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TRANSPORTATION
WORK GROUP REPORT

PREPARED BY:
WORK GROUP 3 OF FUNCTIONAL GROUP 3

MICHAEL PELONE

TOM MUIR

INTERNATIONAL JOINT COMMISSION
WATER LEVELS REFERENCE STUDY
PHASE I

JUNE 1989

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Evaluation Framework for Work Group 3

1. INTRODUCTION

The objective of Work Group 3 was to prepare a framework to assess the impacts and implications of representative measures on Great Lakes commercial navigation (specifically) or transportation interests (generally). Key elements of this framework included:

- o development of a work plan
- o identification of available resources
- o assignment and distribution of work items
- o monitoring work elements and preparation of a Phase I report.

2. APPROACH OF THE WORK GROUP

2.1. Overview

The philosophy of the Co-Chairs for WG-3 (Transportation) was to develop a critical review of past study methodologies and to develop an evaluation framework not constrained by data limitations or past study assumptions. Most of the work effort was centered around identification of the perceptions of the interest class within the Great Lakes transportation sector.

Heavy emphasis was placed upon an interview procedure of various components of the Great Lakes transportation system. Trade associations, shipping organizations, and port authorities and state and federal agencies were contacted to obtain lists of contacts of fleet and dock operators, port associations, shipyards, railroads and other users of the GL/SLS. These lists were reviewed to eliminate duplication and 75 firms were identified as representative of the transport industry or related modes of transport which use the lakes.

Geographic balance and representation of USA and Canadian interests were a primary consideration in the firm selection process. The target firms were contacted by mail and field interviews were arranged. Written summaries of the interviews were prepared and the responses were prepared and the responses were the primary source of information for the assessment of the sensitivity of interest classes to fluctuating lake levels.

The survey instrument reflected the near term high water conditions (1986-1987) and the rapid drop from these near term high to current levels. Data collected on actions or responses of the interest class representatives would hopefully document practicable changes or consequences for the future.

Most interviews were completed during the period August through September 1988. A transportation consultant was utilized during this period to insure that viewpoints of the interest class would be correctly interpreted. Resolution of numerous issues involving ships, terminal operations and commodity characteristics were also facilitated by use of a technical consultant to support Work Group #3.

Table 1 - Distribution of Field Interviews

Interest Sub-Class	Number
Vessel Operators	16
Dock Terminals	25
Railroads	5
Port Associations	12
Ship Yards	3
Total	61

A topical outline of discussion items and field contacts made are provided as a supplement to this report.

2.2. Available Resources

The following staff participated in the preparation of this Phase I report:

1. Michael Pelone
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2.3. Review of Past Reports

Review of past reports was limited to studies authorized by the International Joint Commission. Each study developed similar approaches to measurement of navigation impacts.

Appendix D - Commercial Navigation, Lake Erie Water Level Study, July 1981.

Appendix E - Commercial Navigation, International Great Lakes Levels Study, December 1973.

A literature search for similar or related reports has been completed and numerous reports on transportation have been identified. These reports will be reviewed in more detail as part of the initial work in Phase II. It is expected that related research on transportation issues within the Great Lakes region will contribute to an improved assessment of impacts on the transportation interest class in Phase II.

3. DESCRIPTION OF THE INTEREST CLASS

The five Great Lakes and inter-connecting channels are a natural resource which has been physically altered to accommodate the early business and industrial sectors to facilitate historical industrial development of the Mid-West region. While a large portion of this transportation network involved open water navigation, the connecting channels and man-made locks and canals often limit the exploitation of naturally deep lakes or harbors. At other locations, extensive man-made alterations are necessary each year to repair navigation infrastructure which may be damaged by natural forces (i.e., lake storms, high or low water, etc.) or must be constantly maintained to artificial dimensions in terms of minimum depths from deep water conditions. These channels often extend upstream into river channels which flow into the Great Lakes. These engineering works intrude into the natural environment and are maintained at design depths or widths at great expense. Environmental restrictions may also inhibit the extent and timing of annual maintenance, repair and replacement of the existing navigation infrastructure and future planning for capital improvements.

The existing Great Lakes transportation system reflects the technical requirements of the lake-type bulk vessels more than the ocean fleets. Historical evolution of the dimensions of the locks, channels and port/harbors facilities has been at a slow but continuous pace. The largest size vessels are now a 1000 ft. x 105 ft. self-unloading type which were constructed during the 1970's. There are now 13 of these largest size ships operating in the upper lakes. Limiting dimensions of the Welland Canal locks preclude these ships from operating beyond eastern Lake Erie. All other ships are physically able to navigate throughout the GL/SLS, but typically operate on trade routes which are defined by the competitive economics of freight rate structures, supply and demand for raw materials or other institutional constraints.

Standard Seaway depths are 27 ft. LWD and most of the largest Great Lakes harbors have been dredged to compatible depths. Vessels operating in the lower lakes can enter or depart the lakes at a maximum draft of 26.0 ft.

Table 2 - GL/SLS Connecting Channels - Physical Description

CHANNEL CHANNEL	CONTROLLING DEPTH (ft)	LENGTH (miles)	CHANNEL WIDTH (ft)	FALL (ft)	RESTRICTIVE WIDTH (ft)
St. Marys River	27	63-75	300-1500	22	75 & 105
Straits of Mackinac	30	0.8	1250	0	NA
St. Clair River	27	46	700-1400	-	600
Lake St. Clair	27.5	17	700-800	8	NA
Detroit River	27.5	32	300-1260	-	100
Welland Canal	27	27	192-350	326	76
St. Lawrence River	27	189	225-600	226	76

Notes:

1. Lock widths show maximum ship size allowed.
2. 75 feet restrictive width for the MacArthur, Sabin, and Davis Locks; 105 feet restrictive width for the Poe Lock.
3. Width restrictions at the Blue Water Bridge.
4. Lock restrictions.
5. A 4.5 mile section of the reach between Locks 7 and 8 is restricted to one-way navigation. The effect of the one-way restriction on lock capacity at this lock subsystem should be minimal after widening.

This maximum draft reflects a maximum design condition of the present day Seaway construction project which reflects multiple users with a compromise between navigation, hydropower and riparian interests. This limitation is also necessary due to fluctuating outflows and water levels in the Great Lakes. The end result of these dimensions is that only a minority of the present day ocean fleet can utilize the GL/SLS waterways.

3.1. Trade Patterns

Canadian flag vessels dominate shipping activity in the lower lakes and move the majority of export grain to terminals in the Gulf of St. Lawrence. These ships bring Labrador iron ore upbound on their return trip to steel mills in the Lake Ontario or Lake Erie basins. A substantial volume of US export coal moves to Canadian steam utilities or steel plants in Lake Ontario. This combination of compatible commodity movements is advantageous to Canadian flag operators. At this time, there is no substantial potential or actual use of U.S.A. flag vessels in the lower lakes. Most of the fluctuations in water levels above the long term averages cannot be used to the ship owners advantage when transiting the lower lakes trade routes. Tonnage volumes for the last ten years is provided as Figure 1.

In contrast, the U.S.A. fleet operates primarily on upper lakes trade routes and consists of a larger portion of older smaller vessels designed to carry iron ore and limestone. A wider range of ship dimensions, including maximum size 1000 ft. bulk ships, are available to U.S.A. shipping interests. However, advantageous lake levels or sustained high flows cannot be typically used due to limits of interior volumes within the older U.S.A. fleet. Also, a higher proportion of U.S.A. ships may leave their destination harbor without a backhaul cargo. For example, inbound vessels at Cleveland Harbor, OH are typically fully loaded, but these domestic ships usually leave the harbor in ballast due to lack of return cargo.

3.2. Locks and Channels

Federal construction of the Poe Lock at Sault Ste. Marie in 1968 allowed the latest generation of maximum size ships to operate between Lake Superior and Michigan/Huron/Erie. These ships can carry more than 60,000 short tons which is more than twice as much as Seaway-size lakers. Ships dependent upon the Poe Lock now account for the majority of the carrying capacity of the U.S. fleet. In contrast, Canadian bulk carriers operate without restriction in all 5 lakes and comprise the majority of the carrying capacity for export grain (downbound) and imported iron ore (upbound). A profile of major man-made navigation improvements are shown in Figure 2.

Regulations and information which navigation interests must know are contained in "The Seaway Handbook". These regulations are applicable to both Canadian and U.S.A. portions of the Seaway. As such, they constitute the "rules of the road" for commercial and pleasure craft. They are a critical part of the institutional framework for USA, Canadian or foreign commercial navigation interests.

The more important restrictions imposed upon users of the Seaway include length, beam and draft restrictions of ships. Vessel speeds, pilotage requirements and payments of tolls are also covered. Maximum ship drafts are specified by the operating agencies and reflect seasonal restrictions of levels and flows in Lake Ontario and the St. Lawrence River.

Lake Ontario outflows are regulated by Plan 1958-D which benefits the interests along Lake Ontario and the river. High water conditions are mitigated on Lake Ontario while hydropower and navigation interests are facilitated on the river. Tables 2 includes descriptive data for existing locks in the St. Lawrence River and the Welland

Canal.

3.2. Major Commodity Flows

There is an extensive historical basis involving the movement of iron ore from western Lake Superior to the south shore ports of Lakes Michigan and Erie. Major changes in the lock sizes at the Welland Canal and St. Lawrence River have evolved to support commodity movements of iron ore, grain, coal limestone and liquid bulk products.

Iron ore volumes experienced a substantial downturn in the late 1970's and early 1980's. Rationalization of the iron and steel producing facilities have produced cumulative effects on other movements of coal and limestone. These effects have caused a major change in the freight rate structure and the market environment is more price sensitive. Upbound iron ore movements from the Gulf of St. Lawrence are geographically compatible with downbound grain exports. This relationship, which has provided the stability for expansion of the Canadian fleet, may be eroded by decrease in the extent of raw material volumes required at Cleveland, OH, Detroit, MI and Chicago, IL and interior locations.

Annual volumes of export and import traffic expected to develop have not been realized following completion of the latest Seaway project. Ocean ships responded quickly to the opening of the Seaway locks, but early attempts at U.S. flag liner service (scheduled arrivals and departures) failed. Only a very small amount of general cargo is carried into the lakes and consists primarily of steel products (inbound) and manufactured products (outbound). Almost all of this tonnage is carried on small, foreign flag vessels which usually leave with a cargo of grain.

The size and types of foreign flag ships in 1989 remain essentially the same as it began more than 25 years ago in 1959. In contrast, high speed container ships connecting U.S.A. coastal areas with international port centers have substantially increased their annual volumes of tonnage and containers. Railroads continue to make competitive inroads into the Great Lakes port hinterland traffic potential. Improved rail networks have been created from merged operations of competitive lines and the net result is a more price competitive transportation environment for waterborne commerce. The balance of general cargo traffic which remains captive to the lakes route now consists of heavy lift and specialty break-bulk traffic. The relatively long transit times, limiting canal drafts and ship size limitations imposed by the Seaway project locks are likely to restrict growth to those market niches that the Great Lakes export route presently accommodates.

The Great Lakes fleet is composed of two distinct subtypes of vessels; self-loading and bulk freighters. The largest ships are owned by U.S. shipping interests and are captive to the upper lakes trade routes. Canadian flag ships comprise the largest portion of the Great Lakes fleet. Distribution of ownership of the 1987 Great Lakes fleet is shown in Table 3.

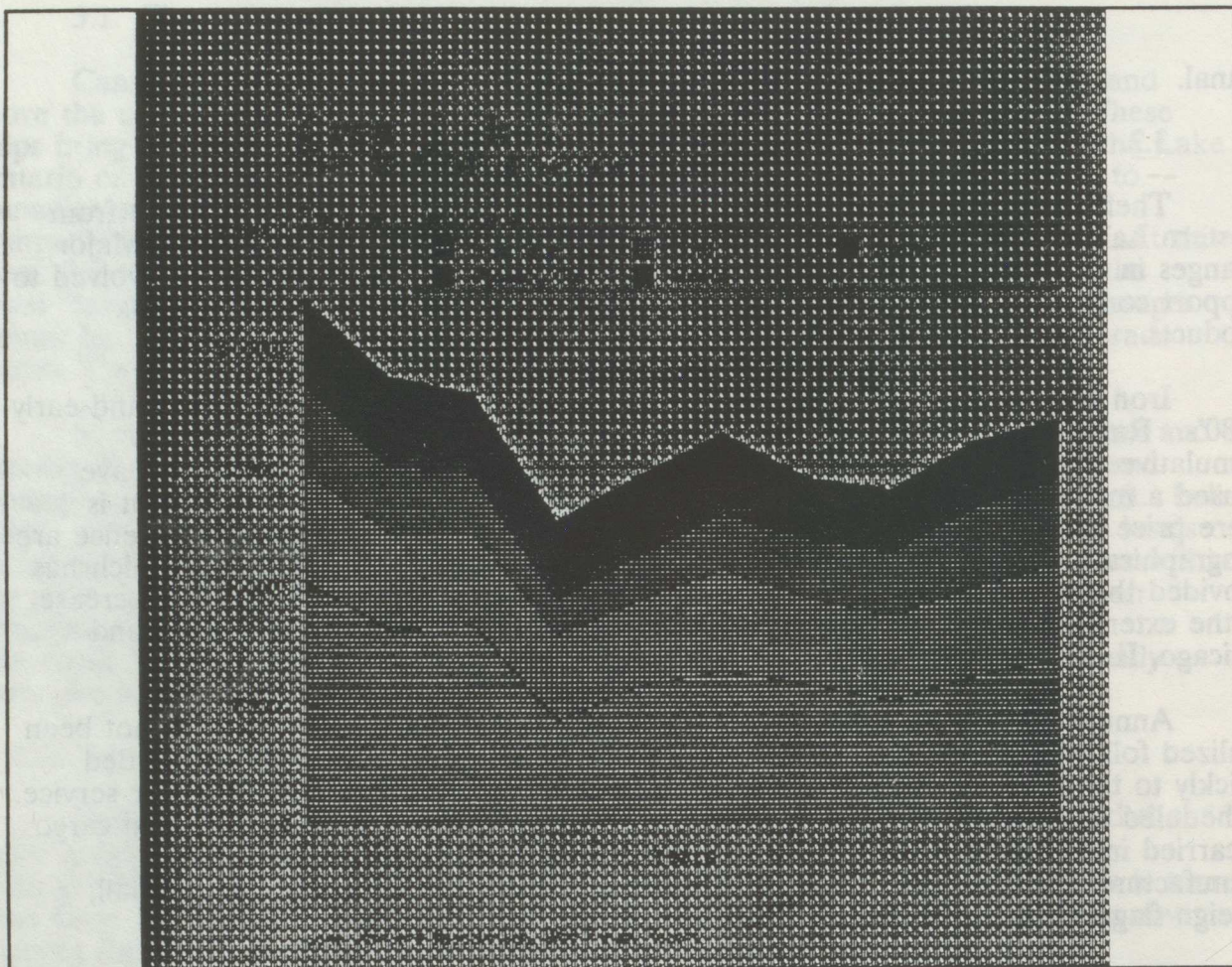


Figure 1

Table 3 - Classification of Vessels

Vessel Class	Length Interval (ft.)	Ship DWT. (n.tons)	Immersion Factor	Ownership		Total
				U.S.A.	Canada	
10	950/1099'	59,000	210	13	0	13
9	850/949'	44,500	180	1	0	1
8	731/849'	32,850	160	11	3	14
7	700/730'	26,850	120	5	65	70
6	650/699'	23,200	100	8	9	17
5	600/649'	20,150	95	36	11	47
4	550/599'	14,100	65	4	0	4
3	500/549'	11,750	55	1	0	1
2	400/499'	9,100	40	0	1	1
1	<= 399'	n/a	n/a	0	11	11
				79	100	179

FIGURE 2

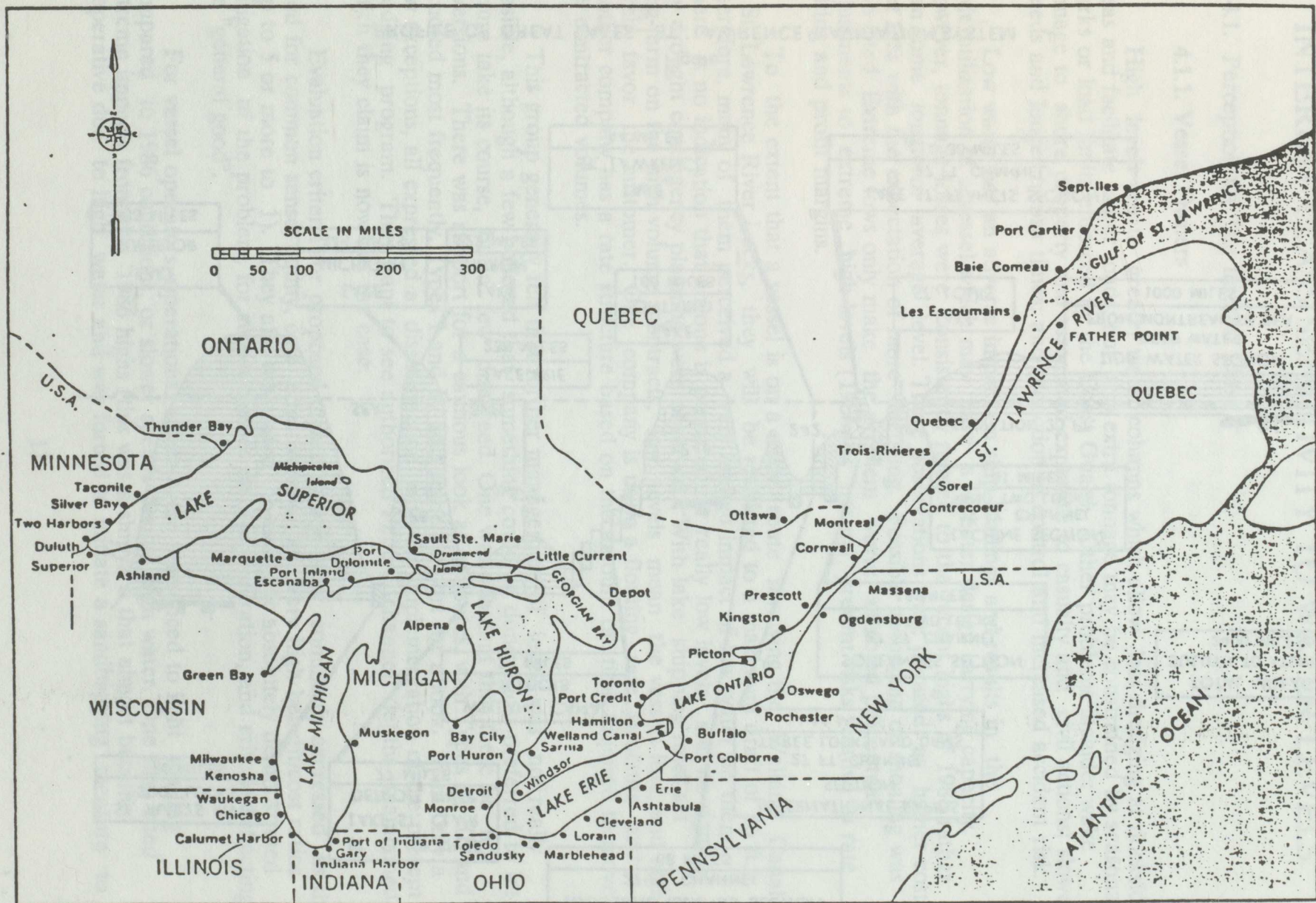


Figure 2
GREAT LAKES—ST. LAWRENCE NAVIGATION SYSTEM

FIGURE 3.

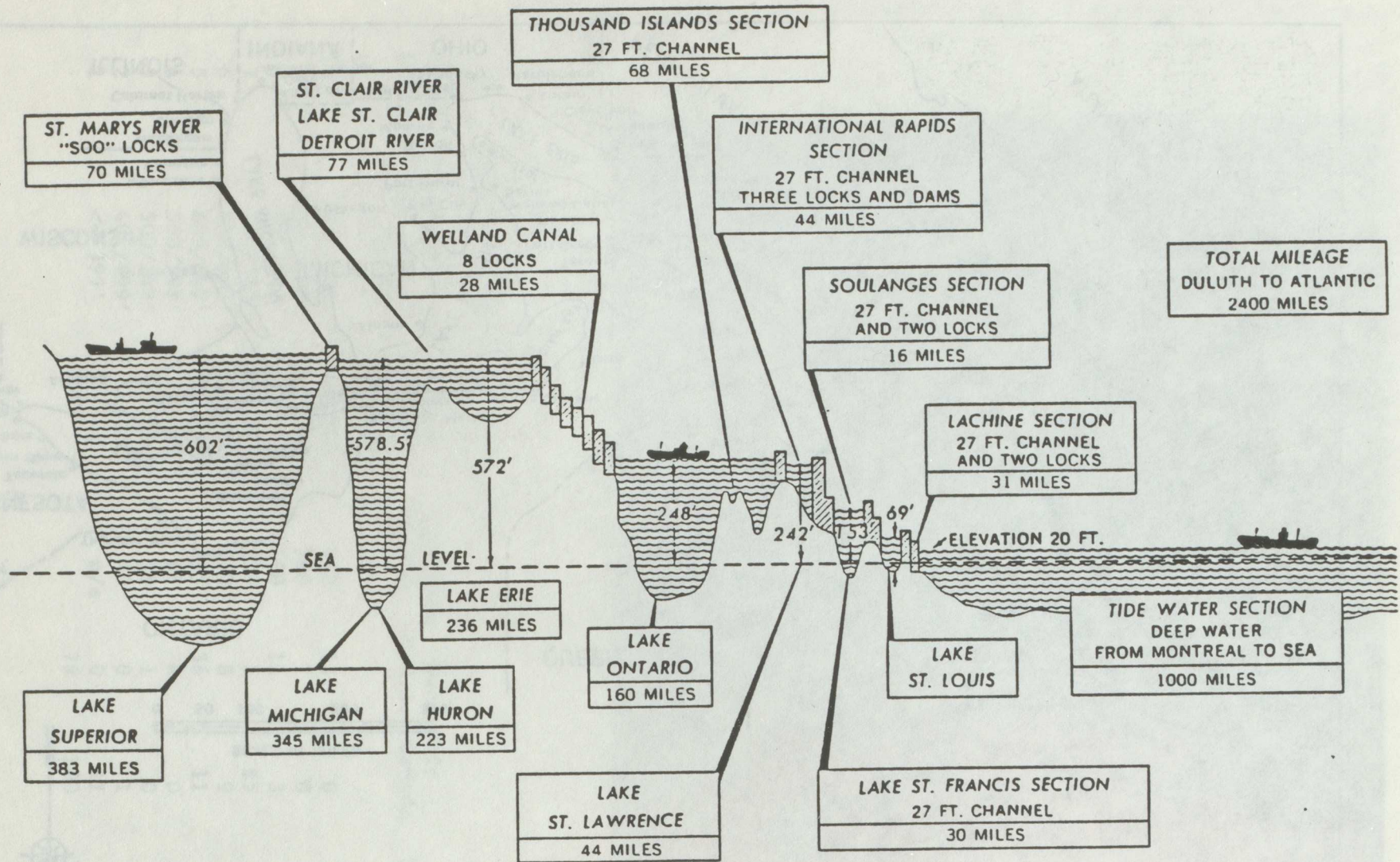


Figure 3

PROFILE OF GREAT LAKES—ST. LAWRENCE NAVIGATION SYSTEM

4. INTEREST CLASS SENSITIVITY TO WATER LEVELS

4.1. Perception Of The Interest Class

4.1.1. Vessel Owners

High levels create greater water columns which allow less dredging at dockside areas and facilitate larger loads, but this extra tonnage may be constrained by seasonal marks or load limits enforced by the Coast Guard. Other problems include: wake damage to shore property and associated exposure to casualty and civil actions; slower speeds and longer transit times; and reduction in control and increased accident risk.

Low water has an adverse impact on ship loadings and results in the underutilization of a vessel which may have a greater design carrying capacity. However, tonnage losses were consistently related to the recent highs of 1986 rather than some longterm average level. These observations were phrased as higher costs and fees with the expectation of more dredging. Possible grounding or shoaling was also cited. Extreme lows only make the problem worse as noted perceptual adjustments to extreme high levels (1986) as "normal" present risks relative to rate setting and profit margins.

To the extent that a vessel is on a trade route involving the Welland Canal or St. Lawrence River Locks, they will be restricted to a maximum draft of 26 ft. Therefore, many of them perceived a very limited impact of low water on them. There is no indication that anyone is prepared for really low levels, and no signs of any drought contingency planning were observed. With lake shipping rates set long-term on the high volume contracts, low levels mean the vessels lose, and high levels favor the customer. One company is using a floating rate structure and another company has a rate structure based on the amount of time required to move the contracted volumes.

This group generally felt that further management of levels was not really feasible, although a few believed that something could be done. Most preferred to let nature take its course, but a few disagreed. One was adamant that there be no diversions. There was support for a cautious look at measures, with Types II, III, and V noted most frequently. Types I and IV had some support for a look. With only a few exceptions, all expressed a dissatisfaction with the implementation of the present dredging program. They want to see authorized Federal channel depths maintained, which they claim is now not the case.

Evaluation criteria for proposed measures was most commonly expressed as the need for common sense, equity, cost effectiveness, and very high benefit/cost ratios (up to 5 or more to 1). They also advocated the need for absolutely demonstrated mitigation of the problem, for sunset clauses on study duration, and criteria reflecting the "general good".

For vessel operators, operational effects were referenced to light loading compared to 1986 conditions, or slower speeds during high water. One firm cited extreme impacts from the 1986 highs (this was a shipyard that almost became inoperative due to high water and was forced to initiate a sandbagging measure to

avoid further damages). Most actions taken, if any, were of a precautionary nature, although there were several firms which were forced to spend money to complete necessary actions to protect themselves against seasonal lake storm effects.

Overall, concerns for regional and national economic conditions were considered to be more important than concerns for water levels, although these perceptions have not been severely tested by extreme lows. Acknowledging that the perceptions stated by interest groups do not reflect an extremely low water condition, and what is calculated as a tonnage/revenue loss using this perception, some rethinking on this matter would seem in order. Furthermore, only two fleet operators of the 16 interviewed stated that water levels hurt or were more significant relative to other costs of business. Again, perhaps some thought on the "surprise" aspect of new lows relative to their experience or expectations, with a view to what the marginal impact would be is in order.

4.1.2. Shipper/Receivers or Dock Terminals

For this group, impacts of high water ran the spectrum from small gains, no impact, flooding, and dock erosion, to seepage, sinkholes, shutdowns, and "fits". Low levels mostly involved impacts associated with light loading, increased dredging, increased loading/unloading time, and dock and pier rotting. Some firms were not impacted at all.

With only two exceptions out of 23, all contacts perceived levels as being essentially unmanageable. Thus, most favored letting nature take its course, however, this view was sometimes a conditional one in that one had to keep watch that things didn't get totally out of hand. There was a little support for attempts to dampen the extremes, but opposition to diversions was strongly expressed by one contact.

Support for measures was split, with about equal numbers in favor as against. Supporters suggested Types III, II, and I in that order of frequency. Type V was noted specifically, and Type IV was included when support was expressed for measures in general. Those against measures cited the need for planning and adapting, or just said no. Again, this group was emphatic about the need to maintain authorized channel depths with more dredging. They were complaining that it was not being done. Problems with soil erosion and dredge spoil disposal were noted, along with the need to move more decisively on these matters.

Operational effects expected at high lake levels were flood protection, diking, sandbagging. Lows caused light loading, more dredging, and in one case extreme lows would require major modifications. A number of contacts reported no operational effects at all. Most actions taken were precautionary, with a few reactionary or necessary.

With the exception of three contacts who felt extreme lows were as important as general economic conditions, all others did not perceive water levels as a problem. A similar perception was expressed about the relative importance of general business parameters.

4.1.3. Railroads

For this group, high water impacts ranged from nil to an expectation of dock erosion at loading areas. Low water also had mostly no impact, with exceptions being dredging, some light loading, and the need to operate longer and in bad weather.

Virtually all contacts felt that management of levels was not possible. Most agreed to let nature take its course, but some suggested we give it a little help. Suggested measures included dredging, Types II, III, IV and all others, in that order. Again, the existing dredging program was criticized as not being implemented.

Under criteria, cost effectiveness and substantial excess of benefits over costs were the favorites. Some contacts offered none and one felt that no measures would prove to be cost effective. The need to consider the general good was again mentioned.

Most contacts had made no operational changes, however one had made a few modifications, and one other had some ship loading problems when levels were too high. Most had taken no actions at all, but there were two that used precautions. Where applicable, business conditions and other costs were all perceived to be more important than water levels.

4.1.4. Ports and Associations

Impacts of high water on this group were mixed. In some cases high water was favorable (the higher the better; no dredging), and some had adapted their facilities. Others suffered flood damage and pumping costs. Most had negligible or no impacts.

Low water impacts were more consistently negative, although Seaway users perceived that they were okay. Dredging, dockwall stress, boat ramp problems and the possibility of severe shoaling were cited. One port has extensive rock channels and cannot deepen in a cost effective manner. Double handling of cargo due to inadequate dock dimensions was cited at one location. In one other case, a special feeling about the intrinsic value of the Great Lakes and the need to let them be was expressed.

Most perceived that management was not possible. One suggested that we adapt, another that we limit our efforts, and yet another said that the Corps must be involved. A Lake Ontario interest said they were just fine with that lake, and were not familiar with the other lakes. Almost all said let nature be, and felt we should be more sensitive, adapt, accommodate, and work with nature. Adamant opposition to diversions was again expressed.

The need for authorized dredging was again expressed, and structures were also mentioned. Two contacts did not support either. Strong cost effectiveness, high benefit/cost ratios, and identifiable success in mitigating the problem were again cited.

Some operational effects were noted, including dock and storm sewer modifications due to high water, dredging, light loading, and mode shifting. All took some actions, mostly precautionary, some reactionary and necessary. One

advocated the development of a Lakes-wide contingency plan.

Again, with a couple of exceptions noting extreme lows, almost all contacts felt that business conditions and costs were more important than water levels. The need for some rethinking on this may be needed.

4.1.5. Shipyards

High water impacts ranged from positive, to tradeoffs between lower rates and damaged docks, to negligible to no impacts. Low levels were positive for one contact in the ship repair business due to increased vessel groundings which would ultimately bring him more ship repair business. Others paid higher rates, or had difficulty getting deeper draft vessels into dry-dock.

Most felt that levels couldn't be managed, and expressed the view to let nature take its course. One felt that measures should be explored. Definite opposition to more regulation and to measures was expressed. Measures supported spanned the range when all contacts were added. The problems with the perceived lack of authorized dredging were again expressed, mostly with emphasis. The dredging of backwater areas was suggested.

Common sense, large benefit to cost ratios before, and the general good were again expressed as criteria. Most contacts responded that operational effects were not applicable to them, and some expressed the same views regarding business conditions and costs. Where applicable, these latter factors are perceived as more important than water levels. Again, this general pattern of group thinking may have its limits of applicability, and may need to be reviewed.

4.2. Sensitivity To Fluctuating Water Levels

4.2.1. Past Studies and Focus

Based on the actual experience of the twentieth century, episodes of water levels near to and/or exceeding the high and low points in the 100-year period of record have been a recurring problem. Moreover, changes in water levels can happen very rapidly. These important characteristics of the Great Lakes were observed during two previous major water level studies conducted by the IJC. The first study was due to the 1962-1964 period of extreme lows that reportedly had severe impacts on shipping.

From these lows, water levels rose by 1973 to what were then record all-time highs for some areas, prompting another study directed towards Lake Erie. Subsequently, water levels receded towards more middle ground, only to again assault and exceed their all-time highs, culminating in the storms of 1985 and 1986, particularly, the December 1985 record-smashing blow and seiche on Lake Erie. Since that time, water levels have once again receded towards middle ground, this time very rapidly.

From this experience, it can be observed that the impacts of fluctuating water levels involve a number of factors that include the nature and response of the interest. Important among these are: (a) the real-time incidence and sequence of changes in water level states, and in the component processes (e.g. precipitation, evaporation,

runoff, and tributary inflows) that together determine these states; and, (b) the planning assumptions and adaptive responses that interests make, either explicit or tacit. The basing of plans solely on certainty expectations regarding possible extremes of water supplies is a one-dimensional focus that ignores the real-time environmental and other conditions that exist in conjunction with fluctuating water levels.

One important assumption made in past planning efforts is that real experienced impacts at extreme events are simply proportional to impacts around average or middle conditions (this is best described system linearity). Another assumption is that any event, no matter how extreme, can be reversed with no lasting or structural impact or change to the interest class and/or connected systems (system reversibility). Neither of these assumptions is generally true.

Furthermore, wide and growing uncertainty bands in the forecasts of growth scenarios that are used for "planning", are usually averaged or smoothed as well, creating, in effect, another synthetic certainty. These and other tacit assumptions, together with the nature of the interest class create a situation that makes the interest vulnerable to many unaccounted for possible changes in multiple and interdependent real-time conditions. This situation includes, but is more complicated than, some "below average" measure of past water level fluctuations only.

Transportation interests must confront these fluctuations, however, the nature of their use of the lakes is more varied and complex. For some interest subclasses, institutional and legal constraints on ship size, loading limits, and channel depths exist. Moreover, the general impacts of water level fluctuations are discontinuous. Ships have a narrowly bounded, finite capacity that is unaffected over most of the range of lake levels. Economic consequences are reflected in a continuous reduction in capacity but only below a certain threshold level.

Planning by this interest class is dominated by the forecasting of economic and market conditions. Environmental conditions are essentially ignored, and adequate draft is taken for granted, except of course when it starts to disappear. Low levels that cause light-loading can have major impacts. The extent of impact not only depends on the extremity, frequency, and duration of the low levels, but also on the profit margins of individual fleet operators and general economic conditions prevailing at the time. Adaptive responses are possible, but their effectiveness in reversing impacts and leaving the interest unchanged or intact in structure has a limit, and has not been fully investigated at this time.

Other transportation subclasses may be impacted only at extremely high and low levels. While the entire transportation industry includes an element of diversity and flexibility, and the water-based shipping sector can respond to low levels by changing its pricing practices, the interest subclasses and downstream clients are interdependent, making one-dimensional assessments of impacts somewhat misleading and basically inadequate. Other inadequacies related to the importance of real-time environmental conditions, and limits on impact extrapolation (linearity) have been noted above.

Overall, the present conclusion is that the transportation interest is especially sensitive to water levels that are at the low end of the range of extremes. Further, this group would be sensitive to an increased range and rate of fluctuation, both high and

low. This sensitivity involves not only the water level fluctuations, but also general environmental conditions that accompany the fluctuations, and the state or condition of the interest and connected systems, including other related, all in real time.

4.2.2. An Overview of Past Studies

Past studies considered in this review analyzed the impacts of water level fluctuations due to a number of causes or measures. These studies examined the impact of structural works, diversions out of the Great Lakes, and lake level impact estimates due to climate change. All examined reports are more or less related, using common water level baseline data, and essentially common economic data and models of the transportation (primarily comprised of commercial navigation interests).

While too many technical assumptions were made in these analyses to be covered here, it is judged that sufficient consistency exists between the studies for the purposes intended in this overview. Some essential aspects of these assumptions are contained in the Work Group #3 (transportation) report.

However, important major assumptions underlie the methodologies used for analysis. Impacts of water level fluctuations caused by various measures are derived from comparative analysis of static or given situations. The hydrologic base case in all studies is the period of record of Great Lakes average levels and flows. Each alternative investigated represents a new equilibrium set of average levels and flows resulting from the instantaneous and complete adjustment from the base to some specified changes, (ie., structural changes, diversion plans, re-regulation plans, etc.) or the specified time-path of changes, being evaluated. In some cases, new minimum and maximum average levels were reported.

There is no consideration of the general environmental conditions accompanying the water level changes. This is important, because in reality, the period during which the water level changes are being experienced other system components are effecting changes in net basin supplies. It is these components of change that make up the recognizable content, or information, of real "time".

The economic analyses are partial equilibrium evaluations using production cost models in a benefit-cost framework. The structural descriptions are often very detailed, however, there are no dynamics specified, only scalar growth. There is no consideration of real-time interactions between the environment and the economy. Also, there is no similar time-dependent consideration of the economic condition of the interest, of connected interests, or of general economic conditions.

Therefore, it is the conclusion of this review that existing studies represent some progress in the evaluation of water level fluctuation impacts, however, because they lack any consideration of context, they are lower-bound estimates of the sensitivity of the interest. This is particularly the case for extreme low levels, and their probable association with heat and drought, for which virtually no interest has a contingency plan.

The International Lake Erie Regulation (ILER, July-1981) study evaluation of Measure 25N, showed the following changes in the mean levels of the Great Lakes indicated:

Superior	-0.07 ft.
Michigan-Huron	-0.22 ft.
Erie	-0.59 ft.
Ontario	+0.02 ft.

Transportation cost increases under this plan were estimated to average \$10 million (1979) per year over the 50 year project period. Hydropower impacts amounted to an annual average loss of \$2.5 million (1979). Unless otherwise indicated, all dollar amounts are in 1979 terms.

Both of these numbers have been criticized as involving assumptions that turned out to both overstate and understate the impacts. Sensitivity analysis in the ILER Report showed that transportation cost increases may be overstated by a factor of ten due to forecasting errors and different assumptions. A critique of this study by the University of Wisconsin reported a 30 percent lower estimate of adverse impacts if capital costs were excluded from the economic model used in this study.

Also, the choice of timing of the low levels expected to occur, discounted the present value of the costs to both interests. The real price escalations for oil assumed in the replacement energy valuations for New York power interests, and the use of a relatively high peak capacity valuation factor, have been criticized as overstating the adverse impacts. This escalation procedure is not now viewed as a reasonable, as it introduces further problems or complexities inherent in any forecasting method.

On the other hand, suggestions that replacement costs should or could reflect current prices in the "wheeled" energy market assume that such replacement will always be available (infinite elasticity of supply). Interviews with these interest class representatives found that most utilities assume that shortfalls can be made up by such purchases (see Power Working Group report).

There appears to be little or no collective sense of what will happen if everyone "heads for the door" at once, or if there are limits to transmission capabilities. This point is another indicator of the fallacies inherent in thinking and planning only in average or expected value terms, and in extrapolating actions that may be valid for individuals or small groups in times of relative plenty, to arbitrary size groups in times that may reflect shortage.

Current examples of this misplaced confidence were evident in New England and Quebec in 1988. New England was denied power this summer as a consequence of the need to meet load demands in New York State. As a result, these utilities had problems meeting their demands, and the problem could worsen during the winter of 1988-89. There is no "on demand" interconnection solution to this problem. Also, Hydro-Quebec which is normally an aggressive interconnected exporter of electrical power, is now looking to buy winter backup power commitments, partly because of lower than expected reservoir supplies.

These factors reflect the high levels of uncertainty and risk facing utility planners.

Faced with such uncertainty, it can be argued on both economic and environmental grounds, that utility investment plans only be undertaken for projects with payback periods of five years.

The Wisconsin study (David, et al 1988) considered a number of scenarios of diversions out of the Great Lakes. A diversion of 10,000 cfs out of Lake Superior had the following impacts on mean lake levels:

Superior	-0.59 ft.
Michigan-Huron	-0.70 ft.
Erie	-0.48 ft.

Lake Ontario was not analyzed. Based on methods and data either derived from or acceptably consistent with the ILER study, this report estimated annual average losses to shipping and hydro interests of \$7.36 million, and \$73.1 million, respectively. This is compared to an estimate by the Diversions and Consumptive Uses study of a 5,000 cfs diversion out of Superior. Mean lake level declines based upon that analysis were:

Superior	-0.19 ft.
Michigan-Huron	-0.33 ft.
Erie	-0.23 ft.

Adverse impacts were comprised of annual losses of \$17.6 million to shipping, and \$40.2 million to hydro interests. Economic methods and data were the same as in the ILER report.

An example of a 30,000 cfs diversion (David, et al), considered to be the upper limit of feasibility, resulted in the following impacts on mean lake levels:

Superior	-0.99 ft.
Michigan-Huron	-2.16 ft.
Erie	-1.48 ft.

This resulted in average annual losses of \$21.1 million to shipping, and \$217.8 million to hydropower interests.

Studies and reports by Marchand et al (1988), and Sanderson (1987) provide estimates of the impacts of climate change scenarios on Great Lakes levels, and for commercial navigation and hydropower. The combined climate change and consumptive use scenario in the Sanderson study resulted in the following mean lake level declines:

Superior	-1.0 ft.
Michigan-Huron	-2.7 ft.
Erie	-2.3 ft.
Ontario	-2.3 ft.

Losses to Canadian shipping alone amounted to an average annual \$64.9 million, or an increase in existing transportation costs of about 30 percent.

With existing fixed rate schedules or contracts in place, this situation might

bankrupt the industry. Even with flexible pricing in place, questions of competitiveness would be raised. Also, links with the thermal power interest, through price, and possibly reduced availability of fossil fuel shipments, are evident (see the Power Working Group report). The present drought related declines in grain movements through the Great Lakes tend to make the interest more sensitive (see the Transportation Working Group report).

This example shows that the condition of the transportation interest (and related economic interests such as consuming or producing industries) at the time of the water levels fluctuations is important. It is also important to note that these levels of adverse impacts, or worse, are possible even without the above climate change or consumptive use scenario. Based on the period of record, there are monthly minimum water levels that are 1.7, 2.8, 2.6, and 3.1 feet below the means, for Superior, Michigan-Huron, Erie, and Ontario, respectively. Moreover, between January 1987 and January 1989, Huron and Erie declined by almost 3 feet. Transportation interests reported impacts during 1988 attributed to less than desired depths in the St. Lawrence river and the need to light-load at other locations within the connecting channels in the upper Great Lakes area. The interest sensitivity to further declines appears evident.

What is of critical importance are the transient extrema, that may or may not be associated with the instability of a changing (non-stationary) mean or average environmental condition, like climate and related factors relevant to this discussion. The nature of the possible behavior between the environment and economic system, together with all the interests contained therein, will be qualitatively different at extrema. There are system reliability thresholds, which if exceeded can lead to irreversible events with truly non-linear aspects. Interest capacity to absorb economic and other impacts is limited and should be incorporated into any evaluation methodology which is responsive to the concerns of each interest group.

When only the two sets of average conditions are considered, like before climate change or diversion, and after these events, the impacts on interests may appear relatively minor. However, the ability of the interest to "weather" the conditions that exist as the systems move between the two averages, or sets of conditions, including possible transient extremes of relative short duration for which the interest or system lacks sufficient reserve or resistance, is another story.

In conclusion, available data and studies suggest that the interest classes considered here are sensitive and vulnerable to further periods of heat and drought and further declines in water levels and flows. These conditions are possible within the experience of the period of record. Climate change related impacts may superimpose and severely worsen the situation, possibly synergistically. General economic system interdependence raises the possibility of far-reaching impacts in both space and time.

Work is required on real-time simulation of actual power systems and networks, using observations from the heat and drought and cold and wind experiences of recent years. Transportation and power interests need to make arrangements and obtain the necessary information to develop contingency plans to address further declines in water levels and related environmental conditions like drought. Development and use of non-stationary stochastic and related chaos or surprise concepts, models, and understanding is an appropriate step at this time in earth history.

Transportation Working Group report) through the Great Lakes tend to make the meteorological conditions (see the Working Group report) a hypothesis. It is possible that the conditions would be tested. Also, links with the thermal power interest through price and bankruptcy the industry. Even with flexible pricing in place, a decision to invest in new capacity would be based on the expected return on investment. The expected return on investment is a function of the expected return on investment. The expected return on investment is a function of the expected return on investment.

This example shows that the condition of the transportation network and related economic interests such as consuming or producing electricity at the end of the water level fluctuations is important. It is also important to note that there is a level of uncertainty associated with the condition of the transportation network. The level of uncertainty is a function of the condition of the transportation network. The level of uncertainty is a function of the condition of the transportation network. The level of uncertainty is a function of the condition of the transportation network.

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5. IMPACTS OF MEASURES

The relative effect of each representative measure must be evaluated against a basis of comparison (ie., existing conditions). Complicating the impact assessment is the lack of a response by the interest class to scenarios of extreme high and low water level which have ever been experienced. Most contacts indicated that marginal changes in water levels between extreme highs and lows are difficult to measure.

5.1. Procedures For Assessing Impacts

5.1.1. Introduction to the Problem

The Great Lakes shipping (vessel fleet) component is mainly concerned with water levels that may affect the cargo-carrying capacity of their fleet for bulk commodities. The impacts are said to be increased costs of transportation, and in the absence of cost recovery, losses in revenue and profits. For the transportation sector as a whole, some modal and/or route substitution for bulk commodities is possible, particularly grains. For coal, iron ore and limestone, the potential for other modes/routes is not clear. A few items on selected trade routes may have no practical alternative except the Great Lakes.

Ports and harbors are mainly concerned with potential damage to infrastructure from specified water levels that are above some desired norm, with seasonal storm effects being another consideration. Water levels below this norm are also said to interfere with loading and safe passage.

5.1.2. Towards the Credible Assessment of Impacts

Impact assessment methods are credible to the extent that they satisfy certain primary empirical or data requirements. Credible methods are based on experience and refer to observation. Operationally, this means that the methods' assumptions, limiting conditions, variable definitions and values, and rules linking them, are real and can be tested; their accuracy and adequacy can be disputed; and their meaning cannot be defined arbitrarily.

A substantive method contains a pattern of statements that is structurally and dynamically isomorphic to the observable world. Such a pattern can perform calculations transferable to the real world. These can link actions to impacts (providing a menu of outcomes to choose from), and can suggest an intervention strategy (a means of producing a preferred outcome). Overall, credible methods provide expectations of, and means for controlling events, insofar as is possible.

The filling of these requirements demands a refined and high quality technical knowledge base, involving concepts and methods for dealing with contingencies and unpredictable phenomena. Moreover, it is important to consider that the scope and availability of information and data needs, and therefore resource needs, is directly dependent on the a priori problem definition that underlies any recommended impact assessment procedure.

For example, is there only a problem if the net impact results (probably economic) of some assessment method says there is? In other words, is it some assessment method that decides the nature of the problem, or does the problem definition exercise decide the method? Alternatively, is the problem an inability to explain, predict and/or fix the incidence and sequence of changes in the rainfall, snowfall, wind, and temperature (heat) actually experienced and observed? More generally, this includes processes which affect water levels and events or changes therein, and related impacts, including those of measures.

The first definition assumes at the outset that the problem is basically unknown, and works from that point of view. This leads to a head-on descriptive and analytical approach whose data and resource needs increase exponentially as the diversity of interests and the spectrum of effects and impacts considered grows. Since there are limits to what can be done with qualitative description, and without numbers, pressures to move to large-scale quantitative models, with major structural and forecasting data requirements, and numerous assumptions, are the logical end point of this view. Because of this tendency, it is important to understand that there is also a limit to what can be done with numbers, as there is to what can be done without them.

Experience has shown that all these needs, particularly those requiring determinism and forecasts of the future, cannot be credibly met. Moreover, the marginal impacts that most measures may have on interests can be so small relative to the scale of the interest, that significance in terms of scientific standards of measurement, and ordinary practicality, may not be possible. Lastly, this view of the problem is one of tradeoffs and conflict between interests, and assumes that the phenomena behind water level highs and lows, and the effects and impacts on different interests can be arbitrarily added and subtracted with meaning.

The alternative definition observes that great big models don't work, and starts with a careful specification of the problem, working backwards from that specified known to develop a "model" to fit. This approach may assume that extremely high and low water levels, and the rain, snow, heat, and wind (storm) experience and observation of the forcing phenomena, are a problem per se; and that the details of certain processes and events are incomplete and unpredictable in principle. It is also assumed that technical and/or social "fixes" can never fully match the scale of the phenomena, and that the interests' perceptions of, and relationship to, fluctuating water levels and background causes are part of the problem.

In this case, data and model needs should be much smaller since the problem is perceived as a given, and the focus of the analysis is on the planning of anticipation, prevention, adaptation and coping strategies and solutions. Modeling and/or analysis might focus on extrema, exploring the general nature of such events, and accompanying environmental conditions, as indicators or signals of change and environmental stress. Such explorations might yield insights that allow inferences about the timing, prospects and effectiveness of various response actions or measures.

5.1.3. Methods of Assessment

5.1.3.1. Overview and Critique

If a detailed analytical assessment of impacts is wanted, it must meet very high standards of data quantity and quality to be credible. The underlying descriptive data base should be as complete as possible, possibly approaching the coverage of a census method or total inventory. To the extent that existing information is outdated, extrapolated from samples of self-administered questionnaires, or incomplete, credibility of the models prediction will be lacking. This data need should not be underestimated as great variability in relevant interest characteristics exists, and collection and use of the data are costly.

To measure the impacts of the status quo or "without" situation, a fact-finding census of affected interests could be undertaken to seek defensible evidence of an actual impact and the surrounding circumstances. If restrictions to future carrying capacity, revenue losses, or damages to physical plant are the impacts of concern interests would be required to "prove" losses through appropriate documentation, with culpability in law for false information. This would require an intense and coordinated response by a number of agencies to ensure some form of auditing process.

To the extent that a detailed measurement of "actual" effects and impacts cannot be directly measured, physical modeling can be considered, however, credible models involving complex variables are usually data intensive. The making of assumptions to reduce or substitute for data needs usually decreases credibility.

5.1.3.2. Review of Previous Lake Level Studies

Methods for assessing the impacts of "with" measure situations have traditionally been variants of transportation cost models. Different data records of lake level conditions are usually imposed upon a transportation model. This hydraulic and hydrologic information was readily available as the International Great Lakes Levels Board (IGLLB) developed a large model along these lines; a model that was revised and used in the Lake Erie Limited Regulation study.

The approach was to estimate transportation costs "without", and "with" the measure, and take the difference as the benefit or loss to commercial navigation. Generally, the only measures evaluated involved control/diversion works of some kind, and the Lake Erie study only considered reducing high levels on that lake.

It is difficult to recommend any existing assessment method, since they all involve simplifying and other assumptions that are highly discretionary and tend to be the dominant factors in derived results and conclusions. These models require long-term (50 year) predictions of various important driving factors, and past efforts have come under criticism. With some hindsight, the basis of these criticisms is seen to be valid. Specifically, the results and conclusions end of these methods is dominated by the assumptions end, and the truly modeled part that sits in between is often little more than a calculator.

The methodology of the IGLLB study, updated for the Lake Erie study, provides a good basis on which to look at these criticisms, and the key strengths and weaknesses of the existing studies. The Lake Erie study indicates that; "the assessment methodology is composed primarily of forecasts and projections concerning the operation of the future navigation system." The reliance of the major study components on discretionary assumptions dominated the results, and was the single main weakness in the study.

Without a single noted exception, all of the assumptions acted to overestimate the impacts on commercial navigation. These included: full capacity utilization of the fleet and inclusion of fixed costs in the impact calculation; overstated changes in fleet composition towards larger vessels which incur larger impacts; inflated tonnage forecasts; and inflated fuel cost forecasts.

More fundamentally, it was assumed that there would be no major economic depressions during the period of projection, or political policies that affect relationships between modes/routes of transportation. The energy crisis that induced the economic problems of the early 1980's, hitting the steel industry very hard, and the continuing North American farm depression, compounded by drought, have had major impacts on the Great Lakes shipping industry, which continue today. Some media reports indicate that Canadian policies might be encouraging, through subsidy, rail transport of grain to West coast ports, although changing markets may be an influence as well.

Given these major changes, it is difficult to turn around and make simple judgments about how the impact estimates of the Lake Erie study may be "corrected". Although sensitivity analysis of the major economic and political assumptions was not done, it was done for certain factors related to tonnage, ship capital costs, and fuel costs. The 1980's depression led to a substantial decline in tonnage from which the industry has not yet been recovered. Fleet utilization levels have not approached any level near capacity constraints, and actual market conditions within the Great Lakes may now make future replacement costs lower. After steeply rising in 1979-80, fuel costs have fallen sharply and remain stable.

Taken together, if the model was reinitialized using assumptions reflecting the realities of the 1980's, these unmet assumptions led to overestimates of 30% for capital costs, 30% for fuel costs, and at least the 15% sensitivity estimate for no-growth in tonnage. Actual declines in tonnage may double this last number. Thus, based on the Lake Erie study logic, impact estimates could be overstated by as much as ten times.

These observations reflect what might be considered the strength of the existing studies; the explicit statement of major assumptions, and some exploration of their possible error and implications. One further strength is the perspective provided by including an estimate of the scale of the total interest considered, so it can be compared to the impact estimate.

In the Lake Erie study, using their assumptions, the regulation plan with the greatest impact (25N) involved a cost increase of about 10 million dollars per year, compared to an average annual total cost of transporting bulk commodities of \$1,800 million. This marginal impact is 1/180th of the total, or almost one-half of

one percent. Considering the possible overestimates, the impact could be down around 1 million dollars. Total costs would also be lower but not proportionally, implying an even less significant relative impact. Putting this in the further perspective of the total transportation system, and the deep, structural changes in economic conditions now ongoing, makes such impacts even more difficult to assess with credibility.

5.1.3.3. Recommendations for Assessment Of Impacts

The studies considered here, and others like them, involve a great deal of data collection and modeling effort to estimate a very small relative impact. Moreover, in the end, the results are driven and dominated by arbitrary assumptions, rather than by knowledge of the underlying phenomena. This raises serious questions that must be answered before another similar exercise is considered.

One important observation relates to the proven impossibility of prediction (if that really needed to be shown again), and the lack of credibility and even utility of decision methods based on such things. Furthermore, the scale of certain aspects of the issue and of certain interests, has grown to such an extent that the real practicality of decisions based on forecasts of continued scale increases of economic variables included in transportation cost models (ie., tonnage and fleet size and composition) is in serious question.

Scale is not just size, but also has a qualitative dimension. The current period of history is dominated by change in virtually everything that industrial society has come to hold as doctrine. Any approach to a contemporary problem which doesn't embrace the reality of change will fail.

This implies that new approaches and new concepts are needed to assess the various types of impacts and evaluations of measures. One suggestion made above was to explore the extrema of the total phenomena causing fluctuating water levels, with the purpose of designing and evaluating strategies based on prevention, adaptation, resiliency and redundancy. Care must be taken not to overemphasize quantitative approaches at the expense of creative thought and alternative methods. Selection of a relatively few key factors, well presented and analyzed, can be far superior to large models and piles of undigested data.

Priorities for the remainder of the study could involve the further development of new approaches in cooperation with other Work Groups and Functional Groups. Some of these other study elements may also face even more pressures to accommodate new economic and environmental realities.

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6. CRITIQUE OF THE INTEREST CLASS PERCEPTIONS

6.1. Vessel Operators

Vessel operators consistently expressed a concern for the effects of higher costs (in whatever form they may be defined) as a consequence of water level fluctuations. It appears that many firms are now rethinking the traditional fixed price contract negotiations for even their largest customers. Increased competitive pressures and the need to maintain short term profitability is creating incentives for new rate environments such as floating rate structures, charging customers as a function of ship time used or incentives for the customers to maintain dockside depths which provide adequate water columns for the vessel operator to use. It is expected that innovative rate setting procedures will be used in the future to share the risk between the vessel operator and the customers.

Fluctuating water levels were not a concern for those vessels which transit the locks and channels of the lower lakes. Limits to the operating drafts are enforced by the lock operating agencies and prevented the recent high water levels from being used as a windfall gain. In response to this limitation most Canadian vessels have been designed to maximize the interior carrying capacity for iron ore and grain such that the load line limit of 26.0 ft. would be maximized. This has led to the evolution of a Canadian fleet that can carry more tons at Seaway draft than their U.S. counterparts. This is also one of the reasons that U.S. flag vessels have not been able to compete successfully on the lower lakes trade routes. These internally efficient ships are more flexible than their U.S. counterparts when competing on the same trade routes at less than maximum drafts.

6.2. Docks and Terminals

Interviews of dock operators indicated that there is a concern for depths adjacent to the dockfaces where the ships unload. High water allows them to defer maintenance at these locations, whereas low water forces them to confront issues such as budget constraints or disposal volume and disposal site constraints. There is a very strong theme that is revealed and that is, if the Federal government would dredge more often there is an expectation that the remaining materials may either be intercepted within the Federal channels or slough into the Federal channel. Either way, the net effect could be the externalization of costs which otherwise accrue to the private dock owner.

Most dock operators do not believe that lake level management schemes or new regulation plans may be beneficial to them. To the extent that they live with lake levels every day of the year, or face seasonal storms or damage under certain lake levels, their assessment should not be taken lightly.

Certain locations face sustained erosion from high levels due to the condition of natural bank slopes. However, most of the larger operations have steel or timber cribbed dock faces which are more resistant to high levels and potential storm damage.

Dock operators are the intermediary between the vessel and the end user

surveys required for each vessel may become increasingly difficult to schedule for the largest ships now in operation. The loss of additional ship yards due to sustained flooding problems from high lake levels will result in increased costs to the customer base.

6.5. Port Associations

Most of the concerns expressed by the port associations are similar to dock operators since in many cases port operate or lease facilities to dock management firms or cargo transfer entities. Most have experienced operational problems when water is high in terms of disruptions to utilities such as power or electric. Site drainage concerns was also stated to be a major concern.

A concern for more precise dredging was expressed by most contacts but there appears to be some confusion in terms of their understanding of the scope of the Corps maintenance authority. Most of the port associations have an active dredging program since they must serve a large number of vessel and are typically funded by revenues received for services provided (ie., wharfage, dockage and lease revenues from port terminal buildings, etc.) or, at some locations, by a legal taxing authority. These port authorities are actively involved with the Corps dredged material permit process for disposal of materials. They also have a history of annual dredging, at least over some portion of the local or adjacent dockside areas.

Most of the port authorities have a well developed relationship with their political representatives which makes this sub-group of the interest class unique. The history of water resource development at Federal harbors in the Great Lakes has always involved the port associations as major "players". Therefore, they are the best equipped to maximize use of political associations to redress problems with high and low water levels. This may continue to be a unique advantage when existing CDF sites are filled and low water prevails.

Dredging becomes a localized solution to a low water condition. Areas dredged can be prioritized as necessary within the harbor. In contrast, the implementation of a new control structure located outside the harbor area cannot be controlled by local interests.

Minimal changes in the water depths at loading terminals are preferred since it minimizes disruption to transportation schedules and train movements. Sharp swings in the commodity flow through-put at loading dock operations may adversely feed back into their logistics chain to complicate rail car requirements, train schedules or seasonal stockpiles. These costs can be very large at the upper lakes terminals (ore or grain docks) or lower lakes (coal) terminals. Large annual volumes of bulk commodities are involved in the transfer from railcars to ships and this results in a desire for a stable operating environment.

7. SUMMARY AND CONCLUSIONS

The summary of the interviews of each sub-group of the interest class has produced insight into major items for future consideration in the Phase II evaluation methodology.

7.1. Additional Studies

Phase II technical studies are required to further define the scope of specific types of problems and to assist in estimating the practicality of continuing on to quantify the net effects on the interest class. In several cases this will result in a new area of investigation, in others it is a refinement of previous methods.

7.1.1. Analysis of Dredge Material Disposal Sites

- a.1. obtain original design volumes and estimates of remaining storage volume
- a.2. estimates of annual fill rates and the relationship to a range of expected lake levels
- a.3. estimates of quantity of material which must be removed to reestablish original authorized channel depths in Federal channels
- a.4. estimates of quantity of material to be removed from adjacent channels in areas outside of the harbor limit lines for areas of active docks & piers
- a.5. disposal costs (initial construction and annual placement) for new facilities necessary to be constructed as a result of extreme low water levels

7.1.2. Detailed Hydraulic Analysis

Additional hydraulic studies must be completed to refine the degree of impact in the lower lakes and river channels. The response by fleet operators indicates that the lower lakes are immune from variations perceived to occur in the upper lakes. Further data must be developed by Functional Group #1 to describe the magnitude of flow variation for these interests. This should be available in the early part of Phase II. This will determine if a system or sub-system analysis should be pursued and the level of detail that must be incorporated into any measurement scheme.

7.1.3. Great Lakes Port Facilities

An inventory of ports to obtain detailed physical condition survey data is required to verify the effects on shipping interests at the loading/unloading channels. Each dock has a unique exposure to storms and wind effects that produce vessel delays. This is a potential area of impact where little information is available other than the subjective perceptions of local contacts.

7.1.4. Foreign Vessel Operators

Salty ships were described to be intentionally overloaded at the head of the

lakes in advance of their arrival at the Welland Canal which has a maximum downbound draft of 26.0 ft. This strategy allows them to arrive at the Lake Erie side of the canal (i.e., Port Colbourne, Ont.) at the maximum allowable draft. Therefore, there is a small but positive gain to foreign ships operating in the upper lakes when lake levels are high, at least for a portion of the distance.

7.1.5. Erosion Damages

Another tangible effect of high water is the erosion damages that fleet operators claim to have paid. The extent of these damages which increase the operating costs of navigation interests has not been documented. Early Phase II studies should be completed to scope the level of detail that should be pursued to incorporate this externalized cost to riparians in future transport cost models. It may be that actual data will indicate a minimal cost to the fleet operators. Coast Guard agencies on the U.S. and Canada are expected to participate in this investigation. Topics to be addressed include:

- o who assesses the financial penalties (i.e., Coast Guard or civil litigation)
- o who enforces existing laws which regulate the speed of commercial ships in confined channels
- o what is the role of the riparian (watch-dog or cooperation)
- o what has been the extent of actual fines levied under what conditions and at what locations can we expect these types of damages to occur in the future

Transportation includes movement of goods in Great Lakes shipping channels into and out of Great Lakes ports. Transportation includes the shipment of two major job classes:

- a. Ocean going and lake coast shipping companies
- b. Ports (often represented by port associations)

Both of these groups may also be associated with related transportation interests which comprise part of the regional transportation infrastructure, including truck, rail and air. The work group will concentrate their efforts upon measuring the impact of transportation on the regional economy and social indicators. The work group will also be associated with the Great Lakes water level or measurement studies with the U.S. and Canadian side of the Lake.

OUTLINE OF WORK PLAN

The work group will concentrate their efforts upon measuring the impact of transportation on the regional economy and social indicators. The work group will also be associated with the Great Lakes water level or measurement studies with the U.S. and Canadian side of the Lake.

Work Group # 3

Related issues such as marginal changes in transportation facilities, options to the fleet required to move the forecasted volume in the level of use of locks, channels or terminals resulting from impacts of water level changes will also be considered.

Transportation

In addition, consideration will be given to impacts on related transportation factors which will be displayed at the level of the regional economy. In conducting the Phase I background study, special attention should be paid to assumptions that might be made about:

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- level of water level measurement studies with the U.S. and Canadian side of the Lake
- shipping interests assumptions:
 - * system characteristics
 - * levels and flows
- seasonal loadings and draft limits
- lock and canal capacities
- outlook for total transport volume
- historically dependent on deep-draft vessels and seasonal lake transport
- by the frequency of the seasonal changes in the regional economy
- the of non-transportation factors in the regional economy
- the of non-transportation factors in the regional economy

1. Phase I Work Plan

Transportation includes movement of goods in Great Lakes shipping channels into and out of Great Lakes ports. Transportation interests are comprised of two major sub-classes:

- a. Ocean going and lake carrier shipping companies (often represented by shipping associations), and
- b. Ports (often represented by port associations).

These interest groups exist on both the U.S. and Canadian side of the Lakes. Both of these groups may also be associated with related transportation interests which comprise part of the regional transportation infrastructure, including truck, rail and barge systems.

Water dependent transportation interests can be affected by Great Lakes water levels or measures for dealing with fluctuating water levels. Although the major concern of this interest group is to avoid adverse changes in expected long-term levels of net commercial income, policy and social implications should not be overlooked. The work group will concentrate their efforts upon measuring the direct impacts of measures as they may affect changes in net income of ports and shippers.

Related issues such as marginal changes in transport times, additions or deletions to the fleet required to move the forecasted volumes, change in the level of use of locks, channels or terminals resulting from impacts of measures to deal with water level changes will also be considered.

In addition, consideration will be given to impacts on related transportation sectors which will be displayed at the level of the regional and bi-national economy. In conducting the Phase I background study, special attention should be paid to assumptions that might be made about:

1. The full range of potential lake level conditions (high and low)
2. Shipping interests assumptions:
 - * system characteristics
 - * levels and flows
 - * ports and harbors depths
 - * port docking and loading/unloading equipment
 - * lock and canal capacities
 - * seasonal loadline and draft limits
 - * changes in the market characteristics of major industrial sectors historically dependent on deep-draft lakes transport
 - * outlook for total transport volumes
 - * alternative transport modes as it relates to the Great Lakes connection between interior origins and destinations

3. Ports and Harbors Assumptions:

- * effects of lake levels on infrastructure
- * storm protection requirements
- * vessel loading/unloading equipment
- * market characteristics
- * changes in dredging costs in light of variable water levels
- * changes in the extent of inter-port competition
- * dredging restrictions and implications for port and terminals

The preliminary steps and products of the working group activity are outlined below:

1. Review all past studies that bear both directly and indirectly upon the assigned topic. The studies should include those completed under IJC auspices, by the academic community and by private transportation interests. As a part of this review, an inventory of models and data bases currently available for use by governments should be developed. This inventory should include a description of the models, data and documentation.

2. Present a critical evaluation of existing reports in light of the Great Lakes interest class. In this evaluation, report on the following:

- i) who authored the study
- ii) methods of analysis
- iii) key assumptions
- iv) post study criticisms
- v) possible improvements
- vi) obstacles to improvement of the past studies including disputes over evaluation methods, time and costs for improved methods of analysis, and limits of available models and data.

3. Interview representatives of the interest class and any individuals with relevant expertise regarding the nature of impacts and methods for assessing impacts on the interest class.

Based upon information obtained in steps 1, 2 and 3, a working paper will be prepared which includes the following items:

i) descriptive characteristics to include a highly refined sub-classification of the interest class in terms of uses of the lakes. Consideration will be given to the following: location within the basin, national identity and any other factors which can

be used to differentiate specific sub-groups within the general interest class.

ii) economic linkages within the lakes region and sub-regions

iii) a description of how the interest has been affected by, or has responded to previous changes in lake levels

4. Recommend methods to assess the impacts on the interest, related interests, the regions and the nations within the context of an acceptable accounting framework.

i) emphasis should be paid to basic assumptions, main logical steps and data requirements for impact measurement.

ii) particular attention must be paid to the proper application of the with and without framework for measurement of the effects of the proposed plans.

Estimation of these effects should reflect the extent of the uncertainty which may be inherent in assumptions used within the methodology or decision making framework.

5. Identify the evaluation criteria which reflect the concerns of the interest class.

6. Identify the likely direction and magnitudes of impacts of measures based upon available study information and conceptual frameworks under a range of water level conditions.

7. Prepare a work flow diagram of the activities necessary to implement the procedures defined above to support the Phase II study period 1989-1991.

8. Participate in the preparation of a final report for the Work Group.

SUPPLEMENT 1
FIELD INTERVIEW CONTACT LETTER
OUTLINE OF REPRESENTATIVE MEASURES

- Type I - Public investment in control and diversion works
 - Type II - Public investment to direct land and water use to adapt to short fluctuating levels
 - Type III - Direct public regulation of land and water use
 - Type IV - Public programs to indirectly influence land and water use effects of fluctuating levels
 - Type V - Emergency Response Capacity
(see attachment for amplification of the above)
- What general effect would occur to your firm if these broad types of measures were implemented? Note that specific details have not been finalized. Please consider only the trends or direction or magnitude of these types of measures.
6. Past studies have identified channel dredging or man-made structures as a way

I have been retained by the Buffalo District of the U.S. Army Corps of Engineers to assist in the mandated study by the International Joint Commission. Specifically, I am seeking your assistance in determining what course of action, if any, should be taken to alleviate the consequences of the recent period of high water levels while also focusing on the effects of the current water level conditions in the lakes, rivers, and connecting channels.

Insofar as the purpose of this study is to assist in further policy development, your input is vital. Accordingly, I would like to establish a mutually convenient time for a visit in the near future.

To allow time for reflective thought and to provide an agenda for our meeting, please consider the following

1. What have been the impacts of extreme high or low water levels on your operations?
2. What could be the impacts of extreme high or low water levels on your operations in the future? What evidence can you offer to support your estimates of these impacts?
3. What is your perception of the "manageability" of high and low water levels?
4. Do you favor an approach of "let nature take its course", or do you believe that there are alternatives which can be successfully implemented?
5. If "no" to question 4. above, what measures would you suggest be considered?

Preliminary representative measures have been identified and have been grouped into five types:

Type I Public investment in control and diversion works.

Type II Public investment to direct land and water use to adapt to shore fluctuating levels.

Type III Direct public regulation of land and water use.

Type IV Public programs to indirectly influence land and water or the effects of fluctuating levels.

Type V Emergency Response Capacity
(see attachment for amplification of the above)

What general effect would occur to your firm if these broad types of measures were implemented? Note that specific details have not been finalized. Please consider only the trends or direction or magnitude of these types of measures.

6. Past studies have identified channel dredging or man-made structures as a way

to raise low water and to reduce high water (such as compensating works in river channels). What is your opinion of these methods? Can you suggest any new or innovative plans to consider?

7. What criteria can you suggest should or could be used to evaluate measures?

8. Have you modified your methods of doing business to accommodate various water levels? Do you know of any action(s) taken by your associates to prepare for future reoccurrences of extreme high and low water levels?

9. Can you provide any examples of how your operations were affected?

10. With reference to No. 9, were your actions of a precautionary or speculative nature?

11. Freight rates per ton have declined sharply in recent years in response to general business conditions. Do you believe that fluctuations in the regional economy or national business cycle affect your business more than lake levels?

12. Changes in water levels are just one aspect of doing business within the Great Lakes. How does this compare to other considerations such as labor costs, energy costs, cost of materials, tolls and pilots, or related transport costs?

In the near future, I will be calling you to set up an appointment. In the mean time, if you have any questions, please do not hesitate to contact me at the above numbers.

Very truly yours,

John O. Greenwood
Transportation Consultant

REPRESENTATIVE LIST OF MEASURES

(REVISED 13 January 1989)

TYPE 1 - PUBLIC INVESTMENT IN CONTROL AND DIVERSION WORKS

- 1.2.1 - Full Regulation of Lake Erie (50N)
- 1.3.1 - Manipulation of Interbasin Diversions such as Long Lac-Ogoki and Chicago
- 1.3.10 - A 50,000 cfs Diversion In and Out of the Great Lakes System
- 1.4.4 - Placement of Sills at Lakes' Outlets

TYPE 2 - PUBLIC INVESTMENT TO DIRECT LAND AND WATER USE TO ADAPT TO SHORE FLUCTUATING LEVELS

- 2.1.5 - Barrier Island Construction
- 2.1.12- Structural Floodproofing
- 2.2.4 - Fee Simple Property Rights Purchase with Possible Resale, with Restrictions on Development
- 2.3.1 - Navigation & Access Channel & Harbor Dredging / Deepening

TYPE 3 - DIRECT PUBLIC REGULATION OF LAND AND WATER USE

- 3.1.1 - Mandatory Setback Zoning
- 3.1.6 - Subsidized Structure Relocation
- 3.3.1 - Regulation of Consumptive Uses (Management)

TYPE 4 - PUBLIC PROGRAMS TO INDIRECTLY INFLUENCE LAND AND WATER OR THE EFFECTS OF FLUCTUATING LEVELS

- 4.1.7 - Interest Rate Subsidy Loan
- 4.2.9 - Tax Abatement to Cover Increased Operating Costs
- 4.3.1 - Public Information and Education Programs
- 4.3.5 - Real Estate Disclosure

TYPE 5 - EMERGENCY RESPONSE CAPABILITY

- 5.1 Emergency Sandbag and Diking Assistance
- 5.2 Storm Forecasting
- 5.3 Storage of Water in Lake Superior

TYPE 6 - COMBINATION PLANS

- 6.1 Full Regulation of all the Great Lakes by combining Lake Erie Plan 50N (1.2.1) with Placement of a Sill in the St. Clair River (1.4.4, which is the outlet to Lakes Michigan-Huron
- 6.2 Full Regulation of Lake Erie (1.2.1) with Structural Setback Zoning (3.1.1)
- 6.3 Protective Works for Structures (2.1.1-12) and Regulate the Use of Property in Hazard Areas (3.1.1-6)
- 6.4 Structural Setback Zoning (3.1.1) with Public Information and Education Programs (4.3.1)

NOTE: All Type 6 Measures include Type 5 Measures as a Fallback Position in times of Emergency

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TYPE 2 - PUBLIC PROGRAMS TO IMPROVE WATER QUALITY AND WATER OR THE EFFECTS OF POLLUTATING LEVELS

- 4.1.1 - Interim Rate Study Loan
- 4.1.2 - Treatment to Control Polluting Sources
- 4.1.3 - Public Information and Education Programs
- 4.1.4 - Real Estate Disclosure

TYPE 3 - EMERGENCY RESPONSE CAPABILITY

- 3.1 - Emergency Spill and Diving Assistance
- 3.2 - Storm Forecasting
- 3.3 - Storm Warning

TYPE 4 - COMBINATION PLANS

- 4.1 - Full Regulation of all the Great Lakes by the Great Lakes Basin (GLB) with Full Regulation of the St. Clair River (SCR) and Lake St. Clair (LSC) to Lake Michigan-Huron
- 4.2 - Full Regulation of Lake Erie (LE) with Full Regulation of the St. Clair River (SCR) and Lake St. Clair (LSC) to Lake Michigan-Huron
- 4.3 - Protective Works for Structures (2.1.1.1) and

TYPE 5 - DIRECT TREATMENT

- 5.1 - Structural Backup Zoning (3.1.1) with Public Information and Education Programs (4.1.1)
- 5.2 - All Type 5 Measures include Type 3 Measures as a Backup Position in times of Emergency

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