ECONOMIC, ENVIRONMENTAL, AND SOCIETAL IMPACTS OF RESTRICTIONS TO COMMERCIAL NAVIGATION ON THE ST. LAWRENCE SEAWAY

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Analysis Completed by: **Martin Associates**
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Prepared for:

U.S. Saint Lawrence Seaway Development Corporation
Washington, D.C.

Canadian St. Lawrence Seaway Management Corporation
Cornwall, Ontario

Martin Associates of Lancaster, Pa., is a leading provider of economic analysis and consulting services to the maritime industry. Since 1986, the company has developed more than 1,000 economic impact, strategic planning, financial feasibility, and market studies for major ports and waterway systems throughout the United States and Canada, as well as for ports in Europe, Asia, and the Caribbean. Martin Associates' clients include port authorities, marine terminal operators, private investment groups, ocean carriers, and federal, provincial, and state governments, as well as maritime trade organizations.

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I. SUMMARY

BACKGROUND/METHODOLOGY

Martin Associates of Lancaster, Pa., was retained in 2019 by the U.S. Saint Lawrence Seaway Development Corporation (SLSDC) and the Canadian St. Lawrence Seaway Management Corporation (SLSMC) to analyze the economic, environmental, and societal impacts of commercial navigation disruptions.

The need for such an analysis follows historic high water levels in Lake Ontario in 2017 and 2019, and the subsequent consideration by the International Joint Commission (IJC) and the International Lake Ontario St. Lawrence River Board (ILOSLRB) to increase outflows through the St. Lawrence River beyond those safe for commercial navigation to reduce water levels, that would result in short or long-term disruptions to commercial navigation on the binational St. Lawrence Seaway. This study serves as a comprehensive, multifaceted, propriety commercial data-rich analysis, that extrapolates impacts/effects based on dynamic modeling for each port/area, as opposed to a more generic, static study.

This analysis measures the economic, environmental, and societal impacts associated with four specific possible scenarios related to increased Lake Ontario outflows that would disrupt commercial navigation on the St. Lawrence River:

- **Late opening** *(4 weeks later than schedule/plan)*;
- **Early closing** *(4 weeks earlier than schedule/plan)*;
- **Patterning** *("2 days on / 5 days off" for a period of 8 weeks)*; and
- **Extended midseason closure** *(2, 5, and 8-week periods during the summer/fall months)*

For each of these disruption scenarios, Martin Associates measured four sets of impacts:

- **Economic impacts** – Jobs Lost *(direct, induced, indirect)*; Economic Activity Lost; Personal Income Lost *(direct, re-spending/local consumption, indirect)*; Business Revenue Lost; Local Purchases Lost; and Taxes Lost *(state, provincial, local, federal)*
- **Transportation cost penalty** – for grain and steel movements
- **Environmental and social costs for steel diversion to truck** – Safety *(accidents, loss of life, property damage)*; Environmental *(emissions)*; Infrastructure *(highway degradation, noise pollution, highway congestion)*
- **Costs to carriers** – for laker vessels *(U.S. and Canadian domestic)* and salty vessels *(foreign vessels)*

In completing this analysis, Martin Associates used several datasets and models developed for its July 2018 study, "Economic Impacts of Maritime Shipping in the Great Lakes – St. Lawrence Region."[1] These included proprietary models developed for 40 U.S. and Canadian Great Lakes Seaway System ports and interviews with 770 U.S. and Canadian firms with 1,105 operations to develop direct impacts for jobs, income, revenue, local purchases, and terminal operational specifics such as operations by commodity, modal splits, hinterland distribution patterns, and rail/truck rates. These data were analyzed specifically for the disruption scenarios outlined in the scope of work.

The study methodology is based on analysis of a core group of 40 Canadian and U.S. Great Lakes-St. Lawrence River ports:

U.S. Ports (19)		Canadian Ports (21)	
Ashtabula	Lorain	Baie Comeau	Port Cartier
Burns Harbor	Milwaukee	Becancour	Quebec/Levis
Calcite	Monroe	Goderich	Sarnia
Chicago	Muskegon	Hamilton	Sept Iles/Pointe-Noire
Cleveland	Oswego	Havre-Sainte-Pierre	Sorel
Conneaut	Saginaw	Johnstown	Thunder Bay
Detroit	Superior	Meldrum Bay	Toronto
Duluth	Toledo	Montreal/Contrecoeur	Trois Rivieres
Erie	Two Harbors	Nanticoke	Valleyfield
Green Bay		Oshawa	Windsor
		Port Alfred	

Additionally, the Martin Associates study team conducted detailed interviews with more than 25 U.S. and Canadian Seaway stakeholders, including carriers, service providers, port tenants, and companies representing grain, steel, ore, and fertilizer companies, to determine the logistics supply chain characteristics and the potential impacts of the disruption scenarios.

[1] https://greatlakes-seaway.com/wp-content/uploads/2019/10/eco_impact_full.pdf.

Economic impacts were estimated for the following commodities handled at the marine terminals on the Great Lakes Seaway System and St. Lawrence River:

Commodities Included in Analysis	
Cement	Other Liquid Bulk
Coal	Petroleum Products
General cargo/containers	Salt
Grain	Steel Products
Iron Ore	Stone/aggregates
Other Dry Bulk	

GENERAL FINDINGS

Based on the interviews performed for this analysis and the calculated impacts, disruptions to the St. Lawrence Seaway navigation season would have escalating and lasting long-term economic, environmental, and societal harm depending on the disruption scenario.

The most significant impacts include:

- Significant negative disruption to U.S. and Canadian economies and logistics supply chains;
- Long-term economic harm to ports, carriers, pilots, stevedores, importers/exporters, farmers, and U.S. and Canadian consumers;
- Permanent lost market share for certain cargoes;
- Increased rates for cargoes and prices of raw materials;
- Permanent cargo diversion to truck/rail impacting modal capacity and associated increased environmental and societal costs; and
- Irreparable damage to Seaway competitiveness and credibility with customers.

While the St. Lawrence Seaway may be able to accommodate more capacity in the system, the most serious constraints facing the waterway identified in this analysis relate to logistics supply chain elements currently operating at capacity:

- **Grain elevators *(both at export elevators as well as consignee elevators overseas*)** – The export elevators do not have the capacity to hold additional tonnage under an early closing and, as a result, alternative routings will need to be identified. Furthermore, overseas elevators dependent upon a flow of grain from the Great Lakes operate at capacity and cannot handle additional stockpiled tonnage from the Great Lakes.

- **Iron ore storage/inventories** – The steel mills have limited storage capacity to stockpile ore, and they depend on the opening of the Seaway to receive ore to replenish the raw materials that deplete during the winter months.
- **Steel products** – Steel products operate under just-in-time inventories, and customers do not want to incur inventory carrying costs. The ports receiving the steel products do not have adequate covered and open storage to handle stockpiled steel products.
- **Port storage** – Covered and open storage capacity is limited at ports and terminals.
- **Laker fleet** – The Canadian domestic laker fleet is currently operating at capacity and cannot "double up" sailings to accommodate stockpiling of products that would be lost during the limited navigational scenarios.

Because of these capacity limitations, tonnage impacted under each of the scenarios is essentially lost from the system. In some cases, such as with iron ore, alternative routings are not viable due to lack of rail infrastructure at some ports, as well as limited rail car power and car capacity.

SUMMARY RESULTS

Analysis of Economic, Environmental, and Societal Impacts of Restrictions to Seaway Commercial Navigation

(All impact tables and job/economic impacts are non-additive)

Impacts of Late Opening (4 Weeks) (US$ in millions)	
Jobs Lost	5,268
Economic Activity Lost	$554.9
Personal Income Lost	$248.7
Business Revenue Lost	$445.0
Transportation Cost Penalty	$17.4
Environmental/Social Costs	$5.0
Carrier Costs	$9.3

Impacts of Early Closing (4 Weeks) (US$ in millions)	
Jobs Lost	5,520
Economic Activity Lost	$629.2
Personal Income Lost	$244.1
Business Revenue Lost	$522.9
Transportation Cost Penalty	$15.7
Environmental/Social Costs	$2.8
Carrier Costs	$9.3

Impacts of Patterning (8 Weeks) (US$ in millions)	
Jobs Lost	5,816
Economic Activity Lost	$627.1
Personal Income Lost	$274.5
Business Revenue Lost	$504.1
Transportation Cost Penalty	$20.7
Environmental/Social Costs	$5.7
Carrier Costs	$24.7

Impacts of Extended Closure Midseason (2 Weeks) (US$ in millions)	
Jobs Lost	19,227
Economic Activity Lost	$1,594.6
Personal Income Lost	$1,010.8
Business Revenue Lost	$1,115.8
Transportation Cost Penalty	$139.7
Environmental/Social Costs	$45.0
Carrier Costs	$194.0

Impacts of Extended Closure Midseason (5 Weeks) (US$ in millions)	
Jobs Lost	21,046
Economic Activity Lost	$1,848.4
Personal Income Lost	$1,090.6
Business Revenue Lost	$1,335.5
Transportation Cost Penalty	$141.0
Environmental/Social Costs	$45.0
Carrier Costs	$202.8

Impacts of Extended Closure Midseason (8 Weeks) (US$ in millions)	
Jobs Lost	22,144
Economic Activity Lost	$1,995.4
Personal Income Lost	$1,138.7
Business Revenue Lost	$1,461.9
Transportation Cost Penalty	$141.9
Environmental/Social Costs	$45.0
Carrier Costs	$207.5

II. METHODOLOGY

GENERAL

In completing this analysis, Martin Associates used a number of datasets and models developed for its July 2018 study, "Economic Impacts of Maritime Shipping in the Great Lakes – St. Lawrence Region."[2] These included proprietary models developed for 40 U.S. and Canadian Great Lakes Seaway System ports and interviews with 770 U.S. and Canadian firms with 1,105 operations to develop direct impacts for jobs, income, revenue, local purchases, and terminal operational specifics such as operations by commodity, modal splits, hinterland distribution patterns, and rail/truck rates. Martin Associates also obtained and analyzed accurate, comprehensive commercial data for this report.

The study methodology is based on analysis of a core group of 40 Canadian and U.S. Great Lakes-St. Lawrence River ports. These include:

U.S. Ports (19)		Canadian Ports (21)	
Ashtabula	Lorain	Baie Comeau	Port Cartier
Burns Harbor	Milwaukee	Becancour	Quebec/Levis
Calcite	Monroe	Goderich	Sarnia
Chicago	Muskegon	Hamilton	Sept Iles/Pointe-Noire
Cleveland	Oswego	Havre-Sainte-Pierre	Sorel
Conneaut	Saginaw	Johnstown	Thunder Bay
Detroit	Superior	Meldrum Bay	Toronto
Duluth	Toledo	Montreal/Contrecoeur	Trois Rivieres
Erie	Two Harbors	Nanticoke	Valleyfield
Green Bay		Oshawa	Windsor
		Port Alfred	

To measure the impacts of marine cargo moving via individual ports and private terminals not included in the core group of 40 ports, Martin Associates developed prototype economic impact models. These models were used to expand the individual port impacts to a state/provincial level, thus incorporating the cargo tonnage at all marine terminals located within a specific state or province.

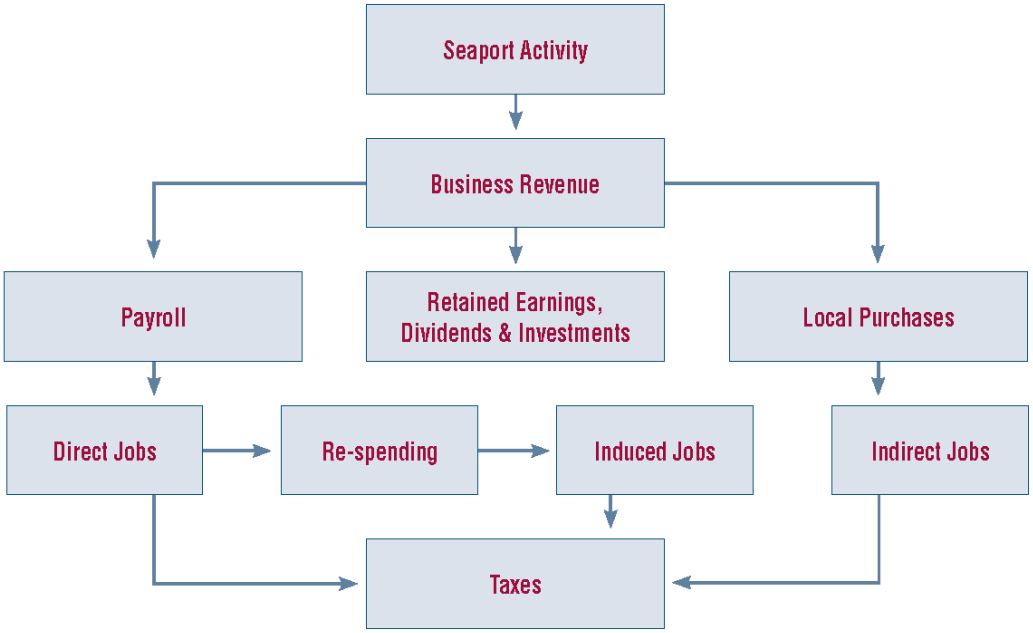
[2] https://greatlakes-seaway.com/wp-content/uploads/2019/10/eco_impact_full.pdf.

Additionally, the Martin Associates study team conducted detailed interviews with more than 25 U.S. and Canadian Seaway stakeholders, including carriers, service providers, port tenants, and companies representing grain, steel, iron ore, and fertilizer companies, to determine the logistics supply chain characteristics and the potential impacts of the disruption scenarios.

FLOW OF ECONOMIC IMPACTS

Waterborne cargo activity at a marine terminal contributes to the local, regional, state/provincial, and national economies by generating business revenue for firms that provide vessel and cargo-handling services at the terminal. These companies, in turn, provide employment and income to individuals, and pay taxes to federal, state/provincial, and local governments. The figure below shows how activity at marine terminals generate impacts throughout the local, regional, state/provincial, and national economies.

Flow of Economic Impacts Generated by Marine Activity



As this figure illustrates, the economic impact of a port cannot be reduced to a single number, as the port activity creates several impacts — the revenue impact, employment impact, personal income impact, and tax impact.

These impacts are non-additive. For example, the income impact is part of the revenue impact, thus, adding these impacts together would result in double-counting.

The analysis also provides a total economic activity value, which is explained later in this section.

CATEGORIES OF IMPACT

Martin Associates analyzed the following economic, environmental, and societal impact areas for each disruption scenario.:

Employment Impacts

Employment is measured in terms of full-time equivalent jobs, as defined by 2,080 hours per year per full-time worker. The employment impact of the port activity consists of three levels of job impacts:

- Direct employment impact — jobs directly generated by seaport activity. Direct jobs generated by marine cargo include jobs with railroads and trucking companies moving cargo between inland origins and destinations, and the marine terminals, as well as the jobs of longshoremen, dockworkers, steamship agents, freight forwarders, stevedores, and others. It should be noted that jobs classified as "directly generated" are those that would experience near-term dislocation if the activity at the marine terminals was discontinued.

- Induced employment impact — jobs created throughout the local, regional, and national economies because individuals directly employed by port activity spend their wages locally on goods and services such as food, housing, and clothing. These jobs are held by residents located throughout the region, since they are estimated based on local and regional purchases.

- Indirect employment impact — jobs created within the region due to purchases of goods and services by firms, not individuals. These jobs are estimated directly from local purchases data supplied by the companies interviewed as part of this study. They include jobs with office supply firms, maintenance and repair firms, parts and equipment suppliers, and others.

Economic Activity Impacts

The total economic activity value calculated in this report consists of 1) the direct business revenue received by the businesses supplying the cargo and vessel handling services, and 2) the re-spending of direct income and consumption expenditures. These two monetary measures of economic impact are additive, since the re-spending impact is in addition to the direct income impact, and the business revenue is independent of other dollar value impacts.

By contrast, direct personal income, business purchases, and taxes are paid from business revenue, and to include these in the total economic impact measure would result in double counting.

Personal Income Impacts

The personal earnings impact is the measure of the employee wages and salaries (excluding benefits) received by individuals directly employed due to port activity. Re-spending of these earnings on goods and services throughout the regional economy is also estimated using a state or provincial personal earnings multiplier, which reflects the percentage of purchases by individuals that are made within the state/province where the port is located. This re-spending generates additional jobs, also known as the "induced" employment impact.

The re-spending effect varies by region. The effect is larger in regions that produce a relatively large proportion of the goods and services consumed by residents, while lower re-spending effects are associated with regions that import a relatively large share of consumer goods and services (since personal earnings "leak out" of the region for these out-of-region purchases).

Business Revenue Impacts

Port activity generates business revenue for firms that provide services. This business revenue is dispersed throughout the economy in several ways; it is used to hire people, purchase goods and services, and pay federal, state, and local taxes.

The remainder may be used to pay stockholders, retire debt, or make investments, or may be held as retained earnings. Note that the only components of the revenue impact that can definitely be identified as remaining in the local economy are those portions dispersed in the following ways: salaries to local employees; local purchases by individuals and businesses directly dependent on the seaport; contributions to federal, state/provincial and local taxes; tenant lease payments to the port authorities; and wharfage and dockage fees paid by the steamship lines to the individual port authorities.

Tax Impacts

Tax impacts are tax payments to federal, state/provincial and local governments by firms and by individuals whose jobs are directly dependent upon and supported (induced and indirect jobs) by activity at the marine terminals.

Transportation Cost Penalty Impacts

The transportation cost penalties are calculated on steel movements that must use coastal ports and surface transportation modes due to the Seaway disruption scenarios.

Environmental/Social Cost Impacts

The environmental/social costs result from steel diversion to the trucking mode due to the disruptions to maritime commercial navigation on the Seaway. These include safety costs (accidents, loss of life, property damage), environmental costs (emissions), and infrastructure costs (highway degradation, noise pollution, highway congestion).

The environmental/social cost impacts for grain diverted to other modes, particularly rail or inland water barge, are not included in this analysis because of the uncertainty to defensibly identify which alternative ports would be used or if the diverted grain would be sold domestically. Therefore, the environmental/social costs in this analysis are understated to some extend without the grain diversion impacts.

Carrier Cost Impacts

These costs include the need for laker vessel operators to cover the cost of the lost round-trip voyages under each scenario as well as the need for salty vessel operators to trade at an opportunity cost in non-Seaway trades, which is based on the reduced value that can be secured when competing against larger vessels with lower operation costs per ton.

SUMMARY OF METHODOLOGY

Data Collection

The cornerstone of Martin Associates' approach is the collection of detailed baseline impact data from firms providing services at the ports and terminals. To ensure accuracy and defensibility, the baseline impact data for the economic analysis were collected from interviews with 770 firms that provide services on the Great Lakes and St. Lawrence River.

In most cases, multiple interviews were conducted with several persons in each firm. The baseline survey data collected from the 770 firms was used to develop operational impact models for each of the 40 ports. This data was also used to develop models to expand the impact calculations beyond the 40 ports and therefore, to estimate state-wide/province-wide impacts.

The Martin Associates study team also conducted detailed interviews with more than 25 U.S. and Canadian Seaway stakeholders, including ports, carriers, service providers, port tenants, and companies representing grain, steel, ore, and fertilizer companies, specifically for this analysis to determine the logistics supply chain characteristics and the impacts of the disruption scenarios.

Additionally, Martin Associates was granted access to confidential/proprietary data, vessel transit logs, and daily pilot assignments/capacity data for the Seaway's Canadian St. Lambert Lock.

Direct Jobs, Personal Income, Business Revenue, and Tax Impacts

The results of these interviews were then used to develop the baseline direct job, revenue, and income impacts for the business sectors and job categories associated with the cargo activity at the marine terminals in the 40 individual port districts for which specific impact models were developed.

Total state and local tax impacts generated by the cargo activity on the St. Lawrence Seaway were estimated from several sources. The U.S. tax impacts were estimated from income indices developed by the Tax Foundation and the U.S. Census Bureau, "State and Local Government Finances," while the Canadian tax impacts were estimated based on data provided to Martin Associates by Revenue Canada. In addition, adjustments were made to reflect the different tax relationships in Quebec at the federal level.

Induced Impacts

Induced impacts are those generated by the purchases of individuals directly employed as a result of port and terminal activity. A portion of the personal earnings received by those directly employed due to activity at the marine terminals is used for purchases of goods and services, both regionally and out-of-region. These purchases, in turn, create additional jobs in the region; these jobs are classified as "induced."

To estimate these induced jobs for the 19 U.S. Great Lakes ports, the study team developed a personal-earnings multiplier for each state with at least one port, using data from the U.S. Bureau of Economic Analysis, Regional Income Division. This personal-earnings multiplier was used to estimate the total personal earnings generated in the state as a result of the activity at the specific Great Lakes port(s) within that state. A portion of this total personal-earnings impact was then allocated to specific local purchases (as determined from consumption data for the relevant state residents), as developed from the U.S. Bureau of Labor Statistics, Consumer Expenditure Survey. These purchases were converted into retail and wholesale induced jobs in the state economy — by combining the purchases with the jobs-to-sales ratios in the supplying industries. A portion of the retail purchases was allocated to wholesale purchases, based on industry-specific data developed from the U.S. Census Bureau. These wholesale purchases were combined with the relevant jobs-to-sales ratios for the wholesale industries associated with the local purchases. These ratios were developed at the state level in which the specific port was located.

To estimate the induced impacts associated with the cargo moving via the 21 Canadian ports, personal-income multipliers for the waterborne transportation sector in Ontario and Quebec were developed by Statistics Canada, Industry Accounts Division, and provided to Martin Associates. Martin Associates developed the distribution of purchases by type of purchase (food at home, food in restaurants, housing, apparel, home furnishings, transportation, medical care, etc.) for each province, using data provided by Statistics Canada. The associated supplying industry jobs-to-sales ratios on a provincial level were also supplied to Martin Associates by Statistics Canada (Provincial Input-Output Models).

These ratios included the retail and wholesale re-spending impacts. The personal consumption expenditures from the port activity were then combined with these job multipliers to estimate the "consumption" induced impacts by the province in which each of the 21 Canadian ports are located.

To estimate the "non-consumption" induced impacts with such sectors as state/provincial governments, education, and other social services, a ratio of state/provincial employment in these key service industries to total state/provincial employment was developed. This ratio was then multiplied by the direct and consumption induced jobs to estimate the total direct and induced job impact.

The re-spending impact includes not only the wage and salary income received by people employed to provide goods and services to the direct job holders, but also the value of the purchases. Therefore, the re-spending/local consumption impact cannot be divided by the induced jobs to estimate the induced income — as this would overestimate the induced personal wage/salary impact per induced job.

A separate induced impacts model was developed for each of the 40 ports, as well as the statewide and province-wide impact models that capture the impacts of cargo and vessel activity and marine terminals not located within one of the 40 specific port districts.

Indirect Jobs

Indirect jobs are generated in the local economy as the result of purchases by companies that are directly dependent upon cargo and vessel activity at ports and marine terminals, including shippers/consignees.

These purchases are for goods such as office supplies and equipment, as well as for services including maintenance and repair, communications and utilities, transportation and professional services. To estimate the indirect economic impact, data on local purchases — by type of purchase — were collected from each of the firms interviewed. These local purchases were then combined with employment-to-sales ratios in local supplying industries, developed from the U.S. Bureau of Economic Analysis, Regional Input-Output Modeling System (RIMS II) for the U.S. ports and from Statistics Canada, Industry Accounts Division, for Canadian ports. The indirect job ratios also account for the in-state/in-province spin-off effects from multiple rounds of supply chains that are required to provide the purchased goods and services. Indirect income, local purchases and taxes are also estimated. A separate indirect impacts model was developed for each of the 40 ports, as well as for the province-wide and state-wide models.

Transportation Cost Impacts

For steel shipments, the destinations of imports via each Great Lakes/Seaway port was provided by importers. The volume of the steel imports was calculated under each disruption scenario by port and allocated by import destination. Mileage differentials were calculated between serving each inland destination via relevant Great Lakes/Seaway port and a coastal port (Camden, N.J., for U.S. imports and Montreal, Que., for Canadian imports). Those mileage differentials were then converted into cost differentials. The ocean voyage costs were estimated from Martin Associates' Voyage Costing Model and verified with carriers for both the Great Lakes/Seaway and coastal routes. The total logistics cost differentials were calculated for steel diverted under each scenario by Great Lakes/Seaway port and inland steel destinations.

For grain shipments, the origins of grain exports for each Great Lakes port were identified from interviews with the grain traders, elevator operators, and port officials. The destinations of grain exports by port were identified from internal trade databases. The next least-cost routing was identified for grain exports from each Great Lakes port for rail, truck, and barge. The ocean voyage costs were calculated using Martin Associates' Voyage Costing Model for coastal port and overseas port pairings. The logistics cost of using each Great Lakes port, weighted by overseas destination, was then computed. Logistics cost differentials were then applied to the grain loss at each Great Lakes port under each scenario.

Environmental and Societal Cost Impacts

The metrics used to measure external social and environmental costs *(see figures on page 14)* were derived from the U.S. Department of Transportation's (USDOT) Benefit-Cost Analysis for Discretionary Grant Applications, June 2018.[3] These metrics relate to safety, environment, and infrastructure and measure the increased use of surface transportation (truck) to move diverted steel cargoes due to commercial navigation disruption for each of the scenarios.

Steel tonnage lost was calculated and converted into truck trips. Vehicle miles traveled (VMT) by Great Lakes ports and inland destinations were calculated by multiplying truck trips by additional mileage incurred to move the steel via a coastal port to the import destinations. Finally, the additional vehicle miles traveled, due to a loss of the steel traffic to a coastal port, were combined with social and environmental metrics and monetized costs, as developed by the USDOT, and adjusted for 2019 current pricing.

It is worth noting that the environmental costs in this analysis do not include the savings of environmental emissions generated by discontinuing water transportation on the Seaway. However, the magnitude of cost savings with the elimination of water movements pales in comparison to the additional environmental costs by moving diverted cargo by truck. For example, truck transportation generates 13 times more carbon dioxide pollutant per ton mile than does water transportation.

[3] https://www.transportation.gov/sites/dot.gov/files/docs/mission/office-policy/transportation-policy/284031/benefit-cost-analysis-guidance-2018.pdf.

Societal and Environmental Costs due to Steel Diversion to Coastal Ports

Safety Impacts

	Accident Probability/100 Million VMT	Value Per Accident (2019$)
Fatal Accident Cost (K)	1.13369	$10,173,564
Severe Injury Accident Cost (A)	78.92426	$217,778
PDO Accident Cost (No Injury)	203.40039	$3,391

Environmental Impacts

Emissions	Tons Emitted Per Million VMT
Nitrogen Oxides (Nox)	3.0193
Volatile Organic Compounds (VOC)	0.11
Fine Particle (PM)	0.1191
Sulfur Dioxide (SO2)	0.0055
Carbon Dioxide	229.8

Cost Metrics	Cost/Short Ton Emitted
Nitrogen Oxides (Nox)	$7,817.75
Volatile Organic Compounds (VOC)	$1,983.84
Fine Particle (PM)	$357,620.90
Sulfur Dioxide (SO2)	$46,204.94

Infrastructure Impacts

Combination Truck (4-Axle)	Cost/VMT
Congestion	$0.4807
Noise	$0.0236
Pavement (Urban Interstate)	$0.2665

Carrier Cost Impacts

For salty vessel carriers, cost impacts are calculated based on opportunity cost per vessel multiplied by the number of voyages per ship lost multiplied by the number of salties impacted under each disruption scenario. For laker vessel carriers, cost impacts are calculated based on the average annual operating and amortized capital costs per voyage multiplied by the number of voyages per ship lost multiplied by the number of lakers impacted under each disruption scenario.

COMMODITIES INCLUDED IN THE ANALYSIS

Economic impacts were estimated for the following commodities handled at the marine terminals on the Great Lakes-St. Lawrence Seaway:

Commodities Included in the Analysis	
Cement	Other Liquid Bulk
Coal	Petroleum Products
General Cargo/Containers	Salt
Grain	Steel Products
Iron Ore	Stone/Aggregates
Other Dry Bulk	

Impacts on economic activity outside of the listed commodity groups are categorized as "Not Allocated." This category includes employers such as the Canadian St. Lawrence Seaway Management Corporation and the U.S. Saint Lawrence Seaway Development Corporation, U.S. Customs and Border Protection, Canadian and U.S. Coast Guards, U.S. Army Corps of Engineers assigned to the Great Lakes Districts, ship repair and boatbuilding, and portions of marine construction activity, to name a few.

DEVELOPMENT OF TONNAGE IMPACTS

In order to determine the tonnage impacts under each of the disruption scenarios, Martin Associates used the following calculations and assumptions based on available data and/or historic averages and stakeholder interview results:

CALCULATIONS	
Average number of days per salty (foreign) vessel roundtrip:	65-70 days per roundtrip
Average number of days per laker (domestic) vessel roundtrip moving between the Great Lakes and the St. Lawrence River:	18 days per roundtrip
Estimated days added to each roundtrip voyage:	Differs for lakers and salties Maximum pilotage capacity per 24-hour period is 8 in each sector of pilotage dispatch along the system On average, 3 vessels requiring pilot assistance arrive at St. Lambert Lock daily in each direction
The number of voyages lost per laker and per salty in estimated based on 285-day navigation season:	65-day roundtrip for a salty; 20,000 metric tons each direction // 190 actual salty vessel equivalents per year (based on actual voyages per year divided by 4 roundtrips per year per salty) 18-day roundtrip for a laker; 28,500 metric tons each direction // 40 unique laker vessel equivalents per year (based on actual laker voyages per year divided by 16 roundtrips per year per laker)

ASSUMPTIONS	
Assumptions for late opening scenario:	Impact strong in early part of the navigation season for steel, iron ore, and fertilizer as inventories need to be replaced Based on 4.3 million metric tons handled (once for salties; twice for lakers) in March/April

ASSUMPTIONS	
Assumptions for early closing scenario:	Assumes all December tonnage for lakers and salties will be lost due to inventory capacity constraints for advanced loadings in earlier months Grain is key due to timing of harvest Steel importers operate under just-in-time service and port and vessel capacities limit advanced loadings Iron ore storage constraints at terminals and facilities limit advanced loadings
Assumptions for patterning scenario for laker vessels:	In most cases, lakers do not require pilotage so shutdown adds 2 days for the shutdown and 1 day for operational consideration – total of 6 days per laker during the 8-week period Reduces each vessel transiting during the 8-week period by 4 roundtrip voyages (from about 15 per year to about 11 per year) Tonnage lost estimated at 1.6 million metric tons
Assumptions for patterning scenario for salty vessels:	3 salties arrive per day; for a 2-day closure, there would be a backlog of 6 ships when reopened 1-day equivalent is required at either end of the closure for operational considerations 4 vessels are cleared each day after opening (assuming 3 arrivals each direction and 4 clearances per 24-hour period per direction) Assumes unlimited anchorages are available and unaffected in the St. Lawrence River by increased flows Does not account for slow steaming costs On average, each vessel adds 9-10 days each direction Reduces each vessel transit during the 8-week patterning period by one voyage per year Tonnage lost estimated at 1.7 million metric tons

ASSUMPTIONS	
Assumptions for extended midseason closure scenario for salty vessels:	To clear 42 salty vessels, with an arrival of 3 vessels requiring pilots per day per direction, and 4 pilot clearances per day per direction, the average delay time for a two-week extended midseason closure could reach 200+ days for a roundtrip salty, thereby eliminating all salty traffic This effect is the same for the other midseason closure scenarios (5 and 8 weeks) All salty tonnage leaves the system
Assumptions for extended midseason closure scenario for laker vessels:	2 Weeks: 2 roundtrip equivalent laker voyages lost per year per laker transiting during the two-week period; 0.5 million metric tons lost 5 Weeks: 3.2 roundtrip equivalent laker voyages lost per year per laker transiting during the five-week period; 1.4 million metric tons lost 8 Weeks: 4.3 roundtrip equivalent laker voyages lost per year per laker transiting during the eight-week period; 2 million metric tons lost
Additional assumptions:	For laker tonnage displaced, the load and discharge volumes are identified from the proprietary database; therefore, laker tonnage is estimated at the loading and discharge ports The commodity-specific tonnage lost under each disruption scenario is used as inputs into the port-specific models and state and province wide models (where the cargo moves to and from ports for which specific models were not developed) to estimate the lost economic impacts

Calculation of Systemwide Economic Impacts

The tonnage lost at each port – by commodity, direction, and ship type (salty vs. laker) – was entered into each port-specific model to calculate the lost economic impact. Similarly, the tonnage handled at ports other than the 40 specific ports was grouped by state and province and used in the other state and province models to develop a comprehensive measure of the economic impact on the binational economies. This lost tonnage at terminals not included in the 40 specific port models was less than 10 percent of total tonnage impacted under each scenario.

Using the 40 port-specific models, and the state and provincial models, the economic impacts at the level of the 40 port districts and the "other state and provincial ports" were then combined to estimate total impacts, by country and in total.

For the purpose of determining economic impacts, the report uses a tonnage handled figure. "Handled" refers both to the shipping (export) of the cargo from a system port, and to the receipt (import) of that cargo in a system port. Because each cargo touchpoint creates economic activity, for the purposes of this study, cargo moved between ports within the region has been handled twice. By contrast, cargo moved between the region's ports and overseas ports has been handled once (in the region).

Total figures on all tables and charts may not add due to rounding. Additionally, all impact tables and job/economic impacts are non-additive.

III. GENERAL FINDINGS

IMPACTS OF DISRUPTING SEAWAY COMMERCIAL NAVIGATION

Based on the interviews performed for this analysis and the calculated impacts, disruptions to the St. Lawrence Seaway navigation season would have escalating and lasting long-term economic, environmental (modal shift), and societal harm depending on the disruption, including:

- Significant negative disruption to U.S. and Canadian economies and logistics supply chains;
- Long-term economic harm to ports, longshore labor, carriers, pilots, stevedores, importers/exporters, farmers, and U.S. and Canadian consumers;
- Increased rates for cargoes and prices of raw materials;
- Permanent lost market share for certain cargoes;
- Permanent cargo diversion to truck/rail impacting modal capacity and associated environmental and societal costs; and
- Irreparable damage to Seaway competitiveness and credibility with customers.

One of the most serious constraints facing the Seaway identified in this analysis is that most logistics supply chain elements supporting Great Lakes/Seaway cargo movements are currently operating at capacity. As such, they cannot easily absorb fluctuations of commodities in the event of disruptions to the Seaway schedule.

- **Grain elevators *(both at export elevators as well as consignee elevators overseas*)** – Because grain is a perishable commodity, export elevators typically cannot hold additional tonnage. As a result, shippers would need to identify alternative routings for the grain, such as the use of coastal ports in British Columbia and Louisiana, or St. Lawrence River ports, outside of the St. Lawrence Seaway, where the grain would be railed to the elevators in the River that would otherwise have been moved by laker vessel shipments. Additionally, grain exports typically move under contract with specified delivery times. If those delivery dates are not met, the sales are void and the transaction does not occur. Furthermore, overseas elevators already operate at capacity and cannot handle additional stockpiled tonnage from the Great Lakes. Hence, these importers will turn to alternative sources.
- **Iron ore storage/inventories** – With limited storage capacity to stockpile ore, steel mills depend on the Seaway's opening to replenish their depleted raw materials after the winter months. Without regular and predictable access to iron ore, steel mills may need to shut down their blast furnaces – the impact of which would be extremely expensive and disruptive to production scheduling.

- **Steel products** – Steel products operate under just-in-time inventories, and customers do not want to incur inventory carrying costs. Furthermore, the ports receiving the steel products do not have adequate covered and open storage to handle stockpiled steel products.
- **Port storage *(covered and open storage)***
- **Laker fleet** – The Canadian domestic laker fleet is currently operating at capacity, and cannot "double up" sailings to accommodate stockpiling of products that would be lost during the limited navigational scenarios.
- **International ("Salty") fleet**– The dimensions of the St. Lawrence Seaway locks in terms of width, length, and depth limit the type and size of vessels that can transit the St. Lawrence Seaway. There are a limited number of foreign flag vessels that can operate on the Seaway and, as a result, an inflow of new vessels to handle increased loads for stockpiling is not realistic.

Because of these capacity limitations, tonnage impacted under each of the scenarios is essentially lost from the system. In some cases, as with ore, alternative routings are not viable due to lack of rail infrastructure at some ports, as well as limited rail car power and car capacity.

Key findings from interviews with U.S. and Canadian Seaway stakeholders to determine the logistics supply chain characteristics and the impacts of the disruption scenarios:

Steel (Importers)

- Imports move under just-in-time inventory
- Customers do not want to take early possession
- Storage capacity is limited at ports for stockpiling
- Coastal ports are used when season is closed, logistics patterns already in place
- Beginning of season is important to satisfy just-in-time demand by customers as steel can now be moved at a lower cost through the Seaway compared to use of coastal ports

Steel (Mills)

- No extra capacity to handle additional tonnage for stockpiling ore
- Inventory system is set to prevent shutdown of furnaces
- Early season is important to re-stock after winter closure

Grain

- Elevators operate at capacity and cannot store additional grain
- Harvest season cannot be controlled to coordinate with early closing, and not enough capacity to store over winter
- Contracts made in advance for specific delivery dates, and these would be in jeopardy and likely not renewed
- Overseas customers have a rigid inventory supply chain
    - Plan for enough capacity to supply their customers with milled product during winter, but require that supply be refilled at beginning of season
    - Cannot stockpile additional grain on a monthly basis, due to capacity constraints in Europe
    - Likely to move to other supply sources; loss of market share to Canadian/U.S. grain exporters

Fertilizer

- Receipt of fertilizer is critical at opening of season, since limited window when can be used on crops
- Purchase contracts made in advance, and often made in October and November when fertilizer prices are lower
- No storage capacity at ports for stockpiling

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CASE STUDY: Long-Term Impacts of 10-Day Disruption at U.S. West Coast Ports in 2002

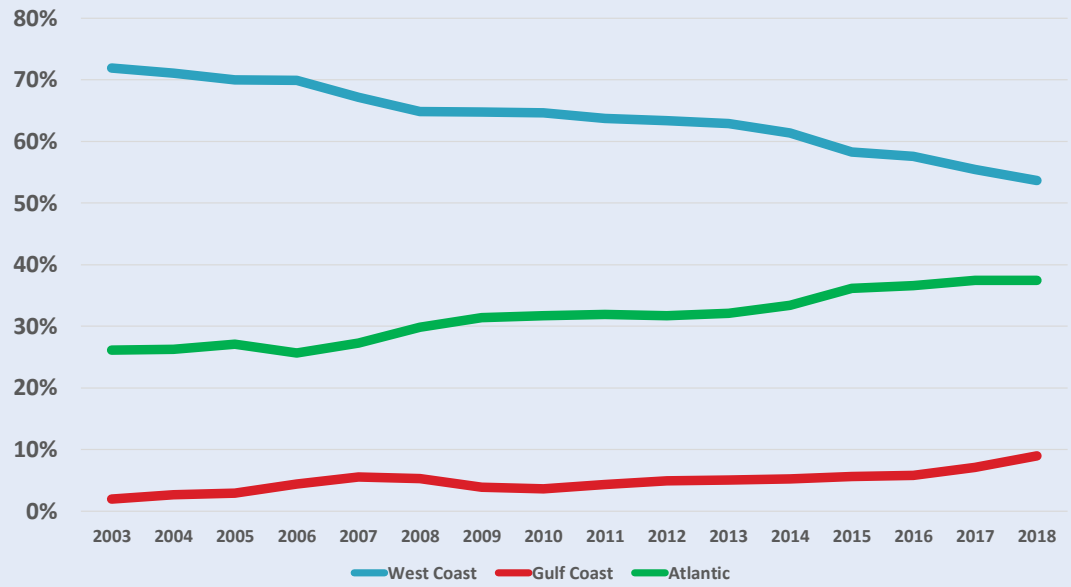
The continuous loss of market share that U.S. West Coast ports have experienced since the 11-day West Coast port lockout in September 2002 at the Ports of Los Angeles/Long Beach, Oakland, and Seattle/Tacoma, is an empirical example of how a single short-term disruption of a logistics supply chain can result in a major long-term impact on the use of the system by importers and exporters.

Between September 29 and October 9, 2002, operations at the West Coast ports stopped due to a lockout imposed by the employees of the International Longshore and Warehouse Union in response to labor slowdowns. The disruption of port operations had an immediate effect not only on the port industry and its employees, but also on the exporters and importers as well as the entire transportation infrastructure and supply chain of the United States.

In response to the 2002 port closure, importers and exporters diverted much of their Asian cargoes to East Coast and Gulf Coast ports, seeking a more stable shipping environment. Many of these alternative logistics supply chains remain in place today, and the West Coast ports have suffered an ongoing loss of market share, particularly with respect to the Asian import container market.

As shown in the chart below, the share of Asian imported containerized tonnage moving via the West Coast ports has fallen from 72 percent in 2003 to 54 percent in 2018, while the share of the Atlantic and Gulf ports has grown from 28 percent in 2003 to 46 percent in 2018.

Share of Asian Imported Containerized Cargo by Port Range



Source: USA Trade OnLine

In short, even a brief dislocation of the logistics supply chain can translate to uncertainty for importers and exporters, leading them to seek alternative routings and threatening the long-term viability of the impacted supply chain.

IV. IMPACT ASSESSMENT

The tables included in this section address the economic, environmental, and societal impacts of each disruption scenario (late opening, early closing, patterning, and extended midseason closure).

The first table on each page examines the economic impacts by each country (U.S. and Canada) and by economic metric (jobs, economic activity, personal income, business revenue, local purchases, and taxes).

The second table on each page provides the measurable results for transportation cost penalties, the environmental and social costs of steel diversion to truck, and the cost to carriers.

All dollar amounts shown are in U.S. dollars. Total figures on all tables and charts may not add due to rounding. Additionally, all impact tables and job/economic impacts are non-additive.

LATE OPENING (4 WEEKS)

IMPACTS	CANADA	UNITED STATES	TOTAL
JOBS LOST			
• Direct	1,319	459	1,778
• Induced	1,615	368	1,983
• Indirect	933	574	1,507
JOBS LOST TOTAL	**3,867**	**1,400**	**5,268**
ECONOMIC ACTIVITY LOST (US$)	**$414,846,000**	**$140,032,000**	**$554,879,000**
PERSONAL INCOME LOST (US$)			
• Direct	$51,481,000	$21,039,000	$72,519,000
• Re-Spending/Local Consumption	$66,951,000	$42,906,000	$109,857,000
• Indirect	$39,866,000	$26,499,000	$66,365,000
PERSONAL INCOME LOST TOTAL	**$158,297,000**	**$90,444,000**	**$248,741,000**
BUSINESS REVENUE LOST (US$)	**$347,895,000**	**$97,126,000**	**$445,022,000**
LOCAL PURCHASES LOST (US$)	**$100,651,000**	**$55,602,000**	**$156,253,000**
STATE/PROVINCIAL/LOCAL TAXES LOST (US$)	**$35,016,000**	**$10,054,000**	**$45,069,000**
FEDERAL TAXES LOST (US$)	**$49,124,000**	**$24,627,000**	**$73,751,000**

TRANSPORTATION COST PENALTY, ENVIRONMENTAL/SOCIAL COSTS, AND COSTS TO CARRIERS – LATE OPENING (4 WEEKS)	
GRAIN AND STEEL TRANSPORTATION COST PENALTY (US$)	**$17,378,916**
ENVIRONMENTAL/SOCIAL COSTS OF STEEL DIVERSION TO TRUCK (US$)	
• Safety (accidents, loss of life, property damage)	$671,036
• Environmental (emissions)	$365,996
• Infrastructure (highway degradation, noise pollution, highway congestion)	$3,988,474
ENVIRONMENTAL/SOCIAL COST OF STEEL DIVERSION TO TRUCK TOTAL	**$5,025,506**
COSTS TO CARRIERS (US$)	
• Lakers	$4,032,000
• Salties	$5,250,000
COSTS TO CARRIERS TOTAL	**$9,282,000**

EARLY CLOSING (4 WEEKS)

IMPACTS	CANADA	UNITED STATES	TOTAL
JOBS LOST			
• Direct	1,640	261	1,901
• Induced	1,987	219	2,206
• Indirect	1,149	265	1,414
JOBS LOST TOTAL	**4,775**	**745**	**5,520**
ECONOMIC ACTIVITY LOST (US$)	**$548,029,000**	**$81,187,000**	**$629,216,000**
PERSONAL INCOME LOST (US$)			
• Direct	$63,813,000	$12,749,000	$76,563,000
• Re-Spending/Local Consumption	$80,522,000	$25,828,000	$106,350,000
• Indirect	$49,056,000	$12,171,000	$61,227,000
PERSONAL INCOME LOST TOTAL	**$193,392,000**	**$50,748,000**	**$244,140,000**
BUSINESS REVENUE LOST (US$)	**$467,507,000**	**$55,359,000**	**$522,866,000**
LOCAL PURCHASES LOST (US$)	**$123,800,000**	**$26,892,000**	**$150,692,000**
STATE/PROVINCIAL/LOCAL TAXES LOST (US$)	**$44,394,000**	**$5,610,000**	**$50,004,000**
FEDERAL TAXES LOST (US$)	**$61,374,000**	**$13,868,000**	**$75,242,000**

TRANSPORTATION COST PENALTY, ENVIRONMENTAL/SOCIAL COSTS, AND COSTS TO CARRIERS – EARLY CLOSING (4 WEEKS)	
GRAIN AND STEEL TRANSPORTATION COST PENALTY (US$)	**$15,732,766**
ENVIRONMENTAL/SOCIAL COSTS OF STEEL DIVERSION TO TRUCK (US$)	
• Safety (accidents, loss of life, property damage)	$370,863
• Environmental (emissions)	$202,276
• Infrastructure (highway degradation, noise pollution, highway congestion)	$2,204,321
ENVIRONMENTAL/SOCIAL COST OF STEEL DIVERSION TO TRUCK TOTAL	**$2,777,460**
COSTS TO CARRIERS (US$)	
• Lakers	$4,032,000
• Salties	$5,250,000
COSTS TO CARRIERS TOTAL	**$9,282,000**

PATTERNING (8 WEEKS)

IMPACTS	CANADA	UNITED STATES	TOTAL
JOBS LOST			
• Direct	1,497	463	1,961
• Induced	1,845	387	2,231
• Indirect	1,084	540	1,624
JOBS LOST TOTAL	**4,426**	**1,389**	**5,816**
ECONOMIC ACTIVITY LOST (US$)	**$484,335,000**	**$142,798,000**	**$627,133,000**
PERSONAL INCOME LOST (US$)			
• Direct	$57,945,000	$22,047,000	$79,992,000
• Re-Spending/Local Consumption	$77,237,000	$45,748,000	$122,985,000
• Indirect	$46,520,000	$24,999,000	$71,518,000
PERSONAL INCOME LOST TOTAL	**$181,702,000**	**$92,794,000**	**$274,495,000**
BUSINESS REVENUE LOST (US$)	**$407,098,000**	**$97,050,000**	**$504,148,000**
LOCAL PURCHASES LOST (US$)	**$116,472,000**	**$52,886,000**	**$169,358,000**
STATE/PROVINCIAL/LOCAL TAXES LOST (US$)	**$39,631,000**	**$10,260,000**	**$49,891,000**
FEDERAL TAXES LOST (US$)	**$56,636,000**	**$25,116,000**	**$81,751,000**

TRANSPORTATION COST PENALTY, ENVIRONMENTAL/SOCIAL COSTS, AND COSTS TO CARRIERS – PATTERNING (8 WEEKS)	
GRAIN AND STEEL TRANSPORTATION COST PENALTY (US$)	**$20,680,582**
ENVIRONMENTAL/SOCIAL COSTS OF STEEL DIVERSION TO TRUCK (US$)	
• Safety (accidents, loss of life, property damage)	$760,310
• Environmental (emissions)	$414,688
• Infrastructure (highway degradation, noise pollution, highway congestion)	$4,519,103
ENVIRONMENTAL/SOCIAL COST OF STEEL DIVERSION TO TRUCK TOTAL	**$5,694,102**
COSTS TO CARRIERS (US$)	
• Lakers	$13,965,000
• Salties	$10,750,000
COSTS TO CARRIERS TOTAL	**$24,715,000**

EXTENDED MIDSEASON CLOSURE (2 WEEKS)

IMPACTS	CANADA	UNITED STATES	TOTAL
JOBS LOST			
• Direct	3,615	2,810	6,425
• Induced	4,682	2,318	7,001
• Indirect	2,641	3,161	5,801
JOBS LOST TOTAL	**10,938**	**8,289**	**19,227**
ECONOMIC ACTIVITY LOST (US$)	**$863,789,000**	**$730,825,000**	**$1,594,615,000**
PERSONAL INCOME LOST (US$)			
• Direct	$141,603,000	$129,344,000	$270,948,000
• Re-Spending/Local Consumption	$203,240,000	$275,603,000	$478,844,000
• Indirect	$113,637,000	$147,364,000	$261,000,000
PERSONAL INCOME LOST TOTAL	**$458,480,000**	**$552,311,000**	**$1,010,791,000**
BUSINESS REVENUE LOST (US$)	**$660,549,000**	**$455,222,000**	**$1,115,771,000**
LOCAL PURCHASES LOST (US$)	**$286,217,000**	**$301,372,000**	**$587,590,000**
STATE/PROVINCIAL/LOCAL TAXES LOST (US$)	**$84,145,000**	**$59,796,000**	**$143,941,000**
FEDERAL TAXES LOST (US$)	**$131,173,000**	**$142,388,000**	**$273,561,000**

TRANSPORTATION COST PENALTY, ENVIRONMENTAL/SOCIAL COSTS, AND COSTS TO CARRIERS – EXTENDED MIDSEASON CLOSURE (2 WEEKS)	
GRAIN AND STEEL TRANSPORTATION COST PENALTY (US$)	**$139,657,056**
ENVIRONMENTAL/SOCIAL COSTS OF STEEL DIVERSION TO TRUCK (US$)	
• Safety (accidents, loss of life, property damage)	$6,012,195
• Environmental (emissions)	$3,279,169
• Infrastructure (highway degradation, noise pollution, highway congestion)	$35,735,045
ENVIRONMENTAL/SOCIAL COST OF STEEL DIVERSION TO TRUCK TOTAL	**$45,026,408**
COSTS TO CARRIERS (US$)	
• Lakers	$4,032,000
• Salties	$190,000,000
COSTS TO CARRIERS TOTAL	**$194,032,000**

EXTENDED MIDSEASON CLOSURE (5 WEEKS)

IMPACTS	CANADA	UNITED STATES	TOTAL
JOBS LOST			
• Direct	4,159	2,875	7,034
• Induced	5,341	2,377	7,718
• Indirect	3,065	3,229	6,294
JOBS LOST TOTAL	**12,565**	**8,481**	**21,046**
ECONOMIC ACTIVITY LOST (US$)	**$1,089,080,000**	**$759,366,000**	**$1,848,446,000**
PERSONAL INCOME LOST (US$)			
• Direct	$162,527,000	$132,818,000	$295,346,000
• Re-Spending/Local Consumption	$230,265,000	$282,659,000	$512,924,000
• Indirect	$131,817,000	$150,501,000	$282,318,000
PERSONAL INCOME LOST TOTAL	**$524,610,000**	**$565,978,000**	**$1,090,588,000**
BUSINESS REVENUE LOST (US$)	**$858,815,000**	**$476,707,000**	**$1,335,522,000**
LOCAL PURCHASES LOST (US$)	**$331,815,000**	**$308,384,000**	**$640,199,000**
STATE/PROVINCIAL/LOCAL TAXES LOST (US$)	**$100,160,000**	**$61,391,000**	**$161,551,000**
FEDERAL TAXES LOST (US$)	**$153,388,000**	**$146,504,000**	**$299,893,000**

TRANSPORTATION COST PENALTY, ENVIRONMENTAL/SOCIAL COSTS, AND COSTS TO CARRIERS – EXTENDED MIDSEASON CLOSURE (5 WEEKS)	
GRAIN AND STEEL TRANSPORTATION COST PENALTY (US$)	**$141,021,882**
ENVIRONMENTAL/SOCIAL COSTS OF STEEL DIVERSION TO TRUCK (US$)	
• Safety (accidents, loss of life, property damage)	$6,012,195
• Environmental (emissions)	$3,279,169
• Infrastructure (highway degradation, noise pollution, highway congestion)	$35,735,045
ENVIRONMENTAL/SOCIAL COST OF STEEL DIVERSION TO TRUCK TOTAL	**$45,026,408**
COSTS TO CARRIERS (US$)	
• Lakers	$12,768,000
• Salties	$190,000,000
COSTS TO CARRIERS TOTAL	**$202,768,000**

EXTENDED MIDSEASON CLOSURE (8 WEEKS)

IMPACTS	CANADA	UNITED STATES	TOTAL
JOBS LOST			
• Direct	4,492	2,919	7,411
• Induced	5,738	2,414	8,152
• Indirect	3,309	3,272	6,581
JOBS LOST TOTAL	**13,539**	**8,605**	**22,144**
ECONOMIC ACTIVITY LOST (US$)	**$1,215,279,000**	**$780,103,000**	**$1,995,382,000**
PERSONAL INCOME LOST (US$)			
• Direct	$175,396,000	$135,054,000	$310,450,000
• Re-Spending/Local Consumption	$246,469,000	$287,015,000	$533,484,000
• Indirect	$142,264,000	$152,470,000	$294,734,000
PERSONAL INCOME LOST TOTAL	**$564,130,000**	**$574,539,000**	**$1,138,668,000**
BUSINESS REVENUE LOST (US$)	**$968,810,000**	**$493,088,000**	**$1,461,898,000**
LOCAL PURCHASES LOST (US$)	**$357,941,000**	**$312,830,000**	**$670,772,000**
STATE/PROVINCIAL/LOCAL TAXES LOST (US$)	**$109,757,000**	**$62,465,000**	**$172,221,000**
FEDERAL TAXES LOST (US$)	**$166,393,000**	**$149,252,000**	**$315,645,000**

TRANSPORTATION COST PENALTY, ENVIRONMENTAL/SOCIAL COSTS, AND COSTS TO CARRIERS – EXTENDED MIDSEASON CLOSURE (8 WEEKS)	
GRAIN AND STEEL TRANSPORTATION COST PENALTY (US$)	**$141,918,804**
ENVIRONMENTAL/SOCIAL COSTS OF STEEL DIVERSION TO TRUCK (US$)	
• Safety (accidents, loss of life, property damage)	$6,012,195
• Environmental (emissions)	$3,279,169
• Infrastructure (highway degradation, noise pollution, highway congestion)	$35,735,045
ENVIRONMENTAL/SOCIAL COST OF STEEL DIVERSION TO TRUCK TOTAL	**$45,026,408**
COSTS TO CARRIERS (US$)	
• Lakers	$17,472,000
• Salties	$190,000,000
COSTS TO CARRIERS TOTAL	**$207,472,000**

V. CONCLUSION

Disruptions to the St. Lawrence Seaway navigation season would have escalating and lasting long-term economic, environmental, and societal harm depending on the disruption scenario. The need for such an analysis follows historic high water levels in Lake Ontario in 2017 and 2019, and the subsequent consideration by the IJC and the ILOSLRB to increase outflows through the St. Lawrence River beyond those safe for commercial navigation to reduce water levels, that would result in short or long-term disruptions to commercial navigation on the Seaway. This study serves as a comprehensive, multifaceted, propriety commercial data-rich analysis, that extrapolates impacts/effects based on dynamic modeling for each port/area, as opposed to a more generic, static study.

For each of the disruption scenarios, Martin Associates measured four sets of impacts (economic impacts, transportation cost penalties, environmental/social costs for steel diversion to truck, costs to carriers). The commercial navigation disruptions and associated impacts (non-additive), were:

LATE OPENING *(4 weeks later than schedule/plan)*

Impacts of Late Opening (4 Weeks) (US$ in millions)	
Jobs Lost	5,268
Economic Activity Lost	$554.9
Personal Income Lost	$248.7
Business Revenue Lost	$445.0
Transportation Cost Penalty	$17.4
Environmental/Social Costs	$5.0
Carrier Costs	$9.3

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EARLY CLOSING *(4 weeks earlier than schedule/plan)*

Impacts of Early Closing (4 Weeks) (US$ in millions)	
Jobs Lost	5,520
Economic Activity Lost	$629.2
Personal Income Lost	$244.1
Business Revenue Lost	$522.9
Transportation Cost Penalty	$15.7
Environmental/Social Costs	$2.8
Carrier Costs	$9.3

PATTERNING *("2 days on / 5 days off" for a period of 8 weeks)*; and

Impacts of Patterning (8 Weeks) (US$ in millions)	
Jobs Lost	5,816
Economic Activity Lost	$627.1
Personal Income Lost	$274.5
Business Revenue Lost	$504.1
Transportation Cost Penalty	$20.7
Environmental/Social Costs	$5.7
Carrier Costs	$24.7

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EXTENDED MIDSEASON CLOSURE *(2, 5, and 8-week periods during the summer/fall months)*

Impacts of Extended Closure Midseason (2 Weeks) (US$ in millions)	
Jobs Lost	19,227
Economic Activity Lost	$1,594.6
Personal Income Lost	$1,010.8
Business Revenue Lost	$1,115.8
Transportation Cost Penalty	$139.7
Environmental/Social Costs	$45.0
Carrier Costs	$194.0

Impacts of Extended Closure Midseason (5 Weeks) (US$ in millions)	
Jobs Lost	21,046
Economic Activity Lost	$1,848.4
Personal Income Lost	$1,090.6
Business Revenue Lost	$1,335.5
Transportation Cost Penalty	$141.0
Environmental/Social Costs	$45.0
Carrier Costs	$202.8

Impacts of Extended Closure Midseason (8 Weeks) (US$ in millions)	
Jobs Lost	22,144
Economic Activity Lost	$1,995.4
Personal Income Lost	$1,138.7
Business Revenue Lost	$1,461.9
Transportation Cost Penalty	$141.9
Environmental/Social Costs	$45.0
Carrier Costs	$207.5

The Great Lakes St. Lawrence Seaway System is a crucial transportation component of the dynamic, interrelated, and complicated economic logistics supply chains that support the economies of the United States and Canada. The consequences of any disruption to those supply chains will have adverse consequences that will go beyond the immediate economic harm to shippers and carriers and well beyond the affected navigation season. Disruptions to the traditional St. Lawrence Seaway commercial navigation season (typically late March to late December each year) would result in negative impacts to the economy, environment, and society.

The most significant impacts of St. Lawrence Seaway disruptions include:

- Significant negative effects to U.S. and Canadian economies and logistics supply chains;
- Long-term economic harm to ports, carriers, pilots, stevedores, importers/exporters, farmers, and U.S. and Canadian consumers;
- Permanent lost market share for certain cargoes;
- Increased rates for cargoes and prices of raw materials;
- Permanent cargo diversion to truck/rail impacting modal capacity and associated environmental and societal costs; and
- Irreversible damage to Seaway competitiveness and credibility with customers.

In conclusion, without consideration of these potential impacts and dislocations on the U.S. and Canadian economies, any interruptions of navigation to control water levels on Lake Ontario, regardless of length or type of disruption, would be ill-advised. Such disruptions would cause irreparable consequences in terms of long-term job losses, costly and disruptive supply chain re-routings that, in many cases, become permanent, environmental damage, and increased production costs to the U.S. and Canadian industrial and agricultural sectors.

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