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ST. LAWRENCE SEAWAY ADDITIONAL LOCKS STUDY

PRELIMINARY FEASIBILITY REPORT

APPENDICES

U.S. Army Engineer District, Buffalo

JULY 1982

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report contains the supporting data for environmental, economic, geotechnical and cost estimating work. It also contains sections on public coordination and study management and a bibliography.

APPENDICES

A. ENVIRONMENTAL

B. ECONOMICS

C. GEOTECHNICAL

D. COST ESTIMATES

E. PUBLIC COORDINATION

F. STUDY MANAGEMENT

G. BIBLIOGRAPHY

APPENDIX A

ENVIRONMENTAL

ST. LAWRENCE SEAWAY - ADDITIONAL LOCKS
ENVIRONMENTAL ASSESSMENT

APRIL 1982

Buffalo District
Corps of Engineers

Summary of Environmental Assessment

Generally, Great Lakes/St. Lawrence Seaway System (GL/SLS) improvements would increase and/or extend the system's capabilities and capacities. Reduced delay at congested locks and improved vessel carrying capacity could be realized.

Limited benefits and impacts would be realized through implementation of nonstructural measures. Preliminary maximum utilization of nonstructural measure studies indicate increased capacities of from 7 to 13 percent. Any adverse effects would pertain primarily to minor construction impacts and impacts of slightly increased vessel traffic. These would be expected to be minor.

Implementation of structural measures would significantly increase the potential benefits over nonstructural measures because significantly more quantities of goods could be transported more efficiently. System capacities could more than double. On the other hand, costs and potential adverse environmental impacts would also increase. Potential adverse impacts to the natural environment pertain to those associated with construction, dredging, and resulting increased vessel traffic and/or of increased vessel size. Generally, potential adverse impacts would occur or be most noticeable in the more restrictive channel, lock and harbor areas. Reference Figures A-4a through A-4f.

Preliminary studies indicate that significant regional benefits could be realized with system improvements. Increased capacity would facilitate business, industry, and agricultural transportation needs of the Great Lakes Region through increased capacity for shipment of anticipated increased commodities, and through rate savings resulting from continued use of the system instead of cargo being forced to use a more expensive route and mode. Some associated employment and income, and community developmental benefits might also be expected, facilitating affected system harbor community and regional stability and growth. In addition, substantial regional energy savings might be realized.

Preliminary studies also indicate that at the Great Lakes regional level, modes that would be impacted positively by implementation of system improvement programs would be the lake carriers and motor carriers. A positive impact means that the "with project case" benefits the industry by allowing it to handle traffic that would otherwise be forced off the Great Lakes/St. Lawrence Seaway System. Modes that would be impacted negatively would be: the railroads, the barge and towing industry, and the U.S. flag liner industry. A negative impact means the lock improvements would cause an alternate transportation mode industry to lose the opportunity to move traffic which would have been forced off the Great Lakes/St. Lawrence Seaway System in absence of the improvement.

Few benefits would be realized by the people or communities along the U.S. International Section of the St. Lawrence River and Seaway as a result of system improvements. Ogdensburg Harbor is the only U.S. commercial harbor along this section of the river and would not benefit significantly from Seaway improvement measures. The remaining U.S. communities along this section of the river are oriented toward recreation and tourism, and the protection of the natural and associated aesthetic and recreational environment is very important to them. Potential adverse impacts of construction, dredging, and increased vessel traffic and/or of larger vessels (and associated potential impacts) are of great concern. Significant long-term adverse impacts to the natural and associated aesthetic and recreational environment could conceivably be detrimental to the attractiveness of the area affecting community and regional (St. Lawrence River vicinity) socioeconomic growth and well being. Although no definite insurmountable long-term adverse impacts of this nature has been identified to date, this aspect should be pursued and examined in greater detail.

ST. LAWRENCE SEAWAY-ADDITIONAL LOCKS
ENVIRONMENTAL ASSESSMENT

INTRODUCTION

The St. Lawrence Seaway was opened to deep-draft navigation in 1959 at which time the Great Lakes-St. Lawrence Seaway (GL/SLS) System provided a link between the Atlantic Ocean and the United States and Canadian Ports located throughout the Great Lakes (Figure 29, Main Report). Major sections of the system include 1,000-statute miles in the St. Lawrence River, the five Great Lakes and approximately 400 miles in connecting channels. Dispersed throughout this system are 16 sets of locks which must be navigated to traverse the entire length of the system. Reference Figures A-1 and A-2, and Tables A-1 through A-3.

Since the opening of the St. Lawrence Seaway, traffic both in tonnage and tons per transit has increased. Various traffic forecast models have been devised to try to predict future trends for the GL/SLS. Trends seem to indicate that continued growth will occur for the system. However, this growth would not be unrestrained growth but in fact would be limited by system constraints, with a major one being the locks. Therefore, it is the present locks, combined with the current operating policy that will restrict future growth on the system.

As growth continues on the GL/SLS, the system steadily is approaching the limit to which it can effectively and economically operate in relation to moving bulk materials and commodities. This limit can be termed capacity. As system capacity approaches, more delays to shipping would be experienced, which translates to increases in waterborne transportation rates and subsequently to increased costs to the nation.

Study Purpose and Need for Proposed Action

The purpose of the St. Lawrence Seaway-Additional Locks Study is to determine the adequacy of the existing locks and channels in the U.S. section of the Seaway in light of present and future needs, and the advisability of their rehabilitation, enlargement, or augmentation. Because of geographic location and traffic patterns, any improvements to the U.S. locks and channels must be accompanied by like improvements to the Canadian components of the St. Lawrence Seaway and the Welland Canal. Therefore, this study will investigate the needs of present and future commerce of the Great Lakes-St. Lawrence Seaway System, and formulate plans of improvement for the U.S. section of the St. Lawrence Seaway, assuming that compatible improvements would be made to the Canadian sections and Welland Canal. These plans will be formulated to meet these needs utilizing national economic development, environmental quality, social well-being, and regional development as parameters to evaluate various plans. This study and the Great Lakes Connecting Channels and Harbors Study - which will investigate the needs of the Upper Great Lakes, connecting channels, and harbors - will be closely coordinated with synchronization of study schedules and funding, exchange of data and plan formulation results, and iterative formulation of total system improvements. Both of the final study reports will thus present the same optimized system while addressing its respective subsystem in detail.

The purpose of this Environmental Assessment as prescribed by the Council on Environmental Quality (CEQ) for implementing the procedural provisions of the National Environment Policy Act (NEPA) (40 CFR Parts 1,500-1,508) is to:

a. Facilitate procedures adapted by the U.S. Army Corps of Engineers to assist agency planning and decision making;

b. Briefly provide sufficient evidence and analysis for determining whether to prepare an Environmental Impact Statement (EIS) or Finding of No Significant Impact (FONSI). NOTE: Although, for a study of this scope the need for an EIS is generally forthright; and,

c. Facilitate preparation of the EIS.

ALTERNATIVES

INTRODUCTION

The alternatives are presented here in tabular form (Tables EA2 and EA3). The Preliminary Feasibility Report (PFR) has a detailed narrative of all the alternatives. The Nonstructural Alternatives Concepts 1 through 5, and Navigation Season Extension Concept 12 were not assessed because they are outside the authorization of this study. Alternative DV1130 was not assessed because it was determined not to be engineeringly feasible.

The exact locations - alignments - where the new locks would be constructed are not currently known. The new lock system would be constructed in the general vicinity of Massena, NY (ref. Figures A-3a and A-3b). Also, all areas of channel modification are not known but Figures A4a through A4f, in the Environmental Appendix, give general locations where some dredging and/or channel modification would be necessary. Table 33 in the Main Report, indicates approximate quantities of material to be excavated and/or dredged for various alternative measures from proposed locations referenced on maps in the Environmental Appendix. In the description of the type of vessels, the term "class" is utilized. The class of a vessel refers to the vessel size. See Table EA1 below.

Table EA1 - Vessel Size

Vessel Class	Length (feet)
7	700-730
8	731-849
9	850-949
10	950-1099
11	1100-1199
12	1200-1299

Table EA2

Measures/ Plans	Nonstructural: Change Operating Procedures	Quasi-strucutural: Improve Efficiency of Existing Docks	Structural: Build Locks	Structural: Improve Navigation Channels	Plan Description
No Action (NA)	-	-	-	-	Maintain existing project with no changes.
Concept 1	+	-	-	-	N-up/N-down (change in operature procedure)
Concept 2	+	-	-	-	Favor cargo-carrying ships.
Concept 3	+	-	-	-	Favor larger ships.
Concept 4	+	-	-	-	Favor lake ships over ocean ships.
Concept 5	+	-	-	-	Congestion tolls.
Concept 6	-	+	-	-	Traveling kevels.
Concept 7	-	+	-	-	Increase ship speed entering the locks.
Concept 8 and 9	-	+	-	-	Decrease lock chambering times.
Concept 10	-	+	-	-	Traffic control system.
Concept 11	-	+	-	-	Nonstructural improvement to maximum utility (combine Concepts 6, 7, 8, and 10).
Concept 12	+	+	-	-	Extend the navigation season up to 10 months.
CVII30	-	-	-	+	Deepen the Seaway from the existing 27.0 feet to 30.0 feet below LWD.
RX27	-	-	+	+	Build two low-lift locks to replace the current locks. The new locks sizes are 115 feet wide by 1,200 feet long. Channel improvements would involve widening only to accommodate the new maximum ship size (105 feet wide by 1,000 feet long).

Table EA2 (Cont'd)

Measures/ Plans	Nonstructural: Change Operating Procedures	Quasi-strucutural: Improve Efficiency of Existing Docks	Structural: Build Locks	Structural: Improve Navigation Channels	Plan Description
RX30	-	-	+	+	Same as RX 27 except deepen the channel from 27.0 feet to 30.0 feet below LWD.
RX32	-	-	+	+	Same as RX 27 except deepen the channel from 27.0 feet to 32.0 feet below LWD.
RXI27	-	-	+	+	Build two low-lift locks to replace the current locks. The new lock sizes are 115 feet wide by 1,350 feet long. Channel improvements would involve widening only to accommodate the new maximum ship size (105 feet wide by 1,100 feet long).
RXI30	-	-	+	+	Same as RX I27 except deepen the channel from 27.0 feet to 30.0 feet below LWD.
RXI32	-	-	+	+	Same as RX I27 except deepen the channel from 27.0 feet to 32.0 feet below LWD.
RXII27	-	-	+	+	Build two low-lift locks to replace the current locks. The new lock sizes are 145 feet wide by 1,460 feet long. Channel improvements would involve widening only to accommodate the new maximum ship size (130 feet wide by 1,200 feet long).
RXII30	-	-	+	+	Same as RX II27 except deepen the channel from 27.0 feet to 30.0 feet below LWD.
RXII32	-	-	+	+	Same as RX II27 except deepen the channel from 27.0 feet to 32.0 feet below LWD.
RX27T	-	-	+	+	Build two low-lift locks to replace the current locks. The new lock sizes are 115 feet wide by 1,800 feet long. Channel improvements would involve widening only to accommodate the new maximum ship size (105 feet wide by 1,000 feet long).
AVII27	-	+	+	+	Add nonstructural improvement to maximum utility (Concepts 6-11). Once capacity is reached, build comparable size (80 feet wide by 860 feet long) locks (two "twin" adjacent to the existing locks) to complement the existing locks (operate both as parallel systems). Channel improvements are needed to allow entrance and exit to the new locks only.

Table EA2 (Cont'd)

Measures/ Plans	Nonstructural: Change Operating Procedures	Quasi-strucutural: Improve Efficiency of Existing Docks	Structural: Build Locks	Structural: Improve Navigation Channels	Plan Description
AX27	-	-	+	+	Operate the existing locks in their present condition. When the Welland Canal improvement is made, add two new low-lift locks (size: 115 feet wide by 1,200 feet wide) to parallel the existing locks. Channel improvements will be required to service the new locks and widen to accommodate the new maximum ship size (105 feet wide by 1,000 feet long) with two-way traffic. No deepening.

Symbols for Measures/Plans

R = Replace Lock(s)
A = Addition of Parallel System
Roman Numeral = Class of Vessel (e.g., XII refers to a Class 12 vessel)
# = Channel Depth (27 feet, 30 feet, 32 feet)
T = Tandem Lock

Example: RX 27T (replace locks with capacity to handle Class 10 vessel at a 27-foot channel depth using a tandum lock design).

Table EA3 - Summary of Structural Plans/Alternatives

Lock Plan/ Channel Depth (ft)	Replace Existing System				New Locks and Existing System	
	110 Feet W X 1,200 Feet L Poe-Sized CX	115 Feet W X 1,350 Feet L CXI	145 Feet W X 1,460 Feet L CXII	115 Feet W X 1,600 Feet L Tandem-Sized 2CVII or 1CX	CVII 80 Feet W X 800 Feet L Parallel Svs. of Seaway-Sized Locks	CVII-CX 110 Feet W X 1,200 Feet L Parallel Sys. Seaway-Sized Poe-Sized
27.0 (26.0 Draft)	RX.'7	RXI27	RXII27	RX27T	AVII27	AX27
30.0 (28.0 Draft)	RX30	RXI30	RXII30	NE	NE	NE
32.0 (30.0 Draft)	RX32	RXI32	RXII32	NE	NE	NE

NE = Not Evaluated.
Roman Numeral = Class of Vessel (e.g., XI = Class 12 vessel)
= Channel Depth (27 feet)

EXISTING CONDITIONS

PHYSICAL ENVIRONMENT

Air Quality

Much of the Great Lakes population is centered around large industrialized centers which produce the majority of pollutants of the region. Air pollution not only affects these industrialized areas, but suburban and rural areas can be affected as well. To help reduce air pollution, the Federal Government enacted the Clean Air Act of 1975, and all the Great Lake States have air quality standards set by the U. S. Environmental Protection Agency (EPA) under the act, as well as plans acceptable to meet the Federal Standards.

New York State's existing air quality classification system is divided into four levels:

Level I : Predominant use is for timber, agricultural crops, dairy farming, or recreation. Human habitat and industry sparse.

Level II : Predominantly single and two-family residences, small farms, limited commercial services and industrial development.

Level III : Densely populated, primarly commercial office buildings, department stores, and light industries in small and medium metropolitan complexes, or suburban areas of limited commercial and industrial development near large metropolitan complexes.

Level IV : Densely populated, primarily commercial office buildings, department stores, and industries in large metropolitan complexes, or areas of heavy industry.

Part 256 of Title 6 - Compilation of Codes, Rules, and Regulations of the State of New York - Subchapter A of Chapter III (Environmental Conservation Law).

The St. Lawrence River is generally classified Level I, except for two areas classified Level II and one area classified Level III. The areas classified Level II are the corporate city limits of Ogdensburg and the corporate city limits of Massena. However, there is an area within the corporate limits of Massena which encompasses some of the St. Lawrence River in the area of the town of Massena, classified Level III.

Water Quality

The Great Lakes-St. Lawrence River system is one of the most unique freshwater resources in the world. It serves as a valuable transportation route, supports a significant fishery both commercial and recreational, and provides vast quantities of clean water for both industrial use and individual consumption. Unfortunately, it also serves as a depository for the by-products and wastes of the populace and industries that line the shoreline of the lakes and their tributaries.

The Government of the United States has undertaken the commitment to "clean up" the Great Lakes system. The means by which improvement in water quality is expected to happen is twofold. First, the Federal Water Pollution Control Act Amendments of 1972 (Public Law 92-500), which dictates to the States that:

> ". . . by July 1983, waters will be clean enough for swimming and recreational uses and clean enough for the protection of fish, shellfish, and wildlife wherever possible, and to have no discharges of pollution into the nations waterways by 1985. This law pertains to all waters within the United States, but should aid significantly in the recovery of the Great Lakes."

The second means for improving water quality in the Great Lakes is the 1978 Canada-United States Great Lakes Water Quality Agreement. This agreement demonstrates the commitment by both Governments to improve water quality by trying to maintain the chemical, physical, and biological integrity of the waters of the Great Lakes through elimination of point and nonpoint source pollution discharges into the Great Lakes-St. Lawrence River system.

Water quality within the New York State portion of the St. Lawrence River is designated Class "A" by the New York State Department of Environmental Conservation (NYSDEC). The classification system, developed by NYSDEC, was established as a classification criteria, a system based on potential use of the water, with consideration given to the existing land practices. Class "A" waters are designated as suitable for drinking, culinary or food processing purposes, and any other usages. This is one of the highest ratings given by NYSDEC and indicates a significant resource.

Topography.

The Great Lakes-St. Lawrence Seaway System spans two major physiographic provinces. Lake Superior, the St. Lawrence River, and part of the north shore of Lake Huron lie in the Laurentian Uplands Province, characterized by low-lying swamps, poorly drained areas, and occasional ranges of hills. Lake Michigan and most of Lakes Huron, Erie, and Ontario lie in the Interior Lowlands Province. In general, the topographical features of the system were created by Pleistocene glaciation. Continental ice sheets, up to 2,000 feet thick, repeatedly advanced and declined, scouring glacial valleys. As the glaciers receded, both large deposits of debris and vast sections of eroded bedrock were irregularly exposed along their paths. The present topography reflects this irregularity, having rolling hills and ridges, depressions with lakes and marshes, and both flat and sloping plains. Elevations within the system range from over 1,900 feet above sea-level at Mt. Curwood in the Huron Mountains to 152 feet above sea-level at Cornwall, Ontario. The major stream areas have a flat profile, and many of the tributary streams have reversed their flows in recent geological times.

Absent from the project area are such strong relief features as mountains, great cliffs, volcanic formations, and sharp-cut valleys. The moderate relief reaches a maximum of less than 150 feet above area water level. Despite the monotony of relief, however, there is enough system or pattern in the topography to guide all of the rivers of the region - even the St. Lawrence - which simply follows a connecting chain of original depressions in handling the overflow from the Great Lakes. It simply spilled over from one depression to another, not always in a very direct line, sometimes in violent rapids and in certain portions of its course occupying a broad valley-like depressed area with interior hilly patches which thereby became islands surrounded by stream water.

NATURAL ENVIRONMENT (Reference Table A4 and Figures A5a through A5f)

Fish.

There are more than 237 species and subspecies of fish throughout the Great Lakes-St. Lawrence River Basin, most of which are indigenous to the basin. However, with the construction of the St. Lawrence Seaway and Welland Canal, new species as the sea lamprey and alewife were able to invade the basin from the sea. In addition, exotic species are present, having been either purposely or inadvertently introduced by man.

The commercial fishery of the lakes has changed over time due to various reasons; such as poor fishery management, introduction of exotic species; and the increasing abundance of the sea lamprey. The once plentiful Lake sturgeon, Lake herring, and Lake white fish declined in the 1920's and led to heavier utilization of Blue pike and Lake trout which also declined significantly.

Presently, Yellow perch, Rainbow smelt, carp, catfish, suckers, walleye, sheepshead, and White fish have dominated the commercial fishery. Most States have stocking programs of both warm and cold water species which add significantly to the sport fishery stock.

The St. Lawrence River has an extensive fishery, comprising approximately 99 species, much of which are utilized for recreational sport fishing. Eleven species are of significant recreational importance to the economy: Smallmouth bass, White bass, Brown bullhead, walleye, White perch, Northern pike, Largemouth bass, Rock bass, Yellow perch, pumpkinseed, sunfish, and muskellunge.

The area of the existing Snell Lock in the vicinity of the Grasse and Raquette Rivers, Massena, NY, supports about 35 fish species including numerous forage fish. This vicinity provides important aquatic spawning, nursery, and feeding habitat. Studies by the U. S. Fish and Wildlife Service (1979) also indicate that another locale, the Thousand Islands area of the St. Lawrence River, is even more productive than the Lake St. Lawrence area upstream of the aforementioned Grasse and Raquette Rivers.

Wildlife.

a. Birds - Approximately 280 species of birds utilize the basin's habitat. They occur either as residents or transients. Waterfowl comprise a relatively small part of this total in comparison to their importance for recreational value.

Shorebirds, perching birds, and predatory birds can be found throughout the basin, utilizing a variety of habitats which include open land; wood lots; riparian shorelines of lakes, rivers, and streams; scrub and brush lands; croplands; pasture lands; and others.

The Massena sector of the river - present location of the St. Lawrence Seaway Locks - has many shorebirds because of the presence of numerous shallow embayments and creek outlets which are prime habitat for these species. Common tern and Ring-billed gull colonies are also frequent here. The open-water areas are important staging areas for Canada geese and migratory ducks, particularly large flocks of Common mergansers, redheads, Ring-necked and Black ducks. Up river from the locks are also important waterfowl staging areas. In contrast, the upland areas in the vicinity of the locks are dominated by Red-wing blackbirds, sparrows, starlings, and American robins (FWS 1979).

b. Mammals - The basin is comprised of 84 million acres of land in the U. S. portion, 75 million acres of which are habitat of varying degrees of quality for a variety of wildlife. The most important big-game animal found throughout the basin is the White-tailed deer; there are also some Black bear. A number of species of smaller animals such as Cottontail rabbit, Snowshoe hare, Gray squirrel, Fox squirrel, muskrat, beaver, raccoon, otter, mink, weasels, woodhuck, Red fox, bobcat, coyote, porcupine, and others inhabit the basin. The portion of the basin north of the 43°N latitude line is forested and only lightly settled. The supply of wildlife habitat (other than croplands) is generally good in this region. Below the 43rd parallel or below the imaginary line between Milwaukee and Buffalo, the basin is heavily settled and has seen extensive industrial and agricultural development. Cropland habitat is the dominant type in this region.

The St. Lawrence River region supports a variety of mammal species that includes big game, such as deer and bear and many of the aforementioned small-game species. The muskrat is the most economically important species. The Massena area, vicinity of the locks, supports 18 species of mammals that are commonly found, 19 others that are either common to rare, rare or seasonally found, with the majority of species being located in the hardwood areas (FWS 1979).

c. Amphibians and Reptiles - The Great Lakes Basin contains approximately 17 species of reptiles and 12 species of amphibians. This includes various species of turtles, snakes, frogs, and toads.

In the Massena area, most upland, wetland, and pond habitats have some frogs and toads. The lock area - Wiley - Dondero Canal/Robinson Creek area - however, has no significant amphibian and reptile resource due to the rapid water level fluctuations from lock operations. The adjacent mature forests do provide cover for more terrestrial amphibians (FWS 1979).

Vegetation

The natural vegetation patterns of the Great Lakes-St. Lawrence River Basin have been greatly modified by man's activities. Much of the once forested land area and shoreline wetlands have been replaced by urban, industrial, recreational, and agricultural development.

Virgin forests still exist, but to a significantly lesser degree in the north woods country of Michigan, Wisconsin, and northern Minnesota. However, the predominant natural vegetation surrounding Lake Erie, Lake Ontario, and southeastern sections of Lakes Huron and Michigan are the broadleaf deciduous forest types, which includes species of oak, hickory, maple, Black cherry, ash, poplar, and a variety of other hardwood trees. Stands of pine and spruce dominate western and northern portions of Lake Superior. In addition, prairie grasslands, wetlands, bogs, and beach areas are interspersed throughout the basin, each with its own unique vegetation types.

The Great Lakes system has thousands of miles of shoreline. Extending out from the shore, to a depth of usually less than 6 meters (approximately 20 feet), is the littoral zone. This zone contains the rooted and free-floating aquatic plants. Major plant species in these communities are water celery, flat-stem pond weed, coontail, water star flower, and waterweed. Located in the shallower areas, such submergent macrophytes as duckweed and additional pond weeds (Potamogeton spp.) became abundant. Pond lilies are common in the shallower embayments, more protected from wave action.

Undisturbed forest areas are rare in the St. Lawrence River Valley. The shoreline vegetation is made up of approximately one-quarter successional fields. This valley has also been developed, as has the whole Great Lakes Basin. The Massena area has basically six cover types: shrubland, deciduous forest, coniferous forest, open areas, wetlands, and urban-industrial areas. The open areas include open fields, agricultural fields, and powerline rights-of-way. The typical vegetation of this cover type are grasses, goldenrod, and milkweed. The shrublands are a successional intermediary between open fields and deciduous forests. Common species in shrublands are hawthorn, buckthorn, staghorn sumac, dogwood, willows, and others (FWS 1979).

Wetlands

The wetland ecosystem is very important to the Great Lakes-St. Lawrence River Basin. Wetlands generally include swamps, marshes, bogs, and similar areas such as sloughs, pot holes, wet meadows, river overflows, mud flats, and natural ponds.

Wetlands form the transition zone between water and land environments and serve multiple functions. They may serve as a spawning and nursery habitat for fish; provide feeding and nesting areas for waterfowl and other fauna; improve water quality by filtering organic and inorganic sediments and pollutants; moderate flooding by storing water; act to recharge groundwater;

and protect shoreline areas by dissipating wave action. They also contribute to local economics by providing the public with such recreational opportunities as hunting, fishing, and bird watching.

The St. Lawrence River system supports large quantities of wetlands, with approximately 7,000 acres in the U. S. Section alone (IJC 1981). However, in the Massena area, wetlands are few and small in size. Most wetlands are located in and along the rivers and consist mainly of emergent cattails (FWS 1979).

Benthos

Benthic communities refers to organisms attached, resting, or living in bottom sediments. Many of these organisms are utilized as food by larger individuals making them an important part of the food web.

It has long been known that benthic organisms provide an excellent indicator as to the conditions present in aquatic environments, and that the benthic fauna of the Great Lakes is a sensitive indicator of aquatic environment condition (Hynes 1980).

The Great Lakes-St. Lawrence Basin is a large system which varies in water quality and substrates from lake to lake, and may even vary in relatively adjacent areas located on the same lake or river. Bottom composition is also a significant determinant as to the type of benthic organisms present. Therefore, benthic populations are usually specific to substrate type and would have to be specifically inventoried for each bottom site proposed for modification.

In the St. Lawrence River, fine particle-feeding mollusks dominate the upriver area (Cape Vincent area), while the communities downstream (area of locks) are more coarse-particle feeders. Down-river benthic organisms are dominated by chironomids, nematode, and caddisfly larval. In the Massena area, the abundance of biomass (amount of living organisms), and diversity of benthic organisms is considerably lower in the Wiley-Dondero Canal than in the rest of the river, and species composition is relatively similar throughout this area (FWS 1979).

Threatened and Endangered Species

A number of plant and animal species within the Great Lakes-St. Lawrence River Basin are considered threatened or endangered. As such, these species are protected by State and/or Federal Regulations. The list of endangered and threatened wildlife and plants published in the Federal Register, dated 20 May 1980, in accordance with the Endangered Species Act of 1973 lists the following species: Indiana bat, Eastern cougar, Gray wolf, Bald eagle, American Peregrine falcon, Arctic Peregrine falcon, Longjaw cisco, Blue pike, and one plant species - Northern wild monkshood.

Each State around the Great Lakes has its own list of endangered species. New York State, through the Department of Environmental Conservation, has produced a list of endangered species of fish and wildlife. In addition, there is an extensive New York State list of protected plants, which is currently being updated and revised and may be available in April 1982.

The St. Lawrence River area is known to support three endangered species: Bald eagle, American Peregrine falcon, and Indiana bat. In addition, a Blanding's turtle (proposed for "Threatened Status" by NYSDEC) was seen at the existing lock area in the 1978-1979 sampling period. Once a final plan is selected, the exact project site would have to be more fully coordinated with NYSDEC and the USFWS and perhaps surveyed, if needed, to ensure that consideration was given to known and identified protected plant and animal species.

Prime and Unique Farmlands

According to Executive Memorandum, dated 30 August 1976, impacts to prime and unique farmlands must be assessed. In the area of the existing locks, there are no farmlands designated prime or unique (U. S. Department Agriculture, 1977) (reference Figure A6).

HUMAN ENVIRONMENT (Reference Figures A1 and A2)

Population.

Most of the 29 million residents within the Great Lakes/St. Lawrence Seaway Basin are located within urban port areas along the shores of the lower Great Lakes (Michigan and Erie). Major urban developments include Milwaukee, WI; Chicago, IL; Detroit, MI; Cleveland, OH; and Buffalo, NY. More than 80 percent of the basin can be found in these major urban centers. The contribution of each Plan Area to total population distribution in 1970 is summarized in Table A5.

The northern and inland portions of the Basin are more sparsely populated relative to other areas located along or near the Great Lakes shoreline. Population densities are lowest in the northern portions of Minnesota, Wisconsin, Michigan, and New York; this characteristic may be attributed to the isolation and more severe winters.

The Great Lakes Basin has contained 14 to 15 percent of the U. S. population over the period 1950 to 1975. During this interval, the Lake Michigan Plan Area included about 45 percent and the Lake Erie Plan Area contained approximately 39 percent of the total population in the Great Lakes Basin. The remaining three Plan Areas (Ontario, Huron, and Superior) contained 9, 4, and 2 percent; respectively.

Total population of St. Lawrence and Jefferson counties which border the immediate project area (reference Figure A2), as of 1970, was 200,499. St. Lawrence County had the larger population of the two, with 111,001, while Jefferson County had a population of 88,508. The city of Ogdensburg, with a population of 14,554, the village of Massena, with a population of 14,042, both of which are located in St. Lawrence County, and the city of Watertown, located in Jefferson County and with a population of 30,787, comprise the major political subdivisions in the area. As of 1970, racial minorities accounted for less than 1 percent of the total population in both counties. Median age for St. Lawrence County, at 24.5, was almost 6 years younger than that of New York State as a whole, while the median age of Jefferson County's population in 1970 shows a very modest growth trend for Jefferson County through 1970, with a net increase of slightly less than 2,000 over the entire 20-year period. St. Lawrence County experienced a considerably greater population increase from 1950 to 1960, at more than 12,000, but had only a modest gain of 752 from 1960 to 1970. Rural residents of Jefferson County, as of 1970, constituted approximately 61 percent of the total population, while about 56 percent of St. Lawrence County's residents were classified as rural. A historical profile of the distribution of the 1970 urban and rural populations in these two counties is shown below (Table EA4). Historical population changes for the study area are presented in Table A8.

Table EA4 - Distribution of the Population

	Population (1970)	Urban Pop. (1970)	Rural Pop. (1970)	Percent Urban	Percent Rural
St. Lawrence County	111,991	49,553	62,438	44.2	55.8
Jefferson County	88,508	34,676	53,832	39.2	60.8
Total	200,499	84,229	116,270	42.0	58.0

The St. Regis Akwesasne Indian Reserve is located on the St. Lawrence River, at the junction of the boundaries of the Provinces of Quebec and Ontario and the State of New York. The Reserve straddles the international boundary and includes within its area a number of islands, the largest of which is Cornwall Island. This area of New York State and Canada has been Mohawk hunting territory. The St. Lawrence County map indicates that this area was occupied intermittantly by tribes of the Iroquois and Huron Algonquin from Canada, both using it for hunting and fishing grounds.

Estimates indicate that there are some 5,500-6,000 Mohawks living in Akwasasne. The population is constantly fluctuating for cultural and social reasons. People frequently travel between one Native area and another and may stay for long periods of time. People may leave to look for work in other parts of the State or Country and then return. "Akwasasne Notes," (Lyons 1981), a periodical published by the Mohawks at Akwasasne, estimates the residents on the American side of the reservation to number 2,500-3,000 as of December 1972. Others note some 4,200 Indians on Cornwall Island, Canada (MacLeans 1980).

Employment.

Employment trends for the eight States bordering the five Great Lakes have paralleled national employment shifts for most major employment sectors during the period 1940-1970. Declines in employment have been concentrated in the primary sector (agriculture and mining) while strong gains in the secondary and tertiary sectors contributed to increases in total employment both in the Great Lakes region and in the United States. Historical employment shifts in the Great Lakes region relative to the United States is illustrated in Tables A6 and A7.

The combined number of employed persons in Jefferson and St. Lawrence Counties, as of 1970, was 67,543 out of a total labor force of approximately 71,557. Of those employed, approximately 68 percent were classified as private wage and salary workers, 10.6 percent were self-employed, and less than 1 percent were classified as unpaid family workers. Operatives represented the largest single occupation group, accounting for 17.5 percent of the total, followed by clerical workers (15.4 percent), craftsmen and foremen (14.7 percent), service workers (14.1 percent), and professional and technical workers (13.5 percent). Operatives also constituted the single largest occupation group in St. Lawrence County (17.1 percent), followed closely by service workers (17 percent), professional and technical workers (15.4 percent), clerical workers (13.9 percent), and craftsmen and foremen (13.6 percent).

Business concerns engaged in manufacturing represented the largest single source of employment for workers in Jefferson County (23.4 percent), followed by professional and related services (19.2 percent), and retail trade establishments (17.4 percent). Professional and related services accounted for 28.7 percent of employed persons in St. Lawrence County in 1970, followed by manufacturing concerns (20.4 percent) and retail trade establishments (15.2 percent). An overview of the employment characteristics in the region can be found in Tables A9 and A10.

Income.

Historically, total personal income and per capita income within the eight States bordering the Great Lakes can be attributed to a heavy concentration of industrial activity. Basin personal income per capita has averaged from 10 to 20 percent above the national average during the period 1950 to 1970. Economic centers which lead the basin in per capita income are the metropolitan areas of Chicago, Detroit, Cleveland, and Rochester.

As of 1969, median income for the 21,707 families in Jefferson County was $8,696. Of these, the largest percentage (26.5 percent) fell into the $10,000 to $14,999 income range, while 24.7 percent of these families had income of $7,000 to $9,999. Among persons 14 years and older in Jefferson County who had some income, more than 52 percent had incomes of less than $4,000. Median income for the 24,765 families in St. Lawrence County, as of 1969, was $8,667 and 51.2 percent of these were evenly divided between the $7,000 to $9,999 and the $10,000 to $14,999 income categories. Both counties lagged well behind New York State in median income for both families and individuals, with the exception of the village of Massena in St. Lawrence County, which closely compared to Statewide median income for both categories. Family income and the distribution of income by group are included in Tables A11 and A12 .

Economic Development.

The physical environment of the Great Lakes Basin has exerted a strong influence over the level and distribution of population and type and distribution of economic activities. The most significant single element is the existence of the five Great Lakes, the largest series of freshwater lakes in the world. This source of water, in addition to abundant mineral resources and large agricultural potential found in the area, has allowed a highly industrial and agricultural area to develop which supports 14 percent of the U. S. population and 4 percent of the total U. S. surface area and contributes a more than proportional share of national economic activity.

The Great Lakes Basin is centrally located between the nation's important agricultural production regions of the north central States and the heavily populated eastern markets. A heavy dependence upon forest and mineral resources has developed in northern parts of the basin, and this area is also the beneficiary of a heavy, seasonal inflow of recreationists and tourists. Low levels of family income are found in this part of the basin - a predictable result of poor farming base experiencing a net outmigration of population.

Manufacturing activity is concentrated within the central part of the basin. Along the lakeshore, there are centers of iron and steel, chemical, and petroleum production. Agricultural activity is pursued throughout the basin although the most productive areas are found in the southern part. Specialized crops can also be found along various lakeshore areas, which experience delayed initial frosts in the fall and later than usual spring thaw - commonly known as "lake effect."

Early economic development and population growth in the basin has been attributed to the vast fresh water resources in the Great Lakes. By the middle of the 18th Century, iron, copper, timber, and agricultural resource development led to a need for transportation of bulk commodities within and between each Great Lake subbasin. This began an era of social investment in Great Lakes navigation facilities which has continued to date. Railroad linkages to major cities and ports along the five lakes also encouraged economic growth. This geographic region has all the attributes necessary for sustained long-term economic growth: fresh water supply, mineral resources, and waterways and connecting channels, capable of water-borne movement of bulk commodities at a low cost.

The economic base of most northern New York counties have been strongly influenced by an abundance of natural resources. Levels of primary industrial activity (forestry, farming, and mining) have declined over the last few decades, and now there are large tracts of land which are not utilized at their maximum potential. The St. Lawrence and Lake Ontario lake plain region, traditional center for regional agricultural pursuits - especially dairy farming activity, has followed national agricultural trends of decreasing agricultural acreage and declining number of farms. Outputs of this phenomena are increasing average farm size and increased levels of food and fiber production. Recreation and tourism are extremely important developments in the St. Lawrence River region and are closely associated with the quality of natural resources.

Land Use and Development.

The U. S. portion of the Great Lakes-St. Lawrence system comprises 64 percent of the total land area (83.6 million acres). The major land uses within this section are forest lands (47.4 percent), agriculture (38.4 percent), urban development (8.4 percent), and miscellaneous uses (5.8 percent). Eighty percent of the U. S. land area is in private ownership. The remainder is owned by Federal, State, and local Governments, mostly in the form of forest, parks, and recreational lands.

Forest land covers nearly one-half of the region, but it is not uniformly distributed. Most of the basin was forested prior to the early 1800s'. Initial cutting and clearing was for agricultural use, but by the last half of the 19th century, increased development of lumbering and other wood-using industries took place. By the early 1900's this resource was depleted, and these industries moved to other areas. Much of the forest lands have been reestablished by natural regeneration and forest management activities.

Extensive agricultural lands exist in Ohio, Pennsylvania, New York, and lower central Michigan. About 28.6 million acres are in cropland and 3.5 million acres are in pasture range. Potatoes, fruit crops, truck crops, and dairying dominate the agricultural scene.

While representing only 8.4 percent of the total land use, urban development areas have a considerable influence over land use decision. More than one-third of the total agricultural lands are located within Standard Metropolitan Statistical Areas, where most of the future urban growth is expected.

Shorelands, with their opportunity for waterborne commerce, water supply, and recreation, have been the focus for development in the region. Of the 432 miles of shoreline along the St. Lawrence River (islands included), approximately 58 percent has some type of development. Recreational facilities and summer cottages represent the bulk of this activity. Frequently this development has occurred within the first 200 to 300 feet inland of the water's edge, with the most inland areas being used for agriculture or left undeveloped. Reference Table A12 and Figures A7a and A7b.

In a technical report entitled, "Development Suitability," the St. Lawrence-Eastern Ontario Commission (SLEOC) classified the region's shorelands as either least suitable or most suitable for development. The report states that rapid land use change is occurring in the area due to highway construction, decreasing farm viability, and increasing demands for seasonal homes and recreational facilities. The SLEOC study examined a shoreline strip approximately 1 mile wide, extending the entire reach of the St. Lawrence River and Eastern Lake Ontario. The study excluded those areas which were already developed, or which had been given a high priority use for environmental protection by the New York State Office of Planning Services. It did mention, however, that much of the previous development has occurred on poorly suitable sites.

There are over 250 recreational facilities within the project, mostly all of which are water-oriented. The majority of these have been developed since the 1938 opening of the Thousand Island Bridge. There was an increase from seven marinas and eight State parks in 1938 to 40 marinas and 22 State parks in 1970. At the present time, Cape Vincent, Clayton, Alexandria Bay, and Thousand Island Pards Area are the major resort centers in the region. These centers contain both public and private recreational facilities and have taken the heaviest development pressure. The State parks alone can handle 800,000 campers, and they attract more than 1 million visitors annually.

Recreation. (Reference Tables A13 through A16 and Figures A8a through A8f)

The Great Lakes-St. Lawrence River Basin has 17.8 million acres of public recreation areas. There is a great diversity of outstanding natural features such as forests, meadows, marshes, shorelines, islands, streams, and lakes (both the Great Lakes and inland lakes). Many of these areas have exceptional scenic, wilderness, and aesthetic qualities which make them nationally significant. Recreational resources are not evenly distributed, being mostly located in the drainages of Lake Superior, Lake Ontario, and the northern parts of Lakes Michigan and Huron. Tourism reflects this uneven distribution, with most of the popular tourist areas being found in these drainages.

In 1970, there were 1,378 acres in national park and wilderness areas and over 540,000 acres of State and local parks. The 1970 estimate of 637.1 million recreation days is expected to increase to 861.3 million user days by 1980 and to 1,863.6 million days by the year 2020. (These figures do not include the man-days spent for fishing, hunting, and trapping, or the recreation days for the use of all-weather terrain vehicles such as snowmobiles.)

Recreational problems include land-use competition, high acquisition costs for lands, public opposition and legal restraints on recreational development, overuse of existing areas, inadequate planning, and environmental degradation. This last category is one of the greatest problem areas. Since 1961, a number of Great Lakes beaches have been closed due to polluted waters. Soil erosion and sedimentation, disposal of dredge spoils, solid waste disposal, thermal waste disposal, and air pollution are a few of the contamination sources adversely affecting the Great Lakes-St. Lawrence River Basin recreational resources.

There are some 250 recreational facilities (combined public and private) within the project area (Table A13). Virtually all of these facilities are directly or indirectly water-related. The majority of these facilities have been developed since the 1938 opening of the Thousand Island Bridge. As an example, in 1938, there were seven marinas and eight State parks in the region. By 1970, these facilities have grown to 40 marinas and 22 State parks. The State parks can handle up to 800,000 campers each summer, and they attract more than 1 million visitors annually.

As mentioned, most of the recreational facilities are water-related. The water-oriented activities include swimming, boating, water skiing, fishing, and waterfowl hunting. The extensive water areas also supply and aesthetic backdrop for the activities located along their shores, such as camping, sunbathing, picnicking, hiking, and golfing, to name a few. In addition, the fisheries and wildlife resources of the area attract vacationing sportsmen and naturalists, and the close proximity of an international border and close range views of ocean-going vessels attract visitors along the St. Lawrence Seaway.

The sportfisheries resource is a major attraction for tourists and is a multi-million dollar industry. The anglers fishing the St. Lawrence River in 1973 spent an estimated $4.9 million in the area in fishing-related expenses, $2.0 million in outside area travel expenses, and $5.0 million for major equipment expenditures (e.g., boats, campers, special clothing) used mainly for fishing.

The St. Lawrence River ranks first among New York State waters for harvest of largemouth bass, northern pike, and muskellunge, and second for smallmouth bass, panfish, and bullheads.

Ice fishing accounts for almost 98 percent of all winter use of the St. Lawrence. Several annual ice fishing derbies are held within the region. Over 2,800 people registered (collectively) for the five derbies held during the winter of 1975-76.

Boating and its support activities are an important part of the recreational-based economy along the St. Lawrence. A 1975 inventory of marinas and boatyards by the St. Lawrence Eastern Ontario Commission showed 65 commercial and 25 public facilities located along the river (reference Table A16 and Figure A8a through A8f).

Hunting is another substantial recreational activity. Waterfowl is the most sought after type of game, with big game (deer and bear) and small game (pheasants, rabbits, squirrels, and varmints) ranking second and third, respectively.

Camping is another major recreational activity. It serves as either the primary activity or as a base for other activities (e.g., boating, fishing, etc.). There are numerous public and private facilities along the St. Lawrence River, including 19 State parks. Tables A14 and A15 list some of these areas and facilities.

Transportation Resources.

Five Great Lakes and the St. Lawrence River comprise a navigation network which provides access to many important industrial centers and agricultural production areas in the north-central section of the United States. Two Canadian provinces, Ontario and Quebec, and eight States border the Great Lakes-St. Lawrence Seaway System. The geographic area contains almost 61 million people and has developed a commercial navigation pattern which moves large amounts of bulk and general cargo between international trading areas. There are many ports and connecting channels which have been constructed and improved over time due to increasing tonnages of grains, iron ore, coal, and manufactured goods.

There are 50 U. S. commercial harbors on the Great Lakes that have received some type of Federal support and their depths range from 16 to 28 feet. In addition, there are 15 private deep-draft harbors along the Great Lakes. A list of these harbors is included in Table A17, while the major ports can be located by reference to Figure A9. Locks have been constructed in three locations: in the St. Marys River (between Lakes Superior and Huron); in the Welland Canal (between Lakes Erie and Ontario); and in the St. Lawrence River (between Lake Ontario and the St. Lawrence River estuary). (Reference Table A3 and Figure A2.)

Water transportation to and through the project region is comprised of St. Lawrence Seaway improvements and the Oswego Canal in conjunction with the New York State Barge Canal. Seaway facilities completed in 1959 are the latest version of a long line of attempts at overcoming impediments to commercial navigation on the St. Lawrence River. The present seaway is composed of seven locks, only two of which lie within U. S. territory. Construction was completed in 1959 and has stimulated levels of traffic on the river, but at the expense of the port facilities which quickly lost their traditional function of a "lake head" transshipment point, as commerce was not able to be shipped directly to markets or to other ports further downriver (Montreal, Quebec) for transshipment to larger oceangoing vessels. This structural dislocation resulted in a decline in the use of the inter-regional rail and highway networks.

Two ports and harbors in the project area which have suffered declines in levels of commercial activity are Oswego and Ogdensburg. An analysis of the comparative statement of traffic for the period 1950-1975 (Table A18), clearly indicates a decline in port utilization which is strongly correlated to completion of seaway facilities in 1959.

Port facilities at Oswego, NY, are located at the mouth of the Oswego River and services the local area as well as the manufacturing center of Syracuse, NY. The Oswego Port Authority maintains and operates general cargo and bulk terminals including facilities for unloading grains and other dry bulk cargoes. Several piers and wharfs have railroad lines to them. Current port activity includes grain elevator storage and operations, general cargo warehousing and handling, marina and restaurant leases to private operators, cement and petroleum distribution by private operators on port-owned land. Construction of an aluminum rolling mill inland from the port has contributed to a steady flow of aluminum ingot receipts. All of the alumina ore for the mill arrives via train from Arvida, Quebec.

Port facilities at Ogdensburg, NY, are situated on the St. Lawrence River about one-quarter mile from the seaway channel and 62 miles by water from

Lake Ontario. Federal project depth at Ogdensburg is 19 feet with the exception of a small entrance channel of 28 feet, dredged and currently maintained by the Port Authority. General cargo berths capable of unloading petroleum products and some dry bulk cargoes are available. More than 8 acres of land are available for open dry bulk storage. A satellite facility located downriver at Waddington, NY, is also owned and operated by the Port Authority. Depth of water at this downriver site is reported to vary between 14 and 18 feet. Fuel oil receipts at the new Port Authority terminal was initiated in 1974 upon completion of a pipeline and this traffic currently represents a high percent of total commercial activity at the terminal.

There are four commercial airports and seven general purpose airstrips in the project vicinity area.

Two limited-access highways serve the region -Interstate 81 connects the largest city on the eastern side of Lake Ontario (Watertown, NY) to the Syracuse Metro-area to the south. This highway provides the main linkage between the Thousand Islands area with population centers located in the central portion and in the Southern Tier of New York State and the north-central portion of Pennsylvania. The second major highway is the Adirondack Northway (Interstate 87) and is roughly parallel, but on the far eastern edge of northern New York. This highway is the principal means of passenger car and truck movements between population and manufacturing centers in the Province of Quebec and eastern New York State. East-west highway routes are local and county roads which are often not maintained during severe winter conditions.

Rail service in the region is limited to freight handling. The main rail line is provided by ConRail service which connects Syracuse to Massena via Watertown with a side connection to Ogdensburg. Branch lines primarily serve a few inland mining centers. There are only a few Canadian railway linkages serving the northeastern part of Franklin County near Malone, NY.

Power Resources - Eastern Lake Ontario and St. Lawrence River - Regional characteristics of low population density, vast open and yet undeveloped areas, and easy access to the shoreline of Lake Ontario makes this part of the Lake Ontario subbasin conductive to power generation stations. Of the 29,971 MW of power currently produced in New York State, 2,605 MW or 8.7 percent is produced along the eastern shoreline of Lake Ontario and the St. Lawrence River. In addition to major facilities along the shoreline, many small hydroelectric plants are located along the rivers which enter the area from adjoining upland areas. The Power Authority of the State of New York (PASNY) accounts for 60 percent of the total power produced from this area.

PASNY owns and operates two facilities, the James A. Fitzpatrick nuclear plant (770 MW) at Nine Mile Point (Oswego County), and the Moses-Saunders Power Dam (800 MW) at Massena (St. Lawrence County) (reference Figure A2). Six privately owned power units are located on the southeastern edge of Lake Ontario. Five of these are fossil-fueled units operated by the city of Oswego, NY, while the other unit is located at Nine Mile Point (Oswego County), a nuclear plant owned and operated by Niagara Mohawk Power Corp. Additional power stations are planned for this general area.

Water-Related Resource Facilities - Table A19 indicates public water supply data for major communities along the St. Lawrence River. Figures A10a through A10f indicate location of major potable and other water intakes, outflows, channel cable crossings, ice boom anchor cables, and ferry crossings in the river.

CULTURAL RESOURCES

A predictive model survey of the U.S. portion of the Lake Ontario and St. Lawrence River shoreline is currently being conducted under contract with the State University of New York at Buffalo for the Buffalo District Corps of Engineers. This study will consist of: an inventory of known architecturally significant and historical sites, an inventory of known submerged cultural resources sites, and a model which can be used to predict archaeological sensitivity of the area.

The results of this study are expected in the fall of 1982. Initial coordination has been instituted with the National Park Service and the New York State Historic Preservation Office as of March 1982.

The St. Lawrence Eastern Ontario Commission identified a number of historic sites along the St. Lawrence River in an inventory taken in 1976. These are identified in Table A-29 and located in Figures A11a through A11f.

WILD AND SCENIC RIVERS

The St. Lawrence River is not identified as a Wild and Scenic River and this project should have no impact on such resources.

COASTAL ZONE

During Stage 3 planning, when more detailed plans are developed, any known areas within the Coastal Zone which may be significantly impacted on will be identified.

ASSESSMENT OF IMPACTS

INTRODUCTION

The following assessment of impacts groups the alternative plans into one of six categories. It is these categories that will be used to assess the major impacts that would be expected to occur to each significant physical, natural and socioeconomic parameter assessed. The categories are as follows: Category 1 - No Action; Category 2 - Nonstructural; Category 3 - Navigation Season Extension; Category 4 - Structural Modifications but retain existing dimensions for the locks; Category 5 - Structural Modifications with wider and/or longer locks; Category 6 - Structural Modifications with deeper drafts occurring in larger locks. Some alternatives however, have similar measures incorporated into them that are common to alternatives found in other categories. Where measures overlap categories, similar, as well as additional impacts would be anticipated. This overlapping can increase the magnitude of impact as well. Table EA 5 depicts the arrangement of alternatives into the various categories.

Preliminary assessment of structural alternatives for physical and natural parameters indicates that "twinning" of the existing lock system is less damaging to the environment than construction of new locks that are wider and longer in size than the existing locks, which in turn is less damaging than increasing the draft (depth) of the locks. It should be noted that for locks of greater width and length, some channels and harbors would have to be widened, and for locks with greater draft, some channels and harbors must be dredged. Some impacts become cumulative when one of the alternative plans involves dredging, lock widening, and lengthening. However, assessment of structural alternatives for socioeconomic parameters at a Great Lakes Regional Level, would probably align with the most (NED) preferred plans of acceptable environmental and social quality. Contrary to this, socioeconomic parameters, the local level (St. Lawrence River vicinity) would align with (EQ) preferred plans, since few benefits would be realized from system improvements in this vicinity, and since natural environmental and associated aesthetic and recreational resources are so important to the St. Lawrence Region. Impacts will address regional impacts (GL/SLS) first and then anticipated local compacts (St. Lawrence River area) in the Impact Assessment part of this document.

It is an assumption of this study and Environmental Assessment that annual tonnage will continue to increase over time. It is also realized that historical records indicate that the actual number of vessel transits are decreasing. This is due to larger class vessels replacing smaller class vessels when they are retired - this computes to more tons per transit. However, the present system is approaching capacity and once reached, transits and tonnage would tend to remain relatively constant. If no improvements to the system were made, the projected annual increase in tonnage would have to be diverted to another mode of transportation if demand was to be met.

Proposed improvements to the system could result in three general types of significant impacts. First, most structural plans require construction of a new lock system. This would result in construction related impacts in the Massena, NY area. It must be noted that in addition to a new lock system at Massena, an additional lock may be required to replace the existing Canadian Iroquois Lock - with an American lock at Waddington, NY. Proposed impacts of constructing this new lock at Waddington, NY, (reference Figure A3b) are not outlined in this assessment but would be expected to be similar in nature to impacts outlined for the Massena, NY area, but possibly of greater magnitude. If this measure is found to be a necessary part of future feasible plans, a complete assessment of anticipated impacts would be performed. Second, nonstructural plans, "twinning" (parallel) improvements and tandem alternatives, would result in allowing for an increase in the number of annual transits being made through the system. The fleet mix would remain similar to present conditions with twinning alternatives, but increase in average ship class would be expected with tandem plans and other parallel systems. Third, structural plans that build either wider and longer locks or increase the operating depth of the system would allow larger class vessels to operate on the St. Lawrence River. This would result in fewer overall annual transits but would actually increase the number of larger ships operating on the system. However, the associated effects of having fewer larger class vessels operating on the system are unknown. Additional information would be required to compare the increase in degree of impact if any, caused by the larger class vessel traversing the system as compared to present smaller class vessels operating on the system. Impacts specific to larger class vessels would have to be identified. Therefore, this section will only assess the impacts caused by proposed construction measures and the difference in ship transit, both increased and decreased, associated with the various alternatives. Reference Table 33, Main Report, for Summary of Impacts table.

Table EA5

Category	Alternatives
1	No Action (NA)
2	Nonstructural (i.e., traveling kevels, traffic control system, decrease lock chambering time, congestion tolls, favor cargo-carrying ships) (Concepts 1 through 11)
3	Navigation Season Extension (see Main Report) (Concept 12)
4	AVII27 ("twinning" of locks), (AX27 and Tandem plans)
5	RX27, RXI27, RXII27, RX27T, AX27 (wider and longer locks)
6	DVII30, RX30, RX32, RXI30, RXI32, RXII30, RXII32 (wider, longer and for deeper locks)

Coordination of Impacts

This study is being coordinated with the Detroit District Corps of Engineers, who is conducting the Great Lakes Connecting Channels and Harbors Study. Their study is investigating navigation improvements to locks, harbors, and channels within the upper four Great Lakes. Therefore, the major area of concern for the St. Lawrence Seaway Additional Locks Study, Buffalo District, would be from the Welland Canal up to and through Montreal, Canada. It is realized that coordination with the Canadians must be established. Currently, this assessment will place major emphasis on only the U.S. portion of Lake Ontario and the St. Lawrence River from Tibbetts Point to Cornwall Island, even though impacts will be first briefly predicted and assessed for the entire Great Lakes/St. Lawrence Seaway, and then for the St. Lawrence River area.

IMPACT ANALYSIS

PHYSICAL ENVIRONMENT

AIR QUALITY

No Action Alternative (Category 1)

Current environmental laws and standards, both Federal and State, are becoming increasingly more strict in regard to emissions into the atmosphere. This promotes air quality and has as its goal cleaner air nationwide, which includes the Great Lakes-St. Lawrence River Region. However, at times in selected local harbors, channels and lock areas of the region, this improved condition may not have the air quality desired. With the Great Lakes-St. Lawrence Seaway System (GL/SLS) moving towards capacity, more traffic is moving through the Great Lakes and River System. The increased vessel traffic alone could cause increased ship emissions, which contributes toward lowering the air quality over the basin, but more likely, in the aforementioned areas where increased numbers of ships temporarily converge. This converging of ships at times causes backups, due to the fact that the system is at or near capacity, therefore, forcing an increased number of vessels to release emissions into the atmosphere that normally would not be released but are emitted due to delay time. These specific ship concentrated waiting line locations could possibly experience reduced levels of air quality.

Nonstructural (Category 2)

The numerous nonstructural measures that could be implemented would allow some increase in the present capacity of the system. This would allow more ships to utilize the system, thereby, increasing activities and ship emissions on the water and in port areas. This could lower air quality throughout the region but the impact is deemed minor.

The nonstructural alternative plans do contain some structural measures, i.e., installing traveling kevels, modifying lock approaches, installing new equipment at locks as pumps, gates, etc. These activities would produce minor increases in emissions from construction vehicles and some construction dusts, thereby temporarily reducing air quality in specific localized areas of the Snell and Eisenhower Locks.

Navigation Season Extension (Category 3)

See main text for explanation of impacts of this alternative on the GL/SLS. This alternative is outside the authorization of this study and will not be assessed further. (Refer to the Navigation Season Extension Report for more information.)

Structural Modifications "Twinning" (Category 4)

Impacts would be very similar as those stated in Category 2, since nonstructural measures would be implemented before capacity is reached. Once capacity is reached, a new lockage system - two twin locks or parallel systems - would be constructed. This plan would first produce minor traffic increases followed by further increases when additional locks were constructed causing increased vessel emissions and port activity. This is anticipated to be a minor negative impact to the regional air quality. In the area of new lock construction, the impact would be more severe. Construction of a new lock system would be a major construction project, utilizing large quantities of heavy construction equipment. Air quality would be reduced in the project area for the duration of the construction period. This impact could be a major impact, but of a temporary duration.

Structural Modifications - Wider and Longer Locks (Category 5)

All plans require the construction of two low-lift locks to replace the existing system. The lock configuration would vary from plan to plan but would be wider and longer than the present lock dimensions (80 Feet X 860 Feet). Air quality could improve regionally due to a decreased number of vessels because tonnage per transit could increase.

As with Category 4 though, this impact is not anticipated to be significant for the region but could possibly be significant for the construction areas, Snell and Eisenhower Locks, Massena, NY, and for the St. Lawrence River channel. Since the locks would be wider and longer, channels would have to be widened to accommodate the new wider and longer vessels. This construction of new locks and channel widening and material disposal could be a major negative impact to air quality due to the increase in construction vehicle emission. However, this impact would only last for the duration of the construction period.

Structural Modification - Deeper Locks (Category 6)

All plans would involve construction of new deeper locks that would accommodate a greater vessel draft. This would involve dredging on the St. Lawrence River. Many of these plans also involve a new lock that is wider and longer as well. The impacts would be the same as for Category 5 but of a greater magnitude since not only widening of the channel would be required, but additional dredging of the St. Lawrence to accommodate the increased draft would be required. These measures combined with disposal of the dredged material would reduce air quality in the construction and disposal area for the duration of the construction period.

WATER QUALITY

Category 1

Traffic forecasts predict an increase in shipping for the GL/SLS. This increase will be a combination of a greater number of oceangoing vessels utilizing the system, together with more transits being made by the existing fleet, and newer and larger ships being built to replace older ships. The increased activity could have the potential to cause a number of adverse effects to water quality as: Higher risk for accidents resulting in hazardous spills; more bilge pumpouts; and spills of fuels and oils when refueling of ships takes place, as examples. However, in light of international water quality agreements, and current Federal Laws, water quality would be expected to improve throughout the GL/SLS, with the potential for minor temporary degradations of water quality, which may occur in some areas of the system, as harbors or refueling points.

Category 2

The measures that make up the nonstructural alternative would provide for increased capacity. This would allow for increased utilization of the system. Increased traffic throughout the system could lead to greater risks of hazardous spills, fuel spillage and other activities that could reduce water quality in port areas and connecting channels as well as in the open lakes. This potential increased risk is anticipated to be minor and would not significantly effect water quality.

Some nonstructural measure involve minor structural modifications to the existing Snell and Eisenhower Locks. These construction activities would unavoidably cause minor, temporary reductions in water quality in the immediate work zone of the locks, by spillage of fuels, oils, and some soils into the surrounding water. This impact is not anticipated to be significant.

Category 4

Impacts would be similar to those stated in Category 2 for water quality. Nonstructural measures would be implemented followed by construction of either twin locks or a parallel system. All plans provide for increased capacity which increases risk of spills, etc, which could reduce water quality throughout the system. In addition, this plan would increase the amount of construction to take place in the existing lock area. This would increase the amount of oils, fuels, and soils that could be accidently introduced into the St. Lawrence River in the area of the existing locks. However, even though this could produce increased quantities of possible pollutants in relation to the nonstructural measures, the overall impact to the water quality in the St. Lawrence River and construction zone, Massena, NY, is anticipated to be minor and temporary in nature.

Category 5

All plans would require the construction of two low-lift locks. This would increase the capacity of the system but allow for decreased overall traffic. Fewer but larger ships would be operating on the system. This means that the chance for accidents would be reduced but the possibility for an accident of greater magnitude exists. Structural modifications would require construction of a new lock, and widening some parts of the channel in the St. Lawrence River and parts of other harbors and channels in the system. This will increase turbidity in the river where widening is required and in the Massena, NY, area where the new locks would be constructed. Widening of the channels would resuspend some bottom sediments, some of which could be toxic in nature. This would reduce water quality in the construction zones. This impact could be significant but would only be temporary in nature and it is anticipated that water quality would return to preconstruction conditions soon after construction is completed.

Category 6

All plans provide for deeper draft in the GL/SLS. This would cause increased turbidity and would resuspend bottom sediments. Some structural plans in Category 6, also require widening the locks. This would cause impacts similar to those stated in Category 5, but would be of greater magnitude since deepening parts of the system would be required as well. Therefore, impacts are projected to be significant in the St. Lawrence River and possibly other areas of the System where dredging and widening would be required. The impacts although possibly major, again, as in Category 5, are expected to last only for the construction period at which time most resuspended particles should again settle out.

TOPOGRAPHY

Category 1

Development within the GL/SLS Basin is expected to continue. This implies that business, and industry would grow and expand, coupled with new construction. Construction would contribute toward altering the existing topography along with any new dredging and dredged disposal sites that would likely have to be implemented to keep pace with an expanding economy, increased vessel traffic and possibly increased vessel draft.

Category 2

There is no significant impact anticipated by implementation of any nonstructural measures.

Categories 4, 5, 6

Each plan requires construction of a new lock system and combination of widening and deepening some areas of the St. Lawrence River System. These modifications will alter the existing topography especially in the area of Massena, NY, where the new locks would be constructed. Specific changes in topography cannot be addressed now, but will be addressed during Stage 3 planning effort. During Stage 3, disposal areas will also be identified for excavated channel material.

Modifications to harbors and channels throughout the system may change local existing topography. These impacts will be addressed in later stages of planning and by other Corps studies (e.g., Great Lakes Connecting Channels and Harbors Study).

NATURAL ENVIRONMENT

FISH

Category 1

The fishery of an area is heavily influenced by the water quality present. Predictions are for improving water quality within the GL/SLS; therfore, fish stocks could probably be expected to improve in the long run.

Many states have both warm- and cold-water fish stocking programs, with emphasis currently being placed on salmonid stocks, particularly salmon. New York State has just opened a new Salmon Hatchery (1980-1981) near Oswego, NY, for the production of salmon to supply the growing demand for Lake Ontario fishermen. The State has also been trying to raise muskullege, a warm water species at Cape Vincent, NY, in sufficient quantities to stock the St. Lawrence River area (NYSDEC).

Category 2

The nonstructural measures are expected to have minimal impact to the fishery of the GL/SLS. Capacity will be increased but it is not expected to have a significant impact on any spawning, nursery or feeding habitats.

Category 4

The nonstructural measures are anticipated to have minimal effects to the fishery of the GL/SLS. The addition of an additional lock system allows more ships to utilize the Great Lakes transportation routes but are not expected to cause any significant impact. The actual construction of the new locks may cause increased turbidity, disturbance and destruction of some spawning, nursery, or feeding habitat in the existing lock area of Massena, NY, but most fish should be able to avoid the area and construction impacts should last for only the construction period.

Category 5

The construction of two new low-lift locks would cause temporary disturbance to the fishery of the existing locks. Some spawning, feeding and nursery habitat may be lost but the resulting larger locks would allow for decreased traffic over the river. However, some channels and harbors, including the St. Lawrence River, would have to be widened in some locations. Depending on the exact locations, fish would be temporarily driven from the area and some significant spawning, nursery or feeding habitat could be disturbed or lost due to the widening operations.

Category 6

All plans require deepening of the system. This could be a major impact to the fishery of the basin especially the St. Lawrence River. With the construction of a new lock that is wider, deeper and larger, major channel modifications would have to be made in some areas of the river. This could cause similar impacts to fish habitats, as in Category 5, but of greater magnitude. The occurrence of larger ships (deeper, wider and longer) could cause a greater disturbance to the fishery in narrow, shallow constricted locations throughout the system.

WILDLIFE

Category 1

Future conditions predict increases in vessel traffic resulting in a greater number of ships passing through the GL/SLS. This impact is not anticipated to be significant since some projected forecast models show the present system to be almost at or near capacity. The increased vessel movement can cause increased disturbance to existing wetlands which is habitat for many wildlife species located within the GL/SLS. This disturbance could have minor negative impacts to various wildlife species.

Category 2

Some increased vessel movement is expected with nonstructural improvements. Impacts could be expected to be similar to those outlined in Category 1. Some minor structural measures would be required. This construction would cause minor, temporary adverse impacts to small mammals, birds, and other wildlife located in the work areas. These species would be temporarily displaced, but no significant lose of wildlife habitat is anticipated.

Category 4

This would combine nonstructural measures and the addition of two twin adjacent locks on a parallel system. This would cause similar impacts as Category 2 and additional impacts of loss of terrestrial habitat in the lock area, Massena, NY. This habitat could include shrublands, deciduous forests, coniferous forests, wetlands and open field areas. This impact to the wildlife utilizing these habitats is not anticipated to be significant due to the fact that there is sufficient suitable adjacent habitat to support the displaced species. Therefore, the impact to the GL/SLS is anticipated to be minor and the impact to the specific construction zone in the St. Lawrence would be moderate at first and then eventually taper off after construction is complete and conditions should return to preconstruction conditions.

Category 5 and 6

Both categories required new lock construction combined with various degrees of channel widening and deepening. The impacts would be similar to those described in Categories 2 and 4. In addition, some riverine habitat will be lost along the St. Lawrence River in areas that are widened. Also, more than likely any dredged material or bank material that is excavated will be disposed of in an upland terrestrial site. This would cause destruction of some types of wildlife habitat and displace various wildlife species.

General Impacts that Could Result from Modification to the St. Lawrence River System by Categories 4, 5, and 6

Other adverse impacts could be anticipated as a result of increased capacity if a greater number of ships and larger ships pass through the GL/SLS. This traffic increase, if it occurred in constricted areas containing shoreline wetlands or in open-water areas utilized by waterfowl, could cause adverse impacts to various populations of wildlife.

The increased number of vessels would result in more vessel noise and an increased frequency of vessel wakes. The wakes may not only increase in number, but also in size in restricted areas since ship size would probably be greater, or if speed limits were raised. These factors could impact on shoreline marshes in the following ways: causing increased erosion resulting in destruction of habitat; creating a greater frequency and expanded range of water level fluctuations causing inundations and flooding nests; and a general increased level of disturbance to wildlife utilizing these areas. These aforementioned factors could adversely affect nesting and brooding waterfowl and shorebird populations present in nearby wetlands. Greater vessel movement in open-water areas or adjacent wetlands that are utilized by waterfowl for feeding or resting, could cause these birds to increase their movements or flush them more frequently, thus causing stress on this aquatic life which could affect them adversely, particularly in colder weather when body energy needs to be conserved. For a more precise assessment, it will be necessary to obtain additional information on physical distrubances caused by larger ships and the impact to wildlife caused by an increased frequency of disturbances.

WETLANDS

Category 1

Wetlands serve many functions as stated in the Existing Conditions Section. Historically, this type of habitat has been on the decline and is becoming a limited (habitat) resource. Federal and State Governments are aware of the importance of wetlands and laws have been passed for the protection of this resource. Unfortunately, even with the passage of environmental laws, wetlands nationally are still declining. Future conditions will depend on the enforcement of these laws and passage of additional legislature to further protect this important habitat.

Category 2

The increased vessel traffic resulting from nonstructural improvements is not anticipated to cause a major significant impact to the GL/SLS.

Category 4

Construction of a new lock system would destroy some small riverine cattail marshes in the Massena, NY, area. This is not presently anticipated to be a significant impact and deemed to be minor in nature.

Category 5 and 6

These plans require the construction of new locks so impacts would be similar to Category 4. These plans also require channel widening and deepening in some locations. These structural modifications could destroy some wetlands throughout the system, especially in connecting channels. The excavated material would probably be disposed of in an upland disposal site, not a wetland. There is also the possibility that the larger ships could cause erosion of wetlands due to larger disturbances and greater drawdown in constricted channels (Reference Section on Wildlife, Categories 4, 5, and 6).

VEGETATION

Category 1

Man's activities have modified and influenced vegetation patterns throughout the GL/SLS. If the Great Lakes Basin continues to grow and develop, more existing vegetated habitat will be destroyed or modified to accommodate new development. Future changes could probably bring altered land use patterns in agriculture and recreational lands and the reduction in woodlands and wildlife habitat areas, as well as introduction of some ornamental plant species.

Category 2

Increased capacity resulting from nonstructural improvements may cause some similar impacts like the ones mentioned in Category 1. However, implementation of nonstructural measures are anticipated to cause no significant impact to vegetation.

Category 4

Impacts would be similar to those outlined in Category 2 and also destruction of various types of habitats in the Massena, NY area where construction of the lock would occur (Reference Impacts on Wildlife Section, Category 4).

Categories 5 and 6

Impacts would be similar to those outlined above in Category 4 and also those outlined for Wetlands Sections, Category 4, 5, and 6. In areas where dredged material is deposited, the vegetation could be disturbed or destroyed and most aquatic vegetation as well, would be destroyed in these excavated areas. This could be a significant adverse impact but could be mitigated somewhat by seeding and planting which would restore some vegetation and help reduce erosion. Not until all specific areas scheduled for modification are identified in later planning stages can the full impact to vegetation and cover types be assessed.

BENTHOS

Category 1

Two parameters which influence the benthic community present in an area are water quality and sediment characteristics. Future trends in water quality throughout the GL/SLS are moving towards zero discharges of pollutants and improving water quality. This improvement in water quality could shift the basin's benthic populations to one dominated by species associated with "clean water" and decrease the number of species associated with sludge and rich organic sediments and even expand "clean water" populations into areas previously not colonized due to past degraded conditions.

Category 2

The nonstructural plans do contain some structural measures and increase the capacity of the system. Most structural measures would occur to the locks themselves and would not impact on the aquatic environment. Therefore, this category would be expected to cause no significant impact to the benthos of the GL/SLS.

Category 4

Some nonstructural measures would be implemented which are anticipated to cause no significant impacts to the benthos. In addition, a new lock system would be constructed. This would destroy or modify some existing benthic habitat during the construction of the approach and exit channels and walls. Present species would probably be destoyed but it is expected that the area would be recolonized from neighboring populations. Also, depending on which lock system is constructed, one high lift lock or twinning system, it would add new benthic habitat to the Massena, NY area.

Category 5

Two new low-lift locks would be constructed. This will modify some existing benthic habitat with similar impacts as were outlined in Category 4. However, all plans involve the construction of a wider lock as compared to existing locks. This would require modifications to some existing areas in the St. Lawrence and other channels and harbors in the Great Lakes Basin. Widening of some channels would require dredging and possibly some bank modifications. These measures would destroy and modify the existing benthic community and habitat. It would be expected that the dredged areas would become recolonized from other benthic communities within the river and/or harbors. The overall impact to the benthos would be adverse and could be significant depending on specific areas of modification but should moderate over time.

Category 6

Impacts for this category would be similar to Categories 4 and 5, but of greater magnitude, due to the fact that the additional structural measure of deepening the entire operating depth of the system would be implemented. This would require extensive dredging throughout the entire GL/SLS. Implementation of any of these alternatives could have a major adverse effect to the benthic communities of the St. Lawrence River as well as other harbors and channels within the system.

THREATENED AND ENDANGERED SPECIES

Category 1

The Endangered Species Act of 1973 established a comprehensive program to conserve endangered and threatened species of fish and wildlife and plants (FR dated 27 February 1980). Future protection of species will depend on continuation of this legislature and the preservation of associated critical habitat.

Category 2

No significant impact is anticipated from implementation of this alternative.

Categories 4, 5, and 6

Each alternative requires construction and modification of existing habitats. Once more details of the plans are developed in later stages of planning, the selected (recommended) plan for implementation will be coordinated with the USF&WS to determine potential impacts the plan would have on any protected species or their critical habitat.

SOCIOECONOMIC ENVIRONMENT

GENERAL

The No Action (Without Conditions) Alternative - Category 1 - was not assessed by individual parameters, but was addressed in a general narrative which follows.

FUTURE CONDITIONS

U. S. Water Resources Council projections of various social and economic variables included in "Series E-OBERS Projections," have been used in estimating future levels of socioeconomic activity for the region which includes the U.S. components of the Seaway. Statistics included in Volume 3 have been aggregated by Bureau of Economic Analysis areas (BEA's). There are 173 BEA's established by the U.S. Department of Commerce for data gathering and analysis purposes. BEA-007 contains 12 counties in central and northern New York, including the two counties adjacent to the St. Lawrence River (St. Lawrence and Jefferson), those counties adjacent to the eastern portion of Lake Ontario (Oswego and Cayuga), and eight other contiguous counties (Franklin, Lewis, Herkimer, Oneida, Madison, Onondaga, Tompkins, and Cortland). Their forecasts of economic activity were used as a general guideline in extending short-term county demographic data (up to the year 2005) to levels of population which can reasonably be expected to prevail by the end of the project planning period. Projections of economic activity are required in this analysis of Corps water resource planning since the expected useful life of most engineering works often equals or exceeds 50 years.

Forecasts of population, income, employment and industry earnings, based upon "Series E OBERS Projections," through U. S. Water Resources Council, are summarized by Plan Area in Tables A20 through A26. Plan Areas Huron and Ontario will exceed the national rate of total industry earnings primarily due to increased levels of economic activity in the industrial areas of Detroit, MI, and Rochester, NY. Industrial sectors contributing strongly to Great Lakes economic activity are listed in order in Table A27. The predominance of electrical and nonelectrical machinery manufacture and fabricated metals activity can be attributed to the proximity of iron and steel producing districts.

Forecasts of alternative futures for the Basin were undertaken by the Great Lakes Basin Commission (GLBC), a State-Federal organization. The GLBC was designated as the principal agency for the coordination of planning for water and related land resources in the Great Lakes Basin among the various Federal, State, local, and nongovernmental entities until it was abolished by Executive Order. The following paragraphs summarize significant population, employment, income and land use projections for the Great Lakes Planning Basin and most probable future trends by lake planning basins.

In the future, the Basin's share of total U.S. population is anticipated to decrease slightly from 14.1 percent in 1980 to 13.5 percent in 2020. A comparison of Great Lakes to U.S. population, employment, and income growth is included in Table A28. Nearly 23.5 million of the Basin's total population of 29.3 million resided in urban centers in 1970. This proportion is projected to remain stable during the 1980-2020 period. Five of the Basin's 32 SMSA's contained more than one million people. These areas are Chicago, 7.0 million; Detroit, 4.2 million; Cleveland, 2.1 million; Milwaukee, 1.4 million; and Buffalo, 1.4 million.

Table A28, which includes existing and projected levels of employment for the nation and the Great Lakes Basin, indicates that the Basin's share of national employment will fall slightly over the project planning period from about 15 percent to a low of 13.8 percent in 2020.

Future growth in total personal and per capita income will follow the same trends as population and employment and decline during the 1980-2020 period. The Basin's share of national personal income is anticipated to drop from 15.4 percent (1980) to 14.5 percent (2020).

While representing only 8.4 percent of the total land use, urban development areas have a considerable influence over land use decision. More than one-third of the total agricultural lands are located within Standard Metropolitan Statistical Areas, where most of the future urban growth is expected. Urban development projections indicate this type of land use will increase from the present 7.0 million acres to 12.1 million acres by the year 2020.

Lake Superior - This planning area is the least population of any Great Lakes Basin region. Future population levels are projected to remain stable at about 530,000. Per capita income levels will remain relatively low in comparison to other economic regions. The Lake Superior region is expected to experience the lowest rate of growth in total industry and manufacturing earnings of any planning area. Duluth-Superior, MN-WS, is the center of industrial activity for that portion of these two States within the Great Lakes Basin and should retain its dominant economic role over the project planning period.

Lake Michigan - Population in this plan is expected to grow at an annual rate of 0.6 percent, a rate equal the Basin average, but below the national average of 0.7 percent. Manufacturing has been among the more rapidly growing sectors of the local economy. Most of this employment growth can be found within the Chicago metropolitan area on the south shore of Lake Michigan. An increasing percentage of total population in this plan area can be expected to reside in major metropolitan areas of Milwaukee, Chicago, South Bend, and Grand Rapids which are also the historical economic centers.

Lake Huron - Most of this plan area consists of the eastern half of the State of Michigan adjacent to Lake Huron. Three major urban areas in this region are Saginaw, Bay City, and Flint, MI. The remaining area is predominately rural in nature. Major employment sectors include paper products, fabricated and primary metals and chemicals. These important industrial sectors have been projected to grow at an average annual rate of three to four percent per year.

Lake Erie - This planning area includes eight SMSA's and can be considered to be the most densely populated and industrialized area in the Basin. Population and employment levels have traditionally increased more rapidly than the Basin average.

There is a high degree of urbanization within the limits of this planning area. Employment forecasts for the manufacturing of chemical and paper products indicate that this area should remain a relatively prosperous economic region during the project planning period.

Lake Ontario and St. Lawrence River Vicinity - The levels of economic activity in this plan area has been traditionally influenced by the economic health of the Rochester and Syracuse, NY, SMSA's. Strong gains have occurred in the manufacturing sector as a result of employment growth in instruments and related products (Rochester), and machinery manufacture and chemicals and allied products (Syracuse). The eastern end of the Lake Ontario subbasin is predominately rural and depends heavily upon seasonal economic activities related to the influx of tourists from outside the region. Primary economic activities (agriculture, lumbering, and mining) comprise the economic base of this part of the Lake Ontario Plan area.

Jefferson, Lewis, and St. Lawrence County - Great Lakes Basin Commission Framework Study Planning Subarea, 5.3 Lake Ontario East Area - The low rate of population growth in the 1940 to 1970 period is projected to continue through 2020, while employment experiences a relatively faster rate of growth. As a result, the labor force participation rate is expected to attain the Basin and national norm of 39 percent by 2010. Per capita income, only 71 percent of the Basin average in 1962, is projected to reach 91 percent of the Basin average by 2020. Total personal income is projected to increase at an annual rate of 3.6 percent, which is below the Basin and national rate of four percent. Total employment is projected to increase 60 percent, and employment in the manufacturing sector is projected to increase 38 percent between 1960 and 2020. In 1970, only 39 percent of the population was classified as urban. Projections show that in 2020, agriculture will employ only 3 percent of the work force. In 1970, it employed eight percent. This factor, along with some increase in the total population of the planning subarea should increase the degree of urbanization.

NOISE

Category 2

Impacts to the entire GL/SLS level would occur primarily due to resulting capabilities for increased vessel traffic; therefore, noise impacts would pertain more to frequency and/or duration rather than intensity. These impacts would be most noticeable in the connecting channels and lock vicinities, and to a lesser degree, at the various harbor locations. These impacts are not anticipated to be significant because of the already existing related navigation noises at the ports and connecting channels.

In the area of the Eisenhower and Snell Locks, Massena, NY, impacts from noise could occur from both resulting capabilities for increased vessel traffic and minor construction and implementation of improved locking facilities (travel kevels, winches, navigation alignment facilities, etc). Construction of lock improvement facilities would create relatively minor short-term noise impacts. Operation of improvement facilities could increase the noise in the lock and channel vicinities, but could be expected to be designed and operated at safe and moderate noise levels, thereby minimizing any significantly adverse related noise impacts.

Category 3

Reference Main Report. Not evaluated further.

Categories 4, 5, and 6

Regional level impacts would pertain to noise associated with increased vessel traffic, increased ship size (long-term), and possible modifications (construction) at port facilities to accommodate increased traffic and/or ship size (dimension and/or drafts). Construction noises would be moderate short-term impacts. Noise associated with increased traffic and/or increased ship size would be gradual and relatively insignificant as compared to existing conditions.

In the St. Lawrence River area, impacts would initially pertain to construction activities in the existing lock vicinities (Snell and Eisenhower Locks) and necessary dredging locations. After construction completion, noise impacts would pertain to the operation of lock facilities and corresponding increased vessel traffic and/or passage of larger ships. Construction activities would be relatively short-term, and these impacts would be less significant, because the immediate construction areas are not densely populated.

AESTHETICS

Category 2

Regional impacts would pertain primarily to increased vessel traffic and harbor activities. These increases would be hardly noticeable and impact on aesthetic appearance of the system would be minor.

Impacts in the St. Lawrence River area would pertain primarily to increased vessel traffic and minor construction and modifications to the existing lock facilities and/or operations. Increased vessel traffic may be viewed as negative or positive; that is: Vessel passage may be seen as detrimental by some shoreline residents, recreation lists and naturalists, but may be of significant interest to seaway tourists. Minor construction and lock modification activities may generally be termed as disruptive adverse impacts for the short-term; but, may add public interest to the lock facilities and operations for the long-term.

Categories 4, 5, 6

Systemwide impacts would pertain to increased vessel traffic and/or increased vessel sizes, and associated modifications at port facilities to toward recreation and tourism; and, the protection of the natural and recreational environment is very important to them. Significant increased vessel traffic along the Seaway could potentially adversely affect the natural ecological system of the river (reference Effects to the Natural Environment Section), and in turn, the existing recreational environments, upon which many of the river shoreline communities and residents depend. Should significant adverse impacts occur to the existing natural and recreational environment, the attractiveness of the river and shoreline may decline and the associated mobility of people (both permanent and seasonal) into this region could decline to some extent. However, in view of the rather limited increased capacities and vesssel traffic associated with nonstructural measures (increase in lock capacity of from 7 to 13 percent), no significant adverse impacts to this degree would be expected. No direct displacement of people would occur in the St. Lawrence River vicinity as a result of implementation of nonstructural measures.

Categories 4, 5, 6

With structural measures, significantly more tonnage of goods could be shipped through the GL/SLS extending system capacities past the year 2000 (GL/SLS-RTS-1981/82).

Potential impacts to population would pertain primarily to: Construction of new locks and channels, resulting increase vessel traffic and/or greater vessel size, and associated increased harbor activities and developments. Construction of new locks and channel facilities may require considerable land areas. However, new facilities would be constructed in proximity to the existing facilities and much of this land is already owned by the Seaway Development Corporations. No significant displacement of persons would be anticipated. Construction and increased vessel traffic and/or vessel size has raised concerns pertaining to: associated potential adverse impacts to the natural and recreational environment and effects to the attractiveness of the channel vicinities; and disruption to river and shoreline activities and developments.

Generally, these type impacts could influence population mobility within the connecting channel areas and could have greater potential and magnitude with implementation of structural measures. This is discussed in more detail in the following sections. Induced and/or stabilizing economic benefits associated with increased harbor activity and associated secondary harbor activities could, in turn, induce and/or stabilize population mobility into the harbor regions. Induced harbor facility improvements requiring some waterfront land utilization may result in some displacement of alternative land use. Although similar to potential impacts from nonstructural measures, impacts (both beneficial and adverse) would be greater in magnitude.

Locally, in the St. Lawrence River area impacts to population would pertain primarily to effects of construction in the vicinity and resulting effects of increased vessel traffic and/or of larger vessels (length and width and/or draft) passing through the Seaway System. With construction of new lock and channel facilities at the Snell and Eisenhower lock vicinities, the threat of localized unemployment is seen by some as a result of a permanent influx of accommodate these increases. Increased traffic and vessel size would occur gradually, and generally would not have a quickly noticeable aesthetic impact. However, facility construction and modification activities might be more quickly evident. These are generally identified as disruptive short-term adverse aesthetic impacts. These would include dredging and disposal activities. Associated modifications to harbor facilities generally would not significantly alter expected harbor features.

The St. Lawrence River area would experiences impacts pertaining primarily to: increased vessel traffic and/or increased ship size (width, length and/or draft), construction activities in the existing lock vicinities (Snell and Eisenhower), and dredging activities if designated. Increased vessel traffic and ship size may be viewed as negative or positive. (See Category 2.) Construction activities may generally be termed as disruptive short-term adverse aesthetic impacts, but modifications may add interest to lock facilities. Possible short- and long-term adverse impacts of construction and particularly dredging activities to the St. Lawrence River aesthetics (including water quality, fish and wildlife, etc), are of particular concern to the people and communities of the region.

POPULATION (MOBILITY, DISPLACEMENT)

Category 2

Generally, nonstructural measures would expedite lockage and passage of vessels through the system. This would increase the system's capacity by an estimated 7 to 13 percent (GL/SLS-RTS-1981/82). Impacts to population would pertain primarily to slightly increased vessel traffic through the lock and connecting channel vicinities (reference Figure A1) and associated slightly increased or sustained harbor activities. Although some concern has been expressed relative to increased vessel traffic and its potential effect to the environment and attractiveness of the connecting channel vicinities, traffic would be increased only slightly with these measures and no significant effect would be anticipated in this regard. No major land areas would be required to implement nonstructural measures, so no significant displacement would be anticipated. Induced and/or stabilized economic benefits associated with growth of harbor activity and associated secondary harbor activities, might in turn induce and/or stabilize population mobility into the harbor regions. Increased vessel traffic may induce harbor facility improvements requiring some additional waterfront land utilization resulting in indirect displacement of some existing alternate land use. Impacts of significant magnitude however, are not strongly indicative of nonstructural measures.

Nonstructural measures would expedite lockage and passage of vessels through the Seaway. Reference Figure A2. Potential impacts to St. Lawrence River area population would pertain primarily to increased vessel traffic and any potential effects on the natural environment, recreation, and the functional (economic) base of associated shoreline communities. Ogdensburg Harbor is the only commercial harbor along the U.S. International Section of the river and would benefit only slightly from seaway improvements. The rest of the U.S. communities along this section of the river are oriented temporary construction workers who are released at the conclusion of the project. In the long run however, overall employment benefits would probably help to negate any employment shifts due to program construction employment. Employment and income opportunities would probably increase in the vicinity during facility construction. Long-term employment at the lock facilities would remain stable or increase slightly.

The areas surrounding the lock sites are generally open fields and not densely populated. The properties are to a large extent owned by the St. Lawrence Seaway Development Corp. Therefore, minimal displacement of people or properties would be expected.

As stated previously, should the quality of the natural and/or recreational environmental suffer significant adverse effects, it is possible that the attractiveness of the vicinity could decline and the associated mobility of people (both permanent and seasonal) into the region could decrease. Effects and mitigative measures in this respect must be identified in further detail.

The St. Regis Band of Mohawks of Canada alleges that construction of the St. Lawrence Seaway and Power Project has, in the last quarter century, adversely affected the air and water quality and the levels and flows regime of the International Rapids section of the St. Lawrence River, thereby prejudicing the land and water resources and the livelihood of the members of the Band. These allegations are presently being investigated by the International Joint Commission (IJC) through appropriate Governmental channels and agencies. Relevant concerns must also be considered in development of any proposed St. Lawrence Seaway improvement plans and this study will be coordinated with the St. Regis Band of Mohawks.

EMPLOYMENT AND INCOME

Categories 2, 4, 5, and 6

GL/SLS regional port activity generates tangible business activity for firms which participate in the transfer of cargo between ship and port, and which provide support services for ships while in port. The Great Lakes-St. Lawrence River Regional Transportation Study, 1981 measured anticipated regional port economic impacts in terms of income and employment as they relate to increased tonnage handling. The two parameters are related by the wages of the sectors participating in port activity.

Per ton factors for income and employment were developed in a comprehensive study for the Port of Baltimore. It identified the number and average income of employees directly related to port activity. This extensive enumeration is felt to have produced a realistic estimate of port economic impact.

Annual cargo traffic for each major U.S. port in the Great Lakes System which would be impacted by lock system improvements were determined using traffic forecast projection data and applying a lock improvement scenario (nonstructural alternatives to maximum utility then 1,350 by 115-foot locks). The regional impacts of this lock improvement program were considered to be representative of the impacts resulting from a combination of nonstructural and structural improvements. The per ton factors for income and employment were then multiplied by the anticipated annual cargo traffic for each major U.S. port in the Great Lakes System to indicate anticipated changes in income and employment relative to regional system improvements.

The study indicated that the lock improvement program (as compared to without project conditions) would protect almost 4,400 port employment positions by 1985, which would be lost if additional traffic were not able to use the Great Lakes System. The employment impact increased to 7,300 jobs by the year 2010, and 23,000 positions by 2050. Direct income related to port activity protected by the improvement program amounted to $97 million in 1985, increasing to $164 million in 2010 and $547 million in 2050. Part of this income would be respent within the local economy. (An income multiplier of 1.4 was utilized to account for this.)

Therefore, both income and employment opportunity would be anticipated (increase) relative to, and at the Great Lakes regional shipping level, as a result of a lock and system improvement program. Because structural alternatives would significantly increase tonnage throughput as compared to nonstructural alternatives, and tonnage throughput would relate to employment and income opportunities, structural alternatives correspondingly would have significantly increased effects over nonstructural alternatives.

It should be noted however, that no anticipated loss (income and employment) to other sectors of the nation were specifically calculated in these terms although studies of intermodal impacts provide some insight.

For the St. Lawrence River vicinity, implementation of structural plans in the vicinity of the existing locks, Massena, NY, would require short-term (1 to 3 years) significant construction effort. In addition, operation and maintenance of the expanded facilities may require additional manpower (work). This would provide some employment and income opportunity in the lock and channel vicinity.

On the other hand, some see the threat of localized unemployment as the result of a permanent influx of temporary construction workers who are released at the conclusion of the project.

LAND USE

Category 2

Impacts at the GL/SLS level would pertain primarily to resulting increased vessel traffic and associated facilitative developments at the connecting lock and channels, and active harbors. No significant land area would be necessary to implement nonstructural measures, therefore, no significant land use impacts would be expected. Increased vessel traffic would be most noticeable at the connecting lock and channel locations and could affect some shoreline structures and activities, but would not be expected to significantly alter patterns of shoreline development. Because increased vessel traffic would be generally dispersed over the Great Lakes System, relatively few land use impacts would be expected at the various harbors; possibly only some modifications to facilitate increased traffic and modification of some storage facilities would occur. These may infringe on alternative land uses.

In the Massena, NY, area impacts would pertain primarily to those identified in the previous paragraph associated with the connecting lock and channel areas. No significant land areas would be required to implement nonstructural measures. Impacts to shoreline structures and activities would be expected to be minor and would not be anticipated to significantly alter patterns of shoreline development.

Categories 4, 5, and 6

The GL/SLS system level would experience impacts that would pertain primarily to: Construction of new locks and channel facilities in the connecting lock and channel vicinities; resulting (long-term) increased vessel traffic and/or of larger vessels; and associated facilitative developments at the connecting lock and channels and active harbors.

Construction of new locks and channel facilities in the connecting lock and channel vicinities (reference Figure(s) A1, A2, and A3) would require many acres of land. Construction, however, would occur in close proximity to the existing lock facilities. Most of this land area is not developed or actively utilized and is already primarily owned by the corresponding GL/SLS System Development Authorities. Therefore, few significant land use impacts would be anticipated.

Gradual increased vessel traffic and/or vessel size would be most noticeable at the connecting lock and channel locations. This could affect some shoreline structures and water related activities in these vicinities (reference Man-Made Resources and Recreation) resulting primarily from wave and drawdown actions of passing vessels.

Implementation of structural plans (involving construction, dredging, increased vessel traffic and/or vessel size) have greater potential for disruption to ecological resources (water quality, fish and wildlife resources, etc) and associated recreational and developmental opportunities. Although some impacts might have the potential to be GL/SLS systemwide (i.e., introduction of foreign species, etc.) most immediate impacts would be noticeable in the restrictive connecting lock and channel vicinities and to a lesser degree in the affected harbor vicinities of the system. Should ecological resources be adversely affected and associated recreational and developmental opportunities diminished, associated land use patterns might be altered accordingly. Although significant impacts are not anticipated, this aspect must be examined in greater detail.

Increased vessel traffic would be less noticeable at the associated GL/SLS System harbors because the overall traffic would be more dispersed. However, harbor developments to facilitate increased vessel traffic and/or vessel size could be expected to occur. These developments could utilize some shorelands that might alternately be used for other purposes. However, since the harbor vicinities are already developed to facilitate navigation needs, these developments would not be expected to significantly affect land use plans. In addition, this would be a gradual impact, generally incorporative to land use development plans and policies.

In the St. Lawrence River area impacts would pertain primarily to: Impacts of construction of new locks and channel facilities (new locks at Snell/Eisenhower and some dredging in the St. Lawrence River) and associated impacts (wave action, drawdown and surge) of either increased vessel traffic or larger vessels transiting the SLS System.

Construction of new lock and channel facilities would require approximately 40 acres of land area. See Figure(s) A3a and A36. Construction would occur in close proximity to the existing lock and channel facilities. Most of this land area is not developed (open field) or actively utilized and is already primarily owned by the St. Lawrence Seaway Development Corporation (SLSDC). However, some utility and transportation road systems would need to be relocated or modified.

Open water disposal of any dredged material is not a readily acceptable disposal method in the river vicinity, particularly if the amount of dredged material is significant. More than likely, any dredged material would be placed in an acceptable existing or newly constructed shoreline or upland disposal site.

Impacts of increased vessel traffic and/or of larger vessels would be most noticeable in the restrictive connecting lock and channel locations (reference, Figures A4a through A4f). These would include effects to shoreline structures and water related activities in these vicinities (reference Man-Made Resources, Recreation and Transportation Sections), resulting primarily from wave and drawdown action of passing vessels. In addition, some have expressed concern that construction efforts and altered vessel traffic could potentially disrupt the existing river ecological environment and associated recreational and developmental opportunities. Although significant impacts of this nature would not be expected, their magnitude is not clearly known at this time and must be investigated in further detail. It is conceivable, however, that should "significant" disruption occur, shoreline land use development could be affected accordingly.

MAN-MADE RESOURCES

(INCLUDING WATER RESOURCE FACILITIES, PUBLIC FACILITIES AND SERVICES)

Category 2

Systemwide impacts would pertain to: Minor modification to existing lock and channel systems; and induced modifications to some harbor facilities to accommodate increased vessel traffic. The nonstructural alternative descriptions are indicative of the type of lock, channel and system modifications that could be implemented (winch installation, guidance systems, etc). Types of improvements of harbor facilities might include: installation of improved traffic control, mooring, loading, unloading and storage sytems, etc; all relatively minor.

In the St. Lawrence River, minor modifications to the existing system would be made as described above and also water resource facilities (water intakes, outflows, dam structures, water crossing facilities) would not be expected to be significantly affected. Dam and hydroelectric facilities would not be affected.

Categories 4, 5, and 6

At the regional level, impacts would pertain primarily to: Major construction of new locks and channel facilities and/or major modification or addition to existing lock and channel facilities. Since the GL/SLS shipping systems are interrelated, some modifications would be expected in all of the connecting lock and channel areas. See the Alternatives Section in the Main Report for possible structural measures considered for the U.S. portion of the St. Lawrence Seaway. Induced harbor facility improvements to facilitate increased vessel traffic and/or increased vessel size would also be expected.

Many port facilities, particularly in the Upper Lakes can facilitate larger vessels. Their modifications would be oriented toward handling increased traffic while modifications at ports with existing limited facilities would be oriented toward handling both increased traffic and larger vessels. Generally, harbor facility modifications would be oriented toward matching GL/SLS System dimensions, where advantageous, for vessel length, width and/or draft and lock throughput capacities. System draft increases would probably necessitate changes of the greatest (most difficult and extensive) magnitude.

Local impacts in the St. Lawrence River area would pertain primarily to: construction of additional lock facilities; modification of existing connecting channel dimensions to match additional lock facilities; and, possible impacts to shore structures/facilities and associated mitigative protection measures. Specifics of additional lock alternatives are addressed in some detail in the Alternatives Section. Modification of existing connecting channels primarily pertains to dredging to achieve desired channel widths and draft. See Figures A3 and A4a through A4f.

NOTE: Major structural modifications and dredging may increase outflow capacities and alter the hydrological/hydraulic characteristics of the river in some areas. But, design criteria preclude any modifications or adverse effects to dam and hydroelectric facilities as a result of implementation of these measures.

Shoreline structures (primarily docks) and water resource facilities (water intakes, outflows, channel cable crossings, boom cables, etc., see Figures A10a through A10b) could be subject to impacts associated with vessel traffic (wave action, drawdown) and possible navigation channel modifications (dredging) resulting from implementation of major structural alternatives. Those particularly affected will be facilities in close proximity to the navigation channels. Notification of dredging activity and/or protective, modification and relocation measures may need to be implemented for some of these facilities.

TRANSPORTATION

(REFERENCE MAN-MADE RESOURCES, BUSINESS AND INDUSTRY, AND RECREATION ALSO)

Categories 2, 4, 5, and 6 (GL/SLS Region)

The Great Lakes/St. Lawrence Seaway Regional Transportation Study, 1981/82, evaluates the intermodal impacts of lock system improvement programs (nonstructural then structural). These impacts are measured in terms of the net increase or decrease of line-haul freight revenues accruing to the segments of the U.S. freight carrier industry serving the Great Lakes Region, including: The railroads, motor carriers, barge operators, and the U.S. Flag Great Lakes and foreign trade fleets.

Potential revenue opportunities might be realized by these various modes in transporting commodities that would be forced off the Great Lakes/ St. Lawrence Seaway System in the absence of system improvements (Without Conditions). Generally, the study compares these potential revenue opportunities for the various modes with and without system improvements, the difference indicating potential impacts.

The study indicated that the modes that would be impacted positively by the implementation of a system improvement program (i.e., nonstructural improvements to maximum utility followed by structural implementation of 1,350- by by 115-foot locks) would be: the lake carriers, and motor carriers. A positive impact means that the "with project" case benefits the industry by allowing it to be able to handle traffic that would otherwise be forced off the Great Lakes/St. Lawrence Seaway System.

The study indicated that the modes that would be impacted negatively would be: The railroads, the barge and towing industry, and the U.S. flagliner industry. A negative impact means the lock improvements cause a modal industry to lose the opportunity to move traffic which would have been forced off the Great Lakes/St. Lawrence Seaway System in the absence of the improvement.

NOTE: The increased draft alternatives and their potential impacts were not addressed in this analysis. Increased draft alternatives could be expected to provide positive benefits to the U.S. flagliner industry in this respect.

It should be clarified too, that the indication of a negative impact does not necessitate loss of potential revenue growth for the modal industry (proportional to the existing revenue source) but loss of additional potential revenue growth attributed to commodities forced off the GL/SLS System in the absence of system improvements.

Study estimates include:

a. Lake Carriers - The "with project" case allows lake carriers to receive $10.3 million in revenue in 1985 that would have been lost if the system reached capacity. This revenue increases to $30.8 million in 2000 and $553 million by 2050. This represents 1.4 percent of this industry's revenue in 1985, increasing to 4.1 percent by 2000 and 36 percent by 2050.

b. Railroads - The "with project" case means a loss of the opportunity to collect $79 million in revenues in 1985, increasing to $140 million by the year 2000 and more than $1 billion in 2050. This is less than two percent of expected revenues in any of these years, however.

c. Barge and Towing Industry - The "with project" case means the loss of the opportunity to collect $25 million in revenue in 1985, increasing to $50 million in 2000 and $113 million in 2050. This is 6.3 percent of total revenues in 1985, and more than 10 percent in 2030 and 2050.

d. Motor Carriers - The "with project" case means a change of less than one percent in any year until 2050.

e. U.S. Flagline Industry - The impact on the liner industry is negligible.

This impact is based on the fact that the Booz Allen & Hamilton Inc. report, dated 1982 on Regional Transportation, indicated that total projected net revenues would not increase significantly for this industry over the evaluated life of the project.

With implementation of structural measures, significant modifications and/or additions to navigation facilities (locks and/or channels would be made. (Reference Figure(s) A1, A2, A3, and Table A3) This would significantly increase and extend facility and system capabilities and capacities. Assuming systemwide modifications, some effects to commercial navigation that might be expected would include: Reduced delay at locks, fleet adjustments (vessel size), fuel savings, improved vessel productivity, increased tonnage throughput, reduced shipping rates and safer navigation. (Reference: GL/SLS-RTS-1981/82 and other pertinent sections.

Category 2 (St. Lawrence River Vicinity)

With implementation of nonstructural measures, minor modifications to the existing navigation lock and channel facilities would be made as indicated in the alternative description. These would expedite movement of vessels and cargoes through the SLS lock system, slightly increasing the system capacity. Slight increased vessel traffic would result. This could slightly irritate any cross channel, recreational boating, and commercial/recreational navigation conflicts, but, these impacts would be expected to be very minor. Although speeded lock processes could create some navigation safety problems, facilities would be expected to be designed to offset any navigation problems.

No significant adverse impacts to other modes of transportation in the area would be expected with implementation of nonstructural measures although some lock procedures could preference full-load commercial navigation over recreational or empty-load navigation during peak periods.

Categories 4, 5, and 6 (St. Lawrence River Vicinity)

With implementation of structural measures, significant modifications and/or additions to navigation facilities (locks and/or channels) would be made as indicated in the alternative descriptions. (Reference Figures(s) A3a and A36 and A4a through A4f). This would significantly increase and extend facility and system capabilities and capacities (reference previous paragraphs).

With implementation of structural measures, increased vessel traffic and/or increased vessel size would be expected. This could irritate any cross channel, recreational boating, and commercial navigation conflicts. Although increased vessel traffic and/or vessel size might be thought to create increased navigation safety problems, facilities would be designed to increase navigation safely. Improved navigation aids would help to facilitate this effort.

Implementation of structural measures would require land area in construction of new lock and channel facilities. (Reference Figure(s) A3a and A36). This would require relocation of some transmission lines and other facilities and would sever (temporarily or possibly permanent) several local roads. This would include Rte. 131 which passes by tunnel under the Eisenhower Lock. Similar tunnel provisions, detours, or other mitigative measures would have to be considered in these vicinities. Access to visitor parking and viewing areas would similarly be disrupted.

ENERGY

Catgegories 2, 4, 5, and 6 (GL/SLS Region)

The Great Lakes/St. Lawrence Seaway Regional Transportation Study, 1981/82, assesses the regional energy use impacts of alternative improvements (assumed nonstructural then a structural improvement). Preliminary analysis indicates that, with implementation of improvements to the Great Lakes/St. Lawrence Seaway System, substantial energy savings could occur over the life of the project because lake transportation, which is relatively fuel efficient, could continue to be used to meet anticipated commodity flow demands.

Energy expended in construction and/or operations of modified and/or new and additional facilities would be expected to be minimal compared to long-term transportation energy consumption. Consequently, significant identified energy savings pertain primarily to changes in energy consumed in line-haul freight operations.

Implementation of structural alternatives would significantly increase the potential for energy savings over nonstructural alternatives, primarily because significantly more quantities of goods could be transported with a relatively minimal increase in energy consumption.

Categories 2, 4, 5, and 6 (St. Lawrence River Vicinity)

Energy resources from the local level (St. Lawrence River and lock vicinities) would be expended in construction of and operation of new or modified lock facilities. However, note second paragraph under Regional Energy.

BUSINESS AND INDUSTRY

(REFERENCE: EMPLOYMENT AND INCOME AND RECREATION SECTION ALSO)

Categories 2, 4, 5, and 6 (GL/SLS Region)

The Great Lakes/St. Lawrence Seaway Regional Transporation Study, 1982/82, identifies benefits and evaluates some impacts of lock system improvement programs (assuming nonstructural then structural improvements) to major business and industry related to the Great Lakes/St. Lawrence Seaway navigation system.

Direct significant benefits to lock system improvements include:
(1) Significant rate savings, resulting from continued use of the Great Lakes/St. Lawrence Seaway System to meet anticipated commodity flow demands, instead of cargo being forced to use more expensive route and mode; (2) Substantial energy savings (over the life of the project) because lake transportation, which is relatively fuel efficient, could continue to be used to meet anticipated commodity flow demands; (3) Reduced delay at congested locks; and, (4) Improved vessel productivity resulting from more cargo per locking operation.

Generally, and in these cases, implementation of structural measures would significantly increase impact potential over nonstructural measures, primarily because significantly more quantities of goods could be transported with a relatively minimal increase in transport cost or fuel expenditure.

Also, port activity generates tangible business activity for firms which participate in the transfer of cargo between ship and port, and which provide support services for ships while in port. These activities would generate some benefits for business in the system port vicinities (reference, Employment and Income Section).

The study also investigated induced industrial production due to reduced freight rates for the major users of the system - the grain, coal, and steel industries. Generally, it was determined that, although significant dollar savings in transportation costs could be realized (attributed to rate savings), this is only one of the many factors influencing domestic production and would not significantly influence the level of grain and coal consumption and production of iron and steel.

Decrease in the delivered costs for foreign producers of imported iron and steel products would also occur. However, as a result of potential economies to the domestic steel industry adjacent to the Great Lakes, no change in market shares between domestic and foreign producers would be expected to occur.

Category 2 (St. Lawrence River Vicinity)

With nonstructural measures, existing commercial navigation facilities would be improved and vessel traffic would increase slightly along the St. Lawrence Seaway. Ogdensburg Harbor is the only U.S. commercial harbor along the International Section of the river and would not gain or loose significantly from nonstructural improvement measures. The remaining U.S. communities along this section of the river are oriented toward recreation and tourism. Increased vessel traffic could heighten concerns of environmental and recreational interests; however, associated impacts are believed to be negligible. Although nonstructural measures may induce some additional interest in the Seaway tourism trade, these businesses and communities would not be expected to be impacted significantly.

Several production plants are located along the St. Lawrence River in the Massena vicinity but would not be impacted significantly by nonstructural measures.

Categories 4, 5, and 6 (St. Lawrence River Vicinity)

Implementation of structural measures along the St. Lawrence Seaway would significantly modify navigation facilities involving construction of new lock facilities at the Snell and Eisenhower Locks, and some degree of channel modifications and/or dredging. Commercial vessel traffic and/or ship size would increase gradually but significantly along the St. Lawrence Seaway.

As stated previously, Ogdensburg Harbor is the only U.S. commercial harbor along the International Section of the river and would not benefit significantly from structural lock and channel improvement measures. The remaining U.S. communities along this section of the river are oriented toward recreation and tourism. The protection of the natural and associated recreational environment is very important to these interests. Potential adverse impacts of construction, dredging, and increased vessel traffic and/or of larger vessels (and associated impacts) are understandably of great concern. Significant adverse impacts to the natural and associated recreational environments could conceivably disrupt the existing and future community and regional base (recreational business and industry). These types of impacts are not anticipated to be significant long-term impacts, but their magnitude is not known at this time and must be examined in greater detail.

Facilities do exist for the public to view the lockage of ships through the St. Lawrence Seaway System. New and/or old locking facilities may induce additional interest in Seaway tourism, which could benefit some businesses in the lock vicinities.

Several industrial production plants are located along the St. Lawrence River in the Massena vicinity but would not be impacted significantly by structural measures.

RECREATION

Category 2

Generally, at the GL/SLS level, nonstructural measures would expedite lockage and passage of vessels through the system. Potential impacts would pertain primarily to restrictions to recreational vessel use of the locks, slightly increased commercial vessel traffic; and impacts on water resources, related facilities, and activities. These effects would occur primarily in the connecting lock and channel areas where the major interface occurs; and, to a lesser degree in the immediate harbor areas. Direct effects might include: preference of commercial vessels to recreational vessels through the locks during peak periods; minor wave action and/or drawdown damage or disruption impacts to docking facilities, boats, and fishing or swimming activities; and, slightly increased conflict between commercial shipping and recreational boating activities. Similar existing effects are relatively minor. Most recreational boaters avoid the deeper central commercial channel areas. With slightly increased vessel traffic, these impacts would generally be of similar magnitude but could occur more frequently.

Additionally, any increased vessel traffic could potentially have some effect on the existing environmental ecological system. This, in turn could affect, for example, sport fisheries and associated fishing and/or other related recreational opportunities as well. Increased vessel traffic resulting from implementation of nonstructural measures, however, would be relatively minor and the magnitude of impacts would not increase significantly. Therefore, no significant impacts of this nature would be anticipated.

In the St. Lawrence River area, water related recreation is particularly important and a sensitive issue to the people and communities located there. Impacts to recreation associated with nonstructural measures in this vicinity would include those types identified in the previous paragraphs.

Categories 4, 5, and 6

Effects at the GL/SLS system level would pertain primarily to immediate impacts of construction; and, gradually, impacts associated with increased vessel traffic and/or the passage of larger vessels, primarily wave action drawdown and turbulence impacts. These impacts would occur primarily in the restrictive connecting lock and channel vicinities and to a lesser degree in the affected harbor vicinities. Reference Figure(s) A1 and A9.

Generally, associated impacts along the St. Lawrence River are representative of the types of impacts that could be expected in the lock and connecting channel vicinities and restrictive harbor areas of the GL/SLS System. These types of impacts are described in more detail in the following sections. Additionally, harbor developments to facilitate increased vessel traffic of greater size, could conceivably consume some shore land that might alternately be used for recreational purposes. However, this would be a gradual impact, generally incorporative to land use development plans and policies.

Effects in the St. Lawrence River vicinity would similarly pertain to impacts of construction, dredging, and gradually, impacts from increased vessel traffic and/or passage of larger vessels. These impacts would occur primarily in the restrictive connecting lock and channel areas. Reference Figures A3 and A3b and A4a through A4f. Potential impacts could affect water related resource shoreline facilities and associated recreational activities. Figures A8a through A8f locate some recreational related facilities. Aesthetics and recreation are important resources in this vicinity. Potential disruption to ecological resources (Water Quality, Fish and Wildlife Resources) in the river and associated adverse impacts to recreation is of major concern to the people and communities along the St. Lawrence River.

New lock and channel construction would disrupt approximately 40 acres of land area (primarily field habitat). Reference Figure(s) A3a and A3b. If determined to be clean material, this would probably be spread and graded in the immediate vicinity and/or used in facilitative berm or levee construction. During construction, unavoidable increased sedimentation into the channels could be expected in the construction vicinities. (Although environmental protective mitigative measures would be implemented according to "Civil Works Construction Guide Specification for Environmental Protection" (CW 01430)). Any dredging could have adverse impacts. See Figures A4a through A4f and Effects to the Natural Environment Sections. These activities would have short-term and possibly long-term impacts to the environment, particularly if construction activities occur in environmental areas significant to the ecology. Should significant adverse impacts occur, existing natural resources (water quality, fishery and wildlife) and associated recreational opportunities could diminish. In view of the existing conditions, however, with respect to the river/seaway relationship, these construction impacts could be expected to be short-term temporary impacts. Further study is necessary and planned to determine the magnitude of these impacts.

In addition, the gradual increased passage of larger vessels through the system could disturb existing habitats because of propeller turbulence, wave action, and drawdown effect, which in turn could also affect the ecological setting and the associated recreational opportunities. These factors need to be examined in more detail, particularly in view of the importance of the resources to the area.

Other recreationally related potential impacts due to increased vessel traffic or size would include: Wave action and drawdown impacts on the shoreline and related facilities (erosion, damage to docks and moored boats); wave action and drawdown impacts on fishing and boating activities; and commercial shipping and recreational boating activity conflicts.

Any increased vessel traffic would increase the possibility of commercial/recreational vessel activity conflicts. Cross channel activity conflict would continue to be of particular concern. However, it could be expected that most recreational boaters could continue to avoid activity in the commercial channel areas. In addition, improved vessel location aids would mitigate potential conflicts and/or collisions.

Facilities do exist for the public to view the passage of ships through the Snell and Eisenhower Locks. Access to these locations would probably be disrupted during construction. These or similar facilities would be restored with project completion. The developmental aspect (History of the River, Original Seaway Development and Facilities) could prove to be of additional interest to the viewer.

AGRICULTURE (DISPLACEMENT OF FARMS)

Category 2

Impacts at the GL/SLS regional level, would pertain primarily to continued availability of navigational modes for shipment of additional agricultural goods, particularly grains, and possibly loss of some shoreline agricultural lands to minor increased erosion or to alternate shoreline land use developments in the channel lock and harbor vicinities. Water transportation constitutes relatively cheaper transportation costs and benefits could be derived from its continued utilization accordingly (reference, Business and Industry). Additional loss of agricultural lands due to erosion or alternate land use development would be minor, as they pertain to nonstructural measures. Erosion would not be expected to increase significantly from increased vessel traffic; little if any additional land would be required to implement nonstructural measures at the lock sites; and any induced harbor facility land use development (generally already fairly well developed) would not be expected to significantly encroach upon valuable agricultural lands. In the St. Lawrence River area, impacts associated with nonstructural measures would be minor, as stated previously. Erosion of agricultural lands would not be expected to increase significantly and little if any land would be required to implement nonstructural measures at the lock vicinity. No displacement of farms would occur.

Categories 4, 5, and 6

Regional impacts (GL/SLS) would pertain primarily to increased availability of the navigational mode for shipment of additional agricultural goods, particularly grains; and possible loss of shoreline agricultural lands to minor increased shoreline erosion in the connecting channels vicinities or alternate shoreline development (facility construction) in the lock and harbor vicinities. Systemwide structural alternative improvements would significantly increase the systems vessel traffic and/or ship size capacities. More agricultural goods could be transported by ship mode. Water bound bulk shipments constitute relatively cheaper transportation costs and significant benefits could be derived accordingly (reference Business and Industry). Although the passage of more and/or larger vessels through the locks and connecting channels may increase the potential for shoreline erosion, mitigative measures would reduce this potential to problem areas. Erosion impacts to agricultural lands would not be significant. Construction of additional lock, channel, and harbor facilities would require acquisition of acres of land near the existing facilities. The majority of these impacted land areas are nonagricultural and are already owned by shipping development interests. No displacement of farms or active agricultural lands would be expected.

In the St. Lawrence River area, impacts would pertain primarily to possible loss of shoreline agricultural lands due to minor increased shoreline erosion; or for construction of additional lock and channel facilities. Reference to the U.S. Department of Agriculture - "Important Farmland of New York" map (see Figure A6), indicates that most of the New York State St. Lawrence River shoreland is greater than 25-percent land of Statewide importance, but less than 25-percent prime farmland. Although the passage of more and bigger vessels through the locks and connecting channels may increase the potential for shoreline erosion, mitigative measures (reduced speed, riprap, etc.) would reduce this potential and significant erosion impacts to agricultural lands would not be expected. Construction of additional lock facilities at the Snell and Eisenhower sites would require approximately 40 acres of land area (see Figure A3a). These are primarily nonagricultural open (field) areas, most of which is already owned by the St. Lawrence Seaway Development Corporation.

PUBLIC FACILITIES AND SERVICES

For water resource facilities, reference Man-Made Resources, this Section.

PROPERTY VALUES AND TAX REVENUE

Category 2

Extended and/or increased system capacity for the GL/SLS would further facilitate business, industry, and agricultural transportation needs of the Great Lakes region. Some associated community development benefits might also be expected. With stabilized or increased growth and development some associated increase in property value and tax revenue could be expected in the active harbor areas.

In the St. Lawrence River area, property values and tax revenues would not be expected to change significantly as a result of implementation of nonstructural measures. Modifications to the existing facilities, and associated land use, property values and tax revenues impacts, would be minor. No severe environmental impacts affecting land use, property values, or tax revenues would be expected.

Categories 4, 5, and 6

Implementation of structural measures would significantly increase and extend capacity in GL/SLS region. These measures would significantly facilitate business, industry and agricultural transportation needs of the Great Lakes region. Some associated income, employment and community developmental benefits would also be expected. With stabilized or increased growth and development, associated increase in property value and tax revenue would be expected, particularly in active harbor areas.

Some have expressed concern that construction efforts and altered vessel traffic could potentially disrupt the existing connecting river and channel ecological environment and associated recreational and developmental opportunities. Although significant impacts of this nature would not be expected, their magnitude is not clear at this time and must be investigated in further detail. It is conceivable, however, that should "significant" disruption occur, some shoreline land use development and associated property values and tax revenues could be affected accordingly.

Although, approximately 40 acres of land would be required for construction of new lock and channel facilities in the Massena, NY area, at considerable investment, pertinent property values and associated tax revenues would not be expected to change significantly in the St. Lawrence River area as a result of implementation of structural measures. Since most of the required property is owned by the St. Lawrence Seaway Development Corporation (U.S. Agency) or other governmental agencies it is tax exempt.

Subsequent to initial construction activity, the 83rd Congress passed Public Law 358 (the Wiley Dondero Act) in 1954 creating the St. Lawrence Seaway Development Corporation as the designated U.S. agency to construct and operate deep-draft navigation works in the International Rapids Section of the St. Lawrence River together with the necessary dredging in the Thousand Islands Sections; and to operate and maintain such works in coordination with the St. Lawrence Seaway Authority of Canada. The SLSDC was further authorized and directed to negotiate with Canada an agreement as to the rate of charges or tolls to be levied for the use of the Seaway. Tolls contribute to the operation, maintenance, and development of the Seaway facilities but do not contribute to local revenue.

As mentioned in the previous section, some have expressed concern that construction efforts and altered vessel traffic could potentially disrupt the existing river and channel ecological environment and, in turn, associated recreational and developmental opportunities. Should this occur, associated effects to land use, property value, and tax revenues would apply accordingly. No significant harbor and developmental growth benefits would be expected along the U.S. International Section of the St. Lawrence River from implementation of structural plans. Accordingly, no associated increase in property value and associated increased tax revenue would be expected.

COMMUNITY COHESION

Category 2

Minor increased system capacity (GL/SLS Region) would facilitate business, industry, and agricultural transportation needs of the region. Some associated community developmental, employment, and income benefits might also be expected. Although of minor impact, generally, these would contribute to the community cohesion of the region.

With nonstructural measures, commercial vessel traffic would increase slightly along the St. Lawrence Seaway. This could heighten concerns of some environmental and recreational interests but would not be expected to significantly affect community cohesion in the area.

Categories 4, 5, and 6

Implementation of structural measures would significantly increase and extend navigation system capabilities. Both associated benefits and potential adverse impacts would increase also. Generally, significant overall benefits would contribute toward community and regional cohesion for those communities benefiting most from the navigation system improvements. However, some polarization of interest groups or regions may be observed at both regional and local levels along the lines of "those who would benefit and those who would not or could sustain potential adverse impacts" (reference, Institutional and Public Views Section).

Implementation of structural measures along the International Section of the St. Lawrence Seaway would involve construction of new lock facilities at the Snell and Eisenhower Lock vicinities and some degree of dredging. Commercial vessel traffic and/or ship size would increase gradually but significantly along the Seaway. Ogdensburg Harbor is the only U.S. commercial harbor along the International Section of the river. It is a small commercial harbor and would not benefit significantly from structural lock and channel improvement measures. The remaining U.S. communities along the river are oriented toward recreation, so tourism and the protection of the natural and associated recreational environment is very important. Although some minor benefits may be derived from the Seaway as a tourist attraction, few overall benefits would be realized at the local level (New York State St. Lawrence River vicinity).

The river communities and the State of New York are therefore generally nonsupportive of any Seaway development measures that could alter or adversely impact the St. Lawrence River as it exists today. Therefore, some increases in community cohesion have been observed at one level resulting from the organization of interest groups to express and promote a specific viewpoint, while at another level, some polarization of interest groups or regions may be observed pertaining to project vs. no-project support (reference Institutional and Public Views Sections).

COMMUNITY AND REGIONAL GROWTH (REFERENCE ALL OTHER SECTIONS)

Category 2

Generally, for the GL/SLS nonstructural measures would expedite lockage and passage of vessels through the system. This would increase the system's capacity by an estimated 7 to 13 percent (Booz-Allen-Hamilton, 1981). Increased capacity would facilitate business, industry and agricultural transportation needs of the region primarily through rate savings resulting from continued use of the system instead of cargo being forced to use a more expensive route and mode. Some associated community developmental, employment and income benefits might also be expected. This would facilitate affected system harbor community and regional growth in the Great Lakes Region.

With nonstructural measures, commercial vessel traffic would increase slightly along the St. Lawrence Seaway. Ogdensburg Harbor is the only U.S. commercial harbor along the International Section of the river and would not loose or benefit significantly from nonstructural improvement measures. The remaining U.S. communities along this section of the river are oriented toward recreation and tourism. Increased vessel traffic could heighten concerns of environmental and recreational interests; however, associated impacts are believed to be negligible. Although nonstructural measures may induce some additional interest in the Seaway tourism trade, these communities would not be expected to loose or benefit significantly.

Categories 4, 5, and 6

With structural measures, significantly more tonnage of goods could be transported through the GL/SLS. These would extend the estimated system capacities past the year 2000 (reference Booz-Allen-Hamilton, 1981/82). Direct benefits would include: (1) Rate savings resulting from continued use of the system instead of cargo being forced to use a more expensive route and mode; (2) Reduced delay at congested locks; and, (3) Improved vessel productivity resulting from more cargo per locking operation. These extended and increased system capacities would significantly facilitate navigational transportation needs of business, industry, and agriculture in the Great Lakes region. Associated community developmental, employment, and income benefits would also be anticipated (reference Booz, Allen, Hamilton, 1981/82), and, since navigation is a relatively fuel efficient means of transportation, significant energy savings would also be realized. This would significantly facilitate affected system harbor community and regional growth in the Great Lakes region.

Some identified potential effects possibly adversely affecting community and regional growth are: Loss of potential revenue and development to alternate modes of transportation and potential adverse impacts to water resources (Water Quality, Fish and Wildlife) and associated recreational development opportunities. Generally (in reference to the prior), the regional communities adversely affected would be those not connected to the Great Lakes Seaway System, but to other transportation modes and (in reference to the latter) the communities affected would be located primarily along the GL/SLS System connecting channels.

Implementation of structural measures along the International Section of the St. Lawrence Seaway would involve construction of new lock facilities at the Snell and Eisenhower Locks and some degree of dredging. Commercial vessel traffic and/or ship size would increase gradually but significantly along the St. Lawrence Seaway. As stated previously, Ogdensburg Harbor is the only U.S. commercial harbor along the International Section of the river and would not loose or benefit significantly from proposed structural navigation improvement measures. The remaining U. S. communities along this section of the river are oriented toward recreation and tourism. The protection of the natural and associated recreational environment is very important to them.

Potential adverse impacts of construction, dredging and increased vessel traffic of larger vessels (and associated impacts) are understandably of great concern. Significant adverse impacts to the natural and associated recreational environments could conceivably disrupt the existing community and regional functional base and potential future community, and regional growth. (See Water Quality, Fisheries, Wildlife and Recreation Sections.) Although these are not expected to be significant long-term impacts, the magnitude fo such impacts are not clearly known at this time and they must be examined in greater detail.

Construction may provide some short-term employment and income opportunities in the construction vicinity but could also stress some community facilities and services. The threat of localized unemployment is also seen by some as the result of a permanent influx of temporary construction workers released at the conclusion of the project. Long-term employment at the lock facilities would remain essentially stable. Although some 40 acres of land would be required to construct the new facilities, this would not be expected to significantly disrupt land use plans in this vicinity.

Facilities do exist for the public to view the lockage of ships through the SLS System. New/old locking facilities may induce addition interest in Seaway tourism which could benefit communities in the lock vicinity.

INSTITUTIONAL

Reference the Main Report for infomation on public coordination, public views, and agency planning and implementation responsibilities.

CULTURAL RESOURCES

Reference Existing Conditions Section of this assessment.

SUMMARY OF IMPACTS

Reference Table 33, Main Report, for Summary of Impacts.

CANDIDATE EQ PLANS

The EQ evaluation considers impacts on ecological, cultural, and aesthetic attributes of significant natural and cultural resources. In evaluating the alternative plans for this study, the most significant EQ resource to be considered is the St. Lawrence River. The river encompasses all three of the aforementioned attributes and has been identified by the U. S. Fish and Wildlife Service, the New York State Department of Environmental Conservation, Save the River, and others as a significant resource.

In establishing critical criteria for the evaluation of EQ Plans, any plan which adversely effects any of the three attributes - ecological, cultural, or aesthetic - of the St. Lawrence River would reduce its desireability of being selected as an EQ Plan. Therefore, any plan which could adversely affect any of the established attributes was initially eliminated during this evaluation.

In evaluating the alternative plans (reference Impact Assessment and Evaluation Section for complete description), the only plans for either the low or high traffic forecasts that seem to cause no major modifications or disruptions (i.e., river dredging, widening, disposal, and channel modifications throughout many portions of the river) to the ecological and aesthetic attributes of the river are the nonstructural and structural portions of Plan AVII27 (low) and Plan AVII27 (high). Impacts to cultural resources cannot be reasonably predicted at this time. However, a cultural resource predictive model is currently being prepared and may be available during the summer of 1982.

Nonstructural measures would create the least significant impact on EQ resource attributes since they would only involve minor modifications at the existing lock sites; whereas the structural alternative, AVII27 (low and high forecast), would require the construction of two new low-lift locks at Massena, NY. Construction of AVII27 would disturb and/or destroy both aquatic and terrestrial habitat and species only in one specific localized area at the location of the existing locks, Massena, NY. The nonstructural plan could be a potential EQ Plan, but it does not meet the overall study objectives and, therefore, is not implementable in itself. Plan AVII27, for both the low and high forecasts, could be considered as a potential candidate EQ Plan.

Structural Alternate Plans RX27 and AX27 require construction and dredging (i.e., channel widening) in the St. Lawrence River. This could be viewed as a negative adverse impact on the ecological and aesthetic attributes of the river resource, but would be temporary in nature. Both alternatives will eventually reduce vessel transits, which could be beneficial since the frequency of disturbances to the river environment caused by vessels would be reduced. However, the actual disturbance per occurrence could be of a greater magnitude, since larger class vessels will be navigating the system. Plan AVII27 allows for more transits of the existing type Class VII vessels, hence no ship size increase; and Plans RX27 and AX27 for fewer total transits, although some transits are of larger Class X vessels. Plans RX27 and AX27 do have more construction-related adverse impacts as compared to

Plan AVII27. However, to adequately compare these alternatives at this stage of planning for determination of EQ benefits, additional information is required; this will have to be obtained in Stage 3 planning. Information on physical differences of hydrodynamic parameters of the larger class vessel (i.e., surge, drawdown, height of vessel generated wave), and the effects of larger propulsion systems as compared to existing Class VII vessels is not completely available and must be obtained. This information will help in assessing if an increased number of Class VII vessel transits is less environmentally damaging than fewer vessel transits by larger Class X vessels. Therefore, the EQ evaluation for this report is only a partial and incomplete evaluation.

Based on current information and continued reassessments and reevaluations pertaining to plan formulation and the planning process, it is recommended that the following plans be considered as EQ Candidate Plans and be carried forth into Stage 3: nonstructural measures in combination with Plan AVII27 and RX27 for the low forecast; nonstructural measures in combination with Plans AVII27 and AX27 for the high traffic forecasts.

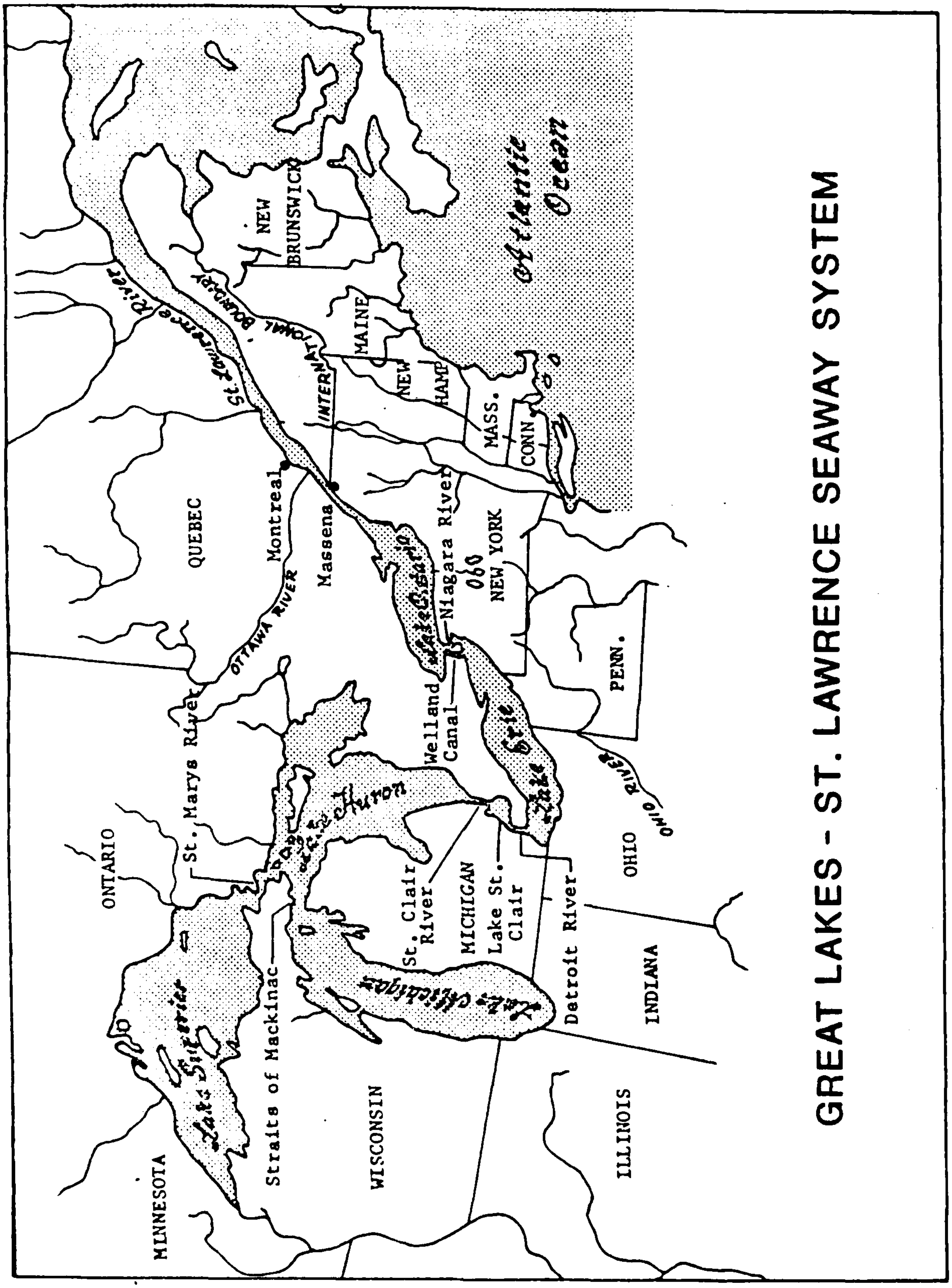
COORDINATION AND COMPLIANCE

The Corps of Engineers has been assigned the responsibility by Congress to conduct the St. Lawrence Seaway Additional Locks Study. The Corps recognizes it responsibility to coordinate and solicit as much input as possible from interested Federal and State agencies, organizations, and the general public. A complete list of all agencies and organizations that this study has been coordinated with thus far can be found in Appendix D, titled Public Involvement, Correspondence, and Coordination.

In an effort to protect the quality of the environment, the preparation of this assessment considered and addressed the following applicable statutes and requirements: Clean Air Act as amended; Clean Water Act of 1977; Coastal Zone Management Act of 1972 as amended; Endangered Species Act of 1973 as amended; Fish and Wildlife Coordination Act; National Historic Preservation Act; National Environmental Policy Act; Wild and Scenic Rivers Act; and the following Executive Orders: 11988, Flood Plain Management; 11990, Protection of Wetlands; 12114, Environmental Effects Abroad of Major Federal Actions; and Executive Memorandum Analysis of Impacts on Prime and Unique Farmlands. Compliance may be only partial at this stage of planning, but will be addressed more fully during later stages of planning to ensure compliance.

The U. S. Fish and Wildlife Service, Cortland, NY, has been coordinated with. This office performed a Biological Survey for site specific areas - anticipated construction zones along the St. Lawrence River - during 1979 and the results were published in a document entitled Biological Survey Along the St. Lawrence River for the St. Lawrence Seaway Additional Locks and Other Navigation Improvement Study (USFWS 1979). This document is available through the National Technical Information Service (NTIS) at the cost of reproduction.

The St. Regis Band of Mohawks of Canada alleges that construction of the St. Lawrence Seaway and Power Project has, in the last quarter century, adversely affected the air and water quality and the levels and flows regime of the International Rapids section of the St. Lawrence River, thereby prejudicing the land and water resources and the livelihood of the members of the Band. These allegations are presently being investigated by the International Joint Commission (IJC) through appropriate Governmental channels and agencies. Relevant concerns must also be considered in develoment of any proposed St. Lawrence Seaway improvement plans and this study will be coordinated with the St. Regis Band of Mohawks.



GREAT LAKES - ST. LAWRENCE SEAWAY SYSTEM

FIGURE A - 1

TABLE A - 1 General Great Lakes Information
(Area in Square Miles)

	Drainage Basin (Land & Water)			Water Surface			Land Surface (1)		
	U. S.	Canada	Total	U. S.	Canada	Total	U. S.	Canada	Total
Lake Superior	37,500	43,500	81,000	20,600	11,100	31,700	16,900	32,400	49,300
Lake Michigan	67,900	0	67,900	22,300	0	22,300	45,600	0	45,600
Lake Huron	25,300	49,500	74,800	9,100	13,900	23,000	16,200	35,600	51,800
Lake St. Clair	2,370	4,150	6,520	162	268	430	2,208	3,882	6,090
Lake Erie	23,600	9,880	33,500	4,980	4,930	9,910	18,620	4,950	23,600
Lake Ontario	16,800	15,300	32,100	3,460	3,880	7,340	13,340	11,420	24,700
Total to Lake Ontario Outlet	173,470	122,330	295,800	60,602	34,078	94,680	112,868	88,252	201,100(3)
Lake Ontario Outlet to Moses-Saunders Dam	1,685(2)	1,325(2)	3,010	120(2)	115(2)	235	1,565(2)	1,210(2)	2,775
Total(3)	175,200	123,600	298,800	60,720	34,190	94,910	114,430	89,450	203,900
Grass-Raquette St. Regis	3,200						3,200		
Total Basin Study Area	178,350			60,720			117,630		

(1) Difference between total basin area and water area.
(2) Estimated breakdown between U. S. and Canada.
(3) Rounded.
Source: Great Lakes Bassin Framework Study, Appendix-1 "Alternative Framework," Great Lakes Basin Commission, 1975
NOTE: The drainage basin area in both U. S. and Canada, above the mouth of the St. Regis River is approximately 302,000 square miles.

TABLE A - 2 Descriptive Data on the Great Lakes

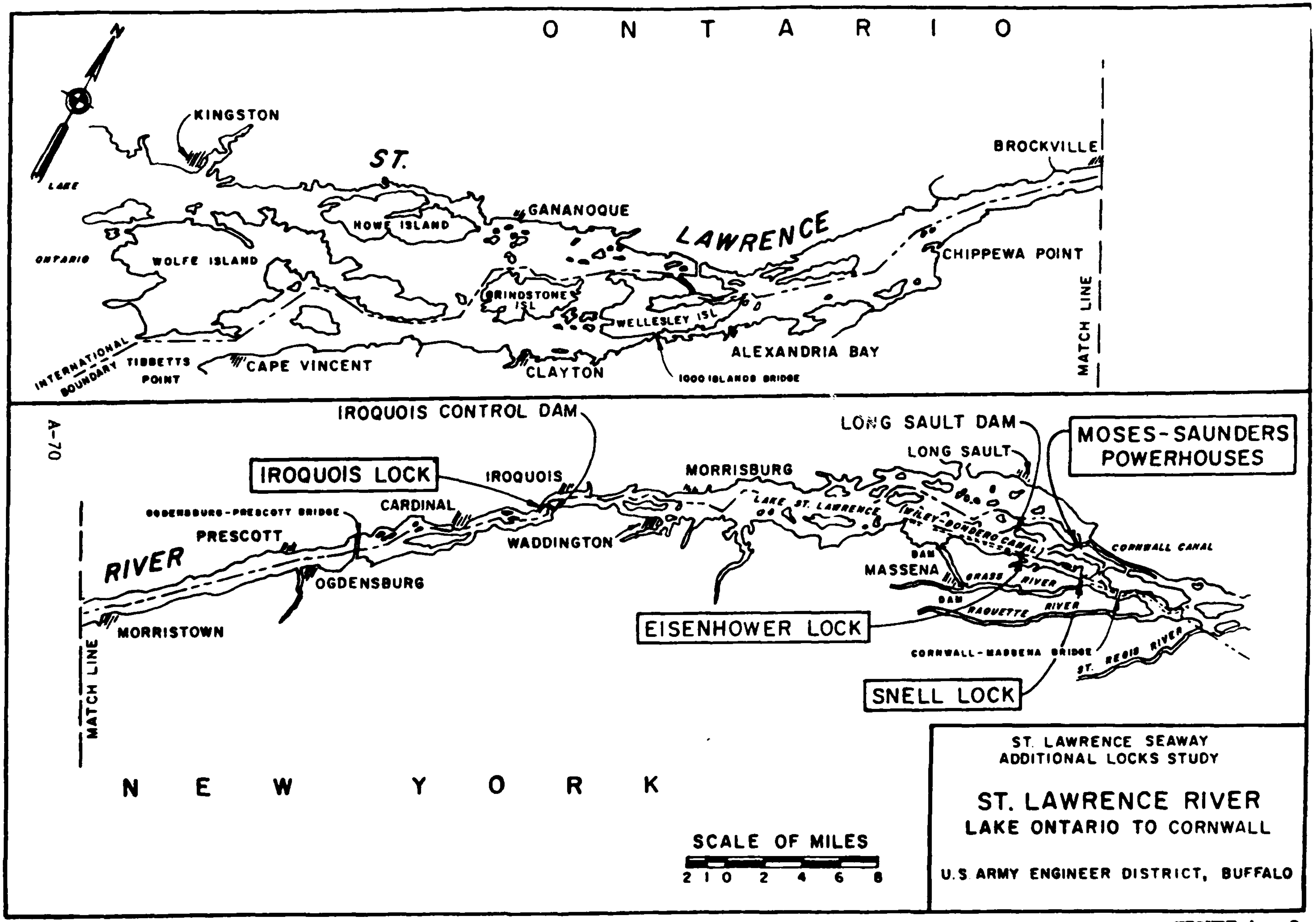
Lake	Monthly Mean Water Stages Above Mean Sea Level (1)			Low Water Datum (LWD)(1)	Dimension			Water Surface Area
	Low	Mean	High		Length	Breadth	Maximum Depth	
	Feet	Feet	Feet	Feet	Miles	Miles	Miles	Square Miles
Lake Superior	598.23	600.39	602.06	600.0	350	160	1,333	31,750
Lake Michigan	575.35	578.70	581.94	576.8	307	118	923	22,300
Lake Huron	575.35	578.70	581.94	576.8	206	101	750	23,100
Lake St. Clair	569.86	573.09	575.70	571.7	26	24	27.5(2)	490
Lake Erie	567.49	570.41	572.76	568.6	241	57	210	9,910
Lake Ontario	241.45	244.77	248.06	242.8	193	53	802	7,600

(1) Internationasl Great Lakes Datum, 1955.
(2) Lake St. Clair has a natural depth of about 21 feet; the figure above is the depth of the navigation channel traversing Lake St. Clair. It is commonly referred to as part of the St. Clair River - Lake St. Clair - Detroit River connecting channel system.
Source: Plan of Study for Great Lakes-St. Lawrence Seaway Navigation Season Extension, U. S. Army Corps of Engineers District, Detroit, July 1976.

TABLE A – 3 Physical Dimensions of the Great Lakes-St. Lawrence Seaway

Reach	Lakes and Channels: Open Waters (Miles)	Channels & Canals (Miles)	Depth (Min.) (Ft.)	Locks: Number	Year Completed	Size (Ft.) Length x Width	Depth Over Sill (Ft.)	Lift (Ft.)
Atlantic Ocean to Father Point, Quebec	700	-	-	-	-	-	-	-
Father Point to Montreal	300		35					
Montreal to Lake Ontario (includes St. Lawrence Seaway)	189	91	27	5 (Can.)	1958	800 x 80	30	226
				2 (U.S.)	1958	800 x 80	30	226
Lake Ontario to Welland Canal	160	-	-	-	-	-	-	-
Welland Canal	-	27	27	8	1932	800 x 80	30	326
Welland Canal to Detroit River	236	-	27	-	-	-	-	-
Detroit River, Lake St. Clair, and St. Clair River	-	77	27	-	-	-	-	-
Lake Huron, St. Clair River to St. Marys River	223	-	-	-	-	-	-	
St. Marys River (includes Soo Locks)	70	2	27	2 (U.S.)	1919	1,350 x 80	23.1	22
				1 (U.S.)	1943	800 x 80	31.0	22
				1 (U.S.)	1968	1,200 x 110	35.0	22
				1 (Can.)	1895	900 x 59	16.8	22
Lake Superior, St. Marys River to Duluth	383	-	-	-	-	-	-	-

Source: Great Lakes Basin Framework Study, Appendix C9 Commercial Navigation (1975).



O N T A R I O
KINGSTON
ST. LAWRENCE
LAKE ONTARIO
WOLFE ISLAND
HOWE ISLAND
GANANOQUE
GRINDSTONE ISL
WELLESLEY ISL
BROCKVILLE
CHIPPEWA POINT
ALEXANDRIA BAY
1000 ISLANDS BRIDGE
CLAYTON
CAPE VINCENT
TIBBETTS POINT
INTERNATIONAL BOUNDARY
MATCH LINE
IROQUOIS CONTROL DAM
IROQUOIS LOCK
IROQUOIS
CARDINAL
OGDENSBURG-PRESCOTT BRIDGE
PRESCOTT
RIVER
OGDENSBURG
MORRISTOWN
MATCH LINE
WADDINGTON
MORRISBURG
LAKE ST. LAWRENCE
LONG SAULT DAM
LONG SAULT
MOSES-SAUNDERS POWERHOUSES
WILEY-DONDERO CANAL
CORNWALL CANAL
DAM
MASSENA
GRASS RIVER
DAM
RAQUETTE RIVER
EISENHOWER LOCK
CORNWALL-MASSENA BRIDGE
ST. REGIS RIVER
SNELL LOCK
N E W Y O R K
SCALE OF MILES
2 1 0 2 4 6 8
ST. LAWRENCE SEAWAY
ADDITIONAL LOCKS STUDY
ST. LAWRENCE RIVER
LAKE ONTARIO TO CORNWALL
U.S. ARMY ENGINEER DISTRICT, BUFFALO

FIGURE A - 2

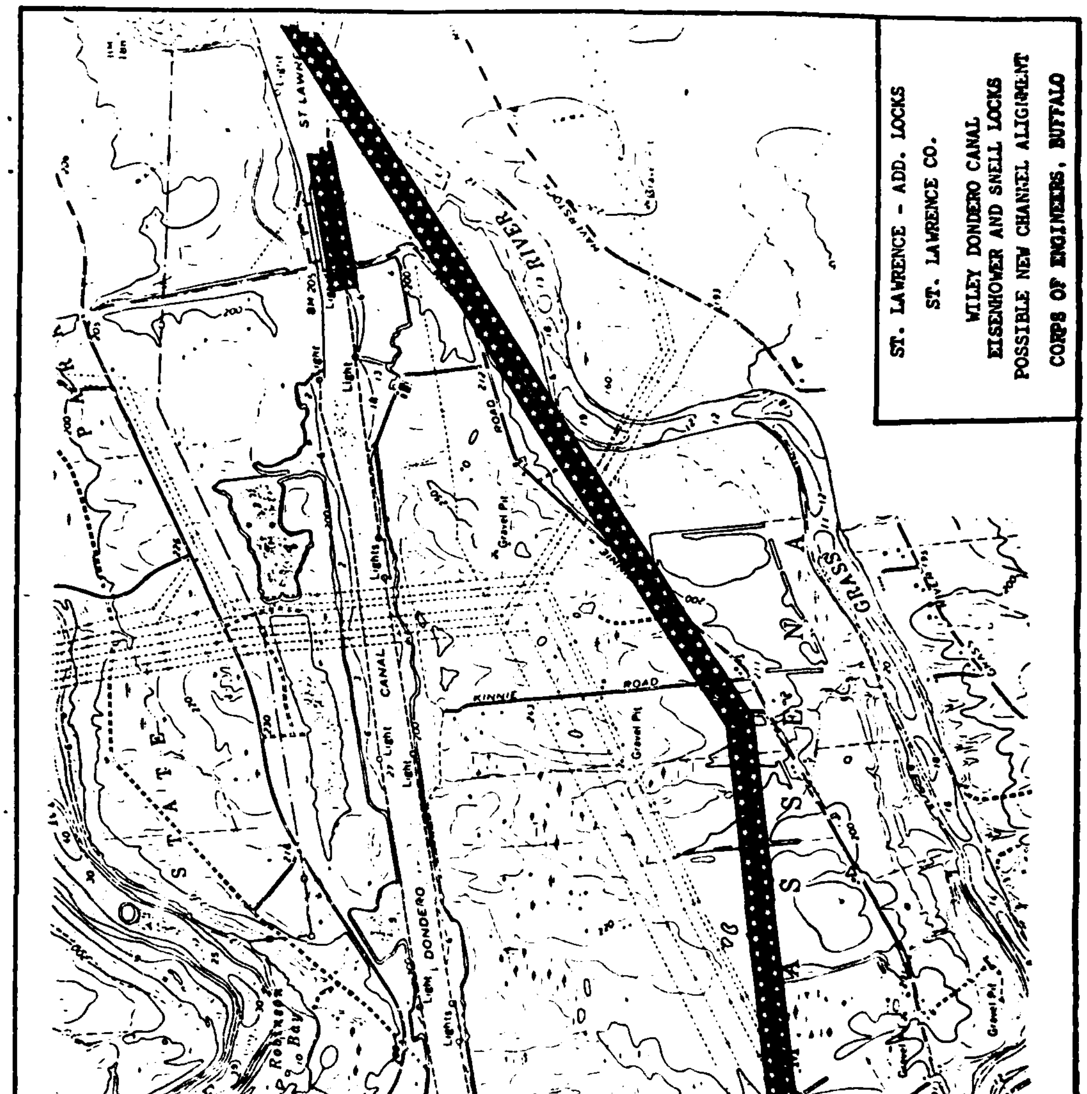
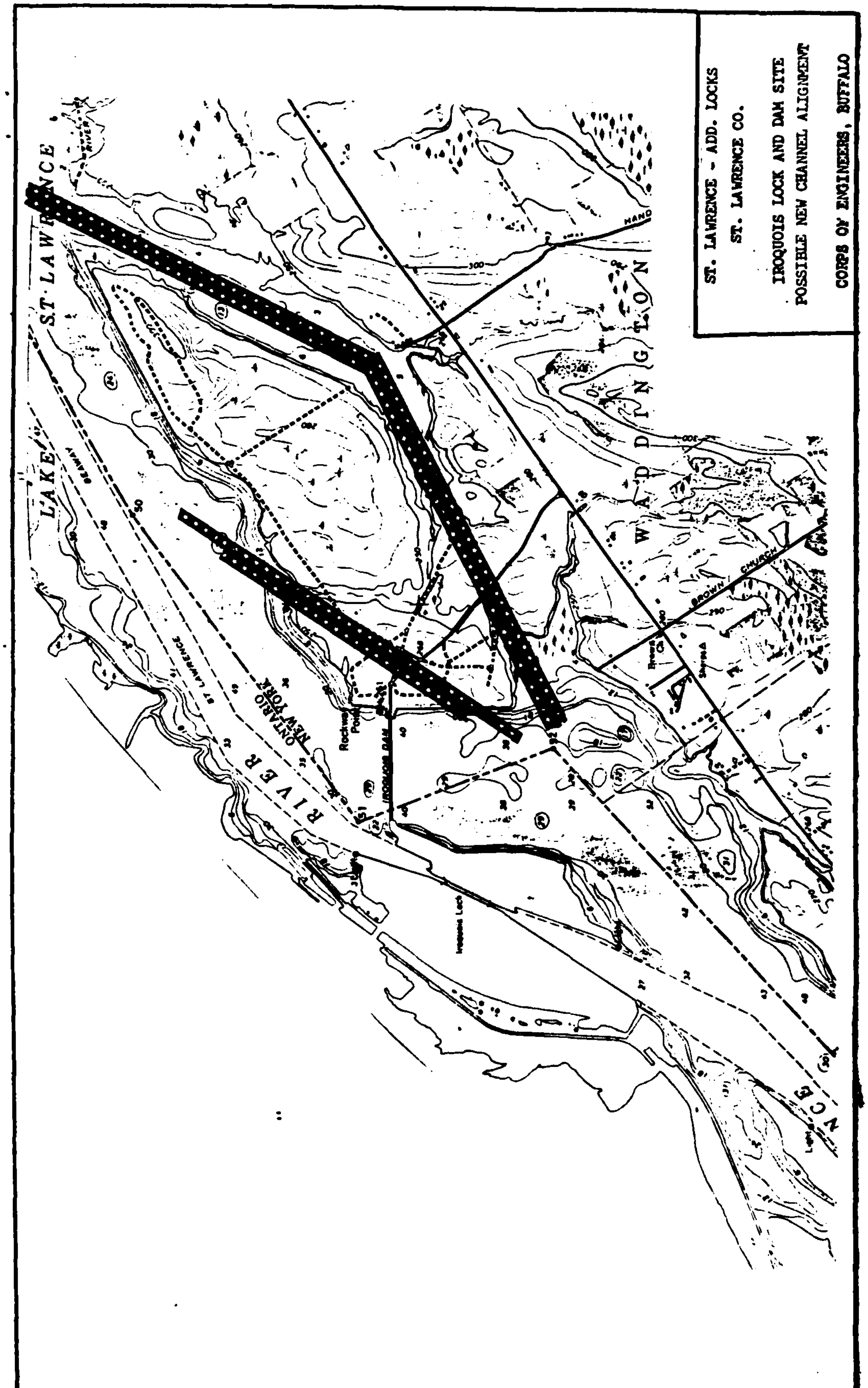

ST. LAWRENCE - ADD. LOCKS
ST. LAWRENCE CO.
WILEY DONDERO CANAL
EISENHOWER AND SNELL LOCKS
POSSIBLE NEW CHANNEL ALIGNMENT
CORPS OF ENGINEERS, BUFFALO
ST LAWRENCE
WILEY
DONDERO
CANAL
KINNIE ROAD
GRASS
RIVER
SEAWAY

FIGURE A - 3a



ST. LAWRENCE - ADD. LOCKS
ST. LAWRENCE CO.
IROQUOIS LOCK AND DAM SITE
POSSIBLE NEW CHANNEL ALIGNMENT
CORPS OF ENGINEERS, BUFFALO

FIGURE A - 3b

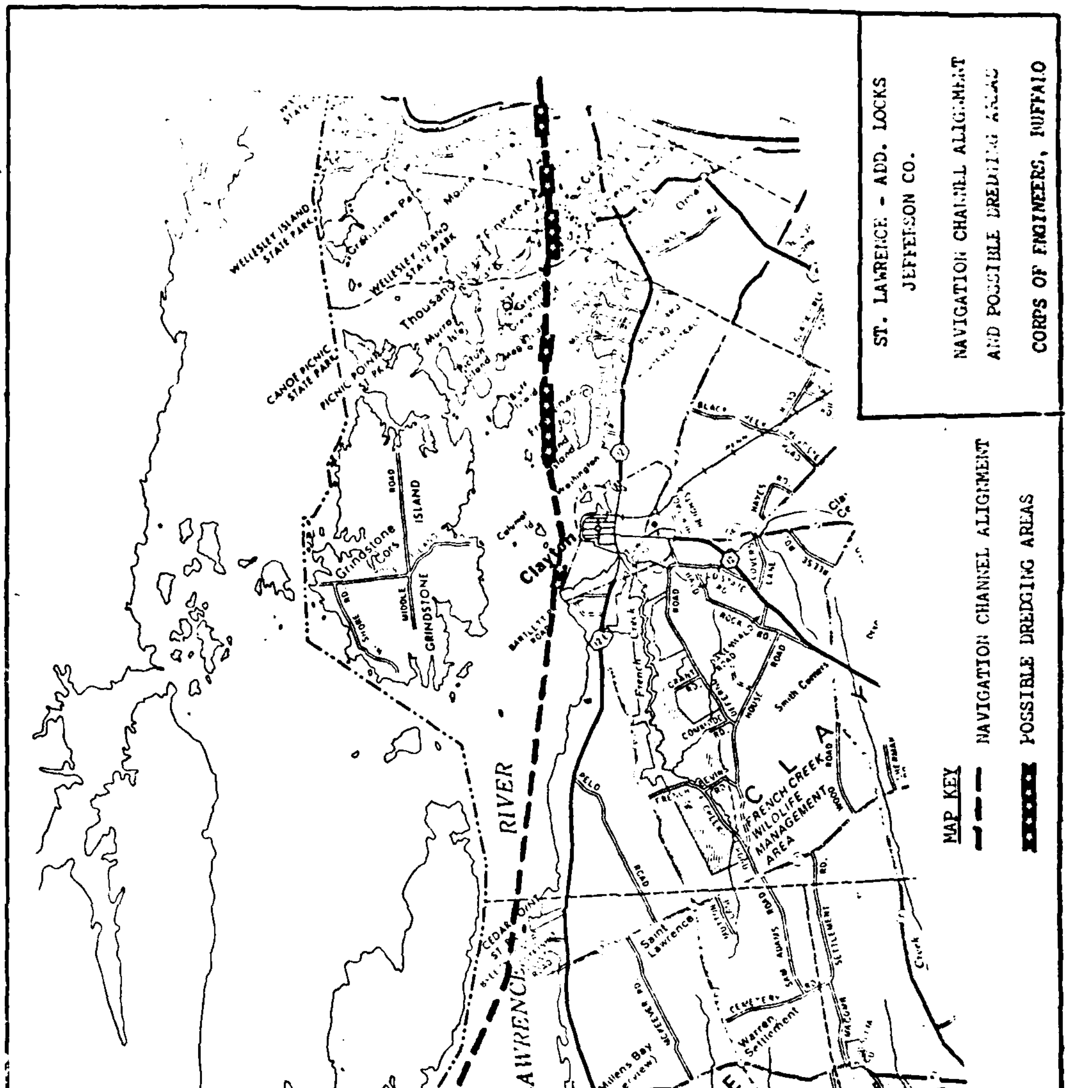

ST. LAWRENCE - ADD. LOCKS
JEFFERSON CO.
NAVIGATION CHANNEL ALIGNMENT
AND POSSIBLE DREDGING AREAS
CORPS OF ENGINEERS, BUFFALO
MAP KEY
NAVIGATION CHANNEL ALIGNMENT
POSSIBLE DREDGING AREAS
ST. LAWRENCE
RIVER
ONTARIO
NEW YORK
Clayton
Cape Vincent
Carleton Island
GRINDSTONE ISLAND
WELLESLEY ISLAND STATE PARK
CANOE PICNIC STATE PARK
BURNHAM POINT STATE PARK
FRENCH CREEK WILDLIFE MANAGEMENT AREA
ASHLAND WILDLIFE MANAGEMENT AREA
CLAY
CAPE VINCENT
Millens Bay
Saint Lawrence
Warren Settlement
Rosiere
Smith Corners
Three Mile Bay

FIGURE A - 4a

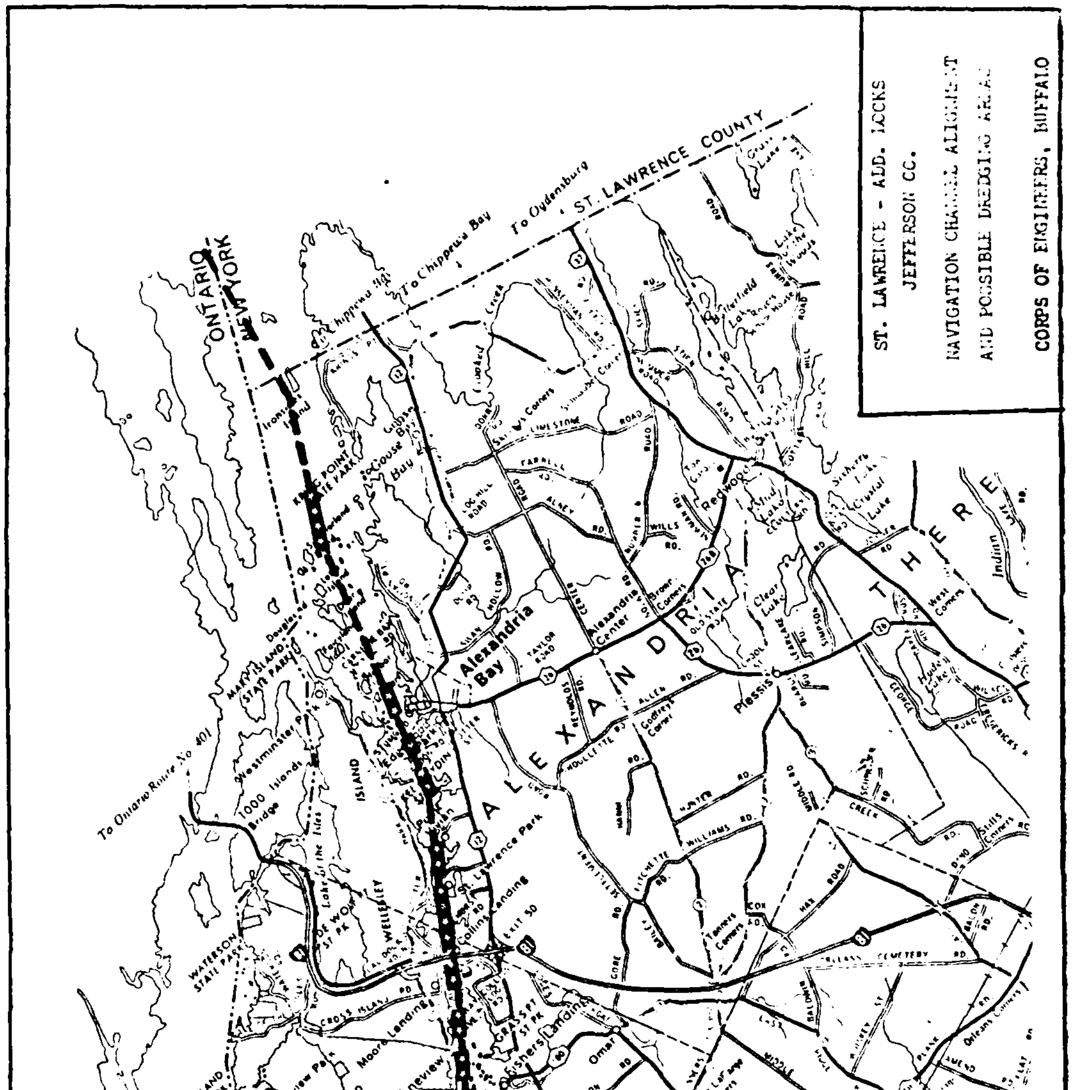

ST. LAWRENCE - ADD. LOCKS
JEFFERSON CO.
NAVIGATION CHANNEL ALIGNMENT
AND POSSIBLE DREDGING AREAS
CORPS OF ENGINEERS, BUFFALO
ST. LAWRENCE COUNTY
ONTARIO
NEW YORK
To Ogdensburg
To Chippewa Bay
To Ontario Route No. 401
ALEXANDRIA
Alexandria Bay
Clayton

FIGURE A - 4b

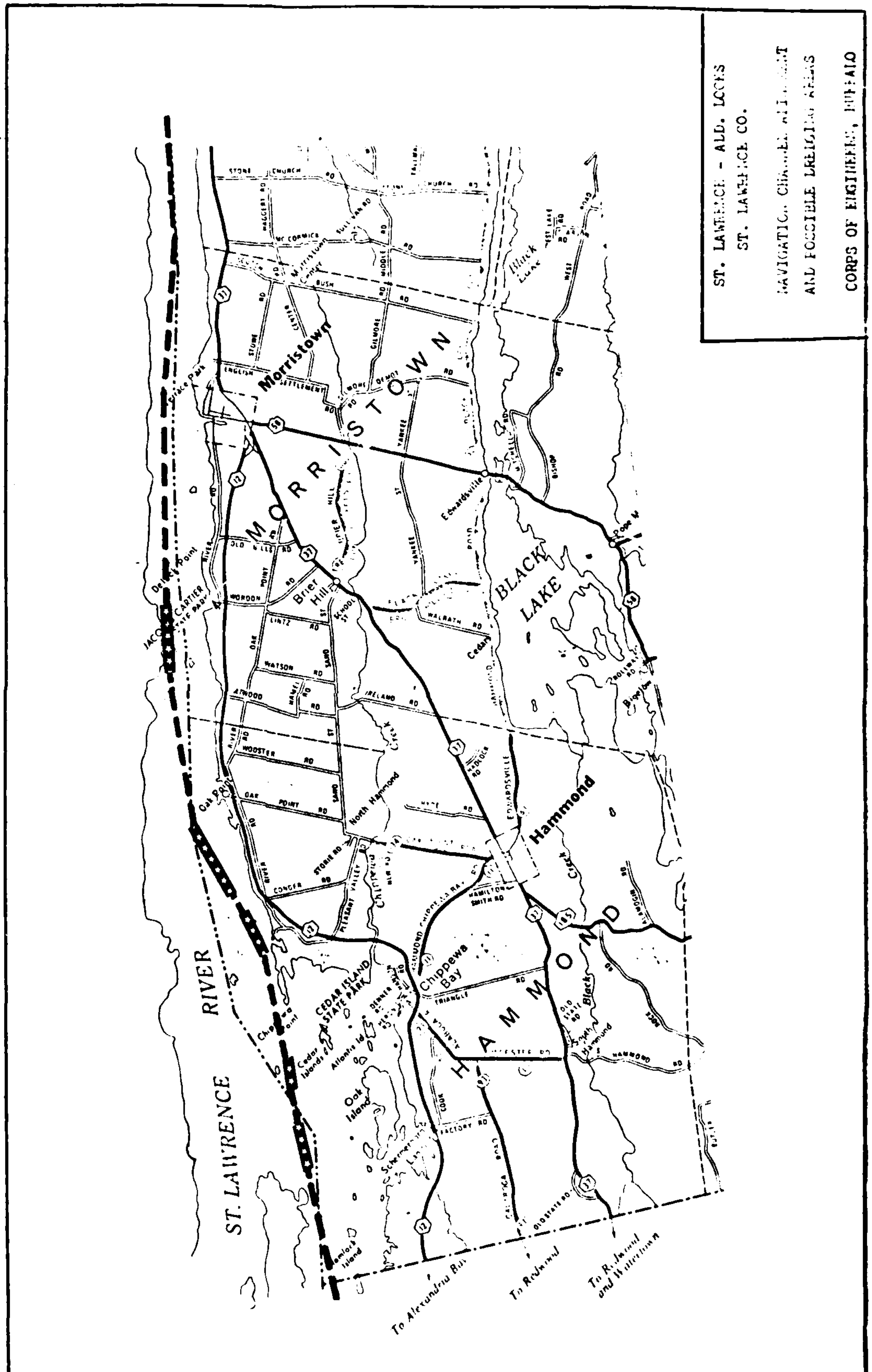

ST. LAWRENCE CO.
CORPS OF ENGINEERS, BUFFALO
ST. LAWRENCE RIVER
MORRISTOWN
Morristown
HAMMOND
Hammond
BLACK LAKE
Brier Hill
Edwardsville
North Hammond
Chippewa Bay
Oak Point
CEDAR ISLAND STATE PARK
Oak Island
To Alexandria Bay
To Redwood

FIGURE A - 4c

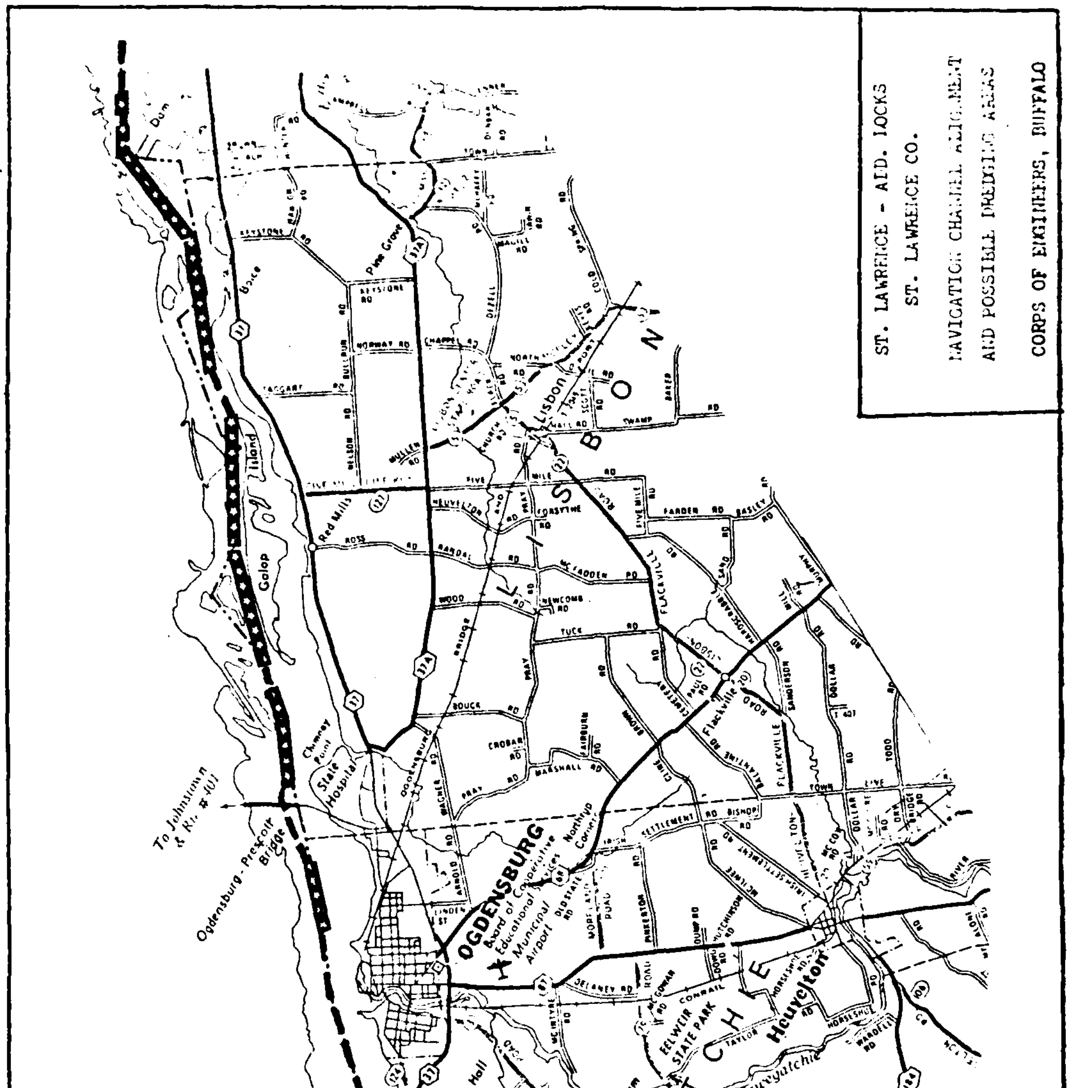
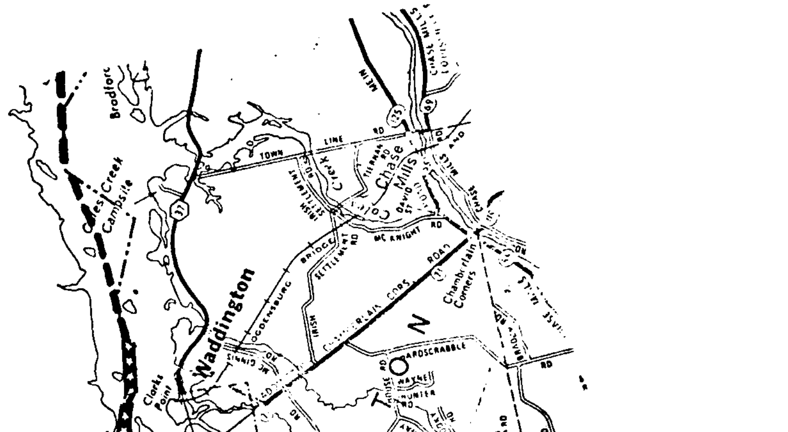

ST. LAWRENCE - AID. LOCKS
ST. LAWRENCE CO.
NAVIGATION CHANNEL ALIGNMENT AND POSSIBLE DREDGING AREAS
CORPS OF ENGINEERS, BUFFALO
OGDENSBURG
Heuvelton
Morristown
Lisbon
Red Mills
Chimney Point
Ogdensburg - Prescott Bridge
To Johnstown & Rt. #401
Galop Island
Oswegatchie
EELWEIR STATE PARK
Municipal Airport
Wadhams Hall
Mater Dei College
State Hospital

FIGURE A - 4d



ST. LAWRENCE - ADD. LOCKS
ST. LAWRENCE CO.

NAVIGATION CHANNEL ALIGNMENT
AND POSSIBLE DREDGING AREAS

CORPS OF ENGINEERS, BUFFALO

FIGURE A - 4e

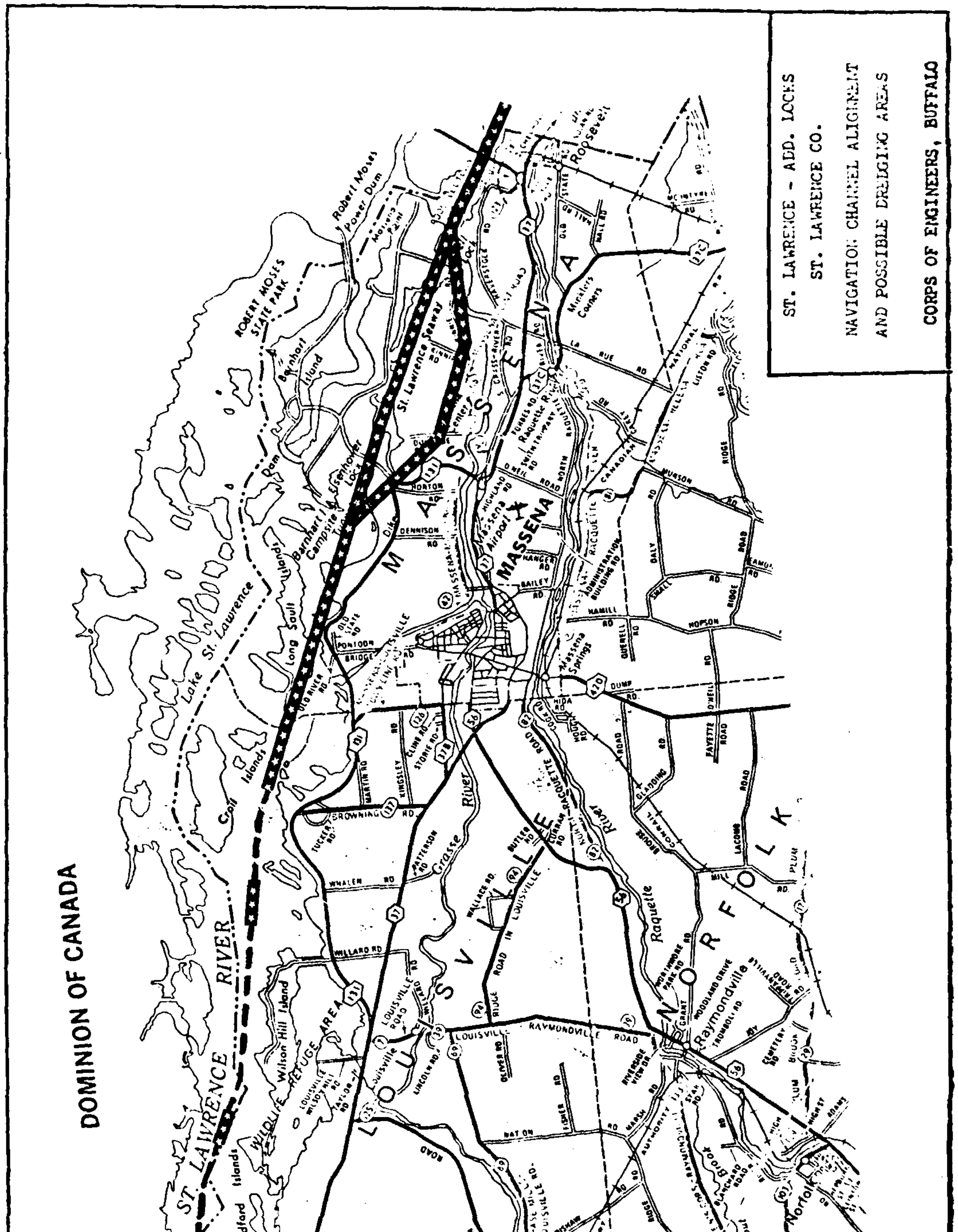

ST. LAWRENCE - ADD. LOCKS
ST. LAWRENCE CO.
NAVIGATION CHANNEL ALIGNMENT
AND POSSIBLE DREDGING AREAS
CORPS OF ENGINEERS, BUFFALO
DOMINION OF CANADA
ST. LAWRENCE RIVER
Lake St. Lawrence
ROBERT MOSES STATE PARK
Robert Moses Power Dam
St. Lawrence Seaway
Barnhart Island
Long Sault Islands
Croil Islands
Wilson Hill Island
WILDLIFE REFUGE AREA
Bradford Islands
MASSENA
Massena Airport
Massena Springs
Grasse River
Raquette River
Raymondville
Norfolk
Waddington
Chase Mills
Roosevelt
Trout Brook

FIGURE A - 4f

SIGNIFICANT ENVIRONMENTAL AREAS

Based upon a review of existing literature and letter or telephone communication with Federal or State agencies having an interest in natural resources, a number of significant environmental areas were identified along the United States Shoreline of the St. Lawrence River. Figures A5a through A5f show approximate locations of 55 of these areas. Each significant area described in Table A-4 is keyed to a number on one of the Figures provided. Additionally, reference materials reviewed or agencies contacted are included in an accompanying bibliography.

TABLE A - 4 Coastal Zone Areas of Significant Environmental Concern

Location: Number	Area	Reference
	NOTE: The St. Lawrence River, from Tibbett Point to Clayton (which includes Carlton Island) is excellent habitat for migrating birds.	15
1	Important wildlife habitat.	2
2	Carlton Island. This is excellent habitat for migrating birds.	15
3	Millen Bay. Numerous sport fish use this area for either spawning, nursery, or feeding area. Some species include northern pike, brown bullhead and rock bass.	15
	NOTE: The shoreline along the St. Lawrence River and its islands from Clayton to Oak Point is high quality avian habitat, including nesting and feeding areas for Bald Eagles and Ospreys.	15
4	French Creek Bay and Marsh. Northern pike habitat and supports significant fisheries. This area is a valuable breeding ground and migration stopover point for waterfowl.	4, 11, 14, 15
5	Flynn Bay Marsh. This area is high quality spawning habitat, particularly for northern pike. The area also an important wildlife habitat.	2, 15

Coastal Zone Areas of Significant Environmental Concern

Location: Number	Area	Reference
	NOTE: The shoreline environment of the St. Lawrence River and islands from Clayton to Oak Point is high quality avian habitat. Nesting and feeding areas are available for great blue herons, bald eagles, ospreys, common gallinules, black terns, common terns, and long-billed marsh wrens. Migrating waterfowl concentrate in the island channels for feeding and resting.	15
6	McCrae Marsh (Grindstone Is). Unique fish habitat as well as wildlife habitat. The marsh is a fish spawning area of high quality, particularly for northern pike.	2, 15
7	Eagle Wing Group Islands. Important habitat for Herring Gulls and Common Terns. The shallows and shoals of this area contain significant smallmouth bass fishery.	16
8	Delaney Marsh (Grindstone Is.) Unique fish habitat; important wildlife and high quality fish spawning area particularly Northern Pike.	2, 15
9	Picton Island. Northern limit of known Turkey Vulture breeding habitat.	16
	Note: The interior wetlands of Wellesley Island are significant habitat for marsh birds and valuable breeding grounds for waterfowl during periods of high water levels.	15
10	South Bay Marsh. High quality avian habitat and bald eagles formly nested in the area.	15
11	Murray Isle Wetland. High quality avian habitat and bald eagles formly nested in the area. Nesting and feeding areas are available for various species of birds, including the endangered bald eagle.	15
12	Eel Bay and Wetland Area. This is a high quality avian habitat area and bald eagles formly nested in this locale. Eel Bay has been known to contain a distinct smallmouth bass population and at one time was a major concentration area for this species. Historically, this area was a major spawning habitat for bass, channel catfish, and possibly muskellunge. These species may still use this area for spawning, nursery or feeding areas. Northern pike habitat is also present and this area is used for ice fishing.	11, 15

Coastal Zone Areas of Significant Environmental Concern

Location Number	Area	Reference
	NOTE: *The general area of the Thousand Islands* reach, in the St. Lawrence River, provides an aquatic and shoreline environment of significant value to wildlife.	3, 17
13	Flatiron Marsh. This marsh is used by migrating waterfowl for feeding and nesting.	15
14	North Flatiron Area Wetland. High quality avian habitat; bald eagles formly nested in the area.	15
15	Bradley Point Area Wetland. High quality avian habitat; bald eagles formly nested in the area.	15
16	Waterson Point Park Wetland. High quality avian habitat; bald eagles formly nested in the area.	15
17	Rift Area Marsh and Wetland. High quality avian habitat; bald eagles formly nested in the area.	15
18	Lake of Isles and Wetland. Concentration of sport fish and high quality avian habitat.	15
19	Barnett Marsh. Significant wetland area and bald eagles formly nested in the area. There is also a concentration of sport fish.	12, 15
20	Desmore Bay. High quality avian habitat; bald eagles formly nested in the area.	15
21	This is a unique vegetation area.	2
22	Westminster Marsh. High quality avian habitat; bald eagles formly nested in this area.	4, 15
23	Fairyland Island. High quality avian habitat; bald eagles formly nested in the area.	15
24	Deer Island Wetland. High quality avian habitat; bald eagles formly nested in the area.	15
25	Blind Bay Marsh. Marsh is important for northern pike and yellow perch. This is an excellent production area for black ducks, mallards, and teal.	4, 15
26	Mullett Creek Bay and Wetland. Supports grass pickerel, brown bullheads, yellow perch. Northern pike spawn in the wetlands upstream.	15

Coastal Zone Areas of Significant Environmental Concern

Location Number	Area	Reference
27	Moore Landing Marsh. This is a valuable breeding area for waterfowl and significant habitat for marsh birds during high water levels.	4, 15
28	This area has a diverse series of habitats. Rock outcroppings colonized by plant communities of herbs, shrubs, and trees.	3
29	Swan Bay Marsh. Important fish spawning area particularly for northern pike.	4, 15
30	Point Vivian Marsh. Unique vegetative area; important fish spawning area particularly for northern pike and bass.	2, 4, 15
31	Keewayden State Park. A small marsh that represents an excellent graminoid wetland.	2
32	Otter Creek. Supports significant fisheries.	14, 15
33	Carnegie Bay and Wetlands. Significant avian habitat.	15
34	Cranberry Creek (near Goose Bay). Muskellunge and northern pike spawning area. Brown bullhead habitat.	15
35	Significant Wetland Area. *(approximate location)*	13
36	Goose Bay and associated marsh (Cranberry Creek enters this bay). Important wildlife area; muskellunge and northern pike spawning area (north and south portions of the bay). Brown bullhead habitat; ice fishing area and high quality avian habitat.	3, 6, 9, 11, 15,
37	Ironsides Island. One of New York State's largest heron rookeries.	8, 9
38	Unique vegetation and fish habitat area; important wildlife and avian habitat.	7, 15
39	Crooked Creek. Muskellunge spawning area at the mouth and supports other significant fisheries. This is also important avian habitat.	11, 14, 15
40	Duck Cove. Area of significant avian habitat.	15
41	Oak Island. Significant avian habitat.	15

Coastal Zone Areas of Significant Environmental Concern

Location Number	Area	Reference
42	Eaglewing Shoals. Nesting site for the common tern.	8
43	Chippewa Bay. Has waterfowl and fishery value. Ice fishing area.	3, 6, 10, 11, 15
44	Chippewa Creek. Unique fish habitat; wildlife area. Muskellunge spawning habitat at mouth of creek; northern pike spawning habitat and important associated wetlands.	2, 11, 13, 14, 15
45	Morristown Bay and wetland. Spawning area for large and smallmouth bass.	15
46	Oswegatchie River, Bay, and vicinity. Wildlife value; muskellunge habitat in localized areas and supports other significant fisheries.	10, 11, 14
47	Tibbits Creek and Marsh. Significant spawning, nursery and feeding habitat for various fish species including yellow perch, smallmouth bass and northern pike.	15
	NOTE: Habitat along the St. Lawrence River and its islands from Waddington to Roosevelttown consists of shallow shorelines and embayments and small tributary outlets which are ideal for waterbirds and shorebirds.	
48	Whitehouse Bay. Significant fisheries for spawning, nursery, and feeding.	15
49	Sucker Brook. Northern pike spawning habitat and supports other significant fisheries.	11, 14, 15
50	Little Sucker Brook. Supports significant fisheries.	14, 15
51	Terrestrial locale near mouth of Brandy Brook. Wildlife value.	10
52	Brandy Brook. Northern pike spawning habitat and supports significant fisheries.	11, 14, 15
53	Coles Creek. Northern pike spawning habitat and supports significant fisheries. This area has breeding habitat for several species of birds.	8, 11, 14, 15
54	Wilson Hill Wildlife Refuge (Nichols Hill Island in this Refuge). This area is particularly attractive to geese and dabbling ducks.	1, 5, 15
55	Grass River. Northern pike spawning habitat.	11

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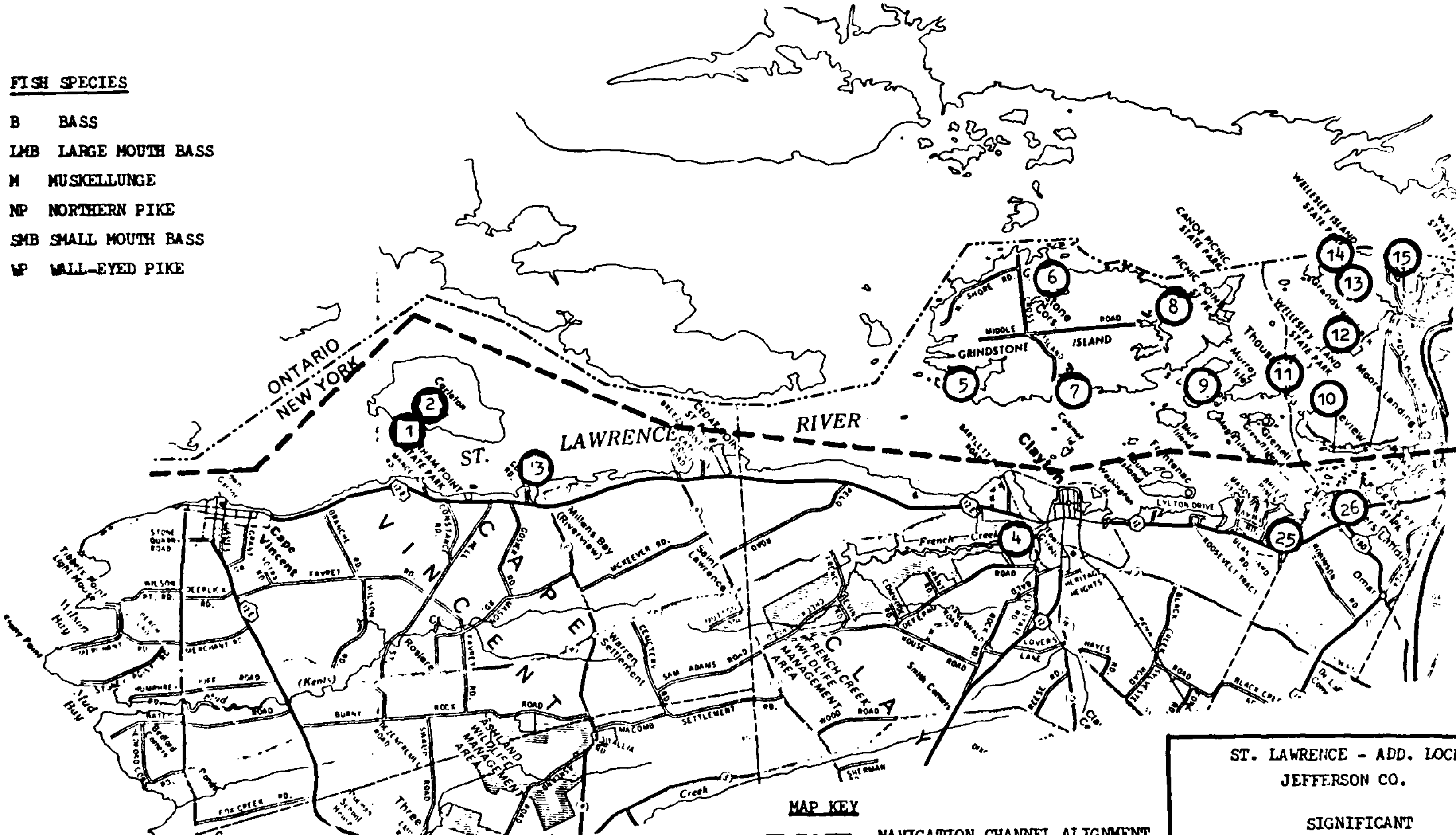
FISH SPECIES

- B BASS
- LMB LARGE MOUTH BASS
- M MUSKELLUNGE
- NP NORTHERN PIKE
- SMB SMALL MOUTH BASS
- WP WALL-EYED PIKE



MAP KEY

- — — — NAVIGATION CHANNEL ALIGNMENT
- ○ LOCATION SYMBOL

Sources: C.O.E., Buffalo Dist.; Significant Environmental Areas extracted from L.O.S.P.S.
-St. Lawrence County, A Map for All Seasons

ST. LAWRENCE - ADD. LOCKS
JEFFERSON CO.

SIGNIFICANT
ENVIRONMENTAL AREAS

CORPS OF ENGINEERS, BUFFALO

FIGURE A - 5a

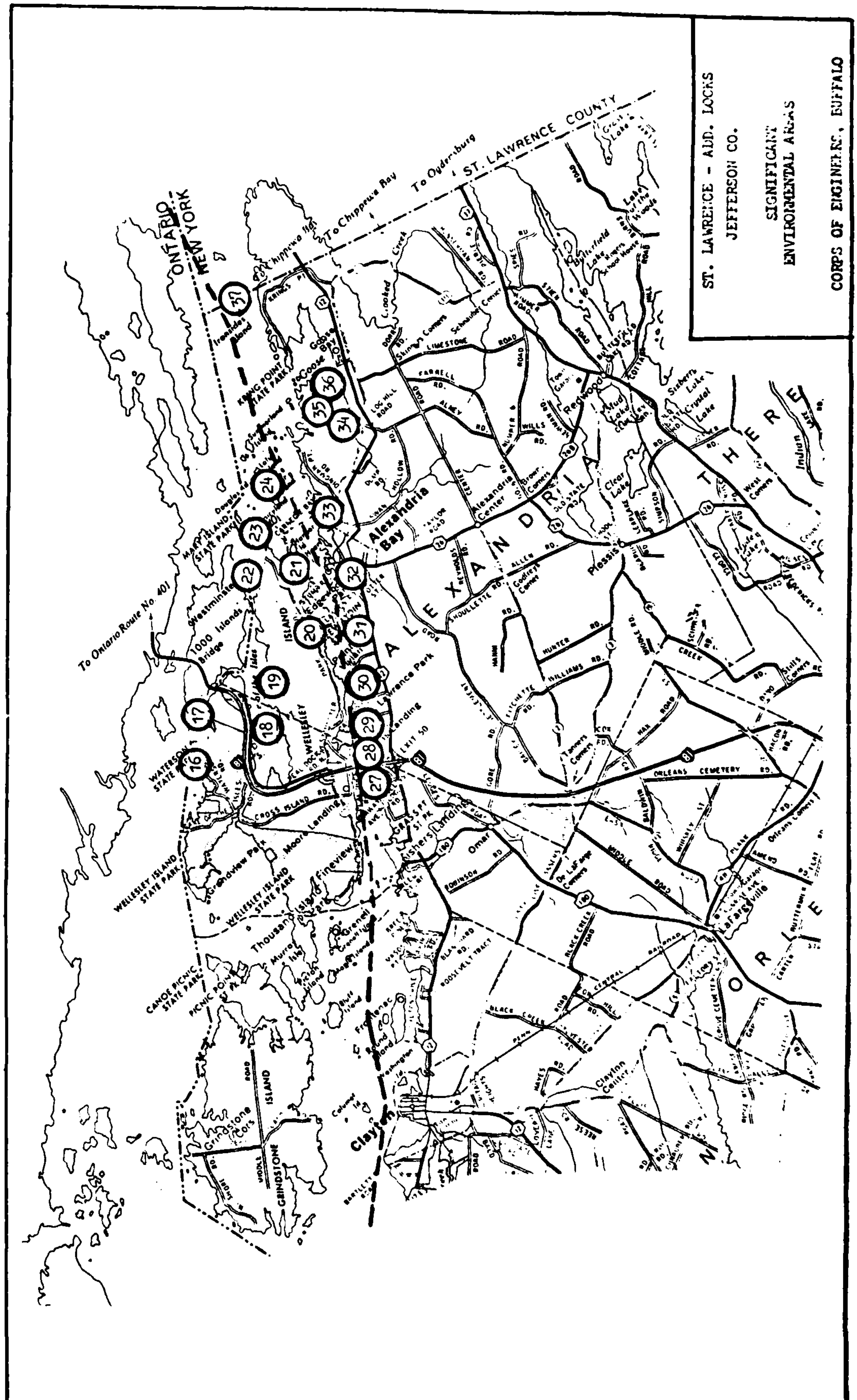

ST. LAWRENCE - ADD. LOCKS
JEFFERSON CO.
SIGNIFICANT ENVIRONMENTAL AREAS
CORPS OF ENGINEERS, BUFFALO
ONTARIO
NEW YORK
ST. LAWRENCE COUNTY
To Ogdensburg
To Chippewa Bay
To Ontario Route No. 401
Alexandria Bay
ALEXANDRIA
THERESA
ORLEANS
Clayton
WELLESLEY ISLAND
1000 Islands Bridge
Westminster
Redwood
Plessis
Lafargeville
Clayton Center
Grindstone

FIGURE A - 5b

ST. LAWRENCE - ADD. LOCKS
ST. LAWRENCE CO.

SIGNIFICANT
ENVIRONMENTAL AREAS

CORPS OF ENGINEERS, BUFFALO

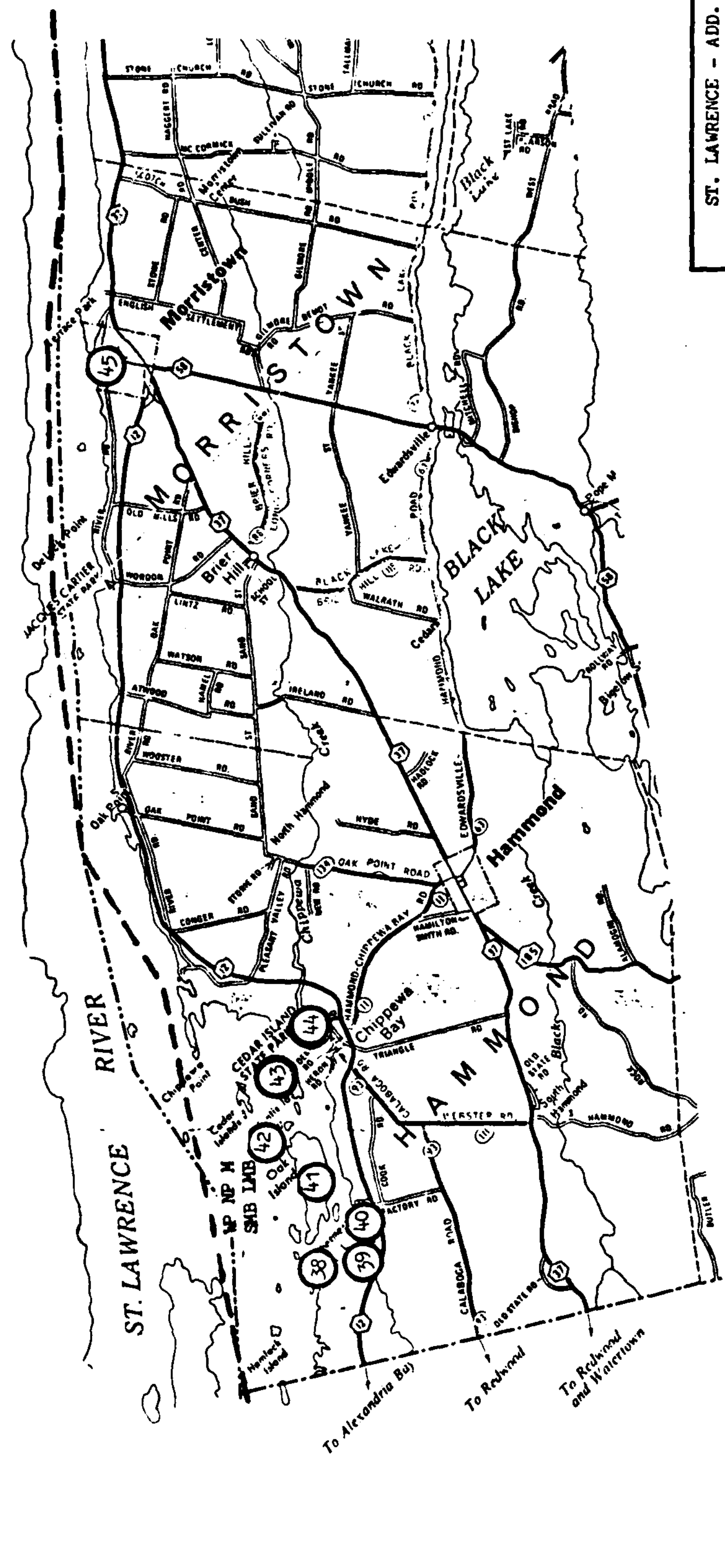


FIGURE A - 5c

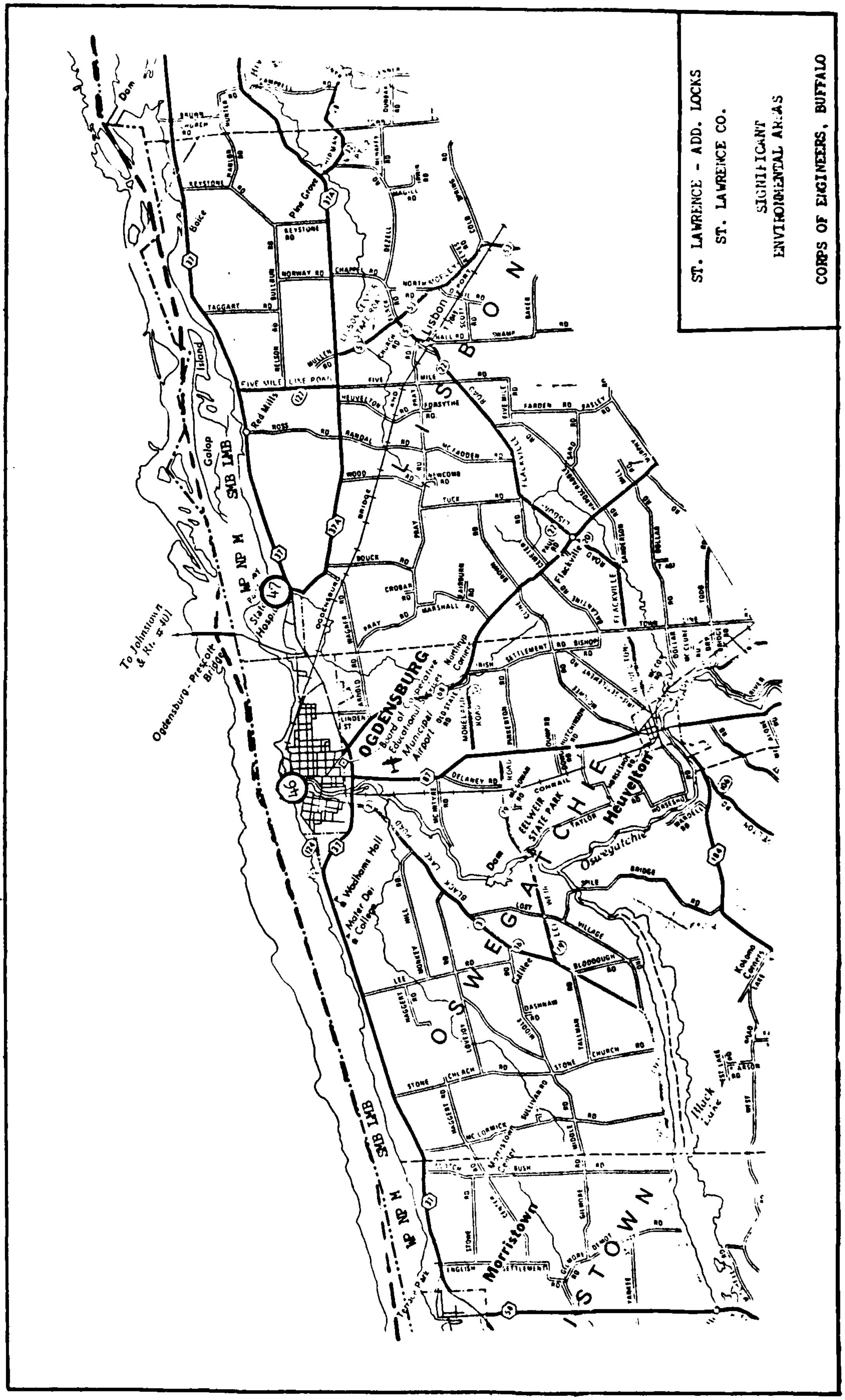

ST. LAWRENCE - ADD. LOCKS
ST. LAWRENCE CO.
SIGNIFICANT
ENVIRONMENTAL AREAS
CORPS OF ENGINEERS, BUFFALO
OGDENSBURG
Heuvelton
Morristown
Ogdensburg - Prescott Bridge
To Johnstown & Rt. #401

FIGURE A - 5d

ST. LAWRENCE - ADD. LOCKS
ST. LAWRENCE CO.

SIGNIFICANT
ENVIRONMENTAL AREAS

CORPS OF ENGINEERS, BUFFALO

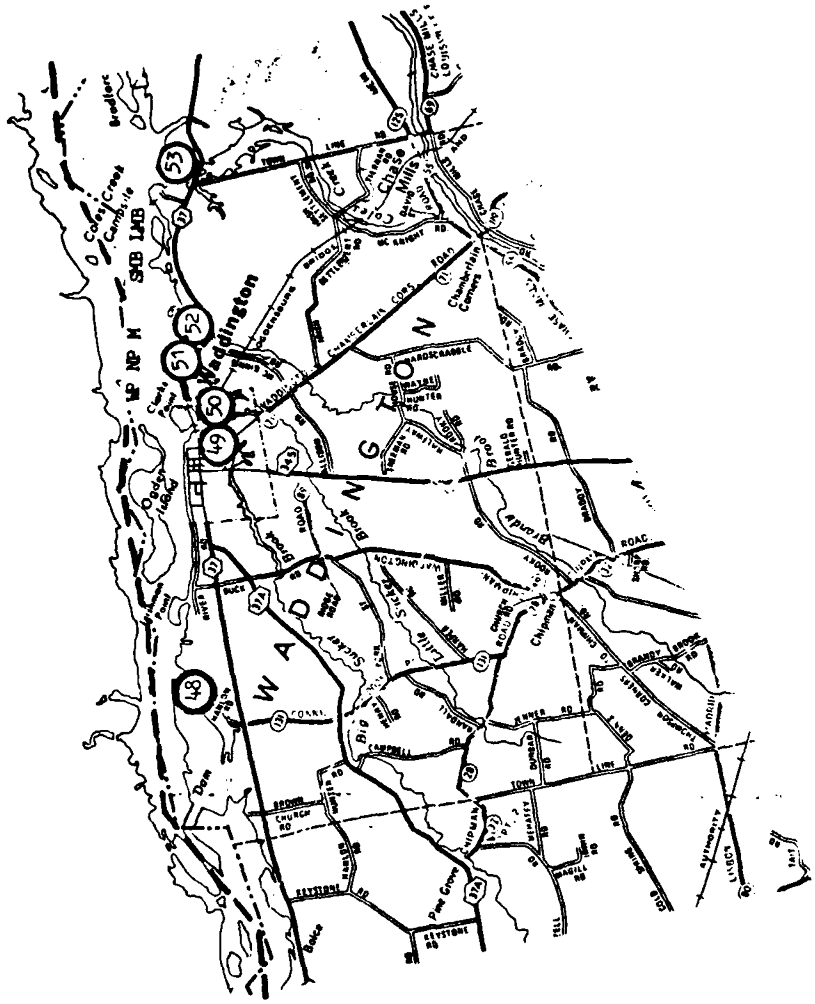
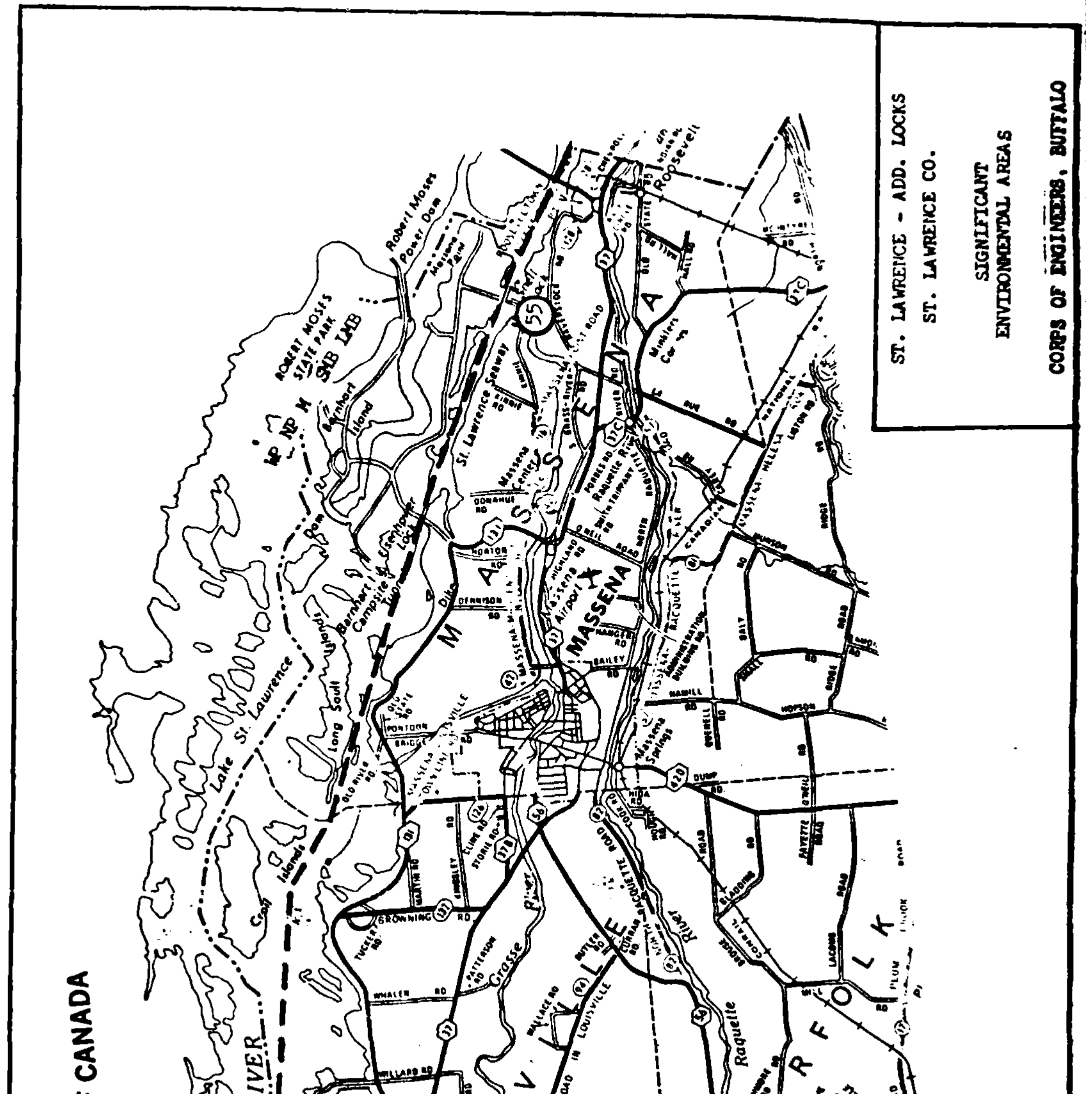


FIGURE A - 5e



ST. LAWRENCE - ADD. LOCKS
ST. LAWRENCE CO.
SIGNIFICANT
ENVIRONMENTAL AREAS
CORPS OF ENGINEERS, BUFFALO
DOMINION OF CANADA
ST. LAWRENCE RIVER
Lake St. Lawrence
ROBERT MOSES STATE PARK
Robert Moses Power Dam
St. Lawrence Seaway
MASSENA
Massena Airport
Massena Springs
Raymondville
Norfolk
Waddington
Chase Mills
Louisville
Wilson Hill Island
Barnhart Island
Long Sault Island
Sheek Island
Bradford Islands
Coles Creek Campsite
Grasse River
Raquette River
Trout Brook
Roosevelt
WILDLIFE REFUGE AREA
LOUISVILLE RAYMONDVILLE ROAD
M A S S E N A
L O U I S V I L L E
N O R F O L K

FIGURE A - 5f

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

IMPORTANT FARMLAND OF NEW YORK

INTERPRETATIONS DERIVED FROM GENERAL SOIL MAP COMPILED BY CORNELL UNIVERSITY AGRICULTURAL EXPERIMENT STATION
CONSTRUCTED 1977 BY CARTOGRAPHIC DIVISION, SOIL CONSERVATION SERVICE U S DEPARTMENT OF AGRICULTURE

AUGUST 1977

A - *Hapludalfs dominant*
- A1 Cazenovia and Mohawk areas
- A2 Hilton areas
- A3 Honeoye areas
- A4 Lansing areas
- A5 Madrid areas
- A6 Ontario areas

Aw - *Ochraqualfs dominant*
- Aw1 Appleton areas
- Aw2 Burdett and Darien areas
- Aw3 Ovid areas

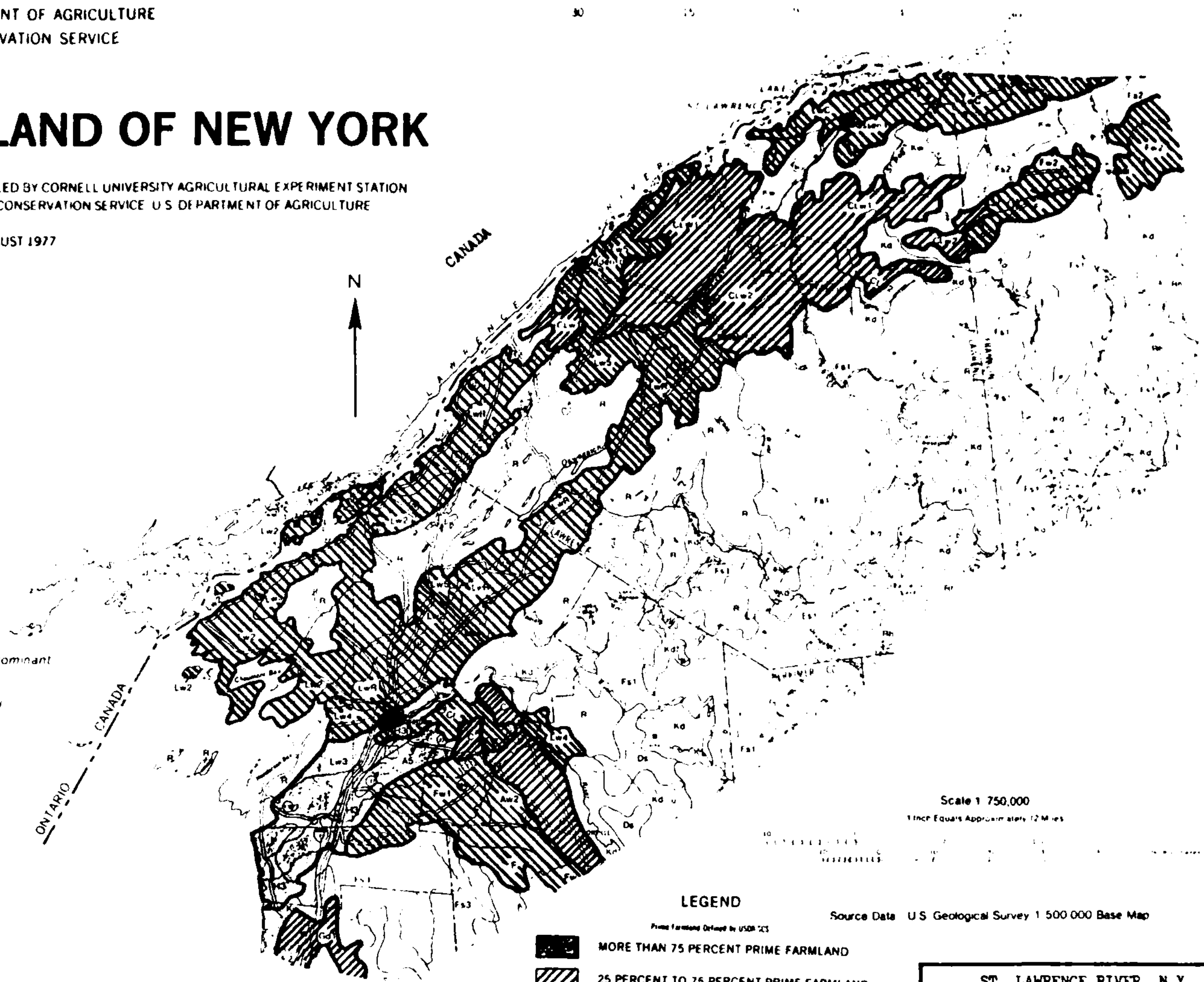
C *Eutrochrepts dominant*
- C Nellis areas
- Cf Farmington areas
- CLw1 Hogansburg-Swanton areas
- CLw2 Pittsfeld Rhinebeck areas

F *Haplorthods Fragiorthods or very stony Fragiaquods dominant*
- F Empeyville areas
- Fs1 Becket Berkshire and Potsdam areas very stony
- Fs2 Westbury and Coveytown areas very stony
- Fs3 Worth areas very stony

Fw *Fragiaquods and frigid Fragiaquepts dominant*
- Fw1 Camroden areas
- Fw2 Westbury and Brayton areas

H - *Hapludalfs dominant*
- H1 Arkport areas
- H2 Howard areas
- H3 Palmyra areas

Lw - *Ochraqualfs or Haplaquepts dominant*
- Lw1 Canandaigua areas
- Lw2 Kingsbury areas
- Lw3 Niagara areas
- Lw4 Odessa and Rhinebeck areas
- Lw5 Swanton-Rhinebeck areas
- LwC Kingsbury Hogansburg areas
- LwR Kingsbury Rock outcrop areas



LEGEND

- MORE THAN 75 PERCENT PRIME FARMLAND
- 25 PERCENT TO 75 PERCENT PRIME FARMLAND
- LESS THAN 25 PERCENT PRIME FARMLAND OR LAND OF STATEWIDE IMPORTANCE
- GREATER THAN 25 PERCENT LAND OF STATEWIDE IMPORTANCE, BUT LESS THAN 25 PERCENT PRIME FARMLAND
- URBAN AREAS

Source: Important Farmland of New York Map

ST. LAWRENCE RIVER, N.Y.
IMPORTANT FARMLANDS OF NEW YORK
U.S. ARMY ENGINEER DISTRICT, BUFFALO

FIGURE A - 6

TABLE A - 5 Great Lakes Region Population and Urban Population by Plan Area, 1970

Plan Area	1970 Population	Percent of Great Lakes Region	Urban Population	Percent of Region Population
1.0 - Lake Superior	533,539	1.8	315,789	1.1
2.0 - Lake Michigan	13,516,965	46.1	11,186,962	38.1
3.0 - Lake Huron	1,236,265	4.2	702,813	2.4
4.0 - Lake Erie	11,513,853	39.3	9,727,303	33.2
5.0 - Lake Ontario	2,531,673	8.6	1,593,388	5.4
TOTAL	29,332,295	100.0	45,459,122	80.2

TABLE A - 6 Historical Employment Great Lakes Basin

Industry	1940	1950	1960	1970
Agriculture	1,969,992	1,694,832	1,133,954	746,733
Mining	359,818	329,157	166,424	133,802
Contract Construction	822,629	1,207,715	1,311,832	1,451,417
Manufacturing	5,547,648	7,631,071	8,639,079	7,867,820
Transportation, Communication, and Public Utilities	1,418,430	1,920,314	3,263,306	1,924,088
Wholesale and Retail Trade	3,360,903	4,393,311	4,716,289	5,689,440
Finance, Insurance, and Real Estate	717,047	861,094	1,131,803	1,468,088
Services	3,547,678	3,974,302	5,266,277	7,287,730
Total Government	649,376	986,291	1,224,844	1,458,198
Total Employment	18,392,996	22,998,097	25,427,378	29,028,116

TABLE A - 7 Changes in Historical Employment Great Lakes and United States 1940-1970

Employment Sector	United States		Great Lakes Region (1)	
	Employment Change	Percent Change	Employment Change	Percent Change (2)
Agriculture	-5,762,450	-3.6	-1,223,259	-3.2
Mining	-296,249	-1.3	-226,016	-3.2
Contract Construction	2,476,739	2.6	628,788	1.9
Manufacturing	9,280,228	2.1	2,320,172	1.2
Transportation, Communication, and Public Utilities	2,033,201	1.7	505,658	1.0
Wholesale and Retail Trade	7,925,889	2.4	2,328,537	1.8
Finance, Insurance, And Real Estate	2,360,167	3.2	751,041	2.4
Services	11,509,991	2.8	3,740,052	2.4
Total Government	4,404,549	4.2	808,822	2.7
Total Employment	33,932,065	1.9	10,635,120	1.5

(1) Includes all eight States bordering Great Lakes.
(2) Average annual compound rate of change.
Source: Regional Employment by Industry, 1940-1970, U. S. Department of Commerce

TABLE A - 8 Historical Population Changes

	Number of Persons					Area	Race, 1970 Percentage of Total		
	Total 1970	Total 1960	Total 1950	Urban 1970	Rural 1970	Square Miles 1970	White	Negro	Other
New York State	18,241,266	16,782,304	14,830,192	15,602,486	2,634,481	47,831.0	86.8	11.9	1.3
Northern Area*	375,639	375,087	340,477	142,415	233,224	9,909.0	98.5	0.8	0.7
Jefferson County	88,508	87,835	85,521	34,676	53,832	1,294.0	99.5	0.2	0.3
Watertown City	30,787	33,306	34,350	30,787	0	9.2	99.4	0.3	0.3
St. Lawrence County	111,991	111,239	98,897	49,553	62,438	2,768.0	99.4	0.2	0.4
Ogdensburg City	14,554	16,122	16,166	14,554	0	4.7	99.3	0.2	0.4
Massena Village	14,042	15,478	NA	14,042	0	4.1	99.6	0.1	0.3

*Includes Clinton, Essex, Franklin, Jefferson, Lewis, and St. Lawrence Counties

TABLE A - 8 Historical Population Changes (Cont'd)

	Age of Population, 1970	Age Groups - Percentage of Population								Population in Households, 1970		Population in Group Quarters, 1970	
	Median Age	18 and over	Under 5	5-14	15-24	25-44	45-54	55-64	65 and over	Number	Per Household	Inmates of Institutions	All Other
New York State	30.3	68.0	8.2	18.6	16.2	24.2	12.0	10.1	10.8	17,775,236	3.0	218,686	243,045
Northern Area*	26.0	63.3	8.8	21.8	18.3	21.3	10.4	8.8	10.5	356,390	3.3	6,180	13,069
Jefferson County	28.7	63.7	9.0	21.2	15.7	20.7	11.3	9.7	12.4	87,395	3.2	603	510
Watertown City	31.6	67.2	8.1	19.2	16.0	19.6	11.7	10.6	14.9	30,120	2.9	430	237
[illegible] County	24.5	64.2	8.4	21.1	21.3	20.4	10.4	8.6	9.8	102,694	3.4	1,933	7,364
[illegible]	33.7	67.3	8.0	19.0	14.6	19.0	11.5	11.4	16.5	12,991	3.1	1,438	125
[illegible]	28.6	62.9	7.9	22.3	15.9	22.2	13.1	9.4	9.2	13,948	3.2	43	51

[illegible] Fact Book, Part 1 and 2, New York State Department of Commerce

AD-A118 522 CORPS OF ENGINEERS BUFFALO NY BUFFALO DISTRICT F/G 13/2
SAINT LAWRENCE SEAWAY ADDITIONAL LOCKS STUDY. APPENDICES.(U)
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2 OF 6

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TABLE A - 9 Labor Force Characteristics in Project Area

	Number Employed	Manufacturing: Total	Manufacturing: Durable Goods	Manufacturing: Non-Durable Goods	Wholesale Trade	Retail Trade	Agriculture	Mining	Construction	Business, Repair Services	Personal Services
New York State	7,124,001	24.2	12.9	11.3	4.4	15.1	1.3	0.2	4.8	4.1	4.0
Northern Area*	122,557	20.2	10.2	10.0	2.2	16.1	7.2	1.7	6.7	1.6	5.3
Jefferson County	31,753	23.4	14.1	9.4	2.5	17.4	6.6	0.3	6.1	1.8	5.0
Watertown City	11,727	22.9	16.8	6.1	3.1	19.1	0.3	0.1	4.6	1.7	4.7
St. Lawrence County	35,790	20.4	13.8	6.7	1.9	15.2	7.3	3.0	5.9	1.3	4.4
Ogdensburg City	4,747	18.5	8.4	10.1	3.9	17.3	0.8	0.3	5.5	1.2	4.9
Massena Village	4,729	38.0	35.4	2.6	1.6	17.5	0.9	0.2	2.2	1.6	4.5

*Includes Clinton, Essex, Franklin, Jefferson, Lewis and St. Lawrence Counties.

Source: <u>Business Fact Book</u>, Part 1 and 2, New York State Department of Commerce.

TABLE A - 9 Labor Force Characteristics in Project Area (Cont'd)

POPULATION 16 YEARS OLD AND OVER

Number	Percent in Labor Force	Civilian Labor Force: Total	Female: Number	Female: Percent	Employed Workers: Number	Percentage of Total: Private Wages Salary Workers	Government Workers	Self-Employed Workers	Unpaid Family Workers
13,029,286	57.3	7,421,579	2,878,027	38.8	7,124,001	76.7	16.8	6.2	0.3
252,712	53.3	130,549	47,801	36.6	122,557	66.4	22.1	10.6	1.0
59,972	56.8	33,582	12,674	37.7	31,753	70.2	17.6	11.1	1.1
21,835	56.9	12,287	5,241	42.7	11,727	76.0	17.2	6.3	0.5
76,462	50.0	37,975	13,093	34.5	35,790	66.0	23.0	10.2	0.8
10,320	49.4	5,063	2,202	43.5	4,747	63.3	30.1	6.2	0.5
9,487	53.3	4,983	1,741	34.9	4,729	75.8	18.0	6.0	0.2

TABLE A - 10 Distribution of Employment by Industry

		OCCUPATION GROUPS - PERCENTAGE OF EMPLOYED									
	Number Employed	Professional, Technical	Farmers Farm Managers	Managers Administrators (except farm)	Clerical Workers	Sales Workers	Craftsmen, Foremen	Operatives	Service Workers: Private Household	Service Workers: Other	Laborers (including Farm Foremen)
New York State	7,124,001	16.7	0.6	8.5	22.4	7.5	12.2	15.1	1.1	11.9	4.0
Northern Area*	122,557	14.2	4.3	7.4	14.2	5.7	13.9	17.0	1.9	14.4	6.9
Jefferson County	31,753	13.5	4.3	7.8	15.4	6.7	14.7	17.5	2.2	11.9	5.9
Watertown City	11,727	15.8	0.1	8.5	20.5	7.5	13.3	15.3	1.9	13.6	3.5
St. Lawrence County	35,790	15.3	4.7	6.8	13.9	5.2	13.6	17.1	1.5	15.5	6.3
Ogdensburg City	4,747	13.0	0.1	7.7	12.9	6.5	14.7	15.5	2.0	23.6	3.9
Massena Village	4,729	16.0	0.4	7.7	17.7	7.2	16.8	17.9	1.2	11.6	3.5

*Includes Clinton, Essex, Franklin, Jefferson, Lewis, and St. Lawrence Counties.

Source: Business Fact Book, Part 1 and 2, New York State Department of Commerce.

TABLE A - 10 Distribution of Employment by Industry (Cont'd)

Professional Related Service	Entertainment Recreation	Finance Insurance Real Estate	Transportation, Communications: Total	Transportation	Communications	Utilities	Public Administration
19.8	1.1	7.5	8.1	4.5	1.8	1.8	5.5
23.9	0.7	3.0	5.3	2.6	1.1	1.6	6.0
19.2	0.6	4.3	6.3	3.4	1.3	1.6	6.5
22.0	0.8	5.9	7.7	3.6	1.9	2.2	7.1
28.7	0.4	2.5	5.1	2.2	0.9	2.0	3.8
33.8	0.6	3.6	3.7	1.4	0.9	1.4	5.8
18.6	0.3	3.4	7.7	3.6	1.2	2.8	3.4

TABLE A - 11 Distribution of Family Income

	Median Income, Families and Unrelated Individuals ($)	Median Income ($)	Number of Families	Under $3,000	$3,000-4,900	$5,000-6,999	$7,000-9,999	$10,000-14,999	$15,000-24,999	$25,000-49,999	$50,000 or more
				Income of Families: Income Groups - Percentage of Families							
New York State	8,510	10,617	4,584,616	8.2	8.3	10.6	18.9	27.5	19.7	5.6	1.2
Northern Area*	6,322	8,412	86,534	10.1	11.7	16.0	24.9	24.3	10.6	2.1	0.3
Jefferson County	7,045	8,696	21,707	9.3	11.3	15.1	24.7	26.5	10.8	1.7	0.4
Watertown City	6,776	8,978	7,493	8.4	10.0	15.2	23.0	28.1	12.9	1.8	0.7
St. Lawrence County	5,754	8,667	24,765	9.7	10.6	14.7	25.6	25.6	11.0	2.5	0.3
Ogdensburg City	7,093	8,986	3,148	7.9	10.3	15.0	23.4	32.1	10.3	0.9	0.2
Massena Village	8,253	9,360	3,550	6.7	9.8	11.9	26.9	27.8	15.2	1.2	0.5

*Includes Clinton, Essex, Franklin, Jefferson, Lewis, and St. Lawrence Counties.

Source: Business Fact Book, Part 1 and 2 New York State Department of Commerce.

TABLE A - 11a Distribution by Income Group

	Persons 14 Years Old and Over With Income: Total Number	Number	Median Income ($)	Loss or: Under $1,000	$1,000-1,999	$2,000-3,999	$4,000-5,999	$6,000-7,999	$8,000-9,999	$10,000-14,999	$15,000-24,999	$25,000 or More
				Income Groups - Percentage of Number With Income								
New York State	13,695,674	10,424,817	4,920	14.6	12.5	16.3	15.0	13.3	9.7	11.8	4.7	2.1
Northern Area (1)	268,704	197,504	3,593	20.2	15.1	18.2	14.8	12.4	8.6	7.7	2.2	0.7
Jefferson County	63,701	48,855	3,747	17.7	15.1	19.6	15.4	12.7	8.6	8.3	2.0	0.6
Watertown City	22,980	18,221	3,764	16.6	16.5	19.1	15.6	12.5	8.3	8.2	2.4	0.7
St. Lawrence County	81,227	57,946	3,442	22.1	15.6	16.7	13.2	11.7	8.8	8.7	2.5	0.8
Ogdensburg City	10,897	7,985	3,693	18.0	16.3	18.7	18.6	13.2	6.8	7.0	1.1	0.3
Massena Village	10,105	6,909	5,104	15.2	12.3	16.2	12.0	13.6	13.0	13.8	3.2	0.7

(1) Includes Clinton, Essex, Franklin, Jefferson, Lewis, and St. Lawrence Counties.
Source: Business Fact Book, Part 1 and 2, New York State Department of Commerce.

TABLE A - 12 Shoreland Use - Lake Ontario and St. Lawrence River

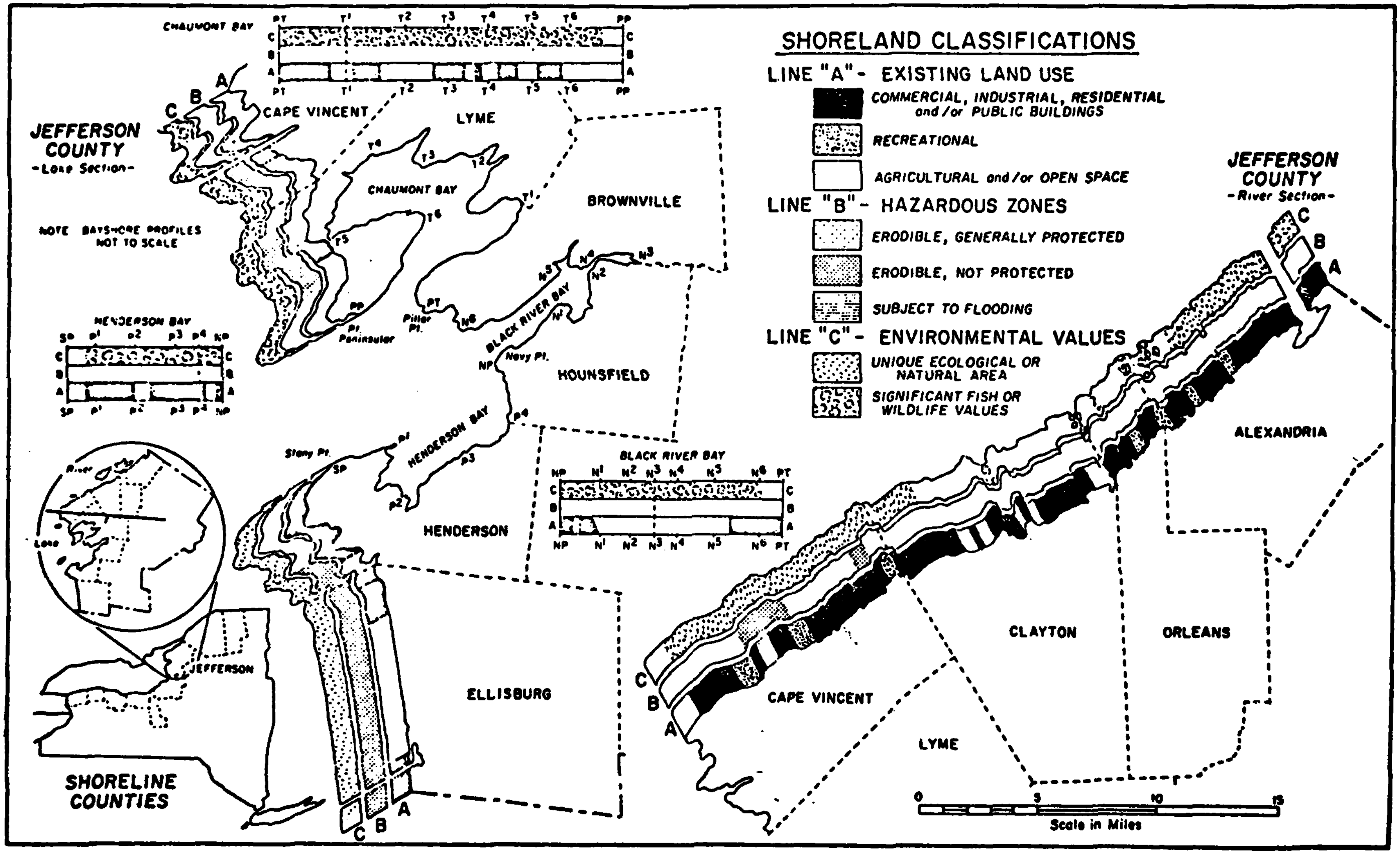
Area	Recreation		Residential[a]		Ag. & Open Space	
	Miles	% of Area	Miles	% of Area	Miles	% of Area
Jefferson County	3.6	3%	62.4	52%	54.0	45%
St. Lawrence County	7.6	10%	31.2	41%	37.2	49%

Hazardous Zones -- Lake Ontario and St. Lawrence River

Area	Erodible (Protected)		Erodible (Not Protected)		Subject to Flooding	
	Miles	% of Area	Miles	% of Area	Miles	% of Area
Jefferson	13.2	11%	12	10%	0	0%
St. Lawrence	0	0%	24	31.6%	0	0%

[a]Residential includes residential, commercial, industrial and public building.

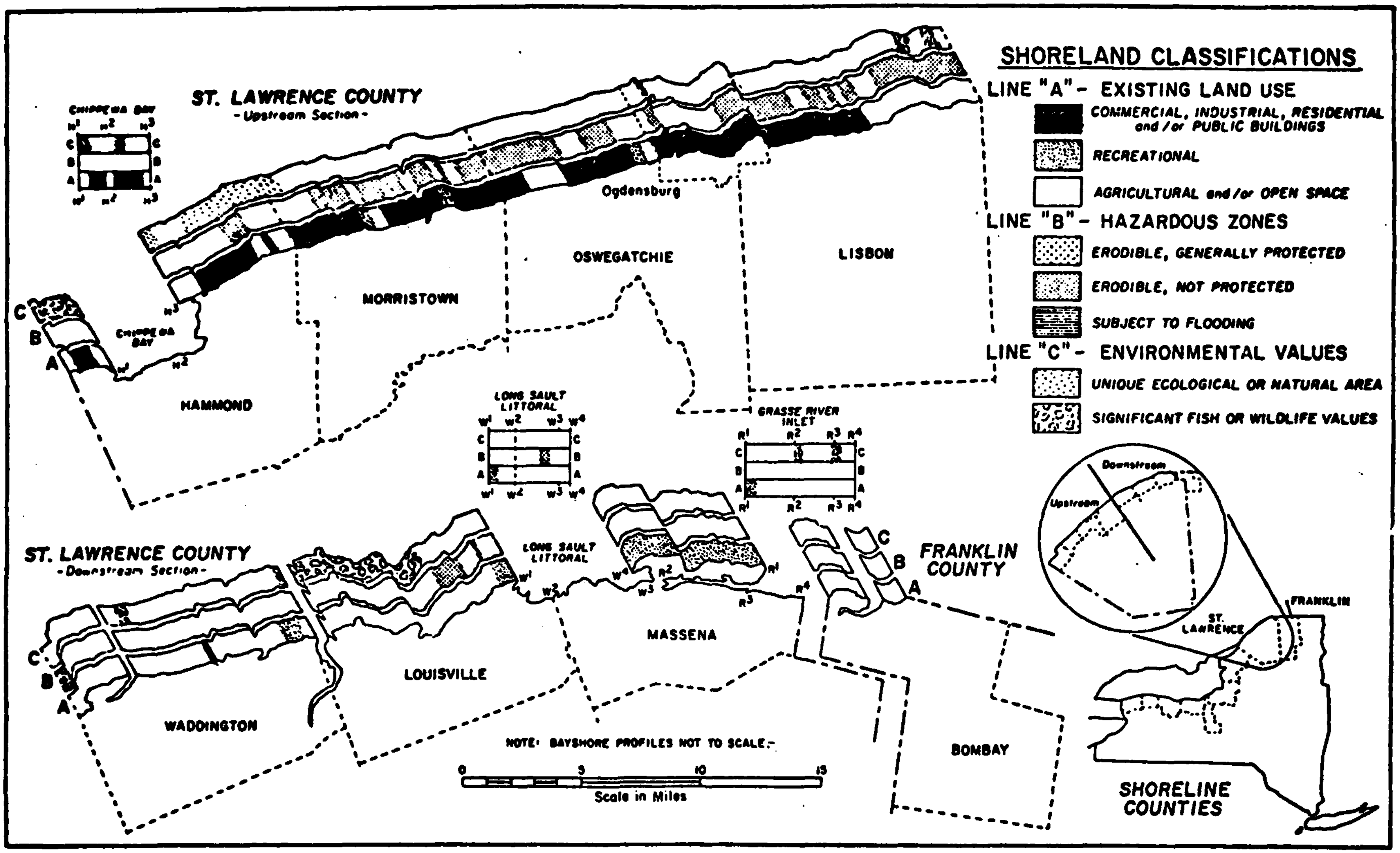
Source: United States data adapted from National Shoreline Study, Department of the Army, August, 1971



Shoreland Uses, Hazardous Areas and Environmental Values: Jefferson County (Source: Great Lakes Regional Inventory Report, National Shoreline Study, Corps of Engineers, 1971)

Source: Lake Ontario and the St. Lawrence River: Analysis of and Recommendations Concerning High Water Levels; State of New York; St. Lawrence-Eastern Ontario Commission.

FIGURE A - 7a



Shoreland Uses, Hazardous Areas and Environmental Values: St. Lawrence and Franklin Counties (Sources: St. Lawrence-Eastern Ontario Shoreline Study, 1972, Soil Conservation Service Personnel Interpretation and Land Use and Natural Resource Inventory Quadrangle Maps, 1968)

Source: Lake Ontario and the St. Lawrence River: Analysis and Recommendations Concerning High Water Levels; State of New York; St. Lawrence-Eastern Ontario Commission.

FIGURE A - 7b

Table A-13 - Recreation Supply in the Coastal Zone of Jefferson and St. Lawrence Counties[1]

Number of Recreation Sites	Total	Jefferson	St. Lawrence
Federal		-	-
State	30	21	9
County	-	-	-
Municipal	29	19	10
Quasi-Public, Non-Profit or Community Service Organization	6	1	5
Private (Closed to Public)	8	4	4
Commercial (Open to Public)	205	154	51
Total	278	199	79

Percentage of Recreation Sites	Jefferson	St. Lawrence
Federal	-	-
State	11%	11%
County	-	-
Municipal	10%	13%
Private	2%	5%
Commercial	77%	71%

1 Source: New York State Parks and Recreation, Office of Planning and Operations; Coastal Zone Management Data

TABLE A - 14 Reference FIGURES A - 8a thru A - 8f.

ST. LAWRENCE SEAWAY - ADDITIONAL LOCKS STUDY
SHORELINE PARKS - MAP KEY

JEFFERSON COUNTY

1 Burnham Point State Park
2 Cedar Point State Park
3 Canoe Picnic and Picnic Point State Park
4 Grass Point State Park
5 Wellesley Island State Park
6 Grandview Park
7 Thousand Island Park
8 Waterson State Park
9 DeWolf Point State Park
10 Keewaydin State Park
11 Mary Island State Park
12 Kring Point State Park

ST. LAWRENCE COUNTY

13 Cedar Island State Park
14 Jacques Cartier State Park
15 Terrace Park
16 St. Lawrence State Park
17 Coles Creek Campsite
18 Croil Island State Park
19 Barnhart Island State Park
20 Robert Moses State Park

TABLE A - 15

Thousand Islands-St. Lawrence Area

Campground	Phone	Reservations	Daily Fees	Sites	With Electricity	With Sewage	Fireplaces	Tables	Dumping Station	Flush Toilets	Dry Toilets	Hot Showers	Swimming	Fishing	Boat Rentals	Launch Site	Children's Play Area	Rec. Bldg.	Camp Store	Ice/Blocks	Ice/Cubes	Laundry
BAY VIEW TRAILER PARK, Box 134. Hammond 13646. Off Route 185, 5 mi E of Hammond.	315: 324-6304		1.75	19	15	13		15	X		2		X	X	X		X					
BIRCH HAVEN, RD 2, Clayton 13624. Route 12E, 2 mi W of Clayton.	315: 686-5253		2.00	60	48	43	30	48		3		2	X	X								
·**BURNHAM POINT STATE PARK**, Cape Vincent 13618. Route 12, 4 mi E of Cape Vincent.	315: 654-5324	No	2.00	52	19		52	52		10		2	X	X	X	X	X			X	X	
·**CANOE-PICNIC POINT STATE PARK**, Alexandria Bay 13607. (Access by boat only.)	315: 482-2133	No	2.00	24			25	25		8				X								
·**CEDAR ISLAND STATE PARK**, Alexandria Bay 13607. (Access by boat only.)	315: 482-2133	No	2.00	6			6	6		2				X								
·**CEDAR POINT STATE PARK**, Clayton 13624. Route 12, 6 mi W of Clayton.	315: 654-2522	No	2.00	206	89		206	206	X	34		12	X	X	X	X	X	X	X	X	X	
DEL'S FISHERMEN'S BAY TRAILER PARK, Point Peninsula, Three Mile Bay 13693.	315: 649-2420		2.50c	67	38	20	20	24	X	8		6	X	X	X	X	X		X			
·**DeWOLF POINT STATE PARK**, Route 2, Alexandria Bay 13607. On Wellesley Island.	315: 482-9144	No	2.00	14			14	14		8		2		X		X						
·**EEL WEIR STATE PARK**, RD, Ogdensburg 13669. Route 87, 8 mi S of Ogdensburg.	315: 393-1977	No	2.00	19			19	19			8			X		X						
·**GRASS POINT STATE PARK**, Alexandria Bay 13607. Route 12, 5 mi S of Alexandria Bay.	315: 686-3057	No	2.00	120	15		120	120	X	30			X	X	X	X	X			X	X	
·**HIGLEY FLOW STATE PARK**, RD 1, Colton 13625. Off Route 56, Colebrook Rd, South Colton.	315: 265-7255	No	2.00	150	50		150	150	X	34			X	X	X	X	X					
·**JACQUES CARTIER STATE PARK**, RD, Ogdensburg 13669. Off Route 37, 2 mi W of Morristown.	315: 393-1977	No	2.00	126	22		126	126	X	23		4	X	X	X	X	X		X	X	X	
·**KEEWAYDIN STATE PARK**, RD 1, Alexandria Bay 13607. Route 12, 1 mi W of Alexandria Bay.	315: 482-2593	No	2.00	20			20	20		8			X	X	X	X						
·**KRING POINT STATE PARK**, Redwood 13679. Off Route 12, 10 mi N of Alexandria Bay.	315: 482-2444	No	2.00	114	38		108	170	X	28			X	X	X	X	X	X	X		X	
·**LONG POINT STATE PARK**, Three Mile Bay 13693. 10 mi off Route 12E.	315: 649-5258	No	2.00	66	26		36		X	8		1		X		X						
·**MARY ISLAND STATE PARK**, Alexandria Bay 13607. (Access by boat only.)	315: 482-2593	No	2.00	10			8	10		4				X								
McLEAR'S COTTAGE COLONY, Box 117, Hammond 13646. (Camping fee is per person.)	315: 375-6508	No	1.00c	50	20	12		25		4			X	X	X		X	X	X			
MERRY KNOLL TRAILER PARK, RD 2, Clayton 13624. 2½ mi W of Clayton.	315: 686-3055		2.25	67	67	45	45	45	X	8		2	X	X	X		X	X	X	X	X	
MOTEL ORAL, Smith Drive, Massena 13662. Route 37, 2 mi E of Massena.	315: 769-5403		4.00c	40	40	12	50	50	X	4		2	X	X	X	X	X		X	X	X	
OASIS, Route 3, Natural Bridge 13665. Route 3, 21 mi E of Watertown.			2.00c	50	20		75	75	X	2		2c					X	X	X			
·**ROBERT MOSES STATE PARK**, Box 386, Massena 13662.	315: 769-8663																					
COLES CREEK AREA, Route 37, 4 mi E of Waddington.		No	2.00	234	204		234	234	X	35		14	X	X	X	X	X		X		X	X
LONG SAULT AREA, off Route 37, 1 mi from Eisenhower Lock.		No	2.00	150	26		150	150	X	24		4	X	X	X	X	X	X			X	
SHANGRI-LA CHAUMONT BAY, Three Mile Bay 13693. County Route 57.	315: 649-2979		2.00	50	25	15		30	X	6		2c	X	X	X	X	X		X			
·**SOUTHWICK BEACH STATE PARK**, Woodville 13698. Route 193.	315: 234-5338	No	2.00	120	50	50	120	120	X	38		14	X				X		X	X	X	
·**WELLESLEY ISLAND STATE PARK**, RD 1, Alexandria Bay 13607.	315: 482-2722	No	2.00	511	130	49	511	511	X	89		18	X	X	X	X	X	X	X	X	X	
·**WESTCOTT BEACH STATE PARK**, Box 396, Sackets Harbor 13685. Route 3.	315: 435-5083	No	2.00	167	45		167	167	X	20		10	X	X		X	X	X	X	X	X	
·**WHETSTONE GULF STATE PARK**, RD, Lowville 13367. Route 12D, 8 mi S of Lowville.	315: 376-6630	No	2.00	55			55	55		24	8		X									
WILSON'S HYDE LAKE, Box 321, Theresa 13691. Off Route 37, Wilson Rd.	315: 628-5962		2.50c	100	100		100	100	X	19		2	X	X	X	X	X		X			

Source: Camping in New York State 1970
State of New York
Dept. of Commerce

TABLE A - 16 Reference FIGURES A - 8a thru A - 8f.

MARINE FACILITIES

SLEOC SURVEY 1975 - 1976

Map No.	Name & Location	# of Pier Moorings	Simulataneous Boat Launching Capacity	Owner-Ship
		Services Provided		
	JEFFERSON COUNTY			
	Cape Vincent			
48	Scott's Marina		1	Private
49	Pond's Marina	20	1	Private
50	Martin's Marina Trailer Park	65	1	Private
51	Snug Harbor Marina	25	2	Private
52	Humphrey's Boat Livery	5		Private
53	Tibbets Point Cottages	10	1	Private
54	Cape Vincent Marina	20		Private
55	Garlock's Marina	6		Private
56	Sportsman Lodge	14		Private
57	Aubrey's Boat Center	44		Private
58	Cape Vincent Village Dock	10	1	Municipal
59	Anchor Marina	105		Private
60	Willow Shores Trailer Park	40	1	Private
61	Burnham Point State Park	10	1	State
62	Angel Rock Lodge	6	1	Private
63	Palmer Court	6	1	Private
64	Moonlight Bay Trailer Park	20	1	Private
65	Lazy Acres	30	1	Private
66	Millen's Bay Marina	25	1	Private
67	Cedar Point State Park	48	1	State
	Clayton			
68	Fair Wind Lodge	4		Private
69	Simpson's Motel	2		Private
70	Denny's Cottages and Motel	15	1	Private
71	French Creek Marina	140	1	Private
72	The Shipyard	80		Private
73	G. W. Mercier, Inc.	110		Private
74	Clayton Municipal Dock	30	1	Municipal
75	Fisherman's Pier	6		Private
76	Clayton Village Dock	10		Municipal
77	Clayton Marina	94	1	Private
78	Snell's Boat Livery	12		Private
79	Cantwell Pier 65	30	1	Private
80	Montante Tourist and Trailer Park	34		Private
81	Lunz's Cottages	25	1	Private
82	Mil's Motel and Beach Cottages	12		Private
83	Hooson's Spicer Marine Basin	35		Private
84	Spicer Bay Marina	50	1	Private
85	Cal's Cottages	40	1	Private
86	Calumet Island Marina	53	1	Private
87	Canoe Picnic Point State Park	18		State
	Orleans			
88	H. Chalk & Son, Inc.	1	100	Private
89	Bill & Jack's Marina	0	12	Private
90	Public Ramp	1	0	Municipal
91	Grass Point State Park	1	30	State
92	Wellesley Island State Park	2	30	State
93	DeWolf State Park	1	4	State
	Alexandria			
94	Swan Bay Trailer Park & Marina	0	20	Private
95	C & S Camps	1	10	Private
96	Barton's Cottages & Trailer Park	1	8	Private

Services Provided

Map No.	Name & Location	# of Pier Moorings	Simultaneous Boat Launching Capacity	Owner Ship
97	Keewaydin State Park	1	104	State
98	Boat Ramp (Crossman Street)	1	0	Municipal
99	Hutchinson's Boat Works, Inc.	0	70	~~Municipal~~ Private
100	Village Dock	0	30	Municipal
101	Charlie's Marina	1	4	Private
102	Boat Ramp (Holland Street)	1	0	Municipal
103	Bonnie Castle Yacht Basin	0	127	Private
104	Lanterman's Channelview Cottages	0	4	Private
105	Mance's Marine Basin and Motel	1	25	Private
106	Gus & Mary's Inn	0	7	Private
107	Goose Bay Launching Ramp	1	0	Municipal
108	Kring Point State Park	1	20	State
109	Butterfield Lake Fishing Access Site	1	0	State
110	Horton's Boat & Camps	1	9	Private
111	Wimmer's Marina	1	10	Private
ST. LAWRENCE COUNTY				
	Hammond			
112	Schermerhorn Boat Sales, Inc.	2	105	Private
113	Chippewa Bay Boat Launching Ramp	1	0	Municipal
114	Mallott's Camps & Trailer Park	1	7	Private
115	Boath's Camps & Boats	0	4	Private
116	Blind Bay Marina	1	18	Private
117	Oak Point Inn	1	0	Private
118	Oak Point Resort	1	2	Private
	Morristown			
119	Jacques Cartier State Park	1	10	State
120	Bay View Restaurant	0	16	Private
121	Morristown Village Dock	1	0	Municipal
122	Wright's Sporting Goods	1	65	Private
123	McLear's Cottage Colony	1	42	Private
124	Black Lake Launching Ramp	1	0	State
	Oswegatchie			
125	Blair's Marina	2	25	Private
126	Cubby's Marina	1	80	Private
127	Morrisette Park	3	0	Municipal
128	Ward's Marina	0	19	Private
	Lisbon			
129	Ryan's Cabins	0	5	Private
	Waddington			
130	Brandy Brook Boat Launch	1	0	State
131	Coles Creek Marina	1	48	State
	Louisville			
132	Wilson Hill Boat Launch	1	0	State
133	Lake St. Lawrence Yacht Club	1	38	Private
	Massena			
134	Massena Boat Launch	1	0	Municipal
135	Robert Moses State Park Marina	1	60	State

Source: St. Lawrence-Eastern Ontario Commission Survey, 1975-76.

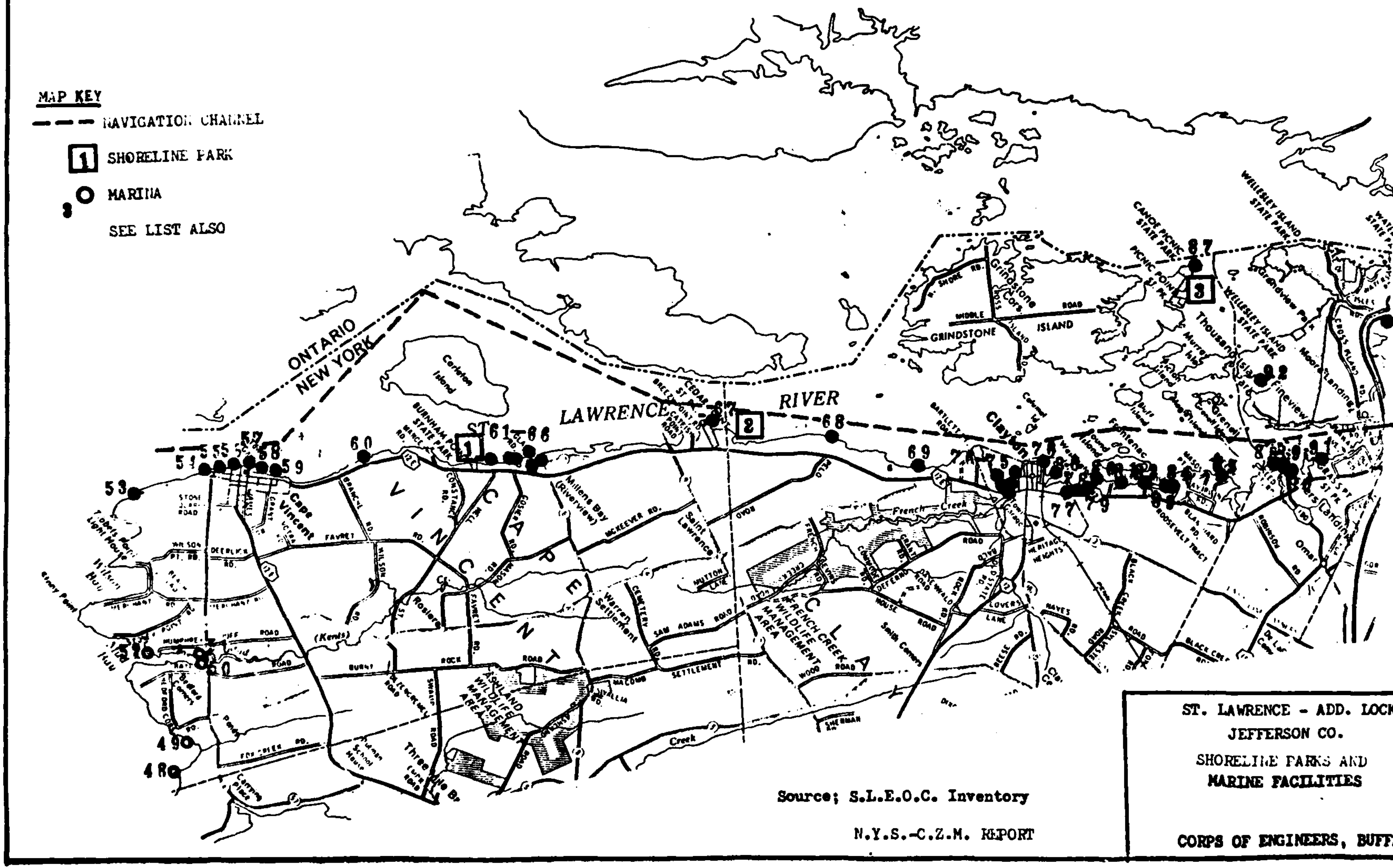
MAP KEY

— — — NAVIGATION CHANNEL

[1] SHORELINE PARK

● ○ MARINA

SEE LIST ALSO



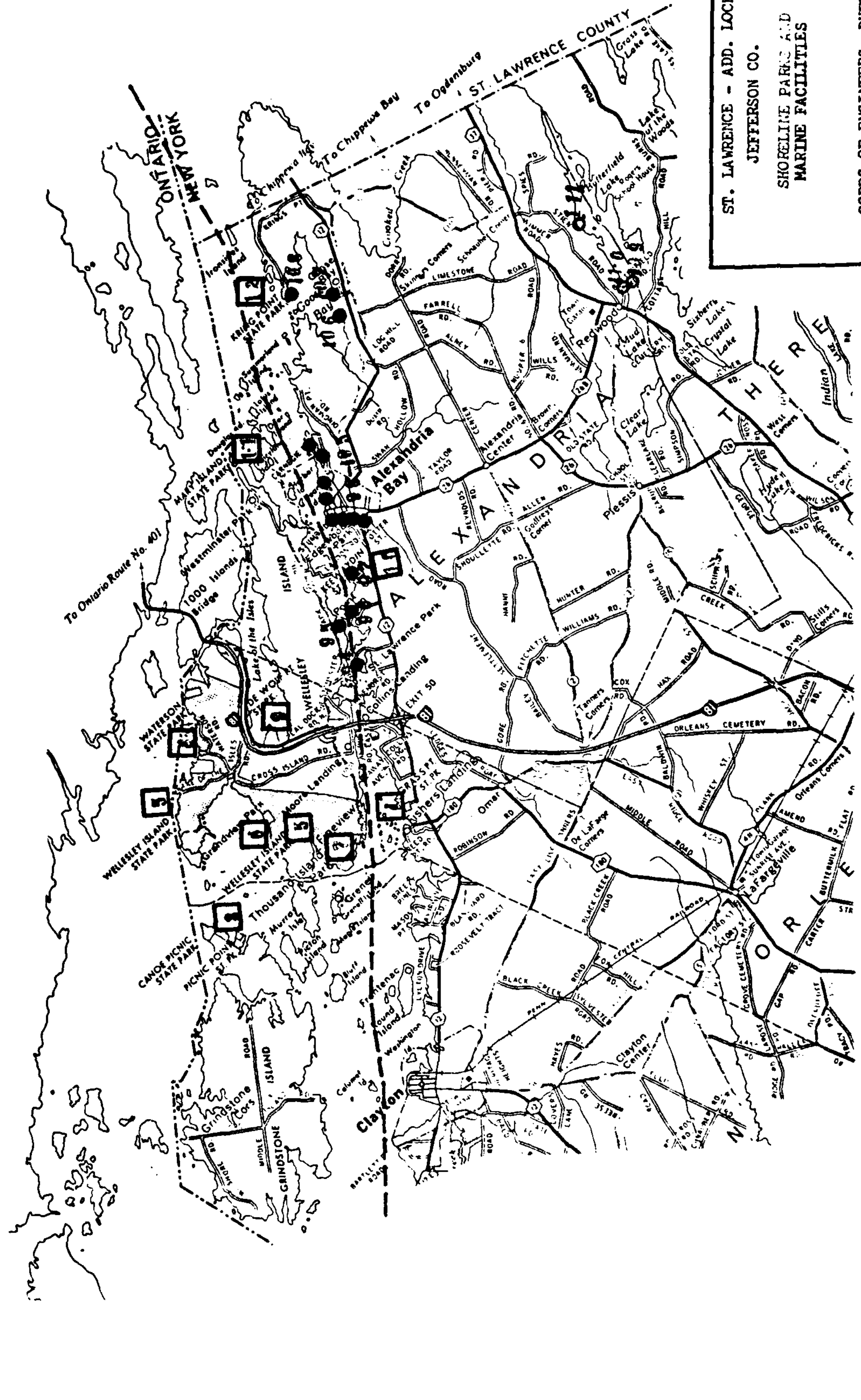
Source; S.L.E.O.C. Inventory

N.Y.S.-C.Z.M. REPORT

ST. LAWRENCE - ADD. LOCKS
JEFFERSON CO.
SHORELINE PARKS AND
MARINE FACILITIES

CORPS OF ENGINEERS, BUFFALO

FIGURE A - 8a



ST. LAWRENCE - ADD. LOCKS

JEFFERSON CO.

SHORELINE PARKS AND MARINE FACILITIES

CORPS OF ENGINEERS, BUFFALO

FIGURE A - 8b

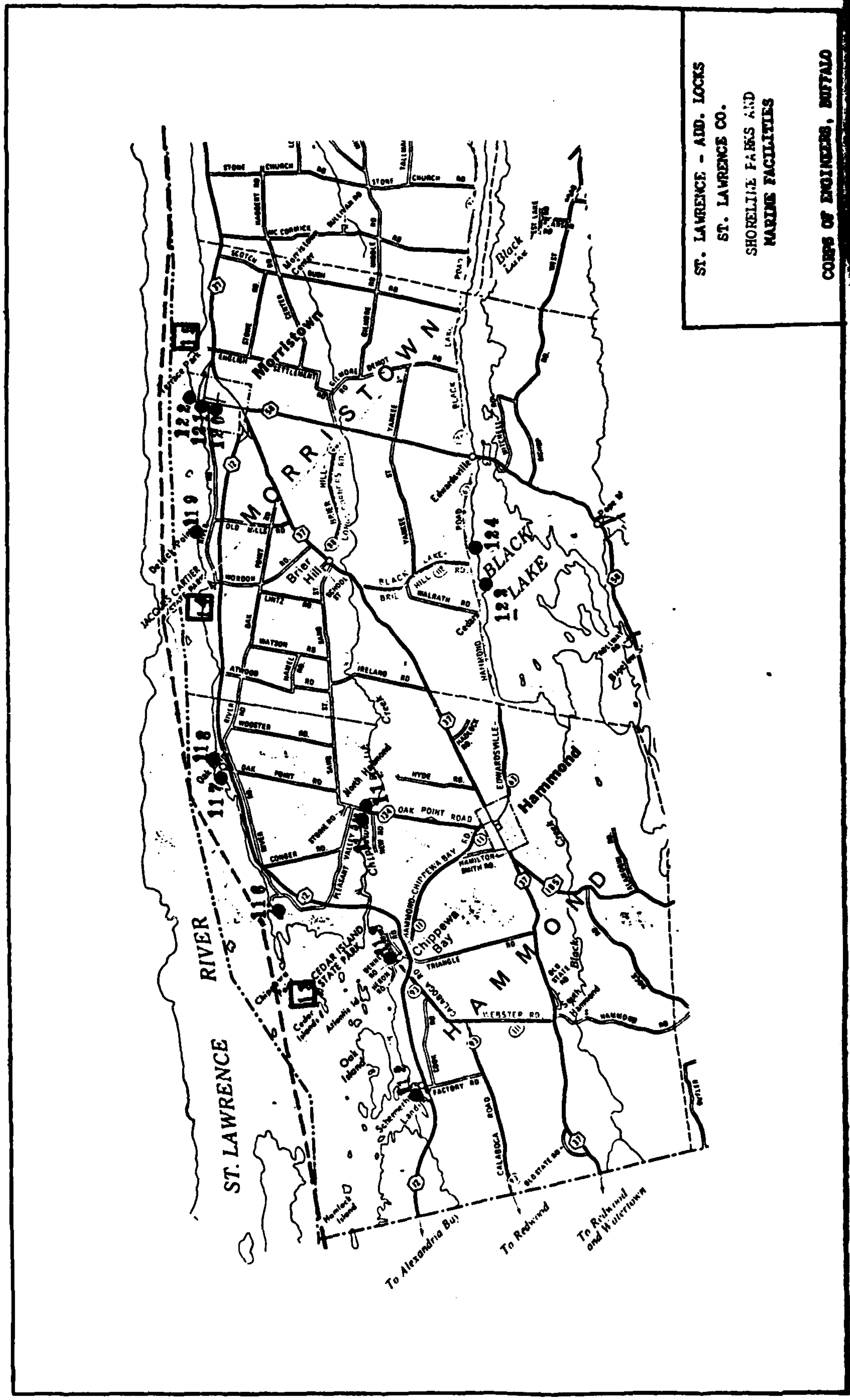

ST. LAWRENCE - ADD. LOCKS
ST. LAWRENCE CO.
SHORELINE PARKS AND
MARINE FACILITIES
CORPS OF ENGINEERS, BUFFALO
ST. LAWRENCE
RIVER
MORRISTOWN
HAMMOND
Morristown
Hammond
BLACK LAKE
Brier Hill
Chippewa Bay
CEDAR ISLAND STATE PARK
JACQUES CARTIER STATE PARK
Edwardsville
To Alexandria Bay
To Redwood
To Redwood and Watertown

FIGURE A - 8c

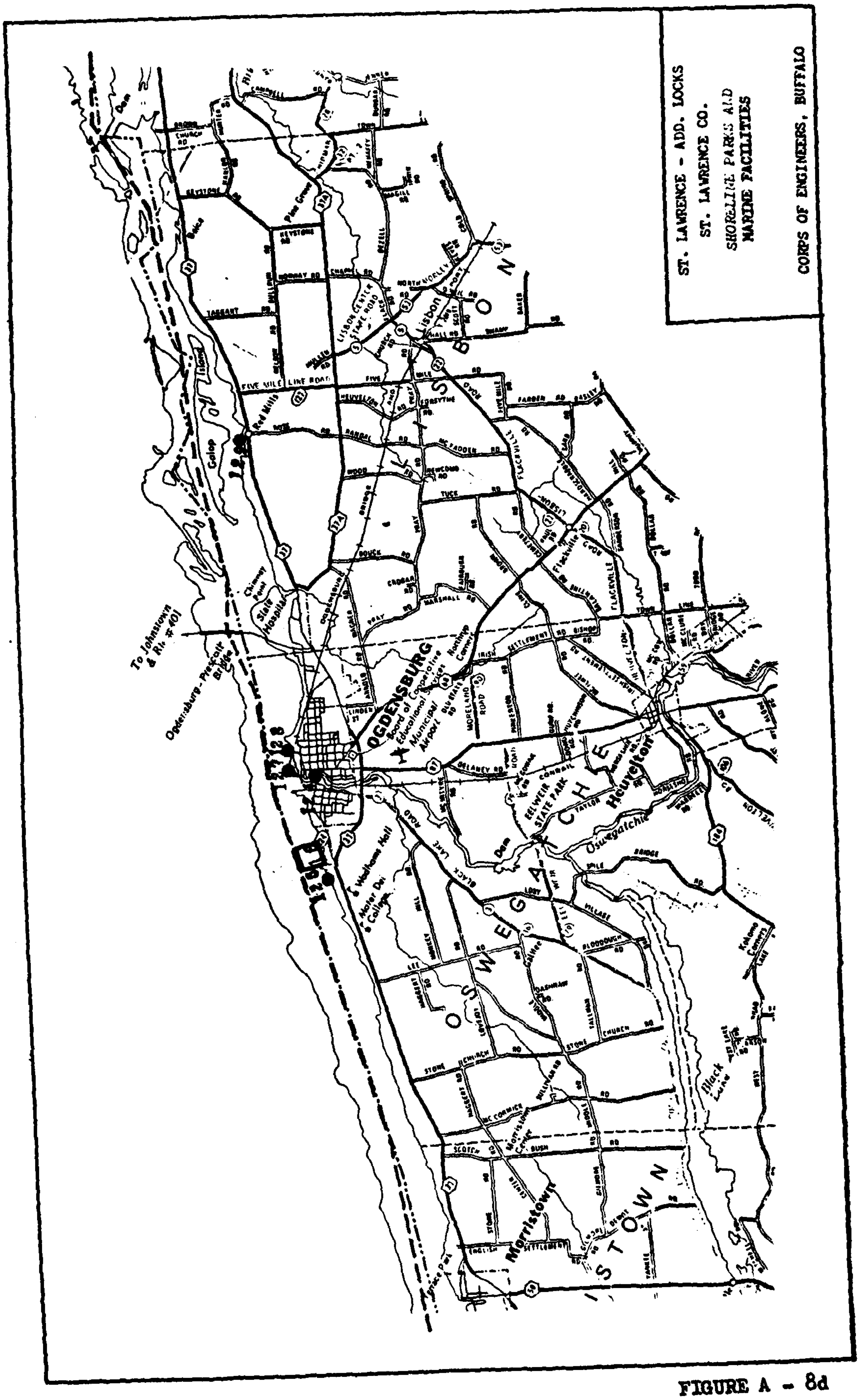

ST. LAWRENCE - ADD. LOCKS
ST. LAWRENCE CO.
SHORELINE PARKS AND
MARINE FACILITIES
CORPS OF ENGINEERS, BUFFALO
OGDENSBURG
Heuvelton
Morristown
Lisbon
To Johnstown & Rt. #401
Ogdensburg - Prescott Bridge

FIGURE A - 8d

ST. LAWRENCE - ADD. LOCKS
ST. LAWRENCE CO.
SHORELINE PARKS AND
MARINE FACILITIES

CORPS OF ENGINEERS, BUFFALO

FIGURE A - 8e

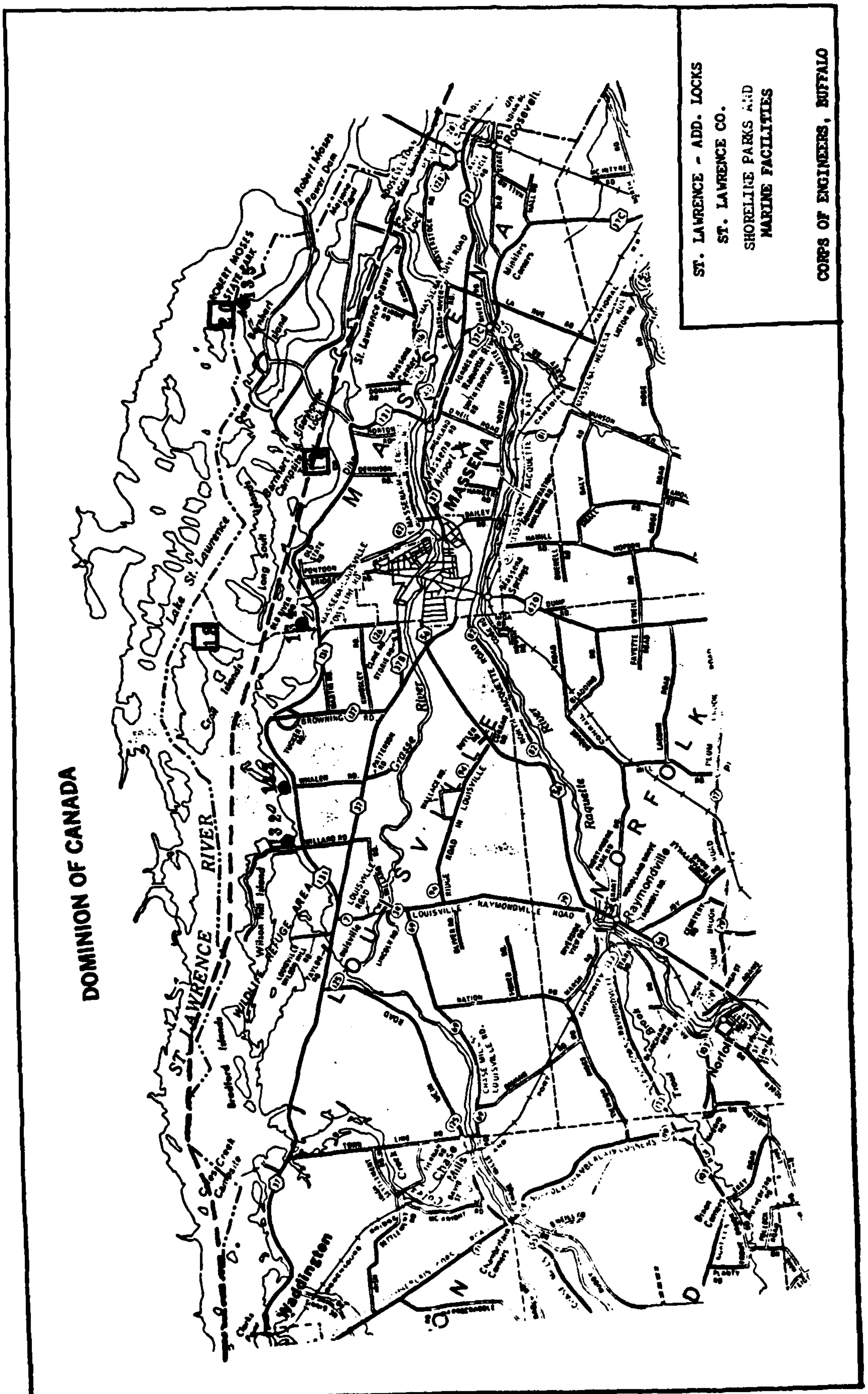
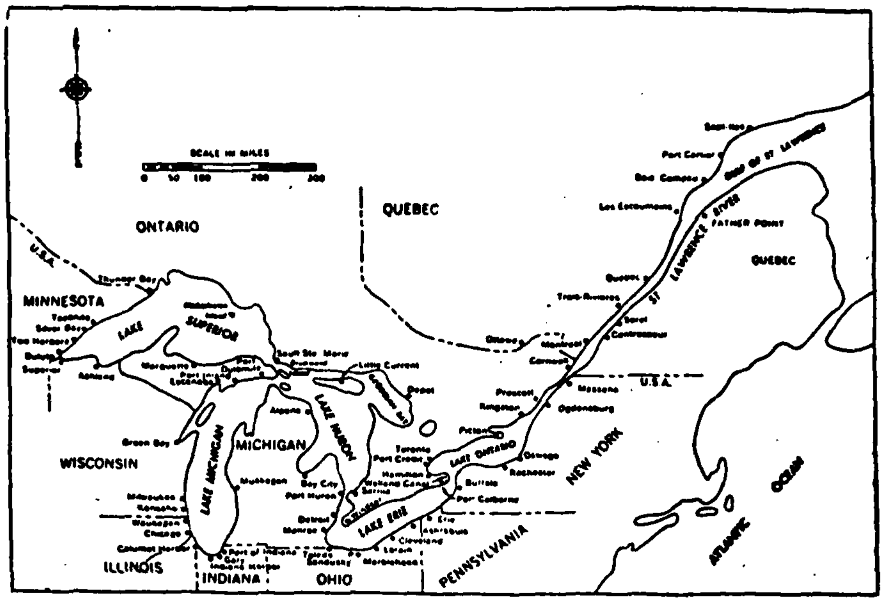

DOMINION OF CANADA
ST. LAWRENCE - ADD. LOCKS
ST. LAWRENCE CO.
SHORELINE PARKS AND
MARINE FACILITIES
CORPS OF ENGINEERS, BUFFALO
ST. LAWRENCE RIVER
Lake St. Lawrence
MASSENA
Waddington
Raymondville
Norfolk
Louisville
Robert Moses Power Dam
Grasse River
Raquette River
St. Lawrence Seaway

FIGURE A - 8f

FIGURE A - 9 Major Harbors on the Great Lakes - St. Lawrence Navigation System



Source: Appendix C9 - Commercial Navigation, Great Lakes Basin Framework Study

TABLE A - 17 U. S. Great Lakes Commercial and Private Harbors

Commercial		Private
Lake Superior	**Lake Michigan (Cont'd)**	**Lake Superior**
Grand Marais, MN	Frankfort, MI	Taconite, MN
Two Harbors, MN	Charlevoix, MI	Silver Bay, MN
Duluth-Superior, MN-WI		
Ashland, WI	**Lake Huron**	**Lake Michigan**
Ontonagon, MI		
Presque Isle, MI	Alpena, MI	Oak Creek, WI
Marquette, MI	Cheboygan, MI	Buffington, IN
Keweenaw Waterway, MI	Saginaw, MI	Gary, IN
	Harbor Beach, MI	Port Dolomite, MI
Lake Michigan		Port Inland, MI
	St. Clair/Detroit Rivers	Escanaba, MI
Menominee, MI & WI		Petoskey Penn Dixie
Green Bay, WI	Marysville, MI	Harbor, MI
Sturgeon Bay, WI	Port of Detroit, MI	
Kewaunee, WI	Detroit River	**Lake Huron**
Two Rivers, WI	Rouge River	
Minitowoc, WI	Trenton Channel	Calcite, MI
Sheboygan, WI	Monroe, MI	Stoneport, MI
Port Washington, WI		Port Gypsum, MI
Milwaukee, WI	**Lake Erie**	Alabaster, MI
Racine, WI		Drummond Island, MI
Kenosha, WI	Toledo, OH	
Waukegan, IL	Sandusky, OH	**Lake Erie**
Chicago, IL	Huron, OH	
Calumet Harbor, IN & IL	Lorain, OH	Marblehead, OH
& Lake Calumet	Cleveland, OH	
Indiana Harbor, IN	Fairport, OH	
Burns Waterway, IN	Ashtabula, OH	
Michigan City, IN	Conneaut, OH	
St. Joseph, MI	Erie, PA	
South Haven, MI	Port of Buffalo, NY	
Holland, MI		
Grand Haven, MI	**Lake Ontario**	
Manistique, MI		
Gladstone, MI	Rochester, NY	
Muskegon, MI	Great Sodus Bay, NY	
White Lake, MI	Oswego, NY	
Ludington, MI	Ogdensburg, NY	
Manistee Harbor, MI		

Source: Draft Plan of Study for G.L./S.L.S. Navigation Season Extension, December 1977.

Table A18 - Comparative Statement of Traffic
(Vessel Traffic in Tons)

Year	Ogdensburg Harbor, NY	Oswego Harbor, NY
1949	474,257	2,315,599
1950	723,245	2,284,498
1951	774,096	3,022,546
1952	679,267	2,239,689
1953	574,574	2,199,030
1954	523,257	1,983,596
1955	525,353	2,801,358
1956	652,083	2,855,016
1957	539,645	2,576,131
1958	476,936	1,868,755
1959	425,147	819,274
1960	394,309	984,637
1961	333,091	666,970
1962	327,560	1,026,101
1963	345,560	569,694
1964	347,060	246,358
1965	658,200	252,566
1966	541,197	449,154
1967	600,156	342,218
1968	299,931	380,033
1969	287,217	424,312
1970	265,558	473,553
1971	237,557	491,196
1972	215,542	779,417
1973	280,039	930,877
1974	214,944	902,343
1975	235,448	847,987
1976	221,402	1,014,135
1977	257,443	1,346,112
1978	204,201	1,215,979
1979	210,377	1,495,967
1980	149,371	860,144

SOURCE: Waterborne Commerce of the United States, Part III, 1949-1980

TABLE A - 19 Public Water Supply Data for Major Communities Along the St. Lawrence River [1]

Municipaly or District	Source	Number of Households or Establishments Served	Population Served[2]	Disin-fection[3]	Filtration	Other Treatment	Average Daily Production (thousand gallons)	Distribution Storage (thousand gallons)
Alexandria Bay	S	400	1,900	X			300	250
Cape Vincent	S	400	750	X			200	190
Clayton	S	768	2,100	X			425	750
Massena	S	4,200	17,670	X	X	L	1,700	1,000
Morristown	S	120	526	X	X	L	66	100
Ogdensburg	S	4,500	14,358	X	X	F	3,160	0
Thousand Island Park	S	325	1,500	X			200	175
Waddington	G	300	948			C	95	200

Legend: G - Ground Water, S - Surface Water, C - Aeration, F - Flouridation, L - Limesoda softening.

1 Source: Northern Area Business Fact Book, Part 1 "Business and Manufacturing," U. S. Dept. of Commerce, 1976 Edition.
2 As of 1974.
3 Disinfection by Chlorine or Chlorine Compound.
4 Amount of fully treated water available for immediate distribution.

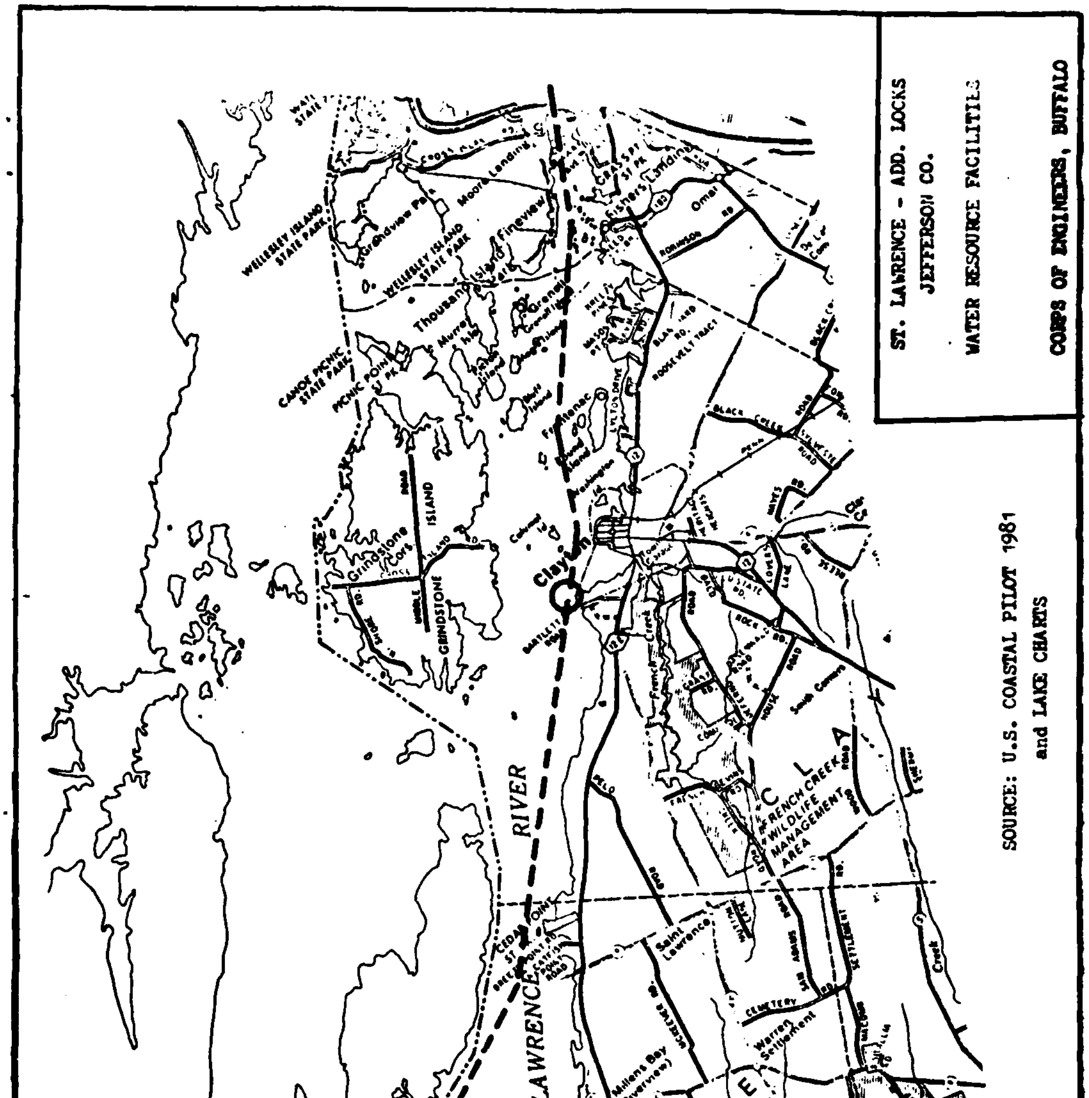
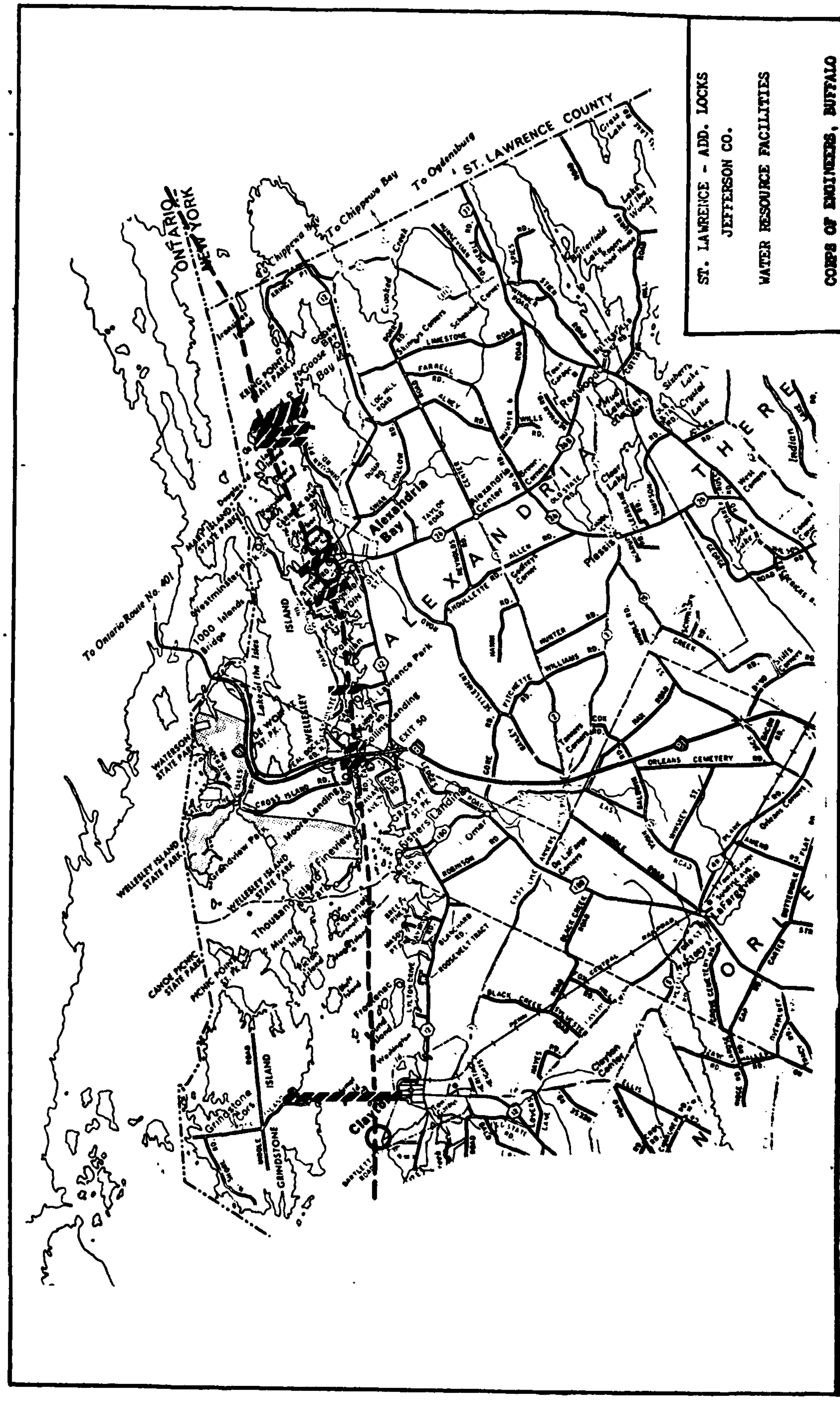

ST. LAWRENCE - ADD. LOCKS
JEFFERSON CO.
WATER RESOURCE FACILITIES
CORPS OF ENGINEERS, BUFFALO
SOURCE: U.S. COASTAL PILOT 1981
and LAKE CHARTS
MAP KEY
NAVIGATION CHANNEL
POTABLE WATER INTAKE
WATER INTAKE
OUTFLOW
AERIAL CABLE
SUBMERGED CABLE
ICE BOOM CABLE
FERRY CROSSING
ST. LAWRENCE RIVER
ONTARIO
NEW YORK
Cape Vincent
Clayton
Carleton Island
Grindstone
Wolfe Island
FRENCH CREEK WILDLIFE MANAGEMENT AREA
ASHLAND WILDLIFE MANAGEMENT AREA
Wilson Bay
Mud Bay

FIGURE A - 10a



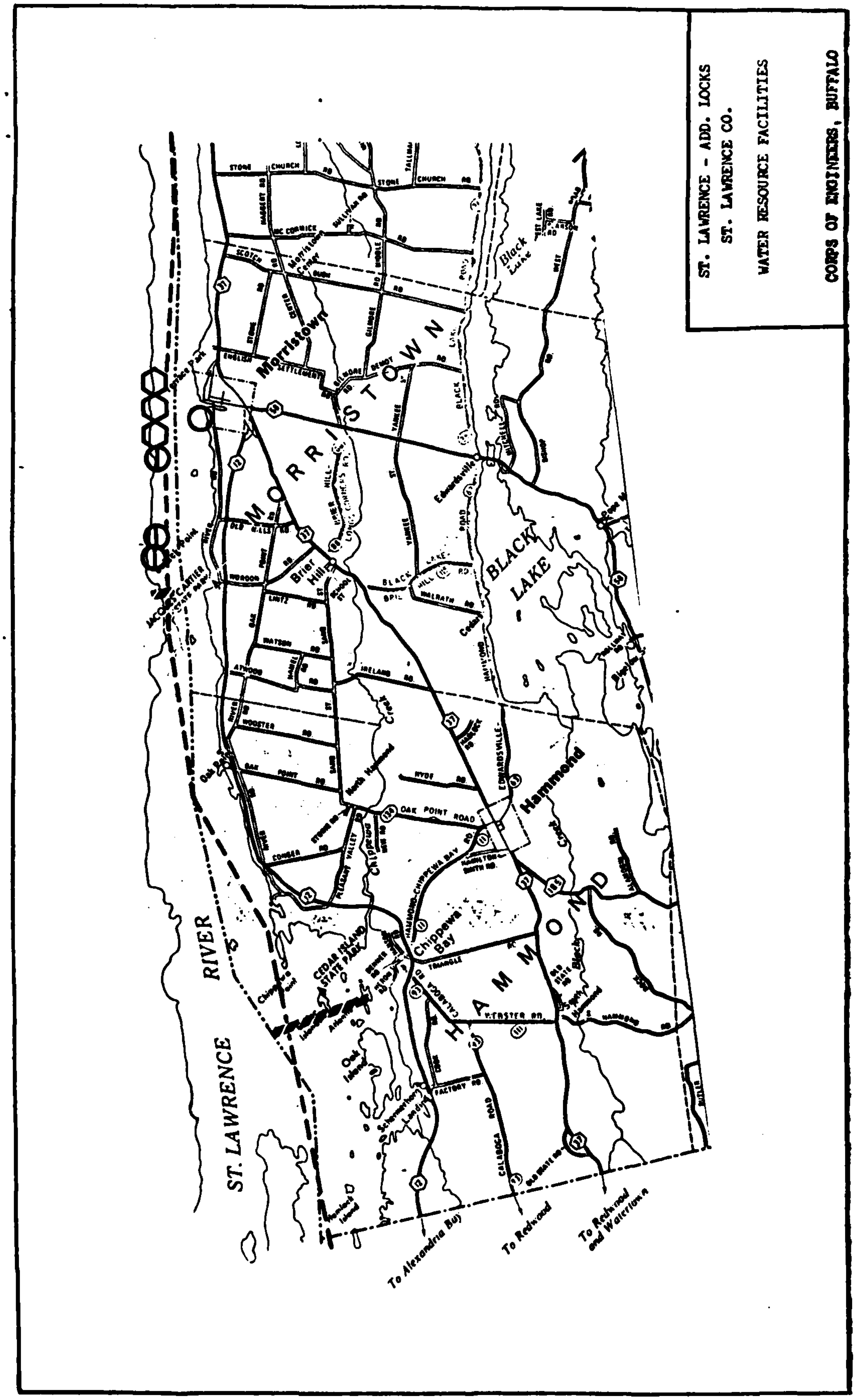
ST. LAWRENCE - ADD. LOCKS

JEFFERSON CO.

WATER RESOURCE FACILITIES

CORPS OF ENGINEERS, BUFFALO

FIGURE A - 10b



A-112

FIGURE A - 10c

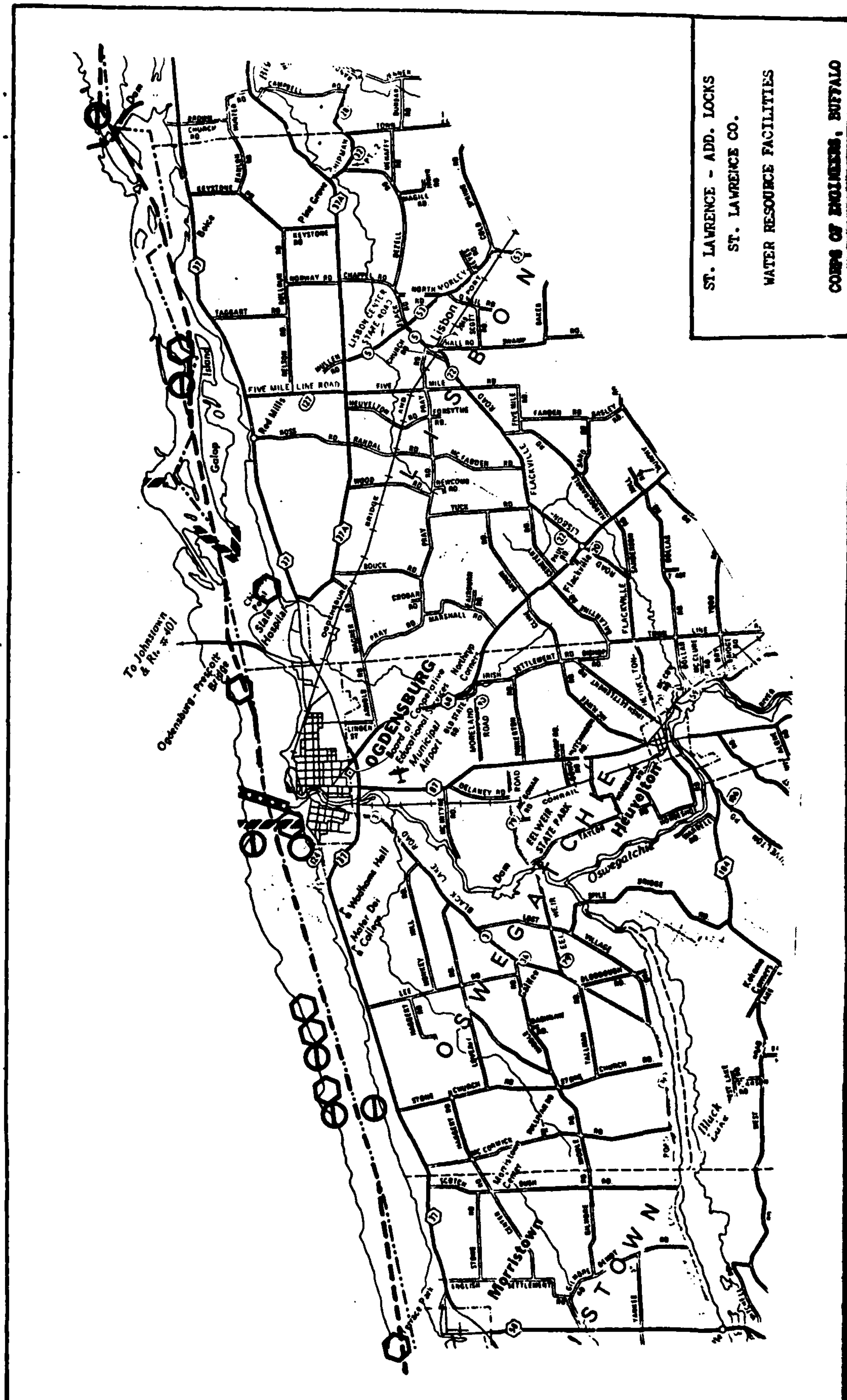

ST. LAWRENCE - ADD. LOCKS
ST. LAWRENCE CO.
WATER RESOURCE FACILITIES
CORPS OF ENGINEERS, BUFFALO
OGDENSBURG
Lisbon
Heuvelton
Morristown
Oswegatchie
Ogdensburg - Prescott Bridge
To Johnstown & Rt. #401
Municipal Airport
EEL WEIR STATE PARK
FIVE MILE LINE ROAD

FIGURE A - 10d

ST. LAWRENCE - ADD. LOCKS
ST. LAWRENCE CO.
WATER RESOURCE FACILITIES

CORPS OF ENGINEERS, BUFFALO

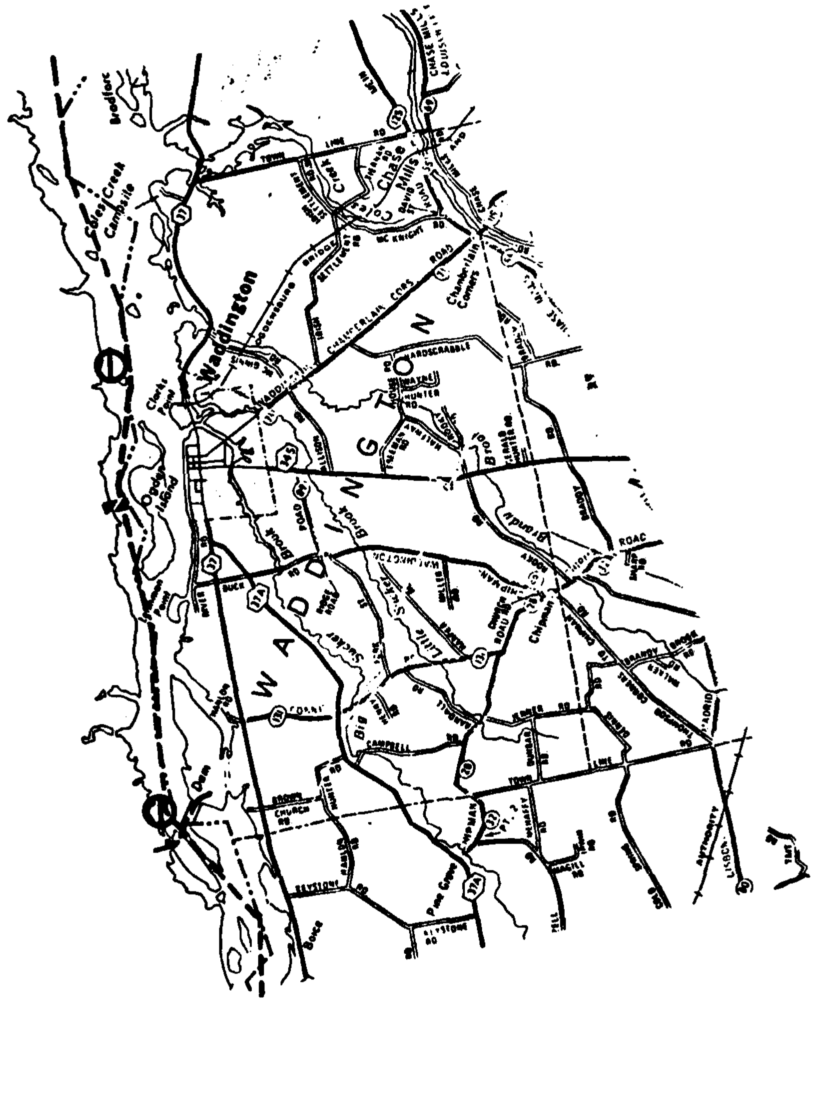


FIGURE A - 10e

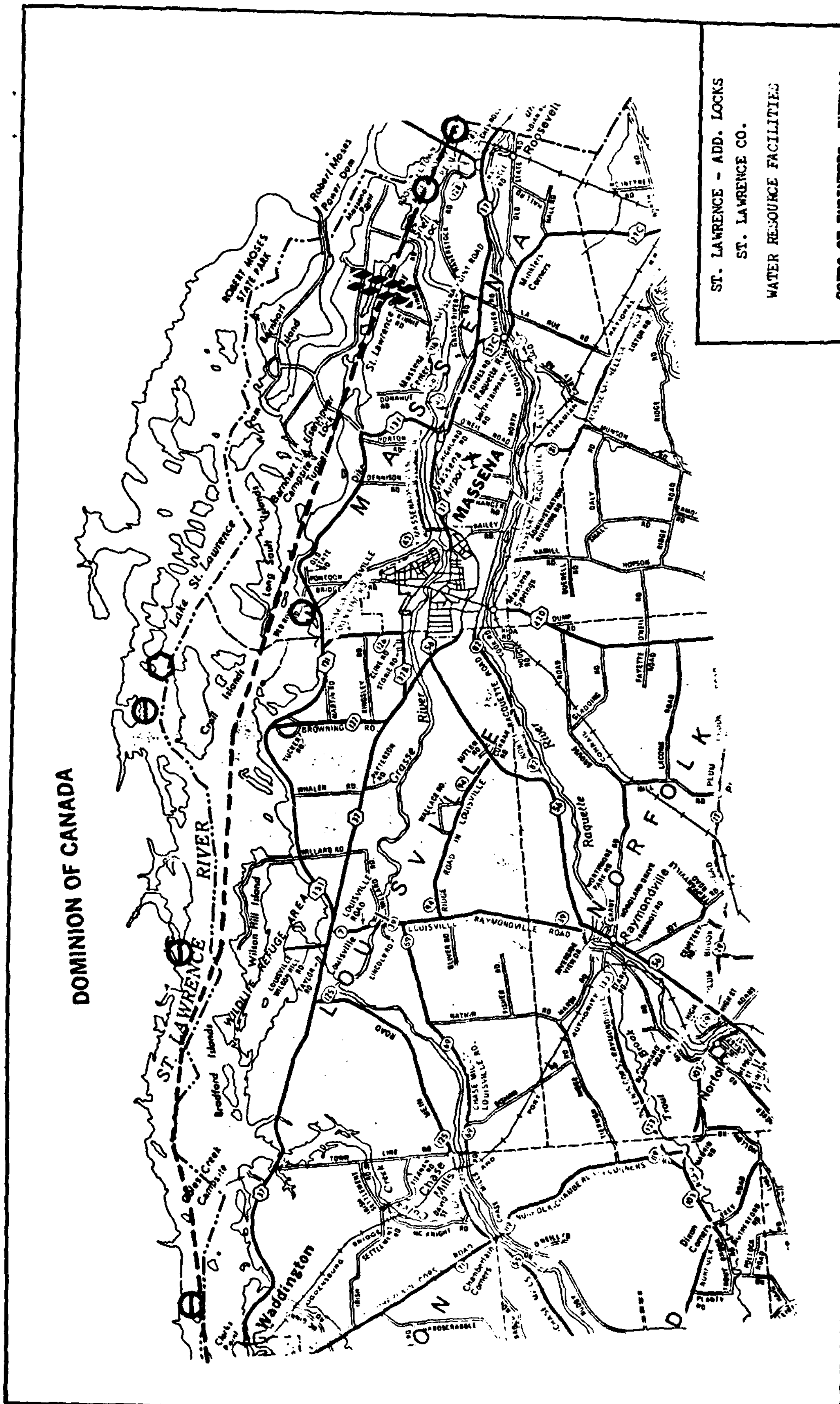

ST. LAWRENCE - ADD. LOCKS
ST. LAWRENCE CO.
WATER RESOURCE FACILITIES
CORPS OF ENGINEERS, BUFFALO
DOMINION OF CANADA
ST. LAWRENCE
RIVER
Lake St. Lawrence
Robert Moses Power Dam
ROBERT MOSES STATE PARK
MASSENA
LOUISVILLE
NORFOLK
Massena
Raymondville
Waddington
Norfolk
Raquette River
Grasse River
WILDLIFE REFUGE AREA
Wilson Hill Island
Long Sault Islands
Croil Islands
Bradford Islands
Massena Airport
Massena Springs
Massena Center
St. Lawrence
Chase Mills
Louisville
Barnhart Island

FIGURE A - 101

TABLE A - 20 Plan Area - United States

	1950 (2)	1962 (1)	1969	1970	1980	1985	1990	2000	2020
Population (midyear)	151,236,648	185,708,000	201,298,000	203,857,864	223,532,000	234,517,300	246,039,000	263,630,000	297,146,000
Per Capita Income (1967 $)	2,064	2,585	3,435	3,476	4,700	5,400	6,100	8,100	13,200
Per Capita Income Relative (U. S. = 1.00)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Total Employment	57,221,773	66,372,649	-	79,306,527	96,114,000	101,121,100	106,388,000	117,891,000	130,534,000
Industry Earnings Forecasts				In Thousands of 1967 Dollars					
Agriculture	23,467,939	18,462,090	20,086,322	19,640,721	21,264,000	22,122,800	23,016,000	25,856,000	32,975,000
Mining	5,129,386	4,908,611	5,418,046	5,647,503	6,498,000	6,896,300	7,319,000	8,402,000	11,106,000
Contract Construction	15,370,217	22,990,095	34,359,988	34,457,902	51,910,100	60,857,100	71,347,000	97,584,000	166,004,000
Manufacturing	74,706,597	115,576,453	161,773,451	156,291,199	219,486,000	252,984,700	291,595,000	388,479,000	641,982,000
Trans., Comm., and Public Utilities	21,047,455	28,694,815	38,611,797	39,925,053	58,672,000	69,036,800	81,233,000	112,976,000	200,497,000
Wholesale and Retail Trade	48,774,013	67,565,645	91,431,489	93,080,363	131,912,000	154,867,400	179,102,000	243,455,000	409,485,000
Finance, Insur. and Real Estate	10,886,662	19,805,660	23,875,247	28,880,241	48,461,000	59,224,100	72,377,000	106,845,000	204,488,000
Services	28,797,423	52,608,614	81,997,846	85,077,671	150,270,000	187,755,300	234,589,000	359,761,000	734,985,000
Government	29,316,295	59,386,445	93,988,132	99,310,475	147,017,000	178,255,800	216,133,000	313,934,000	599,377,000
Total Industry Earnings	257,495,988	389,998,433	556,542,319	562,311,127	837,490,000	992,723,000	1,176,711,000	1,657,332,000	3,000,899,000

(1) Employment is for 1960
(2) Alaska and Hawaii excluded
Source: 1972 OBERS Projections, Vol. 3, U. S. Water Resources Council

TABLE A - 21 Plan Areas - Great Lakes

	1950	1962 (1)	1969	1970	1980	1985	1990	2000	2020
Population (midyear)	21,617,012	26,719,499	28,824,211	29,112,481	31,580,200	32,854,400	33,674,100	36,350,700	40,168,300
Per Capita Income (1967 $)	2,470	2,860	3,890	3,780	5,210	5,910	6,790	8,810	14,170
Per Capita Income Relative (U. S. = 1.00)	1.20	1.11	1.13	1.09	1.11	1.09	1.11	1.09	1.07
Total Employment	8,613,414	9,734,946	-	11,378,925	13,840,400	14,445,700	15,080,500	16,582,100	18,063,100
Total Personal Income (1967 $000)	53,459,019	76,285,557	112,248,538	110,131,348	164,560,700	193,937,100	228,590,300	320,003,600	569,055,000
Industry Earnings Forecasts				In Thousands of 1967 Dollars					
Agriculture	1,614,559	1,139,890	1,151,527	1,109,507	1,253,500	1,289,900	1,327,500	1,469,400	1,554,200
Mining	221,360	229,493	286,960	139,113	408,600	430,600	453,900	519,800	686,100
Contract Construction	2,497,862	3,396,673	5,841,390	5,347,740	8,030,500	9,288,500	10,745,800	14,466,400	23,968,400
Manufacturing	19,573,821	26,807,923	51,816,623	35,296,794	48,839,100	55,496,600	63,078,900	82,523,900	132,781,300
Trans., Comm., and Public Utilities	3,512,516	4,449,862	5,835,447	5,895,361	8,451,300	9,816,700	11,411,000	15,607,100	26,935,300
Wholesale and Retail Trade	8,230,800	10,744,032	14,622,607	14,652,261	20,623,800	23,585,100	26,977,500	36,195,100	59,527,900
Finance, Insur. and Real Estate	1,611,948	2,794,133	3,899,852	3,878,711	6,489,300	7,857,500	9,516,300	13,884,300	25,928,700
Services	4,532,277	7,693,799	11,996,089	12,262,712	21,727,000	26,928,900	33,377,200	50,687,100	101,257,400
Government	3,409,792	6,592,552	10,330,541	11,077,028	17,172,700	20,853,600	25,328,400	37,026,500	70,547,700
Total Industry Earnings	45,204,933	63,848,338	105,781,036	89,659,227	132,995,900	155,549,400	182,216,500	252,339,600	443,177,000

(1) Employment is for 1960
Source: 1972 OBERS Projections, Vol. 3, U. S. Water Resources Council

TABLE A - 22 Plan Area - Lake Superior

	1950	1962 (1)	1969	1970	1980	1985	1990	2000	2020
Population (midyear)	515,329	550,122	537,064	535,542	531,500	531,100	531,000	528,200	532,200
Per Capita Income (1967 $)	1,715	2,115	2,710	2,820	3,935	4,520	5,190	7,040	11,950
Per Capita Income Relative (U.S. = 1.00)	.83	.82	.79	.81	.84	.84	.85	.87	.91
Total Employment	180,206	174,478	-	182,859	200,500	202,600	204,700	214,600	220,600
Total Personal Income (1967 $000)	884,222	1,162,805	1,456,484	1,508,338	2,091,800	2,400,700	2,756,400	3,720,100	6,350,600
Industry Earnings Forecasts			In Thousands of 1967 Dollars						
Agriculture	27,378	12,766	9,391	7,963	10,000	10,700	11,600	12,900	16,600
Mining	71,149	91,545	120,671	1,591	173,900	180,000	186,300	208,300	265,300
Contract Construction	37,101	55,535	61,846	67,111	105,900	119,700	135,500	176,600	282,400
Manufacturing	141,251	135,481	161,398	158,798	213,800	239,500	269,000	365,600	547,500
Trans., Comm. and Public Utilities	100,989	87,594	99,737	94,868	120,200	132,900	147,200	188,100	302,100
Wholesale and Retail Trade	142,455	149,355	172,203	172,766	225,600	248,900	274,700	368,100	526,300
Finance, Insur. and Real Estate	15,215	24,428	29,895	29,788	45,000	53,400	63,400	89,300	158,600
Services	66,883	100,572	140,291	142,498	240,300	289,700	346,700	503,300	953,600
Government	86,530	213,380	284,219	304,410	432,200	516,300	616,900	883,400	1,654,700
Total Industry Earnings	689,031	870,636	1,079,651	979,793	1,566,900	1,790,500	2,051,300	2,755,600	4,707,100

(1) Employment is for 1960
Source: 1972 OBERS Projections, Vol. 3, U.S. Water Resources Council

TABLE A - 23 Plan Area - Lake Michigan

	1950	1962 (1)	1969	1970	1980	1985	1990	2000	2020
Population (midyear)	9,988,365	12,338,385	13,386,122	13,551,843	14,709,300	15,281,800	15,877,000	16,862,500	18,630,000
Per Capita Income (1967 $)	2,560	3,050	4,065	3,890	5,330	6,030	6,820	8,950	14,320
Per Capita Income Relative (U.S. = 1.00)	1.24	1.18	1.18	1.12	1.13	1.12	1.12	1.10	1.08
Total Employment	4,111,550	4,675,422	-	5,446,825	6,595,900	6,865,800	7,147,400	7,823,500	8,475,600
Total Personal Income (1967 $000)	25,586,403	37,604,446	54,428,606	52,720,618	78,386,000	92,131,400	108,290,400	150,924,400	266,727,600
Industry Earnings Forecasts			In Thousands of 1967 Dollars						
Agriculture	771,330	528,768	516,235	483,743	[illegible]	565,400	580,100	639,400	512,100
Mining	99,619	87,510	78,434	71,141	89,200	91,800	94,500	105,100	133,400
Contract Construction	1,206,515	1,793,182	2,890,455	2,671,845	4,045,000	4,649,200	5,344,100	7,113,400	11,551,300
Manufacturing	8,729,236	12,294,436	16,375,191	15,741,440	21,530,400	24,395,500	27,643,400	36,013,100	57,670,400
Trans., Comm. and Public Utilities	1,793,006	2,300,447	3,002,782	3,035,695	4,295,000	4,950,600	5,706,900	7,702,000	13,031,000
Wholesale and Retail Trade	4,212,699	5,561,752	7,394,969	7,404,823	10,279,700	11,739,000	13,406,600	17,942,800	29,505,300
Finance, Insur. and Real Estate	935,346	1,586,870	2,146,915	2,137,872	3,462,800	4,167,300	5,015,500	7,267,100	13,504,000
Services	2,326,689	3,921,209	5,946,210	6,112,647	10,744,700	13,263,100	16,366,400	24,670,000	48,651,200
Government	1,667,858	3,089,467	4,760,717	5,153,896	7,965,300	9,644,700	11,679,600	17,021,000	32,206,100
Total Industry Earnings	21,742,358	31,163,641	43,111,908	42,813,102	62,963,400	73,466,000	85,837,100	118,473,900	206,765,000

(1) Employment is for 1960
Source: 1972 OBERS Projections, Vol. 3, U.S. Water Resources Council

TABLE A - 24 Plan Area - Lake Huron

	1950	1962 (1)	1969	1970	1980	1985	1990	2000	2020
Population (midyear)	844,052	1,082,382	1,218,622	1,239,877	1,390,900	1,469,500	1,552,800	1,678,500	1,891,8[illegible]
Per Capita Income (1967 $)	1,990	2,530	3,420	3,245	4,700	5,350	6,090	8,115	13,380
Per Capita Income Relative (U. S. = 1.00)	0.96	0.98	1.00	0.93	1.00	0.99	1.00	1.00	1.01
Total Employment	301,543	355,981	-	431,129	552,700	588,200	626,000	706,700	803,100
Total Personal Income (1967 $000)	1,676,650	2,738,024	4,172,363	4,074,260	6,535,000	7,862,200	9,458,800	13,623,900	25,308,[illegible]
Industry Earnings Forecasts			In Thousands of 1967 Dollars						
Agriculture	112,516	78,543	74,815	67,144	74,400	75,400	76,300	84,100	104,400
Mining	7,464	7,135	6,838	6,204	23,800	25,700	27,600	32,200	41,500
Contract Construction	60,555	88,455	180,242	161,657	249,800	297,100	353,200	495,600	881,200
Manufacturing	691,395	1,206,273	1,773,299	1,533,860	2,632,200	[illegible]	3,627,000	4,969,200	8,472,000
Trans., Comm., and Public Utilities	69,157	114,709	134,423	135,616	211,900	257,500	312,800	457,100	875,600
Wholesale and Retail Trade	231,796	307,561	478,406	475,750	718,000	841,600	986,600	1,371,300	2,380,500
Finance, Insur. and Real Estate	23,454	43,607	69,391	70,200	126,600	158,500	198,500	303,400	610,700
Services	105,428	192,361	327,122	331,907	674,000	807,600	1,045,400	1,707,800	3,848,700
Government	96,562	228,178	393,086	415,235	640,800	777,600	963,700	1,373,600	2,572,400
Total Industry Earnings	1,398,327	2,266,822	3,438,120	3,201,573	5,301,500	6,330,800	7,571,100	10,794,300	19,809,000

(1) Employment is for 1960
Source: 1972 - OBERS Projections, Vol. 3, U. S. Water Resources Council

TABLE A - 25 Plan Area - Lake Erie

	1950	1962 (1)	1969	1970	1980	1985	1990	2000	2020
Population (midyear)	8,558,663	10,697,821	11,453,257	11,547,714	12,442,500	12,932,900	13,444,100	14,262,300	15,679,100
Per Capita Income (1967 $)	2,540	2,840	3,890	3,820	5,250	5,940	6,725	8,850	14,260
Per Capita Income Relative (U. S. = 1.00)	1.23	1.10	1.13	1.10	1.12	1.10	1.10	1.09	1.08
Total Employment	3,368,561	3,801,375	-	4,452,410	5,396,100	5,628,300	5,871,400	6,452,300	7,026,700
Total Personal Income (1967 $000)	21,738,661	30,405,051	44,550,025	44,131,039	65,306,800	76,838,700	90,416,000	126,258,800	223,549,100
Industry Earnings Forecasts			In Thousands of 1967 Dollars						
Agriculture	464,410	357,300	357,988	373,919	422,900	437,100	431,800	501,800	629,800
Mining	27,068	27,883	39,280	40,456	88,700	96,800	105,500	125,700	174,500
Contract Construction	1,044,877	1,235,963	2,345,176	2,118,647	3,051,300	3,537,300	4,101,200	5,565,800	9,264,800
Manufacturing	8,852,407	11,428,664	31,082,900	15,512,179	21,111,800	23,885,500	27,030,300	35,116,500	55,906,800
Trans., Comm., and Public Utilities	1,351,324	1,691,772	2,271,125	2,287,177	3,296,100	3,840,000	4,474,100	6,147,200	10,838,400
Wholesale and Retail Trade	3,144,688	4,041,657	5,681,298	5,706,428	8,039,800	9,187,400	10,474,300	13,980,200	22,706,700
Finance, Insur. and Real Estate	555,303	981,704	1,432,614	4,422,203	2,437,800	2,960,700	3,596,200	5,256,300	9,764,900
Services	1,731,728	2,954,671	4,770,526	4,856,711	8,530,500	10,562,500	13,079,900	19,831,000	39,488,000
Government	1,276,830	2,505,304	3,993,464	4,228,387	6,568,300	7,990,100	9,721,400	14,272,500	27,285,900
Total Industry Earnings	18,448,635	25,224,898	51,994,371	36,546,107	53,567,200	62,497,400	62,360,600	100,775,000	175,879,800

(1) Employment is for 1960
Source: 1972 OBERS Projections, Vol. 3, U. S. Water Resources Council

TABLE A - 26 Plan Area - Lake Ontario

	1950	1962 (1)	1969	1970	1980	1985	1990	2000	2020
Population (midyear)	1,710,603	2,050,789	2,229,146	2,237,505	2,506,000	2,639,100	2,780,400	3,019,200	3,453,200
Per Capita Income (1967 $)	2,090	2,620	3,430	3,460	4,885	5,570	6,355	8,440	13,715
Per Capita Income Relative (U. S. = 1.00)	1.01	1.01	1.00	1.00	1.04	1.03	1.04	1.04	1.04
Total Employment	651,554	727,690	-	865,702	1,095,200	1,160,800	1,231,000	1,385,000	1,555,100
Total Personal Income (1967 $000)	3,575,080	5,375,231	7,641,060	7,747,093	12,241,100	14,704,100	17,668,700	25,476,600	47,111,200
Industry Earnings Forecasts			In Thousands of 1967 Dollars						
Agriculture	230,925	162,533	193,098	176,738	194,900	201,300	207,700	231,200	291,300
Mining	16,000	15,420	21,737	19,721	33,000	36,300	40,000	48,500	69,400
Contract Construction	148,734	223,558	363,671	328,480	578,600	685,200	811,800	1,135,000	1,988,700
Manufacturing	1,159,532	1,743,069	2,423,835	2,350,517	3,350,900	3,885,900	4,509,200	6,079,500	10,184,600
Trans., Comm., and Public Utilities	198,038	255,321	327,380	342,005	528,100	637,700	770,000	1,112,700	2,068,200
Wholesale and Retail Trade	499,162	683,707	895,231	892,494	1,340,700	1,568,200	1,835,300	2,552,700	4,408,900
Finance, Insur. and Real Estate	82,630	157,524	221,037	218,648	417,100	517,600	642,700	970,200	1,890,500
Services	301,549	524,986	811,940	818,949	1,587,500	2,007,000	2,538,800	3,975,000	8,295,200
Government	282,012	556,223	899,057	971,100	1,566,100	1,924,900	2,366,800	3,526,000	6,828,600
Total Industry Earnings	2,926,582	4,322,341	6,156,986	6,118,652	9,596,900	11,464,100	14,722,300	19,630,800	36,025,400

(1) Employment is for 1960
Source: 1972 OBERS Projections, Vol. 3, U. S. Water Resources Council

TABLE A - 27 Major Industrial Sectors in the Great Lakes States

State[3/]	Value Added by Manufacture[1/]	Major Industrial Sector[2/] Industry	SIC Code[4/]
Illinois	1,916.1	Electrical Machinery	36
	1,635.3	Machinery, except elec.	35
	1,617.3	Food and kindred prods.	20
Indiana	293.2	Machinery, except elec.	35
	188.9	Petroleum and coal prods.	29
	168.7	Transportation equipment	37
Michigan	5,805.8	Transportation equipment	37
	2,750.4	Machinery, except elec.	35
	1,987.7	Fabricated metal prods.	34
Minnesota	27.6	Food and kindred prods.	20
	13.3	Printing and publishing	27
	7.3	Machinery, except elec.	35
New York	1,714.2	Instruments and related prods.	38
	999.6	Machinery, except elec.	35
	590.2	Primary metal industries	33
Ohio	1,365.6	Machinery, except elec.	35
	1,168.8	Fabricated metal prod.	34
	971.6	Transportation equipment	37
Pennsylvania	91.2	Electrical machinery	36
	87.7	Fabricated metal prod.	34
	78.1	Machinery, except elec.	35
Wisconsin	1,182.1	Machinery, except elec.	35
	547.0	Food and kindred prod.	20
	530.9	Electrical Machinery	36

1/ In millions of dollars
2/ Includes only top three industrial sectors ranked by value added.
3/ Includes only those counties which lie within Great Lakes Basin limits.
4/ Standard Industrial Classification Manual, 1972

Source: Great Lakes Basin Framework Study, Appendix 19, "Economic and Demographi Studies"

TABLE A - 28 Population, Employment, and Income United Statesand Great Lakes 1950 to 2020

	United States	Great Lakes Basin	Percentage (1)
Population			
1950 (2)	151,236,648	21,617,012	14.3
1962 (2)	185,708,000	26,719,499	14.4
1970 (2)	203,857,864	29,112,481	14.3
1980	223,532,000	31,580,200	14.1
1985	234,517,300	32,854,400	14.0
1990	246,039,000	33,674,100	13.7
2000	263,830,000	36,350,700	13.8
2020	297,830,000	40,168,300	13.5
Employment			
1950	57,221,773	8,614,414	15.1
1962	66,372,649	9,734,946	14.7
1970	79,306,527	11,378,925	14.3
1980	96,114,000	13,840,400	14.4
1985	101,121,100	14,445,700	14.3
1990	106,388,000	15,080,500	14.2
2000	117,891,000	16,582,100	14.1
2020	130,534,000	18,063,100	13.8
Personal Income (3)			
1950	312,147,612	53,459,019	17.1
1962	480,053,606	76,285,557	15.9
1970	708,583,931	110,131,348	15.5
1980	1,068,496,000	164,560,700	15.4
1985	1,273,226,200	193,937,100	15.2
1990	1,517,173,000	228,590,300	15.1
2000	2,154,266,00C	320,003,600	14.9
2020	3,931,918,00C	569,055,000	14.5
Per Capita Personal Income (3)			
1950	2,064	2,470	119.7
1962	2,585	2,860	110.6
1970	3,476	3,780	108.7
1980	4,700	5,210	110.9
1985	5,400	5,910	109.4
1990	6,100	6,790	111.3
2000	8,100	8,810	108.8
2020	13,200	14,170	107.3

(1) Great Lakes Basin as percentage of total United States.
(2) Mid-year population.
(3) Value of dollar in 1967.
Source: 1972-OBERS Projections, Vol. 3, U. S. Water Resources Council

TABLE A - 29 SLEOC: HISTORIC SITE INVENTORY

Map No.	Historic Sites
1.	Spy Island and Silas Town Monument
2.	Selkirk Lighthouse
3.	William Johnson House
4.	Stony Point Lighthouse
5.	Lieutenant's House
6.	Battlefield Museum - Commander's House (N.R.)
7.	Samuel Read House
8.	Austin Rogers "Cotton Wood
9.	Bayworth Farm
10.	Greystone Farm
11.	WT #175 - St. Lawrence River [redacted]
12.	Tibbetts Point Lighthouse
13.	Lewis Mance House
14.	Maynard Farm (Lake View)
15.	Cape Vincent Fisheries Station
16.	J - 100
17.	Calumet Island Water Tower
18.	Waving Branches (Ainsworth Octagonal House)
19.	Rock Island Lighthouse (N.R.)
20.	Campbell House
21.	Century House
22.	Cottage on Nobby Island
23.	Boldt Castle (N.R.)
24.	Bonniecastle
25.	Sunken Rock Lighthouse
26.	Building on Ina Island
27.	Idlewild Island
28.	Dark Island Castle (Jorstad Castle)
29.	Crossover Lighthouse
30.	Augustus Chapman House
31.	Pine Eden
32.	Coopernall Home (White Birches)
33.	Colonel Ford House
34.	Customs House (N.R.)
35.	Brick Block
36.	Tomlinson House
37.	Ogden Land Office
38.	Robinson Bay Archeological Conservation Area (N.R.)

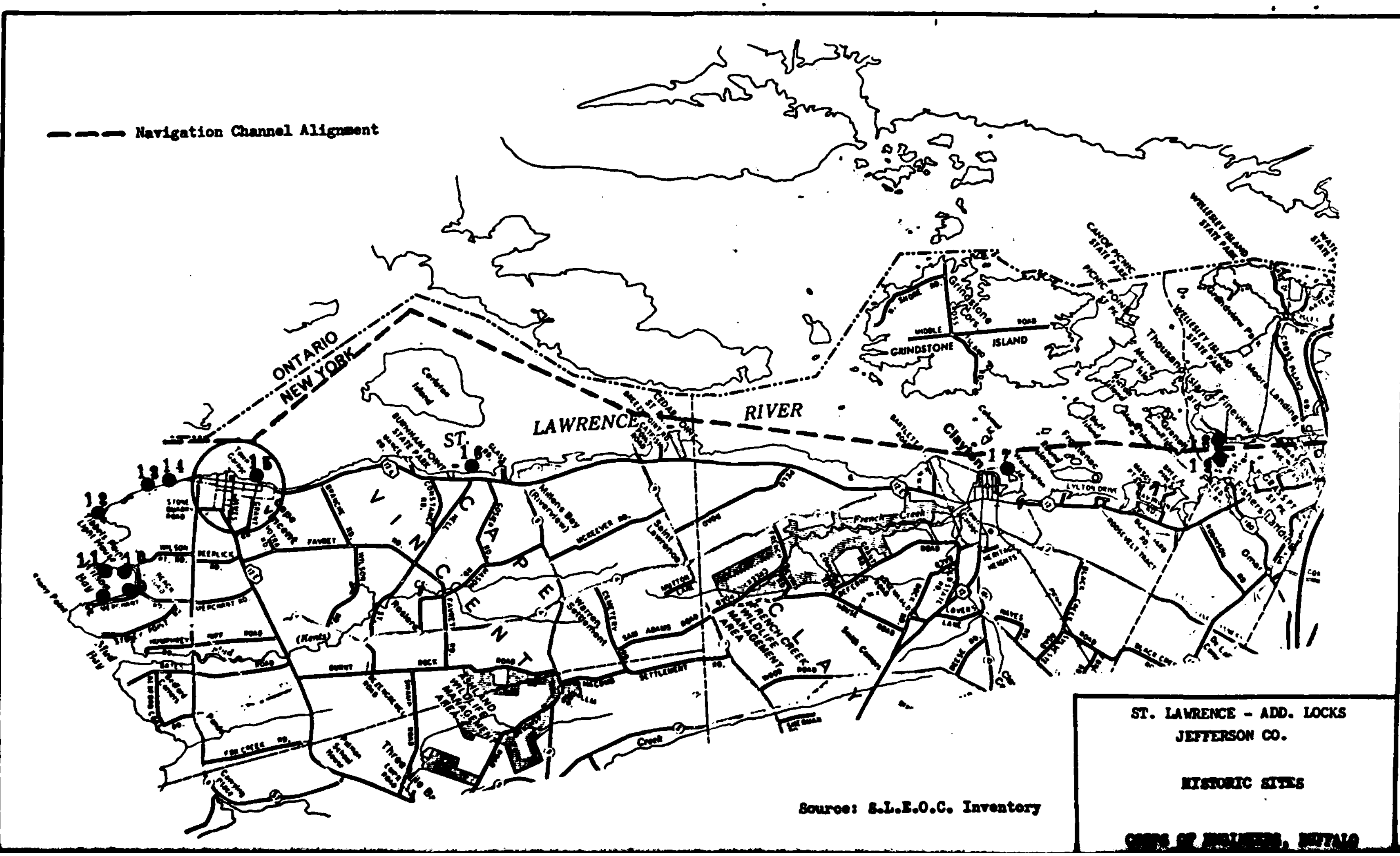
Source: St. Lawrence Eastern Ontario Commission

Elevation of Historic Structures Above St. Lawrence River

Site Name	Point on Structure Nearest the Water	Elevation Above River Level[1]
Customs House	Riverward (Oswegatchie River), upriver (Oswegatchie River) corner of single story attachment to main building.	+2.64 ft.
Ford House	Riverward, upriver corner of main structure riverward, upriver corner of attached structure.	+11.19 ft. +10.53 ft.
White Birches	Riverward, upriver corner of house on ground level.	+18.20 ft.
Pine Eden	Riverward, upriver outside corner of stairwell kneewall (Rod set on ground level next to corner of kneewall).	+16.66 ft.
Chapman House	Riverward corner of wood frame and siding portion of house at estimated top of foundation.	+2.24 ft.
Crossover Island	Boathouse; Top of foundation at SE corner. Base of Lighthouse on north side Center of storm cellar door on down river side of house.	+0.32 ft. +7.92 ft. +7.54 ft.
Ogden Land Office	Center of door on riverward side of house.	+5.10 ft.
The Brick Block	Downriver most house. Center of doorway on riverward side of house.	+5.81 ft.
Tomlinson House	Riverward, upriver corner.	+8.98 ft.

[1]Elevations above river level were taken on April 21, 1978. At that time water levels were near their seasonal maximum. Reference points are give below:

Location	April 21, 1978 Level	Normal Range
Holmes Point	245.90	3 feet
Ogdensburg	245.75	3 feet
Sparrowhawk Point	243.88	4 feet
Waddington	243.26	4 feet



ST. LAWRENCE - ADD. LOCKS
JEFFERSON CO.

HISTORIC SITES

CORPS OF ENGINEERS, BUFFALO

Source: S.L.S.O.C. Inventory

FIGURE A - 11a

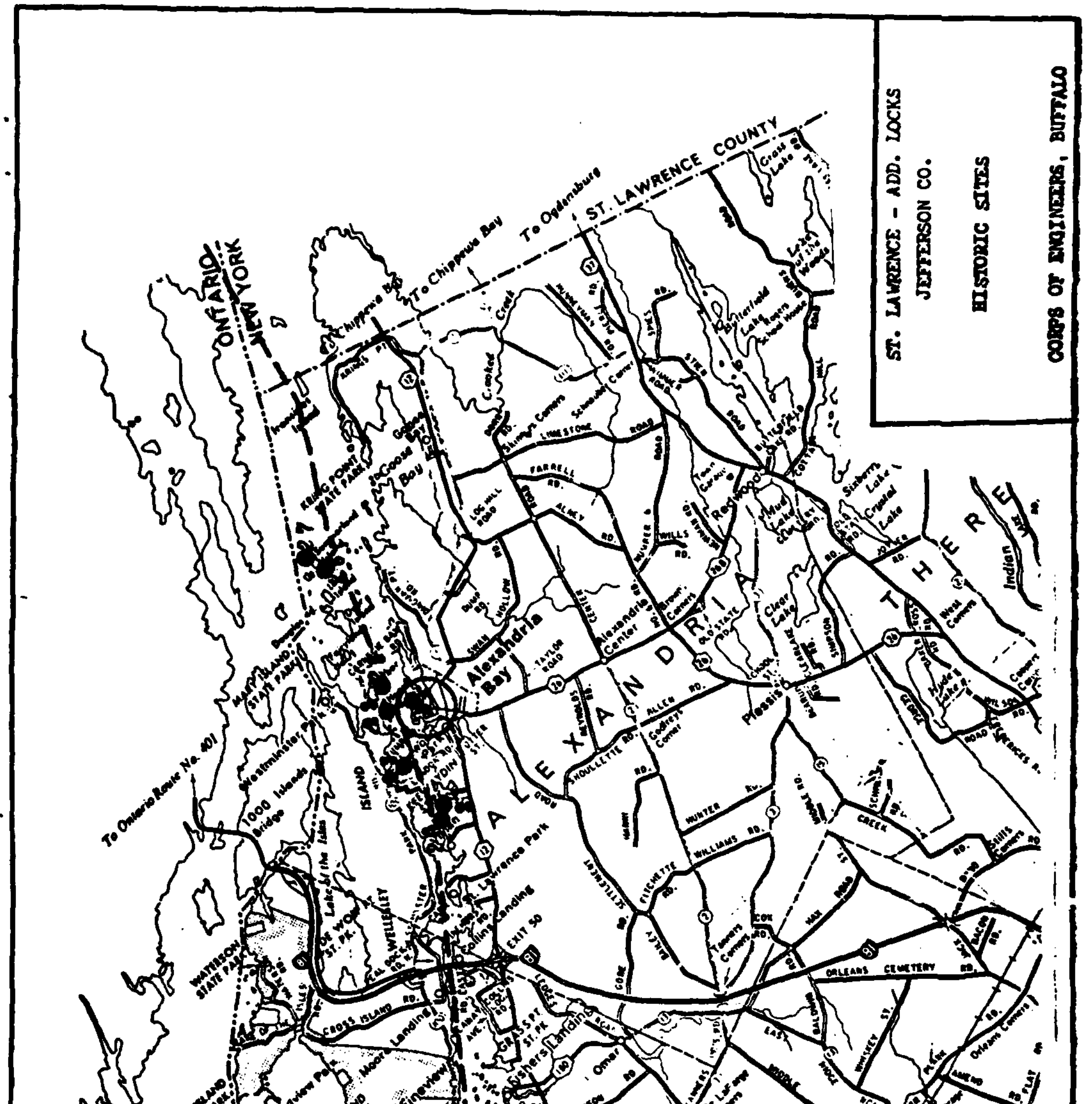

ST. LAWRENCE - ADD. LOCKS
JEFFERSON CO.
HISTORIC SITES
CORPS OF ENGINEERS, BUFFALO
ST. LAWRENCE COUNTY
ONTARIO
NEW YORK
Alexandria Bay
Clayton
Redwood
Plessis
Lafargeville
Thousand Island Park
WELLESLEY ISLAND STATE PARK
GRINDSTONE ISLAND
To Ogdensburg
To Chippewa Bay
To Ontario Route No. 401
1000 Islands Bridge
EXIT 50

FIGURE A - 11b

ST. LAWRENCE - ADD. LOCKS
ST. LAWRENCE CO.

HISTORIC SITES

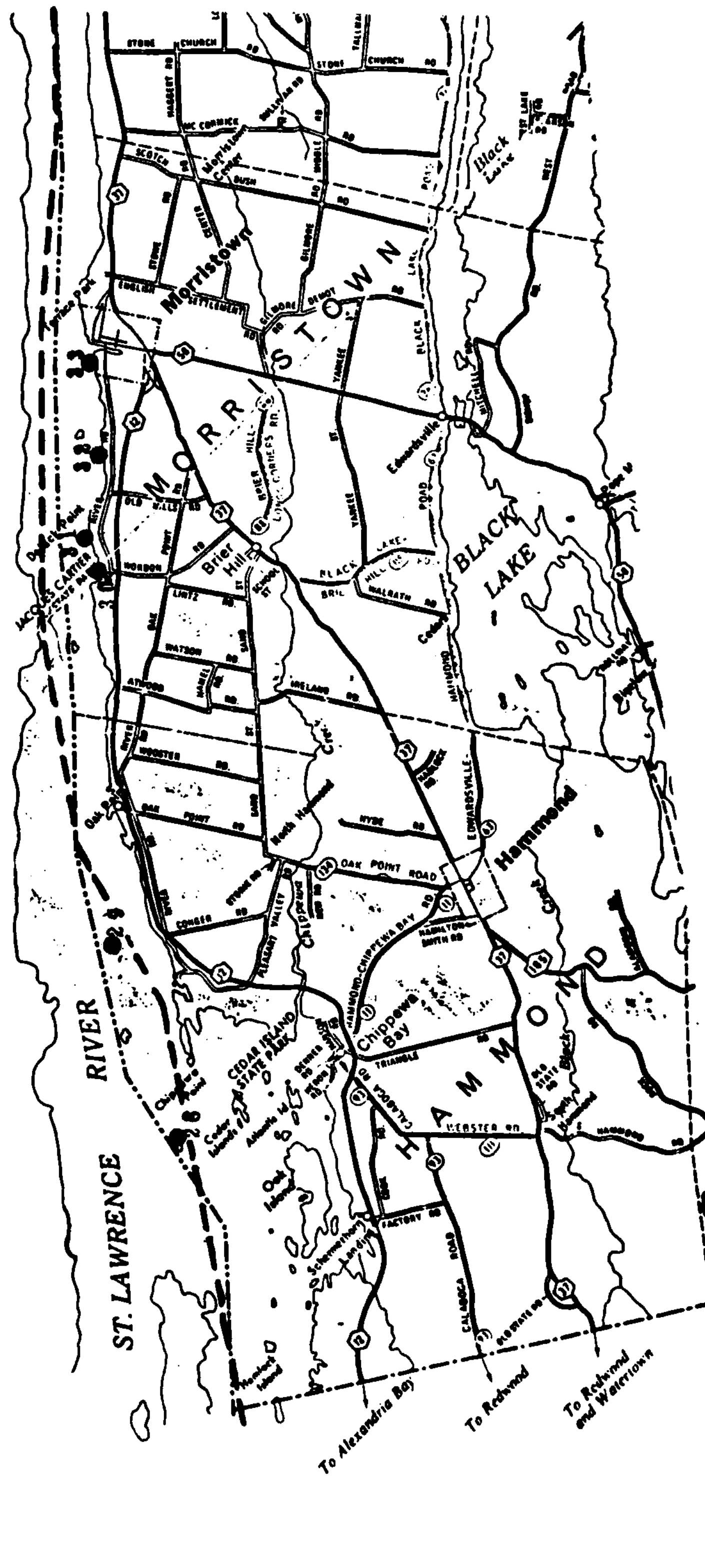
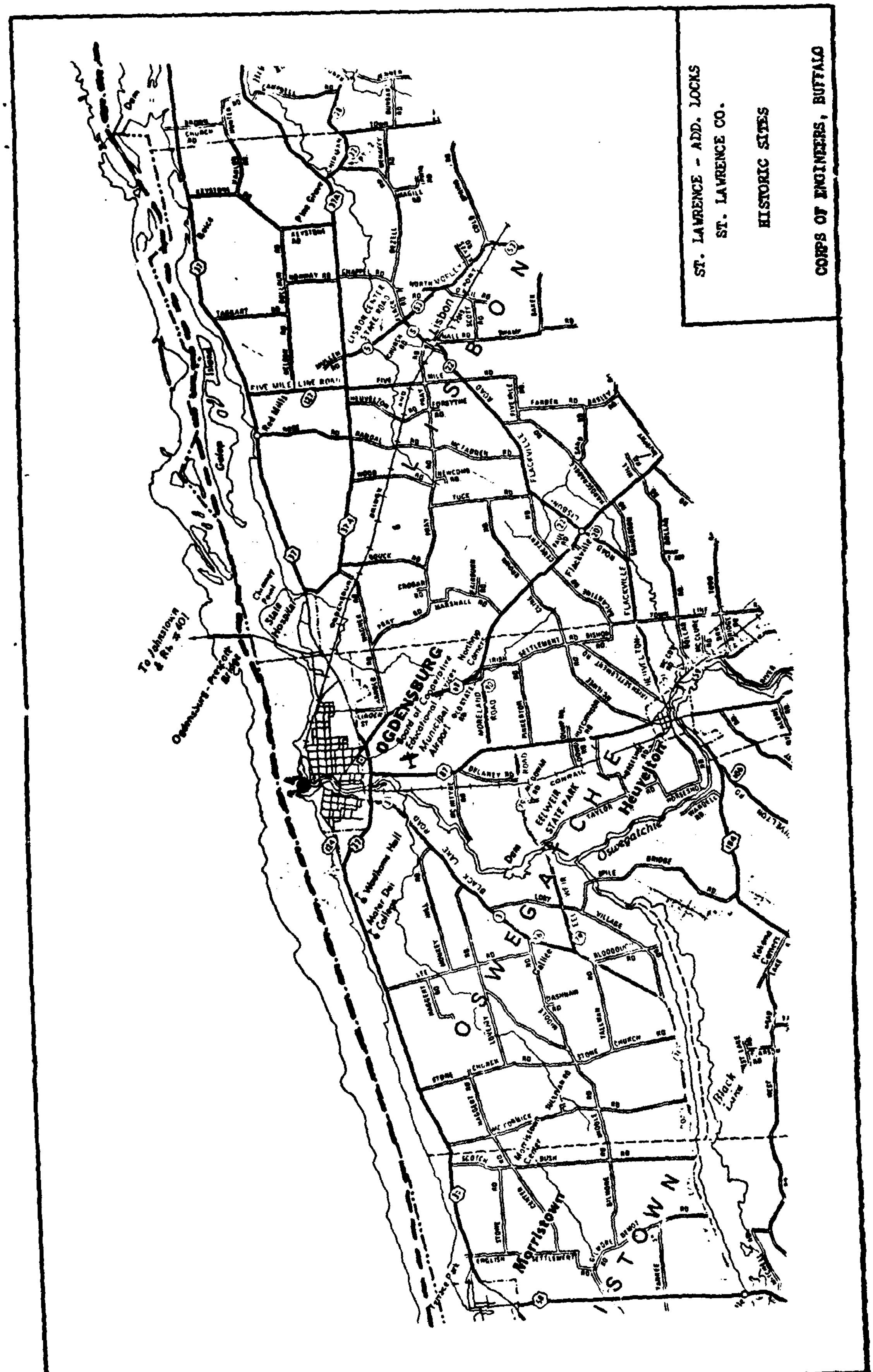


FIGURE A - 11c



ST. LAWRENCE - ADD. LOCKS
ST. LAWRENCE CO.
HISTORIC SITES
CORPS OF ENGINEERS, BUFFALO
OGDENSBURG
Heuvelton
Morristown
LISBON
OSWEGATCHIE
Oswegatchie
EELWEIR STATE PARK
Municipal Airport
Ogdensburg - Prescott Bridge
To Johnstown & Rt. #401
State Hospital
Mater Dei College
Black Lake

FIGURE A - 11d

ST. LAWRENCE - ADD. LOCKS
ST. LAWRENCE CO.

HISTORIC SITES

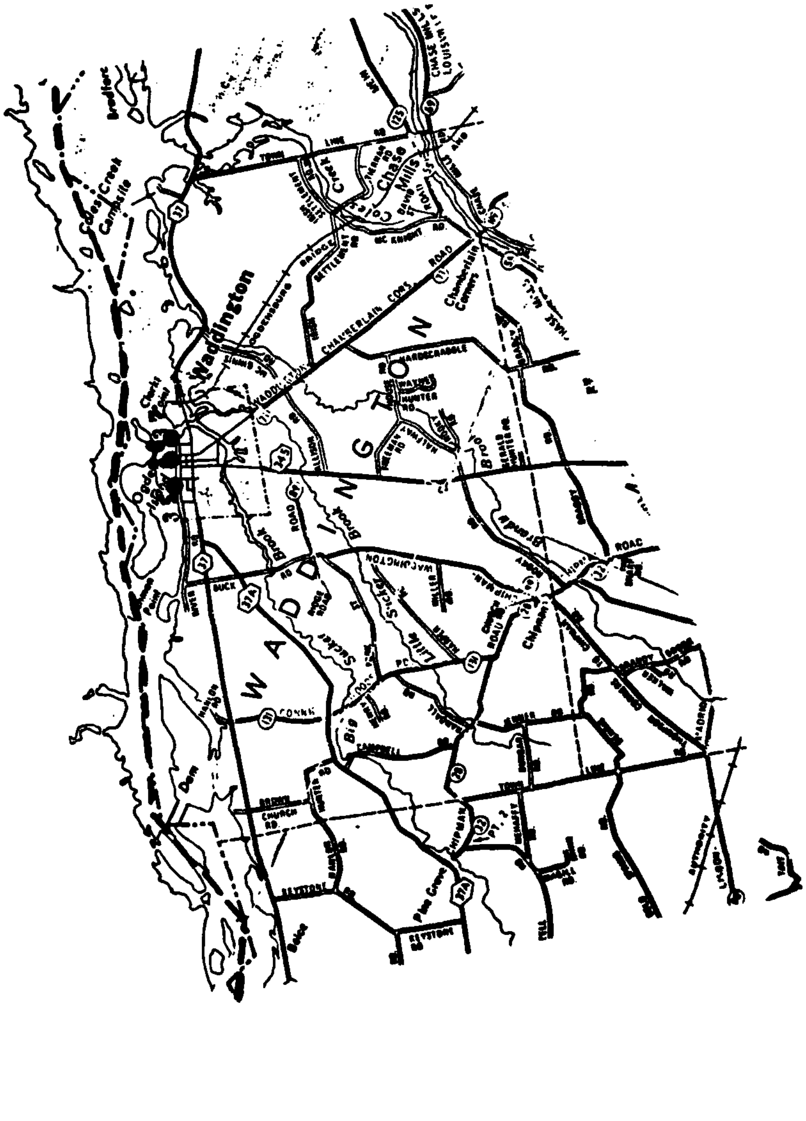
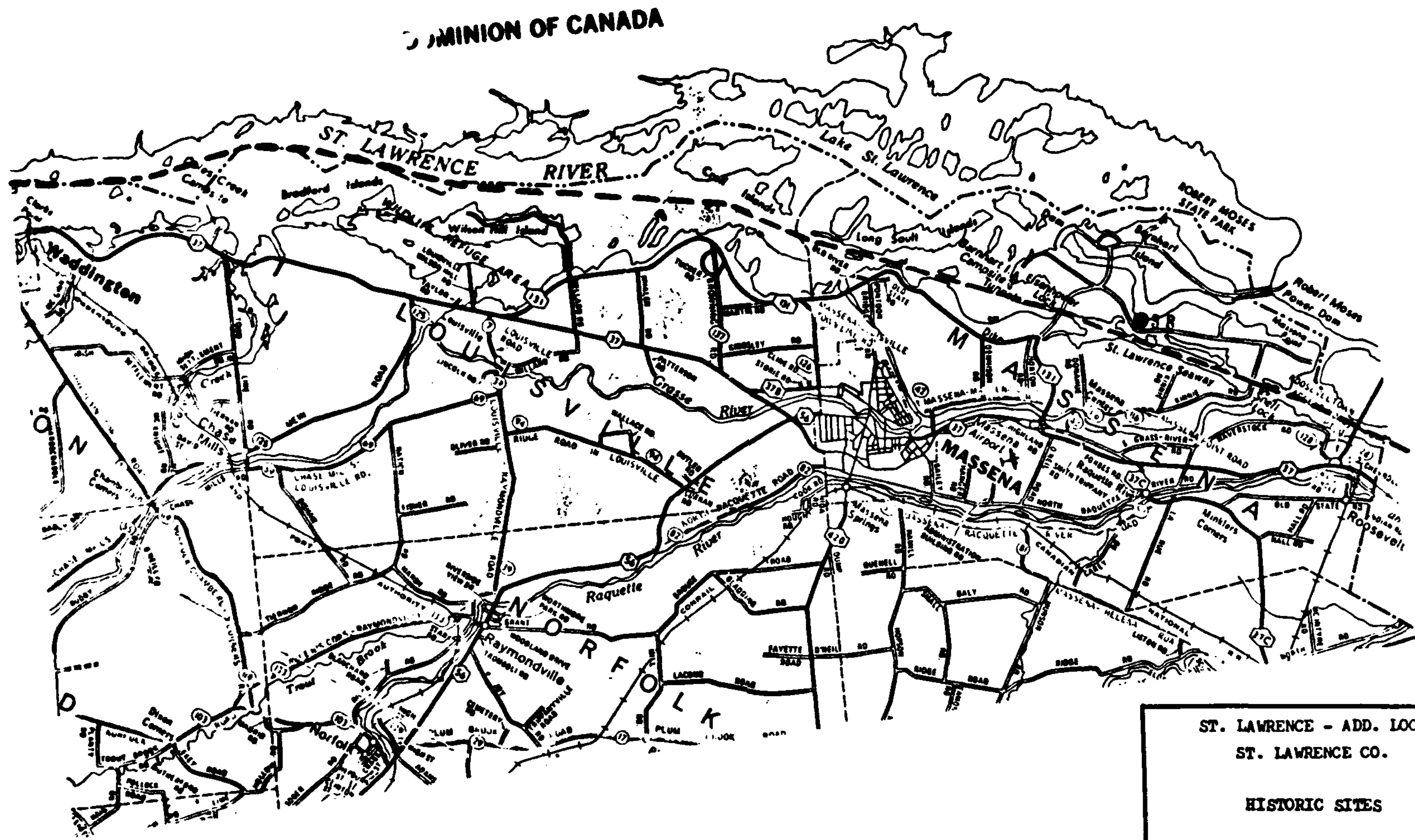


FIGURE A - 11e



ST. LAWRENCE - ADD. LOCKS
ST. LAWRENCE CO.

HISTORIC SITES

CORPS OF ENGINEERS, BUFFALO

FIGURE A - 11f

APPENDIX B

ECONOMICS

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TABLES

TABLE OF CONTENTS (Cont'd)

TABLES (Cont'd)

FIGURES

TABLE OF CONTENTS (Cont'd)

FIGURES (Cont'd)

Summary of the Economic Assessment

This appendix evaluates several alternatives for increasing physical capacity of the existing U.S. locks in the St. Lawrence River. A lock capacity model, U.S. and Canadian fleet composition, future levels of traffic and related lock parameters form the basis for the economic evaluation. Two types of lock modifications (i.e., larger locks or duplicate parallel locks) are feasible alternatives if the Welland Canal is modified at a point in time prior to U.S. actions in the St. Lawrence River.

Two levels of traffic have been considered in the analysis and have been evaluated in light of two levels of lock utilization (i.e., 80 percent and 90 percent). Results of this analysis should be interpreted as a range of economic feasibility for future U.S. Federal investments. Additional refinement of critical study variables is required if further study of future U.S. lock capacity is recommended.

Detailed cost estimates and study cost assumptions can be reviewed in Appendix D and the Main Report, respectively.

B1. OVERVIEW OF GREAT LAKES/ST. LAWRENCE SEAWAY SYSTEM

B1.1 Introduction.

Since the opening of the St. Lawrence Seaway to deep-draft navigation in 1959, vessel transits and numbers have declined; vessel size and tonnage throughput has increased. The shift to larger vessels, laker and ocean, has been faster than the rate of growth in tonnage demand. Various studies agree that the long-term outlook is for continuation of increasing traffic levels in future years. This traffic is steadily approaching the capacity of the existing system and as it nears this capacity, delays to shipping will be encountered. This in turn will manifest itself as increases in transportation costs.

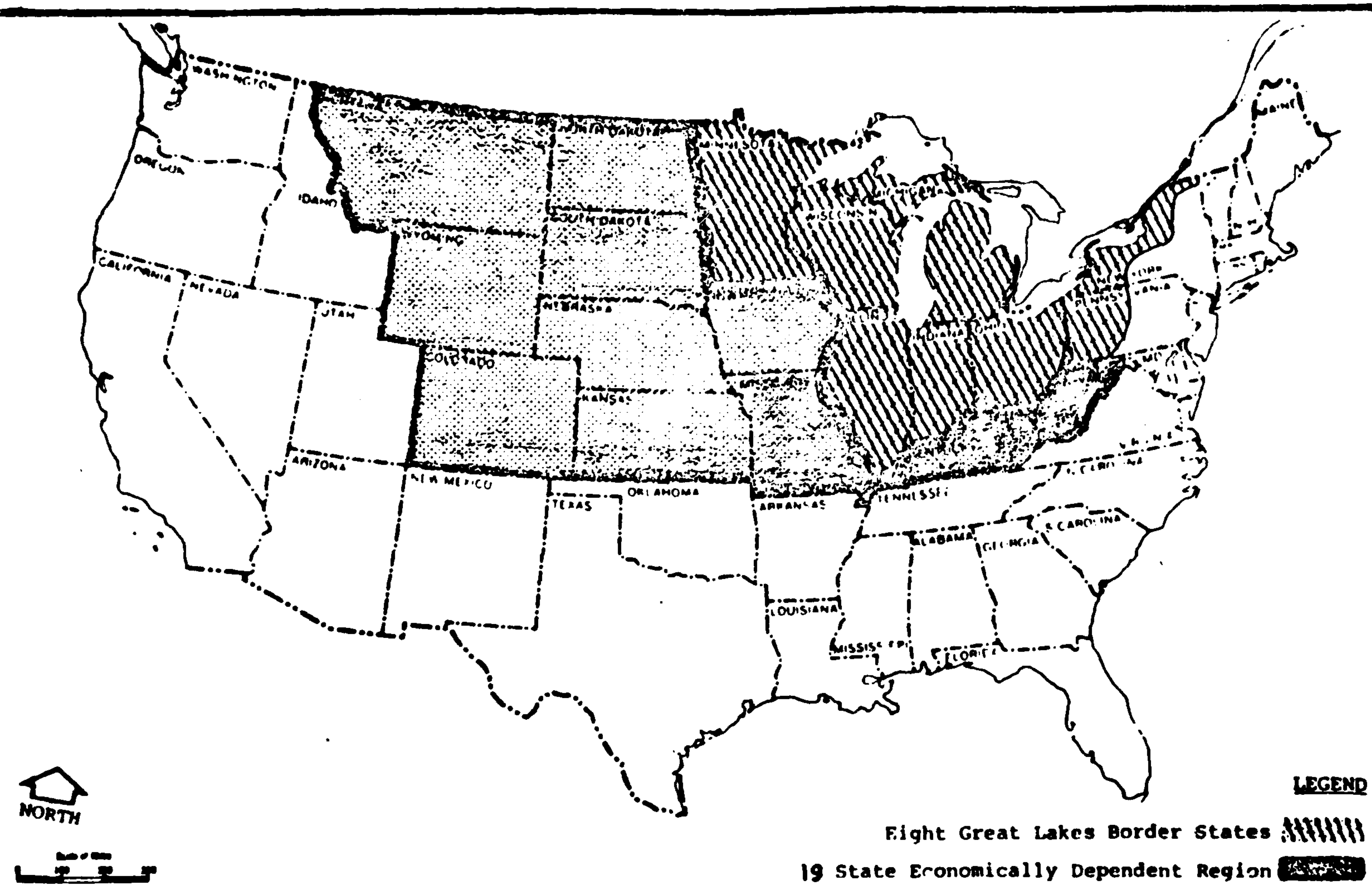
Economies of scale are also being demonstrated on the GL/SLS system and in the world fleet. Larger ships are more efficient in relation to their size and as such are able to transport more cargo at a reduced cost per ton. The present size restriction of existing Seaway-size locks restricts the maximum vessel dimensions which can utilize the system. This not only prevents the potential savings from use of a larger vessel but also the competitiveness of the Great Lakes in the world market. This is especially evident in view of the ever increasing size of ocean vessels in the world fleet.

The geographic region commercially and economically tributary to the Great Lakes Region includes eight states bordering the lakes (Minnesota, Wisconsin, Illinois, Indiana, Michigan, Ohio, Pennsylvania, and New York) and their contiguous states. The provinces of Ontario and Quebec, along the northern shoreline of the Great Lakes and St. Lawrence River, have significant economic linkages to the region.

Harbors on the Great Lakes are served by an extensive network of commercial transportation systems (railroads, highways, airways, and pipelines) which link the area with other parts of the U.S. and Canada and compete with the waterborne mode for the movement of bulk and general cargos. The general area within the United States adjacent to and indirectly served by the GL/SLS is shown in Figure B1.

Annual traffic volumes have fluctuated with national and international market conditions of supply and demand for bulk and general cargo commodities. Although there have been short-term increases and decreases in the level of traffic moving over the St. Lawrence River, the long-term trend has been increasing during the period which followed the completion of the St. Lawrence Seaway project. The major upbound commodity movements consist of iron ore from Canadian mines in Labrador and Quebec, miscellaneous other bulk and manufactured products including steel products. Principal downbound shipments consist of U.S. and Canadian grain flows, miscellaneous other bulk and general cargo exports. Historical traffic movements for the Welland Canal and St. Lawrence River are provided in Figure B2.

Characteristics of the fleet transiting the Welland Canal and St. Lawrence River have also changed over time. Larger vessels comprise more of the total annual transits and transport a greater than proportional share of total



GREAT LAKES ECONOMIC REGION

FIGURE B1.

FIGURE B2

ST LAWRENCE SEAWAY SYSTEM
HISTORICAL TONNAGE

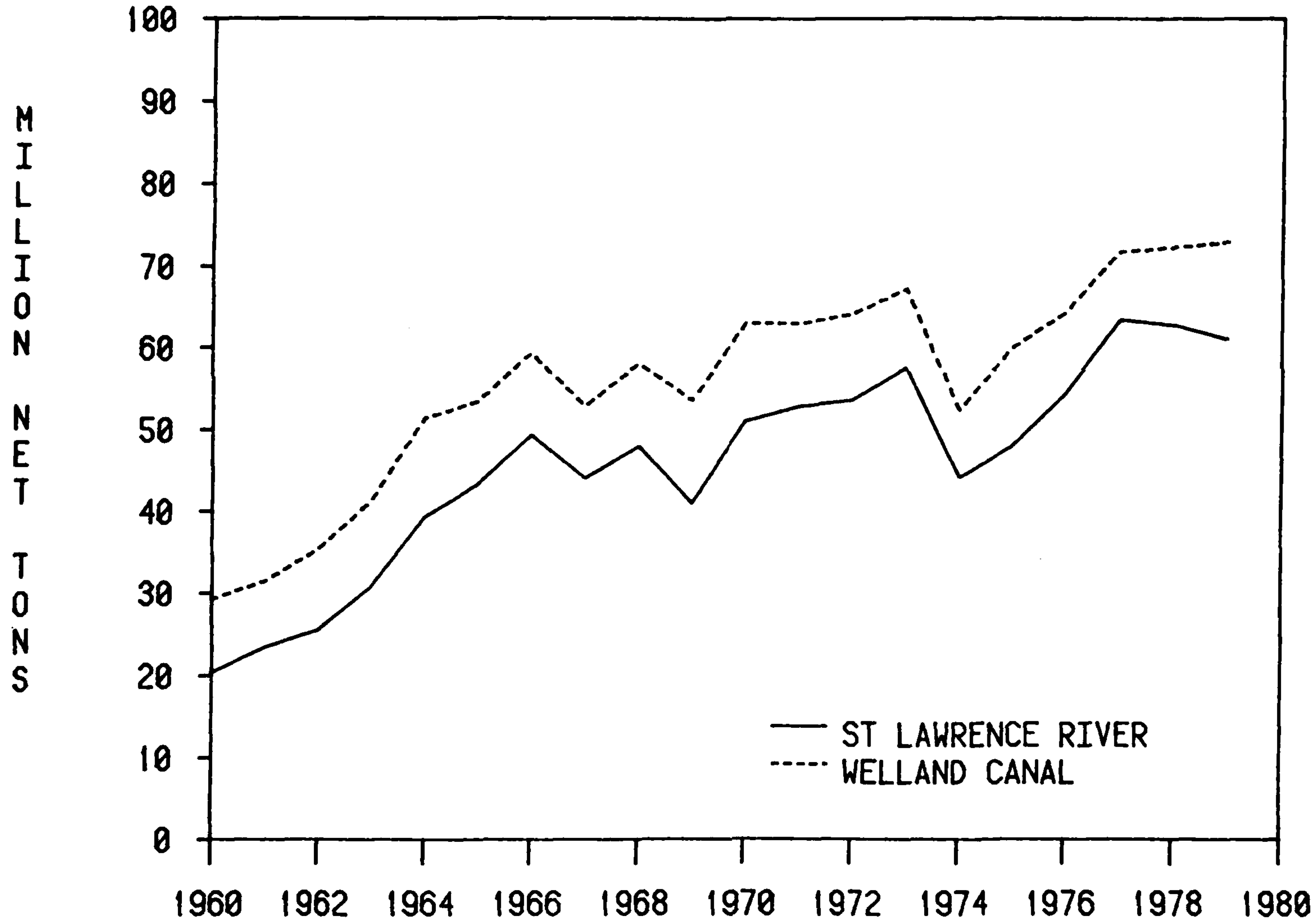
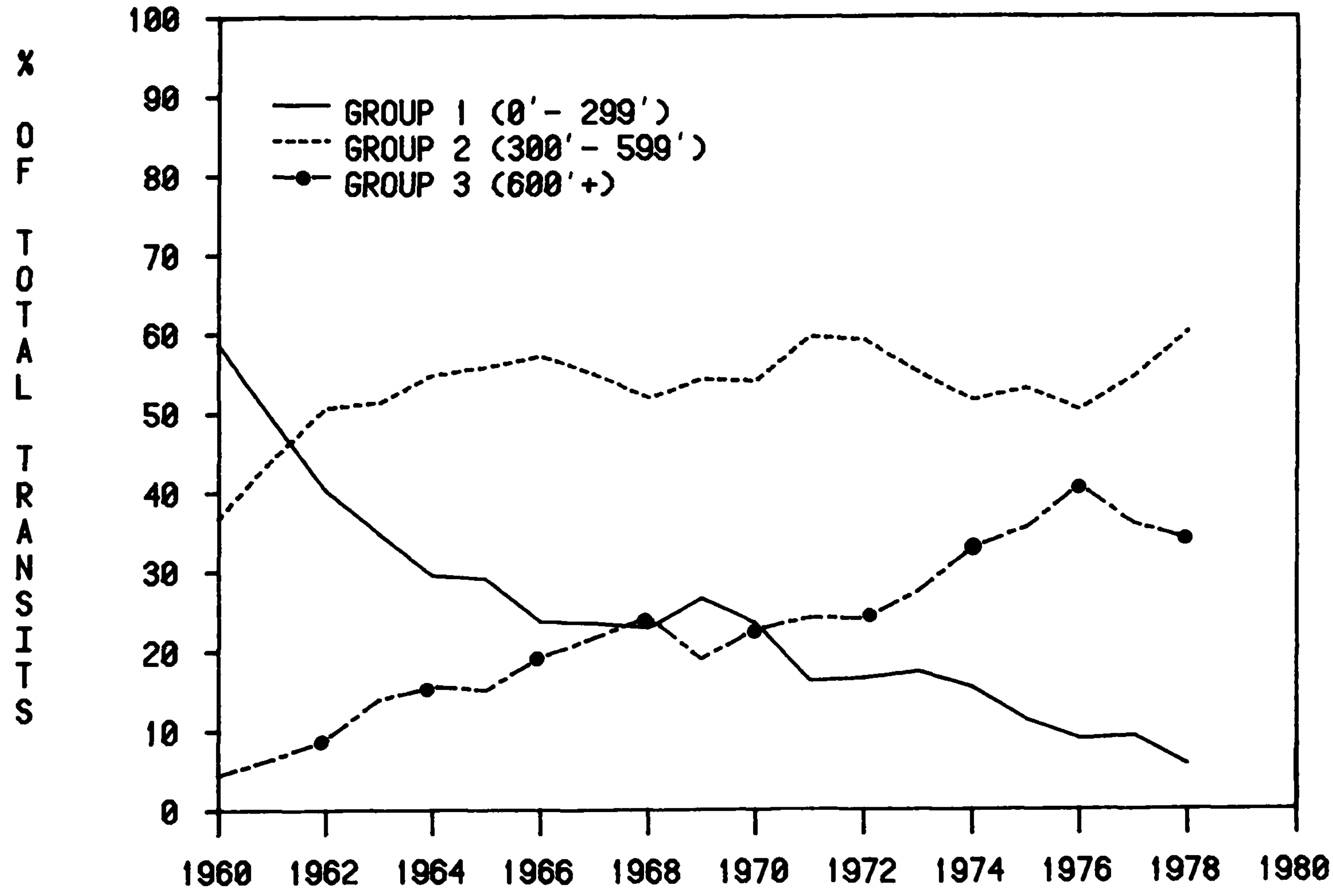


FIGURE B3

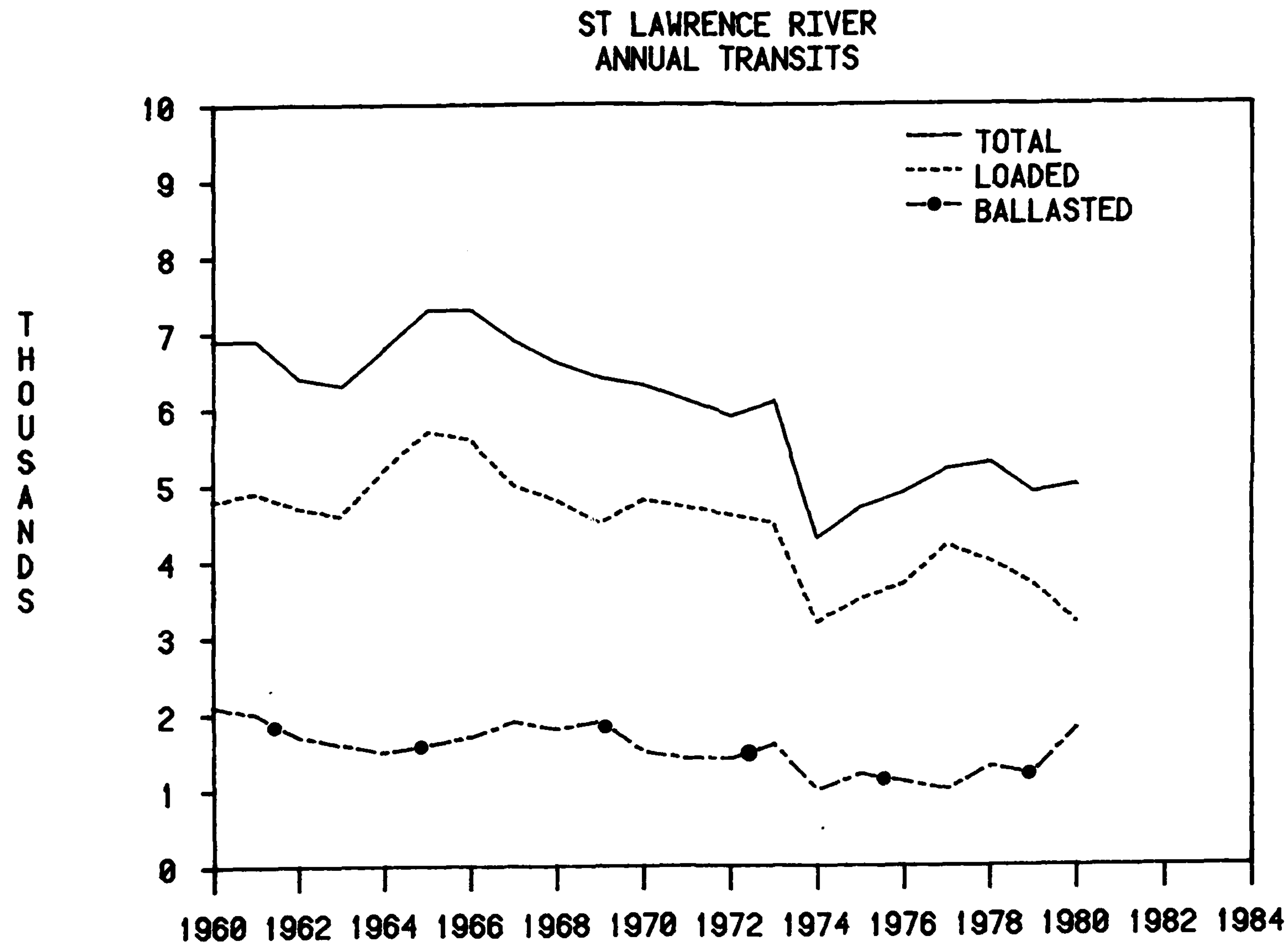
ST LAWRENCE RIVER
TOTAL TRANSITS



cargo moving through each of these subsections. A summary of the change in the use of larger vessels on the St. Lawrence River is provided in Figure B3.

Each origin/destination/commodity movement (O/D/C) generates a potential return movement of cargo. In some instances, there is traffic available for the return trip while other locations within the GL/SLS do not offer a return cargo and vessels return in ballast. For example, shiploads of grain downbound from the head of the lakes to Montreal can take advantage of the return flow of iron ore moving to U.S. steel-producing centers on Lake Erie. However, complimentary traffic movements do not always exist within the system. Downbound vessels moving coal through the Welland Canal to Hamilton and Toronto, Ontario do not have much potential for a backhaul cargo movement on the upbound trip. This results in a high level of ballasted (empty) transits at the Welland Canal as a percent of total transits and the subsequent loss of a lockage which could otherwise be used for cargo. A comparison of the historical changes in loaded and ballasted vessel activity at St. Lawrence River Locks is provided in Figure B4.

FIGURE B4 - LOADED AND BALLAST TRANSITS



B2. OVERVIEW OF ECONOMIC EVALUATION

B2.1 Traffic Forecasts.

Forecasts of commodity flows which are expected to use the GL/SLS were developed after review of actual commodity flows for the base year of 1978 and identification of long-term growth rates expected within major industrial sectors (i.e., steel industry, electric utilities and the agricultural area serviced by the Great Lakes). Forecasts were prepared for United States and Canadian movements of:

Wheat	Petroleum
Soybeans	Cement
Barley	Nonmetallic Minerals
Corn	Other Dry Bulk
Sunflower Seeds	Pig Iron, Slag, Scrap
Limestone	Steel
Iron Ore	Nonsteel General Cargo
Coal	

Total U.S. waterborne movements were examined in terms of origin and destination harbors. Canadian shipments were disaggregated only to interregional flows which required transit through one or more locks. Both categories of movements were aggregated into commodity subtotals which would require at least one lockage between the origin and destination.

Base year U.S. traffic movements in 1978 are referenced to harbor and specific dock data collected by the Corps of Engineers. Individual origin/destination/commodity statistics were subsequently aggregated in terms of 40 major harbors; smaller harbors were defined in terms of geographic regions such as "other Lake Ontario ports," "other Lake Erie ports," etc. Fifteen individual commodity groups were forecasted to the year 2050. Consolidation of each projection into major commodity families was required as input to the lock capacity model. For purposes of economic analysis, the major commodity families are show below.

Commodity Name	Commodity Family
Wheat	Grains
Soybeans	Grains
Barley and Rye	Grains
Corn	Grains
Oilseeds	Grains
Limestone	Stone
Iron Ore	Iron Ore
Coal	Coal
Petroleum Products	Other Bulk
Cement	Other Bulk
Nonmetallic Minerals	Other Bulk
Raw Materials Nec	Other Bulk
Dry Bulk Nec	Other Bulk
General Cargo	General Cargo
Steel Products	General Cargo

(Nec = Not elsewhere classified).

A basic assumption in the development of the demand for future waterborne transportation is that commodity movements would be unconstrained by any restrictions at locks, harbors and connecting channels. In addition, resource constraints such as productive agricultural acreage or natural resource limitations (i.e., depletion of ore/coal deposits or loss of topsoil in prime agricultural areas) were not considered.

A variety of analytical approaches were utilized to estimate the level of future commodity movements. Grain products, iron ore, limestone and iron and steel products were estimated using stepwise multiple regression. Coal forecasts were developed after a survey of major coal users was completed. The remaining commodities were associated with the explanatory variable most likely to affect future shipments or receipts.

Major shipments of bulk materials between Canada-Canada and Canada-foreign port pairs were also investigated. For Canadian grains, multiple regression analysis was used. Forecasts of future iron ore consumption were obtained from major Canadian steel producers. All remaining Canadian commodity movements were associated with an explanatory variable most likely to affect shipments or receipts.

B2.2 Transportation Freight Rates.

Detailed investigations of the freight rates for a Great Lakes routing and the next most competitive alternate route were completed during 1981. A file of freight rate information was completed for major commodity movements using the Great Lakes in the base year of the study. Rail, truck, barge, laker and ocean rates were collected to quantify total transportation costs for each route. These costs reflect the estimated costs or rates which are paid for storage, terminal charges, dockage and wharfage and other related expenses.

The collection of component freight rates involved the following steps:

- Identification of port-to-port shipments from Waterborne Commerce Statistics collected by the Corps of Engineers.

- Estimation of true origin and destination and specific commodity group for each shipment.

- Identification of freight rates for each commodity routing.

- Identification of an alternative route for shipment if the Great Lakes system were at capacity and not available.

- Estimation of freight rates for these alternative routes, if large annual volumes are not presently moving on the identified alternate route, a similar O/D/C was found which was a representative estimate of a similar, but competitive situation.

There are several sources of inaccuracy associated with using actual rates at a single point in time to estimate transportation rate savings. These are as follows:

• Rates fluctuate over time according to market conditions. At the present time, many freight rates have been quite volatile, for example:

- Since passage of the Staggers Act which changed rail ratemaking requirements, commodity rates for many high-volume coal movements have been replaced by contract rates.

- Laker rates have been depressed and some ships laid up because steel and iron ore shipments have decreased significantly.

- Rail and barge grain rates, which are highly seasonal, have been adversely impacted by the Russian grain embargo and the Midwestern drought.

- Liner rates to Europe were subject to intense competition between conference members and an independent; two carriers have withdrawn from the trade.

• Rates vary significantly depending on weight minimums, actual volume shipped, specific commodity description, origin and destination. Every attempt was made to identify the rate at which traffic is moving, and to avoid artificial or "paper" rates. However, there is no way to confirm that a rate extracted from a tariff is the rate at which the goods are shipped.

• Little or no tonnage is currently moving along many of the alternative routes identified for bulk commodities. Rates were estimated for these movements either by railroads directly or by using rates for similar movements. While it is felt that these rates are representative of the rates that would actually be charged, there is no way to validate the rates.

A general overview of the freight rate investigation is provided in Table B1. Designation of an alternate routing was always based upon the most competitive geographic route. The additional transportation costs per ton will become the basis for the measurement of rate savings benefits after the existing lock system becomes capacity constrained.

B2.3 Great Lakes Fleet.

Insight into the composition of the current fleet utilizing the GL/SLS is necessary in order to forecast the future fleet which is most likely to operate in the future. A fleet mix for future years depends on the characteristics of the existing fleet and the relative growth of major commodity movements.

A detailed profile of both the American and Canadian vessels now in service including annual ship retirements, new shipyard construction and the types of vessels (i.e., bulk freighters, self-unloaders, tank barges, cement carriers and powered tankers) was obtained through interviews and analysis of secondary data. A current fleet profile for the base line condition (1978) was developed and records of vessel transits by vessel size were constructed based upon available lock records.

Table B1 - Freight Rate Investigations

Commodity	Source of Freight Rates	Current Routes	Alternative Routes
Iron Ore	Skillings Mining Review	Lake Michigan destinations from Upper Lakes	Rail from Upper Lakes
	Bessemer & Lake Erie Railroad	Other destinations from Upper Lakes	Labrador ore via coastal ports
		Labrador ore via the lower lakes	Labrador ore via coastal ports
Coal	Railroads	Lake Erie ports to Lake Superior destinations	All rail routing from origin mine to point of consumption
	Published rail tariffs	Lake Erie ports to Canadian Lake Ontario destinations	Same as above
	Lake carriers	Western coal via Duluth-Superior to the St. Clair River	Same as above
	Utilities		
Grain	Drewry's shipping statistics Railroads Grain merchants and terminals Grain brokers	Overland haul (truck or rail) to port terminals	Rail or barge to Atlantic, Gulf and Pacific Coasts; or transshipment at Gulf of St. Lawrence
Other Bulk Commodities	Published rail tariffs Lake carriers Terminal operators Charter fixtures	Port-to-port shipments from lakeside origins or destinations	All rail movement between same points; exports or imports assumed to be routed through New Orleans or Baltimore
Steel and Other General Cargo	Published conference and independent tariffs Published rail and truck tariffs Water and rail carriers serving Canadian ports	Rail or truck to port	Shipment via Montreal, Baltimore or New Orleans

The current U.S. Great Lakes fleet is composed primarily of Class 5 ships (overall length between 600 and 649 feet) with an average carrying capacity of about 15,000-cargo tons. There are 13 vessels in the U.S. fleet that are maximum size (1,000 feet X 105 feet). The Canadian fleet is predominantly Class 7 vessels which have overall lengths between 700 and 730 feet and average cargo capacities of 26,000 tons. The ship classification system which is used in this study is provided in Table B2.

Table B2 - Ship Classification System

Vessel Class	Overall Length in Feet (Min)	Overall Length in Feet (Max)	Mean Vessel Speed (MPH)	Maximum Carrying Capacity (Short Tons)	Capacity Increase With Draft (Short Tons/Inch)
3	(Pleasure Craft, Non-Commercial Vessels, and Ice Lockages)				N/A
4	0	599	13.8	9,500	0.0 (1)
5	600	699	13.9	21,000	91.8 (2)
6	400	699	14.7	15,000	61.8
7	700	749	14.7	27,000	113.1
8	750	849	14.9	28,000	115.6
9	850	989	14.9	45,000	167.1
10	990	1,099	14.9	60,000	207.1

(1) Class 4 ships do not exceed present design draft of 25.5 feet.

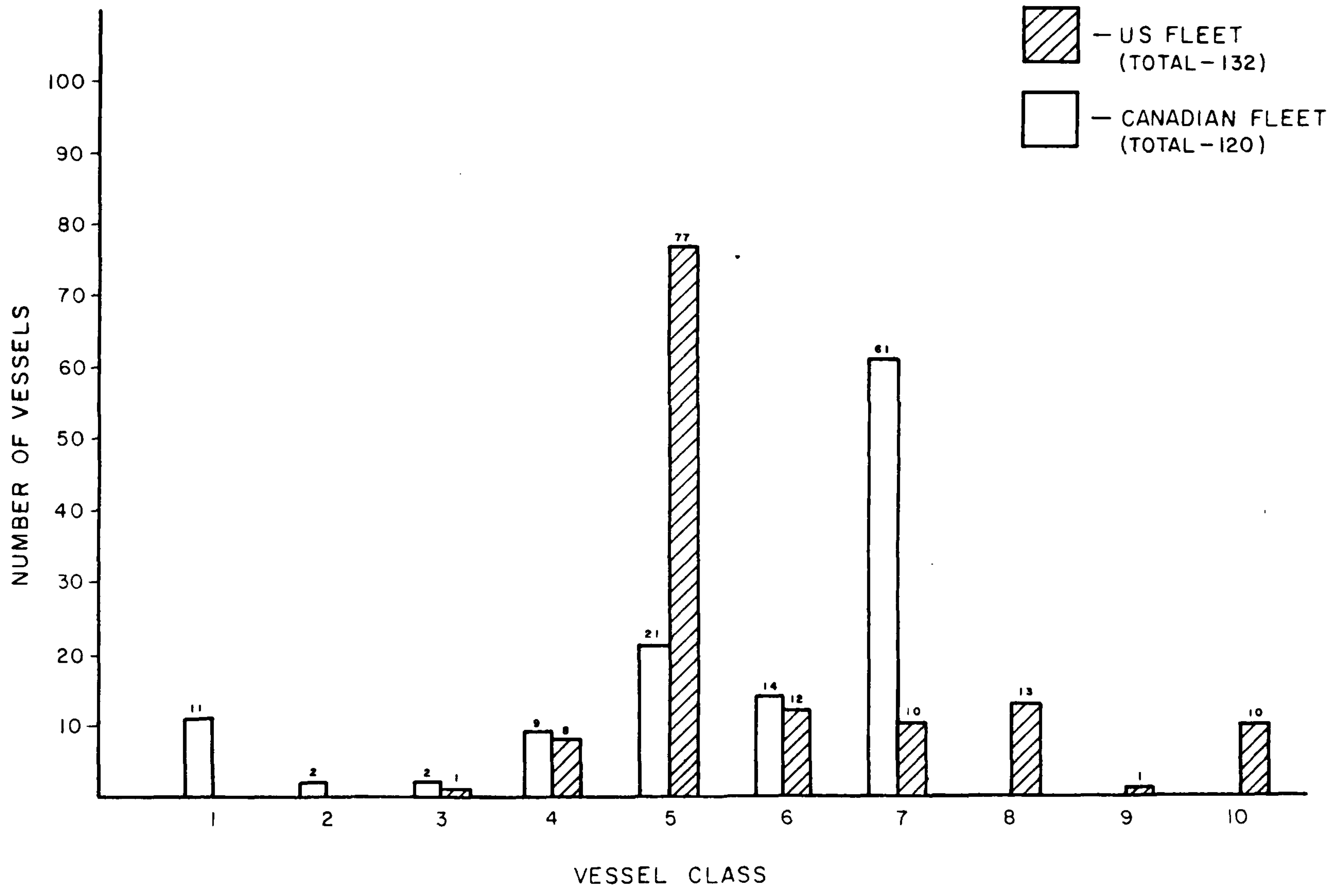
(2) Includes Laker Class 5 and 6.

N/A Not applicable to this category.

Historical shipbuilding trends in terms of U.S. ship construction have been concentrated in Class 5 vessels which serve customers in the smaller ports and in Class 10 vessels to increase the efficiency of operations for high volume bulk movements between established U.S. origin-destination port pairs. Canadian shipbuilding has been concentrated in Seaway-size Class 7 vessels. Fleet compositions are shown in Figure B5. Changes in the composition of the Great Lakes Fleet for the period following completion of the St. Lawrence Seaway project are shown in Figure B6.

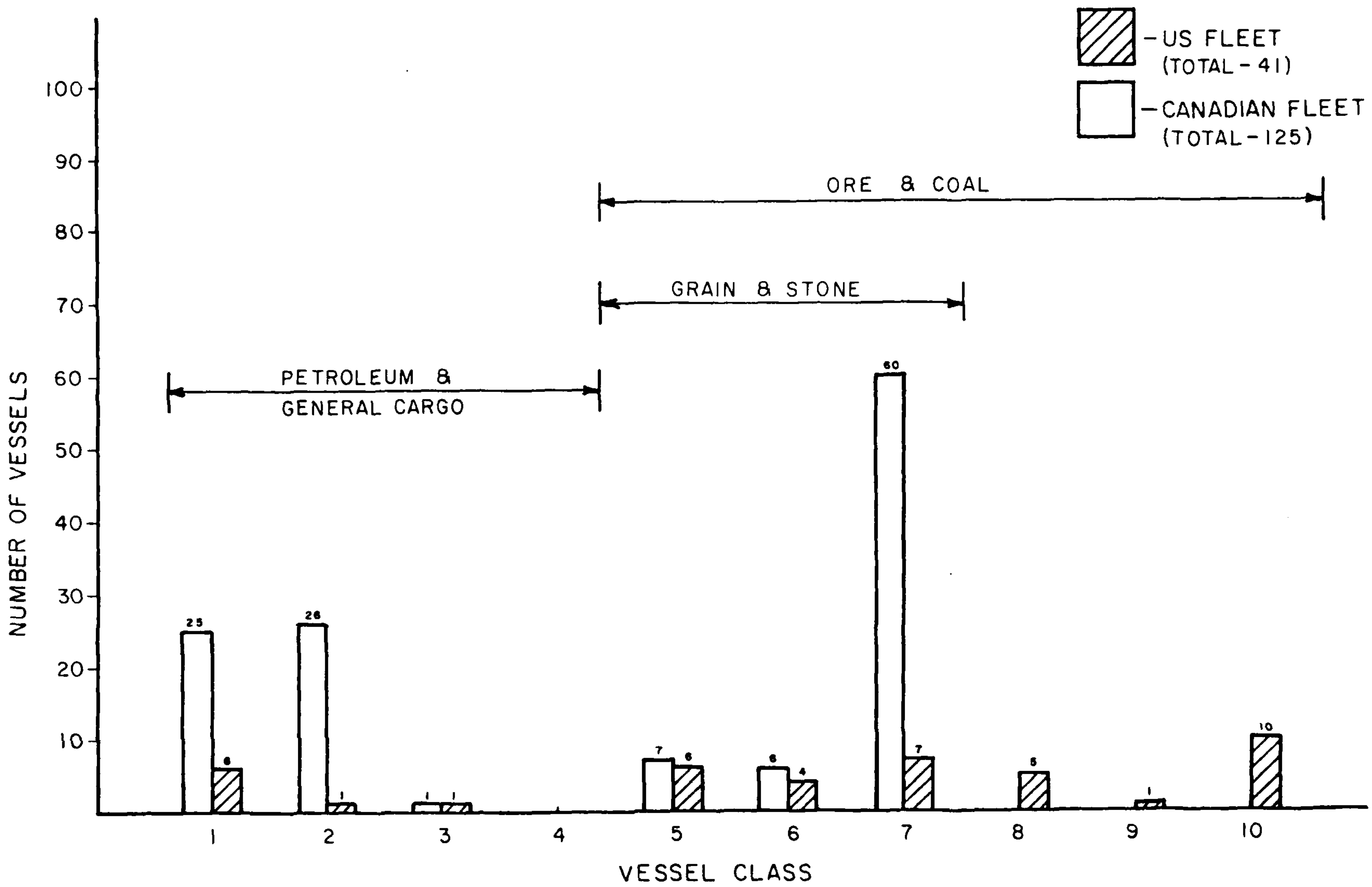
Future fleets have been formulated in response to expected growth in bulk commodity movements and the possible modification of the locks, connecting channels and harbors in the GL/SLS.

FIGURE B5



1980 GREAT LAKES FLEET - BULK-FREIGHTER & SELF-UNLOADERS

FIGURE B6



NEW VESSELS REGISTERED BETWEEN 1958 & 1980

For example, if commodity demand follows current trends, and if no physical changes are made to the system, then additions to the baseline fleet will follow recent shipbuilding trends. If, however, an unusual change is predicted for a particular commodity, then the baseline fleet expands with a larger portion of ships built to meet that increased demand. Also, if a system expansion alternative includes physical changes to locks and channels, then the most probable fleet response is changed to reflect shipbuilding trends that could be expected as a result of these physical changes. In all cases, ships are only added to the fleet to meet the commodity demand. The new fleets developed to meet this demand can then be used to determine the impact on the GL/SLS system capacity and operating conditions.

B2.4 Lock Capacity Investigations.

The capacity of any navigation system including the Great Lakes/St. Lawrence Seaway System is determined by the limiting or constraining element; the element which has the slowest processing time. In very general terms, the GL/SLS system can be thought of as a series of locks, connecting channels, and harbors. The complexity inherent in the three lock systems, and five connecting channels, and over forty harbors becomes even more significant when the numerous trade routes between the various harbors for inland traffic and for the ocean trade are also considered. Generally, for navigation systems equipped with locks, the traffic capacity defined either in terms of annual tonnage or annual vessel transits is constrained by the locks.

As the annual tonnage shipped on the GL/SLS navigation system continues to increase in the future, the demand for service at the locks will increase accordingly, and as the capacity limits of the system are approached vessels will begin to experience long waiting times and long vessel queues at the locks. The resulting inability of the system to effectively service its customers would be reflected in a decrease in the popularity and use of the system, with an adverse impact on the economic growth of the eight contiguous states. Forecasted cargos which exceed the existing capacity would be forced to seek alternate means of transport to satisfy regional raw material requirements to support their industrial base.

Any transportation system interested in serving its customers over the long-term must plan to provide an expanded capacity when the need for such capacity is required by the system users. For a simple system having one major constraining component, the removal of the constraint at that one point removes the system constraint. For a more complex system, such as the GL/SLS navigation system, the multiplicity of locks, connecting channels, and harbors presents a more challenging assignment to the planners addressing the removal of system capacity constraints over the long term. An analysis of the entire system is required to ensure that removal of a constraint at one feature or location does not simply result in movement of the constraint to another feature or location with relatively little, if any, improvement in overall system capacity.

Capacity of a lock system may be defined in general terms as the level of tonnage at which a small increase in throughput will cause large, unreasonable delays for ships using the locks. For the purposes of this study, capacity would be realized at existing St. Lawrence River locks whenever average lock utilization became 90 percent for any individual month for the period May through November. An alternate definition of 80 percent was also used in the evaluation. This range of capacity utilization was required in order to reflect the unique physical constraints which might occur at each location.

Lock utilization is the time the lock is actually processing ships relative to the total time available for ship processing, expressed as a percent. Lock utilization of 90 percent generally results in an average vessel waiting time of approximately 6 hours and an average queue length of four ships. Lock utilizations of greater than 90 percent may result in much larger waiting times and queue lengths, because these quantities increase exponentially near capacity.

A number of alternatives are available to the lock operating agency which could either postpone or eliminate a high degree of lock utilization and the attendant delays and vessel queues. Capacity expansion measures may be physical improvements to the system, whether major construction or minor modifications, or they may be changes in operating procedure. In either case, the ultimate goal is to meet the projected cargo demands during the period of useful life for proposed lock modifications without exceeding the capacities of the lock systems.

St. Lawrence River
Constraining Lock Statistics

Percent Lock Utilization	Average Daily Queue (Number of Ships)	Average Daily Waiting Time (Hours Per Ship)
70	0.8	1.3
75	1.1	1.7
76	1.2	1.8
79	1.5	2.2
82	1.8	2.6
84	2.2	3.1
86	2.7	3.7
87	3.0	4.1
89	3.3	4.6
90	4.3	5.9

B3. OVERVIEW OF STUDY APPROACH

B3.1 Introduction.

Detailed studies to support an engineering and economic evaluation of improvements to the GL/SLS were initiated in October 1980. This investigation required that traffic and fleet forecasts be integrated with an analytical lock capacity model to determine the approximate date of physical capacity for the existing locks at the Soo, Welland Canal, and St. Lawrence River. Engineering costs for a number of alternative plans of improvement were developed and compared with the appropriate economic gains to determine if further, detailed study would be recommended. A number of supporting documents and/or separate studies were also produced. The contribution of each component to the plan formulation and evaluation process is provided in Figure B7.

Six of the study elements deal with the supply of transportation service in the Great Lakes and the preliminary cost of system improvements. These elements are described below:

- Description of the Physical System. This report is a compilation of data which describes the physical and operational characteristics of the locks, connecting channels and harbors.

- Existing and Future Great Lakes Fleet. This report describes the current fleet and develops an estimate of the future fleet based on predictions of commodity demand, vessel retirement schedules and fleet building trends.

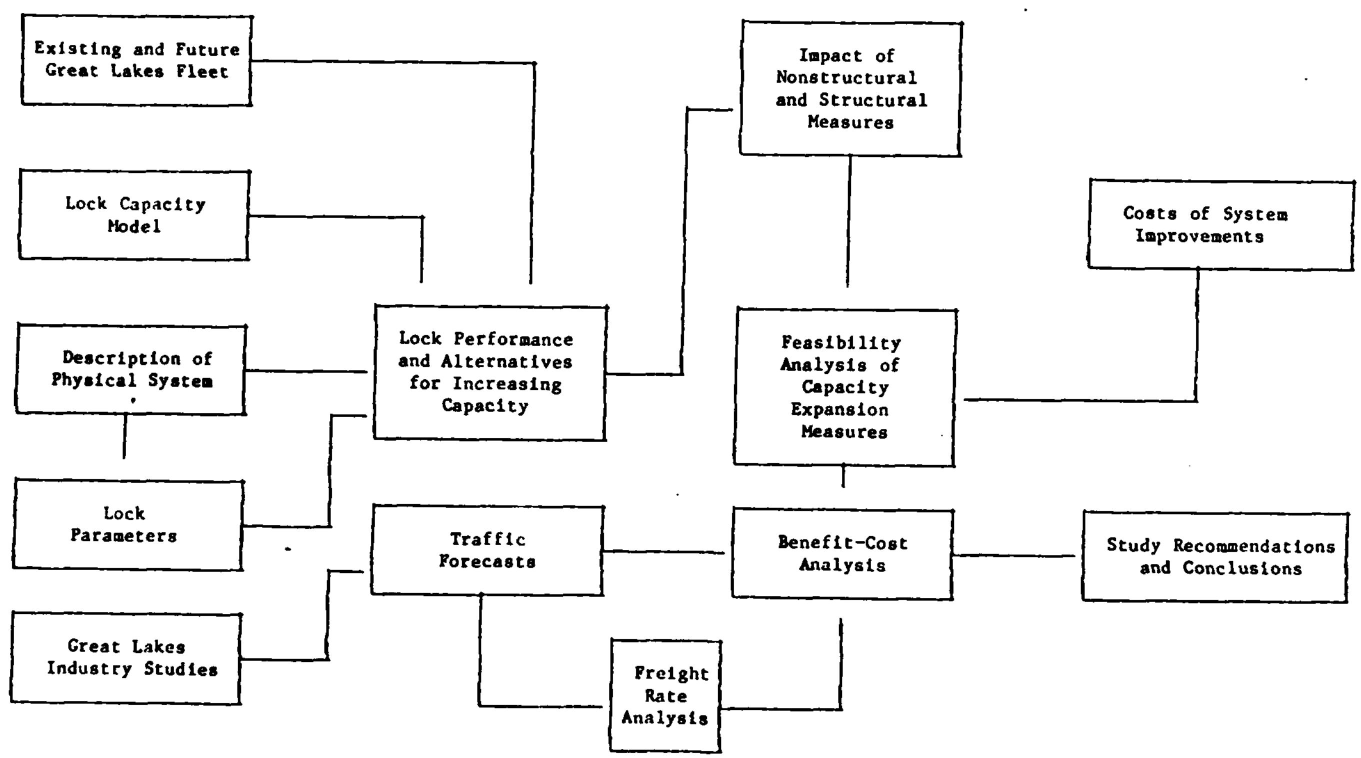
- Update of the Maximum Ship Size Study. Construction and maintenance costs of alternative system improvements, originally formulated in December 1977, are updated in this report.

- Evaluation of Lock Capacity Models. In this report, 12 lock capacity models are evaluated and a criteria for selection of the most productive lock capacity model is established.

- Lock Performance and Alternatives for Increasing Capacity. This report describes locking procedures at each lock system, identifies operational problems, and discusses structural and nonstructural techniques for increasing lock capacity.

- Feasibility Analysis of Capacity Expansion Measures. This report describes calibration of the lock capacity model and its subsequent application to a number of individual and composite measures to increase physical capacity of the GL/SLS. This preliminary evaluation process became the basis for further refinements on the relative economic merits of the individual plans of improvement.

FIGURE B7 - STUDY PROCESS



The other four study elements deal with the demand for transportation service in the system and the benefits attributed to system improvements. These reports are described below:

- Competitive Position of the Great Lakes for Containerized Cargo. This report summarizes historical trends in general cargo shipping on the Great Lakes, and evaluates the potential for future general cargo shipping in terms of shipper requirements and carrier operating costs.

- Great Lakes Industry Studies. Separate reports were prepared for the grain and steel industries and for the industries which are major coal consumers in the Great Lakes area. These reports identify trends and the outlook for production and consumption of the major commodities shipped via the lakes, location of major plants, and analysis of commodity distribution systems.

- Traffic Forecasts. Traffic forecasts were developed for a base year of 1978 and extended to the year 2050. The forecasts contain detail for 15 commodities. The forecasts of U.S. trade (including domestic, Canadian and overseas) identify U.S. shipping and/or receiving port. Canadian trade is identified by lock system and direction.

- Rate Analysis. Freight rate information was developed for the major commodity movements currently using the Great Lakes system. Rail, truck, barge, laker and ocean rates were collected in order to identify total transportation costs for current Great Lakes routes and for the least expensive alternative.

B4. MAJOR COMMODITY MOVEMENTS

B4.1 Introduction.

Major industrial or economic sectors which constitute significant users of the current GL/SLS transportation system include the iron and steel industry, the grain industry and the electric utility industry. Detailed studies for each category of commercial user were completed prior to a determination of future traffic flows. These industries are described in terms of: historical trend and outlook for production and consumption of major raw material inputs/outputs, location of major plants or production areas, trends and outlook for Great Lakes shipments, alternative raw material sources and identification of existing commodity distribution systems.

B4.2 Iron and Steel Industry.

The basic raw materials consumed in the production of steel are iron ore, coke, limestone and scrap steel. Major sources of iron ore include the Lake Superior (i.e., upper lakes) and Quebec/Labrador (i.e., lower lakes). Historically, shipments to southern Lake Michigan and Lake Erie harbors consisted of natural iron ore, however, concentration of low-grade iron ore into pellets with an iron content of 66 percent or more is the dominant method of shipment.

Coal of coking quality is mined primarily in West Virginia, Pennsylvania and Kentucky and accounts for about 80 percent of the steel industry's supply. As a result of its location, little of the metallurgical grade coal shipped to the Great Lakes region steel plants travels on the GL/SLS system. However, there are significant movements via the Great Lakes from Lake Erie to Canadian steel mills at Sault Ste. Marie, Nanticoke and Hamilton, Ontario.

Limestone and lime products are also required in the production of pig iron and steel. Limestone deposits are relatively abundant, but significant amounts are located in Michigan, Pennsylvania and Ohio. Limestone shipments frequently originate from harbors in Michigan or Ohio and rely upon self-unloading freighters for transportation to the lakeside steel producing districts. Limestone is not economically transshipped inland due to its low value, high unit weight and abundance of inland competing sources of supply.

Steel production centers have been geographically grouped into 12 "Districts." About 70 percent of American steel capability and production is centered in those districts which use the Great Lakes directly or which transship via lakeside harbors. The Canadian steel industry is highly concentrated in the province of Ontario.

The steel mills in the Great Lakes area are located adjacent to Lake Erie, with the exception of Chicago, Cincinnati, Youngstown and Pittsburgh. The latter three districts receive ore by rail from Lake Erie ports. Investigation of the long-term outlook for future steel production concluded that capacity will be expanded in place, in addition to existing facilities, and in new electric furnaces. An overview of the growth potential for Great Lakes steel districts is shown below.

Table B3 - Great Lakes Steel Districts

	Million Tons				Growth Rate		
	1979	1985	1990	2000	1979-1985	1985-1990	1990-2000
					(Percent)	(Percent)	(Percent)
Buffalo	4.0	4.3	4.9	5.6	1.3	2.4	1.4
Pittsburgh	24.0	25.2	28.5	32.8	0.8	2.5	1.4
Youngstown	8.2	7.3	8.2	9.4	-1.8	2.2	1.4
Cleveland	8.7	8.8	10.1	11.3	0.3	2.6	1.2
Detroit	10.9	11.6	13.1	15.1	1.1	2.4	1.4
Chicago	32.6	34.5	39.5	45.2	1.0	2.6	1.4
Cincinnati	5.7	6.0	6.8	7.8	1.1	2.4	1.4
St. Louis	4.4	54.0	6.1	7.0	3.5	2.3	1.4
Southern	12.7	13.2	14.7	16.8	0.6	2.1	1.4
Western	8.7	8.6	9.9	11.3	-0.2	2.8	1.4
North East Coast	15.6	15.2	17.6	18.2	-0.5	3.0	0.4
Total	135.5	140.1	159.1	180.51			

SOURCE: DRI, The Long-Term Outlook for the U.S. Steel Industry, 1980.

Iron ore deposits of the Lake Superior ranges are essentially the sole U.S. source of iron ore and agglomerates for American steel plants in the Great Lakes hinterland. The rest of the iron ore comes either from the Canadian Lake Superior region or the Quebec/Labrador range. In the past 5 years, 76 percent of total ore destined to the Great Lakes from Great Lakes ports has been loaded at harbors on the northwestern shore of Lake Superior. Canada normally provides all of the foreign iron ore imports into the Great Lakes. There is no indication that there is any important quality differentiation between Canadian and American ores.

Major factors influencing sourcing are economics, availability, transportation infrastructure and captive ownership. Captive ownership of raw material sources and transportation equipment (i.e., fleets) is a significant consideration in an evaluation of traffic flows. There are about 140 American bulk carriers operating on the Great Lakes, most of which transport ore.

B4.3 Grain Industry.

The major U.S. grains moving on the GL/SLS are wheat, corn, soybeans, barley and rye. In 1978, about 8 million tons of wheat, 7 million tons of corn, 3 million tons of soybeans, and 400,000 tons of barley and rye moved on the GL/SLS. U.S. production of each of these grains is concentrated in a few states and the Great Lakes/St. Lawrence Seaway provides a competitive export route for several of them. Eight states produce about 70 percent of the total U.S. wheat production, while seven states produce about 75 percent of national corn production. The contribution of individual states to total national grain production is shown in Table B4.

Physical movements of grains usually consist of a farm-to-elevator transfer. Further movement to either a rail terminal or a river terminal is usually via truck. A number of marketing options are available to each farmer, country elevator operator or grain merchant.

The decision to sell for export or domestic consumption is based on a comparison of the prices for each marketing option, as well as the cost of transporting grain to the point of transfer. Marketing decisions that provide the greatest reward (i.e., selling price less cost of transportation) drive the routing of grain flows in each year.

Similar factors that affect the export versus domestic consumption marketing decision also drives the decision as to which port to select for grain exports. Individual ports are selected which offer the greatest financial return to the shipper. It is this port selection process combined simultaneously with the export versus domestic consumption decision that affects the traffic movements of grain through Great Lakes ports.

The majority of the grain movements on the GL/SLS are for export. Domestic movements of wheat to Buffalo, NY only comprise about 20 percent of total wheat movements. Changes in the annual level of grain shipments on the lakes is affected by factors such as the availability of grain and shifts in the geographic demand areas from traditional European countries to Pacific Rim countries. Vessel availability and costs also affect the routing of U.S. grain exports. Historically, downbound grain movements to Gulf of St. Lawrence terminals have been compatible with the upbound iron ore movements.

The primary port areas handling grain on the GL/SLS include Chicago, Duluth-Superior, Saginaw, and Toledo, OH. Duluth-Superior is the leader in terms of wheat shipments and was also responsible for the barley exports on the Great Lakes in 1979. Toledo handled the majority of the soybean shipments, while the Port of Chicago accounted for the bulk of Great Lakes corn shipments. A summary of the relative port shares are provided in Table B5. Changes in the level of grain exports via Great Lakes ports for the period 1970-1980 are shown in Figure B8.

Table B4 - U.S. Grain Production Centers

State	1979 Production in Millions of Bushels			
	Wheat	Corn	Soybean	Barley
Iowa		1,626	310	
Illinois		1,358	374	
Indiana		664	154	
Minnesota	90	606	163	41
Nebraska	87	794		
Ohio		418	147	
Texas	138			
Kansas				
Oklahoma	217			
Montana	117			41
Kansas	410			
North Dakota	252			76
Washington	118			
Wisconsin		307		
Missouri			187	
Idaho				49
California				47
Production Subtotal	1,429	5,773	1,335	254
U.S. Total	2,142	7,764	2,268	378
Percent of Nation	67	74	59	67

SOURCE: Crop Reporting Board, U.S. Dept. of Agriculture, 1979 and 1980.

FIGURE B8

U.S. GRAIN EXPORTS INSPECTED FOR SHIPMENTS
THROUGH GL/SLS PORTS

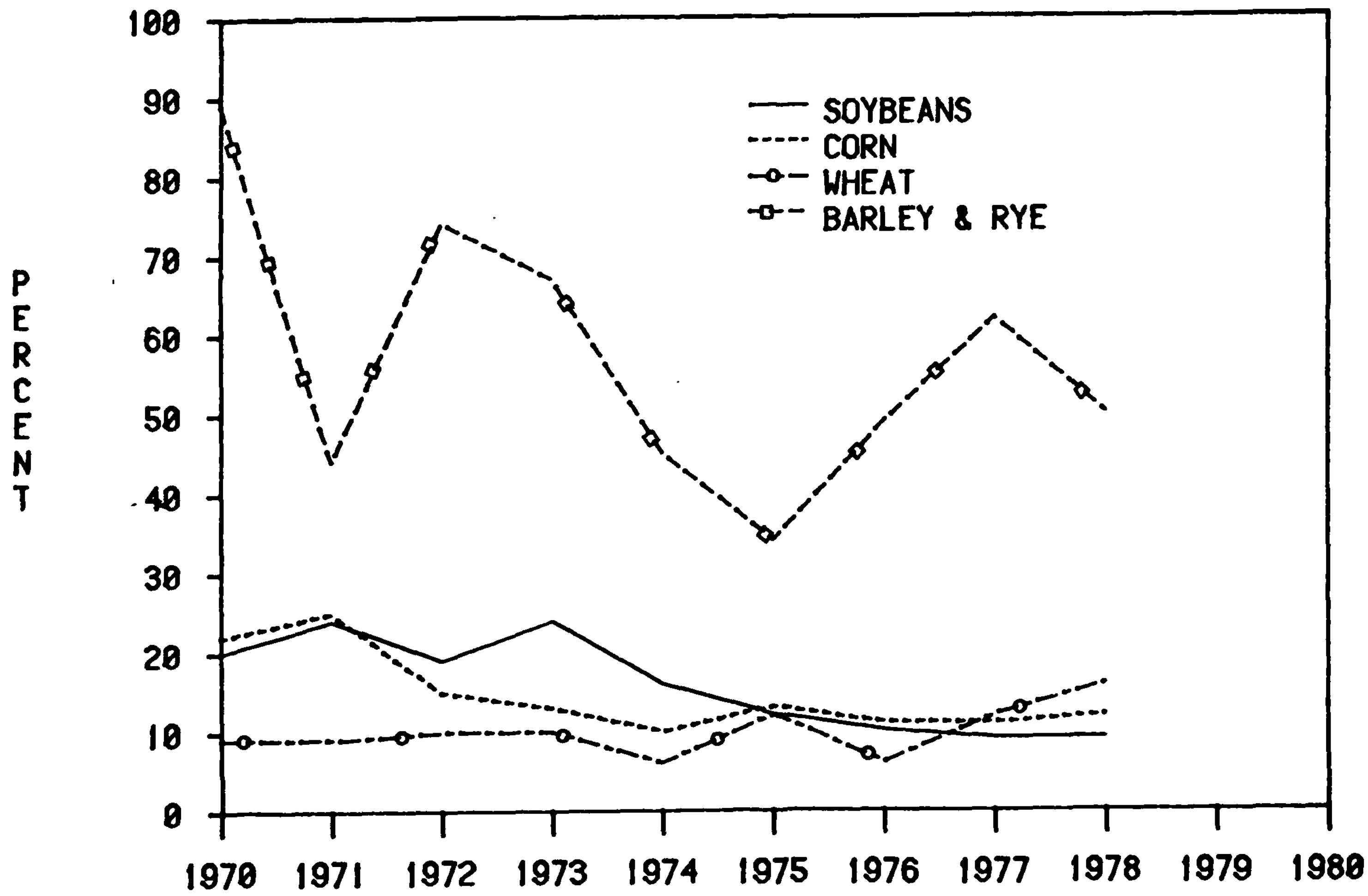


Table B5 - Grain Shipments by Great Lakes Harbors

Port Area	Type of Grain: Wheat	Barley & Rye	Soybeans	Corn
Chicago, IL	323	-	18,758	118,653
Percent of Total Great Lakes	0.2	-	31.0	43.0
Duluth-Superior, WS/MN	134,015	16,580	2,629	51,239
Percent of Total Great Lakes	89.0	100.0	4.0	18.0
Toledo, OH	13,608	-	38,332	101,554
Percent of Total Great Lakes	9.0	-	62.0	37.0
Saginaw, MI	2,455	-	2,048	6,038
Percent of Total Great Lakes	2.0	-	0.3	2.0

SOURCE: Agricultural Marketing Service, USDA - Grain Market News.

Large volumes of Canadian grain are also shipped from Thunder Bay, Ontario to lower lakes ports for either transshipment or direct shipment to foreign markets. Prairie provinces such as Manitoba, Alberta, and Saskatchewan were responsible for shipments of 27.5-million metric tons in 1979 via the GL/SLS. Marketing of all Canadian grain is handled by the Canadian Wheat Board, a division of the Canadian Government. Decisions to export or sell domestically and the choice of export port is controlled by the Canadian Government.

Thunder Bay receives prairie grain via the Canadian National and Canadian Pacific railroads. Grains are stored and cleaned in the elevators during the months when the GL/SLS sytem is closed. Winter shipments of grain occur between the prairie elevators and East Coast ports for milling or direct export. This rail movement occurs only in winter months and does not compete with lake shipments during the open navigation season.

When the navigation season opens, the cleaned grain is usually shipped from Thunder Bay by lakers to lower St. Lawrence ports. These laker shipments are often the backhaul leg of iron ore movements from ore deposits in Labrador and eastern Canada. Utilization of Great Lakes ports for Canadian grain shipments is expected to decline relative to West Coast harbor alternatives. This shift is primarily due to the anticipated increase in the demand for wheat by Pacific Rim countries. As demand increases in these countries, the Canadian Wheat Board will seek to minimize its transportation costs by routing prairie grain through West Coast terminals and elevators.

B4.4 Electric Utility Industry.

Steam coal movements on the Great Lakes are based upon the demand for domestic coal consumption by electric utilities. Public utilities in border states such as Wisconsin, Illinois, Indiana, Michigan, and Ohio account for 97 percent of coal consumption.

Coal is a desirable fuel for a number of reasons:

- Domestic oil and gas reserves are diminishing and there is uncertainty about the availability of imported oil.

- Safety and licensing procedures for nuclear plants involve lengthy delays and public reviews and hearings.

- Coal is cost-competitive with oil despite expenditures for pollution control equipment costs.

Great Lakes States currently generate about 50 percent of their electricity from coal. Indiana and Ohio produce at least 85 percent of their output from coal-fired generators. Additions to future generating capacity will also burn coal.

There are 62 power plants that burn coal that are located within 40 miles of the Great Lakes. All of these plants are potential candidates for future receipts of coal and are summarized below:

	Existing		Projected (1990)	
	No. of Plants	Capacity (MW)	No. of Plants	Capacity (MW)
New York	4	1,873	3	2,952
Illinois	5	4,722	1	3,300
Indiana	5	4,124	1	776
Michigan	23	10,508	6	1,757
Ohio	13	4,774	-	-
Minnesota	-	-	-	-
Wisconsin	10	3,039	3	1,634
Pennsylvania	2	750	1	625

NOTE: MW = megawatts.
SOURCE: Inventory of Power Plants, U.S. Department of Energy, 1979.

Most of the coal which uses the GL/SLS originates from the Appalachian coal fields in Pennsylvania, Ohio, West Virginia, Kentucky, Virginia and Alabama. Power plants in areas adjacent to the lakes receive coal from several source states. Individual plants receive coal from one to four states, often from different mines within the same state. Sourcing practices include a mixture of short- and long-term supply contracts, as well as spot purchases.

Great Lakes coal movements are frequently intermodal. Unit trains move the coal from the mine to the harbor, where it is either stockpiled or loaded directly into bulk vessels. Self-unloading bulk carriers transport the coal to upper lakes destinations or to Canadian consumers adjacent to Lake Ontario via the Welland Canal. Other transport modes such as truck, pipeline or barges are used but do not affect shipments on the Great Lakes. The majority of coal shipments on the lakes involve harbors along Lake Erie. There is one Canadian and six U.S. ports that account for all of the domestic coal movements.

The trend in coal movements on the Great Lakes is towards increased use of western coal. A major rail-to-ship transfer facility has been constructed in Duluth-Superior, MN, and western coal shipments increased from 800,000 tons in 1974 to 4 million tons in 1978. Most of this coal is shipped to the Detroit Edison generating plant on the St. Clair River and must transit the Soo Locks.

The long-term outlook for this transfer facility is very optimistic. A recent study by the National Energy Transportation Board predicted that as much as 40 million tons per year might be shipped from terminals located on western Lake Superior to lower lakes destinations.

B4.5 Lock Dependent Traffic Flows.

Forecasts of commodity movements which involve at least one U.S. harbor have been prepared at the individual port-pair level. Canadian flows have been identified at the regional level only. Total movements through each of the three locks became the basis for an economic evaluation of proposed lock improvements. Tonnage forecasts were subsequently converted to an equivalent level of annual vessel movements after consideration of current fleet characteristics in the base year.

Intralake movements were not considered in an analysis of lock improvements for the St. Lawrence River. Cross-lake traffic which involves U.S. ports on Lake Ontario consists primarily of cement receipts and barge activity which exits/enters the New York State Barge Canal at Oswego Harbor, NY.

Commodity flow forecasts which requires transit through at least one lock node presume that no other physical constraints affect the origin/destination/commodity flow. This time series is based upon an unconstrained analysis of potential Great Lakes movements.

Traffic projections developed during 1981 were subsequently compared with other sources of commodity forecasts published by other public agencies. The National Waterways Study projections which have become the basis for an assessment of the capability of the existing United States waterway network were found to be substantially above the traffic forecasts developed during 1981. A second projection series obtained from the St. Lawrence Seaway Development Corporation was identified as approximately midway between the National Waterway Study and the Corps of Engineers time series. A comparison of the upper and lower limits of future commodity flows are provided in Figure B9.

A tabulation of the low forecast commodity movements which transit each separate lock location is presented in Tables B6, B7, and B8. A graphical presentation follows in Figures B10 through B15.

Table B6 - Soo Locks Traffic - Low Forecast Scenario
(Thousands of Short Tons)

Downbound	1978	1980	1985	1990	2000	2010	2020	2030	2040	2050
Iron Ore	67,699	69,216	73,007	80,554	90,495	104,196	118,656	134,166	150,710	168,055
Coal	2,846	3,372	4,685	11,702	17,338	19,749	17,951	17,991	18,036	18,085
Grain	23,857	25,832	30,769	34,886	35,279	38,125	40,986	44,558	48,137	52,416
Stone	0	0	0	0	0	0	0	0	0	0
Other Bulk	1,961	2,024	2,182	2,354	2,735	3,173	3,684	4,281	4,980	5,804
General Cargo	833	854	907	959	1,068	1,192	1,326	1,482	1,655	1,848
	97,196	101,298	111,550	130,455	146,915	166,435	182,603	202,478	223,518	246,208
Upbound	**1978**	**1980**	**1985**	**1990**	**2000**	**2010**	**2020**	**2030**	**2040**	**2050**
Iron Ore	178	183	197	224	254	292	332	375	425	478
Coal	4,817	5,313	6,551	5,418	6,858	7,511	8,238	9,045	9,942	10,939
Grain	0	0	0	0	0	0	0	0	0	0
Stone	1,995	2,013	2,060	2,307	2,543	2,884	3,302	3,780	4,328	4,955
Other Bulk	2,475	2,553	2,749	2,953	3,471	4,063	4,782	5,654	6,718	8,017
General Cargo	736	764	833	854	943	1,056	1,141	1,303	1,469	1,651
	10,201	10,826	12,390	11,756	14,069	15,806	17,795	20,157	22,882	26,040
Total	107,397	112,124	123,940	142,211	160,984	182,241	200,398	222,635	246,400	272,248

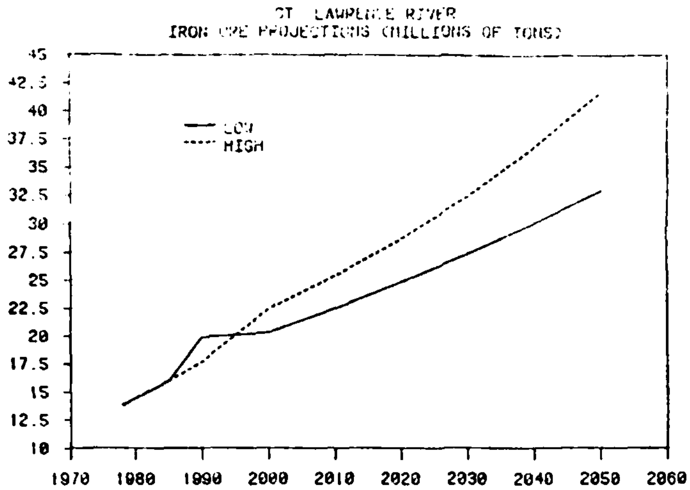
Table B7 - Welland Canal Traffic - Low Forecast Scenario
(Thousands of Short Tons)

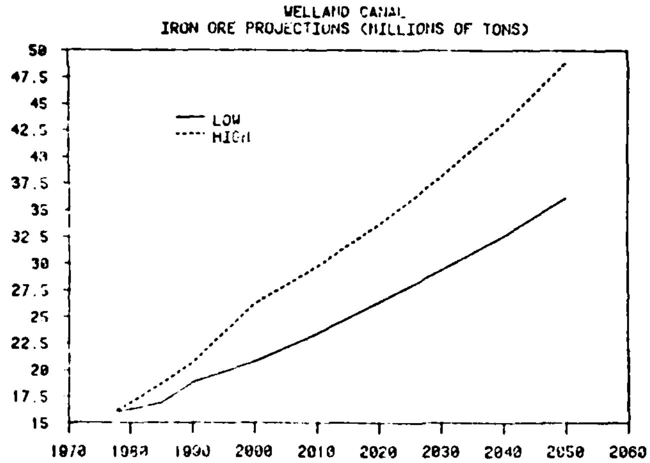
Downbound	1978	1980	1985	1990	2000	2010	2020	2030	2040	2050
Iron Ore	4,919	4,901	4,855	5,418	5,497	5,895	6,342	6,846	7,411	8,045
Coal	5,906	5,823	5,615	5,155	5,714	5,718	5,723	5,729	5,736	5,744
Grain	29,755	31,481	35,794	38,696	40,364	43,645	46,959	50,965	54,954	59,682
Stone	110	110	112	126	139	157	180	206	236	271
Other Bulk	6,333	6,562	7,136	7,868	9,119	10,556	12,277	14,295	17,053	20,466
General Cargo	1,114	1,165	1,292	1,345	1,530	1,763	1,973	2,323	2,714	3,166
	48,137	50,042	54,804	58,608	62,363	67,734	73,454	80,364	88,104	97,374
Upbound	**1978**	**1980**	**1985**	**1990**	**2000**	**2010**	**2020**	**2030**	**2040**	**2050**
Iron Ore	11,148	11,391	12,000	13,383	15,309	17,544	19,911	22,445	25,125	28,078
Coal	0	0	0	0	0	0	0	0	0	0
Grain	6	7	8	20	23	25	25	25	25	25
Stone	46	47	49	55	62	69	80	90	103	119
Other Bulk	3,864	3,939	4,125	4,331	4,757	5,148	5,684	6,390	7,271	8,621
General Cargo	4,792	6,209	9,750	8,250	8,711	10,621	9,069	13,454	17,221	21,117
	19,856	21,593	25,932	26,039	28,862	33,407	34,769	42,404	49,745	57,960
Total	67,993	71,635	80,736	84,647	91,225	101,141	108,223	122,768	137,849	155,334

Table B8 - St. Lawrence River Traffic - Low Forecast Scenario
(Thousands of Short Tons)

Downbound	1978	1980	1985	1990	2000	2010	2020	2030	2040	2050
Iron Ore	0	0	0	0	0	0	0	0	0	0
Coal	1	1	1	1	1	2	2	2	3	3
Grain	28,745	30,409	34,570	37,295	38,816	42,010	45,153	49,006	52,841	57,391
Stone	110	110	112	126	139	157	180	206	236	270
Other Bulk	5,501	5,708	6,226	6,939	8,126	9,491	11,086	13,094	15,633	18,915
General Cargo	1,313	1,374	1,526	1,611	1,863	2,174	2,481	2,962	3,522	4,199
	35,670	37,602	42,435	45,972	48,945	53,834	58,902	65,270	72,235	80,778
Upbound	**1978**	**1980**	**1985**	**1990**	**2000**	**2010**	**2020**	**2030**	**2040**	**2050**
Iron Ore	13,826	14,451	16,015	19,873	20,263	22,495	24,860	27,389	30,067	33,016
Coal	1,003	1,029	1,095	1,161	1,279	1,411	1,556	1,715	1,890	2,084
Grain	6	7	8	20	23	25	25	25	25	25
Stone	46	47	49	55	62	69	80	90	103	119
Other Bulk	5,301	5,380	5,576	5,788	6,201	6,654	7,185	7,809	8,545	9,420
General Cargo	5,592	7,036	10,647	9,231	9,861	11,963	10,648	15,325	19,459	23,822
	25,774	27,950	33,390	36,128	37,689	42,617	44,354	52,353	60,089	68,486
Total	61,444	65,552	75,825	82,100	86,634	96,451	103,256	117,623	132,324	149,264

FIGURE B9 - TRAFFIC PROJECTIONS FOR THE GREAT LAKES - ST. LAWRENCE SEAWAY SYSTEM





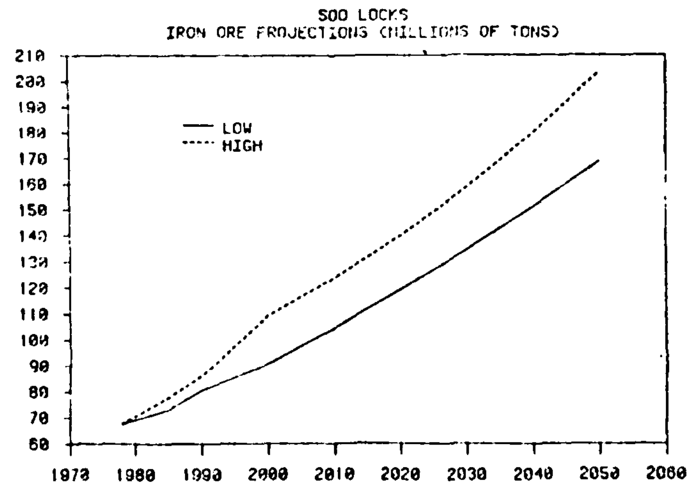


FIGURE B10

ST LAWRENCE SEAWAY
TONNAGE PROJECTIONS

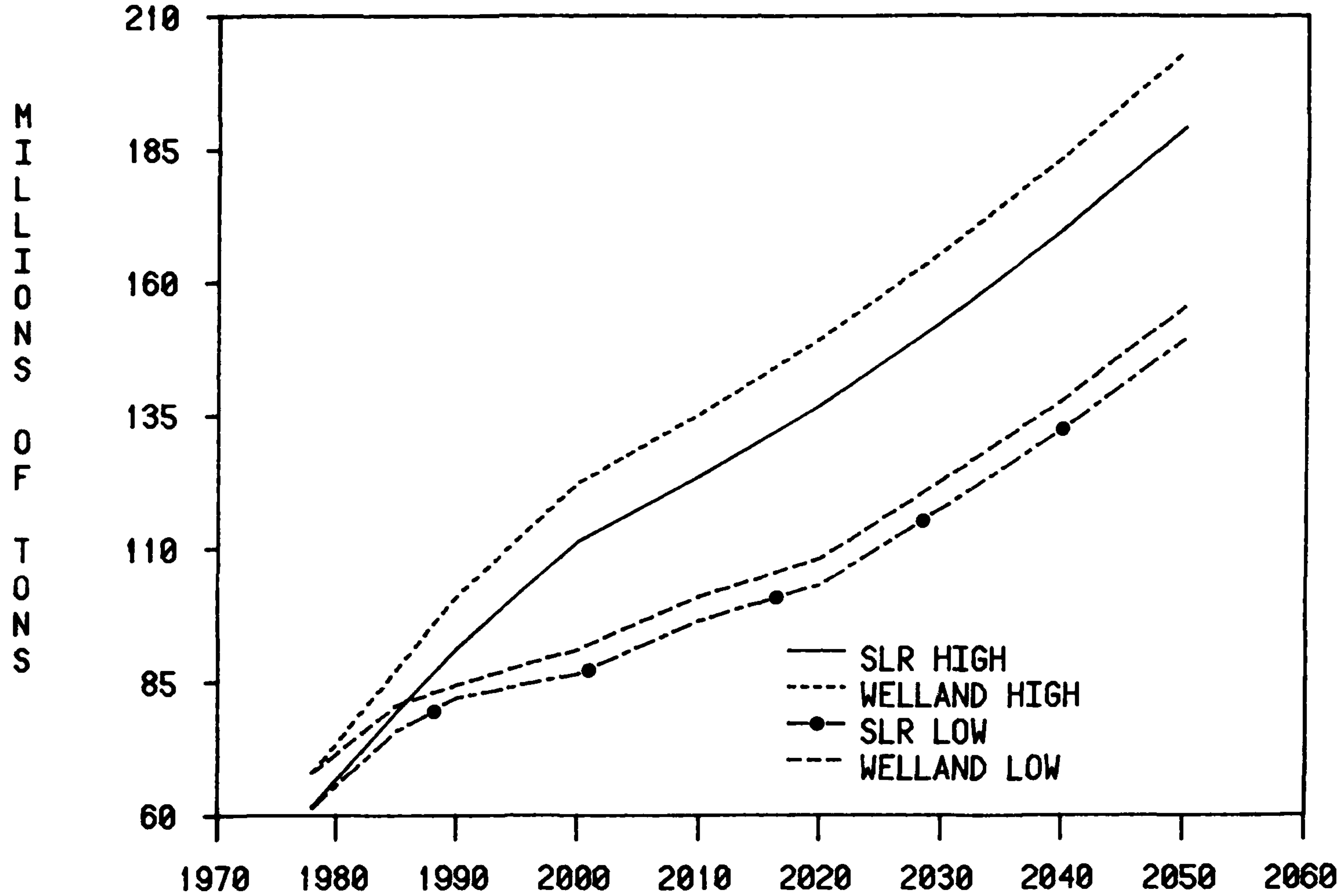


FIGURE B11

ST LAWRENCE RIVER
TOTAL PROJECTIONS

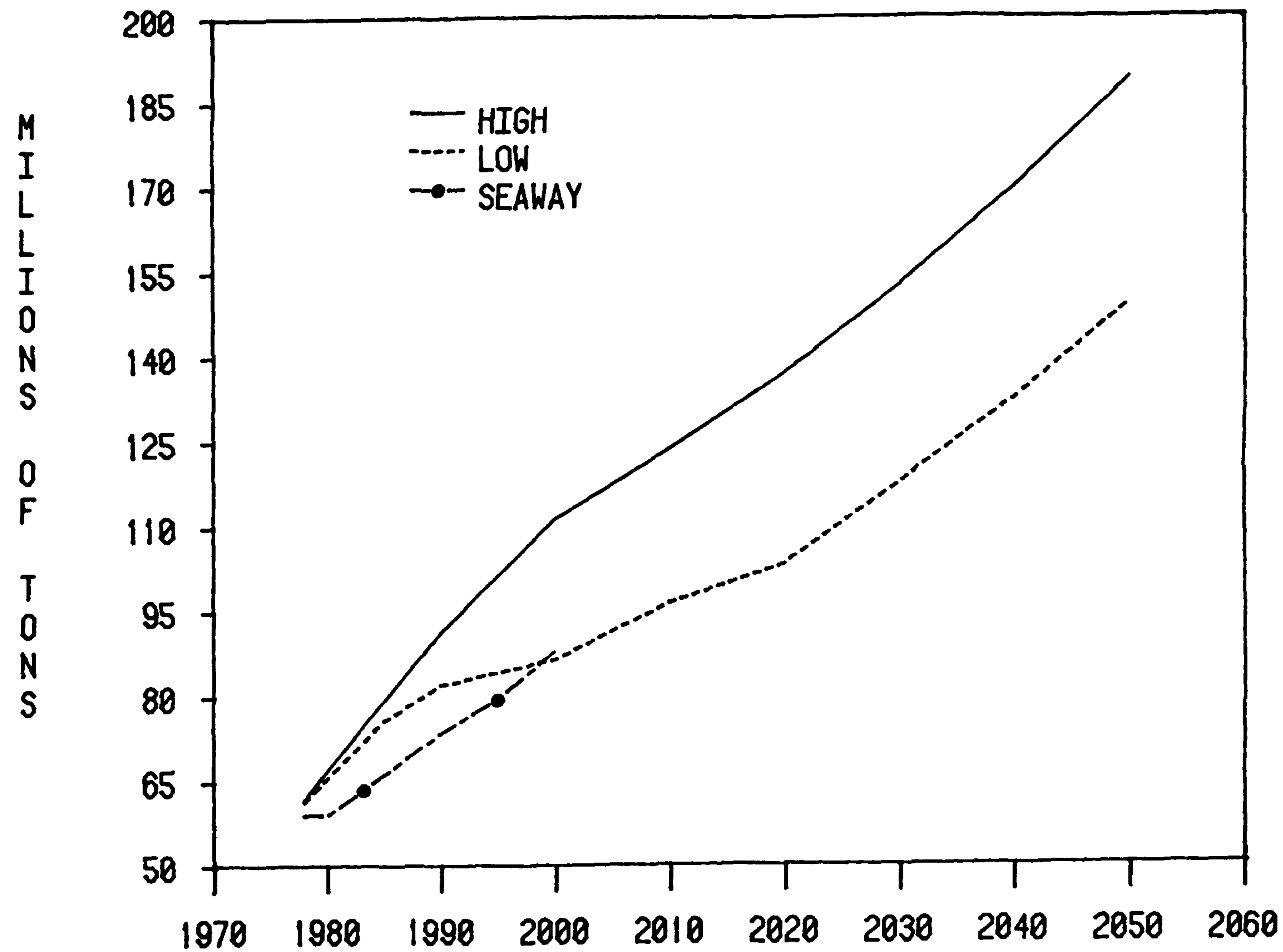


FIGURE B12

ST LAWRENCE RIVER
GRAIN PROJECTIONS

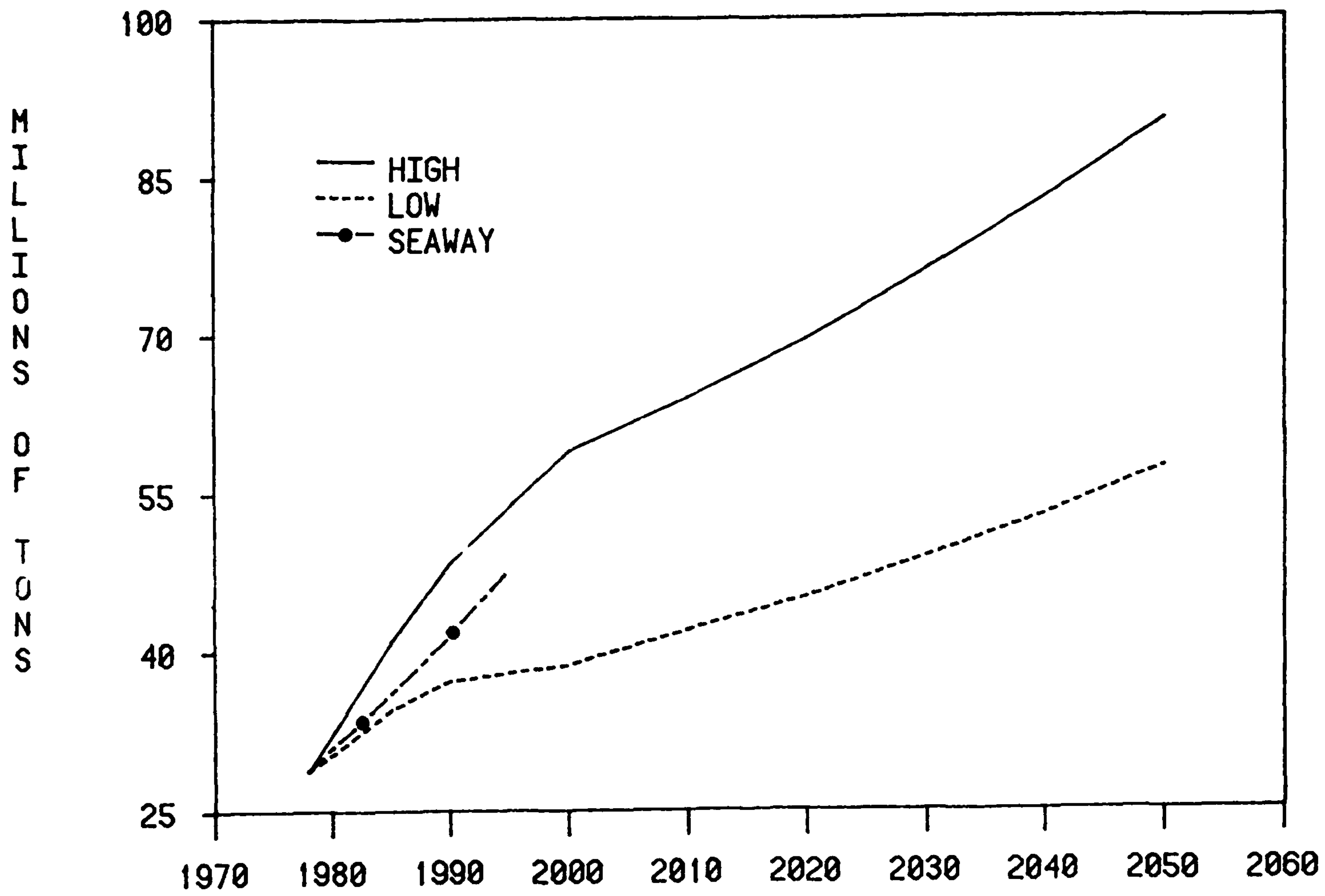


FIGURE B13

ST. LAWRENCE RIVER
IRON ORE PROJECTIONS (MILLIONS OF TONS)

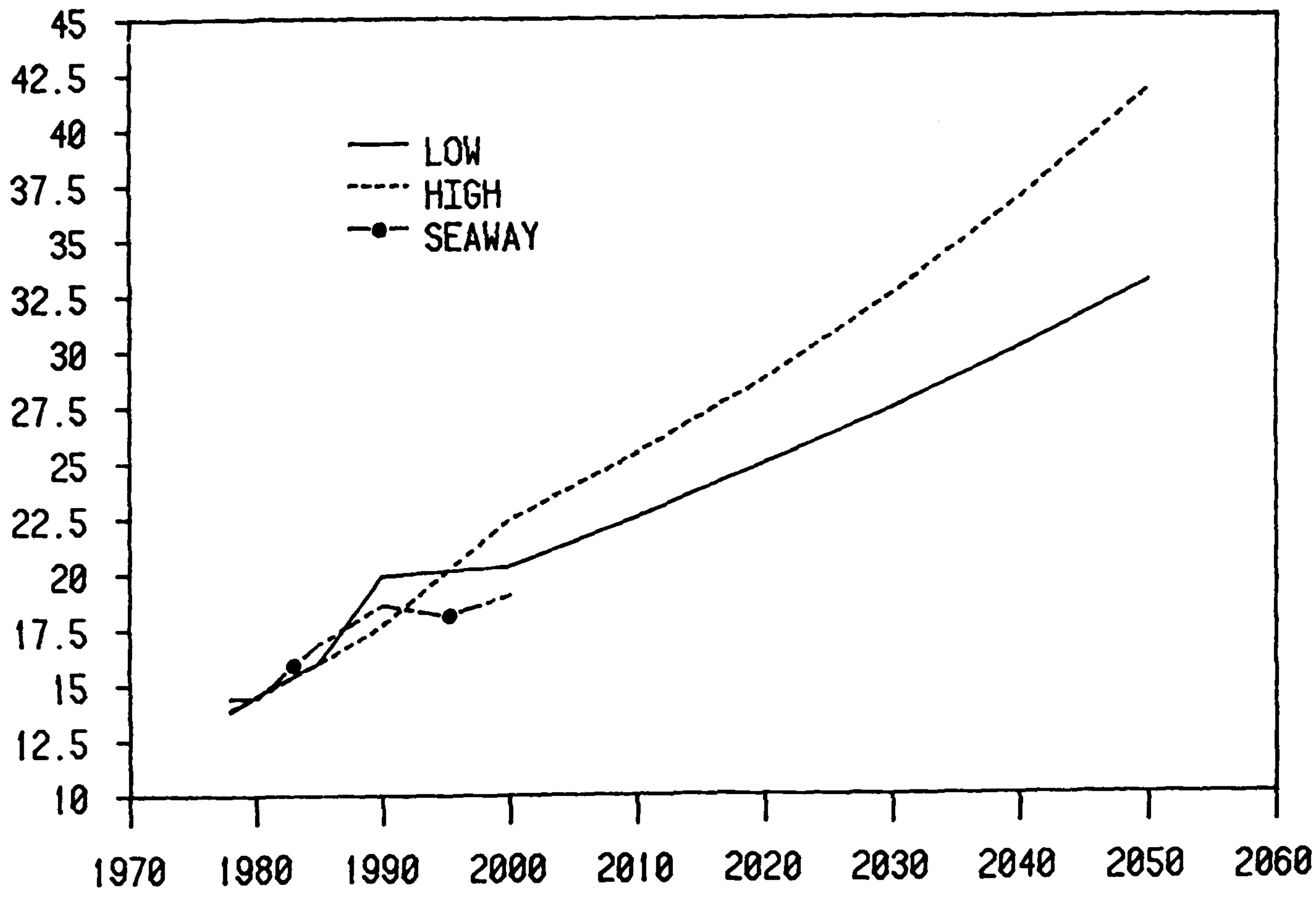


FIGURE B14

ST LAWRENCE RIVER
COAL PROJECTIONS

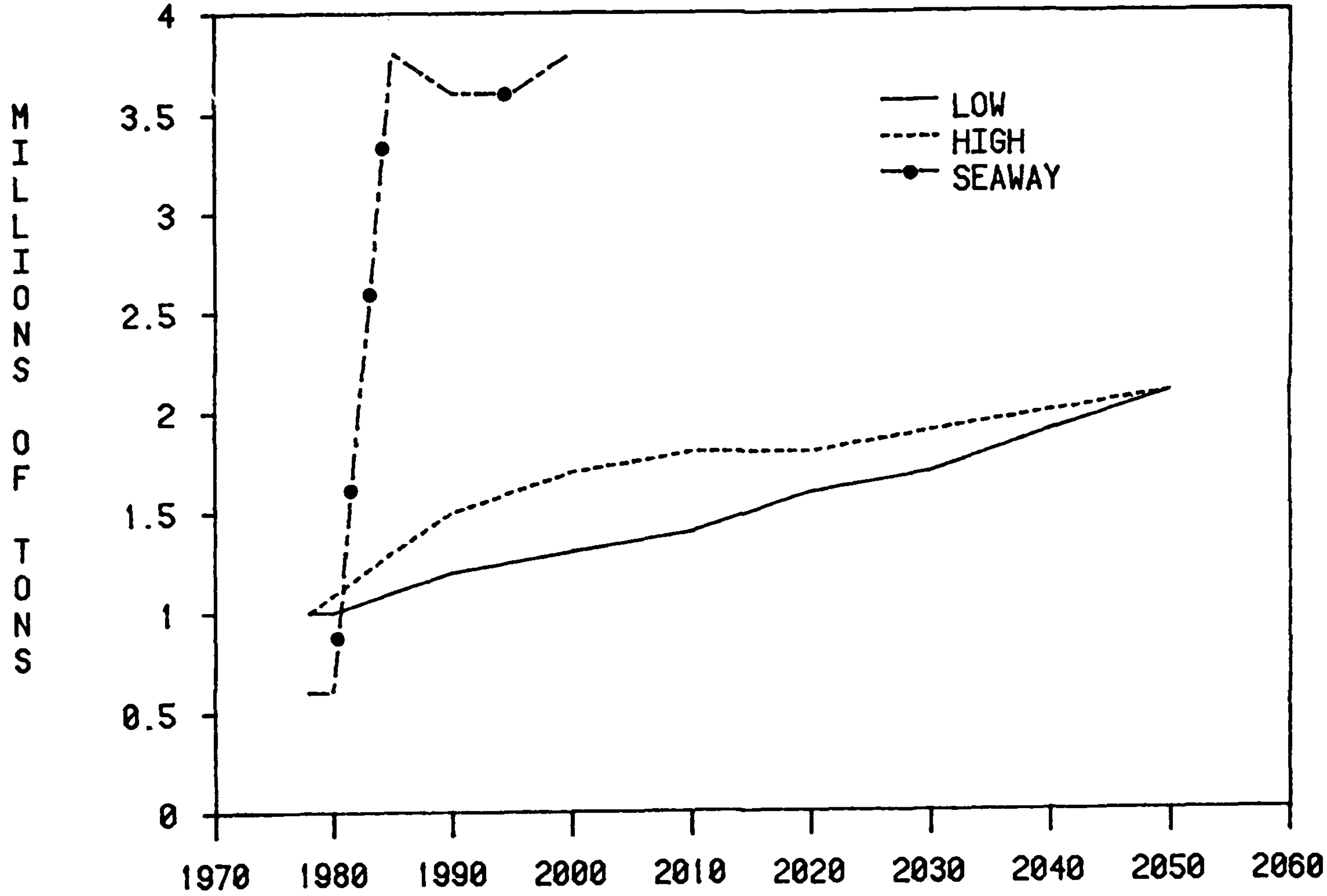


FIGURE B15

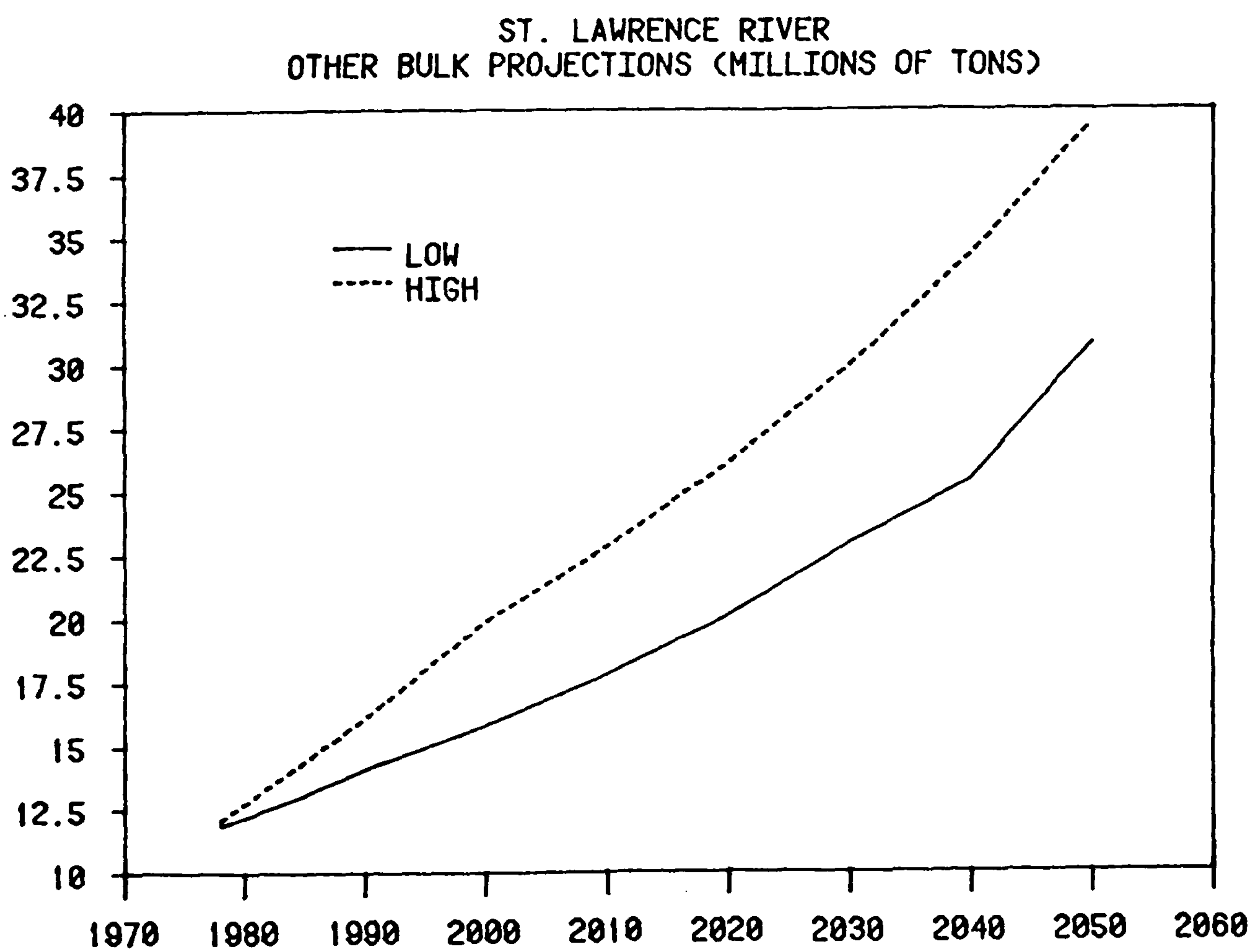
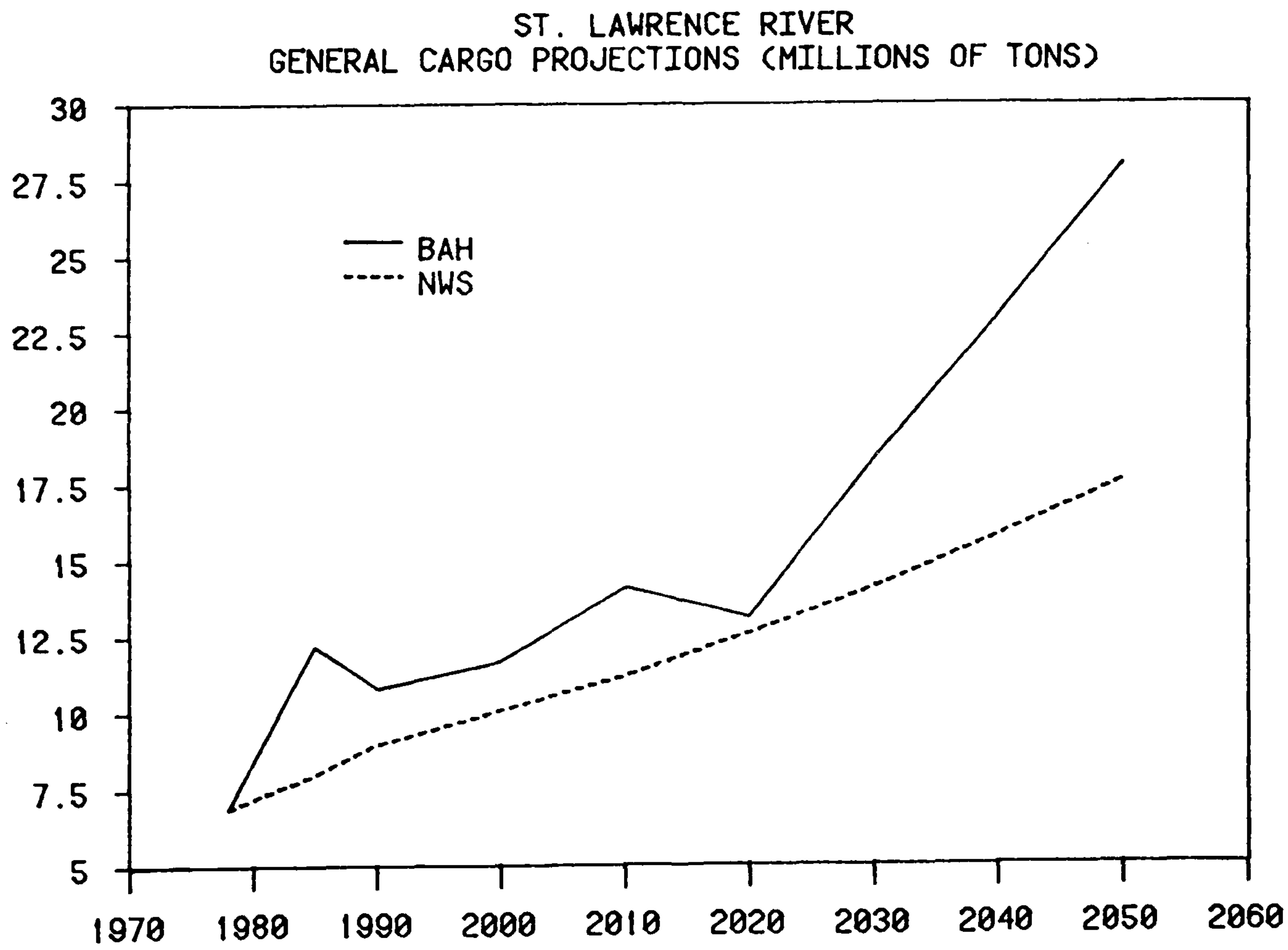

ST. LAWRENCE RIVER
OTHER BULK PROJECTIONS (MILLIONS OF TONS)
LOW
HIGH
40
37.5
35
32.5
30
27.5
25
22.5
20
17.5
15
12.5
10
1970
1980
1990
2000
2010
2020
2030
2040
2050
2060

FIGURE B16


ST. LAWRENCE RIVER
GENERAL CARGO PROJECTIONS (MILLIONS OF TONS)
BAH
NWS
30
27.5
25
22.5
20
17.5
15
12.5
10
7.5
5
1970
1980
1990
2000
2010
2020
2030
2040
2050
2060

B5. GREAT LAKES FLEET

B5.1 Introduction.

Information was obtained for the current fleet and planned fleet changes (i.e., vessel construction, purchases and vessel retirements). Field interviews with all major fleet operators were conducted during 1981 and detailed vessel transit records at each lock location were obtained. This section of the report includes a summary of these investigations.

Research into the existence of long-range shipbuilding plans scheduled for the next 5 years or more into the future concluded that little information exists. This condition may be partially attributed to the relatively short construction interval for new vessels and lack of confidence by the private sector in the short-term growth rates for bulk material transportation.

Recent vessel construction activity has been concentrated within two size categories. Maximum size vessels (i.e., 1,000 feet X 105 feet) have been built for the high annual volume trade routes. This results in substantial economies of scale for the iron ore and coal shipments which originate from western Lake Superior. Smaller ships with overall lengths between 500 and 700 feet are built to accommodate a more diverse commodity mix between harbors which are frequently physically restricted in terms of available channel depths.

Bulk freighters and self-unloaders are considered as the primary fleet affecting Seaway system capacity since the remaining category of vessels, (i.e., tankers and package freighters) are few in number. These smaller vessels are often engaged in intralake transport and have only a slight impact on the capacity of the system.

The Canadian fleet is dominated by Class 7 vessels with a nominal length of 700 to 730 feet and carrying capacity of about 26,000 deadweight (DWT). No vessels in the Canadian fleet are greater than the dimensions which can be accommodated by the existing lock sizes at the Welland Canal or St. Lawrence River.

Future fleet forecasts have been formulated for a number of alternative future conditions. If the GL/SLS system is not structurally altered, the current fleet will be adjusted in a manner similar to historical patterns of change. A significant increase in any type of commodity movement would produce a larger response of ship sizes most likely to move the volume. Also, if a GL/SLS structural modification is implemented, the anticipated fleet response would reflect shipbuilding trends in response to the lock size available.

B6. LOCK CAPACITY STUDIES

B6.1 Lock Capacity Model

A lock capacity model was used to determine if, or when in time, the Soo, Welland, and St. Lawrence River Lock Systems can be expected to reach capacity as a function of:

- Cargo traffic projections
- Vessel fleet projections
- Vessel operating characteristics and locking times
- Lock operating characteristics
- Length of navigation season
- Available operating time defined as total time adjusted for weather delays, lock malfunction delays, and daylight-only navigation periods in the early and late navigation season.
- Pleasure craft and noncommercial vessel locking requirements.

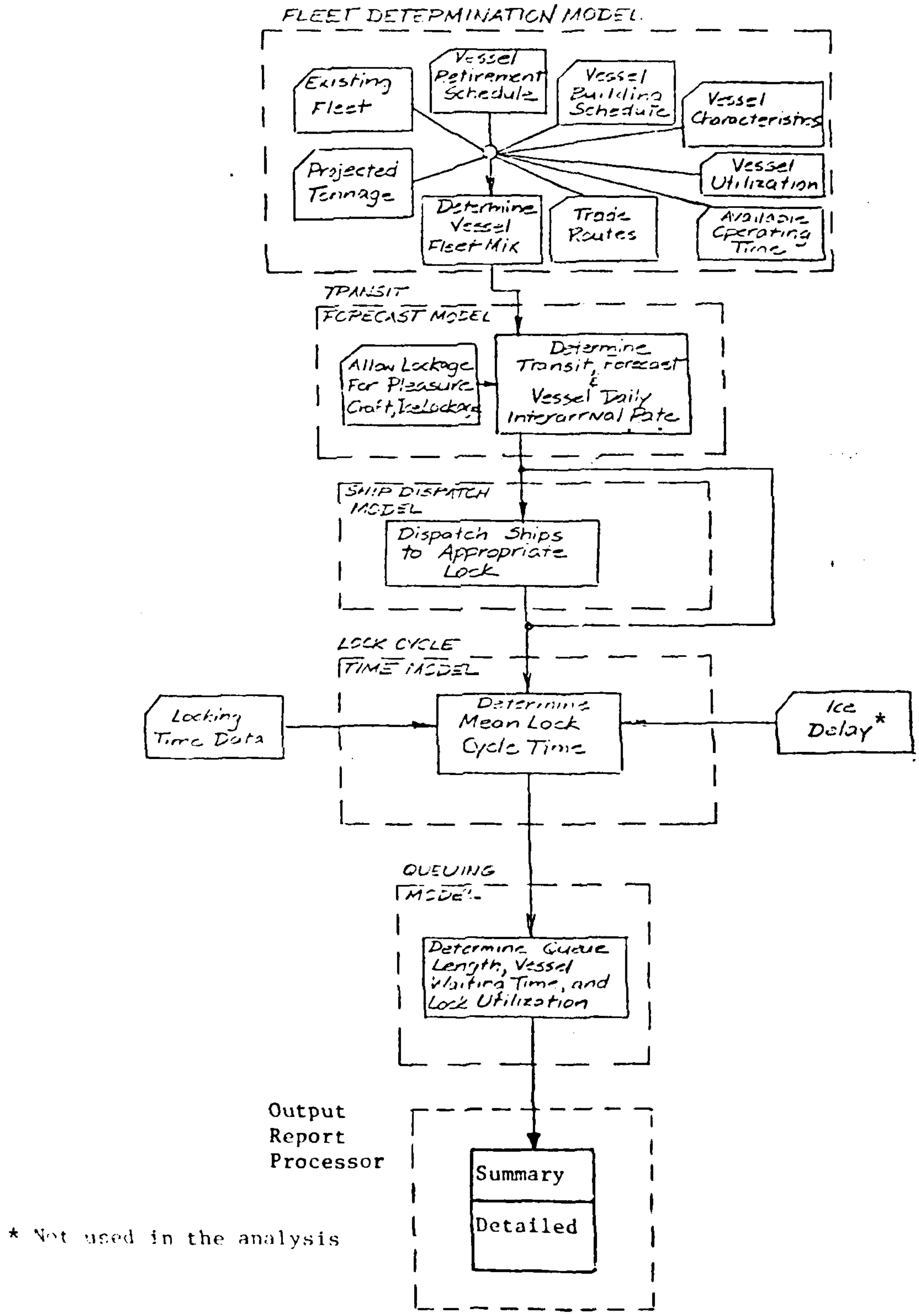
Overall, the lock capacity model can be described as a queuing model which analyzes steady-state lock operations and vessel-lock interaction. For a given set of the above-listed data and a specific base year, the model generates the following output for 14 separate time periods (10 months plus early and late April, and early and late December):

- Cargo transported by commodity and direction
- Vessel operating fleet
- Yearly vessel transit demand by vessel class, commodity, and direction
- Daily vessel transit demand by vessel class and direction
- Lock cycle time by direction (mean and standard deviation)
- Average vessel waiting time by direction
- Average vessel queue length by direction
- Lock utilization by month for a specified navigation season

Using this output, an independent decision can then be made as to whether or not a capacity condition has occurred based on a prescribed capacity criteria such as average vessel waiting time, average vessel queue length, and lock utilization. A conceptual overview of the lock capacity model is included as Figure B15A.

Figure B16a

Conceptual Block Diagram for Lock Capacity Model



* Not used in the analysis

B7. BENEFIT EVALUATION

B7.1 Introduction

A summary of the major study assumptions which form the basis for an evaluation of any Federal interest which may exist for modification of existing U.S. locks in the St. Lawrence River is shown below:

- No major resource constraints occur which might otherwise prevent forecasted levels of traffic from occurring.
- Future water levels in the GL/SLS are not altered such that existing channel depths fall below Low Water Datum or current minimum channel depths now available within the connecting channels.
- No major disruptions (i.e., equipment failure or vessel accidents) at the existing locks such that traffic movements are physically impaired.
- Welland Canal is unconstrained such that U.S. locks in the St. Lawrence River are allowed to reach their physical capacity.
- Welland Canal investments instituted by Canadian Government are recaptured by Canadian users primarily, or if some degree of user-charges are implemented, the costs per ton do not alter the choice of a GL/SLS commodity routing.
- No institutional changes or future subsidies to competing modes of bulk material transport which might otherwise alter levels of future waterway traffic.
- Future capital investments in the Great Lakes fleet continue to be made by U.S. and Canada.
- No financial or capital restrictions prevent the anticipated fleet response rates attributed to individual plans of improvement from occurring.
- No change in toll structure such that low value commodities, or movements which are marginal users of the GL/SLS, are economically prohibited from the waterborne mode.
- Pre-capacity delay costs attributed to increasing levels of traffic do not affect the traffic forecast such that growth rates for major commodity movements are reduced from the level forecasted at each lock location.

Economic benefits are conceptually defined as the potential savings which could be attributed to structural and/or nonstructural modifications to existing locks in the St. Lawrence River. The evaluation in this preliminary feasibiltity study is from the perspective of the U.S. Federal interest, that is, what benefits might accrue in the future to commodity flows which involve at least one U.S. Great Lakes harbor and which also passes through the Eisenhower and Snell Locks. The decision rules which form the basis for the quantification of economic benefits which involve various combinations of U.S., Canadian or Foreign origin-destination-commodity flows is shown below.

- No benefits taken for Canada-Canada routings or Canada-Foreign (import and export) movements.

- One-half of the rate savings per ton for U.S.-Canada harbor pairs; this portion to be further subdivided if the commodity routing also requires transit via the Soo Locks.

- All of the rate savings per ton for U.S.-Foreign harbor pairs is considered to accrue to the U.S. shipper; this share to be further subdivided if a commodity routing also requires transit via the Soo Locks.

- Delay savings which occur in the St. Lawrence River are restricted to the percentage of total traffic which involves at least one U.S. harbor and which requires transit via St. Lawrence River Locks.

- Vessel productivity benefits to be restricted to the percentage of total traffic which involves at least one U.S. harbor and which requires transit via St. Lawrence River Locks; this portion to be further subdivided if the commodity routing also requires transit via the Soo Locks.

B7.2 Economic Definitions.

A number of terms and concepts are used in this economic evaluation. Several of the major terms are defined below:

- Capacity Date - A unique point in time when the Welland Canal or St. Lawrence River Locks reach a specified degree of lock utilization for the normal navigation season. This date for the Welland Canal also becomes the initial year of similar modifications at the St. Lawrence River Locks if larger locks are to be built. Capacity studies for the Welland Canal are required to identify the productive period of time for which tonnage can be accommodated, since any subsequent secondary future constraint would prohibit growth in the major commodity movements at the St. Lawrence River Locks. Capacity dates are identified for both the high and low levels of traffic forecasts and two levels of lock utilization (i.e., 80 to 90 percent).

- Plan Base Year - A point in time when U.S. investments are required to facilitate future traffic or alleviate delays for existing traffic movements. These investments could consist of either larger locks or modifications to existing locks which would facilitate total fleet movements, vessel operations or tonnage throughput at the Eisenhower or Snell Locks in the St. Lawrence River. This discrete year was identified by a capacity evaluation for the Welland Canal for each of two levels of traffic and degrees of assumed lock utilizations (i.e., 80 and 90 percent). All future benefits are discounted to this date and subsequently converted to an average annual value.

- Rate Savings Benefits - Future traffic diversions which would occur under the "without project condition," which could otherwise remain on the GL/SLS with a particular plan of improvement, were evaluated for each plan of improvement. All future rate savings were discounted to their present value in the plan base year and subsequently amortized over the useful life of the project. For the purpose of this evaluation, this period was restricted to the lesser of their engineering useful life or 50 years from the base year.

- Welland Canal Constraints - Canadian improvements are presumed to be made at the existing locks and channels at the Welland Canal in such a manner that the U.S. locks in the St. Lawrence River reach their physical capacity. Detailed benefit-cost studies for the Welland Canal were considered to be outside the present study authority. Implementation of larger locks at the Welland Canal only will not allow movements of the design vessel beyond Lake Ontario without compatible modifications to the locks and channels in the St. Lawrence River. Therefore, U.S. investments in larger locks are presumed to be made within a timeframe compatible with the capacity date for the Welland Canal. This action allows system-wide shipments and receipts utilizing maximum size design vessels at a point in time well before the present locks in the St. Lawrence River would otherwise reach their unique physical capacity.

- St. Lawrence River Locks in Canada - All plans of improvement formulated for the U.S. locks are also presumed to be implemented at all other lock locations in the St. Lawrence River. Formulation of larger locks was restricted in size or scope to a level necessary to accommodate a 50-year traffic forecast for the St. Lawrence River if a similar improvement would successfully pass the required annual traffic at the Welland Canal.

- Fleet Productivity Benefits - Changes in the physical dimensions of the current GL/SLS fleet associated with each level of improvement is based upon the most likely private sector response identified during field interviews of GL/SLS system users in 1981. Any increase in lock size is considered to be adequate to induce a future fleet response with the result that larger vessels replace a portion of the smaller bulk carriers. Larger vessels are very likely to be operating in the lower lakes in the event of a major lock construction program. U.S. imports of iron ore from Canadian Gulf of St. Lawrence ports shift from Class 7 Seaway size towards maximum size design vessels. U.S. exports of grain are also anticipated to be moving in larger vessels in the future if larger locks are built. Both commodity flows (downbound grain and upbound iron ore) are geographically compatible movements under existing conditions. This benefit category is measured as the cumulative decrease in average cost per ton for iron ore and grain in all years which follow the plan Base Year.

B7.3 Future Traffic Scenarios.

Levels of future traffic are difficult to predict with accuracy. However, the general direction of changes in annual traffic for the St. Lawrence River appears to be one of long-term growth and has been documented by independent reports on future commodity movements. Recent sources of information on this subject include the National Waterways Study investigations (Corps of Engineers - 1981) in support of this study and a recent report under preparation by the St. Lawrence Seaway Development Corporation. All studies conclude that there is likely to be long-term growth for bulk commodity movements within the GL/SLS.

The configuration of existing locks in the system is unique in that a capacity condition at a single location will have an impact upon the level of traffic at the remaining locks. Therefore, two levels of traffic have been carried forward into this study in order to formulate future lock facilities which could accommodate a range of traffic flows. Contractor studies produced for the Corps of Engineers in support of this capacity study have been designated as the "low traffic forecast." The upper limit of commodity movements is the National Waterway Study forecasts developed by the Institute for Water Resources, Corps of Engineers, Washington, DC.

Recent declines in the near-term economic outlook for the Great Lakes region have reduced the rate of increase in raw material movements. Therefore, this study is based primarily upon the forecast scenario with a small, but positive, growth rate for the future. This low forecast scenario is best described as a continuation of historical trends within the region. Further disaggregations of the forecasted traffic movements between the U.S. and Canada, by direction of movement can be found in Tables B9, B10, and B11.

B7.4 Overview of Future Economic Benefits.

Three categories of benefits have been evaluated in this feasibility study: delay savings benefits, rate savings benefits, and vessel productivity benefits.

a. Delay Savings Benefits. Increases in traffic moving through the St. Lawrence River locks will result in a rising level of delays over time. Estimates of future delay hours are provided biannually by the lock capacity model. Data inputs (i.e., future traffic and future fleet responses) are continuously processed until the prescribed level of lock utilization is equalled or exceeded. At this point in time, an improvement to the locks can be instituted or the simulation process is ended.

Improvements to the St. Lawrence River can also occur independently or in conjunction with the need for improvements at the Welland Canal. Compatibility was always maintained between the physical characteristics of an improved Welland Canal and new locks which would be added in the St. Lawrence River. This action would effectively result in a precapacity investment decision for the St. Lawrence River. Actual dates of capacity if the St. Lawrence River locks were independent of the Welland Canal are shown in Table 12.

Table B9 - U.S. and Canadian Traffic - St. Lawrence River
Low Forecast Scenario

	1978	1980	1985	1990	2000	2010	2020	2030	2040	2050	1980-2050 Annual Growth Rate (Percent)
Iron Ore											
Canadian	2,766	4,342	4,299	6,964	5,641	5,641	5,641	5,641	5,641	5,641	0.4
U.S.A	11,060	10,109	11,716	12,909	14,622	16,854	19,219	21,748	24,426	27,375	1.4
Subtotal	13,826	14,451	16,015	19,873	20,263	22,495	24,860	27,389	30,067	33,016	1.2
Coal											
Canadian	1,002	1,022	1,095	1,161	1,279	1,411	1,556	1,715	1,890	2,084	1.0
U.S.A	1	1	1	1	1	2	2	2	3	3	-
Subtotal	1,003	1,023	1,096	1,162	1,280	1,413	1,558	1,717	1,893	2,087	1.0
Grain											
Canadian	11,975	13,908	19,087	22,278	24,745	27,263	29,679	32,811	35,944	39,668	1.5
U.S.A	16,776	16,508	15,491	15,037	14,094	14,772	15,499	16,220	16,922	17,748	0.1
Subtotal	28,751	30,416	34,578	37,315	38,839	42,035	45,178	49,031	52,866	57,416	
Stone											
Canadian	0	0	0	0	0	0	0	0	0	0	-
U.S.A	156	157	161	181	201	226	260	296	339	389	1.3
Subtotal	156	157	161	181	201	226	260	296	339	389	1.3
Other Bulk											
Canadian	5,522	5,624	6,129	6,645	7,521	8,523	9,607	10,873	12,317	13,962	1.3
U.S.A	5,280	5,464	5,673	6,082	6,806	7,622	8,664	10,030	11,861	14,373	1.4
Subtotal	10,802	11,088	11,802	12,727	14,327	16,145	18,271	20,903	24,178	28,335	1.3
General Cargo											
Canadian	1,162	1,196	1,334.5	1,481.1	1,788	2,137.2	2,578.2	3,143.1	3,869.7	4,812.1	2.0
U.S.A	5,743	7,214	10,838.3	9,360.9	9,936	11,999.8	10,550.8	15,143.9	19,111.3	23,208.9	1.7
Subtotal	6,905	8,410	12,172.8	10,842.0	11,724	14,137.0	13,129.0	18,287.0	22,981.0	28,021.0	1.7
Canadian Subtotal	22,427.0	26,092	31,944.5	38,529.1	40,974	44,975.2	49,061.2	54,183.1	59,661.7	66,167.1	1.3
U.S.A. Subtotal	39,016.0	39,453	43,880.3	43,570.9	45,660	51,475.8	54,194.8	63,439.9	72,662.3	83,096.9	1.1
Total Traffic	61,443	65,545	75,824.8	82,100	86,634	96,451	103,256	117,623	132,324	149,264	1.2
Percent U.S. Traffic	63.5	60.2	57.9	53.1	52.7	53.4	52.5	53.9	54.9	55.7	

United States traffic is defined as future movements which involve at least one U. S. Harbor.

Table B10 - U.S. and Canadian Traffic - St. Lawrence River Downbound

Downbound	1978	1980	1985	1990	2000	2010	2020	2030	2040	2050
Iron Ore										
Canadian	0	0	0	0	0	0	0	0	0	0
U.S.A	0	0	0	0	0	0	0	0	0	0
Subtotal	0	0	0	0	0	0	0	0	0	0
Coal										
Canadian	0	0	0	0	0	0	0	0	0	0
U.S.A	1	1	1	1	1	2	2	2	3	3
Subtotal	1	1	1	1	1	2	2	2	3	3
Grain										
Canadian	11,975	13,908	19,087	22,278	24,745	27,263	29,679	32,811	35,944	39,668
U.S.A	16,770	16,501	15,483	15,017	14,071	14,747	15,474	16,195	16,897	17,723
Subtotal	28,745	30,409	34,570	37,295	38,816	42,010	45,153	49,006	52,841	57,391
Stone										
Canadian	0	0	0	0	0	0	0	0	0	0
U.S.A	110	110	112	126	139	157	180	206	236	270
Subtotal	110	110	112	126	139	157	180	206	236	270
Other Bulk										
Canadian	3,824	3,910	4,267	4,653	5,315	6,084	6,909	7,887	9,011	10,302
U.S.A	1,677	1,798	1,959	2,286	2,811	3,407	4,177	5,207	6,622	8,613
Subtotal	5,501	5,708	6,226	6,939	8,126	9,491	11,086	13,094	15,633	18,915
General Cargo										
Canadian	351.3	362.8	410.9	462.7	573.9	700.9	864.2	1,076.3	1,352.9	1,716.2
U.S.A	961.7	1,011.2	1,115.1	1,148.3	1,289.1	1,473.1	1,616.8	1,885.7	2,169.1	2,482.8
Subtotal	1,313.0	1,374.0	1,526.0	1,611.0	1,863.0	2,174.0	2,481.0	2,962.0	3,522.0	4,199.0

Canadian commodity flows defined as: Canada - Canada
Canada - Foreign
Foreign - Canada

Table B11 - U.S. and Canadian Traffic - St. Lawrence River Upbound

Upbound	1978	1980	1985	1990	2000	2010	2020	2030	2040	2050
Iron Ore										
Canadian	2,766	4,342	4,299	6,964	5,641	5,641	5,641	5,641	5,641	5,641
U.S.A	11,060	10,109	11,716	12,909	14,622	16,854	19,219	21,748	24,426	27,375
Subtotal	13,826	14,451	16,015	19,873	20,263	22,495	24,860	27,389	30,067	33,016
Coal										
Canadian	1,002	1,022	1,095	1,161	1,279	1,411	1,556	1,715	1,890	2,084
U.S.A	0	0	0	0	0	0	0	0	0	0
Subtotal	1,002	1,022	1,095	1,161	1,279	1,411	1,556	1,715	1,890	2,084
Grain										
Canadian	0	0	0	0	0	0	0	0	0	0
U.S.A	6	7	8	20	23	25	25	25	25	25
Subtotal	6	7	8	20	23	25	25	25	25	25
Stone										
Canadian	0	0	0	0	0	0	0	0	0	0
U.S.A	46	47	49	55	62	69	80	90	103	119
Subtotal	46	47	49	55	62	69	80	90	103	119
Other Bulk										
Canadian	1,698	1,714	1,862	1,992	2,206	2,439	2,698	2,986	3,306	3,660
U.S.A	3,603	3,666	3,714	3,796	3,995	4,215	4,487	4,823	5,239	5,760
Subtotal	5,301	5,380	5,576	5,788	6,201	6,654	7,185	7,809	8,545	9,420
General Cargo										
Canadian	810.7	833.2	923.8	1,018.4	1,214.1	1,436.3	1,714.0	2,066.8	2,516.8	3,095.9
U.S.A	4,781.3	6,202.8	9,723.2	8,212.6	8,646.9	10,526.7	8,934.0	13,258.2	16,942.2	20,726.1
Subtotal	5,592.0	7,036.0	10,647.0	9,231.0	9,861.0	11,963.0	10,648.0	15,325.0	19,459.0	23,822.0

Canadian commodity flows defined as: Canada - Foreign
Canada - Canada
Foreign - Canada

Table B12 - Lock Capacity Dates and Traffic

Traffic Forecast Scenario	Welland Canal: Initial Capacity Date (1)	Welland Canal: Secondary Capacity Date (2)	St. Lawrence River: Initial Capacity Date (1)	St. Lawrence River: Secondary Capacity Date (2)
LOW				
90 % Utilization	1982	1992	2002	2018
Tonnage (000)	75,113	85,961	88,395	101,892
80 % Utilization	1978	1984	1988	2010
Tonnage (000)	67,873	78,865	79,585	96,264
HIGH				
90 % Utilization	1980	1982	1988	1994
Tonnage (000)	72,307	79,007	85,020	98,738
80 % Utilization	1978	1980	1984	1990
Tonnage (000)	66,943	73,455	76,726	91,024

(1) Nonstructural investments presumed to be made; these improvements are a composite of traveling kevels, reduced dump fill times and traffic control systems.

(2) Structural investments presumed to be made; these would be variable by plan.

Traffic moving between Lakes Erie and Ontario is the cause of initial capacity at the Welland Canal. These locks are between the U. S. locks at Sault Ste. Marie, MI, and Massena, NY. Future improvements at these locks are critical, since without modification, the U. S. locks in the St. Lawrence River would not attain their maximum lock utilization. Physical compatibility between these locks and the existing Canadian locks in the Welland Canal can be maintained by implementing similar lock sizes which may reasonably be built at the Canadian Welland Canal Locks. This would require a simultaneous lock construction program to be implemented before the date that SLR locks become constrained under either the high or low traffic forecast.

Delays which might otherwise exist in the precapacity years (i.e., before 2002 or 1988 under the low traffic forecast scenario) are reduced and the without project level of maximum delay is pushed into the future as additional capacity is created by modification or construction of new locks.

Illustrations of the change in annual delays between the without project condition and each of the plans of improvement formulated is shown in Figures B16 through B23. The area between each of these delay functions are delay reduction benefits. A constant level of future delay hours after the initial capacity date is based upon the presumed diversion of traffic expected to occur after this date. No increase in traffic moving via the water mode is allowed to affect the prevailing level of annual delay beyond this point in time.

FIGURE B17

LOW TRAFFIC FORECAST DELAYS
90% LOCK UTILIZATION

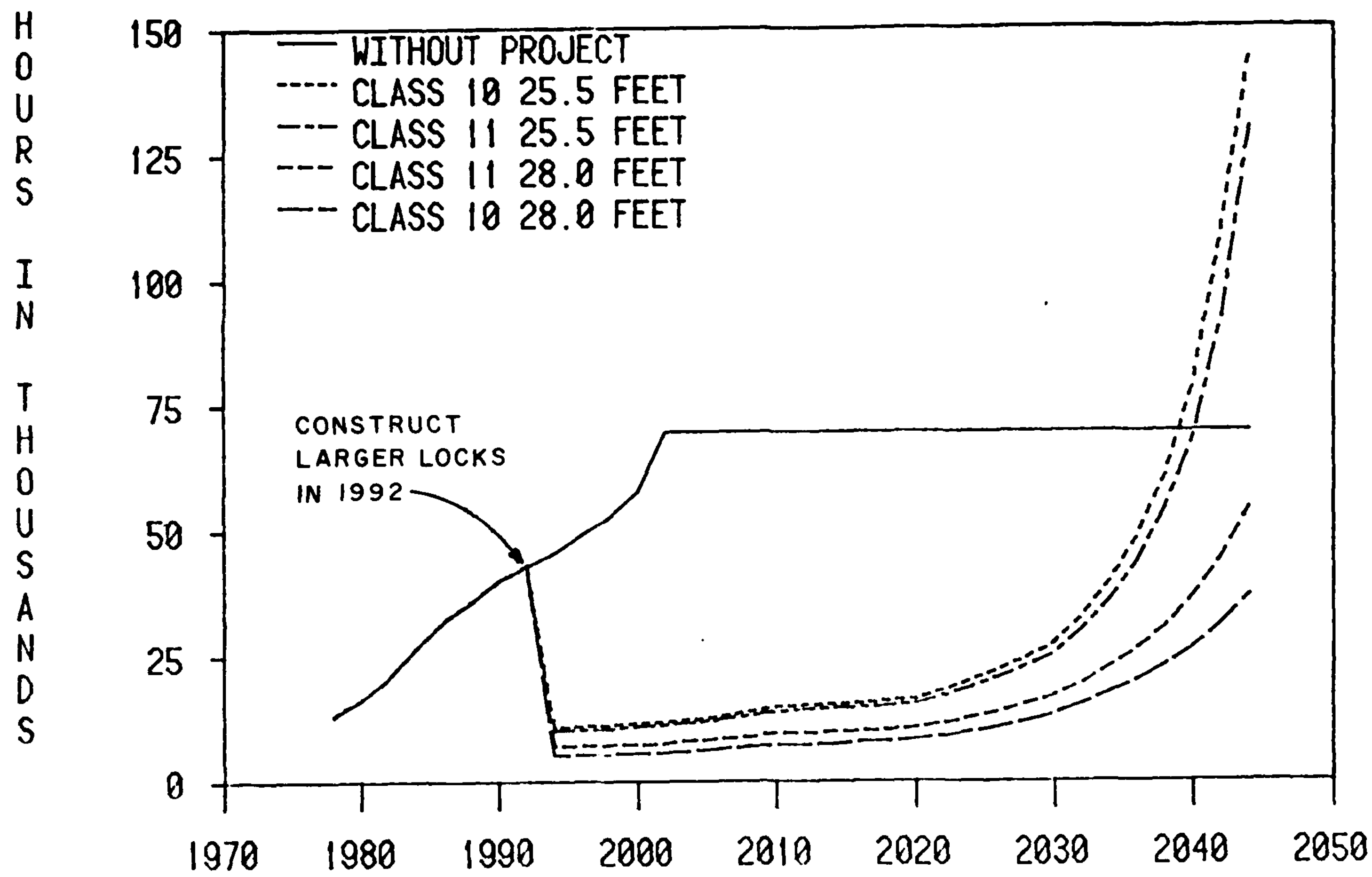


FIGURE B18

LOW TRAFFIC FORECAST DELAYS
80% LOCK UTILIZATION

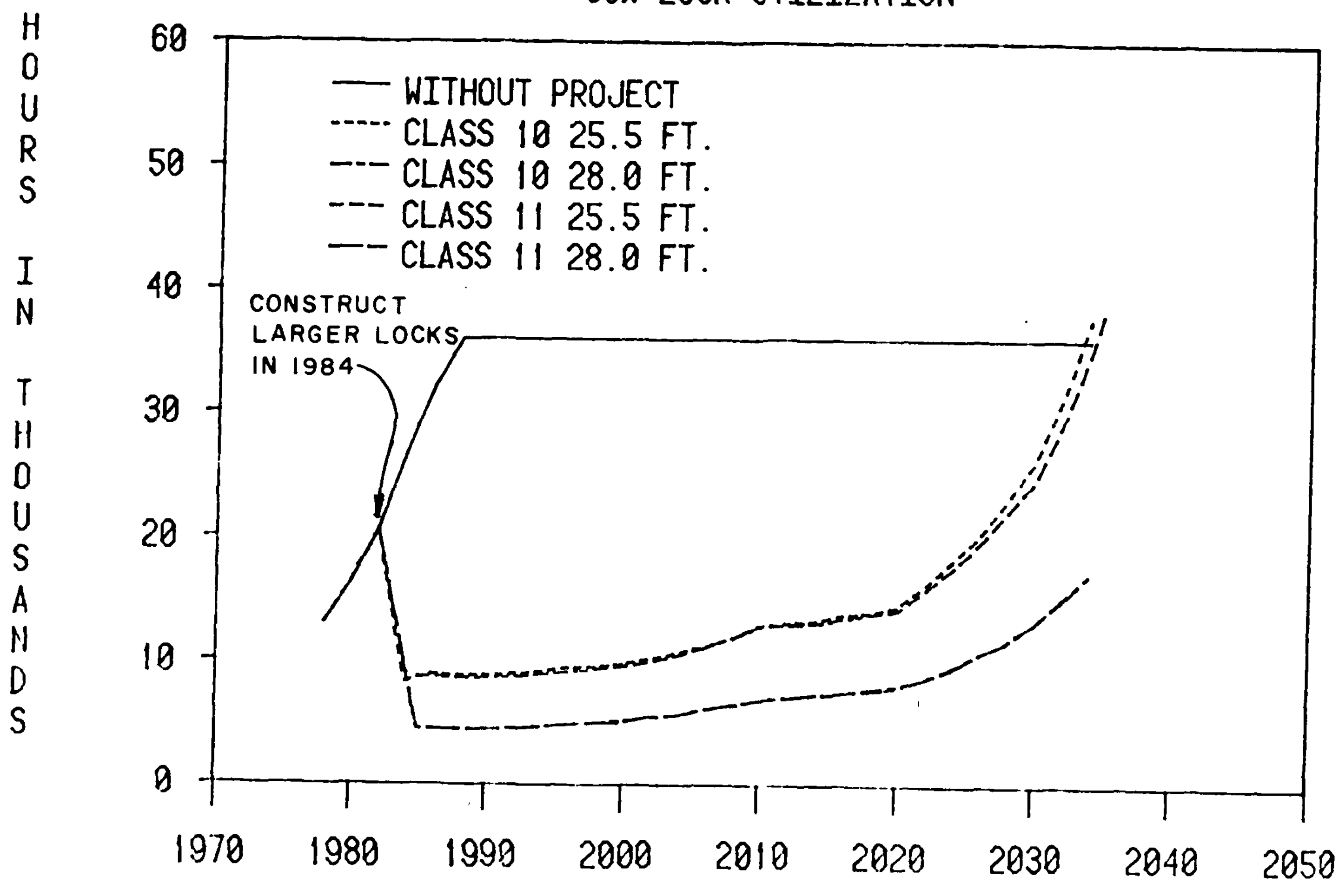


FIGURE B19

LOW TRAFFIC - TWIN SEAWAY SIZE LOCKS
90% LOCK UTILIZATION

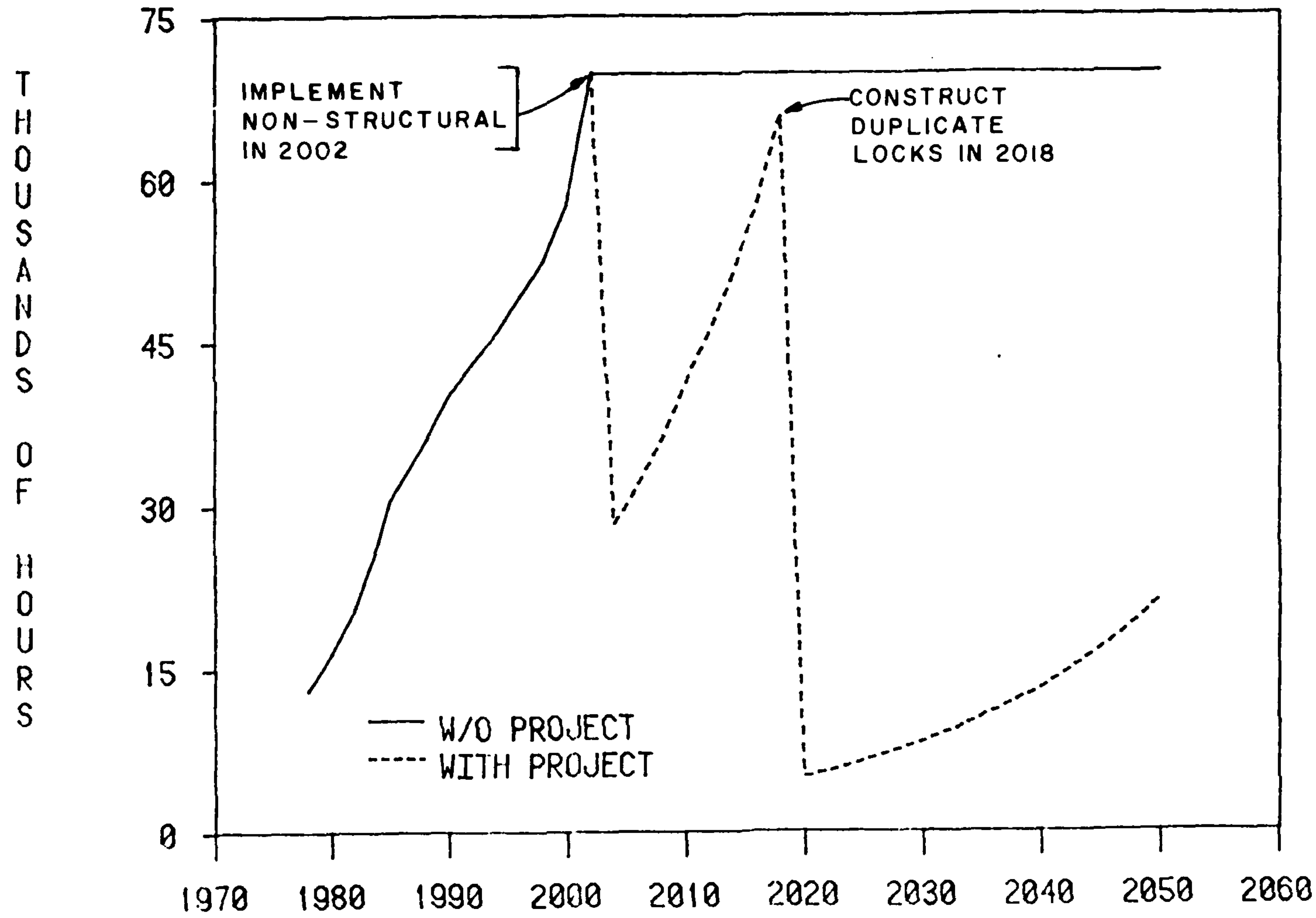


FIGURE B20

LOW TRAFFIC - TWIN SEAWAY SIZE LOCKS
80% LOCK UTILIZATION

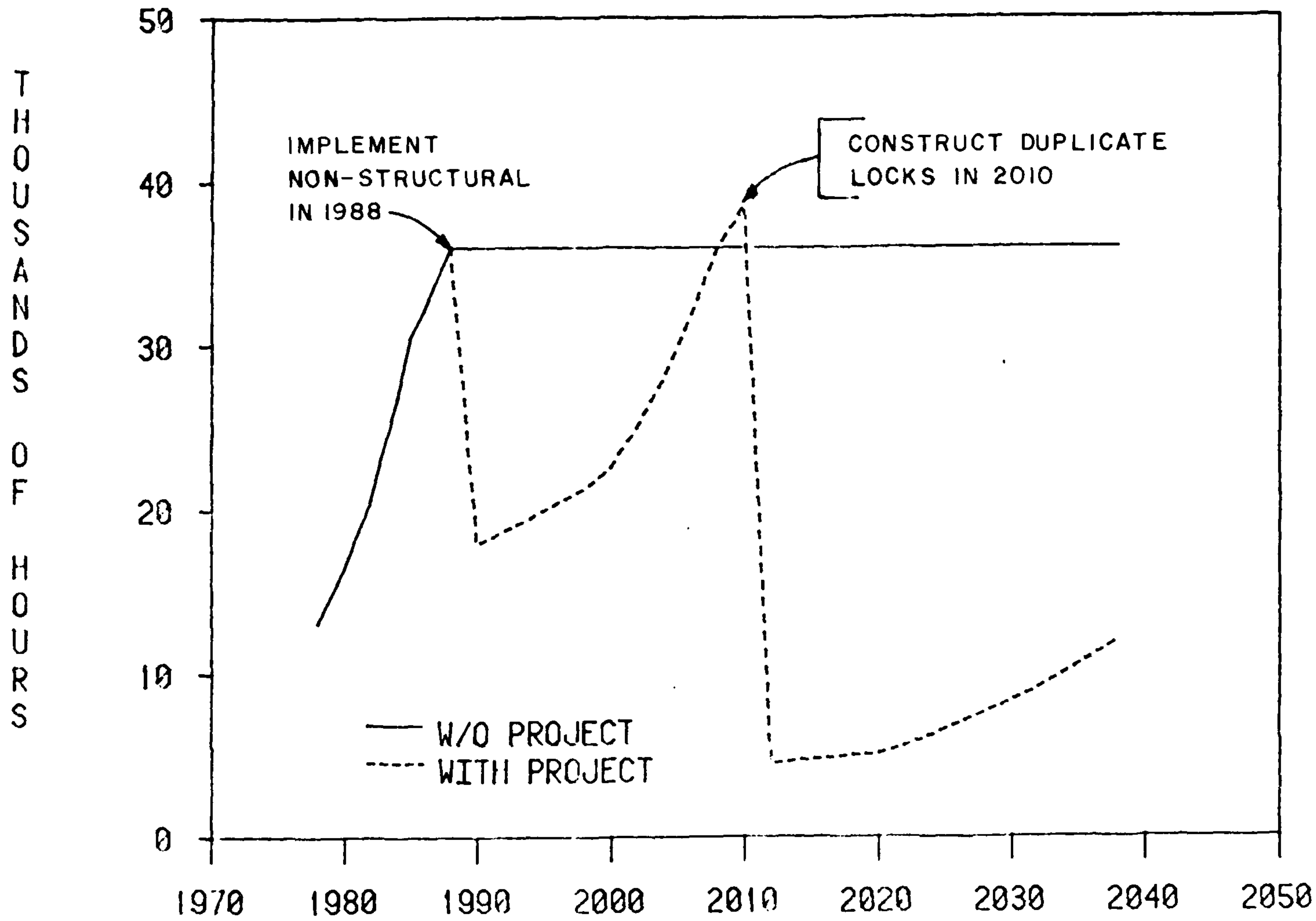
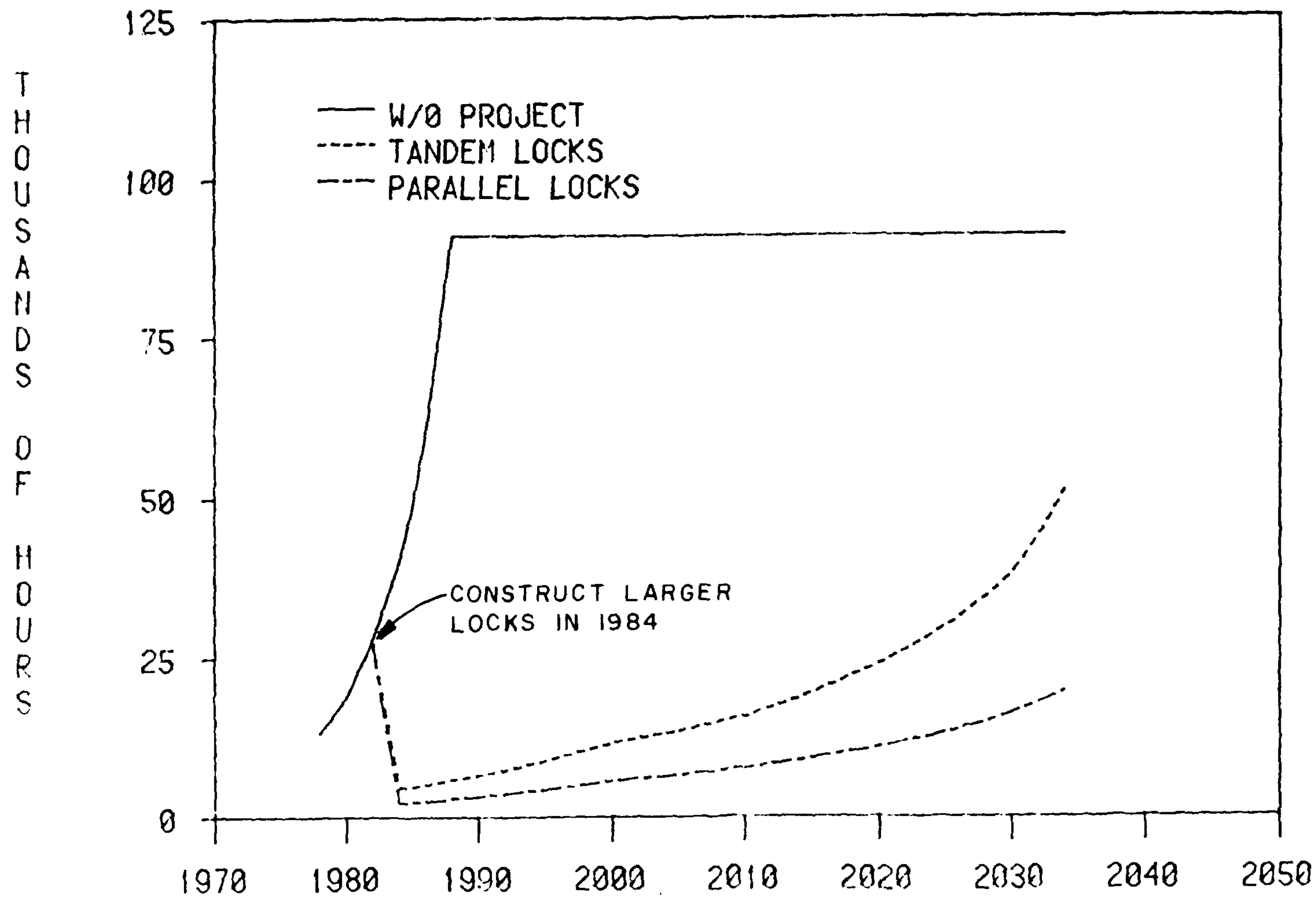


FIGURE B21

HIGH TRAFFIC FORECAST DELAYS
90% LOCK UTILIZATION



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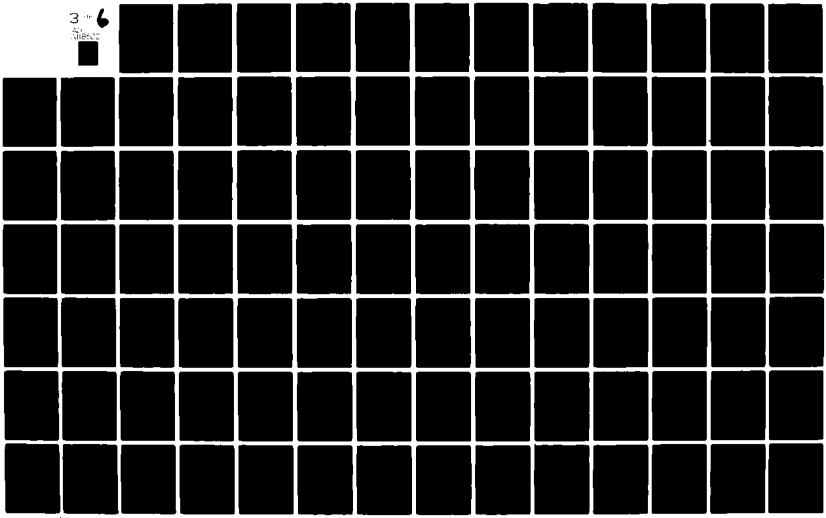


FIGURE B22

HIGH TRAFFIC FORECAST DELAYS
80% LOCK UTILIZATION

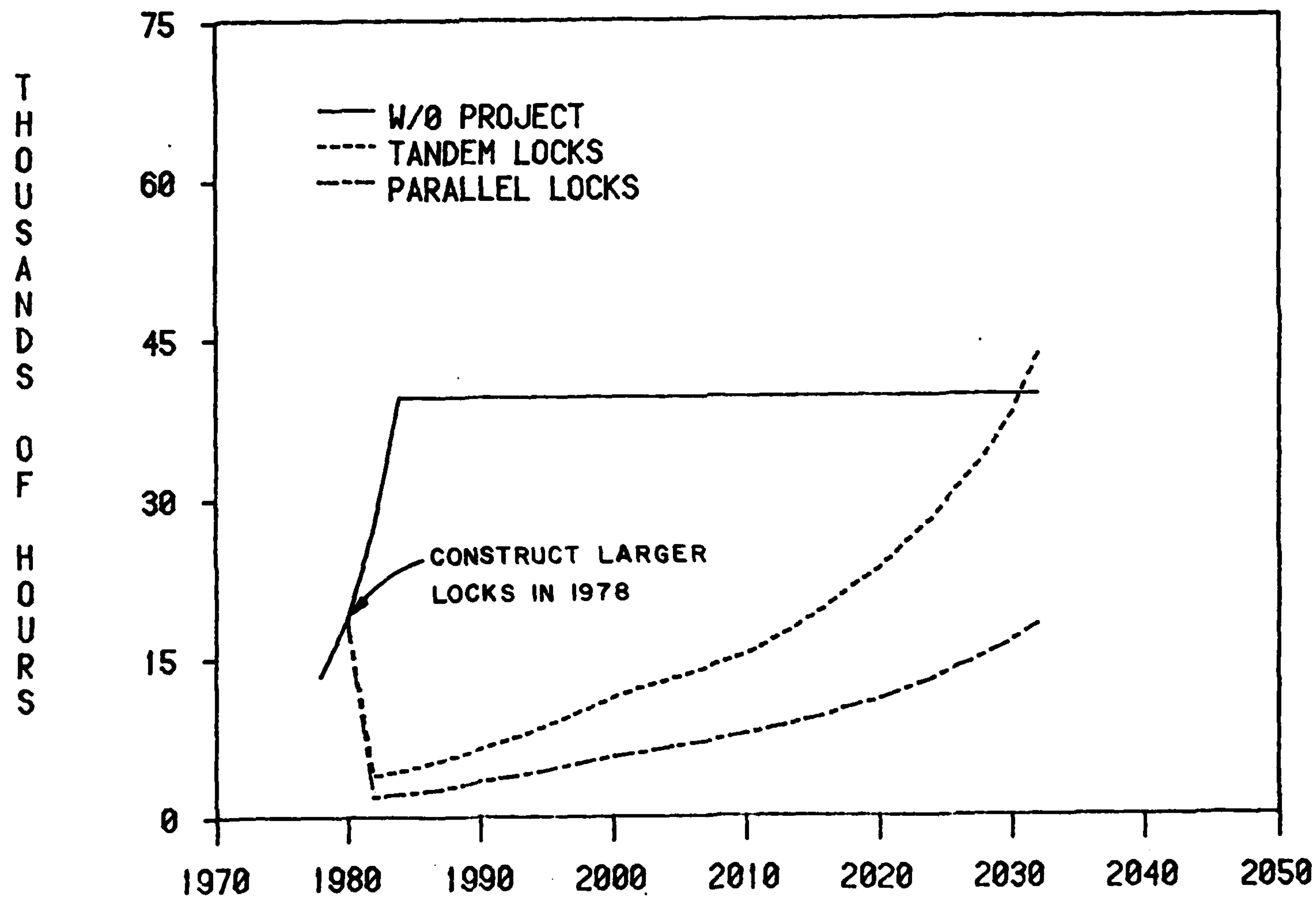


FIGURE B23

HIGH TRAFFIC - TWIN SEAWAY SIZE LOCKS
90% LOCK UTILIZATION

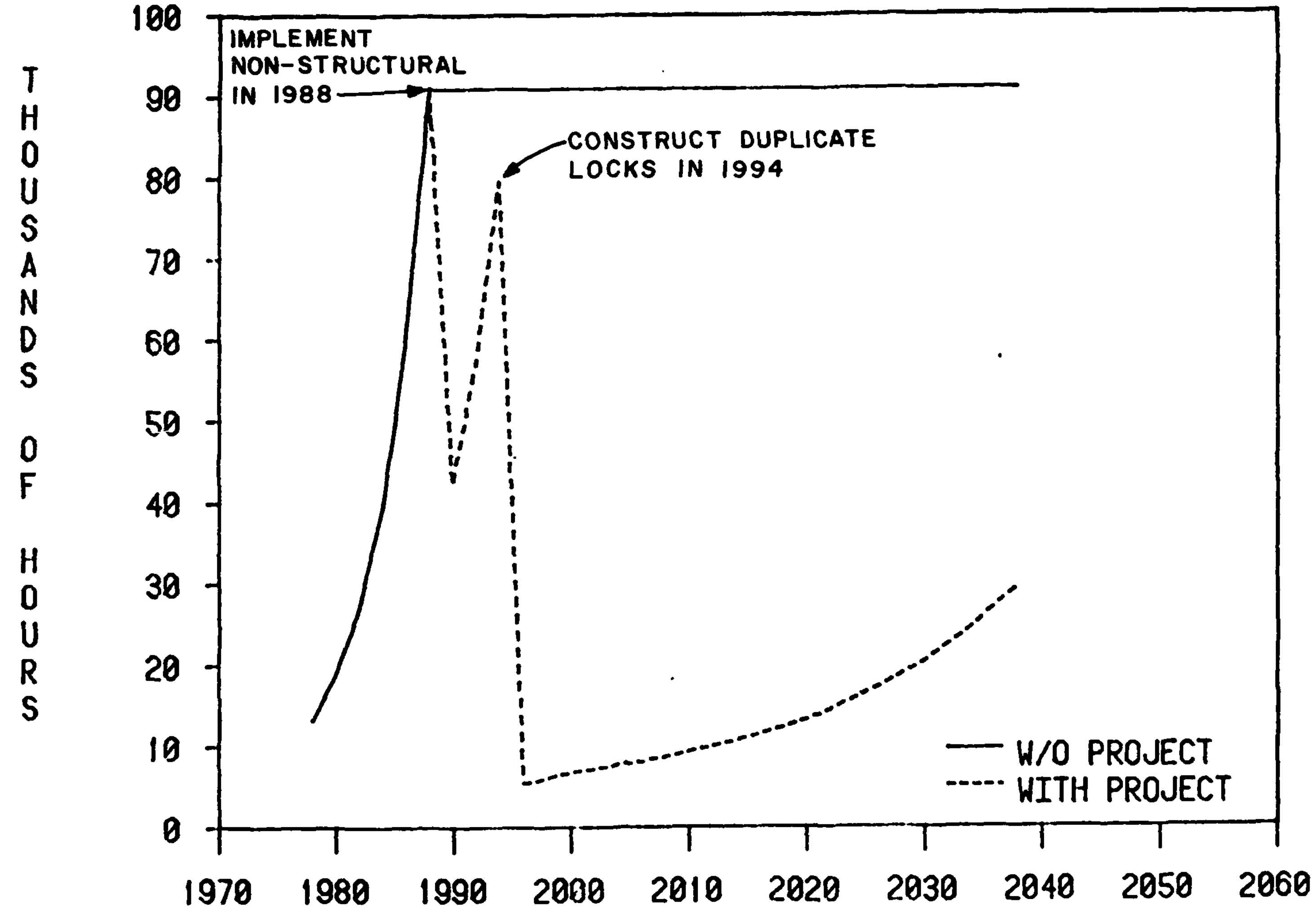
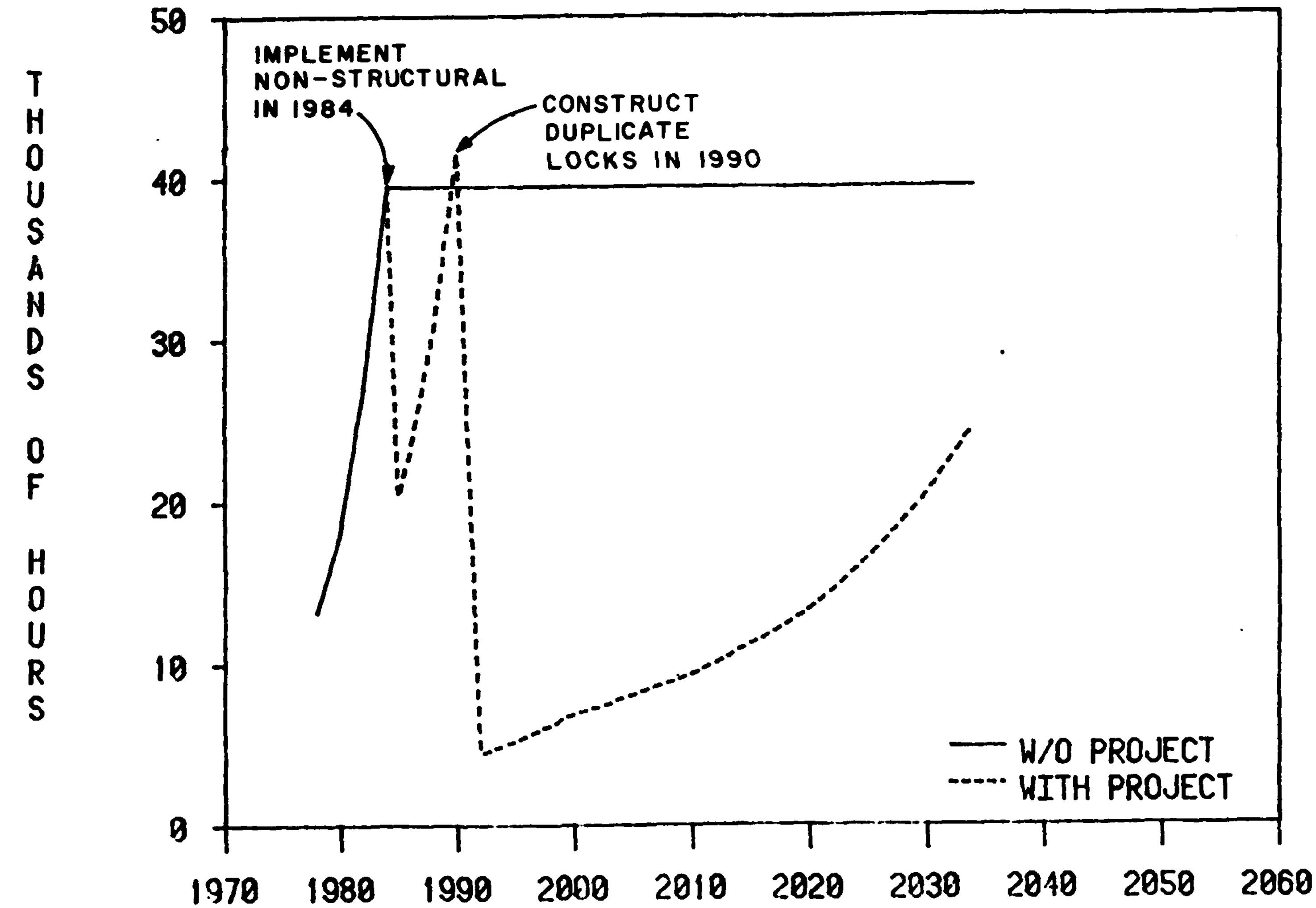


FIGURE B24

HIGH TRAFFIC - TWIN SEAWAY SIZE LOCKS
80% LOCK UTILIZATION



Delays which occur as the improved facilities become fully utilized may exceed the previous level of without project delays since significant changes in fleet mix will have occurred during this interval. During the period between these points in time, additional tons will have been serviced and these benefits (i.e., rate savings based on future tons moving via the water mode) will be credited to the plan. Therefore, differences in total average annual delay hours for similar time periods is the basis for delay reduction benefits.

Future delay hours under the alternative of twin seaway-size locks decreases, then rises to an intermediate peak value, then declines. These changes are a result of individual plan components; nonstructural improvements provide a short-term relief from initial capacity conditions. Structural modifications which follow result in a longer term reduction in annual delay hours relative to the base case. All other plans for the low traffic consist of structural modifications only. Total annual delay hours at the end of the nonstructural plan increment may exceed the without project level since changes in the fleet characteristics may have occurred during this intermediate period.

Delay calculations under the high traffic scenario have also been estimated. A similar method of evaluation (i.e., with project minus without project levels of delay for a similar time period) was also used to estimate future delay reduction benefits. A summary of the delay savings for both traffic forecasts and two levels of maximum lock utilization is provided in Tables B13 and B14.

Table B13 - Summary of Delay Reduction Benefits - Low Traffic

Alternative Condition	Average Annual Delays ($ 000)	Savings Over Base Case ($ 000)
Lock Utilization: 90 Percent		
Base Case (1)	44,434	-
Class 10 at 25.5 feet	11,582	32,852
Class 10 at 28.0 feet	5,358	39,076
Class 11 at 25.5 feet	10,770	33,664
Class 11 at 28.0 feet	7,105	37,329
Base Case	48,567 (2)	-
Class 7 at 25.5-foot draft	22,962	25,605
Lock Utilization: 80 Percent		
Base Case (3)	24,316	-
Class 10 at 25.5 feet	7,558	16,758
Class 10 at 28.0 feet	3,986	20,330
Class 11 at 25.5 feet	7,538	16,778
Class 11 at 28.0 feet	3,988	20,328
Base Case	24,911 (4)	-
Class 7 at 25.5-foot draft	14,158	10,753

(1) Annual delays increase from 1994 to a maximum value in 2002; future delays between 2002 and 2044 held constant. Base case delays shown are the equivalent average annual delay costs for U. S. traffic flows only.

(2) Delays associated with the initial capacity condition in 2002 are presumed to remain at this maximum value for all future time periods.

(3) Annual Delays increase from 1984 to a maximum value in 1988; future delays between 1988 and 2034 held constant. Base case delays shown are the equivalent average annual delay costs for U. S. traffic flows only.

(4) Delays associated with the initial capacity condition in 1988 are presumed to remain at this maximum value for all future time periods.

Table B14 - Summary of Delay Reduction Benefits - High Traffic

Alternative Condition	Average Annual Delays ($ 000)	Savings Over Base Case ($ 000)
Lock Utilization: 90 Percent		
Base Case (1)	59,105	-
Tandem Lockages	6,316	52,789
Parallel Locks	3,695	55,410
Base Case	63,388 (2)	-
Class 7 at 25.5-foot draft	20,591	42,797
Lock Utilization: 80 Percent		
Base Case (3)	27,013	-
Tandem Lockages	6,858	20,155
Parallel Locks	3,435	23,578
Base Case	27,332 (4)	-
Class 7 at 25.5-foot draft	11,429	15,903

(1) Annual delays increase from 1984 to a maximum value in 1988; future delays between 1988 and 2034 held constant. Base case delays shown are equivalent average annual delay costs for U. S. traffic flows only.

(2) Delays associated with the initial capacity condition in 1988 are presumed to remain at this maximum value for the period 1988 to 2038.

(3) Annual delays increase from 1982 to a maximum value in 1984; future delays between 1988 and 2032 held constant. Base case delays shown are the equivalent average annual delay costs for U. S. traffic flows only.

(4) Delays associated with the initial capacity condition in 1984 are presumed to remain at this maximum value for the period 1982 to 2034.

b. Rate Savings Benefit. The benefit evaluation of proposed commercial navigation projects is based upon the legislative requirements required by Public Law 89-670; 89th Congress, Second Session, Section 7(1) "Transportation Investment Standards" which explicity states that:

> "The primary direct navigation benefits of a water resource project are defined as the product of the savings to shippers using the waterway and the estimated traffic that would use the waterway; where the savings to shippers shall be constructed to mean the difference between (a) the freight rates or charges prevailing at the time of the study for the movement by the alternative means, and (b) those which would be charged on the proposed waterway; and where the estimate of traffic that would use the waterway will be based on such freight rates, taking into account projections of the economic growth of the area . . ."

Pursuant to PL 89-670, each Corps navigation study will include an estimate of savings to shippers via the considered waterway, measured as the product of the estimated waterway traffic and the estimated unit savings to shippers from the movement of that traffic via the waterway. The unit savings will be measured as the difference between the rates shippers are actually paying for transportation at the time of the study and the rates they probably would pay for transportation via the improved waterway.

Growth in future traffic through the St. Lawrence River locks will result in physical capacity conditions at some point in the future. Future traffic forecasted to move into or out of the Great Lakes Region beyond this point will require alternate transportation networks. This alternate transportation system will have higher costs per ton relative to the prevailing waterborne routing. These additional costs are the basis for the rate savings benefits.

Calculation of this category of benefit requires the identification of a future date of capacity based upon an assumed degree of lock utilization. The level of traffic forecast (i.e., high or low) is also a determinant of the date of initial capacity. Growth in tonnage beyond this point is considered to divert away from waterborne transportation to an alternate waterway route or an overland haul between the origin and destination. The product of the diverted tonnage and the additional costs per ton for all future years represents the undiscounted future benefit stream. All future benefits are discounted to the plan base year for each alternative.

Two types of improvements have been evaluated. One category of plan is implemented at a future date which is compatible with similar improvements at the Welland Canal. The second type of plan would be implemented at the future date when the St. Lawrence River would reach its initial physical capacity. The major difference between each category of plan is the extent of discounting required to bring future rate savings benefits back to their equivalent value at each base year. Only that portion of the rate savings benefits which lie within the project life cycle of the considered improvement is credited to each plan. Future rate savings for the low traffic scenario are shown in Tables B15 and B16.

Table B15 - Summary of Rate Savings Benefits - Low Traffic Forecast
Lock Utilization of 90 Percent

Design Vessel and Maximum Draft	Thousands of Dollars							
	Iron Ore	Coal	Grain	Stone	Other Bulk	General Cargo	Total	
	$	$	$	$	$	$	$	
Class 10 at 25.5 Feet	5,311	0.0	784	0.0	3,130	18,372	27,597	SLR Locks are credited with all U.S. traffic rate savings between 2002 and 2012; followed by a split of benefits with Soo Locks for period 2012-2044.
Class 10 at 28.0 Feet Class 11 at 25.5 Feet Class 11 at 28.0 Feet	5,310	0.0	759	0.0	3,116	18,338	27,523	Soo Locks improved to a compatible level with SLR and Welland Canal to facilitate system wide commodity flows. Traffic rate savings are split with U.S. investments at Soo Locks for entire plan evaluation period.
Class 7 at 25.5 Feet								
Nonstructural (1)	7,536	0.0	1,133	0.0	3,940	16,514	29,123	Twin Seaway locks to be built following the period of nonstructural improvements initiated in 2002.
Structural	2,683	0.0	319	0.0	2,236	20,963	26,201	
Total	10,219	0.0	1,452	0.0	6,176	37,477	55,324	

(1) Nonstructural improvements consist of a composite plan which includes traveling kevels, reduced dump/fill times and traffic control systems.

Table B16 - Summary of Rate Savings Benefits - Low Traffic Forecast
Lock Utilization of 80 Percent

Design Vessel and Maximum Draft	Thousands of Dollars							
	Iron Ore	Coal	Grain	Stone	Other Bulk	General Cargo	Total	
	$	$	$	$	$	$	$	
Class 10 at 25.5 Feet	7,017	0.0	1,608	0.0	3,780	11,370	23,775	SLR Locks are credited with all U.S. traffic rate savings between 1988 and 2004; followed by a split of benefits with Soo Locks for period 2004-2038.
Class 10 at 28.0 Feet Class 11 at 25.5 Feet Class 11 at 28.0 Feet	7,016	0.0	1,548	0.0	3,772	11,342	23,678	Soo Locks improved to a compatible level with SLR and Welland Canal to facilitate system wide commodity flows. Traffic rate savings are split with U.S. investments at Soo Locks for entire plan evaluation period.
Class 7 at 25.5 Feet								
Nonstructural (1)	7,506	0.0	1,827	0.0	3,870	11,524	24,727	Twin Seaway Locks to be built following the period of nonstructural improvements initiated in 1988.
Structural	1,487	0.0	181	0.0	987	3,633	6,288	
Total	8,993	0.0	2,008	0.0	4,857	15,157	31,015	

(1) Nonstructural improvements consist of a composite plan which includes traveling kevels, reduced dump/fill times and traffic control systems.

An alternate level of traffic was also considered in the calculation of future rate savings benefits. High traffic growth could result if annual growth rates based upon the National Waterways study were to occur in the future. Higher long-term growth rates would accelerate the date of a capacity condition at the St. Lawrence River locks. This would effectively result in a larger rate savings benefits for each considered plan of improvement. A summary of future rate savings benefits which would occur under a high traffic forecast is provided in Table B17.

c. Freight Rate Investigations. Individual O/D/C's identified as actively using the St. Lawrence River locks were used as the basis for gathering freight rates. Freight rates were collected for a substantial percentage of movements recorded in the base year (1978) and were the basis for quantifying transportation rate savings benefits. Rate differentials for major origin - destinations and the percent rate coverage are shown below. Rate savings benefits have been evaluated for individual commodity routings and rate differnetials have been apportioned between U.S. investments at the Soo Locks if a commodity routing requires transit via the locks at Sault Ste. Marie and the St. Lawrence River locks.

Freight Rate Coverage for St. Lawrence River Traffic Flows

Commodity	United States Traffic (1)	Traffic With Freight Rates	Percent Coverage	Average Unit Rate Savings
				$/NT
Iron Ore	11,059,500	10,798,850	98	7.05
Coal	600	0	0	0
Grain	16,775,300	15,543,900	93	4.75
Other Bulk	5,435,100	3,668,500	67	6.20
Steel	3,621,800	3,214,700	89	20.65
Other General Cargo	2,120,500	1,207,100	57	20.65

(1) Consists of U.S.-U.S., U.S,-Canada and U.S.-Foreign shipments or receipts recorded in 1978 which involve at least one U. S. Harbor.

Transportation rate savings for individual commodity groups expected to use a Great Lakes transport routing are based upon the difference between the total costs of a waterway mode and the total costs for shipment via the next most competitive alternative. Total costs include all handling and service charges, including inventory charges to reflect the time penalty or time savings which would be incurred for each type of routing. Average values per ton for major commodity groups, incremental time penalties and an inventory cost based upon an estimated cost of capital of 18 percent are shown below.

Table B17 - Summary of Rate Savings Benefits - High Traffic Forecast

Design Vessel and Maximum Draft	Thousands of Dollars						
	Iron Ore	Coal	Grain	Stone	Other Bulk	General Cargo	Total
	$	$	$	$	$	$	$
Lock Utilization: 90 Percent							
Tandem Lockages (1)	10,747	0.0	8,132	0.0	7,474	19,771	46,124
Parallel Locks (1)	10,747	0.0	8,132	0.0	7,474	19,771	46,124
Twin - Seaway (2)	14,986	0.0	11,214	0.0	27,797	10,479	64,476
Lock Utilization: 80 Percent							
Tandem Lockages (1)	11,797	0.0	10,798	0.0	10,479	64,476	57,895
Parallel Locks (1)	11,797	0.0	10,798	0.0	8,505	26,795	57,895
Twin - Seaway (2)	13,906	0.0	12,652	0.0	10,049	31,698	68,305

(1) Maximum size vessel is Class 10 which operates at existing drafts.

(2) Maximum size vessel is Class 7 which operates at existing drafts.

Commodity	Estimated Value	Ave Transit Times: Great Lakes	Ave Transit Times: Alternate Route	Time Penalty	Daily Inventory Cost	Great Lakes Freight Rate Adjustment
	$/NT				Cents/NT	$/NT
Steel	375	21	21	0	18	0.0
General Cargo	1,480	31	16	+15	73	+10.95
Iron Ore	25	5	7	- 2	1.2	- 0.025
Grains	152	2	11	- 9	7.5	- 0.675

Detailed comparisons between a Great Lakes transportation routing and the next most competitive alternative have been tabulated for the major origin-destinations. Rate differentials form the basis of transportation rate savings. Negative rate savings have been excluded from the benefits analysis. This unusual condition may have occurred in the study year for a variety of reasons: captive ownership of Great Lakes vessels, institutional constraints, short-term fluctuations in the demand for or supply of tidewater vessels, or random errors in the preparation of estimated total freight rates per ton for specific commodity routings.

d. Vessel Utilization Benefits. These future economic savings are based upon the decrease in unit transportation costs (dollars per ton) over a future time period which follows construction of larger locks or deeper channels in the St. Lawrence River. Fleet response to larger locks would include utilization of the maximum size design vessel operating at maximum allowable channel drafts to move the high volume dry bulk commodity requirements. Compatibility between downbound grain flows and upbound iron ore under existing conditions is expected to continue into the future. Therefore, this benefit evaluation was restricted to a measurement of decreases in the costs of shipping future levels of iron ore and grain. These benefits were further reduced to measure only that portion which would accrue to U.S. interests (i.e., restricted to traffic movements which involve at least one U.S. harbor).

Vessel hourly operating costs by ship size and transit times were used to estimate the total transportation costs per ton for future time periods. Lock capacity model outputs, such as the number of loaded vessel transits for each commodity group and physical characteristics of each type of vessel moving these commodities (i.e., average speed and trip capacity) were used to estimate the cost of waterborne transportation over the plan evaluation period. Average transport costs per ton decline rapidly following completion of larger locks as the future fleet response factors are processed by the lock capacity model. However, this sharp decline slowly flattens out for the balance of the forecast period.

Cumulative savings per ton are discounted for each future time period to a plan base year. The base year is defined as that point in time when an initial U.S. Federal investment is made at the U.S. locks in the St.Lawrence River. The present value of all future savings is subsequently converted to an equivalent average annual savings.

Individual plans of improvement for the low traffic forecast were evaluated based upon future transit statistics provided by the lock capacity model. Several plans that accommodate similar maximum design vessels may have only slight variations, therefore, vessel productivity savings may be approximately the same for several lock replacement alternatives.

The methodology will result in a larger level of savings per ton for alternatives which can accommodate the largest future vessel size expected to operate in the the St. Lawrence River. Also, individual plans with an early date of implementation will also be credited with larger vessel utilization savings. Expectations of higher traffic volumes (NWS forecast level) will also result in larger future savings. This is attributed to the nearly proportional relationship this category of economic benefits displays relative to the annual volumes of iron ore and grain processed at the St. Lawrence River locks.

Initial estimates of these future benefits were based upon total commodity movements. Only a portion of these total reductions in cost can be credited to U.S. investments. Origin/Destination/Commodity (O/D/C) movements were reviewed to determine the percent of total movements of each commodity which would involve at least one U.S. harbor. About 80 percent of all future iron ore activity involve shipments from Canadian Labrator-Quebec mines to U.S. Lake Erie destinations. These O/D/C's do not require transit via the Soo locks, therefore, 80 percent of the future cost reductions for iron ore (i.e., vessel utilization savings) was credited as a U.S. benefit.

Grain movements via the St. Lawrence River may involve origins above and below the Soo locks. An estimate of all grain flows which involve at least one U.S. harbor was further refined to reflect transit via the Soo locks and St. Lawrence River locks, in addition to the extent of future grain movements which would require a Welland/St. Lawrence River lock routing only. Total cost reduction savings for all future grain flows was calculated. Two adjustment factors were applied to estimated savings based upon whether or not compatible improvements would also have to be made at both upper and lower Great Lakes/St. Lawrence Seaway lock locations, or if only the lower locks would require modifications.

Future fleet composition or response to a particular plan of improvement directly affects the total number of annual vessel movements and the rate of change (increase or decrease) during the plan evaluation period. Fleet responses were developed based upon field interviews and a review of the ships constructed following completion of the Poe Lock. A matrix of future fleets which produce reductions in the future transportation costs is provided in Table B18.

Table B18 - Future Fleet Response - St. Lawrence River Locks

Scenario	Marginal Response Rate by Vessel Class								
	4	5	6	7	8	9	10	11	12
Without Project Conditions									
Ore	0.00	0.20	0.00	0.80	-	-	-	-	-
Coal	0.00	0.10	0.10	0.80	-	-	-	-	-
Stone	0.00	0.20	0.10	0.70	-	-	-	-	-
Grain	0.00	0.05	0.35	0.60	-	-	-	-	-
Other Bulk	0.20	0.30	0.30	0.20	-	-	-	-	-
General Cargo	0.20	0.00	0.80	0.00	-	-	-	-	-
Poe-Size Locks (1,000 X 105-Foot Design Vessels)									
Ore	0.00	0.00	0.10	0.10	0.00	0.00	0.80	-	-
Coal	0.00	0.00	0.05	0.35	0.10	0.00	0.50	-	-
Stone	0.25	0.05	1.10	0.60	0.00	0.00	0.00	-	-
Grain	0.00	0.00	0.15	0.05	0.00	0.00	0.80	-	-
Other Bulk	0.20	0.30	0.30	0.20	0.00	0.00	0.00	-	-
General Cargo	0.10	0.10	0.40	0.05	0.30	0.05	0.00	-	-
1,100- X 105-Foot Design Vessel Size									
Ore	0.00	0.00	0.10	0.10	0.00	0.00	0.60	0.20	-
Coal	0.00	0.00	0.05	0.35	0.10	0.00	0.40	0.10	-
Stone	0.25	0.05	0.10	0.60	0.00	0.00	0.00	0.00	-
Grain	0.00	0.00	0.15	0.05	0.00	0.00	0.60	0.20	-
Other Bulk	0.20	0.30	0.30	0.20	0.00	0.00	0.00	0.00	-
General Cargo	0.10	0.10	0.40	0.05	0.30	0.05	0.00	0.00	-
1,200- X 130-Foot Design Vessel Size									
Ore	0.00	0.00	0.10	0.10	0.00	0.00	0.30	0.30	0.20
Coal	0.00	0.00	0.05	0.35	0.10	0.00	0.20	0.20	0.10
Stone	0.25	0.05	0.10	0.60	0.00	0.00	0.00	0.00	0.00
Grain	0.00	0.00	0.15	0.05	0.00	0.00	0.30	0.30	0.20
Other Bulk	0.10	0.15	0.20	0.20	0.20	0.15	0.00	0.00	0.00
General Cargo	0.10	0.10	0.20	0.10	0.30	0.20	0.00	0.00	0.00

A summary of the intermediate calculations for each plan considered is provided in Tables B19 through B24.

Table B19 - Future Unit Transportation Costs Class 10 at 25.5-foot Draft

(80 Percent Lock Utilization)

Future Time Periods	Transits by Vessel Class: 4 Grain	4 Iron Ore	5 Grain	5 Iron Ore	6 Grain	6 Iron Ore	7 Grain	7 Iron Ore	10 Grain	10 Iron Ore	Average Costs Per Ton: Grain	Average Costs Per Ton: Iron Ore
											$	$
1984	207	-	152	231	900	0	775	399	-	-	12.202	4.598
1985	65	-	81	123	600	7	625	332	180	72	10.236	4.210
1990	0	-	58	89	549	24	629	344	252	140	9.572	4.031
2000	0	-	23	37	424	24	635	345	314	164	9.178	3.925
2010	0	-	16	26	249	33	522	290	450	228	9.419	3.766
2020	0	-	7	7	234	43	467	266	530	282	8.133	3.664
2030	0	-	0	0	205	61	178	119	704	425	7.282	3.696
2038 (1)	0	-	0	0	194	64	157	112	765	425	7.185	3.410

(1) Calculation of reduction in cost per ton truncated in project year 50. Data inputs required to estimate interpolated vessel transits and costs per ton may fall outside of project evaluation period.

Table B20 - Future Unit Transportation Costs Class 10 at 25.5-foot Draft

(90 Percent Lock Utilization)

Future Time Periods	Transits by Vessel Class: 5 Grain	5 Iron Ore	6 Grain	6 Iron Ore	7 Grain	7 Iron Ore	10 Grain	10 Iron Ore	Average Costs Per Ton: Grain	Average Costs Per Ton: Iron Ore
									$	$
1994	133	206	935	0	1,045	580	-	-	11.557	4.587
2000	20	30	425	17	882	499	228	98	9.906	4.171
2010	18	23	242	24	721	415	385	174	8.995	3.938
2020	7	7	228	37	642	375	471	235	8.580	3.820
2030	0	0	204	56	227	151	687	375	7.396	3.476
2040	0	0	187	64	188	134	768	425	7.234	3.439
2044	0	0	196	69	172	127	802	446	7.191	3.425

Table B21 - Future Unit Transportation Costs
Class 11 at 25.5-foot Draft
(80 Percent Lock Utilization)

Future Time Periods	Transits by Vessel Class: 4		5		6		7		10		11		Average Costs Per Ton	
	Grain	Iron Ore	Grain	Iron Ore	Grain	Iron Ore	Grain	Iron Ore	Grain	Iron Ore	Grain	Iron Ore	Grain	Iron Ore
													$	$
1984	151	-	142	242	875	0	826	392	-	-	-	-	12.058	4.613
1985	50	-	81	135	597	7	706	344	113	48	38	17	10.442	4.316
1990	0	-	58	96	543	22	708	351	164	98	55	31	9.797	4.026
2000	0	-	23	39	417	24	716	356	211	116	68	40	9.398	3.966
2010	0	-	16	30	244	31	587	298	317	164	103	53	8.615	3.772
2020	0	-	7	7	228	40	524	274	377	204	120	64	8.256	3.636
2030	0	-	0	0	204	58	193	123	516	285	165	92	7.312	3.439
2040 (1)	0	-	0	0	187	64	163	111	574	321	187	104	7.210	3.414

(1) Calculation of reduction in costs per ton truncated in project year 50. Data inputs required to estimate interpolated vessel transits and costs per ton may fall outside of project evaluation period.

Table B22 - Future Unit Transportation Costs
Class 11 at 25.5-foot Draft

(90 Percent Lock Utilization)

Future Time Periods	Transits by Vessel Class 5 Grain	5 Iron Ore	6 Grain	6 Iron Ore	7 Grain	7 Iron Ore	10 Grain	10 Iron Ore	11 Grain	11 Iron Ore	Average Costs Per Ton Grain	Average Costs Per Ton Iron Ore
											$	$
1994	129	203	936	0	1,045	581	-	-	-	-	11.537	4.578
2000	20	30	425	17	882	499	166	72	55	24	9.894	4.176
2010	16	23	241	20	720	414	284	129	92	40	8.982	3.907
2020	7	7	225	37	642	374	346	172	112	55	8.560	3.798
2030	0	0	204	55	227	150	509	276	164	88	7.423	3.456
2040	0	0	187	64	187	133	566	314	181	120	7.207	3.447
2044	0	0	192	68	172	127	591	330	190	109	7.174	3.450

Table B23 - Future Unit Transportation Costs
Class 10 at 28.0-foot Draft

(80 Percent Lock Utilization)

Future Time Periods	Transits by Vessel Class										Average Costs Per Ton	
	4		5		6		7		10			
	Grain	Iron Ore	Grain	Iron Ore	Grain	Iron Ore	Grain	Iron Ore	Grain	Iron Ore	Grain	Iron Ore
1984	151	-	142	242	875	0	826	392	-	-	12.058	4.613
1985	50	-	77	132	550	5	669	327	48	24	8.703	3.650
1990	0	-	54	93	500	16	674	337	122	96	8.267	3.547
2000	0	-	23	39	384	17	681	344	196	124	8.114	3.520
2010	0	-	16	30	220	31	560	287	362	195	7.711	3.480
2020	0	-	7	7	205	40	498	262	450	252	7.504	3.404
2030	0	-	0	0	188	55	182	117	668	371	6.958	3.292
2038 (1)	0	-	0	0	174	64	157	108	748	419	6.892	3.295

(1) Calculation of reduction in costs per ton truncated in project year 50. Data inputs required to estimate interpolated vessel transits and costs per ton may fall outside of project evaluation period.

Table B24 - Future Unit Transportation Costs
Class 10 at 28.0-foot Draft

(90 Percent Lock Utilization)

Future Time Periods	Transits by Vessel Costs 5 Grain	5 Iron Ore	6 Grain	6 Iron Ore	7 Grain	7 Iron Ore	10 Grain	10 Iron Ore	Average Costs Per Ton Grain	Average Costs Per Ton Iron Ore
1994	129	203	936	0	1,045	581	-	-	11.225	4.578
2000	17	30	386	7	840	479	122	55	7.280	3.597
2010	16	23	213	24	686	397	306	137	6.879	3.530
2020	7	7	204	31	611	359	401	202	6.873	3.465
2030	0	0	187	55	213	145	654	357	6.947	3.321
2040	0	0	172	63	180	127	737	409	6.898	3.307
2050 (1)	0	0	194	71	143	111	824	464	6.943	3.292

(1) Calculation of reduction in costs per ton truncated in project year 50. Data inputs required to estimate interpolated vessel transits and costs per ton may fall outside of project evaluation period.

B7.5 Summary and Conclusions.

A range of alternative plans were evaluated to address future capacity problems for the U.S. locks in the St. Lawrence River. Each plan was considered as a mutually exclusive alternative to be implemented either in conjunction with a similar improvement at the Welland Canal (as in the case of larger locks) or initiated at a future date when the existing locks in the St. Lawrence River would become capacity constrained (as in the case of duplicate locks). Economic feasibility was restricted to a comparison of U.S. benefits to expected U.S. costs. A summary of the benefits for each plan is provided in Tables B25 and B26.

Table B25 - Summary of Benefits - Low Traffic Forecast

Base Year	Maximum Vessel Size and Operating Draft	Rate Savings (Thousands of Dollars)	Delay Savings (Thousands of Dollars)	Vessel Productivity (1): Iron Ore (Thousands of Dollars)	Vessel Productivity (1): Grain (Thousands of Dollars)	Total Average Annual Benefits (Millions of Dollars)
		$	$	$	$	
	Class 10 at 25.5 feet					
1985	80 percent	23,800	16,800	10,300	65,700	116.6
1994	90 percent	27,600	32,900	9,500	49,700	119.7
	Class 11 at 25.5 feet					
1985	80 percent	23,700	16,800	10,300	43,400	94.2
1994	90 percent	27,500	33,700	9,500	36,700	107.4
	Class 10 at 28.0 feet					
1985	80 percent	23,700	20,300	17,400	64,800	126.2
1994	90 percent	27,500	39,100	15,900	62,800	145.3
	Class 11 at 28.0 feet					
1985	80 percent	23,700	20,300	17,400	65,900	127.3
1994	90 percent	27,500	37,300	12,800	54,500	132.1
	Twin Seaway/Class 7 at 25.5 feet					
1988	80 percent	31,000	10,800	0	0	41.8
2002	90 percent	55,300	25,600	0	0	80.9

(1) Based upon percent of total commodity movements which involve at least one U. S. harbor.

Table B26 - Summary of Benefits - High Traffic Forecast

Base Year	Maximum Vessel Size and Operating Draft	Thousands of Dollars				Millions of Dollars
		Rate Savings	Delay Savings	Vessel Productivity (1) Iron Ore	Vessel Productivity (1) Grain	Total Average Annual Benefits
		$	$	$	$	$
	Tandem Locks/Class 10 at 25.5 feet					
1982	80 percent	57,900	20,100	9,900	101,200	189.1
1984	90 percent	46,100	52,800	10,600	94,600	204.1
	Parallel Locks/Class 10 at 25.5 feet					
1982	80 percent	57,900	23,600	9,900	101,200	192.6
1984	90 percent	46,100	55,400	10,400	94,100	206.0
	Twin Seaway/Class 7 at 25.5 feet					
1984	80 percent	68,300	15,900	0	0	84.2
1988	90 percent	64,500	42,800	0	0	107.3

(1) Based upon percent of total commodity movements which involve at least one U. S. harbor.

SUPPLEMENT 1

Freight rate investigations completed in support of this lock capacity study during 1981 are shown in summary form in this supplement. General origins or destinations and the estimated total cost of these commodity movements are provided for general reference only. Detailed documentation has been developed by Booz, Allen and Hamilton, Inc., in their report titled Analysis of Freight Rates, September 1981

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Table S1 - Freight Rate Summary

Commodity: General Cargo (Non-steel Products)

Great Lakes Routing			Alternate Routing (2)			Transportation
Origin	Destination	Total Cost (1) ($/NT)	Mode	Destination	Total Cost (1) ($/NT)	Rate Differential
Europe	Chicago	127.10	O/T-R	Montreal	191.20	64.10
Europe	Detroit	155.50	O/T-R	Montreal	127.00	-28.50
Chicago	Europe	138.00	T-R/O	Montreal	157.30	19.30
Overseas	Toledo	180.80	R/O	Baltimore	174.90	- 5.90
Detroit	Europe	165.60	T-R/O	Montreal	128.00	-37.60

O = Ocean Haul
T = Truck Haul
R = Rail Haul

(1) Total costs per ton include all related charges for services required to move the material from origin to ultimate destination.

(2) Alternate routing shown is the least cost option available at the time of this study. Intermodal requirements frequently involve transshipment at deep-draft ocean ports.

Table S2 - Freight Rate Summary

Commodity: General Cargo (Steel Products)

Great Lakes Routing			Alternate Routing (2)			Transportation
Origin	Destination	Total Cost (1) ($/NT)	Mode	Destination	Total Cost (1) ($/NT)	Rate Differential
Europe	Detroit	38.09	O/R	Baltimore	69.07	30.98
Overseas	Cleveland	53.60	O/R	Baltimore	67.59	13.99
Overseas	Chicago	46.35	O/B	Gulf Coast Ports	63.18	16.83
Overseas	Toledo	52.07	O/R	Baltimore	74.51	22.44

O = Ocean Haul
R = Rail Haul
B = Barge Haul

(1) Total costs per ton include all related charges for services required to move the material from origin to ultimate destination.

(2) Alternate routing shown is the least cost option available at the time of this study. Intermodal requirements frequently involve transshipment at deep-draft ocean ports.

Table S3 - Freight Rate Summary

Commodity: Iron Ore

Great Lakes Routing: Origin	Destination	Total Cost (1) ($/NT)	Alternate Routing (2): Mode	Origin	Total Cost (1) ($/NT)	Transportation Rate Differential
Western L. Superior	Chicago	13.02	All Rail	-	17.01	3.99
Western L. Superior	Detroit	11.76	W/R	Quebec	20.43	8.67
Western L. Superior	Toledo	19.94	W/R	Quebec	18.51	-1.43
Western L. Superior	Huron	19.38	W/R	Quebec	17.10	-2.28
Western L. Superior	Lorain	12.47	W/R	Quebec	18.46	5.99
Western L. Superior	Cleveland	12.47	W/R	Quebec	18.47	6.00
Western L. Superior	Conneaut	20.42	W/R	Quebec	17.10	-3.32
Western L. Superior	Ashtabula	20.20	W/R	Quebec	17.29	-2.91
Presque Is.	Conneaut	16.21	W/R	Quebec	17.10	0.89
Presque Is.	Ashtabula	15.97	W/R	Quebec	17.30	1.33
Western L. Superior	Buffalo	14.88	W/R	Quebec	17.85	2.97
Canada/ St. Lawrence	Buffalo	7.25	W/R	Quebec	17.85	10.60
Canada/ St. Lawrence	Conneaut	15.14	W/R	Quebec	17.10	1.96
Canada/ St. Lawrence	Cleveland and Lorain	7.49	W/R	Quebec	18.47	10.98
Canada/ St. Lawrence	Toledo	14.96	W/R	Quebec	18.51	3.55
Canada/ St. Lawrence	Detroit	7.49	W/R	Quebec	20.43	12.94
Canada/ St. Lawrence	Ashtabula	13.58	W/R	Quebec	17.30	3.72
Canada/ St. Lawrence	Chicago, Gary & Burns Harbor	8.84	All Rail	Quebec	17.00	8.16

(1) Total costs per ton include all related charges for services required to move the material from origin to ultimate destination.

(2) Alternate routing shown is the least cost option available at the time of this study. Intermodal requirements frequently involve transshipment at deep-draft ocean ports.

Table S4 - Freight Rate Summary

Commodity: Coal

Great Lakes Routing: Origin	Destination	Total Cost (1) ($/NT)	Alternate Routing (2): Mode	Origin	Total Cost (1) ($/NT)	Transportation Rate Differential
Conneaut Harbor	Taconite Harbor	20.05	All Rail	Appalachian: Coal Mines	28.96	8.91
Ashtabula & Conneaut Hrb	Ashland	14.87	All Rail	Appalachian: Coal Mines	27.75	12.88
Toledo Harbor	Ashland	17.08	All Rail	Appalachian: Coal Mines	26.83	9.75
Calumet Harbor	Taconite	15.90	All Rail	Appalachian: Coal Mines	20.77	4.37
Toledo & Sandusky Hrb	Duluth, MN	15.75	All Rail	Appalachian: Coal Mines	27.75	12.00
Ashtabula Harbor	Duluth, MN	13.68	All Rail	Appalachian: Coal Mines	28.96	15.28
Toledo Harbor	Silver Bay Taconite	16.24	All Rail	Appalachian: Coal Mines	29.02	12.78
Toledo and Sandusky Hrb	Presque Is. & Marquette	15.41	All Rail	Appalachian: Coal Mines	26.00	10.59
Ashtabula & Conneaut Hrb	Presque Is. & Marquette	14.14	All Rail	Appalachian: Coal Mines	26.00	11.86
Superior, WS	St. Clair, MI	13.51	All Rail	Appalachian: Coal Mines	31.00	17.4
Ashtabula & Conneaut Hrb	Hamilton, Ontario	17.18	All Rail	Appalachian: Coal Mines	22.33	5.15

(1) Total costs per ton include all related charges for services required to move the material from origin to ultimate destination.

(2) Alternate routing shown is the least cost option available at the time of this study. Intermodal requirements frequently involve transshipment at deep-draft ocean ports.

Table S5 - Freight Rate Summary

Commodity: Other Bulk

Item	Great Lakes Routing: Origin	Great Lakes Routing: Destination	Great Lakes Routing: Total Cost (1) ($/NT)	Alternate Routing (2): Mode	Alternate Routing (2): Origin	Alternate Routing (2): Total Cost (1) ($/NT)	Transportation Rate Differential
Scrap Steel	Detroit	Europe and Asia	51.03	R/O	Baltimore	57.80	6.77
Coke	Europe	Calumet and Burns Hrb.	35.00	R/O	New Orleans	41.01	6.01
Cement and Clinker	Aldena, MI	Duluth/ Superior	4.00	R/O	Tranship at Escanaba to Rail Car	19.38	15.38
Coke	Europe	Toledo	30.25	R/O	Baltimore	36.40	6.15
Coke	Europe	Detroit	30.50	R/O	Baltimore	37.38	6.88
Coke	Europe	Buffalo	29.50	R/O	New York	34.80	5.30
Oil	South America	Oswego	32.22	R/O	Transfer to Barge at Albany	35.69	3.47
Oil	Gulf of St Lawrence	Oswego	32.22	R/O	Same as Above	35.69	3,47
Lime-stone	Calcite	Ashland	4.71	R/O	Transship at Escanaba to Rail Car	19.38	14.67
Lime-stone	Calcite	Duluth/ Superior	4.71	R/O	Same as Above	19.38	14.67
Oats	Duluth/ Superior	All Foreign Destination	54.72	All Rail	West Coast Ports	57.82	3.10
Oil	Indiana Harbor	Duluth/ Superior	7.60	All Rail	Whiting, IN	28.00	20.40

(1) Total costs per ton include all related charges for services required to move the material from origin to ultimate destination.

(2) Alternate routing shown is the least cost option available at the time of this study. Intermodal requirements frequently involve transshipment at deep-draft ocean ports.

Table S6 - Freight Rate Summary

Commodity: Grains

Item	Great Lakes Routing: Origin	Destination	Total Cost (1) ($/NT)	Alternate Routing (2): Mode	Origin	Total Cost (1) ($/NT)	Transportation Rate Differential
Wheat	Duluth/ Superior	Overseas	54.72	All Rail	West Coast Ports	57.82	3.10
Barley & Rye	Duluth/ Superior	Overseas	47.22	T/R	West Coast Ports	53.70	6.48
Sun-flower Seeds	Duluth/ Superior	Overseas	52.66	T/R	Gulf Coast Ports	55.38	2.72
Wheat	Duluth/ Superior	Buffalo, NY	37.72	All Rail	Midwest Elevators	47.72	10.00
Barley & Rye	Duluth/ Duperior	Buffalo, NY	30.22	All Rail	Midwest Elevators	40.22	10.00
Corn	Duluth/ Superior	Overseas	40.78	T/R	Gulf Coast Ports	39.62	- 1.16
Corn	Chicago	Overseas	34.20	T/R/ B	Gulf Coast Ports	33.58	- 0.67
Soy-beans	Chicago	Overseas	34.12	T/R/ B	Gulf Coast Ports	34.76	0.64
Corn	Milwaukee	Overseas	33.10	T/B	Gulf Coast Ports	38.92	5.82
Corn	Toledo	Overseas	30.64	T/R	East Coast Ports	34.30	3.66
Soy-beans	Toledo	Overseas	30.12	T/R	East Coast Ports	33.78	3.66
Wheat	Saginaw	Overseas	31.18	T/R	East Coast Ports	37.82	6.64
Corn	Saginaw	Overseas	31.98	T/R	East Coast Ports	37.88	5.90

(1) Total costs per ton include all related charges for services required to move the material from origin to ultimate destination.

(2) Alternate routing shown is the least cost option available at the time of this study. Intermodal requirements frequently involve transshipment at deep-draft ocean ports.

SUPPLEMENT 2

LOCK CAPACITY DATA FILES

Each lock system is represented by its own data file. Each data file includes not only system, lock and vessel data, but incorporates run parameters which allows the model to evaluate each part of the GL/SLS separately or as a complete system-wide run. Run parameters determine the lock system, maximum vessel class, locking time range(s) and length of operating season to be analyzed.

Portions of the data file have been adjusted to reflect either new information or modifications to the existing program developed by ARCTEC, Inc. The St. Lawrence River data is shown below.

ST. LAWRENCE RIVER LOCKS
DATA FILE

```
1,3                      GUMOGU, DATA FILE IDENTIFIER : L210B10
 7                       MAXIMUM VESSEL CLASS
0,1,0,0                  SEASON EXTENSIONS  (8.5,9.5,9.0,10.0)
1,0,0                    LOCKING TIMES (NORMAL,LOW,HIGH)
0.70,0.70,0.70,0.70,0.70,0.70,0.70,0.70,0.70       SHIP UTILIZATION FACTORS
1.00,5.00,05.00,00.00,36.00,00.33,00.00,00.00     FACTOR,CALFAC,SYSFAC,SYSADD,SYSTEM
0.90,9999                 UTILIZATION AT CAPACITY, YEAR FOR IMPROV AT SLR ONLY
```

See note 1.

```
FACTORS TO INCREASE/DECREASE TRAFFIC FORECASTS BY COMMODITY TYPE
WHT  SYB  RHR  CRN  OSD  STN  ORE  RAW  COL  PET  CEM  NMT  DBL  GEN  STL
1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00
```

Adjustment factors for future commodity movements. This option was not used.

```
FLEET MIX SHIP BUILDING FACTORS - 1978 FLEET WITHOUT PROJECT CONDITIONS
ORE  COAL  STONE GRAIN OBULK GCARGO    CLASS
0.00  0.00  0.00  0.00  0.20  0.20       4
0.20  0.10  0.20  0.05  0.30  0.00       5 (LAKER 5 & 6)
0.00  0.10  0.10  0.35  0.30  0.80       6 OCEAN VESSELS
0.80  0.80  0.70  0.60  0.20  0.00       7
CARRYING CAPACITY BY SHIP CLASS (IN SHORT TONS) AT 25.5 DRAFT
   4      5      6      7
09500. 21000. 15000. 27000.  IRON ORE _ STONE
08700. 14000. 15000. 21000.  COAL _ GRAIN
08700. 14000. 15000. 21000.  BULK _ GENERAL CARGO
MAXIMUM CAPACITY BY SHIP CLASS (IN SHORT TONS) REGARDLESS OF DEPTH
   4      5      6      7
09500. 25100. 36900. 38500.        IRON ORE - STONE
08700. 17800. 29600. 31300.        COAL - GRAIN
08700. 17600. 29600. 31300.        OTH. BLK. - GEN. CARGO
```

Represents the upper limit of vessel carrying capacities for the current (base line) fleet.

```
DAYS PER OPERATING PERIOD
  JAN  FEB  MAR  APR  APR  MAY  JUN  JUL  AUG  SEP  OCT  NOV  DEC  DEC
   0.   0.   0.  15.  15.  31.  30.  31.  31.  30.  31.  30.  15.   0.
```

Adjustment factors for fractional navigation seasons (ie., 2 week operation in December; 8.5 months)

```
TRANSIT DISTRIBUTION FACTOR FOR VALIDATION
  JAN  FEB  MAR  APR  APR  MAY  JUN  JUL  AUG  SEP  OCT  NOV  DEC  DEC
 .000 .000 .000 .020 .040 .130 .124 .124 .124 .124 .124 .130 .040 .020
 .000 .000 .000 .030 .045 .125 .120 .120 .120 .120 .120 .125 .040 .035
 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000
CARGO PROJECTIONS  **** 1978 ****  (SHORT TONS / YEAR)
DOWNBOUND
15549.  2365.  2683.  6666.  1282.   110.    0.     809.   1.    889.
1.      1127.  2675.  1118.  195.
                **** 1978 ****
UPBOUND
0.      0.     6.     0.     0.      46.    13826.  17.   1003.  1985.
107.    827.   2365.  1868.  3724.
                **** 1985 ****
DOWNBOUND
20034.  1704.  4283.  7252.  1297.   112.    0.     861.   1.    965.
1.      1267.  3132.  1220.  306.
                **** 1985 ****
UPBOUND
0.      0.     8.     0.     0.      49.    16015.  16.   1095.  2100.
132.    922.   2406.  2037.  8610.
                **** 1990 ****
DOWNBOUND
22478.  1807.  5463.  6237.  1310.   126.    0.     1050.  1.    1021.
1.      1376.  3489.  1297.  314.
                **** 1990 ****
UPBOUND
0.      0.     20.    0.     0.      55.    19873.  18.   1161.  2181.
151.    996.   2442.  2165.  7066.
                **** 2000 ****
DOWNBOUND
```

Low traffic forecasts by decade and commodity group. See note 2 for alternate level of traffic. Sequence of commodities is the same as the commodity adjustment matrix shown above.

```
23337.   1991.    6284.    5866.    1338.    139.     0.       1234.    1.       1124.
2.       1626.    4140.    1460.    403.
                       **** 2000 ****
UPBOUND
0.       0.       23.      0.       0.       62.      20263.   18.      1279.    2334.
200.     1150.    2499.    2430.    7431.
                       **** 2010 ****
DOWNBOUND
25081.   2112.    7048.    6405.    1364.    157.     0.       1466.    2.       1235.
2.       1957.    4831.    1645.    529.
                       **** 2010 ****
UPBOUND
0.       0.       25.      0.       0.       69.      22495.   19.      1411.    2500.
256.     1321.    2558.    2727.    9236.
                       **** 2020 ****
DOWNBOUND
26898.   2154.    7647.    7062.    1392.    180.     0.       1742.    2.       1358.
2.       2419.    5565.    1852.    629.
                       **** 2020 ****
UPBOUND
0.       0.       25.      0.       0.       80.      24860.   19.      1556.    2679.
327.     1524.    2636.    3060.    7588.
                       **** 2030 ****
DOWNBOUND
29381.   2198.    8296.    7712.    1419.    206.     0.       2071.    2.       1494.
2.       3079.    6448.    2086.    876.
                       **** 2030 ****
UPBOUND
0.       0.       25.      0.       0.       90.      27389.   20.      1715.    2675.
418.     1768.    2728.    3435.    11890.
                       **** 2040 ****
DOWNBOUND
31864.   2242.    8946.    8341.    1448.    236.     0.       2460.    3.       1646.
2.       4051.    7474.    2350.    1172.
                       **** 2040 ****
UPBOUND
0.       0.       25.      0.       0.       103.     30067.   20.      1890.    3087.
534.     2061.    2683.    3857.    15602.
                       **** 2050 ****
DOWNBOUND
34289.   2287.    10244.   9108.    1463.    270.     0.       2923.    3.       1817.
3.       5508.    8664.    2648.    1551.
                       **** 2050 ****
UPBOUND
0.       0.       25.      0.       0.       119.     33016.   21.      2084.    3319.
682.     2410.    2982.    4331.    19491.
HOURS AVAILABLE FOR LOCKING OPERATIONS BY MONTH
 JAN  FEB  MAR  APR  APR  MAY  JUN  JUL  AUG SEPT  OCT  NOV  DEC  DEC
23.2 23.0 23.7 23.2 23.2 23.2 23.3 23.3 23.2 23.2 23.2 22.9 23.2 23.2
LOCKING TIME IN MINUTES BY SHIP CLASS
   4     5     6     7    SHIP CLASS
0034. 0034. 0039. 0041.   DOWN      FOR CONSTRAINING LOCK
0034. 0034. 0040. 0041.   UP
0031. 0031. 0036. 0037.   DOWN      FOR NON-CONSTRAINING LOCK
0031. 0031. 0036. 0037.   UP
LOW TIMES
   4     5     6     7    SHIP CLASS
0034. 0034. 0038. 0040.   DOWN      FOR CONSTRAINING LOCK
0033. 0033. 0039. 0040.   UP
0031. 0031. 0035. 0036.   DOWN      FOR NON-CONSTRAINING LOCK
```

```
0031. 0031. 0035. 0036.  UP
HIGH TIMES
  4     5     6     7    SHIP CLASS
0035. 0035. 0040. 0042.  DOWN      FOR CONSTRAINING LOCK
0035. 0035. 0041. 0041.  UP
0032. 0032. 0037. 0039.  DOWN      FOR NON-CONSTRAINING LOCK
0032. 0032. 0037. 0037.  UP
LOCKING TIME STANDARD DEVIATION IN MINUTES BY SHIP CLASS
  4     5     6     7    SHIP CLASS
002.7 002.7 002.8 003.0  DOWN      FOR CONSTRAINING LOCK
002.7 002.7 002.8 003.0  UP
002.3 002.3 002.7 002.8  DOWN      FOR NON-CONSTRAINING LOCK
002.3 002.3 002.7 002.8  UP
VALIDATION BIAS TRAFFIC FACTORS
 L.AP  L.AP  L.DC  L.DC
01.00 00.80 00.20 00.80
TURNBACK TIME IN MINUTES BY LOCK
CON.  NON-C.
0000. 0000. 0000.
SHIP COST ($/HOUR) BY SHIP CLASS
   4       5       6       7       8       9       10      11     SHIP CLASS
000373. 000396. 000254. 000435. 000423. 000553. 000579. 000632.  OPERATING COST
000287. 000356. 000236. 000438. 000493. 000630. 000767. 000877.  CAPITAL COST
NON-COMMERCIAL CRAFT DAILY ARRIVAL _ ICE LOCKAGES
JAN  FEB  MAR  APR  APR  MAY  JUN  JUL  AUG  SEP  OCT  NOV  DEC  DEC
00.0 00.0 00.0 00.0 00.0 00.0 01.0 01.5 01.5 01.0 00.0 00.0 00.0 00.0   UP
02.0 03.0 03.0 01.0 00.0 00.0 01.0 01.5 01.5 01.0 00.0 00.0 00.0 00.0   DN
LOADING FACTOR - FLOAD
O   C   S   G    OB  GC
1.001.001.001.000.950.85
ONE WAY DISTANCES(DISIN)
  ORE   COAL   STONE  GRAIN  O BULK G CARGO
01025. 00237. 00187. 01412. 00542. 01080.   DN
00588. 00589. 00589. 01043. 00589. 00684.   UP
LOADING RATE (FILL)
  ORE   COAL   STONE  GRAIN  O BULK G CARGO
02800. 09000. 02800. 01481. 00600. 00150.   4
02800. 09000. 02800. 01481. 00600. 00150.   5
02800. 09000. 02800. 01481. 00600. 00150.   6
02800. 09000. 02800. 01481. 00600. 00150.   7
UNLOADING RATE (EMPTY)
  ORE   COAL   STONE  GRAIN  O BULK G CARGO
02800. 01848. 00700. 01266. 00150. 00150.   4
02800. 01848. 00700. 01266. 00150. 00150.   5 LAKER 5 & 6
11200. 01848. 06720. 01266. 00150. 00150.   6 OCEAN VESSELS
11200. 01848. 06720. 01266. 00150. 00150.   7
HOURS PER MO. PER SEASON EXTENSION (HRS)
JAN  FEB  MAR  APR  APR  MAY  JUN  JUL  AUG  SEP  OCT  NOV  DEC  DEC
000. 000. 000. 150. 348. 718. 698. 722. 718. 690. 714. 688. 150. 000.    ORE EXT. 1-8.5MO.DL.ONLY
000. 000. 000. 150. 348. 718. 698. 722. 718. 690. 714. 688. 150. 000.    COAL
000. 000. 000. 150. 348. 718. 698. 722. 718. 690. 714. 688. 150. 000.    STONE
000. 000. 000. 150. 348. 718. 698. 722. 718. 690. 714. 688. 150. 000.    GRAIN
000. 000. 000. 150. 348. 718. 698. 722. 718. 690. 714. 688. 150. 000.    O BULK
000. 000. 000. 150. 348. 718. 698. 722. 718. 690. 714. 688. 150. 000.    G CARGO
000. 000. 000. 348. 348. 718. 698. 722. 718. 690. 714. 688. 359. 000.    ORE EXT. 2-8.5MO.24HR.
000. 000. 000. 348. 348. 718. 698. 722. 718. 690. 714. 688. 359. 000.    COAL
000. 000. 000. 348. 348. 718. 698. 722. 718. 690. 714. 688. 359. 000.    STONE
000. 000. 000. 348. 348. 718. 698. 722. 718. 690. 714. 688. 359. 000.    GRAIN
000. 000. 000. 348. 348. 718. 698. 722. 718. 690. 714. 688. 359. 000.    O BULK
000. 000. 000. 348. 348. 718. 698. 722. 718. 690. 714. 688. 359. 000.    G CARGO
```

This portion of the data file was not used. Vessel delays are calculated outside the lock capacity model.

Other bulk unloading rates have been adjusted from 143 to 150 TPH to have parity with general cargo.

Several months have been adjusted slightly to correspond to the number of days per month matrix and daily hours available. See note 3.

```
000. 000. 000. 348. 348. 718. 698. 722. 718. 690. 714. 688. 359. 382.    ORE  EXT. 3-9MO.24HR.
000. 000. 000. 348. 348. 718. 698. 722. 718. 690. 714. 688. 359. 382.    COAL
000. 000. 000. 348. 348. 718. 698. 722. 718. 690. 714. 688. 359. 382.    STONE
000. 000. 000. 348. 348. 718. 698. 722. 718. 690. 714. 688. 359. 382.    GRAIN
000. 000. 000. 348. 348. 718. 698. 722. 718. 690. 714. 688. 359. 382.    O BULK
000. 000. 000. 348. 348. 718. 698. 722. 718. 690. 714. 688. 359. 382.    G CARGO
719. 000. 000. 348. 348. 718. 698. 722. 718. 690. 714. 688. 359. 382.    ORE  EXT. 4-10MO.24HR.
719. 000. 000. 348. 348. 718. 698. 722. 718. 690. 714. 688. 359. 382.    COAL
719. 000. 000. 348. 348. 718. 698. 722. 718. 690. 714. 688. 359. 382.    STONE
719. 000. 000. 348. 348. 718. 698. 722. 718. 690. 714. 688. 359. 382.    GRAIN
719. 000. 000. 348. 348. 718. 698. 722. 718. 690. 714. 688. 359. 382.    O BULK
719. 000. 000. 348. 348. 718. 698. 722. 718. 690. 714. 688. 359. 382.    G CARGO
VESSEL SPEED BY MONTH AND CLASS (VSA)
 JAN  FEB  MAR  APR  APR  MAY  JUN  JUL  AUG  SEP  OCT  NOV  DEC  DEC
00.0 00.0 00.0 10.7 13.9 13.9 13.9 13.9 13.9 13.9 13.9 13.9 13.0 00.0    4    EXT. 1-8.5MO.DL.ONLY
00.0 00.0 00.0 11.8 14.7 14.7 14.7 14.7 14.7 14.7 14.7 14.7 13.7 00.0    5
00.0 00.0 00.0 13.4 14.7 14.7 14.7 14.7 14.7 14.7 14.7 14.7 14.4 00.0    6
00.0 00.0 00.0 12.2 14.7 14.7 14.7 14.7 14.7 14.7 14.7 14.7 14.0 00.0    7
00.0 00.0 00.0 10.7 13.9 13.9 13.9 13.9 13.9 13.9 13.9 13.9 13.9 00.0    4    EXT. 2-8.5MO.24HR.
00.0 00.0 00.0 11.8 14.7 14.7 14.7 14.7 14.7 14.7 14.7 14.7 13.7 00.0    5
00.0 00.0 00.0 13.4 14.7 14.7 14.7 14.7 14.7 14.7 14.7 14.7 14.4 00.0    6
00.0 00.0 00.0 12.2 14.7 14.7 14.7 14.7 14.7 14.7 14.7 14.7 14.0 00.0    7
00.0 00.0 00.0 10.7 13.9 13.9 13.9 13.9 13.9 13.9 13.9 13.9 13.9 13.0    4    EXT. 3-9MO.24HR.
00.0 00.0 00.0 11.8 14.7 14.7 14.7 14.7 14.7 14.7 14.7 14.7 14.7 13.7    5
00.0 00.0 00.0 13.4 14.7 14.7 14.7 14.7 14.7 14.7 14.7 14.7 14.7 14.4    6
00.0 00.0 00.0 12.2 14.7 14.7 14.7 14.7 14.7 14.7 14.7 14.7 14.7 14.0    7
11.6 00.0 00.0 10.7 13.9 13.9 13.9 13.9 13.9 13.9 13.9 13.9 13.9 13.0    4    EXT. 4
12.7 00.0 00.0 11.8 14.7 14.7 14.7 14.7 14.7 14.7 14.7 14.7 14.7 13.7    5
13.9 00.0 00.0 13.4 14.7 14.7 14.7 14.7 14.7 14.7 14.7 14.7 14.7 14.4    6
13.1 00.0 00.0 12.2 14.7 14.7 14.7 14.7 14.7 14.7 14.7 14.7 14.7 14.0    7
RELATIVE DEMAND INDEXES (DIN)                                                                 See note 4.
 JAN  FEB  MAR E.AP L.AP  MAY  JUN  JLY  AUG  SEP  OCT  NOV E.DC L.DC
00.0 00.0 00.0 06.0 07.0 10.0 10.0 10.0 10.0 10.0 10.0 10.0 06.3 00.0   EXT. 1      8.5 MONTH-DAYLITE ONLY
00.0 00.0 00.0 06.0 07.0 10.0 10.0 10.0 10.0 10.0 10.0 10.0 07.0 00.0   EXT. 2      8.5 MONTH-24 HOUR
00.0 00.0 00.0 06.0 07.0 10.0 10.0 10.0 10.0 10.0 10.0 10.0 08.0 07.0   EXT. 3       9 MONTH - 24 HOUR
06.0 00.0 00.0 06.0 07.0 10.0 10.0 10.0 10.0 10.0 10.0 10.0 08.0 07.0   EXT. 4 10 MONTH- 24 HOUR
VESSEL RETIREMENT FRACTIONS (PD)
  4    5    6    7               YEAR
0.00 0.00 0.00 0.00              1978
0.56 0.30 0.20 0.00              1985
1.00 0.50 0.30 0.00              1990
1.00 0.80 0.50 0.00              2000
1.00 0.65 0.40 0.20              2010
1.00 0.95 0.85 0.30              2020
1.00 1.00 0.95 0.60              2030
1.00 1.00 1.00 0.85              2040
1.00 1.00 1.00 0.90              2050
BASE YEAR FLEET (BASFFT)
  4      5     6     7
0.00   5.70  0.00  6.40          ORE
0.90   0.30  0.00  0.50          COAL
0.30   0.70  0.40  0.10          STONE
11.20  4.70  22.10 7.90          GRAIN
2.80   0.40  7.40  0.00          O BULK
4.20   0.70  11.40 0.00          G CARGO
BIASED TRAFFIC FACTOR (BTF)
 JAN  FEB  MAR E.AP L.AP  MAY  JUN  JLY  AUG  SEP  OCT  NOV E.DC L.DC
0.00 0.00 0.00 0.50 0.10 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.50 0.00   EXT. 1
0.00 0.00 0.00 0.50 0.10 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.50 0.00   EXT. 2
0.00 0.00 0.00 0.50 0.10 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.10 0.00   EXT. 3
```

```
0.50 0.00 0.00 0.50 0.10 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.10 0.00   EXT. 4
EXTENDED SEASON DISTRIBUTION FRACTIONS
J=1     F=2     M=3     EAPR=4 LDEC=5
0.0000 0.0000 0.0000 1.0000 0.0000        IS=1
0.0000 0.0000 0.0000 0.5000 0.5000        IS=3
0.5000 0.0000 0.0000 0.2500 0.2500        IS=4
CAPCITY INCREASE WITH DEPTH (SHORT TONS PER INCH)
  4      5      6      7
0.00   97.00  97.00  109.00
```

See note 5.

```
1                    CAPACITY EXPANSION? 1=YES,0=NO
1                    CAPACITY EXPANSION MEASURE
0.075  0.075                  LOCKING TIME          TRAVELING KEVELS
0.025  0.025                  REDUCTION FACTORS     INCREASE SHIP SPEED
0.055  0.010                                        FASTER PUMP-FILL
0.045  0.045                                        TRAFFIC CONTROL
0.130  0.130                                        MAXIMUM UTILITY
5                    LOCKING TIME REDUCTION SELECTOR
1                    CAPACITY EXPANSION?
3                    INCREASE ALLOWABLE DRAFT
25.5                 NEW DRAFT
1                    DEEPER DRAFT AND LARGER SHIPS
1                    CAPACITY EXPANSION MEASURE 2
2                    BUILD LARGER LOCKS
11                   MAXIMUM SHIP CLASS
```

Variable by plan. Individual values were changed prior to each lock capacity model run.

```
0.70 0.70 0.70 0.70 0.70        ZBFF
 FLEET MIX BUILDING FACTORS
 ORE   COAL STONE GRAIN OBULK GCARGO           CLASS-DUP. PDE LOCK FLEET FACTORS
0.00   0.00  0.10  0.00  0.20  0.10              4
0.00   0.00  0.20  0.00  0.30  0.10              5
0.10   0.05  0.40  0.15  0.30  0.40              6
0.10   0.45  0.30  0.05  0.20  0.05              7
0.00   0.00  0.00  0.00  0.00  0.30              8
0.00   0.00  0.00  0.00  0.00  0.05              9
0.80   0.50  0.00  0.80  0.00  0.00             10
0.00   0.00  0.00  0.00  0.00  0.00             11
0.00   0.00  0.00  0.00  0.00  0.00             12
```

Variable by plan. Individual values are shown in Appendix B.

```
SHIP CARRYING CAPACITIES AT 25.5 DRAFT
   8      9      10      11      12
28000. 45000. 60000. 66000. 85000.            ORE
24000. 28000. 60000. 66000. 85000.            COAL
28000. 45000. 60000. 66000. 85000.            STONE
24000. 28000. 60000. 66000. 85000.            GRAIN
24000. 28000. 60000. 52200. 57200.            O BULK
24000. 28000. 60000. 52200. 57200.            G CARGO
```

Physical capacities for Class 11 and 12 vessels reduced from the initial ARCTEC data values. Relationships based upon percent change in length or length and beam.

```
SHIP CARRYING CAPACITIES REGARDLESS OF SYSTEM DEPTHS
   8      9      10      11      12
37600. 49800. 76000. 85000. 107000.       IRON ORE
27200. 28000. 76000. 85000. 107000.       COAL
37600. 49800. 76000. 85000. 107000.        STONE
27200. 28000. 76000. 85000. 107000.        GRAIN
27200. 28000. 61400. 68800. 81000.        OTHER BULK
27200. 28000. 61400. 68800. 81000.        GENERAL CARGO
```

Represents the upper limit for vessel trip capacity. This modification to the original data file was required to evaluate any deepening alternative.

```
LOCKING TIMES (NORMAL)
  4     5     6     7     8     9     10    11    12
34.0  34.0  38.0  40.0  45.0  53.0  57.0  61.0  73.0
34.0  34.0  38.0  40.0  45.0  53.0  57.0  61.0  73.0
34.0  34.0  38.0  40.0  45.0  53.0  57.0  61.0  73.0
34.0  34.0  38.0  40.0  45.0  53.0  57.0  61.0  73.0
```

Variable for parallel and tandem lock alternatives. See note 6.

```
LOCKING TIMES (LOW)
  4     5     6     7     8     9     10    11    12
```

```
34.0  34.0  38.0  40.0  45.0  53.0  57.0  61.0  73.0
34.0  34.0  38.0  40.0  45.0  53.0  57.0  61.0  73.0
34.0  34.0  38.0  40.0  45.0  53.0  57.0  61.0  73.0
34.0  34.0  36.0  40.0  45.0  53.0  57.0  61.0  73.0
LOCKING TIME (HIGH)
  4     5     6     7     8     9    10    11    12
34.0  34.0  38.0  40.0  45.0  53.0  57.0  61.0  73.0
34.0  34.0  36.0  40.0  45.0  53.0  57.0  61.0  73.0
34.0  34.0  36.0  40.0  45.0  53.0  57.0  61.0  73.0
34.0  34.0  36.0  40.0  45.0  53.0  57.0  61.0  73.0
LOCKING TIME STANDARD DEVIATION
  4     5     6     7     8     9    10    11    12
2.7   2.7   2.8   3.0   2.8   2.8   2.8   2.8   2.8
2.7   2.7   2.8   3.0   2.8   2.8   2.8   2.8   2.8
2.7   2.7   2.8   3.0   2.8   2.8   2.8   2.8   2.8
2.7   2.7   2.8   3.0   2.8   2.8   2.8   2.8   2.8
LOADING RATES
 ORE    COAL    STONE   GRAIN   OBULK   GCARGO          CLASS
2800.  9000.   2800.   1481.   600.    150.              8
2800.  9000.   2800.   1481.   600.    150.              9
2800.  9000.   2800.   1481.   600.    150.             10
2800.  9000.   2800.   1481.   600.    150.             11
2800.  9000.   2800.   1481.   600.    150.             12
UNLOADING RATES
 ORE    COAL    STONE   GRAIN   OBULK   GCARGO          CLASS
11200. 6720.   6720.   1266.   150.    150.              8
11200. 6720.   6720.   1266.   150.    150.              9
11200. 6720.   6720.   1266.   150.    150.             10
11200. 6720.   6720.   1266.   150.    150.             11
11200. 6720.   6720.   1266.   150.    150.             12
VESSEL SPEED
JAN  FEB  MAR  1APR 2APR MAY  JUN  JUL  AUG  SEP  OCT  NOV  1DEC 2DEC *VESSEL CLASS*
14.2 0.0  0.0  14.2 14.9 14.9 14.9 14.9 14.9 14.9 14.9 14.9 14.9 14.8      8
14.2 0.0  0.0  14.2 14.9 14.9 14.9 14.9 14.9 14.9 14.9 14.9 14.9 14.8      9
14.2 0.0  0.0  14.2 14.9 14.9 14.9 14.9 14.9 14.9 14.9 14.9 14.9 14.8     10
14.2 0.0  0.0  14.2 14.9 14.9 14.9 14.9 14.9 14.9 14.9 14.9 14.9 14.8     11
14.2 0.0  0.0  14.2 14.9 14.9 14.9 14.9 14.9 14.9 14.9 14.9 14.9 14.8     12
RETIREMENT PERCENTAGES
 8     9    10    11    12
0.0   0.0   0.0   0.0   0.0       1978
0.0   0.0   0.0   0.0   0.0       1985
0.0   0.0   0.0   0.0   0.0       1990
0.2   0.0   0.0   0.0   0.0       2000
0.3   0.0   0.0   0.0   0.0       2010
0.8   0.0   0.2   0.0   0.0       2020
0.92  0.0   0.3   0.0   0.0       2030
1.0   1.0   0.5   0.0   0.0       2040
1.0   1.0   0.6   0.1   0.0       2050
CAPACITY INCREASE WITH DEPTH
  8      9      10      11      12
121.00 155.00 207.00 234.00 305.00
0                CAPACITY EXPANSION?
```

Other bulk unloading rates have been adjusted from 143 to 150 TPH to have parity with general cargo.

Other bulk unloading rate adjusted from 143 to 150 TPH to achieve parity with general cargo.

Note 1: Percent lock utilization in percent. The time period whenever one month during the May thru November season equals or exceeds this upper limit becomes the date of implementation of a specified improvement.

The second value is a manual override option used to force the SLR locks to be improved to coincide with physical changes at the Welland Canal.

Note 2: High traffic forecasts by decade by commodity group is shown below: These estimates represent the unconstrained commodity flows.

			**** 1978 ****							
UPBOUND										
	0.0	0.0	0.0	0.0	0.0	1995.	136.	0.0	4809.	0.0
	0.0	0.0	2555.	711.	0.0					
			**** 1985 ****							
DOWNBOUND										
	35000.	0.0	0.0	0.0	0.0	100.	77900.	0.0	3500.	0.0
	0.0	0.0	2400.	934.	0.0					
			**** 1985 ****							
UPBOUND										
	0.	0.	0.	0.	0.	2400.	100.	0.0	6000.	0.0
	0.0	0.0	3100.	863.	0.0					
			**** 1990 ****							
DOWNBOUND										
	41500.	0.0	0.0	0.0	0.0	100.	86200.	0.0	4200.	0.0
	0.0	0.0	2700.	1200.	0.0					
			**** 1990 ****							
UPBOUND										
	0.0	0.0	0.0	0.0	0.0	2700.	100.	0.0	7100.	0.0
	0.0	0.0	3500.	849.	0.0					
			**** 2000 ****							
DOWNBOUND										
	47500.	0.0	0.0	0.0	0.0	100.	109000.	0.0	5900.	0.0
	0.0	0.0	3400.	1300.	0.0					
			**** 2000 ****							
UPBOUND										
	0.0	0.0	0.0	0.0	0.0	3200.	200.	0.0	7900.	0.0
	0.0	0.0	4400.	1000.	0.0					
			**** 2010 ****							
DOWNBOUND										
	51800.	0.0	0.0	0.0	0.0	100.	123400.	0.0	6100.	0.0
	0.0	0.0	3900.	1500.	0.0					
			**** 2010 ****							
UPBOUND										
	0.0	0.0	0.0	0.0	0.0	3700.	200.	0.0	8200.	0.0
	0.0	0.0	5100.	1100.	0.0					
			**** 2020 ****							
DOWNBOUND										
	56400.	0.0	0.0	0.0	0.0	100.	139700.	0.0	6300.	0.0
	0.0	0.0	4500.	1700.	0.0					
			**** 2020 ****							
UPBOUND										
	0.0	0.0	0.0	0.0	0.0	4200.	200.	0.0	8500.	0.0
	0.0	0.0	5900.	1300.	0.0					
			**** 2030 ****							
DOWNBOUND										
	61800.	0.0	0.0	0.0	0.0	100.	158200.	0.0	6600.	0.0
	0.0	0.0	5200.	1900.	0.0					
			**** 2030 ****							
UPBOUND										
	0.0	0.0	0.0	0.0	0.0	4800.	200.	0.0	8800.	0.0
	0.0	0.0	6800.	1400.	0.0					
			**** 2040 ****							
DOWNBOUND										
	67300.	0.0	0.0	0.0	0.0	100.	179200.	0.0	6800.	0.0
	0.0	0.0	6100.	2100.	0.0					
			**** 2040 ****							
UPBOUND										
	0.0	0.0	0.0	0.0	0.0	5400.	300.	0.0	9100.	0.0
	0.0	0.0	7900.	1600.	0.0					
			**** 2050 ****							
DOWNBOUND										
	73800.	0.0	0.0	0.0	0.0	100.	202900.	0.0	7100.	0.0
	0.0	0.0	7000.	2400.	0.0					
			**** 2050 ****							
UPBOUND										
	0.0	0.0	0.0	0.0	0.0	6200.	300.	0.0	9400.	0.0
	0.0	0.0	9100.	1800.	0.0					

Note 3: Season extension 1 is defined as existing 8.5 month navigation period (1 April - 15 December) with day-light only operation in early and late weeks of the season.

Season extension 2 is defined as existing 8.5 month navigation period with 24 hour operation for all months.

Season extension 3 and 4 are based on 24 hour operation for all months as indicated.

Note 4: Values developed by ARCTEC for early navigation months incorporated into the base case operating period. Other monthly index values vary slightly from the original data file provided by ARCTEC.

Note 5: Immersion factors (short tons per inch) adjusted to reflect the average physical characteristics for selected U.S. and Canadian Great Lakes vessels. Class 6 (ocean) vessels is based upon OCE foreign vessel characteristics.

Note 6: Lock service times for the alternatives are shown below.

Welland Canal | St. Lawrence River Locks

a. Twin Seaway Size

Welland Canal

LOCKING TIMES (NORMAL)

4	5	6	7
17.3	17.3	21.0	22.0
18.3	18.3	21.8	22.3
17.0	17.0	19.3	20.3
17.0	17.0	19.5	20.3

St. Lawrence River Locks

LOCKING TIMES (NORMAL)

4	5	6	7
17.0	17.0	19.3	20.5
17.0	17.0	19.5	20.5
16.3	16.3	18.5	19.3
16.3	16.3	18.5	19.3

b. Parallel Poe-size

Welland Canal

LOCKING TIMES (NORMAL)

4	5	6	7	8	9	10
17.3	17.3	21.0	22.0	49.0	61.0	67.0
18.3	18.3	21.8	22.3	49.0	61.0	67.0
17.0	17.0	19.3	20.3	45.0	53.0	57.0
17.0	17.0	19.5	20.3	45.0	53.0	57.0

St. Lawrence River Locks

LOCKING TIMES (NORMAL)

4	5	6	7	8	9	10
17.0	17.0	19.3	20.5	45.0	53.0	57.0
17.0	17.0	19.5	20.5	45.0	53.0	57.0
16.3	16.3	18.5	19.3	41.0	48.0	52.0
16.3	16.3	18.5	19.3	41.0	48.0	52.0

c. Tandem Lockages

Welland Canal

LOCKING TIMES (NORMAL)

4	5	6	7	8	9	10
24.0	24.0	27.0	29.0	49.0	61.0	67.0
24.0	24.0	27.0	29.0	49.0	61.0	67.0
24.0	24.0	27.0	28.0	45.0	53.0	57.0
24.0	24.0	27.0	28.0	45.0	53.0	57.0

St. Lawrence River Locks

LOCKING TIMES (NORMAL)

4	5	6	7	8	9	10
24.0	24.0	27.0	28.0	45.0	53.0	57.0
24.0	24.0	27.0	28.0	45.0	53.0	57.0
24.0	24.0	27.0	28.0	45.0	53.0	57.0
24.0	24.0	27.0	28.0	45.0	53.0	57.0

SUPPLEMENT 3

LOCK CAPACITY MODEL SUMMARY STATISTICS

Selected summary statistics (i.e., short reports) have been included for purposes of report review. These short reports are provided for the Welland Canal and St. Lawrence River for each increment of lock size and channel depths relative to the existing lock sizes.

***** GL/SLS LOCK CAPACITY MODEL *****
***** WELLAND CANAL *****

**** SEASON EXTENSION 1 LOCKING TIME NORM*****

RUN BY NCBPD - EH

12

**** TRAFFIC FORECAST LOW ****
**** NON-STRUCTURAL 10% ****
**** STRUCTURAL 1200 X 115 LK X 25.5 D ****

		TRANSITS			CON-DELAY		UNCON-DELAY			COMPOSITE SHIP CLASS							AVG	TOT
YEAR	LK UTIL	TOT	IDD	ACT TONS	DOWN	UP	DOWN	UP	TOTAL	ORE	COL	STN	GRN	OTB	GCO	TOT	DELAY	PROC
1978	83.0	6872	4347	67990	5985	7058	12510	12734	38287	5.8	5.8	7.0	6.1	5.6	5.6	5.9	5.6	16578
1980	88.0	7095	4550	71640	8664	10729	15396	15695	50484	5.9	6.0	7.0	6.1	5.6	5.6	5.9	7.1	16868
1982	90.0	7292	4745	75113	13193	15545	18601	19139	66478	6.0	6.1	7.0	6.2	5.6	5.6	6.0	9.1	17086
***** NONSTRUCTURAL MAXIMUM UTILITY *****																		
1984	81.0	7511	4918	78915	5740	6616	11869	12085	36310	6.2	6.2	7.0	6.3	5.6	5.6	6.0	4.8	16522
1985	84.0	7643	5006	80735	6827	7998	13166	13409	41400	6.3	6.3	7.0	6.3	5.6	5.6	6.0	5.4	16686
1986	85.0	7673	5002	81520	7251	8534	13586	13848	43219	6.4	6.3	7.0	6.4	5.6	5.7	6.1	5.6	16739
1988	87.0	7718	4979	83077	8186	9726	14402	14683	46997	6.6	6.7	7.0	6.4	5.6	5.7	6.1	6.1	16814
1990	88.0	7784	4960	84643	9408	11331	15395	15698	51832	6.8	6.8	7.0	6.5	5.6	5.7	6.2	6.7	16914
1992	90.0	7869	5038	85961	11096	13779	16681	17021	58577	6.8	6.8	7.0	6.5	5.6	5.7	6.2	7.4	17028
**** CAPACITY WAS INCREASED BY BUILDING LARGER LOCKS ****																		
1994	60.0	6763	4363	87280	1973	1999	4859	4865	13696	7.2	7.1	7.0	7.1	5.8	6.3	6.7	2.0	15430
1996	61.0	6747	4359	88596	2036	2062	4954	4964	14016	7.3	7.1	7.0	7.1	5.8	6.4	6.7	2.1	15451
1998	61.0	6743	4364	89905	2104	2129	5064	5071	14368	7.3	7.2	7.0	7.2	5.8	6.4	6.7	2.1	15476
2000	62.0	6715	4358	91230	2167	2191	5159	5166	14683	7.4	7.2	7.0	7.3	5.8	6.4	6.8	2.2	15508
2002	63.0	6735	4371	93204	2270	2295	5329	5333	15227	7.5	7.4	7.0	7.4	5.8	6.4	6.8	2.3	15562
2004	64.0	6793	4430	95193	2412	2439	5577	5585	16013	7.5	7.4	7.0	7.5	5.8	6.5	6.8	2.4	15623
2006	65.0	6822	4465	97171	2533	2560	5767	5777	16637	7.6	7.4	7.0	7.6	5.8	6.5	6.9	2.4	15676
2008	66.0	6846	4491	99164	2710	2736	6073	6078	17597	7.6	7.4	7.0	7.7	5.7	6.5	6.9	2.6	15726
2010	67.0	6871	4524	101145	2831	2858	6241	6248	18178	7.7	7.4	7.0	7.8	5.7	6.6	7.0	2.6	15790
2012	68.0	6908	4538	102556	2980	3009	6492	6498	18979	7.8	7.4	7.0	7.8	5.7	6.6	7.0	2.7	15812
2014	68.0	6945	4554	103974	3146	3176	6762	6767	19851	7.8	7.4	7.0	7.9	5.7	6.6	7.0	2.9	15862
2016	69.0	6973	4564	105387	3351	3384	7108	7116	20959	7.9	7.4	7.0	7.9	5.7	6.5	7.0	3.0	15911
2018	70.0	7016	4585	106813	3528	3562	7381	7387	21858	7.9	7.4	7.0	8.0	5.7	6.5	7.0	3.1	15969
2020	71.0	7032	4604	108233	3711	3749	7655	7662	22777	8.0	7.4	7.0	8.0	5.7	6.5	7.0	3.2	16022
2022	73.0	7060	4640	111132	4026	4067	8014	8019	24126	8.2	7.7	7.0	8.2	5.7	6.6	7.1	3.4	16094
2024	74.0	7078	4685	114034	4389	4441	8420	8432	25682	8.4	7.7	7.0	8.3	5.6	6.6	7.1	3.6	16179
2026	75.0	7078	4712	116952	4791	4849	8842	8850	27332	8.5	8.0	7.0	8.5	5.6	6.6	7.1	3.9	16251
2028	77.0	7099	4760	119861	5201	5265	9207	9215	28888	8.7	8.1	7.0	8.7	5.6	6.6	7.2	4.1	16336
2030	78.0	7100	4807	122768	5733	5614	9712	9723	30982	8.9	8.2	7.0	8.9	5.6	6.6	7.2	4.4	16411
2032	82.0	7291	4934	125782	7179	7289	11426	11429	37323	9.0	8.2	7.0	8.9	5.6	6.6	7.2	5.1	16611
2034	85.0	7474	5069	128802	9191	9363	13452	13465	45471	9.0	8.2	7.0	9.0	5.6	6.6	7.2	6.1	16800
2036	89.0	7656	5190	131814	12836	13143	16513	16526	59018	9.0	8.3	7.0	9.0	5.6	6.6	7.2	7.7	16990
2038	90.0	7862	5329	134089	17223	17313	20462	20330	75328	9.0	8.5	7.0	9.0	5.5	6.6	7.2	9.6	17178

RUN BY NCBPD - EB

***** GL/SLS LOCK CAPACITY MODEL *****
***** WELLAND CANAL *****

**** SEASON EXTENSION 1 LOCKING TIME NORM*****
SLR CONSTRAINED - 80% LOCK UTILIZATION
**** TRAFFIC FORECAST LOW ****
**** NON-STRUCTURAL 10% ****
**** STRUCTURAL 1200 X 115 LK X 25.5 D ****

YEAR	LK UTIL	TRANSITS TOT	TRANSITS LDD	ACT TONS	CON-DELAY DOWN	CON-DELAY UP	UNCON-DELAY DOWN	UNCON-DELAY UP	TOTAL	ORE	COL	COMPOSITE SHIP CLASS STN	GRN	OTB	GCO	TOT	AVG DELAY	TOT PRUC
1978	81.0	6872	4347	67873	5937	6727	12420	12734	37818	5.8	5.8	7.0	6.1	5.6	5.6	5.9	5.5	15243
***** NONSTRUCTURAL MAXIMUM UTILITY *****																		
1980	73.0	7098	4553	71640	3519	3948	8633	8775	24875	5.9	6.0	7.0	6.1	5.6	5.6	5.9	3.5	14772
1982	77.0	7307	4746	75280	4398	4983	10020	10196	29597	6.0	6.1	7.0	6.2	5.6	5.6	6.0	4.1	14987
1984	81.0	7524	4918	78865	5726	6517	11843	12085	36171	6.2	6.2	7.0	6.3	5.6	5.6	6.0	4.8	15208
**** CAPACITY WAS INCREASED BY BUILDING LARGER LOCKS ****																		
1985	57.0	6628	4333	80734	1660	1684	4211	4215	11770	6.8	6.8	7.0	6.8	5.8	6.1	6.4	1.8	13941
1986	57.0	6607	4303	81518	1659	1683	4185	4192	11719	6.9	6.8	7.0	6.9	5.8	6.2	6.5	1.8	13934
1988	57.0	6522	4227	83073	1642	1660	4083	4091	11476	7.1	6.9	7.0	7.0	5.8	6.2	6.6	1.8	13934
1990	57.0	6430	4149	84648	1650	1671	4054	4064	11439	7.4	7.1	7.0	7.1	5.8	6.3	6.7	1.8	13948
1992	57.0	6437	4150	85966	1701	1720	4136	4144	11701	7.4	7.1	7.0	7.2	5.8	6.3	6.7	1.8	13991
1994	58.0	6472	4191	87280	1729	1750	4166	4173	11818	7.5	7.1	7.0	7.2	5.8	6.3	6.7	1.9	14005
1996	58.0	6470	4198	88585	1791	1814	4275	4285	12165	7.6	7.1	7.0	7.3	5.8	6.4	6.8	1.9	14034
1998	59.0	6466	4203	89904	1851	1875	4375	4382	12483	7.6	7.1	7.0	7.4	5.8	6.4	6.8	2.0	14066
2000	59.0	6435	4202	91229	1905	1926	4455	4458	12744	7.7	7.4	7.0	7.5	5.8	6.4	6.8	2.1	14119
2002	60.0	6483	4228	93203	2016	2039	4649	4655	13359	7.7	7.4	7.0	7.6	5.8	6.4	6.9	2.1	14180
2004	61.0	6513	4257	95191	2128	2152	4840	4849	13969	7.8	7.4	7.0	7.6	5.7	6.5	6.9	2.3	14233
2006	62.0	6552	4297	97169	2278	2298	5103	5111	14790	7.9	7.4	7.0	7.8	5.7	6.5	6.9	2.3	14294
2008	63.0	6599	4341	99162	2397	2419	5292	5300	15408	7.9	7.4	7.0	7.8	5.7	6.5	7.0	2.4	14355
2010	65.0	6630	4381	101144	2548	2571	5543	5550	16212	7.9	7.4	7.0	8.0	5.7	6.6	7.0	2.5	14401
2012	65.0	6684	4404	102557	2682	2708	5769	5778	16937	8.0	7.4	7.0	8.0	5.7	6.6	7.0	2.6	14434
2014	66.0	6725	4424	103971	2838	2864	6032	6038	17772	8.1	7.4	7.0	8.0	5.7	6.5	7.0	2.7	14494
2016	67.0	6763	4438	105391	2992	3019	6281	6288	18580	8.1	7.4	7.0	8.1	5.7	6.5	7.0	2.9	14540
2018	68.0	6792	4448	106806	3145	3177	6521	6530	19373	8.2	7.4	7.0	8.1	5.7	6.5	7.1	3.0	14601
2020	69.0	6839	4478	108232	3350	3385	6856	6864	20455	8.2	7.5	7.0	8.2	5.7	6.5	7.1	3.1	14708
2022	71.0	6889	4540	111128	3632	3669	7193	7198	21692	8.4	7.7	7.0	8.3	5.6	6.6	7.1	3.4	14780
2024	73.0	6917	4582	114038	4042	4089	7735	7746	23612	8.5	7.8	7.0	8.5	5.6	6.6	7.1	3.7	14887
2026	74.0	6966	4647	116951	4469	4519	8242	8248	25478	8.7	8.0	7.0	8.6	5.6	6.6	7.2	3.9	14983
2028	76.0	7008	4706	119859	4943	5002	8762	8768	27475	8.9	8.1	7.0	8.8	5.6	6.6	7.2	4.2	15069
2030	78.0	7061	4768	122772	5521	5592	9365	9373	29851	9.0	8.2	7.0	9.0	5.6	6.6	7.2	4.9	15251
2032	81.0	7250	4907	125627	6798	6859	10964	10970	35591	9.0	8.2	7.0	9.0	5.6	6.6	7.2		

***** GL/SLS LOCK CAPACITY MODEL *****
***** ST. LAWRENCE RIVER *****
** CAPACITY DATE FORCED TO COINCIDE WITH THE WELLAND **
**** SEASON EXTENSION 2   LOCKING TIME NORM*****

**** TRAFFIC FORECAST LOW ****
**** NON-STRUCTURAL 13% ****
**** STRUCTURAL 1200 X 115 LK X 25.5 D ****

YEAR	LK UTIL	TRANSITS TOT	TRANSITS LDD	ACT TONS	CON-DELAY DOWN	CON-DELAY UP	UNCON-DELAY DOWN	UNCON-DELAY UP	TOTAL	ORE	COL	COMPOSITE SHIP CLASS STN	GRN	OTB	GCO	TOT	AVG DELAY	TOT PROC
1978	59.0	5844	3981	61448	1531	1558	5028	5032	13149	6.4	5.8	0.0	5.9	5.5	5.5	5.8	2.3	2975
1980	63.0	6107	4220	65550	1969	2007	6221	6227	16424	6.3	5.6	0.0	6.0	5.5	5.6	5.8	2.7	3184
1982	68.0	6391	4452	69662	2553	2607	7701	7704	20565	6.2	5.6	7.0	6.1	5.5	5.6	5.9	3.2	3428
1984	73.0	6709	4679	73777	3487	3571	9832	9834	26724	6.2	5.4	7.0	6.2	5.6	5.6	5.9	4.0	3700
1985	76.0	6843	4786	75824	4090	4196	11081	11084	30451	6.3	5.7	7.0	6.3	5.5	5.6	6.0	4.4	3845
1986	77.0	6899	4809	77084	4376	4494	11638	11644	32152	6.3	5.9	7.0	6.3	5.6	5.6	6.0	4.7	3901
1988	80.0	7008	4864	79585	5041	5188	12864	12872	35965	6.4	6.2	7.0	6.4	5.6	5.6	6.0	5.1	4025
1990	82.0	7093	4902	82102	5838	6025	14188	14194	40245	6.5	6.7	7.0	6.4	5.6	5.7	6.1	5.7	4145
***** NONSTRUCTURAL MAXIMUM UTILITY *****																		
1992	65.0	7189	4959	83006	2292	2338	7051	7053	18734	6.5	6.8	7.0	6.5	5.6	5.7	6.1	2.6	3332
**** CAPACITY WAS INCREASED BY BUILDING LARGER LOCKS ****																		
1994	51.0	5949	4186	83916	1078	1079	4331	4331	10819	7.3	7.4	7.0	7.1	5.8	6.4	6.6	1.8	2625
1996	52.0	5957	4193	84823	1103	1104	4430	4435	11072	7.3	7.4	7.0	7.2	5.8	6.4	6.7	1.9	2654
1998	52.0	5977	4207	85729	1119	1120	4493	4497	11229	7.4	7.4	7.0	7.2	5.8	6.4	6.7	1.9	2671
2000	53.0	5996	4234	86631	1163	1163	4666	4670	11662	7.4	7.4	7.0	7.3	5.8	6.4	6.7	1.9	2699
2002	53.0	6020	4252	88596	1199	1199	4803	4806	12007	7.5	7.4	7.0	7.4	5.8	6.5	6.8	2.0	2721
2004	54.0	6046	4279	90561	1240	1241	4971	4975	12427	7.6	7.4	7.0	7.5	5.7	6.5	6.8	2.1	2763
2006	54.0	6063	4303	92523	1293	1293	5181	5185	12952	7.7	7.4	7.0	7.6	5.7	6.5	6.8	2.1	2777
2008	56.0	6131	4330	94485	1377	1378	5526	5527	13808	7.8	7.4	7.0	7.8	5.7	6.5	6.9	2.3	2855
2010	57.0	6173	4352	96453	1475	1476	5908	5914	14773	7.8	7.4	7.0	7.9	5.7	6.6	6.9	2.4	2915
2012	57.0	6199	4373	97809	1500	1501	6021	6025	15047	7.9	7.4	7.0	7.9	5.7	6.6	6.9	2.4	2922
2014	57.0	6203	4387	99173	1527	1528	6119	6122	15296	8.0	7.5	7.0	8.0	5.7	6.6	6.9	2.5	2933
2016	58.0	6223	4412	100537	1560	1561	6250	6253	15624	8.0	7.9	7.0	8.0	5.7	6.6	7.0	2.5	2961
2018	58.0	6233	4427	101893	1590	1591	6377	6378	15936	8.1	7.9	7.0	8.1	5.7	6.6	7.0	2.6	2986
2020	59.0	6247	4466	103261	1635	1636	6558	6563	16392	8.2	7.9	7.0	8.1	5.6	6.6	7.0	2.6	3007
2022	60.0	6354	4521	106134	1802	1803	7226	7230	18061	8.3	7.9	7.0	8.3	5.6	6.6	7.0	2.8	3095
2024	62.0	6444	4578	109001	1998	1999	8004	8010	20011	8.5	7.9	7.0	8.4	5.6	6.6	7.0	3.1	3180
2026	64.0	6525	4627	111873	2202	2203	8821	8826	22052	8.7	8.0	7.0	8.6	5.6	6.6	7.1	3.4	3272
2028	66.0	6628	4696	114750	2450	2450	9809	9813	24522	8.8	8.3	7.0	8.7	5.6	6.6	7.1	3.7	3371
2030	68.0	6747	4765	117622	2723	2723	10910	10913	27269	9.0	8.5	0.0	8.9	5.5	6.6	7.1	4.0	3467
2032	71.0	6926	4894	120562	3249	3248	13011	13012	32520	9.0	8.5	0.0	8.9	5.5	6.6	7.1	4.7	3622
2034	74.0	7117	5020	123506	3936	3937	15759	15759	39391	9.1	8.5	0.0	9.0	5.5	6.6	7.1	5.5	3785
2036	77.0	7333	5168	126446	4833	4835	19350	19354	48372	9.1	8.5	0.0	9.0	5.5	6.6	7.1	6.6	3947
2038	81.0	7522	5290	129388	6020	6020	24095	24097	60232	9.1	8.5	0.0	9.0	5.5	6.6	7.1	8.0	4131
2040	85.0	7785	5431	132327	7798	7799	31213	31219	78029	9.1	8.5	6.5	9.1	5.5	6.6	7.1	10.1	4318
2042	89.0	7947	5582	135515	10824	10825	43310	43314	108273	9.1	8.5	6.5	9.1	5.5	6.6	7.1	13.6	4527
2044	90.0	8162	5726	138069	14466	14293	57879	57183	143821	9.1	8.5	6.5	9.1	5.5	6.6	7.1	17.6	4696

RUN BY NCBPD - EB

***** GL/SLS LOCK CAPACITY MODEL *****
***** ST. LAWRENCE RIVER *****
** BY ITSELF **
**** SEASON EXTENSION 2 LOCKING TIME NORM*****
SLR CONSTRAINED - 80% LOCK UTILIZATION
**** TRAFFIC FORECAST LOW ****
**** NON-STRUCTURAL 13% ****
**** STRUCTURAL 1200 X 115 LK X 25.5 D ****

		TRANSITS			CON-DELAY		UNCON-DELAY					COMPOSITE SHIP CLASS					AVG	TOT
YEAR	LK UTIL	TOT	LDD	ACT TONS	DOWN	UP	DOWN	UP	TOTAL	ORE	COL	STN	GRN	OTH	GCO	TOT	DELAY	PROC
1978	59.0	5844	3981	61448	1531	1558	5028	5032	13149	6.4	5.8	0.0	5.9	5.5	5.5	5.8	2.3	13732
1980	63.0	6118	4220	65550	1969	2007	6221	6227	16424	6.3	5.6	0.0	6.0	5.5	5.6	5.8	2.7	13941
***** NONSTRUCTURAL MAXIMUM UTILITY *****																		
1982	54.0	6358	4446	69660	1236	1257	4176	4179	10848	6.3	5.6	7.0	6.1	5.5	5.6	5.9	1.7	13524
**** CAPACITY WAS INCREASED BY BUILDING LARGER LOCKS ****																		
1984	47.0	5063	3970	73770	822	822	3305	3308	8257	6.9	6.7	0.0	6.8	5.6	6.1	6.4	1.5	13163
1985	48.0	5713	4023	75827	885	887	3557	3561	8890	7.0	6.7	7.0	6.9	5.7	6.2	6.4	1.6	13213
1986	48.0	5722	4022	77082	886	886	3560	3562	8894	7.1	6.7	7.0	7.0	5.7	6.2	6.5	1.6	13213
1988	48.0	5651	3965	79587	884	884	3548	3551	8867	7.3	7.2	7.0	7.1	5.7	6.3	6.6	1.6	13209
1990	48.0	5594	3937	82097	880	881	3534	3537	8832	7.5	7.2	7.0	7.2	5.7	6.3	6.7	1.6	13209
1992	48.0	5614	3944	83014	901	903	3613	3616	9033	7.6	7.2	7.0	7.3	5.7	6.4	6.7	1.6	13227
1994	49.0	5625	3957	83917	913	914	3663	3665	9155	7.6	7.2	7.0	7.3	5.7	6.4	6.7	1.6	13255
1996	49.0	5637	3967	84821	941	942	3777	3782	9442	7.7	7.6	7.0	7.4	5.7	6.4	6.7	1.7	13262
1998	49.0	5650	3981	85725	954	955	3827	3831	9567	7.8	7.6	7.0	7.5	5.7	6.4	6.8	1.7	13276
2000	50.0	5662	3995	86642	973	975	3905	3910	9763	7.8	7.6	7.0	7.5	5.7	6.5	6.8	1.7	13305
2002	50.0	5699	4028	88600	1017	1017	4085	4087	10206	7.9	7.6	7.0	7.7	5.7	6.5	6.8	1.8	13333
2004	51.0	5732	4061	90561	1065	1067	4277	4281	10690	8.0	7.6	7.0	7.8	5.7	6.5	6.9	1.9	13368
2006	52.0	5783	4111	92529	1112	1112	4465	4468	11157	8.0	8.0	7.0	7.9	5.7	6.5	6.9	1.9	13411
2008	53.0	5831	4126	94485	1182	1183	4749	4750	11864	8.1	8.0	7.0	8.0	5.7	6.6	6.9	2.0	13460
2010	54.0	5908	4166	96443	1281	1282	5140	5143	12846	8.2	8.0	7.0	8.1	5.6	6.6	7.0	2.2	13534
2012	55.0	5947	4214	97813	1300	1300	5213	5218	13031	8.3	8.0	7.0	8.2	5.6	6.6	7.0	2.2	13556
2014	55.0	5954	4233	99172	1325	1327	5316	5320	13288	8.3	8.0	7.0	8.2	5.6	6.6	7.0	2.2	13570
2016	55.0	5973	4253	100538	1364	1364	5467	5469	13664	8.4	8.0	7.0	8.3	5.6	6.6	7.0	2.3	13587
2018	56.0	5994	4278	101893	1395	1396	5589	5590	13970	8.4	8.0	7.0	8.3	5.6	6.6	7.0	2.3	13619
2020	56.0	6023	4309	103252	1440	1441	5776	5779	14436	8.5	8.0	7.0	8.3	5.6	6.6	7.0	2.4	13644
2022	58.0	6135	4375	106132	1612	1613	6455	6459	16139	8.6	8.0	7.0	8.5	5.6	6.6	7.1	2.6	13743
2024	60.0	6271	4465	109006	1810	1811	7251	7256	18128	8.7	8.0	7.0	8.6	5.6	6.6	7.1	2.9	13852
2026	63.0	6390	4541	111879	2015	2015	8071	8074	20175	8.9	8.5	7.0	8.7	5.6	6.6	7.1	3.2	13958
2028	65.0	6519	4623	114747	2305	2307	9239	9246	23097	9.0	8.5	7.0	8.9	5.6	6.6	7.1	3.5	14075
2030	67.0	6681	4723	117625	2617	2618	10483	10489	26207	9.1	8.5	0.0	9.0	5.5	6.6	7.1	3.9	14181
2032	70.0	6862	4855	120562	3099	3098	12408	12409	31014	9.1	8.5	0.0	9.0	5.5	6.6	7.1	4.5	14343
2034	73.0	7061	4986	123504	3754	3754	15026	15028	37562	9.2	8.5	0.0	9.1	5.5	6.6	7.1	5.3	14506
2036	77.0	7281	5138	126442	4611	4612	18456	18459	46138	9.1	8.5	0.0	9.1	5.5	6.6	7.1	6.3	14690
2038	80.0	7487	5256	129389	5752	5754	23024	23032	57562	9.2	8.5	0.0	9.1	5.5	6.6	7.1	7.7	14852

******* GL/SLS LOCK CAPACITY MODEL *******
******* WELLAND CANAL *******

**** SEASON EXTENSION 1 LOCKING TIME NORM*****

RUN BY NCBPD - ER

**** TRAFFIC FORECAST LOW ****
**** NON-STRUCTURAL 10% ****
**** STRUCTURAL 1200 X 115 LK X 28.0 D ****

YEAR	LK UTIL	TRANSITS TOT	TRANSITS LDO	ACT TONS	CON-DELAY DOWN	CON-DELAY UP	UNCON-DELAY DOWN	UNCON-DELAY UP	TOTAL	COMPOSITE SHIP CLASS ORE	COL	STN	GRN	OTB	GCO	TOT	AVG DELAY	TOT PROC
1978	83.0	6872	4347	67990	5985	7058	12510	12734	38287	5.8	5.8	7.0	6.1	5.6	5.6	5.9	5.6	15764
1980	88.0	7095	4550	71640	8664	10729	15396	15695	50484	5.9	6.0	7.0	6.1	5.6	5.6	5.9	7.1	16054
1982	90.0	7292	4745	75113	13193	15545	18601	19139	66478	6.0	6.1	7.0	6.2	5.6	5.6	6.0	9.1	16274
***** NONSTRUCTURAL MAXIMUM UTILITY *****																		
1984	81.0	7511	4918	78915	5740	6616	11869	12085	36310	6.2	6.2	7.0	6.3	5.6	5.6	6.0	4.8	15708
1985	84.0	7643	5006	80735	6827	7998	13166	13409	41400	6.3	6.3	7.0	6.3	5.6	5.6	6.0	5.4	15872
1986	85.0	7673	5002	81520	7251	8534	13586	13848	43219	6.4	6.3	7.0	6.4	5.6	5.7	6.1	5.6	15925
1988	87.0	7718	4979	83077	8186	9726	14402	14683	46997	6.6	6.7	7.0	6.4	5.6	5.7	6.1	6.1	16000
1990	88.0	7784	4960	84643	9408	11331	15395	15698	51832	6.8	6.8	7.0	6.5	5.6	5.7	6.2	6.7	16100
1992	90.0	7669	5038	85961	11096	13779	16681	17021	58577	6.8	6.8	7.0	6.5	5.6	5.7	6.2	7.4	16214
**** CAPACITY INCREASED BY INCREASING ALLOWABLE SHIP DRAFT TO 28.00 FEET ****																		
**** CAPACITY WAS INCREASED BY BUILDING LARGER LOCKS ****																		
1994	52.0	6131	3928	87275	1209	1223	3122	3130	8684	7.1	6.9	7.0	6.9	5.9	6.3	6.6	1.4	14141
1996	52.0	6141	3946	88591	1249	1263	3190	3195	8897	7.1	7.1	7.0	7.0	5.9	6.3	6.6	1.4	14159
1998	53.0	6146	3959	89906	1276	1291	3225	3232	9024	7.2	7.2	7.0	7.1	5.8	6.4	6.7	1.5	14198
2000	53.0	6152	3965	91226	1343	1360	3361	3368	9432	7.3	7.2	7.0	7.2	5.8	6.4	6.7	1.5	14220
2002	54.0	6163	3985	93200	1413	1425	3480	3486	9804	7.4	7.2	7.0	7.3	5.8	6.4	6.7	1.6	14269
2004	55.0	6190	4012	95194	1499	1515	3646	3652	10312	7.4	7.2	7.0	7.4	5.8	6.5	6.8	1.7	14320
2006	56.0	6231	4056	97171	1583	1597	3790	3798	10768	7.5	7.2	7.0	7.5	5.8	6.5	6.8	1.7	14373
2008	57.0	6274	4101	99165	1675	1690	3956	3961	11282	7.5	7.2	7.0	7.6	5.8	6.5	6.9	1.8	14434
2010	58.0	6305	4132	101148	1778	1793	4139	4143	11853	7.6	7.4	7.0	7.7	5.7	6.6	6.9	1.9	14487
2012	59.0	6336	4145	102556	1859	1875	4283	4287	12304	7.7	7.4	7.0	7.8	5.7	6.6	6.9	1.9	14534
2014	60.0	6373	4165	103972	1960	1976	4466	4471	12873	7.6	7.4	7.0	7.8	5.7	6.5	7.0	2.0	14580
2016	61.0	6401	4173	105385	2054	2071	4634	4643	13402	7.8	7.4	7.0	7.9	5.7	6.5	7.0	2.1	14634
2018	61.0	6430	4184	106810	2153	2173	4803	4810	13939	7.9	7.4	7.0	7.9	5.7	6.5	7.0	2.2	14680
2020	62.0	6462	4216	108230	2261	2282	4986	4996	14525	7.9	7.4	7.0	8.0	5.7	6.5	7.0	2.2	14719
2022	64.0	6504	4263	111135	2434	2455	5202	5209	15300	8.1	7.5	7.0	8.1	5.7	6.5	7.0	2.4	14809
2024	65.0	6509	4290	114037	2671	2696	5533	5539	16439	8.3	7.8	7.0	8.3	5.6	6.6	7.1	2.5	14880
2026	67.0	6517	4321	116953	2900	2931	5816	5824	17471	8.5	7.8	7.0	8.5	5.6	6.6	7.1	2.7	14984
2028	68.0	6548	4372	119863	3165	3193	6128	6134	18620	8.7	8.1	7.0	8.7	5.6	6.6	7.2	2.8	15040
2030	70.0	6575	4415	122770	3482	3517	6500	6507	20006	8.9	8.2	7.0	8.9	5.6	6.6	7.2	3.0	15155
2032	73.0	6745	4546	125783	4093	4134	7364	7392	23003	9.0	8.2	7.0	8.9	5.6	6.6	7.2	3.4	15308
2034	76.0	6915	4671	128803	4884	4939	8467	8474	26764	9.0	8.2	7.0	9.0	5.6	6.6	7.2	3.9	15458
2036	79.0	7065	4780	131813	5927	6003	9782	9791	31503	9.0	8.3	7.0	9.0	5.6	6.6	7.2	4.5	15626
2038	82.0	7250	4905	134840	7446	7555	11500	11508	38009	9.0	8.3	7.0	9.0	5.6	6.6	7.2	5.2	15811
2040	86.0	7405	5015	137848	9698	9871	13672	13683	46924	9.1	8.3	7.0	9.1	5.5	6.6	7.2	6.3	16008
2042	90.0	7671	5170	141343	14076	14423	16995	17003	62497	9.1	8.3	7.0	9.1	5.5	6.6	7.2	8.1	16240

***** DL/SLS LOCK CAPACITY MODEL *****
***** WELLAND CANAL *****

**** SEASON EXTENSION 1 LOCKING TIME FORM*****

**** TRAFFIC FORECAST LOW ****
**** NON-STRUCTURAL 10% ****
**** STRUCTURAL 1200 X 115 LE X 28 D ****

PAGE 1
RUN DATE 82/03/11

RUN BY

YEAR	LK UTIL	TRANSITS TLT	TRANSITS LOD	ACT TLAS	CUM-DELAY DOWN	CUM-DELAY UP	GROUP-DELAY DOWN	GROUP-DELAY UP	TOTAL	CRE	COL	COMPOSTIE SHIP CLASS STR	CRN	OTB	GCO	TOT	AVG DELAY	TOT PROC
1978	81.0	6872	4347	67873	5937	6727	12420	12734	37818	5.8	5.8	7.0	6.1	5.6	5.6	5.9	5.5	4466
***** NONSTRUCTURAL MAXIMUM UTILITY *****																		
1980	73.0	7096	4553	71640	3519	3948	8633	8775	24875	5.9	6.0	7.0	6.1	5.6	5.6	5.9	3.5	4015
1982	77.0	7307	4746	75280	4390	4903	10020	10196	29597	6.0	6.1	7.0	6.2	5.6	5.6	6.0	4.1	4230
1984	81.0	7524	4918	78865	5726	6517	11843	12065	36171	6.2	6.2	7.0	6.3	5.6	5.6	6.0	4.8	4451
**** CAPACITY INCREASED BY INCREASING ALLOWABLE SHIP DRAFT TO 28.00 FEET ****																		
**** CAPACITY WAS INCREASED BY BUILDING LARGER LOCKS ****																		
1985	43.0	5591	3603	80736	716	725	1965	1968	5372	6.6	6.8	0.0	6.5	5.8	6.1	6.3	1.0	2406
1986	43.0	5570	3581	81513	724	734	1971	1976	5405	6.7	6.9	0.0	6.6	5.8	6.1	6.3	1.0	2406
1988	43.0	5466	3519	83076	727	736	1966	1952	5361	6.9	6.9	0.0	6.7	5.8	6.2	6.4	1.0	2406
1990	43.0	5380	3445	84615	725	734	1915	1920	5294	7.1	7.0	0.0	6.8	5.9	6.3	6.5	1.0	2406
1992	44.0	5440	3481	85965	750	759	1963	1969	5441	7.2	6.9	0.0	6.9	5.8	6.3	6.6	1.0	2449
1994	44.0	5548	3493	87274	791	759	2046	2052	5689	7.3	6.9	7.0	7.0	5.8	6.3	6.6	1.0	2467
1996	45.0	5459	3506	88594	821	830	2103	2107	5861	7.4	6.9	7.0	7.1	5.8	6.3	6.6	1.1	2502
1998	46.0	5467	3519	89907	844	854	2144	2149	5991	7.4	7.1	7.0	7.2	5.8	6.3	6.7	1.1	2534
2000	46.0	5442	3513	91227	877	868	2203	2207	6175	7.5	7.2	7.0	7.2	5.8	6.4	6.7	1.1	2567
2002	47.0	5520	3571	93208	945	952	2337	2342	6576	7.6	7.2	7.0	7.4	5.8	6.4	6.8	1.2	2624
2004	48.0	5571	3617	95190	1001	1012	2451	2457	6921	7.7	7.2	7.0	7.5	5.8	6.5	6.8	1.2	2684
2006	49.0	5586	3647	97171	1073	1063	2563	2590	7329	7.7	7.2	7.0	7.6	5.7	6.5	6.9	1.3	2738
2008	50.0	5663	3697	99162	1136	1148	2710	2715	7711	7.8	7.2	7.0	7.7	5.7	6.5	6.9	1.4	2799
2010	51.0	5730	3760	101143	1223	1233	2672	2878	8206	7.8	7.2	7.0	7.8	5.7	6.6	7.0	1.4	2856
2012	52.0	5746	3757	102558	1276	1288	2570	2970	8510	7.9	7.2	7.0	7.9	5.7	6.5	7.0	1.5	2906
2014	53.0	5791	3783	103973	1337	1346	3084	3090	8857	7.9	7.4	7.0	7.9	5.7	6.5	7.0	1.5	2948
2016	54.0	5926	3801	105390	1409	1417	3215	3220	9261	8.0	7.4	7.0	8.0	5.7	6.5	7.0	1.6	3002
2018	55.0	5841	3795	106807	1459	1472	3305	3310	9546	8.1	7.5	7.0	8.0	5.7	6.5	7.0	1.6	3045
2020	55.0	5876	3825	108228	1541	1553	3456	3460	10010	8.1	7.5	7.0	8.1	5.7	6.5	7.0	1.7	3080
2022	57.0	5961	3900	111133	1703	1719	3718	3726	10866	8.3	7.5	7.0	8.3	5.6	6.6	7.1	1.8	3191
2024	59.0	6010	3960	114037	1691	1906	4016	4023	11836	8.5	7.8	7.0	8.4	5.6	6.6	7.1	2.0	3277
2026	61.0	6067	4018	116953	2076	2094	4289	4295	12756	8.7	7.8	7.0	8.6	5.6	6.6	7.2	2.1	3384
2028	63.0	6114	4072	119659	2296	2315	4599	4605	13815	8.8	8.1	7.0	8.8	5.6	6.6	7.2	2.3	3491
2030	64.0	6223	4153	122773	2560	2580	4963	4970	15073	9.0	8.2	7.0	9.0	5.6	6.6	7.2	2.4	3591
2032	67.0	6341	4262	125784	2959	2966	5601	5609	17155	9.1	8.3	7.0	9.0	5.6	6.6	7.2	2.7	3727
2034	70.0	6513	4387	128602	3406	3476	6343	6347	19614	9.1	8.3	7.0	9.0	5.6	6.6	7.2	3.0	3898
2036	73.0	6679	4509	131612	4054	4096	7219	7229	22598	9.1	8.3	7.0	9.1	5.6	6.6	7.2	3.4	4023
2038	75.0	6827	4616	134642	4631	4671	8273	8279	26263	9.1	8.3	7.0	9.1	5.5	6.6	7.2	3.8	4183
2040	79.0	7002	4736	137686	5690	5919	9521	9526	30796	9.1	8.3	7.0	9.1	5.5	6.6	7.2	4.4	4362
2042	81.0	7190	4873	140771	7239	7256	11384	11315	37174	9.2	8.3	7.0	9.1	5.5	6.6	7.2	5.2	4544

***** GL/SLS LOCK CAPACITY MODEL *****
***** ST. LAWRENCE RIVER *****
** CAPACITY DATE FORCED TO COINCIDE WITH THE WELLAND **
**** SEASON EXTENSION 2 LOCKING TIME NORM*****

PAGE 1
RUN DATE 82/03/09
RUN BY NCBPD - EH

**** TRAFFIC FORECAST LOW ****
**** NON-STRUCTURAL 13% ****
**** STRUCTURAL 1200 X 115 LK X 28.0 D ****

YEAR	LK UTIL	TRANSITS TOT	TRANSITS LDD	ACT TONS	CON-DELAY DOWN	CON-DELAY UP	UNCON-DELAY DOWN	UNCON-DELAY UP	TOTAL	ORE	COL	COMPOSITE SHIP CLASS STN	GRN	OTB	GCO	TOT	AVG DELAY	TOT PROC
1978	59.0	5844	3981	61448	1531	1558	5028	5032	13149	6.4	5.8	0.0	5.9	5.5	5.5	5.8	2.3	2975
1980	63.0	6107	4220	65550	1969	2007	6221	6227	16424	6.3	5.6	0.0	6.0	5.5	5.6	5.8	2.7	3184
1982	68.0	6391	4452	69662	2553	2607	7701	7704	20565	6.2	5.6	7.0	6.1	5.5	5.6	5.9	3.2	3428
1984	73.0	6709	4679	73777	3487	3571	9832	9834	26724	6.2	5.4	7.0	6.2	5.6	5.6	5.9	4.0	3700
1985	76.0	6843	4786	75824	4090	4196	11081	11084	30451	6.3	5.7	7.0	6.3	5.5	5.6	6.0	4.4	3845
1986	77.0	6899	4809	77084	4376	4494	11638	11644	32152	6.3	5.9	7.0	6.3	5.6	5.6	6.0	4.7	3901
1988	80.0	7008	4864	79585	5041	5188	12864	12872	35965	6.4	6.2	7.0	6.4	5.6	5.6	6.0	5.1	4025
1990	82.0	7093	4902	82102	5838	6025	14188	14194	40245	6.5	6.7	7.0	6.4	5.6	5.7	6.1	5.7	4145
***** NONSTRUCTURAL MAXIMUM UTILITY *****																		
1992	65.0	7189	4959	83006	2292	2338	7051	7053	18734	6.5	6.8	7.0	6.5	5.6	5.7	6.1	2.6	3332
**** CAPACITY INCREASED BY INCREASING ALLOWABLE SHIP DRAFT TO 28.00 FEET ****																		
**** CAPACITY WAS INCREASED BY BUILDING LARGER LOCKS ****																		
1994	39.0	4988	3475	83906	505	505	2030	2033	5073	7.1	7.0	0.0	6.8	5.8	6.3	6.5	1.0	1996
1996	40.0	5024	3507	84820	522	522	2095	2098	5237	7.1	7.0	7.0	6.9	5.8	6.4	6.5	1.0	2035
1998	40.0	5034	3512	85717	535	534	2156	2156	5381	7.2	7.0	7.0	7.0	5.8	6.4	6.6	1.1	2049
2000	41.0	5040	3520	86643	553	554	2228	2231	5566	7.2	7.0	7.0	7.1	5.8	6.4	6.6	1.1	2085
2002	41.0	5100	3570	88589	574	575	2315	2316	5780	7.3	7.0	7.0	7.2	5.8	6.4	6.7	1.1	2102
2004	42.0	5132	3599	90571	611	612	2459	2460	6142	7.4	7.4	7.0	7.3	5.7	6.5	6.7	1.2	2155
2006	43.0	5176	3640	92524	643	644	2589	2591	6467	7.5	7.4	7.0	7.5	5.7	6.5	6.8	1.2	2191
2008	44.0	5214	3675	94494	681	683	2752	2756	6872	7.6	7.5	7.0	7.6	5.7	6.5	6.8	1.3	2237
2010	45.0	5272	3711	96447	722	722	2906	2908	7258	7.7	7.5	7.0	7.7	5.7	6.6	6.9	1.4	2293
2012	45.0	5299	3739	97808	735	735	2961	2965	7396	7.8	7.5	7.0	7.8	5.7	6.6	6.9	1.4	2311
2014	46.0	5303	3753	99172	757	758	3045	3048	7608	7.9	7.5	7.0	7.9	5.7	6.6	6.9	1.4	2325
2016	46.0	5324	3765	100538	783	784	3148	3148	7863	7.9	7.5	7.0	7.9	5.7	6.6	6.9	1.5	2350
2018	47.0	5363	3794	101889	810	812	3260	3263	8145	8.0	7.5	7.0	8.0	5.7	6.6	6.9	1.5	2385
2020	47.0	5386	3827	103256	845	846	3396	3399	8486	8.0	7.5	7.0	8.0	5.7	6.6	7.0	1.6	2403
2022	48.0	5449	3862	106122	904	904	3629	3631	9068	8.2	7.9	7.0	8.2	5.6	6.6	7.0	1.7	2473
2024	50.0	5556	3945	108999	993	994	3984	3989	9960	8.4	8.0	7.0	8.4	5.6	6.6	7.0	1.8	2558
2026	52.0	5637	3994	111881	1084	1084	4352	4353	10873	8.6	8.0	0.0	8.5	5.6	6.6	7.1	1.9	2639
2028	53.0	5720	4045	114748	1195	1196	4792	4796	11979	8.8	8.0	0.0	8.7	5.6	6.6	7.1	2.1	2721
2030	55.0	5821	4111	117618	1337	1338	5364	5366	13405	9.0	8.2	0.0	8.9	5.6	6.6	7.1	2.3	2813
2032	57.0	6006	4238	120567	1523	1524	6100	6103	15250	9.0	8.5	0.0	8.9	5.6	6.6	7.1	2.5	2929
2034	60.0	6174	4347	123505	1731	1733	6941	6945	17350	9.0	8.5	0.0	9.0	5.5	6.6	7.1	2.8	3057
2036	62.0	6349	4462	126445	1995	1997	7997	8006	19995	9.0	8.5	0.0	9.0	5.5	6.6	7.1	3.1	3180
2038	65.0	6526	4581	129384	2303	2304	9221	9225	23053	9.1	8.5	0.0	9.0	5.5	6.6	7.1	3.5	3314
2040	67.0	6718	4696	132328	2655	2656	10635	10641	26587	9.1	8.5	0.0	9.1	5.5	6.6	7.1	4.0	3438
2042	70.0	6884	4823	135509	3125	3127	12515	12520	31287	9.1	8.5	0.0	9.1	5.5	6.6	7.1	4.5	3586
2044	73.0	7071	4952	138696	3692	3692	14779	14783	36946	9.1	8.5	0.0	9.1	5.5	6.6	7.1	5.2	3735
2046	76.0	7253	5079	141885	4442	4443	17786	17793	44464	9.2	8.5	0.0	9.1	5.5	6.6	7.1	6.1	3891
2048	79.0	7430	5201	145070	5423	5424	21706	21711	54264	9.2	8.5	0.0	9.1	5.5	6.6	7.1	7.3	4053
2050	83.0	7645	5330	148267	6767	6769	27088	27093	67717	9.2	8.5	6.0	9.2	5.5	6.6	7.1	8.9	4212

***** GL/SLS LOCK CAPACITY MODEL *****
***** ST. LAWRENCE RIVER *****
***** CAPACITY DATE FORCED TO COINCIDE WITH THE WELLAND *****
**** SEASON EXTENSION 2 LOCKING TIME NORM*****
**** 80% LOCK UTILIZATION ****
**** TRAFFIC FORECAST LOW ****
**** NON-STRUCTURAL 13% ****
**** STRUCTURAL 1200 X 115 LK X 28 D ****

YEAR	LK UTIL	TRANSITS TOT	TRANSITS LDP	ACT TONS	CON-DELAY DOWN	CON-DELAY UP	UNCON-DELAY DOWN	UNCON-DELAY UP	TOTAL	ORE	COL	COMPOSITE SHIP CLASS STN	GRN	OTB	GCO	TOT	AVG DELAY	TOT PROC
1978	59.0	5844	3981	61448	1531	1558	5028	5032	13149	6.4	5.8	0.0	5.9	5.5	5.5	5.8	2.3	10064
1980	63.0	6107	4220	65550	1969	2007	6221	6227	16424	6.3	5.6	0.0	6.0	5.5	5.6	5.8	2.7	10273
1982	68.0	6370	4452	69662	2553	2607	7701	7704	20565	6.2	5.6	7.0	6.1	5.5	5.6	5.9	3.2	10517
***** NONSTRUCTURAL MAXIMUM UTILITY *****																		
1984	58.0	6711	4683	73777	1558	1588	5106	5108	13360	6.2	5.4	7.0	6.2	5.6	5.6	5.9	2.0	10064
**** CAPACITY INCREASED BY INCREASING ALLOWABLE SHIP DRAFT TO 28.00 FEET ****																		
**** CAPACITY WAS INCREASED BY BUILDING LARGER LOCKS ****																		
1985	38.0	4894	3398	75825	447	449	1805	1808	4509	6.6	6.2	0.0	6.5	5.7	6.1	6.2	.9	9011
1986	38.0	4903	3394	77087	448	448	1812	1814	4522	6.7	6.2	0.0	6.6	5.7	6.1	6.3	.9	9011
1988	38.0	4839	3354	79591	448	448	1805	1808	4509	7.0	6.7	0.0	6.7	5.8	6.2	6.4	.9	9015
1990	38.0	4763	3313	82098	447	448	1804	1806	4505	7.2	7.2	0.0	6.9	5.8	6.3	6.5	.9	9015
1992	38.0	4808	3340	83022	453	455	1831	1835	4574	7.3	7.2	0.0	7.0	5.8	6.3	6.5	1.0	9025
1994	38.0	4828	3359	83906	477	478	1920	1924	4799	7.3	7.2	7.0	7.0	5.8	6.3	6.6	1.0	9043
1996	39.0	4856	3383	84824	486	487	1956	1959	4888	7.4	7.6	7.0	7.1	5.8	6.4	6.6	1.0	9071
1998	39.0	4860	3388	85729	504	505	2027	2028	5064	7.5	7.6	7.0	7.2	5.8	6.4	6.6	1.0	9076
2000	40.0	4865	3408	86636	515	515	2077	2079	5186	7.6	7.6	7.0	7.2	5.8	6.4	6.7	1.1	9110
2002	40.0	4942	3460	88599	545	545	2192	2195	5477	7.7	7.6	7.0	7.4	5.7	6.4	6.7	1.1	9135
2004	41.0	4967	3479	90564	569	570	2291	2293	5723	7.8	7.6	7.0	7.5	5.7	6.5	6.8	1.2	9191
2006	42.0	5015	3523	92526	605	606	2440	2440	6091	7.9	7.6	7.0	7.6	5.7	6.5	6.8	1.2	9244
2008	43.0	5061	3562	94486	644	645	2592	2594	6475	8.0	7.6	7.0	7.8	5.7	6.5	6.9	1.3	9280
2010	44.0	5167	3610	96451	686	687	2763	2766	6902	8.1	7.6	7.0	7.9	5.7	6.6	6.9	1.3	9336
2012	44.0	5145	3620	97809	708	708	2843	2846	7105	8.1	8.0	7.0	8.0	5.7	6.6	6.9	1.4	9350
2014	45.0	5161	3647	99176	726	726	2914	2918	7284	8.2	8.0	7.0	8.0	5.7	6.6	7.0	1.4	9368
2016	45.0	5187	3670	100534	748	747	3003	3005	7503	8.3	8.0	7.0	8.1	5.7	6.6	7.0	1.4	9400
2018	46.0	5243	3715	101889	773	774	3107	3111	7765	8.3	8.0	7.0	8.1	5.6	6.6	7.0	1.5	9425
2020	46.0	5290	3728	103254	799	800	3214	3216	8029	8.4	8.0	7.0	8.2	5.6	6.6	7.0	1.5	9453
2022	48.0	5359	3803	106125	867	867	3485	3485	8704	8.5	8.0	7.0	8.3	5.6	6.6	7.0	1.6	9534
2024	49.0	5462	3878	108997	960	962	3857	3861	9640	8.7	8.2	7.0	8.5	5.6	6.6	7.1	1.8	9601
2026	51.0	5561	3939	111877	1068	1069	4286	4289	10712	8.8	8.2	0.0	8.6	5.6	6.6	7.1	1.9	9704
2028	53.0	5675	4014	114744	1169	1170	4691	4694	11724	9.0	8.2	0.0	8.8	5.6	6.6	7.1	2.1	9792
2030	55.0	5751	4086	117623	1311	1312	5263	5266	13152	9.1	8.5	0.0	9.0	5.5	6.6	7.1	2.3	9894
2032	57.0	5968	4210	120558	1502	1503	6026	6030	15061	9.1	8.5	0.0	9.0	5.5	6.6	7.1	2.5	10001
2034	59.0	6138	4322	123502	1711	1710	6858	6857	17136	9.1	8.5	0.0	9.0	5.5	6.6	7.1	2.8	10128
2036	62.0	6322	4446	126441	1971	1972	7901	7905	19749	9.1	8.5	0.0	9.0	5.5	6.6	7.1	3.1	10255
2038	64.0	6505	4570	129385	2275	2276	9116	9121	22788	9.2	8.5	0.0	9.1	5.5	6.6	7.1	3.5	10382
2040	67.0	6678	4677	132327	2622	2623	10503	10507	26255	9.2	8.5	0.0	9.1	5.5	6.6	7.1	3.9	10520
2042	70.0	6859	4806	135510	3092	3095	12387	12392	30966	9.2	8.5	0.0	9.1	5.5	6.6	7.1	4.5	10665
2044	73.0	7050	4938	138699	3654	3655	14632	14633	36574	9.2	8.5	0.0	9.1	5.5	6.6	7.1	5.2	10820
2046	76.0	7236	5069	141886	4386	4387	17560	17565	43898	9.2	8.5	0.0	9.2	5.5	6.6	7.1	6.1	10972
2048	79.0	7417	5193	145075	5345	5346	21399	21409	53499	9.2	8.5	0.0	9.2	5.5	6.6	7.1	7.2	11135
2050	81.0	7603	5320	147642	6345	6283	25393	25143	63164	9.2	8.5	6.0	9.2	5.5	6.6	7.1	8.3	11279

***** GL/SLS LOCK CAPACITY MODEL *****
***** WELLAND CANAL *****

**** SEASON EXTENSION 1 LOCKING TIME NORM*****

RUN BY NCBPO - EB

**** TRAFFIC FORECAST LOW ****
**** NON-STRUCTURAL 10% ****
**** STRUCTURAL 1350 X 115 LK X 25.5 D ****

YEAR	LK UTIL	TRANSITS TOT	TRANSITS LDD	ACT TONS	CON-DELAY DOWN	CON-DELAY UP	UNCON-DELAY DOWN	UNCON-DELAY UP	TOTAL	ORE	COL	COMPOSITE SHIP CLASS STN	GRN	OTB	GCO	TOT	AVG DELAY	TOT PROC
1978	83.0	6872	4347	67990	5985	7058	12510	12734	38287	5.8	5.8	7.0	6.1	5.6	5.6	5.9	5.6	17070
1980	88.0	7095	4550	71640	8664	10729	15396	15695	50484	5.9	6.0	7.0	6.1	5.6	5.6	5.9	7.1	17360
1982	90.0	7292	4745	75113	13193	15545	18601	19139	66478	6.0	6.1	7.0	6.2	5.6	5.6	6.0	9.1	17580
***** NONSTRUCTURAL MAXIMUM UTILITY *****																		
1984	81.0	7511	4918	78915	5740	6616	11869	12085	36310	6.2	6.2	7.0	6.3	5.6	5.6	6.0	4.8	17014
1985	84.0	7643	5006	80735	6827	7998	13166	13409	41400	6.3	6.3	7.0	6.3	5.6	5.6	6.0	5.4	17178
1986	85.0	7673	5002	81520	7251	8534	13586	13848	43219	6.4	6.3	7.0	6.4	5.6	5.7	6.1	5.6	17231
1988	87.0	7718	4979	83077	8186	9726	14402	14683	46997	6.6	6.7	7.0	6.4	5.6	5.7	6.1	6.1	17306
1990	88.0	7784	4960	84643	9408	11331	15395	15698	51832	6.8	6.8	7.0	6.5	5.6	5.7	6.2	6.7	17406
1992	90.0	7869	5038	85961	11096	13779	16681	17021	58577	6.8	6.8	7.0	6.5	5.6	5.7	6.2	7.4	17520
**** CAPACITY WAS INCREASED BY BUILDING LARGER LOCKS ****																		
1994	60.0	6733	4338	87280	1961	1984	4844	4846	13635	7.2	7.1	7.0	7.1	5.8	6.3	6.7	2.0	15908
1996	61.0	6728	4344	88596	2020	2049	4945	4955	13973	7.3	7.1	7.0	7.2	5.8	6.4	6.7	2.1	15940
1998	61.0	6732	4359	89905	2088	2113	5054	5060	14315	7.4	7.2	7.0	7.3	5.8	6.4	6.8	2.1	15954
2000	62.0	6705	4353	91231	2152	2178	5150	5160	14640	7.4	7.2	7.0	7.3	5.8	6.4	6.8	2.2	15993
2002	62.0	6718	4361	93204	2245	2270	5297	5306	15118	7.5	7.2	7.0	7.4	5.8	6.4	6.8	2.3	16039
2004	63.0	6769	4415	95193	2382	2407	5545	5552	15886	7.6	7.2	7.0	7.5	5.8	6.5	6.9	2.3	16093
2006	64.0	6799	4452	97171	2506	2532	5750	5758	16546	7.6	7.2	7.0	7.6	5.8	6.5	6.9	2.4	16125
2008	65.0	6821	4476	99164	2667	2693	6030	6033	17423	7.7	7.2	7.0	7.7	5.7	6.5	6.9	2.6	16179
2010	66.0	6820	4498	101145	2781	2809	6191	6199	17980	7.8	7.4	7.0	7.8	5.7	6.6	7.0	2.6	16240
2012	67.0	6882	4524	102556	2936	2966	6461	6469	18832	7.8	7.4	7.0	7.9	5.7	6.6	7.0	2.7	16286
2014	68.0	6918	4539	103973	3097	3126	6732	6734	19689	7.9	7.4	7.0	7.9	5.7	6.6	7.0	2.8	16346
2016	69.0	6945	4547	105387	3292	3325	7064	7071	20752	8.0	7.4	7.0	8.0	5.7	6.5	7.0	3.0	16396
2018	70.0	6987	4571	106813	3451	3486	7308	7314	21559	8.0	7.4	7.0	8.1	5.7	6.5	7.0	3.1	16457
2020	71.0	6978	4591	108233	3628	3665	7580	7589	22462	8.1	7.4	7.0	8.1	5.7	6.5	7.1	3.2	16500
2022	72.0	7026	4620	111132	3910	3949	7908	7910	23677	8.3	7.7	7.0	8.3	5.7	6.6	7.1	3.4	16575
2024	73.0	7035	4657	114035	4236	4287	8273	8287	25083	8.5	7.9	7.0	8.5	5.6	6.6	7.1	3.6	16628
2026	75.0	7028	4679	116953	4609	4662	8680	8688	26639	8.7	8.1	7.0	8.6	5.6	6.6	7.2	3.8	16721
2028	76.0	7056	4734	119861	5008	5069	9077	9085	28239	8.9	8.2	7.0	8.9	5.6	6.6	7.2	4.0	16796
2030	78.0	7054	4769	122769	5498	5571	9564	9572	30205	9.1	8.3	7.0	9.1	5.6	6.6	7.3	4.3	16875
2032	81.0	7242	4905	125782	6811	6912	11190	11193	36106	9.1	8.3	7.0	9.1	5.6	6.6	7.3	5.0	17050
2034	85.0	7420	5036	128803	8635	8787	13146	13161	43729	9.2	8.4	7.0	9.2	5.6	6.6	7.3	5.9	17239
2036	88.0	7614	5166	131812	11906	12175	16128	16137	56346	9.2	8.5	7.0	9.2	5.6	6.6	7.2	7.4	17460
2038	90.0	7802	5293	134329	16357	16541	20002	19987	72887	9.2	8.5	7.0	9.2	5.5	6.6	7.2	9.3	17649

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***** CLOSED LOCK CAPACITY MODEL *****
***** WELLAND CANAL *****

**** SEASON RATE STUDY 1 LOCKING TIME NORM*****

**** TRAFFIC FORECAST LOW ****
**** NON-STRUCTURAL 10% ****
**** STRUCTURAL 1350 X 115 X 25.5 ****

RUN BY

80 %
LOCK UTILIZATION

YEAR	LF UTIL	TRANSITS TOT	TRANSITS LEG	ACT TONS	CUM-DELAY DOWN	CUM-DELAY UP	INCL CUM-DELAY DOWN	INCL CUM-DELAY UP	TOTAL	CAF	COL	COMPOSITE SHIP CLASS STN	GRA	OTB	GCO	TOT	AVG DELAY	TOT PROC
1976	61.	6?72	4347	67873	5937	6727	12420	12734	37818	5.8	5.8	7.0	6.1	5.6	5.6	5.9	5.5	4486
					***** NONSTRUCTURAL MAXIMUM UTILITY *****													
1980	73.	7098	4553	71640	3519	3948	6633	8775	24875	5.9	6.0	7.0	6.1	5.6	5.6	5.9	3.5	4015
1982	77.	7307	4746	75280	4396	4963	10020	10196	29597	6.0	6.1	7.0	6.2	5.6	5.6	6.0	4.1	4230
1984	81.	7524	4918	78865	5720	6517	11683	12085	36171	6.2	6.2	7.0	6.3	5.6	5.6	6.0	4.8	4451
					**** CAPACITY WAS INCREASED BY BUILDING LARGER LOCKS ****													
1985	57.	6627	4332	80734	1654	1678	4206	4212	11750	6.9	6.8	7.0	6.8	5.8	6.1	6.5	1.8	3173
1986	57.	6587	4287	81518	1655	1674	4179	4165	11691	7.0	6.8	7.0	6.9	5.8	6.2	6.5	1.8	3177
1988	57.	6512	4221	83073	1634	1652	4075	4062	11443	7.2	6.9	7.0	7.0	5.8	6.2	6.6	1.8	3177
1990	57.	6429	4147	84648	1626	1647	4016	4025	11314	7.4	6.9	7.0	7.1	5.8	6.3	6.7	1.8	3166
1992	57.	6428	4145	85967	1687	1711	4129	4138	11665	7.4	7.1	7.0	7.2	5.8	6.3	6.7	1.8	3191
1994	[illegible]	6452	4177	87279	1716	1738	4159	4165	11780	7.5	7.1	7.0	7.3	5.8	6.3	6.8	1.8	3216
1996	[illegible]	6443	4179	88585	1772	1794	4249	4262	12077	7.6	7.1	7.0	7.3	5.8	6.4	6.8	1.9	3234
1998	[illegible]	6452	4196	89904	1823	1845	4332	4338	12338	7.7	7.1	7.0	7.4	5.8	6.4	6.8	1.9	3262
2000	[illegible]	6415	4183	91229	1879	1901	4428	4431	12639	7.7	7.2	7.0	7.5	5.8	6.4	6.9	2.0	3291
2002	[illegible]	6456	4210	93203	1993	2015	4633	4639	13280	7.8	7.2	7.0	7.6	5.8	6.4	6.9	2.1	3345
2004	61.	6469	4241	95191	2097	2118	4807	4815	13837	7.8	7.2	7.0	7.7	5.7	6.5	6.9	2.1	3395
2006	62.	6531	4266	97169	2229	2253	5044	5052	14578	7.9	7.4	7.0	7.8	5.7	6.5	7.0	2.2	3445
2008	63.	6560	4310	99162	2364	2388	5274	5282	15308	8.0	7.4	7.0	7.9	5.7	6.5	7.0	2.3	3509
2010	[illegible]	6592	4361	101144	2506	2531	5513	5519	16071	8.0	7.4	7.0	8.0	5.7	6.6	7.0	2.4	3562
2012	65.	6666	4399	102557	2626	2648	5707	5715	16696	8.1	7.4	7.0	8.1	5.7	6.6	7.1	2.5	3616
2014	[illegible]	6706	4415	103971	2770	2796	5958	5967	17491	8.2	7.4	7.0	8.1	5.7	6.5	7.1	2.6	3669
2016	67.	6732	4420	105391	2938	2965	6248	6254	18405	8.2	7.4	7.0	8.2	5.7	6.5	7.1	2.7	3723
2018	[illegible]	6757	4425	106806	3080	3109	6469	6474	19132	8.2	7.4	7.0	8.2	5.7	6.5	7.1	2.8	3783
2020	69.	6827	4461	108232	3255	3265	6752	6760	20052	8.3	7.5	7.0	8.3	5.7	6.5	7.1	2.9	3837
2022	70.	6849	4515	111128	3549	3587	7146	7154	21436	8.5	7.8	7.0	8.4	5.6	6.6	7.2	3.1	3898
2024	72.	6883	4565	114039	3912	3955	7621	7634	23122	8.7	8.0	7.0	8.6	5.6	6.6	7.2	3.4	4012
2026	[illegible]	6917	4609	116951	4311	4357	8117	8120	24905	8.9	8.1	7.0	8.8	5.6	6.6	7.2	3.6	4080
2028	75.	6965	4660	119860	4736	4795	8596	8607	26734	9.0	8.2	7.0	9.0	5.6	6.6	7.3	3.8	4160
2030	77.	6992	4734	122773	5274	5343	9193	9201	29011	9.2	8.3	7.0	9.1	5.6	6.6	7.3	4.1	4280
2032	81.	7203	4873	125780	6546	6640	10795	10799	34760	9.2	8.4	7.0	9.2	5.6	6.6	7.3	4.8	4451

S211812-W

***** GL/SLS LOCK CAPACITY MODEL *****
***** ST. LAWRENCE RIVER *****
** CAPACITY DATE FORCED TO COINCIDE WITH THE WELLAND **
**** SEASON EXTENSION 2 LOCKING TIME NORM*****

RUN DATE 82/02/17
RUN BY NCBPD - EB

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**** TRAFFIC FORECAST LOW ****
**** NON-STRUCTURAL 13% ****
**** STRUCTURAL 1350 X 115 LK X 25.5 D ****

YEAR	LK UTIL	TRANSITS TOT	TRANSITS LDD	ACT TONS	CON-DELAY DOWN	CON-DELAY UP	UNCON-DELAY DOWN	UNCON-DELAY UP	TOTAL	ORE	COL	STN	GRN	OTB	GCO	TOT	AVG DELAY	TOT PROC
1978	59.0	5844	3981	61448	1531	1558	5028	5032	13149	6.4	5.8	0.0	5.9	5.5	5.5	5.8	2.3	2975
1980	63.0	6107	4220	65550	1969	2007	6221	6227	16424	6.3	5.6	0.0	6.0	5.5	5.6	5.8	2.7	3184
1982	68.0	6391	4452	69662	2553	2607	7701	7704	20565	6.2	5.6	7.0	6.1	5.5	5.6	5.9	3.2	3428
1984	73.0	6709	4679	73777	3487	3571	9832	9834	26724	6.2	5.4	7.0	6.2	5.6	5.6	5.9	4.0	3700
1985	76.0	6843	4786	75824	4090	4196	11081	11084	30451	6.3	5.7	7.0	6.3	5.5	5.6	6.0	4.4	3845
1986	77.0	6899	4809	77084	4376	4494	11638	11644	32152	6.3	5.9	7.0	6.3	5.6	5.6	6.0	4.7	3901
1988	80.0	7008	4863	79585	5041	5188	12864	12872	35965	6.4	6.2	7.0	6.4	5.6	5.6	6.0	5.1	4025
1990	82.0	7093	4902	82102	5838	6025	14188	14194	40245	6.5	6.7	7.0	6.4	5.6	5.7	6.1	5.7	4145
***** NONSTRUCTURAL MAXIMUM UTILITY *****																		
1992	65.0	7189	4959	83006	2292	2338	7051	7053	18734	6.5	6.8	7.0	6.5	5.6	5.7	6.1	2.6	3332
**** CAPACITY WAS INCREASED BY BUILDING LARGER LOCKS ****																		
1994	50.0	5945	4185	83914	1008	1010	4049	4052	10119	7.3	7.0	7.0	7.2	5.8	6.4	6.7	1.7	2562
1996	51.0	5941	4179	84823	1035	1036	4149	4153	10373	7.4	7.0	7.0	7.2	5.8	6.4	6.7	1.7	2601
1998	51.0	5961	4193	85729	1049	1050	4208	4210	10517	7.4	7.4	7.0	7.3	5.8	6.4	6.7	1.8	2615
2000	51.0	6005	4220	86631	1094	1095	4393	4395	10977	7.5	7.4	7.0	7.3	5.8	6.4	6.7	1.8	2632
2002	52.0	6004	4239	88596	1129	1130	4532	4535	11326	7.6	7.4	7.0	7.5	5.8	6.5	6.8	1.9	2671
2004	53.0	6030	4267	90562	1167	1168	4660	4684	11699	7.7	7.4	7.0	7.6	5.7	6.5	6.8	1.9	2707
2006	53.0	6043	4285	92525	1230	1231	4937	4941	12339	7.8	7.4	7.0	7.7	5.7	6.5	6.9	2.0	2724
2008	55.0	6112	4314	94485	1303	1304	5225	5229	13061	7.8	7.5	7.0	7.8	5.7	6.5	6.9	2.1	2805
2010	56.0	6185	4340	96454	1390	1392	5576	5581	13939	7.9	7.5	7.0	8.0	5.7	6.6	6.9	2.3	2862
2012	56.0	6182	4357	97808	1423	1425	5708	5715	14271	8.0	7.5	7.0	8.0	5.7	6.6	7.0	2.3	2880
2014	56.0	6186	4375	99174	1456	1455	5834	5835	14580	8.1	7.5	7.0	8.1	5.7	6.6	7.0	2.4	2887
2016	57.0	6201	4394	100537	1473	1474	5911	5914	14772	8.1	7.5	7.0	8.1	5.7	6.6	7.0	2.4	2915
2018	57.0	6217	4415	101894	1512	1510	6055	6055	15132	8.2	7.5	7.0	8.2	5.7	6.6	7.0	2.4	2929
2020	58.0	6225	4440	103261	1548	1550	6210	6217	15525	8.3	7.5	7.0	8.2	5.7	6.6	7.0	2.5	2954
2022	59.0	6320	4488	106131	1703	1705	6824	6829	17061	8.4	7.5	7.0	8.4	5.6	6.6	7.1	2.7	3039
2024	61.0	6403	4539	109002	1876	1877	7523	7527	18803	8.6	8.0	7.0	8.5	5.6	6.6	7.1	2.9	3124
2026	63.0	6499	4601	111875	2066	2067	8278	8281	20692	8.8	8.0	7.0	8.7	5.6	6.6	7.1	3.2	3216
2028	65.0	6598	4668	114750	2290	2291	9171	9176	22928	9.0	8.2	7.0	8.9	5.6	6.6	7.1	3.5	3311
2030	66.0	6709	4740	117625	2530	2531	10132	10136	25329	9.2	8.6	7.0	9.1	5.5	6.6	7.2	3.8	3389
2032	69.0	6885	4856	120563	3010	3010	12052	12057	30129	9.2	8.6	7.0	9.1	5.6	6.6	7.1	4.4	3548
2034	73.0	7092	4997	123502	3593	3594	14388	14392	35967	9.2	8.6	7.0	9.1	5.5	6.6	7.1	5.1	3707
2036	76.0	7297	5135	126446	4364	4364	17468	17469	43665	9.3	8.6	7.0	9.2	5.5	6.6	7.1	6.0	3876
2038	79.0	7489	5260	129386	5416	5417	21680	21684	54197	9.2	8.6	7.0	9.2	5.5	6.6	7.1	7.2	4046
2040	83.0	7693	5398	132328	6829	6830	27328	27334	68321	9.3	8.6	7.0	9.3	5.5	6.6	7.1	8.9	4226
2042	87.0	7920	5558	135517	9128	9128	36519	36521	91296	9.3	8.6	7.0	9.3	5.5	6.6	7.1	11.5	4414
2044	90.0	8132	5696	138673	13007	13004	52045	52034	130090	9.3	8.8	7.0	9.3	5.5	6.6	7.1	16.0	4618

RUN BY NCBPD - EB

***** GL/SLS LOCK CAPACITY MODEL *****
***** ST. LAWRENCE RIVER *****
***** CAPACITY DATE FORCED TO COINCIDE WITH THE WELLAND *****
**** SEASON EXTENSION 2 LOCKING TIME NORM*****
**** 80% LOCK UTILIZATION ****
**** TRAFFIC FORECAST LOW ****
**** NON-STRUCTURAL 13% ****
**** STRUCTURAL 1350 X 115 LK X 25.5 D ****

YEAR	LK UTIL	TRANSITS TOT	TRANSITS LOD	ACT TONS	CON-DELAY DOWN	CON-DELAY UP	UNCON-DELAY DOWN	UNCON-DELAY UP	TOTAL	ORE	COL	COMPOSITE SHIP CLASS STN	GRN	OTB	GCO	TOT	AVG DELAY	TOT PROC
1978	59.0	5844	3981	61448	1531	1558	5028	5032	13149	6.4	5.8	0.0	5.9	5.5	5.5	5.8	2.3	13503
1980	63.0	6107	4220	65550	1969	2007	6221	6227	16424	6.3	5.6	0.0	6.0	5.5	5.6	5.8	2.7	13712
1982	68.0	6370	4452	69662	2553	2607	7701	7704	20565	6.2	5.6	7.0	6.1	5.5	5.6	5.9	3.2	13956
***** NONSTRUCTURAL MAXIMUM UTILITY *****																		
1984	58.0	6711	4683	73777	1558	1588	5106	5108	13360	6.2	5.4	7.0	6.2	5.6	5.6	5.9	2.0	13503
**** CAPACITY WAS INCREASED BY BUILDING LARGER LOCKS ****																		
1985	48.0	5802	4077	75827	868	869	3489	3493	8719	7.0	6.7	7.0	6.9	5.7	6.1	6.4	1.5	12970
1986	48.0	5797	4057	77079	867	868	3480	3484	8699	7.0	6.7	7.0	6.9	5.7	6.2	6.5	1.5	12970
1988	48.0	5755	4036	79593	858	859	3446	3450	8613	7.3	6.7	7.0	7.1	5.7	6.2	6.6	1.5	12973
1990	47.0	5647	3981	82100	860	861	3451	3455	8627	7.4	7.2	7.0	7.2	5.8	6.3	6.7	1.5	12945
1992	48.0	5691	3993	83008	877	878	3524	3527	8806	7.5	7.2	7.0	7.3	5.8	6.3	6.7	1.5	12973
1994	48.0	5709	4009	83918	898	899	3607	3611	9015	7.5	7.2	7.0	7.3	5.8	6.4	6.7	1.6	12987
1996	49.0	5716	4016	84823	913	914	3666	3669	9162	7.7	7.6	7.0	7.4	5.7	6.4	6.7	1.6	13019
1998	49.0	5721	4018	85725	941	942	3778	3785	9446	7.7	7.6	7.0	7.4	5.7	6.4	6.8	1.7	13033
2000	49.0	5737	4044	86643	956	956	3839	3842	9593	7.8	7.6	7.0	7.5	5.7	6.4	6.8	1.7	13040
2002	50.0	5772	4071	88598	999	1000	4013	4017	10029	7.9	7.6	7.0	7.6	5.7	6.5	6.8	1.7	13090
2004	51.0	5813	4112	90561	1044	1044	4192	4196	10476	8.0	7.6	7.0	7.7	5.7	6.5	6.9	1.8	13132
2006	52.0	5852	4141	92520	1105	1105	4424	4426	11060	8.1	7.6	7.0	7.9	5.7	6.5	6.9	1.9	13182
2008	53.0	5908	4156	94493	1185	1187	4753	4758	11883	8.1	7.6	7.0	8.0	5.7	6.5	6.9	2.0	13231
2010	54.0	5996	4195	96443	1279	1280	5127	5129	12815	8.2	7.6	7.0	8.1	5.7	6.6	7.0	2.1	13305
2012	54.0	5998	4218	97811	1297	1297	5202	5205	13001	8.3	7.6	7.0	8.2	5.7	6.6	7.0	2.2	13305
2014	55.0	6009	4247	99176	1310	1311	5256	5258	13135	8.4	7.6	7.0	8.2	5.6	6.6	7.0	2.2	13333
2016	55.0	6011	4253	100532	1345	1345	5396	5398	13484	8.5	8.0	7.0	8.3	5.6	6.6	7.0	2.2	13348
2018	56.0	6034	4280	101902	1382	1382	5546	5547	13857	8.5	8.0	7.0	8.3	5.6	6.6	7.1	2.3	13380
2020	56.0	6040	4300	103250	1415	1415	5673	5674	14177	8.5	8.0	7.0	8.4	5.6	6.6	7.1	2.3	13397
2022	58.0	6186	4395	106136	1575	1576	6316	6322	15789	8.7	8.2	7.0	8.5	5.6	6.6	7.1	2.6	13500
2024	60.0	6290	4458	109004	1758	1759	7054	7060	17631	8.8	8.2	7.0	8.7	5.6	6.6	7.1	2.8	13599
2026	62.0	6404	4534	111879	1952	1952	7821	7825	19550	9.0	8.2	7.0	8.8	5.6	6.6	7.1	3.1	13691
2028	64.0	6529	4619	114747	2214	2215	8871	8873	22173	9.1	8.6	7.0	9.0	5.6	6.6	7.1	3.4	13797
2030	66.0	6655	4696	117625	2464	2466	9871	9876	24677	9.3	8.8	7.0	9.1	5.5	6.6	7.2	3.7	13899
2032	69.0	6841	4824	120565	2914	2916	11673	11679	29182	9.3	8.8	7.0	9.2	5.5	6.6	7.2	4.3	14051
2034	72.0	7044	4961	123505	3483	3485	13950	13954	34872	9.3	8.8	7.0	9.2	5.5	6.6	7.1	5.0	14203
2036	75.0	7266	5115	126443	4257	4257	17040	17041	42595	9.3	8.8	7.0	9.2	5.5	6.6	7.1	5.9	14365
2038	79.0	7445	5227	129387	5228	5229	20930	20935	52322	9.3	8.6	7.0	9.3	5.5	6.6	7.1	7.0	14542
2040	81.0	7652	5376	131803	6313	6261	25270	25058	62902	9.4	8.6	7.0	9.3	5.5	6.6	7.1	8.2	14711

***** GL/SLS LOCK CAPACITY MODEL *****
***** WELLAND CANAL *****

**** SEASON EXTENSION 1 LOCKING TIME NORM*****

RUN BY NCBPD - EB

**** TRAFFIC FORECAST LOW ****
**** NON-STRUCTURAL 10% ****
**** STRUCTURAL 1350 X 115 LK X 28.0 D ****

YEAR	LK UTIL	TRANSITS TOT	TRANSITS LDD	ACT TONS	CON-DELAY DOWN	CON-DELAY UP	UNCON-DELAY DOWN	UNCON-DELAY UP	TOTAL	ORE	COL	COMPOSITE SHIP CLASS STN	GRN	DTB	GCO	TOT	AVG DELAY	TOT PROC
1978	83.0	6872	4347	67990	5985	7058	12510	12734	38287	5.8	5.8	7.0	6.1	5.6	5.6	5.9	5.6	4507
1980	88.0	7095	4550	71640	8664	10729	15396	15695	50484	5.9	6.0	7.0	6.1	5.6	5.6	5.9	7.1	4797
1982	90.0	7292	4745	75113	13193	15545	18601	19139	66478	6.0	6.1	7.0	6.2	5.6	5.6	6.0	9.1	5017
***** NONSTRUCTURAL MAXIMUM UTILITY *****																		
1984	81.0	7511	4918	78915	5740	6616	11869	12085	36310	6.2	6.2	7.0	6.3	5.6	5.6	6.0	4.8	4451
1985	84.0	7643	5006	80735	6827	7998	13166	13409	41400	6.3	6.3	7.0	6.3	5.6	5.6	6.0	5.4	4615
1986	85.0	7673	5002	81520	7251	8534	13586	13848	43219	6.4	6.3	7.0	6.4	5.6	5.7	6.1	5.6	4668
1988	87.0	7718	4979	83077	8186	9726	14402	14683	46997	6.6	6.7	7.0	6.4	5.6	5.7	6.1	6.1	4743
1990	88.0	7784	4960	84643	9408	11331	15395	15698	51832	6.8	6.8	7.0	6.5	5.6	5.7	6.2	6.7	4843
1992	90.0	7869	5038	85961	11096	13779	16681	17021	58577	6.8	6.8	7.0	6.5	5.6	5.7	6.2	7.4	4957
**** CAPACITY INCREASED BY INCREASING ALLOWABLE SHIP DRAFT TO 28.00 FEET ****																		
**** CAPACITY WAS INCREASED BY BUILDING LARGER LOCKS ****																		
1994	52.0	6123	3924	87275	1205	1221	3123	3131	8680	7.1	6.9	7.0	7.0	5.9	6.3	6.6	1.4	2884
1996	52.0	6134	3943	88591	1241	1255	3181	3188	8865	7.2	6.9	7.0	7.0	5.9	6.3	6.6	1.4	2902
1998	53.0	6117	3934	89906	1271	1283	3222	3229	9005	7.2	7.2	7.0	7.1	5.8	6.4	6.7	1.5	2941
2000	53.0	6107	3942	91226	1330	1345	3339	3346	9360	7.3	7.2	7.0	7.2	5.8	6.4	6.7	1.5	2963
2002	54.0	6149	3977	93200	1394	1408	3449	3454	9705	7.4	7.2	7.0	7.3	5.8	6.4	6.8	1.6	2998
2004	55.0	6177	4006	95193	1489	1505	3639	3646	10279	7.4	7.2	7.0	7.4	5.8	6.5	6.8	1.7	3063
2006	56.0	6216	4047	97170	1567	1583	3775	3784	10709	7.5	7.2	7.0	7.5	5.8	6.5	6.9	1.7	3113
2008	57.0	6255	4090	99165	1658	1672	3944	3949	11223	7.6	7.2	7.0	7.6	5.8	6.5	6.9	1.8	3177
2010	58.0	6288	4117	101148	1762	1776	4131	4135	11804	7.7	7.2	7.0	7.8	5.7	6.6	7.0	1.9	3216
2012	59.0	6313	4131	102556	1834	1849	4260	4262	12205	7.7	7.2	7.0	7.8	5.7	6.6	7.0	1.9	3263
2014	59.0	6340	4141	103972	1919	1936	4411	4417	12683	7.8	7.2	7.0	7.9	5.7	6.5	7.0	2.0	3309
2016	60.0	6375	4158	105386	2023	2042	4604	4613	13282	7.9	7.2	7.0	7.9	5.7	6.5	7.0	2.1	3352
2018	61.0	6401	4167	106809	2124	2140	4780	4787	13831	7.9	7.4	7.0	8.0	5.7	6.5	7.0	2.2	3395
2020	62.0	6408	4192	108229	2225	2245	4956	4965	14391	8.0	7.4	7.0	8.0	5.7	6.5	7.0	2.2	3437
2022	63.0	6469	4241	111135	2394	2414	5179	5186	15173	8.2	7.5	7.0	8.2	5.7	6.5	7.1	2.3	3523
2024	65.0	6473	4269	114037	2601	2625	5461	5470	16157	8.4	7.8	7.0	8.4	5.6	6.6	7.1	2.5	3612
2026	66.0	6482	4301	116953	2820	2847	5736	5747	17150	8.6	8.1	7.0	8.6	5.6	6.6	7.2	2.6	3677
2028	68.0	6496	4337	119862	3077	3104	6063	6067	18311	8.9	8.2	7.0	8.8	5.6	6.6	7.2	2.8	3783
2030	69.0	6554	4380	122770	3359	3392	6393	6403	19547	9.1	8.3	7.0	9.0	5.6	6.6	7.3	3.0	3844
2032	72.0	6691	4512	125782	3939	3978	7263	7269	22449	9.1	8.3	7.0	9.1	5.6	6.6	7.3	3.4	4012
2034	75.0	6854	4630	128803	4685	4737	8326	8332	26080	9.2	8.4	7.0	9.1	5.6	6.6	7.3	3.8	4165
2036	78.0	7004	4739	131812	5652	5720	9593	9599	30564	9.2	8.4	7.0	9.2	5.6	6.6	7.3	4.4	4337
2038	82.0	7203	4876	134840	7069	7168	11284	11291	36812	9.2	8.4	7.0	9.2	5.6	6.6	7.3	5.1	4515
2040	85.0	7346	4980	137850	9134	9290	13417	13431	45272	9.2	8.4	7.0	9.3	5.5	6.6	7.3	6.2	4712
2042	89.0	7585	5136	141344	13025	13324	16670	16672	59691	9.3	8.5	7.0	9.3	5.5	6.6	7.2	7.9	4933
2044	90.0	7800	5271	143932	17626	17750	20860	20775	77011	9.3	8.5	7.0	9.3	5.5	6.6	7.2	9.9	5135

***** DELTSIS LOCK CAPACITY MODEL *****
***** WELLAND CANAL *****

80 %
LOCK UTILIZATION

**** SEASON EXTENSION 1 LOCKING TIME NORM*****

RUN BY

**** TRAFFIC FORECAST LOW ****
**** NON-STRUCTURAL 10% ****
**** STRUCTURAL 1350 x 115 LK Y 28.00 ****

YEAR	LK UTIL	TRANSITS TOT	TRANSITS LPD	ACT TONS	CUM-DELAY DOWN	CUM-DELAY UP	FLOW-DELAY DOWN	FLOW-DELAY UP	TOTAL	COMPOSITE SHIP CLASS CHF	COL	STN	GRN	OTH	GCO	TOT	AVG DELAY	TOT PROC
1976	[illegible]	6872	4347	67873	5937	6767	12420	12734	37818	5.8	5.8	7.0	6.1	5.6	5.6	5.9	5.5	4486
***** NON-STRUCTURAL MAXIMUM UTILITY *****																		
1980	75.0	7094	4553	71640	3514	5948	5633	6775	24875	5.9	6.0	7.0	6.1	5.6	5.6	5.9	3.5	4015
1982	77.0	7307	4746	75280	6398	4963	10020	10196	29597	6.0	6.1	7.0	6.2	5.6	5.6	6.0	4.1	4230
1984	[illegible]	7524	4918	78865	5726	6517	11865	12065	30171	6.2	6.2	7.0	6.3	5.6	5.6	6.0	4.8	4451
**** CAPACITY INCREASED BY INCREASING ALLOWABLE SHIP DRAFT TO 28.00 FEET ****																		
**** CAPACITY WAS INCREASED BY BUILDING LARGER LOCKS ****																		
1985	[illegible]	5551	3603	80736	716	725	1963	1968	5372	6.6	6.8	0.0	6.5	5.8	6.1	6.3	1.0	2406
1986	[illegible]	5501	3573	81515	723	750	1971	1976	5804	6.7	6.9	0.0	6.6	5.8	6.1	6.3	1.0	2406
1988	[illegible]	5367	3521	83076	724	753	1905	1951	5353	6.9	6.9	0.0	6.7	5.8	6.2	6.4	1.0	2406
1990	[illegible]	5360	3442	84645	724	753	1915	1922	5294	7.2	7.0	0.0	6.8	5.9	6.3	6.5	1.0	2406
1992	[illegible]	5020	3463	85965	746	755	1956	1960	5923	7.2	6.9	0.0	6.9	5.8	6.3	6.6	1.0	2441
1994	[illegible]	5601	3490	87274	793	801	2060	2065	5719	7.3	6.9	7.0	7.0	5.8	6.3	6.6	1.1	2467
1996	[illegible]	5456	3506	88594	816	826	2101	2105	5850	7.4	6.9	7.0	7.1	5.8	6.3	6.6	1.1	2495
1998	[illegible]	5457	3514	89907	842	850	2145	2148	5963	7.5	6.9	7.0	7.2	5.8	6.3	6.7	1.1	2524
2000	[illegible]	5436	3507	91227	866	875	2164	2189	6110	7.6	7.2	7.0	7.3	5.8	6.4	6.7	1.1	2556
2002	[illegible]	5096	3555	93207	940	948	2336	2344	6570	7.6	7.2	7.0	7.4	5.8	6.4	6.8	1.2	2616
2004	[illegible]	5515	3594	95190	993	1004	2437	2445	6879	7.7	7.2	7.0	7.5	5.8	6.5	6.8	1.2	2670
2006	[illegible]	5576	3627	97171	1062	1072	2576	2583	7293	7.8	7.2	7.0	7.6	5.7	6.5	6.9	1.3	2731
2008	[illegible]	5634	3677	99172	1130	1140	2705	2711	7606	7.9	7.2	7.0	7.8	5.7	6.5	6.9	1.4	2791
2010	[illegible]	5690	3738	101183	1212	1222	2868	2872	8174	7.9	7.2	7.0	7.9	5.7	6.6	7.0	1.4	2848
2012	[illegible]	5721	3742	102556	1260	1270	2955	2958	8441	8.0	7.2	7.0	8.0	5.7	6.5	7.0	1.5	2866
2014	55.	5760	3762	103973	1324	1333	3074	3084	8829	8.0	7.2	7.0	8.0	5.7	6.5	7.0	1.5	2945
2016	[illegible]	5769	3774	105390	1392	1403	3208	3212	9215	8.1	7.2	7.0	8.1	5.7	6.5	7.0	1.6	2961
2018	[illegible]	5915	3702	106807	1441	1453	3292	3297	9483	8.2	7.3	7.0	8.1	5.7	6.5	7.0	1.6	3023
2020	55.	5843	3815	108227	1513	1523	3020	3451	9695	8.2	7.3	7.0	8.2	5.7	6.5	7.1	1.7	3077
2022	57.0	5750	3865	111133	1676	1691	3699	3707	10773	8.4	7.5	7.0	8.4	5.6	6.6	7.1	1.8	3163
2024	59.0	5974	3934	114037	1656	1872	3991	3997	11716	8.6	7.8	7.0	8.5	5.6	6.6	7.2	2.0	3259
2026	[illegible]	6027	3994	116952	2030	2047	4248	4253	12578	8.8	8.1	7.0	8.7	5.6	6.6	7.2	2.1	3352
2028	[illegible]	6066	4059	119858	2240	2256	4554	4559	13609	9.0	8.2	7.0	8.9	5.6	6.6	7.3	2.2	3452
2030	[illegible]	6204	4123	122773	2476	2496	4687	4892	14751	9.2	8.4	7.0	9.1	5.6	6.6	7.3	2.4	3552
2032	[illegible]	6292	4250	125784	2686	2894	5534	5541	16657	9.2	8.4	7.0	9.2	5.6	6.6	7.3	2.7	3684
2034	[illegible]	6362	4355	128601	3330	3360	6254	6258	19202	9.3	8.4	7.0	9.2	5.6	6.6	7.3	3.0	3844
2036	72.0	6609	4401	131513	3905	3943	7116	7125	22009	9.2	8.4	7.0	9.2	5.6	6.6	7.3	3.3	3998
2038	75.0	6777	4555	134442	4606	4657	8096	8104	25465	9.3	8.4	7.0	9.3	5.5	6.6	7.3	3.6	4144
2040	76.0	6938	4695	137650	5594	5659	9380	9393	30032	9.3	8.4	7.0	9.3	5.5	6.6	7.3	4.3	4316
2042	[illegible]	7129	4853	141028	7031	7057	11242	11213	36543	9.3	8.4	7.0	9.3	5.5	6.6	7.3	5.1	4508

S211812-W

***** GL/SLS LOCK CAPACITY MODEL *****
***** ST. LAWRENCE RIVER *****
** CAPACITY DATE FORCED TO COINCIDE WITH THE WELLAND **
**** SEASON EXTENSION 2 LOCKING TIME NORM*****

**** TRAFFIC FORECAST LOW ****
**** NON-STRUCTURAL 13% ****
**** STRUCTURAL 1350 X 115 LK X 28.0 D ****

YEAR	LK UTIL	TRANSITS TOT	TRANSITS LOD	ACT TONS	CON-DELAY DOWN	CON-DELAY UP	UNCON-DELAY DOWN	UNCON-DELAY UP	TOTAL	ORE	COL	COMPOSITE SHIP CLASS STN	GRN	OTB	GCO	TOT	AVG DELAY	TOT PROC
1978	59.0	5844	3981	61448	1531	1558	5028	5032	13149	6.4	5.3	0.0	5.9	5.5	5.5	5.8	2.3	2975
1980	63.0	6107	4220	65550	1969	2007	6221	6227	16424	6.3	5.6	0.0	6.0	5.5	5.6	5.8	2.7	3184
1982	68.0	6391	4452	69662	2553	2607	7701	7704	20565	6.2	5.6	7.0	6.1	5.5	5.6	5.9	3.2	3428
1984	73.0	6709	4679	73777	3487	3571	9832	9834	26724	6.2	5.4	7.0	6.2	5.6	5.6	5.9	4.0	3700
1985	76.0	6843	4786	75824	4090	4196	11081	11084	30451	6.3	5.7	7.0	6.3	5.5	5.6	6.0	4.4	3845
1986	77.0	6899	4809	77084	4376	4494	11638	11644	32152	6.3	5.9	7.0	6.3	5.6	5.6	6.0	4.7	3901
1988	80.0	7008	4864	79585	5041	5188	12864	12872	35965	6.4	6.2	7.0	6.4	5.6	5.6	6.0	5.1	4025
1990	82.0	7093	4902	82102	5838	6025	14188	14194	40245	6.5	6.7	7.0	6.4	5.6	5.7	6.1	5.7	4145
***** NONSTRUCTURAL MAXIMUM UTILITY *****																		
1992	65.0	7189	4959	83006	2292	2338	7051	7053	18734	6.5	6.8	7.0	6.5	5.6	5.7	6.1	2.6	3332
**** CAPACITY INCREASED BY INCREASING ALLOWABLE SHIP DRAFT TO 28.00 FEET ****																		
**** CAPACITY WAS INCREASED BY BUILDING LARGER LOCKS ****																		
1994	44.0	5402	3781	83912	686	687	2757	2760	6890	7.2	7.0	7.0	7.0	5.8	6.3	6.6	1.3	2251
1996	44.0	5414	3788	84824	702	704	2828	2831	7065	7.3	7.0	7.0	7.1	5.8	6.4	6.6	1.3	2265
1998	45.0	5427	3800	85728	724	724	2914	2916	7278	7.3	7.0	7.0	7.1	5.8	6.4	6.6	1.3	2279
2000	45.0	5463	3819	86634	735	736	2954	2958	7383	7.4	7.0	7.0	7.2	5.8	6.4	6.7	1.4	2304
2002	46.0	5478	3848	88598	770	771	3102	3104	7747	7.5	7.0	7.0	7.3	5.8	6.5	6.7	1.4	2346
2004	47.0	5499	3868	90566	809	810	3246	3250	8115	7.6	7.4	7.0	7.5	5.7	6.5	6.8	1.5	2382
2006	47.0	5534	3908	92527	843	843	3386	3389	8461	7.7	7.4	7.0	7.6	5.7	6.5	6.8	1.5	2417
2008	48.0	5567	3929	94490	888	890	3567	3571	8916	7.8	7.4	7.0	7.7	5.7	6.5	6.9	1.6	2459
2010	49.0	5635	3969	96450	958	958	3843	3844	9603	7.8	7.5	7.0	7.9	5.7	6.6	6.9	1.7	2509
2012	50.0	5644	3979	97808	970	972	3894	3897	9733	8.0	7.5	7.0	7.9	5.7	6.6	6.9	1.7	2537
2014	50.0	5646	3991	99172	983	984	3942	3945	9854	8.0	7.5	7.0	8.0	5.7	6.6	7.0	1.7	2555
2016	50.0	5668	4018	100532	1007	1008	4044	4046	10105	8.1	7.5	7.0	8.1	5.7	6.6	7.0	1.8	2569
2018	51.0	5691	4038	101896	1038	1039	4166	4170	10413	8.1	7.5	7.0	8.1	5.7	6.6	7.0	1.8	2597
2020	51.0	5740	4059	103250	1072	1072	4304	4307	10755	8.2	7.5	7.0	8.2	5.7	6.6	7.0	1.9	2611
2022	53.0	5788	4113	106123	1154	1154	4628	4632	11568	8.4	7.5	7.0	8.3	5.6	6.6	7.0	2.0	2696
2024	54.0	5864	4157	108994	1272	1273	5104	5108	12757	8.5	8.0	7.0	8.5	5.6	6.6	7.1	2.2	2770
2026	56.0	5951	4214	111876	1394	1395	5588	5593	13970	8.8	8.0	7.0	8.7	5.6	6.6	7.1	2.3	2862
2028	57.0	6034	4266	114757	1547	1548	6204	6208	15507	9.0	8.0	0.0	8.9	5.6	6.6	7.1	2.6	2933
2030	59.0	6124	4337	117622	1701	1702	6812	6816	17031	9.2	8.7	0.0	9.1	5.6	6.6	7.2	2.8	3021
2032	62.0	6312	4451	120562	1946	1948	7791	7797	19482	9.2	8.7	0.0	9.1	5.5	6.6	7.2	3.1	3166
2034	64.0	6489	4567	123501	2267	2268	9085	9092	22712	9.2	8.7	0.0	9.1	5.5	6.6	7.2	3.5	3286
2036	67.0	6691	4707	126439	2626	2627	10516	10522	26291	9.2	8.7	0.0	9.2	5.5	6.6	7.2	3.9	3431
2038	70.0	6864	4817	129385	3072	3073	12302	12305	30752	9.3	8.7	0.0	9.2	5.5	6.6	7.1	4.5	3576
2040	73.0	7064	4950	132323	3676	3676	14717	14721	36790	9.2	8.7	0.0	9.3	5.5	6.6	7.1	5.2	3731
2042	76.0	7252	5085	135515	4416	4416	17674	17681	44187	9.3	8.7	0.0	9.3	5.5	6.6	7.1	6.1	3891
2044	79.0	7451	5223	138697	5427	5429	21730	21735	54321	9.3	8.7	0.0	9.3	5.5	6.6	7.1	7.3	4053
2046	83.0	7639	5350	141879	6819	6821	27292	27297	68229	9.3	8.9	6.0	9.3	5.5	6.6	7.1	8.9	4226
2048	86.0	7833	5484	145078	8827	8830	35325	35334	88316	9.4	8.9	6.0	9.3	5.5	6.6	7.1	11.3	4406
2050	90.0	8049	5623	148265	12373	12374	49504	49508	123759	9.3	8.9	6.0	9.3	5.5	6.6	7.1	15.4	4587

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***** GL/SLS LOCK CAPACITY MODEL *****
***** ST. LAWRENCE RIVER *****

**** SEASON EXTENSION 2   LOCKING TIME NORM*****

RUN BY NCBPD - EB

**** TRAFFIC FORECAST LOW ****
**** NON-STRUCTURAL ****
**** STRUCTURAL 1350 X 115 LK X 28.0 D ****

YEAR	LK UTIL	TRANSITS TOT	TRANSITS LDD	ACT TONS	CON-DELAY DOWN	CON-DELAY UP	UNCON-DELAY DOWN	UNCON-DELAY UP	TOTAL	ORE	COL	COMPOSITE SHIP CLASS STN	GRN	OTB	GCO	TOT	AVG DELAY	TOT PRUC
1978	59.0	5844	3981	61448	1531	1558	5028	5032	13149	6.4	5.8	0.0	5.9	5.5	5.5	5.8	2.3	13368
1980	63.0	6107	4220	65550	1969	2007	6221	6227	16424	6.3	5.6	0.0	6.0	5.5	5.6	5.8	2.7	13577
1982	68.0	6370	4452	69662	2553	2607	7701	7704	20565	6.2	5.6	7.0	6.1	5.5	5.6	5.9	3.2	13821
***** NONSTRUCTURAL MAXIMUM UTILITY *****																		
1984	58.0	6711	4683	73777	1558	1588	5106	5108	13360	6.2	5.4	7.0	6.2	5.6	5.6	5.9	2.0	13368
**** CAPACITY INCREASED BY INCREASING ALLOWABLE SHIP DRAFT TO 28.00 FEET ****																		
**** CAPACITY WAS INCREASED BY BUILDING LARGER LOCKS ****																		
1985	38.0	4891	3395	75826	451	452	1824	1826	4553	6.6	6.2	0.0	6.6	5.7	6.1	6.2	.9	12315
1986	38.0	4903	3393	77087	448	449	1814	1816	4527	6.8	6.2	0.0	6.6	5.7	6.1	6.3	.9	12315
1988	38.0	4832	3348	79591	443	443	1791	1793	4470	7.0	6.2	0.0	6.8	5.8	6.2	6.4	.9	12319
1990	38.0	4747	3303	82098	449	450	1810	1812	4521	7.2	7.2	0.0	6.9	5.8	6.3	6.5	1.0	12319
1992	38.0	4795	3327	83021	453	455	1831	1835	4574	7.3	7.2	0.0	7.0	5.8	6.3	6.5	1.0	12329
1994	38.0	4815	3347	83907	476	477	1919	1922	4794	7.4	7.2	7.0	7.0	5.8	6.3	6.6	1.0	12347
1996	39.0	4844	3372	84823	486	487	1959	1960	4892	7.5	7.6	7.0	7.1	5.8	6.4	6.6	1.0	12375
1998	39.0	4848	3378	85729	504	505	2030	2032	5071	7.5	7.6	7.0	7.2	5.8	6.4	6.6	1.0	12382
2000	40.0	4847	3398	86637	510	510	2054	2055	5129	7.7	7.6	7.0	7.3	5.8	6.4	6.7	1.1	12407
2002	40.0	4921	3442	88599	545	546	2190	2194	5475	7.8	7.6	7.0	7.4	5.7	6.4	6.7	1.1	12439
2004	41.0	4954	3470	90562	567	567	2279	2280	5693	7.8	7.6	7.0	7.6	5.7	6.5	6.8	1.1	12495
2006	42.0	5000	3509	92527	603	604	2432	2431	6070	7.9	7.6	7.0	7.7	5.7	6.5	6.8	1.2	12541
2008	43.0	5036	3543	94484	645	646	2597	2599	6487	8.1	7.6	7.0	7.9	5.7	6.5	6.9	1.3	12584
2010	44.0	5157	3593	96453	687	688	2766	2770	6911	8.2	7.6	7.0	8.0	5.7	6.6	6.9	1.3	12640
2012	44.0	5125	3604	97810	705	705	2828	2832	7070	8.2	7.6	7.0	8.0	5.7	6.6	7.0	1.4	12654
2014	45.0	5142	3631	99176	727	727	2918	2921	7293	8.2	7.6	7.0	8.1	5.7	6.6	7.0	1.4	12672
2016	45.0	5164	3652	100535	747	747	3001	3002	7497	8.3	7.6	7.0	8.2	5.7	6.6	7.0	1.5	12697
2018	46.0	5208	3685	101889	768	769	3087	3090	7714	8.4	7.6	7.0	8.2	5.6	6.6	7.0	1.5	12725
2020	46.0	5259	3705	103253	792	793	3187	3189	7961	8.5	7.6	7.0	8.3	5.6	6.6	7.0	1.5	12750
2022	48.0	5322	3773	106125	865	865	3477	3478	8685	8.6	8.2	7.0	8.4	5.6	6.6	7.1	1.6	12836
2024	49.0	5433	3855	108997	950	951	3814	3817	9532	8.8	8.2	7.0	8.6	5.6	6.6	7.1	1.8	12905
2026	51.0	5535	3917	111879	1067	1068	4282	4285	10702	8.9	8.2	7.0	8.8	5.6	6.6	7.1	1.9	13001
2028	53.0	5640	3984	114745	1166	1168	4681	4688	11703	9.1	8.2	7.0	9.0	5.6	6.6	7.2	2.1	13096
2030	54.0	5731	4062	117623	1314	1315	5269	5272	13170	9.3	8.8	7.0	9.1	5.5	6.6	7.2	2.3	13170
2032	57.0	5946	4193	120560	1491	1492	5980	5987	14950	9.3	8.8	7.0	9.2	5.5	6.6	7.2	2.5	13305
2034	59.0	6106	4295	123503	1706	1707	6841	6846	17100	9.3	8.8	7.0	9.2	5.5	6.6	7.2	2.8	13425
2036	62.0	6293	4424	126443	1952	1953	7825	7830	19560	9.3	8.8	7.0	9.2	5.5	6.6	7.2	3.1	13559
2038	64.0	6468	4539	129386	2250	2251	9019	9021	22541	9.4	8.8	7.0	9.3	5.5	6.6	7.2	3.5	13679
2040	67.0	6630	4654	132329	2612	2614	10465	10469	26160	9.3	8.8	7.0	9.3	5.5	6.6	7.2	3.9	13817
2042	70.0	6821	4775	135510	3059	3060	12255	12258	30632	9.4	8.8	7.0	9.3	5.5	6.6	7.2	4.5	13962
2044	73.0	7011	4904	138697	3642	3643	14587	14590	36462	9.4	8.8	7.0	9.3	5.5	6.6	7.1	5.2	14121
2046	76.0	7196	5034	141884	4340	4341	17374	17379	43434	9.4	9.0	7.0	9.3	5.5	6.6	7.1	6.0	14269
2048	79.0	7382	5163	145077	5286	5287	21163	21169	52905	9.4	9.0	7.0	9.3	5.5	6.6	7.1	7.2	14432
2050	81.0	7582	5278	147708	6293	6240	25189	24975	62697	9.4	9.0	7.0	9.4	5.5	6.6	7.1	8.3	14569

***** GL/SLS LOCK CAPACITY MODEL *****
***** WELLAND CANAL *****

RUN BY NCRPD - EB

**** SEASON EXTENSION 1 LOCKING TIME NORM*****
**** TWIN-SIZED PARALLEL LOCKS ****
**** TRAFFIC FORECAST LOW ****
**** NON-STRUCTURAL 10% ****
**** STRUCTURAL 800 X 80 LK X 25.5 D ****

YEAR	LK UTIL	TRANSITS TOT	TRANSITS LOD	ACT TONS	CON-DELAY DOWN	CON-DELAY UP	UNCON-DELAY DOWN	UNCON-DELAY UP	TOTAL	ORE	COL	COMPOSITE SHIP CLASS STN	GRN	OTB	GCO	TOT	AVG DELAY	TOT PROC
1978	83.0	6872	4347	67990	5985	7058	12510	12734	38287	5.8	5.8	7.0	6.1	5.6	5.6	5.9	5.6	4507
1980	88.0	7095	4550	71640	8664	10729	15396	15695	50484	5.9	6.0	7.0	6.1	5.6	5.6	5.9	7.1	4797
1982	90.0	7292	4745	75113	13193	15545	18601	19139	66478	6.0	6.1	7.0	6.2	5.6	5.6	6.0	9.1	5017
***** NONSTRUCTURAL MAXIMUM UTILITY *****																		
1984	81.0	7511	4918	78915	5740	6616	11869	12085	36310	6.2	6.2	7.0	6.3	5.6	5.6	6.0	4.8	4451
1985	84.0	7643	5006	80735	6827	7998	13166	13409	41400	6.3	6.3	7.0	6.3	5.6	5.6	6.0	5.4	4615
1986	85.0	7673	5002	81520	7251	8534	13586	13848	43219	6.4	6.3	7.0	6.4	5.6	5.7	6.1	5.6	4668
1988	87.0	7718	4979	83077	8186	9726	14402	14683	46997	6.6	6.7	7.0	6.4	5.6	5.7	6.1	6.1	4743
1990	88.0	7784	4960	84643	9408	11331	15395	15698	51832	6.8	6.8	7.0	6.5	5.6	5.7	6.2	6.7	4843
1992	90.0	7869	5038	85961	11096	13779	16681	17021	58577	6.8	6.8	7.0	6.5	5.6	5.7	6.2	7.4	4957
**** CAPACITY WAS INCREASED BY BUILDING LARGER LOCKS ****																		
1994	27.0	7475	4841	87283	242	250	586	589	1667	6.9	6.9	7.0	6.7	5.9	5.9	6.4	.2	1563
1996	28.0	7557	4896	88595	253	262	609	612	1736	6.9	6.9	7.0	6.7	5.8	5.9	6.4	.2	1595
1998	28.0	7671	4986	89898	262	271	631	633	1797	6.9	7.0	7.0	6.8	5.8	5.8	6.4	.2	1599
2000	29.0	7770	5038	91230	272	282	655	660	1869	6.9	7.0	7.0	6.8	5.8	5.8	6.4	.2	1656
2002	29.0	7886	5143	93207	286	296	686	691	1959	6.9	7.0	7.0	6.8	5.8	5.8	6.4	.2	1656
2004	30.0	8054	5280	95191	303	314	725	732	2074	6.9	7.0	7.0	6.8	5.8	5.8	6.4	.3	1713
2006	31.0	8198	5388	97175	320	329	762	763	2174	6.9	7.0	7.0	6.8	5.8	5.8	6.4	.3	1770
2008	32.0	8400	5493	99165	346	358	824	827	2355	6.9	7.0	7.0	6.8	5.8	5.8	6.4	.3	1828
2010	33.0	8600	5625	101149	372	384	883	886	2525	6.9	7.0	7.0	6.9	5.7	5.8	6.4	.3	1870
2012	33.0	8709	5678	102555	385	399	911	915	2610	6.9	7.0	7.0	6.9	5.7	5.8	6.4	.3	1888
2014	33.0	8808	5751	103972	399	414	943	947	2703	6.9	7.0	7.0	6.9	5.7	5.8	6.4	.3	1892
2016	34.0	8913	5829	105386	417	430	982	985	2814	6.9	7.0	7.0	6.9	5.7	5.8	6.4	.3	1949
2018	35.0	9035	5902	106809	431	447	1015	1021	2914	6.9	7.0	7.0	6.9	5.7	5.8	6.4	.3	1960
2020	35.0	9150	5969	108224	454	468	1062	1068	3052	6.9	7.0	7.0	6.9	5.7	5.8	6.4	.3	2002
2022	36.0	9407	6161	111134	495	510	1151	1157	3313	6.9	7.0	7.0	6.9	5.7	5.8	6.4	.4	2067
2024	38.0	9687	6359	114036	544	565	1261	1268	3638	6.9	7.0	7.0	6.9	5.6	5.8	6.4	.4	2163
2026	39.0	9983	6561	116958	602	623	1385	1390	4000	6.9	6.9	7.0	6.9	5.6	5.8	6.4	.4	2242
2028	41.0	10279	6763	119855	666	688	1520	1528	4402	6.9	6.9	7.0	6.9	5.6	5.8	6.4	.4	2327
2030	42.0	10577	6965	122771	730	759	1661	1669	4819	6.9	6.9	7.0	6.9	5.6	5.8	6.3	.5	2409
2032	44.0	10866	7152	125780	809	838	1825	1832	5304	6.9	6.9	7.0	6.9	5.6	5.8	6.3	.5	2509
2034	45.0	11161	7348	128802	896	929	2006	2018	5849	6.9	6.9	7.0	6.9	5.6	5.8	6.3	.5	2588
2036	47.0	11462	7548	131812	990	1028	2199	2208	6425	6.9	6.9	7.0	6.9	5.6	5.8	6.3	.6	2702
2038	49.0	11755	7741	134836	1097	1140	2411	2423	7071	6.9	6.9	7.0	6.9	5.6	5.8	6.3	.6	2787
2040	51.0	12061	7936	137851	1215	1264	2647	2657	7783	6.9	6.9	7.0	6.9	5.6	5.8	6.3	.6	2880
2042	53.0	12379	8155	141347	1364	1418	2934	2948	8664	6.9	6.9	7.0	6.9	5.6	5.8	6.3	.7	3005
2044	55.0	12720	8388	144837	1528	1593	3248	3265	9634	6.9	6.9	7.0	6.9	5.6	5.8	6.3	.8	3120
2046	57.0	13062	8622	148349	1728	1804	3625	3643	10800	6.9	6.9	7.0	6.9	5.6	5.8	6.3	.8	3234
2048	59.0	13392	8846	151836	1954	2043	4036	4057	12090	6.9	6.9	7.0	6.9	5.6	5.8	6.3	.9	3366
2050	61.0	13736	9065	155336	2214	2318	4495	4518	13545	6.9	6.9	7.0	6.9	5.6	5.8	6.3	1.0	3476

***** GL/SLS LOCK CAPACITY MODEL *****
***** WELLAND CANAL *****
***** TWIN-SIZED PARALLEL LOCKS *****
**** SEASON EXTENSION 1 LOCKING TIME NORM*****
**** 80% LOCK UTILIZATION ****
**** TRAFFIC FORECAST LOW ****
**** NON-STRUCTURAL 10% ****
**** STRUCTURAL 800 X 80 LK X 25.5 D ****

		TRANSITS			CON-DELAY		UNCON-DELAY					COMPOSITE SHIP CLASS					AVG	TOT
YEAR	LK UTIL	TOT	LDD	ACT TONS	DOWN	UP	DOWN	UP	TOTAL	ORE	COL	STN	GRN	OTB	GCO	TOT	DELAY	PROC
1978	81.0	6872	4347	67873	5937	6727	12420	12734	37818	5.8	5.8	7.0	6.1	5.6	5.6	5.9	5.5	4486
***** NONSTRUCTURAL MAXIMUM UTILITY *****																		
1980	73.0	7098	4553	71640	3519	3948	8633	8775	24875	5.9	6.0	7.0	6.1	5.6	5.6	5.9	3.5	4015
1982	77.0	7307	4746	75280	4398	4983	10020	10196	29597	6.0	6.1	7.0	6.2	5.6	5.6	6.0	4.1	4230
1984	81.0	7524	4918	78865	5726	6517	11843	12085	36171	6.2	6.2	7.0	6.3	5.6	5.6	6.0	4.8	4451
**** CAPACITY WAS INCREASED BY BUILDING LARGER LOCKS ****																		
1985	26.0	7218	4730	80732	207	216	510	514	1447	6.6	6.6	0.0	6.6	5.8	5.8	6.2	.2	1474
1986	26.0	7228	4735	81515	212	221	518	522	1473	6.7	6.6	7.0	6.6	5.8	5.8	6.3	.2	1478
1988	26.0	7274	4732	83075	219	228	537	539	1523	6.8	6.7	7.0	6.6	5.8	5.8	6.3	.2	1492
1990	27.0	7311	4730	84645	228	236	549	554	1567	6.9	6.9	7.0	6.7	5.8	5.9	6.4	.2	1535
1992	27.0	7426	4803	85965	237	247	574	578	1636	6.9	6.9	7.0	6.7	5.8	5.9	6.4	.2	1538
1994	28.0	7512	4863	87283	245	254	590	595	1684	6.9	6.9	7.0	6.7	5.8	5.9	6.4	.2	1585
1996	28.0	7605	4932	88594	256	263	614	616	1749	6.9	6.9	7.0	6.7	5.8	5.9	6.4	.2	1599
1998	28.0	7702	5002	89900	265	275	638	640	1818	6.9	6.9	7.0	6.7	5.8	5.8	6.4	.2	1606
2000	29.0	7784	5051	91228	274	285	659	662	1880	6.9	7.0	7.0	6.8	5.8	5.8	6.4	.2	1656
2002	29.0	7922	5167	93207	288	299	695	701	1983	6.9	7.0	7.0	6.8	5.8	5.8	6.4	.3	1663
2004	30.0	8077	5291	95189	305	317	732	734	2088	6.9	7.0	7.0	6.8	5.7	5.8	6.4	.3	1713
2006	31.0	8224	5405	97178	323	336	771	776	2206	6.9	7.0	7.0	6.8	5.7	5.8	6.4	.3	1770
2008	32.0	8420	5520	99166	345	356	820	826	2347	6.9	7.0	7.0	6.8	5.7	5.8	6.4	.3	1828
2010	33.0	8676	5656	101149	374	388	887	893	2542	6.9	7.0	7.0	6.8	5.7	5.8	6.4	.3	1877
2012	33.0	8745	5722	102555	386	400	913	917	2616	6.9	7.0	7.0	6.8	5.7	5.8	6.4	.3	1888
2014	33.0	8831	5782	103972	400	416	947	953	2716	6.9	7.0	7.0	6.9	5.7	5.8	6.4	.3	1892
2016	34.0	8933	5855	105386	416	430	980	983	2809	6.9	7.0	7.0	6.9	5.7	5.8	6.4	.3	1949
2018	35.0	9055	5910	106810	433	449	1020	1026	2928	6.9	7.0	7.0	6.9	5.7	5.8	6.4	.3	1988
2020	35.0	9183	5980	108222	458	473	1069	1077	3077	6.9	7.0	7.0	6.9	5.7	5.8	6.4	.3	2002
2022	36.0	9434	6180	111133	497	514	1159	1164	3334	6.9	7.0	7.0	6.9	5.6	5.8	6.4	.4	2067
2024	38.0	9698	6378	114036	545	563	1262	1267	3637	6.9	7.0	7.0	6.9	5.6	5.8	6.4	.4	2170
2026	39.0	9989	6572	116957	600	619	1382	1387	3988	6.9	6.9	7.0	6.9	5.6	5.8	6.4	.4	2242
2028	41.0	10281	6769	119855	664	688	1521	1530	4403	6.9	6.9	7.0	6.9	5.6	5.8	6.3	.4	2327
2030	42.0	10585	6975	122772	732	760	1666	1675	4833	6.9	6.9	7.0	6.9	5.6	5.8	6.3	.5	2409
2032	44.0	10873	7162	125779	811	840	1829	1836	5316	6.9	6.9	7.0	6.9	5.6	5.8	6.3	.5	2509
2034	45.0	11166	7356	128802	896	929	2006	2018	5849	6.9	6.9	7.0	6.9	5.6	5.8	6.3	.5	2588
2036	47.0	11464	7551	131812	990	1027	2198	2208	6423	6.9	6.9	7.0	6.9	5.6	5.8	6.3	.6	2702
2038	49.0	11760	7749	134836	1096	1139	2409	2421	7065	6.9	6.9	7.0	6.9	5.6	5.8	6.3	.6	2787
2040	51.0	12063	7939	137851	1213	1261	2643	2654	7771	6.9	6.9	7.0	6.9	5.6	5.8	6.3	.6	2880
2042	53.0	12384	8163	141347	1364	1419	2934	2947	8664	6.9	6.9	7.0	6.9	5.6	5.8	6.3	.7	3005
2044	55.0	12718	8391	144836	1531	1595	3253	3270	9649	6.9	6.9	7.0	6.9	5.6	5.8	6.3	.8	3120
2046	57.0	13064	8629	148349	1728	1803	3624	3643	10798	6.9	6.9	7.0	6.9	5.6	5.8	6.3	.8	3234
2048	59.0	13399	8855	151835	1954	2043	4037	4056	12090	6.9	6.9	7.0	6.9	5.6	5.8	6.3	.9	3366
2050	61.0	13738	9071	155336	2212	2315	4491	4514	13532	6.9	6.9	7.0	6.9	5.6	5.8	6.3	1.0	3476

***** GL/SLS LOCK CAPACITY MODEL *****
***** ST. LAWRENCE RIVER *****
***** BY ITSELF *****
**** SEASON EXTENSION 2 LOCKING TIME NORM*****
**** TWIN-SIZED PARALLEL LOCKS ****
**** TRAFFIC FORECAST LOW ****
**** NON-STRUCTURAL 13% ****
**** STRUCTURAL 800 X 80 LK X 25.5 D ****

		TRANSITS			CON-DELAY		UNCON-DELAY			COMPOSITE SHIP CLASS							AVG	TOT
YEAR	LK UTIL	TOT	LOD	ACT TONS	DOWN	UP	DOWN	UP	TOTAL	ORE	COL	STN	GRN	OTB	GCO	TOT	DELAY	PROC
1978	59.0	5844	3981	61448	1531	1558	5028	5032	13149	6.4	5.8	0.0	5.9	5.5	5.5	5.8	2.3	2975
1980	63.0	6107	4220	65550	1969	2007	6221	6227	16424	6.3	5.6	0.0	6.0	5.5	5.6	5.8	2.7	3184
1982	68.0	6391	4452	69662	2553	2607	7701	7704	20565	6.2	5.6	7.0	6.1	5.5	5.6	5.9	3.2	3428
1984	73.0	6709	4679	73777	3487	3571	9832	9834	26724	6.2	5.4	7.0	6.2	5.6	5.6	5.9	4.0	3700
1985	76.0	6843	4786	75824	4090	4196	11081	11084	30451	6.3	5.7	7.0	6.3	5.5	5.6	6.0	4.4	3845
1986	77.0	6899	4809	77084	4376	4494	11638	11644	32152	6.3	5.9	7.0	6.3	5.6	5.6	6.0	4.7	3901
1988	80.0	7008	4864	79585	5041	5188	12864	12872	35965	6.4	6.2	7.0	6.4	5.6	5.6	6.0	5.1	4025
1990	82.0	7093	4902	82102	5838	6025	14188	14194	40245	6.5	6.7	7.0	6.4	5.6	5.7	6.1	5.7	4145
1992	83.0	7161	4958	83006	6358	6573	15009	15015	42955	6.5	6.8	7.0	6.5	5.6	5.7	6.1	6.0	4194
1994	84.0	7218	5011	83909	6918	7166	15806	15814	45704	6.6	6.8	7.0	6.5	5.6	5.7	6.1	6.3	4262
1996	86.0	7279	5066	84822	7638	7926	16825	16832	49221	6.6	6.8	7.0	6.5	5.6	5.7	6.1	6.8	4325
1998	87.0	7334	5115	85721	8381	8720	17729	17733	52563	6.6	6.8	7.0	6.5	5.6	5.6	6.1	7.2	4396
2000	89.0	7427	5173	86633	9597	10023	19156	19164	57940	6.7	6.8	7.0	6.5	5.6	5.6	6.1	7.8	4466
2002	90.0	7567	5296	88395	12485	12773	22217	22225	69700	6.7	6.8	7.0	6.5	5.6	5.6	6.1	9.2	4600
***** NONSTRUCTURAL MAXIMUM UTILITY *****																		
2004	74.0	7743	5422	90565	3724	3807	10322	10328	28181	6.7	6.8	7.0	6.5	5.5	5.6	6.1	3.6	3781
2006	76.0	7902	5542	92519	4325	4428	11541	11545	31839	6.7	6.7	7.0	6.5	5.5	5.6	6.1	4.0	3890
2008	79.0	8069	5668	94488	5048	5178	12880	12883	35989	6.7	6.7	7.0	6.6	5.5	5.6	6.1	4.5	4018
2010	82.0	8224	5793	96450	6017	6186	14538	14544	41285	6.7	6.7	7.0	6.6	5.5	5.6	6.1	5.0	4155
2012	84.0	8351	5861	97815	6909	7119	15897	15902	45827	6.7	6.7	7.0	6.6	5.5	5.6	6.1	5.5	4261
2014	86.0	8470	5932	99173	8035	8310	17448	17455	51248	6.7	6.7	7.0	6.6	5.5	5.6	6.1	6.1	4371
2016	88.0	8581	5995	100541	9490	9859	19203	19211	57763	6.7	6.7	7.0	6.6	5.5	5.6	6.1	6.7	4470
2018	90.0	8684	6065	101892	11467	11992	21224	21229	65912	6.7	6.7	7.0	6.6	5.5	5.6	6.1	7.6	4576
**** CAPACITY WAS INCREASED BY BUILDING LARGER LOCKS ****																		
2020	30.0	8371	5783	103250	285	287	986	987	2545	6.9	7.0	7.0	6.9	5.7	5.8	6.4	.3	1583
2022	31.0	8656	5978	106125	317	318	1091	1091	2817	6.9	7.0	7.0	6.9	5.7	5.8	6.3	.3	1646
2024	32.0	8963	6190	108996	352	353	1206	1206	3117	6.9	7.0	7.0	6.9	5.7	5.8	6.3	.3	1710
2026	34.0	9261	6390	111885	389	393	1331	1332	3445	6.9	7.0	7.0	6.9	5.6	5.8	6.3	.4	1795
2028	35.0	9568	6600	114749	430	434	1461	1462	3787	6.9	7.0	7.0	6.9	5.6	5.8	6.3	.4	1858
2030	36.0	9880	6806	117623	473	475	1605	1606	4159	6.9	6.9	0.0	6.9	5.6	5.8	6.3	.4	1925
2032	38.0	10160	6999	120562	520	522	1754	1755	4551	6.9	6.9	0.0	6.9	5.6	5.8	6.3	.4	2014
2034	39.0	10456	7197	123499	574	576	1929	1929	5008	6.9	6.9	7.0	6.9	5.6	5.8	6.3	.5	2077
2036	41.0	10747	7390	126440	632	635	2116	2117	5500	6.9	6.9	7.0	6.9	5.6	5.8	6.3	.5	2173
2038	42.0	11044	7591	129390	695	699	2315	2316	6025	6.9	6.9	7.0	6.9	5.6	5.8	6.2	.5	2236
2040	44.0	11333	7786	132325	764	765	2522	2522	6573	6.9	6.9	6.5	6.9	5.6	5.8	6.2	.6	2307
2042	45.0	11630	7984	135510	844	847	2778	2779	7248	6.9	6.9	6.5	6.9	5.6	5.8	6.2	.6	2402
2044	47.0	11946	8202	138693	932	936	3055	3056	7979	6.9	6.9	6.5	6.9	5.6	5.8	6.2	.7	2491
2046	48.0	12242	8399	141886	1029	1032	3351	3352	8764	6.9	6.9	6.5	6.9	5.6	5.8	6.2	.7	2565
2048	50.0	12550	8610	145078	1138	1144	3684	3686	9652	6.9	6.9	6.5	6.9	5.6	5.8	6.2	.8	2660
2050	52.0	12861	8821	148264	1263	1268	4055	4056	10642	6.9	6.9	6.5	6.9	5.6	5.8	6.2	.8	2752

***** GL/SLS LOCK CAPACITY MODEL *****
***** ST. LAWRENCE RIVER *****
***** BY ITSELF, WITH 80% LOCK UTILIZATION *****
**** SEASON EXTENSION 2   LOCKING TIME NORM*****
**** TWIN-SIZED PARALLEL LOCKS ****
**** TRAFFIC FORECAST LOW ****
**** NON-STRUCTURAL 13%   ****
**** STRUCTURAL 800 X 80 LK X 25.5 D ****

RUN DATE 82/03/17

RUN BY NCBPD - EB

YEAR	LK UTIL	TRANSITS TOT	TRANSITS LDD	ACT TONS	CON-DELAY DOWN	CON-DELAY UP	UNCON-DELAY DOWN	UNCON-DELAY UP	TOTAL	ORE	COL	COMPOSITE SHIP CLASS STN	GRN	UTB	GCU	TOT	AVG DELAY	TOT PROC
1978	59.0	5844	3981	61448	1531	1558	5028	5032	13149	6.4	5.8	0.0	5.9	5.5	5.5	5.8	2.3	2975
1980	63.0	6107	4220	65550	1969	2007	6221	6227	16424	6.3	5.6	0.0	6.0	5.5	5.6	5.8	2.7	3184
1982	68.0	6391	4452	69662	2553	2607	7701	7704	20565	6.2	5.6	7.0	6.1	5.5	5.6	5.9	3.2	3428
1984	73.0	6709	4679	73777	3487	3571	9832	9834	26724	6.2	5.4	7.0	6.2	5.6	5.6	5.9	4.0	3700
1985	76.0	6643	4786	75824	4090	4196	11081	11084	30451	6.3	5.7	7.0	6.3	5.5	5.6	6.0	4.4	3645
1986	77.0	6899	4809	77084	4376	4494	11638	11644	32152	6.3	5.9	7.0	6.3	5.6	5.6	6.0	4.7	3901
1988	80.0	7010	4864	79585	5041	5188	12864	12872	35965	6.4	6.2	7.0	6.4	5.6	5.6	6.0	5.1	4025
***** NONSTRUCTURAL MAXIMUM UTILITY *****																		
1990	64.0	7092	4901	82102	2178	2220	6756	6760	17914	6.5	6.7	7.0	6.4	5.6	5.7	6.1	2.5	3283
1992	65.0	7162	4959	83006	2292	2338	7051	7053	18734	6.5	6.8	7.0	6.5	5.6	5.7	6.1	2.6	3332
1994	66.0	7217	5010	83909	2397	2444	7303	7309	19453	6.6	6.8	7.0	6.5	5.6	5.7	6.1	2.7	3381
1996	67.0	7275	5061	84823	2532	2583	7643	7648	20406	6.6	6.8	7.0	6.5	5.6	5.7	6.1	2.8	3431
1998	68.0	7334	5115	85721	2650	2705	7923	7927	21205	6.7	6.8	7.0	6.5	5.6	5.6	6.1	2.9	3477
2000	69.0	7425	5169	86634	2842	2900	8385	8390	22517	6.7	6.8	7.0	6.5	5.6	5.6	6.1	3.0	3526
2002	71.0	7575	5296	88597	3232	3300	9258	9265	25055	6.7	6.8	7.0	6.5	5.6	5.6	6.1	3.3	3639
2004	74.0	7743	5422	90565	3724	3807	10322	10328	28181	6.7	6.8	7.0	6.5	5.5	5.6	6.1	3.6	3781
2006	76.0	7902	5542	92519	4325	4428	11541	11545	31839	6.7	6.7	7.0	6.5	5.5	5.6	6.1	4.0	3890
2008	79.0	8069	5668	94488	5048	5178	12880	12883	35989	6.7	6.7	7.0	6.6	5.5	5.6	6.1	4.5	4018
2010	81.0	8224	5793	96264	5914	6023	14494	14530	40961	6.7	6.7	7.0	6.6	5.5	5.6	6.1	5.0	4148
**** CAPACITY WAS INCREASED BY BUILDING LARGER LOCKS ****																		
2012	28.0	8052	5514	97821	253	255	881	882	2271	6.9	7.0	7.0	6.9	5.7	5.8	6.3	.3	1505
2014	29.0	8134	5590	99168	261	263	904	905	2333	6.9	7.0	7.0	6.9	5.7	5.8	6.4	.3	1526
2016	29.0	8214	5655	100532	269	269	933	934	2405	6.9	7.0	7.0	6.9	5.7	5.8	6.4	.3	1547
2018	30.0	8294	5723	101893	277	279	962	963	2481	6.9	7.0	7.0	6.9	5.7	5.8	6.4	.3	1576
2020	30.0	8398	5802	103250	287	287	990	990	2554	6.9	7.0	7.0	6.9	5.7	5.8	6.4	.3	1583
2022	31.0	8670	5989	106127	317	318	1092	1093	2820	6.9	7.0	7.0	6.9	5.7	5.8	6.3	.3	1646
2024	32.0	8974	6195	108996	352	353	1207	1207	3119	6.9	7.0	7.0	6.9	5.7	5.8	6.3	.3	1717
2026	34.0	9279	6403	111884	389	393	1331	1332	3445	6.9	7.0	7.0	6.9	5.6	5.8	6.3	.4	1602
2028	35.0	9574	6603	114752	431	433	1465	1466	3795	6.9	7.0	7.0	6.9	5.6	5.8	6.3	.4	1858
2030	36.0	9883	6809	117624	475	477	1609	1610	4171	6.9	6.9	0.0	6.9	5.6	5.8	6.3	.4	1925
2032	38.0	10169	7006	120564	521	523	1756	1757	4557	6.9	6.9	0.0	6.9	5.6	5.8	6.3	.4	2014
2034	39.0	10463	7204	123498	573	577	1929	1931	5010	6.9	6.9	7.0	6.9	5.6	5.8	6.3	.5	2077
2036	41.0	10749	7394	126440	631	636	2115	2116	5498	6.9	6.9	7.0	6.9	5.6	5.8	6.3	.5	2173
2038	42.0	11049	7597	129389	694	698	2313	2314	6019	6.9	6.9	7.0	6.9	5.6	5.8	6.2	.5	2236
2040	44.0	11324	7785	132324	765	765	2525	2525	6580	6.9	6.9	6.5	6.9	5.6	5.8	6.2	.6	2307
2042	45.0	11635	7988	135511	844	847	2779	2780	7250	6.9	6.9	6.5	6.9	5.6	5.8	6.2	.6	2402
2044	47.0	11950	8204	138693	932	938	3059	3059	7988	6.9	6.9	6.5	6.9	5.6	5.8	6.2	.7	2491
2046	48.0	12241	8399	141886	1029	1033	3350	3352	8764	6.9	6.9	6.5	6.9	5.6	5.8	6.2	.7	2565
2048	50.0	12551	8612	145078	1139	1145	3684	3685	9653	6.9	6.9	6.5	6.9	5.6	5.8	6.2	.8	2660
2050	52.0	12856	8822	148265	1263	1267	4055	4056	10641	6.9	6.9	6.5	6.9	5.6	5.8	6.2	.8	2752

***** GL/SLS LOCK CAPACITY MODEL *****
***** ST. LAWRENCE RIVER *****
***** BY ITSELF *****
**** SEASON EXTENSION 2 LOCKING TIME NORM*****
**** 90% LOCK UTILIZATION ****
**** TRAFFIC FORECAST HIGH ****
**** NON-STRUCTURAL 13% ****
**** NO STRUCTURAL IMPROVEMENTS MADE ****

		TRANSITS			CON-DELAY		UNCON-DELAY			COMPOSITE SHIP CLASS							AVG	TOT
YEAR	LK UTIL	TOT	LDD	ACT TONS	DOWN	UP	DOWN	UP	TOTAL	ORE	COL	STN	GRN	OTB	GCO	TOT	DELAY	PROC
1978	59.0	5852	3982	61704	1550	1579	5081	5085	13295	6.4	5.8	7.0	5.9	5.5	5.5	5.8	2.3	2979
1980	66.0	6270	4244	66763	2289	2332	7042	7049	18712	6.3	5.4	7.0	6.1	5.5	5.6	5.9	3.0	3343
1982	74.0	6712	4503	71822	3525	3608	9917	9924	26974	6.3	5.3	7.0	6.2	5.5	5.6	5.9	4.0	3721
1984	82.0	7129	4749	76871	5733	5912	14046	14053	39744	6.2	5.7	7.0	6.3	5.6	5.6	6.0	5.6	4120
1985	85.0	7301	4863	79404	7487	7768	16652	16660	48567	6.3	5.8	7.0	6.3	5.6	5.7	6.0	6.7	4311
1986	89.0	7477	4970	81785	10118	10606	19740	19746	60210	6.3	6.1	7.0	6.4	5.6	5.7	6.1	8.1	4512
1988	90.0	7860	5192	85020	16396	16118	29469	28988	90971	6.4	6.4	7.0	6.4	5.6	5.7	6.1	11.6	4794
***** NONSTRUCTURAL MAXIMUM UTILITY *****																		
1990	82.0	8228	5418	91299	6172	6368	14806	14810	42156	6.5	6.6	7.0	6.5	5.6	5.7	6.2	5.1	4187
1992	88.0	8574	5654	95318	9378	9780	19117	19124	57399	6.5	6.7	7.0	6.5	5.6	5.7	6.2	6.7	4488
1994	90.0	8863	5871	98738	14476	14784	25181	25083	79524	6.6	6.7	7.0	6.5	5.6	5.7	6.2	9.0	4737
1996	90.0	9200	6084	100539	18615	18153	34375	33548	104691	6.6	6.8	7.0	6.5	5.6	5.7	6.2	11.4	4896

* Maximum tonnage throughput for the existing locks after implementation of non-structural improvements.

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RUN BY NCBPD - EB

***** GL/SLS LOCK CAPACITY MODEL *****
***** ST. LAWRENCE RIVER *****
***** BY ITSELF *****
**** SEASON EXTENSION 2 LOCKING TIME NORM*****
**** 80% LOCK UTILIZATION ****
**** TRAFFIC FORECAST HIGH ****
**** NON-STRUCTURAL 13% ****
**** NO CAPACITY EXPANSION, 25.5' D, EXISTING LOCK ****

YEAR	LK UTIL	TRANSITS TOT	TRANSITS LOD	ACT TONS	CON-DELAY DOWN	CON-DELAY UP	UNCON-DELAY DOWN	UNCON-DELAY UP	TOTAL	ORE	COL	COMPOSITE SHIP CLASS STN	GRN	OTB	GCO	TOT	AVG DELAY	TOT PROC
1978	59.0	5852	3982	61704	1550	1579	5081	5085	13295	6.4	5.8	7.0	5.9	5.5	5.5	5.8	2.3	2979
1980	66.0	6270	4244	66763	2289	2332	7042	7049	18712	6.3	5.4	7.0	6.1	5.5	5.6	5.9	3.0	3343
1982	74.0	6712	4503	71822	3525	3608	9917	9924	26974	6.3	5.3	7.0	6.2	5.5	5.6	5.9	4.0	3721
1984	81.0	7157	4749	76726	5648	5748	14029	14036	39461	6.2	5.7	7.0	6.3	5.6	5.6	6.0	5.5	4115
***** NONSTRUCTURAL MAXIMUM UTILITY *****																		
1985	67.0	7306	4868	79404	2509	2562	7602	7608	20281	6.3	5.8	7.0	6.3	5.6	5.7	6.0	2.8	3431
1986	70.0	7477	4971	81786	2917	2979	8571	8576	23043	6.3	6.1	7.0	6.3	5.6	5.7	6.1	3.1	3562
1988	76.0	7855	5191	86545	4114	4216	11149	11151	30630	6.4	6.4	7.0	6.4	5.6	5.7	6.1	3.9	3866
1990	81.0	8228	5418	91024	5999	6097	14746	14735	41577	6.5	6.6	7.0	6.5	5.6	5.7	6.2	5.1	4173
1992	81.0	8564	5654	93211	7304	7174	16725	18442	51645	6.5	6.7	7.0	6.5	5.6	5.7	6.2	6.0	4352

* Maximum tonnage throughput for the existing locks after implementation of non-structural improvements.

**** GL/SLS LOCK CAPACITY MODEL *****
***** WELLAND CANAL *****

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RUN DATE 82/03/17

RUN BY NCBPD - EB

**** SEASON EXTENSION 1 LOCKING TIME NORM*****
**** PARALLEL LOCKS OF EXISTING SIZE ****
**** TRAFFIC FORECAST HIGH ****
**** NON-STRUCTURAL 10% ****
**** STRUCTURAL 800 X 80 LK X 25.5 D ****

YEAR	LK UTIL	TRANSITS TOT	TRANSITS LDD	ACT TONS	CON-DELAY DOWN	CON-DELAY UP	UNCON-DELAY DOWN	UNCON-DELAY UP	TOTAL	ORE	COL	COMPOSITE SHIP CLASS STN	GRN	OTB	GCO	TOT	AVG DELAY	TOT PROC
1978	88.0	6955	4340	68000	7651	9661	14399	14738	46449	6.1	5.8	7.0	5.9	5.5	5.5	5.8	6.7	4755
1980	90.0	7350	4575	72307	15417	16830	21623	22444	76314	6.2	5.9	7.0	6.0	5.5	5.5	5.9	10.4	5167
***** NONSTRUCTURAL MAXIMUM UTILITY *****																		
1982	90.0	7812	4831	79007	9916	12641	16085	16510	55152	6.3	6.1	7.0	6.2	5.5	5.6	6.0	7.1	4933
**** CAPACITY WAS INCREASED BY BUILDING LARGER LOCKS ****																		
1984	30.0	7885	4875	84541	278	293	677	682	1930	6.5	6.5	7.0	6.5	5.7	5.7	6.2	.2	1709
1985	31.0	8089	4990	87300	304	318	733	740	2095	6.6	6.5	7.0	6.5	5.7	5.8	6.2	.3	1762
1986	32.0	8273	5098	90042	331	344	792	798	2265	6.6	6.7	7.0	6.5	5.7	5.8	6.3	.3	1827
1988	34.0	8659	5324	95520	387	404	916	926	2633	6.7	6.7	7.0	6.6	5.8	5.8	6.4	.3	1941
1990	36.0	9024	5540	100998	454	471	1059	1068	3052	6.7	6.8	7.0	6.7	5.8	5.9	6.4	.3	2062
1992	38.0	9387	5766	105277	512	533	1189	1202	3436	6.7	6.9	7.0	6.7	5.8	5.9	6.4	.4	2162
1994	39.0	9723	5974	109561	581	603	1335	1346	3865	6.8	6.9	7.0	6.7	5.8	5.9	6.4	.4	2248
1996	41.0	10070	6195	113839	661	686	1505	1516	4368	6.8	6.9	7.0	6.7	5.8	5.8	6.5	.4	2358
1998	43.0	10412	6407	118123	749	776	1687	1700	4912	6.8	6.9	7.0	6.8	5.8	5.8	6.5	.5	2476
2000	45.0	10749	6625	122400	843	874	1880	1894	5491	6.9	6.9	7.0	6.8	5.8	5.8	6.5	.5	2590
2002	46.0	10960	6764	124978	908	943	2018	2031	5900	6.9	6.9	7.0	6.8	5.7	5.8	6.5	.5	2647
2004	48.0	11166	6903	127556	974	1011	2151	2165	6301	6.9	6.9	7.0	6.8	5.7	5.8	6.5	.6	2722
2006	49.0	11370	7043	130140	1040	1084	2294	2310	6732	6.9	6.9	7.0	6.8	5.7	5.8	6.5	.6	2779
2008	50.0	11569	7178	132715	1125	1163	2448	2464	7200	6.9	7.0	7.0	6.8	5.7	5.8	6.5	.6	2851
2010	51.0	11769	7324	135301	1205	1251	2614	2629	7699	6.9	7.0	7.0	6.8	5.7	5.8	6.5	.7	2925
2012	53.0	12009	7475	138122	1311	1362	2821	2838	8332	6.9	7.0	7.0	6.8	5.7	5.8	6.5	.7	3011
2014	54.0	12250	7638	140941	1426	1481	3038	3056	9001	6.9	7.0	7.0	6.9	5.7	5.8	6.5	.7	3082
2016	56.0	12485	7798	143760	1558	1620	3286	3307	9771	6.9	7.0	7.0	6.9	5.7	5.8	6.5	.8	3182
2018	57.0	12704	7940	146582	1700	1768	3543	3566	10577	6.9	7.0	7.0	6.9	5.7	5.8	6.5	.8	3257
2020	59.0	12923	8100	149401	1856	1933	3831	3853	11473	6.9	7.0	7.0	6.9	5.6	5.8	6.5	.9	3364
2022	61.0	13225	8285	152641	2062	2149	4197	4221	12629	6.9	7.0	7.0	6.9	5.6	5.8	6.5	1.0	3457
2024	63.0	13505	8469	155862	2303	2405	4617	4644	13969	6.9	7.0	7.0	6.9	5.6	5.8	6.5	1.0	3571
2026	65.0	13785	8653	159120	2582	2702	5092	5120	15496	6.9	6.9	7.0	6.9	5.6	5.8	6.5	1.1	3682
2028	67.0	14080	8853	162363	2887	3027	5582	5616	17112	6.9	6.9	7.0	6.9	5.6	5.8	6.5	1.2	3796
2030	69.0	14386	9047	165599	3265	3432	6187	6222	19106	6.9	6.9	7.0	6.9	5.6	5.8	6.5	1.3	3921
2032	71.0	14669	9245	169155	3724	3928	6885	6926	21463	6.9	6.9	7.0	6.9	5.6	5.8	6.5	1.5	4045
2034	74.0	14969	9445	172717	4263	4517	7657	7704	24141	6.9	6.9	7.0	6.9	5.6	5.8	6.4	1.6	4192
2036	76.0	15268	9645	176280	4953	5269	8602	8652	27476	6.9	6.9	7.0	6.9	5.6	5.8	6.4	1.8	4317
2038	79.0	15570	9848	179838	5771	6177	9633	9696	31277	6.9	6.9	7.0	6.9	5.6	5.8	6.4	2.0	4459
2040	81.0	15845	10047	183400	6836	7370	10878	10945	36029	6.9	6.9	7.0	6.9	5.6	5.8	6.4	2.3	4595
2042	85.0	16225	10288	187402	8446	9221	12559	12637	42863	6.9	6.9	7.0	6.9	5.6	5.8	6.4	2.6	4773
2044	88.0	16557	10508	191399	10772	11977	14638	14738	52125	6.9	6.9	7.0	6.9	5.6	5.8	6.4	3.1	4955
2046	90.0	16910	10739	195333	14326	16117	17170	17329	64942	6.9	6.9	7.0	6.9	5.6	5.8	6.4	3.8	5112

* Adjustments to lock capacity model service times (reduction by 50 percent) underestimate future delay hours. Total delay hours should be doubled for comparison with any other plan.

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RUN BY NCBPD - EB

***** GL/SLS LOCK CAPACITY MODEL *****
***** WELLAND CANAL *****
***** 80% LOCK UTILIZATION *****
**** SEASON EXTENSION 1 LOCKING TIME NORM*****
**** PARALLEL LOCKS OF EXISTING SIZE ****
**** TRAFFIC FORECAST HIGH ****
**** NON-STRUCTURAL 10% ****
**** STRUCTURAL 800 X 80 LK X 25.5 D ****

		TRANSITS			CON-DELAY		UNCON-DELAY					COMPOSITE SHIP CLASS					AVG	TOT
YEAR	LK UTIL	TOT	LOD	ACT TONS	DOWN	UP	DOWN	UP	TOTAL	ORE	COL	STN	GRN	OTB	GCO	TOT	DELAY	PROD
1978	81.0	6955	4340	66943	6563	7091	13987	14438	42079	6.1	5.8	7.0	5.9	5.5	5.5	5.8	6.1	4618
***** NONSTRUCTURAL MAXIMUM UTILITY *****																		
1980	81.0	7363	4578	73455	5180	5964	11247	11547	33938	6.2	6.0	7.0	6.0	5.5	5.5	5.9	4.6	4433
**** CAPACITY WAS INCREASED BY BUILDING LARGER LOCKS ****																		
1982	28.0	7529	4666	79030	239	251	586	592	1667	6.5	6.3	7.0	6.3	5.6	5.7	6.1	.2	1595
1984	30.0	7927	4902	84540	283	296	685	691	1955	6.5	6.5	7.0	6.4	5.7	5.7	6.2	.2	1713
1985	31.0	8107	5010	87300	307	319	739	746	2111	6.6	6.5	7.0	6.5	5.7	5.7	6.2	.3	1769
1986	32.0	8301	5118	90042	330	345	792	801	2268	6.6	6.6	7.0	6.5	5.7	5.8	6.3	.3	1627
1988	34.0	8656	5319	95520	367	404	918	925	2634	6.6	6.8	7.0	6.6	5.7	5.8	6.3	.3	1941
1990	36.0	9026	5547	100996	454	469	1053	1067	3043	6.7	6.9	7.0	6.7	5.8	5.9	6.4	.3	2062
1992	38.0	9381	5763	105278	514	533	1187	1200	3434	6.7	6.9	7.0	6.7	5.8	5.9	6.4	.4	2162
1994	39.0	9733	5987	109561	584	606	1340	1351	3881	6.8	6.9	7.0	6.7	5.8	5.9	6.4	.4	2248
1996	41.0	10085	6210	113842	662	686	1505	1516	4369	6.8	6.9	7.0	6.7	5.8	5.8	6.5	.4	2358
1998	43.0	10414	6412	118122	749	775	1685	1699	4908	6.8	6.9	7.0	6.8	5.7	5.8	6.5	.5	2476
2000	45.0	10754	6626	122400	846	877	1887	1903	5513	6.9	7.0	7.0	6.8	5.7	5.8	6.5	.5	2590
2002	46.0	10975	6777	124978	909	944	2019	2033	5905	6.9	7.0	7.0	6.8	5.7	5.8	6.5	.5	2647
2004	48.0	11192	6928	127559	976	1013	2154	2169	6312	6.9	7.0	7.0	6.8	5.7	5.8	6.5	.6	2722
2006	49.0	11378	7049	130139	1047	1087	2300	2314	6748	6.9	7.0	7.0	6.8	5.7	5.8	6.5	.6	2779
2008	50.0	11593	7197	132716	1127	1165	2454	2469	7215	6.9	7.0	7.0	6.8	5.7	5.8	6.5	.6	2856
2010	51.0	11766	7328	135300	1213	1258	2627	2642	7740	6.9	7.0	7.0	6.8	5.7	5.8	6.5	.7	2929
2012	53.0	12026	7488	138122	1317	1367	2830	2845	8359	6.9	7.0	7.0	6.8	5.7	5.8	6.5	.7	3011
2014	54.0	12261	7646	140941	1432	1487	3048	3067	9034	6.9	7.0	7.0	6.9	5.7	5.8	6.5	.7	3086
2016	56.0	12490	7799	143760	1562	1624	3293	3313	9792	6.9	7.0	7.0	6.9	5.6	5.8	6.5	.8	3136
2018	57.0	12712	7943	146582	1702	1774	3556	3575	10607	6.9	7.0	7.0	6.9	5.6	5.8	6.5	.8	3257
2020	59.0	12936	8098	149400	1863	1938	3843	3863	11507	6.9	7.0	7.0	6.9	5.6	5.8	6.5	.9	3364
2022	61.0	13232	8291	152642	2069	2159	4211	4237	12676	6.9	7.0	7.0	6.9	5.6	5.8	6.5	1.0	3464
2024	63.0	13515	8478	155881	2308	2410	4626	4653	13997	6.9	7.0	7.0	6.9	5.6	5.8	6.5	1.0	3571
2026	65.0	13800	8665	159120	2588	2708	5100	5130	15526	6.9	7.0	7.0	6.9	5.6	5.8	6.5	1.1	3689
2028	67.0	14088	8858	162362	2895	3036	5602	5634	17167	6.9	6.9	7.0	6.9	5.6	5.8	6.5	1.2	3796
2030	69.0	14393	9047	165600	3266	3433	6189	6229	19117	6.9	6.9	7.0	6.9	5.6	5.8	6.5	1.3	3921
2032	71.0	14673	9247	169155	3724	3928	6886	6929	21467	6.9	6.9	7.0	6.9	5.6	5.8	6.5	1.5	4052
2034	74.0	14968	9444	172717	4270	4522	7667	7713	24172	6.9	6.9	7.0	6.9	5.6	5.8	6.4	1.6	4199
2036	76.0	15272	9647	176281	4963	5281	8619	8668	27531	6.9	6.9	7.0	6.9	5.6	5.8	6.4	1.8	4317
2038	79.0	15574	9850	179838	5783	6189	9650	9709	31331	6.9	6.9	7.0	6.9	5.6	5.8	6.4	2.0	4467
2040	81.0	15844	10049	183257	6827	7242	10861	10962	35892	6.9	6.9	7.0	6.9	5.6	5.8	6.4	2.3	4609

* Adjustments to lock capacity model service times (reduction by 50 percent) underestimate future delay hours. Total delay hours should be doubled for comparison with any other plan.

RUN BY NCBPD - EB

***** GL/SLS LOCK CAPACITY MODEL *****
***** ST. LAWRENCE RIVER *****
***** BY ITSELF *****
**** SEASON EXTENSION 2 LOCKING TIME NORM*****
**** PARALLEL LOCKS OF EXISTING SIZE ****
**** TRAFFIC FORECAST HIGH ****
**** NON-STRUCTURAL 13% ****
**** STRUCTURAL 800 X 80 LK X 25.5 D ****

		TRANSITS			CON-DELAY		UNCON-DELAY					COMPOSITE SHIP CLASS					AVG	TOT
YEAR	LK UTIL	TOT	LDD	ACT TONS	DOWN	UP	DOWN	UP	TOTAL	ORE	COL	STN	GRN	OTB	GCO	TOT	DELAY	PROC
1978	59.0	5852	3982	61704	1550	1579	5081	5085	13295	6.4	5.8	7.0	5.9	5.5	5.5	5.8	2.3	2979
1980	66.0	6270	4244	66763	2289	2332	7042	7049	18712	6.3	5.4	7.0	6.1	5.5	5.6	5.9	3.0	3343
1982	74.0	6712	4503	71822	3525	3608	9917	9924	26974	6.3	5.3	7.0	6.2	5.5	5.6	5.9	4.0	3721
1984	82.0	7129	4749	76871	5733	5912	14046	14053	39744	6.2	5.7	7.0	6.3	5.6	5.6	6.0	5.6	4120
1985	85.0	7301	4863	79404	7487	7768	16652	16660	48567	6.3	5.8	7.0	6.3	5.6	5.7	6.0	6.7	4311
1986	89.0	7477	4970	81785	10118	10606	19740	19746	60210	6.3	6.1	7.0	6.4	5.6	5.7	6.1	8.1	4512
1988	90.0	7860	5192	85020	16396	16118	29469	28988	90971	6.4	6.4	7.0	6.4	5.6	5.7	6.1	11.6	4794
***** NONSTRUCTURAL MAXIMUM UTILITY *****																		
1990	82.0	8228	5418	91299	6172	6368	14806	14810	42156	6.5	6.6	7.0	6.5	5.6	5.7	6.2	5.1	4187
1992	88.0	8574	5654	95318	9378	9780	19117	19124	57399	6.5	6.7	7.0	6.5	5.6	5.7	6.2	6.7	4488
1994	90.0	8863	5871	98738	14476	14784	25181	25083	79524	6.6	6.7	7.0	6.5	5.6	5.7	6.2	9.0	4737
**** CAPACITY WAS INCREASED BY BUILDING LARGER LOCKS ****																		
1996	31.0	8612	5745	103357	313	314	1074	1075	2776	6.9	6.9	7.0	6.7	5.8	5.9	6.4	.3	1646
1998	32.0	8913	5949	107377	349	352	1196	1197	3094	6.9	6.9	7.0	6.8	5.8	5.9	6.4	.3	1717
2000	34.0	9229	6163	111399	391	394	1328	1329	3442	6.9	6.9	7.0	6.8	5.8	5.8	6.4	.4	1812
2002	35.0	9419	6305	113838	415	418	1414	1415	3662	6.9	6.9	7.0	6.8	5.8	5.8	6.4	.4	1855
2004	36.0	9613	6446	116278	443	446	1495	1497	3881	6.9	7.0	7.0	6.8	5.8	5.8	6.4	.4	1897
2006	36.0	9791	6576	118718	472	472	1585	1586	4115	6.9	7.0	7.0	6.8	5.7	5.8	6.4	.4	1929
2008	37.0	9980	6714	121161	501	505	1682	1684	4370	6.9	7.0	7.0	6.8	5.7	5.8	6.4	.4	1976
2010	38.0	10133	6833	123598	536	536	1789	1790	4651	6.9	7.0	7.0	6.9	5.7	5.8	6.4	.5	2028
2012	39.0	10372	6995	126280	576	579	1920	1922	4997	6.9	7.0	7.0	6.9	5.7	5.8	6.4	.5	2084
2014	40.0	10593	7154	128963	616	619	2048	2050	5333	6.9	7.0	7.0	6.9	5.7	5.8	6.4	.5	2141
2016	41.0	10813	7306	131633	669	670	2206	2207	5752	6.9	7.0	7.0	6.9	5.7	5.8	6.4	.5	2194
2018	43.0	11030	7452	134319	718	721	2364	2365	6168	6.9	7.0	7.0	6.9	5.7	5.8	6.4	.6	2272
2020	44.0	11270	7614	136998	776	778	2541	2543	6638	6.9	7.0	7.0	6.9	5.7	5.8	6.4	.6	2342
2022	45.0	11553	7821	140119	848	852	2768	2769	7237	6.9	7.0	7.0	6.9	5.6	5.8	6.4	.6	2413
2024	47.0	11821	8007	143238	927	931	3013	3014	7885	6.9	7.0	7.0	6.9	5.6	5.8	6.4	.7	2487
2026	48.0	12099	8205	146361	1017	1020	3280	3282	8599	6.9	7.0	7.0	6.9	5.6	5.8	6.4	.7	2566
2028	50.0	12373	8398	149479	1112	1116	3570	3571	9369	6.9	7.0	7.0	6.9	5.6	5.8	6.4	.8	2646
2030	51.0	12671	8597	152600	1220	1225	3868	3889	10222	6.9	6.9	6.5	6.9	5.6	5.8	6.4	.8	2734
2032	53.0	12946	8797	156018	1345	1354	4266	4266	11231	6.9	6.9	6.5	6.9	5.6	5.8	6.4	.9	2823
2034	55.0	13242	9000	159436	1488	1494	4670	4671	12323	6.9	6.9	6.5	6.9	5.6	5.8	6.4	.9	2918
2036	57.0	13532	9197	162859	1651	1656	5136	5138	13581	6.9	6.9	6.5	6.9	5.6	5.8	6.4	1.0	3007
2038	58.0	13825	9399	166284	1830	1839	5652	5652	14973	6.9	6.9	6.5	6.9	5.6	5.8	6.4	1.1	3095
2040	60.0	14121	9585	169701	2031	2039	6200	6201	16471	6.9	6.9	6.5	6.9	5.6	5.8	6.4	1.2	3194
2042	62.0	14431	9819	173562	2285	2294	6895	6898	18372	6.9	6.9	6.5	6.9	5.6	5.8	6.4	1.3	3303
2044	65.0	14755	10050	177459	2591	2603	7709	7710	20613	6.9	6.9	6.5	6.9	5.6	5.8	6.4	1.4	3431
2046	67.0	15076	10279	181336	2943	2956	8621	8623	23143	6.9	6.9	6.5	6.9	5.5	5.8	6.4	1.5	3544
2048	69.0	15400	10509	185221	3344	3361	9634	9635	25974	6.9	6.9	6.5	6.9	5.5	5.8	6.4	1.7	3667
2050	71.0	15720	10743	189093	3846	3866	10854	10856	29422	6.9	6.9	6.5	6.9	5.5	5.8	6.3	1.9	3780

* Adjustments to lock capacity model service times (reduction by 50 percent) underestimate future delay hours. Total delay hours should be doubled for comparison with any other plan.

RUN BY NCBPD - EB

***** GL/SLS LOCK CAPACITY MODEL *****
***** ST. LAWRENCE RIVER *****
***** BY ITSELF *****
**** SEASON EXTENSION 2 LOCKING TIME NORM*****
**** PARRALLEL LOCKS OF EXISTING SIZE, 80% LOCK UTILIZATION ****
**** TRAFFIC FORECAST HIGH ****
**** NON-STRUCTURAL 13% ****
**** STRUCTURAL 800 X 80 LK X 25.5 D ****

YEAR	LK UTIL	TRANSITS TOT	TRANSITS LDD	ACT TONS	CON-DELAY DOWN	CON-DELAY UP	UNCON-DELAY DOWN	UNCON-DELAY UP	TOTAL	ORE	COL	COMPOSITE SHIP CLASS STN	GRN	OTB	GCO	TOT	AVG DELAY	TOT PROC
1978	59.0	5852	3982	61704	1550	1579	5081	5085	13295	6.4	5.8	7.0	5.9	5.5	5.5	5.8	2.3	2979
1980	66.0	6270	4244	66763	2289	2332	7042	7049	18712	6.3	5.4	7.0	6.1	5.5	5.6	5.9	3.0	3343
1982	74.0	6712	4503	71822	3525	3608	9917	9924	26974	6.3	5.3	7.0	6.2	5.5	5.6	5.9	4.0	3721
1984	81.0	7157	4749	76726	5648	5748	14029	14036	39461	6.2	5.7	7.0	6.3	5.6	5.6	6.0	5.5	4113
***** NONSTRUCTURAL MAXIMUM UTILITY *****																		
1985	67.0	7306	4868	79404	2509	2562	7602	7608	20281	6.3	5.8	7.0	6.3	5.6	5.7	6.0	2.8	3431
1986	70.0	7477	4971	81786	2917	2979	8571	8576	23043	6.3	6.1	7.0	6.3	5.6	5.7	6.1	3.1	3562
1988	76.0	7855	5191	86545	4114	4216	11149	11151	30630	6.4	6.4	7.0	6.4	5.6	5.7	6.1	3.9	3866
1990	81.0	8228	5418	91024	5999	6097	14746	14735	41577	6.5	6.6	7.0	6.5	5.6	5.7	6.2	5.1	4173
**** CAPACITY WAS INCREASED BY BUILDING LARGER LOCKS ****																		
1992	28.0	8038	5354	95320	252	252	871	872	2247	6.8	6.7	7.0	6.7	5.8	5.9	6.4	.3	1512
1994	30.0	8338	5556	99341	282	283	974	974	2513	6.8	6.8	7.0	6.7	5.8	5.9	6.4	.3	1590
1996	31.0	8642	5763	103357	315	316	1063	1084	2798	6.9	6.9	7.0	6.7	5.8	5.9	6.4	.3	1653
1998	32.0	8941	5963	107378	353	355	1201	1203	3112	6.9	6.9	7.0	6.8	5.8	5.8	6.4	.3	1724
2000	34.0	9247	6182	111397	394	395	1333	1334	3456	6.9	6.9	7.0	6.8	5.8	5.8	6.4	.4	1812
2002	35.0	9447	6323	113840	417	419	1418	1417	3571	6.9	7.0	7.0	6.8	5.8	5.8	6.4	.4	1855
2004	36.0	9639	6466	116277	449	449	1507	1508	3913	6.9	7.0	7.0	6.8	5.7	5.8	6.4	.4	1904
2006	36.0	9807	6583	118719	477	478	1602	1602	4159	6.9	7.0	7.0	6.8	5.7	5.8	6.4	.4	1936
2008	37.0	9986	6711	121161	505	506	1692	1694	4397	6.9	7.0	7.0	6.8	5.7	5.8	6.4	.4	1985
2010	38.0	10185	6653	123597	537	540	1795	1797	4669	6.9	7.0	7.0	6.9	5.7	5.8	6.4	.5	2028
2012	39.0	10391	7007	126279	577	580	1924	1926	5007	6.9	7.0	7.0	6.9	5.7	5.8	6.4	.5	2084
2014	40.0	10619	7173	128964	623	623	2064	2066	5376	6.9	7.0	7.0	6.9	5.7	5.8	6.4	.5	2141
2016	41.0	10827	7319	131639	670	671	2210	2212	5763	6.9	7.0	7.0	6.9	5.7	5.8	6.4	.5	2194
2018	43.0	11050	7473	134318	719	721	2368	2370	6178	6.9	7.0	7.0	6.9	5.7	5.8	6.4	.6	2279
2020	44.0	11283	7627	136997	780	780	2551	2552	6663	6.9	7.0	7.0	6.9	5.6	5.8	6.4	.6	2342
2022	45.0	11557	7828	140117	849	851	2768	2769	7237	6.9	7.0	7.0	6.9	5.6	5.8	6.4	.6	2413
2024	47.0	11828	8016	143241	930	934	3018	3020	7902	6.9	7.0	7.0	6.9	5.6	5.8	6.4	.7	2494
2026	48.0	12105	8213	146357	1017	1020	3263	3285	8605	6.9	7.0	7.0	6.9	5.6	5.8	6.4	.7	2568
2028	50.0	12374	8400	149479	1114	1119	3578	3579	9390	6.9	7.0	7.0	6.9	5.6	5.8	6.4	.8	2646
2030	51.0	12673	8602	152600	1219	1225	3890	3893	10227	6.9	6.9	6.5	6.9	5.6	5.8	6.4	.8	2734
2032	53.0	12951	8804	156017	1348	1355	4272	4272	11247	6.9	6.9	6.5	6.9	5.6	5.8	6.4	.9	2823
2034	55.0	13240	8999	159436	1489	1495	4677	4678	12339	6.9	6.9	6.5	6.9	5.6	5.8	6.4	.9	2916
2036	57.0	13531	9198	162858	1651	1655	5136	5138	13580	6.9	6.9	6.5	6.9	5.6	5.8	6.4	1.0	3007
2038	58.0	13830	9404	166284	1829	1836	5649	5649	14965	6.9	6.9	6.5	6.9	5.6	5.8	6.4	1.1	3095
2040	60.0	14119	9589	169700	2034	2042	6209	6209	16494	6.9	6.9	6.5	6.9	5.6	5.8	6.4	1.2	3194
2042	62.0	14433	9824	173581	2286	2295	6898	6900	18379	6.9	6.9	6.5	6.9	5.6	5.8	6.4	1.3	3303
2044	65.0	14754	10051	177459	2587	2597	7695	7696	20575	6.9	6.9	6.5	6.9	5.5	5.8	6.4	1.4	3431
2046	67.0	15074	10279	181335	2941	2954	8618	8619	23132	6.9	6.9	6.5	6.9	5.5	5.8	6.4	1.5	3544
2048	69.0	15406	10516	185220	3348	3365	9642	9643	25998	6.9	6.9	6.5	6.9	5.5	5.8	6.4	1.7	3667
2050	71.0	15719	10745	189093	3841	3860	10839	10840	29380	6.9	6.9	6.5	6.9	5.5	5.8	6.3	1.9	3780

* Adjustments to lock capacity model service times (reduction by 50 percent) under-estimate future delay hours. Total delay hours should be doubled for comparison with any other plan.

RUN BY NCBPD - EB

***** GL/SLS LOCK CAPACITY MODEL *****
***** WELLAND CANAL *****
***** PARRALLEL LOCKS *****
**** SEASON EXTENSION 1 LOCKING TIME NORM*****
**** 90% LOCK UTILIZATION ****
**** TRAFFIC FORECAST HIGH ****
**** NON-STRUCTURAL 10% ****
**** STRUCTURAL 1200 X 115 LK X 25.5 D ****

		TRANSITS			CON-DELAY		UNCON-DELAY			COMPOSITE SHIP CLASS							AVG	TOT
YEAR	LK UTIL	TOT	LDD	ACT TONS	DOWN	UP	DOWN	UP	TOTAL	ORE	COL	STN	GRN	OTB	GCO	TOT	DELAY	PROC
1978	88.0	6955	4340	68000	7651	9661	14399	14738	46449	6.1	5.8	7.0	5.9	5.5	5.5	5.8	6.7	4755
1980	90.0	7350	4575	72307	15417	16630	21623	22444	76314	6.2	5.9	7.0	6.0	5.5	5.5	5.9	10.4	5167
***** NONSTRUCTURAL MAXIMUM UTILITY *****																		
1982	90.0	7812	4831	79007	9916	12641	16085	16510	55152	6.3	6.1	7.0	6.2	5.5	5.6	6.0	7.1	4933
**** CAPACITY WAS INCREASED BY BUILDING LARGER LOCKS ****																		
1984	31.0	7182	4459	84546	336	347	767	774	2224	6.8	6.6	7.0	6.7	5.7	6.0	6.4	.3	1748
1985	32.0	7218	4487	87299	374	390	843	851	2458	6.8	6.7	7.0	6.8	5.7	6.0	6.5	.3	1827
1986	33.0	7252	4503	90044	418	432	930	938	2718	6.9	6.9	7.0	6.9	5.7	6.1	6.5	.4	1887
1988	35.0	7315	4539	95521	506	519	1095	1101	3221	7.1	6.9	7.0	7.1	5.8	6.2	6.7	.4	2012
1990	38.0	7417	4602	101001	604	619	1276	1286	3785	7.2	7.2	7.0	7.3	5.8	6.3	6.8	.5	2158
1992	40.0	7557	4709	105282	703	716	1458	1465	4344	7.3	7.3	7.0	7.4	5.8	6.3	6.9	.6	2273
1994	42.0	7698	4605	109563	808	827	1645	1655	4935	7.5	7.3	7.0	7.5	5.8	6.3	6.9	.6	2397
1996	44.0	7824	4887	113837	931	950	1863	1873	5617	7.6	7.4	7.0	7.6	5.8	6.4	7.0	.7	2518
1998	46.0	7969	4985	118120	1068	1091	2099	2109	6367	7.7	7.4	7.0	7.7	5.8	6.4	7.0	.8	2658
2000	48.0	8097	5092	122398	1227	1252	2362	2371	7212	7.8	7.4	7.0	7.8	5.8	6.4	7.1	.9	2775
2002	50.0	8121	5106	124977	1349	1376	2559	2573	7857	7.9	7.4	7.0	7.9	5.7	6.4	7.1	1.0	2857
2004	51.0	8146	5140	127560	1466	1495	2738	2750	8449	8.0	7.5	7.0	8.0	5.7	6.5	7.2	1.0	2950
2006	53.0	8160	5166	130141	1598	1630	2940	2951	9119	8.0	7.5	7.0	8.1	5.7	6.5	7.2	1.1	3036
2008	55.0	8179	5197	132716	1755	1792	3173	3189	9909	8.1	7.6	7.0	8.2	5.7	6.5	7.2	1.2	3136
2010	56.0	8205	5227	135297	1915	1954	3400	3419	10688	8.2	7.7	7.0	8.3	5.7	6.5	7.3	1.3	3211
2012	58.0	8298	5297	138117	2114	2158	3688	3705	11665	8.3	7.7	7.0	8.3	5.7	6.5	7.3	1.4	3314
2014	60.0	8427	5396	140937	2326	2374	3978	3996	12674	8.3	7.8	7.0	8.4	5.7	6.5	7.3	1.5	3421
2016	62.0	8531	5473	143762	2583	2638	4325	4346	13892	8.4	7.8	7.0	8.4	5.6	6.5	7.3	1.6	3521
2018	64.0	8624	5537	146581	2870	2932	4701	4720	15223	8.5	7.8	7.0	8.5	5.6	6.5	7.3	1.8	3635
2020	65.0	8765	5628	149399	3204	3281	5124	5145	16754	8.5	7.8	7.0	8.5	5.6	6.5	7.3	1.9	3731
2022	68.0	8763	5659	152642	3643	3731	5607	5626	18607	8.6	7.9	7.0	8.6	5.6	6.5	7.4	2.1	3878
2024	71.0	8789	5694	155880	4227	4335	6234	6257	21053	8.8	8.0	7.0	8.7	5.6	6.6	7.4	2.4	4024
2026	73.0	8794	5713	159119	4894	5033	6875	6903	23705	8.9	8.1	7.0	8.8	5.6	6.6	7.4	2.7	4163
2028	76.0	8818	5746	162364	5763	5941	7653	7685	27042	9.0	8.3	7.0	9.0	5.6	6.6	7.5	3.1	4331
2030	79.0	8823	5783	165597	6870	7101	8539	8573	31083	9.1	8.3	7.0	9.1	5.6	6.6	7.5	3.5	4484
2032	82.0	9016	5903	169161	8265	8585	9549	9589	35986	9.2	8.3	7.0	9.1	5.6	6.6	7.5	4.0	4645
2034	85.0	9190	6029	172715	10223	10687	10789	10835	42534	9.2	8.3	7.0	9.1	5.6	6.6	7.5	4.6	4812
2036	88.0	9358	6147	176282	13074	13799	12259	12308	51440	9.2	8.3	7.0	9.1	5.6	6.6	7.5	5.5	4987
2038	90.0	9559	6287	179780	17391	18368	13893	14002	63654	9.2	8.4	7.0	9.2	5.6	6.6	7.5	6.7	5144

* Lock service times for Class 4 - Class 7 vessels have been reduced by 50 percent. Class 8 - Class 10 vessel service times not changed. A portion of the total delay hours must be increased for comparability with other plans.

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RUN BY NCBPD - EB

***** GL/SLS LOCK CAPACITY MODEL *****
***** WELLAND CANAL *****
***** PARALLEL LOCKS *****
**** SEASON EXTENSION 1 LOCKING TIME NORM*****
**** 80% LOCK UTILIZATION ****
**** TRAFFIC FORECAST HIGH ****
**** NON-STRUCTURAL 13% ****
**** STRUCTURAL 1200 X 115 LK X 25.5 D ****

YEAR	LK UTIL	TRANSITS TOT	TRANSITS LCD	ACT TONS	CON-DELAY DOWN	CON-DELAY UP	UNCON-DELAY DOWN	UNCON-DELAY UP	TOTAL	ORE	COL	COMPOSITE SHIP CLASS STN	GRN	OTB	GCO	TOT	AVG DELAY	TOT PROC
1978	81.0	6955	4340	66943	6563	7091	13987	14438	42079	6.1	5.8	7.0	5.9	5.5	5.5	5.8	6.1	4618
***** NONSTRUCTURAL AXIMUM UTILITY *****																		
1980	81.0	7363	4578	73955	5180	5964	11247	11547	33938	6.2	6.0	7.0	6.0	5.5	5.5	5.9	4.6	4433
**** CAPACITY WAS INCREASED BY BUILDING LARGER LOCKS ****																		
1982	29.0	6912	4310	79031	287	297	663	672	1919	6.7	6.4	7.0	6.5	5.6	5.9	6.3	.3	1638
1984	31.0	6966	4346	84546	354	364	797	802	2317	6.8	6.7	7.0	6.8	5.7	6.0	6.4	.3	1773
1985	32.0	6983	4365	87300	396	406	874	882	2558	6.9	6.7	7.0	6.9	5.7	6.0	6.5	.4	1634
1986	33.0	7013	4375	90042	434	444	945	954	2777	7.0	6.8	7.0	7.0	5.7	6.1	6.6	.4	[illegible]
1988	35.0	7062	4407	95517	521	535	1113	1118	3287	7.1	7.2	7.0	7.3	5.7	6.2	6.7	.5	[illegible]
1990	38.0	7148	4465	101001	621	635	1294	1300	3850	7.3	7.4	7.0	7.5	5.8	6.3	6.9	.5	2173
1992	40.0	7282	4559	105277	715	733	1465	1476	4389	7.4	7.4	7.0	7.6	5.8	6.3	6.9	.6	2294
1994	42.0	7430	4660	109558	823	841	1658	1667	4989	7.6	7.4	7.0	7.6	5.8	6.4	7.0	.7	2419
1996	44.0	7577	4759	113840	944	961	1867	1878	5650	7.7	7.4	7.0	7.7	5.7	6.4	7.0	.7	2540
1998	46.0	7724	4860	118120	1083	1105	2106	2116	6410	7.8	7.5	7.0	7.8	5.7	6.4	7.1	.8	2658
2000	49.0	7862	4952	122400	1253	1276	2386	2400	7315	7.9	7.6	7.0	7.9	5.7	6.4	7.1	.9	2793
2002	50.0	7901	4994	124976	1368	1394	2570	2580	7912	8.0	7.6	7.0	8.0	5.7	6.4	7.2	1.0	2872
2004	52.0	7941	5038	127562	1490	1517	2755	2768	8530	8.1	7.6	7.0	8.1	5.7	6.5	7.2	1.1	2965
2006	53.0	7961	5064	130140	1623	1652	2954	2967	9196	8.1	7.8	7.0	8.2	5.7	6.5	7.2	1.2	3036
2008	55.0	7989	5098	132717	1773	1808	3178	3194	9953	8.2	7.8	7.0	8.3	5.7	6.5	7.3	1.2	3143
2010	56.0	8015	5126	135295	1933	1970	3405	3418	10726	8.3	7.8	7.0	8.4	5.7	6.5	7.3	1.3	3216
2012	58.0	8129	5209	138119	2132	2176	3692	3706	11706	8.3	7.8	7.0	8.4	5.6	6.5	7.3	1.4	3325
2014	60.0	8246	5295	140939	2348	2394	3984	4000	12726	8.4	7.8	7.0	8.5	5.6	6.5	7.3	1.5	3432
2016	62.0	8365	5382	143760	2603	2658	4323	4341	13925	8.5	7.9	7.0	8.5	5.6	6.5	7.4	1.7	3539
2018	64.0	8464	5453	146583	2904	2966	4720	4737	15327	8.5	7.9	7.0	8.6	5.6	6.5	7.4	1.8	3643
2020	66.0	8575	5533	149399	3237	3312	5130	5151	16830	8.6	7.9	7.0	8.6	5.6	6.5	7.4	2.0	3757
2022	68.0	8626	5584	152643	3680	3768	5621	5642	18711	8.7	8.0	7.0	8.7	5.6	6.5	7.4	2.2	3885
2024	71.0	8678	5636	155879	4250	4360	6227	6250	21087	8.8	8.1	7.0	8.8	5.6	6.6	7.4	2.4	4039
2026	73.0	8703	5663	159121	4932	5070	6889	6916	23807	8.9	8.1	7.0	8.9	5.6	6.6	7.5	2.7	4177
2028	76.0	8754	5713	162357	5792	5968	7653	7688	27101	9.1	8.3	7.0	9.0	5.6	6.6	7.5	3.1	4336
2030	79.0	8774	5759	165597	6881	7112	8527	8557	31077	9.2	8.3	7.0	9.1	5.6	6.6	7.5	3.5	4484
2032	81.0	8979	5887	168832	8156	8356	9514	9555	35581	9.2	8.3	7.0	9.1	5.6	6.6	7.5	4.0	4637

* Lock service times for Class 4 - Class 7 vessels have been reduced by 50 percent. Class 8 - Class 10 vessel service times not changed. A portion of the total delay hours must be increased for comparability with other plans.

***** GL/SLS LOCK CAPACITY MODEL *****
***** ST. LAWRENCE RIVER *****
***** CAPACITY DATE FORCED TO COINCIDE WITH THE WELLAND *****
**** SEASON EXTENSION 2 LOCKING TIME NORM*****
**** PARALLEL LOCKS, 90% LOCK UTILIZATION ****
**** TRAFFIC FORECAST HIGH ****
**** NON-STRUCTURAL 13% ****
**** STRUCTURAL 1200 X 115 LK X 25.5 D ****

YEAR	LK UTIL	TRANSITS TOT	TRANSITS LOD	ACT TONS	CON-DELAY DOWN	CON-DELAY UP	UNCON-DELAY DOWN	UNCON-DELAY UP	TOTAL	ORE	COL	COMPOSITE SHIP CLASS STN	GRN	OTB	GCO	TOT	AVG DELAY	TOT PROC
1978	59.0	5852	3982	61704	1550	1579	5081	5085	13295	6.4	5.8	7.0	5.9	5.5	5.5	5.8	2.3	2979
1980	66.0	6269	4244	66763	2289	2332	7042	7049	18712	6.3	5.4	7.0	6.1	5.5	5.6	5.9	3.0	3343
***** NONSTRUCTURAL MAXIMUM UTILITY *****																		
1982	58.0	6700	4496	71818	1566	1596	5133	5138	13433	6.3	5.3	7.0	6.2	5.6	5.6	5.9	2.0	2986
**** CAPACITY WAS INCREASED BY BUILDING LARGER LOCKS ****																		
1984	23.0	5989	4053	76877	172	173	595	594	1534	6.9	6.4	7.0	6.8	5.7	6.1	6.4	.3	1226
1985	24.0	6010	4082	79400	190	190	651	650	1681	7.0	6.4	7.0	6.9	5.7	6.1	6.5	.3	1272
1986	25.0	6076	4105	81779	205	207	700	699	1811	7.1	6.7	7.0	7.0	5.7	6.2	6.6	.3	1314
1988	26.0	6200	4183	86543	244	244	818	819	2125	7.2	6.7	7.0	7.2	5.7	6.2	6.7	.3	1402
1990	28.0	6251	4235	91301	280	282	932	931	2425	7.3	7.5	7.0	7.4	5.8	6.3	6.8	.4	1487
1992	29.0	6432	4337	95320	316	319	1047	1048	2730	7.5	7.5	7.0	7.5	5.7	6.4	6.8	.4	1561
1994	31.0	6584	4453	99340	362	363	1185	1185	3095	7.6	7.5	7.0	7.6	5.7	6.4	6.9	.5	1646
1996	32.0	6730	4566	103361	405	406	1319	1320	3450	7.7	7.9	7.0	7.7	5.7	6.4	6.9	.5	1713
1998	34.0	6851	4651	107378	452	453	1458	1458	3821	7.8	7.9	7.0	7.8	5.7	6.4	7.0	.6	1809
2000	35.0	6997	4760	111397	507	508	1620	1621	4256	7.9	7.9	7.0	7.9	5.7	6.4	7.0	.6	1872
2002	36.0	7034	4804	113837	549	548	1741	1741	4579	8.0	7.9	7.0	8.0	5.7	6.5	7.1	.7	1925
2004	37.0	7060	4834	116280	582	585	1844	1843	4854	8.1	7.9	7.0	8.1	5.7	6.5	7.1	.7	1978
2006	38.0	7099	4875	118724	622	623	1955	1954	5154	8.2	7.9	7.0	8.2	5.6	6.5	7.1	.7	2035
2008	39.0	7139	4916	121158	672	672	2096	2098	5538	8.2	7.9	7.0	8.3	5.6	6.5	7.2	.8	2091
2010	40.0	7196	4934	123595	716	717	2223	2223	5879	8.3	8.1	7.0	8.4	5.6	6.6	7.2	.8	2144
2012	41.0	7274	5031	126279	770	771	2378	2377	6296	8.4	8.1	7.0	8.4	5.6	6.6	7.2	.9	2201
2014	42.0	7386	5116	128961	830	831	2547	2548	6756	8.4	8.1	7.0	8.5	5.6	6.6	7.2	.9	2254
2016	44.0	7487	5189	131643	893	894	2726	2727	7240	8.5	8.1	7.0	8.5	5.6	6.6	7.2	1.0	2339
2018	45.0	7617	5294	134319	968	969	2935	2934	7806	8.5	8.3	7.0	8.5	5.6	6.6	7.2	1.0	2399
2020	46.0	7707	5377	136999	1034	1037	3123	3123	8317	8.6	8.3	7.0	8.6	5.6	6.6	7.2	1.1	2459
2022	48.0	7793	5443	140115	1134	1137	3390	3391	9052	8.7	8.3	7.0	8.7	5.6	6.6	7.3	1.2	2547
2024	49.0	7842	5488	143241	1233	1235	3655	3654	9777	8.8	8.3	7.0	8.8	5.6	6.6	7.3	1.2	2621
2026	51.0	7895	5540	146354	1353	1354	3971	3973	10651	9.0	8.3	7.0	8.9	5.5	6.6	7.3	1.3	2706
2028	52.0	7958	5600	149480	1483	1484	4303	4300	11570	9.1	8.5	7.0	9.0	5.5	6.6	7.3	1.5	2784
2030	54.0	8060	5660	152594	1629	1632	4674	4673	12608	9.2	8.5	6.5	9.1	5.5	6.6	7.4	1.6	2879
2032	56.0	8215	5785	156018	1803	1606	5119	5119	13847	9.2	8.5	6.5	9.1	5.5	6.6	7.4	1.7	2975
2034	58.0	8403	5921	159437	2009	2015	5635	5637	15296	9.2	8.5	6.5	9.2	5.5	6.6	7.3	1.8	3081
2036	60.0	8593	6056	162859	2241	2246	6201	6200	16888	9.2	8.5	6.5	9.2	5.5	6.6	7.3	2.0	3190
2038	62.0	8762	6171	166282	2493	2498	6795	6795	18581	9.2	8.5	6.5	9.2	5.5	6.6	7.3	2.1	3279
2040	64.0	8989	6305	169698	2790	2795	7483	7480	20548	9.3	8.5	6.5	9.2	5.5	6.6	7.3	2.3	3388
2042	66.0	9151	6451	173579	3192	3200	8392	8390	23174	9.3	8.7	6.5	9.2	5.5	6.6	7.3	2.5	3512
2044	68.0	9360	6602	177456	3659	3665	9398	9395	26117	9.3	8.7	6.5	9.2	5.5	6.6	7.3	2.8	3632
2046	71.0	9571	6757	181335	4191	4204	10498	10500	29393	9.3	8.7	6.0	9.2	5.5	6.6	7.3	3.1	3756
2048	73.0	9782	6910	185218	4869	4885	11838	11837	33429	9.3	8.7	6.0	9.3	5.5	6.6	7.3	3.4	3893
2050	76.0	9979	7069	189100	5700	5718	13375	13374	38167	9.3	8.7	6.0	9.3	5.5	6.6	7.3	3.8	4024

* Lock service times for Class 4 - Class 7 vessels have been reduced by 50 percent. Class 8 - Class 10 vessel service times not changed. A portion of the total delay hours must be increased for comparability with other plans.

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***** GL/SLS LOCK CAPACITY MODEL *****
***** ST. LAWRENCE RIVER *****
***** CAPACITY DATE FORCED TO COINCIDE WITH THE WELLAND *****
**** SEASON EXTENSION 2 LOCKING TIME NORM*****
**** PARALLEL LOCKS, 80% LOCK UTILIZATION ****
**** TRAFFIC FORECAST HIGH ****
**** NON-STRUCTURAL 13% ****
**** STRUCTURAL 1200 X 115 LK X 25.5 D ****

RUN BY NCBPD - EB

		TRANSITS			CON-DELAY		UNCON-DELAY					COMPOSITE SHIP CLASS					AVG	TOT
YEAR	LK UTIL	TOT	LDD	ACT TONS	DOWN	UP	DOWN	UP	TOTAL	ORE	COL	STN	GRN	OTB	GCO	TOT	DELAY	PROC
1978	59.0	5852	3982	61704	1550	1579	5081	5085	13295	6.4	5.8	7.0	5.9	5.5	5.5	5.8	2.3	2979
***** NONSTRUCTURAL MAXIMUM UTILITY *****																		
1980	53.0	6282	4245	66761	1139	1160	3888	3891	10078	6.3	5.4	7.0	6.0	5.5	5.6	5.9	1.6	2703
**** CAPACITY WAS INCREASED BY BUILDING LARGER LOCKS ****																		
1982	22.0	5725	3914	71816	145	146	504	505	1300	6.9	6.4	7.0	6.7	5.6	5.9	6.3	.2	1141
1984	23.0	5782	3944	76869	176	177	604	603	1560	7.1	6.4	7.0	6.9	5.6	6.1	6.5	.3	1226
1985	24.0	5841	3973	79402	190	191	653	652	1686	7.1	6.7	7.0	7.0	5.7	6.1	6.5	.3	1272
1986	25.0	5873	4007	81784	206	208	701	701	1816	7.2	6.7	7.0	7.1	5.7	6.2	6.6	.3	1314
1988	26.0	5975	4070	86540	243	243	812	813	2111	7.3	6.7	7.0	7.4	5.7	6.3	6.7	.4	1396
1990	28.0	6045	4119	91302	284	284	940	941	2449	7.5	7.5	7.0	7.6	5.7	6.4	6.9	.4	1480
1992	29.0	6217	4222	95317	322	322	1050	1049	2743	7.6	7.5	7.0	7.7	5.7	6.4	6.9	.4	1561
1994	31.0	6375	4345	99340	362	364	1179	1180	3085	7.7	7.5	7.0	7.7	5.7	6.4	6.9	.5	1646
1996	32.0	6518	4452	103361	405	406	1312	1313	3436	7.8	7.9	7.0	7.8	5.7	6.4	7.0	.5	1713
1998	34.0	6650	4548	107363	454	454	1458	1458	3824	7.9	7.9	7.0	7.9	5.7	6.4	7.0	.6	1809
2000	35.0	6827	4663	111399	505	507	1611	1612	4235	8.0	7.9	7.0	8.0	5.7	6.5	7.1	.6	1872
2002	36.0	6840	4699	113840	547	550	1735	1734	4566	8.1	7.9	7.0	8.1	5.7	6.5	7.1	.7	1925
2004	37.0	6884	4742	116279	583	585	1844	1842	4854	8.2	7.9	7.0	8.2	5.6	6.5	7.1	.7	1978
2006	38.0	6935	4790	118715	621	622	1952	1952	5147	8.3	7.9	7.0	8.3	5.6	6.5	7.2	.7	2035
2008	39.0	6972	4827	121157	669	669	2084	2082	5504	8.3	7.9	7.0	8.4	5.6	6.5	7.2	.8	2091
2010	40.0	7020	4859	123599	717	716	2221	2220	5876	8.4	8.1	7.0	8.5	5.6	6.6	7.2	.8	2148
2012	41.0	7131	4955	126278	768	768	2364	2364	6264	8.4	8.1	7.0	8.5	5.6	6.6	7.2	.9	2201
2014	42.0	7258	5052	128960	828	828	2535	2535	6726	8.5	8.3	7.0	8.6	5.6	6.6	7.2	.9	2257
2016	44.0	7362	5129	131640	892	893	2720	2720	7225	8.5	8.3	7.0	8.6	5.6	6.6	7.3	1.0	2339
2018	45.0	7485	5221	134321	968	969	2929	2929	7795	8.6	8.3	7.0	8.7	5.6	6.6	7.3	1.0	2402
2020	46.0	7565	5315	137001	1034	1035	3116	3116	8301	8.6	8.3	7.0	8.7	5.6	6.6	7.3	1.1	2459
2022	48.0	7686	5385	140115	1135	1136	3384	3384	9039	8.8	8.3	7.0	8.8	5.6	6.6	7.3	1.2	2547
2024	49.0	7752	5442	143240	1233	1235	3649	3648	9765	8.8	8.3	7.0	8.9	5.5	6.6	7.3	1.3	2621
2026	51.0	7831	5508	146359	1356	1360	3975	3974	10665	9.0	8.3	7.0	9.0	5.5	6.6	7.3	1.4	2706
2028	52.0	7915	5581	149479	1480	1481	4294	4292	11547	9.1	8.5	7.0	9.1	5.5	6.6	7.3	1.5	2784
2030	54.0	8025	5638	152596	1631	1632	4680	4679	12622	9.2	8.5	6.5	9.2	5.5	6.6	7.4	1.6	2879
2032	56.0	8187	5776	156021	1804	1806	5119	5115	13844	9.2	8.5	6.5	9.2	5.5	6.6	7.4	1.7	2975
2034	58.0	8371	5905	159440	2014	2016	5641	5640	15311	9.2	8.5	6.5	9.2	5.5	6.6	7.4	1.8	3081
2036	60.0	8567	6045	162856	2239	2243	6193	6192	16867	9.2	8.5	6.5	9.2	5.5	6.6	7.3	2.0	3190
2038	62.0	8732	6155	166283	2493	2494	6787	6788	18562	9.3	8.5	6.5	9.2	5.5	6.6	7.3	2.1	3279
2040	64.0	8959	6293	169697	2769	2796	7480	7478	20543	9.3	8.5	6.5	9.2	5.5	6.6	7.3	2.3	3386
2042	66.0	9127	6439	173580	3191	3197	8385	8384	23157	9.3	8.7	6.5	9.3	5.5	6.6	7.3	2.5	3512
2044	68.0	9335	6589	177458	3655	3662	9392	9387	26096	9.3	8.7	6.0	9.3	5.5	6.6	7.3	2.8	3632
2046	71.0	9550	6747	181339	4183	4194	10475	10475	29327	9.3	8.7	6.0	9.3	5.5	6.6	7.3	3.1	3756
2048	73.0	9761	6899	185219	4859	4875	11813	11809	33356	9.3	8.7	6.0	9.3	5.5	6.6	7.3	3.4	3893
2050	76.0	9950	7056	189100	5698	5715	13363	13363	38139	9.3	8.7	6.0	9.3	5.5	6.6	7.3	3.8	4024

* Lock service times for Class 4 - Class 7 vessels have been reduced by 50 percent. Class 8 - Class 10 vessel service times not changed. A portion of the total delay hours must be increased for comparability with other

***** GL/SLS LOCK CAPACITY MODEL *****
***** WELLAND CANAL *****

**** SEASON EXTENSION 1 LOCKING TIME NORM*****
**** 30% LOCKING TIME REDUCTION ****
**** TRAFFIC FORECAST HIGH ****
**** NON-STRUCTURAL 10% ****
**** STRUCTURAL 1200 X 115 LK X 25.5 D ****

YEAR	LK UTIL	TRANSITS TOT	TRANSITS LDD	ACT TONS	CON-DELAY DOWN	CON-DELAY UP	UNCON-DELAY DOWN	UNCON-DELAY UP	TOTAL	COMPOSITE SHIP CLASS ORE	COL	STN	GRN	OTB	GCO	TOT	AVG DELAY	TOT PROC
1978	88.0	6955	4340	68000	7651	9661	14399	14738	46449	6.1	5.8	7.0	5.9	5.5	5.5	5.8	6.7	4755
1980	90.0	7350	4575	72307	15417	16830	21623	22444	76314	6.2	5.9	7.0	6.0	5.5	5.5	5.9	10.4	5167
***** NONSTRUCTURAL MAXIMUM UTILITY *****																		
1982	90.0	7812	4831	79007	9916	12641	16085	16510	55152	6.3	6.1	7.0	6.2	5.5	5.6	6.0	7.1	4933
**** CAPACITY WAS INCREASED BY BUILDING LARGER LOCKS ****																		
1984	41.0	7158	4442	84548	670	672	1765	1775	4882	6.8	6.6	7.0	6.7	5.7	6.0	6.4	.7	2326
1985	42.0	7194	4472	87297	729	733	1887	1897	5246	6.9	6.6	7.0	6.8	5.7	6.0	6.5	.7	2397
1986	44.0	7231	4492	90042	802	806	2039	2050	5697	6.9	6.9	7.0	6.9	5.7	6.1	6.5	.8	2472
1988	46.0	7303	4535	95522	946	951	2329	2342	6568	7.1	6.9	7.0	7.1	5.8	6.2	6.7	.9	2615
1990	49.0	7404	4595	101002	1118	1121	2661	2671	7571	7.2	7.2	7.0	7.3	5.8	6.3	6.8	1.0	2768
1992	51.0	7543	4703	105280	1301	1306	3035	3049	8691	7.3	7.3	7.0	7.4	5.8	6.3	6.9	1.2	2897
1994	54.0	7673	4788	109560	1502	1507	3414	3431	9854	7.5	7.4	7.0	7.5	5.8	6.3	6.9	1.3	3057
1996	57.0	7814	4881	113836	1745	1751	3876	3893	11265	7.6	7.4	7.0	7.6	5.8	6.4	7.0	1.4	3197
1998	59.0	7954	4978	118120	2027	2035	4380	4400	12842	7.7	7.4	7.0	7.7	5.8	6.4	7.0	1.6	3350
2000	62.0	8088	5088	122397	2373	2381	4980	5000	14734	7.8	7.4	7.0	7.8	5.7	6.4	7.1	1.8	3500
2002	64.0	8104	5094	124978	2613	2621	5361	5380	15975	7.9	7.5	7.0	7.9	5.7	6.4	7.1	2.0	3603
2004	65.0	8137	5138	127562	2837	2847	5677	5700	17061	8.0	7.5	7.0	8.0	5.7	6.5	7.2	2.1	3675
2006	67.0	8153	5165	130139	3107	3116	6054	6075	18352	8.0	7.5	7.0	8.1	5.7	6.5	7.2	2.3	3776
2008	68.0	8168	5191	132717	3418	3429	6483	6505	19835	8.1	7.6	7.0	8.2	5.7	6.5	7.2	2.4	3849
2010	70.0	8185	5216	135296	3753	3765	6908	6934	21360	8.2	7.7	7.0	8.3	5.7	6.5	7.3	2.6	3956
2012	72.0	8288	5292	138117	4250	4263	7595	7622	23730	8.3	7.7	7.0	8.3	5.7	6.5	7.3	2.9	4067
2014	74.0	8415	5389	140938	4813	4827	8324	8350	26314	8.3	7.8	7.0	8.4	5.7	6.5	7.3	3.1	4188
2016	77.0	8521	5466	143758	5550	5566	9232	9262	29610	8.4	7.8	7.0	8.4	5.6	6.5	7.3	3.5	4331
2018	79.0	8616	5533	146584	6461	6474	10280	10306	33521	8.4	7.8	7.0	8.5	5.6	6.5	7.3	3.9	4446
2020	82.0	8752	5621	149400	7578	7595	11436	11470	38079	8.5	7.8	7.0	8.5	5.6	6.5	7.3	4.4	4573
2022	84.0	8755	5656	152643	9015	9032	12578	12610	43235	8.6	7.9	7.0	8.6	5.6	6.5	7.4	4.9	4719
2024	87.0	8777	5687	155881	11105	11123	14058	14094	50380	8.8	8.0	7.0	8.7	5.6	6.6	7.4	5.7	4863
2026	89.0	8787	5710	159121	14055	14081	15692	15737	59565	8.9	8.1	7.0	8.8	5.6	6.6	7.4	6.8	5019
2028	90.0	8828	5739	161779	17260	17136	17667	17626	69689	9.0	8.2	7.0	9.0	5.6	6.6	7.5	7.9	5129

* Lock service times for Class 4 - Class 7 vessels have been reduced by 30 percent. Class 8 - Class 10 service times not changed. A portion of the total delay hours must be increased for comparability with other plans.

RUN BY NCBPD - EB

***** GL/SLS LOCK CAPACITY MODEL *****
***** WELLAND CANAL *****
**** 30% LOCKING TIME REDUCTION ****
**** SEASON EXTENSION 1 LOCKING TIME NORM*****
**** 80% LOCK UTILIZATION ****
**** TRAFFIC FORECAST HIGH ****
**** NON-STRUCTURAL 10% ****
**** STRUCTURAL 1200 X 115 LK X 25.5 D ****

		TRANSITS			CON-DELAY		UNCON-DELAY					COMPOSITE SHIP CLASS					AVG	TOT
YEAR	LK UTIL	TOT	LOD	ACT TONS	DOWN	UP	DOWN	UP	TOTAL	ORE	COL	STN	GRN	OTB	GCO	TOT	DELAY	PROC
1978	81.0	6955	4340	66943	6563	7091	13987	14438	42079	6.1	5.8	7.0	5.9	5.5	5.5	5.8	6.1	4616
***** NONSTRUCTURAL MAXIMUM UTILITY *****																		
1980	81.0	7363	4578	73455	5180	5964	11247	11547	33938	6.2	6.0	7.0	6.0	5.5	5.5	5.9	4.6	4433
**** CAPACITY WAS INCREASED BY BUILDING LARGER LOCKS ****																		
1982	38.0	6888	4294	79028	560	565	1498	1509	4132	6.7	6.4	7.0	6.6	5.6	5.9	6.3	.6	2165
1984	41.0	6943	4331	84544	664	667	1711	1720	4762	6.9	6.7	7.0	6.8	5.6	6.0	6.4	.7	2312
1985	42.0	6972	4352	87299	729	733	1838	1848	5148	6.9	6.7	7.0	6.9	5.7	6.0	6.5	.7	2380
1986	43.0	6998	4368	90042	789	793	1965	1975	5522	7.0	6.8	7.0	7.0	5.7	6.1	6.6	.8	2447
1988	46.0	7055	4405	95519	929	933	2240	2250	6352	7.2	7.2	7.0	7.3	5.7	6.2	6.7	.9	2590
1990	48.0	7143	4461	100999	1087	1090	2540	2551	7268	7.3	7.4	7.0	7.5	5.8	6.3	6.9	1.0	2736
1992	51.0	7269	4553	105279	1258	1264	2876	2889	8287	7.4	7.4	7.0	7.6	5.8	6.3	6.9	1.1	2882
1994	53.0	7419	4653	109558	1464	1470	3270	3284	9488	7.6	7.4	7.0	7.6	5.8	6.3	7.0	1.3	3004
1996	56.0	7567	4756	113840	1695	1702	3697	3713	10807	7.7	7.4	7.0	7.7	5.7	6.4	7.0	1.4	3175
1998	59.0	7706	4848	118117	1963	1971	4176	4194	12304	7.8	7.5	7.0	7.8	5.7	6.4	7.1	1.6	3316
2000	61.0	7838	4947	122400	2308	2317	4774	4793	14192	7.9	7.6	7.0	7.9	5.7	6.4	7.1	1.8	3471
2002	63.0	7887	4986	124977	2531	2540	5114	5135	15320	8.0	7.6	7.0	8.0	5.7	6.4	7.2	1.9	3560
2004	65.0	7919	5021	127560	2761	2770	5453	5472	16456	8.0	7.6	7.0	8.1	5.7	6.5	7.2	2.1	3657
2006	66.0	7943	5050	130142	3022	3029	5819	5837	17707	8.1	7.8	7.0	8.2	5.7	6.5	7.2	2.2	3735
2008	68.0	7976	5090	132719	3319	3330	6226	6249	19124	8.2	7.8	7.0	8.3	5.7	6.5	7.3	2.4	3842
2010	70.0	7999	5114	135295	3646	3658	6649	6673	20626	8.3	7.8	7.0	8.4	5.7	6.5	7.3	2.6	3921
2012	72.0	8114	5199	138119	4133	4144	7318	7342	22937	8.3	7.8	7.0	8.4	5.6	6.5	7.3	2.8	4046
2014	74.0	8237	5291	140938	4683	4696	8026	8050	25455	8.4	7.8	7.0	8.5	5.6	6.5	7.3	3.1	4170
2016	76.0	8348	5371	143761	5386	5400	8891	8920	28597	8.5	7.9	7.0	8.5	5.6	6.5	7.4	3.4	4284
2018	79.0	8459	5452	146583	6269	6284	9908	9935	32396	8.5	7.9	7.0	8.6	5.6	6.5	7.4	3.8	4434
2020	81.0	8573	5531	149217	7251	7262	11007	11037	36557	8.6	7.9	7.0	8.6	5.6	6.5	7.4	4.3	4548

* Lock service times for Class 4 - Class 7 vessels have been reduced by 30 percent. Class 8 - Class 10 service times not changed. A portion of the total delay hours must be increased for comparability with other plans.

RUN BY NCRPD - EB

***** GL/SLS LOCK CAPACITY MODEL *****
***** ST. LAWRENCE RIVER *****
***** CAPACITY DATE FORCED TO COINCIDE WITH THE WELLAND *****
**** SEASON EXTENSION 2 LOCKING TIME NORM*****
**** 30% LOCKING TIME REDUCTION ****
**** TRAFFIC FORECAST HIGH ****
**** NON-STRUCTURAL 13% ****
**** STRUCTURAL 1200 X 115 LK X 25.5 D ****

YEAR	LK UTIL	TRANSITS TOT	TRANSITS LOD	ACT TONS	CON-DELAY DOWN	CON-DELAY UP	UNCON-DELAY DOWN	UNCON-DELAY UP	TOTAL	COMPOSITE SHIP CLASS ORE	COL	STN	GRN	OTB	GCO	TOT	AVG DELAY	TOT PROC
1978	59.0	5852	3982	61704	1550	1579	5081	5085	13295	6.4	5.8	7.0	5.9	5.5	5.5	5.8	2.3	2979
1980	66.0	6269	4244	66763	2289	2332	7042	7049	18712	6.3	5.4	7.0	6.1	5.5	5.6	5.9	3.0	3343
***** NONSTRUCTURAL MAXIMUM UTILITY *****																		
1982	58.0	6700	4496	71818	1566	1596	5133	5138	13433	6.3	5.3	7.0	6.2	5.6	5.6	5.9	2.0	2986
**** CAPACITY WAS INCREASED BY BUILDING LARGER LOCKS ****																		
1984	33.0	5979	4049	76877	356	357	1438	1440	3591	6.9	6.4	7.0	6.8	5.7	6.1	6.4	.6	1724
1985	34.0	5998	4067	79399	383	382	1543	1542	3850	7.0	6.4	7.0	6.9	5.7	6.1	6.5	.6	1767
1986	35.0	6059	4094	81781	407	407	1642	1643	4099	7.1	6.7	7.0	7.0	5.7	6.2	6.6	.7	1820
1988	36.0	6178	4165	86542	470	470	1893	1894	4727	7.2	6.8	7.0	7.2	5.7	6.2	6.7	.8	1901
1990	38.0	6231	4226	91302	530	530	2136	2137	5333	7.4	7.5	7.0	7.4	5.8	6.3	6.8	.9	2000
1992	40.0	6422	4329	95320	595	596	2388	2391	5970	7.5	7.5	7.0	7.5	5.7	6.4	6.8	.9	2095
1994	42.0	6573	4445	99340	677	678	2717	2718	6790	7.6	7.5	7.0	7.6	5.7	6.4	6.9	1.0	2191
1996	43.0	6714	4551	103361	759	760	3043	3046	7608	7.7	7.9	7.0	7.7	5.7	6.4	6.9	1.1	2275
1998	45.0	6839	4640	107376	845	844	3390	3392	8471	7.8	7.9	7.0	7.8	5.7	6.4	7.0	1.2	2376
2000	47.0	6999	4749	111396	946	948	3792	3795	9481	7.9	7.9	7.0	7.9	5.7	6.4	7.0	1.4	2466
2002	48.0	7021	4795	113839	1013	1013	4065	4067	10158	8.0	7.9	7.0	8.0	5.7	6.5	7.0	1.4	2516
2004	49.0	7053	4829	116280	1071	1071	4299	4301	10742	8.1	7.9	7.0	8.1	5.7	6.5	7.1	1.5	2576
2006	50.0	7082	4862	118726	1135	1136	4546	4549	11366	8.2	7.9	7.0	8.2	5.6	6.5	7.1	1.6	2625
2008	51.0	7128	4909	121156	1217	1217	4880	4881	12195	8.2	7.9	7.0	8.3	5.6	6.5	7.2	1.7	2682
2010	52.0	7180	4930	123596	1286	1286	5159	5161	12892	8.3	8.1	7.0	8.4	5.6	6.6	7.2	1.8	2731
2012	54.0	7266	5024	126280	1402	1402	5615	5615	14034	8.4	8.1	7.0	8.4	5.6	6.6	7.2	1.9	2812
2014	55.0	7382	5114	128960	1524	1526	6109	6112	15271	8.4	8.1	7.0	8.5	5.6	6.6	7.2	2.1	2890
2016	57.0	7475	5181	131643	1659	1660	6646	6648	16613	8.5	8.1	7.0	8.5	5.6	6.6	7.2	2.2	2971
2018	58.0	7610	5288	134319	1823	1823	7300	7300	18246	8.5	8.3	7.0	8.5	5.6	6.6	7.2	2.4	3049
2020	60.0	7697	5373	137001	1975	1975	7907	7907	19764	8.6	8.3	7.0	8.6	5.6	6.6	7.2	2.6	3138
2022	61.0	7787	5436	140117	2166	2166	8671	8673	21676	8.7	8.3	7.0	8.7	5.6	6.6	7.3	2.8	3215
2024	63.0	7836	5482	143242	2364	2364	9466	9464	23658	8.8	8.3	7.0	8.8	5.6	6.6	7.3	3.0	3300
2026	65.0	7891	5537	146355	2607	2606	10432	10437	26082	9.0	8.3	7.0	8.9	5.5	6.6	7.3	3.3	3399
2028	66.0	7954	5596	149481	2875	2875	11511	11510	28771	9.1	8.5	7.0	9.0	5.5	6.6	7.3	3.6	3470
2030	68.0	8060	5660	152596	3190	3190	12765	12765	31910	9.2	8.5	6.5	9.1	5.5	6.6	7.4	4.0	3565
2032	71.0	8210	5781	156018	3680	3680	14720	14719	36799	9.2	8.5	6.5	9.1	5.5	6.6	7.3	4.5	3706
2034	73.0	8399	5919	159437	4293	4294	17177	17181	42945	9.2	8.5	6.5	9.2	5.5	6.6	7.3	5.1	3833
2036	76.0	8592	6056	162859	5041	5041	20168	20169	50419	9.2	8.5	6.5	9.2	5.5	6.6	7.3	5.9	3985
2038	79.0	8762	6170	166282	5979	5980	23920	23923	59802	9.2	8.5	6.5	9.2	5.5	6.6	7.3	6.8	4116
2040	82.0	8978	6295	169697	7213	7212	28843	28839	72107	9.3	8.5	6.5	9.2	5.5	6.6	7.3	8.0	4256
2042	85.0	9149	6450	173577	9202	9201	36793	36786	91982	9.3	8.7	6.5	9.2	5.5	6.6	7.3	10.1	4431
2044	88.0	9357	6601	177454	12171	12170	48663	48656	121660	9.3	8.7	6.5	9.2	5.5	6.6	7.3	13.0	4590
2046	90.0	9549	6757	180874	16185	16079	64703	64281	161248	9.3	8.7	6.5	9.2	5.5	6.6	7.3	16.9	4762

* Lock service times for Class 4 - Class 7 vessels have been reduced by 30 percent. Class 8 - Class 10 service times not changed. A portion of the total delay hours must be increased for comparability with other plans.

***** GL/SLS LOCK CAPACITY MODEL *****
***** ST. LAWRENCE RIVER *****
***** CAPACITY DATE FORCED TO COINCIDE WITH THE WELLAND *****
**** SEASON EXTENSION 2 LOCKING TIME NORM*****
**** 80% LOCK UTILIZATION, 30% LOCKING TIME REDUCTION ****
**** TRAFFIC FORECAST HIGH ****
**** NON-STRUCTURAL 13% ****
**** STRUCTURAL 1200 X 115 LK X 25.5 D ****

RUN BY NCBPD - EB

		TRANSITS			CON-DELAY		UNCON-DELAY					COMPOSITE SHIP CLASS					AVG	TOT
YEAR	LK UTIL	TOT	LDD	ACT TONS	DOWN	UP	DOWN	UP	TOTAL	ORE	COL	STN	GRN	OTB	GCO	TOT	DELAY	PROC
1978	59.0	5852	3982	61704	1550	1579	5081	5085	13295	6.4	5.8	7.0	5.9	5.5	5.5	5.8	2.3	2979
***** NONSTRUCTURAL MAXIMUM UTILITY *****																		
1980	53.0	6282	4245	66761	1139	1160	3888	3891	10078	6.3	5.4	7.0	6.0	5.5	5.6	5.9	1.6	2703
**** CAPACITY WAS INCREASED BY BUILDING LARGER LOCKS ****																		
1982	31.0	5699	3895	71817	298	298	1201	1201	2998	6.9	6.4	7.0	6.7	5.6	5.9	6.3	.5	1601
1984	32.0	5765	3930	76871	345	347	1391	1392	3475	7.1	6.4	7.0	6.9	5.6	6.1	6.5	.6	1685
1985	33.0	5829	3971	79402	367	367	1481	1483	3698	7.1	6.7	7.0	7.0	5.7	6.1	6.5	.6	1731
1986	34.0	5865	4004	81782	391	391	1578	1580	3940	7.2	6.7	7.0	7.1	5.7	6.2	6.6	.7	1777
1988	36.0	5960	4061	86540	445	445	1794	1797	4481	7.3	6.7	7.0	7.4	5.7	6.3	6.7	.8	1873
1990	38.0	6056	4112	91305	511	511	2057	2058	5137	7.5	7.5	7.0	7.6	5.7	6.4	6.9	.8	1975
1992	39.0	6211	4220	95317	577	577	2320	2319	5793	7.6	7.5	7.0	7.7	5.7	6.4	6.9	.9	2056
1994	41.0	6369	4343	99342	650	651	2612	2616	6529	7.7	7.5	7.0	7.8	5.7	6.4	7.0	1.0	2148
1996	43.0	6502	4439	103361	728	728	2926	2929	7311	7.8	7.9	7.0	7.8	5.7	6.4	7.0	1.1	2244
1998	45.0	6645	4545	107381	811	813	3270	3271	8165	8.0	7.9	7.0	7.9	5.7	6.4	7.0	1.2	2346
2000	46.0	6831	4655	111399	910	910	3646	3648	9114	8.0	7.9	7.0	8.0	5.7	6.5	7.1	1.3	2434
2002	47.0	6831	4692	113840	980	980	3923	3924	9807	8.1	7.9	7.0	8.1	5.7	6.5	7.1	1.4	2487
2004	48.0	6879	4739	116280	1038	1038	4155	4157	10388	8.2	7.9	7.0	8.2	5.6	6.5	7.1	1.5	2540
2006	49.0	6927	4785	118715	1101	1101	4415	4416	11033	8.3	7.9	7.0	8.3	5.6	6.5	7.2	1.6	2597
2008	51.0	6968	4824	121155	1179	1179	4726	4726	11810	8.3	7.9	7.0	8.4	5.6	6.5	7.2	1.7	2657
2010	52.0	7022	4858	123596	1251	1252	5014	5017	12534	8.4	8.1	7.0	8.5	5.6	6.6	7.2	1.8	2717
2012	53.0	7119	4945	126280	1357	1357	5435	5435	13584	8.4	8.1	7.0	8.5	5.6	6.6	7.2	1.9	2791
2014	55.0	7250	5046	128961	1481	1481	5936	5937	14835	8.5	8.3	7.0	8.6	5.6	6.6	7.2	2.0	2865
2016	56.0	7358	5124	131640	1616	1616	6475	6477	16184	8.5	8.3	7.0	8.6	5.6	6.6	7.3	2.2	2943
2018	58.0	7474	5213	134321	1772	1771	7097	7098	17738	8.6	8.3	7.0	8.7	5.6	6.6	7.3	2.4	3026
2020	59.0	7555	5305	137003	1926	1926	7709	7710	19271	8.6	8.3	7.0	8.7	5.6	6.6	7.3	2.6	3109
2022	61.0	7679	5378	140115	2119	2120	8487	8488	21214	8.8	8.3	7.0	8.8	5.6	6.6	7.3	2.8	3194
2024	63.0	7745	5435	143239	2320	2319	9282	9281	23202	8.8	8.3	7.0	8.9	5.5	6.6	7.3	3.0	3293
2026	64.0	7824	5503	146359	2577	2577	10316	10320	25790	9.0	8.3	7.0	9.0	5.5	6.6	7.3	3.3	3367
2028	66.0	7907	5577	149479	2835	2834	11346	11344	28359	9.1	8.5	7.0	9.1	5.5	6.6	7.3	3.6	3463
2030	68.0	8022	5635	152596	3167	3167	12678	12678	31690	9.2	8.5	6.5	9.2	5.5	6.6	7.4	4.0	3565
2032	71.0	8185	5772	156020	3649	3648	14600	14598	36495	9.2	8.5	6.5	9.2	5.5	6.6	7.4	4.5	3699
2034	73.0	8373	5905	159440	4253	4254	17023	17026	42556	9.2	8.5	6.5	9.2	5.5	6.6	7.3	5.1	3833
2036	76.0	8560	6040	162857	5002	5002	20013	20012	50029	9.2	8.5	6.5	9.2	5.5	6.6	7.3	5.8	3964
2038	79.0	8727	6151	166283	5924	5923	23685	23686	59218	9.3	8.5	6.5	9.2	5.5	6.6	7.3	6.8	4109
2040	81.0	8958	6292	169338	6988	6964	27954	27852	69758	9.3	8.5	6.5	9.2	5.5	6.6	7.3	7.8	4236

* Lock service times for Class 4 - Class 7 vessels have been reduced by 30 percent. Class 8 - Class 10 service times not changed. A portion of the total delay hours must be increased for comparability with other plans.

SUPPLEMENT 4

SENSITIVITY TESTS

There were several sensitivity tests that were performed on the lock capacity model data inputs to test the relative effects of changes in these parameters to the resultant output of the analyses being performed. These tests were limited because of available time and the large number of capacity runs made for the analyses presented earlier in this appendix. All sensitivity tests were made for the low traffic at 90 percent lock utilization. Certain definable data inputs were set up as variables in the lock capacity model. In addition to those presented earlier, three additional areas were looked at in a preliminary fashion. These parameters were: length of navigation season, the percentage of nonstructural improvement, and low-normal-high lock cycle times.

The sensitivity of the length of navigation season was tested at the Welland Canal for 9 and 10-month seasons. The scenario used was for the low traffic forecast, a Class X vessel operating at current draft, and a 10 percent nonstructural improvement. The comparison of results is shown on Figure 4-1. The results of this test are as follows: the initial capacity date is deferred by 2 years (from 1982 to 1984); the secondary capacity date (after nonstructural improvements) is extended by 7 years (an 8-year extension vs. a 15-year extension); and the tertiary capacity date only results in a 2-year extension. It appears that the intermediate capacity dates can be effectively pushed back by implementation of "full" season extension at the Welland. This does "buy some time" in the event new locks are not constructed in time to handle increasing traffic. However, it does not appear that this parameter has any significant overall effect on the final capacity date. For this reason, the length of navigation season in itself was not considered to be a significant capacity-expansion measure. However, season extension in combination with other capacity-expansion measures may have a significant near-term effect on capacity. No benefit-cost calculations were performed for this scenario.

The second sensitivity test was performed to determine the effect on capacity model results when an alternate level of nonstructural improvement is assumed to be implemented. For all runs at the Welland Canal, a 10 percent factor was assumed (this percent improvement was informally obtained from the Canadians). As a sensitivity test, this factor was reduced to 5 percent to determine the affect on capacity dates. Figure 4-2, "Sensitivity Test - Percent Nonstructural Improvement" provides the comparative test results. It appears from the results shown that such a reduction could cause a significant change in the productivity of a nonstructural improvement. Cutting the nonstructural improvement factor in half reduced the years of nonstructural productivity from 8 to 2 years. This would appear to be a significant reduction, especially in light of the confidence limits associated with the percent of nonstructural improvement attainable. In defense of the results, it should be noted that the traffic forecast up to 1985 has a higher annual growth rate than the period 1985-2000. This fact favors the results of the test run using the 10 percent factor. It appears that a reduction in the assumed percent of nonstructural improvement could have a significant effect on the benefit-cost ratio for this scenario. The costs and benefits are moved up in time, and the proposed alternative is more productive because the benefits do not occur as far out in the future. No benefit/cost analysis was performed for this scenario.

The third sensitivity test involved the low-normal-high lock cycle times for initial capacity at the existing locks. For this test, three runs were made with the lock cycle time being the only factor changed. The three runs produced no changes in the initial capacity dates obtained for the given alternative. Therefore, this parameter was assumed to have no significant effect on the results as applied to this study (no results are illustrated), and was given no further consideration.

In summary, it has been shown that certain data input parameters in the capacity model can have a significant impact upon lock capacity in that they can significantly alter the capacity dates of various plans. Length of season and percent nonstructural improvement were determined to be significant parameters and will require further study in Stage 3 analyses to determine their effect on benefit-cost relationships.

FIGURE 4-1 SENSITIVITY TEST: Length of Season (Welland Canal)

9 MONTH SEASON

***** GL/SLS LOCK CAPACITY MODEL *****
***** WELLAND CANAL *****

**** SEASON EXTENSION (1) LOCKING TIME NORM*

**** TRAFFIC FORECAST LOW ****
**** NON-STRUCTURAL 1?% ****
**** STRUCTURAL 1200 X 115 LK X 25.5 D *

YEAR	LK UTIL	TRANSITS TOT	TRANSITS LOD	ACT TONS	CON-DELAY DOWN	CON-DELAY UP	UNCON-DELAY DOWN	UNCON-DELAY UP	TOTAL
1978	73.0	6872	4347	67990	5985	7058	12510	12734	38287
1980	86.0	7095	4550	71630	8664	10729	15326	15695	50464
1982	90.0	7292	4765	75113	13193	15545	18601	19139	66478
					***** NONSTRUCTURAL MAXIMUM UTILITY				
1984	81.0	7511	4918	78915	5740	6416	11869	12965	36310
1985	84.0	7493	5006	80735	6627	7958	13166	13409	41600
1986	85.0	7473	5002	81520	7251	8530	13596	13848	43219
1988	87.0	7719	4979	83077	8186	9726	14802	14683	46947
1990	82.0	7799	4960	88683	9408	11331	15395	15698	51832
1992	90.0	7869	5038	85941	11096	13779	16681	17021	58577
					**** CAPACITY WAS INCREASED BY BUILDING LARGE				
1994	40.0	6763	4363	87280	1973	1999	4859	4865	13696
1996	41.0	6707	4359	88576	2036	2062	4954	4968	14016
1998	41.0	6743	4364	89905	2104	2129	5044	5071	14369
2000	42.0	6715	4358	91239	2147	2191	5159	5166	14683
2002	43.0	6735	4371	93208	2270	2295	5329	5333	15227
2004	43.0	6793	4430	95193	2412	2432	5572	5595	16013
2006	45.0	6822	4465	97171	2533	2560	5767	5777	16637
2008	46.0	6848	4491	99144	2714	2736	6073	6078	17597
2010	47.0	6871	4529	101105	2831	2858	6241	6248	18178
2012	48.0	6948	4538	102556	2986	3069	6492	6494	18979
2014	48.0	6945	4557	103974	3196	3176	6762	6767	19851
2016	49.0	6973	4567	105387	3351	3384	7108	7116	20959
2018	70.0	7016	4545	106813	3529	3562	7381	7367	21858
2020	71.0	7052	4609	108235	3711	3749	7655	7662	22777
2022	73.0	7068	4640	111132	4026	4067	8014	8019	24126
2024	74.0	7678	4665	114034	4389	4441	8620	8632	25682
2026	75.0	7278	4712	116952	4791	4849	8692	8850	27332
2028	77.0	7597	4760	119561	5201	5265	9207	9215	28888
2030	79.0	7109	4817	122744	5733	5814	9712	9723	30982
2032	82.0	7291	4958	125782	7179	7269	11826	11829	37323
2034	85.0	7478	5069	128492	9191	9363	13452	13965	45971
2036	89.0	7454	5177	131414	12836	13143	16513	16524	59018
2038	95.0	7862	5327	134049	17223	17313	20462	20359	75328

10 MONTH SEASON

***** GL/SLS LOCK CAPACITY M *****
***** WELLAND CANAL *

**** SEASON EXTENSION (2) LOCKING TIME NORM*
**** 90% LOCK UTILIZATION ****
**** TRAFFIC FORECAST LOW ****
**** NON-STRUCTURAL 10% ****
**** STRUCTURAL 1200 X 115 LK X 25.5 D ****

YEAR	LK UTIL	TRANSITS TOT	TRANSITS LOD	ACT TONS	CON-DELAY DOWN	CON-DELAY UP	UNCON-DELAY DOWN	UNCON-DELAY UP	TOTAL
1978	77.0	6765	4287	67987	4335	4958	10038	10231	29562
1980	82.0	7007	4481	71628	5873	6879	12218	12466	37436
1982	87.0	7233	4690	75279	8268	10092	14882	15195	48435
1984	90.0	7441	4869	78815	11976	14602	17691	18221	62490
					***** NONSTRUCTURAL MAXIMUM UTILITY				
1985	78.0	7591	4957	80733	4826	5479	10592	10806	31703
1986	79.0	7606	4959	81519	4940	5675	10795	11001	32470
1988	80.0	7654	4941	83042	5811	6154	11279	11505	34399
1990	81.0	7735	4935	84648	5986	6709	11817	12056	36468
1992	83.0	7828	5014	85966	6602	7604	12563	12922	39791
1994	85.0	7918	5078	87276	7486	8737	13625	13907	43755
1996	87.0	8020	5153	88594	8596	10205	14731	15038	48570
1998	89.0	8117	5223	89907	9959	12100	15895	16231	54185
2000	90.0	8194	5291	91179	11718	14306	17182	17569	60815
					**** CAPACITY WAS INCREASED BY BUILDING LARGE				
2002	59.0	6822	4431	93211	1859	1884	4505	4528	12775
2004	60.0	6845	4459	95191	1903	1968	4644	4668	13223
2006	61.0	6869	4489	97177	2053	2079	4845	4867	13844
2008	62.0	6903	4525	99153	2167	2194	5045	5067	14473
2010	62.0	6928	4575	101146	2282	2309	5233	5256	15080
2012	63.0	6968	4572	102556	2399	2426	5446	5468	15739
2014	64.0	7017	4605	103970	2512	2539	5642	5665	16358
2016	65.0	7047	4615	105391	2635	2663	5850	5871	17019
2018	66.0	7074	4625	106811	2773	2804	6091	6113	17781
2020	67.0	7101	4605	108217	2889	2918	6271	6288	18366
2022	68.0	7108	4670	111128	3110	3143	6547	6567	19367
2024	69.0	7102	4698	114035	3350	3389	6839	6862	20439
2026	70.0	7082	4709	116949	3568	3609	7051	7069	21297
2028	72.0	7083	4743	119853	3951	3898	7359	7382	22490
2030	75.0	7096	4786	122767	4162	4214	7679	7700	23754
2032	76.0	7274	4917	125784	4994	5060	8848	8871	27773
2034	79.0	7454	5051	128796	6081	6168	10248	10267	32764
2036	83.0	7683	5180	131817	7697	7826	12121	12145	39789
2038	87.0	7829	5305	134839	10323	10534	14760	14785	50402
2040	90.0	8084	5446	137844	14887	14875	17914	17955	65231

FIGURE 4-2 SENSITIVITY TEST: Percent Nonstructural Improvement (Welland Canal)

5% Nonstructural

***** GL/SLS LOCK CAPACITY MODEL *****
***** WELLAND CANAL *****

**** SEASON EXTENSION 1 LOCKING TIME MODE

**** TRAFFIC FORECAST LOW ****
**** NON-STRUCTURAL 5% ****
**** STRUCTURAL 1200 × 115 × 25.5 ****

YEAR	LK UTIL	TRANSITS TOT	TRANSITS LDD	ACT TONS	CON-DELAY DOWN	CON-DELAY UP	UNCON-DELAY DOWN	UNCON-DELAY UP	TOTAL
1978	[illegible]	6672	4547	[illegible]	5985	7058	12510	12754	[illegible]
1980	88.0	7005	4550	71040	8004	10729	[illegible]	15205	50164
1982	90.0	7292	4745	75115	[illegible]	15545	[illegible]	19130	66478
***** NONSTRUCTURAL MAXIMUM UTILITY									
1984	90.0	7523	4817	[illegible]	[illegible]	12705	[illegible]	10732	[illegible]
**** CAPACITY WAS INCREASED BY BUILDING LARGE									
1985	[illegible]	6625	4327	80733	2165	2217	5446	5449	15[illegible]7
1986	62.0	6601	4299	81517	2185	2215	5407	5416	15[illegible]
1988	62.0	6526	4231	83073	2155	2186	5203	5271	14875
1990	62.0	64[illegible]8	4157	84018	2171	2201	5258	[illegible]	14[illegible]
1992	63.0	[illegible]	4156	[illegible]	2245	2275	5347	5355	15022
1994	63.0	6448	4188	87[illegible]	[illegible]	2317	5396	[illegible]	15382
1996	64.0	6468	4197	88[illegible]7	2377	2408	5504	5546	15[illegible]
1998	64.[illegible]	64[illegible]	4206	[illegible]04	2468	2500	5671	5690	16[illegible]
2000	65.0	64[illegible]	4205	[illegible]	2545	2578	5791	5800	16717
2002	66.0	64[illegible]7	4221	[illegible]	27[illegible]	2714	[illegible]	6076	17000
2004	67.0	6516	4250	95193	2878	[illegible]	6321	6343	18404
2006	[illegible]	[illegible]	4297	97108	3102	[illegible]	6702	6710	19[illegible]51
2008	[illegible]	[illegible]	4342	[illegible]	[illegible]	3347	70[illegible]	7029	20707
2010	71.0	66[illegible]4	4385	101145	[illegible]	3585	7290	[illegible]	21[illegible]10
2012	72.0	[illegible]	4406	102[illegible]7	3727	[illegible]	7741	[illegible]	23[illegible]01
2014	73.0	67[illegible]	4437	10[illegible]	4027	4071	[illegible]	[illegible]	24[illegible]47
2016	74.0	670[illegible]	4444	10[illegible]	4225	4[illegible]	8504	8513	[illegible]
2018	75.0	6725	4450	100[illegible]05	[illegible]	4617	8888	[illegible]	[illegible]
2020	76.0	[illegible]	4477	10[illegible]	[illegible]13	4973	[illegible]	9404	[illegible]
2022	78.0	[illegible]	45[illegible]9	111127	[illegible]	[illegible]	[illegible]	9978	30[illegible]25
2024	80.0	[illegible]	[illegible]	114[illegible]	[illegible]	[illegible]	10[illegible]	10[illegible]	[illegible]
2026	82.0	[illegible]	46[illegible]	116[illegible]1	7008	7176	11644	11652	37540
2028	84.0	70[illegible]	4767	119[illegible]	[illegible]	[illegible]	125[illegible]	[illegible]	41374
2030	86.0	70[illegible]	4767	122[illegible]	9415	[illegible]	13579	13587	46[illegible]
2032	90.0	7[illegible]	4807	125779	13165	[illegible]	16542	16547	59751

10% Nonstructural

***** GL/SLS LOCK CAPACITY MODEL *****
***** WELLAND CANAL *****

**** SEASON EXTENSION 1 LOCKING TIME MODE

**** TRAFFIC FORECAST LOW ****
**** NON-STRUCTURAL 10% ****
**** STRUCTURAL 1200 × 115 × 25.5 ****

YEAR	LK UTIL	TRANSITS TOT	TRANSITS LDD	ACT TONS	CON-DELAY DOWN	CON-DELAY UP	UNCON-DELAY DOWN	UNCON-DELAY UP	TOTAL
[illegible]	[illegible]	[illegible]72	[illegible]	[illegible]	59[illegible]5	7058	12510	127[illegible]	[illegible]
[illegible]	[illegible]	7095	4550	71040	[illegible]	10729	15[illegible]	15[illegible]	[illegible]
[illegible]	[illegible]	7[illegible]	4745	75113	131[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
***** NONSTRUCTURAL MAXIMUM UTILITY									
[illegible]	[illegible]	7511	4916	7[illegible]015	[illegible]	[illegible]	11[illegible]	12[illegible]	36[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	80735	[illegible]27	7[illegible]8	[illegible]	[illegible]	414[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	81[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	87.0	7718	4[illegible]	8[illegible]077	8166	9726	14402	14[illegible]	40[illegible]7
[illegible]	8[illegible].0	7784	[illegible]	84[illegible]	[illegible]	11521	15[illegible]	150[illegible]8	51[illegible]2
[illegible]	[illegible]	79[illegible]	50[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	170[illegible]1	[illegible]577
**** CAPACITY WAS INCREASED BY BUILDING LARGE									
[illegible]	[illegible]	[illegible]	[illegible]	87[illegible]90	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	61.0	67[illegible]7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	11016
[illegible]	61.0	6743	[illegible]	[illegible]	2104	21[illegible]	50[illegible]	5071	14[illegible]
[illegible]	62.0	6715	[illegible]	91[illegible]	2167	2191	5159	5166	140[illegible]
[illegible]	[illegible]	6705	[illegible]71	[illegible]	2270	[illegible]	[illegible]	[illegible]	15[illegible]
[illegible]	64.0	67[illegible]	44[illegible]	95193	24[illegible]	[illegible]	5577	5585	16[illegible]
[illegible]	65.0	[illegible]	[illegible]	97171	[illegible]	[illegible]	5767	5777	[illegible]
[illegible]	[illegible]	6846	44[illegible]	[illegible]	[illegible]10	[illegible]	6073	[illegible]	175[illegible]7
2010	67.0	6871	45[illegible]	101145	[illegible]	[illegible]	[illegible]	6248	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	10[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	10[illegible]	[illegible]	[illegible]	[illegible]	[illegible]7	[illegible]
[illegible]	[illegible]	6973	[illegible]	10[illegible]87	[illegible]	[illegible]	71[illegible]	7116	[illegible]
[illegible]	70.0	7016	[illegible]	10[illegible]13	[illegible]	[illegible]	7[illegible]81	[illegible]	[illegible]
[illegible]	71.0	7032	[illegible]	10[illegible]33	3711	3740	[illegible]	[illegible]	[illegible]777
[illegible]	[illegible]	7060	[illegible]	1111[illegible]	[illegible]	4067	8014	[illegible]	241[illegible]
[illegible]	74.0	7078	[illegible]	11[illegible]	[illegible]	4411	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	7078	4712	11[illegible]	47[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	77.0	[illegible]	47[illegible]	11[illegible]	[illegible]01	[illegible]	[illegible]	[illegible]15	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	1[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	7[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	7474	[illegible]	12[illegible]02	9191	[illegible]	[illegible]	[illegible]	45471
[illegible]	[illegible]	7676	51[illegible]	131814	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	7802	[illegible]	[illegible]	17[illegible]	17313	[illegible]	[illegible]	[illegible]

APPENDIX C

GEOTECHNICAL

INTRODUCTION

This Appendix contains the detailed geotechnical data used in this study. The geotechnical data it contains was developed specifically for use in the present phase of this study. The data was gathered under contract and reproduced here is the final contract submittal.

ST. LAWRENCE SEAWAY
ADDITIONAL LOCKS STUDY

GEOTECHNICAL REPORT

DEPARTMENT OF THE ARMY
BUFFALO DISTRICT, CORPS OF ENGINEERS
BUFFALO, NEW YORK

MARCH 1981

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PREFACE

The geotechnical report was prepared by Tippetts-Abbett-McCarthy-Stratton, (TAMS) Engineers, Architects and Planners, under contract No. DACW49-80-C-0002, Work Order No. 1 for the U. S. Army Engineer District, Buffalo.

For the preparation of this report, the Buffalo District furnished in preliminary rough draft form a number of the plates and figures, the laboratory test results, geophysical surveys, drilling logs and pressure test data.

Mr. Thomas Bobal of TAMS prepared the report under the guidance of Mr. Harvey Feldman, Project Study Manager. Mr. Mel Hill, Project Manager for the Corps, reviewed the work by TAMS under the supervision of Mr. T. A. Wilkinson, Chief, Geotechnical Section. All Corps work was under the direction of Mr. J. A. Foley, Chief, Design Branch and Mr. Donald M. Liddell, Chief, Engineering Division. Lt Col. Thomas L. Braun, Deputy District Engineer, was the Contracting Officer.

1. INTRODUCTION

The purpose of this report is to present geotechnical data to assist in the selection of future additional lock and channel locations at four proposed alternative sites along a section of the St. Lawrence Seaway. The proposed alternatives include: "Twin" locks at the existing Eisenhower and Snell Locks, a single High-Lift lock with the construction of a new channel, and an additional lock near Iroquois Dam at Point Rockway with construction of a new channel. All the proposed alternative sites are located within the territory of the United States along the St. Lawrence Seaway stretching from near Iroquois Dam downstream to the eastern tip of Cornwall Island near Cornwall, Ontario. Three of the sites, Eisenhower and Snell "Twins" and the High-Lift are located at the eastern end of the area, northeast of Massena, New York (See Plate 1) and the fourth site, Iroquois-Point Rockway, at the western end near Waddington, New York.

The report presents data from a review of literature and previously submitted reports, includes subsurface and geophysical exploration data, observations arrived at from on-site reconnaissance and discussions with individuals familiar with the areas in question, examination of existing rock core samples previously taken at some of the proposed sites, summaries of field and laboratory testing and geologic profiles and sections based on data from previous subsurface exploration programs.

Substantial geotechnical data was obtained from investigations conducted for the existing Eisenhower and Snell Locks. A large portion of this data was obtained at locations which are in the areas of the proposed Eisenhower and Snell "Twin" Locks. Data regarding subsurface conditions for the Iroquois-Point Rockway and the High-Lift sites are very limited and sketchy.

2. REGIONAL GEOLOGY

2.1 Physiography

The project area under consideration is located in the St. Lawrence Lowland, which forms the northern section of the St. Lawrence Valley physiographic province. The lowland is a broad area, less than 1,000 feet in altitude, bordered on the north by the Laurentian plateau and on the south by the uplands of the Adirondack province, where elevations average between 1,000 and 2,000 feet.

On the basis of the varying topography found to the south of the international boundary, the St. Lawrence Lowland can be subdivided into seven fairly distinct subsections (Figure 1). Most of the southwestern half of the lowland, including the Western Tableland, Frontenac Axis, and Black Lake Tableland Subsections, is characterized by: 1) the rare occurrence and small bulk of the till deposits; 2) the large areas of exposed bedrock; 3) the close relationship of the surface topography to bedrock structure; and 4) the predominance of lacustrine sediments which lie directly on the bedrock.

By contrast, the northeastern half of the lowland - roughly that area northeast of a line connecting Ogdensburg and

Canton - has widespread deposits of till with only rare exposures of bedrock. Surface topography is controlled by the glacial deposits rather than the bedrock.

For the most part, the area is underlain by flat to gently dipping Paleozoic sediments, the erosion of which has formed the lowlands. The region underwent peneplaination during the Tertiary, followed by uplift and degradation of the softer rocks to flat-bottomed lowland. Over this late Tertiary erosion surface, the Pleistocene glaciers spread their deposits.

A gently rolling surface of low relief characterizes most of the area. Elevations range from around 150 feet in the northeast near Cornwall to more than 500 feet on some hilltops near Potsdam and Norfolk. The average relief over distances of a mile or less is about 30 feet.

Drainage of the area is controlled by the St. Lawrence River. It flows northeastward 270 miles from Lake Ontario to Quebec and another 370 miles from Quebec to Anticosti Island in the Gulf of St. Lawrence.

The St. Lawrence River has only occupied its present location since the retreat of the last Wisconsin glacier and the recession of the Champlain Sea, some 5,000-6,000 years ago. It has, therefore, not had enough time to cut a valley for itself, but simply follows a connecting chain of glacially-formed depressions, flowing around and among the small bedrock hills at its western end and the hills of glacial till farther east. Consequently, it is ungraded and, prior to construction of the St. Lawrence Seaway, was studded with the now-submerged Galop and Long Sault Rapids.

Due to the regulating effect of Lake Ontario on the surface water discharge, the river is not subject to extreme floods and low water as are normal rivers. By eroding fine material which its normal flow can handle, it has left behind coarser material which acts as an armor protecting the banks from further erosion. Because of this, the St. Lawrence has accomplished relatively little erosion for so large a river.

The three major tributaries to the St. Lawrence from the south - the Grass, Raquette and St. Regis Rivers - also follow valleys made for them by the pattern of glacial deposits. All flow northward off of the Adirondack highlands and then turn eastward upon approaching the St. Lawrence trough to follow the elongate depressions between morainal ridges for several miles before joining the main stream. Many smaller streams flow into these rivers or directly into the St. Lawrence and show a great deal of seasonal fluctuation in discharge. Extensive marshlands are found throughout the area but there are few natural lakes.

2.2 Surficial Geology

The bedrock in the northeastern half of the St. Lawrence Lowland is overlain by a blanket of glacial drift which varies in thickness up to more than 200 feet in places. These unconsolidated deposits were laid down in late Pleistocene time during and after the Wisconsin glaciation. The deposits comprise: (1) till laid down by the glacial ice; (2) clay and other materials deposited in standing bodies of water during and after melting back of the ice; (3) deposits formed by the modification of the till and other sediments; and (4) materials laid down after the large bodies of standing water had been drained. The most complete sequence of these deposits can be seen near Lake St. Lawrence.

On the basis of till fabric and the striations found on underlying rock surfaces, two separate glacial episodes can be identified. The earlier one, the Malone glaciation, moved southwest up the St. Lawrence valley and then spread over the Adirondacks. The Malone has been correlated with the Cary sub-stage of the Wisconsin standard section in the midwestern United States. The later Fort Covington invasion crossed the valley from northwest to southeast and extended only as far as the northern flank of the Adirondack upland. It has been correlated with the Valders substage, the final Wisconsin advance.

With the retreat of the Fort Covington glacier and the formation of an ice barrier in the lower St. Lawrence valley, a fresh-water proglacial lake (Lake Fort Ann) was created covering most of the area. A break in the ice barrier drained the lake, and the subsequent eustatic rise of sea level (due to the inflow of meltwaters from the retreating glaciers) permitted flooding of the lowland by marine waters of the Champlain Sea. The earth's crust, which had been deformed under the enormous weight of the glaciers, gradually began to rebound. The isostatic rise of the land was more rapid than the eustatic rise in sea level, causing the Champlain Sea to recede. This uplift of the land is still occurring to this day.

Three layers of till can be distinguished in the area: the Lower and Middle tills of the Malone episode, and the Upper till of the Fort Covington. The Lower till was deposited over the dolomitic bedrock during the first advance of the Malone glacier from the northeast. It consists of blue-gray, unstratified, mixed deposits of clay, silt, sand and stones. This till, especially that portion immediately overlying bedrock, contains most of the dense, tough basal (lodgement) till that caused difficulties in excavations for the St. Lawrence Seaway. The Lower till is commonly 10-40 feet thick and is widely found in the subsurface in the vicinity of Lake St. Lawrence and probably present throughout the area.

With the recession of the ice front and the formation of a proglacial lake, varved clays and interbedded silt, sand and gravel were deposited on top of the Lower till.

Another glacial advance from the northeast led to the deposition of the Middle till. This till does not differ markedly from the Lower till except in being weathered in some places. It is brown to blue-gray in color and moderately to very dense. It consists of mixed deposits of clay, silt, sand and stones, and although unstratified, it is interbedded in part with the underlying lake deposits. The relationship between the Middle till and zones of stratified drift and sediments is very complex and varies throughout the area. Water-bearing sandy and silty deposits in the till have been found in many hills.

The Lower and Upper tills have been readily distinguished in the walls of several open excavations because of the presence of permeable materials, from which ground water seeped, at the top and bottom of the Middle till.

The recession of the Malone glacier and formation of a proglacial lake again allowed the deposition of varved clays and interbedded silt, sand and gravel.

The Fort Covington glacier, advancing now from the northwest, deposited the Upper till. It is similarly an unstratified, mixed deposit of clay, silt, sand and stones; brown to blue-gray in color; and moderately dense and compact. Commonly 20-60 feet thick, it underlies most of the area and is locally mantled by outwash gravel and sand.

With the recession of the Fort Covington ice and the formation of Lake Fort Ann, varved clays were again laid down along with mixed (slumped) deposits of silt, sand, and gravel containing enclosed masses of till.

Continued recession of the ice front and the subsequent invasion of salt-water brought about formation of the Champlain Sea. In this marine environment were deposited post-glacial marine clays in the lowland areas carved out by the previous glaciation. The clay is blue-gray, extremely sensitive, soft and sticky and contains marine shells and inclusions of plant material. It is commonly 30-60 feet thick. Some thin nearly horizontal lenses of stratified sands and silts are found locally, particularly in areas adjacent to till deposits.

As the Champlain Sea receded, a blanket of marine sand, some 1-10 feet thick, was laid down on the underlying marine clay in the lowlands. Sand and gravel, in the form of beach deposits and deposits of reworked, or winnowed, till, were formed on the tops and sides of many till ridges.

The continued uplift of the land brought about the development of the channels of the St. Lawrence River and its tributaries by the erosion of the glacial and post-glacial deposits. This process is still occurring and deposits of gravel, sand, silt and clay are being formed in and beside stream channels throughout the area. Locally, in poorly drained areas, peat is being formed.

2.3 Bedrock Geology

The only large expanses of exposed bedrock in the St. Lawrence Lowland occur in the southwestern half of the area. Northeast of the Ogdensburg-Canton line the bedrock is covered nearly everywhere by glacial drift and outcrops appear only locally in stream beds and at a few other places. Much valuable information on the bedrock stratigraphy was obtained during exploratory work and excavations made for the St. Lawrence Seaway project.

The lowland is underlain predominantly by flat-lying or gently dipping lower Paleozoic sedimentary rocks (see Plate 2).

These rocks of chiefly Cambrian and Ordovician age overlie a basement complex of Precambrian crystalline rocks. Major unconformities separate the Precambrian from the Paleozoic rocks and the Paleozoic rocks from the Pleistocene glacial drift.

2.3.1 Precambrian Rocks

The basement consists of a complex series of intensely folded, highly metamorphosed sedimentary rocks (limestones, quartzites, schists and gneisses) into which were intruded various types of igneous rocks. This late Precambrian formation is referred to as the Grenville Series. The nearest exposure of the basement rocks in the Lake St. Lawrence area is a reddish granite gneiss which outcrops some 5 miles west of Potsdam. Several deep water wells in the southern part of the area are reported to have penetrated crystalline rock but no details are given in the well records as to the rock structure. A deep test hole drilled in 1900 at Massena reportedly penetrated granite after passing through 500 feet of limestone and several hundred feet of yellow, red and white sandstone.

2.3.2 Paleozoic Rocks

Nearly the entire lowland is underlain by lower Paleozoic sedimentary rocks, chiefly dolomite with subordinate limestone and sandstone. Ordovician dolomite and limestone underlie most of the area in the north and northwest. A broad band of Cambrian or Ordovician sandstone, with some interbedded dolomite, borders the dolomite on the southeast and south. Although outcrops are rare, the gross lithologic character of the rocks is fairly well known from the hundreds of wells which penetrate them, but few detailed well records have been preserved. The thickest section known at a single place is at Massena where the previously mentioned deep test hole went through hundreds of feet of limestone and sandstone. An estimated thickness of 500-600 feet of Paleozoic rocks has been reported at Cornwall. All the Paleozoic strata were slightly deformed after early Ordovician time.

2.3.2.1 Potsdam Sandstone

The lowermost Paleozoic formation around the base of the Adirondacks is the Potsdam Sandstone, which is separated from the Precambrian basement by a major unconformity. Due to the very slow northward transgression of the shallow Cambrian Sea, the Potsdam ranges in age from Late Cambrian in central New York to Early Ordovician along the border of the Canadian Shield. It is named for outcrops around Potsdam, New York, but is not well exposed there. One of the best exposures in the near vicinity is along the St. Regis River at Brasher Falls. In some areas, the Potsdam is locally strongly folded, and is characterized by patchy distribution which suggests deposition on an irregular surface, later erosion, or both.

In its type locality, the Potsdam is a fine- to medium-grained quartz sandstone (essentially a quartzite) which is commonly pebbly at its base. Due to the presence of hematite as a cementing agent, the rock is typically reddish-brown in color, but beds of white sandstone and gray sandstone are also present. It is the hardest and most substantial and resistant of the sedimentary formations. The red sandstone was once used extensively in buildings and pavements in the village of Potsdam. The formation is about 200 feet thick in St. Lawrence County.

2.3.2.2 <u>Theresa Formation</u>

The Theresa Dolomite represents a series of transitional beds between the Potsdam Sandstone and the dolomitic rocks of the Beekmantown Group. It ranges from Late Cambrian to Early Ordovician in age. It has been arbitrarily separated from the Potsdam, where both formations are present, at the lowermost dolomite layer in the sequence. At its type locality north of Watertown in Jefferson County, the Theresa is about 300 feet thick. To the northeast, it is probably somewhat thinner and consists primarily of white, gray or brown sandstone, in part calcareous, with subordinate dolomite and shale. Included in the Theresa are the Heuvelton Sandstone (a bed of white sandstone some 20 feet thick) and the lower part of the Bucks Bridge mixed beds. The Bucks Bridge is sandy in the lower part and dolomitic in the upper part, and lies between the Heuvelton Sandstone and the Ogdensburg Dolomite. In many places the contact between the Theresa and rocks of Beekmantown Age is difficult to recognize and the relation between the rocks may be a gradational one.

2.3.2.3 <u>Beekmantown Group</u>

The Ordovician Beekmantown Group in this area c[illegible]

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the upper part of the Bucks Bridge mixed beds and the Ogdensburg Dolomite, which is essentially equivalent to Division D of the classic Beekmantown section in the Champlain Valley. The rocks are largely black dolomite and gray dolomite containing subordinate limestone, sandstone and shale. Pyrite is widely distributed through the rock as disseminated crystals. Gypsum is common, mostly in small veins and thin layers, but locally it has been found in beds 3 to 5 feet thick.

The Beekmantown represents the uppermost bedrock for a wide expanse from Massena to Ogdensburg and beyond in both directions. At Massena, the dolomite is 500 feet thick and may be even thicker near its contact with the rocks of the Chazy Group along the St. Lawrence River.

2.3.2.4 Chazy Group

A disconformity separates the Beekmantown from the overlying Chazy Group, which is also Ordovician in age. The contact between the two lies along the St. Lawrence River from north of Iroquois Lock to near Cornwall, Ontario. The two groups are quite similar in many respects, but the Chazy consists chiefly of limestone and sandstone with some dolomite and shale. The rock is light gray to almost black in color and approximately 80 feet thick near Long Sault Dam. The formation thickens northward into Canada.

2.3.2.5 Trenton and Black River Groups

The Chazy and the overlying undifferentiated Trenton and Black River Groups are separated by a minor disconformity. The

Trenton-Black River are of Ordovician age and are referred to in Canada as the Ottawa Formation. The rocks outcrop along the Canadian side of the St. Lawrence River west of Cornwall, and consist of gray limestones with some interbedded shale, sandstone and dolomite.

2.4 Structural Geology

The bedrock underlying this section of the St. Lawrence Lowland forms part of the southeast limb of a northeast trending basin, the greater part of which lies on the Canadian side of the river in Ontario and Quebec. The basin is about 100 miles long and some 70 miles wide, extending northwestward from the foothills of the Adirondacks to the Canadian Shield.

2.4.1 Folding

Where exposed, the Paleozoic rocks are found to be either flat-lying or else dipping at 5 degrees or less. In most exposures where the beds are not flat-lying, the strike of the bedding is northeast and the dip northwest; in a few places the beds strike northwest and dip northeast or southwest. In the Canton quadrangle, it has been found that the structure is characterized by folds which strike northeast and by irregular folds, including small domes, which trend in other directions. All indications suggest that in general the strata in this area dip gently northwestward in a homoclinal structure interrupted by tracts of flat-lying or gently folded rocks.

2.4.2 Faulting

Numerous faults have been mapped north of the St. Lawrence River, most of them in the northern part of the lowland near the edge of the Canadian Shield. The faults are of the tensional type and strike along two dominant trends, northeast or east and northwest. Near Ottawa the faults are known to have steep dips.

A major fault striking NW-SE is located on the Canadian side of the St. Lawrence River, northwest of Massena. If extended southeast, it would enter New York about 3 miles southwest of the Massena Power Canal. A well in this area contains highly mineralized water and natural gas, suggesting the presence of a fault trap.

Another fault zone some 200 feet wide was uncovered during excavation for Snell Lock (see Section 3.4.1).

2.4.3 Joints and Fractures

Inclined to near vertical jointing is common in all of the consolidated rocks in this area. Isostatic rebound after the retreat of the Pleistocene glaciers was a major factor in producing the jointing. Because of enlargement by solution, joints in the dolomite bedrock are the most conspicuous. From the examination of outcrops, however, it appears that the joints have not been widened appreciably below the uppermost foot of rock. Moreover, driller's reports indicate that at depth wide openings in the rock are relatively uncommon in most of the area. However, several borings, especially at Snell and Eisenhower Locks, have encountered openings at depths as great as 50 feet into bedrock. In these places the openings were probably formed by the solution of gypsum.

In a few places joints in exposed dolomite have been widened to form small sinkholes at the land surface. Extensive solution openings were probably developed in the dolomite throughout the area in the past, but the upper part of the rock, containing most of these openings, was then removed by glacial erosion.

Horizontal or gently dipping fractures, more or less parallel to the bedding of the dolomite, have been observed in quarry walls. They are wider and more numerous than steeply-dipping fractures. This is confirmed by well data which indicate that the horizontal permeability of the dolomite is commonly much greater than the vertical permeability.

Other types of openings of minor importance have been observed in the dolomite. These include cavities, up to an inch or more in diameter, which are either open or filled with calcite. However, no extensive inter-connections have been found.

2.4.4 Bedrock Surface

In general, the surface of the bedrock slopes northward. Its most prominent feature is a broad valley which trends northeast, passing beneath Madrid and Raymondville. A smaller valley underlies the peninsula separating the St. Lawrence and Grass Rivers near Snell and Eisenhower Locks. Land-surface topography in this area is controlled predominantly by glacial deposits and no consistent relationship exists between the configuration of the bedrock surface and that of the present land surface. Therefore, reliable estimates of the depth to bedrock cannot be made on the basis of land-surface topography alone.

2.5 Seismicity

The St. Lawrence Lowland is a region of relatively high seismic activity. On the Seismic Risk Map of the United States (Figure 2), the area has been given a Zone 3 classification. This means that major damage could occur due to seismic activity.

The historical record of earthquake occurrences has been traced back to 1534. Several shocks with intensities as high as IX and X (on the Modified Mercalli Scale of 1931) have been recorded on the Canadian side of the lowland. In New York, intensities in the range of IV-V are more common, and shocks greater than VIII have not been observed (Coffman and Von Hake, Ref. 5).

2.5.1 Massena-Cornwall Earthquake

The Massena-Cornwall earthquake of September 4, 1944 reached an intensity of VIII. It was estimated to have affected an area of some 175,000 square miles, from Maine to Michigan and as far south as Pennsylvania and Maryland. The epicenter was located near the small community of Massena Center, partway between the larger towns of Massena and Cornwall. Damage in the central area was about $2 million for the two towns. About 90 percent of the chimneys in Massena were destroyed or damaged, with similar damage at Cornwall. The effects of the shock were not distributed in a regular fashion throughout the general area. The greatest disturbance occurred where the surface was underlain by clay and silt; structures founded on rock or on till were not damaged appreciably. A report by Charles P. Berkey (Ref.2) presents a detailed account of the destructive effects of the earthquake. More recently, two earthquakes of intensity V struck Massena in 1961 and 1964.

2.5.2 Seismogenic Provinces

For a long time earthquakes in this region have been explained by the readjustment of the earth's crust, subsequent to the final retreat of the Pleistocene glaciers. It has been suggested that the ice load deformed the crust during the glacial periods, and now it is gradually coming back to its normal position. As the adjustments may occur deep within the earth, major surface faulting, which is rare in this region, need not be present.

Numerous attempts have been made to recognize trends in seismicity and relate them to regional geology or tectonics. One proposal defined a continuous seismic zone along the St. Lawrence River, possibly extending as far south as Arkansas. Another zone of seismicity transverse to the Appalachian trend extending from Boston to Ottawa has been suggested. An attempt to correlate earthquakes with mafic intrusives has also been put forward.

But recent work by Yang and Aggarawal (Ref. 18) on the seismicity of the northeastern U.S. finds no convincing evidence for these theories. Their study leads them to distinguish two distinct seismogenic provinces: (1) the Appalachian Province, a northeasterly trending zone of seismic activity extending from northern Virginia to New Brunswick, Canada; and (2) the Adirondack - Western Quebec Province.

The Adirondack - Western Quebec Province is a northwesterly trending zone, about 200 kilometers wide and at least 500 kilometers long, extending from the Southeast Adirondacks into Western Quebec, Canada. Thrust faulting on planes striking NNW to NW appears to predominate and the inferred axis of maximum horizontal compression is largely uniform and trends WSW, nearly parallel to the calculated absolute plate motion of North America. Little or no seismicity is found where anorthosite outcrops at the surface. The zone does not extend southeastwards to Boston as some have proposed.

Northeast of this province and separated from it by a relatively aseismic area, there is a distinct concentration of earthquake epicenters around La Malbaie, Quebec. The epicenters apparently trend parallel to the St. Lawrence River valley but most of the activity is concentrated in the so-called "Charlevoix zone". Similarly, to the southwest of the province, and not connected to it, there is a pattern of earthquake activity in western New York and western Lake Ontario which is suggestive of a WNW trend transverse to the Central Appalachian fold belt.

Some important conclusions from the Yang-Aggarwal study are:

(1) Seismic activity in the northeast is relatively stationary in space: those areas that have had little or no

seismicity historically are relatively aseismic today, whereas the historically active areas are also active today.

(2) No convincing evidence was found for a continuous zone of seismic activity parallel to the St. Lawrence River, nor for the existence of a Boston-Ottawa seismic zone transverse to the Appalachian trend.

(3) Earthquakes in the Adirondack - Western Quebec area apparently respond to a WSW directed maximum compressive stress related to the plate motion of North America.

(4) The presence of unfaulted igneous intrusives (plutons, batholiths, sills, etc.) apparently inhibits rather than facilitates the occurrence of earthquakes.

2.6 Ground Water

Trainer and Salvas (Ref. 9) carried out a detailed investigation of the ground-water conditions in the Massena-Waddington area of the St. Lawrence Lowland. Their findings hold true for most of the Oriented Till Ridges Subsection where the additional locks project is under study. The following is abstracted from their report.

2.6.1 Aquifers

The unconsolidated deposits lying between the major streams of the area form an unconfined aquifer in which till and sand are the chief water-bearing materials. Confined aquifers are also present but are apparently of small lateral extent; they include the washed drift interbedded with the till sheets and layers of sandy material in the till. All of these unconsolidated aquifers are of low to moderate permeability. Recharge is accomplished by water percolating from the land surface, and locally (immediately along the dikes), from Lake St. Lawrence. The aquifers discharge into the underlying bedrock and into marshes and streams.

The most dependable water supplies in the area, including all the large sources, are obtained from aquifers in the bedrock. The upper part of the bedrock forms a single, more or less continuous aquifer which is confined (artesian) in most places. One or more aquifers also occur at deeper levels in the rock. The bedrock aquifers are recharged by percolation from the overlying deposits in interstream areas and discharge into the major surface streams. Fractures (which appear to be primarily parallel to the bedding but which also include cross joints) are the most important openings and waterways in the bedrock. Intergrain porosity is of little or no consequence. Areal and vertical variations in the size and spacing of the rock openings, and the better development of horizontal openings than those which dip steeply, prevent the accurate prediction of well depths and yields. In general, transmissivity values of the dolomite range from 1,000 to 10,000 gallons per day per foot, but some values as high as 20,000 to 68,000 gpd per foot were determined for several wells.

2.6.2 Water Chemistry

"The ground water is of the calcium magnesium bicarbonate type. In the unconsolidated deposits, and in the upper part of the bedrock in recharge areas, the water is generally of good quality except for high hardness and ojectionable iron in some places. Water from deeper parts of the bedrock contains higher concentrations of dissolved solids and of chloride; in some places these concentrations exceed the maximum limits recommended by the U.S. Public Health Service. In many places this deeper water also contains hydrogen sulfide. Many water supplies from the deep bedrock aquifers are artificially softened, or have the hydrogen sulfide removed by aeration or by chlorination. This deeper, more mineralized water may be Champlain Sea water, older sea water (connate water) long trapped in the rocks, water which has been in contact with buried evaporite deposits, or a combination of such waters. The deeper water has been diluted and partly flushed from the rock by fresh water percolating from above, and at the depths commonly reached by wells in this area it is found most commonly along the rivers where the bedrock aquifers discharge. Two wells which tapped bedrock reservoirs that had previously been tightly sealed yielded highly mineralized water and natural gas. Fault traps are thought the most probable explanation of these reservoirs. The gas was in noncommercial quantities".

2.6.3 Ground Water Use

At present, ground water is being used "chiefly for domestic and farm supplies. Most of the older wells were dug wells drawing from the unconsolidated deposits; most of the newer ones are drilled wells which tap the bedrock. The wells are relatively widely spaced, and the use of water, even for village supplies, seems to have had little effect on the quantity of water available. None of the village supplies is treated except for the aeration of one to remove hydrogen sulfide".

2.6.4 Effect of Lake St. Lawrence

With the flooding of Lake St. Lawrence in 1958, water levels rose in those bedrock wells located between the lake and the Grass River. The areas most affected lay west of Eisenhower Lock, upstream to near Waddington. In some low areas artesian flow was produced where none had previously occurred. And in another area the direction of ground water flow was reversed. A more detailed discussion of the lake effects can be found in Trainer and Salvas (Ref. 9).

3. LOCAL GEOLOGY

3.1 Physiography

The proposed alternative lock sites at Iroquois, Eisenhower, Snell and High-Lift are located in the northeastern half of the St. Lawrence Lowland in the Oriented Till Ridges Subsection. The land is covered by a belt, about 18 miles wide, of low, elongate ridges of till rising from clay and sand-filled intervening lowlands. The mounds of till trend in a northeast-southwest direction and are elongated parallel to the St. Lawrence River. These ridges have been worn down by waves and currents of the post-glacial Champlain Sea. The fine-grained constituents of the till were winnowed out by wave action and washed into the lowlands. This left a coarse stony debris containing marine shells capping the crest of many of the hills. It has been estimated that the morainal topography has been lowered 20 feet or more by this wave-wash and the intervening lowland raised a commensurate amount.

3.1.1 Vicinity, Snell "Twin" Alternative

The Snell alternative site is located in a flat area underlain by marine clay along the left bank of the Grass River near where that stream empties into the St. Lawrence River. It lies a short distance beyond the northeast end of a gently sloping, NE-SW trending till ridge which rises to El 250 some 3,000 feet to the southwest. Before the construction of Snell Lock, a small tributary of the Grass River flowed along the south side of the lock excavation area between the lock site and the edge of the ridge. The topography in the general area prior to construction was nearly flat, with a relief of 25 to 30 feet. The Grass River varies at about El 157 and the small tributary was about El 160. The top of the bank above the Grass River was El 175, and the land surface in the lock area was mostly between Els 180 and 185. The topography north and south of the present lock has been somewhat altered by the construction of dikes; the placement of backfill behind the lock walls; and the construction of spoil piles. The roadway on top of the dikes is about El 207; backfill behind the lock walls was placed to El 205; and spoil was placed in the spoil areas to about El 205.

3.1.2 Vicinity, Eisenhower "Twin" Alternative

The site of the Eisenhower alternative is located on a major NE-SW trending till ridge. The ridge is between 1,500 and 2,000 feet wide and is bounded on the southeast by the sand-filled valley of Robinson Creek. Present-day relief is about 60 feet, from El 250 at the top of the ridge near Eisenhower Lock down to 190 feet at the portal of the highway tunnel. Prior to excavation for the lock, the highest point was at El 263. Robinson Creek is at about El 200. From the top of the tunnel cut, the land slopes away to the east on roughly a 2 percent grade across backfilled terrain.

3.1.3 Vicinity, High-Lift Alternative

The proposed site for the High-Lift alternative lock and channel lies to the south of the Snell and Eisenhower Locks, between the Wiley-Dondero Canal and the Grass River. The Grass River flows northeastward at about El 157 across a clay and sand-filled lowland. To the north it is bordered by the long, gently sloping, NE-SW trending till ridge mentioned previously in connection with the Snell Lock alternative. The ridge reaches El 250 at both ends - southwest of Snell Lock and south of Eisenhower Lock - and in the middle slopes down to about El 210. Several till ridges also border the Grass River to the south, and two lesser ridges can be found just north and northeast of the village of Massena Center.

In addition to the Grass River valley, two smaller lowland areas are located in the vicinity - one along Robinson Creek, and the other along the small stream which enters the Grass River at Massena Center.

3.1.4 Vicinity, Iroquois-Point Rockway Alternative

The topography at the Iroquois site is typical of this subsection. Two northeast-southwest trending ridges of glacial till, each about 1,500 feet wide, cross the area with a clay-filled lowland in between them. Maximum relief is around 60 feet, ranging from an elevation of 300 feet near the northeastern tip of the peninsula to 240 feet at the head of Whitehouse Bay. Whitehouse Bay, which borders the area to the east, was formed by the embayment of Whitehouse Creek after the construction downstream of Long Sault Dam and Lake St. Lawrence.

3.2 Surficial Geology

3.2.1 Vicinity, Snell "Twin" Alternative

The area south of the present Snell Lock (Plate 4) is relatively flat and, as mentioned previously in Section 3.1.1, is located at the northeast end of a large till ridge which stretches to the southwest some four miles to a point south of Eisenhower Lock (Plate 2). A typical cross-section through the general area would show, from top to bottom: 1) backfill material, 2) marine clay, 3) glacial till, and 4) dolomite bedrock (Plate 8). The backfill consists of material excavated during the construction of the Wiley-Dondero Canal and Snell Lock and is essentially a gravelly silty sandy clay with occasional boulders. It is thickest along the south wall of Snell Lock and the western edge of the area where it was used as embankment material. Boring C-701301 shows over 70 feet of backfill. To the south and east the backfill thins out and was not encountered at all in boring C-701310.

Underlying the backfill throughout most of the areas is a very soft marine clay. The clay was deposited in a salt-water environment during the post-glacial invasion of the Champlain Sea (see Section 2.2) and filled the "valleys" in and around the underlying glacial till. Generally speaking, prior to construction the thickness of clay was least where the thickness of till was greatest and greatest where the till thickness was least. The clay is referred to in the literature as the Leda clay, Laurentian clay or Massena clay. It has a flocculent structure, is extremely sensitive, and ranges in color from brown (in the zone of oxidation) to gray or blue-gray below the zone. Boring UD-701308A shows some 18 feet of the brown oxidized clay. During the construction of Snell Lock, the marine clay was found to range in thickness from about 10 to 12 feet near the western end of the upstream approach wall to about 70 feet in the downstream approach area. The 1970 boring program showed that in some places the entire thickness of clay had been removed during construction (boring C-701301) while elsewhere some 50 feet of the material still remains (boring C-701304).

Typical characteristics of the undisturbed clay at Snell Lock (based on laboratory test data contained in Ref. 14, Plate 5) are:

Classification	Clay (CL-CH)
Unit weight in place (wet weight)	106.6 pounds/cubic foot
Density (dry weight)	69.4 pounds/cubic foot
Specific gravity, G	2.82
Liquid limit	50.3
Plastic limit	25.1
Moisture content	53.6 percent
Void ratio	1.54
Cohesion, c	0.43 tons/square foot

In some areas the marine clay overlies glacial till (borings C-701301, C-701304, C-701305, C-701306, C-701307 and C-701309), and in others rests directly upon the dolomite bedrock (borings C-701302, C-701303, C-701308 and C-701310). As shown in Figure 3, the till is confined to three general areas: 1) along the south wall of the present Snell Lock, 2) in the southwest corner of the area, and 3) southeast of the downstream guide wall of Snell Lock. The greatest thickness of till (56 feet) was found in C-701309, north of the lock. In the other borings which encountered till, the thickness averaged less than 3 feet.

During the construction of Snell Lock, an exposed section of till along the north face was mapped (MacClintock, Ref.7). It showed, from top to bottom:

1) marine sand
2) marine clay
3) varved lake clay
4) sand and gravel
5) Upper till (Fort Covington)
6) silt, sand and gravel
7) Middle (?) till (Malone)
8) dolomite bedrock

3.2.2 Area from Snell to Eisenhower Locks

The proposed channel area between Snell and Eisenhower Locks (Plates 3 to 12) is bordered on the south by the long NE-SW trending till ridge mentioned in Section 3.1.2. This ridge is capped by Fort Covington till and underlain down to bedrock by one, or in some places, both of the Malone tills (Middle and Lower tills). To the north the Wiley-Dondero Canal was excavated generally through glacial till. However, in the vicinity of Robinson Creek, just downstream from Eisenhower Lock, the canal passed through thick deposits of marine clay nearly 80 feet deep. Farther downstream, closer to Snell Lock, two additional clay-filled valleys were encountered.

3.2.3 Vicinity, Eisenhower "Twin" Alternative

The Eisenhower alternative site (Plate 11) lies across one of the typically NE-SW aligned hills of the region. A general section through the area would show from top to bottom, a sequence of backfill, glacial till and bedrock. The marine clay, common at the Snell site, is found overlying the till only to the south (near Robinson Creek) and along the eastern slope of the hill. The backfill material is similar to that found at the Snell site and is thickest along the south wall of Eisenhower Lock where it reaches depths of over 100 feet as indicated in borings C-681210 and C-681211. It thins out to the south and east.

The soft gray marine clay is the same material encountered at Snell. Borings UDC-681202 and C-681209 indicate about 40-50 feet of the clay overlying till. Two borings farthest east (UDC-681201 and C-681208) showed about 75 feet of clay on top of dolomite bedrock.

The bulk of the hill is composed of glacial till of Malone and Fort Covington age. Geophysical studies indicated a maximum till thickness of some 110 feet near the entrance to the tunnel which runs beneath Eisenhower Lock (Figure 4). Nearby boring C-681204 showed 99 feet of till overlying bedrock (Plate 13). The till thins out to the south and east and is only about 7 feet thick in boring UDC-681202.

During the construction of Eisenhower Lock, MacClintock was able to map a section through the east end of the excavation. From top to bottom it comprises:

1) marine beach gravels
2) Upper till (Fort Covington)
3) stratified drift, with zones of varved silts and clays 8-10 feet thick
4) Middle till (Malone)
5) stratified drift with varves
6) Lower till (Malone)
7) dolomite bedrock

The Lower till was found to be very dense and difficult to excavate.

Typical characteristics of the undisturbed glacial till at Eisenhower Lock are as follows:

Classification	Sandy silt (ML-CL) with gravel, cobbles and boulders	
Mechanical analysis (not including cobbles and boulders)		
gravel	13	percent
sand	34	percent
fines	53	percent
Unit weight in place (wet weight)	149	pounds/cubic foot
Density (dry weight)	139	pounds/cubic foot
Specific gravity, G	2.74	
Liquid limit	17.4	
Plastic limit	10.7	
Moisture content	7.5	percent
Void ratio	0.24	
*Angle of internal friction, ϕ	35	degrees
*Cohesion, c	2.1	tons/square foot
*Coefficient of permeability, K	48×10^{-6}	centimeters/second

*Averages from tests on only three samples

At the eastern brow of the hill, excavation revealed a mass of "crumpled till", stratified silts, gravels and sands. Since the Fort Covington till generally tends to drape over the underlying Malone tills on the slopes of hills in this region, it is thought that this mass represents a subaqueous slumping of the Fort Covington into the waters of a later proglacial lake.

3.2.4 Vicinity, High-Lift Alternative

The proposed alignment of the High-Lift alternative runs southwestward from Snell Lock parallel to the Grass River, and then near Massena Center turns to the northwest entering Lake St. Lawrence west of Eisenhower Lock (Plate 14). For most of its length, it is bordered on the north by the large till ridge referred to in Section 3.1.3. Just before reaching Robinson Creek, it cuts across the SW edge of the ridge. Two smaller hills of glacial till are traversed near Massena Center. No recent exploratory work has been done in the area, and the types of materials and the depths of surficial deposits can only be roughly approximated from available water well logs. Typically in the area, the till hills are capped with Fort Covington drift, and below one or both of the Malone tills are also likely to be present. The log of well number 457-450-7, for example, shows three distinct till layers separated from each other by water-bearing sand and gravel layers. The drift is 50 to 100 feet thick, lying on a roughly horizontal bedrock surface.

South of the till ridge, the land is flat and low-lying and is underlain by clay and silty clay with, in parts, a coating of a few feet of sand. The present-day topography is a result of the deposition of glacial drift followed by the washing and subduing effects of waves, tides, and currents of the Champlain Sea.

West of the ridge, in the area of Robinson Creek, a sequence of soft gray marine clay overlying glacial till can be expected.

3.2.5 Vicinity, Iroquois-Point Rockway Alternative

The two NE-SW oriented till ridges at the Iroquois-Point Rockway alternative site (Plate 15) are each composed of two sheets of till separated by a layer of glaciolacustrine drift. The drift layer is stratified and contains sand, clay, silt and, in places, stony to bouldery glacial material. The upper till is the Fort Covington and the lower the Malone. The intermediate stratified drift layer represents berg-rafted lake sediment deposited when Malone ice waned by calving into a lake, prior to the advance of Fort Covington ice.

Excavation for the east abutments of Iroquois Dam was carried out through more than 100 feet of drift. This exposed a section, along the north face, which showed 10 feet of fossiliferous marine clay lying on some 10 feet of varved silt and clay, underlain by buff calcareous Fort Covington till. This sequence indicates that a lake followed the Fort Covington episode, and varves as well as till were both exposed to surface oxidation prior to the marine invasion.

In another cut south of the excavation, fossiliferous marine clay in places lies directly on buff till, which becomes blue-gray at the base of the exposure. MacClintock reports that "not only does the clay lie directly on till, but it is seen to lie in small hollows more than 10 feet deep in the surface of the till. At several places, till from tops of the little hillocks is seen to have slumped or moved out over some of the fossiliferous clay in adjacent depressions. This has produced till on top of fossiliferous clay, which would certainly be confusing if encountered in a boring sample, as has undoubtedly been done in some of the seaway explorations" (MacClintock and Stewart, Ref. 8, p. 107-110).

The exposures indicated that "the Fort Covington till had a morainal topography which was modified first by lake waters and then by marine waves and currents". Further excavations have destroyed these exposures.

The lowland area between and to the south of the two till ridges is filled with silty clays. Exploratory work done in 1941 for a proposed Point Rockway Canal alignment indicated surficial deposits in the lowlands consisting of marine clay, glacial till and water-laid or partially water-laid sands (U.S. Army, Ref. 12).

No recent exploratory work has been done in the Point Rockway area. Geologic Profile D-D on Plate 16 is based on data from the 1941 boring program. Original ground conditions have certainly been altered to some degree since construction work was begun, and detailed information as to the present-day character of the surficial deposits is not available.

3.3 Bedrock Geology

The bedrock underlying all four of the proposed additional lock sites is composed of dolomite belonging to the Ordovician Age Beekmantown Group. In the St. Lawrence Valley the uppermost Beekmantown is represented by the Ogdensburg Dolomite. The most recent borings located in the vicinity of Snell and Eisenhower Locks (1968 and 1970) penetrated the upper units of the Ogdensburg but probably did not reach the dolomite of the underlying Bucks Bridge mixed beds.

Limestone and sandstone of the Chazy Group lie above the Beekmantown, and the contact between the two groups follows the St. Lawrence River from north of Iroquois Lock to Cornwall. Chazy rocks outcrop north of the proposed additional lock sites and were not encountered in the 1968 and 1970 boring programs. They were, however, found in previous exploratory programs at the sites of the Long Sault Dam and the powerhouse on Barnhart Island.

3.3.1 Vicinity, Snell "Twin" Alternative

The bedrock is dolomite for the most part but also contains interbedded shale and dolomitic shale layers. The uppermost rock strata is thought to be 70 to 80 feet below the top of the Beekmantown. The rock has been separated into stratigraphic units based on lithology, and brief descriptions of the units are given in Table 1.

The uppermost unit at the site, Unit 27, was encountered in only one boring (C-701303) during the 1970 exploration program. Unit 23 - a dark gray to black laminated dolomitic shale, 1 to 1.4 feet thick - shows up as a good marker bed across much of the site. Borings made during the construction of Snell Lock showed that Units 15 and 5 are replaced or partially replaced by gypsum and/or celestite in and near the fault zone (see Section 3.4) upstream from the limits of the lock walls but are unreplaced dolomite under the lock foundation. Both units were found to be leached to badly leached under the foundation area. In three of the 1970 borings (C-701301, C-701306 and C-701307), Unit 15 was missing completely (see Plate 8). Unit 1 was the lowermost unit encountered by the 1970 borings (i.e., C-701304), but hole GR-1 drilled in the fault zone (see Section 3.4.1) in 1954 penetrated into Unit 0.

3.3.2 Vicinity, Eisenhower "Twin" Alternative

The uppermost rock layer is 50 to 60 feet below the top of the Beekmantown. As at Snell Lock, the bedrock is predominantly dolomite with interbedded shale and dolomitic shale layers. Two gypsum beds are also present, and gypsum is irregularly distributed through some of the dolomite layers as thin seams along partings, as small stringers or veinlets, and as small irregularly shaped replacement bodies.

The rock has been separated on a lithologic basis into stratigraphic units which correlate with the same numbered units at Snell Lock (Table 1). The uppermost unit, Unit 27, was encountered in several borings during the construction of Eisenhower Lock and in three of the 1968 borings (C-681203, C-681210 and C-681211). The dark gray shale of Unit 23 again shows up as a good marker bed across most of the site. Both Units 15 and 5 are replaced by gypsum. In the 1968 borings located downstream of approximately canal Sta. 368+00, Units 15 and 14 are almost completely missing (Plate 13). The lowermost unit, Unit 0, was penetrated only in boring AC-681208 at the extreme downstream end of the site.

3.3.3 Vicinity, High-Lift Alternative

Since the High-Lift proposed alignment runs well south of the Snell and Eisenhower Locks and the Wiley-Dondero Canal, very little boring data from any of the subsurface exploration programs carried out for the St. Lawrence Seaway Project are available. The borings within the site were performed during the 1941 program, and all terminated in the overburden without ever reaching the bedrock (Plate 14). During the 1970 boring program at Snell Lock, two holes (C-701304 and C-701310) were drilled just north of the limits for the proposed High-Lift channel and indicated dolomite bedrock. Boring C-701304 went through Unit 19 at the top of the bedrock surface down into Unit 1 and C-701304 went from Unit 25 to Unit 13 (see Table 1). None of the 1968 borings at Eisenhower Lock are located close enough to the High-Lift alignment to be of much value. Other bedrock data come from water wells located throughout the area but the information is very limited, merely describing the rock as gray to black dolomite.

3.3.4 Vicinity, Iroquois-Point Rockway Alternative

As is the case for the High-Lift site, very little boring data are available here. No exploratory work was carried out at Point Rockway during 1968 or 1970, and the 1941 borings all cluster in the area of the proposed upstream guide wall (Plate 16). The description of the dolomite bedrock is very sketchy. It is generally characterized as a light to dark gray dolomite with numerous stringers of shale and calcite, ranging from badly broken and slightly weathered to sound. No separation into stratigraphic units was made, as at the Snell and Eisenhower Locks.

3.4 Structural Geology

The bedrock structure in the vicinity of the Snell and Eisenhower alternative sites has been fairly well defined from the many borings and geophysical survey lines across the areas. The High-Lift site has so little information available that even the top of bedrock surface can not be established with any great accuracy. Somewhat more information is available at the Iroquois-Point Rockway site, mainly from the 1940-41 boring and seismic survey investigations made for Iroquois Dam.

3.4.1 Vicinity, Snell "Twin" Alternative

The 1970 geophysical survey provides a good picture of the bedrock surface (Figure 3). It showed that "the general configuration of the surface of bedrock at the Snell Lock site starts as a high at approximate elevation 150 feet near the southwest corner of the area investigated. This high slopes to the west at a fairly uniform gradient. To the north and east of this subsurface high the bedrock surface is incised by two stream channels. The northernmost more pronounced buried stream channel cuts through the area in a northeast direction.

A small channel follows a subparallel trend just south of the larger channel. Drill holes C-701308 and C-701310 were both drilled in the vicinity of the buried channels. The seismic depths have generally been confirmed by drill holes, and the change from marine clay to bedrock is sharp with little or no rubble or debris at the contact. The absence of any gravel or debris suggests that if any detritus was present it was washed out of the channels before deposition of the marine clays" (U.S. Army, Ref. 15).

During construction in the 1950's, it was found that "the rock strata in the upstream one-fourth of the foundation area for Snell Lock are folded in a small plunging anticline, the crest of which crosses the foundation diagonally" near canal Sta. 546+50 and plunges to the northeast. "Downstream from the anticline, the rock strata are only very slightly undulated and have a slight dip northward. The dip at most places, except on the flanks of the small anticline, is less than 2 feet per 100 feet" (U.S. Army, Ref. 14).

It was also found that the movement of glacial ice across the bedrock surface "caused fracturing or jointing in the rock and left scratches or striations on the rock surface. The lower part of stratigraphic unit 25, which made up the upper layer of rock over the downstream portion of the foundation area was badly jointed or fractured and was removed with a bulldozer in places without blasting. Drag joints also occurred in stratigraphic unit 24 over parts of the foundation area.

These were nearly vertical at the top of the stratigraphic unit but curved in the lower part of the unit to nearly horizontal. These joints in unit 24 also were very tightly filled with glacial till material that apparently was forced into the joints by the ice as the joints were formed. Two sets of glacial striae were exposed on the rock surface over approximately the downstream third of the foundation area before rock excavation was commenced. One set had a strike around S50°W (Malone glaciation) and the other around S9°E (Fort Covington glaciation)" (U.S. Army, Ref. 14).

No definite evidence of faulting was found during the geophysical survey, however, borings made in 1941 (D-1302, D-1303, D-1304 and others) indicated a fault upstream from the limits of the lock walls. The fault zone is around 200 feet wide and diagonally crosses the canal centerline between approximately Sta. 533+50 and Sta. 539+50. It strikes about N56°E and probably dips very steeply to the northwest. Beds are vertically displaced about 35 feet, with the upthrow side on the northwest. The rock at and adjacent to the fault is badly brecciated and fractured. Boring C-701309 was drilled on the north side of the lock in the area of the fault zone and showed 54.5 feet of dolomite bedrock with numerous high angle and low angle fractures healed with calcite.

Two major joint sets occur at the site, and a few joints belonging to a third set were also found (see below):

Joint Set	Strike	Dip
1. Major	N37°E to N56°E	Very steep to near vertical
2. Major	N80°W to N90°W	Very steep to near vertical
3. Minor	N10°W	Very steep to near vertical

The bedrock is virtually unweathered except for the upper 10 feet of rock where some yellowish-brown or rust-colored staining was observed along partings or bedding planes.

In the foundation rock of Snell Lock "zones of leached rock and small cavities or solution voids are widely distributed in certain stratigraphic zones ... These are mostly parallel to the bedding. The leached zones range in thickness from 0.1 inch to about 3.0 feet and in degree of leaching from a slight change in color to soft, earthy-appearing rock exhibiting honey-combing by solution and high absorption. The cavities range in thickness from about 0.5 inch to about 7 inches and were formed by solution of the rock. Most of the leached zones and cavities are in stratigraphic units 16, 15, 14 and 13 although they were encountered in nearly all the stratigraphic units that were penetrated by explorations in the foundation area. Some of the leached zones and cavities are persistent under a fairly large portion of the foundation area. One such persistent zone is about 2 feet below the top of stratigraphic unit 16. This zone was evidenced in many of the cores as a leached or a soft absorbent zone, or as a cavity. Unit 15 contains cavities and is composed of soft, absorbent, honey-combed rock or contains zones of soft, absorbent, honey-combed rock under most of the foundation area. Unit 14 also contains persistent zones that are absorbent and that are honey-combed by solution" (U.S. Army, Ref. 14).

The "downhole" geophysical test performed in boring C-701305 showed a very low bedrock vertical velocity in the upper 10 feet, probably indicating considerable solutioning and/or weathering. However, it also suggested that "the individual cavities do not have significant lateral extent" (U.S. Army, Ref. 15).

3.4.2 Vicinity, Eisenhower "Twin" Alternative

Figure 5 shows a top of rock contour map based on the results of the 1970 geophysical survey. It can be seen that the bedrock topography is generally more gentle than at the Snell site. The bedrock surface is nearly horizontal to the west and becomes a series of rather broad ridges and valleys trending northeast-southwest from south of boring C-681212 eastward to boring UDC-681201. "There is one steep ridge in the bedrock midway between drill holes C-681203 and C-681205 trending approximately N20°E. The ridge is fairly abrupt with the western side approximately 20 feet higher than the east" (U.S. Army, Ref. 16).

Beneath Eisenhower Lock the rock strata "are very nearly horizontal but have a slight general dip northwestward and contain small undulations. The strike and the direction of dip of the strata varies in accordance with the undulations. The amount of dip for the most part is less than 1°43' or 3 feet per 100 feet" (U.S. Army, Ref. 13).

Three major joint sets occur at the site, as follows:

Joint Set	Strike	Dip
1. Most prominent	N8°W to N20°W	Very steep to near vertical
2. Major	N26°E to N43°E	Very steep to near vertical
3. Major	N70°E to S85°E	Very steep to near vertical

The bedrock is virtually unweathered except for the upper 5 feet where some yellowish-brown or rust-colored staining was observed along partings.

In the foundation rock of Eisenhower Lock "thin zones of leached rock and small solution voids or cavities are widely distributed in certain stratigraphic zones ... They apparently are more common in the downstream portion of the foundation rock than in the upstream portion. Those which are most persistent occur about 3 feet below the top of stratigraphic unit 13, at the top of stratigraphic unit 15, near the bottom and at the top of unit 16, and near the bottom and near the middle of unit 25. They are the result of leaching and solution by ground water and, for the most part, are parallel to the bedding. The leached zones range in thickness from 0.1 inch along bedding planes or partings to about 7.8 inches and in degree of leaching from just a slight difference in color to earthy-appearing rock exhibiting high absorption. The cavities range in thickness from about 0.1 foot to 0.9 foot" (U.S. Army, Ref. 13).

The geophysical survey found no definite evidence of faulting.

3.4.3 Vicinity, High-Lift Alternative

On Plate 14, the line showing approximate top of bedrock is taken from a map prepared by the Buffalo District prior to the 1970 geophysical survey. The areas covered by the survey lie too far beyond the High-Lift alignment to be of much help in more accurately defining the true top of bedrock. Rock appears to come closest to the ground surface (El 140 feet) beneath the Grass River around Sta. 550+00. This roughly corresponds to the bedrock high found at the Snell site. To the west the bedrock slopes gently downward to about El 100 feet before rising again to El 140 feet at Lake St. Lawrence.

Borings and water wells along the alignment provide no information on other structural features, such as jointing, solutioning, or faulting.

3.4.4 Vicinity, Iroquois-Point Rockway Alternative

The best data available on the bedrock structure come from the 1941 borings made along the originally proposed alignment for Iroquois Dam, about 3,000 feet downstream of the present dam. All these borings lie in or near the upstream guide wall area of the proposed site (see Plate 15); no borehole data is available for the lock or downstream guide wall areas. Geophysical data from the 1940-41 survey similarly is limited to the upstream guide wall. No geophysical investigations were carried out at the site during the 1970 program.

On the east near boring D-1046, the bedrock surface starts as a high at about El 210 feet and slopes downward to the northwest to El 160 feet near boring D-1043. The slope is almost 8 feet per 100 feet along this section. The approximate top of rock line along Profile D-D (Plate 16) is based on the rock contours provided in Ref.15.

The boring logs do not provide enough information to determine the strike and dip of the bedding. It may be assumed that the strata follow the regional trend and are either flat-lying or dipping gently at 5° or less to the northwest. In general, the rock appears to be only slightly weathered with some moderately to badly broken zones. No joint sets have been defined, but boring D-1296 indicates that the rock is broken along numerous 60° joints.

Evidence of faulting was discovered in borings D-1050 and D-1053, located about 1,400 feet northwest of the upstream guide wall (Plate 15). Dr. Charles Berkey examined rock cores from these borings in 1944 and determined that "no great amount of movement is indicated, but a strongly stressed condition resulting finally in excessive shattering of the rock". He concluded that "the best that can be said for this Iroquois occurrence is that two of the borings on this site show the existence of typical stress crush zone material which is judged to represent faulting. But the course or orientation of the line of faulting or of the crush zone is not yet determined" (Berkey, Ref. 2).

Other evidence of possible faulting farther east shows up in boring D-1043 (Plate 16) where a cemented breccia zone is described as occurring at about El 134 feet.

3.5 Ground Water

A good deal of ground water information is available at both the Snell "Twin" and Eisenhower "Twin" sites from data collected during construction of the present locks and also from the 1968 and 1970 boring programs. At the High-Lift site, most of the information comes from water well records compiled by Trainer and Salvas (Ref. 9). No basic ground water data is currently available for the Iroquois-Point Rockway site.

3.5.1 Vicinity, Snell "Twin" Alternative

During excavation work for Snell Lock, piezometers were installed in the marine clay overburden and measurements of water levels were taken. At first the piezometric levels registered 7 to 9 feet below ground surface. As excavation progressed, the level adjacent to the lock area dropped, and then rose again after the excavation slope was backfilled.

Prior to construction, water levels were measured in those borings drilled into bedrock and proved to be lower than the levels found in the borings confined to overburden materials. These "bedrock levels" averaged 26 feet below the existing ground surface (or 46 to 72 feet above the bedrock surface). They were about El 158 feet, very close to the level of Grass River, and fluctuations in the ground water levels tended to reflect level changes in Grass River. Dewatering during construction lowered the piezometric level in these borings to top of rock or lower. The levels completely recovered after the lock area was flooded preparatory to opening the lock and canal to navigation.

In the 1970 boring program, water levels were recorded in each hole as drilling progressed. Boring C-701303 (Plate 8) showed the piezometric level to be at the ground surface as the hole was advanced through the overburden of backfill and marine clay. Once the hole went into bedrock, the water level dropped 51.2 feet to about El 154 feet, very close to the level of Grass River. To the east along Profile A-A (Plate 8) in boring

C-701307, the piezometric levels in overburden and bedrock were very close (13.6 feet and 12.4 feet below ground surface, respectively). The bedrock piezometric level was at El 155 feet, again close to the level of Grass River. Farther east in boring C-701305, the water level rose from 12.8 feet below ground surface (hole in overburden) to 4.7 feet (hole in bedrock). The bedrock piezometric level was again El 155 feet.

In boring C-701305, hydrogen sulfide gas was encountered while drilling through the bedrock, approximately between Units 9 and 6. Gas had been previously found in the bedrock in hole GR-23 (Plate 4) during construction in 1955 and a water sample was taken at that time for chemical analysis. The results were as follows:

Iron	2.5 ppm
Sulphates	639 ppm
Chlorides	70 ppm
pH	7.3

3.5.2 <u>Vicinity, Eisenhower "Twin" Alternative</u>

Prior to construction of Eisenhower Lock, water level measurements were taken in boring D-1173, located on the north side of the lock near the upstream pintle (Plate 11). The hole was 70 feet deep, terminating in the till and the water level in the hole was considered representative of the ground water level in the overburden across the top of the ridge. The level fluctuated between 11 and 17 feet below the ground surface (El 245 and 251 feet, respectively). Test pits dug on the upstream and downstream sides of the ridges filled with water to within

4 to 6 feet of the ground surface. As at Snell Lock, the water level adjacent to the lock area dropped during excavation work and then rose again after backfilling.

Borings in bedrock prior to construction showed water levels about 80 to 90 feet (El 160 to 170 feet) below the level in D-1173. These levels were about 20 to 30 feet above the bedrock surface, and fluctuated with changes in the level of the St. Lawrence River. The levels dropped as excavation work progressed and subsequently rose after backfilling was completed.

During the 1968 boring program, water levels were taken in the holes as drilling progressed through overburden into bedrock. In borings UDC-681202, C-681203 and C-681205 (Plate 13), the water levels recorded in the overburden ranged from about 0 to 5 feet below ground surface. Once the holes penetrated into the bedrock, the water levels dropped to approximately El 173 feet, some 30 to 40 feet above the bedrock surface. This is very close to the pre-construction water levels for holes in bedrock.

A slight odor of hydrogen sulfide was detected in the water in the bedrock during construction, but no chemical analysis of the ground water at the site was made.

3.5.3 Vicinity, High-Lift Alternative

The available data from borings and wells along the proposed alignment are plotted on Plate 14. The water levels shown were obtained from Trainer and Salvas (Ref. 9). Because of the limited amount of information in the area, it is difficult to generalize to any great extent on the localized ground water regime.

For the greatest length of the alignment - north of Grass River from Sta. 580+00 upstream to about Sta. 360+00 - the water table slopes to the south and southeast toward Grass River. From Sta. 360+00 to Lake St. Lawrence, the water table slopes toward Robinson Creek. Ground water levels are highest in March or April and lowest in August or September. Recharge of the ground water is greatest in the early spring and late fall.

Wells completed in overburden show a range of water levels of from 5 to 12-1/2 feet below ground surface. The water levels in those wells which extend into the bedrock are generally deeper and show a much wider range - 17 to 67 feet below ground surface.

3.5.4 Vicinity, Iroquois-Point Rockway Alternative

The borings shown on Profile D-D on Plate 16 were drilled in the St. Lawrence River, and no information was recorded concerning piezometric levels in either the overburden or the bedrock. Similarly, no water levels are given for the test pits (see Plate 15) dug on land in the proposed lock area. There are no indications of any wells existing along the proposed alignment. It can only be assumed, therefore, that the ground water regime at the site may be analogous to that found at the Snell "Twin" and Eisenhower "Twin" alternative sites, since the geologic setting at all three sites is similar glacial till and marine clay overlying dolomite bedrock.

4. SUBSURFACE EXPLORATIONS

4.1 Drilling Programs

In 1895, the Deep Waterways Commission was appointed to report on all possible routes for a deep waterway connection between the Great Lakes and the Atlantic Ocean, and since then several subsurface exploration programs have been carried out. Exploratory drilling began in 1898 and has continued off and on through the years until the completion of the present Snell, Eisenhower and Iroquois Locks in 1958. For a study of additional locks proposed in the vicinity of these three sites, further drilling work was done in 1968 (near Eisenhower Lock) and 1970 (near Snell Lock) but no investigations were performed for the Iroquois-Point Rockway or High-Lift alternatives.

Plates 3 to 7, 9 to 12, 14 and 15 show the locations of boreholes and test pits in the vicinity of the alternative sites. Detailed information on the exploratory work performed from 1898 to 1958 is given in Refs. 10 through 17.

4.1.1 Explorations Prior to 1968

The first set of borings (100-series) was performed in 1898-99 for the Board of Engineers on Deep Waterways. The borings were apparently wash borings that were made using a "Sullivan boring machine". Those borings drilled in the vicinity of the present Snell and Eisenhower Locks indicate a considered canal alignment differing somewhat from that of the present Wiley Dondero Canal. None of these borings were drilled at the present lock sites or in the immediate area of the proposed "Twin" alternatives. Similarly, the borings made in the Iroquois-Point Rockway area lie outside the proposed site for the new lock.

Investigations by the St. Lawrence Waterways Joint Board of Engineers in 1925-26 in connection with studies of various plans for the development of the St. Lawrence River included four borings within the excavation area for Snell Lock; one boring in the general vicinity of Eisenhower Lock; and one boring within the upstream guide wall area of the proposed Iroquois-Point Rockway site. A 1932 boring program included two more borings within the excavation area of Snell Lock. These borings were given a 200-, 400- and P-300 series designation.

In 1941, the St. Lawrence River District, United States Engineer Department, carried out a large-scale exploration program to determine the overburden and bedrock conditions for the purpose of locating the lock structures and obtaining information for design. The program consisted of drilling in overburden and bedrock; excavation and sampling of auger holes and test pits; probing in soft overburden; and the determination of bedrock elevations and study of general soil conditions by the seismic method. The boring series was designated D-1000. Numerous borings are located within the general vicinity of the present Snell and Eisenhower Locks. Ten borings lie within the proposed channel area of the High-Lift alternative but none within the lock area itself. The borings at Iroquois-Point Rockway indicate a considered lock and canal alignment along Whitehouse Creek quite different from the present location of Iroquois Lock farther to the west on the Canadian side of the river. Some borings made at the originally proposed location for Iroquois Dam fall within the upstream guide wall area of the proposed alternative lock site, and six of them are shown in profile on Plate 16.

Just prior to construction in 1954-55, further explorations at Snell and Eisenhower Locks were performed by the Massena Area Office, U.S. Army Engineer District, Buffalo, to obtain more definite and detailed site specific subsurface information for the design and construction of the locks. Borings were designated GR- (for Grass River area), RB- (Robinson Bay), etc. Many of these borings lie within the proposed "Twin" lock areas. From 1953 to 1958, over 130 borings (numbered 601 to 693, and 1200 to 1242) were drilled along the alignment of the present Iroquois Lock and fall outside the study area of the Iroquois-Point Rockway alternative.

During the construction of Snell and Eisenhower Locks, foundation explorations (on a closer spacing than before) were performed to determine excavation grades and the need for foundation treatment. These borings continue the GR-, RB-, etc. series.

4.1.2 Explorations in 1968 and 1970

For a feasibility study of additional locks along the St. Lawrence River, the U.S. Corps of Engineers, Buffalo District, carried out two drilling programs with a total of 23 borings in the vicinity of the Snell and Eisenhower Locks. All the drilling work was performed by the Corps of Engineers, Mobile District. No borings were made along the proposed alignments of the High-Lift and Iroquois-Point Rockway alternative.

4.1.2.1 Eisenhower "Twin" - 1968

The 12 borings drilled in this zone lie within or very near the lock and downstream guide wall areas of the proposed "Twin" (see Plates 10 and 11). These holes with their locations and other pertinent data are listed in Table 2, and the detailed geologic logs are attached to this report. Plate 13 shows a geologic profile through four of these borings.

All holes were drilled vertically using a Failing 314 CD-38 drill rig. The drilling took place from May 25 to November 1, 1968. Overburden was cased using 4-inch or 6-inch casing whenever possible and NX casing set whenever bedrock was encountered. In overburden, the holes were advanced using a 5-inch flight auger and when appropriate, the hole was cleaned using a 6-inch side-jetted fishtail. Soil sampling was performed with a 2-inch split-spoon sampler, 3-inch Shelby tube, 4-inch Denison sampler and several double tube core barrels with 2-3/4" x 3-7/8", 4" x 5" and 6" x 7-3/4" size drill bits. Coring in bedrock was done with an NW-size double tube core barrel and an M-series diamond bit. Figures 6 and 7 show photographs of typical rock cores recovered during the drilling program.

Twenty-three undisturbed samples of the marine clay were obtained from borings UDC-681201 (14 tubes) and UDC-681202 (9 tubes), by means of a 3-inch Shelby tube sampler.

The depth of overburden as determined from the borings ranged from 61 feet to 110 feet, averaging around 90 feet across the area. Of the 11 holes drilled into the bedrock, 8 of them continued at least 100 feet below top of rock. Rock core recovery averaged about 96%.

Borehole photographs were taken in borings C-681208 and C-681210, and the logs are attached to this report.

Pressure testing in bedrock was performed in 10 of the 12 borings; procedures and results are discussed in Section 5.3.1.

Upon completion of all drilling and testing, the holes were backfilled with a neat cement grout to the top of rock and from there to the ground surface with sand or a sand/bentonite mixture.

4.1.2.2 Snell "Twin" - 1970

Of the 11 borings drilled in this program, 10 lie within the lock area of the proposed "Twin" and one (C-701309) is located on the north side of the present Snell Lock (see Plate 4). These holes with their locations and other pertinent data are listed in Table 3, and the detailed geologic logs are attached to this report. Plate 8 shows a geologic profile through three of these borings.

The drilling was done from May 12 to July 23, 1970. All holes were drilled vertically, and the drill rig, samplers and other equipment used were the same as described in Section 4.1.2.1. Figures 8 and 9 show photographs of typical rock cores recovered during the drilling.

Eighteen undisturbed samples of the marine clay were taken from borings UC-701306 (16 tubes) and UD-701308A (2 tubes) using a 3-inch Shelby tube sampler.

The depth of overburden in the proposed "Twin" lock area ranged from 42.9 feet to 76 feet, for an average of about 60 feet. Boring C-701309, located on the north side of the lock, had 91.1 feet of overburden. Ten of the borings were continued into the bedrock a maximum of 102 feet, and rock core recovery averaged over 97%.

Borehole photographs were taken in borings C-701303 and C-701306, and the logs are attached to this report.

Pressure testing in bedrock was performed in 10 borings; procedures and results are discussed in Section 5.3.2.

As at the Eisenhower site, backfilling of holes was done with a neat cement grout in bedrock, and sand, or a sand/bentonite mixture, in the overburden.

4.2 Geophysical Surveys

Two separate geophysical surveys have been carried out in connection with studies for the St. Lawrence Seaway Project. The first survey, conducted prior to construction in 1940-41, covered the entire length of the project from Chimney Island (northeast of Ogdensburg) to Cornwall Island, near the mouth of the Raquette River. The seismic refraction method was used, both on land and in the river. The latest survey was conducted in 1970 and was limited to the general area proposed for the "Twin" lock sites south of Snell and Eisenhower Locks. Seismic refraction and electrical resistivity were employed in this investigation.

4.2.1 Seismic Exploration, 1940-41

The seismic investigations were conducted by the St. Lawrence River District of the U.S. Army Corps of Engineers for the general purpose of obtaining data between drill holes to minimize the amount of drilling needed. The work was performed between November 1940 and October 1941, with a 2 month suspension in March and April due to frost conditions. An array of detectors (usually three) was placed on the ground surface and charges of dynamite were exploded at various distances from the detectors. An effort was made to conduct the survey on the same type of overburden. For work on the river, special waterproof equipment was designed. In quiet water the detectors and charges were set using floats; in swift water special procedures had to be worked out (Ref. 11).

From the time-distance graphs obtained by plotting the seismic data, depths to bedrock were computed and top of rock contour maps were drawn. In general, the correlation between seismic information and drilling data was found to be quite satisfactory, except for one area along the proposed alignment for the Point Rockway Canal where comparatively low velocity (5000 feet per second) material originally thought to be clay or till was discovered to be shallow and fractured rock. Another area, near the Massena Power Canal, showed erratic readings and made precise interpretation difficult. This was the result of artificial conditions created in the area by the dumping of spoil from the excavation of the power canal.

Frozen ground also led to uncertainties in interpretation, particularly in the Wiley-Dondero Canal area, by giving abnormally high velocity values for the overburden.

The average velocities for the different materials encountered in the survey area are given in Table 4.

4.2.2 Geophysical Survey - 1970

The geophysical explorations were conducted by the Missouri River Division (MRD) of the U.S. Army Corps of Engineers in order to better define bedrock conditions between boreholes and locate any possible faults in the area south of the present Snell and Eisenhower Locks. The field work was carried out from June 1 to June 24, 1970, using conventional surface seismic refraction methods with reverse shooting, electrical trenching, and vertical electrical sounding with the Wenner electrode configuration. The geophysical equipment was supplied by the MRD Laboratory. Survey coverage was as follows:

Geophysical Method	Snell	Eisenhower
1. Land seismic refraction	7,700 lineal feet	9,350 lineal feet
2. Underwater seismic refraction	1,760 lineal feet	1,100 lineal feet
3. Downhole survey	117 feet in boring C-701305	----------------
4. Resistivity trench	------------------	E-W line with 13 stations
5. Vertical resistivity soundings	5	4

Seismic lines were run both on land and in water; resistivity stations were only on land. All shot points and stations were surveyed by a crew from the Buffalo District, and lithologic control was provided by a number of drill hole logs at both sites.

The average seismic velocities and electrical resistivity values for the various materials encountered are shown in Table 5. Based on these data, depths to bedrock were computed and top of rock contour maps were produced for each site (Figures 3 and 5). In addition, a till isopach map was prepared for the Eisenhower site (Figure 4).

The survey results indicated that little if any till would be encountered during excavation at the Snell site, whereas a considerable thickness (50 to 110 feet) could be found at the Eisenhower site. The velocity of the till at both sites indicated that it would be marginally rippable.

The survey also showed that the configuration of the bedrock surface at the Eisenhower site was generally flat along the west side but had broad N-S trending valleys and ridges to the east. A buried ridge with an abrupt slope was found trending about N20°E through the area near the eastern end. At the Snell site, a bedrock high (about El 150 feet and sloping west, north and east) was found at the SW corner of the area. The bedrock surface is cut by two NE trending channels nearly in the center of the areas.

No definite evidence of faulting was found.

5. FIELD AND LABORATORY TESTING

In the various drilling programs performed since 1895, extensive sampling and testing of the overburden and bedrock materials were done in the general vicinity of three of the four alternative sites. No data is currently available for the area of the High-Lift alternative.

5.1 Soil Testing

For the period prior to 1968, detailed soil data is available from the 1941 and 1954-55 exploration programs. Along the alignment for the 1941 proposed Point Rockway Canal, soil samples were taken with a 2-inch diameter "dry sampling tube" and, for undisturbed samples of clay, a specially constructed spoon which provided samples 4-5/8 inches in diameter. The clays were tested for moisture content, liquid limit, plastic limit, specific gravity, consolidation and quick shear. For a description of sampling and testing procedures, see Ref. 12.

During the 1941 drilling program in the vicinity of Eisenhower Lock, the overburden was sampled using 2-inch split-spoon samplers and NX-size double tube core barrels. The recovered samples were used for classification, moisture content determinations and mechanical analysis tests. In the 1954-55 program, soil samples were recovered by: (1) drive sampling with 2-inch split spoon samplers with brass liners, (2) washing, and (3) coring with NX and 6-inch double tube core barrels. Testing included a full range of identification tests (grain size, Atterberg limits, etc.) as well as triaxial compression tests. See Ref. 13 for detailed sampling procedures and test results.

During the 1941 program at Snell Lock, 1-1/2 inch and 2-inch split-spoon samplers were used to obtain soil samples for classification, moisture content determinations and mechanical analysis tests. The M.I.T. sampler was used to obtain undisturbed samples of clay material for consolidation and shear tests. In the 1954-55 program, 2-inch split-spoon samplers with brass liners were used to recover material for classification tests and moisture determinations. Undisturbed samples for strength tests were obtained with 5-inch Shelby tube samplers. Laboratory testing of the undisturbed samples included determination of moisture content, liquid limits, plastic limits, and density, and triaxial compression tests. The bottom portion of seven (7) of the soils borings was cored with a 6-inch core barrel. The core samples were used for classification and moisture determinations, and some cores were placed in sheet metal tubes for future reference. See Ref. 14 for detailed sampling procedures and test results.

5.1.1 Eisenhower "Twin" - 1968

As mentioned in Section 4.1.2.1, during the 1968 program, soil sampling was performed with a 2-inch split-spoon sampler, 3-inch Shelby tube, 4-inch Denison sampler and several double tube core barrels with 2-3/4" x 3-7/8", 4" x 5", and 6" x 7-3/4" size drill bits. Laboratory testing was done by the North Central Division, U.S. Corps of Engineers, Chicago, Illinois.

In boring UDC-681201, fourteen (14) Shelby tube samples were recovered in the marine clay. The tests performed on this material and the test results are shown in Table 6. The range in values of several important characteristics are:

Liquid Limit (%)	33 to 64
Plastic Limit (%)	17 to 27
Dry density (pcf)	58.3 to 87.2
Water content (%)	34.6 to 70.0

Nine (9) Shelby tube samples of the marine clay were taken from boring UDC-681202 (see Plate 13). Table 6 summarizes the test results and shows the following ranges:

Liquid Limit (%)	45 to 57
Plastic Limit (%)	19 to 25
Dry density (pcf)	61.7 to 76.7
Water content (%)	44.8 to 64.8

In boring C-681206, the backfill along the south side of Eisenhower Lock was sampled using 4" x 5" double tube core barrel. Table 6 shows the test results. Thirty-one (31) of the samples were grouped into eight (8) test series in order to obtain strength envelopes from the triaxial test results. The material is basically silty sand and gravel and shows the following range of values:

Fines content (%)	23 to 44
Liquid Limit (%)	13 to 21
Plastic Limit (%)	10 to 14
Dry density (pcf)	129.9 to 153.3
Water content (%)	2.9 to 9.3

5.1.2 Snell "Twin" - 1970

The procedures and equipment used to sample the overburden are the same as described in Section 4.1.2.1. Laboratory testing was done by the North Central Division, U.S. Corps of Engineers, Chicago, Illinois. The tests performed and their results are shown in Table 7.

In boring UC-701306, sixteen (16) 3-inch diameter Shelby tube samples were recovered in the marine clay. The test results showed the following range of values:

Liquid Limit (%)	40 to 59
Plastic Limit (%)	19 to 26
Dry density (pcf)	61.9 to 78.5
Water content (%)	43.4 to 64.9

Two (2) Shelby tube samples of the marine clay were taken from boring UD-701308A, and the test results showed:

Liquid Limit (%)	58 to 60
Plastic Limit (%)	22 to 23
Dry density (pcf)	74.3 to 89.3
Water content (%)	32.4 to 47.3

5.2 Rock Testing

During the 1941 drilling program for the proposed Point Rockway Canal, rock cores of the dolomite bedrock were obtained and tested to determine whether the rock from the canal excavation was suitable for concrete aggregate.

Rock cores were also taken in the vicinity of the Eisenhower and Snell Locks in the various drilling programs performed prior to 1968 in these areas. The rock was described and classified, but no record of any type of testing is available.

5.2.1 Eisenhower "Twin" - 1968

Rock cores during the 1968 program were obtained with an NX-size double tube core barrel. Selected samples from borings C-681210 and C-681211 were sent to the Ohio River Division Laboratories (ORDL) for testing. The strength tests performed included compressive strength, direct shear, sliding friction, bond shear and triaxial compression. In addition, moisture contents and unit weights were determined and petrographic analyses were made on twelve (12) samples. Table 8 shows a summary of the test results. The water content measurements were quite low (less than 1% in most cases) and it was questionable whether they were truly representative of in situ conditions. Unit weight values ranged from a high of 175.3 pcf for dolomite to 132 pcf for a sample of gypsum. Sample 1A from boring C-681211 was tested to determine Poisson's Ratio, and the recommended average value was found to be 0.075. See Ref.16 for a detailed description of testing procedures and results.

5.2.2 Snell "Twin"-1970

During the 1970 drilling program, rock cores were obtained with an NX-size double tube core barrel. Selected samples from borings C-701302, C-701303 and UC-701306 were sent to ORDL for testing. Strength tests included unconfined compression, direct shear, bond shear, sliding friction (rock on rock) and triaxial compression. Moisture contents, specific gravity and unit weights were also determined, and petrographic analyses were made on twelve (12) samples. Table 9 shows a summary of the test results. The results of the direct shear tests were considered somewhat questionable because the strength of the samples sometimes exceeded the crushing strength of the hydrostone. Water contents were very low - less than 1% in most cases. Unit weights were very similar for all samples tested, ranging from a high of 178.2 pcf for a sample of highly argillaceous dolomite to 173.4 pcf for a typical dolomite. Poisson's Ratio was determined on samples 4 and 6 from boring C-701303, and the recommended average values were 0.16 and 0.26, respectively. See Ref. 17 for a detailed description of testing procedures and results.

5.3 Pressure Testing

There are no records to indicate that water pressure testing of the bedrock was done during the 1941 drilling program along the alignment of the proposed Point Rockway Canal.

In the 1954-55 drilling program at Eisenhower Lock, fifteen (15) of the borings in bedrock were pressure-tested with water using a 5-foot double packer to determine permeability or leakage conditions in the bedrock. During construction in 1956, seventeen (17) additional foundation exploration holes were pressure-tested, again using 5-foot double packers. Because most of the 1956 borings showed flowing water under artesian pressure, flow measurements were substituted for pressure tests in other holes. In total, flow measurements were made on fifteen (15) holes including eight (8) of the holes that were pressure-tested. See Ref. 13 for a detailed description of test procedures and results.

In the 1954-55 drilling program at Snell Lock, nineteen (19) of the exploratory holes in bedrock were pressure-tested with water using a 5-foot double packer. Additionally, a pumping test was performed on hole GR-16, with four other holes serving as observation wells. Permeability tests were performed in five (5) borings. During construction in 1956, pressure tests were performed in seven (7) of the foundation exploration holes. A single packer was used to test a section extending from 20 feet below top of bedrock to the bottom of the hole. See Ref. 14 for a detailed description of test procedures and results.

5.3.1 Eisenhower "Twin" - 1968

Pressure testing in bedrock was performed in ten (10) of the twelve (12) borings drilled in 1968. Both a single packer and a 5-foot double packer set-up were used. The maximum gage pressure was limited to 50 psi and was adjusted accordingly so that the pressure in the zone being tested would not exceed one (1) psi per foot of overlying material. The test results are listed in Table 10.

Of the 151 tests performed, 96 showed water losses greater than 10 gpm. Over 50% of the high loss zones occurred within stratigraphic Units 13 to 16. Sections of Unit 13 were included in nearly 30% of these zones, however, it should be noted that Unit 13 is by far the thickest unit (24.4 feet thick) in the area and it was involved in many more pressure tests than any other single unit.

Fifty (50) tests showed water losses greater than 20 gpm.

Units 13 to 16 accounted for nearly two-thirds of the high loss zones, with Unit 13 included in over 40% of them.

The maximum water loss of 32 gpm occurred when testing the bottom 19 feet of boring UDC-681201. For a 5-foot zone, the maximum was 27 gpm within Units 13 to 16 in boring UDC-681202. Forty (40) tests showed no water loss.

5.3.2 Snell "Twin" - 1970

In the 1970 drilling programs, ten (10) of the eleven (11) borings were pressure-tested in bedrock. The same equipment and test procedures were used as described in Section 5.3.1. The test results are listed in Table 11.

In the 161 tests performed, 63 showed water losses greater than 10 gpm. Units 13 to 16 accounted for more than 60% of the high loss zones, with Unit 13 included in over 20% of them.

The maximum water loss recorded was 19.5 gpm for a 5-foot zone between Units 25 and 26 in boring C-701303. Sixty (60) tests showed no water loss.

6. GEOTECHNICAL ASPECTS

The geotechnical aspects for the design of the four proposed alternative sites can not be discussed in detail since no extensive site specific information is available. There is, however, extensive information regarding subsurface conditions at the sites of the existing Snell, Eisenhower and Iroquois Locks. The proposed sites for the Snell and Eisenhower "Twin" Locks are in close proximity to the existing locks and the locations of several previously drilled borings are within the proposed alternative alignments and therefore can be used in making a reasonable assessment of subsurface conditions. In the vicinity of Snell Lock, about 15 borings exist along the alignment of the proposed "Twin" and about 25 borings for the Eisenhower site. Practically no useful boring information is available for the High-Lift alternative; there is some geophysical data and local water well information, and this has been used in determining subsurface conditions. At the Iroquois site, about 15 previously drilled borings can be located within the proposed alternative alignment and almost all of these are located at the upstream end. In addition, the information obtained from these borings is very sketchy and very little detail is given regarding the materials. Nevertheless, based on this limited information and experiences others have had in previously constructed projects in the vicinity, certain general inferences can be made regarding the alternative sites.

During the construction of Snell, Eisenhower and Iroquois Locks, difficulties were encountered which were directly attributable to the foundation materials. A general description of the subsurface conditions at the four alternative sites has been given in previous paragraphs. It can be seen that there are basically three materials, two of which caused most of the difficulties during the construction, namely; the marine clays and the glacial tills. Dolomite, the underlying bedrock, created few problems. Burke (Ref.3), Armstrong and Burnett (Ref. 1) and Haines and Olson (Ref. 6) describe in detail the design and construction problems encountered during construction of the St. Lawrence Seaway.

The difficulties caused by the marine clays were a result of their weak strength and extreme sensitivity. The design and construction of the canal slopes of major cuts necessitated extensive investigation and testing programs. Resulting cut slopes varied from 1V to 2H in areas where depth of cuts or thickness of clay was shallow to 1V to 10H where relatively deep cuts were required. In areas where dikes were constructed over the clay, they had to be wide and flat sloped for stability purposes. The disposal of the extremely sensitive clays also created a problem. When reworked, the clays became "soup" and it was necessary, therefore, to provide extensive spoil areas to allow the clay to be deposited to shallow depths and very flat slopes. For the same reason, it was very difficult to have construction traffic on the clays.

The problems associated with the glacial tills were basically those of excavation, seepage and trafficability. A detailed description of the difficulties during design and construction is given by the previously mentioned authors and by Cleaves (Ref.4). Excavation problems were caused by the compact to highly compact nature of the basal till (Malone) which also contained boulders. In wintertime, it was necessary to blast the till which became frozen. The presence of sand and silty zones within the tills further increased the difficulties because these materials became "quick", bogging down excavation equipment and causing excessive seepage and stability problems in cuts. In addition, the upper tills, which are less compact, became impassable during seasons of thaw and high rainfall. It is apparent, therefore, that prior to final design, the location and extent of the clays and tills needs to be defined and a final assessment be made as to the viability of the sites. At that time the exact alignment and location should be made for the proposed channels, guide walls and locks. The determination of design parameters will be required also for utiliation in stability and seepage analysis and in evaluating temporary support systems and trafficability.

Since the proposed sites are within Seismic Zone No. 3, dynamic analyses will be needed for the design of proposed structures and cut slopes. Dynamic parameters for the rock and soil types will have to be established and an examination and analysis of seismic data will be required for the selection of a Maximum Credible Earthquake, a Design Earthquake and a Design Accelerogram.

To obtain the aforementioned information, an extensive subsurface exploration and testing program should be carried out at the four sites. These programs should include: the drilling of vertical and inclined holes; obtaining disturbed and undisturbed samples of overburden; core retrieval in rock; seepage testing in overburden and water pressure testing in rock; digging of test pits and trenches, geophysical surveys including shear wave measurements (i.e., cross-hole methods); and laboratory testing of rock and soil samples. It also will be necessary to search for possible sources of construction materials especially fine and coarse aggregate. These probably can be found in the sand and gravel deposits in the tills.

Consideration should be given to the installation of a seismological network for the monitoring of macro- and/or micro-seismic activity and instrumentation for monitoring ground water.

Laboratory testing should include classification and engineering properties tests such as: compaction, permeability, consolidation, direct shear and triaxial compression. Dynamic testing should include simple cyclic shear, cyclic triaxial compression and resonant column.

7. CONCLUSIONS

A review and assessment of the information presented above indicates that construction of the alternative locks and channels at the proposed locations appears to be geotechnically feasible. It is apparent that whichever is the selected location, substantial additional geologic, geophysical and geotechnical investigations will be required prior to the final design. These investigations should include extensive site specific subsurface exploration, field and laboratory testing of soil and rock samples, geophysical surveys, hydrogeologic studies and seismological (dynamic) investigations.

Based on the subsurface conditions determined from available data, it is reasonable to assume that similar bedrock conditions will be revealed by future investigations. Since the surficial deposits are basically glacial in nature, it can be expected that erratic soil conditions will exist throughout the area. However, the major soil types will probably be similar to those which have been encountered in the past.

A major advantage in the future design and construction of project structures will be the experiences gained during the original construction of the Seaway. Knowing in advance in which materials problems can be expected (i.e., the very soft marine clays and the extremely dense glacial tills), and to have design and construction solutions to these problems is a great advantage for any project.

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Table 1
Stratigraphic Units in Bedrock

SYSTEM	STAGE	GROUP	UNIT	THICK-NESS	DESCRIPTION
				0 to 75	MARINE CLAY Borderline Clay (CL-CH) : Generally classified as Fat Clay (CH) with a silty texture; soft to very soft; moist to wet; dark gray to bluish-gray.
PLEISTOCENE	WISCONSINAN			0 to 110	FORT COVINGTON (Glacial Till) Lean Clay to Sandy Clay (CL-SC) : Contains gravel, cobbles and boulders embedded in clay; generally very stiff to hard; dry to slightly damp; gray to brownish-gray.
					MALONE (Glacial Till) Lean Clay to Sandy Clay (CL-SC) : Contains gravel, cobbles and boulders embedded in clay; generally very stiff to hard; dry to slightly damp; gray to brownish-gray.
ORDOVICIAN		BEEKMANTOWN	27	10.4	DOLOMITE: Thick-bedded to massive; occasionally argillaceous, occasional shale partings and bands; moderately hard; very finely crystalline to dense. Contains an Intraformational Conglomerate zone from 0.1 to 1.0-foot thick at or near the base and another 0.2 to 0.9-foot thick from 1.8 to 3.2 feet above the base. The Intraformational Conglomerate consists of small gray dolomite fragments in a lighter gray dolomite matrix. Gray to dark gray.
			26	4.5 to 6.4	DOLOMITE: Thin to medium-bedded; shaly and argillaceous at top and bottom with a basal sandy textured shale, numerous calcite veinlets in darker gray dolomite at top and bottom; moderately hard to hard; finely crystalline to dense; dark gray at top and bottom, bluish-gray in middle.
			25	8.9 to 10.2	DOLOMITE: Thin to medium-bedded; numerous stylolitic shale and calcite partings, shale and dolomitic shale partings, bands and beds with shale band at base; moderately hard to hard; very finely crystalline to dense; Intraformational Conglomerate at base. Unit is pitted and vuggy; medium bluish-gray.
			24	3.4 to 4.6	DOLOMITE: Thin-bedded top and bottom, massive in middle; frequent hairline stylolitic shale partings; moderately hard; dense in upper 0.3-foot and 0.5 to 0.6-foot; finely crystalline in middle; fossiliferous (?); medium gray.

Table 1 (cont'd)
Stratigraphic Units in Bedrock

SYSTEM	STAGE	GROUP	UNIT	THICK-NESS	DESCRIPTION
ORDOVICIAN		BEEKMANTOWN	23	1.0+	SHALE: Laminated, dolomitic; moderately hard; dark gray.
			22	5.1 to 5.6	DOLOMITE: Thick-bedded to massive; argillaceous, several shaly bands throughout; moderately hard; dense; light gray at top, bluish-gray middle and brownish-gray at base.
			21	0.9	SHALE and DOLOMITE: Thin-bedded; shale is dolomitic and dolomite is argillaceous, interbedded; slightly sandy texture at base; moderately hard; dense; dark gray.
			20	3.6 to 4.1	DOLOMITE: Thin to thick-bedded; moderately hard; dense; bluish-gray upper, medium gray in lower. Shale 0.1 to 0.3-foot at base, and 0.3-foot thick approximately 0.7-foot below top. May or may not contain 2 zones of Intraformational Conglomerate; one directly above the upper shale (0.2-foot thick) and one 1.5 feet below top of unit (0.7-foot thick) (Not present in all cores). Calcite veinlets occur 1.1 feet below top.
			19	2.4 to 3.0	DOLOMITE: Thin-bedded; argillaceous, several stylolitic shale partings, basal shale is (0.3-foot thick) platy to laminated, slightly carbonaceous; moderately hard; black. Dolomite contains numerous high angle veinlets of calcite throughout; moderately hard; dense; occasional vugs filled with calcite with some solutioned out; dark gray to black.
			18	2.0 to 3.6	DOLOMITE: Thin to thick-bedded; slightly argillaceous. Basal platy black shale (0.1 to 0.3-foot thick) and bands of shale interbedded with dolomite approximately 0.8-foot and 1.4 feet from base; stylolitic shale partings in upper 0.3-foot; moderately hard; very finely crystalline to dense; occasional pits and vugs in upper 0.7-foot; bluish-gray.
			17	1.1 to 2.1	DOLOMITE: Thin to medium-bedded; very argillaceous, shaly appearance with several black shale partings and bands; moderately hard; dense; very dark gray.
			16	8.5	DOLOMITE: Medium to thick-bedded; slightly argillaceous, shale bands and beds throughout; gypsum bands, beds and masses with occasional partings in lower part; moderately hard; very finely crystalline to dense; occasional pits and vugs where gypsum has been removed; bluish-gray to brownish-gray.

Table 1 (cont'd)
Stratigraphic Units in Bedrock

SYSTEM	STAGE	GROUP	UNIT	THICK-NESS	DESCRIPTION
ORDOVICIAN		BEEKMANTOWN	15	1.4 to 3.8	GYPSUM: Thin to medium-bedded; laminated and inter-bedded satinspar and gypsum in upper part, irregular laminated gypsum in lower part; soft to moderately hard; dense to crystalline; mottled various shades of light and dark gray.
			14	1.9 to 3.8	DOLOMITE: Thin-bedded; argillaceous with gypsum partings and irregular partings at base; a 0.1 to 0.3-foot thick dolomitic shale with partings mark top of unit; moderately hard to hard; dense; medium gray to gray.
			13	24.4	DOLOMITE: Thin to medium-bedded; numerous bands and beds of darker gray shaly to argillaceous dolomite; dark gray to black shale bands approximately 2.4 feet below top, and a black platy carbonaceous shale approximately 2.0 feet above base of unit; moderately hard; dense; pitted and vuggy near basal foot; brownish-gray to bluish-gray.
			12	2.1 to 2.7	DOLOMITE: Thin to medium-bedded; shale partings and stylolitic shale partings throughout. Black platy dolomitic shale (0.2-foot thick) at top, and a basal sandy dolomite (0.04-foot thick). Base of unit is marked by a black fissile shale with gypsum partings. Moderately hard; dense; brown to brownish-gray.
			11	7.1 to 10.7	DOLOMITE: Medium-bedded upper, thick-bedded lower; shale bands in upper 1.1 to 1.5 feet with stylolitic shale partings and bands in upper part, gypsum masses in middle, lower part is nearly a mass of laminated gypsum (3.0 feet); moderately hard; (gypsum is soft to moderately hard) dense; medium gray.
			10	5.6 to 5.9	DOLOMITE: Thin to thick-bedded; argillaceous with shale and gypsum partings and occasional gypsum nodules; moderately hard; dense; medium gray upper, light gray middle and brownish-gray lower.
			9	2.9	DOLOMITE: Thin-bedded; gypsum partings and shale bands, shale band approximately 0.6-foot below top (0.1-foot thick); moderately hard; dense; bluish-gray.
			8	1.7	DOLOMITE: Thin to thick-bedded; very shaly with gypsum partings; moderately hard; occasional pits filled with gypsum; dark gray to black.

Table 1 (cont'd)
Stratigraphic Units in Bedrock

SYSTEM	STAGE	GROUP	UNIT	THICK-NESS	DESCRIPTION
ORDOVICIAN		BEEKMANTOWN	7	1.8	DOLOMITE: Thin-bedded-flaggy appearance with numerous gypsum-satinspar partings; moderately hard; very finely crystalline to dense; brownish-gray to bluish-gray.
			6	2.1 to 2.6	DOLOMITE: Thin-bedded; abundant gypsum partings and stylolitic shale partings. A 0.1-foot thick dolomitic shale at top; moderately hard; very finely crystalline to dense; lower part highly fractured - fractures filled with gypsum; light gray to light bluish-gray.
			5	6.3	GYPSUM and DOLOMITE: Gypsum in upper 0.6 to 0.9-foot (0.4-foot thick), fractured gypsum and shaly dolomite at base; laminated to thin-bedded; gypsum partings throughout; moderately hard; dense; white at top, medium dark gray lower part.
			4	3.1 to 5.0	DOLOMITE: Thin to thick-bedded; argillaceous in top 1.0-foot with sandy textured dolomitic shale band at top (gray to dark gray), several dolomitic shale partings and bands throughout; dense; moderately hard; medium to dark gray.
			3	2.5 to 3.6	SHALE and DOLOMITE: Laminated to thin-bedded; shale interlaminated with gypsum in upper 1.0 to 1.5 feet. Dolomite in middle 0.7-foot and shaly dolomite in basal 0.8-foot. Dolomite and shaly dolomite are dense; shale is soft; dolomite and shaly dolomite are moderately hard; light gray to black.
			2	17.2	DOLOMITE-LIMESTONE: Thin to thick-bedded; shale and stylolitic shale partings throughout, particularly near basal contact, secondary gypsum approximately 1.6 feet and 3.0 feet from top, occasional gypsum partings; moderately hard; very finely crystalline to dense; medium to light gray.
			1	9.3	DOLOMITE: Thin to thick-bedded; argillaceous, numerous shale and argillaceous dolomite partings and bands throughout, gypsum partings and fracture filling common; moderately hard; dense; bluish-gray.
			0	1.2	SHALE: Laminated; dolomitic; moderately hard; dark gray to black.

Notes for Table 1

The description of the soils and bedrock on Table 1 is based on the following criteria:

SOILS

1. Classification - all soils are classified using the Unified Soil Classification System.

2. Consistency - For drive sample borings the following was used to determine relative density or consistency. Consistency for gravels is not used.

Basic Soil Type	Density or Consistency	Range of Standard Penetration Resistance[1]
Cohesionless	Very loose	less than 4 per foot
	Loose	4 to 10
	Medium dense	10 to 30
	Dense	30 to 50
	Very dense	Greater than 50
Cohesive	Very soft	Less than 2 per foot
	Soft	2 to 4
	Medium stiff	4 to 8
	Stiff	8 to 15
	Very stiff	15 to 30
	Hard	Greater than 30

(1) Number of blows from 140-lb. weight falling 30 inches to drive 2-inch OD, 1-3/8-inch ID, sampler

For undisturbed sample borings a pocket pentrometer or torvane was used to determine consistency and the following was used as a guide:

Unconfined Compressive Strength (Tons/Sq Ft)	Consistency
Less than .25	Very soft
.25 - .5	Soft
.5 - 1.0	Medium
1.0 - 2.0	Stiff
2.0 - 4.0	Very stiff
Greater than 4.0	Hard

3. Moisture Content - Moisture content of soil has been described in the following terms:

Dry. No discernible moisture present.

Damp. Enough moisture present to darken the appearance but no moisture on material adheres to the hand.

Moist. Will moisten the hand.

Wet. Visible water present; plastic materials will leave sticky residue in hand when remolded.

Saturated. 100 percent of all the void space is filled with water.

4. Color - Color was described at the time of drilling.

BEDROCK

1. Bedrock classification was based on the rock types described in the foundation reports for the two existing locks. The rock units described in this report are based on the descriptions shown in the foundation reports (see references 13 and 14). In addition to those descriptions the following criteria was used to describe the bedrock. All descriptions are based on a visual examination at the time of drilling.

2. Bedding - Has been described as massive, thin to medium bedded, fissile, cross-bedded, foliated, platy, fragmental, etc., as indicated below:

(a)	Parting	less than 0.02 foot
(b)	Band	0.02 foot to 0.2 foot
(c)	Thin Bed	0.2 foot to 0.5 foot
(d)	Medium Bed	0.5 foot to 1.0 foot
(e)	Thick Bed	1.0 foot to 2.0 feet
(f)	Massive	Over 2.0 feet

Parting and Band refer to single stratum. The term "massive" may be applied to describe a single bed.

3. Lithologic Characteristics - clayey, shaly, calcareous (limy) siliceous, sandy, silty, plastic seams.

4. Hardness.

very soft or plastic - can be indented easily with thumb
soft - can be scratched with fingernail
moderately hard - can be scratched easily with knife; cannot be scratched with fingernail
hard - difficult to scratch with knife
very hard - cannot be scratched with knife

5. Crystallinity or texture.

dense - crystals are so small that they cannot be distinguished with the naked eye.
very finely crystalline - crystals barely discernible with the naked eye.
finely crystalline - crystals are small but easily discernible with naked eye.
crystalline - crystals are medium size - up to 1/8 inch in diameter.
very coarsely crystalline - crystals larger than 1/4 inch in diameter.

6. Pit - Vug - Cavity - In order to more closely define voids found in bed rock, the following terms have been used:

Porous. Smaller than pinhead. Usually not discernible to the naked eye. Their presence is indicated by the degree of absorbency of the core.

Pitted. Pinhead size to 1/4-inch. If they are numerous enough that only thin walls separate the individual pits, the core may be described as honeycombed.

Vug. 1/4-inch to the diameter of the core. The upper limit will vary with the size of core.

Cavity. Larger than the diameter of the core.

7. Structure.

Bedding: flat, gently dipping, steeply dipping.

Fractures: scattered, closely spaced, open, cemented, or tight.

Brecciated (sheared & fragmented).

Joints.

Faulted.

Slickensides.

8. Degree of Weathering. Unweathered, slightly weather; badly weathered.

9. Solution and Void Conditions. Solid, contains no voids; vuggy (pitted); vesicular; porous; cavities; cavernous.

10. Swelling Properties. Nonswelling; swelling

11. Slaking Properties. Nonslaking; slakes slowly on exposure; slakes readily on exposure.

12. Color of Unit.

Table 2

EISENHOWER "TWIN" LOCK

Summary of Boring Data

Boring No.	Location (Canal Stationing)	Elevation (feet) IGLD - 1955			Linear Feet of Drilling	
		Surface	Top of Bedrock	Bottom of Boring	Soil	Rock
UDC-681201	Sta. 384+00 Rg. 7+40 Rt.	201.7	126.1	93.6	75.6	32.5
UDC-681202	Sta. 377+00 Rg. 4+60 Rt.	200.9	139.9	101.6	61.0	38.3
C-681203	Sta. 363+80 Rg. 3+15 Rt.	243.0	144.4	37.9	98.6	106.5
C-681204	Sta. 358+00 Rg. 2+25 Rt.	250.0	141.5	39.0	108.5	102.5
C-681205	Sta. 370+00 Rg. 2+48.6 Rt.	209.6	132.5	30.6	77.1	101.9
C-681206	Sta. 361+10 Rg. 34 Lt.	250.1	-----	172.6	77.5	-----
C-681207	Sta. 363+80 Rg. 6+90 Rt.	233.4	135.2	31.7	98.2	103.5
AC-681208	Sta. 384+00 Rg. 7+15 Rt.	201.1	126.6	25.6	74.5	101.0
AC-681209	Sta. 370+00 Rg. 9+95 Rt.	225.3	132.1	29.1	93.2	103.0
C-681210	Sta. 358+14 Rg. 1+15 Rt.	249.0	139.0	36.9	110.0	102.1
C-681211	Sta. 363+80 Rg. 65 Rt.	248.3	141.1	36.3	107.2	104.8
C-681212	Sta 360+47 Rg. 1+49 Rt.	247.6	143.4	139.1	104.2	4.3

Table 3
SNELL "TWIN" LOCK
Summary of Boring Data

Boring No.	Location (Canal Stationing)	Elevation (feet) IGLD - 1955			Linear Feet of Drilling	
		Surface	Top of Bedrock	Bottom of Boring	Soil	Rock
C-701301	Sta. 545+42 Rg. 5+35 Rt.	206.3	132.0	33.7	74.5	98.3
C-701302	Sta. 545+62 Rg. 3+55 Rt.	205.9	130.9	29.7	75.0	101.2
C-701303	Sta. 545+72 Rg. 2+45 Rt.	205.1	129.1	28.2	76.0	100.9
C-701304	Sta. 557+72 Rg. 6+35 Rt.	165.2	99.2	-2.8	66.0	102.0
C-701305	Sta. 557+61 Rg. 2+45 Rt.	159.7	103.7	6.7	56.0	97.0
UC-701306	Sta. 557+72 Rg. 4+10 Rt.	156.2	103.5	3.2	52.7	100.3
C-701307	Sta. 551+70 Rg. 2+45 Rt.	167.4	120.1	19.8	47.3	100.3
C-701308	Sta. 550+82 Rg. 4+05 Rt.	174.5	121.4	66.7	53.1	54.7
UD-701308A	Sta. 550+87 Rg. 4+05 Rt.	174.5	-----	155.5	19.0	-----
C-701309	Sta 548+12 Rg. 4+20 Lt.	182.1	91.0	36.5	91.1	54.5
C-701310	Sta. 551+72 Rg. 7+70 Rt.	169.5	126.6	80.4	42.9	46.2

Table 4

1940-41 Survey: Seismic Velocities of Materials

Material	Average Seismic Velocities (fps)
1. Very loose material	1000 - 2000
2. Relatively soft material (silt or clay) or loose till	4500 - 5000
3. Compact glacial till	>5000
4. Bedrock	16,400

Table 5

1970 Survey: Seismic Velocities and Electrical Resistivities of Materials

	Average Seismic Velocities (fps)		Average Electrical Resistivity (ohm-ft)	
Material	Snell	Eisenhower	Snell	Eisenhower
1. Soil and backfill	1700-3300	1200-3800	220-4300	97-850
2. Till	6700	7100	325	436
3. Marine clay	5100	4900	820	121
4. Bedrock	16,500	17,200	2500-∞	1323-∞

Table 6

TEST DATA SUMMARY

SHEET 1 OF 2

PROJECT SLS - EISENHOWER "TWIN" LOCK ALTERNATIVE

BORING NO.	SAM. NO.	DEPTH OF SAMPLE	LABORATORY CLASSIFICATION	MECHANICAL ANALYSIS GRAVEL %	SAND %	FINES %	D_{10}	ATTERBERG LIMITS LL	PL	SPECIFIC GRAVITY G	NAT WATER CONT %	NATURAL DRY DENSITY LBS/CU FT	COMPACTION DATA OPT WATER %	MAXIMUM DRY DENSITY LBS/CU FT
UDC-68 1201 El. 201.7 Gr. Surface														
	1	9.3-11.5	Clay (CL-CH)					43	21	2.75				
	2	11.8-14.[illegible]	Clay (CH)					59	24	2.77				
	3	16.8-19.0	Clay (CL)					36	17	2.75				
	4	21.5-23.5	Clay (CL-CH)					48	24	2.76				
	5	26.5-28.5	Clay (CH)					57	26	2.76				
	6	31.5-33.5	Clay (CH)					56	25	2.79				
	7	36.5-39.0	Clay (CH)					64	27	2.77				
	8	41.5-43.7	Clay (CL)					46	25	2.76				
	9	46.5-48.5	Clay (CL)					47	26	2.76				
	10	51.5-53.5	Clay (CL)					46	21	2.77				
	11	56.5-58.5	Clay (CL)					47	23	2.78				
	12	61.5-63.5	Clay (CH)					55	24	2.80				
	13	66.5-68.5	Clay (CL)					47	22	2.79				
	14	71.5-73.6	[illegible] (CL)					33	18	2.76				
UDC-68 1202 El. 200.9 Grd. Surface														
	1	12.0-14.4	Clay (CL)					45	19	2.77				
	2	17.0-19.3	Clay (CH-CL)					52	23	2.77				
	3	22.0-22.5	Sandy Clay (CH)					53	25	2.79				
	4	27.0-29.5	Sandy Clay (CH)					54	25	2.77				
	5	32.0-34.4	Clay (CH)					55	24	2.77				
	6	37.0-39.4	Sandy Clay (CH)					56	24	2.79				
	7	42.0-44.4	Clay (CH)					55	22	2.78				
	8	47.0-49.0	Sandy Clay (CH)					57	25	2.79				
	9	52.0-54.4	Sandy Clay (CH-CL)					50	23	2.77				

BORING NO.	SAM. NO.	SHEAR DATA INITIAL e	DRY DENSITY LBS/CU FT	w_1 %	w_f %	S_1 %	TYPE TEST	SPECIMEN SIZE INCHES	TEST	σ_m T/SQ FT	σ_1 T/SQ FT	c T/SQ FT	φ DEGREES	PERMEABILITY e	K FT/MIN	CONSOLIDATION DATA P_o T/SQ FT	P_c T/SQ FT	C_c	t_{50}	REMARKS
UDC-68 1201																				
	1	1.036	84.3	[illegible]		98.8	T	1.41 x 2.9[illegible]	[illegible]	0.5	[illegible]	[illegible]								
	2	1.317	71.5	50.8		99.3	↑	1.41 x 2.91	↑	↑	1.64	0.57								
	3	1.195	78.5	43.1		100.0		1.34 x 2.94			1.49	[illegible]								
	4	1.792	61.7	65.1		100.3		1.40 x 2.92			1.3[illegible]	0.41								
	5	1.9[illegible]7	59.2	68.4		99.0		1.36 x 2.94			1.31	0.405								
	6	1.902	59.8	67.6		[illegible]		1.35 x 2.95			1.49	0.435								
	7	1.965	58.3	70.0		98.7		1.40 x 2.92			1.32	0.41								
	8	1.831	60.8	65.4		98.6		1.37 x 2.95			1.51	0.505								
	9	1.893	59.5	68.4		99.7		1.38 x 2.94			1.45	0.475								
	10	1.850	60.6	66.4		99.4		1.38 x 2.94			1.47	0.485								
	11	1.7000	64.2	59.3		97.0		1.37 x 2.94			1.66	0.59								
	12	1.642	66.1	57.4		97.9		1.36 x 2.95			2.43	0.965								
	13	1.375	73.3	49.2		99.8	↓	1.39 x 2.94	↓	↓	1.53	0.515								
	14	0.974	87.2	34.6		98.[illegible]	T	1.40 x 2.94	Q	0.5	1.48	0.49								
UDC-68 1202																				
	1	1.253	76.7	44.8		99.1	T	1.40 x 2.94	Q	0.5	1.31	0.405								
	2	1.656	65.1	59.2		99.0	↑	1.39 x 2.94	↑	↑	1.69	0.595								
	3	1.820	61.7	64.8		99.4		1.39 x 2.94			1.40	0.45								
	4	1.786	62.0	64.1		99.4		1.38 x 2.94			1.31	0.405								
	5	1.651	65.2	59.3		99.5		1.39 x 2.94			1.45	0.475								
	6	1.739	63.6	61.7		99.0		1.38 x 2.94			1.21	0.355								
	7	1.477	70.0	52.8		99.4		1.39 x 2.94			1.24	0.37								
	8	1.292	76.3	45.7		99.4	↓	1.39 x 2.94	↓	↓	1.58	0.54								
	9	1.290	75.5	46.3		99.4	T	1.39 x 2.94	Q	0.5	1.53	0.515								

ENG FORM 2086 EDITION OF 1 MAR 58 IS OBSOLETE.
1 JAN 73

T - TRIAXIAL COMPRESSION
UC - UNCONFINED COMPRESSION
DS - DIRECT SHEAR
Q - UNCONSOLIDATED UNDRAINED
S - CONSOLIDATED DRAINED
R - CONSOLIDATED UNDRAINED

Table 6a

Table 6

TEST DATA SUMMARY

PROJECT SLS-EISENHOWER "TWIN" LOCK ALTERNATIVE

SHEET 2 OF 2

BORING NO.	SAM. NO.	DEPTH OF SAMPLE	LABORATORY CLASSIFICATION	MECHANICAL ANALYSIS: GRAVEL %	SAND %	FINES %	D_{10}	ATTERBERG LIMITS: LL	PL	SPECIFIC GRAVITY G	NAT WATER CONT %	NATURAL DRY DENSITY LBS/CU FT	COMPACTION DATA: OPT WATER %	MAXIMUM DRY DENSITY LBS/CU FT	SHEAR DATA: INITIAL e	DRY DENSITY LBS/CU FT	w_1 %	w_F %	S_1 %	TYPE TEST	SPECIMEN SIZE INCHES	TEST	σ_m T/SQ FT	q_1 T/SQ FT	c T/SQ FT	φ DEGREES	PERMEABILITY: e	K FT/MIN.	CONSOLIDATION DATA: P_o T/SQ FT	P_c T/SQ FT	C_c	t_{50}	REMARKS
C-6A1206		El. 2?0.1 Grd. Surf.																															
	2	1.7-2.0	Si. Sand, Gr. (SM)	19	44	37		16	14	2.73	6.3				0.201	141.8	6.3		85.5	T	3.59 x 8.0	Q	2.0	14.8	1.89	35°10'							
①	6	5.2-6.3	Si. Sand, Gr. (SM)	23	37	40		15	13	2.73(E)	5.8				0.240	137.4	6.9		78.5	T	3.87 x 8.2	Q	0.5	9.3									
	8	6.7-7.8	Si. Sand, Gr. (SM)	29.5	33.5	37		Visual		2.75	6.9				0.175	146.1	5.8		91.4	T	3.79 x 10.2	Q	1.0	5.05									
	11	8.6-10.0	Si. Sand, Gr. (SM)	22	34	44		Visual		2.74(E)	7.2				0.199	143.3	7.2		98.6	T	3.83 x 12.25	Q	1.0	5.30	1.37	34°40'							
	12	10.0-11.3	Si. Gravel, Sa. (GM-GC)	38	32	30		17	13	2.73	6.6				0.181	144.2	6.6		100	T	3.87 x 12.15	Q	4.0	11.32									
②	14	12.2-13.3	Si. Sand, Gr. (SM)	32	33	35		16	13	2.74(E)	3.5				0.147	149.1	3.5		66.1	T	3.82 x 10.51	Q	2.0	12.54									
	16	14.0-15.2	Si. Sand, Gr. (SM)	22	41	37		Visual		2.72	5.4				0.185	143.2	5.4		79.7	T	3.88 x 11.12	Q	0.5	7.12									
	17	15.2-15.9	Si. Gravel, Sa. (GM-GC)	44	25	31		15	11	2.73	4.1				0.133	150.4	4.1		84.4	T	3.72 x 9.44	Q	1.0	10.71	1.22	35°50'							
	21	18.7-19.9	Si. Sand, Gr. (SM-SC)	23	34	43		Visual			7.5																						
③	22	19.9-21.1	Si. Gravel, Sa. (GM-GC)	34	32	34		15	10	2.73	4.2				0.153	147.8	4.2		75.5	T	3.71 x 10.29	Q	2.0	12.53									
	56	59.3-60.2	Si. Sand, Gr. (SM)	22	41	37		Visual		2.73(E)	5.6				0.175	145.0	5.6		87.3	T	3.88 x 11.5	Q	0.5	6.74									
	25	22.3-24.0	Si. Sand, Gr. (SM-SC)	20	38	42		15	11	2.72(E)	4.4				0.150	147.6	4.4		79.9	T	3.68 x 10.47	Q	0.5	8.61	1.40	41°							
	26	24.0-26.1	Si. Sand, Gr. (SM-SC)	18	42	40		15	10	2.72	4.9				0.162	146.1	4.9		82.5	T	3.70 x 9.80	Q	2.0	15.78									
④	28	27.6-29.3	Si. Sand, Gr. (SM-SC)	35	37	28		Visual			4.9																						
	29	29.3-30.6	Si. Sand, Gr. (SM-SC)	23	40	37		Visual		2.72	4.3				0.160	146.3	4.3		73.1	T	3.75 x 10.31	Q	1.0	11.24									
	32	32.5-34.0	Si. Sand, Gr. (SM-SC)	21	37	42		Visual		2.72	7.1				0.206	140.7	7.1		93.8	T	3.70 x 9.76	Q	2.0	9.94	0.74	42°20'							
	33	34.0-35.3	Si. Sand (SM-SC)	12	45	43		15	10	2.75	5.3				0.219	140.8	5.3		67.0	T	3.74 x 12.13	Q	1.0	8.45									
⑤	34	35.3-36.5	Si. Sand, Gr. (SM-SC)	32	36	32		16	11	2.74(E)	5.0				0.185	144.3	5.0		74.1	T	3.79 x 11.31	Q	0.5	7.2									
	38	39.4-40.4	Si. Sand (SM-SC)	13	45	42		Visual		2.74(E)	5.5				0.216	140.5	5.5		69.2	T	3.79 x 12.25	Q	4.0	23.76									
	40	40.8-41.8	Si. Sand & Gravel (GM)	30	29	41		Visual			4.3				0.163	147.5	4.3		72.5	T	3.83 x 11.50	Q	0.5	6.29	0.55	47°20'							
	42	42.3-43.5	Si. Sand, Gr. (SM-SC)	32	38	33		15	11		4.6				0.164	145.3	4.6		76.4	T	3.66 x 7.00	Q	1.0	10.56									
⑥	44	44.9-46.0	Si. Sand, Gr. (SM)	20	47	33		13	12		4.3				0.179	144.4	4.3		65.4	T	3.52 x 8.52	Q	2.0	16.13									
	45	49.0-50.3	Si. Gravel, Sa. (GM)	42	33	25		Visual			—																						
	50	53.6-54.7	Si. Sand, Gr. (SM-SC)	26	37	37		14	10	2.76	4.4				0.168	145.9	4.4		71.2	T	3.47 x 10.50	Q	2.0	14.05	0.25	42°16'							
	51	54.7-55.6	Si. Sand & Gravel (GM-GC)	35	34	31		Visual		2.73(E)	6.7				0.239	137.4	6.7		76.0	T	3.57 x 9.41	Q	1.0	5.56									
⑦	53	56.9-56.5	Cl. Gravel, Sa. (GC)	52	22	26		19	11	2.73(E)	3.2				0.124	153.3	3.2		72.3	T	3.70 x 11.04	Q	0.5	11.31									
	54	56.9-58.0	Si. Sand, Gr. (SM-SC)	16	41	43		14	10	2.73	6.3				0.193	142.7	6.3		89.0	T	3.71 x 11.30	Q	4.0	20.51									
	55	58.0-59.3	Cl. Gravel, Sa. (GC)	44	33	23		21	12	2.75	4.8				0.177	145.8	4.8		74.4	T	3.61 x 8.30	Q	2.0	15.55	0.80	45°							
	59	61.6-63.0	Si. Sand, Gr. (SM)	14	52	34		Visual		2.71	9.3				0.302	129.9	9.3		83.6	T	3.77 x 8.99	Q	0.5	7.77									
⑧	62	64.5-65.6	Si. Gravel, Sa. (GM)	40	27	33		14	11	2.74(E)	2.3				0.122	152.5	2.9		52.3	T	3.72 x 10.43	Q	1.0	13.99									
	64	66.2-67.5	Si. Sand & Gravel (SM)	31	34	35		Visual		2.74	4.7				0.186	144.2	4.7		69.6	T	3.65 x 8.23	Q	4.0	28.67									

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NOTE: Circled numbers (⑧) indicate specimens of a given triaxial compression test series.

T - TRIAXIAL COMPRESSION
UC - UNCONFINED COMPRESSION
DS - DIRECT SHEAR
Q - UNCONSOLIDATED UNDRAINED
S - CONSOLIDATED DRAINED
R - CONSOLIDATED UNDRAINED

Table 6b

Table 7

TEST DATA SUMMARY

SHEET 1 OF 1

PROJECT SLS - SNELL "TWIN" LOCK ALTERNATIVE

BORING NO.	SAM. NO.	DEPTH OF SAMPLE	LABORATORY CLASSIFICATION	MECHANICAL ANALYSIS GRAVEL %	MECHANICAL ANALYSIS SAND %	MECHANICAL ANALYSIS FINES %	MECHANICAL ANALYSIS D_{10}	ATTERBERG LIMITS LL	ATTERBERG LIMITS PL	SPECIFIC GRAVITY G	NAT WATER CONT %	NATURAL DRY DENSITY LBS/CU FT	COMPACTION DATA OPT WATER %	COMPACTION DATA MAXIMUM DRY DENSITY LBS/CU FT	SHEAR DATA INITIAL e	SHEAR DATA DRY DENSITY LBS/CU FT	SHEAR DATA W_1 %	SHEAR DATA W_F %	SHEAR DATA S_1 %	SHEAR DATA TYPE TEST	SHEAR DATA SPECIMEN SIZE INCHES	SHEAR DATA TEST	SHEAR DATA σ_m T/SQ FT	SHEAR DATA σ_1 T/SQ FT	SHEAR DATA c T/SQ FT	SHEAR DATA ϕ DEGREES	PERMEABILITY e	PERMEABILITY K FT/MIN	CONSOLIDATION DATA P_0 T/SQ FT	CONSOLIDATION DATA P_C T/SQ FT	CONSOLIDATION DATA C_C	CONSOLIDATION DATA t_{90}	REMARKS
UC-701306		El. 156.2	Grd. Surface																														
	1	6.0-8.5	Clay (CH)					59	26	2.77	62.0	63.7			1.734	63.2	62.7		100.1	T	1.40×2.94	Q	0.5	1.78	0.89								
	2	8.5-10.0	Clay (CH)					59	26	2.77					1.733	63.3	62.7		100.2	↑	1.39×2.95	↑	↑	1.39	0.695								
	3	10.0-12.5	Clay (CH)					56	25	2.77	55.5	68.1			1.504	69.0	54.7		100.8		1.38×2.94			1.90	0.95								
	4	12.5-15.0	Clay (CH)					56	26	2.76					1.694	63.9	61.4		100.1		1.38×2.95			1.76	0.88								
	5	15.0-17.4	Clay (CH)					54	26	2.76	60.5	64.5			1.635	65.4	59.6		100.6		1.37×2.94			1.63	0.815								
	6	17.5-19.9	Clay (CH)					54	25	2.76	59.7	65.3			1.675	64.4	61.0		100.5		1.36×2.94			1.69	0.845								
	7	20.1-22.4	Clay (CH-CL)					51	25	2.76					1.605	66.1	58.6		100.8		1.38×2.94			1.24	0.62								
	8	22.5-24.9	Clay (CH)					52	25	2.76					1.648	65.0	60.0		100.5		1.38×2.95			1.21	0.606								
	9	25.0-27.4	Clay (CH-CL)					50	24	2.77	60.2	64.8			1.672	64.7	60.4		100.0		1.37×2.95			1.38	0.69								
	10	27.5-29.9	Clay (CH)					54	25	2.76					1.728	63.1	62.9		100.4		1.38×2.95			1.46	0.73								
	11	30.0-32.4	Clay (CH)					57	26	2.77	64.4	62.1			1.793	61.9	64.9		100.3		1.37×2.95			1.59	0.795								
	12	32.5-34.8	Clay (CH)					53	25	2.78					1.759	62.9	63.4		100.2		1.38×2.95			1.56	0.78								
	13	35.0-37.4	Clay (CH)					52	23	2.78	64.3	62.2			1.759	62.9	63.4		100.2		1.38×2.94			1.43	0.715								
	14	37.5-39.9	Clay (CH)					58	26	2.80					1.687	65.0	60.3		100.0		1.38×2.94			1.86	0.93								
	15	40.0-42.4	Clay (CH)					55	24	2.80	57.1	67.2			1.604	67.1	57.5		100.4	↓	1.39×2.93	↓	↓	1.15	0.575								
	16	45.0-46.7	Clay (CL)					40	19	2.77					1.201	78.5	43.4		100.0	T	1.38×2.95	Q	0.5	1.11	0.555								
UC-701306		El. 156.2	Grd. Surface																														
	11	30.0-32.4	Clay (CH)					57	26	2.77					1.757	62.7	63.4	59.4	100.0	T	1.40×2.93	S	0.5	2.04									
	13	35.0-37.4	Clay (CH)					52	23	2.78					1.743	62.9	63.3	59.3	100.0	T	1.39×2.94	S	0.5	1.81									
	15	40.0-42.4	Clay (CH)					55	24	2.80					1.585	67.4	56.9	54.5	100.0	T	1.39×2.93	S	0.5	1.90									
UD-701308A		El. 174.5	Grd. Surface																														
	1	6.6-8.4	Clay (CH)					58	23	2.74	33.4	89.3			0.915	89.3	32.4		97.0	T	1.39×2.94	Q	0.5	2.72	1.36								
	2	12.0-14.9	Clay (CH)					60	22	2.78	47.3	74.5			1.335	74.3	41.3		97.5	T	1.36×2.96	Q	0.5	1.89	0.945								

ENG FORM 2086 EDITION OF 1 MAR 68 IS OBSOLETE. 1 JAN 73

T - TRIAXIAL COMPRESSION
UC - UNCONFINED COMPRESSION
DS - DIRECT SHEAR
Q - UNCONSOLIDATE UNDRAINED
S - CONSOLIDATED DRAINED
R - CONSOLIDATED UNDRAINED

Table 7

Table 8

SUMMARY OF ROCK CORE TESTS

ORD Laboratory
Cincinnati, Ohio

Twin Lock Study.

Project Eisenhower Lock, St Lawrence Seaway Date July 1970

Sheet 1 of 2

Identification Data				Strength Tests Data (In pounds per square inch)														Physical Data			
				Compression			Direct Shear			Sliding Friction		Grout on Rock			Triaxial Comp.						
Boring No.	Sample No.	Elev.	Rock Type	Unit Load at Fail.	Mod. Elas "E" 10^6	Tensile	Normal Unit Load	Direct Unit Load at fail.	Max. Slide Resist.	Norm. Stress	Sliding Resist.	Norm. Unit Load	Bond Strength	Max. Slide Resist.	σ_3	Max. $\sigma_1 - \sigma_3$	Ult. $\sigma_1 - \sigma_3$	Nat. Water %	Specific Gravity	Absorption	Unit Weight lb/ft3
C-68	1	136.75'-	Dolomite	16,160	2.11							50	89	79				1.0			173.6
1210		135.8'										100	329	315							
												150	281	246							
	2	129.9'-	Dolomite							50	19	(R/SmR)									173.4
		129.2'								100	41	"									
										150	66	"									
	3	120.3'-	Dolomite												0	11,370		0.5			175.3
		119.4'													2500	43,790		0.5			174.0
	4	115.15'-	Dolomite	13,090	2.54													1.2			173.0
		114.4'																			
	5	113.95'-	Argillaceous															0.8			169.4
		112.8'	dolomite																		
	6	109.4'-	Argillaceous															0.9			171.2
		108.7'	dolomite																		
	7	106.8'-	Argillaceous									50	49	36	(G/SmR)						
		105.9'	dolomite									100	78	68	"						
												150	141	133	"						
	8	101.85'-	Dolomite,												1000	17,590		0.5			167.8
		100.6'	argillaceous												2000	[illegible]		0.3			174.6
															3000	25,340		0.4			172.0
	10	97.0'	Argillaceous															0.3			174.0
		96.4'	dolomite																		

ShR = Sheared Rock Surface G/roR = Grout on rough Rock Surface, Cured 7 days.
R/smR = Smooth Rock Surface G/SmR = Grout on Smooth Rock Surface, Cured 7 days.

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1 April 75 975

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Table 8a

Table 8
SUMMARY OF ROCK CORE TESTS

ORD Laboratory
Cincinnati, Ohio

Twin Lock Study
Project Eisenhower Lock, St. Lawrence Seaway Date July 1970

Sheet 2 of 2

Identification Data				Strength Tests Data (in pounds per square inch)															Physical Data		
				Compression			Direct Shear			Sliding Friction		Grout on Rock			Triaxial Comp.						
Boring No.	Sample No.	Elev.	Rock Type	Unit Load at Fail.	Mod. Elas E 10⁶	Tensile	Normal Unit Load	Direct Unit Load at fail.	Max. Slide Resist.	Norm. Stress	Sliding Resist.	Norm. Unit Load	Bond Strength	Max. Slide Resist.	σ_3	Max. $\sigma_1 - \sigma_3$	Ult. $\sigma_1 - \sigma_3$	Nat. Water	Specific Gravity	Absorption	Unit Weight lb/ft3
C-68	12	84.96'-	Gypsum	1,820														0.4			143.0
1210		83.95'																			
C-68	1A	138.15'-	Dolomite	32,670	5.76													0.3			174.8
1211	1B	137.1'	Dolomite	3,640	0.92													0.3			174.7
	2	135.05'-	Dolomite	16,160	2.38					50	31	(R/SmR)						0.2			173.7
		133.85'								100	56	"									
										150	86	"									
	3	124.1'-	Dolomite												500	23,640		1.7			168.3
		122.9'													1500	33,420		1.5			168.3
															2500	40,830		1.6			168.5
	4	121.7'-	Argillaceous				50	211	211									1.2			169.6
		120.4'	dolomite				100	336	244												
							150	717	903												
	5	120.4'-	Dolomite	18,490	3.05													0.5			173.6
		119.25'																			
	6	114.5'-	Do.ɔmite									50	241	60							
		113.7'										100	233	133							
												150	142	79							
	7	109.55'-	Argillaceous	12,550	2.50													0.3			172.8
		108.4'	dolomite																		
	10	92.9'-	Gypsum	2,225	0.73													3.4			132.0
		91.95'																			

ShR = Sheared Rock Surface G/roR = Grout on rough Rock Surface, Cured 7 days.
R/smR = Smooth Rock Surface G/SmR = Grout on Smooth Rock Surface, Cured 7 days.

Notes for Table 8

1. Concern has been expressed over the fact that the values for unit weight of rock specimens tested in direct shear, triaxial shear, and unconfined compression do not always equal the specific gravity of the specimen times 62.4 pounds/cubic foot.

2. A search of the files was made and all of the of the work and data sheets were examined. It was determined that all values were actual determinations and that the discrepancies could be attributed to the following:

a. Both the specific gravity and the unit weight values were determined under saturated/surface-dry conditions.

b. Both determinations are very sensitive to small changes in water content. Heterogeneous rocks are especially sensitive to changes in water content below 25 percent.

c. The water content of rocks will decrease by 25 percent in 10 minutes when exposed to air at 60-65 percent relative humidity and 20-22°C. (Broch, E., "The Influence of Water on Some Rock Properties," Norwegian Institute of Technology, 1974).

d. The relation, Specific Gravity X 62.4 lbs./cu. ft. = unit weight, holds true only for homogeneous materials. Rock, in particularly this rock, is heterogeneous and, therefore, if a different specimen was used for each of the two tests, the value would differ by at least 4 or 5 lbs./cu. ft. Even if the same specimen was used, the difference could be 1-2 lbs/cu. ft.

Table 9

SUMMARY OF ROCK CORE TESTS

ORD Laboratory
Cincinnati, Ohio

Project Twin Lock Study, Snell Lock, St. Lawrence Seaway   Date April 1971   Sheet 1 of 2

Identification Data				Strength Tests Data (in pounds per square inch)														Physical Data			
				Compression			Direct Shear			Sliding Friction		Grout on Rock			Triaxial Comp.						
Boring No.	Sample No.	Elev.	Rock Type	Unit Load at Fail.	Mod. Elas $\times 10^6$	Tensile	Normal Unit Load	Direct Unit Load at fail.	Max. Slide Resist.	Type Test	Angle	Norm. Unit Load	Bond Strength	Max. Slide Resist.	σ_3	Max. $\sigma_1 - \sigma_3$	Ult. $\sigma_1 - \sigma_3$	Nat. Water	Specific Gravity	Absorption	Unit Weight lb/ft3
C-70	1	119.2'-	Dolomite									50	—	44							
1302		116.6'										100	167	94				0.29	2.79		174.3
												150	137	125							
	2	113.9'-	Dolomite	10,628	1.5										1000	35,000					
		110.6'													2000	91,000		0.84	2.78		173.4
	3	104.7'-	Dolomite												1500	108,500		0.71	2.78		174.4
		103.4'													3000	98,340					
	3	103.4'-	Dolomite				50	318	210						700	79,080		0.88	2.88		174.9
		101.2'					100	721							1400	91,340					
							150	670	346												
	4	101.2'-	Dolomite	14,875	3.4										400	65,800		1.07	2.82		176.7
		98.2													800	104,900					
	5	98.2'-	Argillaceous												1400	90,000		0.25	2.84		174.6
		95.2'	dolomite												2800	146,600					
	6	95.2'-	Dolomite	16,351	3.4										500	76,400		0.66	2.79		174.9
		91.8'													1000	85,800					
	8	88.25'-	Dolomite												1250	82,350		1.38	2.79		174.4
		85.1'													2500	117,800					
C-70	2	110.25'-	Highly argilla-	6,341	0.6		50	123	105									1.16	2.85		178.2
1303		107.1	ceous dolomite				100	220	180												
							150	472	437												
	4	105.3'-	Dolomite																		
		102.25'																			

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ShR = Sheared Rock Surface   G/roR = Grout on rough Rock Surface, Cured 7 days.
R/smR = Smooth Rock Surface   G/SmR = Grout on Smooth Rock Surface, Cured 7 days.

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Table 9
SUMMARY OF ROCK CORE TESTS

ORD Laboratory
Cincinnati, Ohio

Project Twin Lock Study, Snell Lock, St. Lawrence Seaway

Date April 1971

Sheet 2 of 2

Identification Data				Strength Tests Data (in pounds per square inch)														Physical Data			
				Compression		Tensile	Direct Shear			Sliding Friction		Grout on Rock			Triaxial Comp.						
Boring No.	Sample No.	Elev.	Type	Unit Load at Fail.	Mod. Elas E 10^6		Normal Unit Load	Direct Unit Load at fail.	Max. Slide Resist.	Type Test	Angle	Norm. Unit Load	Bond Strength	Max. Slide Resist.	σ_3	Max. $\sigma_1 - \sigma_3$	Ult. $\sigma_1 - \sigma_3$	Nat. Water	Specific Gravity	Absorption	Unit Weight lb/ft3
C-70	5	102.25'-	Dolomite				50	1532	No			50	505	67							
1303		98.8'					100	1300	Sliding			100	Lost	119							
							150	712				150	Bond	158							
	6	98.8'-	Dolomite																		
		95.6'																			
	8	92.2'-	Argillaceous	16,900	3.6										750	83,100		0.47	2.83		175.9
		89.3'	dolomite												1500	123,600					
UC-70	4	97.4'-	Dolomite									50	29	22							
1306		94.55'										100	57	46							
												150	89	67							
	6	93.3'-	Dolomite				50														
		90.3'					100	1315	1140												
							150	1562	1370												
	7	90.3'-	Dolomite									50	53	28							
		86.7'										100	125	145							
												150	171	150							
	8	86.7'-	Dolomite							R/smR	47°				500	64,250		1.35	2.77		173.6
		83.3'		14,920	1.89										1000	66,000					
	11	76.65'-	Dolomite	20,839	2.52										600	67,650		0.64	2.77		175.1
		73.5'													1200	71,600					

ShR = Sheared Rock Surface G/roR = Grout on rough Rock Surface, Cured 7 days.
R/smR = Smooth Rock Surface G/SmR = Grout on Smooth Rock Surface, Cured 7 days.

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Table 9b

Table 10
EISENHOWER "TWIN" LOCK

Summary of Pressure Test Results

Boring No.	Depth of Packer (ft)		Pressure (psi)			Flow (gpm)	Strati-graphic Units
	Top	Bottom	Gage	Static	Actual		
UDC-681201	103.1	108.1	50.0	46.8	97.0	26.0	13
	100.0	108.1	50.0	45.0	95.0	25.0	13
	89.0	108.1	47.6	41.4	89.0	32.0	13
UDC-681202	96.0	99.3	50.0	44.3	94.3	27.0	13
	91.0	96.0	48.8	42.2	91.0	27.0	13-16
	86.0	91.0	43.8	42.2	86.0	4.6	16
	81.0	86.0	43.0	38.0	81.0	1.8	16-18
	76.0	81.0	38.0	38.0	76.0	0.0	18-20
	71.0	76.0	37.0	34.0	71.0	1.4	20-22
	70.0	75.0	36.0	34.0	70.0	0.0	20-22
C-681203	201.0	205.1	50.0	93.6	143.6	0.0	4- 6
	196.0	201.0	50.0	89.3	139.3	0.0	6- 8
	191.0	196.0	50.0	89.3	139.3	0.0	8-10
	186.0	191.0	50.0	84.9	134.9	0.0	10
	181.6	186.0	50.0	84.9	134.9	0.0	10-11
	176.0	181.0	50.0	80.6	130.6	0.0	11-12
	171.0	176.0	50.0	80.6	130.6	0.0	13
	166.0	171.0	50.0	76.2	126.2	19.4	13
	161.0	166.0	50.0	76.2	126.2	23.4	13
	156.0	161.0	50.0	71.9	121.9	16.2	13
	151.0	156.0	50.0	71.9	121.9	25.0	13
	146.0	151.0	50.0	67.6	117.6	10.6	13-15
	141.0	146.0	50.0	67.6	117.6	17.2	15-17
	136.0	141.0	50.0	63.2	113.2	17.8	17
	131.0	136.0	50.0	58.9	108.9	18.8	17-19
	126.0	131.0	50.0	58.9	108.9	8.6	19-20
	121.0	126.0	50.0	58.9	108.9	7.2	20-22
	116.0	121.0	50.0	54.5	104.5	8.4	22-24
	111.0	116.0	50.0	54.5	104.5	11.6	24-25
	106.0	111.0	50.0	50.2	100.2	2.0	25
	101.0	106.0	50.0	50.2	100.2	2.4	25-26

Table 10 (cont'd)

EISENHOWER "TWIN" LOCK

Summary of Pressure Test Results

Boring No.	Depth of Packer (ft)		Pressure (psi)			Flow (gpm)	Strati-graphic Units
	Top	Bottom	Gage	Static	Actual		
C-681204	208.0	211.0	50.0	93.6	143.6	0.0	8- 9
	203.0	208.0	50.0	89.3	139.3	0.0	9-10
	198.0	203.0	50.0	89.3	139.3	0.0	10-11
	193.0	198.0	50.0	84.9	134.9	0.0	11-12
	188.0	193.0	50.0	84.9	134.9	0.0	12-13
	183.0	188.0	50.0	81.6	131.6	1.1	13
	178.0	183.0	50.0	81.6	131.6	22.6	13
	173.0	178.0	50.0	76.2	126.2	22.2	13
	168.0	173.0	50.0	76.2	126.2	24.4	13
	166.0	171.0	50.0	76.2	126.2	24.6	13-14
	161.6	166.6	50.0	71.9	121.9	12.4	14-15
	156.6	161.6	50.0	71.9	121.9	7.4	15-16
	151.6	156.6	50.0	71.9	121.9	22.4	16-17
	146.6	151.6	50.0	67.6	117.6	22.2	17-19
	141.6	146.6	50.0	67.6	117.6	8.4	19-20
	136.6	141.6	50.0	63.2	113.2	6.4	20-22
	131.6	136.6	50.0	63.2	113.2	6.6	22-24
	126.6	131.6	50.0	58.9	108.9	9.0	24-25
	121.6	126.6	50.0	58.9	108.9	10.8	25
	116.6	121.6	50.0	54.5	104.5	1.5	25-26
	111.6	116.6	50.0	54.5	104.5	10.0	26-27
C-681205	176.0	179.0	50.0	80.6	130.6	1.0	2
	171.0	176.0	50.0	76.3	126.3	3.0	2- 3
	166.0	171.0	50.0	76.3	126.3	5.6	3- 4
	161.0	166.0	50.0	71.9	121.9	0.0	5
	156.0	161.0	50.0	71.9	121.9	0.0	5- 7
	151.0	156.0	50.0	67.6	117.6	21.3	7- 9
	146.0	151.0	50.0	67.6	117.6	2.6	10
	141.0	146.0	50.0	63.3	113.3	0.0	10-11
	136.0	141.0	50.0	63.3	113.3	0.0	11-12
	131.0	136.0	50.0	58.9	108.9	0.0	13
	126.0	131.0	50.0	58.9	108.9	20.2	13
	121.0	126.0	50.0	54.6	104.6	16.8	13
	116.0	121.0	50.0	54.6	104.6	2.0	13
	101.0	106.0	50.0	45.9	95.9	25.4	16
	96.0	101.0	50.0	45.9	95.9	17.8	16-18
	91.0	96.0	49.5	41.5	91.0	21.4	18-20
	86.0	91.0	44.5	41.5	86.0	23.5	20-22

Table 10 (cont'd)
EISENHOWER "TWIN" LOCK

Summary of Pressure Test Results

Boring No.	Depth of Packer (ft)		Pressure (psi)			Flow (gpm)	Strati-graphic Units
	Top	Bottom	Gage	Static	Actual		
C-681207	198.5	201.7	50.0	89.3	139.3	0.0	2- 3
	193.5	198.5	50.0	84.9	134.9	0.0	3- 4
	188.5	193.5	50.0	84.9	134.9	0.0	4- 5
	183.5	188.5	50.0	84.9	134.9	0.0	5- 7
	178.5	183.5	50.0	80.6	130.6	0.0	7- 9
	173.5	178.5	50.0	80.6	130.6	0.0	9-10
	168.5	173.5	50.0	76.3	126.3	0.5	10-11
	163.5	168.5	50.0	76.3	126.3	0.0	11-12
	158.5	163.5	50.0	71.9	121.9	0.3	12-13
	153.5	158.5	50.0	71.9	121.9	4.5	13
	148.5	153.5	50.0	67.6	117.6	22.8	13
	143.5	148.5	50.0	67.6	117.6	24.0	13
	138.5	143.5	50.0	63.3	113.3	16.8	13
	131.5	136.5	50.0	63.3	113.3	25.4	14-15
	126.5	131.5	50.0	63.3	113.3	25.8	15-16
	121.5	126.5	50.0	63.3	113.3	24.2	16-17
	116.5	121.5	50.0	58.9	108.9	13.0	17-19
	111.5	116.5	50.0	58.9	108.9	18.0	19-20
	106.5	111.5	50.0	54.6	104.6	13.8	21-22
	101.5	106.5	46.9	54.6	101.5	13.0	22-24
AC-681208	172.0	175.5	50.0	76.3	126.3	0.0	0- 1
	166.9	171.9	50.0	76.3	126.3	10.7	1
	161.9	166.9	50.0	76.3	126.3	11.0	1- 2
	156.9	161.9	50.0	71.9	121.9	15.0	2
	151.9	156.9	50.0	71.9	121.9	11.4	2
	146.9	151.9	50.0	67.6	117.6	9.5	2- 3
	141.9	146.9	50.0	67.6	117.6	8.7	3- 4
	136.9	141.9	50.0	63.2	113.2	6.5	4- 5
	131.9	136.9	50.0	63.2	113.2	6.6	5- 7
	126.9	131.9	50.0	58.9	108.9	5.6	7- 9
	121.9	126.9	50.0	58.9	108.9	6.0	9-10
	116.9	121.9	50.0	54.5	104.5	5.7	10-11
	111.9	116.9	50.0	54.5	104.5	2.6	11-12
	106.9	111.9	50.0	50.2	100.2	23.4	12-13
	101.9	106.9	50.0	50.2	100.2	25.2	13
	96.9	101.9	50.0	45.9	95.9	9.4	13
	91.9	96.9	46.0	45.9	91.9	5.83	13
	86.9	91.9	45.4	41.5	86.9	1.0	13
	81.9	86.9	40.4	41.5	81.9	10.2	13-16

Table 10 (cont'd)
EISENHOWER "TWIN" LOCK

Summary of Pressure Test Results

Boring No.	Depth of Packer (ft)		Pressure (psi)			Flow (gpm)	Strati-graphic Units
	Top	Bottom	Gage	Static	Actual		
AC-681209	188.2	193.2	50.0	89.3	139.3	18.8	2
	183.2	188.2	50.0	89.3	139.3	8.2	2
	178.2	183.2	50.0	80.6	130.6	8.2	2
	173.2	178.2	50.0	80.6	130.6	5.7	2- 4
	168.2	173.2	50.0	80.6	130.6	3.6	4- 5
C-681210	203.2	205.2	50.0	89.3	139.3	0.0	10
	198.2	203.2	50.0	89.3	139.3	0.0	10-11
	193.2	198.2	50.0	89.3	139.3	0.0	11-12
	188.2	193.2	50.0	85.0	135.0	0.0	12-13
	183.2	188.2	50.0	85.0	135.0	7.3	13
	178.2	183.2	50.0	80.7	130.7	20.3	13
	173.2	178.2	50.0	80.7	130.7	5.0	13
	168.2	173.2	50.0	76.4	126.4	24.3	13
	163.2	168.2	50.0	76.4	126.4	2.3	13-15
	158.2	163.2	50.0	72.1	122.1	0.0	15-16
	153.2	158.2	50.0	72.1	122.1	24.0	16
	148.2	153.2	50.0	67.8	117.8	25.0	17-18
	143.2	148.2	50.0	67.8	117.8	0.0	19-20
	138.2	143.2	50.0	63.5	113.5	2.0	20-22
	133.2	138.2	50.0	63.5	113.5	0.0	22-24
	128.2	133.2	50.0	59.2	109.2	1.6	24-25
	123.2	128.2	50.0	59.2	109.2	3.6	25
	118.2	123.2	50.0	54.9	104.9	1.6	25-26
	113.2	118.2	50.0	54.9	104.9	6.6	26-27
C-681211	204.0	209.0	50.0	88.5	138.5	0.0	6- 8
	199.0	204.0	50.0	88.5	138.5	0.0	8-10
	194.0	199.0	50.0	88.5	138.5	0.0	10-11
	189.0	194.0	50.0	88.5	138.5	0.0	11
	184.0	189.0	50.0	79.8	129.8	0.0	11-13
	179.0	184.0	50.0	79.8	129.8	11.6	13
	174.0	179.0	50.0	79.8	129.8	3.0	13
	169.0	174.0	50.0	79.8	129.8	22.0	13
	164.0	169.0	50.0	71.1	121.1	25.0	13
	159.0	164.0	50.0	71.1	121.1	25.0	13-14
	154.0	159.0	50.0	71.1	121.1	2.0	14-15
	149.0	154.0	50.0	71.1	121.1	5.0	15-16
	144.0	149.0	50.0	71.1	121.1	6.0	16-17
	139.0	144.0	50.0	62.4	112.4	0.0	17-19
	134.0	139.0	50.0	62.4	112.4	3.0	19-20
	129.0	134.0	50.0	62.4	112.4	3.0	20-22
	124.0	129.0	50.0	62.4	112.4	1.0	22-24
	119.0	124.0	50.0	53.7	103.7	3.0	24-25
	114.0	119.0	50.0	53.7	103.7	3.5	25

Table 11

SNELL "TWIN" LOCK

Summary of Pressure Test Results

Boring No.	Depth of Packer (ft)		Pressure (psi)			Flow (gpm)	Strati-graphic Units
	Top	Bottom	Gage	Static	Actual		
C-701301	164.3	169.3	50	71.3	121.3	0.0	7-10
	161.8	166.8	50	70.2	120.2	0.0	9-10
	156.8	161.8	50	68.0	118.0	0.0	10-11
	151.8	156.8	50	65.8	115.8	0.03	11
	146.8	151.8	50	63.6	113.6	0.33	11-13
	141.8	146.8	50	61.4	111.4	1.63	13
	136.8	141.8	50	59.2	109.2	0.66	13
	131.8	136.8	50	57.0	107.0	1.93	13
	126.8	131.8	50	54.8	104.8	1.4	13-14
	121.8	126.8	50	52.6	102.6	16.3	14-16
	111.8	116.8	50	48.2	98.2	13.2	16-17
	106.8	111.8	50	46.0	96.0	9.0	18-19
	101.8	106.8	50	43.8	93.8	7.13	19-21
	96.8	101.8	50	41.6	91.6	6.66	21-22
	91.8	96.8	50	39.4	89.4	5.26	22-24
	86.8	91.8	49.6	37.2	86.8	7.3	24-25
	81.8	86.8	46.8	35.0	81.8	7.5	25
	78.8	83.8				15.66	25-26
C-701302	167.8	172.8	50	70.7	120.7	0.0	7- 9
	162.8	167.8	50	68.5	118.5	0.0	9-10
	157.8	162.8	50	66.3	116.3	0.0	10-11
	152.8	157.8	50	64.1	114.1	0.1	11
	147.8	152.8	50	61.9	111.9	0.33	11-13
	142.8	147.8	50	59.7	109.7	0.4	13
	137.8	142.8	50	57.5	107.5	0.33	13
	132.8	137.8	50	55.3	105.3	0.0	13
	127.8	132.8	50	53.1	103.1	13.5	13
	122.8	127.8	50	50.9	100.9	16.5	13-15
	117.8	122.8	50	48.7	98.7	0.85	15-16
	112.8	117.8	50	46.5	96.5	0.5	16-18
	107.8	112.8	50	44.3	94.3	1.7	18-19
	102.8	107.8	50	42.1	92.1	0.6	20-21
	97.8	102.8	50	39.9	89.9	5.0	21-22
	92.8	97.8	50	37.7	87.7	7.3	22-24
	87.8	92.8	50	35.5	85.5	9.6	24-25
	82.8	87.8	50	33.3	83.3	17.5	25
	77.8	82.8	45	31.1	76.1	14.1	25-26

Table 11 (cont'd)

SNELL "TWIN" LOCK

Summary of Pressure Test Results

Boring No.	Depth of Packer (ft)		Pressure (psi)			Flow (gpm)	Strati-graphic Units
	Top	Bottom	Gage	Static	Actual		
C-701303	167.9	172.9	50	78.0	128.0	0.0	6- 8
	168.9	171.9	50	78.0	128.0	0.0	7- 8
	163.9	168.9	50	73.7	123.7	0.0	8-10
	158.9	163.9	50	73.7	123.7	0.0	10-11
	153.9	158.9	50	69.4	119.4	0.0	11
	148.9	153.9	50	69.4	119.4	0.0	11-13
	143.9	148.9	50	65.1	115.1	0.0	13
	138.9	143.9	50	65.1	115.1	0.0	13
	133.9	138.9	50	60.8	110.8	0.26	13
	128.9	133.9	50	60.8	110.8	16.9	13
	123.9	128.9	50	56.5	106.5	14.3	13-15
	118.9	123.9	50	56.5	106.5	1.0	15-16
	113.9	118.9	50	52.2	102.2	0.5	16-17
	108.9	113.9	50	52.2	102.2	0.33	17-19
	103.9	108.9	50	47.9	97.9	1.0	19-20
	98.9	103.9	50	47.9	97.9	12.0	20-22
	93.9	98.9	50	43.6	93.6	1.2	22-24
	88.9	93.9	45	43.6	88.6	2.16	24-25
	83.9	88.9	45	39.3	84.3	16.0	25
	79.9	84.9	40	39.3	79.3	19.5	25-26
C-701304	159.4	164.4	50	71.8	121.8	0.0	1
	156.4	161.4	50	71.8	121.8	0.1	1- 2
	151.4	156.4	50	67.5	117.5	0.2	2
	146.4	151.4	50	67.5	117.5	0.23	2
	141.4	146.4	50	63.2	113.2	2.1	2- 3
	136.4	141.4	50	63.2	113.2	0.7	3- 5
	131.4	136.4	50	58.9	108.9	1.3	5- 6
	126.4	131.4	50	58.9	108.9	0.76	6- 8
	121.4	126.4	50	54.6	104.6	1.8	8-10
	116.4	121.4	50	54.6	104.6	0.83	10-11
	111.4	116.4	50	50.3	100.3	1.03	11
	106.4	111.4	50	50.3	100.3	0.93	11-13
	101.4	106.4	50	46.3	96.3	0.26	13
	96.4	101.4	50	46.3	96.3	0.0	13
	91.4	96.4	45	42.3	87.3	0.33	13
	86.4	91.4	45	42.3	87.3	0.33	13
	81.4	86.4	40	38.0	78.0	14.0	13-15
	76.4	81.4	40	38.0	78.0	7.3	15-16
	71.4	76.4	35	33.7	68.7	14.5	16
	68.4	72.4	35	33.7	68.7	15.0	16-18

Table 11 (cont'd)
SNELL "TWIN" LOCK

Summary of Pressure Test Results

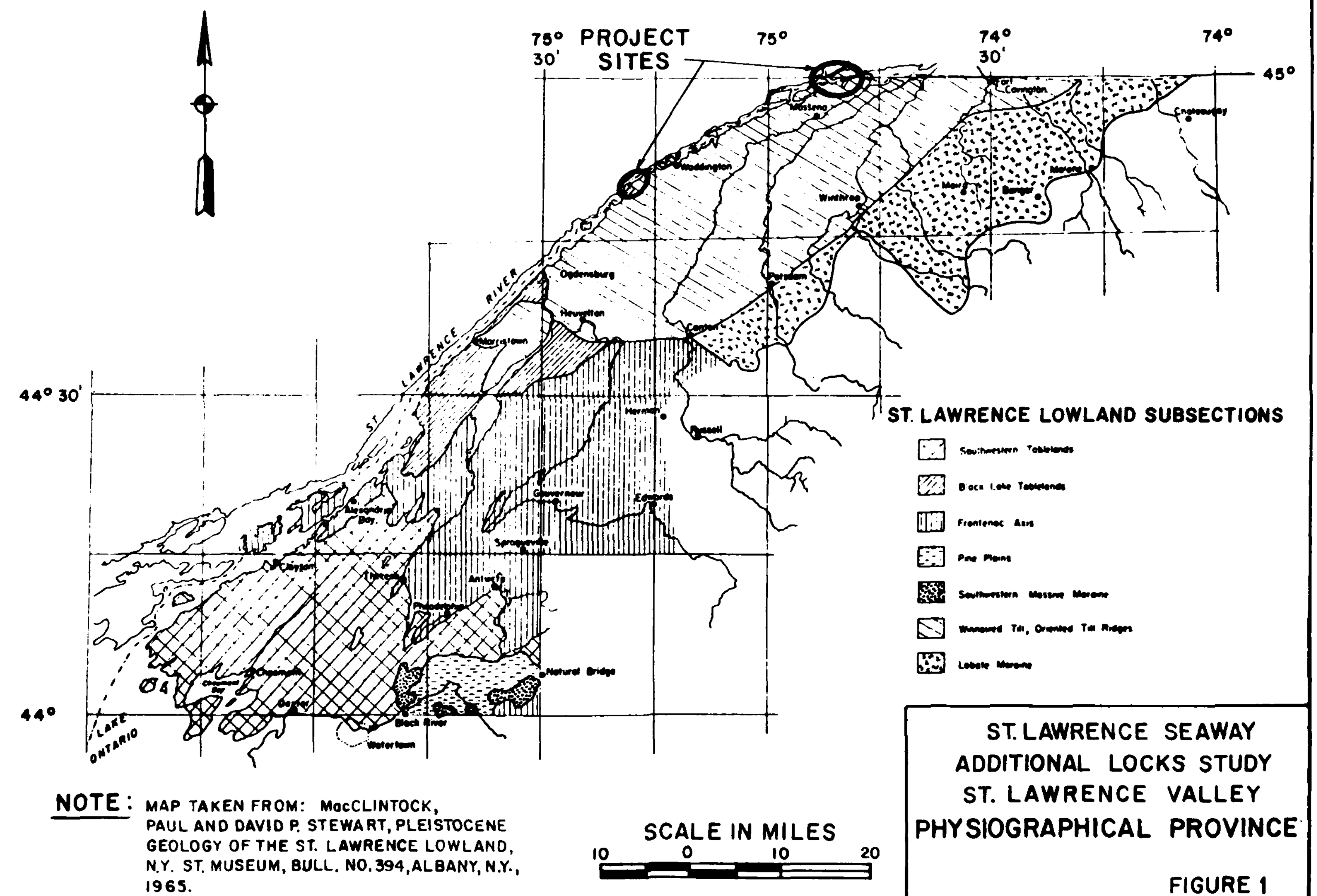
Boring No.	Depth of Packer (ft)		Pressure (psi)			Flow (gpm)	Strati-graphic Units
	Top	Bottom	Gage	Static	Actual		
C-701305	144.3	149.3	50	63.5	113.5	0.0	2
	141.3	146.3	50	63.5	113.5	0.0	2- 4
	136.3	141.3	50	63.5	113.5	0.0	4- 5
	131.3	136.3	50	59.2	109.2	6.6	5- 6
	126.3	131.3	50	59.2	109.2	2.0	6- 9
	121.3	126.3	50	54.9	104.9	0.5	9-10
	116.3	121.3	50	54.9	104.9	1.0	10-11
	111.3	116.3	50	50.6	100.6	0.0	11
	106.3	111.3	50	50.6	100.6	8.6	11-13
	101.3	106.3	50	46.3	96.3	1.16	13
	96.3	101.3	50	46.3	96.3	11.6	13
	91.3	96.3	50	42.0	92.0	3.5	13
	86.3	91.3	45	42.0	92.0	10.5	13
	81.3	86.3	45	37.7	82.7	12.0	13-15
	76.3	81.3	40	37.7	77.7	12.16	15-16
	71.3	76.3	35	33.4	68.4	9.6	16-17
	66.3	71.3	30	33.4	63.4	0.0	17-19
	61.3	66.3	30	29.1	59.1	0.0	19-20
	57.3	62.3	30	29.1	59.1	10.8	20-22
UC-701306	144.5	149.5	50	63.6	113.6	0.0	2
	142.5	147.5	50	63.6	113.6	0.0	2
	137.5	142.5	50	63.6	113.6	0.0	2- 3
	132.5	137.5	50	59.3	109.3	0.0	3- 4
	127.5	132.5	50	59.3	109.3	0.0	4- 5
	122.5	127.5	50	55.0	105.0	0.0	5- 7
	117.5	122.5	50	55.0	105.0	0.0	8-10
	112.5	117.5	50	50.7	100.7	0.0	10
	107.5	112.5	50	50.7	100.7	0.0	10-11
	102.5	107.5	50	46.4	96.4	2.0	11-12
	97.5	102.5	50	46.4	96.4	0.0	12-13
	92.5	97.5	50	42.1	92.1	0.0	13
	87.5	92.5	45	42.1	87.1	0.0	13
	82.5	87.5	45	37.8	82.8	0.0	13
	77.5	82.5	40	37.8	77.8	12.5	13
	72.5	77.5	40	33.5	73.5	10.0	13-16
	67.5	72.5	35	33.5	68.5	10.6	16
	62.5	67.5	35	29.2	64.2	0.0	16-18
	57.5	62.5	30	29.2	59.2	0.0	18-20

Table 11 (cont'd)
SNELL "TWIN" LOCK
Summary of Pressure Test Results

Boring No.	Depth of Packer (ft)		Pressure (psi)			Flow (gpm)	Strati-graphic Units
	Top	Bottom	Gage	Static	Actual		
C-701307	137.1	142.1	50	61.3	111.3	0.0	5- 7
	132.1	137.1	50	57.0	107.0	0.0	7- 9
	127.1	132.1	50	57.0	107.0	0.0	9-10
	122.1	127.1	50	52.7	102.7	0.0	10-11
	117.1	122.1	50	52.7	102.7	0.0	11-12
	112.1	117.1	50	48.4	98.4	0.0	12-13
	107.1	112.1	50	48.4	98.4	0.0	13
	102.1	107.1	50	44.1	94.1	0.0	13
	97.1	102.1	50	44.1	94.1	11.2	13
	92.1	97.1	50	39.8	89.8	13.8	13
	87.1	92.1	50	39.8	89.8	13.9	13-15
	82.1	87.1	45	35.5	80.5	10.2	15-16
	77.1	82.1	40	35.5	75.5	6.0	16-18
	72.1	77.1	35	31.2	66.2	0.0	18-20
	67.1	72.1	35	31.2	66.2	0.0	20-22
	62.1	67.1	30	26.9	56.9	0.0	22-23
	57.1	62.1	30	26.9	56.9	1.2	23-24
	52.1	57.1	30	22.6	52.6	9.0	24-25
C-701308	99.4	104.4	50	46.2	96.2	0.0	13
	97.4	102.4	50	46.2	96.7	14.1	13
	92.4	97.4	50	41.9	91.9	6.0	13-16
	87.4	92.4	45	41.9	86.9	12.0	16
	82.4	87.4	45	37.6	82.6	0.0	16-18
	77.4	82.4	40	37.6	77.6	0.0	18-20
	72.4	77.4	40	33.3	73.3	0.0	20-22
	67.4	72.4	35	33.3	68.3	0.0	22-23
	62.4	67.4	35	29.0	64.0	2.5	23-24
	57.4	62.4	30	29.0	59.0	15.5	24-25
C-701309	137.0	142.0	50	60.3	110.3	0.0	11
	134.5	139.5	50	56.0	106.0	7.5	11-13
	129.5	134.5	50	56.0	106.0	0.0	13
	124.5	129.5	50	51.7	101.7	5.2	13
	119.5	124.5	50	51.7	101.7	6.5	13
	114.5	119.5	50	47.4	97.4	5.0	13
	109.5	114.5	50	47.4	97.4	3.0	13-14
	104.5	109.5	50	43.1	93.1	6.5	14-16
	99.5	104.5	50	43.1	93.1	3.5	16-18
	94.5	99.5	50	38.8	88.8	5.5	18-20

Table 11 (cont'd)
SNELL "TWIN" LOCK
Summary of Pressure Test Results

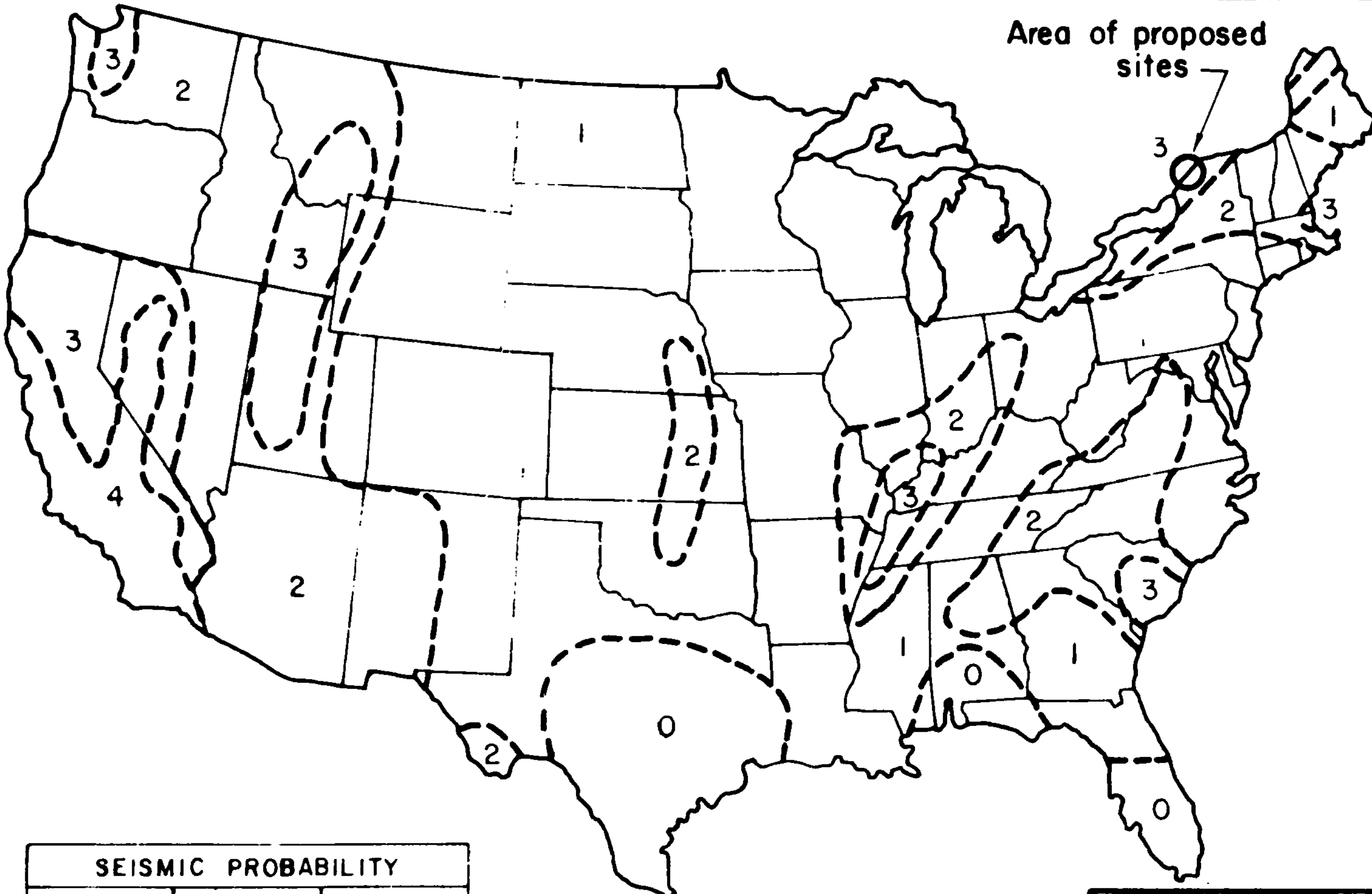
Boring No.	Depth of Packer (ft)		Pressure (psi)			Flow (gpm)	Strati-graphic Units
	Top	Bottom	Gage	Static	Actual		
C-701310	80.6	85.6	45	35.8	80.8	0.8	15-16
	75.6	80.6	40	35.8	75.8	14.6	16-17
	70.6	75.6	40	31.5	71.5	0.0	17-19
	65.6	70.6	35	31.5	66.5	11.5	19-20
	60.6	65.6	30	27.2	57.2	0.0	20-22
	55.6	60.6	30	27.2	57.2	0.0	22-24
	50.6	55.6	25	22.9	47.9	0.0	24-25
	45.6	50.6	25	22.9	47.9	13.5	25



ST. LAWRENCE SEAWAY
ADDITIONAL LOCKS STUDY
ST. LAWRENCE VALLEY
PHYSIOGRAPHICAL PROVINCE

FIGURE 1

NOTE: MAP TAKEN FROM: MacCLINTOCK, PAUL AND DAVID P. STEWART, PLEISTOCENE GEOLOGY OF THE ST. LAWRENCE LOWLAND, N.Y. ST. MUSEUM, BULL. NO. 394, ALBANY, N.Y., 1965.

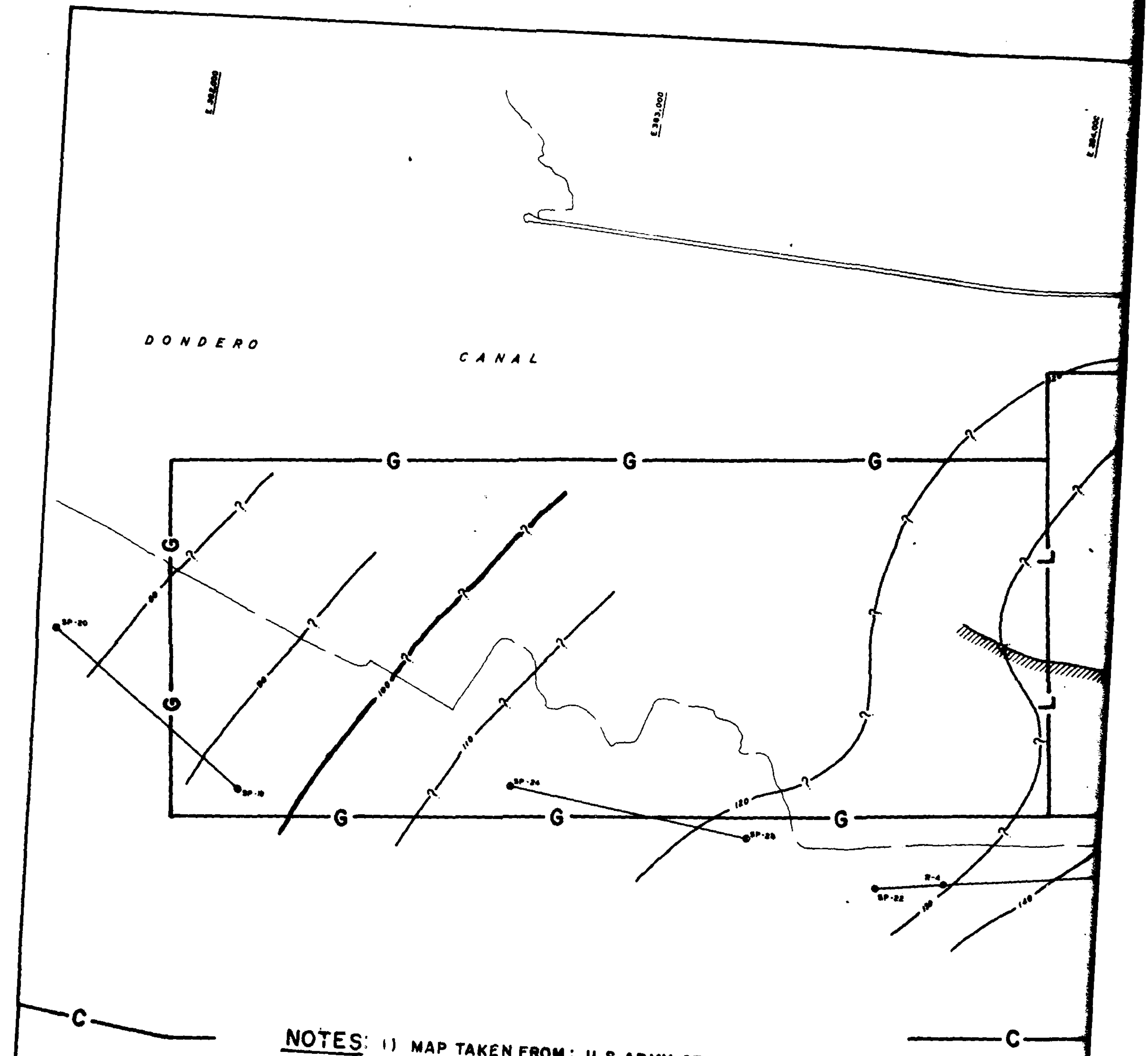


SEISMIC PROBABILITY		
ZONE	DAMAGE	COEFF
0	NONE	0
1	MINOR	0.025
2	MODERATE	0.05
3	MAJOR	0.10
4	GREAT	0.15

ST. LAWRENCE SEAWAY
ADDITIONAL LOCKS STUDY

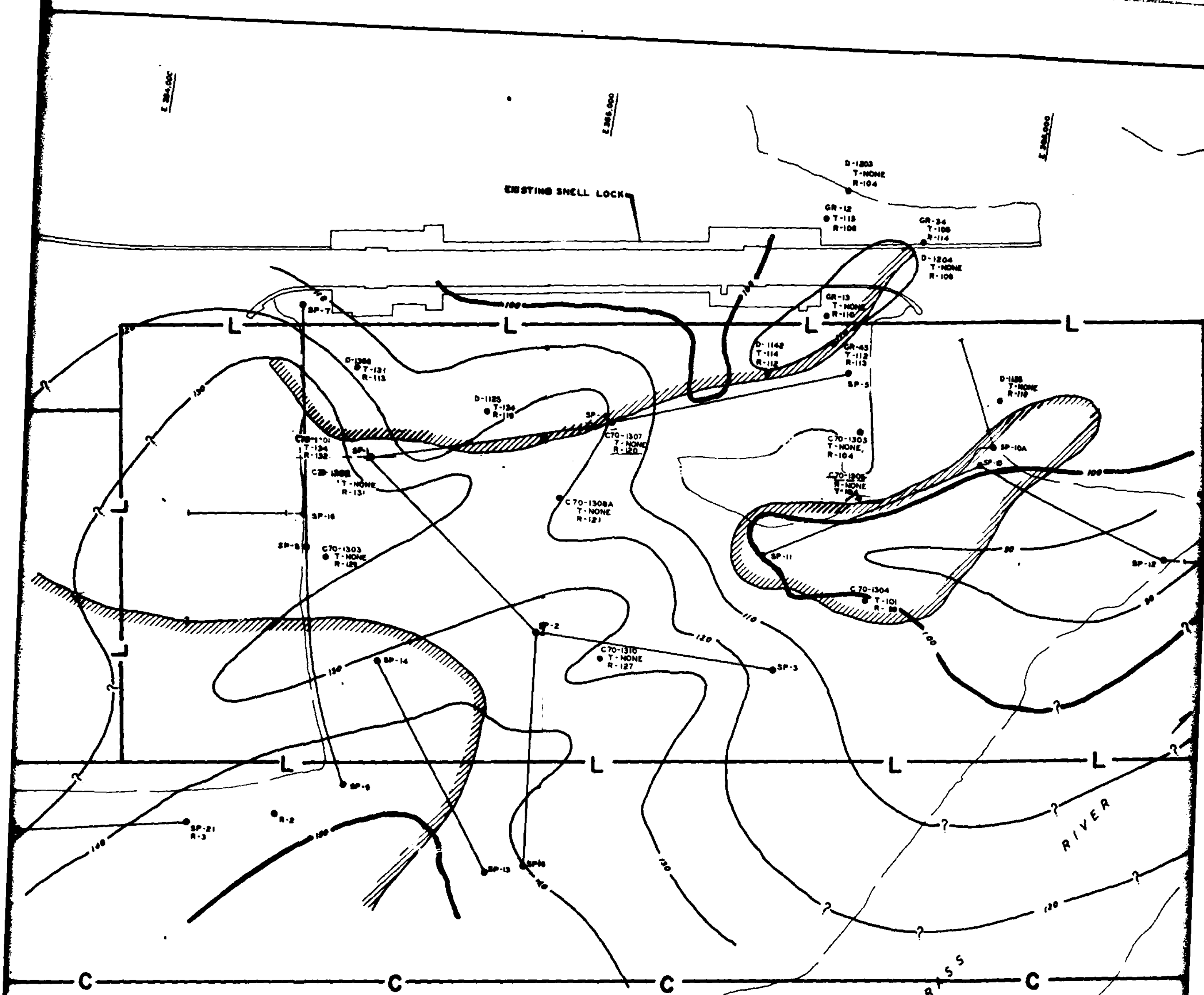
SEISMIC RISK MAP

FIGURE 2



NOTES: 1) MAP TAKEN FROM: U.S. ARMY, ST. LAWRENCE SEAWAY, STUDY OF ADDITIONAL LOCKS, GEOPHYSICAL EXPLORATIONS, CORPS OF ENGINEERS, MISSOURI RIVER DIVISION, 1970.

2) BEDROCK CONTOURS ARE IN FEET ABOVE IGLD, 1955.



LEGEND

SP-1 SP-2 SEISMIC LINE AND SHOT POINT

R-1 RESISTIVITY STATION

C70-1301 T-134 R-132 DRILL HOLE W/ ELEVATION (IGLD, 1955) OF TILL AND BEDROCK

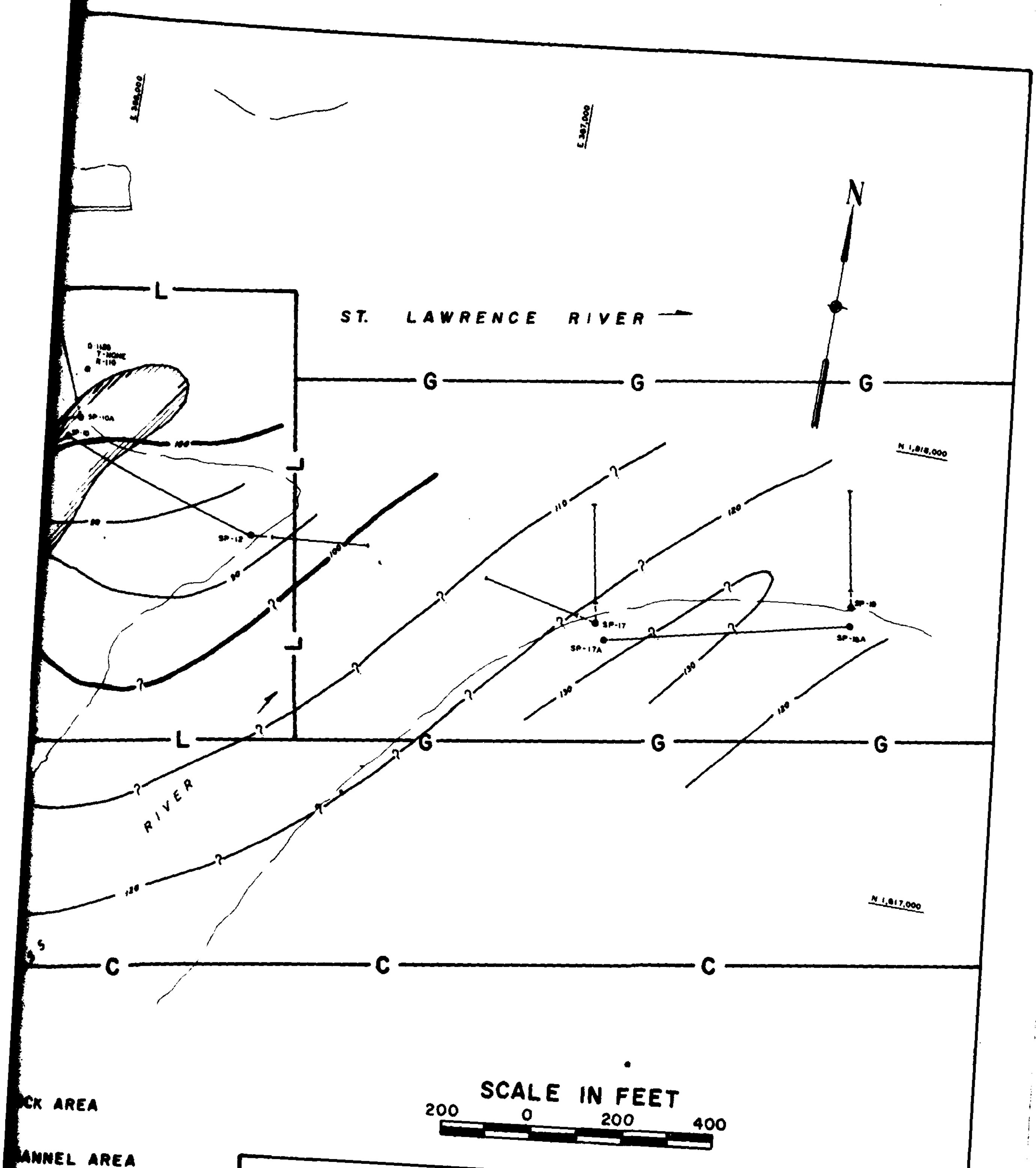
AREAL LIMITS OF TILL

—L— LOCK AREA

—C— CHANNEL AREA

—G— GUIDE WALL AREA

2

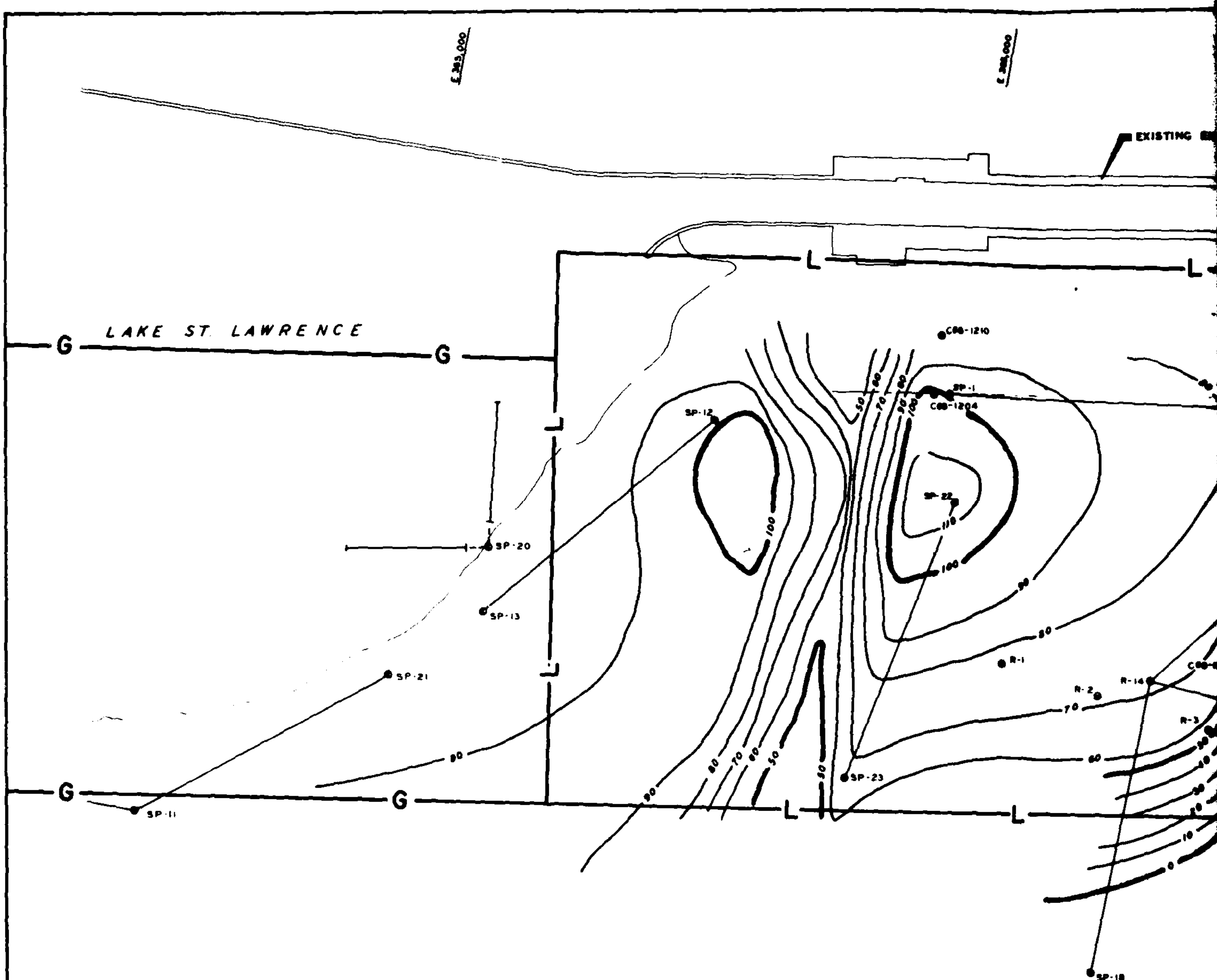


ST. LAWRENCE SEAWAY
ADDITIONAL LOCKS STUDY

TOP OF ROCK CONTOUR MAP
VICINITY, SNELL "TWIN" LOCK ALTERNATIVE

3

FIGURE 3



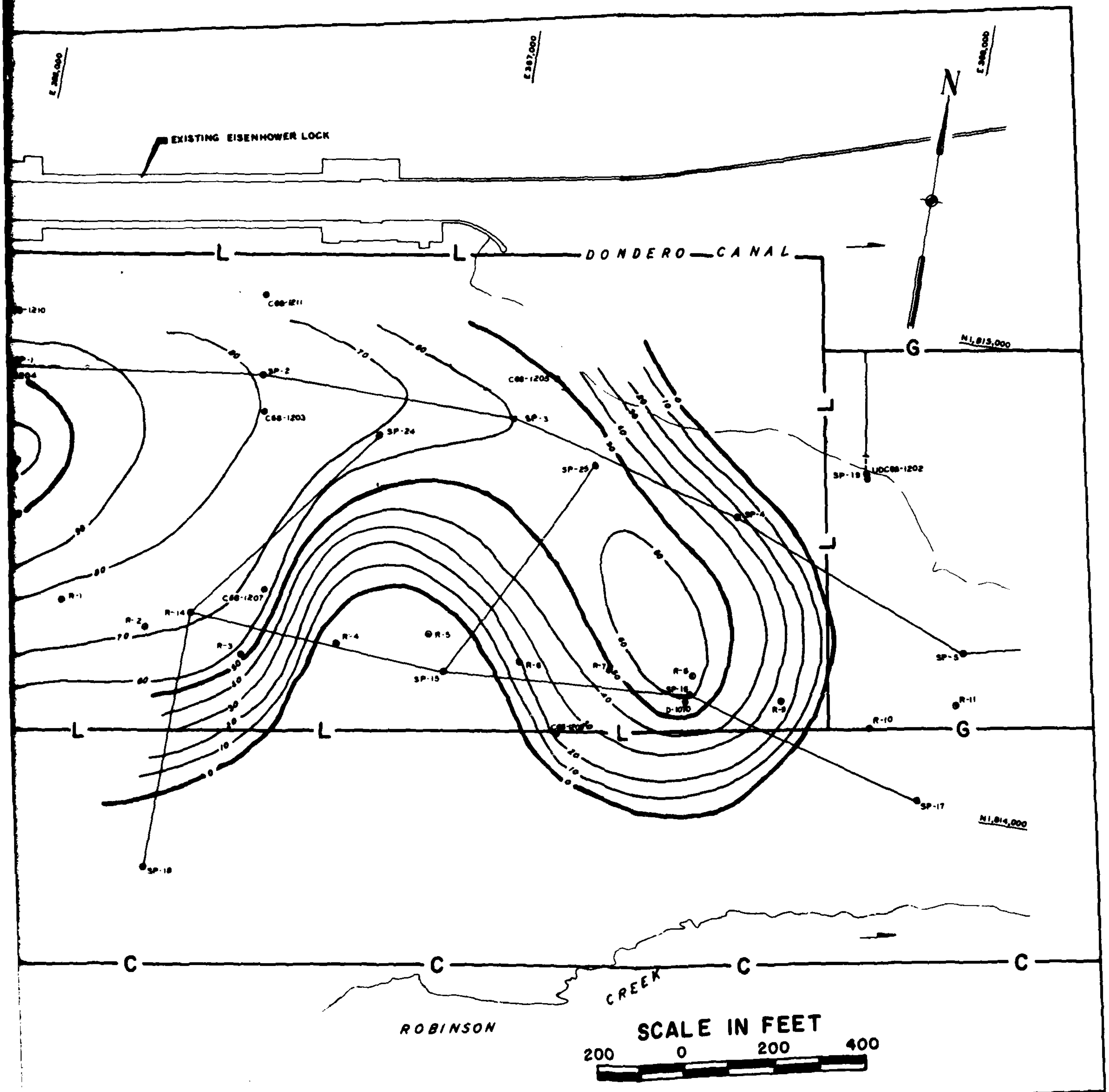
NOTES: 1) MAP TAKEN FROM U.S. ARMY, ST LAWRENCE SEAWAY, STUDY OF ADDITIONAL LOCKS, GEOPHYSICAL EXPLORATIONS, CORPS OF ENGINEERS, MISSOURI RIVER DIVISION, 1970.

2) TILL ISOPACH LINES ARE IN FEET.

—C————————C—

LEGEND

Symbol	Description	Symbol	Description
SP-1 ●———⊗ SP-2	SEISMIC LINE AND SHOT POINT	—L—	LOCK AREA
R-1 ⊙	RESISTIVITY STATION	—C—	CHANNEL AREA
C68 - 1205 ●	DRILL HOLE	—G—	GUIDE WALL AREA



CK AREA

ANNEL AREA

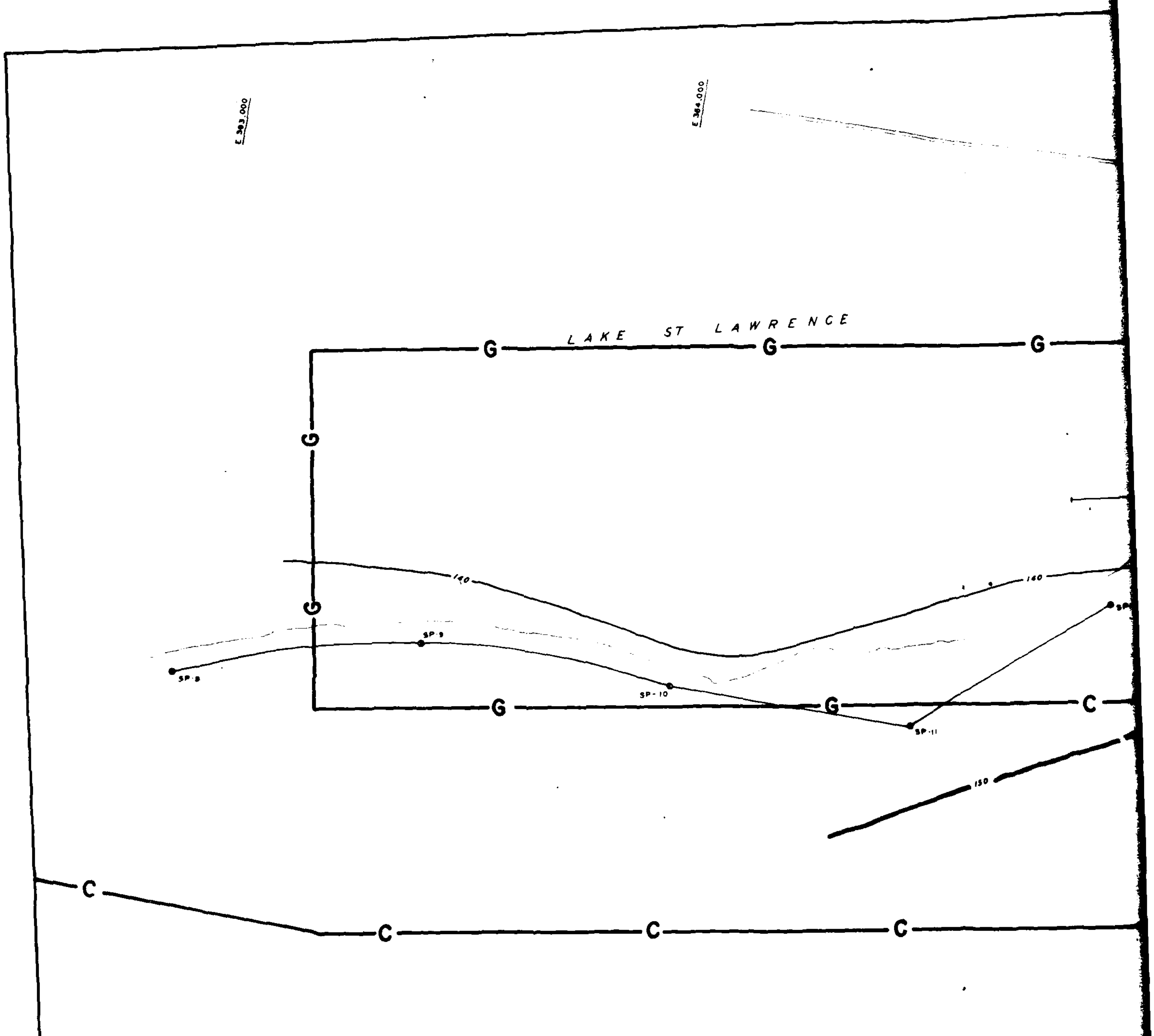
IDE WALL AREA

ST. LAWRENCE SEAWAY
ADDITIONAL LOCKS STUDY

TILL ISOPACH MAP
VICINITY, EISENHOWER "TWIN" LOCK ALTERNATIVE

FIGURE 4

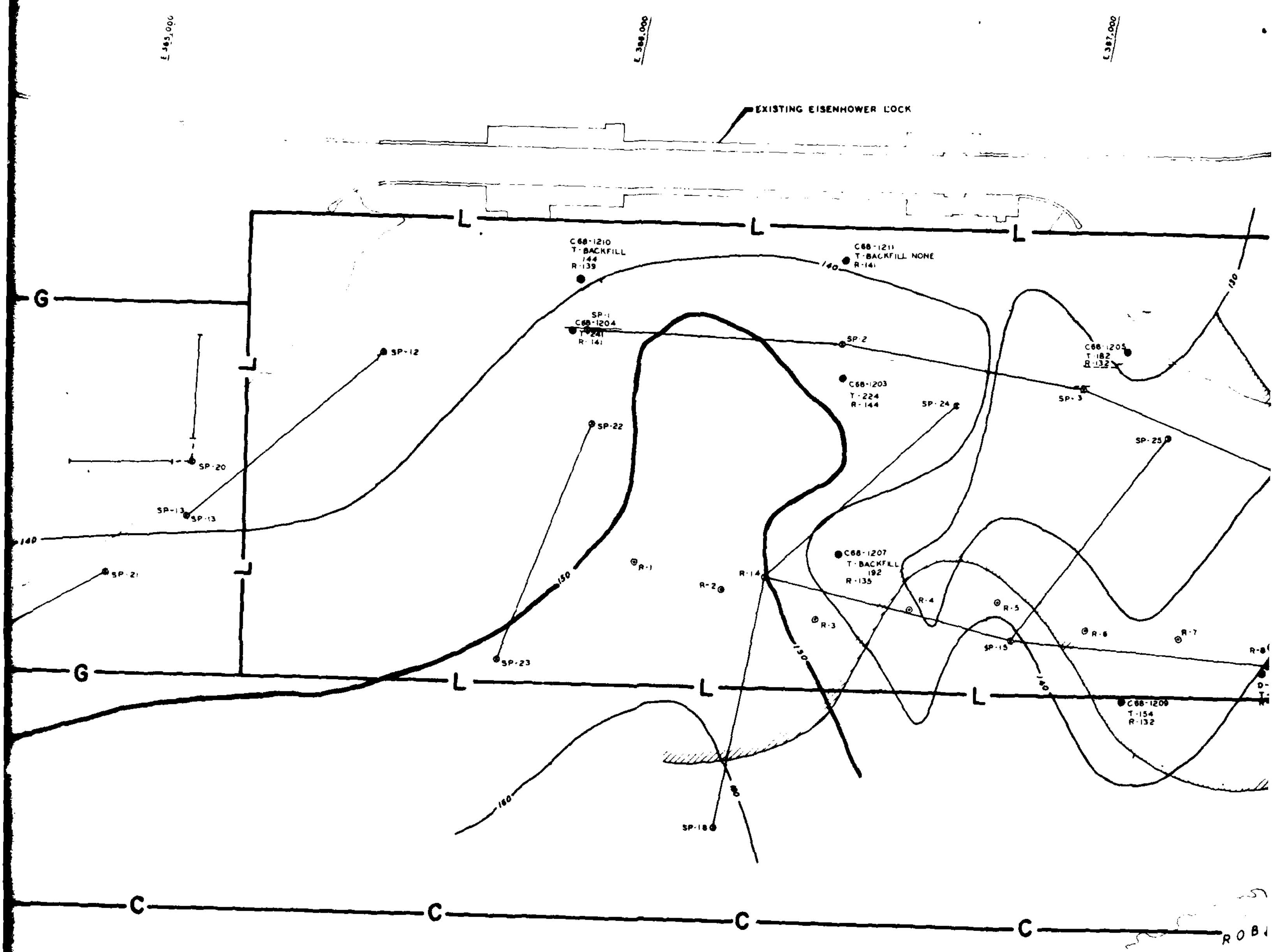
2



NOTES: 1) MAP TAKEN FROM: U.S.ARMY, ST. LAWRENCE SEAWAY, STUDY OF ADDITIONAL LOCKS, GEOPHYSICAL EXPLORATIONS, CORPS OF ENGINEERS, MISSOURI RIVER DIVISION, 1970.

2) BEDROCK CONTOURS ARE IN FEET ABOVE IGLD, 1955.

SP-1



LEGEND

SP-1 —— SP-2	SEISMIC LINE AND SHOT POINT	—L—	LOCK AREA
R-1 ⊙	RESISTIVITY STATION	—C—	CHANNEL AREA
C70-1301 ● T-134 R-132	DRILL HOLE W/ ELEVATION (IGLD,1955) OF TILL AND BEDROCK	—G—	GUIDE WALL AREA
	AREAL LIMITS OF TILL		

2

VIC

AD-A118 522 CORPS OF ENGINEERS BUFFALO NY BUFFALO DISTRICT F/G 13/2
SAINT LAWRENCE SEAWAY ADDITIONAL LOCKS STUDY, APPENDICES.(U)
JUL 82

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5 OF 6
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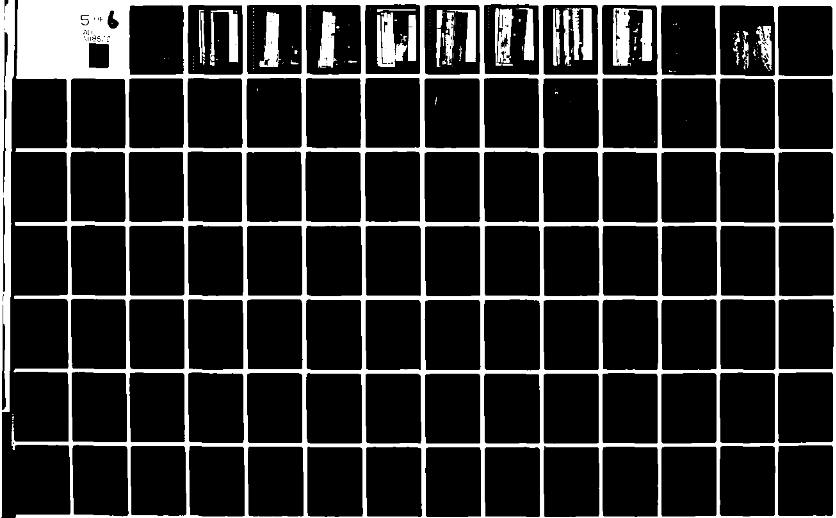
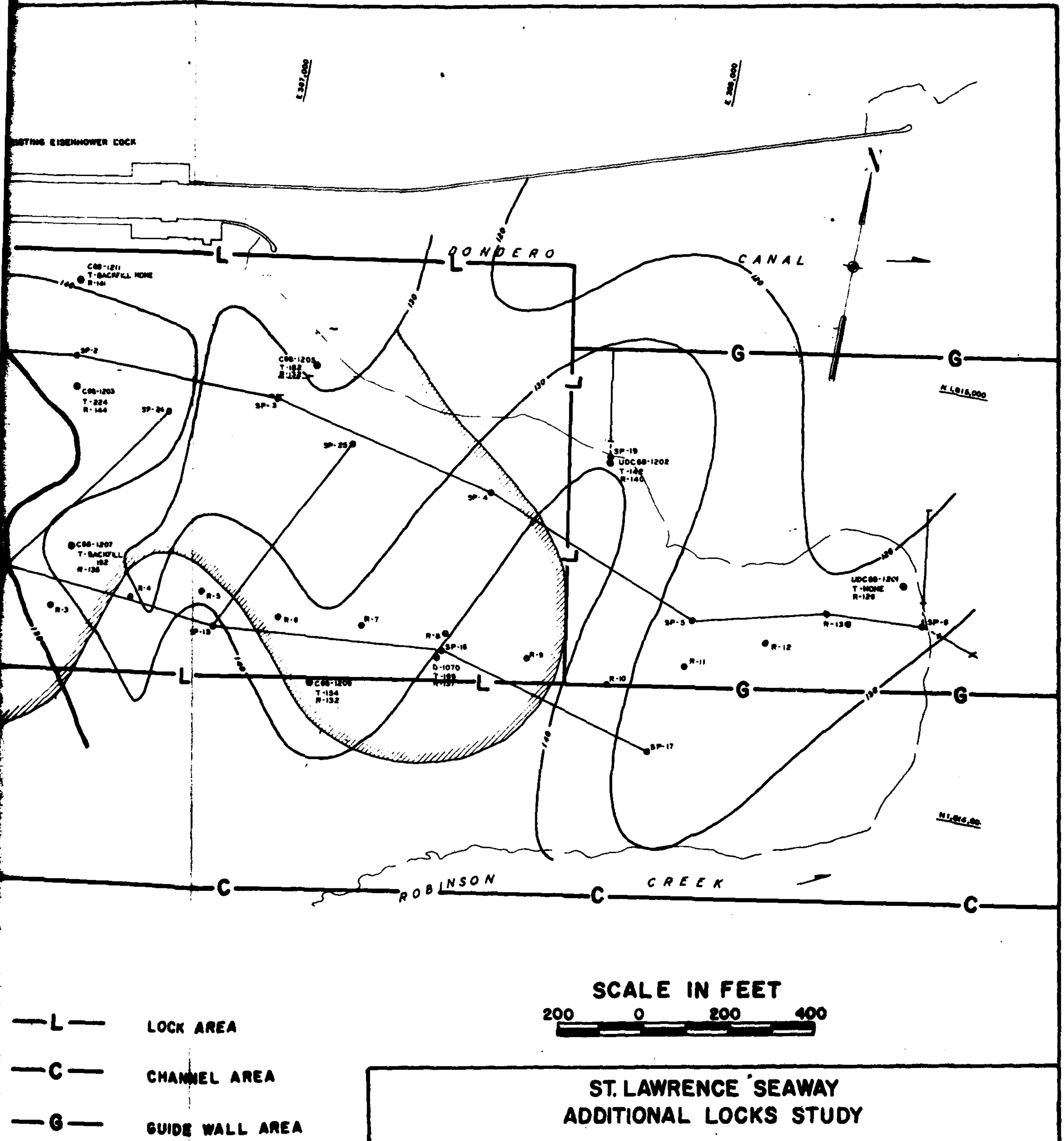




ST. LAWRENCE SEAWAY
ADDITIONAL LOCKS STUDY

TOP OF ROCK CONTOUR MAP
VICINITY, EISENHOWER "TWIN" LOCK ALTERNATIVE

FIGURE 5

3

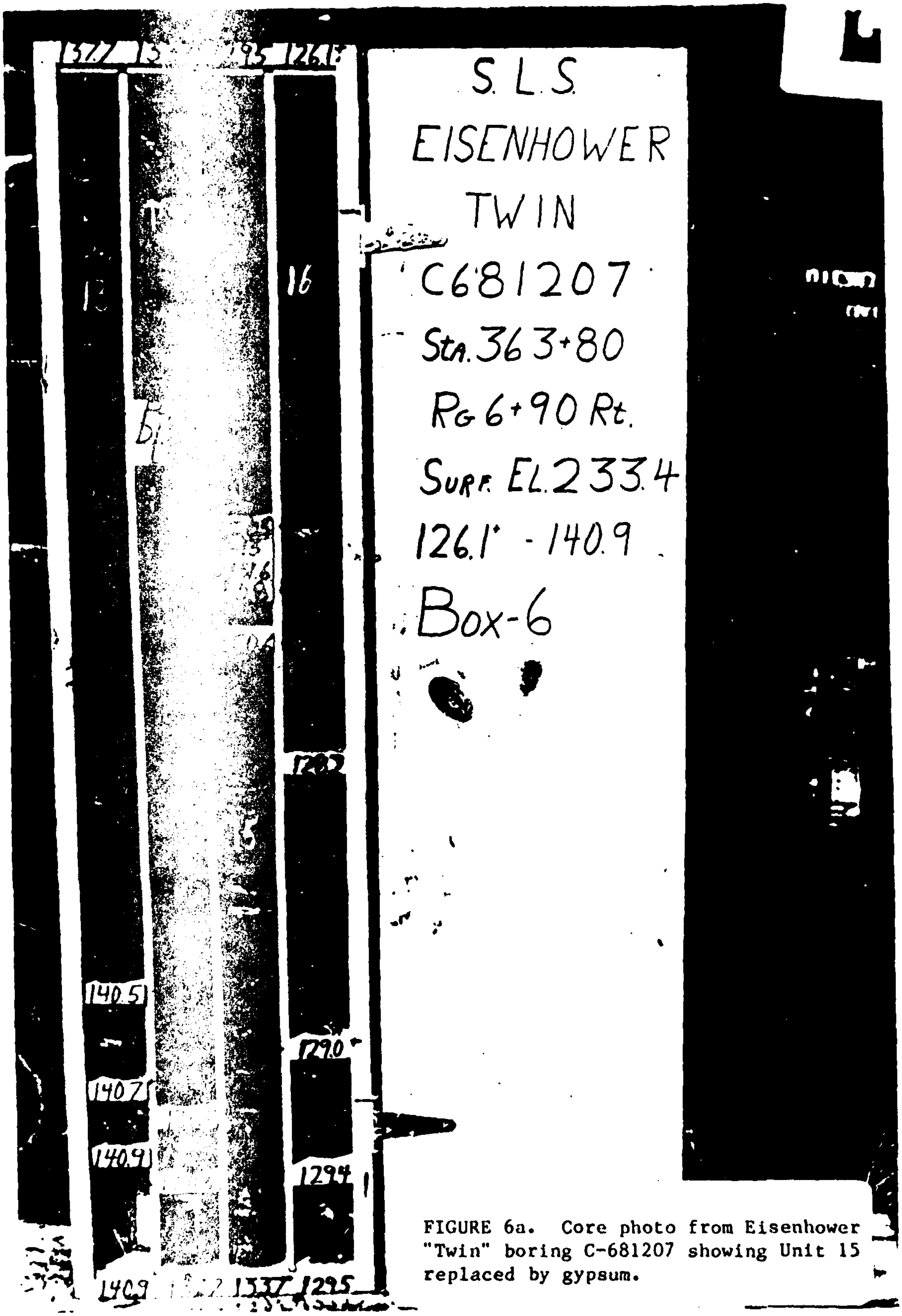


FIGURE 6a. Core photo from Eisenhower "Twin" boring C-681207 showing Unit 15 replaced by gypsum.

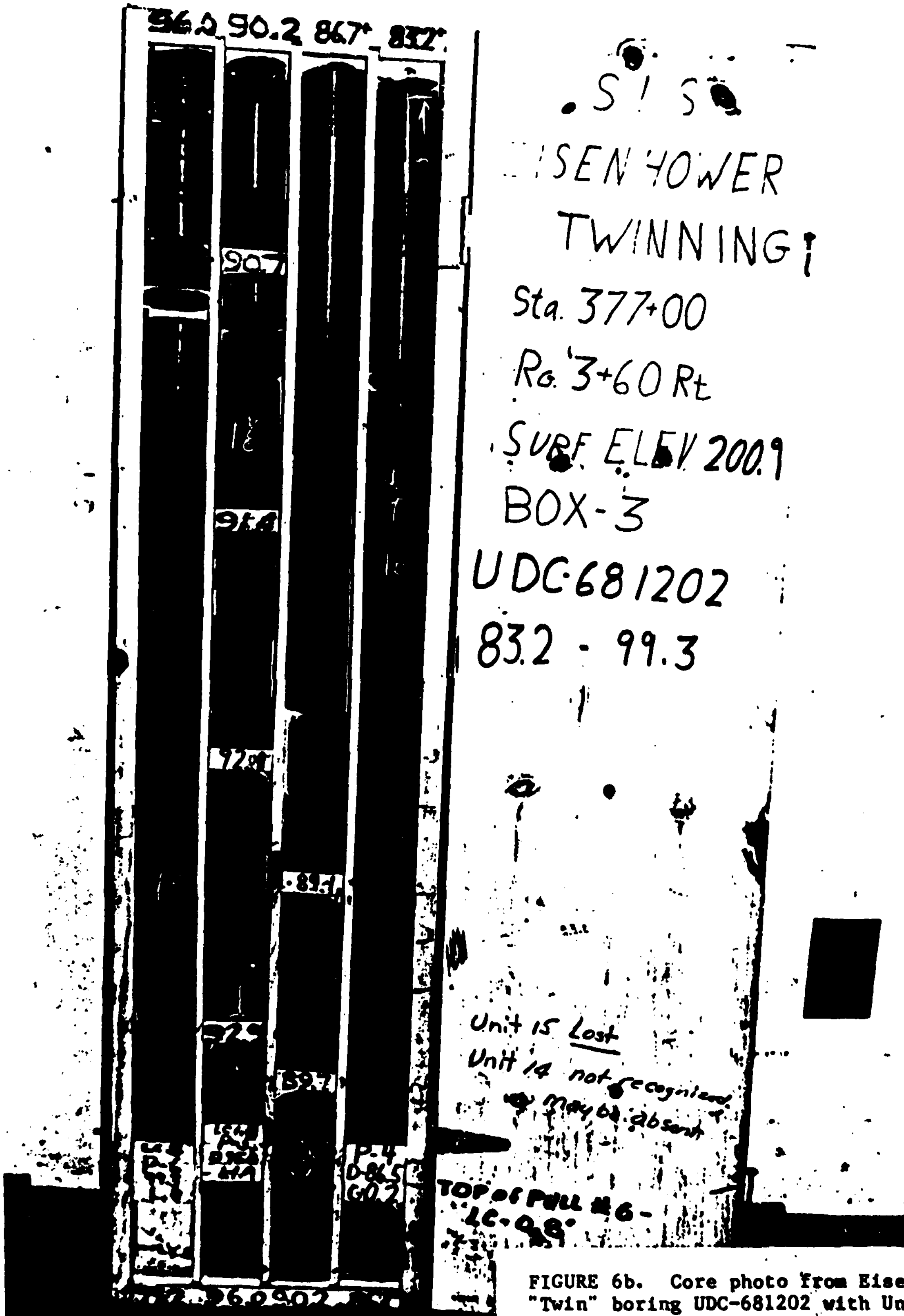


FIGURE 6b. Core photo from Eisenhower "Twin" boring UDC-681202 with Units 14 and 15 missing.

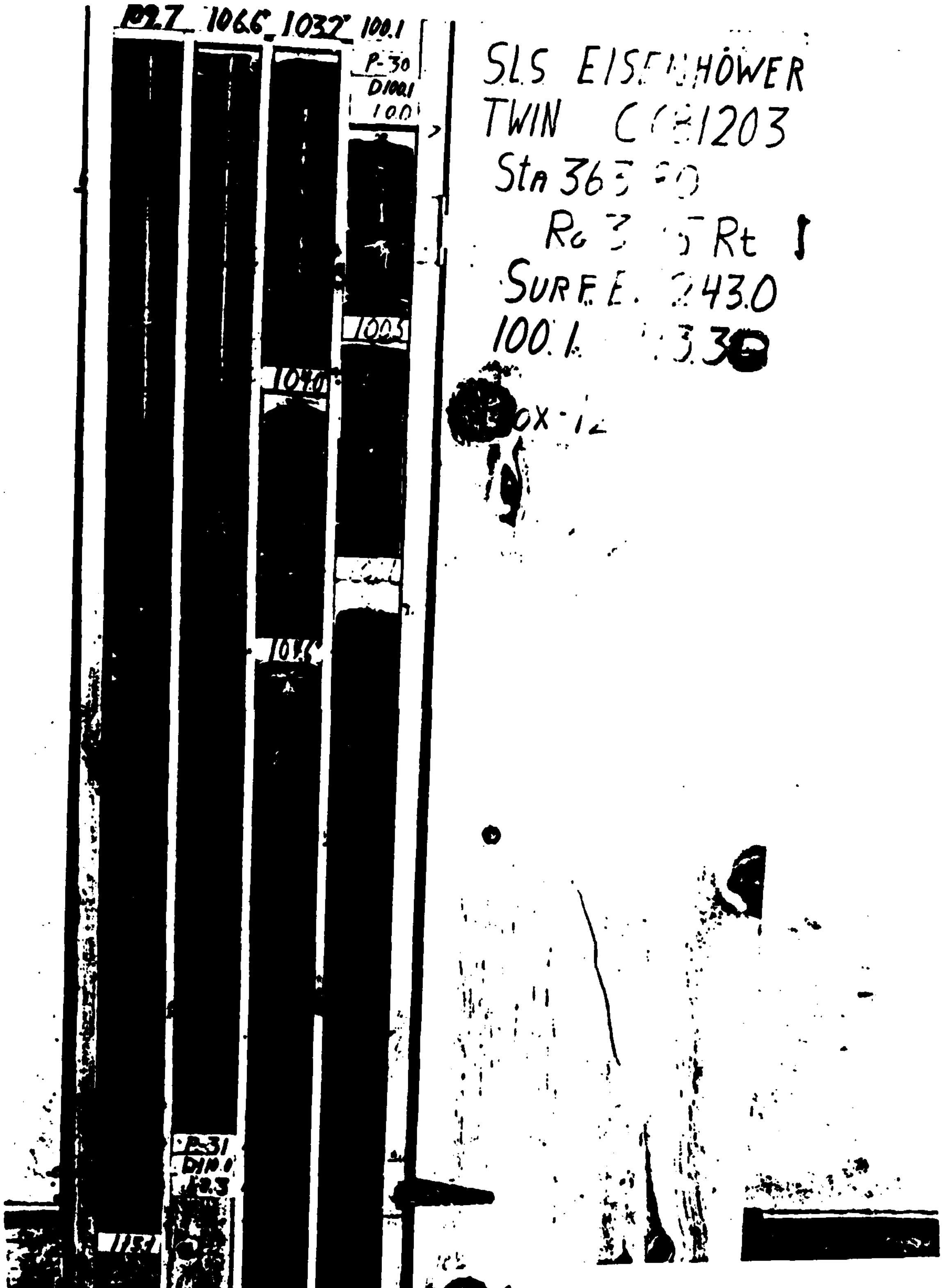


FIGURE 7a. Core photo from Eisenhower "Twin" boring C-681203 showing top of bedrock and intraformational conglomerates in Units 25 and 27.

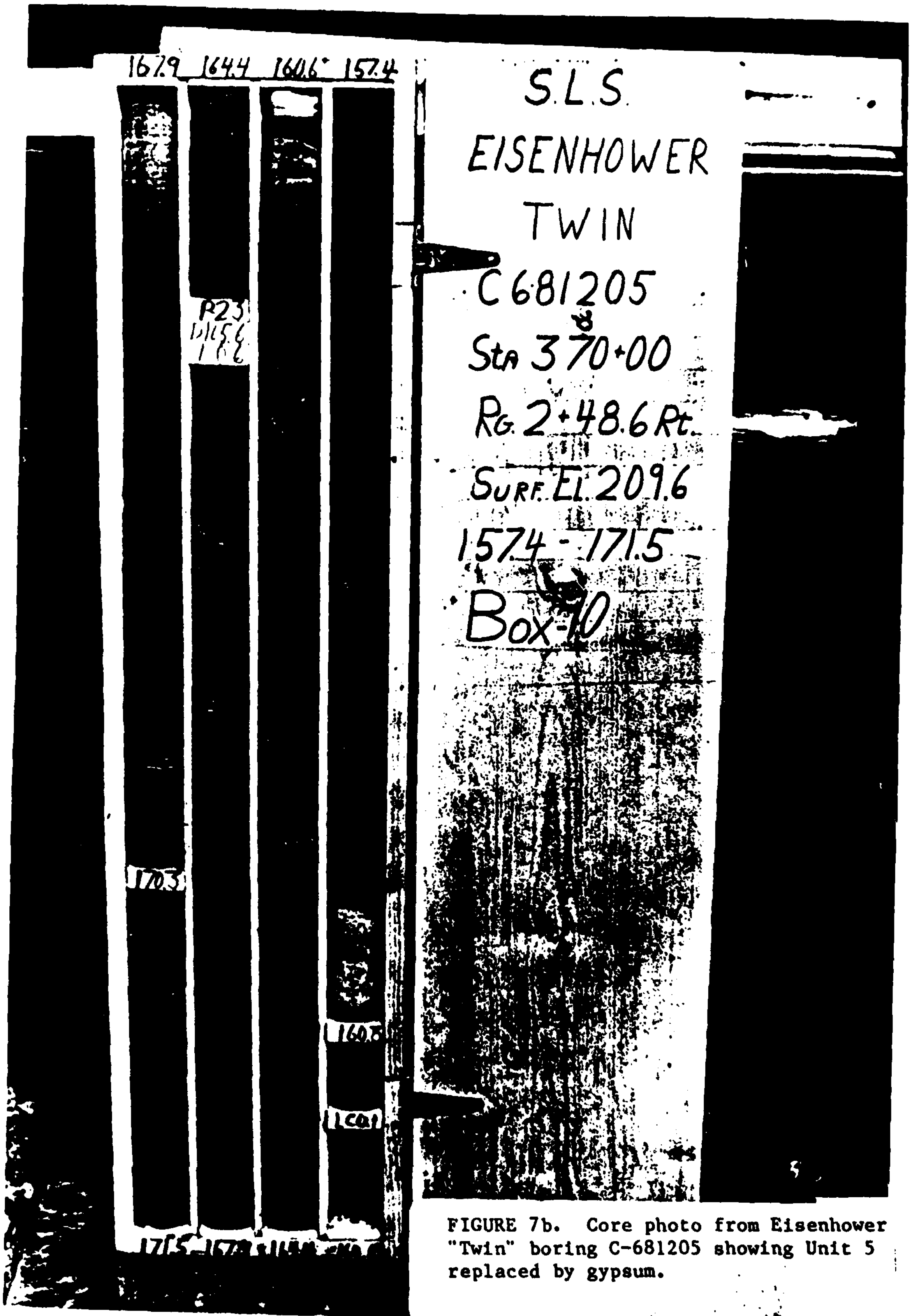


FIGURE 7b. Core photo from Eisenhower "Twin" boring C-681205 showing Unit 5 replaced by gypsum.

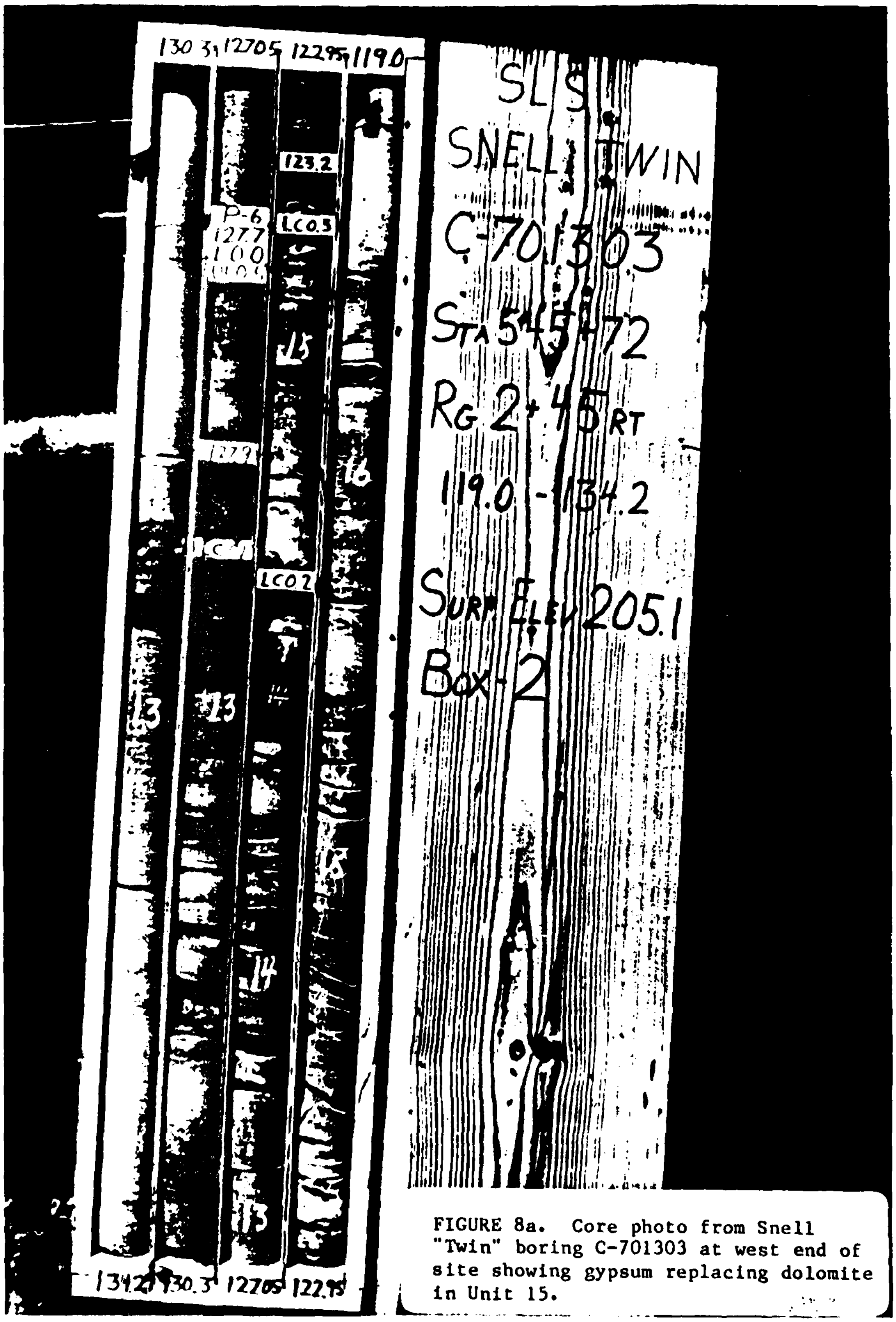


FIGURE 8a. Core photo from Snell "Twin" boring C-701303 at west end of site showing gypsum replacing dolomite in Unit 15.

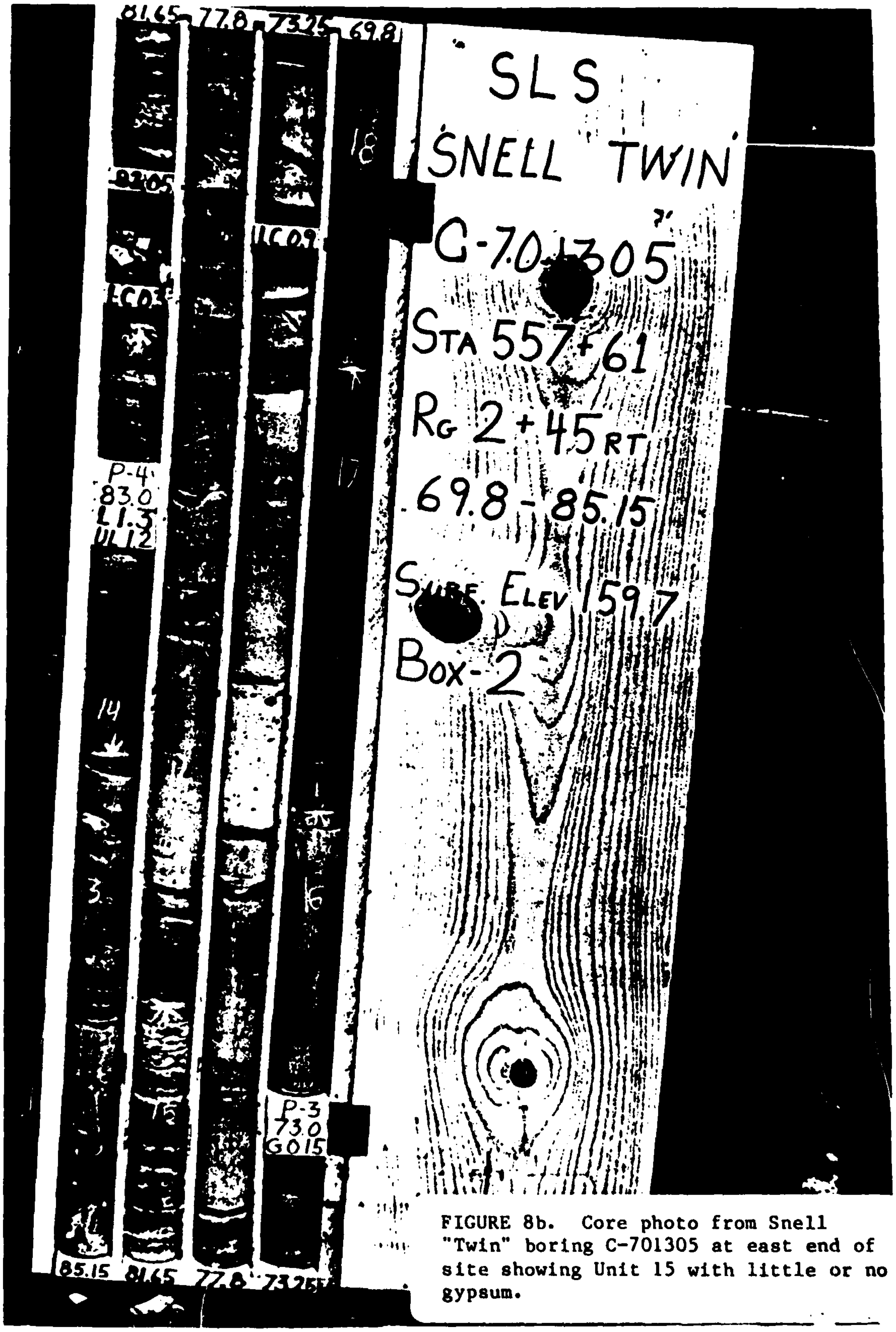


FIGURE 8b. Core photo from Snell "Twin" boring C-701305 at east end of site showing Unit 15 with little or no gypsum.

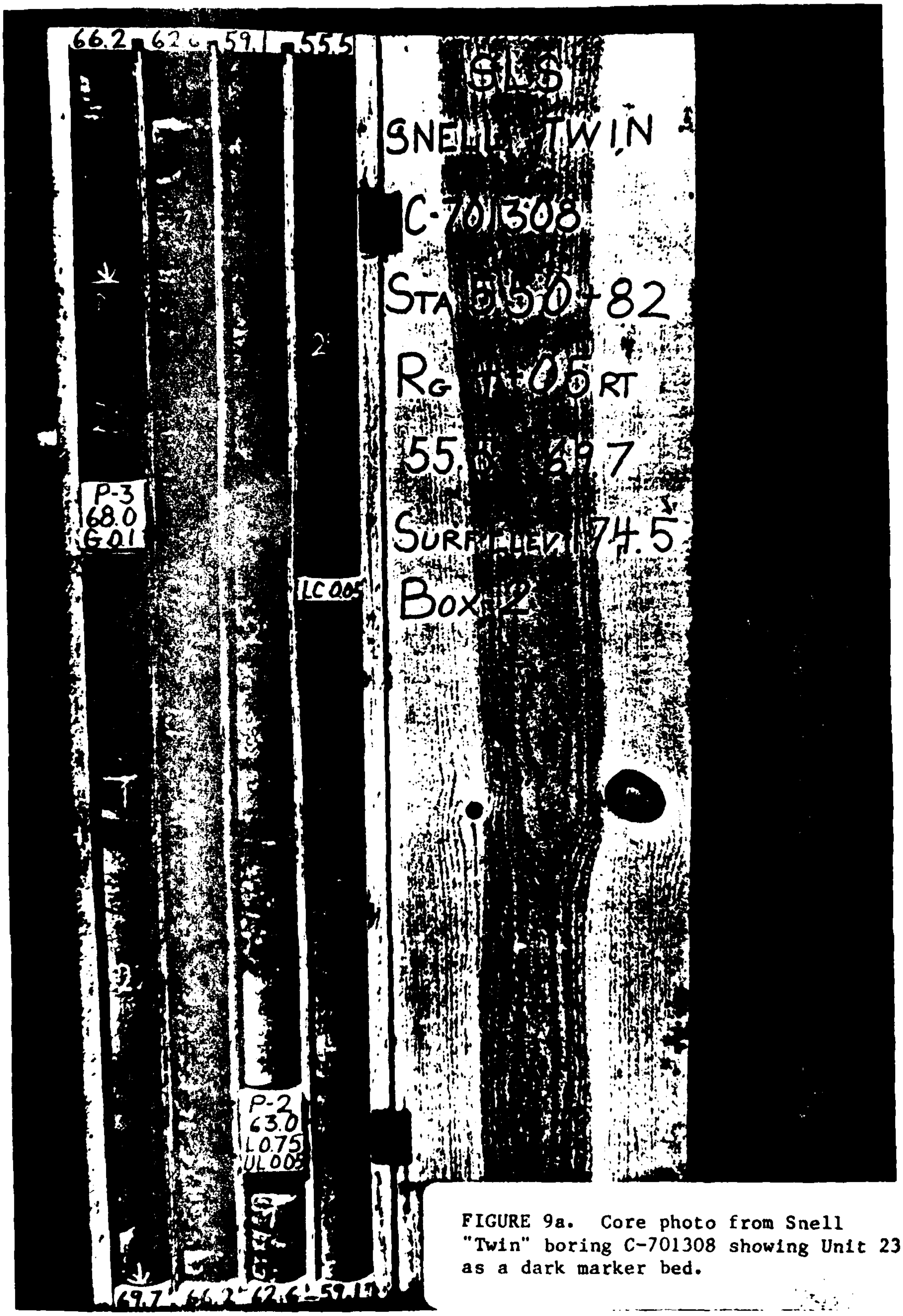


FIGURE 9a. Core photo from Snell "Twin" boring C-701308 showing Unit 23 as a dark marker bed.

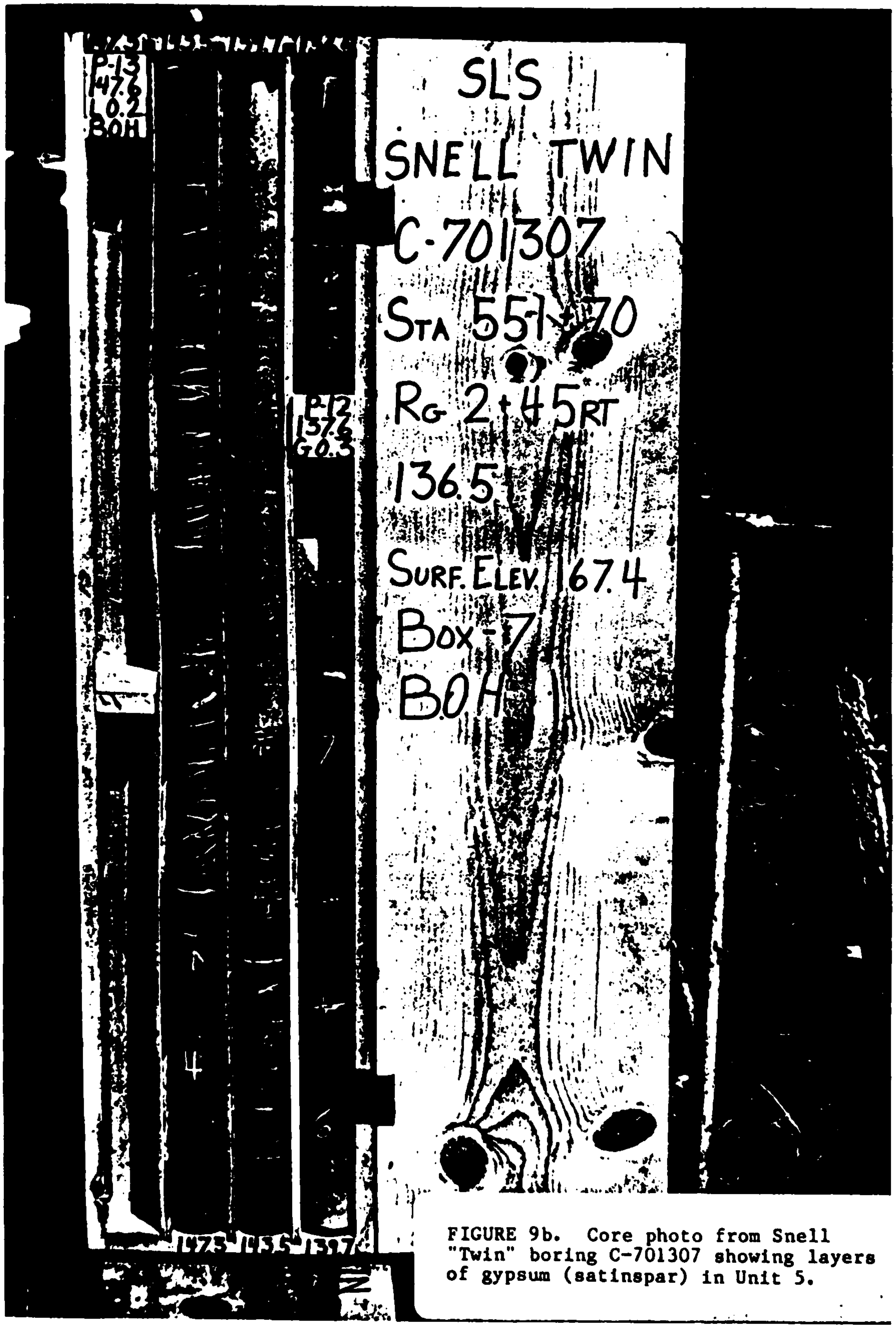
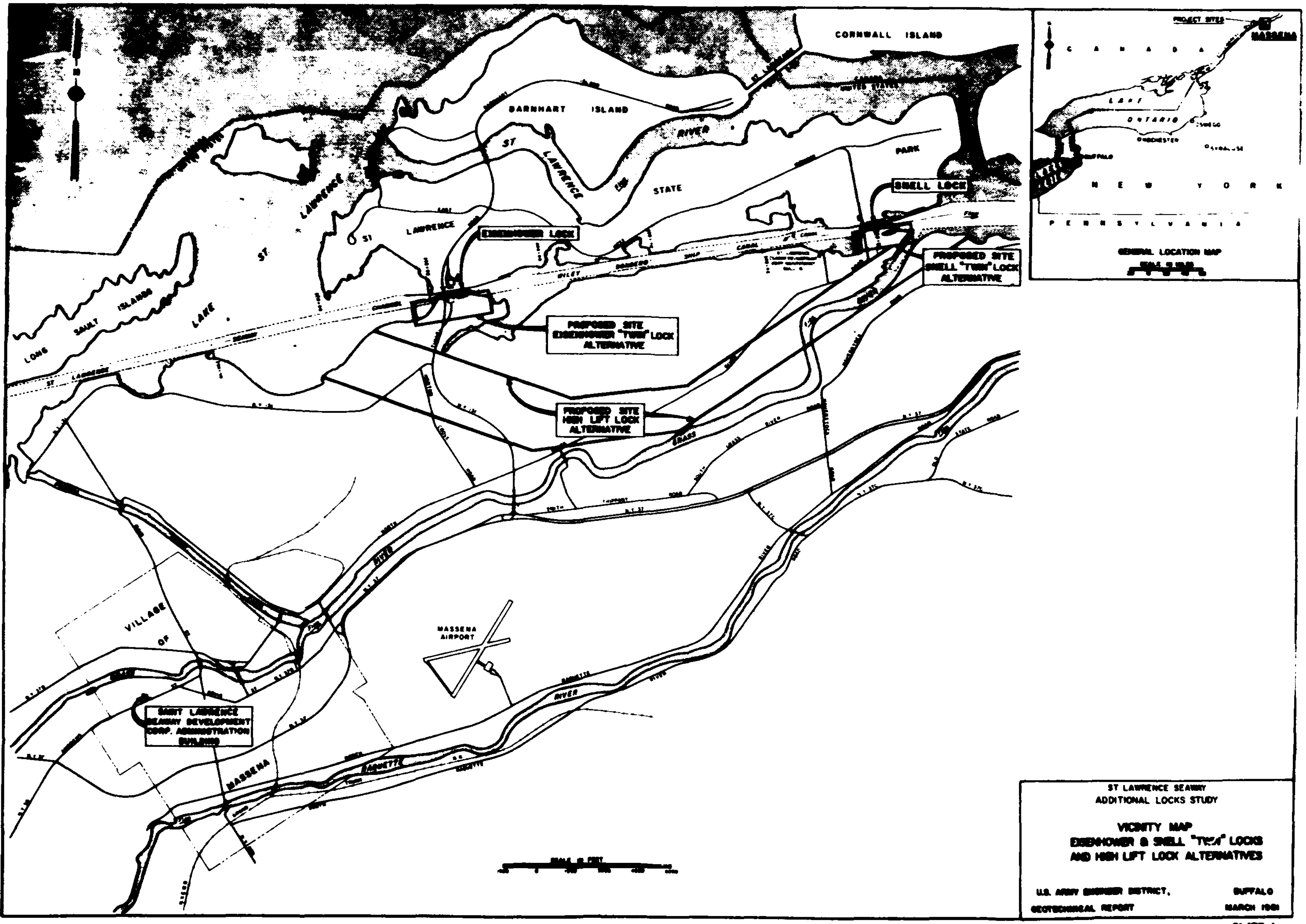


FIGURE 9b. Core photo from Snell "Twin" boring C-701307 showing layers of gypsum (satinspar) in Unit 5.

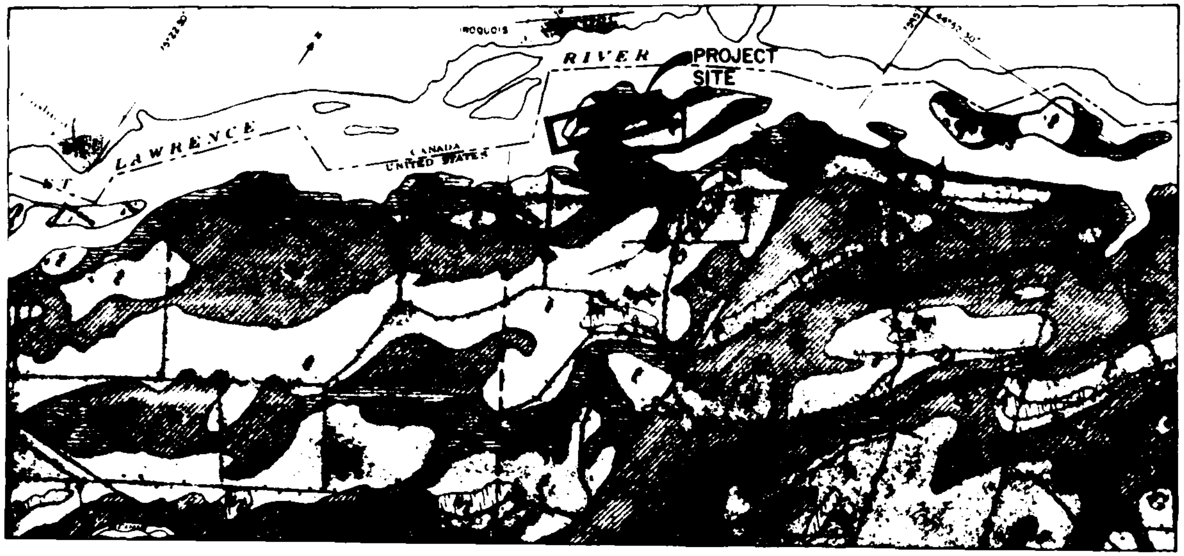


ST LAWRENCE SEAWAY
ADDITIONAL LOCKS STUDY

VICINITY MAP
EISENHOWER & SNELL "TWIN" LOCKS
AND HIGH LIFT LOCK ALTERNATIVES

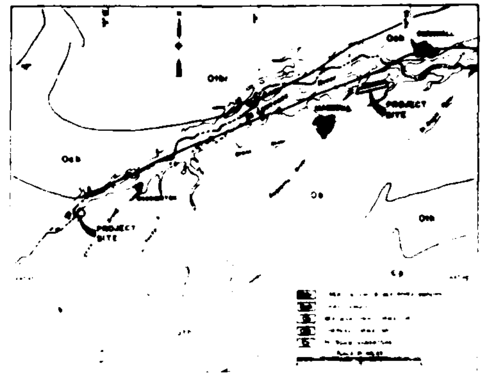
U.S. ARMY ENGINEER DISTRICT, BUFFALO
GEOTECHNICAL REPORT MARCH 1981

PLATE 1



SURFICIAL GEOLOGY - VICINITY, IROQUOIS LOCK - PT. ROCKWAY ALTERNATIVE

SURFICIAL GEOLOGY - VICINITY, SNELL "TWIN", EISENHOWER "TWIN" AND HIGH LIFT LOCK ALTERNATIVES



BEDROCK GEOLOGY OF NORTHERN NEW YORK

LEGEND

- Till (little or no morainal topography)
- wt — Winnowed till (?) poorly rounded gravel
- Sand, silty (widespread but not thick sheets on the lowlands deposited during the shallow phase of lake or sea)
- Clay, silty (deposited in lowlands by either lake or sea)
- Dune sand
- al — Alluvium
- Peat and muck
- Striae
- Till fabric
- Gravel pit
- Boulders

NOTES

1. Map of bedrock geology taken from: Fisher, Donald W., et al, eds., Geologic Map of New York, Map and Chart Series No 5, State Museum and Science Service, Geological Survey, Albany, N.Y. 1962

2. Surficial geology maps taken from: MacClintock, Paul, and Stewart, David P., Pleistocene Geology of the St Lawrence Lowland, Bull No 394, State Museum and Science Service, Albany, N.Y. 1965

SCALE IN MILES

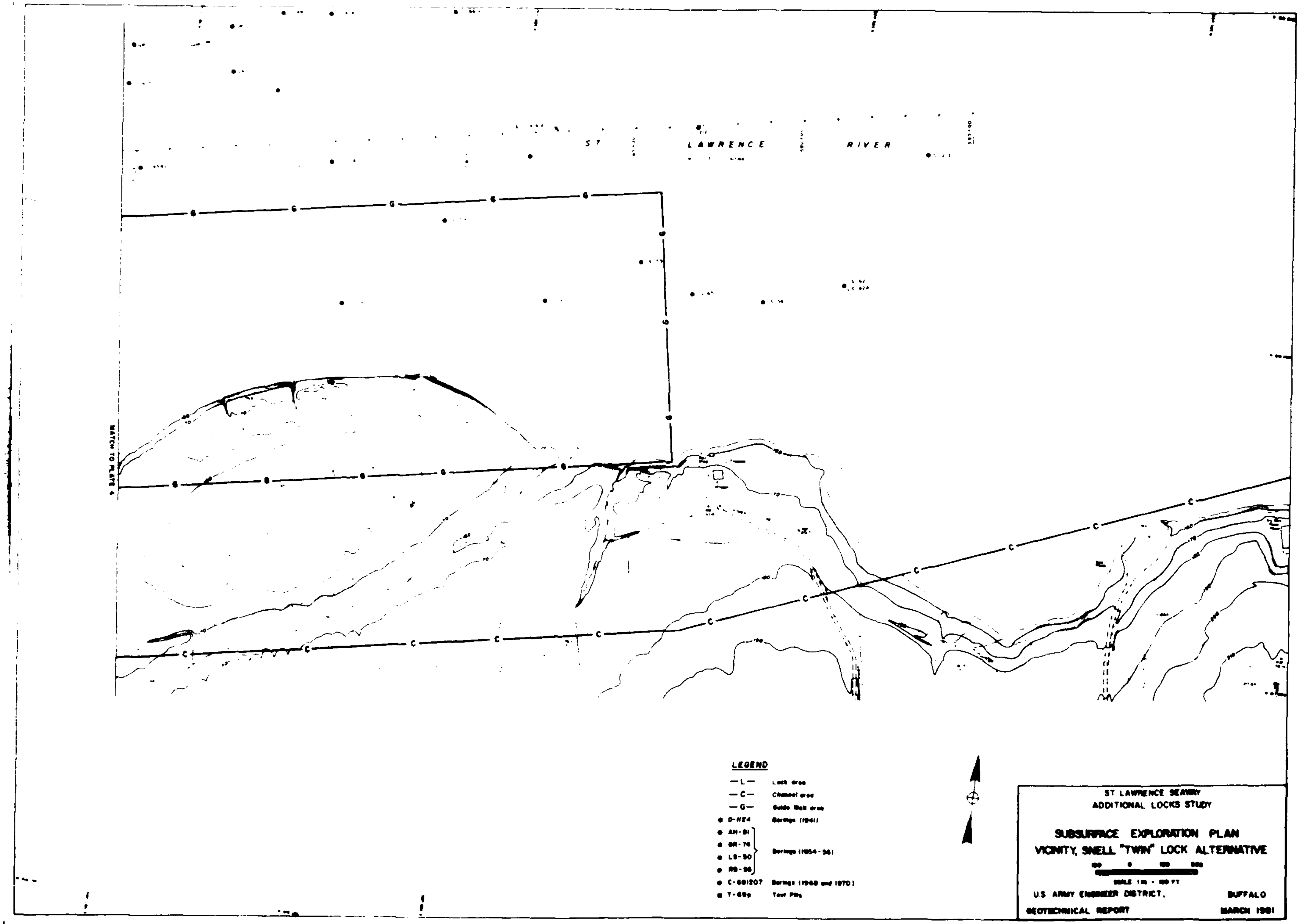
1/2 0 1/2 1 1 1/2 2

ST LAWRENCE SEAWAY
ADDITIONAL LOCKS STUDY

REGIONAL / NEAR REGIONAL BEDROCK AND SURFICIAL GEOLOGY

US ARMY ENGINEER DISTRICT, BUFFALO
GEOTECHNICAL REPORT MARCH 1981

PLATE 2

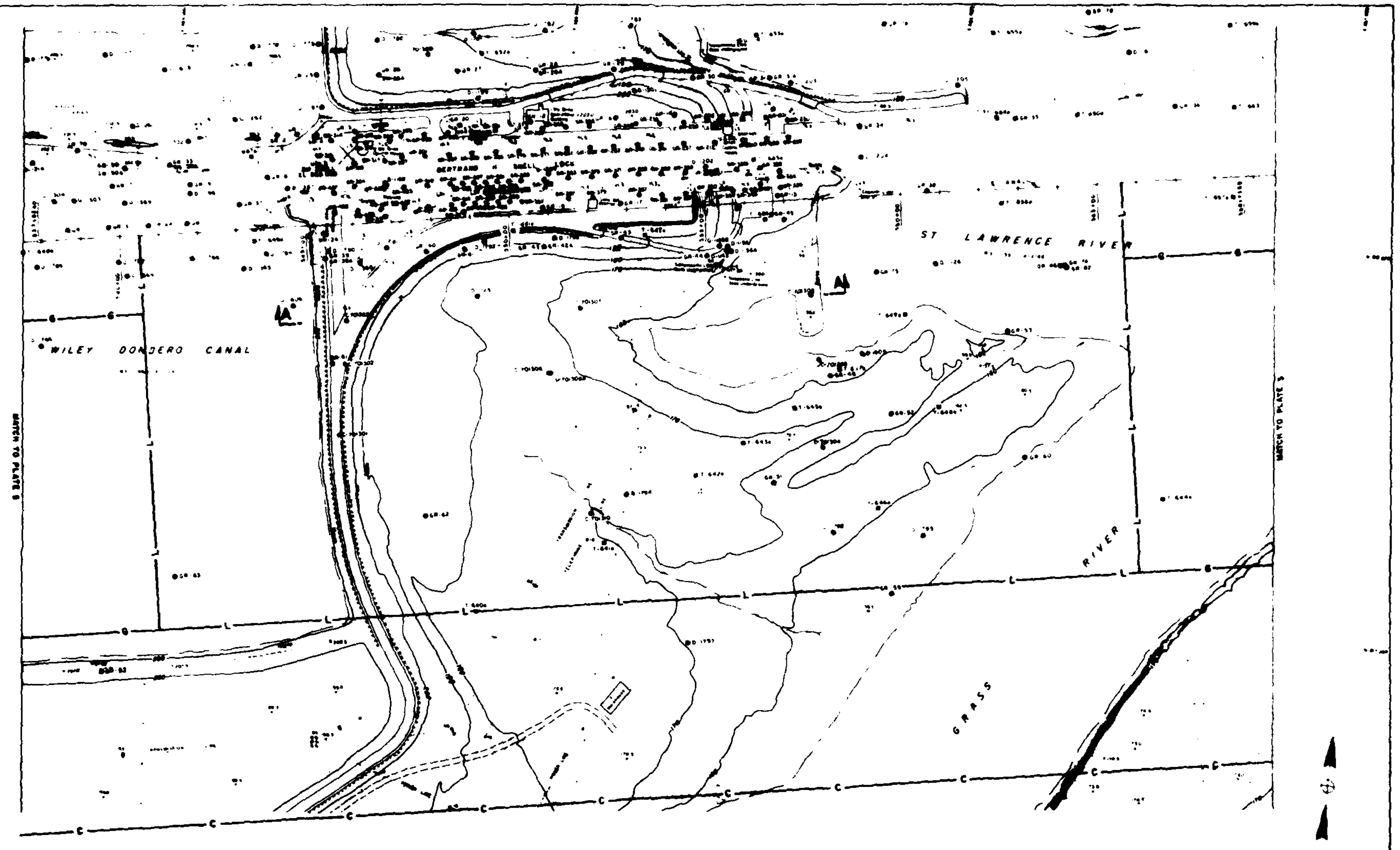


ST LAWRENCE SEAWAY
ADDITIONAL LOCKS STUDY

SUBSURFACE EXPLORATION PLAN
VICINITY, SNELL "TWIN" LOCK ALTERNATIVE

U.S. ARMY ENGINEER DISTRICT, BUFFALO
GEOTECHNICAL REPORT MARCH 1981

PLATE 3



NOTES

1. For legend refer to Plate 3.
2. For Profile A-A, refer to Plate 6.

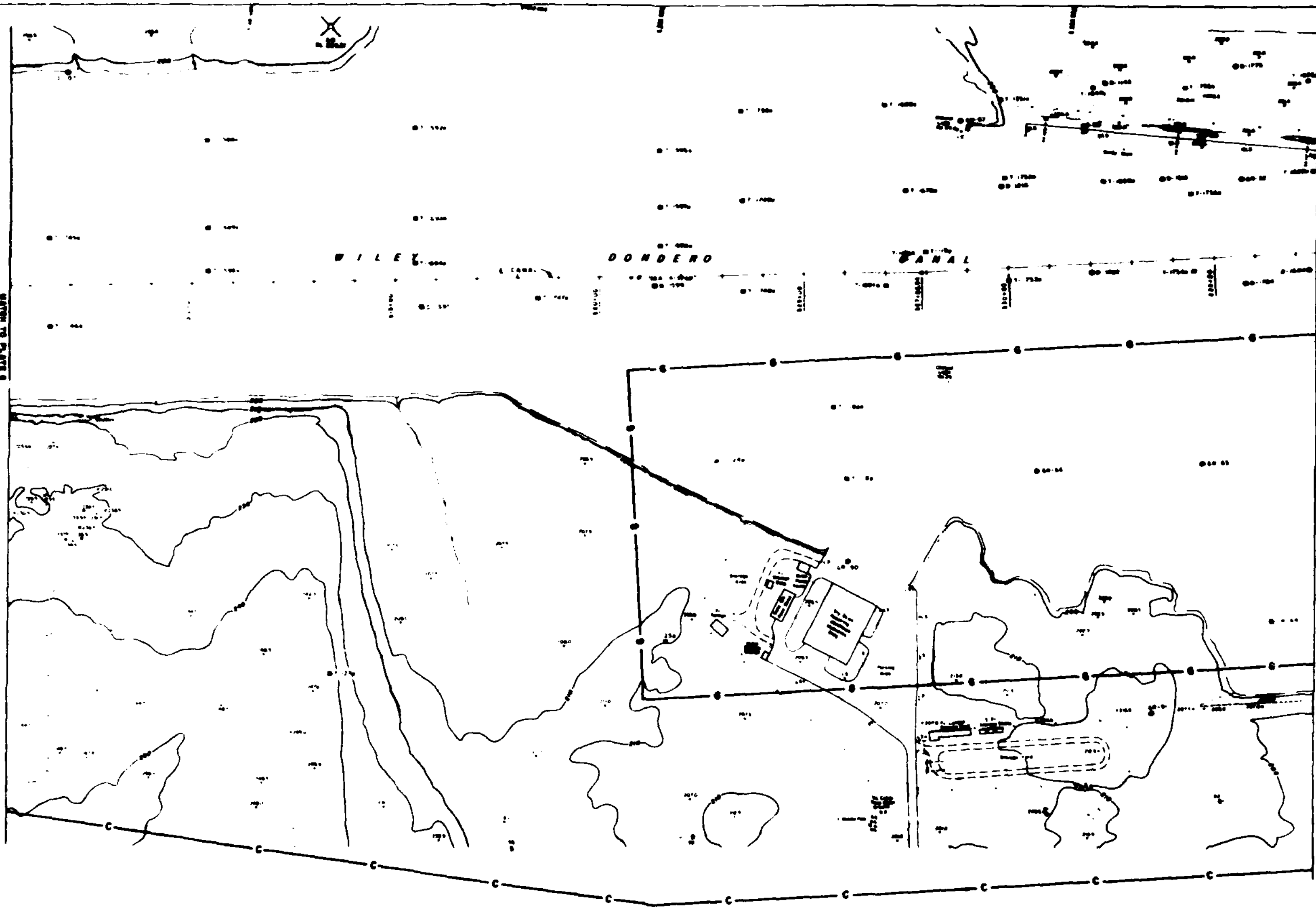
ST LAWRENCE SEAWAY
ADDITIONAL LOCKS STUDY

SUBSURFACE EXPLORATION PLAN
VICINITY, SNELL "TWIN" LOCK ALTERNATIVE

SCALE 1 IN. = [illegible] FT

U.S. ARMY ENGINEER DISTRICT, BUFFALO
GEOTECHNICAL REPORT MARCH [illegible]

PLATE 4



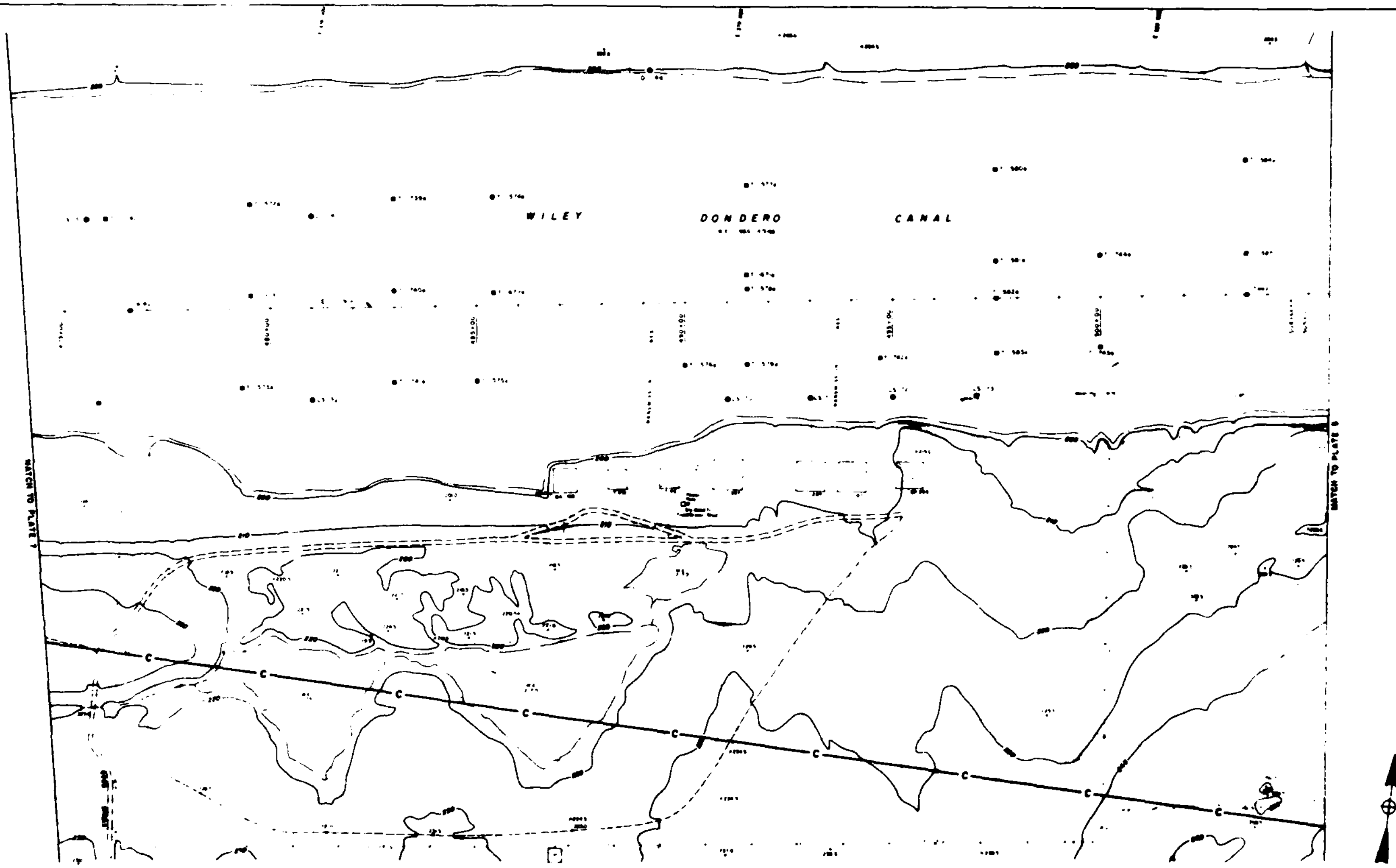
NOTE
For legend, refer to Plate 3

ST LAWRENCE SEAWAY
ADDITIONAL LOCKS STUDY

SUBSURFACE EXPLORATION PLAN
VICINITY, SNELL "TWIN" LOCK ALTERNATIVE

U.S. ARMY ENGINEER DISTRICT, BUFFALO
GEOTECHNICAL REPORT MARCH 1981

PLATE 5

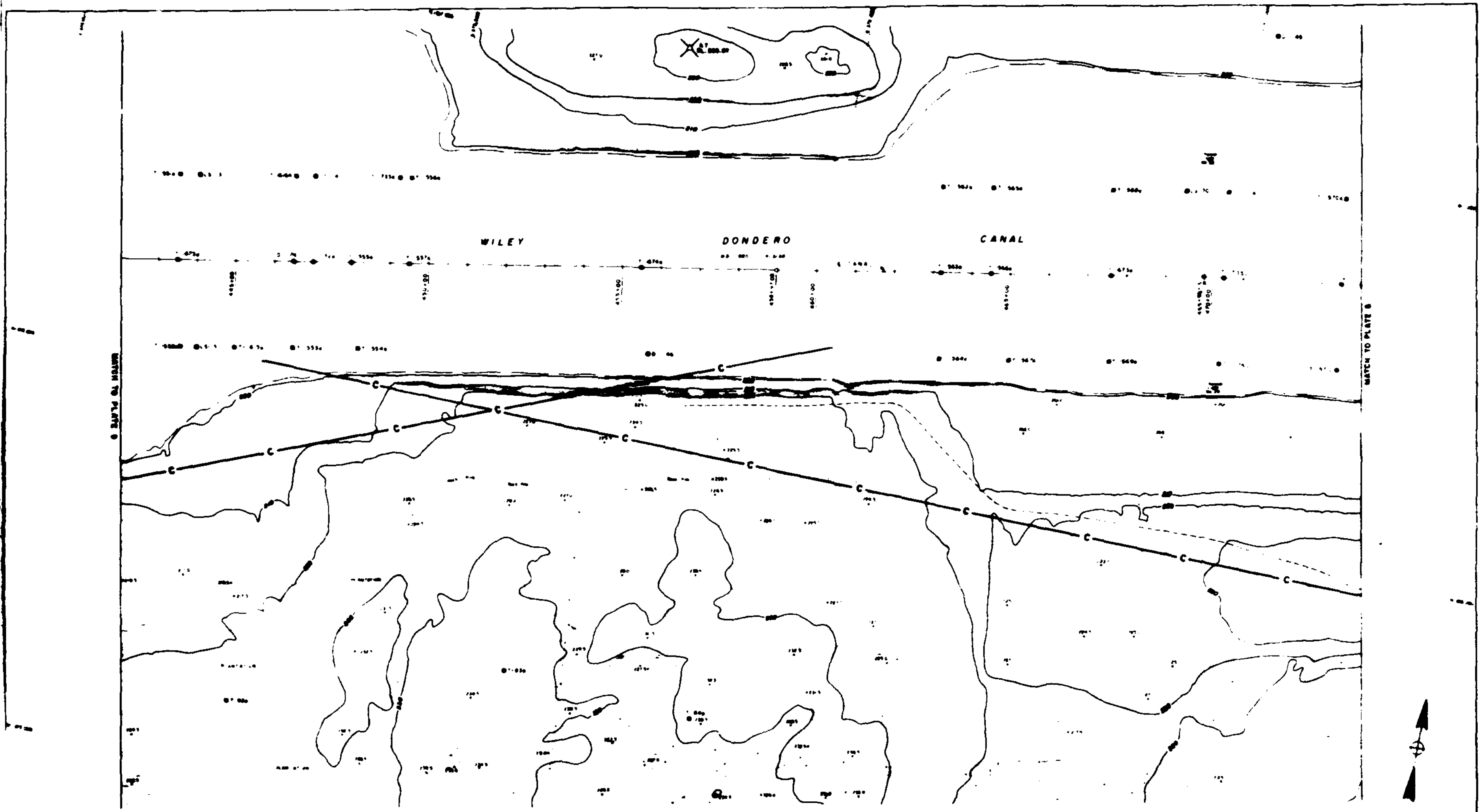


NOTE
For legend, refer to Plate 3

ST LAWRENCE SEAWAY
ADDITIONAL LOCKS STUDY

SUBSURFACE EXPLORATION PLAN
VICINITY, SNELL "TWIN" LOCK ALTERNATIVE

U S ARMY ENGINEER DISTRICT, BUFFALO
GEOTECHNICAL REPORT MARCH 1981



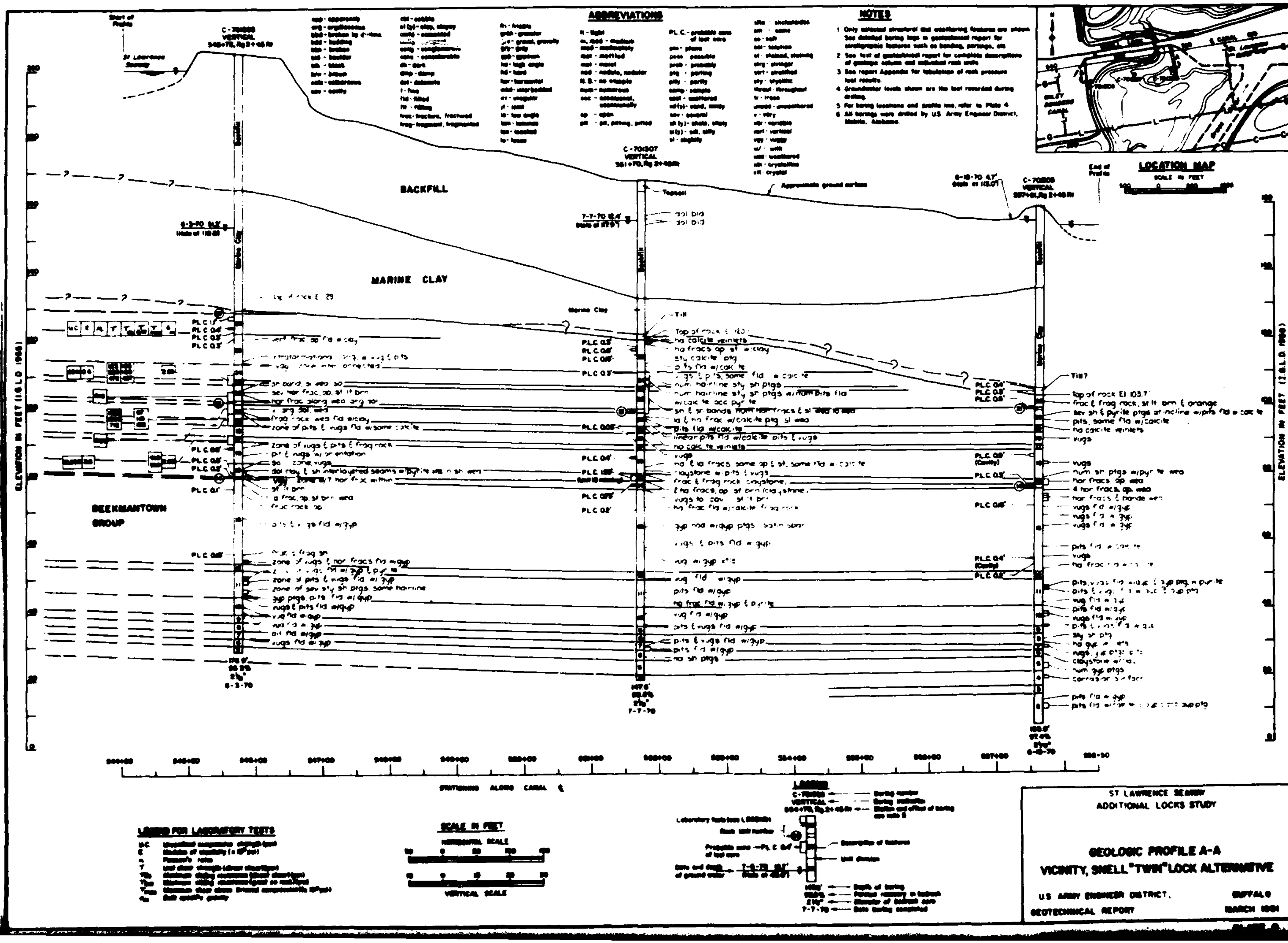
NOTE
For legend, refer to Plate 3

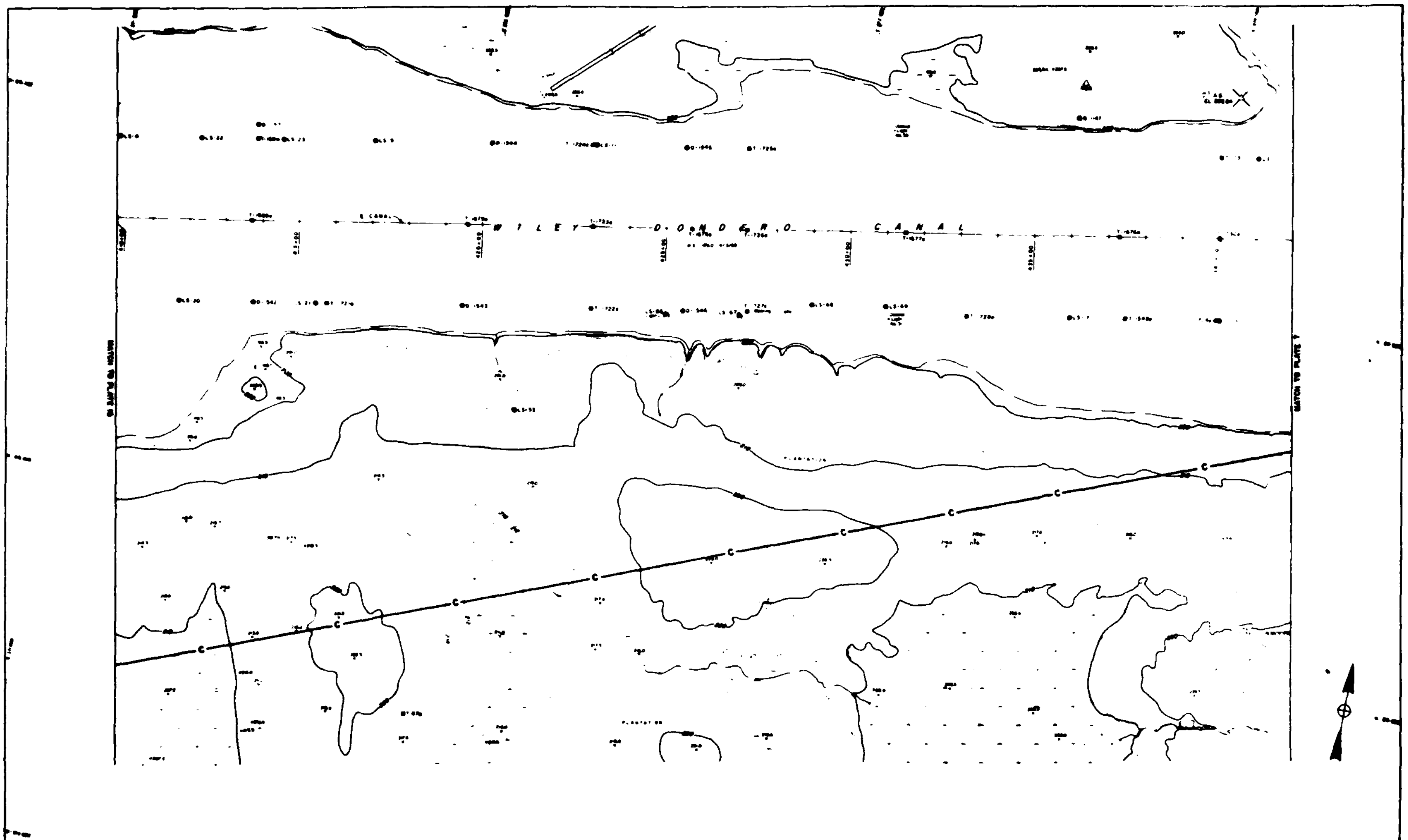
ST LAWRENCE SEAWAY
ADDITIONAL LOCKS STUDY

SUBSURFACE EXPLORATION PLAN
VICINITY, SNELL "TWIN" LOCK ALTERNATIVE

US ARMY ENGINEER DISTRICT, BUFFALO
GEOTECHNICAL REPORT MARCH 1981

PLATE 7


ABBREVIATIONS
NOTES
BACKFILL
MARINE CLAY
BEEKMANTOWN GROUP
LOCATION MAP
SCALE IN FEET
LEGEND FOR LABORATORY TESTS
HORIZONTAL SCALE
VERTICAL SCALE
LEGEND
STATIONING ALONG CANAL ℄
ELEVATION IN FEET (I.G.L.D 1955)
ST LAWRENCE SEAWAY
ADDITIONAL LOCKS STUDY
GEOLOGIC PROFILE A-A
VICINITY, SNELL "TWIN" LOCK ALTERNATIVE
U.S. ARMY ENGINEER DISTRICT, BUFFALO
GEOTECHNICAL REPORT MARCH 1981

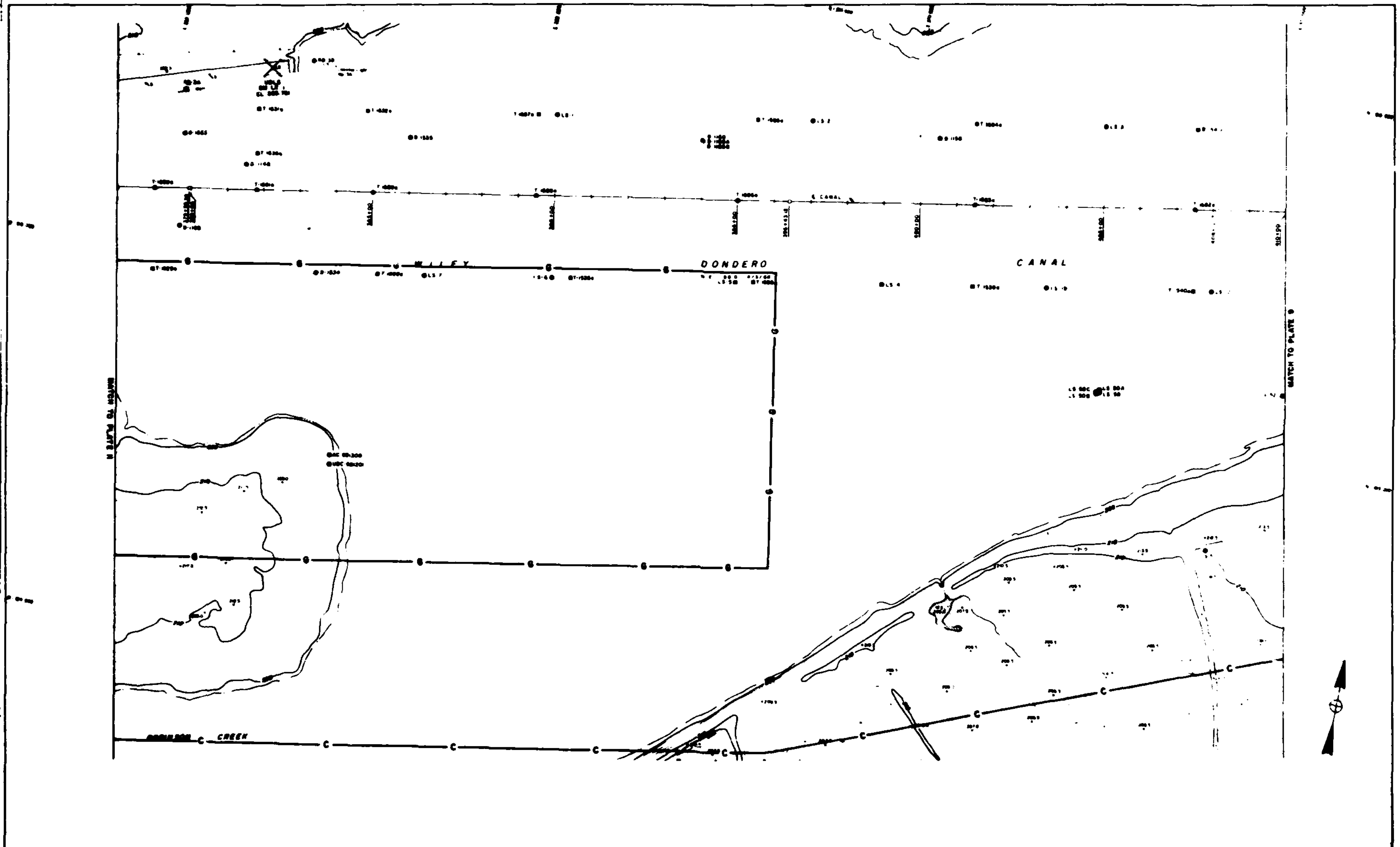


NOTE:
For legend, refer to Plate 3.

ST LAWRENCE SEAWAY
ADDITIONAL LOCKS STUDY

SUBSURFACE EXPLORATION PLAN
VICINITY, EISENHOWER "TWIN" LOCK ALTERNATIVE

U.S. ARMY ENGINEER DISTRICT, BUFFALO
GEOTECHNICAL REPORT MARCH 1981



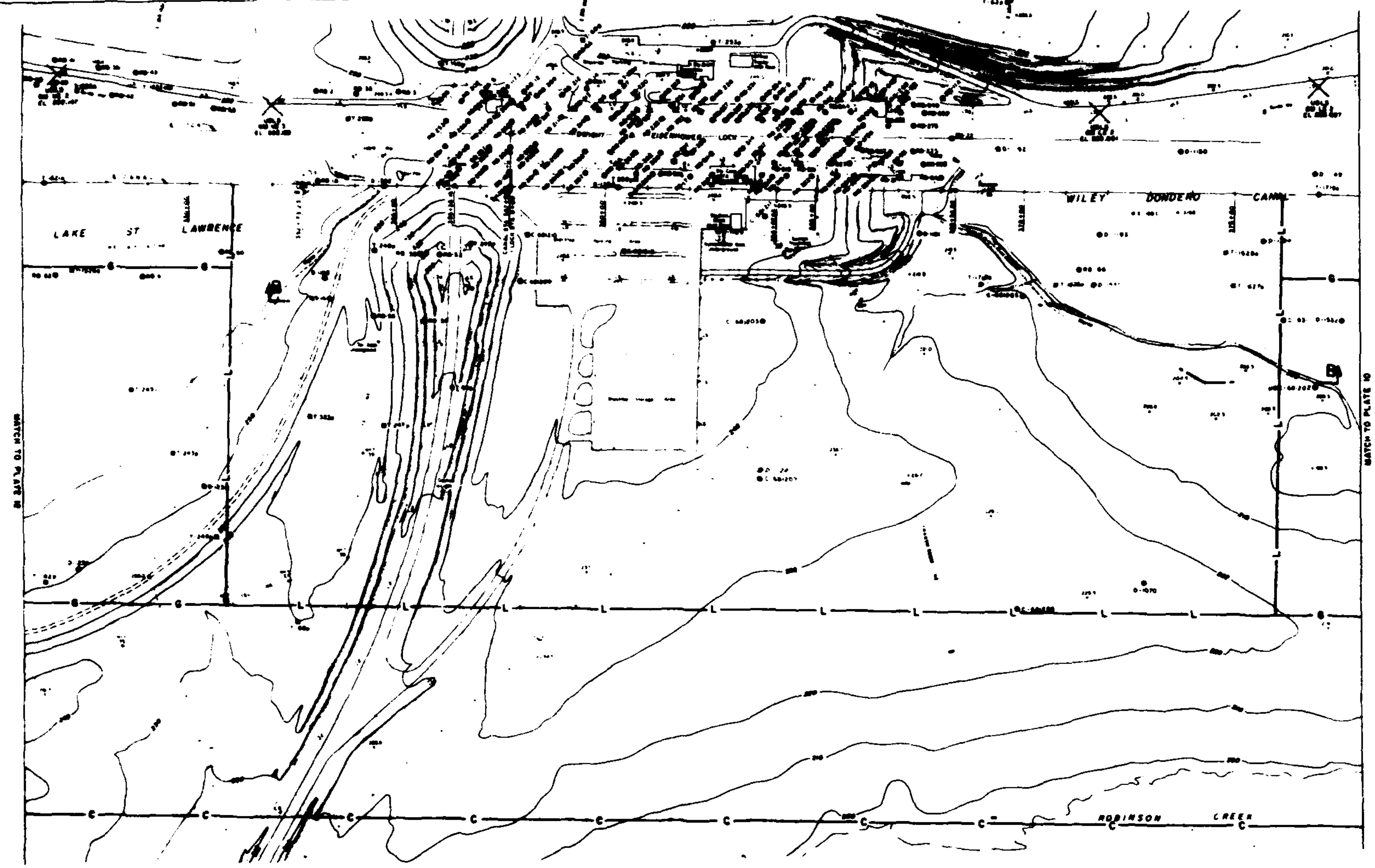
NOTE
For legend, refer to Plate 3.

ST LAWRENCE SEAWAY
ADDITIONAL LOCKS STUDY

SUBSURFACE EXPLORATION PLAN
VICINITY, EISENHOWER "TWIN" LOCK ALTERNATIVE

SCALE: 1 IN = 100 FT

U.S. ARMY ENGINEER DISTRICT, BUFFALO
GEOTECHNICAL REPORT MARCH 1981



NOTES:

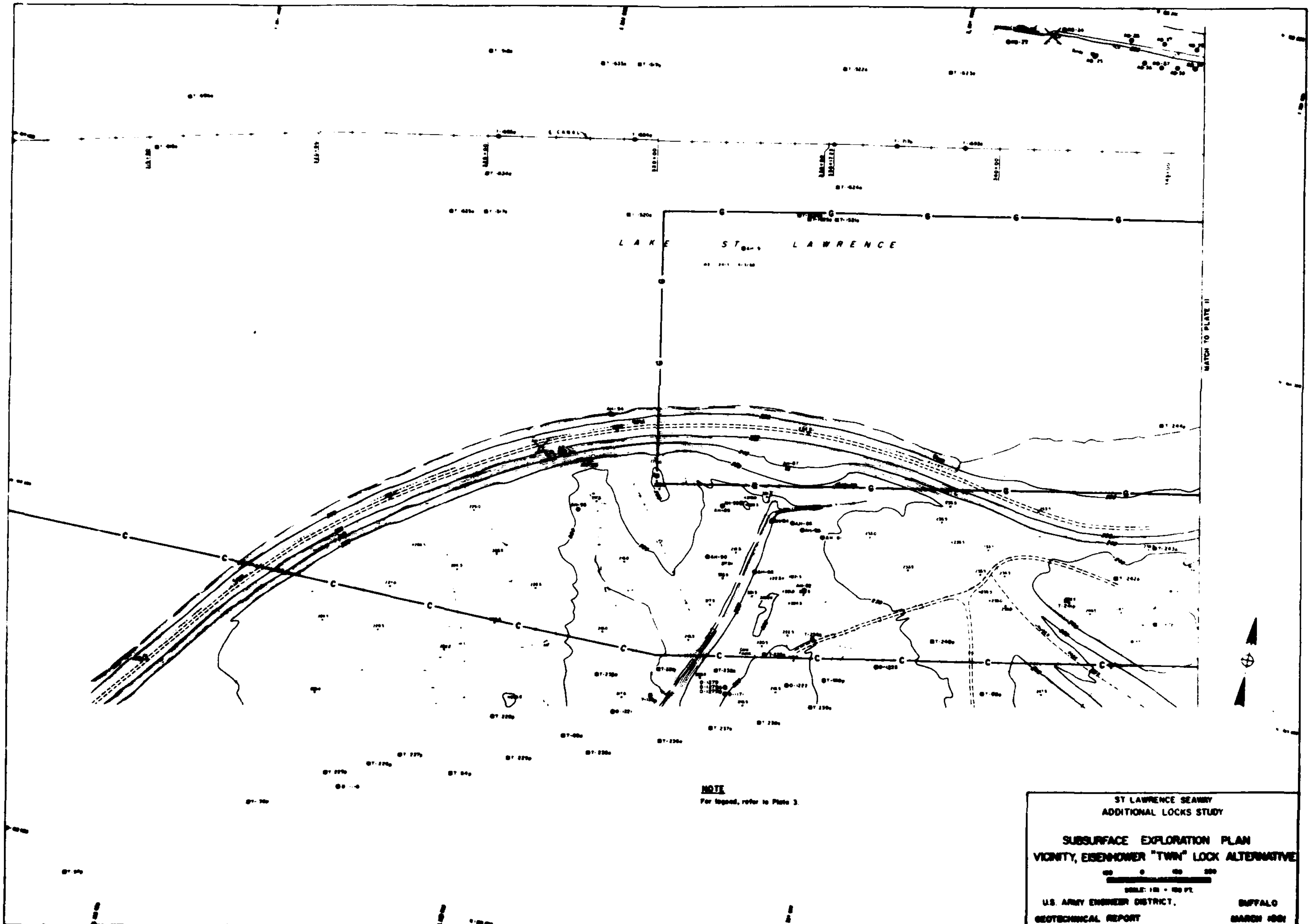
1. For legend, refer to Plate 3
2. For Profile B-B, refer to Plate 13.

ST LAWRENCE SEAWAY
ADDITIONAL LOCKS STUDY

SUBSURFACE EXPLORATION PLAN
VICINITY, EISENHOWER "TWIN" LOCK ALTERNATIVE

U.S. ARMY ENGINEER DISTRICT, BUFFALO
GEOTECHNICAL REPORT MARCH 1981

PLATE 11

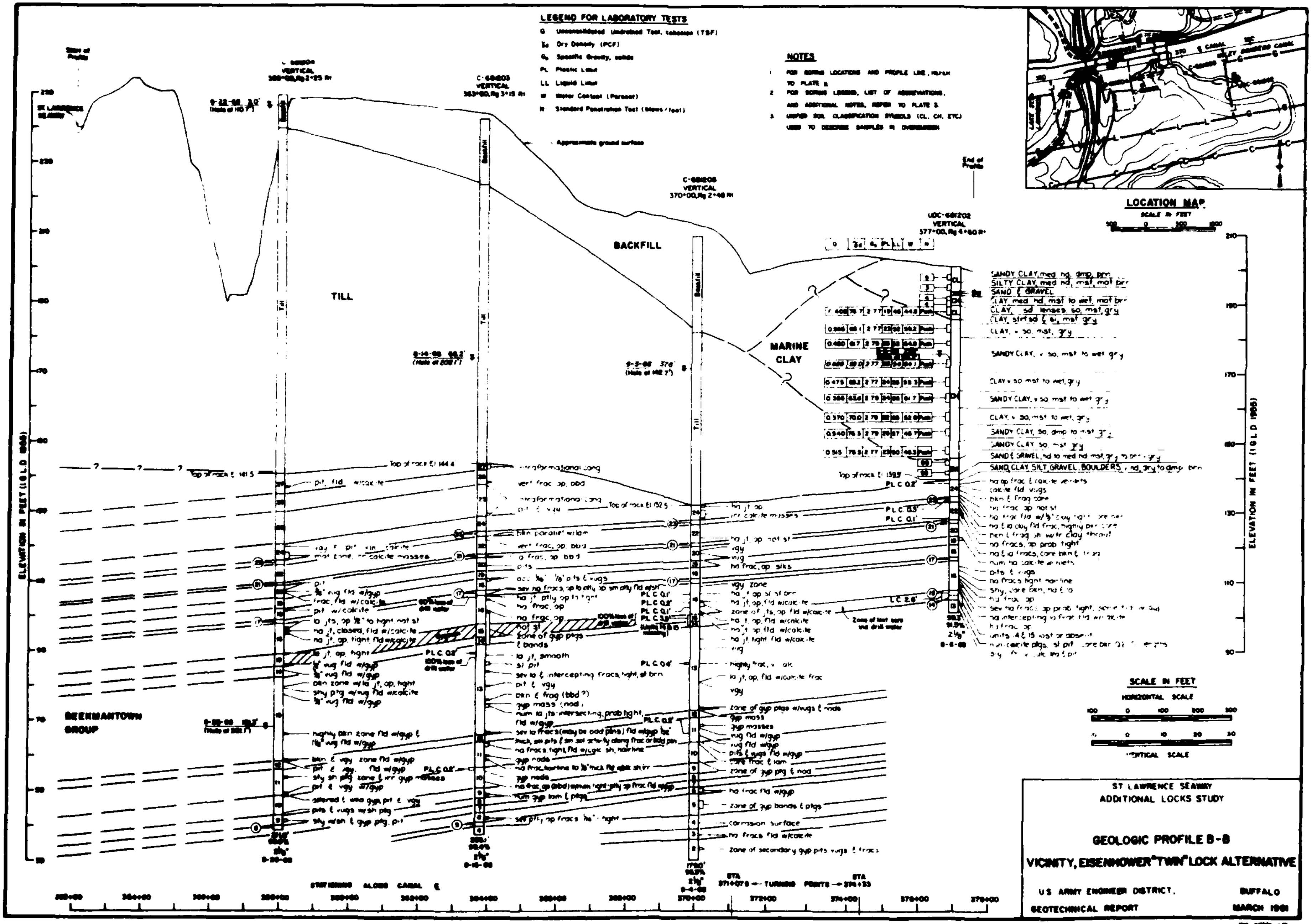


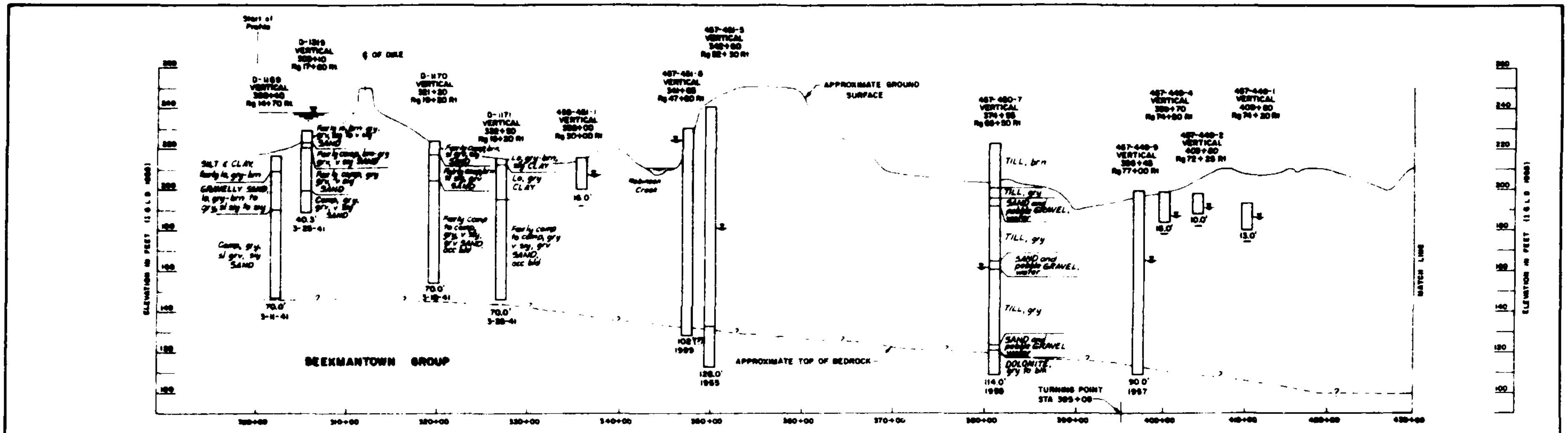
NOTE
For legend, refer to Plate 3.

ST LAWRENCE SEAWAY
ADDITIONAL LOCKS STUDY

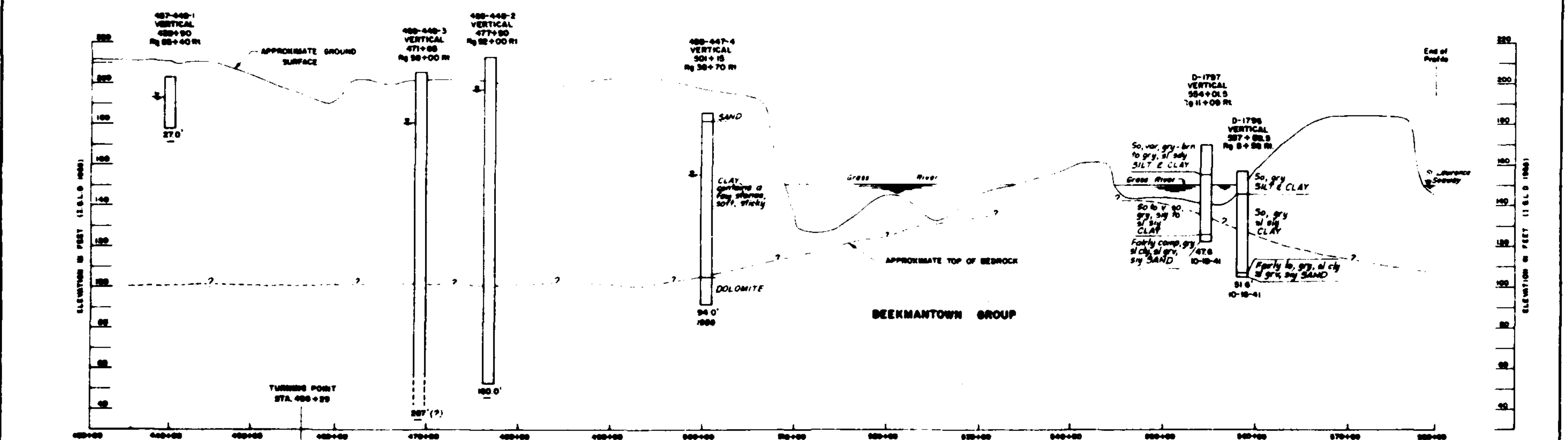
SUBSURFACE EXPLORATION PLAN
VICINITY, EISENHOWER "TWIN" LOCK ALTERNATIVE

U.S. ARMY ENGINEER DISTRICT, BUFFALO
GEOTECHNICAL REPORT MARCH 1981

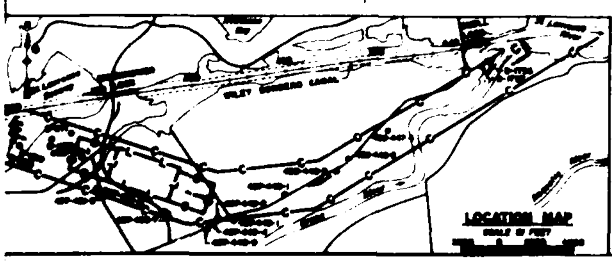

LEGEND FOR LABORATORY TESTS
Q Unconsolidated Undrained Test, cohesion (TSF)
γd Dry Density (PCF)
Gs Specific Gravity, solids
PL Plastic Limit
LL Liquid Limit
W Water Content (Percent)
N Standard Penetration Test (blows/foot)
Approximate ground surface
NOTES
1 FOR BORING LOCATIONS AND PROFILE LINE, REFER TO PLATE 2.
2 FOR BORING LEGEND, LIST OF ABBREVIATIONS, AND ADDITIONAL NOTES, REFER TO PLATE 3.
3 UNIFIED SOIL CLASSIFICATION SYMBOLS (CL, CH, ETC) USED TO DESCRIBE SAMPLES IN OVERBURDEN.
LOCATION MAP
SCALE IN FEET
BACKFILL
TILL
MARINE CLAY
BEEKMANTOWN GROUP
ELEVATION IN FEET (IGLD 1955)
STATIONING ALONG CANAL ℄
SCALE IN FEET
HORIZONTAL SCALE
VERTICAL SCALE
ST LAWRENCE SEAWAY
ADDITIONAL LOCKS STUDY
GEOLOGIC PROFILE B-B
VICINITY, EISENHOWER "TWIN" LOCK ALTERNATIVE
US ARMY ENGINEER DISTRICT, BUFFALO
GEOTECHNICAL REPORT
MARCH 1981



STATIONING ALONG CANAL ℄



STATIONING ALONG CANAL ℄



LEGEND

- D-1796 ← Boring number
- VERTICAL ← Boring inclination
- 387+89.5 ← Station of boring
- Rg 8+56 Rt ← Offset of boring
- ← Material change
- 51.6' ← Depth of boring
- 10-18-41 ← Date boring completed

NOTES

1. All borings are projected into the plane of the profile
2. For list of abbreviations, refer to Plate 6
3. See Note 5 on Plate 15 for soil classification terminology for D series borings
4. Borings numbered 467-449-1, etc., refer to borings and water wells listed in Trainer and Salvas (1962)
5. Approximate top of rock based on rock contour map provided by Corps of Engineers, Buffalo District
6. Stratification of material above approximate top of bedrock not shown due to insufficient data

SCALE IN FEET

HORIZONTAL SCALE

VERTICAL SCALE

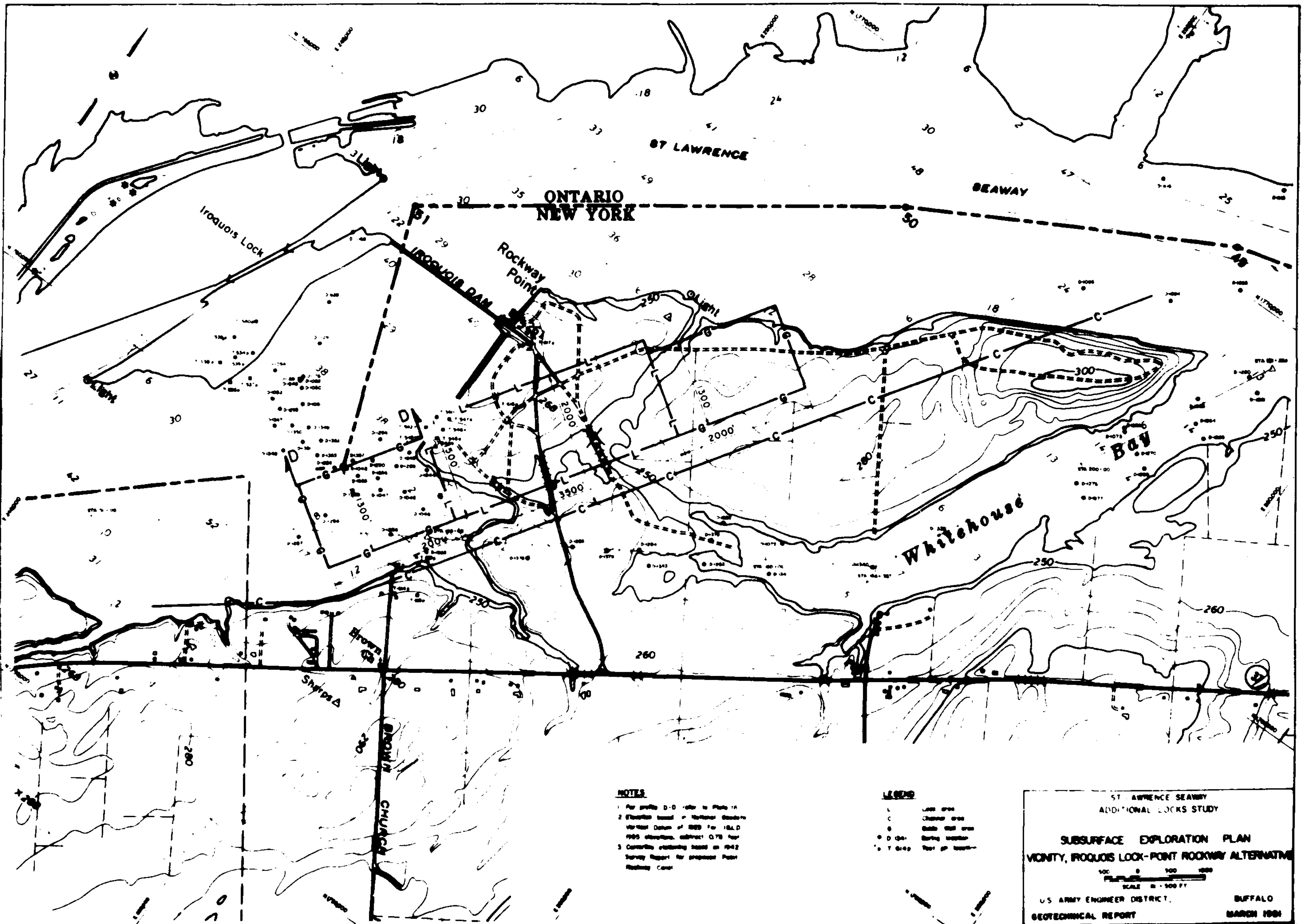
ST LAWRENCE SEAWAY
ADDITIONAL LOCKS STUDY

GEOLOGIC PROFILE C-C

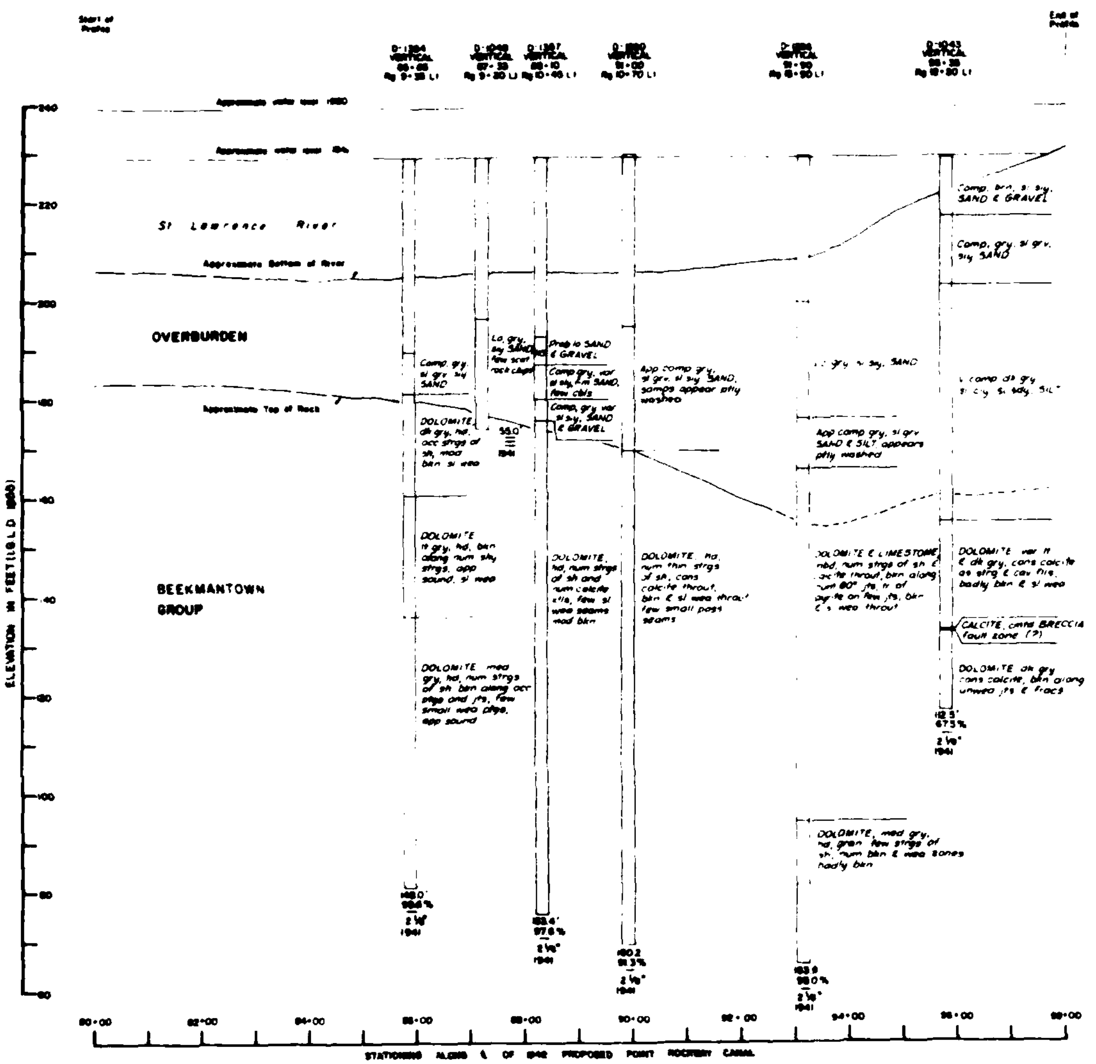
VICINITY, HIGH LIFT LOCK ALTERNATIVE

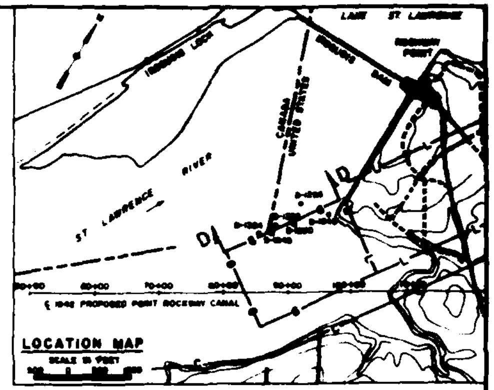
U.S. ARMY ENGINEER DISTRICT, BUFFALO

GEOTECHNICAL REPORT MARCH 1981



ST LAWRENCE
SEAWAY
ONTARIO
NEW YORK
Iroquois Lock
IROQUOIS DAM
Rockway Point
Light
Whitehouse
Bay
Brown
BROWN CHURCH
Sharps
NOTES
LEGEND
ST. LAWRENCE SEAWAY
ADDITIONAL LOCKS STUDY
SUBSURFACE EXPLORATION PLAN
VICINITY, IROQUOIS LOCK-POINT ROCKWAY ALTERNATIVE
U.S. ARMY ENGINEER DISTRICT, BUFFALO
GEOTECHNICAL REPORT





LOCATION MAP

SCALE IN FEET

LEGEND

D-1387 — Boring number
VERTICAL — Boring inclination
88+10 — Station of boring
Rg 10+45 LI — Offset of boring

Material change

153.4' — Depth of boring
97.6% — Percent recovery in bedrock
2 1/8" soil / bedrock — Diameter of sample
1941 — Date boring completed

NOTES

1. The original elevations were based on Mean Sea Level Datum (1912 Adj) and have been converted to International Great Lakes Datum (1955)
2. All borings are projected into the plane of the profile
3. Analyses of overburden material are based on drive sampling. Analyses of rock are based on cores obtained from drilling
4. For boring locations and profile line, refer to Plate 15
5. The soil classification shown uses the following terminology to denote the percentage by dry weight of each component

Term	Proportion
"slightly"	1 - 20%
"adjective"	20 - 40%
"and"	40 - 60%

6. During 1941 boring program, river level was at approximately El. 228.8 feet (I.G.L.D 1955). After construction of Iroquois Dam, river level rose to El. 239.1 feet (I.G.L.D. 1955) - present low water datum above Iroquois Dam
7. Approximate top of rock taken from: Folio of Subsurface Exploration, Final Report 1942, Appendix B-1, St Lawrence River Project, U.S. Engineer Office, Massena, N.Y., Plate 15

SCALE IN FEET

HORIZONTAL SCALE

VERTICAL SCALE

ST LAWRENCE SEAWAY
ADDITIONAL LOCKS STUDY

GEOLOGIC PROFILE D-D
VICINITY, IROQUOIS LOCK -
POINT ROCKWAY ALTERNATIVE

U S ARMY ENGINEER DISTRICT, BUFFALO
GEOTECHNICAL REPORT MARCH 1981

PLATE 16

APPENDIX D

COST ESTIMATES

PRELIMINARY FEASIBILITY REPORT

ST. LAWRENCE SEAWAY/ADDITIONAL LOCKS AND OTHER NAVIGATION IMPROVEMENTS

APPENDIX D
COST ESTIMATES

Table of Contents

LIST OF TABLES

APPENDIX D
COST ESTIMATES

D1. GENERAL

This appendix evaluates a range of alternative lock sizes and corresponding channel and harbor modifications. Federal and non-Federal first costs and investment costs have been estimated for each alternative plan. These preliminary project costs include major expenditures associated with anticipated channel enlargements, new navigation lock construction, highway access tunnels, and harbor improvements throughout the Great Lakes Seaway System.

D2. BASIS OF ESTIMATE

a. Reference Information.

Reference information utilized in these preliminary cost estimates included the following items:

(1) National Oceanic and Atmospheric Administration (NOAA). National Ocean Survey Charts.

(2) U. S. Army Corps of Engineers, Buffalo District. Twin Lock Studies and Cost Estimates. December 1969 (Preliminary Information).

(3) U. S. Army Corps of Engineers, North Central Division. Maximum Ship Size Study. January 1977 (Preliminary Draft).

(4) U. S. Army Corps of Engineers, North Central Division. Update of the Maximum Ship Size Study Costs to January 1981 Dollars. September 1981.

(5) U S. Army Corps of Engineers, Detroit District. Determining Quantities and Costs for Potential Improvement to Harbors for the Great Lakes Connecting Channels and Harbors Study. February 1982 (Draft Report).

(6) U. S. Army Corps of Engineers, Buffalo District. Abstracts of Construction Bids for Eisenhower and Snell Locks. 1956.

b. Unit Prices and Lump-Sum Costs.

Unit prices and lump-sum costs used in these preliminary cost estimates are based on March 1982 price levels. Unit costs are considered to be fair and reasonable costs to a well-equipped and capable Contractor, including Contractor's overhead and profit. Unit costs have been determined from bid abstracts and government estimates for comparable work that has been accomplished by both Buffalo and Detroit Districts of the U. S. Army Corps of Engineers, taking into account special construction and enrivonmental factors that might influence unit costs. At this time, it was necessary to estimate the costs for some major work items on a lump-sum basis, utilizing cost information contained in previous studies listed above.

c. Aids to Navigation.

Costs for aids to navigation associated with each alternative plan were estimated on the basis of 1 percent of the total direct costs estimated for channel enlargements, navigation locks, highway tunnels, and harbor improvements.

d. Real Estate.

Estimates of real estate costs were made on the basis of 2 percent of the total direct costs estimated for channel enlargements, navigation locks and highway tunnels.

e. Contingencies.

The total direct costs for all proposed construction were increased by a contingency factor of approximately 25 percent to determine the total construction cost of each alternative plan.

f. Indirect Costs.

Indirect costs for engineering and design and construction supervision and administration were estimated to be 8 percent and 8 percent respectively, of the total construction cost and added to obtain the total first costs less real estate.

g. Investment Costs.

Investment costs for each alternative plan include simple interest of 7-5/8 percent applied over an average 5-year construction period and added to the total first costs including real estate cost. The average 5-year construction period assumed multi-contract construction and the availability of national or regional Contractors capable of managing large multi-million dollar construction contracts.

h. Detailed Cost Estimates.

Detailed cost estimates for each alternative plan are provided in the attached supplement to this appendix, entitled "Detailed Cost Estimates." A summary of U. S. total investment costs for each alternative plan is included in Table D1.

i. Operation and Maintenance.

No operation and maintenance costs are added to any plan which does not increase the number of U. S. locks (i.e., 2) in the lower system. This is because the present O&M costs are expected to continue even in a "without project" condition. The only time O&M costs are added to the total project costs are: when more than two locks would be in operation (a parallel system would have four locks) and with Plans AVII27 and AX27; or when the nonstructural improvement to maximum utility plan is (AVII27) implemented. The derivation of the O&M costs for Plans AV II27 and AX27 are shown in the supplement to this appendix.

The remaining plans all involve replacement of the existing locks with larger locks. It is assumed that the cost of O&M for these larger locks would be comparable to that for the existing locks. In the case of the "tandem" locks, it is likely that its O&M costs would be higher than the present O&M costs. However, because of the lack of historical data and the preliminary nature of this estimate, it was assumed that no additional O&M cost is added to the "tandem" locks plan cost estimate.

j. Nonstructural Improvements.

Nonstructural improvement costs were developed from the referenced ARCTEC, Inc. work. The nonstructural improvement to maximum utility plan includes traveling levels, decreased dump/fill times, and a traffic control system. Its costs include the improvement itself, and the additional O&M costs for the nonstructural improvement.

Table D1 - Summary of U. S. Total Plan Costs (St. Lawrence River)
Costs in Millions of Dollars (March 1982 Price Levels)

Channel Depth (Feet) / Lock Plan	Replace Existing System: 115' W X 1,200' L Locks - Class X (2)	Replace Existing System: 115' W X 1,350' L Locks - Class XI	Replace Existing System: 145' W X 1,460' L Locks - Class XII	Replace Existing System: Tandem 115' W X 1,800' L Locks 2 - Class VII or 1 Class X	New Locks Plus Existing System: "Twin" 80' W X 860' L Locks - 2 Class VII	New Locks Plus Existing System: 115' W X 1,200' L Locks - 1 Class VII or 1 Class X
27.0 (26.0 Draft)	RX27 (3) 1,040	RXI27 1,086	RXII27 1,425	RX27T 1,192	AVII27 362 (5)	AX27 1,104 (6)
30.0 (28.0 Draft)	RX30 1,913	RXI30 1,964	RXII30 2,361	RX30T 2,081	N.E.	N.E.
32.0 (30.0 Draft)	RX32 2,393	RXI32 2,443	RXII32 2,950	N.E. (4)	N.E.	N.E.

(1) U. S. Total Plan Costs include total investment costs for both Federal and non-Federal construction and operation and maintenance costs, where applicable.

(2) Vessel Size: Class VII - 75' W X 730' L; Class X - 105' W X 1,000' L; Class XI - 105' W X 1,100' L' and Class XII - 130' W X 1,200' L.

(3) RX27 - Scenario number, typical.

(4) N.E. - Not evaluated.

(5) Includes costs of nonstructural improvements and additional Operations and Maintenance.

(6) Includes cost of additional Operations and Maintenance.

PRELIMINARY FEASIBILITY REPORT

ST. LAWRENCE SEAWAY/ADDITIONAL LOCAKS AND OTHER NAVIGATION IMPROVEMENTS

APPENDIX D SUPPLEMENT
DETAILED COST ESTIMATES

Table of Contents

Subject Additional Locks Study - St. Lawrence R., U.S. Section
Computation of Cost Estimates for Class X, XI and XII Locks
Computed by J.N.E. **Checked by** ______ **Date** Mar 1982

Basic Assumptions

1. These scenarios assume that a single highlift lock will be constructed in a new overland channel. The channel will somewhat parallel the existing Wiley-Dondero Canal.

2. Dredging costs will include new channel construction, enlargement of existing channels and dike reconstruction. New channel construction will be estimated based on excavation and dike costs given in the "Twin Locks Study" dated Dec. 1969. Channel costs will be adjusted based on a ratio of channel depths for deeper depth alternatives. Dredging of existing channels will be estimated based on quantities computed by Buffalo District Planning Division and unit costs prepared by Detroit District for the Upper Great Lakes portion of this study and considered applicable to Lower Lakes.

3. Lock costs will be estimated based on lock construction costs given in the "Maximum Ship Size Study" dated Jan 1981. Lock costs will be adjusted between given values, when necessary, based on ratios of lock lengths and channel depths.

4. The cost of a highway tunnel under a new lock will be estimated based on tunnel construction costs given in the MSSS, Jan 1981 report. Tunnel costs will be adjusted between given values, when necessary, based on a ratio of channel depths.

5. Harbor costs will include 20% of the total cost of improving U.S. harbors to accommodate larger and/or deeper draft vessels. The 20% factor is based on a ratio of St. Lawrence Seaway traffic tonnage compared to total harbor traffic tonnage. The total cost of harbor improvements will be estimated based on costs given in a Detroit District draft report dated Feb. 1982.

6. Costs for aids to navigation and real estate will be estimated based on percentage factors given in the MSSS, Jan. 1981. Costs for engineering & design and supervision and administration will be estimated based on percentage factors given in a Feb. 1982 harbor improvement report by Detroit District.

Subject: Additional Locks Study - St. Lawrence R., U.S. Section
Computation of: Cost Estimate - Summary of Dredging Quantities
Computed by: J.N.E. Checked by: Date: Mar 1982

Reference: Dredging quantities calculated by Buffalo District Planning Division and dated Feb. 1982. Quantities include channel improvements required within and adjacent to the existing navigation channel.

SUMMARY OF DREDGING QUANTITIES

Volume in cubic yards

SCENARIO	OVERBURDEN	ROCK
RX27	5,922,048	2,399,925
RX30	11,421,281	4,572,079
RX32	17,918,652	6,559,787
RX127	5,922,048	2,399,925
RX130	11,421,281	4,572,079
RX132	17,918,652	6,559,787
RX1127	9,741,426	3,965,262
RX1130	16,930,750	6,208,211
RX1132	26,177,088	8,667,099

Subject: Additional Locks Study – St. Lawrence R. U.S. Section
Computation of: Cost Estimate – Summary of Harbor Costs
Computed by: J. N. E. Checked by: Date: Mar. 1982

Reference: "Determining Quantities and Costs for Potential Improvements to Harbors for the Great Lakes Connecting Channels and Harbor Study" draft report dated Feb. 1982 by Detroit District.

SUMMARY OF HARBOR COSTS [1]

Thousands of Dollars

SCENARIO	FEDERAL	NON-FEDERAL
RX27	147,744	41,157
RX30	1,233,589	524,525
RX32	1,644,312	627,793
RX127	168,766	53,100
RX130	1,255,677	538,024
RX132	1,667,622	637,410
RX1127	217,476	84,050
RX1130	1,315,500	567,481
RX1132	1,757,506	669,290

1. Construction costs exclusive of contingencies, engineering + design, and supervision + administration.

Subject: Additional Locks Study - St. Lawrence R., U.S. Section
Computation of: Cost Estimate - Summary of Cost Sharing for Harbors
Computed by: J.N.E. Checked by: ______ Date: Mar. 1982

Reference: Cost sharing calculations by Buffalo District Economics Branch and dated 18-19 Mar. 1982.
Harbor improvement costs from "Determining Quantities and Costs for the Great Lakes Connecting Channels and Harbor Study" draft report dated Feb. 1982 by Detroit District.

SUMMARY OF COST SHARING FOR HARBORS

Thousands of Dollars

SCENARIO	TOTAL HARBOR COSTS [1]	HARBOR COSTS SHARED BY U.S. SECTION [2]
RX27	188,901	32,079
RX30	1,758,114	315,757
RX32	2,272,105	395,818
RX127	221,866	40,266
RX130	1,793,701	324,365
RX132	2,305,032	402,917
RY1127	301,526	51,688
RY1130	1,882,981	335,897
RY1132	2,426,796	417,961
AV1127	0	0
RX27T	188,901	32,079
RX30T	1,758,114	315,757
AX27	188,901	32,079
Total	15,286,938	2,696,663

Percentage Shared By U.S. Section $= \frac{2,696,663}{15,286,938} = 17.6\%$

Use 20%

1. Construction costs exclusive of contingencies, engineering + design, and supervision + administration.
2. Based on percentage of St. Lawrence Seaway traffic tonnage compared to total harbor traffic tonnage.

Subject: Additional Locks Study - St. Lawrence R., U.S. Section
Computation of: Cost Estimate - 1,200' x 115' Lock
Computed by: J.N.E. Checked by: ______ Date: Mar. 1982

Scenario - RX27 and AX27,
Vessel Size : 1,000' x 105' x 25.5' draft
Lock Size : 1,200' x 115'
Channel Depth : 27'

Cost Estimate:

Dredging -

ENR "Construction Cost Index" Dec. 1969 to Mar. 1982 = $\frac{3,729}{1,305}$ = 2.8575

New channel -

\$67,088,000 (2.8575) = \$191,702,032

Existing channels -

Overburden	= 5,922,048 cy (\$12.50)	= \$	74,025,600
Rock	= 2,399,925 cy (\$34.50)	=	82,797,412
Total		= \$	348,525,045.

Say \$349,000,000.

Locks -

ENR "Construction Cost Index" Jan. 1981 to Mar. 1982 = $\frac{3,729}{3,372}$ = 1.1059

Interpolate between 1,140' x 115' lock and 1,350' x 115' lock, see Table #12, MSSS, Jan 1981 -

[148,422,000 + (173,685,000 - 148,422,000) 60/210] 1.1059 =

\$172,117,900. Say \$172,000,000.

Subject Additional Locks Study - St. Lawrence R., U.S. Section
Computation of Cost Estimate - 1,200' x 115' Lock
Computed by J.N.E. Checked by ________ Date Mar. 1982

Cost Estimate : cont'd.

Tunnels -

ENR "CC Index", Jan 1981 to Mar 1982 = 1.1059

For 115' lock width, see Table # 16, MSSS, Jan 1981 -

$ 26,871,000 (1.1059) = $ 29,715,883

Say $ 30,000,000

Harbors -

Ref: Summary of harbor costs and cost sharing, pages 3+4.

Federal -

$147,744,000 (0.2) = $ 29,548,000

Say $ 30,000,000

Non-Federal -

$ 41,157,000 (0.2) = $ 8,231,000

Say $ 8,000,000

Subject: Additional Locks Study - St. Lawrence R., U.S. Section
Computation of: Cost Summary: 1,2[illegible] [illegible] Lock
Computed by: J.N.E. Checked by: Date: Mar 1982

Scenario - Vessel Size: 1,000'L x 105'w x 25.5' draft
RX27 Lock Size: 1,200'L x 115'w
AX27 Channel Depth: 27'

COST SUMMARY (MAR. 1982 Price Levels)
MILLIONS OF DOLLARS

Item	Federal	Non-Federal
Dredging	349	—
Locks	172	—
Tunnels	30	—
Subtotal (ST1)	$ 551	$ —
Harbors	30	8
Subtotal (ST2)	$ 581	$ 8
Aids to Navigation (1% x ST2)	6	—
Subtotal (ST3)	$ 587	$ 8
Contingencies (25% x ST3)	146	2
Total Construction Cost	$ 733	$ 10
Engineering + Design (8%)	59	1
Supervision + Administration (8%)	59	1
Total Cost less Real Estate	$ 851	$ 12
Real Estate (2% x ST1)	11	—
Total First Costs	$ 862	$ 12
Interest During Construction (Total First Cost x 7 5/8 % x 5 yrs./2)	164	2
Total Investment Costs	$ 1,026	$ 14

Total First Cost	$ 874
Total Investment Cost	$ 1,040

Subject: Additional Locks Study - St. Lawrence R., U.S. Section
Computation of: Cost Estimate - 1,200' x 115' Lock
Computed by: J.H.E. Checked by: Date: Mar 1982

Scenario - RX30
Vessel Size : 1,000' x 105' x 28' draft
Lock Size : 1,200' x 115'
Channel Depth : 30'

Cost Estimate :

Dredging -

ENR "CC Index", Dec 1969 to Mar 1982 = 2.8575

New channel -

$67,088,000 (2.8575)(30)/27 = $213,002,258

Existing channels -

Overburden	= 11,421,281 ($12.50)	= $142,766,013
Rock	= 4,572,079 ($34.50)	= 157,736,725
Total		= $513,504,996

Say $514,000,000.

Locks -

ENR "CC Index", Jan 1981 to Mar 1982 = 1.1059

Interpolate between 1,140' x 115' lock and 1,350' x 115' lock, see Table # 12, MSSS Jan 1981 -

[163,109,000 + (190,872,000 - 163,107,000) 60/210] (1.1059) =

$189,149,750. Say $189,000,000.

Subject: Additional Locks Study - St. Lawrence R., U.S. Section
Computation of: Cost Estimate - 1,200' x 115' Lock
Computed by: J.U.E. Checked by: ____ Date: Mar 1982

Cost Estimate : cont'd.

Tunnels -

ENR "CC Index", Jan 1981 to Mar 1982 = 1.1059

For 115' lock width, see Table # 16, MSSS Jan 1981 -

$29,599,000 (1.1059) = $ 32,732,702

Say $ 33,000,000

Harbors -

Ref: Summary of harbor costs and cost sharing, pages 3 & 4.

Federal -

$1,233,589,000 (0.2) = $ 246,718,000

Say $ 247,000,000

Non-Federal -

$ 524,525,000 (0.2) = $ 104,905,000

Say $ 105,000,000

Subject: Additional Locks Study - St. Lawrence R., U.S. Section
Computation of: Cost Summary : 1,200' x 115' Lock
Computed by: J.N.E. Checked by: Date: Mar 1982

Scenario - Vessel Size: 1,000'L x 105'w x 28' draft
RX30 Lock Size: 1,200'L x 115'w
Channel Depth: 30'

COST SUMMARY (MAR. 1982 Price Levels)
MILLIONS OF DOLLARS

Item	Federal	Non-Federal
Dredging	514	-
Locks	189	-
Tunnels	33	-
Subtotal (ST1)	$ 736	$ -
Harbors	247	105
Subtotal (ST2)	$ 983	$ 105
Aids to Navigation (1% x ST2)	10	-
Subtotal (ST3)	$ 993	$ 105
Contingencies (25% x ST3)	248	26
Total Construction Cost	$ 1,241	$ 131
Engineering + Design (8%)	100	10
Supervision + Administration (8%)	99	11
Total Cost less Real Estate	$ 1,440	$ 152
Real Estate (2% x ST1)	15	-
Total First Costs	$ 1455	$ 156
Interest During Construction (Total First Cost x 7 5/8 % x 5 yrs./2)	277	29
Total Investment Costs	$ 1,732	$ 181

Total First Cost	$ 1,607
Total Investment Cost	$ 1,913

Subject: Additional Locks Study - St. Lawrence R., U.S. Section
Computation of: Cost Estimate - 1,200' x 115' Lock
Computed by: J.N.E. Checked by: Date: Mar 1982

Scenario — RX32
Vessel Size : 1,000' x 105' x 30' draft
Lock Size : 1,200' x 115'
Channel Depth : 32'

Cost Estimate :

Dredging —

ENR "CC Index", Dec 1969 to Mar 1982 = 2.8575

New channel —

\$67,088,000 (2.8575)(32)/27 = \$ 227,202,408

Existing channels —

Overburden	= 17,918,652 (\$12.50)	= \$	223,983,150
Rock	= 6,559,787 (\$34.50)	=	226,312,652
Total		= \$	677,498,210.
	Say	\$	677,000,000.

Locks —

ENR "CC Index", Jan 1981 to Mar 1982 = 1.1059

Interpolate between 1,140' x 115' lock and 1,350' x 115' lock and between 30' and 34' channel depths, see Table #12, MSSS Jan 1981 —

For 30' channel depth, see page 8 = \$ 189,149,750

For 34' channel depth —

[172,351,000 + (201,687,000 - 172,351,000) 60/210] 1.1059 =

\$ 199,867,228.

Subject Additional Locks Study - St. Lawrence R., U.S. Section
Computation of Cost Estimate - 1,200' x 115' Lock
Computed by J.N.E. **Checked by** ______ **Date** Mar. 1982

Cost Estimate : cont'd.

Locks - cont'd.

For 32' channel depth -

(189,149,750. + 199,867,228.) /2 = $ 194,508,489.

Say $ 195,000,000.

Tunnels -

ENR "CC Index", Jan 1981 to Mar 1982 = 1.1059

Interpolate between 30' and 34' channel depths

For 115' lock width, see Table #16, MSSS, Jan 1981 -

[(29,599,000 + 33,827,000)/2] 1.1059 =

$ 35,070,515. Say $ 35,000,000.

Harbors -

Ref: Summary of harbor costs and cost sharing, pages 3-4.

Federal -

$ 1,644,312,000 (0.20) = $ 328,862,000

Say $ 329,000,000

Non-Federal -

$ 627,793,000 (0.20) = $ 125,559,000

Say $ 125,000,000

Subject: Additional Locks Study - St. Lawrence R., U.S. Section
Computation of: Cost Summary : 1,200' x 115' Lock
Computed by: J.N.E. Checked by: Date: Mar 1982

Scenario - Vessel Size: 1,000'L x 105'w x 30' draft
RX32 Lock Size: 1,200'L x 115'w
Channel Depth: 32'

COST SUMMARY (MAR. 1982 Price Levels)
MILLIONS OF DOLLARS

Item	Federal	Non-Federal
Dredging	677	-
Locks	195	-
Tunnels	35	-
Subtotal (ST1)	$ 907	$ -
Harbors	329	125
Subtotal (ST2)	$ 1,236	$ 125
Aids to Navigation (1% x ST2)	12	-
Subtotal (ST3)	$ 1,248	$ 125
Contingencies (25% x ST3)	312	32
Total Construction Cost	$ 1,560	$ 157
Engineering + Design (8%)	125	12
Supervision + Administration (8%)	125	12
Total Cost less Real Estate	$ 1,810	$ 181
Real Estate (2% x ST1)	19	-
Total First Costs	$ 1,829	$ 181
Interest During Construction (Total First Cost x 7 5/8 % x 5 yrs. /2)	348	35
Total Investment Costs	$ 2,177	$ 216
Total First Cost	$ 2,010	
Total Investment Cost	$ 2,393	

Subject: Additional Locks Study – St. Lawrence R., U.S. Section
Computation of: Cost Estimate – 1,350' x 115' Lock
Computed by: J.N.E. Checked by: Date: Mar 1982

Scenario – RX127
Vessel Size : 1,100' x 105' x 25.5' draft
Lock Size : 1,350' x 115'
Channel Depth : 27'

Cost Estimate :

Dredging –

ENR "CC Index", Dec 1969 to Mar 1982 = 2.8575

New channel –

$67,088,000 (2.8575)	= $191,702,032

Existing channels –

Overburden	= 5,922,048 cy ($12.50)	= $74,025,600
Rock	= 2,399,925 cy ($34.50)	= 82,797,412
Total		= $348,525,045
	Say	$349,000,000

Locks –

ENR "CC Index", Jan 1981 to Mar 1982 = 1.1059

From Table # 12, MSSS, Jan 1981 –

$173,685,000 (1.1059)	= $192,073,359
Say	$192,000,000

Subject: Additional Locks Study - St. Lawrence R., U.S. Section
Computation of: Cost Estimate - 1,350'x115' Lock
Computed by: J.N.E. Checked by: Date: Mar. 1982

Cost Estimate: cont'd.

Tunnels -

ENR "CC Index", Jan 1981 to Mar 1982 = 1.1059

For 115' lock width, see Table #16, MSSS, Jan 1981 -

$26,871,000. (1.1059) = $ 29,715,883.

Say $ 30,000,000.

Harbors -

Ref: Summary of harbor costs and cost sharing, pages 3&4.

Federal -

$ 168,766,000 (0.20) = $ 33,753,000

Say $ 34,000,000

Non-Federal -

$ 53,100,000 (0.20) = $ 10,620,000

Say $ 10,000,000

Subject: Additional Locks Study - St. Lawrence R., U.S. Section
Computation of: Cost Summary : 1,350' x 115' Lock
Computed by: J.N.E. Checked by: Date: Mar 1982

Scenario - Vessel Size: 1,100'L x 105'W x 25.5' draft
R/I 27 Lock Size: 1,350'L x 115'W
Channel Depth: 27'

COST SUMMARY (MAR. 1982 Price Levels)
MILLIONS OF DOLLARS

Item	Federal	Non-Federal
Dredging	349	
Locks	192	
Tunnels	30	—
Subtotal (ST1)	$ 571	$ —
Harbors	34	10
Subtotal (ST2)	$ 605	$ 10
Aids to Navigation (1% x ST2)	6	—
Subtotal (ST3)	$ 611	$ 10
Contingencies (25% x ST3)	153	2
Total Construction Cost	$ 764	$ 12
Engineering + Design (8%)	61	1
Supervision + Administration (8%)	61	1
Total Cost less Real Estate	$ 886	$ 14
Real Estate (2% x ST1)	12	—
Total First Costs	$ 898	$ 14
Interest During Construction (Total First Cost x 7 5/8 % x 5 yrs. /2)	171	3
Total Investment Costs	$ 1,069	$ 17

Total First Cost	$ 912
Total Investment Cost	$ 1,086

Subject: Additional Locks Study - St. Lawrence R., U.S. Section
Computation of: Cost Estimate - 1350' x 115' Lock
Computed by: J.N.E. Checked by: Date: Mar. 1982

Scenario - RX130
Vessel Size : 1,100' x 105' x 28' draft
Lock Size : 1,350' x 115
Channel Depth : 30'

Cost Estimate :

Dredging -

ENR "CC Index", Dec 1969 to Mar 1982 = 2.8575

New channel -

\# 67,088,000 (2.8575)(30)/27 = \# 213,002,258

Existing channels -

Overburden	= 11,421,281 cy (\# 12.50)	= \#	142,766,013
Rock	= 4,572,079 cy (\# 34.50)	=	157,736,725
Total		= \#	513,504,996.
		Say \#	514,000,000.

Locks -

ENR "CC Index", Jan 1981 to Mar 1982 = 1.1059

From Table # 12, MSSS, Jan 1981 -

\# 190,872,000 (1.1059) = \# 211,079,979.

Say \# 211,000,000.

Subject: Additional Locks Study - St. Lawrence R., U.S. Section
Computation of: Cost Estimate - 1350' x 115' Lock
Computed by: J. N. E. Checked by: Date: Mar 1982

Cost Estimate : cont'd.

Tunnels –

ENR "CC Index", Jan 1981 to Mar 1982 = 1.1059

For 115' lock width, see Table #16, MSSS, Jan 1981 –

$ 29,599,000 (1.1059) = $ 32,732,702.

Say $ 33,000,000.

Harbors –

Ref: Summary of harbor costs and cost sharing, pages 3 & 4.

Federal –

$ 1,255,677,000 (0.2) = $ 251,135,400.

Say $ 251,000,000.

Non-Federal –

$ 538,024,000 (0.2) = $ 107,604,800

Say $ 108,000,000

Subject: Additional Locks Study - St. Lawrence R., U.S. Section
Computation of: Cost Summary: 1,350' x 115' Lock
Computed by: J.N.E. Checked by: Date: Mar 1982

Scenario - Vessel Size: 1,100'L x 105'w x 28' draft
RXI30 Lock Size: 1,350'L x 115'w
Channel Depth: 30'

COST SUMMARY (MAR. 1982 Price Levels)
MILLIONS OF DOLLARS

Item	Federal	Non-Federal
Dredging	514	-
Locks	211	-
Tunnels	33	-
Subtotal (ST1)	$ 758	$ -
Harbors	251	108
Subtotal (ST2)	$ 1,009	$ 108
Aids to Navigation (1% x ST2)	10	-
Subtotal (ST3)	$ 1,019	$ 108
Contingencies (25% x ST3)	255	27
Total Construction Cost	$ 1,274	$ 135
Engineering + Design (8%)	102	11
Supervision + Administration (8%)	102	11
Total Cost less Real Estate	$ 1,478	$ 157
Real Estate (2% x ST1)	15	-
Total First Costs	$ 1,493	$ 157
Interest During Construction (Total First Cost x 7 5/8 % x 5 yrs./2)	285	29
Total Investment Costs	$ 1,778	$ 186

Total First Cost	$ 1,650
Total Investment Cost	$ 1,964

Subject: Additional Locks Study - St. Lawrence R., U.S. Section
Computation of: Cost Estimate - 1,350'x115' Lock
Computed by: J.N.E. Checked by: Date: Mar 1982

Scenario - RX132
Vessel Size : 1,100'x105' x 30'draft
Lock Size : 1,350'x115'
Channel Depth : 32'

Cost Estimate:

Dredging -

ENR "CC Index", Dec 1969 to Mar 1982 = 2.8575

New channel -

$ 67,088,000 (2.8575)(32)/27 = $ 227,202,408

Existing channels -

Overburden	= 17,918,652 cy ($12.50)	= $	223,983,150
Rock	= 6,559,787 cy ($34.50	=	226,312,652
Total		= $	677,498,210.
	Say	$	677,000,000.

Locks -

ENR "CC Index", Jan 1981 to Mar 1982 = 1.1059

Interpolate between 30' and 34' channel depths, see Table # 12, MSSS, Jan 1981 -

[(190,872,000 + 201,687,000)/2] 1.1059 =

$ 217,059,981. Say $ 217,000,000.

Subject: Additional Locks Study - St. Lawrence R., U.S. Section
Computation of: Cost Estimate - 1,350' x 115' Lock
Computed by: J.N.E. Checked by: Date: Mar 1982

Cost Estimate: cont'd.

Tunnels -

ENR "CC Index", Jan 1981 to Mar 1982 = 1.1059

Interpolate between 30' and 34' channel depths

For 115' lock width, see Table #16, MSSS, Jan 1981 -

[(29,599,000 + 33,827,000)/2] 1.1059 =

\# 35,070,515. Say \# 35,000,000.

Harbors -

Ref: Summary of harbor costs and cost sharing, pages 3 & 4.

Federal -

\# 1,667,622,000 (0.2) = \# 333,524,400.

Say \# 334,000,000.

Non-Federal -

\# 637,410,000 (0.2) = \# 127,482,000.

Say \# 127,000,000

Subject: Additional Locks Study - St. Lawrence R., U.S. Section
Computation of: Cost Summary : 1,350' X 115' Lock
Computed by: J.N.E. Checked by: Date: Mar 1982

Scenario - Vessel Size: 1,100'L x 105'w x 30' draft
RX1 32 Lock Size: 1,350'L x 115'w
Channel Depth: 32'

COST SUMMARY (MAR. 1982 Price Levels)
MILLIONS OF DOLLARS

Item	Federal	Non-Federal
Dredging	677	
Locks	217	
Tunnels	35	
Subtotal (ST1)	$ 929	$
Harbors	334	127
Subtotal (ST2)	$ 1,263	$
Aids to Navigation (1% x ST2)	13	
Subtotal (ST3)	$ 1,276	$ 127
Contingencies (25% x ST3)	319	32
Total Construction Cost	$ 1,595	$ 159
Engineering & Design (8%)	128	12
Supervision & Administration (8%)	127	13
Total Cost less Real Estate	$ 1,850	$ 184
Real Estate (2% x ST1)	18	
Total First Costs	$ 1,868	$ 184
Interest During Construction (Total First Cost x 7 5/8 % x 5 yrs./2)	356	35
Total Investment Costs	$ 2,224	$ 219

Total First Cost	$ 2,052
Total Investment Cost	$ 2,443

Subject: Additional Locks Study - St. Lawrence R., U.S. Section
Computation of: Cost Estimate - 1,460' x 145' Lock
Computed by: J.N.E. Checked by: Date: Mar 1982

Scenario - RX1127
Vessel Size : 1,200' x 130' x 25.5' draft
Lock Size : 1,460' x 145'
Channel Depth : 27'

Cost Estimate :

Dredging -

ENR "CC Index", Dec 1969 to Mar. 1982 = 2.8575

New channel -

Adjust channel cost based on a ratio of required channel widths.

$$\text{Channel width ratio} = \frac{990' (130' \text{ vessel})}{800' (105' \text{ vessel})} = 1.2375$$

#67,088,000 (2.8575)(1.2375) = #237,231,265.

Existing channels -

Overburden	= 9,741,426 cy	(#12.50)	= # 121,767,825.
Rock	= 3,965,262 cy	(#34.50)	= 136,801,539.
Total			= # 495,800,629
		Say	# 496,000,000

Locks -

ENR "CC Index", Jan 1981 to Mar 1982 = 1.1059

From Table # 12, MSSS, Jan 1981 -

193,827,000 (1.1059) = # 214,347,830.

Say # 214,000,000.

Subject Additional Locks Study - St. Lawrence R., U.S. Section
Computation of Cost Estimate - 1,460' x 145' Lock
Computed by J.N.E. Checked by ______ Date Mar 1982

Cost Estimate : cont'd.

Tunnels -

ENR "cc Index", Jan 1981 to Mar 1982 = 1.1059

For 130' lock width, see Table # 16, MSSS, Jan 1981 -

$33,282,000 (1.1059) = $ 36,805,628.

Say $ 37,000,000.

Harbors -

Ref : Summary of harbor costs and cost sharing, pages 3 & 4.

Federal -

$ 217,476,000 (0.20) = $ 43,495,200.

Say $ 43,000,000.

Non-Federal -

$ 84,050,000 (0.20) = $ 16,810,000.

Say $ 17,000,000.

Subject: Additional Locks Study - St. Lawrence R., U.S. Section
Computation of: Cost Summary : 1,460' x 145' Lock
Computed by: J.N.E. Checked by: Date: Mar 1982

Scenario - Vessel Size: 1,200'L x 130'W x 25.5' draft
RXII27 Lock Size: 1,460'L x 145'W
Channel Depth: 27'

COST SUMMARY (MAR. 1982 Price Levels)
MILLIONS OF DOLLARS

Item	Federal	Non-Federal
Dredging	496	–
Locks	214	–
Tunnels	37	–
Subtotal (ST1)	$ 747	$ –
Harbors	43	17
Subtotal (ST2)	$ 790	$ 17
Aids to Navigation (1% x ST2)	8	–
Subtotal (ST3)	$ 798	$ 17
Contingencies (25% x ST3)	199	4
Total Construction Cost	$ 997	$ 21
Engineering + Design (8%)	80	2
Supervision + Administration (8%)	80	2
Total Cost less Real Estate	$ 1,157	$ 25
Real Estate (2% x ST1)	15	–
Total First Costs	$ 1,172	$ 25
Interest During Construction (Total First Cost x 7 5/8 % x 5 yrs. / 2)	223	5
Total Investment Costs	$ 1,395	$ 30
Total First Cost	$ 1,197	
Total Investment Cost	$ 1,425	

Subject Additional Locks Study - St. Lawrence R., U.S. Section
Computation of Cost Estimate - 1460' x 145' Lock
Computed by J.N.E. **Checked by** ______ **Date** Mar 1982

Scenario — RX1130
Vessel size : 1,200' x 130' x 28' draft
Lock Size : 1,460' x 145'
Channel Depth : 30'

Cost Estimate :

Dredging —

ENR "CC Index", Dec 1969 to Mar 1982 = 2.8575

New channel —

Adjust channel cost based on ratios of required channel widths and depths.

Channel width ratio = 990 (130' vessel) / 800 (105' vessel) = 1.2375

$67,088,000 (2.8575)(1.2375)(30)/27 =

$263,590,294

Existing channels —

Overburden	= 16,930,750 cy ($12.50) =	$211,634,375
Rock	= 6,208,211 cy ($34.50) =	214,183,280
Total		$689,407,949.

Say $690,000,000.

Locks —

ENR "CC Index", Jan 1981 to Mar 1982 = 1.1059

From Table #12, MSSS, Jan 1981 —

$212,569,000 (1.1059) = $235,074,081.

Say $235,000,000.

Subject: Additional Locks Study – St. Lawrence R., U.S. Section
Computation of: Cost Estimate – 1460'x 145' Lock
Computed by: J.N.E. Checked by: ____ Date: Mar 1982

Cost Estimate : cont'd.

Tunnels –

ENR "CC Index", Jan 1981 to Mar 1982 = 1.1059

For 130' lock width, see Table #16, MSSS, Jan 1981 –

$ 36,555,000 (1.1059) = $ 40,425,147.

Say $ 40,000,000.

Harbors –

Ref.: Summary of harbor costs and cost sharing, pages 3 and 4.

Federal –

$ 1,315,500,000 (0.20) = $ 263,100,000.

Say $ 263,000,000.

Non-Federal –

$ 567,481,000 (0.20) = $ 113,496,200.

Say $ 114,000,000.

Subject Additional Locks Study - St. Lawrence R., U.S. Section
Computation of Cost Summary : 1,460' x 145' Lock
Computed by J.N.E. **Checked by** ______ **Date** Mar 1982

Scenario - Vessel Size: 1,200'L x 130'w x 28' draft
RX II 30 Lock Size: 1,460'L x 145'w
Channel Depth: 30'

COST SUMMARY (MAR. 1982 Price Levels)
MILLIONS OF DOLLARS

Item	Federal	Non-Federal
Dredging	690	
Locks	235	–
Tunnels	40	–
Subtotal (ST1)	$ 965	$ –
Harbors	263	114
Subtotal (ST2)	$ 1,228	$ 114
Aids to Navigation (1% x ST2)	12	–
Subtotal (ST3)	$ 1,240	$ 114
Contingencies (25% x ST3)	310	29
Total Construction Cost	$ 1550	$ 143
Engineering + Design (8%)	124	11
Supervision + Administration (8%)	124	11
Total Cost less Real Estate	$ 1,798	$ 165
Real Estate (2% x ST1)	20	--
Total First Costs	$ 1,818	$ 165
Interest During Construction (Total First Cost x 7 5/8 % x 5 yrs./2)	346	32
Total Investment Costs	$ 2,164	$ 197
Total First Cost	$ 1,983	
Total Investment Cost	$ 2,361	

Subject: Additional Locks Study – St. Lawrence R., U.S. Section
Computation of: Cost Estimate – 1460' x 145' Lock
Computed by: J.N.E. Checked by: Date: Mar 1982

Scenario – RX1132
Vessel Size : 1,200' x 130' x 30' draft
Lock Size : 1,460' x 145'
Channel Depth : 32'

Cost Estimate:

Dredging –

ENR "cc Index", Dec 1969 to Mar 1982 = 2.8575

New channel –

Adjust channel cost based on ratios of required channel widths and depths.

Channel width ratio = 990 (130' vessel) / 800 (105' vessel) = 1.2375

\$67,088,000(2.8575)(1.2375)(32)/27 =

\$281,162,980

Existing channels –

Overburden	= 26,177,088 cy	(\$12.50)	= \$327,213,600
Rock	= 8,667,099 cy	(\$34.50)	= 299,014,916
Total			= \$907,391,496.

Say \$907,000,000.

Locks –

ENR "CC Index", Jan 1981 to Mar 1982 = 1.1059

Interpolate between 30' and 34' channel depths, see Table #12, MSSS, Jan 1981 –

[(212,569,000 + 224,833,000)/2] 1.1059 =

\$241,855,287. Say \$242,000,000.

Subject: Additional Locks Study - St. Lawrence R., U.S. Section
Computation of: Cost Estimate - 1460' x 145' Lock
Computed by: J.N.E. Checked by: ____ Date: Mar 1982

Cost Estimate : cont'd.

Tunnels -

ENR "cc Index", Jan 1981 to Mar 1982 = 1.1059

Interpolate between 30' and 34' channel depths

For 130' lock width, see Table # 16, MSSS, Jan 1981 -

[(36,555,000 + 41,875,000)/2] 1.1015 =

$ 43,366,766   Say $ 43,000,000.

Harbors -

Ref : Summary of harbor costs and cost sharing, pages 3 & 4.

Federal -

$ 1,757,506,000 (0.20) = $ 351,501,200.

Say $ 351,000,000.

Non-Federal -

$ 669,290,000 (0.20) = $ 133,858,000.

Say $ 134,000,000.

Subject: Additional Locks Study - St. Lawrence R., U.S. Section
Computation of: Cost Summary: 1460' x 145' Lock
Computed by: J.N.E. Checked by: Date: Mar 1982

Scenario - Vessel Size: 1,200'L x 130'w x 30' draft
RXII 32 Lock Size: 1,460'L x 145'w
Channel Depth: 32'

COST SUMMARY (MAR. 1982 Price Levels)
MILLIONS OF DOLLARS

Item	Federal	Non-Federal
Dredging	907	–
Locks	242	–
Tunnels	43	–
Subtotal (ST1)	$1,192	$ –
Harbors	351	134
Subtotal (ST2)	$1,543	$
Aids to Navigation (1% x ST2)	15	–
Subtotal (ST3)	$1,558	$ 134
Contingencies (25% x ST3)	390	34
Total Construction Cost	$1,948	$ 168
Engineering + Design (8%)	156	13
Supervision + Administration (8%)	156	13
Total Cost less Real Estate	$2260	$ 194
Real Estate (2% x ST1)	24	–
Total First Costs	$2,284	$ 194
Interest During Construction (Total First Cost x 7 5/8 % x 5 yrs./2)	435	37
Total Investment Costs	$2,719	$ 231

Total First Cost	$ 2,478
Total Investment Cost	$ 2,950

Subject Additional Locks Study - St. Lawrence R., U.S. Section
Computation of Cost Estimate - 1,800' x 115' Tandem Lock
Computed by J.N.E. Checked by ______ Date Mar 1982

Scenario - RX27T
Vessel Size : 730' x 75' x 25.5' draft or
1,000' x 105' x 25.5' draft
Lock Size : 860' x 115' (2 chambers) or
1,800' x 115' (1 chamber)
Channel Depth : 27'

Cost Estimate :

Dredging -

ENR "CC Index", Dec 1969 to Mar 1982 = 2.8575

New channel -

\$ 67,088,000 (2.8575) = \$ 191,702,032

Existing channels -

Overburden	= 5,922,048 cy (\$12.50)	= \$	74,025,600
Rock	= 2,399,925 cy (\$34.50)	=	82,797,412
Total		= \$	348,525,045.
		Say \$	349,000,000.

Locks -

The cost of an 1,800' x 115' tandem lock will be assumed to be 1.5 times the cost of a similar 1,200' x 115' single lock. The 1.5 factor will account for increased lock length, an additional set of miter gates and fenders, increased mechanical and electrical equipment, a dual chamber filling and emptying system and increased guide wall lengths.

ENR "CC Index", Jan 1981 to Mar 1982 = 1.1059

Interpolate between 1,140' x 115' lock and 1,350' x 115' lock, see Table #12, MSSS, Jan 1981.

Subject Additional Locks Study - St. Lawrence R., U.S. Section
Computation of Cost Estimate - 1,800'x115' Tandem Lock
Computed by J.N.E. Checked by ________ Date Mar 1982

Cost Estimate : cont'd.

Locks - cont'd.

1.5[148,422,000 + (173,685,000 - 148,422,000) 60/210] (1.1059)

= $ 258,176,850 Say $ 258,000,000.

Tunnels -

ENR "CC Index", Jan 1981 to Mar 1982 = 1.1059

For 115' lock width, see Table #16, MSSS, Jan 1981 -

$ 26,871,000 (1.1059) = $ 29,715,883.

Say $ 30,000,000.

Harbors -

Ref: Summary of harbor costs and cost sharing, pages 3 and 4.

Federal -

$ 147,744,000 (0.20) = $ 29,548,000

Say $ 30,000,000.

Non-Federal -

$ 41,157,000 (0.20) = $ 8,231,000.

Say $ 8,000,000.

Subject: Additional Locks Study - St. Lawrence R., U.S. Section
Computation of: Cost Summary: 1,800' x 115' Tandem Lock
Computed by: J.N.E. Checked by: Date: Mar 1982

Scenario - Vessel Size: 730'L x 75'W x 25.5' draft or 1,000'L x 105'W x 25.5' draft
RX27T Lock Size: 860'L x 115'W or 1,800'L x 115'W
Channel Depth: 27'

COST SUMMARY (MAR. 1982 Price Levels)
MILLIONS OF DOLLARS

Item	Federal	Non-Federal
Dredging	349	-
Locks	258	-
Tunnels	30	-
Subtotal (ST1)	$ 637	$ -
Harbors	30	8
Subtotal (ST2)	$ 667	$ 8
Aids to Navigation (1% x ST1)	7	-
Subtotal (ST3)	$ 674	$ 8
Contingencies (25% x ST3)	168	
Total Construction Cost	$ 842	$ 10
Engineering & Design (8%)	67	1
Supervision & Administration (8%)	67	1
Total Cost less Real Estate	$ 976	$ 12
Real Estate (2% x ST1)	13	-
Total First Costs	$ 989	$ 12
Interest During Construction (Total First Cost x 7 5/8 % x 5 yrs./2)	189	2
Total Investment Costs	$ 1,178	$ 14

Total First Cost	$ 1,001
Total Investment Cost	$ 1,192

Subject: Additional Locks Study - St. Lawrence R., U.S. Section
Computation of: Cost Estimate - 1,800'x115' Tandem Lock
Computed by: J.N.E. Checked by: Date: Mar 1982

Scenario - RX30T
Vessel Size: 730'x75'x28' draft or
1,000'x115'x28' draft
Lock Size: 860'x115' (2 chambers) or
1,800x115' (1 chamber)
Channel Depth: 30'

Cost Estimate:

Dredging -

ENR "CC Index", Dec 1969 to Mar 1982 = 2.8575

New channel -

$ 67,088,000 (2.8575)(30)/27 = $ 213,002,258

Existing channels -

Overburden = 11,421,281 cy ($ 12.50)	=	$ 142,766,013
Rock = 4,572,079 cy ($ 34.50)	=	157,736,725
Total	=	$ 513,504,996.

Say $ 514,000,000.

Locks -

The cost of an 1,800'x115' tandem lock will be assumed to be 1.5 times the cost of a similar 1,200'x115' single lock. See discussion under Scenario RX27T.

ENR "CC Index", Jan 1981 to Mar 1982 = 1.1059

Interpolate between 1,140'x115' lock and 1,350'x115' lock, see Table #12, MSSS, Jan 1981.

1.5[163,109,000 + (190,872,000 - 163,109,000) 60/210](1.1059)

= $ 283,724,624. Say $ 284,000,000

Subject: Additional Locks Study - St. Lawrence R., U.S. Section
Computation of: Cost Estimate - 1,800' x 115' Tandem Lock
Computed by: JNE. Checked by: Date: Mar 1982

Cost Estimate : cont'd.

Tunnels -

ENR "CC Index", Jan 1981 to Mar 1982 = 1.1059

For 115' lock width, see Table #16, MSSS, Jan 1981 -

$ 29,599,000 (1.1059) = $ 32,732,702.

Say $ 33,000,000.

Harbors -

Ref: Summary of harbor costs and cost sharing, pages 3 and 4.

Federal -

$ 1,233,589,000 (0.20) = $ 246,718,000.

Say $ 247,000,000.

Non-Federal -

$ 524,525,000 (0.20) = $ 104,905,000.

Say $ 105,000,000.

Subject Additional Locks Study - St. Lawrence R., U.S. Section
Computation of Cost Summary: 1,800' x 115' Tandem Lock
Computed by J.N.E. **Checked by** ______ **Date** Mar 1982

Scenario - Vessel Size: 730' L x 75' w x 28' draft or 1,000' L x 105' w x 28' draft
RX30T Lock Size: 860' L x 115' w or 1,800' L x 115' w
Channel Depth: 30'

COST SUMMARY (MAR. 1982 Price Levels)
MILLIONS OF DOLLARS

Item	Federal	Non-Federal
Dredging	514	–
Locks	284	–
Tunnels	33	–
Subtotal (ST1)	$ 831	$ –
Harbors	247	105
Subtotal (ST2)	$ 1,078	$ 105
Aids to Navigation (1% x ST2)	11	–
Subtotal (ST3)	$ 1,089	$ 105
Contingencies (25% x ST3)	272	26
Total Construction Cost	$ 1,361	$ 131
Engineering + Design (8%)	109	10
Supervision + Administration (8%)	109	11
Total Cost less Real Estate	$ 1,579	$ 152
Real Estate (2% x ST1)	17	–
Total First Costs	$ 1,596	$ 152
Interest During Construction (Total First Cost x 7 5/8 % x 5 yrs./2)	304	29
Total Investment Costs	$ 1,900	$ 181

Total First Cost	$ 1,748
Total Investment Cost	$ 2,081

Subject: Additional Locks Study - St. Lawrence R., U.S. Section
Computation of: Cost Estimates for Class VII Locks
Computed by: J.N.E. Checked by: Date: Mar 1982

BASIC ASSUMPTIONS

1. This scenario assumes that twin locks will be constructed adjacent to the existing Eisenhower and Snell Locks. The existing Wiley-Dondero Canal would continue to serve the proposed twin lock system with only minor modifications.

2. Dredging costs will include channel modifications necessary to provide improved lock approach conditions and training dikes. Channel modifications will be estimated based on similar costs that were computed in the 1969 Twin Locks Study by Buffalo District. Ninety percent of the 1969 TLS lock approach costs for a "Poe Size" lock will be used for the proposed "Seaway Size" lock approaches and updated to Mar 1982 price levels by an ENR "Construction Cost Index".

3. Lock costs will be estimated based on original lock construction costs. The 1956 construction low bids for Eisenhower and Snell Locks will be escalated to Mar 1982 price levels. Since a 26 year price level adjustment by ENR "CC Index" would provide an unrealistic construction cost, an escalation factor will be developed based on more recent costs of mass concrete. Since the cost of mass concrete approximates half the total cost of an average lock, the unit price of mass concrete is considered to be a good barometer of lock costs.

4. The cost of a highway tunnel under a new lock will be estimated based on tunnel construction costs given in the "Maximum Ship Size Study" dated Jan 1981. Tunnel costs will be adjusted by interpolation between given values based on a ratio of lock widths.

5. No modifications to U.S. harbors are considered necessary for this scenario.

6. Costs for aids to navigation and real estate will be estimated based on percentage factors given in the MSSS, Jan 1981. Costs for engineering & design and supervision and administration will be estimated based on percentage factors given in a Feb 1982 harbor improvement report by Detroit District.

Subject: Additional Locks Study - St. Lawrence R. U.S. Section
Computation of: Cost Estimate - 860' x 80' Lock
Computed by: J.N.E. Checked by: Date: Mar 1982

Scenario - AV1127
Vessel Size: 730' x 75' x 25.5' draft
Lock Size: 860' x 80'
Channel Depth: 27'

Cost Estimate:

Dredging -

ENR "CCIndex", Dec 1969 to Mar 1982 = 2.8575

From 1969 "Twin Locks Study" -

Eisenhower Lock approaches;

\$5,028,000 (0.90)(2.8575) = \$ 12,930,629

Snell Lock approaches:

\$3,237,500 (0.90)(2.8575) = \$ 8,325,957

Total = \$ 21,256,586.

Say \$ 21,000,000.

Locks -

Unit price of mass concrete -

From 1956 construction bids:

Eisenhower Lock = \$ 22.91 per cy (average)

Snell Lock = \$ 27.00 per cy (average)

From 1973 Portland Cement Assoc. publication entitled "Cost of Mass Concrete in Dams" by Kenneth D. Hansen, P.E.:

1973 mass concrete cost = \$ 25.00 per cy.

Subject: Additional Locks Study - St. Lawrence R., U.S. Section
Computation of: Cost Estimate - 860' x 80' Lock
Computed by: J.N.E. Checked by: ______ Date: Mar 1982

Cost Estimate : cont'd.

Locks - cont'd.

ENR "CC Index" = 3,729 (Mar 1982) / 1,895 (1973) = 1.9678

Mar 1982 mass concrete cost =

$25.00 (1.9678) = $49.20 Say $50.00 /cy

Escalation factor based on relative unit prices of mass concrete :

Eisenhower Lock = $50.00 (Mar 82) / 22.91 (1956) = 2.18245

Snell Lock = $50.00 (Mar 82) / 27.00 (1956) = 1.85185

1956 construction bids escalated to Mar 1982 -

Eisenhower Lock :

$24,369,251 (2.18245) = $ 53,184,747

Snell Lock :

$30,423,638 (1.85185) = $ 56,340,070

Total = $ 109,524,817.

Say $ 110,000,000.

Tunnels -

ENR "cc Index", Jan 1981 to Mar 1982 = 1.1059

For 80' lock width -

[$26,871,000 (MSSS, 1981) x 80/115] 1.1059

= $ 20,671,919. Say $ 21,000,000.

Subject: Additional Locks Study - St. Lawrence R., U.S. Section
Computation of: Cost Summary : 860' x 80' Lock
Computed by: J.N.E. Checked by: Date: Mar 1982

Scenario - Vessel Size: 730'L x 75'W x 25.5' draft
AVII 27 Lock Size: 860'L x 80'W
Channel Depth: 27'

COST SUMMARY (MAR. 1982 Price Levels)
MILLIONS OF DOLLARS

Item	Federal	Non-Federal
Dredging	21	
Locks	110	
Tunnels	21	
Subtotal (ST1)	$ 152	$
Harbors	–	
Subtotal (ST2)	$ 152	$
Aids to Navigation (1% x ST2)	2	
Subtotal (ST3)	$ 154	$
Contingencies (25% x ST3)	38	
Total Construction Cost	$ 192	$
Engineering + Design (8%)	16	
Supervision + Administration (8%)	15	
Total Cost less Real Estate	$ 223	$
Real Estate (2% x ST1)	3	
Total First Costs	$ 226	$
Interest During Construction (Total First Cost x 7 5/8 % x 5 yrs./2)	43	
Total Investment Costs	$ 269	$

Total First Cost	$ 226
Total Investment Cost	$ 269

Subject: Additional Locks Study – St. Lawrence R., U.S. Section
Computation of Nonstructural & Additional O&M Costs for Plan AVII 27
Computed by MCK **Checked by** ________ **Date** March 82

I. PLAN AVII 27 allows the SLR locks to reach their capacity since the constraint at the Welland Canal is removed. Because of this sequence of events, nonstructural improvements can be utilized at the SLR locks. The nonstructural costs for the 7 SLR locks is \$91 Million, and the additional yearly O&M for those nonstructural improvements is \$1,110,000. The calculations below show the derivation of the additional costs:

N/S is added in 1985 (80%) of 1988 (90%) - use 1986

$$\text{Cost of N/S} = \left[(\$91{,}000{,}000) \times \tfrac{2}{7}\right] + \tfrac{2}{7}(\$1{,}110{,}000)(12.782)$$

(total N/S; 2 of 7 locks; yearly O&M × PW of annual series)

$$\text{Cost of N/S} = (\$26{,}000{,}000 + \$4{,}000{,}000) = \$30{,}000{,}000$$

II. Because two parallel sets of locks are being operated, there is a new additional O&M cost associated with the new locks. This cost was estimated as follows:

1. The present O&M is around \$7 million of which \$2 million was assumed to be extraordinary maintenance. This leaves an estimated annual O&M of \$5 million.

2. This additional O&M costs must be applied for the 40+ years the second locks will be operating. Therefore, use a PW of annual series factor of 12.421 (for the 7 5/8 % interest rate.

$$\text{Cost of new locks O\&M} = \$5{,}000{,}000 \times 12.421$$

$$\text{Cost of new locks O\&M} = \$63{,}000{,}000$$

III. Total cost of Plan AVII 27 = the investment cost of the new locks + cost of N/S + cost of additional O&M:

$$\$269M + \$30M + \$63M = \underline{\$362{,}000{,}000}$$

Subject: Additional Locks Study - St. Lawrence River U.S. Section
Computation of: Additional O&M Costs for Plan AI 27
Computed by: ____ Checked by: ____ Date: March 82

Because two sets of locks are operated in this plan, the additional O&M costs for the new locks must be considered as an additional cost attributable to this plan.

The additional cost is estimated by taking the approximate current O&M minus what is considered to be extraordinary O&M on the Eisenhower lock. The current figure is $5,000,000. From this subtract $2,000,000 for extraordinary O&M. This leaves $5,000,000 which when applied in a series of 50 years and brought back to present worth (7⅝% interest rate, factor 12.782) totals $64,000,000.

Total cost of Plan AI 27 equals the locks investment cost + the additional O&M:

$1,040,000,000 + $64,000,000 = $1,104,000,000

APPENDIX E

PUBLIC COORDINATION

PUBLIC COORDINATION
APPENDIX E

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PUBLIC COORDINATION

APPENDIX E

E.1 PUBLIC INVOLVEMENT

E1.1 Introduction.

Public involvement is an essential part of the planning process, and is even more important in a study with international implications as is the case with the St. Lawrence Seaway Additional Locks Study. This appendix summarizes the workshops and coordination meetings, and includes pertinent correspondence.

Public involvement for this study took the form of a number of workshops and coordination meetings. The public workshops for this study were held during February 1978. These workshops were conducted by Great Lakes Tommorrow under contract to the Buffalo District, U. S. Army Corps of Engineers. The purpose of these workshops was to identify publics and their concerns, study issues and problems, and alternatives which should be addressed during the study process. The location and dates of the seven workshops held are as follows:

Massena, NY (afternoon and evening)	20 February 1978
Ogdensbury, NY (afternoon and evening)	21 February 1978
Alexandria Bay, NY (afternoon and evening)	22 February 1978
Buffalo, NY (evening only)	24 February 1978

An excerpt of the public concerns of these workshops is presented in the following sections.

The coordination meetings were held at various times during development of the preliminary feasibility studies. The summaries for the more important meetings held are included in this appendix following the workshops summary material. The dates and location of these meetings are as follows:

Environmental Meeting on the GL/SLS	Syracuse, NY	25 January 1980
Interagency Coordination Meeting	Svracuse, NY	15 May 1980
GLC Information Meeting	Buffalo, NY	23 March 1982

In addition to the workshops and coordination meetings many informal plan formulation and coordination meetings took place with SLSA, SLSDC, North Central Division and Detroit District (COE), USFWS, etc. As the final portion of this appendix several letters from other agencies are included to exemplify the coordination and positions taken by them regarding this study.

E1.2 Summary of Workshops.

E1.2.1 Engineering Concerns.

a. Construction.

(1) What will be the requirements for design of contingencies to deal with groundings and leakage?

(2) Will the construction of improvements affect the system's ability to accommodate shipping?

(3) Project evaluation projected through the year 2000 for the potential for technological changes regarding ship design and other mode changes as they would influence system capacity.

(4) Requirements for natural resources to be used in construction/ maintenance and where they will be obtained.

(5) What engineering solutions/alternatives should be considered to deal with adverse impacts?

b. Locks.

(1) Why is the study centered specifically on alternatives for twinning or enlarging present locks?

(2) Is there a need, in terms of numbers of transits, to have more than one lock?

(3) How large must the locks be?

(4) What will be the requirements for the design of locks to mitigate the potential for, and impact of, accidents and spills in or near locks?

(5) Should lock design considered in developing alternative for expansion concentrate on "salties" rather than "lakers"?

c. Navigation.

(1) Determination of the need for safety reforms on the existing system before expanding it.

(2) Reevaluation of the impact of ship size and its relationship to ship speed on the Seaway.

(3) Examination of the potential for increase/decrease in navigation safety if vessesl sizes are increased.

(4) What additional navigation aids will be required?

(5) Development of performance and design standards for ships to ensure navigation safety and efficiency.

(6) Provide a means for continued input from pilots during the course of the study and determine how to place pilots and other system users on boards or technical teams, which evaluate alternatives and determine safety programs for ship and lock design for Seaway use.

d. Lake and River Level Flows. What levels and flows will be required by various alternatives being considered to expand system capacity?

e. Energy and Power Production.

(1) What will be the effect of expanding Seaway capacity on the potential for siting nuclear plans on the river?

(2) What are the induced energy effects of the project, i.e., the impacts on hydrogeneration and energy requirements for construction and maintenance.

E1.2.2 Environmental Concerns.

a. Ecological Impacts.

(1) What are the impacts of the present navigation on the biological productivity of the St. Lawrence River?

(2) Will comprehensive baseline data, using a multidisciplinary approach, be obtained to facilitate sound decision making?

(3) What will be the ecological impacts of temporary population increases attendant to the construction phase of the project?

(4) What will be the effects of larger and/or more vessels on the ecology of the St. Lawrence River?

(5) What will be the cumulative environmental effects of winter navigation and twinning or enlarging the locks?

b. Water Quality.

(1) Will water quality deteriorate or improve if there are more or larger vessels using the system?

(2) Will there be an increased potential for spills of hazardous cargoes?

(3) How much siltation and resuspension of sediments will result from increased dredging and increased ship transits, and what will be the effect of resuspending pollutants such as Mirex, PCB's, etc.?

(4) What other measures will be required to protect water quality with respect to recreation, tourism, fish and wildlife, municipal drinking water supplies, etc.?

c. Hazardous Substance Spills.

(1) Will the potential for more or greater spills of hazardous materials such as oil or chemicals be identified?

(2) How can we deal more effectively with spills under present conditions and under increased system capacity?

(3) How efficient are systems of communication with regard to monitoring and tracing hazardous cargoes?

d. Geology.

(1) Will the geology of the study area be investigated for strata composition, fault location and seismic activities? Are there future plans for geological evaluation?

(2) What are the seismic hazards and their potential to damage the lakes?

(3) Will a geological-geographical evaluation of the entire Great Lakes system be done?

(4) What future plans are there for study of other impacts on the geology of the region, such as nuclear plants, waste disposal sites, and mineral resource recovery?

e. Dredging.

(1) What impacts on environmental quality will result from dredging to deepen and widen channels?

(2) What are the impacts associated with disposal of dredged material?

(3) How will the aesthetic qualities of the area be maintained during dredging and construction?

f. Erosion and Shoreline Impacts.

(1) What effects on erosion will be related to the passage of additional or larger ships throught the project area?

(2) What will be the impact of increased navigation activity on critical shoreline areas such as wetlands?

(3) How does vessel size and speed effect shoreline erosion and appurtenant structures, and how can impacts be mitigated?

g. Socioeconomic.

(1) What are the short- and long-term local economic benefits to the St. Lawrence Valley as opposed to national benefits?

(2) What will be the impact of larger ships on smaller ports such as Waddington and Ogdensburg? How can "port specialties" be identified?

(3) What new industries and port activities might result from the project?

(4) How will the St. Lawrence Seaway Additional Locks Study assist in keeping industry in the basin?

(5) Do we expect that promises made regarding long-term benefits to the local economcy will be fulfilled?

(6) How can "hidden costs" such as property degradation be identified and included in the benefit/cost analyses?

(7) How will increased shipping effect property owners? How will questions of equity related to damage or other impact on "little people" be resolved?

(8) With regard to socioeconomic and environmental impacts on housing, schools, wages, jobs and tourism, is there a possibility of Federal economic relief via designation as an impacted area? Will there be jobs, new exporting, new shipping, public housing?

(9) What opportunities will be lost due to the project - what are the other national needs relative to the resources of the region?

(10) Can expanding the Seaway do something good for the region?

(11) What will be the construction phase impacts on the region and its local communities? Will there be overloads, overbuilding, and additional inflation?

(12) Examine national benefits vs. local/regional costs of community services, the impact of spills, etc.

(13) What will be the economic impact of expansion on tourism, natural areas, water quality, fish and wildlife of the region? Will it be deteriorated or improved or changed?

(14) What are the advantages and disadvantages of Seaway expansion to northern New York (St. Lawrence Valley-Eastern Lake Ontario)? Preservation vs. Development.

(15) What will be the additional demands on local social service systems: police, fire protection, schools, health care, welfare, housing?

(16) What will be the effect of enlarging system capacity (during construction and afterwards) on the existing way of life in the north country?

(17) What will be the impacts on institutional framework of the region?

(18) What will be the impact on the entire tax base of the region, i.e., income, sales, property, credits, incentives, etc., with regard to industrial development?

(19) Will the region be able to supply labor for new industry generated by additional locks?

(20) If local labor is utilized for the project, what will be the impact on the local job market?

(21) Will the project maximize opportunity of participation in the project by minorities and small businesses?

(22) Examine the potential impact of the project on the short- and long-term job market.

(23) Will there be proper payment for land, early payment, proper appraisal, early settlement? Will appraisal be on potential or current use?

(24) What will be the effect of the increase in the numbers and size of vessels on summer season recreational boating, fishing, cottaging, sightseeing, as regards ships/power dam, camping, swimming, day-use picnics, further development of public camp areas, and the tourist industry? (Long- and short-term.) How will conflicts with recreational use, boating, bathing, and fishing be resolved?

(25) What will be the study considertion of summer resident interests?

(26) How can the Seaway become more of an attraction to recreation and tourism?

(27) What are treaty obligations to St. Regis Indians? How will this project impact on them regarding culture, lands, economcy, land claims? How might the Indians impact on the project?

(28) What cost-sharing alternatives are being considered for expansion of the United States-Canadian system capacity?

(29) What is the life expectancy of the Seaway as a whole?

(30) What are the economic implacations of Canadians having costs for 13 locks vs. U.S. for 6 locks? How do we coordinate planning and resolve questions of equity?

(31) Evaluate ways to pass cost of modifications to Seaway on to shipowners, or, those who benefit directly. Include in costs: construction, operation, land loss, esthetic impacts, recreation, local fishing, and guide losses.

(32) Who pays and how, and what amount? How much will be from user fees and how much public tax monies?

(33) Examine the need for changes in toll rates to absorb costs, and the need to charge for worth and build a fund for replacement, repair of system by its users.

(34) Do a system analysis regarding the loss to the country if the project is not undertaken.

(35) In determination of feasibility, what assumptions are used? What economic interests are considered? How is this information used to determine benefit/disbenefit to the local economy?

(36) Find out who is responsible for projecting economic benefit to the region.

(37) What are the long range implications of changes in the amounts and types of nonrenewable resource cargoes being transported or projected for transport through the Great Lakes-St. Lawrence Seaway? When will this traffic peak? When will levels of specific items drop?

(38) What will be the impact of expanding the Seaway on energy problems? Will there be increasing energy industry traffic, more oil spills, need for storage and port facilities?

E1.2.3 Systemwide.

a. Planning Coordination.

(1) Do an information search to identify previous studies applicable to the St. Lawrence Seaway. Integrate them and fill in necessary information gaps with this study.

(2) How will economic and environmental studies mandated for this project be integrated with ongoing and future studies so everything won't continue to be piecemeal? Will you use EPOS from Winter Navigation for data?

(3) What are the impacts of a lack of systematic approach to the cumulative effects of additional locks, upper lakes connecting channels and harbor modifications, vessel size increase, change in lake levels, extended navigation seasons, and the Lake Erie-Lake Ontario water studies?

b. U.S./Canadian Coordination.

(1) What will be expansion sites and locations in both Canada and the United States?

(2) Should the U.S. proceed with the study without agreement that Canada will be engaged in the entire study on a parallel basis? How should this matter be proposed to Congress?

(3) Look at pilot situation - are there enough Canadian pilots to meet present and future traffic needs? Can United States/Canadian differences be resolved?

c. Systemwide Transportation Alternatives.

(1) Examine Seaway shipping projections in light of the shift of industry from the northeast.

(2) Could capacity/efficiency be improved by methods other than expanding the locks, and what are they?

(3) What will be the effect (benefits/disbenefits) on the total transportation system in the northeast?

(4) What will be the regional transportation impacts on other modes? Will increases in local commercial tonnage affect tourism?

(5) How will the study address the impacts of not constructing additional locks on the economy, energy needs, and Canadians?

d. Public Participation.

(1) Can a process be devised for more public input between study phases that is appropriate for the project? Need input prior to having the work for a given phase of the project being accomplished. Determine where decision points are and provide for adequate input by affected parties before contracts are let to a contractor and money invested.

(2) Need to reach publics (local) and heighten involvement.

(3) How can you get information to the public in an organized fashion on a continuing basis?

(4) Broader public representation in study with regard to the need for a mechanism for involvement of publics and agencies on an early and continuing basis.

E1.3 Summary of Workshops/Other not Addressed in the Preliminary Feasibility Report and Why.

E1.3.1 Engineering Concerns.

a. Construction.

(1) How will the system be designed to cope with hazardous cargo? This was not addressed since from a strictly design standpoint, there is little design of the system which would specifically address hazardous cargoes except possibly, channel design. Hazardous cargoes are best controlled by regulations and operational restrictions.

(2) How can quality control for any additional construction in the system be guaranteed and monitored? The objective of this study is to demonstrate the feasibility of possible improvements to the St. Lawrence Seaway. Quality control will be the responsibility of the construction agency. Good quality control is a function of five things: good design, detailed plans and specifications, adequate materials, well-trained inspectors, and quality labor. Since this is concerned with the actual construction and does not impact on the feasibility of the improvement, it will not be addressed in this study.

b. Navigation.

(1) Evaluate the need for restrictions on shipping hazardous cargoes on the Great Lakes-St. Lawrence Seaway (GL/SLS) during inclement weather (especially during extended navigation season). Restrictions on shipping hazardous cargoes on the system is the responsibility of the operation and enforcement agencies, which are the St. Lawrence Seaway Development Corporation and the U.S. Coast Guard, respectively, and not within the authority of the Corps of Engineers. The GL/SLS Navigation Season Extension Program investigated the feasibility of winter navigation. Hazardous cargoes were addressed in its impact assessment.

(2) Determine and implement requirements for pilot training for navigation on the Great Lakes-Seaway System. The U.S. Coast Guard is initiating such a program. This will be financed by the pilotage fee charged to the vessels using the service.

c. Lake and River Levels and Flows.

(1) Will there be an increased potential for flooding below the locks?

(2) What will be the effect on lake levels if proposed diversions at Niagara and Chicago are implemented? How would this impact on requirement for modification of channels and harbors?

(3) How will level/flow requirements for increasing Seaway capacity affect Lake Ontario?

(4) How will required/constant water levels be maintained, especially downriver? How will water levels relate to requirements for speed limits? How will variation in water levels affect fish spawning in the Seaway and Lake Ontario?

(5) What are benefits/disbenefits to be realized from river and lake level regulation?

The impacts of the various alternative plans on the levels and flows of the St. Lawrence and Great Lakes will require careful assessment. These impacts will be investigated, along with possible modifications to the present regulation plan of the St. Lawrence to benefit not only navigation, but also other users such as power, riparian, and environmental. This effort will be coordinated with the ongoing Lake Erie Regulation Study being done by the International Joint Commission and the Lake Ontario Shoreline Protection Study, which has been authorized by Congress but not budgeted for FY 83.

d. Energy and Power Production.

(1) How will additional/larger locks impact on hydroelectric power production? What will more or larger locks require in additional volumes of water (individual as well as total Seaway demand)? How much hydroelectric power will be lost? How will it be replaced?

This will be investigated in conjunction with levels and flows. Additional locks may or may not mean additional loss of available water for power production. Larger locks may mean larger and fewer vessels, thus fewer lockages. The impact upon power production is quantifiable and its monetary loss or gain will be included in the final determination of economic benefits.

E1.3.2 Environment.

a. Ecological Impacts.

(1) What are the impacts of present extended season (December) navigation on the local environment, ice fishing, air quality, public health (from ships' bilges and sewage), water level regulation, local property, etc.?

The impacts of navigation during an extended season (Winter Navigation) was addressed by the Navigation Season Extension Program under the direction of the Detroit District, Corps of Engineers. This program is considering various study scenarios for an extended season (e.g., firm up of December shipping; 10-month season; 11-month season; and all-year navigation). This study produced an Environmental Impact Statement, which included the above listed concerns.

b. Socioeconomic.

(1) Evaluate the potential of the maritime subsidy program with respect to construction and operations of an expanded system. The maritime subsidy progrm applies to the shipping industry and not Federal water resources projects, which receive their funding directly from Congress. Thus, improvements to the system would not be eligible for such subsidies.

E1.3.3 Systemwide.

a. Planning Coordination.

(1) How to integrate public and private planning which might impact on the St. Lawrence Seaway Additional Locks and the Great Lakes Connecting Channels studies?

(2) Will there be a master plan for the St. Lawrence Seaway that will integrate all issues/uses?

(3) How will you integrate fragmented planning, including Canadian planning, into the study?

Both studies have identified the many planning agencies on the GL/SLS system. Through meetings and coordination with these agencies, it will be possible to exchange ideas and coordinate plannng efforts so as to maximize objectives and goals in the best interest of local, regional and national citizenry.

The St. Lawrence-Eastern Ontario Commission is in the process of developing a comprehensive resources development program for the lands and waters along the St. Lawrence River and Eastern Lake Ontario. Their initial step has been the development of goals and objectives for this program. These have been published in Coastal Resources - Goals and Objectives, dated July 1976. The Black River-St. Lawrence Regional Planning Board has a larger geographical area and is also oriented towards comprehensive and coordinated planning. The SLS/AL study will not develop a master plan for the St. Lawrence area since this is the responsible area of the above agencies and their Canadian counterparts. The SLS/AL study will coordinate and integrate its plans with those of SLEOC and BRSLRPB in an effort to make its national goals and objectives compatible with those of the above agencies.

An initial effort to do this has been the incorporation of local goals and objectives into study objectives and criteria for the SLS/AL study.

b. U.S./Canadian Coordination.

(1) Determine how to formally involve Canadian interests and evaluate the most effective means to do so. A request for Canadian coordination for the SLS/AL and GLCCH studies was transmitted to the U.S. State Department and Canadian Ministry of External Affairs through diplomatic channels. The Canadian Marine Transportation Administration under the Ministry of Transport has been designated to represent the Canadian Government in coordinating the SLS/AL study. The Canadian Coast Guard has been designated for the GLCCH study. Procedures will subsequently be established.

(2) How can cooperation with Canada be established at Federal, provincial, and State level? How can red tape be eliminated? How can the economic, social, environmental effects of SLS/AL on the other side of the border be determined? How can/should joint Canadian/U.S. studies of environmental, social, and institutional effects of present Seaway and of expansion alternatives be conducted? What will be the impact on Canadian/U.S. labor relations?

Cooperation with Canada has been established on an informal basis. Unfortunately, diplomatic protocol has limited it initially to only one Federal agency. One of the recommendations of this report is to renew efforts to obtain formal Canadian coordination of the preliminary study results.

(3) What might be the impact if Quebec becomes independent?

The answer to this is not known, and because it is hypothetical and a very sensitive political issue, it will not be addressed by this study directly other than its possible address in the final recommendations to Congress.

c. Systemwide Transportation Alternatives.

(1) What is the relationship between St. Lawrence Additional Locks study and New York Stage Barge Canal (All American Ship Canal) study? Use a cost/benefit ratio to evaluate.

(2) Are there alternative routes for navigation to present system? (All American, all Canadian?)

The Barge Canal study is being conducted by the New York District, Corps of Engineers. Because an improved Barge Canal may divert traffic from the Seaway and vice versa, these two studies are being coordinated, especially in terms of economic projections. However, preliminary results indicate that deep draft Barge Canal alternatives are not economically feasible.

(3) What is the ecological benefit to the national interest of locks vs. railroads, trucks, with volume carried (on basis of 80 million population, and products moving through Great Lakes trade area)?

The Corps is restricted to investigating waterborne transportation. Other modes will be considered only in regard to impacts on them by improvements to the Seaway. Under "No-Action," future traffic over and above the present capacity of the Seaway will be forced to use a more expensive mode of transportation. In this regard, the environmental and economic impacts will be addressed and quantified where possible.

(4) Are there land transportation alternatives, railroad, trucking, or a combination that is as feasible as additional locks?

The SLS/AL study wil investigate all problems attending navigation on the Seaway and the alternative plans for their solution. (See Section 4, "Formulating a Plan.") Because some solutions, e.g., pilotage and ICC regulations are not within the purview of the Corps of Engineers to make recommendations to Congress, they will not be considered in this study.

d. Items Not Dealt With, But Recommended for Final Feasibility Studies.

(1) What is the net cost going to be for electrical generation by PASNY, Ontario-Hydro, Quebec?

Hydraulic studies that will be scheduled in the future to answer technical concerns regarding the hydraulic impacts of operation of larger locks can be modified to include the quantities of water required for lock operation that would otherwise be used for hydropower production. The economic losses by the power interests will be considered in the overall benefit-to-cost ratio.

(2) How and by whom will amount of land needed be determined? Will there be limits on land taking, and a determination of the minimum amount of land required?

A major item of work in the future will consist of the preliminary design and cost estimates for various alternatives that will contribute to increased system capacity. The extent of real estate required will be a function of the physical size of the plan (additional vs. larger locks) under consideration. This work item will address the problems of real estate acquisition and prices to be paid to individual property owners.

APPENDIX E SUPPLEMENT

COORDINATION AND CORRESPONDENCE

DISPOSITION FORM

For use of this form, see AR 340-15, the proponent agency is TAGCEN.

REFERENCE OR OFFICE SYMBOL	SUBJECT
NCBED-PN	Meeting on G.L. - St. Lawrence R. Studies Bray Hall, Syracuse University

TO FILES FROM J. KARSTEN DATE 25 Jan 80 CMT 1
L. BRYNIARSKI

1. 1/17/80 - Meeting was called by Jack Finck (NYSDEC) to bring together State, Federal and others interested in subject studies. An agenda and list of attendees are attached.

2. I talked to the group about the SLS-AL Study giving them some background information on the project. I then proceeded to give the status of the project and covered the following items:

a.) Final POS is presently being sent out,
b.) Scheduled MS 03 (PFR) is now 4/81 (if NCD approves MS change letter),
c.) Environmental work - began Spring 79 and continued into late fall, data being analyzed over this winter. Planning aid letter will be prepared by Aug. 80.
d.) Cultural resources - Phase I (literature search) of a 2 phase (Phase II - 15% max. field verification) "predictive model" type survey is just about ready to begin,
e.) Economic Studies - Batelle Labs. will perform a S.O.W. contract to prepare a S.O.W. for Stage II economic studies. Their work will include a general critque of the traffic forecast, capacity &MVSS studies. After this work is completed another economic contract will be let for the actual Stage II PFR Economic Studies.
f.) Design and engineering studies are beginning with alternative layouts and preliminary cost estimates beginning. A foundations appendix will be performed under contract. We are coordinating and exchanging information with SLSA.
g.) Work on the Eisenhower Lock Special Report (concrete condition survey) has stalled due to the lack of data and cooperation from SLSDC.
h.) Public workshops are currently scheduled to be held this summer (June-July).

3. Throughout my discussion and following, a number of questions and concerns arose. The following is a list of the important items:

a.) Why are we doing this study in a vacuum, i.e., no Canadian participation?
- Informed them of T. Vogt's efforts to get just that, with no success.
b.) Are the 3 studies (NSE, GLCCHS & SLS-AL) being coordinated?
- Yes, mentioned meeting of 11/20/79 as an example.
c.) How come environmental studies are site-specific when this project would have systemwide impacts?
- We are only funded to do site-specific studies. Systemwide studies would have to be done in a method similar to NSE.
d.) NYSDOT was concerned about the way our economic studies are done.
- I informed Gunner Hall that we will be having an independent contractor and will coordinate as much as possible. Hopefully, this will give us an as objective study as possible.

There was a good deal of discussion on all these and some other points. Paul Hamilton (USF&WS) gave a status report of their studies and efforts to date.

DA FORM 1 FEB 62 2496 REPLACES DD FORM 96, WHICH IS OBSOLETE.

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SUBJECT: Meeting on G.L. — St. Lawrence R. Studies
Bray Hall, Syracuse University

4. I talked briefly about the Buffalo Harbor Study. Recent initiation, recon report contract, coordination with USF&WS and study team (with local interests). Gunner Ball (DOT), Jack Finck (DEC), and Bruce McLean (PASNY) all asked to be involved in this study. I told them they would be put on the mailing list and we will coordinate with them whenever possible. There was some mention of the coal transshipment facility, Buffalo as a coal port and a gasification plant (see PASNY brouchure Attached).

5. Three other items were discussed (see agenda) and Len Bryniarski's account of these basically environmental items is attached.

THIS CONCLUDES ACCOUNT BY JAMES W. KARSTEN.

James W. Karsten
JAMES W. KARSTEN
Study Manager, SLSALS

TO: FILES FROM: L. Bryniarski DATE: 25 January 1970 CMT 2

1. General - Meeting was called by Jack Finck (NYSDEC) to bring together State, Federal and others (e.g. Dr. Jim Geis, Save the Rivers representative etc.) to - provide an up-date on studies going on in the above subject area. The following are abbreviated notes on environmental aspects of this meeting:

2. Additional Locks - FWS indicated that studies presently being done by the Cortland Office will probably not be adequate to sufficiently identify and assess system wide impacts completely - that is, beyond immediate contruction impacts.

-FWS (Bill Gill) provided an up-date on biological studies and report they are doing:

a.) Began Field work in Spring 1979 (bird, mammal, veget, & Behthos surveys)
b.) They will attempt to measure direct impact of alternatives.
c.) Fiel work on the above survey were completed in Fall 1979
d.) Summary of basic data collected will be compiled by June 1980
e.) "Planning Aid Letter" will be provided to COE in August 1980
d.) This Fish & Wildlife Report will also include other studies that may be needed on a site-specific and/or systemwide basis.

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3. Lake Ontario "Characterization" Study (Dave Riley - FWS)

- This activity has support of NYSDEC, FWS and possible support from Senator Moynihan's office.

- This study develops a Conceptual Model of the ecosystem being looked at; then gathering of all pertinent current literature that would help support the model.

- Essentially this study involves a very detailed gathering of published and unpublished literature which has three broad objectives.

a.) To provide a systemwide approach in accumulating up-to-date information.

b.) To go deeper than just a literature review to obtain the best current knowledge available; this includes contact with information sources.

c.) To provide a useable product (in series of pamphlets) called "Users Guide".

- The current intent is to update the study every 7 years.

- Time and funding requirement estimates to do initial study: 3 years ±; 980,000.

-Info provided would describe the ecosytem's energy flow, physical features, biological features, abiotic features (e.g. transportation, etc.) and ecological relationships(almost 3 tiered).

All information developed would be plugged into a computer network:

a.) 126 keys words have been identified for use in retrival of data.

b.) Key word used would only lead you to a specific topic in the system(e.g. bibliography, etc.)

- This study will provide another tool that should be used. It will not preclude the need for specific site biological-socio-studies (note: data gathered in this study would also include sociological information - to some degree)

- This study would also be used as a tool to help identify data gap.

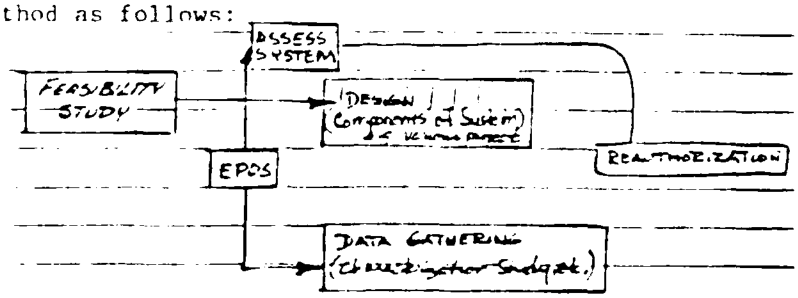
4. EPOA (FWS)

- A product of the EPOS

- EPOA (as it presently is) is not very useable, but needs much reworking. Some portions of are expected to be salvageable.

- I asked the following questions concerning the Adaptive Methods": How is the Adaptive method defined by FWS and how does FWS envision this method to be applied with regards to environmental studies in the EPOA? Dave Riley (FWS, Newton Cors. Mass Regional Office) responded -

He said this method is based to some degree on C.S. Holling's book Adaptive Environmental Assessment." In general, Riley provided a Schematic presentation of the Adaptive Method as follows:



Riley indicated that the adequate method idea breaks down at the "Design" box indicated above, because if significant impacts are reconized in any one of the components project studies it could have a bearing on the future of the overall project. Also, there is a question as to what kind of assessment and data gathering is acceptable.

- NYSDEC and FWS indicated that a critical review of the existing EPOA and Survey report is needed. They indicated that it is necessary to "go back to the EPOS for the time being and review it."

5. General

-Bill Pearce (NYSDEC) emphasized that detailed contour mapping is badly needed along the lake Ontario - St. Lawrence River Shoreline to at least a depth of 20'. The contours should be at [redacted] 6" intervals.

-Tom Brown (NYSDEC) indicated that changes to the current water level scheme needed to be looked at and assessed (1958 D Plan), before assessing possible changes to a new regulation scheme.

-Remember extremes in a regulation plan are as important as averages.

-A suggestion was made to see if (informally) Canadian concerns can be invited as advisors on an Environmental Committee for [redacted] Great Lkaes Management.

-Coordination with NYSDEC, USFWL and acedemia in developing Scopes of Work regarding biological studies was emphasized. Systems studies should provide the overall framework to any site-specific studies identification.

6. "Eagle Program" (George Griebenow FWS)

- Eagle team support characterization studies on St. Lawrence River.

- Purpose of eagle team is to get principle agencies to provide information on characterization studies. Essentially, the team tries to increase the public involvement-Ecosystem approach and 2 phased implementation.

-"Eagle" was originally designed to be an advisory committee to USDI and COE.

- Until now, "Eagle" was funded by the Corps.

- One of its informal goals is to integrste coordination and management of the Graet Lakes System.

-"Eagle" does not conduct studies or control funds.

- Secretary of the interior wants "Eagle" to serve a larger purpose (other than Winter Navigation).

7. IJC Lake Erie Reg. Study (Dieter Bush - FWS)

- It started in 1977.

- 3 plans being considered: GL ISS S

- Contract for evaluation of impact on beaches and boating has not been completed

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- Goal: Maintain historical Lake levels (including normal highs & lows)
- Lake Erie Reg. Bd. is meeting 13 February in Montreal.
*Whole Study on Lake Erie Reg. may end in March. (Fiscal year for Canadians ends in March).
- Must decide what Lake level extremes are desirable and what extremes are detrimental.

THIS CONCLUDES ACCOUNT BY LEONARD BRYNIARSKI.

Leonard J. Bryniarski

LEONARD BRYNIARSKI
Biologist - Environmental Team Leader

AD-A118 522 CORPS OF ENGINEERS BUFFALO NY BUFFALO DISTRICT F/G 13/2
SAINT LAWRENCE SEAWAY ADDITIONAL LOCKS STUDY. APPENDICES.(U)
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NCBED-PN 21 August 1980

MEMORANDUM FOR RECORD

SUBJECT: Interagency Coordination Committee - Minutes of Meeting Held in Syracuse, New York, 16 May 1980

1. The initial meeting of the Interagency Coordination Committee regarding the St. Lawrence Seaway - Additional Locks Study and the Lake Ontario Shoreline Protection Study was held at the Sheraton Motor Inn, on 16 May 1980, in Syracuse, NY. The meeting started at 10:30 a.m. The list of attendees is given on Incl 1.

2. Mr. Charles Gilbert opened the meeting, introduced the participants, and stated the purpose of the Committee. Mr. Gilbert continued by stating the intent of the Lake Ontario Shoreline Protection Study and discussed some of its aspects. He also gave an update on the status of the St. Lawrence Seaway Additional Locks Study. Mr. Gilbert ended his discussion by calling upon Mr. Tom Vogt to give the Committee members some background on the Corps planning process and a review of the Lake Ontario Shoreline Protection Study.

3. The organizational structure of the Corps of Engineers, their mission, and the Corps planning process were explained by Mr. Vogt. He also gave an overview of the Lake Ontario Shoreline Protection Study. Mr. Vogt traced the origins of the study to the high water levels of Lake Ontario during the 1970's, which caused considerable property damage. Authority to study the problem was granted by Section 180 of the 1976 Water Resources Development Act. The Act directed the Corps of Engineers to: (1) develop a plan for shoreline protection and beach erosion control along Lake Ontario; (2) look at proposals for equitable cost sharing; and (3) develop recommendations for regulation of Lake Ontario to insure preservation of the natural environment and hold shoreline damage to a minimum. The limits of the study area were defined to be the U.S. Shoreline of Lake Ontario from Fort Niagara to Tibbetts Point. Mr. Vogt pointed out the importance of coordinating this study effort with other ongoing studies such as the St. Lawrence Seaway - Additional Locks Study, Winter Navigation, and the Coastal Zone Management Study. He stated that the Lake Ontario Study was started in January 1979, and is presently in Stage I of the study process. The emphasis in Stage I is Problem Identification. To aid in the identification of the problem, the Corps contracted for the services of Great Lakes Laboratory of SUC at Buffalo and Great Lakes Tomorrow. The U.S. Fish and Wildlife Service also provided

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considerable input and will continue to do so in the later stages of study. Mr. Vogt went on to say that he expected the Stage I - Draft Reconnaissance Report to be completed in June 1980, and asked the Committee Members to review the report and submit their written comments. He informed the committee members of a series of five workshops which will be held from 23-27 June 1980. Mr. Vogt estimated that Stage II will take approximately 1-1/2 years to complete and Stage III, if required, will take 1-1/2 to 2 years. These estimates assume continuous funding. At this point, Mr. Vogt responded to questions and comments from the committee members. One item of importance that came out of this discussion was that $2,000,000 has been authorized for the Lake Ontario Shoreline Protection Study and to date, $600,000 has been appropriated. The $600,000 is intended to cover expenditures through the end of FY 80.

4. The next presentation was on the St. Lawrence Seaway - Additional Locks Study which was given by Mr. Jim Karsten. Mr. Karsten stated that the purpose of the study is to investigate the problems and needs of the St. Lawrence Seaway and determine what changes would be in the Federal interest. The study was authorized in June 1966 and work was started in 1969. The study's progress through the end of 1979 is as follows:

a. Subsurface investigations were performed during 1970 with the intent of studying the alternatives for twin locks at the Eisenhower and Snell Locks on the St. Lawrence Seaway.

b. Corps model studies of a section of the St. Lawrence River known as Polly's Gut, which was responsible for considerable navigational problems in the approach to Snell Lock.

c. The Stage I - Revised plan of study which was completed at the end of 1979.

d. An economic systems analysis study, initiated by the Corps North Central Division, to provide basic economic information for commercial navigation for the total St. Lawrençe - Great Lakes Navigation System.

The Additional Locks Study is programmed for $2.5 million, with approximately $1.3 million already expended. This fiscal year the study has been allocated $430,000. These funds are being used to complete environmental baseline studies, initiate work on a cultural resources study, perform economic analyses, initiate preliminary design and cost estimates, study concrete deterioration of the Eisenhower Lock, and hold a series of public workshops late in the year. In FY 81, it is expected that the economic studies will be completed along with the preliminary design and cost estimates. The Corps will make every effort to submit the Preliminary Feasibility Report by the scheduled date of April 1981. Once this report is completed, Stage III efforts will be started. This will entail more environmental work, additional cultural resource work, and the initiation of more detailed engineering disign. Mr. Karsten continued by giving an update on the other navigational studies being done on the Great Lakes; i.e., the GL/SLS Navigation Season Extension Study, Great Lakes Connecting Channels and Harbors Study, and the Lake Erie to Eastern Seaboard Study. The Season Extension Study was completed in August 1979 by the Detroit District Office of the Corps. The report recommends up to a 12-month navigation season on the Upper Great Lakes, and a 10-month navigation season on the St. Lawrence Seaway. The Great Lakes Connecting Channels and Harbors Study is being done by the Detroit District. This study includes investigating possible changes at the Soo Locks to determine what improvements will be justified for traffic on the Upper Lakes. The All-American Canal Study is the responsibility of the New York District. The purpose of this study is to determine the feasibility of an American canal route to connect Lakes Erie and Ontario with the Eastern Seaborad. Mr. Karsten concluded his discussion by outlining the alternatives identified during Stage I planning for the St. Lawrence Seaway - Additional Locks Study. The alternatives he discussed were:

a. Modification of the existing system.

b. Addition of locks.

c. All-weather navigation.

d. An alternate trade route.

e. The use of special tugs to increase the efficiency of the locks.

f. Improvements to eliminate navigational control problems due to currents.

A question and answer period followed Mr. Karsten's presentation which concerned the Welland Canal, tonnage figures on the St. Lawrence Seaway System, and flooding in Montreal.

5. Immediately following lunch, Mr. Neil MacCormack, NYS, discussed the purpose and history of the NYS Coastal Zone Management Program. Mr. MacCormack stated the NYS Coastal Zone Management Program was a State effort under the

auspices of a Federal Program authorized by Congress in 1972, and referred to the Coastal Zone Management Act. The Act was later amended in 1976. The program is funded through the Deptartment of Commerce/NOAA/Office of Coastal Zone Management. This office provides the State with funds and sets the standards which the State must meet. The CZM Act makes it optional for the states to join. NYS decided to join 5 years ago. Mr. MacCormack indicated that the final Federal Grant for the NYS Program will expire on 30 June 1980, and that NYS is near the end of its legislative year. Mr. MacCormack indicated that at the present time, the NYS Legislature is considering two bills, which concern the NYS Coastal Zone Management Program. The first one deals with the content of the Coastal Zone Management Program itself, and the second deals specifically with the coastal erosion hazard areas. An important aspect of the first bill is that the State agencies will be asked to comply with the policies developed by the NYS Coastal Zone Management Program in their permitting, capital funding, and planning functions. In this way, existing mechanisms will be used to implement the policies of the NYS Coastal Zone Management Program. The second bill will basically require that coastal erosion hazard areas be identified and that specified regulations for development be adhered to. Mr. MacCormack then asked Fred Howell, NYS, to speak briefly on the erosion legislation. Mr. Howell indicated that the identification process of erosion hazard areas was the responsibility of the State Department of Environmental Conservation. He stated that some preliminary work has been started using old aerial photography, field checks, and some old maps. At this point, Mr. MacCormack indicated to committee members that the erosion bill is moving more quickly through the State Legislature than the program bill. Mr. MacCormack closed the discussion by reiterating his concern about the proximity of the expiration date of the final Federal Grant for the NYS Coastal Zone Management Program.

6. The next speaker on the agenda was Dave Robb, SLSDC. Mr. Robb discussed the subject of winter navigation. He gave some background on the season extension demonstration and feasibility studies. Mr. Robb also discussed the makeup and function of the Board of Engineers for Rivers and Harbors, lake regulation impacts, and scoping. Mr. Robb suggested that one of the functions of the Interagency Committee could be to assist the Buffalo District of the Corps in the scoping process; i.e., defining problems discussing issues that should be raised.

7. A brief introduction of the function of the U.S. Fish and Wildlife Service and an explanation of their interest in the Lake Ontario Shoreline Protection Study and the St. Lawrence Seaway - Additional Locks Study was given by Mr. Bill Gill. Mr. Gill closed his discussion by responding to questions.

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SUBJECT: Interagency Coordination Committee - Minutes of Meeting Held in Syracuse, New York, 16 May 1980

8. Next, Henry Stamatel, SCS, explained the function of the U.S. Soil Conservation Service as it relates to Corps studies.

9. Following Mr. Stamatel's discussion, was a presentation by Dr. Ray of the Great Lakes Laboratory of the State University College at Buffalo, regarding their work for the Corps on the Lake Ontario Shoreline Protection Study. He outlined the objectives of their work and then discussed the methods employed and the results of their efforts. He had many slides that showed existing shoreline conditions along Lake Ontario. This was followed by a question and answer period which primarily was concerned with lakeshore erosion.

10. Mr. Gilbert, in response to a question, defined the role of the Interagency Coordination Committee as it pertains to the Lake Ontario Shoreline Protection Study and the St. Lawrence Seaway - Additional Locks Study. Mr. Gilbert also indicated approximately when he thought the next meeting of the committee would be scheduled. Mr. Tom Vogt discussed in further detail what the committee's role was. Both Messrs. Vogt and Gilbert responded to questions and comments primarily concerning the structure of the Interagency Coordination Committee and the structure and function of the Citizen's Advisory Committee. Mr. Gilbert told the participants that in the near future they will be sent a questionnaire asking them how they see themselves fitting into this type of Interagency Coordination Committee. These responses will be sent out to all committee memebers.

11. Prior to adjourning the meeting, Mr. Gilbert stated that Tom Vogt will establish the time when the Interagency Coordination Committee will meet again.

12. Mr. Charles Gilbert adjourned the meeting at 4:30 p.m.

LIST OF ATTENDEES

William H. Gill	U.S. Fish & Wildlife Service
Harry R. Halldow	Wayne County
Jack Finck	NYS Department of Environmental Conservation
Bruce C. McLean	Power Authority of the State of New York
Don B. Martin	Monroe County
Peter J. R. Buttner	NYS Office of Parks and Recreation
David Robb	St. Lawrence Seaway Development Corporation
Bill Lilley	NYS Department of Public Services
Lyndon D. Billings	Orleans County
William B. Gannon	U.S. Geological Survey
Neil Wilson	Jefferson County
Philip Street	Black River - St. Lawrence Regional Planning Board
Henry Stamatel	U.S. Soil Conservation Service
Philip Bradway	NYS Department of Agriculture and Markets
James W. Pritchett	St. Lawrence County
Fred Howell	NYS Department of Environmental Conservation
Terry Crannell	NYS Department of Environmental Conservation
Neil MacCormack	NYS Department of State - CZM
John Bartholomew	Power Authority of the State of New York
Glenn Mathiasen	Niagara County
John B. Adams III	St. Lawrence Seaway Development Corp.
Dr. Pulak K. Ray	Great Lakes Laboratory
Tom Vogt	U. S. Army Corps of Engineers
Charles E. Gilbert	U. S. Army Corps of Engineers
James Karsten	U. S. Army Corps of Engineers
William P. Erdle	U. S. Army Corps of Engineers

NCBPD-EB 23 March 1982

MEMORANDUM FOR RECORD

SUBJECT: Information Meeting for the SLS/AL and GLCCH Studies

1. An information/coordination meeting was held in Buffalo, NY with several interested public agencies to discuss the plans of improvement formulated for the St. Lawrence River, and the remainder of the Great Lakes. The following individuals were in attendance:

Willaim Gill	USF&WLS, Cortland, NY
Paul Hamilton	"
Steven Patch	"
Thomas Brown	NYS/DEC - Watertown, NY
Gunnar Hall	NYS/DOT - Albany, NY
Steven Runkle	PA Dept. of Env. Resources
Gregory Lago	Save the River, Inc.
William Willis	NCEEP-PB
David Robb	SLSDC, Washington
Charles Gilbert	COE, Buffalo
Daniel Kelly	"
Phillip Frapwell	"
Michael Pelone	"
Jim Karsten	"

2. An agenda for the meeting is attached (Inclosure 1). A number of items were identified for discussion or further investigation. These items are summarized below:

a. Gunnar Hall stated a concern for channels that can accommodate two-way vessel movements. The response was that existing channel design is already in place to handle two-way traffic and these costs are historical (i.e., sunk) costs. Future improvements were costed out using a similar design approach.

b. Consideration should be given to duplicate lock sizes at the St. Lawrence. This may not produce the largest net economic benefits, but would be the least cost plan of improvement. It was indicated this alternative would be presented in the report, but numbers were not prepared in time for this meeting.

c. S. Runkle asked about the project discount rate for our study. The response was that our interest rates are established by WRC for each fiscal year, and that 7-5/8% would be the basis for our evaluation.

d. A concern was raised about the short term need for larger locks in the lower G.L. system. The report should include all relevant information that would make our recommendations as strong as possible.

NCBPD-EB
SUBJECT: Information Meeting for the SLS/AL and GLCCH Studies

e. Delays at east coast coal export harbors and at the Panama Canal were reduced by advance scheduling or reservations. G. Hall stated that a similar system could be used at the SLR locks. Congestion pricing or seasonal scheduling to minimize vessel delays should be considered for the lower lakes. D. Robb stated that seasonal swings in commodity movements do not exist in the St. Lawrence Seaway once the navigation season is under way, and therefore a congestion toll would not be effective.

f. Diversion of Soo Locks traffic to available parallel locks after the Poe Lock or MacArthur Locks are at 90 percent utilization should be considered. Our study may overstate the benefits which accrue to traffic diversions. The response was that this would be further investigated by Detroit District.

g. Gunnar Hall stated that future user charges on the inland waterway system may increase future grain shipments via the St. Lawrence River. This is a scenario which should be considered in our analysis.

h. A question about how future recreational lockages would be provided after larger locks were built was resolved by a description of the data file inputs. Provision has been included for one non-commercial lockage per day during peak warm weather months.

i. Seasonality of commodity movements was further discussed in terms of the data file inputs. Monthly distribution factors are based upon near-capacity conditions, that is, a level monthly volume of each commodity is processed by the capacity model. This was considered to be the most probable response by private shippers as they attempt to maximize their use of the existing locks. This is consistent with D. Robb's statement given earlier.

j. The relationship of Canadian costs and remaining benefits (after U.S. are taken out) which might accrue to future Canadian benefits was identified as a study concern. The draft Stage 2 report will not explicitly compare Canadian feasibility, only a comparsion of U.S. benefits and a variety of cost-sharing scenarios will be identified. Mr. Hall felt such an analysis is needed to show that there would be some Canadian interest (i.e. a net benefit). It was explained that our modeling tools and rate studies are not capable of any accurate measure of Candian benefits.

k. System-wide environmental studies were identified by Tom Brown and Paul Hamilton as necessary for project evaluation. Also, an evaluation of the relative impacts between larger design vessels and existing Seaway-size vessels was stated as a concern by NYS-DEC and USF&WLS. C. Gilbert stated that other public interests could possibly cooperate on funding of requested environmental studies. It was stated that the systemwide studies would be very difficult for the Corps to undertake because the costs are so high ($15 million) relative to the SLSAL study cost ($3 million); the time for these studies and reporting (3-4 years) is well beyond the scheduled time (3 years); and the Corps also feels that these studies could not effectively be accomplished unilaterally, but the Corps was not given the perogative of utilizing formal U.S.- Canadian coordination. This is a very real constraint to the planning process, and although recognized earlier on, communications with the State department constrained the Corps to a unilateral study at this time.

3. P. Frapwell provided a brief review of the environmental assessment conducted to date. Consideration will be given to the change in total transits over time and not to specific levels of future transits by individual vessel sizes.

4. An open discussion period followed:

a. Steve Runkle indicated that preliminary information provided at the meeting may not be as accurate as a complete Stage 2 report.

b. Gunnar Hall wants to see more of the back-up materials that forms the basis of the evaluation.

c. Paul Hamilton requested information on disposal unit costs and disposal options. It was stated that the Corps report included an allowance for generalized disposal unit costs but did not identify specific disposal options.

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
100 Grange Place
Room 202
Cortland, New York 13045

September 10, 1980

Colonel George P. Johnson
District Engineer, Buffalo District
U. S. Army Corps of Engineers
1776 Niagara Street
Buffalo, New York 14207

Dear Colonel Johnson:

This letter is intended as an aid in planning for the feasibility study of Additional Locks and Other Navigation Improvements in the St. Lawrence Seaway, New York. The study was authorized by resolution, on June 15, 1966, of the Committee on Public Works of the United States Senate. This does not constitute the report of the Fish and Wildlife Service under the authority of Section 2(b) of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.).

Past correspondence from this office, letters dated November 19, 1976; May 12, 1978; June 12, 1978; September 11, 1978; and June 13, 1980, have provided input for the development of the Plan of Study. In these letters we expressed our concerns regarding the need for comprehensive river-wide studies on the St. Lawrence River in order to accurately assess the environmental impacts of the project.

A planning effort for the Lake Ontario-St. Lawrence River sub-basin was carried out by an Environmental Planning Team comprised of professionals from several federal, state, and regional agencies. The efforts of this team have provided significant progress toward the development of a detailed program of investigations, including a series of baseline data studies. These baseline studies are listed in the March, 1978 Interim Environmental Plan of Study submitted to the Winter Navigation Board. These studies will be analyzed in an ongoing process to insure that the individual study components will satisfy the needs of the Additional Locks and Other Improvements Feasibility Study. It should be noted that these studies are not as much a part of the Winter Navigation effort or the Additional Locks effort as they are a requirement for any major modification in the St. Lawrence River environment. This requirement will continue until the baseline data and other investigations, necessary to provide the required information for all initial planning studies, are acquired, analyzed, and used to prepare impact assessments. These assessments, by federal water resource development planning standards, should be done before feasibility determinations and recommendations for construction are sent to Congress.

The Additional Locks and Other Navigation Improvements Study is no exception. Major federal actions being considered as a part of the study include the following:

1. Construction of new locks in the Massena area would be undertaken. This would involve the removal and disposal of millions of cubic yards of material from more than 1000 acres of existing forests, fields, wetlands, and river areas. There are two alternative proposals under consideration. The first proposal is to build two locks of an expanded size parallel to and to the south of the Eisenhower and Snell locks. This alternative includes modification of the channel between the locks, increasing its width by cutting and dredging along the southern edge of the Wiley-Dondero Canal. Over 10 million cubic yards of material would need to be dredged and disposed of.

   The second proposal is to construct a new canal parallel to and north of the Grasse River. It would join the existing canal west of the Eisenhower Lock and east of the Snell Lock. The canal would contain one new lock. Dredging and disposal of over 30 million cubic yards of material would be required for this alternative.

2. Construction of a new lock near Iroquois Dam would be undertaken. This lock would be in United States' territory south of Iroquois Dam and would supplement or replace the existing Canadian lock. Over 4 million cubic yards of material would be required to be dredged and disposed of.

3. An increase in size of ships is contemplated which would necessitate channel widening. This would involve excavation along 20 miles of the river in over 22 reaches from Cape Vincent, New York to the Canadian Border.

4. All of these actions would serve to provide for an increase in the navigational capacity and use of the St. Lawrence River, which has a history of navigation accidents, the worst being the 300,000 gallon oil spill of 1976.

As has been discussed, the magnitude of the federal actions being contemplated is great enough to warrant detailed environmental studies and impact assessments in advance of feasibility decision-making by construction agencies. Continuity in the baseline environmental studies is also extremely important, and a break in environmental sampling programs during any one year could result in another year's delay.

The remainder of this letter contains a summary of the ecological resources of the St. Lawrence River, a discussion of the potential environmental impacts of the two lock alignment alternatives, and some future study considerations.

The Ecological Resources of the St. Lawrence River

The St. Lawrence River may be described as vast, unique, and complex with regard to its ecosystem. Of the 600 miles of the river, 125 lie in the United States and provide significantly diverse habitats which support a large and interdependent array of fish and wildlife.

Despite the critical importance of this biotic system, biological data on the area are scarce. In the past, sporadic studies which were limited in scope were undertaken on various aspects of the system. These studies only provided preliminary taxonomic reference. Preliminary studies were initiated by a team of scientists in 1976 to gather data and lay a foundation for future studies. The Environmental Assessment for Winter Navigation was completed during 1978, adding further to the baseline data. In 1979, studies were conducted on some aspects of the system, with the bulk of the effort concentrated in the locks area near Massena. Much more information is needed, though, to begin an understanding of the river's complex biotic system.

A multitude of physical, chemical, and biological components interact to produce the biotic system of the river. In addition to identification of the components, a thorough understanding of the interrelationship between constituents is essential. In a system so large and diverse, a change affecting one component may have a magnifying effect on numerous other constituents. This may be illustrated by a discussion of the terrestrial-riverine and aquatic biotic components of the river system.

Terrestrial-Riverine Components

The terrestrial-riverine components of the system are dependent upon the vegetation of the area. Plants are the primary producers in the complex food webs, without which wildlife could not exist. In addition to providing food, plants also furnish essential habitat for cover and nesting. It is the distribution and composition of plant communities which largely influence the distribution of wildlife.

Vegetation along the St. Lawrence River may be broadly broken into three categories: upland, wetland, and deepwater. Delineation is difficult due to the continuum aspect of environmental factors and species composition.

According to studies by Geis and Luscomb (1972), successional fields comprised 22% of the shoreline area in Jefferson and St. Lawrence Counties. Much of the upland area has been converted to seasonal residences, marinas, businesses, and agriculture. Forests, though usually disturbed, comprised 10% of the area in Jefferson County and 23% in St. Lawrence County. Plant communities considered much more fragile occurred on rock outcrops and wetlands, in 13.2% and 4.0% of the area, respectively.

Recent studies have been conducted in the area in relation to plant community composition (Geis and Hyduke, 1976 and 1978; Geis et al., 1976; Geis and Kee, 1977; Raynal and Geis, 1978; and U. S. Department of Interior, 1980). Less data, however, exist on the effects on communities of changes in environmental factors. Gilman (1976) noted that water regime was the most important factor regulating the occurrence of wetland communities along Lake Ontario. Other factors, including siltation, water quality, wave action, and turbidity, have not been thoroughly addressed.

Some habitats, such as wetlands, may be more productive than others. Distribution and composition of vegetation should be correlated with productivity and corresponding value to wildlife.

Insects have been perhaps the most ignored aspect of study along the river. Only preliminary data from a study by Kurczewski et al. (1976) exist for the river system. This was largely a taxonomic survey. Information regarding the effects of environmental change (e.g. changing vegetational composition, water level, temperature, siltation) on insect populations is lacking. Results of these changes should also be addressed in relation to the role of insects in food webs.

Little information also exists concerning the amphibians and reptiles (collectively known as herptiles) of the St. Lawrence. A total of 18 species of amphibians and 17 species of reptiles are believed to be present along the St. Lawrence River. Alexander (1976) found 22 of these species. Other studies were done by Alexander (1978) and U. S. Department of Interior (1980).

Due to their dependence on the water-land interface, herptile populations could be drastically affected by environmental modifications of the river. Effects of disruptive changes such as pollution, dredging and filling, and water level fluctuations cannot be predicted with present data. The loss of mature deciduous forests could harm populations of terrestrial amphibians. Distribution of herptile populations should also be determined to allow the identification of habitat vital to the continuance of this component of the food web.

Birds are the most abundant vertebrates on the St. Lawrence River in terms of species richness (260+). The majority of these species are migrants, although many species breed along the river. The St. Lawrence River provides a path for a large number of migrants whose distributions vary from South America to the Arctic. Environmental modifications which would disrupt this migratory path could have far-reaching effects on the avian populations of the hemisphere.

Waterfowl are important from an economic viewpoint. Over 20 percent of the New York State migrating waterfowl population uses the St. Lawrence River. The lowlands and marshes are important for the production and harvest of ducks.

Various studies on the river (Maxwell and Smith, 1976, 1978a, 1978b; Dept. of Interior, 1980) have emphasized colonial waterbird concentrations, due to their sensitivity to environmental disruptions, which places them among the species most likely to be impacted by alterations to the river ecosystem. Most colonial waterbird colonies are restricted to low-lying, sparsely vegetated islands which are rarely visited by humans.

Two bird species common to the St. Lawrence River are particularly susceptible to environmental disruptions. Common Terns are stressed due to their poor nesting sites, which are the result of habitat loss to humans and competition from Ring-billed Gulls. Herring Gulls are stressed by chemical contaminants (Maxwell and Smith, 1978a).

There is a great diversity among the mammals of the river region. Herbivores, insectivores, carnivores, and omnivores are all present. For discussion purposes, an arbitrary categorization into two subgroups, small mammals and large mammals, has been made.

Thirty-one species of small mammals, including chiropterans (bats), insectivores (moles and shrews), and smaller rodents (mice and voles), have been noted during studies of the St. Lawrence area (Lackey, 1976). These mammals are essential to the food web, yet little data exist to designate the most productive areas for these populations. Some geographical and vegetational areas of the St. Lawrence River may be of more importance in the production of small mammals; hence, these areas may be of greater importance in the maintenance of the food web. Environmental manipulations affecting these highly productive areas could have farther-reaching biotic effects than changes in other less productive areas.

A 1976 survey of the large mammals of the river revealed that of the 34 species of mammals listed for the northeastern region of the United States, ten have been extirpated from or occur rarely in the St. Lawrence River region. Only six of the 34 are considered abundant throughout the region (Van Druff and Wright, 1976). Taxonomic surveys exist, but ecological data from the area are scarce. Recent studies include Van Druff and Lomolino (1978a,b) and U. S. Dept. of Interior (1980).

The most direct effect on mammals from environmental manipulations of the river would be the destruction or disturbance of habitats. Destruction of hardwoods and old field sites would affect the greatest number of species, while destruction of old fields would affect the greatest number of individuals. Damage to grasslands would cause minimal disturbance due to the low species richness and abundance of mammals in these sites.

Water level fluctuation and siltation could cause problems, particularly in wetlands where such species as muskrat, mink, and beaver could be harmed. Dredge disposal could result in both short-term problems due to habitat destruction, and long-term problems due to edaphic changes. Another problem would be the alteration of island habitats. More species would be affected on large islands and on those close to the mainland.

Mammal populations could also be altered by the reduction of food sources. More information is needed on mammal populations before the effects of environmental manipulation of the river can be analyzed.

The Endangered Species Act of 1973, Public Law 93-205, as amended, lists the following species, which are found in the St. Lawrence-Eastern Ontario region, as endangered:

1) Bald eagle (Haliaeetus leucocephalus)

2) American peregrine falcon (Falco peregrinus)

3) Indiana bat (Myotis sodalis)

New York State has also published a list of protected plant species (Section 193.3, Environmental Conservation Law Section 9-1503). Thorough inventories of the aquatic and emergent plant species of the St. Lawrence River, particularly in the locks area, are not available.

Plans derived from studies of the natural resources of the region should consider the maintenance of rare and endangered species as one of the priorities. A thorough inventory of the endangered, threatened, and rare species of the area is necessary to accomplish this.

Aquatic Components

Primary producers in the aquatic ecosystem are phytoplankton, periphyton, and aquatic macrophytes. These producers form the basis for the remainder of the complex food web. Modifications in the primary producer populations, in terms of distribution and abundance, have a resulting system-wide effect on higher trophic levels. The dynamics of this system-wide ecology cannot be overemphasized.

Preliminary limnological studies of the river were conducted by Mills and Forney (1976). Phytoplankton was found to be most diverse and abundant closer to the river's origin at Lake Ontario. Lowest biomass was observed under ice cover and during mid to late summer, while depth distribution of productivity was determined by available light. One hundred algal forms were noted.

A seasonal change in the abundance of secondary producers (zooplankton) was observed by Mills and Forney (1977) and Mills, Smith, and Forney (1978a,c). Eighty percent of the winter population consisted of cyclopoid copepods. Rotifers predominated from ice-out to early June. Cyclopoid copepods then became most abundant, while in July, cladocerans were predominant. It is not known how this seasonal fluctuation is related to the feeding ecology of fish. Questions such as how a modified environment would affect primary and secondary producers and how these results would affect fish populations do not have answers at this time.

Benthic invertebrates are an important component of the ecosystem due to their role in the food web and because many are sensitive to environmental conditions and may be indicative of changes resulting from activities altering current patterns and transport of organic materials (Mills, Smith, and Forney, 1978b).

The type and abundance of benthic invertebrates are influenced by currents, inflowing streams, aquatic macrophytes, cultural effluents, depths, and substrates. A change in the substrate via dredging or siltation could drastically alter the benthic community, with secondary effects on the whole food web.

The area between Eisenhower and Snell locks has very low benthic invertebrate productivity compared to other areas of the river. This low productivity is due to such factors as dredging, ship wakes, and water level fluctuations, which have left the area with a relatively unproductive substrate.

Since fish are dependent upon the primary and secondary producers of the river, it follows that an understanding of the feeding ecology of fish is necessary to relate the fish distribution to the limnological distribution of the river. The rate of growth and the ultimate size of fish are also dependent upon fish diet (Ringler, 1976). Limited research has been done in this area.

The mortality rate is high for larval fish. Modifications of the environment could significantly alter fish populations if susceptible larval populations were disturbed. The distribution of larval fish populations in the river is not known. A preliminary study by Werner (1976) did report, however, that in the open river, alewife comprised almost 94% of the larval fish catch. Further studies are required to understand the role of larval fish in the ecosystem.

Species composition of adult fish in the St. Lawrence River has been documented due to the fisheries' recreational and economic values (Werner and Ford, 1972; Werner, 1976; Ringler, 1976; U. S. Dept. of Interior, 1976a, 1976b, 1976c, 1980; Dunning and Evans, 1978; Dunning, Evans, and Tarby, 1978; Dunning, Tarby, and Evans, 1978; Cooley, 1978; and Panek, 1979). The effects of environmental manipulation on fish populations, however, has not been studied. A statement from New York State Department of Environmental Conservation (1976) exemplifies this:

> "The fisheries resources of the St. Lawrence River have been subject to a number of serious stresses in the last 50 years... Surprisingly, the fish stocks of the river have never been studied properly and the significance of these past and any future environmental stresses is unknown."

The system-wide ecology of the St. Lawrence River is complex in its entirety. The consequences of any environmental changes in the river are variable since the components of the ecosystem are likewise variable in distribution, abundance, and in roles in the food web. The functional roles of the components are as important to the ecosystem as the individual components themselves.

Discussion of the ecological value of the St. Lawrence River is not complete without mention of the recreational opportunities that are thereby generated. It is the natural setting and the quality of the environment which attracts tourists and sport enthusiasts to the river. It is estimated that the river provides millions of recreation days annually (U.S. Dept. of Interior 1976a). The recreational aspect of the river supports 12 state parks, numerous resorts, and a multitude of hotel-motels, camping facilities, and seasonal homes.

Studies of fishing and hunting use along the river are also unavailable. In a state-wide pilot study by Brown (1976), however, there were 596,000 angler days on the river in 1973. The St. Lawrence River ranks first of all New York State waterways for total harvest of largemouth bass, northern pike, and muskellunge. It ranks second for smallmouth bass, panfish, and bullheads.

The economic impact of fisheries is substantial. During 1973, anglers in the river region spent an estimated $4.9 million in fishing and related expenditures, $2.0 million in related travel expenditures, and an additional $5.0 million in the purchase of major equipment (Brown, 1976).

Total use by hunters and trappers of the area is not known. New York State Department of Environmental Conservation waterfowl checks for 1973 showed 4,378 hunters harvested 3,816 waterfowl in the Wilson Hill and Perch River Wildlife Management Areas and other State lands along the river.

With increases in pollution and decreases in fish and wildlife habitat, recreational value and its associated economic value could suffer, since these values are closely tied to the ecological and environmental quality and character of the river. Changes which affect biological aspects of the river are relayed to the dependent recreational and economic aspects.

Potential Environmental Impacts of Additional Locks

The twin locks proposal would largely involve removal or disturbance of successional fields, as well as dredging a wider channel and approach area at each lock. Approximately 80 acres of open field habitat would be destroyed. An additional five acres of shrubland, consisting mostly of important ecotone areas, would also be destroyed.

The new lock and channel proposal would involve the destruction of agricultural lands and a patchwork of open fields, shrublands, and deciduous forests. Included in the potential location of this channel are approxmately 1150 acres of agricultural lands and open field habitat, 300 acres of shrublands, and 250 acres of deciduous forests. A six acre wetland could also be destroyed. The patchwork arrangement of these habitats provides many ecotones which are important to many species of mammals and birds. In addition, the lower portion of the Grasse River, which is important as a fish nursery area and may be a prime spawning area, would be dredged, channelized, and otherwise permanently altered. Portions of Robinson Creek and the St. Lawrence River would also be affected.

Under the new lock and channel proposal, the construction could be located anywhere within a proposed 1000-foot wide corridor. Locating the channel near the southern edge of this corridor would cause the least disturbance of upland habitats, due to the relative lack of forested areas and the preponderance of open field habitat. However, this location would have severe impacts on the Grasse River, and could affect the residential area of Massena Center. A northerly location would have more severe effects on upland habitat, due to the frequency of deciduous forests. A centralized route would involve the most dredging in the Grasse River, and consequently the most aquatic habitat destruction. The least environmentally destructive location would be a combination of the above routes, with most of the channelization occurring in open field areas.

Several biological studies were conducted in the proposed construction area during 1979 (U.S. Dept. of Interior, 1980). Although these studies only scratch the surface of the information needed to assess the effect of environmental disruptions, some potential problems have emerged.

Many of the islands and open-water areas around Massena are important as feeding and staging areas for waterfowl and other birds. Construction disturbances and water-level fluctuations from locks operations could decrease the waterfowl populations. Gulls and terns that nest in the area could also be affected.

Mammals are abundant in the old fields and hardwoods in the area and would be displaced by construction activities, particularly the new lock and channel alternative. In addition, the large volume of dredge spoil created by these activities would need to be disposed of, with possible harmful effects on mammalian communities. Water-level fluctuations could harm the populations of muskrat, mink, otter, beaver, and raccoon.

Water-level fluctuations could also cause severe impacts on the herptile populations. The Blanding's turtle, which has been proposed for threatened status by State of New York biologists, has been found in the area. This species is very sensitive to environmental perturbations.

Several species of fish were quite abundant near the mouth of the Grasse River. Some of these, such as spottail shiners and fallfish, are important forage fish. These species could be adversely affected by dredging which would occur in this area with either alternative. The importance of this area for spawning is unknown at this time. Further studies, including both adult and larval fish sampling, are necessary to evaluate this component of the ecosystem.

The benthic community in the immediate locks area is not very productive, compared to the rest of the river. Dredging and water-level fluctuations could further reduce these communities. In addition, the most productive areas are those containing emergent macrophytes. Any alterations to these areas could adversely impact the benthic community, particularly amphipods, which are important as a fish food.

Besides the new locks in the Massena area, a new lock has been proposed near Iroquois Dam. Two wetlands, which may be important fish spawning areas, would be destroyed or altered by construction of the lock. Avian species richness is high in this area. The benthic community is also quite productive here. Further studies are necessary to adequately determine the impacts of the construction and operation of this lock. The importance of the area for fish spawning should be carefully evaluated.

In addition to the actual construction of locks, several secondary impacts could occur. Among these are upriver dredging to accommodate larger vessels, island removal for channel widening, and increased ship activity. Large-scale dredging would result in several problems. One would be spoil disposal, which would affect upland habitats and cause probable reductions in the mammalian community. The destruction of benthic communities would alter the food chain, at least temporarily and possibly permanently. This, in turn, could result in the loss of one or more year classes of some species of fish. Dredging could also alter flow patterns, resulting in damage to shoals and wetlands, which are important to many species of fish and wildlife.

Island removal could have severe impacts upon mammalian communities, particularly if the islands are large or near the mainland. Colonial waterbird colonies could also be affected.

Our Fish and Wildlife Coordination Act report will be prepared later in the planning process at which time we will provide our formal recommendations. At this time, however, the Fish and Wildlife Service favors the twin locks alternative as opposed to the new lock and channel alternative. The former alternative would require much less dredging and spoil disposal.

Additionally, the area which would be impacted by the twin locks alternative is already in navigation use and appears to avoid alteration of more valuable areas. It also limits alteration of the Grasse River, an action that would involve increased downstream effects. The lock and channel alternative also involves the destruction of 20 times as much upland habitat, including several hundred acres of valuable shrublands, deciduous forests, ecotones, and wetlands.

This suggestion should be used to aid in your planning and not construed as our acceptance of additional lock construction and associated operational elements.

Future Study Considerations

Questions relating to the effects of increasing navigation on the system have been raised as a part of this study and others. Answers to these questions require information on the effects of present navigation and would benefit from information on the original effects of navigation in the St. Lawrence River. Unfortunately, little information on the effects of the Seaway construction and resulting operations, some of which is similar to what is now being considered, has ever been developed. Detailed biological information is scarce at present for the area, and no attempt to develop a pre-Seaway environmental profile has ever been undertaken. An assessment of the effects of increasing navigation will depend on knowledge of the effects of present navigation and will benefit from historical trends.

The 1979 studies conducted on the St. Lawrence River by the Fish and Wildlife Service were not intended to answer all of the questions that had previously been posed regarding the ecology of the St. Lawrence River. Rather, they were designed to provide specific information on the direct construction impacts of the Additional Locks Project. Complete studies of the river ecosystem are still needed to accurately assess any future projects on the St. Lawrence River.

In our letter of June 8, 1978, we provided you with a list of studies which should be included in the Plan of Study and undertaken as part of the total feasibility effort. We will repeat this list below. These study needs have been coordinated with the chairman of the Lake Ontario-St. Lawrence River Environmental Planning Team, the New York State Department of Environmental Conservation, Region 6, Watertown, New York, and with the scientific advisor to the team. Specific information on the list of studies that follows is available in documents of the Lake Ontario-St. Lawrence River Environmental Planning Team.

The following environmental investigations should be undertaken:

1. Baseline biological studies along the St. Lawrence River; use of the St. Lawrence River habitats by resident and migratory birds. Duration: 3 years.

2. Baseline biological studies along the St. Lawrence River; food chain contribution of the riverine reptiles and amphibians. Duration: 3 years.

3. Baseline biological studies along the St. Lawrence River; significance of aquatic insects as food chain components. Duration: 3 years.

4. Baseline biological studies at validation sites along the St. Lawrence River; distribution and abundance of benthic invertebrates. Duration: 3 years.

5. Baseline biological studies along the St. Lawrence River; the movement and significance of detritus and associated organisms within the river system. Duration: 3 years.

6. Baseline biological studies along the St. Lawrence River; characterization of fish stocks and movement throughout the river system. Duration: 3 years.

7. Baseline biological studies along the St. Lawrence River; determination of fish feeding ecology. Duration: 3 years.

8. Baseline biological studies along the St. Lawrence River; distribution, abundance, and habitat relationships of larval fish. Duration: 3 years.

9. Baseline biological studies along the St. Lawrence River; determination of primary and secondary production. Duration: 3 years.

10. Baseline biological studies at validation sites along the St. Lawrence River; determination of physical and chemical properties. Duration: 3 years.

11. Baseline biological studies at validation sites along the St. Lawrence River; productivity and environmental relationships of aquatic macrophytes in the littoral and wetland habitats. Duration: 3 years.

12. Baseline biological studies along the St. Lawrence River; use of the St. Lawrence River habitats by mammals. Duration: 3 years.

13. Mapping of St. Lawrence River habitats. Duration: 3 years.

14. Identification and characteristics of critical habitats which may be impacted by additional locks and other navigational improvements. Duration: 3 years.

15. Coordination and censuses of baseline data to generate an aquatic model for the St. Lawrence River. Duration: 3 years.

16. Coordination and censuses of baseline data to generate a terrestrial-riverine model for shoreline communities along the St. Lawrence River. Duration: 3 years.

17. Development of a computer-based data storage, geographic indexing and impact characterization system for the St. Lawrence River. Duration: 3 years.

These baseline studies and others in relation to the overall study of the St. Lawrence River ecosystem will involve a dynamic process. As our understanding of the river develops, so may the study orientation.

As we have stated in the past, we feel that basic environmental studies are needed to determine the feasibility of all major construction proposals on the St. Lawrence River. An international ecological study of the St. Lawrence River in advance of the planning for the projects addressed in our previous letters may be a solution to the general lack of data for the St. Lawrence River.

As we have indicated in the study proposals, the level of effort required will entail a large amount of data collection over a three year period and the modeling of the system to facilitate impact assessments. It may still be possible, however, as the study progresses, to indicate early in the planning process which possible projects are not acceptable from an environmental standpoint.

We appreciate the opportunity to participate in the planning process and we anticipate a series of future planning aid letters to assist you in this effort.

Sincerely yours,

Paul P. Hamilton

Paul P. Hamilton
Field Supervisor

US Army Corps of Engineers
Buffalo District

Public Notice

DATE: 4 DECEMBER 1981

The U.S. Army Corps of Engineers, Buffalo District, is conducting a study of the locks and navigation channels that make up the St. Lawrence Seaway portion of the Great Lakes/ St. Lawrence Seaway System. This study was authorized in 1966 by a resolution of the Committee on Public Works of the United States Senate. The purpose of the St. Lawrence Seaway-Additional Locks Study is to determine the adequacy of the existing locks and channels in the United States' section of the Seaway in view of present and future needs, and the advisement of their rehabilitation, enlargement, or augmentation.

An important aspect of this study is public involvement and coordination. It is the Corps intent to keep public officials, public and private organizations, and interested citizens informed on the progress of the study, and to provide opportunities for input on the issues being addressed.

We are now in the process of updating our mailing lists to make certain they are current. In the past you indicated an interest in the study and we would like to confirm your continuing interest. Would you please assist us by marking the statement below which reflects your interest and return it to:

U.S. Army Corps of Engineers
Buffalo District
Planning Division
1776 Niagara Street
Buffalo, New York 14207

Thank you for your cooperation and participation.

Charles E. Gilbert
CHARLES E. GILBERT
Chief, Planning Division

( ) Please remove my name from the mailing list.

( ) I would like to remain on the mailing list and my address is correct (please return your mailing label).

( ) I would like to remain on the mailing list; my new address is:

NAME: ______________________

ADDRESS: ______________________

CITY: ______________ STATE: ________ ZIP: ________

(PLEASE COMPLETE)

NEW YORK STATE
DEPARTMENT OF TRANSPORTATION
William C. Hennessy, Commissioner

1220 Washington Avenue, State Campus, Albany, New York 12232

March 24, 1982

Mr. Charles E. Gilbert
Director of Planning
US Army Corps of Engineers
1776 Niagara Street
Buffalo, New York

Dear Mr. Gilbert:

Your presentation of the St. Lawrence Seaway Additional Locks Study on March 16 was very well prepared and gave a good picture of the Phase II work completed on this survey study. As the NYSDOT representative to the interagency coordination committee for this study, I will address your request for a statement on whether to advance the study into Phase III.

You indicated that a delay of more than six months by your consultants Booz, Allen & Hamilton, Inc. and Arctec, Inc. in completing their technical work, had made it impossible for you to finish the Corps report on Phase II at the time of the meeting. It is my understanding that you will show the expansion of the US St. Lawrence River locks to accommodate the maximum size vessels now used in the Upper Lakes as the most favored alternative. You will show sufficient benefits of this and other lock expansion/addition alternatives to warrant completion of Phase III of the study.

Without the Corps report, showing your analysis and exactly what you will recommend to your Division office at the end of this month, it is difficult for us to support or to reject your position. However, I did raise a number of concerns at the meeting, based on a preliminary review of the consultant reports received a few days earlier. Briefly, these were:

a. The identification of realistic alternatives was incomplete. Non-structural alternatives should have included rescheduling of traffic and congestion pricing.

b. The benefits of general cargo movements are minimal. (Your staff indicated that even though general cargo traffic was forecast to be small, estimates of potential benefits were substantial.)

c. Rates and costs of alternate routes should have been taken into account in predicting future traffic. The impacts of potential user charges should be assessed.

d. Canadian plans for the Welland Canal and Canada's St. Lawrence River locks are all important. Better assessment of their costs and benefits as well as their direct cooperation should be obtained.

I feel that these issues, and environmental issues raised by Mr. Brown of NYS DEC at the meeting, should be addressed next. The opportunity for public review and comments on this study has been essentially non-existent. I realize that this is in part due to inadequate compliance with your study schedule by your consultants. Still, these schedules are not set in concrete, particularly for a project that is contingent on so many external events falling in place. My recommendation is therefore to allow considerable time for review of the Phase II work by all potentially affected interests before proceeding to the final study stage.

Sincerely,

Gunnar Hall
Associate Transportation Analyst

cc: Mr. James Karsten, US Army Corps of Engineers
Mr. John A. Finck, NYS Dept. of Environmental Conservation
Mr. Thomas E. Brown, NYS Dept. of Environmental Conservation

STATE OF NEW YORK
DEPARTMENT OF
ENVIRONMENTAL CONSERVATION
ALBANY, NEW YORK 12233-0001

ROBERT F. FLACKE
COMMISSIONER

APR 13 1982

Dear Colonel Johnson:

This is in response to a request from your staff for comments on Stage 2 studies in relation to the "Connecting Channels, Harbors and Additional Lock Studies".

The basis of our study comments are briefing reports by your staff and continuing study coordination with the U.S. Fish and Wildlife Service. We find it less than satisfactory that we are being asked to comment without the benefit of a completed Stage 2 study report document. However, given the level of information that has been made available to this Agency, I must take a position in opposition to any recommendation seeking Stage 3 study authorization. Our principal objections supporting this position are:

1. Stage 2 environmental assessment is totally inadequate. System-wide environmental impacts have not been addressed and site specific assessments are largely inadequate. Thirdly, shoreline structural and aquatic habitat disturbances that are predicted from the movement of larger vessels has not been assessed.

2. Progressing to Stage 3 will involve substantial added study expenditures that are unjustifiable without an understanding or commitment that the Canadian government is willing to make similar study expenditures or has any major interest in moving in the same shipping expansion directions. This consideration is especially pertinent given the fact that the cost to Canada would greatly exceed projected U.S. expenditures since the larger number of locks requiring expansion are Canadian owned and operated.

3. The study assumptions that form the basis of many of the proposal alternatives have been presented without sufficient documentation.

4. Many of the system expansions proposed represent improvements that would further facilitate winter navigation extension on the St. Lawrence River, a proposal New York State is on record as being in opposition to.

We hope that you will give full consideration to our concerns and our position against Stage 3 study authorization in formulating your recommendations.

Sincerely,

Robert F. Flacke

Robert F. Flacke

Colonel George P. Johnson
District Engineer, Buffalo District
U.S. Army Corps of Engineers
1776 Niagara Street
Buffalo, New York 14207

GREAT LAKES COMMISSION

ESTABLISHED 1955 BY INTERSTATE COMPACT
INSTITUTE OF SCIENCE AND TECHNOLOGY BLDG
2200 BONISTEEL BLVD
ANN ARBOR MICHIGAN 48109
313 665-9135

April 28, 1982

Mr. Carl Argiroff
Chief of Planning
Detroit District
U.S. Army Corps of Engineers
P.O. Box 1027
Detroit, MI 48231

Dear Carl:

This letter is a long overdue thank you for the presentations which you and your staff made to the Great Lakes Commission representatives in February and March. All participants were please to learn of the progress and tentative conclusions of the Corps of Engineers' studies on the Connecting Channels and Harbors of the Upper Lakes and the St. Lawrence Additional Lock Study.

The consensus I sensed from the participants of the briefing sessions was "that the studies should be continued to conclusion." Both the studies represent consideration of potential problems, which while not imminent, will confront us later in this decade and in the 90s. It is critical that we undertake and complete investigations such as these so we can understand the nature of the problems and seek appropriate future solutions.

Any conclusions regarding the depth of channels and harbors within the Great Lakes system should recognize the position of the six western Great Lakes Governors. That position suggests that, generally, the existing depths should be maintained. It is the view of most, if not all, that the potential cost of deepening Great Lakes connecting channels and harbors significantly beyond current depths would be at best prohibitive and at worst ridiculous. Although all would like to be able to handle vessels of significantly deeper draft, there appears to be no rational economic or political justification for correcting what could only be described as a historic error at this time.

On the St. Lawrence, there is clear opposition from the State of New York to major changes in the system. However, it should be noted that reports reaching the Great Lakes Commission indicate that transportation officials in Canada are in fact investigating improvements in both the Welland Canal and the St. Lawrence Seaway.

It is my understanding that they are considering lock sizes which would be similar to that of the Poe Lock at Sault Ste. Marie. All reviewers, whether taking an affirmative or negative stand on the studies' conclusions, should be aware that Canada still maintains the appropriate rights-of-way and necessary authorities to establish their own separate Seaway system. This was the case in 1954, when the U.S. passed the Wiley-Dondero Act, and it remains the circumstance today. If the U.S. wishes to maintain the partnership which was developed when the Seaway was constructed in the late 50s, we must be prepared to consider all options for improvement of the St. Lawrence Seaway system jointly with Canada. Without a study of this type, we will be unprepared for that initiative when and if it comes.

Overall, you may be assured of the Great Lakes Commission's continuing interest in the efforts represented by these studies. Although the Commission cannot be considered a candidate for local sponsorship of any project, as we rely on our respective states for those initiatives, we do maintain continuing interest in all efforts to improve utilization of the transportation system of the Great Lakes and Seaway system. Needless to say, we would expect that any improvements, either now or in the future, would be performed consistent with environmental objectives.

Again, thank you for the excellent briefing by you and your staff.

Sincerely,

Jim

James Fish
Executive Director

JF:pam

US Department
of Transportation

**Saint Lawrence
Seaway Development
Corporation**

800 Independence Ave., S.W.
Washington, D.C. 20591

May 12, 1982

Colonel George P. Johnson
District Engineer
Buffalo District
U.S. Army Corps of Engineers
1776 Niagara Street
Buffalo, New York 14207

Dear Colonel Johnson:

We understand through several informal discussions with your planning staff that Stage 2 of the St. Lawrence Additional Locks Study has been completed and is under review by N.C.D. and that a decision on whether to proceed with Stage 3 will be made shortly. The Saint Lawrence Seaway Development Corporation appreciates the opportunity which we have been given to provide our views during the course of the study.

Recognizing that the Welland is the capacity constraint on the entire seaway system, the Corporation and the Seaway Authority of Canada have recently completed a very detailed, joint seaway commodity flow forecast. Copies of the draft materials were provided to your staff and to N.C.D. as they became available, and copies of the final executive summary were also provided. This forecast falls between the National Waterways Study forecast being utilized by your staff as the high forecast, and the Booz-Allen forecast, which is being used as the low forecast.

As your staff is aware, our Canadian counterpart, the St. Lawrence Seaway Authority, has been working on the problem of providing additional capacity at the Welland Canal in anticipation of that node reaching capacity in the near future. The Canadian approach is to delay the investment in new locks by optimizing use of the existing works through improvements in channel alignment and approach walls and by improvements in the traffic control system for the Welland. Other improvements such as the use of shunter tugs and hydraulic modifications to shorten the lock cycle times have also been investigated. Canada also has under active study the firming-up of the existing season through the provision of an all-weather navigation system and extension of the navigation season on the system. Following exhaustion of the potential for optimization of the existing lock system, plans call for new, larger (Poe-sized) locks on the entire system.

It is our information that the Canadians have in hand detailed alternative plans for a new, all-Canadian, Poe-sized system for the Welland and St. Lawrence and are proceeding with what you would label advanced engineering and design. These plans have not been made public, and probably will not be made public until such time as a decision to proceed (on the basis of need) has been made. However, this does suggest that the U.S. should proceed with its planning efforts in order that we not find ourselves in a politically embarrassing position in the future. Current traffic on the system is rather evenly split between U.S. and Canadian cargo, with future projections for a shift toward more U.S. than Canadian cargo. There are strong foreign policy (and national defense) considerations which alone would dictate the need for U.S. planning for new locks on the system -- considerations which are difficult to integrate into the traditional Corps Benefit/Cost analysis.

On the basis of the above, it seems clear that you should proceed with Stage 3 planning efforts. In that connection the Saint Lawrence Seaway Development Corporation would be pleased to discuss a formal, interagency agreement for our participation. In the interim, please be assured of our continued interest in and support of your efforts toward providing additional U. S. locks on the St. Lawrence River as they become needed.

Sincerely yours,

Robert D. Kraft

Robert D. Kraft, Director
Plans and Policy Development

APPENDIX F

STUDY MANAGEMENT

STUDY MANAGEMENT

APPENDIX F

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APPENDIX F

F1. INTRODUCTION

This appendix outlines the proposed work effort and schedule for the Final Feasibility Studies (FFS). It must be noted that the level of effort and schedule are heavily dependent on the results of Canadian coordination and any information obtained thereby. This coordination will be sought at the beginning of FFS. The next section gives a brief description of the individual work elements making up the FFS. Following that is a Critical Path Method (CPM) diagram showing the timing of the work elements.

F2. COORDINATION OF THE PRELIMINARY FEASIBILITY REPORT (PFR)

The PFR and a report summary will be coordinated with government, State and private agencies, as well as, the U.S. and Canadian publics who have indicated interest in the Additional Locks Study. Following the opportunity to review and comment on the documentation, public workshops will be held to further help define the ideas and concerns which need to be addressed during the final phase of the feasibility study.

F3. FINAL FEASIBILITY STUDIES

Following the proposed workshops and Canadian coordination, a review will be made of the proposed feasibility studies listed by organization code below to determine if they need to be modified or supplemented in any way. If necessary, their scope or direction may change as a result of either the Public Workshops or the Canadian coordination.

Final Feasibility Studies are briefly described as follows:

a. Public Involvement.

Following the Public Workshops, continuing coordination will be maintained utilizing newsletters, and agency/group meetings. Key meetings will take place during plan formulation and during review and coordination of the draft reports.

b. Institutional Studies.

A cursory review for several areas is proposed under this work item. These areas are: a look at the past association between countries (in construction of the present Seaway), and a look at the local sponsor role.

c. Social Studies.

Supplemental effort to earlier work will be required in this area. Up-to-date data collection and field work will acquire information on population, land use, recreation, and water facilities.

d. Cultural Resources.

The efforts during the FFS will be to complete the literature search and development of the predictive model along with field testing the predictive model. The testing is required for plan impact analysis, and preparation of a Cultural Resources Survey Report.

e. Biological Studies.

There are two major work items which fall under this heading. The first is sediment analysis and bioassay, to determine the physical and chemical characteristics of materials which are proposed for dredging. This work will help determine the method and type of material disposal required. The second area involves site-specific field studies to further examine biological parameters (benthos, fisheries, wildlife, vegetation, and impacts at disposal sites) in all potentially impacted areas. The scope of these studies will be developed following coordination with the USF&WS, NYSDEC, and Detroit District, and be dependent on available funding.

f. Fish and Wildlife Studies.

The USF&WS will provide the Corps a planning aid letter which will help to determine whether one high-lift or two lower-lift locks would be preferable at Massena, NY. The potential impacts of any U.S. facilities to replace those in Canada at Iroquois will also be evaluated. Following that work, the USF&WS will participate in preparation of Scope of Work for biological studies, monitoring field work, and review of Contractor's reports. After all field work is completed, they will prepare a Coordination Act Report which will form the basis for the development of the Draft EIS. They will further be called upon to participate in review of the draft reports and coordination.

g. Economic Studies.

The first proposed work item is to utilize the modified capacity model to check on the parallel and tandem lock simulations done in previous studies. Other areas of expected effort are: gathering of additional transportation rate data for selected commodities and commodity groups; better development of the Great Lakes current and future fleets based upon historical trends and proposed future development, obtaining better estimates of Welland Canal capacity and coordination of expected improvements at this location (a higher level of Canadian coordination is proposed as the vehicle to accomplish this).

h. Hydrology and Hydraulics Investigations.

The impacts of dredging the river will be assessed to determine if any significant change to the levels and flows would occur. The impact of larger lock size on hydropower generation would also be studied to determine potential impacts.

i. Foundations and Materials Investigations.

Studies here will include: selection of suitable disposal areas preliminary design of containment structures, and preparation of a preliminary materials survey to aid in determining material availability and costs.

j. Design and Cost Estimates.

Work here will include preliminary designs of "Poe-sized" (and/or "Seaway-sized") lock for replacement (or additional) locks to the Eisenhower and Snell locks. These preliminary lock designs along with additional design and estimating work relative to dredged materials and their disposal will refine earlier cost estimates. The location of disposal site and development of criteria for them will also be required.

k. Real Estate Studies.

Studies will look at the location and costs of real estate for proposed lock and dredged material disposal sites.

l. Study Management.

A study manager along with a study team is proposed to manage all studies, coordination, funding, and scheduling of the FFS. Environmental, Economics, Design and Public involvement specialists will work closely with the study manager.

m. Plan Formulation.

Plan formulation is an important aspect of any study. During final feasibility plan formulation, extensive coordination, and involvement between all interested publics will take place to insure that all voices are heard as alternate plans are formulated for final evaluation.

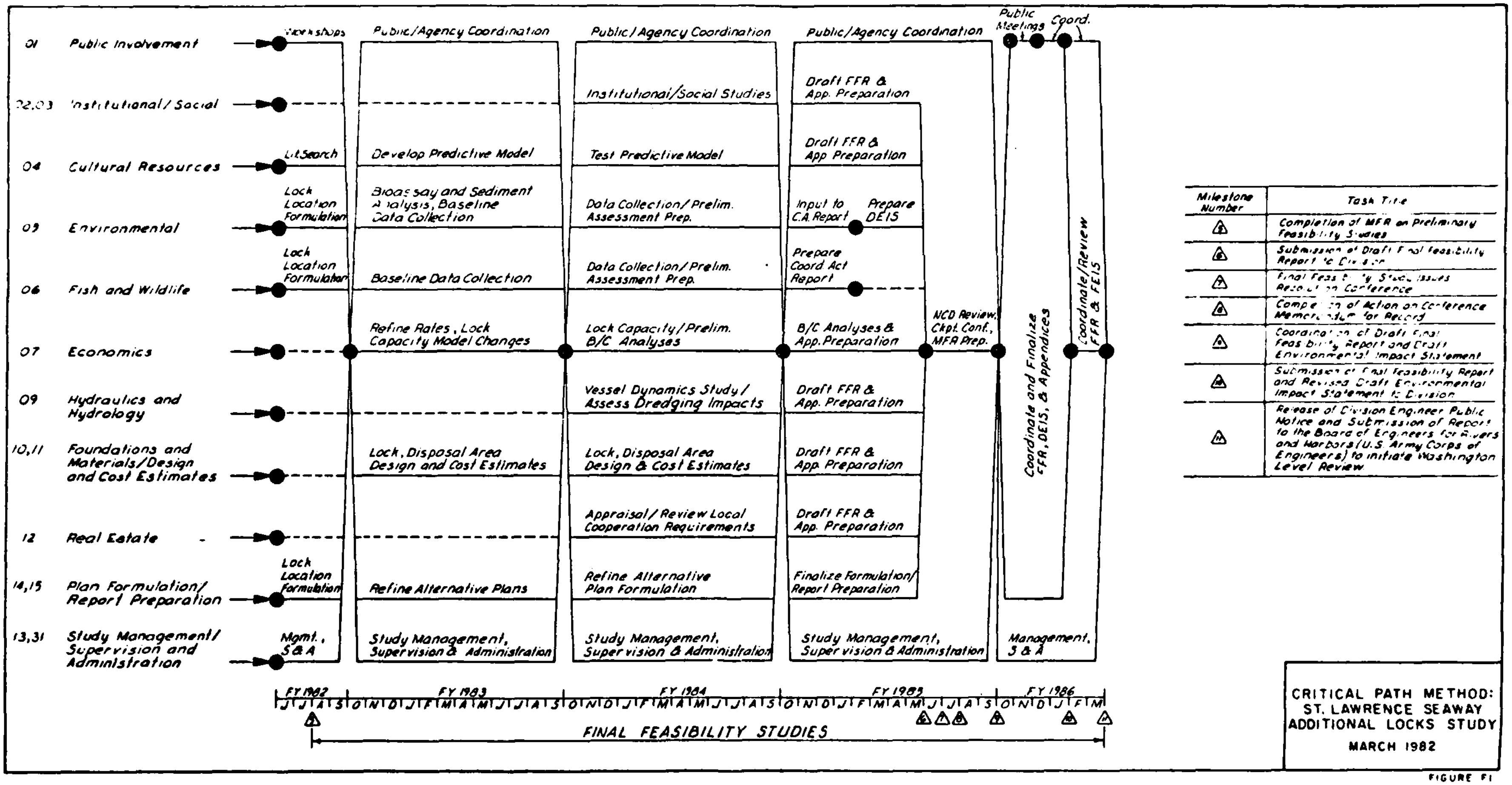
n. Report Preparation.

At the end of the FFS, a DFFR/DEIS will be prepared for review. Following review and coordination of this document, these reports will be finalized. The release of the Division Engineer's Notice will end the feasibility study.

F4. STUDY SCHEDULE

The study schedule including milestones and sequence and timing of proposed studies is shown on the attached critical path method (CPM) outline (Figure F-1). This CPM will be used to organize and conduct the FFS.

Periodic review and updating of the CPM will measure the progress of the study as it takes place. The Study Schedule is dependent upon Canadian coordination, an appropriate level of funding, and adequate priority (both at the District and division level) in order to deliver a timely and accurate report to address the problem, as requested in the study authorization.



CRITICAL PATH METHOD:
ST. LAWRENCE SEAWAY
ADDITIONAL LOCKS STUDY
MARCH 1982

FIGURE F1

APPENDIX G

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