CANADIAN TRANSPORTATION RESEARCH FORUM
LE GROUPE DE RECHERCHES SUR LES TRANSPORTS AU CANADA

PROCEEDINGS OF

SEVENTEENTH ANNUAL MEETING

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Volume 1

MONTREAL, QUEBEC — MAY 26, 27 & 28, 1982

Compiled by: R. Lande
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HOW IS IT THAT THE WELLAND CANAL CONTINUES TO MEET INCREASING TONNAGE DEMAND

Prepared by the
Operational Planning Division
St. Lawrence Seaway Authority

for the

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HOW IS IT THAT THE WELLAND CANAL CONTINUES TO MEET INCREASING TONNAGE DEMAND

Introduction

In May 1981, many Canadian Newspapers carried a headline such as "*Seaway Collapse Forecast*" (The Globe and Mail) and "*Seaway Expansion is Urgent*" (The Citizen). Those headlines were introducing a report by an Ontario Task Force which, in an otherwise balanced presentation of maritime needs in the Great Lakes system, stated: "*It is still unlikely that even all of the improvements (recommended in the report) combined will allow the system to meet the 1985 forecast demand*". The Ontario Task Force conclusion is only the latest of such expressions of concern which appear with remarkable regularity. Indeed, at this 1982 CTRF Convention, four of the papers being submitted under the topic of capacity relate in one way or another to the problems of the Seaway-Great Lakes system.

And yet, there has been no serious congestion for any extended period in more than 15 years, and this is in spite of a sustained growth in tonnage demand. Furthermore, Seaway Authority staff suggest that there are at least ten clear years ahead where the present Welland Canal can provide very acceptable service. Why then do analysts outside the Seaway have such consistent difficulty in making realistic projections? This paper will review the factors which are most important in the projection of future activity and suggest how their misrepresentation in the analysis could easily lead to erroneous conclusions.

General Background To Seaway Capacity Problems

The St. Lawrence Seaway Authority is responsible for providing, operating and maintaining a deep waterway between the Port of Montreal and Lake Erie in conjunction with the Saint Lawrence Seaway Development Corporation in the United States. The St. Lawrence part of the system was build jointly by Canada and the United States of America and was officially opened in June 1959. Together with the international power project at Cornwall/Massena, that system cost $1 billion and remains until this date one of the most ambitious civil engineering project ever realized. The Welland Canal is the fourth canal

FIGURE 1

THE ST. LAWRENCE SEAWAY

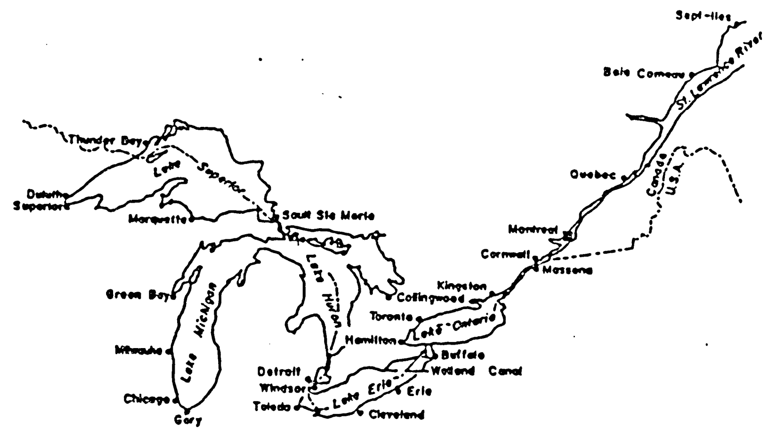
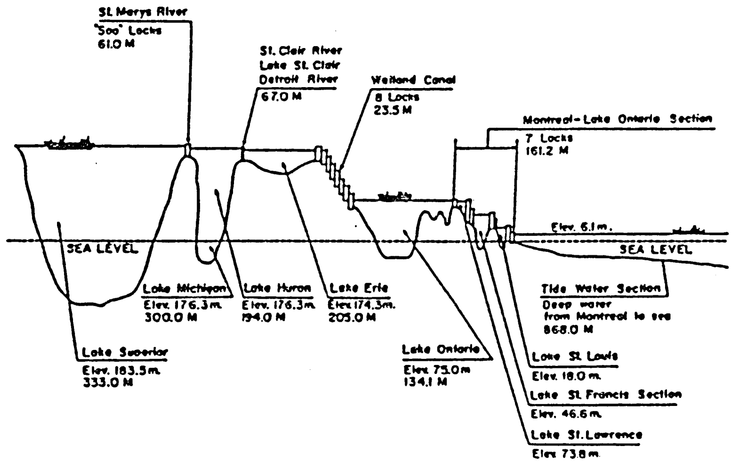


FIGURE 2

THE ST. LAWRENCE SEAWAY

PROFILE VIEW

MILEAGE DULUTH TO ATLANTIC OCEAN-2034 NAUTICAL MILES



built to bypass the mighty Niagara Falls, the first canal being placed in service in 1829.

The Seaway system takes vessels from 6 metres above sea level at Montreal (Figure 2) through seven locks (five Canadian and two American) to Lake Ontario, 75 metres above sea level. The Welland Canal with its eight locks lifts them to Lake Erie at an elevation of 174 metres. All Seaway locks are similar in size and accommodate vessels up to 222.5 metres in length and 23.2 metres in beam.

By going through the St. Clair River and the Detroit River, vessels can continue on to Lake Huron and finally, with the help of the Sault Ste. Marie Locks operated by the U.S. Corps of Engineers, to Lake Superior, 184 metres above sea level.

While travelling the 2034 nautical miles separating the Atlantic Ocean from Duluth, Minnesota, the vessels use 16 waterfed locks, a gigantic nautical staircase leading to the heartland of North America. On the way in, they may bring steel from Europe, iron ore from Labrador or more exotic cargoes from the far away ports of the world.

The efficiency with which the system moves its bulk cargoes challenges the imagination. As many as three 100 car unit trains can be dumped into one laker, to be moved with a fuel efficiency three times better than that of rail and twelve times better than road. The total cargo-distance put together by the domestic users of the Seaway in a 9-month navigation season is larger than that of C.P. Rail and rivals that of C.N. Rail.

Cargo tonnage has been increasing on both sections of the Seaway. On the Montreal-Lake Ontario Section, the tonnage has increased from 18 million tonnes in 1959 to 50.6 million tonnes in 1981, with an all time record of 57.4 million tonnes being carried in 1977. On the Welland Section, cargo tonnage has followed a similar pattern with coal and other Lake Ontario destined traffic accounting for some 9 million tonnes over that on the Montreal-Lake Ontario Section. The Welland carried 58.9 million tonnes in 1981 as compared to a record of 66.2 million tonnes in 1979.

The Welland Canal's eight locks, and several channel restrictions form a series of bottlenecks over its short length of 23 nautical miles. The surge of traffic resulting from the opening of the St. Lawrence section in 1959 brought the Welland its first major capacity test, and a series of modifications followed. In 1964, Welland cargo jumped

several million tonnes over the previous year to reach 52 million tonnes and it was common to have more than twenty vessels waiting at both ends of the canal. Among the delayed cargoes were shipments of Canadian export grain, a commodity which has historically held an high profile in Canadian politics. In addition, many of the vessels waiting days at a time to transit were Canadian owned lakers, which in today's dollars cost in the order of $40 million to build. The Minister of Transport's Ottawa office was swamped with telegrams and a decision to act was quickly forthcoming. The firm of 'Josef Kates and Associates' was engaged to rapidly implement a host of improvements to the canal operation. The program cost $26 million (1965 dollars) and by 1967 service was once again at a reasonable level, even with further increases in demand.

At the same time, the fact that many Seaway cargoes could not move on any other route led to feverish planning for a fifth Welland Canal which would cost $2 billion in today's dollars. This mammoth project would take a minimum of 10 years and huge staff increases to implement and even then the real payoff associated with its larger vessels could not be gained until a similar sum was invested in larger locks for the Montreal to Lake Ontario Section and the inland fleet was rebuilt to the larger dimensions. The $188 million Welland By-pass, a wide straight channel, 13 kilometres in length, which replaced a narrow winding section laced with bridge crossings, was given the green light for a 1973 completion. However, the rest of the new canal project lost its momentum and imminent implementation was no longer spoken of as the 1960's came to an end.

The new canal had been cancelled but as the introduction to this paper noted, prophets of doom have since predicted at regular intervals that the need for a new canal was imminent. Why is it that their analyses have consistently overestimated the Welland capacity problem?

What is Capacity

We should begin with the more basic question - what is capacity? The word 'capacity' is often associated with 'tonnage', but the frequent changes in tonnage patterns make this indicator difficult to work with. Furthermore, it is a vessel that must be moved through the canal and it is a line up of waiting vessels that first evidences a shortage of capacity. Therefore, the most realistic technical expression of capacity is 'annual vessel transits', a number which remains relatively constant from year to year. This understanding was developed through some very detailed and thorough computer simulation work. (The Seaway Authority received special Canadian and International recognition for this work during the 1981 competitions for the application of Operations Research and Management Science.)

The Welland operation has a large number of uncontrollable factors which point to the use of activity simulation as the only viable tool to investigate the behavior of the Welland Canal. Mathematical programming must be rejected because of the magnitude of the problem and queueing theory is not applicable because of the complexity of the problem. For example:

a) each lock must provide service in two directions, but only one direction can be handled at one time;

b) there are eight locks in series, separated by five reaches, and each lock has unique operating characteristics;

c) there are one-way movement restrictions between certain points where reaches are too narrow or have bridges;

d) arrivals at the canal entrances are random; and,

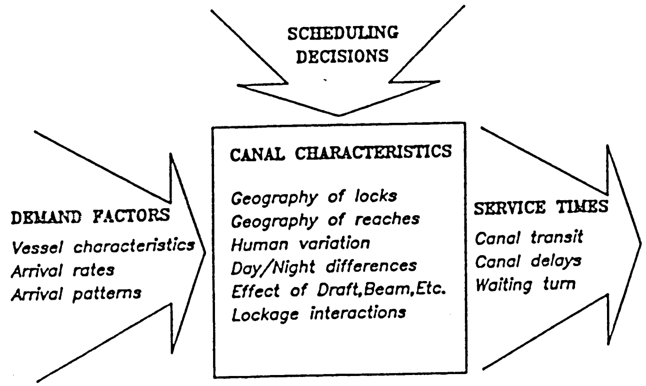
e) the performance characteristics of the arriving vessels vary widely and are not entirely predictable.

Figure 3 schematically illustrates the modular arrangement of the Welland Canal Simulation Model.

Because of a traditional belief that the trend towards larger vessels had a large impact on lockage capacity, the simulation's demand factors were changed so as to test the effect of this on the capacity relationship. The study concluded that, contrary to popular belief, by the mid-1970's there were already enough large vessels going through the canal to consistently slow down the overall traffic under heavy demand conditions, and even an extremely high proportion of large vessels would show little effect on the analysis of capacity. It was therefore decided to use a single, 'typical' lockage mix in the

FIGURE 3

WELLAND CANAL SIMULATION MODEL



development of a capacity curve to tie together demand (average arrivals in lockages/day) and the resulting service times (average transit plus wait time). As indicated in Figure 4, thirty lockages per day was chosen as a practical capacity limit, a limit which reflected the Authority's strong desire to avoid prevalent congestion.

Thirty lockages per day multiplied by the nominal length of the season produces a very theoretical figure from which identifiable losses must be substracted (e.g. adverse weather, season start up). Then by reviewing the past and future fleets and putting their length distributions into a 'tandem' probability model', the number of lockages that would contain more than one vessel can be estimated and annual transit capacity limits calculated. These results are shown in Figure 5. Today's annual commercial capacity then is estimated at 7200 transits. Favourable weather would permit more transits while strikes or major accidents could lower the figure.

As Figure 5 illustrates, without canal modifications transit capacity would remain virtually constant after the mid 1970's. If the demand for transits were to consistently

FIGURE 4

WELLAND CANAL

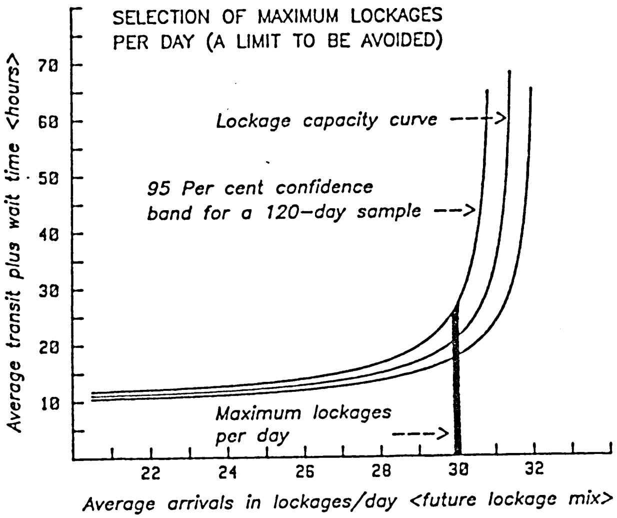
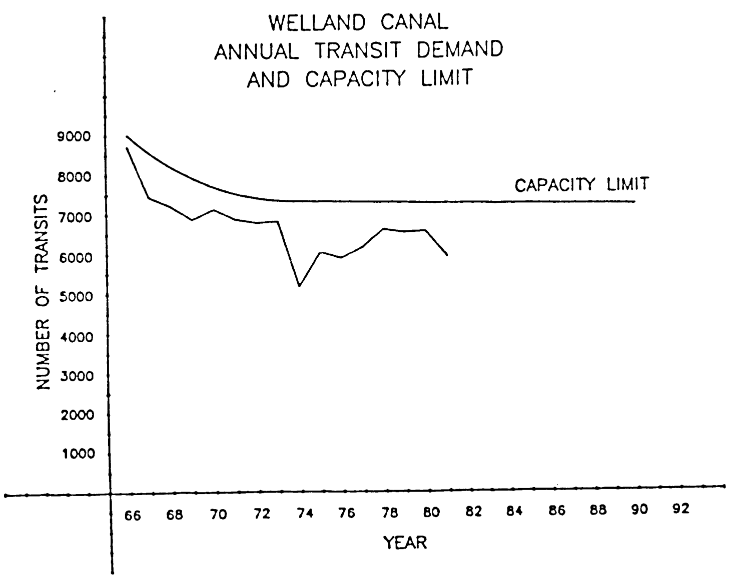


FIGURE 5



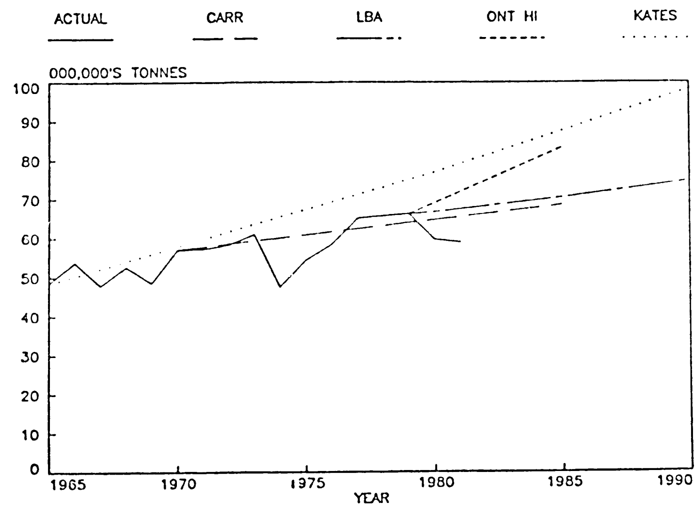
exceed that capacity, the canal would have to be improved, or perhaps a new canal constructed, but as the actual demand on Figure 5 indicates, there has been no recent threat in this regard. Again we ask - why all the dire predictions?

Commodity Forecasts

As indicated in the background section, tonnage has risen dramatically since the opening of the St. Lawrence Section in 1959. Even after the initial surges of traffic which caused the mid-sixties congestion, traffic has continued to grow at a steady sustained rate, rising from 47 million tonnes in 1964 to 66 million tonnes in 1979. And, there is general agreement that the future will see continued growth in the Seaway traffic. The question is how much. In Figure 6, some of the forecasts since the mid-sixties' problems are presented to illustrate the wide variance in such projections. When we compare the actual figures to the predictions, we can see that forecasts for future growth in the Welland can prove to be unduly optimistic.

FIGURE 6

WELLAND CANAL
ANNUAL CARGO DEMAND
FORECAST AND ACTUAL



In some forecasts, one could wonder if the predictions did not reflect more a hope than a factual based analysis. There is always a temptation to expand the forecast by including new waves of cargo. For example, western Canadian shipments of grain have been running into rail capacity problems and a Seaway enthusiast could reason this through to a significant increase in the proportion of Canadian grain that would move through the Seaway route. Similarly, in the case of the very large U.S. exports of agricultural products, a small shift in their overall flow could be translated into a very large impact on the Great Lakes operation. The most recent example of such new cargoes is the movement of American export coal through the Great Lakes system as an alternative to the congested East Coast ports. If such new sources of additional cargo receive too much emphasis in a forecast, there is no doubt that the final numbers will be much too optimistic and of course the resulting conclusion that a new canal is urgently required will inevitably show itself to be in considerable error.

Furthermore, Figure 6 shows only total tonnage and we can discover other important sources of error. One which goes in the direction of producing congestion is the directional split. In the early 70's, planning projections assumed that 65% of the cargo would be downbound. Even at this proportion, a considerable number of the upbound transits would be empty vessels, returning for their next load of downbound cargo. But worse still, the tonnage forecasts produced in the latter 1970's were predicting greater than 70% downbound and the actual data of the year 1980 saw an 80/20 split. For any given number of total projected tonnes, such a shift towards further imbalance requires more transits and therefore increases the challenge to capacity. Looking only at the total tonnage numbers then is like putting one's head in the sand.

Similarly, the total numbers make no commentary on the type of cargo being carried. Analysts may assume, either explicitly or subconsciously, that the same number of tonnes will always be moved in each transit as they visualize how their optimistic future tonnage will be carried. In so doing it is easy to conclude that vessels will be waiting all over the place only a few years down the road. Of course, this is anything but a realistic representation of the problem. For instance, the Seaway has shifted dramatically away

from the ocean vessel/general cargo image that was associated with the building of the St. Lawrence section in the fifties - today, 95% of the Welland cargo is categorized as bulk. This is not a subtle change when we consider that a general cargo ship requiring one capacity transit might carry say 2000 tonnes, whereas the large bulk carrier in the following transit could move through 25000 tonnes.

The most recent example of this ongoing evolution of the nature of business was Canada Steamship Lines' decision to cease their package freight fleet activity. The disappearance of this business will reduce the total cargo in the Welland Canal by say half a million tonnes, 0.8% of total tonnage. At the same time, the Welland can now make available another 120 transits, 1.7% of capacity, to new cargo. If the new cargo was carried in large bulk carriers, it would amount to more than 2 million tonnes. It is not the intention of these comments to suggest whether or not such a shift in the nature of Seaway business is desirable, but rather to indicate that the changes taking place below the surface of total tonnage numbers can introduce rather dramatic errors as the numbers are projected into the future.

By virtue of these shifts in the nature of business then, the average tonnes per transit has been increasing. But as well, within the bulk business itself, there has been a steady introduction of new maximum size vessels so that the average tonnes per loaded transit for the bulk fleet has been steadily improving. In Figure 7, we can see the changes in the numbers of vessels operating at different efficiency levels and it is evident that the introduction of new vessels in the more efficient 'bulk type' categories is an important factor in projecting the operation of the Welland Canal. Although not a major factor in this discussion, it is interesting to note that the apparent fleet efficiency improves when the proportion of downbound cargo increases. This is because the large vessels are able to turn around faster and make more transits in a season.

In Figure 8, the average tonnes per transit is plotted for recent years. In this case, the changes coming from improvements in the efficiency of the fleet cannot be distinguished from the more subtle shifts in the nature of the business. Nevertheless, the two factors are complementary and they combine to produce an encouraging trend.

FIGURE 7

WELLAND CANAL
CHANGE IN FLEET
(LOADED DOWNBOUND VESSELS)

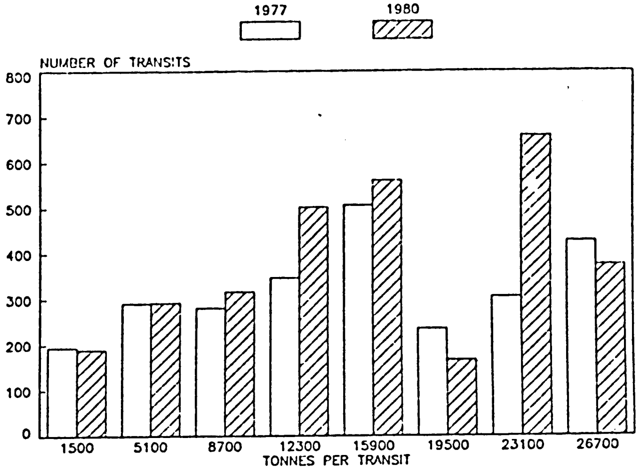
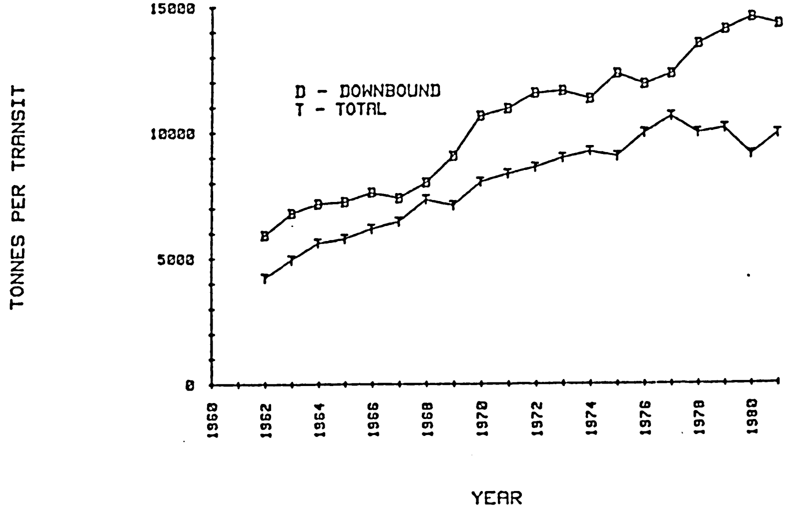


FIGURE 8

WELLAND CANAL FLEET EFFICIENCY



A projection of new cargo without projecting an improvement in the fleet, would most certainly produce a conclusion of very early congestion. For example, if we took the 1980 actual cargo and assumed that it had to be carried on say the 1970 fleet, the Welland would have to provide service to an additional 1540 transits, 23% more than the actual total. Fleet efficiency is deemed to be the most important of the projection factors by the internal Seaway analysts, so important that the shipping companies are consulted annually as to their planned building activity, the trades in which vessels will be employed and their vessel retirements. But in addition, it has been recognized that short term fluctuations in building intentions cannot be applied to long term optimistic tonnage growth trends. Historical experience indicates that if tonnage is to expand at an optimistic rate, then we can assume that the ship operators will also expand their fleets with large, modern vessels at an equivalent rate. Indeed, we can suggest that if shipbuilding is projected at a low rate over the long term, we should question the validity of any optomistic tonnage forecast. In any case, we should be very hesitant to project an optimistic growth rate in future tonnage together with a marginally improved fleet.

So to summarize, there were two main sources of error in the past projections of imminent capacity shortages:

a) overly optimistic projections of total tonnage, often associated with unestablished new trades; and,

b) underestimating improvements in tonnes/loaded transits, whether from the introduction of large vessels or from shifts in the nature of business.

Present Seaway Authority Projections

Having pointed out the pitfalls in other analyses, it is only appropriate to present the Seaway Authority's present view of the future and how it has influenced planning for system improvements.

First of all, we should note that each year, a forecast of cargo tonnage for the coming season is prepared within the authority and since 1975, a long range forecast has also been prepared and updated annually. In addition, the Authority in collaboration with The Saint Lawrence Seaway Development Corporation contracted for a consultant study of commodity demand to the year 2000. This extensive one-year study by a consortium of Canadian and U.S. consultants will be completed by April 1982.

But for planning purposes, it has been determined that financial requirements and system capacity requirements cannot be based on exactly the same scenarios. Therefore, these aspects of planning employ two different forecasts. The financial planning set could be considered the 'low side' of the forecasted averages while capacity planning is associated with the 'high side' of the forecasts.

The long range forecasts employed in capacity planning are shown in the following table.

Welland Traffic Forecasts

(million tonnes)

	1985	1990	1995
Upbound	20.7	23.5	26.1
Downbound	53.9	59.5	65.2
Total	74.6	83.0	91.3

These forecasts are considerably higher than those used to estimate future revenue, in order to ensure that the system capacity plans do in fact result in sufficient capacity being made available - if anything, they err on the high side. Such a steadily increasing tonnage demand would be sufficiently attractive to generate a steady introduction of maximum size vessels (say about three per year on the average). The combined effect would require additional Welland transit capacity around the year 1988 if the canal were left unimproved. Even so, demand surges could always precipitate earlier limited periods of congestion.

In response, the Authority has underway a program of improvements which will on the average add more than 100 transits to the annual Welland capacity in each year of its present 5 year plan. The program involves physical modifications such as widening certain

restricted sections to permit two-way navigation and the provision of additional mooring facilities at key points in the system, as well as the introduction of computer-assisted Traffic Control.

The total cost associated with the improvements in this planning period is in the order of $55 million. Their total effect is expected to increase the annual Welland capacity by 800 transits bringing it to a total of about 8000, and providing sufficient capacity to meet the above forecast of demand for at least the next ten years.

It is worth noting as an aside that this scenario does not foresee any extension of the navigation season. The present navigation season ranges from about April 1 to December 15 on the Montreal-Lake Ontario Section and to December 30 on the Welland Canal. This is an extension of some four weeks on the Montreal-Lake Ontario Section and two weeks on the Welland since the Seaway opened in 1959. An economic study of Canadian benefit and costs for further extensions has indicated that firming up the present 8½-month season is justifiable, but that extending the season to 9½ or 11 months is not at this time. A subsequent 1981 study has reconfirmed the findings regarding a 9½-month season.

Furthermore, any extension of the season would require 24-hour navigation. It is expected that electronic navigation aids would provide the best solution to replacing the floating aids which must be removed under ice conditions and in this respect, a committee has been formed with participation by the Authority, The Saint Lawrence Seaway Development Corporation and the Canadian and American Coast Guards.

Concurrent with the above efforts a one-year study has been initiated to establish the feasibility of a long term plan which would phase-in expenditures through the incremental additions of capacity in the form of twinned larger locks. This option will then be compared to other new lock building schemes, as the need for new facilities becomes more definitive.

Conclusions

The Seaway Authority must be prepared to improve the present Welland Canal as required to ensure acceptable service to future demand; that would include a recommendation to the Federal Government for the implementation of new facilities should it prove necessary.

However, nothing is to be gained by crying wolf. We must recognize that today's Seaway system came into being only in 1959, a relatively short time ago for such major new facilities, and a time of maturation is always required before the originally envisaged potential can begin to manifest itself. Even today, when we could suggest that the system is 'mature', it is by no means static and projections of future activity must reflect the ongoing evolution of business.

If there are other reasons for building new Welland facilities, then let them be heard, but they should not hide behind a spurious analytical process that seriously underestimates the capacity of the present system.