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WELL CLOSURE METHODS AND PROCEDURES PHASE II

Delivery Order 5031

Prepared for

McClellan Air Force Base

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DISCLAIMER

This report has been prepared for the United States Air Force for the purpose of aiding in the implementation of a final remedial action plan under the Interagency Agreement (IAG). As the report relates to actual or possible releases of potentially hazardous substances, its release prior to Air Force final decision on remedial action is in the public interest. The limited objectives of this report, the ongoing nature of remediation, and the evolving knowledge of site conditions and chemical effects on the environment and health all must be considered when evaluating this report, since subsequent facts may become known which may make this report premature or inaccurate. Acceptance of this report in performance of the contact under which it was prepared does not mean that the U.S. Air Force or the Department of Defense adopts the conclusions, recommendations, or other views expressed herein, which are those of the contractor only and do not necessarily reflect the official position of either department.

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Introduction

McClellan Air Force Base (AFB) is located about 7 miles northeast of downtown Sacramento, California (see Figure 1). The base was originally established in 1936 as an air repair depot and supply base for the War Department. During World War II, McClellan AFB became a major industrial facility; in the early 1950s, it became a jet fighter maintenance depot. Today, McClellan AFB is an Air Force Logistics Command Center, occupying about 2,600 acres and employing more than 20,000 people.

Historically, McClellan AFB has used a variety of hazardous materials as part of routine operations and maintenance activities. These hazardous materials have included industrial solvents, caustic cleaners, electroplating wastes containing heavy metals, jet fuels, and a variety of oils and lubricants (Radian Corporation, 1990). In August 1979, the McClellan AFB Environmental Protection Committee created a special groundwater contamination task force to determine whether groundwater quality problems existed in the area. This voluntary action was prompted by concern that previous use of toxic chemicals, particularly trichloroethylene (TCE), could have affected groundwater quality. Samples collected from several wells on and near the base during 1979 and 1980 confirmed the presence of TCE in certain wells. As a result, those wells were taken out of service.

Since the discovery of groundwater contamination, investigations have been conducted at McClellan AFB under the Air Force Installation Restoration Program. Results of these investigations show that contamination is mainly confined to the uppermost groundwater zones beneath the base. Drinking water wells in the vicinity of the base draw primarily from deeper groundwater zones (Radian Corporation, 1990). Heavy pumping from many of these wells has created a downward gradient of flow in the groundwater system beneath the base.

However, concern mounted that existing inactive water supply wells at McClellan AFB may serve as conduits, allowing contaminated groundwater near the water table to migrate to deeper zones through the casing and gravel pack and potentially threaten downgradient drinking water supplies. Therefore, McClellan AFB issued a Statement of Work in June 1990 that authorized a Water Well Abandonment Project to decommission several inactive water supply wells on the base.

Originally, eight inactive water supply wells were targeted for decommissioning. However, four of these wells (Base Wells [BW-] 3, 6, 16, and 19) were eliminated from consideration because they could not be located. Later, City Well 150 (CW-150), on Astoria Street near the southwestern base boundary, was added to the list for decommissioning. The general locations of the five wells abandoned during this project are shown in Figure 2.

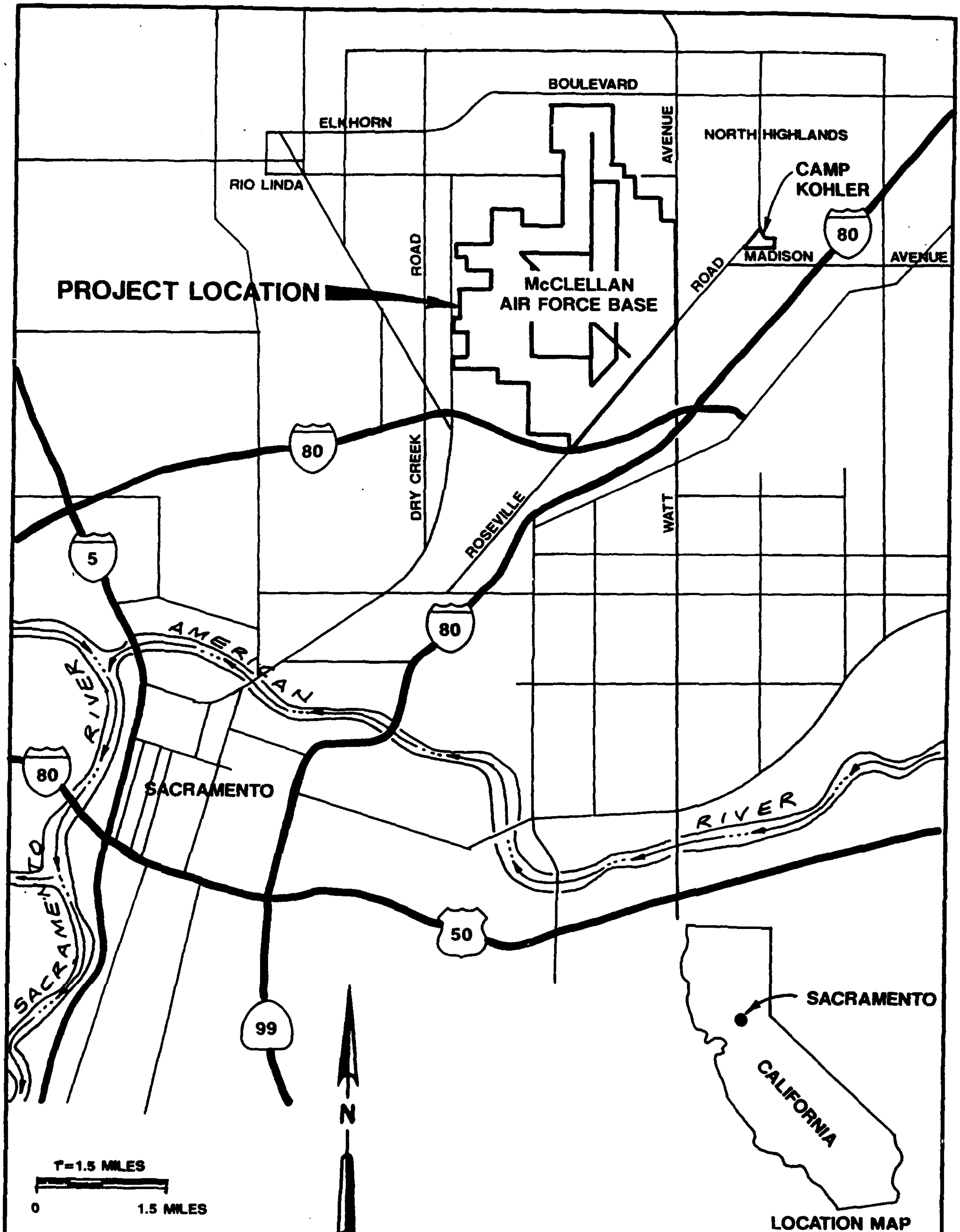

FIGURE 1
LOCATION OF McCLELLAN AIR FORCE BASE

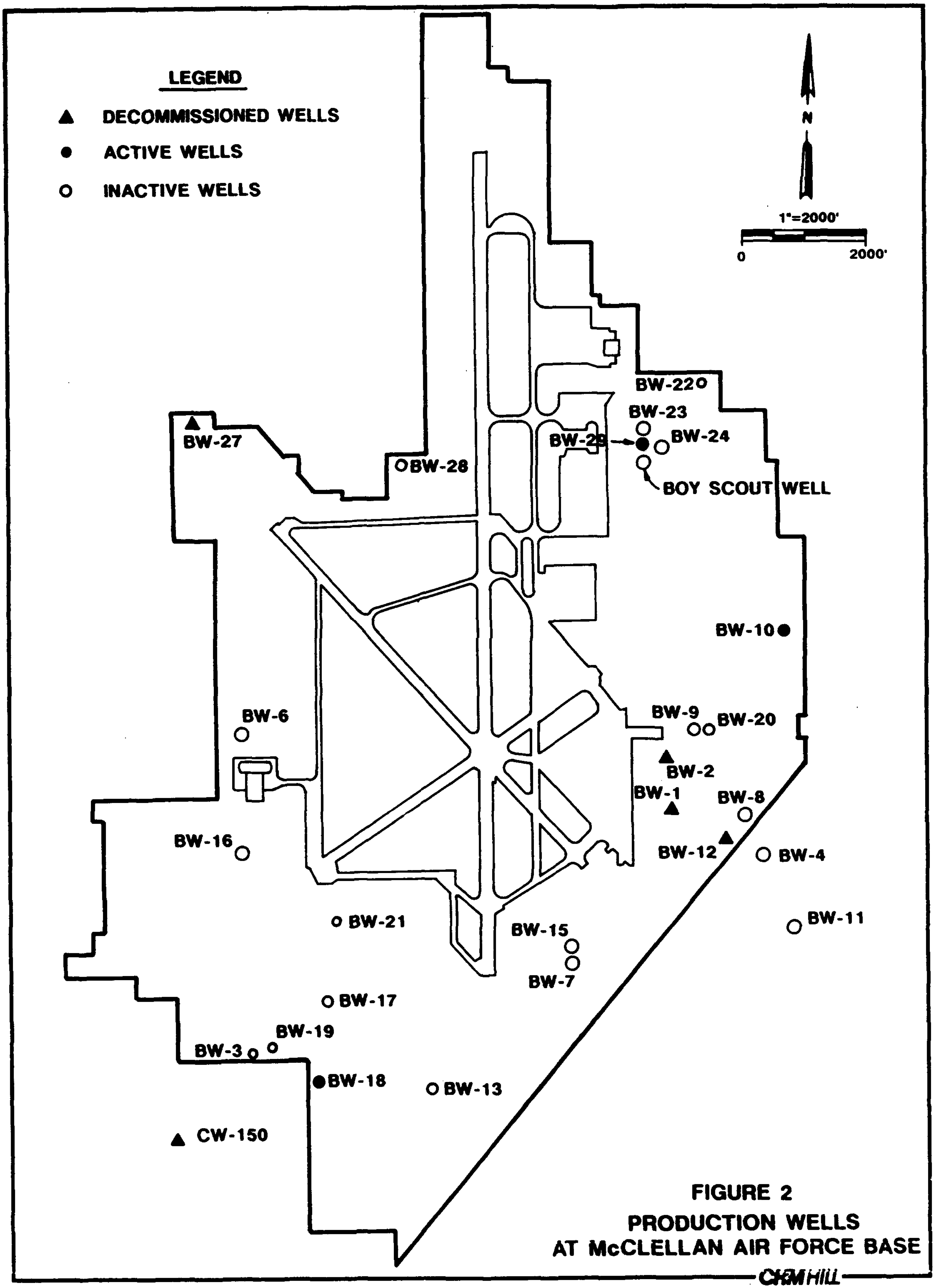

FIGURE 2
PRODUCTION WELLS
AT McCLELLAN AIR FORCE BASE

On September 30, 1991, McClellan AFB issued a contract that initiated a second phase of water well decommissioning on and near the base. Phase II includes the decommissioning of BW-7, -13, -17, -20, and -28: five inactive water supply wells at McClellan AFB. One other inactive well, BW-8, will be sealed in its upper zone and then returned to service for standby use in fire emergencies. The general location of these wells is shown in Figure 2.

In addition, Phase II includes the decommissioning of two wells formerly constructed as part of a seismic survey at nearby Camp Kohler (see Figure 3). Two other wells at Camp Kohler, Laundry Wells (LW-) 1 and 2, have been previously abandoned by filling the casing with concrete. Neither of the wells are presently visible at the ground surface, and LW-2 has not been precisely located. LW-2 will be located, and LW-1 and LW-2 will be redrilled and decommissioned. The general location of these wells is shown in Figure 3. Thus, Phase II of the Water Well Abandonment Project at McClellan AFB provides for the modification or decommissioning of up to 10 additional wells.

This Well Closure Methods and Procedures Report addresses the decommissioning and modification of wells during Phase II. Based on a review of existing files and documents and field work conducted at Camp Kohler, the report will provide a brief history of the wells, describing their construction details and discussing their hydrogeological setting. An inventory of all McClellan AFB wells is also provided. This inventory lists McClellan AFB water supply wells and summarizes what is currently known about their status. The report also proposes an approach to decommissioning the Phase II wells and modifying BW-8. The approach to decommissioning is based on the successful approach followed during Phase I. A Site Safety Plan that will govern safety procedures during the field work is provided in Appendix A. Well logs obtained for McClellan AFB production wells from the California Department of Water Resources (DWR) are provided in Appendix B. Cement bond logs run on the two seismic wells at Camp Kohler are provided in Appendix C. Finally, Appendix D contains a response to comments received from the regulatory agencies on the Draft Well Closure Methods and Procedures Report for Phase II.

Hydrogeology

The following discussion of geology and groundwater is taken primarily from investigations performed on behalf of McClellan AFB by Radian Corporation, whose staff has worked at the base since 1984. Hydrogeologic conditions in the immediate vicinity of base wells subject to decommissioning are described in the sections below.

Regional Geology

McClellan AFB is located in the Great Valley Geologic Province, a large depositional basin bounded by the Sierra Nevada on the east and Coast Range on the west (see Figure 4). The basin is filled with a thick sequence of sedimentary deposits, mainly derived from the Sierra Nevada in the vicinity of the base.

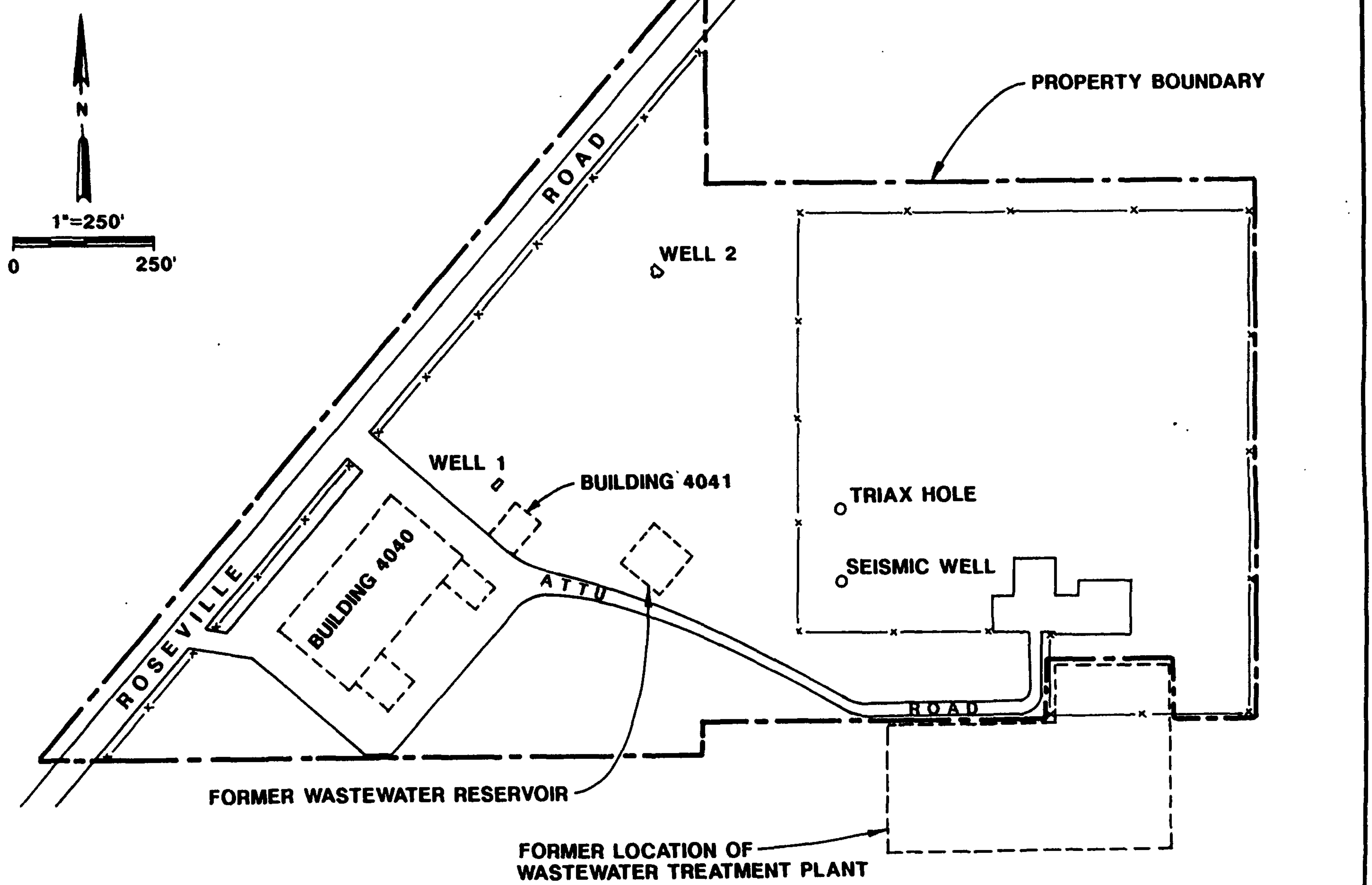

FIGURE 3
WELLS AT CAMP KOHLER
McCLELLAN AIR FORCE BASE

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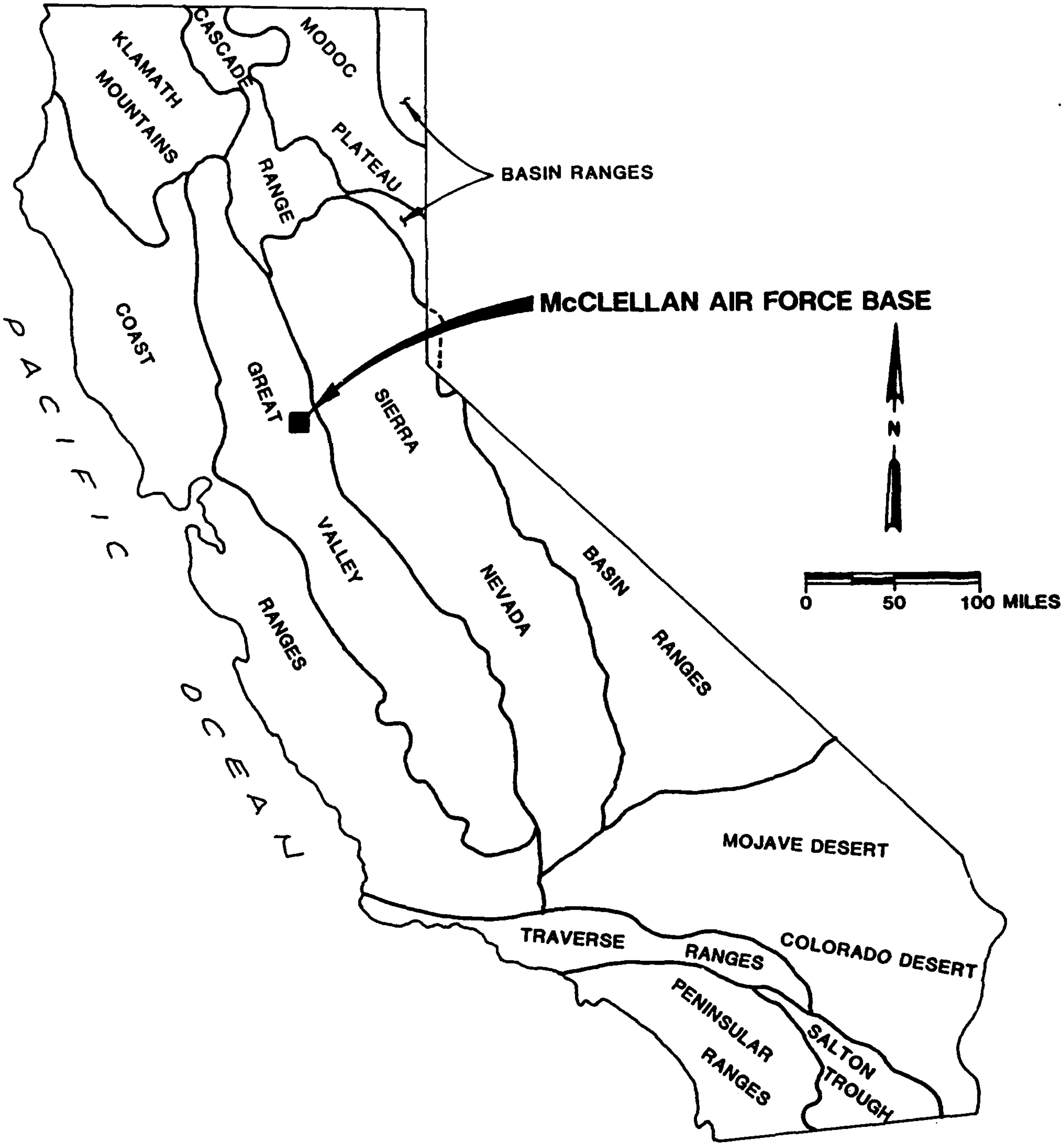

FIGURE 4
GEOLOGIC SETTING OF McCLELLAN AIR FORCE BASE

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Near-surface deposits near McClellan AFB are unconsolidated Quaternary sediments of the Riverbank, Turlock Lake, and Laguna Formations that extend from the surface to a depth of about 400 feet. These units consist of alluvium deposited by meandering streams, mainly as coarse-grained streambed sands and gravels, and fine-grained overbank silts and clays. As streams meandered across the valley, they alternately deposited, eroded, and redeposited sediment in a complex pattern. Thus, deposits exist as discontinuous interfingered lenses that are difficult to correlate from one location to another (Radian Corporation, 1991). Because of their similarity of origin and deposition, sediments of the Riverbank, Turlock Lake, and Laguna Formations are also difficult to distinguish from each other.

Underlying these formations in the vicinity of McClellan AFB is the Mehrten Formation, a Pliocene-age unit that lies at depths beneath about 400 feet. Although this formation also consists mainly of unconsolidated alluvium, it is distinguishable by its lithology and color. The Mehrten Formation is derived from volcanic material that was deposited as black to blue sands, silts, gravels, and clays (California DWR, 1978).

Although correlations have been difficult, geologic and geophysical logs collected from monitoring wells constructed between 1980 and 1991 have allowed investigators to distinguish several zones that appear to have roughly similar characteristics and be widely distributed at the base. These zones, designated as Zones A through F, are considered to act as preferential pathways for horizontal groundwater flow. However, evidence suggests that the subsurface system acts as one groundwater flow system, with hydraulic communication among the zones (Radian Corporation, 1991).

Groundwater

Historically, groundwater in the McClellan AFB area moved from the northeast to the southwest. However, withdrawals from pumping wells in the region have gradually caused gradients to change and water levels to decline. Today, a regional pumping depression approximately centered under the base and south of the base has caused regional groundwater to flow generally to the south (Radian Corporation, 1990).

Monitoring wells installed at McClellan AFB as a part of ongoing environmental investigations have allowed groundwater levels to be monitored and local groundwater flow patterns to be determined. These efforts have revealed local deviations from the regional flow pattern, caused mainly by the operation of extraction wells on base and by on-base and off-base water supply wells (Radian Corporation, 1991). The locations of active and inactive base supply wells is shown in Figure 2.

In the southeast area of the base, groundwater in the upper zones, which roughly correspond to the A, B, and C zones described above, appears to flow mainly toward the west-southwest, probably toward active well BW-18 (Radian Corporation, 1991). Previous investigations had noted a local flow to the northeast toward BW-8 prior to 1985, when the well was taken off-line (McClaren, 1986). Active well BW-10 may still influence flow patterns in this area. Pumping wells southeast of McClellan AFB may also influence local flow patterns (Radian Corporation, 1991).

Groundwater flow in the southwest and central portions of the base appears to be toward the south-southwest. Locally, flow appears to be converging toward active production well BW-18. However, groundwater flow may also be influenced by the pumping of off-base supply wells located south of the base (Radian Corporation, 1991).

In the northwest area of the base, groundwater in the uppermost zones appears to be flowing toward extraction wells on the northwest base boundary. Flow directions in the north and northeast areas of the base are mainly toward the southwest in the uppermost zones. Lack of data prevent an understanding of flow directions in the deeper zones (Radian Corporation, 1991).

Vertical gradients of groundwater flow have been generally downward around McClellan AFB, as groundwater moves to points of discharge in pumping wells. The strongest downward gradients have been observed in the uppermost zones. However, gradients vary seasonally and locally in response to patterns of pumping (Radian Corporation, 1991).

Aquifer tests have been performed in many parts of the base by various contractors as part of ongoing environmental investigations. Results have been varied, both because of the different lengths of the tests and methods used to interpret the data, and because of the natural heterogeneity of the subsurface geology. Values of transmissivity have ranged from about 1,200 to 28,600 gpd/ft, while values of hydraulic conductivity have ranged from about 97 to 500 gpd/ft^2 (Radian Corporation, 1990).

Groundwater levels beneath McClellan AFB have declined more than 60 feet during the 20th century because of withdrawals for agriculture and urban water uses (McLaren, 1986). Today, the water table occurs at a depth of about 95 to 105 feet beneath the surface, with seasonal fluctuations of up to 5 feet. In the deeper zones, groundwater occurs under generally semiconfined conditions (Radian Corporation, 1991).

Wells to be Decommissioned or Modified

Information on McClellan AFB production wells was obtained by a search of files at the base Civil Engineering Section and the California DWR, and by a review of environmental reports previously issued by the base.

McClellan AFB has established a consecutive numbering sequence for its supply wells. As it has acquired or constructed wells, it has assigned them the next available number in sequence. Today, 29 wells have been assigned numbers (Luhdorff and Scalmanini Consulting Engineers [LSCE], 1984).

This section provides information on the six base supply wells scheduled for decommissioning or modification under the present Phase II task order (BW-7, -8, -13, -17, -20, and -28) and the four wells at Camp Kohler (LW-1 and -2, and the two seismic wells). Available Well Drillers' Reports for base supply wells are presented in Appendix B. The known locations of the wells are shown in Figures 2 and 3.

Base Well 7

History and Well Data

BW-7 is located in the southeastern part of McClellan AFB in a parking lot about 100 feet east of Building 429 (see Figure 5). All that is visible today is a 12-inch-diameter steel casing extending about 3 feet above the pavement and fitted with a removable steel cap. Previously, there was some confusion about whether this well was BW-7 or BW-16, thought to be located in the vicinity of Building 440 immediately across Dudley Boulevard. However, research has indicated that the well is most likely BW-7.

BW-7 was first located in 1982 by Engineering-Science as part of the Phase II Installation Restoration Program (IRP) at McClellan AFB. Establishing the location of BW-7 was included as an IRP activity because of the potential for cross-contamination of aquifers by contaminants. Interviews with base personnel had led Engineering-Science to believe that the well had been grouted in the late 1960s or early 1970s, but utility records provided only an approximate location for the well and contained no record of previous abandonment. Engineering-Science located the buried well building with a magnetic flux indicator, and the site was excavated. This excavation revealed that the well was sealed with a non-waterproof fabricated cap and confirmed previous records that described a 24-inch conductor casing enclosing the 12-inch casing, with a gravel pack annulus. After sounding the well, it was found that an obstruction was present at a depth of 80 feet. An extension was welded onto the casing to bring it above grade, and the excavation was filled in. Engineering-Science then attempted to drill out the obstruction, presumed to be grout, through "rotary-wash" drilling, but was unsuccessful (Engineering-Science, 1983).

Well construction details for BW-7, obtained from McClellan AFB Civil Engineering records, are summarized in Table 1. It is uncertain when the well was constructed. A well log obtained from DWR (Appendix B) indicates that the well was drilled in 1941 by "Aulman," but the lithology on this log conflicts with base records and casts doubt on its accuracy. According to Luhdorff and Scalmanini (1984), the gravel pack was not destroyed during the previous abandonment of BW-7. A recent sounding of BW-7 conducted for this project confirmed an obstruction at a depth of about 80 feet below grade.

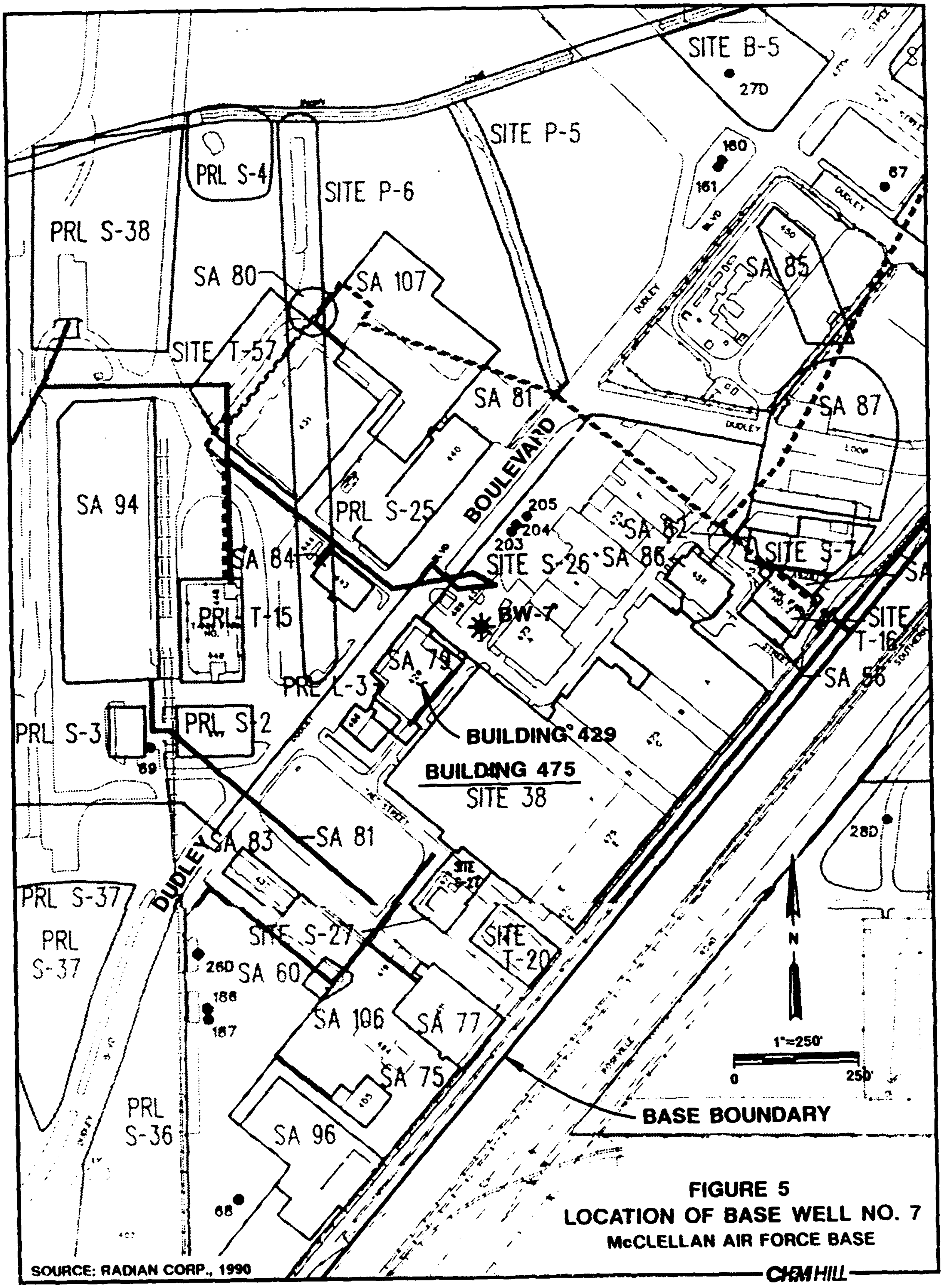

FIGURE 5
LOCATION OF BASE WELL NO. 7
McCLELLAN AIR FORCE BASE

Table 1 Well Data: Base Well 7			
Location:		East of Building 429 on Dudley Boulevard	
Status:		Inactive since 1955 due to contamination	
Driller:		Aulman	
Method:	Rotary	Date:	July 1941
Surface Conductor Casing Diameter:	24 inches	Depth:	50 feet
Seal:	Concrete	Depth:	25 to 50 feet
Blank Casing:	12-inch-diameter #10 steel double casing	Depth:	0 to 398 feet
Borehole Diameter:	22 inches	Depth:	50 to 398 feet
Perforations:	Type of perforation uncertain	Depth:	170 to 398 feet
Gravel Pack:	Pea gravel	Depth:	0 to 398 feet

Groundwater Quality

According to base records, BW-7 went inactive in 1955 due to the presence of a contaminant variously described as "oil" and "solvent." Engineering-Science referred to the contaminant as cresylic acid (Engineering-Science, 1983), and Luhdorff and Scalmanini referred to it as phenols (Luhdorff and Scalmanini, 1984). Base records indicate that the contaminant was first detected in a water main in November 1954, and discovered in BW-7 in June 1955. The well was placed on inactive status in July 1955 after a long period of pumping failed to eliminate the oily contamination. The pump was pulled in September 1955 and various attempts to rehabilitate the well through pumping out the contaminant were made through 1959. Records indicate that from 1.5 to 8 feet of floating product were measured in the well at various times during that period, with the source of the contamination uncertain. A video survey run in the well in 1959 found the casing to contain "heavy slime and algae," as well as oil.

Samples collected from monitoring wells in the vicinity of BW-7 have contained contaminants. Well 67, located about 1,200 feet northeast of BW-7, contained 1.1 ppb of 1,1,1-trichloroethane (1,1,1-TCA) in 1985, and 4.7 ppb of 1,2-dichloroethane (1,2-DCA) in 1986 (Radian Corporation, 1990). Recent investigations of shallow groundwater contamination found 64 ppb of TCE in the second quarter of 1991 in Well 203, about 250 feet northeast of BW-7, and 2,400 ppb in Well 209, about 750 feet north of BW-7. Each of these wells is potentially upgradient of BW-7. Lower concentrations of TCE were found at deeper zones in monitoring wells near BW-7 (Radian Corporation, 1991).

Local Geology

A driller's log of subsurface geology encountered during the drilling of BW-7 was located in base records. This log describes varying intervals of clay, hardpan, sand, and gravel along the borehole. Of greatest concern in abandonment are the depths of sand and gravel zones, where formation losses of cement may potentially take place. Because the entire well is cemented during the decommissioning approach taken at McClellan AFB, the location of zones of lower permeability, such as clay and hardpan, are of lesser importance. The driller's log describes the following depths of sand and gravel zones: sand and fine gravel from 115 to 130 feet; sand and gravel from 181 to 192 feet; fine gravel and sand from 196 to 224 feet; fine gravel from 255 to 261 feet; fine sand and gravel from 269 to 277 feet; cobbles and gravel from 281 to 295 feet; and intermingled sand and gravel with hard layers from 325 to 398 feet. The most permeable of the intervals appear to be from 196 to 224 feet, 255 to 261 feet, and 281 to 295 feet. The water table was about 103 feet below the ground surface near BW-7 in the second quarter of 1991 (Radian Corporation, 1991).

Base Well 8

History and Well Data

There are conflicting data both on well construction details and subsurface lithology at BW-8. This well is located in Pumphouse Building 91, which is adjacent to and north of Building 338 on Howard Street in the eastern part of McClellan AFB (see Figure 6). A well log for BW-8 obtained from DWR is included in Appendix B. McClellan AFB files and drawings, and a 1980 video survey were also reviewed for BW-8. Well construction details taken from the video survey and the LSCE (1984) report are summarized in Table 2.

Table 2
Well Data: Base Well 8

Location:		Inside Building 91 on Howard Street (north of Building 338)
Status:		Inactive since 1985 due to high iron and magnesium levels
Driller:		Unknown
Method:	Rotary	Date: July 1942
Surface Conductor Casing Diameter:	24 inches	Depth: 43 feet
Seal:	Concrete	Depth: 18 to 43 feet
Blank Casing:	12-inch-diameter 10-gage double steel	Depth: 625 feet
Borehole Diameter:	22 inches	Depth: 732 feet
Perforations:	Unknown	Depth: Unknown
Gravel Pack:	Unknown	Depth: Unknown

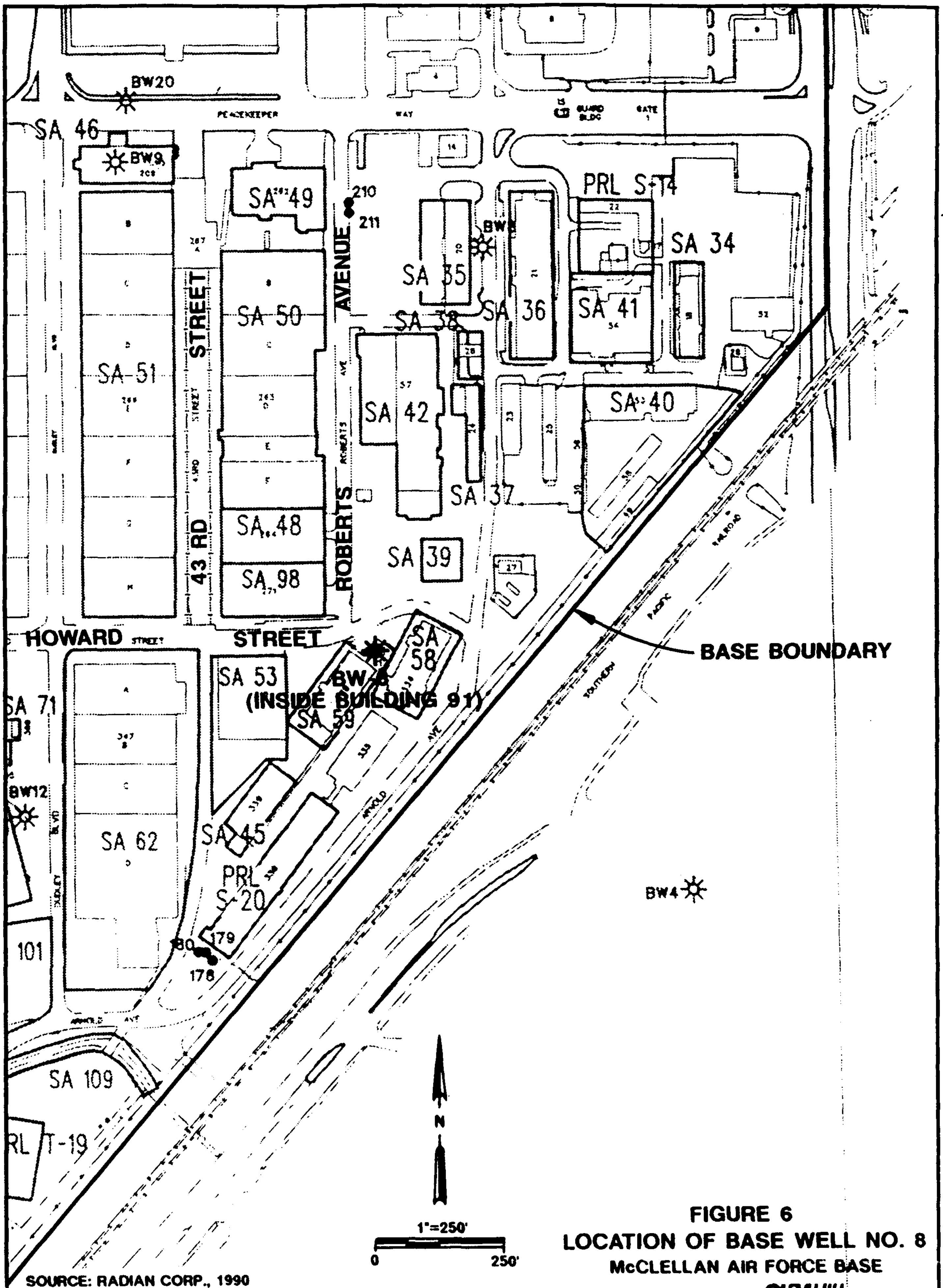

FIGURE 6
LOCATION OF BASE WELL NO. 8
McCLELLAN AIR FORCE BASE

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According to the well log obtained from DWR, BW-8 was drilled in July 1942. No other information is available on the age of the well. However, a notation on the log indicates the data were obtained from the Army, and other data on the log conflict with data on file at McClellan AFB. Well construction details are available on Drawing No. U-44 on file at the base, on the well log obtained from DWR, on a handwritten note on file at the base, from correspondence from a pump contractor (Odell, 1980), and from the L&S report (L&S, 1985). The L&S report references Air Force Drawing P.U. 662, not found during this investigation. Information was also obtained from a downhole video survey performed in 1980, and reviewed for this investigation.

All of the data sources agree that BW-8 contains a 43-foot, 24-inch-diameter, 10-gage double steel conductor casing. The outside of this conductor casing is sealed with concrete from 18 to 43 feet. Most of the sources agree that the production casing is 12-inch-diameter, 10-gage double steel. However, the pump contractor's letter states that the casing is 10 inches in diameter. According to the drawings and the handwritten note, the casing was contained within a 22-inch-diameter borehole that extended from the conductor casing to the bottom of the well.

The depth of the casing is uncertain. LSCE (1984) state that the casing extends to approximately 625 feet. This depth was confirmed in the 1980 video survey. However, the drawings show the casing extending to 389 feet, while the well log and handwritten note state that it extends to 398 feet. A note on one of the drawings declares that there is a "large cavity" from 666 feet to the bottom at 785 feet. The pump contractor also states that the depth of the well is 800 feet. The 1980 video survey revealed that an open hole extended beyond the bottom of the casing to a depth of 732 feet. This hole appeared to be larger than the casing.

Similarly, the perforated interval of the casing is uncertain. The drawings show the well as perforated from 170 to 389 feet. The well log and handwritten note state the perforations as extending from 170 to 398 feet. Luhdorff and Scalmanini state that information on the perforated interval was unavailable, while the handwritten note on the drawing states that there are no perforations. Perforations were not visible on the video survey, but this may have been due to the scale present on the casing. However, it is also uncertain whether the well casing is enclosed within a gravel pack.

BW-8 contains a Peerless oil-lubricated turbine pump with a 100-hp electric motor. Records conflict on the depth at which the pump is set, being either 170 feet (LSCE, 1985) or 200 feet (Odell, 1980). During a 1980 pump service, the pump column had to be jacked out of the well, since the pump column and well casing were apparently not in plumb (Odell, 1980). Base records indicate that in a pump test in 1980 the well discharged 1,046 gpm with a drawdown of 21 feet, for a specific capacity of 49.8 gpm/ft. BW-8 is completed below grade in Building 91, a concrete pumphouse. Access is through a 10-foot-square trapdoor in the roof.

During Phase II, the pump will be removed from BW-8 and a downhole video survey performed in the casing. If the casing is obscured by iron bacteria, it will be cleaned and a second video survey will be performed. The video survey will then reveal the actual construction details and confirm which data set, if any, actually describes the well construction details of BW-8.

Groundwater Quality

According to base records, BW-8 was placed on standby status in 1985 due to high iron and magnesium levels. Other contaminants have also been detected in BW-8, the most notable being TCE. The highest level of TCE found in this well was 61 ppb in 1981 (Radian Corporation, 1991). There are few wells located in the immediate vicinity of BW-8. However, Monitoring Well (MW-) 178, located about 700 feet southwest of BW-8, contained 90 ppb of TCE and 16 ppb of carbon tetrachloride in April 1991 (Radian Corporation, 1991). BW-12, located about 700 feet west-southwest of BW-8, contained trace amounts of pesticides and herbicides and levels of TCE ranging up to 54 ppb in 1982 (Engineering Science, 1983). Monitoring Well 210, located about 900 feet north of BW-8, contained 3.7 ppb of TCE and 4.5 ppb of carbon tetrachloride in May 1991. Monitoring Well 212, located about 1,100 feet northeast of BW-8, contained 5.5 ppb of TCE, and trace amounts of 1,1,1-TCA and chloroform in April 1991. Each of the monitoring wells described here is completed in the shallow groundwater zone. Groundwater in this area flows mainly toward the southwest, although production wells located south of the base may influence flow directions in the vicinity of BW-8 (Radian Corporation, 1991).

Local Geology

As with the well construction details, conflicting data represent the borehole lithology at BW-8. Three versions purport to represent the lithology recorded by the driller. One version is found on the well log obtained from DWR and a handwritten note on file at the base; another version is found on two separate drawings on file at the base; and a third version is found in LSCE (1984) and yet another drawing on file at the base.

Borehole lithology is important at BW-8 because this well is not intended to be decommissioned. Rather, the objective is to seal the uppermost groundwater zone where contaminants are potentially found (within about 200 feet of the ground surface), and then return the well to service on a standby basis for use in fire emergencies.

It would be desirable to seal the well in a unit of low permeability at a depth of between about 160 to 200 feet. Above this depth, it is useful to know the zones that may contain materials of high permeability, where losses of cement to the formation may potentially occur. The depth to groundwater in spring 1991 was about 107 feet (Radian Corporation, 1991).

Following the video survey of BW-8, it may be possible to determine which geologic log accurately depicts the lithology at BW-8. If the survey reveals one data set to accurately describe the well construction details, the associated geologic log will most likely will describe the subsurface lithology.

Base Well 13

History and Well Data

BW-13 is located in Building 614, a concrete pumphouse located about 150 feet south of Dudley Boulevard in the southern part of McClellan AFB. Figure 7 shows the location of BW-13 and Table 3 summarizes the available information on this well. Original construction drawings and well logs were not located for BW-13. Data are derived mainly from a photolog taken in 1961 and pump service records on file at Civil Engineering, and LSCE (1984).

Table 3
Well Data: Base Well 13

Location:		Inside Building 614 on Dudley Boulevard (south edge of base)
Status:		Inactive since 1988 due to TCE and carbon tetrachloride contamination
Driller:		Unknown
Method:	Rotary	Date: 1945
Surface Conductor Casing Diameter:	Unknown	Depth: Unknown
Seal:	Unknown	Depth: Unknown
Blank Casing:	14-inch-diameter steel reducing to 12-inch-diameter steel at 147 feet	Depth: 0 to 391 feet
Borehole Diameter:	Unknown	Depth: 0 to 391 feet
Perforations:	Unknown type	Depth: 178 feet--total depth
Gravel Pack:	Gravel	Depth: 0 to 391 feet

The 1961 photolog noted the following problems in the casing: possible hole from 120 to 122 feet; vertical seam open from 156 to 166 feet, 170 to 177 feet, and 192 to 196 feet; and light to moderate scale from 274 to 391 feet. During a servicing of the pump in 1982, it was noted that the well was very crooked. The pump is a Peerless turbine pump set at a depth of 160 feet, with an electric motor. A 1988 pump test found that the well discharged 424 gpm, with a specific capacity of 31.4 gpm/ft of drawdown. BW-13 is completed below grade. Access is through a 4-foot by 4-foot trapdoor in the roof of Building 614.

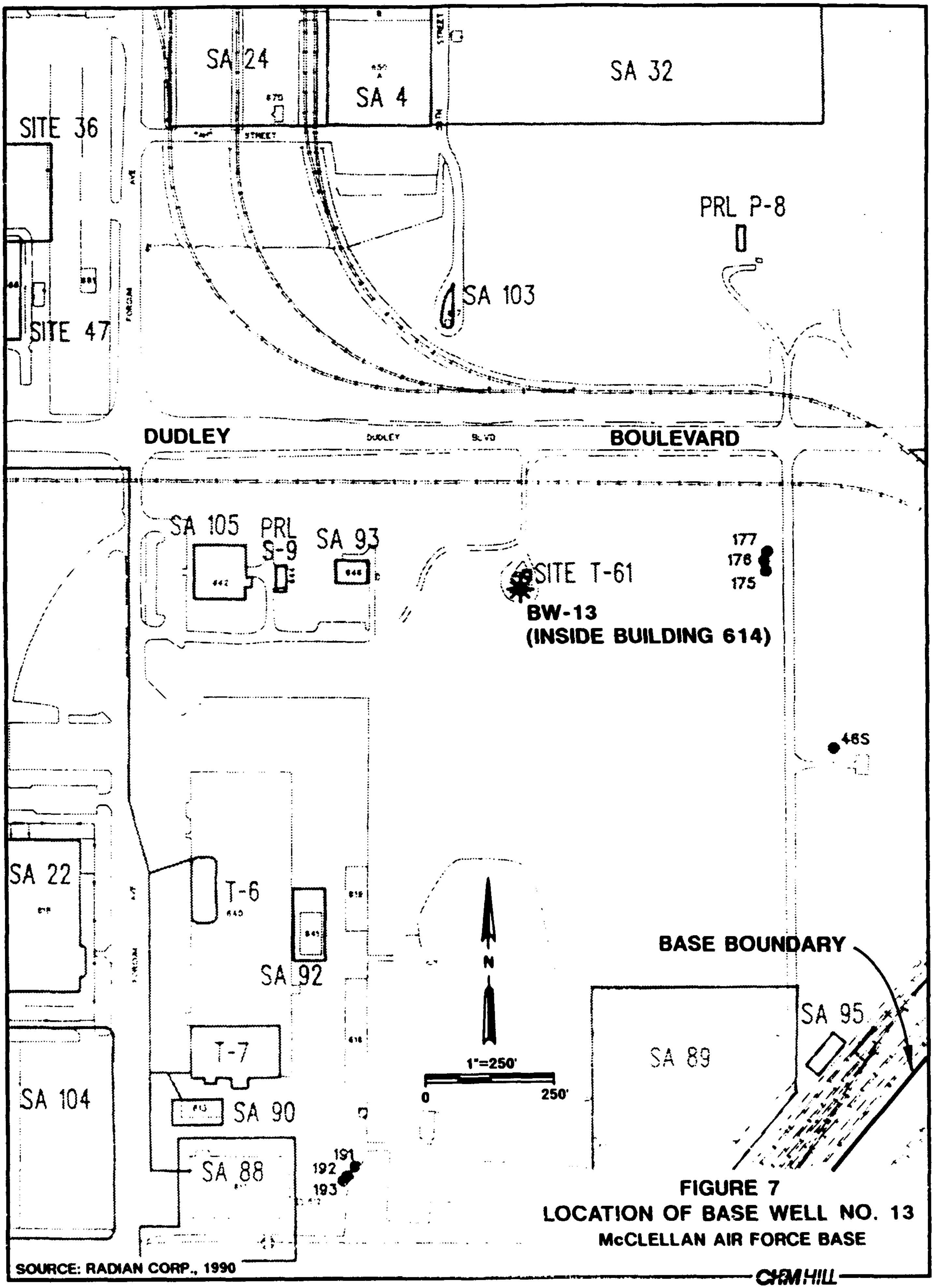

FIGURE 7
LOCATION OF BASE WELL NO. 13
McCLELLAN AIR FORCE BASE

Groundwater Quality

BW-13 was removed from service in September 1988 after a series of sampling episodes found carbon tetrachloride above the Maximum Contaminant Level (MCL) of 5 ppb. It had previously been taken out of service for a time in 1987 because tetrachloroethylene (PCE) concentrations exceeded the drinking water standard. Weekly samples collected between May and September 1988 found carbon tetrachloride concentrations ranging from 0.6-9.2 ppb. TCE was found at levels ranging from not-detected to 4.3 ppb. Other contaminants detected included chloroform, Freon-113, and toluene.

Few monitoring wells in the vicinity of BW-13 lie either upgradient or downgradient from BW-13. Groundwater in the area flows nearly due west, toward BW-18, which is located about 2,200 feet west of BW-13. MW-175, -176, and -177, located about 500 feet east of BW-13, contained no detectable levels of organic contaminants in April 1991 (Radian Corporation, 1991).

Local Geology

No borehole lithologic logs are available for BW-13. However, during the construction of MW-175, -176, and -177, a pilot hole (8-P) was drilled. Both a geologic and geophysical log are available for 8-P. Although alluvial deposits such as those in which BW-8 is constructed tend to be quite variable, the logs of 8-P identify permeable zones that could affect the decommissioning of BW-13. These logs show a very permeable sand unit from a depth of about 92 to 105 feet; a gravelly sand from about 220 to 230 feet; and a sand and gravel unit that extends from about 360 to 390 feet. The latter unit in particular may extend to BW-13. Groundwater was found about 100 feet below the ground surface in January 1991 (Radian Corporation, 1991).

Base Well 17

History and Well Data

BW-17 is located inside Building 699, a pumphouse on the east side of Kilzer Avenue about 750 feet north of Dudley Boulevard in the southwest part of the base. Information on BW-17 was taken from the well log on file at DWR and from McClellan AFB records. Table 4 summarizes the known data and Figure 8 shows the location of BW-17.

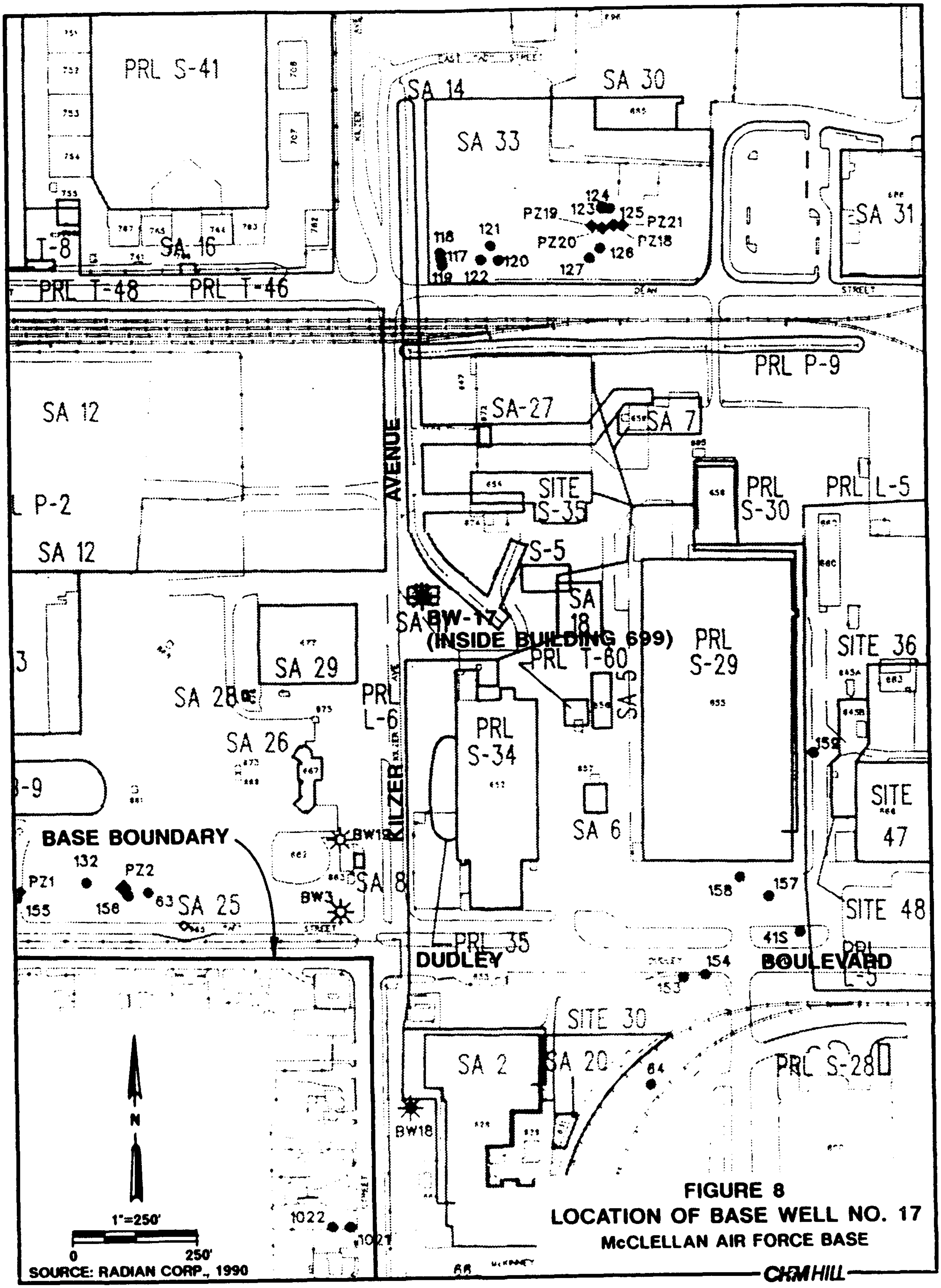

FIGURE 8
LOCATION OF BASE WELL NO. 17
McCLELLAN AIR FORCE BASE

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Table 4 Well Data: Base Well 17		
Location:		Inside Building 699 on Kilzer Avenue
Status:		Inactive since 1985 due to TCE contamination
Driller:		Unknown
Method:	Cable Tool	Date: Prior to 1947
Surface Conductor Casing Diameter:	Unknown	Depth: Unknown
Seal:	Unknown	Depth: Unknown
Blank Casing:	16-inch-diameter steel	Depth: 0 to 344 feet
Borehole Diameter:	16 inches	Depth: 0 to 390 feet
Perforations:	Unknown	Depth: 216 to 224 feet; 286 to 294 feet; 302 to 312 feet
Gravel Pack:	Not applicable	Depth: Not applicable

BW-17 was apparently drilled by the cable tool method, in which the casing is driven into the ground. Therefore, there is no gravel pack surrounding the casing. The well was originally drilled to 930 feet in depth. However, files indicate that the well was sealed off below 390 feet because of the high iron content of the water below that depth. This sealing took place in 1947 and consisted of filling the casing with mud from 760 to 930 feet, and sand from 420 to 760 feet. The casing was then ripped from 400 to 420 feet, and a concrete plug was set from 390 feet to 420 feet.

The original construction drawing for BW-17 described the perforations as extending from 216 to 225 feet, 262 to 270 feet, 284 to 290 feet, and 300 to 308 feet in depth. The perforated interval listed in Table 4 was based on a 1971 photographic survey performed in the well. This survey also described the bottom of the well as lying at 344 feet, rather than 390 feet. This discrepancy may be due to sediment filling the lowermost section of the casing.

BW-17 currently has installed a Floway oil-lubricated turbine pump with bowls set at 150 feet. In 1972 it discharged 1,100 gpm with a specific capacity of 61.1 gpm/ft of drawdown. BW-17 is a surface completion in a concrete pumphouse. Access is through a 4-foot by 4-foot trapdoor in the roof.

Groundwater Quality

Base records indicate that BW-17 was placed on inactive status in 1985 due to TCE contamination. However, the only sample results that have been located to date show no contamination in this well in 1982 (Engineering Science, 1983). Several monitoring wells are located about 700 feet north of BW-17 and are screened at various depths beneath the ground surface. Contamination appears to be confined mainly to the uppermost groundwater zone, and groundwater flows to the south in this part of the base toward BW-18. Monitoring Well 120, screened in this zone, yielded samples with TCE concentrations ranging from 9.3 to 26 ppb, chloroform ranging from 0.35 to 1.9 ppb, and 1,2-DCE ranging from not-detected to 18 ppb between 1986 and 1988. The historical maximum TCE value in this well was 87 ppb (Radian Corporation, 1990).

Local Geology

The original drillers lithology log for BW-17 was located as part of this investigation. This log shows the following intervals of materials of potentially high permeability that may affect the decommissioning of BW-17: lava sand from 153 to 171 feet; sand and fine rock from 216 to 230 feet; lava sand from 262 to 275 feet; fine gravel from 284 to 290 feet and 300 to 311 feet; and soft lava sand from 376 to 390 feet. Groundwater was found about 100 feet below the ground surface in January 1991 (Radian Corporation, 1991).

Base Well 20

History and Well Data

BW-20 is located in a vault in a parking lot adjacent to Peacekeeper Way and just south of Building 200 in the eastern part of the base. It was drilled in 1953 to replace nearby BW-9, which supposedly collapsed, and has recently served as a standby emergency source for Building 200. Well construction details are taken mainly from construction drawings on file at McClellan AFB and are summarized in Table 5. Figure 9 shows the location of BW-20.

BW-20 is equipped with a Johnson oil-lubricated turbine pump with a 75-hp electric motor. Capacity of the well is uncertain. Access to the well is through a removable concrete lid supported by metal gridwork.

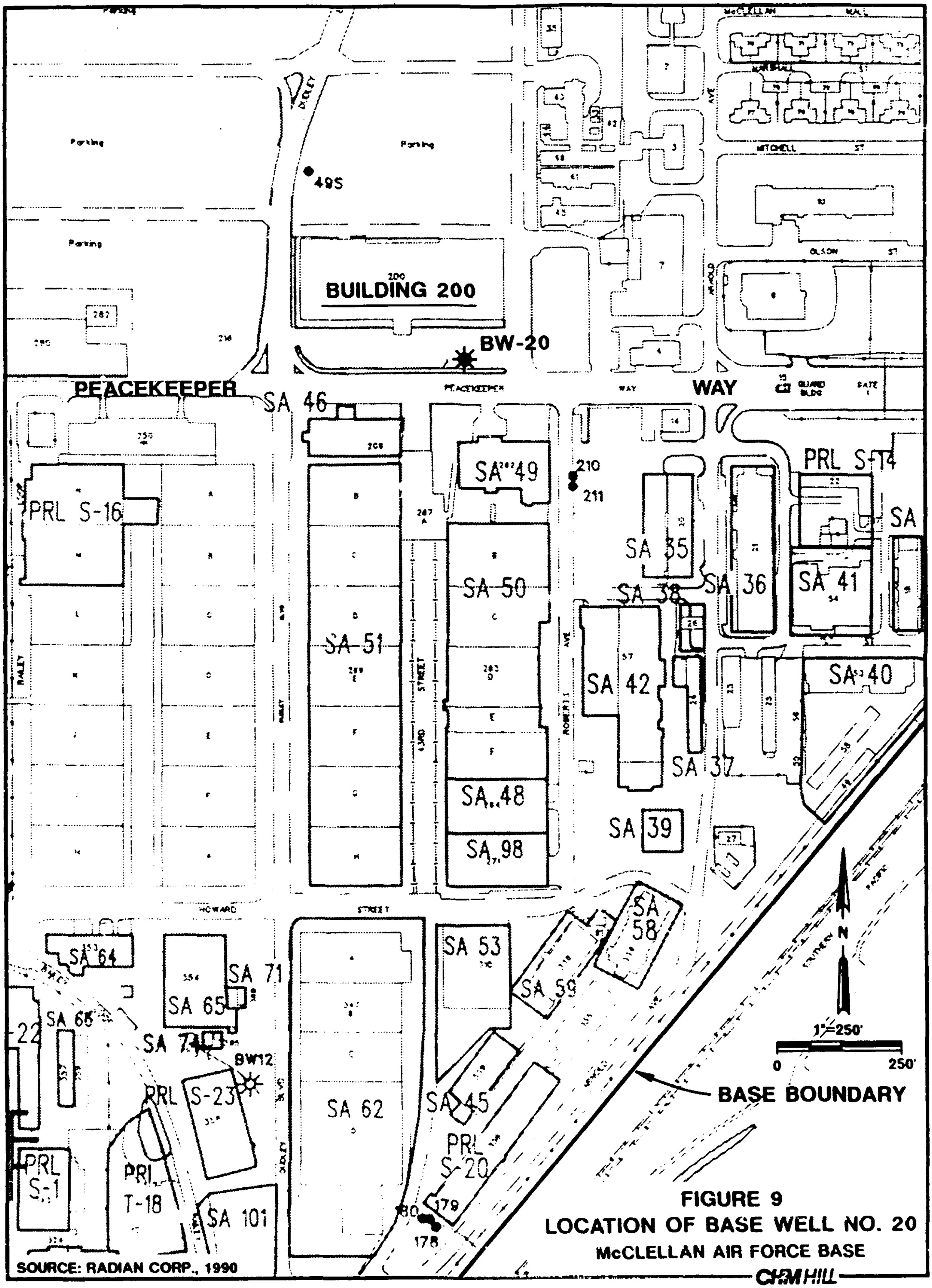

FIGURE 9
LOCATION OF BASE WELL NO. 20
McCLELLAN AIR FORCE BASE

CH2M HILL

Table 5 Well Data: Base Well 20		
Location:		South of Building 200 in parking lot next to Peacekeeper Way
Status:		Standby source for Building 200
Driller:		Western Well Drilling Company
Method:	Rotary	Date: October 1953
Surface Conductor Casing Diameter:	32-inch steel	Depth: 67 feet
Seal:	Cement Grout	Depth: 0 to 67 feet
Blank Casing:	14-inch-diameter steel	Depth: 0 to 600 feet
Borehole Diameter:	32 inches	Depth: 67 to 600 feet
Perforations:	1/8-inch x 3-inch slots	Depth: 178 to 190 feet, 234 to 274 feet, 338 to 374 feet, 494 to 506 feet, 564 to 598 feet
Gravel Pack:	3/16- to 3/8-inch pea gravel	Depth: 0 to 600 feet

Groundwater Quality

No data were located on groundwater quality in BW-20. However, sample data exist for MW-210 and -211, located about 500 feet east of BW-20. Groundwater in this area of the base flows from east to west, so these wells are approximately upgradient from BW-20. MW-210, screened in the uppermost groundwater zone, contained TCE at 4.1 ppb, carbon tetrachloride at 6.1 ppb, and 1,1-DCE at 0.76 ppb in May 1991. MW-211, constructed adjacent to 210 and screened in a deeper zone, contained TCE at 1.0 ppb and benzene at 0.40 ppb in May 1991 (Radian Corporation, 1991).

Local Geology

The original driller's log is available at McClellan AFB. This log shows units of potentially high permeability that may affect the decommissioning of BW-20 at the following depths: fine sand from 200 to 204 feet; loose fine to medium sand from 354 to 381 feet; fine to medium sand from 491 to 505 feet; and fine to coarse sand and sandy silt from 550 to 600 feet. A pilot hole drilled in conjunction with MW-210 and 211 in May 1990 lies about 500 feet from BW-20. Geologic and geophysical logs indicate that a zone of permeable sands and gravels lies at a depth of 145 to 160 feet.

Base Well 28

History and Well Data

BW-28 is located on Patrol Road next to Building 1082 along the northwest boundary of McClellan AFB. According to base personnel, this private domestic well was obtained by the Air Force during a land purchase. Construction details are derived from a diagram on file at McClellan AFB and are summarized in Table 6. Figure 10 shows the location of the well. BW-28 is located outdoors and contains a 2-hp Town and Country submersible pump capable of discharging about 30 gpm (LSCE, 1984). Water Department personnel stated that the water table dropped below the pump setting during the summer of 1991.

Table 6
Well Data: Base Well 28

Location:		Next to Building 1082 on Patrol Road on the northwest base boundary
Status:		Inactive since about 1990
Driller:		Unknown
Method:	Cable Tool	Date: 1966
Surface Conductor Casing Diameter:	14 inches	Depth: 76 feet
Seal:	Cement Grout	Depth: 0 to 60
Blank Casing:	8-inch-diameter steel	Depth: 0 to 248 feet
Borehole Diameter:	Not applicable	Depth: 76 to 248 feet
Perforations:	Milled slots	Depth: 144 to 147 feet; 205 to 212 feet; 233 to 236 feet
Gravel Pack:	Not applicable	Depth: Not applicable

Groundwater Quality

Limited data are available for samples collected from BW-28. According to McClellan AFB records, samples collected in 1979 indicated levels of cadmium and chromium above drinking water standards, but these samples were later determined to be in error. Samples collected by Engineering-Science in 1982 found no detectable levels of volatile organics, but did find the herbicides 2,4-D and 2,4,5-T at levels of 0.008 ppb, and 0.002 ppb, respectively (Engineering-Science, 1983).

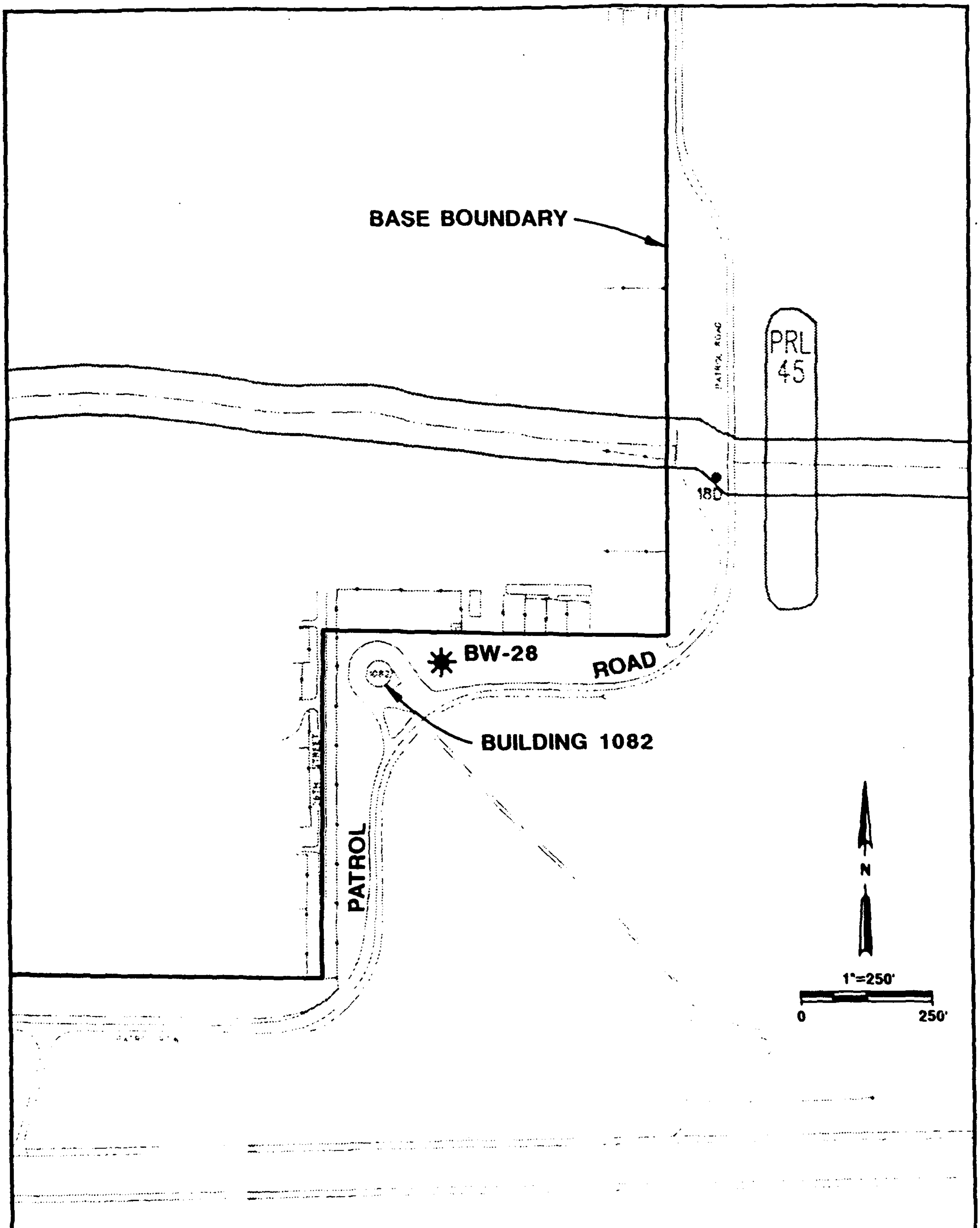

FIGURE 10
LOCATION OF BASE WELL NO. 28
McCLELLAN AIR FORCE BASE

SOURCE: RADIAN CORP., 1990

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A double completion monitoring well was constructed in 1982 about 500 feet northeast of BW-28. Groundwater in this area appears to move south to southwesterly (Radian Corporation, 1991). The shallow well, MW-18s, was screened across the water table at a depth of 90 to 100 feet. The deeper well, MW-18d, was screened from 130 to 140 feet below the ground surface. Samples collected from MW-18s in 1982 contained the following concentrations of pesticides and herbicides: aldrin-0.052 ppb; alpha-BHC-0.032 ppb; lindane-0.036 ppb; heptachlor epoxide-0.027 ppb; and 2,4-D-0.138 ppb. A 1982 sample collected from MW-18d had the following concentrations of pesticides and herbicides: aldrin-0.01 ppb; beta-BHC-0.005 ppb; heptachlor epoxide-0.017 ppb; 2,4-D-0.122 ppb; and 2,4,5-T-0.022 ppb (Engineering-Science, 1983). More recent data have not been located for these wells.

Local Geology

The driller's log showing lithology at BW-28 was not located for this investigation. A geologic log for nearby MW-18 was obtained, however. This log describes silts and clays for nearly the entire interval of the borehole, with only minor zones of sandy materials.

Camp Kohler Wells

History and Well Data

Laundry Wells. Camp Kohler is a 35-acre annex of McClellan AFB located about 1 mile east of the main McClellan AFB facility on Roseville Road (see Figure 1). A large military laundry was operated here from about 1942 to 1973. This laundry has since been demolished and the site is currently vacant except for a Federal Aviation Administration radar facility and office building. Four wells are located at Camp Kohler, as shown on Figure 2.

The laundry used two water supply wells, identified as LW-1 and -2. Although the laundry operations discontinued in 1973, a previous investigation determined that the wells were used as a drinking water source until 1981. An attempt was made to sample the wells in 1985, but it was found that the wells were abandoned with their pumps still in place (Radian Corporation, 1985). These wells are not visible today. No records are available at McClellan AFB regarding the fate of these wells, nor do either of the two area water districts, Northridge Water District and Arcade Water District, have any information on the wells.

Investigation of McClellan AFB records uncovered slides taken during a photographic survey of LW-1 and -2 in 1971. In addition, an Eaton Drilling Company well log was located. According to Marshall Eaton, the log most likely refers to LW-2 (Eaton, 1991, pers. comm.). Other Camp Kohler well records were located at McClellan AFB and DWR, but appear to refer to one or more wells in other parts of Camp Kohler beyond the present boundaries. Formerly, Camp Kohler occupied a much larger tract of land than at present.

According to this research, LW-1 was about 420 feet deep. Although iron bacteria obscured much of the casing, perforations were visible at depths of 138 feet, 356 to 358 feet, 396 to 400 feet, and 404 to 420 feet. LW-2 was constructed in 1955 to a depth of 514 feet. This well contained a 50-foot, 24-inch-diameter conductor casing, and 496 feet of 14-inch-diameter, 3/16-inch steel production casing. Perforations consisted of 3/16-inch by 2-inch vertical slots at depths of 190 to 202 feet, 238 to 248 feet, 264 to 284 feet, 320 to 330 feet, 347 to 355 feet, 380 to 411 feet, 437 to 440 feet, 463 to 468 feet, and 476 to 496 feet. The casing was contained within a filter pack consisting of 3/8- to 3/4-inch pea gravel.

As a part of the present investigation, the locations of the former wells were tentatively identified by a team of surveyors using old maps of the laundry complex. These locations were then excavated with a backhoe. LW-1 was successfully located by this method. The excavation found that LW-1 was abandoned with concrete about 3 feet below the ground surface. No evidence of the pump was visible. However, LW-2 was not located, even though several pits were excavated. Based on the 1985 Radian report and the verification that LW-1 was abandoned, it is probably safe to conclude that LW-2 has also been abandoned.

Seismic Wells. The other two wells at Camp Kohler were constructed as part of a seismic survey. These wells, known as the Seismic Well and the Triax Hole, are still present. According to construction diagrams on file at McClellan AFB, the wells were constructed in 1969. It is uncertain why the survey was performed or who constructed the wells. The Seismic Well is 500 feet deep and contains 7-inch-diameter 17.0# API Grade steel casing that extends about 1.5 feet above grade. The borehole diameter is unknown. The Triax Hole is 200 feet deep and contains 11 3/4-inch-diameter 42# API Grade steel casing that extends about 2 feet above grade. The borehole diameter in this well is 13¾ inches. Both wells are sealed along their entire length with cement and are not open to groundwater at any point. Both contain 10-foot cement plugs at their base.

Cement bond surveys were conducted in the seismic wells in December 1991 to evaluate the integrity of the cement seals in which they are encased. As a preparation for these surveys, the caps on the wells were removed and the wells filled with water. The quality of a cement bond survey is greatly enhanced if the sonic transmitter is immersed in water at a minimum pressure of about 200 pound per square inch (psi). Had the wells not been watertight, it would have been necessary to pump water into the wells during the survey. However, the wells held the water with no apparent leakage. The survey found that the seal on both wells was adequately bonded to the casing and the borehole wall to prevent groundwater from migrating among subsurface zones. In both wells, minor disruptions in the seals were noted at or above the water table. Copies of the cement bond logs are provided in Appendix C.

Groundwater Quality

Camp Kohler was investigated in 1984 as part of the overall IRP investigation taking place at McClellan AFB. The Camp Kohler investigation was prompted by concern about deteriorating water quality in Arcade Water District Well No. 31, located about 2,000 feet west of Camp Kohler. From about 1960 until the well was taken out of service in 1979, samples from the well indicated a gradual increase in levels of hardness, chlorides and total dissolved solids (TDS). Hardness ($CaCO_3$) increased from about 150 to 600 mg/l during this time, while chlorides increased from about 75 to 450 mg/l and TDS increased from about 250 to about 850 mg/l (CH2M HILL, 1981). The old laundry at Camp Kohler had contained a concrete-lined wastewater holding basin that stored wastewater for pumping to a wastewater treatment plant. The concern was whether water may have leaked from the basin, infiltrated to the groundwater, and migrated to Arcade Well No. 31.

Soil and water samples were collected from the basin in March 1984. Results found levels of cadmium, chromium, copper, lead, nickel, and lead high enough to cause the sediments within the basin to be classified as hazardous (Radian Corporation, 1985). This finding initiated additional sampling, including 16 soil samples to a depth of 30 feet in 5 borings around the outside of the basin; seven exploratory borings drilled to an average depth of 310 feet, with collection of soil samples and groundwater samples at various depths; and additional sediment sampling within the basin.

Results of groundwater samples found chloride and TDS levels in excess of drinking water standards in deep samples from one boring located southwest of the basin, and the deepest sample from one other boring. Iron and manganese exceeded drinking water standards in all groundwater samples. Constituents in soil samples were generally at background levels, except for samples taken from within the former wastewater holding basin. These samples again exceeded hazardous levels (Radian Corporation, 1985).

The investigators concluded that the basin was not the source of the degraded water in Arcade Well No. 31, for the following reasons: the basin was lined with concrete; the groundwater samples containing high levels of chlorides and TDS were collected from deep zones, and were not found in the uppermost groundwater samples; and a 1979 sample from LW-1, taken when the well was being used as a drinking water source, had shown background levels of these constituents. The investigators speculated that contaminants may have originated at a wastewater treatment plant located east of Camp Kohler (Radian Corporation, 1985).

Local Geology

A drillers' log was located for LW-2 as part of this investigation. This log showed an alternating sequence of gravel, sand, and clay. Subsurface permeable zones consisted of gravel units at 163 to 170 feet, 191 to 197 feet, 240 to 246 feet, 270 to 281 feet, 320 to 327 feet, 381 to 406 feet, and 435 to 439 feet; and a sand unit from 480 to 497 feet. Geologic logs were kept for the seven deep exploration borings completed during the 1984 IRP investigation at Camp Kohler.

Geologic cross sections were prepared from these logs that reveal a heterogeneity typical of alluvial sediments in the McClellan AFB area. However, zones of sands and gravels were correlated at various depths among the boreholes. Major zones of materials of relatively high permeability were found at depths of about 140 to 160 feet; 230 to 260 feet; and 270 to 310 feet. Groundwater was found at a depth below 115 feet. Although the groundwater gradient was not well-defined in the area, it was believed to flowing toward the southwest (Radian Corporation, 1985).

Status of Water Supply Wells at McClellan AFB

A total of 35 wells have been identified during data collection activities associated with the well decommissioning program at McClellan AFB. These include 29 water supply wells designated in McClellan AFB files as BW-1 through BW-29. Over McClellan AFB's years of operation, McClelian AFB has constructed these wells or acquired land with existing wells. Two additional wells have been located at McClellan AFB as part of this investigation. Four wells are located at Camp Kohler—two former laundry wells, and two wells constructed as part of a seismic survey, as described earlier in this report. The locations of the McClellan AFB wells are shown in Figure 2 and the locations of the Camp Kohler wells are shown in Figure 3. Table 7 summarizes the status of production wells at McClellan AFB.

Four McClellan AFB wells and one City of Sacramento well were decommissioned during the first phase of well abandonment at the base. These include BW-1, BW-2, BW-12, BW-27, and City Well 150. Five wells at McClellan AFB, BW-7, BW-13, BW-17, BW-20, and BW-28, are scheduled for decommissioning during Phase II. BW-8 is scheduled for modification during Phase II. The four wells at Camp Kohler, LW-1, LW-2, the Seismic Well and the Triax Hole, are also scheduled for decommissioning during Phase II. Known data on these wells has been summarized in previous sections of this report. Three production wells—BW-10, BW-18, and BW-29—are currently actively pumping at McClellan AFB. This section will summarize the currently known information on the remaining McClellan AFB water supply wells.

Base Wells 3, 6, 16, and 19

BW-3, BW-6, BW-16, and BW-19 were originally scheduled for decommissioning during the first phase, but could not be located in 1990. BW-3, BW-16, and BW-19 have now been tentatively located. BW-3 and BW-19 are thought to be in the southwest part of the base near Buildings 662 and 667 at the intersection of Bell Avenue and Kilzer Avenue. A recent field inspection discovered what appears to be two former wells in a field about 200 yards west of the Bell/Kilzer intersection. The location of these wells is shown on Figure 11. One of the wells, presumed to be BW-3, has a 6-inch-diameter casing. BW-3 is thought to be an old agricultural well, acquired during an earlier expansion of the base. It was reportedly abandoned by McClellan AFB Water Department personnel (LSCE, 1984). The other well, presumed to be BW-19, contains a 14-inch-diameter casing. This well was reportedly constructed in 1952 to a depth of 360 feet, at about the same time that nearby wells BW-17 and BW-18 were constructed.

Table 7
Status of Existing McClellan AFB Production Wells

Well No.	Location	Comments
1	Building 231	Decommissioned in 1991.
2	Building 232	Decommissioned in 1991.
3	Southwest in field near Bell Avenue and Kilzer Avenue	Tentatively located with BW-19. Casing filled with concrete.
4	Near Watt Avenue and Roseville Road, off the base	Inactive. Not visible. Located on old maps.
5	Off the base on Old Garden Highway	Known as "Old River Dock Well." Constructed in 1941.
6	Near Patrol Road and Buildings 714 and 715	Inactive. Has not been located. Thought to be old agricultural well.
7	Near Building 429	Will be decommissioned during Phase II.
8	Building 91	Uppermost portion to be sealed during Phase II, then returned to standby status.
9	Near Building 200	Reported to have collapsed. Not visible. Located on old maps in parking lot near BW-20.
10	East near Building 93 on O'Malley Avenue	Active well.
11	Southeast of the Base, near Watt Avenue and Winona Street	Inactive. Not visible. Located on old maps.
12	Building 395	Decommissioned in 1991.
13	Building 614	Will be decommissioned during Phase II.
14	Unknown	Uncertain status. No known location. May be located at Whitney and Eastern Avenue.
15	North of Building 440 on Dudley Boulevard	Inactive, status uncertain.
16	Site 22 on Patrol Road	Inactive. Not visible. Located on old maps.
17	Building 699	Will be decommissioned during Phase II.
18	Southwest near Building 664 on Winters Street	Active well.
19	Southwest in field near Bell Avenue and Kilzer Avenue	Tentatively located with BW-3. Casing filled with concrete. Reported to have collapsed.

Table 7
Status of Existing McClellan AFB Production Wells

Well No.	Location	Comments
20	In parking lot south of Building 200	Will be decommissioned during Phase II.
21	Near Building 689	Status uncertain. Has not been located. Thought to be an old agricultural well. May have served the old Aero Club.
22	Near Building 1445	Status uncertain. Has not been located. Thought to lie near northeast corner of building.
23	Near Building 1455	May have been found during parking lot construction. Thought to be an old agricultural well.
24	Near Building 1455	May have been found during parking lot construction. Thought to be an old agricultural well.
25	Off the base at the Lincoln Communication site	Active well.
26	Off the base at the Davis Communication site	Active well. Water may be contaminated.
27	Near Building *1099*	*Decommissioned in 1991.*
28	Near Building 1082	Will be decommissioned during Phase II.
29	North area, in Building 1455 on Perrin Avenue	Active well.
Old 29	About 25 feet northeast of BW-29	Was abandoned in 1984 due to sand; new BW-29 drilled just south of former site.
Boy Scout Well	About 75 feet south of BW-29, near Building 1457	Casing is visible, but well status is uncertain.
LW-1	Camp Kohler	Uncovered by backhoe. Has been filled with concrete.
LW-2	Camp Kohler	Located on old maps, but not uncovered. Thought to be abandoned.
Seismic Well	Camp Kohler	Casing exterior sealed wtih cement. Not a water well.
Triax Hole	Camp Kohler	Casing exterior sealed wtih cement. Not a water well.

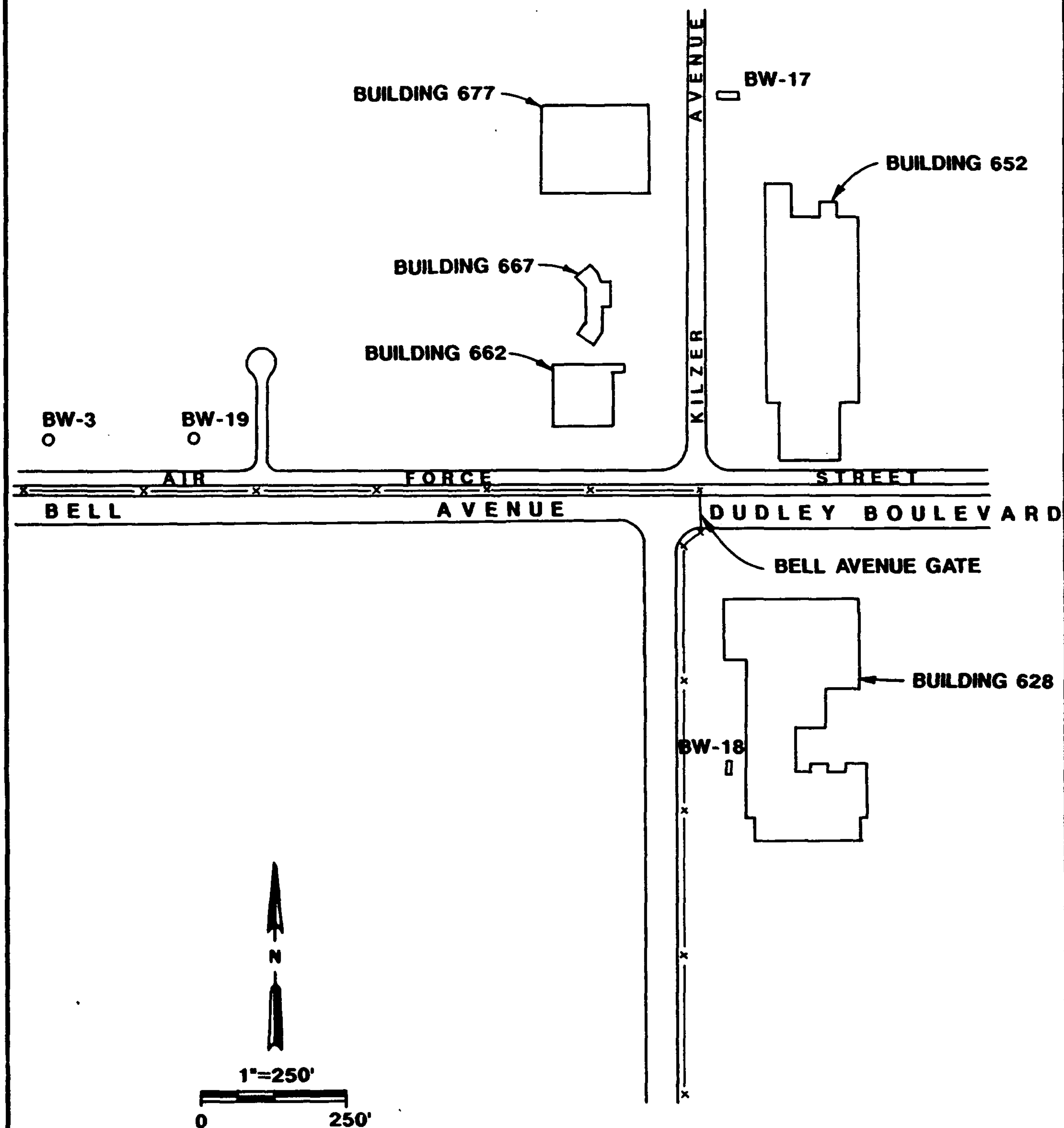

FIGURE 11
LOCATION OF
BASE WELLS NO. 3 AND 19
McCLELLAN AIR FORCE BASE

SOURCE: FIELD INSPECTION, 1992

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These three wells served a nearby water treatment facility. Perforations in BW-19 extended from 174 to 193 feet, 214 to 239 feet, and 305 to 360 feet. BW-19 is said to have collapsed (LSCE, 1984). The casing in both BW-3 and BW-19 extends a few inches above the ground surface and is filled with concrete with gravel aggregate.

BW-16 was thought to be located in the southeast area of the base, based on the recollections of Water Department personnel and a previous investigation (LSCE, 1984). However, during this investigation an old map was located in McClellan AFB files that depicts the location of BW-16 in the western part of the base near Patrol Road. The location of the former well is shown in Figure 12. Although the exact location of the well is shown on the old map, it is not visible today and its status is unknown.

BW-6 is also thought to be located in the western part of the base, in the vicinity of the present industrial wastewater treatment plant (see Figure 2). According to LSCE (1984), this well is probably another former agricultural well acquired during an early expansion of the base. No records have been obtained for the well, nor has any visible structure been observed in the field.

Base Well 9

BW-9 is located in a parking lot south of Building 200 on Peacekeeper Way in the eastern portion of McClellan AFB. Previously the precise location of this well was unknown. However, during this investigation an old map was found that shows the location of this well relative to known features, including BW-20 and an existing water line. This location is shown on Figure 13, which indicates that BW-9 lies about 200 feet west of BW-20. There is currently no visible evidence of BW-9 at the site.

Very little is known about BW-9. Information presented in a previous investigation (LSCE, 1984) has been found to have been mistaken. According to Water Department personnel, BW-20 was constructed in 1953 to replace BW-9, which apparently had collapsed. Drawings indicate that BW-9 was located in subsurface vault, typical of wells constructed during WWII. Based on the well number, BW-9 was probably constructed after 1942, when BW-8 was constructed. No information has been found regarding BW-9 well construction details.

Base Well 15

BW-15 was previously thought to be located several miles away from McClellan AFB, on the corner of Whitney and Eastern Avenues (LSCE, 1985). As part of this investigation, however, old maps dating from 1945 and 1955 were found that located BW-15 immediately north of Building 440, on Dudley Boulevard across the street from BW-7 in the southeast portion of the base. The location of well BW-15 is shown in Figure 14.

BW-16 had previously been thought to be located in this area (LSCE, 1985) but, as described above, was found to be located in the western part of the base. Robert Zenda of the Water Department recalled that a below-grade well was constructed on the corner of Whitney and Eastern Avenues at a site presently occupied by a church (conservation with Robert Zenda, December 18, 1991). However, field inspection failed to find any sign of a well.

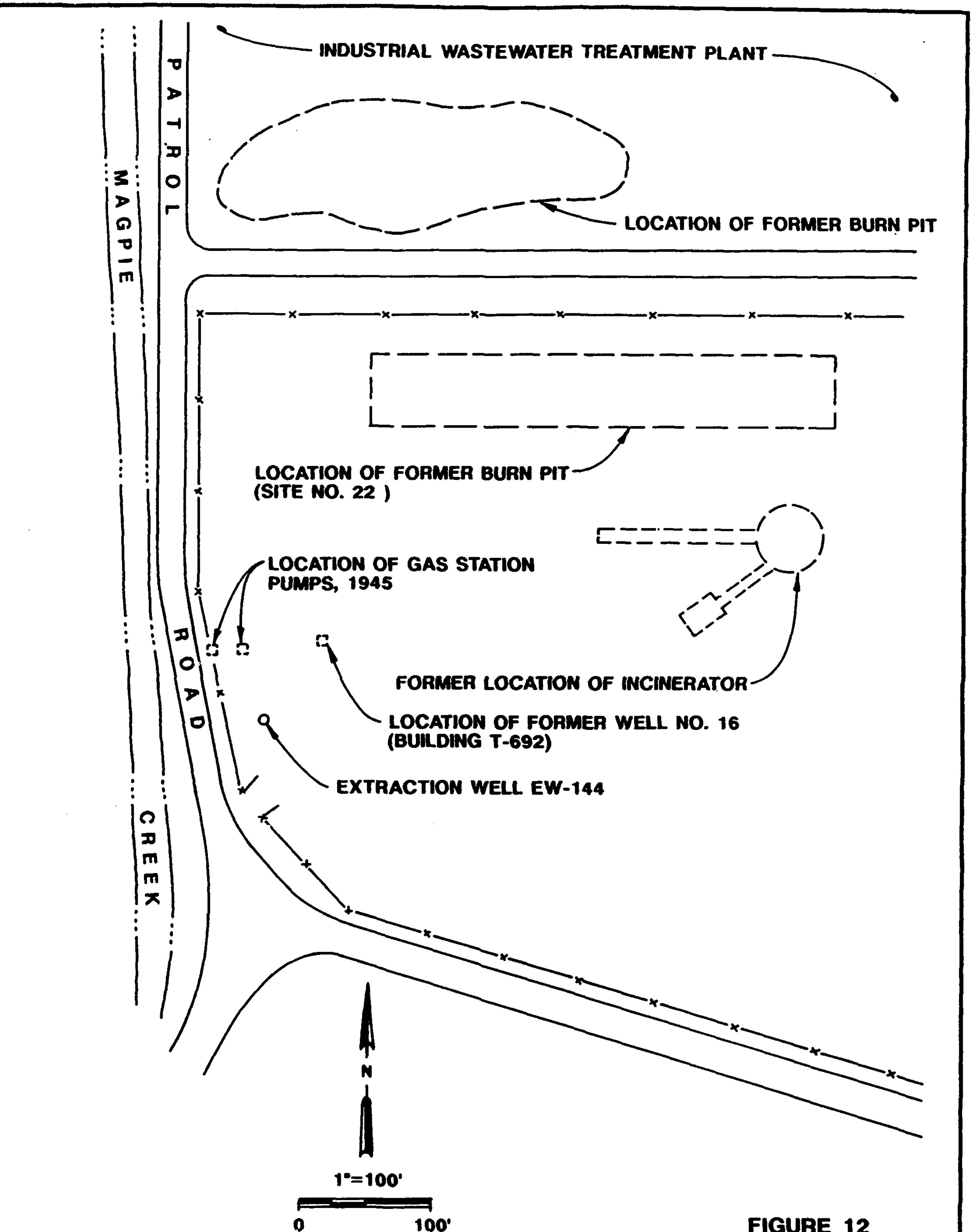

FIGURE 12
LOCATION OF
BASE WELL NO. 16
McCLELLAN AIR FORCE BASE

SOURCE: McCLELLAN FIELD UTILITY MAP, SHEETS NO. 18 & 19, 1945
AIRPHOTO OF McCLELLAN AFB, 1987

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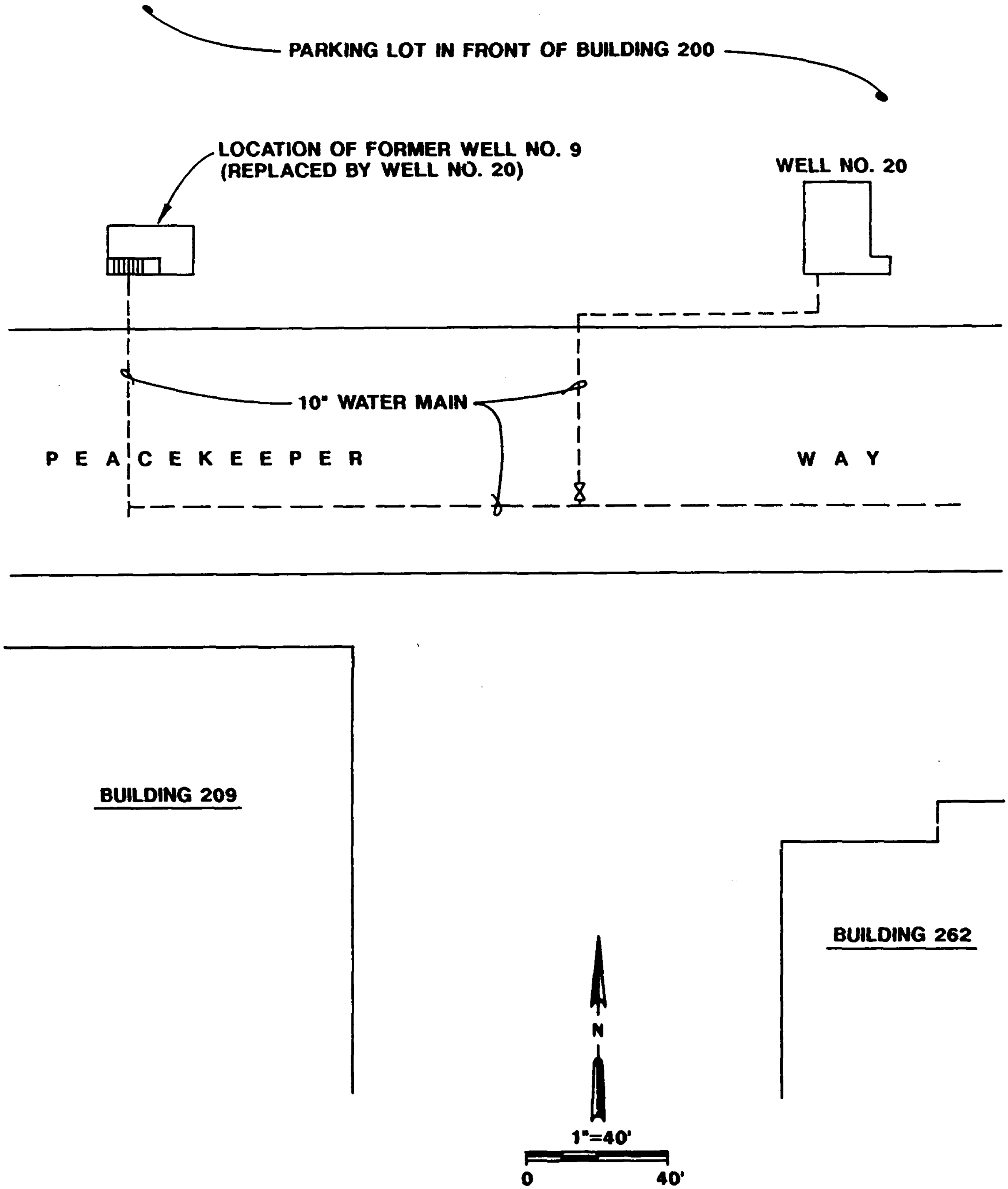

SOURCE: McCLELLAN AFB UTILITY MAP "UTILITIES ON "J" STREET FROM 40th TO 44th STREETS, SHEET NO. 205, 1955

FIGURE 13
LOCATION OF
BASE WELLS NO. 9 AND 20
McCLELLAN AIR FORCE BASE

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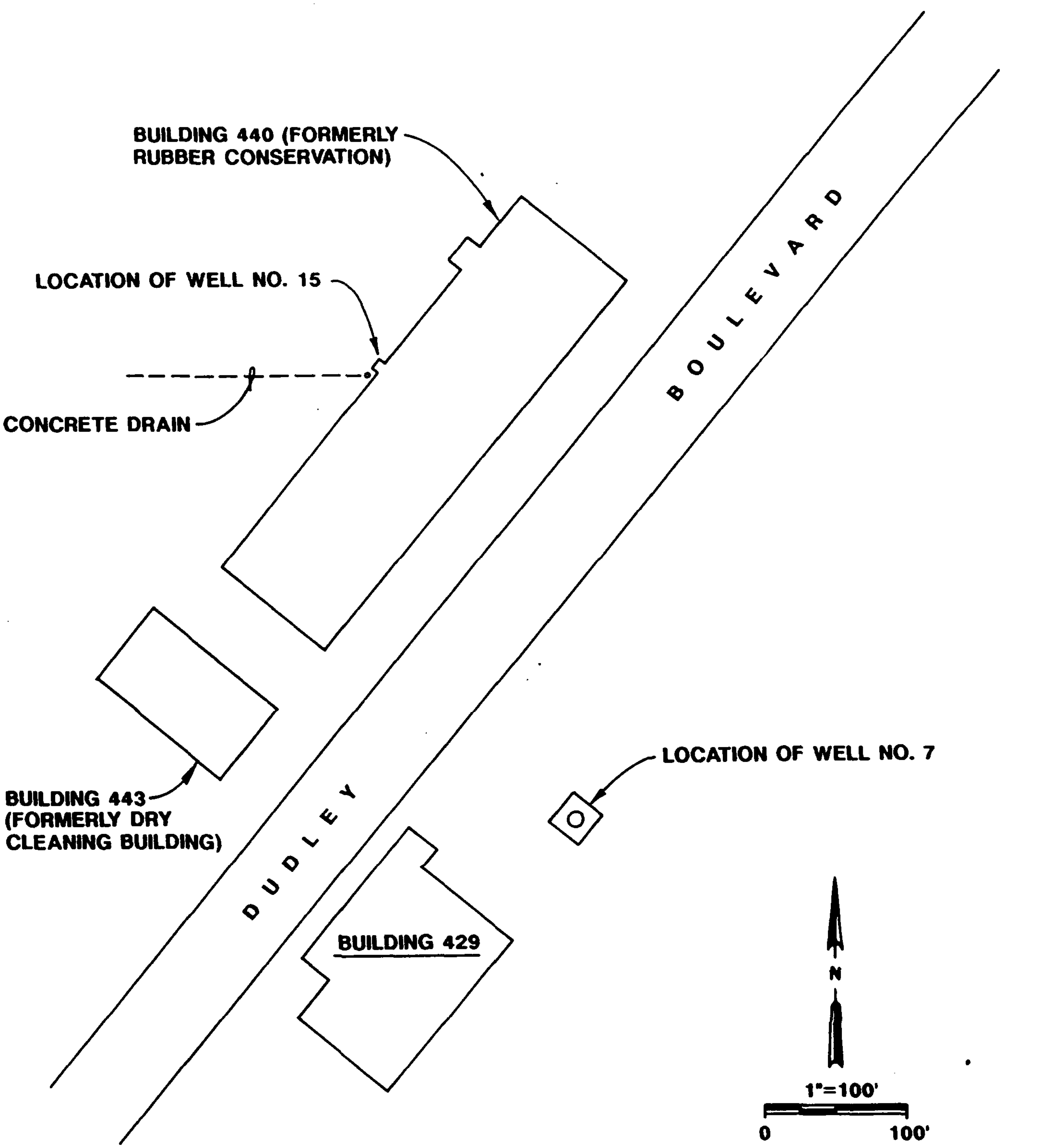

SOURCE: McCLELLAN FIELD UTILITY MAP, SHEET NO. 9, 1945

FIGURE 14
LOCATION OF
BASE WELLS NO. 7 AND 15
McCLELLAN AIR FORCE BASE

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A well log was found at DWR that identified a well located at the Rubber Conservation Building at McClellan Field (see Appendix B). Old maps identify Building 440 as the Rubber Conservation Building, and the building to the west as the Dry Cleaning Facility (presently Building 443). Therefore, the log probably refers to BW-15. According to the log, BW-15 was constructed in 1943 to a total depth of 305 feet. The casing was 12 inches in diameter, and perforated from a depth of 245 to 270 feet. All that is visible today is a concrete pad with a circular hole covered with asphalt. Concrete footings that were probably used to support a pump motor are also visible, as is a drain leading away from the former well location.

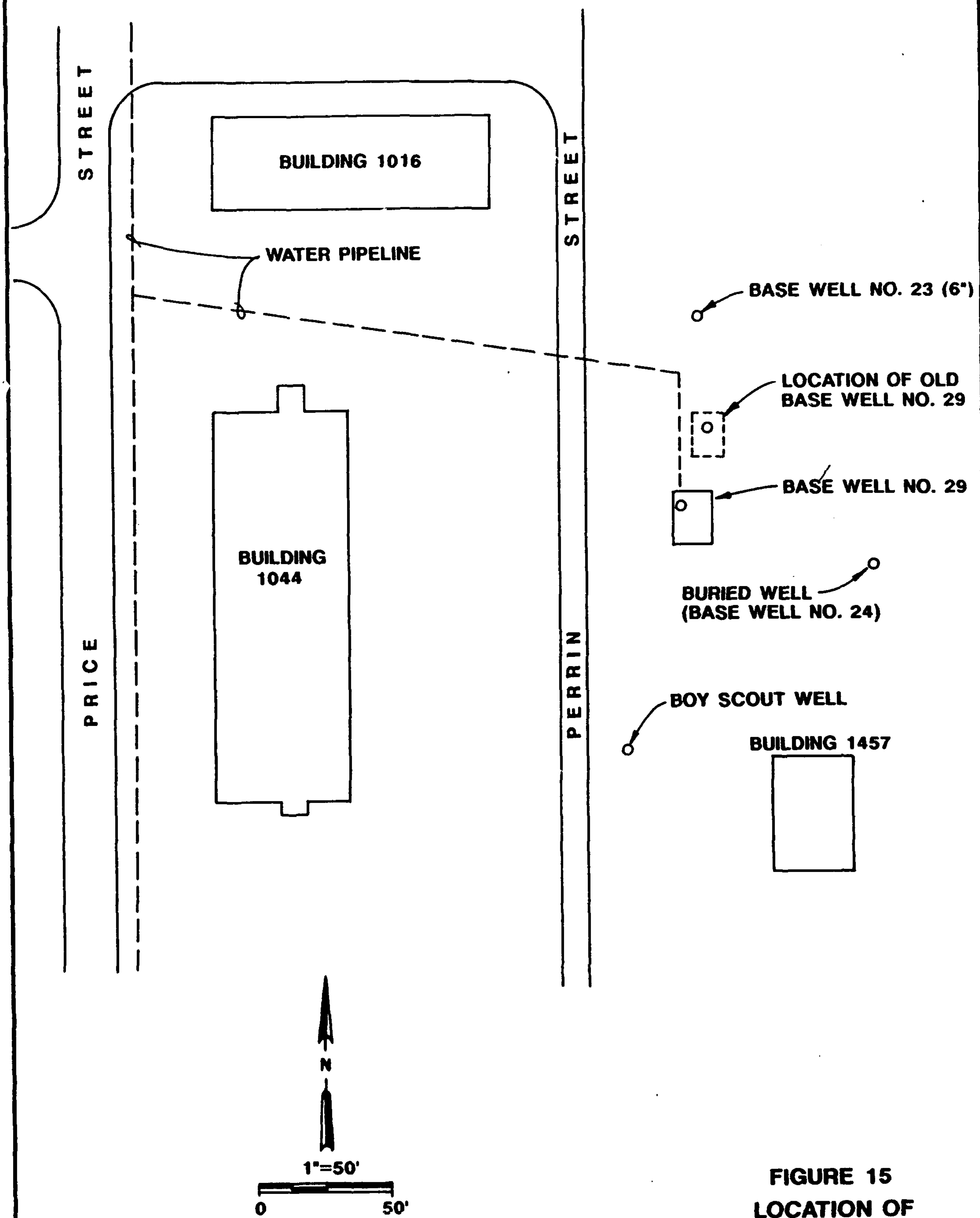
Wells in the Vicinity of Base Well 29

Four wells are known to be present in the immediate vicinity of BW-29, an active production well located on Perrin Avenue in the northeastern part of the base. These wells are thought to be BW-23, BW-24, "old" BW-29, and the "Boy Scout Well." The locations of the wells is shown in Figure 15. Another well, BW-22, is located at Building 1440 about 1,300 feet northeast of BW-29. The location of this well is shown in Figure 2.

According to a previous investigation, interviews with base personnel had indicated that BW-22, BW-23, and BW-24 were old agricultural wells acquired during early expansion of McClellan AFB. BW-23 and BW-24 were thought to be located in general vicinity of the present location of BW-29 (CSCE, 1984). Recent parking lot construction at BW-27 uncovered two old wells that may be BW-23 and BW-24. The well north of BW-29, assumed here to be BW-23, had a 6-inch-diameter casing. Workers determined that this well had not been abandoned, and welded a plate on the casing (conversation with Robert Zenda, December 18, 1991). The present investigation located a 1984 map that identified an "old agricultural well" at that location. Both BW-23 and BW-24 will be protected by the paving contractors for potential future access to the wells.

Mr. Zenda of the Water Department also described a well in this area called the "Boy Scout Well." Field inspection located a well with 6-inch-diameter casing sticking up out of the ground in front of Building 1457 on Perrin Avenue. Building 1457 has historically been used for Boy Scout activities at McClellan AFB. A cap has been welded onto the casing, so that field personnel were unable to determine whether the well has been grouted.

BW-29 has been constructed twice at this location. The original well was built in 1981 by Water Development Corporation. Drawings found during this investigation located the well at the position shown in Figure 15. Old BW-29 was drilled to a total depth of 604 feet, and then cemented to a depth of 400 feet. It contained 16-inch-diameter casing in a 26-inch-diameter borehole, with 50 feet of conductor casing. No information is available on the screened interval. Unfortunately, the gravel feed tube was inadvertently covered by the cement sanitary seal, so that gravel could not be added to the well. As a result, the well began pumping sand. Eventually, so much sand was pumped that a depression was visible at the ground surface. According to base Civil Engineering personnel, the casing was cut below grade and a metal plate was welded over it.



SOURCE: WELL 29 PLANS, McCLELLAN CIVIL ENGINEERING DEPARTMENT, 1980, 1984
FIELD INSPECTION, 1992

FIGURE 15
LOCATION OF BASE WELL NO. 29 AND NEARBY WELLS
McCLELLAN AIR FORCE BASE

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This plate was then buried. The present BW-29 was constructed in 1984 by the Maggiora Brothers. BW-29 is 580 feet deep and contains 190 feet of screen, according to McClellan AFB files.

BW-22 was located near one of the corners of Building 1440, which houses recreational equipment checkout for base personnel. This well is thought to have been an agricultural well originally, and later served Building 1440. Eventually Building 1440 was placed on the McClellan AFB water supply system. The fate of the well is uncertain (Robert Zenda, 1992, pers. comm.). A field inspection revealed no sign of the well. However, a circuit box labeled "Well Pump" was found on the northeast corner of the building.

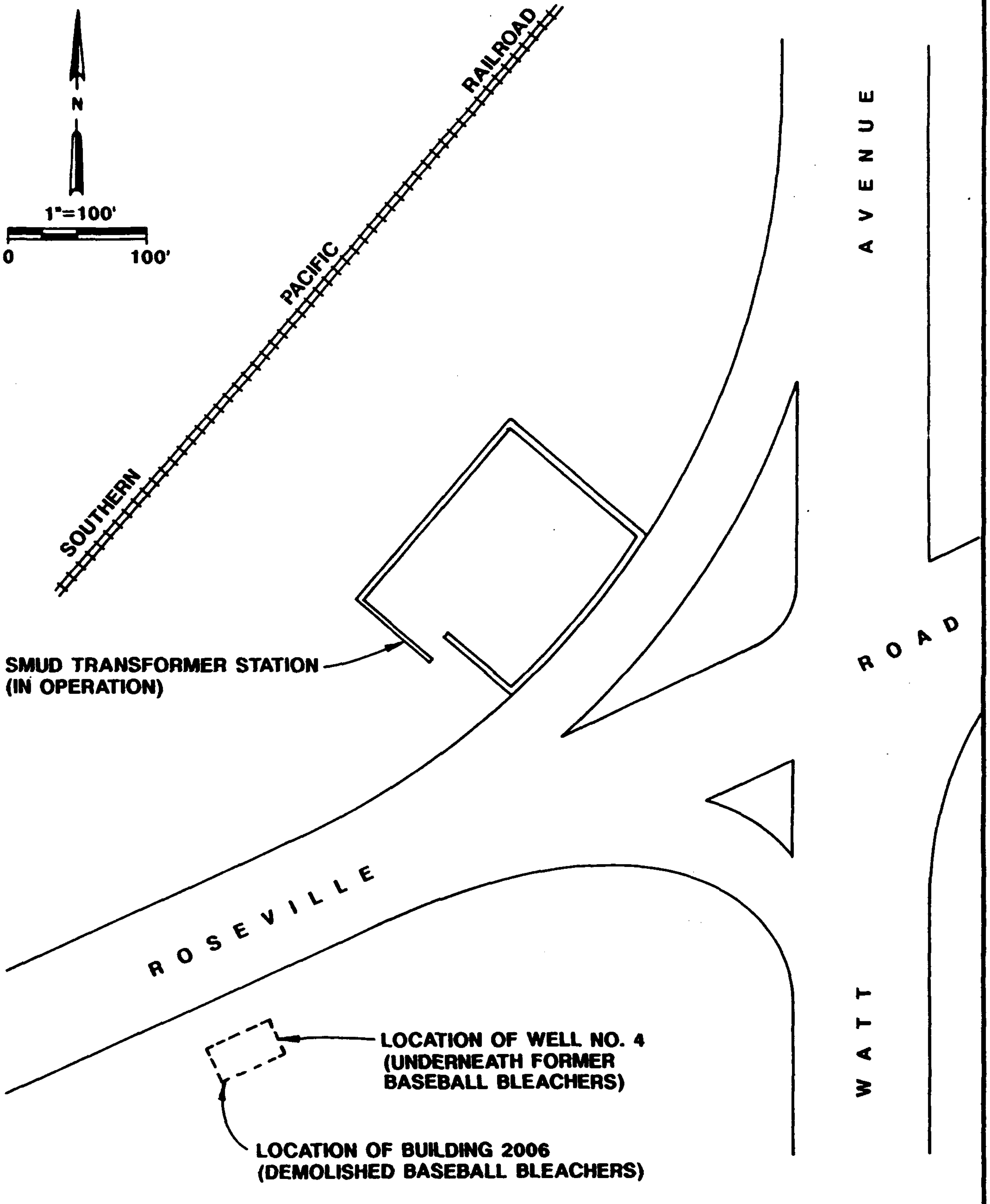
Wells Located Outside McClellan AFB Boundaries

Five wells are located outside the present boundaries of McClellan AFB: BW-4, BW-5, BW-11, BW-25, and BW-26. Two of these wells, BW-4 and BW-11, are presently inactive and no longer visible. The other wells are currently operating and serving off-base facilities. A sixth well is thought to have been located near the present corner of Whitney and Eastern Avenues, but the status and number of this well is uncertain as described previously.

Well BW-4 is located south of Roseville Road about 400 feet west of the intersection with Watt Avenue (see Figure 16). This area was formerly the Winstead Athletic Field, located in a region of McClellan AFB known informally as "Splinter City." BW-4 was located directly beneath the bleachers next to a baseball diamond, and served as an irrigation well for the field. As part of this investigation, maps were located that show the location of the former well. Field inspection revealed no sign of the well, but piles of concrete rubble are visible that are likely the remains of the old bleachers. BW-4 was a rotary well drilled in July 1941 to a depth of 382 feet. It contained 12-inch-diameter casing that was perforated from 169 to 382 feet, and a 24-inch-diameter conductor casing that extended to a depth of 81 feet. BW-4 is known to be gravel-packed, but the details of the pack and the borehole diameter are unknown (LSCE, 1984). It is uncertain when the well was taken out of service, but Winstead Athletic Field is thought to have been present until the mid 1980s.

Well BW-5 is known as the "Old River Dock well." This well is located on Old Garden Highway, several miles southwest of McClellan AFB. Constructed in 1941 to a depth of 368 feet, BW-5 is still in service. Construction drawings and geologic information on the well are on file at the base.

Well BW-11 is located about 75 feet north of the current intersection of Winona Street and Watt Avenue about one-half mile south of McClellan AFB, in the area formerly known as "Splinter City" (see Figure 17). It is not presently visible at the surface, but maps were located during this investigation that show the former location of the well. BW-11 was constructed in 1945 in a subsurface vault, as was typical of McClellan AFB wells from that time. The well was 378 feet deep, according to a photolog on file at the Base. Casing was 14-inch-diameter steel, reducing to 12 inches in diameter at a depth of 140 feet. Perforations extend from 154 feet to the total depth of the well.



SOURCE: McCLELLAN FIELD UTILITY MAP , SHEET NO. 2, 1945

FIGURE 16
LOCATION OF
BASE WELL NO. 4
McCLELLAN AIR FORCE BASE

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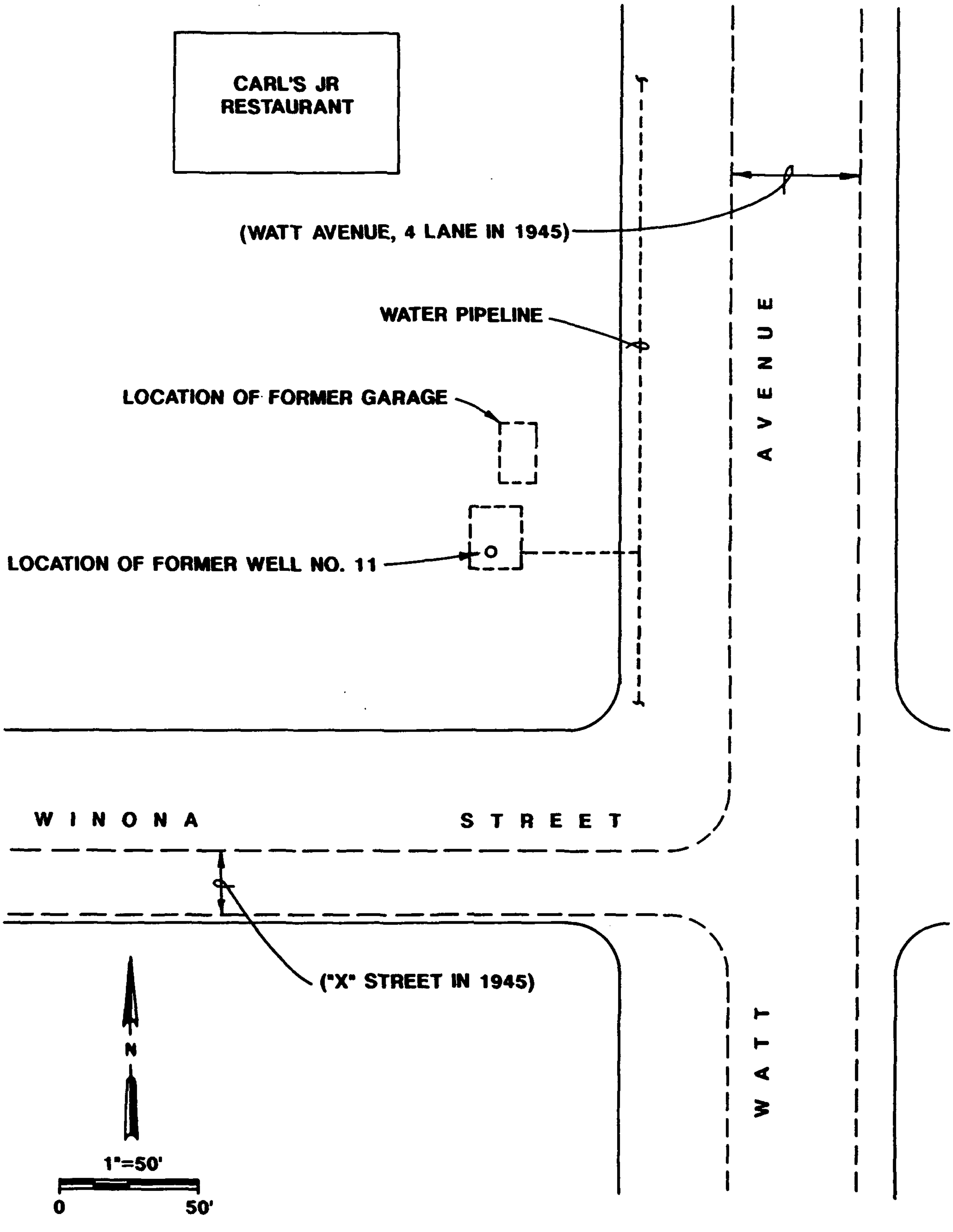

FIGURE 17
LOCATION OF
BASE WELL NO. 11
McCLELLAN AIR FORCE BASE

SOURCE: McCLELLAN FIELD UTILITY MAP, SHEET NO. 2, 1945
AIRPHOTO OF McCLELLAN AFB, 1987

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The well is thought to have been gravel packed. However, details of the borehole diameter and surface seal are unknown. It is also uncertain when or how the well was taken out of service. However, BW-11 was still online in 1984 (LSCE, 1984). At some point in the past, BW-11 was reported to have been contaminated with gasoline (conversation with Robert Zenda, January 3, 1992).

Well BW-25 is located at the Lincoln Communication site. It is reported to be an active well, drilled to a total depth of 408 feet. Other data has not been obtained for this well.

Well BW-26 is located at the Davis Communication site. This well is also an active well, being used for fire protection, irrigation, and cooling tower water. Construction data on file at the base reveal that the well was constructed in 1951 to a depth of 358 feet, with 10-inch-diameter casing installed to a depth of 320 feet. However, the casing apparently collapsed at a depth of about 225 feet. Subsequently in 1986 8⅝-inch-diameter casing was inserted into the well. This casing is screened from depths of 102 to 122 feet, and 140 to 201 feet. A cement plug was placed in the casing below 201 feet. BW-26 has experienced contamination by TCE, PCE, and 1,1-DCE, according to records on file at the Water Department. Data from 1988 indicate that TCE concentrations ranged from trace amounts to 6.0 ppb between 1986 and 1988, while PCE concentrations ranged from trace amounts to 3.2 ppb, and 1,1-DCE ranged from trace amounts to 3.0 ppb. However, Mr. Zenda stated that TCE levels had ranged as high as 3,000 ppb in previous years (Robert Zenda, 1992, pers. comm.). Records indicate that underground storage tanks were removed from the site. Current remedial efforts include the implementation of a Remedial Investigation for groundwater contamination.

Other Wells

Two wells have not been located at McClellan AFB. These include BW-14 and BW-21. No information has been found regarding the location or disposition of BW-14. It is possible that this well was located on the corner of Whitney and Eastern Avenues, several miles southeast of McClellan AFB. BW-21 is reported to be an old agricultural well. Apparently, this well served as the "Aero Club Well." At some point in the past the club was lodged in an original old farmhouse, that lay in the vicinity of the present Building 696 (Conversation with Robert Zenda, January 3, 1992). The general location of this well is in the south-central portion of the base (see Figure 2). Further search of old base maps may precisely locate this well.

Decommissioning Base Wells

Two subcontractors will be employed in the abandonment of base wells: a drilling subcontractor who will provide a drill rig or crane with a mast to hang equipment over the hole and other specialized equipment such as perforating equipment, and who can perform downhole television surveys; and a subcontractor who specializes in the mixing and pumping of grouts under pressure for well abandonments. All cementing operations will be performed under the supervision of a California Registered Geologist or Professional Engineer from CH2M HILL who will maintain a chronological record of field activities.

Field work will be arranged so that only personnel from the drilling crew will be allowed to work over the open well and handle oil or water removed from it. These personnel will be trained in safety aspects of work involving potential contact with hazardous materials and participate in an ongoing medical evaluation program, as required by the Occupational Safety and Health Administration. CH2M HILL will provide screening of ambient air with a photo-ionization instrument. It is not anticipated that base wells will pose a safety risk from hazardous materials if proper safety procedures are followed. Safety requirements are detailed in Appendix A in the Site Safety Plan.

During Phase I it was found that state or county permits were not necessary for well decommissioning at McClellan AFB, because the work is governed by the terms of the InterAgency Agreement, which provides for supervision by representatives of the various agencies of the county and state. The Well Closure Methods and Procedures Report prepared for Phase I (CH2M HILL, 1991) contains a complete description of ordinary permit requirements and well abandonment regulations.

All equipment used in well abandonment that may come into contact with groundwater will be decontaminated prior to arrival at each well. This decontamination will consist of steam-cleaning. Equipment will be steam-cleaned at the contractor's yard prior to arrival at the first well. Equipment that is used in wells and contacts groundwater will be steam-cleaned when it is pulled from the well. Steam-cleaning water will be allowed to run back down the well to avoid disposal problems. Disposal of wastewater, if necessary, is discussed at the end of this document.

Preliminary Activities

As preparation for abandonment or modification of base wells, a pump contractor will be supervised in the removal of existing turbine pumps from five inactive wells (BW-8, BW-13, BW-17, BW-20, and BW-28). Wells BW-8, BW-13,and BW-17 are each located inside buildings (BW-8 and BW-13 are contained in vaults) and will need to be removed through trapdoors in the roof. BW-20 is located in a vault in a parking lot. Concrete pads will have to be removed to gain access to this well. The contractor will mobilize a pump rig to each well head, dismantle the pump, and pull it from the well. All pump equipment-wellhead motors, pump column piping, pump shafts and bowls, strainers, etc., will be transported to the Defense Reutilization and Marketing Office (DRMO) at Building 700. Pump equipment will be steam-cleaned as it is pulled from the well, and prior to delivery to DRMO.

Plumbing at BW-8 will be temporarily capped pending reinstallation of the pump. At BW-13, the water line from the pump will be disconnected from the main line near the power pole and a blind flange installed on the "T." At BW-17, the 12-inch valve on the supply line from the well located about 85 feet south of Building 663 will be removed, and blind flanges installed on both ends of the pipe. At BW-20, the 2-way valve in the vault will be removed and replaced with pipe spool.

A field log will be maintained during this and all other field activities. This log will provide a chronological record of all field activities. Field notes will be organized so that each page is numbered and dated. The well number or location will be written on each page. A fresh page will be used at each new well. The field notes will also include a daily sketch, if applicable, that depicts the well with grout intervals, perforated intervals, or other pertinent information. In addition, pictures will be taken to record the highlights of field work, and provide a basis for agency presentations. A record of pictures taken will be recorded in the notes.

Following removal of the pumps, a contractor specializing in downhole television surveys will lower a television camera down each well to be abandoned or modified. This survey will provide information on the condition of the casing, such as the presence of encrustations or obstructions in the casing or fill material in the bottom of the well, and the ability of the casing to withstand cementing pressures, as indicated by the presence of cracks and holes, and corrosion along the perforations. The television survey will also indicate whether pump lubricating oil is floating on the top of the water in the well, and provide a preliminary indication of well construction details (casing diameter, intervals of perforations, depth of the casing, etc.).

Any pump lubricating oil found in the wells will then be bailed from the wells and stored in 55-gallon drums. Arrangements will be made for the oil to be disposed to a petroleum recycler. Air Force personnel will sign any manifests or forms required by the petroleum recycler.

After the pump lubricating oil has been removed, it will be necessary to perform some rehabilitation on the wells. Based on experience gained during the first phase of well abandonment at McClellan AFB, it is expected that all wells except the seismic wells and redrilled wells will be contaminated with iron bacteria. However, wells revealed during the initial television survey to be free of obstructions that block a view of the casing will not require rehabilitation. Wells that are considered to require some rehabilitation will be cleaned with a steel brush fabricated for each well diameter to remove gelatinous masses of iron bacteria and encrustations of iron oxide. The purpose of the cleaning will be to allow improved evaluation of the condition of the well casing. For this reason, it is assumed that only the upper portion of BW-8, which will be sealed off, will require cleaning with a steel brush.

Following the cleaning of the casing, excessive debris lying in the bottom of the wells will be bailed out and stored in 55-gallon drums at the wellhead. Ten feet or less of soft sediment should not affect the cementing operations. If greater than 10 feet of sediment is found, then it will be necessary to remove it. It is assumed that no more than 25 55-gallon drums will be required for all the wells. Any salvageable materials found in the wells, such as piping, will be transported to DRMO.

Cores will then be drilled into the concrete pads at the wellhead of each well that will be abandoned or modified, with the exception of the seismic wells. The coring will be accomplished with a small hand-held drill, and cores will be extended to the top of the gravel pack annulus in each well, a distance of only about 1 to 2 feet. The purpose of the coring is to determine the composition of the gravel pack and the diameter of the annular space. This information will reduce uncertainty during cement volume calculations when the wells are being sealed.

A second television survey will be performed in each well that has been cleaned by brushing. As before, this survey will provide information on the condition of the casing, such as the presence of encrustations or obstructions in the casing and the ability of the casing to withstand cementing pressures, as indicated by the presence of cracks and holes, and corrosion along the perforations. The television survey will also provide an indication of well construction details.

When video tapes of the television survey of wells on base are received, a technical memorandum will be prepared for submission to the Air Force Project Officer. This memorandum will summarize field activities to that point and discuss the findings of the television survey and coring into the wellhead pads. If any additional work is found to be necessary prior to abandonment based on the results of the survey, that work will be described and recommendations made in the technical memorandum. Similarly, the technical memorandum will propose any modifications to the "Well Closure Methods and Procedures" report that appear to be necessary based on the results of the survey and coring. Agency approval will be obtained before performing any of the modifications recommended in the technical memorandum.

Grout Materials

Cement grout mixtures used to seal the annular space around a well casing must display certain properties. Grout should be of low permeability to resist the flow of fluids through them, be capable of bonding to both the well casing and borehole wall to provide a tight seal, develop sufficient strength within a short period to permit completion of the abandonment without excessive delay, be chemically inert or nonreactive with formation materials or groundwater, be easily mixed, be of a consistency that will allow the grout to remain in a pumpable state for an adequate period of time, have minimal penetration into permeable zones, and be safe to handle (Gaber and Fisher, 1988).

Various types of cement mixtures are available that display these properties and accommodate varying geological and chemical conditions found in the subsurface. Experience in the oil industry led the American Petroleum Industry (API) to establish specifications for classes of cement. API Class G and H cements, which are specially formulated to be used with additives and suitable under a wide range of pressure and temperature conditions, will be used in the decommissioning of base wells.

Common Portland cement is made from limestone (or other materials high in calcium carbonate), clay, or shale, with some iron and aluminum oxides added if they are not present in sufficient quantity in the clay or shale. The principal compounds formed during the burning process that produces cement are tricalcium aluminate, tetracalcium aluminoferrite, tri-calcium silicate, and dicalcium silicate. API Class G or H cement is chemically similar to common Portland cement but is manufactured to more rigorous chemical and physical specifications which result in a more uniform, fine-grained product (Halliburton Services, 1981). The typical hydraulic conductivity of a neat cement, composed of Portland cement and water (6 gallons per 94-pound sack), is about 10^{-7} centimeters per second (Gaber and Fisher, 1988).

Class H cement is commonly mixed by Halliburton Services in a 50/50 ratio with pozzolans, siliceous materials that develop cementing properties by reacting chemically in the presence of lime and water. When mixed with cement in dry bulk form, pozzolans decrease the weight of the slurry, provide low permeability and low water/solids ratio, and make pumping easier. The 50/50 mixture, marketed by Halliburton as Pozmix, has a hydraulic conductivity of less than 10^{-10} cm/sec after curing (Halliburton Services, 1981). Pozmix will be the basic cement used in decommissioning wells at McClellan AFB.

A special cement known as standard fine cement will also be used during cementing operations. Marketed by Halliburton Services as Micro Matrix Cement, this cement will be used in wells with fragile casings or where long intervals of existing perforations are found in wells. Micro Matrix Cement is chemically similar to Portland cement. However, Matrix Cement particle sizes are approximately 10 times smaller than standard cement particles. This property reduces the viscosity of the cement and enables it to penetrate openings as fine as 0.05 mm (Halliburton Services, 1991).

The amount of water mixed with the cement has an important effect on the properties of the cement. Tests have indicated that 5.2 gallons of water are required to hydrolyze one 94-pound sack of Portland cement, producing a slurry weight of 15.6 lb/gal (Driscoll, 1986). Less water than this will not hydrate the cement and will cause a high-viscosity product that is difficult to pump. Too much water causes shrinkage, as water is squeezed out of the mixture into permeable formations, or as cement settles to the bottom of the mixture. The proper mixture produces effective bridging of cement particles in the pores of permeable formations, which prevents penetration of the grout into these formations (Driscoll, 1986). DWR regulations specify that 4.5 to 6.5 gallons of water per sack of cement be used, depending on the cement type and additives used (DWR, 1981). The appropriate water-to-cement ratio will be continually monitored during the decommissioning of base wells through use of density measurements with an electronic cement balance.

Various additives may be added to the cement to improve the characteristics of the grout material. During the decommissioning of base wells, these may include bentonite powder, CFR-3, calcium chloride, Flocele, and quick-setting gypsum cement. Bentonite is a colloidal clay (chiefly montmorillonite). Addition of bentonite increases the slurry and set volume and reduces shrinkage because of the water adsorption properties of colloidal clay. Bentonite also reduces the weight of the cement column, which is beneficial where permeable formations will not sustain a high hydrostatic pressure. Finally, addition of bentonite improves the fluidity of the mixture by increasing the suspension qualities, thus reducing the settling out or separation of cement particles from the slurry (Halliburton Services, 1985). If the percentage of bentonite exceeds about 6 percent, excessive shrinkage of the cement will occur (Driscoll, 1986). During the decommissioning of base wells, about 2 percent bentonite powder will be mixed with water prior to the addition of the cement.

CFR-3 is a dispersant, or friction reducer, that is composed of sulfonic acid salt. CFR-3 improves the mixing of other components of the grout by increasing the turbulent flow of the slurry. This is a property that aids when using small-diameter tremmie pipes and attempting to infiltrate gravel packs and formation walls. It also densifies the cement, aids in fluid-loss control, and increases salt tolerance of the grout if calcium chloride is added (Halliburton Services, 1985).

Calcium chloride is added to the mix in quantities of about 2 percent to accelerate the early strength of the cement, thus reducing the time required for the mix to set up. Available in either powdered or flake form, it can be added either to the dry mix or to the mixing water. For example, Class H cement with 2 percent calcium chloride achieves a compressive strength of 1,100 psi after 6 hours at 95°F (Halliburton Services, 1981).

Two other additives may be used to reduce losses to permeable formations. Flocele consists of cellulose film flakes, about 3/8-inch in diameter, that are chemically inert and do not affect the compressive strength of the cement (Halliburton Services, 1985). Flocele will be added to the mixing water at a ratio of about 0.75 percent by weight. Cal-Seal, or gypsum (calcium sulfate), sets up in 20 minutes when blended with Portland cement. In addition, it expands 0.3 percent in setting, forming a tight seal. These properties make Cal-Seal a good choice to seal lost circulation zones (Halliburton Services, 1985). Cal-Seal will be mixed with Class G cement at a ratio of about 8 percent to help seal off permeable zones.

Grout will be mixed in the field with a recirculating mixer. The mixer and a diesel-powered positive-displacement pump will be delivered to the site on a truck and trailer.

Grout Placement

Several methods are commonly employed to decommission water wells. The most common technique involves first perforating the well casing adjacent to units of low permeability, such as clay or silt, and adjacent to aquifers containing deleterious water. A tremmie pipe is then suspended in the casing and grout pumped next to these zones, while sand is placed next to aquifers containing good quality water. A variation involves perforating and cementing the entire length of the casing in one lift. In all cases, the tremmie pipe is suspended near the bottom of the zone to be sealed, and grout is pumped from the bottom to the top of the zone. In addition, the uppermost 20 feet is always sealed.

Improved grout control and gravel pack penetration is achieved by maintaining a desired level of pressure on the grout in excess of hydrostatic pressure as it sets up in the hole. The amount of pressure applied depends on the characteristics of the cement slurry, size of the perforations, characteristics of the gravel pack and formation, temperature, and depth of the interval being sealed. A maximum pressure, or fracture pressure, represents an upper limit that should not be exceeded in grout placement. Above this level, grout penetration of the gravel pack and formation may not be uniform, due to the development of fractures, or routes of less resistance, through which the grout would preferentially flow.

A step-rate injectivity test is commonly used in oil well abandonment to estimate the fracture pressure of a formation. However, an accepted practice in water-well abandonment is to limit pressures to less than 1 psi per foot of depth below the surface. In this way, each lift in the hole is grouted until the volume of grout is sufficient to fill the voids in a hypothetical cylinder of casing and surrounding soil, or until resistance builds up to the pressure limit (Albritton, 1982). In the bottom of a 400-foot-deep well, for example, pressures should not exceed 400 psi.

Pressure at the surface (downstream from the pump) will be monitored with a gauge. During Phase I, this pressure never exceeded about 50 psi. Since this pressure is propagated evenly throughout the fluid, the pressure downhole should be equal to the pressure at the pump plus the pressure exerted by the column of fluid (0.458 psi/ft for water above the water table). The water table at McClellan AFB lies about 100 feet below the ground surface. Therefore, the pressure in the well should not rise much above 100 psi.

Grout placement by applying external pressure in excess of hydrostatic pressure is known as squeeze grouting. Pressure is maintained by sealing off the casing while pumping fluid into the casing with a positive displacement pump and monitoring pressures at the surface with a gauge. When the seal is placed at the surface, the technique is referred to as a Bradenhead squeeze. This technique would be less effective in base wells because of pressure losses through perforations above the interval being sealed. Pressures may also be maintained downhole through the use of drillable grout plugs, or retrievable balloon packers, retrievable tension-set packers (set by applying a tension, or pull, on the packer with the pipe attached to the packer), or retrievable cup-packers (set by the fluid pressure below the packer, which creates a seal by forcing the cup against the well casing). Grout is squeezed through the perforations and into the gravel pack by the high forces developed through the hydraulic effect of transmitting pressure through a small-diameter pipe and into a large-diameter pipe (the casing).

Two main approaches were most successful in properly abandoning wells at McClellan AFB during the first phase of well decommissioning. One approach, application of a downhole squeeze utilizing a cup packer, is a low-cost method applicable for wells screened intermittently along the length of the casing with casing that is capable of withstanding the hydraulic pressures generated by the packer. The other approach, special low-viscosity cements and application of a head of water, is a more expensive method that is applicable for wells screened continuously along the length of the casing or those that contain weak or damaged casing. Both approaches call for the well to be cemented in stages, with external pressure applied to the cement to force it into the gravel pack. These approaches will be followed during Phase II. In either case, wells that are believed to pose fewer technical challenges will be decommissioned before more difficult wells.

Abandonment With a Packer

Wells that are perforated at intervals along the casing and judged to be capable of withstanding high pressures, based on television survey evaluation, are suitable for cementing using a cup packer. Grout may consist of Portland cement with additives to improve performance. At McClellan AFB, the grout mix that worked well in the first phase consisted of API Class H cement, pozzolans, 2 percent bentonite gel, and 3 percent calcium chloride. This grout should be pre-mixed dry at the plant, and mixed with water at the job site. The steps in abandoning with a packer are as follows:

- Perforate the casing immediately prior to cementing if necessary.
- Set the cup packer in a blank section of casing above the interval to be cemented. Chain the tremmie pipe down evenly at the wellhead.
- Calculate a volume of cement necessary to fill the casing and 40 percent of the gravel pack to a point about 2 feet above the perforated interval.
- Calculate a volume of water necessary to fill the casing above the cement and below the cup packer, plus the entire tremmie pipe, and all surface piping downstream from the volume gauge.
- Pump a sufficient amount of water into the well to establish circulation and estimate the permeability of the formation.
- Mix the required volume of grout with a recirculating mixer to the desired density. Collect a sample and set it aside in the shade.
- Pump the required volume of grout with a positive displacement pump. Monitor the injection rate (less than 20 gpm) and the pressure (less than 100 psi).
- Pump the required volume of water slowly (less than 20 gpm) and monitor the pressure (less than 100 psi). Watch the tremmie pipe and chains for possible buckling. This is especially important in wells with large-diameter casing.
- Withdraw the cup packer from the well immediately to prevent it from being cemented in place.

- Inject cement wash water into the well.

- Tag the cement in the well with a weighted line after the cement sample sets up (minimum of 3 hours).

- Perforate the next interval, if necessary.

- Cement the well in a series of lifts. The length of the lift is determined by the length of existing perforations, the expected lithology, and the outcome of the previous lift.

On the next-to-last lift, the casing should be perforated about 15 feet above the water table.

The cement volume should then be calculated to bring the top of the cement to about 1 or 2 feet above the water table. As the cement sets up, water should drain out of the casing into the formation above the water table. This avoids the need to dispose of potentially contaminated water. On the final lift, cement should be brought to within 5 to 10 feet of the ground surface. It will be necessary to pump cement wash water into a tank trunk for disposal on the final lift. The earth will be excavated and the casing cut about 3 feet below grade. Finally, the cement should be topped off to the ground surface on outdoor wells. Wells located within buildings will be cemented so that the top of the cement is flush with the floor surface. All equipment should be steam-cleaned before use at the next well.

Perforation of the casing will take place immediately prior to cementing. The length of casing to be perforated will not exceed the length of the interval to be cemented on the next lift. Typically, perforation will be accomplished with a mills knife perforator, in which hydraulics cause the blade to cut into the casing. Four perforations will be cut per row, with one row per foot. Each perforation will be about one-third inch in thickness, and about 3 inches in length. Based on the conclusions drawn during the Preliminary Work, it may be necessary to employ an alternative method of perforation in certain wells. This method may be explosive shot perforation, hydro-jetting, or some other method, and will be described in the Technical Memorandum.

The length of the interval to be cemented will depend on the length of existing perforations and the experience of previous lifts in that well. Expected lithology may also affect the length. For example, shorter lengths may be necessary in zones of high permeability because of the need to employ special techniques (see the discussion below). In general, decommissioning at a given well will begin with a short lift of about 15 feet, and increase with experience to a maximum of no more than about 50 feet.

Abandonment with a Low-Viscosity Cement

A different approach is necessary in wells that are perforated continuously for great lengths or that contain casing that is judged too weak to sustain the pressure generated by use of the cup packer. Setting a cup packer within a perforated zone is pointless because the closed piston necessary to generate hydraulic pressure may not be obtained. Setting a cup packer within a zone of weak casing risks casing collapse or may cause holes to open, thereby allowing sediment to flow into the well.

Studies performed by Halliburton have shown that neat cement, cement containing pozzolans, and cement containing CFR-3 will be forced through well perforations and into a surrounding gravelpack mixed with formation material under a driving pressure of less than 30 psi. The hydrostatic pressure of a column of water is about 0.433 psi per foot. Thus, a driving pressure of 30 psi is obtained by a column of water about 70 feet high. A feasible abandonment technique below a depth of 70 feet would therefore involve pumping grout into the interval to be sealed, raising the tremmie pipe above the grout, and then adding water sufficient to maintain a column of water at least 70 feet high above the grout. In other words, the hydrostatic pressure of a column of water greater than 70 feet should provide sufficient pressure to force the grout mixture into the gravel pack.

In wells with weak casing or that are perforated continuously for long lengths, the approach will be to cement the well in a series of lifts using a low-viscosity cement. At McClellan AFB standard fine cement with the addition of CFR-3 was found to work well during the first phase. The tremmie pipe should be set about 10 feet off the bottom, and water circulated down the hole prior to cementing. After the cement is pumped, an attempt should be made to apply a head of water to the well. At McClellan AFB, the static water level is about 90 to 110 feet below the ground surface. A head of water provides about 45 to 55 psi of pressure, which is transmitted directly to the top of the cement. It may not be possible to maintain a full head during the early stages of abandonment because the water will be lost to the formation. As the well is cemented off, however, it becomes easier to apply the head. Success with this method is observed by comparing the calculated top of cement for the volume pumped with the actual top as measured by the tag.

Zones of High Permeability

Potential problems may result when grouting next to very permeable formations. Inability to maintain pressure at the wellhead may be countered by any or a combination of several techniques (Halliburton Services, 1985):

- Blocking circulation loss channels with flaky, fibrous, granular, or gelling additives. These may include walnut shells, bentonite, quick-setting gypsum cement, or Portland cement with an accelerator.
- Plugging with quick-setting cements which set up while flowing into channels.
- Lightening the column of slurry and/or decreasing the pressure.
- Using the hesitation method-placing cement in alternate pumping/waiting periods, encouraging the controlled deposition of cement solids against the formation.

Modification of Base Well 7

Available records indicate that BW-7 is probably grouted from a depth of about 80 feet to a total depth of about 398 feet. In order to ensure that the gravel park is properly sealed, it will be necessary to drill the well out and perforate the entire length of casing. However, a potential problem may result from the fact that previous efforts to drill out the inside of the casing were unsuccessful. For example, the former pump or pump column may be in the casing. The television survey may provide insight that will assist in developing an appropriate approach. Alternative methods of abandonment may involve rotary overwash of the casing, or drilling out the gravel pack with a small diameter drill bit, followed by cementing the annulus with a tremmie pipe. Any abandonment approach that differs from the approach described in previous sections of this report will be approved by the regulatory agencies in advance. If this approach can be developed based on the results of the television survey, it will be outlined in the technical memorandum prepared after preliminary work on the McClellan AFB wells is complete.

Modification of Base Well 8

BW-8 will be cemented through the uppermost groundwater zones, then returned to service. It is assumed here that this upper seal will extend to a depth of about 170 feet below ground surface. Construction drawings indicate that the perforations in BW-8 may begin at a depth of 170 feet and extend to a depth of nearly 400 feet. Sealing the well at this depth would preserve these perforations and maintain the specific capacity of the well, which will be used on a standby basis for fire protection.

Unfortunately, the available data are contradictory regarding the well construction details and geology in the vicinity of the well borehole. Drawings that indicate that the perforations begin at a depth of 170 feet also show that the formation just above this interval consists of hardpan. Other drawings show this interval as consisting of yellow clay. Either material should be suitable for sealing. After the television survey is performed, it may be possible to identify the correct drawing and associated borehole geology. The technical memorandum prepared at the conclusion of the television surveys will address the question of where to set the seal in BW-8.

Following the placement of the seal in the casing and gravel pack, the cement that is inside the casing will be drilled out. Because the wellhead is located in a subsurface vault, special measures must be taken during drilling. It will be necessary to weld additional extension casing from the wellhead to the trapdoor in the ceiling above the well. Then, a rotary table or power swivel will be fastened to the top of the casing, and drill stem suspended in the casing from a crane. Following the drilling of the casing, the pump will be reinstalled in BW-8.

Base Wells 17 and 28

BW-17 and BW-28 were both drilled by the cable tool method. The main difference between a well drilled by the cable tool method and one drilled by the rotary method from a well abandonment perspective is that there is no gravel pack associated with a cable tool well. Since there is no gravel pack, the calculations for cement volumes must be adjusted. Cement volumes will therefore be calculated based on the inside volume of the casing, plus an additional 10 percent to fill the micro-annulus outside the casing. This additional 10 percent is felt to be conservative since subsurface clays may be expected to have swelled up tightly against the well casing. Otherwise the decommissioning approach will be the same as other wells, with grout applied under pressure in a series of lifts.

Camp Kohler Wells

LW-1 has been found to be abandoned at Camp Kohler, although it is uncertain whether the pump was cemented in the casing. LW-2 has not been located. It will be necessary to do additional excavating with a backhoe at a location identified on recently acquired aerial photographs. If this is unsuccessful, it may be necessary to perform a geophysical magnetometer survey to locate LW-2. This well has probably been abandoned with concrete also, and the pump may also lie in the hole. An initial step for these wells may be to drill a core into the concrete to determine whether the pump is present, and whether a gravel pack is present between the production casing and conductor casing. If no pump column is found, then the core will be extended into the concrete for a few feet.

Afterward, the concrete may be drilled out using mud rotary techniques and a tricone drill bit. The casing would then be perforated and cemented as at other wells. The actual approach followed to decommission LW-1 and LW-2 will depend on field conditions. If an alternative approach to decommissioning the wells is developed, it will be submitted to the regulatory agencies for approval prior to beginning the work. It is expected that LW-1 and LW-2 will be decommissioned before BW-7, which is located in an area of potential contamination at McClellan AFB. Experience gained at LW-1 and LW-2 should be helpful at BW-7.

The Seismic Well and the Triax Hole were given a cement bond survey to evaluate the integrity of the cement seal that completely contains the casing throughout the length of the well. Copies of the cement survey logs are included in Appendix C. The surveys indicated that the seal appeared to be in relatively good condition in the Seismic Well, which is 500 feet deep. The cement seal in this well probably provides adequate isolation of aquifer zones.

The log for the Triax Hole appeared to be ambiguous, with conflicting signals of the quality of the cement seal. According to base records, the Triax Hole is 200 feet deep with a surface elevation of 110 feet. The water table elevation in the vicinity of Camp Kohler in 1989 was about -35 feet Mean Sea Level with long-term trends indicating gradual decline (Radian Corporation, 1991). Therefore, the depth to water at present is approximately 135-140 feet below the ground surface. The Seismic Well will be cemented in one continuous operation by pumping a sand cement mix through a tremmie pipe that has been lowered to within a few feet of the bottom of the wells. The Triax Hole will be decommissioned by pressure-grouting. A detailed approach will be provided in the Technical Memorandum that will follow a television survey performed during the Preliminary Work.

Disposal of Waste Materials

Two main categories of waste may be generated during the decommissioning of base wells: pump lubricating oil removed from the casing prior to cementing; and water generated during the decontamination of equipment between wells. Pump lubricating oil will be stored in 55-gallon drums at the well site. Although the California Health and Safety Code requires that used oil be managed as a hazardous waste, provisions allow for the oil to be recycled. By recycling the used oil, the RCRA Land Ban is bypassed (California Department of Toxic Substances Control, 1990, pers. comm.).

Manifesting requirements for used oil are thus greatly simplified. The recycler must fill out a uniform hazardous waste manifest for each vehicle operated during a particular day, completing both the generator and hauler sections using the hauler's name. The hauler will attach receipts for each quantity of used oil received from a generator and give copies of receipts to each generator of used oil, identifying the generator and the hauler, the amount and the date, and stating the manifest number. The generator must keep receipts for at least 3 years.

Two tests must be performed on the oil by the recycler: a chloro-detect test and a flash point test. These tests may be performed in the field prior to hauling the oil. The chloro-detect test will detect chlorides and halides, including contaminants potentially present in water, at a level of 1,000 ppm. The flash point test will determine whether the oil has a flash point less than 140°F. If contaminants are present above 1,000 ppm, or if the flash point of the oil is less than 140°F, the oil can still be recycled, but the Air Force will be immediately notified. However, it is not expected that these levels will be exceeded.

CH2M HILL will make arrangements for shipping, handling, and disposal of the drummed oil as approved by the Air Force. However, the Air Force will sign any manifests as generator. The Air Force will be given 48-hour notice before collection of the oil by the recycler.

The decommissioning process has been designed so that no wastewater will be generated and will therefore require no disposal. If it should become necessary to generate wastewater for disposal from decontamination or some unanticipated event during the field work, this water will be pumped into a portable Baker tank and transported to the groundwater treatment plant on base for treatment and disposal. If the water is unacceptable for treatment at the groundwater treatment plant, such as because of high turbidity, it will be delivered to the industrial wastewater treatment plant. The Air Force will be given 48-hour notice before delivery of the well water to either treatment plant.

Conclusion

After base wells have been decommissioned or modified, CH2M HILL will prepare an Informational Field Report, summarizing all field activities associated with the field work, as recorded in the field log. This report will be prepared and signed by a licensed professional, and will include any conclusions and recommendations that may be necessary. All field notes will be included as appendixes.

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MASTER SITE SAFETY PLAN

McCLELLAN AIR FORCE BASE
Sacramento County, California

Prepared for

McCLELLAN AIR FORCE BASE
Sacramento County, California

Prepared by

CH2M HILL

3840 Rosin Court, Suite 110
Sacramento, California 95834

October 1991

SAC/T192/043.51

CH2M HILL
SITE SAFETY PLAN

I. GENERAL INFORMATION

CLIENT: McClellan Air Force Base JOB NO: SAC28722
PROJECT MANAGER: Starr Dehn
SITE NAME: McClellan Air Force Base (MAFB)
SITE LOCATION: McClellan Air Force Base, California
PURPOSE OF FIELD VISIT(S): Source testing, site survey, waste minimization and treatability studies, site inspections (see Attachment A).
DATE OF VISIT(S): April 30, 1990 through 1992
BACKGROUND INFORMATION: Complete ___ Preliminary X
INFORMATION AVAILABLE FROM: SAC (office)
OVERALL HAZARD SUMMARY: Serious ___ Moderate ___ Low ___ Unknown X

II. SITE CHARACTERISTICS

A. Site Description and Overview of Planned Activities (attach site map):

- McClellan Air Force Base is located north of Sacramento, California. According to Dave Faulkner (Navy), the base is approximately 3 miles north-south and approximately 2 miles east-west in length

- The description of planned activities are listed in Attachment A

- The base is on the Central California Valley with excellent city street and interstate highway access. Access by air is excellent

- Toxic or hazardous substances known or expected onsite, discussion of physical and chemical properties, and probable pathways of migration or dispersion will be addressed on a task-specific basis in the CH2M HILL Site Safety Plan Addendum (see attached addendum form)

- Emergency response support is available from MAFB. First response is obtained from the fire department and calls can be made to the department directly or through the duty officer (see telephone numbers Section VI, J). The base has a Disaster Response Force, as second response, which consists of military personnel, the bioenvironmental group, and the on-base clinic.

B. Status (active, inactive, unknown; and nature of any site activity):

Active Air Force base

C. History (worker or nonworker injury; complaints from public; previous investigations or remedial action):

The MAFB is a RCRA facility and a CERCLA site. The site is on the National Priority List.

D. Principal Materials Handling Activities (type, amount, and location of wastes or hazardous materials disposed of, stored, treated, or handled at the site):

Not applicable.

E. Features and Unusual Features (water supply, telephone, radio, power lines, gas lines, watermains, suspect terrain, etc.):

Utility lines, both above ground and below ground, may pose a safety hazard for team members during excavation or boring. If a driller is used, the driller must maintain a safe clearance (at least 20 feet) between overhead utility lines and the drill-rig mast at all times during site operations. The location of utility lines must be determined prior to startup and the utility must be contacted 48 hours prior to excavation or drilling by contacting Underground Services Alert at 800/422-4133 and Tom Egan, MAFB Engineering at 916/643-4875.

III. WASTE CHARACTERISTICS

A. Waste Type(s):

Liquid X Solid X Sludge X Gas X

B. Characteristic(s):

Corrosive X Ignitable X Radioactive ___ Mixed Waste ___

Volatile X Toxic X Reactive ___ Unknown ___ Other (name) ___

IV. HAZARD EVALUATION

A. Overall Hazard Level:

The hazard level of each activity will be assessed and reported on the addendum form.

B. Chemical Hazards:

The major types of processes in operation on the base are paint removal, painting, plating, and foundry. Each process has overall types of chemicals that are associated with the process. For example, in the removal of paint, paint removers containing compounds such as methylene chloride, are used. In the painting operations, toluene- and xylene-based paints are applied to parts. Plating processes contain several types of chemicals including degreasers, acids, rust removers, and cyanide. Finally, foundries may contain metallic fumes. The above processes are not inclusive of all the base operations as are the examples of the process associated chemicals. Therefore, for each task and/or site visit, a SSP addendum will be attached to the overall SSP which addresses each site's hazard. The addendum will contain more detailed information on chemical hazards and will address task and/or site-specific chemical hazards.

C. Physical Hazards:

The major potential physical hazards possible at the site are: flammability of vapors, explosive conditions; utilities; moving and mobile equipment; trips, slips, and falls; and heat stress. These physical hazards may not represent every site at MAFB, therefore, for each task and/or site, a SSP addendum will contain more detailed information on physical hazards and will address task and/or site-specific physical hazards.

Explosions of vapor in confined spaces can be fatal, and workers must be attentive to this danger and guard against carelessness at all times. The lower explosive limit (LEL) is compound specific. When the vapors are heavier than air, their explosivity and flammability hazard are increased. Vapors will tend to concentrate near the ground and in low lying areas, and will not be readily mixed or diluted with ambient air. When monitoring LEL, it is important to take measurements at ground level. In order to prevent explosivity and flammability hazards, each team member must make sure that no spark sources, such as lighters, matches, unapproved flashlights, etc., are brought into the exclusion zone. The Site Safety Coordinator (SSC) must inspect the exclusion zone for spark sources including wiring, motors, etc., and enforce the requirements for fire prevention, including intrinsically safe electrical equipment, spark arrestors on vehicles, and exclusion of unauthorized personnel.

D. Hazards Posed by Site Activities:

Hazards may exist from moving process equipment (such as pumps and conveyors and mobile equipment (such as forklifts). Personnel must be alert for these hazards, and protect clothing and hair from entrapment in equipment, and use common sense in these situation. To protect from slips, trips, and falls,proper precautions and good judgement must be exercised. Personnel should be especially alert when working near pits and excavations. Exercising caution, using safe ladder practices, and using the buddy system around stacks is important.

E. Heat and Cold Stress Hazards:

Heat stress is a hazard of concern during summer months. Heat stress at hazardous waste sites usually occurs because impermeable protective clothing decreases natural body ventilation. Attachment B addresses heat stress hazards specifically.

F. Biological Hazards:

G. Unusual Hazards:

(Note: List unique hazards of site, if any.) (Insects, snakes, microbes, etc.)

H. Hazards Posed by Chemical Substances Provided by CH2M HILL:

In accordance with 20 CFR 1910.1200, Hazard Communication, Material Safety Data Sheets are provided for the following chemicals: (list) (Examples, sample preservatives, calibration gases, etc.)

V. PROCEDURES

A. SITE ORGANIZATION:

Map/Sketch Attached Yes Site Secured Yes

Perimeter Identified Yes

Zone(s) of Contamination Identified No

B. SITE PERSONNEL:

Team Organization

Team Member/Office	Responsibility
Starr Dehn/SAC	Project Administrator/Observer
John Castleberry/SAC	Project Scientist/Level C
Susanne Davis/SAC	Project Scientist/Level C
Bill Morgan/MGM	Project Scientist/Level C
John Spitsley/RDD[a]	Project Scientist/Observer
Allison Gammel/SFO[a]	Project Scientist/Observer
Pamela Beekley/SAC[a]	Project Scientist/Observer
Sue Keydel/SFO	Project Scientist/Level C SSC
Robert Koster/SAC	Project Scientist/Level C
Karla Ebert/SAC	Project Scientist/Level C SSC
Chuck Ouellette/SAC	Project Scientist/Level C

[a]Observers must remain in clean areas and upwind of the exclusion zone. Observers will not conduct sampling activities.

Each of the team members named above has been certified as fit for the anticipated work by the CH2M HILL medical surveillance program, and has completed the training requirements of 29 CFR 1910.120. In addition, each is currently certified by the American Red Cross, or equivalent, in both first aid and CPR.

C. ONSITE ENGINEERING CONTROLS:

Onsite engineering controls include covers for waste piles and cuttings and barricades to keep unauthorized people from entering contaminated areas.

D. WORK PRACTICES:

Site personnel will avoid any visibly contaminated areas onsite. In general, work practices shall be designed to decrease time of exposure, increase distance to the source, o~ shield the exposed individual.

E. PERSONAL PROTECTIVE EQUIPMENT:

Basic Site Level of Protection:

A ____ B ____ C X D X

Polycoated Tyvek coveralls with nitrile outer gloves and latex inner gloves will be worn when splash protection is needed. Nitrile outer gloves and latex inner gloves will be worn during sampling and when handling samples. Safety glasses, hard hat, and neoprene steel toe/shank boots will be worn while onsite. A TLD or equivalent badge must be worn by all team members.

Level C will include the equipment listed above plus a full-face air purifying respirator (APR) with organic vapor cartridges (GMC-H).

Task	Initial Level of Protection
Site inspection and walkthrough	Level D
Source testing	Level C (may be downgraded to Level D by SSC if HNu readings are less than 1 ppm.)
Treatability studies	Must prepare an amendment with further descriptions of each activity to be conducted.
Other tasks	Must prepare an amendment with further descriptions of task

F. GENERAL HAZARDOUS WASTE SITE MONITORING EQUIPMENT AND PROCEDURES:

Periodic monitoring of the site is required to determine the effectiveness of engineering controls, to re-evaluate levels of protection, and determine if site conditions have changed. At a minimum, monitor at the beginning of each shift, periodically (e.g., every 15 minutes) throughout the work, whenever work begins at a new area onsite or when different contaminants are encountered or a different work activity begins. Specific monitoring locations and frequencies are given below.

Carefully inspect each piece of monitoring equipment prior to work startup. Failure of any of the equipment listed below to work properly must be reported to the Project Manager immediately.

1. Explosimeter/0_2 meter: Calibrate prior to each day's activities according to manufacturer's instructions. Recharge at the end of each day. Monitor (Note to Preparer: Specify frequency, location) and record measured levels in the log book (Note to Preparer: Specify frequency).
   Action levels:

   Explosive Atmosphere (measured at source, i.e., borehole, test pit, etc.)

   Action Levels (measured at the borehole):

   - Less than 5 percent LEL--Continue drilling.
   - Greater than 5 to 20 percent LEL--Continue drilling with caution.
   - Greater than 20 percent LEL-Shutdown drilling operations and allow area to ventilate until LEL falls below 10 percent before resuming work. Mechanical ventilation (i.e., blower) may be required to reduce flammable vapors to below 20 percent. Do not place blower in atmospheres greater than 20 percent of the LEL.

   Oxygen (measured in breathing zone)

≤19.5%	Shut down drilling operations and ventilate until O_2 increases to above 19.5%
19.5% to 25%	Monitor
≥25%	Evacuate

2. Rad-mini (used at sites where exposure to ionizing radiation is not expected): Check background and check response using a Coleman lantern mantle. Monitor continuously and record location and time of alerts in the log book.

   Action levels: The Rad-Mini is used on initial entry to sites or where exposure to radiation is not expected but may occur (trenching operations, opening containers, etc.). The Rad-mini sounds an alarm at 10 mRem/hr. Site personnel will mark the spot where the alarm occurred, leave the site following as nearly as possible the path taken into the site, and call the Project Manager to arrange for health physics support. The following action levels apply during routine use of radiation survey meters at sites where exposure to radiation is not expected but may be possible.

   - Background to 1 mR/hr above background--continue operations; identify zone of radiation contamination and minimize work time in this area.

   - 1 mR/hr to 2 mR/hr above background--notify SSP approver of measurements and any unusual conditions or specific control measures.

   - Greater than 2 mR/hr above background--stop operations; evacuate work area; and notify SSP approver. Field work will require health physics evaluation and protection measures to be implemented before proceeding with field activities.

3. HNU (with 10.2 eV Lamp): Calibrate prior to each day's activities, according to manufacturer's instructions. Record calibration in the SSC log book. Recalibrate after cleaning the lamp or when background levels drift. This instrument is sensitive to humidity and may require periodic lamp cleaning if it is humid. Monitor for background concentrations (specify frequency, location) and then upon initial entry record measured levels in the log books (specify frequency). Monitor continuously while drilling or performing intrusive activities. Readings should be recorded every 1/2 hours.

   Action levels: Note to preparer: Action levels for the 10.2 eV HNU are specified based on knowledge of the contaminants present, the response of the instrument to those contaminants or mixtures of contaminants, weather conditions, engineering controls, and level of personal protection being worn. In situations where information does not exist for a more informed decision, monitor continuously, record readings at a minimum of 15-minute intervals and use the following action levels:

Reading	Action/PPE
0-1 ppm above background[a,b]	Level D; continue monitoring
>1-5 ppm above background[b]	Level C; full facepiece respirator with GMC-H cartridges. Continue monitoring.
>5 ppm	Call safety plan approver

[a]Background is established offsite and upwind before the start of daily activities.
[b]Readings are taken in the breathing zone over a 5-minute period.

G. SITE ENTRY PROCEDURES:

- Conduct Site Safety briefing before starting field activities
- Determine wind direction, install wind flags, and establish work zones onsite (e.g., exclusion zone; contamination reduction zone; and support zone)
- Set up decontamination facilities.
- If toilet facilities are not located within a 3-minute walk from the decontamination facilities, either provide a chemical toilet and hand washing facilities or have a vehicle available (not the emergency vehicle) for transport to nearby facilities.
- Conduct site entry monitoring using the HNu, explosimeter/ O_2 detector and Rad mini.

H. WORK LIMITATIONS: (Time of day, etc.)

- No eating, drinking, or smoking onsite.
- No contact lenses onsite.
- No facial hair that would interfere with respirator fit.

- Buddy system at all times in exclusion zone.
- CH2M HILL employees to wear TLD badges or equivalent at all times when on or near the site.
- Site work will be performed during daylight hours whenever possible. Any work conducted during hours of darkness will require the following minimum illumination intensity:

General Site Areas	5 foot-candles
First Aid Station/Office/Lab	30 foot-candles
Storerooms, Changehouse, Toilets, Rest Areas	10 foot-candles

- Motors used in the exclusion zone will be non-sparking electrical motors or equipped with spark arrestors.
- Fuel supplies will be properly stored and grounded.

I. DECONTAMINATION PROCEDURES:

Set up decontamination area upwind of the exclusion zone. Water and TSP detergent should be placed in buckets prior to beginning work. The decontamination area should be a sufficient distance from the work in the exclusion zone so that the decon area will not become contaminated by splashing water or flying dirt.

Personnel Decontamination Procedures:

Wash boots and outer gloves in detergent and water, rinse, and remove outer gloves; remove and bag coveralls; if cotton coveralls are used, bag in plastic bags and wash prior to rewearing; remove respirator, if worn; remove surgical gloves and dispose in a plastic trash bag; wash hands and face; sanitize respirator nightly, if used; take a shower and wash hair as soon as possible after leaving the site.

Equipment Needed:

Buckets, detergent, cleaner-sanitizer, brushed, garbage bags, hand soap, and paper towels.

For Sampling Equipment:

Follow procedures outlined in sampling plan.

For Heavy Equipment:

Wash off the bucket of the backhoe or the drilling equipment with detergent and water; rinse in water. Use the hNu to monitor the backhoe or drilling equipment. If hNu readings are detected from the equipment, steam clean it prior to removing it from the site.

Documentation:

It is the responsibility of the SSC to make sure that all equipment coming offsite is properly decontaminated according to the procedures outlined above. At a minimum, visual indication of contamination will be removed, and no organic vapors detectable above background should remain. The equipment and samples will be clean, dry, and free from stains, deposits, encrustations, or discoloration. Documentation of decontamination must be made in the field log notebook, which will bec ome part of the permanent project file. A suitable tag is to be placed on each piece of decontaminated CH2M HILL equipment (or group of equipment, such as a bag of hand tools) stating the date of decontamination and initialed by the SSC.

J. MATERIAL HANDLING PROCEDURES:

The following general material handling procedures apply:

- Drums and containers meeting the appropriate DOT, OSHA, and EPA regulations for the waste contents (e.g., decon water) will be used.
- Site operations will be organized to minimize the amount of drum or container movement.
- DOT salvage drums and suitable quantities of absorbent will be available and used on sites where hazardous waste spills could occur.
- Electrically powered material handling equipment used to transfer decon solutions will meet the requirements of 29 CFR 1910.307 for the classification of materials being handled.

Disposal of Materials Generated During Field Work:

- Material generated during field work (decontamination fluids, disposable protective gear or sampling devices, drilling cuttings, well development fluids, etc.) will be considered as contaminated and handled accordingly unless adequate monitoring or analytical data exists to properly classify the materials as non-hazardous.

- Material generated offsite (well drilling fluids, etc.) will be returned to the site unless otherwise specified by the site owner or responsible party.

- Ultimate responsibility for disposal of the material rests with the site owner or responsible party. CH2M HILL may coordinate analysis, packaging, storage, transport and disposal of waste material, but will not assume responsibility for the waste (i.e., sign manifests as generator, etc.). Prior to beginning field work, the waste handling procedures will be agreed to with the client, site owner, and / or responsible party.

- Laboratory samples will be returned to the site, client, site owner, or responsible party for disposal following analysis unless otherwise specified.

VI. EMERGENCY RESPONSE PLAN

A. Pre-Emergency Planning:

The SSC is to perform the following pre-emergency planning tasks before starting field activities and will coordinate emergency response with the operating facility when appropriate:

- Locate nearest telephone to the site and inspect onsite communications (air horns, two-way radios).

- Confirm and post emergency telephone numbers (Form 311) and route to hospital.

- Post site map marked with locations of emergency equipment and supplies.

- Review emergency response plan for applicability to any changed site conditions, alterations in onsite operations, or personnel availability.

- Drive route to hospital.

- Evaluate capabilities of local response teams.

- Where appropriate and acceptable to the client, inform emergen cy room / ambulance service and emergency response teams of anticipated types of site emergencies.

- Designate one vehicle as the emergency vehicle; place hospital directions and map inside; keep keys in ignition during field activities.

- Inventory and check-out site emergency equipment and supplies.

- Setup emergency personnel decontamination station(s).

B. <u>Personnel Roles and Lines of Authority</u>:

The SSC takes the lead in emergencies. The SSC has the authority to stop any site activities posing an immediate health and safety hazard to site personnel and must notify the Project Manager or designee as soon as practical of this action. The Project Manager is ultimately responsibl e for health and safety of the CH2M HILL workers.

C. <u>Training</u>:

At least two personnel currently certified in both first-aid and CPR will be present during field activities within the exclusion zone. The site's Emergency Response plan will be reviewed in the initial site safety briefing and will include:

- Emergency procedures for personnel injury, or suspected overexp osures, fires, explosions, chemical, and vapor releases.

- Location of onsite emergency equipment and supplies of clean water.

- Local emergency contacts, hospital routes, evacuation routes, and assembly points.

- Site communication and location of nearest phone to the site.

- Names of onsite personnel trained in first aid and CPR.

- Notification procedures for contacting CH2M HILL's medical consultant and team member's occupational physician.

- The emergency response plan will be rehearsed at least once before site activities begin, and periodically afterwards.

- New workers on the site will be briefed on the emergency response plan before entering the exclusion zone.

D. Communications:

The "buddy system" will be enforced for field activities involving potential exposure to hazardous, toxic or radioactive materials, and during any work within the exclusion zone. Each person will observe his/her partner for symptoms of chemical overexposures or heat stress and provide emergency assistance when warranted. Personnel working in the exclusion zone will maintain line of sight contact or maintain communications (e.g., two-way radios) with the site support facilities. Offsite communications will consist of either onsite telephone service or using the nearest telephone to the site.

E. Emergency Signals:

The following emergency signals shall be used:

Grasping throat with hand	Emergency--help me
Thumbs up	OK; understood
Grasping buddy's wrist	Leave site now
2 short blasts or sounds, repeated	All clear
Continual sounding of horn	Emergency--leave site

F. PPE and Emergency Equipment and Supplies:

The following emergency equipment and supplies will be available onsite with the locations marked on the site map and posted in the support zone:

- 20-lb ABC fire extinguisher(s)
- First-aid kit
- Stretcher or blanket
- Supplies of clean water
- Eye wash
- Deluge shower (when required for emergency decon)
- PPE (protective clothing, boots, and gloves)
- Air monitoring equipment

G. Emergency Recognition and Prevention:

Prevention of emergencies will be aided by the effective implementation of the health and safety procedures specified in this SSP. The initial site safety briefing will emphasize recognition of the types of emergencies anticipated onsite. Periodic safety briefings will be conducted by the SSC as field activities proceed. Hazards that warrant specific emergency recognition and prevention techniques will be discussed.

H. Site Security and Control:

(Note to preparer: Identify, locate, and describe road and approaches to site, security measures such as fencing and guards, flagging or other means of marking zones, and access control procedures, such as sign-in logs, access control points, etc.)

I. Emergency Medical Treatment and First-Aid:

- Prevent further injury, perform appropriate decontamination, and notify the SSC and the Project Manager.
- Initiate first aid and get medical attention for the injured immediately.
- Depending upon the type and severity of the injury, call the medical consultant and/or occupational physician.
- Notify the Health and Safety Manager.
- Notify the injured person's personnel office.
- Notify the client representative.
- Prepare an incident report. The SSC is responsible for preparing and submitting the report to the Director of Health and Safety and to the CH2M HILL corporate personnel office within 48 hours.
- The SSC will assume charge during a medical emergency.

J. <u>Emergency Routes and Telephone Numbers (Map to be Posted)</u>

	<u>Building 123</u>
Duty Officer	32751 (on base) 916/643-2751 (of base)
Police	112 (on base) 916/643-6168 (off base)
Fire	117 (on base) 916/643-5622 (off base)
Emergency Assistance	116 (on base)
Ambulance	116 (on base)
Site Contact	916/643-3675--Charles Miles
Utilities	34875 (on base) 916/643-4875 (off base)
McClellan Clinic	35420 (on base) 916/646-8420 Urgent Care Hours: 0730 to 1900
General Hospital	American River Hospital 4747 Engle Road. Carmichael, CA 95608 916/848-2100
Directions to Hospital	Exist McClellan Air Force Base through the main gate to Watt Avenue. Turn right onto Watt Avenue and travel south to Whitney Avenue. Turn left onto Whitney Avenue and travel east to Mission Avenue. Turn left onto Mission Avenue and travel north to Engle Road. Turn right (east)onto Engle Road. Hospital is at 4747 Engle Road. (See attached map.)
CHEMTREC	800/424-9300
TOSCA Hotline	202/554-1404
CDC	404/452-4100
National Response Center	800/424-8802
EPA ERT Emergency	201/321-6660
RCRA Hotline	800/424-9346

K. <u>Emergency Decontamination</u>: Personnel will be decontaminated to the extent feasible (usually a "gross decon" or deluge) but life saving and first-aid procedures take priority over personnel decontamination efforts. The personnel decontamination procedures specified in Section V.J of this SSP will apply for injuries deemed non-life threatening by the SSC.

L. <u>Evacuation Routes and Procedures</u>: Onsite evacuation routes will be designated. Personnel will exit the site exclusion zone / contamination reduction zone and assemble at the onsite assembly point in the support zone. The SSC will account for personnel at the onsite assembly point and notify local emergency responders. The SSC will assess the need for site evacuation based on the degree of hazard posed to site personnel remaining in the support zone. Offsite evacuation routes and assembly points will also be designated. A person designated by the SSC will account for personnel at the offsite assembly point. The SSC and an assistant will remain onsite in the event of site evacuation (if feasible) to assist local responders and advise them on the nature and location of the incident.

Onsite and offsite evacuation routes / assembly points will be designated on the site map and posted. They will be based on site topography and layout; anticipated safe distances for places of refuge; prevailing weather conditions; and anticipated location magnitude of site emergencies. Wind flags will be installed in the exclusion and support zones to assist personnel in determining upwind evacuation routes.

Evacuation Routes (Onsite and Offsite): Evacuation routes will be dependent on the type of accident and wind direction. MAFB has first and second responders to handle evacuations (see Section II, A).

Assembly Points (Onsite and Offsite): Assembly points vary by building and areas. Therefore, it will be the responsibility of the SSC to determine the assembly point for each location from the appropriate base representative.

M. Critique of Response and Follow-up: The SSC will evaluate the effectiveness of the emergency response and recommend procedures for improving emergency response to the SSP approver. Follow-up activities include notification of the injured person's personnel office within 24 hours of the injury. Incidents of suspected overexposures will require the notification of CH2M HILL's medical consultant and the injured's occupational physician so that they may provide assistance and relevant information to the local hospital's emergency room physician.

VI. EMERGENCY CONTACTS

- CH2M HILL Medical Consultant

Name:	Dr. Kenneth Chase, Washington Occupational Health Associates, Inc.
Phone:	202/463-6698 (8-5 EST) 202/463-6440 (after hours answering service; physician will return call within 30 minutes)

- CH2M HILL Health and Safety Manager

  Name: David Lincoln/SEA
  Phone: 206/453-5005

- District Health and Safety Officer (HSO)

  Name: Lynn Laszewski/SEA
  Phone: 206/453-5005

- Occupational Physician

  Name: Dr. Allen Krohn
  Phone: 916/246-7464
  Address: Redding Industrial Occupational health Center
  1920 California Street
  Redding, California 96001

- Occupational Physician

  Name: Health Check
  Ralph K. Davis Medical Center
  Phone: 415/565-6000
  Address: Castro and Duboce Street
  San Francisco, California 94114

- Occupational Physician

  Name: Drs. Robinson, Webb, Strong, Yates
  Phone: 205/262-0342; 205/262-0390
  Address: 1722 Pine Street, Suite 309
  Montgomery, Alabama 36194-2701

- CH2M HILL Project Manager

  Name: Starr Dehn/SAC
  Phone: 916/920-0300

- Client Contact

  Name: Larry Button/Charlie Thorpe
  Phone: 916/643-1250

- CH2M HILL Regional Manager

  Name: Steve DeCou
  Phone: 916/920-0300

- Personnel Office

  Name: Scott Olsen
  Phone: 916/920-0300

If an injury occurs, notify the injured person's personnel office as soon as possible after obtaining medical attention for the injured. Notification MUST be made within 24 hours of the injury.

- CH2M HILL Director of Health and Safety for Waste Management and Industrial Processes

  Name: David Lincoln
  Phone: 206/453-5005
  Address:

- CH2M HILL Corporate Personnel Office

  Name: Marie Haezenbrouck/DEN
  Phone: 303/771-0900 (O)
  Address: CH2M HILL
  6060 South Willow
  Englewood, CO 80111

VIII. PLAN APPROVAL

This site safety plan has been written for the use of CH2M HILL's employees and subcontractors. CH2M HILL claims no responsibility for its use by others. The plan is written for the specific site conditions, purposes, dates, and personnel specified and must be amended if these conditions change.

PLAN PREPARED BY: Robert Evangelista (name/office/home phone) Date: 4/24/90

APPROVED BY: Jane Stansfield (name/office/home phone) Date: 4/27/90

APPROVED BY: ______________ (name/office/home phone) Date: ______________

(Note to Preparer: SSPs for sites where the potential exists for exposure to ionizing radiation require the approval of the Radiation Health Officer.)

MODIFIED BY:	Karla Ebert/SAC	Date:	10/24/91
MODIFICATIONS APPROVED BY:	Jayne Stansfield/DEN	Date:	10/24/91

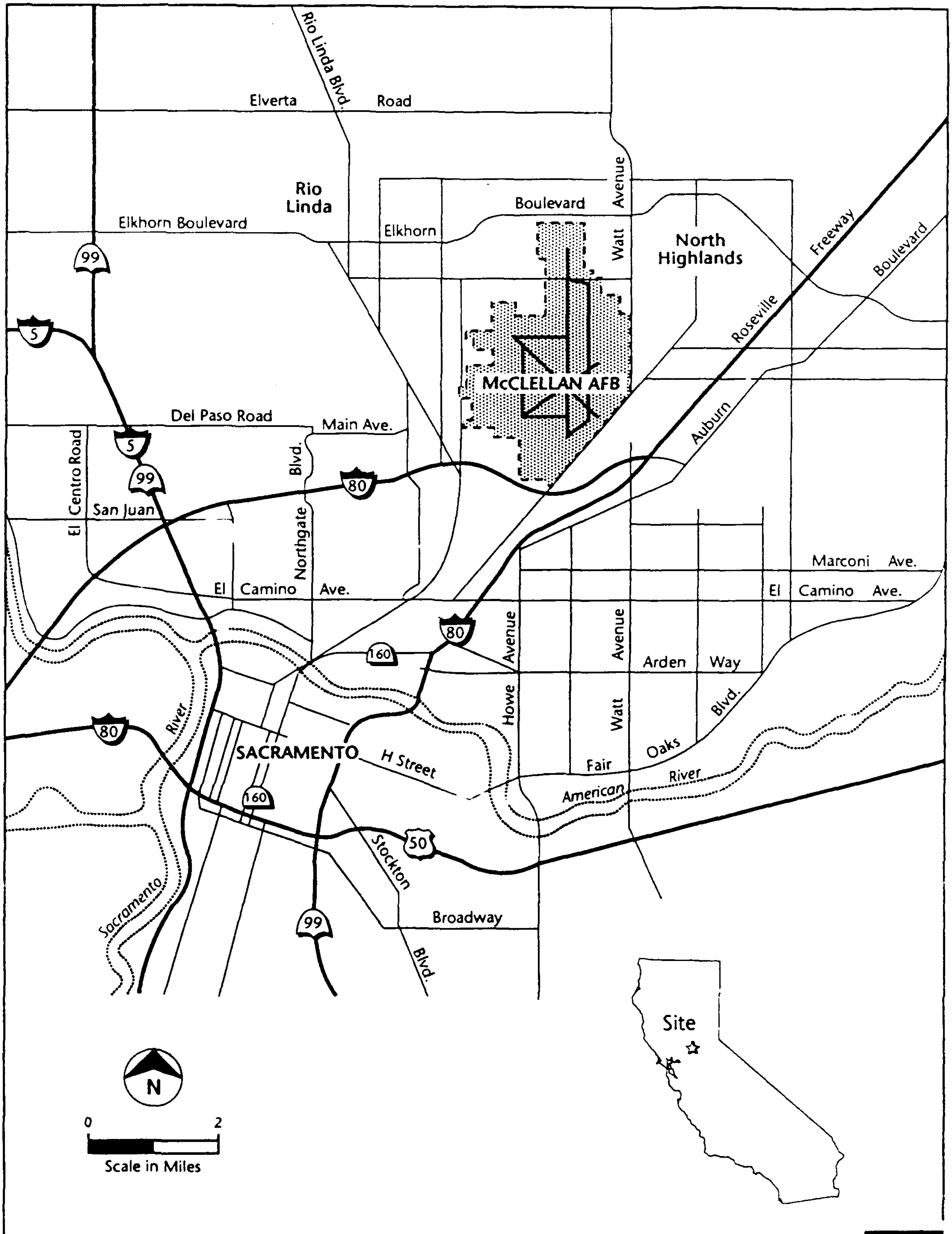
Attachments:

- Site Map
- Form 311, Emergency Phone Numbers
- Form 533, Record of Hazardous Waste Field Activity
- MSDS where applicable
- Attachment A--Descriptions of Planned Activities
- Attachment B--Heat Stress/Cold Stress Hazards
- Attachment C--Health and Safety Site Meeting
- Site Safety Plan Addendum

Distribution of approved plan:

Project Manager (responsible for distribution to team members and client)
Health and Safety Manager

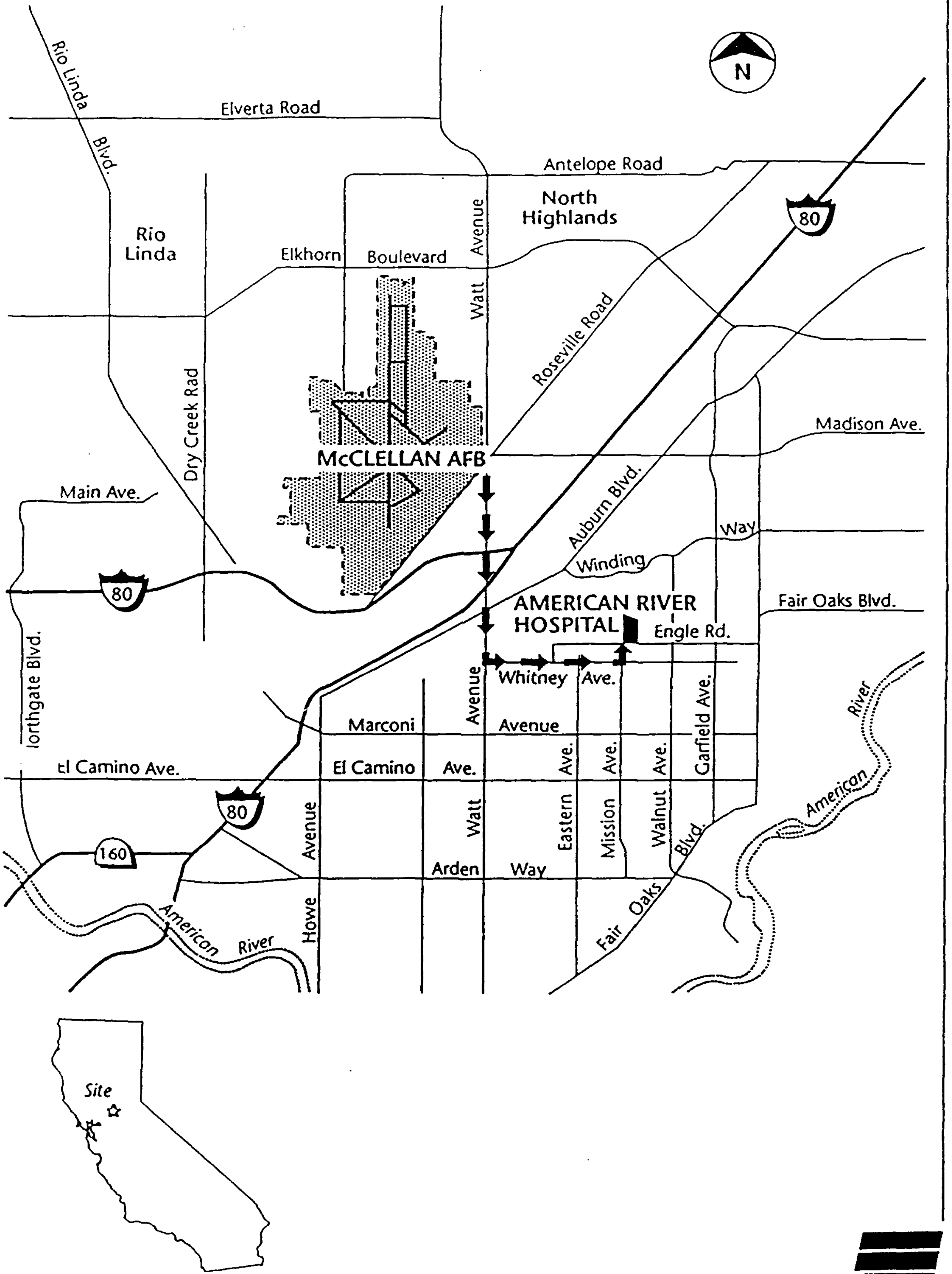
SAC28722 13.02 Location Map 01-17-91alo



Location of McClellan AFB

CH2M HILL

SAC28722.03.02 Route to Hospital 02-20-91sfo



Route to American River Hospital

FORM 311
EMERGENCY TELEPHONE NUMBERS

Police Department	Address:	Phone: Contact:
Fire Department	Address:	Phone: Contact:
Paramedic	Address:	Phone: Contact:
Fire Report	Address:	Phone: Contact:
Ambulance Service	Address:	Phone: Contact:
Water Department	Address:	Phone: Contact:
Gas Utility	Address:	Phone: Contact:
Electric Utility	Address:	Phone: Contact:
Telephone Utility	Address:	Phone: Contact:
Hospital	Address:	Phone: Contact:
Owner	Address:	Phone: Contact:

This notice is located at : ______________________________

FORM 533

RECORD OF HAZARDOUS WASTE FIELD ACTIVITY

SITE NAME:
SITE SAFETY COORDINATOR:
PROJECT NUMBER:
RECORD OF ACTIVITIES FOR (DATES):

EMPLOYEE NAME / NUMBER	TOTAL DAYS ONSITE	DAYS IN LEVEL B	DAYS IN LEVEL C	DAYS IN LEVEL D	DAYS AS SSC LEVEL B	DAYS AS SSC LEVEL C	DAYS AS SSC LEVEL D	ACTIVITIES PERFORMED

Attachment A
DESCRIPTION OF PLANNED ACTIVITIES

This Description of Planned Activities encompasses a broad range of possible tasks to be issued as task orders against contract No. F04699-90-D-0035. This section defines the range of tasks CH2M HILL shall be responsible to perform as per Section 4.0 (Technical Requirements) of the above contract.

•Conduct field sampling of drums, spill sites, tanks (above and underground), monitoring wells, past waste disposal sites, etc., and perform sample characterization studies to include analysis of a wide variety of contaminants in complex matrices, including up to 297 compounds listed as hazardous by EPA.

•Perform laboratory and field tests of environmental monitoring and testing equipment, to include validation of manual/instrumental methods, continuous monitors, analytical support and Mathematical models using EPA, ASTM, NR, and/or equivalent procedures specified by the Air Force.

•Perform photogrammetric analyses of environmental and infrared photographs.

•Perform geophysical studies to include, but not be limited to, studies involving magnetometer, metal detection, earth resistivity, terrain conductivity, seismic, gravity, ground penetrating radar and shallow (less than 400 feet, in most cases) borehole logging.

•Perform hydrogeological investigations to determine the magnitude and extent of groundwater contamination.

•Determine the direction and rate of movement of contaminants and estimate the degree of risk associated with contaminant migration.

•Develop methods to mitigate the adverse environmental effects of pollutant migration.

•Develop leachate monitoring and analysis programs to comply with state or EPA regulations required for landfills and other hazardous waste treatment and disposal sites which are currently operated or have been operated in the past by the U.S. Air Force.

•Perform onsite geological/hydrological investigations required to assist the Air Force in selecting proper locations for new solid/hazardous waste treatment, storage, or disposal sites or other facilities.

•Perform sampling of soil and water in the unsaturated (vadose) zone above the water table using techniques recommended by the National Water Well Association (NWWA).

•Perform aquifer tests to determine the porosity, permeability, specific yield, drawdown and extent of cones of depression developed in aquifers in which contamination has been found or is suspected.

•Conduct comprehensive water supply and water distribution studies.

•Perform evaluations of domestic water, industrial wastewater, domestic wastewater, and groundwater treatment plants.

•Perform water and wastewater characterization, to include ambient short-term and continues water monitoring.

•Conduct inflow/infiltration studies into industrial, reclamation and groundwater extract/treatment systems at McClellan AFB and its Satellite Locations.

•Perform treatability studies, pilot plant investigations, and toxicity and bioassay determinations.

•Prepare evaluations and analyses providing sufficient detail to allow development of National Pollutant Discharge Elimination Systems (NPDES) permit applications, certifications and discharge monitoring reports.

•Conduct instream biological monitoring and fish-kill investigations.

•Perform laboratory analyses of potable water, groundwater, wastewater, soil. sludges, biologicals, fuels or commercial products and other environmental samples.

•Perform studies to ensure personnel safety, including the use of explosimeters, gas detectors, and survey meters and other equipment necessary to monitor air quality during site operations.

•Prepare evaluations and analyses, providing sufficient details to aid development of state or EPA-mandated permit applications, certifications, discharge monitoring reports and groundwater monitoring reports.

•Perform necessary analyses and reduction of any physical/chemical samples or data acquired under activities outlined herein.

•Provide analytical results in both hard copy and other formats suitable for archiving, including computer format.

•When required and specified in the delivery order, prepare sites for sampling/ monitoring and restore sites upon completion of work.

•Identify, evaluate, design and prototype processes, equipment, and facilities which minimize the generation of hazardous wastes or improve environmental quality.

•Develop permits and various applications as required by the guidance documents.

•Conduct Community Relations Program requirements in accordance with SARA.

•Prepare Site-Specific Spill Plans, maintain and reviewed annually in accordance with Air Force policy, guidance and directives.

•Develop Base Spill Prevention and Response Plans.

•Conduct quarterly review of regulatory requirements regarding the Resource Conservation and Recovery Act (RCRA), the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), and the Superfund amendments and on-going RCRA and CERCLA/SARA Programs and other background documents as required.

•Prepare Statements of Work.

•Perform waste minimization assessments and recommend process modifications that eliminate or reduce the use, generation, and disposal of hazardous materials within production process. The assessments shall include:

- Analyze the results of waste audits to identify the most promising areas for waste minimization.

- Identify, devise, and prototype new approaches to reduce and minimize hazardous wastes through process modification of emission/effluent control.

- Investigate process technology and develop conceptual system designs to prevent and reduce industrial pollution and hazardous waste generation.

- Determine the environmental consequences of present and proposed environmental regulations of any recommended process or equipment changes.

- Recommend control technology for toxics and pollutants to address recovery/recycle and reduction, optimization treatment (chemical and biological), onsite treatment, and substitution with less toxic/hazardous materials.

- Prepare detailed drawing packages, plans, and designs for waste minimization pilot projects relative to equipment design and modifications including charts, graphs, return on investments, and cost estimates.

- Document, evaluate, and integrate the results of pilot projects in ongoing industrial processes operations through process modifications or prototype development.

•Conduct and administer the Hazardous Waste Training Program to Base employees including requirements under 29 CFR 1910.120.

•Conduct Underground Storage Tank Annual Precision Leak Testing.

•Conduct Environmental Audit Assessment of base facilities and operation in accordance with Air Force and SM-ALC/EM policy, guidance, and directives.

•Perform Inspection Services and Construction Management for Environmental Investigations, construction Project or Remedial Action Implementation.

•Develop and maintain a computer data base for tracking hazardous waste generator/management data and all delivery order project information.

•Maintain an inventory of McClellan Air permits. Develop tracking system to monitor environmental compliance. This inventory and tracking system will be maintained in a microcomputer within the Directorate of Environmental Management.

•Provide engineering and services to operate and maintain interim Remedial Measures and Remedial Actions implemented by McClellan AFB in accordance with CERCLA/SARA. This includes the McClellan Groundwater and Treatment Plant and existing and future groundwater extractor systems. Operation and maintenance shall be conducted in accordance with existing procedures.

•Prepare Environmental Assessments for proposed Air Force activities in water usage, wastewater discharge, solid waste disposal, hazardous waste cleanup, and contaminated groundwater cleanup.

•Document performance of existing and future McClellan water, wastewater, solid waste, and groundwater treatment facilities (including groundwater extraction systems) to include performance evaluations of individual unit processes within a treatment facility.

•Prepare comprehensive studies to determine potable water supply, storage and distribution requirements for McClellan AFB and its Satellite Locations.

Attachment B
HEAT STRESS/COLD STRESS HAZARDS

Heat Stress

Wearing PPE puts a hazardous waste worker at considerable risk of developing heat stress. This can result in health effects ranging from transient heat fatigue to serious illness or death. Heat stress is caused by a number of interacting factors, including environmental conditions, clothing, workload, and the individual characteristics of the worker. Because heat stress is probably one of the most common (and potentially serious) illnesses at hazardous waste sites, regular monitoring and other preventive precautions are vital.

Monitoring Heat Stress. Because the incidence of heat stress depends on a variety of factors, all workers, even those not wearing protective equipment, should be monitored.

Workers wearing semipermeable or impermeable protective clothing should be monitored when the temperature in the work area is above 70°F (21°C).

To monitor the worker, measure:

- Heart Rate--Count the radial pulse during a 30-second period as early as possible in the rest period.
  - If the heart rate exceeds 110 beats per minute at the beginning of the rest period, shorten the next work cycle by one-third and keep the rest period the same.
  - If the heart rate still exceeds 110 beats per minute at the next rest period, shorten the following work cycle by one-third.
- Oral temperature--Use a clinical thermometer (3 minutes under the tongue) or similar device to measure the oral temperature at the end of the work period (before drinking).
  - If oral temperature exceeds 99.6°F (37°C), shorten the next work cycle by one-third without changing the rest period.
  - If oral temperature still exceeds 99.6°F (37.6°C) at the beginning of the next rest period, shorten the following work cycle by one-third.
  - Do not permit a worker to wear a semipermeable or impermeable garment when his/her oral temperature exceeds 100.6°F (38.1°C).

- Body water loss, if possible. Measure weight on a scale accurate to ±0.25 lb at the beginning and end of each work day to see if enough fluids are being taken to prevent dehydration. Weights should be taken while the employee wears similar clothing or, ideally, is nude. The body water loss should not exceed 1.5 percent total body weight loss in a work day.

Initially, the frequency of physiological monitoring depends on the air temperature adjusted for solar radiation and the level of physical work (see Table 1). The length of the work cycle will be governed by the frequency of the required physiological monitoring.

Table 1
SUGGESTED FREQUENCY OF PHYSIOLOGICAL MONITORING FOR FIT AND ACCLIMATIZED WORKERS[a]

Adjusted Temperature[b]	Normal Work Ensemble[c]	Impermeable Ensemble
90°F (32.2°C) or above	After each 45 minutes of work	After each 15 minutes of work
87.5°-90°F (30.8°C-32.2°C)	After each 60 minutes of work	After each 30 minutes of work
77.5°-82.5°F (25.3°-28.1°C)	After each 120 minutes of work	After each 90 minutes of work
72.5°-77.5°F (22.5°-25.3°C)	After each 150 minutes of work	After each 120 minutes of work

[a]For work levels of 250 kilocalories/hour.
[b]Calculate the adjusted air temperature (ta adj) by using this equation: ta adj °F = ta °F + (13 x % sunshine). Measure air temperature (ta) with a standard mercury-in-glass thermometer, with the bulb shielded from radiant heat. Estimate percent sunshine by judging what percent time the sun is not covered by clouds that are thick enough to produce a shadow. (100 percent sunshine = no cloud cover and a sharp, distinct shadow; 0 percent sunshine = no shadows.)
[c]A normal working ensemble consists of cotton coveralls or other cotton clothing with long sleeves and pants.

Prevention of Heat Stress. Proper training and preventive measures will help avert serious illness and loss of work productivity. Preventing heat stress is particularly important because once someone suffers from heat stroke or heat exhaustion, that person may be predisposed to additional heat injuries. To avoid heat stress, management should take the following steps:

- Adjust work schedules:
  - Modify work/rest schedules according to monitoring requirements
  - Mandate work slowdowns as needed
  - Rotate personnel: alternate job functions to minimize overstress or overexertion at one task

- Add additional personnel to work teams.

- Perform work during coolers hours of the day if possible or at night if adequate lighting can be provided.

- Provide shelter (air-conditioned, if possible) or shaded areas to protect personnel during rest periods.

- Maintain workers' body fluids at normal levels. This is necessary to ensure that the cardiovascular system functions adequately. Daily fluid intake must approximately equal the amount of water lost in sweat, i.e., 8 fluid ounces (0.23 liters) of water must be ingested for approximately every 8 ounces (0.32 kg) of weight lost. The normal third mechanism is not sensitive enough to ensure that enough water will be drunk to replace lost sweat. When heavy sweating occurs, encourage the worker to drink more. The following strategies may be useful:

  - Maintain water temperature at 50° to 60°F (10° to 15.6°C).

  - Provide small disposable cups that hold about 4 ounces (0.1 liter).

  - Have workers drink 16 ounces (0.5 liters) of fluid (preferably water or dilute drinks) before beginning work.

  - Urge workers to drink a cup or two every 15 to 20 minutes, or at each monitoring break. A total of 1 to 1.6 gallons (4 to 6 liters) of fluid per day are recommended, but more may be necessary to maintain body weight.

  - Weigh workers before and after work to determine if fluid replacement is adequate.

- Encourage workers to maintain an optimal level of physical fitness:

  - Where indicated, acclimatize workers to site work conditions: temperatures, protective clothing, and workload.

  - Urge workers to maintain normal weight levels.

- Provide cooling devices to aid natural body heat exchange during prolonged work or severe heat exposure. Cooling devices include:

  - Field showers or hose-down areas to reduce body temperature and/or to cool off protective clothing.

  - Cooling jackets, vests, or suits.

- Train workers to recognize and treat heat stress. As part of training, identify the signs and symptoms of heat stress (see Table 2).

Table 2 SIGNS AND SYMPTOMS OF HEAT STRESS
• Heat rash may result from continuous exposure to heat or humid air
• Heat cramps are caused by heavy sweating with inadequate electrolyte replacement. Signs and symptoms include: - Muscle spasms - Pain in the hands, feet, and abdomen
• Heat exhaustion occurs from increased stress on various body organs including inadequate blood circulation due to cardiovascular insufficiency or dehydration. Signs and symptoms include: - Pale, cool, moist skin - Heavy sweating - Dizziness - Nausea - Fainting
• Heat stroke is the most serious form of heat stress. Temperature regulation fails and the body temperature rises to critical levels. Immediate action must be taken to cool the body before serious injury and death occur. Competent medical help must be obtained. Signs and symptoms are: - Red, hot, usually dry skin - Lack of or reduced perspiration - Nausea - Dizziness and confusion - Strong, rapid pulse - Coma

Cold Stress

Although northern California is not prone to bitter-cold temperatures, cold stress may still be a potential problem. Cold stress is possible when work performed over water is at temperatures of 50°F or less. The ultimate effects of cold stress is hypothermia, which is a decrease in the deep core body temperature. At temperatures of 35°F, workers in water, or whose clothing becomes wet, should be provided with an immediate change of clothing. They may need to be treated for hypothermia. Workers who wear impermeable protective clothing are susceptible to chilling because their cotton underclothing may become wet with perspiration.

Windchill index. The windchill factor is the cooling effect of any combination of temperature and wind velocity of air movement. The windchill index is shown in Table 3. The windchill index does not take into account that part of the body which is exposed to cold, the level of activity and its effect on body heat production, and the amount of clothing being worn.

Table 3
WINDCHILL INDEX

	ACTUAL THERMOMETER READING (F)									
Wind speed in mph	50	40	30	20	10	0	-10	-20	-30	-40
	EQUIVALENT TEMPERATURE (F)									
calm	50	40	30	20	10	0	-10	-20	-30	-40
5	48	37	27	16	6	-5	-15	-26	-36	-47
10	40	28	16	4	-9	-21	-33	-46	-58	-70
15	36	22	9	-5	-18	-36	-45	-58	-72	-85
20	32	18	4	-10	-25	-39	-53	-67	-82	-96
25	30	16	0	-15	-29	-44	-59	-74	-88	-104
30	28	13	-2	-18	-33	-48	-63	-79	-94	-109
35	27	11	-4	-20	-35	-49	-67	-82	-98	-113
40	26	10	-6	-21	-37	-53	-69	-85	-100	-116
Over 40 mph (little added effect)	LITTLE DANGER (for properly clothed person)				INCREASING DANGER (danger from freezing of exposed flesh)			GREAT DANGER (Danger from freezing of exposed flesh)		

Note: The human body senses "cold" as a result of both the air temperature and the wind velocity. Cooling of exposed flesh increases rapidly as the wind velocity goes up. Frostbite can occur at relatively mind temperatures if wind penetrates the body insulation. For example, when the actual air temperature of the wind is 40°F (4.4°C) and its velocity is 30 mph (48 km/h), the exposed skin would perceive this situation as an equivalent still air temperature of 13°F (-11°C).

Attachment C
HEALTH AND SAFETY SITE MEETING

We the undersigned have read this Site Safety Plan and fully understand its contents and will adhere to procedures set forth in this document.

Name	Affiliation	Title	Date

CH2M HILL Site Safety Plan
Addendum for Well Abandonment-Phase II
Addendum for field activities and site personnel
Addendum should be accompanied by the MAFB Master Site Safety Plan

McClellan Air Force Base
Sacramento, California

Client: McClellan Air Force Base
Project No.: SAC28722.31
Project Manager: Chuck Elliott
Site Name: McClellan Air Force Base
Dates of Field Visit: January through December, 1992

Purpose of Field Visit: During this phase of the project, CH2M HILL personnel will supervise subcontractors in the decommissioning of five base wells (BW-7, BW-13, BW-17, BW-20, and BW-28), two laundry wells (LW-1 and LW-2), and two seismic wells. CH2M HILL personnel will also supervise subcontractors in the modification to BW-8. Decommissioning involves the following tasks: pull existing pumps from the wells, bail waste oil from the wells, perform downhole television surveys, perforate the casing, and inject cement grout under pressure to fill the well from bottom to top.

Hazard Evaluation: Onsite activities involve potential hazards of heat stress; vehicular traffic on roadways; and a slight possibility of exposure to the bacteria that causes Lyme disease through contact with the rabbit population in the area.

Well abandonment activities pose safety hazards to personnel in the immediate vicinity of heavy equipment such as the drill rig and cement mixers. To protect personnel from overhead falling objects (i.e., bolts, wrenches, pieces of pipe), hard hats must be worn in the immediate vicinity of the drill rig. Safety glasses are also required to protect against flying projectiles that could be caused by hammering fittings/connections and driving casing. Drilling activities near overhead electrical lines will be avoided. The drill rig mast shall remain as far as practical from all overhead utility lines. Continuous monitoring with an HNu will be performed to identify potential inhalation hazards.

A summary of hazards from chemical constituents found at one or more of the well sites is presented below.

Chlorinated Solvents: Possible low levels of chlorinated compounds may be encountered in groundwater from the well. The primary avenue of exposure is inhalation and dermal contact. Some of these compounds act as central nervous system depressants that produce visual disturbances, mental confusion, fatigue, and nausea. The OSHA PELs for chlorinated solvents can be as low as 1 ppm, depending on the solvent.

Metals: Heavy metals typically have a high affinity for soil particles, creating potential for both inhalation and dermal contact from dust created during drilling operations. Metals are absorbed in the bloodstream and produce fever, dizziness, mental confusion, and nausea. The OSHA PELs for several heavy metals are: arsenic 0.5 mg/m^3, cadmium 0.2 mg/m^3, lead 50 micrograms per cubic meter (ug/m^3), antimony 0.5 mg/m^3, and barium 0.5 mg/m^3.

Solvents and Paints: Organic chemicals in general act as anesthetics and irritants to the eyes, respiratory system, and skin. Eye contact may cause irritation, dermatitis, cell damage, and necrosis. Chronic toxicities include kidney, liver, heart, and lung damage. The OSHA PELs for common solvents and paint constituents are: toluene 100 ppm, xylene 100 ppm, acetone 750 ppm, and benzene 1 ppm.

During Phase I of this project, the Explosimeter, the Rad-mini and the HNU were used for monitoring purposes. The only "hits" were observed on the HNU when monitoring inside the well.

Site Personnel:

Team Member	Responsibility
Chuck Elliott	SSC Level C
Rob Pexton	Field Scientist
Chuck Ouellette	Field Engineer
Suzanne Davis	Field Engineer
Karla Ebert	Field Scientist

Level of Protection:

A ______ **B** ______ **C** __X__ **D** __X__

Poly coated Tyvek coveralls with nitrile outer gloves and latex inner gloves will be worn when splash protection is needed. Nitrile outer gloves and latex inner gloves will be worn during sampling and when handling samples. Safety glasses, hard hat, and neoprene steel toe/shank boots will be worn while onsite. A TLD or equivalent badge must be worn by all team members.

Monitoring Equipment: The HNU with the 11.7 eV lamp will be used at the site for monitoring purposes. The 11.7 eV lamp will be used because many of the chlorinated solvents have ionization potentials above 10.2 and are therefore not detected by the 10.2 eV bulb. Readings will be recorded every half hour. Continuous monitoring will occur while drilling or performing intrusive activities. The following action levels will be used:

Reading	Action
0-1 ppm	Level D; Continue Monitoring
1-5 ppm	Level C; Full facepiece respirator with GMC-H Cartridges. Continue Monitoring.
>5 ppm	Call Safety Plan Approver

Equipment will be calibrated offsite and upwind before the start of daily activities. Reading will be taken in the breathing zone over a 5-minute period.

Personal Restrictions: The cementers are not 40-hour health and safety trained for hazardous waste work. Because they do not have the appropriate training, they will not be allowed to work within the exclusion zone. The cementers will set up their operations at least 25 feet upwind from the well head and will not enter the exclusion zone at any time. A 25-foot radius circle will be established as the exclusion zone around each well. It will be delineated with flagging tape, cones, and barricades. It is the responsibility of the SSC to enforce the policy that non-trained personnel will remain outside this zone.

Any equipment that is used in the exclusion zone must be decontaminated prior to the cementers handling the equipment.

Addendum Written By: Karla Ebert/SAC

Date: 12/3/91

Addendum Approved By: Allen Macenski/LAO

Date: 12/3/91

7N/5E·1N1 — 1N1 —

USGS-CAL-T1
May 1948

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
WATER RESOURCES BRANCH

No. 9/5E-1M1

Other Nos. 24.9

WELL LOG

State Calif. County Sacramento Subarea Arcade

Owner McClellan Field Well 1

Location 1550 feet north, 4650 feet west of SE corner of section 1 (USGS-FK)

Drilled by Eaton Address Woodland

Date April 1937 Casing diam. 24" Land-surf. alt. 74

Source of data U.S.Army - Mr. Knapton

(Enter type of well, perforations, yield, and drawdown at end of log)

Correlation	Material	Thickness (feet)	Depth (feet)
	clay and hardpan		30
	sand (water)		36
	hardpan		83
	sand (water)		89
	clay, gray		133
	sand, gray packed		174
	hardpan and sandstone		232
	sand (water)		236
	hardpan		247
	sand (water)		252
	sand and gravel		266
	clay		268
	sand and gravel		294
	hardpan		311
	sand		315
	hardpan (broken by sand and gravel)		378
	sand and gravel		396
	hardpan		400

C-2

Record by FK Date 9-27-48 Sheet 1 of 1

9N/5E-1N2
-1N2-

USGS-CAL-T1
May 1948

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
WATER RESOURCES BRANCH

No. 9/5E-1N2
Other Nos. 244

WELL LOG

State Calif. County Sacramento Subarea Arcade

Owner McClellan Field Well 2

Location 2100 feet north, 4650 feet west of SE corner of section 1 (USGS) FK

Drilled by Eaton Address

Date April 1937 Casing diam. 24" Land-surf. alt. 75

Source of data U. S. Army

(Enter type of well, perforations, yield, and drawdown at end of log)

Correlation	Material	Thickness (feet)	Depth (feet)
	clay and hardpan, red sandy		33
	sand		38
	hardpan		54
	hardpan, broken		68
	hardpan		80
	sand		84
	hardpan		104
	sand		110
	clay		143
	sand		155
	hardpan		170
	clay		176
	sand		178
	hardpan		186
	sand		197
	hardpan		214
	clay		217
	clay and hardpan		276
	sand		298
	hardpan		309
	sand		315
	hardpan		342
	sand		363
	hardpan		372
	sand		405

3 Record by [illegible] Date [illegible] Sheet [illegible] of [illegible]

USGS-CAL-T1
May 1948

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
WATER RESOURCES BRANCH

— 1P1 —

No. 9/5E-1L1

Other Nos. 276

WELL LOG

State Calif. County Sacramento Subarea Arcade

Owner McClellan Field Well 8

Location 1350 feet north, 2750 feet west of SE corner of section 1 (USGS) FK

Drilled by not stated Address

Date July 1942 Casing diam. 24" Land-surf. alt. 80

Source of data U. S. Army - Mr. Knapton

(Enter type of well, perforations, yield, and drawdown at end of log)

Correlation	Material	Thickness (feet)	Depth (feet)
	fill		6
	hardpan		24
	sand		41
	clay, hard		54
	hardpan and clay		97
	clay, sandy gray		115
	sand and gravel, fine		130
	clay, sandy		159
	lava and hardpan		181
	sand and gravel		192
	hard cemented formation		198
	sand and fine gravel		224
	hard lava sand		255
	gravel, fine		261
	cemented formation, hard		269
	gravel and sand, fine		277
	cemented formation, hard		281
	cobbles and gravel		325
	sand and gravel		398
	perf; 170-398		

USGS-CAL-T1
May 1948

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
WATER RESOURCES BRANCH

No. 9/5E-11A1
Other Nos. 257

WELL LOG

State California County Sacramento Subarea Arcade Well #7

Owner War Department, Quartermaster Corp., McClellan Field, Contract 787 qm 55CIN 15 Item 3

Location

Drilled by Aulman Address

Date July 1941 Casing diam. Land-surf. alt. 70'

Source of data Driller

(Enter type of well, perforations, yield, and drawdown at end of log)

Correlation	Material	Thickness (feet)	Depth (feet)
	Red soil		3
	Hard pan		15
	Hard brittle lava sand		81
	Hard pan		93
	Hard brittle lava sand		160
	Clay, yellow		180
	Hard sand		226
	Loose sand		247
	Hard sand		256
	Fine gravel		262
	Hard lava		301
	Fine gravel		305
	Hard pan		317
	Sand and fine gravel		330
	Hard pan		336
	Sand and fine gravel		379
	Hard pan		382

C-5

Record by ok Date 9-20-48 Sheet ___ of ___

USGS-CAL-T1
May 1948

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
WATER RESOURCES BRANCH

No. 9/5E-11A2
Other Nos. 258

WELL LOG

State California County Sacramento Subarea Arcade

Owner U.S. Engineer Office McClellan Field - Rubber Conservation Bldg.

Location 4300 feet north, 900 feet west of SE corner of section 11 (USGS) FK

Drilled by Kirchgater Address

Date 1943 Casing diam. 12" Land-surf. alt. 70'

Source of data

(Enter type of well, perforations, yield, and drawdown at end of log)

Correlation	Material	Thickness (feet)	Depth (feet)
	soil		2
	hardpan		12
	sand, brown		14
	clay		38
	sand, fine		41
	clay, white		87
	clay and sand mixed		102
	sand, (Water Temp. 68°)		104
	clay, yellow		135
	clay, brick		148
	sand, muck		155
	clay, white		176
	sandstone		210
	clay, brown		245
	sand, brown heavy with mica		256
	sand, coarse and gravel fine		270
	clay, soft and sand, fine, mixed		298
	clay, white sticky		305
	W. L. 31'		
	Perf: 245-270		
	1000 GPM @ 71'		

Record by Date Sheet of

9N/5E-11E1

USGS-CAL-T1
May 1948

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
WATER RESOURCES BRANCH

No. 9/5E-11E1

Other Nos. 257

WELL LOG

State Calif. County Sacramento Subarea Arcade

Owner McClellan Field, Well 17

Location 3450 feet north, 5100 feet west of SE corner of section 11 (USGS) FK

Drilled by ____ Address ____

Date ____ Casing diam. 14" Land-surf. alt. 60'

Source of data Mr. Knapton - McClellan Field

(Enter type of well, perforations, yield, and drawdown at end of log)

Correlation	Material	Thickness (feet)	Depth (feet)
	clay, red		2
	hardpan		39
	sand		45
	clay		53
	hardpan		153
	sand, lava sand		171
	cemented hard		179
	hardpan		216
	sand and fine rock		230
	cement hard		262
	sand, lava sand		275
	hardshell		276
	hardpan		284
	find gravel		290
	hardpan		300
	fine gravel		311
	hardpan, red		376
	sand, lava		390
	hardpan, red		441
	sand, lava		463
	hardpan		507
	sand, lava		530
	hard cement		532
	fine rocks		540
	hardpan		571
	sand, lava		595
	cement		597
	sand and rock		655
	lava		695
	clay, yellow		725
	hardpan		
	hard cement		
	hard gravel		
	gravel~~clay, blue~~		
	clay, blue		881

(This well has high iron content below 390' and has been sealed off below that depth.)

ORIGINAL
File with DWR

CONFIDENTIAL LOG
Water Code Sec. 13752

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
WATER WELL DRILLERS REPORT

Do Not Fill In
№ 58851
State Well No. 9N/5E-11M
Other Well No.

(1) OWNER:
Name McClellan AFB
Address SACRAMENTO

(2) LOCATION OF WELL:
County
Owner's number, if any Well No. 18
Township, Range, and Section 09N 05E-11M
Distance from cities, roads, railroads, etc.

(3) TYPE OF WORK (check):
New Well ☒ Deepening ☐ Reconditioning ☐ Destroying ☐
If destruction, describe material and procedure in Item 11.

(4) PROPOSED USE (check):
Domestic ☐ Industrial ☒ Municipal ☐
Irrigation ☐ Test Well ☐ Other ☐

(5) EQUIPMENT:
Rotary ☐
Cable ☐
Other ☐

(6) CASING INSTALLED:
STEEL: SINGLE ☒ DOUBLE ☐ OTHER:

If gravel packed

From ft.	To ft.	Diam.	Gage or Wall	Diameter of Bore	From ft.	To ft.
0	408	14"		30"	0	409

Size of shoe or well ring:
Size of gravel:
Describe joint

(7) PERFORATIONS OR SCREEN:
Type of perforation or name of screen

From ft.	To ft.	Perf. per row	Rows per ft.	Size in. x in.
169	185			
210	260			
304	349			
378	387			

(8) CONSTRUCTION:
Was a surface sanitary seal provided? Yes ☒ No ☐ To what depth 50 ft.
Were any strata sealed against pollution? Yes ☐ No ☒ If yes, note depth of strata
From ft. to ft.
From ft. to ft.
Method of sealing Cement Grout

(9) WATER LEVELS:
Depth at which water was first found, if known ft.
Standing level before perforating, if known ft.
Standing level after perforating and developing ft.

(10) WELL TESTS:
Was pump test made? Yes ☒ No ☐ If yes, by whom?
Yield: 1200 gal./min. with 59 ft. drawdown after —— hrs.
Temperature of water Was a chemical analysis made? Yes ☐ No ☐
Was electric log made of well? Yes ☐ No ☐ If yes, attach copy

(11) WELL LOG:
Total depth ft. Depth of completed well ft.
Formation: *Describe by color, character, size of material, and structure*

ft. to ft.	
0 - 7	Hard Pan
7 - 11	Sandy Silt
11 - 14	Hard Pan
14 - 20	Fine Sand Gray
20 - 30	Hard Sandy Clay
30 - 36	Fine Black Sand
36 - 49	Sandy Clay
49 - 52	Sandy Clay Hard
52 - 65	Fine Sandy Clay
65 - 80	Fine Sand
80 - 90	Clay
90 - 92	Loose Shale
92 - 98	Hard "
98 - 136	Gray "
136 - 165	Hard Sandy Red Clay
165 - 192	Hard Shale Gravel
192 - 207	Hard Red Sandy Clay
207 - 219	Yellow Clay
219 - 224	Clay Showing Sand
224 - 240	Sand
240 - 246	Cobble Stones (Gravel 2")
246 - 261	Sand
261 - 280	Cobble Stone (Gravel 2" Max)
280 - 318	Yellow Joint Clay
318 - 340	Red Sandy Clay
340 - 354	Clay
354 - 370	Fine Sand w/clay streaks
370 - 388	Fine Sand
388 - 404	Clay
404 - 408	Sand

Work started 10/18 1952. Completed 2/12 1953

WELL DRILLER'S STATEMENT:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME J. B. Heard Co
(Person, firm, or corporation) (*Typed or printed*)

Address

[SIGNED]
(*Well Driller*)

License No. Dated 2/12/53 19

SKETCH LOCATION OF WELL ON REVERSE SIDE

CONFIDENTIAL LOG
Water Code Sec. 13752

DWR 188 (REV 9-68)

25179-950 9-68 50M TRIP OSP

Well #27

STATE OF CALIFORNIA

OWNER:

LOCATION OF WELL: 2148

TYPE OF WORK: New well X

PROPOSED USE: Other X

EQUIPMENT: Rotary X

CASING INSTALLED:

0	261 ft	6Diam	
0	71	12"	

0	
13	71
8	261

joint welded

PERFORATIONS:

perforation mill

3/18 in. length 1 1/2

175	185
200	210
240	260

CONSTRUCTION:

X Yes 71

Method of Sealing: cement grout

WATER LEVELS:

WELL TESTS:

WELL LOG:

0	4	top soil
4	40	hard shaley clay
40	130	shaley clay
130	135	coarse sand
135	175	shaley clay
175	185	coarse sand
185	204	shaley clay
204	208	coarse sand
208	254	shaley clay
254	260	sand & gravel

2 copies

6/19 62 6/29 62

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME Baton Drilling Co

Address P. O. Box 975

Woodland, California

Signed [illegible]

License No [illegible]

DWR 183 (REV. 3-54)

RESPONSE TO COMMENTS

SUBJECT: Draft Well Closure Methods Report
Water Well Abandonment Phase II
McClellan AFB

REVIEWER: Alexander MacDonald, Regional Water Quality Control Board

DATE: June 30, 1992

Comment: Base Well BW-17 was drilled using the cable tool method. Thus, there is no gravel pack associated with the well. There are no special procedures provided in the report for dealing with this type of well. The current proposed procedures only deal with wells with an annulus and call for perforating the casing, along with pressure grouting. Staff does not recommend this procedure on a well without a gravel packed annulus. The well should be pressure grouted to the surface with no perforation of the casing.

Response: The main difference between a well drilled by the cable tool method and one drilled by the rotary method from a well abandonment perspective is that there is no gravel pack associated with the cable tool well. Base Well (BW-) 28 is also constructed by the cable tool method. Since there is no gravel pack, the calculation for cement volume must be adjusted. It is recommended that cement volumes be calculated based on the inside volume of the casing, plus an additional 10 percent to fill the micro-annulus outside the casing. This additional 10 percent is felt to be conservative since subsurface clays may be expected to have swelled up tightly against the well casing. The Well Closure Methods and Procedures Report (the Procedures) will be modified to reflect this approach. Otherwise the decommissioning approach should be the same as other wells, with grout applied under pressure in a series of lifts. This approach is felt to be necessary because of the heterogeneity of the subsurface geology in the vicinity of McClellan AFB. In this way, all zones outside the casing will be sealed for maximum protection against the possibility of contaminants migrating along the casing.

RESPONSE TO COMMENTS

SUBJECT: Draft Well Closure Methods Report
Water Well Abandonment Phase II
McClellan AFB

REVIEWER: Richard McJunkin and Will Rowe, Department of Toxic Substance Control, Technical and Support Services Branch

DATE: June 30, 1992

Comment: General

1) Procedures

The decommissioning methods outlined in the Procedures lack sufficient detail.

Recommendations

Each well addressed in the Procedures should have a detailed decommissioning plan tailored to local or well-specific lithology, yield, and construction features.

Response: It is not possible in this report to provide more details on the decommissioning approach with regard to well construction details because of the contradictory and often conflicting information that exists for the wells. Preliminary work on the wells will involve pulling pumps, cleaning the casing, jackhammering the pad to expose the gravel pack, and downhole television surveying. Following this work, it will be possible to describe in greater detail the decommissioning approach at individual wells (such as intervals that will be perforated, cement volume calculations, etc.) that are based on well construction details. This description will be written in a Technical Memorandum that will be prepared following the preliminary work. Regulatory agencies will have an opportunity to review this Technical Memorandum.

It is also not possible to account for well-specific lithology or yield in advance because of the complexity of the subsurface hydrogeology. The approach described in this report attempts to deal with these factors by field testing the approximate permeability of a given interval prior to cementing; varying the height of individual cemented intervals; and varying the composition of the cement and additives. These adjustments will be documented in the field notes and described in the Informational Field Report that will be prepared following the field work.

Comment: General

2) **Sample Wells Before Decommissioning**

Recommendation:

Before decommissioning, water levels should be measured and samples collected and analyzed. The water surface should be tested for floating product and, if present, a sample should be taken and analyzed.

Response: Water levels will be measured during the decommissioning of the wells. Floating products will be removed during preliminary work following removal of pumps from the wells. This product is expected to consist primarily of petroleum-based pump lubricating oil, and will be stored in 55-gallon drums. It will be tested as part of disposal, according to normal State of California procedures. Water in the wells will not be tested, because: (1) water will not be generated at the surface during normal abandonment procedures, and therefore will not have to be disposed; (2) appropriate sampling procedures would require that a large volume of water be pumped, and this water would require expensive disposal procedures; and (3) groundwater characterization samples to support the ongoing remedial investigation at McClellan AFB are best collected from monitoring wells, rather than these production wells with their lengthy perforated intervals.

Comment: General

3) **Decommission Uncomplicated Wells First**

Recommendation:

Before decommissioning complex wells, such as Base Well 7, decommission wells which are less likely to present technical problems. The experience gained from these wells will help with potentially troublesome wells like Base Well 7.

Response: The Procedures will be modified to reflect this approach. It is also hoped that experience gained during Phase I will prove valuable during the present work.

Comment: Well Decommissioning

These issues should be addressed in a work plan on a well-by-well basis. The following considerations should be applied to each well:

1) Identification of Low Permeability Zones

The Procedures do not discuss the locations of low permeability zones in the lithology of each well. Low permeability zones should be sealed to reestablish preexisting aquitards.

Recommendation:

Identification and sealing of low permeability zones in each well should be addressed in the Procedures. Well logs and geophysical logs should be presented with the description of decommissioning of each well. This information will dictate the location of perforating intervals.

Response: The Drillers Logs are often contradictory for base wells at McClellan AFB or are so inaccurate that they are almost unusable. Geologic and geophysical logs prepared in nearby monitoring wells are not usable because of the heterogeneity of the geology. This uncertainty is dealt with by pressure-grouting the entire well in a series of short lifts, and by varying the length of the lifts and the cement composition in response to observed conditions at a given well.

Comment: Well Decommissioning

2) Perforating the Casing

The Procedures do not discuss how casings will be perforated to assure sealing of the low permeability intervals and the filter pack.

Recommendation:

The Procedures should be amended to specify the methods for perforating blank casing in each well including perforation size, density, and depths, and interval lengths.

Response:

The Technical Memorandum will specify intervals of perforation in each well following the downhole television surveys that will indicate where the existing intervals of perforation lie. The entire casing will be perforated, with perforation of a given interval occurring immediately prior to cementing that interval. The Procedures specify that perforation will be with a mills knife perforator. Language will be added to show that perorations will be four per row, with one row per foot. Each perforation will be about one-third inch in thickness, and about 3 inches in length. The Technical Memorandum may also recommend that certain wells be perforated by explosive shot perforation, based on the conclusions drawn during the preliminary work.

Comment: Well Decommissioning

3) Grout Lifts

The Procedures insufficiently discuss how many lifts will be used. Insufficient criteria or rationale are provided for determining how many lifts will be used in well decommissioning. The section titled "Abandonment With a Packer" does not define how existing perforations, expected lithology, and the outcome of the previous lift will determine packer placement.

Recommendation:

The Procedures should include rationale and criteria for determining the number and placement of grout lifts in each well.

Response: The Procedures will be modified to provide more detail on this subject. It is expected that decommissioning at a given well will begin with a short lift of about 15 feet and that the lift size will increase if all goes well to a maximum of no more than 50 feet. As described in the comment above, the size of a lift will be influenced by the existing perforations, expected lithology, and outcome of the previous lift. More rationale and criteria will be included.

Comment: Well Decommissioning

4) Hydrofracting

The Procedures do not discuss how hydrofracting will be avoided during grouting. There is some discussion on page 48 of "rule of thumb" estimates of grout pressure; however, the Procedures do not describe how pressure will be monitored and controlled.

Recommendation:

The Procedures should be amended to include methods for determining appropriate pressure and pressure-control.

Response: Hydrofracting was discussed in the Procedures on page 47 under measures taken to avoid exceeding the fracture pressure of the formation. Pressure at the surface (downstream from the pump) will be monitored with a gauge. During Phase I, this pressure never exceeded 50 psi. Since this pressure is propagated evenly throughout the fluid, the pressure downhole should be equal to the pressure at the pump plus the pressure exerted by the column of fluid (0.458 psi/ft for water above the water table). The Halliburton "rule of thumb" says that hydrofracting will not occur if pressure does not exceed about 1 psi/ft beneath the ground surface. This pressure should not be exceeded at McClellan AFB, as long as gauge pressures at the surface do not exceed about 100 psi. The Procedures will be expanded to provide more discussion on these points.

Comment: Well Specific

1) **Base Well 7**

According to the Procedures, no information exists about the type of cement used, nor grout takes, during the original decommissioning of this well in the 1960s. Without this information, there is no way to gauge how effectively the filter pack was invaded by the original decommissioning.

Recommendation:

To assure and document that this well is properly decommissioned, it should be decommissioned after experience is gained by decommissioning a similar well in a non-contaminated area. Well LW-1 at Camp Kohler provides an opportunity to drill-out a grouted well and decommission by perforated casing and re-injecting. This experience will help in tackling the likely enormous technical problems presented by Base Well 7.

Response: The Technical Memorandum will propose an approach to decommissioning these wells after the television survey has been done. As suggested, BW-7 will be decommissioned after the Camp Kohler Laundry wells have been decommissioned.

Comment: Well Specific

2) **Base Well 8**

The Procedures explain that the upper zone of the well will be grouted, then rebored to allow continued use of the lower, uncontaminated interval. This approach may not completely seal the upper interval, especially when the emplaced grout is being drilled-out. During drilling, there is potential for the seal to be fractured, thereby introducing unseen contaminant pathways. This approach leaves too many potential problems unaddressed.

Recommendation:

The entire well should be completely decommissioned. Replacing it with a new well in a non-contaminated area assures the integrity of the seal which isolates the contaminated upper interval.

Response: McClellan AFB has decided to delay decommissioning BW-8 for about 6 to 12 months until water hook-ups with City of Sacramento have been accomplished. Until that time, BW-8 will remain inactive as a fire emergency well. After the water hook-up, BW-8 will be completely decommissioned as recommended. The Technical Memorandum will provide details on the approach to decommissioning.

RESPONSE TO COMMENTS

SUBJECT: Draft Well Closure Methods Report
Water Well Abandonment Phase II
McClellan AFB

REVIEWER: David Wang, Department of Toxic Substance Control

DATE: June 30, 1992

Comment: The workplan provides only general guidelines that may be followed for decommissioning base wells. A major element missing from the draft Well Closure Workplan is a description of the well perforation process. The Department believes the perforation technique applied to Base Well-1 (Well Closure - Phase I) may have caused the decommissioning problems encountered at Base Well-1. The Department recommends adding specific and detailed descriptions on the decommissioning procedures for each well.

Response: More detailed procedures will be provided in the Technical Memorandum that will be produced after the pumps are removed and the wells are television surveyed. Perforation procedures will depend on existing perforation intervals and an evaluation of the condition of the well casing based on the television survey. Perforations will be made only immediately prior to cementing a given lift of a well, and will typically be cut with a mills knife at four perforations per row and one row per foot of casing.

Comment: The Department does not support trying to keep Base Well-8 in operation for fire fighting. Nearby monitoring wells have found contaminated groundwater at 175-200 feet below ground surface. Partial decommissioning of the base well may not adequately prevent cross contamination of aquifers, and will impact the effectiveness of the lower section. The Department recommends using other base wells located further north for fire fighting reserves.

Response: McClellan AFB has decided to delay decommissioning BW-8 for about 6 to 12 months until water hook-ups with City of Sacramento have been accomplished. Until that time, BW-8 will remain inactive as a fire emergency well. After the water hook-up, BW-8 will be completely decommissioned as recommended. The Technical Memorandum will provide details on the approach to decommissioning.

RESPONSE TO COMMENTS

SUBJECT: Draft Well Closure Methods Report
Water Well Abandonment Phase II
McClellan AFB

REVIEWER: Mark Malinowski, Department of Toxic Waste Substances

DATE: June 30, 1992

Comment: General

The draft workplan should describe the well decommissioning process to be followed for each well. Previous perforation techniques applied to Base Well-1 (Well Closure - Phase I) may have caused the decommissioning problems encountered at Base Well-1. The perforation process, perforation intervals and number of lifts to be used should be described for each individual well.

If specific decommissioning information is not available or cannot be determined until after the well cleaning and video survey, the Department recommends a Technical Memo, describing the proposed decommissioning procedures for each well, be prepared and submitted to the agencies for review and comments.

The emphasis of well decommissioning should be placed on perforating and sealing the aquitard zones. Very little geologic information has been provided to ensure that the zones of interest are adequately determined prior to initiating decommissioning procedures. The Department recommends that nearby pilot boring and monitor well logs (lithologic and geophysical) be include during the discussion on zones considered for perforation.

The Department questions the necessity of running video surveys prior to cleaning the wells since the wells should be cleaned regardless of the video results. The video survey after the cleaning would serve to determine which well construction diagram is accurate.

Permits and regulatory requirements (State and local) should be included or referenced from Phase I workplan.

The Base Wells should be tested for water level, presence of floating product and sampled for contaminants prior to abandonment.

Decommissioning of BW-7 should be attempted after drilling-out the Camp Kohler well LW-1. The experience gained from the LW-1 well should help in the BW-7 effort.

The Department does not support trying to keep Base Well 8 in operation for fire fighting. Nearby monitoring wells have found contaminated groundwater at 175-200 feet below ground surface. Deeper aquifer zones have not been tested; however, contamination is expected. The Department recommends using base wells located further north, if possible, for fire fighting reserves.

The Department requires that McAFB provide information on future efforts for Base Wells 4, 5, 9, 11, 14, 16, 22, 23, 24, Old BW-29 and the "Boy Scout Well".

Well construction diagrams should be included for each well and where possible lithologic logs from nearby pilot holes or monitor wells should be included for comparison to driller logs.

Response: It is not possible in this report to provide more details on the decommissioning approach with regard to well construction details because of the contradictory and often conflicting information that exists for the wells. Preliminary work on the wells will involve pulling pumps, cleaning the casing, jackhammering the pad to expose the gravel pack, and downhole television surveying. Following this work, it will be possible to describe in greater detail the decommissioning approach at individual wells (such as intervals that will be perforated, cement volume calculations, etc.) that are based on well construction details. This description will be written in a Technical Memorandum that will be prepared following the preliminary work. Regulatory agencies will have an opportunity to review this Technical Memorandum.

It is also not possible to account for well-specific lithology or yield in advance because of the complexity of the subsurface hydrogeology. The approach described in this report attempts to deal with these factors by field testing the approximate permeability of a given interval prior to cementing; varying the height of individual cemented intervals; and varying the composition of the cement and additives. These adjustments will be documented in the field notes and described in the Informational Field Report that will be prepared following the field work. Because of the continual variation characteristic of alluvial materials, it is best to pressure-grout the well casing throughout the entire saturated interval, rather than attempting to isolate aquitards and only sealing them.

It is recommended that television surveys be run both before and after cleaning the casing. For one thing, television surveys are relatively inexpensive to run. In addition, the first video may indicate that the casing is in poor enough condition that conventional wire brush cleaning would risk casing collapse and a more gentle cleaning or no cleaning may be warranted. Finally, in some cases the well casing may be found to be clean enough to allow adequate evaluation of the condition of the casing, and a second video may not need to be run.

It was found during the first phase that State and County permits were not necessary for well decommissioning at McClellan AFB, because the work is governed by the terms of the Inter Agency Agreement, which provides for supervision by representatives of the various agencies of the County and State.

Water levels will be measured during the decommissioning of the wells. Floating product will be removed during preliminary work following removal of pumps from the wells. This product is expected to consist primarily of petroleum-based pump lubricating oil, and will be stored in 55-gallon drums. It will be tested as part of disposal, according to normal State of California procedures. Water in the wells will not be tested, because: (1) water will not be generated at the surface during normal abandonment procedures, and therefore will not have to be disposed; (2) appropriate sampling procedures would require that a large volume of water be pumped, and this water would require expensive disposal procedures; and (3) groundwater characterization samples to support the ongoing remedial investigation at McClellan AFB are best collected from monitoring wells, rather than these production wells with their lengthy perforated intervals.

The Procedures will be modified to specify that LW-1 and LW-2 at Camp Kohler will be abandoned before BW-7. It is also hoped that experience gained during Phase I will prove valuable during the present work.

McClellan AFB has decided to delay decommissioning BW-8 for about six to twelve months until water hook-ups with City of Sacramento have been accomplished. Until that time, BW-8 will remain inactive as a fire emergency well. After the water hook-up, BW-8 will be completely decommissioned as recommended. The Technical Memorandum will provide details on the approach to decommissioning.

McClellan AFB will continue to evaluate other wells for decommissioning in the future. The Procedures attempted to facilitate this process by gathering information on well locations and construction details. It is expected that there will be a Phase III following completion of the present work.

Contradictory well logs and diagrams were obtained for various wells when gathering data for the preparation of the procedures, and therefore only the original Well Drillers Report was included for a given well when available. The Technical Memorandum that will be prepared following completion of the preliminary work will include actual information on well construction, as well as the appropriate geologic log, if available.

Comment: Page 4, paragraph 3, Permits and regulatory requirements should be included or referenced from Phase I workplan.

Response: It was found during Phase I that state and county permits were not necessary for well decommissioning at McClellan AFB, because the work is governed by the terms of the InterAgency Agreement, which provides for supervision by representatives of the various agencies of the county and state. However, because the regulatory requirements set standards that are met or exceeded in all phases of well decommissioning at McClellan AFB, Phase I work plan will be referenced in this context.

Comment: Page 18, Table 4 indicates a casing diameter of 16" while the drillers log indicates a 14". Correct or explain the discrepancy.

Response: The actual diameter is 16 inches, so the table is correct and the drillers log is incorrect.

Comment: Page 19, paragraph 3, The drillers log indicates a TD of 881 feet and the text indicates 930 feet. Correct or explain the discrepancy.

Response: The 930-foot depth was taken from McClellan AFB files. It is unknown which depth is correct. However, the actual original borehole depth will not affect the well decommissioning.

Comment: Page 20, The drillers log for a BW-20 should be included in the appendix. Logs form monitor wells 210 and 211 should also be presented.

Response: A drillers log was not located for BW-20. Available information was taken from McClellan AFB files. Geologic logs from wells 210 and 211 would serve no purpose since they are 500 feet away from BW-20.

Comment: Page 31, paragraph 4, BW-9. BW-9 should be further investigated and properly decommissioned in future efforts.

Response: Agreed. This well will be the object of future decommissioning efforts.

Comment: Page 35, paragraph 1, BW-15. BW-15 should be further investigated and properly decommissioned in future efforts.

Response: Agreed. This well will be the object of future decommissioning efforts.

Comment: Page 40, paragraph 5, Remedial efforts at the Davis site include implementation of a Remedial Investigation for groundwater contamination.

Response: The text will be modified to reflect this fact. The decommissioning of BW-26, however, is not a part of the Remedial Investigation.

Comment: Page 42, paragraph 2, What type of "licensed professional"?

Response: The text will be modified to read a "California Registered Geologist or Professional Engineer."

Comment: Page 42, paragraph 4, All equipment that comes into contact with groundwater should be decontaminated prior to arrival at each well.

Response: The text will be modified to reflect this statement.

Comment: Page 43, paragraph 1, Since the equipment used in cementing will be decontaminated, how will the equipment taken from base wells (pumps, bowls, strainers, etc.) be treated prior to sending to DRMO.

Response: All pump equipment will be steam-cleaned as it is pulled out of the well. Steam cleaning water will be allowed to run back down the well to avoid disposal problems. The text will be modified to reflect this statement.

Comment: Page 43, paragraph 4, The Department questions the necessity of running video surveys prior to cleaning the wells since the wells should be cleaned regardless of the video results. The video survey after the cleaning would serve to better determine which well construction diagram is accurate.

Response: It is recommended that television surveys be run both before and after cleaning the casing. First, television surveys are relatively inexpensive to run. In addition, the first video may indicate that the casing is in poor enough condition that conventional wire brush cleaning would risk casing collapse and a more gentle cleaning or no cleaning may be warranted. Finally, in some cases the well casing may be found to be clean enough to allow adequate evaluation of the condition of the casing, and a second video may not need to be run.

Comment: Page 44, paragraph 4, The technical memo should also include specific decommissioning information for each well (e.g. perforation interval, type of perforation tool-knife, bullet, explosive-, number of lifts needed and interval of lifts, etc.

Response: The Technical Memorandum will attempt to supply this information.

Comment: Page 47, paragraph 1, Perforation of the entire well and then cementing is probably the cause of the decommissioning problems encountered at BW-1 during Phase I. The Department does not support use of "perforation and cementing the entire casing in one lift" technique.

Response: This approach is only mentioned because it is the conventional method of decommissioning wells. The text goes on to say that the casing will be perforated just prior to cementing each lift (pages 48-49).

Comment: Page 48, Bullet 1. Describe the criteria to be used in determining if/when perforation of the casing is necessary.

Response: Blank sections of casing will be perforated prior to cementing unless the television survey reveals that the casing is too weak to sustain perforation.

Comment: Page 49, Bullet 4. The perforated interval(s) should be identified for each well.

Response: The Technical Memorandum will describe intervals to be perforated based on the results of the television survey, which will identify intervals of existing perforations. However, final decisions on perforation will be made in the field and be based on results of prior episodes of perforation for that well.

Comment: Page 49, paragraph 2. Specify if wells located within buildings will <u>not</u> be excavated 3 feet below grade.

Response: Wells located within buildings will not be excavated 3 feet below grade. Instead, the cement will be brought up flush with the floor surface. The Procedures will be modified to clarify this.

Comment: Page 50, BW-7. The Department recommends attempting to seal the lower section of BW-7 and overwashing and removing the upper 170-200 feet.

Response: The Technical Memorandum will propose an approach to decommissioning BW-7. This approach will most likely be similar to the approach used in LW-1 and LW-2 at Camp Kohler. Decommissioning of BW-7 will also most likely follow the decommissioning of the Camp Kohler wells in order to benefit from the experience gained at Camp Kohler.

Comment: Page 51, paragraph 2, BW-8. Contamination has been found at 175' BGS. The Department recommends that BW-8 be completely decommissioned and not used as a fire fighting reserve well.

Response: McClellan AFB has decided to delay decommissioning BW-8 for about 6 to 12 months until water hook-ups with City of Sacramento have been accomplished. Until that time, BW-8 will remain inactive as a fire emergency well. After the water hook-up, BW-8 will be completely decommissioned as recommended. The Technical Memorandum will provide details on the approach to decommissioning.

Comment: Page 51, Camp Kohler Wells. Provide any of the driller or lithologic logs for the Seismic and Triax Holes. The Departments evaluation of the cement bond logs indicate that a poor seal (if any) exists. The Department recommends perforating the casing and squeezing the hole with cement.

Response: No driller or lithologic logs are available for the Seismic Well and Triax Holes. McClellan AFB agrees that the acoustic bond log for the Triax Hole contains contradictory signals and may indicate that the cement seal is poor or nonexistent. This well will be decommissioned through pressure-grouting. A detailed approach will be provided in the Technical Memorandum. The data from the acoustic bond log for the Seismic Well, however, are relatively unambiguous. Therefore it is recommended that this well be decommissioned as proposed in the Procedures.

Comment: Page 53, paragraph 3, All water generated during the decommissioning effort (not just decontamination water) should be pumped into a Baker tank and sent to the GWTP for disposal. Use of berms and evaporation is not acceptable.

Response: The decommissioning process has been designed so that no water will be generated and will therefore require no disposal. Decontamination will take place with a steam cleaner fitted with a circular sprayer mounted to the well head, with steam jets directed downward into the well. In this way decontamination water will flow back down the hole. If it should become necessary to generate wastewater for disposal through some unanticipated event during the field work, this water will be collected in a Baker Tank and disposed at the Groundwater Treatment Plant, as recommended here. The Procedures will be modified to reflect this language.

Comment: Page 9, paragraph 2, Edit. Should reference to BW-16 be BW-15?

Response: During the record search for this project, it was found that the well that was previously thought to be BW-16 was actually BW-15. BW-16 was located along Patrol Road in the western portion of McClellan AFB.

Comment: Page 31, paragraph 3, Base Well 6 is not identified on Figure 2.

Response: The presumed location of BW-6 will be plotted on Figure 2.

FINAL PRINT

HALLIBURTON
LOGGING SERVICES, INC.

BOND LOG

MSG COLLAR CBL LOG

5" = 100'

COMP. MCCLELLAN AFB
WELL TRIAX HOLE
FIELD CAMP KOHLER
COUNTY SACRAMENTO ST. CALIF

COMPANY MCCLELLAN AFB

WELL TRIAX HOLE

FIELD CAMP KOHLER

COUNTY SACRAMENTO STATE CALIF.

API NO.
LOCATION

OTHER SERVICES

SEC. TWP. RGE.

PERMANENT DATUM	GROUND LEVEL	ELEV.	ELEV.: K.B.
LOG MEASURED FROM	GROUND LEVEL	FT. ABOVE PERM. DATUM	D.F.
DRILLING MEASURED FROM	GROUND LEVEL		G.L.

DATE & TIME LOGGED	12/19/91	TYPE OF FLUID IN HOLE	WATER
RUN NO.	ONE	DENSITY OF FLUID	8.59
DEPTH - DRILLER	200.00	FLUID LEVEL	FULL
DEPTH - LOGGER	195.00	CEMENT TOP EST. - LOGGED	SURF.
BTM. LOGGED INTERVAL	187	EQUIPMENT : LOCATION	51533 WOLD.
TOP LOGGED INTERVAL	35.00	RECORDED BY	JOHN GUNBY
MAX TEMP. DEGREE	NOT RECORDED	WITNESSED BY	MR. ELLIOT

CEMENTING DATA	SEE REMARKS	PROTECTION STRING	PRODUCTION STRING	LINER
DATE/TIME CEMENTED				
PRIMARY/SQUEEZE				
EXPECTED				
COMP. STRENGTH				
CEMENT VOLUME				
CEMENT TYPE/WEIGHT				
FORMULATION				
MUD TYPE/MUD WEIGHT				

RUN	BOREHOLE RECORD			CASING AND TUBING RECORD			
NO.	BIT	FROM	TO	SIZE	WGT.	FROM	TO
				11.75		200.00	SURF.

FOLD HERE

SERVICE TICKET NO.: 44652 API SERIAL NO.: PGM VERSION: H L S DLS HD 1.0

THE WELL NAME, LOCATION, CEMENTING DATA AND BOREHOLE DESCRIPTION FURNISHED BY CLIENT

CEMENTING DATA

(1)

SERVICE TICKET NO.: 44652 | API SERIAL NO.: | PGM VERSION: H L S DLS HD 1.0

THE WELL NAME, LOCATION, CEMENTING DATA AND BOREHOLE DESCRIPTION FURNISHED BY CLIENT

CEMENTING DATA

CEMENT PUMPED		e				
PRECEDING FLUID	VOLUME	BBL			/ JOINT FROM	TO
RETURNS	FULL	PARTIAL	NONE	CENTRALIZERS	/ JOINT FROM	TO
PIPE ROTATED/RECIPICATED	DURING PUMPING	YES	NO		/ JOINT FROM	TO
	AFTER PLUG DOWN	YES	NO			
PLUG PUMPED		YES	NO		/ JOINT FROM	TO
PLUG LANDING PRESSURE:				CENTRALIZERS	/ JOINT FROM	TO
PRESSURE HELD		HRS AFTER PUMPING			/ JOINT FROM	TO

EQUIPMENT DATA

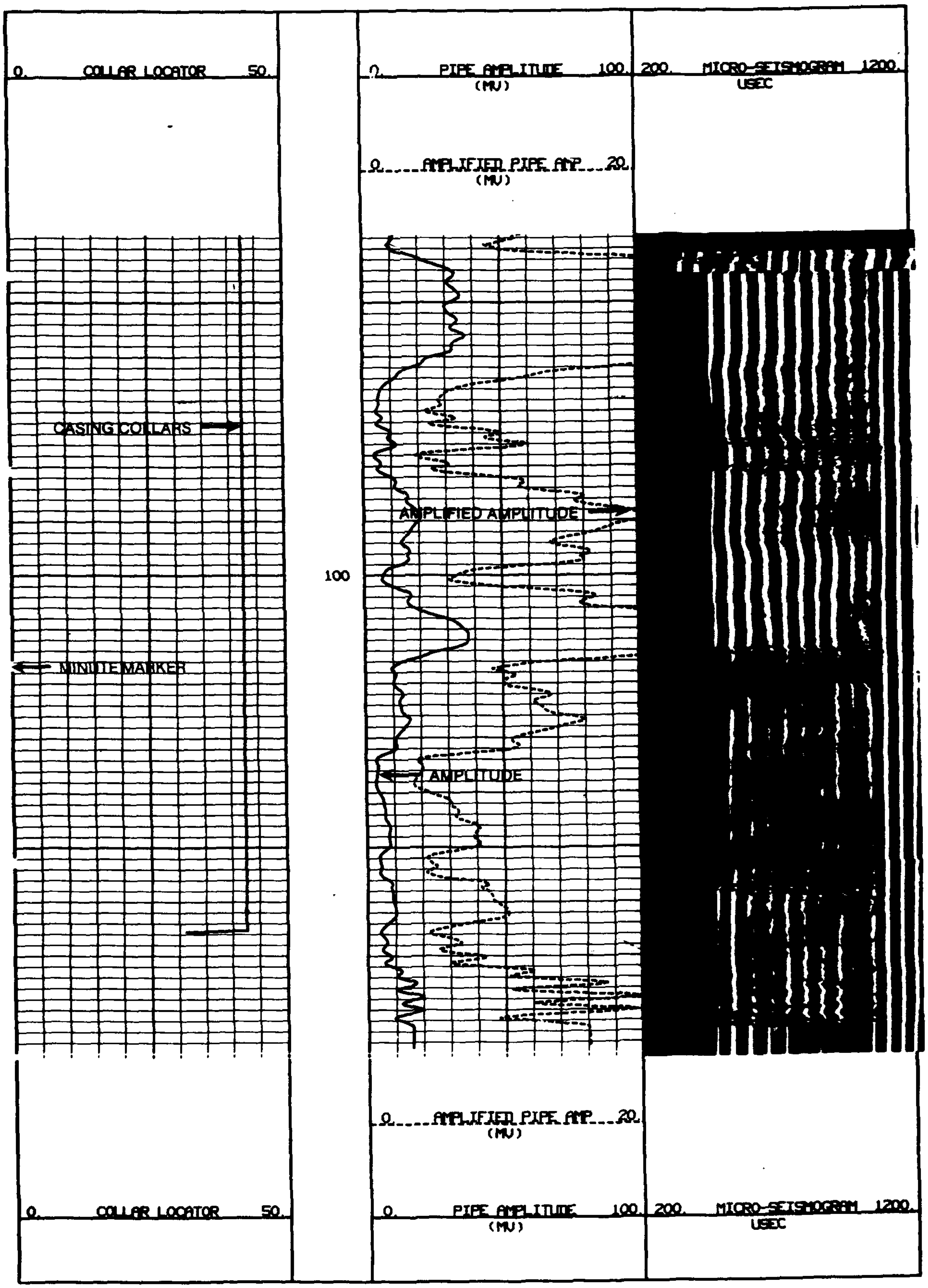
GAMMA		NEUTRON		ACOUSTIC	
RUN NO.		RUN NO.		RUN NO.	ONE
SERIAL NO.		SERIAL NO.		SERIAL NO.	107989
MODEL NO.		MODEL NO.		MODEL NO.	271
DIAMETER		DIAMETER		NO. OF CENT	TWO
DETECTOR MODEL NO.		LOG TYPE		SPACING	3 AND 5 FEET
TYPE		SOURCE TYPE			
LENGTH		SERIAL NO.			
DISTANCE TO SOURCE		STRENGTH			

LOGGING DATA

GENERAL					GAMMA		NEUTRON		ACOUSTIC	
RUN	DEPTHS		WELL HEAD	SPEED	SCALE		SCALE		SCALE	
NO.	FROM	TO	PRESSURE	FT./MIN.	L	R	L	R	L	R
ONE	195.00	35.00	200							

REMARKS: NO CEMENT DATA AT TIME OF LOG.
REPEAT SECTION OFF DEPTH TO MIAN LOG.
TT CURVE AND COLLARS DID NOT LOG DUE TO PIPE SIZE.

3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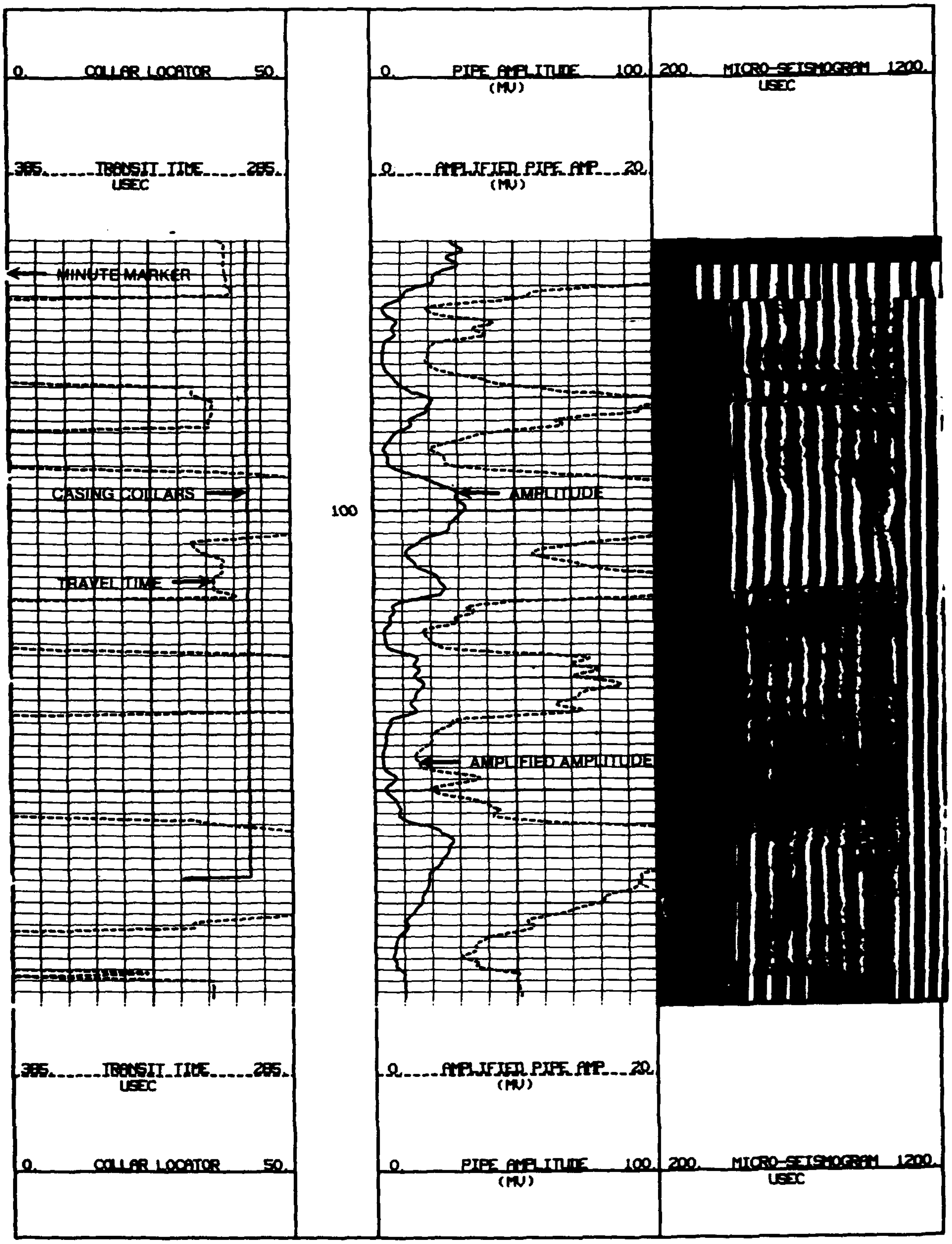
0. PIPE AMPLITUDE 100.
(MV)
200. MICRO-SEISMOGRAM 1200.
USEC
0. AMPLIFIED PIPE AMP 20.
(MV)
CASING COLLARS
AMPLIFIED AMPLITUDE
100
MINUTE MARKER
AMPLITUDE
0. AMPLIFIED PIPE AMP 20.
(MV)
0. COLLAR LOCATOR 50.
0. PIPE AMPLITUDE 100.
(MV)
200. MICRO-SEISMOGRAM 1200.
USEC

4



WELL LOCATION :

WELL NAME

5

WELL LOCATION :

WELL NAME :

ENG H L S DLS CH V4.32 LIS 03/08/91

LOG TAPE ID 00007000

DATE 12/19/91

ENG H L S DLS CH V4.32 LIS 03/08/91

PARAMETER TABLE

TDRV	TNUM	RATE	TOOL	AZER	DSNR	3->6
OFF	1.	20.	271	18.	14.	NO
THS1	THS2	DIST	PID	TOD	KT	KSLS
0.	0.	2.	2.441	1.6875	1.	1.
TRIG	MSGR	VIEW	SWCH	GRDM		
NEG	AF	AN	13.	ON		
MNEU -	SO	CWGT	ASKY			
CLIM	0.	0.	NO			
BS	CSIZ	TELE	LIS	DLY	DIR	PLOT
0.	11.75	YES	NO	YES	UP	FULL

ENG H L S DLS CH V4.32 LIS 03/08/91

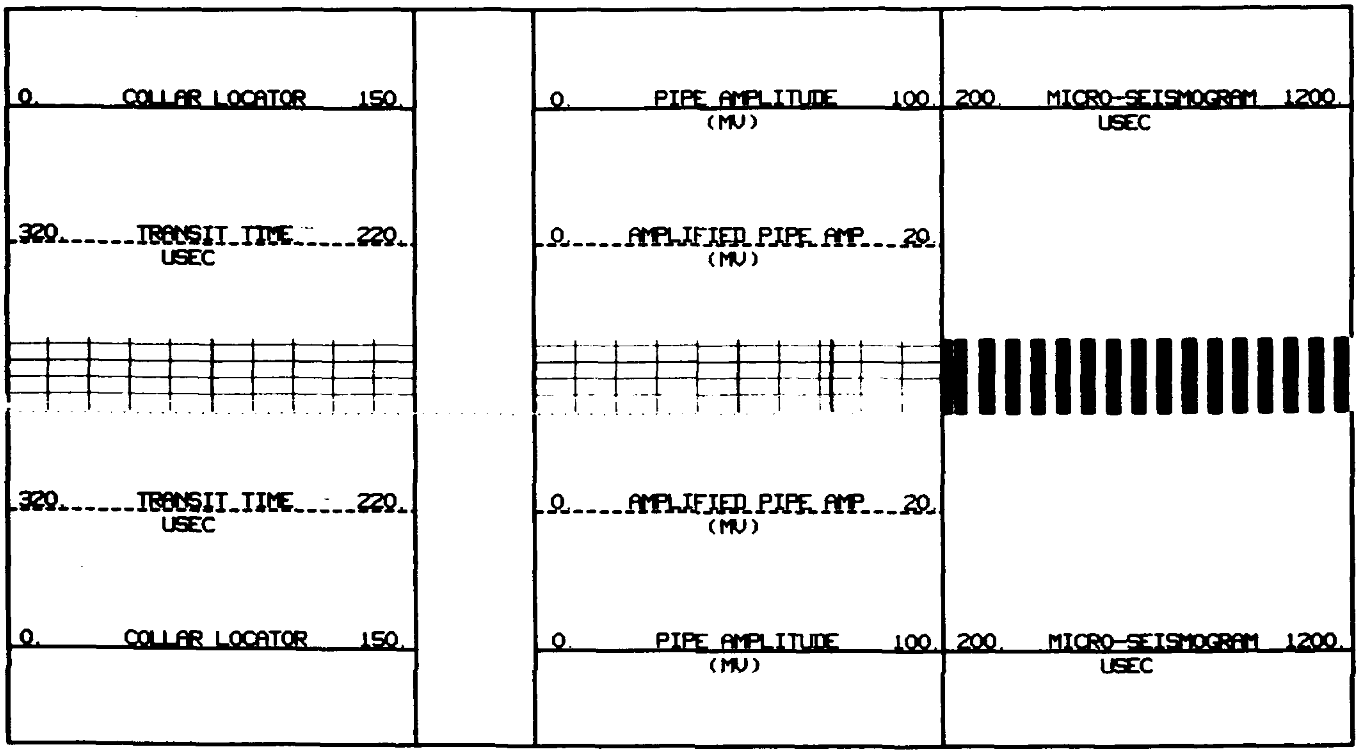
SERVICE	ID	TRK	UNIT	SCL L	SCL R	RBASE L	RBASE R	TYPE	STYP	OPFL	IPFL	OFF	LIS	CVCT 1 2L
CCL	1	1		0.	50.	Y	Y	0	LIN	0.	0.	5.	Y	YNY1
CCLU	6	1		0.	10.	Y	Y	0	LIN	0.	0.	0.	Y	QNN
AMPP	7	2	(MV)	0.	100.	0	0	0	LIN	0.	1.25	0.	Y	YNY3
APAM	5	2	(MV)	0.	20.	0	0	0	LIN	0.	0.	0.	Y	FNF
MSG	4	3	USEC	200.	1200.	0	0	0	LIN	0.	0.	0.	N	YNQ
TT	8	1	USEC	385.	285.	0	0	0	LIN	0.75	1.25	0.	Y	FNF2

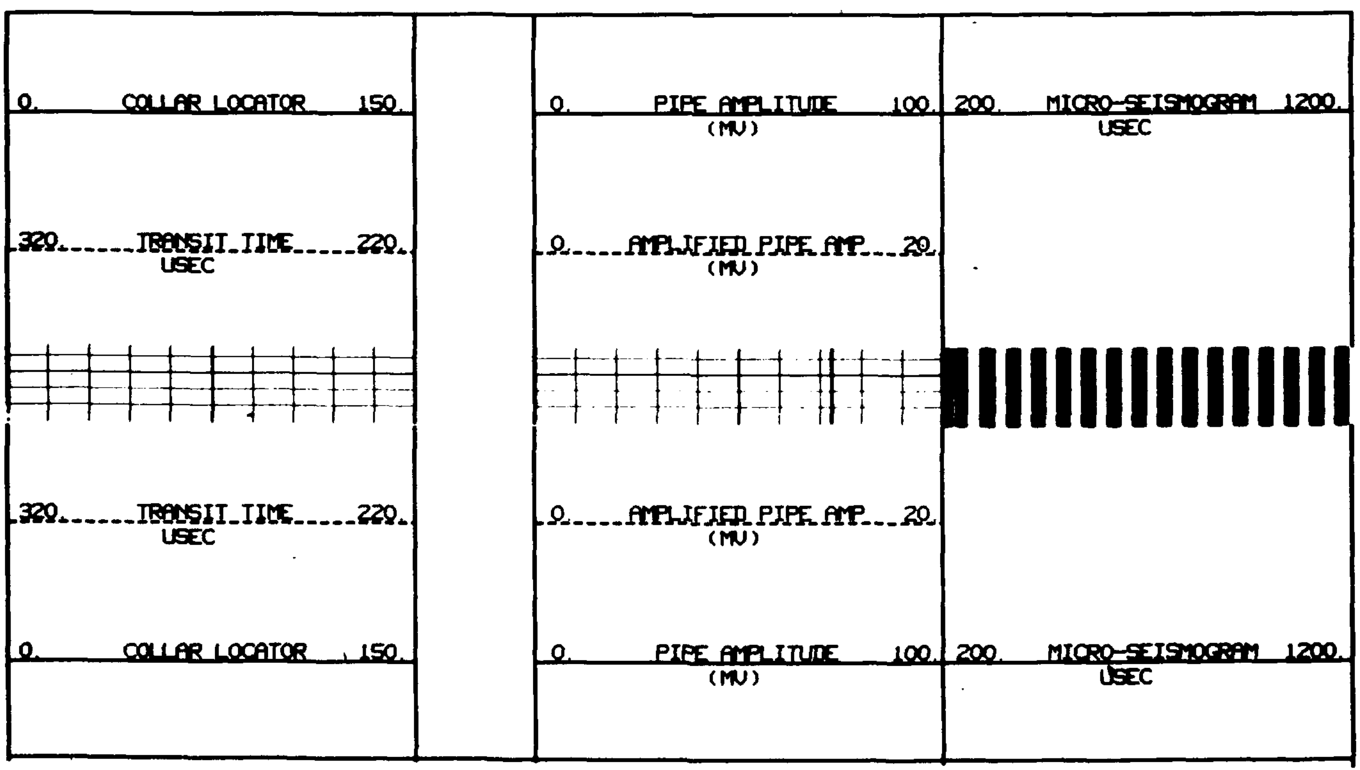
ENG H L S DLS CH V4.32 LIS 03/08/91

TOOL TABLE

SUB	SERIAL #	MODEL	SOURCE #	CALB #	NRM1	INT1	NRM2	INT2	DLY	TCH
CCL	107809	271	0	0	0.0125	0	0.	0	21.4	12
AMPP	107809	271	0	0	-0.0327	4093	0.	0	0.	24
TT	107809	271	0	0	677.4	0	0.	0	0.	20
GP1	0	0	0	0	0.	0	0.	0	0.	0
GP2	0	0	0	0	0.	0	0.	0	0.	0

6

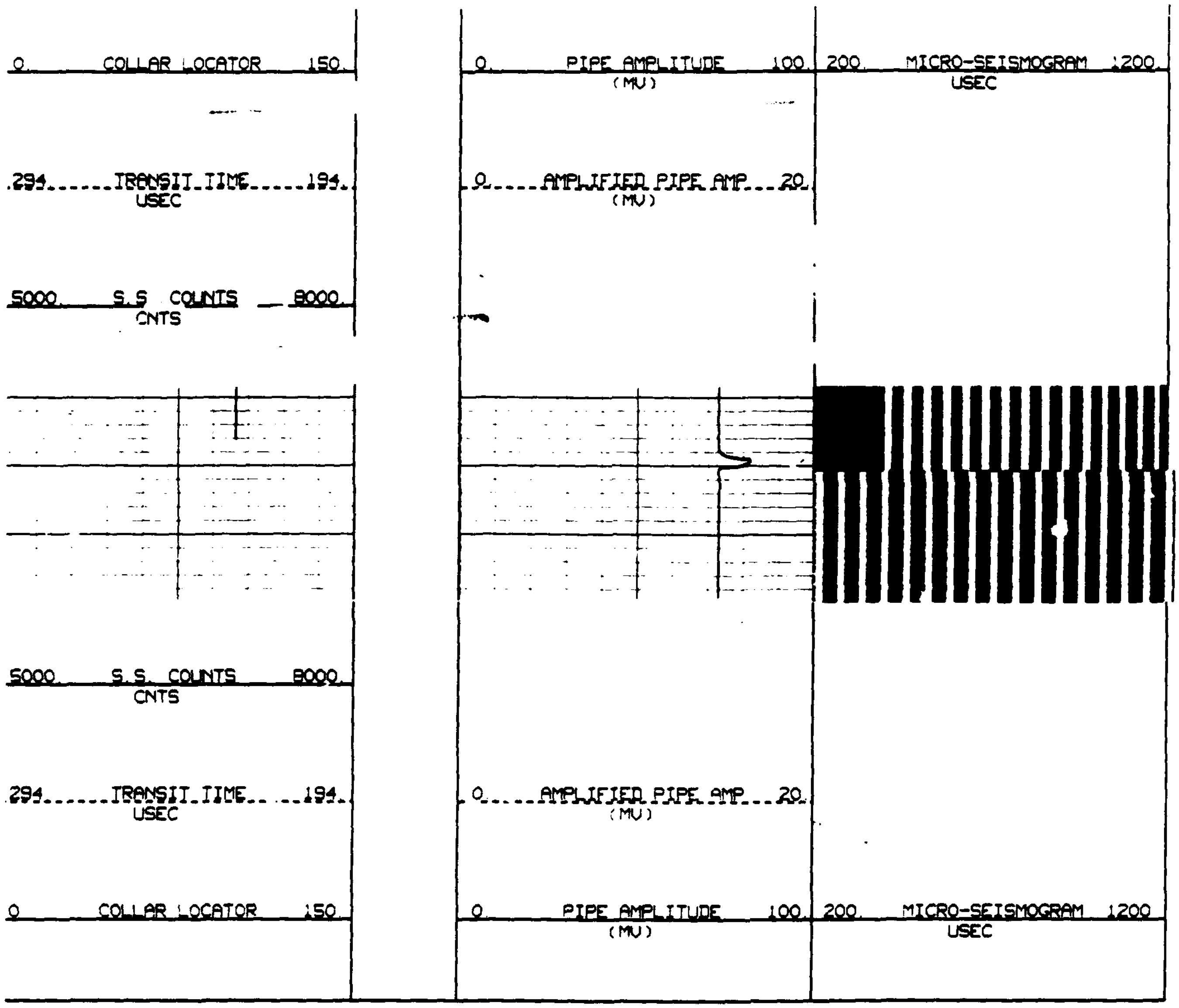




PIPE AMPLITUDE SHOP CALIBRATION
TOOL NUMBER 107809 PERFORMDED ON
12/09/91 IN 5.50 CASING WITH

7

PIPE AMPLITUDE SHOP CALIBRATION
TOOL NUMBER 107809 PERFORMED ON
12/09/91 IN 5.50 CASING WITH
500 PSI.



FINAL PRINT

HALLIBURTON LOGGING SERVICES, INC.

BOND LOG

MSG COLLAR CBL LOG

5" = 100'

COMP. MCCLELLAN AFB
WELL SEISMIC WELL
FIELD CAMP KOHLER
COUNTY SACRAMENTO ST. CALIF

COMPANY	MCCLELLAN AFB
WELL	SEISMIC WELL
FIELD	CAMP KOHLER
COUNTY	SACRAMENTO STATE CALIF.
API NO. LOCATION SEC. TWP. RGE.	OTHER SERVICES

PERMANENT DATUM	GROUND LEVEL	ELEV.	ELEV.: K.B.
LOG MEASURED FROM	GROUND LEVEL	FT. ABOVE PERM. DATUM	D.F.
DRILLING MEASURED FROM	GROUND LEVEL		G.L.

DATE @ TIME LOGGED	12/19/91	TYPE OF FLUID IN HOLE	WATER
RUN NO.	ONE	DENSITY OF FLUID	8.59
DEPTH - DRILLER	500.00	FLUID LEVEL	FULL
DEPTH - LOGGER	493.00	CEMENT TOP EST. - LOGGED	SURF.
BTM. LOGGED INTERVAL	485	EQUIPMENT : LOCATION	51533 WDLD.
TOP LOGGED INTERVAL	35.00	RECORDED BY	JOHN GUNBY
MAX TEMP. DEGREE	NOT RECORDED	WITNESSED BY	MR. ELLIOT

CEMENTING DATA	SEE REMARKS	PROTECTION STRING	PRODUCTION STRING	LINER
DATE/TIME CEMENTED				
PRIMARY/SQUEEZE				
EXPECTED				
COMP. STRENGTH				
CEMENT VOLUME				
CEMENT TYPE/WEIGHT				
FORMULATION				
MUD TYPE/MUD WEIGHT				

RUN NO.	BOREHOLE RECORD BIT	FROM	TO	CASING AND TUBING RECORD SIZE	WGT.	FROM	TO
				7.00		500.00	SURF.

FOLD HERE

SERVICE TICKET NO.: 4461   API SERIAL NO.:   PGM VERSION: H L S DLS HD 1.0

THE WELL NAME, LOCATION, CEMENTING DATA AND BOREHOLE DESCRIPTION FURNISHED BY CLIENT

CEMENTING DATA   / JOINT FROM   TO

1

FOLD HERE

SERVICE TICKET NO.: 44051   API SERIAL NO.:   PCM VERSION: H L S DLS HD 1.0

THE WELL NAME. LOCATION. CEMENTING DATA AND BOREHOLE DESCRIPTION FURNISHED BY CLIENT

CEMENTING DATA

CEMENT PUMPED	@		/ JOINT FROM	TO
PRECEDING FLUID	VOLUME BBL	CENTRALIZERS	/ JOINT FROM	TO
RETURNS	FULL PARTIAL NONE		/ JOINT FROM	TO
PIPE ROTATED/RECIPICATED	DURING PUMPING YES NO			
	AFTER PLUG DOWN YES NO		/ JOINT FROM	TO
PLUG PUMPED	YES NO	CENTRALIZERS	/ JOINT FROM	TO
PLUG LANDING PRESSURE:			/ JOINT FROM	TO
PRESSURE HELD	HRS AFTER PUMPING			

EQUIPMENT DATA

GAMMA		NEUTRON		ACOUSTIC	
RUN NO.		RUN NO.		RUN NO.	ONE
SERIAL NO.		SERIAL NO.		SERIAL NO.	107009
MODEL NO.		MODEL NO.		MODEL NO.	271
DIAMETER		DIAMETER		NO. OF CENT	TWO
DETECTOR MODEL NO.		LOG TYPE		SPACING	3 AND 5 FEET
TYPE		SOURCE TYPE			
LENGTH		SERIAL NO.			
DISTANCE TO SOURCE		STRENGTH			

LOGGING DATA

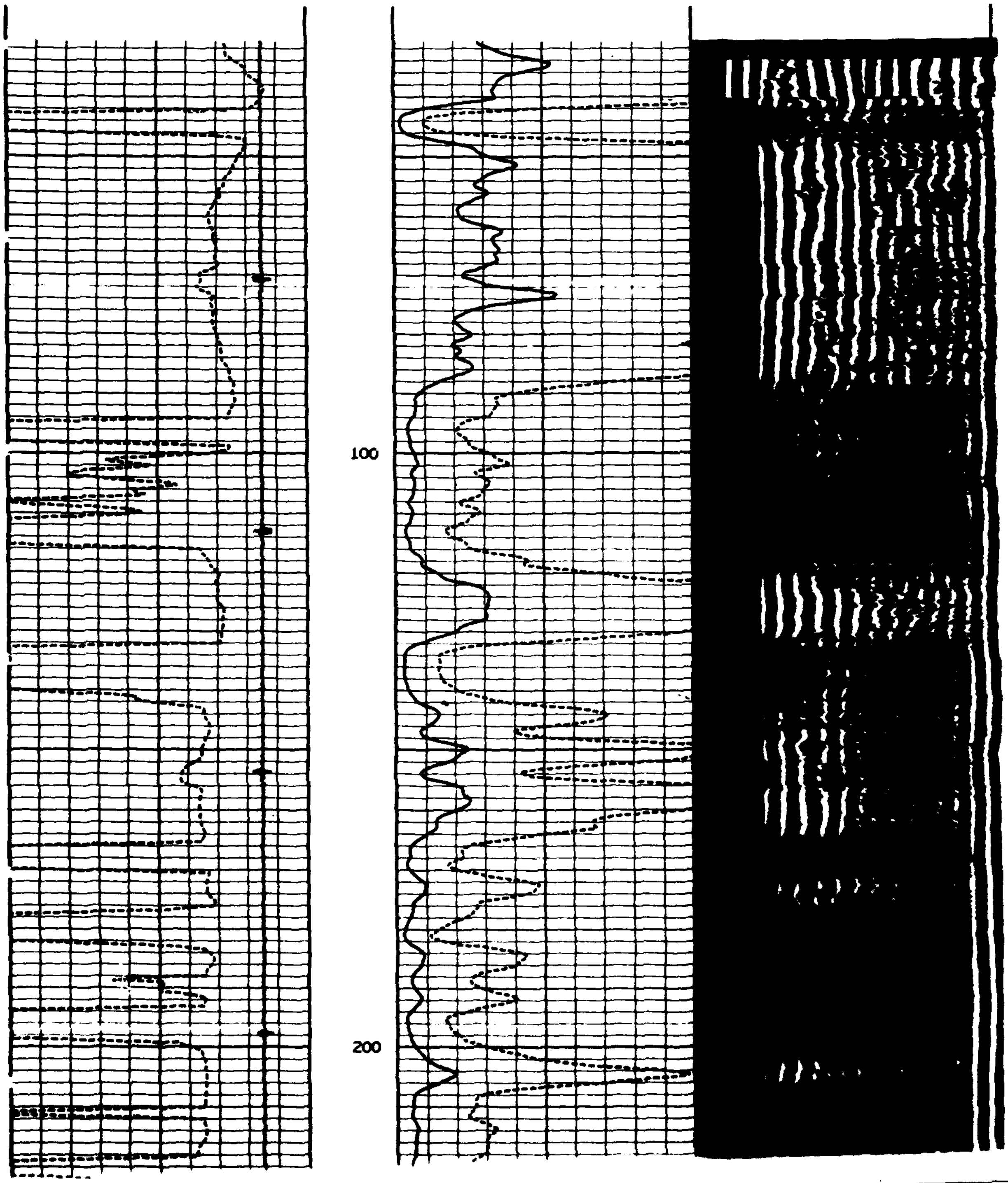
RUN NO.	DEPTHS FROM	DEPTHS TO	WELL HEAD PRESSURE	SPEED FT./MIN.	GAMMA SCALE L	GAMMA SCALE R	NEUTRON SCALE L	NEUTRON SCALE R	ACOUSTIC SCALE L	ACOUSTIC SCALE R
ONE	450.00	35.00	100							

REMARKS: NO CEMENT DATA AT TIME OF LOG.
REPEAT SECTION OFF DEPTH TO MIAN LOG.

2

(3)

0. COLLAR LOCATOR 50.	0. PIPE AMPLITUDE 100. (MV)	200. MICRO-SEISMOGRAM 1200. USEC
320. TRANSIT TIME 220. USEC	0. AMPLIFIED PIPE AMP 20. (MV)	



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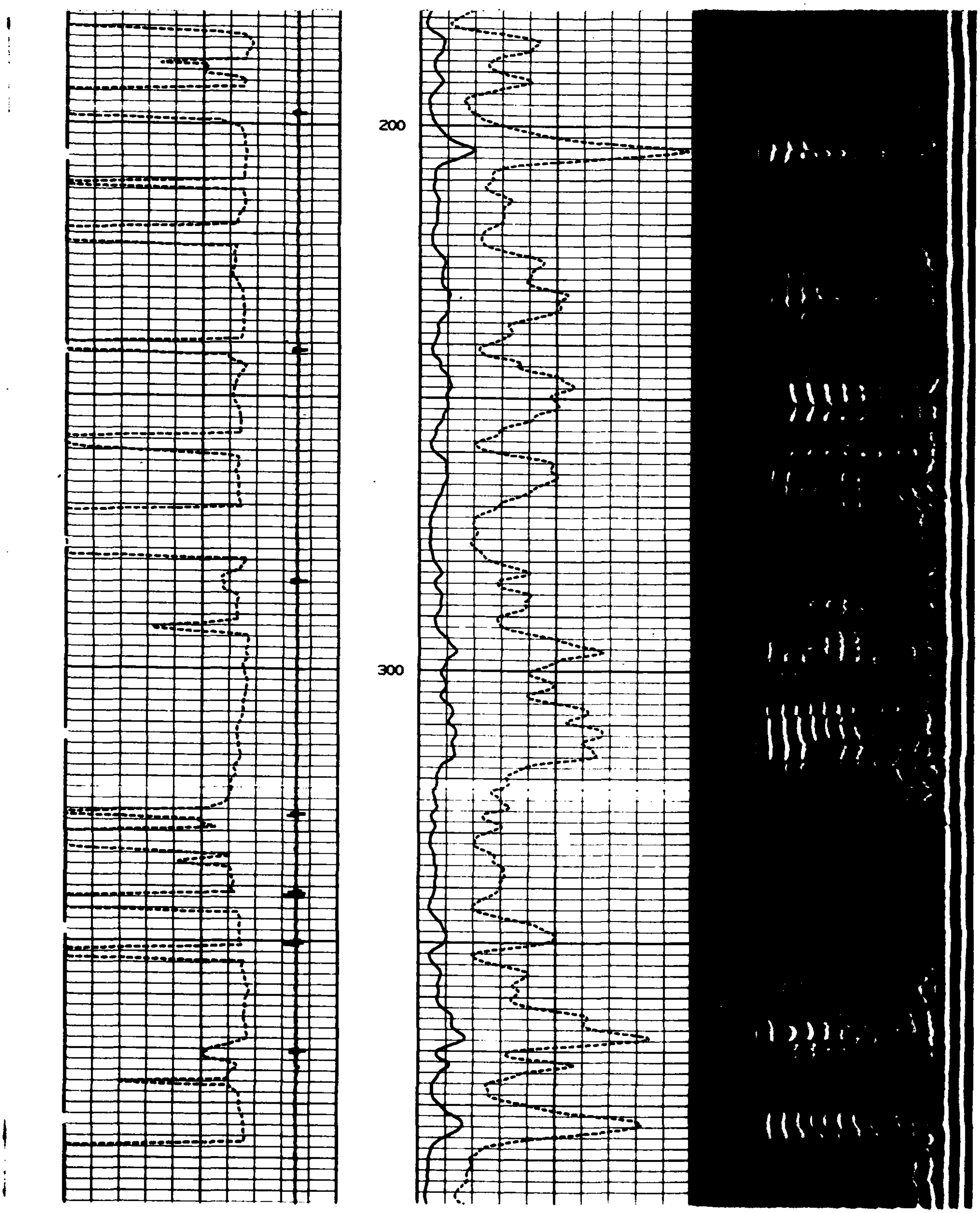
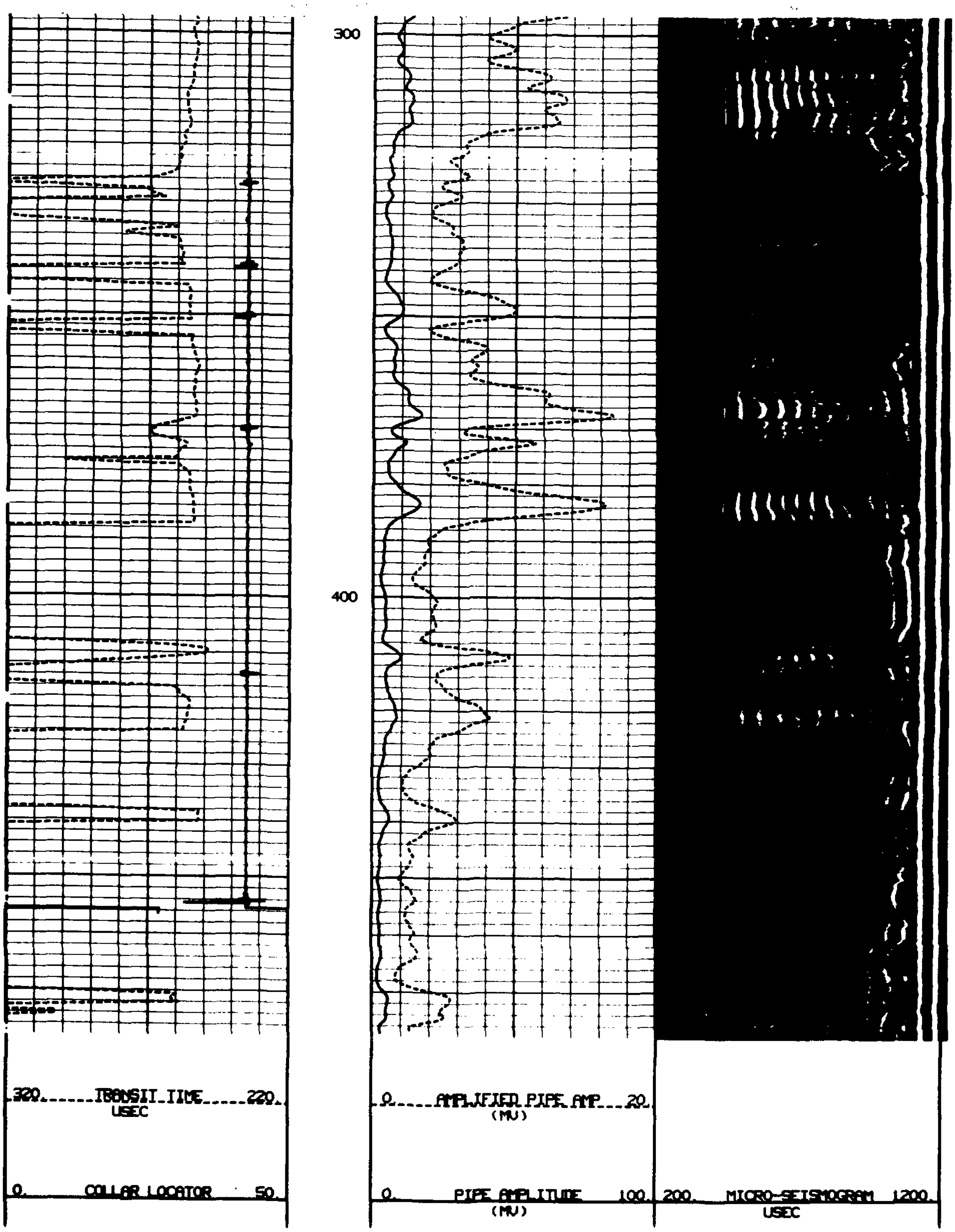


5


300
400
320. TRANSIT TIME 220.
USEC
0. COLLAR LOCATOR 50.
0. AMPLIFIED PIPE AMP 20.
(MV)
0. PIPE AMPLITUDE 100.
(MV)
200. MICRO-SEISMOGRAM 1200.
USEC

6

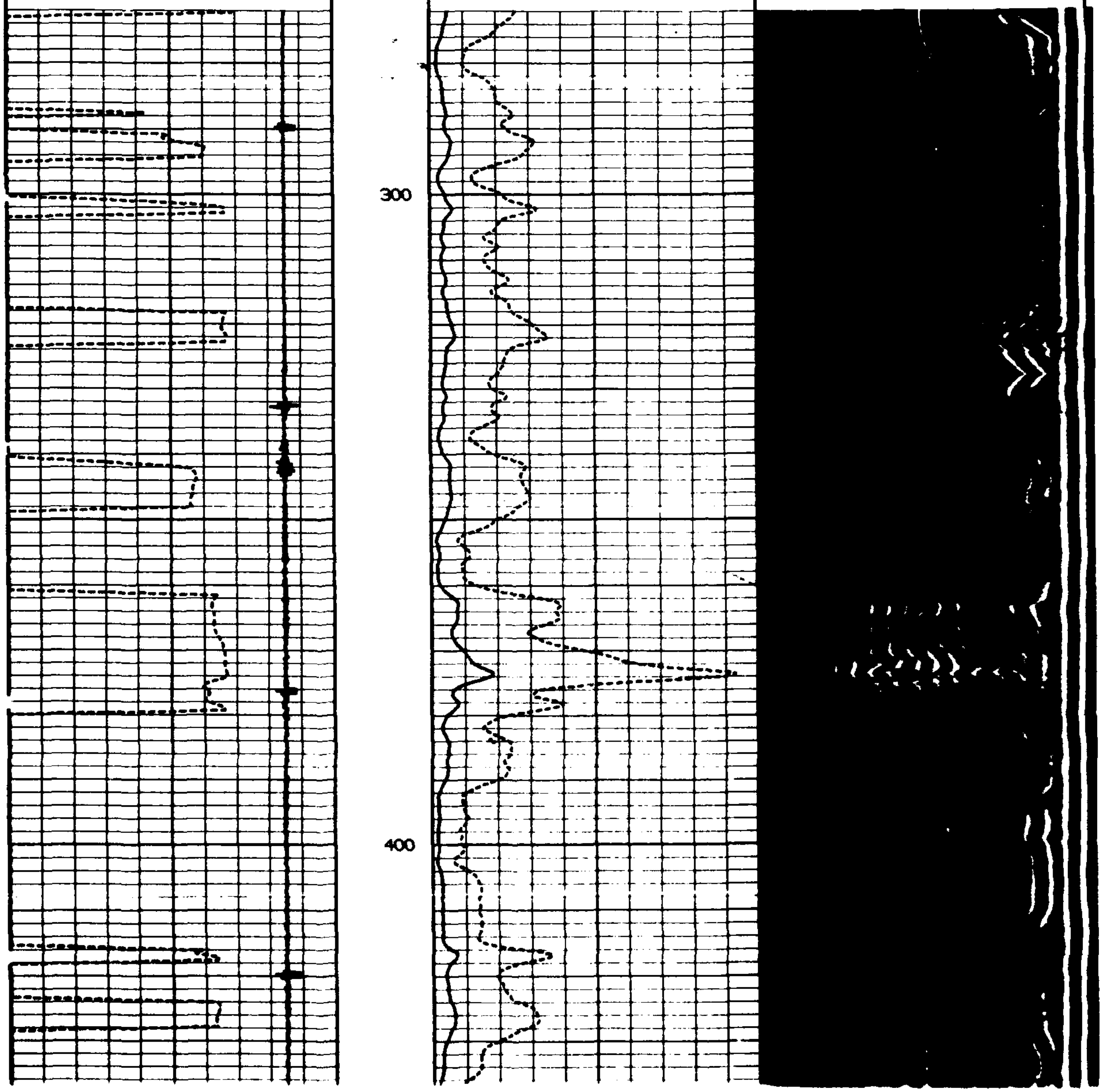
USEC

(MV)

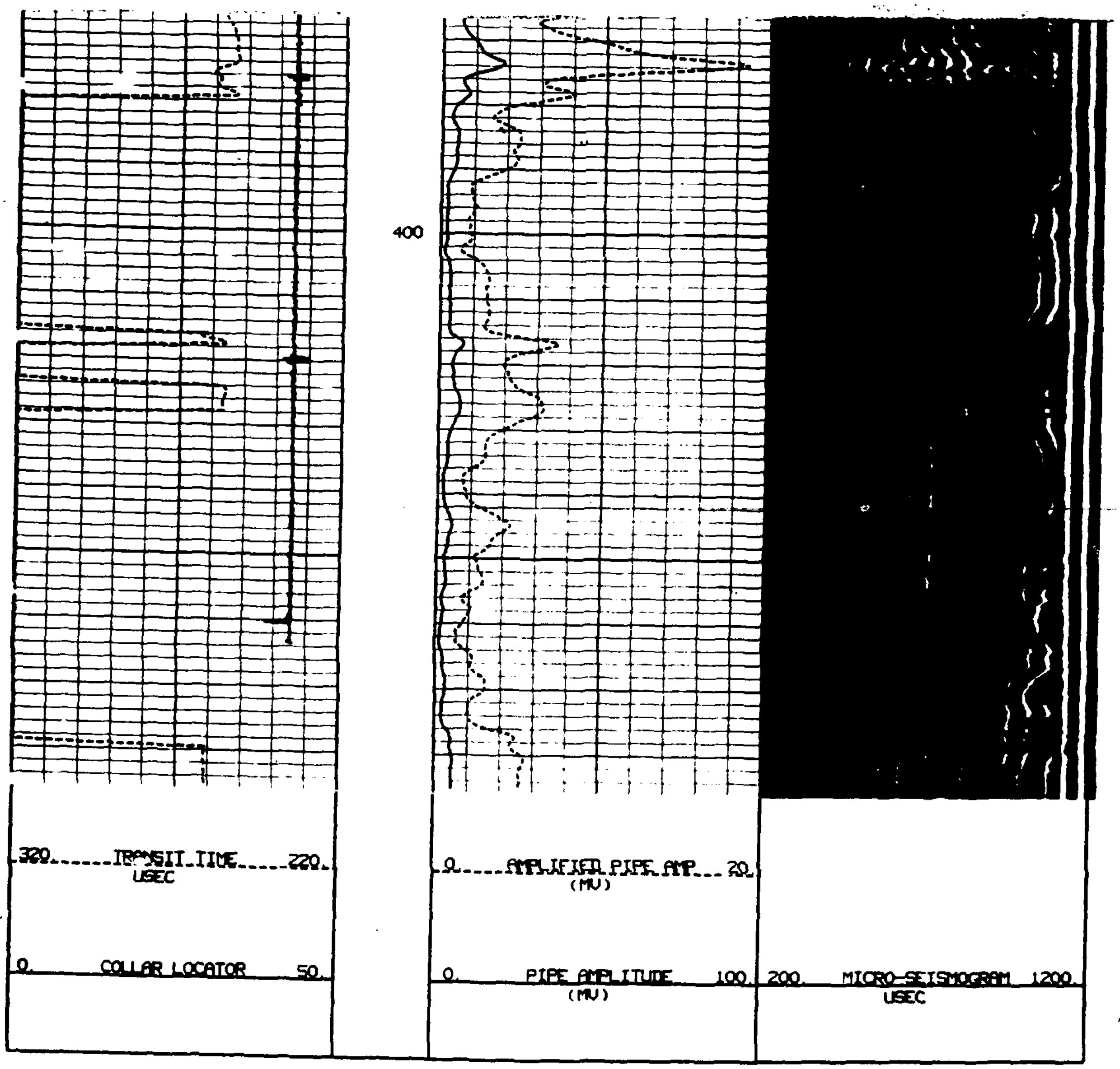
0. COLLAR LOCATOR 50. | 0. PIPE AMPLITUDE 100. (MV) | 200. MICRO-SEISMOGRAM 1200. USEC

0. COLLAR LOCATOR 50. | 0. PIPE AMPLITUDE 100. (MV) | 200. MICRO-SEISMOGRAM 1200. USEC

320. TRANSIT TIME 220. USEC | 0. AMPLIFIED PIPE AMP 20. (MV)



7



400
320. TRANSIT TIME 220.
USEC
0. COLLAR LOCATOR 50.
0. AMPLIFIED PIPE AMP 20.
(MV)
0. PIPE AMPLITUDE 100.
(MV)
200. MICRO-SEISMOGRAM 1200.
USEC

WELL LOCATION

WELL NAME

8

ENG H L S DLS CH V4.32 LIS 03/08/91

LOG TAPE ID 00007000

DATE 12/19/91

WELL LOCATION :

WELL NAME :

ENG H L S DLS CH V4.32 LIS 03/08/91

LOG TAPE ID 00007000

DATE 12/19/91

ENG H L S DLS CH V4.32 LIS 03/08/91

PARAMETER TABLE

TDRV	TNUM	RATE	TOOL	AZER	DSNR	3->6
OFF	1.	20.	271	18.	14.	NO
THS1	THS2	DIST	PID	TOD	KT	KSLS
0.	0.	2.	2.441	1.6875	1.	1.
TRIG	MSGR	VIEW	SWCH	GRDM		
NEG	AF	AN	13.	ON		
MNEU	SO	CWGT	ASKY			
CLIM	0.	0.	NO			
BS	CSIZ	TELE	LIS	DLY	DIR	PLOT
0.	7.00	YES	YES	YES	UP	FULL

ENG H L S DLS CH V4.32 LIS 03/08/91

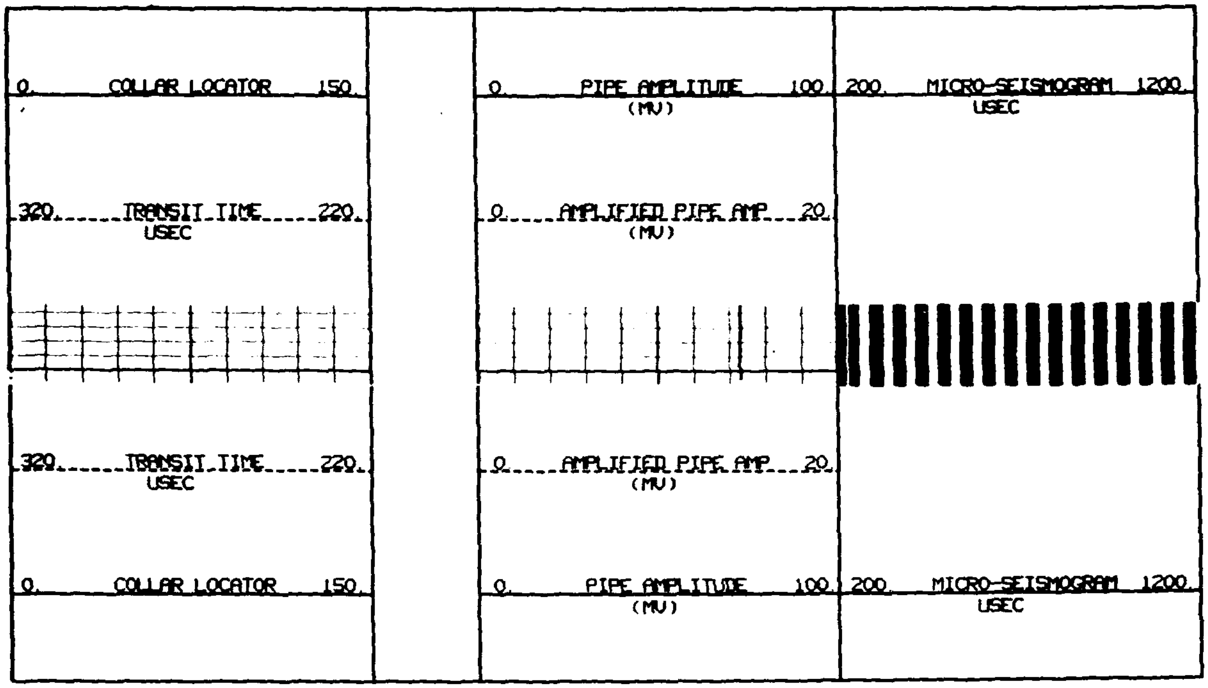
SERVICE	ID	TRK	UNIT	SCL L	SCL R	RBASE L	RBASE R	TYPE	STYP	OPFL	IPFL	OFF	LIS	CVCT 1 2L
CCL	1	1		0.	50.	Y	Y	0	LIN	0.	0.	5.	Y	YNY1
CCLU	6	1		0.	10.	Y	Y	0	LIN	0.	0.	0.	Y	QNN
AMPP	7	2	(MV)	0.	100.	0	0	0	LIN	0.	1.25	0.	Y	YNY2
APAM	5	2	(MV)	0.	20.	0	0	0	LIN	0.	0.	0.	Y	FNF
MSG	4	3	USEC	200.	1200.	0	0	0	LIN	0.	0.	0.	N	YNQ
TT	8	1	USEC	320.	220.	0	0	0	LIN	0.75	1.25	0.	Y	FNF3

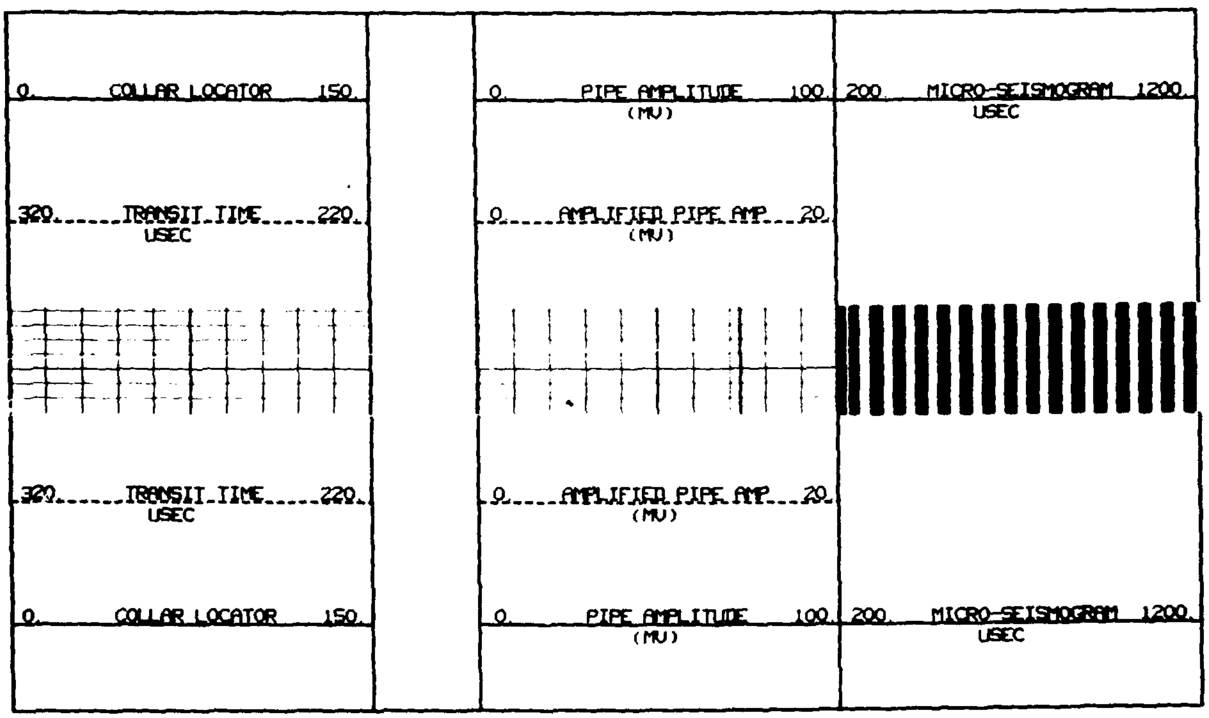
ENG H L S DLS CH V4.32 LIS 03/08/91

TOOL TABLE

SUB	SERIAL #	MODEL	SOURCE #	CALB #	NRM1	INT1	NRM2	INT2	DLY	TCH
CCL	107809	271	0	0	0.0125	0	0.	0	21.4	12
AMPP	107809	271	0	0	-0.0284	4092	0.	0	0.	24
TT	107809	271	0	0	600.85	0	0.	0	0.	20
GP1	0	0	0	0	0.	0	0.	0	0.	0
GP2	0	0	0	0	0.	0	0.	0	0.	0

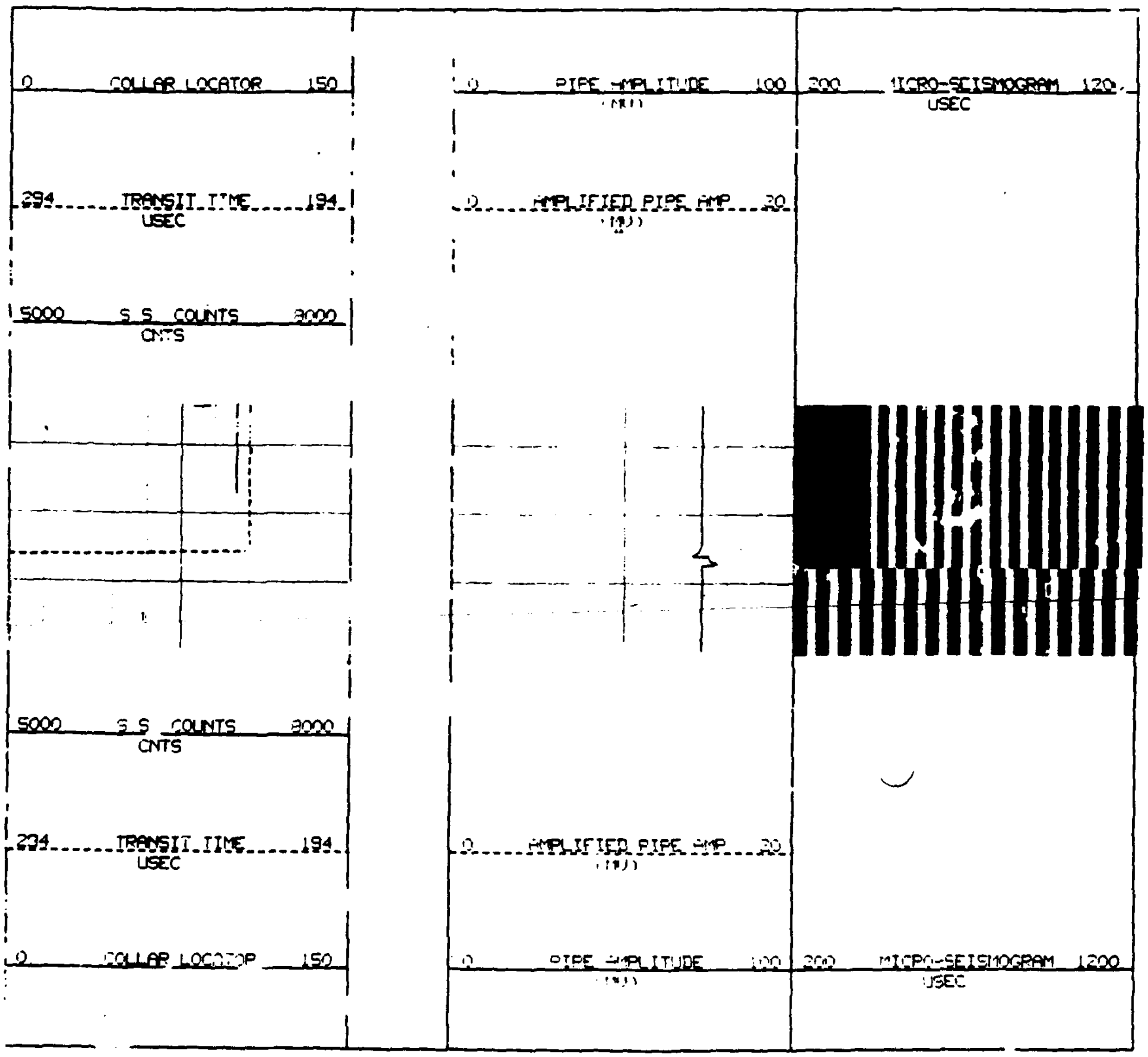
9


0. COLLAR LOCATOR 150.
0. PIPE AMPLITUDE 100.
(MV)
200. MICRO-SEISMOGRAM 1200.
USEC
320. TRANSIT TIME 220.
USEC
0. AMPLIFIED PIPE AMP 20.
(MV)
320. TRANSIT TIME 220.
USEC
0. AMPLIFIED PIPE AMP 20.
(MV)
0. COLLAR LOCATOR 150.
0. PIPE AMPLITUDE 100.
(MV)
200. MICRO-SEISMOGRAM 1200.
USEC


0. COLLAR LOCATOR 150.
0. PIPE AMPLITUDE 100.
(MV)
200. MICRO-SEISMOGRAM 1200.
USEC
320. TRANSIT TIME 220.
USEC
0. AMPLIFIED PIPE AMP 20.
(MV)
320. TRANSIT TIME 220.
USEC
0. AMPLIFIED PIPE AMP 20.
(MV)
0. COLLAR LOCATOR 150.
0. PIPE AMPLITUDE 100.
(MV)
200. MICRO-SEISMOGRAM 1200.
USEC

10

PIPE AMPLITUDE SHOP CALIBRATION
TOOL NUMBER 107809 PERFORMOED ON
12/09/91 IN 5 50 CASING WITH
500 PSI



Appendix D
Response to Comments