetlands as operationally possible. Comparison of the four preliminary site layouts with the best and worst case scenarios indicates that these layouts have minimized the loss of wetlands wherever possible. Siting of on-site facilities, such as the wastewater disposal and water supply systems will also consider minimization of wetland impacts.

Impacts to wetlands could be further avoided in the first year of construction by initiating facility construction during dry periods of the year (e.g. the autumn). Such action would avoid disturbing the wetland's hydrologic cycles during the growing season of that year by permitting undisturbed percolation of seasonal high water levels. By postponing construction activities until fall, impacts to breeding and molting waterfowl could also be minimized.

Loss of specific wetland habitats may be mitigated by in-kind replacement or recreation of the functional values of the lost wetlands. This could be accomplished either on-site, or off-site but very nearby. Mitigation for lost wetland habitat could also be achieved by expanding present wetland habitats located nearby or by contributing to existing expansion or development projects of other agencies or citizen groups.

Aquatic impacts may be minimized by using best management practices throughout the construction phase. Control measures could be used to minimize soil erosion and wind loss. Turbidity and sedimentation in drainage ditches could then be minimized. Precise mitigation measures will be finalized following consultation with state and federal agencies and site-specific evaluations.

Mitigation measures would not be required for off-site disposal of wastewater, as this method would result in minimal wetland and aquatic impacts. For the on-site wastewater disposal method, however, impacts could be minimized by locating necessary structures near established facilities in previously disturbed areas, or by not disturbing in or near wetland habitats. Wetland and aquatic impacts from on-site development of a water supply system could be minimized in the same fashion, so that additional wetland and aquatic habitats would not be affected.

In summary, these recommendations are intended only to serve as guidelines in the mitigation for wetland and aquatic impacts. Precise mitigation measures have not yet been developed, but shall be addressed in full in subsequent mitigation plans, and in the upcoming 404 permit documentation.

6.7 CONCLUSIONS

The preliminary site layout at the Tx-North CSA would affect a total of approximately 241 acres of wetlands, including 62 acres which would be filled and 179 acres which would be cleared or fenced. The majority of these wetlands would be seasonally-flooded (PEMC) habitats. Final design modification may result in more or less wetlands being affected as a result of the buffer zone configurations. Minimal aquatic impacts would be expected because very little aquatic habitat exists in the study area. There would be no potential wetland impacts associated with the location of an off-site wastewater disposal system.

The preliminary site layout at the Tx-South CSA would affect a total of approximately 280 acres of wetlands, including about 23 acres which would be filled and 257 acres which would be cleared or fenced. The majority of the affected wetlands will be farmed, temporarily-flooded (PEMA) wetlands. Minimal aquatic impacts would be expected, since very few aquatic habitats are found in this study area. Minimal impacts would be expected as a result of wastewater disposal and development of a water supply system.

The preliminary site layout the Rx-East CSA would affect approximately 15 acres of wetlands, most of which are dominated by mixed palustrine emergent/scrub shrub (PEM/PSS) vegetation. All wetlands within the sector boundaries would be expected to be directly affected. No indirect impacts would be expected. Potential aquatic impacts would include increased stream turbidity and sedimentation, and accelerated soil erosion. The location of an on-site wastewater disposal system would not be expected to affect additional wetland habitats, since the system would minimize wetland impacts by being placed in previously disturbed areas near established facilities, or by avoiding discharging in nearby wetlands.

The preliminary site layout for the Rx-West CSA would affect approximately four acres of wetlands. All wetlands contained within the sector boundaries are expected to be disturbed. Minimal aquatic impacts would be expected from construction and operational activities, because few aquatic habitats are found in the study area. Location of a wastewater disposal system and development of a water supply system would not be expected to affect additional wetlands, since they would be located very close to existing facilities and thereby avoid further wetland impacts.

REFERENCES

Burke, D.G., E.J. Meyers, R.W. Tiner, Jr., and H. Groman. 1988. Protecting Nontidal Wetlands. American Planning Association. PAS Report No. 412/413.

Cowardin, L.M., V. Carter, F.C. Golet, and E. LaRoe. 1979. Classification of Wetlands and Deepwater Habitats of the United States. U.S. Fish and Wildlife Service. FWS/OBS-79/31.

Federal Interagency Committee for Wetland Delineation. 1989. Federal Manual for Identifying and Delineating Jurisdictional Wetlands. U.S. Army Corps of Engineers, U.S. Environmental Protection Agency, U.S. Fish and Wildlife Service, and U.S.D.A. Soil Conservation Service, Washington, DC, Cooperative Technical Publication.

Hubbard, D.E. 1988. Glaciated Prairie Wetland Functions and Values: A Synthesis of the literature. U.S. Fish and Wildlife Service Biological Report No. 88 (43).

Kantrud, H.A., J. Millar, and A.G. van der Valk. 1989. Vegetation of Wetlands of the Prairie Pothole Region. pp. 132-187 in: Northern Prairie Wetlands. A. van der Valk, editor. Iowa State University Press, Ames, Iowa.

Kantrud, H.A. and R.E. Stewart. 1977. Use of Natural Basin Wetlands by Breeding Waterfowl in North Dakota. J. Wildl. Manage. 41: 243-253.

Linder, R.L. and D.E. Hubbard. 1982. Wetland Values in the Praire Pothole Region of North America. pp. 27-39 in: Proceedings of the Great Plains Agricultural Council, North Platte, Nebraska.

Maclay, R.W., T.C. Winter, and L.E. Bidwell. 1972. Water Resources of the Red River of the North Drainage Basin in Minnesota. U.S. Geological Survey Water Resources Investigations 1-72.

Minnesota Department of Natural Resources (MNDNR). 1990a. Personal Communication. M. Larson. February 2.

Minnesota Department of Natural Resources (MNDNR). 1990b. Personal Communication. D. Ashe. February 2.

Minnesota Department of Natural Resources (MNDNR). 1990c. Personal Communication. G. Mehmel. February 5.

Minnesota State Climatology Office. 1989. Daily Precipitation Data for Marshall, Pennington, and Red Lake Counties, MN for 1 November 1988 through 30 May 1989. Minnesota Dept. of Natural Resources, St. Paul, Minnesota.

National Oceanographic and Atmospheric Administration (NOAA). 1989. National Weather Service. Daily Precipitation Data for Aberdeen, SD for 1 November 1988 through 30 May 1989.

Reed, P.B. Jr. 1988. National List of Plant Species That Occur in Wetlands: 1988 Minnesota. United States Fish and Wildlife Service Inland Freshwater Ecology Section, St. Petersburg, Florida.

Sather-Blair, S. and R.L. Linder. 1980. Pheasant Use of South Dakota Wetlands During the Winter. Proc. South Dakota Acad. Sci. 59: 147-155.

Sloan, C.E. 1972. Groundwater Hydrology of Prairie Potholes in North Dakota. U.S. Geological Survey Professional Paper No. 585-C.

South Dakota Game, Fish and Parks Department (SDGFPD). 1990. Personal Communication. B. Hanten. February 5.

South Dakota Water and Natural Resources Department (SDWNRD). 1990. Personal Communication. J. Bortnem. February 2.

Soil Conservation Service (SCS). 1989. T. Martin, Personal Communication. U.S. Department of Agriculture. August 4.

Soil Conservation Service (SCS). 1975. Soil Survey of Marshall County, South Dakota. U.S. Department of Agriculture.

Soil Conservation Service (SCS). 1984. Soil Survey of Pennington County, Minnesota. U.S. Department of Agriculture.

Soil Conservation Service (SCS). 1987a. Preliminary Soil Maps for Brown County, South Dakota. U.S. Department of Agriculture.

Soil Conservation Service (SCS). 1987b. Hydric Soils of the United States. U.S. Department of Agriculture.

Soil Conservation Service (SCS). 1988a. Hydric Soils of South Dakota. South Dakota Technical Guide Notice SD-228. U.S. Department of Agriculture.

Soil Conservation Service (SCS). 1988b. Preliminary Soil Maps for Polk County, Minnesota. U.S. Department of Agriculture.

Soil Conservation Service (SCS). 1989. Draft Wetlands Maps of Numedal and Bray Townships, Pennington County, Minnesota, in Accordance With the Swampbuster Provision of the 1985 U.S. Farm Bill. U.S. Department of Agriculture.

Stewart, R.E. and H.A. Kantrud. 1972. Vegetation of Prairie Potholes, North Dakota, in Relation to Quality of Water and Other Environmental Factors. U.S. Geological Survey Professional Paper No. 585-D.

Tiner, R.W. Jr. 1984. Wetlands of the Unites States: Current Status and Recent Trends. U.S. Fish and Wildlife Service.

United States Army Corps of Engineers (COE). 1987a. Wetlands Evaluation Technique (WET) Volume II: Methodology. Waterways Experimental Station, Vicksburg, MS.

United States Army Corps of Engineers (COE). 1987b. Wetlands Delineation Manual. Technical Report Y-87-1. Waterways Experimental Station, Vicksburg, MS.

United States Army Corps of Engineers (COE). 1989. Aerial Photography of the OTH-B Central Radar System Study Areas in South Dakota and Minnesota. Photos taken 6 May 1989.

United States Air Force (USAF). 1987. Final Environmental Impact Statement Proposed Central Radar System, Over-The-Horizon Backscatter Radar Program. Department of the Air Force, Hanscom AFB, MA.

United States Air Force (USAF). 1988. Record of Decision: Central Radar System Environmental Impact Statement, Over-The-Horizon Backscatter Radar Program. Department of the Air Force, Hanscom AFB, MA.

United States Fish and Wildlife Service (USFWS). 1989. R. Erikson Personal Communication. July 5.

United States Fish and Wildlife Service (USFWS). 1980. Preliminary National Wetlands Inventory (NWI) maps for Milbank SW region.

United States Fish and Wildlife Service (USFWS). 1983. Preliminary National Wetlands Inventory (NWI) maps for Viking SE region.

United States Fish and Wildlife Service (USFWS) and Canadian Wildlife Service (CWS). 1986. North American Waterfowl Management Plan. A Strategy for Cooperation. Joint Publication of the USFWS and Environment Canada.

United States Fish and Wildlife Service (USFWS). 1987. Letter from R.F. Welford, Field Office Supervisor, to S.C. Maurice, U.S. Soil Conservation Service 9 April.

United States Geological Survey (USGS). 1975. Geology and Water Resources of Marshall County, South Dakota Part 1: Geology and Water Resources. Bulletin 23. Prepared in Cooperation With the South Dakota Geological Survey, Marshall County, and the Oahe Conservancy Sub-District.

Walker, B.H. and R.T. Coupland. 1970. Herbaceous Wetland Vegetation in the Open Grove and Grassland Regions of Saskatchewan. Can. J. Bot. 48: 1861-1878.

Winter, T.C. 1989. Hydrological Studies of Wetlands in the Northern Prairies. pp. 16-54 in: Northern Prairie Wetlands, A. van der Valk, editor. Iowa State University Press, Ames, Iowa.

APPENDIX A

COMMON AND SCIENTIFIC NAMES OF WETLAND VEGETATION

APPENDIX A

COMMON AND SCIENTIFIC NAMES OF WETLAND VEGETATION

Common Name	Scientific Name	Indicator Status[1]
Alders	*Alnus spp.*	OBL - FAC
American elm	*Ulmus americana*	FACW$^-$
American slough grass	*Beckmannia syziagachne*	OBL
Arrow arum	*Peltandra virginica*	**
Arrowheads	*Sagittaria spp.*	OBL
Ashes	*Fraxinus spp.*	FACW - FAC
Aspens	*Populus spp.*	FACW - FAC
Asters	*Aster spp.*	OBL - FACU
Baltic rush	*Juncus balticus*	OBL
Barley grass	*Hordeum spp.*	FACW
Barnyard grass	*Echinochloa crusgalli*	FACW DRA
Big bluestem	*Andropogon gerardii*	FAC$^-$
Black spruce	*Picea mariana*	FACW
Bladderworts	*Utricularia spp.*	OBL
Bluejoint reedgrass	*Calamagrostis canadensis*	FACW$^+$
Bog laurel	*Kalmia polifolia*	OBL
Bog rosemary	*Andromeda glaucophylla*	OBL
Bog birch	*Betula pumila*	OBL
Box elder	*Acer negundo*	FACW
Broadleaf cattail	*Typha latifolia*	OBL
Bulrushes	*Scirpus spp.*	OBL
Burreeds	*Sparganium spp.*	OBL
Cattails	*Typha spp.*	OBL
Chokecherry	*Prunus virginiana*	FAC$^-$
Clustered field sedge	*Carex praegracilis*	FACW
Common bladderwort	*Utricularia macrorhiza*	OBL
Common buttonbush	*Cephalanthus occidentalis*	OBL
Common water parsnip	*Sium sauve*	OBL
Common water plantain	*Alisma planago-aquatica*	OBL
Cordgrasses	*Spartina spp.*	FACW
Cottonsedges	*Eriophorum spp.*	OBL
Ditch grasses	*Ruppia spp.*	**
Dock	*Rumux spp.*	OBL - FACW
Dogwoods	*Cornus spp.*	FACW - FAC
Duckweed	*Lemna spp.* and	OBL
Duckweed	*Spirodela spp.*	OBL
Eastern cottonwood	*Populus deltoides*	FAC
Elms	*Ulmus spp.*	FACW - FAC$^+$
False aster	*Aster sp.*	FAC
Fowl bluegrass	*Poa palustris*	FACW
Foxtail barley	*Hordeum jubatum*	FACW
Giant burreed	*Sparganium eurycarpum*	OBL
Giant goldenrod	*Solidago gigantea*	FACW
Giant reed	*Phragmites australis*	FACW$^+$
Goldenrods	*Solidago spp.*	OBL - FACU$^-$
Grapevine	*Vitus spp.*	FACW$^-$ - FACU$^-$

Common Name	Scientific Name	Indicator Status[1]
Green ash	*Fraxinus pennsylvanica*	FACW
Hardstem bulrush	*Scirpus acutus*	OBL
Hawthorne	*Crataegus spp.*	FAC, FACW+
Hoary willow	*Salix candida*	OBL
Hornwort	*Ceratophyllum demersum*	OBL
Hummock sedge	*Carex stricta*	OBL
Hybrid cattail	*Typha x glauca*	OBL
Knotweeds	*Polygonum spp.*	OBL - FACU
Labrador tea	*Ledum groenlandicum*	OBL
Ladies thumb smartweed	*Polygonum persicaria*	FACW
Leatherleaf	*Chamaedaphne calyculata*	OBL
Loblolly bay	*Pinus taeda*	**
Lowland white aster	*Aster simplex*	FACW
Mannagrasses	*Glyceria spp.*	OBL
Milkweed	*Asclepias spp.*	OBL - FACU
Mosses	*Drepanocladus spp.*	OBL
Narrowleaf cattail	*Typha augustifolia*	OBL
Nodding smartweed	*Polygoneum lapathifolium*	OBL
Northern reedgrass	*Calamagrostis stricta*	FACW+
Northern white cedar	*Thuja occidentalis*	FACW
Pennsylvania smartweed	*Polygonum pennsylvanicum*	FACW
Pickerelweed	*Pontederia cordata*	OBL
Poison ivy	*Toxicodendron radicans*	FAC+
Pond buttercup	*Ranunculus subrigidus*	OBL
Pond pine	*Pinus serotina*	**
Pondweeds	*Potamogeton spp.*	OBL
Prairie cordgrass	*Spartina pectinata*	FACW+
Quackgrass	*Agropyron repens*	FACU
Quaking aspen	*Populus tremula*	FAC
Red bay	*Persea borbonia*	**
Red maple	*Acer rubrum*	FAC
Red-osier dogwood	*Cornus stolonifera*	FACW
Reed canarygrass	*Phalaris arundinarea*	FACW+
River bulrush	*Scirpus fluviatilis*	OBL
Roses	*Rosa spp.*	OBL - FACU
Rubus	*Rubus spp.*	OBL - FACU-
Rushes	*Juncus spp.*	OBL - FACU
Saltgrass	*Distichlis stricta* and *D. spicata*	FACW
Sartwell sedge	*Carex sartwellii*	FACW
Saw grass	*Cladium jamaicense*	**
Seaside arrow grass	*Triglochin maritimum*	OBL
Sedges	*Carex spp.*	OBL - FACU
Shortawn foxtail	*Alopecurus aequalis*	OBL
Silky dogwood	*Cornus amomum*	FACW+
Slender bulrush	*Scirpus heterochaetus*	OBL
Slough sedge	*Carex trichocarpa*	**
Slough sedge	*Carex atherodes*	OBL
Smartweeds	*Polygonum spp.*	OBL - FACW
Softstem bulrush	*Scirpus validus*	OBL

Common Name	Scientific Name	Indicator Status[1]
Spikerushes	*Eleocharis spp.*	OBL - FACW
Sweet bay	*Magnolia virginiana*	**
Switchgrass	*Panicum virgatum*	FAC+
Tall mannagrass	*Glyceria grandis*	OBL
Water fern	*Salvinia spp.* and	**
	Marsilea vestita	OBL
Water hyacinth	*Eichhornia crassipes*	**
Water lettuce	*Pistia stratiotes*	**
Water nut	*Trapa natans*	**
Water plantain	*Alisma spp.*	OBL
Water smartweed	*Polygonum amphibium*	OBL
Waterweed	*Elodea spp.*	OBL
White water-crowfoot	*Rannunculus trichophyllus*	OBL
Whitetop	*Scolochloa festucacea*	OBL
Wild rice	*Zizania aguatica*	OBL
Willows	*Salix spp.*	OBL - FACU
Wooly sedge	*Carex lanuginosa*	OBL
Yellow water buttercup	*Ranunculus flabellaris*	OBL

(1) OBL - Obligate Wetland Plants - occur almost always (estimated >99%) in wetlands under natural conditions.

FACW - Facultative Wetland Plants - usually occur (estimated >67% to 99%) in wetlands, but also occur (1% to 33%) in nonwetlands.

FAC - Facultative Plants - with similar likelihood (estimated 33% to 67%) of occurring in both wetlands and nonwetlands.

FACU - Facultative Upland Plants - occur sometimes (estimated 1% to 33%) in wetlands, but occur more often (estimated >67% to 99%) in nonwetlands.

UPL - Obligate Upland Plants - rarely occur (estimated <1%) in wetlands, but occur almost always (estimated >99% in nonwetlands under natural conditions.

DRA - The species normally occurs at the indicated estimated probability in wetlands, but only during periods when standing water is absent.

\+ - Indicates a frequency toward the higher end of the category (more frequently found in wetlands).

\- - Indicates a frequecy toward the lower end of the category (less frequency found in wetlands).

** - Not known

Sources: Reed, P.B., Jr. (1988); ACOE (1987b).

APPENDIX B

COMMON AND SCIENTIFIC NAMES OF WETLAND ANIMALS

APPENDIX B

COMMON AND SCIENTIFIC NAMES OF WETLAND WILDLIFE

Common Name	Scientific Name
Bass	*Micropterus spp.*
Beaver	*Castor canadensis*
Black crappie	*Pomoxis nigromaculatus*
Blue-winged teal	*Anas discors*
Brook stickleback	*Culaea inconstans*
Canvasback	*Aythya valisineria*
Crayfish	*Cambarus spp.*
Crayfish	*Procambarus spp.*
Dabbing ducks	*Anas spp.*
Diving ducks	*Aythya spp.*
Fathead minnow	*Pimephales promelas*
Green-winged teal	*Anas crecca*
Gadwal	*Anas strepera*
Leech	*Erpobdella spp.*
Leech	*Helobdella spp.*
Lesser scaup	*Aytha affinis*
Mallard	*Anas platyrhynchos*
Mink	*Mustela vision*
Minnows	Cyprinidae
Muskrat	*Ondatra zibethicus*
Northern pike	*Exox lucius*
Pheasant	*Phasianus colchicus*
Pintail	*Anas acuta*
Raccoon	*Procyon lotor*
Red fox	*Vulpes vulpes*
Redhead	*Aythya americana*
Shoveller	*Anas crecca*
Walleye	*Stizostedion vitreum*
White crappie	*Pomoxis annularis*
White-tailed deer	*Odocoileus virginianus*

APPENDIX C

ACREAGE OF AFFECTED WETLANDS
FOR PRELIMINARY SITE LAYOUTS BY SECTOR

APPENDIX C
ACREAGE OF AFFECTED WETLANDS FOR THE TX-NORTH
PRELIMINARY LAYOUT BY SECTOR

		Preliminary Site Layout (Without Buffer)										Preliminary Site Layout (Buffer)				Buffer Overlaps			
		East		West		SE		SW		TOTAL									
Wetland Type	Code	Filled	Excl.	Filled	Excl.	Filled	Excl.	Filled	Excl.	Filled	Excl.	E	W	SE	SW	E/W	E/SE	W/SW	SW/S
Palustrine Unconsolidated Bottom																			
- Semipermanent excavated	PUBFx						1				1			9					
Palustrine Emergent																			
- Temporary	PEMA	2	6	6	5	<1	1	<1	1	9	15	2	4	<1	4			2	
- Temporary, farmed	PEMAf																		
- Temporary, farmed	PEMAbf														3				
- Saturated	PEMB		1								1								
- Seasonal	PEMC	3	9.	7	54	20	43	16	48	46	154	9	92	6	158			9	24
- Semipermanent	PEMF			6	2		1			6	3		10						
- Semipermanent, excavated	PEMFx		3			1	2			1	5				<1				
TOTAL WETLANDS		5	18	19	61	21	48	16	49	62	179	11	106	16	166	0	0	11	24

APPENDIX C
ACREAGE OF AFFECTED WETLANDS FOR THE TX-SOUTH
PRELIMINARY LAYOUT BY SECTOR

		Preliminary Site Layout (Without Buffer)										Preliminary Site Layout (Buffer)				Buffer Overlaps			
		East		West		SE		SW		TOTAL									
Wetland Type	Code	Filled	Excl.	Filled	Excl.	Filled	Excl.	Filled	Excl.	Filled	Excl.	E	W	SE	SW	E/W	E/SE	W/SW	SW/S
Palustrine Unconsolidated Bottom - Semipermanent excavated	PUBFx		<1	<1	1	<1	<1			<1	2	<1	<1	<1	1				
Palustrine Emergent - Temporary	PEMA		1			<1	2		1	<1	4	<1	<1	4	<1				
- Temporary farmed	PEMAf	4	13	8	135	1	5	9	64	22	216	12	107	13	76	1		14	3
- Seasonal	PEMC											4	24	4					
- Seasonal farmed	PEMCf	<1	35							<1	35	11		1					
Palustrine Emergent/Seasonal Forested	PEM/PFOC												3						
TOTAL WETLANDS		5	49	8	136	2	7	9	65	23	257	27	113	23	78	1		14	3

APPENDIX C

ACREAGE OF AFFECTED PALUSTRINE WETLANDS FOR THE SE-EAST PRELIMINARY SITE LAYOUT BY SECTOR

Wetland Type	Code	Preliminary Site Layout (Without Buffer) East Filled	West Filled	SE Filled	SW Filled	Total Filled	Preliminary Site Layout (Buffed) E	W	SE	SW	Buffer Overlap E/SW	W/SW/E	W/SW	E/W	E/W/SE	E/SE
Palustrine Unconsolidated Bottom																
- Semipermanent	PUBF															
- Intermittently exposed excavated	PUBGx									<1						
Palustrine Emergent																
- Temporary	PEMA							<1								
- Temporary, drained	PEMAd		<1		<1	<1			<1	1	<1					
- Temporary, farmed	PEMAf	3	<1	3	2	8	2	8	5	2	<1			2	2	2
- Saturated	PEMB															
- Saturated, organic	PEMBg								11							
- Seasonal	PEMC									<1						
- Seasonal farmed	PEMCf							2								
Palustrine Scrub-Shrub Broadleaf	PSS1							<1								
- Temporary	PSS1A		<1			<1								<1		
Palustrine Scrub-Shrub Broadleaf																
- Saturated	PSS1B															
- Seasonal	PSS1C		<1			<1		5		<1			2			
Palustrine Forested Broadleaf																
- Saturated	PFO1B															
Palustrine Emergent/ Scrub-Shrub																
- Seasonal, drained	PEM/PSS1Cd															
Palustrine Emergent/ Scrub-Shrub																
- Saturated, organic	PEM/ PSS1Cd			6		6			16							
Palustrine Emergent Forested Broadleaf																
- Saturated	PEM/PFO1B								16							
TOTAL WETLANDS		3	1	9	2	15	2	16	48	5	<1	0	2	2	2	2

APPENDIX C
ACREAGE OF AFFECTED PALUSTRINE WETLANDS FOR THE RX-WEST PRELIMINARY SITE LAYOUT BY SECTOR

Wetland Type	Code	Preliminary Site Layout (Without Buffer) East Filled	West Filled	SE Filled	SW Filled	Total Filled	Preliminary Site Layout (Buffer) E	W	SE	SW	Buffer Overlaps SW/SE	E/SE	W/SW	W/E	SE/W/E	SW/W/E	SE/SW/W/E
Palustrine Unconsolidated Bottom - Semipermanent excavated	PUBF						<1										
Palustrine Emergent - Temporary	PEMA		<1		<1	<1		<1	1								
- Temporary drained	PEMAd			<1		<1			<1	<1							
- Temporary farmed	PEMAf	1				1	3	4		4							
- Seasonal	PEMC				<1	<1				4							
- Seasonal, farmed	PEMCf	1				1	2			1				1			
Palustrine Scrub-Shrub/ Broadleaf - Saturated	PSS1B								<1								
Palustrine Forested	PFO						2										
Palustrine Forested Broadleaf - Saturated	PFO1B																
Palustrine Scrub-Shrub/ Forested - Saturated	PSS1/PFO1B																
TOTAL WETLANDS		2	<1	<1	1	4	7	4	1	6	0	0	0	1	0	0	0

TECHNICAL STUDY 7

OVER-THE-HORIZON BACKSCATTER RADAR PROGRAM
CENTRAL RADAR SYSTEM

MAMMALS

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TECHNICAL STUDY 7

MAMMALS

7.1 INTRODUCTION

The U.S. Air Force (USAF) has proposed to construct the Central Radar System (CRS) Over-the-Horizon Backscatter (OTH-B) radar facility in the north central United States. In the Record-of-Decision (USAF, 1988), the USAF selected a study area at Amherst, South Dakota for the transmit sectors, and a study area near Thief River Falls, Minnesota for the receive sectors (Fig. 7-1). The USAF has since identified two concentrated study areas (CSAs) within each general study area previously chosen. The transmit (Tx) site CSAs have been named Tx-North (Tx-N) and Tx-South (Tx-S), while the receive (Rx) CSAs have been named Rx-East (Rx-E) and Rx-West (Rx-W) (Figs. 7-2 and 7-3). These CSAs have been selected through a screening process involving environmental, operational, and socioeconomic considerations (Technical Study 1, EIAP Overview).

This document evaluates the mammal species of concern within the general study areas and the potential impacts of the project. The affected environment section of this study discusses general life history, specific important habitats within the general and concentrated study areas and, when known, the species' relative abundance. Species considered are those outlined in Table 7-1 and have been selected based upon field surveys and oral and written communication with the South Dakota Game, Fish and Parks Department (SDGFPD) and the Minnesota Department of Natural Resources (MNDNR). Other small mammals are not addressed due to their high population numbers, ubiquitous nature and low economic importance. Threatened and endangered mammals are addressed in Technical Study 8, Threatened and Endangered Species. Threatened and endangered mammals with current or historical ranges coinciding with the study areas include swift fox at the transmit study area and gray wolf at the receive study area.

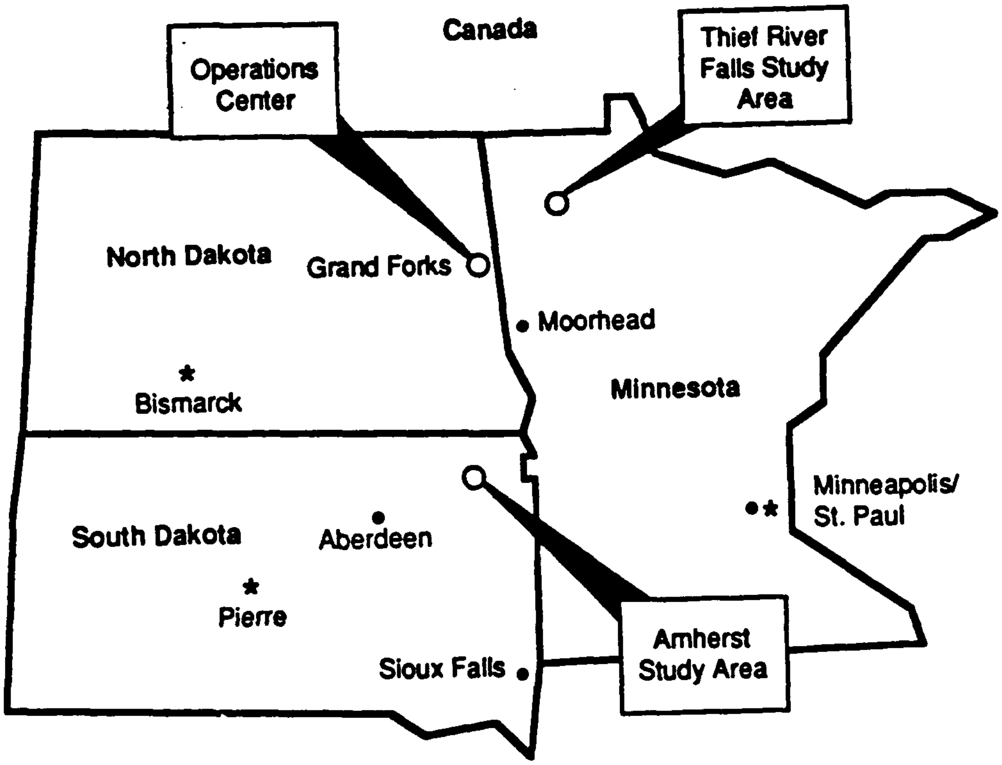


FIGURE 7-1. LOCATION OF THE CRS TRANSMIT AND RECEIVE STUDY AREAS

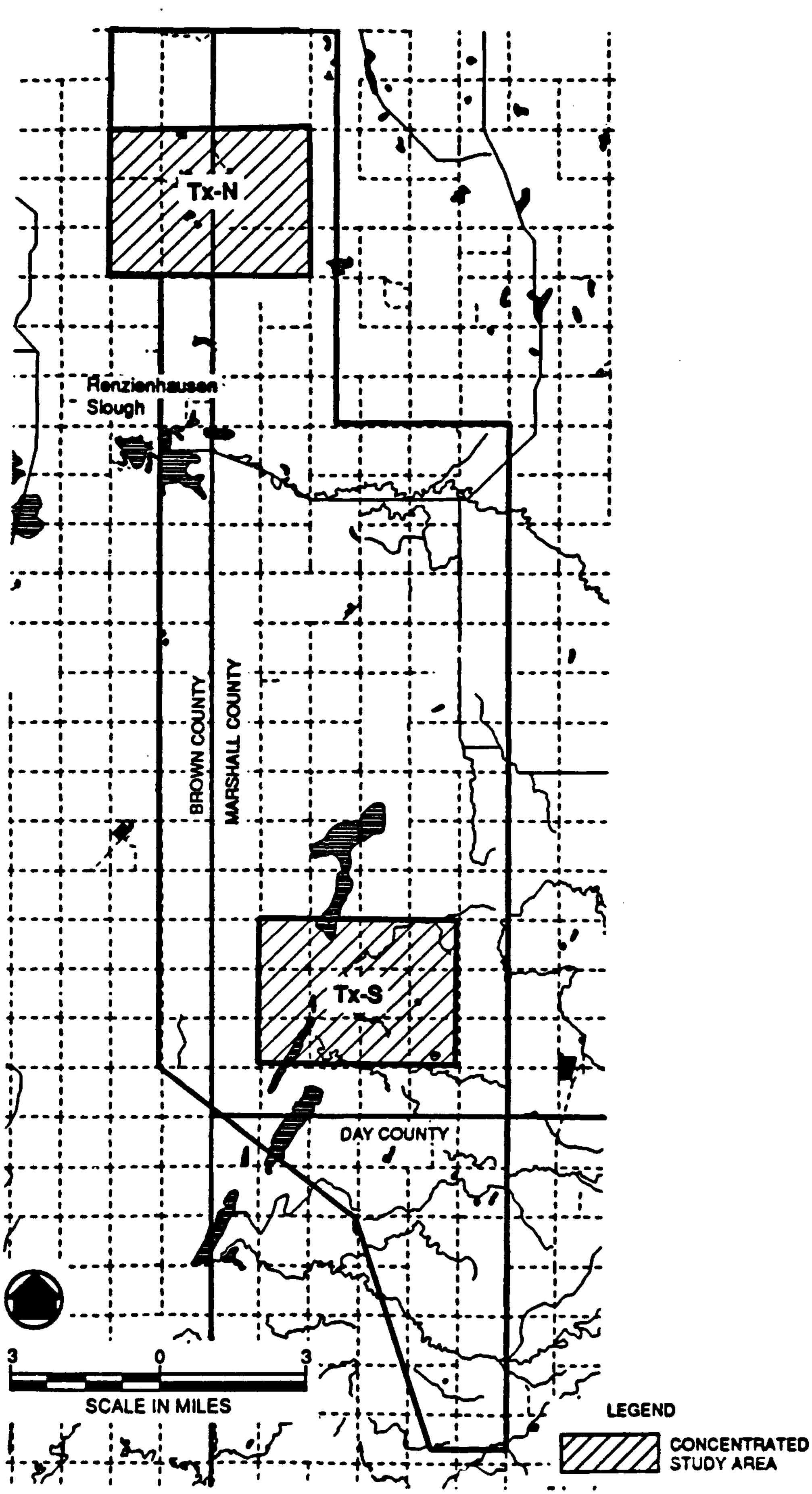


FIGURE 7-2. AMHERST, SD TRANSMIT STUDY AREA CONCENTRATED STUDY AREA LOCATIONS

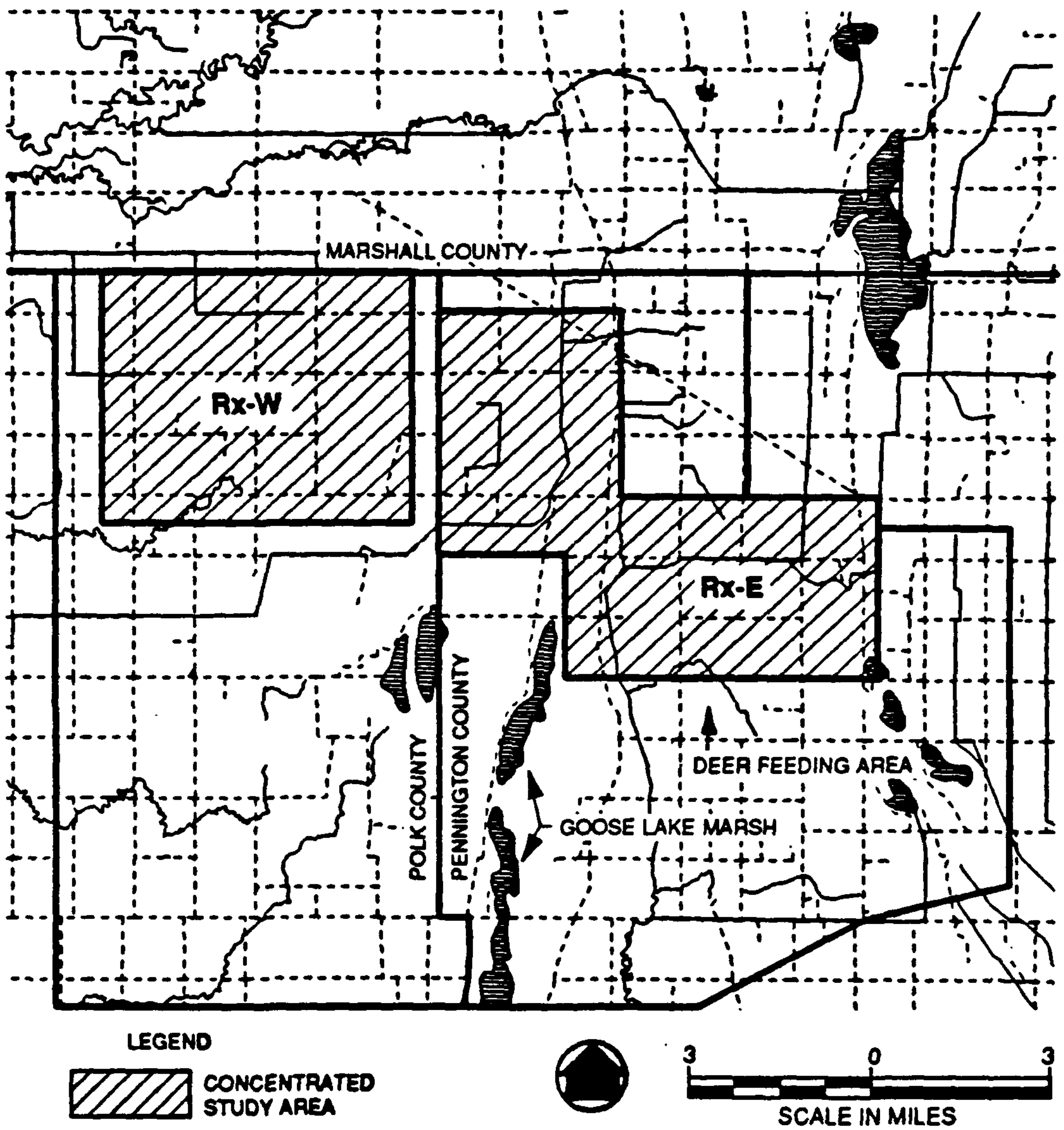


FIGURE 7-3. THIEF RIVER FALLS, MN RECEIVE STUDY AREA CONCENTRATED STUDY AREA LOCATIONS

TABLE 7-1. PRINCIPAL MAMMALS PRESENT IN THE AMHERST, SD AND THIEF RIVER FALLS, MN STUDY AREAS

Species	Habitat	Food	Home Range	Comments	Reference
Large Mammals					
While-tailed deer *Odocoileus virginianus*	Interspersed woodlands and fields, marshes swamps	Woody browse, forbs, crops	165-640 acres	Game animal	Hesselton and Hesselton, 1982; Halls, 1978
Moose *Alces alces*	Boreal forest	Early successional woody browse, aquatic plants	3.1-6.2 mi^2	Game animal	Coady, 1982; Franzman, 1978
Pronghorn *Antilocapra americana*	Grassland, mixed grassland -brushland	Browse, succulent forbs	4-16 mi^2	Game animal herding, migratory	Yoakum, 1978; Kitchen and O'Gara, 1982
Small Mammals					
Red fox *Vulpes vulpes*	Open fields, interspersed woods and fields	Small rodents, birds, jackrabbit	1 - 7 mi^2	Valuable furbearer	Burt and Grossen-heider, 1976; Nelsor, 1982

TABLE 7-1 (Continued). PRINCIPAL MAMMALS PRESENT IN THE AMHERST, SD AND THIEF RIVER FALLS, MN STUDY AREAS

Species	Habitat	Food	Home Range	Comments	Reference
Small Mammals (Continued)					
Swift fox *Vulpes velox*	Prarie grassland	Small mammals	See Technical Study 8	Endangered species in SD	Samuel and Nelson, 1982;Burt and Gross-enheider, 1976
Coyote *Canis latrans*	Open grassland, brushland jackrabbit	Small rodents, birds,	5-26 mi^2	Pack animal	Burt and Grossen-heider,1976; Bekoff,1982
Gray Wolf *Canis lupus*	Forests, tundra	Birds,deer, moose,caribou and other mammals	390-780km^2	Threatened species in MN	Paradiso and Nowak, 1982;Burt and Grossen-heider,1976
Muskrat *Ondatra Zibethicus*	Lakes, ponds streams,marshes	Aquatic vegetation	490 feet	Valuable furbearer	Burt and Grossen-heider,1976; Fritzell, 1989; Perry, 1982

TABLE 7-1 (Continued). PRINCIPAL MAMMALS PRESENT IN THE AMHERST, SD AND THIEF RIVER FALLS, MN STUDY AREAS

Species	Habitat	Food	Home Range	Comments	Reference
Small Mammals (Continued)					
Beaver <u>Castor canadensis</u>	Streams, ponds alder, maple poplar, willow	Aspen, birch	6 mi	Valuable furbearer, lives in colonies, creates wetland habitat	Burt and Grossenheider,1976; Hill, 1982
Badger <u>Taxidea taxus</u>	Grassland, desert	Small rodents	3-7 mi^2	Controls rodent pop.	Burt and Grossenheider,1976; Lindzey,1982
Mink <u>Nustela vison</u>	Streams, lakes	Fish, eggs, small mammals, birds, frogs, crayfish	1-3 mi	Valuable furbearer	Burt and Grossenheider,1976; Linscombe et al, 1982
Weasel (longtail) <u>Mustela frenata</u>	Brushland, grassland, wetlands, lakes,swamps	Small mammals birds,	30-40 acres	Controls rodent pop.	Burt and Grossenheider,1976; Svendsen, 1982

TABLE 7-1 (Continued). PRINCIPAL MAMMALS PRESENT IN THE AMHERST, SD AND THIEF RIVER FALLS, MN STUDY AREAS

Species	Habitat	Food	Home Range	Comments	Reference
Small Mammals (Continued)					
Striped Skunk *Mephitis mephitis*	Mixed woods, brushland, open fields, close to water	Rodents, eggs, insects, berries, carrion	500 - 1000 acres	Furbearer	Burt and Grossenheider, 1976; Godin, 1982; Fritzell, 1989
Jackrabbit *Lepus townsendi*	Open/brushy fields	grasses, green vegetation, bark, buds, twigs	223.5 acres	Game animal	Burt and Grossenheider, 1976; Dunn et al. 1982
Raccoon *Procyon lotor*	Streams, lakes wetlands, wooded areas near wetlands	omnivorous; fruits, nuts, small rodents, insects, aquatic invertebrates	.6 - .8 miles	Furbearer	Burt and Grossenheider, 1976; Kaufmann, 1982
Bobcat *Lynx rufus*	Swamps, forests	Small mammals, birds, insects, reptiles	0.6 - 201.0 km^2	Furbearer, kills livestock	Burt and Grossenheider, 1976; McCord and Cardoza, 1982

7.2 AFFECTED ENVIRONMENT

7.2.1 Methods

This report is based upon data obtained from USAF large mammal aerial surveys and from existing information concerning mammals in the region. To gather information on large mammal presence, general habitat use, and areas of concentration during winter, aerial surveys were flown in a single-engine, fixed-wing aircraft at an altitude of approximately 400-500 feet above ground level. The general study areas were overflown in early morning and late afternoon during favorable weather conditions, which included clear skies, low winds, no precipitation, and sufficient snow cover. The flight paths used in these surveys are shown in Figures 7-4 through 7-6.

One aerial survey was conducted at the Amherst study area on 14 January 1988 and two at the Thief River Falls study area on 11 January 1988 and 13 January 1988. The 1988 aerial survey over the Amherst study area covered only the northern portion of the general study area. Two additional surveys were conducted at the Amherst study area on 28 and 29 January, 1989. An additional four surveys were conducted at the Thief River Falls study area on 26 and 27 January 1989 and 14 and 15 February 1989. Incidental observations of large mammals by CRS avian study field personnel during fall 1987 supplied some additional insight into fall activity patterns.

Vegetation and wetlands in the study areas were examined to determine the suitability of habitats present for supporting mammals populations. Vegetation analysis was performed by DPA International Ltd. (DPA, 1989) for the USAF and is thoroughly discussed in Technical Study 5, Vegetation. Wetlands of the study areas were classified by U.S. Fish and Wildlife Service National Wetland Inventory maps and aerial photographs and are examined in Technical Study 6, Wetlands and Aquatics.

The MNDNR and the SDGFPD also provided information on mammals inhabiting the general study areas. From these sources, a matrix of information was prepared for the principal mammal species of concern in the general study areas (Table 7-1).

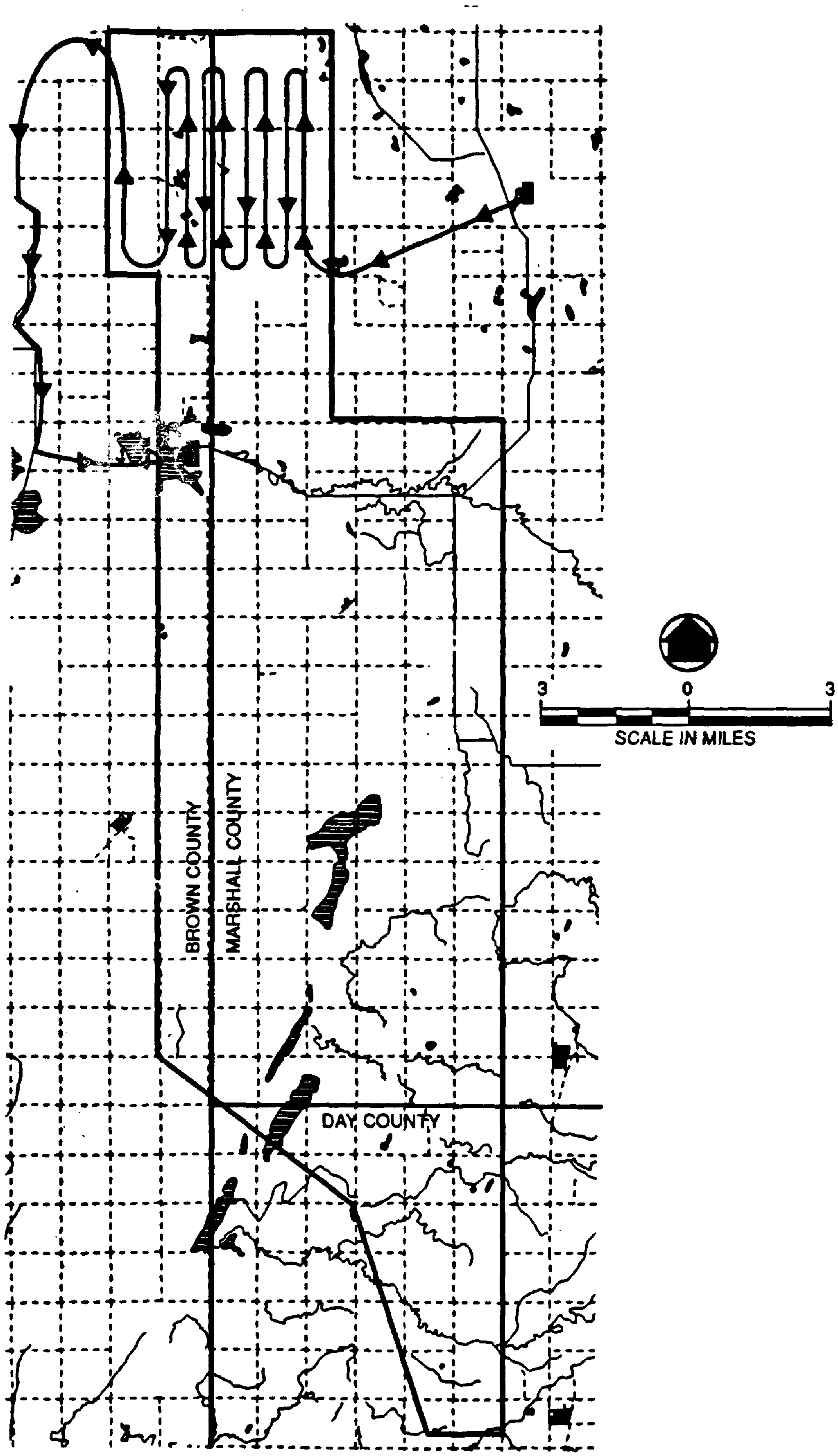


FIGURE 7-4. AMHERST, SD TRANSMIT STUDY AREA.
1988 AERIAL SURVEY FLIGHT PATH

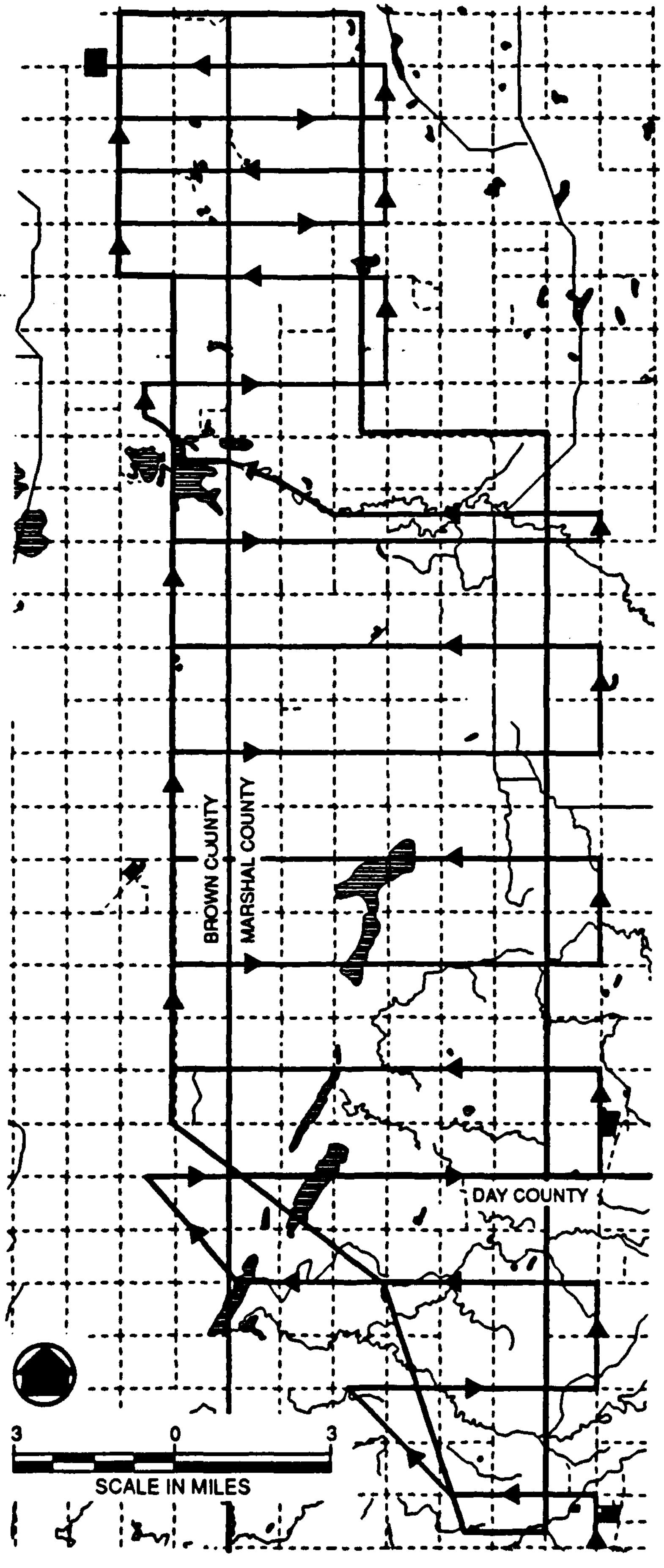


FIGURE 7-5. AMHERST, SD TRANSMIT STUDY AREA 1989 AERIAL SURVEY FLIGHT PATH

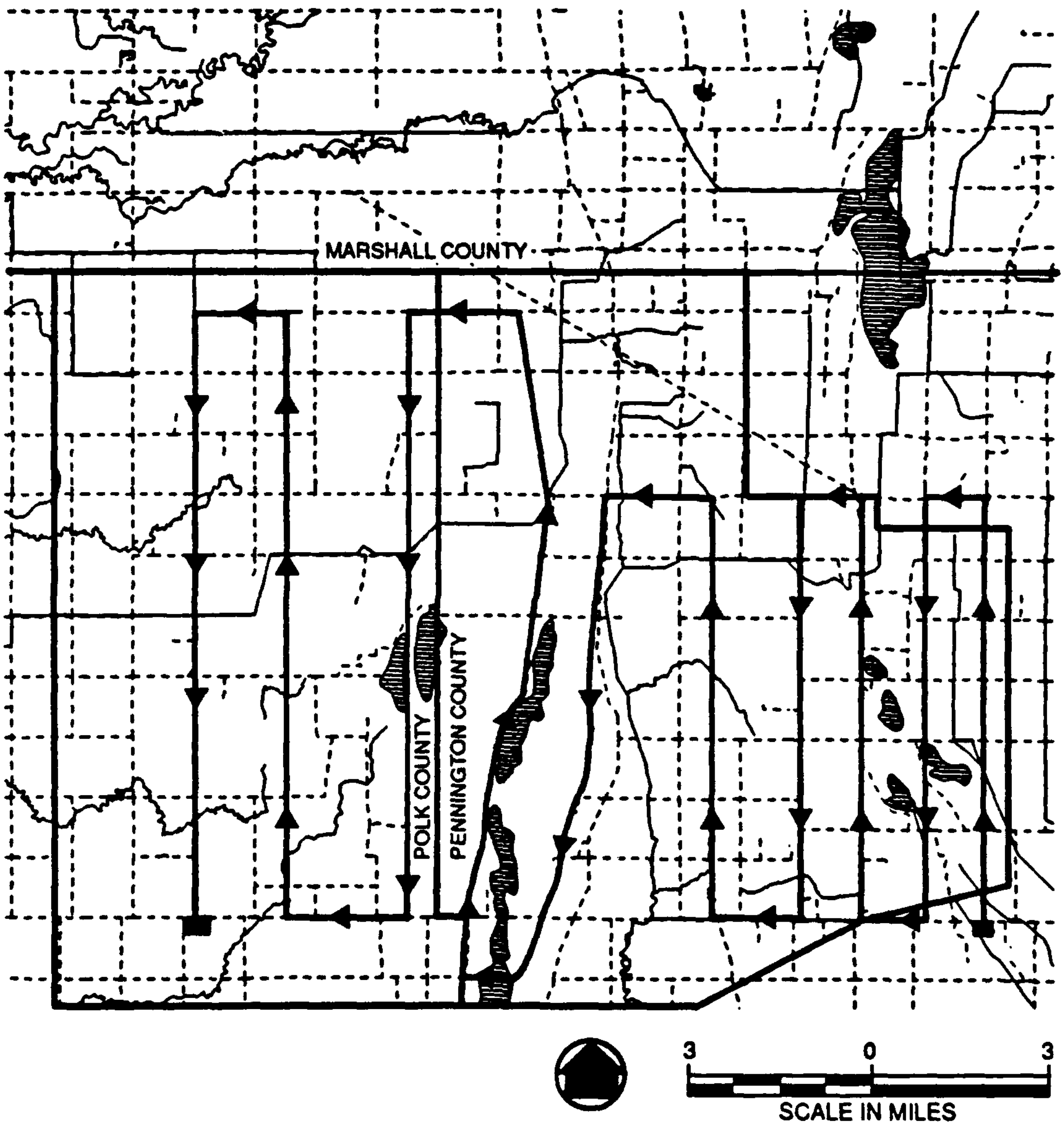


FIGURE 7-6. THIEF RIVER FALLS, MN RECEIVE STUDY AREA 1988 AND 1989 AERIAL SURVEY FLIGHT PATH

7.2.2 Transmit Site

7.2.2.1 White-tailed Deer. Inhabitants of much of North America, white-tailed deer are present throughout South Dakota (Fig. 7-7). The presence of suitable wintering habitat can be an important factor affecting the survival ability of a deer population in this region (Moen, 1973; Halls, 1978; Hesselton and Hesselton, 1982). During winter, white-tailed deer in South Dakota typically inhabit woods or marshes supporting thick emergent vegetation such as cattails (*Typha* species) and bulrushes (*Scirpus* species). Heavy cover present in these habitat types provides protection from hunters and other predators, as well as sheltering deer from inclement weather (Sparrowe and Springer, 1970; Kannowski, 1979; Fritzell, 1989)

Some wetlands in the general study area support vegetation used by deer for winter cover. Of the wetlands present in the general study area, approximately 91 percent are classified as palustrine emergent types, which characteristically support vegetation that deer depend upon for cover. The majority of these wetlands are either temporarily or seasonally flooded (Technical Study 6). However, semipermanently flooded wetlands, which are not abundant in the general study area, generally hold water for longer time periods (Technical Study 6) and provide better habitat for deer than do either of the types prevalent in the general study area (Kannowski, 1979).

Winter aerial surveys in both 1988 and 1989 illustrate the importance of marshes as winter deer habitat. During winter 1988 aerial surveys, 58 percent of the deer groups (39 percent total animals) observed were located in marsh habitat. Winter 1989 aerial surveys supported this observation, as 38 percent of the deer groups (63 percent total animals) were observed in marshland (Table 7-2). Because only approximately 6 percent of the general study area

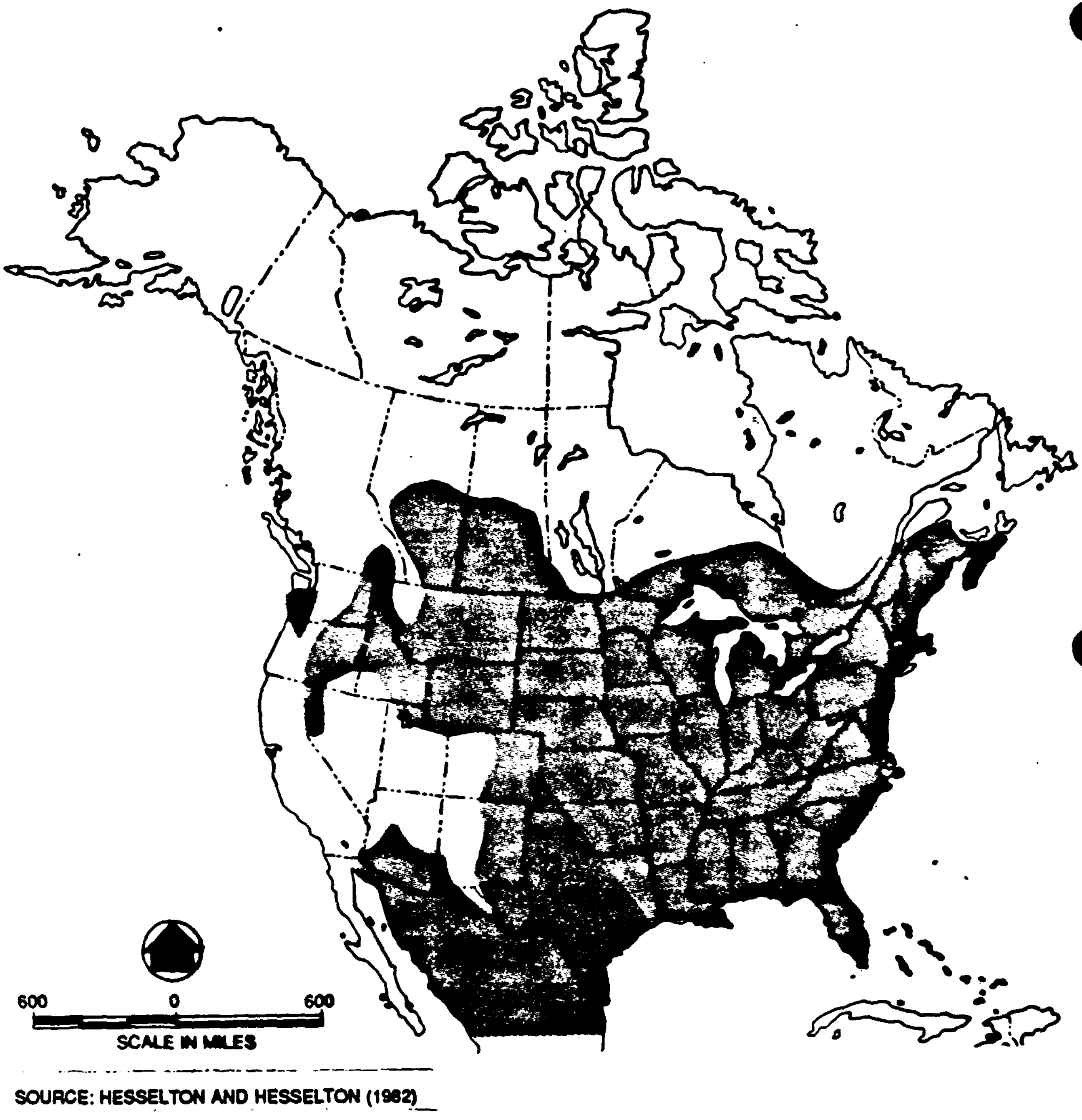


FIGURE 7-7. RANGE OF WHITE-TAILED DEER IN NORTH AMERICA

TABLE 7-2. NUMBERS OF DEER AND HABITAT USE OBSERVED DURING THE AMHERST,SD AND THIEF RIVER FALLS, MN LARGE MAMMAL AERIAL SURVEYS

				% Groups (% Individuals)			
Date	# Flights	# Groups	#Individuals	Marsh	Woods	Fields	Crops
Amherst							
1988	1	12	67	58(39)	42(61)	0(0)	0(0)
1989	2	7	279	38(63)	0(0)	13(19)	50(19)
Thief River Falls							
1988	2	40	206	10(9)	88(88)	0(0)	3(3)
1989	4	66	349	0(0)	96(91)	0(0)	5(9)

is wetland (Technical Study 6), the relatively large percentage of deer observed in marshes during the winter aerial surveys illustrates that deer in the study area are attracted to wetlands. Renzienhausen Slough (Fig. 7-2), in the northern part of the general study area, but just south of the Tx-North (Tx-N) CSA, is an important winter deer concentration area. The majority of deer (52 percent total animals) observed during January 1989 aerial surveys were located near this marsh. Due to heavy cover, only 2 deer (3 percent total animals) were observed in Renzienhausen Slough during the 1988 aerial survey. Subsequent ground surveys in 1988, however, noted numerous deer tracks in the area of Renzienhausen Slough. Similarly, during 1989 ground surveys conducted in the area of Renzienhausen Slough, numerous deer tracks and approximately 40 deer were observed, suggesting heavy use of this marsh during winter months.

The general study area also supports some limited wooded habitat in the form of natural tree stands and shelterbelts that would provide suitable wintering areas for deer. These areas, however, are not abundant, comprising only about 2 percent of the general study area (Technical Study 5). The 1988 winter aerial surveys illustrate that the limited wooded areas in the general study area are also important wintering areas for deer, as 42 percent of the groups (61 percent total animals) were observed in wooded areas (Table 7-2). During 1989 aerial surveys however, no deer were observed in woods, suggesting that woods are less critical wintering areas than marshes in this area.

Because cover is not abundant in fields, this habitat generally does not attract permanent winter deer populations. Fields may, however, be used for forage and travel (Sparrowe and Springer, 1970). Approximately 17 percent of the general study area is open grassland supporting native vegetation (Technical Study 5) that could be visited at times by deer. Although many deer were seen in fields by fall 1987 CRS avian research personnel, none of the deer observed during winter 1988 aerial surveys were located in fields (Table 7-2). The avian observations suggest that deer use fields to some extent for travel and forage during fall. However, the winter aerial surveys suggest that fields in the general area are used for travelling, but not frequently used for bedding during winter months. Although deer were not seen in fields during 1988 aerial surveys, numerous tracks were observed in fields during 1988 winter ground surveys. During 1989 aerial surveys, 13 percent of the deer groups sighted (19 percent total animals) were in fields, all of which were travelling.

In contrast to winter habitat availability, the presence of summer habitat is generally not a critical factor in the survival of a deer population. During summer months, food and cover are plentiful and do not typically limit a deer population (Halls, 1978; Sparrowe and Springer, 1970). Woodlots, shrub grassland and hay lands generally offer suitable summer habitat for deer (Hesselton and Hesselton, 1982). In South Dakota, deer may also seek the cover afforded by cornfields during summer months (Sparrowe and Springer, 1970). Upland shrub grasslands and cornfields are present in the general study area that could provide suitable summering habitats for deer. Although not abundant, wooded areas and hay lands also occur that could serve as summer deer habitat (Technical Study 5).

Forage availability can also be a factor in attracting and supporting a deer population. White-tailed deer forage on a wide variety of vegetation, and have even adapted their foraging behavior to include agricultural crops and ornamental plants (Connover and Kania, 1988). Deer in agricultural areas of South Dakota have been observed to forage heavily on crops year round. Waste corn is a particularly important forage source for wintering deer (Sparrowe and Springer, 1970). The general study area is predominantly agricultural land and, therefore, probably provides valuable food resources for white-tailed deer. Agricultural land comprises approximately 75 percent of the general study area (Technical Study 5). Willow (*Salix* spp.) and aspen (*Populus* spp.) are also preferred forage of deer in South Dakota. Willow occurs in both natural tree stands and wetlands throughout the general study area (Technical Studies 5 and 6).

The number of deer inhabiting the general study area is unknown. The SDGFPD (1989c) estimates that the deer concentration throughout Day, Marshall, and Brown counties, including the general study area, is approximately 3 to 4 deer/square mile. Fort Sisseton, approximately 15 miles to the east of

Langford, South Dakota, reportedly supports a much larger deer population (SDGFPD, 1989c). During a 1988 winter aerial survey of 16 square miles in the northern portion of the general study area (Fig 7-4), 67 deer were observed (Fig 7-8; Table 7-2). This yields a deer concentration similar to that estimated by the SDGFPD, approximately 4 deer/square mile. In a morning aerial survey of the entire general study area in February 1989 (Fig 7-5), 188 deer were observed, and 91 deer were observed during a subsequent afternoon survey (Fig 7-9; Table 7-2). These observations yield approximate deer concentrations of .6 to 1.25 animals per square mile. These are, however, undoubtedly minimum estimates because an unknown number of animals are always missed when conducting aerial surveys of this type.

7.2.2.1.1 Tx-North Concentrated Study Area. Deer concentrations within the Tx-North (Tx-N) concentrated study area (CSA) during winter are not expected to be high. Dominating the Tx-N CSA are open fields (Technical Study 5), rather than habitats which support heavy cover that deer depend upon for protection during winter months. Approximately 77 percent of the Tx-N CSA is characterized as upland field comprised primarily of native grass species that have been grazed extensively in recent years (Technical Study 5). Deer will most likely not be attracted to these open areas, but may travel through the pastures of the CSA en route to nearby marshes and wooded areas outside of the Tx-N CSA. Although no deer were observed in fields during winter 1988 aerial surveys (Table 7-2), numerous tracks were noted in fields during ground surveys, which indicates that deer may utilize these areas to some degree for travelling. Of the deer groups observed during 1989 aerial surveys, 13 percent (19 percent total animals) were in fields (Table 7-2).

Wetlands or woodlands, which might provide necessary winter deer cover, are present but not dominant within the Tx-N CSA, comprising approximately 14 and 1 percent of the terrain respectively (Technical Studies 5 and 6). Of the wetlands present in the Tx-N CSA, approximately 98 percent are classified as palustrine emergent which support cover that could attract deer during winter months. Some cattails and bulrushes are also present in drainage ditches and could provide some limited winter cover for deer (Technical Study 5).

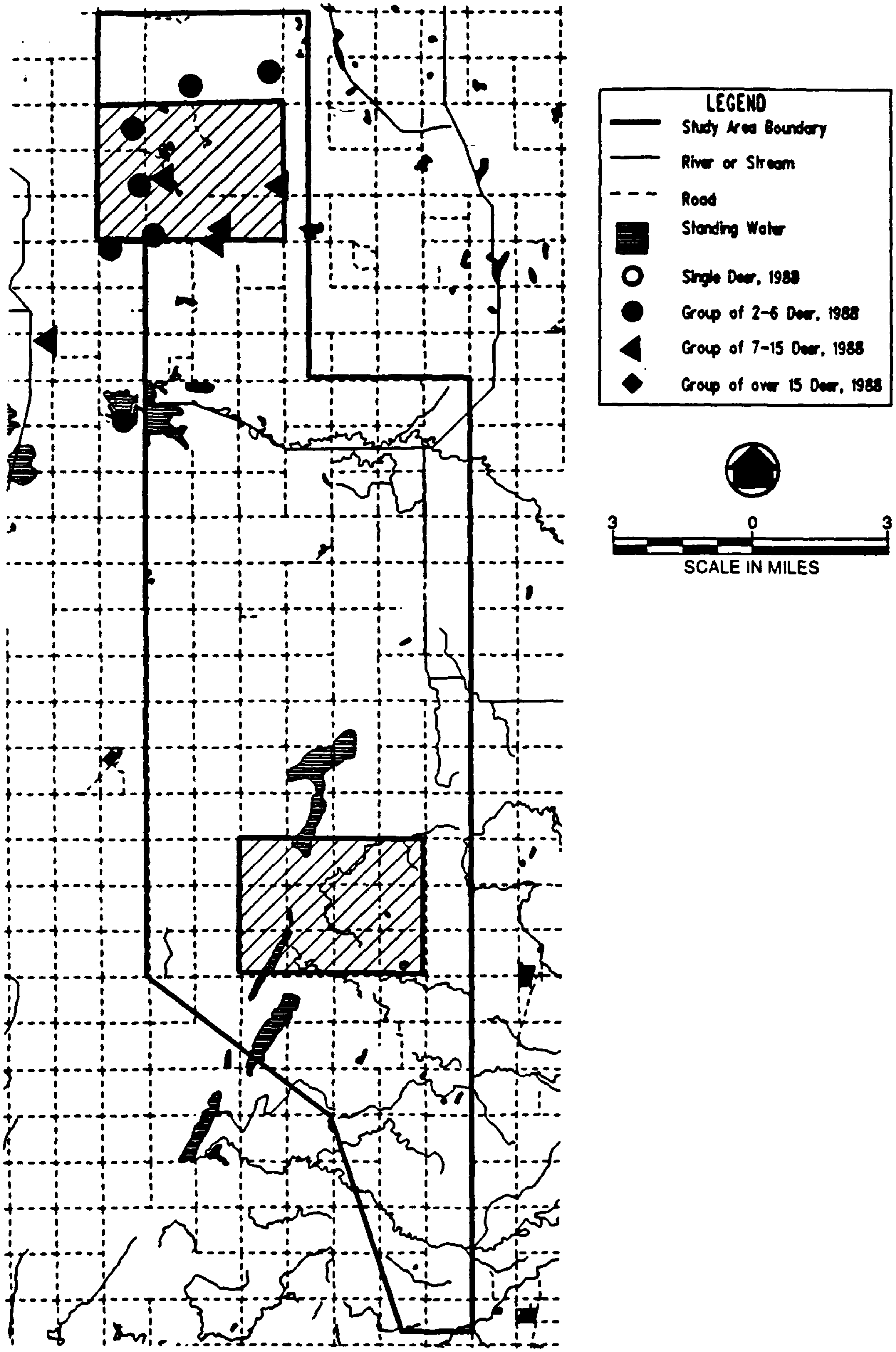


FIGURE 7-8. AMHERST, SD TRANSMIT STUDY AREA 1988 AERIAL DEER OBSERVATIONS

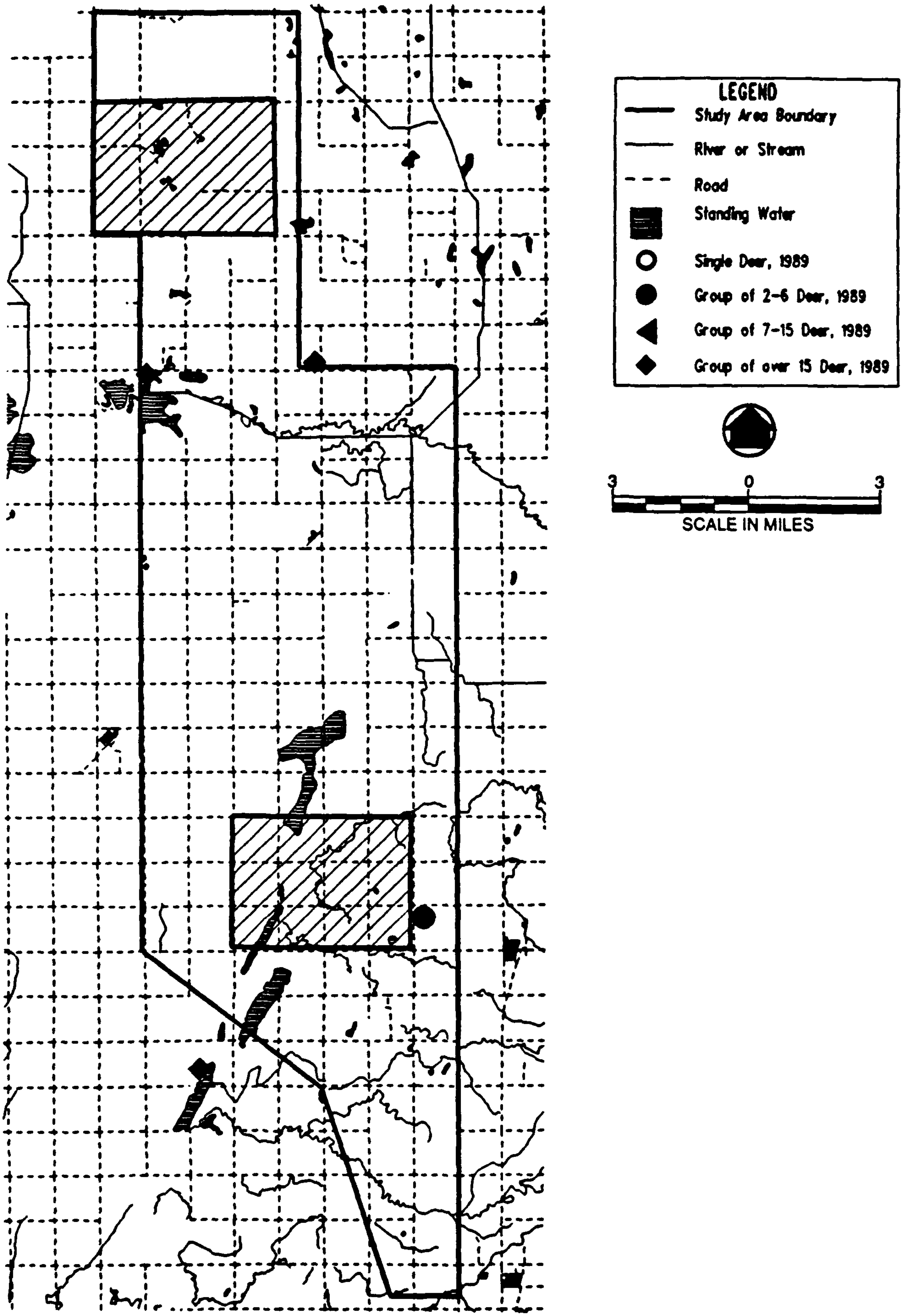


FIGURE 7-9. AMHERST, SD TRANSMIT STUDY AREA/ 1989 AERIAL DEER OBSERVATIONS

Winter aerial surveys confirm that the Tx-N CSA does contain some wintering deer habitat. During January, 1988 aerial surveys, 67 deer in 12 groups were observed (Fig. 7-8; Table 7-2). However, none of the deer groups observed during 1989 aerial surveys were located within the Tx-N CSA (Fig 7-9). Based on 1989 large mammal aerial surveys, as discussed above, Renzienhausen Slough is the nearest area of winter concentration.

The scarcity of forage in the Tx-N CSA may reduce expected deer concentrations there. Preferred deer forage, particularly willow and woody browse, is not abundant in the Tx-N CSA. Agricultural crops are also particularly scarce in the Tx-N CSA, as compared to both the general study area overall and the Tx-S CSA (Technical Study 5). Deer may, however, travel through the area in search of forage, as indicated by the observations of tracks during ground surveys.

Summer deer concentrations are not likely to be high in the Tx-N CSA due to the lack of forage there. Cornfields, which are used by deer in South Dakota during summer months (Sparrowe and Springer, 1970), are also not abundant due to the low agricultural use of the Tx-N CSA. Shrub grassland present, however, could provide some suitable summer habitat (Technical Study 5).

7.2.2.1.2 Tx-South Concentrated Study Area. Like the Tx-N CSA, the Tx-South (Tx-S) CSA does not provide abundant cover that deer need for protection during winter months. Although cottonwood *(Populus deltoides)*, green ash *(Fraxinus pennsylvanica)* and willow trees do occur in isolated small wooded areas, woodlands are generally scarce, comprising less than 1 percent of the area of the CSA (Technical Study 5). Wetlands are present in the CSA, but are typically planted with an agricultural crop, and do not support thick vegetation that deer depend on for cover during winter months (Technical Study 6). Cattails, although not abundant, do occur and could provide some limited wintering areas for deer (Technical Study 6).

Because winter deer habitat is not abundant in the Tx-S CSA, it is unlikely that a large deer population is present during winter. Winter 1989 aerial surveys confirm this. No deer groups were observed within the Tx-S CSA during 1989 aerial surveys (Fig. 7-9). The Tx-S CSA was not overflown during the 1988 winter surveys.

Although forage availability is less critical for deer survival than wintering habitat, an abundant food supply within the Tx-S CSA could attract deer. Agricultural land dominates the Tx-S CSA (Technical Study 5) and could serve as a food source for deer travelling through the region. Corn grown in the CSA could be foraged by deer throughout the year, although crops are abundant in the region outside of the Tx-S CSA as well.

Summer deer populations are likely to be higher in the Tx-S CSA than in the Tx-N CSA due to the more abundant agricultural food supply present within the Tx-S CSA. Because the Tx-S CSA is highly agricultural (Technical Study 5), cornfields are also more prevalent than in the Tx-N CSA and could be used by deer during summer months.

7.2.2.2 Pronghorn. The range of pronghorn, which are gregarious, herding animals, extends throughout the western prairies of the United States and includes portions of South Dakota (Fig. 7-10). Pronghorn habitat is characterized by rolling, open grassland or mixed brushland-grassland with a varied vegetation composition (Yoakum, 1978). Various characteristics are important in determining the suitability of an area for supporting a pronghorn population.

Suitable pronghorn habitat typically consists of 40 to 60 percent grass, 10 to 30 percent succulent forbs and 5 to 20 percent shrubs. Shrub or grassland consisting primarily of one species generally will not support pronghorn populations (Yoakum, 1978). Open shrub grassland comprises approximately 17 percent of the general study area (Technical Study 5) and could support a pronghorn population.

Available water is also important to the survival of a pronghorn population. Typically, regions that attract pronghorn receive 10 to 14 inches of precipitation per year (Kitchen and O'Gara, 1982). Pronghorn are reported to depend on open water sources, especially during dry seasons, particularly fall, and during times of drought. Water sources in areas that support large numbers of pronghorn occur approximately every 1 to 5 miles, although smaller concentrations of pronghorn occur where water is less available (Yoakum,

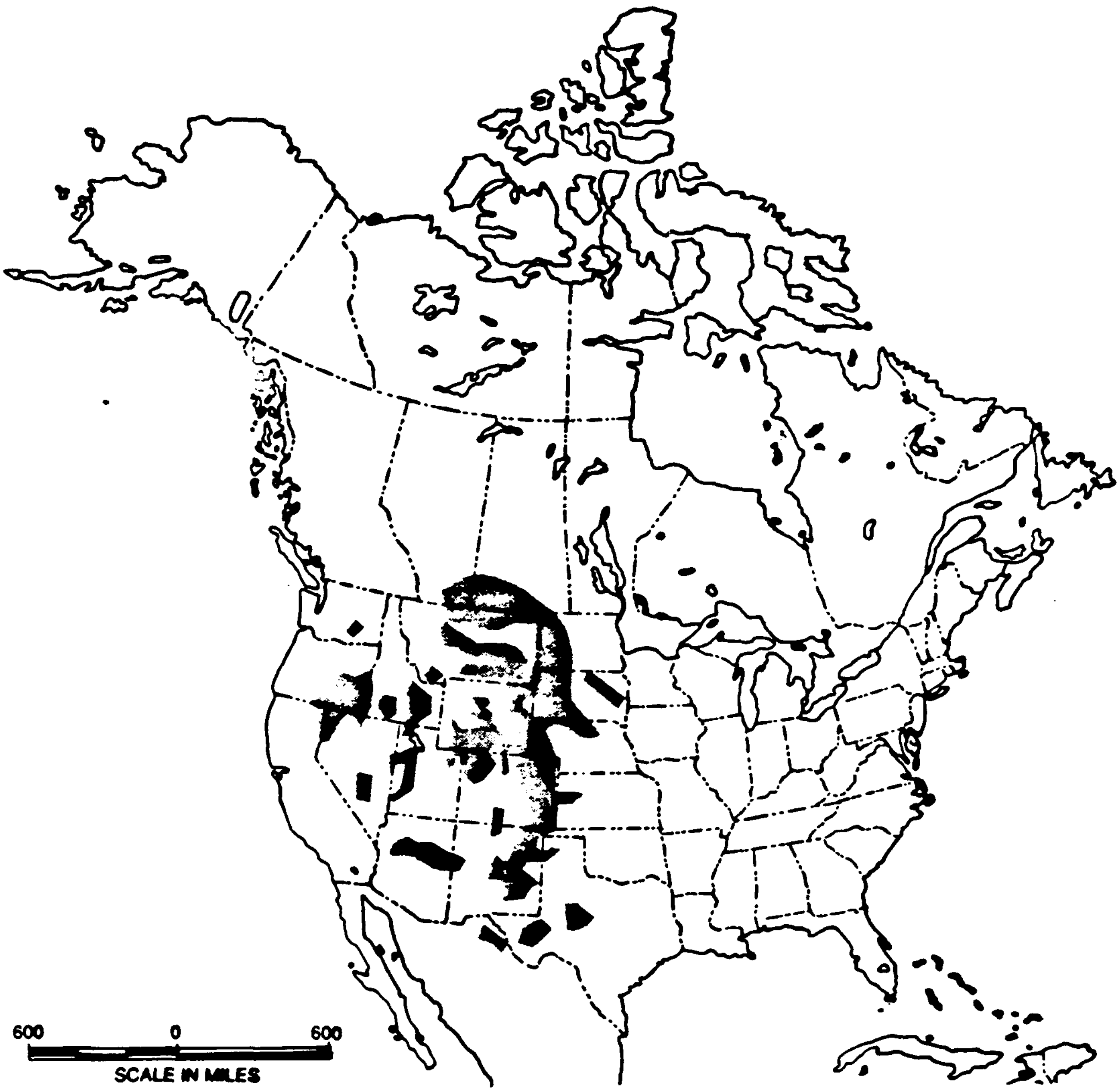


FIGURE 7-10. RANGE OF PRONGHORN IN NORTH AMERICA

1978). Because permanent open water is present in the general study area, primarily in the form of stock ponds and artesian wells, (Technical Study 6), it is possible that pronghorn could be found there. Although semipermanent riverine and lacustrine wetlands are present in the general study area, they are scarce, comprising approximately 2 percent of the terrain (Technical Study 6).

The presence of appealing forage may also be a factor in attracting pronghorn. The diet of the pronghorn is varied, but succulent vegetation is clearly preferred forage. Succulent forbs are heavily foraged throughout the year, except in the fall when dessication may make them less attractive forage for pronghorn. Woody browse is also important forage, especially during fall and winter when forbs are not preferred due to loss of succulence or are inundated by snow. Due to the lack of forb vegetation during dry periods, forage on forbs is likely to decrease during droughts or dry seasons, resulting in a greater use of woody browse species. Grasses are important forage in spring. None of these forage types, however, are dominant within the general study area (Technical Study 5). Pronghorn have also been known to forage on agricultural crops such as those present in the general study area, although this is not the most preferred type of forage (Yoakum, 1978; Kitchen and O'Gara, 1982).

Pronghorn movements are dictated primarily by food and water availability. Because these requirements are in abundance in spring and summer, pronghorn generally do not need to travel large distances during these periods. During winter and fall, however, movement is typically greater. Pronghorn will move out of regions of heavy snow into areas where less snow allows access to forage and water (Yoakum, 1978). At these times, physical barriers such as fences frequently impede pronghorn movements and may affect survival rates by preventing both escape from increasing snow depths and access to available forage (Yoakum, 1978).

Pronghorn densities within the general study area are not expected to be high. The SDGFPD (1989a) reported that the majority of pronghorn in the region inhabit the area to the east of the general study area. Although pronghorn have not historically inhabited the region near the general study area (SDGFPD, 1989d), the SDGFPD (1989c) reported a pronghorn herd of approximately 30 animals east of Amherst, SD in the winter of 1988/1989. A second herd was observed to the east of the general study area, near Britton, SD (SDGFPD, 1989d). The herds probably moved south from North Dakota as a result of heavy snows (SDFGD, 1989d). In addition, two herds of pronghorn were observed within the general study area in September, 1989 (DPA, 1989). No pronghorn were observed in the general study area during 1988 and 1989 winter aerial surveys.

7.2.2.2.1 Tx- North Concentrated Study Area. The Tx-N CSA contains some habitat that could potentially support pronghorn. Open grassland, which is suitable pronghorn habitat, dominates the Tx-N CSA (Technical Study 5). Wetlands are also present throughout the CSA, comprising approximately 14 percent of the terrain (Technical Study 6). Temporarily and seasonally flooded wetlands (Technical Study 6), stock ponds and artesian wells present in the Tx-N CSA could attract pronghorn by providing the animals with a water source. However, there have not been any known recent documentations of pronghorn in the Tx-N CSA.

7.2.2.2.2 Tx-South Concentrated Study Area. Although pronghorn herds have not historically inhabited this area (SDGFPD, 1989d), the Tx-S CSA does support suitable pronghorn habitat. The two pronghorn herds observed in the Tx-S CSA in September 1989 (DPA, 1989) confirm that the Tx-S CSA could be used by pronghorn. Open fields that pronghorn frequent are not the most prevalent type of terrain within the Tx-S CSA, but abundant croplands (Technical Study 5) could provide a food source for pronghorn. Other forage types, however, are more important in the pronghorn diet (Yoakum, 1978; Kitchen and O'Gara, 1982).

7.2.2.3 Small furbearers. Small furbearers expected to be present in the general study area include muskrat, striped skunk, badger, coyote, red fox, raccoon, weasel and jackrabbit (SDGFPD, 1989b; Table 7-1). Wetlands comprise only approximately 6 percent of the general study area, the majority of which are temporarily and seasonally flooded (Technical Study 6) and could attract muskrat, striped skunk, red fox, weasel and raccoon (Fritzell, 1989; Kannowski, 1979).

Muskrat are common inhabitants of wetlands as they feed and build dens in wetlands. Although muskrats inhabit a variety of wetland types, semipermanent or permanent wetlands that retain water throughout the winter are optimal muskrat habitat (Perry, 1982; Fritzell, 1989; Kannowski, 1979). These preferred wetlands are not the most prevalent types in the general study area, but some semipermanent wetlands are present (Technical Study 6) and could provide suitable muskrat habitat. Temporary wetlands, which hold water for only a few weeks of the growing season, and seasonal wetlands, which hold water for more extended periods (Technical Study 6), predominate in the general study area. These dominant wetland types offer suitable foraging for both striped skunk and red fox which feed on waterfowl and small wetland mammals, among other forage types (Fritzell, 1989; Kannowski, 1979;). Raccoon use wetlands of the type present in the study area for foraging and denning, and weasel may frequent wetland areas in search of small mammal prey (Fritzell, 1989).

Although beaver have been reported throughout Day, Brown and Marshall counties (SDGFPD, 1989b), they generally require stream and pond habitat (Hill, 1982; Fritzell, 1989; Kannowski, 1979). Because these habitat types comprise only approximately 2 percent of the wetlands present in general study area (Technical Study 6), beaver are not likely to inhabit the general study area in large numbers. Similarly, mink inhabit the region of Day, Brown and Marshall counties (SDGFPD, 1989b), but are not likely to be abundant in the general study area because they typically favor semipermanent or permanent wetlands (Kannowski, 1979; Fritzell, 1989) which comprise only approximately 17 percent of the wetlands present in the general study area (Technical Study 6).

Grasslands, present throughout the general study area, would provide suitable habitat for coyote, badger and jackrabbit (Bekoff, 1982; Lindzey, 1982; Dunn et al. 1982). Jackrabbit may also use wetlands of the study area for resting (Kannowski, 1979).

7.2.2.3.1 Tx-North Concentrated Study Area. Open grassland dominates the Tx-N CSA (Technical Study 6) and provides suitable habitat for coyote, badger and jackrabbit. Wetlands are present throughout the Tx-N CSA, comprising approximately 14 percent of the terrain, most of which are temporarily and seasonally flooded (Technical Study 6). Striped skunk, red fox, weasel and raccoon may use these wetlands for foraging. Muskrat are also likely to be present throughout the study area near wetlands, except during times of drought or other periods when these wetlands do not hold water.

7.2.2.3.2 Tx-South Concentrated Study Area. In contrast to the abundant open grasslands of the Tx-N CSA, croplands that are less likely to attract coyote, badger and jackrabbit dominate the Tx-S CSA (Technical Study 5). The wetlands of the Tx-S CSA are similarly less appealing to small furbearers than those of the Tx-N CSA. Although there are similar numbers of wetlands in both Tx CSAs, the majority of wetlands in the Tx-S CSA are temporarily flooded croplands. They do not support typical wetland vegetation, such as cattails and bulrushes, (Technical Study 6) that would attract small furbearers.

Muskrat use cattails, bulrushes and other typical wetland vegetation for forage and den building. Similarly, small wetland mammals, which provide food for furbearers, generally forage on typical wetland vegetation rather than the crops which dominate the wetlands in the Tx-S CSA (Fritzell, 1989). The absence of an abundant food source for red fox, stiped skunk, weasel and raccoon reduces the likelihood of these animals inhabiting the Tx-S CSA in large numbers.

7.2.3 Receive Site

7.2.3.1 White-tailed deer. The range of white-tailed deer extends throughout Minnesota, including the Thief River Falls study area (Fig. 7-7). As winter approaches, deer in Minnesota typically move into swamps and marshes with thick vegetation (Rongstad and Tester, 1969). During winter months, deer movements are typically more restricted than in summer. This behavior pattern probably serves as a means of conserving energy during the stressful winter season (Mooty and Karns, 1987). Warmer temperatures and decreasing snow depths of spring allow deer to return to upland woods and fields (Hesselton and Hesselton, 1982; Rongstad and Tester 1969).

Availability of winter habitat is a critical factor in limiting the deer population in cold regions (Halls, 1978; Hesselton and Hesselton, 1982). The dense cover of marshes and swamps supply deer with necessary protection from predators, hunters, snow and cold. White cedar *(Thuja occidentalis)* swamps in particular provide good wintering habitat for deer (Rongstad and Tester, 1969). Balsam fir *(Abies balsamea)* is also an important source of winter cover for deer (Wetzel et al, 1975). Mooty and Karns (1987) reported that areas characterized by a mixture of balsam fir, trembling aspen *(Populus tremuloides)* and paper birch *(Betula papyrifera)* were particularly important habitats for deer in Minnesota during the winter, but were also utilized throughout the remainder of the year. Although white cedar, balsam fir and paper birch do not occur in the general study area, limited numbers of forested wetlands are present (Technical Study 6) and could serve as wintering areas for deer. Trembling aspen is also present in both forested wetlands and shelterbelts of the general study area (Technical Studies 5 and 6) and could provide winter cover for deer.

Deer observations during 1988 and 1989 aerial surveys illustrate the importance of cover provided by woodlands and marshes as wintering habitat for deer. Although few deer were observed in marshes or woods during fall 1987 by avian research personnel, 88 percent of deer groups sighted (88 percent total animals) were observed in woodlands and 10 percent of the groups sighted (9 percent total animals) were observed in marshes during the winter 1988 aerial surveys (Table 7-2). During 1989 aerial surveys, 96 percent of the deer groups observed (91 percent total animals) were in woods. No deer were observed in marshes during 1989 aerial surveys (Table 7-2), suggesting that woods in the general study area are more important for deer than marshes during winter months. Woodlands and wetlands each comprise approximately 6 percent of the general study area (Technical Study 5 and 6). Although these habitat types are relatively scarce, the high percentage of deer observed in these areas during aerial flights illustrates that they are important wintering areas for deer. Concentrations of deer were observed in the easternmost portion of the general study area (Figs. 7-11 and 7-12), where wetlands and woodlands are probably responsible for attracting deer.

Deer inhabit a variety of areas during summer months. Suitable summer habitat is generally comprised of an interspersion of woodlots, fields and shrublands (Hesselton and Hesselton, 1982). Areas characterized by either dense vegetation or complete lack of cover are less likely to attract a large deer population during these seasons (Hazard, 1982). Fields, pastures and hay lands with some intermittent cover provide suitable summer habitat for deer (Hesselton and Hesselton, 1982; Kohn and Mooty, 1971). Deer in Minnesota also use upland deciduous and mixed woods throughout the summer and early fall (Kohn and Mooty, 1971). Wooded areas and fields are present throughout the general study area that could provide suitable deer habitat throughout summer and fall. Pasture and hay land, however, are not abundant (Technical Study 5).

As is typical of deer inhabiting northern areas, white-tailed deer in Minnesota utilize many different plant species for forage. Although primarily browsers, feeding on the stems, twigs and leaves of woody growth, their diet is dictated by forage availability (Hesselton and Hesselton, 1982). Both browse and succulent forbs contribute to the deer's diet (Halls, 1978). A study of deer foraging patterns during summer months in north-central Minnesota showed that 68 percent of deer forage consisted of browse species and 32 percent consisted of forb species (Kohn and Mooty, 1971). Although deer are likely to forage on grasses as well, these species are not thought to comprise a significant amount of deer forage (Halls, 1978; Kohn and Mooty, 1971).

Of browse species foraged, hazel *(Corylus* spp.), quaking aspen, willow, paper birch, maple *(Acer* spp.) and dogwood *(Cornus* spp.) are among those preferred by deer. Preferred forb species include aster *(Aster* spp.), purple pea *(Lathyrus venosus)*, jewelweed *(Impatiens pallida)*, bracken fern *(Pteridium aquilinum)*, goldenrod *(Solidago* spp.) and juneberry *(Amelanchier* spp.). Young vegetation is generally preferred over older, mature growth (Wetzel et al., 1975; Kohn and Mooty 1971). Although the above vegetation has been shown to be

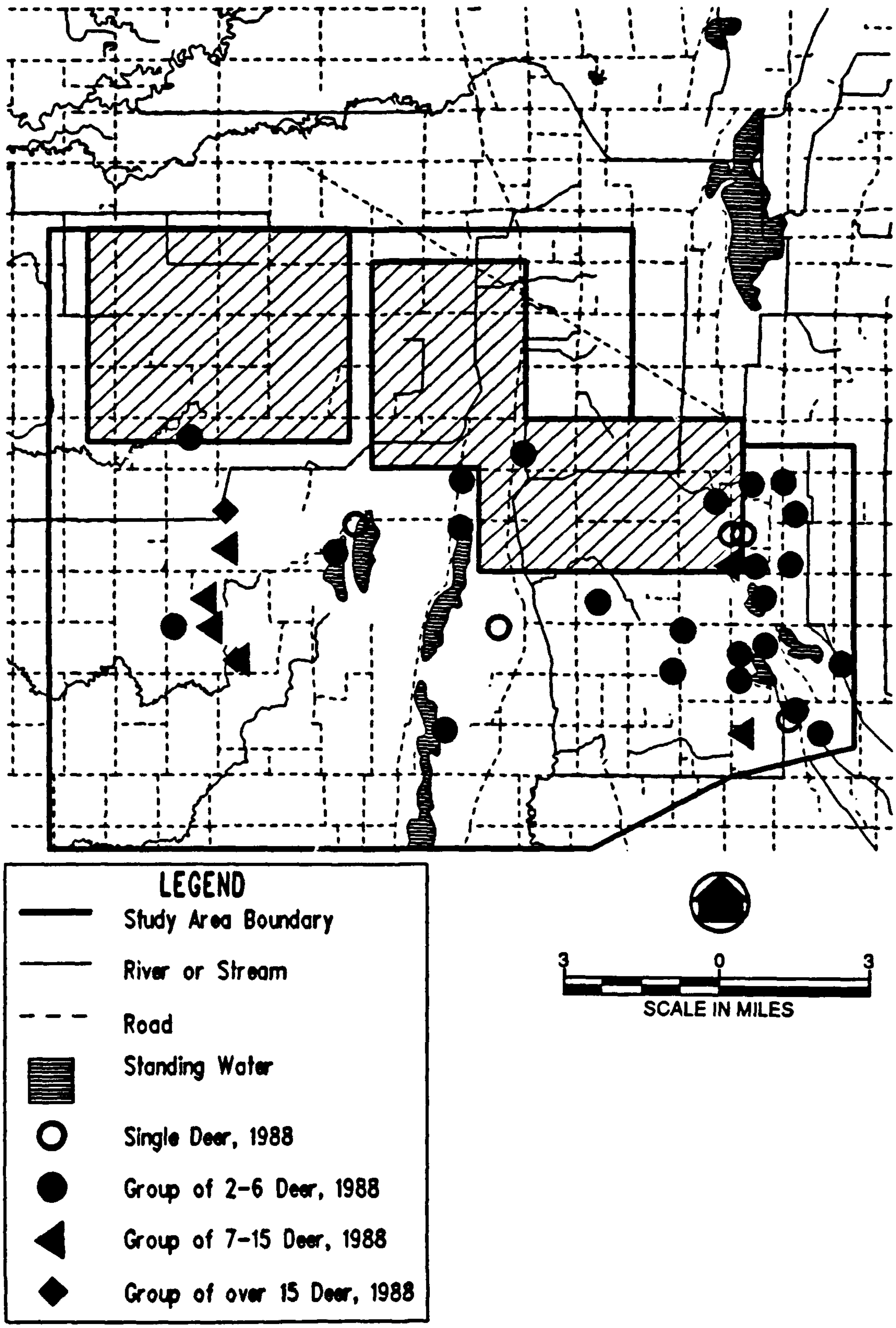


FIGURE 7-11. THIEF RIVER FALLS, MN RECEIVE STUDY AREA 1988 AERIAL DEER OBSERVATIONS

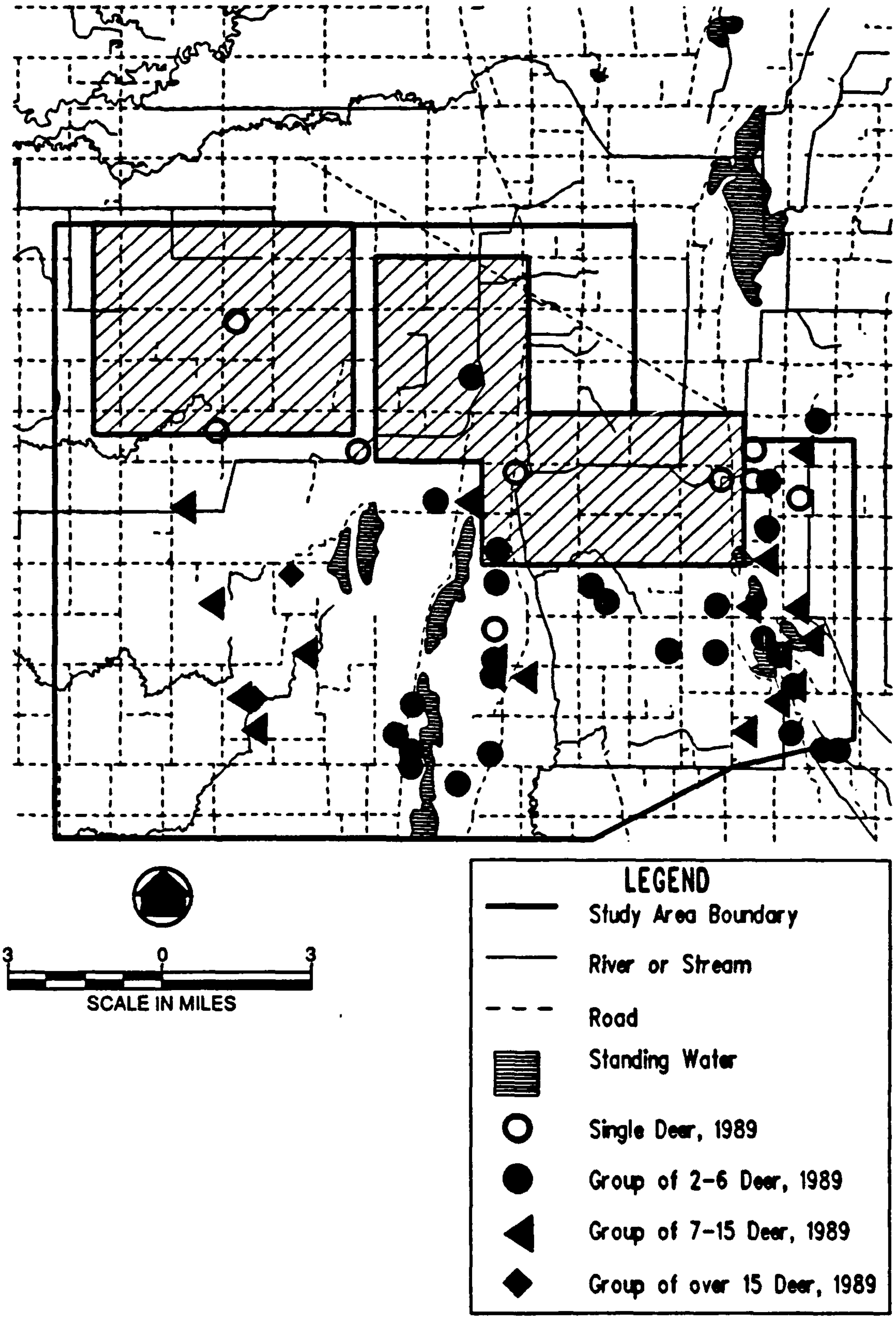


FIGURE 7-12. THIEF RIVER FALLS, MN RECEIVE STUDY AREA 1989 AERIAL DEER OBSERVATIONS

preferred, deer are capable of adapting their foraging patterns in response to habitat conditions (Hesselton and Hesselton, 1982). Still, areas supporting preferred forage are more likely to attract and support large deer populations (Kohn and Mooty, 1971). Deer in agricultural areas may also forage on crops, such as corn, alfalfa and soybeans (Hesselton and Hesselton, 1982). Corn and soybeans are grown throughout the general study area (Technical Study 5) and could be a food source for deer. In the general study area willow, quaking aspen, goldenrod, and aster species could provide forage for deer.

The densities of deer in the general study area during different seasons are not known. The MNDNR (1989a) does not record deer census data throughout the year in the region that includes the general study area. The MNDNR (1989c) did record, however, that a deer feeder in Section 14 of Bray Township in the general study area (Fig. 7-3) fed approximately 60 deer during the 1988/1989 winter. The MNDNR estimated deer concentrations during the 1988/1989 winter to be 15 deer per square mile of habitat in western Pennington county (1989c). Overall deer concentrations are estimated to be approximately 4-5 deer per square mile in the region that includes the general study area (MNDNR, 1989e).

Deer densities estimated from 1988 and 1989 aerial survey results are lower than MNDNR estimates. The combined data from 1988 and 1989 aerial surveys yield minimum deer densities of approximately .7 to 1.9 deer per square mile. These are, however, undoubtedly minimum estimates because an unknown number of animals are always missed when conducting surveys of this type. During winter 1988 aerial surveys of the general study area, 40 deer groups (206 total animals) were observed in the general study area. During the two mammal surveys conducted in January 1989, 15 deer groups (83 total animals) were observed in the general study area in the morning survey, and 17 groups (76 total animals) in the afternoon survey. During the February 1989 aerial surveys, 20 deer groups (116 total animals) were observed in the morning survey and 14 groups (74 total animals) in the afternoon survey (Table 7-2).

7.2.3.1.1 Rx-East Concentrated Study Area. The Rx-E CSA contains more attractive winter habitat than the Rx-W CSA. Woodlands and marshes that provide deer with winter cover are more abundant there than in the Rx-W CSA (Technical Studies 5 and 6). Results of the 1988 and 1989 aerial surveys show that there is a higher deer population at the Rx-E CSA than at the Rx-W CSA during winter. Four deer groups were seen in the Rx-E CSA during surveys conducted in both years (Figs. 7-11 and 7-12).

The agricultural land that dominates the CSA (Technical Study 5) could provide a food source for deer during summer, as well as for animals travelling through the area during the entire of the year. Shrub grassland and natural and planted tree stands in the Rx-W CSA provide suitable summer habitat for deer.

7.2.3.1.2 Rx-West Concentrated Study Area. Winter deer populations are likely to be lower in the Rx-W CSA than in the Rx-E CSA because heavy cover provided by marshes and woods is not abundant in the Rx-W CSA (Technical Studies 5 and 6). Woodlands or shelterbelts that could provide deer with necessary cover comprise only 2 percent of the Rx-W CSA (Technical Study 5). Wetlands are similarly scarce, comprising approximately 4 percent of the concentrated study area. The majority of the wetlands in the CSA are characterized as palustrine emergent and do not support the woody cover which deer depend upon for protection during winter months (Technical Study 6).

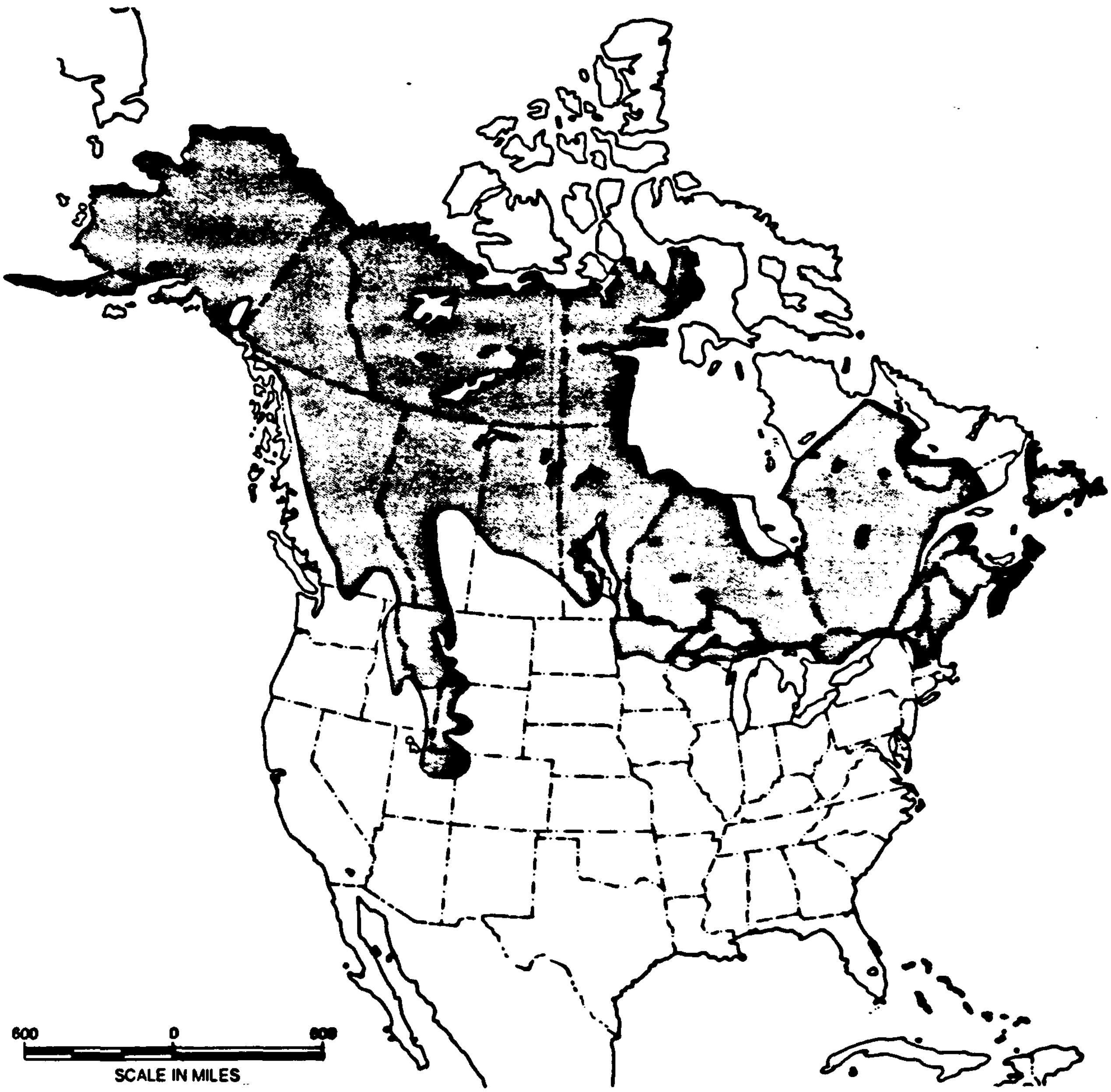
The relatively few deer groups observed in the Rx-W CSA, as compared to the general study area overall, during both 1988 and 1989 aerial surveys confirm that attractive winter deer habitat is not present there. During 1988 aerial surveys, a single deer group on the boundary of the CSA was observed (Fig. 7-11). Aerial surveys conducted in 1989 yielded similar results, as only two animals, one on the CSA boundary, were observed (Fig. 7-12).

As in the Rx-E CSA, crops are prevalent in the Rx-W CSA (Technical Study 5) that could serve as a food source for deer. Summer habitat present for deer in the Rx-W CSA does not differ significantly from that available in the Rx-E CSA and includes shrub grassland and natural and planted tree stands.

7.2.3.2 Moose. The general study area is located near the southern boundary of the present day distribution of moose (Fig. 7-13), which are inhabitants of northern boreal forests (Franzman 1978). In Minnesota, habitat comprised of an interspersion of quaking aspen, willow and marsh is important habitat for moose (Coady, 1982). This type of habitat is present but not predominant within the general study area (Technical Studies 5 and 6). Moose in Minnesota typically move into marshes and other lowlands in spring and remain there throughout the summer (Phillips et al., 1973). The onset of winter induces a move into upland, densely wooded areas (Phillips et al., 1973; Peek et al., 1974). This habitat change probably serves to optimize forage conditions, as upland wooded areas offer moose suitable browse forage throughout winter months (Coady, 1982). Spring movement out of wintering areas appears to be correlated with decreasing snow depths (Phillips et al. 1973; Van Ballenberghe and Peek 1971).

Observations of moose during the winter aerial surveys demonstrate that woods are the habitat type most frequented by moose during winter. Although wooded areas comprise only about 6 percent of the terrain of the general study area (Technical Study 5), the majority of moose observed were in woods. Of the moose observed, 84 percent of the groups (84 percent total animals) were in woodlands during 1988 surveys and 97 percent of the groups (97 percent total animals) during 1989 surveys (Table 7-3).

Forage availability is an important factor influencing moose abundancy. Moose generally prefer early successional stages of woody browse throughout the year, although it is particularly important forage in winter when it may be the only available food source (Franzman 1978). Balsam fir, quaking aspen, and paper birch are among the most significant forage species in the Minnesota region (Coady, 1982; Allen, 1979). Red osier dogwood *(Cornus stolonifera)* also supplies nutritious food for moose in Minnesota throughout the fall until winter, when its use may be precluded by snow cover (Coady, 1982). Red osier dogwood and quaking aspen are present throughout the general study area. Balsam fir and paper birch, however, are absent from the general study area (Technical Study 5). Willow *(Salix spp.)*, which moose browse on throughout the year (Phillips et al., 1973; Van Ballenberghe and Peek, 1971), also grows



Source: Coady (1982)

FIGURE 7-13. RANGE OF MOOSE IN NORTH AMERICA

TABLE 7-3. NUMBERS OF MOOSE AND HABITAT USE OBSERVED DURING THIEF RIVER FALLS, MN LARGE MAMMAL AERIAL SURVEYS.

				% Groups (%Individuals)				
Date	# Flights	# Groups	#Individuals	Marsh	Woods	Shelterbelt	Fields	Crops
1988	2	46	119	13(13)	84(84)	0(0)	3(3)	0(0)
1989	4	88	235	1(1)	97(97)	<1(<1)	0(0)	1(1)

throughout the general study area (Technical Study 5). Other preferred moose forage species include mountain ash *(Sorbus americana)*, juneberry, red maple *(Acer rubrum)*, fire cherry *(Prunus pennsylvanica)*, squashberry *(Viburnum edule)*, black ash *(Fraxinus nigra)* and american yew *(Taxus canadensis)* (Allen, 1979).

Small, shallow lakes that support aquatic vegetation are important foraging areas for moose during spring and summer months (Coady, 1982). Aquatic vegetation may be an important spring source of protein and sodium for moose. Moose typically enter spring very depleted of these nutrients (Allen, 1979). Millfoil *(Myriophyllum exalbescens)* and cattail are among preferred forage species throughout the summer (Phillips et al., 1973). Cattail species are present in palustrine emergent wetlands and drainages throughout the general study area and could also provide food for moose (Technical Study 6).

Census data for moose in the region during different seasons is not available (MNDNR, 1989c; MNDNR, 1989e). The MNDNR (1989e) reports that the general study area is located within a region supporting good moose habitat. MNDNR observations during the 1988/1989 winter indicated that moose were slightly less abundant than deer in western Pennington County. Moose were most prevalent near Goose Lake marsh (Fig. 7-3) (MNDNR, 1989c). The MNDNR conducts January censuses in two moose census areas that are within the easternmost portion of the general study area (Fig. 7-14). The MNDNR recorded 28 moose in area 167 in 1989, 30 moose in area 167 in 1985 and 23 moose in area 169 in 1984 (MNDNR, 1989b).

Winter aerial surveys conducted over the general study area in 1988 and 1989 permitted rough estimates of the resident winter moose population. During 1988 aerial surveys of the general study area, a total of 46 groups of moose (119 total animals) were observed (Fig. 7-15; Table 7-3). During January 1989 surveys, 15 moose groups (49 total animals) were observed in the morning surveys and 24 groups (53 total animals) in the afternoon. During February 1989 surveys, 39 moose groups (102 total animals) were sighted in the morning and 25 moose groups (71 total animals) in the afternoon (Fig 7-16; Table 7-3). These 1988 and 1989 aerial observations yield approximate moose

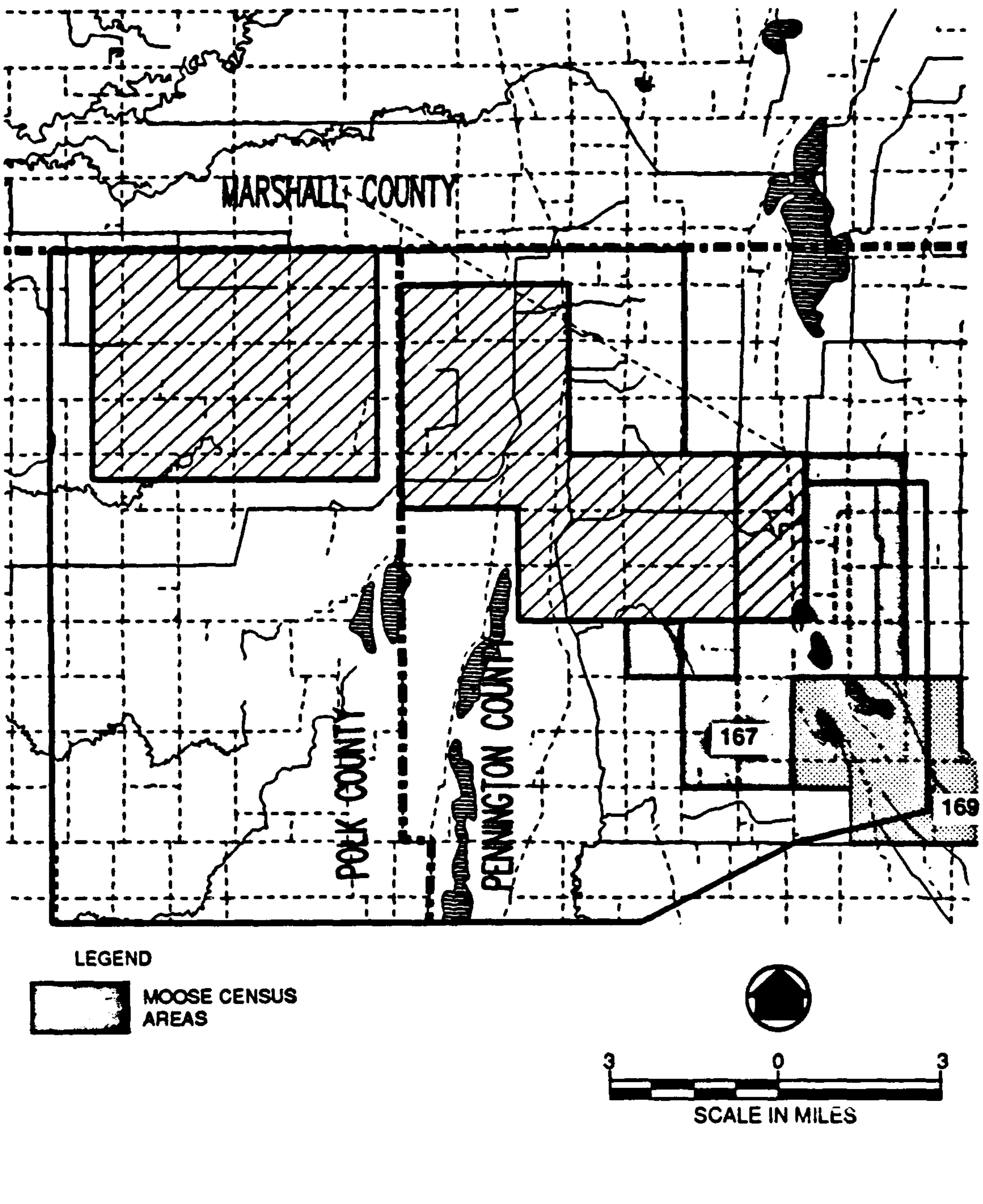


FIGURE 7-14. THIEF RIVER FALLS, MN RECEIVE STUDY AREA MNDNR MOOSE CENSUS AREAS/

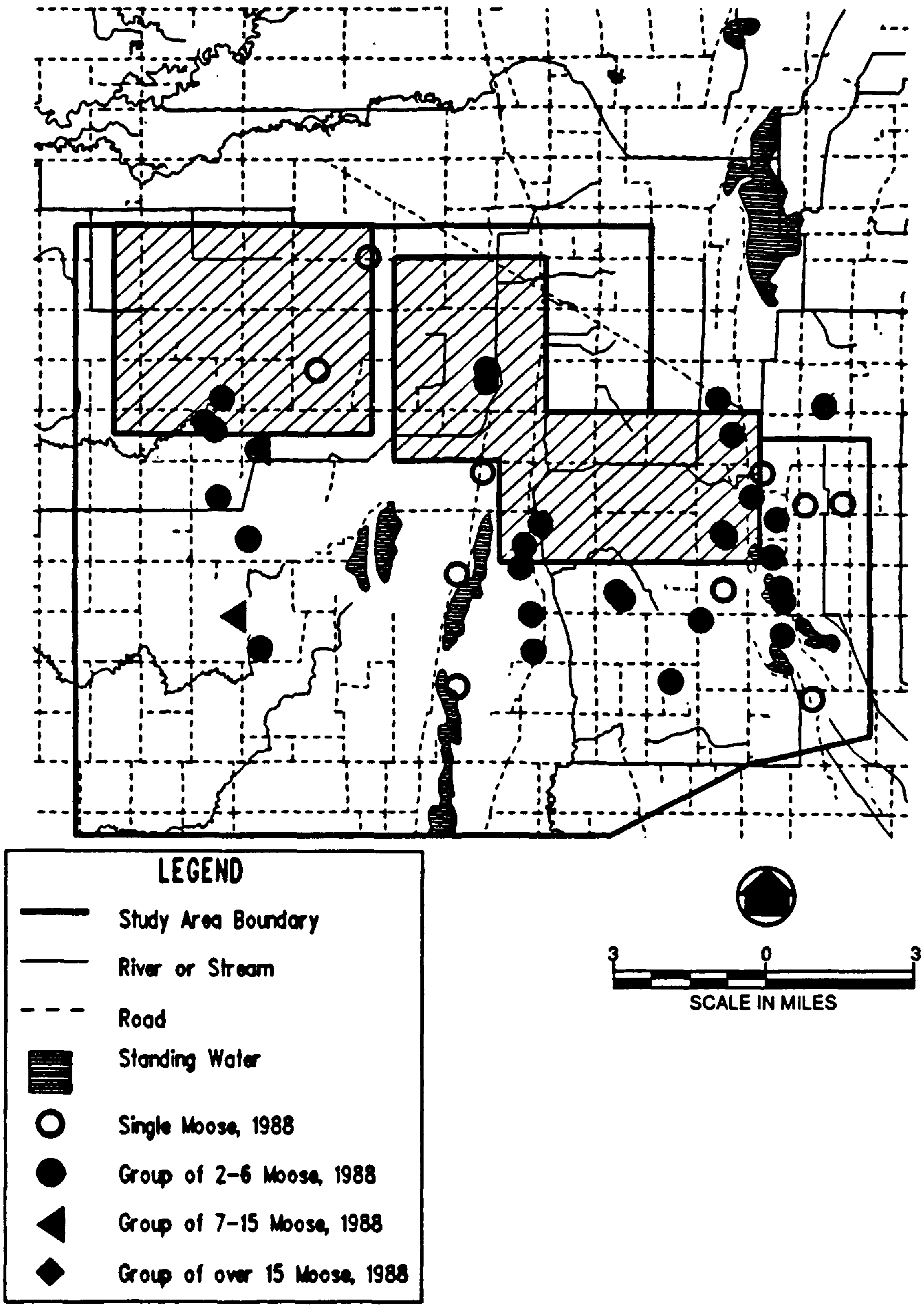


FIGURE 7-15. THIEF RIVER FALLS, MN RECEIVE STUDY AREA/ 1988 AERIAL MOOSE OBSERVATIONS

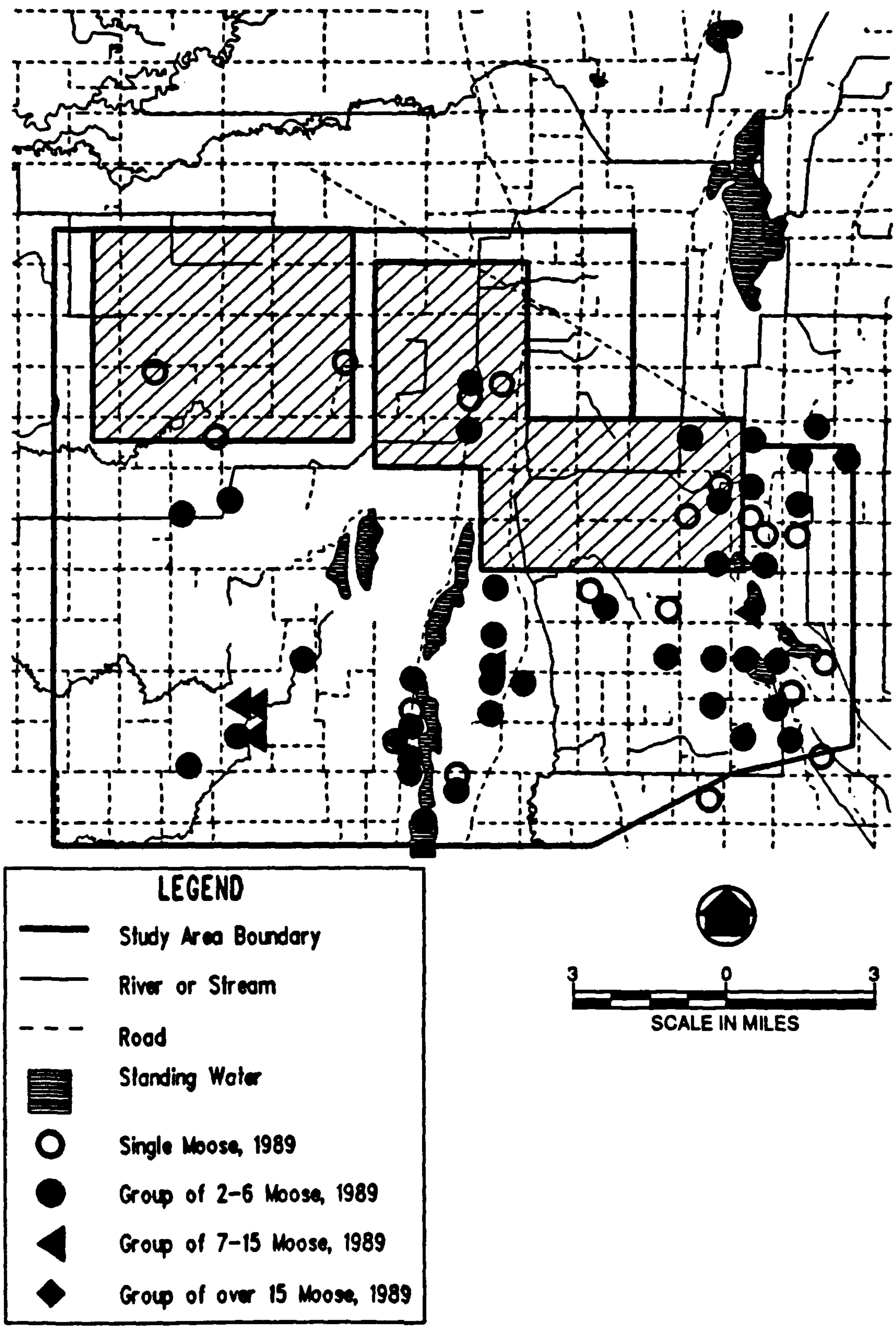


FIGURE 7-16. THIEF RIVER FALLS, MN RECEIVE STUDY AREA/ 1989 AERIAL MOOSE OBSERVATIONS

densities of .4 to 1.1 moose per square mile within the general study area. These are, however, undoubtedly minimum estimates because an unknown number of animals are always missed when conducting aerial surveys of this type.

7.2.3.2.1 Rx-East Concentrated Study Area. The Rx-E CSA is likely to attract more moose than the Rx-W CSA because woodlands and wetlands that offer suitable moose habitat are more prevalent in the Rx-E CSA. In addition, these types are abundant on the eastern edge of the general study area near the Rx-E CSA therefore increasing the attractiveness of the Rx-E CSA for moose (Technical Studies 5 and 6). Wetlands in the concentrated study area are both palustrine emergent and palustrine scrub/shrub, which contain preferred forage species such as cattails, willow and aspen (Technical Study 6). Wooded areas are present throughout the concentrated study area (Technical Study 5) and provide good wintering habitat for moose.

Wooded areas and wetlands are most abundant in the easternmost portion of the Rx-E CSA (Technical Studies 5 and 6), which probably provides good habitat for moose year round. During 1988 aerial surveys, 4 moose groups were sighted in this area, and 5 were observed in 1989 (Figs. 7-15 and 7-16). The western section of the CSA also contains sections of wooded areas and wetlands that would provide attractive habitat for moose. In 1988, 2 moose groups were sighted in this region, and 4 groups were observed there in 1989 (Figs.7-15 and 7-16).

7.2.3.2.2 Rx-West Concentrated Study Area. The Rx-W CSA as a whole does not offer moose attractive habitat because cropland and grassland, which are generally not preferred moose habitats, dominate the terrain (Technical Study 5). Although natural wooded areas are scarce in the CSA, there is a concentration of these woodlands in the southwest corner of the CSA (Technical Study 5) that could attract moose. Five moose groups were sighted in the CSA during 1988 aerial surveys (Fig. 7-15) and three animals were observed there during 1989 aerial surveys (Fig. 7-16), the majority of which were in or near this wooded region.

The lack of preferred moose forage throughout the Rx-W CSA also reduces the likelihood that the CSA would attract a large moose population. Although wooded areas support red osier dogwood and quaking aspen, both of which are preferred by moose, wooded areas are generally scarce, as stated above. Small wetlands are present throughout the Rx-W CSA, and support cattails that might attract foraging moose. However, these areas are scarce, comprising only 4 percent of the CSA (Technical Study 6).

7.2.3.3 Small Furbearers. Habitat which could support small furbearers is present throughout the general study area, and according to the MNDNR (MNDNR, 1989c; MNDNR, 1989d; MNDNR, 1989e), small furbearers are likely to inhabit the general study area. Striped skunk and red fox are reported to be abundant in the region including the general study area. In addition, wetland areas of the region support moderate populations of muskrat, mink and raccoon. According to the MNDNR (1989c; 1989d; 1989e) other furbearers which occasionally inhabit the region of the general study area include coyote, bobcat, badger and weasels.

7.2.3.3.1 Rx-East Concentrated Study Area. The Rx-E CSA is characterized by habitat which is generally more attractive to small furbearers than that of the Rx-W CSA. Red fox and striped skunk are probably present in the Rx-E CSA in higher numbers because wooded areas are more abundant there as compared to the Rx-W CSA (Technical Study 5). Similarly, wetlands are more prevalent in the Rx-E CSA (Technical Study 6), which therefore offers more attractive habitat for raccoon and muskrat. Although bobcat are probably rare in the Rx-W CSA, they may be found in the easternmost portion of the Rx-E CSA, where an interspersion of woods and wetlands provides suitable habitat (Technical Studies 5 and 6). Coyote, badger and weasel are likely inhabit the the Rx-E CSA in numbers similar to those of the Rx-W CSA. Because suitable mink habitat is not present within the Rx-E CSA, mink are not likely to be found.

7.2.3.3.2 Rx-West Concentrated Study Area. The Rx-W CSA offers suitable habitat for some small furbearers. Red fox probably inhabit the Rx-W CSA in fairly high numbers, as they prefer an interspersion of open and wooded habitats (Samuel and Nelson, 1982). Similarly, striped skunk is typically attracted to brushland and woodland near wetlands, and is therefore likely to be present in the concentrated study area (Godin, 1982). Wetlands present in the CSA provide suitable raccoon and muskrat habitat (Kaufmann, 1982; Perry, 1982). It is unlikely, however, that there is a high raccoon or muskrat population in the CSA because wetlands, while present, are not abundant, comprising only approximately 4 percent of the overall CSA terrain (Technical Study 6). Likewise, mink probably do not inhabit the CSA because of the lack of wetland habitat (Linscome et al., 1982; Technical Study 6). Furthermore, mink are most often found near streams and lakes (Linscombe et al., 1982), which are scarce within the Rx-W CSA (Technical Study 6). Coyote, badger and weasels may also inhabit the concentrated study area in lower numbers. Bobcat are probably rare within the CSA because they prefer swamps and forests (McCord and Cardoza, 1982), which are not prevalent (Technical Studies 5 and 6).

7.3 ENVIRONMENTAL CONSEQUENCES

The USAF has conducted a number of environmental studies to gather baseline habitat and wildlife information in each study area in order to identify potential impacts to mammal species. Potential impacts upon mammals have been avoided or minimized whenever possible when determining the Tx and Rx preliminary site layouts (Technical Study 1, EIAP Overview), which are illustrated in Figures 7-17 through 7-20. For example, the abundance of woodlands and wetlands on the eastern edge of the Rx-E CSA was identified as a potential wintering area for white-tailed deer and was consequently avoided for location of the facilities. Other large wetland complexes and wooded areas which are expected to support mammal species have also been avoided during the site selection process. These measures are expected to significantly reduce potential impacts to mammals.

The following section evaluates the potential impacts of the CRS project on the mammals in the study areas, and discusses possible mitigation measures to further reduce these impacts. Many of the details of these mitigation concepts will be subsequently developed as the site selection, system design, and mitigation process evolves, and will be included in the USAF's comprehensive mitigation plan.

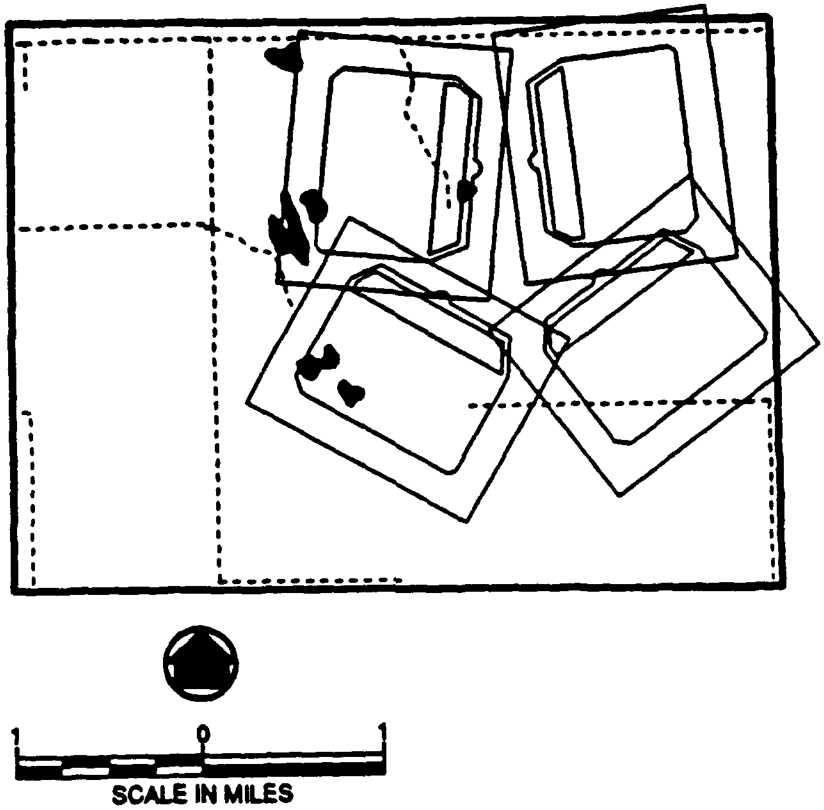


FIGURE 7-17. TX-NORTH PRELIMINARY SITE LAYOUT

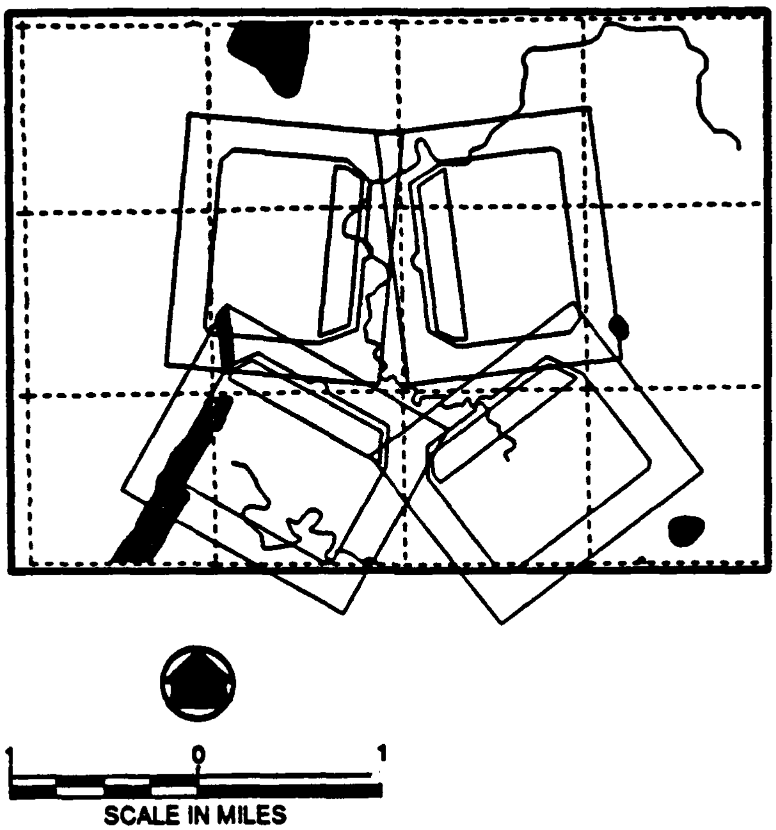


FIGURE 7-18. TX-SOUTH PRELIMINARY SITE LAYOUT

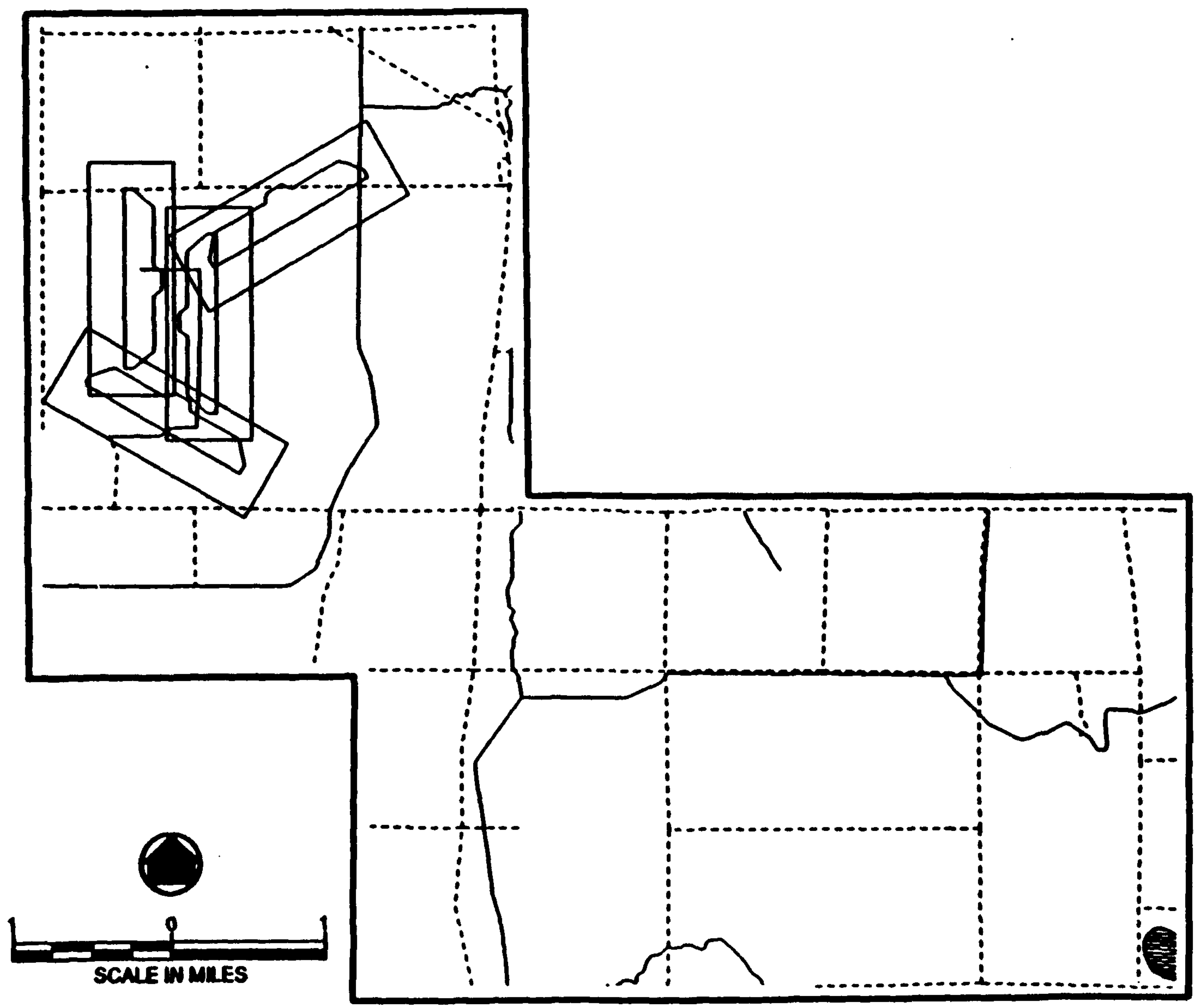


FIGURE 7-19. RX-EAST PRELIMINARY SITE LAYOUT

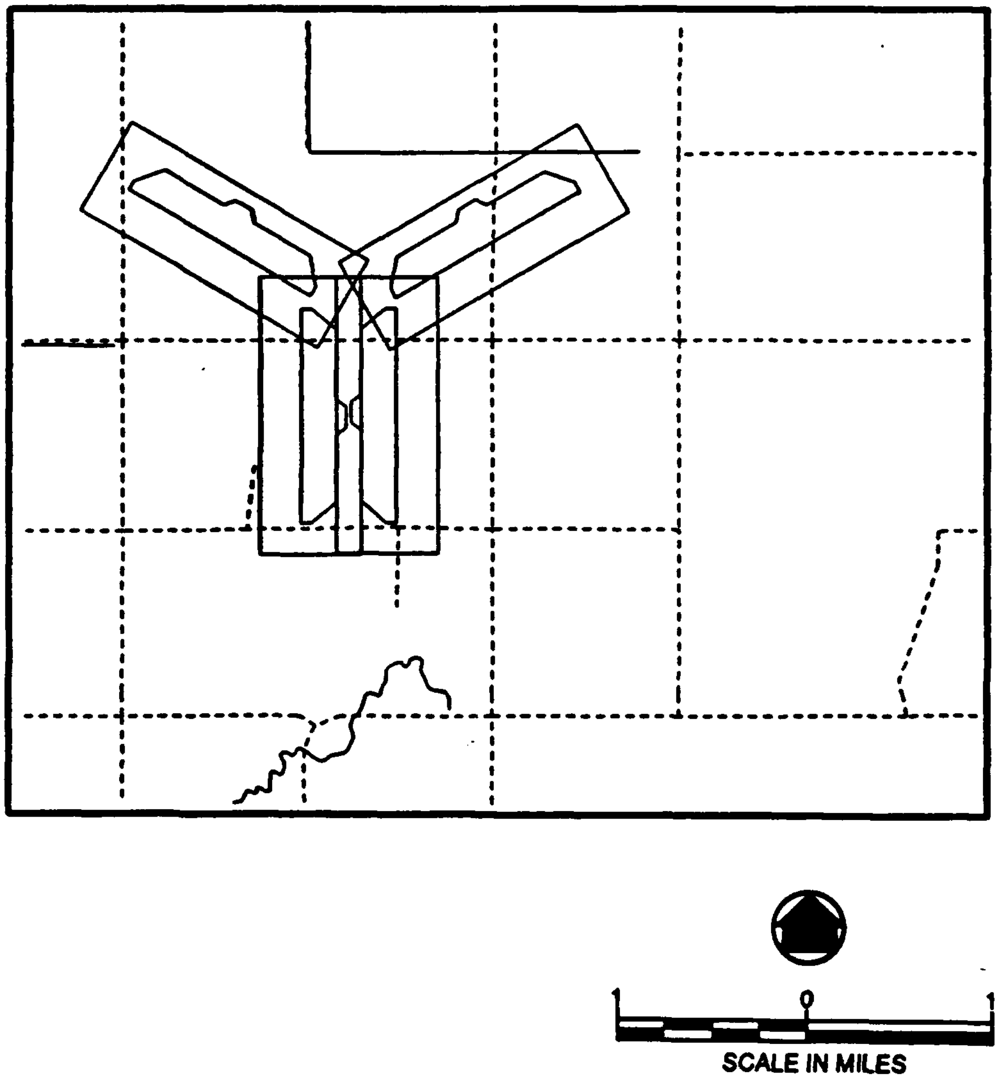


FIGURE 7-20. RX-WEST PRELIMINARY SITE LAYOUT

7.3.1 General Impacts

Potential impacts of the CRS on regional mammal populations considered in this consequences section include loss of habitat, interference with movements, increased human-caused mortality, and, at the Tx CSAs, exposure to radiofrequency radiation (RFR).

Habitat will be lost to mammals through either removal, due to the construction of the antenna and groundscreen, support building, roads and fences, or, in the case of the Tx site, exclusion by the protective fence. The amounts of wetlands and woodlands taken by each preliminary site layout were quantified (Technical Studies 5 and 6) and compared for each CSA within the Tx and Rx study areas to determine if potential impacts differed significantly between CSAs. The habitat contained by the buffer zone was also examined to determine if facility shifts would alter the expected impacts.

The extensive physical barrier created by the four sectors also has the potential to disrupt the movements of deer, moose and pronghorn. The extent to which this impact will significantly affect these mammals, and the differences in magnitude of this impact are examined at each CSA.

Some human-caused mortality, primarily through collisions with project vehicles, will probably be the direct result of project related vehicular traffic. The significance of this impact and time periods when this impact will be highest are examined and compared for both CSAs within each general study area to determine if this impact differs significantly between the preliminary site layouts. The potential impact to mammals from RFR exposure at both Tx CSAs is also examined.

This impact analysis is directed toward the species of concern presented earlier in the affected environment section, which have been identified through communication with the SDGFPD and the MNDNR, and through field surveys (as discussed in Section 7-2). Potential impacts upon these species are presented in Tables 7-4 and 7-5 to allow comparison and identification of possible mitigation measures. Impacts to white-tailed deer, moose, and

TABLE 7-4. POTENTIAL IMPACTS UPON MAMMALS OF CONCERN AT THE AMHERST, SD STUDY AREA

Species	Tx-N		Tx-S	
	Impact	Mitigation/Remarks	Impact	Mitigation/Remarks
Large Mammals				
White-tailed deer	Winter habitat loss; disruption of movements; increased human-caused mortality	Avoid marshes; enforce speed limits	Winter habitat loss; disruption of movements; increased human-caused mortality	Avoid marshes; enforce speed limits; less likely to attract deer than Tx-N
Pronghorn	Disruption of movements; increased human-caused mortality	Rare use of area; minute impact; no mitigation anticipated	Disruption of movements; increased human-caused mortality	Slight use of area; minute impact; no mitigation anticipated
Small Mammals				
Muskrat	Habitat loss; increased human-caused mortality	Avoid wetlands; enforce speed limits	Habitat loss; increased human-caused mortality	Avoid wetlands; enforce speed limits; habitat less prevalent than in Tx-N
Striped Skunk	Habitat loss; increased human-caused mortality	Avoid wetlands; enforce speed limits	Habitat loss; increased human-caused mortality	Avoid wetlands; enforce speed limits; habitat less prevalent than in Tx-N
Badger	Habitat loss; increased human-caused mortality	Minute impact; enforce speed speed limits	Habitat loss; increased human-caused mortality	Minute impact; enforce speed limits

TABLE 7-4 (Continued). POTENTIAL IMPACTS UPON MAMMALS OF CONCERN AT THE AMHERST, SD TRANSMIT STUDY AREA

	Tx-N		Tx-S	
Species	Impact	Mitigation/Remarks	Impact	Mitigation/Remarks
Small Mammals (Continued)				
Coyote	Habitat loss; increased human-caused mortality	Minute impact; enforce speed limits	Habitat loss; increased human-caused mortality	Minute impact; enforce speed limits
Red fox	Habitat loss; increased human-caused mortality	Avoid wetlands; enforce speed limits	Habitat loss; increased human-caused mortality	Avoid wetlands; enforce speed limits; habitat less prevalent than in Tx-N
Racoon	Habitat loss; increased human-caused mortality	Avoid wetlands; enforce speed limits	Habitat loss; increased human-caused mortality	Avoid wetlands; enforce speed limits; habitat less prevalent than in Tx-N
Jackrabbit	Habitat loss; increased human-caused mortality	Avoid wetlands; enforce speed limits	Habitat loss; increased human-caused mortality	Avoid wetlands; enforce speed limits; habitat less prevalent than in Tx-N
Weasel	Habitat loss; increased human-caused mortality	Avoid wetlands; enforce speed limits	Habitat loss; increased human-caused mortality	Avoid wetlands; enforce speed limits; habitat less prevalent than in Tx-N

TABLE 7-5. POTENTIAL IMPACTS UPON MAMMALS OF CONCERN AT THE THIEF RIVER FALLS, MN RECEIVE STUDY AREA

Species	RX-W Impact	RX-W Mitigation/Remarks	RX-E Impact	RX-E Mitigation/Remarks
Large Mammals				
White-tailed Deer	Winter habitat loss; disruption of movements; increased mortality	Avoid marshes and woods; enforce speed limits	Winter habitat loss; disruption of movements; increased human-caused mortality	Avoid marshes and woods; enforce speed limits
Moose	Habitat loss; disruption of movements; increased human-caused mortality	Avoid marshes and woods; enforce speed limits	Habitat loss; disruption of movements; increased human-caused mortality	Avoid marshes and woods; enforce speed limits
Small Mammals				
Striped Skunk	Habitat loss; increased human-caused mortality	Avoid wetlands and woodlands; enforce speed limits	Habitat loss; increased human-caused mortality	Avoid wetlands and woodlands; enforce speed limits
Red Fox	Habitat loss; increased human-caused mortality	Avoid wetlands woodlands; enforce speed limits	Habitat loss; increased human-caused mortality	Avoid wetlands and woodlands; enforce speed limits
Muskrat	Habitat loss; increased human-caused mortality	Avoid wetlands; enforce speed limits	Habitat loss; increased human-caused mortality	Avoid wetlands; enforce speed limits
Raccoon	Habitat loss; increased human-caused mortality	Avoid wetlands; enforce speed limits	Habitat loss; increased human-caused mortality	Avoid wetlands; enforce speed limits

TABLE 7-5 (Continued). POTENTIAL IMPACTS UPON MAMMALS OF CONCERN AT THE THIEF RIVER FALLS, MN RECEIVE STUDY AREA

Species	Rx-W		Rx-E	
	Impact	Mitigation/Remarks	Impact	Mitigation/Remarks
Small Mammals (Continued)				
Coyote	Habitat loss; increased human-caused mortality	Low use of area; minute impact; no mitigation anticipated	Habitat loss; increased human-caused mortality	Low use of area; minute impact; no mitigation anticipated
Bobcat	Little	Habitat not present; minute impact; no mitigation mitigation anticipated	Habitat loss; increased human-caused mortality	Low use of area; minute impact no mitigation anticipated
Badger	Habitat loss; increased human-caused mortality	Low use of area; minute impact; no mitigation anticipated	Habitat loss; increased human-caused mortality	Low use of area; minute impact; no mitigation mitigation
Weasels	Habitat loss; increased human-caused mortality	Low use of area; minute impact; no mitigation anticipated	Habitat loss; increased human-caused mortality	Low use of area; minute impact; no mitigation anticipated

pronghorn are discussed in greater detail because of their documented occurrence in the concentrated study areas and their high economic importance due to their status as game animals.

7.3.2 Transmit Site

As Table 7-4 indicates, white-tailed deer, pronghorn and numerous small furbearers are considered the potentially-affected mammal species at the Amherst transmit CSAs. Potential impacts to these species at each Tx CSA are discussed below.

7.3.2.1 White-tailed deer. Potential impacts upon white-tailed deer at the Tx CSAs include loss of habitat, interference with movements, increased human-caused mortality, and exposure to radio frequency radiation (RFR).

7.3.2.1.1 Tx-N Concentrated Study Area. Potential impacts to critical wintering deer habitat have been minimized by avoiding, as much as possible, wetlands that may, or are known to, attract deer during winter months. During the 1988 aerial survey of the Tx-N CSA, a majority of the deer observed within the Tx-N CSA were concentrated in its southwest corner (Fig. 7-8), where wetland habitat provides deer with suitable wintering areas. As a result, this southwest corner of the Tx-N CSA was avoided when situating the Tx-N sectors. However, the Tx-N preliminary site layout would still exclude fromuse approximately 240 acres of palustrine emergent wetlands (Table 7-6) that could potentially serve as wintering areas for deer. The buffer zone contains an additional 325 acres of palustrine emergent wetlands. The percentage of wetlands taken is slightly higher in the buffer zone than in the preliminary site layout (Technical Study 6), indicating that facility shifts could result in slightly greater, although insignificant, impacts to deer. However, any loss of wintering wetland habitat will be effectively replaced through mitigation required for the loss of wetlands.

In addition to loss of wetlands, approximately 18 acres of woodlands would be enclosed by the Tx-N preliminary site layout fence and therefore unavailable for use. Because there are only 4 acres of woodlands contained within the

TABLE 7-6. APPROXIMATE ACRES OF HABITAT REMOVED BY TRANSMIT AND RECEIVE PRELIMINARY SITE LAYOUTS

		Habitat Removed			
Preliminary Site Layouts	Habitat	Disturbed(1) Area (acres)	Exclusion Area (acres)	Facility Total (acres)	Buffer Zone (acres)
Tx-N	Woodland	0	18	18	4
	PEM (2)	62	178	240	325
Tx-S	Woodland	5	8	13	20
	PEM (2)	23	255	278	251
	PEM/PFO	0	0	0	3
Rx-W	Woodland	1	NA	1	6
	PEM (2)	3	NA	3	16
	PFO (2)	0	NA	0	2
Rx-E	Woodland	0	NA	0	14
	PEM (2)	9	NA	9	39
	PSS (2)	1	NA	1	8
	PEM/PSS	6	NA	6	16
	PEM/PFO	0	NA	0	16

1. Disturbed area includes the locations of the antenna and groundscreen, support buildings, roads, and fences.

2. PEM = Palustrine Emergent Wetlands
PSS = Palustrine Shrub/Scrub Wetlands
PFO = Palustrine Forested Wetlands

buffer zone for the Tx-N sectors, facilities shifts could result in similar impacts on deer. This loss of woodlands, however, will not constitute a significant impact to the deer population because in this region marshes rather than woods provide the most substantial source of critical winter cover (Sparrowe and Springer, 1970). Further mitigation is therefore not anticipated to compensate for loss of wooded areas.

In addition to removing or excluding winter habitat, the Tx-N preliminary site layout will also remove some summer habitat, including some deer forage. Throughout the study area, however, there is an abundance of agricultural land (Technical Study 5), which provides summer habitat (Sparrowe and Springer, 1970) and preferred forage (Hesselton and Hesselton, 1982) for deer in this region. Because of the abundance of summer habitat and forage provided by agricultural land in the surrounding area, loss of summer habitat and food resources at the Tx-N CSA will not significantly impact the deer population or require additional mitigation.

White-tailed deer inhabiting the region may travel through the CSA when travelling between winter and summer habitats. The barrier created by the four transmit sectors could disrupt deer movements by causing the animals to travel longer distances and therefore expend more energy in order to reach their destination. The deer are not expected to travel along definite routes but rather, due to their relatively solitary nature, would probably travel as individuals or in small groups to and from a wide dispersion of summer home ranges (Hesselton and Hesselton, 1982). Therefore, it is expected that relatively few deer would be affected. For the deer that are affected, the maximum diversion of approximately 2½ miles (the approximate width of the Tx-N preliminary site layout) and the subsequent additional effort required will be insignificant when compared to documented distances travelled during seasonal movements (Halls, 1978). Any interference with deer movements between habitats will therefore not significantly affect the animals or result in a noticeable affect on the population. Consequently, further mitigation is not required to compensate for this impact.

The amount of potential increase in human-caused mortality due to additional collisions with automobiles remains unknown. The amount of impact is directly related to the number of project related vehicles and personnel required and the number of miles travelled by these vehicles and personnel to and from work. Increased traffic in the area would be highest during peak construction daylight hours, when as many as 1500 supply transport truck trips and about 200 workers could be travelling to and from the site every day, and lower during non-peak construction, when an average of no more than 450 truck trips and about 30 to 40 personnel will be required each day (Technical Study 3, Transportation). Project related traffic will be minimal during the operational phase, when personnel will only travel to and from the site. A majority of the construction related vehicles will travel during daylight hours. Because deer are most active during twilight hours, before construction would begin, and are relatively sedentary during daylight hours (Hesselton and Hesselton, 1982), collisions resulting from construction vehicules should be rare. The potential increases from project traffic during non-daylight hours are not expected to be significant when compared to existing traffic levels, even during the peak construction period (Technical Study 3, Transportation). As a result, there should not be a significant increase at either CSA in deer road-kills due to the project. Even so, collisions will still be minimized by establishing and enforcing appropriate speed limits on all project roads. No further mitigation is considered necessary.

Project related road-kills could also result from security vehicles patrolling the perimeter of the site at intervals of up to one loop per hour. It is highly unlikely, however, that this traffic would cause a significant increase in deer road-kills, as the vehicles would be travelling at extremely slow speeds. Therefore, no mitigation is considered necessary to compensate for this possible source of project related human-caused mortality.

Radio frequency radiation (RFR) from the transmit antenna has the potential to affect deer in close proximity to the radiating structure. However, the location of the exclusion fence surrounding the antenna structure ensures that RFR levels immediately outside the fence are not high enough to harm deer or other large mammals (USAF, 1986). The 8 foot wooden exclusion fence to be built around each sector will prevent large mammals from entering the exclusion area. This fence not only protects the animals from harmful levels of RFR, but also ensures that the facility groundscreen and transmit facilities are not damaged by mammal intrusions. Further measures will therefore not be required to mitigate for this impact.

7.3.2.1.2 Tx-S Concentrated Study Area. As is the case of the Tx-N CSA, wetlands that may provide critical wintering habitat for deer have been avoided to the maximum possible extent when locating the antenna sectors. There is no particular part of the Tx-S that is known or is more likely to serve as wintering deer habitat. The Tx-S preliminary site layout would remove from use approximately 278 acres of wetlands (Table 7-6). However, these wetlands are typically planted with an agricultural crop (Technical Study 6) and do not support thick marsh-type vegetation that provides cover for deer in this region during winter months (Sparrowe and Springer, 1970; Kannowski, 1979). The Tx-S buffer zone contains an additional 251 acres of these wetlands. Due to the similar percentage of wetlands taken by the preliminary site layout and the buffer zone (Technical Study 6), facilities shifts are not likely to differ in their impact on wetland habitat. Although the wetlands lost do not offer high quality habitat for deer, any lost habitat value will be replaced through mitigation required for loss of wetlands.

The potential impacts on wetlands at the Tx-S CSA are not as great as those at the Tx-N CSA because of the low habitat quality of wetlands lost at the Tx-S CSA. For the same reason, facility shifts within the buffer zone would have a greater, although still insignificant, effect at the Tx-N CSA.

Approximately 13 acres of woodlands would be disturbed or excluded from use by the Tx-S preliminary site layout. Although the buffer zone for the Tx-S preliminary site layout includes an additional 20 acres of woodlands, facility shifts would not result in significantly greater impacts to wooded deer habitat because of the similar distribution of the woods in the buffer zone (Technical Study 5). However, even a loss of 20 acres of woodlands will not significantly impact the deer population for the reasons outlined above for the Tx-N CSA. Further mitigation is therefore not required to compensate for the effect of lost woodlands on the deer population.

Although still insignificant, the impact to deer resulting from loss of wooded areas is slightly higher at the Tx-N CSA than at the Tx-S CSA. The Tx-S preliminary site layout removes 7 fewer acres of woods than the Tx-N preliminary site layout. Impacts to woodlands resulting from facility shifts are not likely to differ between CSAs.

The Tx-S preliminary site layout will potentially affect summer habitat and food resources in the same manner as outlined for Tx-N. As detailed for Tx-N, this loss will not be significant or require additional mitigation.

As discussed for the Tx-N preliminary sector layout, the antenna sectors could disrupt deer movements. For the same reasons related for the Tx-N CSA, this interference will not significantly impact the deer population. Therefore, mitigation will not be required to compensate for this impact.

The potential increase in road collisions due to the location of the Tx-S preliminary site layout is similar to that discussed for the Tx-N preliminary site layout, as (1) the number of vehicles and personnel required for construction and operation of the CRS project would be the same regardless of which CSA is selected (Technical Study 3, Transportation) and (2) construction supplies will likely be trucked to either site along major arterials and through equal deer habitat types. As a result, road-kills are not expected to differ significantly between the Tx-N CSA and the Tx-S CSA. No significant impacts are expected on the deer population; further mitigation will not be required.

Potential RFR impacts on deer at the Tx-S CSA are the same as those discussed at the Tx-N CSA, and are not expected to be significant.

7.3.2.2 Pronghorn. Potential impacts upon pronghorn at the Tx CSAs are similar to those outlined for deer and include loss of habitat, interference with movements, increased human caused mortality, and exposure to RFR.

7.3.2.2.1 Tx-N Concentrated Study Area. Although the Tx-N sectors will remove from availability some open fields that are suitable pronghorn habitat, this will not significantly affect regional pronghorn populations because of the abundance of open fields and pastures (Technical Study 5) and the species' extensive home range (Table 7-1). Furthermore, pronghorn are probably not abundant within the Tx-N CSA, since there have not been any recent sitings of pronghorn within or in close proximity to the CSA. Mitigation will therefore not be required to compensate for losc pronghorn habitat.

The Tx-N sectors could potentially interfere with pronghorn movements by causing the animals to travel larger distances and expend more energy in order to avoid the barrier created. However, pronghorn have not historically inhabited the region near the Tx-N CSA (SDGFPD, 1989d). Because the Tx-N CSA is not known to be habitually used by pronghorn, the Tx-N preliminary site layout is not expected to significantly impact the regional pronghorn population or require additional mitigation.

Increased road-kills due to project traffic have the potential to be higher, although still insignificant, for pronghorn than for deer because pronghorn are active throughout the day (Kitchen and O'Gara, 1982). Pronghorn should, however, be readily apparent during daylight hours to construction traffic, which will be travelling at low speeds. Construction traffic should therefore be able to avoid collisions with pronghorn. Furthermore, collisions with pronghorn are unlikely at the Tx-N CSA, because there have been no recent observations of pronghorn there (SDGFPD, 1989d). Therefore, impacts to pronghorn due to increased human-caused mortality will not be significant and further mitigation is not anticipated.

For the same reason discussed for deer at the Tx-N CSA, potential RFR impacts to pronghorn will not be significant or require further mitigation.

7.3.2.2.2 Tx-S Concentrated Study Area. The source of potential impacts to pronghorn due to the Tx-N preliminary site layouts are the same as those discussed for the Tx-S CSA. The magnitude of potential impacts to pronghorn at the Tx-S CSA are expected to be slightly higher than those outlined for the

Tx-N CSA because pronghorn have been recently sited within the Tx-S CSA (DPA, 1989). However, these impacts are still not expected to be significant due to the species seldom use and low population densities in the area.

7.3.2.3 Small Furbearers. Potential impacts to small furbearers at the Tx-N CSA result primarily from loss of habitat, human-caused mortality and exposure to RFR.

7.3.2.3.1 Tx-North Concentrated Study Area. As discussed above, wetlands were avoided to the maximum possible extent when siting the Tx-N preliminary site layout. However, some wetlands will be unavoidably removed from availability (Table 7-6) that provide suitable habitat for muskrat, striped skunk, red fox, raccoon, jackrabbit and weasel (Table 7-4). However, this lost mammal habitat value will be effectively replaced through mitigation required for loss of wetlands.

The Tx-N preliminary sector layout could also potentially affect badger and coyote due to loss of habitat (Table 7-4). Some open grassland, which could provide habitat for these furbearers, will be lost as a result of the Tx-N preliminary site layout. Grasslands, however, occur throughout the general study area (Technical Study 5). The grassland acreage lost to the Tx-N sectors is a very small percentage of the total regional acreage of this habitat. As a result, impacts to these furbearers are not expected to be significant or require additional mitigation.

The majority of the small furbearers present are primarily nocturnal (Burt and Grossenheider, 1976). Human-caused mortality of small furbearers due to road-kills is therefore not expected to be significant for the same reasons discussed for deer.

There is some potential that the wooden exclusion fence will not exclude small furbearers at all times because they may be able to burrow or slip between the wooden slats in the exclusion fence. Although the levels of RFR inside the fence are dangerous for humans and larger mammals, small furbearers will not be significantly impacted due to their small size and orientation to the RF field (USAF, 1986). The USAF will, to the maximum extent possible, maintain the area within the exclusion fence to avoid attracting small furbearers and other wildlife into the restricted zone. Therefore, additional mitigation will not be required to compensate for this impact.

7.3.2.3.2 Tx-South Concentrated Study Area. Potential impacts to small furbearers resulting from loss of wetland habitat are likely to be lower at the Tx-S CSA than at the Tx-N CSA because wetland habitats that attract small furbearers are not as abundant in the Tx-S CSA (Table 7-6). Therefore, initial population densities are, in all likelihood, lower at the Tx-S CSA. Any impacts to small furbearer habitat will still be replaced through mitigation required for loss of wetlands.

Potential impacts to small furbearers due to increased human-caused mortality will not differ from that at the Tx-N CSA or be significant for the reasons discussed for deer.

Potential RFR impacts on small furbearers are the same as discussed above for the Tx-N CSA. These impacts are insignificant and do not necessitate further mitigation.

7.3.3 Receive Site

As Table 7-5 indicates, white-tailed deer, moose, and small furbearers are the potentially-affected mammal species at the Thief River Falls receive CSAs.

7.3.3.1 White-tailed Deer. Loss of habitat, interference with movements, and increased human-caused mortality are the potential impacts to deer at the Rx CSAs. Exposure to RFR is not a potential impact at the Rx study area because the receive antenna does not emit RFR.

7.3.3.1.2 Rx-E Concentrated Study Area. Loss of critical habitat was minimized by locating the Rx-E preliminary site layout so as to avoid, to the maximum possible extent, woods and marshes that provide heavy cover, which is critical to deer survival during stressful winter months (Halls, 1978;

Rongstad and Tester, 1969). The eastern edge of the CSA contains this type of winter deer habitat, and is also immediately adjacent to an abundance of woodlands and wetlands, outside of the CSA, that could attract deer during winter months. This part of the Rx-E CSA was therefore avoided when determining the preliminary site layout. As a result of avoidance, no acres of woodlands would be lost to the facilities. Approximately 15 acres of either palustrine emergent wetlands (PEM), palustrine shrub/scrub wetlands (PSS), or transitional wetlands between the two will be lost (Table 7-6). However, PEM wetlands do not typically support woody cover (Technical Study 6), and PSS types support slightly more woody cover, but still not as much as woodlands or palustrine forested wetlands (PFO) (Technical study 6). The wetlands lost will therefore not result in a substantial loss of winter cover for deer. Any loss of winter wetland habitat will, however, be effectively replaced through mitigation required for loss of wetlands.

The buffer zone contains approximately 14 acres of woodlands and 79 acres of wetlands. The acreage of wetlands taken includes a greater amount of woody cover than the total for the preliminary site layout. Although the majority of wetlands in the buffer zone are PEM types, there are greater acreages of PSS and PFO contained in the buffer than in the facility total (Table 7-6). Because of the greater amount of woody cover in both woodlands and wetlands of the buffer zone, facility shifts could result in slightly greater, although insignificant, impacts than those outlined for the preliminary site layout.

In addition to removing or excluding winter habitat, the Rx-E preliminary site layout will also remove some summer habitat, including forage. However, open fields and shrubland, which provide suitable summer habitat for deer (Hesselton and Hesselton, 1982) are abundant in the region (Technical Study 5). Because of the abundance of fields and shrubland, loss of summer habitat will not significantly affect the deer population or require additional mitigation.

Potential impacts to deer movements by the antenna structure at the Rx-E CSA are the same as those discussed for the Tx CSAs. Although some deer could be diverted a maximum of 2 1/2 miles (the approximate width of the Rx-E preliminary site layout), the additional effort required to travel this distance will be insignificant when compared to documented distances travelled by deer during seasonal movements (Halls, 1978). As discussed for the Tx-N CSA, potential impacts to deer movements will not be significant or require additional mitigation.

Potential increases in road-kills of deer due to project related vehicular traffic are expected to be insignificant for the same reasons outlined for deer at the Tx CSAs and will not require additional mitigation.

8.3.3.1.1 **Rx-W Concentrated Study Area.** Loss of critical wintering deer habitat has been minimized as discussed for the Rx-E preliminary site layout. Because the concentration of woodlands in the southwest corner of the Rx-W provides quality wintering habitat for deer, this part of the CSA was avoided when locating the Rx-W sectors. As a result, the use of only approximately one acre of woodlands and 3 acres of wetlands would be precluded by the Rx-W sectors (Table 7-6). These acreages represent a minimal loss of woody cover and therefore will not have a significant impact on the deer population. Further mitigation is therefore not anticipated to compensate for lost wintering habitat. However, deer will benefit from any mitigation resulting from loss of wetlands.

The Rx-W buffer zone contains an additional 6 acres of woodland and 18 acres of wetlands. The vast majority of wetlands lost are palustrine emergent. However, approximately 2 acres of the wetlands are PFO types which provide excellent wintering deer habitat due to the abundance of woody cover they provide (Rongstad and Tester, 1969; Technical Study 6). Because the buffer zone contains a greater acreage of woody cover than the preliminary site layout, facility shifts could result in slightly higher, although insignificant, impacts to deer by removing greater amounts and higher quality wintering habitat.

Potential impacts due to winter habitat loss at the Rx-W CSA are similar to those at the Rx-E CSA. Neither preliminary site layout removes PFO wetlands or natural tree stands which offer the best possible source of quality woody cover (Hesselton and Hesselton, 1982). The Rx-W preliminary site layout, however, will remove one acre of planted trees, whereas the Rx-E preliminary site layout will not remove any trees (Technical Study 5). Impacts resulting from facility shifts are likely to be higher, although still insignificant, at the Rx-E CSA because the buffer zone there includes more acres of woody cover (containing 14 acres of mostly natural tree stands (Technical Study 5), and 16 acres of PEM/PFO). The PEM/PFO habitat offers some woody cover, but not as much as pure PFO (Technical Study 6). The buffer zone at the Rx-W CSA contains fewer acres of high quality cover, as it contains only 6 acres of woodlands, most of which are planted tree stands (Technical Study 5), and 2 acres of PFO wetlands.

Potential impacts due to lost summer habitat, including some forage, and interference with movements are the same as at the Rx-E CSA and are insignificant for reasons detailed for the Rx-E CSA.

The potential for increases in road-kills of deer are discussed in the sections on the Tx-N CSA. Potential impacts due to project related vehicular traffic are slightly higher, although still insignificant, at the Rx-W CSA than at the Rx-E CSA because personnel and construction supplies going to the CSAs will likely be coming from Thief River Falls, Minnesota (Technical Study 3, Transportation) which lies to the northeast of the general study area. Because the Rx-W CSA will require driving a slightly longer distance than would the Rx-E CSA, the probability is higher that collisions with deer would occur. However, human-caused mortality is still not expected to be significant because deer are most active during twilight rather than daylight hours, as discussed for deer at the Tx-N CSA.

7.3.3.2 Moose. Potential impacts upon moose at the Rx CSAs include loss of habitat, interference with movements and increased human-caused mortality.

7.3.3.2.1 Rx-E Concentrated Study Area. As discussed for deer, the Rx-E preliminary site layout would not remove any acres of woodland, which is critical habitat for moose during winter months (Coady, 1982). Mitigation will therefore not be required to compensate for impacts due to loss of wooded habitat.

Despite efforts to avoid wetlands, the Rx-E preliminary site layout would remove approximately 9 acres of wetlands (Table 7-6). Only approximately 7 acres of these wetlands are characterized as palustrine emergent types (Table 7-6), which provide moose with summer habitat and preferred forage (Coady, 1982). Loss of wetland habitat will be effectively replaced through mitigation required for wetland loss.

The buffer zone at the Rx-E CSA contains approximately 14 acres of woodlands and an additional 79 acres of wetlands, the majority of which are PEM. Because habitat percentages are higher in the buffer zone than in the preliminary sector layout (Technical Studies 5 and 6), facilities shifts could result in slightly greater, although insignificant, impacts.

The barrier created by the Rx-E preliminary site layout has the potential to disrupt moose movements when the animals are travelling between summer and winter habitat. Moose, like deer, could be diverted a maximum of 2 1/2 miles (the approximate width of the Rx-E preliminary site layout). However, the additional effort required to travel this distance will be insignificant when compared to documented distances travelled by moose during seasonal movements (Coady, 1982). Therefore, potential impacts to movements are not expected to significantly affect moose or require additional mitigation.

The impact to moose resulting from increased human-caused mortality is generally the same as that outlined for deer at the Tx-N CSA. However, the potential for increased numbers of road-kills due to project related traffic is higher, although insignificant, for moose than for deer because moose are diurnal animals (Coady, 1982). Moose should, however, be readily apparent during daylight hours to construction traffic, which will be travelling at slow speeds. Construction-related traffic should therefore be able to avoid collisions with moose. Therefore, impacts due to increased numbers of road-kills of moose are not expected to be significant. No additional mitigation is anticipated.

7.3.3.2.2 Rx-West Concentrated Study Area. As discussed previously approximately one acre of planted trees and 3 acres of PEM wetlands will be lost due to the Rx-W preliminary site layout. This loss of acreage is minimal, as compared to available habitat, and thus is not expected to significantly impact the moose population. Furthermore, the planted tree stands taken do not remove the highest quality winter cover, which is typically provided by forests (Coady 1982). The minimal loss of wetlands is not expected to significantly impact the moose population, but will nevertheless be mitigated through mitigation required for loss of wetlands.

The buffer zone contains approximately 6 acres of woodlands and 18 acres of wetlands. The percentage of woodlands taken by the buffer zone and the preliminary site layout is approximately the same (Technical Study 5), indicating that facility shifts are not likely to differ significantly in their impacts to winter moose habitat. However, the buffer zone contains a slightly higher percentage of wetlands than does the preliminary site layout (Technical Study 6), indicating that facility shifts could result in slightly higher, although still insignificant, impacts to summer moose habitat.

Although still expected to be insignificant, potential impacts to the moose population are slightly higher at the Rx-W CSA because the Rx-W preliminary site layout will remove more acres of wetlands that could serve as summer habitat for moose. There is no significant difference in woodlands removed by the Rx-E and Rx-W preliminary site layouts. Facility shifts are likely to result in slightly higher, although still insignificant, impacts at the Rx-E CSA because the Rx-E buffer zone contains 14 acreas of mostly natural tree stands (Technical Study 5).

Potential impacts to moose at the Rx-W CSA resulting from interference with movements are the same as at the Rx-E CSA and are not expected to be significant.

Increases in the number of moose road-kills at the Rx-W CSA are not expected to be significant or require additional mitigation for the reasons discussed for moose at the Rx-E CSA. However, as discussed for deer at the Rx-W CSA, the potential impacts to moose resulting from increased number of road-kills are slightly higher, although still insignificant, at the Rx-W CSA than at the Rx-E CSA due to the longer distances travelled by project-related vehicles.

7.3.3.2 Small Furbearers. The potential impacts to small furbearers at the Rx CSAs are loss of habitat and increased human-caused mortality.

7.3.3.2.1 Rx-East Concentrated Study Area. Striped skunk, red fox, muskrat, and raccoon, which are associated with wetlands, have the potential to be impacted due to loss of wetland habitat. Approximately 15 acres of wetlands will be lost due to the preliminary site layout (Table 7-6). The buffer zone contains an additional 79 acres of wetlands. Because the buffer zone contains a higher percentage of wetlands than does the preliminary site layout (Technical Study 6), facilities shifts could result in slightly higher, although insignificant, impacts to these furbearers. Any habitat loss, however, will be effectively replaced through mitigation required for loss of wetlands.

Loss of woodlands, wetlands and grasslands also has the potential to impact coyote, bobcat, badger and weasels which inhabit these habitat types. This impact, however, is not expected to be significant because they are only occasionally found in the region (MNDNR, 1989b). Mitigation is therefore not considered necessary to compensate for this impact. However, these species will benefit from any mitigation resulting from loss of wetlands.

Human-caused mortality of small furbearers due to road-kills is not expected to be significant for the reasons previously discussed in the Tx-N CSA section.

7.3.3.2.2 Rx-West Concentrated Study Area. Potential impacts to furbearers associated with wetlands are lower at the Rx-W CSA than at the Rx-E CSA because the Rx-W preliminary site layout removes only approximately 3 acres of wetlands (Table 7-6). The buffer zone at the Rx-W CSA contains an additional 18 acres of wetlands. Because the buffer zone contains a higher percentage of wetlands than does the preliminary site layout (Technical Study 6), facility shifts could result in slightly greater, although still insignificant, impacts to furbearers. Any lost habitat, however, will be effectively replaced through mitigation required for loss of wetlands.

As discussed above, coyote, bobcat, badger and weasels are not expected to be significantly impacted by habitat loss because of their low population densities in the area.

For reasons discussed for deer at the Rx-W CSA, potential impacts to small furbearers due to road-kills will be slightly greater, although still insignificant, at the Rx-W CSA.

7.3.4 Mitigation

The USAF is committed to mitigation for unavoidable project impacts to ensure that regional mammal populations are not significantly affected. Mitigation measures which have been or will be used include avoidance of critical woodlands and wetlands that may or are known to attract mammals, wetland habitat mitigation, and low speed limits on project roads. At the transmit site, mitigation also includes the construction of a fence to exclude to prevent animals from exposure to high levels of RFR. A similar fence at the Rx site excludes animals from the facility in order to prevent their injury and damage to the antennas.

The resulting impacts to regional mammal populations will not be significant. Therefore, additional mitigation is not anticipated. The USAF is preparing a comprehensive mitigation plan to address these and other project impacts for both construction and operation of the CRS.

REFERENCES

Allen, Durward L. 1979. *Wolves of Minong: Their Vital Role in a Wild Community.* Houton Mifflin Company, Boston.

Bekoff, M. 1982. Coyote (*Canis latrans*). Pages 447-459 in *Wild Mammals of North America: Biology, Management and Economics.* J.A. Chapman and G.A. Feldhamer, eds. Johns Hopkins University Press, Baltimore.

Burt, W.H. and R.P. Grossenheider. 1976. *Field Guide to the Mammals.* Third edition. Houghton Mifflin Company, Boston.

Coady, J.W. 1982. Moose *(Alces alces).* Pages 902-922 in *Wild Mammals of North America: Biology, Management and Economics.* J.A. Chapman and G.A. Feldhamer, eds. Johns Hopkins University Press, Baltimore.

Connover, M.R. and G.S. Kania. 1988. Browsing preference of white-tailed deer for different ornamental species. *Wildlife Society Bulletin.* 16(2):175-179.

DPA International Ltd. 1989. Land Cover/Land Use Mapping for the Proposed Over-The-Horizon Backscatter Radar Sites in Northwestern Minnesota and Northeastern South Dakota. Prepared for U.S. Air Force, Electronic Systems Division, Hanscom Air Force Base Massachusetts and U.S. Army Corps of Engineers, Omaha, Nebraska.

Dunn, J.P., J.A. Chapman and R.E. Marsh. 1982. Jackrabbits (*Lepus californicus and Allies).* Pages 124-145 in *Wildlife Mammals of North America: Biology, Management and Economics.* J.A. Chapman and G.A. Feldhamer, eds. Johns Hopkins University Press, Baltimore.

Franzman, A.W. 1978. Moose. Pages 67-82 in *Big Game of North America: Ecology and Management.* J.L. Schmidt and D.L. Gilbert, eds. Stackpole Books. Harrisburg, Pennsylvania.

Fritzell, E.K. 1989. Mammals in Prarie Wetlands. Pages 268-301 in *Northern Prarie Wetlands.* A. Vander Valk, ed. Iowa State University Press. Ames, Iowa.

Godin, A.J. 1982. Striped and Hooded Skunks (*Mephitis mephitis* and Allies). Pages 674-687 in *Wild Mammals of North America: Biology, Management and Economics.* J.A. Chapman and G.A. Feldhamer, eds. Johns Hopkins University Press, Baltimore.

Halls, L.K. 1978. White-tailed Deer. Pages 43-65 in *Big Game of North America: Ecology and Management.* J.L. Schmidt and D.L. Gilbert, eds. Stackpole Books. Harrisburg, Pennsylvania.

Hazard, E.B. 1982. *The Mammals of Minnesota.* University of Minnesota Press, Minneapolis.

Hesselton, W.T. and R.M. Hesselton 1982. White-tailed Deer (*Odocoileus virginiaus)*. Pages 878-901 in ***Wild Mammals of North America: Biology, Management and Economics***. J.A. Chapman and G.A. Feldhamer, eds. Johns Hopkins University Press, Baltimore.

Hill, E.P. 1982. Beaver *(Castor canadensis)*. Pages 256-281 in ***Wild Mammals of North America: Biology, Management and Economics***. J.A. Chapman and G.A. Feldhamer, eds. Johns Hopkins University Press, Baltimore.

Kannowski, P.B., ed. 1979. Fish and Wildlife Resources Technical Paper, James River Basin, North and South Dakota. Institute for Ecological Studies. University of North Dakota. Research Report No. 29.

Kaufmann, J.H. 1982. Raccoon and Allies (*Procyon lotor* and Allies). Pages 567-585 in ***Wild Mammals of North America: Biology, Management and Economics***. J.A. Chapman and G.A. Feldhamer, eds. Johns Hopkins University Press, Baltimore.

Kitchen, D.W. and B.W. O'Gara. 1982. Pronghorn (*Antilocapra americana*). Pages 960-971 in ***Wild Mammals of North America: Biology, Management and Economics***. J.A. Chapman and G.A. Feldhamer, eds. Johns Hopkins University Press, Baltimore.

Kohn, B.E. and J.J. Mooty. 1971. Summer habitat of White-tailed Deer in North -Central Minnesota. ***Journal of Wildlife Management***. 35(3):476-487.

Lindzey, F.G. 1982. Badger (*Taxidea taxus*). Pages 653-663 in ***Wild Mammals of North America: Biology, Management and Economics***. J.A. Chapman and G.A. Feldhamer, eds. Johns Hopkins University Press, Baltimore.

Linscombe, G., N. Kinler and R.J. Avlerich. 1982. Mink (*Mustela vison*). Pages 629-643 in ***Wild Mammals of North America: Biology, Management and Economics***. J.A. Chapman and G.A. Feldhamer, eds. Johns Hopkins University Press, Baltimore.

Mautz, William M. 1978. Nutrition and Carrying Capacity. Pages 321-348 in ***Big Game of Noreth America: Ecology and Management***. J.L. Schmidt and D.L. Gilbert, eds. Stackpole Books. Harrisburg, Pennsylvania.

McCord, C.M. and J.E. Cardoza. 1982. Bobcat and Lynx (*Felis rufus and F. lynx*). Pages 728-768 in ***Wild Mammals of North America: Biology, Management and Economics***. J.A. Chapman and G.A. Feldhamer, eds. Johns Hopkins University Press, Baltimore.

Minnesota Department of Natural Resources (MNDNR). 1989a. Personal Communication, W. Berg (Research Biologist). September 28.

Minnesota Department of Natural Resource (MNDNR). 1989b. Memo from George Davis (MNDNR) to J. Doyle (M&E/H&N). October 18.

Minnesota Department of Natural Resources (MNDNR). 1989c. Letter from G. Mehmel (Assistant Area Wildlife Manager), to J. Doyle (M&E/H&N). October 27.

Minnesota Department of Natural Resources (MNDNR). 1989d. Personal Communication, G. Mehmel (Assistant Area Wildlife Manager). November 15.

Minnesota Department of Natural Resources (MNDNR). 1989e. Personal Communication, T. Wolfe. November 15.

Moen, A.N. 1973. *Wildlife Ecology*. Freeman, San Francisco.

Mooty, J.J., P.D. Karns and T.K. Fuller. 1987. Habitat Use and Seasonal Range Size of White-tailed Deer in Northcentral Minnesota. *Journal of Wildlife Management*. 51(3):644-648.

Paradiso, J.L. and R.M. Nowak. 1982. Wolves *(Canis lupus and Allies)*. Pages 460-474 in *Wild Mammals of North America: Biology, Management and Economics*. J.A. Chapman and G.A. Feldhamer, eds. Johns Hopkins University Press, Baltimore.

Peek, J.M., R.E. LeResche, and D.R. Stevens. 1974. Dynamics of Moose Aggregations in Alaska, Minnesota, and Montana. *Journal of Mammalogy*. 55(1):126-136.

Perry, H.R., Jr. 1982. Muskrats (Ondatra zibethicus and Neofiber alleni). Pages 282-325 in Wild Mammals of North America: Biology, Management and Economics. J.A. Chapman and G.A. Feldhamer, eds. Johns Hopkins University Press, Baltimore. 1147 pp.

Phillips, R.L., W.E. Berg and D.B. Siniff. 1973. Moose Movement Patterns and Range Use in Northwestern Minnesota. *Journal of Wildlife Management*. 37(3):266-277.

Rongstad, O.J. and J.R. Tester. 1969. Movements and Habitat Use of White-tailed Deer in Minnesota. *Journal of Wildlife Management*. 33(2):366-379.

Samuel, D.E. and B.B. Nelson. 1982. Foxes (*Vulpes vulpes* and Allies). Pages 475-490 in *Wild Mammals of North America: Biology, Management and Economics*. J.A. Chapman and G.A. Feldhamer, eds. Johns Hopkins University Press, Baltimore.

South Dakota Game, Fish and Parks Department (SDGFPD). 1989 a. Personal Communication, K. Shea (Conservation Officer). October 17.

South Dakota Game, Fish and Parks Department (SDGFPD). 1989b. Personal Communication, A. Miller (Supervisor Animal Damage Control). October 18.

South Dakota Game, Fish and Parks Department (SDGFPD). 1989c. Personal Communication, D. Alvine. October 19.

South Dakota Game, Fish and Parks Department (SDGFPD). 1989d. Personal Communication, D. Alvine, October 24.

Sparrowe, R.D. and P.F. Springer. 1970. Seasonal Activity Patterns of White-tailed Deer in Eastern South Dakota. *Journal of Wildlife Management*. 34(2):420-430.

Svendson, G.E. 1982. Weasels (*Mustela* species). Pages 613-628 in *Wild Mammals of North America: Biology, Management and Economics*. J.A. Chapman and G.A. Feldhamer, eds. Johns Hopkins University Press, Baltimore.

United States Air Force (USAF). 1986. Draft Environmental Impact Statement: Proposed Central Radar System, Over-the-Horizon Backscatter Program.

United States Air Force (USAF). 1988. Record of Decision: Central Radar System Environmental Impact Statement, Over-The-Horizon Backscatter Radar Program.

Van Ballenberghe, V. and J.M. Peek. 1971. Radiotelemetry Studies of Moose in Northeastern Minnesota. *Journal of Wildlife Management*. 35(1):63-71.

Wetzel, J.H., J.R. Wambaugh and J.M. Peek. 1975. Appraisal of White-tailed Deer Winter Habitats in Northeastern Minnesota. *Journal of Wildlife Management*. 39(1):59-66.

Yoakum, J.D. 1978. Pronghorn. Pages 103-121 in *Big Game of North America: Ecology and Management*. J.L. Schmidt and D.L. Gilbert, eds. Stackpole Books. Harrisburg, Pennsylvania.

TECHNICAL STUDY 8

CENTRAL RADAR SYSTEM
OVER-THE-HORIZON BACKSCATTER RADAR PROGRAM

AVIAN RESOURCES

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TECHNICAL STUDY 8
AVIAN RESOURCES

8.1 INTRODUCTION

The U.S. Air Force (USAF) has proposed to construct an Over-the-Horizon Backscatter (OTH-B) radar facility in the Northcentral United States (USAF, 1986). In their Record of Decision (USAF, 1988), the USAF selected a study area near Amherst, South Dakota for the transmit portion of the radar system and a study area near Thief River Falls, Minnesota for the receive portion of the radar system (Fig. 8-1). Since the issuance of the Record of Decision, the USAF has identified two concentrated study areas and two preliminary site layouts within each study area through a screening process involving physical, environmental, operational, and logistical considerations (Technical Study 1).

This technical study describes the affected environment, potential impacts, and mitigation measures relating to avian resources at the Amherst and Thief River Falls study areas for the OTH-B Central Radar System (CRS). A complete description of the facilities can be found in Technical Study 2; only brief explanations of facilities will be included in this section, when appropriate. Descriptions of the two sites can be found in Technical Studies 4 (hydrology and water quality), 5 (vegetation), and 6 (wetlands). Scientific names for all avian species mentioned in the text can be found in Appendix A.

8.2 AFFECTED ENVIRONMENT

8.2.1 Background Information

The OTH-B CRS will be located within the Prairie Pothole Region, which is one of the most important waterfowl and waterbird production areas in North America (van der Walk, 1989). The OTH-B CRS also lies along the boundary of the Central (Amherst study area) and Mississippi (Thief River Falls study area) Flyways, which are two important migration corridors for birds in North America (Lincoln, 1979; Bellrose, 1980) (Fig. 8-1).

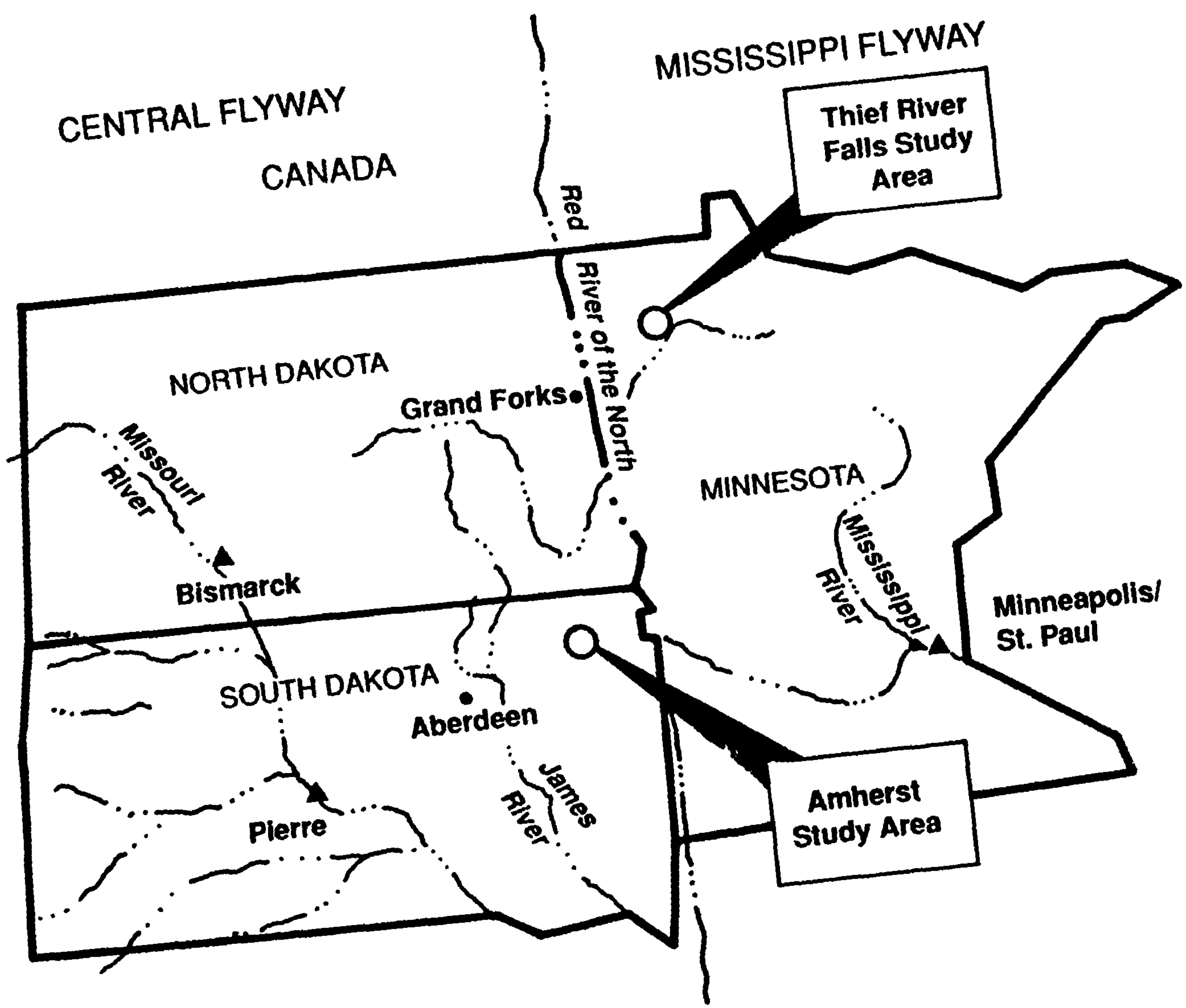


FIGURE 8-1. LOCATION OF THE CENTRAL RADAR SYSTEM TRANSMIT AND RECEIVE STUDY AREAS

The Amherst study area is located within the James River Valley, and the numerous state and federal wildlife areas located in close proximity to the study area indicate the general importance of this region for breeding and migrating birds (Fig. 8-2). Major migration corridors for numerous species of dabbling and diving ducks, several species of geese, and tundra swans pass through this region (Bellrose, 1980). The James River Basin may also contain up to 1 million pairs of breeding waterfowl per year, producing thousands of young each year (Kannowski, 1979). Dakota Lake and Tewaukon National Wildlife Refuges (NWR), in North Dakota, are used as migration resting areas for large numbers of waterfowl. Sand Lake and Waubay NWRs, in South Dakota, are also used by large numbers of migrating and breeding waterfowl and other waterbirds (Fig. 8-2). Other species of birds, such as shorebirds, passerines, and raptors also pass through this region, but their numbers and migration patterns are generally not well documented.

Sand Lake NWR is the closest federal or state refuge to the Amherst study area, located within 10 miles of the study area (Fig. 8-2). This refuge is one of the major waterfowl staging areas in the Central Flyway, especially for snow geese (Bellrose, 1980; UND, 1988). Peak goose populations (mainly lesser snow geese) at this refuge typically range from 75,000 to nearly 400,000 birds in the spring. Fall population peaks are normally lower, in the range of 55,000 to 225,000 birds (UND, 1988). Peak spring duck populations range from 30,000 to 350,000 birds, depending upon water conditions and the previous year's productivity. Fall duck peaks typically range between 60,000 and 300,000 birds (UND, 1988).

Spring waterfowl and waterbird populations at Sand Lake consist largely of snow geese, mallards, lesser scaup, and American coot, although at least nine other species normally have mean monthly populations exceeding 5,000 birds. Mean monthly populations for coots may exceed 20,000 birds (UND, 1988).

Fall populations consist largely of snow geese, mallards, and American coots, although mean monthly populations of four other dabbling duck species typically exceed 15,000 birds. American coot average monthly populations may exceed 50,000 birds (UND, 1988).

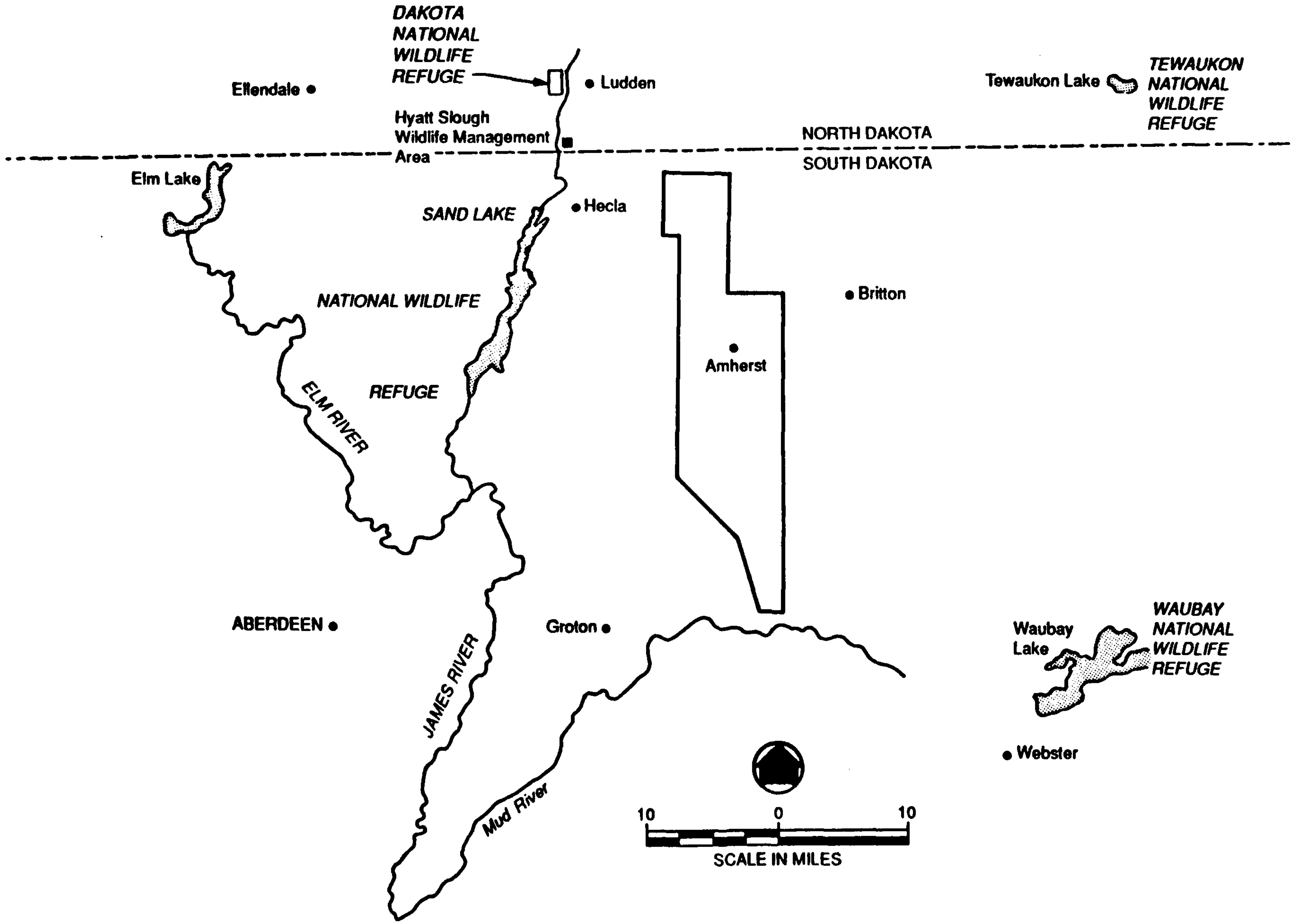


FIGURE 8-2. MAJOR PHYSIOGRAPHIC FEATURES AND MAJOR STATE AND FEDERAL WILDLIFE AREAS IN THE VICINITY OF THE AMHERST TRANSMIT STUDY AREA

Average annual use days may exceed 10 million for ducks and gulls/terns at Sand Lake; over 30 million annual use days have been recorded for Franklin's gull alone in some years (UND, 1988). Average annual use days for geese and coots are in the general range of 3 to 5 million. Substantial numbers of other waterbirds, such as grebes, pelicans, cormorants, and shorebirds also use the refuge (UND, 1988).

Agassiz NWR is the nearest major wildlife area to the Thief River Falls study area (Fig. 8-3). UND (1988) has summarized bird usage patterns at this refuge.

At Agassiz NWR in the spring, peak goose populations are low, ranging from 800 to 5,000 birds. Fall use is higher, with peak numbers ranging from 8,000 to 28,000 geese (mostly Canada geese). Spring duck populations range from 15,000 to 70,000 and, in fall, from 30,000 to 130,000 (UND, 1988).

Average monthly spring populations typically exceed 2,000 birds for mallards, blue-winged teal, lesser scaup and American coots. Coot populations may approach an average of 8,000 birds. Mallards and American coots are most abundant in fall, with average monthly populations of coots approaching 35,000 birds (UND, 1988).

Gulls (primarily Franklin's gull) and terns may record up to 4 million use days at Agassiz during July through September. Substantial use by grebes, loons, pelicans, cormorants, and shorebirds has also been recorded, with use typically approaching 100,000 use days for most groups. Pelicans, for example, recorded a total of 90,000 use days at Agassiz during the period from April through September (UND, 1988).

Pembina Wildlife Management Area, a state wildlife area partially within the Thief River Falls study area and containing Goose Lake, is also used by moderate to high numbers of waterfowl, coots, and other waterbirds, although quantitative population estimates apparently do not exist prior to the USAF's avian field program.

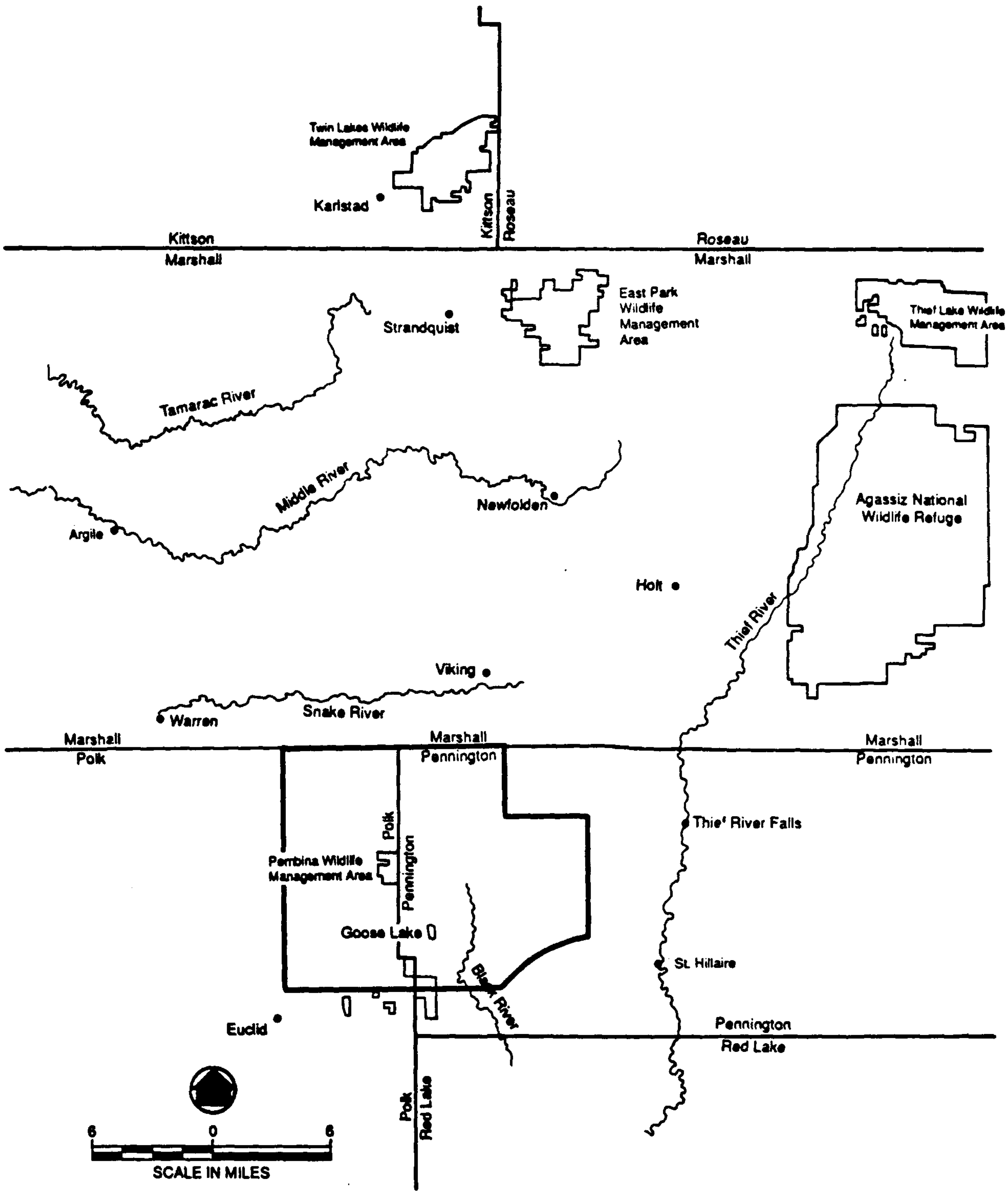


FIGURE 8-3. MAJOR PHYSIOGRAPHIC FEATURES AND MAJOR STATE AND FEDERAL WILDLIFE AREAS IN THE VICINITY OF THE THIEF RIVER FALLS RECEIVE STUDY AREA

Spring migration through the project region occurs from March through early June, with migration typically several days to several weeks earlier at the Amherst study area relative to the Thief River Falls study area. Raptors, winter finches, and corvids are typically the first migrants observed, beginning their movements in early March. Waterfowl typically migrate through this region during late March and April, with most species of waterbirds migrating during the second half of April and into May, although gulls and terns typically migrate as early as late March. Shorebirds and most insectivorous passerines migrate late, with movements concentrated in May and early June (Whitney et al., 1978; Janssen, 1987; UND, 1988).

In fall, migration is usually more protracted for most bird groups and shorebirds and many species of passerines begin their southward migrations as early as late July and August. Waterbirds and raptors generally migrate during September and early to mid October, with waterfowl generally migrating from late September into early to mid November. Late passerines (e.g. winter finches) may persist through the end of November (Whitney et al., 1978; Janssen, 1987; UND, 1988). Fall migration is usually several days to several weeks earlier at the Thief River Falls study area, depending upon weather and water conditions.

Eagles, hawks, falcons, harriers, vultures, sandhill cranes, and pelicans are primarily diurnal migrants. Some species of passerines, such as swallows, blackbirds, larks, jays, crows, and doves are also primarily diurnal migrants. Ducks, geese, swans, cormorants, loons, grebes, shorebirds, herons, gulls, and terns migrate both by day and night, although some groups, such as shorebirds and ducks, may migrate mostly at night. Rails, coots, and most passerines are almost exclusively nocturnal migrants (Terres, 1980; AEIDC, 1987).

8.2.2 Methods

In order to quantify avian use and flight behavior at the Amherst and Thief River Falls study areas, extensive site-specific studies of spring and fall migration periods were conducted in 1989 (UMN, 1989a; 1989b; ABR, 1989;

1990a). Less intensive sampling was also conducted at these two sites in the fall of 1987 and the spring of 1988 (M&E/H&N, 1989). Spring 1989 studies also extended into the beginning of the breeding season, allowing some data to be collected on the breeding populations at the two study areas. The methodology used during these studies is summarized below and is presented in detail in the above referenced reports.

8.2.2.1 Field Surveys. Study methodology and procedures differed somewhat among seasons due primarily to changing program priorities and the updating of siting decisions. Table 8-1 summarizes the procedures used at the Amherst and Thief River Falls study areas for each season, while a brief explanation of each method listed in this table is included below.

Station observations. Two primary (North and South stations) and one secondary (Renzienhausen Slough station) observation stations were established within the Amherst study area to monitor bird movements through this region (Fig. 8-4). Table 8-2 shows which of these stations were used during each study. Three primary (West, East, and Central stations) and two secondary (Goose Lake and Southeast stations) observation stations were used in the Thief River Falls study area (Fig. 8-5). Table 8-3 shows which of these stations were used during each study. Since the Southeast station was not used during 1989 studies, data from this station are limited and are not considered in this technical study.

Observation stations in both study areas were placed in locations where topography and the distribution of shelterbelts and other obstructions allowed relatively unobstructed viewing in all directions. Observations were either conducted from ground level or from platforms mounted in the back of pick-up trucks which placed the observer approximately 10 feet above ground level.

Observers, using binoculars and spotting scopes, collected data on the number, species, and flight behavior of birds observed flying through the study areas during daylight hours. Birds were counted and flight data were recorded as birds crossed transect lines extending north, east, south, and west from an observation station. Weather data were collected periodically during all observation sessions.

TABLE 8-1. FIELD SURVEY METHODOLOGY USED DURING EACH MIGRATION SEASON AT THE THIEF RIVER FALLS RECEIVE STUDY AREA AND THE AMHERST TRANSMIT STUDY AREA

Method	Fall 1987	Spring 1988	Spring 1989	Fall 1989
Station Observations	X	X	X	X
Road Surveys			X	X
Surveillance Radar			X	X
Long-range			X	X
Short-range			X	X
Altitude Radar			X	X
Night-Vision Scope			X	X
Aerial Surveys	X	X	X	X
Tower Collision Study			X	X
Lek Surveys			X	

TABLE 8-2. OBSERVATION STATIONS USED DURING EACH MIGRATION SEASON AT THE AMHERST TRANSMIT STUDY AREA

Station[1]	Fall 1987	Spring 1988	Spring 1989	Fall 1989
North	X	X	X	X
South			X	X
Renzienhausen Slough				X

1. Locations of observation stations are shown on Figure 8-4.

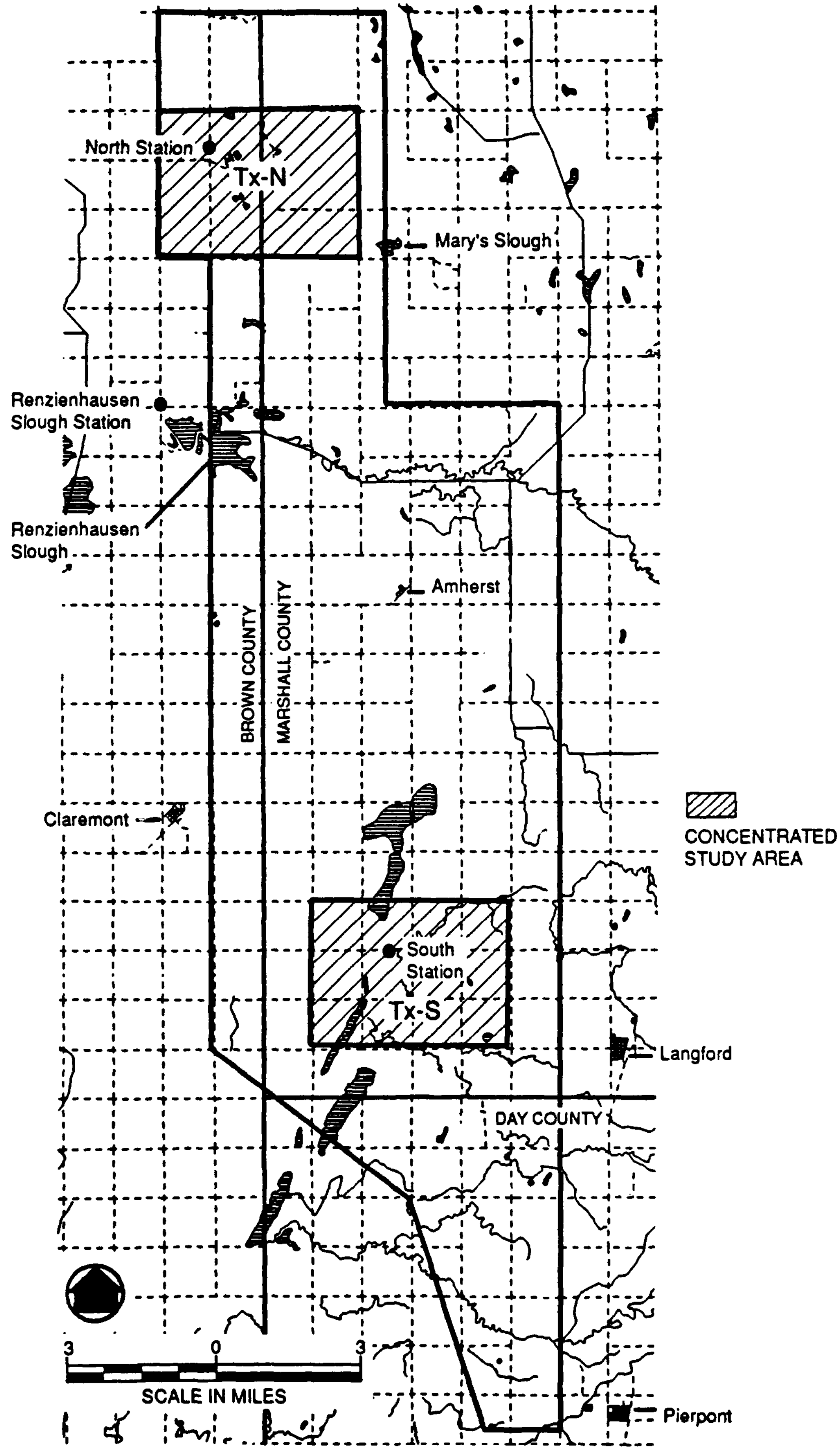


FIGURE 8-4. AMHERST, SD TRANSMIT STUDY AREA DAYLIGHT SAMPLING LOCATIONS USED DURING AVIAN STUDIES

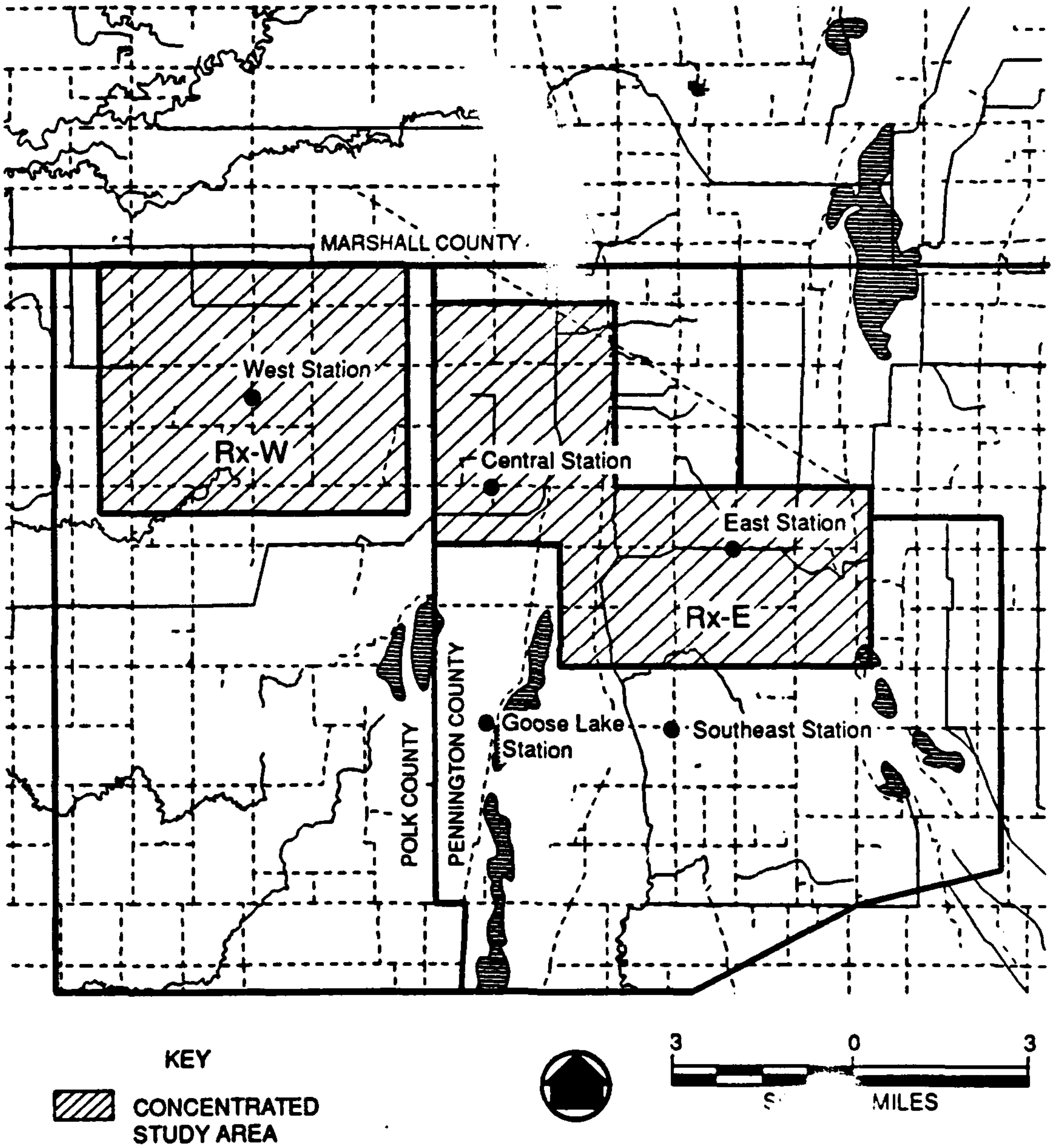


FIGURE 8-5. THIEF RIVER FALLS, MN RECEIVE STUDY AREA DAYLIGHT SAMPLING LOCATIONS USED DURING AVIAN STUDIES

TABLE 8-3. OBSERVATION STATIONS USED DURING EACH MIGRATION SEASON AT THE THIEF RIVER FALLS RECEIVE STUDY AREA

Station(1)	Fall 1987	Spring 1988	Spring 1989	Fall 1989
West	X	X	X	X
Central	X	X		X
East	X	X	X	X
Goose Lake	X	X	X	X
Southeast	X	X		

1. Locations of observation stations are shown on Figure 8-5.

Table 8-4 shows the periods sampled during each season at each study area. Sampling was most intensive during the spring and fall of 1989, averaging 10 to 11 hours per day at each primary station at Amherst and 10 to 12 hours per day at each primary station at Thief River Falls. Sampling intensity was similar in the fall of 1987 at Amherst but only averaged 4 hours per day at each primary station at Thief River Falls. Secondary stations were sampled less intensively, averaging 3 to 4 hours per day during these three studies. Spring 1988 sampling was limited to 9 days in Amherst (average of 4 hours per day of sampling) and 11 days in Thief River Falls (average of 2 hours per day at each primary and secondary station). The timing of observation sessions among days was rotated to sample all daylight hours when the entire daylight period was not sampled.

Road surveys. Road surveys were conducted at each study area during the spring and fall of 1989. Table 8-4 lists the dates road surveys were conducted. Five survey routes, each consisting of 15 stops, were set up within each study area for a total of 75 sampling points per study area. Each route was surveyed approximately once per week. Sampling consisted of a single observer conducting 10 minute observation sessions at each of the 15 sampling points along a survey route. Data on all birds seen or heard were collected; data collection was similar to that conducted for station observations. Surveys began at dawn and lasted between 3 and 4 hours.

TABLE 8-4. STATION OBSERVATION AND ROAD SAMPLING DATES - AMHERST AND THIEF RIVER FALLS STUDY AREAS

Study	Stations		Road	
	Start	Finish	Start	Finish
THIEF RIVER FALLS				
Fall 1987	15 September	9 November[1]	NO SAMPLING	
Spring 1988	9 April	19 April[2]	NO SAMPLING	
Spring 1989	26 March	15 June[3]	2 April	15 June[4]
Fall 1989	1 September	16 November	15 August	16 November[5]
AMHERST				
Fall 1987	15 September	14 November[6]	NO SAMPLING	
Spring 1988	30 March	7 April	NO SAMPLING	
Spring 1989	25 March	15 June[7]	3 April	15 June[8]
Fall 1989	1 September	21 November[9]	1 September	21 November[10]

1. No sampling on 16,18 September at the Central Station; 15 September at the East Station; 23 September, 4,17,18,23,24,25 October, 7,8 November at the Goose Lake Station.

2. No sampling on 13 April at the West Station; 12,17 April at the Central Station; 12,17,19 April at the East Station; 19 April at the Goose Lake Station.

3. No sampling on 3 April at the West Station; 26 March - 16 April at the Goose Lake Station.

4. No sampling on 7,8,10,15,17,22,24,28,30 April; 1,8,13,15,20,22,24,25,28 May; 1,3,10,12 June.

5. No sampling on 19,20,26,27 August; 2,3,9,10,11,16,17,23,24,28,30 September; 5,6,8,14,15,22,27,28,29 October; 4,5,8,11,12,15 November.

6. No sampling on 22 September.

7. No sampling on 2,23,24 April, 24 May at the North Station; 22,24 April; 6 June at the South Station.

8. No sampling on 8,14,15,21,22,28,29 April; 5,6,12,13,17,20,21,26,31 May; 3,4,6,8,14 June.

9. No sampling on 1 September at the South Station.

10. No sampling on 8 September; 20 November.

Radar observations. A mobile radar lab consisting of a marine radar unit (surveillance radar) was used at each study area during spring and fall 1989 studies to monitor bird migration at night and other periods of poor visibility. The surveillance radar unit was also used during a limited number of daylight hours. Surveillance radar allowed observation and tracking of flocks of birds over a large area, collecting information on migration rates, flight direction, and flight patterns. The radar lab also contained a second radar unit (vertical-beam or altitude radar) which enabled the flight altitude of birds to be measured.

Two sampling stations were used for radar observations within each study area, with each station sampled every other night. Figure 8-6 shows the location of the sampling stations for the Amherst study area and Figure 8-7 shows the sampling stations used within the Thief River Falls study area. During spring 1989, only one radar lab was available to cover both study areas, so this lab was rotated at approximately weekly intervals between study areas. Table 8-5 shows the dates radar sampling occurred during each season at each study area.

The surveillance radar unit was used at two range settings, long-range (3 nautical miles (nm)) and short-range (0.75 nm). At long-range, flocks of large-bodied birds could be observed at distances up to 4 or 5 statute miles; single hawks were routinely observed out to 3 miles. The short-range setting improved target resolution from about 300 feet (at long-range) to about 100 feet, allowing small, single birds (passerines and shorebirds) to be observed with greater frequency at ranges up to 0.75 nm (ABR, 1989; 1990a). The altitudes of most targets observed on the surveillance radar were not known since altitude could not be measured with this type of equipment and correlation with targets observed on vertical-beam radar, where altitudes were known, was generally not possible.

The vertical radar unit could detect even the smallest sized birds at altitudes between about 100 and 5900 feet above ground level (agl) at the range setting used (0.75 nm). Return echoes from the ground and surrounding vegetation obscured birds flying within approximately 100 feet of the ground, making them impossible to observe. This equipment's measurement accuracy was

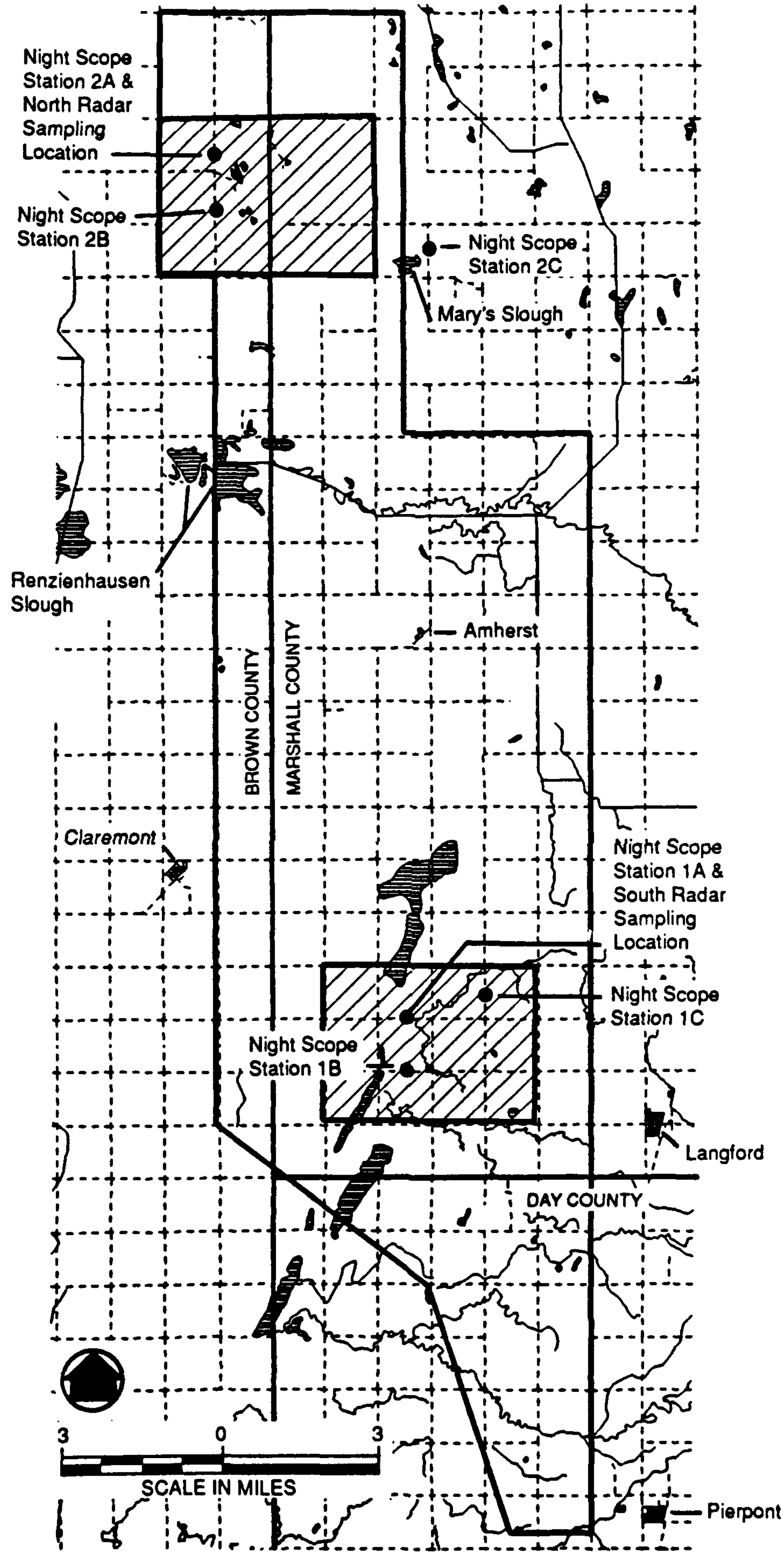


FIGURE 8-6. AMHERST, SD TRANSMIT STUDY AREA NIGHT-VISION SCOPE AND RADAR SAMPLING LOCATIONS USED DURING AVIAN STUDIES

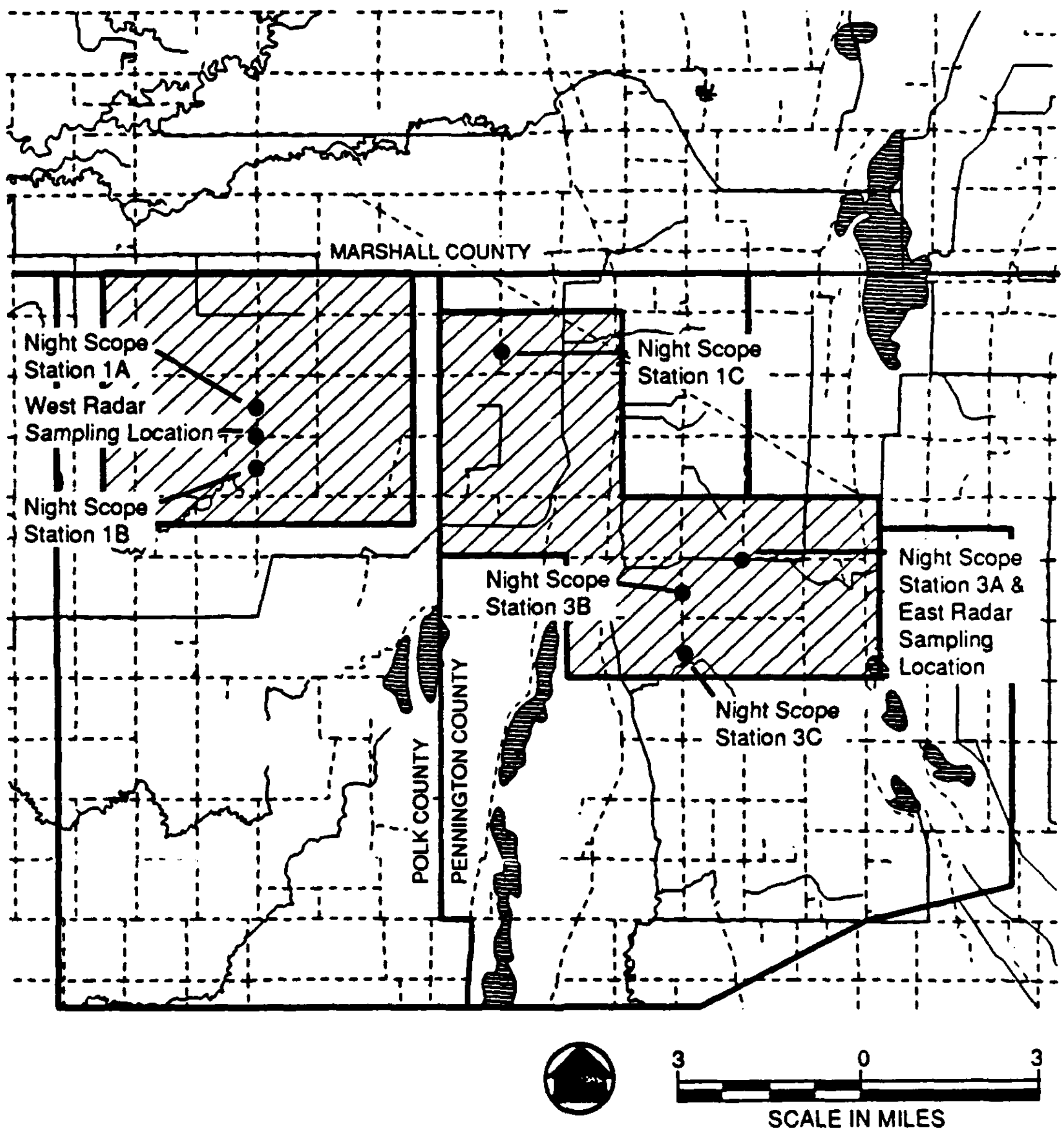


FIGURE 8-7. THIEF RIVER FALLS, MN RECEIVE STUDY AREA NIGHT-VISION SCOPE AND RADAR SAMPLING LOCATIONS USED DURING AVIAN STUDIES

TABLE 8-5. RADAR AND NIGHT-VISION SCOPE SAMPLING DATES - AMHERST AND THIEF RIVER FALLS STUDY AREAS

Study	Night-Vision Scope		Radar	
	Start	Finish	Start	Finish
THIEF RIVER FALLS				
Fall 1987	NO SAMPLING		NO SAMPLING	
Spring 1988	NO SAMPLING		NO SAMPLING	
Spring 1989	9 April	14 June(1)	16 March	2 June(2)
Fall 1989	1 September	16 November(3)	15 August	13 November(4)
AMHERST				
Fall 1987	NO SAMPLING		NO SAMPLING	
Spring 1988	NO SAMPLING		NO SAMPLING	
Spring 1989	9 April	15 June(5)	19 March	5 June(6)
Fall 1989	1 September	14 November(7)	25 August	18 November(8)

1. No sampling on 30 April; 4,24,25,30,31 May; 6,11 June.
2. No sampling on 18-27,29-31 March; 1-4,11-15,21-26 April; 7-12,19-24 May.
3. No sampling on 1,4 October.
4. No sampling on 18,21 August.
5. No sampling on 10,14 April; 30 May.
6. No sampling on 28,29 March; 5-10,16-20,27-30 April; 1-6,13-18,25-31 May; 1,2 June.
7. No sampling on 10,20 September; 1 October; 4 November.
8. No sampling on 20 September; 9 October.

better than ± 1 percent, or within ± 20 feet at the maximum range used (about 5900 feet agl). For general information on the use of marine radar in bird migration studies, refer to Eastwood (1967) and Gauthreaux (1980; 1985) and for more specific information on the units used in this study, refer to ABR (1989; 1990a).

During each hour of radar sampling, 30 minutes of observation were conducted at the long-range setting and 10 minutes were conducted at the short-range setting. Vertical-beam sampling was essentially continuous, done concurrently with surveillance radar sampling. Weather information was collected every 30 minutes. Since raindrops and snowflakes reflect back the out-going radar energy, they produce a clutter of echoes on the radar screen, effectively obscuring any echoes which may have been produced by flying birds. Because of this, the radar units were not used during periods of rain or heavy snow (ABR, 1989; 1990a).

Night-vision scope observations. Because the vertical radar unit could not sample below about 100 feet agl, a five power night-vision scope was used to obtain information on nocturnal flights below this altitude. Figures 8-6 and 8-7 show the sampling locations used during night-vision scope observations for the Amherst and Thief River Falls study areas, respectively. Table 8-5 shows the dates of night-vision scope sampling at each study area for each season.

Two night-vision scopes were used at each study area and observation stations were sampled in pairs, with each station sampled every third night. Observation sessions generally began one hour after sunset and lasted approximately three hours. These scopes could not be used during periods of precipitation as moisture would damage their electronics. Tests with fixed targets indicate that large birds are visible out to a maximum of 2500 feet and small birds are visible out to a maximum of 1100 feet using this technique, although maximum distances were highly variable during tests (UMN, 1989a).

Aerial surveys. Systematic aerial surveys of the Amherst and Thief River Falls study areas and vicinities were conducted during the spring and fall 1989 seasons. Surveys followed a set route and concentrated on wetland habitats. Figures 8-8 and 8-9 show the area of coverage for the Amherst and Thief River Falls study areas, respectively. Aerial surveys conducted during spring 1988 and fall 1987 were not of sufficient duration and intensity to compare with the 1989 data and are not considered in this technical study.

The purpose of the aerial surveys was to determine the chronology of migration and the composition, distribution, and habitat use of birds (mostly waterfowl) in the area of the radar facilities.

Tower collision assessment. Periodic searches for bird carcasses at two communication towers near the Amherst study area (Fig. 8-10) and four towers near the Thief River Falls study area (Fig. 8-11) were conducted during spring and fall 1989 migration seasons to assess bird collision potential with man-made objects in the project area. During each survey, the area within approximately 50 feet of the tower and any associated guy wires was systematically searched for dead birds. Surveys were conducted at regular intervals of 5 to 14 days in spring 1989 and 3 to 5 days in fall 1989.

Lek surveys. During spring 1989, previously known or suspected sharp-tailed grouse and greater prairie-chicken lek sites were checked for activity. Locations where these two species were observed during road surveys were investigated further during lek surveys. Once a site was determined to be an active lek, it was monitored once a week in the early morning hours by a single observer equipped with binoculars and a spotting scope to determine the number of birds using the lek.

8.2.2.2 Analysis. With one exception, individual species are not considered in this technical study but are grouped together largely on a taxonomic basis for the following reasons: 1) field identification was often restricted to a higher taxonomic division than species (e.g. ducks), 2) species within larger groups usually have similar flight patterns and behaviors, 3) a large number of species were observed, making individual analyses impractical, and 4)

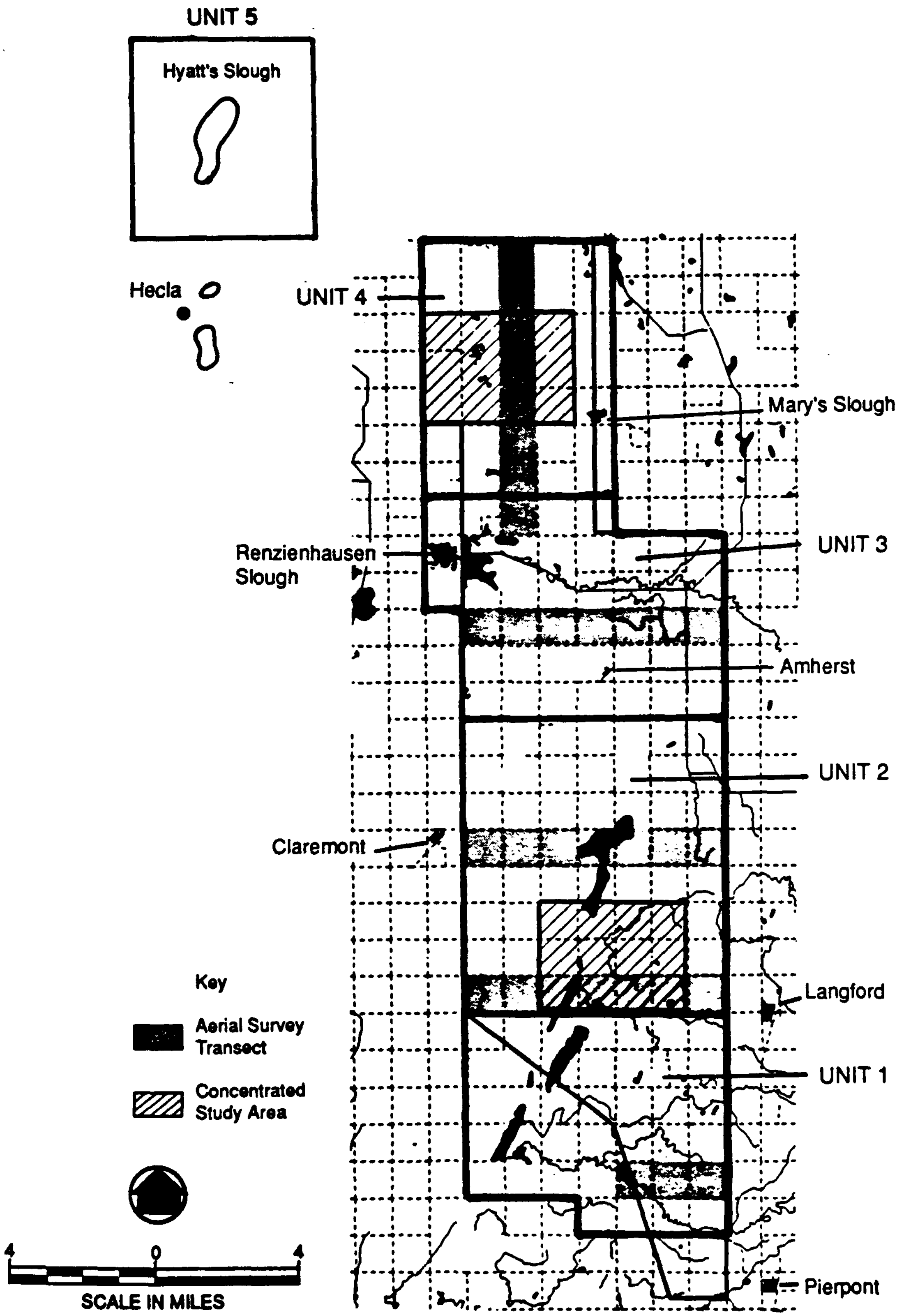


FIGURE 8-8. AMHERST, SD TRANSMIT STUDY AREA
AERIAL SURVEY TRANSECTS AND AERIAL SURVEY UNIT LOCATIONS

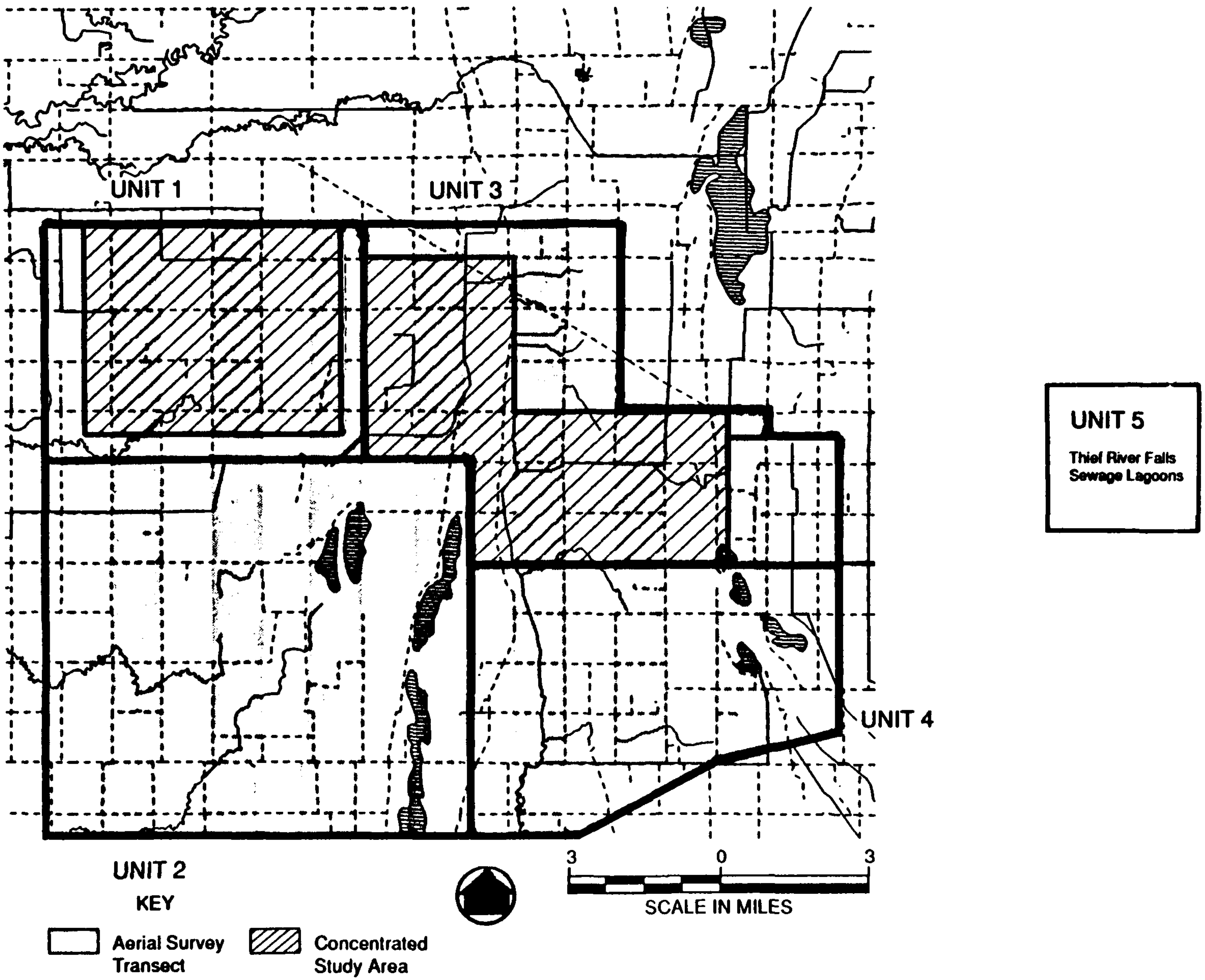


FIGURE 8-9. THIEF RIVER FALLS, MN RECEIVE STUDY AREA AERIAL SURVEY TRANSECTS AND AERIAL SURVEY UNIT LOCATIONS

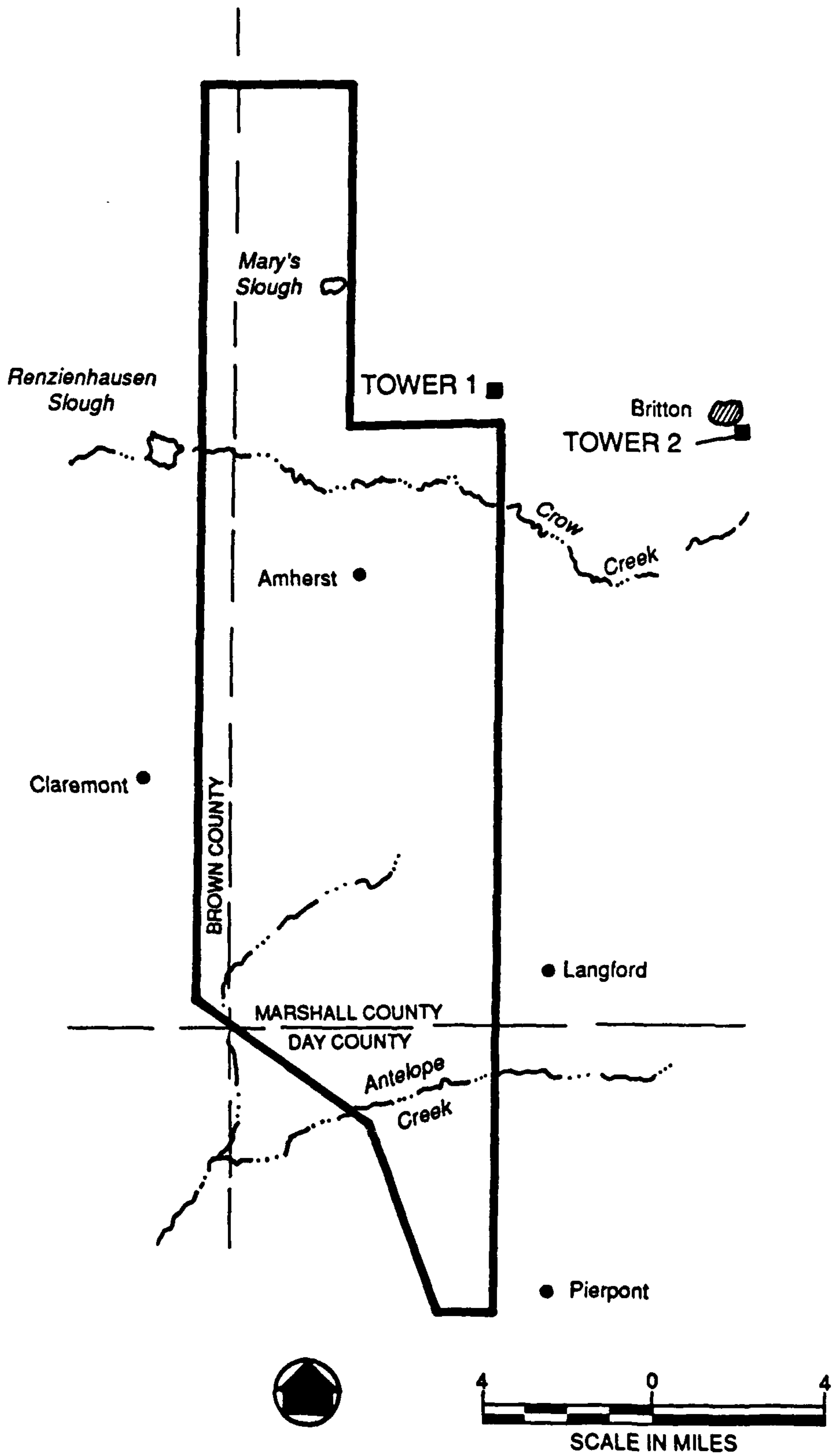


FIGURE 8-10. AMHERST, SD TRANSMIT STUDY AREA LOCATIONS OF TOWERS SEARCHED FOR DEAD BIRDS DURING AVIAN STUDIES

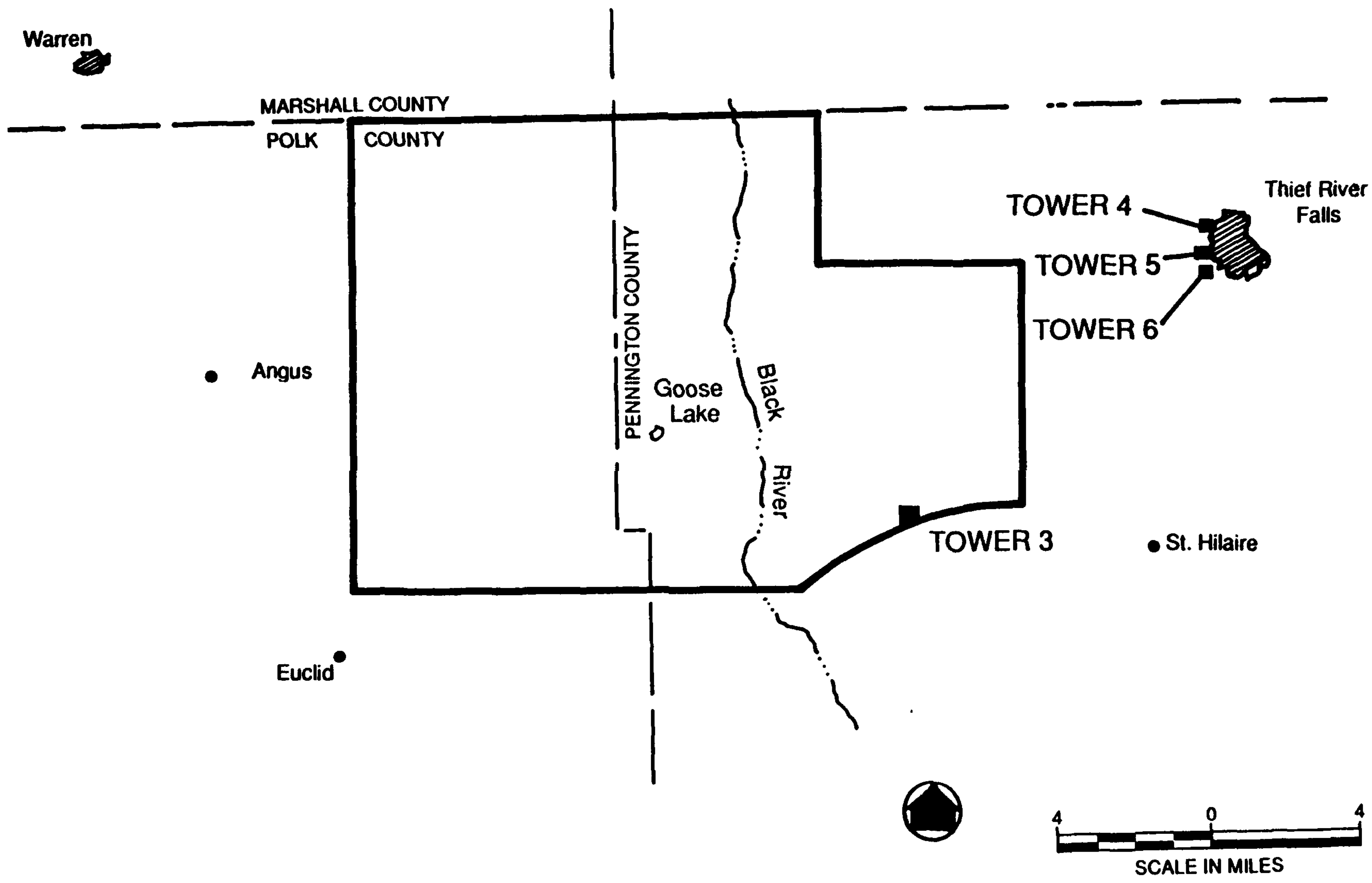


FIGURE 8-11. THIEF RIVER FALLS, MN RECEIVE STUDY AREA LOCATIONS OF TOWERS SEARCHED FOR DEAD BIRDS DURING AVIAN STUDIES

grouping increases sample sizes and better summarizes the data. Therefore, the following groups were recognized:

1) Waterfowl - all species of ducks, geese, swans, and cormorants.

2) Ducks - all species of ducks.

3) Geese/Cormorants - all species of geese and cormorants.

4) Swans - all species of swans.

5) Raptors - all species of vultures, hawks, eagles, harriers, ospreys, falcons, and owls.

6) Eagles/hawks - all species of eagles and hawks.

7) Harriers - all species of harriers.

8) Falcons - all species of falcons.

9) Owls - all species of owls.

10) Shorebirds - all species of shorebirds.

11) Waterbirds - all species of rails, coots, loons, grebes, herons, pelicans, gulls, terns, and kingfishers.

12) Gamebirds - all species of grouse, partridge, prairie-chickens, and pheasants.

13) Passerines - all species of songbirds, woodpeckers, doves, cuckoos, nighthawks, and swifts.

14) Blackbirds - all species of blackbirds, meadowlarks, orioles, and starlings.

15) Nonblackbird Passerines - all species included in the Passerine category but not included in the Blackbird category.

There is some overlap in the above categories and not all groups are used in all analyses. Individual species covered include the sandhill crane. Since only one species of harrier (northern harrier) and one species of swan (tundra swan) are likely to be seen in either study area, these categories also effectively cover one species.

Since it was not possible to obtain information on species identification or flock size using the radar units, the term "target" is used to describe a single radar sighting throughout this report rather than "flock" or "group". Thus, migration rates are expressed as "targets per hour", and other analyses use "percentages of targets" or "number of targets".

8.2.3 Transmit Study Area

Since the Renzienhausen Slough secondary observation station was used only during the fall 1989 season, information from this station is presented in the tables only for some analyses to compare with data from the primary observation stations. Data from this station, however, are not discussed in the text.

8.2.3.1 Species Composition and Numbers. A total of 202 species of birds were identified at the Amherst transmit study area during all studies combined, 157 during the spring and 164 during the fall (Appendix A). Slightly more species (132) were observed from the South station than from the North station (125) (Table 8-6).

TABLE 8-6. NUMBER OF SPECIES IDENTIFIED AT EACH OBSERVATION STATION BY SEASON AT THE AMHERST TRANSMIT STUDY AREA

Season	Station		
	North	South	Renzienhausen Slough
Fall 1987	46	-	-
Spring 1988	18	-	-
Spring 1989	96	105	-
Fall 1989	70	86	57
Total Species (All Seasons)	125	132	57

Table 8-7 shows the number of birds observed during daylight hours from each observation station for each of the four seasons studied. Because there were different numbers of observation hours during each season, numbers have been converted to birds per observation hour for comparisons. Since a certain proportion of observed bird movements were local in nature, it is possible that individual birds were counted more than one time. No effort was made to control for these local birds in the analyses, however, field observers tried to avoid the double counting of birds during each individual observation session.

At the North station, the observed numbers of ducks, swans, raptors, gamebirds, and passerines were higher in fall and the number of geese/cormorants and shorebirds were higher in spring. Trends for sandhill cranes and waterbirds were not clearly evident. Geese/cormorants (mostly snow geese) were most abundant during all seasons at the North station, except for fall 1987 when ducks were most abundant (Table 8-7). At the South station, observed numbers of all species groups were higher in fall, except for geese/cormorants and sandhill cranes, which were higher in spring (Table 8-7). Geese/cormorants (mostly snow geese) were most abundant during both of the seasons sampled at the South station.

In general, more birds of all species groups were observed at the South station than at the North station during 1989 seasons (Table 8-7). Exceptions were ducks and blackbirds which were more abundant at the North station but only during the fall season. Approximately equal numbers of blackbirds were observed between the two stations during the spring season, while more ducks were observed at the South station during spring. Gamebird numbers were similar between stations during both seasons.

The difference in numbers between the two stations is most likely due to the large amount of water which existed at the South station due to extensive spring flooding (Technical Study 4). A good portion of this water persisted into the fall season. Waterbirds, in particular, were much more abundant at the South station but this open water also attracted other species which use water areas, including waterfowl, shorebirds, sandhill cranes, and some

TABLE 8-7. NUMBER OF BIRDS OBSERVED FROM OBSERVATION STATIONS DURING DAYLIGHT HOURS AT THE AMHERST TRANSMIT STUDY AREA

Species Group	Season	Number of Birds (Birds per Hour)					
		North Station		South Station		Renzienhausen Slough	
Waterfowl	Fall 87	963153	(1615.03)	---	---		
	Spring 88	172921	(4860.06)	---	---		
	Spring 89	1040464	(1209.70)	2054908	(2273.88)	---	
	Fall 89	720318	(829.88)	843908	(980.25)	847098	(2456.99)
- Ducks	Fall 87	375369	(629.42)	---	---		
	Spring 88	1232	(34.63)	---	---		
	Spring 89	16810	(19.54)	80853	(89.47)	---	
	Fall 89	193749	(223.22)	118270	(137.38)	178811	(518.64)
- Geese/Cormorants	Fall 87	309600	(519.14)	---	---		
	Spring 88	170221	(4784.18)	---	---		
	Spring 89	1014979	(1180.07)	1972463	(2182.65)	---	
	Fall 89	303607	(349.79)	570638	(662.83)	474107	(1375.14)
- Swans	Fall 87	924	(1.55)	---	---		
	Spring 88	33	(0.93)	---	---		
	Spring 89	30	(0.03)	104	(0.12)	---	
	Fall 89	82	(0.56)	522	(0.61)	650	(1.89)
Raptors	Fall 87	534	(0.90)	---	---		
	Spring 88	20	(0.56)	---	---		
	Spring 89	209	(0.24)	344	(0.38)	---	
	Fall 89	725	(0.84)	1094	(1.27)	351	(1.02)
- Eagles/Hawks	Fall 87	385	(0.65)	---	---		
	Spring 88	6	(0.17)	---	---		
	Spring 89	98	(0.11)	217	(0.24)	---	
	Fall 89	489	(0.56)	789	(0.92)	234	(0.68)

TABLE 8-7 (Continued). NUMBER OF BIRDS OBSERVED FROM OBSERVATION STATIONS DURING DAYLIGHT HOURS AT THE AMHERST TRANSMIT STUDY AREA

Species Group	Season	Number of Birds (Birds per Hour)					
		North Station		South Station		Renzienhausen Slough	
- Harriers	Fall 87	68	(0.11)	---	---		
	Spring 88	13	(0.37)	---	---		
	Spring 89	70	(0.08)	64	(0.07)	---	
	Fall 89	90	(0.10)	147	(0.17)	57	(0.17)
- Falcons	Fall 87	20	(0.03)	---	---		
	Spring 88	0	(0.00)	---	---		
	Spring 89	21	(0.02)	20	(0.02)	---	
	Fall 89	81	(0.09)	55	(0.06)	21	(0.06)
- Owls	Fall 87	35	(0.06)	---	---		
	Spring 88	0	(0.00)	---	---		
	Spring 89	0	(0.00)	2	(>0.01)	---	
	Fall 89	4	(>0.01)	2	(>0.01)	3	(0.01)
Shorebirds	Fall 87	26	(0.04)	---	---		
	Spring 88	20	(0.56)	---	---		
	Spring 89	617	(0.72)	2054	(2.27)	---	
	Fall 89	98	(0.11)	4368	(5.07)	217	(0.63)
Sandhill cranes	Fall 87	102	(0.17)	---	---		
	Spring 88	3	(0.08)	---	---		
	Spring 89	421	(0.49)	491	(0.54)	---	
	Fall 89	0	(0.00)	143	(0.17)	56	(0.16)
Waterbirds	Fall 87	39	(0.07)	---	---		
	Spring 88	115	(3.23)	---	---		
	Spring 89	1954	(2.27)	24211	(26.79)	---	
	Fall 89	5013	(5.78)	64213	(74.59)	8208	(23.81)

TABLE 8-7 (Continued). NUMBER OF BIRDS OBSERVED FROM OBSERVATION STATIONS DURING DAYLIGHT HOURS AT THE AMHERST TRANSMIT STUDY AREA

Species Group	Season	Number of Birds (Birds per Hour) North Station		South Station		Renzienhausen Slough	
Gamebirds	Fall 87	200	(0.34)	---	---		
	Spring 88	3	(0.08)	---	---		
	Spring 89	11	(0.01)	11	(0.01)	---	
	Fall 89	87	(0.10)	59	(0.07)	22	(0.06)
Passerines	Fall 87	298667	(500.81)	---	---		
	Spring 88	616	(17.31)	---	---		
	Spring 89	13260	(15.42)	27454	(30.38)	---	
	Fall 89	187498	(216.02)	166099	(192.93)	707661	(2052.56)
- Blackbirds	Fall 87	271662	(455.53)	---	---		
	Spring 88	522	(14.67)	---	---		
	Spring 89	11886	(13.82)	12521	(13.86)	---	
	Fall 89	148720	(171.34)	74355	(86.37)	600647	(1742.17)
- Nonblackbirds	Fall 87	21876	(36.68)	---	---		
	Spring 88	13	(0.37)	---	---		
	Spring 89	1368	(1.59)	14912	(16.50)	---	
	Fall 89	34662	(39.93)	77178	(89.65)	60055	(174.19)
Total[1]	Fall 87	1262722	(2117.35)	---	---		
	Spring 88	173698	(4881.90)	---	---		
	Spring 89	1057505	(1229.51)	2121702	(2347.79)	---	
	Fall 89	917335	(1056.86)	1088233	(1264.05)	1567055	(4545.22)

1. Includes unidentified birds.

passerine species. Raptors were also more abundant at the South station and may have been attracted to the foraging opportunities the large number of other birds provided. In most years, when reduced amounts of water would be present at the South station, the differences between stations would probably be much less.

8.2.3.2 Migration Chronology and Rates. Diurnal migration rates were calculated by dividing the total number of birds observed during daylight hours for each day's observation by the total number of daytime observation hours for that day. These are mean hourly migration rates (birds per hour) and not daily rates (birds per day). The following figures are not meant to imply a continuum of migration rates; continuous lines were used simply to show trends. Nocturnal rates were calculated in a similar manner and are expressed as targets per hour.

8.2.3.2.1 Daylight periods. At the Amherst study area during the spring season, ducks and geese were generally the first migrants observed in large numbers, as open water became available, followed by waterbirds (mostly gulls and terns), early passerines, swans, sandhill cranes and raptors, blackbirds, cormorants, late passerines, then shorebirds. In the fall, shorebirds, waterbirds, and early passerines were generally the first migrants leaving the Amherst region, followed by raptors, blackbirds, later passerines (e.g. horned larks), cormorants and sandhill cranes, ducks, geese, late passerines, and then swans.

Duck migration in spring, as observed from the North and South stations, generally occurred during the last week of March through the middle of April, with peak rates occurring during the last week of March as open water became available (Table 8-8; Fig. 8-12). The number of ducks seen during aerial surveys increased abruptly during the first week of April, as ducks began to arrive, then declined quickly to relatively low levels by the first week of May (Fig. 8-14). Fall duck migration rates were generally low until late October/early November when they peaked sharply. Rates remained at high levels through the middle of November before declining as waterbodies began to freeze (Table 8-8; Fig. 8-12). Peaks were earlier in 1987 than in 1989 at the

TABLE 8-8. PEAK DAILY MIGRATION RATES (BIRDS PER HOUR) OBSERVED FROM OBSERVATION STATIONS DURING DAYLIGHT HOURS AT THE AMHERST TRANSMIT STUDY AREA

Species Group	Season	Peak Rate [Birds per Hour] (Date) North Station		South Station		Renzienhausen Slough	
Waterfowl	Fall 87	11626.43	(8 Nov)	---	---		
	Spring 88	13188.00	(4 Apr)	---	---		
	Spring 89	24057.58	(31 Mar)	71737.08	(30 Mar)	---	
	Fall 89	14773.33	(10 Nov)	11733.89	(13 Nov)	42352.80	(14 Nov)
- Ducks	Fall 87	4221.96	(28 Oct)	---	---		
	Spring 88	221.50	(30 Mar)	---	---		
	Spring 89	366.33	(29 Mar)	1815.83	(27 Mar)	---	
	Fall 89	5017.78	(10 Nov)	1446.00	(5 Nov)	12813.60	(14 Nov)
- Geese/Cormorants	Fall 87	6359.20	(6 Nov)	---	---		
	Spring 88	13096.20	(4 Apr)	---	---		
	Spring 89	23992.50	(31 Mar)	71235.83	(30 Mar)	---	
	Fall 89	5636.23	(12 Nov)	11223.26	(13 Nov)	23220.00	(6 Nov)
- Swans	Fall 87	16.80	(9 Nov)	---	---		
	Spring 88	3.64	(31 Mar)	---	---		
	Spring 89	1.09	(8 Apr)	1.64	(5 Apr)	---	
	Fall 89	11.38	(8 Nov)	10.53	(15 Nov)	69.60	(6 Nov)
Raptors	Fall 87	14.27	(27 Sept)	---	---		
	Spring 88	1.52	(5 Apr)	---	---		
	Spring 89	2.17	(29 Mar)	2.92	(13 Apr)	---	
	Fall 89	6.04	(22 Sept)	8.39	(8 Oct)	15.00	(1 Oct)
- Eagles/Hawks	Fall 87	13.75	(27 Sept)	---	---		
	Spring 88	0.57	(5 Apr)	---	---		
	Spring 89	0.75	(25 Mar)	2.55	(13 Apr)	---	
	Fall 89	4.73	(13 Sept)	8.12	(8 Oct)	10.83	(1 Oct)

TABLE 8-8 (Continued). PEAK DAILY MIGRATION RATES (BIRDS PER HOUR) OBSERVED FROM OBSERVATION STATIONS DURING DAYLIGHT HOURS AT THE AMHERST TRANSMIT STUDY AREA

Species Group	Season	Peak Rate [Birds per Hour] (Date)					
		North Station		South Station		Renzienhausen Slough	
- Harriers	Fall 87	0.77	(17 Sept)	---	---		
	Spring 88	0.89	(2 Apr)	---	---		
	Spring 89	0.43	(5 May)	0.73	(15 Apr)	---	
	Fall 89	0.39	(5 Sept)	0.85	(2 Oct)	2.50	(1 Oct)
- Falcons	Fall 87	0.32	(28 Sept)	---	---		
	Spring 88	0.00	(-----)	---	---		
	Spring 89	0.25	(8 June)	0.33	(26 Mar)	---	
	Fall 89	1.36	(18 Sept)	0.40	(8 Sept)	1.00	(1 Oct)
- Owls	Fall 87	0.83	(20 Sept)	---	---		
	Spring 88	0.00	(-----)	---	---		
	Spring 89	0.00	(-----)	0.14	(12 Apr)	---	
	Fall 89	0.11	(14 Nov)	0.09	(16 Oct)	0.50	(24 Sept)
Shorebirds	Fall 87	0.95	(28 Sept)	---	---		
	Spring 88	1.50	(30 Mar)	---	---		
	Spring 89	4.40	(17 May)	18.56	(11 May)	---	
	Fall 89	1.42	(10 Sept)	57.00	(26 Sept)	11.71	(4 Sept)
Sandhill cranes	Fall 87	5.60	(16 Oct)	---	---		
	Spring 88	0.55	(31 Mar)	---	---		
	Spring 89	9.53	(14 Apr)	11.46	(13 Apr)	---	
	Fall 89	0.00	(-----)	9.10	(28 Oct)	44.80	(6 Nov)
Waterbirds	Fall 87	2.25	(25 Sept)	---	---		
	Spring 88	8.00	(5 Apr)	---	---		
	Spring 89	18.60	(30 Apr)	456.18	(1 Apr)	---	
	Fall 89	99.32	(22 Sept)	1289.20	(11 Sept)	625.10	(16 Sept)

TABLE 8-8 (Continued). PEAK DAILY MIGRATION RATES (BIRDS PER HOUR) OBSERVED FROM OBSERVATION STATIONS DURING DAYLIGHT HOURS AT THE AMHERST TRANSMIT STUDY AREA

Species Group	Season	Peak Rate [Birds per Hour] (Date)					
		North Station		South Station		Renzienhausen Slough	
Gamebirds	Fall 87	1.56	(6 Oct)	---	---		
	Spring 88	0.36	(1 Apr)	---	---		
	Spring 89	0.16	(3 Apr)	0.25	(10 June)	---	
	Fall 89	0.98	(9 Oct)	1.30	(16 Sept)	5.82	(19 Oct)
Passerines	Fall 87	10256.56	(18 Oct)	---	---		
	Spring 88	55.81	(5 Apr)	---	---		
	Spring 89	201.08	(26 Mar)	654.73	(1 Apr)	---	
	Fall 89	7734.43	(28 Sept)	1439.90	(22 Oct)	33962.57	(8 Sept)
- Blackbirds	Fall 87	10254.52	(18 Oct)	---	---		
	Spring 88	54.86	(5 Apr)	---	---		
	Spring 89	195.75	(26 Mar)	144.93	(3 May)	---	
	Fall 89	7703.30	(28 Sept)	688.83	(10 Sept)	33348.00	(8 Sept)
- Nonblackbirds	Fall 87	1520.00	(20 Sept)	---	---		
	Spring 88	1.09	(1 Apr)	---	---		
	Spring 89	30.50	(22 May)	650.18	(1 Apr)	---	
	Fall 89	723.50	(10 Sept)	809.85	(23 Oct)	5274.23	(13 Sept)

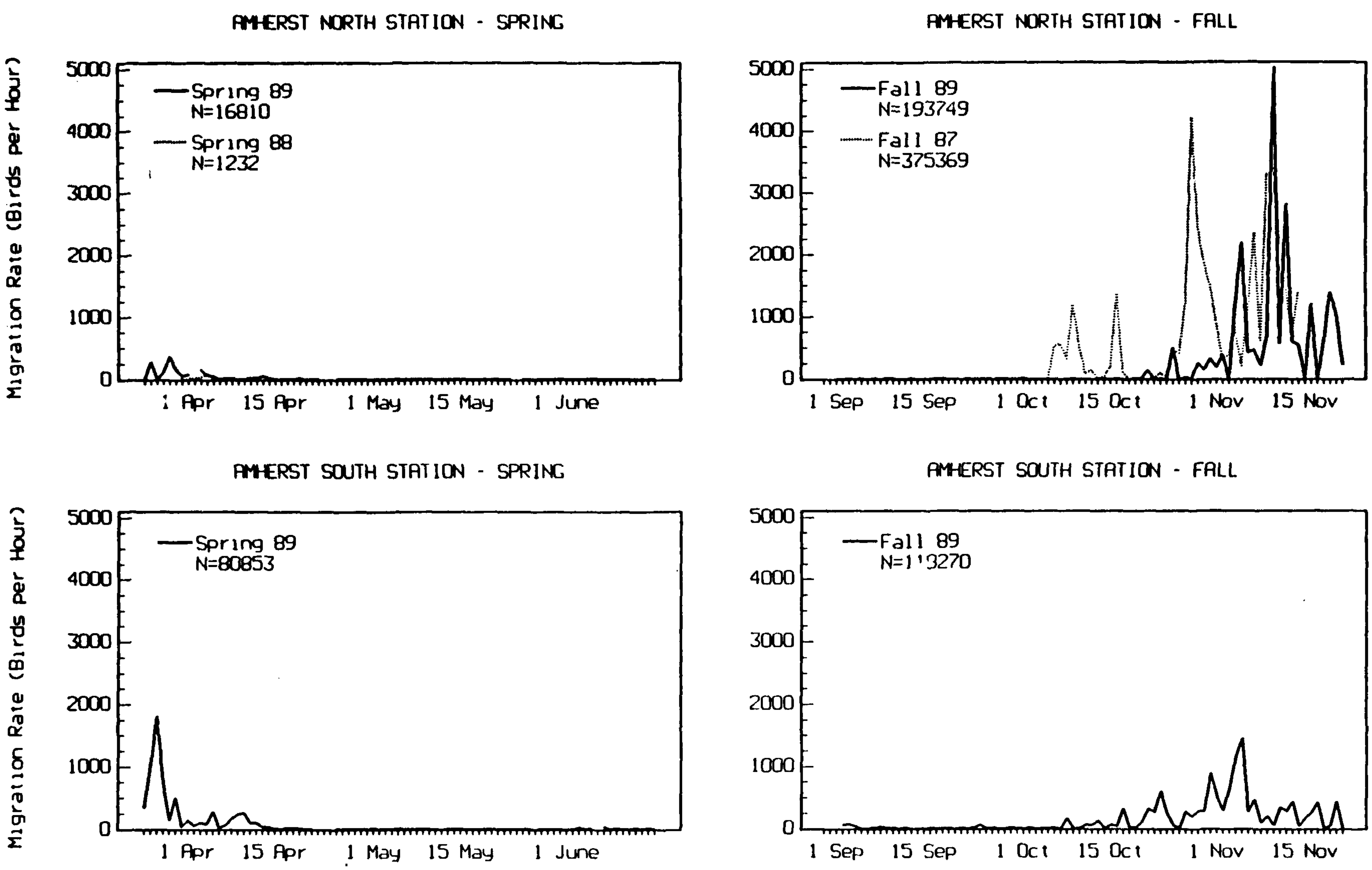


FIGURE 8-12. AMHERST, SD TRANSMIT STUDY AREA DIURNAL MIGRATION RATES - DUCKS

North station. Numbers of ducks observed during aerial surveys were relatively constant in September and October before peaking in early November. The number of ducks rapidly declined during the middle of November as open water became unavailable (Fig. 8-14).

Peak migration rates for ducks were much higher in fall than in spring at the North station but similar between seasons at the South station (Table 8-8; Fig. 8-12). Peak numbers of ducks observed during aerial surveys were about twice as high in spring, however (Fig. 8-14). Comparing the two stations, peak rates were much higher in spring at the South station but much higher in fall at the North station (Table 8-8; Fig. 8-12).

Spring migration of geese was mainly confined to the last week of March and the first week of April. Cormorants migrated mostly during late April and early May (Fig. 8-13). Numbers of geese and cormorants observed during aerial surveys were relatively low and did not peak until the third week of April (Fig. 8-14), suggesting that the majority of birds observed from the stations flew through the area without stopping. However, many geese could have stopped over during the six to seven day periods between aerial survey flights. Fall goose migration was mostly confined to the first two weeks of November while cormorants migrated during late October and early November (Fig. 8-13). Numbers of geese observed during aerial surveys were generally low in September and October, peaked sharply during the first week of November, then steadily declined through the third week of November as open water became unavailable (Fig. 8-14).

Peak migration rates for geese/cormorants were much higher in spring than in fall at both the North and South stations (Table 8-8; Fig. 8-13). Peak numbers of geese observed during aerial surveys were much higher in fall, however (Fig. 8-14). Peak rates were much higher at the South station during both spring and fall 1989 (Table 8-8; Fig. 8-13).

In spring, swan migration occurred primarily during early to mid-April (Fig. 8-15). Relatively few swans were observed during spring aerial surveys. Fall migration rates were low until mid to late October when they

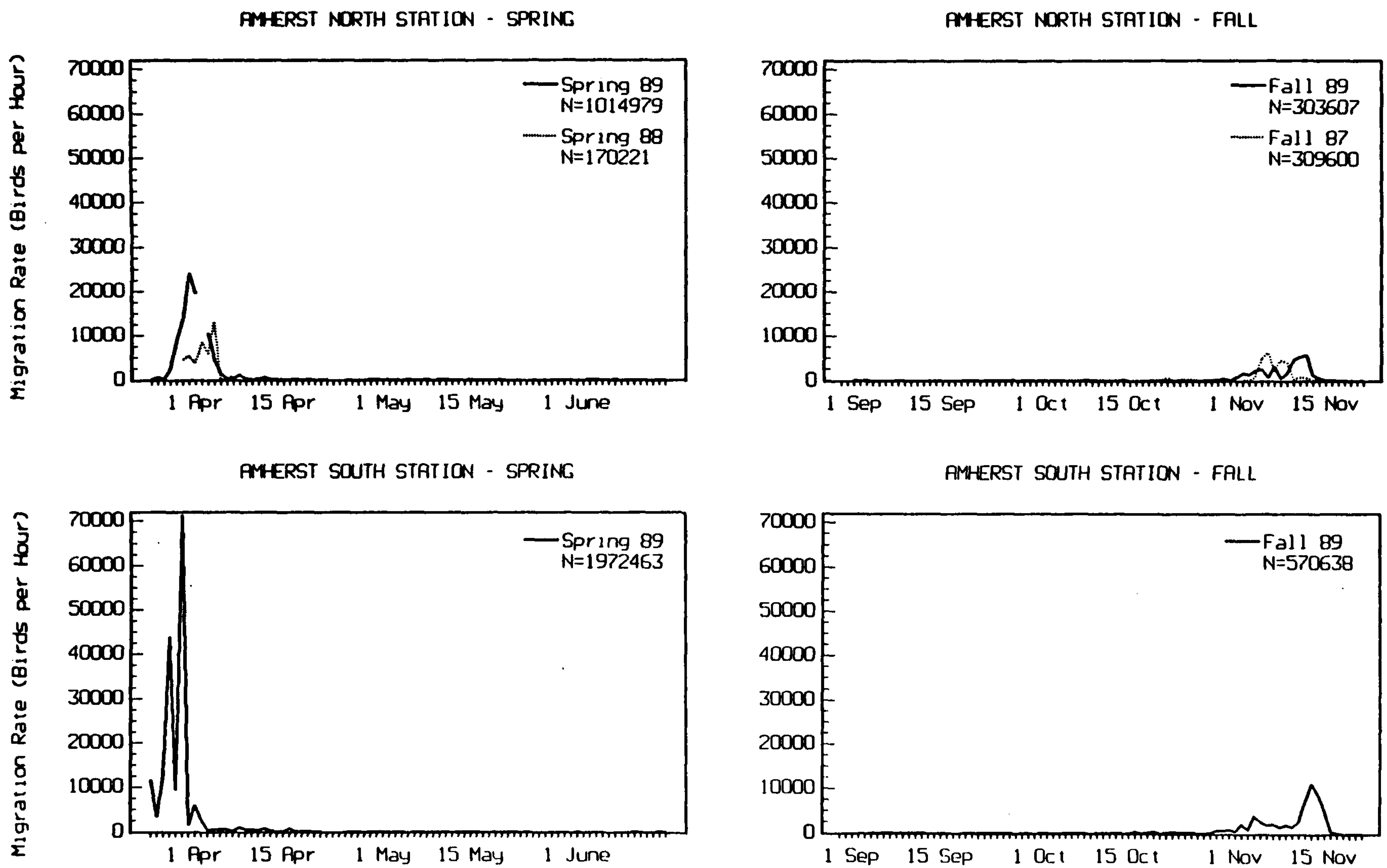


FIGURE 8-13. AMHERST, SD TRANSMIT STUDY AREA DIURNAL MIGRATION RATES - GEESE/CORMORANTS

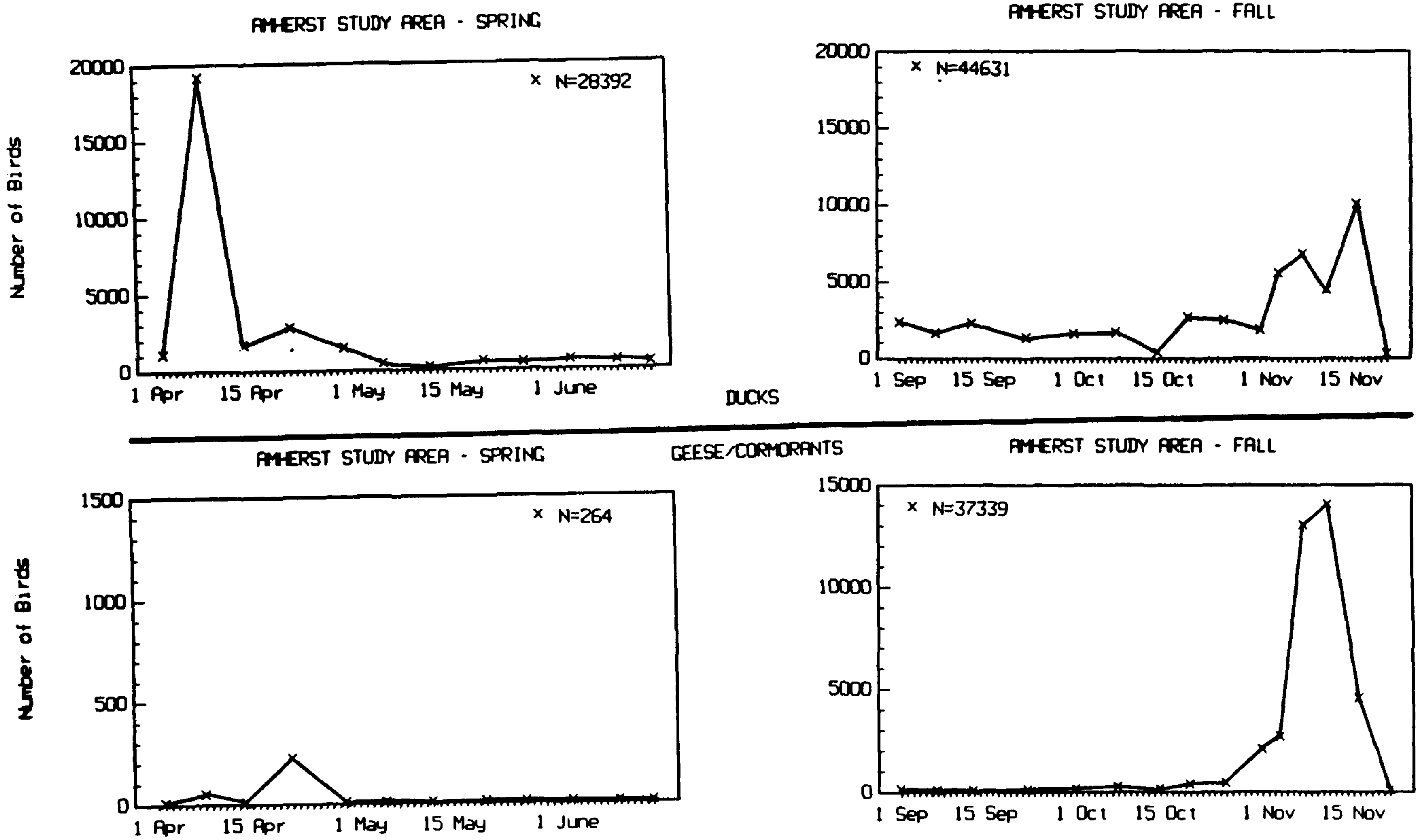


FIGURE 8-14. AMHERST, SD TRANSMIT STUDY AREA
DUCK AND GOOSE/CORMORANT CHRONOLOGY AND NUMBERS
AERIAL SURVEYS

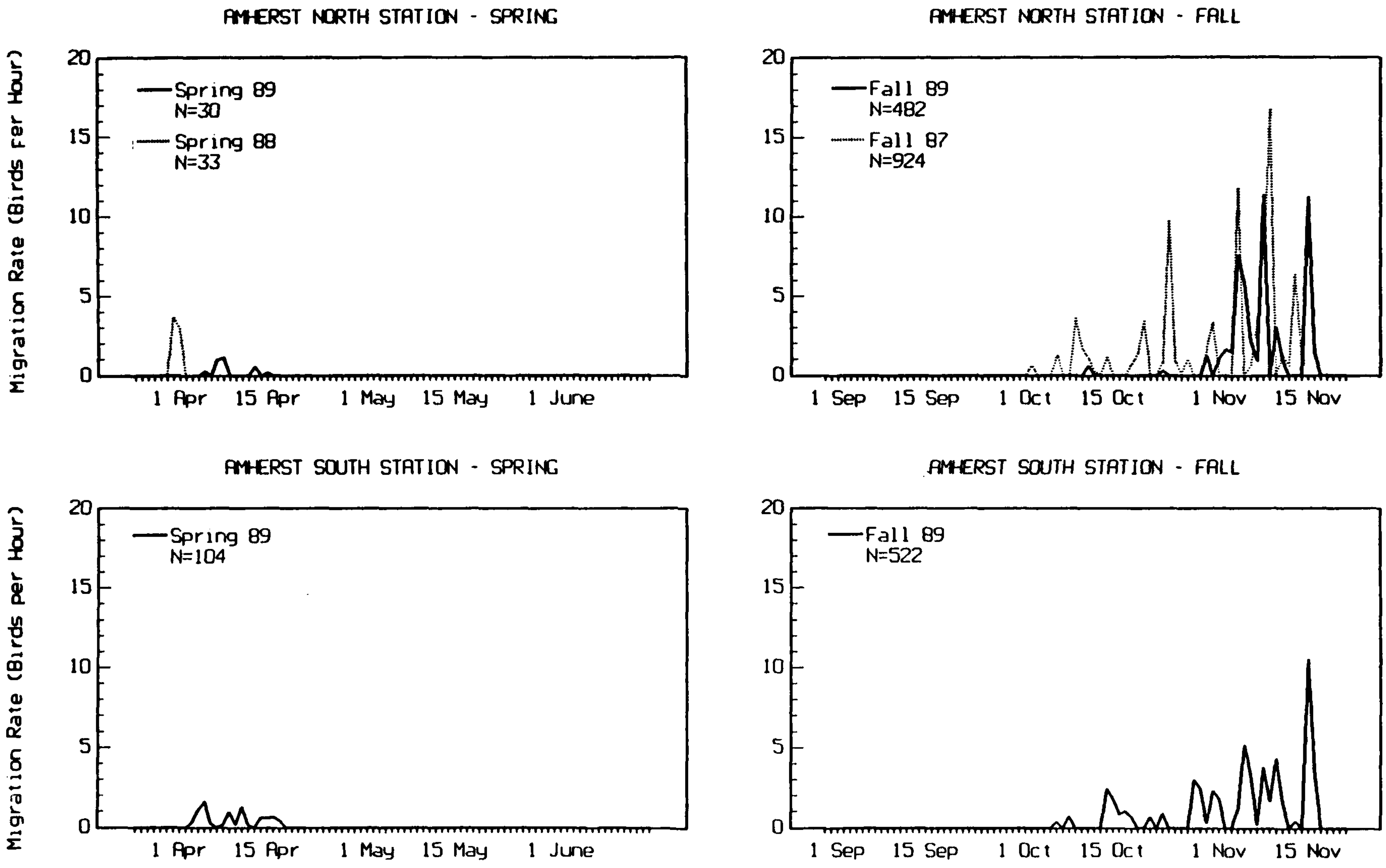


FIGURE 8-15. AMHERST, SD TRANSMIT STUDY AREA DIURNAL MIGRATION RATES - SWANS

increased abruptly, with high rates persisting through mid-November (Fig. 8-15). Peaks tended to be earlier during 1987 than during 1989 at the North station. As in spring, few swans were observed during fall aerial surveys.

Peak migration rates for swans were much higher in fall than in spring at both the North and South stations (Table 8-8; Fig. 8-15). Peak rates were similar between the North and South stations during both spring and fall 1989 (Table 8-8; Fig. 8-15).

Migration trends for all waterfowl (Figs. 8-16; 8-17) were similar to those described for ducks and geese. Overall, peak rates for all waterfowl were higher in spring than in fall at both stations but peak rates were higher at the North station in fall and at the South station in spring (Table 8-8).

Spring shorebird migration occurred mostly during the month of May, with peak rates observed near the middle of this month (Fig. 8-18). Numbers of shorebirds observed during aerial surveys showed a bimodal distribution, with peaks near the first of May and the first of June (Fig. 8-19). In fall, most observed migration occurred during September, with peak rates occurring near the middle of this month (Fig. 8-18). However, some species of shorebirds typically migrate as early as late July (Whitney et al.,1978), so it is possible that peak rates occurred before fall observations commenced. Peak numbers were observed in mid-September during aerial surveys, with a smaller peak during the first week of October (Fig. 8-19). Shorebird migration was minimal after the middle of October (Figs. 8-18; 8-19).

Overall and peak rates of shorebird migration were higher in spring than in fall at the North station, but higher in fall than in spring at the South station (Tables 8-7; 8-8). It is possible that shorebirds were attracted to the exposed mudflats caused by the evaporation of spring flooding near the South station, resulting in higher observed rates in fall at this station. Overall and peak rates were much higher at the South station than at the North station during both spring and fall (Tables 8-7; 8-8).

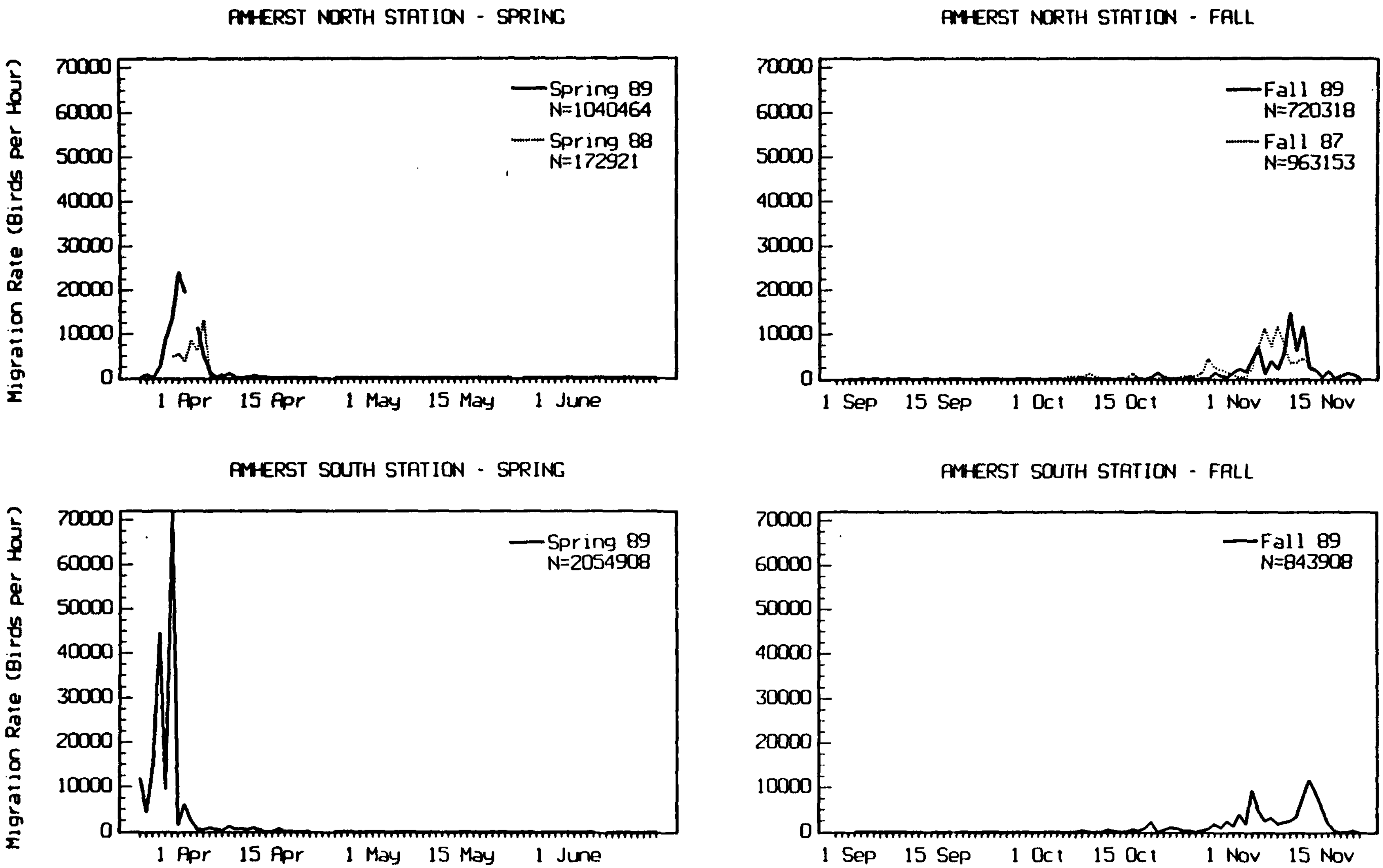


FIGURE 8-16. AMHERST, SD TRANSMIT STUDY AREA
DIURNAL MIGRATION RATES - ALL WATERFOWL

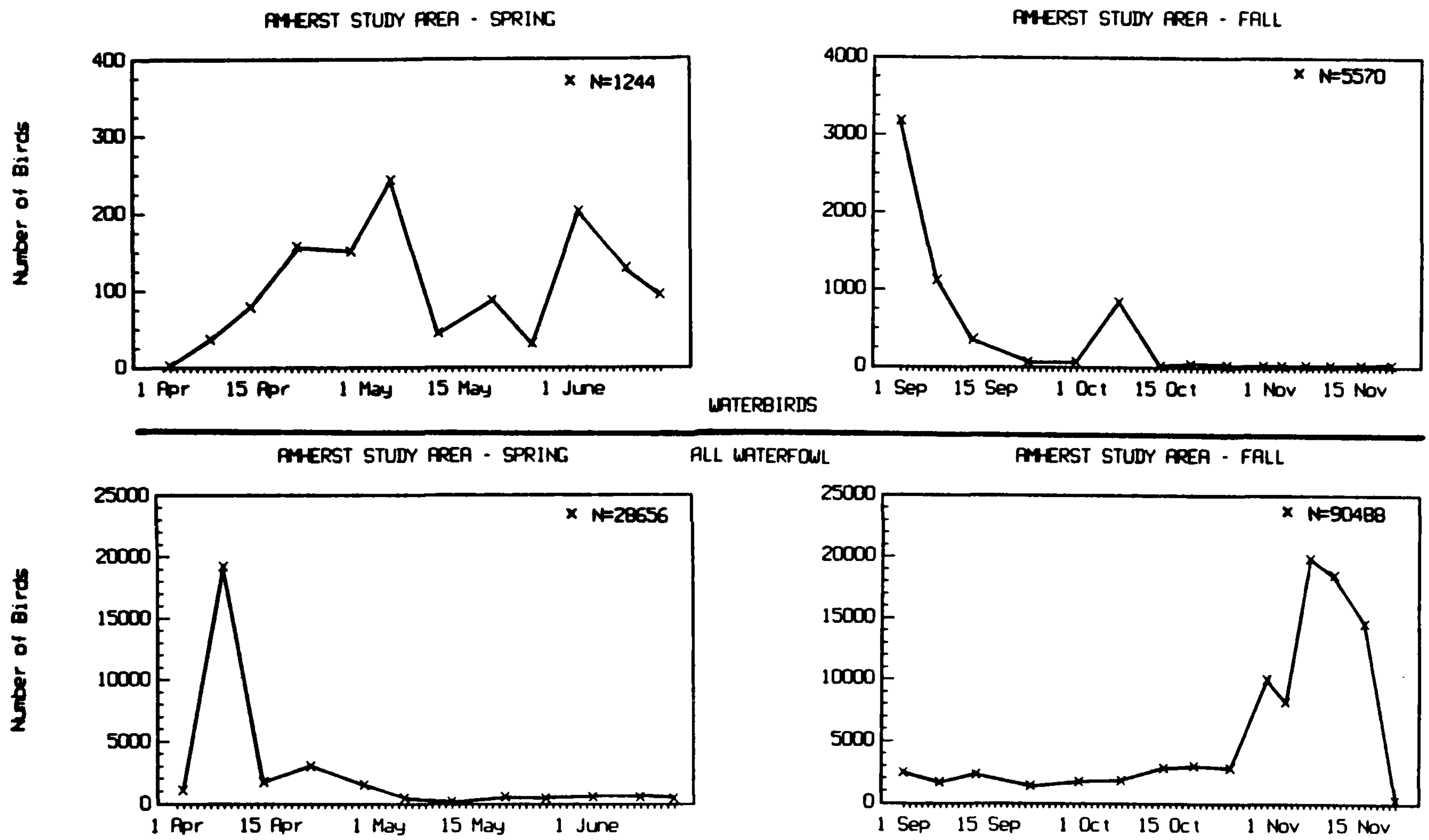


FIGURE 8-17. AMHERST, SD TRANSMIT STUDY AREA WATERFOWL AND WATERBIRD CHRONOLOGY AND NUMBERS AERIAL SURVEYS

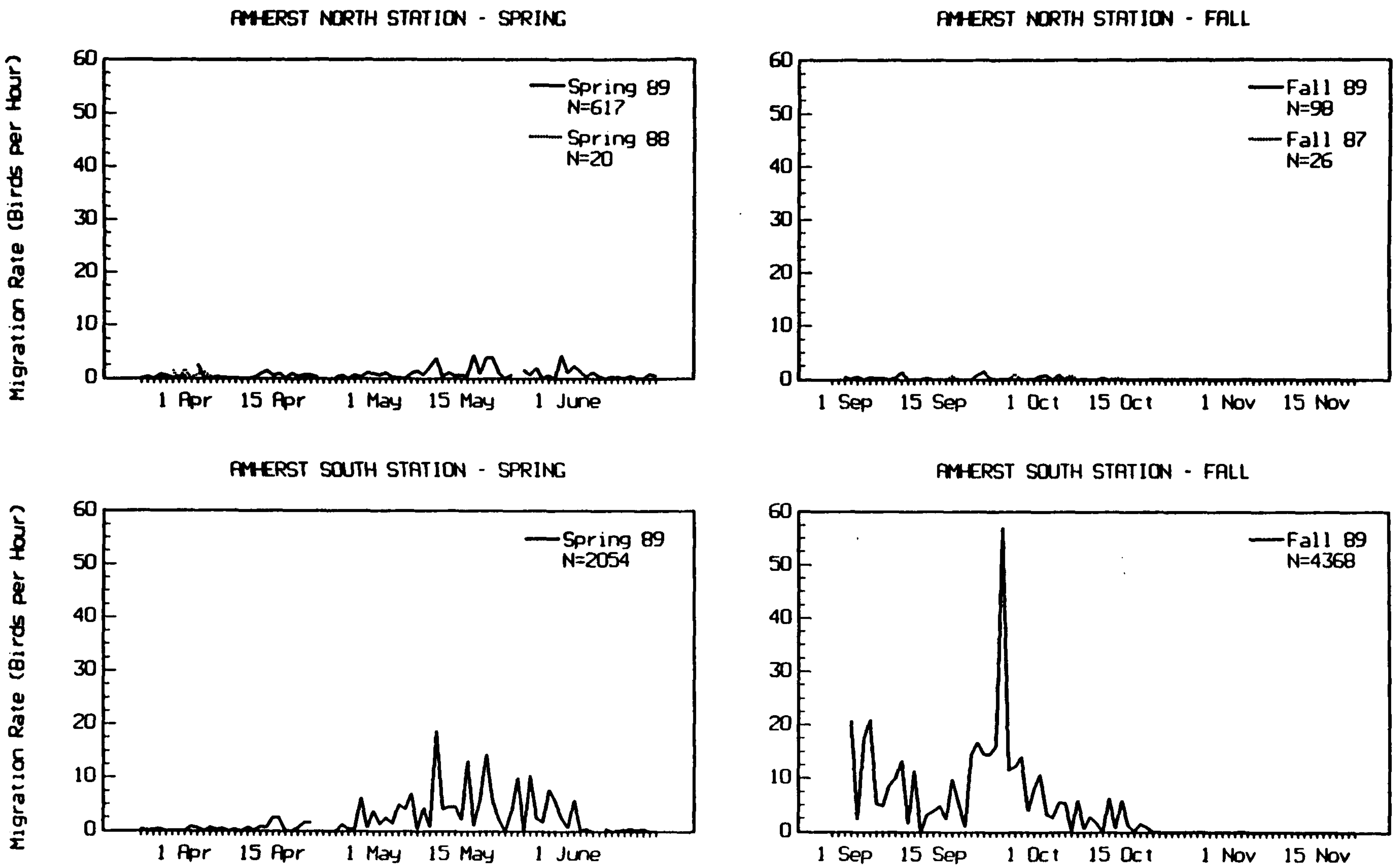


FIGURE 8-18. AMHERST, SD TRANSMIT STUDY AREA DIURNAL MIGRATION RATES - SHOREBIRDS

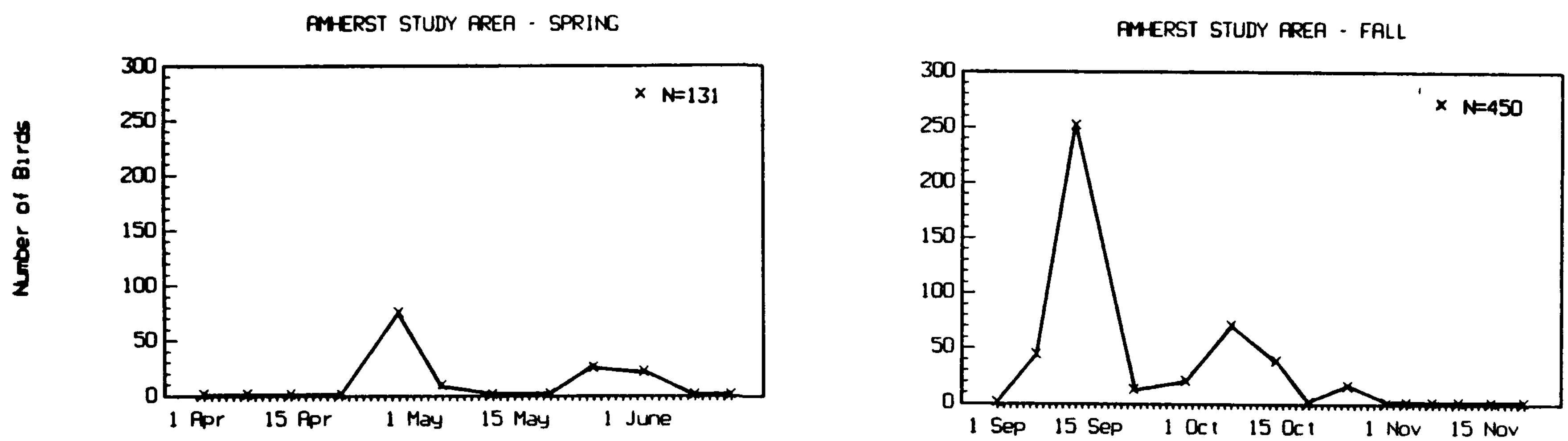


FIGURE 8-19. AMHERST, SD TRANSMIT STUDY AREA SHOREBIRD CHRONOLOGY AND NUMBERS - AERIAL SURVEYS

Spring sandhill crane migration was essentially limited to the first two weeks of April with peak rates occurring near the middle of April. Fall migration occurred during the last week of October and the first week of November in 1989; observed migration was earlier in 1987, although sample sizes (N=102) were small for this season (Fig. 8-20). Few cranes were observed during aerial surveys in either season.

Relatively few cranes were observed at either station during spring or fall. Overall and peak rates were similar among stations and seasons (Tables 8-7; 8-8).

Waterbird migration in spring occurred over the entire study period, with peak rates observed near the first of April as open water became available (Fig. 8-21). Waterbirds showed a gradual buildup in numbers during aerial surveys from the first of April until they peaked during the first week of May. Numbers declined after this time but peaked again near the first of June (Fig. 8-17). Fall migration appeared to be already underway as observations commenced on the first of September, with peak rates occurring during the first three weeks of September. Peak rates occurred later at the North station than at the South Station (Fig. 8-21). Peak numbers of waterbirds were observed during the first aerial survey (1 September) and gradually decreased over the next two weeks. A smaller peak was observed during the first week of October (Fig. 8-17).

Peak rates for waterbirds were higher in fall 1989 than in spring 1989 at both stations, although few waterbirds were observed from the North station during fall 1987 studies. Overall and peak rates were much higher at the South station during both spring and fall, most likely due to the extensive flooding in the area near this station (Tables 8-7; 8-8).

Raptors are early spring migrants and migration was already underway when spring observations began in late March. Migration rates were relatively stable at 1 to 2 birds per hour over the course of the spring studies, although rates were slightly higher during the first two weeks of April (Fig. 8-22). Fall migration was characterized by a constant low level of

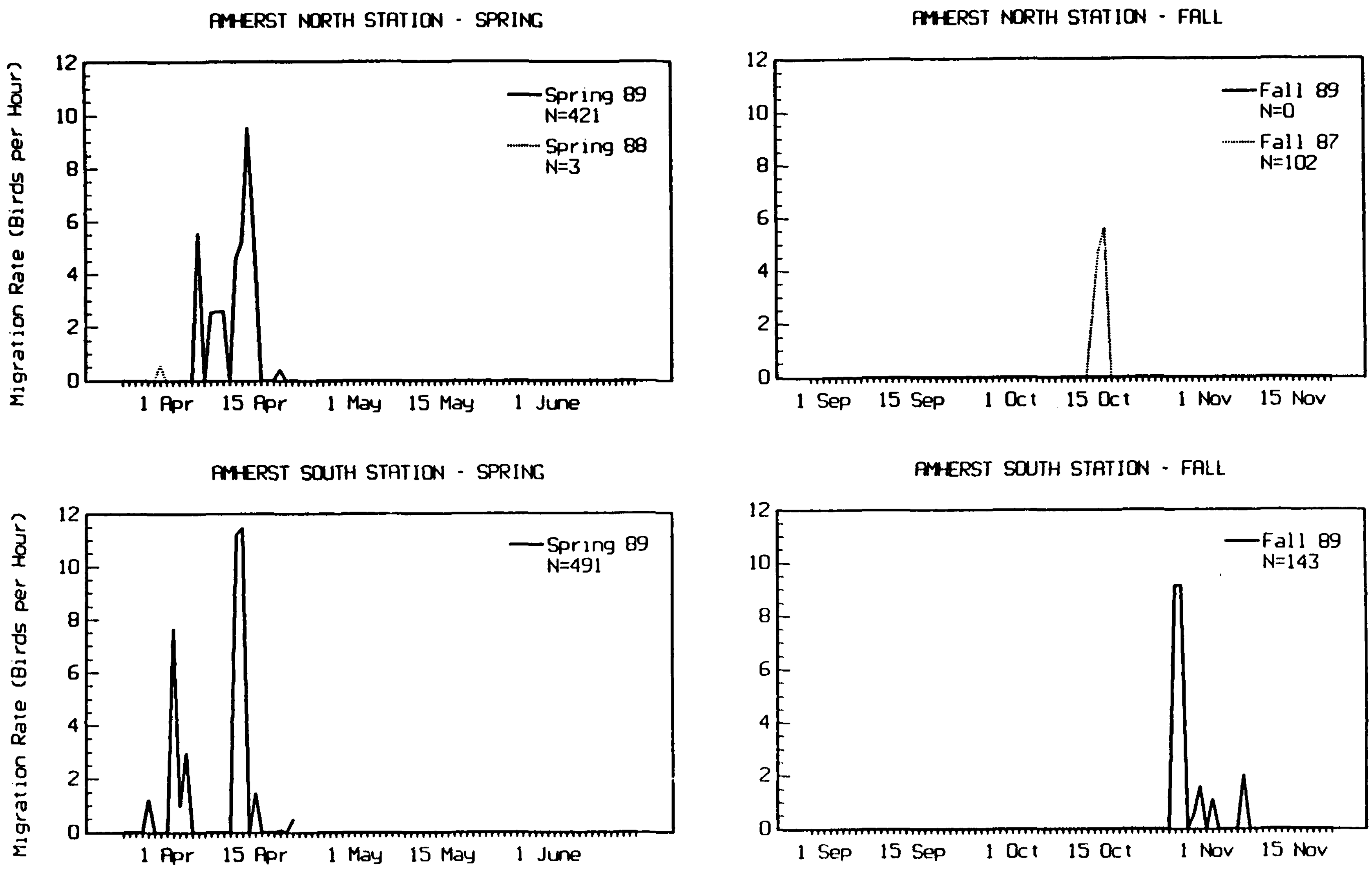


FIGURE 8-20. AMHERST, SD TRANSMIT STUDY AREA DIURNAL MIGRATION RATES - SANDHILL CRANES

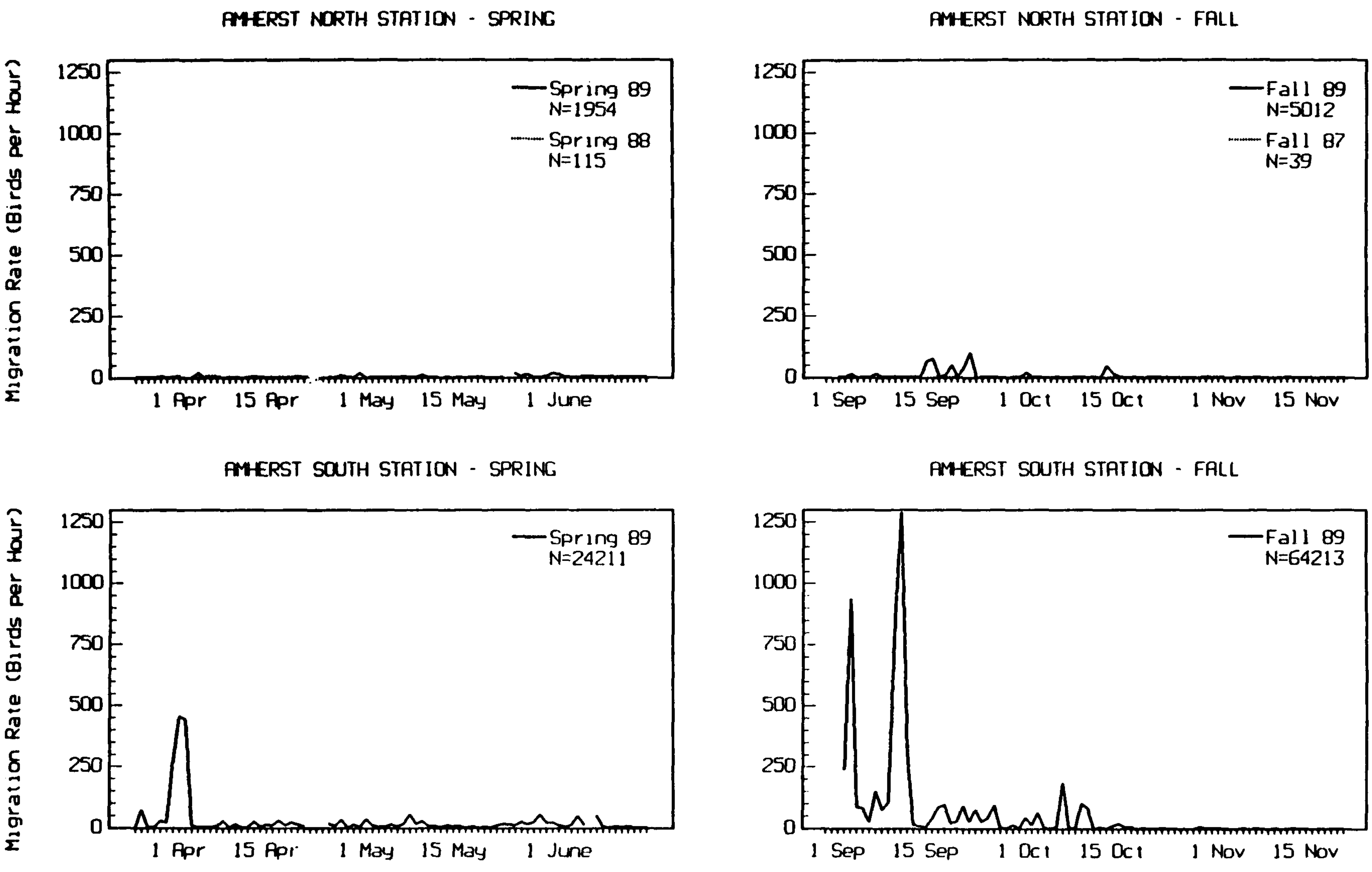


FIGURE 8-21. AMHERST, SD TRANSMIT STUDY AREA DIURNAL MIGRATION RATES - WATERBIRDS

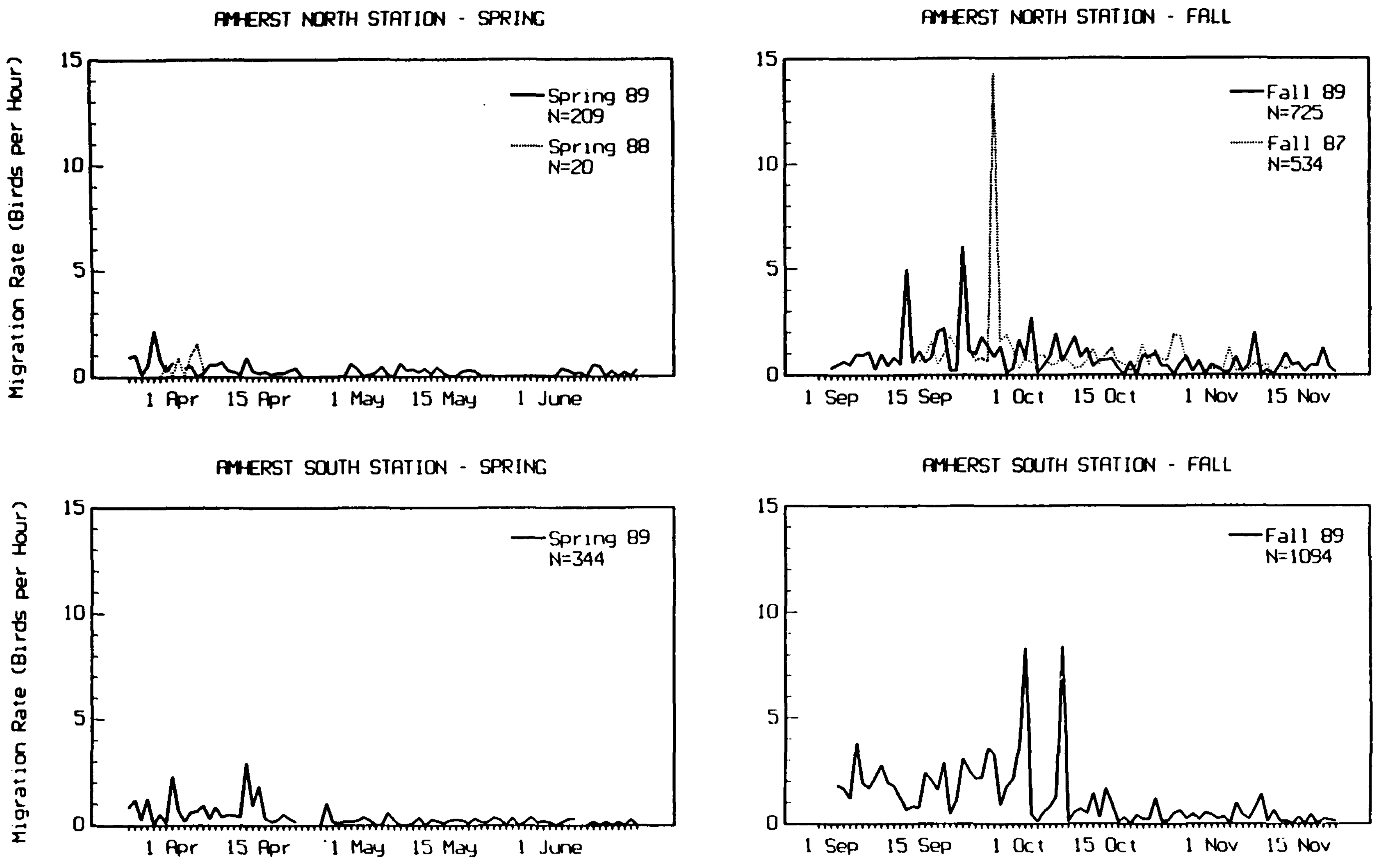


FIGURE 8-22. AMHERST, SD TRANSMIT STUDY AREA
DIURNAL MIGRATION RATES - RAPTORS

movement of 1 to 3 birds per hour, with sharp peaks of between 6 and 14 birds per hour occurring in late September/early October. Peaks were one to two weeks later at the South station (Fig. 8-22). Overall and peak rates were substantially higher in fall than in spring at both stations and overall and peak rates were slightly higher at the South station in both spring and fall 1989 (the only seasons when both stations were sampled) (Tables 8-7; 8-8).

Spring passerine migration was characterized by multiple peaks, with rates generally highest in April and early May. Blackbirds tended to peak earlier than nonblackbird passerines and peaks for blackbirds also tended to be earlier at the North station than at the South station (Figs. 8-23; 8-24; 8-25). Fall migration also occurred in multiple peaks with blackbirds tending to peak during the first two weeks of October and nonblackbird passerines peaking in mid-September (mostly swallows) and again in late October and early November (largely larks and longspurs)(Figs. 8-23; 8-24; 8-25).

Overall and peak rates for all passerines were much higher in fall than in spring at both stations. Overall and peak rates were higher at the North station for blackbirds in fall but rates were similar between stations in the spring. Rates for nonblackbird passerines were higher at the South station during both seasons, but especially during spring (Tables 8-7; 8-8).

8.2.3.2.2 Nocturnal periods. The long-range setting of the surveillance radar unit generally sampled large-bodied birds such as ducks and swans; smaller species, such as passerines, were generally not observed at this range setting unless they were in large flocks. To correct for this bias, the radar unit was also used on short-range, where the increased sensitivity of the radar unit allowed single passerines to be observed. However, the short-range setting only permitted a much smaller area to be sampled.

Nocturnal spring 1989 migration rates, as measured by long-range radar, were highest at the North station during the third week of April and highest at the South station during the first two weeks of April (Fig. 8-26). Spring sampling at Amherst was not continuous, however, as the radar lab was

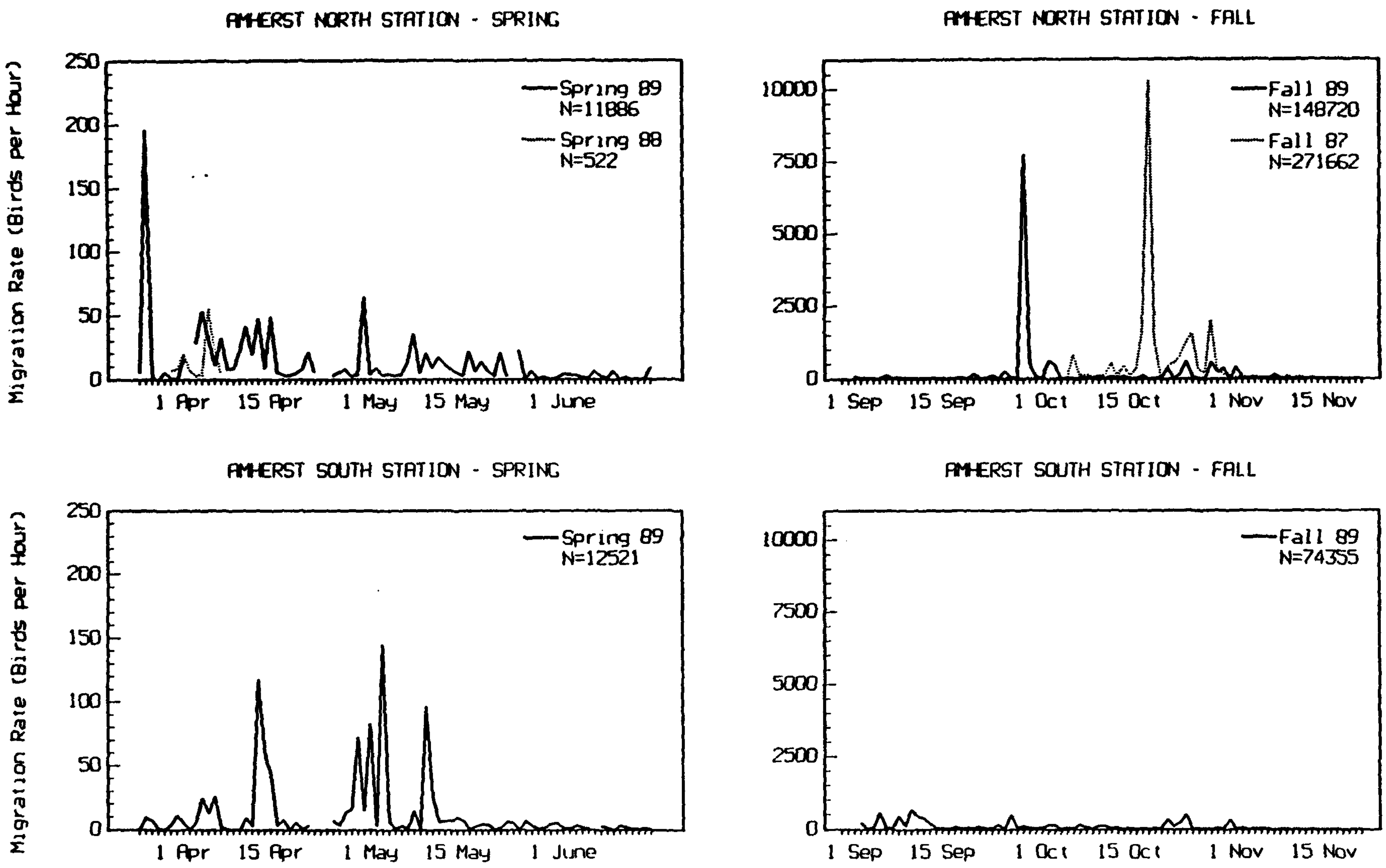


FIGURE 8-23. AMHERST, SD TRANSMIT STUDY AREA DIURNAL MIGRATION RATES - BLACKBIRDS

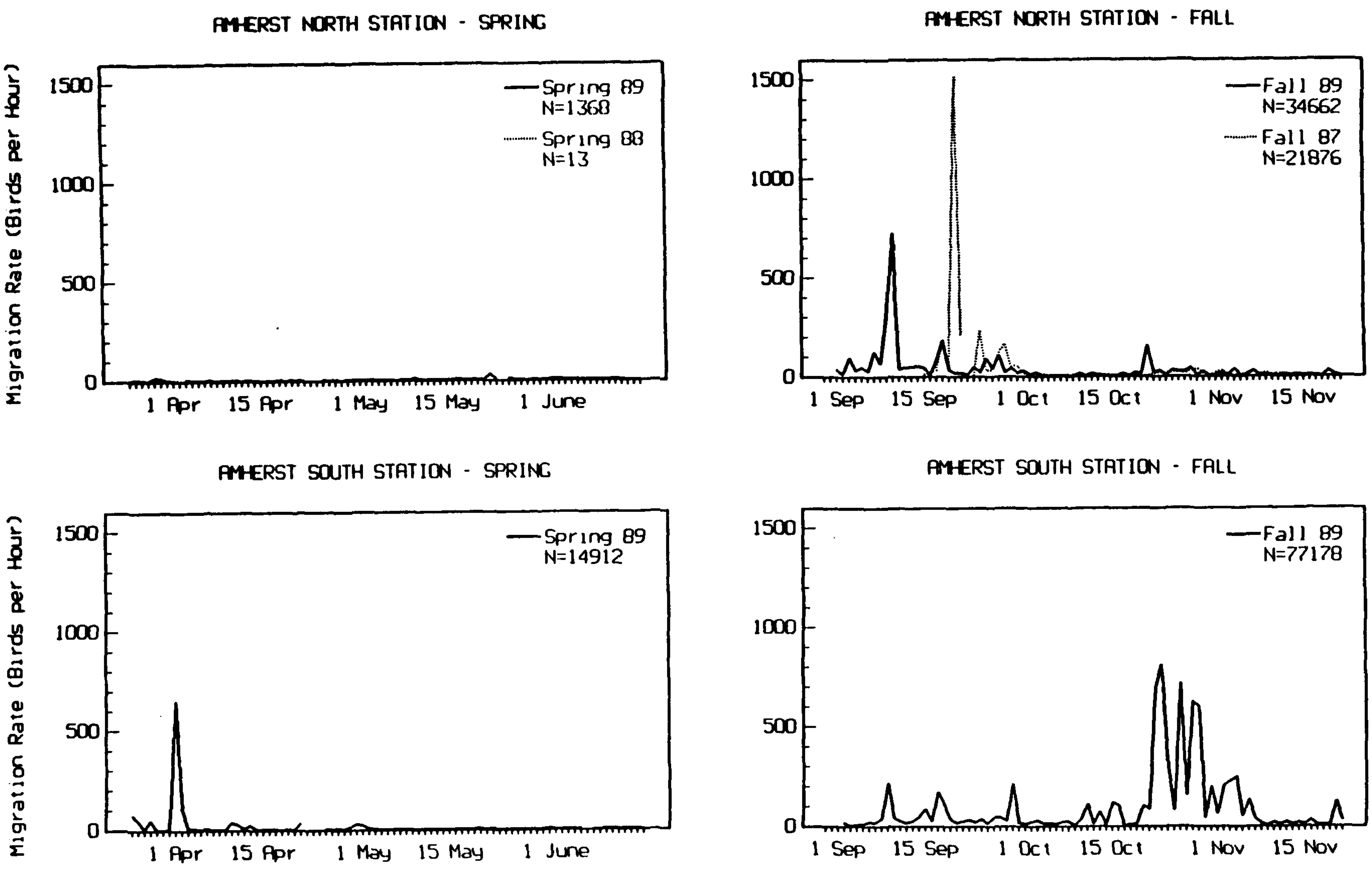


FIGURE 8-24. AMHERST, SD TRANSMIT STUDY AREA
DIURNAL MIGRATION RATES - NONBLACKBIRD PASSERINES

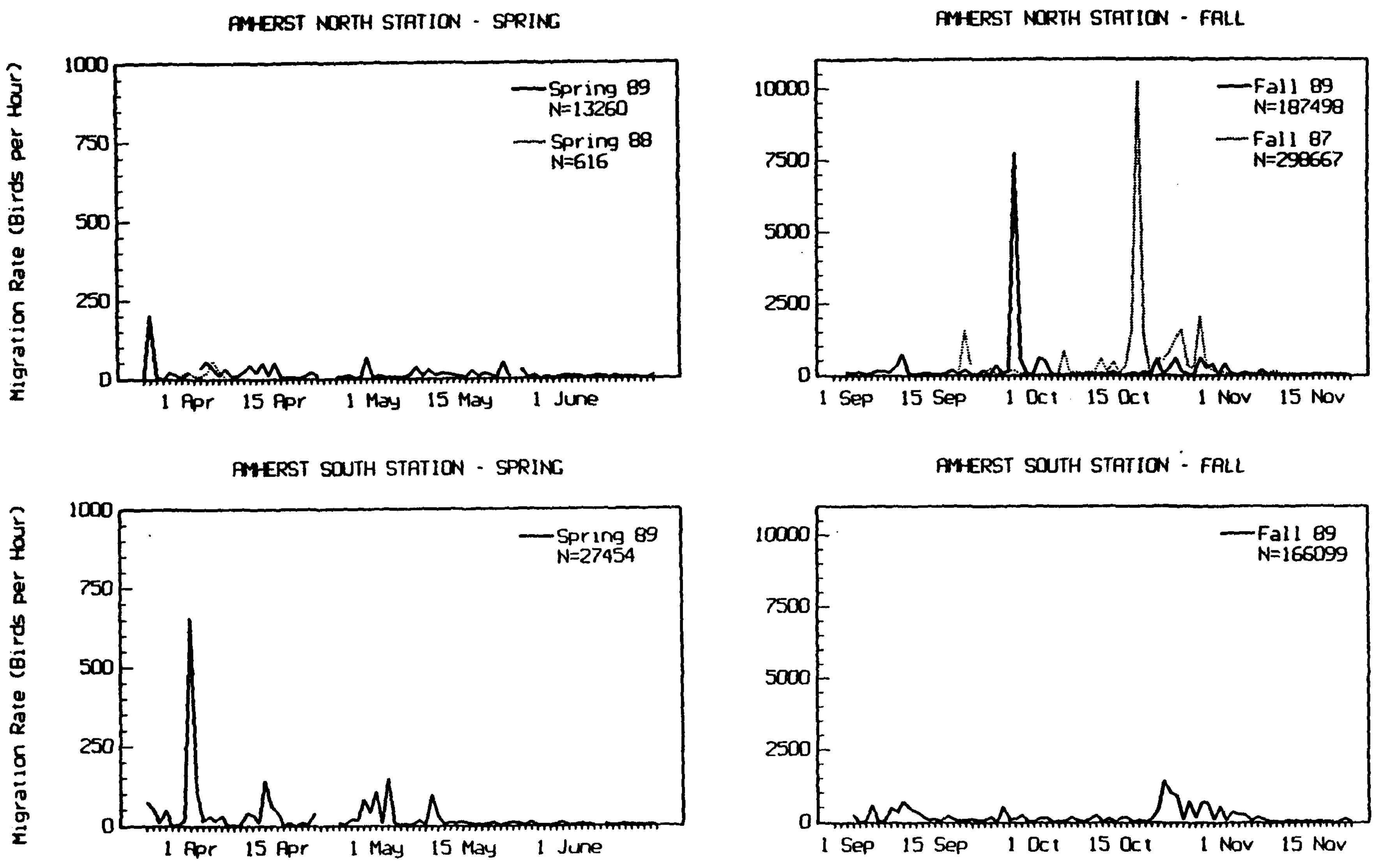


FIGURE 8-25. AMHERST, SD TRANSMIT STUDY AREA DIURNAL MIGRATION RATES - ALL PASSERINES

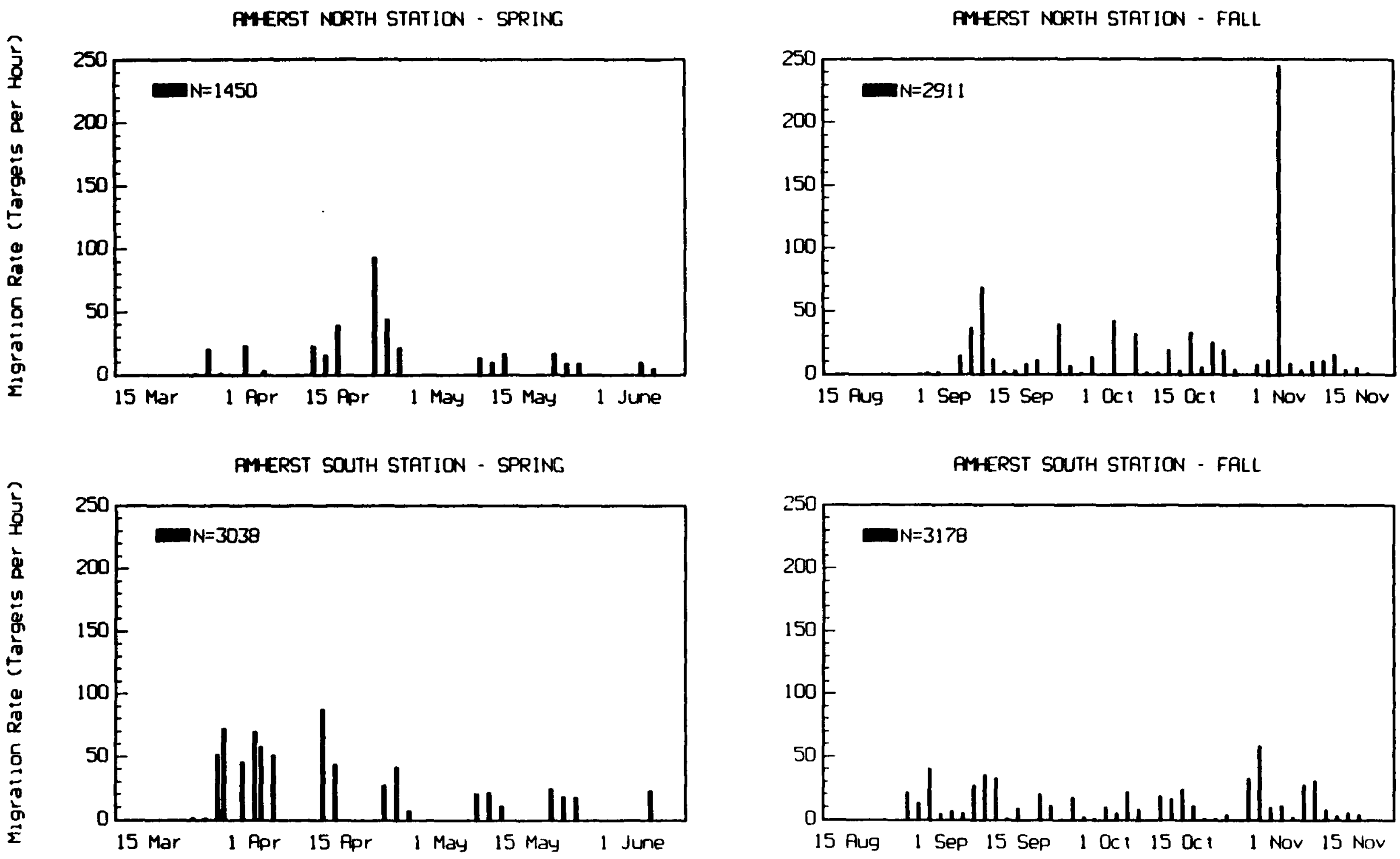


FIGURE 8-26. AMHERST, SD TRANSMIT STUDY AREA NOCTURNAL MIGRATION RATES - LONG-RANGE RADAR

stationed in Thief River Falls for about half of the migration season. Thus, peaks could have been missed when the radar lab was not on-site. Peak spring rates were similar between stations, at about 90 targets per hour (Table 8-9).

TABLE 8-9. PEAK NIGHTLY MIGRATION RATES (TARGETS PER HOUR) OBSERVED USING RADAR DURING NOCTURNAL AND CREPUSCULAR HOURS AT THE AMHERST TRANSMIT STUDY AREA

	Peak Rate [Targets per Hour] (Date)							
	Long-Range				Short-Range			
Season	North Station		South Station		North Station		South Station	
Spring 89	93.3	(21 Apr)	88.0	(12 Apr)	287.4	(15 Apr)	749.5	(22 Apr)
Fall 89	245.0	(1 Nov)	58.7	(29 Oct)	526.5	(22 Oct)	428.1	(30 Aug)

Fall 1989 nocturnal migration, measured using long-range radar, was characterized by higher rates in early September, during the period of observed peak diurnal waterbird movement, and during early November, during the period of observed peak diurnal waterfowl movement (Figs. 8-16; 8-21; 8-26). Overall rates were similar between stations, but the one night peak was much higher at the North station (245 targets per hour) than at the South station (60 targets per hour) (Table 8-9). Spring and fall migrations were difficult to compare since sampling was not continuous in the spring but rates appeared to be generally similar between seasons (Fig. 8-26).

Short-range radar generally samples a higher proportion of smaller birds, such as passerines and shorebirds, within a radius of about three-quarters of a mile of the radar location, although larger birds are also observed if they are within range. During spring 1989, migration rates, as measured by short-range radar, were generally highest during mid to late April at the North station and during late March to early May at the South station, although sampling was not continuous during the spring season. Overall and peak rates were much higher at the South station (Fig. 8-27; Table 8-9), probably reflecting higher rates of local, nocturnal movements near the flooded areas north and west of the radar sampling station.

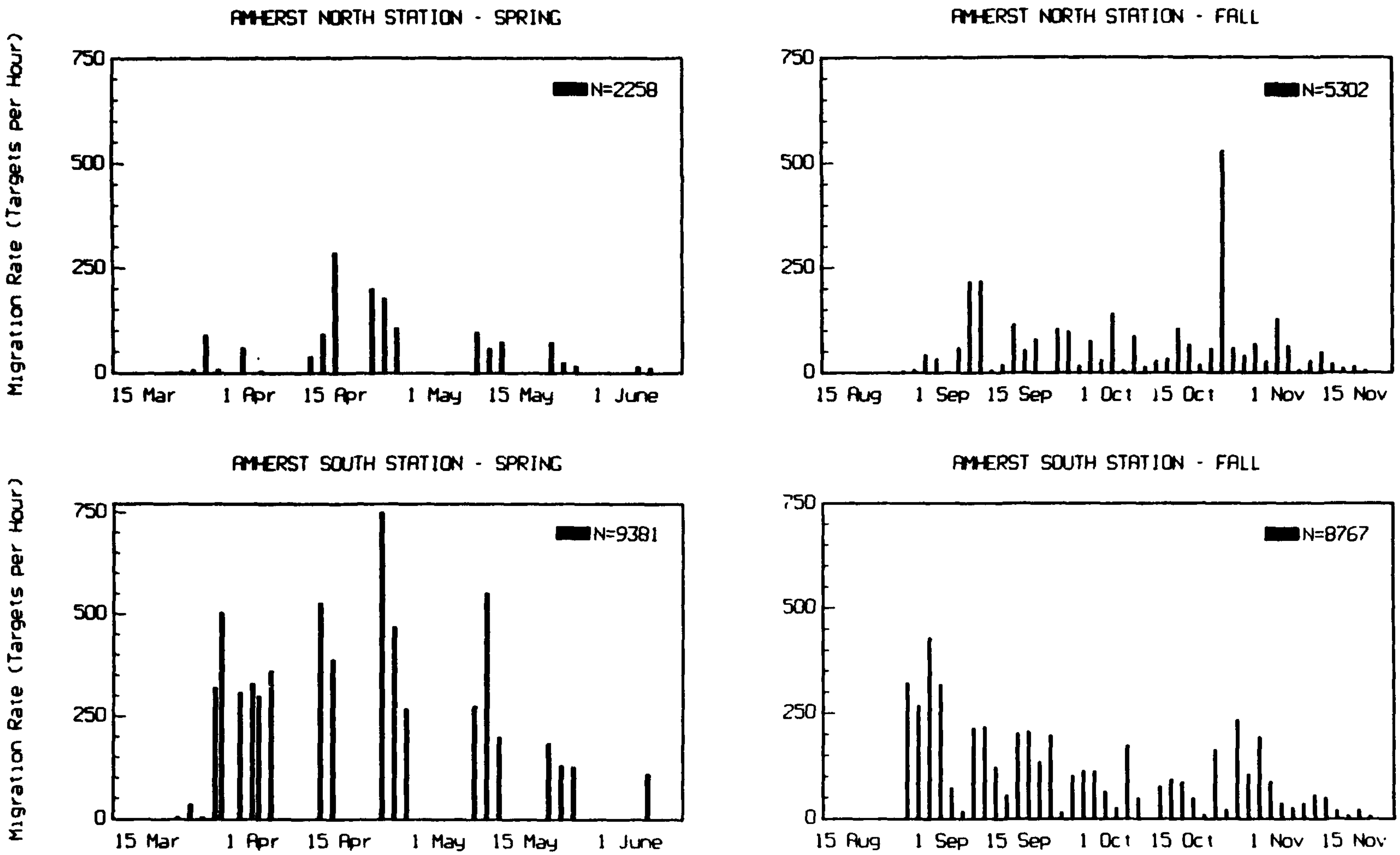


FIGURE 8-27. AMHERST, SD TRANSMIT STUDY AREA NOCTURNAL MIGRATION RATES - SHORT-RANGE RADAR

During fall 1989 migration, short-range rates were generally highest during late August and early September, when passerines, shorebirds, and waterbirds were observed migrating during diurnal hours and during late October when waterfowl and passerines were observed migrating during diurnal hours (Figs. 8-16; 8-18; 8-21; 8-25; 8-27). Overall rates appeared to be higher at the South station and peak rates were similar between stations, although the one night peak rate occurred in late August at the South station and during mid-October at the North station (Fig. 8-27; Table 8-9).

Although difficult to compare for reasons stated previously, observed rates appeared to be similar between seasons at the North station using short-range radar but higher during spring at the South station. This probably is a reflection of the greater amount of water near the South station in spring relative to fall; birds using this water area would more likely be within the 0.75 mile radius of short-range coverage in spring than in fall.

8.2.3.2.3 Time of day comparison. Analysis of concurrent radar and station observations has shown that most data collected using the two techniques are not directly comparable (ABR, 1988b; 1988c). Therefore, migration rates were compared during daylight, twilight (dawn and dusk), and nocturnal periods using radar data only. In the spring, mean migration rates were lowest, as measured by both short-range and long-range radar, during nocturnal hours and highest during twilight hours. This trend was evident at both the North and South stations (Table 8-10). In the fall, the patterns were more variable. Long-range observations at the North station indicated that rates were lowest during daylight hours and highest during nocturnal hours, whereas mean rates were lowest during twilight hours and highest during nocturnal hours using short-range radar. At the South station, observed rates were similar during all periods using the long-range radar setting but lowest during twilight hours and highest during daylight hours using the short-range radar setting (Table 8-10). These trends at the South station likely reflected a large amount of local movements around the flooded fields to the north and northwest of the station.

TABLE 8-10. MEAN MIGRATION RATES (TARGETS PER HOUR) AT THE AMHERST TRANSMIT STUDY AREA DURING DIFFERENT PERIODS OF THE DAY AS MEASURED BY LONG-RANGE AND SHORT-RANGE RADAR

Study	Period of Day	Long-Range		Short-Range	
		North	South	North	South
Spring 1989	Daylight Hours	20.3	53.2	76.4	422.9
	Twilight Hours	24.4	71.5	82.3	651.1
	Nocturnal Hours	14.6	27.7	65.4	230.9
Fall 1989	Daylight Hours	5.0	14.1	34.9	135.4
	Twilight Hours	8.9	15.6	31.2	89.5
	Nocturnal Hours	13.9	13.2	74.4	111.3

8.2.3.2.4 Weather effects. Birds generally migrate during fair weather, and migration rates tend to be lower during poor weather conditions (Richardson, 1978). An analysis was conducted for five species groups comparing migration rates during periods of poor weather (defined by the presence of either snow or rain) with periods of fair weather (defined by the lack of precipitation) (Table 8-11). However, visibility is usually reduced during periods of precipitation, especially during snow storms, and this may bias the results by causing fewer birds to be observed during periods of precipitation than during periods of fair weather. Since the sampling period for spring 1988 studies was so short, data from this season are not used in this analysis.

Migration rates for ducks at the North station were highest during fair weather in fall but highest during periods of snow in spring 1989. At the South station, duck migration rates were highest during precipitation periods during both spring (rain) and fall (snow) (Table 8-11). For geese, migration rates were highest during fair weather for two of the three seasons at the North station, the exception being the fall of 1989 when rates were highest during periods of snow. At the South station, rates were similar between periods of fair weather and rain in spring 1989, but highest during periods of snow in fall 1989 (Table 8-11). For waterfowl as a group, rates were highest during fair weather for all seasons at the North station, but highest during periods of precipitation (rain in spring and snow in fall) at the South station (Table 8-11). Since many species of waterfowl do not leave this

TABLE 8-11. EFFECTS OF PRECIPITATION ON MIGRATION RATE AT THE AMHERST TRANSMIT STUDY AREA DURING DAYLIGHT HOURS

Species Group	Study	Migration Rate (Birds per Hour)		
		No Precipitation	Rain	Snow[1]
NORTH STATION				
Ducks	Fall 87	654.65	52.75	0.00
	Spring 89	21.98	11.92	29.28
	Fall 89	232.51	108.61	37.33
Geese	Fall 87	540.58	23.22	1.96
	Spring 89	1421.26	167.29	417.68
	Fall 89	356.05	59.19	539.25
Waterfowl	Fall 87	1681.54	77.87	5.40
	Spring 89	1455.62	179.28	446.96
	Fall 89	854.82	241.47	745.62
Raptors	Fall 87	0.92	0.33	0.49
	Spring 89	0.27	0.11	0.57
	Fall 89	0.86	0.38	0.47
Passerines	Fall 87	521.15	23.87	28.97
	Spring 89	17.25	6.41	47.20
	Fall 89	224.07	58.43	141.08
SOUTH STATION				
Ducks	Spring 89	69.56	268.43	155.33
	Fall 89	132.52	179.06	255.56
Geese	Spring 89	2226.31	2250.30	178.89
	Fall 89	663.15	604.35	756.35
Waterfowl	Spring 89	2297.85	2519.72	335.22
	Fall 89	969.74	1115.39	1145.37
Raptors	Spring 89	0.35	0.43	0.22
	Fall 89	1.33	0.44	0.25
Passerines	Spring 89	23.99	20.16	0.78
	Fall 89	201.64	77.36	55.31

1. Includes sleet and hail.

region until open water becomes unavailable and cold weather drives them south in the fall, and migrate early in the spring just as waterbodies are melting, the higher rates observed during periods of snow in some seasons are expected, since snow commonly occurs at these times.

Raptors usually migrated during fair weather periods, except during spring 1989 when rates were highest during snow (North station) and rain (South station). Passerine migration rates were highest during fair weather except during spring 1989 at the North station, when they were highest during periods of snow (Table 8-11).

The effects of wind speed (measured at ground level) on migration rates were also examined (Table 8-12). Ducks tended to fly at higher rates during calm or low wind conditions (<15 miles per hour) whereas geese showed no clear trends, indicating that they were relatively unaffected by wind conditions. Raptors generally flew at the highest rates during north winds of greater than 15 miles per hour. Winds of this type would be tailwinds only in fall, although winds at heights above ground level may have differed from those at ground level in both speed and direction. Passerines tended to fly at the highest rates during calm or low wind conditions (Table 8-12).

8.2.3.3 Flight Altitude. Flight altitude data were collected from the observation stations using discrete altitude categories in fall 1987 and spring 1988. In spring and fall 1989, altitude was directly estimated as well as calculated from field measurements of angle and distance (see UMN, 1989a; 1989b). Data from these seasons were converted to altitude categories to allow for comparisons with fall 1987 and spring 1988 data. One of the altitude categories used during field collection in fall 1987 and spring 1988 was 101 to 500 feet above ground level (agl). This category was broken into two altitude categories (101 to 150 and 151 to 500 feet) when spring and fall 1989 data were converted to better categorize flight altitudes relative to the transmit antenna structure. Each transmit antenna will be composed of six subarrays of different heights, the tallest being 135 feet. Two 150 foot guy-wire supported sounder antennas will also be present at each of the four antenna sectors (Technical Study 2). In the figures and discussion to follow,

TABLE 8-12. EFFECTS OF WIND SPEED ON MIGRATION RATE AT THE AMHERST TRANSMIT STUDY AREA DURING DAYLIGHT HOURS

Species Group	Study	Migration Rate (Birds per Hour)			
		No wind	1-15 MPH	>15 MPH NORTH(1)	>15 MPH SOUTH(2)
NORTH STATION					
Ducks	Fall 87	1312.04	492.06	217.39	1003.68
	Spring 89	28.59	18.54	27.58	4.17
	Fall 89	74.19	262.39	162.79	241.64
Geese	Fall 87	932.95	469.28	495.82	115.13
	Spring 89	802.69	1842.21	879.63	11.93
	Fall 89	30.38	361.26	642.51	438.56
Waterfowl	Fall 87	3435.01	1351.44	821.69	1165.68
	Spring 89	831.28	1879.52	908.10	16.11
	Fall 89	189.23	886.07	1173.34	999.30
Raptors	Fall 87	0.26	0.94	1.31	0.55
	Spring 89	0.19	0.22	0.31	0.24
	Fall 89	0.52	0.81	1.51	0.77
Passerines	Fall 87	180.36	683.53	92.74	702.15
	Spring 89	11.61	17.74	17.83	11.13
	Fall 89	854.98	150.32	9.39	45.83
SOUTH STATION					
Ducks	Spring 89	149.58	74.88	129.67	30.72
	Fall 89	160.25	145.79	164.82	61.51
Geese	Spring 89	3066.21	2621.81	2823.51	63.26
	Fall 89	637.16	569.48	1328.76	673.35
Waterfowl	Spring 89	3215.79	2700.09	2953.95	94.00
	Fall 89	932.65	922.22	1698.42	811.24
Raptors	Spring 89	0.13	0.32	0.35	0.48
	Fall 89	1.54	1.17	1.50	1.37
Passerines	Spring 89	54.14	22.95	13.99	44.19
	Fall 89	277.86	204.79	88.64	146.73

1. Includes Northwest, North, and Northeast winds.
2. Includes Southwest, South, and Southeast winds.

"above maximum antenna height" is above 150 feet agl, except for fall 1987 and spring 1988, where above 100 feet agl is used, because of the different data collection procedures used during these seasons.

8.2.3.3.1 Daylight periods. A decrease in detectability with increasing altitude, which is more severe for smaller birds but occurs for larger-bodied birds as well, has been shown to occur during periods of concurrent radar observations during studies for the USAF's Alaskan Radar System (ABR, 1988a; 1988b; 1988c). Thus, it is likely that the proportion of birds flying in the lower altitude categories is overestimated relative to the higher categories by the visual observation techniques used during daylight hours.

Flight altitudes were generally higher for all species groups in fall than in spring, except for gamebirds and waterbirds which were similar between seasons. Trends for sandhill cranes were not clear due to low sample sizes. In general, altitudes were higher at the North station than at the South station for ducks and raptors. A comparison of altitudes between stations for other species groups showed that altitudes were similar between stations or that no clear trends were evident (Figs. 8-28 to 8-38; Table 8-13).

For ducks, 19.1% flew below 150 feet agl (0.8% below 100 feet agl for fall 1987 and spring 1988) at the North station during 1989 studies while 50.3% flew below 150 feet agl at the South station (Fig. 8-28; Table 8-13). For geese/cormorants, 41.5% flew below 150 feet agl during 1989 (1.0% below 100 feet agl for fall 1987 and spring 1988) at the North station versus 30.5% below 150 feet agl for the South station (Fig. 8-29; Table 8-13). About half of the swans (48.4%) flew below 150 feet agl (24.1% below 100 feet agl for fall 1987 and spring 1988) at the North station while 50.7% flew below 150 feet agl at the South station (Fig. 8-30; Table 8-13). For all waterfowl, the numbers were 37.5% below 150 feet agl in 1989 (1.1% below 100 feet agl in 1987/1988) at the North station and 31.6% below 150 feet agl at the South station (Fig. 8-31; Table 8-13).

Shorebirds were almost always observed flying below the maximum height of the antenna structure with 91.0% flying below 150 feet agl in 1989 at the North

TABLE 8-13. PERCENTAGE OF BIRDS FLYING BELOW THE MAXIMUM HEIGHT OF THE ANTENNA STRUCTURE DURING DAYLIGHT HOURS AT THE AMHERST TRANSMIT STUDY AREA - STATION OBSERVATIONS

Species Group	Season	Flight Altitude[1] (Percentage < 150 feet agl) North Station	South Station
Waterfowl	Fall 87	1.1	-
	Spring 88	0.8	-
	Spring 89	50.8	30.8
	Fall 89	20.7	33.4
	Total (89 only)	37.5	31.6
-Ducks	Fall 87	0.8	-
	Spring 88	13.1	-
	Spring 89	49.7	62.2
	Fall 89	16.5	42.8
	Total (89 only)	19.1	50.3
-Geese/Cormorants	Fall 87	1.2	-
	Spring 88	0.6	-
	Spring 89	50.3	29.6
	Fall 89	15.9	33.5
	Total (89 only)	41.5	30.5
-Swans	Fall 87	16.5	-
	Spring 88	75.8	-
	Spring 89	53.3	84.0
	Fall 89	48.1	44.3
	Total (89 only)	48.4	50.7
Raptors	Fall 87	48.4	-
	Spring 88	85.0	-
	Spring 89	79.8	85.6
	Fall 89	66.5	71.5
	Total (89 only)	69.4	74.8
-Eagles/Hawks	Fall 87	32.0	-
	Spring 88	50.0	-
	Spring 89	76.7	84.6
	Fall 89	58.0	66.8
	Total (89 only)	61.0	70.6

TABLE 8-13 (Continued). PERCENTAGE OF BIRDS FLYING BELOW THE MAXIMUM HEIGHT OF THE ANTENNA STRUCTURE DURING DAYLIGHT HOURS AT THE AMHERST TRANSMIT STUDY AREA - STATION OBSERVATIONS

Species Group	Season	Flight Altitude(1) (Percentage < 150 feet agl)	
		North Station	South Station
-Harriers	Fall 87	97.0	-
	Spring 88	100.0	-
	Spring 89	86.7	98.4
	Fall 89	93.3	91.2
	Total (89 only)	90.5	93.3
-Falcons	Fall 87	90.0	-
	Spring 88	-	-
	Spring 89	95.3	90.0
	Fall 89	97.5	80.0
	Total (89 only)	97.1	82.7
-Owls	Fall 87	100.0	-
	Spring 88	-	-
	Spring 89	-	100.0
	Fall 89	100.0	50.0
	Total (89 only)	100.0	75.0
Shorebirds	Fall 87	82.6	-
	Spring 88	100.0	-
	Spring 89	92.9	95.9
	Fall 89	79.6	80.5
	Total (89 only)	91.0	85.4
Sandhill cranes	Fall 87	86.3	-
	Spring 88	0.0	-
	Spring 89	25.7	72.7
	Fall 89	-	16.8
	Total (89 only)	25.7	59.1
Waterbirds	Fall 87	89.8	-
	Spring 88	67.8	-
	Spring 89	85.5	71.1
	Fall 89	58.5	68.0
	Total (89 only)	65.9	68.7

TABLE 8-13 (Continued). PERCENTAGE OF BIRDS FLYING BELOW THE MAXIMUM HEIGHT OF THE ANTENNA STRUCTURE DURING DAYLIGHT HOURS AT THE AMHERST TRANSMIT STUDY AREA - STATION OBSERVATIONS

Species Group	Season	Flight Altitude(1) (Percentage < 150 feet agl) North Station	South Station
Gamebirds	Fall 87	100.0	-
	Spring 88	100.0	-
	Spring 89	100.0	100.0
	Fall 89	100.0	100.0
	Total (89 only)	100.0	100.0
Passerines	Fall 87	37.4	-
	Spring 88	75.3	-
	Spring 89	97.1	81.3
	Fall 89	59.5	90.0
	Total (89 only)	62.0	88.8
-Blackbirds	Fall 87	32.0	-
	Spring 88	86.0	-
	Spring 89	97.6	89.7
	Fall 89	50.2	87.7
	Total (89 only)	53.7	88.0
-Nonblackbirds	Fall 87	96.9	-
	Spring 88	100.0	-
	Spring 89	92.2	74.0
	Fall 89	96.0	98.5
	Total (89 only)	95.9	94.7

1. Fall 1987 and Spring 1988 less than 100 feet agl.

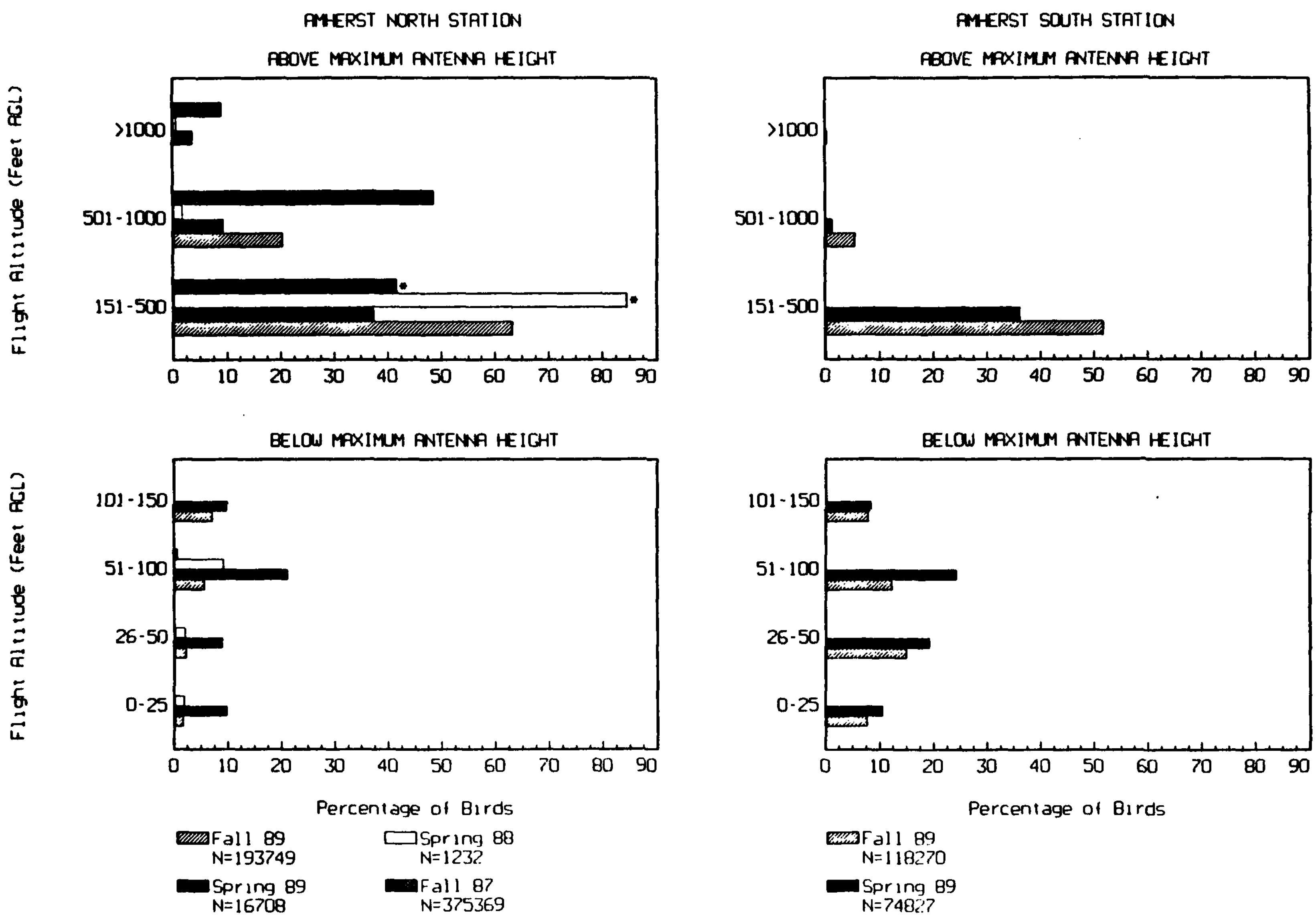


FIGURE 8-28. AMHERST, SD TRANSMIT STUDY AREA DIURNAL FLIGHT ALTITUDES - DUCKS (*Includes Birds Between 101 and 150 Feet AGL - See Text)

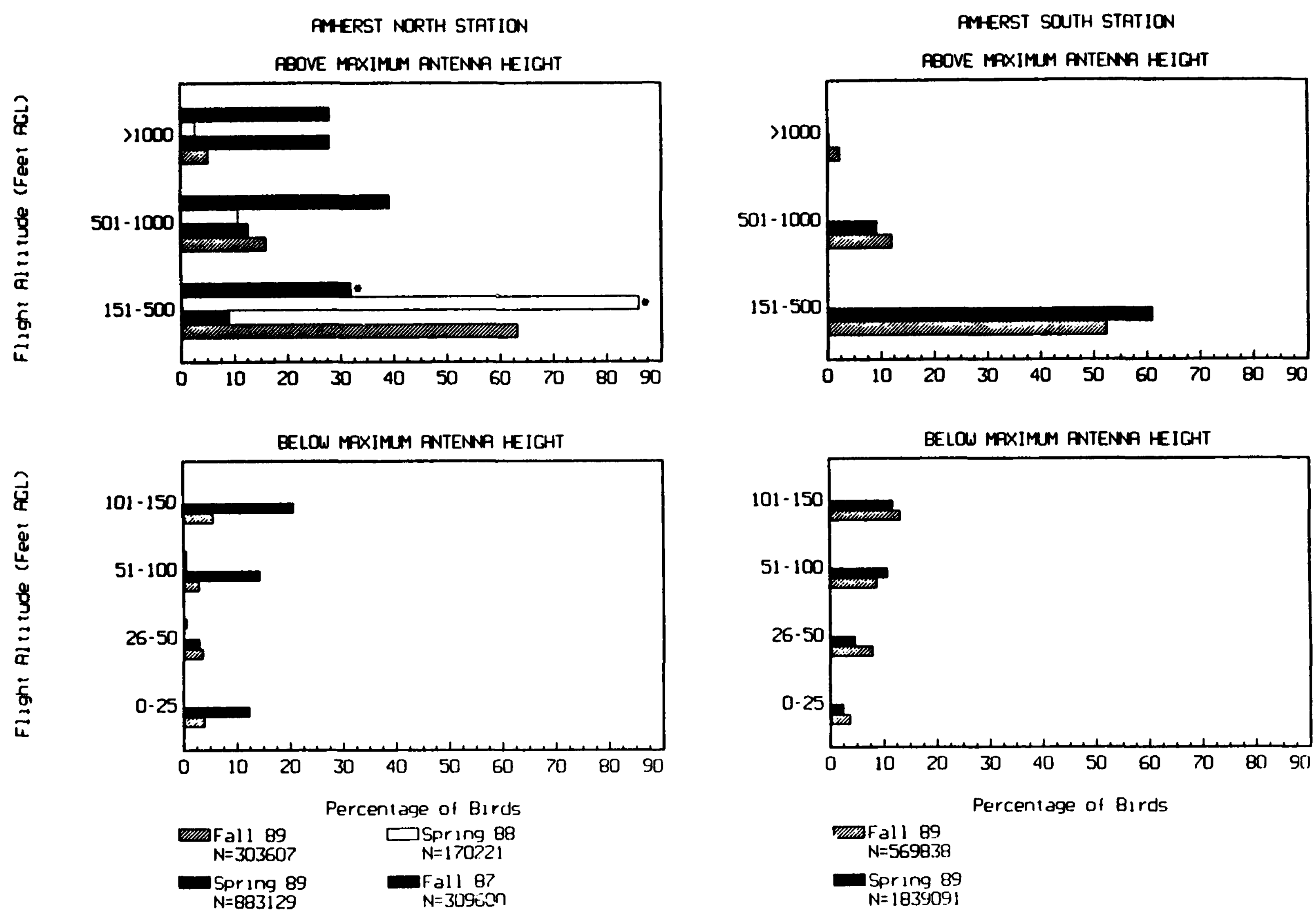


FIGURE 8-29. AMHERST, SD TRANSMIT STUDY AREA DIURNAL FLIGHT ALTITUDES - GEESE/CORMORANTS (*Includes Birds Between 101 and 150 Feet AGL - See Text)

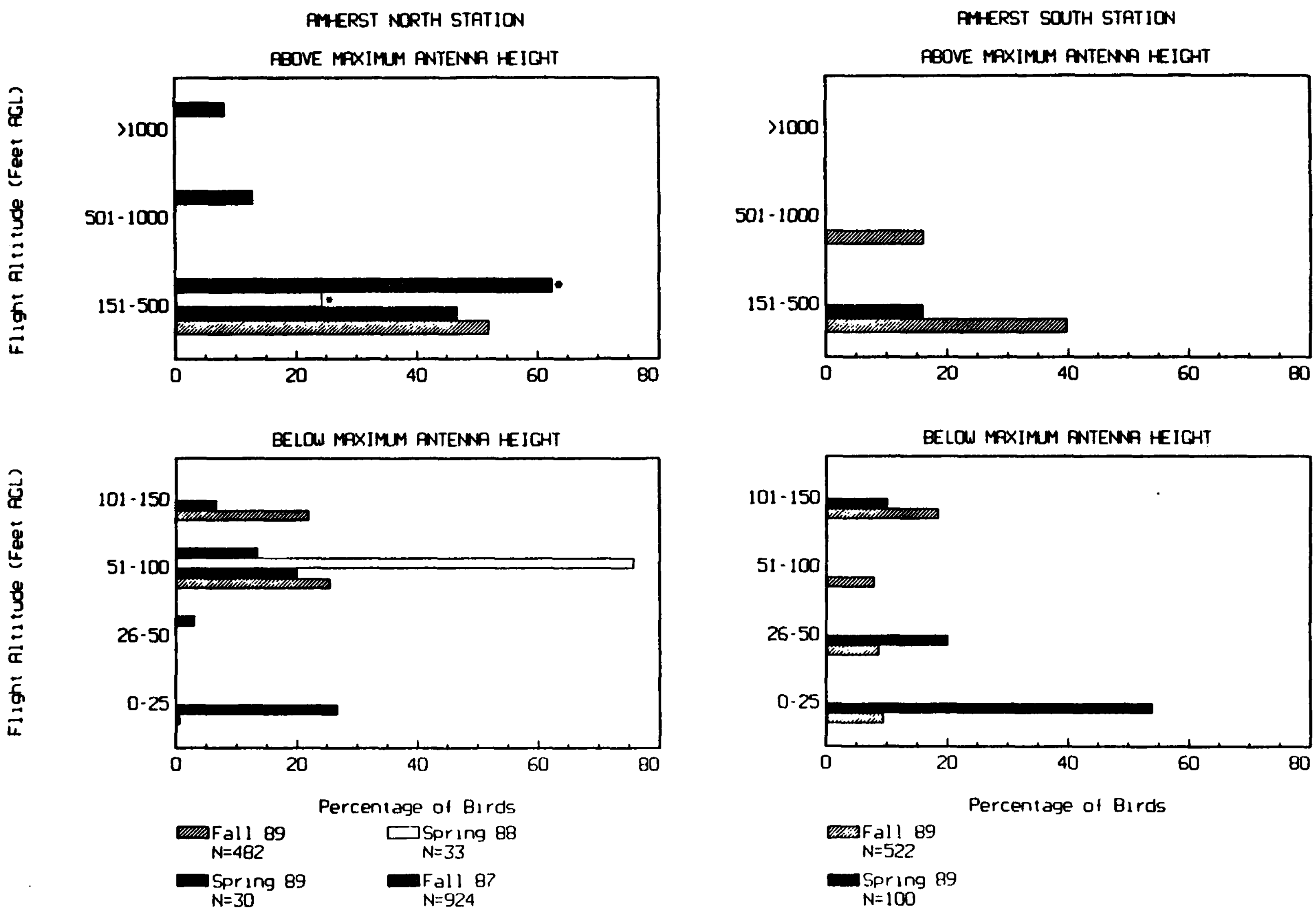


FIGURE 8-30. AMHERST, SD TRANSMIT STUDY AREA DIURNAL FLIGHT ALTITUDES - SWANS (*Includes Birds Between 101 and 150 Feet AGL - See Text)

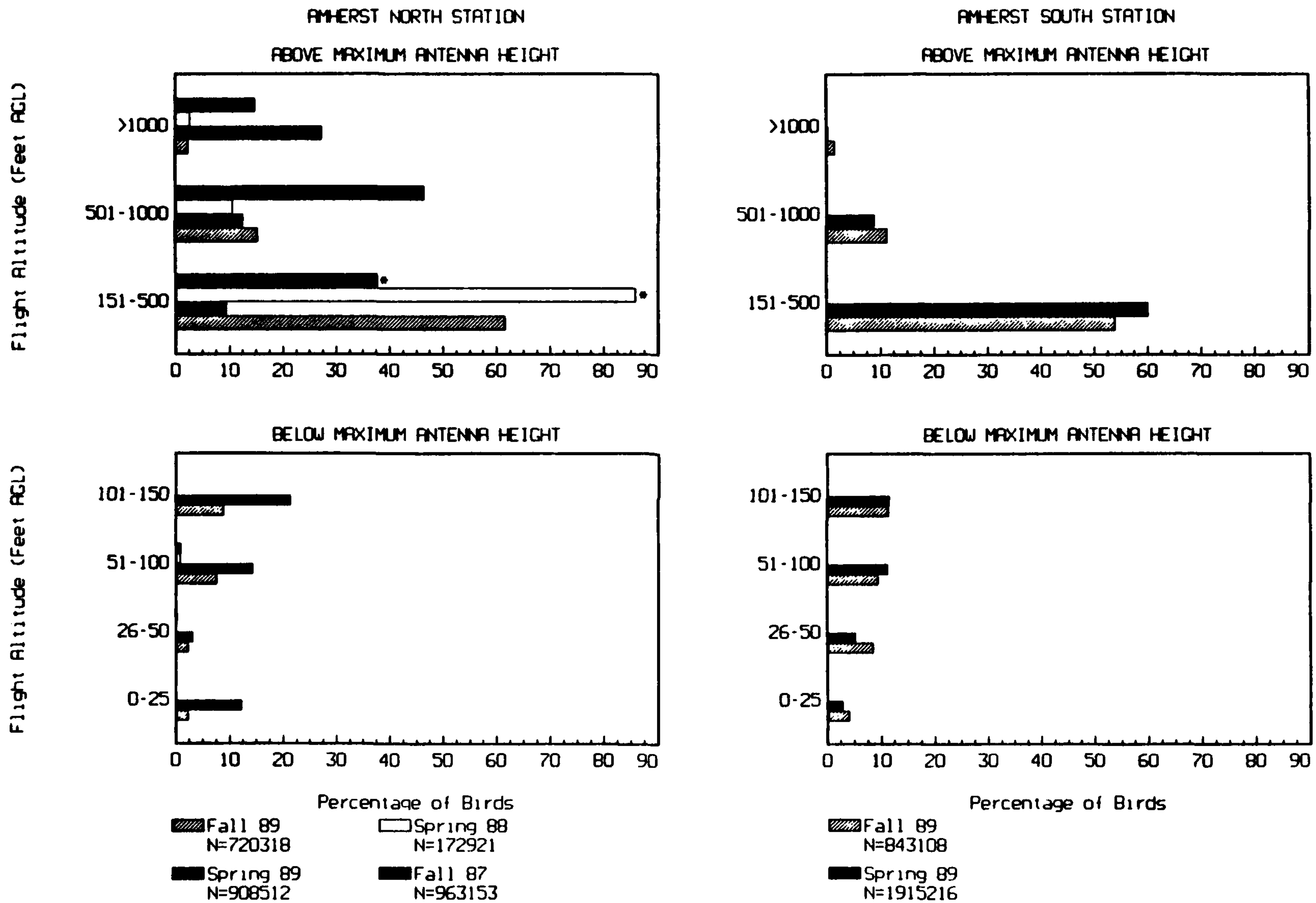


FIGURE 8-31. AMHERST, SD TRANSMIT STUDY AREA DIURNAL FLIGHT ALTITUDES - ALL WATERFOWL
(*Includes Birds Between 101 and 150 Feet AGL - See Text)

station (90.7% below 100 feet agl in 1987/1988) versus 85.4% below 150 feet agl at the South station (Fig. 8-32; Table 8-13). At the North station, 25.7% of the sandhill cranes flew below 150 feet agl (83.8% below 100 feet agl for 1987/1988) while 59.1% flew below 150 feet agl at the South station in 1989 (Fig. 8-33; Table 8-13). Waterbirds flew below 150 feet agl 65.9% of the time in 1989 (73.4% below 100 feet agl in 1987/1988) at the North station versus a nearly identical 68.7% below 150 feet agl at the South station (Fig. 8-34; Table 8-13).

Raptors as a group usually flew below the maximum height of the antenna structure with 69.4% flying below 150 feet agl (49.7 % below 100 feet agl for 1987/1988) in 1989 at the North station versus 74.8% below 150 feet agl at the South station (Fig. 8-35; Table 8-13). Harriers, falcons, and owls flew lower than eagles and hawks at both stations (Table 8-13). All observed gamebirds flew below the maximum height of the antenna structure at both stations (Table 8-13).

Passerines flew below 150 feet 62% of the time at the North station (37.4% below 100 feet agl for 1987/1988) in 1989 versus 88.8% below 150 feet agl at the South station. Blackbirds flew higher than nonblackbird passerines at both stations (Figs. 8-36; 8-37; 8-38; Table 8-13).

8.2.3.3.2 Nocturnal periods. Nocturnal flight altitudes were sampled using the vertical-beam radar unit, which could sample birds flying at altitudes between about 100 and 5900 feet agl. Because the radiation pattern from this unit was an inverted cone with 12° divergence (ABR, 1989; 1990a), the total airspace sampled was relatively small and the amount of area sampled increased as altitude increased. To correct for this differential sampling with altitude, the data were partitioned into 200 foot altitude categories, and the number of targets in each category was adjusted to correct for the different areas sampled, using the highest altitude category as the standard.

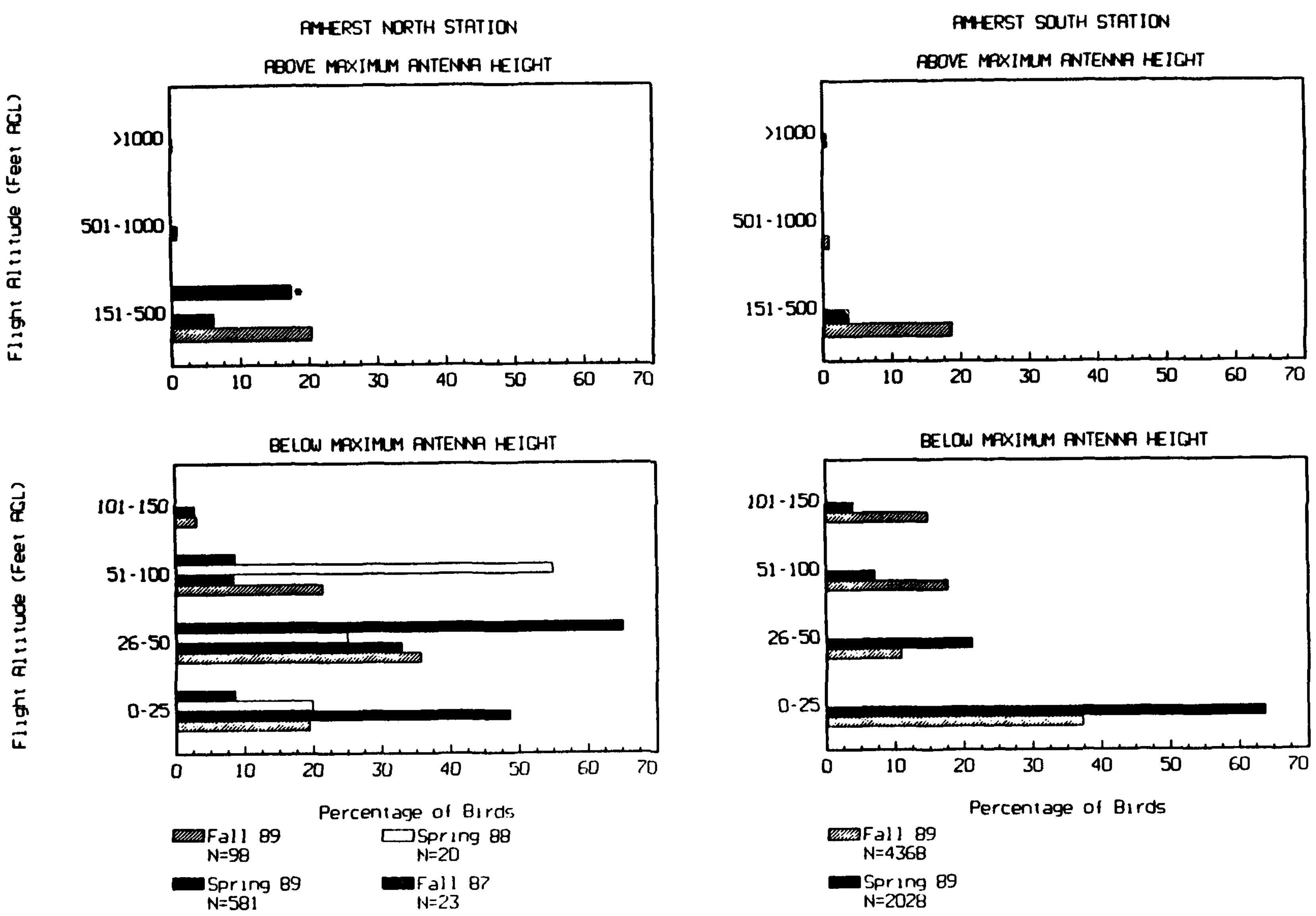


FIGURE 8-32. AMHERST, SD TRANSMIT STUDY AREA DIURNAL FLIGHT ALTITUDES - SHOREBIRDS
(*Includes Birds Between 101 and 150 Feet AGL - See Text)

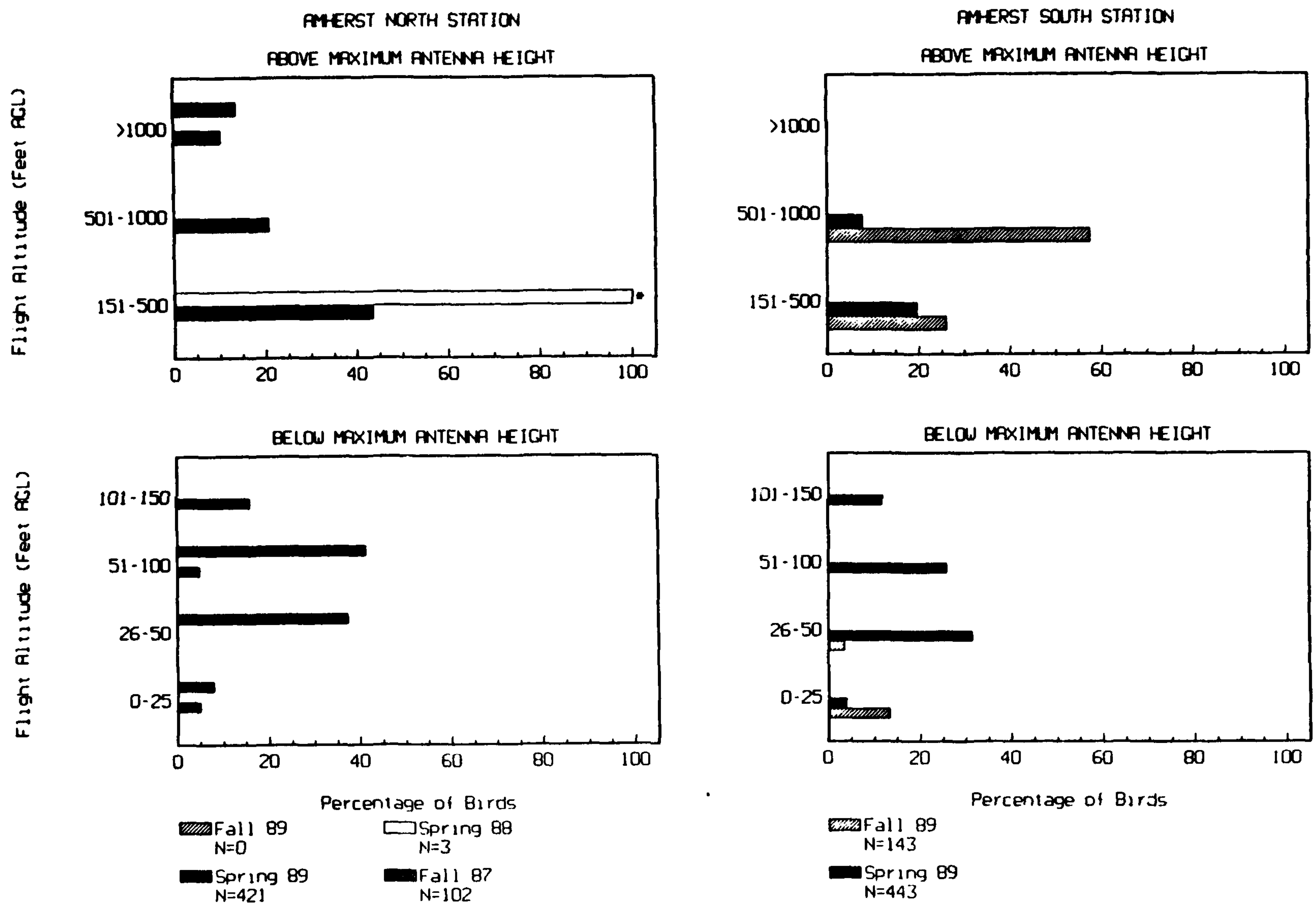


FIGURE 8-33. AMHERST, SD TRANSMIT STUDY AREA DIURNAL FLIGHT ALTITUDES - SANDHILL CRANES (*Includes Birds Between 101 and 150 Feet AGL - See Text)

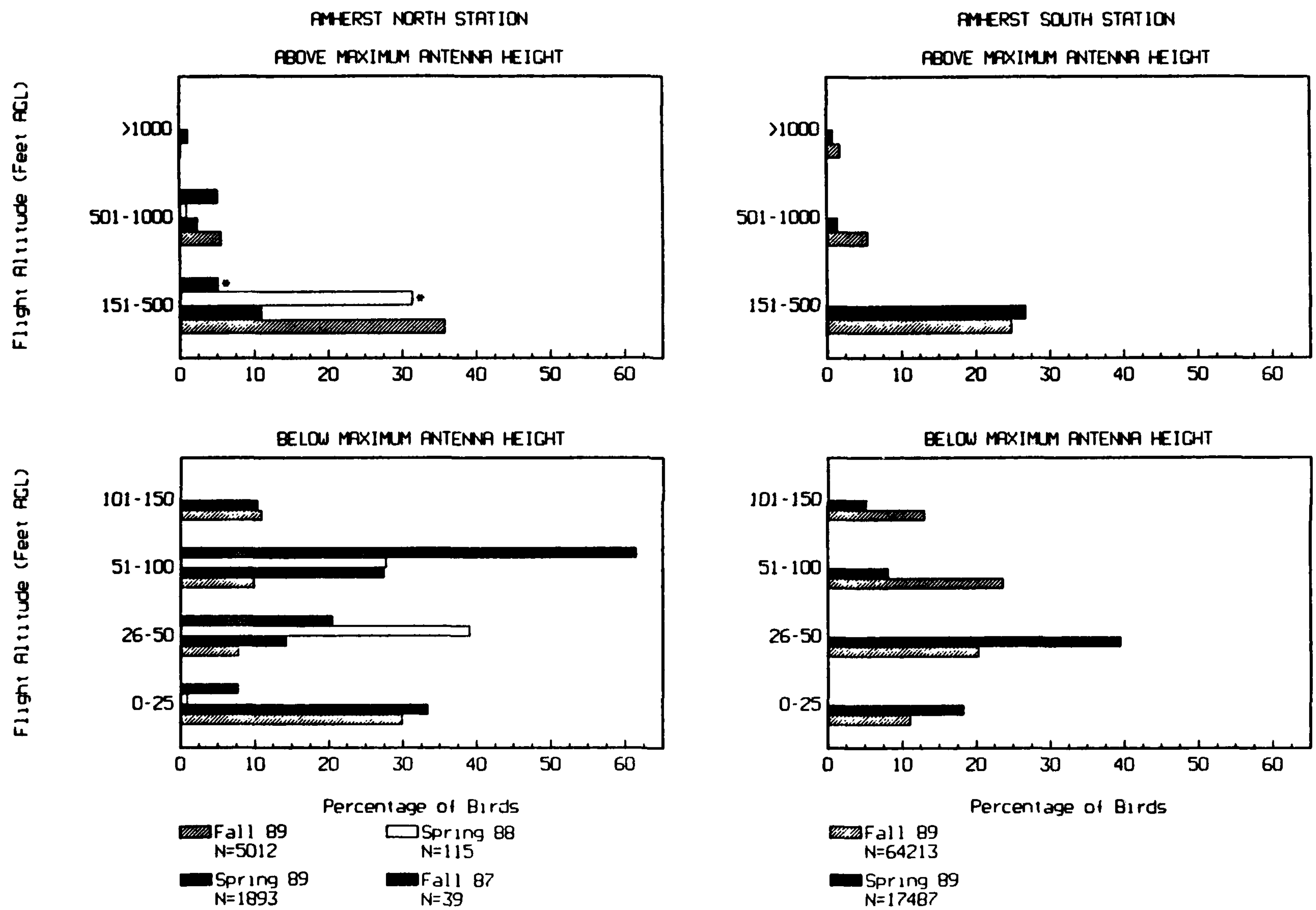


FIGURE 8-34. AMHERST, SD TRANSMIT STUDY AREA DIURNAL FLIGHT ALTITUDES - WATERBIRDS (*Includes Birds Between 101 and 150 Feet AGL - See Text)

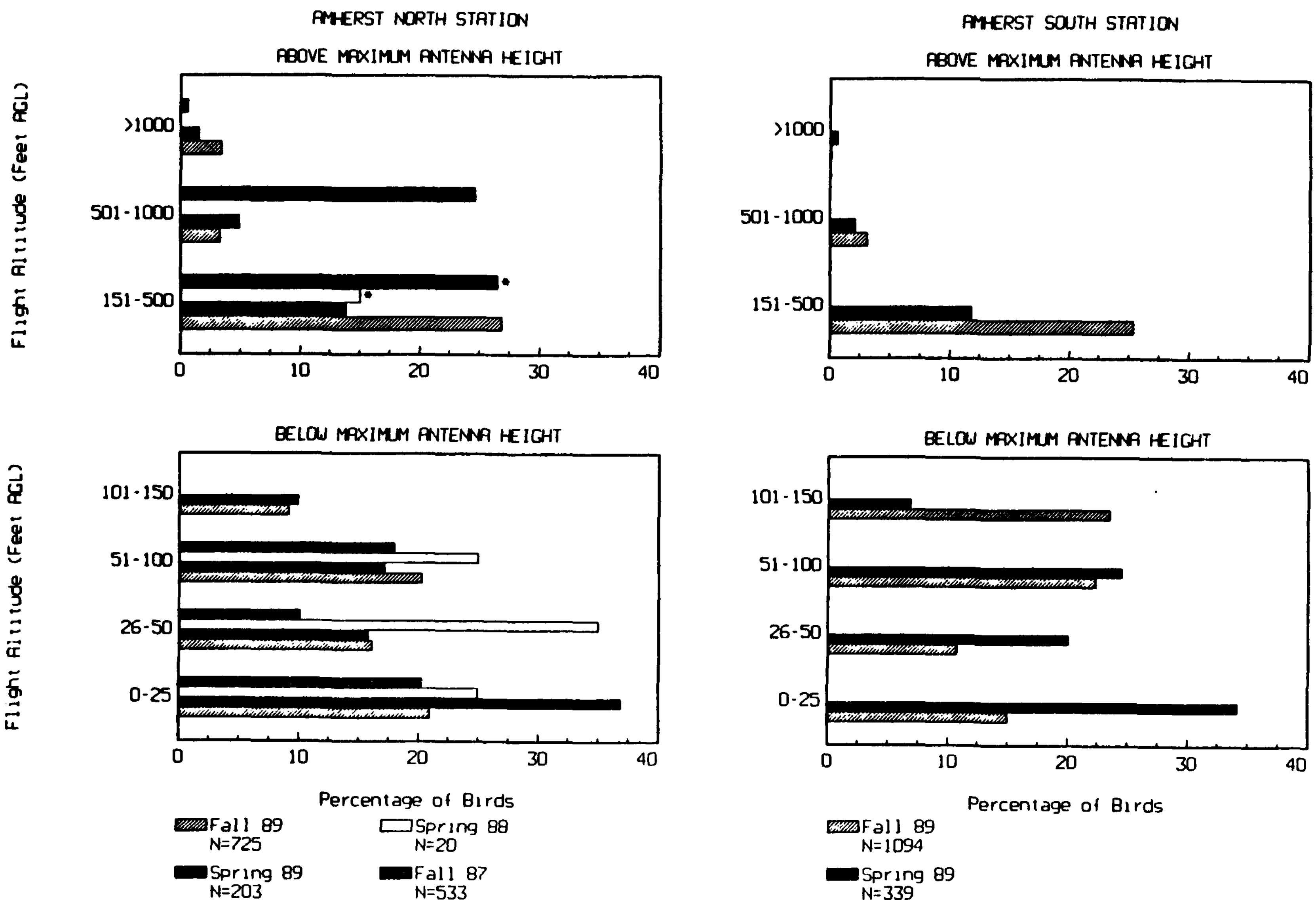


FIGURE 8-35. AMHERST, SD TRANSMIT STUDY AREA DIURNAL FLIGHT ALTITUDES - RAPTORS (*Includes Birds Between 101 and 150 Feet AGL - See Text)

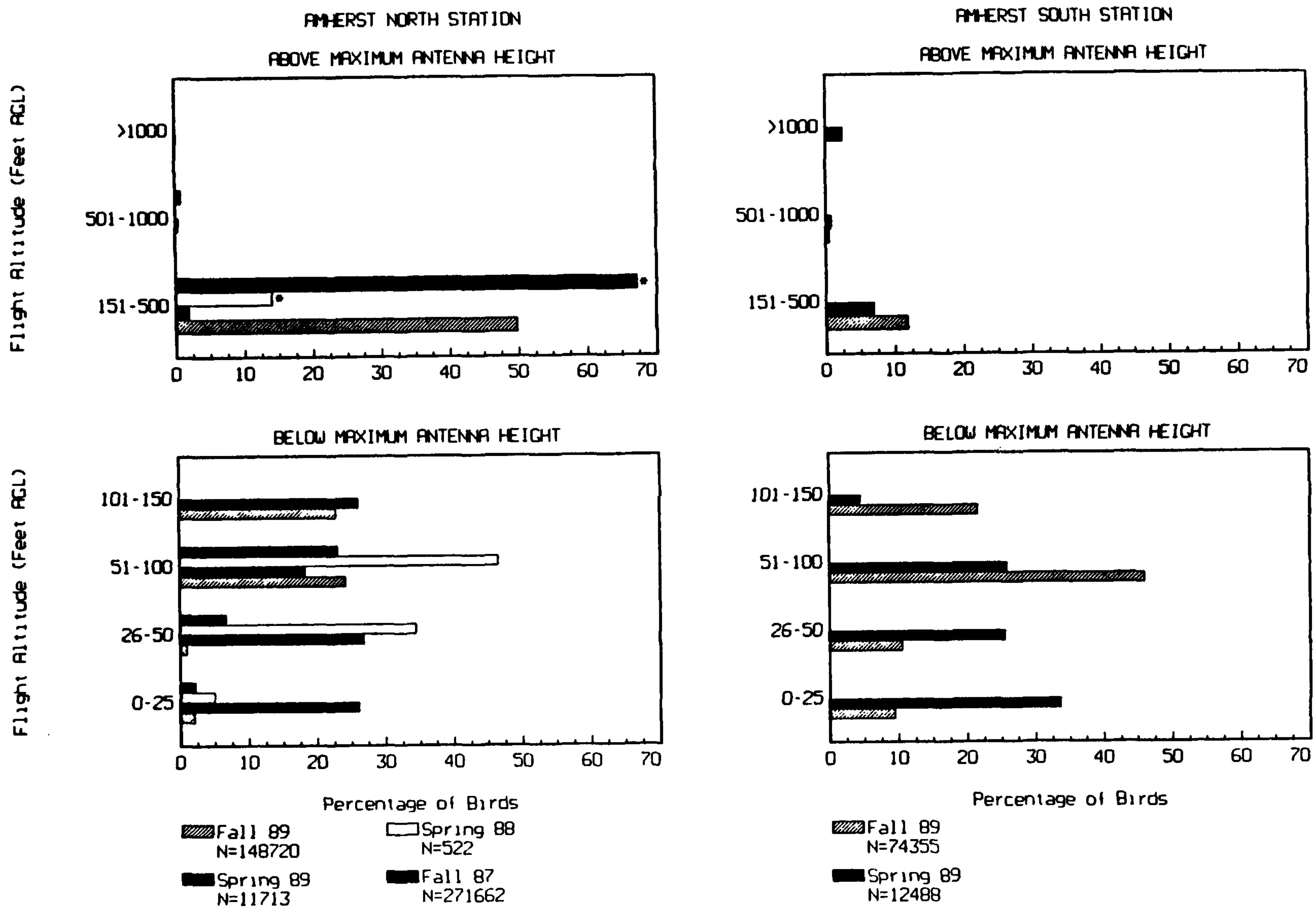


FIGURE 8-36. AMHERST, SD TRANSMIT STUDY AREA DIURNAL FLIGHT ALTITUDES - BLACKBIRDS (*Includes Birds Between 101 and 150 Feet AGL - See Text)

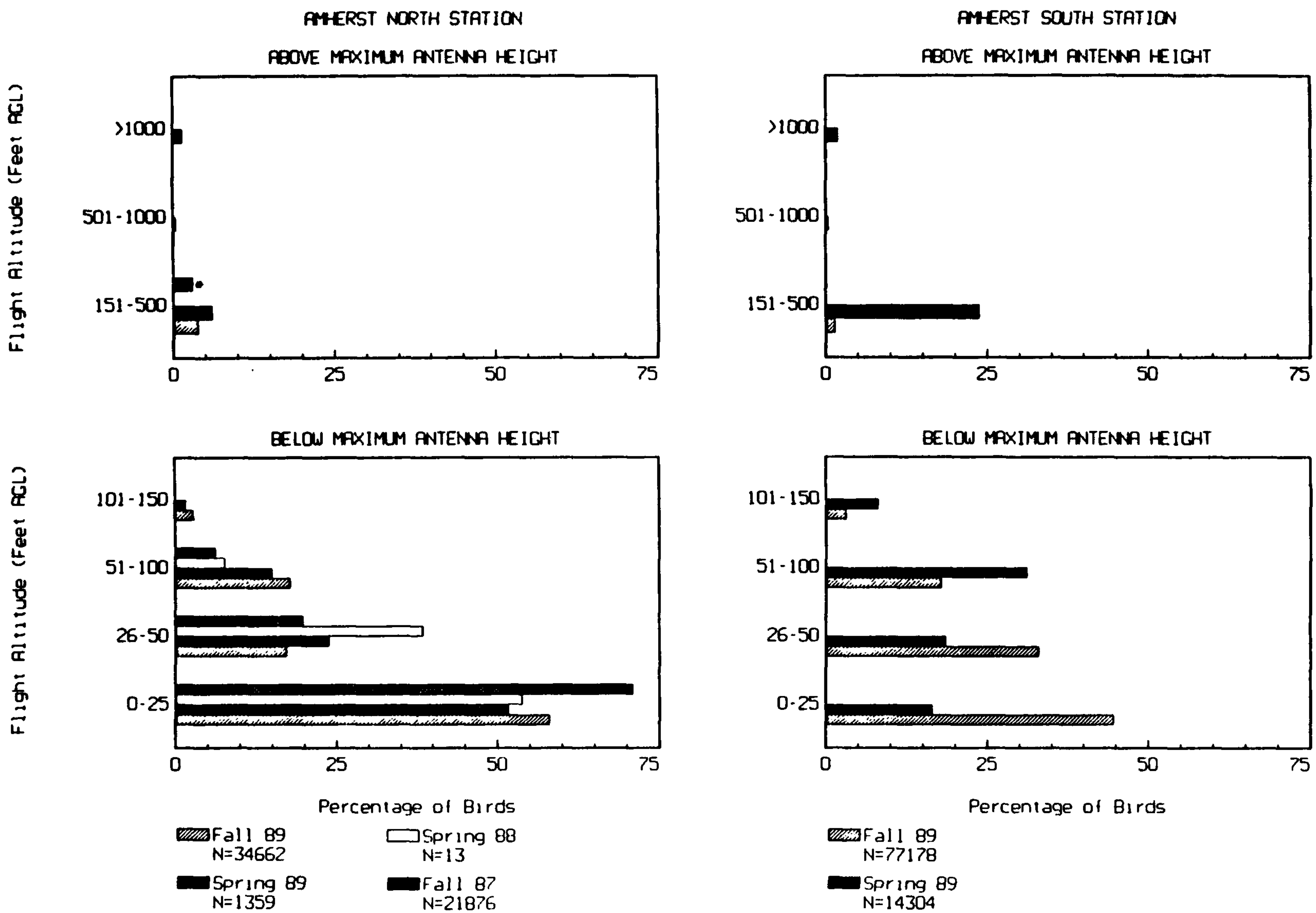


FIGURE 8-37. AMHERST, SD TRANSMIT STUDY AREA DIURNAL FLIGHT ALTITUDES - NONBLACKBIRD PASSERINES (*Includes Birds Between 101 and 150 Feet AGL - See Text)

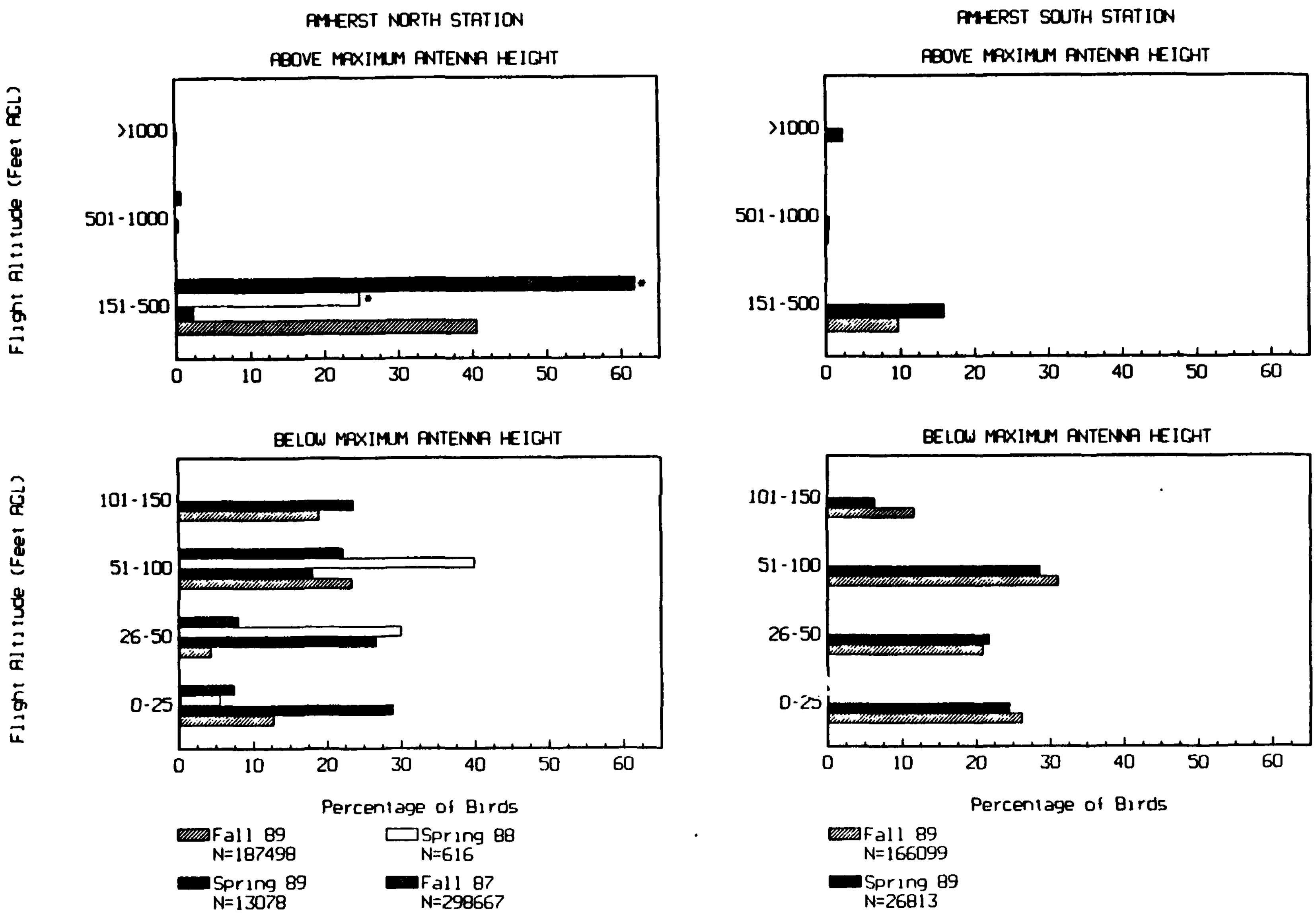


FIGURE 8-38. AMHERST, SD TRANSMIT STUDY AREA DIURNAL FLIGHT ALTITUDES - ALL PASSERINES (*Includes Birds Between 101 and 150 Feet AGL - See Text)

The greatest percentage of targets observed during spring flew between 300 and 500 feet agl at both stations (Fig. 8-39). However, mean nightly altitudes averaged over 1000 feet agl during the main movement period of waterfowl (25 March to 25 April) at the South station and averaged approximately 900 feet agl at the North station during this period. Mean nightly altitudes late in spring were only 33 to 50 percent of those observed during the peak period of movement at both stations (ABR, 1989).

The flight altitude distribution in the fall was much lower with over half of the targets at each station in the 100 to 300 foot altitude category (Fig. 8-39). Mean nightly altitudes did not vary much through the fall season at either station, exceeding 1000 feet agl on only 3 nights (26 August, 15 September, and 21 October) at the South station and three nights (1, 7, and 9 November) at the North station (ABR, 1990a).

During 1989 studies, night-vision scopes were used to sample birds flying below 100 feet agl, because the vertical-beam radar unit could not sample below this altitude. A total of 53 birds were observed at the three northern stations (2A, 2B, and 2C - see Fig. 8-6) in spring (0.37 birds per hour) while only 25 birds (0.17 birds per hour) were observed at these three stations in the fall (Table 8-14). For the three southern stations (1A, 1B, and 1C - see Fig. 8-6) a total of 4614 birds (26.61 birds per hour) were observed in spring while only 8 birds (0.05 birds per hour) were observed at these stations in the fall (Table 8-14). This large seasonal difference at the southern station can be explained by the fact that the extensive flooding at station 1A, where most of the birds were observed, was within range of the scope in spring but not in fall, when the water had receded. Most of the birds observed at station 1A in spring were waterfowl or waterbirds (Table 8-14).

In order to make a direct comparison between the night-vision scope and vertical radar data sets, the number of flocks observed with the night-vision scope was converted to the number of targets which would have been observed within a comparable airspace on the vertical radar using techniques developed by ABR (1990b). An effective sampling distance of 400 feet was assumed for the night-vision scope, since this was the modal distance a 12 inch target

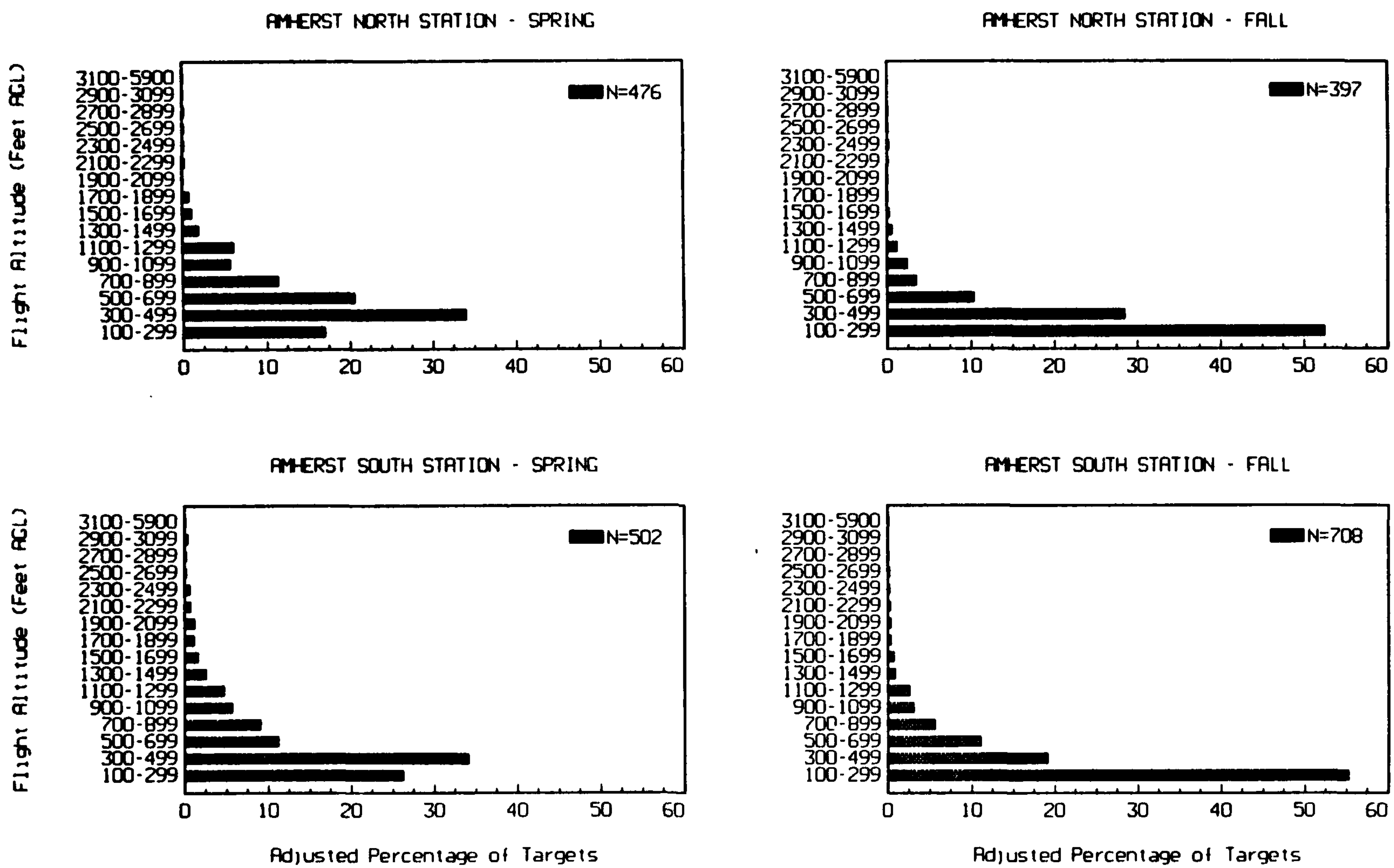


FIGURE 8-39. AMHERST, SD TRANSMIT STUDY AREA NOCTURNAL FLIGHT ALTITUDES - VERTICAL-BEAM RADAR

TABLE 8-14. NUMBER OF BIRDS FLYING BELOW 50 FEET ABOVE GROUND LEVEL DURING NOCTURNAL HOURS AT THE AMHERST TRANSMIT STUDY AREA - NIGHT-VISION SCOPE OBSERVATIONS

Station[1]	Study	Observation Hours	Number of Birds (Flocks)						
			Passerines	Raptors	Waterfowl	Waterbirds	Shorebirds	Unknown	Total
1A	Spring 89	102.1	12 (9)	3 (3)	2196 (318)	2062 (324)	0 (0)	168 (50)	4441 (704)
	Fall 89	60.1	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (1)	1 (1)
1B	Spring 89	36.3	8 (8)	0 (0)	42 (17)	2 (2)	54 (4)	0 (0)	106 (31)
	Fall 89	54.4	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	5 (1)	5 (1)
1C	Spring 89	35.0	18 (6)	0 (0)	34 (10)	5 (1)	10 (1)	0 (0)	67 (18)
	Fall 89	56.8	1 (1)	0 (0)	0 (0)	0 (0)	0 (0)	1 (1)	2 (2)
2A	Spring 89	67.6	4 (3)	0 (0)	15 (2)	0 (0)	0 (0)	1 (1)	20 (6)
	Fall 89	56.5	0 (0)	1 (1)	0 (0)	0 (0)	0 (0)	3 (2)	4 (3)
2B	Spring 89	40.2	0 (0)	0 (0)	4 (2)	0 (0)	0 (0)	0 (0)	4 (2)
	Fall 89	41.9	0 (0)	1 (1)	0 (0)	0 (0)	0 (0)	14 (8)	15 (9)
2C	Spring 89	36.4	4 (1)	0 (0)	21 (6)	3 (1)	1 (1)	0 (0)	29 (9)
	Fall 89	53.1	1 (1)	1 (1)	0 (0)	0 (0)	0 (0)	4 (2)	6 (4)
Total	Spring 89	317.6	46 (27)	3 (3)	2312 (355)	2072 (328)	65 (6)	169 (51)	4667 (770)
	Fall 89	322.8	2 (2)	3 (3)	0 (0)	0 (0)	0 (0)	28 (15)	33 (20)
	Total	640.4	48 (29)	6 (6)	2312 (355)	2072 (328)	65 (6)	197 (66)	4700 (790)

1. Station locations can be found on Figure 8-6.

could be seen during target tests (UMN, 1989a). At a distance of 400 feet, the maximum altitude sampled with the scope was approximately 50 feet agl. Only data from the two primary night-vision scope stations (1A and 2A) were used since these stations were in the same locations as the radar sampling stations (Fig. 8-6). Since not all vertical-beam and night-vision scope observations were concurrent, the number of flocks observed with the night-vision scope was adjusted to correct for differences in sampling intensity.

The results of this analysis suggest that 0.8% of flocks flew within 50 feet of the ground in spring and 0.9% of flocks flew within 50 feet of the ground in fall at the North station. At the South station, percentages within 50 feet agl were 37.7% in the spring and 0.2% in the fall. The reasons for the high percentage of low flying birds at the South station in spring were previously discussed.

8.2.3.3.3 **Time of day comparison.** Although the flight altitude data collected by visual observers during daylight hours, by the vertical-beam radar, and using the night-vision scope were not directly comparable, they suggest that flight altitudes, especially of passerines, were higher during nocturnal hours than during diurnal hours. This has also been reported by other investigators (e.g. Eastwood and Rider, 1965; Gauthreaux, 1978).

A direct comparison using radar data alone was possible, however. In spring, mean flight altitudes were significantly higher during nocturnal periods than during either twilight or daylight periods. This trend occurred at both stations (ABR, 1989). In the fall, birds at both sampling stations generally flew at significantly higher altitudes during nocturnal and twilight hours than during daylight periods (ABR, 1990a).

8.2.3.3.4 **Weather effects.** Weather conditions are known to affect the flight altitude of birds. In general, daytime migrants will fly lower when there is poor visibility, dense cloud cover accompanied by low cloud ceilings, or precipitation, and also when flying into strong headwinds (Gauthreaux, 1978). The effects of cloud ceiling height, precipitation, and wind on flight altitudes is examined here for five species groups during daylight hours.

Insufficient data were available for an analysis during nocturnal hours, since the radar unit could not be used effectively during periods of inclement weather.

At the North station, only geese and passerines flew consistently higher during periods of high (>1000 feet agl) cloud ceilings than during periods of low (<1000 feet agl) cloud ceilings. Raptors flew higher during high cloud ceilings in the fall but not in the spring and flight altitudes for ducks showed considerable variability among seasons between the two cloud ceiling categories (Table 8-15). Trends at the South station were unclear for all groups (Table 8-15), perhaps because local bird movements are not affected by cloud ceiling heights as much as migratory movements; the South station had a higher rate of local movements, especially in spring around the flooded area. It should be noted that visibility is usually reduced during low ceiling periods and birds flying within or above the clouds may be hidden from a visual observer.

Precipitation, especially snow, generally reduced flight altitudes for all bird groups at both stations during daylight hours (Table 8-16). Exceptions were raptors in spring 1989 at the North station and geese in fall 1989 at the South station, which flew lowest during periods with no precipitation. However, visibility is generally reduced during periods of precipitation, especially snow, and flight altitude distributions observed during these periods may be especially biased towards the lower altitudes. Regardless of this potential bias, these results, in combination with those for the effects of weather on migration rate (Table 8-11), show that significant numbers of birds, especially waterfowl, fly at altitudes below the maximum height of the transmit antenna structure during periods of precipitation, when visibility is reduced and the potential for collisions may be greater.

Flight altitudes for ducks at the North station were generally lowest when winds (as measured from ground level) were calm or less than 15 mph, regardless if they were headwinds, tailwinds, or crosswinds. At the South station, duck altitudes were usually highest during tailwinds exceeding 15 mph

TABLE 8-15. EFFECTS OF CLOUD CEILING HEIGHT ON FLIGHT ALTITUDE AT THE AMHERST TRANSMIT STUDY AREA DURING DAYLIGHT HOURS

Species Group	Study	Percentage Flying Below 150 Feet AGL[1] For Cloud Ceiling Height:	
		<1000 ft agl	>1000 ft agl
NORTH STATION			
Ducks	Fall 87	0.8	0.7
	Spring 89	87.3	47.8
	Fall 89	11.8	16.8
Geese	Fall 87	10.8	1.1
	Spring 89	96.3	39.5
	Fall 89	24.9	14.7
Waterfowl	Fall 87	4.2	1.1
	Spring 89	96.4	39.7
	Fall 89	[illegible].2	20.9
Raptors	Fall 87	69.6	47.3
	Spring 89	65.0	80.7
	Fall 89	72.4	66.2
Passerines	Fall 87	97.1	33.7
	Spring 89	99.8	95.5
	Fall 89	100.0	58.0
SOUTH STATION			
Ducks	Spring 89	44.9	83.1
	Fall 89	41.8	43.1
Geese	Spring 89	42.1	30.0
	Fall 89	27.0	34.5
Waterfowl	Spring 89	42.5	31.6
	Fall 89	29.9	34.0
Raptors	Spring 89	92.2	91.0
	Fall 89	84.0	69.9
Passerines	Spring 89	75.3	94.7
	Fall 89	96.6	88.7

1. Flight altitude less than 100 feet agl for Fall 1987.

TABLE 8-16. EFFECTS OF PRECIPITATION ON FLIGHT ALTITUDE AT THE AMHERST TRANSMIT STUDY AREA DURING DAYLIGHT HOURS

Species Group	Study	Percentage of Birds Flying Below 150 Feet AGL[1]		
		No Precipitation	Rain	Snow[2]
NORTH STATION				
Ducks	Fall 87	0.7	1.2	---
	Spring 89	49.0	86.6	91.8
	Fall 89	16.3	9.9	71.1
Geese	Fall 87	1.2	0.0	100.0
	Spring 89	54.2	87.4	12.4
	Fall 89	13.8	2.0	71.4
Waterfowl	Fall 87	1.2	0.8	100.0
	Spring 89	54.7	87.4	17.3
	Fall 89	19.9	5.0	61.4
Raptors	Fall 87	48.0	66.7	66.7
	Spring 89	81.3	55.6	50.0
	Fall 89	65.7	100.0	80.0
Passerines	Fall 87	37.4	39.5	11.9
	Spring 89	96.0	99.6	99.8
	Fall 89	58.3	99.9	100.0
SOUTH STATION				
Ducks	Spring 89	86.1	25.0	100.0
	Fall 89	42.9	20.9	68.8
Geese	Spring 89	31.6	36.4	100.0
	Fall 89	34.9	2.2	29.5
Waterfowl	Spring 89	33.6	35.0	100.0
	Fall 89	34.4	5.0	45.6
Raptors	Spring 89	90.5	97.1	100.0
	Fall 89	71.2	81.3	100.0
Passerines	Spring 89	90.8	76.5	100.0
	Fall 89	89.8	95.1	100.0

1. Flight altitude less than 100 feet agl for Fall 1987.
2. Includes sleet and hail.

and during headwinds of less than 15 mph (Table 8-17). Geese and raptors generally flew highest during tailwind conditions at both stations. Passerines flew highest during calm or tailwind conditions at the North station but no trends were evident at the South station (Table 8-17).

8.2.3.4 Flight Direction.

8.2.3.4.1 Daylight periods. Flight directions for ducks were generally north or northwest in the spring but highly variable in the fall, indicating a high proportion of local movements at both stations in the fall (Fig. 8-40). Goose/cormorant movements showed more directionality in the spring, with the principal flight direction being north at both stations. While south was the most common flight direction during fall 1989 at both stations, geese exhibited a considerable amount of local east-west movements, especially during fall 1987 at the North station (Fig. 8-41). Spring swan movement patterns were almost exclusively in their expected migratory directions (north, northwest, and west; Bellrose, 1980) at the North station, with flight directions exhibiting more variability at the South station. In fall, swan flight directions were mostly east, southeast, or south at both stations, again suggesting a high proportion of migratory movements (Fig. 8-42). Flight directions for all waterfowl showed more consistency in the spring than in the fall and did not differ greatly between stations (Fig. 8-43).

Shorebirds showed considerable variability in their flight directions during both spring and fall, especially at the North station. However, north was the most common flight direction in spring and south was the most common flight direction in fall at both stations during 1989 studies (Fig. 8-44).

Relatively few sandhill cranes were observed at either station during avian studies. Of those observed in spring, most flew in the three northerly directions (north, northeast, and northwest), while fall directions were exclusively in the three southerly directions (south, southeast, southwest) at the South station, but highly variable at the North station (Fig. 8-45).

TABLE 8-17. EFFECTS OF WIND ON FLIGHT ALTITUDE AT THE AMHERST TRANSMIT STUDY AREA DURING DAYLIGHT HOURS

Species Group	Study	Percentage of Birds Flying Below 150 Feet AGL[1]						
		No Wind	Headwind		Tailwind		Crosswind	
			<15	>15	<15	>15	<15	>15 MPH
NORTH STATION								
Ducks	Fall 87	0.7	0.3	0.7	0.1	0.3	0.0	3.0
	Spring 89	18.5	59.0	49.4	58.2	44.8	61.3	30.3
	Fall 89	23.2	16.1	5.3	20.9	17.9	23.7	1.8
Geese	Fall 87	0.0	3.9	3.1	0.0	0.1	0.0	0.0
	Spring 89	62.1	75.0	25.3	26.6	59.3	74.9	90.1
	Fall 89	23.9	15.9	23.2	6.6	16.7	8.0	15.9
Waterfowl	Fall 87	0.5	2.3	1.5	0.1	0.3	0.0	1.7
	Spring 89	58.0	74.9	26.0	26.8	55.9	77.4	86.1
	Fall 89	26.9	20.1	23.3	18.4	14.0	19.4	21.5
Raptors	Fall 87	89.7	78.3	87.5	28.2	37.2	58.1	83.3
	Spring 89	81.3	76.7	89.5	76.7	76.5	100	81.8
	Fall 89	86.4	69.6	81.8	55.2	37.9	76.9	82.0
Passerines	Fall 87	41.1	57.3	66.9	4.4	40.2	62.9	97.4
	Spring 89	66.1	93.4	99.1	98.8	99.3	91.8	99.8
	Fall 89	34.2	93.6	98.5	62.8	93.0	93.6	100
SOUTH STATION								
Ducks	Spring 89	100.0	70.6	95.2	96.5	78.6	96.2	81.5
	Fall 89	64.8	31.4	48.6	37.9	19.0	59.8	37.4
Geese	Spring 89	100.0	87.4	16.8	95.9	22.9	32.0	88.5
	Fall 89	31.6	54.5	37.0	25.1	12.3	57.8	31.7
Waterfowl	Spring 89	100.0	86.7	18.6	96.0	24.8	39.2	86.7
	Fall 89	33.7	44.8	39.9	27.2	13.2	43.0	36.3
Raptors	Spring 89	75.0	82.2	92.5	86.7	96.6	96.6	96.7
	Fall 89	92.9	76.0	90.2	59.9	54.4	75.8	89.1
Passerines	Spring 89	100.0	92.4	72.1	99.5	86.9	62.0	100
	Fall 89	93.8	82.1	100	92.4	96.7	87.4	99.1

1. Flight altitude less than 100 feet agl for Fall 1987.

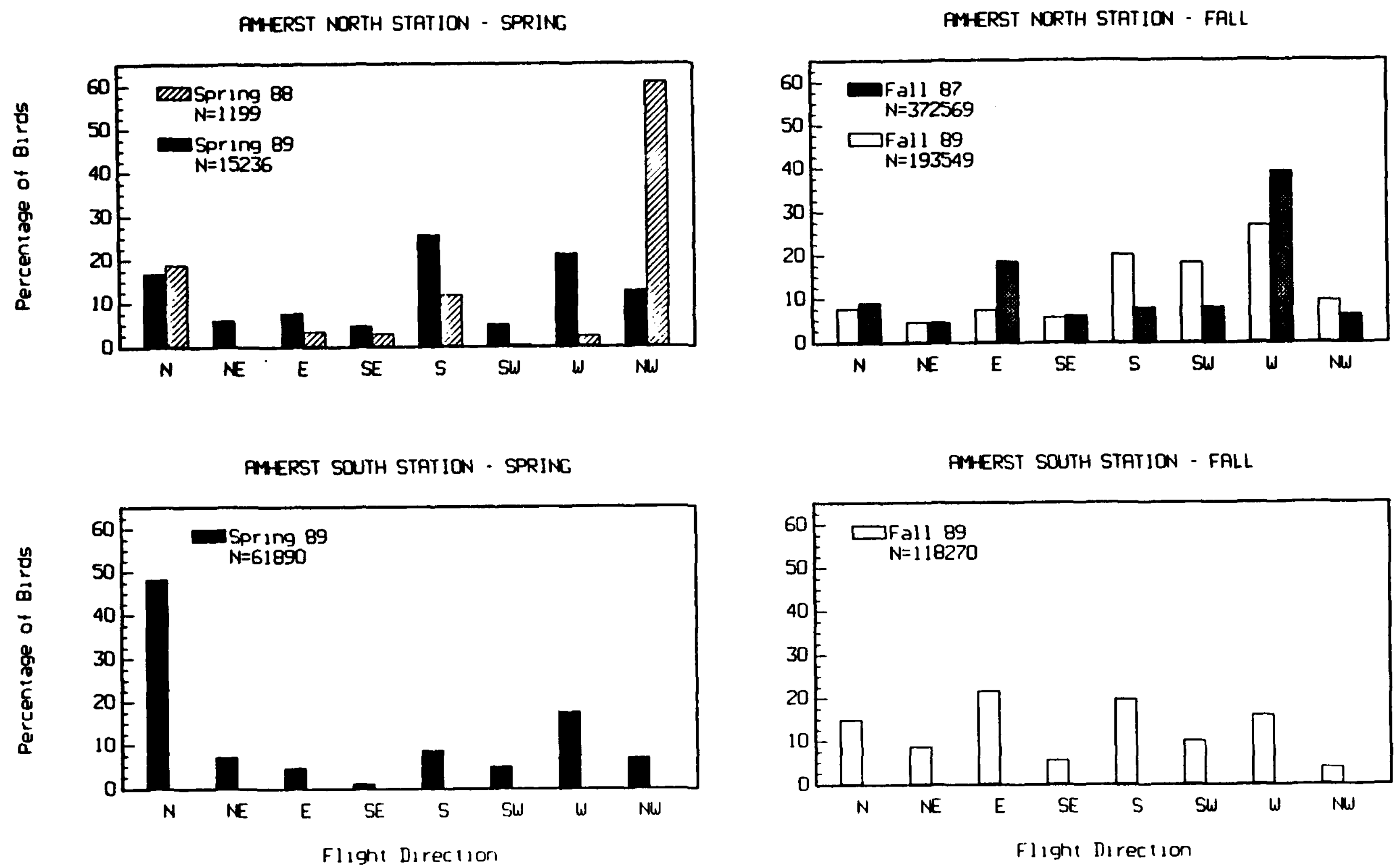


FIGURE 8-40. AMHERST, SD TRANSMIT STUDY AREA DIURNAL FLIGHT DIRECTIONS -DUCKS

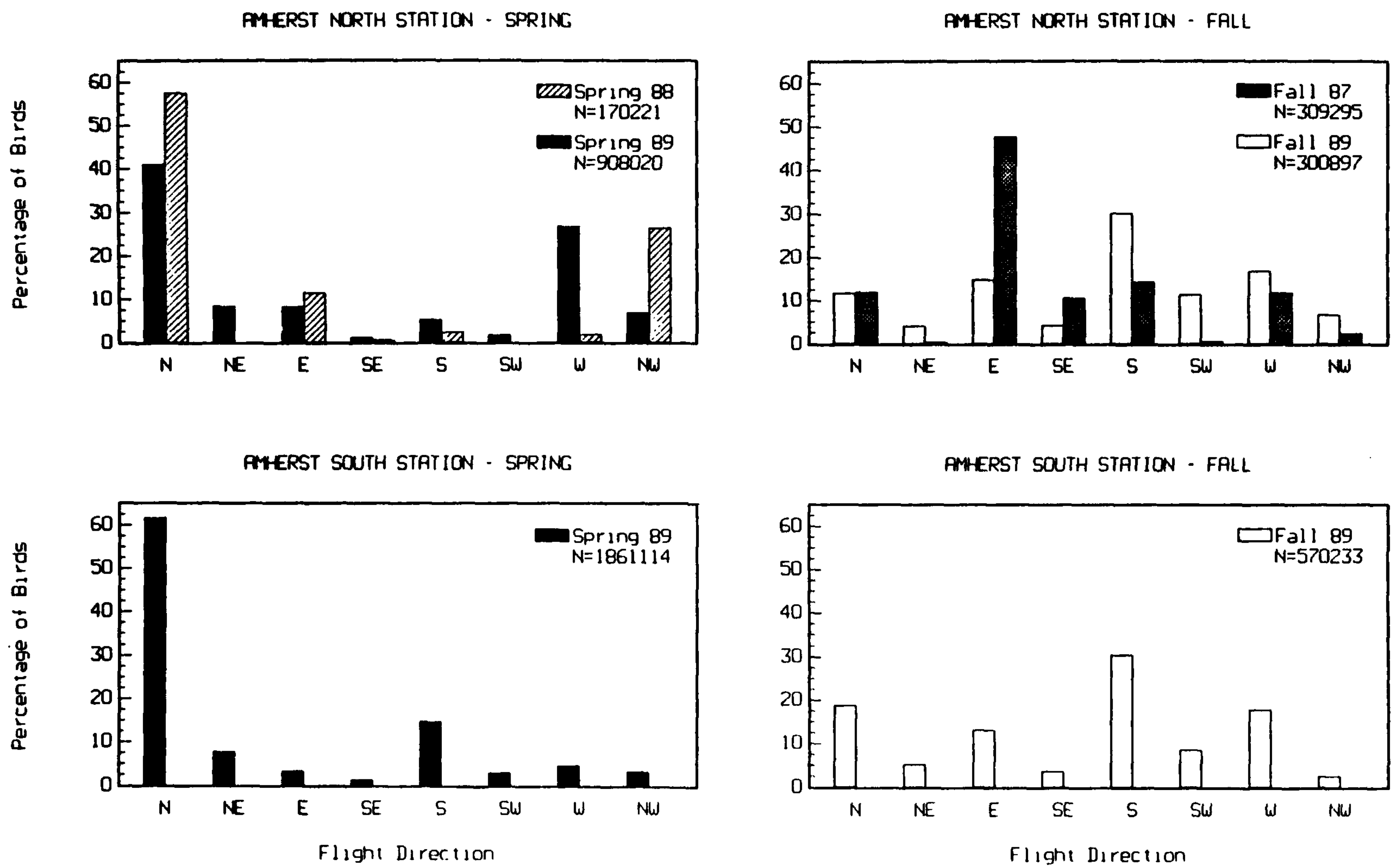


FIGURE 8-41. AMHERST, SD TRANSMIT STUDY AREA DIURNAL FLIGHT DIRECTIONS -GEESE/CORMORANTS

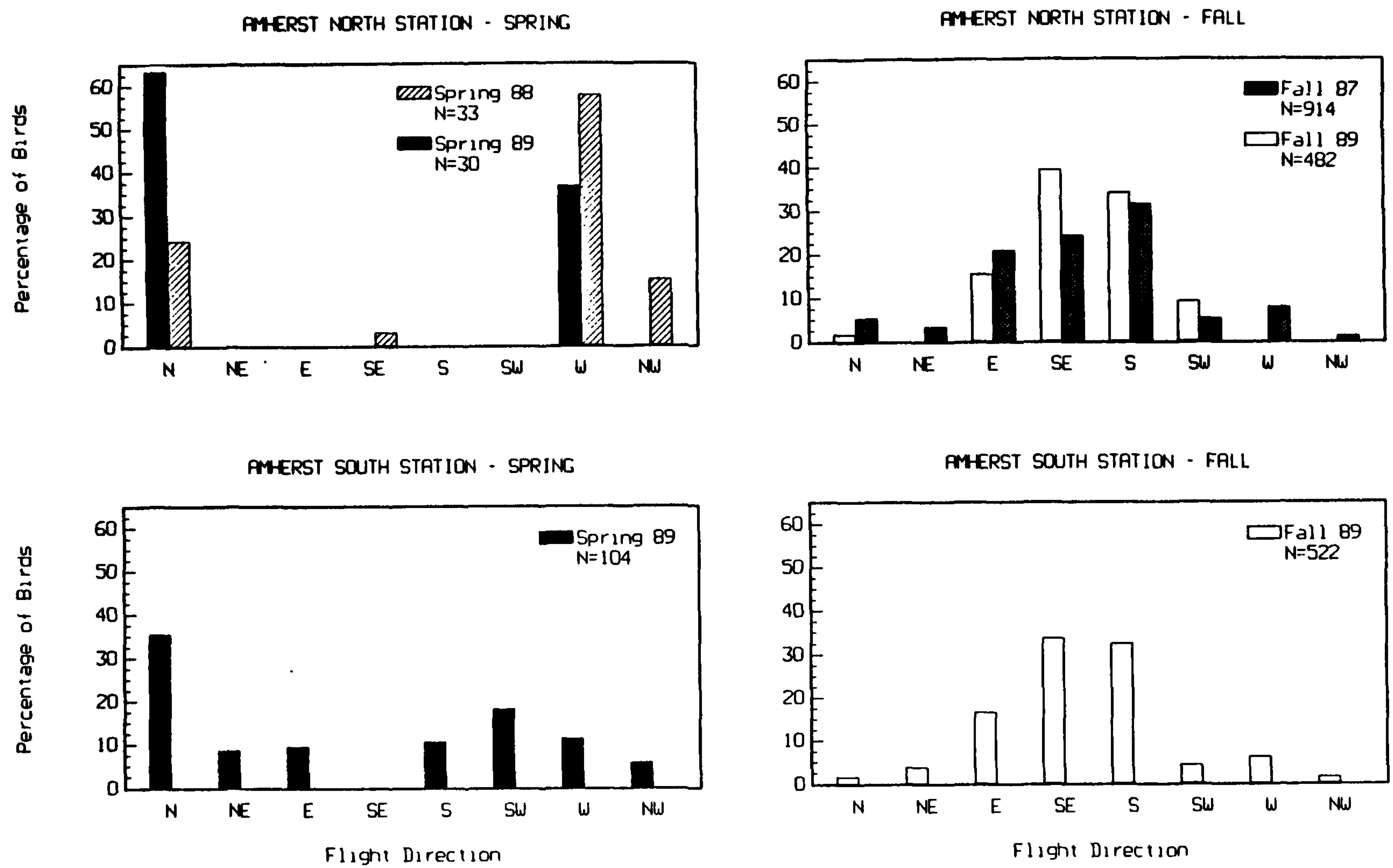


FIGURE 8-42. AMHERST, SD TRANSMIT STUDY AREA DIURNAL FLIGHT DIRECTIONS -SWANS

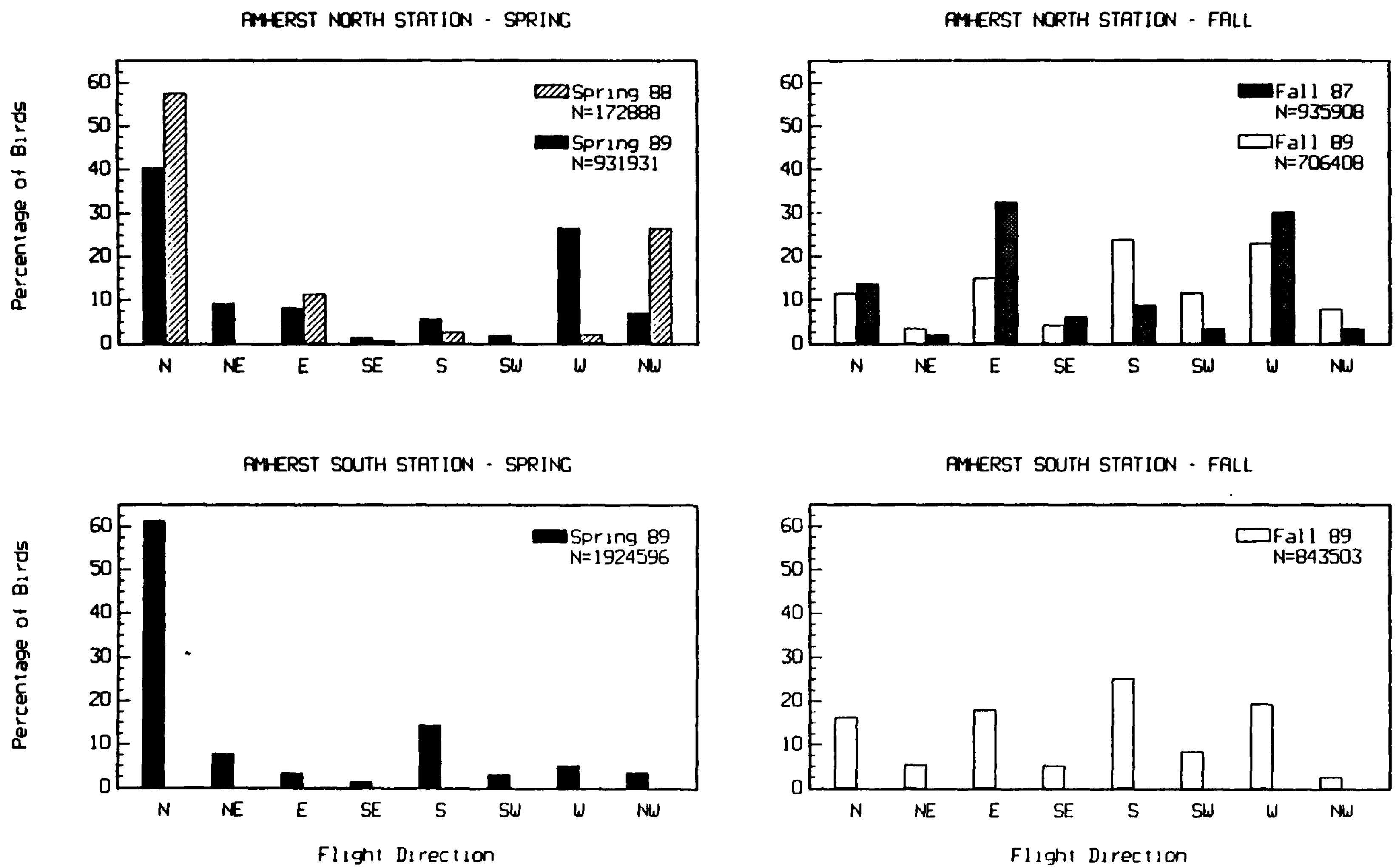


FIGURE 8-43. AMHERST, SD TRANSMIT STUDY AREA DIURNAL FLIGHT DIRECTIONS -ALL WATERFOWL

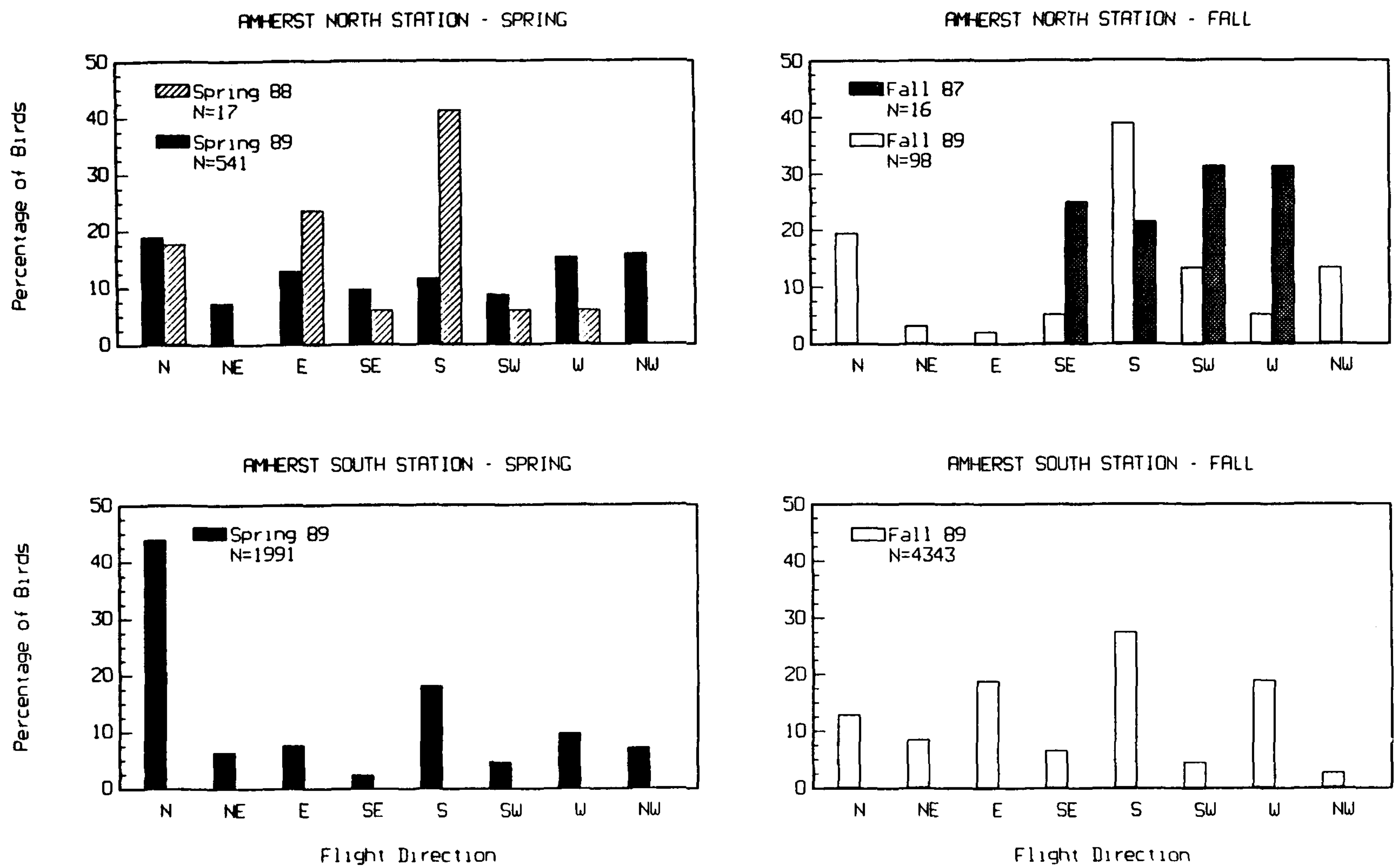


FIGURE 8-44. AMHERST, SD TRANSMIT STUDY AREA DIURNAL FLIGHT DIRECTIONS -SHOREBIRDS

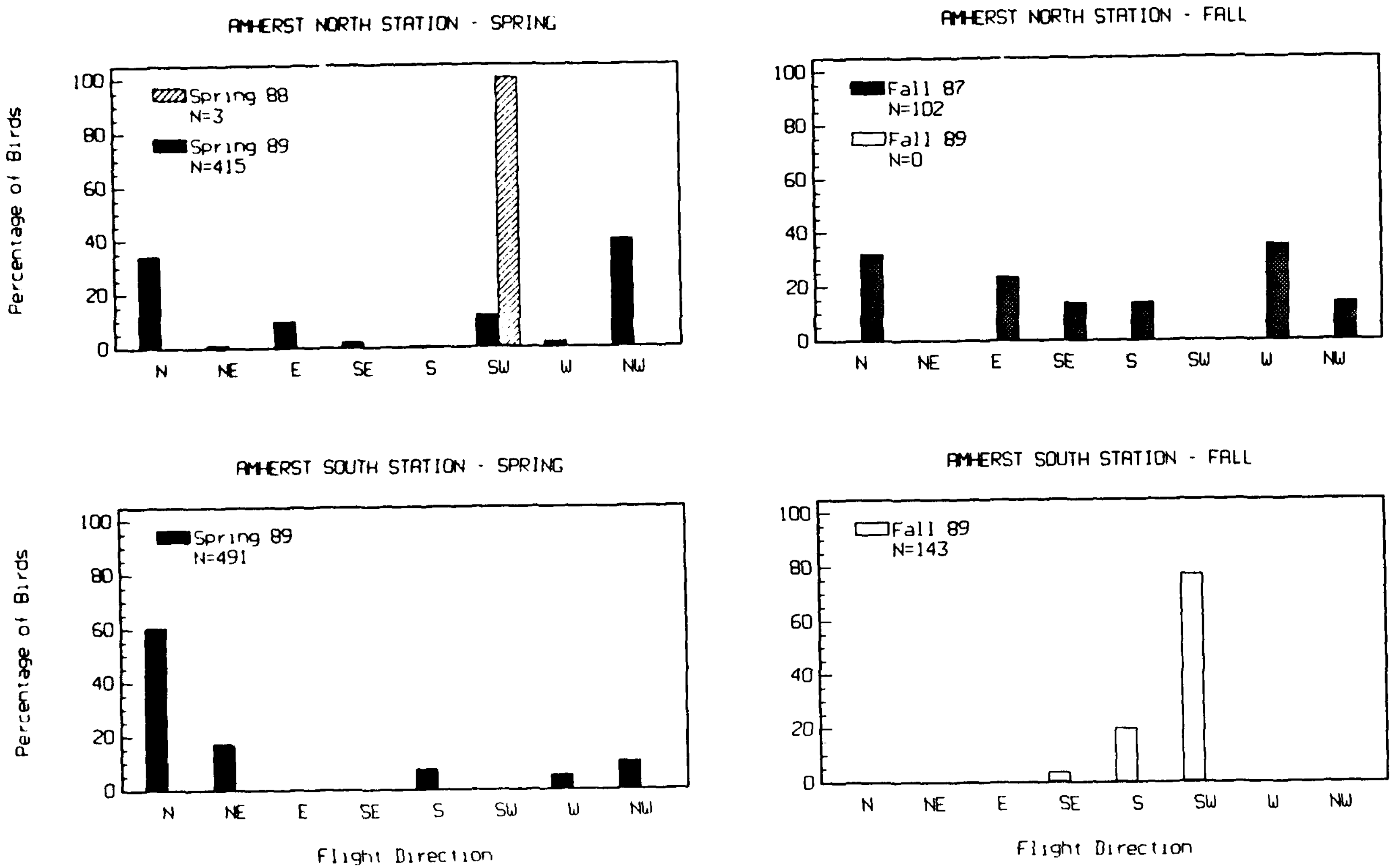


FIGURE 8-45. AMHERST, SD TRANSMIT STUDY AREA DIURNAL FLIGHT DIRECTIONS -SANDHILL CRANES

Waterbird flight directions were highly variable in both spring and fall at the North station, suggesting a large proportion of local movements. At the South station, fall flight directions were more variable than spring flight directions, which were mainly north (Fig. 8-46).

Raptor flight directions were generally north in the spring and south in the fall at both stations (Fig. 8-47), although the degree of variability in the distributions suggests a fair proportion of local movements during all seasons at both stations. These local movements were largely of foraging northern harriers.

Spring passerine movements were largely north, northwest, or west at the North station and north at the South station. Flight direction distributions were similar for blackbirds and nonblackbird passerines (Figs. 8-48; 8-49; 8-50). In fall, flight directions were mostly south at the South station, with blackbirds showing more variability than nonblackbird passerines. At the North station, the principal flight direction for nonblackbird passerines was northeast, while blackbirds flew mostly south or southeast (and also west in fall 1987) (Figs. 8-48; 8-49; 8-50).

8.2.3.4.2 Nocturnal periods. As observed using long-range radar, north and northwest were the principle flight directions in the spring at both stations. During fall, most birds flew south or southeast during nocturnal hours at both stations (Fig. 8-51). Flight directions were more variable in the spring, suggesting a greater proportion of local movements but were very similar between stations (Fig. 8-51).

8.2.3.5 Flight Corridors. During daylight hours, data were collected as birds crossed transect lines extending north, south, east, and west from an observation station. One data item collected was which transect the bird or flock crossed; data were only collected for the first transect crossing (or recorded as overhead if birds passed directly over the observer). Plotting the distribution of the percentage of birds by transect crossed allows a rough quantification of bird movement patterns in the vicinity of each observation station. A more quantitative assessment of flight corridors is more difficult

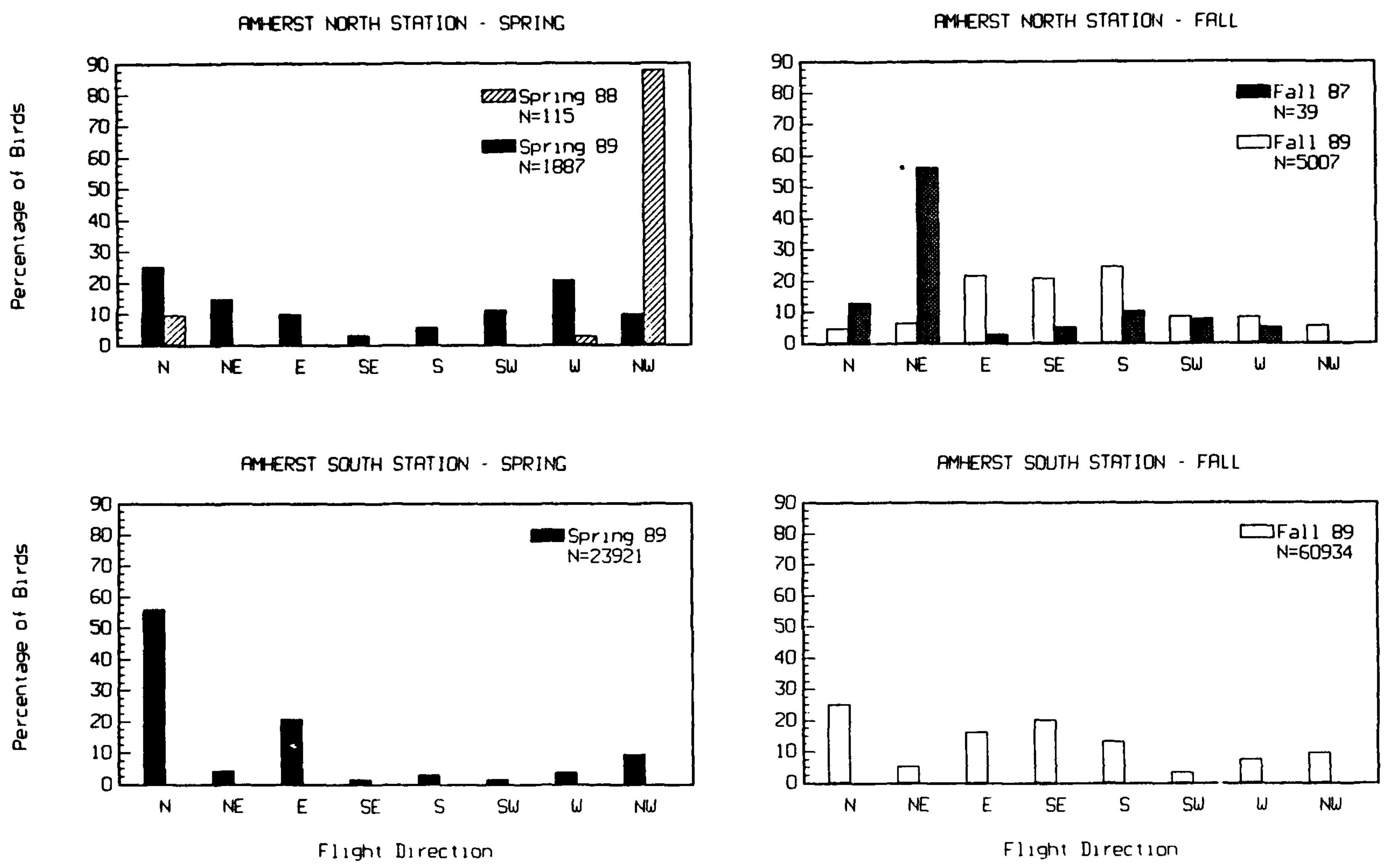


FIGURE 8-46. AMHERST, SD TRANSMIT STUDY AREA DIURNAL FLIGHT DIRECTIONS -WATERBIRDS

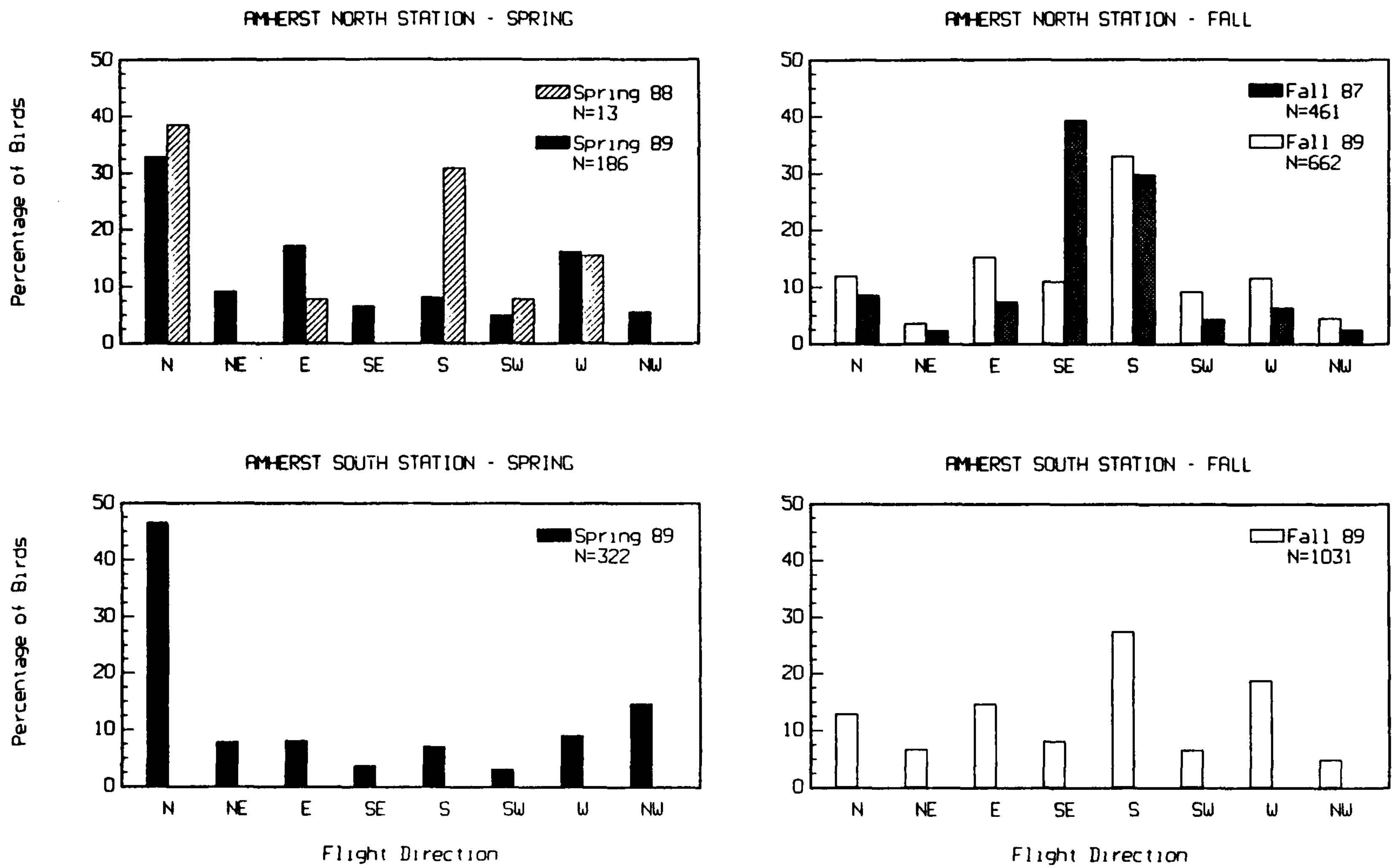


FIGURE 8-47. AMHERST, SD TRANSMIT STUDY AREA DIURNAL FLIGHT DIRECTIONS - RAPTORS

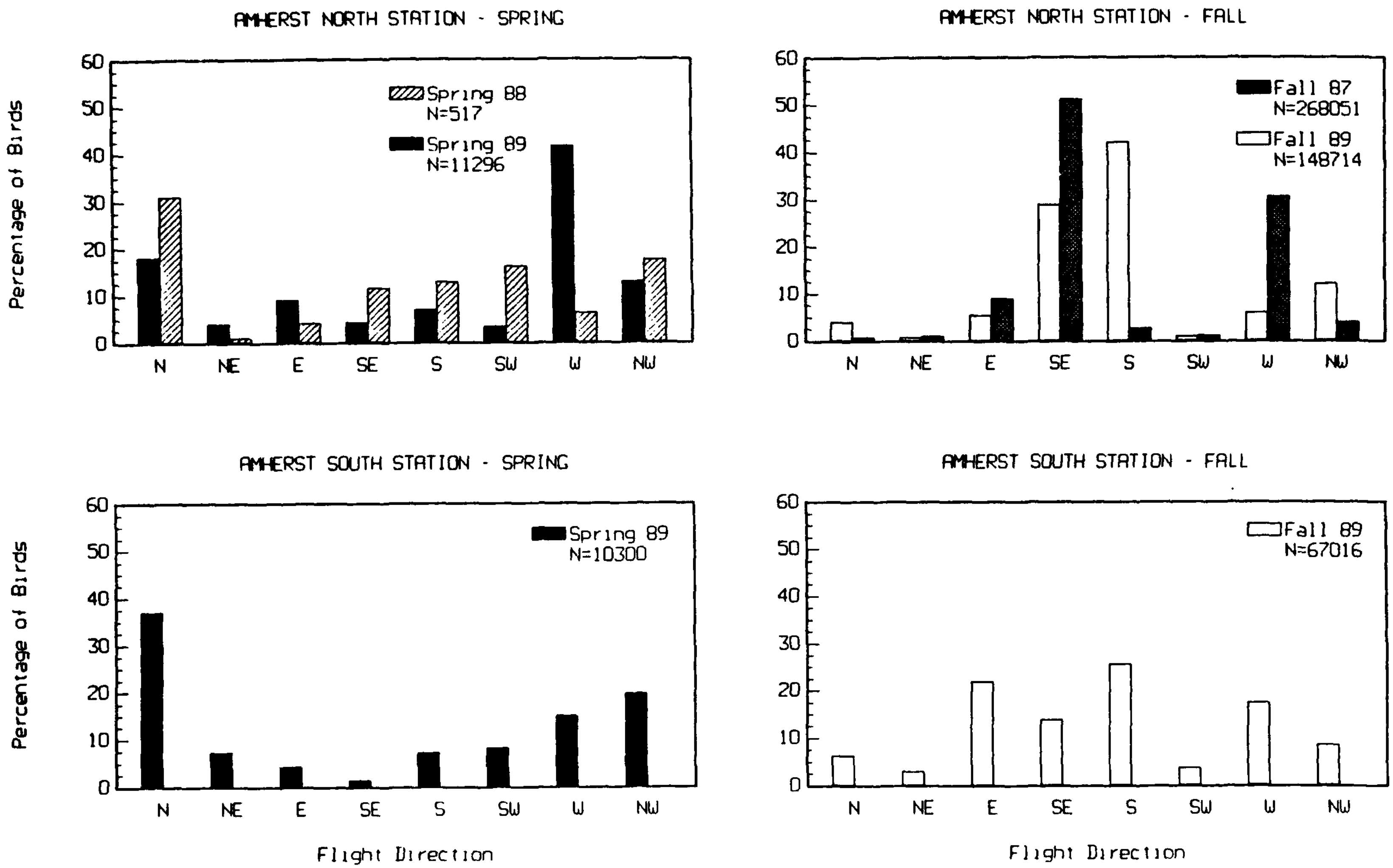


FIGURE 8-48. AMHERST, SD TRANSMIT STUDY AREA DIURNAL FLIGHT DIRECTIONS - BLACKBIRDS

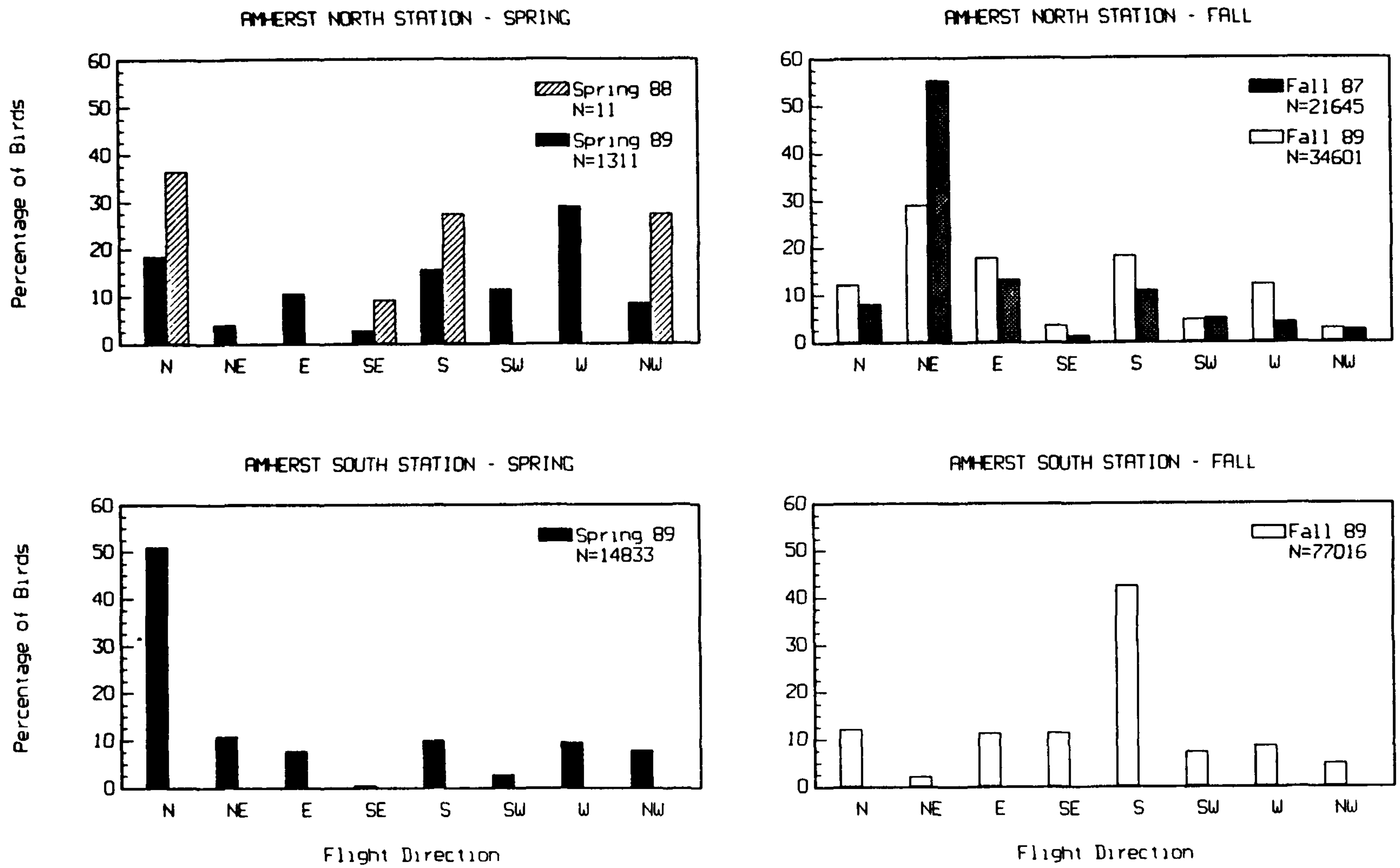


FIGURE 8-49. AMHERST, SD TRANSMIT STUDY AREA
DIURNAL FLIGHT DIRECTIONS - NONBLACKBIRD PASSERINES

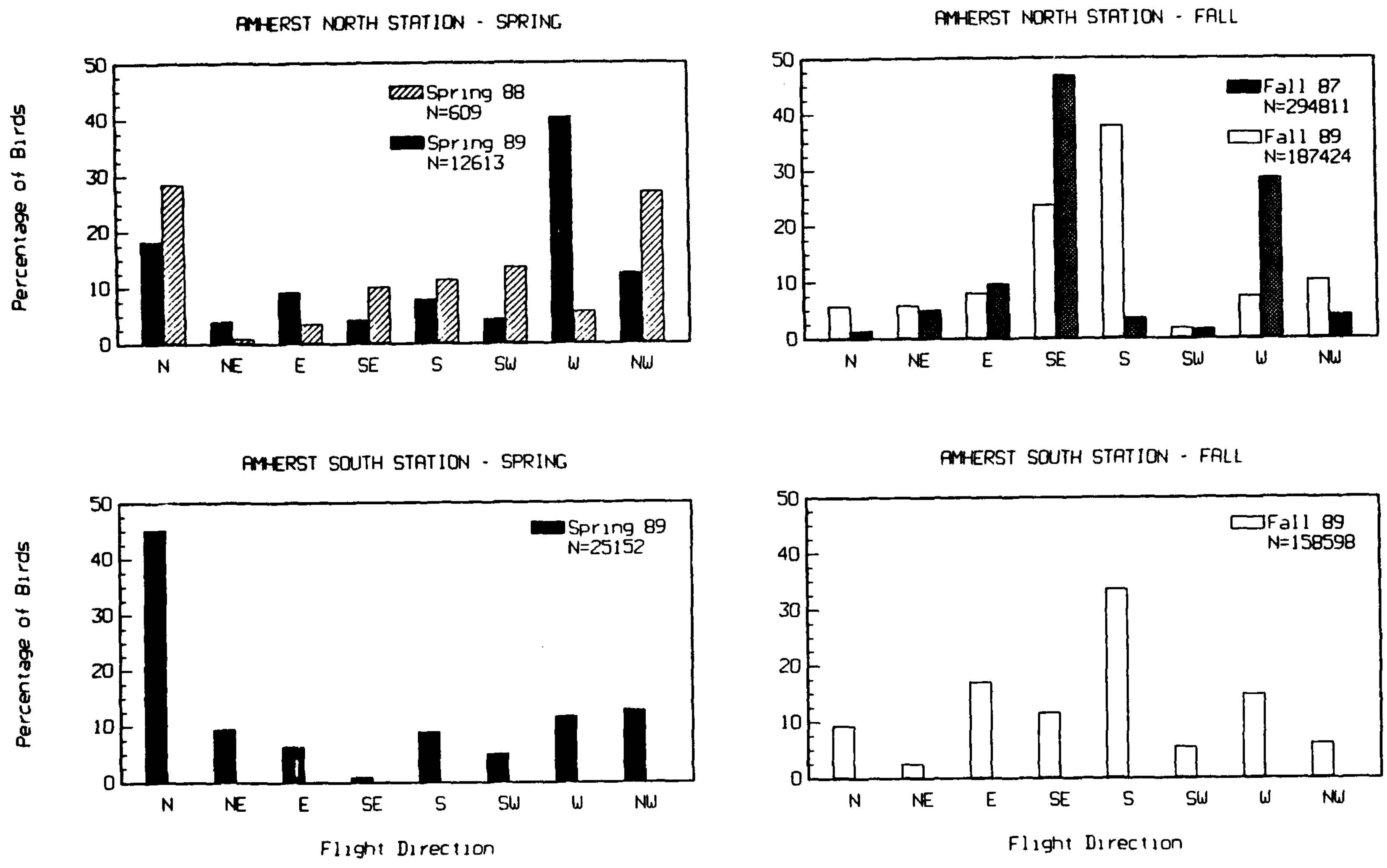


FIGURE 8-50. AMHERST, SD TRANSMIT STUDY AREA DIURNAL FLIGHT DIRECTIONS - ALL PASSERINES

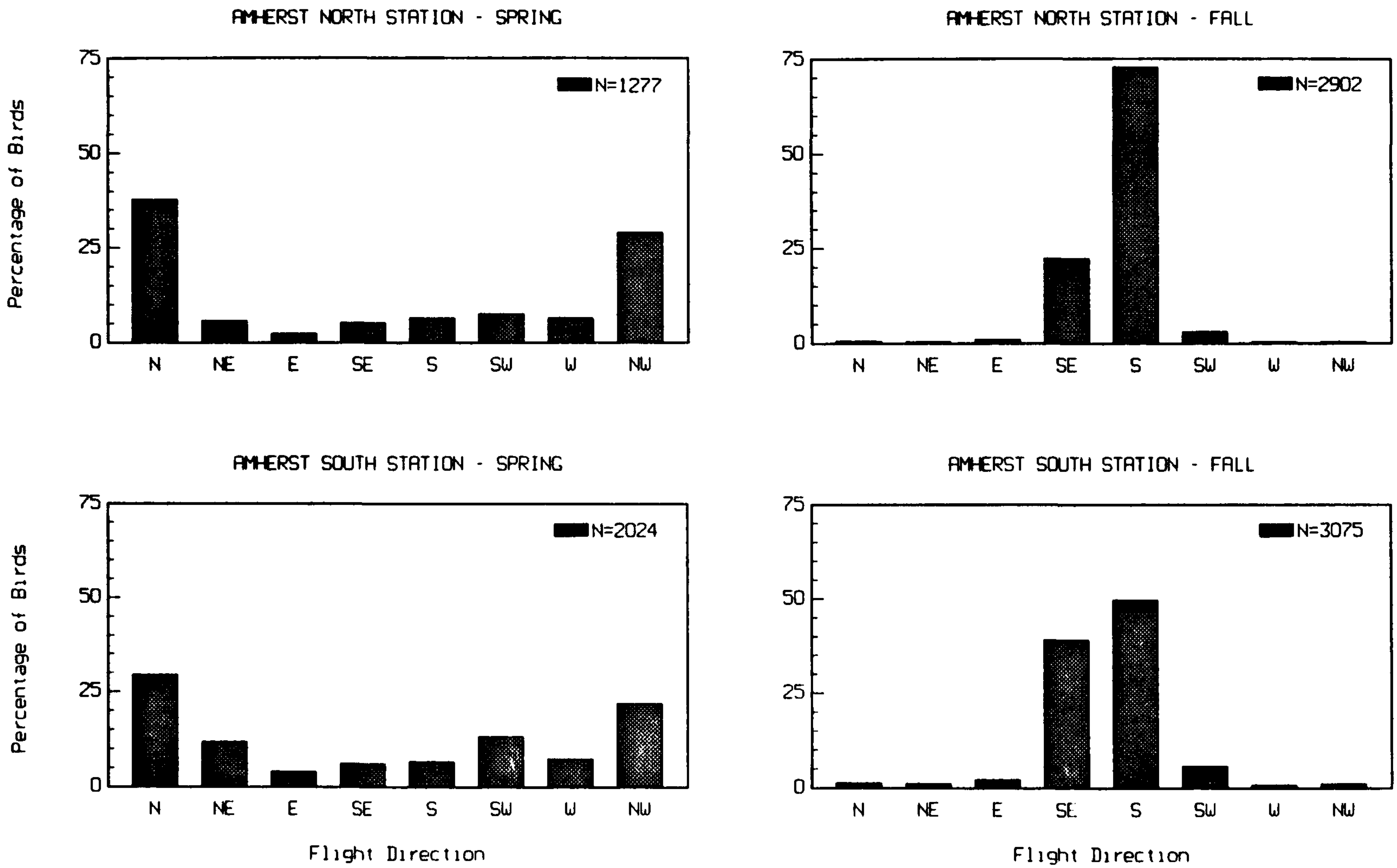


FIGURE 8-51. AMHERST, SD TRANSMIT STUDY AREA
NOCTURNAL FLIGHT DIRECTIONS - LONG-RANGE RADAR

because annual variation in migration corridors is not unusual. Environmental factors such as wind patterns can strongly influence bird flight patterns (Gauthreaux, 1978; Richardson, 1978; Kessel, 1984), especially on the small scale needed for this type of analysis. For example, birds flying during periods when strong winds are blowing perpendicular to their direction of travel often drift off course. Also, the extent and distribution of open water will heavily influence the movements of waterfowl, waterbirds, and shorebirds.

A comparable analysis during nocturnal hours was conducted simply by comparing the number of targets crossing transects extending east and west from each radar sampling location.

8.2.3.5.1 Daylight periods. The flight corridor analysis for the North station is presented in Table 8-18. Table 8-19 shows the flight altitudes by transect crossed for the North station. Comparable analyses for the South station can be found in Tables 8-20 and 8-21.

At the North station, ducks and geese (and all waterfowl) were most often observed crossing south of the observation station (Table 8-18). Large flocks of ducks and geese were often observed flying east and west between Mary's Slough, fields several miles south of the station, and presumably Sand Lake National Wildlife Refuge (Fig. 8-2). These flights were especially evident in the fall near dusk and dawn. Although these were foraging flights, altitudes were generally not lower than for other transects, except in the fall of 1989 (Table 8-19). No other strong patterns were evident for other species groups.

Flight patterns at the South station tended to be heavily influenced by the large amount of flooding which existed west, northwest, and north of the station. This flooding was more extensive in the spring; by fall, most of the water to the west of the station had dried up, although significant amounts of water (and exposed mudflats) were still evident north and northwest of the station.

TABLE 8-18. FLIGHT CORRIDORS OBSERVED FROM THE NORTH OBSERVATION STATION DURING DAYLIGHT HOURS AT THE AMHERST TRANSMIT STUDY AREA

Species Group	Season	Percentage of Birds Crossing Transect				
		North	South	Overhead	West	East
Waterfowl	Fall 87	3.1	67.7	2.4	17.5	9.4
	Spring 88	0.3	18.2	10.2	15.0	56.2
	Spring 89	31.5	42.3	9.2	5.7	11.4
	Fall 89	9.3	40.9	6.6	29.3	14.0
-Ducks	Fall 87	6.2	64.4	4.5	7.0	17.9
	Spring 88	4.0	2.7	35.2	23.3	34.9
	Spring 89	15.6	51.0	16.8	5.9	10.6
	Fall 89	11.0	42.5	11.8	15.7	19.0
-Geese/Cormorants	Fall 87	0.8	67.6	1.8	24.0	5.9
	Spring 88	0.3	18.4	10.1	14.5	56.8
	Spring 89	32.1	42.7	9.2	5.7	10.2
	Fall 89	5.2	36.1	7.8	36.7	14.1
-Swans	Fall 87	15.8	15.2	15.1	26.6	27.3
	Spring 88	57.6	15.2	0.0	3.0	24.2
	Spring 89	0.0	63.3	36.7	0.0	0.0
	Fall 89	9.5	19.3	17.4	30.9	22.8
Raptors	Fall 87	5.8	18.0	16.1	18.3	41.8
	Spring 88	15.4	7.7	23.1	15.4	38.5
	Spring 89	22.4	42.7	14.7	9.1	11.2
	Fall 89	24.8	22.7	2.6	25.0	24.8
Shorebirds	Fall 87	0.0	6.3	87.5	0.0	6.3
	Spring 88	0.0	23.5	17.6	23.5	35.3
	Spring 89	26.0	27.7	19.6	16.2	10.4
	Fall 89	17.3	13.3	10.2	45.9	13.3
Waterbirds	Fall 87	0.0	16.7	63.9	11.1	8.3
	Spring 88	39.1	7.0	23.5	20.0	10.4
	Spring 89	22.8	26.7	22.1	26.0	2.3
	Fall 89	17.3	25.0	8.0	18.4	31.3
Passerines	Fall 87	9.2	19.6	65.1	2.4	3.8
	Spring 88	5.9	16.3	46.1	13.3	18.4
	Spring 89	14.3	38.6	23.2	12.5	11.4
	Fall 89	10.6	19.2	8.7	56.0	5.5

TABLE 8-19. FLIGHT ALTITUDES OBSERVED FROM THE NORTH OBSERVATION STATION BY TRANSECT DURING DAYLIGHT HOURS AT THE AMHERST TRANSMIT STUDY AREA

Species Group	Season	Flight Altitude (Percentage <150 Ft AGL)[1]				
		North	South	Overhead	West	East
Waterfowl	Fall 87	3.2	0.3	9.8	2.0	0.4
	Spring 88	5.4	1.2	2.5	0.9	0.3
	Spring 89	5.1	65.1	54.3	93.7	99.4
	Fall 89	8.4	31.7	1.0	17.3	10.7
-Ducks	Fall 87	3.9	0.4	0.7	0.7	0.3
	Spring 88	12.5	18.8	18.5	5.0	5.7
	Spring 89	36.3	63.8	60.3	77.8	87.8
	Fall 89	16.5	19.2	1.6	17.5	17.7
-Geese/Cormorants	Fall 87	0.0	0.0	36.2	2.0	0.8
	Spring 88	0.8	0.6	2.2	0.9	0.2
	Spring 89	4.9	65.1	54.2	93.9	99.5
	Fall 89	3.1	24.4	0.0	16.3	1.1
-Swans	Fall 87	26.2	20.7	33.6	5.1	5.3
	Spring 88	100.0	100.0	---	100.0	0.0
	Spring 89	---	84.2	0.0	---	---
	Fall 89	100.0	16.1	100.0	33.6	33.6
Raptors	Fall 87	62.5	38.7	80.6	56.6	23.6
	Spring 88	100.0	100.0	100.0	100.0	80.0
	Spring 89	90.6	80.3	76.2	84.6	93.8
	Fall 89	81.5	66.9	23.5	54.0	58.0
Shorebirds	Fall 87	---	100.0	71.4	---	100.0
	Spring 88	---	100.0	100.0	100.0	100.0
	Spring 89	97.8	88.4	84.6	95.3	98.2
	Fall 89	100.0	38.5	100.0	77.8	84.6
Waterbirds	Fall 87	---	100.0	100.0	25.0	100.0
	Spring 88	62.2	87.5	77.8	95.7	0.0
	Spring 89	95.8	82.3	72.0	89.1	100.0
	Fall 89	56.7	48.9	100.0	64.5	53.1
Passerines	Fall 87	45.1	30.4	32.6	67.0	80.5
	Spring 88	91.7	100.0	76.9	7.4	92.0
	Spring 89	97.2	96.4	97.9	99.2	98.1
	Fall 89	69.7	88.7	64.9	43.9	80.8

1. Fall 1987 and Spring 1988 less than 100 feet agl.

TABLE 8-20. FLIGHT CORRIDORS OBSERVED FROM THE SOUTH OBSERVATION STATION DURING DAYLIGHT HOURS AT THE AMHERST TRANSMIT STUDY AREA

Species Group	Season	Percentage of Birds Crossing Transect				
		North	South	Overhead	West	East
Waterfowl	Spring 89	26.4	9.6	11.9	32.1	20.0
	Fall 89	30.7	21.8	8.4	25.6	13.4
-Ducks	Spring 89	19.2	6.2	8.1	49.6	16.9
	Fall 89	44.2	11.4	4.6	30.9	8.9
-Geese/Cormorants	Spring 89	27.2	10.0	12.3	30.1	20.4
	Fall 89	26.0	19.4	11.3	26.2	17.0
-Swans	Spring 89	33.0	0.0	0.0	61.0	6.0
	Fall 89	29.7	4.2	18.2	22.4	25.5
Raptors	Spring 89	15.2	13.0	10.5	23.8	37.5
	Fall 89	26.6	26.5	1.6	20.4	25.0
Shorebirds	Spring 89	12.5	15.2	7.4	40.4	24.6
	Fall 89	43.9	7.0	1.9	35.4	11.9
Waterbirds	Spring 89	8.4	9.7	26.3	40.9	14.6
	Fall 89	24.8	10.5	1.3	29.5	34.0
Passerines	Spring 89	9.9	28.6	21.6	17.8	22.1
	Fall 89	15.0	25.6	5.4	25.2	28.9

TABLE 8-21. FLIGHT ALTITUDES OBSERVED FROM THE SOUTH OBSERVATION STATION BY TRANSECT DURING DAYLIGHT HOURS AT THE AMHERST TRANSMIT STUDY AREA

Species Group	Season	Flight Altitude (Percentage <150 Ft AGL)				
		North	South	Overhead	West	East
Waterfowl	Spring 89	90.6	45.0	60.5	86.4	58.6
	Fall 89	51.0	36.8	6.8	27.7	13.2
-Ducks	Spring 89	96.7	95.7	67.1	97.8	94.4
	Fall 89	59.0	31.9	2.1	34.1	28.3
-Geese/Cormorants	Spring 89	90.1	41.6	60.0	84.3	55.5
	Fall 89	52.2	45.0	7.3	30.7	12.0
-Swans	Spring 89	100.0	---	---	73.8	100.0
	Fall 89	49.7	68.2	0.0	49.6	60.9
Raptors	Spring 89	92.9	97.2	89.7	89.4	80.8
	Fall 89	82.0	80.8	6.3	63.6	69.1
Shorebirds	Spring 89	90.2	98.7	93.1	95.6	98.8
	Fall 89	94.4	76.0	81.5	67.3	69.4
Waterbirds	Spring 89	73.9	75.1	22.1	97.7	78.6
	Fall 89	68.3	44.6	7.5	69.8	79.5
Passerines	Spring 89	77.3	50.7	98.7	88.4	85.9
	Fall 89	90.8	84.4	88.2	95.0	88.8

North and west were the two most commonly crossed transects at the South station for ducks, geese/cormorants, swans (and all waterfowl), shorebirds and waterbirds in both spring and fall. Passerines and raptors did not exhibit any obvious trends during either season (Table 8-20). This shows the strong influence this flooded area had on bird movement patterns in the area of the South station. Much of this activity consisted of locally moving birds and flight altitudes were generally lowest for the west and north transects for ducks, geese/cormorants, and waterbirds, but not for shorebirds or swans (Table 8-21).

8.2.3.5.2 Nocturnal periods. More targets flew east of the North radar station than flew west of this location during both spring and fall (Table 8-22). Movements may have been influenced by Mary's Slough and a small north-south ridge which lie southeast and east, respectively, of the sampling location. At the South station, many more targets passed west of the radar unit in the spring, where the region of extensive flooding existed. This pattern was not observed in the fall, as the number of targets passing west and east of the South radar station was approximately equal (Table 8-22). The large flooded area to the west of the radar sampling site was largely dry in the fall, with water still existing more than a mile to the north and northwest of the station. Thus, the influence of this water area on nocturnal movement patterns was less evident in fall.

8.2.3.5.3 Time of day comparison. As indicated by long-range radar data, more targets passed east of the North radar station during nocturnal hours in both spring and fall while equal numbers of targets passed east and west of the radar station during daylight hours in the spring and more targets passed west of the station during daylight hours in the fall (Table 8-22).

At the South station, more targets passed west of the radar unit during both daylight and nocturnal hours in the spring. However, more targets passed east of the radar unit during both daylight and nocturnal hours in the fall (Table 8-22).

TABLE 8-22. MIGRATION CORRIDORS DURING NOCTURNAL AND DIURNAL HOURS AT THE AMHERST TRANSMIT STUDY AREA AS MEASURED BY LONG-RANGE RADAR

	Number of Targets (Percentage)			
	West of Radar Unit		East of Radar Unit	
	Day	Night	Day	Night
NORTH STATION				
Spring 1989	477 (49)	626 (43)	487 (51)	823 (57)
Fall 1989	111 (54)	1233 (42)	95 (46)	1676 (58)
SOUTH STATION				
Spring 1989	1320 (61)	1884 (62)	862 (39)	1155 (38)
Fall 1989	272 (41)	1495 (47)	400 (59)	1673 (53)

8.2.3.6 Flock Size

8.2.3.6.1 Daylight periods. Table 8-23 lists the mean and maximum flock sizes by species group for birds observed at each station. In general, mean flock sizes were higher for all species groups in the fall than in the spring except for geese/cormorants (and all waterfowl) and sandhill cranes. Mean flock sizes for geese/cormorants (and all waterfowl) were higher in the spring and mean flock sizes for sandhill cranes were similar between seasons (Table 8-23).

Mean flock sizes were higher at the North station for all waterfowl, ducks, swans, and blackbirds and higher at the South station for raptors, shorebirds, sandhill cranes, waterbirds, gamebirds, and nonblackbird passerines. Mean flock sizes of geese/cormorants were similar between stations (Table 8-23).

8.2.3.7 Tower Collision Assessment Study. Relatively few dead birds were located during the collision assessment study at two towers in the vicinity of the Amherst study area (Fig. 8-10; Table 8-24). Passerines were the most common collision victims, followed by waterbirds (mostly rails and coots), shorebirds and ducks. One gamebird was also found. Since all of these

TABLE 8-23. MEAN AND MAXIMUM FLOCK SIZES OBSERVED FROM OBSERVATION STATIONS DURING DAYLIGHT HOURS AT THE AMHERST TRANSMIT STUDY AREA

Species Group	Season	Flock Size			
		North Station		South Station	
		Mean	Maximum	Mean	Maximum
Waterfowl	Fall 87	417.7	30000	----	----
	Spring 88	499.8	26000	----	----
	Spring 89	608.1	150000	406.9	300000
	Fall 89	413.3	18000	298.5	18000
	Total	474.4	150000	368.0	300000
-Ducks	Fall 87	262.5	20000	----	----
	Spring 88	16.0	150	----	----
	Spring 89	15.3	1200	23.6	15000
	Fall 89	312.5	6500	117.0	3120
	Total	182.1	20000	44.8	15000
-Geese/Cormorants	Fall 87	625.5	20000	----	----
	Spring 88	657.2	26000	----	----
	Spring 89	1677.7	150000	1243.7	300000
	Fall 89	436.8	18000	420.2	18000
	Total	875.6	150000	863.8	300000
-Swans	Fall 87	14.9	64	----	----
	Spring 88	8.3	19	----	----
	Spring 89	6.0	11	4.3	10
	Fall 89	14.6	60	10.7	80
	Total	14.1	64	8.6	80
Raptors	Fall 87	1.4	100	----	----
	Spring 88	1.1	2	----	----
	Spring 89	1.1	3	1.3	15
	Fall 89	1.3	50	1.6	80
	Total	1.3	100	1.5	80
-Eagles/Hawks	Fall 87	1.6	100	----	----
	Spring 88	1.2	2	----	----
	Spring 89	1.1	3	1.3	9
	Fall 89	1.3	50	1.8	80
	Total	1.4	100	1.7	80

TABLE 8-23 (Continued). MEAN AND MAXIMUM FLOCK SIZES OBSERVED FROM OBSERVATION STATIONS DURING DAYLIGHT HOURS AT THE AMHERST TRANSMIT STUDY AREA

Species Group	Season	Flock Size			
		North Station		South Station	
		Mean	Maximum	Mean	Maximum
-Harriers	Fall 87	1.1	4	----	----
	Spring 88	1.0	1	----	----
	Spring 89	1.2	3	1.0	1
	Fall 89	1.0	2	1.1	4
	Total	1.1	4	1.0	4
-Falcons	Fall 87	1.4	3	----	----
	Spring 88	0.0	0	----	----
	Spring 89	1.1	2	1.1	2
	Fall 89	1.3	14	1.1	3
	Total	1.3	14	1.1	3
-Owls	Fall 87	1.4	3	----	----
	Spring 88	0.0	0	----	----
	Spring 89	0.0	0	2.0	2
	Fall 89	1.0	1	1.0	1
	Total	1.3	3	1.3	2
Shorebirds	Fall 87	2.2	6	----	----
	Spring 88	1.8	4	----	----
	Spring 89	2.7	33	6.8	70
	Fall 89	2.8	15	13.1	170
	Total	2.6	33	10.1	170
Sandhill cranes	Fall 87	11.3	14	----	----
	Spring 88	3.0	3	----	----
	Spring 89	17.5	55	18.9	78
	Fall 89	0.0	0	17.9	65
	Total	15.5	55	18.6	78
Waterbirds	Fall 87	1.9	18	----	----
	Spring 88	5.6	18	----	----
	Spring 89	7.8	190	23.5	5000
	Fall 89	32.6	350	137.2	3500
	Total	16.0	350	58.9	5000

TABLE 8-23 (Continued). MEAN AND MAXIMUM FLOCK SIZES OBSERVED FROM OBSERVATION STATIONS DURING DAYLIGHT HOURS AT THE AMHERST TRANSMIT STUDY AREA

Species Group	Season	Flock Size			
		North Station		South Station	
		Mean	Maximum	Mean	Maximum
Gamebirds	Fall 87	2.8	11	----	----
	Spring 88	1.0	1	----	----
	Spring 89	1.2	2	2.2	3
	Fall 89	4.6	8	5.9	12
	Total	2.9	11	4.7	12
Passerines	Fall 87	147.3	100000	----	----
	Spring 88	5.7	80	----	----
	Spring 89	11.4	2300	24.5	2800
	Fall 89	70.9	50000	49.2	4500
	Total	84.1	100000	43.1	4500
-Blackbirds	Fall 87	363.7	100000	----	----
	Spring 88	5.4	80	----	----
	Spring 89	15.0	2300	20.4	2000
	Fall 89	266.1	50000	86.5	4000
	Total	197.1	100000	58.9	4000
-Nonblackbirds	Fall 87	22.4	5000	----	----
	Spring 88	1.6	2	----	----
	Spring 89	3.7	100	29.8	2800
	Fall 89	17.7	1500	34.0	1500
	Total	17.5	5000	33.3	2800

TABLE 8-24. RESULTS OF THE TOWER MORTALITY STUDIES - AMHERST TRANSMIT STUDY AREA

Tower Number	Location	Height (ft)	Guy Wires	Lights	Number of Surveys	Season	Number	Species Group
1	West of Britton, SD - AT&T Tower	308	NO	Flashing White Strobes	6	Spring 89	1	Duck
							2	Passerine
							3	Subtotal
					24	Fall 89	0	Subtotal
						Total	3	
2	Britton, SD - TV Tower	400	YES	Flashing Red	6	Spring 89	6	Waterbird
							7	Passerine
							1	Shorebird
							1	Gamebird
							1	Unknown
							16	Subtotal
					24	Fall 89	1	Duck
							4	Waterbird
							16	Passerine
							1	Shorebird
							22	Subtotal
						Total	38	

species groups, except gamebirds, migrate mostly at night, most, if not all, collisions probably occurred during nocturnal hours. Total numbers were similar between spring and fall, although sampling intensity was four times higher in the fall (Table 8-24). The vast majority of the collisions occurred at the taller, guyed tower, versus the shorter, unguyed tower.

Due to foraging by scavengers and to birds not found during searches because of obscuring vegetation or other reasons, these counts must be considered minimum counts, especially for passerines, as many birds may have been removed by scavengers before they were found during surveys or they may have been missed entirely during searches. Also, only a limited area was sampled, and collision victims falling outside of the surveyed area would not be located. The counts of passerines were probably most affected by scavenging activity, as the small body size of these birds allows scavengers to remove them whole; this has been observed to occur during these types of studies (ABR, 1988a). The remains of larger birds, such as swans or cranes, would most likely be located even if the carcass was scavenged, as enough bones and feathers would remain for location and identification.

Based upon these results, collisions with man-made objects occur for a wide variety of species groups in the Amherst area, with collision rates for passerines relatively higher than for other groups. Among larger-bodied birds, ducks, shorebirds, and especially rails and coots appear to be most at risk of collision mortality with man-made structures.

8.2.3.8 Avian Concentration Areas. The Amherst study area region was divided into 5 aerial survey units for comparison of bird distribution patterns (Fig. 8-8). These distribution patterns are shown on Figures 8-52, 8-53, and 8-54 for five species groups. On these figures, the black shading represents birds observed on transects while the cross-hatching represents birds observed while circling wetland complexes. Major wetland complexes included Hyatt's Slough (Unit 5), Mary's Slough (Unit 4), Renzienhausen Slough (Unit 3), and the South Slough (Unit 1) (Fig. 8-8). The North Concentrated Study Area is contained within Unit 4 and the South Concentrated Study Area is located within Unit 2.

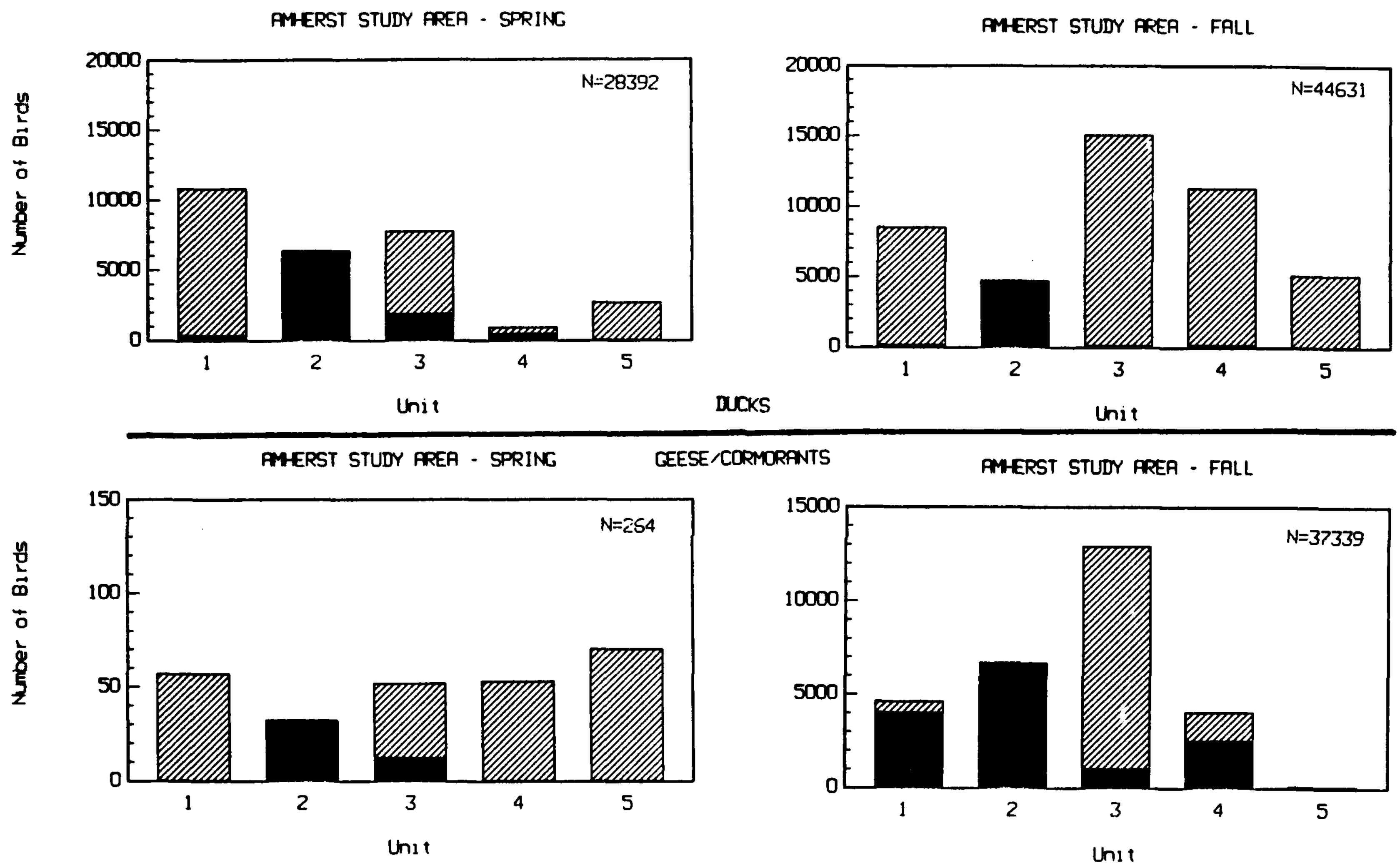


FIGURE 8-52. AMHERST, SD TRANSMIT STUDY AREA DUCK AND GOOSE/CORMORANT DISTRIBUTION PATTERNS AERIAL SURVEYS

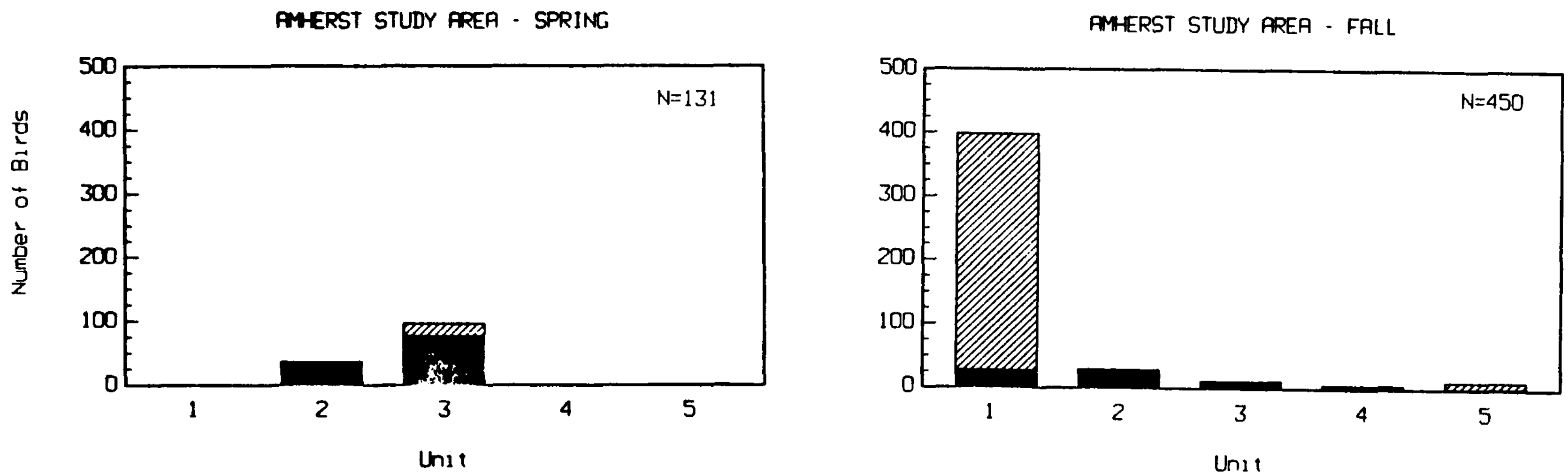


FIGURE 8-53. AMHERST, SD TRANSMIT STUDY AREA SHOREBIRD DISTRIBUTION PATTERNS - AERIAL SURVEYS

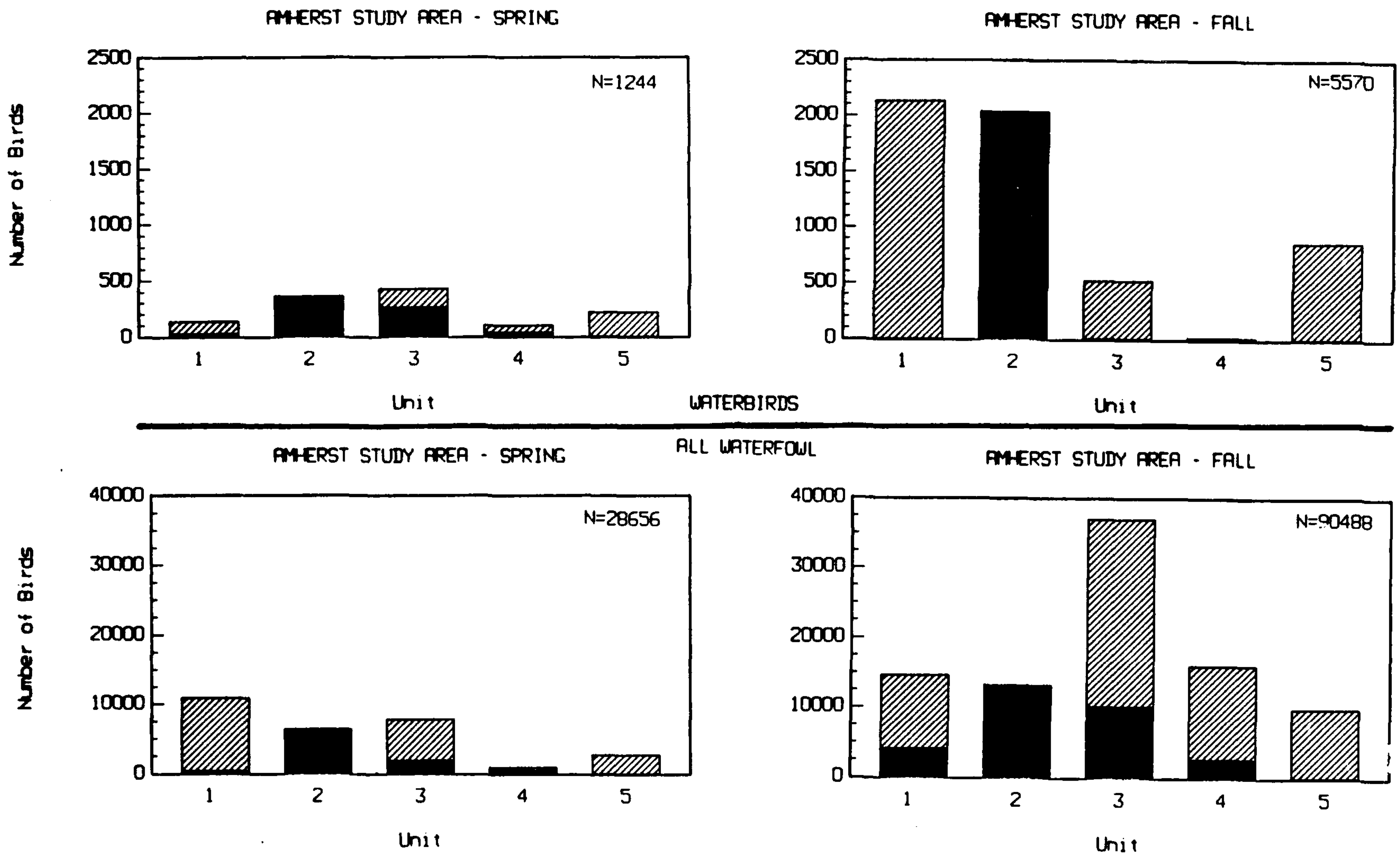


FIGURE 8-54. AMHERST, SD TRANSMIT STUDY AREA WATERFOWL AND WATERBIRD DISTRIBUTION PATTERNS AERIAL SURVEYS

The percentage of ducks using each aerial survey unit was highest in Unit 1 in spring and in Unit 3 in the fall. Duck use was lowest in Unit 4 in spring and in Unit 2 in the fall (Fig. 8-52). Reduced amounts of water in temporarily flooded areas in Unit 2 probably resulted in its lower use in the fall; this unit contains no major, permanent wetland.

Relatively few geese and cormorants were observed during aerial surveys in the spring. Use was reasonably uniform over all survey units during this season (Fig. 8-52). In the fall, significant numbers, mostly geese, were observed in all units except Unit 5. Unit 3 had the most use, and the majority of the use within this unit was at Renzienhausen Slough (Fig. 8-52).

In the spring, shorebirds were only observed in Units 2 and 3, with numbers higher in Unit 3. In the fall, Unit 1 received a disproportionate amount of the total use, with most shorebirds observed in the vicinity of the South Slough (Fig. 8-53).

Waterbird use was relatively uniform over all aerial survey units in the spring. During fall, Units 1 and 2 received the highest levels of use, while Unit 4 received the least use (Fig. 8-54).

Total waterfowl use was highest in Units 1 and 3 in the spring and lowest in Unit 4 during this season. Waterfowl numbers were highest in Unit 3 in the fall; the other four units received about equal levels of use during this season (Fig. 8-54).

Results from the road surveys were also compiled using the same units as for the aerial surveys (Fig. 8-8), except that Unit 5 was not sampled during road surveys. Because a different number of road survey stations were contained within each unit, numbers were weighted to compensate for differing sampling intensity. Thus, the numbers should only be used relative to each other; they are not the actual numbers observed.

During road surveys, ducks were most common in Units 2 and 3 in the spring and in Unit 4 in the fall. Goose/cormorant use was highest in Unit 4 in spring and relatively uniform among units in the fall. Of the few swans observed, most occurred in Unit 2 in spring and in Units 3 and 4 in the fall. Total waterfowl use was highest in Units 2 and 3 in the spring and highest in Unit 4 in the fall (Table 8-25).

Waterbirds were most commonly observed in Units 2 and 3 in the spring and in Unit 4 in the fall while shorebirds were most common in Unit 3 in the spring and in Unit 2 in the fall. Raptor use was relatively uniform over all units in the spring but highest in Unit 1 in the fall. Gamebirds were most common in Units 2 and 4 in the spring and in Unit 2 in the fall (Table 8-25).

Blackbirds and all passerines were most common in Unit 4 during both spring and fall. Use by nonblackbird passerines was relatively uniform in the spring but highest in Unit 1 in the fall (Table 8-25).

8.2.3.9 Breeding Bird Populations. Two greater prairie-chicken leks and one sharp-tailed grouse lek were located within the Amherst study area. One grouse (ST1) lek and one chicken (PC1) lek were within the North Concentrated Study Area (CSA) while the second chicken lek (PC2) was located just north of the North CSA (Fig. 8-55). Use of these leks is summarized in Table 8-26. Based upon habitat preferences and habitat present, these species are likely to nest only with the North CSA.

No raptor or waterfowl nests were discovered during spring aerial surveys. These species groups are likely to breed within the Amherst study area and low to moderate numbers are likely to breed within each CSA, based upon habitat present. Dabbling duck breeding densities would most likely be higher in the North CSA than in the South CSA during most years, as the North CSA contains a higher proportion of seasonal and semi-permanent wetlands and suitable upland areas (Technical Studies 5 and 6) commonly used by some species of dabbling ducks. Nesting by other waterfowl species (diving ducks, geese, and swans) is considered unlikely within either CSA during most years. Ground nesting raptors (e.g. northern harriers, short-eared owls) would also likely nest at higher densities at the North CSA, based upon habitat preferences. Woodland raptors require wooded areas to nest, and these areas are not common in either CSA (Technical Study 5).

TABLE 8-25. WEIGHTED NUMBER OF BIRDS OBSERVED DURING ROAD SURVEYS BY UNIT AT THE AMHERST TRANSMIT STUDY AREA

Species Group	Season	Weighted Number of Birds[1]			
		Unit 1	Unit 2	Unit 3	Unit 4
Waterfowl	Spring 89	1442	6191	5638	3871
	Fall 89	13537	23834	18819	31874
-Ducks	Spring 89	1066	4837	4896	935
	Fall 89	634	2863	3031	4848
-Geese/ Cormorants	Spring 89	376	1304	735	2935
	Fall 89	10429	11637	14174	15756
-Swans	Spring 89	0	19	0	0
	Fall 89	0	1	4	3
Waterbirds	Spring 89	221	773	730	319
	Fall 89	90	615	168	753
Shorebirds	Spring 89	223	167	363	162
	Fall 89	61	194	77	124
Raptors	Spring 89	11	15	13	10
	Fall 89	72	51	54	26
Gamebirds	Spring 89	7	11	5	14
	Fall 89	6	16	2	6
Passerines	Spring 89	1633	1994	1679	2707
	Fall 89	11710	7793	12366	15419
-Blackbirds	Spring 89	1175	1556	1153	2349
	Fall 89	5612	3596	9885	10809
-Nonblack-birds	Spring 89	456	435	524	358
	Fall 89	5044	3948	2279	4525

1. Numbers are weighted by sampling intensity and do not represent the actual number observed.

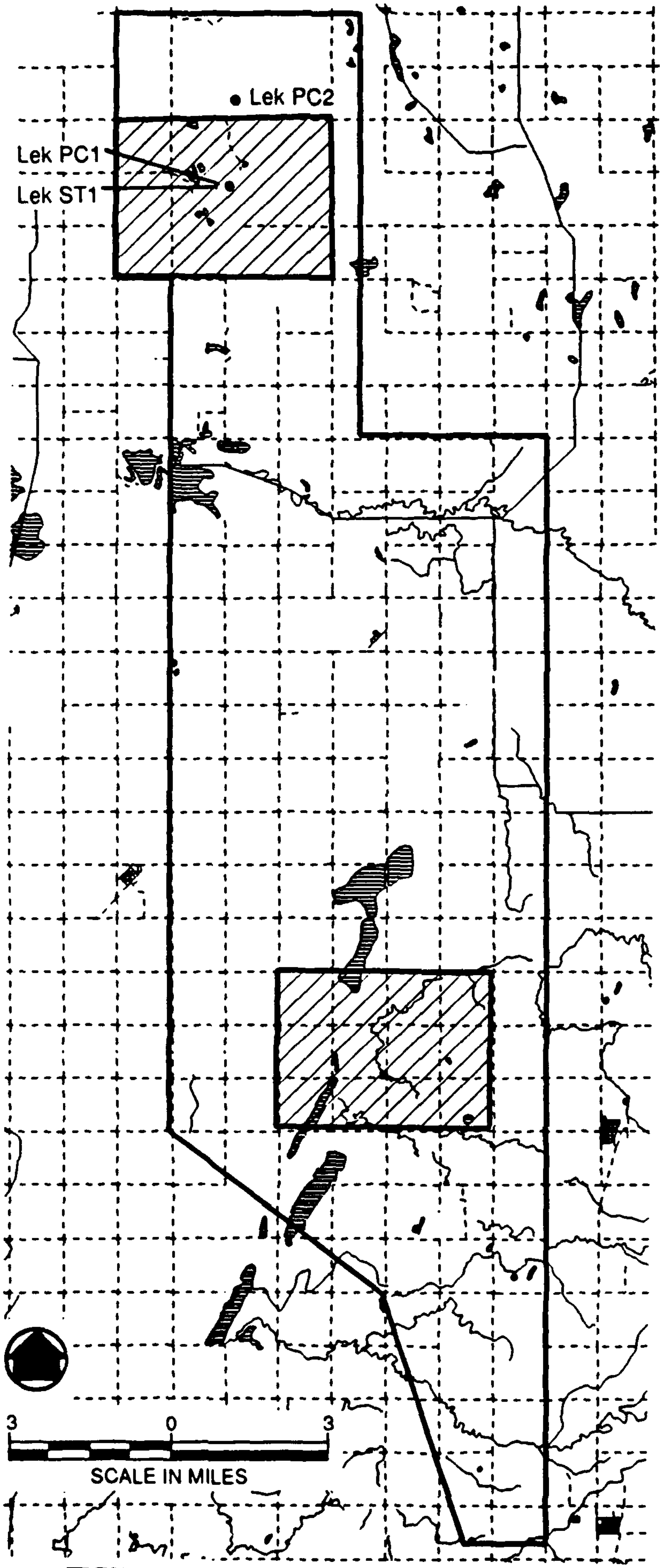


FIGURE 8-55. LOCATIONS OF SHARP-TAILED GROUSE AND GREATER PRAIRIE-CHICKEN LEKS WITHIN THE AMHERST, SD TRANSMIT STUDY AREA

TABLE 8-26. SUMMARY OF ACTIVITY AT SHARP-TAILED GROUSE AND GREATER PRAIRIE-CHICKEN LEK SITES WITHIN THE AMHERST TRANSMIT STUDY AREA

Lek[1]	Season	Maximum Number of Birds Observed		
		Total (Date)	Males	Females
GREATER PRAIRIE-CHICKEN				
PC1	Fall 87	6 (30 Sept)	-	-
	Spring 88	7 (31 Mar)	-	-
PC2	Spring 88	12 (2 Apr)	-	-
	Spring 89	9 (16 Apr)	3	6
SHARP-TAILED GROUSE				
ST1	Fall 87	12 (5 Nov)	-	-
	Spring 88	1 (1-7 Apr)	1	0

1. Locations of leks are shown on Figure 8-55.

Suitable habitat for some upland nesting shorebirds (e.g. marbled godwit, killdeer) exists, especially within the North CSA. Waterbird nesting densities are probably low within both CSAs in most years and sandhill cranes are not likely to nest within either CSA, based upon habitat present.

Because the USAF did not have right-of-entry through most of the study area, no breeding bird censuses could be conducted at either CSA to determine passerine breeding densities. Average total breeding densities of 0.58 pairs per acre have been reported for passerines nesting in native grassland habitat in Jamestown, ND (Kannowski, 1979). It is likely that breeding passerine densities would be higher at the North CSA, which is mostly grassland, than at the South CSA, which is mostly cultivated (Technical Study 5).

8.2.4 Receive Study Area

8.2.4.1 Species Composition and Numbers. A total of 194 species of birds were identified at the Thief River Falls receive study area during all studies combined, 164 during the spring season and 164 during the fall season (Appendix A). More species (106) were observed from the East station, followed by the Goose Lake station (100), the West station (96), and the Central station (73) (Table 8-27). The Central station, however, was only sampled during three of the four study seasons, which may account for its lower number of species.

TABLE 8-27. NUMBER OF SPECIES IDENTIFIED AT EACH OBSERVATION STATION BY SEASON AT THE THIEF RIVER FALLS RECEIVE STUDY AREA

Season	Station			
	West	Central	East	Goose Lake
Fall 1987	32	32	37	41
Spring 1988	17	8	17	25
Spring 1989	75	--	71	67
Fall 1989	67	72	80	72
Total Species (All Seasons)	96	73	106	100

Table 8-28 shows the number of birds observed during daylight hours from each observation station for each of the four seasons studied. As for Amherst, these numbers have been standardized to birds per observation hour for comparisons. Since a certain proportion of observed bird movements were local in nature, it is possible that individual birds were counted more than one time. No effort was made to control for these local birds in the analyses, however, field observers tried to avoid the double counting of birds during each individual observation session.

At the West station, the observed numbers of ducks, swans, geese/cormorants, waterbirds, and passerines were higher in spring and the number of raptors,

TABLE 8-28. NUMBER OF BIRDS OBSERVED FROM OBSERVATION STATIONS DURING DAYLIGHT HOURS AT THE THIEF RIVER FALLS RECEIVE STUDY AREA

Species Group	Season	Number of Birds (Birds per Hour)			
		West Station	Central Station	East Station	Goose Lake
Waterfowl	Fall 87	4566 (19.53)	7776 (34.24)	12269 (57.39)	11344 (79.33)
	Spring 88	127 (4.84)	166 (10.94)	453 (25.17)	3995 (179.55)
	Spring 89	95951 (100.37)	--- (----)	49215 (50.35)	7014 (20.75)
	Fall 89	25817 (33.48)	22850 (29.68)	31529 (40.94)	42692 (185.70)
-Ducks	Fall 87	39 (0.17)	787 (3.47)	790 (3.70)	6779 (47.41)
	Spring 88	14 (0.53)	1 (0.07)	248 (13.78)	3132 (140.76)
	Spring 89	10848 (11.35)	--- (----)	8887 (9.09)	2039 (6.03)
	Fall 89	484 (0.63)	1031 (1.34)	996 (1.29)	33913 (147.51)
-Geese/Cormorants	Fall 87	4500 (19.24)	6460 (28.44)	11178 (52.28)	3654 (25.55)
	Spring 88	113 (4.30)	165 (10.88)	200 (11.11)	759 (34.11)
	Spring 89	81947 (85.72)	--- (----)	39230 (40.13)	4887 (14.46)
	Fall 89	24334 (31.56)	21131 (27.45)	30163 (39.17)	8414 (36.60)
-Swans	Fall 87	2 (0.01)	0 (0.00)	0 (0.00)	0 (0.00)
	Spring 88	0 (0.00)	0 (0.00)	0 (0.00)	34 (1.53)
	Spring 89	1698 (1.78)	--- (----)	543 (0.56)	64 (0.19)
	Fall 89	531 (0.69)	236 (0.31)	298 (0.39)	74 (0.32)
Raptors	Fall 87	191 (0.82)	261 (1.15)	115 (0.54)	156 (1.09)
	Spring 88	23 (0.88)	11 (0.73)	11 (0.61)	32 (1.44)
	Spring 89	377 (0.39)	--- (----)	349 (0.36)	105 (0.31)
	Fall 89	701 (0.91)	747 (0.97)	620 (0.81)	291 (1.27)
-Eagles/Hawks	Fall 87	70 (0.30)	120 (0.53)	46 (0.22)	68 (0.48)
	Spring 88	6 (0.23)	2 (0.13)	1 (0.06)	7 (0.31)
	Spring 89	149 (0.16)	--- (----)	160 (0.16)	12 (0.04)
	Fall 89	291 (0.38)	380 (0.49)	312 (0.41)	72 (0.31)
-Harriers	Fall 87	85 (0.36)	93 (0.41)	22 (0.10)	67 (0.47)
	Spring 88	11 (0.42)	6 (0.40)	8 (0.44)	23 (1.03)
	Spring 89	88 (0.09)	--- (----)	92 (0.09)	71 (0.21)
	Fall 89	328 (0.43)	242 (0.31)	156 (0.20)	183 (0.80)

TABLE 8-28 (Continued). NUMBER OF BIRDS OBSERVED FROM OBSERVATION STATIONS DURING DAYLIGHT HOURS AT THE THIEF RIVER FALLS RECEIVE STUDY AREA

Species Group	Season	Number of Birds (Birds per Hour) West Station	Central Station	East Station	Goose Lake
-Falcons	Fall 87	15 (0.06)	15 (0.07)	15 (0.07)	3 (0.02)
	Spring 88	4 (0.15)	3 (0.20)	1 (0.06)	2 (0.09)
	Spring 89	42 (0.04)	--- (----)	43 (0.04)	2 (0.01)
	Fall 89	53 (0.07)	84 (0.11)	67 (0.09)	15 (0.07)
-Owls	Fall 87	1 (<0.01)	1 (<0.01)	2 (0.01)	2 (0.01)
	Spring 88	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
	Spring 89	2 (<0.01)	--- (----)	1 (<0.01)	3 (0.01)
	Fall 89	6 (0.01)	3 (<0.01)	1 (<0.01)	9 (0.04)
Shorebirds	Fall 87	223 (0.95)	77 (0.34)	270 (1.26)	175 (1.22)
	Spring 88	22 (0.84)	12 (0.79)	14 (0.78)	20 (0.90)
	Spring 89	561 (0.59)	--- (----)	628 (0.64)	262 (0.78)
	Fall 89	1781 (2.31)	1677 (2.18)	857 (1.11)	764 (3.32)
Sandhill cranes	Fall 87	56 (0.24)	249 (1.10)	87 (0.41)	1803 (12.61)
	Spring 88	5 (0.19)	64 (4.22)	114 (6.33)	667 (29.98)
	Spring 89	2386 (2.50)	--- (----)	3853 (3.94)	564 (1.67)
	Fall 89	1547 (2.01)	2225 (2.89)	1318 (1.71)	712 (3.10)
Waterbirds	Fall 87	1 (<0.01)	2 (0.01)	2 (0.01)	38 (0.27)
	Spring 88	3 (0.11)	0 (0.00)	11 (0.61)	4 (0.18)
	Spring 89	5892 (6.16)	--- (----)	7814 (7.99)	1189 (3.52)
	Fall 89	2186 (2.84)	2273 (2.95)	3540 (4.60)	1476 (6.42)
Gamebirds	Fall 87	14 (0.06)	14 (0.06)	18 (0.08)	6 (0.04)
	Spring 88	0 (0.00)	0 (0.00)	0 (0.00)	2 (0.09)
	Spring 89	10 (0.01)	--- (----)	59 (0.06)	2 (0.01)
	Fall 89	171 (0.22)	305 (0.40)	243 (0.32)	18 (0.08)
Passerines	Fall 87	7580 (32.41)	18856 (83.03)	4592 (21.48)	16315 (114.10)
	Spring 88	1650 (62.86)	1395 (91.96)	845 (46.94)	3750 (168.54)
	Spring 89	62957 (65.85)	--- (----)	125850 (128.75)	41598 (123.07)
	Fall 89	33142 (42.99)	34070 (44.25)	41463 (53.84)	114615 (498.54)

TABLE 8-28 (Continued). NUMBER OF BIRDS OBSERVED FROM OBSERVATION STATIONS DURING DAYLIGHT HOURS AT THE THIEF RIVER FALLS RECEIVE STUDY AREA

Species Group	Season	Number of Birds (Birds per Hour)			
		West Station	Central Station	East Station	Goose Lake
-Blackbirds	Fall 87	1579 (6.75)	11893 (52.37)	434 (2.03)	13131 (91.83)
	Spring 88	63 (2.40)	339 (22.35)	16 (0.89)	3544 (159.28)
	Spring 89	16352 (17.10)	--- (----)	7577 (7.75)	28157 (83.30)
	Fall 89	3437 (4.46)	11955 (15.53)	3676 (4.77)	75800 (329.71)
-Nonblackbirds	Fall 87	4532 (19.38)	4792 (21.10)	3222 (15.07)	2291 (16.02)
	Spring 88	702 (26.74)	908 (59.85)	248 (13.78)	108 (4.85)
	Spring 89	26672 (27.90)	--- (----)	112721 (115.32)	9835 (29.10)
	Fall 89	28386 (36.82)	19409 (25.21)	32536 (42.25)	28139 (122.40)
Total(1)	Fall 87	12633 (54.02)	27235 (119.92)	17353 (81.16)	29838 (208.67)
	Spring 88	1830 (69.71)	1648 (108.64)	1448 (80.44)	8470 (380.67)
	Spring 89	168552 (176.31)	--- (----)	188421 (192.76)	50941 (150.71)
	Fall 89	65443 (84.88)	64170 (83.35)	79678 (103.46)	160573 (698.45)

1. Includes unidentified birds.

shorebirds, and gamebirds were higher in fall. Sandhill crane numbers were similar between seasons. Geese/cormorants were most abundant in spring and passerines were most abundant in the fall (Table 8-28).

Ducks, swans, sandhill cranes, waterbirds, and passerines were more common in spring at the East station while geese/cormorants, raptors, shorebirds, and gamebirds were more common in fall. Passerines were most abundant during both spring and fall at the East station (Table 8-28).

Since the Central station was not sampled in spring 1989 and only sampled briefly in spring 1988, no seasonal trends in numbers could be obtained. Passerines were most abundant in fall at the Central station (Table 8-28).

At the Goose Lake station, sandhill cranes and swans were more numerous in spring while ducks, geese/cormorants, raptors, shorebirds, waterbirds, gamebirds, and passerines were more numerous in fall. Passerines were most abundant during both seasons (Table 8-28).

In general, more ducks, total waterfowl, sandhill cranes, shorebirds, raptors, and passerines were observed at the Goose Lake station during both spring and fall for seasons when all four stations were sampled. In addition, geese/cormorants were most abundant in spring and waterbirds were most abundant in fall at the Goose Lake station (Table 8-28). Geese/cormorants in fall, waterbirds in spring, and gamebirds in spring were most abundant at the East station. Swans were the only species group most common at the West station (during both seasons) while gamebirds in fall were the only species group most abundant at the Central station (Table 8-28).

8.2.4.2 Migration Chronology and Rates. Diurnal migration rates were calculated by dividing the total number of birds observed during daylight hours for each day's observation by the total number of daytime observation hours for that day. These are mean hourly migration rates (birds per hour) and not daily rates (birds per day). The following figures are not meant to imply a continuum of migration rates; continuous lines were used simply to show trends. Nocturnal rates were calculated in a similar manner and are expressed as targets per hour.

8.2.4.2.1 Daylight periods. At the Thief River Falls study area during the spring season, raptors were generally the first migrants observed, followed by geese, ducks, early waterbirds (mostly gulls and terns), swans, sandhill cranes, early passerines, blackbirds, cormorants, late passerines, then shorebirds and late waterbirds. Fall migration was more protracted but early passerines (e.g. swallows) were generally the first migrants observed leaving the Thief River Falls region, followed by blackbirds, raptors, shorebirds, sandhill cranes, waterbirds and cormorants, ducks, geese, late passerines (e.g. longspurs and buntings), and then swans.

Duck migration in spring, as seen from the observation stations, generally occurred during the first three weeks of April, with peak rates occurring in mid-April as open water became available (Table 8-29; Fig. 8-56), although low numbers of ducks were observed throughout the study period. The number of ducks observed during aerial surveys increased abruptly during mid-April, as ducks began to arrive, then declined quickly to relatively low levels by the first of May. Two smaller peaks were also observed during the first week of May and the first week of June (Fig. 8-58). Fall duck migration rates exhibited numerous sharp peaks from mid-September until the end of October at the Goose Lake station, a good proportion of which were probably local movements. Peak rates at the other stations generally occurred from mid-October through early November before declining as waterbodies began to freeze (Table 8-29; Fig. 8-56). Numbers of ducks observed during aerial surveys were relatively constant in September before peaking in early October. The number of ducks steadily declined through the first week of November, when open water became unavailable (Fig. 8-58).

Peak migration rates for ducks were generally higher in the fall at the Goose Lake station but higher in the spring at the East and West stations (Table 8-29; Fig. 8-56). Peak numbers of ducks observed during aerial surveys were over twice as high in the spring (Fig. 8-58). Peak rates during both seasons were generally highest at the Goose Lake station.

TABLE 8-29. PEAK DAILY MIGRATION RATES (BIRDS PER HOUR) OBSERVED FROM OBSERVATION STATIONS DURING DAYLIGHT HOURS AT THE THIEF RIVER FALLS RECEIVE STUDY AREA

Species Group	Season	Number of Birds (Birds per Hour)			
		West Station	Central Station	East Station	Goose Lake
Waterfowl	Fall 87	382.00 (2 Oct)	326.31 (9 Oct)	961.11 (27 Oct)	439.75 (16 Sept)
	Spring 88	22.89 (10 Apr)	82.50 (10 Apr)	65.20 (11 Apr)	687.43 (13 Apr)
	Spring 89	1489.43 (15 Apr)	---- (-----)	926.96 (7 Apr)	419.50 (17 Apr)
	Fall 89	423.51 (1 Nov)	403.86 (1 Nov)	349.00 (1 Nov)	1132.78 (26 Sept)
-Ducks	Fall 87	8.00 (12 Oct)	54.60 (17 Oct)	60.87 (6 Nov)	439.75 (16 Sept)
	Spring 88	4.50 (12 Apr)	0.67 (18 Apr)	61.00 (13 Apr)	354.86 (13 Apr)
	Spring 89	305.93 (14 Apr)	---- (-----)	239.63 (7 Apr)	83.00 (17 Apr)
	Fall 89	11.55 (1 Nov)	35.20 (29 Sept)	22.50 (21 Oct)	944.79 (7 Oct)
-Geese/Cormorants	Fall 87	382.00 (2 Oct)	326.31 (9 Oct)	938.89 (27 Oct)	149.25 (28 Sept)
	Spring 88	22.67 (10 Apr)	82.50 (10 Apr)	63.60 (11 Apr)	285.71 (13 Apr)
	Spring 89	1436.00 (15 Apr)	---- (-----)	673.48 (7 Apr)	335.00 (17 Apr)
	Fall 89	406.77 (1 Nov)	389.12 (1 Nov)	327.94 (1 Nov)	625.17 (26 Sept)
-Swans	Fall 87	0.67 (10 Oct)	0.00 (-----)	0.00 (-----)	0.00 (-----)
	Spring 88	0.00 (-----)	0.00 (-----)	0.00 (-----)	6.86 (13 Apr)
	Spring 89	20.64 (12 Apr)	---- (-----)	12.41 (18 Apr)	21.50 (19 Apr)
	Fall 89	21.26 (2 Nov)	21.99 (5 Nov)	20.34 (5 Nov)	20.14 (2 Nov)
Raptors	Fall 87	4.00 (16 Sept)	9.33 (20 Sept)	14.75 (19 Sept)	8.00 (22 Sept)
	Spring 88	3.43 (9 Apr)	1.50 (15 Apr)	1.50 (14 Apr)	5.00 (9 Apr)
	Spring 89	5.79 (12 Apr)	---- (-----)	1.85 (22 May)	1.50 (17 Apr)
	Fall 89	4.77 (6 Oct)	5.88 (25 Sept)	6.55 (7 Sept)	6.33 (17 Oct)
-Eagles/Hawks	Fall 87	1.75 (18 Oct)	7.33 (20 Sept)	5.53 (19 Sept)	8.00 (22 Sept)
	Spring 88	0.57 (15 Apr)	1.00 (11 Apr)	0.50 (14 Apr)	2.00 (9 Apr)
	Spring 89	3.10 (14 Apr)	---- (-----)	1.54 (22 May)	0.67 (28 May)
	Fall 89	4.17 (6 Oct)	4.59 (25 Sept)	2.70 (7 Sept)	3.67 (17 Oct)
-Harriers	Fall 87	2.00 (16 Sept)	2.75 (14 Oct)	0.80 (18 Sept)	2.52 (2 Oct)
	Spring 88	2.29 (9 Apr)	1.33 (16 Apr)	1.00 (14 Apr)	3.00 (9 Apr)
	Spring 89	0.83 (11 Apr)	---- (-----)	0.34 (12 Apr)	1.00 (18 Apr)
	Fall 89	1.39 (8 Oct)	0.82 (4 Oct)	0.98 (23 Oct)	3.00 (29 Sept)

TABLE 8-29 (Continued). PEAK DAILY MIGRATION RATES (BIRDS PER HOUR) OBSERVED FROM OBSERVATION STATIONS DURING DAYLIGHT HOURS AT THE THIEF RIVER FALLS RECEIVE STUDY AREA

Species Group	Season	Number of Birds (Birds per Hour)			
		West Station	Central Station	East Station	Goose Lake
-Falcons	Fall 87	1.00 (16 Sept)	0.67 (20 Sept)	2.76 (19 Sept)	0.47 (17 Sept)
	Spring 88	0.67 (10 Apr)	1.33 (9 Apr)	0.67 (9 Apr)	0.67 (15 Apr)
	Spring 89	0.36 (28 Mar)	---- (-----)	0.57 (26 Mar)	0.17 (20 Apr)
	Fall 89	0.50 (16 Sept)	1.69 (8 Sept)	2.08 (7 Sept)	1.01 (18 Sept)
-Owls	Fall 87	0.18 (14 Oct)	0.18 (23 Sept)	0.33 (9 Nov)	0.26 (20 Sept)
	Spring 88	0.00 (-----)	0.00 (-----)	0.00 (-----)	0.00 (-----)
	Spring 89	0.07 (20 Apr)	---- (-----)	0.07 (17 Apr)	0.50 (17 Apr)
	Fall 89	0.20 (23 Sept)	0.10 (3 Oct)	0.10 (24 Oct)	0.66 (14 Nov)
Shorebirds	Fall 87	10.95 (23 Sept)	5.71 (28 Sept)	16.00 (17 Sept)	14.81 (11 Oct)
	Spring 88	3.50 (19 Apr)	6.00 (16 Apr)	2.00 (13 Apr)	11.00 (9 Apr)
	Spring 89	4.59 (20 May)	---- (-----)	3.52 (18 Apr)	5.00 (17 May)
	Fall 89	110.80 (7 Oct)	42.99 (3 Oct)	10.55 (16 Sept)	41.39 (16 Sept)
Sandhill cranes	Fall 87	21.00 (8 Oct)	25.33 (21 Sept)	17.97 (19 Sept)	167.09 (20 Sept)
	Spring 88	2.86 (9 Apr)	28.00 (19 Apr)	45.50 (16 Apr)	172.40 (16 Apr)
	Spring 89	42.07 (21 Apr)	---- (-----)	62.21 (21 Apr)	17.83 (23 Apr)
	Fall 89	39.15 (30 Oct)	39.92 (30 Oct)	37.51 (29 Oct)	66.23 (18 Oct)
Waterbirds	Fall 87	0.14 (24 Sept)	0.20 (24 Sept)	0.40 (18 Sept)	7.07 (20 Oct)
	Spring 88	0.50 (14 Apr)	0.00 (-----)	2.00 (13 Apr)	0.57 (13 Apr)
	Spring 89	140.21 (17 Apr)	---- (-----)	147.41 (7 Apr)	52.83 (2 May)
	Fall 89	54.28 (1 Nov)	47.08 (1 Nov)	99.01 (14 Sept)	331.13 (14 Oct)
Gamebirds	Fall 87	4.09 (3 Nov)	2.15 (30 Oct)	18.00 (24 Oct)	0.64 (12 Oct)
	Spring 88	0.00 (-----)	0.00 (-----)	0.00 (-----)	0.57 (13 Apr)
	Spring 89	0.27 (3 June)	---- (-----)	1.72 (12 Apr)	0.50 (18 Apr)
	Fall 89	3.09 (22 Oct)	3.11 (25 Oct)	4.30 (12 Nov)	2.65 (10 Sept)
Passerines	Fall 87	226.00 (2 Oct)	394.50 (15 Oct)	83.43 (6 Oct)	796.30 (11 Oct)
	Spring 88	159.50 (18 Apr)	277.00 (15 Apr)	197.00 (10 Apr)	579.60 (16 Apr)
	Spring 89	904.28 (17 Apr)	---- (-----)	1991.20 (17 Apr)	1215.33 (27 Apr)
	Fall 89	302.80 (15 Nov)	132.30 (29 Oct)	429.86 (11 Nov)	3593.38 (7 Sept)

TABLE 8-29 (Continued). PEAK DAILY MIGRATION RATES (BIRDS PER HOUR) OBSERVED FROM OBSERVATION STATIONS DURING DAYLIGHT HOURS AT THE THIEF RIVER FALLS RECEIVE STUDY AREA

Species Group	Season	Number of Birds (Birds per Hour)			
		West Station	Central Station	East Station	Goose Lake
-Blackbirds	Fall 87	126.75 (19 Sept)	353.75 (15 Oct)	31.80 (19 Sept)	758.50 (13 Oct)
	Spring 88	27.00 (12 Apr)	66.67 (9 Apr)	4.50 (10 Apr)	579.60 (16 Apr)
	Spring 89	251.93 (20 Apr)	---- (-----)	117.20 (17 Apr)	419.67 (5 May)
	Fall 89	63.93 (5 Sept)	103.41 (10 Oct)	146.15 (7 Sept)	2533.11 (10 Sept)
-Nonblackbirds	Fall 87	225.60 (2 Oct)	143.25 (14 Oct)	50.00 (17 Sept)	81.45 (26 Sept)
	Spring 88	107.50 (18 Apr)	224.50 (15 Ap.·)	45.75 (15 Apr)	49.71 (13 Apr)
	Spring 89	196.08 (30 Apr)	---- (-----)	1852.33 (17 Apr)	861.00 (27 Apr)
	Fall 89	302.80 (15 Nov)	116.14 (13 Nov)	429.86 (11 Nov)	1722.52 (7 Sept)

Spring migration of geese was mainly confined to the second and third weeks of April. Cormorants migrated mostly during the last week of April and the first two weeks of May. Smaller peaks of geese and cormorants were also observed during the first week of June (Fig. 8-57). Numbers of geese observed during aerial surveys peaked sharply during mid-April with much smaller peaks of cormorants near the first of May and geese and cormorants during the first week of June (Fig. 8-58), in agreement with patterns seen during station observations (Fig. 8-57). Fall goose/cormorant migration was protracted with numerous peaks from mid-September until the first week of November (Fig. 8-57). Numbers of geese/cormorants observed during aerial surveys were generally constant from mid-September until early November (Fig. 8-58).

Peak migration rates for geese/cormorants were generally similar between seasons at the East and Goose Lake stations but were much higher during the spring season at the West station (Table 8-29; Fig. 8-57). Considerable flooding occurred around the West station in the spring of 1989, accounting for the higher rates observed in spring at this station. Peak numbers of geese and cormorants observed during aerial surveys were much higher in spring as well (Fig. 8-58). Peak rates were fairly uniform among stations in the fall but were highest at the West station in the spring (Table 8-29; Fig. 8-57).

In spring, swan migration occurred mainly during the second and third weeks of April (Fig. 8-59). Relatively few swans were observed during spring aerial surveys. Fall migration rates were low until the beginning of November when they peaked sharply, remaining at high levels through mid-November (Fig. 8-59). As in spring, few swans were observed during fall aerial surveys, suggesting that most swans migrated through the study area without stopping.

Peak migration rates for swans were similar between fall and spring migrations (Table 8-29; Fig. 8-59). Peak rates were also similar among stations during both spring and fall 1989 (Table 8-29; Fig. 8-59), although overall migration rates were highest at the West station (Table 8-28).

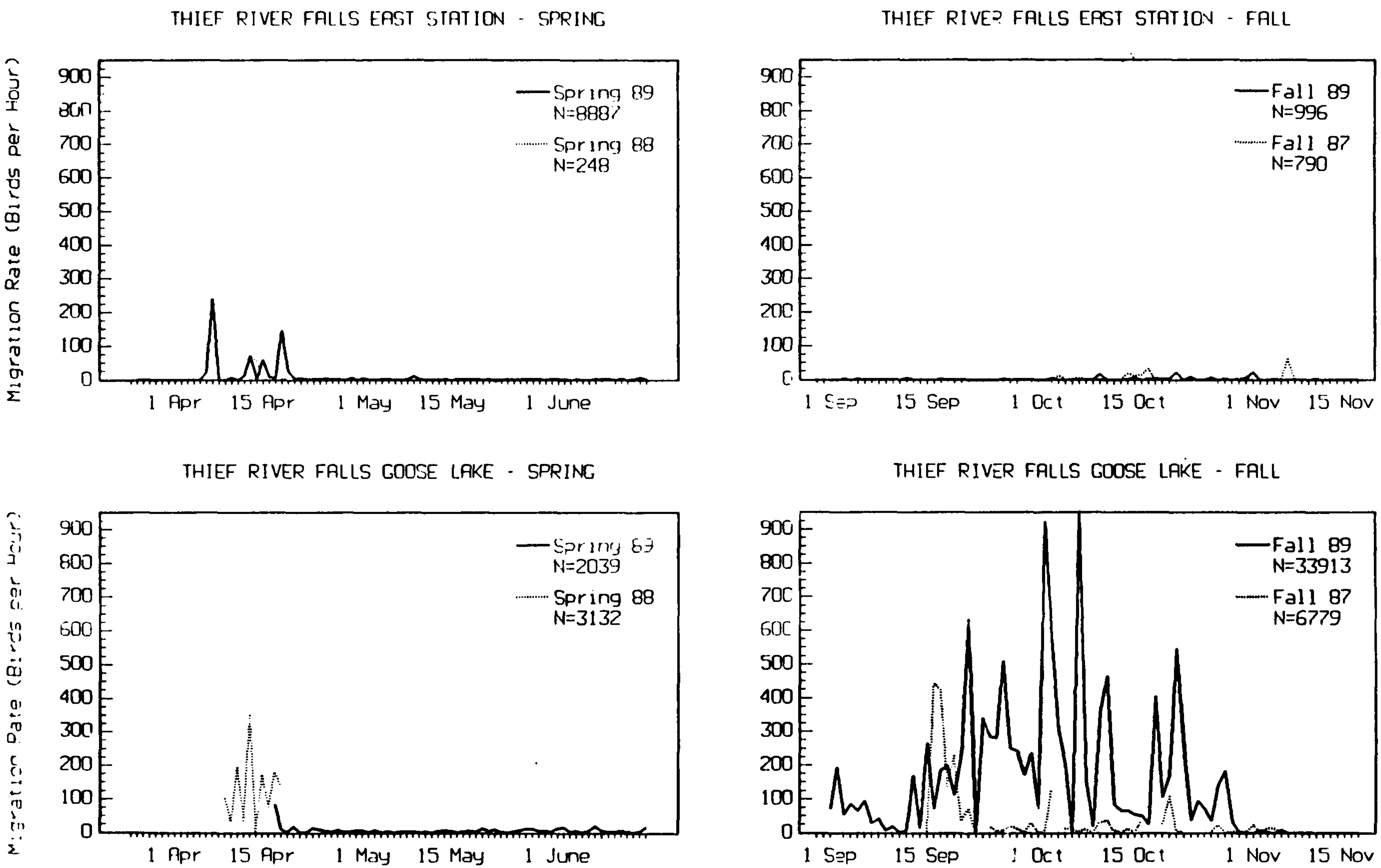
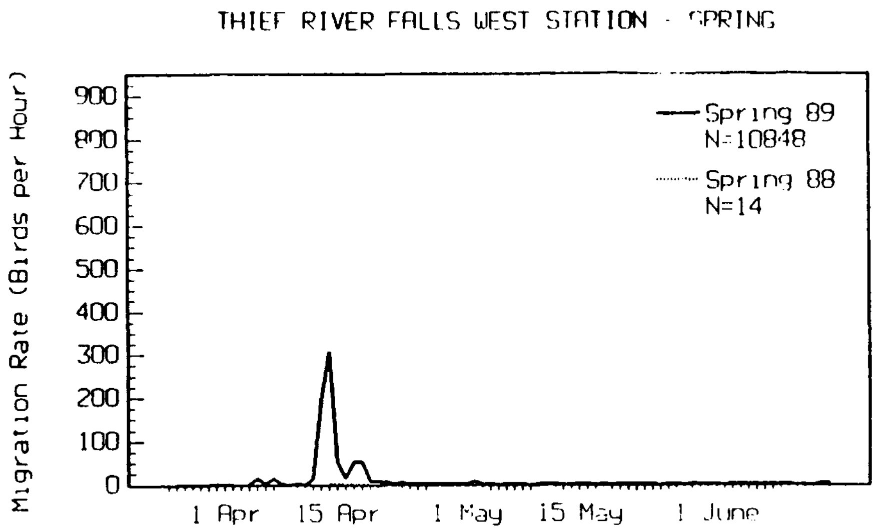
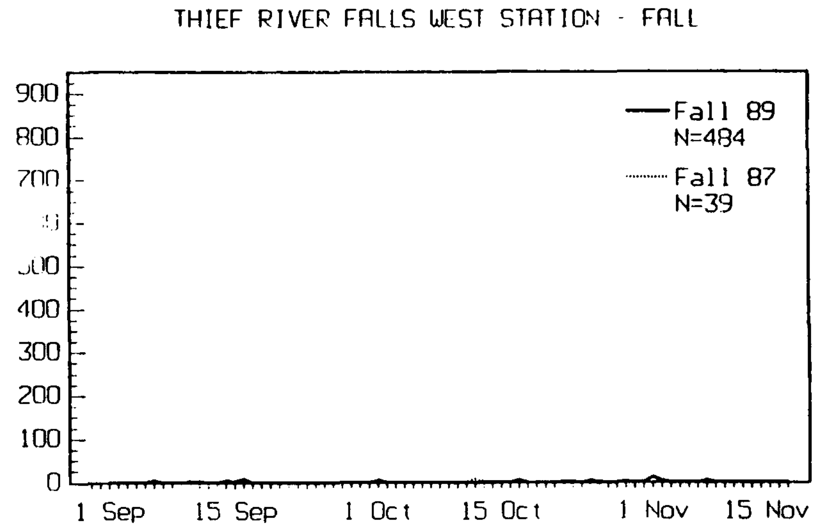


FIGURE 8-56. THIEF RIVER FALLS, MN RECEIVE STUDY AREA DIURNAL MIGRATION RATES - DUCKS





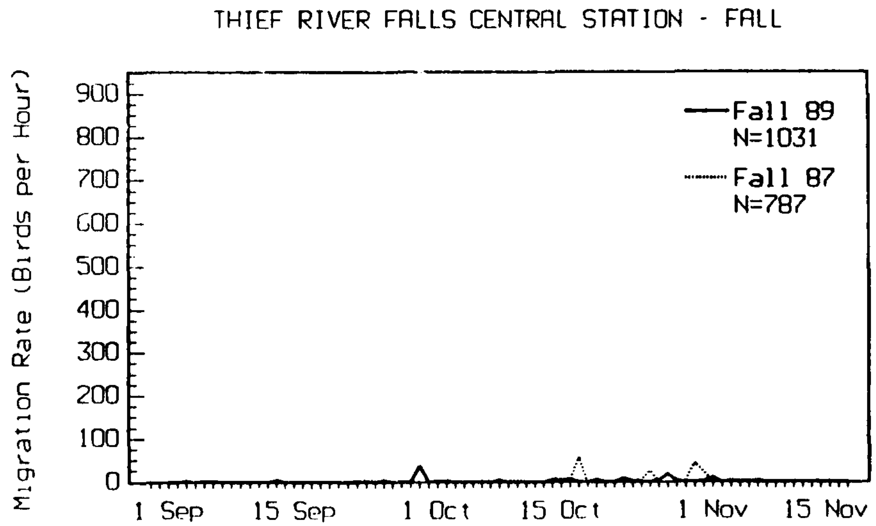


FIGURE 8-56. THIEF RIVER FALLS, MN RECEIVE STUDY AREA DIURNAL MIGRATION RATES - DUCKS (CONTINUED)

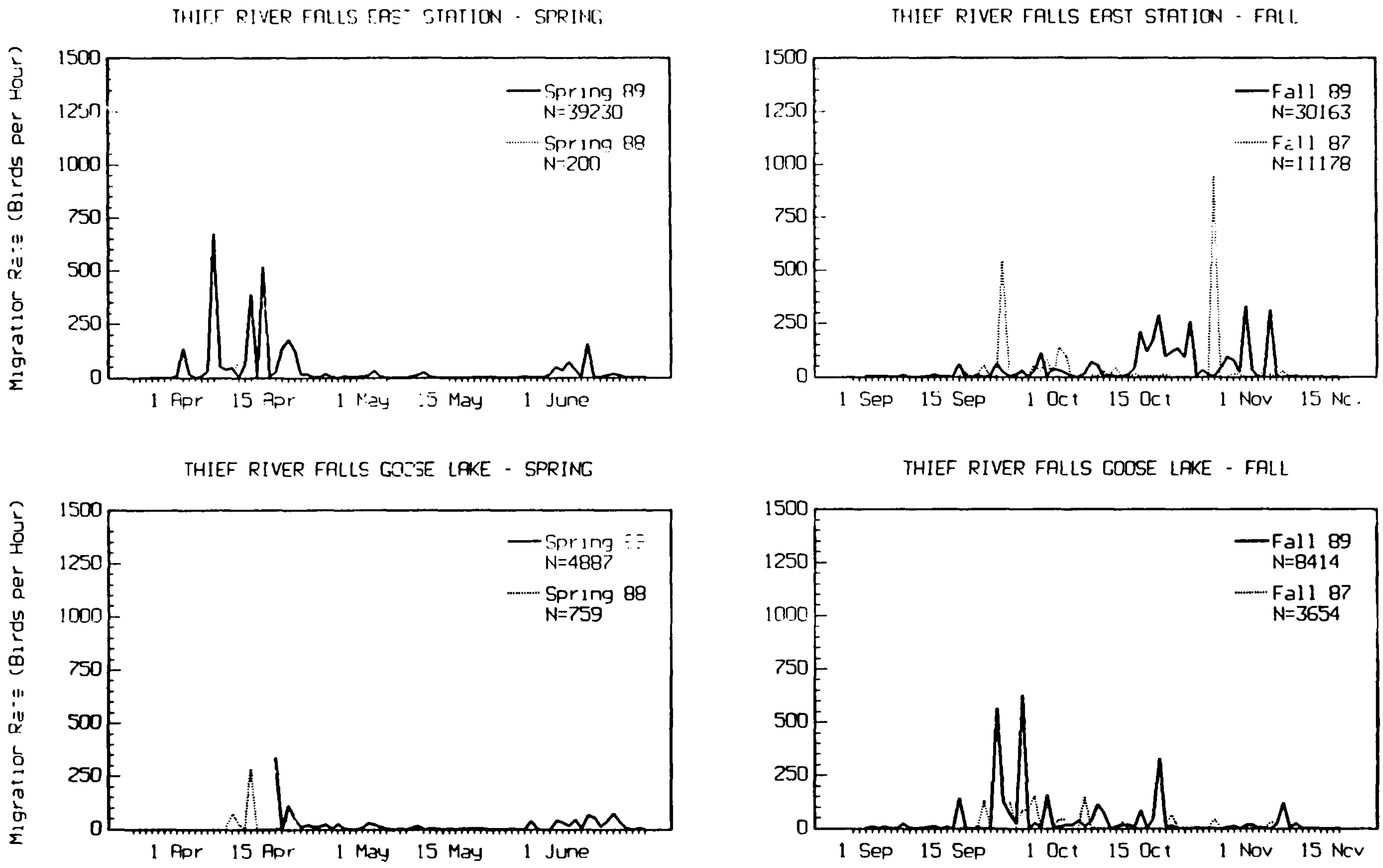


FIGURE 8-57. THIEF RIVER FALLS, MN RECEIVE STUDY AREA DIURNAL MIGRATION RATES - GEESE/CORMORANTS

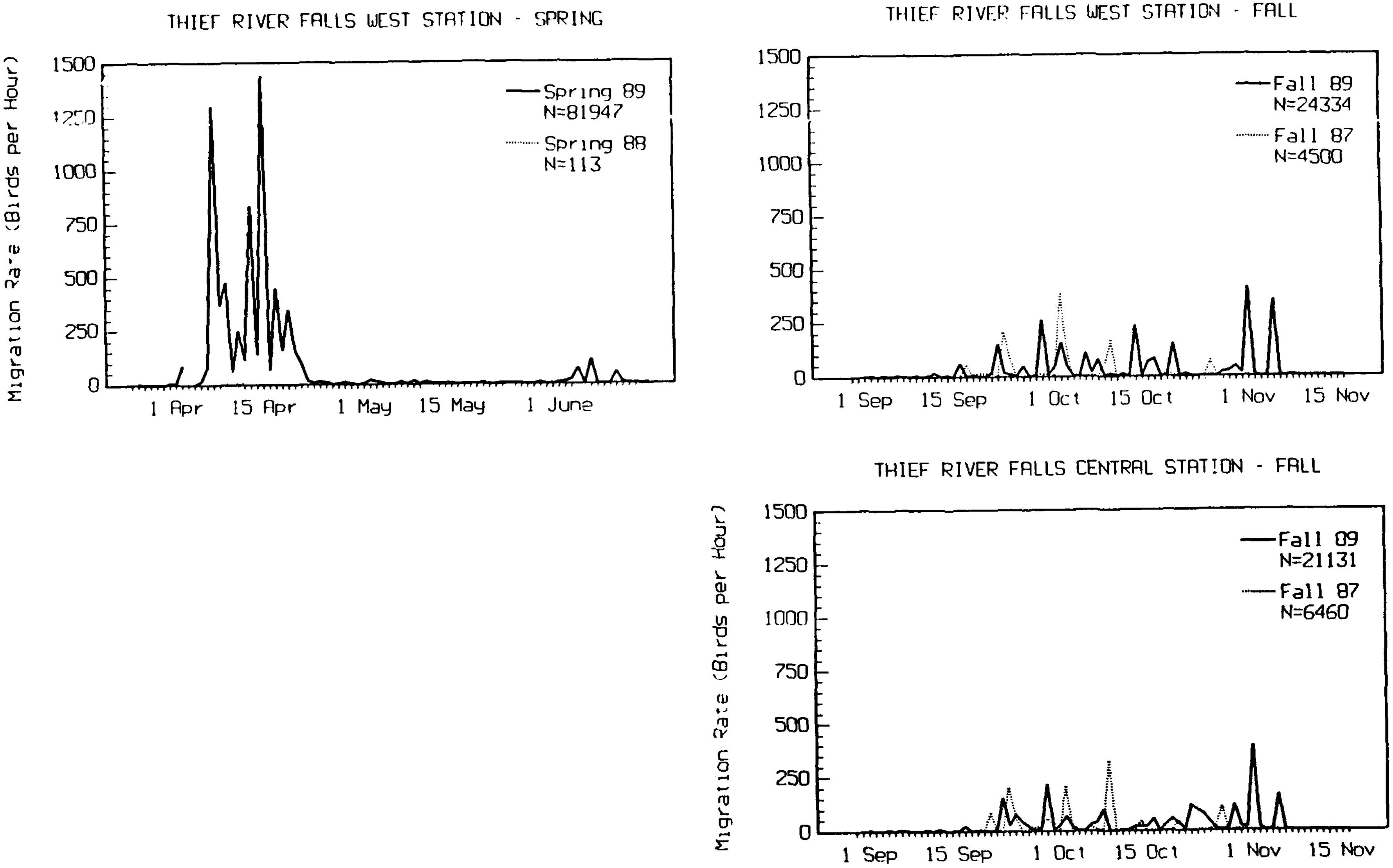


FIGURE 8-57. THIEF RIVER FALLS, MN RECEIVE STUDY AREA DIURNAL MIGRATION RATES - GEESE/CORMORANTS (CONTINUED)

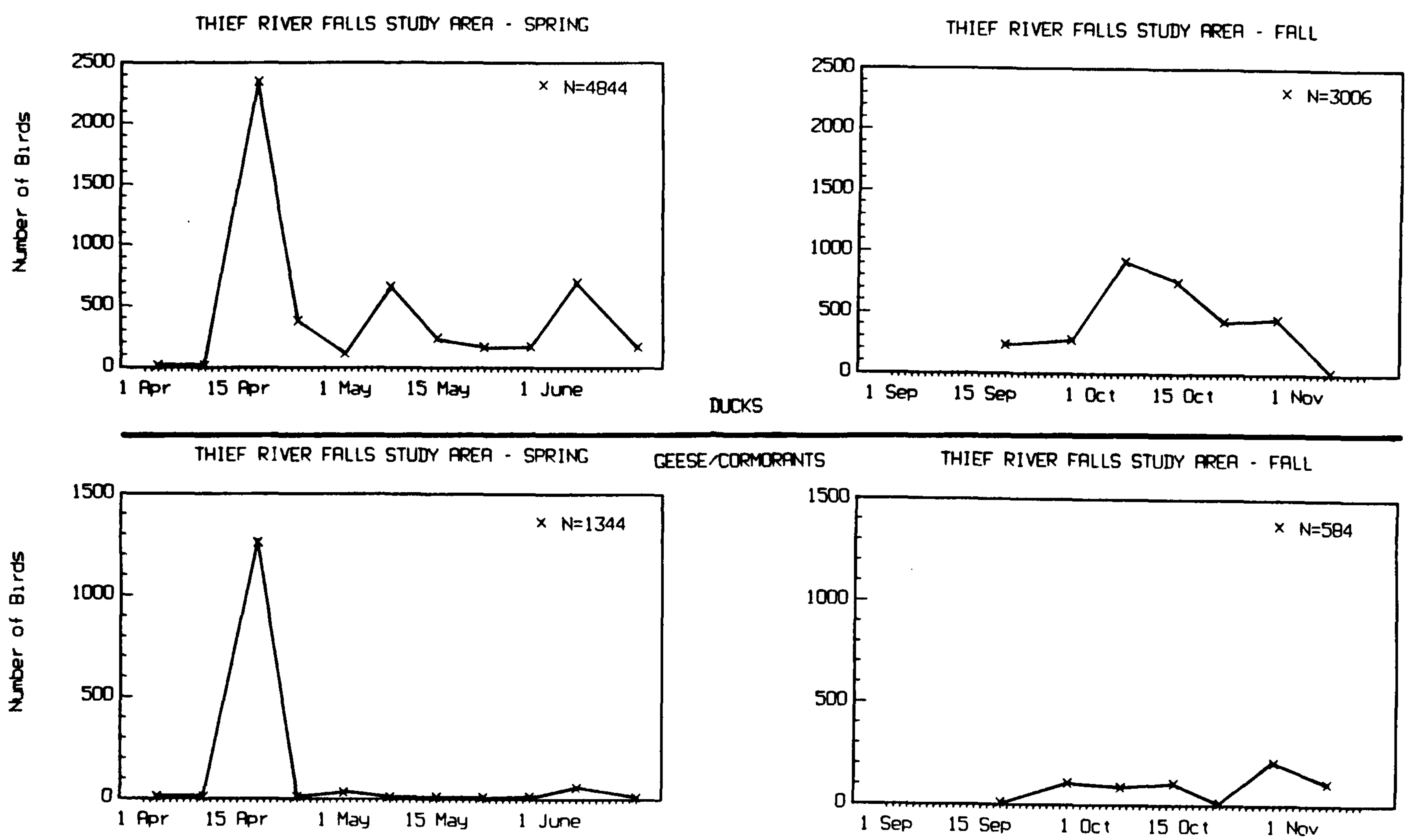


FIGURE 8-58. THIEF RIVER FALLS, MN RECEIVE STUDY AREA DUCK AND GOOSE/CORMORANT CHRONOLOGY AND NUMBERS AERIAL SURVEYS

Migration trends for all waterfowl (Figs. 8-60; 8-61) were similar to those described for ducks and geese. Overall, peak rates for all waterfowl were higher in spring than in fall at the West station, higher in fall than in spring at the Goose Lake station, and similar between seasons at the East station (Table 8-29). Highest peak rates occurred at Goose Lake in the fall and at the West station in the spring (Table 8-29).

Spring shorebird migration began about mid-April and continued through the end of the study period (15 June), with rates generally higher after 15 May (Fig. 8-62). Few shorebirds were observed during aerial surveys in spring. In fall, most observed migration occurred between 15 September and 15 October, with peak rates later at the West and Central stations than at the East and Goose Lake stations (Fig. 8-62; Table 8-29). However, some species of shorebirds typically begin migrating as early as late July (Janssen, 1987), so it is probable that peak rates occurred before fall observations commenced for some shorebird species. Few shorebirds were observed during fall aerial surveys. Shorebird migration was minimal after the middle of October (Fig. 8-62).

Overall and peak rates of shorebird migration were higher in fall than in spring at all stations (Tables 8-28; 8-29). Peak rates were highest at the West station in fall but relatively uniform among stations in the spring (Table 8-29).

The main period of spring sandhill crane migration occurred between 1 April and 1 May with peak rates occurring during the second and third weeks of April (Fig. 8-63). Two distinct peaks of cranes were observed during aerial surveys, one in mid-April and the second around the first of May (Fig. 8-64). Fall migration occurred mostly during the last three weeks of October in 1989 but during the third week of September during 1987 (Fig. 8-63). Few cranes were observed during aerial surveys in fall, with most observed during the second half of September (Fig. 8-64).

Overall and peak rates were highest at the Goose Lake station during both seasons for sandhill cranes. Peaks rates were similar between seasons at each station (Tables 8-28; 8-29).

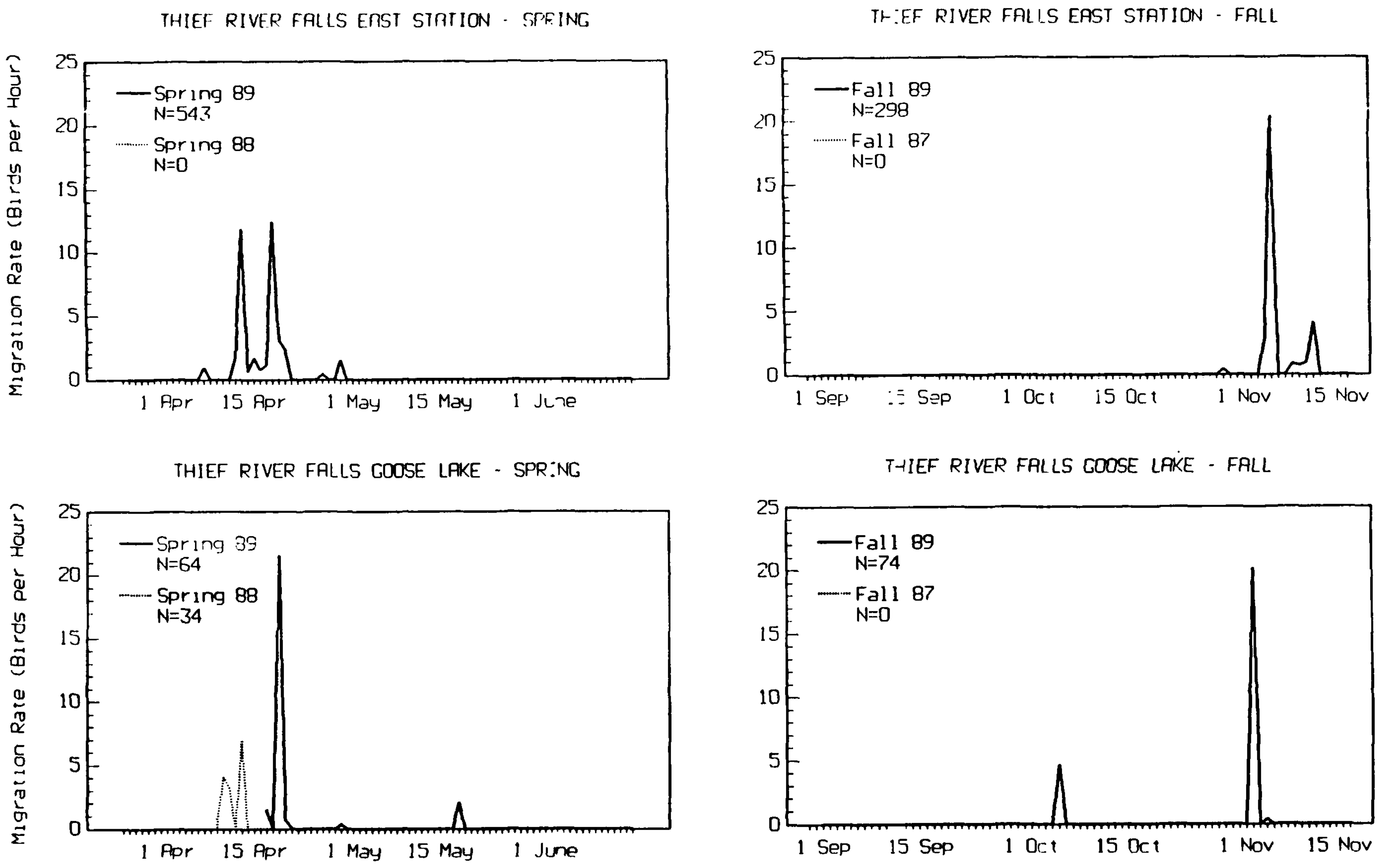


FIGURE 8-59. THIEF RIVER FALLS, MN RECEIVE STUDY AREA DIURNAL MIGRATION RATES - SWANS

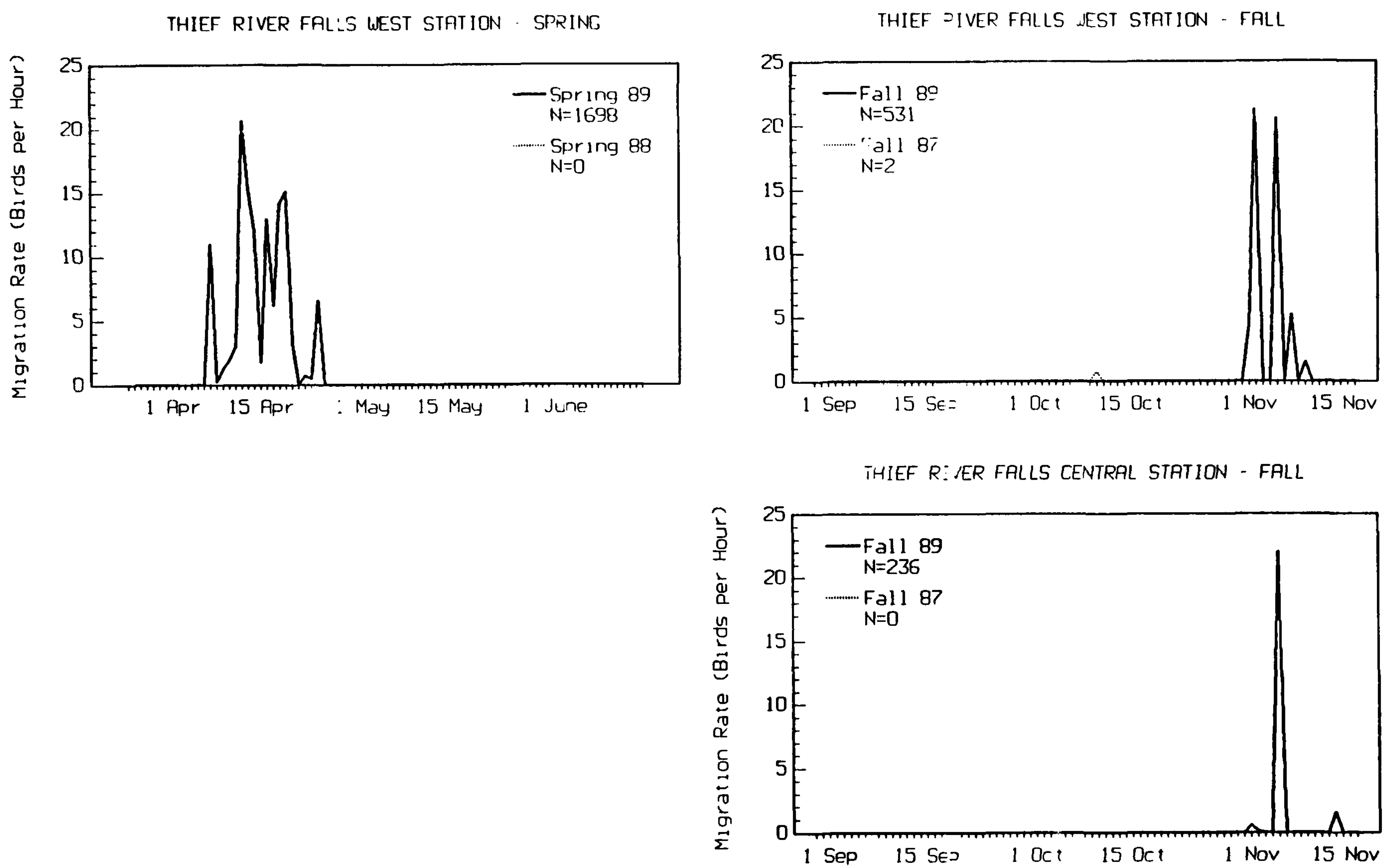


FIGURE 8-59. THIEF RIVER FALLS, MN RECEIVE STUDY AREA DIURNAL MIGRATION RATES - SWANS (CONTINUED)

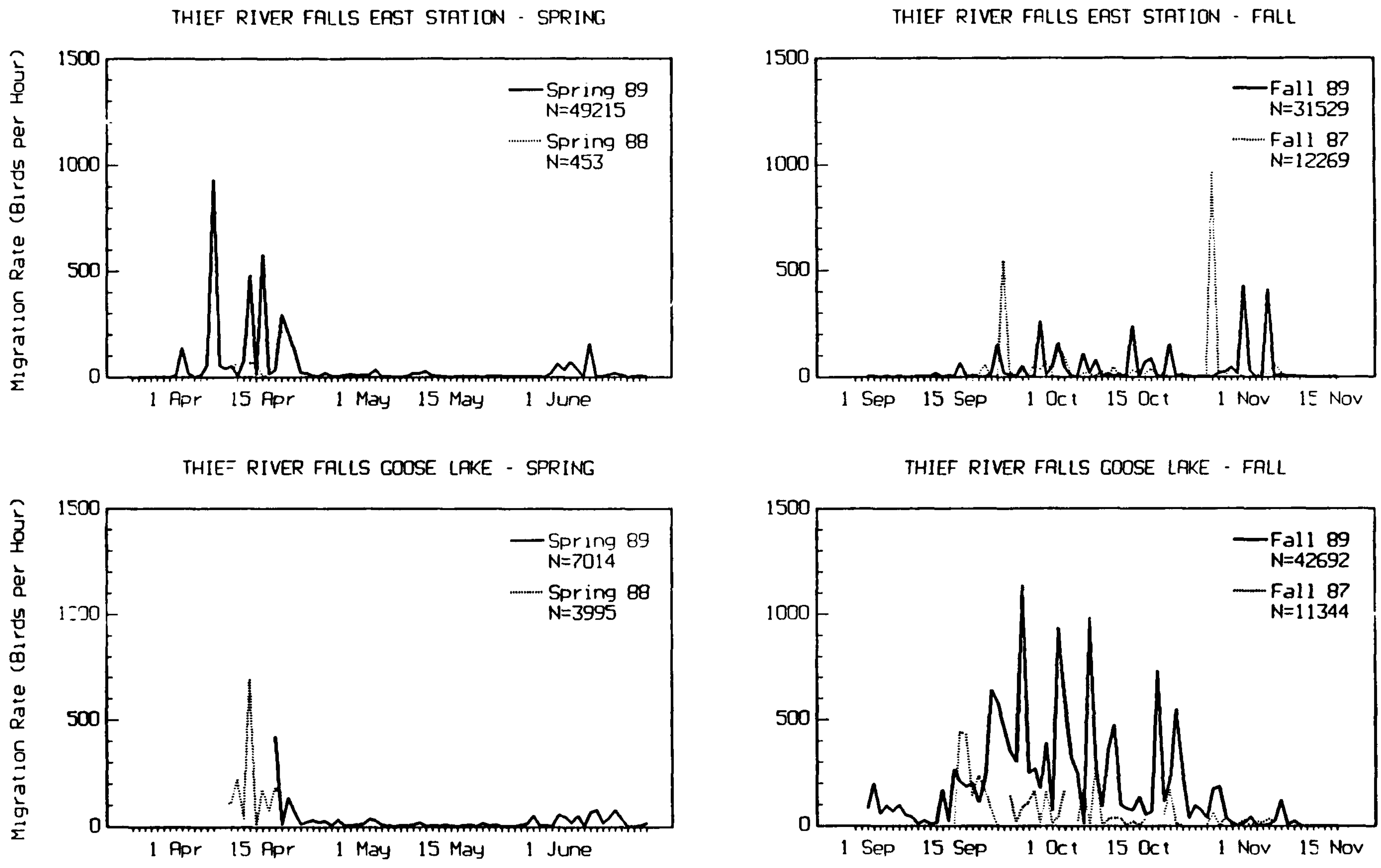


FIGURE 8-60. THIEF RIVER FALLS, MN RECEIVE STUDY AREA DIURNAL MIGRATION RATES - ALL WATERFOWL

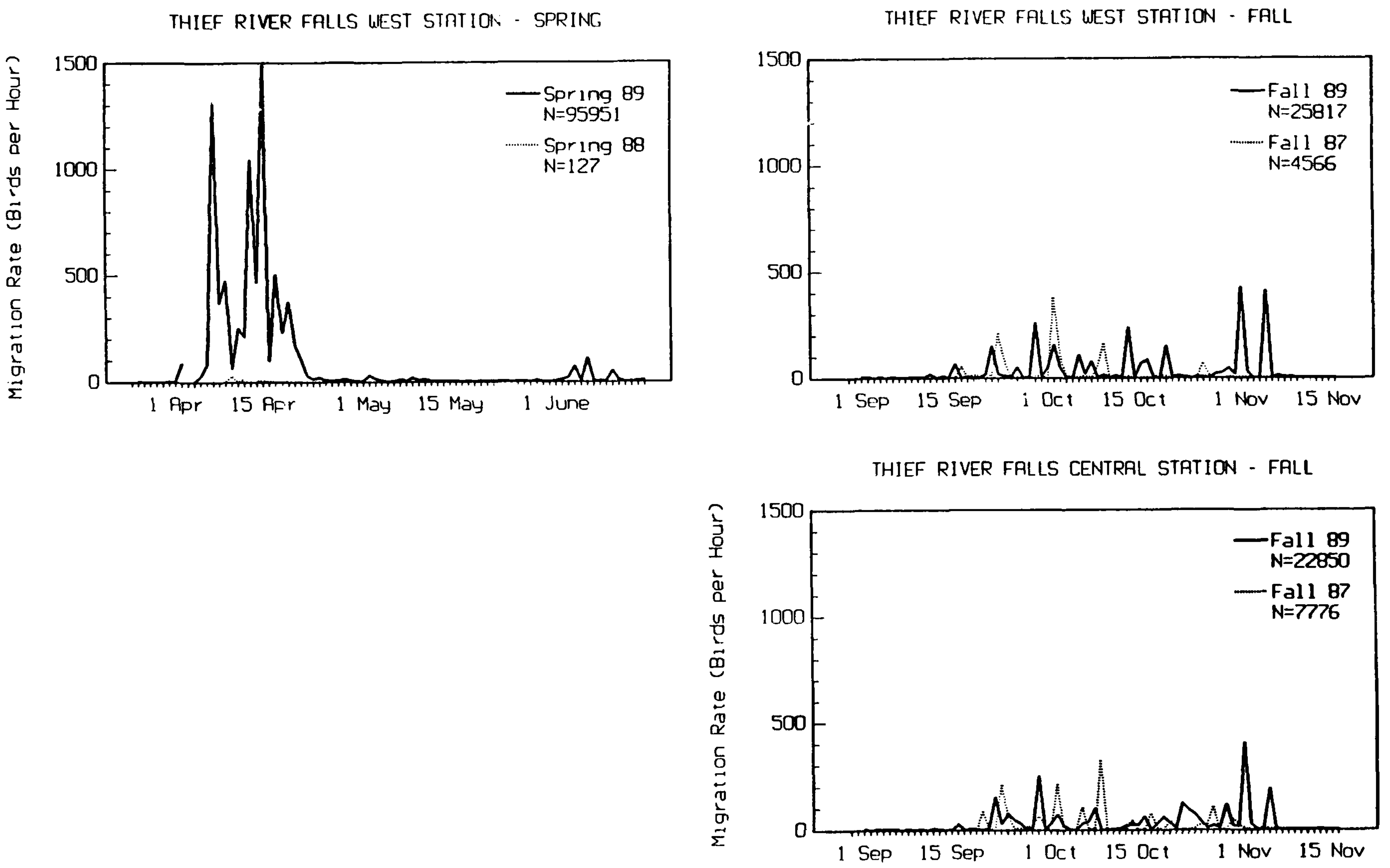


FIGURE 8-60. THIEF RIVER FALLS, MN RECEIVE STUDY AREA DIURNAL MIGRATION RATES - ALL WATERFOWL (CONTINUED)

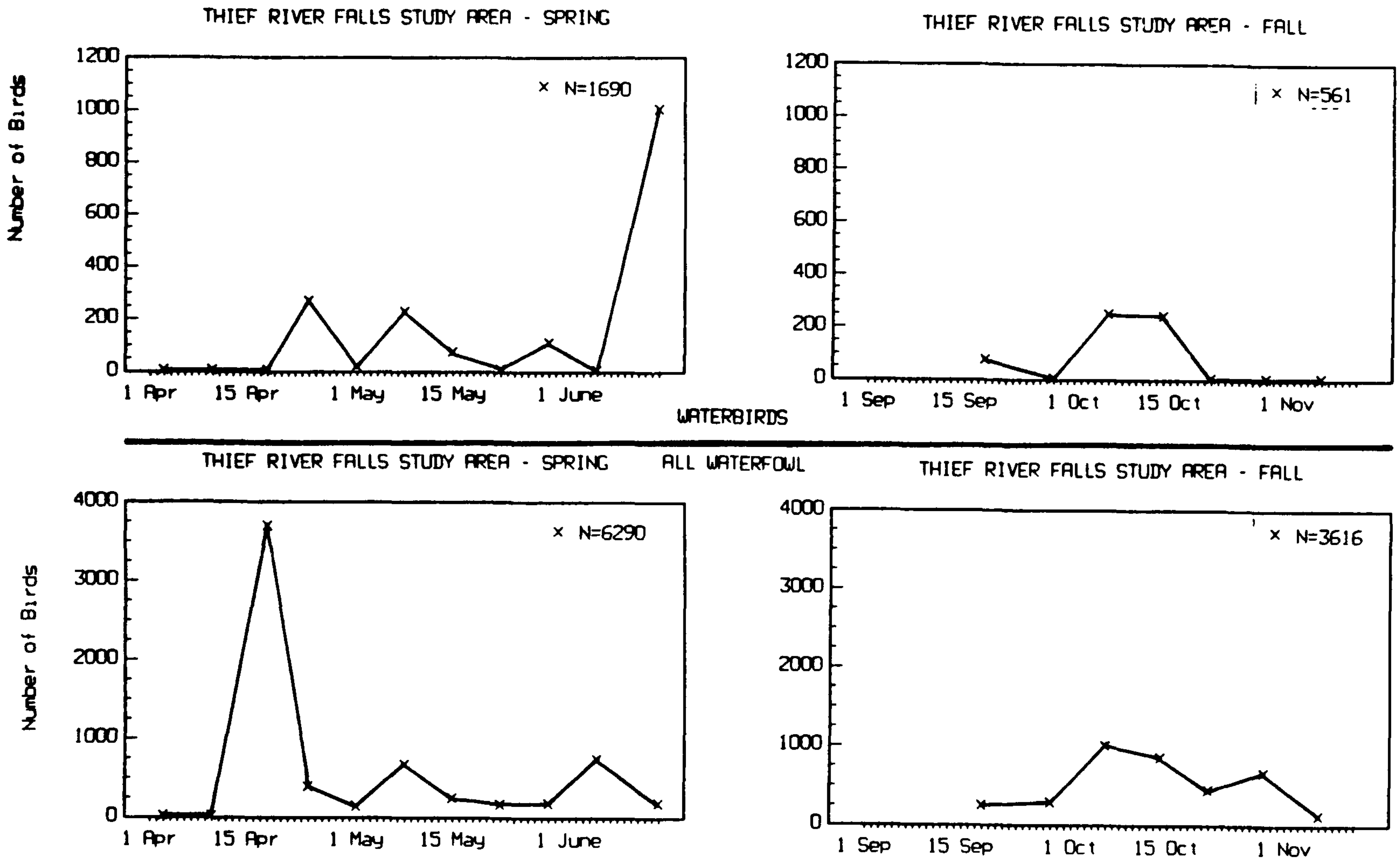


FIGURE 8-61. THIEF RIVER FALLS, MN RECEIVE STUDY AREA WATERFOWL AND WATERBIRD CHRONOLOGY AND NUMBERS AERIAL SURVEYS

Waterbird migration in spring 1989 occurred over the entire study period, with peaks observed near mid-April, early May, and early to mid-June (Fig. 8-65). Aerial surveys also showed peaks during the third week of April, the second week of May, and a large peak in mid-June as studies ceased (Fig. 8-61). Fall 1989 migration was protracted, with scattered peaks occurring from mid-September until early November; few waterbirds were observed in 1987 (Fig. 8-65). Peak numbers were observed during the first and second weeks of October during aerial surveys, although peak numbers may have been missed during the first two weeks of September as aerial surveys were late in getting started (Fig. 8-61).

Peak waterbird rates were higher in the fall than in the spring at the Goose Lake station but higher in spring than in fall at the East and West stations. Peak rates were similar among East, West, and Central stations and highest at the Goose Lake station in fall and lowest at this station in the spring (Table 8-29).

Raptors are early spring migrants and migration was already underway when observations began in late March. Migration rates were relatively stable at 1 to 2 birds per hour over the course of the spring studies, although rates were noticeably higher during mid-April (Fig. 8-66). Fall migration was characterized by a constant low level of movement of 2 to 4 birds per hour, with sharp peaks in middle to late September 1987; peaks were more variable in 1989 (Fig. 8-66). Peak rates tended to be higher in fall than in spring at all but the West station, where they were equal between seasons. Peak rates were highest at the East station in fall and at the West station in spring (Table 8-29).

Spring passerine migration was characterized by multiple peaks, with rates generally highest between 15 April and 15 May. Blackbirds and nonblackbird passerines tended to peak near the same times (Figs. 8-67; 8-68; 8-69). Fall migration also occurred in multiple peaks with blackbirds tending to peak during the first three weeks of September in 1989 and the last two weeks of October in 1987. Nonblackbird passerines peaked in early to mid-September (mostly swallows), and again in late October and early November (largely larks and longspurs) (Figs. 8-67; 8-68; 8-69).

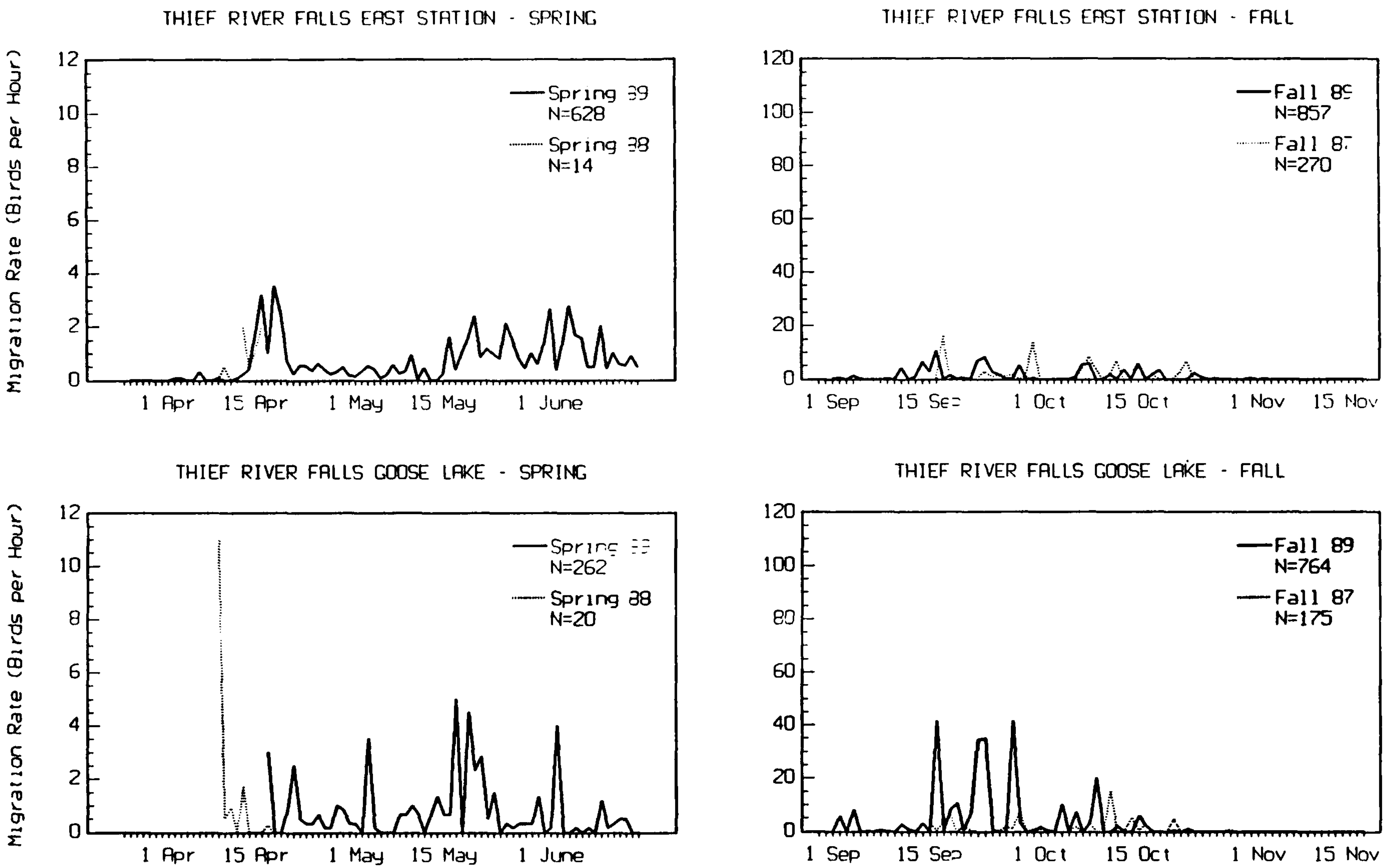
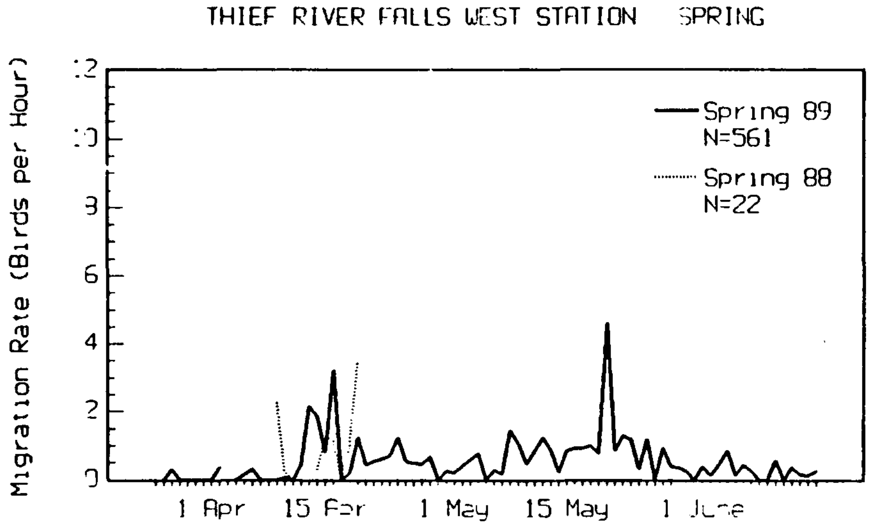
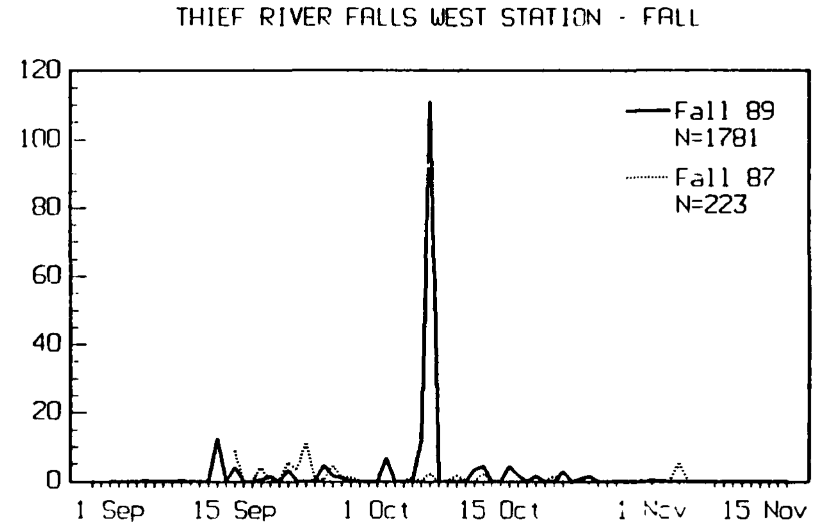


FIGURE 8-62. THIEF RIVER FALLS, MN RECEIVE STUDY AREA DIURNAL MIGRATION RATES - SHOREBIRDS





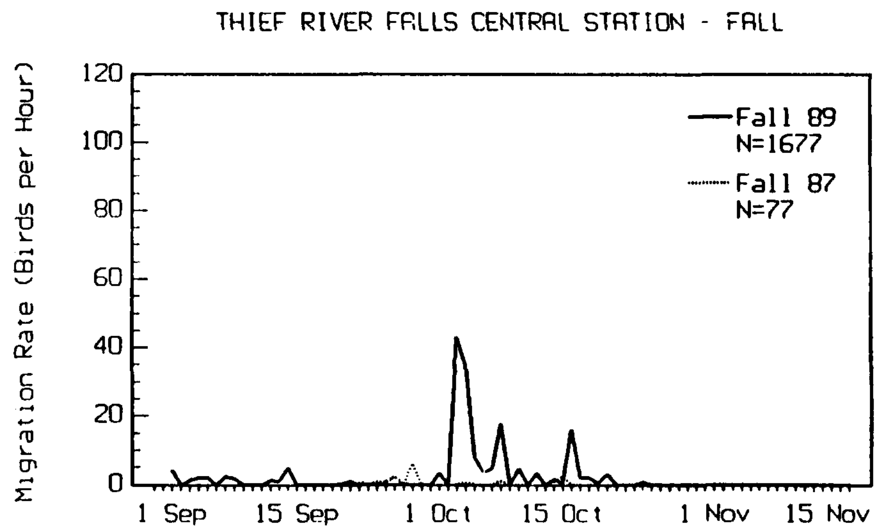


FIGURE 8-62. THIEF RIVER FALLS, MN RECEIVE STUDY AREA DIURNAL MIGRATION RATES - SHOREBIRDS (CONTINUED)

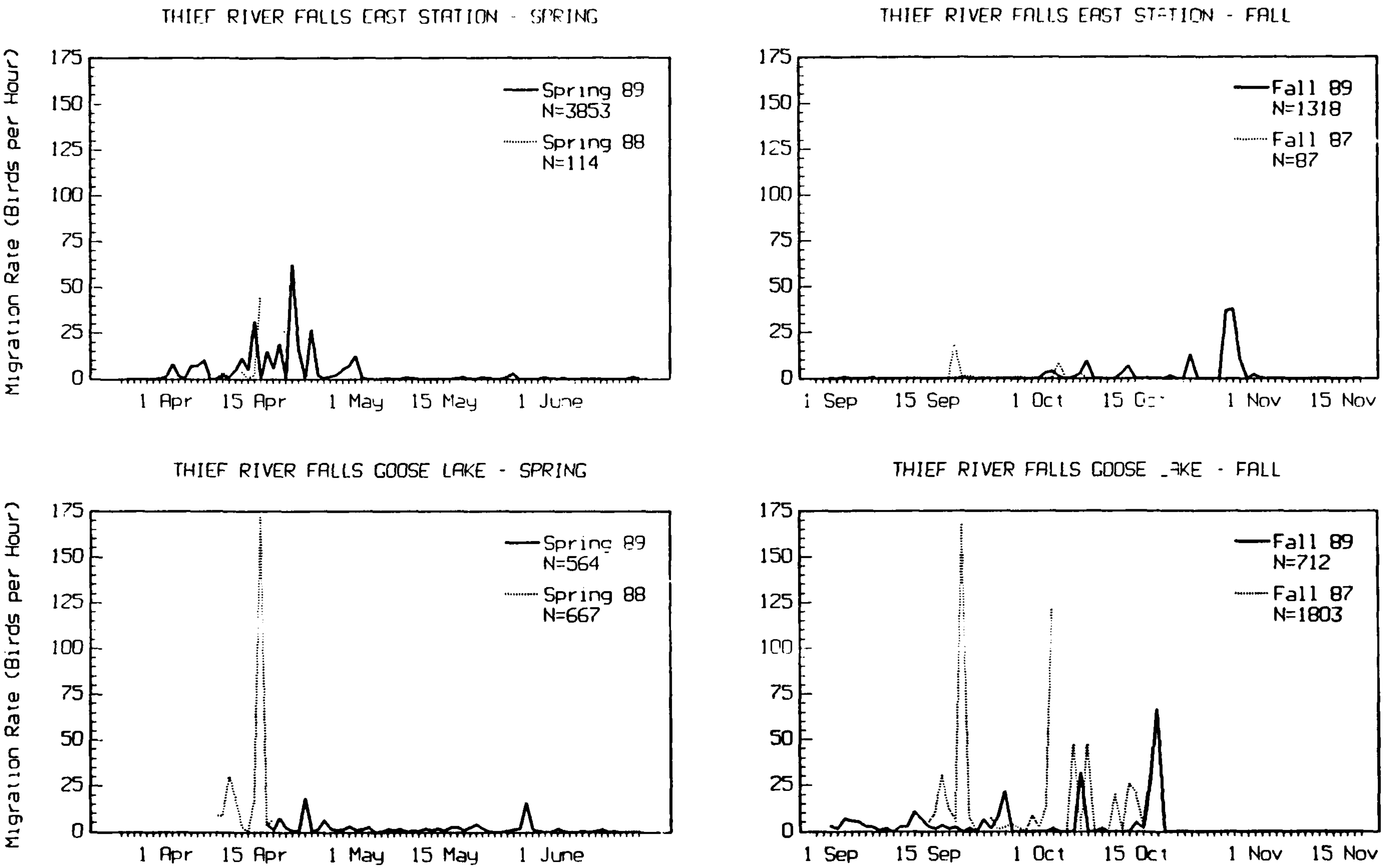
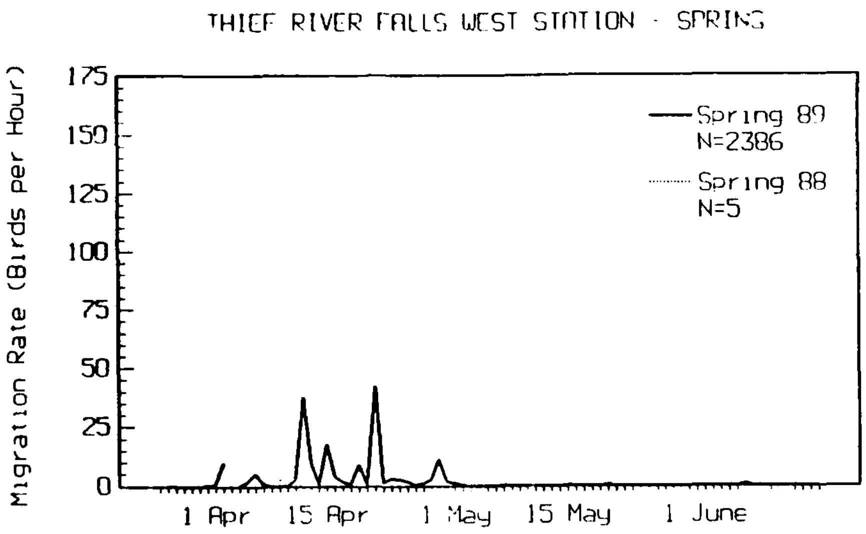
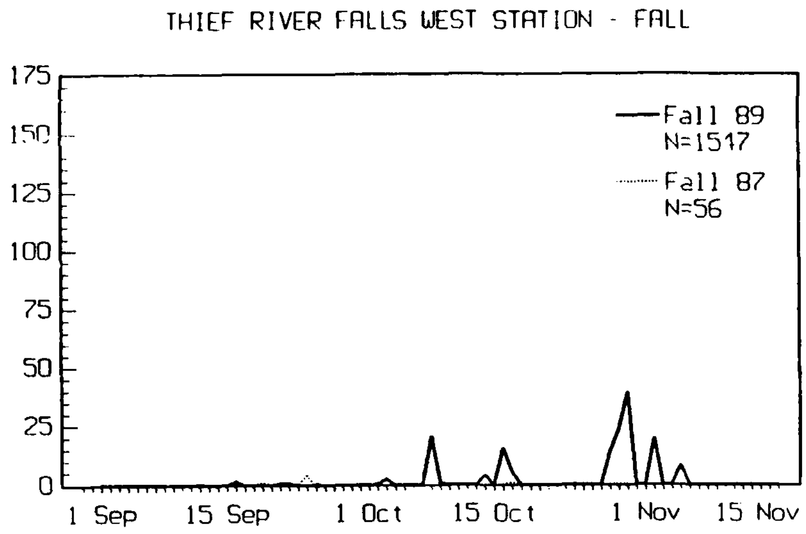


FIGURE 8-63. THIEF RIVER FALLS, MN RECEIVE STUDY AREA DIURNAL MIGRATION RATES - SANDHILL CRANES





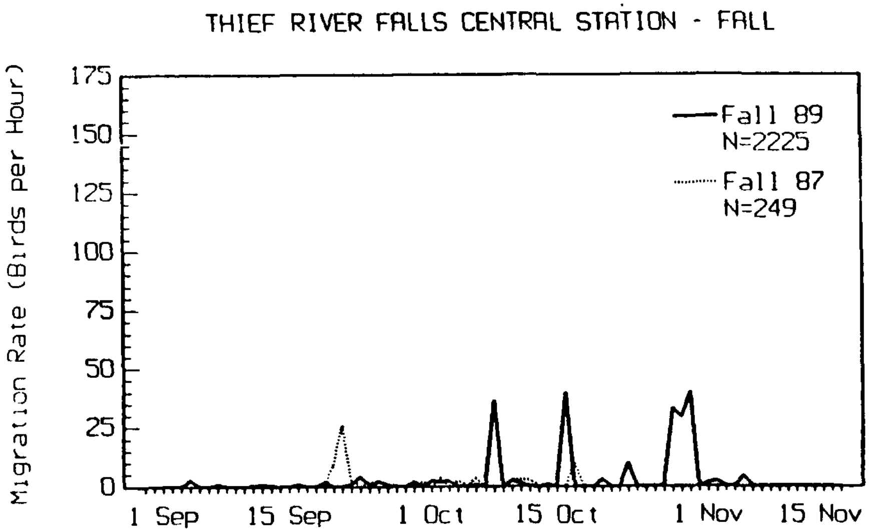


FIGURE 8-63. THIEF RIVER FALLS, MN RECEIVE STUDY AREA DIURNAL MIGRATION RATES - SANDHILL CRANES (CONTINUED)

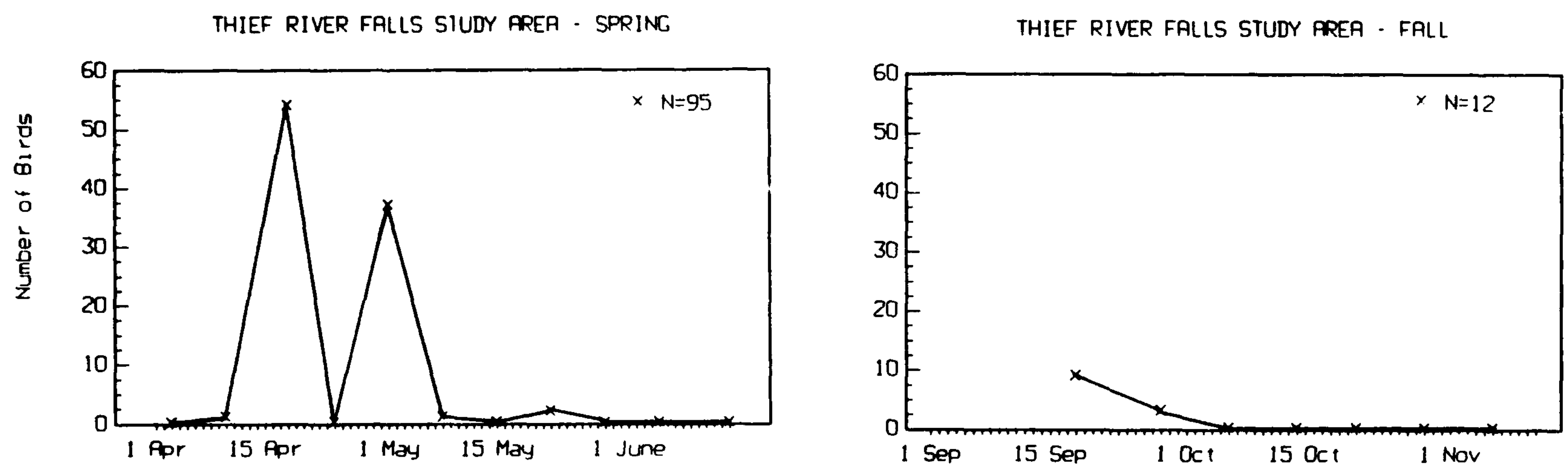


FIGURE 8-64. THIEF RIVER FALLS, MN RECEIVE STUDY AREA SANDHILL CRANE CHRONOLOGY AND NUMBERS - AERIAL SURVEYS

Peak rates for all passerines were higher in fall than in spring at the Goose Lake station and higher at the East and West stations in spring than in fall. Overall and peak rates were highest at the Goose Lake station for blackbirds in both fall and spring. Rates for nonblackbird passerines were highest at the Goose Lake station during fall and at the East station in spring (Tables 8-28; 8-29).

8.2.4.2.2 Nocturnal periods. The long-range setting of the surveillance radar unit generally sampled large-bodied birds such as ducks and swans; smaller species, such as passerines, were generally not observed at this range setting unless they were in large flocks. To correct for this bias, the radar unit was also used on short-range, where the increased sensitivity of the radar unit allowed single passerines to be observed. However, the short-range setting only permitted a much smaller area to be sampled.

Nocturnal spring 1989 migration rates, as measured by long-range radar, were highest at both the West and East stations during mid-April (Fig. 8-70), when waterfowl, waterbirds, and shorebirds showed daytime peaks (Figs. 8-60; 8-62; 8-65). Spring sampling at Thief River Falls was not continuous, however, as the radar lab was stationed in Amherst for about half of the migration season. Thus, peaks could have been missed when the radar lab was not on-site. Peak rates were similar between stations, at about 90 targets per hour (Table 8-30).

Fall 1989 nocturnal migration, observed using long-range radar, was characterized by peaks in late August, mid to late September, early and mid-October, and during early November (Fig. 8-70). Peak rates were higher at the West station (85 targets per hour) than at the East station (52 targets per hour) (Table 8-30). Spring and fall migrations were difficult to compare since sampling was not continuous in the spring but peak rates appeared to be generally similar between seasons at the West station but higher during spring at the East station (Fig. 8-70; Table 8-30).

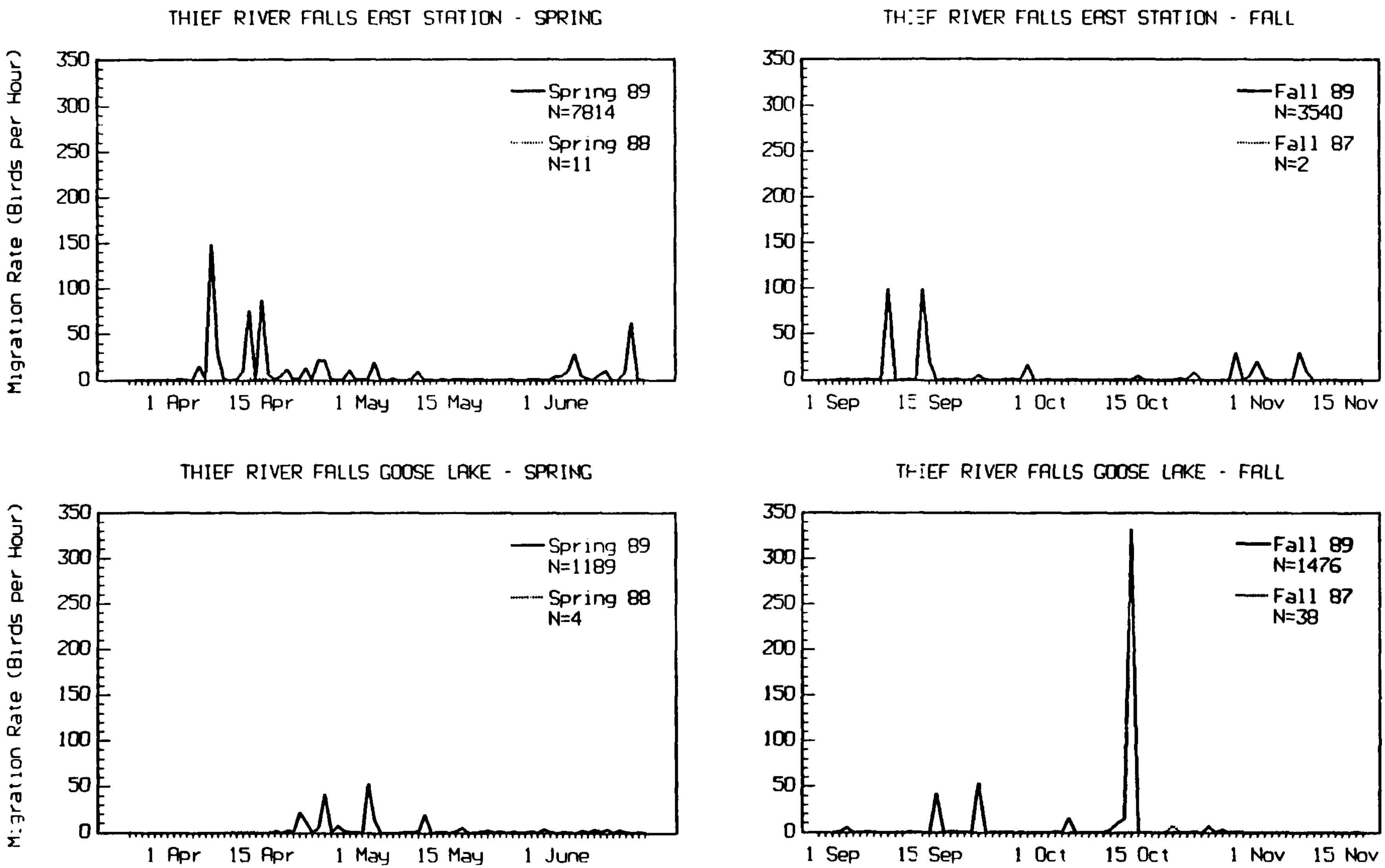


FIGURE 8-65. THIEF RIVER FALLS, MN RECEIVE STUDY AREA DIURNAL MIGRATION RATES - WATERBIRDS

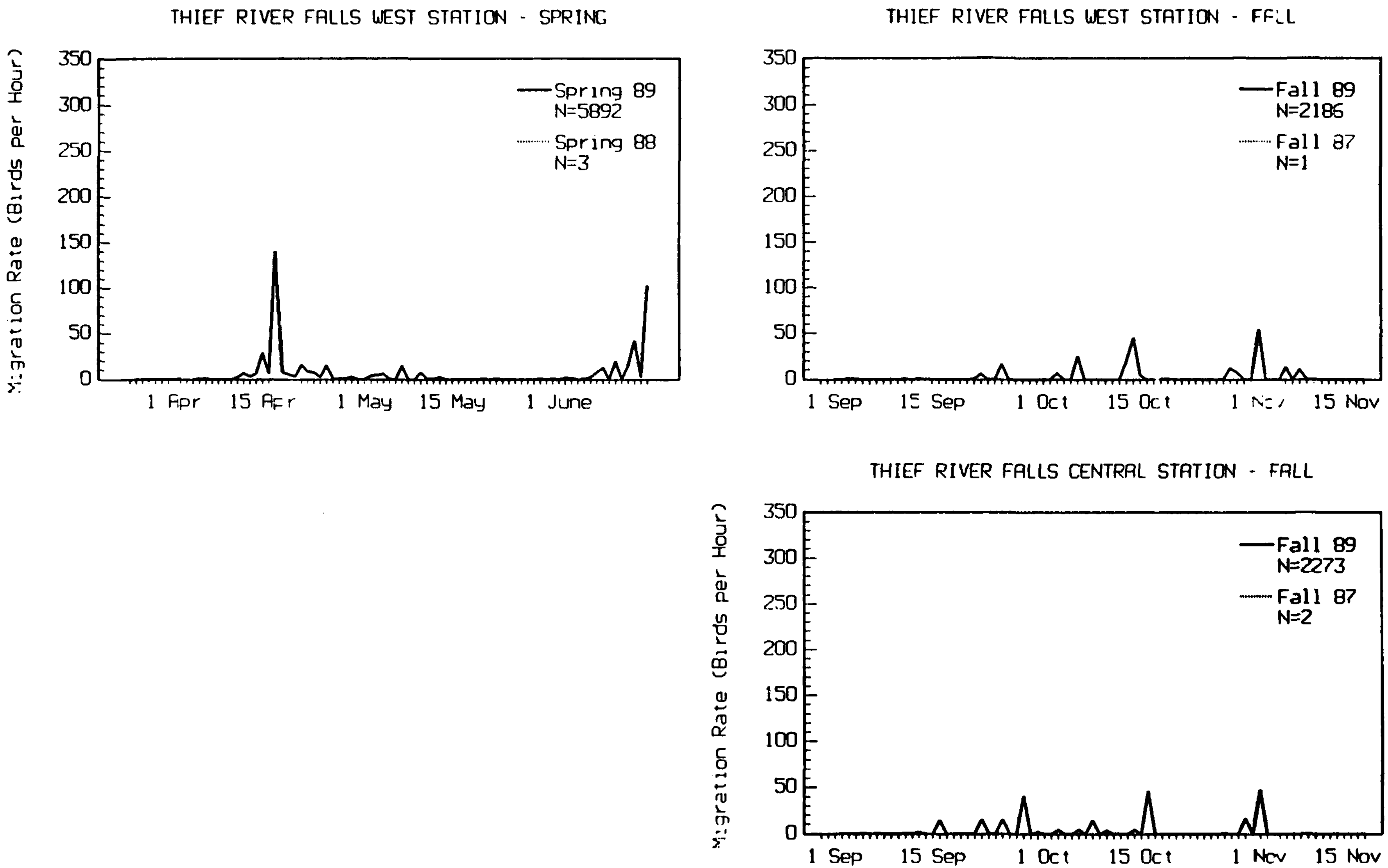


FIGURE 8-65. THIEF RIVER FALLS, MN RECEIVE STUDY AREA DIURNAL MIGRATION RATES - WATERBIRDS (CONTINUED)

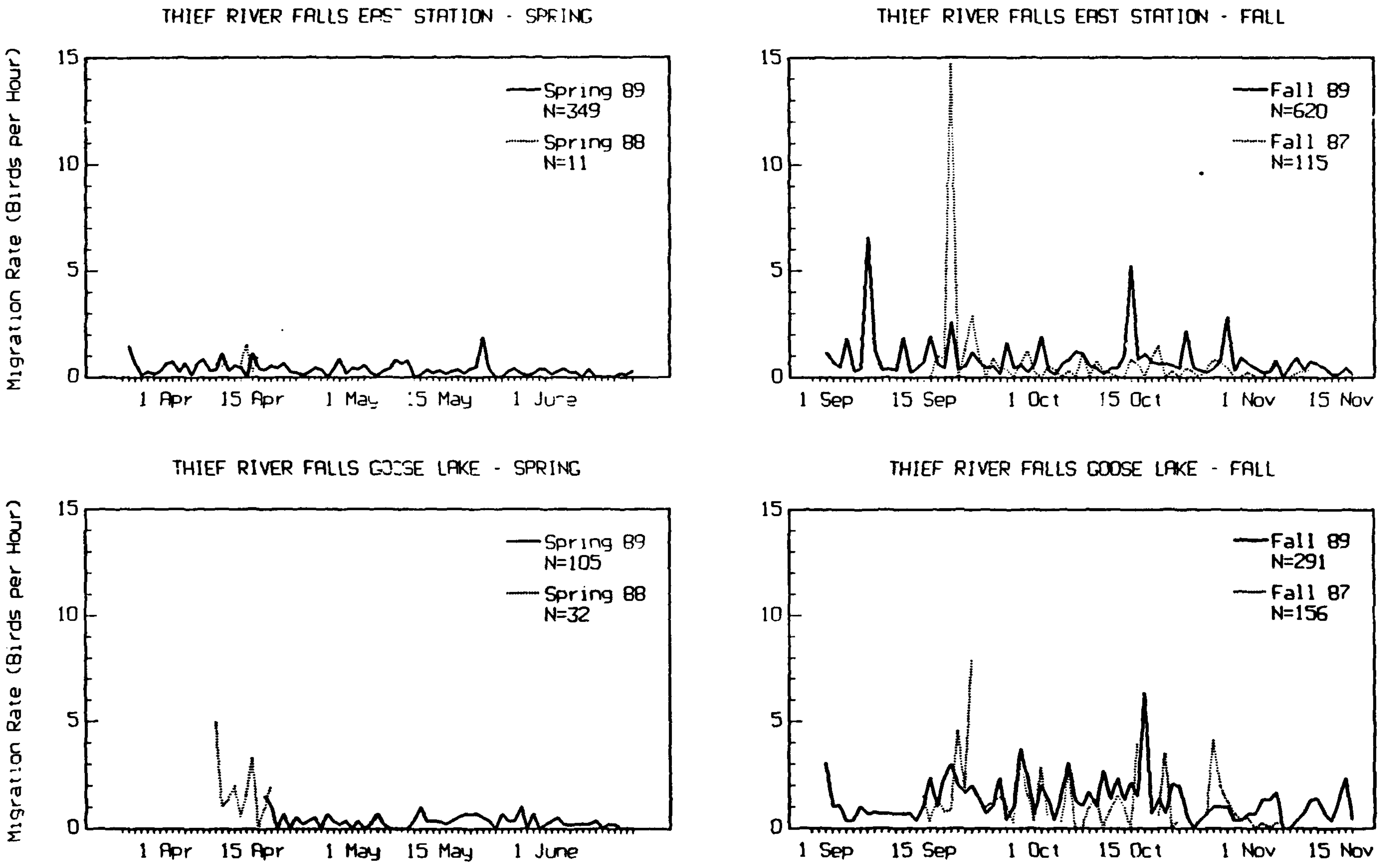


FIGURE 8-66. THIEF RIVER FALLS, MN RECEIVE STUDY AREA DIURNAL MIGRATION RATES - RAPTORS

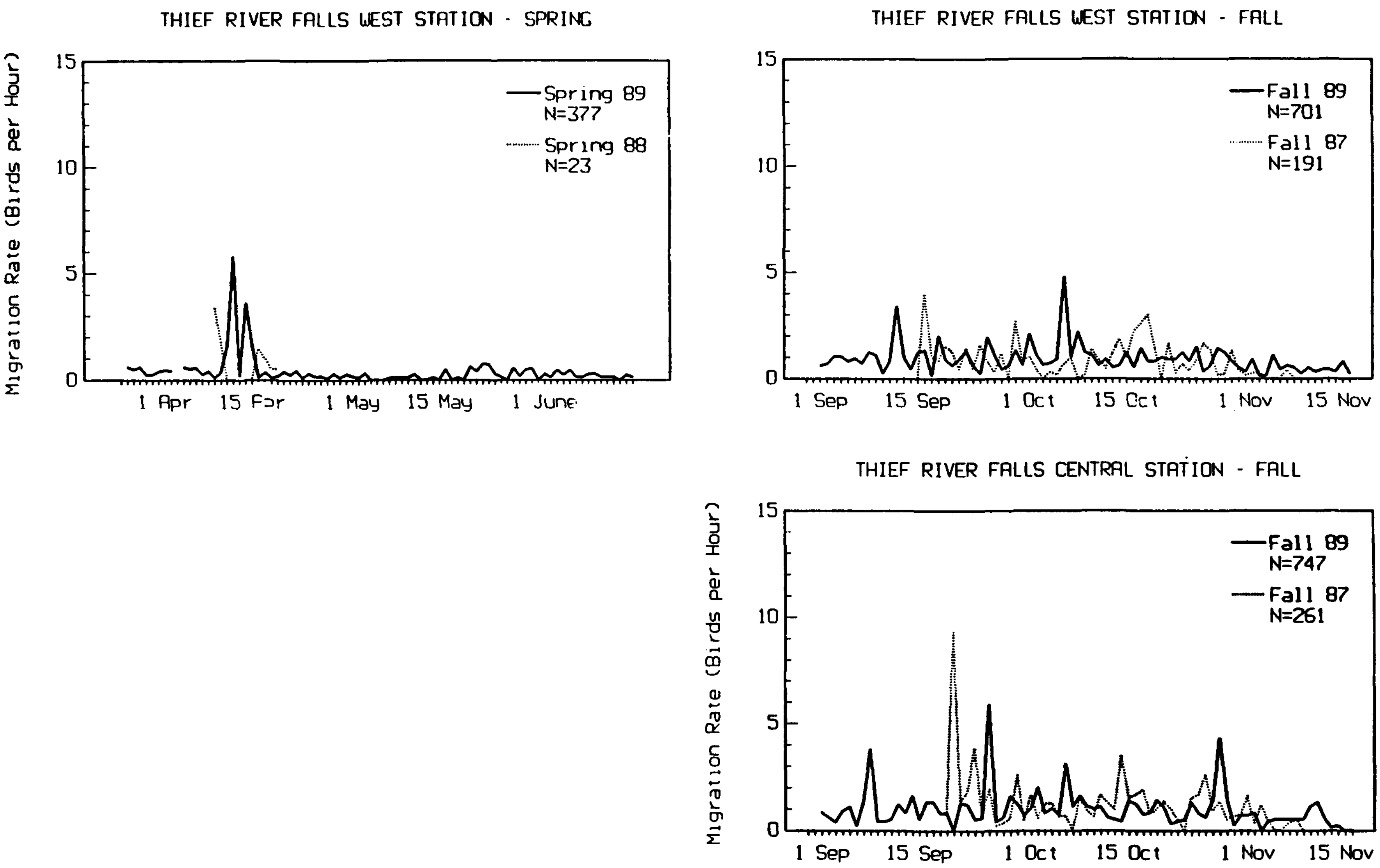


FIGURE 8-66. THIEF RIVER FALLS, MN RECEIVE STUDY AREA DIURNAL MIGRATION RATES - RAPTORS (CONTINUED)

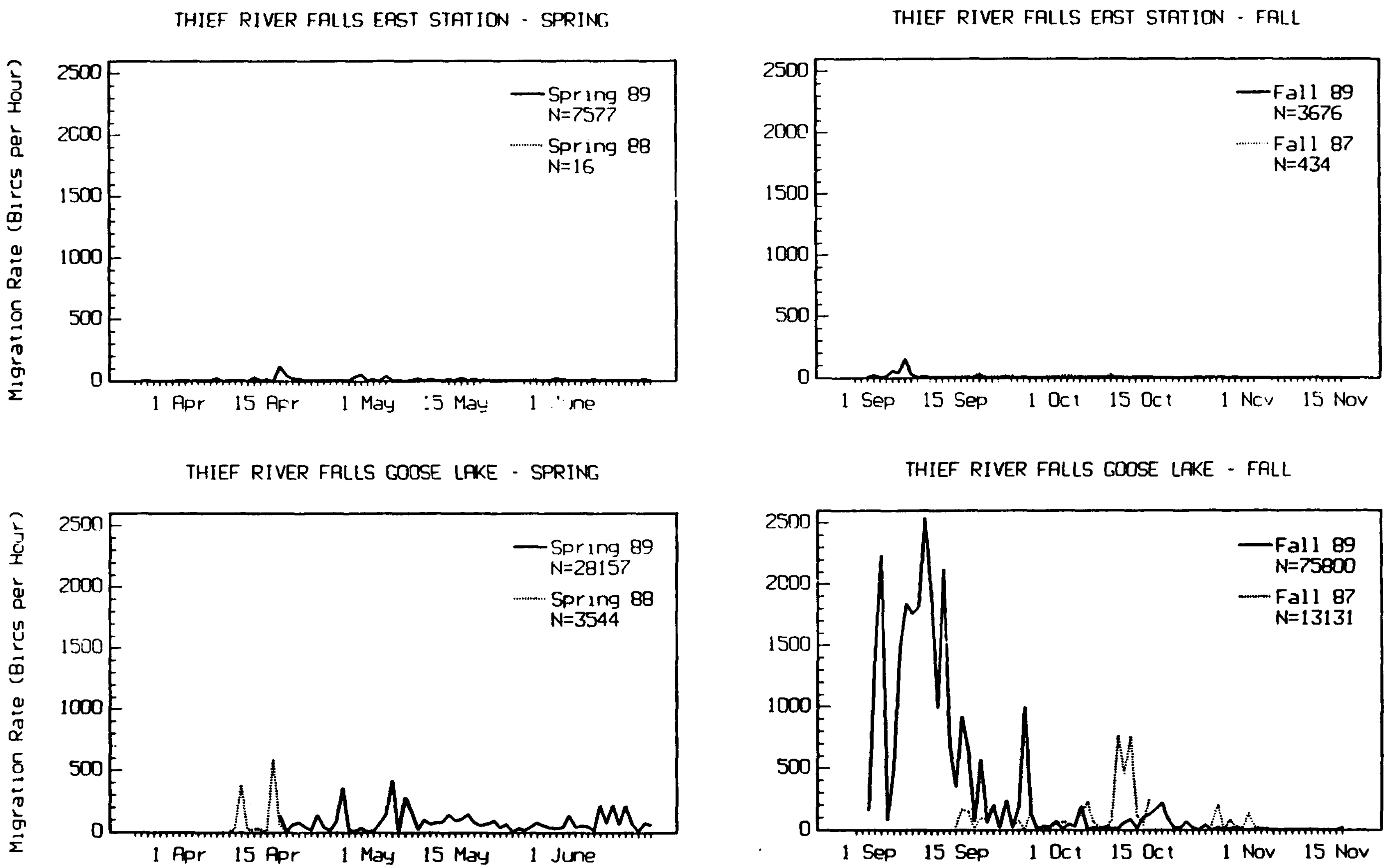
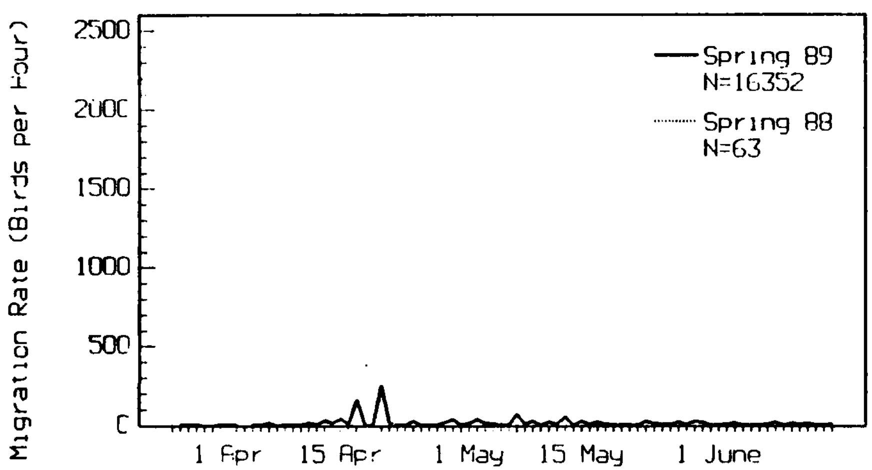
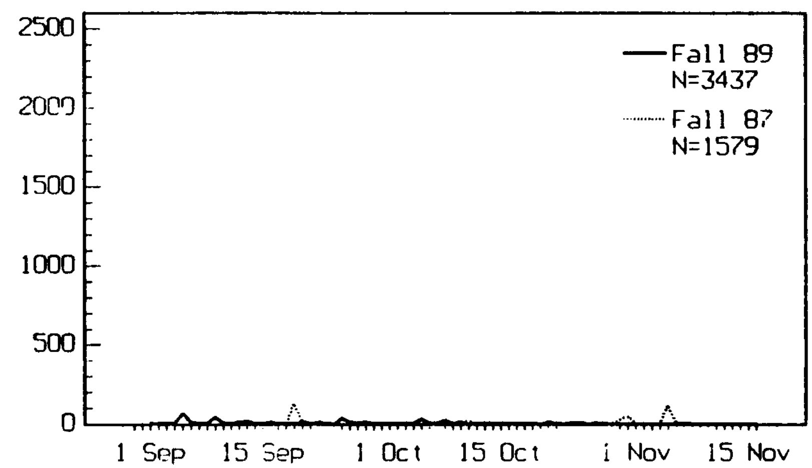


FIGURE 8-67. THIEF RIVER FALLS, MN RECEIVE STUDY AREA DIURNAL MIGRATION RATES - BLACKBIRDS

THIEF RIVER FALLS WEST STATION - SPRING



THIEF RIVER FALLS WEST STATION - FALL



THIEF RIVER FALLS CENTRAL STATION - FALL

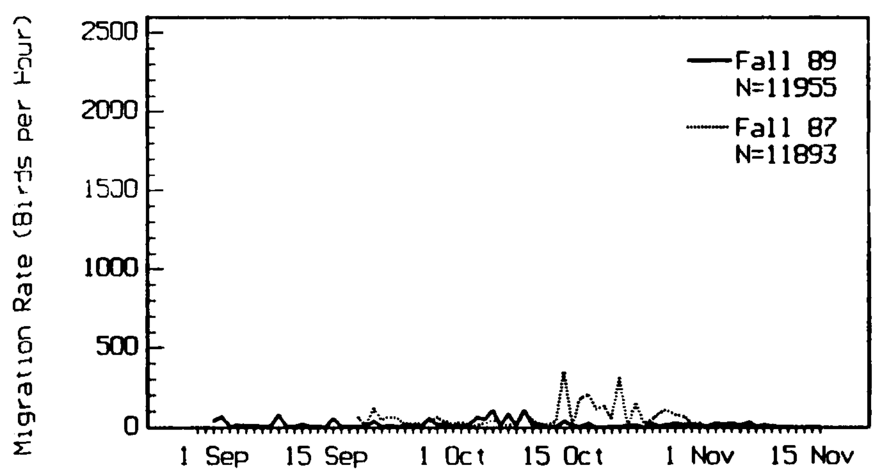


FIGURE 8-67. THIEF RIVER FALLS, MN RECEIVE STUDY AREA DIURNAL MIGRATION RATES - BLACKBIRDS (CONTINUED)

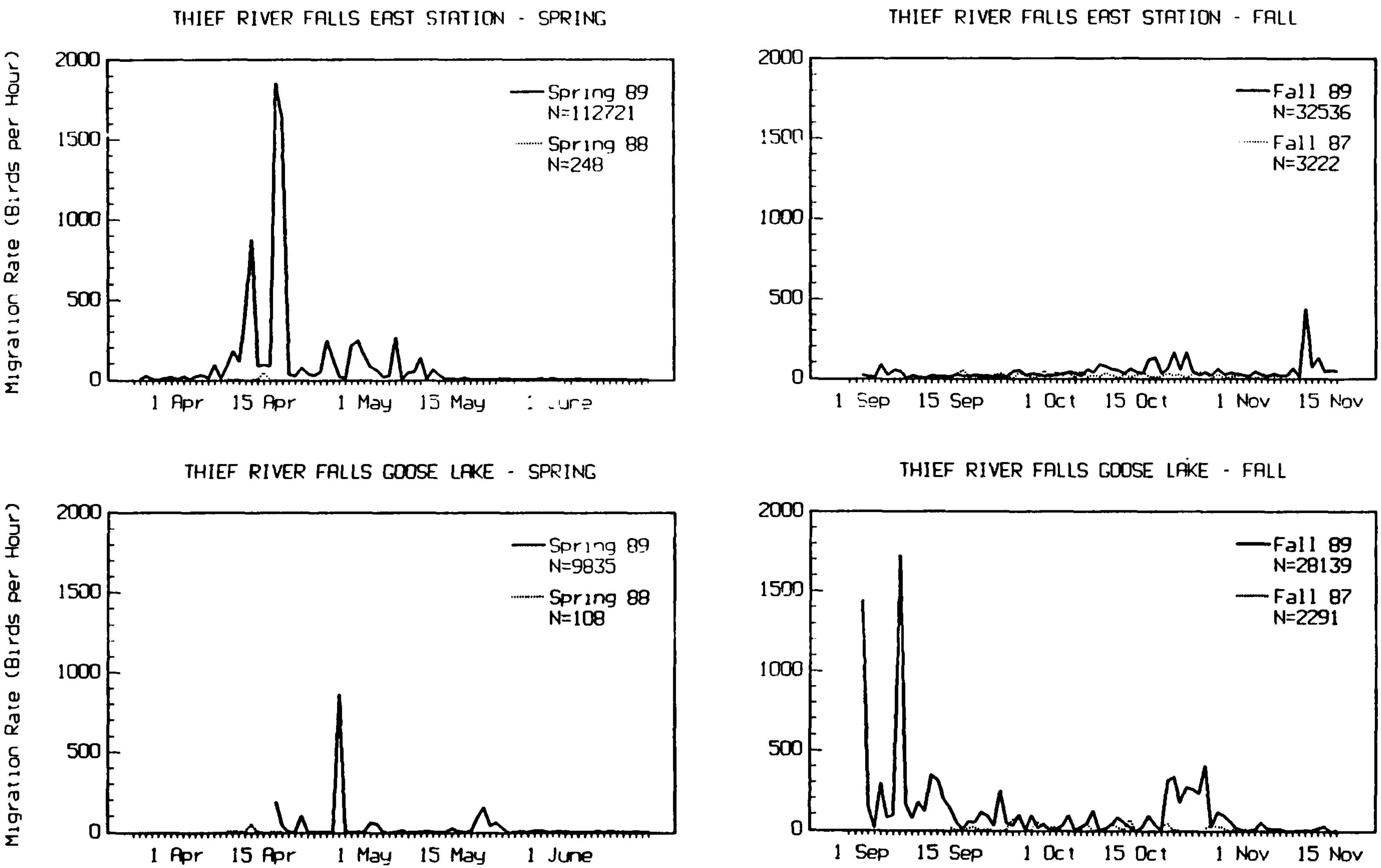
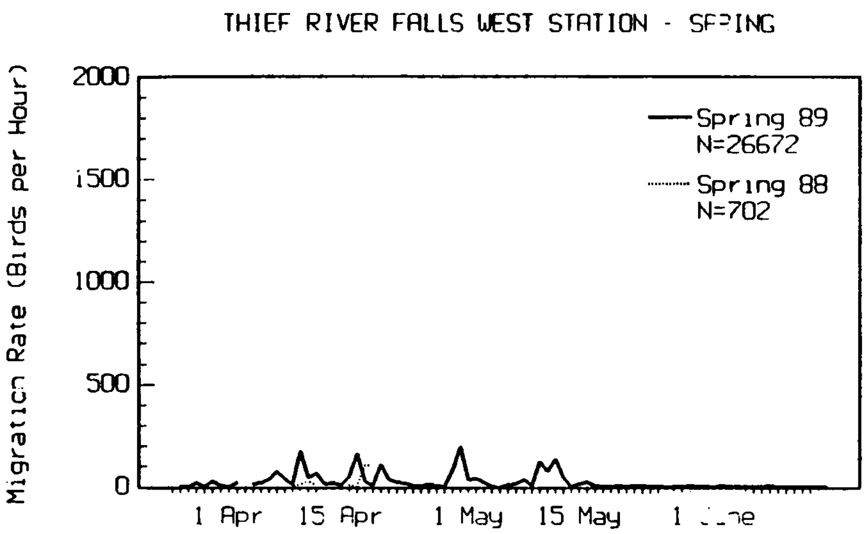
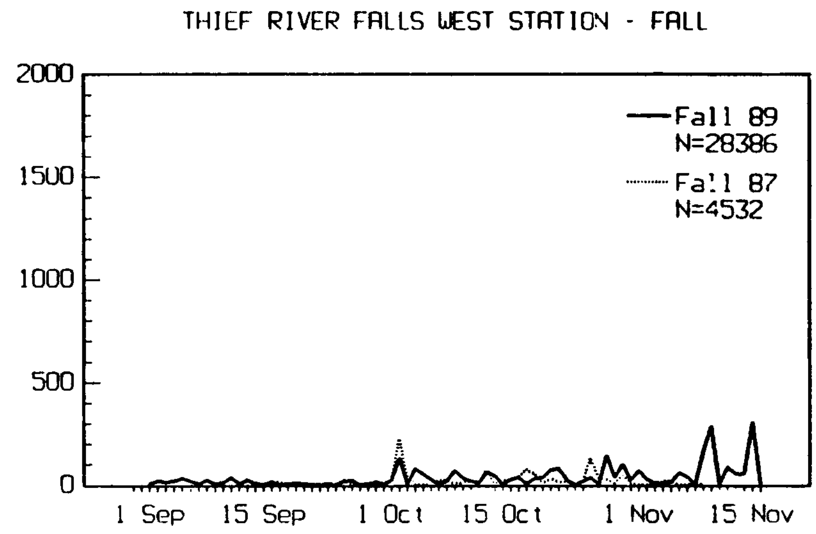


FIGURE 8-68. THIEF RIVER FALLS, MN RECEIVE STUDY AREA DIURNAL MIGRATION RATES - NONBLACKBIRD PASSERINES





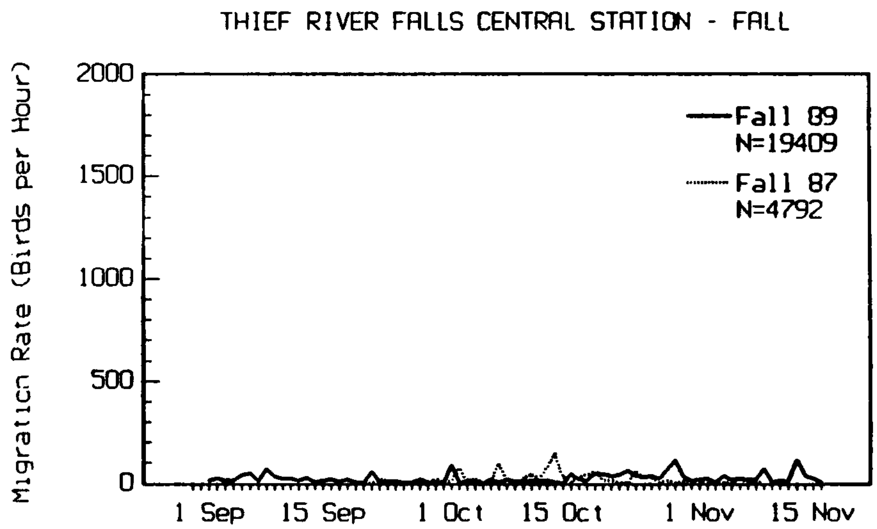


FIGURE 8-68. THIEF RIVER FALLS, MN RECEIVE STUDY AREA DIURNAL MIGRATION RATES - NONBLACKBIRD PASSERINES (CONTINUED)

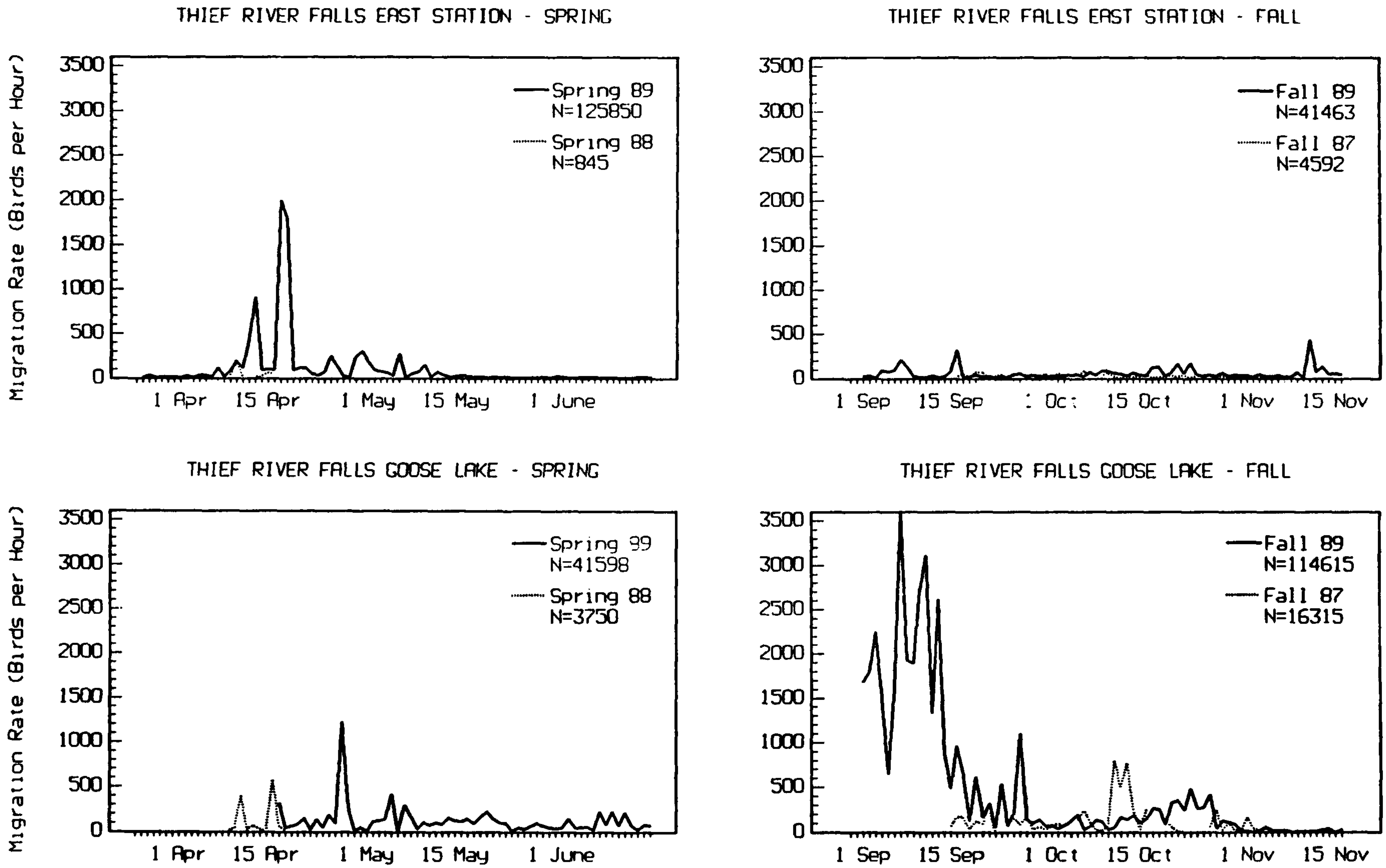
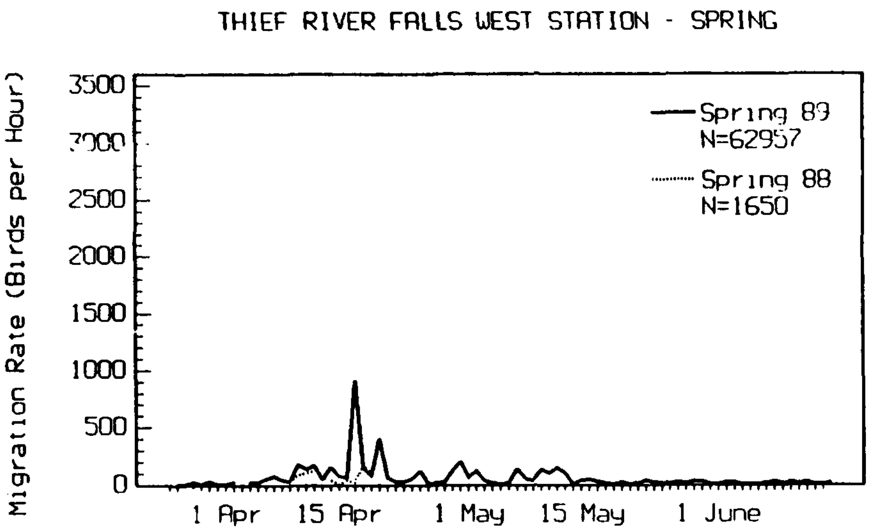
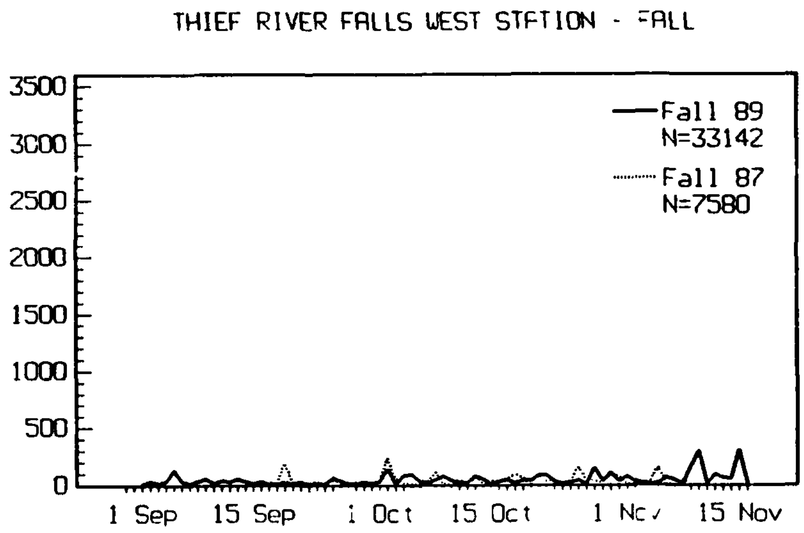


FIGURE 8-69. THIEF RIVER FALLS, MN RECEIVE STUDY AREA DIURNAL MIGRATION RATES - ALL PASSERINES





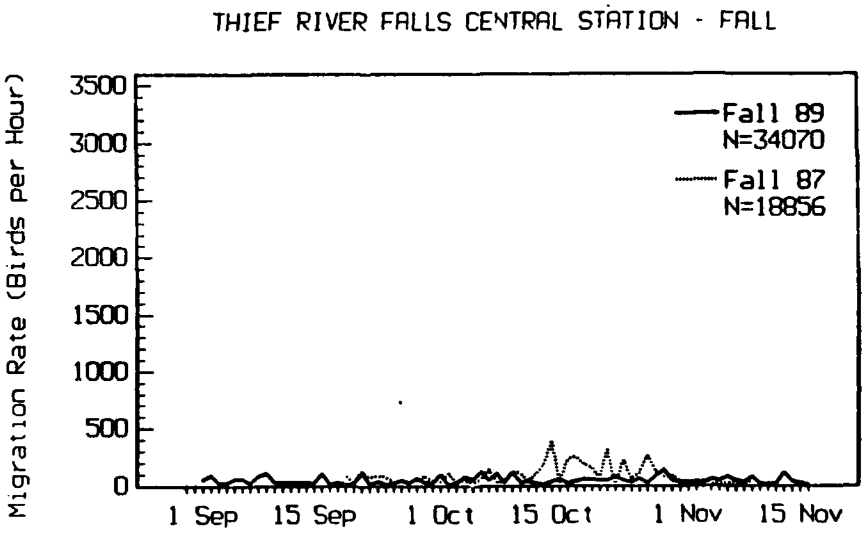


FIGURE 8-69. THIEF RIVER FALLS, MN RECEIVE STUDY AREA
DIURNAL MIGRATION RATES - ALL PASSERINES (CONTINUED)

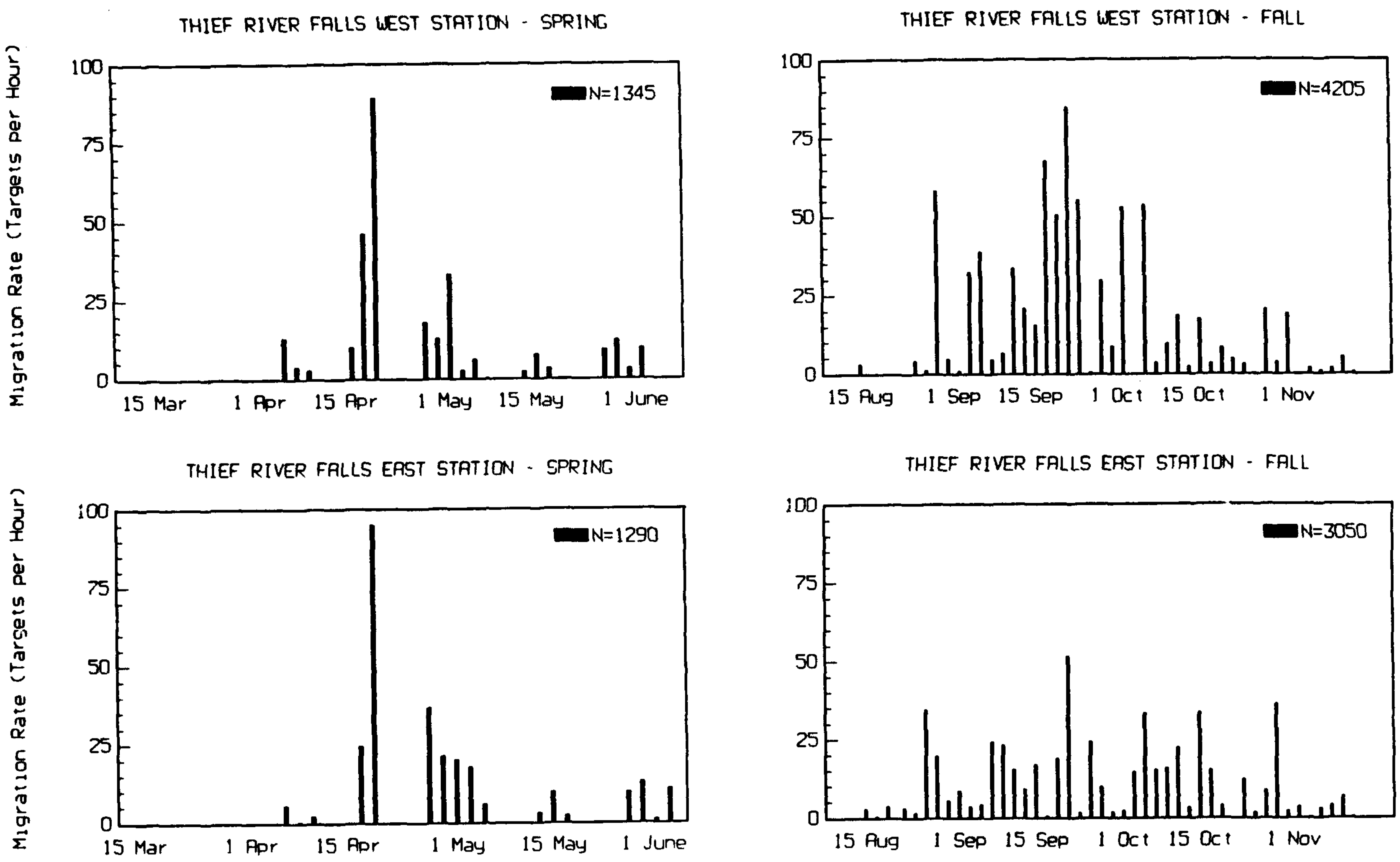


FIGURE 8-70. THIEF RIVER FALLS, MN RECEIVE STUDY AREA NOCTURNAL MIGRATION RATES - LONG-RANGE RADAR

TABLE 8-30. PEAK NIGHTLY MIGRATION RATES (TARGETS PER HOUR) OBSERVED USING RADAR DURING NOCTURNAL AND CREPUSCULAR HOURS AT THE THIEF RIVER FALLS RECEIVE STUDY AREA

	Peak Rate [Targets per Hour] (Date)			
	Long-Range		Short-Range	
Season	West Station	East Station	West Station	East Station
Spring 89	89.2 (20 Apr)	95.0 (19 Apr)	662.9 (18 Apr)	346.8 (19 Apr)
Fall 89	84.6 (22 Sep)	51.5 (21 Sep)	855.3 (18 Sep)	1535.1 (9 Sep)

Short-range radar generally samples a higher proportion of smaller birds, such as passerines and shorebirds, within a radius of about three-quarters of a mile of the radar location, although larger birds are also observed if they are within range. During spring 1989, migration rates, as measured by short-range radar, were generally highest during mid-April and early May at both stations, although sampling was not continuous. Peak rates were much higher at the West station in spring (Fig. 8-71; Table 8-30).

During fall 1989 migration, short-range rates were generally highest during the first three weeks of September at the West station and during mid-September and early to mid-October at the East station (Fig. 8-71). Peak rates were much higher at the East station (1535 targets per hour) than at the West station (855 targets per hour) (Fig. 8-71; Table 8-30).

Although difficult to compare for reasons stated above, peak rates appeared to be higher in the fall at both stations, using short-range radar, with the difference in rates much greater between seasons at the East station (Fig. 8-71; Table 8-30).

8.2.4.2.3 Time of day comparison. Analysis of concurrent radar and station observations has shown that most data collected using the two techniques are not directly comparable (ABR, 1988a; 1988b; 1988c). Because of this, migration rates were compared during daylight, twilight (dawn and dusk), and nocturnal periods using radar data only. In the spring, mean migration rates were lowest, as measured by both short-range and long-range radar, during

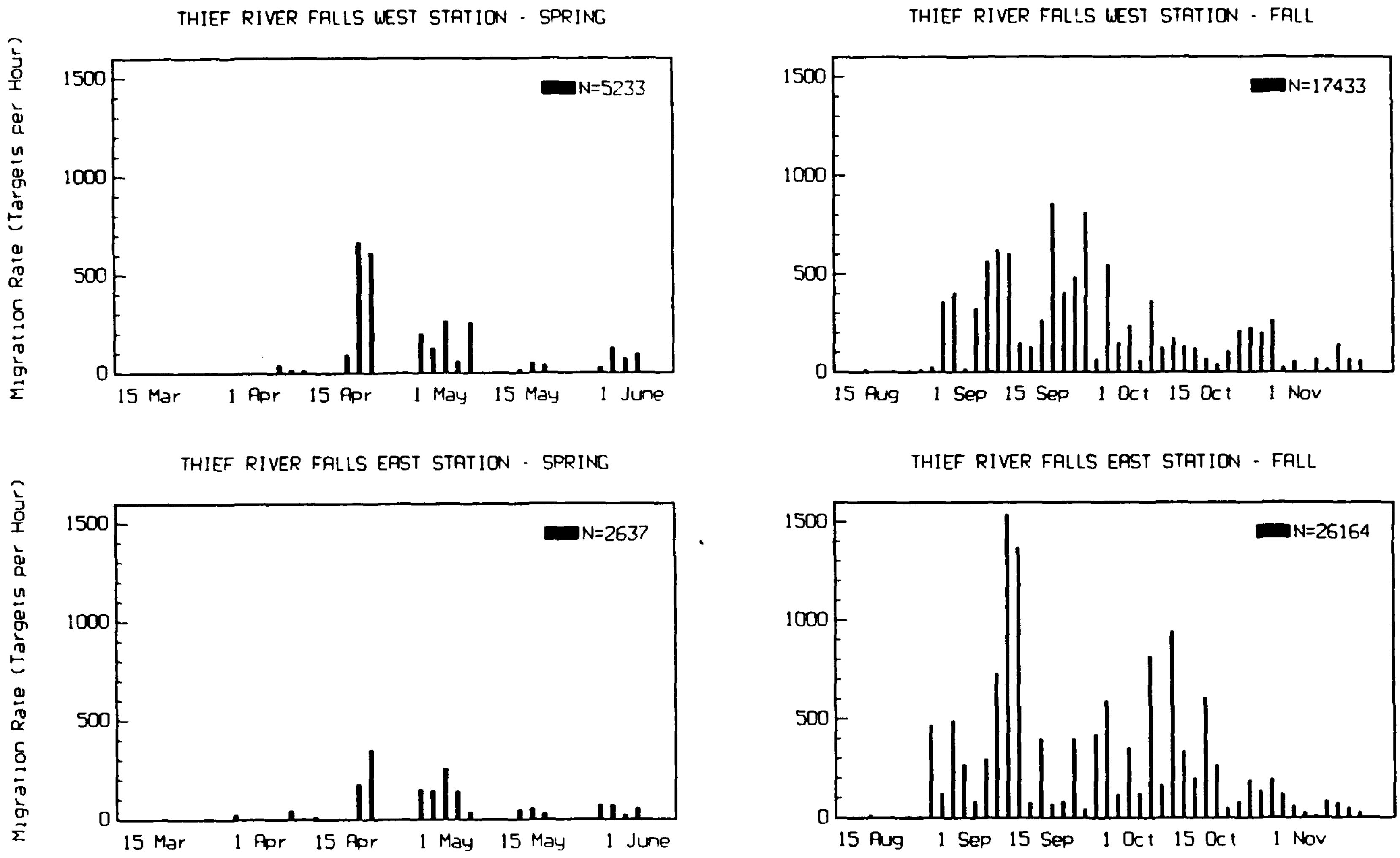


FIGURE 8-71. THIEF RIVER FALLS, MN RECEIVE STUDY AREA NOCTURNAL MIGRATION RATES - SHORT-RANGE RADAR

twilight hours and highest during daylight hours, except during short-range sampling at the West station, when nocturnal rates were highest (Table 8-31). In the fall, mean migration rates were lowest during daylight hours using both short-range and long-range settings, except during short-range sampling at the East station, when twilight rates were lowest. The highest rates occurred during nocturnal hours at both stations with both range settings in fall (Table 8-31).

TABLE 8-31. MEAN MIGRATION RATES (TARGETS PER HOUR) AT THE THIEF RIVER FALLS RECEIVE STUDY AREA DURING DIFFERENT PERIODS OF THE DAY AS MEASURED BY LONG-RANGE AND SHORT-RANGE RADAR

Study	Period of Day	Long-Range		Short-Range	
		West	East	West	East
Spring 1989	Daylight Hours	18.3	23.2	132.9	167.1
	Twilight Hours	13.6	9.6	84.9	80.1
	Nocturnal Hours	16.7	18.5	177.8	120.8
Fall 1989	Daylight Hours	4.9	7.0	73.1	131.5
	Twilight Hours	11.5	6.5	93.2	110.7
	Nocturnal Hours	18.6	13.1	233.0	300.9

8.2.4.2.4 Weather effects. Birds generally migrate during fair weather, and migration rates tend to be lower during poor weather conditions (Richardson, 1978). An analysis was conducted for four species groups comparing migration rates during periods of poor weather (defined by the presence of either snow or rain) with periods of fair weather (defined by the lack of precipitation) (Table 8-32). However, visibility is usually reduced during periods of precipitation, especially during snow storms, and this may bias the results by causing fewer birds to be observed during periods of precipitation than during periods of fair weather. Since the sampling period for spring 1988 studies was so short, data from this season are not used in this analysis. Also, the Central station was not sampled in spring 1989, so little spring data exist for this station.

Sandhill cranes and raptors both migrated at the highest rates during fair weather periods at all stations (Table 8-32). Cranes, especially, were rarely observed flying during periods of precipitation. Passerines also flew mostly

TABLE 8-32. EFFECTS OF PRECIPITATION ON MIGRATION RATE AT THE THIEF RIVER FALLS RECEIVE STUDY AREA DURING DAYLIGHT HOURS

Species Group	Study	Migration Rate (Birds per Hour) No Precipitation	Rain	Snow[1]
WEST STATION				
Sandhill cranes	Fall 87	0.26	0.00	0.00
	Spring 89	2.66	0.21	0.00
	Fall 89	2.14	0.94	0.03
Waterfowl	Fall 87	20.61	1.09	15.31
	Spring 89	95.27	87.11	23.66
	Fall 89	32.86	11.97	51.44
Raptors	Fall 87	0.87	0.08	0.00
	Spring 89	0.41	0.11	0.30
	Fall 89	0.94	0.52	0.41
Passerines	Fall 87	34.34	4.19	11.22
	Spring 89	67.85	26.16	11.62
	Fall 89	43.01	12.69	69.28
CENTRAL STATION				
Sandhill cranes	Fall 87	1.17	0.00	0.00
	Spring 89	----	----	----
	Fall 89	3.11	0.24	0.26
Waterfowl	Fall 87	34.14	19.29	94.14
	Spring 89	----	----	----
	Fall 89	30.55	20.42	9.62
Raptors	Fall 87	1.16	1.13	0.62
	Spring 89	----	----	----
	Fall 89	0.99	0.71	0.41
Passerines	Fall 87	85.36	54.82	30.56
	Spring 89	----	----	----
	Fall 89	44.49	37.32	22.49
EAST STATION				
Sandhill cranes	Fall 87	0.43	0.18	0.00
	Spring 89	4.10	0.74	2.85
	Fall 89	1.53	0.00	0.00

TABLE 8-32 (Continued) . EFFECTS OF PRECIPITATION ON MIGRATION RATE AT THE THIEF RIVER FALLS RECEIVE STUDY AREA DURING DAYLIGHT HOURS

Species Group	Study	Migration Rate (Birds per Hour)		
		No Precipitation	Rain	Snow[1]
Waterfowl	Fall 87	61.80	2.86	14.19
	Spring 89	43.65	26.23	168.26
	Fall 89	41.65	15.05	42.97
Raptors	Fall 87	0.55	0.27	0.50
	Spring 89	0.35	0.15	0.31
	Fall 89	0.85	0.37	0.20
Passerines	Fall 87	22.09	20.04	4.01
	Spring 89	134.65	37.35	9.28
	Fall 89	55.10	30.82	38.72

1. Includes sleet and hail.

during periods of fair weather, except that they were observed flying at the highest rate during periods of snow at the West station in the fall of 1989 (Table 8-32). Waterfowl were often observed migrating at moderately high rates during periods of snow, especially in the fall. This is expected since many species of waterfowl do not leave this region until open water becomes unavailable and cold weather drives them south, the same period when snow commonly occurs. Trends for waterfowl were similar among stations (Table 8-32).

The effects of wind speed (measured at ground level) on migration rates were also examined (Table 8-33). Sandhill cranes did not exhibit any clear trends, although rates were often high during periods when winds exceeded 15 mph. Raptors and waterfowl usually took advantage of strong tailwinds, with rates generally highest during strong southerly winds in the spring and during strong northerly winds in the fall (Table 8-33). Trends for passerines were not clear, except at the Central station where rates were highest during low (less than 15 mph) wind conditions.

8.2.4.3 Flight Altitude. Flight altitude data were collected from the observation stations using discrete altitude categories in fall 1987 and spring 1988. In spring and fall 1989, altitude was directly estimated as well as calculated from field measurements of angle and distance (see UMN, 1989a; 1989b). Data from these seasons were converted to altitude categories to allow for comparisons with fall 1987 and spring 1988 data. The OTH-B Central Radar System receive antenna structures will have a maximum height of approximately 65 feet (Technical Study 2). The nearest breakpoints to the maximum height of the antenna structure used in data collection are 50 and 100 feet agl. Results are usually reported for both of these altitudes (i.e. percentage below 50 feet agl and percentage below 100 feet agl). However, in the figures and discussion to follow, the term "below maximum antenna height" is defined as below 100 feet agl. However, 35 feet of this total height will not be occupied by project structures (i.e. heights between 65 and 100 feet agl), and the 100 foot height is used to estimate potential impacts on a "worst case" basis.

8.2.4.3.1 Daylight periods. A decrease in detectability with increasing altitude, which is more severe for smaller birds but occurs for larger-bodied birds as well, has been shown to occur during periods of concurrent radar observations during studies for the USAF's Alaska Radar System (ABR, 1988a; 1988b; 1988c). Thus, it is likely that the proportion of birds flying in the lower altitude categories is overestimated relative to the higher categories by the visual observation techniques used during daylight hours.

Flight altitudes were generally higher for all species groups, but especially for waterfowl, in fall than in spring, except for raptors, gamebirds, shorebirds, and passerines which were similar between seasons. In general, altitudes were highest at the West station for passerines, at the East station for raptors, at the Central station for ducks, geese/cormorants, swans (and all waterfowl), sandhill cranes, and waterbirds, and at the Goose Lake station for shorebirds. Gamebirds had similar altitude distributions at all stations (Figs. 8-72 to 8-82; Table 8-34). The preceding was for all seasons combined, but since altitudes were generally higher in fall than in spring and the Central station was sampled very little in the spring, these results may be biased. A comparison among stations during fall only (when adequate samples existed at all stations) showed that swans, ducks, geese/cormorants (all waterfowl), and raptors flew highest at the East station while only sandhill cranes and waterbirds flew highest at the Central station, although altitudes were only slightly lower for swans than at the East station. Shorebirds and passerines flew highest at Goose Lake and no groups flew highest at the West station (Table 8-34; Figs. 8-72 to 8-82).

For ducks, 40.4% flew below 100 feet agl (26.8% below 50 feet agl) at the West station, 40.9% flew below 100 feet agl (7.7% below 50 feet agl) at the Central station, 46.1% flew below 100 feet agl (39.3% below 50 feet agl) at the East station, while 57.1% flew below 100 feet agl (21.1% below 50 feet agl) at the Goose Lake station (Fig. 8-72; Table 8-34).

For geese/cormorants, 26.6% (15.9%) flew below 100 (50) feet agl at the West station versus 8.6% (1.0%) below 100 (50) feet agl for the Central station, 22.6% (12.6%) below 100 (50) feet agl at the East station, and 28.0% (13.3%) below 100 (50) feet agl at the Goose Lake station (Fig. 8-73; Table 8-34).

TABLE 8-33. EFFECTS OF WIND SPEED ON MIGRATION RATE AT THE THIEF RIVER FALLS RECEIVE STUDY AREA DURING DAYLIGHT HOURS

Species Group	Study	Migration Rate (Birds per Hour)			
		No wind	1-15 MPH	>15 MPH NORTH(1)	>15 MPH SOUTH(2)
WEST STATION					
Sandhill cranes	Fall 87	0.00	0.35	0.09	0.27
	Spring 89	0.00	2.48	1.47	2.56
	Fall 89	----	2.57	2.25	0.00
Waterfowl	Fall 87	21.35	21.16	9.85	35.39
	Spring 89	0.00	94.52	66.31	146.95
	Fall 89	----	31.28	78.34	3.30
Raptors	Fall 87	0.68	0.72	0.99	1.27
	Spring 89	1.50	0.36	0.47	0.36
	Fall 89	----	0.79	1.51	0.74
Passerines	Fall 87	17.90	29.78	47.54	47.05
	Spring 89	2.26	71.65	49.73	62.50
	Fall 89	----	44.43	45.22	38.33
CENTRAL STATION					
Sandhill cranes	Fall 87	2.87	0.89	0.00	2.27
	Spring 89	----	----	----	----
	Fall 89	0.00	3.71	2.40	0.06
Waterfowl	Fall 87	3.78	37.44	61.52	16.73
	Spring 89	----	----	----	----
	Fall 89	0.00	31.01	49.85	10.77
Raptors	Fall 87	0.67	1.09	1.91	1.20
	Spring 89	----	----	----	----
	Fall 89	0.69	0.80	1.78	0.84
Passerines	Fall 87	59.36	92.95	75.46	65.60
	Spring 89	----	----	----	----
	Fall 89	1.39	47.14	40.06	27.59
EAST STATION					
Sandhill cranes	Fall 87	0.10	0.36	0.38	1.79
	Spring 89	1.15	3.06	1.52	8.23
	Fall 89	----	1.52	3.07	0.06

TABLE 8-33 (Continued). EFFECTS OF WIND SPEED ON MIGRATION RATE AT THE THIEF RIVER FALLS RECEIVE STUDY AREA DURING DAYLIGHT HOURS

Species Group	Study	Migration Rate (Birds per Hour)			
		No wind	1-15 MPH	>15 MPH NORTH[1]	>15 MPH SOUTH[2]
Waterfowl	Fall 87	103.84	32.90	138.51	26.15
	Spring 89	4.16	30.98	50.76	103.90
	Fall 89	----	46.59	72.81	8.85
Raptors	Fall 87	0.29	0.43	1.11	0.75
	Spring 89	0.23	0.34	0.28	0.41
	Fall 89	----	0.58	1.33	0.64
Passerines	Fall 87	13.09	22.92	19.97	26.90
	Spring 89	12.93	125.77	142.51	94.79
	Fall 89	----	44.11	82.66	47.00

1. Includes northwest, north, and northeast winds.
2. Includes southwest, south, and southeast winds.

TABLE 8-34. PERCENTAGE OF BIRDS FLYING BELOW THE MAXIMUM HEIGHT OF THE ANTENNA STRUCTURE DURING DAYLIGHT HOURS AT THE THIEF RIVER FALLS RECEIVE STUDY AREA - STATION OBSERVATIONS

Species Group	Season	Flight Altitude (Percentage)							
		West Station		Central Station		East Station		Goose Lake	
		< 50 ft	< 100 ft	< 50 ft	< 100 ft	< 50 ft	< 100 ft	< 50 ft	< 100 ft
Waterfowl	Fall 87	3.7	16.4	0.9	10.4	1.0	6.0	15.8	38.3
	Spring 88	21.3	91.3	0.0	21.7	34.9	72.6	22.6	83.3
	Spring 89	22.0	34.6	---	---	29.3	42.7	28.9	55.9
	Fall 89	1.0	5.3	1.7	11.6	0.8	6.2	17.9	46.8
	Total	17.0	28.0	1.5	11.4	15.9	25.5	19.0	48.5
-Ducks	Fall 87	0.0	53.8	2.3	25.6	5.6	9.7	14.4	47.8
	Spring 88	7.1	28.4	0.0	100.0	58.1	98.0	23.5	91.9
	Spring 89	27.8	40.6	---	---	45.5	51.6	55.6	81.3
	Fall 89	7.4	34.7	11.9	52.6	6.8	13.3	20.2	54.3
	Total	26.8	40.4	7.7	40.9	39.3	46.1	21.1	57.1
-Geese/Cormorants	Fall 87	3.7	15.9	0.0	3.5	0.7	5.8	15.4	21.1
	Spring 88	23.0	99.1	0.0	21.2	7.0	43.0	20.3	55.5
	Spring 89	21.1	33.7	---	---	25.5	40.4	18.0	45.5
	Fall 89	0.6	4.4	1.3	10.0	0.6	6.1	9.1	18.4
	Total	15.9	26.6	1.0	8.6	12.6	22.6	13.3	28.0
-Swans	Fall 87	0.0	0.0	---	---	---	---	---	---
	Spring 88	---	---	---	---	---	---	35.3	76.5
	Spring 89	35.2	56.1	---	---	52.4	68.1	26.6	26.6
	Fall 89	9.8	18.8	0.0	2.1	0.0	0.0	0.0	18.9
	Total	29.1	47.2	0.0	2.1	33.5	43.5	16.9	33.2
Raptors	Fall 87	60.2	76.4	57.5	78.2	33.9	46.9	45.8	65.2
	Spring 88	65.2	82.6	54.6	72.8	72.7	81.8	75.0	78.1
	Spring 89	41.9	53.0	---	---	48.1	61.9	71.4	90.5
	Fall 89	60.0	74.8	49.0	66.9	43.9	60.2	74.1	81.7
	Total	55.1	69.1	51.2	69.9	44.5	59.5	66.1	78.7

TABLE 8-34 (Continued). PERCENTAGE OF BIRDS FLYING BELOW THE MAXIMUM HEIGHT OF THE ANTENNA STRUCTURE DURING DAYLIGHT HOURS AT THE THIEF RIVER FALLS RECEIVE STUDY AREA - STATION OBSERVATIONS

Species Group	Season	Flight Altitude (Percentage)							
		West Station		Central Station		East Station		Goose Lake	
		< 50 ft	< 100 ft	< 50 ft	< 100 ft	< 50 ft	< 100 ft	< 50 ft	< 100 ft
-Eagles/Hawks	Fall 87	34.3	61.4	37.5	65.8	17.4	37.0	13.2	41.1
	Spring 88	16.7	50.0	0.0	0.0	0.0	0.0	14.3	42.9
	Spring 89	45.6	56.5	---	---	18.6	39.1	41.7	66.7
	Fall 89	22.7	48.5	18.5	44.8	19.6	41.5	25.0	47.2
	Total	30.8	52.6	23.0	49.6	19.1	40.3	20.7	45.9
-Harriers	Fall 87	90.6	96.5	92.6	97.8	95.5	100.0	86.6	97.0
	Spring 88	79.8	100.0	100.0	100.0	100.0	100.0	91.3	95.7
	Spring 89	75.7	87.8	---	---	90.1	94.5	87.4	97.2
	Fall 89	93.6	97.3	92.5	97.1	89.7	96.2	95.7	99.0
	Total	90.4	95.9	92.7	97.3	90.6	96.1	91.9	98.0
-Falcons	Fall 87	80.0	100.0	66.7	93.3	53.4	53.4	33.3	33.3
	Spring 88	100.0	100.0	0.0	66.7	0.0	100.0	100.0	100.0
	Spring 89	54.7	83.3	---	---	78.6	81.0	50.0	50.0
	Fall 89	67.9	86.8	67.8	85.7	53.7	76.1	85.7	85.7
	Total	65.8	87.7	65.6	86.3	61.6	75.2	76.2	76.2
-Owls	Fall 87	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	Spring 88	---	---	---	---	---	---	---	---
	Spring 89	100.0	100.0	---	---	0.0	100.0	100.0	100.0
	Fall 89	83.3	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	Total	88.9	100.0	100.0	100.0	75.0	100.0	100.0	100.0
Shorebirds	Fall 87	62.4	99.1	70.1	88.3	61.4	91.4	41.1	89.7
	Spring 88	77.3	100.0	16.7	91.7	92.9	100.0	50.0	75.0
	Spring 89	56.4	71.9	---	---	68.9	83.0	34.5	76.2
	Fall 89	75.0	83.6	86.3	89.9	51.3	79.8	31.7	82.2
	Total	70.2	82.8	85.1	89.8	59.4	82.9	33.9	81.9

TABLE 8-34 (Continued). PERCENTAGE OF BIRDS FLYING BELOW THE MAXIMUM HEIGHT OF THE ANTENNA STRUCTURE DURING DAYLIGHT HOURS AT THE THIEF RIVER FALLS RECEIVE STUDY AREA - STATION OBSERVATIONS

Species Group	Season	Flight Altitude (Percentage)							
		West Station		Central Station		East Station		Goose Lake	
		< 50 ft	< 100 ft	< 50 ft	< 100 ft	< 50 ft	< 100 ft	< 50 ft	< 100 ft
Sandhill cranes	Fall 87	7.1	37.5	12.8	22.8	27.6	33.3	35.8	58.7
	Spring 88	0.0	0.0	51.6	89.0	12.3	14.9	69.1	75.1
	Spring 89	24.8	34.7	---	---	29.4	50.5	57.7	91.2
	Fall 89	0.3	3.4	0.0	6.2	0.1	1.2	17.3	30.1
	Total	14.4	21.8	2.6	9.9	21.4	36.7	41.5	61.0
Waterbirds	Fall 87	0.0	100.0	100.0	100.0	50.0	100.0	86.8	86.8
	Spring 88	33.0	100.0	---	---	63.7	81.8	25.0	100.0
	Spring 89	18.1	37.3	---	---	16.6	25.6	22.1	34.8
	Fall 89	0.4	12.9	1.1	6.9	6.1	7.5	1.2	7.8
	Total	12.2	29.2	1.1	6.9	13.4	20.0	11.5	20.8
Gamebirds	Fall 87	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	Spring 88	---	---	---	---	---	---	100.0	100.0
	Spring 89	100.0	100.0	---	---	69.5	100.0	100.0	100.0
	Fall 89	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	Total	100.0	100.0	100.0	100.0	94.4	100.0	100.0	100.0
Passerines	Fall 87	71.1	92.5	69.4	90.2	63.1	88.1	52.6	86.6
	Spring 88	52.7	94.7	59.2	100.0	29.7	85.1	96.5	98.9
	Spring 89	47.9	70.9	---	---	77.1	90.3	83.9	99.1
	Fall 89	76.8	92.3	68.0	91.8	65.9	93.5	52.2	80.6
	Total	59.0	79.8	68.3	91.5	73.8	91.0	60.7	85.9
-Blackbirds	Fall 87	79.6	99.1	77.8	96.3	36.0	67.3	51.0	85.8
	Spring 88	14.2	100.0	94.7	100.0	50.0	100.0	87.6	98.8
	Spring 89	55.3	72.0	---	---	78.8	90.2	86.2	99.5
	Fall 89	61.5	90.0	61.8	94.2	75.6	98.0	54.8	82.8
	Total	58.2	77.4	70.1	95.3	76.2	91.8	62.7	87.5

TABLE 8-34 (Continued). PERCENTAGE OF BIRDS FLYING BELOW THE MAXIMUM HEIGHT OF THE ANTENNA STRUCTURE DURING DAYLIGHT HOURS AT THE THIEF RIVER FALLS RECEIVE STUDY AREA - STATION OBSERVATIONS

Species Group	Season	Flight Altitude (Percentage)							
		West Station		Central Station		East Station		Goose Lake	
		< 50 ft	< 100 ft	< 50 ft	< 100 ft	< 50 ft	< 100 ft	< 50 ft	< 100 ft
-Nonblackbirds	Fall 87	64.7	88.9	65.6	87.9	73.3	94.5	70.3	90.9
	Spring 88	74.0	99.7	49.7	100.0	33.4	79.8	90.7	98.1
	Spring 89	56.2	73.7	---	---	77.9	90.9	84.3	98.9
	Fall 89	79.5	93.1	72.2	90.4	74.3	92.1	55.6	81.0
	Total	68.1	84.4	70.1	90.3	76.9	91.3	67.3	91.1

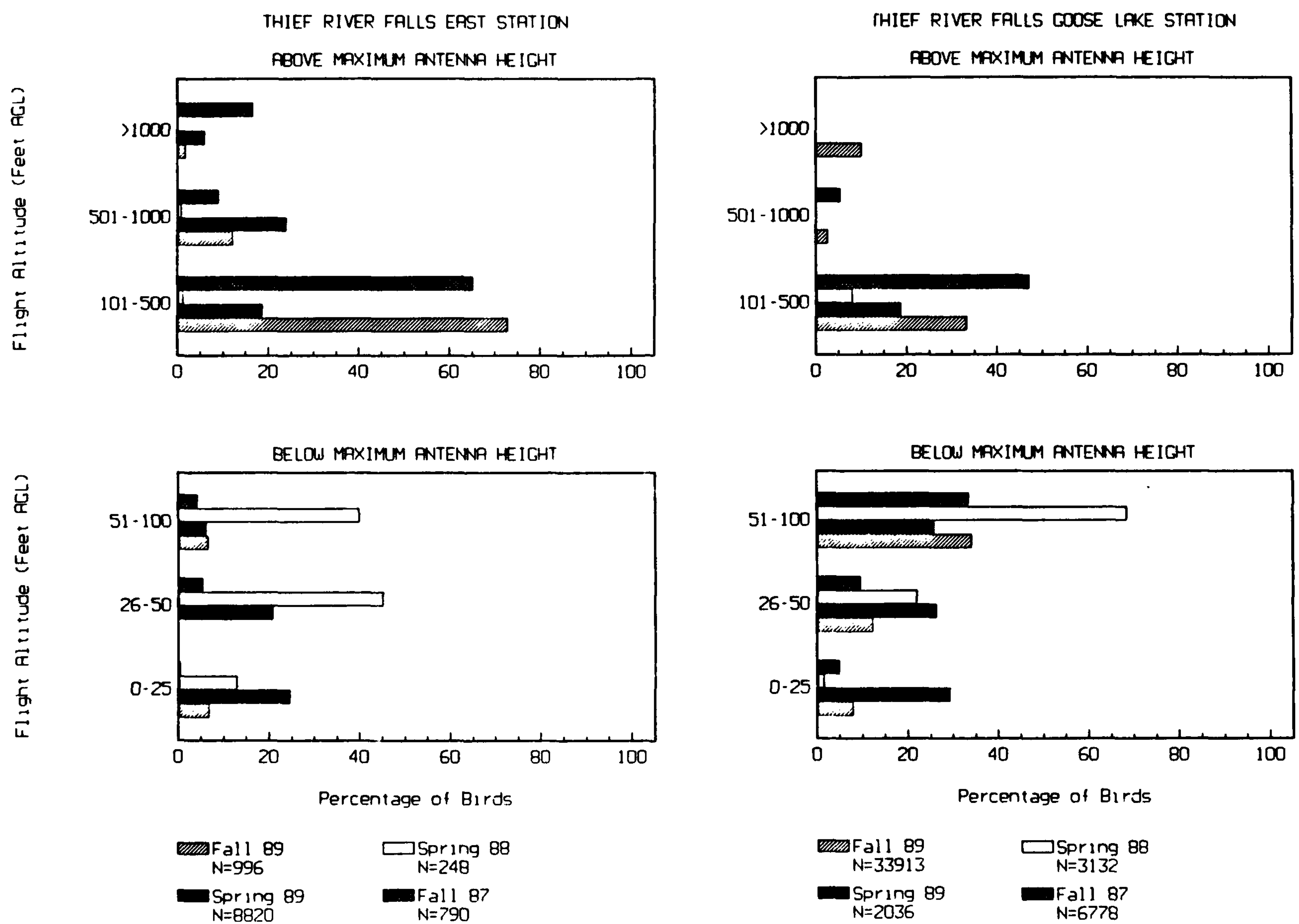


FIGURE 8-72. THIEF RIVER FALLS, MN RECEIVE STUDY AREA DIURNAL FLIGHT ALTITUDES - DUCKS

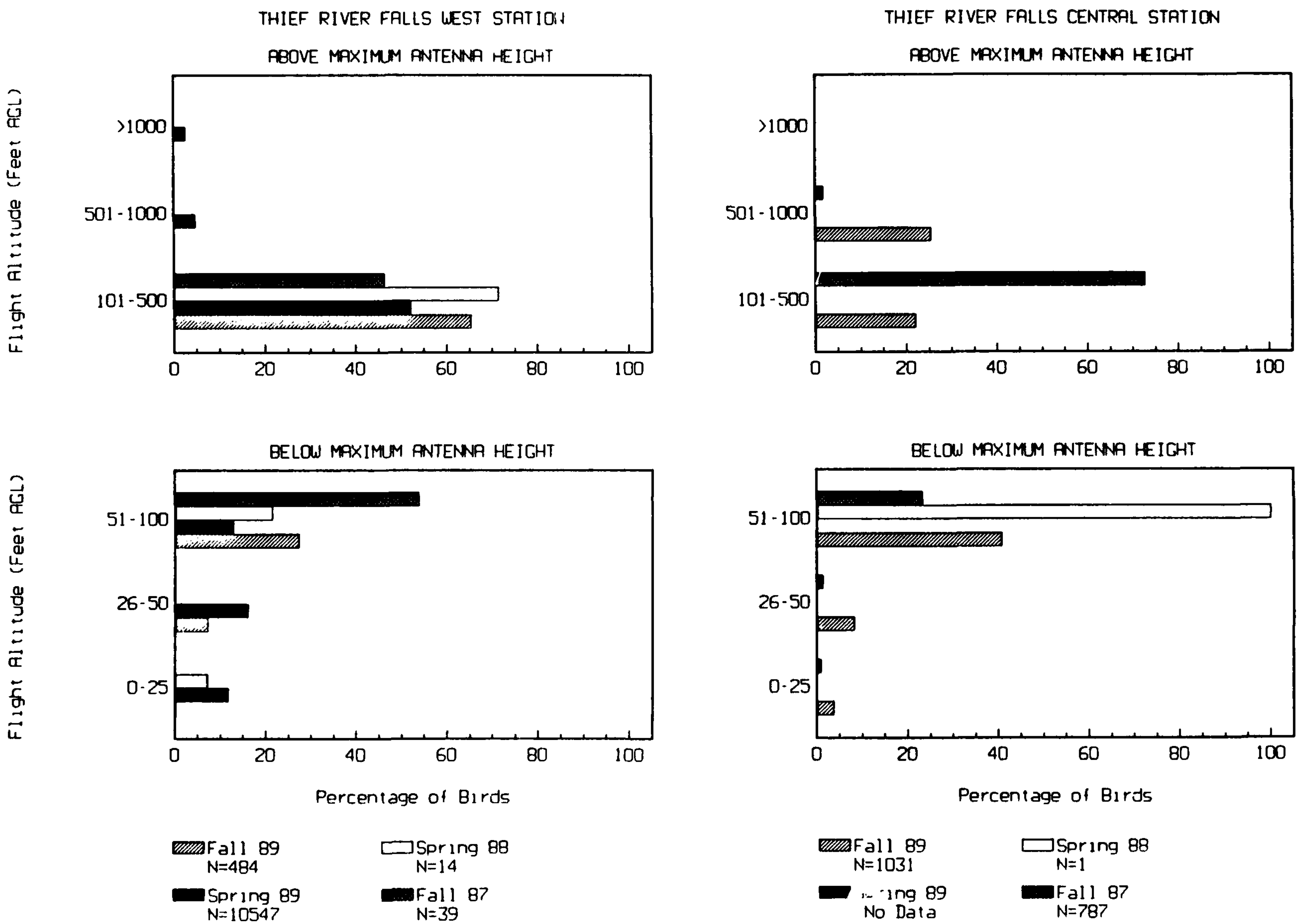


FIGURE 8-72. THIEF RIVER FALLS, MN RECEIVE STUDY AREA DIURNAL FLIGHT ALTITUDES - DUCKS (CONTINUED)

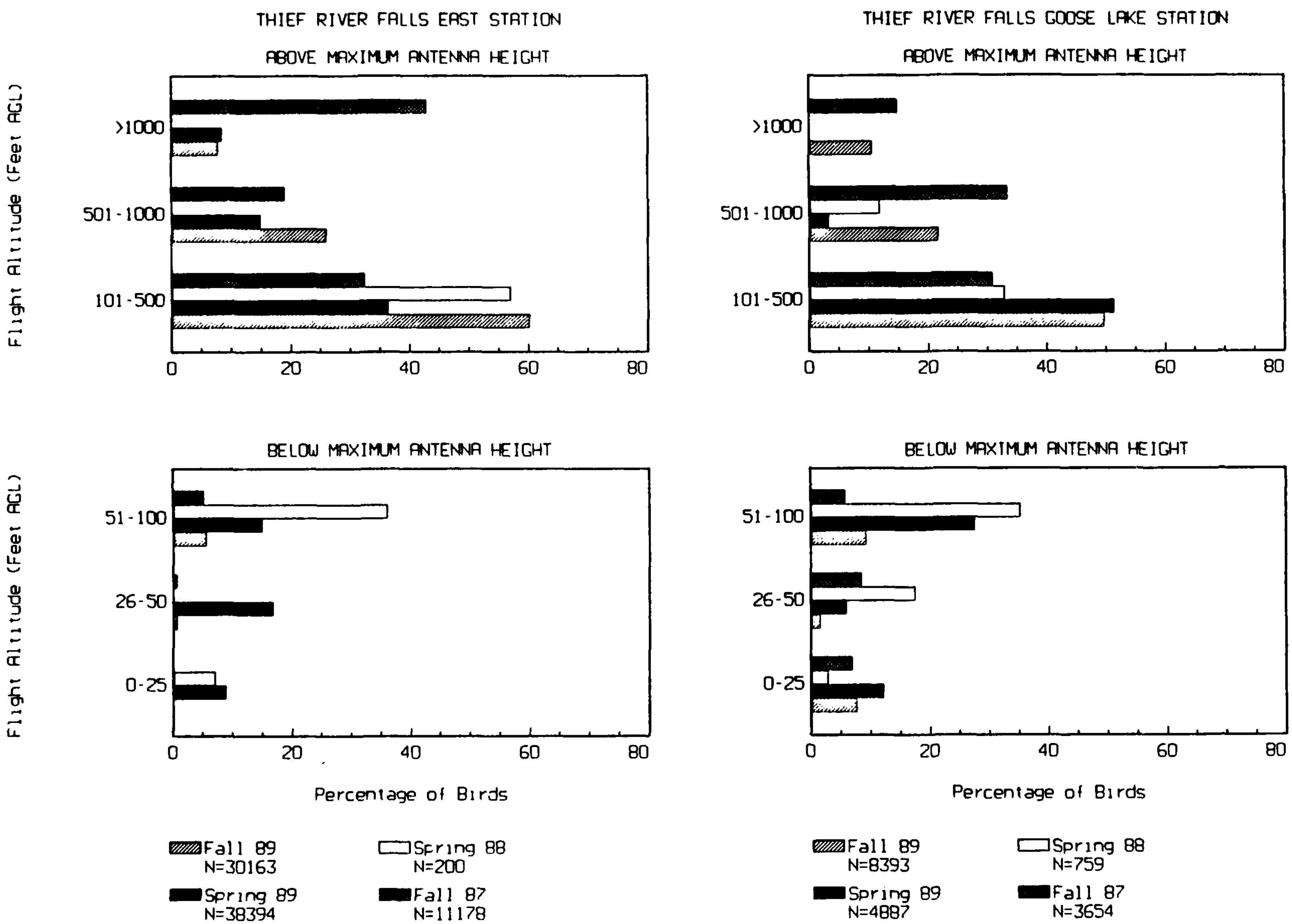


FIGURE 8-73. THIEF RIVER FALLS, MN RECEIVE STUDY AREA DIURNAL FLIGHT ALTITUDES - GEESE/CORMORANTS

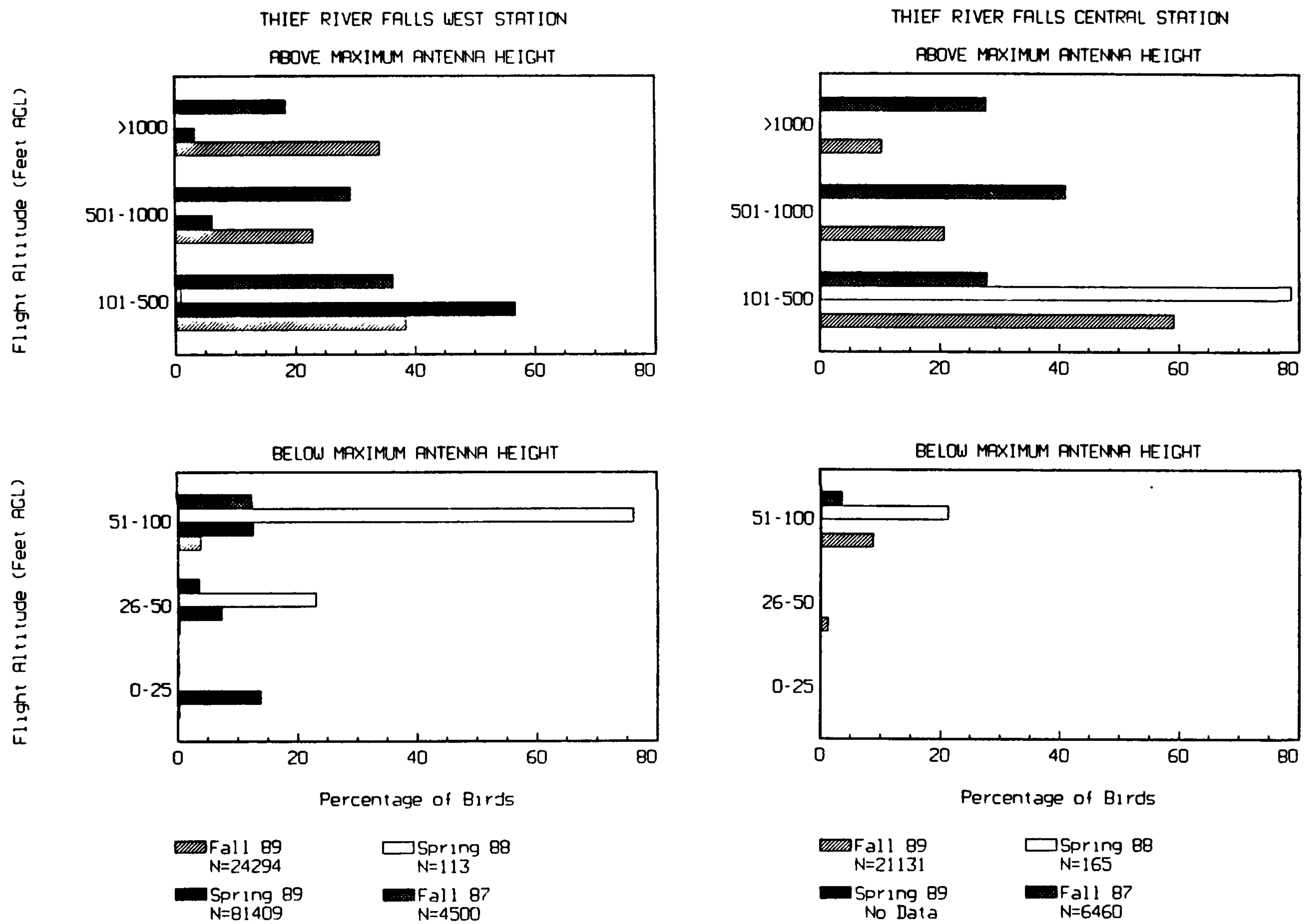


FIGURE 8-73. THIEF RIVER FALLS, MN RECEIVE STUDY AREA DIURNAL FLIGHT ALTITUDES - GEESE/CORMORANTS (CONTINUED)

About half of the swans (47.2%) flew below 100 feet agl (29.1% below 50 feet agl) at the West station while 2.1% (0%) flew below 100 (50) feet agl at the Central station, 43.5% (33.5%) flew below 100 (50) feet agl at the East station, and 33.2% (16.9%) flew below 100 (50) feet agl at the Goose Lake station (Fig. 8-74; Table 8-34). For all waterfowl, the numbers were 28% (17%) below 100 (50) feet agl at the West station, 11.4% (1.5%) below 100 (50) feet agl at the Central station, 25.5% (15.9%) below 100 (50) feet agl at the East station, and 48.5% (19.0%) below 100 (50) feet agl at the Goose Lake station (Fig. 8-75; Table 8-34).

Shorebirds were usually observed flying below 100 feet agl with 82.8% (70.2%) flying below 100 (50) feet agl at the West station, 89.8% (85.1%) observed below 100 (50) feet agl at the Central station, 82.9% (59.4%) below 100 (50) feet agl at the East station, and 81.9% (33.9%) below 100 (50) feet agl at the Goose Lake station (Fig. 8-76; Table 8-34).

At the West station, 21.8% (14.4%) of the sandhill cranes flew below 100 (50) feet agl, 9.9% (2.6%) flew below 100 (50) feet agl at the Central station, 36.7% (21.4%) flew below 100 (50) feet agl at the East station, while 61% (41.5%) flew below 100 (50) feet agl at the Goose Lake station (Fig. 8-77; Table 8-34).

Waterbirds flew below 100 (50) feet agl 29.2% (12.2%) of the time at the West station, 6.9% (1.1%) at the Central station, 20% (13.4%) at the East station versus 20.8% (11.5%) below 100 (50) feet agl at the Goose Lake station (Fig. 8-78; Table 8-34).

Raptors as a group often flew below 100 feet agl with 69.1% (55.1%) flying below 100 (50) feet agl at the West station versus 69.9% (51.2%) below 100 (50) feet agl at the Central station, 59.5% (44.5%) below 100 (50) feet agl at the East station, and 78.7% (66.1%) at the Goose Lake station (Fig. 8-79; Table 8-34). Harriers, falcons, and owls flew lower than eagles and hawks at all stations (Table 8-34). All observed gamebirds flew below the maximum height of the antenna structure at all stations, with nearly all flights below 50 feet agl (Table 8-34).

Passerines flew below 100 (50) feet agl 79.8% (59%) of the time at the West station, 91.5% (68.3%) of the time at the Central station, versus 91% (73.8%) and 85.9% (60.7%) below 100 (50) feet agl at the East and Goose Lake stations, respectively. Blackbirds and nonblackbird passerines had similar altitude distributions at each station (Figs. 8-80; 8-81; 8-82; Table 8-34).

8.2.4.3.2 Nocturnal periods. Nocturnal flight altitudes were sampled using the vertical-beam radar unit, which could sample birds flying at altitudes between about 100 and 5900 feet agl. Because the radiation pattern from this unit was an inverted cone with 12° divergence (ABR, 1989; 1990a), the total airspace sampled was relatively small and the amount of area sampled increased as altitude increased. To correct for this differential sampling with altitude, the data were partitioned into 200 foot altitude categories, and the number of targets in each category was adjusted to correct for the different areas sampled, using the highest altitude category as the standard.

The greatest percentage of targets observed during spring flew between 300 and 500 feet agl at both the East and West radar sampling stations. The altitude distribution was higher at the East station than at the West station (Fig. 8-83).

The flight altitude distribution in the fall was much lower with over half of the targets at each station in the 100 to 300 foot altitude category (Fig. 8-83). Mean nightly altitudes did not vary much throughout the fall season at either station, exceeding 1000 feet agl on only 1 night (1 November) at the West station and two nights (29 October and 10 November) at the East station (ABR, 1990a).

During 1989 studies, night-vision scopes were used to sample birds flying below 100 feet agl, because the vertical-beam radar unit could not sample below this altitude. A total of 950 birds were observed at the two western stations (1A and 1B - see Fig. 8-7) in spring (7.91 birds per hour) while only 8 birds (0.06 birds per hour) were observed at these stations in the fall (Table 8-35). For the one central night-vision station (1C), one bird was observed during each season, for a rate of 0.03 and 0.01 birds per hour for

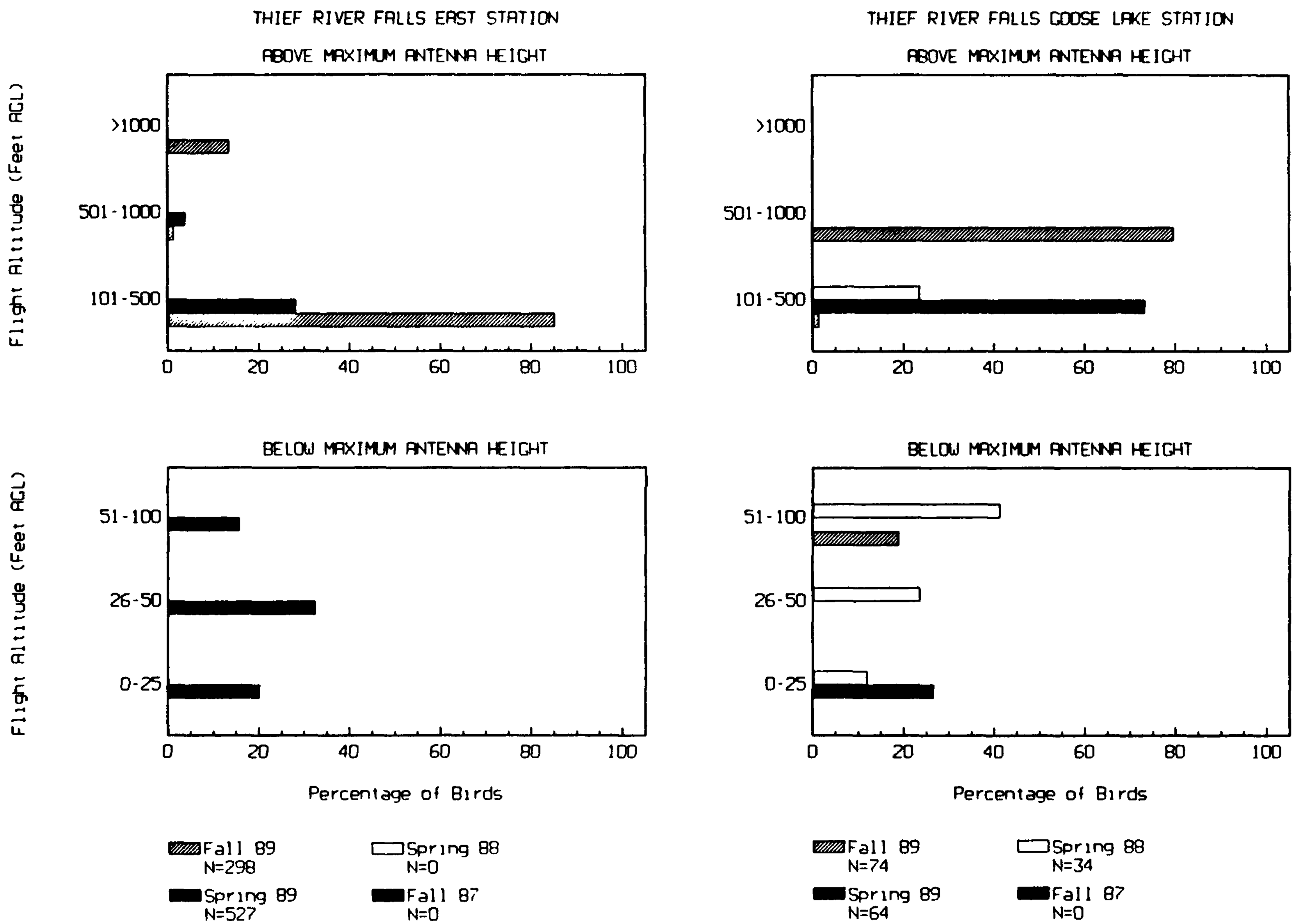


FIGURE 8-74. THIEF RIVER FALLS, MN RECEIVE STUDY AREA DIURNAL FLIGHT ALTITUDES - SWANS

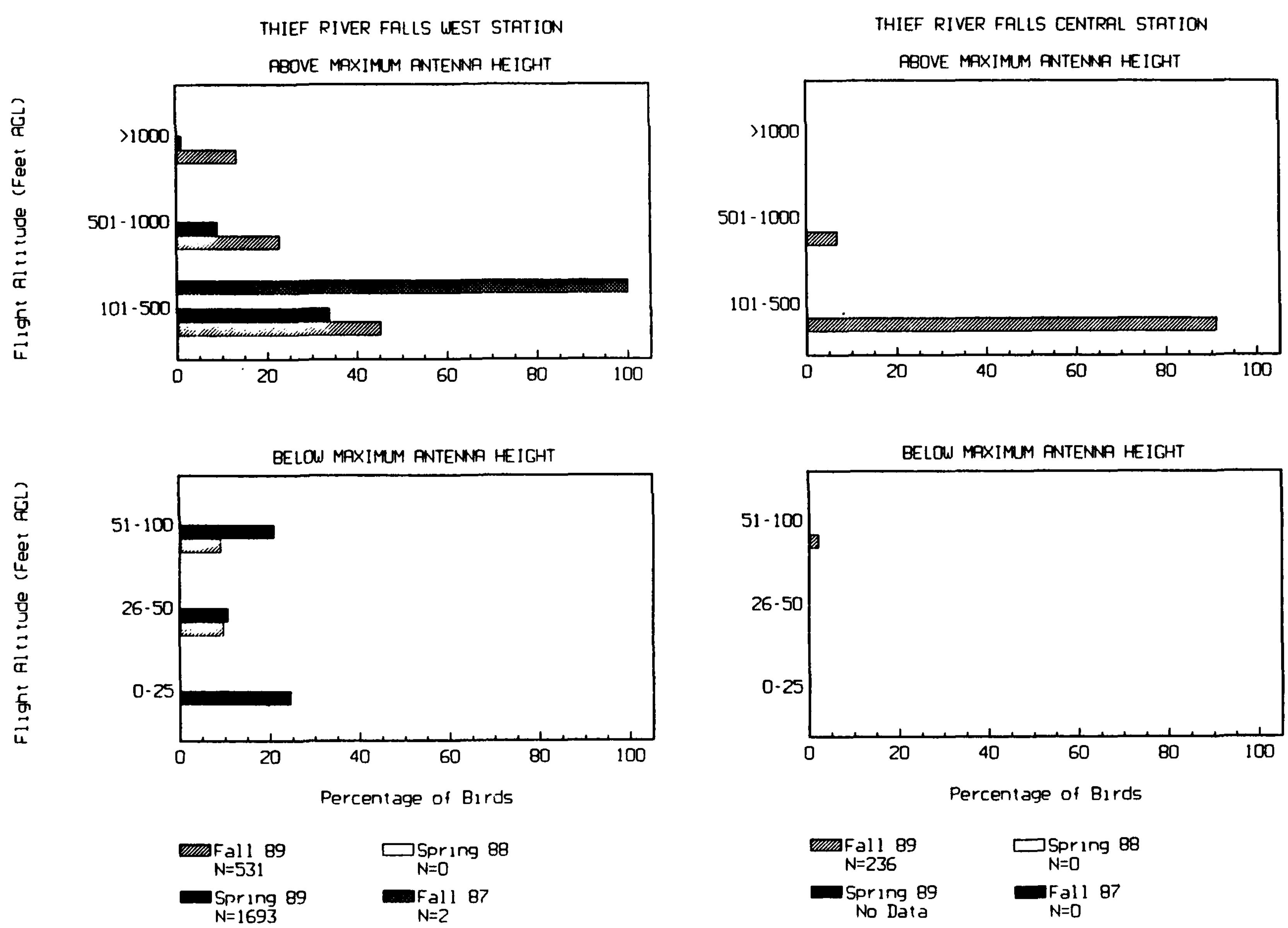


FIGURE 8-74. THIEF RIVER FALLS, MN RECEIVE STUDY AREA DIURNAL FLIGHT ALTITUDES - SWANS (CONTINUED)

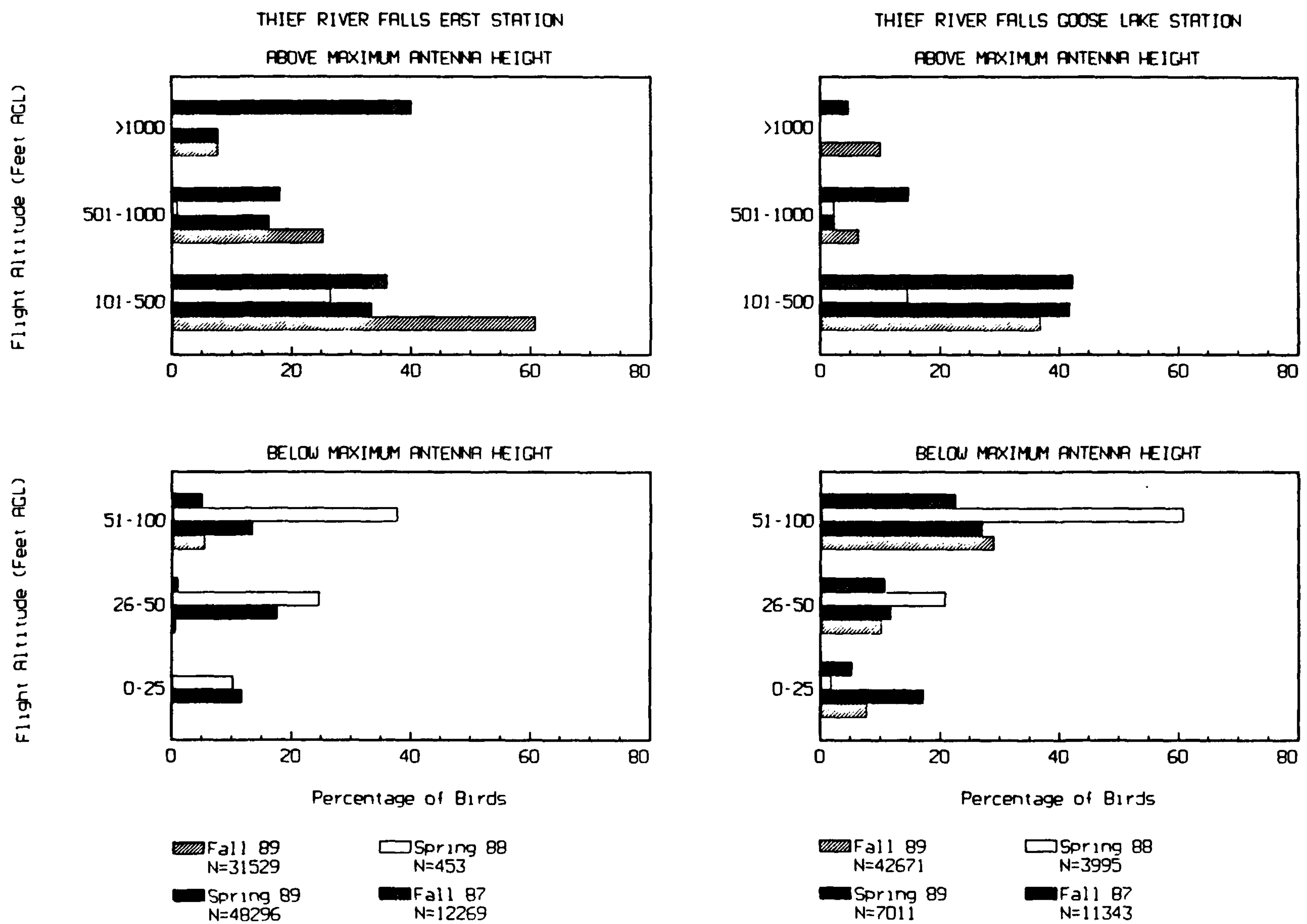


FIGURE 8-75. THIEF RIVER FALLS, MN RECEIVE STUDY AREA DIURNAL FLIGHT ALTITUDES - ALL WATERFOWL

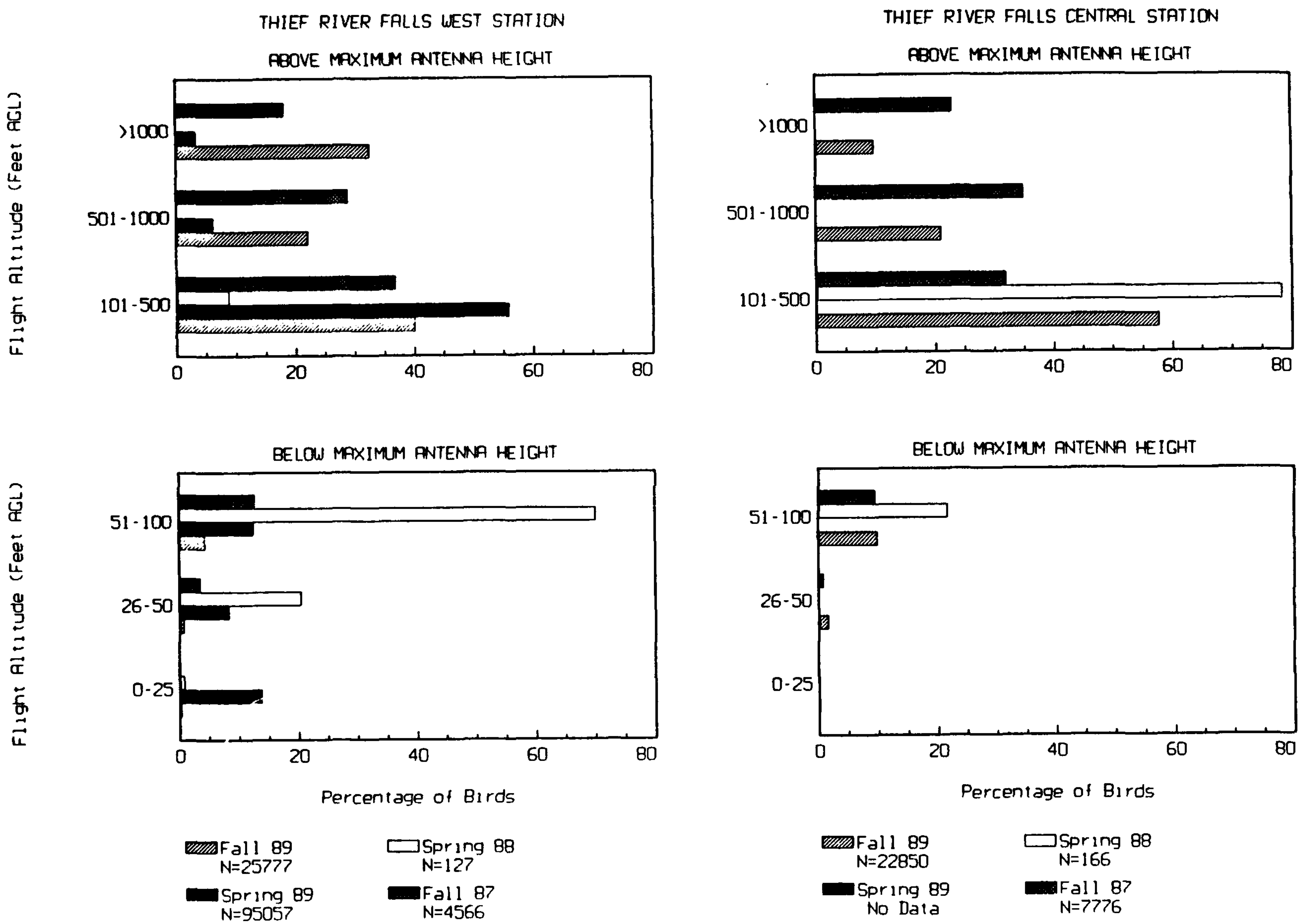


FIGURE 8-75. THIEF RIVER FALLS, MN RECEIVE STUDY AREA DIURNAL FLIGHT ALTITUDES - ALL WATERFOWL (CONTINUED)

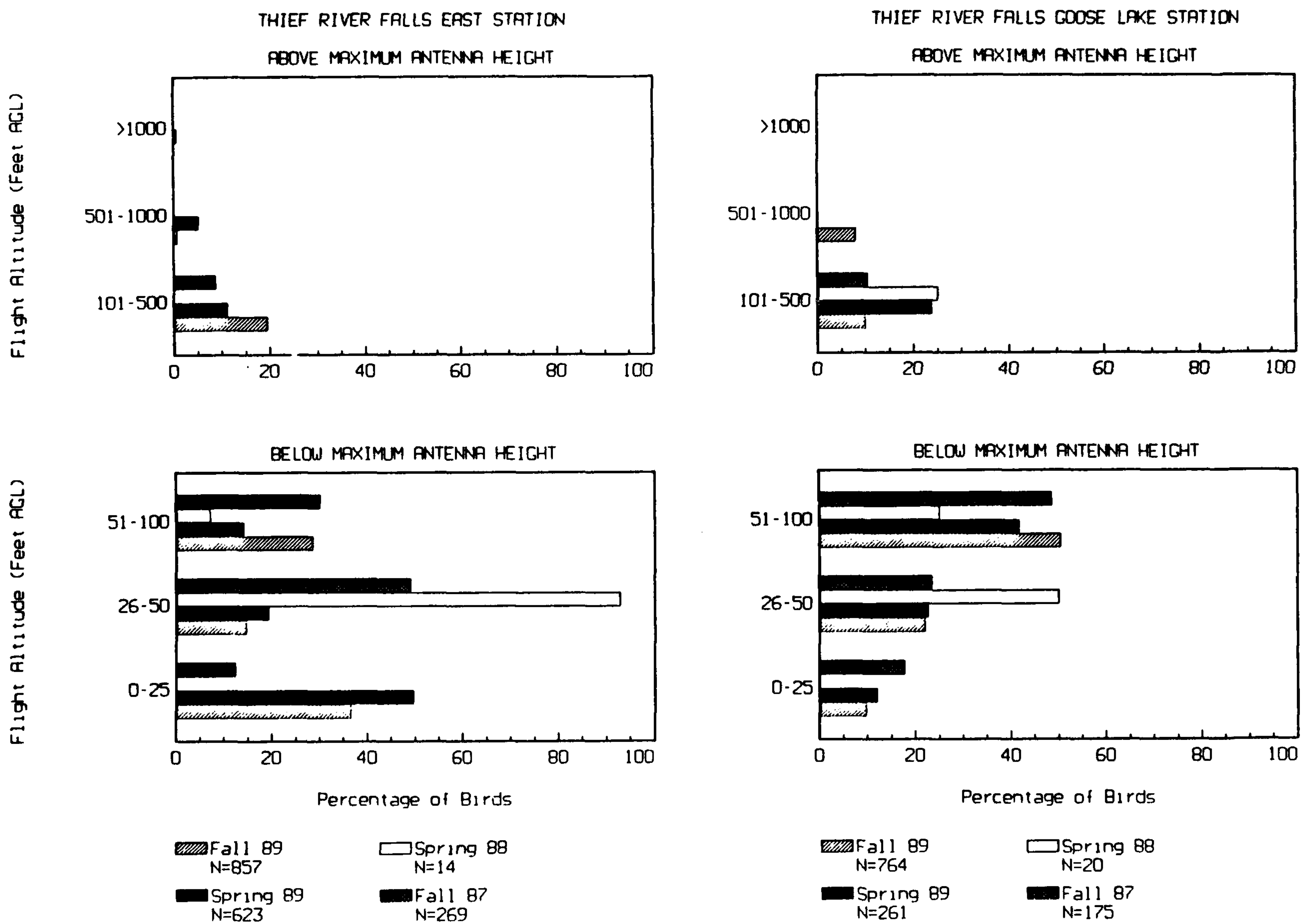


FIGURE 8-76. THIEF RIVER FALLS, MN RECEIVE STUDY AREA DIURNAL FLIGHT ALTITUDES - SHOREBIRDS

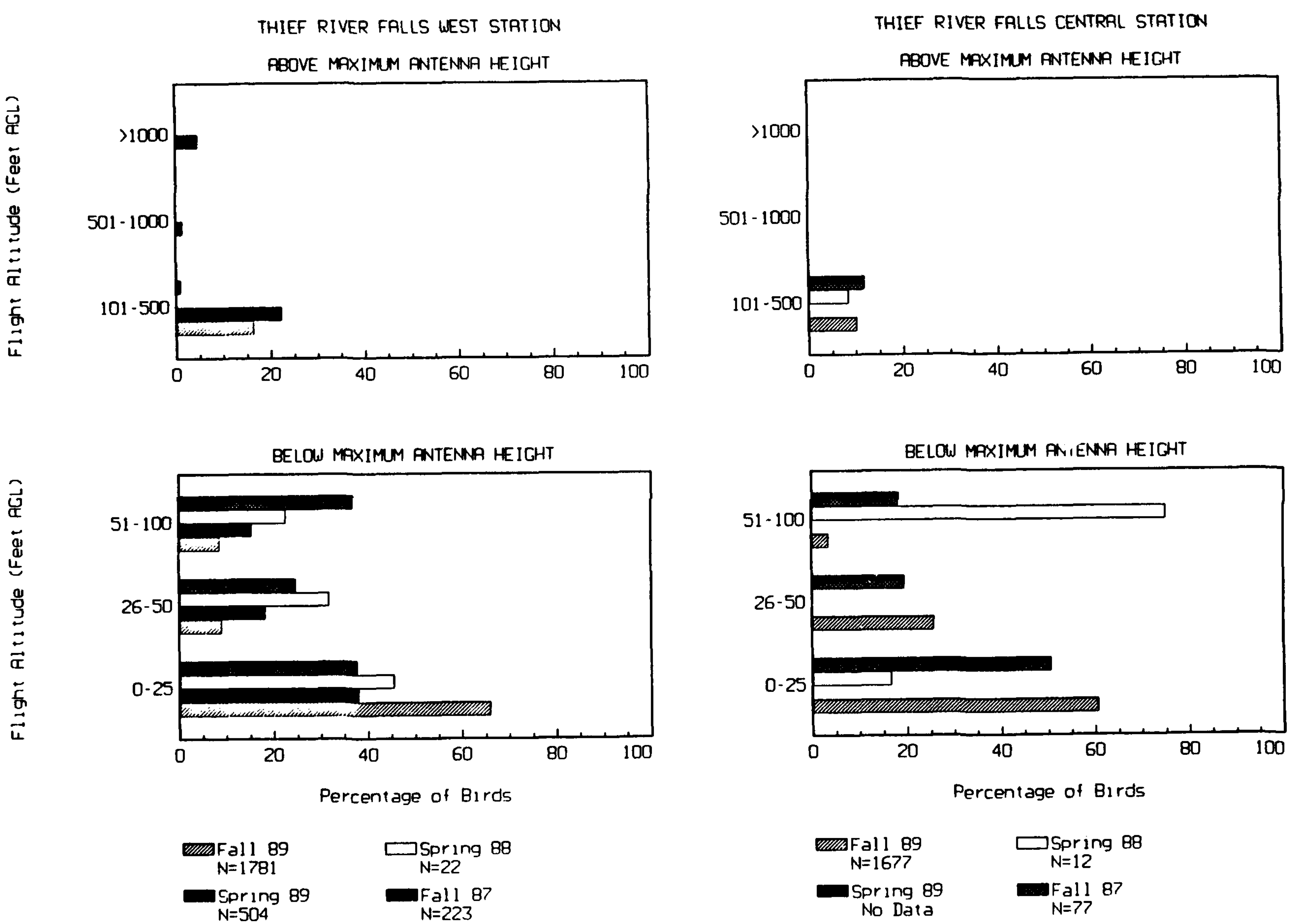


FIGURE 8-76. THIEF RIVER FALLS, MN RECEIVE STUDY AREA DIURNAL FLIGHT ALTITUDES - SHOREBIRDS (CONTINUED)

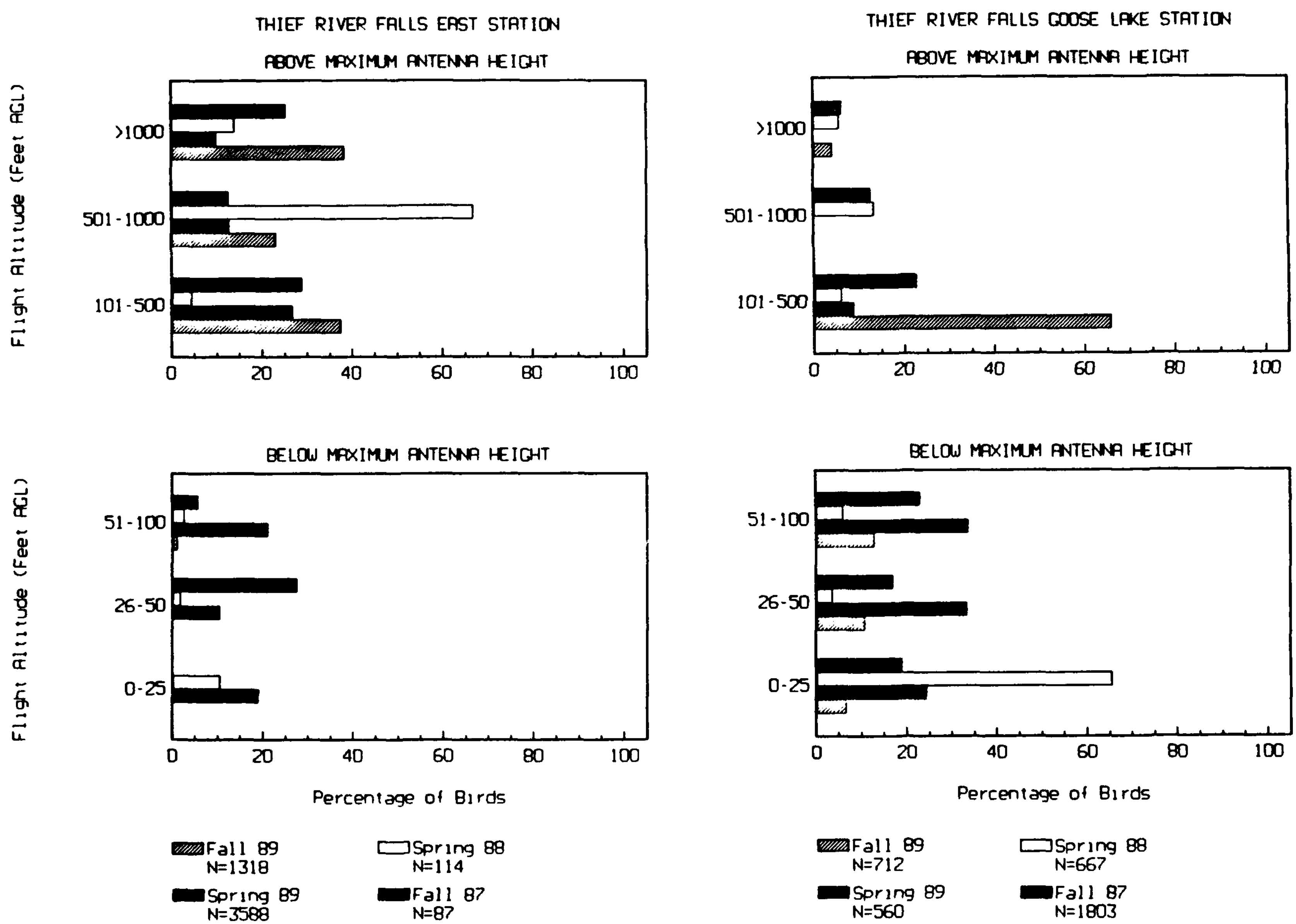


FIGURE 8-77. THIEF RIVER FALLS, MN RECEIVE STUDY AREA DIURNAL FLIGHT ALTITUDES - SANDHILL CRANES

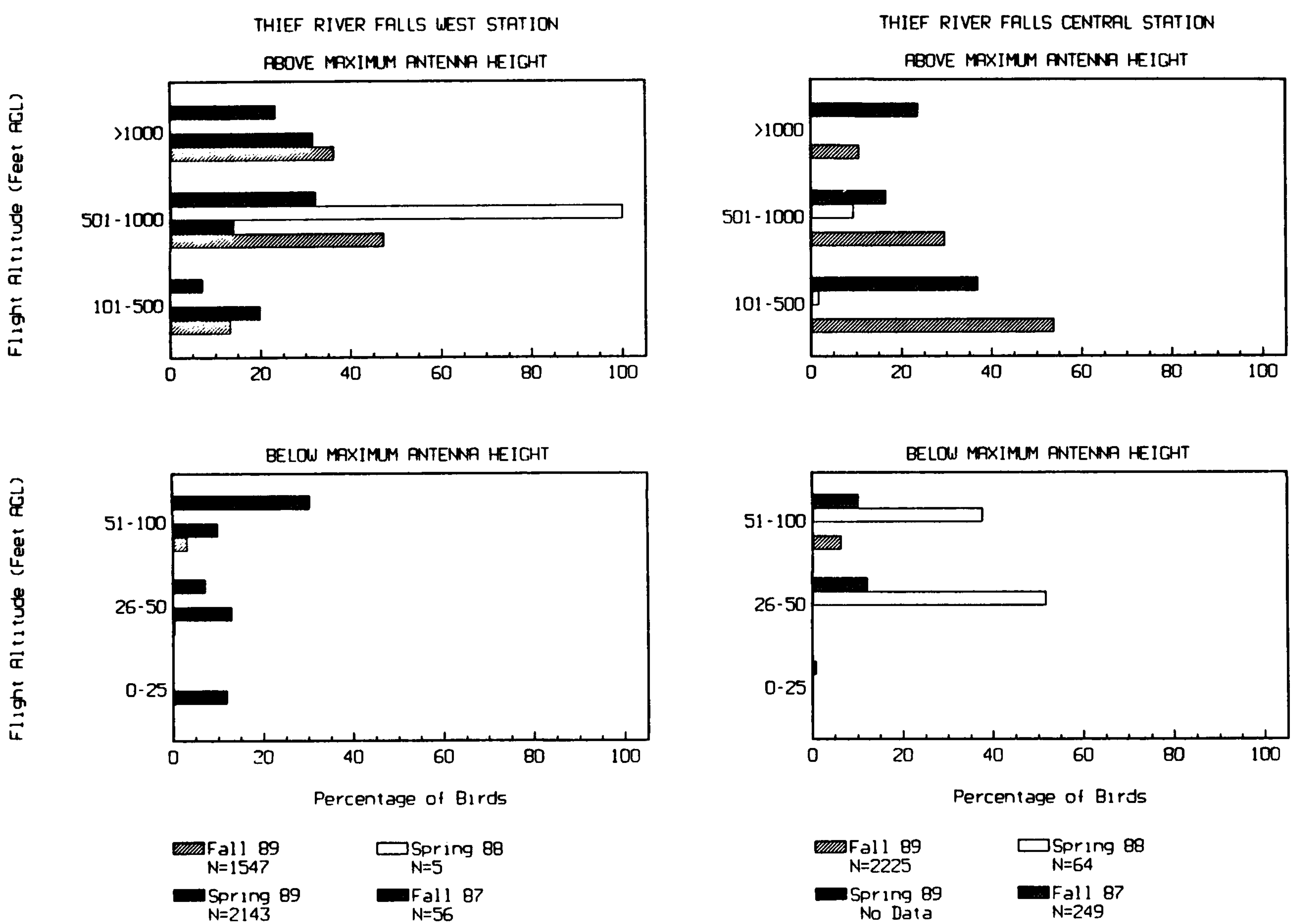


FIGURE 8-77. THIEF RIVER FALLS, MN RECEIVE STUDY AREA DIURNAL FLIGHT ALTITUDES - SANDHILL CRANES (CONTINUED)

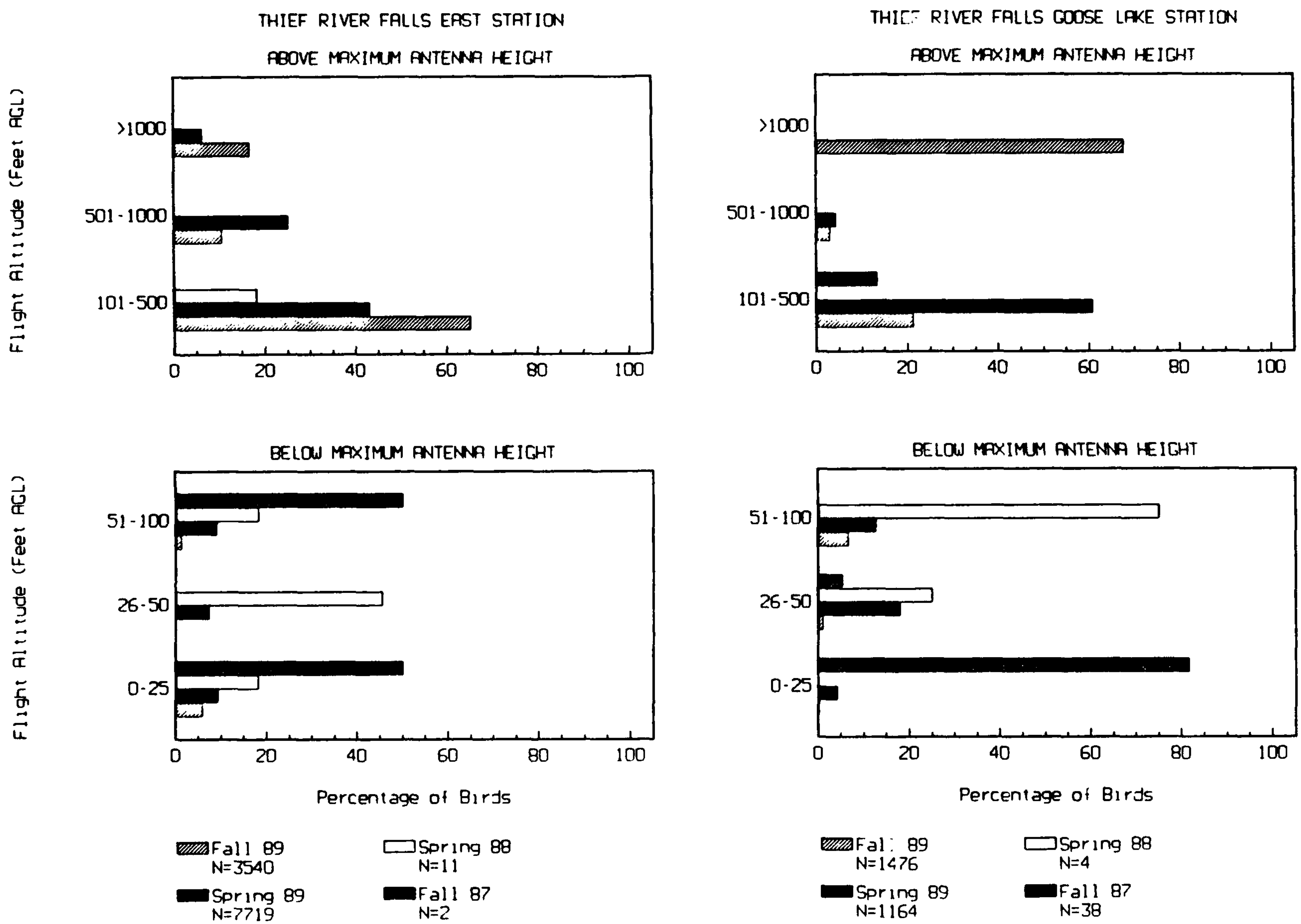


FIGURE 8-78. THIEF RIVER FALLS, MN RECEIVE STUDY AREA DIURNAL FLIGHT ALTITUDES - WATERBIRDS

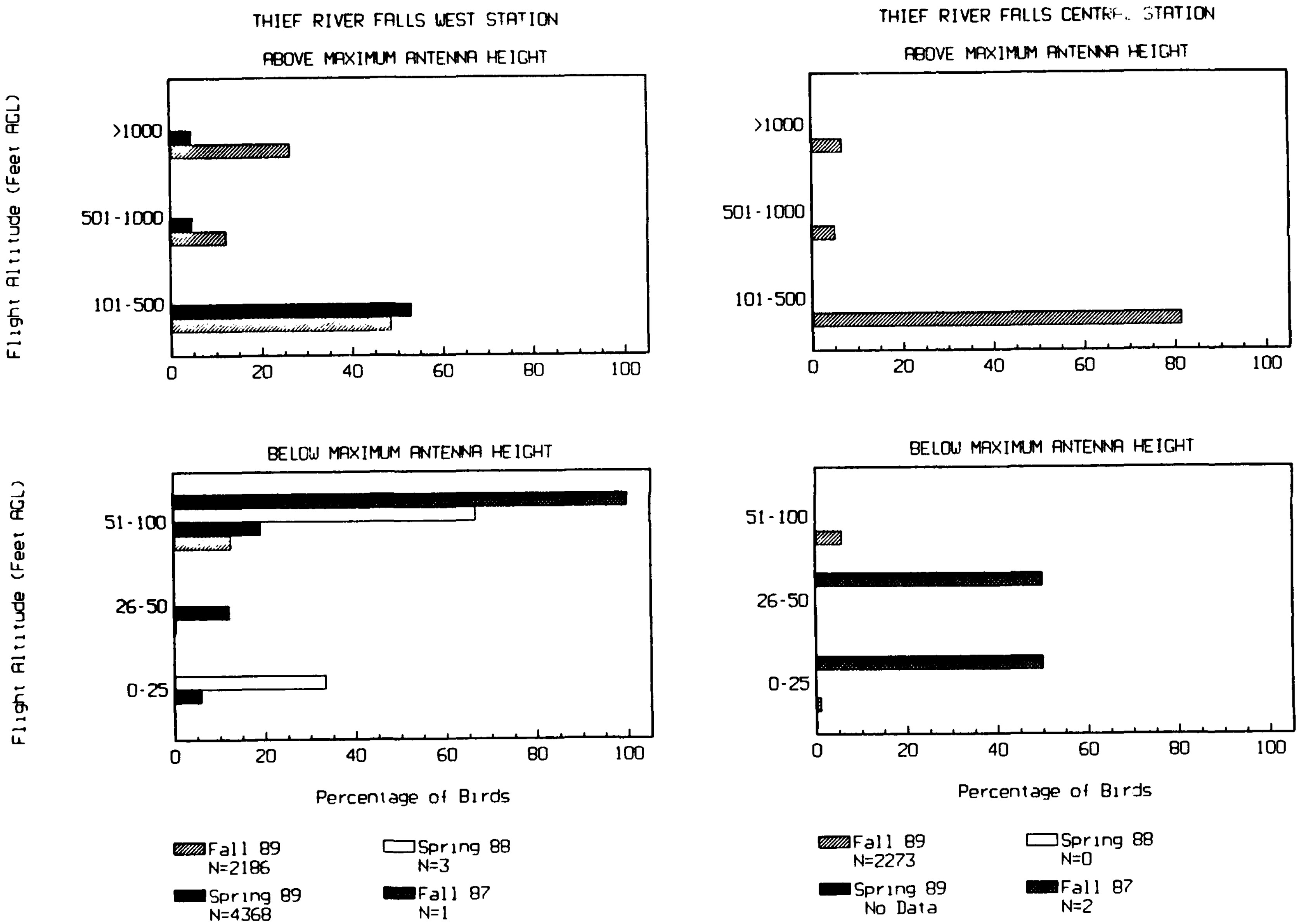


FIGURE 8-78. THIEF RIVER FALLS, MN RECEIVE STUDY AREA DIURNAL FLIGHT ALTITUDES - WATERBIRDS (CONTINUED)

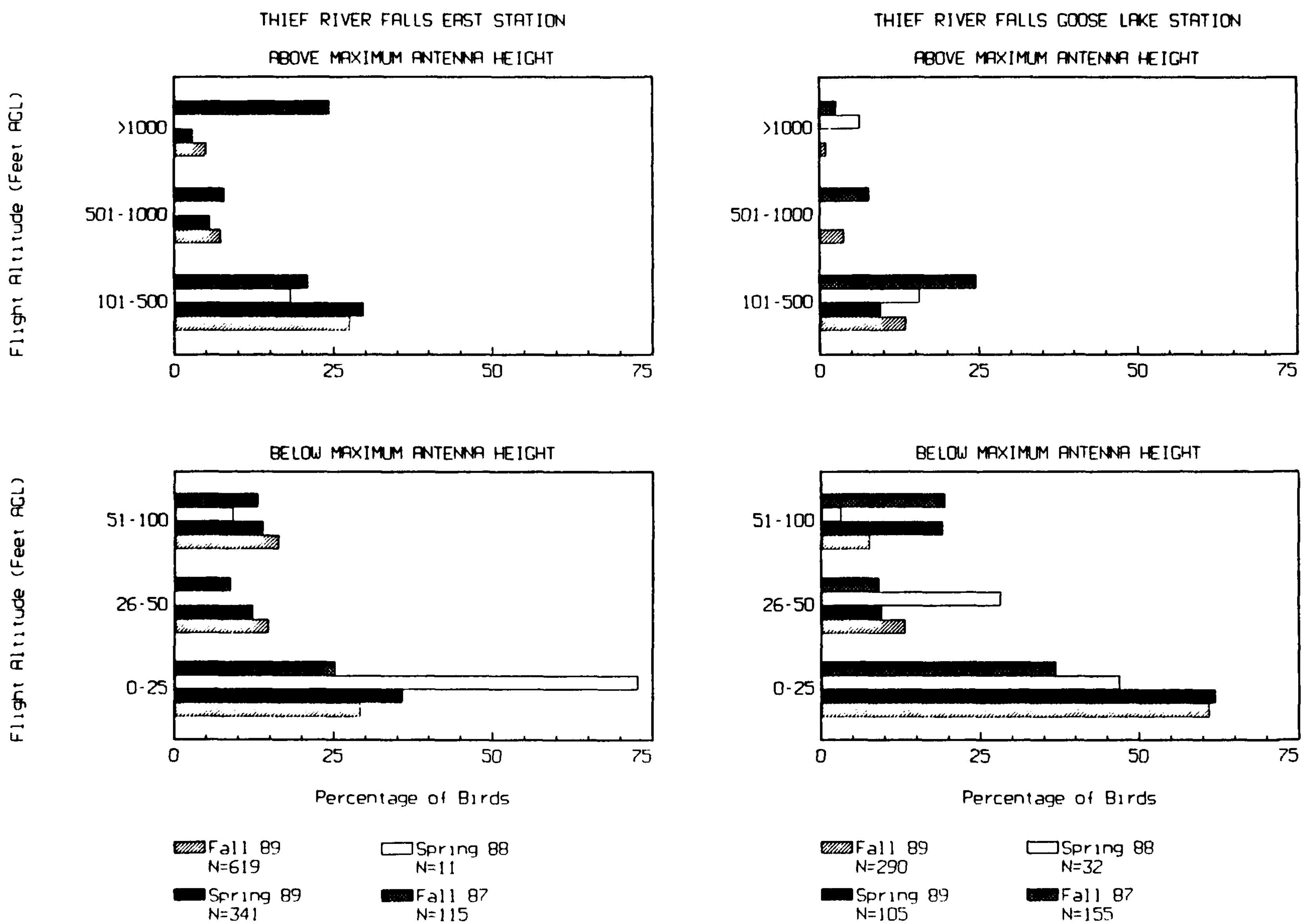


FIGURE 8-79. THIEF RIVER FALLS, MN RECEIVE STUDY AREA DIURNAL FLIGHT ALTITUDES - RAPTORS

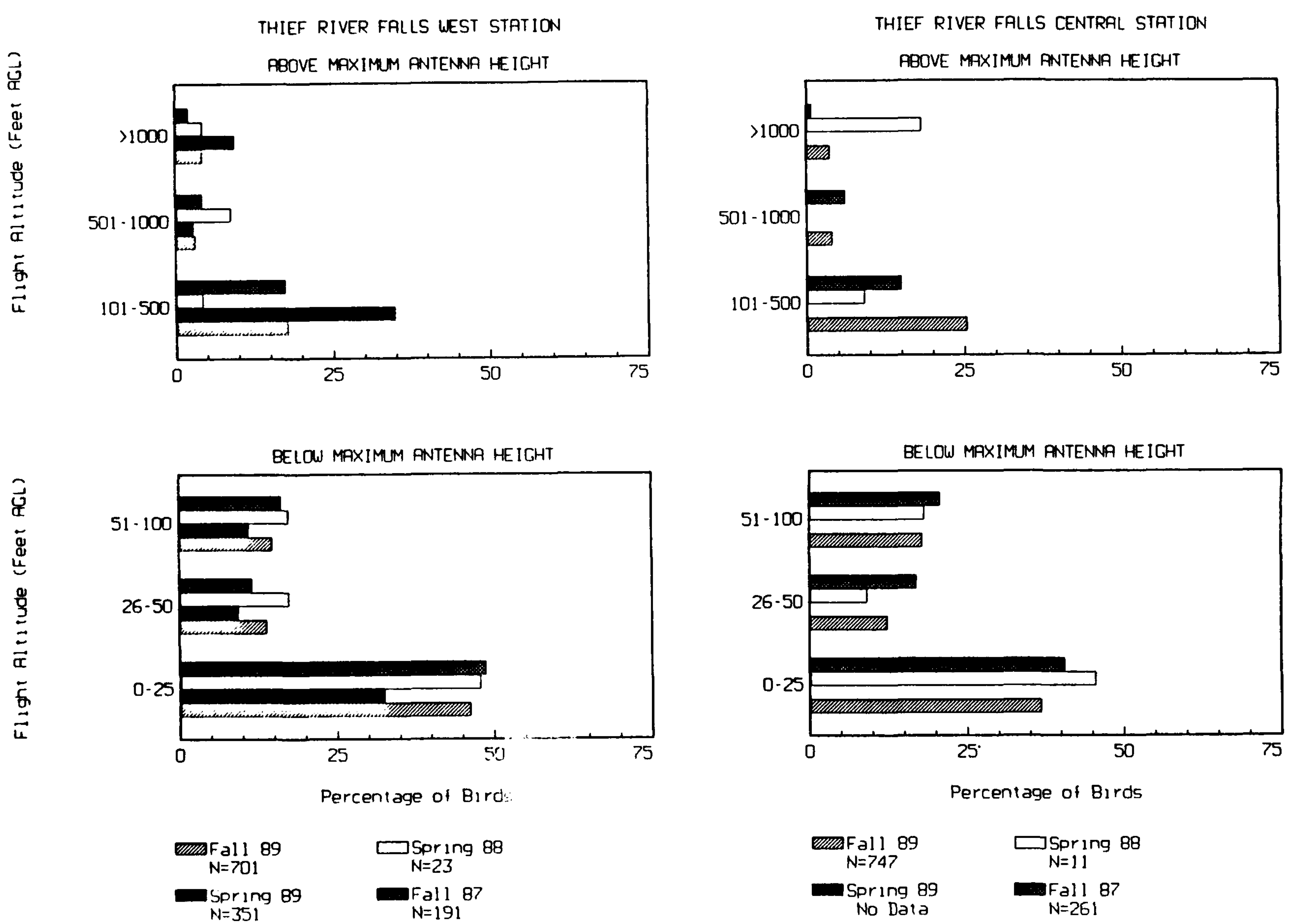


FIGURE 8-79. THIEF RIVER FALLS, MN RECEIVE STUDY AREA DIURNAL FLIGHT ALTITUDES - RAPTORS (CONTINUED)

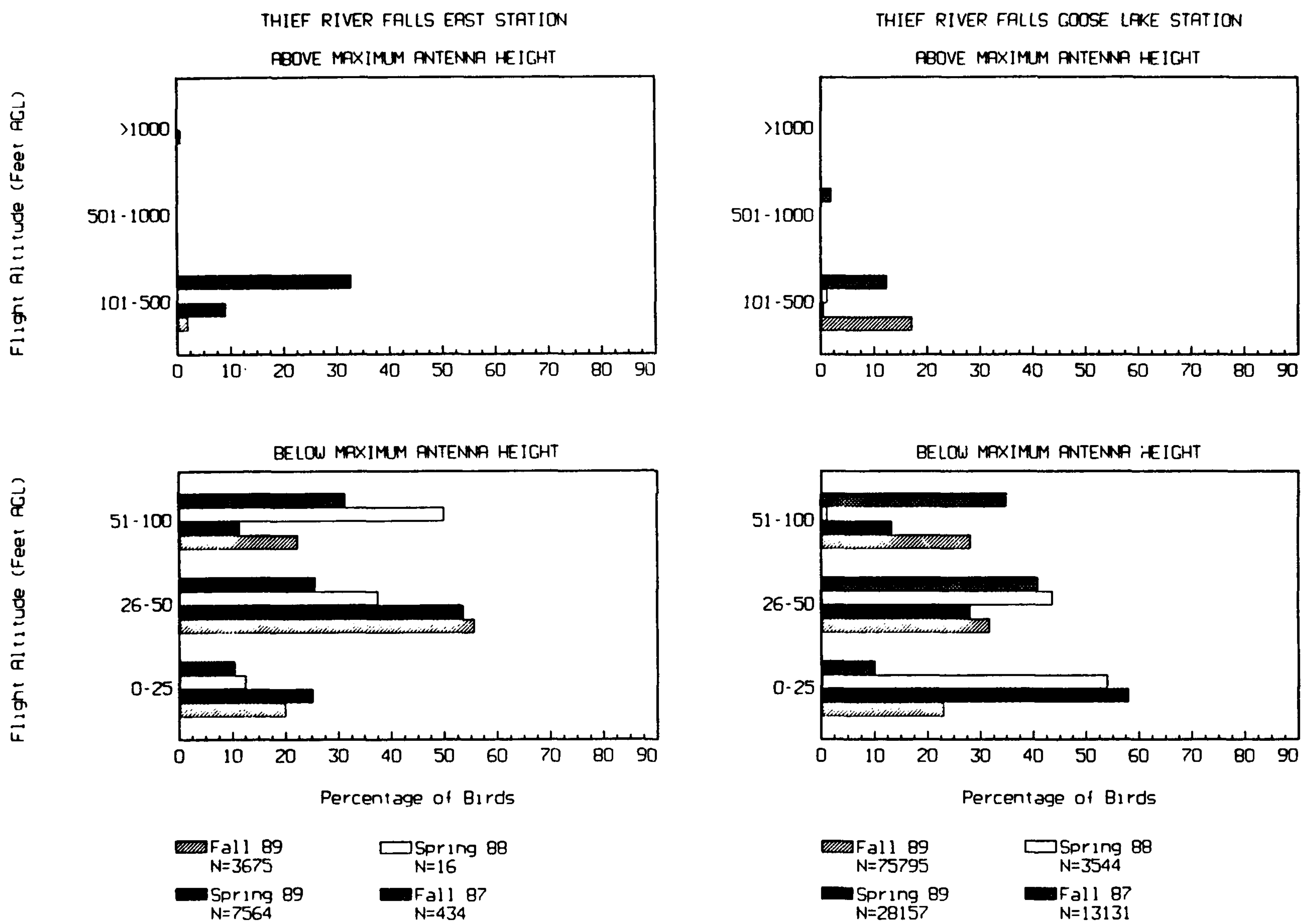


FIGURE 8-80. THIEF RIVER FALLS, MN RECEIVE STUDY AREA DIURNAL FLIGHT ALTITUDES - BLACKBIRDS

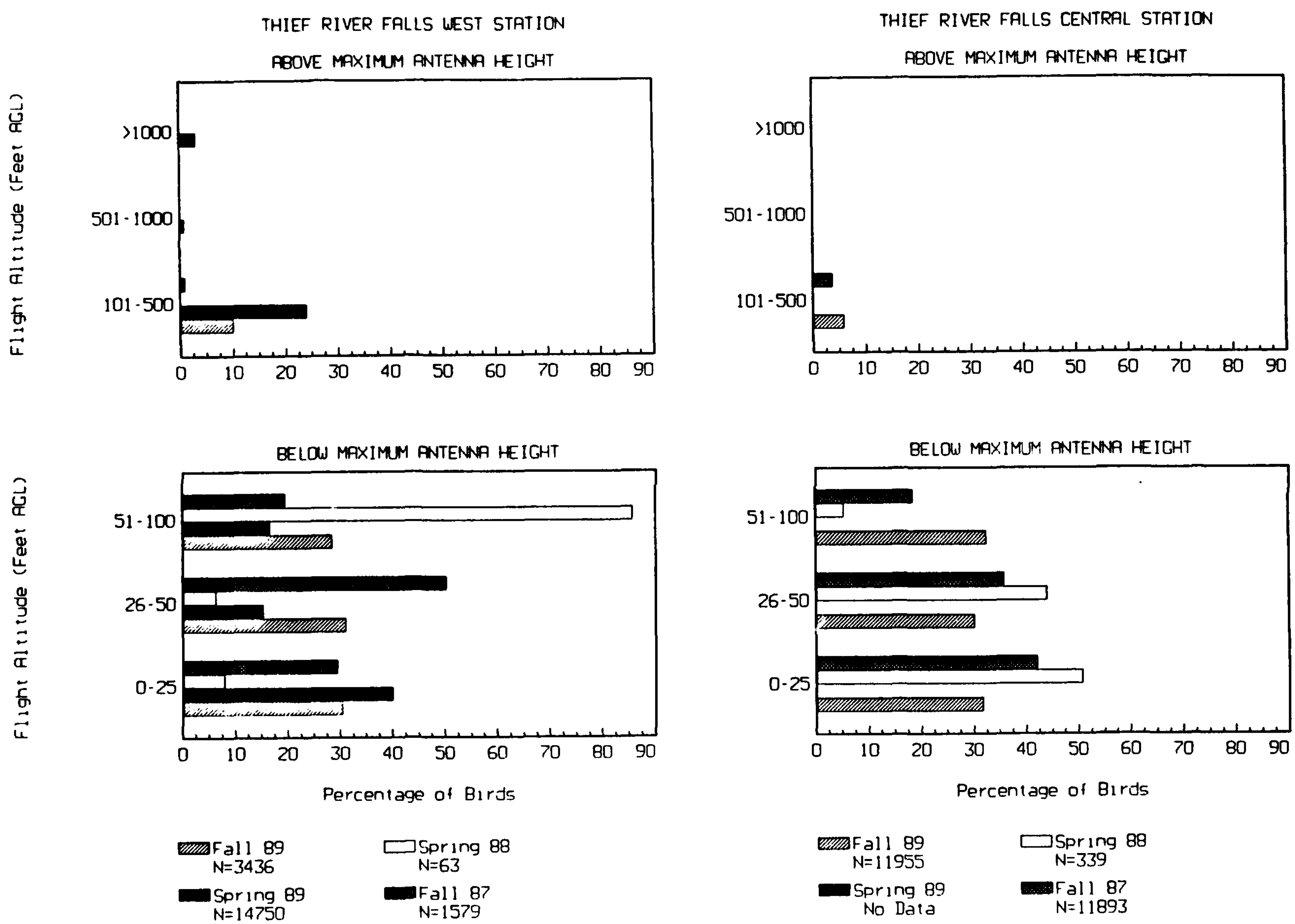


FIGURE 8-80. THIEF RIVER FALLS, MN RECEIVE STUDY AREA DIURNAL FLIGHT ALTITUDES - BLACKBIRDS (CONTINUED)

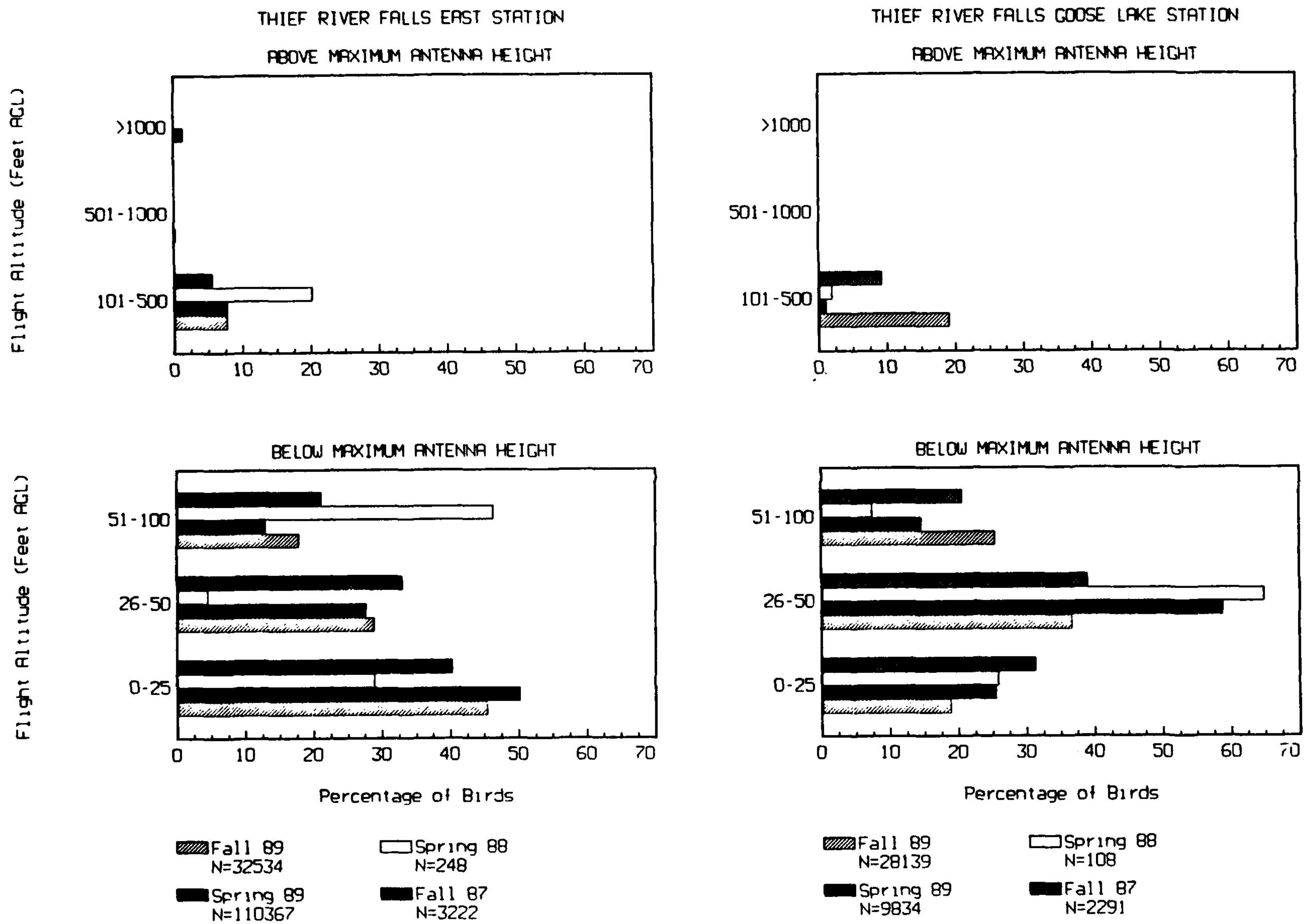


FIGURE 8-81. THIEF RIVER FALLS, MN RECEIVE STUDY AREA DIURNAL FLIGHT ALTITUDES - NONBLACKBIRD PASSERINES

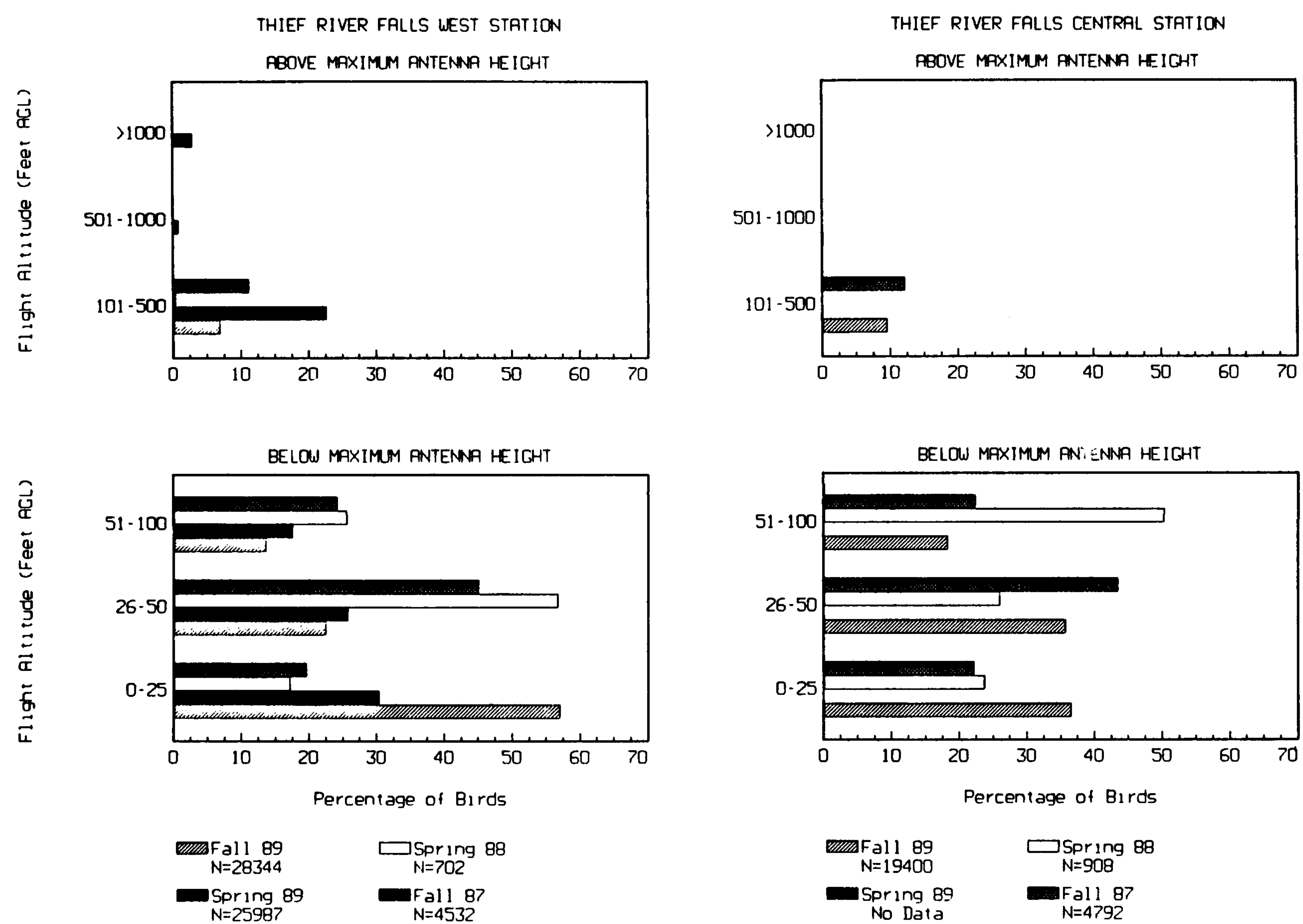


FIGURE 8-81. THIEF RIVER FALLS, MN RECEIVE STUDY AREA DIURNAL FLIGHT ALTITUDES - NONBLACKBIRD PASSERINES (CONTINUED)

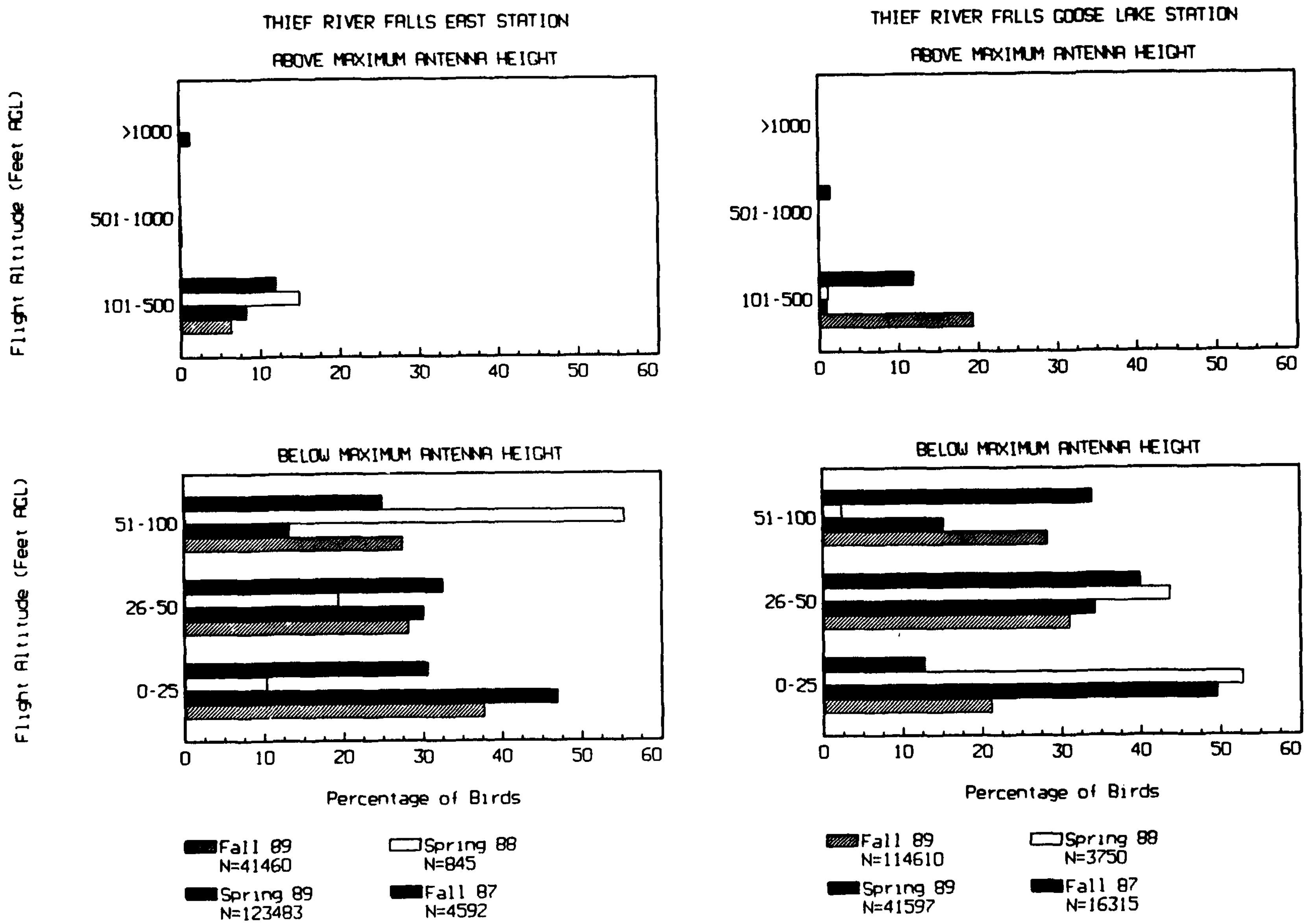


FIGURE 8-82. THIEF RIVER FALLS, MN RECEIVE STUDY AREA DIURNAL FLIGHT ALTITUDES - ALL PASSERINES

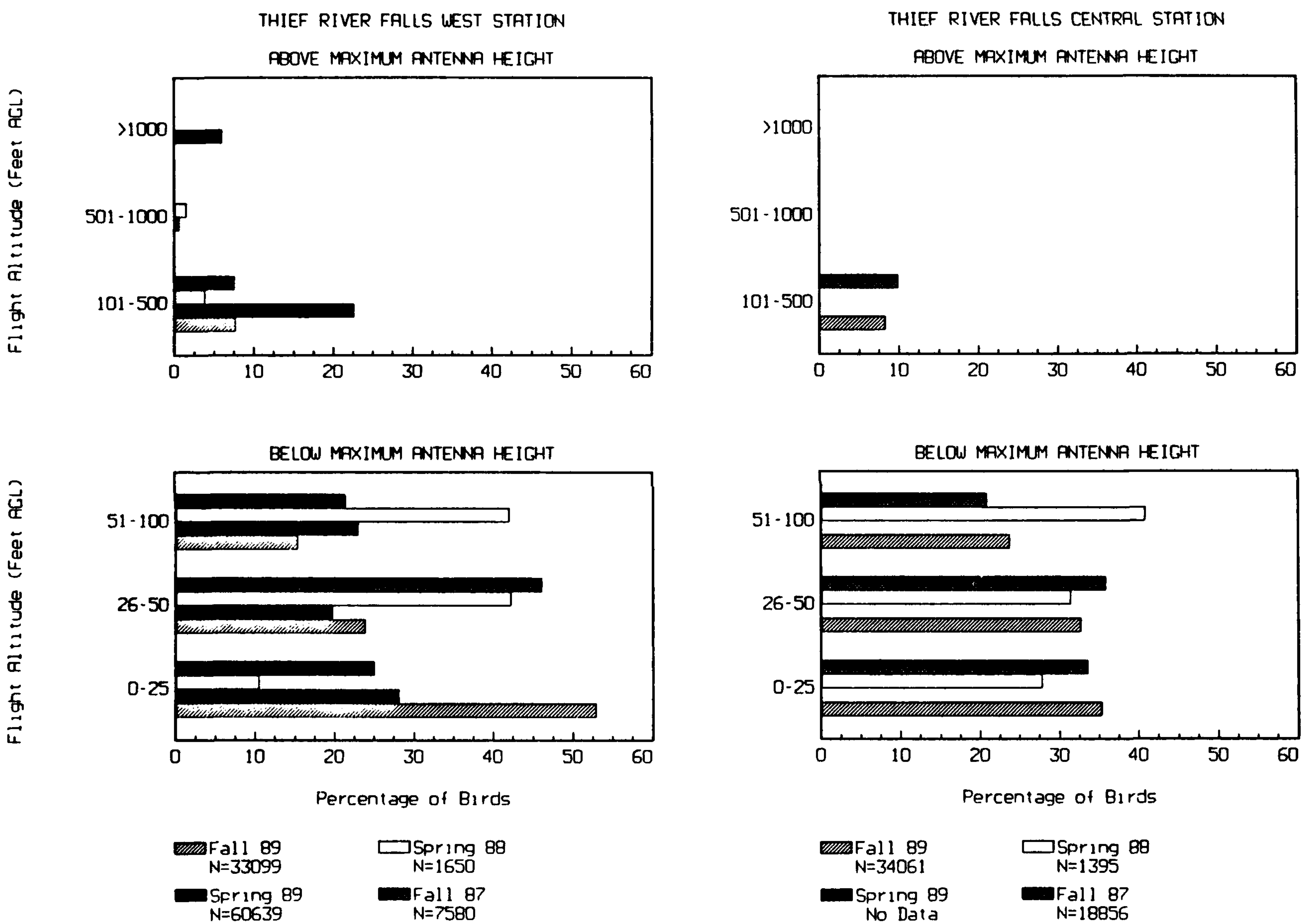


FIGURE 8-82. THIEF RIVER FALLS, MN RECEIVE STUDY AREA DIURNAL FLIGHT ALTITUDES - ALL PASSERINES (CONTINUED)

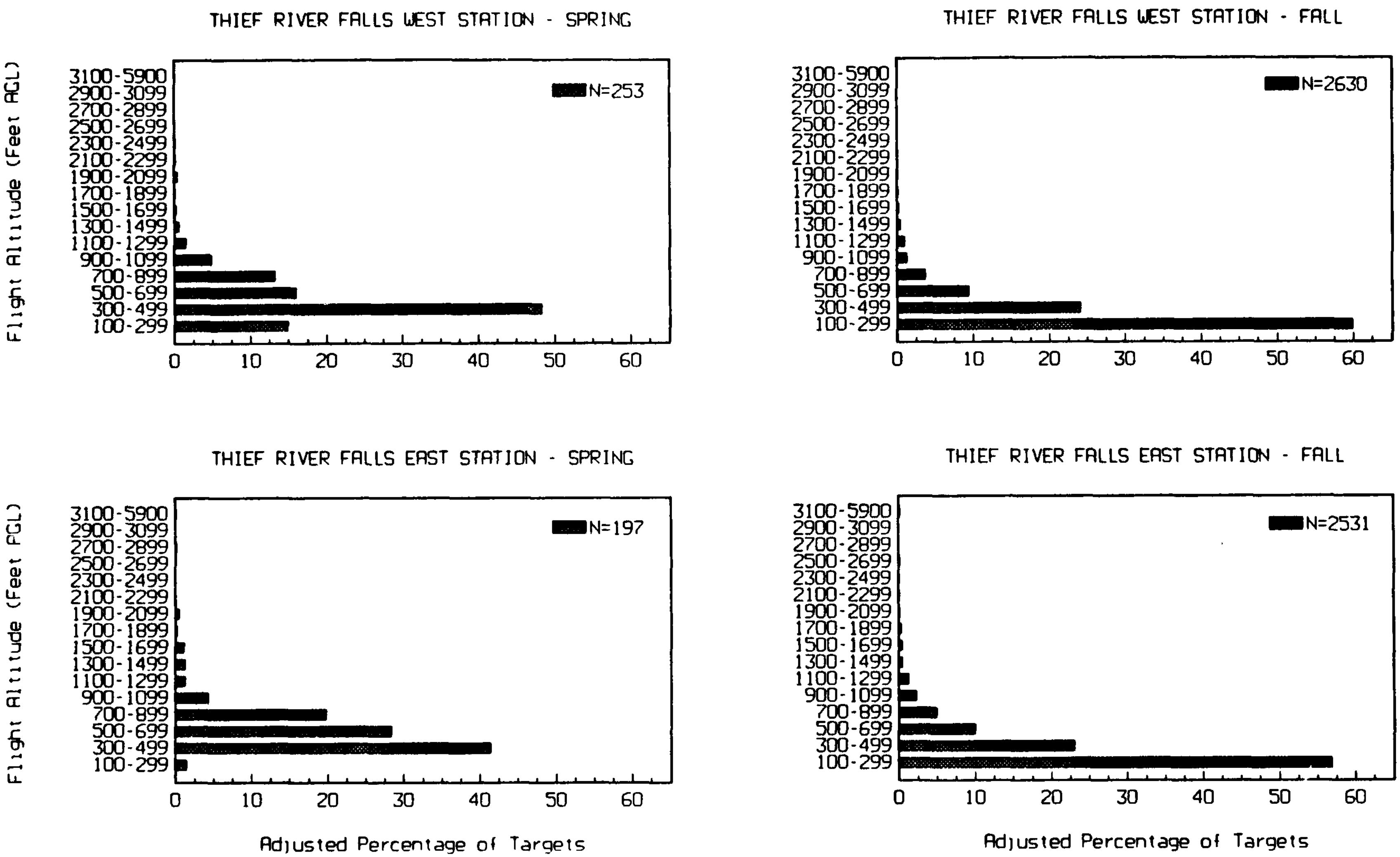


FIGURE 8-83. THIEF RIVER FALLS, MN RECEIVE STUDY AREA NOCTURNAL FLIGHT ALTITUDES - VERTICAL-BEAM RADAR

TABLE 8-35. NUMBER OF BIRDS FLYING BELOW 50 FEET ABOVE GROUND LEVEL DURING NOCTURNAL HOURS AT THE THIEF RIVER FALLS RECEIVE STUDY AREA - NIGHT-VISION SCOPE OBSERVATIONS

Station[1]	Study	Observation Hours	Number of Birds (Flocks)						
			Passerines	Raptors	Waterfowl	Waterbirds	Shorebirds	Unknown	Total
1A	Spring 89	91.4	2 (1)	0 (0)	768 (12)	1 (1)	0 (0)	154 (4)	925 (18)
	Fall 89	69.8	1 (1)	3 (3)	0 (0)	0 (0)	0 (0)	2 (2)	6 (6)
1B	Spring 89	28.7	0 (0)	0 (0)	25 (1)	0 (0)	0 (0)	0 (0)	25 (1)
	Fall 89	74.3	0 (0)	1 (1)	0 (0)	0 (0)	1 (1)	0 (0)	2 (2)
1C	Spring 89	34.7	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (1)	1 (1)
	Fall 89	72.5	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (1)	1 (1)
3A	Spring 89	100.1	1 (1)	0 (0)	149 (5)	0 (0)	0 (0)	2 (2)	152 (8)
	Fall 89	67.8	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	2 (1)	2 (1)
3B	Spring 89	26.7	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
	Fall 89	76.0	0 (0)	0 (0)	0 (0)	0 (0)	12 (8)	1 (1)	13 (9)
3C	Spring 89	34.7	0 (0)	0 (0)	41 (2)	0 (0)	0 (0)	1 (1)	42 (3)
	Fall 89	72.7	0 (0)	1 (1)	0 (0)	0 (0)	0 (0)	0 (0)	1 (1)
Total	Spring 89	316.3	3 (2)	0 (0)	983 (20)	1 (1)	0 (0)	158 (8)	1145 (31)
	Fall 89	433.1	1 (1)	5 (5)	0 (0)	0 (0)	13 (9)	6 (5)	25 (20)
	Total	749.4	4 (3)	5 (5)	983 (20)	1 (1)	13 (9)	164 (13)	1170 (51)

1. Station locations can be found on Figure 8-7.

spring and fall, respectively (Table 8-35). For the three eastern stations (3A, 3B, and 3C) a total of 194 birds (1.20 birds per hour) were observed in spring while only 16 birds (0.07 birds per hour) were observed at these stations in the fall (Table 8-35).

In order to make a direct comparison between the night-vision scope and vertical radar data sets, the number of flocks observed with the night-vision scope was converted to the number of targets which would have been observed within a comparable airspace on the vertical radar using techniques developed by ABR (1990b). An effective sampling distance of 400 feet was assumed for the night-vision scope, since this was the modal distance a 12 inch target could be seen during target tests (UMN, 1989a). At a distance of 400 feet, the maximum altitude sampled with the scope was approximately 50 feet agl. Only data from the two primary night-vision scope stations (1A and 3A) were used since these stations were in the same general locations as the radar sampling stations (Fig. 8-7). Since not all vertical-beam and night-vision scope observations were concurrent, the number of flocks observed with the night-vision scope was adjusted to correct for differences in sampling intensity.

The results of this analysis suggest that 2.5% of flocks flew within 50 feet of the ground in spring and 0.2% of flocks flew within 50 feet of the ground in fall at the West station. At the East station, percentages within 50 feet agl were 1.5% in the spring and 0.1% in the fall. These seasonal differences are interesting as the altitude distribution observed using the vertical-beam radar was lower in fall than in spring at both stations for birds flying over 100 feet agl (Fig. 8-83).

8.2.4.3.3 Time of day comparison. Although the flight altitude data collected by visual observers during daylight hours, by the vertical-beam radar, and using the night-vision scope were not directly comparable, they suggest that flight altitudes, especially of passerines, were higher during nocturnal hours than during diurnal hours. This has also been reported by other investigators (e.g. Eastwood and Rider, 1965; Gauthreaux, 1978).

A direct comparison using radar data alone was possible, however. In spring, mean flight altitudes were higher during nocturnal periods than during either twilight or daylight periods at the East station, but were highest during twilight hours at the West station (ABR, 1989). In the fall, birds at both sampling stations generally flew at significantly higher altitudes during nocturnal and twilight hours than during daylight periods (ABR, 1990a).

8.2.4.3.4 Weather effects. Weather conditions are known to affect the flight altitude of birds. In general, daytime migrants will fly lower when there is poor visibility, dense cloud cover accompanied by low cloud ceilings, or precipitation, and also when flying into strong headwinds (Gauthreaux, 1978). The effects of cloud ceiling height, precipitation, and wind on flight altitudes is examined here for four species groups during daylight hours; insufficient data were available for an analysis during nocturnal hours, as the radar unit could not be operated effectively during inclement weather periods. These analyses exclude the spring 1988 season since the sampling period was so short and also do not include the secondary Goose Lake station.

At the West station, only sandhill cranes flew consistently higher during periods of high (>1000 feet agl) cloud ceilings than during periods of low (<1000 feet agl) cloud ceilings. Raptors and waterfowl showed considerable variability among seasons between the two cloud ceiling categories. Passerines generally flew higher during low cloud ceiling periods (Table 8-36). All species groups flew higher in fall 1987 during high cloud ceiling periods, but all groups, except raptors, flew higher in fall 1989 during low ceiling periods at the Central station (Table 8-36). In general, all species groups flew higher during high cloud ceiling periods at the East station, although only raptors showed strong tendencies (Table 8-36). However, visibility is usually reduced during low ceiling periods and birds flying within or above the clouds may be hidden from a visual observer.

Precipitation usually reduced flight altitudes for all bird groups at all stations during daylight hours (Table 8-37). Sandhill cranes showed the most variability at all stations, probably because relative few cranes were observed flying during periods of precipitation. Trends were strongest at the

TABLE 8-36. EFFECTS OF CLOUD CEILING HEIGHT ON FLIGHT ALTITUDE AT THE THIEF RIVER FALLS RECEIVE STUDY AREA DURING DAYLIGHT HOURS

Species Group	Study	Percentage Flying Below 100 Feet AGL For Cloud Ceiling Height:	
		<1000 ft agl	>1000 ft agl
WEST STATION			
Sandhill cranes	Fall 87	---	---
	Spring 89	55.8	35.6
	Fall 89	28.6	3.2
Waterfowl	Fall 87	57.1	14.7
	Spring 89	31.3	36.9
	Fall 89	0.0	5.4
Raptors	Fall 87	56.0	79.6
	Spring 89	80.0	49.8
	Fall 89	78.9	74.2
Passerines	Fall 87	79.3	93.9
	Spring 89	39.7	73.6
	Fall 89	99.3	90.4
CFNTRAL STATION			
Sandhill cranes	Fall 87	100.0	17.2
	Spring 89	---	---
	Fall 89	0.0	6.7
Waterfowl	Fall 87	47.9	6.6
	Spring 89	---	---
	Fall 89	1.2	12.1
Raptors	Fall 87	97.8	74.0
	Spring 89	---	---
	Fall 89	76.2	66.3
Passerines	Fall 87	92.4	89.8
	Spring 89	---	---
	Fall 89	86.2	92.4
EAST STATION			
Sandhill cranes	Fall 87	100.0	31.8
	Spring 89	25.9	53.1
	Fall 89	62.5	1.0

TABLE 8-36 (Continued). EFFECTS OF CLOUD CEILING HEIGHT ON FLIGHT ALTITUDE AT THE THIEF RIVER FALLS RECEIVE STUDY AREA DURING DAYLIGHT HOURS

Species Group	Study	Percentage Flying Below 100 Feet AGL For Cloud Ceiling Height:	
		<1000 ft agl	>1000 ft agl
Waterfowl	Fall 87	13.9	5.7
	Spring 89	62.2	44.2
	Fall 89	5.0	6.3
Raptors	Fall 87	87.5	43.9
	Spring 89	78.9	57.5
	Fall 89	83.5	55.9
Passerines	Fall 87	88.5	88.0
	Spring 89	96.8	89.5
	Fall 89	98.9	92.9

TABLE 8-37. EFFECTS OF PRECIPITATION ON FLIGHT ALTITUDE AT THE THIEF RIVER FALLS RECEIVE STUDY AREA DURING DAYLIGHT HOURS

Species Group	Study	Percentage of Birds Flying Below 100 Feet AGL		
		No Precipitation	Rain	Snow[1]
WEST STATION				
Sandhill cranes	Fall 87	37.5	---	---
	Spring 89	36.0	0.0	---
	Fall 89	3.4	0.0	100.0
Waterfowl	Fall 87	16.3	100.0	0.0
	Spring 89	36.6	28.5	98.9
	Fall 89	5.5	8.0	0.0
Raptors	Fall 87	76.4	100.0	---
	Spring 89	50.2	80.0	100.0
	Fall 89	74.4	84.2	92.3
Passerines	Fall 87	92.4	100.0	100.0
	Spring 89	70.7	91.8	88.6
	Fall 89	91.7	91.1	99.8
CENTRAL STATION				
Sandhill cranes	Fall 87	22.9	---	---
	Spring 89	---	---	---
	Fall 89	6.3	0.0	0.0
Waterfowl	Fall 87	11.1	0.0	0.0
	Spring 89	---	---	---
	Fall 89	12.2	0.0	0.8
Raptors	Fall 87	76.8	100.0	100.0
	Spring 89	---	---	---
	Fall 89	67.2	59.3	75.0
Passerines	Fall 87	90.7	74.8	100.0
	Spring 89	---	---	---
	Fall 89	91.4	97.4	96.1
EAST STATION				
Sandhill cranes	Fall 87	31.8	100.0	---
	Spring 89	52.7	21.7	4.3
	Fall 89	1.5	---	---

TABLE 8-37 (Continued). EFFECTS OF PRECIPITATION ON FLIGHT ALTITUDE AT THE THIEF RIVER FALLS RECEIVE STUDY AREA DURING DAYLIGHT HOURS

Species Group	Study	Percentage of Birds Flying Below 100 Feet AGL		
		No Precipitation	Rain	Snow[1]
Waterfowl	Fall 87	5.7	12.5	41.2
	Spring 89	41.8	30.2	81.0
	Fall 89	6.5	7.1	0.0
Raptors	Fall 87	44.0	100.0	100.0
	Spring 89	58.8	100.0	50.0
	Fall 89	59.0	85.7	87.5
Passerines	Fall 87	87.7	93.8	100.0
	Spring 89	90.5	72.1	99.3
	Fall 89	93.0	99.7	99.5

1. Includes sleet and hail.

East and West stations and weakest at the Central station (Table 8-37). Visibility is usually reduced during periods of precipitation, especially snow, and flight altitude distributions observed during these periods may be especially biased towards the lower altitudes.

In general, flight altitudes for all species groups, except sandhill cranes, were highest during tailwind conditions at all stations. This trend was strongest for raptors (Table 8-38). Sandhill cranes showed no clear trends, probably due to low sample sizes.

8.2.4.4 Flight Direction.

8.2.4.4.1 Daylight periods. Flight directions for ducks were highly variable in the spring, indicating a high proportion of local movements at all stations, although north was generally the most common flight direction in 1989 (Fig. 8-84). In fall, flight directions were generally south, southeast, or southwest at the three primary stations but still showed considerable variability, especially in 1989. At Goose Lake, flight directions were principally east and west, indicating local movements between Goose Lake marsh and a wildlife area to the west of the station (Fig. 8-84).

Goose/cormorant movements showed more directionality than did duck movements, with the principal flight directions in spring being north, northeast, or northwest at all stations except Central, where sample sizes were small. South, southeast, and southwest were the most common flight directions during fall at all stations, although a fair proportion of observed movement was west at all stations (Fig. 8-85). This relates to the fact that snow geese were often observed flying west in the fall whereas Canada geese, which were more abundant, usually flew in the three southerly directions.

Spring swan movement patterns were generally in their expected migratory directions (north, northwest, and west; Bellrose, 1980) at the East and West stations, with flight directions exhibiting more variability at the Goose Lake station. No swans were observed at the Central station during limited spring sampling (Fig. 8-86). In fall, swan flight directions were mostly east, southeast, or south at all stations, again suggesting a high proportion of migratory movements (Fig. 8-86).

Flight directions for all waterfowl showed more consistency in the fall than in the spring, except at Goose Lake where they were highly variable. Patterns did not differ greatly among primary stations (Fig. 8-87).

Shorebirds showed considerable variability in their flight directions during both spring and fall at all stations, suggesting that most observed diurnal movements were local in nature (Fig. 8-88).

Sandhill crane movements were generally north or northeast in the spring of 1989; sample sizes were small in 1988. Flight directions in spring were more variable at Goose Lake where a high proportion of local movements were observed as cranes staged and roosted in this area. In fall, flight directions were generally in the three southerly directions (south, southeast, southwest) at the primary stations, but highly variable at the Goose Lake station for the same reasons as in spring (Fig. 8-89).

Waterbird flight directions were principally north or northwest in the spring at all stations, except Central, where no waterbirds were observed during limited sampling. Few waterbirds were observed in fall 1987. During fall 1989, flight directions were generally south or southeast at the West and Central stations, principally east at the Goose Lake station, and highly variable at the East station (Fig. 8-90).

Raptor flight directions were generally north in the spring and south in the fall at all stations, although the degree of variability in the distributions suggests a fair proportion of local movements during all seasons at all stations (Fig. 8-91). These local movements were largely of foraging northern harriers.

Spring passerine movements were largely north at the East and Central stations and highly variable at the West and Goose Lake stations. Flight direction distributions differed for blackbirds and nonblackbird passerines at all but

TABLE 8-38. EFFECTS OF WIND ON FLIGHT ALTITUDE AT THE THIEF RIVER FALLS RECEIVE STUDY AREA DURING DAYLIGHT HOURS

Species Group	Study	Percentage of Birds Flying Below 100 Feet AGL							
		No Wind	Headwind		Tailwind		Crosswind		
			<15	>15	<15	>15	<15	>15	MPH
WEST STATION									
Sandhill cranes	Fall 87	----	100	0.0	0.0	----	56.7	0.0	
	Spring 89	----	42.3	45.0	41.3	48.1	26.1	37.3	
	Fall 89	----	2.4	----	2.8	7.1	0.0	----	
Waterfowl	Fall 87	0.1	16.1	----	7.8	34.8	61.4	0.9	
	Spring 89	----	46.4	26.9	41.4	34.7	54.7	20.5	
	Fall 89	----	7.1	2.3	6.8	3.0	4.0	23.1	
Raptors	Fall 87	66.7	79.2	100	48.4	66.7	94.4	91.7	
	Spring 89	----	81.5	92.8	71.4	43.1	9.5	56.0	
	Fall 89	----	86.1	94.4	58.6	54.9	88.1	92.1	
Passerines	Fall 87	91.2	96.7	99.7	81.6	64.9	90.6	100	
	Spring 89	----	75.1	90.4	60.7	86.0	69.0	69.3	
	Fall 89	----	94.2	99.0	80.6	94.4	89.1	88.5	
CENTRAL STATION									
Sandhill cranes	Fall 87	12.3	39.1	67.6	25.0	----	15.6	----	
	Spring 89	----	----	----	----	----	----	----	
	Fall 89	----	16.4	53.8	2.1	0.0	8.9	----	
Waterfowl	Fall 87	14.0	55.9	11.8	0.9	0.3	21.1	7.2	
	Spring 89	----	----	----	----	----	----	----	
	Fall 89	0.0	11.6	15.4	12.6	1.0	16.7	5.7	
Raptors	Fall 87	78.9	91.7	77.8	65.6	78.6	100	100	
	Spring 89	----	----	----	----	----	----	----	
	Fall 89	----	89.0	89.6	55.6	46.9	76.8	76.0	
Passerines	Fall 87	99.9	90.5	99.8	76.2	98.4	82.1	100	
	Spring 89	----	----	----	----	----	----	----	
	Fall 89	100.0	96.2	94.6	84.8	90.8	93.8	93.0	
EAST STATION									
Sandhill cranes	Fall 87	----	----	100	0.0	16.7	----	----	
	Spring 89	0.0	51.8	69.4	72.5	39.7	39.1	39.9	
	Fall 89	----	0.7	----	2.0	1.9	0.0	0.0	

TABLE 8-38 (Continued). EFFECTS OF WIND ON FLIGHT ALTITUDE AT THE THIEF RIVER FALLS RECEIVE STUDY AREA DURING DAYLIGHT HOURS

Species Group	Study	Percentage of Birds Flying Below 100 Feet AGL						
		No Wind	Headwind		Tailwind		Crosswind	
			<15	>15	<15	>15	<15	>15 MPH
Waterfowl	Fall 87	11.8	5.4	100	2.8	0.7	1.4	13.2
	Spring 89	----	43.0	60.7	37.2	46.3	61.2	31.9
	Fall 89	----	8.5	25.3	3.3	3.9	5.7	3.0
Raptors	Fall 87	100.0	57.1	80.0	50.0	13.2	83.3	100
	Spring 89	----	83.0	70.2	42.6	69.4	66.7	66.7
	Fall 89	----	71.2	75.5	54.1	55.2	82.2	69.8
Passerines	Fall 87	99.0	94.3	100	61.6	85.2	80.0	87.4
	Spring 89	55.4	94.8	91.2	92.0	79.1	96.7	68.2
	Fall 89	----	89.3	97.3	93.1	97.4	78.8	92.1

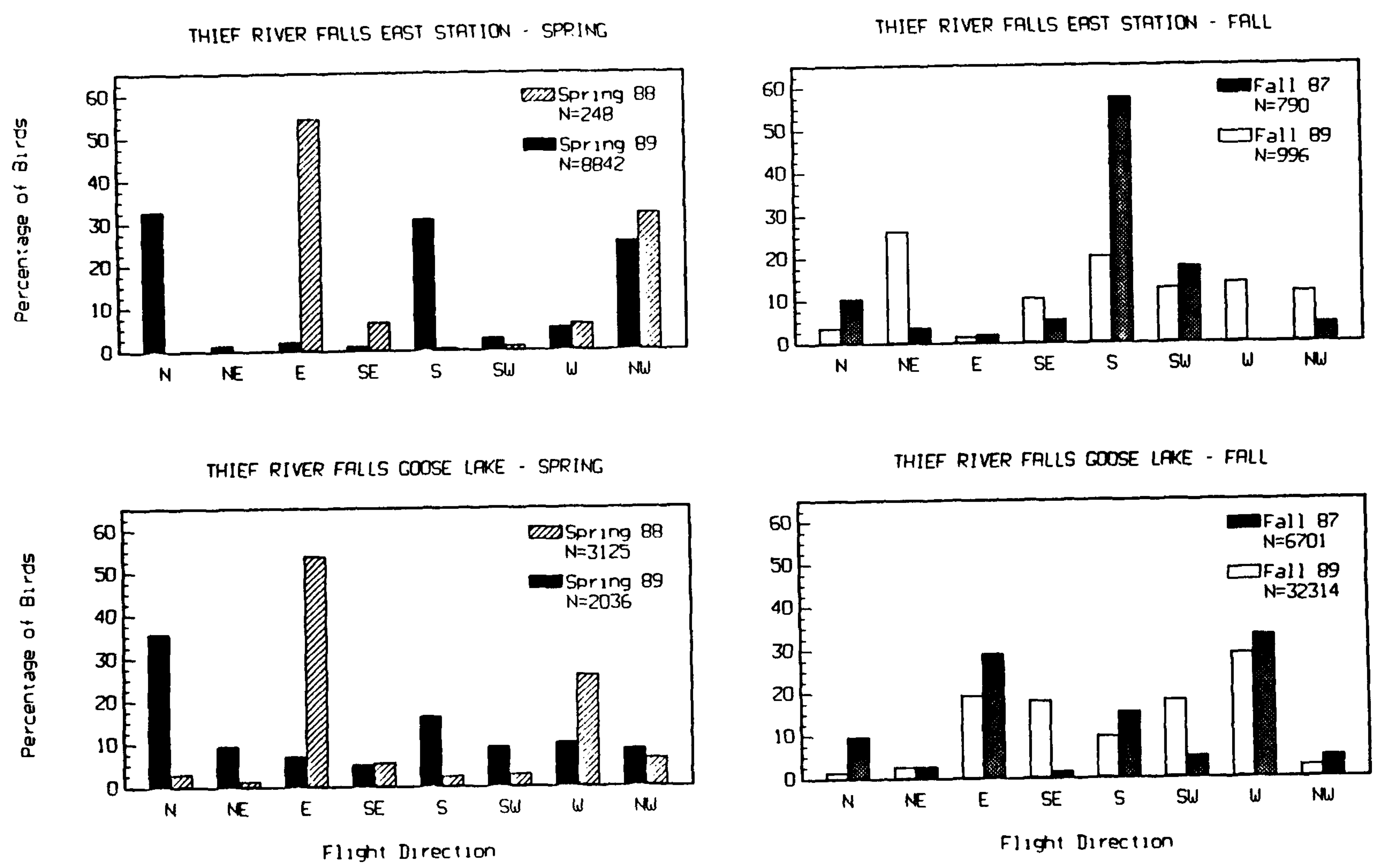


FIGURE 8-84. THIEF RIVER FALLS, MN RECEIVE STUDY AREA DIURNAL FLIGHT DIRECTIONS - DUCKS

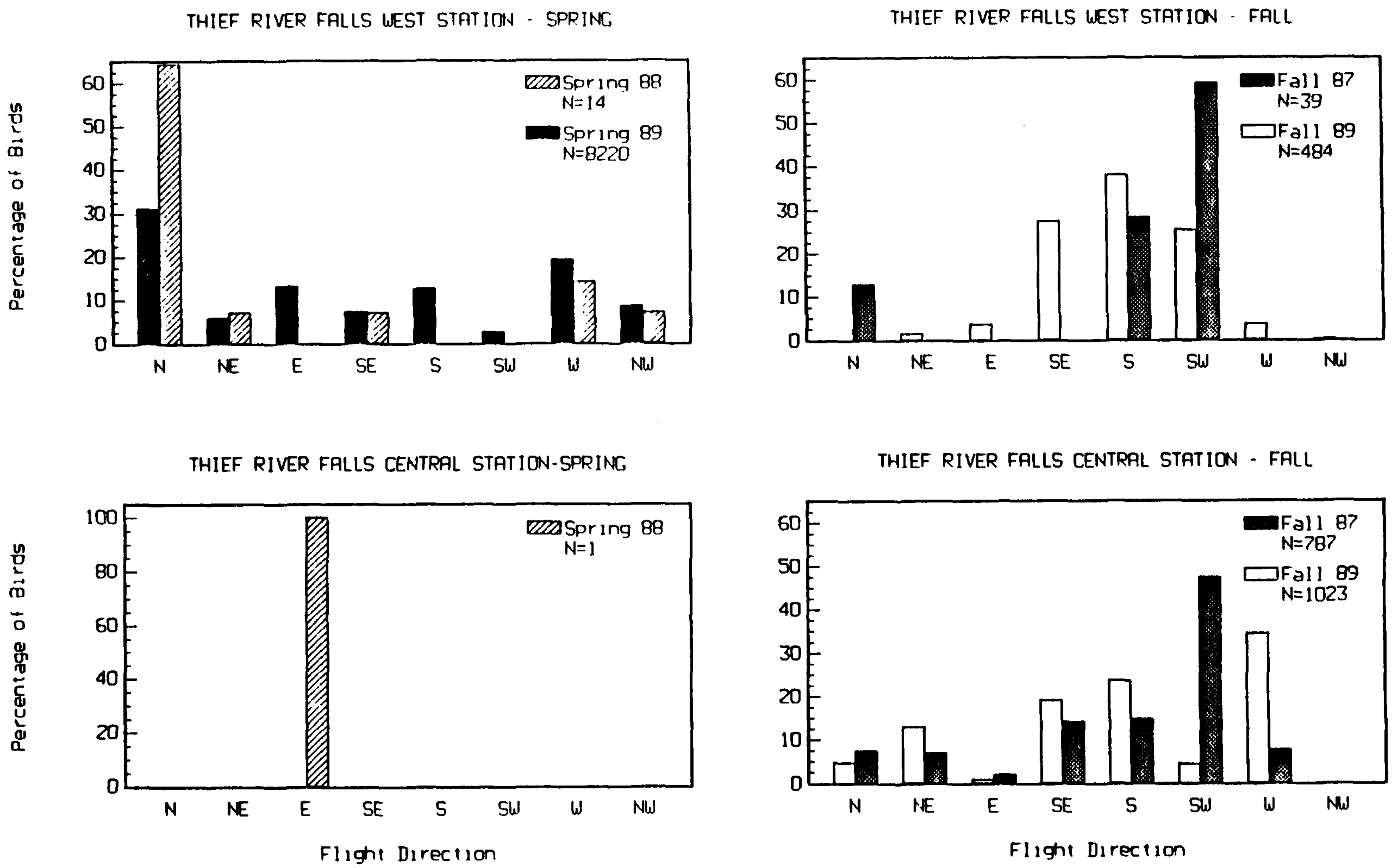


FIGURE 8-84. THIEF RIVER FALLS, MN RECEIVE STUDY AREA DIURNAL FLIGHT DIRECTIONS - DUCKS (CONTINUED)

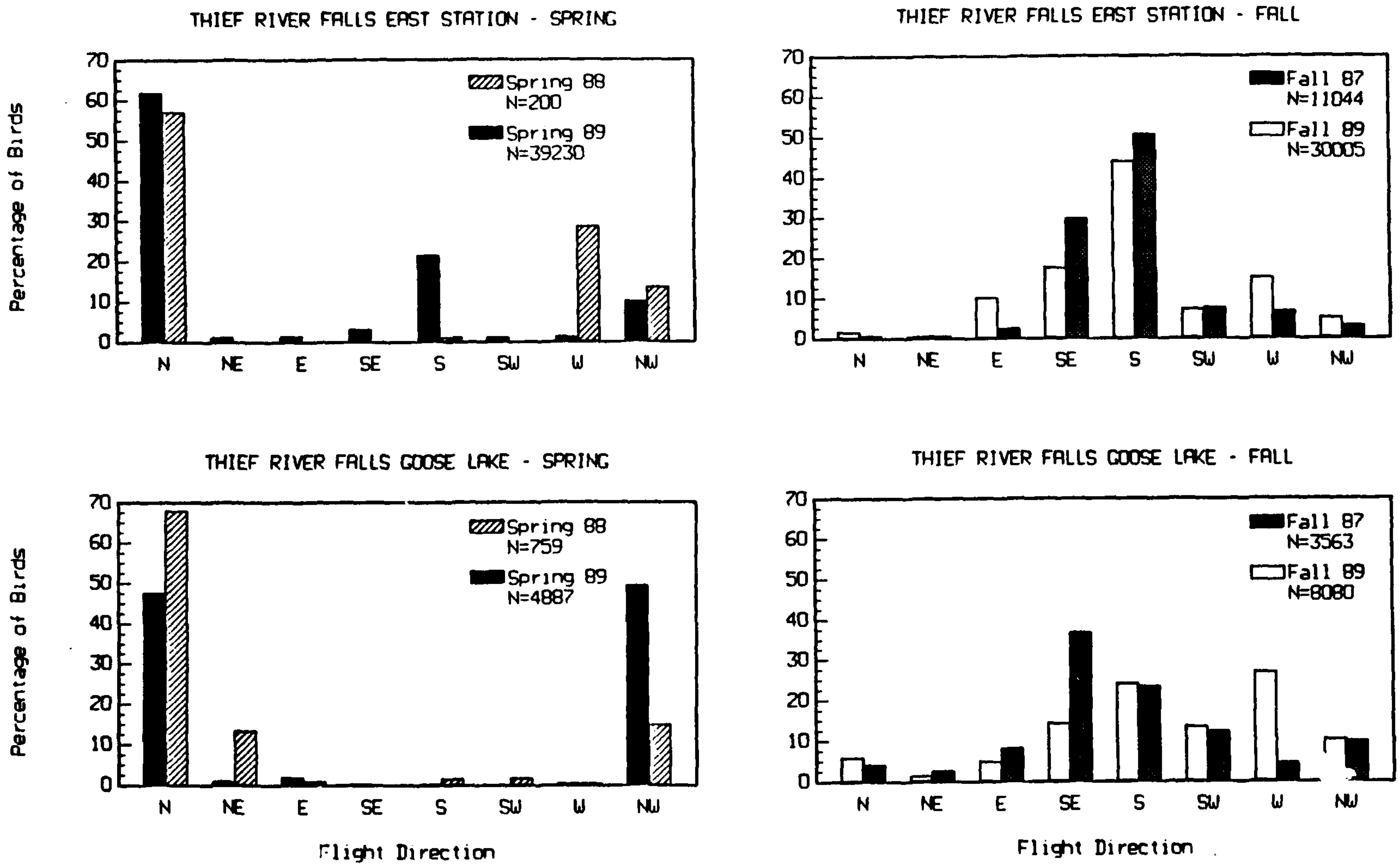


FIGURE 8-85. THIEF RIVER FALLS, MN RECEIVE STUDY AREA DIURNAL FLIGHT DIRECTIONS - GEESE/CORMORANTS

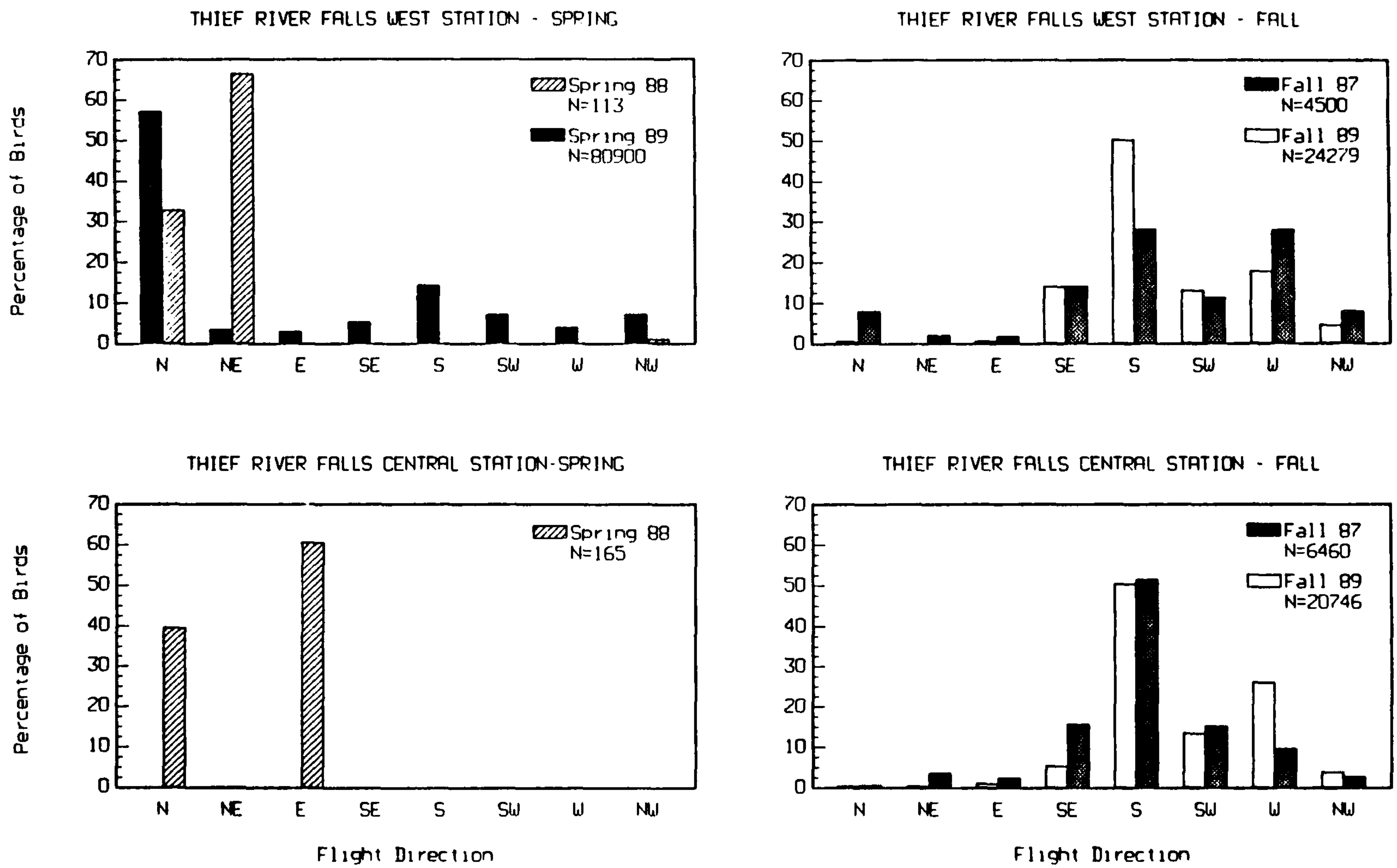


FIGURE 8-85. THIEF RIVER FALLS, MN RECEIVE STUDY AREA DIURNAL FLIGHT DIRECTIONS - GEESE/CORMORANTS (CONTINUED)

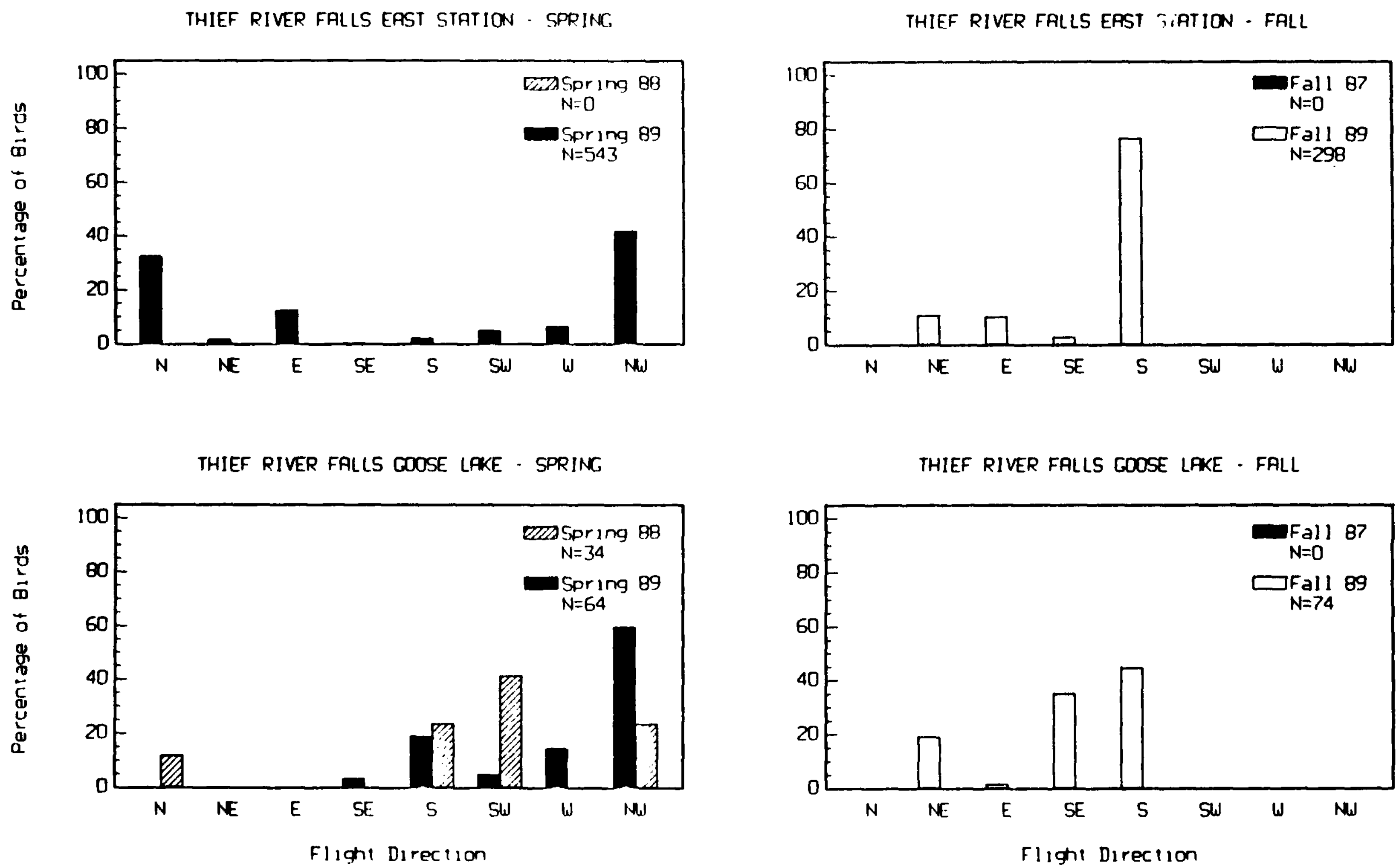


FIGURE 8-86. THIEF RIVER FALLS, MN RECEIVE STUDY AREA DIURNAL FLIGHT DIRECTIONS - SWANS

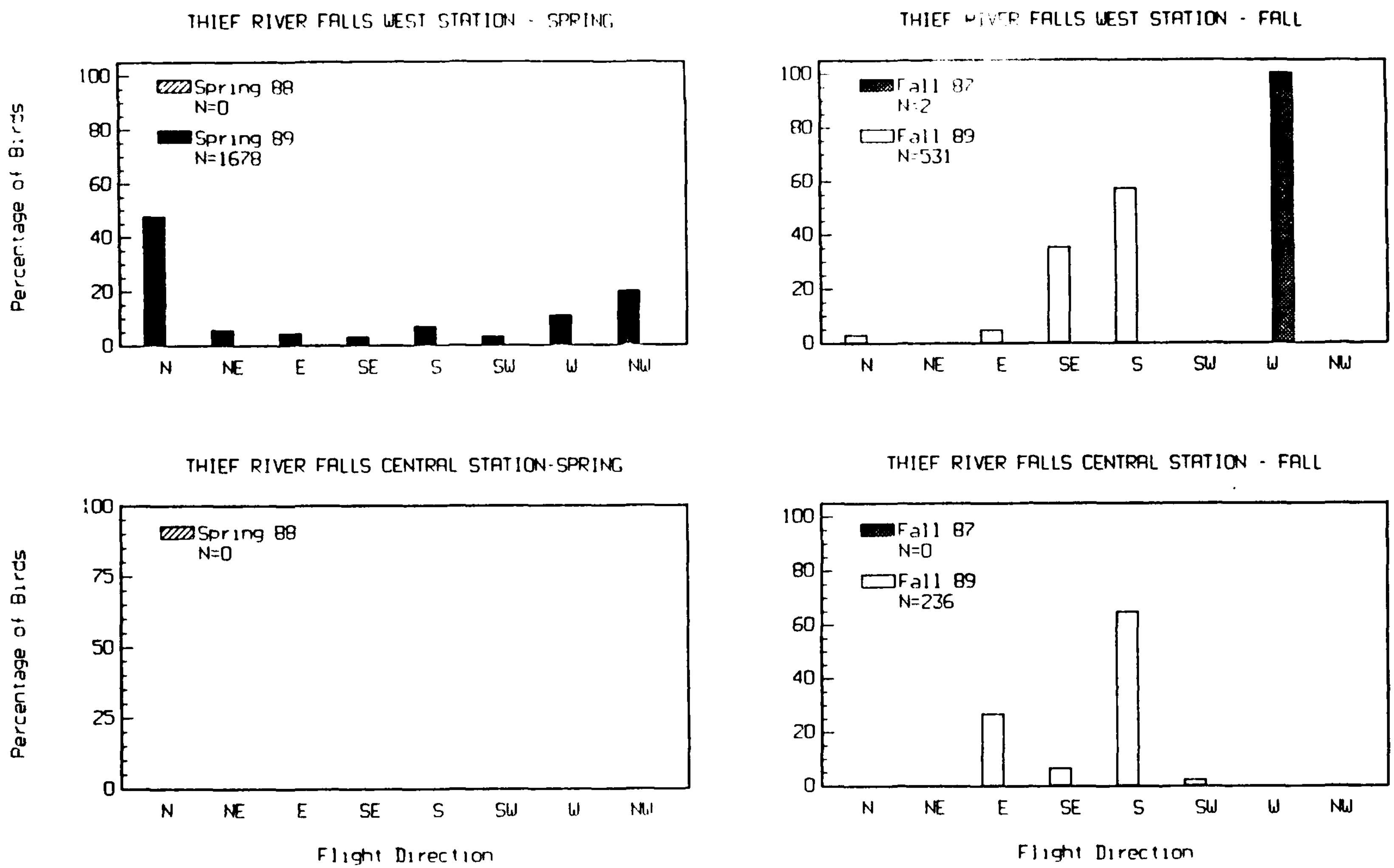


FIGURE 8-86. THIEF RIVER FALLS, MN RECEIVE STUDY AREA DIURNAL FLIGHT DIRECTIONS - SWANS (CONTINUED)

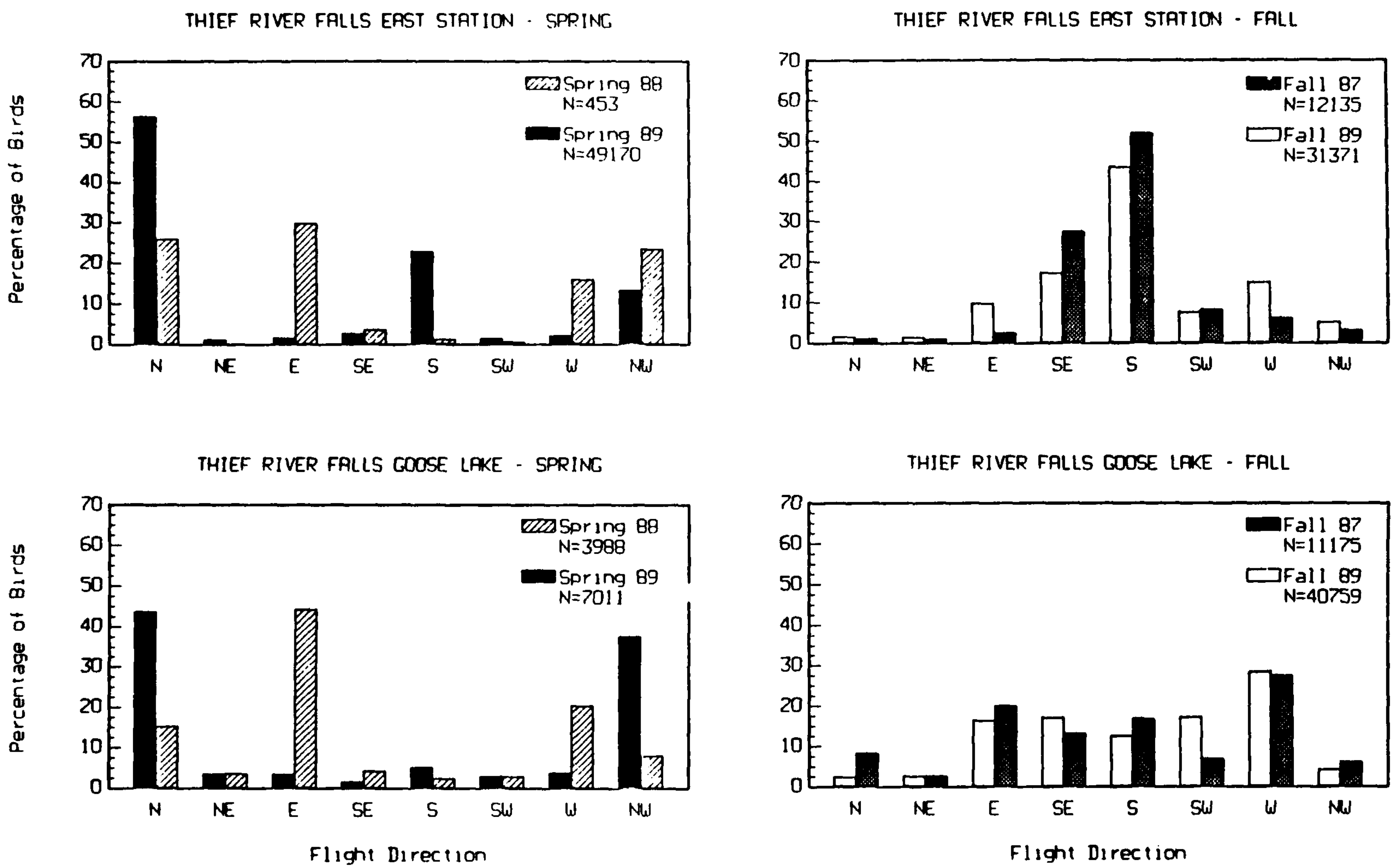


FIGURE 8-87. THIEF RIVER FALLS, MN RECEIVE STUDY AREA DIURNAL FLIGHT DIRECTIONS - ALL WATERFOWL

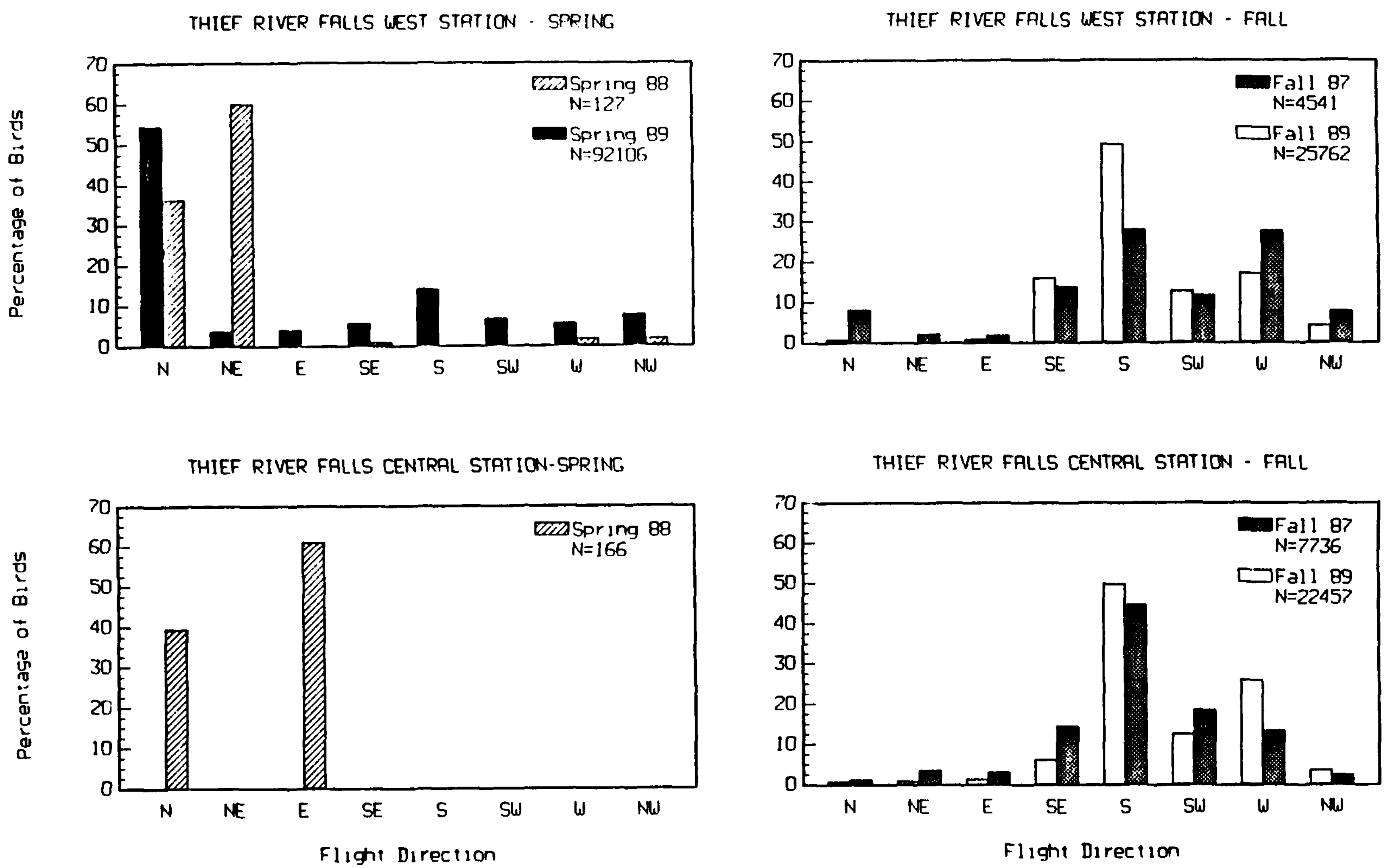


FIGURE 8-87. THIEF RIVER FALLS, MN RECEIVE STUDY AREA DIURNAL FLIGHT DIRECTIONS - ALL WATERFOWL (CONTINUED)

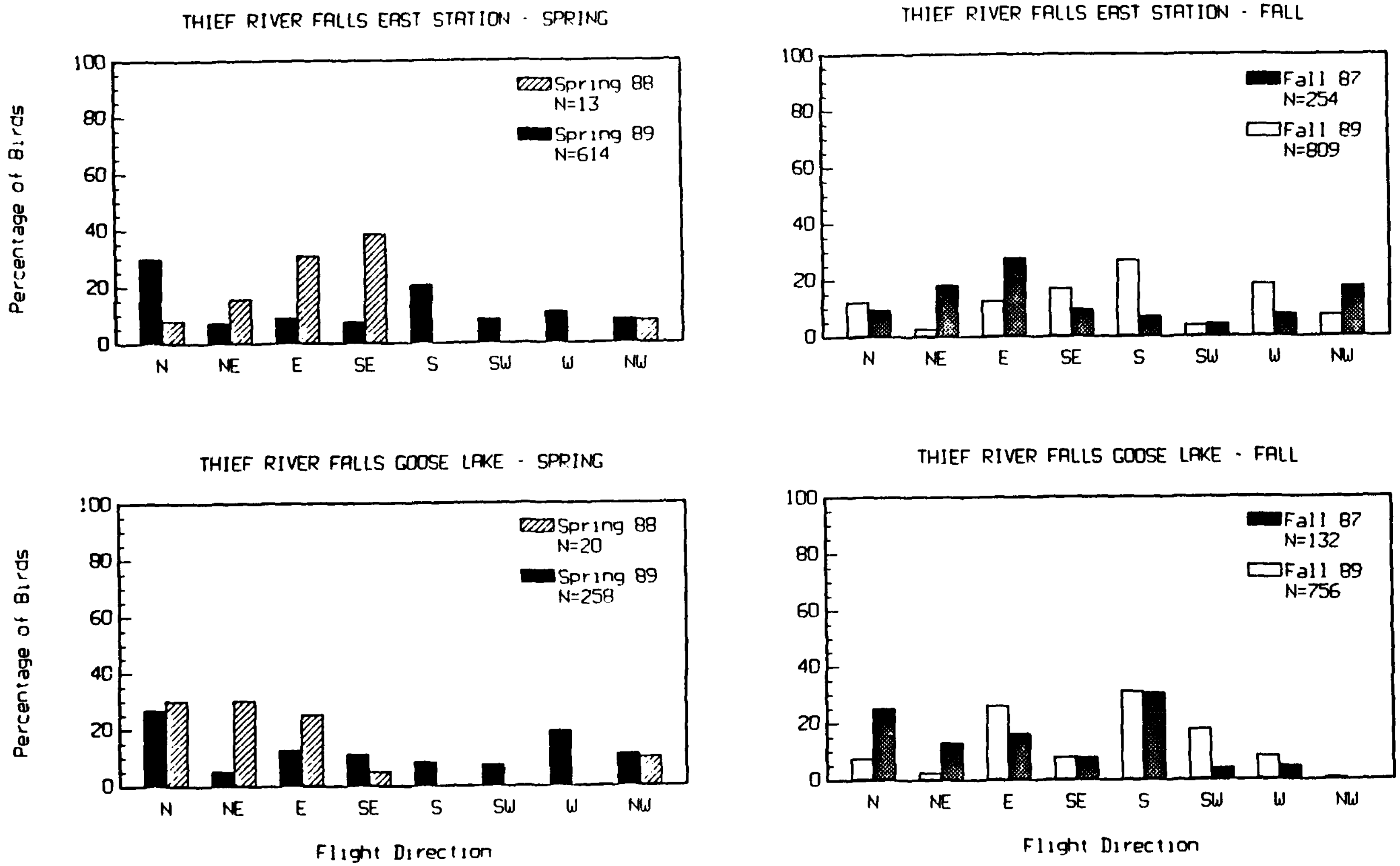


FIGURE 8-88. THIEF RIVER FALLS, MN RECEIVE STUDY AREA DIURNAL FLIGHT DIRECTIONS - SHOREBIRDS

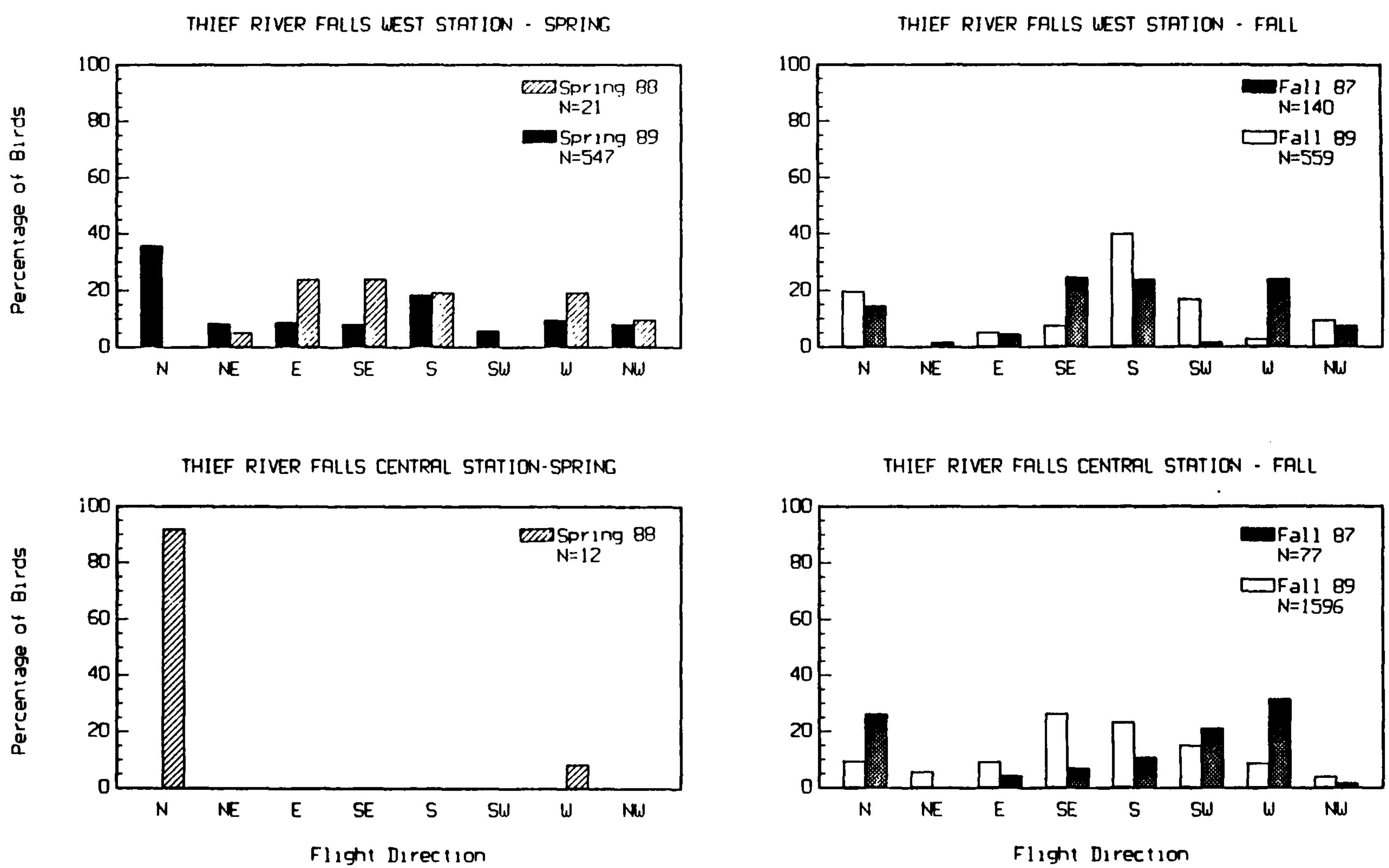


FIGURE 8-88. THIEF RIVER FALLS, MN RECEIVE STUDY AREA DIURNAL FLIGHT DIRECTIONS - SHOREBIRDS (CONTINUED)

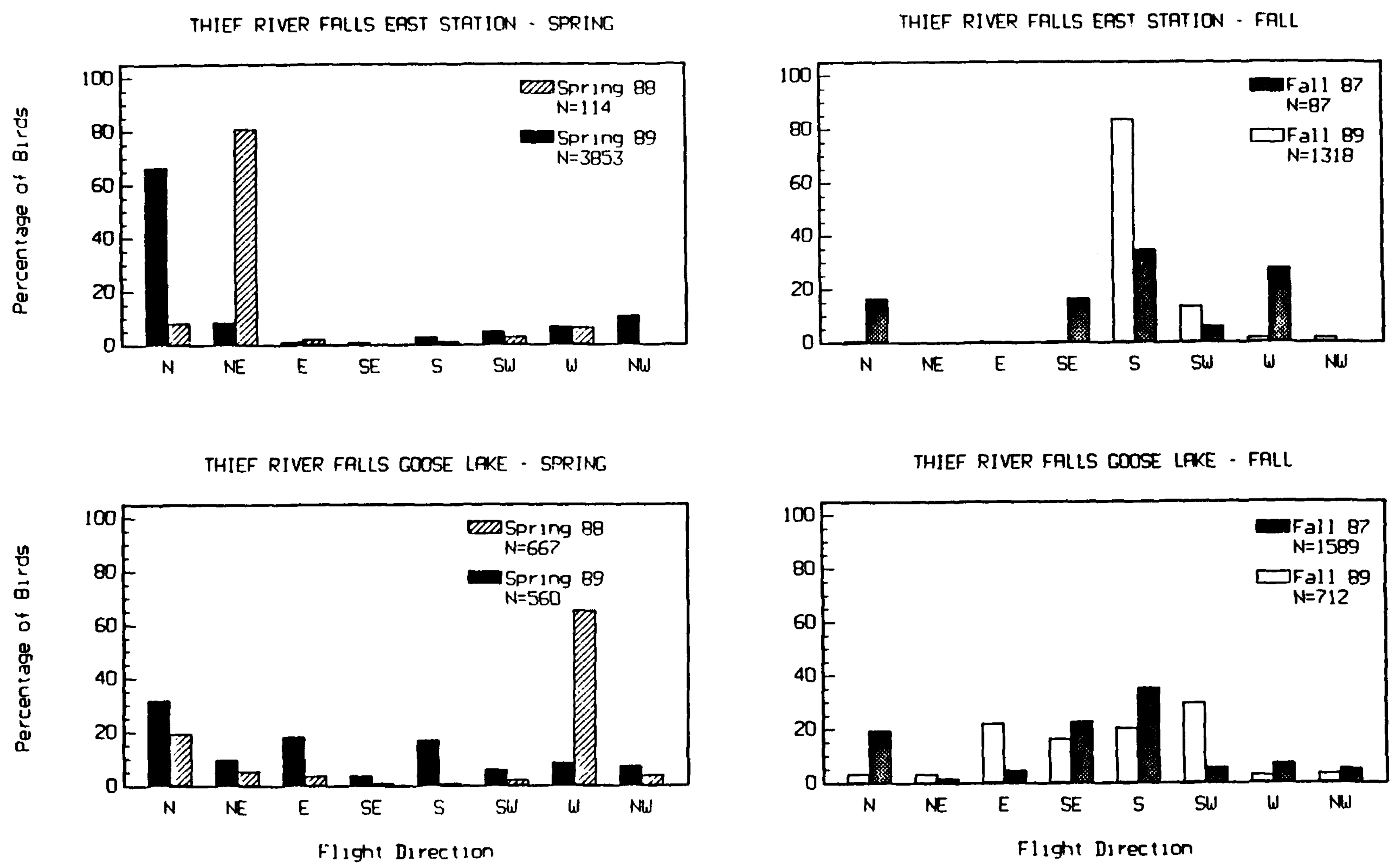


FIGURE 8-89. THIEF RIVER FALLS, MN RECEIVE STUDY AREA DIURNAL FLIGHT DIRECTIONS - SANDHILL CRANES

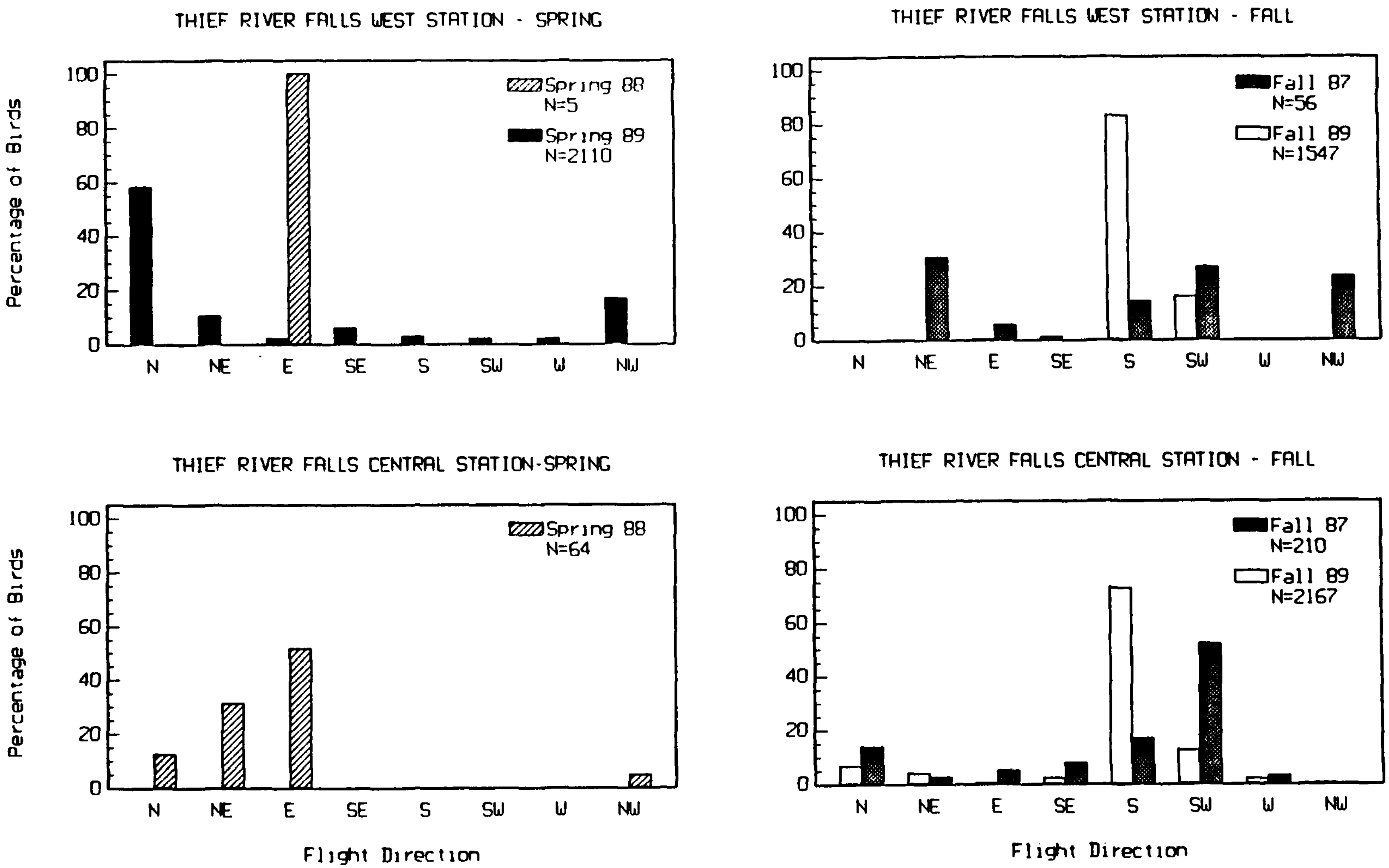


FIGURE 8-89. THIEF RIVER FALLS, MN RECEIVE STUDY AREA DIURNAL FLIGHT DIRECTIONS - SANDHILL CRANES (CONTINUED)

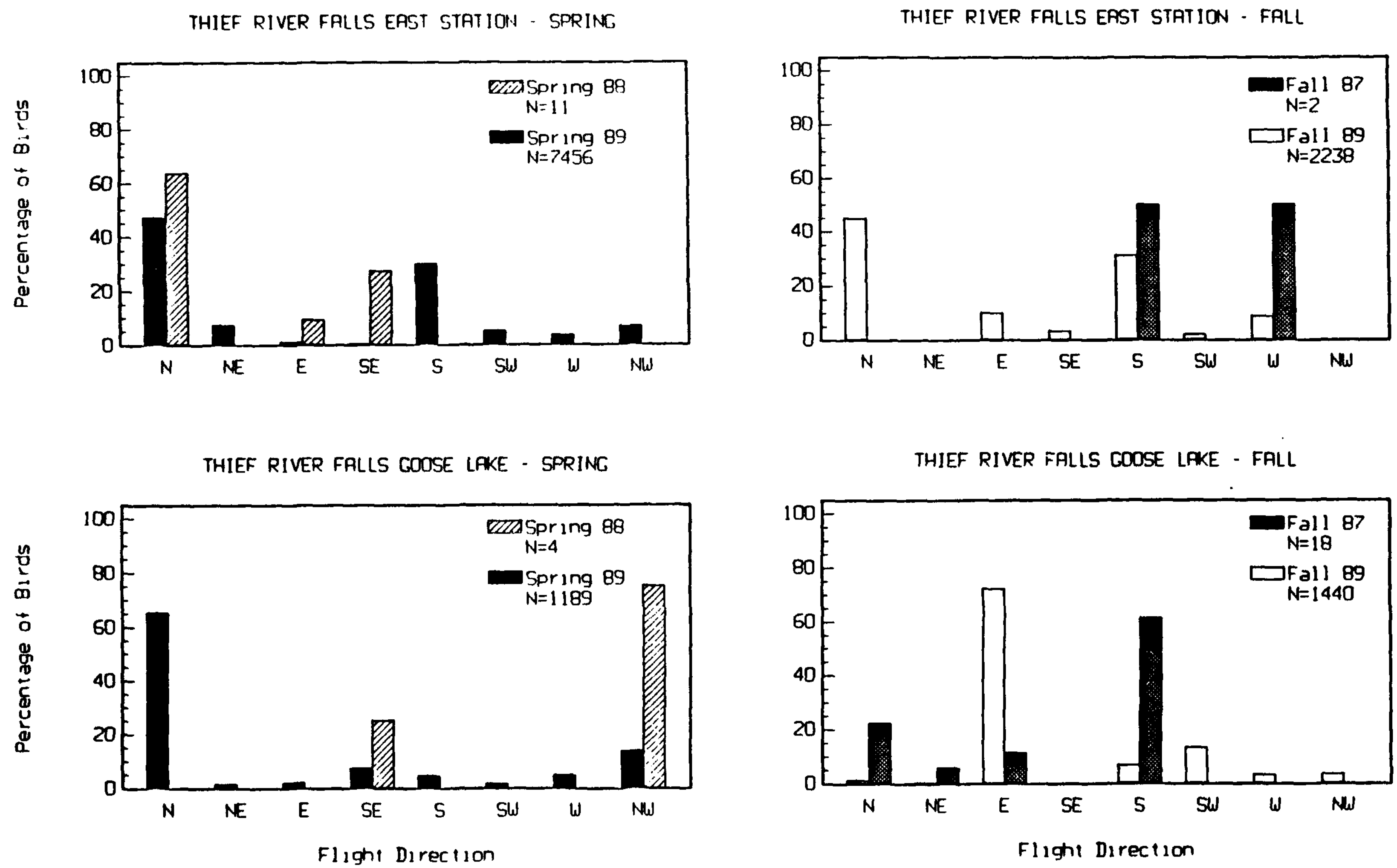


FIGURE 8-90. THIEF RIVER FALLS, MN RECEIVE STUDY AREA DIURNAL FLIGHT DIRECTIONS - WATERBIRDS

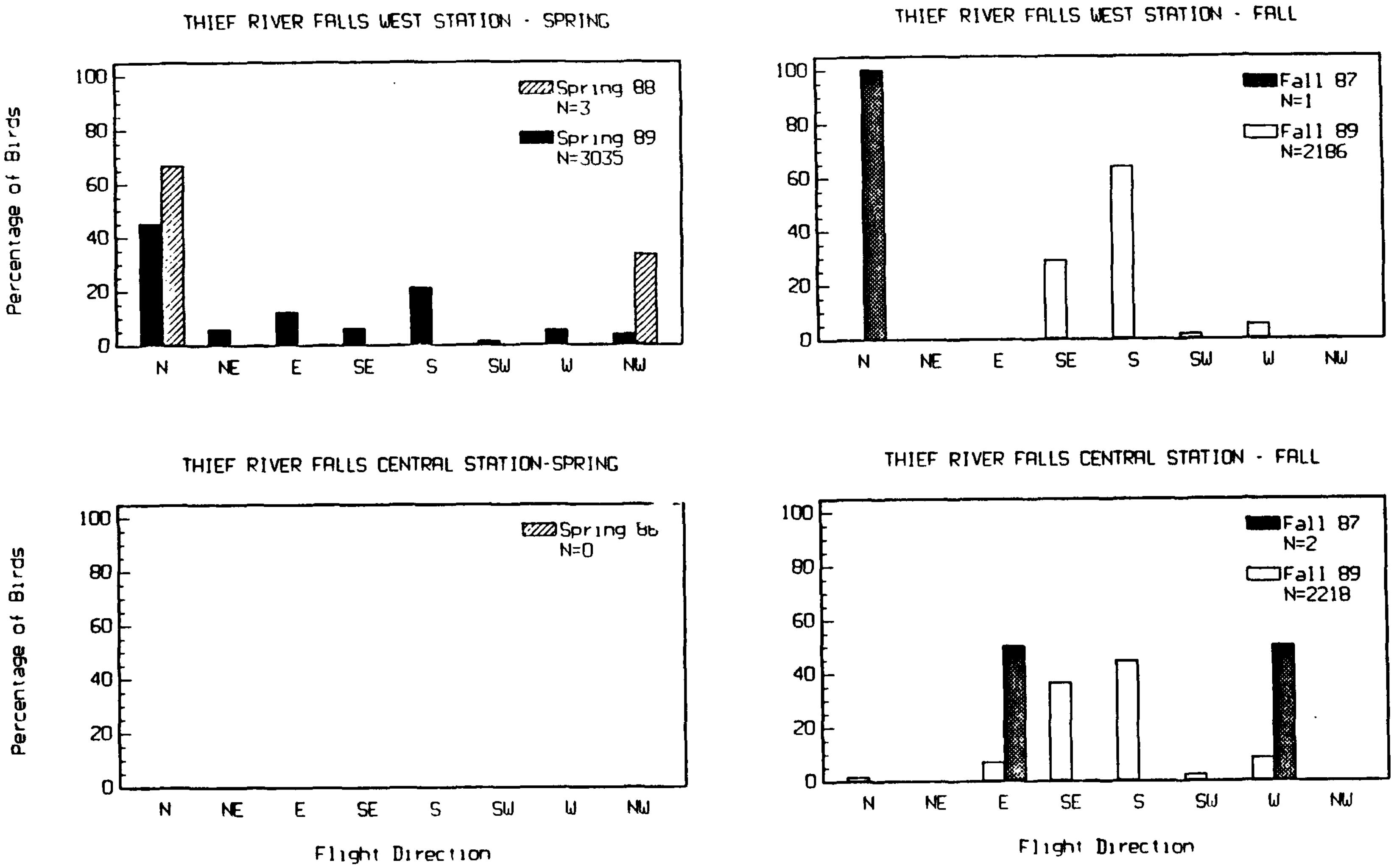


FIGURE 8-90. THIEF RIVER FALLS, MN RECEIVE STUDY AREA DIURNAL FLIGHT DIRECTIONS - WATERBIRDS (CONTINUED)

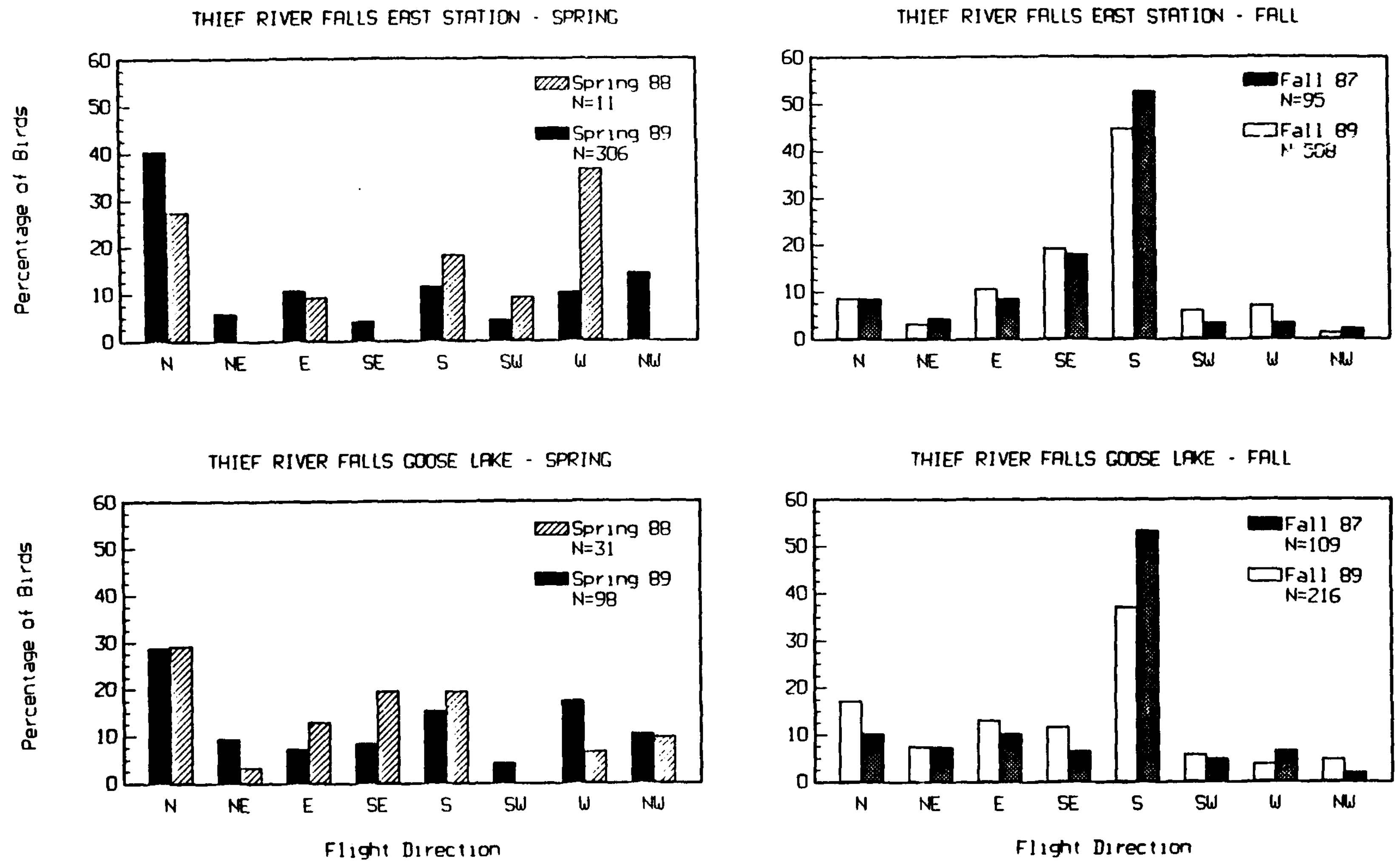


FIGURE 8-91. THIEF RIVER FALLS, MN RECEIVE STUDY AREA DIURNAL FLIGHT DIRECTIONS - RAPTORS

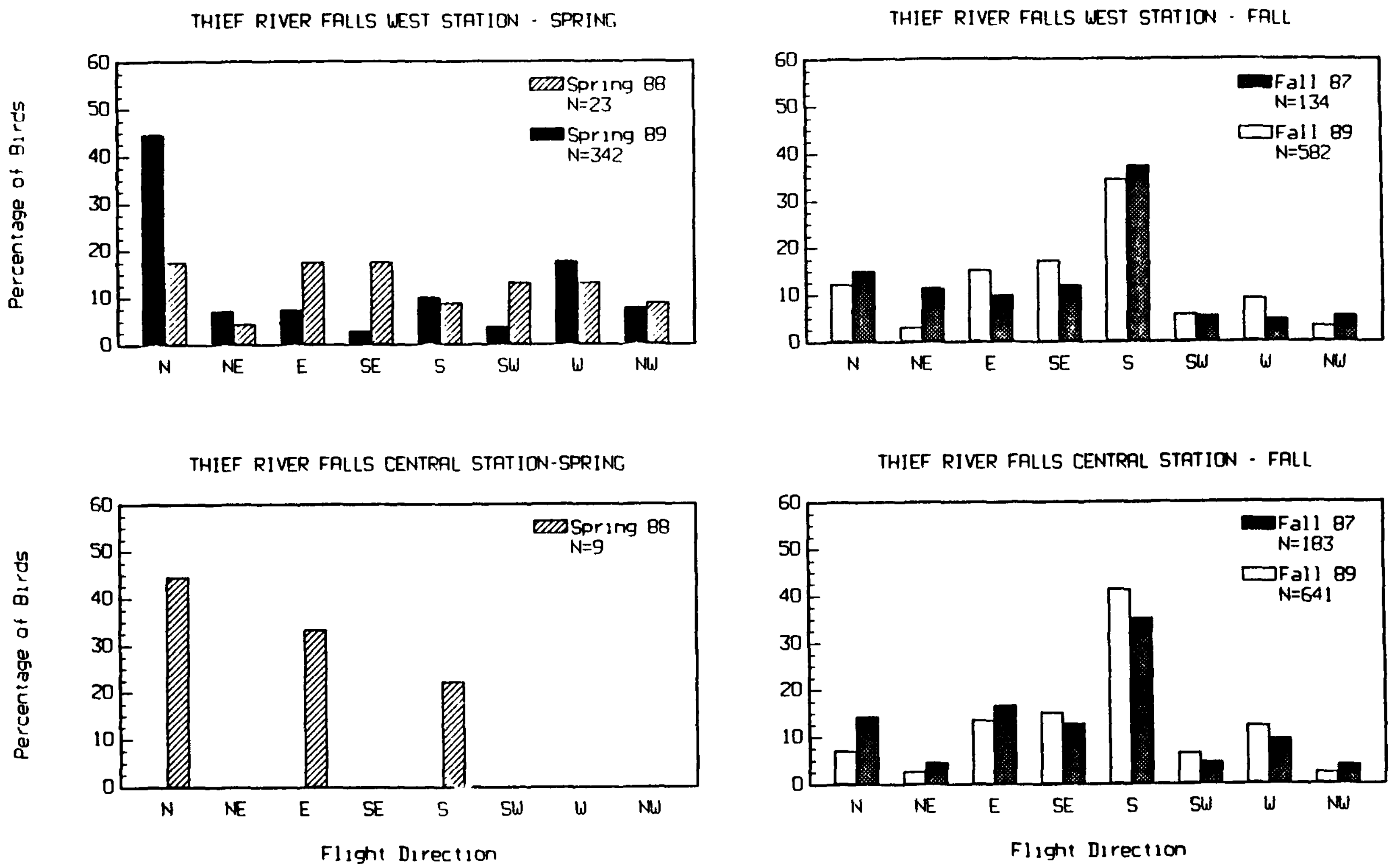


FIGURE 8-91. THIEF RIVER FALLS, MN RECEIVE STUDY AREA DIURNAL FLIGHT DIRECTIONS - RAPTORS (CONTINUED)

the East station (Figs. 8-92; 8-93; 8-94). In fall, flight directions were highly variable at all stations, although south was usually the most common flight direction. Blackbirds generally showed more directionality than nonblackbird passerines (Figs. 8-92; 8-93; 8-94).

8.2.4.4.2 Nocturnal periods. As observed using long-range radar, north and northwest were the principal flight directions in the spring at both stations. During fall, most birds flew south or southeast during nocturnal hours at both stations (Fig. 8-95). Flight directions were more variable in the spring, suggesting a greater proportion of local movements but were very similar between stations (Fig. 8-95).

8.2.4.5 Flight Corridors. During daylight hours, data were collected as birds crossed transect lines extending north, south, east, and west from an observation station. One data item collected was which transect the bird or flock crossed; data were only collected for the first transect crossing (or recorded as overhead if birds passed directly over the observer). Plotting the distribution of the percentage of birds by transect crossed allows a rough quantification of bird movement patterns in the vicinity of each observation station. A more quantitative assessment of flight corridors is more difficult because annual variation in migration corridors is not unusual. Environmental factors such as wind patterns can strongly influence bird flight patterns (Gauthreaux, 1978; Richardson, 1978; Kessel, 1984), especially on the small scale needed for this type of analysis. For example, birds flying during periods when strong winds are blowing perpendicular to their direction of travel often drift off course. Also, the extent and distribution of open water will heavily influence the movements of waterfowl, waterbirds, and shorebirds.

Unlike the analysis conducted at Amherst, birds flying in directions other than due east or due west were recoded as crossing either the west or east transect. The total number of birds (by species group) observed at the three primary stations was then calculated, and the percentage of this total number crossing west, east, or overhead at each of the three primary stations was determined. Thus, the percentage of the total number of birds observed on an east (East station, east transect) to west (West station, west transect) gradient was calculated for each season to determine where birds were most abundant and to gain insight into their flight patterns. Data from the Goose Lake station were not used in this analysis. The Central station was not sampled in the spring of 1989, so percentages at the East and West stations will be inflated relative to the other seasons.

The results of this analysis are presented in Table 8-39. The percentages do not add up to 100 percent on each line of this table, due to east-west bird movements; these movements were substantial for some groups during some seasons. Flight altitudes by transect crossed are presented in Table 8-40.

A comparable analysis during nocturnal hours was conducted simply by comparing the number of targets crossing transects extending east and west from each radar location.

8.2.4.5.1 Daylight periods. Ducks in fall were most frequently observed flying in the extreme eastern portion of the Thief River Falls study area. During spring, most ducks were observed west of the east station, along the beach ridge (Table 8-39). Geese/cormorants in fall showed similar patterns as ducks, with the greatest percentage flying in the extreme eastern portion of the study area. In 1987, movement up the beach ridge was also common. During spring, percentages were generally highest on the West station's east transect and the East station's west transect, suggesting that the greatest number of birds were flying through the center of the study area, perhaps following the beach ridge and the Goose Lake marsh complex. Swans were most commonly observed in the extreme western portion of the study area during both seasons (Table 8-39). Patterns for all waterfowl were similar to those described for ducks and geese (Table 8-39).

Raptors exhibited no strong patterns during any season, suggesting that migration was relatively uniform over the study area (Table 8-39). Sandhill cranes were most commonly observed in the center of the study area and along the beach ridge (Table 8-39). This pattern is expected since cranes often

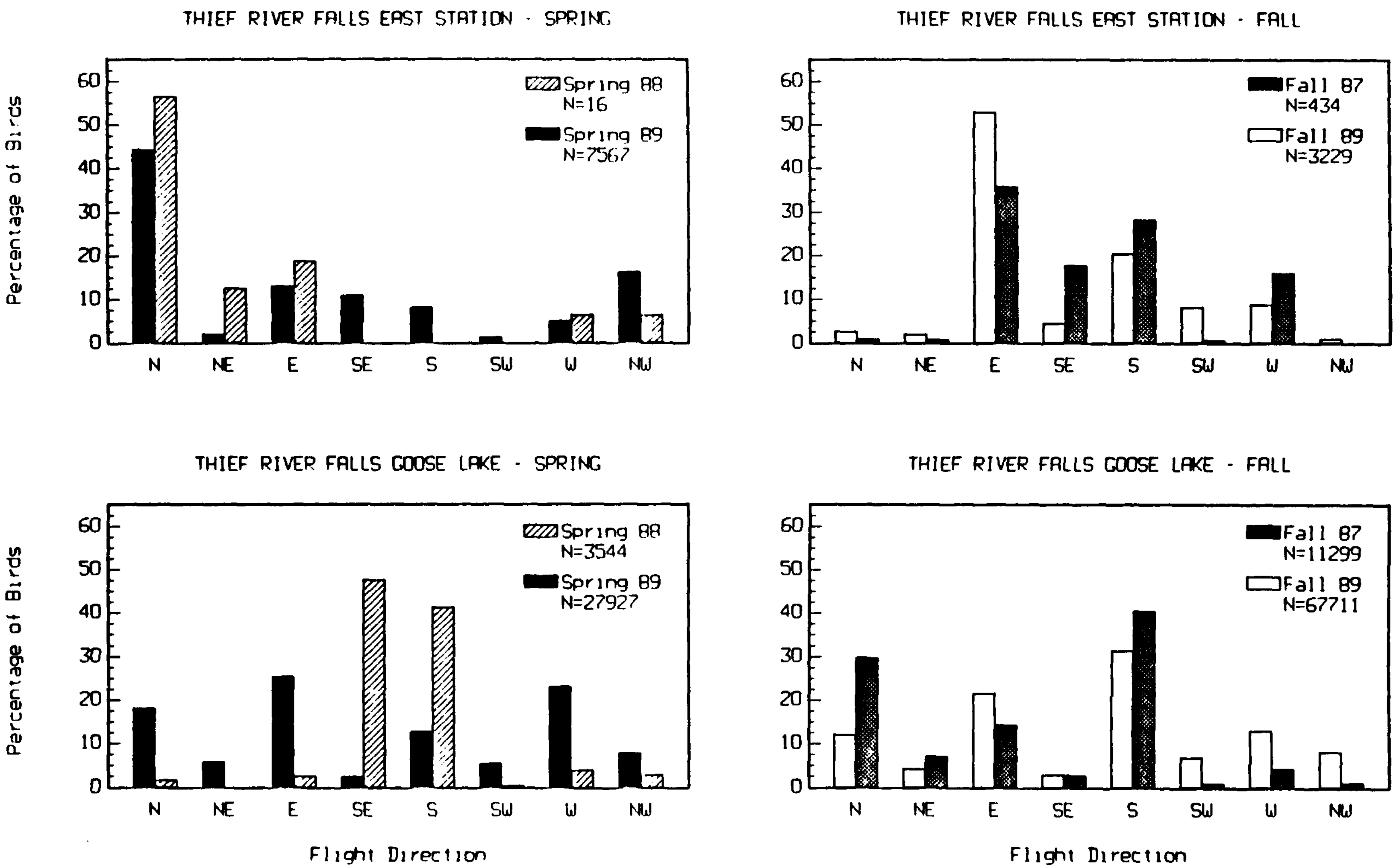


FIGURE 8-92. THIEF RIVER FALLS, MN RECEIVE STUDY AREA DIURNAL FLIGHT DIRECTIONS - BLACKBIRDS

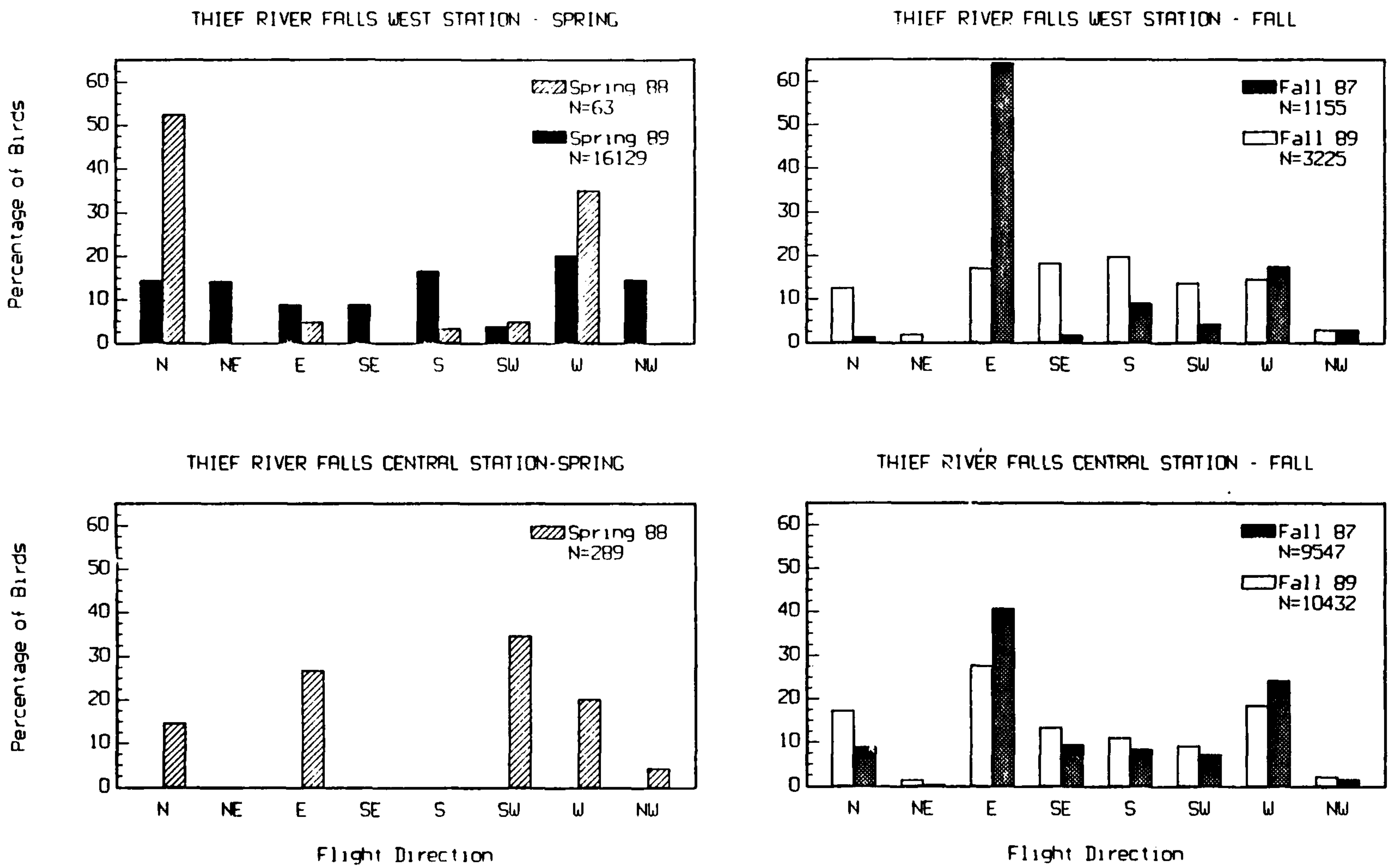


FIGURE 8-92. THIEF RIVER FALLS, MN RECEIVE STUDY AREA DIURNAL FLIGHT DIRECTIONS - BLACKBIRDS (CONTINUED)

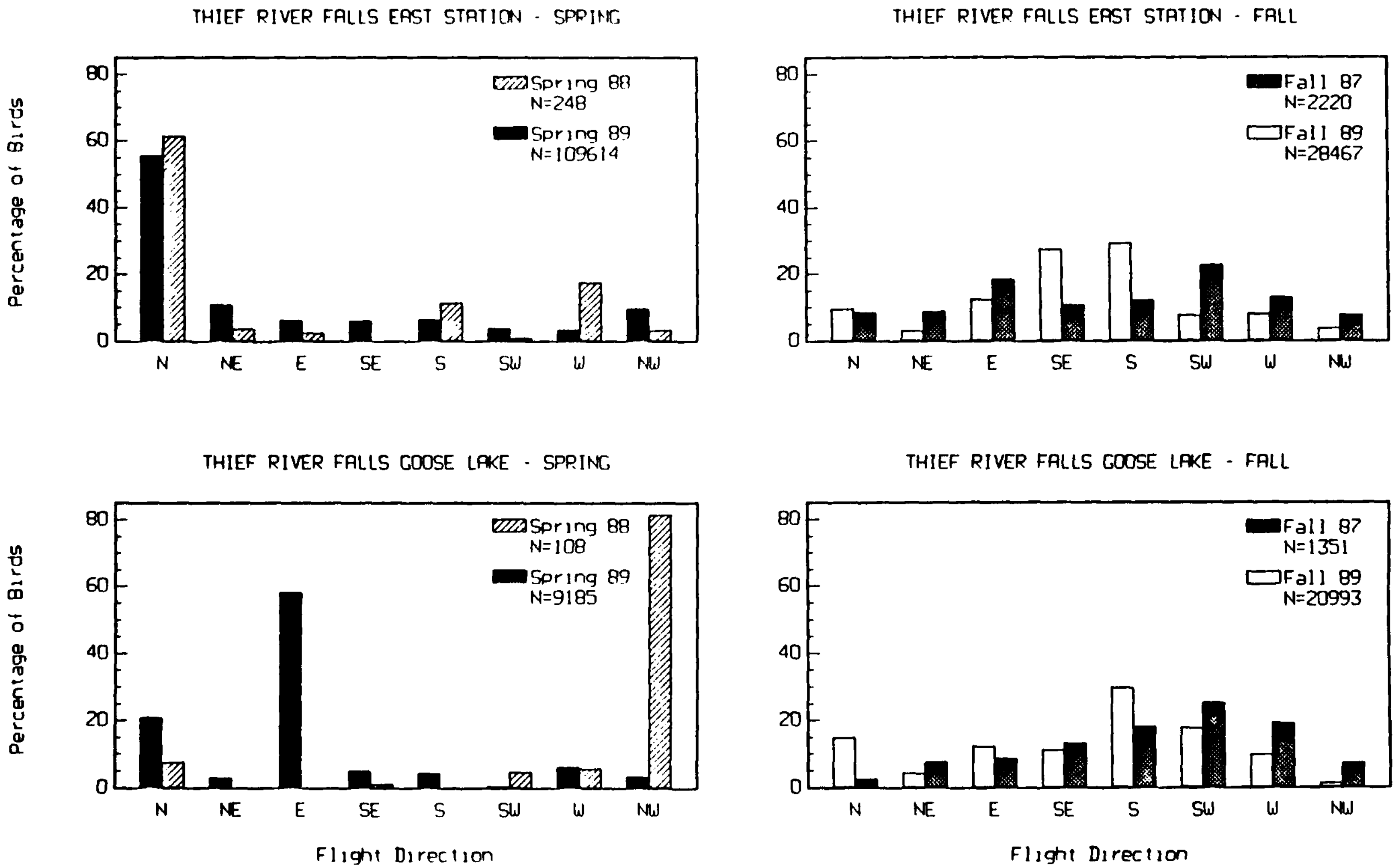


FIGURE 8-93. THIEF RIVER FALLS, MN RECEIVE STUDY AREA DIURNAL FLIGHT DIRECTIONS - NONBLACKBIRD PASSERINES

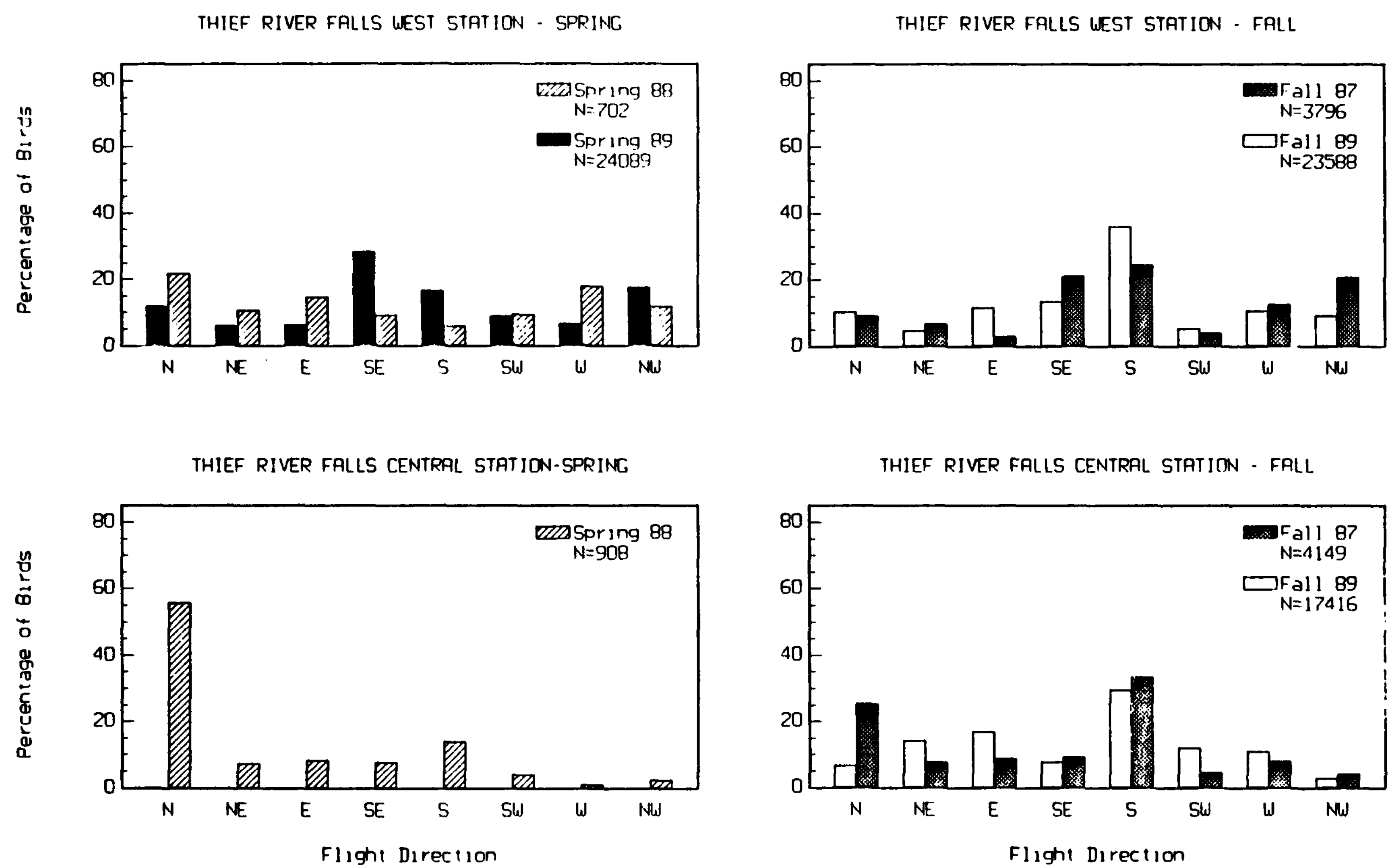


FIGURE 8-93. THIEF RIVER FALLS, MN RECEIVE STUDY AREA DIURNAL FLIGHT DIRECTIONS - NONBLACKBIRD PASSERINES (CONTINUED)

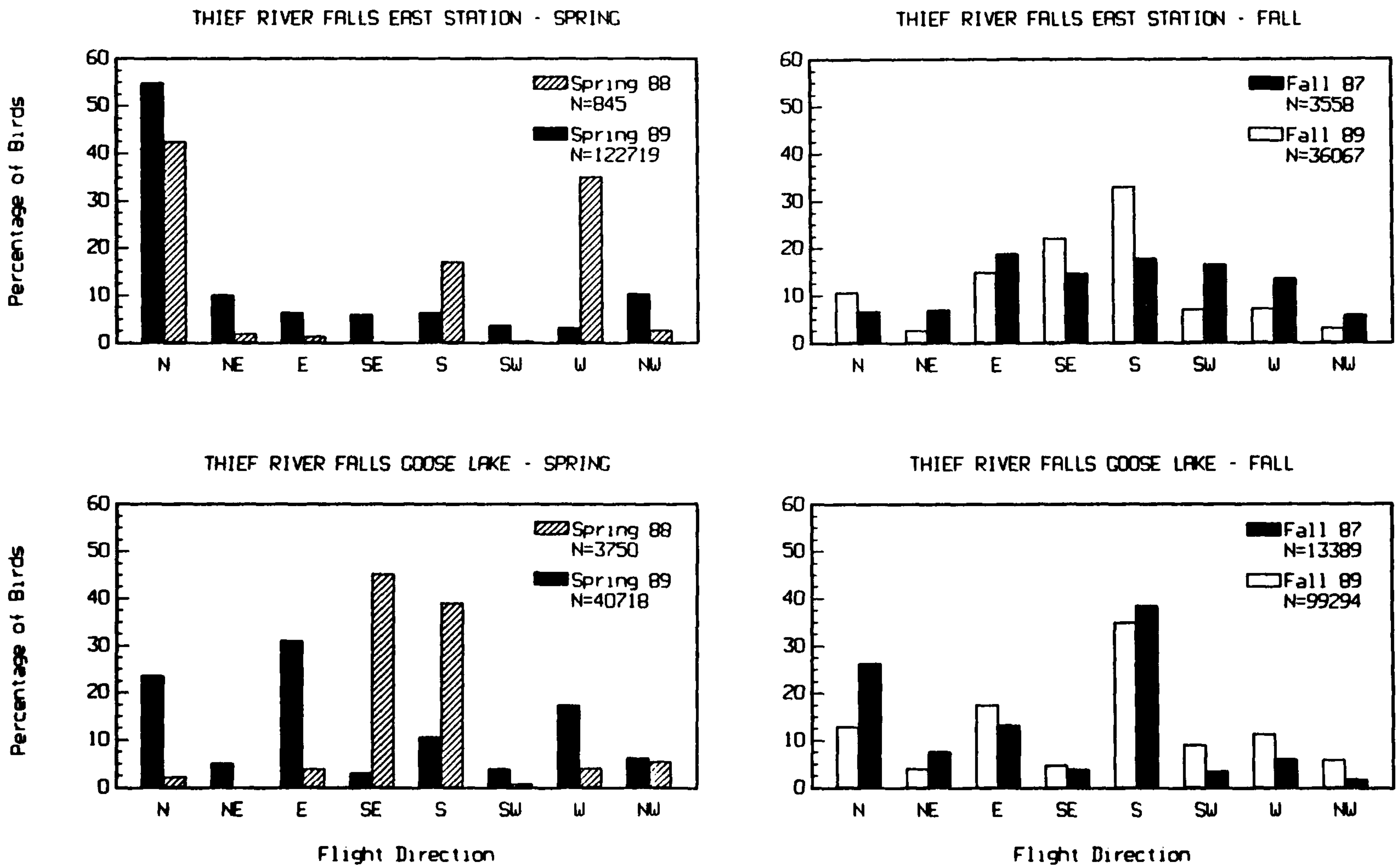


FIGURE 8-94. THIEF RIVER FALLS, MN RECEIVE STUDY AREA DIURNAL FLIGHT DIRECTIONS - ALL PASSERINES

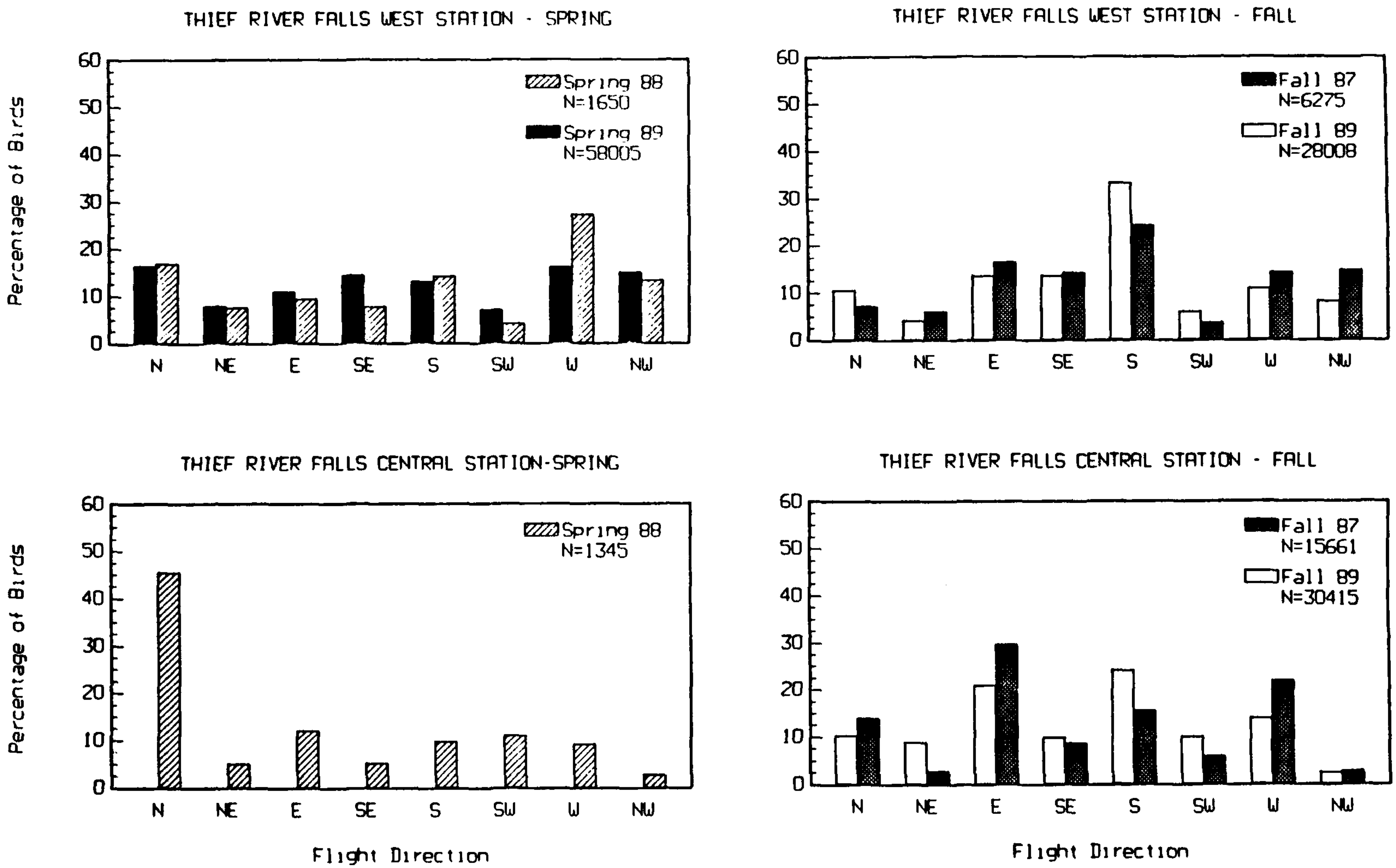


FIGURE 8-94. THIEF RIVER FALLS, MN RECEIVE STUDY AREA DIURNAL FLIGHT DIRECTIONS - ALL PASSERINES (CONTINUED)

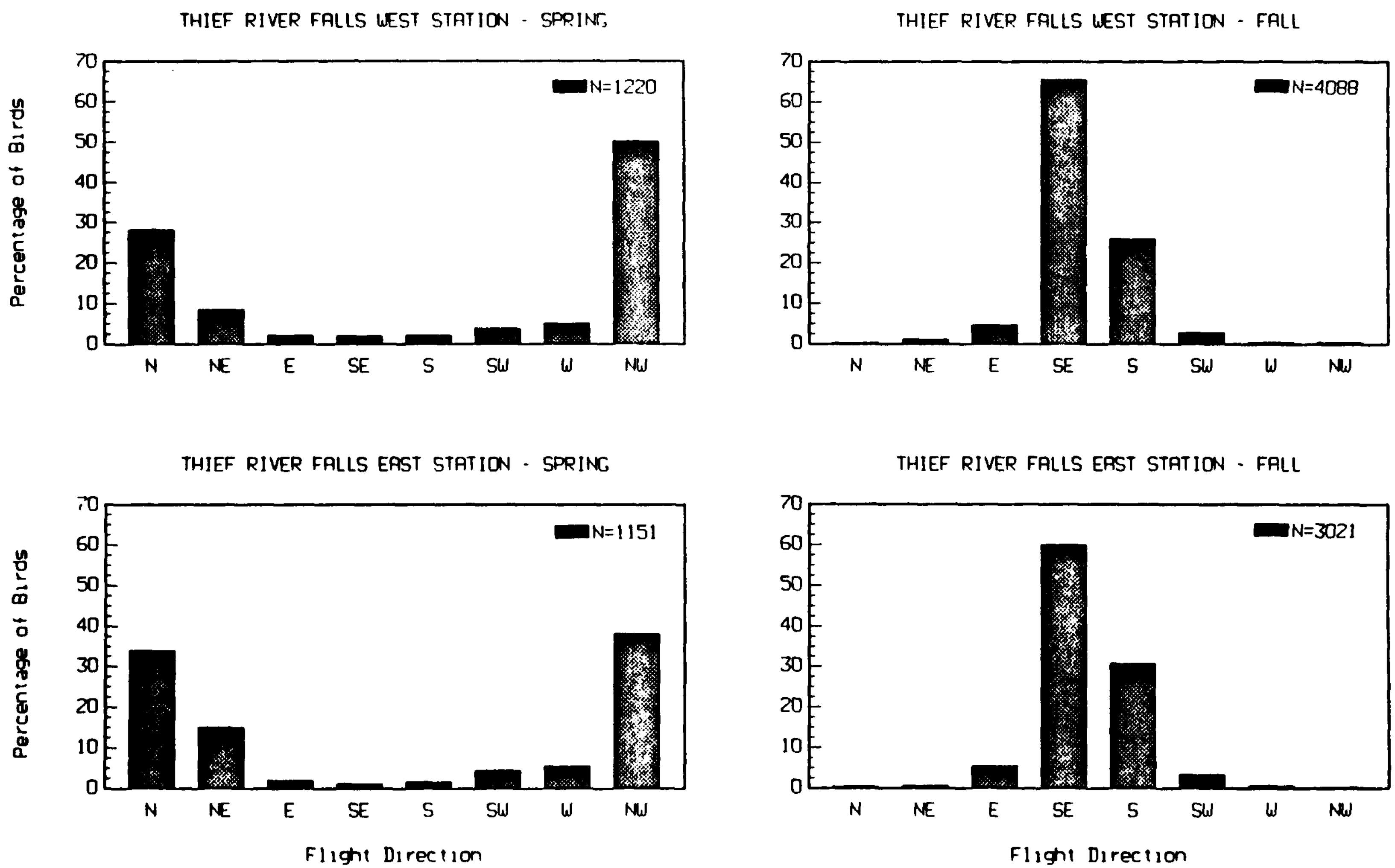


FIGURE 8-95. THIEF RIVER FALLS, MN RECEIVE STUDY AREA NOCTURNAL FLIGHT DIRECTIONS - LONG-RANGE RADAR

roosted in the vicinity of Goose Lake (in the center of the study area) during both spring and fall, as well as at several other locations in the eastern portion of the study area in spring.

Shorebirds were generally observed flying in the central and eastern portions of the study area in fall and the distribution was relatively uniform over the study area in the spring (Table 8-39). Waterbirds tended to favor the beach ridge area, especially in spring; patterns were more uniform in fall (Table 8-39). Passerines tended to be more commonly observed flying through the center of the study area, although this pattern was not strongly evident.

Flight altitude patterns by transect crossed did not reveal any strong patterns. In general, waterbirds and passerines flew higher in the eastern portion of the study area, waterfowl flew higher in the central portion of the study area, and sandhill cranes tended to fly lowest along the beach ridge (Table 8-40).

8.2.4.5.2 **Nocturnal periods.** More targets flew west of the East radar station than flew east of this location during both spring and fall (Table 8-41). Movements appear to have been strongly influenced by the north-south running beach ridge which lies several miles west of the East sampling station. At the West station, many more targets passed east of the radar unit in the fall. This pattern was not observed in the spring, as the number of targets passing west and east of the West radar station was approximately equal (Table 8-41).

8.2.4.5.3 **Time of day comparison.** Data from long-range radar observations showed that more targets passed west of the East radar station during nocturnal hours for both spring and fall while equal numbers of targets passed east and west of the radar station during daylight hours in the fall and more targets passed west of the station during daylight hours in the spring (Table 8-41).

TABLE 8-39. FLIGHT CORRIDORS OBSERVED FROM PRIMARY OBSERVATION STATIONS DURING DAYLIGHT HOURS AT THE THIEF RIVER FALLS RECEIVE STUDY AREA

Species Group	Season	Percentage of Birds Crossing Transect								
		West Station			Central Station			East Station		
		West	Overhead	East	West	Overhead	East	West	Overhead	East
Waterfowl	Fall 87	3.5	3.7	5.1	6.7	5.5	15.0	20.0	4.8	22.0
	Spring 88	3.9	0.3	13.0	4.0	0.0	4.7	28.0	0.4	4.7
	Spring 89	19.0	3.4	29.0	---	---	---	19.0	0.8	12.0
	Fall 89	10.0	1.7	12.0	6.8	1.6	10.0	7.9	1.8	18.0
-Ducks	Fall 87	1.3	0.6	0.6	9.9	24.0	10.0	6.4	11.0	33.0
	Spring 88	0.4	0.8	3.4	0.0	0.0	0.0	36.0	1.1	0.4
	Spring 89	11.0	1.1	19.0	---	---	---	32.0	0.3	15.0
	Fall 89	8.8	0.6	6.6	11.0	0.0	10.0	11.0	1.9	17.0
-Geese/Cormorants	Fall 87	3.8	4.0	5.6	6.6	4.3	16.0	21.0	4.5	22.0
	Spring 88	5.9	0.0	18.0	6.3	0.0	7.3	24.0	0.0	6.1
	Spring 89	19.0	3.8	31.0	---	---	---	17.0	0.9	11.0
	Fall 89	9.7	1.8	12.0	6.6	1.7	10.0	7.9	1.9	19.0
-Swans	Fall 87	*(1)	*	*	*	*	*	*	*	*
	Spring 88	*	*	*	*	*	*	*	*	*
	Spring 89	41.0	3.1	16.0	---	---	---	11.0	0.0	9.7
	Fall 89	38.0	0.0	6.2	6.4	0.1	1.4	7.3	0.0	6.1
Raptors	Fall 87	5.8	13.0	9.3	11.0	15.0	9.3	9.3	7.3	6.4
	Spring 88	12.0	4.7	23.0	4.7	2.3	9.3	9.3	2.3	4.7
	Spring 89	23.0	3.4	17.0	---	---	---	16.0	2.9	18.0
	Fall 89	7.6	2.0	13.0	11.0	1.4	12.0	8.8	0.5	12.0
Sandhill cranes	Fall 87	0.0	4.6	6.7	23.0	13.0	11.0	7.4	6.7	8.2
	Spring 88	0.0	0.0	0.0	5.5	0.0	11.0	53.0	0.0	4.4
	Spring 89	15.0	1.6	14.0	---	---	---	27.0	2.4	28.0
	Fall 89	8.3	0.5	11.0	17.0	2.2	13.0	17.0	3.3	3.8

TABLE 8-39 (Continued). FLIGHT CORRIDORS OBSERVED FROM PRIMARY OBSERVATION STATIONS DURING DAYLIGHT HOURS AT THE THIEF RIVER FALLS RECEIVE STUDY AREA

Species Group	Season	Percentage of Birds Crossing Transect								
		West Station			Central Station			East Station		
		West	Overhead	East	West	Overhead	East	West	Overhead	East
Shorebirds	Fall 87	6.8	20.0	0.0	2.3	10.0	0.0	3.7	46.0	4.4
	Spring 88	13.0	8.7	11.0	20.0	4.3	0.0	13.0	11.0	2.2
	Spring 89	20.0	4.8	12.0	---	---	---	21.0	2.4	20.0
	Fall 89	7.0	0.0	9.9	15.0	1.1	25.0	11.0	0.0	5.6
Waterbirds	Fall 87	*	*	*	*	*	*	*	*	*
	Spring 88	*	*	*	*	*	*	*	*	*
	Spring 89	15.0	0.2	6.3	---	---	---	53.0	1.3	14.0
	Fall 89	18.0	0.6	10.0	18.0	0.0	7.3	20.0	0.1	9.2
Passerines	Fall 87	1.9	14.0	4.5	5.6	22.0	6.0	1.0	12.0	2.0
	Spring 88	6.7	8.3	12.0	5.7	13.0	9.2	8.5	2.0	3.6
	Spring 89	11.0	4.1	8.1	---	---	---	32.0	7.3	20.0
	Fall 89	12.0	1.8	6.4	8.5	1.2	11.0	13.0	2.6	12.0

1. Insufficient data.

TABLE 8-40. FLIGHT ALTITUDES OBSERVED FROM PRIMARY OBSERVATION STATIONS BY TRANSECT DURING DAYLIGHT HOURS AT THE THIEF RIVER FALLS RECEIVE STUDY AREA

Species Group	Season	Flight Altitude (Percentage <100 Ft AGL)								
		West Station			Central Station			East Station		
		West	Overhead	East	West	Overhead	East	West	Overhead	East
Waterfowl	Fall 87	7.1	37.7	20.4	8.8	5.3	3.6	5.3	10.5	1.8
	Spring 88	93.1	100.0	92.6	0.0	*(a)	100.0	43.8	100.0	85.7
	Spring 89	34.7	18.6	40.0	---	---	---	37.8	22.1	53.2
	Fall 89	4.7	1.1	7.0	4.7	0.0	5.9	5.7	2.0	7.6
-Ducks	Fall 87	10.0	100.0	100.0	73.1	10.5	16.5	37.6	17.1	0.8
	Spring 88	0.0	100.0	22.2	*	*	*	96.8	100.0	100.0
	Spring 89	55.0	6.9	50.6	---	---	---	46.4	83.3	58.9
	Fall 89	33.3	100.0	41.0	20.2	*	41.3	20.6	0.0	19.6
-Geese/Cormorants	Fall 87	7.1	37.0	19.7	1.6	3.1	2.9	4.8	9.3	1.9
	Spring 88	96.4	*	100.0	0.0	*	100.0	0.0	*	100.0
	Spring 89	32.9	18.7	38.9	---	---	---	35.8	19.1	51.6
	Fall 89	3.1	0.0	6.8	3.8	0.0	5.0	5.1	2.0	7.3
-Swans	Fall 87	*	*	*	*	*	*	*	*	*
	Spring 88	*	*	*	*	*	*	*	*	*
	Spring 89	59.5	44.9	53.7	---	---	---	43.8	*	83.2
	Fall 89	18.5	*	0.0	7.4	0.0	0.0	0.0	*	0.0
Raptors	Fall 87	72.2	70.7	82.8	84.8	75.0	72.4	27.6	69.6	30.0
	Spring 88	100.0	100.0	60.0	100.0	100.0	25.0	50.0	100.0	100.0
	Spring 89	31.1	40.0	78.8	---	---	---	71.4	76.5	53.6
	Fall 89	68.9	8.8	76.4	71.6	8.0	54.5	69.9	0.0	60.1
Sandhill cranes	Fall 87	*	0.0	0.0	24.2	0.0	81.3	0.0	10.5	13.0
	Spring 88	*	*	*	40.0	*	95.2	2.1	*	75.0
	Spring 89	30.8	0.0	48.2	---	---	---	54.9	81.1	43.2
	Fall 89	6.3	0.0	3.2	9.4	0.0	5.3	1.2	0.0	1.6

TABLE 8-40 (Continued). FLIGHT ALTITUDES OBSERVED FROM PRIMARY OBSERVATION STATIONS BY TRANSECT DURING DAYLIGHT HOURS AT THE THIEF RIVER FALLS RECEIVE STUDY AREA

Species Group	Season	Flight Altitude (Percentage <100 Ft AGL)								
		West Station			Central Station			East Station		
		West	Overhead	East	West	Overhead	East	West	Overhead	East
Shorebirds	Fall 87	100.0	97.7	*	10.0	100.0	*	100.0	91.9	63.2
	Spring 88	100.0	100.0	100.0	100.0	100.0	*	100.0	100.0	100.0
	Spring 89	76.3	39.6	73.1	---	---	---	84.9	85.2	77.7
	Fall 89	85.4	100.0	42.5	81.8	0.0	92.3	78.4	0.0	49.4
Waterbirds	Fall 87	*	*	*	*	*	*	*	*	*
	Spring 88	*	*	*	*	*	*	*	*	*
	Spring 89	71.8	63.6	26.2	---	---	---	16.5	68.7	50.4
	Fall 89	17.3	0.0	11.0	7.2	*	10.1	0.4	0.0	0.7
Passerines	Fall 87	81.5	83.7	100.0	87.3	94.2	82.3	97.5	88.1	38.9
	Spring 88	99.6	100.0	82.0	100.0	100.0	100.0	100.0	100.0	64.0
	Spring 89	72.2	83.4	79.2	---	---	---	94.9	57.5	95.0
	Fall 89	93.0	60.7	96.0	83.7	74.3	95.2	94.0	79.4	94.7

a. Insufficient data.

TABLE 8-41. MIGRATION CORRIDORS DURING NOCTURNAL AND DIURNAL HOURS AT THE THIEF RIVER FALLS RECEIVE STUDY AREA AS MEASURED BY LONG-RANGE RADAR

	Number of Targets (Percentage)			
	West of Radar Unit		East of Radar Unit	
	Day	Night	Day	Night
WEST STATION				
Spring 1989	354 (49)	668 (50)	370 (51)	677 (50)
Fall 1989	162 (48)	1341 (33)	175 (52)	2774 (67)
EAST STATION				
Spring 1989	675 (72)	956 (74)	263 (28)	334 (26)
Fall 1989	213 (48)	1932 (64)	233 (52)	1111 (36)

At the West station, similar percentages of targets passed east and west of the radar unit during both daylight and nocturnal hours in the spring. However, more targets passed east of the radar unit during nocturnal hours in the fall; numbers were similar during daylight hours (Table 8-41).

8.2.4.6 Flock Size

8.2.4.6.1 Daylight periods. Table 8-42 lists the mean and maximum flock sizes by species group for each station. In general, mean flock sizes were higher for all species groups, except raptors and passerines, in the fall than in the spring. Mean flock sizes for raptors and passerines were similar between seasons (Table 8-42).

Mean flock sizes were highest at the West station for swans, geese/cormorants, and shorebirds, highest at the Central station for sandhill cranes, highest at the East station for waterbirds, gamebirds, and nonblackbird passerines, and highest at Goose Lake for blackbirds. Mean flock sizes of all waterfowl were similar among primary stations. Mean flock sizes of ducks and raptors were similar among the four stations (Table 8-42).

TABLE 8-42. MEAN AND MAXIMUM FLOCK SIZES OBSERVED FROM OBSERVATION STATIONS DURING DAYLIGHT HOURS AT THE THIEF RIVER FALLS RECEIVE STUDY AREA

Species Group	Season	Flock Size							
		West Station		Central Station		East Station		Goose Lake	
		Mean	Maximum	Mean	Maximum	Mean	Maximum	Mean	Maximum
Waterfowl	Fall 87	40.8	212	45.0	350	45.8	350	25.6	650
	Spring 88	11.6	75	41.5	100	18.1	75	12.4	300
	Spring 89	70.9	4000	----	----	56.5	1700	9.0	350
	Fall 89	72.5	1500	63.3	1100	74.9	1000	68.3	2300
	Total	69.0	4000	57.2	1100	59.0	1700	29.9	2300
-Ducks	Fall 87	7.8	13	22.5	260	37.6	350	19.2	650
	Spring 88	2.3	7	1.0	1	17.7	75	11.2	300
	Spring 89	25.5	2500	----	----	30.0	1700	3.2	75
	Fall 89	19.4	80	34.4	350	33.2	225	72.6	2300
	Total	24.6	2500	27.6	350	30.3	1700	26.3	2300
-Geese/Cormorants	Fall 87	42.9	212	51.3	350	46.2	270	45.1	400
	Spring 88	22.6	75	55.0	100	25.0	50	21.7	100
	Spring 89	112.1	4000	----	----	76.0	1500	36.5	350
	Fall 89	77.7	1500	68.4	1100	79.6	1000	56.5	600
	Total	96.1	4000	63.4	1100	70.5	1500	44.4	600
-Swans	Fall 87	2.0	2	0.0	0	0.0	0	0.0	0
	Spring 88	0.0	0	0.0	0	0.0	0	6.8	14
	Spring 89	10.6	140	----	----	11.1	75	9.1	22
	Fall 89	40.9	90	23.6	88	29.8	85	18.5	33
	Total	12.7	140	23.6	88	14.3	85	10.8	33

TABLE 8-42 (Continued). MEAN AND MAXIMUM FLOCK SIZES OBSERVED FROM OBSERVATION STATIONS DURING DAYLIGHT HOURS AT THE THIEF RIVER FALLS RECEIVE STUDY AREA

Species Group	Season	Flock Size							
		West Station		Central Station		East Station		Goose Lake	
		Mean	Maximum	Mean	Maximum	Mean	Maximum	Mean	Maximum
Raptors	Fall 87	1.1	3	1.1	4	1.2	13	1.1	3
	Spring 88	1.1	1	1.2	2	1.0	1	1.1	2
	Spring 89	1.7	70	----	----	1.2	19	1.1	4
	Fall 89	1.2	18	1.2	9	1.3	26	1.2	7
	Total	1.3	70	1.2	9	1.2	26	1.2	7
-Eagles/Hawks	Fall 87	1.1	2	1.1	4	1.1	4	1.1	2
	Spring 88	1.0	1	2.0	2	1.0	1	1.2	2
	Spring 89	1.7	40	----	----	1.3	19	1.1	2
	Fall 89	1.3	18	1.3	9	1.3	9	1.3	7
	Total	1.3	40	1.2	9	1.3	19	1.2	7
-Harriers	Fall 87	1.1	3	1.1	2	1.1	2	1.1	3
	Spring 88	1.1	2	1.0	1	1.0	1	1.1	2
	Spring 89	1.2	11	----	----	1.0	2	1.1	2
	Fall 89	1.2	5	1.1	3	1.1	4	1.2	4
	Total	1.1	11	1.1	3	1.0	4	1.1	4
-Falcons	Fall 87	1.0	1	1.0	1	1.2	3	1.0	1
	Spring 88	1.0	1	1.5	2	1.0	1	1.0	1
	Spring 89	1.0	1	----	----	1.1	3	1.0	1
	Fall 89	1.2	4	1.2	3	1.2	4	1.0	1
	Total	1.1	4	1.2	3	1.1	4	1.0	1

TABLE 8-42 (Continued). MEAN AND MAXIMUM FLOCK SIZES OBSERVED FROM OBSERVATION STATIONS DURING DAYLIGHT HOURS AT THE THIEF RIVER FALLS RECEIVE STUDY AREA

Species Group	Season	Flock Size							
		West Station		Central Station		East Station		Goose Lake	
		Mean	Maximum	Mean	Maximum	Mean	Maximum	Mean	Maximum
-Owls	Fall 87	1.0	1	1.0	1	1.0	1	1.0	1
	Spring 88	0.0	0	0.0	0	0.0	0	0.0	0
	Spring 89	1.0	1	----	----	1.0	1	1.0	1
	Fall 89	1.2	2	1.0	1	1.0	1	1.0	1
	Total	1.1	2	1.0	1	1.0	1	1.0	1
Shorebirds	Fall 87	8.0	50	5.9	20	8.2	30	3.4	17
	Spring 88	1.8	4	4.0	9	1.6	3	2.0	6
	Spring 89	2.0	32	----	----	2.1	19	2.4	25
	Fall 89	49.5	1100	24.3	100	13.4	50	12.1	92
	Total	7.2	1100	20.8	100	4.3	50	5.3	92
Sandhill cranes	Fall 87	8.0	15	11.9	50	6.7	24	9.8	90
	Spring 88	5.0	5	7.1	20	7.1	40	16.7	250
	Spring 89	11.4	150	----	----	13.4	160	2.7	86
	Fall 89	37.7	180	27.5	325	33.8	210	10.6	200
	Total	15.5	180	22.9	325	15.1	210	7.5	250
Waterbirds	Fall 87	1.0	1	1.0	1	1.0	1	2.9	20
	Spring 88	1.5	2	0.0	0	2.2	5	1.3	2
	Spring 89	30.4	1500	----	----	35.0	800	9.5	300
	Fall 89	68.3	300	66.9	400	84.3	1000	61.5	700
	Total	35.3	1500	63.2	400	41.8	1000	16.4	700

TABLE 8-42 (Continued). MEAN AND MAXIMUM FLOCK SIZES OBSERVED FROM OBSERVATION STATIONS DURING DAYLIGHT HOURS AT THE THIEF RIVER FALLS RECEIVE STUDY AREA

Species Group	Season	Flock Size							
		West Station		Central Station		East Station		Goose Lake	
		Mean	Maximum	Mean	Maximum	Mean	Maximum	Mean	Maximum
Gamebirds	Fall 87	14.0	14	14.0	14	18.0	18	2.0	3
	Spring 88	0.0	0	0.0	0	0.0	0	1.0	1
	Spring 89	1.3	2	----	----	5.4	25	1.0	1
	Fall 89	7.1	14	7.6	24	9.7	40	6.0	8
	Total	5.9	14	7.8	24	8.6	40	2.8	8
Passerines	Fall 87	13.7	475	18.9	300	8.1	85	29.6	1000
	Spring 88	17.9	150	16.6	150	14.8	150	27.0	350
	Spring 89	25.8	2300	----	----	65.8	3500	12.2	5000
	Fall 89	19.9	2400	17.6	1000	26.4	4000	130.5	5000
	Total	22.2	2400	18.0	1000	42.0	4000	35.3	5000
-Blackbirds	Fall 87	23.6	475	32.8	300	9.6	69	46.6	1000
	Spring 88	5.3	30	16.1	100	1.8	4	33.1	350
	Spring 89	13.6	1500	----	----	11.5	1700	10.0	2000
	Fall 89	12.0	300	30.2	900	26.1	1200	321.2	5000
	Total	13.6	1500	31.0	900	13.7	1700	35.1	5000
-Nonblackbirds	Fall 87	12.6	300	10.8	150	8.5	85	12.8	200
	Spring 88	13.5	100	19.3	150	8.6	68	5.4	60
	Spring 89	26.8	2300	----	----	97.5	3500	20.4	5000
	Fall 89	21.9	2400	14.0	1000	23.6	4000	50.9	5000
	Total	22.3	2400	13.4	1000	50.6	4000	32.7	5000

The Goose Lake station had the lowest mean flock sizes for most bird groups, including geese/cormorants, swans, all waterfowl, sandhill cranes, waterbirds and gamebirds (Table 8-42). This is expected since the Goose Lake region attracted many local birds which tend to move in smaller flocks, especially in spring. Mean flock sizes were lowest for shorebirds at the East station and for nonblackbird passerines at the Central station. Blackbirds had about equally low mean flock sizes at the East and West stations. Mean flock sizes for ducks and raptors were similar among stations (Table 8-42).

8.2.4.7 Tower Collision Assessment Study. Relatively large numbers of dead birds were located during the collision assessment study at four towers in the vicinity of the Thief River Falls study area (Fig. 8-11; Table 8-43). Passerines were the most common collision victims, followed by waterbirds (two rails and a gull), and ducks. Since all of these species groups, migrate partly or mostly at night, most, if not all, collisions probably occurred during nocturnal hours. Total numbers (standardized by sampling effort) were much higher in the fall (2.63 birds per survey) than in the spring (0.71 birds per survey) (Table 8-43). Nearly 40 species of birds were represented in fall kills (ABR, 1990a). The vast majority of the collisions occurred at the two taller, guyed towers versus either the medium-height (300 feet) unguyed tower or the short (150 foot) guyed tower.

Due to foraging by scavengers and to birds not found during searches because of obscuring vegetation or other reasons, these counts must be considered minimum counts, especially for passerines, as many birds may have been removed by scavengers before they were found during surveys or they may have been missed entirely during searches. Also, only a limited area was sampled, and collision victims falling outside of the surveyed area would not be located. The counts of passerines were probably most affected by scavenging activity, as the small body size of these birds allows scavengers to remove them whole; this has been observed to occur during these types of studies (ABR, 1988a). The remains of larger birds, such as swans or cranes, would most likely be located even if the carcass was scavenged, as enough bones and feathers would remain for location and identification.

TABLE 8-43. RESULTS OF THE TOWER MORTALITY STUDIES - THIEF RIVER FALLS RECEIVE STUDY AREA

Tower Number	Location	Height (ft)	Guy Wires	Lights	Number of Surveys	Season	Number	Species Group
3	Thief River Falls, MN - South of East Station	499	YES	Flashing Red	5	Spring 89	2	Passerine
							2	Subtotal
					20	Fall 89	164	Passerine
							2	Unknown
							166	Subtotal
						Total	168	
4	Thief River Falls, MN - Cable TV Tower	485	YES	Flashing Red	6	Spring 89	2	Waterbird
							7	Passerine
							9	Subtotal
					22	Fall 89	1	Waterbird
							42	Passerine
							1	Unknown
							44	Subtotal
						Total	53	

TABLE 8-43 (Continued). RESULTS OF THE TOWER MORTALITY STUDIES - THIEF RIVER FALLS RECEIVE STUDY AREA

Tower Number	Location	Height (ft)	Guy Wires	Lights	Number of Surveys	Season	Number	Species Group
5	Thief River Falls, MN - Police Tower	316	NO	Flashing & Non-Flashing Red	5	Spring 89	1	Duck
							1	Passerine
							2	Subtotal
					21	Fall 89	6	Passerine
							1	Unknown
							7	Subtotal
						Total	9	
6	Thief River Falls, MN - Bell Telephone	150	YES	Non-Flashing Red	5	Spring 89	1	Duck
							1	Passerine
							2	Subtotal
					21	Fall 89	3	Passerine
							1	Unknown
							4	Subtotal
						Total	6	

Based upon these results, collisions with man-made objects occur for a wide variety of species in the Thief River Falls area, with collision rates for passerines (primarily warblers, sparrows, and vireos) relatively higher than for other groups. Among larger-bodied birds, ducks and rails appear to be most at risk of collision mortality with man-made structures.

8.2.4.8 Avian Concentration Areas. The Thief River Falls study area region was divided into 5 aerial survey units for comparison of bird distribution patterns (Fig. 8-9). These distribution patterns are shown on Figures 8-96, 8-97, and 8-98 for five species groups. The West Concentrated Study Area is contained in Unit 1 and the East Concentrated Study Area is located within Unit 3.

The percentage of ducks using each aerial survey unit was highest in Unit 2 in spring and in Unit 5 in the fall. Duck use was lowest in Unit 3 in spring and in Unit 1 in the fall (Fig. 8-96). Goose and cormorant use patterns were very similar to those observed for ducks with observed use highest in Unit 2 in spring and in Unit 5 in fall (Fig. 8-96).

Waterbird use was highest in Unit 1 in the spring and confined almost entirely to Unit 5 in the fall. Unit 3 received little use during either season (Fig. 8-97).

Total waterfowl use was highest in Unit 2 in the spring and lowest in Unit 3 during this season. Waterfowl numbers were highest in Unit 5 in the fall; the other four units received minimal use during this season (Fig. 8-97).

Sandhill cranes were observed using Units 2 and 4 in the spring and Units 3 and 4 in the fall. Levels of use were relatively low during both seasons (Fig. 8-98).

Results from the road surveys were also compiled using the same units as for the aerial surveys (Fig. 8-9), except that Unit 5 was not sampled during road surveys. Because a different number of road survey stations were contained in each unit, numbers were weighted to compensate for differing sampling

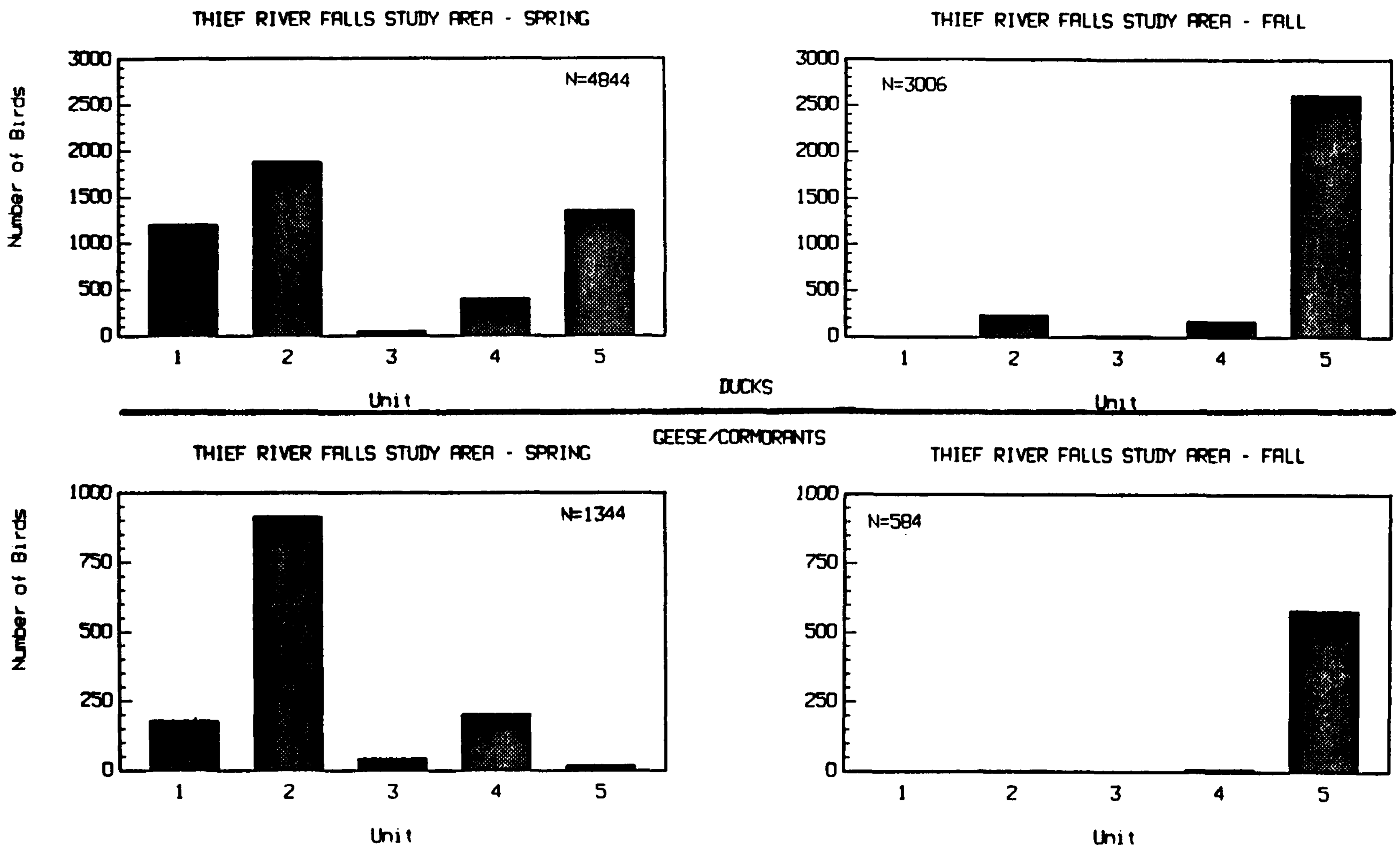


FIGURE 8-96. THIEF RIVER FALLS, MN RECEIVE STUDY AREA DUCK AND GOOSE/CORMORANT DISTRIBUTION PATTERNS AERIAL SURVEYS

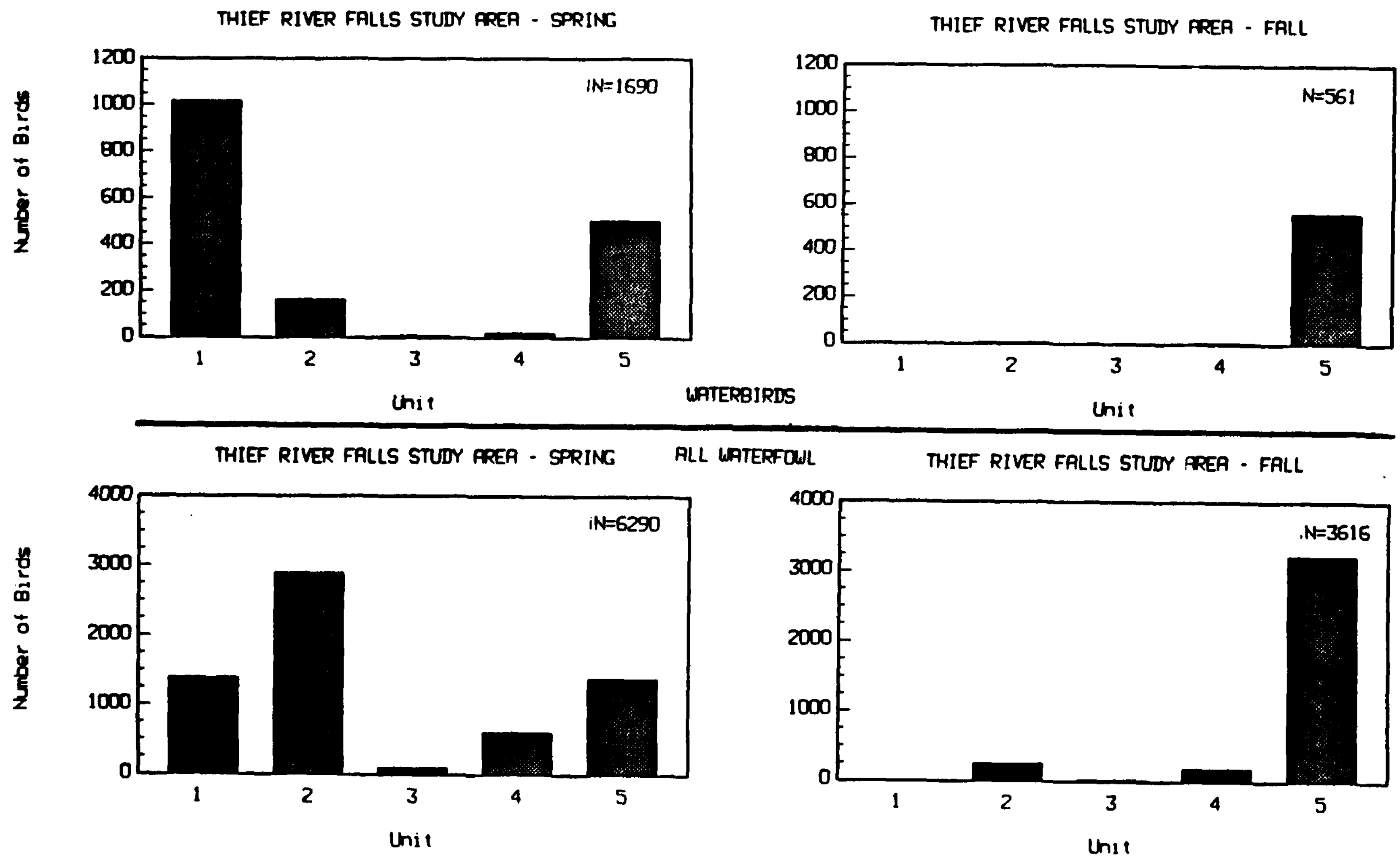
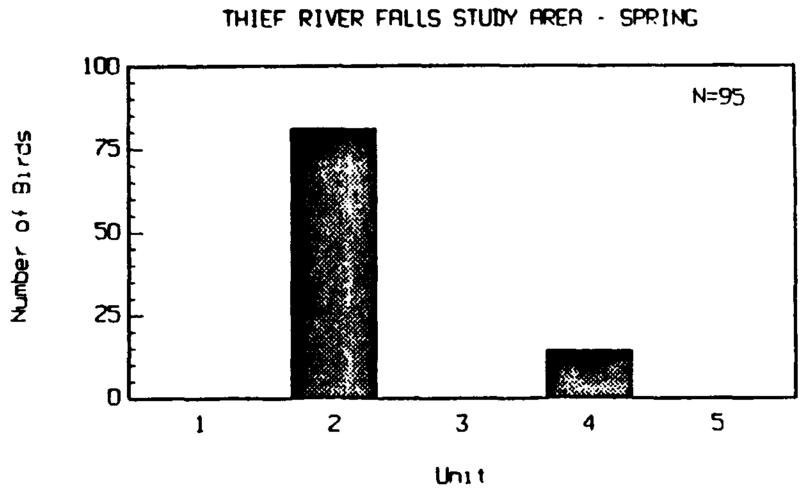


FIGURE 8-97 THIEF RIVER FALLS, MN RECEIVE STUDY AREA WATERFOWL AND WATERBIRD DISTRIBUTION PATTERNS AERIAL SURVEYS



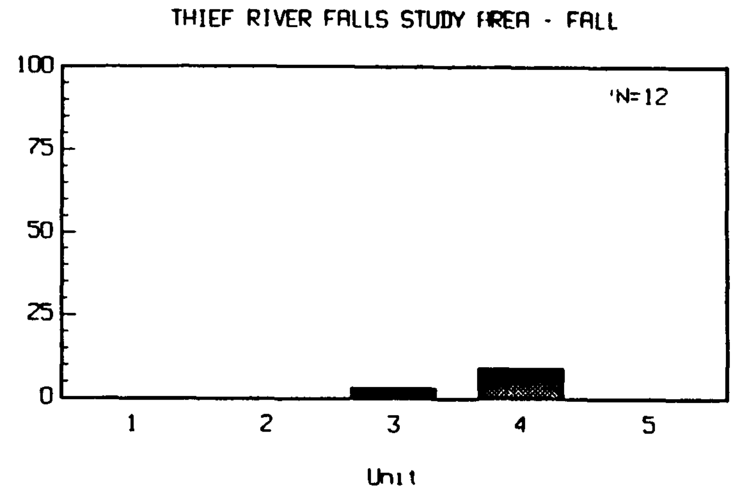


FIGURE 8-98. THIEF RIVER FALLS, MN RECEIVE STUDY AREA SANDHILL CRANE DISTRIBUTION PATTERNS - AERIAL SURVEYS

intensity. Thus, the numbers should only be used relative to each other; they are not the actual numbers observed.

During road surveys, ducks were most common in Unit 2 in both spring and fall. Goose/cormorant use was highest in Unit 2 in spring and in Unit 3 in the fall. Of the few swans observed, most occurred in Unit 2 in both spring and fall. Total waterfowl use was highest in Unit 2 in the spring and highest in Units 2 and 3 in the fall (Table 8-44).

Waterbirds were most commonly observed in Unit 3 in the spring and in Unit 2 in the fall while shorebirds were relatively uniform in distribution in both spring and fall. Raptor use was relatively uniform over all units in the spring but highest in Unit 2 in the fall. Gamebirds were most common in Unit 4 in the spring and in Unit 1 in the fall (Table 8-44).

Blackbirds and all passerines were most common in Unit 2 during the spring. Total passerine use was relatively uniform over all units in the fall and blackbirds were most common in Units 2 and 4 in the fall. Use by nonblackbird passerines was relatively uniform in both the spring and the fall (Table 8-44).

8.2.4.9 Breeding Bird Populations. One greater prairie-chicken and four sharp-tailed grouse leks were located within the Thief River Falls study area. One grouse (ST3) lek was within the West Concentrated Study Area (CSA) while two grouse leks (ST1 and ST2) were located within the East CSA. The fourth grouse lek and the one prairie-chicken lek were not located within either CSA (Fig. 8-99). Use of these leks is summarized in Table 8-45. These species may also nest in grassland areas (Conservation Reserve Program (CRP) lands) within the CSAs.

TABLE 8-44. WEIGHTED NUMBER OF BIRDS OBSERVED DURING ROAD SURVEYS BY UNIT AT THE THIEF RIVER FALLS RECEIVE STUDY AREA

Species Group	Season	Weighted Number of Birds[1]			
		Unit 1	Unit 2	Unit 3	Unit 4
Waterfowl	Spring 89	637	2541	59	88
	Fall 89	891	1195	1342	346
-Ducks	Spring 89	31	728	21	21
	Fall 89	31	507	7	27
-Geese/ Cormorants	Spring 89	596	1786	30	61
	Fall 89	860	675	1335	320
-Swans	Spring 89	11	25	8	6
	Fall 89	0	7	0	0
Waterbirds	Spring 89	49	20	265	13
	Fall 89	5	72	2	53
Shorebirds	Spring 89	52	54	40	57
	Fall 89	54	70	5	63
Sandhill cranes	Spring 89	15	75	19	75
	Fall 89	5	42	7	12
Raptors	Spring 89	14	16	12	11
	Fall 89	59	85	39	33
Gamebirds	Spring 89	10	16	17	25
	Fall 89	49	6	17	6
Passerines	Spring 89	1743	4135	2575	1849
	Fall 89	5484	5965	4315	5845
-Blackbirds	Spring 89	828	2686	993	442
	Fall 89	1670	3329	1122	3385
-Nonblack-birds	Spring 89	906	1445	1581	1408
	Fall 89	3372	2534	3005	2364

1. Numbers are weighted by sampling intensity and do not represent the actual number observed.

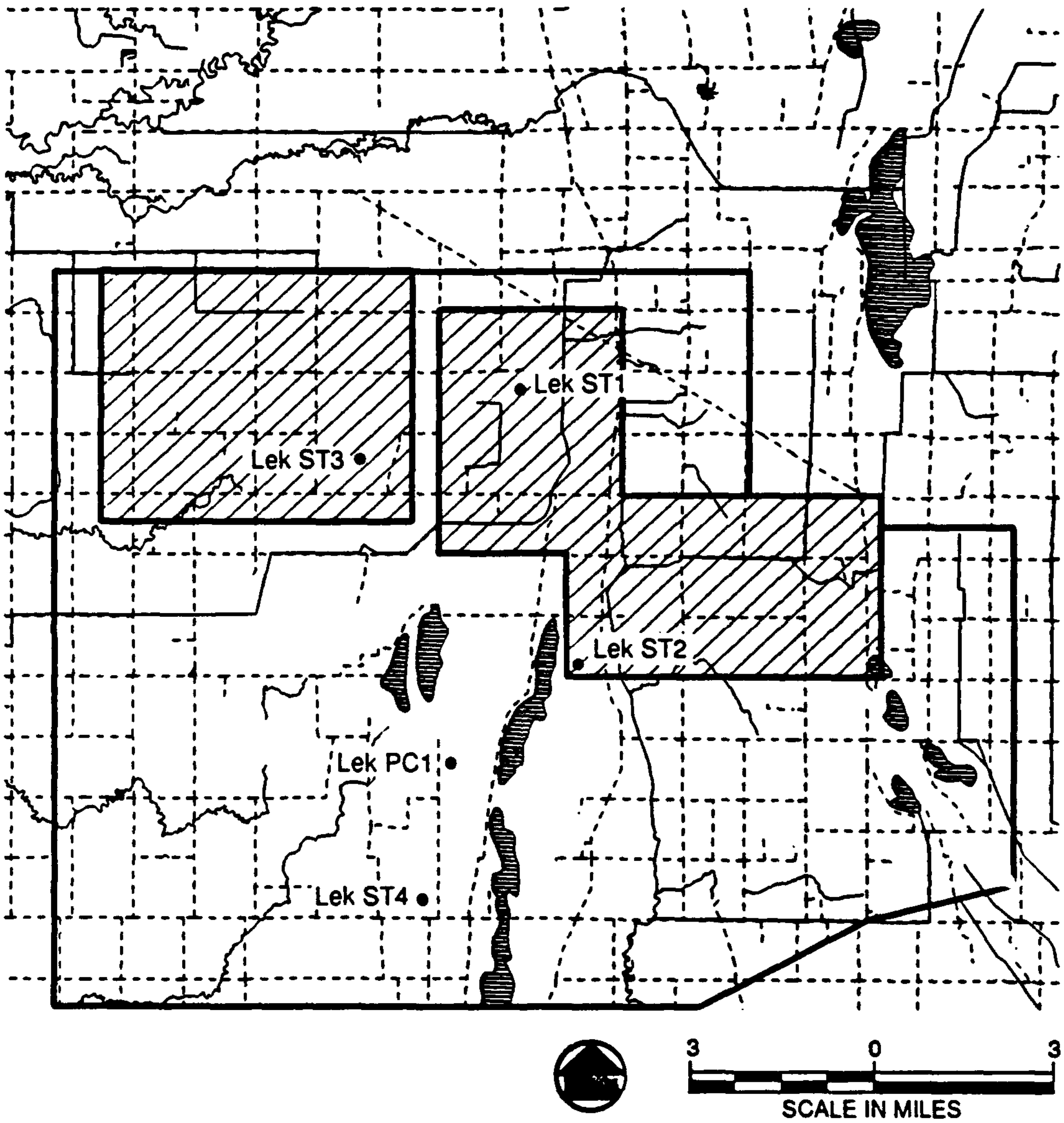


FIGURE 8-99. LOCATIONS OF SHARP-TAILED GROUSE AND GREATER PRAIRIE-CHICKEN LEKS WITHIN THE THIEF RIVER FALLS, MN RECEIVE STUDY AREA

TABLE 8-45. SUMMARY OF ACTIVITY AT SHARP-TAILED GROUSE AND GREATER PRAIRIE-CHICKEN LEK SITES WITHIN THE THIEF RIVER FALLS RECEIVE STUDY AREA

Lek[1]	Season	Maximum Number of Birds Observed		
		Total (Date)	Males	Females
GREATER PRAIRIE-CHICKEN				
PC1	Spring 89	8 (24 Apr)	5	3
SHARP-TAILED GROUSE				
ST1	Spring 89	4 (16 May)	-	-
ST2	Spring 89	5 (16 May)	4	0
ST3	Spring 89	10 (15 May)	5	1
ST4	Spring 89	10 (24 Apr)	4	0

1. Locations of leks are shown on Figure 8-99.

No raptor or waterfowl nests were discovered during spring aerial surveys. While these species groups likely breed within the Thief River Falls study area, large numbers are unlikely to breed within either CSA during most years. Duck breeding densities would most likely be higher in the Goose Lake region as this area contains a higher proportion of wetlands, although nesting by some species of dabbling ducks probably occurs in upland (grassland) habitats on both CSAs. Ground nesting raptors (e.g. northern harriers) would likely nest at about equal densities at the two CSAs, based on habitat preferences. Woodland raptors require wooded areas to nest, and these areas are slightly more common in the East CSA, but are generally uncommon in either CSA (Technical Study 5).

Small numbers of upland nesting shorebirds may nest on CRP lands within the CSAs. Nesting by waterbird species is likely to be uncommon within the CSAs. Sandhill cranes are likely to nest only in the Goose Lake area within the Thief River Falls study area.

Because the USAF did not have right-of-entry to much of the study area, no breeding bird censuses could be conducted at either CSA to determine passerine breeding densities. It is likely that breeding passerine densities would be only slightly higher at the East CSA, which contains slightly more wooded areas (Technical Study 5).

8.3 ENVIRONMENTAL CONSEQUENCES

This section will address the potential impacts of the OTH-B Central Radar System project on avian resources. Potential impacts to be addressed include disturbance to gamebird leks and other nesting species, habitat loss, and direct impacts due to collisions with project structures.

8.3.1 Methods

Based upon the field data from the avian and vegetation studies (Technical Study 5), the effects of the quantity and type of habitat to be lost to the project will be qualitatively evaluated for each species group. Disturbance to gamebird leks will be evaluated from data on lek sites gathered during avian studies within each study area. Habitat loss and disturbance evaluations will be done for the North and South preliminary site layouts at Amherst (Figs. 8-100 and 8-101) and the East and West preliminary site layouts at Thief River Falls (Figs. 8-102 and 8-103).

Potential collision mortality with project structures will be evaluated at two levels. The first level will describe overall potential impacts at each study area. The second level will evaluate the relative potential mortality between the North and South Concentrated Study Areas at the Amherst transmit study area (Figs. 8-100 and 8-101). Because of the large size of the East Concentrated Study Area at Thief River Falls, the second level analysis at this study area will compare the relative impacts among the West Concentrated Study Area (Rx-W CSA), the western portion of the East Concentrated Study Area (Rx-E CSA (W) - west of the beach ridge), and the eastern half of the East Concentrated Study Area (Rx-E CSA (E) - east of the beach ridge) (Figs. 8-102 and 8-103).

For those species or species groups which the field data, or information from the literature, suggest are at risk of significant collision mortality, general mitigation measures to compensate for these impacts will be outlined.

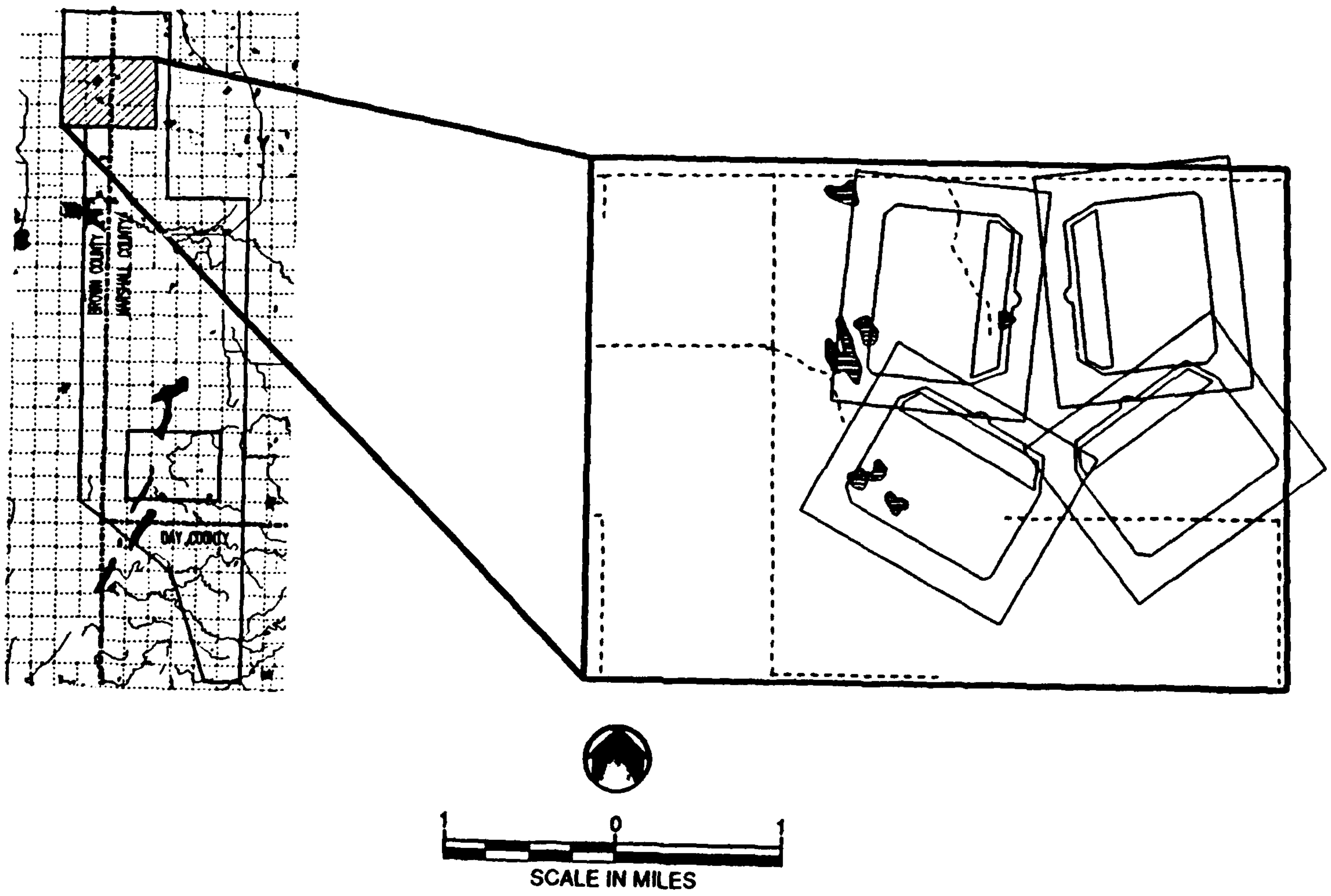


FIGURE 8-100. TX-NORTH CONCENTRATED STUDY AREA
AND PRELIMINARY SITE LAYOUT

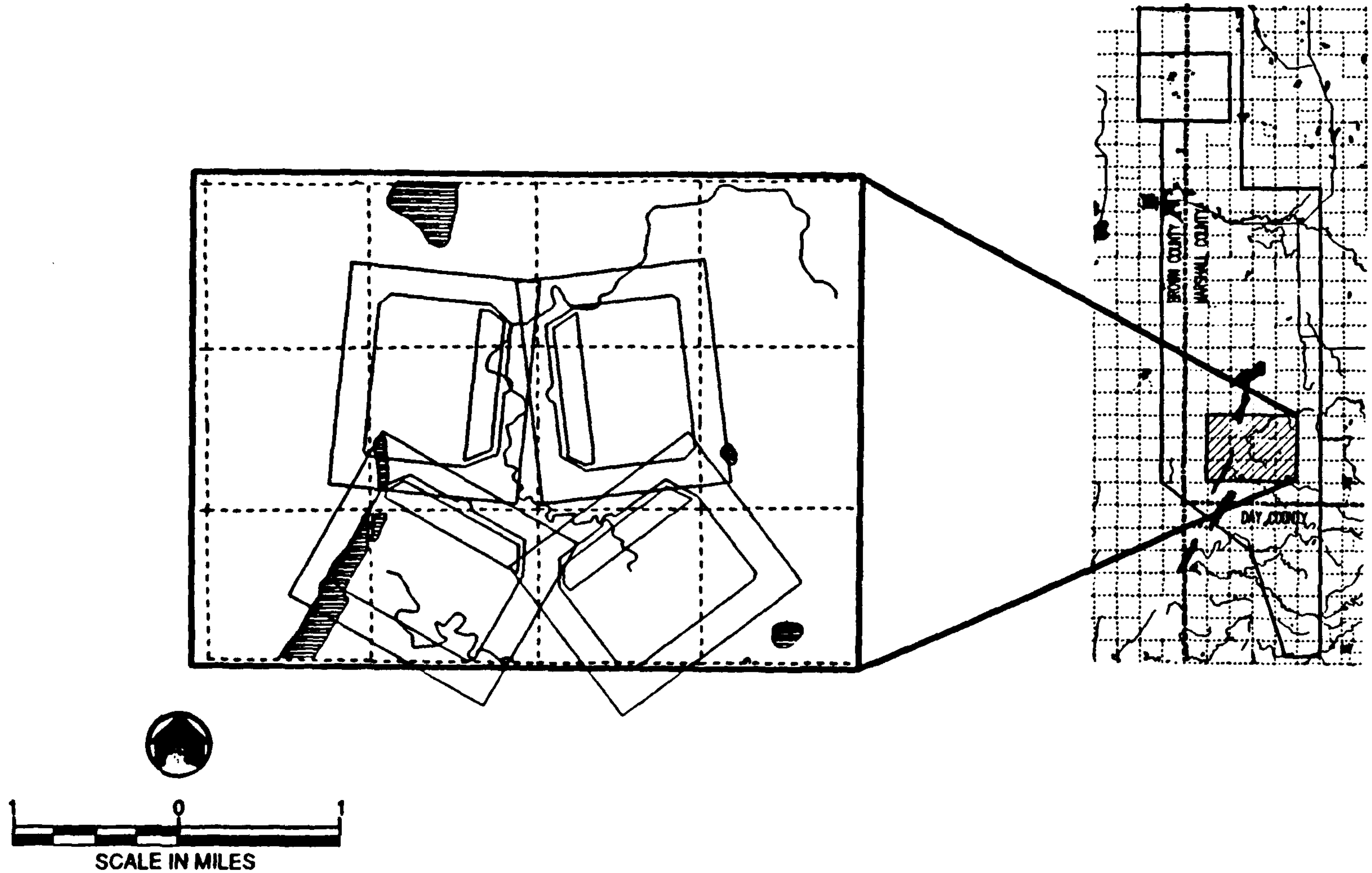


FIGURE 8-101. TX-SOUTH CONCENTRATED STUDY AREA AND PRELIMINARY SITE LAYOUT

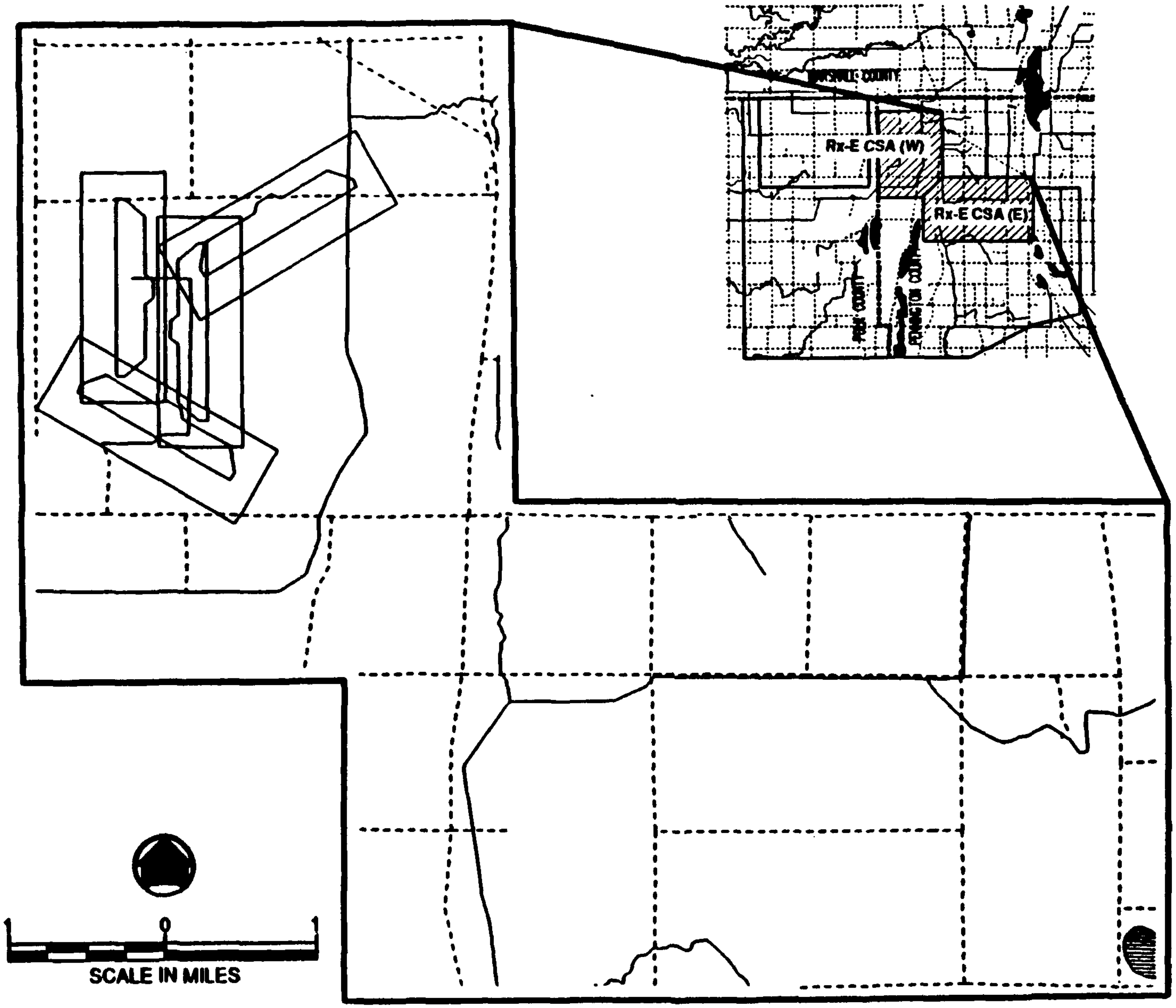


FIGURE 102. RX-EAST CONCENTRATED STUDY AREA AND PRELIMINARY SITE LAYOUT

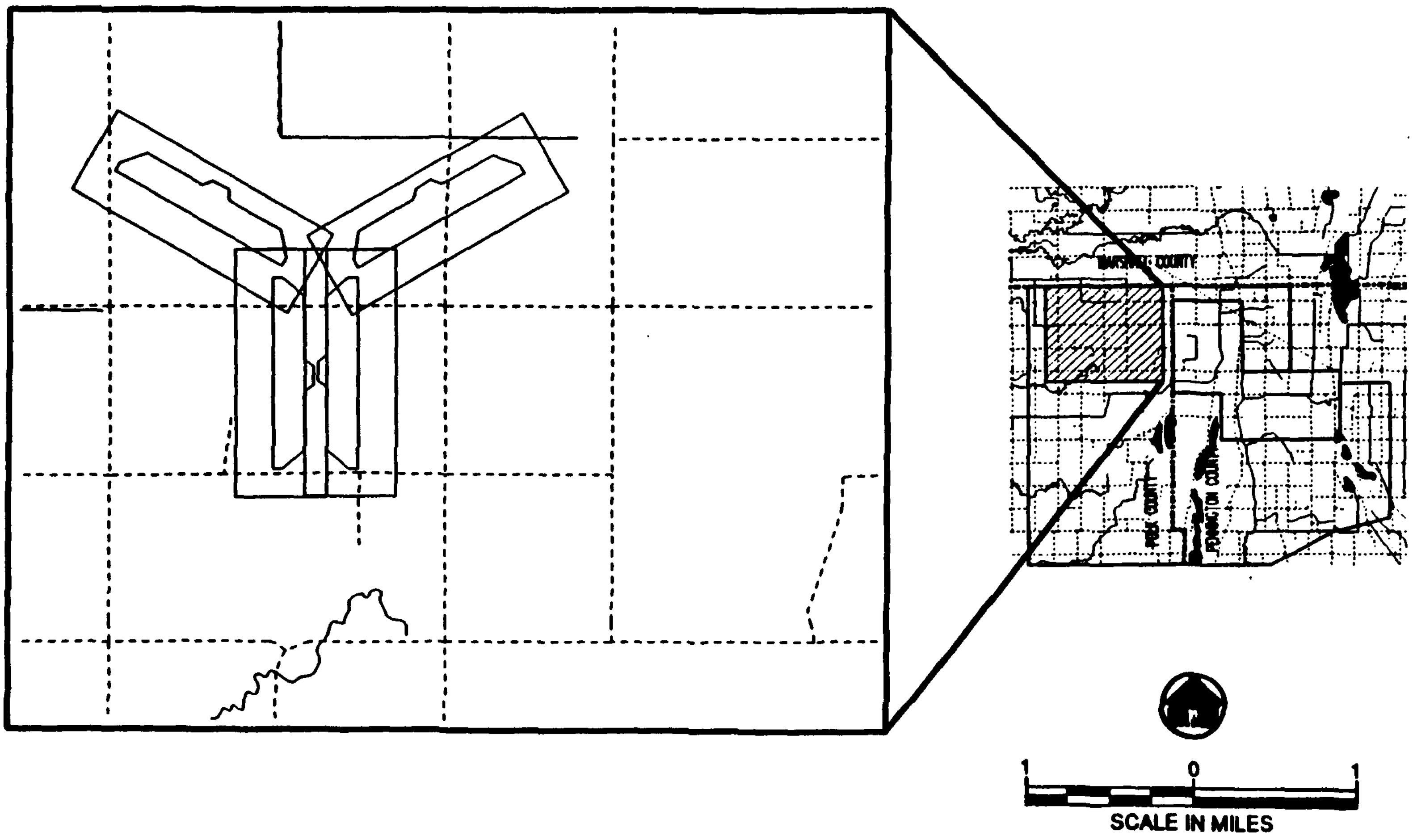


FIGURE 8-103. RX-WEST CONCENTRATED STUDY AREA AND PRELIMINARY SITE LAYOUT

8.3.2 Transmit Site

8.3.2.1 Habitat loss. Just over 500 acres of habitat are expected to be disturbed (includes the fill area but not the exclusion area) at the Tx-N preliminary site layout, the majority (about 80% or 400 acres) of which is native rangeland. The remaining 20 percent consists mostly of various wetland types dominated by seasonal palustrine emergent wetlands (Technical Study 6). Wooded areas are virtually nonexistent within the area of the Tx-N preliminary site layout (Technical Study 5).

Native rangeland is generally rare in the Amherst study area region, with most land currently under cultivation. Native rangeland is utilized during the breeding season by many species of ground nesting passerines (e.g. western meadowlarks) but nesting densities would vary depending upon the intensity of grazing by domestic livestock (Owens and Myres, 1973; Kantrud, 1981). High intensity grazing removes tall cover used to conceal nests, and nests may also be trampled. A number of ground nesting raptors (e.g. northern harrier and short-eared owl) also utilize grassland habitat types such as exist at the Tx-N preliminary site layout (Duebbert and Lokemoen, 1977). Active display grounds (leks) of both greater prairie-chickens and sharp-tailed grouse were located within the Tx-N preliminary site layout. Both of these lek sites were within the fill area of the Tx-N preliminary site layout, so they would be destroyed during construction if this site is chosen. These species may also nest within the preliminary site layout, since the habitat appears suitable (Manske and Barker, 1987). Actual nesting densities are unknown, however, because lack of right-of-entries during the spring season precluded conducting breeding bird censuses.

The Tx-N preliminary site layout contains numerous small seasonal wetlands, many with associated wetland vegetation. Several species of dabbling ducks (e.g. mallards) probably utilize these seasonal wetlands for nesting during all but the driest years as well as upland areas containing sufficient vegetation. Nesting densities are probably similar to regional levels for this type of habitat. No other waterfowl, such as diving ducks and geese, likely breed on this area as these species prefer to nest on or near semi-permanent or permanent wetlands. Waterbirds, many of whom are colonial breeders, and shorebirds are also unlikely to breed at the Tx-N preliminary site layout in large numbers although nests of some species of upland nesting shorebirds (e.g. marbled godwit, killdeer) are likely to occur.

The Tx-N preliminary site layout provides poor quality breeding habitat for woodland raptors and forest passerines as wooded areas are almost nonexistent. Those present are small shelterbelts and are of minimal value as nesting areas to these species. Loss of these small pockets of habitat is expected to have a negligible effect on nesting birds.

The Tx-S preliminary site layout is dominated by agricultural lands (over 90% or 450 acres). The remaining area consists mainly of upland field (5% or 35 acres) habitat. Wooded areas and seasonal wetlands are generally uncommon, although many acres of temporary farmed wetlands do exist (Technical Studies 5 and 6). These temporary wetlands, when flooded, do provide resting and, depending upon the substrate and water depth, feeding areas for a variety of waterfowl and waterbirds. Due to the lack of vegetation to serve as cover, these areas are of low value to nesting waterfowl. While agricultural areas may serve as important foraging areas for birds, they are generally of low value as breeding habitat relative to native grasslands for most species (Higgins et al., 1987). Loss of these areas should have a negligible effect on breeding birds.

In summary, the Tx-N preliminary site layout contains some relatively uncommon habitat types which are used by nesting birds, including active lek sites of two gamebird species. Also, wetland areas which may be used by nesting ducks are also contained within the Tx-N preliminary site layout. Since duck populations are currently at or near record low numbers due to drought and the loss of breeding habitat (USDI and CWS, 1986), all such wetland areas are considered valuable. The Tx-S preliminary site layout contains little valuable avian breeding habitat. Thus, impacts to breeding birds are expected to be much more severe at the Tx-N preliminary site layout than at the Tx-S preliminary site layout.

8.3.2.2 Disturbance. Most nesting birds are sensitive to noise with the degree of sensitivity varying by species. Responses range from nest abandonment and reduced productivity to increased levels of alarm responses (White and Thurow, 1985; Manci et al., 1988). The construction of the CRS transmit facility will potentially disturb locally breeding birds in the immediate vicinity of the construction zone, although the operation of the facility should result in little or no disturbance.

Since breeding bird populations are expected to be much higher at the Tx-N preliminary site layout than at the Tx-S preliminary site layout, potential disturbance effects are expected to be much greater at the Tx-N site. The most severe effects will be nest destruction and reduced productivity and will probably be highest for ground nesting raptors. Spring construction may also interfere with activity at greater-prairie chicken and sharp-tailed grouse lek sites in the Tx-N preliminary site layout, although the level of disturbance necessary to cause abandonment of a lek is not known. Relatively few alternate lek sites are known to be available in the general area, should these leks be physically destroyed by construction or rendered unusable due to high noise levels. Attempts to recreate leks for gamebird species generally are unsuccessful (e.g. Tate et al., 1979).

8.3.2.3 Collision Mortality. A number of factors influence the potential for birds colliding with the antenna structures. Among the most important of these factors are the flight paths and flight altitudes of birds relative to the antenna structures; only those birds flying within flight paths which intersect the antenna structures and are flying below the maximum height of the antenna structure are at risk of collision. Other factors which influence collision risk potential are the flying ability of the birds and their visual acuity; these factors, which differ by species, determine a bird's ability to see and to avoid an obstacle when flying on a "collision course". Quantitative information on these two factors is generally not available, however. Factors which influence the potential severity of collision mortality include the number of birds flying within the site (the more birds flying through the site, the higher the potential impact), the population status of these species (abundant species can sustain higher levels of mortality without severe impact to the population), flock size (species flying in large flocks may be more at risk of large-scale kills during poor flying conditions), the time of day species are active (nocturnal migrants are more prone to collisions due to decreased visibility), migration patterns (species with protracted migrations have a lower risk of large-scale kills), and weather conditions (species which typically fly during inclement weather periods have a greater risk of collision). Table 8-46 summarizes these factors in a qualitative manner by species or species group for the Amherst study area as a whole. Quantitative techniques to precisely predict the number of collisions with man-made structures are not available (USFWS, 1989). This table also provides a summary of the relative potential impacts between the Tx-N and Tx-S CSAs. Table 8-47 provides a summary of peak and mean migration rates for altitudes under 150 feet agl.

Collision mortality can be thought of as occurring in two types. The first type is chronic mortality. This is the cumulative kill over time, generally from multiple events involving relatively few birds per event. The second type is large-scale, episodic mortality. As the name implies, these are discrete episodes, involving the death of relatively large numbers of birds per event.

Based upon this analysis, the collision potential for raptors, gamebirds, sandhill cranes, and some species of waterbirds is considered to be relatively low at the Amherst study area. Risk of collision is higher for shorebirds, geese, and swans, and highest for ducks, some species of waterbirds, and passerines. The risk of collision is probably greatest for most groups at the Tx-N CSA in most years, but highest at the Tx-S CSA during years with extensive flooding for most species of water-dependent birds (e.g. waterfowl, waterbirds, shorebirds, and cranes). The rationale for this assessment is discussed below for each species group.

Raptors: Eagles, hawks, harriers, falcons, and owls are extremely manueverable in flight and possess excellent vision. Collision mortality with man-made objects is generally considered uncommon for these raptors (Orlendorff et al., 1981), although collisions with power lines are known to occur on occasion (Thompson, 1978; Olendorff et al., 1981). All of these birds, except owls, are mainly active during daylight hours, when visibility is generally good. During periods of poor weather, when visibility is reduced, migration rates for raptors are generally lower (Table 8-11).

Raptors are also struck by vehicles, on occasion (e.g. Schmutz and Fyfe, 1987). This type of mortality event occurs more frequently for species which forage on road-killed animals.

Only moderate numbers of eagles and hawks were observed during daylight hours at the Amherst study area, although about two-thirds of these birds flew below 150 feet agl. Moderate numbers of northern harriers were also observed. These birds soar during migration like hawks and eagles but were often observed foraging at low altitudes (generally less than 25 feet agl) during avian studies. Observed numbers of falcons and owls were very low. Owls are slow, low-level flyers while foraging during nocturnal hours. Owls were observed flying below 50 feet agl during night-vision scope observations, especially in the fall at the North stations.

Raptors, as a group, are probably most vulnerable to collisions when foraging, since they are distracted and less vigilant in regard to obstructions, and generally fly at low altitudes (Orlendorff et al., 1981). Studies at towers and power lines (e.g. Orlendorff et al., 1981; ABR, 1988b; 1988c) suggest that foraging and migrating raptors, in general, have little difficulty avoiding obstructions such as guy or transmission wires, although occasional collisions do occur, probably when the bird is distracted while foraging or during poor weather, when visibility is reduced. This risk is probably higher for owls, because of their nocturnal foraging habits and the reduced visibility of the backscreen during low light levels. No raptor carcasses were located during tower searches conducted as part of the CRS avian studies.

Collision risk is probably similar between the Tx-N and Tx-S CSAs for eagles, hawks, harriers, and falcons, but higher at the Tx-N CSA for owls based upon habitat and observed numbers. Over the life of the project, only low numbers of raptor collisions are expected to occur, probably with the wire-mesh backscreen, although this loss is not expected to be significant.

TABLE 8-46. FACTORS WHICH INFLUENCE COLLISION RISK POTENTIAL BY SPECIES OR SPECIES GROUP AT THE AMHERST TRANSMIT STUDY AREA

Factor[1]	Species/Species Group											
	Ducks	Geese	Swans	Sandhill Cranes	Eagles/ Hawks	Harriers	Falcons	Owls	Shorebirds	Waterbirds	Passerines	Gamebirds
Population Status	+	-	0	0	+	+	+	0	0	0	+	0
Abundance at Site												
-Study Area	+	+	0	-	0	0	-	-	0	0	+	0
-North CSA	+	+	0	-	-	0	-	0	-	-	+	+
-South CSA	+	+	0	-	0	0	-	-	0	+	+	-
Migration Patterns												
-Study Area	+	+	+	+	-	-	-	-	-	+	0	+
-North CSA	+	+	+	+	-	-	-	-	-	+	0	+
-South CSA	+	+	+	+	-	-	-	-	0	+	0	+
Local Movements												
-Study Area	+	+	-	-	-	+	-	+	+	0	+	+
-North CSA	+	+	-	-	-	+	-	+	+	0	+	+
-South CSA	+	+	-	-	-	+	-	+	+	0	+	+
Flight Path												
-Study Area	0	0	0	-	0	+	0	0	0	0	+	0
-North CSA	0	0	0	-	0	+	0	+	0	0	+	+
-South CSA	0	0	0	0	0	+	0	-	0	0	+	-
Nocturnal Flight Altitude												
-Study Area	0	-	-	N/A[2]	N/A	N/A	N/A	+	0	+	+	N/A
-North CSA	0	-	-	N/A	N/A	N/A	N/A	+	0	+	+	N/A
-South CSA	0	0	-	N/A	N/A	N/A	N/A	+	0	+	+	N/A

TABLE 8-46 (Continued). FACTORS WHICH INFLUENCE COLLISION RISK POTENTIAL BY SPECIES OR SPECIES GROUP AT THE AMHERST TRANSMIT STUDY AREA

Factor[1]	Species/Species Group										
	Ducks	Geese	Swans	Sandhill Cranes	Eagles/ Hawks	Harriers	Falcons	Owls	Shorebirds	Waterbirds	Passerines	Gamebirds
Diurnal Flight Altitude												
-Study Area	0	0	0	0	0	+	+	N/A	+	0	+	+
-North CSA	0	0	0	-	0	+	+	N/A	+	0	+	+
-South CSA	+	0	0	0	0	+	+	N/A	+	0	+	+
Flock Size												
-Study Area	+	+	0	0	-	-	-	-	-	0	+	-
-North CSA	+	+	0	0	-	-	-	-	-	-	+	-
-South CSA	+	+	0	0	-	-	-	-	0	0	0	-
Weather Factors												
-Study Area	+	+	+	-	-	-	-	-	0	+	0	-
-North CSA	+	+	+	-	-	-	-	-	0	+	0	-
-South CSA	+	+	+	-	-	-	-	-	0	+	0	-
Flying Ability	-	0	+	+	-	-	-	-	-	0	-	+
Visual Acuity	-	-	-	-	-	-	-	-	-	-	-	-
Wing span	0	0	+	+	+	+	0	+	-	0	-	0
Nocturnal Migration	+	0	0	-	-	-	-	+	+	+	+	-
Frequency of Reported Collisions	+	-	+	+	-	-	-	-	0	+	+	0

1. Ranks: - = Low risk, 0 = Moderate risk, + = High risk.
2. Not applicable.

Table 8-47. Peak and Mean Migration Rates (Birds per Hour) Observed For Altitudes Less than 150 Feet AGL During Daylight Hours at the Amherst Study Area

Species Group	Season	Peak Day Rate <150 ft (1)		Mean Rate <150 ft (2)	
		North Station	South Station	North Station	South Station
Waterfowl	Spring 89	132.9	16439.0	614.5	700.4
	Fall 89	3642.3	4242.8	171.8	327.4
-Ducks	Spring 89	68.8	477.9	9.71	55.65
	Fall 89	493.3	413.6	36.83	58.80
-Geese/Cormorants	Spring 89	132.8	16225.9	593.6	646.1
	Fall 89	35.6	4160.3	55.6	222.0
-Swans	Spring 89	1.09	1.64	0.02	0.10
	Fall 89	1.44	1.16	0.27	0.27
Raptors	Spring 89	1.33	2.92	0.19	0.33
	Fall 89	1.62	8.03	0.56	0.91
Shorebirds	Spring 89	4.40	18.56	0.67	2.18
	Fall 89	0.75	47.67	0.09	4.08
Waterbirds	Spring 89	18.60	456.18	1.94	19.05
	Fall 89	23.15	794.96	3.38	50.72
Passerines	Spring 89	197.7	377.5	14.97	24.70
	Fall 89	2930.4	971.6	128.53	173.64

1. Migration Rate (Birds per Hour) for birds below 150 feet agl on the day with the peak daily migration rate (Table 8-8).

2. Migration Rate (Birds per Hour) for birds below 150 feet agl over the entire study period.

Gamebirds: Most species of gamebirds fly infrequently, generally covering relatively short distances between foraging and roosting areas. Flight altitudes during these movements tend to be low, generally below 50 feet agl and these birds are not considered agile fliers. Activity is usually higher in the spring, especially for species which display at leks. These birds are nonmigratory, generally remaining in the area year round and most activity is diurnal, although these birds commonly fly during twilight periods.

Collisions of these species with man-made structures are known to occur (Thompson, 1978). In addition, these species forage and obtain grit along roadsides, and are sometimes struck by vehicles. Occasional collisions are expected with the transmit antenna structures over the life of the project, and additional birds may be killed due to increased project-related traffic. These losses are not expected to be severe because of the diurnal tendencies of these species and since local birds may become acclimated to the location of the facility. Based on habitat factors, the Tx-N CSA is more attractive to these birds and collision losses are expected to be higher at the Tx-N CSA, relative to the Tx-S CSA.

Sandhill Cranes: Relatively few sandhill cranes were observed at the Amherst study area and those birds which were observed tended to move rapidly through the region, generally in a few closely spaced pulses of migration. Whitney et al. (1978) report that most sandhill crane migration in South Dakota occurs in the Missouri River Valley and further west, well away from the Amherst study area. This species is primarily a diurnal migrant, often flying at high altitudes. Cranes observed during the avian studies often flew above 150 feet agl and usually flew during good weather conditions, when they should have little difficulty seeing and avoiding large obstacles in their flight path. Although cranes are known to collide with man-made objects, such as power lines, in the midwestern U.S. (Faanes, 1987), the low number of cranes observed on the study area suggests that collisions with the CRS radar antennas will be minimal for this species. The risk of collisions is expected to be slightly higher at the Tx-S CSA during years when large amounts of floodwater is present, but similar between CSAs otherwise.

Waterbirds: Some species of waterbirds, such as gulls, terns, grebes, loons, cormorants, and herons migrate during both daylight and nocturnal hours and many are agile fliers. Pelicans, which soar like raptors and cranes, are almost exclusively diurnal migrants (Terres, 1980). Although all of these species are known to collide with man-made objects (Thompson, 1978), reported rates of collision are generally low for most species.

Gulls and terns were commonly observed at the Amherst study area and would often fly during periods of precipitation. These species are mainly active during daylight hours and are agile fliers. However, gull collision rates with power lines can often be substantial (Krapu, 1974; Rusz et al., 1986; Faanes, 1987). Cormorants were commonly observed migrating through the study area at high altitudes, although low altitude local movements were also observed, especially in spring at the South station. Collision mortality for this group is expected to be low during most years. Pelicans and herons were observed in low to moderate numbers. Pelicans, which frequently soar and fly mostly during diurnal hours, are expected to be very infrequent collision victims. Herons, which often fly at dusk, dawn, and during nocturnal hours at low altitudes, are expected to be occasional collision victims, with low levels of mortality occurring each year. Herons are occasional collision victims at powerlines (Faanes, 1987). Grebes and loons were rarely observed at the Amherst study area, and are not likely to be killed in any large numbers.

Thus, it is expected that low to moderate numbers of gulls, and relatively low numbers of the other waterbird species listed above will collide with the transmit antenna structures. As with most other groups discussed, collisions will probably be most frequent in wet years, especially at the Tx-S CSA. In normal years, collision rates should not be greatly different between the two CSAs.

In summary, it is likely that collisions with the antenna structures by raptors, gamebirds, sandhill cranes, and most species of waterbirds will be minimal. Of the few expected collisions, more will likely occur at the Tx-N CSA for raptors and gamebirds and at the Tx-S CSA for sandhill cranes and waterbirds.

Swans: Relatively few swans were observed at the Amherst study area during daylight hours and those birds which were observed tended to move rapidly through the region, generally in a few closely spaced pulses of migration. Bellrose (1980) reports that a major migration corridor passes through this region of South Dakoka connecting breeding areas in Alaska and Canada with wintering areas on the Chesapeake Bay. Since this species will migrate during either diurnal or nocturnal hours, many birds may have passed through during nocturnal hours; this was known to occur on several evenings at the North station in 1987, as large numbers of tundra swans were heard calling overhead.

About half of the observed swans flew above the maximum height of the transmit antenna during daylight hours; nocturnal migration was probably at altitudes well above 150 feet agl. Swans are known to collide with man-made objects, such as towers and power lines (Thompson, 1978; ABR, 1988a), and this species group often flies during periods of poor weather, especially in fall, when cold, snowy weather forces them south. Although collisions with the CRS transmit antennas are expected to occur only in low numbers during most years, moderate to large numbers may be killed during poor weather conditions in some years. Based upon observed numbers and movement patterns, the risk of collisions is expected to be slightly higher at the Tx-S CSA during years when large amounts of floodwater is present, but generally higher at the Tx-N CSA during most other years.

Shorebirds: Shorebirds are mainly nocturnal migrants, often migrating at high altitudes (Drury and Keith, 1962; Nisbet, 1963; Bellrose, 1980), although some nocturnal flights below 50 feet agl were documented at the South station during night-vision scope observations in spring. Low to moderate numbers of shorebirds were observed during daytime hours at the Amherst study area and most flew below 150 feet agl. Shorebirds did not apparently stage in appreciable numbers in the vicinity of either station, although appreciable numbers probably migrate through, and stage in, the James River Valley in years when open water is abundant.

Although these birds are extremely manueverable in flight, they often fly during periods of precipitation (rain) when visibility is reduced and during periods of darkness. Several shorebird carcasses were located during tower searches in the Amherst area, indicating that these birds do collide with man-made objects. However, large numbers of shorebird collisions are not expected with the CRS antennas in most years. Collision mortality is expected to be relatively low at the Tx-N CSA, based upon the low number of shorebirds observed and the habitat present. Collision mortality is expected to be considerably higher at the Tx-S CSA only during years when abundant standing water is present, as in 1989. During 1989, many shorebirds were attracted to the open water and mudflats near the South station to forage. Collision mortality at the Tx-S CSA during flood years is expected to be moderate, but relatively low in other years.

Geese: Large numbers of geese pass through the Amherst study area region each spring and fall. This region is within a major migration corridor for snow geese (Bellrose, 1980), with peak numbers observed at nearby Sand Lake NWR often exceeding 200,000 birds (UND, 1988). Moderate numbers of Canada geese also pass through the region in spring and fall, as do moderate number of greater white-fronted geese, especially in spring (Whitney et al., 1978; Bellrose, 1980).

Geese generally flew through the study area in large pulses in early spring, as open water became available, and during late fall, just prior to freeze-up. Weather conditions during these periods are often poor, and geese were observed flying at high rates during these periods when snow limited visibility. Large numbers of geese also staged and rested on local waterbodies, and flew at relatively low altitudes to nearby fields to forage (Table 8-47). Migratory movements were generally at altitudes well above 150 feet agl during daylight hours, and mean nocturnal altitudes measured with vertical-beam radar were higher during the period of peak waterfowl movement, averaging over 1000 feet agl on some nights. Bellrose (1980) reports that migrating snow geese usually fly at altitudes exceeding 2000 feet. Other investigators have also reported that flight altitudes for most birds tend to be higher during nocturnal migration than during daytime movements (Eastwood and Rider, 1965; Gauthreaux, 1978), so it is likely that few migrating geese will fly below 150 feet agl during nocturnal hours. Local movements were generally below 150 feet agl, however.

Behavioral studies (ABR, 1988b; 1988c) suggest that these birds should have little trouble seeing and avoiding the antenna structures during daylight hours. While the visibility of the backscreen to birds is not known, the support poles should be easily seen from considerable distances during clear weather conditions. Geese are known to collide with man-made objects, especially power lines (Thompson 1978), with most of these collisions probably take place during low-level local movements during periods of limited visibility. However, large flocks of geese were often observed being flushed from fields in the fall by hunters; these birds would mill around at low altitudes in a confused fashion and would be more susceptible to colliding with nearby man-made objects (Anderson, 1978).

In general, moderate numbers of geese will probably collide with the antenna structures during most years. However, the risk of large-scale mortality is considered high at the Amherst transmit study area since these birds fly in large flocks and often during poor weather conditions. In a typical year, the Tx-N CSA would probably have a higher risk of collision mortality for geese, as several permanent wetland complexes attract birds to this area, as do fields to the south of the site. In years when flooding is extensive (such as 1989), the Tx-S CSA would probably have a higher risk of an episodic collision event occurring, as well higher levels of chronic mortality.

Based upon the above discussion, it is likely that swan and shorebird collisions with the antenna structure will occur at low to moderate levels, and collisions by geese at moderate to high levels. Collision risk is considered higher at the Tx-N CSA for geese and swans during most years, but higher at the Tx-S CSA for all three groups during years with significant amounts of flooding.

Ducks: Ducks are largely nocturnal migrants and are known to frequently collide with man-made objects, especially power lines (e.g. Stout and Cornwell, 1976; Thompson, 1978; Anderson, 1978). Several duck carcasses were also found during tower searches. Moderate to large numbers of ducks migrate through the Amherst study area during daylight hours, and it is suspected that a fair proportion of radar targets observed on long-range radar were nocturnally migrating ducks. Ducks stage and nest in moderate to large numbers in the Amherst region, with large concentrations occurring on permanent and temporary wetlands near both CSAs. About 20 percent of the ducks observed during daylight hours flew below 150 feet agl at the Tx-N CSA but about half were below this altitude at the Tx-S CSA. Much of this low-level flying was probably local movements. Nocturnal flight altitudes observed with the vertical-beam radar were generally higher than diurnal flight altitudes, especially during peak waterfowl migration. However, nocturnal duck flights below 50 feet agl were observed near water areas, especially in spring during night-vision scope observations. Low-level, local movements near dawn and dusk, when visibility is reduced are also common for this species group and ducks often fly during periods of inclement weather.

Waterfowl, including ducks, may be struck by vehicles, especially during the breeding period (Stout and Cornwell, 1976). This mortality is not generally considered significant.

Based upon the large size of the transmit antennas and their proximity to major wetland complexes, duck collisions with the structures are likely to occur, especially during nocturnal and poor weather periods. In most years, this mortality is likely to be higher at the Tx-N CSA, which is near a number of large, permanent wetlands and contains numerous seasonal wetlands likely to be used by breeding ducks. Most of these collisions will probably be isolated incidents of single or paired birds flying near dusk and dawn, since this is the general mortality pattern for this group (Stout and Cornwell, 1976). During years of extensive flooding, mortality at the Tx-S CSA is expected to be higher, and based upon the level of use and the flight altitudes observed at the Tx-S station in 1989 (Table 8-47), this mortality may be substantial. The possibility of large-scale kills, as discussed for geese, is considerable at either CSA, but especially at the Tx-S CSA during wet years. Chronic, yearly mortality is expected to be higher than for geese at both CSAs, based upon known flight behaviors and flight patterns of these two groups.

Waterbirds: Several species of waterbirds, such as rails and coots, are almost exclusively nocturnal migrants and are known to be frequent collision victims with man-made structures (Table 8-24; Avery et al., 1978; Anderson, 1978; Faanes, 1987). These species are not generally strong fliers and typically migrate at low altitudes (Terres, 1980). Although few rails and coots were observed flying through the study area during daylight sampling, large numbers of coots were observed resting on local waterbodies, including Sand Lake and Waubay NWRs, and wetlands north of Groton, SD. Coot and rail carcasses were also located during tower searches in both spring and fall.

It is expected that relatively large numbers of rails and coots will collide with the transmit antenna structures. As with most other groups discussed, collisions will probably be most frequent in wet years, especially at the Tx-S CSA. In normal years, collision rates should not be greatly different between the two CSAs.

Passerines: Passerines (doves, woodpeckers, and swifts are included for this discussion) frequently collide with tall man-made objects (e.g. Avery, 1978; Avery et al., 1978), and the severity of collision mortality is generally proportional to the height of the structure (ABR, 1989; 1990a). Passerines are also frequently killed due to collisions with vehicles, especially species such as swallows, blackbirds, and larks which forage or rest on road surfaces.

Passerines generally flew below 150 feet agl during daylight hours, although these highly maneuverable birds generally have little difficulty avoiding collisions with man-made structures during periods of good visibility (ABR, 1988b; 1988c). Most species of passerines are nocturnal migrants, although some commonly observed species such as blackbirds and swallows migrate primarily during daylight hours. Flight altitudes during nocturnal hours are generally higher than during daylight hours (Eastwood and Rider, 1965; Gauthreaux, 1978, ABR, 1989; 1990a). However, passerines were observed flying below 50 ft agl during night-vision scope observations, and altitude distributions on the vertical-beam radar indicate that a large percentage of migrants flew below 300 feet agl in the fall, when the highest collision rates for passerines have been reported (Avery et al., 1978).

The susceptibility of passerines to collide with man-made objects makes large numbers of chronic collisions with the transmit antenna structures highly probable because of the large size of the structures and the relatively large number of passerines observed within the study area during daylight hours and (presumably) on short-range radar during nocturnal hours. Passerines which encounter the structure at night will not necessarily collide. The small wingspan of these species should allow some birds to pass unharmed through the structure, especially the open lattice backscreen structure which exists above 75 feet, even during poor visibility periods.

Large, episodic mortality events are also possible, especially during poor weather conditions. These could occur relatively frequently, especially in fall. With the documented decline in many numbers of passerine species (by the USFWS Breeding Bird Survey), this additional mortality, when added to the thousands of other birds killed annually at other man-made structures (Jaroslow, 1979), may prove significant. Since passerines typically migrate along a broad front during nocturnal migration and short-range radar results were similar between stations in fall, when higher rates of passerine collisions would be expected, collision mortality for passerines is expected to be similar between the two CSAs.

Summary: In summary, it is expected that collisions of eagles, hawks, falcons, most waterbird species, and sandhill cranes with the antenna structures may occur but will be relatively uncommon. Owl, harrier, and gamebird collisions may occur more frequently. Swans and shorebirds have higher chances of colliding with the structures, and small numbers of collisions will likely occur throughout the life of the project. Large numbers of collisions are not expected to occur except under the most unusual circumstances for these two species groups. Geese, ducks, some species of waterbirds, and passerines may suffer moderate to high rates of mortality due to collisions with the antenna structures at this site. The total number of kills for each of these species groups could be significant when both chronic and large-scale, eposodic events are considered. In most years, collision mortality is expected to be higher at the Tx-N CSA for most species groups, but may be higher in wet years at the Tx-S CSA for many species groups.

8.3.2.4 Mitigation. The redesign of the transmit antenna structure, making the backscreen more open and visible for those sections over 75 feet, is expected to result in reduced levels of bird collisions during daylight hours. The effectiveness of the redesign in reducing collisions during nocturnal hours will probably be less, especially for species with large wingspans, such as swans. Siting decisions which avoided, to a large extent, placing facilities near major wetland areas should also reduce, to a large extent, potential collision mortality as well as loss of valuable avian habitat.

Various mechanisms can be employed to make the antenna structures more visible. During daylight hours, various marking devices, such as plastic streamers, balls, and other markers, have been used successfully to reduce bird collisions with power lines (e.g. Beaulaurier, 1981), and could be used on the lower 75 feet of the CRS transmit antennas to make the backscreen more visible. Various lighting schemes may possibly be employed to reduce collisions during nocturnal hours. These will be investigated further and the most promising methods will be incorporated, where possible, in the Mitigation Plan for the project.

The USAF, in consultation with the USFWS and the South Dakota Department of Game, Fish, and Parks, will develop a collision monitoring program to document the number of collisions with the antenna structures after they are constructed. Data from this program will be used to determine the need for additional compensation measures for species or species groups which incur serious levels of mortality due to collisions with the project structures.

Mitigation for in-kind habitat loss should not be necessary if the Tx-S site is chosen since no critical or scarce habitat would be removed by the project. Mitigation for lost wetland breeding areas and gamebird lek sites may be necessary should the Tx-N site be selected. However, many bird species may also benefit from any wetland mitigation efforts which might be required, since this habitat type is used by many avian species. Disturbance to nesting birds can be minimized during construction and operation of the facility by curtailing disturbances during the critical periods of the nesting season, where feasible, in the vicinity of nests or broods. Significant collision mortality could require additional mitigation for the enhancement or creation of avian habitat. The need for this would be evaluated by the USAF and the responsible state and federal agencies as part of the on-going mitigation planning process.

8.3.3 Receive Site

8.3.3.1 Habitat loss. About half of the habitat which would be disturbed at the Rx-E preliminary site layout location is actively cultivated, while most of the other half is upland fields (mostly CRP lands). Upland forests and wetland habitat are virtually nonexistent within the area of the East preliminary site layout (Technical Study 5), although small amounts of ephemeral wetlands may exist for brief periods in spring during peak runoff (Technical Study 6).

Upland field habitat was formerly rare in agricultural areas, but the CRP program has substantially increased the number of acres of this cover type in many areas in the Midwest. Upland fields, if left relatively undisturbed, are utilized during the breeding season by many species of ground nesting passerines (e.g. western meadowlarks). Nesting densities would decrease depending upon the intensity and type of disturbance (fire, mowing, grazing) to these areas (Owens and Myres, 1973; Kantrud, 1981). Ground nesting raptors, principally northern harriers in this area, also utilize grassland habitat types such as exist at the Rx-E preliminary site layout (Duebbert and Lokemoen, 1977). One active display ground of sharp-tailed grouse was located within the Rx-E preliminary site layout (Fig. 8-99); this site would likely be destroyed during construction if this preliminary site layout were chosen. Nesting by gamebirds, such as sharp-tailed grouse and gray partridge, is also likely to occur within this cover type (Manske and Barker, 1987). Actual nesting densities are unknown, however, because lack of right-of-entries during the spring season precluded conducting breeding bird censuses. Upland agricultural areas generally provide suboptimal breeding habitat for most species, with nesting densities much reduced relative to grasslands for most species (Higgins et al., 1987).

Waterbirds, many of which are colonial breeders, are unlikely to breed at the Rx-E preliminary site layout. Upland nesting waterfowl (e.g. mallard and pintail) and upland nesting shorebirds (e.g. common snipe, marbled godwit) may breed in the upland field habitat, especially if they are reasonably close to water or wetland areas. Densities are probably low to moderate, depending upon local conditions in the spring. Nesting by sandhill cranes is unlikely in the Rx-E preliminary site layout; Goose Lake marsh is the only likely breeding area for this species within the Thief River Falls study area.

The Rx-E preliminary site layout provides poor quality breeding habitat for woodland raptors and forest passerines as wooded areas are relatively rare. Large woodlots do exist within the eastern half of the Thief River Falls study area but were largely avoided when the Rx-E preliminary site layout, and the Rx-E CSA, were selected.

The Rx-W preliminary site layout is dominated by agricultural lands (about 85% of the disturbed land area). The remaining area consists mainly of upland field habitat. Wooded areas and wetlands are uncommon (Technical Study 5). While agricultural areas may serve as important foraging areas for birds, they are generally of low value as breeding habitat relative to native grasslands for most species (Higgins et al., 1987). Loss of these areas should have a negligible effect on breeding birds.

In summary, the Rx-E preliminary site layout contains a higher percentage of habitat types which are useful to nesting birds, including an active lek site of sharp-tailed grouse. The Rx-W preliminary site layout contains lower amounts of quality avian breeding habitat. Thus, impacts to breeding birds are expected to be slightly higher at the Rx-E preliminary site layout than at the Rx-W preliminary site layout.

8.3.3.2 Disturbance. Most nesting birds are sensitive to noise with the level of sensitivity varying by species. Responses range from nest abandonment and reduced productivity to increased levels of alarm responses (White and Thurow, 1985; Manci et al., 1988). The construction of the CRS receive facility will potentially disturb locally breeding birds in the immediate vicinity of the construction zone, although the operation of the facility should result in little or no disturbance.

Since breeding bird populations are expected to be slightly higher at the Rx-E preliminary site layout than at the Rx-W preliminary site layout, potential disturbance effects are expected to be greater at the Rx-E site. The most severe effects include nest destruction, nest abandonment, and reduced productivity and will probably be highest for ground nesting passerines. Spring construction may also interfere with activity at sharp-tailed grouse lek sites in the Rx-E preliminary site layout, although the level of disturbance necessary to cause abandonment of a lek is not known.

8.3.3.3 Collision mortality. A qualitative assessment of collision risk potential, similar to that conducted for the Amherst study area, was done for the Thief River Falls study area. Quantitative techniques to precisely predict the number of collisions with man-made structures are not available (USFWS, 1989). Table 8-48 summarizes this analysis by species or species group for the Thief River Falls study area as a whole, as well as providing a summary of the relative impacts among the Rx-W CSA and the western (Rx-E (W) CSA) and eastern (Rx-E (E) CSA) portions of the Rx-E CSA. These areas correspond to the West, Central, and East stations used in the discussion contained in the Affected Environment section. However, the Rx-E (E) CSA is not presently being considered for the actual siting of the antennas. The two preliminary site layouts presently being considered are located in the Rx-W CSA and the Rx-E (W) CSA (Figs. 102; 103). Table 8-49 provides a summary of peak and mean migration rates for altitudes below 100 feet agl.

Based upon this analysis, the collision potential for raptors, gamebirds, and most species of waterbirds is considered to be relatively low at the Thief River Falls study area. Risk of collision is higher for shorebirds, ducks, geese, swans, and sandhill cranes and highest for some species of waterbirds (rails and coots) and passerines. The risk of collision appears to be relatively similar overall among the three areas, but several species groups show some differences. The rationale for this assessment is discussed below for each species group.

Raptors: Eagles, hawks, harriers, falcons, and owls are extremely manueverable in flight and possess excellent vision. Collision mortality with man-made objects is generally considered uncommon for these raptors (Orlendorff et al., 1981), although collisions with power lines are known to occur on occasion (Thompson, 1978; Olendorff et al., 1981). All of these birds, except owls, are mainly active during daylight hours, when visibility is generally good; during periods of poor weather, when visibility is reduced, migration rates for raptors are generally lower (Table 8-32).

Raptors are also struck by vehicles on occasion (e.g. Schmutz and Fyfe, 1987). This type of mortality event occurs more frequently for species which forage on road-killed animals.

Only low to moderate numbers of eagles and hawks were observed during daylight hours at the Thief River Falls study area, with the majority of these birds flying above 50 feet agl and about half flying above 100 feet agl. Low to moderate numbers of northern harriers were also observed. These birds soar during migration like hawks and eagles but were usually observed foraging at low altitudes (generally less than 25 feet agl) during avian studies. Observed numbers of falcons and owls were low and very low, respectively, although daylight observations would not be expected to document large numbers of owl sightings. Owls are slow, low-level flyers while foraging during nocturnal hours. Owls were observed flying below 50 feet agl during night-vision scope observations, especially in the fall at the West stations.

Raptors, as a group, are probably most vulnerable to collisions when foraging, since they are distracted and less vigilant in regard to obstructions, and generally fly at low altitudes (Orlendorff et al., 1981). Studies at towers and power lines (e.g. Orlendorff et al., 1981; ABR, 1988b; 1988c) suggest that foraging and migrating raptors, in general, have little difficulty avoiding obstructions such as guy or transmission wires, although occasional collisions do occur, probably when the bird is distracted while foraging or during poor weather, when visibility is reduced. This risk is probably higher for owls, because of their nocturnal foraging habits and the reduced visibility of the

TABLE 8-48. FACTORS WHICH INFLUENCE COLLISION RISK POTENTIAL BY SPECIES OR SPECIES GROUP AT THE THIEF RIVER FALLS RECEIVE STUDY AREA

Factor[1]	Species/Species Group											
	Ducks	Geese	Swans	Sandhill Cranes	Eagles/ Hawks	Harriers	Falcons	Owls	Shorebirds	Waterbirds	Passerines	Gamebirds
Population Status	+	-	0	0	+	+	+	0	0	0	+	0
Abundance at Site												
-Study Area	0	0	-	0	0	0	-	-	0	0	+	0
-West CSA	0	0	0	0	-	0	-	-	0	0	+	0
-East CSA:West	0	0	-	+	0	0	-	-	0	0	+	0
-East CSA:East	0	0	-	0	-	-	-	-	0	+	+	0
Migration Patterns												
-Study Area	+	+	+	+	-	-	-	-	-	+	0	+
-West CSA	+	+	+	+	-	-	-	-	0	+	-	+
-East CSA:West	+	+	+	+	-	-	-	-	0	+	-	+
-East CSA:East	+	+	+	+	-	-	-	-	-	+	0	+
Local Movements												
-Study Area	+	-	-	0	-	+	-	+	+	-	+	+
-West CSA	0	-	0	0	-	+	-	+	+	-	+	+
-East CSA:West	+	-	-	+	-	+	-	+	+	-	+	+
-East CSA:East	+	-	-	0	-	+	-	+	+	0	0	+
Flight Path												
-Study Area	0	0	0	0	0	0	0	0	0	0	0	0
-West CSA	-	-	+	-	0	0	0	0	0	0	0	0
-East CSA:West	-	0	-	+	0	0	0	0	0	0	0	0
-East CSA:East	+	+	-	0	0	0	0	0	0	+	0	0
Nocturnal Flight Altitude												
-Study Area	0	-	-	N/A[2]	N/A	N/A	N/A	+	0	0	0	N/A
-West CSA	0	0	+	N/A	N/A	N/A	N/A	+	0	0	0	N/A
-East CSA:West	0	-	-	N/A	N/A	N/A	N/A	+	0	0	0	N/A
-East CSA:East	0	0	0	N/A	N/A	N/A	N/A	+	+	0	0	N/A

TABLE 8-48 (Continued). FACTORS WHICH INFLUENCE COLLISION RISK POTENTIAL BY SPECIES OR SPECIES GROUP AT THE THIEF RIVER FALLS RECEIVE STUDY AREA

Factor(1)	Species/Species Group											
	Ducks	Geese	Swans	Sandhill Cranes	Eagles/ Hawks	Harriers	Falcons	Owls	Shorebirds	Waterbirds	Passerines	Gamebirds
Diurnal Flight Altitude												
-Study Area	0	-	0	0	0	+	+	N/A	+	0	+	+
-West CSA	0	0	0	0	0	+	+	N/A	+	0	+	+
-East CSA:West	0	-	-	0	0	+	+	N/A	+	0	+	+
-East CSA:East	0	-	0	-	-	+	+	N/A	+	0	+	+
Flock Size												
-Study Area	0	+	0	0	-	-	-	-	0	+	0	-
-West CSA	0	+	+	0	-	-	-	-	+	0	0	-
-East CSA:West	0	+	0	0	-	-	-	-	0	0	0	-
-East CSA:East	0	+	0	0	-	-	-	-	-	+	+	0
Weather Factors												
-Study Area	+	+	+	-	-	-	-	-	0	+	0	-
-West CSA	+	+	+	-	-	-	-	-	0	+	0	-
-East CSA:West	+	+	+	-	-	-	-	-	0	+	0	-
-East CSA:East	+	+	+	-	-	-	-	-	0	+	0	-
Flying Ability	-	0	+	+	-	-	-	-	-	0	-	+
Visual Acuity	-	-	-	-	-	-	-	-	-	-	-	-
Wing span	0	0	+	+	+	+	0	+	-	0	-	0
Nocturnal Migration	+	0	0	-	-	-	-	+	+	+	+	-
Frequency of Reported Collisions	+	-	+	+	-	-	-	-	0	+	+	0

1. Ranks: - = Low risk, 0 = Moderate risk, + = High risk.
2. Not applicable.

Table 8-49. Peak and Mean Migration Rates (Birds per Hour) Observed For Altitudes Less Than 100 Feet agl During Daylight Hours at the Thief River Falls Receive Study Area

Species Group	Season	Peak Day Rate <100 ft (1)			Mean Rate <100 ft (2)		
		West Station	Central Station	East Station	West Station	Central Station	East Station
Waterfowl	Fall 87	32.80	0.62	7.78	3.20	3.56	3.44
	Spring 89	384.29	-	392.52	34.73	-	21.50
	Fall 89	0.00	0.49	0.00	1.77	3.44	2.54
-Ducks	Fall 87	0.00	23.45	0.00	0.09	0.89	0.36
	Spring 89	27.45	-	68.22	4.61	-	4.69
	Fall 89	0.00	35.20	0.00	0.22	0.70	0.17
-Geese/ Cormorants	Fall 87	32.80	0.62	7.78	3.06	1.00	3.03
	Spring 89	353.36	-	310.44	28.89	-	16.21
	Fall 89	0.00	0.00	0.00	1.39	2.75	2.39
-Swans	Fall 87	*(3)	*	*	*	*	*
	Spring 89	10.43	-	12.41	1.00	-	0.38
	Fall 89	0.00	0.00	0.00	0.13	0.01	0.00
Raptors	Fall 87	3.00	0.54	0.00	0.63	0.90	0.25
	Spring 89	0.07	-	0.38	0.21	-	0.22
	Fall 89	3.28	1.50	2.60	0.68	0.65	0.49
Shorebirds	Fall 87	10.95	5.71	0.00	0.94	0.30	1.15
	Spring 89	4.59	-	3.10	0.42	-	0.53
	Fall 89	110.00	42.99	0.50	1.93	1.96	0.89
Sandhill Cranes	Fall 87	21.00	0.00	0.00	0.09	0.25	0.14
	Spring 89	17.11	-	30.62	0.87	-	1.99
	Fall 89	0.00	0.00	0.00	0.07	0.18	0.02

Table 8-49. (Continued) Peak and Mean Migration Rates (Birds per Hour) Observed For Altitudes Less Than 100 Feet agl During Daylight Hours at the Thief River Falls Receive Study Area

Species Group	Season	Peak Day Rate <100 ft (1)			Mean Rate <100 ft (2)		
		West Station	Central Station	East Station	West Station	Central Station	East Station
Waterbirds	Fall 87	*	*	*	*	*	*
	Spring 89	36.69	-	1.11	2.30	-	2.05
	Fall 89	0.00	0.00	0.10	0.37	0.20	0.35
Passerines	Fall 87	226.00	392.00	69.14	29.98	74.89	18.92
	Spring 89	411.66	-	1621.00	46.69	-	116.26
	Fall 89	302.80	101.80	421.44	39.68	40.62	50.34

1. Migration Rate (Birds per Hour) for birds below 100 feet agl on the day with the peak daily migration Rate (Table 8-29).

2. Mean Migration Rate (Birds per Hour) for birds below 100 feet agl over the entire study period.

3. Insufficient data.

backscreen during low light levels. Among diurnal raptors, harriers are probably at greatest risk of collisions, given their low altitude foraging flights. Thus, over the life of the project, low numbers of raptor collisions are expected to occur, probably with the wire-mesh backscreen, although this loss is not expected to be significant.

Collision risk is probably similar among the Rx-W CSA, Rx-E (W) CSA, and Rx-E (E) CSAs for all raptor groups based upon observed flight patterns and behaviors within the Thief River Falls study area.

Gamebirds: Most species of gamebirds fly infrequently, generally covering relatively short distances between foraging and roosting areas. Flight altitudes during these movements tend to be low, generally below 50 feet agl and these birds are not considered agile fliers. Gamebirds are nonmigratory, generally remaining in the area year round and most activity is diurnal, although these birds commonly fly during twilight periods.

Collisions of these species with man-made structures are known to occur (Thompson, 1978). In addition, these species forage and obtain grit along roadsides, and are sometimes struck by vehicles. Occasional collisions are expected with the receive antenna structures over the life of the project, and additional birds may be killed due to increased project-related traffic. These losses are not expected to be severe, based upon the diurnal tendencies and flight patterns of these species. Collision losses are expected to be relatively similar among the three areas.

Waterbirds: Most species of waterbirds, such as gulls, terns, grebes, loons, cormorants, and herons migrate during both daylight and nocturnal hours and many are agile fliers. Pelicans, which soar like raptors and cranes, are almost exclusively diurnal migrants (Terres, 1980). Although most of these species also are known to collide with man-made objects (Thompson, 1978), reported rates of collision are generally low for most species.

Gulls were commonly observed at the Thief River Falls study area in spring but were much rarer in fall. Many of these spring sightings were of Franklin's gulls; large numbers often aggregate at nearby Agassiz NWR (Janssen, 1987). In general, terns were uncommonly observed. These species are mainly active during daylight hours and are agile fliers. However, gull collision rates with power lines can often be substantial (Krapu, 1974; Rusz et al., 1986; Faanes, 1987). One gull (Franklin's) was found during tower searches in spring.

Cormorants were commonly observed, but usually flew at altitudes well over 100 feet agl. Because of this, they are expected to infrequently collide with the antenna structures. Herons, mostly great blue herons, were observed in low to moderate numbers and pelicans were observed in low numbers and only in spring. Pelicans, which frequently soar and fly mostly diurnal hours, are expected to be very infrequent collision victims due to their general rarity at the site and their flight behavior. Herons, which often fly at dusk, dawn, and during nocturnal hours at low altitudes, are expected to be occasional collision victims, with low levels of mortality occurring each year. Herons are occasional collision victims at powerlines (Faanes, 1987). Grebes and loons were rarely observed at the Thief River Falls study area, and are not likely to be killed in any large numbers.

Thus, it is expected that low to moderate numbers of gulls, and low numbers of most other waterbirds will collide with the receive antenna structures. These collisions are expected at greater frequency in the spring, and rarely in the fall. Based on the higher numbers and flight altitudes observed, slightly more collisions would be expected at the Rx-E (E) CSA.

In summary, it is likely that collisions with the antenna structures by raptors, gamebirds, and most waterbirds will be minimal. Collision mortality will likely be similar at the CSAs for raptors and gamebirds but slightly higher at the Rx-E (E) CSA for some species of waterbirds.

Shorebirds: Shorebirds are mainly nocturnal migrants, often migrating at high altitudes (Drury and Keith, 1962; Nisbet, 1963; Bellrose, 1980), although some nocturnal flights below 50 feet agl were documented during fall night-vision scope observations. Low to moderate numbers of shorebirds were observed during daylight hours at the Thief River Falls study area and the majority flew below 50 feet agl, except at the East station where only about a third flew below 50 feet agl. Shorebirds did not apparently stage in appreciable numbers in the Thief River Falls study area, and large-scale migration would not be expected through the study area during most years.

Although these birds are extremely manueverable in flight, they often fly during periods of precipitation (rain) when visibility is reduced and during periods of darkness. Although no shorebird carcasses were located during tower searches in the Thief River Falls area, these birds do collide with man-made objects (Thompson, 1978). However, only low numbers of shorebird collisions are expected with the CRS receive antenna structures in most years, with higher numbers occurring in spring than in fall. Collision mortality is expected to be slightly higher at the Rx-W CSA, based upon the number of shorebirds observed and their flight altitude distribution.

Sandhill Cranes: The Thief River Falls study area is on the western edge of the main sandhill crane migration corridor through Minnesota (Janssen, 1987). Moderate numbers of sandhill cranes were observed at the Thief River Falls study area. Many of these cranes roosted in the study area during the migration period, largely in the vicinity of Goose Lake but also at sites in the eastern and central portions of the study area.

This species is primarily a diurnal migrant, often flying at high altitudes. Cranes observed during the avian studies usually flew above 100 feet agl, except at Goose Lake where altitudes were lower. Cranes usually flew during good weather conditions, when they should have little difficulty seeing and avoiding large obstacles in their flight path, although they are prone to collisions during poor visibility periods. Cranes are known to collide with man-made objects, such as power lines, in the midwestern U.S. (Faanes, 1987), and low to moderate numbers of cranes are expected to collide with the CRS receive antennas during low-level local movements. Based upon observed flight corridors and altitudes, collisions are expected to be more frequent in the central region of the study area (Rx-E (W) CSA), especially in the vicinity of the beach ridge.

Swans: Relatively few swans were observed at the Thief River Falls study area during daylight hours, especially during the fall season. Those birds which were observed tended to move rapidly through the region, generally in a few closely spaced pulses of migration, especially in the fall. Local movements were more common in the spring, especially after dark at the West station. The area near this station is prone to flooding and a significant amount of water was present in the spring of 1989. Although few swans were observed during aerial surveys, grounded swans were heard on several nights northwest of the West station and were occasionally observed on Goose Lake. Bellrose (1980) reports that the major tundra swan migration corridor in North America passes directly through this region of Minnesota, connecting breeding areas in Alaska and Canada with wintering areas on the Chesapeake Bay. Since this species will migrate during either diurnal or nocturnal hours, many birds may have passed through during nocturnal hours.

About half of the observed swans flew below 100 feet agl and about a third flew below 50 feet agl during daylight hours; most nocturnal migration was probably at altitudes well over 100 feet agl, although low-level (less than 50 feet agl) nocturnal movements were observed in spring during night-vision scope observations, especially at the West station. Swans are known to collide with man-made objects, such as towers and power lines (Thompson, 1978; ABR, 1988a) and this species group often flies during periods of poor weather, especially in fall, when cold, snowy weather forces them south. Collisions with the CRS receive antennas are expected to occur in low to moderate numbers during most years, especially in spring, and moderate to large numbers of swans may be killed during poor weather conditions in some years. The risk of collisions is expected to be higher at the Rx-W CSA, based upon observed numbers, movement patterns, and the tendency for this area to flood in the spring.

Geese: Moderate to large numbers of Canada geese pass through the Thief River Falls region each spring and fall (Bellrose, 1980; Janssen, 1987). Lower numbers of snow geese also pass through the region, with numbers typically higher in the fall. Small numbers of greater white-fronted geese may also pass through the area, especially in spring. The main fall white-fronted goose migration corridor is well west of the study area (Bellrose, 1980; Janssen, 1987).

Geese generally flew through the study area in large pulses in early spring. Fall migration was more protracted but still pulse-like in nature, with peak movements typically occurring in early November. Weather conditions during these periods are often poor, and geese were observed flying at high rates during these periods when snow limited visibility. Moderate numbers of geese also staged and rested on local waterbodies. Migratory movements were generally at altitudes well above 100 feet agl during daylight hours, and mean nocturnal altitudes measured with vertical-beam radar were generally higher during the period of peak waterfowl movement, averaging over 1000 feet agl on some nights. Other investigators have also reported that flight altitudes for most birds tend to be higher during nocturnal migration than during daytime movements (Eastwood and Rider, 1965; Gauthreaux, 1978), so it is likely that few migrating geese will fly below 100 feet agl during this period. Local movements were generally below 100 feet agl during daylight hours, and were more common in the spring. During nocturnal hours, small flocks of Canada geese were also observed flying below 50 feet agl during night-vision scope observations at all stations in the spring.

Behavioral studies (ABR, 1988b; 1988c) suggest that these birds should have little trouble seeing and avoiding the antenna structures during daylight hours. While the visibility of the backscreen to birds is not known, the support poles should be easily seen from considerable distances during clear weather conditions. Geese are known to collide with man-made objects, especially power lines (Thompson 1978), with most of these collisions probably taking place during low-level local movements during periods of limited visibility.

In general, low to moderate numbers of geese are expected to collide with the antenna structures, with mortality rates expected to be much higher in the spring than in the fall. However, the risk of large-scale kills cannot be discounted since these birds fly in large flocks and often during poor weather conditions. Based upon data collected during the avian studies on abundance, flight altitudes, and movement patterns, collision mortality is expected to be similar among the CSAs.

Ducks: Ducks are largely nocturnal migrants and are known to frequently collide with man-made objects, especially power lines (e.g. Stout and Cornwell, 1976; Thompson, 1978; Anderson, 1978). Several duck carcasses were also found during tower searches. Low to moderate numbers of ducks migrate through the Thief River Falls study area during daylight hours, and it is suspected that a fair proportion of radar targets observed on long-range radar were nocturnally migrating ducks. Ducks stage and nest in moderate numbers in the Thief River Falls region, with concentrations occurring on permanent and temporary wetlands near Goose Lake and within the Rx-W CSA in spring. The majority of ducks observed during daylight hours flew above 100 feet agl, with altitude distributions lower near Goose Lake. Most low-level flights were probably local movements. Nocturnal flight altitudes were generally higher than diurnal flight altitudes, especially during peak waterfowl migration, as observed on the vertical-beam radar. However, nocturnal duck flights below 50 feet agl were observed in the spring during night-vision scope observations. Low-level, local movements near dawn and dusk, when visibility is reduced are also common for this species group and ducks often fly during periods of inclement weather.

Waterfowl, including ducks, may be struck by vehicles, especially during the breeding season (Stout and Cornwell, 1976). This mortality is generally not considered significant.

Duck collisions with project structures are likely to occur, especially during nocturnal and poor weather periods. Most of these kills will probably be of single birds or pairs flying at low altitudes during low light conditions (Stout and Cornwell, 1976). Collisions are likely to be higher in the spring and higher during wet years. In drier years, most ducks will probably concentrate in permanent wetland areas, which generally occur well away from the CSAs. Collision mortality is expected to be slightly higher at the Rx-E (E) CSA, based upon observed numbers and altitude distributions, although spring mortality may be higher at the Rx-W CSA during wet years.

Based upon the above discussion, it is likely that shorebird collisions with the antenna structures will occur at low to moderate levels, and collisions by sandhill cranes, ducks, swans, and geese at moderate levels. Collision risk is considered higher at the Rx-W CSA for swans and shorebirds, higher at the Rx-E (W) CSA for sandhill cranes, and higher at the Rx-E (E) CSA for ducks. Goose collision mortality is expected to be similar among CSAs.

Waterbirds: Several species of waterbirds, such as rails and coots, are almost exclusively nocturnal migrants and are known to have frequent collisions with man-made structures (Table 8-43; Avery et al., 1978; Anderson, 1978; Faanes 1987). These species are not generally strong fliers and typically migrate at low altitudes (Terres, 1980). Rails are difficult to observe and data on migrational movements are lacking for many species in Minnesota, although several (e.g. sora) are known to be common migrants through the Thief River Falls area (Janssen, 1987). Coots are abundant migrants in this region of Minnesota, with concentrations as high as 36,000 birds reported at nearby Agassiz NWR (Janssen, 1987); moderate numbers were also observed resting and feeding on Goose Lake.

It is expected that moderate numbers of rails and coots will collide with the receive antenna structures based upon their migration tendencies and relative abundance in the region. Insufficient information is available to determine the relative impact among CSAs for these species since so few were observed during daylight hours and target identification during nocturnal radar observations was not possible.

Passerines: Passerines (doves, woodpeckers, and swifts are included for this discussion) frequently collide with tall man-made objects (e.g. Avery, 1978; Avery et al., 1978), and the severity of collision mortality is generally proportional to the height of the structure (ABR 1989; 1990a). Passerines are also frequently killed due to collisions with vehicles, especially species such as swallows, blackbirds, and larks which forage or rest on road surfaces.

Passerines generally flew below 50 feet agl during daylight hours, although these highly maneuverable birds generally have little difficulty avoiding collisions with man-made structures during periods of good visibility (ABR, 1988b; 1988c). Most species of passerines are nocturnal migrants, although some commonly observed species such as blackbirds, swallows, and horned larks migrate primarily during daylight hours, and flight altitudes during nocturnal hours are generally higher than during daylight hours (Eastwood and Rider, 1965; Gauthreaux, 1978; ABR, 1989; 1990a). Although passerines were rarely observed flying below 50 ft agl during night-vision scope observations, altitude distributions on the vertical-beam radar indicate that a large percentage of migrants flew below 300 feet agl in the fall, when the highest collision rates for passerines have been reported (Avery et al., 1978). In addition, large numbers of passerines of many different species were located during tower searches at Tower 3, on the southern edge on the Thief River Falls study area. Most of these were killed during a single mortality event, when a minimum of 140 birds of at least 25 species collided with the tower in late September. Weather conditions during this period were clear and warm (ABR, 1990a).

The susceptibility of passerines to collide with man-made objects indicates that chronic collisions with the receive antenna structures are highly probable because of the large size of the structures and the relatively large number of passerines observed within the study area during both daylight hours and (presumably) on short-range radar during nocturnal hours. Passerines which encounter the structure at night will not necessarily collide, however. The small wingspan of these species, combined with the 10 foot spaces between poles at heights above 35 feet, will allow some birds to pass unharmed through the structure, even during poor visibility periods.

Large, episodic mortality events are also possible, especially during poor weather conditions. These may occur relatively frequently, especially in fall. With the documented decline in many numbers of passerine species by the USFWS Breeding Bird Survey, this additional mortality, when added to the thousands of other birds killed annually at other man-made structures (Jaroslow, 1979), may prove significant. Since passerines typically migrate along a broad front during nocturnal migration and short-range radar results were similar between stations in fall, when higher rates of passerine collisions would be expected, collision mortality for passerines is expected to be similar among the CSAs.

Summary: It is expected that collisions of eagles, hawks, falcons, and most waterbird species with the antenna structures will be relatively rare events. Owl, harrier, gull, and gamebird collisions may occur more frequently but should still be relatively uncommon. Sandhill cranes, ducks, geese, swans, and shorebirds have higher collision risks, and low to moderate numbers of collisions will likely occur throughout the life of the project. Large-scale collision events are not expected to occur frequently, and chances of this type of event are highest for geese. Some species of waterbirds and passerines have moderate to high chances of colliding with the antenna structures at this site. The total number of kills for these species groups could be significant both on an annual, chronic basis and a repeated, episodic basis.

Collision mortality is expected to be highest at the Rx-W CSA for swans and shorebirds, highest at the Rx-E (W) CSA for sandhill cranes, and highest at the Rx-E (E) CSA for some waterbird species and ducks. Other species groups are expected to have similar levels of collision mortality among CSAs. However, none of the differences among CSAs are great for any species group, and total, overall impacts are not expected to be greatly different among areas.

8.3.3.4 Mitigation. The redesign of the receive antenna structure, which eliminated the wire-mesh backscreen above 35 feet, is expected to result in reduced levels of bird collisions. Various mechanisms can be employed to make the antenna structures more visible. During daylight hours, various marking devices, such as plastic streamers, balls, and other markers, have been used successfully to reduce bird collisions with power lines (e.g. Beaulaurier, 1981), and could be used on the CRS receive antennas. Various lighting schemes may possibly be employed to reduce collisions during nocturnal hours. These will be investigated further and the most promising methods will be incorporated, where possible, in the Mitigation Plan for the project.

The USAF, in consultation with the USFWS and the Minnesota Department of Natural Resources will develop a collision monitoring program to document the number of collisions with the antenna structures after they are constructed. Data from this program will be used to determine the need for additional compensation measures for species or species groups which incur serious levels of mortality due to collisions with the project structures.

Avoidance of high quality avian habitats and known areas of high bird density (e.g. Goose Lake) during the site selection process should result in reduced impacts to avian resources.

Mitigation for in-kind habitat loss is not presently considered necessary since no critical or scarce habitat would be removed by the project for either preliminary site layout. Disturbance to nesting birds can be minimized during construction and operation of the facility by curtailing disturbances during the critical periods of the nesting season, where feasible, in the vicinity of nests or broods. Significant collision mortality could require additional mitigation for enhancement or creation of avian habitat. The need for this would be evaluated by the USAF and the responsible state and federal agencies as part of the on-going mitigation planning process.

REFERENCES

Alaska Biological Research (ABR), 1988a. OTH-B Avian Field Survey Program, Fall 1987. Unpublished Report for Metcalf & Eddy/Holmes & Narver, Wakefield, MA. 261 pp.

Alaska Biological Research (ABR), 1988b. OTH-B Avian Field Survey Program, Spring 1988. Unpublished Draft Report for Metcalf & Eddy/Holmes & Narver, Wakefield, MA. 279 pp.

Alaska Biological Research (ABR), 1988c. OTH-B Avian Field Survey Program, Fall 1988. Unpublished Report for Metcalf & Eddy/Holmes & Narver, Wakefield, MA. 203 pp.

Alaska Biological Research (ABR), 1989. Avian Research Program for the Over-the-Horizon Backscatter Central Radar System, Spring 1989: Radar Studies of Bird Migration, Unpublished Report Prepared for Metcalf & Eddy/Holmes & Narver and the University of Minnesota. 102 pp.

Alaska Biological Research (ABR), 1990a. Avian Research Program for the Over-the-Horizon Backscatter Central Radar System: Radar Studies of Bird Migration, Fall 1989. Unpublished Draft Report Prepared for Metcalf & Eddy/Holmes & Narver and the University of Minnesota. 111 pp.

Alaska Biological Research (ABR), 1990b. OTH-B Avian Survey Field Program, Spring 1989. Unpublished Report for Metcalf & Eddy/Holmes & Narver, Wakefield, MA. 226 pp.

American Ornithologists' Union (AOU), 1983. *Check-list of North American Birds, 6th edition,* Allen Press, Lawrence, KS. 877 pp.

Anderson, W.L., 1978. Waterfowl Collisions With Power Lines At a Coal-Fired Power Plant. *Wildlife Society Bulletin.* 6(2):77-83.

Arctic Environmental Information and Data Center (AEIDC), 1987. Avian Flight Behaviors During Migration In Relation To Environmental Factors: A Literature Review. Unpublished Report for Metcalf & Eddy/Holmes & Narver, Wakefield, MA. 71 pp.

Avery, M.L. (ed.), 1978. Impacts of Transmission Lines on Birds In Flight. Office of Biological Services, U.S. Fish and Wildlife Service. FWS/OBS - 78/48. 151 pp.

Avery, M.L., P.F. Springer, and J.F. Cassel, 1978. The Composition and Seasonal Variation of Bird Losses at a Tall Tower in Southeastern North Dakota. *American Birds.* 32(6):1114-1121.

Beaulaurier, D.L., 1981. Mitigation of Bird Collisions With Transmission Lines. Boneville Power Administration, Portland, OR. 83 pp.

REFERENCES (Continued)

Bellrose, F.C., 1980. *Ducks, Geese, and Swans of North America, Third Edition,* Stackpole Books, Harrisburg, PA. 540 pp.

Duebbert, H.F. and J.T. Lokemoen, 1977. Upland Nesting of American Bitterns, Marsh Hawks, and Short-Eared Owls. *The Prairie Naturalist.* 9:33-40.

Drury, W.H. and J.A. Keith, 1962. Radar Studies of Songbird Migration in Coastal New England. *Ibis.* 104(4):449-489.

Eastwood, E., 1967. *Radar Ornithology.* Methrien and Co. Ltd., London. 278 pp.

Eastwood, E. and G.C. Rider, 1965. Some Radar Measurements of the Altitude of Bird Flight. *British Birds.* 58(10): 393-426.

Faanes, C.A., 1987. Bird Behavior and Mortality in Relation to Power Lines in Prairie Habitats. U.S. Fish and Wildlife Service, Fish and Wildlife Technical Report 7. 24 pp.

Gauthreaux, S.A., Jr., 1978. Migratory Behavior and Flight Patterns. Pages 12-26 in M. Avery, (ed.). *Impacts of Transmission Lines on Birds in Flight.* Office of Biological Services, USFWS, Washington, DC. FWS/OBS-78/48.

Gauthreaux, S.A., Jr., 1980. Direct Visual And Radar Methods for the Detection, Quantification, and Prediction of Bird Migration. Special Publ. No. 2, Dept. Zool., Clemson Univ., Clemson, SC. 67 pp.

Gauthreaux, S.A., Jr., 1985. *Radar, Electro-Optical and Visual Methods of Studying Bird Flight Near Transmission Lines.* Final Report, Prepared for Electric Power Research Institute, Palo Alto, CA. 76 pp.

Higgins, K.F., D.E., Nomsen, and W.A. Wentz, 1987. The Role of the Conservation Reserve Program in Relation to Wildlife Enhancement, Wetlands and Adjacent Habitats in the Northern Great Plains. Pages 99-104 in J.E. Mitchell (ed.), Impact of the Conservation Reserve Program in the Great Plains. USDA For. Serv. Gen. Tech. Rep. RM-158.

Janssen, R.B., 1987. *Birds in Minnesota.* University of Minnesota Press, Minneapolis, MN. 352 pp.

Jaroslow, B.D., 1979. A Review of Factors Involved in Bird-Tower Kills, and Mitigative Procedures. Pages 469-473 in G.A. Swanson (tech. coord.), A Mitigation Symposium. USDA For. Serv. Gen. Tech. Rep. RM-65.

Kannowski, P.B. (ed.), 1979. Fish and Wildlife Resources Technical Paper, James River Basin, North and South Dakota. University of North Dakota Research Report No. 29.

REFERENCES (Continued)

Kantrud, H.A., 1981. Grazing Intensity Effects on the Breeding Avifauna of North Dakota Native Grasslands. *Can. Field-Nat.* 95(4):404-417.

Kessel, B., 1984. Migration of Sandhill Cranes, *Grus canadensis,* in East-Central Alaska, With Routes Through Alaska and Western Canada. *Can. Field-Nat.* 98(3):279-292.

Krapu, G.L., 1974. Avian Mortality From Collisions with Overhead Wires in North Dakota. *Prairie Naturalist.* 6:1-6.

Lincoln, F.C., 1979. Migration of birds, revised ed. U.S. Fish Wildlife Serv. Circ. No. 16. 119 pp.

Manci, K.M., D.N., Gladwin, R. Villella, and M.G. Cavendish, 1988. Effects of Aircraft Noise and Sonic Booms on Domestic Animals and Wildlife: A Literature Synthesis. U.S. Fish Wildl. Serv. NERC 88/29. 88 pp.

Manske, L.L., and W.T. Barker, 1987. Habitat Usage by Prairie Grouse on the Sheyenne National Grasslands. Pages 8-20 in A.J. Bjugstad (tech. coord.), Prairie Chickens on the Sheyenne National Grasslands. USDA For. Serv. Gen. Tech. Rep. RM-159.

Metcalf & Eddy/Holmes & Narver (M&E/H&N), 1989. Over-the-Horizon Backscatter Central Radar System Avian Field Program, Fall 1987 and Spring 1988 Studies. Unpublished Report Prepared for U.S. Air Force, Electronics System Division, Bedford, MA. 96 pp. plus supplements.

Nisbet, I.C., 1963. Measurement With Radar Of The Height of Nocturnal Migration Over Cape Cod, Massachusetts. *Bird-Banding* 34(2):57-67.

Olendroff, R.R., A.D. Miller, and R.N. Lehman, 1981. *Suggested Practices for Raptor Protection on Power Lines: The State of the Art in 1981.* Raptor Research Report No. 4, Raptor Research Foundation, Inc., 111 pp.

Owens, R.A., and M.T. Myres, 1973. Effects of Agriculture Upon Populations of Native Passerine Birds of an Alberta Fescue Grassland. *Can. J. Zool.* 51:697-713.

Richardson, W.J., 1978. Timing and Amount of Bird Migration in Relation to Weather: A Review. *Oikos.* 30:224-272.

Rusz, P.J., H.H. Prince, R.D. Rusz, and G.A. Dawson, 1986. Bird Collisions with Transmission Lines Near a Power Plant Cooling Pond. *Wildlife Society Bulletin.* 14:441-444.

Schmutz, J.K. and R.W. Fyfe, 1987. Migration and Mortality of Alberta Ferruginous Hawks. *The Condor.* 89:169-174.

REFERENCES (Continued)

Stout, I.J. and G.W. Cornwell, 1976. Nonhunting Mortality of Fledged North American Waterfowl. *J. Wildl. Manage.* 40(4):681-693.

Tate, J., Jr., M.S. Boyce, and T.R. Smith, 1979. Response of Sage Grouse to Artifically Created Display Ground. Pages 459-463 in G.A. Swanson (tech. Coord.), A Migration Symposium. USDA For. Serv. Gen. Tech. Rep. RM-65.

Terres, J.K., 1980. *The Audubon Society Encyclopedia of North American Birds*. Alfred A. Knopf, N.Y. 1109 pp.

Thompson, L.S., 1978. Transmission Line Wire Strikes: Mitigation Through Engineering Design and Habitat Modification. Pages 27-52 in M. Avery (ed). *Impacts of Transmission Lines on Birds in Flight*. Office of Biological Services, USFWS. FWS/OBS-78/48.

United States Air Force (USAF), 1986. Draft Environmental Impact Statement: Proposed Central Radar System, Over-the-Horizon Backscatter Radar Program.

United States Air Force (USAF), 1988. Record of Decision: Central Radar System Environmental Impact Statement, Over-the-Horizon Backscatter Radar Program.

U.S. Department of the Interior and Canadian Wildlife Service (USDI and CWS), 1986. *North American Waterfowl Management Plan*. U.S. Fish Wildlife Serv., Wash. D.C. 31 pp.

United States Fish and Wildlife Service (USFWS), 1989. Memorandum from USFWS Nebraska State Supervisor to USFWS Field Supervisor, Western Alaska Ecological Services, Anchorage, AK, March 6, 1989. 7 pp.

University of Minnesota (UMN), 1989a. Over-the-Horizon Backscatter Central Radar System Avian Field Program Spring 1989 Data Preliminary Results Section. Unpublished Report for U.S. Air Force, Electric Systems Division. 343 pp.

University of Minnesota (UMN), 1989b. Over-the-Horizon Backscatter Central Radar System Avian Field Program Fall 1989 Preliminary Report. Unpublished Report for U.S. Air Force, Electronic Systems Division. 272 pp.

University of North Dakota (UND), 1988. Wildlife Resources and Avian Migration Chronology in Northwestern Minnesota and Northeastern South Dakota. Research Report No. 38. 80 pp.

Van der Walk, A. (ed.), 1989. *Northern Prairie Wetlands*. Iowa State Univ. Press, Ames., IA. 400 pp.

REFERENCES (Continued)

White, C.M., and T.L. Thurow, 1985. Reproduction of Ferruginous Hawks Exposed to Controlled Disturbance. *The Condor*. 87:14-22.

Whitney, N.R., Jr., Harnell, B.E., Harris, B.H., Holden, N., Johnson, J.W., Rose, B.J., and Springer, P.F., 1978. *The Birds of South Dakota, An Annotated Check List*. The South Dakota Ornithologists' Union, Vermillion, S.D. 311 pp.

APPENDIX A. BIRD SPECIES OBSERVED AT THE THIEF RIVER FALLS AND AMHERST STUDY AREAS DURING AVIAN FIELD STUDIES

Species[1]		Thief River Falls[2]		Amherst[3]	
Common Name	Scientific Name	Fall	Spring	Fall	Spring
Common loon	*Gavia immer*	G	W EG		
Pied-billed grebe	*Podilymbus podiceps*	E	X	X	X
Western grebe	*Aechmophorus occidentalis*	WCE	W	X	X
Horned grebe	*Podiceps auritus*	G		X	
Red-necked grebe	*Podiceps grisegena*	W			X
Eared grebe	*Podiceps nigricollis*				S
American white pelican	*Pelecanus erythrorhynchos*		W EG	NSR	NS
Double-crested cormorant	*Phalacrocorax auritus*	WCEG	W EG	NSR	NS
American bittern	*Botaurus lentiginosus*	G	G	NS	X
Black-crowned night-heron	*Nycticorax nycticorax*		G	S	S
Great blue heron	*Ardea herodias*	WCEG	W EG	NSR	NS
Little blue heron	*Egretta caerulea*				NS
Green-backed heron	*Butorides striatus*		E	N	
Great egret	*Casmerodius albus*		W EG	S	S
Tundra swan	*Cygnus columbianus*	WCEG	W EG	NSR	NS
Snow goose	*Chen caerulescens*	WCEG	W EG	NSR	NS
Ross's goose	*Chen rossii*			X	
Greater white-fronted goose	*Anser albifrons*	CE	EG	SR	NS
Canada goose	*Branta canadensis*	WCEG	W EG	NSR	NS
Brant	*Branta bernicla*				NS
Wood duck	*Aix sponsa*	G	G	X	X
Green-winged teal	*Anas crecca*	G	X	S	S
Mallard	*Anas platyrhynchos*	WCEG	W EG	NSR	NS
Gadwall	*Anas strepera*	G			NS
Northern pintail	*Anas acuta*	CEG	W EG	NSR	NS
Blue-winged teal	*Anas discors*	G	EG	N R	NS
Cinnamon teal	*Anas cyanoptera*				S
Northern shoveler	*Anas clypeata*	G	EG	NSR	NS
American wigeon	*Anas americana*	G	G		NS
Eurasian wigeon	*Anas penelope*				S
Canvasback	*Aythya valisineria*	G	G	SR	NS
Redhead	*Aythya americana*	X	X	X	NS
Ring-necked duck	*Aythya collaris*	G	G		NS
Greater scaup	*Aythya marila*		G		
Lesser scaup	*Aythya affinis*	X	G	X	NS
Common goldeneye	*Bucephala clangula*		G	X	NS
Barrow's goldeneye	*Bucephala islandica*				S
Bufflehead	*Bucephala albeola*	X		X	NS
Oldsquaw	*Clangula hyemalis*			X	
Ruddy duck	*Oxyura jamaicensis*	G	X		X

APPENDIX A (continued)

Species[1]		Thief River Falls[2]		Amherst[3]	
Common Name	Scientific Name	Fall	Spring	Fall	Spring
Hooded merganser	*Lophodytes cucullatus*	X			
Common merganser	*Mergus merganser*		EG	S	NS
White-winged scoter	*Melanitta fusca*	E			S
Turkey vulture	*Cathartes aura*	WCE	W E	S	
Osprey	*Pandion haliaetus*		W	S	
Bald eagle	*Haliaeetus leucocephalus*	WCEG	W E	NSR	NS
Northern harrier	*Circus cyaneus*	WCEG	WCEG	NSR	NS
Cooper's hawk	*Accipiter cooperii*	WCEG	W E	N R	NS
Sharp-shinned hawk	*Accipter striatus*	WCEG	W E	NS	NS
Northern goshawk	*Accipter gentilis*	X		X	NS
Red-shouldered hawk	*Buteo lineatus*		W	N	
Broad-winged hawk	*Buteo platypterus*	WCEG	E		NS
Swainson's hawk	*Buteo swainsoni*	WCE	W	NSR	NS
Ferruginous hawk	*Buteo regalis*	EG		NSR	
Red-tailed hawk	*Buteo jamaicensis*	WCEG	W EG	NSR	NS
Rough-legged hawk	*Buteo lagopus*	WCEG	W EG	NSR	N
Golden eagle	*Aquila chrysaetos*	WCE		S	N
American kestrel	*Falco sparverius*	WCEG	W EG	NSR	NS
Merlin	*Falco columbarius*	WCEG	W E	NSR	NS
Peregrine falcon	*Falco peregrinus*	WCEG	E	NS	
Prairie falcon	*Falco mexicanus*	WCEG		NSR	N
Gray partridge	*Perdix perdix*	WCEG	E	NSR	NS
Ring-necked pheasant	*Phasianus colchicus*	X	X	N R	S
Greater prairie-chicken	*Tympanuchus cupido*	WCE	W	N	N
Sharp-tailed grouse	*Tympanuchus phasianellus*	WCEG	W G	N	N
Ruffed grouse	*Bonasa umbellus*		X		
American coot	*Fulica americana*	G	E	X	NS
Sora	*Porzana carolina*	EG	X		
Yellow rail	*Coturnicops noveboracensis*		X		
King rail	*Rallus elegans*				NS
Virginia rail	*Rallus limicola*		X		N
Sandhill crane	*Grus canadensis*	WCEG	WCEG	NSR	NS
Killdeer	*Charadrius vociferus*	WCEG	WCEG	NSR	NS
Semipalmated plover	*Charadrius semipalmatus*	C	W E		S
Mountain plover	*Charadrius montanus*				S
Black-bellied plover	*Pluvialis squatarola*	WCE		S	NS
Lesser golden-plover	*Pluvialis dominica*	WCEG	W	S	S
American avocet	*Recurvirostra americana*			X	NS
Greater yellowlegs	*Tringa melanoleuca*	WCEG	W E	S	NS
Lesser yellowlegs	*Tringa flavipes*	EG	X	S	NS
Solitary sandpiper	*Tringa solitaria*	E		N	X
Willet	*Catoptrophorus semipalmatus*	C	G		NS
Spotted sandpiper	*Actitis macularia*	E	X		N
Upland sandpiper	*Bartramia longicauda*		W EG	X	NS

APPENDIX A (continued)

Species[1]		Thief River Falls[2]		Amherst[3]	
Common Name	Scientific Name	Fall	Spring	Fall	Spring
Long-billed curlew	*Numenius americanus*				S
Marbled godwit	*Limosa fedoa*	X	W EG	N	NS
Hudsonian godwit	*Limosa haemastica*				X
Ruddy turnstone	*Arenaria interpres*			X	
Red knot	*Calidris canutus*				X
White-rumped sandpiper	*Calidris fuscicollis*				NS
Baird's sandpiper	*Calidris bairdii*			X	N
Least sandpiper	*Calidris minutilla*			X	NS
Pectoral sandpiper	*Calidris melanotos*	E		S	X
Semipalmated sandpiper	*Calidris pusilla*				X
Dunlin	*Calidris alpina*				X
Buff-breasted sandpiper	*Tryngites subruficollis*			X	
Short-billed dowitcher	*Limnodromus griseus*				N
Long-billed dowitcher	*Limnodromus scolopaceus*				X
Common snipe	*Gallinago gallinago*	EG	W EG	NSR	N
American woodcock	*Scolopax minor*		G		
Wilson's phalarope	*Phalaropus tricolor*		X	X	NS
Franklin's gull	*Larus pipixcan*	G	W EG	NSR	NS
Bonaparte's gull	*Larus philadelphia*				S
Ring-billed gull	*Larus delawarensis*	CEG	W	NSR	NS
Herring gull	*Larus argentatus*	E	EG		NS
California gull	*Larus californicus*			N	
Forster's tern	*Sterna forsteri*	WCE		S	S
Common tern	*Sterna hirundo*	W			NS
Black tern	*Chlidonias niger*		W EG	NSR	NS
Rock dove	*Columba livia*	WCEG	W	NSR	S
Mourning dove	*Zenaida macroura*	WCEG	W EG	NSR	NS
Black-billed cuckoo	*Coccyzus erythropthalmus*	W	W		
Barred owl	*Strix varia*			X	
Great horned owl	*Bubo virginianus*	W	X	NSR	
Snowy owl	*Nyctea scandiaca*	E	W		
Short-eared owl	*Asio flammeus*	WCEG	G	N	
Burrowing owl	*Athene cunicularia*				S
Common nighthawk	*Chordeiles minor*	WCEG	W EG	NSR	S
Chimney swift	*Chaetura pelagica*	X	G	NS	N
Belted kingfisher	*Ceryle alcyon*	G	W		
Red-bellied woodpecker	*Melanerpes carolinus*			X	
Red-headed woodpecker	*Melanerpes erythrocephalus*	X		X	X
Downy woodpecker	*Picoides pubescens*	CE	X	NS	X
Hairy woodpecker	*Picoides villosus*	W EG	W	N R	S
Yellow-bellied sapsucker	*Sphyrapicus varius*	X	X		
Pileated woodpecker	*Drycocpus pileatus*	W	X		
Northern flicker	*Colaptes auratus*	WCEG	WCEG	NSR	NS
Olive-sided flycatcher	*Contopus borealis*	X		X	

APPENDIX A (continued)

Species(1)		Thief River Falls(2)		Amherst(3)	
Common Name	Scientific Name	Fall	Spring	Fall	Spring
Eastern wood-pewee	*Contopus virens*	X	X	X	
Least flycatcher	*Empidonax minimus*	E	X		X
Alder flycatcher	*Empidonax alnorum*		X		
Eastern phoebe	*Sayornis phoebe*	X	X	X	X
Say's phoebe	*Sayornis saya*				S
Great crested flycatcher	*Myiarchus crinitus*	X	X		
Western kingbird	*Tyrannus verticalis*	X	EG	NS	NS
Eastern kingbird	*Tyrannus tyrannus*	X	W EG	N	NS
Horned lark	*Eremophila alpestris*	WCEG	WCEG	NSR	NS
Purple martin	*Progne subis*			S	NS
Bank swallow	*Riparia riparia*	WCEG	W EG	NSR	NS
Barn swallow	*Hirundo rustica*	WCEG	W EG	NSR	NS
Cliff swallow	*Hirundo pyrrhonota*	W	W EG	NSR	N
Northern rough-winged swallow	*Stelgidopteryx serripennis*	C	W EG		NS
Tree swallow	*Tachycineta bicolor*	W EG	W EG	NS	NS
Blue jay	*Cyanocitta cristata*	WCEG	W EG	NS	N
Black-billed magpie	*Pica pica*	WCEG	W EG	N	
American crcw	*Corvus brachyrhynchos*	WCEG	WCEG	NSR	NS
Common raven	*Corvus corax*	W EG	E		
Black-capped chickadee	*Parus atricapillus*	WCEG	X	X	X
Red-breasted nuthatch	*Sitta canadensis*	X		X	
White-breasted nuthatch	*Sitta carolinensis*	W	X	X	
Brown creeper	*Certhia americana*	X		X	
House wren	*Troglodytes aedon*	E	X	X	X
Marsh wren	*Cistothorus palustris*	X	X	X	
Sedge wren	*Cistothorus platensis*		X	X	S
Ruby-crowned kinglet	*Regulus calendula*	X	X		
Golden-crowned kinglet	*Regulus satrapa*	X		X	
Eastern bluebird	*Sialia sialis*	X	X	N	N
Mountain bluebird	*Sialia currucoides*		X		
American robin	*Turdus migratorius*	CEG	W E	NSR	NS
Hermit thrush	*Catharus guttatus*	X	X		
Veery	*Catharus fuscescens*		X		
Swainson's thrush	*Catharus ustulatus*			X	
Wood thrush	*Hylocichla mustelina*		X		
Varied thrush	*Ixoreus naevius*			X	
Gray catbird	*Dumetella carolinensis*	X	X	X	
Northern mockingbird	*Mimus polyglottos*		X		
Sage thrasher	*Oreoscoptes montanus*	X	E		
Brown thrasher	*Toxostoma rufum*		G	N	N
Sprague's pipit	*Anthus spragueii*	E	X		
Water pipit	*Anthus spinoletta*	WC		SR	
Cedar waxwing	*Bombycilla cedrorum*	C	X	X	X

APPENDIX A (continued)

Species[1]		Thief River Falls[2]		Amherst[3]	
Common Name	Scientific Name	Fall	Spring	Fall	Spring
Loggerhead shrike	*Lanius ludovicianus*		E	N	X
Northern shrike	*Lanius excubitor*	W G			S
European starling	*Sturnus vulgaris*	WCEG	W EG	NSR	NS
Red-eyed vireo	*Vireo olivaceus*	X	X	X	
Solitary vireo	*Vireo solitaius*	X			
Warbling vireo	*Vireo gilvus*	X	X	X	
Yellow-throated vireo	*Vireo flavifrons*		X		
Orange-crowned warbler	*Vermivora celata*		X	X	
Nashville warbler	*Vermivora ruficapilla*	W			
Tennesee warbler	*Vermivora peregrina*	X			
Wilson's warbler	*Wilsonia pusilla*	X			
Palm warbler	*Dendroica palmarum*	G	X	N	
Yellow-rumped warbler	*Dendroica coronata*	WCEG	G	NS	X
Bay-breasted warbler	*Dendroica castanea*				X
Yellow warbler	*Dendroica petechia*	E	EG	X	
Common yellowthroat	*Geothlypis trichas*	X	X	X	X
Mourning warbler	*Oporornis philadelphia*			X	
Black-and-white warbler	*Mniotilta varia*	X			
American redstart	*Setophaga ruticilla*	X	X		N
Ovenbird	*Seiurus aurocapillus*		X	X	X
Northern waterthrush	*Seiurus noveboracensis*			X	N
Scarlet tanager	*Piranga olivacea*		X		
Rose-breasted grosbeak	*Pheucticus ludovicianus*	X	W	X	
Indigo bunting	*Passerina cyanea*	X	W		S
Dickcissel	*Spiza americana*			X	NS
Rufous-side towhee	*Pipilo erythrophthalmus*	X		X	N
American tree sparrow	*Spizella arborea*	WCE	E	NSR	S
Field sparrow	*Spizella pusilla*	X		N	NS
Chipping sparrow	*Spizella passerina*	E	E	NS	X
Clay-colored sparrow	*Spizella pallida*	C	X	S	N
Vesper sparrow	*Pooecetes gramineus*	WCEG	W E	NS	S
Lark sparrow	*Chondestes grammacus*			N	S
Lark bunting	*Calamospiza melanocorys*			S	NS
Savannah sparrow	*Passerculus sandwichensis*	WCEG	W G	NSR	S
Grasshopper sparrow	*Ammodramus savannarum*	X	X	S	
Le Conte's sparrow	*Ammodramus leconteii*	G	X	X	
Fox sparrow	*Passerella iliaca*	X	X		
Song sparrow	*Melospiza melodia*	WCEG	W EG	N R	X
Lincoln's sparrow	*Melospiza lincolnii*	X	X	S	
Swamp sparrow	*Melospiza georgiana*	X	X	X	
White-throated sparrow	*Zonotrichia albicollis*	X	X	S	X
White-crowned sparrow	*Zonotrichia leucophrys*	X	X	N	X
Harris' sparrow	*Zonotrichia querula*	CE	W	S	X
Dark-eyed junco	*Junco hyemalis*	E	W E	S	S
Lapland longspur	*Calcarius lapponicus*	WCEG	W E	NSR	

APPENDIX A (continued)

Species(1)		Thief River Falls(2)		Amherst(3)	
Common Name	Scientific Name	Fall	Spring	Fall	Spring
Chestnut-collared longspur	*Calcarius ornatus*			N	
Smith's longspur	*Calcarius pictus*			NS	
Snow bunting	*Plectrophenax nivalis*	WCEG	W E	NSR	
Bobolink	*Dolichonyx oryzivorus*	WCEG	W EG	NSR	NS
Red-winged blackbird	*Agelaius phoeniceus*	WCEG	WCEG	NSR	NS
Western meadowlark	*Sturnella neglecta*	WCEG	WCEG	NSR	NS
Yellow-headed blackbird	*Xanthocephalus xanthocephalus*	CEG	W EG	NSR	NS
Rusty blackbird	*Euphagus carolinus*	CE	X	N	N
Brewer's blackbird	*Euphagus cyanocephalus*	CEG	W EG	R	NS
Common grackle	*Quiscalus quiscula*	WCEG	W EG	NSR	NS
Brown-headed cowbird	*Molothrus ater*	WC G	W EG	NSR	NS
Orchard oriole	*Icterus spurius*			X	X
Northern oriole	*Icterus galbula*	X	W EG	X	X
Purple finch	*Carpodacus purpureus*			X	
White-winged crossbill	*Loxia leucoptera*	X			
Common redpoll	*Carduelis flammea*		W		
Pine siskin	*Carduelis pinus*	WCE	X	S	
American goldfinch	*Carduelis tristis*	WCEG	W EG	NSR	NS
Evening grosbeak	*Coccothraustes vespertinus*		X		
House sparrow	*Passer domesticus*	C	X	S	S

1. Nomenclature follows AOU checklist (AOU, 1983).
2. W = West Station; C = Central Station; E = East Station; G = Goose Lake Station; X = Observed during road, aerial, or general observations.
3. N = North Station; S = South Station; R = Renzienhausen Slough Station; X = Observed during road, aerial, or general observations.

TECHNICAL STUDY 9

CENTRAL RADAR SYSTEM
OVER-THE-HORIZON BACKSCATTER RADAR PROGRAM

THREATENED AND ENDANGERED SPECIES

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TECHNICAL STUDY 9

THREATENED AND ENDANGERED SPECIES

9.1 INTRODUCTION

The U.S. Air Force (USAF) has proposed to construct an Over-the-Horizon Backscatter (OTH-B) radar facility in the north central United States (Fig. 9-1). This facility will be known as the Central Radar System (CRS). In its Record of Decision (USAF, 1988), the USAF selected a study area near Amherst, South Dakota for the transmit portion of the radar system and a study area near Thief River Falls, Minnesota for the receive portion of the radar system (Figs. 9-2 and 9-3). Through a screening process involving physical, environmental, and operational considerations the USAF has identified two concentrated study areas (CSA's) within each study area for the antenna sectors (Technical Study, 1 EIAP Overview).

This technical study describes the affected environment relating to species listed as threatened and endangered by the U.S. Fish and Wildlife Service (USFWS) under the Endangered Species Act of 1973 (16 U.S.C. 1536), as amended, which are known to occur in the regions affected by the OTH-B project. An endangered species is "any species which is in danger of extinction throughout all or a significant portion of its range," and a threatened species is "any species which is likely to become endangered within the forseeable future throughout all or a significant portion of its range" (16 U.S.C. 1536). Impacts of the CRS project on threatened and endangered species and mitigation measures are also discussed. While the focus of this section is on species listed under the above Act, consideration is also given to species listed as threatened and endangered by the South Dakota and Minnesota state legislatures.

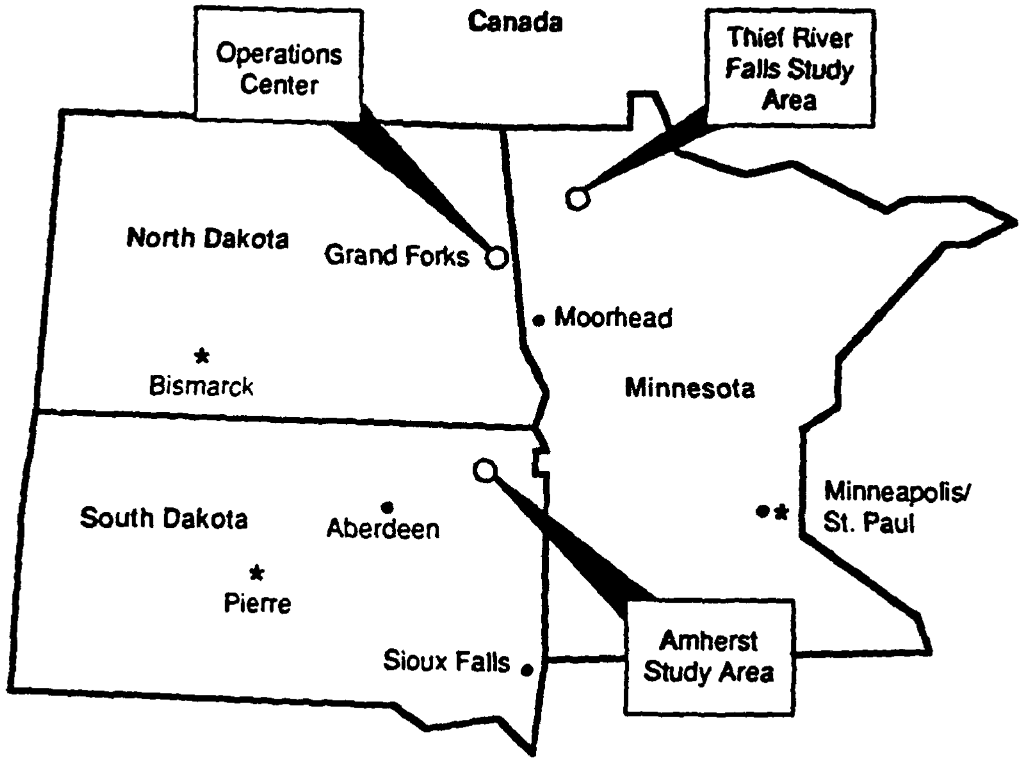


FIGURE 9-1. LOCATION OF THE CENTRAL RADAR SYSTEM TRANSMIT AND RECEIVE STUDY AREAS

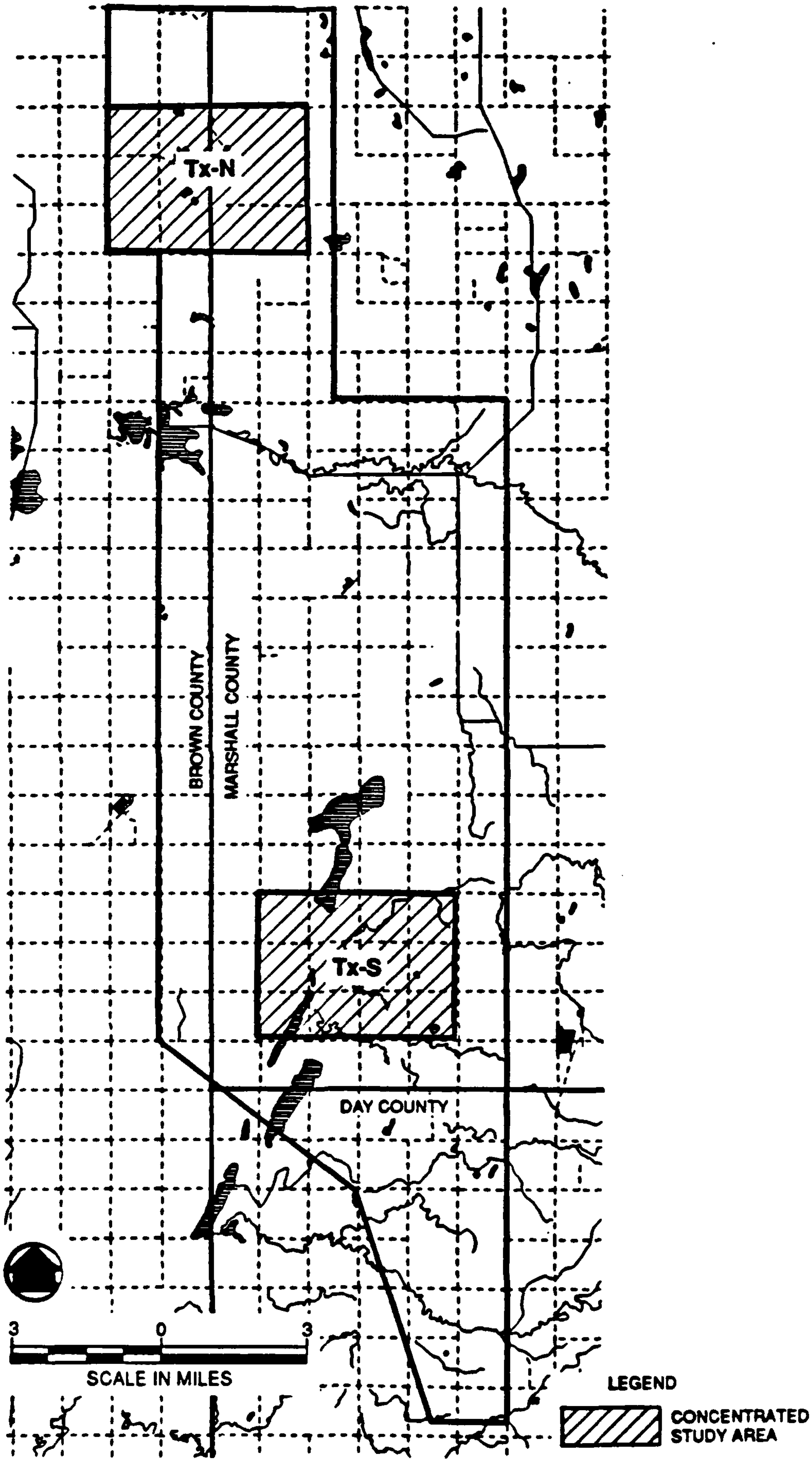


FIGURE 9-2. AMHERST, SD TRANSMIT STUDY AREA AND CONCENTRATED STUDY AREAS

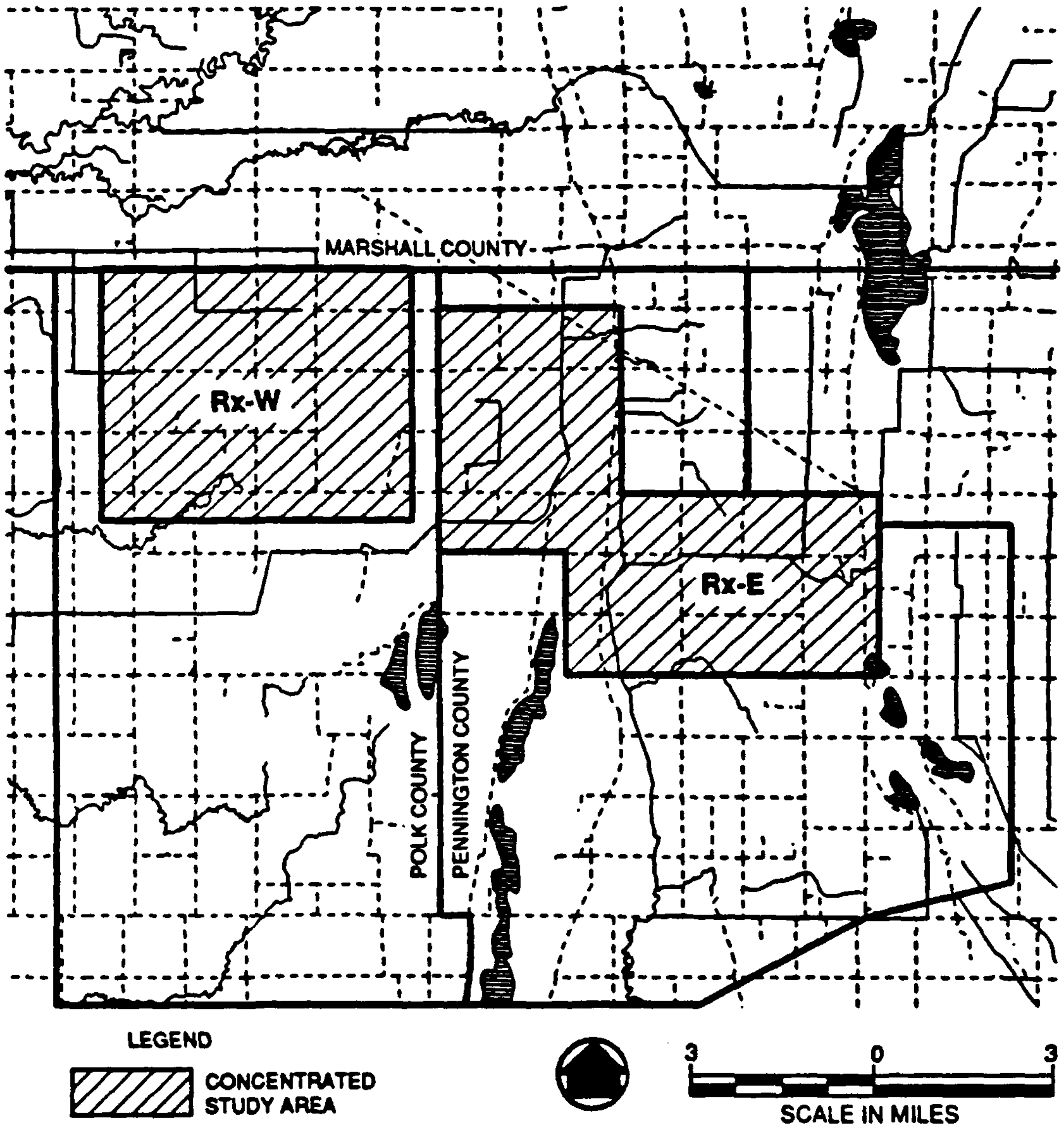


FIGURE 9-3. THIEF RIVER FALLS, MN RECEIVE STUDY AREA AND CONCENTRATED STUDY AREAS

9.2 METHODS

As a means of evaluating potential impacts to threatened and endangered species, pertinent information was gathered on species which may inhabit each of the two study areas. In addition, both state (South Dakota Game, Fish, and Parks Department and Minnesota Department of Natural Resources) and federal (USFWS, Twin Cities and Pierre Offices) resource agencies were contacted. These agencies submitted current lists of threatened and endangered species whose range overlaps the two study areas (USFWS, 1990a; USFWS, 1990b). An assessment of the likely impacts to birds, mammals, reptiles, vegetation, and insects was conducted from these information sources.

In addition to the above information, four seasons of avian surveys provided field information on threatened and endangered birds. Studies were conducted in the fall of 1987, spring of 1988, and spring and fall of 1989 to document avian use of the Amherst and Thief River Falls study areas (Technical Study 8, Avian Resources). The avian studies included ground-based observations from fixed locations (Figs. 8-4 and 8-5), road surveys, and aerial surveys. Observations of flight behavior and movement rates of threatened or endangered species were noted. (See Technical Study 8 for a detailed discussion of the avian study methodology.)

Comprehensive field surveys for threatened and endangered plants, insects, and reptiles have not been conducted on either study area because rights-of-entry have not been provided to the USAF by landowners on the majority of lands within the study area boundaries. In the previous Final Environmental Impact Statement developed to select study areas for the project (USAF, 1987), the USAF committed to conducting field surveys for special-status species once the preferred location and alignment of the antennas is selected. These surveys will confirm or deny the presence of threatened and endangered species on the selected sites.

For each species whose range may overlap the study area, the current status, available habitat, and likelihood of the species occurring on the site are discussed. The likelihood of each species occurring on each site was determined by evaluating the available habitat in comparison to the known distributions and relative densities of the species. For threatened and endangered birds, the results of the avian surveys are discussed.

9.3 AFFECTED ENVIRONMENT

9.3.1 TRANSMIT SITE

The ranges of many several threatened and endangered species overlap the Amherst study area (Table 9-1). Nonetheless, the only threatened or endangered species known to occur in the study area are bird species that were observed during the CRS avian surveys. These bird species inhabit the study area during spring and fall migration. The occurrence at the Amherst study area of mammal, plant, reptile, or insect species listed on federal or state threatened or endangered species lists can not been determined until rights-of-entry are secured and a preferred layout is selected.

9.3.1.1 Federally Listed Fauna. Species on the federal threatened and endangered species list which may occur in the Amherst study area are discussed below and include one mammal, one insect, and five bird species (Table 9-1). No fish or reptile species which are federally threatened or endangered are known to occur currently or historically in the region surrounding the Amherst study area.

9.3.1.1.1 Swift Fox. The swift fox, a federally endangered species, is the only rare mammal which may occur in or near the Amherst study area. The swift fox historically inhabited a large area in the Great Plains, including the region surrounding the James River Valley in eastern South Dakota (Fig. 9-4) (Kannowski, 1979). Swift fox populations were severely depleted from the early 1800's to the 1950's, primarily because of trapping, poisoning, free-ranging hunting dogs, and changes in land use (Samuel and Nelson, 1987). Although there have been indications in recent years that the species has increased and is beginning to return to its original range, the recovery of swift fox populations is limited by the lack of suitable habitat (Kannowski, 1979). The swift fox, the most subterranean of the North American

TABLE 9.1 THREATENED AND ENDANGERED SPECIES THAT MAY INHABIT THE AMHERST STUDY AREA

Common Name	Scientific Name	Status
Federally Listed Species		
Swift fox	*Vulpes velox*	Endangered
Peregrine falcon	*Falco peregrinus*	Endangered
Bald eagle	*Haliaeetus leucocephalus*	Endangered
Whooping crane	*Grus americana*	Endangered
Piping plover	*Charidrius melodus*	Threatened
Eskimo curlew	*Numenius borealis*	Endangered
Burying beetle	*Nicrophorus americanus*	Endangered
Western prairie fringed orchid	*Platanthera praeclara*	Threatened
State Listed Species		
Osprey	*Pandion haliaeetus*	Threatened
Buff-breasted sandpiper	*Tryngites subruficollis*	Threatened
Northern redbelly snake	*Storeria occipitomaculata*	Threatened
Northern lined snake	*Tropidoclonion lineatum*	Threatened

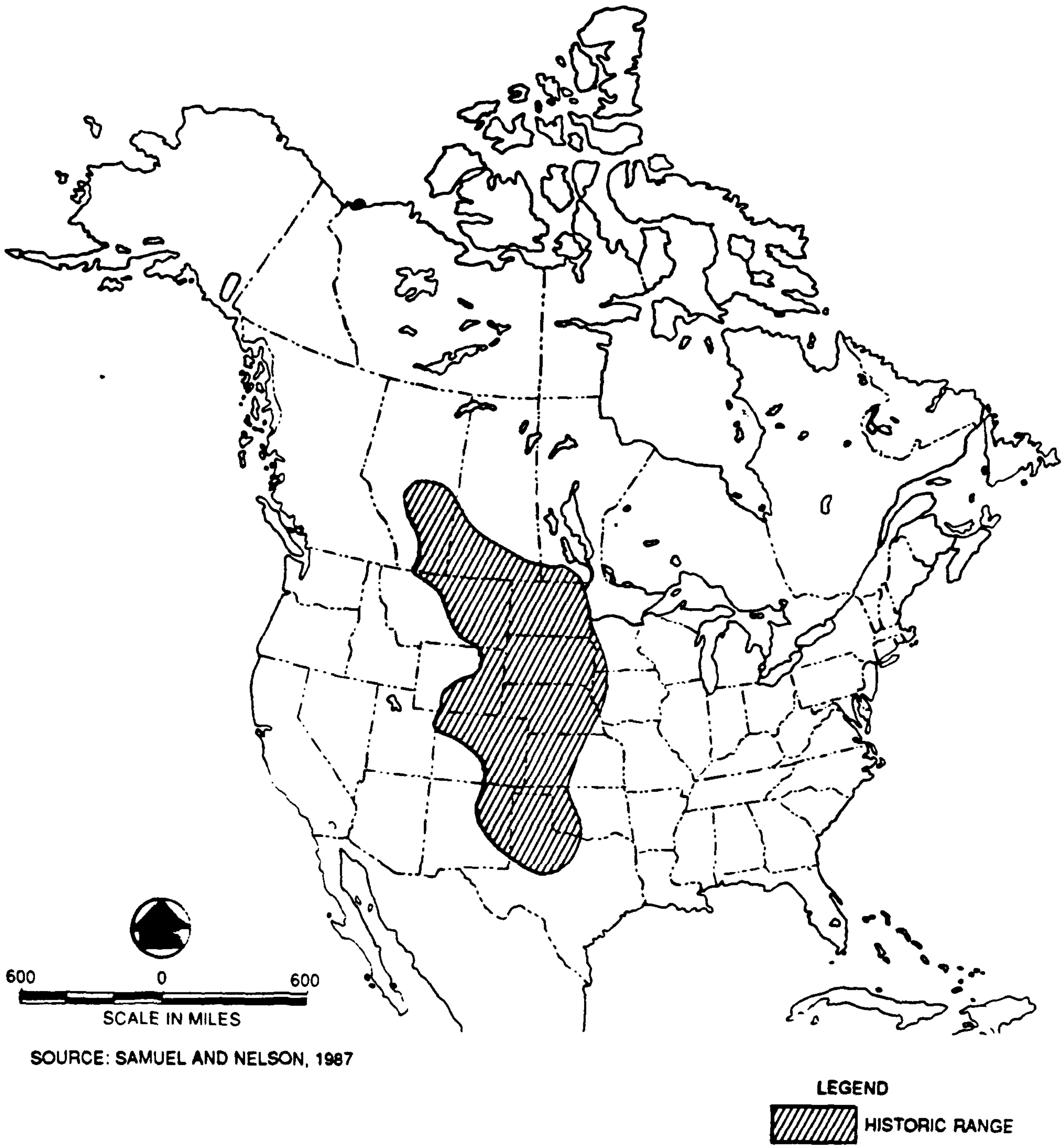


FIGURE 9-4. HISTORIC RANGE OF THE SWIFT FOX

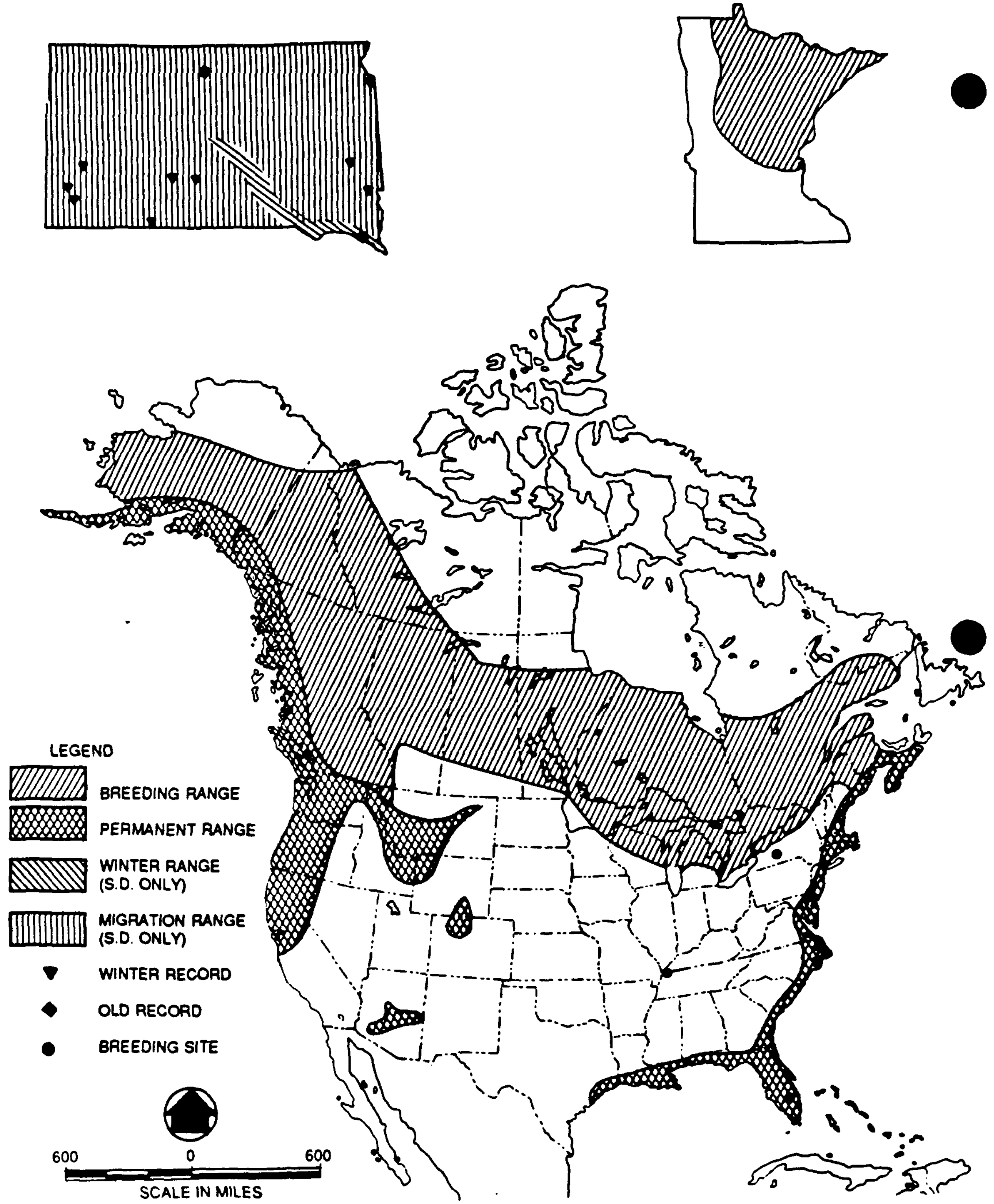
native foxes, uses dens in short-grass prairies and pasture lands. The diet of the swift fox consists mainly of rabbits (*Leopardae* spp.), thirteen-lined squirrels (*Spermophilus tridecemlineatus*), deer-mice (*Peromyscus maniculatus*), voles (*Microtus* spp.), and birds (Samuel and Nelson, 1987).

Suitable habitat, in the form of native prairie, exists for the swift fox at the Tx-N CSA. However, the contiguous available habitat is probably not large enough to support a swift fox population. The lack of documented swift fox observations in the region for the past several decades suggests that it is highly unlikely that the fox currently inhabits the Amherst study area.

9.3.1.1.2 Bald Eagle. The bald eagle was listed as endangered in South Dakota in 1978 after several decades of nationwide decline. It formerly nested in 45 of the 48 contiguous states. As of 1981, approximately 1250 occupied bald eagle nests remained in 30 states, with over 90 percent of these nests in ten states: Florida, Minnesota, Wisconsin, Washington, Michigan, Oregon, Maine, California, Maryland, and Virginia (Fig. 9-5) (USFWS, 1983). Despite these dwindling numbers in the U.S., bald eagle populations in Alaska and Canada are relatively stable (bald eagles are not federally listed in Alaska). Thousands of eagles move southward from Canada to the U.S. during the winter. Consequently, during wintering periods (November through March) the northern U.S. may support over 13,000 bald eagles (USFWS, 1983).

In South Dakota the bald eagle has never been a common breeding species and has historically been limited to the Missouri River basin during migration and wintering periods (USFWS, 1983). After periods of low activity in the state during the 1950's and 1960's, migrating bald eagles have become more common in recent years because of the eagle's nationwide recovery. During midwinter surveys in 1979, 1980, and 1981 a total of 841 bald eagles were observed in South Dakota (USFWS, 1983).

Bald eagles are extremely sensitive to human disturbance, and the national and state-wide decline of eagle populations are directly attributable to human interactions. The reasons most often cited for declining bald eagle populations are habitat loss, shooting, trapping, electrocution, disease, and



SOURCES: PETERSON, 1975; HARRELL ET AL, 1978; JANNSEN, 1987; CLARK AND WHEELER, 1987.

FIGURE 9-5. RANGE OF THE BALD EAGLE

contamination. The decimating effects of the pesticide dichloro-diphenyl trichloro-ethane (DDT) and its metabolites on bald eagle populations during the 1940's and 1950's are well documented (USFWS, 1983; Coffin and Pfannmuller, 1988). These metabolites caused thinning of bald eagle eggshells and a corresponding reproductive failure. The national eagle population has recovered somewhat since the banning of DDT and the listing of the species on the federal threatened and endangered species list. Another significant contaminant effect involves lead poisoning of eagles due to the ingestion of geese and ducks crippled by lead-shot (USFWS, 1988).

In response to the listing of the eagle on the threatened and endangered species list, the USFWS produced a recovery plan which is aimed at restoring bald eagle populations to sustainable levels (i.e., self-sustaining breeding populations). The recovery plan for the northern states region expresses a goal of 1200 total breeding areas throughout sixteen states of the Great Plains (including South Dakota) by the year 2000, with each nest having an average annual production of at least one young per nest (USFWS, 1983). Components of the plan include annual surveys, habitat assessments, site-specific management plans, and improved coordination of information and efforts (USFWS, 1983).

Because of the bald eagle's sensitivity to human disturbance, a primary habitat consideration is distance from human activity. For each eagle nesting site the USFWS recovery plan recommends at least a 640-acre area screened from human activity (USFWS, 1983). Bald eagles typically feed near lakes, rivers, and large wetlands and prey on such items as fish, live and dead waterfowl, carrion, and small mammals (USFWS, 1983; Coffin and Pfannmuller, 1988; Jones and Stokes & Associates, 1988).

A total of 82 bald eagles were observed in the study area during the 1987, 1988, and 1989 avian surveys. All of the sightings occurred during the spring (45 sightings) and fall (37 sightings) of 1989. Sixty-two of the 82 sightings occurred from fixed stations in the two CSA's, while the other 20 sightings occurred in the overall study area during road surveys and general observations. More eagles (42) were observed at the Tx-S CSA than at the Tx-N

CSA (20), particularly in the spring of 1989, when 29 eagles were observed at the Tx-S CSA and 11 were observed at the Tx-N CSA. The relative abundance of eagles at the Tx-S CSA is probably attributable to the extensive flooding that occurred at the Tx-S CSA in 1989. This flooding attracted a large number of waterfowl and other bald eagle prey species.

The majority of bald eagles observed at both sites were either perching, resting on the ground, or flying below 150 feet. At the Tx-N CSA 65 percent (13 of 20) of the eagles observed were below 150 feet, and at the Tx-S CSA 86 percent (36 of 42) of the eagles observed were below 150 feet. This data may be slightly biased because the abnormal flooding conditions at the Tx-S CSA may have attracted an unusual number of eagles to that site.

It is important to note that a few additional biases may occur in the avian data. First, positive identifications of species are facilitated when birds fly at low altitudes. For example, while an immature bald eagle flying at 600 feet may have been recorded as an "unidentified eagle/buteo," that same bird flying at 100 feet would likely be properly identified as an immature bald eagle. This unavoidable bias may result in skewing the altitude estimates toward the lower end. Second, altitude estimate bias for all species is common in observations of bird flight behavior. This bias, which also results in skewing data toward lower altitudes, is discussed in Technical Study 8.

9.3.1.1.3 Peregrine Falcon. The peregrine falcon is one of the most widely distributed species in the world, with over 20 subspecies historically recognized. Three subspecies currently inhabit the U.S. Both Peale's peregrine falcon (*Falco peregrinus pealei*) and the Arctic peregrine falcon (*Falco peregrinus tundrius*) inhabit Alaska and the Northwest Territories and are not known to occur in the Northern Great Plains, while the American peregrine falcon (*Falco peregrinus anatum*) historically inhabited much of the lower 48 states (USFWS, 1987).

The American peregrine falcon was federally listed as endangered in response to declining populations in the 1950's and 1960's. Nesting peregrine populations, which numbered 350 pairs prior to the species' decline, were eliminated in the eastern and central U.S. by 1965 (USFWS, 1987). The current range of the peregrine falcon is considerably restricted (Fig. 9-6). In South Dakota breeding records of the falcon are extremely rare. Historical records of summer peregrine falcon residents include early 20th century records in the Black Hills of Western South Dakota and near Fort Sisseton, fifteen miles east of the study area. However, the peregrine falcon has not occurred as a breeding species in the state for over 40 years (USFWS, 1987; Harrell, 1978).

The causes of peregrine falcon population declines in the contiguous 48 states are identical to the causes of bald eagle population declines. Populations were generally stable until the 1940's, when human interference and pesticide applications began to significantly affect peregrine populations. Between 1948 and 1968 a 20 to 26 percent reduction in eggshell weight was noted; this effect was directly attributed to the bioaccumulation of DDT and its metabolites in breeding falcons (USFWS, 1987).

The USFWS has initiated a recovery program intended to restore peregrine falcon populations to sustainable levels (USFWS, 1987). The program covers a sixteen state region, including South Dakota, and has a goal of restoring 175 to 200 nesting pairs to the wild in these states by 2000. Critical steps in the program include an inventory of potential nesting and release sites, definition and protection of migratory routes, and protection of nesting and wintering habitat (USFWS, 1987). Currently the recovery program involves the annual captive production of 100-150 young for release in the wild (USFWS, 1987). Efforts in the early 1980's to reintroduce peregrine falcons to former habitat have been moderately successful in the region, and the current population is stable if not increasing (USFWS, 1987; Coffin and Pfannmuller, 1988).

Like bald eagles, peregrine falcons are highly susceptible to human disturbance (USFWS, 1987). Suitable falcon habitat is characterized by open areas near lakes, rivers, or sparsely vegetated wetlands that offer little cover for prey. The best habitat contains interspersed water and perching trees and is significantly removed from human activity. Peregrine falcons

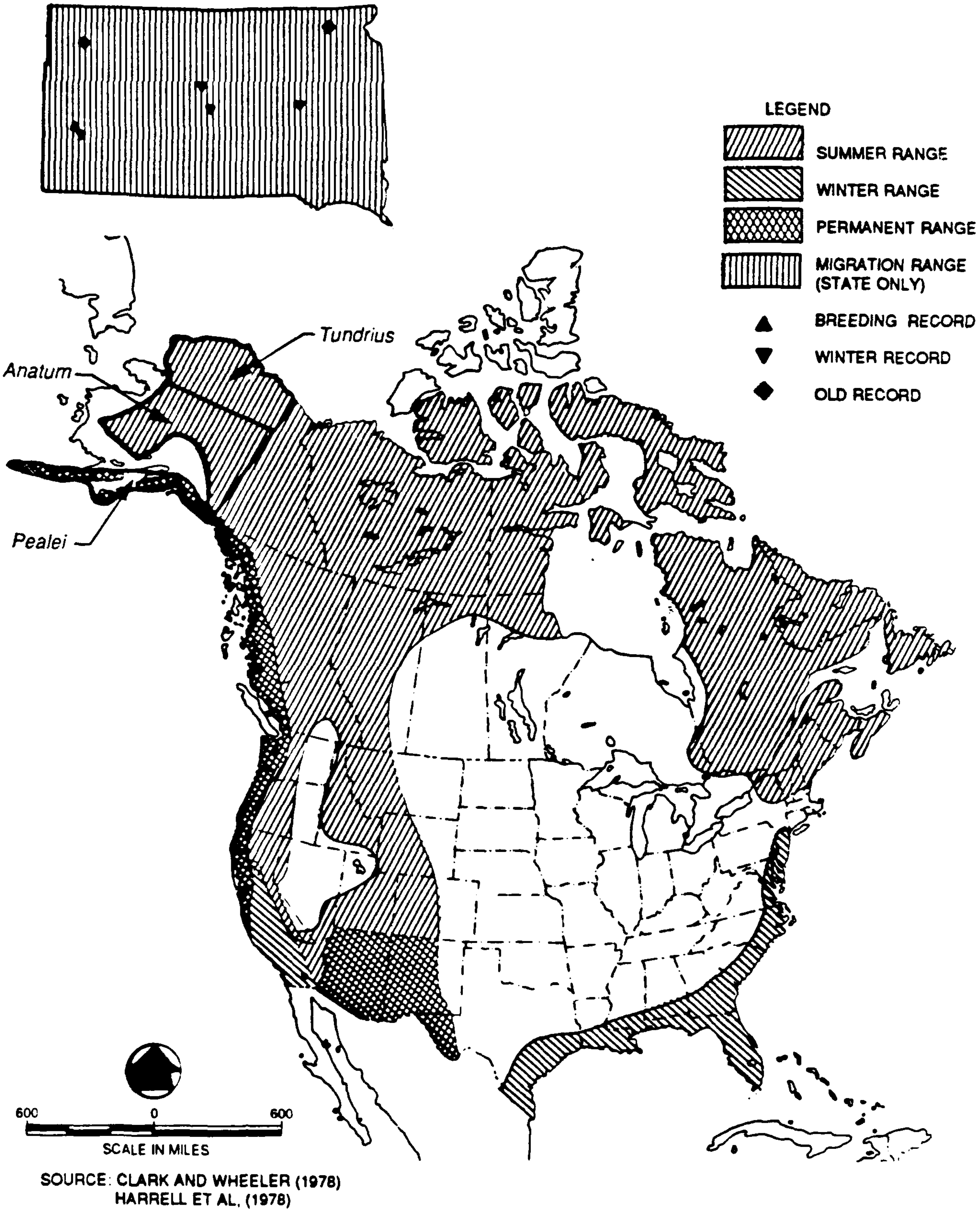


FIGURE 9-6. RANGE OF THE PEREGRINE FALCON

most often feed by the aerial pursuit and capture of other birds, including gulls, shorebirds, waterfowl, and passerines (USFWS, 1987; Coffin and Pfannmuller, 1988). Therefore, availability of prey is also an important habitat requirement.

During migration peregrine falcon flight behavior varies greatly, from soaring at high altitudes when winds are favorable to direct low-level flight when facing a headwind. The peregrine falcon is widely noted for its flight velocity; on level flights an adult can reach speeds of 60 miles per hour, and during a dive a falcon can achieve speeds approaching 250 mph (Cochran and Applegate, 1986). Although primarily a diurnal migrant, the falcon is also suspected to migrate at night (Cochran, 1988).

Two positive peregrine falcons sightings were recorded during the CRS avian surveys. Both sightings occurred in the fall of 1989, one each at the Tx-N and Tx-S CSA's, and in both cases the birds were flying below 150 feet.

9.3.1.1.4 Piping Plover. Three distinct populations of the piping plover exist in the U.S. Two of these, the Great Lakes and Atlantic populations, are federally listed as endangered, and the third, the Northern Great Plains population, is listed as threatened (USFWS, 1988). The Northern Great Plains population inhabits riverbanks and lakeshores of the north central U.S. (including South Dakota) during the summer and migrates to the Gulf Coast during the winter (Fig. 9-7). The current population of breeding piping plovers in the Northern Great Plains consists of 680 pairs, although this population is considered to be declining (USFWS, 1988).

The USFWS recorded 97 breeding pairs of piping plovers in South Dakota during 1986 and 1987 surveys. Although most of these pairs were located along banks and sandbars of the Missouri River, a few pairs were recorded in wetlands of northeastern South Dakota, including one observation in Day County (USFWS, 1988). Older records also indicate the presence of breeding plovers in Day County (Harrell, 1978).

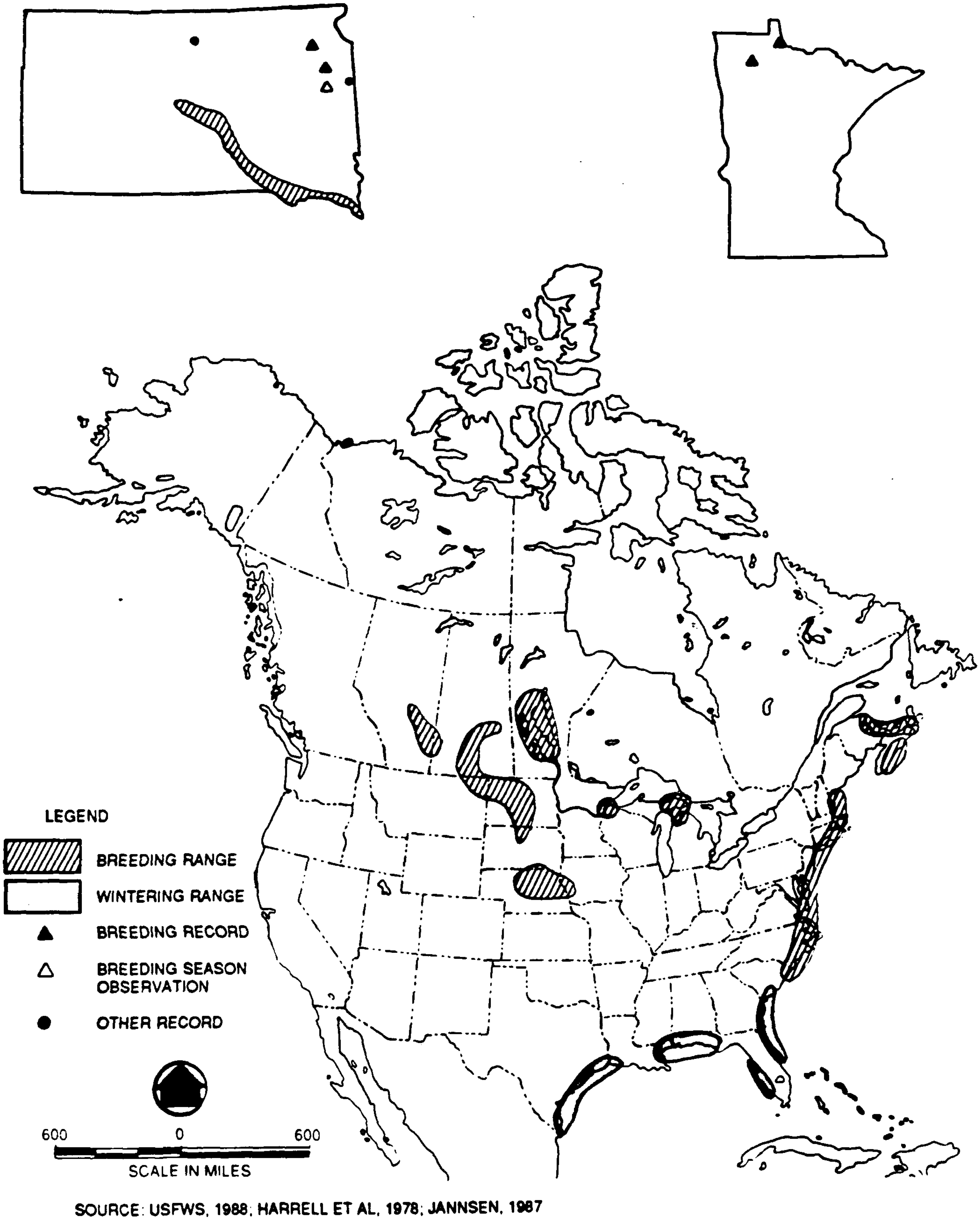


FIGURE 9-7. RANGE OF THE PIPING PLOVER

The decline of piping plover populations throughout their range is primarily attributable to human disturbance. Shooting, nest destruction (from sources including shoreline development, beach traffic, and livestock trampling), alteration of water levels, and predation of eggs by gulls, skunks, and foxes have contributed significantly to population declines (USFWS, 1988).

In 1988 the USFWS initiated a recovery plan intended to reverse the declining trends in regional piping plover populations. The recovery plan set as a goal 1300 nesting pairs of piping plovers in the Northern Great Plains by 2000, with 350 of these pairs nesting in South Dakota. The USFWS considers breeding populations of this size to be sustainable in the wild (USFWS, 1988).

In the Northern Great Plains, piping plovers usually make their nests on river sandbars or on sandy unvegetated shores of lakes or rivers. Man-made alterations of water level can therefore have adverse effects on nesting habitat. In open prairies plovers inhabit sparsely vegetated sloughs and saline wetlands. In pastures such nesting areas are highly susceptible to damage from livestock (USFWS, 1988). Availability of adequate food supplies is also an important habitat requirement. Piping plovers feed on exposed substrate by pecking for infaunal (buried) invertebrates such as worms, molluscs, crustaceans, and insects. Plovers have also been observed eating grasshoppers and spiders (USFWS, 1988).

No piping plovers were observed during the 1987, 1988, or 1989 CRS avian surveys. This absence of sightings is attributable to the lack of suitable nesting and feeding habitat in the study area.

9.3.1.1.5 Eskimo Curlew. The Eskimo curlew is an extremely rare federally endangered species that formerly bred in Arctic America, wintered in South America, and migrated along the East Coast in the fall and through the Great Plains in the spring (Peterson, 1975). The Eskimo curlew has been on the brink of extinction rangewide since the end of the 19th century, and there is little documentation of current nesting sites. Recently, however, nesting in the Canadian Northwest Territories has been recorded, and every few years there are sightings along the historical migration routes in spring and fall, particularly on the Texas coast in spring and Atlantic coast in summer and fall (Farrand, 1983).

In South Dakota the curlew was formerly common to abundant as a spring migrant in the eastern portion of the state. Historic records indicate the springtime occurrence of the curlew along the Missouri River in southeastern South Dakota. However, no Eskimo curlew sightings have occurred in the state for over 100 years (Harrell, 1978). No Eskimo curlews were observed during the 1987, 1988, or 1989 CRS avian surveys.

9.3.1.1.6 Whooping Crane. The whooping crane is federally listed as endangered and is one of the rarest birds in the United States. The large stature and majestic flight of the whooping crane have made it the focus of numerous studies. The whooping crane was never abundant, and estimates in the mid-19th century indicate that there were perhaps never more than 1500 individuals. When the surveys indicated in 1941 that the nation-wide whooping crane population declined to 15 individuals, intense restoration efforts were initiated by state and federal agencies (USFWS, 1986; Jannsen, 1988; Coffin and Pfannmuller, 1988). These efforts have gradually bolstered the population, and 135 whooping cranes existed in the wild by 1986. This limited population currently breeds at Wood Buffalo National Park in northern Alberta, migrates through the central U.S., and winters in coastal Texas (Fig. 9-8) (Coffin and Pfannmuller, 1988; Peterson, 1975).

Although the whooping crane formerly bred in southeast North Dakota, west central Minnesota, and northwestern Iowa, there are no historical records of the crane breeding in South Dakota (Harrell, 1978). Nonetheless, it is likely that the entire breeding population migrates through South Dakota in the spring and fall, although the main migration corridor is generally west of the study area (Harrell, 1978).

As with most other endangered species, the decline of whooping crane populations is primarily attributable to human disturbance. Habitat loss, such as the conversion of prairie potholes to agricultural land, eliminated many of areas preferred by cranes during migration. Shooting and other human

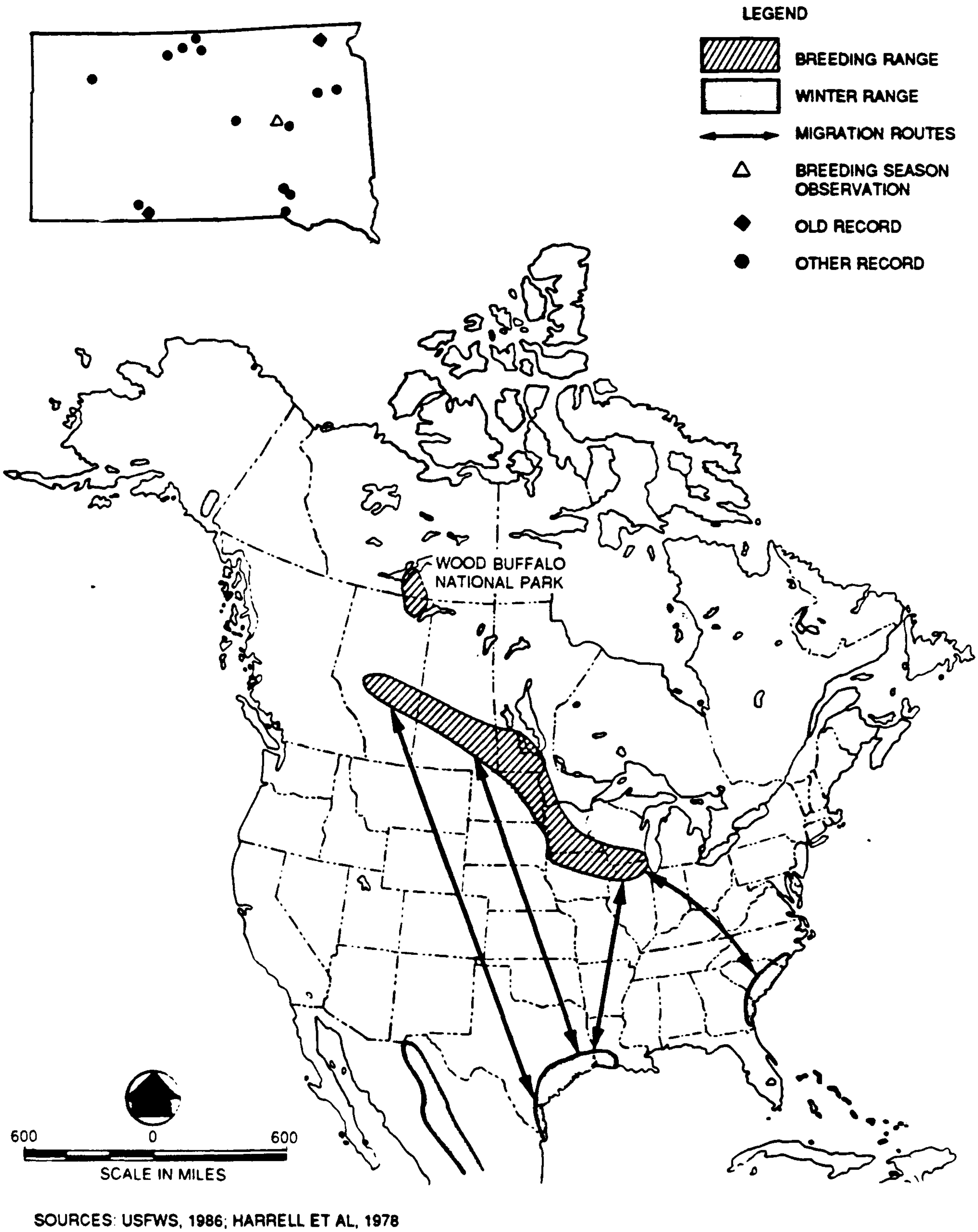


FIGURE 9-8. HISTORIC RANGE OF THE WHOOPING CRANE

activity have also contributed significantly to the decline (USFWS, 1886). While restoration efforts can not realistically reclaim and recreate former habitat, they have been successful at generating favorable public opinion toward the crane. The goal of the current USFWS recovery plan is to have 90 nesting pairs in the wild by 2020 (USFWS, 1986).

During migration the crane prefers areas well isolated from human activity. Whooping cranes often migrate in mixed flocks with sandhill cranes and stop to rest and feed in shallow wetlands and fields which contain cattails, sedges, and aquatic plants (USFWS, 1986; Harrell, 1978). Both the Tx-N and Tx-S CSA's contain suitable habitat for migrating whooping cranes, particularly in the spring when wetlands are extensive on both sites. Although the Tx-S CSA may contain a greater area of standing water in most years, the whooping crane might be more likely to stop at the Tx-N CSA because it is relatively more isolated from human activity.

No whooping cranes were observed during the 1987, 1988, or 1989 CRS avian surveys.

9.3.1.1.7 Burying Beetle. The burying beetle, once distributed across most of eastern North America, has disappeared from most of its original range (50 CFR 17). Two documented populations of the beetle exist, one in eastern Oklahoma and one on an island off the coast of New England. Outside of these two known colonies, only two individual specimens have been identified in the last ten years, each near one of the two existing populations. The cause of the burying beetle's decline is unknown, although some authors speculate that a yet unidentified species-specific parasite or disease may be responsible (50 CFR 17).

The burying beetle, a member of the family Silphidae, measures one to one and one half inches in length and is the largest of its genus in North America (50 CFR 17). It feeds solely on carrion, and buried carrion is used to support egg masses. The availability of humus and topsoil suitable for burying carrion is the primary habitat requirement. The most effective method of identifying and locating the burying beetle is to survey possible habitat either in late May to early June when beetles emerge after overwintering or in late summer when young emerge from buried egg masses and disperse (USFWS, 1989b; USFWS, 1990a).

Suitable habitat, in the form of uncultivated vegetation with thick humus layers, exists for the burying beetle at portions of the Tx-N and Tx-S CSA's. Nonetheless, it is doubtful that the burying beetle occurs in the study area because of the extreme rarity of the insect nationwide.

9.3.1.2 Federally Listed Flora. The Western prairie fringed orchid is the only federally listed threatened and endangered plant which may occur in the Amherst study area. The orchid is listed as threatened and historically occurred in both Minnesota and South Dakota (Fig. 9-9). Habitat typically consists of moist, calcareous or subsaline tallgrass prairies and sandy sedge meadows with full sunlight. Within these habitats orchid populations usually occur in sinuous swales and sedge-dominated lowlands that originate from groundwater seeps at the edge of ancient beach ridges (Coffin and Pfannmuller, 1988). The orchid can best be located when it blossoms in late July; however, it will often not blossom if drought conditions or heavy grazing occur (USFWS, 1990b; 50 CFR 17).

In the last two decades technology has allowed formerly marginal lands to be cultivated, and habitat for the orchid has declined. One source estimates that orchid populations have declined over 60 percent from their historic numbers (Coffin and Pfannmuller, 1988). In 1983 alone, over 5,000 acres of orchid habitat were lost. Several other factors, including fire protection, heavy cattle grazing, mining gravel on beach ridges, and use of pesticides and herbicides may have contributed to the orchid's decline (50 CFR 17). Apparently orchid populations are jeopardized by heavy litter buildup in the soils. The suppression of low intensity prairie fires, formerly common in the region, has eliminated potential orchid habitat. Hawkmoths (Sphingidae spp.) are required for pollination of the orchid; thus, threats to the hawkmoth are necessarily threats to the Western prairie fringed orchid (50 CFR 17).

The orchid, a perennial herb, currently occurs in 37 known populations in seven states. In South Dakota the orchid was historically found in wet

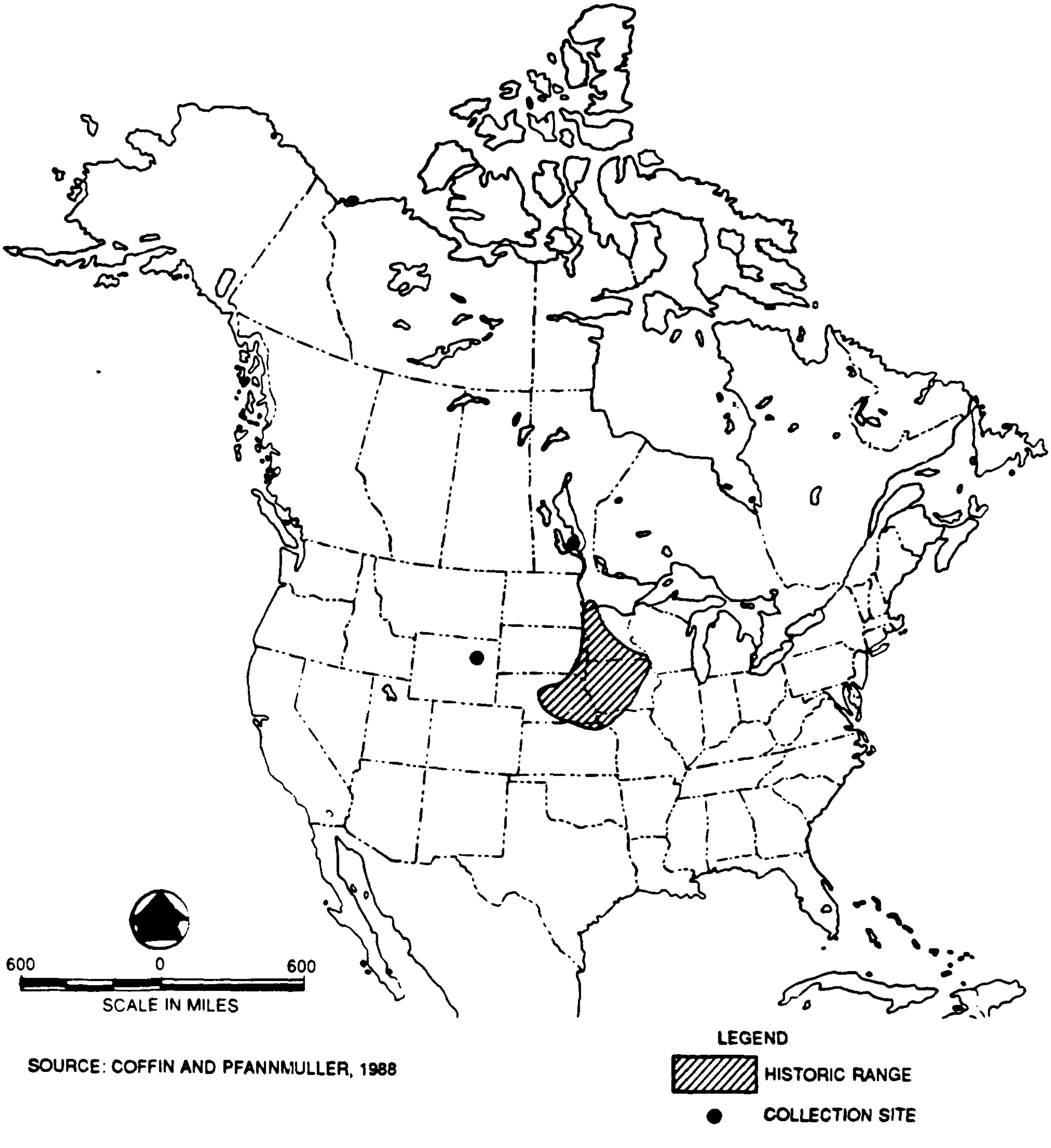


FIGURE 9-9. HISTORIC RANGE OF THE WESTERN PRAIRIE FRINGED ORCHID

meadows of the Big Sioux River Valley. Although there are presently no known occurrences of the orchid in South Dakota, suitable habitat exists throughout the eastern portion of the state, including the native prairie at the Tx-N CSA and the undisturbed low-lying lands at the Tx-S CSA (USFWS, 1989a; USFWS, 1990a).

9.3.1.3 State-Listed Fauna. The State of South Dakota maintains a list of flora and fauna that are threatened or endangered in the state. Species listed as threatened or endangered on the federal list are generally given the same status on the state list. South Dakota threatened and endangered species which may occur in the study area are listed in Table 9-1.

No plant, mammal, fish, or insect species on the South Dakota threatened and endangered species list are known to occur in or near the Amherst study area. Two threatened reptiles (the northern redbelly snake and northern lined snake) may occur on or near the study area, and two threatened birds, the osprey and buff-breasted sandpiper, were observed in the study area during the USAF 1989 avian surveys.

The northern redbelly snake and northern lined snake both occur in eastern South Dakota (Houtcooper, 1985). The northern redbelly snake is an eastern snake which typically inhabits open woods and sphagnum bogs, and the northern lined snake inhabits prairies and open lands in the central U.S. (Conant, 1975). Conant (1975) describes the northern lined snake as abundant through much of its range, sometimes even appearing in urban areas. Despite its abundance elsewhere, the northern lined snake is threatened in South Dakota because the southeastern portion of the state is the northernmost limit of its range (Houtcooper, 1985; Conant, 1975). Although both state-threatened snakes may occur in the study area, the presence of the northern redbelly snake is unlikely because of the lack of suitable habitat (open woods), and the occurrence of the northern lined snake is unlikely because its range is historically only the southeast corner of South Dakota.

The osprey, a state-threatened species, is nearly worldwide in distribution. In the U.S. the osprey occurs primarily along the Atlantic Coast, Great Lakes, and waters of the Pacific Northwest, although several natural resource agencies have successfully established inland populations (Coffin and Pfannmuller, 1988). Populations of the osprey declined dramatically during the 1950's and 1960's, primarily because of increased concentrations of DDT in fish, which are the osprey's exclusive prey item. Since the elimination of DDT in the early 1970's, osprey populations have recovered somewhat. In the contiguous U.S., osprey breeding populations currently number approximately 8,000 pairs (Coffin and Pfannmuller, 1988).

Ospreys are typically associated with lakes, large rivers, and waterways where fish populations are adequate. They often place nests atop large structures, such as trees or utility poles, near the water's edge (Coffin and Pfannmuller, 1989). Ospreys were formerly known to breed in some locations in South Dakota but are currently observed as migrants only (Houtcooper et al, 1987). Although two ospreys were observed at the Tx-S CSA during the 1989 avian surveys (both flying above 150 feet), it is unlikely that ospreys nest on the site because of the absence of significant fish habitat (Technical Study 6, Wetlands and Aquatics). This lack of suitable habitat at the Tx-N CSA suggests that ospreys would not use this site to any extent.

The buff-breasted sandpiper is listed as threatened in South Dakota. It typically summers in the Arctic, winters in Argentina and migrates through the Great Plains of the U.S. (Peterson, 1975). The South Dakota National Heritage Program lists the buff-breasted sandpiper's status as "undetermined," signifying the need for further information on current abundance and distribution (Houtcooper et al, 1987).

One buff-breasted sandpiper was observed during the CRS 1989 fall avian surveys. This bird was observed in the study area but outside both CSA's. Although suitable habitat exists at the Tx-N CSA in the form of short-grass prairie, it is unlikely that the species is more than a rare migrant in the study area.

9.3.2 RECEIVE SITE

Several federally listed threatened or endangered species may occur in the Thief River Falls study area (Table 9-2). However, the presence of federally listed plant, mammal, reptile, or insect species can not be determined until rights-of-entry are obtained and the preferred layout of the site is selected. For these groups of species brief descriptions of the historical and current status of species whose range includes the study area are provided, as well as an evaluation of the available habitat at the receive site. In addition, in cases where information is adequate, the likelihood of each species occurring in the study area is assessed.

Several birds on federal and state threatened and endangered species lists are known to occur in the Thief River Falls study area or were observed during the CRS USAF avian surveys. Because the federally listed birds which may occur in the Thief River Falls study area also may occur in the Amherst study area their range, history, and national population trends are discussed in sections addressing the transmit site. The discussion here is limited to species which may occur in Minnesota only and the species observed during the 1987, 1988, and 1989 Thief River Falls CRS avian studies.

9.3.2.1 Federally Listed Fauna.

9.3.2.1.1. Gray Wolf. The gray wolf is the only federally-listed mammal which may occur in the Thief River Falls study area. The wolf is federally listed as endangered in each of the lower 48 states except Minnesota, where it is listed as threatened. Prior to European settlement the gray wolf inhabited most of North America, but increasing habitat disturbance, reduction of prey populations, and human activity have reduced the wolf's natural range to less than one percent of its former level (Fig. 9-10) (Coffin and Pfannmuller, 1988; Fritts and Mech, 1981). Accelerated decline of wolf populations began in the late 1800's when the U.S. Predator Control Program established a policy of granting bounties on wolves. Until their abolition in 1965, these bounties served to eliminate the wolf from most of its natural range (Coffin and Pfannmuller, 1988).

TABLE 9-2. THREATENED AND ENDANGERED SPECIES THAT MAY OCCUR IN THE THIEF RIVER FALLS STUDY AREA

Common Name	Scientific Name	Status
Federally Listed Species		
Gray wolf	*Canis lupus*	Threatened
Peregrine falcon	*Falco peregrinus*	Endangered
Piping plover	*Charidrius melodus*	Threatened
Bald eagle	*Haliaeetus leucocephalus*	Threatened
Western prairie fringed orchid	*Platanthera praeclara*	Threatened
State-Listed Species		
Assiniboia skipper	*Hesperia assiniboia*	Endangered
Baird's sparrow	*Ammodramus bairdii*	Endangered
Sprague's pipit	*Anthus spraguii*	Endangered
Chestnut-collared longspur	*Calcarius ornatus*	Endangered
Burrowing owl	*Athene cunicularia*	Endangered
Loggerhead shrike	*Lanius ludovicianus*	Threatened
Hall's sedge	*Carex halli*	Threatened
Sterile sedge	*Carex sterilis*	Threatened
Hair-like beak rush	*Rhynchospora capillacea*	Threatened
Annual skeleton weed	*Lygodesma rostrata*	Threatened

Source: Paradiso and Nowak (1982)

FIGURE 9-10. RANGE OF THE GRAY WOLF

In Minnesota, historical patterns mirrored the national trends. In addition to the reasons noted above, the decline of wolf populations in Minnesota has been attributed to declines in white-tail deer (a principal prey species) populations as the northern forests matured. Gray wolves in Minnesota are currently restricted to the boreal forests and tundra of the northern third of the state; this region is the southernmost limit of the wolf's current range (Coffin and Pfannmuller, 1988). Current estimates of 1,000 to 1,200 wolves in this region make this the largest population of wolves in the lower 48 states, and wolf populations in Minnesota are generally considered to be large enough to be relatively safe (Paradiso and Nowak, 1987). Although the gray wolf was originally listed as endangered in all 50 states, stabilizing and steadily increasing populations in the 1970's caused its status to be downgraded to threatened in Minnesota in 1978. In accordance with the 1974 listing, the U.S. Congress established a zone of critical habitat for the wolf in Minnesota (50 CFR 17). This area (Fig. 9-11) lies over 100 miles northeast of the Thief River Falls study area.

Gray wolves apparently do not require a specific vegetative cover type; the fact that they formerly inhabited several regions of the continent is evidence of their adaptability to various conditions. Rather than land form, climate, or vegetation, the occurrence and vigor of gray wolf populations likely depends more on the abundance and distribution of large prey, such as deer, moose, elk, and caribou, and isolation from human activity (Coffin and Pfannmuller, 1988). Given a stable food supply, a pack of wolves (usually eight or less) will occupy a range of approximately 1100 square miles. The only requirement for wolves' growth and reproduction is a den, which can be a rock crevice, turned over stump, or a small protected depression in the ground. Dens are used for approximately two months during the year to provide shelter for newborn pups (Paradiso and Nowak, 1987). Although both CSA's contain adequate prey populations, both sites provide equally poor conditions for the wolf because of the considerable human activity in the area.

Fritts and Mech (1981) show the Thief River Falls study area to be just west of the peripheral range of the gray wolf in Minnesota (Fig. 9-12). The nearest population of gray wolves is a group of 10 to 12 individuals that

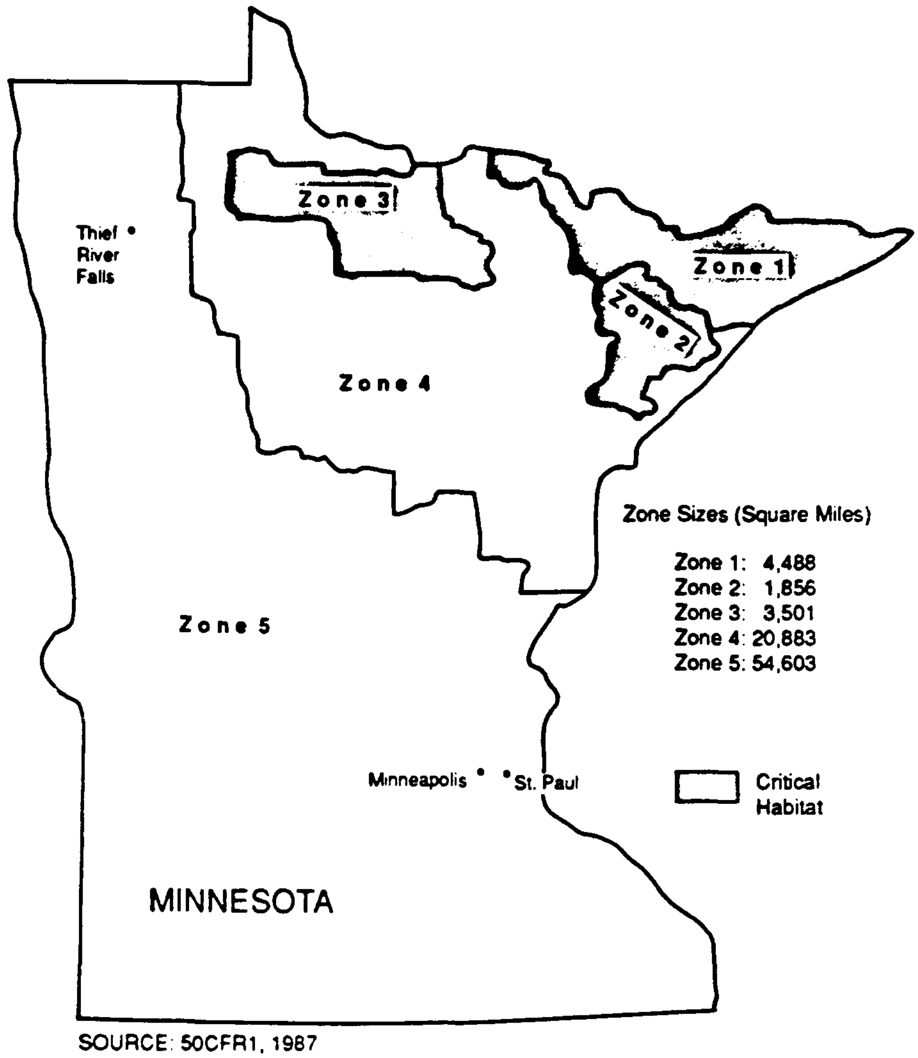
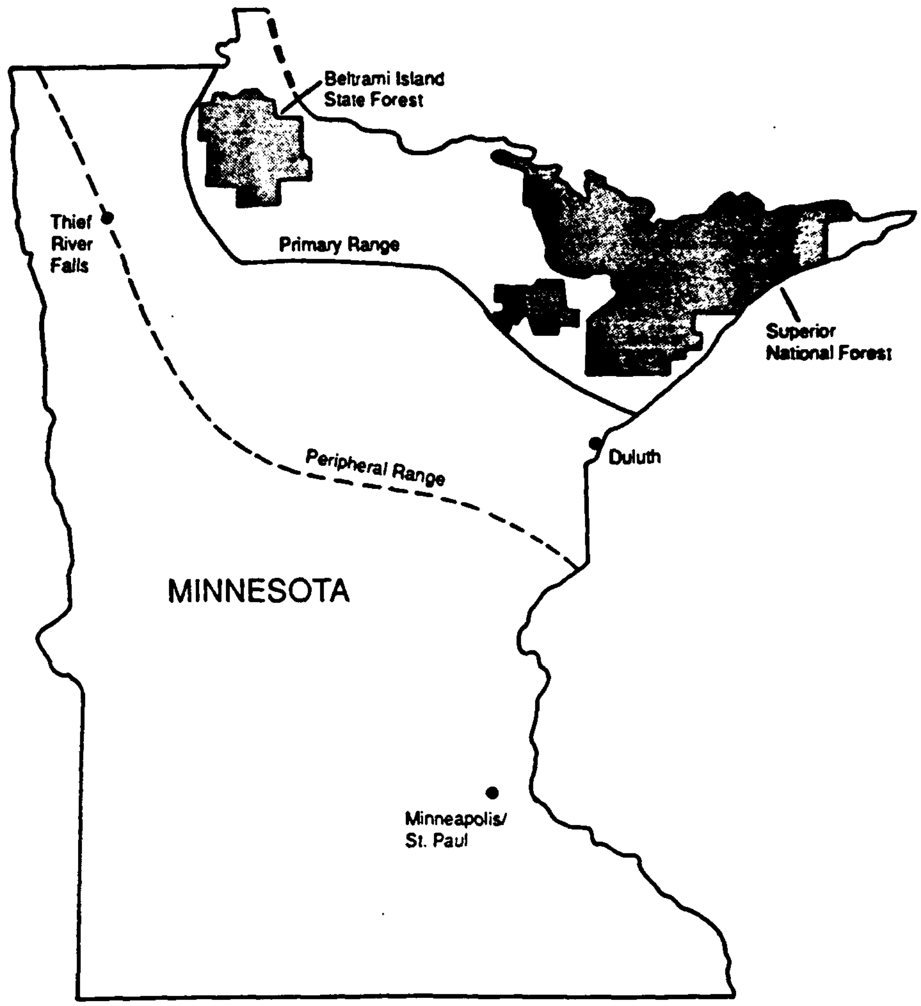


FIGURE 9-11. ZONES OF CRITICAL HABITAT FOR THE GRAY WOLF IN MINNESOTA



Source: Fritts and Mech, 1981

FIGURE 9-12. RANGE OF THE GRAY WOLF IN MINNESOTA

inhabit a 130 square mile home range near Agassiz National Wildlife Refuge, approximately 25 miles northeast of the study area (USFWS, 1990c). Although highly unlikely, it is possible that severe prey shortages in the wolves' primary range could force wolves to stray south and west into the Thief River Falls study area.

9.3.2.1.2 Bald Eagle. The bald eagle is federally listed as threatened in Minnesota. Historically, nesting was reported as common in Minnesota, particularly along the major rivers and lakes of the state. Eagle populations have declined statewide in the last century. Although 190 known nests were identified in the state in 1981, most were in the northeast portion (USFWS, 1983). Breeding bald eagles have not been documented in Marshall, Pennington, or Polk County since 1962 (Jannsen, 1987).

During fall migration bald eagles may occur in the state in significant numbers. Over 100 eagles were observed at Hawk Ridge, near Duluth (approximately 230 miles southeast of the Thief River Falls study area) on one day in November, 1983 (Jannsen, 1987). In addition, statewide surveys conducted in 1979, 1980, and 1981 recorded 2091 eagles, the highest number of any state (USFWS, 1983).

Of the 32 bald eagles observed during the CRS avian surveys, 31 were observed in the spring (11 sightings) and fall (20 sightings) of 1989. Twenty-three sightings occurred from the fixed avian stations (Fig. 8-5), and the remainder occurred in the overall study area during road surveys or general observations. Although the sample size is too small to allow for statistical comparisons, some information on locations of observations and flight altitudes is noteworthy. Within the Rx-W CSA, only two of ten (20 percent) bald eagles recorded were observed perching in trees, resting on the ground, or flying under 65 feet. On the other hand, eight of fourteen (57 percent) eagles recorded within the Rx-E CSA were observed under 65 feet. The comparatively higher activity and relatively lower flight altitudes recorded at the Rx-E CSA may be attributable to the proximity of that CSA to the Goose Lake wetland complex, which provides significant foraging habitat. Eagles observed at the Rx-E CSA may have been either leaving or arriving at this foraging area.

9.3.2.1.3 Peregrine Falcon. The peregrine falcon is federally listed as endangered in Minnesota and occurs primarily as a rare migrant. It was a regular summer resident of the state until 1960, and the breeding population in the state once totalled 30 or 40 pairs (Jannsen, 1987; Coffin and Pfannmuller, 1988). In the last 25 years habitat disturbance, DDT, and other factors have combined to extirpate the peregrine falcon as a breeding bird in the state. The last documented breeding site in the state was along the Mississippi River in 1962 (Coffin and Pfannmuller, 1988).

Since the implementation of the Eastern Peregrine Falcon Recovery Plan (USFWS, 1987) and consequent release of individuals on the north shore of Lake Superior, peregrine populations have increased. Seventeen peregrine falcons were observed on Hawk Ridge in eastern Minnesota on one day in 1984 (Jannsen, 1987).

Nine peregrine falcon sightings were recorded during the CRS avian surveys; all nine sightings occurred in either the spring (one sighting) or fall (eight sightings) of 1989. Of the seven sightings which occurred from stations within the CSA's, three were from the Rx-W CSA and four were from the Rx-E CSA. In the majority of sightings (two of three at the Rx-W CSA and three of four at the Rx-E CSA) the birds were either resting or flying below 65 feet.

9.3.2.1.4 Piping Plover. Two distinct populations of piping plovers inhabit parts of Minnesota; the Great Lakes population is endangered and the Northern Great Plains population is threatened. Historically over 90 percent of the nesting piping plovers in Minnesota occurred on two islands in Lake of the Woods, which is approximately 80 miles northeast of the Thief River Falls study area (USFWS, 1988). Surveys conducted by the USFWS in 1986 and 1987 indicated that just seven breeding pairs inhabit these islands. There are no current or historic records of piping plovers breeding in Marshall, Polk, or Pennington Counties (Jannsen, 1987; Coffin and Pfannmuller, 1988). Neither the Rx-W nor the Rx-E CSA offer significant habitat for the piping plover. No piping plovers were observed during the 1987, 1988, or 1989 CRS avian surveys.

9.3.2.2 Federally Listed Flora. The Western prairie fringed orchid is the only federally listed species which may occur in or near the Thief River Falls study area. The national range and typical habitat requirements of the orchid are discussed in section 9.3.1.2. In Minnesota six isolated Western prairie fringed orchid colonies exist in four counties, and several other colonies have recently declined to the point of extirpation. As recently as the 1970's, orchid populations in Minnesota numbered in the thousands, and over 20,000 acres of habitat existed on the ancient beach ridges east of Crookston, Minnesota (approximately 20 miles south of the study area) (Coffin and Pfannmuller, 1988). Habitat for the orchid exists at the Rx-E CSA on a portion of the ancient beach ridge of the Glacial Lake Agassiz. Because it was recently listed, comparatively fewer efforts have been made to locate and protect Western prairie fringed orchid colonies, and it is therefore more likely to exist in unidentified locations.

9.3.2.3 State-Listed Fauna. One insect and five bird species on the Minnesota threatened and endangered species list may occur or were observed in the Thief River Falls study area (Table 9-2). No mammals or reptiles on the list are known to occur in the study area.

The assiniboia skipper, a small butterfly, is listed as endangered by the state of Minnesota. It has been observed in Polk County at a location approximately 20 miles west of the study area, although the most extensive assiniboia skipper community recorded is in Clay County, approximately 70 miles south of the study area (Coffin and Pfannmuller, 1988). The skipper typically inhabits dry, sandy prairies and beach ridges associated with shorelines of Glacial Lake Agassiz. The beach ridge at the Rx-E CSA contains suitable habitat for the skipper. Of the five bird species on the Minnesota list of threatened and endangered species, four (Baird's sparrow, chestnut collared longspur, burrowing owl, Sprague's pipit) are endangered and one (loggerhead shrike) is threatened.

Baird's sparrow and Sprague's pipit are both regional endemic species restricted to the Great Plains of the U.S. and the prairie provinces of southern Canada. Historically, both species were known to breed in suitable dry uplands of the Red River Valley, and Sprague's pipit was considered a common inhabitant (Coffin and Pfannmuller, 1988). Since the 1920's the range of both Baird's sparrow and Sprague's pipit has been greatly reduced by habitat conversion, and both species now only breed sparingly in the Red River Valley. For the last two decades both species have been regularly observed only on the Fenton Prairie in Clay County, approximately 70 miles south of the Thief River Falls study area. Breeding has never been documented at this location. Although breeding records from southwest Pennington County and northwest Polk County exist for both species, all records from these two locations are more than 40 years old (Coffin and Pfannmuller, 1988).

Baird's sparrow prefers dry, native grassland (mixed-grass prairie) where the grass is fairly long and provides dense cover (Coffin and Pfannmuller, 1988). Sprague's pipit prefers similar habitat but can tolerate grasslands that are lightly grazed, mowed or burned. Much of land in the Thief River Falls study area is either wooded or cropped and therefore provides little habitat for these species. However, some lands in the Conservation Reserve Program (CRP) may contain suitable habitat. No observations of Baird's sparrow were recorded during the CRS avian surveys, but 21 observations of Sprague's pipit were recorded. The occurrence in the study area of both species is probably as a rare or accidental migrant (USFWS, 1986).

The chestnut-collared longspur is also endemic to the Great Plains region of the U.S., although it has a slightly larger range than Baird's sparrow and Sprague's pipit. In the 19th century the chestnut-collared longspur occurred in dry upland prairie throughout the Red River Valley. By the 1930's the longspur had disappeared from that part of the state and had become limited to Glacial Lake Agassiz beach ridges in northwestern Minnesota. Although recent records indicate sightings of migrants throughout the state, the only known breeding colony is on an ancient beach ridge in Clay County, approximately 70 miles south of the study area. In 1985 a minimum of 135 males were observed on that site.

The chestnut-collared longspur prefers short, sparse vegetative cover such as grazed or hayed mixed-grass prairie, mowed hayfields, and heavily grazed pasture. One historic breeding record (over 40 years old) of the species exists in western Polk County (Coffin and Pfannmuller, 1988). Although no sightings of chestnut-collared longspurs were recorded during the avian surveys, such habitat is abundant at the Thief River Falls study area. It is possible that the species could colonize and breed in the area.

In contrast to the preceding three species, the loggerhead shrike is widely distributed throughout most of the continental U.S. and Canada. However, the loggerhead shrike has experienced a drastic decline in the last two decades throughout the U.S. The shrike was formerly a common breeding species in Minnesota but is now rare as a breeding bird in the state (Coffin and Pfannmuller, 1988). Minnesota contains only a few isolated regions (southwestern, east-central) where the loggerhead shrike is consistently reported to breed each year. In Minnesota, as with other regions, intensive farming is mainly responsible for the species' decline. Furthermore, because it is a predator, pesticide contamination may be a factor in the bird's decline (Coffin and Pfannmuller, 1988).

The loggerhead shrike prefers open country and dry upland prairie where hedgerows, shelterbelts, and small wooded areas are common. Observation records from the avian surveys include one loggerhead shrike sighting near the Rx-E CSA. Although the shrike has been observed in the study area, the last breeding site in the region was documented over forty years ago in southwestern Polk County (Coffin and Pfannmuller, 1988).

With the exception of a small population in southern Florida, the burrowing owl is primarily a western species that exists at the eastern edge of its range in Minnesota. The burrowing owl formerly bred throughout the western portion of the state (Coffin and Pfannmuller, 1988). The abundance of the species began to decline approximately 40 years ago when habitat conversion accelerated. The last viable population of breeding burrowing owls was documented in the central part of the state in the early 1960's. In the last fifteen years there have been just four breeding records of the species throughout the state, none of which are near the Thief River Falls study area (Coffin and Pfannmuller, 1988).

Preferred habitat for the burrowing owl is heavily grazed pasture or native mixed-grass prairie which allows the owl to dig a small nest. Often the owl uses burrows vacated by badgers and ground squirrels (Coffin and Pfannmuller, 1988). The avian surveys produced no sightings of burrowing owls in the Thief River Falls study area, and little suitable habitat is available. Therefore, it is highly unlikely that the owl occurs on the site other than as an extremely rare migrant.

9.3.2.4 State-Listed Flora. Four state-listed threatened plant species occur in Polk County and may occur in the study area: Hall's sedge, sterile sedge, hair-like beak rush, and annual skeleton weed. Historical observations of Hall's sedge, sterile sedge, and hair-like beak rush include several records in southwest Polk County (Coffin and Pfannmuller, 1988). These three species are typically found in moist, calcareous or subsaline prairies and sedge meadows. In Polk County these species are located in sinuous swales (sedge-dominated lowlands) that originate from mineral-rich, alkaline groundwater seeps at the edge of ancient beach ridges of the Glacial Lake Agassiz (Coffin and Pfannmuller, 1988). Because irrigation often alters patterns of groundwater flow, water-using activities several kilometers from these sedges can significantly damage their habitat.

The annual skeleton weed occurs in sand dunes throughout Minnesota, but it is generally local and uncommon. It apparently prefers unstable sand dunes where shifting sand prevents the establishment of competing vegetation. The weed occurs in three to five kilometers of intermittent habitat in Agassiz Dunes Scientific and Natural Area in southern Polk County (Coffin and Pfannmuller, 1988).

Indian ricegrass is a common grass of plains and semi-arid regions of the West. It is rare in Minnesota because it does not normally occur that far east. A single indian ricegrass community occurs in southern Polk County (Coffin and Pfannmuller, 1988).

Suitable habitat exists at both Rx CSA's for Hall's sedge, sterile sedge, and the annual skeleton weed . All three of these speci s typically inhabit groundwater seepage areas at the base of glacial lake beaches. These species may inhabit the uncultivated area just west of the glacial lake beach in the Rx-E CSA (the northern portion of the Goose Lake wetland system) (Fig. 9-13).

9.4 ENVIRONMENTAL CONSEQUENCES

This section addresses the potential impacts of the CRS project on threatened and endangered species. The discussion of impacts on birds is restricted to evaluating the impacts on threatened and endangered birds that were observed in each study area during the CRS avian surveys. Because of the extensive coverage of the CRS avian surveys, impacts to species not observed in the surveys are considered negligible. Qualitative assessments for the bald eagle and peregrine falcon were conducted for each study area on which these species were observed. In addition, assessments for the osprey and buff-breasted sandpiper were conducted for the two Tx CSA's and for Sprague's pipit and the loggerhead shrike for the two Rx CSA's. Potential impacts on birds include both direct impacts (mortality due to collisions with vehicles and project structures) and indirect impacts (habitat loss). Assessments of potential collision impacts are based on a synthesis of avian survey data and present knowledge concerning collisions of birds with fixed structures. Measures which may reduce or mitigate collision impacts are also discussed.

As noted in section 9.3.1, vegetation surveys intended to identify threatened and endangered plants (and possibly insects) on the study areas will be conducted once rights-of-entry are granted and the final proposed alignment of the facilities is selected. Because the occurrence of threatened and endangered mammals, plants, and insects on each CSA will remain undetermined until surveys are completed, discussions of impacts on these species will focus on disturbance and loss of habitat.

9.4.1 Transmit Site

9.4.1.1 Birds. Although no threatened or endangered birds are known to nest in either of the two Amherst CSA's, the following federal and state listed species were observed migrating through the CSA's during the CRS avian

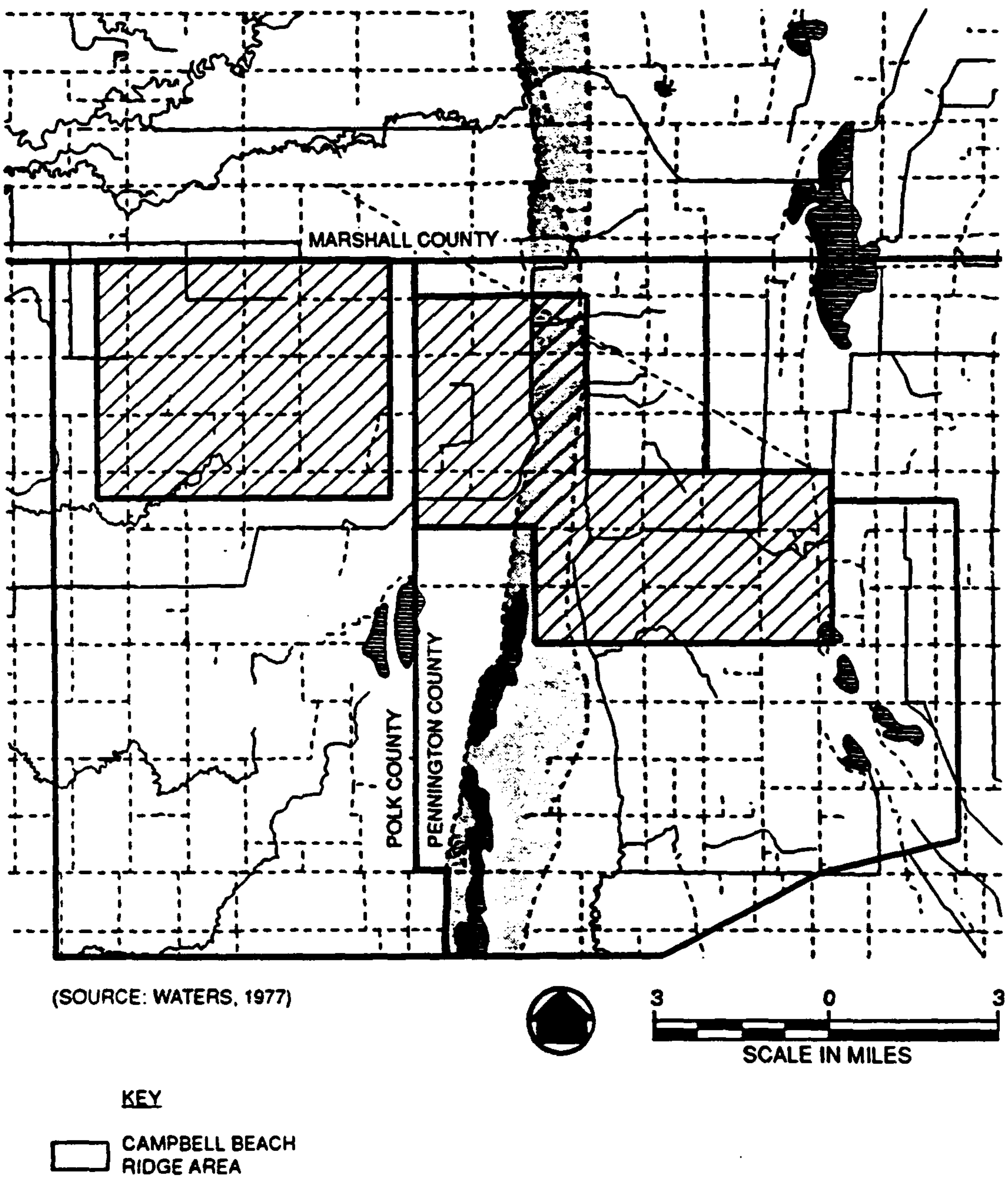


FIGURE 9-13. THIEF RIVER FALLS, MN RECEIVE STUDY AREA LOCATION OF CAMPBELL BEACH RIDGE

surveys: bald eagle (both Tx-N and Tx-S), peregrine falcon (both Tx-N and Tx-S), osprey (Tx-S), and buff-breasted sandpiper (Tx-S). The osprey and buff-breasted sandpiper likely occurred at Tx-S because of the habitat provided by the large flooded field. As noted previously, potential impacts include collisions and habitat loss. Collisions will be evaluated in relation to the maximum height (150 feet) of the structures at the transmit site and in relation to project-related traffic.

9.4.1.1.1 Bald Eagle.

9.4.1.1.1.1 Direct Impacts. Potential for bald eagle collisions with the antennas depends on several factors, including frequency of movement over the site, pattern and altitude of flights, and use of the site for feeding. Eagles generally migrate along corridors containing large lakes, rivers, and wetlands with open water (Peterson, 1975). Such a corridor exists along the James River at Sand Lake National Wildlife Refuge, approximately ten miles east of the two CSA's. Many of the eagles migrating through the region likely follow the James River Corridor (USFWS, 1990c).

Nonetheless, a moderate amount of eagle movement was observed at both Tx-N and Tx-S CSA's as part of the USAF 1987, 1988, and 1989 avian surveys. As noted in section 9.3.1.1.2, more bald eagle observations occurred at the Tx-S CSA than at the Tx-N CSA, and in the majority of observations at both sites the eagles were either perching, resting on the ground, or flying below 150 feet. Furthermore, a higher percentage of the observations (86 percent compared to 65 percent) at the Tx-S CSA were of birds flying at low altitudes. According to this data, the risk of collision is comparatively higher at the Tx-S CSA for two reasons: first, there were more eagles observed at the Tx-S CSA, and second, a higher proportion of these recorded birds were flying low.

Under most daylight conditions when foraging would occur, the antenna would be highly visible. Bald eagles are extremely maneuverable in flight and possess excellent vision, and collision mortality with man-made objects is generally uncommon (Olendorff et al, 1981). In average and good light conditions bald eagles would be capable of seeing and avoiding the antennas. If bald eagles were present during periods of low visibility (e.g. dawn, dusk, foggy conditions) collisions would be more likely. However, migration rates for raptors during such conditions are generally lower than during good weather conditions (Technical Study 8).

Bald eagles that forage on mammal carcasses along nearby roads could be injured or killed by project-related traffic, particularly if the incidence of road-killed deer increases. The maximum daily increase in local traffic would be 60 trips per day to and from the site during construction (Technical Study 3, Transportation). According to preliminary construction plans, this traffic increase would most likely occur during late spring and summer when local bald eagle movements are comparatively low.

9.4.1.1.1.2 **Indirect Impacts.** Currently no bald eagles are known to nest in either of the two Amherst CSA's or at nearby Sand Lake National Wildlife Refuge (USFWS, 1990d). Therefore, no essential breeding habitat would be removed. At the Tx-N CSA approximately 500 acres of wetlands and native rangeland would be filled or otherwise disturbed, and at the Tx-S CSA about 70 acres of wetland and upland prairie would be disturbed (Technical Studies 5 and 6). This habitat supports waterfowl and small mammals on which the bald eagle feeds during migration. However, the habitat is not particularly unique in its ability to support bald eagles, and similar habitat exists throughout the region.

In summary, the OTH-B project is not expected to significantly affect migrating bald eagles and should not remove any essential eagle habitat. While a few eagles may collide with the structure during periods of low visibility, collisions are expected to be uncommon. Bald eagle populations in the region are increasing (USFWS, 1983), and any mortality resulting from the CRS project is not expected to jeopardize the continued recovery of the regional bald eagle population. However, since collisions cannot be completely ruled out, particularly at the Tx-S CSA, the USAF should maintain coordination with the USFWS and consider initiating a formal consultation process pursuant to the Endangered Species Act Section 7 (16 USC 1531 et seq.). This process would allow the USFWS to further assess potential impacts and reasonable and prudent mitigation measures.

9.4.1.1.2 Peregrine Falcon.

9.4.1.1.2.1 Direct Impacts. Since peregrine falcons are chiefly diurnal migrants, possess excellent visual acuity, and are extremely maneuverable in flight, mortality due to collisions with man-made structures is normally negligible (AEIDC, 1987). In the proceedings of an international conference on peregrine falcon populations (Hickey, 1969), there is no mention of collision-induced mortality in the extensive discussion of mortality factors. In one case in which collision-induced mortality with power lines was documented, over half the killed birds were subadults (Olendorff and Lehman, 1986).

Peregrine falcons would seem to be most vulnerable to collisions when hunting because they catch prey during high-speed dives and may be less aware of collision hazards during pursuit of prey (Olendorff et al, 1981; Roseneau et al, 1981). In one study (Olendorff and Lehman, 1986), six of 17 peregrine collisions with power lines occurred near areas with abundant prey, suggesting that peregrines may have been more susceptible to collisions when foraging. In this respect peregrines are more vulnerable to collisions than eagles and ospreys, which soar and hover more frequently and do not dive at such high speeds. Nonetheless, although peregrine collisions with the structures are possible, it is unlikely that impacts to the peregrine falcon population would be significant because of the extremely low numbers of peregrines (only two observations during the CRS avian surveys) that migrate through either study area.

Peregrine falcons eat primarily live prey and would scavenge road kills only on rare occasions. Thus, peregrine mortality due to collisions with project-related vehicles is unlikely at either CSA.

9.4.1.1.2.2 Indirect Impacts. No peregrine falcons are known to breed or overwinter in either of the two Amherst CSA's or in Sand Lake National Wildlife Refuge (USFWS, 1990d). Suitable foraging habitat, in the form of numerous waterfowl-supporting wetlands, exists throughout the spring at both the Tx-N and Tx-S CSA's and in the fall at the Tx-S CSA when flooding conditions persist. In abnormally wet years, the likelihood of collisions would probably be somewhat higher at the Tx-S CSA because the large wetland at that site provides habitat for waterfowl, a chief prey species. In average or dry years the likelihood of collisions is probably greater at the Tx-N CSA because of the greater amount of habitat available at that site.

According to the preliminary layout, much more habitat would be lost at the Tx-N CSA than at the Tx-S CSA. Approximately five hundred acres of upland prairie and wetland habitat would be filled or disturbed at the Tx-N CSA while approximately 70 acres of upland prairie and wetland habitat would be filled or disturbed at the Tx-S CSA (Technical Studies 5 and 6). As is the case with the bald eagle, the availability of similar or more favorable foraging habitat in the region suggests that the loss of habitat at both Tx-N and Tx-S CSA's as a result of CRS construction and operation would not significantly affect migrating peregrine falcons.

In summary, although project-related mortality is not expected to significantly reduce the regional peregrine falcon population, the possibility of collisions with project structures can not be ruled out. Therefore, the USAF should consider initiating a formal Endangered Species Act Section 7 consultation process with the USFWS.

9.4.1.1.3 Osprey.

9.4.1.1.3.1 Direct Impacts. Ospreys, like bald eagles, are probably less susceptible to collisions with stationary objects than smaller raptors because they generally fly slower and soar more frequently and would presumably have more time to see and react to objects in their flight path (Olendorff et al, 1981; Clark and Wheeler, 1987). In addition, ospreys migrating through the region are more likely to travel along river corridors where fish are available. Any ospreys that migrate through the study area are more likely to use the Tx-S CSA in wet years because of the large wetland in the CSA. In average or dry years neither the Tx-N CSA nor the Tx-S CSA provides significant habitat for the osprey. Only two osprey observations were recorded during the CRS avian surveys of 1987, 1988, and 1989; in both cases the ospreys were flying above 150 feet.

Because of the low numbers of ospreys that migrate through the study area, the potential for collisions with project-related structures is considered low, and if they occur collisions are not likely to significantly affect regional osprey populations. Because ospreys typically feed on fish and do not generally scavenge on roads (Clark and Wheeler, 1987), ospreys are highly unlikely to be killed by project-related traffic.

9.4.1.1.3.2 Indirect Impacts. Although 62 acres of wetlands would be disturbed at the Tx-N CSA and 23 acres of wetlands would be disturbed at the Tx-S CSA (Technical Study 6), this habitat is relatively unimportant to ospreys because these wetlands do not contain fish species. The James River and bordering wetlands at Sand Lake National Wildlife Refuge provide much more attractive foraging habitat. No ospreys are known to breed in either of the two Amherst CSA's. Consequently, the loss of this habitat is not expected to significantly affect migrating ospreys in the region.

9.4.1.1.4. Buff-breasted Sandpiper.

9.4.1.1.4.1 Direct Impacts. Shorebirds such as the buff-breasted sandpiper are mainly nocturnal migrants, often migrating at extremely high altitudes (Drury and Kieth, 1962; Nisbet, 1963). As a result, incidences of shorebird collisions with towers are not as common as incidences of passerine collisions (Technical Study 8). Because of their in-flight maneuverability during the day, their propensity to migrate at high altitudes at night, and the low number of individuals which migrate through the study area (one observation during CRS avian surveys), significant collision impacts on buff-breasted sandpiper populations are not expected at either the Tx-N or Tx-S CSA's.

9.4.1.1.4.2 Indirect Impacts. No buff-breasted sandpipers are known to breed in either of the two CSA's or at Sand Lake National Wildlife Refuge. During migration buff-breasted sandpipers prefer plowed and newly planted fields, wet meadows, and mowed uplands (Harrell, 1978). Nearly all the land disturbed by the CRS project at both the Tx-N and Tx-S CSA's exhibits these characteristics. It is unlikely, however, that loss of this habitat would significantly affect buff-breasted sandpiper populations because of the low number of individuals that migrate through the site and because of the abundance of available habitat in the region.

9.4.1.2 Other Species. This section addresses disturbance and removal of habitat for mammal, plant, and reptile species which may be present in the study area. The discussion of disturbed habitat in this section parallels the discussion of disturbed habitat in Technical Study 6 (Vegetation). Disturbed habitat includes areas to be used for the antennas and groundscreen in addition to land which would be converted to access roads, buildings, parking lots, and filled areas.

Native prairie type habitat supports the swift fox, burying beetle, Western prairie fringed orchid, and northern lined snake. The preliminary site layout would disturb approximately 400 acres of such habitat (native rangeland) on the Tx-N CSA and about 35 acres of such habitat (ungrazed planted grassland, ungrazed native grassland, and native rangeland) on the Tx-S CSA (Technical Study 6). Wetland habitat, which may support the Western prairie fringed orchid, would also be disturbed. On the Tx-N CSA 62 acres of wetlands would be filled or disturbed, and on the Tx-S CSA only 23 acres of wetlands would be filled or disturbed (Technical Study 6). From these figures it is apparent that the Tx-N CSA contains considerably more suitable habitat for these species than the Tx-S CSA.

The extent of potential impacts to each species depends on the number of individuals or colonies identified on the site and the vigor of populations in the region. For example, if burying beetles are identified in either of the CSA's, the impact to regional burying beetle populations may be determined to be negligible if burying beetles are found to be abundant in surrounding habitat. The extent of potential impacts might also depend on the location of the species within each CSA. Mobile species which are relatively intolerant of human activity, such as the swift fox, might be forced to relocate to nearby habitat at the initiation of the construction phase.

For non-mobile species, such as the Western prairie fringed orchid (and burying beetle to a lesser extent), three possibilities exist, depending on if and where in the CSA the species is identified. If the species is identified in a location that is to be disturbed or filled, the USAF could opt to alter the site layout to avoid the species altogether. If the USAF chooses not to alter the site layout, they must prepare a biological assessment of the species of concern at the site. If the assessment determines that the CRS project may have a significant effect on the species, the Endangered Species Act Section 7 consultation process must be initiated with the USFWS. Under the Section 7 process the USAF and USFWS would negotiate possible methods of mitigating impacts to the species.

A second possible outcome of the surveys is that a threatened or endangered species is identified within the enclosed area but outside of any proposed filled or disturbed zones. In this case a Western prairie fringed orchid colony could survive, although it is possible that in the absence of grazing the colony would eventually be eliminated due to competition from non-native weed species. A burying beetle population identified within the non-disturbed enclosed area would be affected only if adequate access to food supplies (carrion) were eliminated.

A third possible result of the surveys is that a burying beetle population or Western prairie fringed orchid colony is identified within the area acquired by the USAF but outside the enclosed area. In such a case, protection of this area from further disturbance and human activity could protect the population. Periodic management efforts, such as control of competing vegetation, could help to maintain an orchid colony as a viable population. Nonetheless, protection of Western prairie fringed orchid colonies outside of the enclosed area would not necessarily result in maintenance of the population. Groundwater levels must be adequate to provide the orchid with moist soils at most times of the year. Even if the species were protected from human activity, significant alterations of surface and groundwater hydrology could eliminate it from the site. If the orchid were identified in an area potentially affected by alterations in local hydrology, efforts to artificially create favorable hydrological conditions could be undertaken to ensure the species' survival.

9.4.1.3 Summary and Conclusions: Transmit Site. With one exception, for most of the species discussed the Tx-N CSA contains more suitable habitat (native prairie and wetlands) than the Tx-S CSA. Moreover, according to the preliminary site layout more acres of habitat would be disturbed at the Tx-N CSA than at the Tx-S CSA. The principal exception is the large wetland that forms at Tx-S in wet years or years with abnormal spring runoff conditions. Under these conditions the Tx-S CSA provides preferable habitat for the bald eagle, peregrine falcon, and osprey.

Although significant impacts to threatened and endangered birds are unlikely at either CSA, the possibility of bald eagle and peregrine falcon collisions cannot be eliminated. For these two species the USAF should maintain coordination with the USFWS and consider initiating a formal Endangered Species Act Section 7 consultation process to assess potential impacts and evaluate possible mitigation measures.

9.4.2 Receive Site

9.4.2.1. Gray Wolf. The nearest permanent population of gray wolves is at Agassiz National Wildlife Refuge (USFWS, 1990c). The Thief River Falls study area is outside the peripheral range of the gray wolf and contains little suitable habitat. It is highly unlikely that gray wolves would stray as far south and west as the receive site. If they do, the fence surrounding the CRS facilities would prevent wolves from contact with any project structures. As a result, the CRS project is not expected to significantly affect regional gray wolf populations (USFWS, 1990b).

9.4.2.2 Birds. The following impact discussion will mirror the impact discussion for the transmit site. Potential impacts (collisions with structures and vehicles and loss of habitat) are similar; however, at the receive site the maximum height of the structures would be 65 feet rather than 150 feet (Technical Study 2, Facilities). The following federal and state-listed threatened and endangered bird species were observed during the CRS avian surveys of 1987, 1988, and 1989: bald eagle, peregrine falcon, Sprague's pipit, and loggerhead shrike. Impacts to species not observed in the study area during these avian surveys are considered negligible.

9.4.2.2.1 Bald Eagle.

9.4.2.2.1.1 Direct Impacts. The general flight patterns and behavior of bald eagles as they relate to the potential for collisions are discussed in section 9.4.2.1.1. No bald eagles are known to nest in either of the two Rx CSA's; the only eagles present in the area are likely migratory. Within the Rx-W CSA, only 20 percent of the bald eagles recorded were observed flying under 65 feet. On the Rx-E CSA 57 percent of eagles observed within the Rx-E CSA were observed flying under 65 feet. The larger number and lower flight of eagles observed at the Rx-E CSA is likely attributable to the proximity of that CSA to the Goose Lake wetland complex. However, given the presently increasing status of bald eagle populations in the region, project-related mortality at either location is not expected to jeopardize the continued existence of the regional bald eagle population. Nevertheless, since collisions cannot be ruled out, particularly at the Rx-E CSA, the USFWS should consider initiating a formal consultation process with the USFWS to further assess potential impacts and possible mitigation measures.

Collisions with project-related vehicles can be reduced through implementation of vehicle speed restrictions and prompt removal of carcasses. The potential for an increase in road-killed bald eagles at either Rx-E or Rx-W is similar to that for the Tx sites because the increase in traffic would be the same. Collisions with vehicles are not expected to constitute a significant impact on bald eagle populations.

9.4.2.2.1.2 Indirect Impacts. The CRS project would require the disturbance or filling of approximately 260 acres of habitat (upland prairie and wetlands) at the Rx-E CSA and about 80 acres of habitat (upland prairie and wetlands) at the Rx-W CSA (Technical Studies 5 and 6). However, this habitat is not unique, given the preponderance of similar and more favorable habitat in the region. Loss of this habitat is not anticipated to significantly affect migrating bald eagles.

9.4.2.2.2. Peregrine Falcon.

9.4.2.2.2.1 Direct Impacts. The flight patterns and behavior of peregrine falcons as they relate to the potential for collisions are discussed in section 9.4.1.1.2. No peregrine falcons are known to nest in either of the two CSA's. However, at least nine peregrine observations were recorded during the CRS 1987, 1988, and 1989 avian surveys; three at the Rx-W CSA and four at the Rx-E CSA. In most (seven of nine) of the observations at both sites the peregrines were soaring above 65 feet. Because of the relatively small numbers of peregrines that migrate through the site and the relatively high flight altitudes recorded, it is unlikely that project-related mortality would have a significant impact on regional peregrine populations. Nonetheless, it is possible that over the lifetime of the project a few peregrines may collide with the antenna while foraging. Because of this possibility, formal consultation with the USFWS in accordance with Section 7 of the Endangered Species Act should be considered as a future step in evaluating potential impacts and mitigation.

The potential for an increase in road-killed peregrine falcons at either Rx-E or Rx-W is similar to that for the Tx sites because the increase in traffic would be the same. Peregrine falcons generally do not feed on road-killed animals. Therefore, collisions with vehicles are not expected to cause a significant impact on peregrine falcon populations.

9.4.2.2.2.2 Indirect Impacts. The CRS project would require the disturbance or filling of approximately 260 acres of habitat (upland prairie and wetland) at the Rx-E CSA and 80 acres of habitat (upland prairie and wetland) at the Rx-W CSA (Technical Studies 5 and 6). However, this habitat is not unique, given the availability and proximity of similar and more favorable habitat in the region. Loss of this habitat is thus not anticipated to significantly affect migrating peregrine falcons.

9.4.2.2.3. **Sprague's Pipit and Loggerhead Shrike.**

9.4.2.2.3.1 **Direct Impacts.** Sprague's pipit and the loggerhead shrike, like most passerines, are low-flying migrants that are unlikely to travel through the study area in large numbers (USFWS, 1986a). Although these two species are much smaller than waterfowl and raptors, they nonetheless have only a small chance of passing unharmed through the 24 inch by 24 inch wire mesh that would comprise the lower portion of the backscreen (Technical Study 2). However, few if any collisions with the structure are likely over the lifetime of the project because both species are only accidental migrants. This low rate of mortality is not expected to significantly reduce regional populations of these species. Furthermore, both Sprague's pipit and the loggerhead shrike do not generally forage along roadsides, and collisions with project-related vehicles are therefore expected to be a negligible mortality factor.

9.4.2.2.3.1 **Indirect Impacts.** Sprague's pipit prefers dry native grasslands. The CRS project would disturb or remove approximately 245 acres of such habitat (ungrazed planted grassland) at the Rx-E CSA and 75 acres of habitat at the Rx-W CSA. The loggerhead shrike prefers both grasslands and shelterbelts; no shelterbelts would be removed at the Rx-E CSA, and one acre of shelterbelts would be removed at the Rx-W CSA. However, because of the considerable amount of similar habitat in the region and the relatively low number of Sprague's pipits and loggerhead shrikes that depend on habitat within the CSA's, loss of this habitat would not significantly affect migrating populations of Sprague's pipits or loggerhead shrikes.

9.4.2.3 **Other Species.** This section addresses disturbance and removal of habitat for species whose presence on the Rx sites will remain undetermined until rights-of-entry are obtained and comprehensive surveys are conducted. These species include the federally listed Western prairie fringed orchid and state-listed assiniboia skipper, Hall's sedge, sterile sedge, indian ricegrass, annual skeleton weed, and hair-like beak rush. As stated in the preceding section, disturbed habitat consists of land which would be converted by the antenna and groundscreen to roads, buildings, and parking areas.

Native prairie type habitat typically supports the federally listed Western prairie fringed orchid and the state-listed assiniboia skipper, Hall's sedge, sterile sedge, and hair-like beak rush. The preliminary site layout would disturb approximately 245 acres of such habitat (ungrazed planted grassland) on the Rx-E CSA and 75 acres of such habitat on the Rx-W CSA (Technical Study 5). Wetland habitat, which may support each of the plants listed above, would also be disturbed. On the Rx-W CSA approximately fifteen acres of wetlands would be filled or disturbed, and on the Rx-E CSA approximately four acres of wetlands would be filled or disturbed (Technical Study 6).

From these figures it is apparent that the likelihood of one or more of these prairie-dependent species being disturbed at the Rx-E CSA is greater than that at the Rx-W CSA because of the greater amount of habitat that would be disturbed at Rx-E. The most probable location of all these species is along the ancient beach of the Glacial Lake Agassiz near the center of the Rx-E CSA (Figure 9-13). This location contains sandy soils and groundwater seepage areas that provide excellent habitat for these species. Any surveys for vegetation in the Rx-E CSA should therefore be concentrated along this location.

As is the case with the transmit site, the extent of impacts to these species would depend on their specific location in relation to the preliminary layout of the structure. The possibilities and ramifications of identifying threatened and endangered species within the CSA's are outlined in section 9.4.1.2. Species identified outside the disturbed area would likely be unaffected by CRS activities and could be protected by periodic management. If the surveys indicate the presence of the threatened or endangered species within the area designated as the preferred layout, the CRS project could significantly affect the species, and Section 7 consultation with the USFWS, including preparation of a biological assessment, would be required. Although no such requirement applies to state-listed species, efforts would be made, where practicable, to avoid these species.

9.4.2.4 Summary and Conclusions: Receive Site. Although the Rx-E and Rx-W CSA's contain similar habitat, the potential for impacts to threatened and endangered species is probably greater at Rx-E than at Rx-W because more potential habitat would be disturbed at the Rx-E CSA. Plants such as the Western prairie fringed orchid are more likely to occur in the Rx-E CSA because of the unique habitat provided by the ancient beach ridge of the Glacial Lake Agassiz. Vegetation survey efforts should focus on this habitat. Furthermore, the comparatively larger area of grasslands at Rx-E may make that site more attractive to state-listed birds such as the Sprague's pipit and loggerhead shrike. Data from the avian surveys indicates that the Rx-E CSA may be more attractive to the bald eagle and peregrine falcon, probably because of the proximity of that CSA to the Goose Lake wetland complex. Because collision impacts to the bald eagle and peregrine falcon at either site can not be ruled out, the USAF should maintain coordination with the USFWS and consider initiating an Endangered Species Act Section 7 process to further evaluate the potential impacts to the bald eagle and peregrine falcon.

9.5 POSSIBLE MITIGATION MEASURES

9.5.1. Birds

In 1987 the USAF initiated an effort for the Alaskan Radar System (ARS) to redesign both the transmit and receive antenna structures so that bird collision impacts would be reduced. This effort resulted in the replacement of the wire-mesh backscreen with a more open and visible lattice structure above certain heights (75 feet on the A and B bands of the transmit antenna and 35 feet on entire length of the receive antenna, Technical Study 1). This redesigned antenna will also be utilized for the CRS. This measure is expected to significantly reduce the potential for collisions, as the ability of avian species to see and avoid the transmit and receive structures, or to pass through the structures, will be improved for heights above 75 and 35 feet, respectively. In addition, the USAF will consult with state and federal agencies to determine appropriate measures to enhance the visibility of the antenna.

A monitoring program may be designed to help further determine the extent of impacts and required mitigation. If collisions with structures are observed, as determined by a collision monitoring program, various methods (e.g. streamers, balls, and other marking devices) can be used to make the antennas more visible. These devices have been used successfully to reduce bird collisions with power lines during daylight hours, when bald eagles and peregrine falcons are most active (Beaulaurier, 1981; Faanes, 1987).

Methods to mitigate loss of native prairie and wetlands at the transmit and receive sites, as discussed in Technical Studies 5 and 6, would also mitigate losses of habitat for threatened and endangered birds.

9.5.2. Other Species

Detailed methods to mitigate impacts to threatened and endangered mammals, plants, reptiles, and insects will not be developed unless new information, including any future surveys, indicate that these species are present in the CSA's. No mitigation for threatened and endangered mammals (swift fox and gray wolf) is considered necessary because of the unlikeliness of these species occurring in the study areas. As discussed in section 9.4.1.2, if plants are identified on the site, mitigation may consist of simply altering the site design to avoid the location of these plants. Other possible mitigation for plants includes protection and enhancement of plant colonies identified within the CSA but outside of the proposed disturbed area. Enhancement might include locally controlling the surface and groundwater to create favorable habitat conditions. Such a program could include seasonal monitoring to ensure the survival and propagation of the species. As a last resort, the possibility of transplanting plant colonies to a protected site could be investigated. Mitigation for threatened and endangered insects and reptiles might also include avoidance, protection and enhancement of habitat, and transplant of colonies as a last resort.

REFERENCES

Arctic Environmental Information and Data Center (AEIDC), 1987. Avian Flight Behaviors During Migration in Relation to Environmental Factors: A Literature Review. Unpublished report for Metcalf & Eddy/Holmes and Narver, Wakefield, MA.

Beaulaurier, D., 1981. Mitigation of Bird Collisions with Transmission Lines. Bonneville Power Administration, Portland, OR.

Clark, W. and B. Wheeler, 1987. A Field Guide to Hawks. Houghton Mifflin Co. Boston.

Cochran, W., 1988. Factors Affecting Peregrine Concentrations in Coastal Areas. In: T. Cade, J. Enderson, C. Thelander, and C. White (eds.). Peregrine Falcon Populations, Their Management and Recovery. The Peregrine Fund, Inc. Boise, ID.

Cochran, W., and R. Applegate, 1986. Speed of Flapping Flight of Merlins and Peregrine Falcons. The Condor. 88(3):397-398.

Coffin, B. and L. Pfannmuller, ed., 1988. Minnesota's Endangered Flora and Fauna. University of Minnesota Press. Minneapolis.

Conant, R., 1975. A Field Guide to Reptiles and Amphibians of Eastern and North Central America. Second Edition. Houghton Mifflin Co., Boston.

Drury, W., and J. Keith, 1962. Radar Studies of Songbird Migration in Coastal New England. Ibis. 104(4): 449-489.

Faanes, C., 1987. Bird Behavior and Mortality in Relation to Power Lines in Prairie Habitats. U.S. Fish and Wildlife Service, Fish and Wildlife Technical Report 7.

Farrand, J., Jr. (ed.), 1983. The Audubon Society Master Guide to Birding, Volume I. Alfred A. Knopf, Inc. New York, NY.

Fritts, S. and L. Mech, 1981. Dynamics, Movements, and Feeding Ecology of a Newly Protected Wolf Population in Northwestern Minnesota. Wildlife Monographs No. 80. A publication of the Wildlife Society.

Haig, S., and L. Oring, 1987. Population Studies of Piping Plovers at Lake of the Woods, Minnesota, 1982-1987. The Loon, vol. 59, pp. 112-117.

Harrell, (ed.), 1978. The Birds of South Dakota: an Annotated Checklist. The South Dakota Ornithologists Union with the Cooperation of the W.H. Over Museum. Vermillion, South Dakota.

Hickey, J.D. (ed.), 1969. Peregrine Falcon Populations: The Proceedings of an International Conference Sponsored by the University of Wisconsin, 1965. The University of Wisconsin Press, Madison, WI.

Houtcooper, W., Ode, D., Pearson, J., and G. Vandel III, 1985. Rare Plants and Animals of South Dakota. Prairie Naturalist 17(3), pp. 143-165. Published by the South Dakota Natural Heritage Program of the South Dakota Department of Game, Fish, and Parks.

Jannsen, R., 1987. Birds In Minnesota. University of Minnesota Press, Minneapolis.

Jones and Stokes Associates, 1987. Biological Assessment for the Bald Eagle at the Over-the Horizon Backscatter Radar Receive Site Modoc National Forest. Prepared for the U.S. Air Force, Air Force Systems Command, Electronic Systems Division, Hanscom AFB, MA.

Kannowski, P. (ed.), 1979. Fish and Wildlife Resources Technical Paper on the James River Basin, North and South Dakota. Institute for Ecological Studies, University of North Dakota Research Report No. 29. Grand Forks, ND.

Minnesota Department of Natural Resources, 1984. Checklist of Endangered and Threatened Animal and Plant Species of Minnesota.

Nisbet, I., 1963. Measurement with Radar of the Height of Nocturnal Migration over Cape Cod, Massachusetts. Bird Banding 34(2): 57-67.

Olendorff, R., A. Miller, and R. Lehman, 1981. Suggested Practices for Raptor Protection on Power Lines: The State of the Art in 1981. Raptor Research Report No. 4, Raptor Research Foundation, Inc.

Olendorff, R., and R. Lehman, 1986. Raptor Collisions with Utility Lines: An Analysis Using Subjective Field Observations. Final report prepared for Pacific Gas and Electric Company, San Ramon, CA.

Paradiso, J., and R. Nowak, 1987. Wolves. In: Chapman, J., and G. Feldhamer, ed., Wild Mammals of North America: Biology, Management, and Economics. The Johns Hopkins University Press, Baltimore.

Roseneau, D., C. Tull, and R. Nelson, 1981. Protection Strategies for Raptors Along the Planned Northwest Alaskan Pipeline Company by LGL Alaska Research Associates, Inc.

Sayler, R., Willins, M., and N. Seabloom, 1988. Wildlife Resources and Avian Migration Chronology in Northwestern Minnesota and Northeastern South Dakota. Institute for Ecological Studies, University of North Dakota Research Report No. 38. Grand Forks, ND.

Samuel, D., and B. Nelson, 1987. Foxes. In: Chapman, J., and G. Feldhamer, ed., Wild Mammals of North America: Biology, Management, and Economics. The Johns Hopkins University Press, Baltimore.

United States Air Force (USAF), 1987. Final Environmental Impact Statement: Proposed Central Radar System, Over-Horizon-Backscatter Radar Program. Electronic Systems Design (ESD), Hanscom AFB, MA.

United States Air Force (USAF), 1988. Record of Decision: Central Radar System, Over-the-Horizon Backscatter Radar Program. Electronic Systems Design (ESD), Hanscom AFB, MA.

U.S. Congress, 1987. 50 CFR Chapter 1 (1 October 1987 Edition). Subpart D: Threatened Wildlife.

United States Fish and Wildlife Service (USFWS), 1983. Northern States Bald Eagle Recovery Team. Prepared by USFWS, Twin Cities, MN.

United States Fish and Wildlife Service (USFWS), 1986a. Whooping Crane Recovery Plan. U.S. Fish and Wildlife Service, Albuquerque, NM.

United States Fish and Wildlife Service (USFWS), 1986b. Checklist for Birds at Agassiz National Wildlife Refuge, MN.

United States Fish and Wildlife Service (USFWS), 1987. Eastern Peregrine Falcon Recovery Plan. Prepared by USFWS, Newton Corner, MA.

United States Fish and Wildlife Service (USFWS), 1988. Great Lakes and Northern Great Plains Piping Plover Recovery Plan. Prepared by USFWS, Twin Cities, MN.

United States Fish and Wildlife Service (USFWS), 1989a. Letter from M.S. Zschomler, South Dakota State Supervisor, to Interested Party (October 12).

United States Fish and Wildlife Service (USFWS), 1989b. Personal communication with N. McPhillips, Threatened and Endangered Species Coordinator, Minneapolis, MN. (December 12).

United States Fish and Wildlife Service (USFWS), 1989c. 50 CFR Part 17. Rules and Regulations for 50 CFR Part 17, Endangered and Threatened Wildlife and Plants, Determination of Endangered Status for the American Burying Beetle. Vol. 54, No. 133. July 13.

United States Fish and Wildlife Service (USFWS), 1989d. 50 CFR Part 17. Rules and Regulations for 50 CFR Part 17, Endangered and Threatened Wildlife and Plants, Determination of Threatened Status for Eastern and Western Prairie Fringed Orchid. Vol. 54, No. 187. September 29.

United States Fish and Wildlife Service (USFWS), 1990a. Letter from M.S. Zschomler, South Dakota State Supervisor, to R. L. Goodner, CRS Program Manager (January 22).

United States Fish and Wildlife Service (USFWS), 1990b. Letter from R.F. Welford, Field Office Supervisor, to R.L. Goodner, CRS Program Manager (January 18).

United States Fish and Wildlife Service (USFWS), 1990c. Personal communication with A. Bennett, Biologist at Agassiz National Wildlife Refuge, MN. (January 30).

United States Fish and Wildlife Service (USFWS), 1990d. Personal communication with W. Schultz, Biologist at Sand Lake National Wildlife Refuge, SD. (January 31).

TECHNICAL STUDY 10

CENTRAL RADAR SYSTEM
OVER-THE-HORIZON BACKSCATTER RADAR PROGRAM

POWER CORRIDORS BIOLOGICAL RESOURCES

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10.1 INTRODUCTION

The U.S. Air Force (USAF) has proposed to construct an Over-The-Horizon Backscatter (OTH-B) Central Radar System (CRS) in the north central United States. In its Record of Decision (USAF, 1988), the USAF selected a study area near Amherst, South Dakota for the transmit facilities and a study area near Thief River Falls, Minnesota, for the receive facilities (Figure 10-1). As described in Technical Study 1, Environmental Impact Analysis Process Overview (EIAP), the USAF has narrowed the proposed location of the facilities to two concentrated study areas (CSAs) within each study area (Figures 10-2 and 10-3).

Both the transmit and receive facilities will require electric power from an external source. Power will be provided at the transmit site by overhead transmission lines and at the receive site by either overhead or underground lines. Power lines for the transmit site will be constructed by the U.S. Department of Energy, Western Area Power Administration (Western). The transmit power lines will originate at substations near Groton, South Dakota and Forman, North Dakota. Power for the transmit site will be supplied by an independent electric company through competitive bidding. Power for the receive site will originate from one of three substations: a PKM Electric Cooperative substation in Radium, Minnesota, or one of two Red Lake Electric Cooperative substations near Thief River Falls, Minnesota.

This Technical Study describes the existing environment within the selected power line study areas and evaluates the environmental impacts associated with constructing and operating the CRS power lines. In addition, this study describes the screening process used in defining potential corridors for the transmit and receive site power lines.

10.2 POWER LINE ENVIRONMENTAL IMPACT ANALYSIS PROCESS OVERVIEW

The EIAP for the power line corridors involved screening possible power line corridors, evaluating existing environmental conditions within the corridors, and assessing potential environmental impacts to these corridors. The process

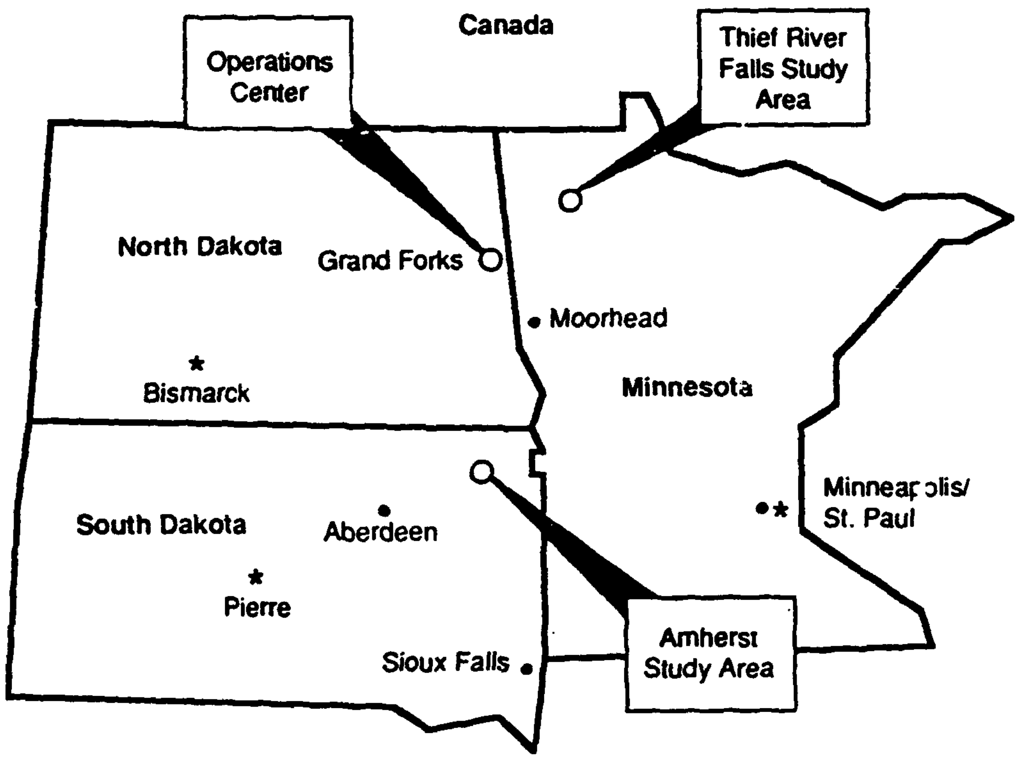

FIGURE 10-1. LOCATION OF THE CENTRAL RADAR SYSTEM TRANSMIT AND RECEIVE STUDY AREAS

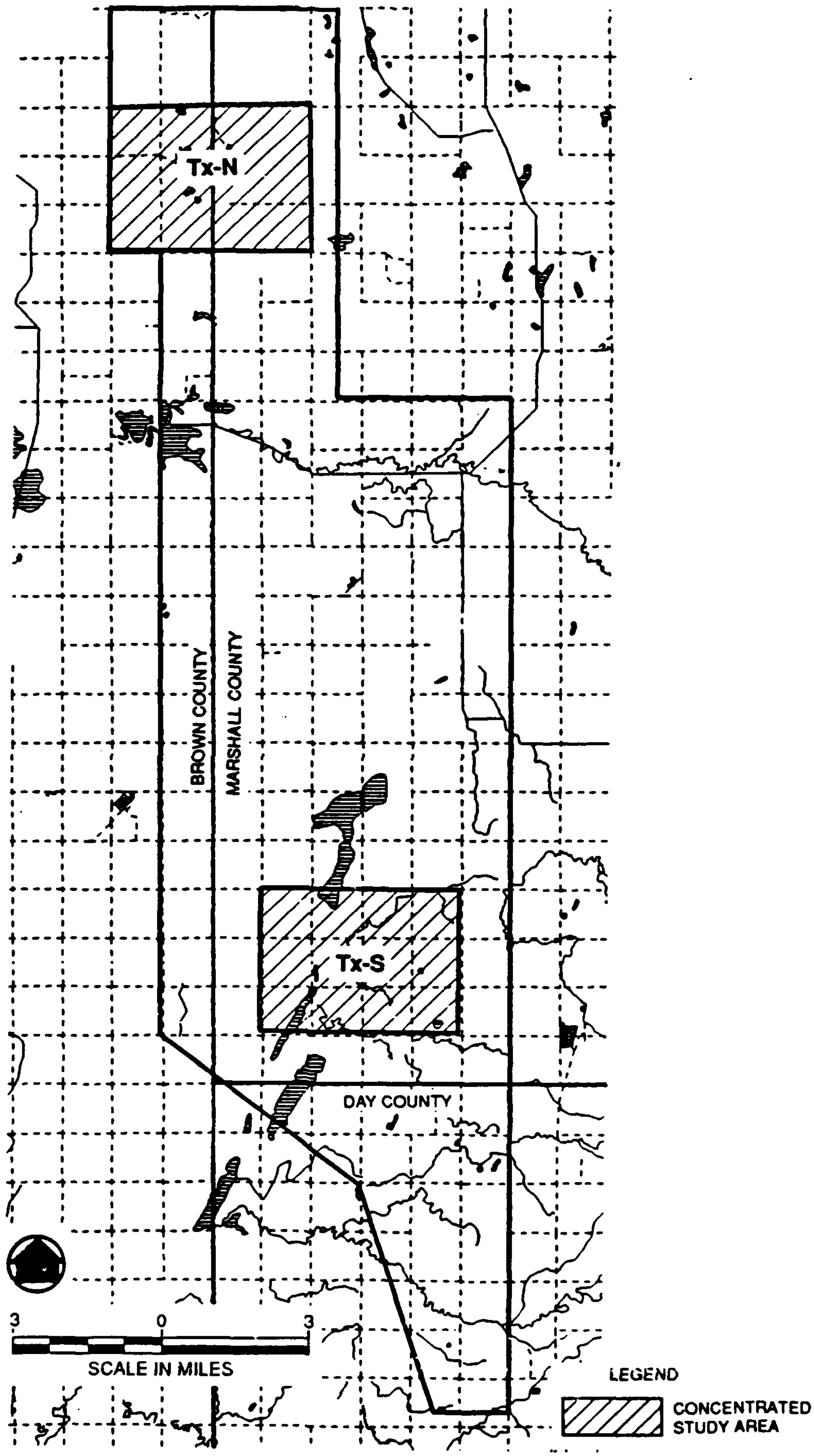

FIGURE 10-2. AMHERST TRASNMIT STUDY AREA AND CONCENTRATED STUDY AREAS

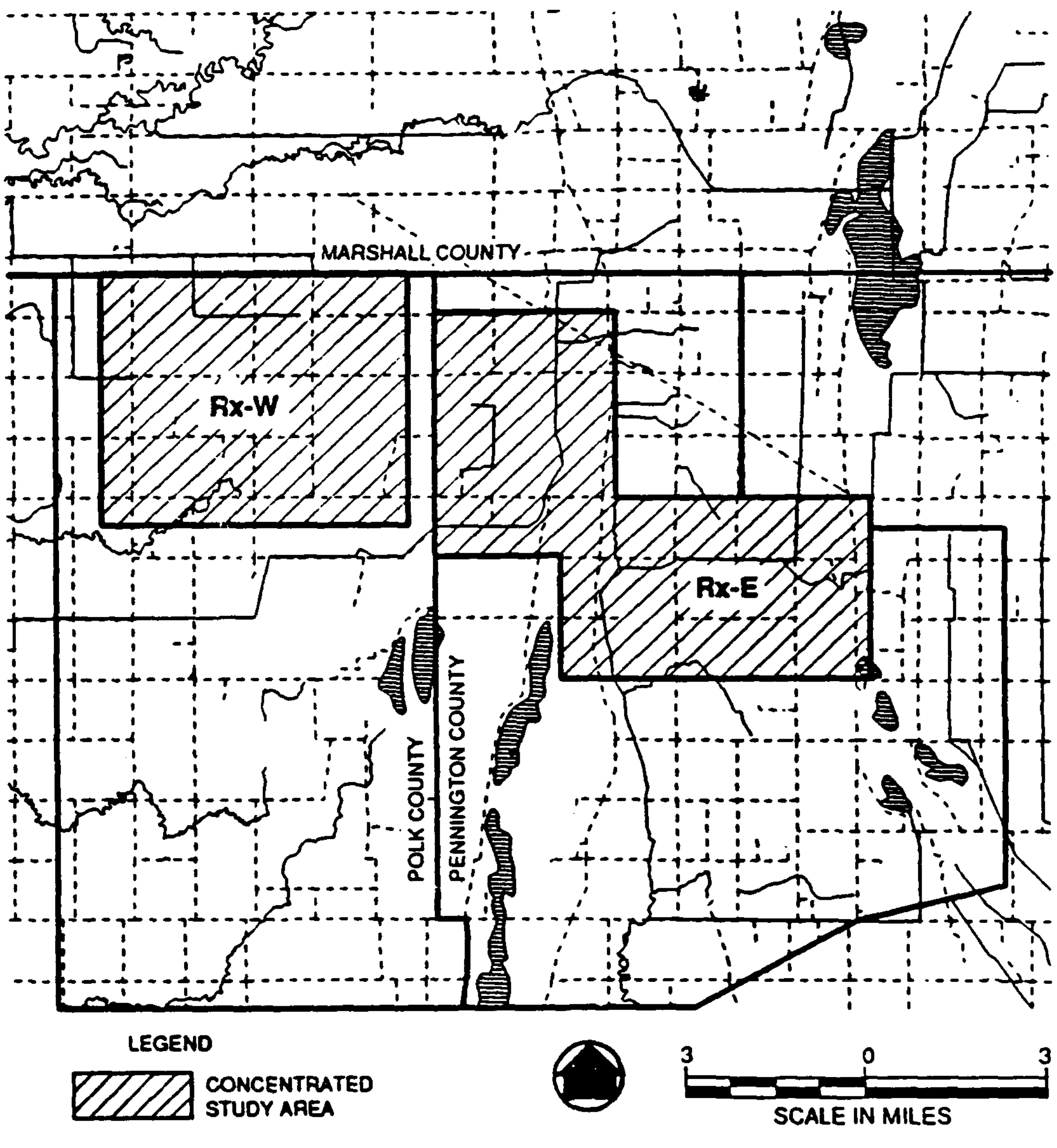

FIGURE 10-3. THIEF RIVER FALLS RECEIVE STUDY AREA AND CONCENTRATED STUDY AREAS

of selecting power line corridors differed substantially between the transmit and receive sites. This process is discussed in section 10.2.1 for the transmit site and in section 10.2.2 for the receive site.

In accordance with the 1988 Record of Decision, the USAF established environmental agency review meetings in December, 1989. In addition to the state agencies, the U.S. Fish and Wildlife Service (USFWS) and U.S. Army Corps of Engineers (COE) participated in these meetings. Consultation continued with agencies throughout the EIAP. The USAF also held public scoping meetings in Britton, South Dakota, and Thief River Falls, Minnesota, after selection of alternate power line corridors.

Agency consultation will also be required for the preparation of a Borrower's Environmental Report (BER) by the receive site power supplier. The Rural Electrification Association will require the supplier to prepare a BER, which generally includes a project description, a presentation of alternatives to the project, and analysis of existing environmental conditions and potential project impacts (PKM, 1989; RLEC, 1989). The receive site power supplier should consult with the USFWS, COE, Department of Interior, Soil Conservation Service, Department of Agriculture, state and county Historical Societies, and state Department of Natural Resources during preparation of the BER.

10.2.1 Transmit Site Power Lines

10.2.1.1 Background

Western will construct and maintain the transmit site power lines. Overhead 115 kilovolt (kV) power lines will provide electricity to the CRS transmit facility. Power lines will be constructed to the transmit facility from Western substations near Groton, SD, and Forman, ND (Figure 10-4). Power will be provided through one substation as the primary feeder. The other substation will keep the line energized on standby in case the power system has a malfunction or power interruption. At both substations, Western will control the wheeling and switching of power to the site.

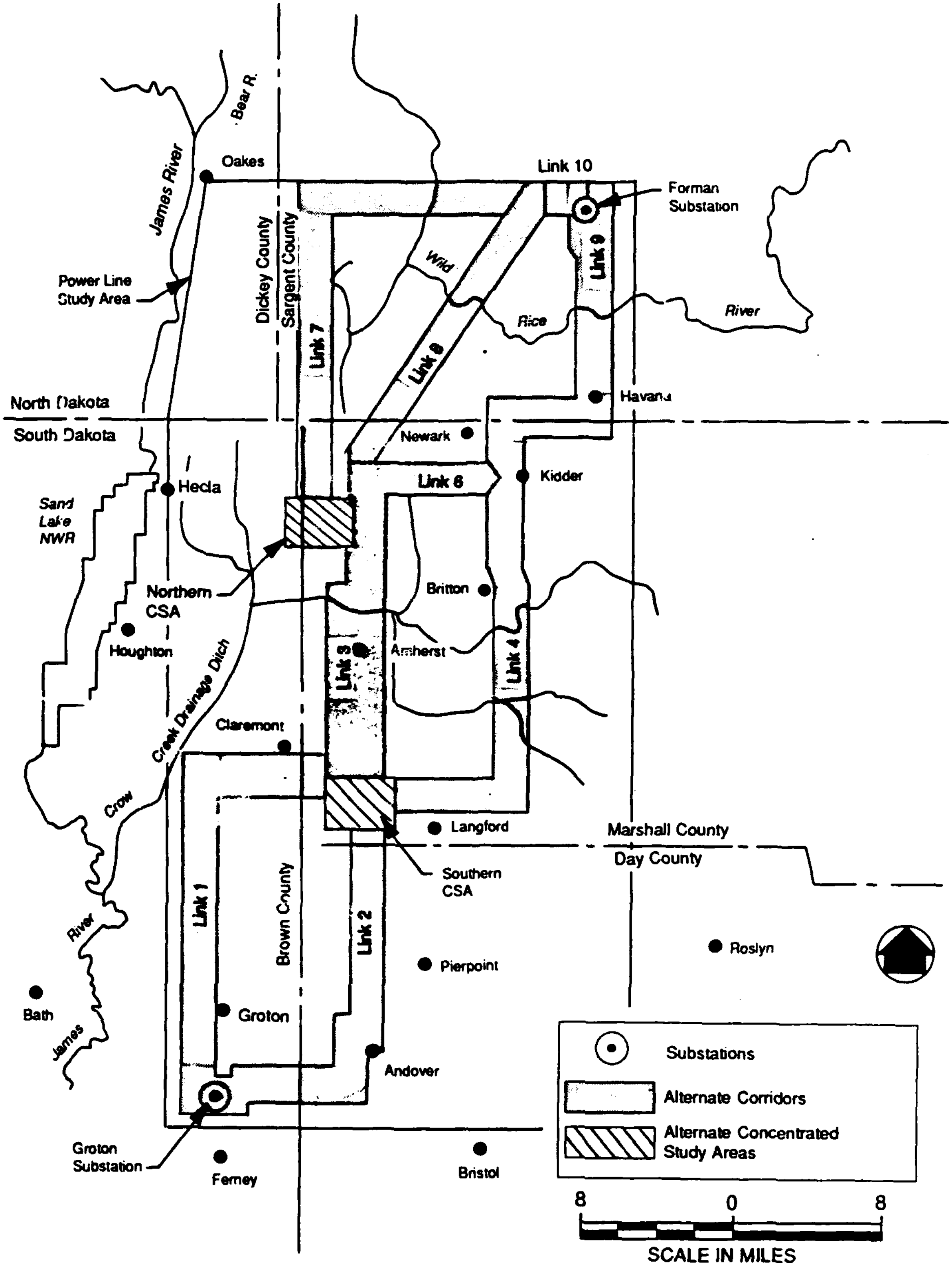

FIGURE 10-4. TRANSMIT SITE POWER LINE CORRIDORS

10.2.1.2 Selection of Transmit Power Line Study Area

A 1500 square mile power line study area was selected for the transmit power lines based on the locations of the two CSAs and the two Western substations (Figure 10-4). The power line study area was selected to include all probable areas the power line could traverse from the two substations to the two CSAs. The power line study area is bounded by North Dakota Highway 11 to the north, the James River to the northwest, a line parallel to South Dakota Route 37 to the west, a line nine miles south of Groton to the south, and a line eleven miles east of Langford to the east. The power line study area encompasses parts of Brown, Marshall, and Day Counties in South Dakota and parts of Sargent and Dickey Counties in North Dakota. The James River, and more specifically, Sand Lake and Dakota Lake National Wildlife Refuges, which are critically important areas for migrating waterfowl, were not included in the power line study area.

Other transmit site power alternatives that were considered but rejected for operational and environmental reasons included constructing both lines from one substation and running one of the lines off an existing power line. The need for ensuring backup power in case of failure of a primary line precluded use of only one substation, since loss of power at the substation would affect both lines. Tapping into an existing line was ruled out for several reasons. First, tapping into either Western's Groton-Ellendale line or Groton-Summit line would require construction of a new substation at the intersection of the new and existing lines. Construction of a new substation would be cost prohibitive and could have potentially significant environmental impacts. Second, tapping into Western's line from Groton to Ellendale, North Dakota would require several miles of east-west line in or near Sand lake National Wildlife Refuge, causing a relatively high probability of bird collisions.

Alternative corridors were selected within the power line study area from the Groton and Forman substations to each CSA (Figure 10-4). Each corridor is roughly two miles wide. The actual power line will be located on a 125 foot wide right-of-way (ROW) that could be placed anywhere within the corridor.

Three steps were used in the corridor selection process: establishment of environmental criteria, resource mapping, and final selection.

The environmental criteria used in selecting alternate power line corridors within the power line study area were determined by the USAF, in consultation with Western and state and federal natural resource agencies. The following agencies were contacted: North Dakota Department of Game and Fish; North Dakota Parks and Recreation Department; U.S. Fish and Wildlife Service, Kulm, N.D., Wetlands Management District Office; U.S. Fish and Wildlife Service, Tewaukon, N.D., Wetlands Management District Office; South Dakota Game Fish and Parks Department; U.S. Fish and Wildlife Service regional office, Pierre, S.D.; U.S. Fish and Wildlife Service regional office, Bismarck, N.D.; U.S. Army Corps of Engineers Regulatory Branch, Omaha District, Pierre, S.D., and the South Dakota Department of Transportation, Pierre, S.D.

The power line corridors were selected in consideration of exclusion areas and avoidance areas. Exclusion areas are areas through which the power line should not cross, and include, but are not necessarily limited to, the following:

- National Wildlife Refuges
- National historic sites
- Known cultural and archaeological sites
- Homes and public facilities
- Local, state, and federal parks and recreation areas

Avoidance areas are areas through which the power line should not be routed unless there is no reasonable alternative. Avoidance areas included the following:

- Semi-permanent and permanent wetlands listed on the USFWS National Wetlands Inventory (NWI) maps
- USFWS Waterfowl Production Areas (WPAs)
- State Waterfowl Management Areas (North Dakota) and Game Production Areas (South Dakota)

- Known and potential threatened and endangered species habitat
- Population centers
- Shelterbelts, prime farmland, and center pivot irrigation systems

In addition to designating exclusion and avoidance criteria, the USAF attempted to minimize disturbance caused by the CRS power line corridors by maximizing the use of existing rights-of-way. To achieve this goal, several population centers were included within alternative corridors, but these population centers can be avoided when selecting the final alignment of the ROW within the two-mile wide corridor.

Once the criteria for corridor selection were established, the important resources in the transmit power line study area were mapped using the following sources: USGS 7.5 minute series topographic maps, USFWS National Wetlands Inventory (NWI) maps, U.S. Geological Survey National High Altitude Photographs (USGS NHAP) 1:24,000 color infrared aerial photos, and investigations by the U.S. Bureau of Reclamation in conjunction with the Garrison Diversion Project. The NWI maps were the primary source of information for locating and identifying wetlands.

The available information was compiled and transcribed onto a composite base map of the power line study area. All exclusion areas and avoidance areas (particularly areas with a high density of wetlands) were mapped, as were natural heritage records of important wildlife observations and habitat (e.g. greater prairie chicken, *Tympanuchus cupido*, booming grounds), population centers and potential historic sites (Figure 10-5).

Using the established criteria as a basis, several two-mile-wide corridors were selected for further study. To facilitate analysis, the corridors have been divided into separate links (Figure 10-4). One or more links comprise a

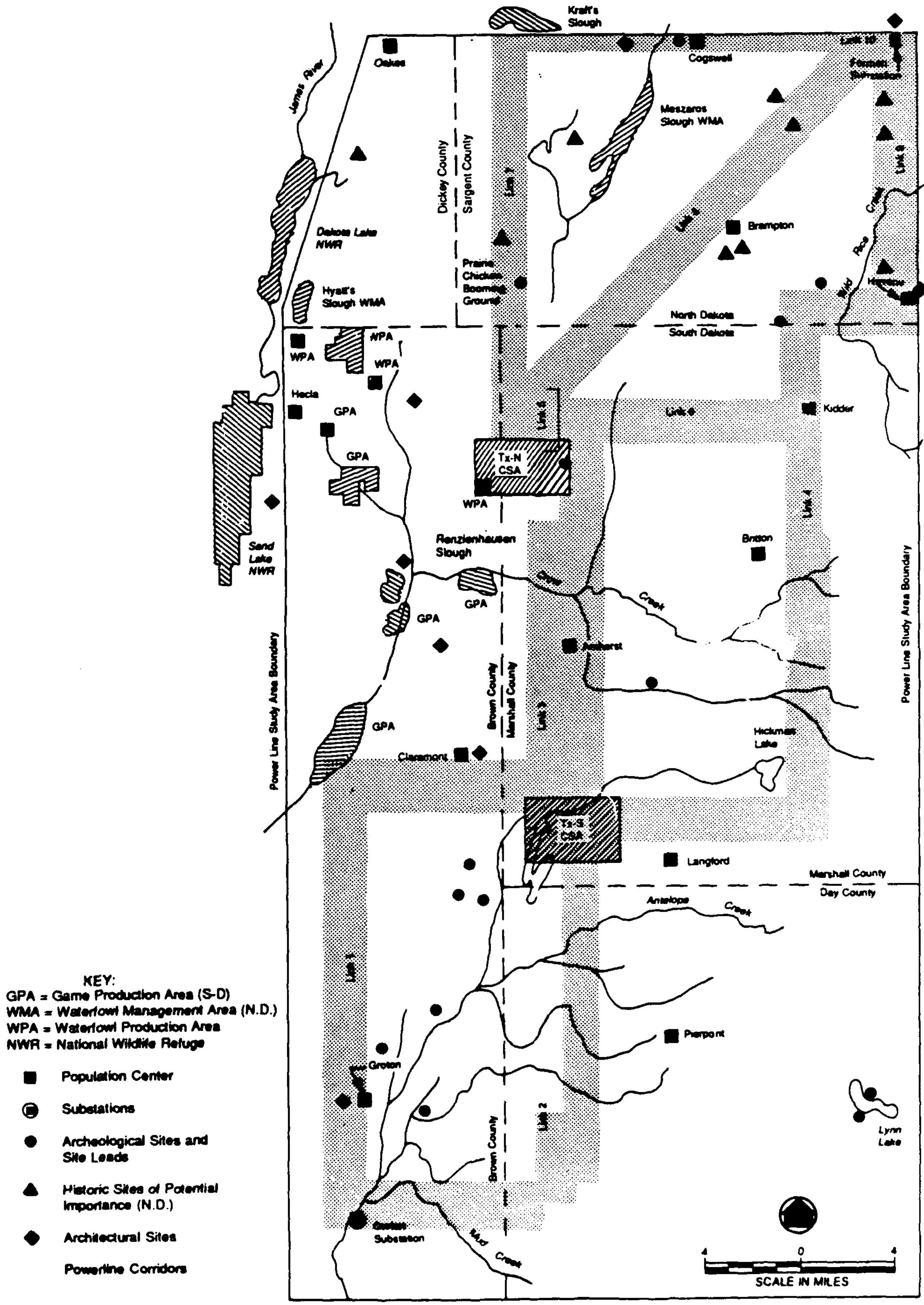

FIGURE 10-5. IMPORTANT RESOURCES IN THE TRANSMIT POWER LINE STUDY AREA

specific corridor, and the corridors are labeled according to their component links. Two corridors have been delineated from the Groton substation to each of the transmit CSAs (corridors 1 and 2 to the Tx-S CSA and corridors 1-3 and 2-3 to the Tx-N CSA). Three corridors have been selected from the Forman substation to the Tx-N CSA (corridors 10-7, 8-5, and 9-6-5), and four corridors (corridors 8-5-3, 9-6-5-3, and 9-4) were chosen from Forman to the Tx-S CSA.

All exclusion areas and most of the avoidance areas listed in section 10.2.1.4 were avoided. Wetlands and areas of crop land were impossible to avoid completely because of their abundance and distribution in the study area. Other criteria, such as homes, must be avoided once the final power line routes are established. With the exception of one diagonal link from Forman to the Tx-N CSA (Link 8), which was included for both environmental and cost reasons, the proposed corridors maximize the use of existing power line and road rights of way.

Important resources in the North Dakota portion of the power line study area include Meszaro's Slough and Hyatt's Slough State Waterfowl Management Areas (WMAs), seven federal WPAs, the proposed Kraft's Slough National Wildlife Refuge, and a prairie chicken booming ground area just north of the state border. Prairie chickens are listed as threatened in North Dakota (ND Game and Fish Dept., 1986; U.S. Department of the Interior, 1979). Meszaros' and Hyatt's sloughs are the largest permanent wetlands in the North Dakota portion of the power line study area. Both WMAs are important resting areas for migrating waterfowl, particularly mallards (*Anas platyrhynchos*) and snow geese (*Chen caerulescens*) (Technical Study 8, Avian Resources). The WPAs also provide important nesting, resting and feeding habitat for migrating waterfowl. All WPAs and WMAs were avoided during the corridor selection process. Kraft's Slough is just north of the power line study area border. Because of its unique pattern of water and vegetation interspersion, it supports an exceptionally large number of migrating and breeding birds, including as many as 10,000 breeding pairs of Franklin's gulls (*Larus pipixcan*) in some years (U.S. Department of the Interior, 1979).

In South Dakota, important resources in the power line study area include Putney Slough and Renzienhausen Slough State Game Management Areas and five federal WPAs. Renzienhausen Slough, which is co-managed by the state and Ducks Unlimited, is a critical resting area for migrating waterfowl because it holds water throughout the year (Technical Study 8). The WPAs, including one in the southwestern portion of the Tx-N CSA, provide important habitat and food for both waterfowl and upland game. Each of these resource areas was avoided during the corridor selection process.

10.2.2 Receive Site

At the receive site, state law dictates that the power line supplier be determined by the franchise area in which the CRS facility is located. The selected electric supplier will also construct and maintain the receive site power lines. Different utility companies serve the two receive (Rx) site CSAs. PKM Electric Cooperative serves the Rx-W CSA region and would be the power supplier if the Rx-W CSA is selected for the CRS facilities. Red Lake Electric Cooperative serves the Rx-E CSA region and would be the power supplier if the Rx-E CSA is selected.

Regardless of which CSA and utility supplier are selected, the receive site power line contractor will be required by the Rural Electrification Administration to pursue actions leading to preparation of a BER. The purpose of a BER is to evaluate potential environmental consequences of constructing and operating a transmission line. A BER will not be prepared, however, until the specific power supplier is selected. Because the BER would contain pertinent environmental information and analysis, the evaluation of environmental impacts at the receive site in this Technical Study will be only generally addressed.

Although a comprehensive corridor screening process has not been conducted for the receive site, tentative corridors have been proposed (Figure 10-6). All

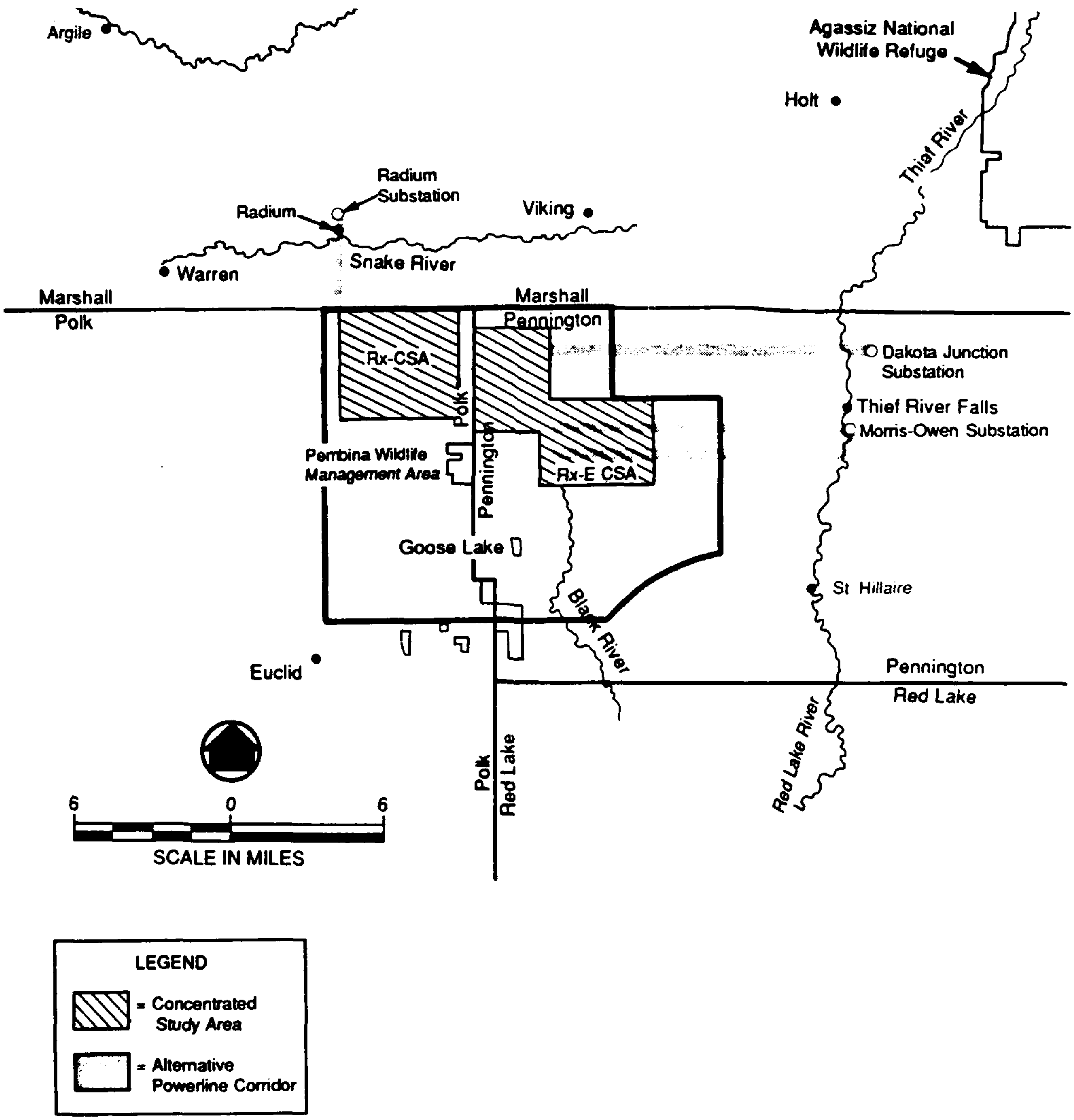

FIGURE 10-6. RECEIVE SITE POWER LINE CORRIDORS

receive power line corridors are 1000 feet wide. The actual ROW will be much smaller and may be placed anywhere in the corridor.

Preliminary information indicates that if the Rx-W CSA is selected, PKM Electric Cooperative would route the power line from the Radium, Minnesota substation (four miles north of the Rx-W CSA) to the CSA (Figure 10-7). This corridor was selected because it makes optimum use of existing power line and roadway alignments. Accordingly, use of this corridor will minimize land acquisition and environmental impacts.

If the Rx-E CSA is selected, two possible Red Lake Cooperative substations could be used: (1) Morris-Owen, approximately seven miles east of the CSA and just south of Thief River Falls, or (2) Dakota Junction, approximately thirteen miles east of the CSA and two miles northeast of Thief River Falls (Figure 10-8). These corridors were selected because they maximize use of existing power line and roadway alignments. Use of the Dakota Junction substation is preferred by Red Lake Electric Cooperative because it is farther from the city of Thief River Falls and would require crossing the Thief River rather than the larger Red Lake River.

10.2.3 Mitigation

This Technical Study also describes potential mitigation measures where unavoidable environmental impacts are possible. Mitigation measures may be required for potential impacts to vegetation, wetlands, and wildlife. A Draft Mitigation Plan is to be developed by the USAF in conjunction with the project Environmental Impact Statement (EIS) and will describe specific mitigation measures for unavoidable impacts identified in the EIS (Technical Study 1, EIAP Overview).

10.3 FACILITIES

This section augments Technical Study 2 (Facilities) by providing a description of the approximate size, clearing requirements, and anticipated construction methods for the proposed CRS power lines. The information

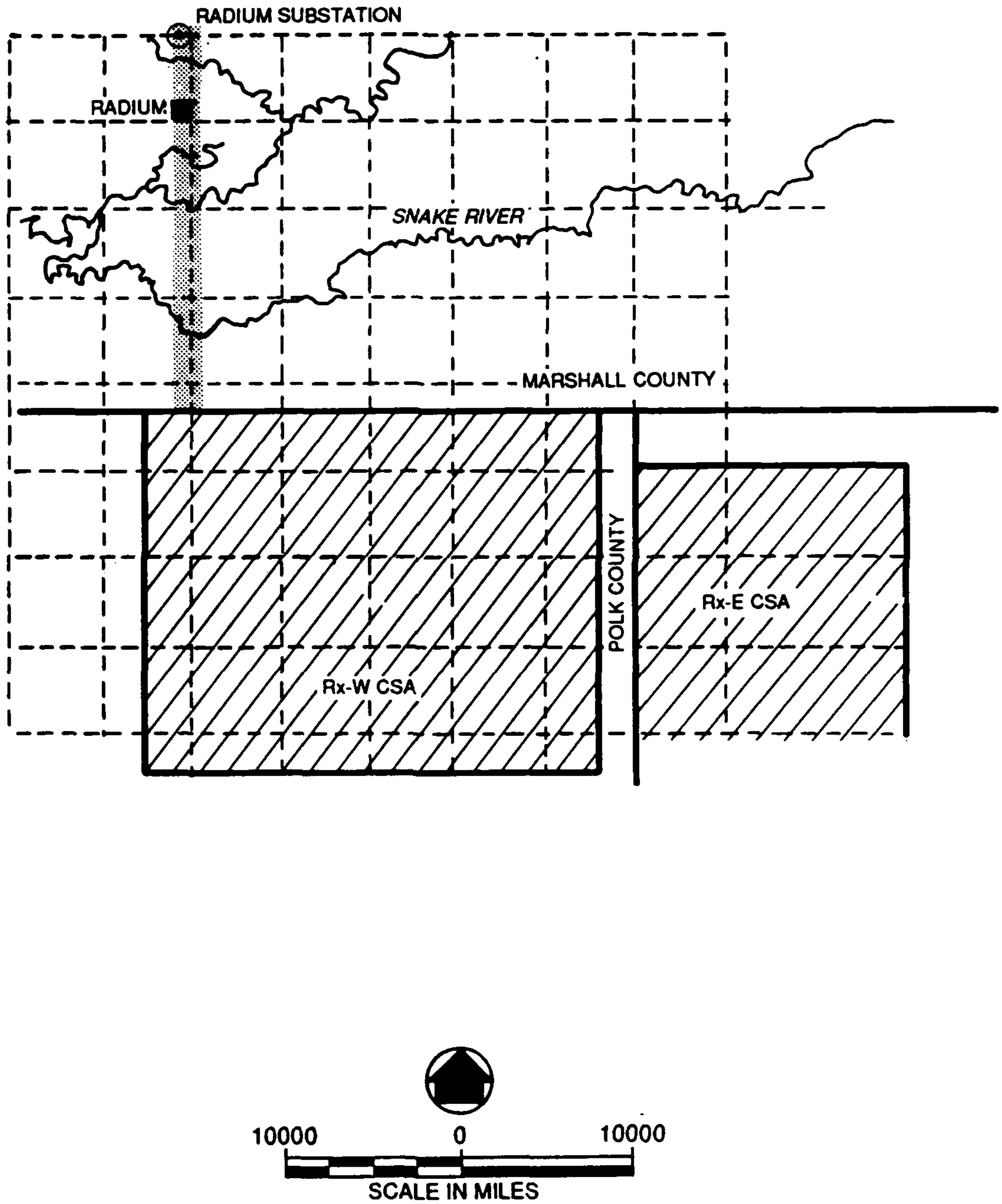

FIGURE 10-7. Rx-W CSA POWERLINE CORRIDER

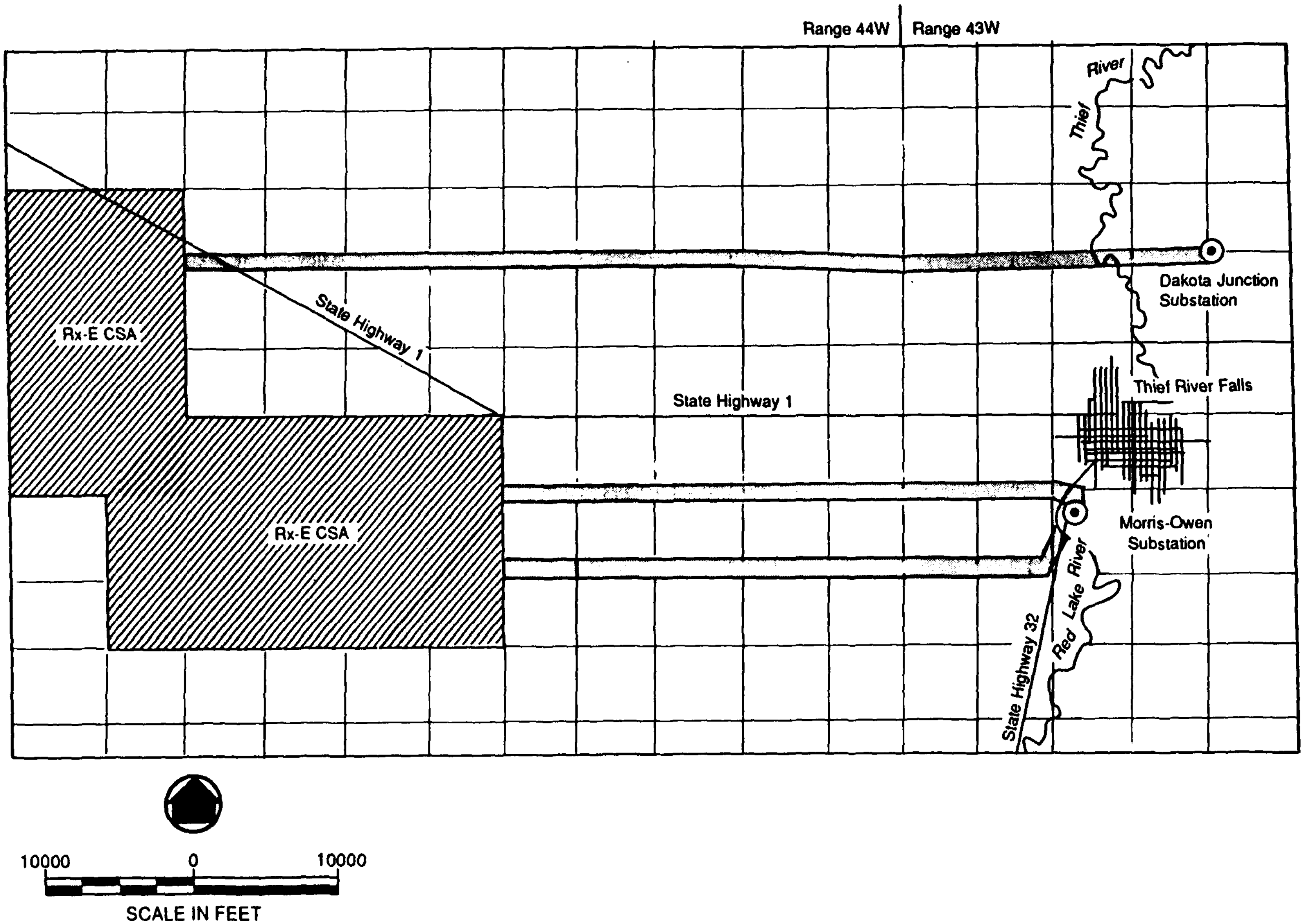

FIGURE 10-8. Rx-E CSA POWER LINE CORRIDORS

provides the baseline for assessing potential impacts of the power lines in both this Technical Study and in the EIS. Information for the transmit site power lines was provided by Western (1990a). Information for the receive site was provided by PKM Electric Cooperative and Red Lake Electric Cooperative (PKM, 1989; RLEC, 1989).

10.3.1 Transmit Site

10.3.1.1. Substations

The CRS power requirements will necessitate expansion of the Forman substation, erection of additional substation equipment at the Groton and Forman substations, and construction of a new substation at the selected CRS site. Expansion of the Forman substation would require approximately 11,000 square feet of additional land; no additional land is required for the Groton substation. The Groton and Forman substation equipment will include a 115-kV circuit breaker, concrete foundations, high-voltage switches, steel support structures, and 115-kV metering equipment (Western, 1990a). The substation erected at the transmit site will include six 115-kV circuit breakers, two 115/12.47 kV transformers, a control building, 115-kV switches, and associated concrete foundations. The low voltage (12.47 kV) side will have additional switches and conductor wires for distribution to the four transmit sites. The Groton, Forman, and on-site substations will each be enclosed by an eight-foot high chain link commercial grade fence (Western, 1990a). The transformers at the new on-site substation will operate in compliance with all federal, state, and local noise regulations (Western, 1990a).

Approximately 50 to 100 truck trips would be made to both the Groton and Forman substations to deliver materials. The on-site substation would require 100 to 150 trips. The number of construction personnel at both the Groton and Forman substations would vary between five and fifteen over a six-month period. The CRS on-site substation would require between ten and twenty construction personnel over an eight-month period. Construction work would be conducted five days per week during normal working hours (7 a.m. to 5 p.m. typically) (Western, 1990a).

10.3.1.2 Power Lines

The transmission lines for the CRS transmit facilities will be designed for 115-kV operation. Transmission poles will be either single pole steel structures or wood pole H-frames. Single poles would carry three phase conductor wires and one overhead ground wire, and H-frame structures would carry three phase wires and two overhead ground wires (Figure 10-9). The minimum ROW required to satisfy electrical requirements of a typical 115 kV line is 80 feet (Western, 1990a). Western typically purchases a wider ROW than is required to facilitate maintenance and ease of access. Western recommends a minimum ROW purchase of 100 feet for the CRS transmission lines, and prefers a purchase of a 125 foot ROW (Western, 1990a).

The height of the poles would depend on the type of pole used and the spacing of the poles. Wood H-frame poles would be approximately 55 feet high and would have an average ruling span, or distance between poles, of 700 feet. Steel poles would be approximately 95 feet high and would have an average ruling span of 1000 feet. Some modification or alteration of pole spacing could occur so that important topographic, natural resource, or cultural features within the ROW can be avoided. For wood poles, spacing can range from six to eight poles per mile (maximum ruling span is 875 feet). For steel poles, spacing can range from four to five poles per mile (maximum ruling span is 1200 feet) (Western, 1990). For either type pole, the minimum ground clearance of the conductor wires is 22 feet. Thus, spans longer than the average span may require taller poles in order to maintain the minimum ground clearance for the conductor wires (Western, 1990a).

At each pole site, two or three holes will be augered, with trenching between poles for installing grounds. This activity would disturb an area of approximately 10 by 30 feet (300 square feet). If the terrain is not level, a level crane landing of approximately 20 by 40 feet (800 square feet) would be required. Several guy anchors, each disturbing about 10 square feet, may need to be installed at sites where the power line turns (Western, 1990a). For the purposes of the environmental analysis, it is assumed that the average area disturbed would be 300 square feet per pole site.

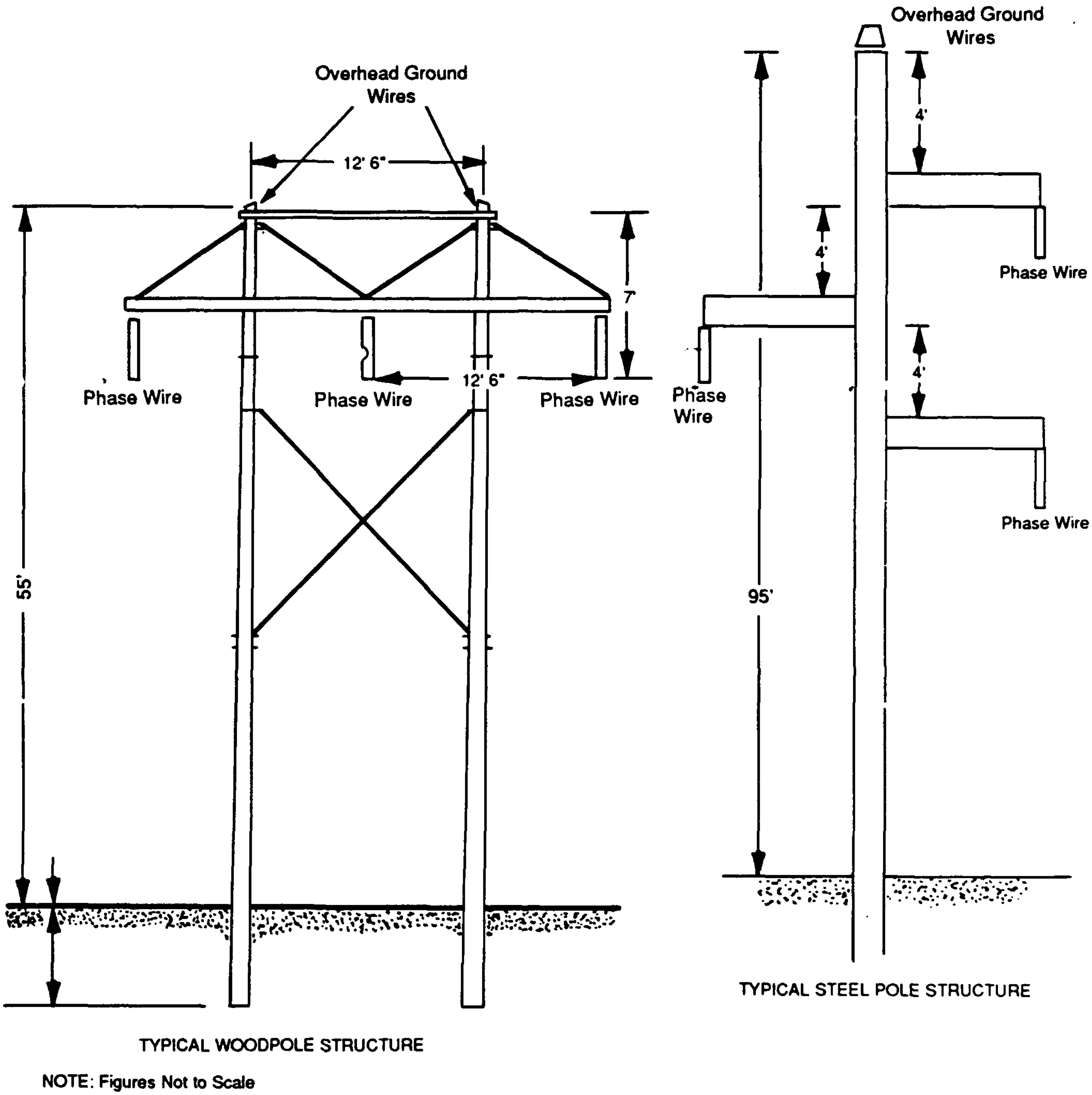

FIGURE 10-9. TYPICAL CONFIGURATION OF TRANSMIT SITE POWER LINE POLES

The major activities involved in power line construction include improving access, trimming and clearing trees, constructing access gates, excavating and grading soils, preparing pole foundations, delivering materials, assembling and erecting structures, stringing conductor wires, and site cleanup and restoration. Tree trimming and clearing would be required to maintain adequate clearance. Herbicides such as Kovar and Roundup are typically used at the request of the landowners to control weeds around the structures (Western, 1990a).

The frequency and number of access points to the power line would depend on whether the line is adjacent to an existing road or utility ROW. Where access is required through private property, an approximately 30 foot wide easement would be purchased for an access route. Actual use of access ROWs would be limited to vehicle widths (Western, 1990a).

When the power lines are no longer needed, Western would remove the improvements and quitclaim the easement back to the underlying landowner. The ROW would be restored in accordance with the conditions of the original easement agreement (Western, 1990a).

Employment on the transmission line is estimated to peak during construction with approximately 25 to 30 workers for about eight months. Normal working hours (Monday through Friday, 7 a.m. to 5 p.m) would be used. Each single pole or H-frame structure would require 15 to 20 truck or vehicle round-trips (e.g. 30 to 40 one-way trips) during construction (Western, 1990a).

10.3.2 Receive Site

The receive site main transmission line will likely be 12.47 kV. As noted previously, the power provider at the receive site will depend on which CSA is selected for the CRS facilities.

10.3.2.1 Rx-W CSA: Power Supplied by PKM Electric Cooperative

PKM could construct either overhead or underground power lines. Overhead lines would be strung on wood T-frame poles that would be a maximum height of 45 feet. Transmission poles would carry a total of four conductor wires (three phase conductor wires and one neutral conductor wire). Typical arrangement of conductor wires on poles is shown in Figure 10-10. When strung next to a road, overhead lines are usually placed 50 feet or more from the road centerline. Underground lines would be buried 40 to 48 inches, although the minimum depth requirement is 36 inches. Buried conductor wires are placed using a static plow, which creates a trench about four inches wide. Underground lines adjacent to roads are usually placed 100 feet or more from the road center line or 50 feet from existing overhead lines. Paved roads would be crossed by boring beneath them, and gravel roads could be crossed by boring or placing a trench through the roadway (PKM, 1989).

PKM has proposed that the CRS power lines follow section lines. The electric cooperative's preferred option of constructing a line from Radium is to replace an existing single-phase 7200 volt overhead transmission line with a buried line and then construct new CRS lines overhead in the same ROW. The proposed route from Radium to the substation is adjacent to County Road 36 in Marshall County and County Road 68 in Polk County (PKM, 1989).

10.3.2.2 Rx-E CSA: Power Supplied by Red Lake Electric Cooperative

No upgrade or expansion would be required at either the Morris-Owen or Dakota Junction substations. The lines from the Morris-Owen substation to the Rx-E CSA would have to cross the Red Lake River. The line from the Dakota Junction station would be slightly longer and would have to cross the Thief River. Red Lake Electric Cooperative usually crosses the river with overhead lines, although underground lines could be used (RLEC, 1989).

According to Red Lake Electric Cooperative, ROWs are easier to obtain for underground lines because most farmers prefer underground lines. Underground

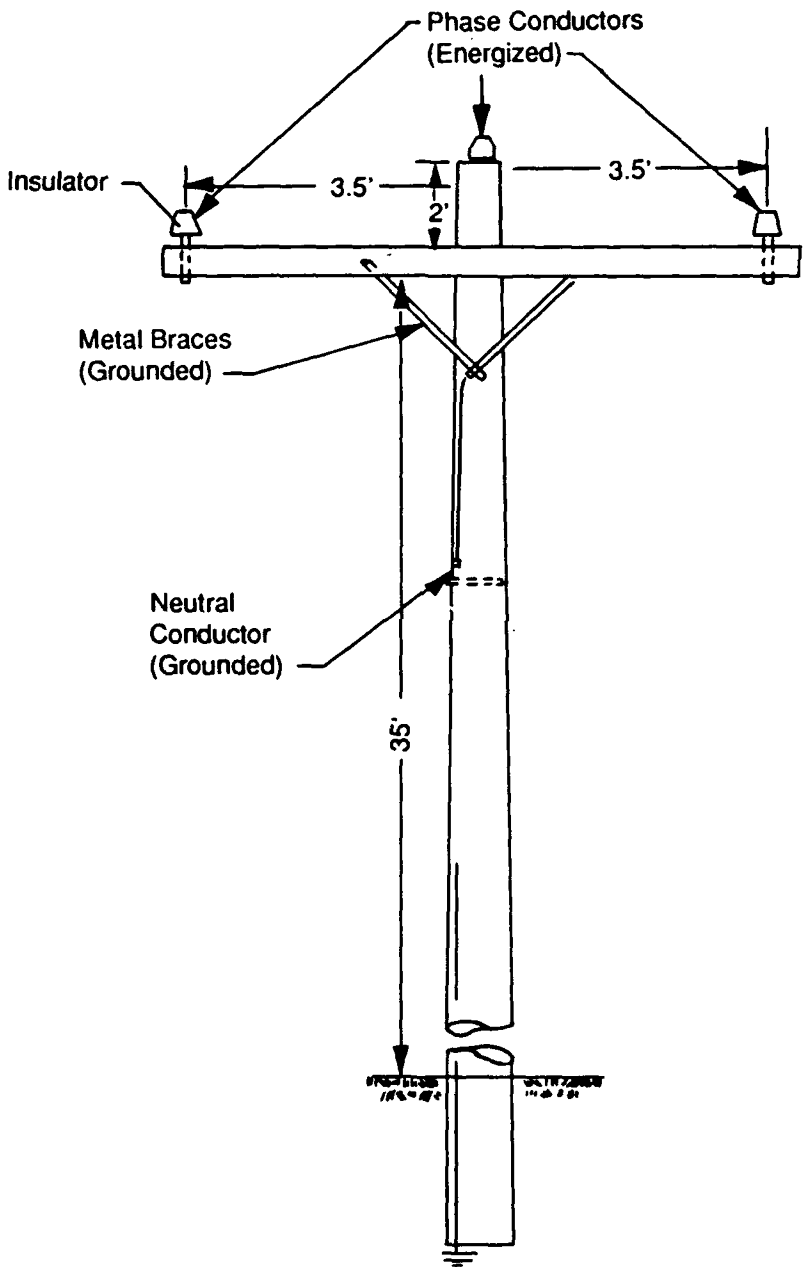

FIGURE 10-10. TYPICAL CONFIGURATION OF ABOVE-GROUND RECEIVE SITE POWER LINE POLES

lines also tend to be more reliable because weather problems are eliminated (RLEC, 1989). Red Lake Electric Cooperative usually buries underground lines about 150 feet from the center line of an adjacent road. The line is buried with a plow that digs a trench about four inches wide and 48 inches deep. The plow typically disturbs an area about fifteen feet wide. Buried lines require a junction box that is approximately five feet by three feet by two feet at each section line. Junction boxes are usually placed on a fiberglass pad. Red Lake Electric Cooperative usually attempts to concentrate construction efforts during the fall so that impacts to cropland are minimized (RLEC, 1989).

Red Lake Electric Cooperative overhead poles are typically 35 feet high and are buried to a depth of six feet. For the receive site power line, poles would support four wires (three conductor wires and one neutral wire) (Figure 10-9). Red Lake Electric Cooperative poles are usually spaced an average of 270 feet apart (twenty poles per mile) and require a minimum clearance of 25 feet from bottom wire to ground (RLEC, 1989). Some alteration or modification in pole spacing and pole height could be used to avoid any important topographic, natural resource, and cultural features identified within the ROW.

10.4 AFFECTED ENVIRONMENT

This section describes the existing biotic characteristics of the selected transmit and receive power line corridors. Quantitative wetland information specific to the power line corridors was developed for the USAF by Hammon, Jensen, Wallen and Associates (1990). SRI International (1990) and the United States Agricultural Stabilization and Conservation Service (USASCS, 1990a; USASCS, 1990b; USASCS, 1990c; USASCS, 1990d) also provided quantitative descriptions of some vegetation types in the selected power line corridors. Analysis of other biotic characteristics (vegetation, mammals, birds, and threatened and endangered species) is primarily qualitative and is based on USGS 7.5 minute topographic maps, USGS NHAP aerial photographs, and field investigations by Metcalf & Eddy/Holmes & Narver. Additional detailed information on regional biotic resources is provided in other Technical Studies.

10.4.1 Vegetation

10.4.1.1 Transmit Site

The typical vegetation types of the Amherst, South Dakota region are discussed in Technical Study 5, Vegetation. A qualitative vegetation analysis was conducted on the selected power line corridors using topographic maps, aerial photographs, and NWI maps. Information on regional vegetation types was also obtained through avian and wetland investigations in 1987, 1988, and 1989. Some quantitative descriptions of land cover types were provided by SRI International (1990) and the USASCS. Acreages of cultivated land and grassland in each link were calculated by SRI International from landsat photography. The USASCS office in Marshall County, South Dakota (USASCS, 1990d) and Sargent County, North Dakota (USASCS, 1990b) estimated the acreage of native prairie in each link. The USASCS offices in Day and Marshall Counties in South Dakota (USASCS, 1990c; USASCS, 1990d) and Sargent County in North Dakota (USASCS, 1990b) also provided acres of irrigated land in each link. Woodland acreage was approximated for each link from topographic maps and aerial photographs. Information specific to each link was then summed by corridor (Table 10-1).

Links 2, 4, 6 and 9 are over 60% cultivated land. Thus, the power line corridors containing these links (2, 2-3, 9-4, 9-6-5, 9-6-5-3) are highly agricultural (Table 10-1). Link 1 in South Dakota and links 8 and 10 in North Dakota also cross primarily cultivated land. The chief crops on this land are spring wheat, flax, corn, oats, barley, alfalfa, sunflowers, and sorghum. Much of this crop land contains temporarily-flooded palustrine emergent (USFWS classification type PEMA) wetlands that are cultivated when the water diminishes in the spring. (See Technical Studies 5 and 6, Vegetation and Wetlands). Approximately 5 percent of link 4 (USASCS, 1990d) and 2 percent of link 8 (USASCS, 1990b) is irrigated.

The majority of land in links 3, 5 and 7 is rangeland and prairie, much of which is used as pasture and hay land. The western portion of link 7 crosses through the Hecla Sandhills, a relatively unique landform that supports native vegetation such as big bluestem (*Andropogon gerardi*), blue grama (*Bouteloua gracilis*), and associated grasses and forbs. (A complete list of regional vegetation is in Tables 5-3 and 5-4, Technical Study 5). Although link 7 is primarily rangeland and prairie, it also includes some cultivated land, approximately 15 percent of which is irrigated (USASCS, 1990b).

Trees in the power line corridors occur primarily in shelterbelts and in drainage swales. Characteristic trees in the region are cottonwood (*Populus deltoides*), green ash (*Fraxinus pennsylvanicum*), American elm (*Ulmus americana*), boxelder, (*Acer negundo*), oaks (*Quercus* spp.), willows (*Salix* spp.), chokecherry (*Prunus virginiana*), plum (*Prunus* spp.), and russian olive (*Elaeagnus angustifolia*). Habitat provided by woodlands is important because of the relative scarcity of this vegetation type in the region. Link 8 in North Dakota contains the highest percentage of woodlands (approximately 11 percent). The remainder of the links (Table 10-1), are 1 percent or less woodland.

According to U.S. Soil Conservation Service (SCS) estimates, the transmit study area contains up to 62 percent prime farmland or farmland of statewide importance (SCS, 1975; SCS, 1989a; SCS, 1989b; Technical Study 5). While some of the links (links 1, 2, 3, 4, 6, 9, and 10) are likely to contain a similar proportion of prime and important farmland, the amount of prime and important farmland is likely to be less in links 5, 7 and 8 which traverse the Hecla Sandhills.

10.4.1.2 Receive Site

The typical vegetation types of the Thief River Falls, Minnesota region are also discussed in Technical Study 5, Vegetation. Information on vegetation within the power line corridors was obtained from USGS 7.5 minute series topographic maps and on-site field investigations. Approximately four-fifths of the land in the receive study area is cultivated, and a similar proportion in the power line corridors is likely cropped. In the Rx-W power line corridor, approximately 75 percent of the land is cultivated and none of the land is grassland or native prairie. Predominant crops in the region are spring wheat, sunflowers, oats, barley, sorghum, alfalfa, sunflowers, soybeans, and sugar beets. Crop species are usually rotated periodically so that different crop species are planted on a given parcel of land each year. Small areas of isolated mesic and wet blacksoil prairie also occur in the area.

In the receive study area, up to 69 percent of the land may qualify as prime farmland, depending on the drainage characteristics. Because land use and topography in the proposed power line corridors are similar to land use and topography in the receive study area, a similar percentage of prime farmland is likely to occur in the 1000-foot wide powerline corridors (SCS, 1977; SCS, 1984; SCS, 1989b; SCS, 1989c).

Trees in the corridors occur mainly in shelterbelts, drainage swales, and forested wetlands. Shrub species occur most often in the understory of forested areas and in palustrine shrub/scrub wetlands. Tree species common in the region include cottonwood, trembling aspen (*Populus tremuloides*), balsam poplar (*Populus balsamifera*), and bur oak (*Quercus macrocarpa*). Shrub species common in the region include pussy willow (*Salix discolor*), chokecherry, red-osier dogwood (*Cornus stolinifera*), and hazel-nut (*Corylus* spp.). Wooded areas are more prevalent in the Rx-E corridors than in the Rx-W corridors (Table 10-1). Of the three alternative Rx-E powerline corridors, the Morris-Owen corridor E2 contains the largest percentage of woodlands (approximately 34 percent; Table 10-1).

10.4.2. Wetlands

10.4.2.1 Transmit Site

The vegetative, hydrologic, and edaphic characteristics of typical prairie pothole wetlands in the Amherst region are discussed in Technical Study 6, Wetlands and Aquatics. Wetland types common in the Amherst study area are also common in the transmit power line corridors. Wetlands within the transmit power line corridors were evaluated using USGS 7.5 minute series topographic maps, NHAP infrared aerial photographs, and USFWS NWI maps. Total wetland

TABLE 10-1. APPROXIMATE VEGETATION TYPE PERCENTAGES IN POWER LINE CORRIDORS[1]

	Grassland[2] (%)	Cultivated Land[3] (%)	Native Prairie[4] (%)	Woodlots and Shelterbelts (%)
Tx-N				
Groton				
Corridor 1-3	43	45	-[5]	1
Corridor 2-3	31	56	-[5]	1
Forman				
Corridor 10-7	35	40	22	<1
Corridor 10-8-5	30	49	21	1
Corridor 9-6-5	30	62	11	1
Tx-S				
Groton				
Corridor 1	43	49	-[5]	1
Corridor 2	23	66	-[5]	<1
Forman				
Corridor 10-8-5-3	36	44	14	1
Corridor 9-6-5-3	34	54	9	1
Corridor 9-4	28	64	11	1
Corridor 10-7-5-3	37	39	11	<1
Tx-W				
Radium	0	75	0	8
Rx-E				
Dakota Junction (E1)	-[5]	-[5]	-[5]	11
Morris-Owen (E2)	-[5]	-[5]	-[5]	34
Morris-Owen (E3)	-[5]	-[5]	-[5]	21

1. Sources: USASCS, 1990a; USASCS, 1990b; USASCS 1990c; USASCS. 1990d.
2. Acres of grassland change yearly.
3. Acres of cultivated land change yearly.
4. Native Prairie is estimated from non-crop land.
5. This information is currently not available.

acreage and acreage by USFWS wetland type (Cowardin et al, 1979) were calculated for each link by Hammon, Jensen, Wallen and Associates (1990) using a line-transect sampling method. These figures were then summed by corridor (Table 10-2). The most common wetland habitat in the corridors is palustrine emergent (PEM) wetland. The most common hydrological regimes of wetlands in the corridors are, in descending order, temporarily flooded palustrine emergent (PEMA), seasonally flooded palustrine emergent (PEMC), and semi-permanently flooded palustrine emergent (PEMF) wetlands, respectively. These three wetland types comprise approximately 90 percent of the wetlands in the power line corridors. The remaining 10 percent of the wetlands include palustrine aquatic bed (PAB), saturated palustrine emergent (PEMB), palustrine unconsolidated bottom (PUB), palustrine shrub-scrub (PSS), and palustrine forested (PFO) (Hammon et al, 1990).

The corridors extending from Forman generally contain greater percentages of wetlands and contain a higher percentage of PEMC and PEMF wetlands than the corridors extending from Groton. Corridors in South Dakota, particularly those extending from Groton, contain predominantly PEMA wetlands, many of which are likely farmed. The specific acreage and type of wetlands in each corridor are discussed further in section 10.5.2.3, which addresses wetland impacts. All links except 5 and 6 include some intermittent and permanent streams which would have to be crossed by the power lines. The greatest number of stream crossings would be required in links 2 and 4 (24 and 22, respectively) and therefore in the corridors containing these links (2, 2-3, 9-4). Links 1, 3, 7, 8, 9 and 10 would require fewer stream crossings (9, 4, 9, 7, 2 and 2 respectively).

Technical Study 6 contains the results of a USFWS Wetland Evaluation Technique (WET 2.0) assessment of typical wetlands in the study area. The social, hydrological, and wildlife functions and values of these three wetland types generally correspond to the duration of standing water (Technical Study 6). Consequently, PEMF wetlands are relatively more valuable than PEMC wetlands, which are in turn more valuable than PEMA wetlands. PEMF wetlands are flooded throughout the growing season in most years and typically support emergent vegetation throughout the year. PEMC wetlands are flooded for extended

TABLE 10-2. SUMMARY OF WETLAND ACRES AND TYPES IN POWER LINE CORRIDORS[1]

	Total Wetland (Acres)	Total Wetland (%)	PEMA (%)	PEMC (%)	PEMF (%)	OTHER[2] (%)
Tx-N						
Groton						
Corridor 1-3	2741	5	63	21	1	16
Corridor 2-3	2052	5	79	13	1	7
Forman						
Corridor 10-7	4219	10	23	50	17	10
Corridor 10-8-5	2657	10	43	28	24	4
Corridor 9-6-5	3377	8	46	27	23	5
Tx-S						
Groton						
Corridor 1	1878	5	55	23	1	21
Corridor 2	1189	3	79	11	0	10
Forman						
Corridor 10-8-5-3	3520	7	45	27	24	4
Corridor 9-6-5-3	4240	6	53	25	19	4
Corridor 9-4	3826	6	50	26	15	9
Corridor 10-7-5-3	5386	8	32	43	17	8
Rx-W						
Radium	9	1	14	41	29	17
Rx-E						
Dakota Junction (E1)	53	3	0	7	0	91
Morris-Owen (E2)	88	6	2	5	0	93
Morris-Owen (E3)	57	4	9	7	0	84

1. Source: Hammon, Jensen, Wallen, & Assoc., 1990.
2. Other wetland types in the transmit corridors include PFOA, PSS1, PUBF, RSBF, PABF, and PEMB. Other wetlands in the recieve corridors include PEMB, PEM/SS, and PSS. These wetland types are discussed in detail in Technical Study 6, Wetlands and Aquatics.

periods during the growing season and typically support emergent vegetation for that part of the growing season. PEMA wetlands are flooded for only brief periods during the growing season and usually support both upland and emergent plant species. Many PEMA wetlands in the power line corridors are cultivated in late spring once the standing water has dissipated.

10.4.2.2 Receive Site

10.4.2.2.1 Wetlands in the Receive Study Area. The typical wetland types of the Thief River Falls region are discussed in Technical Study 6. The predominant wetland types in the receive study area are also likely to occur in the receive power line corridors. The most common wetlands in the general study area are PEM wetlands. These PEM wetlands consist primarily of saturated (PEMB) and semi-permanently flooded (PEMF) wetlands. Mixed palustrine emergent/scrub-shrub (PEM/PSS) wetlands, palustrine unconsolidated bottom (PUB) wetlands, and palustrine forested (PFO) wetlands are also common in the study area. Functions and values of typical PEM and PFO wetlands in the receive study area are discussed in Technical Study 6 and are used in this section to represent functions and values of PEM and PFO wetlands in the power line corridors. Riverine wetlands are uncommon but occur along large drainages in the study area.

10.4.2.2.2 Wetlands in the Rx-E Power Line Corridors. Hammon, Jensen, Wallen, and Associates (1990) summarized wetland types in the power line corridors using a line-transect survey methodology (Table 10-2). Approximately 3 percent of the Dakota Junction to Rx-E CSA is wetlands (approximately 53 acres). PEMC wetlands comprise approximately 7 percent of the wetlands in the Dakota Junction to Rx-E CSA corridor. These wetlands support emergent vegetation and contain standing water for extended periods during the growing season. Typical PEMC wetlands in the region are valuable for migrating wildlife, groundwater recharge, floodflow alteration, and nutrient removal and transformation (Technical Study 6). The remainder of the wetlands in the corridor are PEMB.

Wetlands comprise approximately 6 percent (approximately 88 acres) of Morris-Owen corridor E2 and approximately 4 percent (approximately 57 acres) of corridor E3 (Table 10-2). As is the case for the Dakota Junction corridor, the majority of these wetlands are either PEM, PSS or PEM/PSS.

10.4.2.2.3 Wetlands in the Rx-W Power Line Corridor. The power line corridor from the Radium Substation to the Rx-W CSA is one percent wetland, or about 9 acres (Table 10-2), which is a significantly smaller amount of wetlands than in any of the three corridors at the Rx-E CSA. PEMC wetlands are the type most prevalent in the Rx-W corridor. Table 10-2 summarizes the wetland types present in the Rx-W power line corridor as determined by Hammon, Jensen, Wallen and Associates (1990).

10.4.3 Mammals

The principal mammals that inhabit both the transmit and receive study areas are also presumed to inhabit the respective power line corridors. These species are listed in Table 7-1 (Technical Study 7, Mammals) and include white-tailed deer (*Odocoileus virginianus*), red fox (*Vulpes vulpes*), coyote (*Canis latrans*), muskrat (*Ondatra zibethicus*), striped skunk (*Mephitis mephitis*), badger (*Taxidea taxus*), mink (*Mustela vison*), jackrabbit (*Lepus townsendi*), longtail weasel (*Mustela frenata*), raccoon (*Procyon lotor*), and in Minnesota, moose (*Alces alces*).

Several types of important habitat exist in both the transmit and receive study areas. Cultivated lands provide forage for white-tailed deer at both sites, moose in Minnesota, and possibly pronghorn (*Antilocapra americana*) in South and North Dakota. If not overgrazed, pasture and hayland provide habitat for white-tailed deer and ground-dwelling mammals. Wetlands provide habitat for mink, muskrat, skunk, red fox, weasel, raccoon, deer in South Dakota, North Dakota and Minnesota and moose in Minnesota. Forested areas provide habitat for white-tailed deer, moose, and small mammals. The abundance and habitat of these species in the two study areas are discussed in detail in Technical Study 7.

10.4 3.1 Transmit Site

Wildlife habitat in the transmit power line corridors generally corresponds to the types of wetlands and vegetation that occur in those corridors. The corridors extending from the Groton substation and links 8 and 9 extending from Forman contain predominantly agricultural land and PEMA wetlands. This type of habitat supports white-tailed deer year-round. Link 7 contains a higher percentage of native vegetation and PEMC and PEMF wetlands. This habitat type supports a large number of mammal species. Because of its abundance of wetlands and native vegetation, link 7 likely contains the most high-value wildlife habitat.

10.4.3.2 Receive Site

Field investigations conducted by Metcalf & Eddy/Holmes & Narver indicate that the majority of land in the receive power line corridors is cultivated. This land may provide forage for white-tailed deer (Technical Study 7). PEMC wetlands, which are the predominant wetland type in the Dakota Junction to Rx-E CSA corridor, provide habitat for mink, muskrat, skunk, red fox, weasel, raccoon, and moose. Forested and shrub-scrub areas wetlands, which are relatively scarce in the region, also provide habitat for moose.

10.4.4 Birds

10.4.4.1 Transmit Site

Technical Study 8 describes the existing avian resources in the Amherst study area and, to a lesser extent, the surrounding region. The comprehensive discussion in Technical Study 8 is generally applicable to the power line study area.

The study area lies in the Central Flyway and supports hundreds of thousands of migrating birds each spring and fall. According to 1987, 1988, and 1989 CRS avian studies, the most abundant migrants in the study area are passerines and waterfowl (Technical Study 8). Geese and dabbling ducks such as mallards use the wetlands and agricultural lands in the region as resting and feeding areas during both spring and fall migration. Generally more migrants travel through the area in the spring, when migration movements are typically more clustered. Important wetlands in the region, including Sand Lake National Wildlife Refuge, Dakota Lake National Wildlife Refuge, Renzienhausen Slough Game Production Area, and Hyatt's Slough Waterfowl Management area, serve as nesting, resting, and feeding areas and attract a large diversity of waterfowl during migration periods. Other species abundant during migration include shorebirds and raptors.

10.4.4.2 Receive Site

Technical Study 8 describes the existing avian resources in the Thief River Falls study area. Since the power line corridors only extend for a few miles beyond the study area boundaries, the discussion in Technical Study 8 is applicable to the power line corridors.

The study area lies on the eastern edge of the Central Flyway and supports numerous species of migrating birds in the spring and fall. According to the 1987, 1988, and 1989 CRS avian surveys, the most abundant groups of migrants in the study area are passerines and waterfowl. Passerines are likely the most abundant migrants during the night (Technical Study 8). Agassiz National Wildlife Refuge, approximately 15 miles northeast of Thief River Falls, is an important nesting, resting, and feeding area for waterfowl in the region. Locally, the Goose Lake wetland complex provides important habitat for migrating birds. Other species groups abundant during migration include shorebirds and raptors.

10.4.5. Threatened and Endangered Species

10.4.5.1 Transmit Site

In accordance with Section 7 of the Endangered Species Act, the Pierre, SD office of the USFWS provided a list of federally threatened and endangered flora and fauna that may be affected by the CRS facility and powerlines

(USFWS, 1990a; USFWS 1990b). These species are the bald eagle (*Haliaeetus leucocephalus*), peregrine falcon (*Falco peregrinus*), whooping crane (*Grus americana*), piping plover (*Charidrius melodus*), eskimo curlew (*Numenius borealis*), burying beetle (*Nicrophorus americanus*), and Western prairie fringed orchid (*Platanthera praeclara*). Technical Study 9, Threatened and Endangered Species, documents observations of bald eagles and peregrine falcons in both transmit and receive study areas. Eighty-two bald eagles were sighted in the Amherst study area during the 1987, 1988, and 1989 CRS avian surveys. The fact that the majority of these eagles were observed near the large wetland at the Tx-S CSA supports the fact that migrating eagles tend to congregate at large wetlands and along waterways. Only two verified peregrine falcon sightings occurred in the Amherst study area during the CRS avian surveys, one each at the Tx-N and Tx-S CSAs. No whooping cranes, piping plovers or eskimo curlews were observed during the avian surveys; no effects on these species are expected (Technical Study 9).

While the Western prairie fringed orchid has not been identified in the transmit study area, Technical Study 9 includes a discussion of the likelihood of the orchid occurring in the study area. The Tx-N CSA and adjoining Hecla Sandhills provide suitable habitat for the Western prairie fringed orchid (USFWS, 1990). Links 7 and 8, which traverse the Sandhills, are therefore likely to contain suitable habitat for the orchid. Link 5 also includes native prairie which could provide habitat for the orchid. The other links contain primarily agricultural land and are thus not expected to contain significant Western prairie fringed orchid habitat. The burying beetle is not known to inhabit the study area and therefore is not expected to be affected by the project (Technical Study 9). The power line corridors will, however, be surveyed in the summer of 1990 to determine the presence of the Western prairie fringed orchid and burying beetle.

10.4.5.2 Receive Site

The Twin Cities Office of the USFWS (USFWS, 1990) provided a list of federally threatened and endangered species that may occur in the Thief River Falls study area. These species are the bald eagle, peregrine falcon, piping plover, and gray wolf (*Canis lupus*). Because of similarities in habitat types between the study area and power line corridors, the abundance of the four federally listed species in the receive power line corridors is likely similar to the abundance of these species in the receive study area. Thirty-two bald eagles were observed during the CRS avian surveys. Ten of twenty-four eagles sighted from the fixed stations were either resting on the ground, perching in trees, or flying below 65 feet, although relatively more (eight of fourteen) birds were observed flying low at the Rx-E CSA than the Rx-W CSA (two of ten). Nine peregrine falcons were recorded in the study area during the CRS avian surveys. In the majority of sightings the birds were either flying below 65 feet or resting on the ground or in trees. No piping plovers or gray wolves were observed or are known to inhabit the study area. The USFWS has determined that there will be no adverse effect on the gray wolf (USFWS. 1990c). The project will also have no effect on the piping plover (Technical Study 9). Rare plant surveys will be conducted in the summer of 1990 to determine the presence of state-listed threatened species.

10.5 ENVIRONMENTAL CONSEQUENCES

10.5.1 General Characterization of Impacts

Potential impacts to vegetation, wetlands and mammals will result primarily from ground disturbances that occur during construction of the power lines and substation expansion. These impacts will be largely temporary (up to eight months) and will depend on the season in which most construction activity occurs. The greatest impacts to biotic resources could occur if construction begins in the spring, when wetlands contain a maximum of water, soils are wet and susceptible to erosion, plants are sprouting, and wildlife are producing and rearing their young. Furthermore, spring construction could impair seasonal agricultural activities such as tilling and planting.

The most important variable in assessing impacts of a power line at the transmit or receive site is the length of the power line. The potential for impacts to vegetation, wetlands, mammals, birds, and threatened and endangered species varies directly with the power line distance. These distances are shown in Table 10-3. At the transmit site, both corridors from Groton to the Tx-S CSA are roughly equal in length, as are both corridors from Groton to the Tx-N CSA. The shortest corridor from Forman to the Tx-N CSA is corridor 10-8-5, and corridors 10-7 and 9-6-5 are approximately equal in length. The four corridors from Forman to the Tx-S CSA are generally the longest corridors in the power line study area. Among these four Forman to Tx-S CSA corridors, corridor 10-8-5-3 is the shortest, and corridor 10-7-5-3 is the longest. At the receive site, the corridor to the Rx-W CSA is approximately four miles, and at the Rx-E CSA, the corridors from the Morris-Owen substation are roughly equal in length to the corridor from the Dakota Junction substation. Because power line distance may be the overriding factor in determining impacts to biotic resources, these distances are important in comparing the potential environmental impacts between corridors.

10.5.1.1 General Impacts - Transmit Corridors

At the transmit site, steel or concrete single poles or wood H-frame poles will be used (Figure 10-9). Depending on the type of pole structure selected, between four and eight poles per mile will be required. Ground disturbance will result from the movement of machinery and vehicles at the site of each pole. Approximately 300 square feet will be disturbed at each site, although slightly more land will likely be disturbed if a two-pole, H-frame design is used or if the terrain is extremely sloped. Land disturbance will also occur as vehicles move along the ROW and access routes. Approximately 15 to 20 trips will be made to each pole location.

An additional 11,000 square feet will be disturbed as a result of expansion of the Forman substation.

Potential impacts to birds and threatened and endangered species from the transmit power lines will occur for the duration of the project or until the power lines are decommissioned and removed. Construction impacts to birds should be minimal because construction will not significantly affect the abundance of suitable habitat in the region.

10.5.1.2 General Impacts - Receive Corridors

Potential environmental impacts at the receive site will depend on the type of line used. Overhead lines may have temporary impacts to vegetation, mammals, and wetlands during construction. The predominant impact will be the disturbance of approximately 300 square feet at the site of each pole, with approximately 20 poles per mile. Potential permanent impacts associated with overhead lines would be limited to the few square feet permanently disturbed by the poles. Underground lines would have potential short-term impacts related to construction but virtually no long-term impacts.

10.5.2 Vegetation

10.5.2.1 Transmit Site

Vegetation disturbances will occur from construction of the on-site substation, expansion of the Forman substation, movement of machinery at the pole sites, and movement of machinery along the power line ROW. Construction of the on-site substation will require the removal of approximately 250,000 square feet of vegetation. Approximately 11,000 square feet of vegetation will be removed at the Forman substation. In the power line ROWs, disturbance will be concentrated at the four to eight pole sites per mile, where approximately 300 square feet of vegetation will be temporarily disturbed and a few square feet of vegetation will be permanently removed. Values for total vegetation disturbed per corridor by construction work at pole sites is shown in Table 10-3. Vegetation in the ROW will be temporarily disturbed from the activity required to lay conductor wires, and vegetation along access routes will be temporarily disturbed by the 15 to 20 trips that will be made to each pole site. Native grasses and forbs will likely reestablish during the following growing season.

Permanent impacts would occur from the removal of vegetation at the pole sites and as a result of the loss of prime farmland at the pole sites. Both temporary and permanent impacts to farmland would be minimal if power lines were erected in existing ROWs.

TABLE 10-3. APPROXIMATE POWER LINE DISTANCES AND ACREAGE DISTURBED

	Approximate Distance to CSA (Miles)	Approximate Area Disturbed (acres)[1]
Tx-N		
Groton		
Corridor 1-3	40	2.2
Corridor 2-3	38	2.1
Forman		
Corridor 10-7	31	1.7
Corridor 10-8-5	23	1.3
Corridor 9-6-5	28	1.5
Tx-S		
Groton		
Corridor 1	26	1.4
Corridor 2	24	1.3
Forman		
Corridor 10-8-5-3	37	2.0
Corridor 9-6-5-3	42	2.3
Corridor 9-4	44	2.4
Corridor 10-7-5-3	48	2.6
Rx-W	4.5	7.3 (underground) 0.2 (overhead)
Rx-E		
Dakota Junction (E1)	13	23.6 (underground) 0.7 (overhead)
Morris-Owen (E2)	11.25	20.5 (underground) 0.6 (overhead)
Morris-Owen (E3)	11.50	20.9 (underground) 0.6 (overhead)

[1] Disturbance for overhead lines at the transmit site was calculated assuming an average of 300 square feet disturbed per pole site for eight poles per mile. Disturbance for overhead lines at the receive site was calculated assuming 300 square feet disturbed per pole site for twenty poles per mile. Disturbance for underground lines was calculated assuming disturbance for a fifteen foot width for the length of a corridor.

A ROW would probably be cleared in shelterbelts and forested areas crossed by the powerline. Clearing might not be necessary if there is a fourteen foot clearance of the conductor (Western, 1990a). Herbicides will be applied to prevent regeneration. Use of herbicides in conjunction with landowner approval and in accordance with manufacturer's instructions should ensure that no adverse affects of herbicides occur. Periodic maintenance of the power lines may be required to trim or prune trees which may interfere with the lines. With the exception of the pole sites, the only permanent impacts to vegetation will result from the removal of trees in shelterbelts and forested wetlands.

Specific comparisons between corridors indicate that little or no native vegetation will be disturbed in links 1, 2, 4 and 6 in South Dakota and in links 8, 9 and 10 in North Dakota because these links contain predominantly agricultural land. The greatest disturbance to native vegetation would occur in link 7, which contains the greatest amount of native pasture and hayland. Most impacts would nonetheless be temporary, however, as most of the vegetation removed or disturbed would likely regenerate during the following growing season.

Relatively more prime and statewide important farmland would likely be disturbed in the links originating from Groton because the land in the vicinity of the Tx-S CSA is likely to contain more prime and statewide important farmland as compared to the region north of the Tx-S CSA (Technical Study 5). Conversely, impacts to important farmland in links originating in Forman would be comparatively less.

10.5.2.2 Receive Site

Temporary vegetation impacts would occur during construction of both overhead and underground lines. Comparatively more temporary disturbance would occur from construction of underground lines because the machine employed to bury the conductor wires would disturb a fifteen-foot wide strip along the length of the ROW. Following construction, natural vegetation would be reestablished or crops could be reseeded.

All receive power lines would have little or no permanent vegetation impacts, particularly if lines are installed underground. Permanent vegetation impacts would occur only if overhead lines are constructed. In such a case, permanent vegetation disturbance would be concentrated at the approximately twenty structure locations per mile at each site.

Impacts to prime farmland would depend on both the type of line used and the structure of poles used. Underground lines would cause only temporary effects on prime farmland during construction and these impacts would be minimal if construction occurred during the late fall, when agricultural activity is relatively low. Overhead lines would cause both temporary and permanent impacts to prime farmland. Temporary impacts would occur during construction, and permanent impacts would occur as a result of effectively losing approximately 2000 square feet (10 square feet per pole times twenty poles per mile) of land per mile for single poles and 4000 square feet of land per mile for H-frame poles. Minimal impacts to prime farmland would occur at the Rx-W CSA power line because this line will likely be constructed in an existing ROW; impacts would be limited to construction disturbance at the new pole sites.

10.5.2.3 Mitigation

Where possible, original land and crop contours will be maintained so that excessive root damage is avoided and resprouting can occur. In construction areas where recontouring of the land is required, revegetation and/or reseeding with original species will occur after the final grade has been established.

Impacts to farmland will be minimized by attempts to align the ROW so that agricultural operations are least affected. The optimum alignment would be to place the corridor within an existing ROW (such as is the case at the Rx-W CSA). If this is not possible, alignment as close to an existing ROW as possible can minimize the additional ROW width. Sides of fields and half and quarter sections will be used wherever possible. Where soil compaction has occurred in cultivated fields, the construction contractor will, at the landowner's request, plow the ROW to minimize the effects of that compaction. Following construction of the power lines, normal farming operations will be allowed to continue within the ROW.

10.5.3 Wetlands

10.5.3.1 Transmit Site - General Impacts

Construction of overhead lines will require erection and maintenance of single steel or wood H-frame poles. Disturbance will likely be temporary and will result primarily from movement of machinery around the pole sites. Location of pole sites will be modified within limits to avoid placing poles in wetlands, particularly PEMC and PEMF wetlands. Approximately 300 square feet will be temporarily disturbed at each pole site. Wetland vegetation disturbed by construction machinery would likely naturally regenerate by the following growing season. Hydrological patterns, including surface water and groundwater movement, would also likely return to normal soon after construction is complete.

Permanent impacts to wetlands could occur at the on-site substation or at the pole sites. Wetlands will be avoided to the maximum extent possible when constructing the on-site substation. Wetland impacts would occur at the on-site substation only if there were no alternative to constructing the new substation in a wetland. Up to 250,000 square feet of wetland could be permanently altered at the on-site substation location. Permanent wetland impacts could occur at the pole sites if poles were placed directly in a wetland. Even in this case, as long as adjacent soil types, drainage patterns, and vegetation are maintained near their original state, minimal permanent wetland impacts would occur.

Two factors are important in evaluating the wetland impacts of each power line corridor: total number of wetland acres affected and type of wetland affected. Specific wetland impacts cannot be determined until the final alignment of the ROW is determined. For the purposes of this analysis, however, it is assumed that the wetland acreages and types presented in

Table 10-2 can be used to approximate the likelihood of wetland impacts from the final power line alignment.

10.5.3.2 Transmit Site - Corridor Specific Impacts

10.5.3.2.1 Groton to Tx-N CSA. A comparison between Corridors 1-3 and 2-3 indicates that the total wetland percentage in each is approximately equal (Table 10-2). Both corridors also contain approximately equal percentages of PEMF wetlands. Although corridor 1-3 contains a higher percentage of PEMC wetlands than corridor 2-3, the predominant wetlands in both corridors are PEMA types, which are relatively less valuable than PEMC and PEMF wetlands because of their water regime (Technical Study 6). Corridor 2-3, however, would require a greater number of stream crossings (28) than would corridor 1-3 (13).

10.5.3.2.2 Forman to Tx-N CSA. A comparison between the Forman to Tx-N CSA corridors indicates that Corridor 10-7 would have greater impacts than corridors 10-8-5 and 9-6-5. Of the three Forman to Tx-N CSA corridors, corridor 10-7 has both the largest wetland acreage and the highest percentage of PEMC wetlands (Table 10-2). The likelihood of wetland impacts in corridor 10-8-5 are comparable to the likelihood of impacts in corridor 9-6-5; although corridor 10-8-5 has a smaller wetland acreage, it has a larger total wetland percentage as well as larger percentages of PEMC and PEMF wetlands. In addition, corridor 9-6-5 would require only two stream crossings, while corridor 10-8-5 would require 9 crossings.

10.5.3.2.3 Groton to Tx-S CSA. Corridors 1 and 2 contain similar percentages of wetlands (5 and 3 percent respectively; Table 10-2). Construction of a power line in link 2, however, would require crossing 24 intermittent and permanent streams, while corridor 1 would include only 9 streams.

10.5.3.2.4 Forman to Tx-S CSA. There are four possible corridors from Forman to the Tx-S CSA. Of the four corridors, wetland impacts would clearly be the most significant in corridor 10-7-5-3 because this corridor contains the largest wetland acreage (5386), the largest total wetland percentage

(8 percent) and the largest percentage of PEMC wetlands (43 percent) (Table 10-2). This corridor also runs perpendicular to the main flight pattern of migratory birds. Corridors 9-4 and 9-6-5-3 contain the lowest total wetland percentage of the four Forman to Tx-S corridors (approximately 6 percent). The two corridors also contain similar percentages of PEMC and PEMF wetlands (Table 10-2). Corridor 9-4, however, would require 24 intermittent and permanent stream crossings, while corridor 9-6-5-3 includes only 6 streams.

10.5.3.3 Receive Site - General Impacts

Wetland impacts from overhead lines at the receive site would be similar to those discussed above for the transmit site, except that 20 poles per mile would be used at the receive site. Construction of underground lines would require disturbance of an approximately fifteen foot wide strip in the ROW for the length of the corridor. This disturbance would be largely temporary, and any wetland vegetation disturbed would be likely to naturally regenerate by the following growing season.

10.5.3.4 Receive Site - Corridor Specific Impacts

10.5.3.4.1 Corridors to Rx-E CSA. Wetlands acreages in the receive power line corridors have been measured using a line transact sampling methodology (Hammon et al, 1990). The power line corridor from Dakota Junction to the Rx-E CSA, would result in the least impacts to wetlands because it contains the smallest acreage (53 acres) and percentage (3 percent) of total wetlands (Table 10-2). The greatest impacts to wetlands would result in Morris-Owen corridor E2, which contains the largest total wetland acreage (88 acres) and percentage (6 percent).

10.5.3.4.2 Corridor to Rx-W CSA

The power line corridor from Radium to the Rx-W CSA includes only 9 acres of wetlands (Table 10-2). Wetland impacts at the Rx-W CSA power line corridors are therefore not expected to be significant.

10.5.3.5 Mitigation

If overhead lines are used, the spacing of poles can be altered or modified within practicable limits so that important wetlands are avoided. In areas of high wetland concentrations, such as Tx site link 7 in North Dakota, it is probable that poles will be placed in a wetland. Even in these cases, attempts would be made to minimize the duration and extent of disturbance within the wetland by keeping machinery out of the wetland as much as possible.

Construction impacts could be further minimized by restructuring surface drainage patterns to their original form. Wetland vegetation removed or severely damaged would be replaced with native wetland species.

10.5.4. Mammals

10.5.4.1 General Impacts - Both Sites

The primary effect of powerline construction to mammals would be habitat disturbance. In all cases habitat disturbance would be predominantly temporary. The only potential permanent habitat impacts would be the destruction of dens of ground dwelling mammals such as badgers and woodchucks (*Marmota monax*). This destruction could occur as a result of pole erection for overhead lines or burial of underground lines. In view of the limited area of disturbance and the availability of suitable habitat within the region, however, impacts are not expected to be significant.

Potential direct impacts to mammals include electrocution (for small climbing mammals such as squirrels) and collisions with project-related vehicles. Squirrels (*Sciurus* spp.) are not common in the area, and mammal collisions with project related traffic are not anticipated to be significant at either transmit or receive power lines because of the relatively small number of trips made and construction will occur during daylight hours, when collisions are less likely (Technical Study 7).

10.5.4.2 Transmit Site

Post-construction habitat is likely to be the same as pre-construction habitat. Habitat in the South Dakota links, which contain primarily agricultural land, would be temporarily disturbed. The only potential permanent impacts could occur in links 3, 5, 7, and 8, where construction activity could destroy the dens of ground-dwelling mammals in rangeland and pasture. Because of the abundance of similar habitat in the region, however, these impacts will not be significant.

10.5.4.3 Receive Site

The majority of land in both receive power line corridors is agricultural. Impacts to mammals, such as foraging white-tail deer, could occur temporarily as a result of habitat disturbance during construction. The only potential permanent impact is electrocution to small mammals such as squirrels. Small mammal electrocutions could occur where power lines pass through forested areas or shelterbelts. Electrocutions to small mammals, however, will not affect local populations of small mammals.

10.5.4.4 Mitigation

Mitigation of mammal impacts is not considered necessary because potential impacts will be insignificant.

10.5.5 Birds

10.5.5.1 Transmit Site

Potential project impacts to avian resources include habitat loss and direct impacts due to collision with overhead wires or electrocution. General mitigation measures to avoid or reduce the potential for these impacts are outlined in section 10.5.5.2.4.

10.5.5.1.1 Collision Risk. Numerous bird species, representing 13 orders, have been documented as victims of collisions with overhead wires (Thompson, 1978). Waterfowl (especially dabbling ducks), rails and coots, gulls, grebes, and shorebirds are generally the species groups reported as suffering the highest mortality rates. Other species groups (e.g., cranes) may suffer relatively high levels of mortality in localized situations. Passerines, doves, woodpeckers, and raptors are generally considered to have lower collision risks with overhead wires, and this is usually attributed to the higher maneuverability of these species (Krapu, 1974; Anderson, 1978; Thompson, 1978; Olendorff et al, 1981; Malcolm, 1982; Rutz et al, 1986; Olendorff and Lehman, 1986; Faanes, 1987).

Studies of bird behavior at power lines have shown that the most common reaction is to fly over the line (Faanes, 1987). Since the conductor wires are more visible and usually lower than the neutral static wire, most reported collisions are usually with this static wire; as birds flare to avoid the conductors, they collide with the static wire. Although little information is available on the differences between the two wire configurations (single-pole and H-frame) considered in this study, the H-frame configuration may be less hazardous to flying birds. The H-frame configuration has the three conductor wires orientated in one horizontal plane, with the two ground wires in a second horizontal plane above the conductors (Figure 10-9). The single-pole configuration has each wire (three conductors and one ground) in its own plane, with the ground wire on top. Thus, the single-pole wire configuration occupies more vertical airspace than does the H-frame configuration and may therefore represent a greater collision risk.

Bio/West (1989) has summarized reported collision rates with transmission lines. Reported rates range from 0.002% to 1.08% of the estimated number of birds crossing the transmission line corridor. These estimates, however, and estimates of collision mortality per mile of power line, are heavily influenced by local conditions. Thus, it is not possible to make predictions of the number of birds which may be killed by the transmission lines addressed in this study, although an evaluation of the relative severity of potential collision risk is possible among alternative corridors. In comparison to the potential avian impacts associated with the CRS antenna facilities, the potential avian impacts of the power lines are significantly less.

The maximum height of the single-pole configuration is 95 feet, and the maximum height for the H-frame configuration is approximately 55 feet. Most migrating birds, including most of the birds aloft during nocturnal hours, generally fly at altitudes above 100 feet above ground level (Technical Study 8) and would be at little risk of collisions. Most collisions probably would occur during low level local movements, especially during inclement weather and low light conditions. Dabbling ducks and geese, in particular, frequently make low altitude flights from roosting to feeding areas near dusk and dawn, when visibility is reduced. The probability of birds crossing the transmission line corridor would depend on the interspersion of habitat types and the presence of flyways.

Because waterbirds are most frequently reported as colliding with overhead wires, the number of wetland acres contained within each power line corridor (Table 10-2) alternative was used as an index to compare the relative risks of collisions. The percentage of wetlands within three types, temporary, seasonal, and semi-permanent, was also considered during these comparisons. Since temporary wetlands are attractive to a smaller number of avian species and persist for shorter periods, they will not attract as many species groups to the vicinity of the power line over as long a period of time as the other wetland types. The deeper water and more permanent nature of seasonal and semi-permanent wetland types makes them more attractive to species groups such as cormorants and diving ducks. Seasonal and semi-permanent wetlands also generally support higher breeding populations of waterbirds than do temporary wetlands, and young birds making their first flights may be at greater risk of collisions with nearby power lines.

Comparisons were made among alternatives within 4 groups: 1) Tx-N CSA alternatives from Groton; 2) Tx-N CSA alternatives from Forman; 3) Tx-S CSA alternatives from Groton; and 4) Tx-S CSA alternatives from Forman.

10.5.5.1.1.1. Groton to Tx-N CSA. Two alternative corridors (1-3 and 2-3) are contained within this group. Total length of the two corridors is approximately equal (Table 10-3). The percentages of wetlands in both are also approximately equal (Table 10-3), although corridor 1-3 contains a higher total wetland acreage and a higher percentage of seasonal wetlands (Table 10-2). Both alternatives pass near major wetland areas, however, and are likely to attract waterfowl. Therefore, corridors 1-3 and 2-3 would probably result in similar avian impacts.

10.5.5.1.1.2. Forman to Tx-N CSA. This group contains three alternatives (10-7; 10-8-5; and 9-6-5). Corridors 10-7 and 9-6-5 are of approximately equal length (approximately 31 and 28 miles, respectively) while corridor 10-8-5 is shorter, at about 23 miles (Table 10-3). Corridor 10-7, because of its longer length, higher density of wetland acres (136.1 acres per mile), and higher percentage of seasonal wetlands is considered the worst of the three alternatives for birds. Furthermore, in North Dakota the east/west orientation of corridor 10-7 is perpendicular to the predominant direction of bird movement. Corridor 10-7 also runs perpendicular and adjacent to the proposed 5,000 acre Kraft Slough National Wildlife Refuge, an important nesting area for Franklin's gulls (DOI, 1979). In addition, an existing power line parallels just over half of this corridor, and depending upon the orientation of the two lines to each other and the wire configurations, this may increase the number of bird kills relative to a single power line. If the visibility of the lines is significantly increased by the additional lines, however, collisions may be reduced in these double-line areas.

Corridors 10-8-5 and 9-6-5 have similar wetland densities (115.5 and 120.6 acres per mile), and similar percentages of seasonal and semi-permanent wetlands (Table 10-2). Since corridor 10-8-5 is shorter, and corridor 9-6-5 contains an existing line over much of its length, total collision mortality would probably be less at 10-8-5 relative to corridor 9-6-5. Thus, from a bird collision standpoint, corridor 10-8-5 is considered the preferred alternative within this group.

10.5.5.1.1.3. Groton to Tx-S CSA. This group contains two alternatives, corridors 1 and 2. Corridor 2 is two miles shorter (Table 10-3), contains fewer total wetland acres, and lower percentages of seasonal and semi-permanent wetlands (Table 10-2) relative to corridor 1. Because both alternatives pass near major wetland areas, however, neither corridor is preferred from a bird collision perspective. However, corridor 1 would avoid the western portion of the Tx-S CSA, which contains a large wetland that attracts waterfowl (Technical Study 8).

10.5.5.1.1.4. Forman to Tx-S CSA. There are four alternatives within this group (10-8-5-3; 9-6-5-3; 9-4; and 10-7-5-3). Corridors 9-6-5-3 and 9-4 contain the lowest percentages of total wetlands (6 percent) and similar percentages of semi-permanent and seasonal wetlands (Table 10-2). Corridor 9-6-5-3, however, is approximately two miles shorter (Table 10-3) and is preferred. From an avian impact perspective, corridor 10-7-5-3 is considered the worst among the four alternatives.

10.5.5.1.2 Electrocution Risk. In open country such as exists in the Amherst region, many large birds, particularly raptors, often use power poles as hunting or resting perches. These birds may be electrocuted if they touch two conducting wires simultaneously or touch a conducting wire and a grounded structure simultaneously when perched, taking off, or landing (Olendorff et al, 1981). The risk of electrocution is a function of wire spacing and the wingspan of the bird. For either the single pole or H-frame pole configurations, the spacing between conductor wires and between conductor and neutral wires exceeds guidelines provided by the Raptor Research Foundation for minimizing electrocution of raptors (WAPA, 1990b). Thus, impacts to raptors (and other large-wingspan birds such as herons and cranes) due to electrocution would be minimal.

10.5.5.1.3 Avian Habitat Loss. Some habitat (approximately 300 square feet per pole) may be temporarily disturbed during construction, but minimal habitat is expected to be permanently lost if power line placement follows existing right-of-ways or roads. Some minor habitat modifications (e.g. trimming of tree branches) may occur in these instances but are expected to be insignificant. Some woodland habitat will be altered if new corridors pass through wooded areas, since trees would have to be cleared along the right-of-way. Other habitat types (e.g. grassland) would not be structurally altered by power line placement and poles and wires would provide new "habitat" in the form of perching and nesting locations.

10.5.5.2 Receive Site

Potential project impacts to avian resources include habitat loss and direct impacts due to collision with overhead wires or electrocution. General mitigation measures to offset these potential impacts are outlined in section 10.5.5.2.4.

10.5.5.2.1 Collision Risk. A general discussion of avian collisions with overhead wires is contained in section 10.5.5.1.1. The risk of collision is nonexistent if wires are installed underground. At the Rx-W CSA, an existing line is in the proposed corridor and either the existing or the new power line will likely be buried. Consequently, no new impacts will occur, assuming that a wire configuration similar to the existing one is used. For the two Rx-E CSA alternatives, lines may be buried or overhead, regardless of the presence of existing lines. Thus, two overhead lines may run next to each other along these corridors if there are existing lines. Even if overhead wires are used, the power line will be buried within 0.5 miles of the radar facility.

The overhead wire configuration design, if used, will have three conductor wires above and the ground wire below on poles of approximately 35 feet in height (Figure 10-10). Similar poles commonly occur within the Thief River Falls study area to service individual residences, although these poles usually have fewer wires. Small diameter distribution wires appear to be responsible for a major portion of the total birds killed at overhead wires because they are abundant and because the small diameter of the wires makes them less visible (Thompson, 1978). Although the proposed power line corridors are relatively short, some bird collisions are expected to occur. While the amount of this mortality is impossible to predict, it is not expected to significantly affect regional populations of any avian species. A comparison of the relative risk of corridors to each CSA indicates that the Radium to Rx-W CSA corridor is preferable simply because it is several miles shorter.

10.5.5.2.2 Electrocution Risk. The risk of raptor electrocution is minimal if wires are installed underground. Raptor electrocutions may occur at the overhead wires used for this project unless the design is modified or raptor protection devices are installed. The severity of this potential impact is not expected to be great because the Rural Electrification Association (REA) must build distribution lines following guidelines established for minimizing electrocutions.

Low voltage distribution wires (less than 69 kV), such as those used at the receive site, represent the greatest electrocution danger for raptors since the wires are close enough together to be touched simultaneously by a bird with even a moderate wingspan. Most documented raptor electrocutions, especially eagles, are at distribution wires (Olendorff et al, 1981).

10.5.5.2.3 Habitat Loss. Some habitat will be temporarily disturbed during construction (approximately 300 square feet per pole for overhead construction or a 15 foot wide corridor for underground installation), but no habitat is expected to be lost if the power line placement follows existing right-of-ways or roads, as expected. Some minor habitat modifications (e.g. trimming of tree branches) may occur if overhead wires are installed but are expected to be insignificant.

The shorter length of the Radium to Rx-W CSA corridor suggests that use of this corridor would involve less habitat impacts than the Rx-E corridors.

10.5.5.2.4 Mitigation. Mitigation for lost habitat will probably not be necessary because habitat losses will be minimal in comparison to existing habitat in the area. Mitigative measures (e.g. installing perch guards) may be necessary to minimize the possibility of raptor electrocutions if wires are constructed overhead.

Final corridor selection among CSA alternatives and the placement of the power line within the selected corridor should avoid crossing wetlands or bisecting known avian flight corridors (e.g. between major wetlands and fields used for foraging), where possible, to minimize potential bird collisions. Selection of the Rx-W CSA, and therefore the Radium to Rx-W CSA power line corridor, would result in the least impact to birds. Areas with high potential for bird collisions may be monitored for dead birds after construction as part of the project bird collision monitoring plan. Areas which show high rates of collision may have marking devices, such as aviation marker balls or spiral vibration dampers, installed on the wires. These devices have been shown to reduce collision rates with overhead wires (Beaulaurier, 1981). Significant collision mortality could require additional mitigation for enhancement or creation of avian habitat. The need for this mitigation would be evaluated by the USAF and the responsible state and federal agencies as part of the on-going mitigation planning process.

10.5.6 Threatened and Endangered Species

10.5.6.1 General Impacts - Both Sites

Impacts to endangered birds include electrocution and collisions with power lines and with project related traffic. The risk of electrocution at the transmit site is negligible because of the spacing and arrangement of the conductor wires. At the receive site, raptor electrocutions may occur unless the design is modified or protective devices are installed. The potential for bird collisions with project traffic at both transmit and receive sites is considered insignificant because construction will occur during the day, when feeding or resting birds are visible in the road. The bald eagle is at the greatest risk of collision with the line itself because of the eagle's extremely large (up to six feet) wingspan. The impacts to both endangered birds and plants resulting from habitat loss are considered insignificant because they would be predominantly temporary.

10.5.6.2 Transmit Site

Large wetland areas serve as the primary habitat for both the bald eagle and peregrine falcon. Therefore, the likelihood of collision impacts to these species corresponds closely to the likelihood of wetland impacts. Construction of a power line in links 7, 8, and 9, which have a relatively high density of PEMC and PEMF wetlands, would therefore be more likely to result in bald eagle or peregrine falcon impacts.

Habitat disturbances would likely be temporary and are therefore not considered a significant potential impact to the bald eagle or peregrine falcon.

Potential habitat for the Western prairie fringed orchid is most abundant in links 5, 7 and 8, which traverse the Hecla Sandhills. Link 3 is predominantly rangeland and could also potentially provide habitat for the orchid. Construction of a power line in these corridors would therefore be more likely to disturb an orchid colony. Construction in the other links, which are predominantly agricultural, would have less likelihood of affecting the orchid.

10.5.6.3 Receive Site

Because they would traverse the northern portion of the Goose Lake wetland system, which provides resting and foraging habitat to bald eagles and peregrine falcons, the power lines for Rx-E would cause a greater risk to these raptors than would a power line from Radium to Rx-W. The Radium to Rx-W powerline would replace an existing power line; therefore, few if any incremental impacts would be expected.

Construction activity would temporarily disturb habitat at all locations. This disturbance, however, is not expected to cause significant impacts to the bald eagle or peregrine falcon.

No impacts are anticipated for the piping plover or gray wolf because these species were not observed and are not expected to occur in the study area.

10.5.6.4 Mitigation

Mitigation measures discussed in section 10.5.5.2.4. for birds will mitigate impacts to the bald eagle and peregrine falcon. As noted previously, the most effective method of minimizing bird collisions is to place the power line next to an existing power line of similar size and structure. At the receive site, addition of a new line on an existing ROW would require burying of the original line, resulting in no net increase in the potential for avian collisions.

At the transmit site, prior to construction of the power lines, Western supervisory personnel will be instructed on the protection of cultural and ecological resources. The construction contract will address federal and state laws regarding antiquities and plants and wildlife, and the importance of these resources and the purpose and necessity of protecting them (Western, 1990a). Illustrations of protected resources that might occur in the area will be supplied in order to assist in identification. Selected power lines may be surveyed for the Western prairie fringed orchid before the final location of the poles is determined and before construction occurs.

10.5.7 Summary of Impacts

Potential impacts to biological resources are summarized in Table 10-4. Potential impacts to resources were classified as either high, moderate or low by considering the sensitivity, quality and quantity of the affected resource as well as the duration of the impact. Resource alterations that would result from potential impacts were considered high if the change to the resource would be substantial, moderate if the change would be limited, and low if the change would be insignificant or minor. Power line construction and operation at either the transmit or receive site will not cause significant impacts to vegetation or mammals. Potential impacts to wetlands could occur during construction but would likely be temporary. These impacts can be minimized by

TABLE 10-4. SUMMARY OF RELATIVE BIOLOGICAL IMPACTS OF POWER LINES CORRIDORS

	POTENTIAL FOR IMPACTS				
	Vegetation	Mammals	Wetlands	Birds	T&E Species
Transmit Corridors					
Groton to Tx-N CSA					
Corridor 1-3	Low	Low	Moderate	Moderate	Low
Corridor 2-3	Low	Low	Moderate	Moderate	Low
Forman to Tx-N CSA					
Corridor 10-7	Low	Low	High	High	Low
Corridor 10-8-5	Low	Low	High	Moderate	Low
Corridor 9-6-5	Low	Low	High	Moderate	Low
Groton to Tx-S CSA					
Corridor 1	Low	Low	Moderate	Moderate	Low
Corridor 2	Low	Low	Low	Moderate	Low
Forman to Tx-S CSA					
Corridor 10-8-5-3	Low	Low	High	Moderate	Low
Corridor 9-6-5-3	Low	Low	Moderate	Moderate	Low
Corridor 9-4	Low	Low	Moderate	Moderate	Low
Corridor 10-7-5-3	Low	Low	High	High	Low
Receive Corridors					
Radium to Rx-W CSA	Low	Low	Low	Low	Low
Dakota Junction to Rx-E CSA (E1)	Low	Low	Low	Low	Low
Morris-Owen to Rx-E CSA (E2)	Low	Low	Moderate	Low	Low
Morris-Owen to Rx-E CSA (E3)	Low	Low	Moderate	Low	Low

proper alignment of the ROW within the corridor and by modifications to pole spacing. Potential impacts to birds, including the endangered bald eagle and peregrine falcon, are possible at the transmit site and only if overhead lines are used at the receive site.

10.5.7.1 Preferred Corridors - Transmit Site

Based on the previous analyses, impacts to biotic resources can be minimized by use of the following power line corridors: corridor 1-3 from Groton to the Tx-N CSA; corridor 9-6-5 from Forman to the Tx-N CSA; corridor 1 from Groton to the Tx-S CSA, and corridor 9-6-5-3 from Forman to the Tx-S CSA. While resource impacts are similar for the two alternative corridors from Groton to the Tx-N CSA, corridor 1-3 is preferred over 2-3 because it would require fewer stream crossings. Of the three corridors from Forman to the Tx-N CSA, corridor 9-6-5 is preferred as it would require fewer stream crossings and would result in slightly less impacts to wetlands. Corridor 1 is environmentally preferred over corridor 2 from Groton to the Tx-S CSA because it would require fewer stream crossings and because it would avoid the large wetland to the south of the Tx-S CSA which attracts a large number of waterfowl, therefore resulting in slightly less potential for avian impacts. Corridor 9-6-5-3 is preferred for Forman to the Tx-S CSA because it would require fewer stream crossings and result in roughly equal impacts to other biological resources. Use of corridors from Groton would generally involve fewer environmental impacts than use of corridors from Forman. The selection of a CSA would have an insignificant effect on power line impacts because no matter which CSA is chosen for the CRS facilities, one power line must originate from the Groton substation; and one must originate from the Forman substation.

10.5.7.2 Preferred Corridors - Receive Site

Use of the existing power line corridor from Radium to the Rx-W CSA would cause fewer environmental impacts to these resources than use of any of the corridors to the Rx-E CSA. Among the three alternative corridors identified for the Rx-E CSA, corridor E1 from the Dakota Junction substation is environmentally preferred. Potential impacts to vegetation, mammals, birds and threatened and endangered species are expected to be equal for all three Rx-E alternatives. The Dakota Junction E1 corridor, however, would result in fewer effects on wetlands.

REFERENCES

Anderson, W.L., 1978. Waterfowl Collisions With Power Lines At a Coal-Fired Power Plant. Wildlife Society Bulletin. 6(2):77-83.

Beaulaurier, D.L., 1981. Mitigation of Bird Collisions With Transmission Lines. Bonneville Power Administration, Portland, OR.

Bio/West, Inc., 1989. Great Falls-Conrad 230 KV Transmission Line Post-Construction Bird Monitoring Study. Final Report Submitted to J.F. Sato and Associates, Golden, CO.

Cowardin, L.M., V. Carter, F.C. Golet, and F. LaRoe, 1979. Classification of Wetlands and Deepwater Habitats of the United States. U.S. Fish and Wildlife Service. FWS/OBS-79/31.

Faanes, C.A., 1987. Bird Behavior and Mortality in Relation to Power Lines in Prairie Habitats. U.S. Fish and Wildlife Service, Fish and Wildlife Technical Report 7.

Hammon, Jensen, Wallen, & Associates, Inc., 1990. Unpublished wetlands acreage data for CRS power line corridors.

Krapu, G.L., 1974. Avian Mortality From Collisions With Overhead Wires in North Dakota. Prairie Naturalist. 6:1-6.

Malcolm, J.M., 1982. Bird Collisions With a Power Transmission Line and Their Relation to Botulism at a Montana Wetland. Wildlife Society Bulletin. 10:297-304.

North Dakota Fish and Game Department, 1986. North Dakota Outdoors. Volume XLIX. Number 2.

Olendorff, R.R., A.D. Miller, and R.N. Lehman, 1981. Suggested Practices for Raptor Protection on Power Lines: The State of the Art in 1981. Raptor Research Report No. 4, Raptor Research Foundation, Inc.

Olendorff, R.R. and R.N. Lehman, 1986. Raptor Collisions With Utility Lines: An Analysis Using Subjective Field Observations. Final Report prepared for Pacific Gas and Electric Company, San Ramon, CA.

PKM Electric Cooperative (PKM), 1989. R. Baird and C. Reisen (General Manager). Personal Communication. November 15.

Red Lake Electric Cooperative (RLEC), 1989. R. Kennedy (General Manager). Personal Communication. November 15.

Rutz, P.J., H.H. Prince, R.D. Rutz, and G.A. Dawson, 1986. Bird Collisions With Transmission Lines Near a Power Plant Cooling Pond. Wildlife Society Bulletin. 14:441-444.

SRI International, 1990. J. Manitakos, Personal Communication.

Soil Conservation Service (SCS), 1975. Soil Survey of Marshall County, South Dakota. U.S. Department of Agriculture.

Soil Conservation Service (SCS), 1977. General Soils Map of Polk County, Minnesota. U.S. Department of Agriculture.

Soil Conservation Service (SCS), 1984. Soil Survey of Pennington County, Minnesota. U.S. Department of Agriculture.

Soil Conservation Service (SCS), 1989a. R.B. Heschke. Personal Communication. U.S. Department of Agriculture. October 12.

Soil Conservation Service (SCS), 1989b. Farmland Conversion Impact Rating for the Over-the-Horizon Backscatter Program in Marshall County, South Dakota. U.S. Department of Agriculture. October 12.

Soil Conservation Service (SCS), 1989c. Wayne Bachman. Personal Communication. U.S. Department of Agriculture. December 28.

Thompson, L.S., 1978. Transmission Line Wire Strikes: Mitigation Through Engineering Design and Habitat Modification. Pages 27-52 In M. Avery (ed). Impacts of Transmission Lines on Birds in Flight. Office of Biological Services, U.S. Fish and Wildlife Service. FWS/OBS-78/48.

United States Agricultural Stabilization and Conservation Service (USASCS), 1990a. Marshall County, Minnesota, Personal Communication. April 30.

United States Agricultural Stabilization and Conservation Service (USASCS), 1990b. Sargent County, North Dakota. Memorandum from W. Veil (County Executive Director) to J. Doyle (Metcalf & Eddy/Holmes & Narver). May 1.

United States Agricultural Stabilization and Conservation Service (USASCS), 1990c. Day County, South Dakota. Kathy Lundquist, Personal Communication. April 25.

United States Agricultural Stabilization and Conservation Service (USASCS), 1990d. Marshall County, South Dakota. Harland Petersen (County Executive Director), Personal Communication. April 30.

United States Air Force (USAF), 1988. Record of Decision Central Radar System Environmental Impact Statement, Over-the-Horizon Backscatter Program.

United States Fish and Wildlife Service (USFWS), 1980. Preliminary National Wetlands Inventory (NWI) maps for Milbank SW region.

United States Fish and Wildlife Service (USFWS), 1983. Preliminary National Wetlands Inventory (NWI) maps for Viking SE region.

United States Fish and Wildlife Service (USFWS), 1990a. Letter from M.S. Zschomler (South Dakota State Supervisor) to Maj. R.L. Goodner (CRS Program Manager). January 22.

United States Fish and Wildlife Service (USFWS), 1990b. Letter from M.S. Zschomler (South Dakota State Supervisor) to Maj. R.L. Goodner (CRS Program Manager). March 1.

United States Fish and Wildlife Service (USFWS), 1990c. Letter from M.S. Zschomler (South Dakota State Supervisor) to Maj. R.L. Goodner (CRS Program Manager). January 18.

United States Department of Interior (DOI), 1979. Garrison Diversion Unit Biological Investigations - 1978 Annual Report. Water and Power Resources Service, Missouri-Souris Project.

United States Department of Interior (DOI), 1980. Garrison Diversion Unit Biological Investigations - 1979 Annual Report. Water and Power Resources Service, Missouri-Souris Project.

Western Area Power Administration (Western), 1990a. Letter from R.J. Harris (Assistant Area Manager for Engineering, Operations, and Maintenance), to P.V. Sitkus (Director Acqusition Civil Engineering, U.S. Air Force). February 16.

Western Area Power Administration (Western), 1990b. J. Bridges, Personal Communication. April 2.