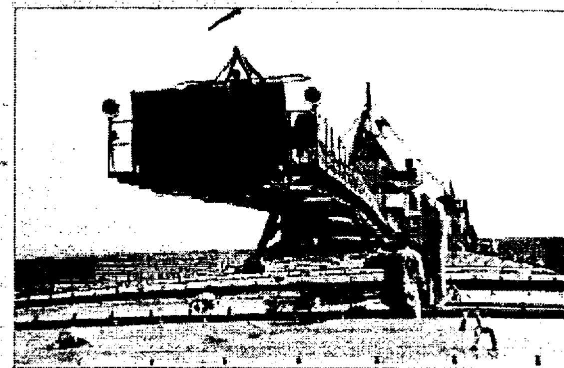

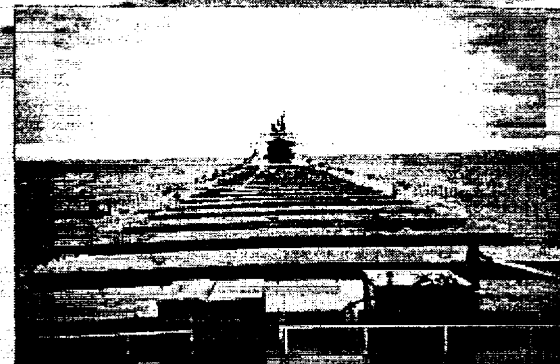

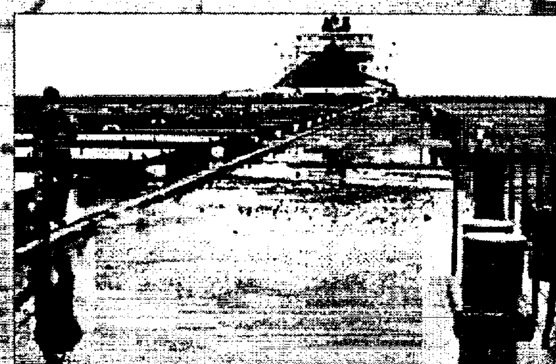

A STUDY OF DRY CARGO RESIDUE DISCHARGES IN THE GREAT LAKES

PREPARED FOR

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EXECUTIVE SUMMARY

This study's purpose is to satisfy the Congressional Mandate in the FY2000 U.S. Coast Guard (USCG) Appropriations Bill, directing the Secretary of Transportation (hence the U.S. Coast Guard) to conduct a study on the effectiveness of the U.S. 1997 Enforcement Policy for Cargo Residues in the Great Lakes by 30 September 2002. This "policy" currently is embodied in Ninth Coast Guard District (CGD9) Instruction 16460.1 (originally issued on 22 September 1993, updated on 1 March 1995, and further modified on 28 January 1997), outlining the conditions under which "dry cargo residues" may be discharged by vessels, and setting forth requirements for USCG monitoring and enforcement. The instruction specifies, by commodity, the areas of the Great Lakes where dry cargo residues may be discharged. The policy has been promulgated within the shipping community as a Notice to Mariners.

The motivation behind the CGD9 Policy is to address an ongoing discontinuity and apparent contradiction between the language in several laws and regulations and its practical application to the handling of dry cargo residues by bulk carriers on the Great Lakes (and potentially other inland waters of the United States). This discontinuity has provoked some debate and controversy over the past several years, such that Congress has directed the U.S. Coast Guard to develop regulations to clarify and resolve the enforcement policy for dry cargo residues. This study is designed to provide the U.S. Coast Guard (as well as other involved agencies) with the best information available to develop these regulations. It involves investigation of three separate but related focus areas: (1) a legal and policy analysis, (2) an analysis of the volume and distribution of dry cargo discharges and the effectiveness of current pollution prevention measures, and (3) an analysis of the environmental impacts of dry cargo discharges under the current directives.

The legal and policy analysis investigates the applicability of various laws and regulations with regard to their intent and specific provisions as related to the dry cargo residue issue. Consistencies and inconsistencies between the CGD9 Policy (which will probably form the basis for regulation development) and various laws and regulations are noted. Canadian laws and policy also are reviewed for consistency with the CGD9 Policy. The expectations of important stakeholders are investigated to determine the levels of acceptance and opposition that regulations are likely to encounter.

The pollution prevention analysis seeks to determine the amount of material that is being lost during loading and unloading, and discharged in transit. The analysis is based on discharge amounts reported from previous studies adjusted for current dry cargo commodity tonnages being transported by U.S. and Canadian bulk carriers. In addition, specific data are collected on the amounts of dry cargo residue currently being discharged along transit routes and through a careful analysis of dry cargo washdown records during the 2001 shipping season. The study also documents the current waste minimization and discharge mitigation procedures employed by industry, as well as the constraints that it is operating under (e.g., lack of reception facilities, complications during adverse weather, etc.).

The environmental impact analysis seeks to specify the impacts of the dry cargo discharges by commodity and area of discharge. Detailed information is gathered on environmental conditions in the areas of frequent discharge (vessel tracklines and ports) and specific areas already heavily stressed by pollution. Data are gathered on the specific composition of the commodities with special attention to additives. A detailed analysis is conducted of the relative impact of dry cargo residue being discharged on each vessel trackline segment being utilized. The overall impact on each segment is assessed, and desirable conditions and practices to minimize environmental impact under the current policy and future regulations are identified.

The specific recommendation and conclusions of the study are as follows:

1) Analysis of international conventions, laws, regulations, and policy indicates that the current CGD9 Policy, which is an effective adaptation of the Act to Prevent Pollution from Ships (APPS) for the bulk carrier trade in the Great Lakes, provides a valid framework for formal regulations under APPS regulating dry cargo discharges in the Great Lakes. Accordingly, it should serve as the basis for these regulations.
2) The U.S. Coast Guard should pursue these regulations in collaboration with U.S. Environmental Protection Agency (EPA) and other agencies, ensuring that the best management practices (BMPs) adopted be as consistent as possible with BMPs that might be prescribed under the Clean Water Act (CWA).
3) Analysis of dry cargo residue discharges indicates that a standardized format should be developed for estimating, recording, and collecting dry cargo discharge amounts aboard bulk carriers. This format should entail keeping a separate logbook in a standard format that can be checked routinely and copied for further analysis. Discharge amounts should be estimated in pounds, and discharge start and stop positions should be recorded in latitude and longitude. The nature of the discharge material (e.g., coal, stone, or combination) and source (deck or tunnel) should be specified clearly. Vessel operators also should be trained on appropriate methods for gathering and recording data.
4) Every effort should be made to continue to minimize dry cargo discharges on deck and in the tunnels aboard bulk carriers. Discharges greater than 1,000 lbs should be avoided and reported aggressively. It is in the best interest of industry to keep dry cargo discharges at a *de minimus* level consistent with the intent and language of the Annex V of MARPOL 73/78, Regulations for the Prevention of Pollution by Garbage from Ships (MARPOL V) Guidelines so that they continue to be valid routine vessel operational discharges for regulatory purposes.
5) With regard to additional environmental protection measures, there are a variety of strategies for reducing the impacts of dry cargo washdown or sweeping practices as currently exist on the Great Lakes. Complete elimination or severe reduction of commodity inputs is one approach that radically would reduce the impacts of dry cargo on the Lakes. However, there are a number of economic and practical reasons why this approach currently is not feasible. A more practical approach is to continue to limit dry cargo discharges to specific zones within the Lakes. There are two basic approaches that can be taken in terms of recommending zones for input or restriction from input: (1) limit inputs to areas that already are impacted highly from an environmental standpoint, or (2) restrict inputs to areas that already are impaired environmentally to allow these areas to "recover." The first approach favors adopting the CGD9 Policy as currently promulgated. The second approach may have merit for future consideration, but will require more detailed, longer-term, scientific investigation to confirm environmental impact in areas of higher discharge frequency, and ensure that changing the current policy does not lead to more widespread versus more restricted contamination.
6) The results of this study have provided additional information on the statistics of materials shipped and the amounts that are being discharged into the water column on an annual basis. However, this is a 1-year snapshot that may need to be repeated at some prescribed interval (e.g., every 5 years) to monitor commodity input and the effectiveness of regulations and industry initiatives in lowering this input. Continuation of the washdown data collection program currently being conducted by industry on a voluntary basis will assist in this greatly.

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1.0 INTRODUCTION

1.1 Purpose of Study

The immediate purpose of this study is to satisfy the Congressional Mandate in the FY2000 U.S. Coast Guard (USCG) Appropriations Bill, which directs the Secretary of Transportation (and hence the U.S. Coast Guard) to conduct a study of the effectiveness of the U.S. 1997 Enforcement Policy for Cargo Residues in the Great Lakes by 30 September 2002. This policy currently is embodied in Ninth Coast Guard District (CGD9) Instruction 16460.1 (originally issued on 22 September 1993, updated on 1 March 1995, and further modified on 28 January 1997), which outlines the conditions under which "dry cargo residues" may be discharged by vessels, and sets forth requirements for USCG monitoring and enforcement. The instruction specifies, by commodity, the areas of the Great Lakes where dry cargo residues may be discharged. In the past, the policy has been promulgated within the shipping community as a Notice to Mariners. The results of this study will be used in the interim to evaluate the effectiveness and level of compliance with the current policy, and ultimately to develop regulations that formalize this policy.

1.2 Background

The motivation behind the CGD9 Policy and subsequently this study lies in an ongoing discontinuity and apparent contradiction between the language in several laws and regulations and their practical application to the handling of dry cargo residues by bulk carriers on the Great Lakes (and potentially other inland waters of the United States).

The genesis of the discontinuity lies in the U.S. adoption of Annex V of MARPOL 73/78, Regulations for the Prevention of Pollution by Garbage from Ships (MARPOL V), which prohibits the discharge of garbage at certain distances from nearest land. The distances are based on the standard international baseline method for determining distance from shore. Under MARPOL V, garbage is defined to include "operational wastes." Although MARPOL V itself did not specify dry cargo residues as being included under operational wastes, in 1988 the International Maritime Organization/Marine Environmental Protection Committee (IMO/MEPC) decided to include cargo residues in the definition of operational waste in publishing the MARPOL V Implementation Guidelines. The definition of cargo residues, also called cargo sweepings, included the residues of bulk dry cargo generally carried in the Great Lakes.

In 1987, the United States implemented MARPOL V through the Act to Prevent Pollution from Ships (APPS) and in 1990 issued regulations under 33 CFR Part 155 that prohibited the discharge of garbage in all internal waters including the Great Lakes. Accordingly, the discharge of cargo residues or sweepings in the Great Lakes was prohibited as defined in MARPOL V and APPS. The immediate complication for bulk carriers in the Great Lakes is that they cannot go "offshore" to discharge residues as the Great Lakes are entirely within inland waters, and, to a large extent there are no clearly practical waste management alternatives to discharging these residues.

Whether Congress recognized the implications of the APPS in the Great Lakes and intended that the discharge dry cargo residues be categorically prohibited there is unclear. It is also noteworthy that IMO in its Guidelines for the Implementation of Annex V does specifically address the issue of dry cargo residues calling for minimization of discharges through aggressive waste management, but does not call for an absolute "no discharge" standard.

The dilemma posed by the strict enforcement of APPS with respect to dry cargo residues in the Great Lakes was immediately evident to the Great Lakes Carriers and other shipping companies. For bulk carriers, the incidental operational discharges of dry cargo residues from decks and cargo hold washdown had been common practice for 75 years. Moreover, Canada had not adopted MARPOL V such that its vessels would not be subject to the restrictions while in Canadian waters while U.S. vessels would be restricted. It immediately brought this to the attention of the U.S. Coast Guard. The U.S. Coast Guard responded with the Ninth District Instruction and Notice to Mariners as a reasonable best management practice (BMP) resolution of the immediate dilemma, pending more complete resolution and formalization of a solution through the regulatory process.

However, there was continuing concern within the Ninth District over the "face value" contradiction between the APPS and the CGD9 Policy. In addition, it was noted that the policy might be in contradiction to provisions of the Clean Water Act (CWA), which prohibit the discharge of pollutants including garbage into U.S. waters without a National Pollution Discharge Elimination System (NPDES) permit from the U.S. Environmental Protection Agency (EPA). Although the CWA does not specifically call out dry cargo residues and operational discharges from vessels as garbage, in a broader perspective, the CWA may be interpreted to prohibit these discharges in internal waters. The CWA defers regulation of vessel discharges for sewage and oil pollution to the U.S. Coast Guard, but not specifically for other discharges inside U.S. waters. The general approach to regulating vessel discharges (sewage and oily wastes) has been for EPA to define a standard, and for the U.S. Coast Guard to develop a technology-based solution or BMP solution that implements, monitors, and enforces this standard.

The APPS and CWA contradictions with the CGD9 Policy have led to various attempts to reconcile this discontinuity. One proposed solution crafted by a consortium of federal agencies was to handle dry cargo residues under the CWA by issuing a general or regional NPDES permit that would allow discharges at certain levels and under certain areas. This would make the CWA versus the APPS the primary applicable governing law, and 40 CFR the primary governing regulation for managing dry cargo discharges. The obvious benefit would be consistency within U.S. law and a specific CWA pollution-control standard for the bulk carriers. The main drawbacks would be the potential for states to request and impose multiple standards throughout the Great Lakes and departure from the current practice of having the U.S. Coast Guard regulate discharges from larger vessels.

A separate resolution to the problem, which was supported by the shipping companies, simply was to have Congress amend the APPS to exclude cargo residues from the materials that were otherwise prohibited from being discharged in the Great Lakes. This was embodied in Section 415 of HR Bill 2204 (known as the Glenn Amendment) considered by Congress in 1998, at roughly the same time as the interagency proposal for a regional NPDES permit was being considered.

Ultimately, neither proposal was adopted. One can surmise that the complications of the CWA/NPDES approach were considered significant and, at the same time, Congress was reluctant to modify the APPS in what might be perceived as an arbitrary concession to the shipping industry. Instead the U.S. Coast Guard was directed by Congress to continue its current policy until 2002 and subsequently until 2004, pending completion of the study and formulation of a specific regulatory solution to the issue. Hence, the current project is being undertaken.

1.2.1 Scope of the Current Study

This study is designed to provide the U.S. Coast Guard (as well as other involved agencies) with the best information available to develop regulations that will resolve the dry cargo issue by developing formal regulations to address the issue. It involves investigation of three separate, but related, focus areas:

- Legal and policy analysis
- Analysis of the volume and distribution of dry cargo discharges and effectiveness of current pollution prevention measures
- Analysis of the environmental impacts of dry cargo discharges under the current directives

The legal and policy analysis investigates the applicability of various laws and regulations, with regard to their intent and specific provisions, to the dry cargo residue issue. International Protocols and Guidelines, and U.S. laws and regulations analyzed include MARPOL V (and Implementation Guidelines), APPS, CWA, Ocean Dumping Act, Refuse Act, and applicable and related regulations in 33 CFR and 40 CFR. Consistencies and inconsistencies between the CGD9 Policy (which will probably form the basis for regulation development) and these laws and regulations are noted. Canadian laws and policy are also reviewed for consistency. The expectations of important stakeholders are being investigated to determine the level of acceptance and opposition that regulations are likely to encounter. Important stakeholders include other federal and state agencies, Canadian agencies, the shipping industry, and involved non-governmental organizations (NGOs).

The pollution prevention analysis seeks to determine the amount and categories of dry cargo transported in the Great Lakes, number of shipments by commodity, and transit routes for these shipments. It also investigates the amount of material that is being lost during loading and unloading, and discharged in transit. Some of this information is being obtained from the U.S. Army Corps of Engineers (USACE) waterborne commerce database and from a Canadian Coast Guard (CCG) study completed in 1993 (Melville Shipping, 1993). Additional and more detailed data are being collected on the transit routes and discharge areas for bulk carriers, and the amount of material discharged during transit. These will provide information on the volume and percentage of cargo lost during loading and unloading, and during washdown in transit. The study also documents the current waste minimization and discharge mitigation procedures employed by the industry and the constraints that they are operating under (e.g., lack of reception facilities, complications during adverse weather). This information is being sought from USCG Marine Safety Offices (MSOs), the Lake Carriers Association (LCA), and Canadian shipping companies, as well as other government, industry, and NGO stakeholders.

The environmental impact analysis seeks to specify the impacts of the dry cargo discharges by commodity and area of discharge. Preliminary data on the general impacts by commodity and habitat type already have been obtained from the 1993 National Oceanic and Atmospheric Administration (NOAA)/Great Lakes Environmental Research Laboratory (GLERL) workshop (Reid and Meadows, 1999) and the 1993 CCG study (Melville Shipping, 1993). More information is being gathered on environmental conditions in the areas of frequent discharge (vessel track lines and ports), specific areas already heavily stressed by pollution (identified as Areas of Concern [AOCs] in the CCG study), specific composition of the commodities with special attention to additives, dispersal mechanisms, and deposition patterns for discharges material, and previous and planned investigations on the impact of dry cargo discharges on habitat and living resources. The analysis summarizes the desirable conditions and practices to minimize environmental impact under the current policy and future regulations.

The final report for the study includes conclusions and recommendations on the operational feasibility and effectiveness of the current policy; the economic impact of the current policy on government and the shipping industry; potential enhancements and alternatives to the current policy along with cost and benefit considerations; the implications of formalizing the policy through regulations including requirements for implementation, monitoring and enforcement; and the need for additional data and research that would be useful in formulating dry cargo regulations.

1.3 Previous Studies of the Dry Cargo Residue Discharge in the Great Lakes

Two previous studies have investigated the magnitude and impact of dry cargo residue discharges in the Great Lakes—one initiated in Canada by the CCG and one in the United States resulting from a workshop coordinated through the NOAA GLERL.

1.3.1 The CCG Study

The CCG study by Melville Shipping, Ltd. in association with LGL Ltd. for the CCG (Melville Shipping, 1993) looked at the magnitude and impact of non-regulated cargo residues from ships operating in the Great Lakes—particularly in Canadian waters and ports—to determine if control measures were required. The investigation studied the commodities moved during 1989, which was chosen for being relatively current and for having the widest range of commodities to access. Five Canadian ports in the Great Lakes were reviewed: Hamilton, Sarnia, Sault Ste. Marie, Thunder Bay, and Nanticoke. All ports except Nanticoke are considered AOCs in that they have been targeted for special attention. A concerted effort is being made to mitigate environmental damage done in the past in these AOCs, and to eliminate sources of ongoing pollution. Environmental problems in these AOCs include sediments contaminated by toxic substances, elevated nutrient levels in the water, and large amounts of organic input that degrade water quality.

Various existing regulations were studied as background, and the investigation focused on commodities for which there is no current regulatory requirement to report accidental discharges, more specifically dry cargo residues. The environmental impacts of these cargo residues were assessed and specific recommendations for future actions presented.

As with the current USCG study, the CCG study included a review of current Canadian laws and regulations that might be applicable to the dry cargo issue. These included the Canada Shipping Act, Federal Fisheries Act, Ontario Provincial Legislation, the Great Lakes Water Quality Agreement, and MARPOL V. The current USCG policy on dry cargo discharges also was reviewed.

The CCG study found that commodities moved in bulk on the Great Lakes that are covered by existing legislation regarding discharges include:

- Pollutant substances as defined by Schedule I of the Pollutant Substances Regulations
- Oil and oily mixtures as defined by the Oil Pollution Prevention Regulations
- Substances and chemicals as defined by the Dangerous Chemicals and Noxious Liquid Substances Regulations

However, as of 1993, there was no obligation under the Canada Shipping Act, the Great Lakes Water Quality Agreement, or MARPOL V and related guidelines to report the accidental spillage of cargo residues for the commodities considered in this study. It should be noted that Canada has yet to ratify MARPOL V. However the Federal Fisheries Act does forbid the deposit of deleterious substances in any waters frequented by fish. In Ontario, the Ministry of the Environment uses reference levels to determine harmful concentrations and, by the levels, only about 7% of the spilled cargo would meet the criteria under the Federal Fisheries Act. The CCG study noted that Guidelines to Annex V of MARPOL place an obligation to minimize ship residue, but do not prohibit such discharges absolutely. The CCG study also reviewed the USCG approach to dry cargo residues set forth in the CGD9 Policy stating that the U.S. Coast Guard considers the Great Lakes and its shipping system to be a Special Case where a more lenient view would be appropriate. The CCG study supported the USCG approach, noting that minimization rather than elimination of cargo residue may be more practical and acceptable.

As part of the CCG study, Statistics Canada data were used for detailed analysis of cargo movements and traffic. The data were reviewed by ship operators and port officials, and the following top ten commodities by volume were chosen for further study: coal and peat for fuel, iron pellets, wheat/seed, rock salt, cement, potassium chloride, manganesic dolomite, rape seed, metallic salts, and barley/seed.

The total cargo movements examined accounted for 4,598 movements and 67,887,894 tonnes. This represents 89% of the cargo moving through Canadian Great Lakes ports in 1989. The five ports examined represented the most significant ports on the Great Lakes based on the total quantity of cargos for these commodities and were representative of most cargo movements.

A database on the quantities and sources of spills during the loading and unloading process was produced based on discussions and responses from questionnaires sent to various shipping companies. These estimates were then validated by observation of ten actual ship loading/discharge operations.

In general, the quantities spilled were extremely small when compared with the quantity of cargo loaded and discharged. The total spillage by ships using the five ports considered in the study was 673,509 kg, about 5% of which was spilled in port. From a cargo of 30,000 tonnes it is likely that only about 200 kg would be lost. Most of this would be deposited on deck and would be swept into the cargo holds or washed overboard once the ship is out of confined waters.

Losses occurred about 5% in port and 95% in unrestricted water. Total losses were usually less than 0.001% of cargo carried. Self-unloader estimates ranged from 80–455 kg when loading and 135–570 kg when discharging. The variation depends on the cargos being carried, the terminal being used and the need for the vessel to clean tunnels/holds between cargos.

The CCG study noted that the combination of new technology and procedures has resulted in a dramatic reduction in spillage entering the environment. Substantial spillage may have occurred in the past during the loading and unloading process because of less sophisticated equipment and a lower level of concern about the protection of the environment. However, with today's self-unloaders, highly controllable conveyors, and chute systems complete with dust reducing covers and guide chutes the loss is greatly reduced. Also, the normal procedures for dealing with spillage prevent it from being deposited into the water in the vicinity of the port. The washdown of cargo in virtually all cases takes place while the ship is in transit, not in ports or other confined waters. The distance traveled during the washdowns is in the range of 15 to 100 nautical miles.

According to the responses from ship operators, most cargo losses are caused by high chutes, narrow hatches, conveyor run-off, vessel movement without warning, wind-blown dust, loose cargo, overfilled clams, and clam buckets not properly sealed.

The amount of spillage varies with different cargos. Grain and coal cargos are susceptible to being blown by the wind, and iron ore fines and wetted stone tend to leave a muddy spillage on the deck.

The CCG study further noted that if deck and cargo hold washdowns were prohibited it could reduce the spillage of material going over the side, up to 50%. However, this would require additional use of brooms and shovels and this is not considered to be very practical by the operators. The study concluded that quantities spilled are so small that they are approaching the point where further reductions may be impractical. Greater reductions in spilled quantities may be possible with improving technology and procedures, but the reductions are likely to be small and have relatively little impact on the environment.

With respect to environmental impacts of dry cargo residues in Canadian waters, the current cumulative impacts of pollutants from all sources over the years include the contamination of water and sediment with metals and chemicals; eutrophication (an oversupply of nutrients that causes increased plant production, which in turn cause decreases in water clarity and quality); reduction in water quality through decreased oxygen concentrations; and contamination of fish, wildlife, and aquatic biota with metals and chemicals. Ships probably have contributed a very small percentage of the material that has accumulated in sediments and that is presently dissolved in water. The contribution of the material spilled by ships to the cumulative impacts now observed in the Great Lakes, in general, likely are small. But they have contributed to these impacts. Overall, the cumulative effect of discharges by ships has probably been negligible to minor in harbors and negligible in lakes.

In summary, the CCG study concluded that while cargos are lost during regular ship operations, the quantity that is lost and the damage done is minimal. The authors noted that to comply with the Federal Fisheries Act and the spirit of the general movement to improve environmental quality in the Great Lakes area, the spillage of cargo residues should be minimized, especially in the AOCs.

The highest priority should be to minimize the spillage of iron and all metals in Lake Erie and Hamilton Harbor. Anoxic conditions in Lake Erie and Hamilton Harbor could lead to release of the metals from the ore. Another high priority would be to reduce spillage of non-ferrous materials in the open lakes, Thunder Bay, and other ports that have a problem with metal contamination since the metals in these ores can be very toxic.

The second priority should be a reduction in the spillage of iron ore and related ferrous material and coal in the five ports. Of lower priority would be to reduce the spillage of materials that have a biological oxygen demand, including grain, seed, and pulp, as well as fertilizer materials in Thunder Bay and Hamilton. The lowest priority would be to reduce spillage of materials such as aggregates and building materials, and non-metallic minerals such as dolomite, potash, and gypsum.

The CCG study further recommended that a more extensive validation study be conducted into the losses occurring during the loading and discharging of cargos to establish independent quantities being lost in port and the related causes. This should be conducted to validate as wide a range of cargos as possible. Also, loading and unloading operations should be examined in detail to ensure that consideration has been given to extenuating losses during all stages of the handling process. Guidelines should then be created to identify prudent cargo handling operations both in port and when cleaning holds, decks, tunnels and belts. The authors also recommended that AOCs should be documented for ship operators and avoided, if possible, when cleaning operations are done.

1.3.2 The NOAA/GLERL Workshop

The NOAA/GLERL workshop on dry cargo residue discharges was conducted in 1993. The workshop proceedings was published in 1999 (Reid and Meadows, 1999).

The workshop was designed to bring together members of the scientific, shipping, and regulatory communities to discuss the environmental implications of cargo sweeping in the Laurentian Great Lakes. The specific goals of the workshop were to identify the scientific questions that must be answered and to obtain the necessary information to answer those questions to have a sound scientific basis and understanding about the possible environmental effects of cargo residues for the final USCG cargo sweeping regulations. The workshop broke into three separate groups—risk to fisheries and habitat, sediment accumulation and toxicity, and water-column impacts—to look at specific risk areas and to share knowledge and discuss further information and studies that may be needed.

The **risk to fisheries and habitat workgroup** was asked to consider the potential for changes in bottom habitat nature and quality that might result from an accumulation of cargo residues in a particular area over time. The group identified and discussed four critical bottom habitats (plant bed, mud/silt, sand, and rocky shoals) as well as seven potential risks posed by the discharge of commodities (smothering and suffocation, osmotic stress, toxicity, nutrient enrichment, change in bottom substrate composition, filling of interstitial spaces in bottom substrate, and aesthetics).

The group concluded that residues of cement, grain, coarse limestone, and wood pulp and chips from vessels are not likely to cause serious environmental damage or produce negative impacts on plants or animals in the Great Lakes. Residues of taconite pellets and finely divided limestone, coal, and sand may affect coarse- and rocky-substrate habitats adversely by filling interstitial spaces. Workgroup members agreed that there is a major lack of knowledge; therefore, there is a strong need for research to determine if exposure to iron ore, taconite pellets, coal, coke, rock salt, millscale, and slag cause any measurable toxic effects in Great Lakes plants and animals.

The group also concluded that research is needed to further determine and evaluate the environmental effects of cargo residues and recommended that detailed chemical analyses of specific commodities; literature searches; laboratory experiments, including toxicity bioassays and determination of oxygen demand; and related field testing and measurements be conducted to accomplish this.

This **sediment accumulation and toxicity workgroup** reviewed the potential effects of cargo residues that reach and accumulate in soft-bottom sediments. Workgroup members identified scientific questions required to address the potential effects of cargo residues and identified a two-tiered approach to answer the most important questions including:

- Does cargo sweeping adversely affect bottom sediments or the biota that reside in or near this sediment?
- What are the chemical compositions of the cargo commodities?
- Are the deposited materials in the sediment from cargo commodities?
- Is deposition of cargo residues changing the physical structure of the bottom sediments and the habitat for the benthos?
- How does cargo sweeping relate to and compare with other discharges of similar or the same compounds into the Great Lakes?

The group concluded that information on the chemical composition of the dry cargos would be extremely helpful in designing further experiments and field studies. It also found that a literature survey of benthic community and sediment composition data and location of shipping tracks would be required for the best experimental design.

The **water-column impacts workgroup** discussed the possible effects that cargo sweeping might have in the water column (the portion of the lake from the water's surface to immediately above, but not including, the bottom sediments). Since large particles of dense material settle rapidly into the sediments, the group focused on the potential environmental effects of the finer-grained and readily dissolvable portions of the commodities and the light fractions that might either float or be fixed in the water column for relatively long periods (more than 1 day). Both the toxicological and water quality effects of the dry bulk commodities were studied.

The group found that short-term changes in the local turbidity that could result from cargo sweeping would produce little environmental consequence within the water column. It did find, however, that the potential for toxic chemicals to be introduced into the water column from the commodity residues and of any materials used in treating the commodities could not be properly evaluated. Further information was needed on the following: (1) cargo statistics regarding which bulk cargos are carried and which result in the need for cargo sweeping, (2) the chemical composition of the cargo, (3) the physical characteristics of the discharge quantities into the water column, and (4) the bioavailability, solubility, toxicity, and nutrient potentials of the materials found in the dry bulk cargos.

The workgroup recommended that the statistical data on the materials shipped, the detailed chemical composition of these materials, and the amounts of these materials discharged into the water column be compiled. Modeling studies of the dispersal of materials having the physical characteristics of the various types of cargo residues introduced into the Great Lakes should also be conducted, with verification of field experiments.

The three workgroups agreed that an appropriate scientific basis for regulatory and procedural decisions is lacking, and recommended that further research should explore, measure and evaluate the environmental effects of cargo residue discharge in the Great Lakes with a series of literature searches, laboratory and field studies, measurements and experiments. The workshop participants also recommended that a group of Great Lakes scientists should be formed to advise the U.S. Coast Guard and LCA on specific areas or fisheries habitats that may be at risk from cargo sweeping, on a case-by-case basis. Although the risk to fisheries and habitat workgroup expressed concern about permitting cargo sweeping in new areas, it was recommended that consideration be given to continuing cargo sweeping activities in the same areas used historically for that purpose, until there is a scientific basis for changing that practice.

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2.0 PROFILE OF THE GREAT LAKES BULK CARRIER INDUSTRY

2.1 Shipping Companies and Fleet Composition

The Great Lakes bulk carrier industry consists of three categories of shipping companies and the vessels they operate:

- U.S.-flag vessels, most of which belong to the companies represented by the Lake Carriers Association (LCA)
- Canadian-flag vessels, most of which belong to the companies represented by the Canadian Shipowners Association (CSA)
- Foreign-flag vessels, which are owned by overseas companies and enter and leave the Great Lakes during each voyage

As of May 2001, there were 12 LCA member companies with a total of 58 vessels in operation. LCA company membership, number of vessels, and shipping volume are summarized in Table 2.1. Table 2.2 shows the distribution of U.S.-flag bulk carriers by vessel length and combined carrying capacity.

Discussions with the LCA confirmed that most U.S.-flag shipments are handled by four major bulk carrier companies: American Steamship Company, The Interlake Steamship Company, Oglebay Norton Company, and USS Great Lakes Fleet, Inc. Together, these companies operate 41 of the 58 vessels, or about 70% of the U.S.-flag fleet, with fleet size and operations as follows:

- **American Steamship Company:** This company has 11 vessels transporting iron ore, limestone, eastern coal, and western coal. Primary vessel routes include Superior to St. Claire (cargo coal), Duluth to Lorain (iron ore), and Superior to Detroit (iron ore).
- **The Interlake Steamship Company:** This company has 10 vessels transporting iron ore and coal from Duluth and Sturgeon Bay to Toledo.
- **Oglebay Norton Company:** This company has 12 vessels transporting limestone, iron ore, and coal. The primary iron ore route is from Duluth/Superior to Toledo.
- **USS Great Lakes Fleet, Inc.:** This company has eight vessels, three of which carry only taconite pellets (iron ore), according to the company's Web site at *http://www.gltx.com/*. The primary destination for the iron ore is Gary, Indiana.

U.S.-flag vessels engaged in the Great Lakes bulk cargo trade are almost exclusively self-unloading, with all loading machinery located at the terminal and all unloading material located aboard ship.

The CSA represents owners of Canadian-flag ships operating in the waters of the Great Lakes, the St. Lawrence Seaway, the Arctic, the Maritimes, and the Eastern North American Seaboard. Table 2.3 shows current CSA membership and types of vessels operated by each company for 2000.

The three largest Great Lakes Canadian companies are Algoma Central Corporation, Upper Great Lakes Group Inc., and Canada Steamship Lines. Algoma and Upper Great Lakes Group work together in a partnership called Seaway Marine Transport, and during the 2001–2002 season, this partnership operated a total of 20 self-unloading vessels and 22 conventional bulk cargo vessels. Canada Steamship Lines (managed by ACOMARIT Canada) operated 11 self-unloading vessels and 6 bulk cargo vessels.

Table 2.1 Lake Carriers Association Summary of Membership as of May 2001.

Member	Number of Vessels	Gross Registered Tonnage	Mid-Summer Capacity (gross tons)
American Steamship Company	11	228,724	411,371
Bethlehem Steel Corporation	2	68,582	119,000
Cement Transit Company	2	11,497	19,800
Central Marine Logistics, Inc.	3	38,827	86,200
Cleveland Tankers Ship Management Inc.	2	9,757	13,410
Erie Sand Steamship Co.	1	9,790	15,173
Grand River Navigation Company, Inc.	3	30,101	45,000
Inland Lakes Management, Inc.	3	21,780	35,965
The Interlake Steamship Company	10	199,290	363,960
Oglebay Norton Company	12	183,295	340,525
USS Great Lakes Fleet, Inc.	8	168,622	321,750
VanEnkevort Tug & Barge Inc.	1	17,002	40,000
Totals	**58**	**987,768**	**1,811,385**

Source: Lake Carriers Association Annual Report, 2001. Contact the Lake Carriers Association at Suite 915, 614 West Superior Avenue, Cleveland, Ohio 44113-1383 or at the organization's Web site (*http://www.lcaships.com/*).

Table 2.2 Distribution of Vessels in Class, Vessel Length, and Combined Carrying Capacity for U.S.-Flag Dry-Bulk Carriers.

Vessel Class	Number of Vessels in Class	Vessel Length	Combined Carrying Capacity	Number of Vessels in Service	Carrying Capacity in Service
X	13	950'–1,099'	778,680	12	719,680
IX	1	850'–949'	43,900	1	43,900
VIII	11	731'–849'	317,470	11	317,470
VII	7	700–730	193,478	5	144,778
VI	7	650'–699'	170,825	4	102,900
V	15	600'–649'	278,657	9	175,014
II	1	400'–499'	4,600	1	4,600
Totals	**53**	**N/A**	**1,755,810**	**43**	**1,508,342**
Cement Carriers					
IV	2	550'–599'	19,800	1	8,500
III	3	500'–549'	45,165	2	32,865
II	1	400'–499'	8,400	0	0
Totals	**6**	**N/A**	**73,365**	**3**	**41,365**

Source: Lake Carriers Association Web site (*http//:www.lcaships.com/*).

Table 2.3 Membership and Fleet Composition for Canadian Shipowners Association.

Member	Bulkers	Self-Unloaders	Tankers	Others	Total
Algoma Central Corporation	7	14	6		27
Canada Steamship Lines	1	10			11
Groupe Desgagnes, Inc.	3		3	3	9
Transport Nanuk Inc.				2	2
Oceanex (1997) Inc.				3	3
N. M. Patterson & Sons, Ltd.	7				7
P&H Shipping	2				2
Shell Canada Products, Ltd.			1		1
Upper Lakes Group, Inc.	13	8			21
Totals	**33**	**32**	**10**	**8**	**83**

Source: Canadian Shipowners Association Report, 2000–2001. Contact the Canadian Shipowners Association at 350 Sparks Street, Suite 705, Ottawa, Ontario, Canada K1R 7S8 or at the organization's Web site (*http://www.shipowners.ca/*).

For conventional bulk cargo vessels (bulkers), the loading and unloading machinery is located at the terminal; for self-unloading vessels, the unloading machinery is located aboard ship. Figure 2.1 shows the basic configuration of a self-unloading vessel. The self-unloader is equipped with an unloading boom on deck and a conveyor belt that runs underneath the cargo holds along the entire length of the vessel. During unloading, the cargo is allowed to flow onto the conveyor belt at a controlled flowrate and is transported to the stern of the vessel. On reaching the stern, cargo is sandwiched between two additional conveyor belts that transport the material up to the deck in a U-shaped trajectory. On reaching the deck, the material is deposited onto a third conveyor belt that runs along an articulating boom that is swung out over the side to deposit the material on the dock. Figure 2.2 shows the details of the self-unloading mechanism.

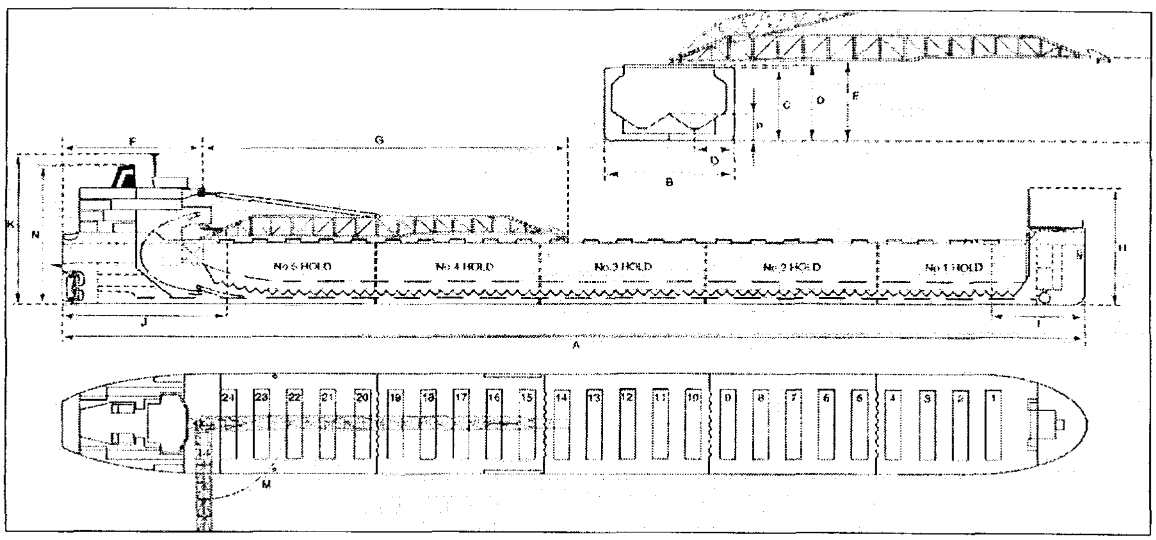

Figure 2.1 Drawing Showing the Basic Configuration of a Self-Unloading Bulk Carrier (e.g., 35,568-DWT CSL Vessel NIAGARA).

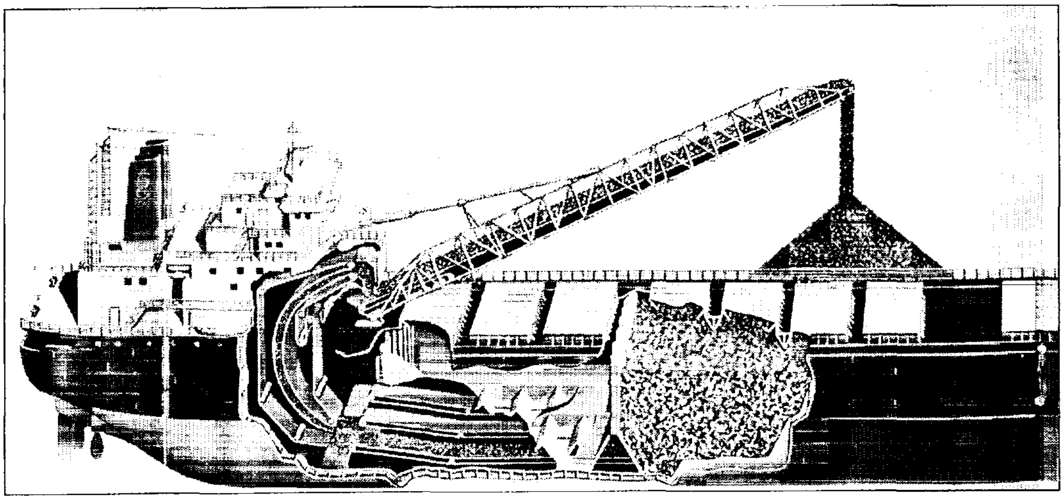

Figure 2.2 Drawing Showing the Configuration and Workings of the Self-Unloading Machinery.

For the conventional bulk cargo carrier (described as a bulker or straight-decker), there is no machinery onboard (Figure 2.3). Cargo holds are of the standard configuration and must be unloaded with clamshell buckets from cranes. To remove the last amounts of cargo from the holds, small front-end loaders (bobcats) actually are placed down inside the cargo holds to move material from the sides and corners of the hold to the center where it is accessible to the clamshells.

Foreign-flag vessels handle only a small portion of the Great Lakes bulk carrier trade. According to U.S. Army Corps of Engineers (USACE) data and discussions with LCA, foreign-flag vessels generally bring finished steel products into the Great Lakes (which does not involve dry cargo residue) and then load primarily grain as the export cargo for the return trip. It is estimated that the foreign-flag bulk carrier fleet consists of roughly 12–20 vessels, making approximately 350 trips with grain per year (as compared, for example, with over 5,000 U.S. shipments of iron ore).

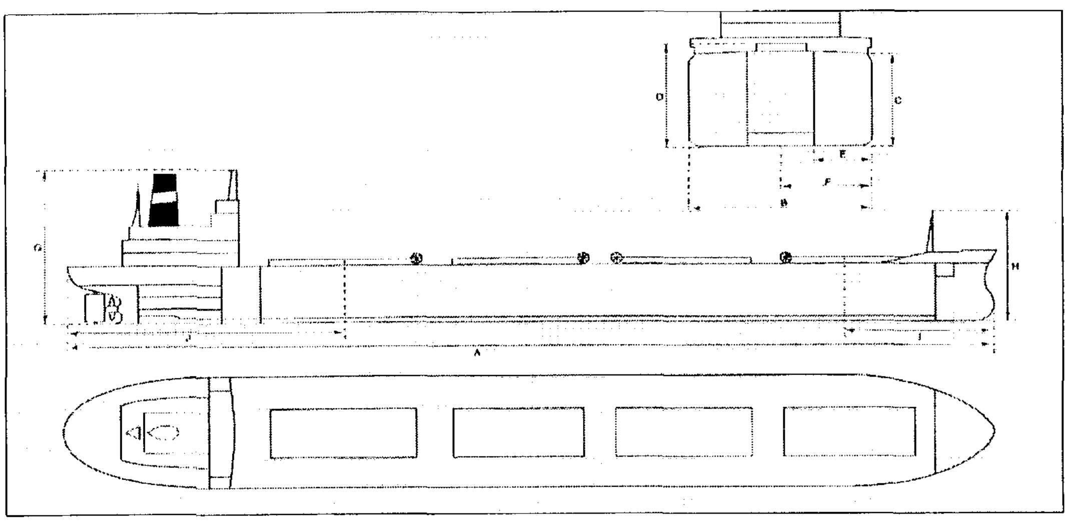

Figure 2.3 Drawing Showing the Basic Configuration of a Conventional (Non Self-Unloading) Bulk Carrier (e.g., 56,900-DWT CSL Vessel FERBEC).

2.2 Commodities Transported, Points of Origin, and Destinations

Background information about commodities transported as bulk dry cargo in the Great Lakes was obtained from the 1993 National Oceanic and Atmospheric Administration (NOAA)/Great Lakes Environmental Research Laboratory (GLERL) workshop proceedings (Reid and Meadows, 1999), the 1993 Canadian Coast Guard (CCG) study (Melville Shipping, 1993), and a pamphlet produced by the LCA, as well as the association's Web site (*http://www.lcaships.com/*). Specific details of 1999 Great Lakes commodity movement associated with U.S. ports and waterways was obtained from the USACE report "Waterborne Commerce of the United States" (USACE, 1999).

A total of 165.5 million net tons of dry bulk cargo moved on the Great Lakes during the 2001 navigation season, a decrease of 6.7% compared to 2000. As always, U.S.- and Canadian-flag tankers carried the vast majority of these cargos. Third-flag participation in the reported trades was again limited almost exclusively to the export grain trade. Table 2.4 shows the total tonnage of cargo moved within the Great Lakes by LCA and CSA vessels combined from 1997 to 2001. As indicated in the Table 2.4, tonnages by commodity have remained relatively constant except for the notable decrease in iron ore tonnage from 2000 to 2001.

Table 2.4 Bulk Cargo Tonnages Transported on the Great Lakes 1997–2002.

Commodity	2001	2000	1999	1998	1997
Iron Ore					
From Lake Superior	41,351,806	49,809,596	49,141,455	52,364,958	54,462,824
From Lake Michigan	5,937,047	7,350,464	7,970,571	7,842,835	6,383,103
From Eastern Canada	8,570,932	10,904,848	11,669,537	12,154,804	11,153,177
Total Iron Ore	55,859,785	68,064,908	68,781,563	72,362,597	71,999,104
Coal					
From Lake Superior	18,422,317	17,197,300	17,277,532	16,812,688	16,085,063
From Lake Michigan	2,605,338	2,363,983	2,546,297	2,296,314	2,418,608
From Lake Erie	22,727,498	23,713,938	21,281,005	22,529,725	22,005,155
Total Coal	43,755,153	43,275,221	41,104,834	41,638,727	40,508,826
Stone					
From U.S. Ports	30,019,426	30,941,329	31,820,724	35,022,458	33,813,235
From Canadian Ports	7,105,451	7,111,363	6,592,338	5,996,201	5,326,505
Total Stone	37,124,877	38,052,692	38,413,062	41,018,659	39,139,740
Salt	8,626,348	6,710,614	7,032,755	8,424,230	8,386,689
Cement	5,548,658	5,350,000	5,596,738	5,621,150	5,400,329
Potash	563,882	688,858	606,014	801,829	767,400
Grain	14,011,286	15,099,337	15,866,884	15,585,978	16,648,744
Total	**165,489,989**	**177,241,630**	**177,401,850**	**185,453,170**	**182,850,832**

Source: 1999 U.S. Army Corps of Engineers data. To convert iron ore to gross tons, multiply by 0.89286.

A more detailed breakdown of dry cargo movement in and out of individual ports can be obtained by analyzing 1999 USACE data on U.S. waterborne commerce. Data from 1999 were used in the analysis as these are the most recent data available. Table 2.5 provides a breakdown to tonnages loaded and unloaded in U.S. ports by commodity based on 1999 USACE data. The U.S. Great Lakes principal bulk dry cargo commodities are iron ore, coal, and limestone. Together, these accounted for 85% of the U.S. Great Lakes dry cargo loading and unloading in 1999. The commodity counts include the total amount of dry cargo loaded and unloaded at U.S. Great Lakes ports. This results in "double counting" shipments that both start and end in the United States. However, since residues are produced and washed overboard in both the loading and unloading processes, this double counting is considered relevant to determining the amount of cargo residue being discharged.

The five U.S. ports with the most dry cargo shipping activity are shown in Table 2.6. These ports all handle a wide variety of cargo types and represent about 35.5% of the total commodity traffic. One-third to one-half of the iron ore, coal, cement, metals, and salts, as well as most of the minerals, grain, coke, and fertilizer, are moved through these ports. Most of the limestone, gypsum, and slag are handled in other ports. Many other ports handle a large quantity of one or two commodities. The 1999 loading and unloading port and amounts for the top three commodities are given in Tables 2.7 (iron ore), 2.8 (coal), and 2.9 (limestone).

Table 2.5 1999 Commodity Totals (Thousand Tons) for U.S. Loading and Unloading.

Commodity	Load	Unload	Total	%
Iron Ore	56,109	62,421	119,530	41.9
Coal	40,727	21,229	61,956	21.7
Limestone	33,085	27,010	60,095	21.0
Minerals	3,867	11,176	15,043	5.2
Cement	3,520	6,977	10,497	3.7
Grain	8,730	1,000	9,730	3.4
Coke (coal and petroleum)	1,999	1,476	3,475	1.2
Gypsum	1,045	1,051	2,096	0.7
Slag	1,001	909	1,910	0.6
Metals	376	658	1,034	0.3
Salts (inorganic and metallic)	290	312	602	0.2
Fertilizer	16	377	393	0.1
Total	**150,765**	**134,596**	**285,361**	**100.0**

Source: 1999 U.S. Army Corps of Engineers data.

Table 2.6 1999 Commodity Activity (1,000 Tons) in Five Major U.S. Great Lakes Ports.

Port	Load	Unload	Total	%
Superior/Duluth	38,235	3,930	42,165	14.83
Chicago	7,204	11,271	18,475	6.50
Detroit	241	14,573	14,814	5.21
Cleveland	1,565	12,595	14,160	4.98
Toledo	6,828	4,564	11,392	4.00
Total	**54,073**	**46,933**	**101,006**	**35.50**

Table 2.7 1999 Iron Ore Activity (1,000 Tons).

Port	Load	Unload	% of Commodity
Superior/Duluth	16,440	—	13.75
Detroit	67	7,024	5.93
Cleveland	349	6,522	5.75
Chicago	55	3,039	2.59
Toledo	—	3,101	2.60
Two Harbors	11,872	—	9.93
Silver Bay	4,407	—	3.68
Taconite Harbor	7,722	—	6.46
Esconaba	7,572	—	6.33
Presque Island	7,625	—	6.37
Indiana Harbor	—	11,363	9.50
Gary	—	8,310	6.95
Burns Harbor	—	5,707	4.77
Lorain	—	12,168	10.17
Ashtabula	—	3,586	3.00
Conneaut	—	2,583	2.16
Total	**56,109**	**63,421**	**99.94**

Source: 1999 U.S. Army Corps of Engineers data.

Table 2.8 1999 Coal Activity (1,000 Tons).

Port	Load	Unload	% of Commodity
Superior/Duluth	16,412	76	26.61
Detroit	—	1,785	2.88
Cleveland	—	91	0.15
Chicago	2,091	1,104	5.16
Toledo	5,060	—	8.17
Sandusky	4,772	—	7.70
Ashtabula	5,791	—	9.35
Conneaut	5,255	—	8.48
Presque Island	—	1,734	2.80
Milwaukee	—	1,154	1.86
Muskegan	—	1,286	2.07
St. Clair	—	5,298	8.55
Monroe	—	1,711	2.76
Total	**39,381**	**14,239**	**86.54**

Source: 1999 U.S. Army Corps of Engineers data.

Table 2.9 1999 Limestone Activity (1,000 Tons).

Port	Load	Unload	% of Commodity
Superior/Duluth	27	2,939	4.93
Detroit	22	3,113	5.22
Cleveland	30	3,966	6.65
Chicago	—	1,021	1.70
Toledo	143	14	0.26
Port Island	5,536	—	9.21
Drummond Island	1,668	—	2.78
Calcite	8,949	—	14.89
Stoneport	8,789	—	14.62
Marblehead	3,042	—	5.06
Port Dolomite	3,065	—	5.10
Buffington Harbor	—	1,498	2.49
Burns Harbor	—	708	1.18
Fairport Harbor	—	1,918	3.19
Kelly Island	—	1,080	1.80
Ashtabula	—	604	1.01
Conneaut	—	769	1.28
Erie	—	751	1.25
Total	**31,271**	**18,381**	**82.62**

Source: 1999 U.S. Army Corps of Engineers data.

Discussions with the LCA indicate that the trade patterns and routes followed by the Great Lakes bulk carrier fleet are fairly well-defined and do not vary significantly within a season or from year to year; however, the amounts of some commodities vary from year to year. The Table 2.10 shows commodity data (thousand tons) from the LCA for the last 3 years compared with the 1999 USACE data (the most recent year for which these data are available). Also included are the 1999 CSA data showing commodities on all Canadian-flag ships to all ports. The last two rows show the breakout of U.S. port exports and imports to/from first Canada then other foreign ports.

Table 2.10 Commodity Activity (1,000 Tons) Comparison.

Iron Ore	Coal	Limestone	Salt	Grain	Source
117,566	61,956	60,095		9,730	1999 USACE (all flag)
53,183	21,969	28,392	1,310	347	1999 LCA (U.S. flag)
53,243	21,108	27,933	838	351	2000 LCA (U.S. flag)
44,183	21,394	27,334	876	351	2001 LCA (U.S. flag)
20,444	17,918	11,188	5,947	9,266	1999 CSA (Canadian flag)
8,274	19,581	3,336		4,189	1999 COE (all flag) to/from Canadian ports
—	61	—		3,599	1999 COE (all flag) to/from foreign ports

USACE = U.S. Army Corps of Engineers, LCA = Lake Carriers Association, CSA = Canadian Shipowners Association.

Note that the USACE data represent all commodities loaded and unloaded at U.S. ports (except for salt, which is not available from the USACE data), while the LCA data represent only those commodities carried by LCA members. All "Jones Act" trade (U.S. port to U.S. port) will be double counted in the USACE data. The CSA data represent all the commodities transported by its members. According to its Web site (*http://www.shipowners.ca/*), about 29% of the Canadian trade is in the Great Lakes (whereas all LCA trade is in the Great Lakes). Although there are no complete data showing which flag vessels carry exactly how much of each commodity between which ports, this table gives a fairly good picture of the breakdown of the commodity trade.

Figures 2.4 and 2.5 show the originating and destination ports for bulk cargos transported to and from U.S. Great Lakes ports. According to the LCA, some vessels, particularly the 1,000-foot vessels, will travel a set route with only a limited selection of cargos. Other smaller vessels will "tramp"—that is, move from port to port, loading and unloading cargos of opportunity. This also is the practice followed by many Canadian vessels. Vessels transiting the Great Lakes generally follow specific tracklines as delineated on Great Lakes navigational charts such that dry cargo residue discharges are concentrated in these tracklines.

2.3 Destinations and Economic Significance of Bulk Cargos

Approximately 80% of the cargos carried by U.S.-flag bulk carriers are destined for a Great Lakes Basin steel mill. The Great Lakes states account for more than 70% of the nation's steel-making capacity. Indiana is the largest steel-producing state in the nation. Ohio is ranked second in terms of production. Great Lakes steel mills employ approximately 90,000 men and women. The production of 1 ton of steel requires roughly 1.3 tons of iron ore, plus quantities of fluxstone (limestone) and coal. U.S.-flag bulk carriers carry iron ore mined in Minnesota and Michigan. These mines generate direct employment for roughly 8,000 men and women.

Limestone (fluxstone and aggregate) for the steel and construction industries is one of the Great Lakes' "big three" cargos. Fluxstone is used as a purifying agent in the steel-making process. Aggregate is used in a number of ways—as a base for highways and in other construction projects. Seven of the eight U.S. stone-loading ports are located in Michigan; the eighth is in Ohio. The construction industry also relies on U.S.-flag bulk carriers to deliver cement loaded in Alpena and Charlevoix, Michigan to distribution terminals on all five Lakes.

Coal for power generation is the third largest commodity carried by U.S.-flag bulk carriers. The coal trade is divided into two segments. Eastern coal is mined in West Virginia, eastern Kentucky, Pennsylvania, Ohio, and Illinois. Western coal is mined in Montana and Wyoming. Power-generating plants are found on all five Great Lakes.

The bulk cargo trade is therefore an integral part of the Great Lakes economy, as well as the U.S. and Canadian national economies. The steel in cars; the coal that produces the electricity that lights homes and powers industrial machinery; the stone for roads, building construction, and landscaping; the salt that deices roads in winter; the wheat for food products; the heating oil that heats homes, schools, and businesses—all these products and more crisscross the Great Lakes safely and efficiently.

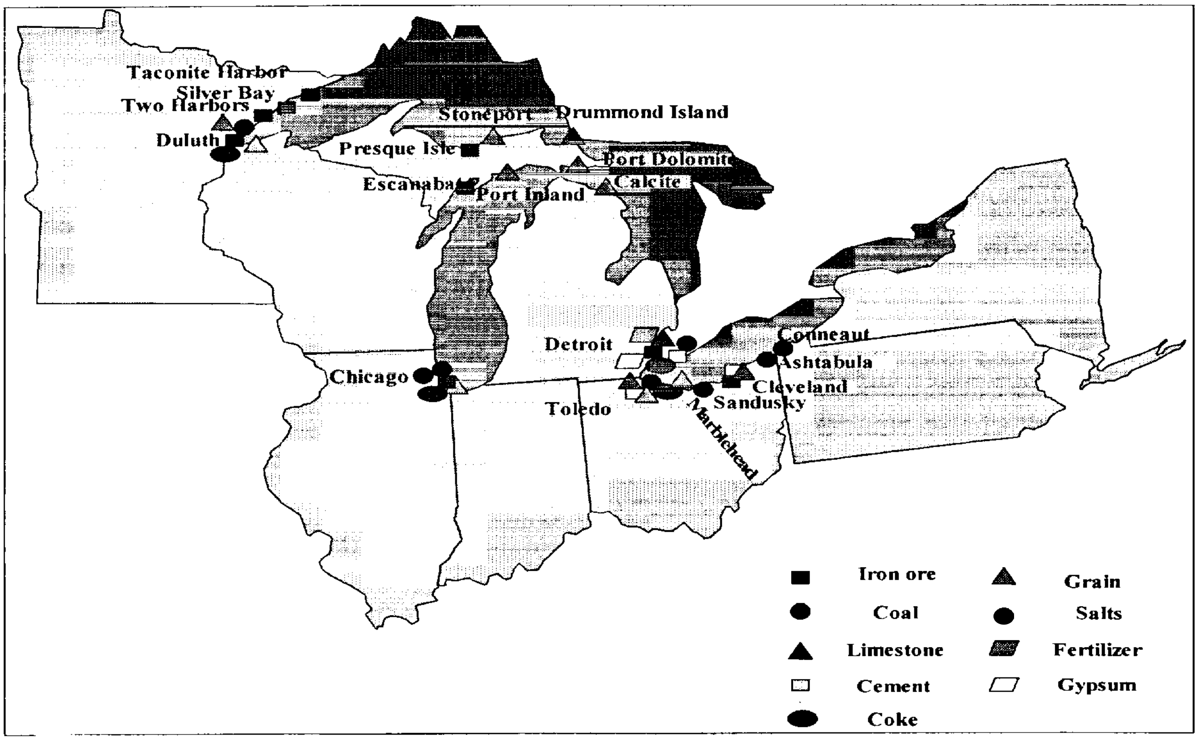

Figure 2.4 Origin (Loading) Ports for U.S. Great Lakes Bulk Cargos.

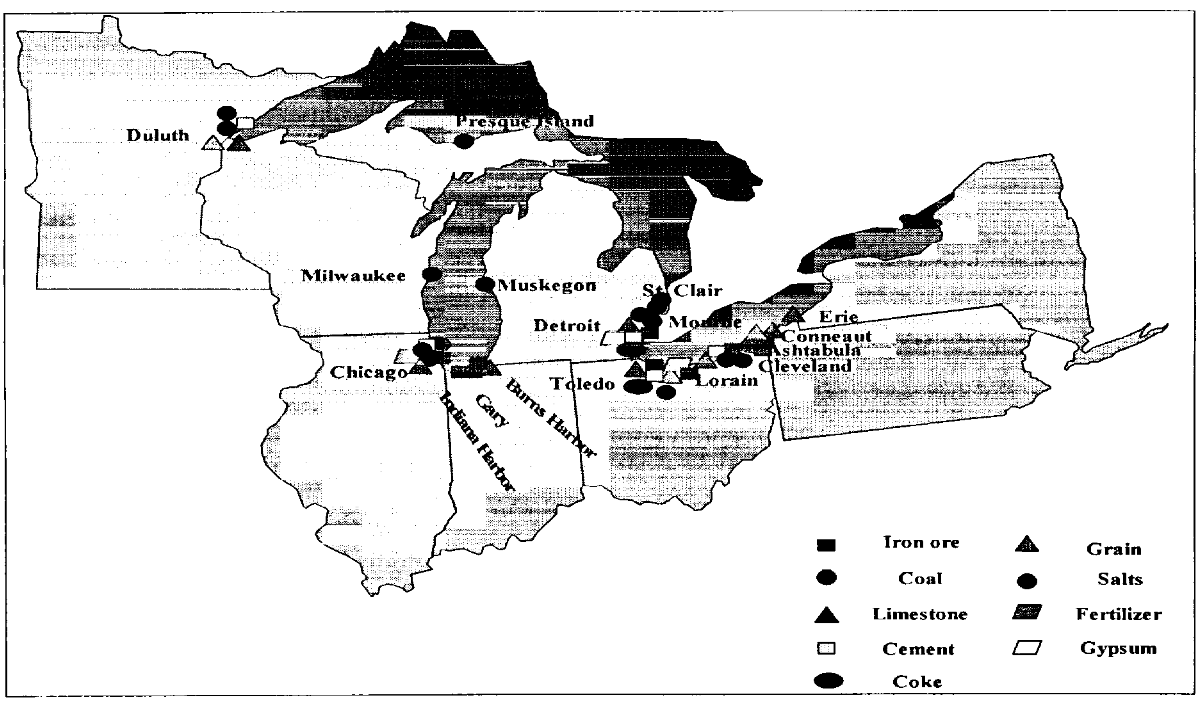

Figure 2.5 Destination (Unloading) Ports for U.S. Great Lakes Cargos.

However, in recent years the bulk carrier industry has faced challenges that require constant adaptation to make the dry cargo transport more efficient. Vessels have grown in size and complexity, loading and unloading operations have been mechanized and automated, and schedules have been tightened so that time spent at the terminal is minimized absolutely. Any delays in loading, unloading, and transit severely jeopardize the fiscal integrity of a company's operation. The situation is further complicated by reduced crew size and shortages of professional mariners to serve aboard the vessels. Consequently, the bulk carrier industry has become a finely tuned and complex enterprise that constantly must meet the challenges of a fluctuating market and numerous regulatory mandates, while maintaining its revenue stream to stay in business.

2.4 References

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3.0 ANALYSIS OF INTERNATIONAL CONVENTIONS, LAWS, REGULATIONS, AND POLICY

3.1 Background

In 1987, the United States adopted Annex V of MARPOL 73/78, Regulations for the Prevention of Pollution by Garbage from Ships (MARPOL V). MARPOL V prohibits the discharge of plastics anywhere in the ocean, and specifies areas for the allowable discharge of "garbage," including domestic and operational waste generated during the normal operation of a ship. The Act to Prevent Pollution from Ships (APPS) adopted Annex V and made the various provisions of MARPOL V legally binding in the United States. In 1988, the International Maritime Organization/Marine Environmental Protection Committee (IMO/MEPC) issued more detailed Guidelines for the Implementation of MARPOL V, which specified that "operational wastes" included "cargo residues." Cargo residues were defined as "remnants of any cargo material on board that cannot be placed in proper cargo holds (loading excess and spillage) or which remain in cargo holds and elsewhere after unloading procedures are completed (unloading residual and spillage)." APPS provisions were incorporated in U.S. Coast Guard (USCG) regulations in 1990 that prohibit the discharge of all garbage in the internal waters of the United States, including the Great Lakes (33 CFR Part 151).

As such, the provisions for disposal of cargo residue clearly applied to discharges of what is commonly called "cargo sweepings" by bulk cargo carriers in the Great Lakes. Cargo sweepings are residues of bulk dry cargo including iron ore, coal, coke, salt, grain, stones, gravel, sand, clay, slag, wood, fertilizers, etc. found in holds, cargo tunnels, machinery, or on deck after loading and loading. The common longstanding practice in the Great Lakes has been to wash down decks, cargo holds, and other spaces as necessary after loading/unloading and to discharge the water and residual material overboard.

Enforcement of the APPS and 33 CFR Part 151 became problematic in the Great Lakes immediately. Under the MARPOL V regime as applied to oceangoing vessels, cargo residues would be retained onboard until the vessel was beyond the 12-mile limit from shore as measured from the baseline from which the territorial sea is measured. There material could be discharge immediately over the side. However, for dry bulk carriers on the Great Lakes, this is not possible since the Lakes are completely within internal waters of the United States or Canada. Strictly interpreted, the APPS provisions make the Great Lakes a "no discharge zone" for U.S. carriers operating anywhere in the Lakes and foreign-flag vessels operating in U.S. waters. Whether this was intended under the APPS or was a legislative oversight is not entirely clear. However, the latter might be suspected since the MARPOL V Guidelines specifically define operational wastes as including cargo residues following the passage of the APPS.

This placed the U.S. Coast Guard (and more specifically the Ninth District) in a difficult situation. From a strict legal and environmental perspective, cargo residue discharges could be considered as prohibited anywhere in the Great Lakes. From a practical standpoint, imposition of a strict "no discharge" standard on the Great Lakes bulk carriers placed a significant burden on industry. Bulk carriers are large vessels, comparable in size to other oceangoing vessels, that essentially are landlocked for the purposes of MARPOL V.

Implementing a "no discharge" provision for these vessels would require that all material be recovered after loading and unloading, and transferred to shore. This poses a severe challenge for the industry both operationally and logistically because of the size of the vessels, complexity of the cargo holds and deck configuration, limited crew size, and lack of shoreside transfer and reception capabilities.

In an attempt to strike a balance between environmental protection and sustaining commerce on the Great Lakes while following the overall intent of MARPOL V and the APPS, in 1993 the Ninth District developed an "interim enforcement policy" that allowed the discharge of cargo residues at a distance of 12 miles from shore, and closer to shore in cases where there would be no imminent environmental effects and where operational considerations required a modification of the 12-mile limit. This policy was promulgated as Ninth District Instruction 16460.1 of 22 September 1993.

Although the Ninth Coast Guard District (CGD9) Policy provided a workable interim solution to the problem, there were concerns on the part of the Ninth District over the legal integrity of the policy and its viability in light of potential long-term environmental impacts of dry cargo discharges. To help resolve the environmental issue, the Ninth District requested National Oceanic and Atmospheric Administration (NOAA) Great Lakes Environmental Research Laboratory (GLERL) to form an *ad hoc* Scientific Steering Committee to review the information available on the issue and advise the Ninth District on the environmental implications and effectiveness of the existing policy.

In August 1994, the Scientific Steering Committee found that the enforcement policy was for the most part environmentally sound, but made various recommendations to adjust the enforcement zones based on the nature of specific material discharged and various ecological considerations. The committee noted that for most cargos, the 12-mile enforcement zone was not an environmental necessity, except in specific areas to protect sensitive habitats and spawning areas. A workshop was subsequently convened, in collaboration with other U.S. and Canadian agencies, as well as industry and private stakeholders, to investigate the environmental impact of cargo residue discharges on the Great Lakes. This workshop produced recommendations for longer-term monitoring and research on the impact dry cargo residue discharges (as outlined above in Section 1.3.2)

The results of the Scientific Steering Committee review and the 1993 NOAA/GLERL workshop provided better environmental insight on the issue and led to refinement of the enforcement policy in a revised CGD9 Instruction 16460.1A of 1 March 1995.

This revised policy delineated the enforcement zones for each Great Lake, by specific cargo, using distance from shore criteria and with specific areas of particular concern designated by latitude and longitude. It further defined USCG implementation actions in terms of surveillance, violation reporting, and investigation.

Although the environmental issues had been dealt with in some measure, the legal issues remained. The Ninth District continued to be concerned about the contradiction between its enforcement policy and the mandates of the APPS and the Clean Water Act (CWA), which at face value prohibited such discharges in the Great Lakes, and other internal waters of the United States. Consultations with the Office of the Chief Counsel at USCG Headquarters indicated that there was no readily available legal interpretation that could resolve the issue. Accordingly, an Interagency Task Group consisting of the U.S. Coast Guard, NOAA, U.S. Environmental Protection Agency (EPA) and U.S.

Department of Justice (DOJ) was formed to develop a regulatory strategy that would somehow reconcile the dry cargo residue issue for Great Lakes and other U.S. internal waters.

The strategy ultimately proposed called for regulation of dry cargo discharges in internal waters of the United States under the CWA rather than the APPS through the development of a regional (or model) National Pollution Discharge Elimination System (NPDES) permit that could be adopted and tailored on a region-by-region and state-by-state basis to deal with the dry cargo issue. The primary advantage of the CWA/NPDES approach was that it would be legally sound and would fully address regional and state concerns (a key concern of the EPA in discharging its responsibilities under the CWA). The main disadvantage would be subjecting the shipping industry to a multiple jurisdiction/multiple permit system. It also departed from the practice of the U.S. Coast Guard taking the lead in management and enforcement of marine environmental compliance regulations impacting the shipping industry. This proposal was referred to as the Administrations Proposal in the ensuing discussions and debate.

This proposal clearly was not favored by the shipping industry as represented by the Lake Carriers Association (LCA), which in turn petitioned Congress to resolve the issue through direct legislative action. This produced Section 415 of H.R. Bill 2204 (the Glenn Amendment), which essentially exempted dry cargo discharges from the APPS provisions for the Great Lakes. This solved the problem from the LCA's perspective but set a precedent for piecemeal amendments to environmental legislation, and did not address the issue of discharges in other internal waters of the United States.

From the standpoint of the U.S. Coast Guard, neither position was entirely satisfactory. The Glenn Amendment was considered flawed because it only dealt with the Great Lakes and was not favored by the EPA and DOJ. As for the Administrations Proposal (CWA/NPDES approach), USCG Headquarters (G-MSO/G-LMI) originally supported the strategy but then reversed its position during the period January–February 1998 in favor of the traditional approach of having the U.S. Coast Guard regulate vessel marine environmental compliance matters as a separate program from NPDES. It should be noted that as the debate over how to proceed on dry cargo residues ensued, the U.S. Coast Guard ceased publishing the policy as a District Instruction and instead promulgated the policy as a Notice to Mariners.

In the end, Congress deferred on the Glenn Amendment by essentially referring the issue back to the U.S. Coast Guard in the FY1998 and subsequently FY2000 Omnibus Appropriation (Section 1117), which charges the U.S. Coast Guard to continue the current enforcement policy (until 2004) and conduct a study that will form the basis for developing regulations "to implement and regulate incidental discharges from vessels of residues of non-hazardous and non-toxic dry bulk cargos into waters of the Great Lakes." This outcome has tasked the U.S. Coast Guard specifically with resolving what appears to complex issue, but also reaffirms the USCG lead agency role in developing and implementing marine environmental compliance regulations specific to the shipping industry. Interestingly, the mandate in Section 1117 does not address dry cargo residue discharges for internal waters other than the Great Lakes.

3.2 Analysis of Laws and Regulations

In view of the complexities of the situation as outlined above, it is not expected that a review of the current laws, regulations, and policy regarding dry cargo discharges will offer an obvious and clear-cut resolution to the issue. However, in formulating a regulatory solution to the problem, it is necessary that these regulations be as consistent as possible with current laws, regulations, and policy, and that any ambiguities be investigated and discussed fully so that the final logic behind the regulatory development process is clear. Accordingly, the following analysis carefully will review all international conventions, U.S. and Canadian laws and regulations, and state and agency agreements and policies that are relevant to the dry cargo issue. The review of international conventions is appropriate in that shipment between ports on the Great Lakes often involves international commerce between the United States and Canada. For the same reason, the laws and regulations of both countries must be investigated to ensure that there is reasonable harmony between the two. Regional and state policies will be investigated since various regional federal and state agencies are stakeholders in implementing, monitoring, and enforcing marine pollution prevention regulations applicable to the Great Lakes. Dry cargo vessels operate in various coastal waters, ports, and harbors that fall under state jurisdictions and programs.

3.2.1 International Conventions

There are two major international conventions that are relevant to the dry cargo residue issue:

- The Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, 1972, as amended (known as the London Convention)
- The International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto (known as MARPOL 73/78)

Consideration and discussion of these two conventions is warranted as they reflect the philosophy, strategy, and priorities of the international community, and in many cases form the basis of legislation at the national level.

The London Convention came into force on 30 August 1975 with the IMO being designated as the responsible Secretariat. This convention prohibits the dumping of certain hazardous materials, and requires a prior special permit for the dumping of various other specific materials and a general permit for other wastes and matter. "Dumping" in the context of the London Convention refers to the deliberate disposal of wastes and other matter from vessels, aircraft, platforms, or other man-made structures. Over the years restrictions on the type of materials that can be dumped have become tighter. In 1993, the convention was amended to prohibit the dumping of low-level radioactive wastes and industrial wastes (phased out by 31 December 1995), and to prohibit incineration of wastes at sea. In 1996, the London Convention was further strengthened by adoption of the "precautionary approach," which requires that "appropriate preventative measures be taken when there is reason to believe that wastes or other matter introduced into the marine environment are likely to cause harm even when there is no conclusive evidence to prove a causal relation between inputs and their effects." In general, the convention now prohibits dumping of any wastes or other matter with the exception of the following:

- Dredged material
- Sewage sludge
- Fish waste
- Vessels, platforms, and man-made structures
- Inert, inorganic geological material
- Organic material of natural origin
- Bulky items on unharmful material when shoreside disposal is impracticable

With regard to dry cargo residue discharges, three concepts within the London Convention appear relevant. First, the international consensus is that dumping of these materials should not be undertaken if there is a reasonable (albeit unproven) suspicion that they are harming the environment—that is, a conservative approach should be taken. Second, it is noted that the dumping of inert, inorganic geological material and organic material of natural origin is permitted assuming the criteria of a precautionary approach are met. Thirdly, and most importantly, the primary focus of the London Convention is the deliberate dumping of materials in the ocean as a disposal alternative to landside management or disposal. There appears to be some questions as to whether the incidental discharge of dry cargo constitutes dumping in the context of the London Convention.

MARPOL is the primary international convention covering prevention of the marine environment by ships from operational or accidental causes. It is a combination of two treaties adopted in 1973 and 1978, and has been updated throughout the years (hence MARPOL 73/78). MARPOL addresses pollution by oil, chemicals, harmful substances in packaged form, sewage, and garbage as covered in the five annexes of the convention. Another annex dealing with air pollution is under development.

Annex V of MARPOL specifically addresses the issue of garbage and various solid wastes that are discharged at sea as part of a ships general operation or by accident. The general provisions of Annex V govern the discharge of garbage from vessels in two general geographical locations: inside special areas and outside of special areas. **Discharge** (as specified in the Annex V Guidelines for Implementation) means release, howsoever caused, including escape, disposal, spilling, leaking, pumping, emitting, or emptying. **Garbage** includes all kinds of victual, domestic, and operational waste generated during the normal operation of the ship. A **special area** is a sea area where, for recognized technical reasons in relation to its oceanographic and ecological condition and the particular character of its traffic, the adoption of special mandatory methods for the prevention of pollution are required. The specific provisions of MARPOL V are provided in Table 3.1.

With regard to the discharge of operational wastes, further clarification is provided in the Guidelines for the Implementation of Annex V first promulgated in 1988. These guidelines more specifically define operational waste as "all cargo-associated waste and maintenance waste, and cargo residues defined as garbage in Section 1.7.10." Section 1.7.10 more specifically define cargo residues as "remnants of any cargo material that cannot be placed in proper cargo holds (loading excess and spillage) or which remain in cargo holds or elsewhere after unloading procedures are completed (unloading residual and spillage)". Section 1.7.10 also states that "cargo residues are expected to be in small quantities."

Table 3.1 Summary of At-Sea Garbage Disposal Regulations for Vessels.

Garbage Type	All Vessels Except Platforms	
	Outside Special Areas	Inside Special Areas
Plastics including synthetic ropes, fishing nets, and plastic garbage bags	Disposal prohibited	Disposal prohibited
Floating dunnage, lining, and packing materials	> 25 miles offshore	Disposal prohibited
Paper, rags, glass, metal, bottles, crockery, and similar refuse	> 12 miles offshore	Disposal prohibited
All other garbage including paper, rags, glass, etc. comminuted or ground	> 3 miles offshore	Disposal prohibited
Food waste not comminuted or ground	> 12 miles offshore	Disposal prohibited
Food waste comminuted or ground	> 3 miles offshore	> 12 miles offshore

Source: Annex V of MARPOL 73/78, Regulations for the Prevention of Pollution by Garbage from Ships (MARPOL V).

The management and minimization of cargo residues is addressed in Section 3.4 of the Guidelines for the Implementation of Annex V, which recognizes that "cargo residues are created through inefficiencies in loading, unloading and on-board handling." Section 3.4.1 acknowledges that "in certain cases it may be difficult for port reception facilities to handle such residues. It is therefore recommended that cargo be unloaded as efficiently as possible in order to avoid or minimize cargo residues." Section 3.4.2 further recommends that "spillage of the cargo during transfer operations should be carefully controlled, both on board and from dockside. Since this spillage typically occurs in port, it should be completely cleaned up prior to sailing and either delivered to the intended cargo space or into a port reception facility. Shipboard areas where spillage is most common should be protected such that residues are easily recovered."

With regards to dry cargo discharges in the Great Lakes, three concepts in MARPOL V and the Guidelines for the Implementation of Annex V are noteworthy. First, dry bulk cargo residues fall squarely within the purview of MARPOL V, while it is questionable as to whether provisions of the London Convention apply. Second, the Guidelines for the Implementation of Annex V clearly call for the minimization of these discharges through clean up in port, even for vessels that subsequently proceed to the open ocean where discharge is unrestricted. Thirdly, although the guidelines state that discharge of dry cargo residues should be minimized and avoided to every extent possible, it recognizes the need for reception facilities to accomplish this, and stops short of a no discharge declaration.

3.2.2 U.S. Laws and Regulations

There are two U.S. laws (and their accompanying regulations) that are relevant to dry cargo discharge: APPS, which implemented MARPOL V and CWA, which is the fundamental U.S. law governing water pollution in the United States. A third law, the Ocean Dumping Act (ODA), has some relevance to the overall problem of dumping material into the ocean but does not apply specifically to the Great Lakes. Several other laws and regulations are relevant to establishing the USCG traditional role as lead agency in implementing, monitoring, and enforcing marine environmental compliance regulations in the United States. Each of these three main U.S. laws will be discussed in terms of overall intent; jurisdiction by location; applicability to dry cargo residues as a pollutant; and provisions for implementing, permitting, monitoring, and enforcing. Other laws and regulations will be discussed as they relate to the dry cargo discharge issue.

Act to Prevent Pollution from Ships (APPS), 33 USC Chapters 1901 and 1902

As stated previously, the APPS is the U.S.-implementing legislation for MARPOL 73/78. It tasks the Secretary of Transportation and hence the U.S. Coast Guard with implementing all provisions of MARPOL 73/78. In 1987, APPS was amended by the Marine Plastic Pollution Research and Control Act, which implemented the various provisions of MARPOL V. In terms of jurisdiction, the APPS covers all U.S. vessels and foreign vessels operating in U.S. waters. Hence, this law applies to all vessels, seagoing or not, operating in U.S. waters. Geographically it includes both the internal navigable waters of the United States, the contiguous zone, and the Exclusive Economic Zone (EEZ). In terms of pollutants addressed, it covers garbage as defined in MARPOL V, which encompasses operational wastes and hence dry cargo residues as per the Annex V Guidelines. Restrictions on the discharge of garbage and other materials are the same as those in Annex V, with exceptions for U.S. military vessels. It also covers U.S. ports and terminals for the purposes of addressing reception facilities as prescribed by the various annexes of MARPOL 73/78.

USCG implementation, monitoring, and enforcement activities are covered under 33 CFR Part 151, which addresses recordkeeping requirements, waste management plans, placards, and other compliance provisions. The provisions in 33 CFR 151.51–151.77 do not contain any exceptions for dry cargo residues or the discharge of such materials in the Great Lakes. According to the provisions of 33 CFR Part 151, discharge of dry cargo residues is prohibited at distances less than 12 nautical miles from land and in navigable waters of the United States. *Hence, as currently written, APPS and 33 CFR Part 151 only can be interpreted to prohibit the discharge of dry cargo residues in U.S. waters of the Great Lakes. In Canadian waters of the Great Lakes, U.S. vessels would be prohibited from discharging any closer than 12 miles from shore. This, of course, is the genesis of the dry cargo residue controversy.*

Clean Water Act (CWA), 33 USC 1521 et seq.

The Federal Water Pollution Control Act (FWPCA) as amended, also called the CWA as amended, is the most comprehensive water pollution control legislation under U.S. law. The CWA establishes the basic scheme for restoring and maintaining the chemical, physical, and biological integrity of the nation's waters. Its longer-term goal is the elimination of all pollutant discharges into U.S. waters. Under Section 1362, garbage is included as a pollutant although the CWA does not mention cargo residues specifically.

The primary water pollution management, control, and elimination mechanism from the CWA is the NPDES, under which a permit is required from the EPA or an authorized state for discharge of any pollutant from a point source or non-point source into U.S. waters. Initially, NPDES permits were applied only to point source, effluent-type pollutant discharges. These discharges were permitted and managed through effluent standards and technology-based control measures. In more recent years, the NPDES permit has been applied to various other sources, including municipal and industrial storm runoff, runoff from construction sites, and pollution from aquaculture and silvaculture sites to name a few. Generally, these non-point-source discharges are managed through a best management practice (BMP) approach as opposed to an effluent standard and technology-based control measure. The NPDES program has become the default permitting mechanism for water pollutant discharges in the United States in the absence of other provisions.

However, in the case of pollutant discharges from vessels, the CWA generally defers to the U.S. Coast Guard for regulation, monitoring, and enforcement, which is accomplished through the so-called exclusion clause. Specifically, NPDES regulations (40 CFR 122.3(a)) exclude the following from NPDES requirements:

> "Any discharge of sewage from vessels, effluent from properly functioning marine engines, laundry, shower, and galley sink wastes, or any other discharge incidental to the normal operation of a vessel. This exclusion does not apply to rubbish, trash, garbage, or other such materials discharged overboard; nor to other discharges when the vessel is operating in a capacity other than as a means of transportation such as when used as an energy or mining facility, a storage facility or a seafood processing facility, or when secured to a storage facility or a seafood processing facility, or when secured to the bed of the ocean, contiguous zone or waters of the United States for the purpose of mineral or oil exploration or development."

This exclusion was first promulgated on 22 May 1973. Section 402 of the CWA establishes the NPDES permit program to regulate the discharge of pollutants from point sources to waters of the United States. While the CWA defines the term "point source" to include a "vessel or other floating craft," it distinguishes vessels from other point sources in several respects.

First, the discharge of sewage from vessels is regulated under a separate, non-NPDES program. The CWA's definition of "pollutant" expressly excludes "sewage from vessels" within the meaning of Section 312. Section 312 in turn, defines "sewage" to mean "human body wastes and the waste from toilets and other receptacles intended to receive or retain body wastes except that, with respect to commercial vessels on the Great Lakes, such term shall include gray water." Hence, wastewater discharges from vessels are considered excluded from the NPDES program within the Great Lakes.

Second, the CWA defined "discharge of a pollutant" to include: "(A) any addition of any pollutant to navigable waters from any point source, (B) any addition of any pollutant to the waters of the contiguous zone or the ocean from any point source *other than* a vessel or other floating craft." Hence, in coastal areas of the United States, the CWA would not apply to vessels beyond 12 miles from shore, and APPS would be the sole law governing operational discharges. The U.S. waters of the Great Lakes are, of course, considered navigable waters.

Taken together, the language and concepts embodied within the CWA exclusionary clause pose additional complications when dealing with dry cargo residue discharges from vessels. Clearly there is support for the notion that vessels are a separate point-source category under the CWA with routine operational discharges excluded from the NPDES program. However, the language of the exclusionary clause indicates that "rubbish, trash, and garbage" are not excluded from the NPDES program. From a strictly legal perspective, the pivotal issue is where dry cargo residue discharges fall in the context of the CWA. Are they operational discharges, particularly when the residues are contained in a water stream, similar to sewage and gray water discharges? Or are they to be considered a subset of garbage discharges consistent with the language in MARPOL V and the implementation guidelines? Certainly a case can be made for the former interpretation particularly when small quantities of the material are washed or pumped overboard in a fluid stream.

Beyond the legal interpretation of the CWA language with respect to NPDES application to vessel discharges, there are the pragmatic issues of NPDES program application to vessel issues. These issues recently were addressed by the EPA with respect to NPDES application to vessel ballast water discharges, which are known to contribute to the introduction of invasive species into U.S. waters. Currently, vessel ballast water management primarily is addressed under the National Invasive Species Act (NISA) and its implementing regulations. However, as with APPS and the dry cargo residue issue, there are questions as to whether the CWA and NPDES also apply to ballast water management and invasive species control. The EPA was petitioned by a California environmental non-governmental organization (NGO) and a coalition of other concerned stakeholders to address this question. The EPA recently completed a study on this matter (EPA, 2001).

In examining the regulation of ballast water discharges in navigable waters under the CWA, the EPA report noted the exclusionary clause and the CWA approach toward vessels as discussed above. The report concluded that the inclusion of ballast water under the NPDES umbrella was questionable from a legal standpoint. However, the report also noted that there were several practical constraints to regulating ballast water discharges under NPDES. Potential shortcomings were noted as follows:

- The fact that states have primary responsibility for the NPDES program hampers the program's utility in providing uniform regulation of point sources, such as vessels that routinely move between states. The EPA believes that as a general matter, it is better that mobile point sources such as vessels be subject to uniform controls. While the EPA has used NPDES permits to regulate vessels and other floating craft, most of that regulation has been directed towards vessels engaged in non-transportation-related activities (such as oil and gas exploration, seafood processing, and seabed mining) in federal waters (outside the 3-mile limit).
- Using the NPDES program to regulate ballast water discharges could subject ballast water discharges to overlapping regulatory regimes. NISA already imposes ballast water management requirements, and there appear to be a number of existing and emerging state laws to control the introduction of ballast-water aquatic nuisance species (ANS). The imposition of NPDES requirements on top of NISA and state laws may detract from those other efforts.

With respect to NPDES program application to the dry cargo residue discharge problem, it is clear that the problem with multiple state regulations and overlapping national regulatory regimes would apply to dry cargo residues as well. Although these problems could be addressed in a separate NPDES program targeted to vessels, the EPA report noted that development of such regulations would complicated and time consuming. In the final analysis, the EPA report recommended that no immediate regulatory initiative under NPDES be taken for ballast water management, but rather that regulation, monitoring, and enforcement be left to the U.S. Coast Guard under NISA, at least until the effectiveness of current USCG efforts could be assessed.

With regard to the relationship between EPA regulations under the CWA and USCG regulations for vessels, it should be noted that under Section 1342 (g) governing "other regulations for safe transportation, handling, carriage, storage, and stowage of pollutants," the CWA states that:

> "Any permit issued under this section for the discharge of pollutants into the navigable waters from a vessel or other floating craft shall be subject to any applicable regulations promulgated by the Secretary of the Department in which the Coast Guard is operating, establishing specifications for safe transportation, handling, carriage, storage, and stowage of pollutants."

Hence, the CWA recognizes that regulations promulgated by the EPA under the CWA should be consistent with those promulgated by the U.S. Coast Guard under other laws.

Overall, the following observations can be made with respect to dry cargo residue discharges and the various provision of the CWA. First, in a more general sense, and in the absence of other governing legislation and regulations, the provisions of the CWA and the NPDES requirements may apply to the dry cargo residue discharges in the Great Lakes in a strict legal sense. However, the provisions of the CWA also clearly establish the precedent for the U.S. Coast Guard taking the lead in developing and implementing regulations for vessel-related water pollution control issues, particularly for what can be considered operational issues. In addition, there are clear, practical constraints in applying the NPDES permitting requirements to operational vessel discharges, and these have been documented and recognized by the EPA in addressing the ballast water management problem. Given this precedent and the mandate of Congress that the U.S. Coast Guard establish such regulations for dry cargo discharges in the Great Lakes, it appears that such regulations would preempt the NPDES requirement. This does not preclude the collaboration between the U.S. Coast Guard and EPA in the establishment of technology-based measures or BMPs to control and minimize such discharges, as was done in developing Marine Sanitation Device and Oily Water Discharge Regulations.

Ocean Dumping Act (ODA), as amended, 33 USC 1401 et seq.

The ODA provides the primary authority to the EPA and U.S. Army Corps of Engineers (USACE) to regulate the dumping of materials into the coastal and ocean waters of the United States, specifically to "those waters of the open seas lying seaward of the baseline from which the territorial sea is measured, as provided for in the Convention on the Territorial Sea and the Contiguous Zone." The EPA has responsibility for the majority of materials that might be disposed of at sea; the USACE has responsibilities for the disposal of dredged material. The ODA addresses any vessel, aircraft, or other conveyance departing the United States for the purpose of transporting material to sea for disposal, and any foreign vessel entering the contiguous zone or EEZ for the purpose of dumping. The EPA and USACE accomplish permitting, with at-sea monitoring and enforcement being coordinated with the U.s. Coast Guard. Since 1992, virtually all ocean dumping in U.S. waters, with the exception of dredged material, has ceased. General permits remain in place for activities such as burial at sea and the construction of artificial reefs.

With respect to dry cargo discharges in the Great Lakes and internal waters of the United States, the ODA appears to not be applicable in terms of legislative intent and jurisdiction. First, the intent of ODA is to control the transport of material for the purpose of dumping—that is, the overall purpose of the voyage is dumping. For dry cargo discharges, the purpose of the voyage clearly is transport of the material in maritime commerce. Second, the ODA does not apply to the internal waters of the United States, specifically the Great Lakes. The geographic character of the Great Lakes that has caused the dry cargo controversy makes the ODA provisions not applicable.

Beyond the fact that the ODA technically does not apply to the Great Lakes, Congress recently has expressed its intent that the APPS, not the ODA or other laws, governs dry cargo discharges involving agricultural cargos. Specifically, the House USCG Appropriations Bill 2001 (Section 204, Discharge of Agricultural Cargo Residue) states that:

"Notwithstanding any other provision of law, the discharge from a vessel of any agricultural cargo residue material in the form of hold washings shall be governed exclusively by the provisions of the Act to Prevent Pollution from Ships (33 USC 1901 *et seq.*) that implement Annex V to the International Convention for the Prevention of Pollution from Ships."

Although this clause was directed at U.S. vessels operating outside of U.S. navigable waters, it reinforces the concept that the APPS and not the ODA should govern operational discharges from U.S. vessels at sea. However, it also should be noted that the EPA has challenged this interpretation stating that both the APPS and the ODA should apply to the routine discharge of operational waste from vessels. This reflects ongoing concern that vessels should not hold garbage onboard arbitrarily while in port and later discharged at sea in an after-the-fact manner to avoid paying dockside garbage disposal fees. It perhaps also reflects EPA's distaste for Congress' modifying the application of environmental legislation in an after-the-fact manner using appropriations bill language. At the moment, this issue continues to be under debate.

Other Related U.S. Laws and Regulations

There are two other laws and regulations that bear mentioning with regard to the dry cargo discharge issue. One law is the **Rivers and Harbors Act of 1899, 33 USC 401 *et seq.*** (also known as the Refuse Act), which prohibits the unauthorized obstruction of navigable waters in general, and specifically prohibits the discharge of "refuse and other substances." This law largely has been superseded by the CWA and the APPS for the control of pollution from garbage.

Another law is the **Shore Protection Act of 1988, 33 USC 2601 *et seq.***, which addresses the transport of municipal and commercial wastes in the coastal waters of the United States. It requires that vessels whose purpose is transporting municipal and commercial waste in coastal waters must obtain a permit to do so from the U.S. Coast Guard. The provisions of this law are implemented by regulations in 33 CFR 151.1000–1024. This affirms the USCG lead role in marine environmental compliance issues. It also is noteworthy that, for the purpose of these regulations, coastal waters include the "Great Lakes and their connecting waters."

3.2.3 Canadian Laws and Regulations, and U.S. Canadian Agreements

Because the United States shares the waters of the Great Lakes with Canada, it is important to understand how Canadian laws and regulations affect the dry cargo issue, and the implications of any international agreements that are in place. In reviewing these laws and regulations, it is important to note that the Canadians have not yet ratified Annex V of MARPOL 73/78, such that there is no direct Canadian counterpart to the MARPOL V provisions in the APPS.

A comprehensive review of Canadian laws and regulations that relate to the dry cargo residue discharge issue is contained in the 1993 Canadian Coast Guard (CCG) study (Melville Shipping, 1993). The primary Canadian law governing the discharge of pollutants into Canadian waters by vessels is the Canada Shipping Act. This act covers the wider range of vessel pollutants and enables several individual regulations, including those implementing the provisions of Annexes I and II of MARPOL that Canada has ratified. The Canadian Shipping Act obligates a vessel's master to report discharges under the following regulations:

- Pollutant Substances Regulations
- Oil Pollution Prevention Regulations
- Great Lakes Sewage Pollution Prevention Regulations
- Garbage Pollution Regulations
- Dangerous Chemicals and Noxious Liquid Substances Regulations

The only materials transported in bulk on the Great Lakes that fall under these regulations are:

- Pollutant substances as defined by Schedule I of the Pollutant Substances Regulations
- Oil and oily mixtures as defined by the Oil Pollution Regulations
- Dangerous chemicals under the Noxious Liquid Substances Regulations

None of these materials falls within the purview of the current USCG dry cargo residue discharge policy, and therefore does not conflict with the policy.

In addition, Canada has a number of other regulations in place that relate to the carriage of bulk cargos or pollution. These include regulations for dangerous bulk materials transportation, dangerous cargo shipping, grain cargo transportation, and timber cargo transportation. None of these is directly relevant to the USCG dry cargo residue discharge policy.

Another Canadian law that has some relevance to the discharge of dry cargo residues into the Great Lakes is the Federal Fisheries Act, which forbids depositing deleterious substances in waters that are directly harmful to fish and fish habitats. Depending on the material, amount, and location of dry cargo residue discharges, this law could come into play in Canadian waters.

The CCG study (Melville Shipping, 1993) discussed the provisions of MARPOL V, making the same observations as in Section 3.1 above, specifically that MARPOL V intended minimization, not total elimination, of dry cargo residue discharges. The report further discussed the provisions of the 1972 Great Lakes Water Quality Agreement between the United States and Canada, which was adopted to promote U.S.-Canadian cooperation in addressing Great Lakes water pollution issues. The agreement was revised and expanded in 1978, and focused specifically on toxic discharge substances in the Great Lakes and the need to take an ecosystems approach to examining the problems in the Great Lakes Basin. Annex 5 of the agreement specifically addresses the discharge of vessel wastes but does not deal directly with the dry cargo residue issue or conflict with the current USCG policy.

With respect to the USCG policy, which was being formulated at the time of the report (Melville Shipping, 1993), the CCG made the following observation on the USCG dilemma under the APPS:

> "The guidelines to Annex V of MARPOL place an obligation on the ship operator to 'minimize' cargo residue. While initially adopting a more rigorous view (referring to a no discharge position under APPS), the U.S. Coast Guard may now prefer to think of the Great Lakes as a Special Case where a more lenient view would be appropriate. Minimization rather than elimination of cargo residue may be an acceptable philosophy."

In summary, the CCG found the CGD9 approach to be reasonable and practicable. Communications with Tom Morris of Transport Canada and Chris Wiley of the CCG indicate that Canadian laws and regulations, as well as their assessment of the CGD9 approach, remain unchanged at present.

3.2.4 State and Local Regulations in the Great Lakes

An in-depth review of all applicable state and local regulations that might be relevant to the dry cargo residue issue has not yet been conducted. However, CGD9 personnel and LCA representatives were queried regarding any challenges to the current policy that may have been brought forward under such laws and regulations. To date, there have been no such challenges. In fact, both U.S. and Canadian stakeholders queried to date have indicated that the dry cargo residue issue is not a controversial one at present ("not a hot topic") as are other issues such as toxics pollution, invasive species, or oxygen depletion because of nutrient enrichment.

3.2.5 Application of the APPS and CWA to Dry Cargo Discharges on the Inland River System

In addition to the Great Lakes, there are dry bulk cargos being transported on the major inland rivers as well. Accordingly, a cursory investigation was conducted to determine the extent to which dry cargo discharges are an issue on the inland river system, what regulations may be invoked to control these discharges, and how these practices relate to the current situation on the Great Lakes.

Information on this issue was gathered from personnel at USCG Marine Safety Offices (MSO) New Orleans, Louisiana; Louisville, Kentucky; and Huntington, West Virginia as well as from the Louisiana Department of Environmental Quality, Ohio Environmental Protection Agency, and Kentucky Department of Environmental Protection. For the most part, the situation in all locations was the same. Dry cargo on the rivers is carried in barges, and discharges do occur in the Mississippi and Ohio Rivers as a result of the bulk carrier trade. In New Orleans, bulk cargoes are loaded aboard oceangoing conventional bulk carriers, and some discharges have been observed.

Discharges occur during the loading and unloading operation, which is accomplished by machinery located at the terminal (there are no self-unloading barges on the rivers). Clamshells and conveyor belt arms accomplish much of the loading and unloading. All personnel queried indicated that incidental discharges during loading and unloading (primarily from blowing dust, incidental spillage from clamshells, etc.) do occur at the terminals, but that there currently is no program in place to regulate these discharges. The only exception to this is for products that cause a sheen such as petroleum coke. For instance, in Huntington, West Virginia a program for loading SynFuel (a mixture of coal and petroleum) has been established to minimize discharges using BMPs. Likewise, coke discharges resulting in a sheen have been investigated in New Orleans, Louisiana. Otherwise, these loading and unloading discharges are considered a low priority item and not pursued.

In addition to loading and unloading discharges, discharges occur when the barge cargo tanks are cleaned. Environmental cleanup contractors accomplish this cleaning, which is permitted in each state under NPDES. Permits may be issued to the contractor performing the cargo tank cleaning or to the vessel owner or operator. In most instances, permits specify that BMPs be employed, such as removing all loose material from the tank before washdown and dilution so as not to leave a visible plume in the water. Enforcement actions have been taken against contractors performing barge-cleaning operations without a permit.

Some exceptions to this BMP approach were noted. For instance, in Ohio barge-cleaning effluent is pumped to tank trucks and disposed of in public sewage treatment systems. In Kentucky, a concentration-based NPDES approach is used that sets an upper limit on certain contaminants. Effluents are monitored periodically, and if other contaminants of concern are noted, the permit provisions are adjusted to account for them.

The significance with respect to dry cargo discharges in the Great Lakes is that these discharges do occur but are considered to be of minor environmental significance. Although the tank cleaning operations are regulated under NPDES, permits are issued to local contractors by the state in which the contractor is operating, thus avoiding the multiple-jurisdiction/multiple-permit dilemma for the barge owner or operator. In addition, the NPDES is based on BMP, which could just as well be implemented under the APPS.

3.3 Review of the CGD9 Policy

The original CGD9 Policy on the enforcement of MARPOL V and cargo residues was published as a Ninth District Instruction 16460.1, dated 22 September 1993. The stated purpose of the Instruction was to "set forth an interim enforcement policy regarding the incidental discharge of cargo residues," what are commonly called cargo sweepings. The policy was to apply only to dry cargo residues and did not alter the enforcement policy on discharge of any other material (e.g., oil waste, untreated sewage, plastics, dunnage, or other things commonly understood as garbage) from vessels in the Great Lakes.

The original instruction (Paragraph 2b) goes into some detail on the overall need for and rationale behind the policy. MARPOL V was implemented into U.S. domestic law by amendments to the APPS (33 USC 1902) and by USCG regulations in 33 CFR Part 151. The APPS stipulates that MARPOL V applies to all U.S. vessels operating anywhere and to all vessels (of any country) operating within the navigable waters of the United States. The instruction reaffirmed that the discharge of plastics clearly was prohibited. The instruction further noted that the APPS did not specify how the MARPOL V regime of allowable discharges for other types of ship-generated wastes was to be applied in the Great Lakes using the allowable distances from shore specified under MARPOL V. Under MARPOL, this distance is measured from the baseline from which the territorial sea is measured. In the Great Lakes, this baseline approach was deemed irrelevant as the Great Lakes are considered internal waters of the United States and Canada. The instruction also noted that no discharges were allowed within 3 miles of nearest land but indicated that even this could be problematic in the Great Lakes.

Ninth District Instruction 16460.1 also describes (Paragraph 2c and 2d) the specific nature of cargo residues, the current and long-standing practice of washing these residues over the side, and the potentially economically devastating impact that imposition of a no discharge standard would have on Great Lakes shipping. The instruction goes on to note that current USCG regulations implementing the MARPOL V provisions in the APPS (33 CFR 151.66 published in 1989) clearly prohibit the discharge of garbage. As defined in the regulations, the term "garbage" includes cargo residues (33 CFR 151.05). The instruction further notes that the prohibition is somewhat problematic in light of the Canadian unwillingness to follow such a strict interpretation, and the obligation under the revised Great Lakes Water Quality Agreement of 1978 to "seek compatible regulations for the prevention of pollution in those waters" (published in 54 FR 18390). The instruction noted that efforts currently were underway to resolve the issue with the Canadians, and further noted that a CCG study was underway to delineate the environmental effects associated with the discharge of dry cargo residue. It noted that the U.S. Coast Guard was initiating similar efforts. Both efforts were designed to formulate a scientific basis for developing a U.S.-Canadian policy that was acceptable to both nations and consistent with the Great Lakes Water Quality Agreement.

Having noted the above issues, the instruction (Paragraphs 2f and 2g) states the CGD9 intention to adopt a conservative enforcement policy that prohibits and enforces the discharge of dry cargo residues within 12 miles of land, even though discharges closer to land might be acceptable environmentally. The interim period specified in the instruction was during the study period, to last until the end of 1994. During this period, the U.S. Coast Guard would continue to investigate the environmental effects both within and outside of 12 miles. In implementing the policy (Paragraph 3), the instruction indicates that the enforcement area could be adjusted based on Captain of the Port (COTP) recommendations and consideration of material toxicity and environmental sensitivity, but in no cases were discharges allowed any closer than 3 miles of land. Since its initial implementation, a number of such waivers have been requested by industry through the LCA and to a large extent have been granted. These waivers generally have been requested to prevent significant departures by bulk carriers from established vessel routes in complying with the CGD9 Policy that can be time consuming and potentially hazardous from a vessel traffic standpoint.

Four important observations can de made regarding the original Ninth District Instruction 16460.1:

1) *It clearly recognized that there was a face value contradiction between the CGD9 Policy and the APPS.*
2) *It sought to strike a balance between the intent of the APPS and MARPOL V in protecting the environment, and the operational and economic realities of bulk cargo shipping on the Great Lakes.*
3) *It clearly recognized the international implications with Canada and the need to harmonize U.S.-Canadian policy and regulations.*
4) *It only was intended to cover an interim period from September 1993 through December 1994.*

The instruction was revised in March 1995 (Ninth District Instruction 16460.1A, dated 1 March 1995), thus superseding and canceling the original instruction. The new instruction referred to the original instruction as defining the rationale and intent of the CGD9 Policy, and further noted that the Scientific Steering Committee convened by the NOAA GLERL obtained additional information on the environmental effects of dry cargo residue discharges. It noted that the committee had identified additional research needs on the long-term effects of dry cargo discharges, but in the interim provided general support for the USCG enforcement policy as "an appropriate means of protecting against any short-term risk to the environment, subject to specific suggestions for refinement of the enforcement policy."

The 1995 instruction states that, based on the report from the Scientific Steering Committee, submissions from the shipping industry, and continuing discussions with the members of the committee, a more detailed regime was developed to refine the balance between environmental protection and navigation. This regime specified for each of the Great Lakes, and by cargo type, the allowable zones for discharge of dry cargo. The zones were delineated in detail by distance from shore and geographic areas specified by latitude and longitude. The instruction also provided detailed enforcement action guidance for COTPs and USCG units for conducing surveillance, reporting, and investigating apparent violations under the revised enforcement policy.

As indicated in Section 2.0 above, as the debate over the CGD9 enforcement gained national visibility and alternate approaches to resolving the issue were put forth, the Ninth District ceased promulgating the policy via instruction and disseminated the policy by Notice to Mariners. To date, the policy remains in effect as per the instructions from Congress in the FY2000 Appropriations Bill. In the meantime, additional recordkeeping provisions have been added via a Cargo Residue Washdown Policy formulated by the Great Lakes Regional Waterways Management Forum, effective as of 11 October 1999. Under this policy, vessel masters are instructed to log the time and location of washdown operations and estimated the amount of material (in lbs/kg) that has been discharged overboard. Foreign-flag vessel masters are advised to have a copy of the CGD9 enforcement policy onboard. The U.S. Coast Guard is monitoring for compliance actively to ensure that cargo residue washdowns are accomplished in accordance with current enforcement policy and that the proper log entries have been made.

In summary, the CGD9 enforcement policy, albeit subject to various challenges and uncertainties, appears to be a viable mechanism in managing dry cargo discharges. The LCA and shipping companies support it, and compliance generally is good. As such, it provides a good foundation for future regulatory action.

3.4 Legal and Policy Analysis—Findings and Conclusions

3.4.1 Findings

The discussion in this section provides a general overview of the evolution of the dry cargo residue discharge issue as it pertains to the U.S. Coast Guard, and identifies and summarizes the key international conventions, national laws and regulations, and regional agreements that bear on this issue. Based on this discussion, the following observations can be made:

1) The face value contradiction between the CWA and the APPS, and the CGD9 enforcement policy continues to exist. There is no obvious and straightforward legal or regulatory interpretation that alters this. However, it is clear that the CGD9 Policy is consistent with the intent and goals of MARPOL V as adapted to the specific circumstances within the Great Lakes. It also is consistent with similar provisions under the CWA and NPDES, which rely on BMP as a means of minimizing pollutant discharge.
2) The provisions of the ODA do not apply to this issue. This is supported by international convention, which treats cargo residues under MARPOL V versus the London Convention, and the intent and jurisdiction of the ODA itself.
3) The policy is at least as environmentally strict as existing Canadian laws and regulations governing such discharges, and was judged by the CCG study (Melville Shipping, 1993) as being a reasonable, albeit conservative, approach to managing dry cargo discharges.
4) Dry cargo discharges from barges and vessels do occur on the inland rivers, but these discharges are not considered as significant pollution problems. NPDES regulates barge cargo hold cleaning. Permits are issued to cleanup contractors that operate at a given location and not to the barge owners or operators, thus avoiding multiple-jurisdiction/multiple-permit problems. As these permits are based on BMP, the same result easily could be accomplished under the CGD9 Policy based on the APPS.
5) While there is some uncertainty regarding the legal and regulatory defensibility of the current policy, it has proved robust and acceptable in the Ninth District as a means of effectively

addressing dry cargo residue discharges. It is supported and being adhered to by the shipping industry and is not being challenged actively at the regional and state levels.

6) Although an argument might be made for managing dry cargo residue discharges under the CWA/NPDES program, the CWA exclusionary clause and precedent would indicate that the APPS and implementing regulations should be the primary regime for managing, monitoring, and implementing enforcement provisions for these discharges. There also are several practical constraints in applying CWA/NPDES provisions to vessel discharges, which clearly have been recognized by the EPA in addressing the ballast water management issue. There does not appear to be an obvious, overriding advantage to regulating dry cargo residue discharges under the CWA/NPDES program.
7) As the U.S. Coast Guard has been directed by Congress (in the FY2000 Appropriations Bill) to formulate regulations resolving the issue (providing a legislative mandate), it appears that these regulations will supercede related regulatory provision under the CWA. A present, it does not appear that EPA or any other federal or state agency will challenge the USCG initiative.

3.4.2 Recommendations

1) The current CGD9 Policy, which is an effective adaptation of the APPS for the bulk carrier trade in the Great Lakes, provides a valid framework for formal regulations under the APPS regulating dry cargo discharges in the Great Lakes. Accordingly, it should serve as the basis for these regulations.
2) The U.S. Coast Guard should pursue these regulations in collaboration with the EPA and other agencies, ensuring that the BMPs adopted are as consistent as possible with BMPs that might be prescribed under the CWA.

3.5 References

EPA (U.S. Environmental Protection Agency), 2001. Aquatic Nuisance Species in Ballast Water Discharges: Issues and Options [draft report for public comment]. Prepared by the U.S. Environmental Protection Agency, Office of Water, Washington, D.C. 10 September 2001.

Melville Shipping, 1993. Review and Investigation of Procedures Governing the Discharge of Non-Regulated Cargo Residues from Ships in the Great Lakes. Prepared for the Canadian Coast Guard, Ship Safety by Melville Shipping, Ltd. in association with LGL Ltd., Ottawa, Ontario. Canadian Coast Guard Ship Safety Report SSC 014SS.T8080-2-6861/B.

Reid, D. F., and G. A. Meadows, 1999. Proceedings of the Workshop on the Environmental Implications of Cargo Sweepings in the Great Lakes. NOAA Technical Memorandum ERL GLERL-114. National Oceanic and Atmospheric Administration, Great Lakes Environmental Research Laboratory, Ann Arbor, Michigan.

4.0 DRY CARGO RESIDUE DISCHARGES—ORIGIN, AMOUNT, DISTRIBUTION, AND PREVENTION MEASURES

To determine the effectiveness of the current U.S. Coast Guard (USCG) dry cargo residue discharge policy and the environmental risks associated with continuing dry cargo residue discharges in the Great Lakes, it is first necessary to review the sources and causes of these discharges, characterize the magnitude and geographic extent of these discharges, and assess nature and effectiveness of pollution prevention measures currently in place.

As discussed in Section 1.0, the Great Lakes bulk carrier fleet consists of three categories of vessels:

- U.S.-flag vessels, most of which belong to the Lake Carriers Association (LCA)
- Canadian-flag vessels, most of which belong to the Canadian Shipowners Association (CSA)
- Foreign-flag vessels, which enter the Great Lakes from overseas

The LCA and CSA were extremely helpful in providing fleet, cargo, residue, and pollution prevention information for this study. It was determined that foreign-flag vessels contribute a negligible amount of residue to the Lakes, so they were not pursued further for this study.

Background information about commodities transported as bulk dry cargo in the Great Lakes was obtained from the 1993 National Oceanic and Atmospheric Administration (NOAA)/Great Lakes Environmental Research Laboratory (GLERL) workshop proceedings (Reid and Meadows, 1999), the 1993 Canadian Coast Guard (CCG) study (Melville Shipping, 1993), and a pamphlet produced by the LCA, as well as the association's Web site (*http://www.lcaships.com/*). Specific details of 1999 Great Lakes commodity movement associated with U.S. ports and waterways was obtained from the U.S. Army Corps of Engineers (USACE) report "Waterborne Commerce of the United States" (USACE, 1999). This information is summarized in Section 2.0.

Descriptions of the dry cargo operations and sources of potential cargo loss were obtained from the CCG study (Melville Shipping, 1993), as well as discussions and site visits with the shipping companies in the LCA and CSA. This included discussions with LCA management personnel, shipping company executives, and the masters and crew of the vessels.

A key element of this study was determining the amount of material being discharged throughout the Great Lakes by cargo type on an annual basis, and the geographic distribution of this material within the Lakes. This determination was facilitated by the current voluntary practice of documenting such discharges by the bulk carrier fleets (both U.S. and Canadian). Under the current practice, vessels have been instructed to log each dry cargo residue discharge, noting the date, time, beginning position, ending position, quantity discharged, and nature of the material discharge for each discharge event. This practice was unknown at the outset of this study, but the value of obtaining an annual snapshot of discharge amounts and distributions was recognized. An extensive effort was conducted as part of this study to capture these data to provide a comprehensive profile of dry cargo discharges for the 2000–2001 shipping season.

Finally, an assessment was made of the current pollution measures being employed by the industry, their effectiveness, and the degree to which dry cargo residue discharges could be further minimized. The goal was to assess the longer-term feasibility of moving to a no discharge standard, as well as ensuring that dry cargo residues are kept in the category of operational *de minimus* discharges and do not become a major marine pollution issue in the Great Lakes.

4.1 Origin, Composition, and Causes of Dry Cargo Residue Discharges

Dry cargo residues that are subject to discharge from bulk carriers originate in the loading and unloading process at the origin and destination terminals. It is during these two processes that a small amount of material is lost in transfer and becomes subject to wash down and overboard discharge as the vessel proceeds from port to port. Under the current Ninth Coast Guard District (CGD9) Policy, all deliberate discharges occur in transit and not in the port areas. Larger spills of dry cargo are quite rare and occur only as a result of vessel casualty.

4.1.1 Commodity and Residue Properties

Cargo sweepings consists of the cargo residues (whole particles, broken pieces, and dust) and potential additives (added to improve cargo handling), small amounts of debris (e.g., paint chips) from the deck and holds, and small amounts of other materials such as lubricants, surfactants, and stack emissions associated with normal ship operations.

The following list gives available information about the commodities listed in Tables 2.4 and 2.5 and the forms of their residues, if known. Figure 4.1 shows samples of various major commodities transported that were collected during the course of the study. Currently, information is limited concerning the overall distribution of the particle sizes, other than the whole range is present, from full-sized pieces to dust. Note that 85% of the cargo to and from U.S. ports consists of iron ore, coal, and limestone. The residues from these commodities are the most significant for studying environmental effects.

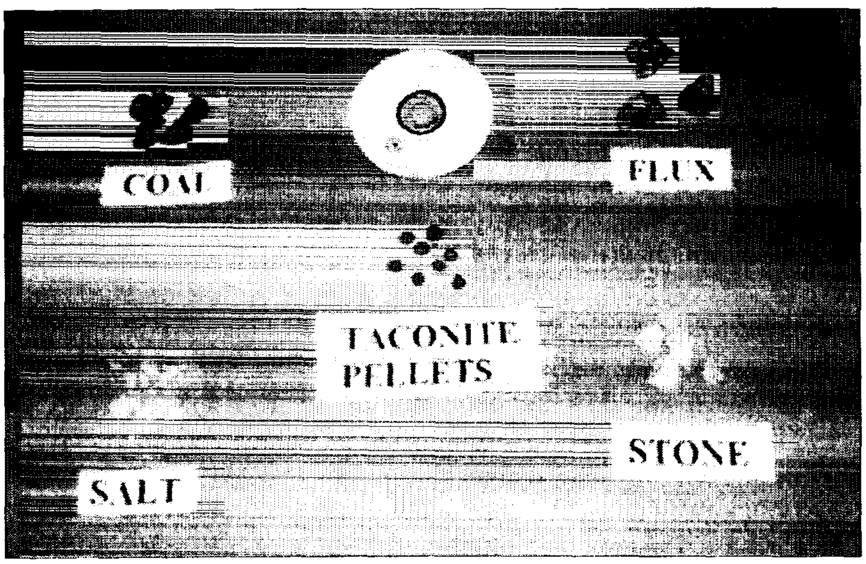

Figure 4.1 Photograph Showing Samples of Dry Cargo Commodities. The computer CD in the center provides a baseline for judging relative size of various commodities.

Iron Ore

According to the LCA, almost all iron ore is currently transported in the form of taconite pellets. Taconite is an iron-bearing chert containing 25–30% hematite and magnetite. It is a low-grade ore that is pelletized for blast furnace reduction. Pellets collected on site were approximately 1 cm in diameter; it is presumed that this is a typical size. Taconite residue consists of whole pellets, broken pellets of various sizes, and dust.

Coal

Coal is organic matter that has been subject to high pressure and heat on geologic time scales. Bituminous coal, also called soft coal, is a form of coal that yields pitch and tar as it burns and also produces much smoke and ashes. Coal samples (lumps) collected on site had a maximum length of approximately 3 cm and a width of approximately 1.5 cm. It is not known if these are typical dimensions for most coal cargos. Coal residue consists of whole lumps, broken lumps of various sizes, and dust.

Limestone

Limestone is a natural rock material consisting primarily of calcium carbonate. When magnesium also is present, it is called **dolomite**. It may have associated trace minerals and other constituents. Limestone samples (chunks) collected on site had a maximum length of approximately 2.5 cm and a width of approximately 1.5 cm. It is not known if these are typical dimensions for limestone (and dolomite). Limestone residue consists of whole chunks, broken chunks of various sizes, and dust. **Gypsum** is a natural mineral compound, hydrated calcium sulfate, and also may include anhydrite. It is included with limestone under **stone**.

Minerals

This category includes sand, gravel, clay, and other non-metal minerals. **Sand** is a commonly used term for natural rock and mineral detritus with particle sizes ranging from 2 to 1/16 mm diameter, most often composed of quartz and siliceous minerals. Silt and clay may be mixed in unwashed sand. **Gravel** is a commonly used term for natural rock and mineral fragments with diameters in the range of 76 mm to approximately 5 mm, with individual pieces being more or less rounded. **Clay** is a general name given to a suite of very small (less than 0.005 mm) mineral particles composed of hydrous aluminum and magnesium silicates that are the decomposition products of natural rock weathering. These inert materials contribute only minimally to the ecosystem.

Cement

Cement is a powdered substance made of calcium oxide and clay that may be premixed with washed sand or gravel. On U.S.-flag vessels, cement is transported without residues because it is handled in a vacuum line aboard specially equipped vessels. Therefore, the only cement residue reported is for Canadian-flag vessels.

Grain

Grain includes wheat, corn, rice, barley, rye, oats, soybeans, and other seeds. According to the NOAA/GLERL workshop proceedings (Reid and Meadows, 1999), grain loading is controlled tightly and produces little residue, just fugitive hulls and dust. Grain apparently is not pumped from the tunnels of the vessels before loading the next commodity. Very little grain is transported on U.S.-flag vessels (none on the ships surveyed during this study). Therefore, the only grain residue reported is for Canadian-flag vessels.

Coke

Coke is a derivative of either coal or petroleum. It contains only elemental carbon and residual mineral impurities that were present in the original material.

Slag

This is a generic term applied to a product of smelting that contains, mostly as silicates, those substances left over after the production of the target metal. It has a lower specific gravity than the target metal. It also is called cinder. **Millscale** is a black scale of magnetic iron oxide formed on iron and steel as a by-product of steelmaking (when heated for rolling, forging, etc.). It is ground to small diameter and taken to Gary, Indiana to extract remaining iron.

Metals

This includes iron and steel scrap, non-ferrous ores, and non-ferrous scrap. None of these is included in the residue data.

Salts

The salts include inorganic and metallic salts listed in the USACE data table. Rock salt (sodium chloride), which according to the LCA is transported in quantities around 6 million net tons per year, was not listed in the 1999 USACE data. None of the U.S.-flag ships surveyed carried loads of salt, although many of the Canadian-flag ships did.

Fertilizer

There is not much specific information available about the type of fertilizer shipped, but it is apparently mostly **potash**. Potash is a term generally understood to mean one or more salts of potassium, particularly potassium carbonate, but possibly potassium hydroxide, or a mixture of several potassium salts.

4.1.2 Sources and Causes of Dry Cargo Residue during Bulk Carrier Operations

Descriptions of the dry cargo operations and sources of potential cargo loss were obtained from the CCG study (Melville Shipping, 1993), and discussions and site visits with the LCA and CSA shipping companies and vessels. The loading and unloading processes and associated losses are addressed below.

According to the LCA, almost all modern dry-bulk loading facilities on the Great Lakes use conveyor-belt loading systems to load vessels quickly, although some gravity-loading chute systems continue to be used. Substantial spillage may have occurred in the past during the loading process because of less sophisticated loading equipment than presently exists, perhaps because of a lower level of environmental concern. Today, vessel and port personnel are aware of the need to minimize the amount of spillage onto the deck that will require cleanup. Many of the loading installations have equipment designed to reduce losses, including troughed conveyor belts, dust covers over the belts, dust collection and control systems, side boards and skirt boards to keep the cargo trained on the center of the belt, and telescoping chutes that guide the cargo into the hold of a ship. Additionally, according to the LCA, the officer on the ship who is in charge of the loading operations is always on deck and in continuous communication with the shoreside loading operator to assure the proper amount of cargo is loaded and is loaded in a sequence that minimizes hull stress and trim of the vessel (see figure 4.2). If there is any difficulty, including excess spillage on deck, the vessel's loading officer will stop the loading process.

Cargo losses during loading operations may be caused by high chutes, narrow hatches, conveyor run-off/bounce, vessel movement without warning, fugitive dust (wind blown), loose cargo, overfilling holds, and spilling while changing holds. Losses may occur as the loading apparatus is shifted from one hold to another as residual material continues to exit the loading arm. The holds must be loaded in a specific sequence to prevent excessive stresses on the ship's hull. Figure 4.3 shows a typical spillage pattern caused by moving the cargo-loading arm. Small pieces of cargo may be jolted loose when the loading rig moves to another location on the ship.

When cargo is wet or when loading in the rain, some moisture sticks to the loading rig belt and there may be drips of water that fall off to the deck where the belt returns. At times, when frozen cargo is loaded, some particles may get thrown off or bounce off of the belts onto the deck of the ship.

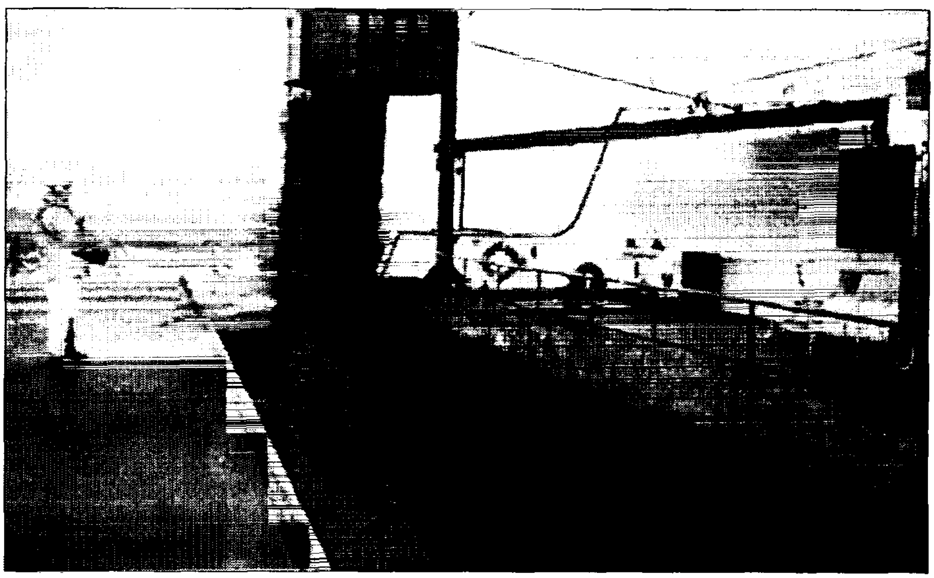

Figure 4.2 Photograph Showing Coal Being Deposited from the Terminal Loading Arm into the Cargo Hold.

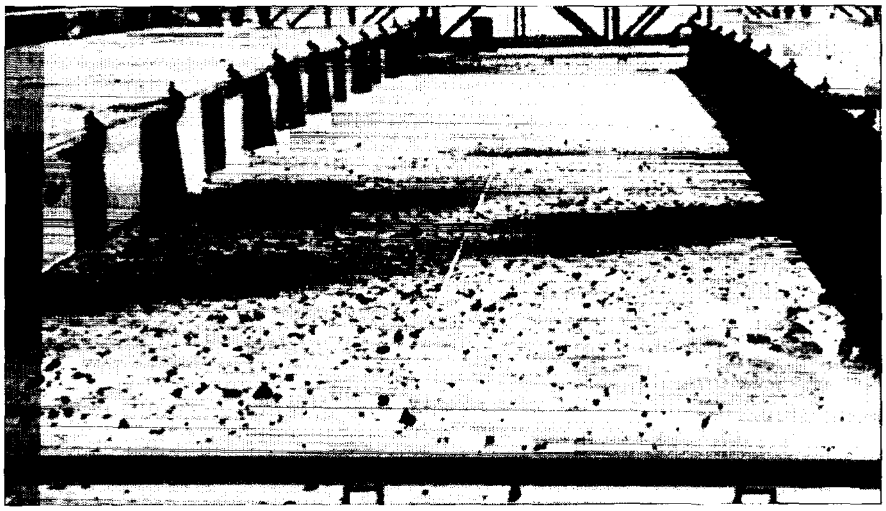

Figure 4.3 Typical Discharge Pattern Resulting from Moving the Cargo Loading Arm Between Cargo Holds.

The normal procedures for dealing with spillage prevent it from being deposited into the water in the vicinity of the loading port. If there is time, the crew will shovel as much spilled cargo as possible into the holds through open hatches. However, as soon as the loading process is complete, the hatches are sealed for the vessel to get underway. Any remaining spillage, particularly around the last holds filled, must be washed off once underway. Most of the residues are washed down while the ship is in transit, but an almost negligible amount may be lost while the ship is in port, especially on a windy day. Generally, the decks are washed after every loading process for crew safety (see Figure 4.4). One exception: occasionally the decks are not washed after limestone loading, which is evidently not as dangerous to walk on as taconite pellets. Another exception: one operator made shuttle trips in which the track did not take the vessel outside of the restriction zone, so the operator only deviated once in every six trips or so to do a washdown.

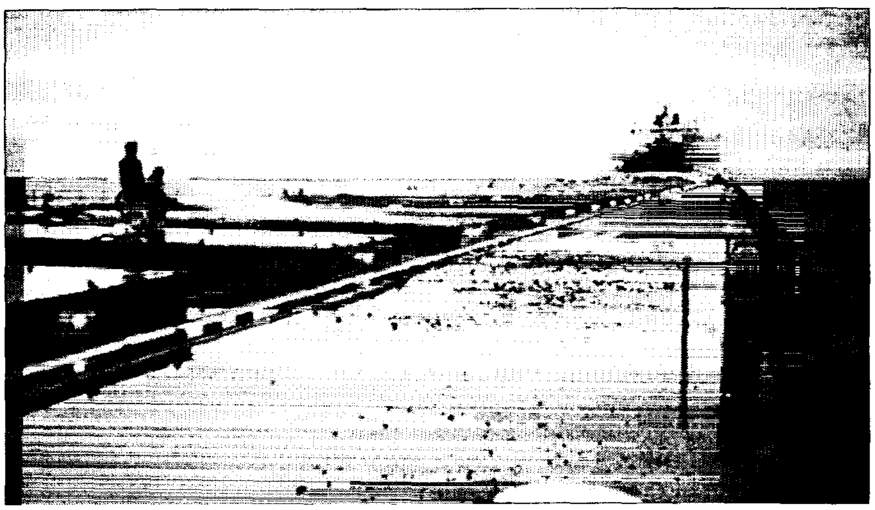

Figure 4.4 Photograph Showing a Deck Washdown Evolution in Transit After Loading Coal in Duluth-Superior.

Although the records show that washdown may occur virtually anywhere along the ship's trackline that is not in a restricted zone, it appears that many vessels try to wash down the deck as soon after leaving port as possible, which means that the tracklines near the ports have a greater percentage of residue deposited than areas farther away. Since it is not as critical for safety, tunnel washing tends to occur based on crew availability and may be conducted every few trips rather than during each transit.

Virtually all U.S.-flag vessels and over half the Canadian-flag vessels are self-unloaders. These ships do not require shoreside infrastructure for unloading the cargo to the consignee's terminal. According to the LCA, current practice is for the customer to have a stockpile area adjacent to where the vessel berths (see Figure 4.5). The vessel ties up and swings its unloading boom (250-foot average length) over the dock and unloads the cargo into a pile or hopper. For the Canadian conventional bulkers (a.k.a., straight-deckers), the cargo is grabbed out of the holds using shoreside machinery and piled directly onto the wharf.

As described in Section 2.0 above, the primary unloading apparatus is the conveyor belt system that transports the cargo from the bottom of the cargo hold (where it flows by gravity onto the conveyor belt), up to the deck, and along the unloading boom length. Spillage from this process occurs primarily in the long tunnels that run the length of the vessel adjacent to the conveyor belt. These tunnels provide access to the machinery and allow vessel personnel to operate the gates that control the flow of material onto the belts. Figures 4.6 and 4.7 show the tunnel and the conveyor belt. For safety and efficient operation, material spilled in these tunnels must be periodically washed toward the stern of the vessel and into a sump. To the extent possible material may be shoveled back onto the belt and deposited onto the pier. However, residual material in the sump is discharged over the side in transit.

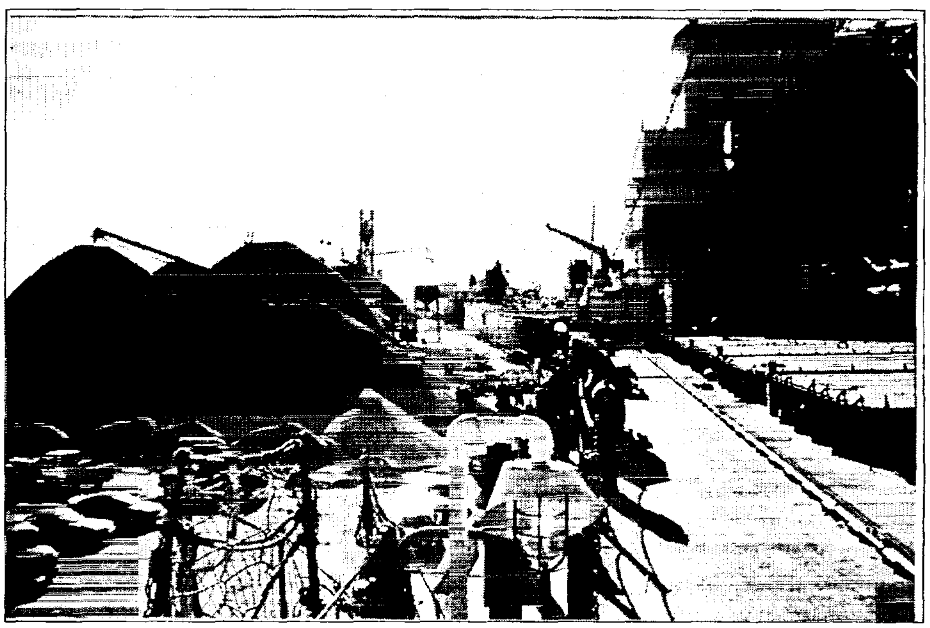

Figure 4.5 Photograph Showing Piles of Bulk Cargo Deposited on the Pier in Hamilton, Ontario from Bulk Carriers.

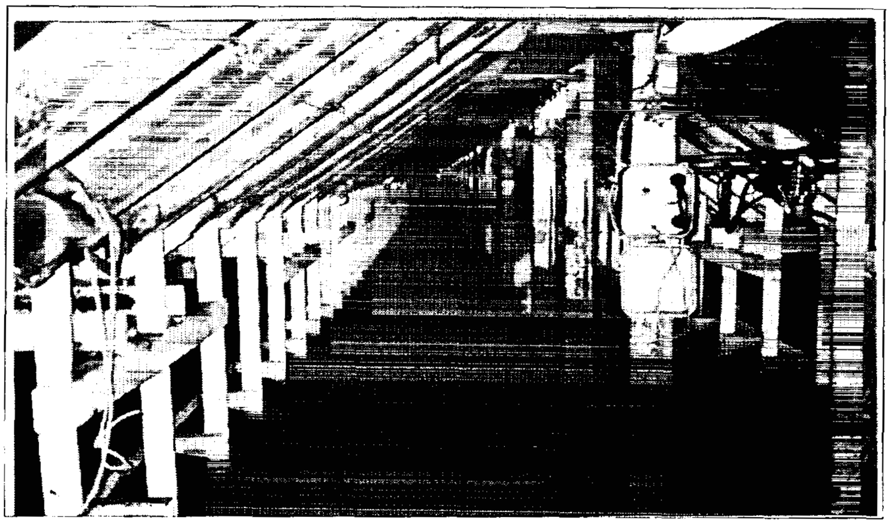

Figure 4.6 Photograph Showing the Tunnel in the Bottom of a Bulk Carrier that Houses the Unloading Gates and Conveyor Belt.

According to the LCA, cargo spillage during unloading can occur when small pieces strike the rubber conveyor belt in such a way as to fall off the belt and into the unloading tunnel. Another way for cargo to spill into the unloading tunnel is when it sticks or hangs up in the hold and then breaks free and flows rapidly onto the belt. Yet another way is when the cargo is wet, and water actually drips into the unloading tunnel, gets carried past belt-cleaning (scraper) systems, and falls onto the tunnel deck. Mechanical failure and operation errors (belt overloading) can also occur. However, all vessels have continuous communications with the unloading operator. Radio systems are used.

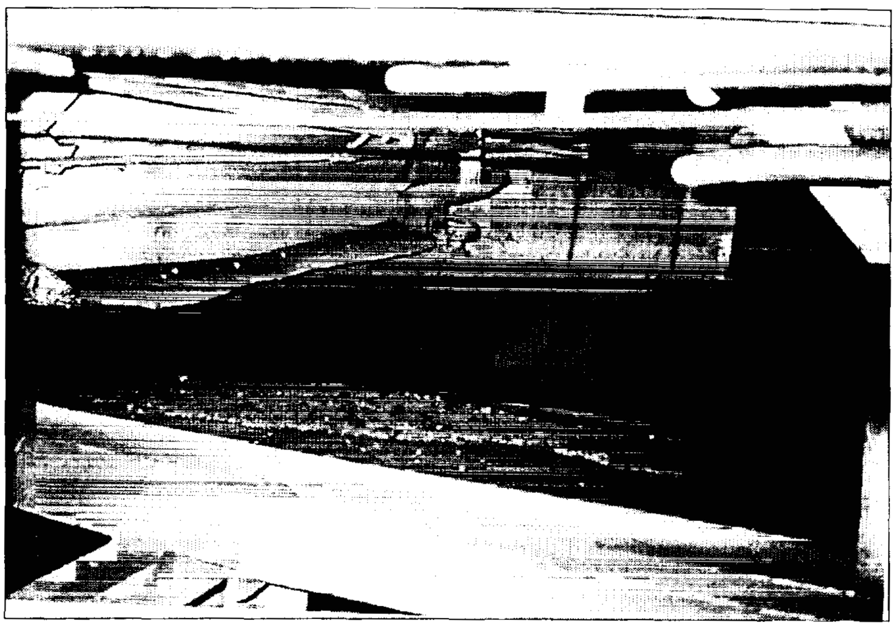

Figure 4.7 Photograph Showing the Unloading Conveyor Belt in the Tunnel.

There are also indicator light systems that tell the unloading gate operator how much cargo is loaded on the belt. These adjustable loading indicators are set by the deck officer and have a margin of safety that assures conveyor belt overloading does not take place. In many cases, vessels have reduced the unloading rate to minimize the potential of any spillage in the unloading tunnel.

During cargo loading operations, the cargo itself may contain significant water. Washed limestone, rain- or snow-covered cargo, and even dust control water will cause water slurry to drain from the cargo hold into the unloading tunnel while the vessel is in transit to the unloading port. Often, the quantity of water in the tunnel must be pumped out in approved locations during the transit to prevent damage to tunnel belt rollers and to prevent tunnel belts from slipping when they are started.

Generally, the decks are washed after every unloading process for safety of the crew. Cargo residue in the holds is washed partially during the unloading process. If there is a different cargo to be loaded next (requiring a clean hold), the holds will be washed thoroughly once underway. Tunnels generally are washed every two to three trips.

4.2 Analysis of Dry Cargo Discharge Volumes and Distribution Patterns

To determine the effectiveness of the current USCG dry cargo residue discharge policy and the environmental risks associated with continuing discharges in the Great Lakes, it was necessary to characterize the magnitude and geographic extent of these discharges, and the nature and effectiveness of pollution prevention measures currently in place. Data and documentation supporting this analysis include:

- The number and types of vessels operating, and the amount of cargo that is being transported throughout the Great Lakes System
- The origin and destination ports for various types of cargo
- The trade routes generally followed by bulk carriers within the Great Lakes
- The physical characteristics of the cargo being transported
- The mechanisms by which portions of the cargo are lost during the loading, unloading, and transport process such that they are being discharged overboard
- The overall volumes of the various cargo types that are being discharged into the Great Lakes
- How the dry cargo discharges are distributed geographically throughout the Great Lakes
- Pollution prevention measures currently in place and feasibility and potential costs of improvements

4.2.1 Determining the Amount and Distribution of Dry Cargo Residues Discharged Throughout the Great Lakes

A key element of this study was the determination of the amount of material being discharged throughout the Great Lakes by cargo type on an annual basis, and the geographic distribution of this material within the Lakes. This determination was facilitated by the current voluntary practice of documenting such discharges by the bulk carrier fleets (both U.S. and Canadian). An extensive effort was conducted as part of this study to capture these data to provide a comprehensive profile of dry cargo discharges for the 2000–2001 shipping season.

To demonstrate compliance with the Great Lakes Regional Waterways Management Forum Cargo Residue Washdown Policy (promulgated 11 October 1999), vessel owners and operators in the Great Lakes agreed to enter into the vessel's log book the time and location when cargo residue washdown commences and ceases, along with the product being washed down and an approximate quantity. A strategy was devised in consultation with the LCA to collect these dry cargo residue washdown data from a representative number of vessels. Similar efforts were formulated to capture washdown data for the Canadian fleet. It is unclear whether or how foreign-flag vessels were complying with the policy. As noted earlier, their primary contribution appeared to be from loading grain, about 350 trips per year. The residue per load (according to the data collected from Canadian vessels) averages about 300 lbs per load. If the foreign-flag vessels conducted washdowns while still in the lakes, this would amount to a total of approximately 105,000 lbs of grain per year spread amongst all the segments covered by the vessels. Therefore, it was determined that foreign-flag contribution to the residue totals probably was negligible.

The strategy to gather the data and supporting information from the vessels was implemented in two stages. Stage 1 involved riding or visiting several carriers from each company to observe washdown procedures, interviewing vessel personnel, and extracting data from that vessel's log or record book. The initial trip also provided an opportunity to observe vessel loading procedures; tour the vessels; see the machinery and waste minimization systems installed aboard the vessels; and become familiar with the characteristics, operations, and itineraries of the various vessel types. The Stage 1 visit indicated that all vessels visited diligently were recording washdown data in accordance with the policy promulgated by LCA, making it worthwhile to gather enough washdown data to produce a comprehensive profile for the 2001 season which can serve as a benchmark for evaluating washdown distribution and volumes in future years.

Stage 2 of the data gathering effort was conducted at various ports around the Great Lakes while the carriers were in port for the winter, collecting data from the rest of the fleet sample by extracting data from the logs aboard ship, or borrowing the logs for a day and then returning them to the vessel. During this stage, study personnel collected data from ships in Toledo, Ohio; Duluth, Minnesota; Cleveland, Ohio; and Sturgeon Bay. Data also were collected from Canadian-flag vessels tied up in Port Colburn and Hamilton, as well as directly from the Canadian companies' headquarters in St. Catherines and Montreal. As part of the data collection effort, the following data were extracted from vessel logs:

- Cargo load and unload ports
- Type and tonnage of cargo loaded or unloaded that was discharged via washdown
- Time/date and location washdown operations began and ended
- Amount and location aboard ship of dry cargo residue (e.g., on deck or in tunnels)

Methods for recording the data varied between companies (with some slight variations between vessels within a company). The primary methods encountered were:

- Line items in the official deck log (using same ink and style as other entries)
- Entries in the remarks section at the bottom of the log page
- Stamp form placed in the remarks column of the official deck log
- Separate log for washdown documentation

In addition to the variation in where the data are recorded, there are also differences in the way the data are recorded. Some vessels report "location" as distance from shore, distance and bearing to a geographic feature, and sometimes in latitude and longitude. Statute miles are generally used instead of nautical miles. In all cases, the logs are kept on the vessel (although it is not clear for how long), as there is no standard repository, which makes data retrieval somewhat problematic.

Amplifying information on loading, unloading, and washdown procedures was gathered in discussions with vessel and shipping company personnel during the visits. Topics investigated include how often washdowns generally were conducted; whether there were specific areas along the standard routes where the material is discharged or is it more random based on time of day, weather conditions, etc.; what additional measures could be taken to capture dry cargo residue aboard ship; whether the vessels experienced navigational difficulties in complying with the discharge exclusion zones; how the vessels estimated the amount of material that is being discharged; and whether there were specific waste minimization procedures that have been set forth for conducting dry cargo residue washdown operations. The answers to these questions are included in their appropriate sections.

The washdown data for each vessel were compiled, entered into an EXCEL spreadsheet workbook, and analyzed. The data from selected ships visited were plotted on nautical charts of the Lakes to delineate the primary discharge zones. The restriction limits outlined in the USCG policy also were drawn on the charts to determine how the washdown tracks compared to the discharge areas delineated in the CGD9 Policy. Based on the vessel tracklines and prevailing dry cargo discharge areas, the Great Lakes were divided up into trackline segments and discharge regions. After the available data were compiled and analyzed, discharge volumes by commodity were assigned to the segments so that dry cargo discharge hot spots (if any) could be identified. The discharge intensity in any region was then assessed against the environmental sensitivity within that region to determine if the discharge practices are consistent with minimizing environmental degradation, which is the overall goal of the CGD9 Policy. (The results of the discharge intensity versus environmental sensitivity analysis are provided in Section 5.0.) Table 4.1 provides the specific trackline segments identified for the purposes of this study. Figure 4.8 shows the more prominent discharge zones delineated for the washdown data.

Cargo residue amounts during the loading process vary between operators and by commodity type. Grain and coal cargos are susceptible to being blown by the wind, and iron ore fines and wetted stone tend to leave a muddy spillage on the deck. Estimates (in lbs) from U.S.- and Canadian-flag vessels surveyed are given in Table 4.2. *The numbers are somewhat lower than those given in the 1993 CCG study (Melville Shipping, 1993) but closely resemble the current values from the Canadian fleet.*

It is normal for cargo loss during unloading to be greater than during loading because of cleaning out the tunnels. Unloading spillage also varies with cargo type. Dust from grains can be considerable, and cargos that hang up or have a high volume (i.e., low-density cargos) are more susceptible to spillage. The quantity of cargo left on deck to be washed down varies from operator to operator, but in all cases is considered to be small; the quantity of cargo left in the holds and tunnels is more considerable. Estimates (in pounds) from the U.S.- and Canadian-flag vessels surveyed are given below. Again, the numbers are somewhat higher than those given in the CCG study (Melville Shipping, 1993) but closely resemble the current values from the Canadian fleet.

Table 4.1 Great Lakes Trackline Segments Used for This Dry Cargo Discharge Analysis.

Erie	
EE	Erie east, between 81°30' and 80°30' W
EFE	Erie far east, east of 80°30' W (Canadian fleet only)
EO	Erie other
EW	Trackline west, 81°30' to 82°30' W, north of 41°45'
Huron	
HN	North of 45°10' (north of Middle Island light)
HC	Central, between 44°°10' and 45°10' (Pt. Aux Barques to Middle Island, includes Sturgeon Point)
HS	South of 44°10' (includes Harbor Beach, Port Sanilac, and Lexington)
Michigan	
MN	North of 45°00' on west side, north of 44°30' on east side (Frankfort)
MCW	Central west, between 43° and 45° N, west of 87° W
MCE	Central east, between 43° and 44°30' N, east of 87° W
MS	South of 43°00'
Ontario	
ONT	Anywhere in Lake Ontario (Canadian fleet only)
Superior	
SC	Central (88°40'–87°20')
SET	East trackline (all latitudes east of 86°, north of 47°10' from 87°20' to 86°)
SEO	East other
SWT	West trackline (all latitudes west of 91°30', north of 47°20' from 91°30' to 88°40')

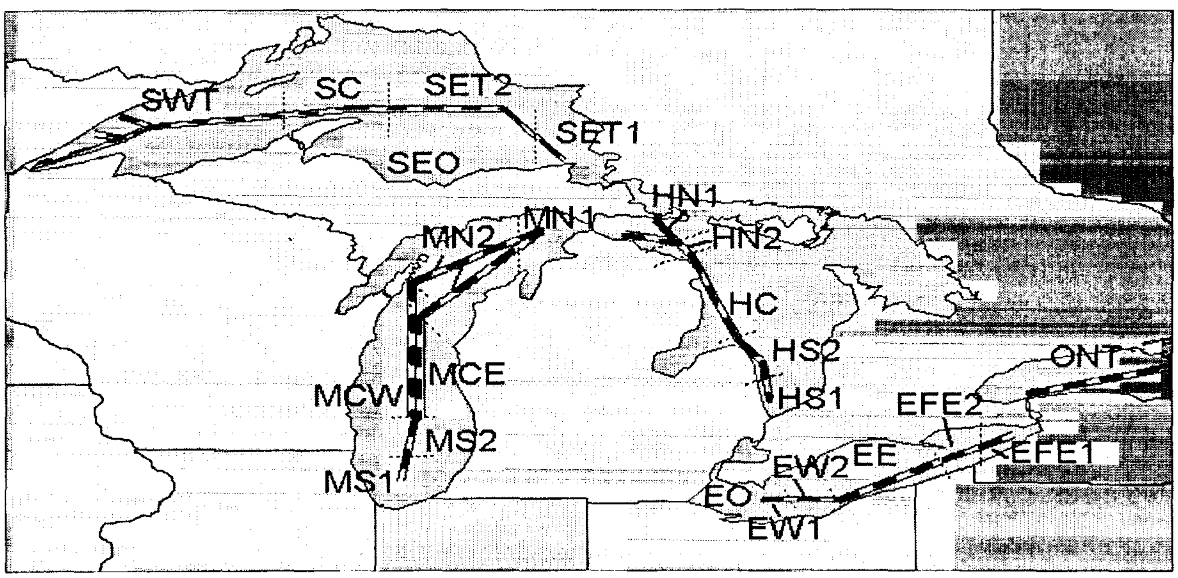

Figure 4.8 Original Dry Cargo Residue Washdown Tracklines in the Great Lakes.
Note: Figure is based on preliminary analysis of washdown data from three vessels.

Table 4.2 Estimated Commodity Residue Losses After Loading.

Commodity	U.S. Data (lbs)	Melville Shipping, 1993 (lbs)
Iron ore/pellets	50–500	500–2,000
Coal	75–400	100–750
Stone	50–400	100–500

An attempt was made to determine whether residues were a result of deck or tunnel washing. Some vessels recorded these data in the washdown log entries, but many did not. The numbers in the tables above are based on a rough analysis of a sampling of vessels that provided the necessary data. It may be useful from a pollution prevention standpoint to understand how much residue is generated from each aspect of the process. However, any attempt to further determine the breakdown of residue amounts from loading versus unloading would be difficult because of the variety of forms in which the data were recorded and collected.

All washdown data were assigned to segment location by commodity. Table 4.3 gives the U.S. fleet raw data for commodity residue (in lbs) per segment. Table 4.4 gives the Canadian fleet raw data for commodity residue (in lbs) per segment. Table 4.5 shows the comparison of tonnage discharged (based on the raw data collected) versus the tonnage transported (as provided in Table 2.4), both by total tonnages and commodity tonnages.

Since the raw data collected represented roughly 30–50% of the vessels operating in the Lakes, the raw residue discharge numbers can be doubled to provide a conservative estimate of the total annual amount of material discharged. This assumption is used in the Section 5.0 analysis below. The effect of doubling the numbers is also shown in Table 4.4. Even with doubling the raw data discharge totals, the relative percentage of cargo discharged versus cargo transported remains small (approximately 0.006%).

Table 4.3 U.S. Raw Data for Commodity Residue (in lbs) per Great Lakes Trackline Segment.

Segment	Total	Iron	Coal	Stone	Coke	Slag
EE	2,0195	8,890	7,045	4,260	0	0
EO	28,360	4,455	615	22,590	0	700
EW	21,612	8,385	5,337	7,890	0	0
HC	120,866	13,494	21,393	85,309	670	0
HN	49,379	12,742	4,370	28,129	4,138	0
HS	93,200	33,634	18,019	41,372	0	175
MCE	52,610	22,360	11,275	16,285	115	2,575
MCW	24,077	12,650	8,572	2,855	0	0
MN	54,137	9,265	12,992	31,130	50	700
MS	69,377	43,290	5,427	18,370	1,365	925
SC	12,372	9,267	2,605	500	0	0
SEO	26,472	23,292	2,280	900	0	0
SET	45,978	30,175	13,725	2,078	0	0
SWT	98,814	56,058	40,671	2,085	0	0
Total	**717,449**	**287,957**	**154,326**	**263,753**	**6,338**	**5,075**

Table 4.4 Canadian Raw Data for Commodity Residue (in lbs) per Great Lakes Trackline Segment.

Segment	Total	Iron	Coal	Stone	Coke	Slag	Cement/ Sand	Salt	Grain	Potash
EE	55,750	18,100	32,425	0	300	0	1,450	2,750	725	0
EFE	27,515	3,100	17,915	0	1,000	0	1,150	3,150	1,200	0
EO	10,490	1,600	4,040	2,150	800	0	300	800	800	0
EW	20,685	2,750	10,210	1,200	725	300	400	1,825	2,375	900
HC	17,175	1,725	4,160	4,455	500	2,000	500	1,510	2,175	150
HN	41,495	18,125	12,420	6,025	0	0	1,000	1,850	2,075	0
HS	18,030	4,500	8,330	2,800	0	0	0	1,900	500	0
MCE	6,775	3,050	750	475	1,300	500	0	500	200	0
MCW	500	0	0	0	0	0	0	500	0	0
MN	3,850	650	1,050	1,000	300	0	400	450	0	0
MS	4,775	2,500	0	0	1,325	0	0	0	700	250
ONT	19,405	4,350	4,380	1,000	1,700	1,950	400	2,825	2,800	0
SC	5,445	1,000	1,820	0	0	0	400	1,100	975	150
SEO	13,095	7,775	3,900	645	400	0	300	0	75	0
SET	23,815	7,410	7,720	880	0	150	0	30	6,975	650
SWT	18,015	5,950	7,465	1,100	0	0	200	1,500	1,500	300
Total	**286,815**	**82,585**	**116,585**	**21,730**	**8,350**	**4,900**	**6,500**	**20,690**	**23,075**	**2,400**

4.2.2 Determining Size Distribution for Individual Discharges

Washdown data were collected from over 50% of the U.S. fleet and from enough Canadian-flag vessels to cover about 50% of their trade in U.S. waters. There were many gaps and inconsistencies. For instance, many records were missing washdown start or end locations or amounts. Many vessels, especially those that recorded the information directly in the navigation logs, obviously had not recorded all events (based on what is known about the need for washdown when changing cargo types). For some vessels, some or all of the loading data were missing. The methods used to estimate the amount of residue obviously varied between companies, and possibly vessels within a company. There were cases in which similar vessels with similar cargos and routes gave vastly different estimates of residue, an average of 25 lbs versus 400 lbs, for example. Despite these issues, there were enough data to provide a reasonable estimate of annual totals by segment and commodity.

Table 4.5 Comparison of Dry Cargo Residue Discharged by Commodity Versus Total Tonnage Transported for Washdown Data Collected (in Tons).

	Total	Iron	Coal/Coke	Stone	Cement	Salt	Grain
U.S. Discharges	356	144	80	132			
Canadian Discharges	138	41	62	11	3	10	11
Total Discharged	494	185	142	143	3	10	11
Total Transported	165,489,989	55,859,785	43,755,153	37,124,877	5,548,658	8,626,348	14,011,286
% Discharged of Total	0.003	0.0003	0.0003	0.0004	0.00005	0.0001	0.00007
2 × % Discharged	0.006	0.0006	0.0006	0.0008	0.0001	0.0002	0.00014

In addition to determining the total amounts and distribution of dry cargo discharges along trackline segments in the Great Lakes, an analysis was performed to determine the average size of individual discharges as a function of commodity type. This information may provide valuable estimates that can be used in the future to estimate the amount of material deposited in the Great Lakes as a function of number of vessel trips by commodity along a given route or tonnage transported in a given year along a route. It also provides insight on how much variation there may be in estimates of discharge volume made by the crew in logging the discharge data. As noted during the data gathering process, there is a considerable range in the amount of material reported in a given discharge (as shown in Table 4.2). Finally, an analysis of size distribution of the individual estimates provides information on what constitutes a large deviation from the normal (e.g., mean or average) discharge amount. This in turn provides guidance on what should be considered a spill or reportable quantity in the development of subsequent dry cargo discharge regulations.

Accordingly, an analysis of variance (ANOVA) was conducted on a preliminary data set to determine whether there are significant differences between vessels, cargos, and trackline segments with regard to input size. The analysis showed that there was a significant difference between vessels ($p < 0.01$) indicating that there were different washdown practices that resulted in differing amounts of cargo inputs. *However, this also may have been an indication of differences in recordkeeping and estimating inputs by the operators of different vessels.* The analysis showed that different cargos resulted in significantly different inputs (by weight) ($p < 0.01$). The various trackline segments also received significantly different inputs ($p < 0.01$).

The amount of dry cargo discharged into the lakes during washdown operations varied from negligible (10 lbs or less) to as much as 66,150 lbs (this particular discharge was caused by a vessel casualty and emergency offloading operation, and was not an operational discharge). There were differences between vessels in the amount of dry cargo discharged during washdown operations, as well as between commodities and between trips with the same commodity on the same vessel. It is unclear whether these differences represent *actual* variations in inputs or differences in recordkeeping and estimating inputs.

Input sizes (as recorded) were analyzed with regard to commodity type and vessel size (both by deadweight tonnage and by overall length) to develop size frequency distributions. These size distributions can be used to develop standards of average and expected dry cargo inputs from washdown operations, and distinguish thresholds for classifying inputs as spill incidents rather than as routine operational inputs. Table 4.6 provides the statistical data for the dry cargo residue inputs observed. The size distributions for the washdown data collected as part of this study are shown graphically in Figure 4.9.

It is recommended that the thresholds for spill incidents be established based on percentiles of inputs. (Percentiles correspond to the percentage of operations in the cumulative probability distribution in Figure 4.9. A 1,000-lb input occurs in only 1% of operations. Ninety-nine percent of inputs are *smaller* than this, making 1,000 lbs the ninety-ninth percentile of inputs.) These thresholds can be overall thresholds encompassing all vessel types and commodities, commodity specific, or based on potential environmental impact of the commodities. In this way, somewhat larger inputs of less harmful substances might be tolerated.

Table 4.6 Sizes of Commodity Inputs from Dry Cargo Washdown Operations.

Commodity	Commodity Inputs (lbs)			
	Minimum Input	Maximum Input	Mean Input[1]	Median Input[2]
Iron	10	44,100	324	50
Coal/Coke	10	66,150	382	60
Stone	10	2,000	235	100
Limestone	10	1,000	108	10
Salt	10	600	177	25
Grain	10	4,410	194	20
Sand	10	600	150	20
Millscale/Slag	10	2,205	188	20
Potash	10	500	257	160
Gypsum	10	1,000	256	40
All Commodities	**10**	**66,150**	**305**	**50**

[1]Mean input is the average input (i.e., the total amount of input divided by the number of input operations).

[2]Median input is the input size for which 50% of inputs are the same size or smaller and 50% of inputs are larger.

The threshold of input size chosen to represent a reportable quantity will impact the potential number of discharge reports and actions that the enforcement officials will need to contend with. If the ninety-ninth percentile of input is used as the reportable quantity threshold, approximately 1 in 100 (1%) washdowns would be expected to result in a reportable spill incident based on current discharge data. Based on current dry cargo commerce trips, that would mean an estimated 50 spill incidents would be reported to the U.S. Coast Guard annually throughout the Great Lakes. If the threshold is lowered to the ninetieth percentile, 1 in 10 (10%) of the cargo residue washdowns would be expected to result in a reportable spill incident. In this case, an estimated 500 spill incidents would be reported annually throughout the Great Lakes. The ninety-ninth percentile threshold would mean that inputs of one-half ton or larger would be considered spill incidents. With a ninetieth percentile threshold, inputs of 500 lbs (one-quarter ton) would be considered spill incidents.

4.3 Waste Minimization and Pollution Prevention

One of the objectives of this study was to investigate and describe effective waste minimization procedures and pollution prevention options that can be applied to monitor and control discharges. These options may include both procedural and technology-based alternatives.

As discussed in Section 4.1, ship and terminal operators have worked together over the years to minimize the cargo losses during loading and unloading operations. All companies have expended considerable resources to reduce cargo residue and dust and subsequent crew cleanup time. Efforts include using better belt scrapers and belt side guides, modifying gate lips, and installing spray nozzles at all transfer points and even each gate. Loading facilities also have expended considerable efforts to reduce and minimize any potential cargo residue and dust. At chute-loading docks, any chute defect that may cause cargo spillage is reported immediately to the dock by the vessel and repairs are commenced. Some facilities have been required to improve the suppression of airborne dust to meet state air pollution standards.

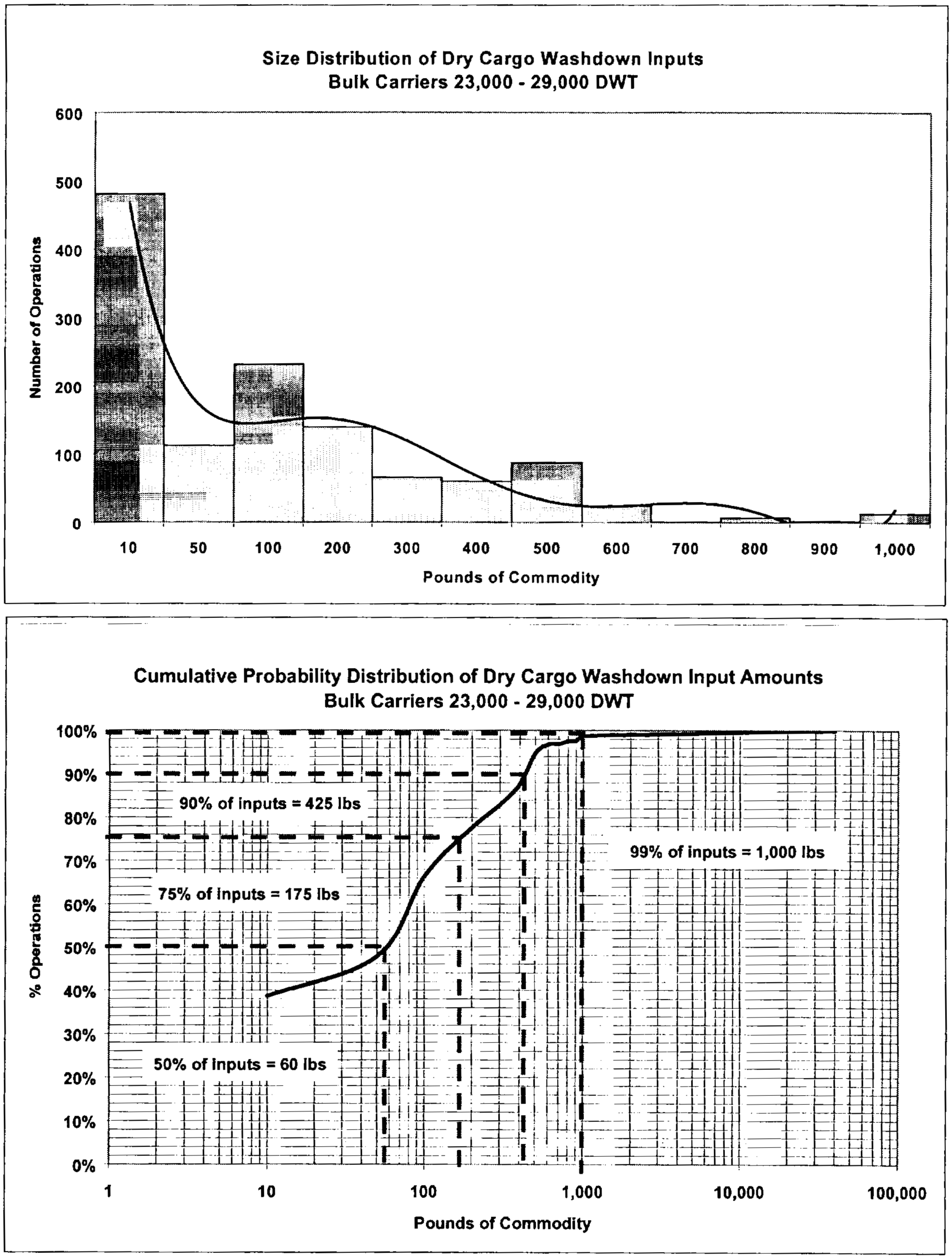

Figure 4.9 Size Distribution Plots for Dry Cargo Inputs.

Reduction also has included less frequent complete washdown. At coal docks rinsing of the cargo hold goes right to the belts so that there is less to wash down later. This water is part of the dust suppression. When the vessel is carrying the same cargo, there is less of a complete washdown of holds. The hoses just knock down the large hang-ups. In the tunnels particularly, the two- and three-belt vessels wash the tunnels every second or third trip, just to keep the working space safe for access. The current strategy is to wash down less and clean up more.

The current technology and procedures used by shipping companies and ports has reduced greatly the quantities of cargo spilled into the environment during the loading and discharging of ships. The quantities are so small that they are approaching the point that further reductions may be impractical. It will never be possible to eliminate completely windblown dust nor the occasional loss because of overfilled clamshell grabs or conveyor belts. Greater reductions in spilled quantities may be possible with ever improving technology and procedures, but the reductions are likely to be small, having relatively little impact on the environment.

Information was obtained on the cost effectiveness—potential levels of protection and an order of magnitude estimate of time and money—of various options with LCA personnel. The measures discussed included:

- Making complete sweep downs of the decks and disposing of the material ashore
- Installing combings (and/or sump) on deck and a sump in the tunnel with pumps to a holding tank onboard (no discharge option)
- Using shoreside disposal

The complete text of LCA's response is included as Appendix A and summarized below.

1) **Complete sweep down of the decks and disposal of the material ashore.** This could not be done in a timely fashion with current ship personnel. It would involve having shoreside crews available at every dock on call 24 hours per day, 7 days per week from early April until late December. According to the LCA, hiring and training large numbers of workers, often unfamiliar with shipboard operations for cleanup operations to be available in all kinds of weather on short notice at the shores of separate locations, would impose an extraordinary expense on every ship operator and would likely lead to delays. Estimates to clean just the decks are $400,000 per year per vessel. This does not include removing sweepings from the tunnels, which would be more complex and labor intensive. The alternative of vacuuming the entire exposed area of the deck with vessel crew also is considered to be even less feasible.
2) **Installing combings (and/or sump) on deck and a sump in the tunnel with pumps to a holding tank on board (no discharge option).** Technically, it is possible to install deck combings at an estimated cost of $300,000 to $400,000 per vessel. However, Great Lakes Load Line Regulations would not permit this because containing water would add to the deck height and reduce the vessel's stability. Additionally, trying to contain all water and sweepings from the deck would require installation of several collection sumps on the weather deck with associated pumps, electrical installations, piping systems, and controls along both sides of the vessel for the entire length of the deck, as well as holding tanks to collect the water. The classification society would not permit penetrations required by the sumps. The potential cost of at least $500,000 per vessel would be needed if these modifications were even technically possible.

3) **Shoreside disposal considerations.** According to LCA, there are currently no methods or means aboard any ship to offload large volumes of water ashore. If the water and sweepings were to be pumped ashore, they would have to be done while the vessel was either loading or unloading cargo—when crewmembers already are involved in ongoing operations. In addition, shoreside infrastructure and receiving facilities are not available in any port within the Great Lakes to handle any volume of colored water and cargo sweepings. Getting the contained water and sweepings ashore will pose many challenges and problems to the vast number of different loading and unloading facilities that the vessels visit and in all kinds of weather conditions, including freezing. Finally, the number and size of shoreside holding tanks will vary depending on the frequency and type of vessel visits. Any shoreside installation will have to undergo state and local regulatory permit review and provide environmentally sound disposal. For all these reasons, shoreside disposal of slurry and water from operating vessels is not feasible.

4.4 Dry Cargo Residue Discharge Analysis—Findings and Recommendations

4.4.1 Findings

An analysis was conducted to determine the nature and scope of dry cargo residue discharges in the Great Lakes focusing on the origins and causes of these discharges, physical characteristics of the material discharged, amount discharged by commodity, size distribution of individual discharges, and feasibility and effectiveness of current and potential pollution prevention measures. The findings of this analysis are as follows:

1) The Great Lakes bulk carrier trade involves about 120–130 vessels transporting three major and seven to nine minor commodities between a number of ports in the United States and Canada (and grain to other foreign ports). Trade routes are well defined and do not vary significantly within a season or from year to year.
2) In accordance with an agreement between U.S. and Canadian agencies and the U.S. and Canadian shipping industry, vessel operators both in the U.S. and Canada routinely are recording data on dry cargo residues. A comprehensive survey of these data was conducted as part of this study to provide an accurate baseline profile of dry cargo residue discharges for the 2001 shipping season, including the amount of various cargos discharged and the geographic distribution of these discharges.
3) Under normal circumstances, the amount of cargo spilled during loading and unloading operations is minimal. Ship operators have been cooperative in recording washdown times and amounts. However, methods for recording the data varied among companies (with some slight variations between vessels within a company). Also, methods for estimating the amount of residue varied widely, and were inconsistent among similar vessels. This is reflected in the wide range of estimates noted in Section 4.2.2 above.
4) The analysis of dry cargo discharge washdown data for the 2001 shipping season shows that the amount of material entering the Great Lakes versus the amount transported is small, on the order of 0.003–0.006%.
5) Occasionally, equipment or operator problems—or in extreme cases vessel casualties—result in more than minimal amounts being spilled. It is recommended that discharge quantities over a

certain amount be reported immediately. Based on the analysis presented in Section 4.2.2 above, a reportable quantity of 1,000 lbs should be considered in developing subsequent regulations.

6) The current technology and procedures used by shipping companies and ports greatly has reduced the quantities of cargo spilled into the environment during the loading and discharging of ships. The quantities are so small that they are approaching the point that further reductions may be impractical. It will never be possible to eliminate windblown dust completely or the occasional loss because of overfilled clamshell grabs or conveyor belts. Greater reductions in spilled quantities may be possible with ever improving technology and procedures but incremental reductions are likely to be small, having relatively little impact on the environment.
7) As for the possibility of complete discharge elimination, this would be technically and economically prohibitive in the current fleet, and most likely would involve a new generation of "green ship" bulk carriers. Determining the timing, engineering feasibility, and economic impact of such an initiative would require a far more extensive analysis than can be undertaken in the context of this study. Effort expended on any such initiative should be weighed against the gains that could be realized by addressing other vessel and non-vessel pollutant inputs to the Great Lakes.

4.4.2 Recommendations

1) A standardized format should be developed for estimating, recording, and collecting dry cargo discharge amounts aboard bulk carriers. This should entail keeping a separate logbook in a standard format that can be routinely checked and copied for further analysis (the three-ring binder versions maintained by a number of vessels greatly facilitated the data collection effort). Discharge amounts should be estimated in pounds, and discharge start and stop positions should be recorded in latitude and longitude. The nature of the discharge material (e.g., coal, stone, or combination) and source (deck or tunnel) should be specified clearly.
2) Vessel operators should be trained on appropriate methods for gathering and recording the data. This might include referencing volumes to a standard size container (e.g., 5-gallon bucket or 30-gallon trash can) and providing tables on the pounds of material that this volume would translate to for various materials (e.g., iron ore, coal, stone). This would allow some measure of eyeball calibration in estimating the amount of material that might be deposited on deck.
3) Every effort should be made to continue to minimize dry cargo discharges on deck and in the tunnels. Discharges greater than 1,000 lbs should be avoided aggressively and reported. To the extent possible, material spilled on deck should be shoveled into cargo holds. Material spilled in tunnels should be shoveled back onto the belts as time and safety considerations permit. It is in the best interest of the industry to keep dry cargo discharges at a *de minimus* level consistent with the intent and language of the Annex V of MARPOL 73/78, Regulations for the Prevention of Pollution by Garbage from Ships (MARPOL V) Guidelines so that they continue to be valid routine vessel operational discharges for regulatory purposes. This will justify their regulation by the U.S. Coast Guard and also avoid attracting attention of regulatory agencies and the public to this issue.

4.5 References

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5.0 ASSESSMENT OF THE ENVIRONMENTAL IMPACTS OF DRY CARGO DISCHARGES IN THE GREAT LAKES

Having gathered a substantial amount of data on the amount and distribution of dry cargo discharges in the Great Lakes, the next step in this study is an overall assessment of how these discharges may impact the environmental resources in the Great Lakes, and the effectiveness of the current Ninth Coast Guard District (CGD9) Policy in mitigating these impacts. Steps in this analysis included:

- Development of an overall approach
- Characterization of current environmental conditions
- Assessment of dry cargo discharge loading versus environmental impact by commodity, Lake, and trackline segment
- Analysis of the effectiveness of the current policy in mitigating environmental impacts

5.1 General Approach to Identifying Environmental Impacts

A comprehensive approach to identifying environmental impacts of vessel dry cargo sweeping/washdown activities should involve *identification*, *characterization*, and *quantification* of the dry cargo commodity inputs: identification of input locations, characterization of the fates of inputs, and an examination of the effects on the existing habitats and biota in the Great Lakes (see Figure 5.1). Final recommendations for an *environmentally sound*, dry cargo washdown policy for the Great Lakes ideally should be based on an evaluation of three basic location-specific factors:

- **Environmental sensitivity of input locations.** The environmental sensitivity of a particular dry cargo washdown location is based on its proximity to sensitive shoreline, benthic, and water-column features; the presence of sensitive floral and/or faunal species or communities; and the presence of threatened or endangered species (as designated by federal and/or state regulations). The general environmental "health" of the general area involved is also of importance in the sensitivity of washdown areas. The cumulative input of other pollutants (e.g., oil, chemicals) from point and non-point sources, eutrophication, over-fishing, coastal erosion, invasive (exotic) species introduction, and other sources of ecological degradation can increase the sensitivity of certain areas.
- **Characteristics of dry cargo commodities.** The physical and chemical characteristics of each specific commodity—as well as the characteristics of any chemical and/or physical interactions between commodities—are crucial in determining environmental impacts. The *solubility* of the components of each commodity, the chemical *toxicity* of commodity components, the *physical nature* (e.g., grain or particle size) of the commodity, and the potential for causing *eutrophication* influence the overall environmental impacts of each commodity on specific species, the larger ecological communities, and the habitats of these communities.
- **Commodity amounts.** The actual *amounts* of the commodity inputs entering the water in each location will determine the extent of environmental impact. The inputs should be viewed on a cumulative basis.

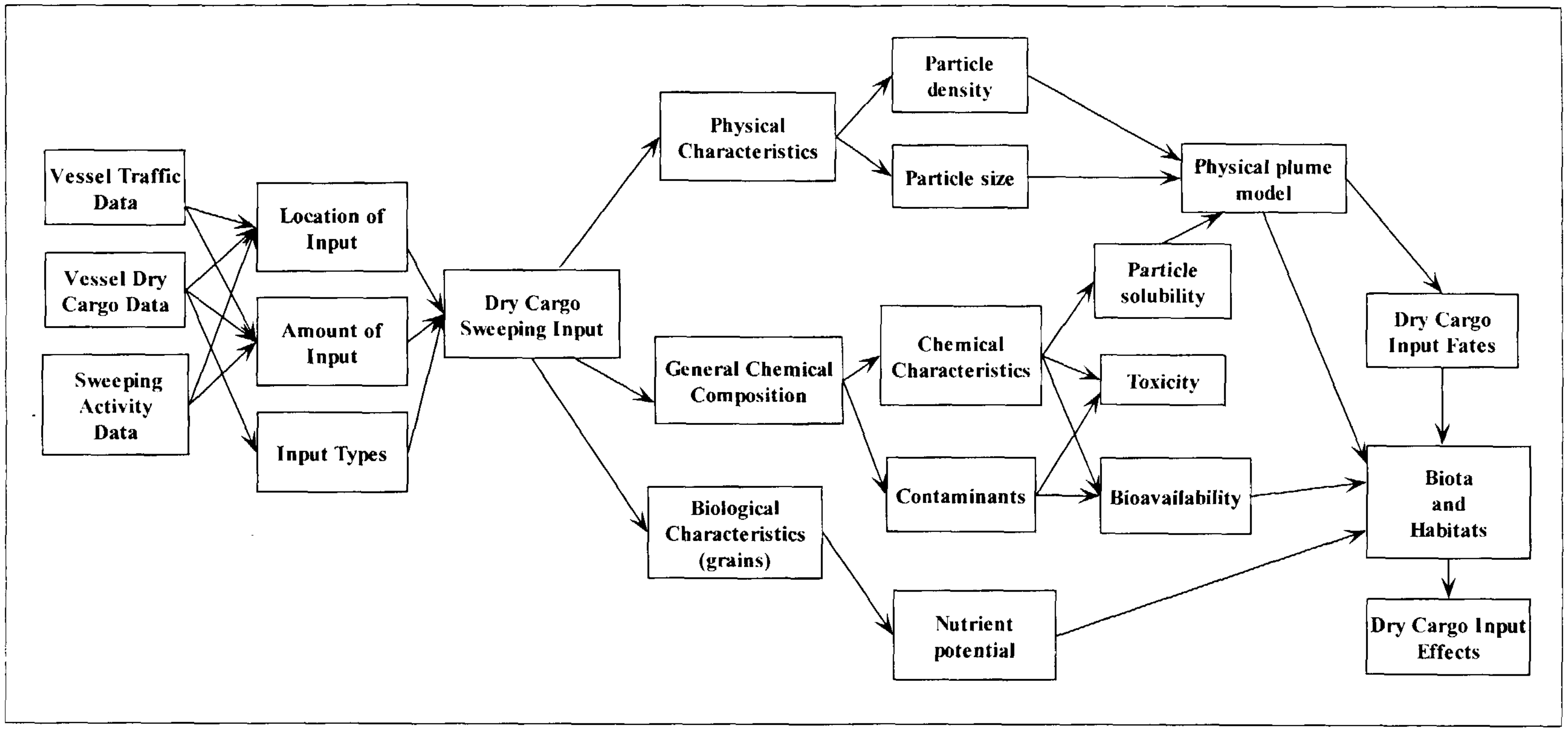

Figure 5.1 Diagram Showing Factors—Inputs, Fates, and Effects—Considered in Dry Cargo Sweepings Impact Analysis.

The above approach has been applied in this study as much as possible with existing environmental sensitivity information on the Great Lakes, coupled with commodity input estimates based on current data. Because each of the above factors is *location specific,* a basic geographical analysis of the inputs and environmental sensitivity has been conducted in this study based on available information. The sensitivity of the current U.S. Great Lake dry cargo sweeping tracks was viewed in relation to the amount of each type of commodity being deposited. Where dry cargo washdowns or sweepings are being conducted in locations determined to be of higher environmental sensitivity, recommendations for more preferable washdown or sweeping locations have been made.

5.2 General Environmental Health of Great Lakes

The Great Lakes encompass a unique closed system of inland freshwater seas that span more than 750 miles. The five major lakes, smaller lakes, bays, and connecting rivers contain about 5,500 cubic miles of water covering a total of 94,000 square miles. The Great Lakes is the largest freshwater system on earth containing roughly 18% of the world's water supply. Additionally, the Great Lakes System has played and continues to play a major role in the commerce of both the United States and Canada. One tenth of the U.S. population and one quarter of the Canadian population reside along the shores of the Lakes (EPA and Government of Canada, 1995) (see Tables 5.1 and 5.2.) The Great Lakes Basin also supports a unique array of habitats and diverse populations of flora and fauna. Though the Great Lakes is a system of waterbodies, each individual Lake has unique characteristics in terms of size, depth, and retention time. These characteristics are presented in detail in Figures 2–7 of Appendix B, which is the complete environmental assessment prepared by Environmental Research Consulting as part of this study and has been condensed as Section 5.0.

Being a unique closed-water system and generating vast commerce and industry in the region, the Great Lakes have been stressed from an environmental perspective over the last 150 years and even more stressed over the last few decades (see Table 5.3). The rates of habitat destruction, coastal erosion, and toxic pollutant and excess nutrient input have been increasing rapidly until fairly recently. In the past several years, state and federal environmental agencies and groups have focused greater attention on protection of the Great Lakes System, especially with respect to some of its unique problems, such as introducing invasive exotic species, increasing salinity, and decreasing water levels.

Table 5.1 Great Lakes Statistics.

Lake	Lake Volume (cu mi)	Number of Islands	Shore Length (mi)		Area (sq mi)	
			Lake	Islands	Lake	Islands
Superior	2,831	41	1,627	646	32,424	610
Michigan	1,147	21	1,335	217	22,349	151
Huron	814	66	1,826	1,025	24,472	1,529
St. Clair	1	15	118	99	463	27
Erie	113	7	820	81	9,959	39
Ontario	400	16	932	217	7,566	127
Total	**5,306**	**166**	**6,657**	**2,285**	**97,233**	**2,482**

Source: Based on Schwab and Sellers, 1996.

Table 5.2 Physical Features of Great Lakes.

	Lake System					
Feature	**Superior**	**Michigan**	**Huron**[1]	**Erie**[2]	**Ontario**[3]	**Total**
Elevation[4] (ft)	600	577	577	569	243	—
Length (mi)	350	307	206	241	193	—
Breadth (mi)	160	118	183	57	53	—
Average Depth (ft)	483	279	195	62	283	—
Maximum Depth (ft)	1,332	925	750	210	802	—
Volume (cu mi)	2,900	1,180	850	116	393	5,439
Water Area (sq mi)	31,700	22,300	23,000	9,910	7,340	94,250
Land Drainage (sq mi)	49,300	45,600	51,700	30,140	24,720	201,460
Total Area (sq mi)	81,000	67,900	74,700	40,050	32,060	295,710
Shoreline Length[5] (mi)	2,726	1,638	3,827	871	712	10,210
Retention Time (yrs)	191	99	22	2.6	6	—
U.S. Population[6]	425,548	10,057,026	1,502,687	10,017,530	2,704,284	24,707,075
Canada Population[6]	181,573	—	1,191,467	1,664,639	5,446,611	8,484,290
Total Population[6]	607,121	10,057,026	2,694,154	11,682,169	8,150,895	33,191,365
Outlet	St. Mary's R.	Straits Mackinac	St. Clair R.	Niagara R./ Welland Canal	St. Lawrence R.	—

[1]Lake Huron includes St. Mary's River.

[2]Lake Erie includes St. Clair-Detroit system.

[3]Lake Ontario includes Niagara River.

[4] Measured at low water datum.

[5]Including islands; total lengths greater than sum of lake shorelines with inclusion of connecting channels (excluding St. Lawrence River).

[6]1990–1991 data. Source: U.S. Environmental Protection Agency and Government of Canada, 1995.

Table 5.3 Stress Analysis of Threats to Great Lakes Biodiversity.

	Toxics		Nutrients		Acidification		Salinity		Siltation		Habitat Destruction	
Area	**Severity**	**Scope**	**Severity**	**Scope**	**Severity**	**Scope**	**Severity**	**Scope**	**Severity**	**Scope**	**Severity**	**Scope**
Open Lake	M	M	M	L	—	—	—	—	L	L	—	—
Coastal Shore	—	—	—	—	—	—	—	—	—	—	H	L
Lakeplain	M	L	M	L	—	—	M	M	—	—	H	H
Tributaries	H?[1]	H	M	H	—	—	L	L	H	H	H	M
Upland	—	—	—	—	L	L	—	—	—	—	H	H
Wetland	M	H	M	H			M	M	—	—	H	M
Avg. Score	**M**		**M**		?[2]		**L**		**L**		**H**	

H = high, M = moderate, L = low.

[1]There is some question about the high score given for severity of toxics in tributaries.

[2]The total stress impact is unknown for the average score for acidification.

Source: U.S. Environmental Protection Agency, Great Lakes National Program Office, Chicago, Illinois.

5.2.1 Areas of Concern

Environment Canada and the U.S. Environmental Protection Agency (EPA) (Environment Canada and EPA, 1999; EPA, 2000) designated specific Great Lakes locations as Areas of Concern (AOCs) based on criteria such as ecological health, habitat sensitivity or degradation, human health risks, and human use and welfare importance (Table 5.4). Figure 5.2 shows the locations of the currently designated AOCs. (**Note:** Issues regarding classifications and designations of AOCs are further discussed in the 2001 U.S. Policy Committee report "Restoring United States Areas of Concern: Delisting Principles and Guidelines," available on-line at *http://www.epa.gov/grtlakes/aoc/delist.html.*) Figures 5.3 and 5.4 show areas that support significant biodiversity and areas that have suffered serious environmental impacts.

5.2.2 Pollutant Input Into Great Lakes

Industry and commerce in the Great Lakes region have caused inputs of various pollutants, including petroleum products and chemicals. Figures 11–16 in Appendix B provide details on petroleum spillage from vessels and facilities into each of the Great Lakes since 1985.

With few exceptions, the petroleum spills in the Lakes involve refined products rather than crude oil. The amount of spillage varies from year to year, and is generally dominated in quantity by a few larger spills. The vast majority of spills are less than 10 gallons. The average annual spillage into each Lake over the last 18 years is relatively low with the exception of Lake Erie, which averages nearly 8,000 gallons per year, and Lake Michigan, which averages just over 15,000 gallons per year because of a single 115,000-gallon facility spill in 1990. Spills of other non-petroleum chemicals have been reported on a few occasions, as shown in Table 5.5.

Input of petroleum, chemicals, and other pollutants from non-point sources, such as urban and agricultural runoff, may be several orders of magnitude greater than inputs through spills from point sources, such as vessels, pipelines, and facilities. The actual annual input of pollutants from non-point sources is considerably more difficult to measure or even estimate than point source spills. The results of a recent study on petroleum inputs into the marine environment indicate that the petroleum input (and thus polycyclic aromatic hydrocarbon input) from urban runoff is several orders of magnitude larger than inputs from spills from vessels and facilities (NRC, 2002). Urban runoff in the Great Lakes could be significant considering the size of the drainage basin and large number of industrialized cities in the region (see Figure 17 in Appendix B).

Inputs of other types of pollutants from runoff have not been well documented but are believed to be significant. The U.S. Army Corps of Engineers (USACE) reports that, based on records of dredging conducted in the harbors of the Great Lakes, approximately 5 to 6 million tons of material are deposited into the lakes on an annual basis (personal communication, Doug Zandy, USACE, Operations and Technical Services Division). The majority of this input is from land runoff. The input of salt from halite or road salt applied in cities and towns surrounding the Great Lakes could be substantial. Annually, over 8 million tons of halite are transported between ports in the Lake. Over 90% of this salt stays in the Great Lakes drainage basin and eventually ends up in the Lakes.

Table 5.4 Great Lakes Areas of Concern: Ecological Impairments as of June 1999.

Area of Concern		Criteria					
		Fish/Wildlife Degradation	**Benthos Degradation**	**Eutrophication**	**Plankton Degradation**	**Fish/Wildlife Habitat Loss**	**Score Total Impairment**
Lake Superior	Peninsula Harbor	Yes	Yes	No	No	Yes	3
	Jackfish Bay	Yes	Yes	No	No	Yes	3
	Nipigon Bay	Yes	Yes	Yes	No	Yes	4
	Thunder Bay	Yes	Yes	No	Yes	Yes	4
	St. Louis Bay	Yes	Yes	Yes	No	Yes	4
	Torch Lake	No	Yes	No	No	Yes	2
	Deer Lake	No	No	No	No	No	0
Lake Michigan	Manistique R.	No	Yes	No	No	Yes	2
	Menominee R.	Yes	Yes	No	No	Yes	3
	Lower Green Bay	Yes	Yes	Yes	Yes	Yes	5
	Sheboygan R.	Yes	Yes	Yes	Yes	Yes	5
	Milwaukee Est.	Yes	Yes	Yes	Yes	Yes	5
	Waukegan Harbor	?	Yes	No	Yes	Yes	2
	Grand Calumet R.	Yes	Yes	Yes	Yes	Yes	5
	Kalamazoo R.	Yes	Yes	No	No	Yes	3
	Muskegon Lake	Yes	Yes	No	No	Yes	3
	White Lake	Yes	Yes	Yes	No	Yes	4
Lake Huron	Saginaw R./Bay	Yes	Yes	Yes	Yes	Yes	4
	Collingwood Har.	No	No	No	No	No	0
	Severn Sound	Yes	Yes	Yes	Yes	Yes	5
	Spanish Harbor	?	Yes	No	No	?	1
Lake Erie	Clinton R.	Yes	Yes	Yes	No	Yes	4
	Rouge R.	Yes	Yes	Yes	No	Yes	4
	R. Basin	Yes (Fish)	Yes	Yes	?	Yes	4
	Maumee R.	Yes	Yes	Yes	?	No	3

continued on next page

Table 5.4 Great Lakes Areas of Concern: Ecological Impairments as of June 1999 (*continued*)

Area of Concern		Criteria					
		Fish/Wildlife Degradation	Benthos Degradation	Eutrophication	Plankton Degradation	Fish/Wildlife Habitat Loss	Score Total Impairment
Lake Erie, *continued*	Black R.	Yes	Yes	?	?	Yes	3
	Cuyahoga R.	Yes	Yes	Yes	?	Yes	4
	Ashtabula R.	Yes	Yes	No	?	Yes	3
	Presque Isle Bay	No	No	No	No	No	0
	Wheatley Harbor	No	No	?	No	Yes	1
Lake Ontario	Buffalo R.	?	Yes	No	No	Yes	2
	Eighteen Mile Cr.	?	Yes	No	?	No	1
	Rochester Bay	Yes	Yes	Yes	Yes	Yes	5
	Oswego R.	Yes	?	Yes	?	Yes	2
	Bay of Quinte	Yes	Yes	Yes	Yes	Yes	5
	Port Hope	No	No	No	No	No	0
	Metro Toronto	Yes	Yes	Yes	?	Yes	4
Connect Channels	Hamilton Harbor	Yes	Yes	Yes	?	Yes	4
	St. Mary's R.	Yes	Yes	Yes	No	Yes	4
	St. Clair R.	No	Yes	No	No	Yes	2
	Detroit R.	Yes (Wildlife)	Yes	No	No	Yes	3
	Niagara R. (Can.)	No	Yes	Yes	?	Yes	3
	Niagara R.(NY)	Yes	Yes	No	No	Yes	3
	St. Lawrence R.	No	Yes	Yes	?	Yes	3

[1]Score based on total number impaired uses from this table (0 = low, 5 = high, ? = impact unknown).

Note: Shading indicates criteria that are being impacted or are of great concern.

Source: Based on Environment Canada and EPA, 1999.

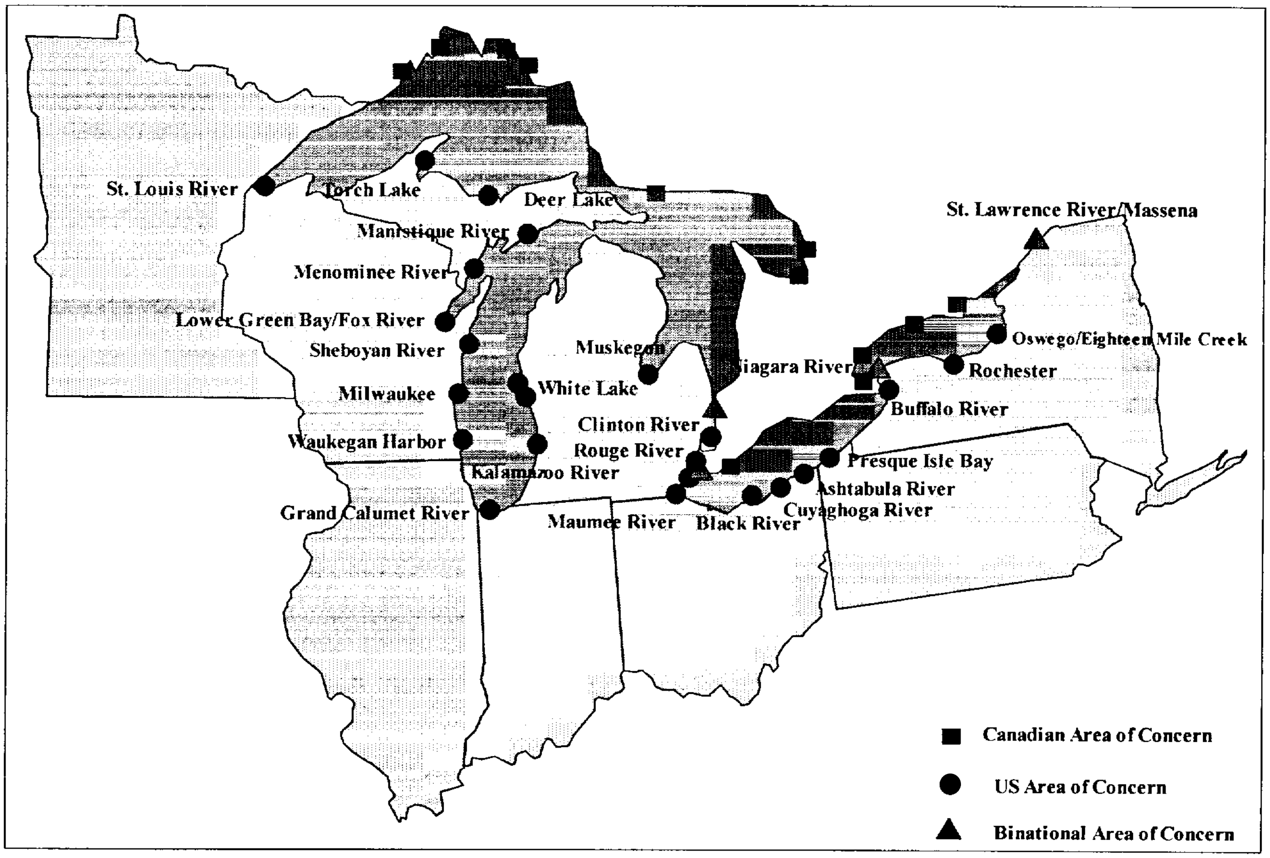

Figure 5.2 Great Lakes Areas of Concern. Source: EPA, 2000.

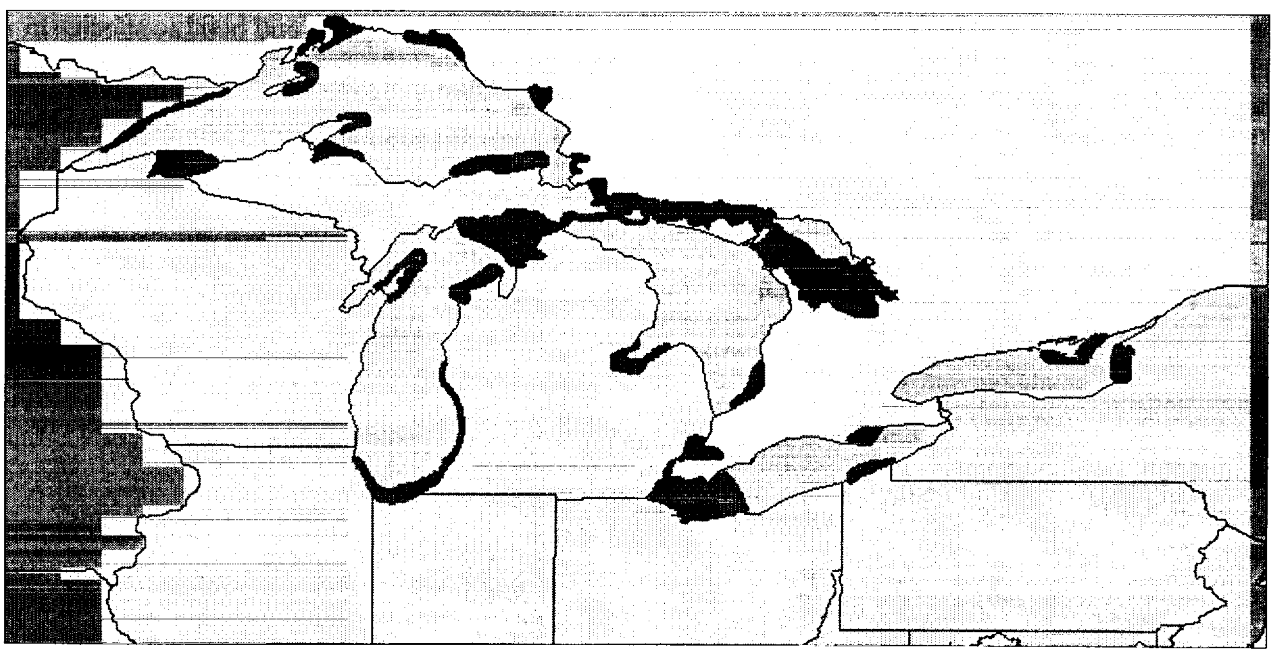

Figure 5.3 Great Lakes Areas with Significant Biodiversity. Source: EPA, 1994.

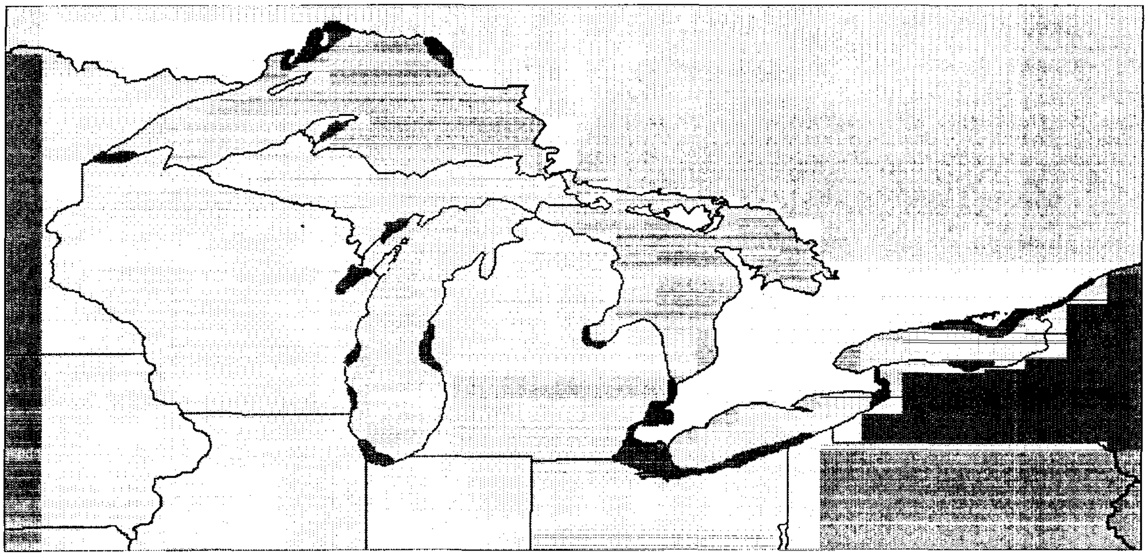

Figure 5.4 Great Lakes Environmentally Impaired Areas.

The impact of these inputs depends entirely on the composition of the pollutants. Toxicity can be a significant stressor for habitats and specific populations, particularly fish (EPA and Government of Canada, 1995). Some contaminants, such as polycyclic biphenyls (PCBs) can bioaccumulate continuously in the food chain with the highest levels then occurring in the eggs of fish-eating birds such as herring gulls (EPA and Government of Canada, 1995).

Excess phosphorus and nitrogen input from fertilizers and decomposing organic material in agricultural and forest runoff can cause eutrophication, which in turn stimulates green plant and algae overproduction (NRC, 2000). This overproduction causes oxygen depletion through decomposition of the organic matter, which then changes the distribution and diversity of fish and benthic species in the Lakes. The condition of the Lakes has improved in the last two decades with respect to phosphorus concentration because of the elimination of phosphorus from detergents though Lake Ontario and Lake Erie, and pockets in Lake Michigan and Lake Huron continue to be somewhat stressed (EPA, 2000).

5.3 Characteristics and Potential Environmental Impacts of Dry Cargo

5.3.1 Characteristics of Dry Cargo Commodities

The potential impacts of dry cargo inputs depend on the characteristics of the individual commodities. The degree of solubility in water, length of residence in water, degree of precipitation to the lake bottom, and toxicity to flora and fauna determine the potential for environmental impacts.

Coal

Bituminous coal includes both anthracite (the hardest coal) and lignite (the softest coal). Its chemical formula is S/C102H78O10N2. Coal typically is composed of fixed carbon (50–72%), fused polycyclic aromatic hydrocarbons (PAHs) (17–37%) and 5–13% of the following ingredients, each of which makes up a proportion of the whole in the range shown—water (3–8%), sulfur (0.5–1.8%), and elemental and compounds of hydrogen (4.2–5.2%)—nitrogen (1.3–1.6%), and chlorine (0.03–0.2%).

Table 5.5 U.S. Coast Guard Reports of Chemical Spills From Vessels.

Date	City	State	Waterbody	LAT	LON	Vessel Name	Vessel Type	Operation	Material	Amount in Water
10/9/88	Rogers City	MI	Lake Huron	N45298	W085523	OLS 30	Tank barge	None	Calcium chloride	4,857 tons
1/13/89	Mackinaw City	MI	Lake Huron	N45503	W084365	ENERCHEM CATALYST	Tank ship	Underway	Caustic soda solution	30 gallons
8/19/99	Boyne City	MI	Lake Michigan	N45130	W085020	Unnamed (MC5875PC)	Recreational	Discharge	Isobutylamine	5 gallons
1/29/89	Buffalo	NY	Lake Erie	N42503	W078521	KIISLA	Tank ship	Underway	Toluene	30 gallons
1/29/89	Buffalo	NY	Lake Erie	N42503	W078521	KIISLA	Tank ship	Underway	Xylene	30 gallons
8/15/92	Au Gres	MI	Lake Huron	N44066	W083339	M/V LOUIS R. DESMARAIS	Freight ship	Discharge	Xylene	30 gallons
6/17/98	Massena	NY	St. Lawrence River	N44590	W074510	MOUNTAIN BLOSSOM	Tank ship	Allision (in port)	Xylene	200 gallons

NEC = not elsewhere classified.

Source: Data from Environmental Research Consulting databases as derived from USCG casualty data.

After deposition, coal breaks into component fractions, including up to 1.7 mg/gram of PAHs, which are very persistent in sediments. PAHs can be released from coal into water with serious impacts on biota. Coal dust retards plant growth and could cause wetland damage. PAHs are known to have serious impacts on ecosystems and many organisms.

Petroleum Coke

Petroleum coke is a derivative of petroleum that contains elemental carbon and residual mineral impurities. It is relatively insoluble in water but does eventually leach out various components. Leachate from petroleum coke can contain a variety of heavy metals that can impact organisms at relatively low doses. The toxicity of the carbon portion of coke is relatively low, having been measured at $LD_{50} > 5{,}000$ mg/kg (rat).

Metals and Ores

Ores are minerals or aggregates of minerals that contain a variety of elements—particularly metals—that can be extracted through refining and smelting processes. A variety of metallic ores are transported between and from various ports in the Great Lakes. The ores have different potentials to cause environmental impacts. The magnitude of their impacts depends on their chemical and physical composition. All ores have the potential to accumulate in the benthic regions of the Lakes (bottoms) and cause transient smothering or crushing of organisms as they fall. The accumulation of the pieces of ore can change the benthic substrate enough to impact the diversity of benthic organisms. The accumulations can create a variety of new habitats and reproductive areas for fish and other organisms.

Copper

Copper ore (Cu) is soluble in acidic water but precipitates at pH > 6.5. The maximum safe concentration for aquatic life is 2 µg/L (micrograms per Liter). Concentrations as low as 16 ppm can cause impacts with severe impacts at 110 ppm. The residence time of mobilized copper in water is 89 years.

Nickel

Nickel ore is soluble in water of neutral pH. The maximum concentration safe for aquatic life is 65 µg/L. Concentrations as low as 16 ppm can cause impacts. Severe impacts occur at 75 ppm. The residence time of mobilized nickel is unknown.

Lead

Lead ore, known as galena, is a simple compound composed of lead and sulfur (PbS). It also may contain small amounts of silver (Ag), antimony (Sb), arsenic (As), and copper (Cu). It is nearly insoluble, but acidic and anoxic conditions, which are common in the Great Lakes, will increase the leaching rate. It is very toxic and can have devastating long-term impacts. The maximum safe concentration for aquatic life is 2 µg/L. Concentrations as low as 31 ppm can cause impacts, with severe impacts at 250 ppm. The residence time of mobilized lead is unknown, though evidence seems to point at a relatively long life.

Iron

Iron ore is the most commonly carried metallic ore in the Great Lakes. It comes in different forms.

There are two main types of iron ore—hematite and magnetite. Hematite typically contains iron oxide (Fe_sO_3, 92.2%); silica (SiO_2, 5.4%); aluminum oxide (Al_2O_3, 1.4%); and traces (< 0.14% each) of phosphorus (P_2O_3), manganese oxide (MnO), calcium oxide or lime (CaO), potassium oxide (KO), sodium oxide (NaO), and sulfur (S). The chemical composition of magnetite is $(Fe,\underline{Mn},\underline{Mg},\underline{Zn},\underline{Ni})^{2+}(Fe,\underline{Al},\underline{Cr},\underline{Mn},\underline{V})^{3+}{}_2O_4)$. It also may contain impurities: titanium, manganese, magnesium, zinc, nickel, aluminum, chromium, and vanadium. Iron oxides tend to leach slowly from iron ores to form stable ferric hydroxide ($Fe(OH)_3$) particles that can precipitate or remain suspended. Acidic and anoxic conditions increase the leaching rate. The solubility of iron ore varies. There are no toxicological data available for iron ore. The maximum safe concentration for aquatic life is 300 μg/L, but concentrations as low as 31 ppm can cause impacts. Severe impacts can occur at 40,000 ppm. The residence time of mobilized iron is 160 days.

Taconite is a low-grade iron ore pelletized for blast furnace reduction. Basically, it is an iron-bearing chert containing 25–30% hematite and magnetite. It typically contains iron (65.6%); silica (5.4%); and traces (< 0.3% each) of phosphorus, manganese, calcium oxide, potassium oxide, sodium oxide, and sulfur. It generally is insoluble in fresh water, but slightly soluble under acidic conditions. Since it is composed mainly of iron ores, it has the same basic environmental impacts as hematite and magnetite.

The two common zinc ores are sphalerite and marmatite. Generally they are composed of zinc sulfide (ZnS, 85–89%), iron sulfide (FeS, 8–10%), silica (SiO_2, 1–2%), copper (Cu, 0.3–0.8%), and cadmium (Cd, 0.1%). Zinc will exist as an ion, but at a neutral pH, the solubility is relatively low. It will be released slowly at neutral pH and will tend to precipitate. Acidic and anoxic conditions will increase the leaching rate. Zinc ore is highly soluble in acidic water. It has a relatively low toxicity (LD_{50} > 5,000 mg/kg). The maximum concentration safe for aquatic life is 320 μg/L, but concentrations as low as 120 ppm can cause impacts. Severe impacts occur at 820 ppm. The residence time of mobilized zinc is 37 years.

Aluminum

The most common aluminum ore is bauxite. Its chemical composition is aluminum hydroxide ($Al(OH)_2$); aluminum oxide monohydrate ($Al_2O_3 \cdot H_2O$); silica (SiO_2); iron oxide (Fe_2O_3); and traces of calcium and magnesium ($CaO \cdot MgO$), titanium (TiO_2), and potassium and sodium ($K_2O \cdot Na_2O$). Aluminum ore is soluble and mobilized in acidic water. Acidic and anoxic conditions will increase leaching rate of the metals in bauxite. The maximum concentration safe for aquatic life is 5 μg/L. Concentrations that cause impacts are unknown. There are no known toxic effects. The residence time of mobilized aluminum is 113 days.

Manganese

Manganese ore is composed of manganese oxide (MnO_2), aluminum oxide (Al_2O_3), iron oxide (Fe_2O_3), and silica (SiO_2). It has a relatively low solubility (< 0.1%) but will dissolve in water regardless of pH. No toxicity information available. Manganese is oxidized and sedimented quickly. Acidic and anoxic conditions will increase the leaching rate. Manganese ore oxidizes and sediments quickly when dissolved. Concentrations as low as 460 ppm can cause impacts. Severe impacts occur at 1,100 ppm. The residence time of mobilized copper is 292 days.

Waste Ore Materials

Millscale

Millscale is a "waste" material derived from iron-ore refining. It generally is composed of 70% iron oxide (Fe_2O_3). The other components vary depending on the source of the material. It has negligible solubility. There are no toxicological data available. Since it is composed mainly of iron, its impacts are similar to those described for hematite and magnetite.

Slag

Slag is composed of the residues that remain after the smelting of various metallic ores. A common chemical formulation for slag is silica (SiO_2, 30–60%), calcium oxide (CaO, 30–50%), aluminum oxide (Al_2O_3, 0–20%), magnesium oxide (MgO, 0–20%), iron oxide (Fe_2O_3, 0–10%), titanium oxide (TiO_2, 0–5%), and manganese oxide (MnO_2, 0–2%).

It has negligible solubility (< 0.1%) in water, but slowly can leach out various components. Iron oxides leach slowly to form stable precipitating ferric hydroxide ($Fe(OH)_3$) particles. Acidity and anoxic conditions in the water can increase the leach rate. There are no specific toxicological data available. Its impacts can be expected to be similar to the various metallic components. The silica portion, however, is completely insoluble and has little impact.

Inorganic Salts

Halite (Sodium Chloride)

Salt or halite is composed primarily of sodium chloride (NaCl), but often contains sodium hexacyanoferrate ($C_6FeN_6Na_4 \cdot 10H_2O$), which is added an anti-caking agent. Sodium hexacyanoferrate releases hydrogen cyanide (HCN) when dissolved in water (Ohno, 1990). Cyanide is extremely toxic to aquatic life—LC_{50} 96 hours of 0.123mg/L (fathead minnows), LD_{100} of 10 mg/kg (rat), and LD_{50} of 1.1 mg/kg (rabbit). Sodium chloride is highly soluble in water. Sodium concentrations already are elevated in the Great Lakes (by a factor of three in the last 50 years). Additional input of salt to these freshwater lakes would be a major concern.

Fluorospar

Fluorspar is an inorganic salt composed of fluorite or calcium fluoride (CaF_2), with traces of silica (SiO_2) and calcium carbonate ($CaCO_3$). It has a relatively low solubility in water (16 mg/L) and thus generally is not available to aquatic life. Its toxicity is relatively low and has been measured at LD_{50} of 4,250 mg/kg (rat). Since calcium fluoride is not very soluble in water, it is not available to aquatic life.

Potash

There are various potassium-containing compounds that are called potash, including potassium chloride (KCl), also known as potassium muriate; potassium hydroxide (KOH); and potassium carbonate (K_2CO_3), also known as salt of tartar, carbonic acid, and dipotassium salt. Each compound has completely different characteristics. While it is unclear exactly which compound described as "potash" is being transported in the U.S. portion of the Great Lakes, it is most likely potassium chloride, as this is the compound reported by the Canadian Coast Guard (CCG) to be transported by Canadian vessels (Melville Shipping, 1993a).

Potassium chloride is completely soluble in cold water, but tends to become incorporated into mineral structure after dissolution. It is not listed as hazardous material under the Clean Water Act (CWA). Its toxicity has been measured at LD_{50} of 1,500 mg/kg (mouse) and LD_{50} of 2,600 mg/kg (rat).

Potassium hydroxide is completely soluble in cold water, but it chemically reacts with water. Heat is generated if it comes in contact with water or carbon dioxide in the air. It is more toxic than potassium chloride, having a measured toxicity of LD_{50} of 273 mg/kg (rat). (**Note:** *Considering the reactivity of this compound, it is unlikely to be carried in open containers in vessels.*)

Potassium carbonate also is completely soluble in cold water; however, like potassium chloride, it tends to become incorporated into mineral structures after dissolution. It is less toxic than potassium hydroxide, with toxicity levels measured at LD_{50} of 1,870 mg/kg (rat) and LD_{50} of 2,510 mg/kg (mouse).

Fertilizers

Fertilizers have a variety of formulations depending on their intended use. They all contain a source of nitrogen, phosphorus, and potassium, as well as traces of other minerals. They typically contain nitrogen and phosphorus salts (ammonium, potassium, sodium salts of nitrate, nitrate, and phosphorus). They may contain urea as nitrogen source. A typical formulation contains urea ($CO(NH_2)_2$), triple superphosphate ($Ca \cdot 2H_3O_4P$), monoammonium phosphate ($NH_4H_2PO_4$), diammonium phosphate ($(NH_4)_2H_2PO4$), potassium sulfate (K_2SO_4), potash of magnesium sulfate ($K \cdot MgSO_4$), potassium chloride (KCl), calcium carbonate ($CaCO_3$), and sulfur (S). All these components are highly soluble and are nutrients essential for plant life. High concentrations can cause toxic reactions. Fertilizers also can cause eutrophication, which is already a concern in many locations in the Great Lakes because of runoff from agricultural lands (containing excess fertilizers and other nutrients).

Organic Materials

Like fertilizers, organic materials can cause or contribute to eutrophication and the overproduction of plants such as algae. Decomposing organic matter can deplete benthic oxygen levels, thus creating anoxic conditions, which can damage aquatic animals. The decomposition also can cause the formation of anaerobic sludge that releases toxic methane and hydrogen sulfide.

Grains

As organic materials, grains can cause or contribute significantly to eutrophication and benthic oxygen depletion.

Wood Chips and Pulp

Processed wood consists of cellulose fibers alone or cellulose with lignin. As organic wood chips and pulp, processed wood can cause or contribute significantly to eutrophication and benthic oxygen depletion. Most portions of wood are relatively insoluble, but eventually can break down in water. Lignin in wood pulp can discolor water.

Wood chips and pulp for paper production can contain Dioxin (dioxinium perchlorate, hydronium perchlorate, or perchloric acid, $HClO4$), a chemical used in processing. Dioxin is highly soluble in water and known to be extremely environmentally hazardous (LC_{100} for *Cyprinun caprio* is 180 ppm/24 hrs at 25°C). Dioxin and other organic processing chemicals in wood pulp and paper can be extremely injurious to aquatic life.

Building Materials

Sand, Rocks, and Gravel

Rocks are aggregates that can be composed of a large number of compounds, including metallic ores, and thus can have the impacts of metallic ores as described above. Gravel is composed of crushed rocks. Sand generally is composed of quartzite or silica dioxide (SiO_2). This compound can also be a major component of rocks.

Sand and many of the components of rocks and gravel generally are insoluble. They have no known toxicity and no direct or indirect effects on animals. Their release from a moving vessel briefly may increase turbidity in the water column and smother bottom-dwelling animals as the particles and pieces fall. Accumulations of aggregates and large pieces of building materials could increase habitats for fish by increasing the roughness of the bottom sediment and increasing the diversity of bottom habitats.

Clay

Clay generally is composed of kaolinite ($Al_2Si_2O_5(OH)_4$, > 60%), silica (SiO_2, < 30%), mica ($K_2(Mg,Fe)_6Al_2Si_2O_{20}(OH,F)_4$, < 10%), and titanium oxide (TiO_2, < 2.6%). It has negligible solubility in water, but can break down in smaller particles that can become suspended in water. There are no known toxic effects to clay itself, though it may contain traces of contaminants that may have impacts.

Cement

Cement, also known as Portland cement, generally contains tricalcium silicate ($3CaO{\cdot}SiO_2$), dicalcium silicate ($2CaO{\cdot}SiO_2$), tricalcium aluminate ($3CaO{\cdot}Al_2O_3$), tetracalcium aluminoferrate ($4CaO{\cdot}Al_2O_3{\cdot}Fe_2O_3$), calcium hydroxide ($Ca(OH)_2$), magnesium hydroxide ($Mg(OH)_2$), calcium oxide ($CaO$), calcium carbonate ($CaCO_3$), and magnesium carbonate ($MgCO_3$). It is insoluble to slightly soluble (0.1–1.0%). Cement is rated as non-hazardous by the EPA and has no recognized unusual toxicity to animals and plants with an LD_{50} of 400 mg/kg (rat). Its release into the water briefly may increase turbidity in the water column and smother bottom-dwelling animals on deposition.

Gypsum

Gypsum is composed of calcium sulfate dihydrate ($CaSO_4 \cdot 2H_2O$). It also may include anhydrous form of calcium sulfate ($CaSO_4$) and traces of silicon and aluminum. Gypsum is very slightly (0.3%) to moderately soluble in cold water. It may release calcium into water depending on whether the water already is saturated with calcium (hard water) or not (soft water). Calcium is not toxic and is rated as non-hazardous by the EPA.

Limestone/Dolomite

Limestone generally is composed of calcium carbonate ($CaCO_3$) or magnesium carbonate ($MgCO_3$), and calcium/magnesium dicarbonate (CaMg(CO3)2). The dolomite form of limestone includes magnesium. It also may have trace elements—often < 1% silica (SiO2). Different components of limestone can leach out in water. Solubility increases as pH decreases (more acidic). Calcium carbonate has a solubility of 0.001%. Magnesium carbonate has a solubility of 0.01%.

Calcium carbonate has a low potential to affect aquatic organisms. Acute aquatic effects have been measured only at very high concentrations (48-hour LC50 of 56,000 mg/L (mosquito fish) and LD50 of 6,450 mg/kg (rat)). Calcium carbonate is not expected to cause oxygen depletion in aquatic systems. There are no toxicological data available on magnesium carbonate.

5.3.2 Relative Important Rankings

The chemical and physical characteristics of the major dry cargo commodities shipped in the Great Lakes were rated individually by their propensity to cause various types of impacts to the Great Lakes environments (as shown in Table 5.6). The rating scale is such that "5" is the highest impact and "1" is the lowest impact.

For each of four basic benthic (bottom) habitat types—plant bed, mud-silt, sand, and rocky shoals—the commodities were rated based on impacts of smothering, toxicity, nutrient enrichment, and substrate change. Water-column impacts included toxicity and water quality. Sediment impacts included accumulation and sediment toxicity.

Total ranks were calculated by adding the ranks for individual impact components for each habitat, water column, and sediment. Total impact ranking scores were calculated for each commodity by calculating a grand total of all individual environmental component scores (i.e., the additive value of each total rank for the four habitat types added to the total ranks for water column and sediment).

Coal and coke received the highest total impact score based on their potential toxicity (primarily from leaching PAHs) and their capacity to cause smothering as well as substrate change. Iron ore also received a relatively high impact score based on its toxicity and potential to cause smothering and substrate change.

It is important to view these ranks and scores as relative numbers rather than as absolute numbers. For example, inputs of the coal or coke are not necessarily twice as harmful as equal volumes or weights of sand or stone because the impact score of coal and coke is 84 and the score for sand and stone is 42. The ranks were computed as a method for compiling the various impact components (e.g., toxicity, smothering) into a single relative score to be able to compare the potential impacts of inputs measured and estimated for the Great Lakes vessel trips as described below in Section 5.4.

Table 5.6 Ranked Relative Impacts of Dry Cargo Commodities on Great Lakes Environments.

Impact Types	Impacts	Commodity Impact Ranking[1]									
		Iron Ore	**Coal Coke**	**Limestone**	**Cement Sand Stone**	**Grain**	**Fertilizer**	**Gypsum**	**Millscale Slag**	**Potash**	**Salts**
Benthic Habitat: Plant Bed	Smothering	5	5	3	5	1	1	1	1	1	1
	Toxicity	5	5	1	1	1	1	1	3	1	3
	Nutrient Enrichment	1	1	1	1	5	5	1	1	5	1
	Substrate Change	1	5	1	1	1	1	1	1	1	1
	Total Rank	**12**	**16**	**6**	**8**	**8**	**8**	**4**	**6**	**8**	**6**
Benthic Habitat: Mud-Silt	Smothering	5	5	1	5	1	1	3	5	1	1
	Toxicity	5	5	1	1	1	1	3	5	1	3
	Nutrient Enrichment	1	1	1	1	3	5	1	1	5	1
	Substrate Change	1	5	5	1	1	1	1	1	1	1
	Total Rank	**12**	**16**	**8**	**8**	**6**	**8**	**8**	**12**	**8**	**6**
Benthic Habitat: Sand	Smothering	1	5	1	5	1	1	1	5	1	1
	Toxicity	1	5	1	1	1	1	1	5	1	3
	Nutrient Enrichment	1	1	1	1	3	5	1	1	5	1
	Substrate Change	1	5	5	1	1	1	1	1	1	1
	Total Rank	**4**	**16**	**8**	**8**	**6**	**8**	**4**	**12**	**8**	**6**
Benthic Habitat: Rocky Shoals	Smothering	5	5	1	5	1	1	3	5	1	1
	Toxicity	1	5	1	1	1	1	3	1	1	3
	Nutrient Enrichment	1	1	1	1	3	5	1	1	5	1
	Substrate Change	5	5	5	3	1	1	1	5	1	1
	Total Rank	**12**	**16**	**8**	**10**	**6**	**8**	**8**	**12**	**8**	**6**
Water Column	Toxicity	5	5	1	1	2	4	1	3	4	3
	Water Quality	5	5	1	1	2	4	1	3	4	3
	Total Rank	**10**	**10**	**2**	**2**	**4**	**8**	**2**	**6**	**8**	**6**
Sediment	Accumulation	5	5	3	5	1	1	1	1	1	1
	Sediment Toxicity	5	5	1	1	1	2	2	4	2	3
	Total Rank	**10**	**10**	**4**	**6**	**2**	**3**	**3**	**5**	**3**	**4**
Total Impact Ranking		**60**	**84**	**36**	**42**	**32**	**43**	**43**	**53**	**43**	**34**

[1]Relative ranking of commodity-specific impact within habitat section. 5 = *highest* impact, 1 = *lowest* impact.

5.4 Current Dry Cargo Inputs

A large variety of dry cargo commodities is shipped from one port to another in the Great Lakes. The vessels carrying the cargo tend to travel along the routes shown in Figure 5.5. The inputs of the various dry cargo commodities into each of the trackline segments shown in Figure 5.5 were estimated based on commodity- and segment-specific data collected from ship logs and ship inspections as described elsewhere in this report. The collected input data were used to make estimates of actual annual inputs by doubling the input data collected to account for the input data that were not available or that were missed in the sampling process. Since data from approximately one-half of the Canadian fleet and two-thirds of the U.S. fleet were collected, the estimates may slightly err on the higher side. The data that are presented in this section are meant solely for approximating annual inputs for the purpose of deriving information on potential environmental impacts.

The input data are in the form of pounds for each segment. Table 5.7 shows the total inputs for inputs from both U.S. and Canadian vessels for each segment and for each Lake. Table 5.8 shows the same segment and Lake inputs on a *per square mile* basis for all vessels. The square miles refer only to the *areas encompassed by each travel/washdown segment*, not for the Lake as a whole. Table 5.9 shows the same segment and Lake inputs on a *per acre* basis for U.S. and Canadian vessels. Again, the acres refer only to the *areas encompassed by each travel/washdown segment*, not for the Lake as a whole. Table 5.10 shows the segment and Lake inputs on a *linear mile* basis for all vessels. These data reflect the amount of input *per mile traveled. Since the washdown segments are not linear but actually have a width (and theoretically a depth) to them, these data cannot be used to estimate actual inputs in particular locations and their potential impacts.*

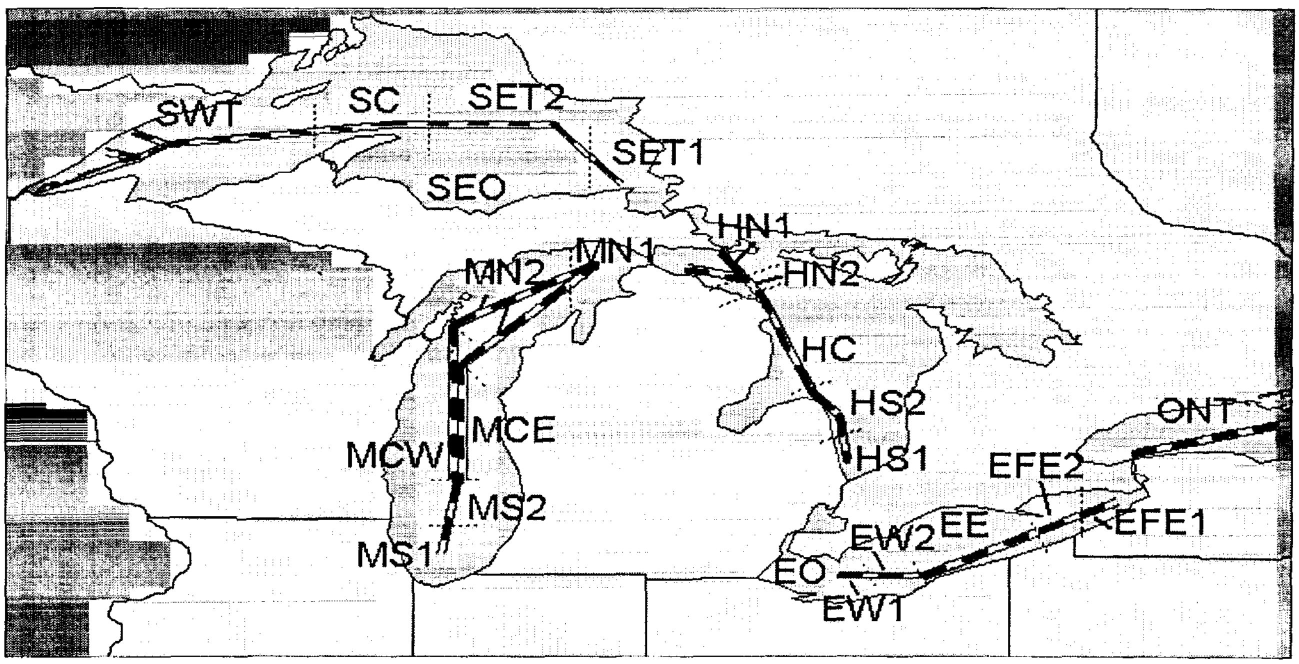

Figure 5.5 Major Tracklines of Dry Cargo Sweeping/Washdowns in the Great Lakes. Segments for inputs are designated according to protocol established in Table 4.1.

Table 5.7 Estimated Total Annual Input of Dry Cargo into Great Lakes Shipping Lanes (U.S. and Canadian Vessels).

Segment[1]	Estimated Total Annual Commodity Input[2] (lb)												
	Iron	**Coal**	**Stone**	**Grain**	**Salt**	**Coke**	**Gypsum**	**Millscale**	**Slag**	**Cement**	**Sand**	**Potash**	**Total**
EE	53,980	78,930	8,520	1,450	5,500	600	0	0	0	2,900	0	0	151,880
EFE-1	4,650	26,873	0	1,800	4,725	1,500	0	0	0	1,725	0	0	41,273
EFE-2	1,550	8,958	0	600	1,575	500	0	0	0	575	0	0	13,758
EO	12,110	9,310	45,160	1,600	1,600	1,600	20	1,400	0	0	600	0	77,700
EW-1	5,568	7,774	3,945	1,188	913	363	0	0	150	200	0	450	21,149
EW-2	16,703	23,321	11,835	3,563	2,738	1,088	0	0	450	600	0	1,350	63,446
Erie	**94,560**	**155,164**	**69,460**	**10,200**	**17,050**	**5,650**	**20**	**1,400**	**600**	**6,000**	**600**	**1,800**	**369,204**
HC	30,438	51,106	167,726	4,350	3,020	2,340	2,892	0	4,000	400	600	300	276,082
HN-1	15,434	8,398	14,051	1,038	925	2,069	14	0	0	100	400	0	45,440
HN-2	46,301	25,193	42,153	3,113	2,775	6,207	41	0	0	300	1,200	0	136,319
HS-1	19,067	13,175	20,614	250	950	0	73	88	0	0	0	0	55,615
HS-2	57,201	39,524	61,841	750	2,850	0	218	263	0	0	0	0	166,845
Huron	**168,440**	**137,394**	**306,384**	**9,500**	**10,520**	**10,616**	**3,236**	**350**	**4,000**	**800**	**2,200**	**300**	**680,300**
MCE	50,820	24,050	31,770	400	1,000	2,830	800	0	6,150	0	0	0	118,770
MCW	25,300	17,144	5,710	0	1,000	0	0	0	0	0	0	0	49,154
MN-1	4,958	7,021	15,365	0	225	175	200	0	350	0	200	0	28,994
MN-2	14,873	21,063	46,095	0	675	525	600	0	1,050	0	600	0	86,981
MS-1	22,895	2,714	9,165	350	0	1,345	31	30	433	0	0	125	37,086
MS-2	68,685	8,141	27,494	1,050	0	4,035	92	90	1,298	0	0	375	111,258
Michigan	**187,530**	**80,132**	**135,598**	**1,800**	**2,900**	**8,910**	**1,722**	**120**	**9,280**	**0**	**800**	**500**	**432,242**
Ontario	**8,700**	**8,760**	**0**	**5,600**	**5,650**	**3,400**	**1,800**	**0**	**3,900**	**800**	**0**	**0**	**38,810**
SC	20,534	8,850	1,000	1,950	2,200	0	0	0	0	800	0	300	35,634
SEO	62,134	12,360	1,800	150	0	800	0	0	0	600	0	0	79,134
SET-1	18,793	10,723	1,039	3,488	15	0	0	0	75	0	0	325	34,897
SET-2	56,378	32,168	3,117	10,463	45	0	0	0	225	0	0	975	104,690
SWT	124,016	96,272	4,170	3,000	3,000	0	0	0	0	400	0	600	233,658
Superior	**281,854**	**160,372**	**11,126**	**19,050**	**5,260**	**800**	**0**	**0**	**300**	**1,800**	**0**	**2,200**	**488,012**
All	**741,084**	**541,822**	**522,568**	**46,150**	**41,380**	**29,376**	**6,778**	**1,870**	**18,080**	**9,400**	**3,600**	**4,800**	**2,008,568**

[1]Trackline segment names refer to Figure 5.5.

[2]Estimates based on doubling data obtained from ship logs representing approximately 50% of trips.

Table 5.8 Estimated Annual Input of Dry Cargo Per Square Mile into Great Lakes Shipping Lanes (U.S. and Canadian Vessels).

Segment[1]	Estimated Total Annual Commodity Input[2] (lb/sq. mi.)												
	Iron	Coal	Stone	Grain	Salt	Coke	Gypsum	Millscale	Slag	Cement	Sand	Potash	Total
EE	642.62	939.64	17.26	17.26	65.48	7.14	0.00	0.00	0.00	34.52	0.00	0.00	1,808.10
EFE-1	465.00	2,687.25	180.00	180.00	472.50	150.00	0.00	0.00	0.00	172.50	0.00	0.00	4,127.30
EFE-2	32.29	186.61	12.50	12.50	32.81	10.42	0.00	0.00	0.00	11.98	0.00	0.00	286.63
EO	356.18	273.82	47.06	47.06	47.06	47.06	0.59	41.18	0.00	0.00	17.65	0.00	2,285.29
EW-1	556.75	777.35	118.75	118.75	91.25	36.25	0.00	0.00	15.00	20.00	0.00	45.00	2,114.85
EW-2	428.27	597.96	91.35	91.35	70.19	27.88	0.00	0.00	11.54	15.38	0.00	34.62	1,626.81
Erie	**420.27**	**689.62**	**45.33**	**45.33**	**75.78**	**25.11**	**0.09**	**6.22**	**2.67**	**26.67**	**2.67**	**8.00**	**1,640.91**
HC	32.38	54.37	4.63	4.63	3.21	2.49	3.08	0.00	4.26	0.43	0.64	0.32	293.70
HN-1	154.34	83.98	10.38	10.38	9.25	20.69	0.14	0.00	0.00	1.00	4.00	0.00	454.40
HN-2	144.69	78.73	9.73	9.73	8.67	19.40	0.13	0.00	0.00	0.94	3.75	0.00	426.00
HS-1	190.67	131.75	2.50	2.50	9.50	0.00	0.73	0.88	0.00	0.00	0.00	0.00	556.15
HS-2	173.34	119.77	2.27	2.27	8.64	0.00	0.66	0.80	0.00	0.00	0.00	0.00	505.59
Huron	**94.10**	**76.76**	**5.31**	**5.31**	**5.88**	**5.93**	**1.81**	**0.20**	**2.23**	**0.45**	**1.23**	**0.17**	**380.06**
MCE	498.24	235.78	3.92	3.92	9.80	27.75	7.84	0.00	60.29	0.00	0.00	0.00	1,164.41
MCW	188.81	127.94	0.00	0.00	7.46	0.00	0.00	0.00	0.00	0.00	0.00	0.00	366.82
MN-1	247.88	351.05	0.00	0.00	11.25	8.75	10.00	0.00	17.50	0.00	10.00	0.00	1,449.68
MN-2	36.27	51.37	0.00	0.00	1.65	1.28	1.46	0.00	2.56	0.00	1.46	0.00	212.15
MS-1	2,289.50	271.35	35.00	35.00	0.00	134.50	3.05	3.00	43.25	0.00	0.00	12.50	3,708.60
MS-2	1,295.94	153.59	19.81	19.81	0.00	76.13	1.73	1.70	24.48	0.00	0.00	7.08	2,099.21
Michigan	**257.24**	**109.92**	**2.47**	**2.47**	**3.98**	**12.22**	**2.36**	**0.16**	**12.73**	**0.00**	**1.10**	**0.69**	**592.92**
Ontario	**69.60**	**70.08**	**44.80**	**44.80**	**45.20**	**27.20**	**14.40**	**0.00**	**31.20**	**6.40**	**0.00**	**0.00**	**310.48**
SC	31.59	13.62	3.00	3.00	3.38	0.00	0.00	0.00	0.00	1.23	0.00	0.46	54.82
SEO	103.56	20.60	0.25	0.25	0.00	1.33	0.00	0.00	0.00	1.00	0.00	0.00	131.89
SET-1	187.93	107.23	34.88	34.88	0.15	0.00	0.00	0.00	0.75	0.00	0.00	3.25	348.97
SET-2	45.84	26.15	8.51	8.51	0.04	0.00	0.00	0.00	0.18	0.00	0.00	0.79	85.11
SWT	70.87	55.01	1.71	1.71	1.71	0.00	0.00	0.00	0.00	0.23	0.00	0.34	133.52
Superior	**65.09**	**37.04**	**4.40**	**4.40**	**1.21**	**0.18**	**0.00**	**0.00**	**0.07**	**0.42**	**0.00**	**0.51**	**112.70**
All	**102.94**	**75.26**	**6.41**	**6.41**	**5.75**	**4.08**	**0.94**	**0.26**	**2.51**	**1.31**	**0.50**	**0.67**	**279.01**

[1]Trackline segment names refer to Figure 5.5.

[2]Estimates based on doubling data obtained from ship logs representing approximately 50% of trips.

Table 5.9 Estimated Annual Input of Dry Cargo Per Acre into Great Lakes Shipping Lanes (U.S. and Canadian Vessels).

Segment[1]	Estimated Total Annual Commodity Input[2] (lb/acre)												
	Iron	**Coal**	**Stone**	**Grain**	**Salt**	**Coke**	**Gypsum**	**Millscale**	**Slag**	**Cement**	**Sand**	**Potash**	**Total**
EE	1.004	1.468	0.158	0.027	0.102	0.011	0.000	0.000	0.000	0.054	0.000	0.000	2.825
EFE-1	0.727	4.199	0.000	0.281	0.738	0.234	0.000	0.000	0.000	0.270	0.000	0.000	6.449
EFE-2	0.050	0.292	0.000	0.020	0.051	0.016	0.000	0.000	0.000	0.019	0.000	0.000	0.448
EO	0.557	0.428	2.075	0.074	0.074	0.074	0.001	0.064	0.000	0.000	0.028	0.000	3.571
EW-1	0.870	1.215	0.616	0.186	0.143	0.057	0.000	0.000	0.023	0.031	0.000	0.070	3.304
EW-2	0.669	0.934	0.474	0.143	0.110	0.044	0.000	0.000	0.018	0.024	0.000	0.054	2.542
Erie	**0.657**	**1.078**	**0.482**	**0.071**	**0.118**	**0.039**	**0.000**	**0.010**	**0.004**	**0.042**	**0.004**	**0.013**	**2.564**
HC	0.051	0.085	0.279	0.007	0.005	0.004	0.005	0.000	0.007	0.001	0.001	0.000	0.459
HN-1	0.241	0.131	0.220	0.016	0.014	0.032	0.000	0.000	0.000	0.002	0.006	0.000	0.710
HN-2	0.226	0.123	0.206	0.015	0.014	0.030	0.000	0.000	0.000	0.001	0.006	0.000	0.666
HS-1	0.298	0.206	0.322	0.004	0.015	0.000	0.001	0.001	0.000	0.000	0.000	0.000	0.869
HS-2	0.271	0.187	0.293	0.004	0.013	0.000	0.001	0.001	0.000	0.000	0.000	0.000	0.790
Huron	**0.147**	**0.120**	**0.267**	**0.008**	**0.009**	**0.009**	**0.003**	**0.000**	**0.003**	**0.001**	**0.002**	**0.000**	**0.594**
MCE	0.778	0.368	0.487	0.006	0.015	0.043	0.012	0.000	0.094	0.000	0.000	0.000	1.819
MCW	0.295	0.200	0.067	0.000	0.012	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.573
MN-1	0.387	0.549	1.200	0.000	0.018	0.014	0.016	0.000	0.027	0.000	0.016	0.000	2.265
MN-2	0.057	0.080	0.176	0.000	0.003	0.002	0.002	0.000	0.004	0.000	0.002	0.000	0.331
MS-1	3.577	0.424	1.432	0.055	0.000	0.210	0.005	0.005	0.068	0.000	0.000	0.020	5.795
MS-2	2.025	0.240	0.811	0.031	0.000	0.119	0.003	0.003	0.038	0.000	0.000	0.011	3.280
Michigan	**0.402**	**0.172**	**0.291**	**0.004**	**0.006**	**0.019**	**0.004**	**0.000**	**0.020**	**0.000**	**0.002**	**0.001**	**0.926**
Ontario	**0.109**	**0.110**	**0.000**	**0.070**	**0.071**	**0.043**	**0.023**	**0.000**	**0.049**	**0.010**	**0.000**	**0.000**	**0.485**
SC	0.049	0.021	0.002	0.005	0.005	0.000	0.000	0.000	0.000	0.002	0.000	0.001	0.086
SEO	0.162	0.032	0.005	0.000	0.000	0.002	0.000	0.000	0.000	0.002	0.000	0.000	0.206
SET-1	0.294	0.168	0.016	0.054	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.005	0.545
SET-2	0.072	0.041	0.004	0.013	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.133
SWT	0.111	0.086	0.004	0.003	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.209
Superior	**0.102**	**0.058**	**0.004**	**0.007**	**0.002**	**0.000**	**0.000**	**0.000**	**0.000**	**0.001**	**0.000**	**0.001**	**0.176**
All	**0.161**	**0.118**	**0.113**	**0.010**	**0.009**	**0.006**	**0.001**	**0.000**	**0.004**	**0.002**	**0.001**	**0.001**	**0.436**

[1]Trackline segment names refer to Figure 5.5.

[2]Estimates based on doubling data obtained from ship logs representing approximately 50% of trips.

Table 5.10 Estimated Annual Input of Dry Cargo Per Linear Mile into Great Lakes Shipping Lanes (U.S. and Canadian Vessels).

Segment[1]	Estimated Total Annual Commodity Input[2] (lb/mile)												
	Iron	Coal	Stone	Grain	Salt	Coke	Gypsum	Millscale	Slag	Cement	Sand	Potash	Total
EE	642.62	939.64	101.43	17.26	65.48	7.14	0.00	0.00	0.00	34.52	0.00	0.00	1,808.10
EFE-1	465.00	2,687.25	0.00	180.00	472.50	150.00	0.00	0.00	0.00	172.50	0.00	0.00	4,127.30
EFE-2	32.29	186.61	0.00	12.50	32.81	10.42	0.00	0.00	0.00	11.98	0.00	0.00	286.63
EO	356.18	273.82	1,328.24	47.06	47.06	47.06	0.59	41.18	0.00	0.00	17.65	0.00	2,285.29
EW-1	556.75	777.35	394.50	118.75	91.25	36.25	0.00	0.00	15.00	20.00	0.00	45.00	2,114.85
EW-2	428.27	597.96	303.46	91.35	70.19	27.88	0.00	0.00	11.54	15.38	0.00	34.62	1,626.81
Erie	**420.27**	**689.62**	**308.71**	**45.33**	**75.78**	**25.11**	**0.09**	**6.22**	**2.67**	**26.67**	**2.67**	**8.00**	**1,640.91**
HC	323.81	543.68	1,784.32	46.28	32.13	24.89	30.77	0.00	42.55	4.26	6.38	3.19	2,937.04
HN-1	1,543.35	839.75	1,405.10	103.75	92.50	206.90	1.35	0.00	0.00	10.00	40.00	0.00	4,543.95
HN-2	1,446.89	787.27	1,317.28	97.27	86.72	193.97	1.27	0.00	0.00	9.38	37.50	0.00	4,259.95
HS-1	1,906.70	1,317.45	2,061.35	25.00	95.00	0.00	7.25	8.75	0.00	0.00	0.00	0.00	5,561.50
HS-2	1,733.36	1,197.68	1,873.95	22.73	86.36	0.00	6.59	7.95	0.00	0.00	0.00	0.00	5,055.91
Huron	**941.01**	**767.56**	**1,711.64**	**53.07**	**58.77**	**59.31**	**18.08**	**1.96**	**22.35**	**4.47**	**12.29**	**1.68**	**3,800.56**
MCE	498.24	235.78	311.47	3.92	9.80	27.75	7.84	0.00	60.29	0.00	0.00	0.00	1,164.41
MCW	188.81	127.94	42.61	0.00	7.46	0.00	0.00	0.00	0.00	0.00	0.00	0.00	366.82
MN-1	495.75	702.10	1,536.50	0.00	22.50	17.50	20.00	0.00	35.00	0.00	20.00	0.00	2,899.35
MN-2	72.55	102.75	224.85	0.00	3.29	2.56	2.93	0.00	5.12	0.00	2.93	0.00	424.30
MS-1	2,289.50	271.35	916.45	35.00	0.00	134.50	3.05	3.00	43.25	0.00	0.00	12.50	3,708.60
MS-2	1,295.94	153.59	518.75	19.81	0.00	76.13	1.73	1.70	24.48	0.00	0.00	7.08	2,099.21
Michigan	**364.84**	**155.90**	**263.81**	**3.50**	**5.64**	**17.33**	**3.35**	**0.23**	**18.05**	**0.00**	**1.56**	**0.97**	**840.94**
Ontario	**69.60**	**70.08**	**0.00**	**44.80**	**45.20**	**27.20**	**14.40**	**0.00**	**31.20**	**6.40**	**0.00**	**0.00**	**310.48**
SC	315.91	136.15	15.38	30.00	33.85	0.00	0.00	0.00	0.00	12.31	0.00	4.62	548.22
SEO	1,035.57	206.00	30.00	2.50	0.00	13.33	0.00	0.00	0.00	10.00	0.00	0.00	1,318.90
SET-1	1,879.25	1,072.25	103.90	348.75	1.50	0.00	0.00	0.00	7.50	0.00	0.00	32.50	3,489.65
SET-2	458.35	261.52	25.34	85.06	0.37	0.00	0.00	0.00	1.83	0.00	0.00	7.93	851.13
SWT	708.66	550.13	23.83	17.14	17.14	0.00	0.00	0.00	0.00	2.29	0.00	3.43	1,335.19
Superior	**650.93**	**370.37**	**25.70**	**44.00**	**12.15**	**1.85**	**0.00**	**0.00**	**0.69**	**4.16**	**0.00**	**5.08**	**1,127.05**
All	**502.09**	**367.09**	**354.04**	**31.27**	**28.04**	**19.90**	**4.59**	**1.27**	**12.25**	**6.37**	**2.44**	**3.25**	**1,360.82**

[1]Trackline segment names refer to Figure 5.5.

[2]Estimates based on doubling data obtained from ship logs representing approximately 50% of trips.

Total estimated inputs of each major commodity were estimated for each of the five major Lakes for all vessels, as shown in Table 5.11. Inputs per square mile were calculated for each Lake, again for all vessels, as shown in Table 5.12. Table 5.13 shows the segment dimensions used in the analysis.

Figures 5.6–5.11 show the relative inputs in pounds per acre for coal, coke, grain, iron ore (including taconite), salt, and stone on maps by segment. (Since the inputs for the other commodities were in the two lowest categories, the maps are not shown here.) Figure 5.12 shows the *total* input of all commodities per acre. Figures 5.13–5.17 show each Lake and the relative proportions of inputs of each commodity by weight for each trackline segment. Figure 5.18 shows the relative proportions of the inputs for all commodities for all Lakes combined. Tables 5.14–5.15 show the commodity input for each Lake in terms of total area and total volume, respectively.

Theoretically, the inputs of the dry cargo will be "diluted" by the water in the Lakes. Each Lake differs in size and depth. It is important to view the inputs of the commodities in this perspective. The inputs of each dry cargo commodity are shown in terms of input *per total Lake area* in Table 5.14 and in terms of input *per total volume of Lake* in Table 5.15.

A review of the input data reveals that the inputs are distributed unevenly through the Lakes with certain trackline segments receiving disproportionate amounts of input. The inputs are related directly to the commodities loaded and unloaded in various ports and the routes that are traveled by cargo vessels. Most iron ore is transported (and washed down) in Lake Superior. Nearly 60% of the stone, 61% of the sand, and 48% of the gypsum are washed down in Lake Huron. Coal transport and washdown are distributed more evenly, occurring relatively evenly in Lakes Superior, Erie, and Huron. Most of the salt, cement, and millscale is washed down in Lake Erie.

The largest percentage—over one-third—of total dry cargo input occurs in Lake Huron. The smallest percentage—less than 2%—occurs in Lake Ontario. The relative percentages for specific commodities vary.

The largest inputs (by weight) are of iron ore (including taconite), coal, and stone. Certain trackline segments receive a majority of input of a particular commodity. For example, segment HC in Lake Huron receives nearly one-third of all stone input. The largest percentage of iron ore input occurs in segment SWT of Lake Superior.

Some commodities are carried only in a relatively small number of trackline segments, such as gypsum, which is only carried in nine segments. Forty-three percent of the total gypsum input occurs in one trackline segment—HC in Lake Huron.

The inputs should be viewed in perspective to the unique characteristics of each Lake. For example, the smallest and shallowest Lake, Lake Erie, receives a disproportionate amount of the input on a per-area and -volume basis. Lake Erie receives nearly two and a half times as much input of dry cargo on a per-area basis and nearly 19 times as much input on a per-volume basis as the largest and deepest Lake, Lake Superior.

In addition to the physical size of the Lakes, the inputs also must be considered with respect to the characteristics of the individual commodities, as described above in Section 5.3, and with respect to the environmental sensitivities and conditions of the Lakes, as discussed above in Section 5.2.

Table 5.11 Estimated Total Annual Input of Dry Cargo into Great Lakes (U.S. and Canadian Vessels).

	Estimated Annual Commodity Input[1] (lb)												
Lake	**Iron**	**Coal**	**Stone**	**Grain**	**Salt**	**Coke**	**Gypsum**	**Millscale**	**Slag**	**Cement**	**Sand**	**Potash**	**Total**
Erie	94,560	155,164	76,160	10,200	17,050	5,650	20	1,400	600	6,000	600	1,800	369,204
Huron	168,440	137,394	332,944	9,500	10,520	10,616	3,236	350	4,000	800	2,200	300	680,300
Michigan	187,530	80,132	138,548	1,800	2,900	8,910	1,722	120	9,280	0	800	500	432,242
Ontario	8,700	8,760	200	5,600	5,650	3,400	1,800	0	3,900	800	0	0	38,810
Superior	281,854	160,372	16,376	19,050	5,260	800	0	0	300	1,800	0	2,200	488,012
All	**741,084**	**541,822**	**564,228**	**46,150**	**41,380**	**29,376**	**6,778**	**1,870**	**18,080**	**9,400**	**3,600**	**4,800**	**2,008,568**

[1]Estimates based on doubling data obtained from ship logs representing approximately 50% of U.S. and Canadian data.

Table 5.12 Estimated Annual Input of Dry Cargo Per Square Mile of Great Lakes (U.S. and Canadian Vessels).

	Estimated Annual Commodity Input[1] (lb) Per Square Mile												
Lake	**Iron**	**Coal**	**Stone**	**Grain**	**Salt**	**Coke**	**Gypsum**	**Millscale**	**Slag**	**Cement**	**Sand**	**Potash**	**Total**
Erie	9.54	15.66	7.69	1.03	1.72	0.57	0.00	0.14	0.06	0.61	0.06	0.18	37.26
Huron	7.32	5.97	14.48	0.41	0.46	0.46	0.14	0.02	0.17	0.03	0.10	0.01	29.58
Michigan	8.41	3.59	6.21	0.08	0.13	0.40	0.08	0.01	0.42	0.00	0.04	0.02	19.38
Ontario	0.27	0.28	0.01	0.18	0.18	0.11	0.06	0.00	0.12	0.03	0.00	0.00	1.22
Superior	38.40	21.85	2.23	2.60	0.72	0.11	0.00	0.00	0.04	0.25	0.00	0.30	66.49
All	**7.86**	**5.75**	**5.99**	**0.49**	**0.44**	**0.31**	**0.07**	**0.02**	**0.19**	**0.10**	**0.04**	**0.05**	**21.31**

[1]Estimates based on doubling data obtained from ship logs representing approximately 50% of U.S. and Canadian data.

Table 5.13 Dry Cargo Sweeping/Washdown Segments in Great Lakes.

Segment[1]	Segment Length (mi)	Segment Width (mi)	Segment Area (sq mi)	Segment Area (acres)
EE	84	1	84	53,760
EFE-1	10	1	10	6,400
EFE-2	48	1	48	30,720
EO	34	1	34	21,760
EW-1	10	1	10	6,400
EW-2	39	1	39	24,960
Erie Total	**225**	—	**225**	**144,000**
HC	94	10	940	601,600
HN-1	10	10	100	64,000
HN-2	32	10	320	204,800
HS-1	10	10	100	64,000
HS-2	33	10	330	211,200
Huron Total	**179**	—	**1,790**	**1,145,600**
MCE	102	1	102	65,280
MCW	134	1	134	85,760
MN-1	10	2	20	12,800
MN-2	205	2	410	262,400
MS-1	10	1	10	6,400
MS-2	53	1	53	33,920
Michigan Total	**514**	—	**729**	**466,560**
Ontario Total	**125**	—	**125**	**80,000**
SC	65	10	650	416,000
SEO	60	10	600	384,000
SET-1	10	10	100	64,000
SET-2	123	10	1,230	787,200
SWT	175	10	1,750	1,120,000
Superior Total	**433**	—	**4,330**	**2,771,200**
All Lakes Total	**1,476**	—	**7,199**	**4,607,360**

[1]Trackline segment names refer to Figure 5.5.

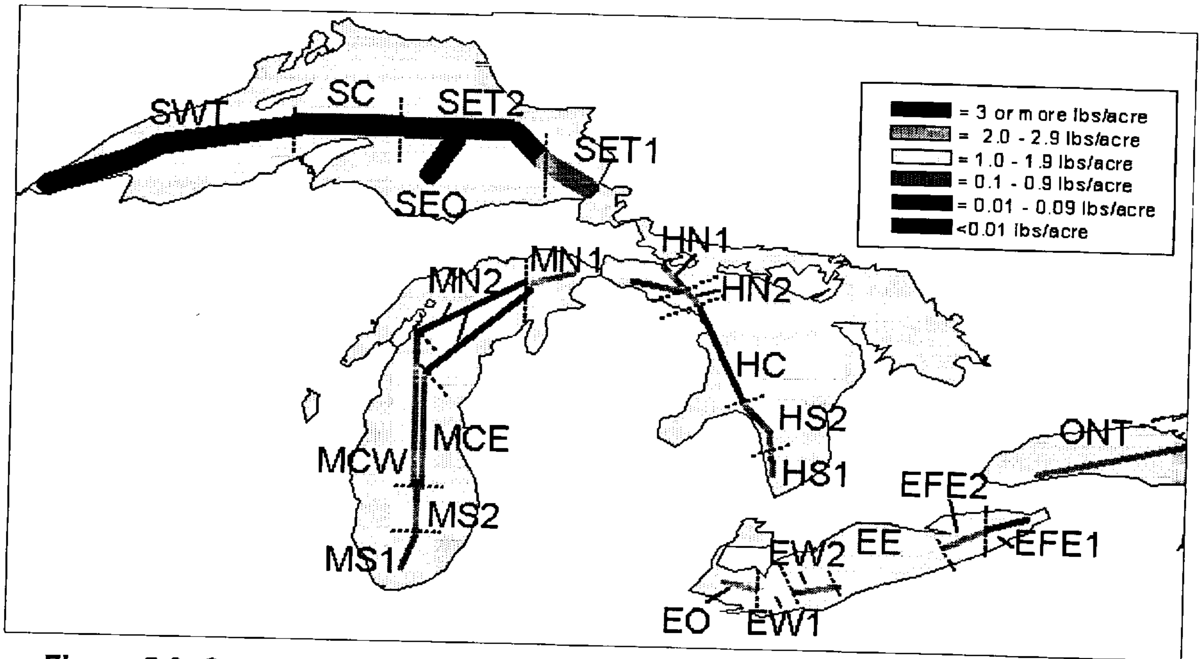

Figure 5.6 Great Lakes Dry Cargo Sweeping Tracklines—Coal Input (lbs/acre).

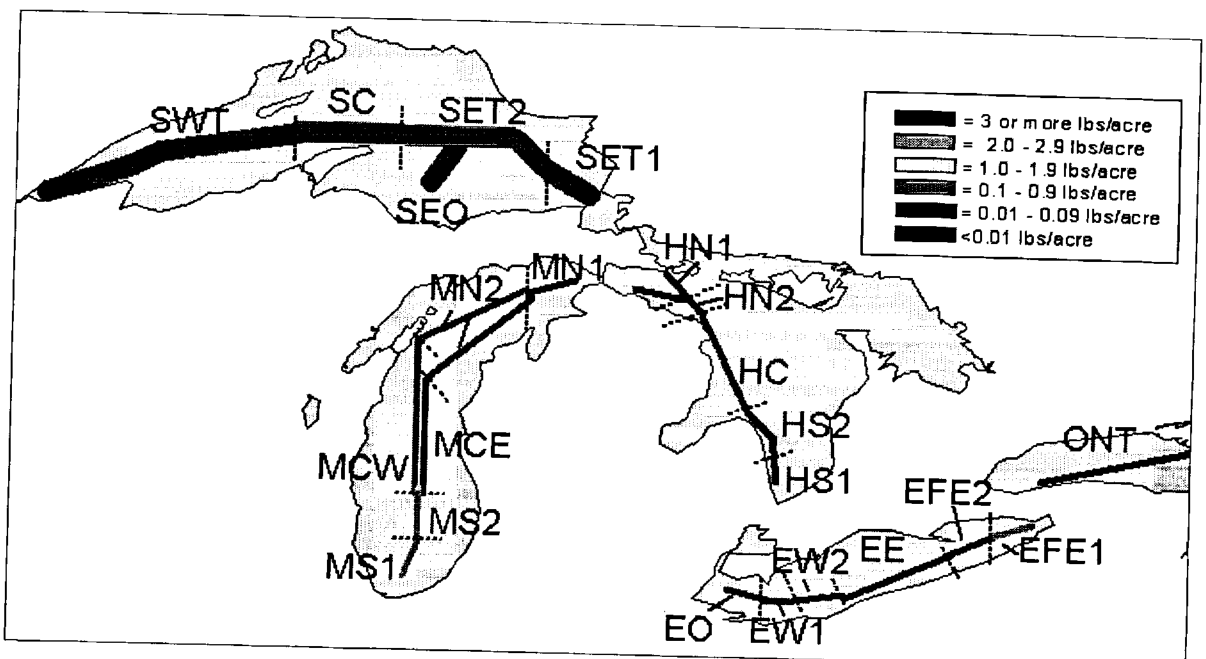

Figure 5.7 Great Lakes Dry Cargo Sweeping Tracklines—Coke Input (lbs/acre).

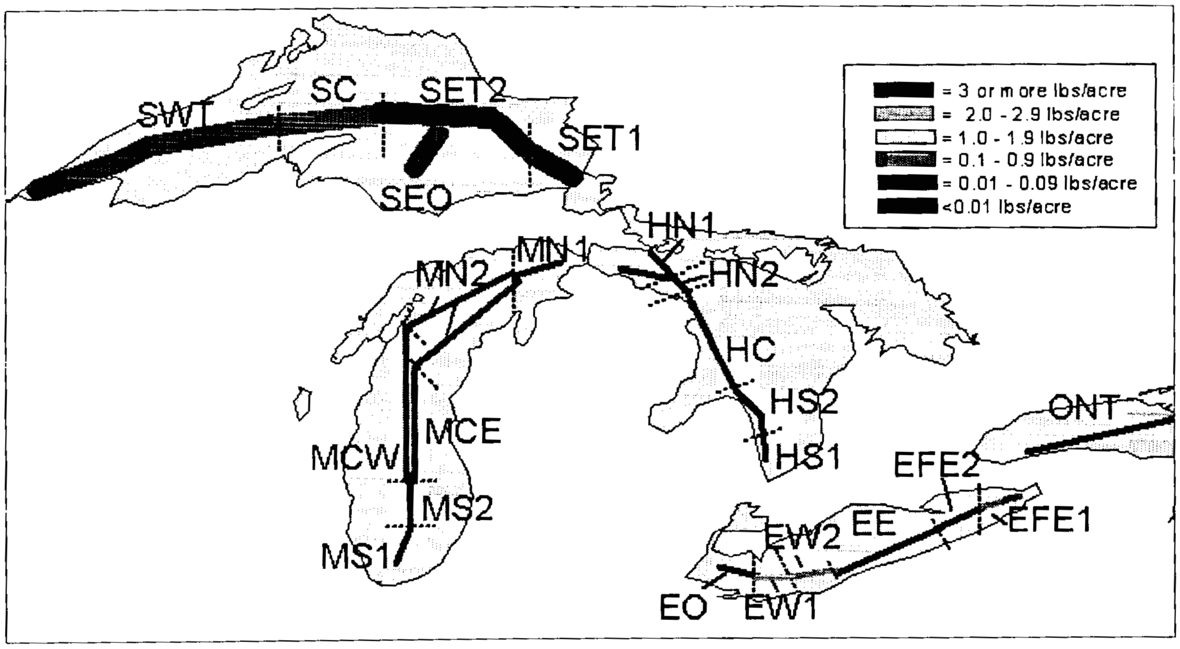

Figure 5.8 Great Lakes Dry Cargo Sweeping Tracklines—Grain Input (lbs/acre).

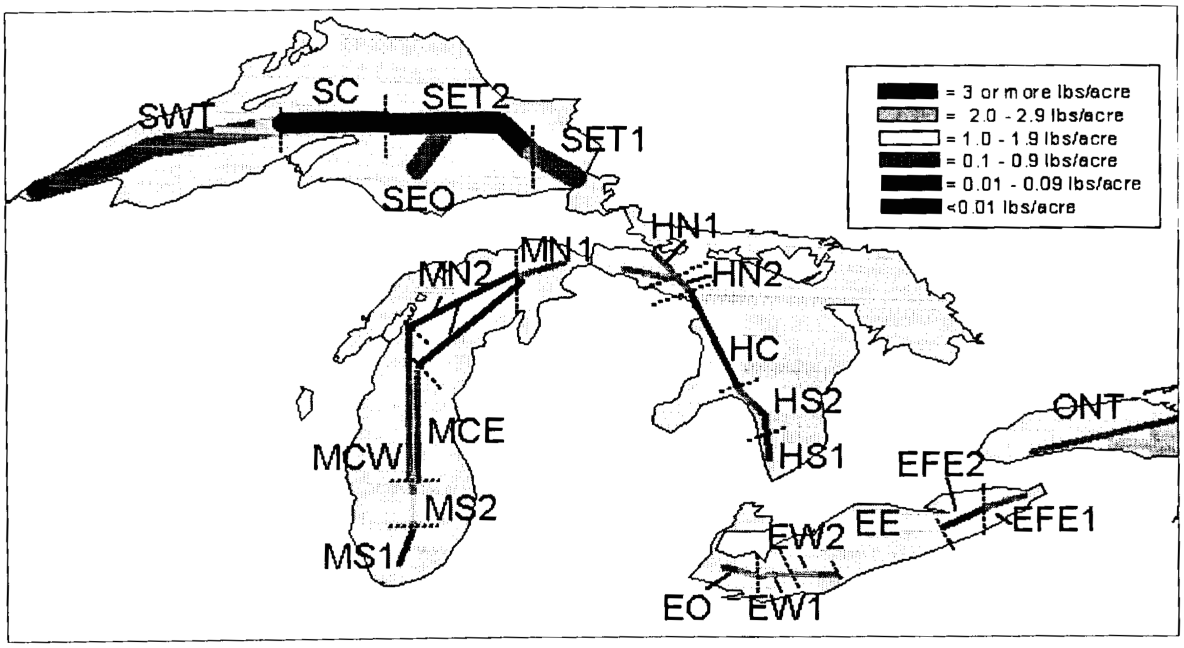

Figure 5.9 Great Lakes Dry Cargo Sweeping Tracklines—Iron Input (lbs/acre).

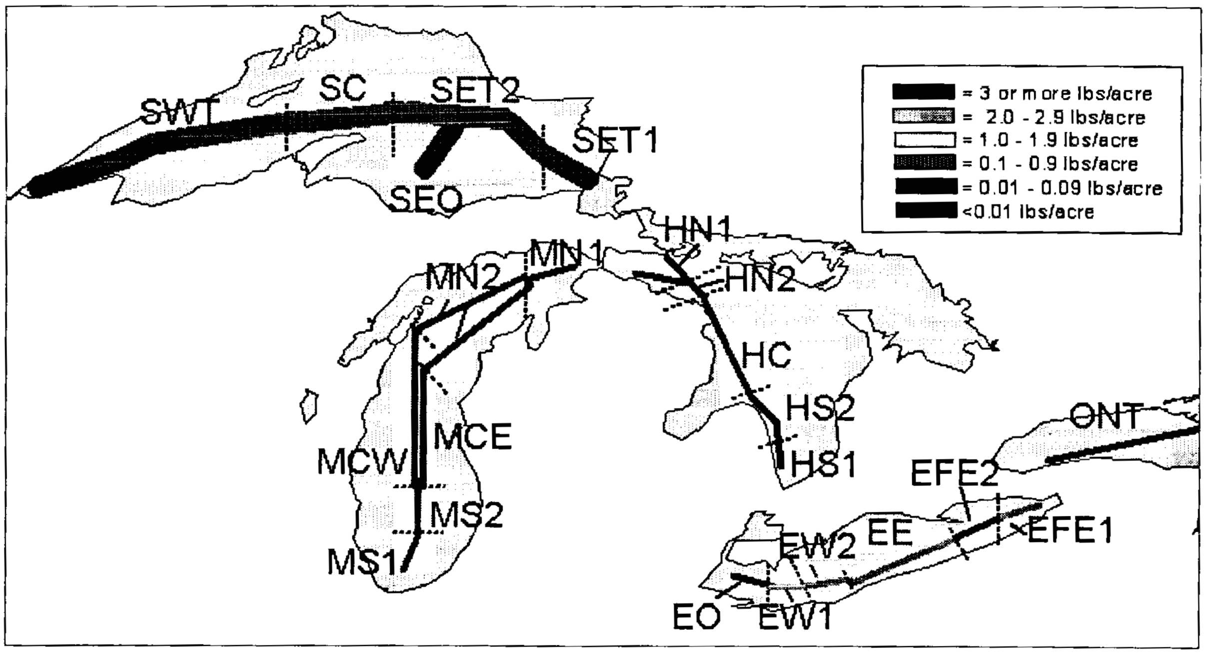

Figure 5.10 Great Lakes Dry Cargo Sweeping Tracklines—Salt Input (lbs/acre).

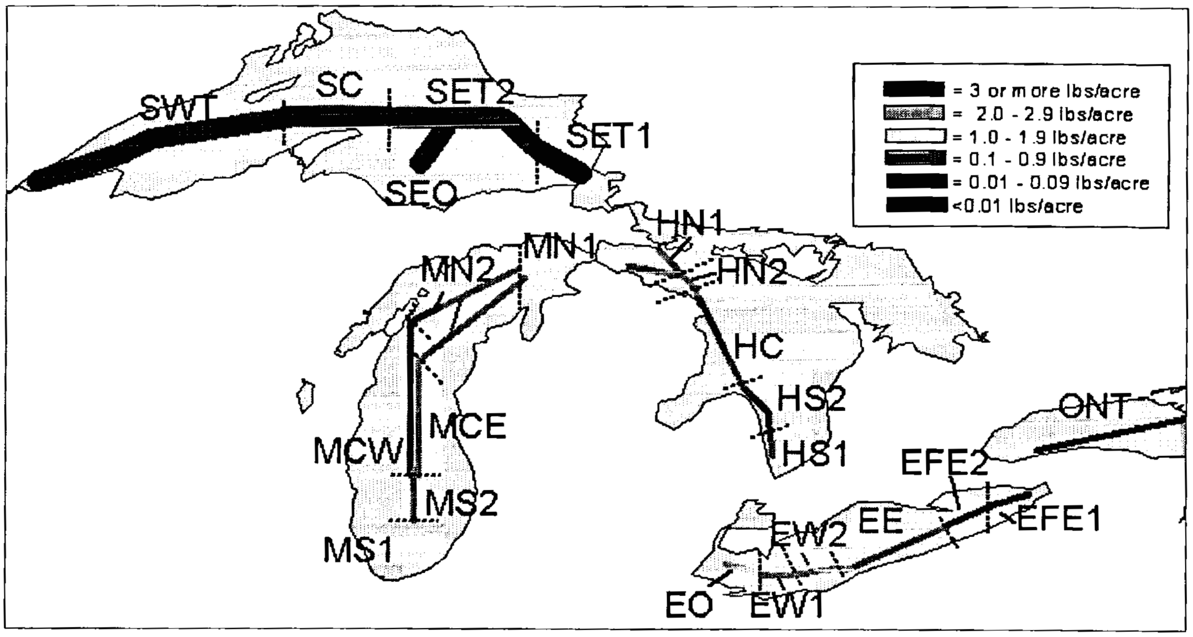

Figure 5.11 Great Lakes Dry Cargo Sweeping Tracklines—Stone Input (lbs/acre).

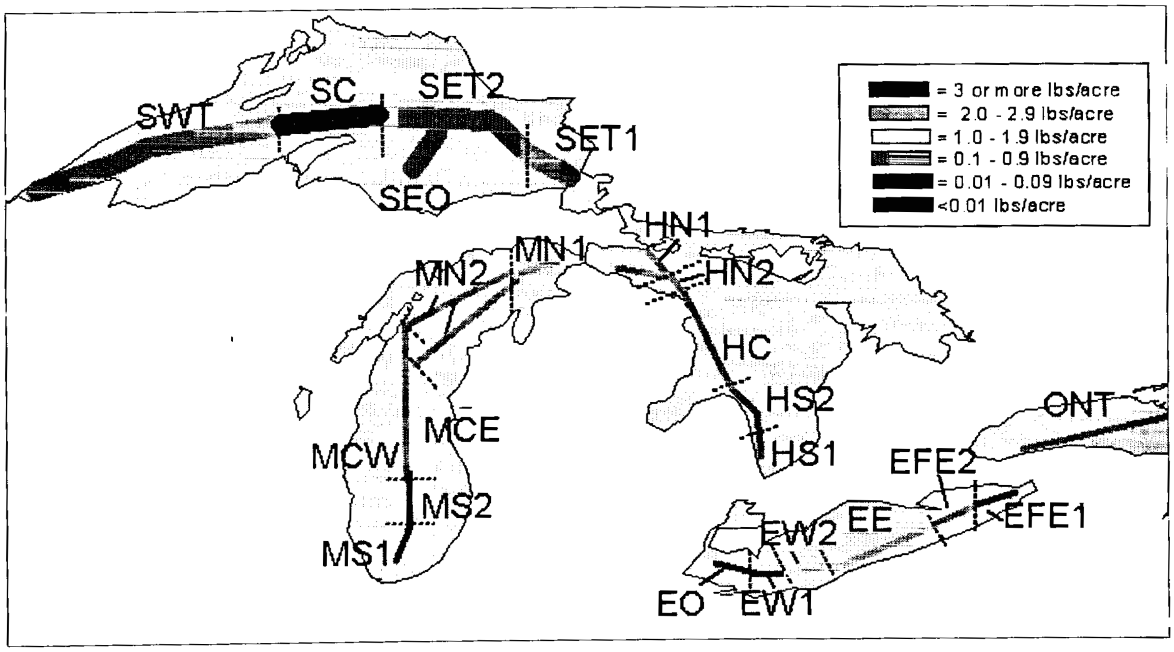

Figure 5.12 Great Lakes Dry Cargo Sweeping Tracklines—Total Annual Input (lbs/acre).

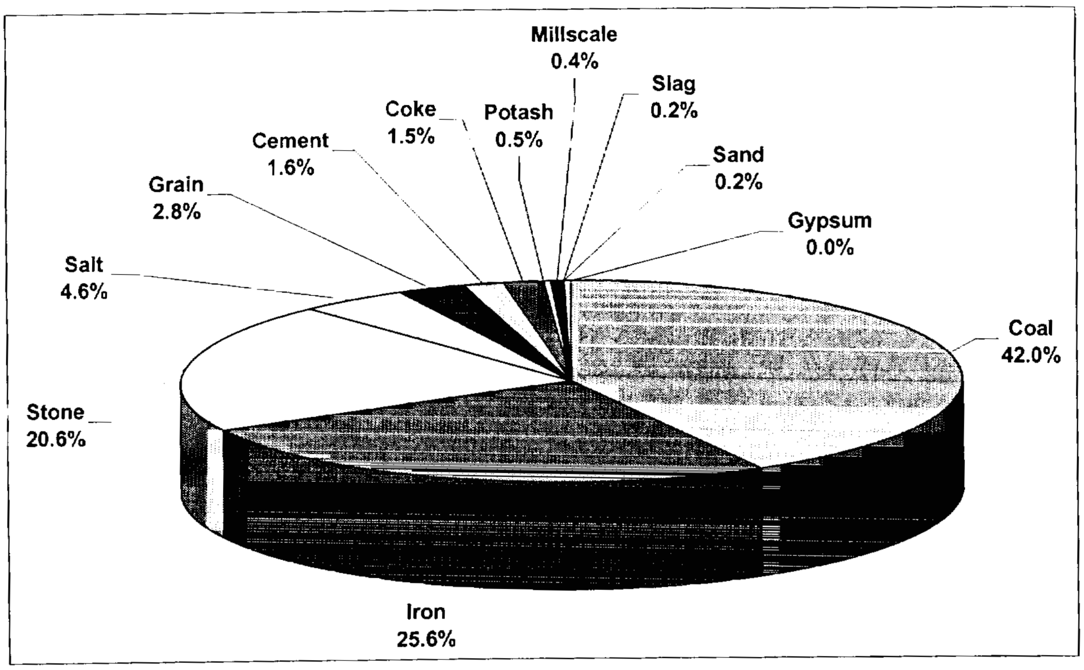

Figure 5.13 Relative Proportion of Inputs for Lake Erie (All Trackline Segments).

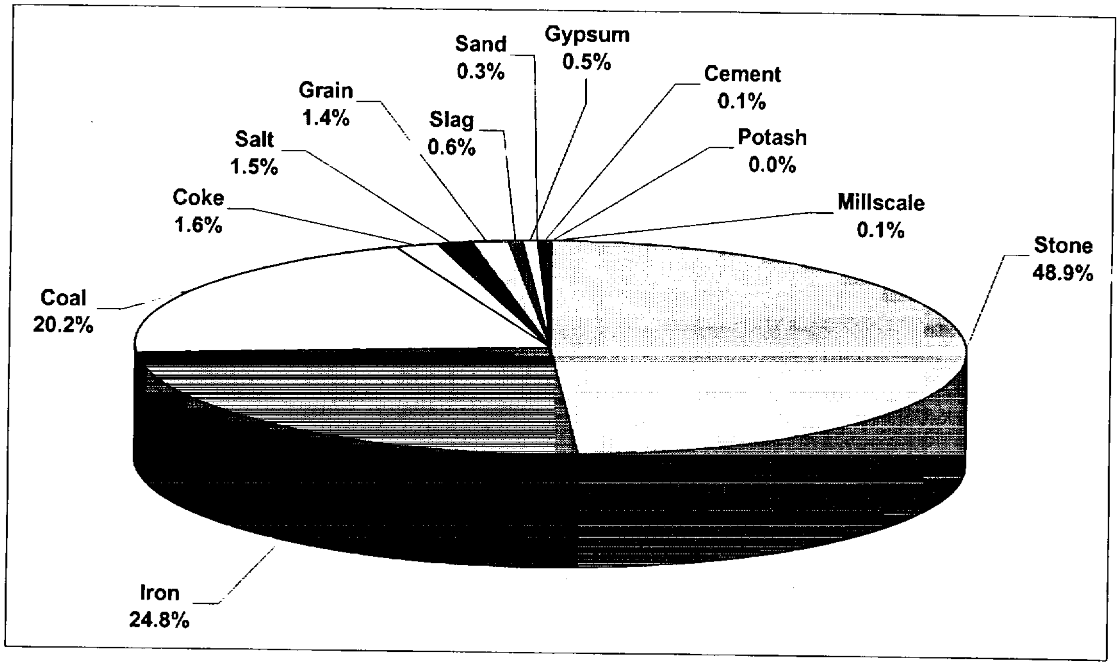

Figure 5.14 Relative Proportions of Inputs for Lake Huron (All Trackline Segments).

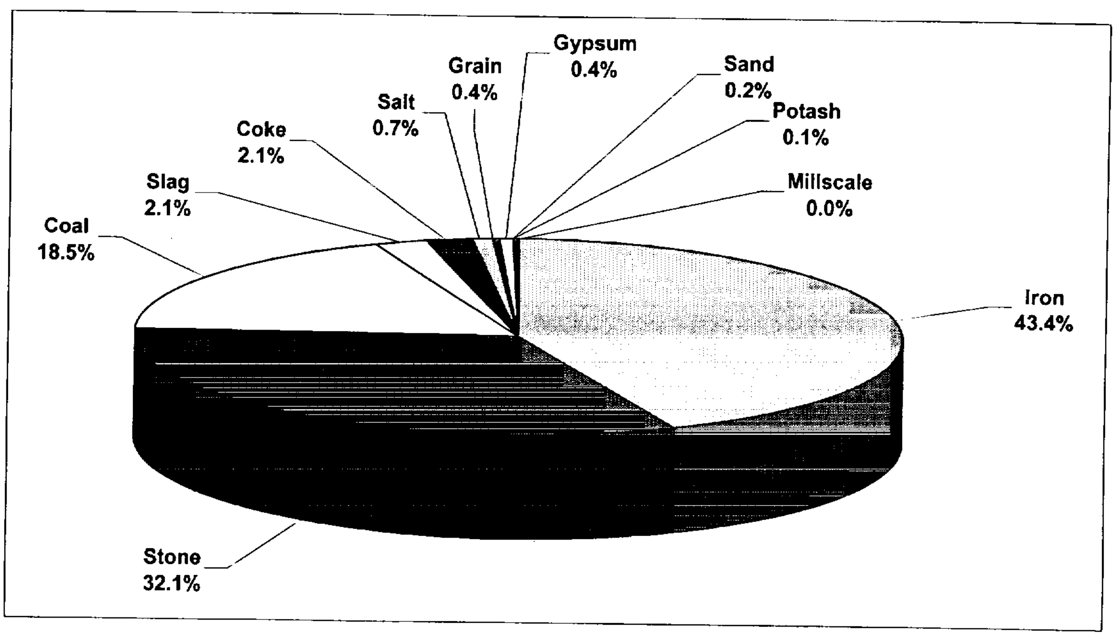

Figure 5.15 Relative Proportions of Inputs for Lake Michigan (All Trackline Segments).

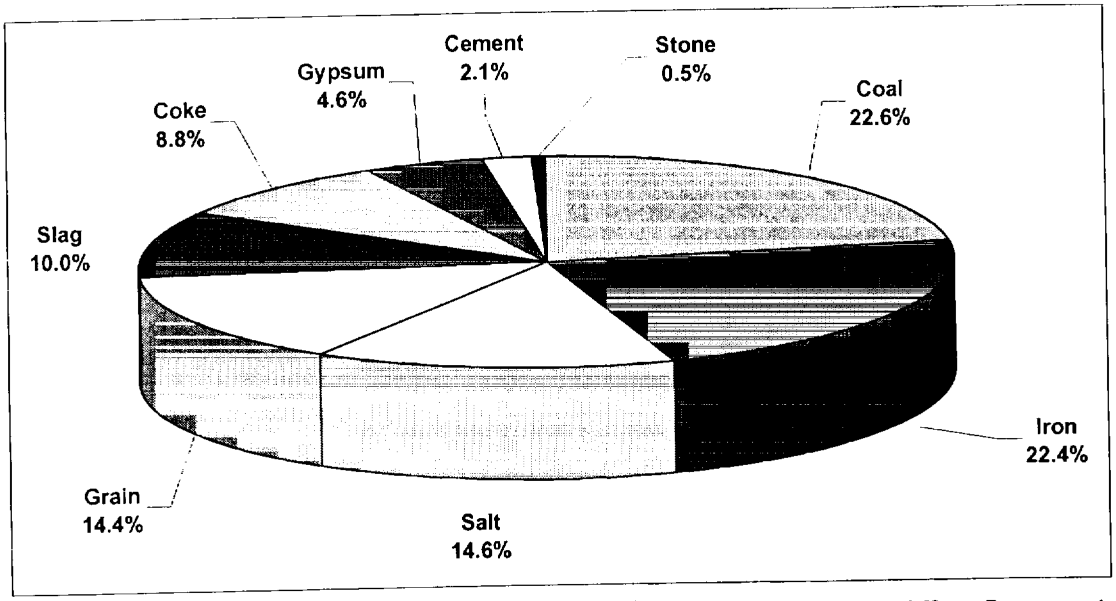

Figure 5.16 Relative Proportion of Inputs for Lake Ontario (All Trackline Segments).

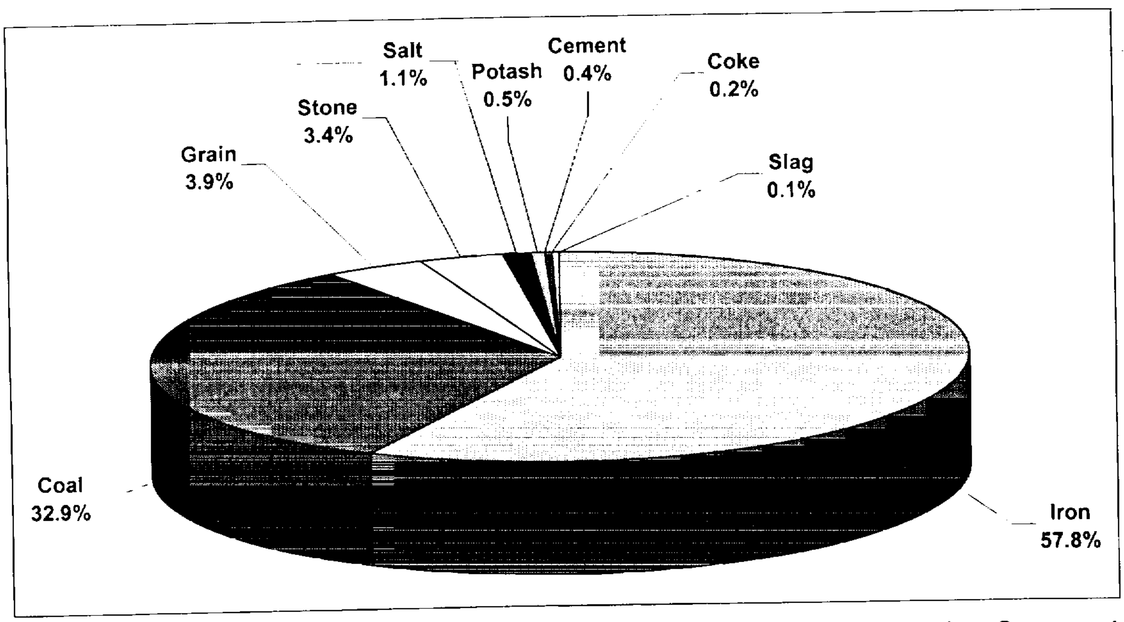

Figure 5.17 Relative Proportion of Inputs for Lake Superior (All Trackline Segments).

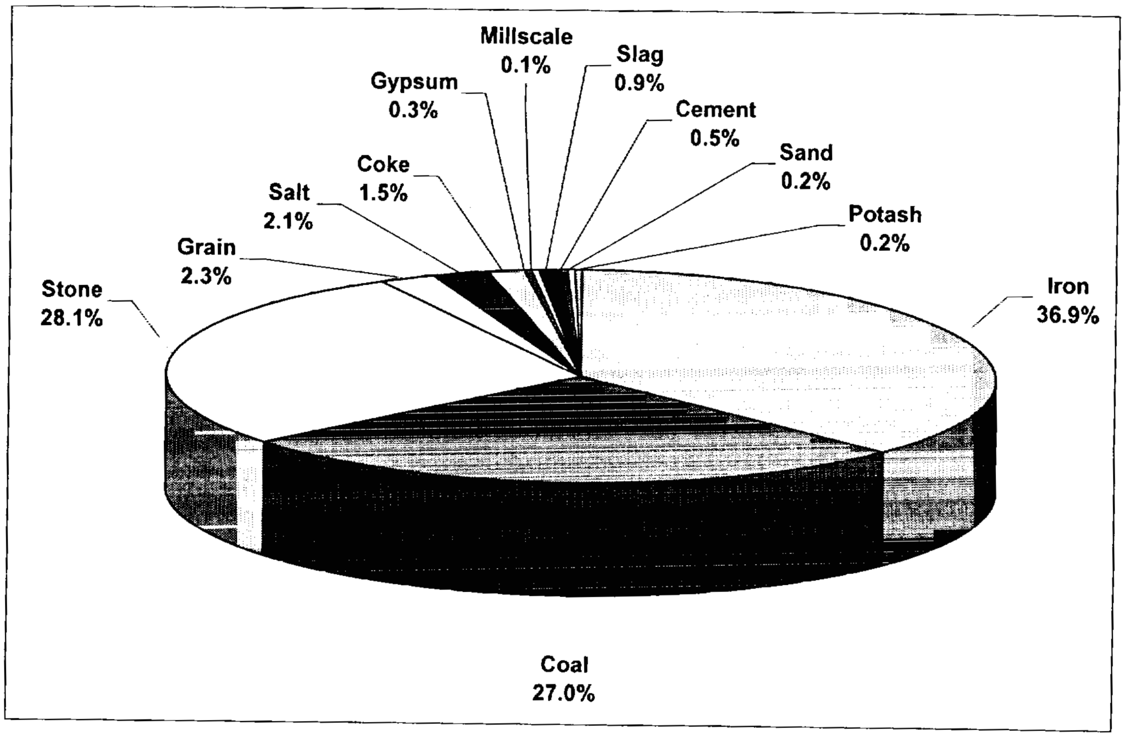

Figure 5.18 Relative Proportion of Inputs for All Great Lakes Combined.

Table 5.14 Annual Inputs of Dry Cargo Per Total Area of Great Lakes.

	Lake Input (lbs/square mile)					
Commodity	**Erie**	**Huron**	**Michigan**	**Ontario**	**Superior**	**Total**
Iron	9.49	6.76	8.39	1.15	8.69	**7.62**
Coal	15.58	5.51	3.59	1.16	4.95	**5.57**
Stone	7.65	13.35	6.20	0.03	0.51	**5.80**
Grain	1.02	0.38	0.08	0.74	0.59	**0.47**
Salt	1.71	0.42	0.13	0.75	0.16	**0.43**
Coke	0.57	0.43	0.40	0.45	0.02	**0.30**
Gypsum	0.00	0.13	0.08	0.24	0.00	**0.07**
Millscale	0.14	0.01	0.01	0.00	0.00	**0.02**
Slag	0.06	0.16	0.42	0.52	0.01	**0.19**
Cement	0.60	0.03	0.00	0.11	0.06	**0.10**
Sand	0.06	0.09	0.04	0.00	0.00	**0.04**
Potash	0.18	0.01	0.02	0.00	0.07	**0.05**
All Commodities	**37.07**	**27.28**	**19.34**	**5.13**	**15.05**	**20.66**

Table 5.15 Annual Inputs of Dry Cargo Per Total Volume of Great Lakes.

Commodity	Lake Input (lbs/cubic mile)					
	Erie	**Huron**	**Michigan**	**Ontario**	**Superior**	**Total**
Iron	836.81	206.67	163.50	21.75	99.56	**139.67**
Coal	1,373.13	168.58	69.86	21.90	56.65	**102.11**
Stone	673.98	408.52	120.79	0.50	5.78	**106.34**
Grain	90.27	11.66	1.57	14.00	6.73	**8.70**
Salt	150.88	12.91	2.53	14.13	1.86	**7.80**
Coke	50.00	13.03	7.77	8.50	0.28	**5.54**
Gypsum	0.18	3.97	1.50	4.50	0.00	**1.28**
Millscale	12.39	0.43	0.10	0.00	0.00	**0.35**
Slag	5.31	4.91	8.09	9.75	0.11	**3.41**
Cement	53.10	0.98	0.00	2.00	0.64	**1.77**
Sand	5.31	2.70	0.70	0.00	0.00	**0.68**
Potash	15.93	0.37	0.44	0.00	0.78	**0.90**
All Commodities	**3,267.29**	**834.72**	**376.85**	**97.03**	**172.38**	**378.55**

5.5 Environmental Significance of Dry Cargo Inputs

Currently, there is no definitive methodology for measuring environmental impact of measured dry cargo discharges since relatively little is known about impacts of these commodities on particular habitats and populations. Most studies on pollutant input have focused on petroleum. There have been two major—but *inconclusive*—studies related to impacts of dry cargo discharges in the Great Lakes: the 1993 study commissioned by the CCG (Melville Shipping, 1993a, b), and the 1993 National Oceanic and Atmospheric Administration (NOAA)/Great Lakes Environmental Research Laboratory (GLERL) workshop (Reid and Meadows, 1999).

5.5.1 The CCG Study

The 1993 CCG study (Melville Shipping, 1993a) focused on inputs that occurred in ports rather than in shipping lanes. The potential and suspected environmental impacts of dry cargo sweepings and discharges were summarized based on surveys of literature and available studies. The major environmental concerns of study were:

- **Eutrophication.** Oversupply of nutrients can cause increased plant production, which decreases water clarity and quality. Decomposition in shallow water can then decrease oxygen levels.
- **Aquatic habitats.** Pollutants that have a high biological oxygen demand (i.e., use up oxygen to decompose in the water) can deplete oxygen and degrade habitats for fish and other aquatic fauna. Suspended solids can increase turbidity and affect plant production and animal behavior.
- **Loss of wetlands.** Loss of wetland habitats because of discharge of pollutants decreases nursery and brood rearing areas for fish and waterfowl. Loss of wetlands also decreases the cleansing of water before it enters the Lakes.
- **Esthetics.** Visual attributes can be affected adversely by discharges.

- **Toxic substances.** The presence of toxic substances such as heavy metals and organic compounds can have serious environmental impacts.
- **Other issues.** Thermal pollution, water levels, erosion, and loss of habitats are also of concern in the Great Lakes.

The suspected environmental impacts of spills/discharges of major commodities shipped and handled in *Canadian* Great Lakes ports are shown in Table 5.16. Additional conclusions about specific commodities included the following:

Metals

- Spilled metals generally are bound in ores, thus making them not readily mobile or available to enter reactions that would make them available to organisms.
- The metals would persist in the lakes for a long time, creating long-term (more than 5 years) effects.
- Anoxic conditions in Lake Erie in particular could lead to the release of iron and other metals from the ore.

Coal

- Spilled coal slowly will release small amounts of PAHs in very localized areas.
- Coal dust retards plant growth and causes wetland damage.
- Coal would persist, creating long-term (more than 5 years) effects.

Grain/Wood Pulp

- Large amounts of decomposing organic matter can deplete benthic oxygen levels, thus damaging aquatic animals and also causing the creation of anaerobic sludge that releases toxic methane and hydrogen sulfide.
- The biological oxygen demand of spilled grain and wood pulp is small because the individualized spills are small.
- Increases in biological oxygen demand from grain, pulp, and ore metals are small when compared with increases from industrial inputs.

Aggregates/Building Materials

- Finer particles of aggregates can cause localized smothering of benthic animals with transitory effects.
- Cement inputs briefly might increase the turbidity in the water column.
- Accumulation of large pieces of aggregates (e.g., rock, limestone) could increase habitats for fish by increasing the roughness of the bottom sediment, thereby increasing the diversity of bottom habitats.

Table 5.16 Impacts of Major Commodities Shipping in Canadian Great Lakes Ports.

Commodity	Port	Existing Problems	Commodity Impacts[1]
Coal	Hamilton	PAH sediment	Minor
	Thunder Bay	None	Negligible
	Sault Ste. Marie	PAH sediment	Minor
	Sarnia	PAH sediment	Minor
	Nantikoke	Sensitive area	Minor
	Open Lakes	None	Negligible
Iron Ore	Hamilton	Contaminated sediment/water	Moderate
	Sault Ste. Marie	Contaminated sediment/water	Minor
	Nantikoke	Sensitive area	Minor
	Lake Erie	Anoxia	Moderate
	Other Lakes	Contaminated fish	Negligible
Other Ores/ Metals	Hamilton	Contaminated sediment/biota	Moderate
	Thunder Bay	Contaminated sediment/fish	Minor/moderate
	Sault Ste. Marie	Contaminated sediment/fish	Minor
	Lake Erie	Anoxia	Moderate
	Other Lakes	Contaminated fish	Minor
Non-Metallic Minerals	Hamilton	None	Negligible
	Sarnia	None	Negligible
	Thunder Bay	None	Negligible
	Open Lakes	None	Negligible
Grain/Seed	Hamilton	Oxygen depletion	Negligible/minor
	Sarnia	Oxygen depletion	Negligible/minor
	Thunder Bay	None	Negligible
	Open Lakes	None	Negligible
Pulp/Wood	Thunder Bay	Oxygen depletion	Negligible/minor
	Open Lakes	None	Negligible
Aggregates	Sarnia	None	Negligible
	Sault Ste. Marie	None	Negligible
	Open Lakes	None	Negligible
Fertilizer Material	Thunder Bay	None	Negligible
	Hamilton	Eutrophication	Negligible/minor
	Open Lakes	None	Negligible

PAH = polycyclic aromatic hydrocarbon.

[1]Impact ratings: negligible = having essentially no effects; minor = resulting in less than 1% change in environment carrying capacity, animal population size, or other attribute; moderate = resulting in 1% to 10% change in environment carrying capacity, animal population size, or other attribute; major = resulting in 10% or greater change in environment carrying capacity, animal population size, or other attribute.

Source: Melville Shipping, 1993a.

Salts

- Sodium concentrations in the Lakes already are elevated (by a factor of three in the last 50 years), thus making additional input of sodium chloride (halite) a concern.
- Road salt and other forms of halite often contain anti-caking agents, such as sodium hexacyanoferrate (III) that can release toxic cyanide into the water.
- Potash (potassium chloride) is very soluble but tends to incorporate into mineral structure, thus making it less of a threat.

Like this current study, the CCG study (Melville Shipping, 1993a) included measurements and estimates of inputs from shipping (in Canadian ports only) and evaluations of the potential impacts of the inputs The major conclusions of the CCG study on the impacts of the inputs based on the amounts involved were as follows:

- Small quantities of dry cargo are spilled in any one event.
- Spills of materials in ports are very small, and spills in the Lakes are diluted with large amounts of water.
- The effects of the spills are probably very small.
- Ships probably have contributed a very small percentage of the material that has accumulated in sediments and that presently is dissolved in the water.
- Many ports have limited water circulation so that materials spilled will tend to accumulate in the harbor, thereby contributing to existing problems.
- The cumulative impact of all pollutants from all sources has led to the severe degradation of the overall environment of the Great Lakes. The impacts of any one of these spills or of all spills over the course of 1 year probably are negligible to minor in harbors.
- The minor impacts of these spills would have a widespread prevalence throughout the Great Lakes.

5.5.2 The NOAA/GLERL Workshop

In 1993, the NOAA/GLERL workshop was convened to discuss the environmental implications of dry cargo sweeping from vessels in the Great Lakes (Reid and Meadows, 1999). The workshop divided into the following three workgroups:

- **Risk to fisheries and habitat** to consider the potential for changes in bottom habitat character and quality that might result from an accumulation of cargo residues in a particular area over time
- **Sediment accumulation and toxicity** to consider the potential effects of cargo residues that reach and accumulate in soft-bottom sediments
- **Water-column impacts** to consider the potential effects of cargo sweepings in the water column

Risk to Fisheries and Habitat Workgroup

This workgroup concluded that residues of cement, grain, coarse limestone, and wood pulp or chips are not likely to cause serious environmental damage to or produce negative impacts on plants and animals in the Great Lakes. However, the workgroup also concluded that residues of taconite pellets and finely divided limestone, coal, sand, and possibly slag adversely may alter coarse and rocky substrate habitat by filling interstitial spaces (see Table 5.17).

Table 5.17 Suspected Ecological Impacts from Dry Cargo Sweepings on Great Lakes Fishery Resources and Habitats.

Commodities	Risks to Bottom Habitats			
	Plant Bed	Mud/Silt	Sand	Rocky Shoals
Iron ore	1, 3	1, 3?	0	1, 6
Coal-coke	5b, 3, 1	3, 1, 5b	3, 1, 6	3, 1, 6
Limestone	1?	5a, 5c	5c, 6 (site dependent)	5c, 6
Gypsum	0?	1?	0	1?
Potash	4a	4a	4a	4a
Fertilizer	4a	4a	4a	4a
Urea-SD	Minor	Minor	Minor	Minor
Grain	4a	Minor	?	?
Float dust	2?	2?	2?	2?
Salt	3?	3?	3?	3?
Wood pulp	?	?	?	?
Sand	0	1?	0	1, 6 (minor)
Other millscale	3?	1, 3	1, 3	?
Slag	3?	1, 3	1, 3	1, 6

1 = smothering/suffocation, 2 = osmotic stress, 3 = toxicity (a = acute, b = chronic), 4 = nutrient enrichment (a = enhanced productivity, b = over-enrichment and algal blooms), 5 = bottom substrate change (a = physical, b = biological, c = habitat creation), 6 = filling of interstitial spaces in bottom substrate, ? = impact unknown.

Source: Reid and Meadows, 1999.

The workgroup concluded that there is a critical lack of knowledge and a need for research on the toxic effects of iron ore, taconite pellets, coal, coke, rock salt, millscale, and slag on plants and animals in the Great Lakes. The workgroup further concluded that specific research is needed to determine and evaluate properly the environmental implications of cargo residues, and recommended a series of studies to accomplish this, including detailed chemical analyses of specific commodities, laboratory experiments (toxicity bioassays and determination of oxygen demand), and related field testing and measurements.

Sediment Accumulation and Toxicity Workgroup

This workgroup identified four key questions that should be addressed in determining the potential effects of dry cargo residues that reach and accumulate in soft-bottom sediments:

- Does cargo sweeping adversely affect bottom sediments or the biota that reside in or near these sediments?
- What are the chemical compositions of the cargo commodities?
- Are the deposited materials in the sediment from cargo sweeping activities toxic or bioaccumulated by benthic organisms?
- Is deposition of cargo residues changing the physical structure of the bottom sediments (e.g., increasing the amount of hard substrate), therefore changing the habitat for the benthos?
- How do cargo-sweeping activities relate to and compare with other discharges of similar or the same compounds in the Great Lakes?

Since insufficient data and information currently exist to answer these questions, the workgroup developed a two-tiered approach for conducting a future assessment: (I) assess the toxicity and bioaccumulation of cargo residue-associated contaminants to benthic communities, and (II) then assess cause-and-effect relationships and factors controlling the bioavailability of contaminants associated with cargo residues.

The workgroup concluded that *if* impacts of cargo residues on benthic communities *were* observed, Tier II studies would be required to determine cause-and-effect relationships and factors controlling the bioavailability of contaminants associated with cargo residues deposited on soft-bottom sediments. The workgroup then recommended a series of field studies. To date, these studies have not been conducted.

Water-Column Impacts Workgroup

This workgroup evaluated dry bulk commodities for both toxicological and water-quality effects (Table 5.18). The workgroup concluded that the short-term changes in local turbidity that may result from cargo sweepings would be of little demonstrable environmental consequence within the water column.

The workgroup concluded that the potential for *toxic* chemicals to be introduced into the water column from dry cargo residues or from any materials used in treating those commodities could not be evaluated properly with currently available information. The workgroup expressed additional concerns regarding possible effects on biotic communities growing proximal to air-water and sediment-water interfaces.

Table 5.18 Potential Water-Column Effects from Dry Bulk Commodities in the Great Lakes.

Commodity	Toxic Effects	Water Quality Effects	Proposed Severity Ranking[1]
Taconite/Iron Ore	Suspected/unknown	Suspected/unknown	1
Coal	Suspected/unknown	Suspected/unknown	2
Coke	Suspected/unknown	Suspected/unknown	2
Limestone	None	Suspected/unknown	10
Gypsum	None	Suspected/unknown	10
Potash	Suspected/unknown	Suspected/unknown	4
Fertilizer	Suspected/unknown	Suspected/unknown	5
Grain	None	Suspected/unknown	6
Rock Salt	Suspected/unknown	Suspected/unknown	3
Sand/Gravel	None	Suspected/unknown	10
Clay And Refractories	None	Suspected/unknown	10
Wood Pulp	Suspected/unknown	Suspected/unknown	9
Slag	Suspected/unknown	Suspected/unknown	7
Millscale	Suspected/unknown	Suspected/unknown	8

[1]Highest concern over commodities with ranking of 1, lowest with ranking of 10.

Source: Reid and Meadows, 1999.

The major issues identified with respect to water-column impacts were as follows:

- **Cargo statistics.** Detailed information is required regarding identification of bulk cargos carried and regularly washed down.
- **Chemical composition of cargo.** Detailed information is needed to prioritize research into possible environmental effects.
- **Physical characteristics of discharge plume.** Chemical and biological analyses are needed in context of physical properties of discharge plumes.
- **Environmental effects.** Information is needed on bioavailability, solubility, toxicity, and nutrient potential of the materials found in dry bulk cargos.

The workgroup recommended that necessary statistical data on materials shipped, detailed chemical composition of the materials, and amounts of these materials discharged to the waters of the Great Lakes because of cargo sweepings under normal and worst-case conditions be compiled. The workgroup concluded that the dispersal of materials from cargo sweepings, once introduced into the water column, is known insufficiently. Overall, the workgroup concluded that a series of additional studies would need to be conducted before a reliable environmental risk assessment could be made. None of the additional studies has been completed as of the writing of this report.

5.5.3 Analysis of Environmental Impacts of Estimated Dry Cargo Inputs

Without a proscribed methodology for estimating the environmental impacts of the measured dry cargo inputs, a methodology was devised for this report. The methodology is intended to approximate the approach described in Section 1.0 to the extent possible with existing data and knowledge.

The analysis methodology employed three components for *each commodity*:

- Impact ratings by zone or habitat type
- Estimated inputs of commodity
- Environmental information for locations in each Lake

The findings in the CCG study (Melville Shipping, 1993a) and NOAA/GLERL workshop (Reid and Meadows, 1999), along with other information derived from a literature review, were used to develop the matrix of environmental sensitivities and impact ratings as shown previously in Table 5.6. The impacts of each commodity were viewed in terms of toxicity, potential for causing nutrient enrichment and eutrophication, propensity for sedimentation and contamination of sediments, residence time, potential to cause smothering of benthic organisms, and potential for changing the benthic substrate in a significant manner through accumulation.

Environmental sensitivity maps (from EPA Region 5) and other map data, bathymetry maps (see Figures 2–6 in Appendix B), maps of biodiversity (Figure 5.3), and maps of environmentally-stressed or environmentally impaired areas (Figure 5.4) for the five major Lakes in the Great Lakes System were examined for various criteria to approximate the locations of zones that would be especially sensitive to dry cargo inputs. These zones were designated based on a number of criteria, including:

- Presence of threatened or endangered species, and/or presence of globally significant biodiversity elements (EPA, 1994) (see Table 2A in Appendix B)
- Presence of vulnerable and/or globally significant habitats (EPA, 1994) (see Table 1A in Appendix B)
- Shallower depths that might exacerbate the magnitude of impacts because of less dilution and spreading of inputs (see Table 5.2 above and Figures 2–6 in Appendix B)
- General environmental impairment from pollutant input from industrial and urban sources (including runoff), anoxic conditions, increased acidity, increased salinity, or other causes (see Figure 5.4)
- Designation as AOC by EPA or other authorities (Figure 5.2 and Table 5.4)
- Long Lake retention times (Table 5.2)

Environmental sensitivity ratings were applied to each of the segment zones, which included the actual input locations (along the traffic zone) and the areas in the vicinity of the segments. The sensitivity ratings were developed on the basis of the following five-point scale: highest sensitivity (5), high sensitivity (4), medium sensitivity (3), low sensitivity (2), and lowest sensitivity (1).

The input estimates of each of the commodities (as presented in Section 5.4) were considered with respect to their input on a per-area and per-volume basis in the each Lake as a whole and by trackline segment. In addition, the inputs into each of the trackline segments were considered by individual commodity and by the overall input of *all* dry cargo commodities in each region (as in Figure 5.12). The inputs were considered in categories of relative *per-acre input*, as shown in the maps in Figures 5.6–5.12.

Inputs, estimated in this study for 1 year, were considered in terms of potential accumulation over several decades in the past and at least 2 decades into the future. The rates of input in the past may have been somewhat higher since there were likely fewer voluntary efforts to limit inputs from shipping. The accumulation of inputs from past shipping activities would likely be at least 50 to 70 times as high as measured in this study. The inputs for the present year were deposited on top of the inputs from previous decades.

Changes in shipping patterns or types and amounts of dry cargo commodities shipped by waterborne transport could impact inputs in the future significantly. Changes in other environmental factors in the Great Lakes System also could influence the degree and manner in which future inputs of dry cargo impact the Lakes. It is not possible to forecast what impacts future inputs might have on the Great Lakes.

Each segment was categorized with respect to inputs (by each commodity and by all commodities combined) by a rating of the inputs (as in Figures 5.6–5.12). The categories of input used are as follows: highest (6) equals 3.0 or more lbs/acre, higher (5) equals 2.0–2.9 lbs/acre, moderate–high (4) equals 1.0–1.9 lbs/acre, moderate (3) equals 0.1–0.9 lbs/acre, low (2) equals 0.01–0.09 lbs/acre, and lowest (1) equals less than 0.01 lbs/acre. Each segment was then evaluated based on an overall impact *rating* that was derived from multiplying the commodity impact rating, by the input rating, by the environmental sensitivity ratings (Table 5.19) as follows:

$$\textbf{\textit{total dry cargo impact}} = \textbf{\textit{commodity impact}} \times \textbf{\textit{input}} \times \textbf{\textit{environmental sensitivity}}$$

Table 5.19 Total Dry Cargo Impact Rating.

Rating Type	Rating Scale	Description
Commodity Impact	As shown in Table 5.6	Rates commodities in terms of impact to habitats by toxicity, accumulation and substrate change, smothering potential, and nutrient enrichment.
Commodity Input	Highest (6) = 3.0 or more lbs/acre Higher (5) = 2.0–2.9 lbs/acre Moderate–High (4) = 1.0–1.9 lbs/acre Moderate (3) = 0.1–0.9 lbs/acre Low (2) = 0.01–0.09 lbs/acre Lowest (1) = < 0.01 lbs/acre	Rates annual commodity inputs on basis of per-area (lbs/acre) inputs.
Environmental Sensitivity	Highest (5) High (4) Medium (3) Low (2) Lowest (1)	Rates segments for environmental sensitivity based on presence of sensitive and/or threatened species or habitats, general biodiversity, preexisting environmental impairment, lake retention time.

The commodity impact rating for each zone was derived for all commodities and for the commodities taken together (total). The impact rating of the commodity was adjusted to account for the type of habitats, water depth, and general features present in each segment, meaning that ratings used from Table 5.6 were based on the segment features. This would adjust the commodity impact based on the environmental features of each segment. *For analysis, the commodity impact rating for all commodities combined used is the average of the scores for the individual substances rather than the total impact rating score in Table 5.6.* The total impact rating score is merely a total of all scores for the individual habitat types, and is meant to provide a means of judging the overall impact that that commodity has on a variety of habitats.

The relative impacts of the dry cargo inputs (for individual commodities and total commodity input) for each trackline segment and for each Lake are shown in the following sections. Justification for the environmental sensitivity ratings, which also impact the commodity impact ratings in terms of relevant habitat types, are shown in Table 5.20. Details of the relative impact rankings and justification of environmental sensitivity ratings are provided in Tables 36–63 of Appendix B.

The total impact ratings for all commodities for all trackline segments were analyzed with respect to their distribution. Figure 5.19 and Table 5.21 show the distribution of the scores, which ranged from a low of 9 to a high of 960. A probability distribution function was created from this distribution, as shown in Figure 5.20. This distribution shows the "percentile" of rank scores compared to all other scores. For example, a score of 325 is in the ninetieth percentile, which means that is *higher* than 90% of the scores for all segments. Only 10% of the segments (by commodity) have a *worse* score. This distribution provides a method for comparing the scores in all of the segments by commodity to give a sense of the degree of impact of a particular commodity in a particular segment with the estimated input that that segment received in during the last year. The percentile groups for *all* segments are shown in Table 5.22.

Table 5.20 Environmental Characteristics Determining Sensitivity Ratings by Trackline Segment.

Segment[1]	Shallow Depth	Anoxia	Environmental Impairment	Areas of Concern	Sensitive Species Habitats	Biodiversity	Long Retention
Lake Erie							
EE	■	■		■			
EFE-1	■	■	■	■			
EFE-2	■	■				■	
EO	■	■	■	■	■ ■	■	
EW-1	■	■	■	■		■	
EW-2	■	■	■	■	■		
Lake Huron							
HC					■ ■		■
HN-1	■				■ ■	■	■
HN-2					■		■
HS-1	■		■		■		■
HS-2	■				■		■
Lake Michigan							
MCE				■	■		■
MCW				■	■ ■		■
MN-1	■			■	■ ■	■	■
MN-2					■ ■ ■	■	■
MS-1	■		■		■ ■	■	■
MS-2					■		■
Lake Ontario							
ONT	■		■	■		■	
Lake Superior							
SC			■	■	■	■	■
SEO	■			■	■ ■	■	■
SET-1	■				■	■	■
SET-2							■
SWT	■		■	■	■ ■		■

■ = some concern, ■ ■ = more concern, ■ ■ ■ = higher concern. A blank cell indicates no concern; the issue is not applicable or it has not reached a level of concern at this time.

[1]Trackline segment names refer to Figure 5.5.

5.5.4 Environmental Sensitivity Zones

Table 5.23 shows the overall impacts of each commodity to the different Lakes. Lake Erie and Lake Michigan are shown to be the most highly impacted by current levels of dry cargo input. Lake Ontario is impacted moderately, and Lakes Huron and Superior are impacted to a lesser extent.

While the percentile scores provide a sense of which segments are receiving the highest impacts from inputs of particular commodities, they do not provide any evaluation of the impacts to trackline segments *within* a commodity type. To answer questions such as "Which segment is impacted most by coal?" or "If it is necessary to do washdowns of millscale in Lake Erie, which segment would be least impacted?" an additional analysis was conducted to determine general sensitivity to inputs of each commodity. The classification of sensitivity for each segment to a particular commodity was derived from both the commodity impact rating and the environmental sensitivity rating. The segments were classified as high, medium, or low sensitivity within each Lake (for use in situations in which washdowns *must* occur within a particular Lake) and in all Lakes (where washdowns could occur in a different Lake when routes allow).

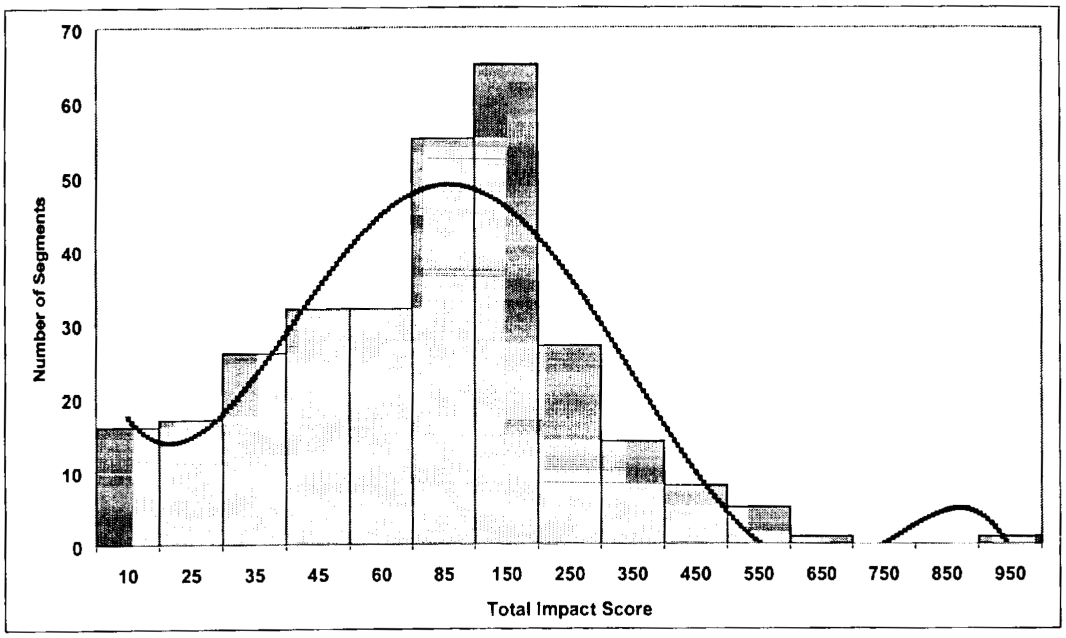

Figure 5.19 Distribution of Total Impact Rank Scores for All Trackline Segments.

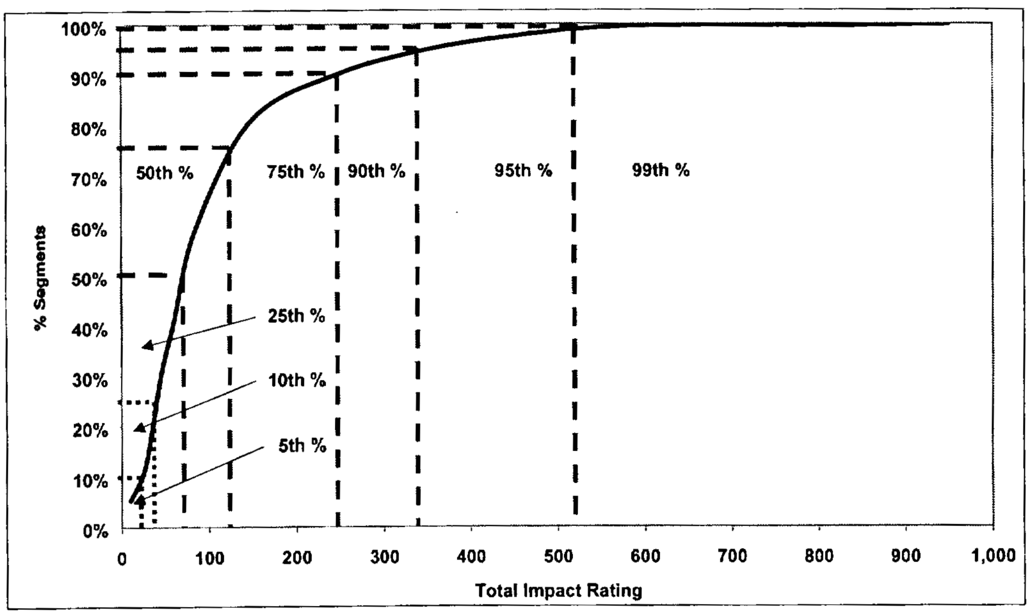

Figure 5.20 Cumulative Probability Distribution of Total Impact Ratings for All Trackline Segments.

Table 5.21 Final Dry Cargo Impact Ratings.

	Segment[1]																						
Commodity	**EE**	**EFE1**	**EFE2**	**EO**	**EW1**	**EW2**	**HC**	**HN1**	**HN2**	**HS1**	**HS2**	**MCE**	**MCW**	**MN1**	**MN2**	**MS1**	**MS2**	**ONT**	**SC**	**SEO**	**SET1**	**SET2**	**SWT**
Iron Ore	256	288	128	480	384	384	128	480	96	288	192	192	288	480	240	960	160	270	256	480	288	64	480
Coal	288	648	216	540	576	432	144	540	108	324	216	216	324	540	360	540	108	324	288	360	324	48	360
Coke	56	126	56	140	112	112	32	160	32	48	32	56	42	140	70	210	42	96	64	80	48	16	80
Stone	84	42	28	350	168	168	78	195	39	117	78	72	72	240	180	240	36	39	48	60	72	12	60
Sand	32	48	32	160	64	64	32	80	16	48	32	32	48	160	80	80	16	48	64	80	48	16	80
Grain	144	324	144	360	432	432	72	360	72	108	72	72	108	180	180	360	72	216	144	180	216	48	180
Cement	36	81	36	45	72	72	22	55	11	33	22	18	27	65	45	45	9	66	44	55	33	11	55
Gypsum	34	51	34	85	68	68	46	115	23	69	46	92	69	230	115	115	23	138	92	115	69	23	115
Salt	102	153	68	170	204	204	46	230	46	138	92	92	138	230	115	115	23	138	92	115	69	23	115
Potash	28	42	28	70	112	112	32	80	16	48	32	28	42	70	70	140	28	48	64	80	48	16	80
Slag	28	42	28	70	112	112	32	80	16	48	32	56	42	140	70	140	28	96	64	80	48	16	80
Millscale	38	57	38	190	76	76	38	95	19	57	38	38	57	95	95	95	19	57	76	95	57	19	95
ALL	**94**	**159**	**70**	**222**	**198**	**186**	**59**	**206**	**41**	**111**	**74**	**80**	**105**	**214**	**135**	**253**	**47**	**128**	**108**	**148**	**110**	**26**	**148**
	Erie						**Huron**					**Michigan**						**Ont.**	**Superior**				

[1]Trackline segment names refer to Figure 5.5.

Table 5.22 Final Dry Cargo Impact Rating Percentiles (All Segments).

	Segment[1]																						
Commodity	**EE**	**EFE1**	**EFE2**	**EO**	**EW1**	**EW2**	**HC**	**HN1**	**HN2**	**HS1**	**HS2**	**MCE**	**MCW**	**MN1**	**MN2**	**MS1**	**MS2**	**ONT**	**SC**	**SEO**	**SET1**	**SET2**	**SWT**
Iron Ore	90	90	75	95	95	95	75	95	50	90	75	75	90	95	90	99	75	90	90	95	90	25	95
Coal	90	99	75	99	99	95	75	99	50	90	75	75	90	99	95	99	50	90	90	95	90	25	95
Coke	25	75	25	75	50	50	10	75	10	25	10	25	25	75	50	75	25	50	25	50	25	5	50
Stone	50	25	10	90	75	75	50	75	10	50	50	50	50	90	75	90	10	10	25	25	50	5	25
Sand	20	25	10	75	25	25	10	50	5	25	10	10	25	75	50	50	5	25	25	50	25	5	50
Grain	75	90	75	95	95	95	50	95	50	50	50	50	50	75	75	95	50	75	75	75	75	25	75
Cement	10	50	10	25	50	50	10	25	5	10	10	5	10	25	25	25	5	25	25	25	10	5	25
Gypsum	10	25	10	50	25	25	25	50	10	25	25	50	25	75	50	50	10	75	50	50	25	10	50
Salt	50	75	25	75	75	75	25	75	25	75	50	50	75	75	50	50	10	75	50	50	25	10	50
Potash	10	25	10	50	50	50	10	50	5	25	10	10	25	50	50	75	10	25	25	50	25	5	50
Slag	10	25	10	50	50	50	10	50	5	25	10	25	25	75	50	75	10	50	25	50	25	5	50
Millscale	10	25	10	75	50	50	10	50	5	25	10	10	25	50	50	50	5	25	50	50	25	5	50
ALL	**50**	**75**	**50**	**75**	**75**	**75**	**25**	**75**	**25**	**50**	**50**	**50**	**50**	**75**	**50**	**90**	**25**	**75**	**50**	**75**	**50**	**10**	**75**
	Erie						**Huron**					**Michigan**						**Ont.**	**Superior**				

[1]Trackline segment names refer to Figure 5.5.

Note: Shading indicates an impact-rating percentile of 90 or greater.

Table 5.23 Overall Environmental Impact Rank[1] from Dry Cargo Input.

Commodity	Erie	Huron	Michigan	Ontario	Superior
Iron Ore	4	1	5	2	3
Coal	5	1	4	3	2
Coke	5	2	3	4	1
Stone	4	3	4	1	2
Sand	4	1	5	2	3
Grain	5	1	3	4	2
Cement	4	1	2	5	3
Gypsum	1	2	4	5	3
Salt	5	2	3	4	1
Potash	5	1	4	2	3
Slag	3	1	4	5	2
Millscale	5	3	2	1	4
All	**5**	**1**	**4**	**3**	**2**
Average Rank	**4**	**2**	**4**	**3**	**2**

[1]Rank of dry cargo impact ratings averaged across the segments in each Lake.

Table 5.24 shows a general ranking from *low* to *high* of segment sensitivity to each commodity *within* each lake and for *all* the Lakes.

5.6 Concerns of Environmental Non-Governmental Organizations

To learn of any concerns that environmental organizations might have with regard to Great Lakes dry cargo issues, an extensive interview was conducted with Jennifer Nalbone, Habitat and Biodiversity Coordinator for Great Lakes United. This non-governmental organization (NGO) was selected as representative of environmentalist and community concerns in the region. Great Lakes United is a bi-national coalition made up of member organizations representing environmentalists; conservationists; hunters and anglers; labor unions; community groups; and citizens of the United States, Canada, and First Nations and Tribes. The umbrella organization of Great Lakes United coordinates its efforts through five issue-based task forces:

- **Clean production** to advocate pollution prevention and other measures to eliminate the use and release of persistent toxic substances
- **Biodiversity and habitat protection** to strengthen grassroots efforts to counter wise-use and other anti-environmental initiatives
- **Healthy communities** to work to clean up the most contaminated sites around the Great Lakes and St. Lawrence River
- **Sustainable water use** to advocate sustainable water-use policies and other efforts to protect water quantities in the Great Lakes Basin
- **Nuclear-free Great Lakes** to advocate an end to the discharge of radioactive substances in the Great Lakes Basin, and the phase out and shutdown of all basin nuclear power plants

Table 5.24 Dry Cargo Impact Sensitive Ratings for Great Lakes Trackline Segments.

	Segment[1]																						
Commodity	**EE**	**EFE1**	**EFE2**	**EO**	**EW1**	**EW2**	**HC**	**HN1**	**HN2**	**HS1**	**HS2**	**MCE**	**MCW**	**MN1**	**MN2**	**MS1**	**MS2**	**ONT**	**SC**	**SEO**	**SET1**	**SET2**	**SWT**
Within Lakes																							
Iron Ore	L	M	L	H	M	M	M	H	L	M	M	L	M	H	H	H	L	n/a	M	H	M	L	H
Coal	L	M	L	H	H	H	M	H	L	M	M	M	M	H	H	H	L	n/a	H	H	H	L	H
Coke	L	L	L	H	M	M	M	H	L	M	M	L	M	M	M	M	L	n/a	M	H	M	L	H
Stone	L	M	L	H	M	M	L	H	L	M	L	L	L	M	M	M	L	n/a	M	M	L	L	M
Sand	L	M	L	H	H	H	L	M	L	M	L	L	M	M	M	M	L	n/a	M	M	L	L	M
Grain	L	M	L	H	H	H	M	H	L	H	M	M	M	H	H	H	L	n/a	H	H	M	L	H
Cement	L	M	L	M	M	M	L	M	L	M	L	L	L	M	M	M	L	n/a	M	M	L	L	M
Gypsum	L	M	L	H	M	M	L	H	L	M	L	L	M	H	H	H	L	n/a	H	H	M	L	H
Salt	L	M	L	H	M	M	L	H	L	M	L	L	M	H	H	H	L	n/a	H	H	M	L	H
Potash	L	M	L	H	M	M	M	H	L	M	M	L	M	M	M	M	L	n/a	M	M	L	L	M
Slag	L	L	L	M	M	M	M	H	L	M	M	L	M	M	M	M	L	n/a	M	M	L	L	M
Millscale	L	M	L	H	M	M	M	H	L	M	M	M	M	H	H	H	L	n/a	M	H	M	L	H
All	**L**	**M**	**L**	**H**	**H**	**H**	**L**	**H**	**L**	**M**	**L**	**L**	**M**	**H**	**H**	**H**	**L**	**n/a**	**M**	**H**	**M**	**L**	**H**
Between All Lakes																							
Iron Ore	M	M	M	H	H	H	M	H	L	M	M	M	M	H	H	H	L	M	H	H	M	L	H
Coal	M	M	M	H	H	H	M	H	L	M	M	M	M	H	H	H	L	M	H	H	M	L	H
Coke	L	L	L	M	M	M	L	H	L	L	L	L	L	M	M	M	L	L	M	H	L	L	H
Stone	L	L	L	H	M	M	L	H	L	L	L	L	L	M	M	M	L	M	M	M	L	L	M
Sand	L	M	L	H	M	M	L	H	L	M	L	L	M	H	H	H	L	M	M	H	M	L	H
Grain	M	M	M	H	H	H	M	H	L	M	M	M	M	H	H	H	L	M	H	H	M	L	H
Cement	L	L	L	M	L	L	L	H	L	L	L	L	L	H	M	M	L	M	M	H	M	L	H
Gypsum	L	L	L	M	M	M	L	H	L	M	L	L	M	H	H	H	L	M	M	H	M	L	H
Salt	L	M	L	M	M	M	L	H	L	M	L	L	M	H	H	H	L	M	H	H	M	L	H
Potash	L	L	L	H	M	M	L	H	L	M	L	L	L	H	H	H	L	M	M	H	M	L	H
Slag	L	M	L	H	M	M	L	H	L	M	L	L	M	H	H	H	L	M	M	H	M	L	H
Millscale	L	M	L	H	M	M	L	H	L	M	L	L	M	H	H	H	L	M	M	H	M	L	H
All	**L**	**M**	**L**	**H**	**M**	**M**	**L**	**H**	**L**	**M**	**L**	**L**	**M**	**H**	**H**	**H**	**L**	**M**	**M**	**H**	**M**	**L**	**H**
	Erie						**Huron**					**Michigan**						**Ont.**	**Superior**				

H = high, M = moderate, L = low.

[1]Trackline segment names refer to Figure 5.5.

The most significant *current* concerns of Great Lakes United relate to regulation of ballast water management and other issues related to introduction of invasive species, potential impacts of the proposed installation of trans-Lake utility pipelines (natural gas and electric cables), water level reduction in the Lakes and the need for water conservation in Lake and basin areas, and promotion of "clean production" practices to avoid the need for toxic mitigation. The organization actively is promoting a new action agenda of its top priorities in one "package" for Great Lakes restoration. Ms. Nalbone cited the need for assigning a realistic cost value to a comprehensive Great Lakes restoration plan to give concerned stakeholders a sense of the magnitude of the environmental issues of concern for the Great Lakes.

Two weeks in advance of the interview on dry cargo issues, Ms. Nalbone was provided with printed copies of the two most comprehensive reports on environmental impacts of dry cargo currently available: the CCG study (Melville Shipping, 1993a) and the NOAA/GLERL workshop proceedings (Reid and Meadows, 1999).

According to Ms. Nalbone, dry cargo residues had not been a matter of any concern to Great Lakes United prior to this study's contact with the organization regarding the issue. Neither the organization nor its membership appeared to have any knowledge of the practice of dry cargo sweeping/washdown in the Great Lakes or any potential environmental impacts of dry cargo residues in the region.

After review of the provided background materials and a general introductory education on dry cargo issues, Great Lakes United had a number of concerns that it wanted to make known to the USCG and others involved in policy making with regard to dry cargo input in the Great Lakes:

- **Public input into rulemaking process.** If the USCG or any other regulating agency is making any new policy with regard to dry cargo input into the Great Lakes, there must be *public input.* Great Lakes United would prefer that this input be solicited from the organization (and its member groups) in *advance* of any Notice of Proposed Rulemaking (NPRM) in the Federal Register. The organization is concerned that there may not be enough time to educate the membership on dry cargo concerns, hold the necessary public meetings, and solicit recommendations for policy if the USCG merely publishes an NPRM.
- **Consideration of cumulative effects of shipping industry.** The issue of dry cargo sweeping/washdown should not be viewed in isolation from other impacts on the shipping industry to the Great Lakes. Great Lakes United tends to view the cumulative effects of an entire *industry* (e.g., power plants, shipping) on the Lake ecosystems under the approach that "the whole does not necessarily equal the sum of its parts." Dry cargo sweeping should then not be viewed as something separate from the prevention of oil and chemical spillage, or ballast water management, for example. It is better to have more comprehensive regulation of a particular industry rather than regulation of parts of industry practices.
- **Communication with resource management.** The impacts of dry cargo on Great Lakes fisheries should be assessed fully through cross-communication among resource managers and researchers. Currently there is little information on fish movement or locations of fishing grounds, as well as inadequate mapping of aquatic habitats. Great Lakes United believes that there must be a Lakes-wide assessment of fisheries before formulating any definitive policy on dry cargo shipping issues.
- **Initiation of recommended field and laboratory studies.** The NOAA/GLERL workshop proceedings (Reid and Meadows, 1999) recommended a number of studies that should be

conducted to gain a better understanding of the impacts of dry cargo inputs. It is understandable that lack of funding has been the major impediment to following through on these recommended studies. Great Lakes United recommends that state resource agencies partner with federal and provincial (Canadian) agencies to provide leverage for funding. Since the shipping industry is the "cause" of the dry cargo input, it should be called to task in funding research initiatives. In the view of Great Lakes United, the Lake Carriers Association (LCA) has been very "solid" in taking initiatives with regard to ballast-water management and should be approached on dry cargo issues as well. Putting industry into a decision-making role with regard to regulation could foster cooperation with regard to reducing or eliminating dry cargo input by shipping.

- **Consideration of residue removal in port.** Great Lakes United poses the question of whether or not there could be a mechanism for cleaning shipdecks of dry cargo residue *in port*. The cost should be borne by both the shipper and the cargo "provider" with cost recovery from the commodity that would otherwise be lost in sweeping or washdown. There should not be an assumption that the practice as it currently stands *must* continue.
- **Recognition of annual variability of inputs.** The CCG study (Melville Shipping, 1993a) indicates that the assessment provided in the study for one particular year may not be the same as that which would be obtained in future years as there are variations in shipping trends. Great Lakes United stresses that these variations should be taken into account in making any assessment of environmental impacts.
- **Recognition of cumulative nature of inputs.** The CCG study (Melville Shipping, 1993a) concludes that the overall impact of dry cargo input from shipping is "negligible." Great Lakes United is concerned that while the annual input may indeed be negligible, the cumulative effect may be greater than assumed.
- **Designation of washdown zones.** If the practice of dry cargo sweeping/washdown *must* occur offshore, it should only occur in designated zones. Great Lakes United recognizes that these zones might fluctuate with regard to changes in fish spawning areas. Perhaps because of this difficulty, it might be easier to designate limited zones as those areas currently used for washdowns.
- **Stricter interpretation of MARPOL V.** Great Lakes United is concerned that the viewpoint that Annex V of MARPOL 73/78, Regulations for the Prevention of Pollution by Garbage from Ships (MARPOL V) should be interpreted more "loosely" for the Great Lakes than for the ocean environment is invalid. The fact that the Great Lakes constitute a unique closed freshwater ecosystem should mean that MARPOL V ought to be interpreted *more strictly* in this region than for the marine environment.

Finally, Ms. Nalbone emphasized that the interview conducted with her as the representative of Great Lakes United for this report should *not* be construed to constitute "public input" or as input by Great Lakes United for pre-NPRM commentary on policy making on dry cargo issues. The group would continue to expect to have further input to the rulemaking process in the future.

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5.7 Findings and Recommendations on Environmental Issues

The general lack of research and data on the impacts of specific dry cargo commodities on ecosystems, Lake habitats, and animal and plant species limits the ability to develop a definitive methodology for determining the environmental impacts of current dry cargo inputs into the Great Lakes. The types of field research and laboratory studies recommended by the NOAA/GLERL workshop must be completed before this type of analysis would be possible.

Until these studies are completed, the non-parametric rating system used in this study on impacts of estimated dry cargo inputs offers some preliminary insights into *relative* impacts in different washdown segments and allows for comparison between the impacts of different commodities.

5.7.1 Findings

1) Overall, the estimated annual inputs from dry cargo washdowns and sweepings appear to be relatively low when compared to the other environmental problems of the Great Lakes System as a whole and of the individual Lakes. The estimated annual inputs are undoubtedly small in comparison to other loadings of pollutants, particularly urban and agricultural runoff from the large number of heavily populated and industrialized cities and towns that surround the lakes in both the United States and Canada.
2) The over 1,000 tons of dry cargo that is washed down into the Great Lakes on an annual basis must be viewed in the context of continual accumulation from past shipping as well as future shipping, particularly in locations in the Lakes where large numbers of ships tend to conduct washdown procedures on a regular basis.
3) The Lakes have different sensitivities to dry cargo inputs based on their physical attributes (e.g., depth, retention time, area), environmental conditions (e.g., anoxia, AOCs), and ecological attributes (e.g., biodiversity). Lakes Erie and Michigan appear to be experiencing the highest impacts, Lakes Huron and Superior relative lower impacts.
4) The most highly impacted trackline segments are the southern part of Lake Michigan (MS-1) and the western-most part of Lake Erie (EO). These segments are receiving relatively higher amounts of impact and also show high environmental impairment from the large amount of commerce and industry in these regions. These areas, however, also are designated as areas of high biodiversity and each has several endangered and/or threatened species in its waters or on nearby shorelines.
5) Iron ore, coal, coke, slag, and millscale present the greatest potential for environmental impacts. Coal and coke can leach PAHs, substances known to be toxic to many organisms. Iron ore, taconite pellets, slag, and millscale can leach harmful compounds as well. Leaching rates are increased in anoxic and acidic conditions. Lake Erie is known to be anoxic due to eutrophication. All Lakes are subject to inputs by acid rain that results from sulfur dioxide and nitrogen oxide emissions in the atmosphere. The leachates from iron-containing commodities and coal or coke can impact water quality and contaminate sediments.
6) Input of commodities that can contribute to nutrient enrichment and resultant eutrophication (e.g., grain, fertilizer, and potash) is relatively low in comparison with other commodities. Increased shipping of these commodities could cause localized problems.
7) Salt input is also currently relatively low, though increases in the shipping of this commodity could cause localized problems. The increased salinity of the Lakes has caused considerable

environmental impact that is exacerbated by lowering Lake levels. The input of salt by washdowns from bulk carriers is dwarfed by the input from urban runoff of road salt.

8) Inputs are probably relatively well "diluted" and spread out, especially in the deeper and wider areas of Lake Superior and deep sections of other Lakes. The trackline segments that are 10 miles wide in Lake Superior allow the inputs to be spread over larger areas causing less impact.

5.7.2 Recommendations

The Great Lakes comprise a unique closed freshwater system that provides both a valuable resource for waterborne commerce and a unique set of environmental sensitivities to the activities associated with this commerce. The challenge for policy makers is to find ways to allow for the mutual coexistence of this commerce and the protection of the unique ecosystems of the Great Lakes.

With regard to environmental protection, there are a variety of strategies for reducing the impacts of dry cargo washdown or sweeping practices as currently exist on the Great Lakes. Complete elimination or severe reduction of commodity inputs is one approach that would reduce the impacts of dry cargo on the Lakes radically. There are a number of economic and practical reasons why this approach may not be feasible currently.

A more practical approach may be to limit washdown procedures to specific zones within the Lakes. There are two basic approaches that can be taken in terms of recommending zones for input or restriction from input:

- **Limit inputs to areas that *already* are impacted highly from an environmental standpoint.** The philosophy behind this approach is that certain areas already are impacted highly due to industrialization and activities related to commerce, or perhaps due to urban and/or agricultural runoff. If inputs from dry cargo are added to these areas rather than to other more "pristine" areas, it will not cause undue damage in more highly valued areas. One consideration with this approach is that if inputs are limited to these zones (and inputs to other zones designated as protected or sensitive are disallowed), it will *increase* the impacts in the input zones as there will be greater inputs from discharges that would otherwise have occurred in the other zones.

OR

- **Restrict inputs to areas that are already environmentally impaired to allow these areas to "recover."** The reasoning here is that these areas already are stressed highly from inputs of all kinds of pollutants and other environmental problems. If the washdown inputs are distributed over a larger area, they will cause less of an impact across the board. Limiting inputs to already impacted or impaired areas will allow these areas to recover. Restricting washdowns in these highly impacted areas will somewhat increase the inputs to other areas. If the inputs are widely distributed and not concentrated in specific locations, the impacts should be minor.

The decision to take one or the other of the above approaches should be made by evaluating a number of factors related to the value that various stakeholders place on promoting practices that allow highly impacted areas to recover and protecting less industrialized, natural areas. This type of evaluation should involve state and local officials as well as environmental organizations.

The analysis conducted in this study gave some weight to existing environmental impairments in determining environmental sensitivity. This, in essence, leans somewhat in the direction of the second approach by increasing the sensitivity rating of the impaired areas. The high, medium, and low sensitivity zones in Table 5.24 take environmental impairment into account as a factor that increases sensitivity.

The sensitivity zones are offered as a way to allow for environmentally sound decisions to be made with regard to choosing zones that would cause relatively less impact when it is necessary or desirable to conduct a washdown and other in-port waste reduction, or other excess cargo removal is not economical or practical. When possible, washdowns should be conducted in zones that have low or medium potential for impact rather than zones that have high potential for impact as shown in Table 5.24. When it is necessary to conduct washdowns within a particular Lake, the zones that are designated as "low" or "medium" should be selected if practicable. When it is possible to delay or schedule washdowns on an inter-Lake trip, the lower sensitivity zones between the Lakes should be selected. In all cases, washdowns should not be conducted closer than 6 miles to shore or within ports or harbors.

5.8 References

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6.0 OVERALL CONCLUSIONS AND RECOMMENDATIONS

Having performed the analysis outlined in Sections 2.0 through 5.0, the following general conclusions can be drawn regarding various aspects of the dry cargo discharge issue and the U.S. Coast Guard (USCG) current policy and future rulemaking to address this issue. Specific issues to be addressed include:

- Operational feasibility and effectiveness of the current policy
- Economic impact of the current policy on government and the shipping industry
- Environmental impact of the dry cargo residue discharges under the current policy
- Potential enhancements and alternatives to the current policy along with cost and benefit considerations
- Implications of formalizing the policy through regulations including requirements for implementation, monitoring, and enforcement
- Need for additional data and research that would be useful in formulating dry cargo regulations

6.1 Conclusions

6.1.1 Operational Feasibility and Effectiveness of the Current Policy

The current Ninth Coast Guard District (CGD9) Policy for controlling dry cargo residue discharges has proved robust and workable since its implementation in 1993. Consistent with the goals and intent of Annex V of MARPOL 73/78, Regulations for the Prevention of Pollution by Garbage from Ships (MARPOL V) and Act to Prevent Pollution from Ships (APPS), it has reduced the potential for further pollution in the ports and harbors surrounding the Great Lakes. It also has been successful in keeping incidental discharges of the more potentially harmful materials (e.g., coal and iron) further offshore and away from sensitive shoreline ecosystems, and has restricted discharges of any material in areas of high environmental sensitivity in the Great Lakes.

Both the regulatory and the scientific communities have accepted the CGD9 Policy. The controversy that has arisen regarding the policy is not focused on its goals or effectiveness, but rather under which U.S. laws and regulations the policy should be administered. Specifically, should dry cargo residue discharges be regulated by the USCG under the APPS or by the U.S. Environmental Protection Agency (EPA) under the National Pollution Discharge Elimination System (NPDES) provisions of the Clean Water Act (CWA)? Based on the information gathered in this study, it is likely that the discharge area restrictions and best management practice (BMP) approach adopted under either statute essentially would be equivalent.

The policy also has been accepted and is being adhered to by the bulk carrier shipping industry. Dry cargo discharges are being conducted within the designated areas, and both the U.S. and Canadian bulk carriers are making a diligent effort to record properly discharge data consistent with the voluntary procedure adopted by the Lake Carriers Association (LCA) and Canadian Shipowners Association (CSA) members.

6.1.2 Impact of the Current Policy on Government and the Shipping Industry

At present, the impacts of the CGD9 Policy on government and industry are not problematic. The USCG monitors compliance through routine checks of the dry cargo residue discharge log entries during routine marine safety inspections of vessels. Both the LCA and CSA are attentive to the policy and have been aggressive in fostering compliance by their member companies. There have been no specific violations of the policy warranting enforcement action.

There is no indication that adherence to the policy has compromised the safety or economic viability of bulk carrier operations. The bulk carriers have been able to schedule dry cargo residue operations around ship operations and weather to keep the vessels clean and safe while staying within the designated discharge areas. Where operational difficulties and safety issues have arisen because of the shortness of transit between adjacent ports, waivers have been requested and granted or denied consistent with marine safety and environmental protection considerations. In summary, the industry has adapted to the provisions of the CGD9 Policy with minimal economic impact.

6.1.3 Environmental Impact of the Dry Cargo Residue Discharges Under the Current Policy

The environmental implications of the current policy have been a major focus of this study as outlined in Section 5.0. It is important to recognize that there are two separate issues related to the environmental impact of the dry cargo residue discharges:

- The long-term cumulative impact of dry cargo residue discharges relative to the impact of other pollutants entering the Great Lakes ecosystem
- The short-term, specific impact of the CGD9 Policy on minimizing the environmental impacts of dry cargo discharges that do occur

The analysis and discussion in Section 5.0 focus primarily on the second issue. Much of the insight on the first issue comes from the Canadian Coast Guard (CCG) study (Melville Shipping, 1993), the NOAA/GLERL workshop (Reid and Meadows, 1999), and anecdotal information gathered during the course of this study. It is clear from speaking with USCG personnel in the Ninth District, non-governmental organization (NGOs, as represented by Great Lakes United), and industry (as represented by LCA) that dry cargo discharges do not command high visibility in the Great Lakes as a significant pollution issue. Invasive species, nutrient enrichment and dissolved oxygen depletion, oil and chemical spills, and toxic contaminants in sediments appear to be the major pollution issues of interest. Declining water levels and limiting species diversity are other environmental problems of immediate concern.

With regards to the volume of other material deposited in the Great Lakes, U.S. Army Corps of Engineers (USACE) dredging data indicate that roughly 5 to 6 million tons of sediment per year may be deposited in Great Lakes harbors, most of this due to land runoff. On a volume basis, dry cargo residue volumes are insignificant. It is notable that in the extensive literature search that accompanied the environmental assessment, there was no mention of dry cargo discharges except in the two reports specifically addressing the issue—the CCG study and the NOAA/GLERL workshop proceedings.

With respect to the environmental impact of the CGD9 Policy, the question is whether or not the current discharge area restrictions, when coupled with the industry routes and operating procedures, are producing the optimum result in mitigating potential environmental damage. Given any set of discharge zones and BMPs prescribed by regulation or policy, the bulk carrier industry will seek to comply while minimizing the impact on its own operations and economic viability. This will result in a discharge pattern such as that reported in Section 5.0 that causes more material to be deposited in some sections of the vessel tracklines than others.

The current analysis indicates that over 1,000 tons of dry cargo residue is discharged into the Great Lakes on an annual basis. The most highly impacted trackline segments are the southern part of Lake Michigan (MS-1) and the western-most part of Lake Erie (EO). These segments are receiving relatively higher amounts of impact and also show high environmental impairment from the large amount of commerce and industry in these regions. These areas, however, also are designated as areas of high biodiversity, and each has several endangered and/or threatened species in its waters or on nearby shorelines. In addition, Lake Erie is known to be anoxic due to eutrophication, making it particularly susceptible to damage from metal deposits (e.g., iron ore).

Iron ore, coal, coke, slag, and millscale present the greatest potential for environmental impacts. Coal and coke can leach polycyclic aromatic hydrocarbons (PAHs), substances known to be toxic to many organisms. Iron ore, taconite pellets, slag, and millscale can leach harmful compounds as well. Leaching rates are increased in anoxic (as in Lake Erie) and acidic conditions. All Lakes are subject to inputs by acid rain that results from sulfur dioxide and nitrogen oxide emissions in the atmosphere. The leachates from iron-containing commodities, and coal or coke can impact water quality and contaminate sediments.

Salt input is currently relatively low, though increases in the shipping of this commodity could cause localized problems. The increased salinity of the Lakes has caused considerable environmental impact that is exacerbated by lowering Lake levels. The input of salt by washdowns from bulk carriers is dwarfed by the input from urban runoff of road salt. For instance, annual salt input from roadways in the city of Cleveland alone amounts to 90,000 tons versus the 10 tons of salt residue accounted for in the dry cargo residue data for 2001.

Input of commodities that can contribute to nutrient enrichment and resultant eutrophication (e.g., grain, fertilizer, and potash) is relatively low in comparison with other commodities. Increased shipping of these commodities could cause localized problems.

6.1.4 Potential Enhancements and Alternatives to the Current Policy Along with Cost and Benefit Considerations

With regard to reducing or eliminating the volume of dry cargo residue discharges, the current technology and procedures used by the bulk carriers has reduced greatly the quantities of cargo spilled into the environment during the loading and discharging of ships. The quantities are so small that they are approaching the point that further reductions may be impractical. It will never be possible to eliminate windblown dust completely or the occasional loss because of overfilled clamshell grabs or conveyor belts. Further reductions in spilled quantities may be possible with ever-improving technology and procedures, but incremental reductions are likely to be small, having relatively little impact on the environment.

As for the possibility of complete discharge elimination, this would be prohibitive both technically and economically in the current fleet (as discussed in Section 4.0), and most likely would involve a new generation of "green ship" bulk carriers. Determining the timing, engineering feasibility, and economic impact of such an initiative would require a far more extensive analysis than can be undertaken in the context of this study. Effort expended on any such initiative should be weighed against the gains that could be realized by addressing other vessel and non-vessel pollutant inputs to the Great Lakes.

With regard to attempting to adjust the current distribution patterns of dry cargo residue in the Great Lakes by modifying the restricted zones in the CGD9 Policy, there are two schools of thought to be considered.

The first approach is to not adjust the restricted zone but to continue to discharge dry cargo residue into areas that *already* are impacted highly from an environmental standpoint. Specifically, the **risk** fisheries and habitat workgroup at the NOAA/GLERL workshop expressed concern about permitting cargo sweeping in new areas, and recommended that consideration be given to continuing cargo sweeping activities in the same areas used historically for that purpose, until there is a scientific basis for changing that practice. The philosophy behind this approach is that certain areas already are impacted highly because of industrialization and activities related to commerce, or perhaps because of urban and/or agricultural runoff. If inputs from dry cargo are added to these areas rather than to other more "pristine" areas, it will not cause undue damage in more highly valued areas.

The second approach is to restrict dry cargo residue discharges in areas that already are impaired environmentally to allow these areas to "recover." The reasoning here is that these areas already are highly stressed from inputs of all kinds of pollutants and other environmental problems. If the washdown inputs are distributed over a larger area they will cause less of an impact across the board. Limiting inputs to already impacted or impaired areas will allow these areas to recover. Restricting washdowns in these highly impacted areas will somewhat increase the inputs to other areas. If the inputs are widely distributed and not concentrated in specific locations, the impacts should be minor.

The decision to take one or the other of the above approaches should be made by evaluating a number of factors related to the value that various stakeholders place on promoting practices that allow highly impacted areas to recover and protecting less industrialized, natural areas. This type of evaluation should involve input from state and local officials as well as environmental organizations. It should address each of the highly impacted segments individually and consider where the material most likely would be discharged if that segment were restricted, remembering that the alternative segment may be the next adjacent segment along the trackline.

6.1.5 Implications of Formalizing the Policy Through Regulations

The "face value" contradiction between the CWA and APPS, and the CGD9 enforcement policy continues to exist. There is no obvious and straightforward legal or regulatory interpretation found in this study that completely resolves this issue. However, it is clear that the CGD9 Policy is consistent with the intent and goals of MARPOL V as adapted to the specific circumstances within the Great Lakes. It also is consistent with similar provisions under the CWA and NPDES, which rely on BMP as a means of minimizing pollutant discharge. Furthermore, the policy has been embraced and adhered to by the bulk carrier industry.

The policy is at least as environmentally strict as existing Canadian laws and regulations governing such discharges and was judged by the CCG study (Melville Shipping, 1993) as being a reasonable, albeit conservative, approach to managing dry cargo discharges. It also is consistent with the BMP approach taken in regulating dry cargo residue discharges from barges and oceangoing vessels on the major inland rivers.

Although arguments might be made for managing dry cargo residue discharges under the CWA/NPDES program, the CWA exclusionary clause and precedent would indicate that the APPS and implementing regulations should be the primary regime for managing, monitoring, and implementing enforcement provisions for these discharges. There are also several practical constraints in applying CWA/NPRES provisions to vessel discharges, specifically issues of multiple jurisdictions and permitting provisions with different states, which clearly have been recognized by the EPA in addressing the ballast water management issue. In any event, providing monitoring and enforcement of regulations under CWA/NPDES would be difficult without direct participation by the U.S. Coast Guard. There does not appear to be an obvious, overriding advantage to regulating dry cargo residue discharges under the CWA/NPDES program.

6.1.6 Need for Additional Data and Research that Would be Useful in Formulating Dry Cargo Regulations

The literature search and interviews conducted for this study indicate a general lack of research and data on the impacts of specific dry cargo commodities on ecosystems, Lake habitats, and animal and plant species. This limits the ability to develop a definitive methodology for determining the environmental impacts of current dry cargo inputs into the Great Lakes and pursuing a more comprehensive environmental impact analysis. The NOAA/GLERL workshop's water-column impacts workgroup recommended a number of additional research efforts—gathering statistical data on the materials shipped, making a detailed analysis of the chemical composition of these materials, and compiling data on the amounts of these materials discharged into the water column. The workgroup also recommended that modeling studies of the dispersal of materials having the physical characteristics of the various types of cargo residues introduced into the Great Lakes be conducted, with verification of field experiments.

The results of this study have provided additional information on the statistics of materials shipped and the amounts that are being discharged into the water column on an annual basis. However, this is a 1-year snapshot and may need to be repeated at some prescribed interval (e.g., every 5 years) to monitor commodity input and the effectiveness of regulations and industry initiatives in lowering this input. Continuation of the washdown data collection program currently being conducted on a voluntary basis by the industry will assist in this greatly.

The study also has compiled data on the chemical composition of bulk trade commodities from the literature. No laboratory analysis of the materials was attempted as part of this study. The more important question with respect to the environmental impact of these commodities is the compounds that they release and the rates at which this release occurs in various Great Lakes environments (e.g., water column, oxygenated benthic environments, anoxic benthic environments). Insight on this could be gained by conducting laboratory studies at a reasonable expense (e.g., in test tanks that simulate these environments).

With regard to dispersion modeling studies, it is not clear that these will be particularly valuable in the near term. Much of the material discharges is relatively insoluble and sinks to the bottom. The dispersal mechanism is not so much environmental factors (e.g., Great Lakes currents), but rather the movement and discharge patterns of the vessels themselves. A more immediate question is whether discharge of dry cargo residues, particularly in the more heavily impacted trackline segments, is producing a detectable and significant increase in the amount of material found on the bottom of these segments. This could be investigated initially through direct sampling across these segments and comparing the results to samples in an adjacent control area where deposition is likely to be minimal. Such an effort could be scaled to be reasonable in cost.

6.2 Recommendations

1) The current CGD9 Policy, which is an effective adaptation of the APPS for the bulk carrier trade in the Great Lakes, provides a valid framework for formal regulations under the APPS regulating dry cargo discharges in the Great Lakes. Accordingly it should serve as the basis for these regulations. The U.S. Coast Guard should pursue these regulations in collaboration with EPA and other agencies, ensuring that the BMPs and standards adopted be as consistent as possible with BMPs that might be prescribed under the CWA.
2) An important question that remains is whether the restriction zones in the current policy should be adjusted to distribute the dry cargo residue discharges more evenly among trackline segments, and relieve the stress on the more heavily impacted segments. Two approaches have been suggested. The first approach is to not adjust the restricted zone, but to continue to discharge dry cargo residue into areas that already are impacted highly from an environmental standpoint. The strategy here is to limit the extent of pollution. The second approach is to restrict dry cargo residue discharges in areas that already are impaired environmentally to allow these areas to "recover. A clear resolution of this issue will require additional study and input from the scientific community. One approach to resolving this would be to re-convene a scientific advisory panel to review the results of this study and provide input on how the restricted zones might be adjusted (if at all). There also should be representation from industry in this effort to provide input on how limiting discharges in one trackline segment may cause increased discharges in another. However, it is possible that, in the absence of more definitive research, the issue will continue to be open to debate. Unless there is a clear consensus on which approach is favored, the current restriction zones should be maintained.
3) A standardized format should be developed for estimating, recording, and collecting dry cargo discharge amounts aboard bulk carriers. This should entail keeping a separate logbook in a standard format that can be checked routinely and copied for further analysis (the three-ring binder versions maintained by a number of vessels greatly facilitated the data collection effort). Discharge amounts should be estimated in pounds, and discharge start and stop positions should be recorded in latitude and longitude. The nature of the discharge material (e.g., coal, stone, or combination) and source (deck or tunnel) clearly should be specified. Vessel operators should be trained on appropriate methods for gathering and recording data. This might include referencing volumes to a standard size container (e.g., 5-gallon bucket or 30-gallon trash can) and providing tables on the pounds of material that this volume would translate to for various materials (e.g., iron ore, coal, stone). This would allow some measure of "eyeball calibration" in estimating the amount of material that might be deposited on deck.

4) Every effort should be made to continue to minimize dry cargo discharges on deck and in tunnels. Discharges greater than 1,000 lbs should be avoided and reported aggressively. To the extent possible, material spilled on deck should be shoveled into cargo holds. Material spilled in tunnels should be shoveled back onto the belts as time and safety considerations permit. It is in the best interest of the industry to keep dry cargo discharges at a *de minimus* level consistent with the intent and language of the MARPOL V Guidelines so that they continue to be valid routine vessel operational discharges for regulatory purposes.

6.3 References

Melville Shipping, 1993. Review and Investigation of Procedures Governing the Discharge of Non-Regulated Cargo Residues From Ships into the Great Lakes. Prepared for the Canadian Coast Guard, Ship Safety by Melville Shipping, Ltd. in association with LGL Ltd., Ottawa, Ontario. Canadian Coast Guard Ship Safety Report SSC 014SS.T8080-2-6861/B.

Reid, D. F., and G. A. Meadows, 1999. Proceedings of the Workshop on the Environmental Implications of Cargo Sweepings in the Great Lakes. NOAA Technical Memorandum ERL GLERL-114. National Oceanic and Atmospheric Administration, Great Lakes Environmental Research Laboratory, Ann Arbor, Michigan.

ACRONYMS AND ABBREVIATIONS

ANOVA	analysis of variance
ANS	aquatic nuisance species
AOC	Area of Concern
APPS	Act to Prevent Pollution from Ships
BMP	best management practice
CCG	Canadian Coast Guard
CGD9	Ninth Coast Guard District
COTP	USCG Captain of the Port
CSA	Canadian Shipowners Association
CWA	Clean Water Act
DOJ	U.S. Department of Justice
EEZ	Exclusive Economic Zone
EPA	U.S. Environmental Protection Agency
FWPCA	Federal Water Pollution Control Act
GLERL	NOAA Great Lakes Environmental Research Laboratory
IMO	International Maritime Organization
LCA	Lake Carriers Association
MARPOL	International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978
MEPC	IMO Marine Environmental Protection Committee
MSO	USCG Marine Safety Office
NGO	non-governmental organization
NISA	National Invasive Species Act
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollution Discharge Elimination System
NPRM	Notice of Proposed Rulemaking
NRC	National Research Council
ODA	Ocean Dumping Act
USACE	U.S. Army Corps of Engineers
USCG	U.S. Coast Guard

GLOSSARY

Acute: Characterized by a time period that is relatively short in comparison with the lifespan of an organism.

Acute toxicity: Characteristic of a chemical to cause a toxic response in organisms immediately or shortly after exposure to the chemical.

Adverse effect: An impairment of biological functions *or* description of ecological processes that results in unfavorable changes in an ecosystem.

Aggregates: Crushed stone or gravel.

Alga(e): Stemless plants floating in marine or fresh water, including seaweed and **phytoplankton**.

Ambient water quality criterion (criteria): Estimate of how much of a chemical could be present in the water without harming human health or aquatic life.

Anoxia: Complete absence of oxygen (see **hypoxia**).

Apparent effects thresholds (ADTs): The highest concentration of a chemical at which statistically significant differences in observed adverse effects do not occur, provided that the concentration also is associated with observance of a statistically significant difference in adverse biological effects (U.S. Environmental Protection Agency, 1997. The Incidence and Severity of Sediment Contamination in Surface Waters of the United States. Volume 1: National Sediment Quality Survey. U.S. environmental Protection Agency Science and Technology. EPA 823-R-97-006. U.S. Environmental Protection Agency, Washington, DC).

Area of concern: A waterbody (e.g., river, harbor, bay) within the Great Lakes Basin that has been identified as having impairment of beneficial uses attributable to chemical contamination.

Bathymetry: Measurement of the depth of large bodies of water.

Benthic: Referring to the bottom of a lake or the sea.

Benthic abundance: The quantity or relative degree of plentifulness of organisms living in or on the bottom of streams, rivers, lakes, or oceans.

Benthos: The flora and fauna living at the bottom of a lake or the sea.

Bioaccumulation: Net uptake of a chemical into the tissues of an organism as the result of direct contact with a medium, such as water or soil, or through diet.

Bio-availability: The degree to which a chemical can be taken into the tissues of an exposed organism.

Biodegradation: **Decomposition** of a chemical substance by natural biological processes.

Biodiversity: The variety of organisms in an ecosystem.

Biological effects correlation approach: A method for relating the incidence of adverse biological effects to the dry-weight sediment concentration of a specific chemical at a particular site based on an evaluation of field and laboratory data.

Biological oxygen demand (BOD): Oxygen needed to break down organic matter. BOD is high in **eutrophic** lakes and waters polluted with sewage. BOD is low in **oligotrophic** lakes and clean mountain streams.

Biomagnification factor: A measure of the degree of increase in the tissue concentration of a chemical with each **trophic level** in a food chain.

Chronic: Characterized by a time period that represents a substantial portion of the lifespan of an organism.

Chronic intake level. Exposure to a chemical expressed as the mass of a substance contacted per unit body weight over a long-term exposure period (often expressed as mg/kg-day over a lifetime) (compare to **dose**).

Chronic toxicity: Characteristic of a chemical to produce a toxic response when an organism is exposed over a long period of time.

Community: Interacting populations of species of animals and plants living in the same habitat.

Contaminated sediment: **Sediment** that contains chemical substances at concentrations that pose a known or suspected threat to aquatic life, wildlife, or human health.

Decomposition: Decay or breakdown of organic matter by bacteria and fungi into simpler constituents, such as methane (CH_3) and carbon dioxide (CO_2).

Demersal species: Swimming organisms that prefer to spend the majority of time on or near the bottom of a body of water.

Divalent metals: Metals that are available for reaction in a valence state of two (*i.e.*, carrying a positive electric charge of two units).

Dose: The amount of chemical taken into an organism per unit time.

Ecological risk assessment: Evaluation of the likelihood of adverse effects on organisms, populations, and communities from chemicals present in the environment.

Ecosystem: An ecological community of plants and animals together with its physical environment, regarded as a unit.

Equilibrium concentration: The concentration at which a system is in balance due to equal action by opposing forces within the system. When the partitioning of a **non-ionic organic chemical** between organic carbon and pore water and partitioning of a **divalent metal** between solid and solution phases are assumed to be at equilibrium, an organism in the sediment is assumed to receive an equal exposure to the contaminant from water only or from an equilibrated phase. the pathway of exposure might include **pore water** (respiration), sediment carbon (ingestion), sediment organism (ingestion), or a combination of routes (U.S. Environmental Protection Agency, 1997. The Incidence and Severity of Sediment Contamination in Surface Waters of the United States. Volume 1: National Sediment Quality Survey. U.S. environmental Protection Agency Science and Technology. EPA 823-R-97-006. U.S. Environmental Protection Agency, Washington, DC).

Eutrophic: Overly-enriched with organic matter (see **eutrophication**).

Eutrophication: The process by which a body of water becomes enriched with organic material. This material is formed in the system by primary productivity (i.e., photosynthetic activity) and may be stimulated to harmful levels by anthropogenic introduction of high concentrations of nutrients (i.e., nutrient over-enrichment) such as nitrogen and phosphorus. Eutrophication can lead to excessive, and sometimes toxic, production of algal biomass, increase in decomposing bacteria. loss of important habitat, changes in biodiversity and distribution of species, and depletion of dissolved oxygen (**hypoxia** and **anoxia**) and associated mortality in populations (National Research Council, 2000. Clean Coastal Waters: Understanding and Reducing the Effects of Nutrient Pollution. National Research Council, Water Science and Technology Board, Ocean Studies Board, Committee on the Causes and Management of Eutrophication. National Academy Press, Washington, DC).

Habitat: The place where animals and plants normally live, often characterized by a dominant plant form or physical characteristic.

Hypoxia: Oxygen deficiency generally equal to 2.0 milligrams oxygen per liter. **Eutrophication** is accompanied by an increased demand for oxygen due to greater respiration of the increased biomass of plants and animals supported in a nutrient-loaded ecosystem. Hypoxia (or **anoxia**) can occur if the loss of oxygen caused by increased respiration is not offset by the direct introduction of additional oxygen through mixing or photosynthesis. Hypoxia (and **anoxia**) Hypoxia (and **anoxia**) are more likely to occur in summer months as warming of the water column leads to stratification preventing introduction and mixing of oxygen from surface waters with **benthic** layers (National Research Council, 2000. Clean Coastal Waters: Understanding and Reducing the Effects of Nutrient Pollution. National Research Council, Water Science and Technology Board, Ocean Studies Board, Committee on the Causes and Management of Eutrophication. National Academy Press, Washington, DC).

Interstitial water: Water in an opening or space, as between rock, soil, or sediment (also known as **pore water**).

LC_{100} concentration of a substance that results in 100% mortality in a **population** of test organisms.

LC_{50} concentration of a substance that results in 50% mortality in a **population** of test organisms.

LD_{100} dose of a substance that results in 100% mortality in a **population** of test organisms.

LD_{50} dose of a substance that results in 50% mortality in a **population** of test organisms.

Leachate: Components of a compound that slowly dissolve (leach out) in water.

LOAEL (lowest observed adverse effect level): The lowest concentration or dose of a chemical at which a significant adverse effects were observed in experimental trials (compare to **NOAEL**).

Microbial toxicity test: Type of toxicity test in which members of the microbial community (*i.e.*, bacteria) are used as the test organism. Microbial responses in toxicity tests have been recommended as early warning indicators of ecosystem stress (U.S. Environmental Protection Agency, 1997. The Incidence and Severity of Sediment Contamination in Surface Waters of the United States. Volume 1: National Sediment Quality Survey. U.S. environmental Protection Agency Science and Technology. EPA 823-R-97-006. U.S. Environmental Protection Agency, Washington, DC).

Microgram (µg): 10^{-6} grams (0.000001 grams) or 1 millionth of a gram.

NOAEL (no observed adverse effect level): The highest concentration or dose at which no significant adverse effects were observed in experimental trials (compare to **LOAEL**).

Non-ionic organic chemicals: Compounds that do not form ionic bonds and thus do not break into ions when dissolved in water. These compounds are more likely to remain in contact with and interact with sediment compounds or other compounds in water.

Non-point source pollution: Pollution from diffuse sources without a single point of origin or pollution not introduced into a receiving stream from a specific outlet. Such pollutants are generally carried off the land by storm water runoff. Sources include atmospheric deposition, agriculture, silviculture, urban runoff, mining, construction, and land disposal of waste.

Non-polar organic chemicals: Compounds that do not exhibit a strong dipole moment (i.e., there is little difference between the electrostatic forces holding the chemical together. The compounds tend to be less soluble in water. In aquatic systems, non-polar chemicals are more likely to be associated with sediments or other non-polar compounds than with surrounding water.

Oligotrophic: Relatively poor in plant nutrients.

PH: p(otential) of H(ydrogen); a measure of the acidity or alkalinity of a solution, equal to 7 for neutral solutions, increasing with alkalinity (base) and decreasing with increasing acidity. The pH scale ranges from 0 (most acidic) to 14 (most basic or alkaline).

Phytoplankton: Microscopic plants floating or drifting in marine or fresh water (microscopic **algae**).

Plankton: Microscopic organisms floating or drifting in marine or fresh water (see **phytoplankton** and **zooplankton**).

Point source pollution: Pollution contributed by any discernible, confined, and discrete conveyance, such as a vessel, facility, pipe, container, or channel.

Polycyclic aromatic hydrocarbons (PAHs): A group of over 100 different organic chemicals that are formed during the incomplete burning of coal, oil and gas, garbage, or other organic substances like tobacco or charbroiled meat. PAHs are usually found as a mixture containing two or more of these compounds, such as soot. PAHs are found in coal tar, crude oil, creosote, and roofing tar. Most

PAHs do not dissolve easily in water. They stick to solid particles and settle to the bottoms of lakes or rivers. Microorganisms can break down PAHs in soil or water after a period of weeks to months. PAHs are composed of multiple benzene rings. Many PAHs are suspected carcinogens.

Population: A group of individuals of the same species interacting within a given **habitat**.

Pore water: See **interstitial water**.

ppm: Parts per million (usually of water); representation of concentration in water (e.g., 1 ppm lead is one part of lead for every million parts of water).

Resuspension: Stirring up of sediments back into the water column by storms, vessel traffic, and other forces.

Riparian: The land and habitat along the bank of a river, stream, or lake, often including active flood plain areas.

Sediment: The organic and inorganic matter that settles at the bottom of a lake or ocean.

Sedimentation: The process through which organic and inorganic matter that settles to the bottom of a lake or ocean.

Sludge: Large amounts of organic matter settled on the bottom of a body of water, which in an anaerobic (oxygen-depleted) state can release methane and hydrogen sulfide that can be toxic to many aquatic organism (N. D. Christie and A. Moldan, 1977. Effects of fish factory effluent on the benthic macrofauna of Saldana Bay. Marine Pollution Bulletin 8:41–45).

Threshold: The chemical concentration (or **dose**) at which physical or biological effects begin to be produced.

Toxicity: The property of a chemical substance manifested by its ability to causes a harmful effect (e.g., disease, death, reduced growth, modified behavior) (see **chronic toxicity** and **acute toxicity**).

Transport and fate: A description of how a chemical is carried through the biological and physical parts of the environment.

Trophic level: Successive level of nourishment in a food chain (e.g., herbivore, carnivore); feeding level.

Zooplankton: Microscopic animals floating or drifting in marine or fresh water.

Lake Carriers' Association

RICHARD W. HARKINS
VICE PRESIDENT - OPERATIONS
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E-Mail: harkins@lcaships.com

April 12, 2002

Mr. Pete Tebeau
Potomac Management Group
214 Thames Street
Groton, CT 08340

Dear Mr. Tebeau:

QUESTIONS REGARDING CARGO RESIDUE SWEEPINGS

Environment protection and stewardship continues to be one of the priorities for all Lake Carriers' Association member companies. The Great Lakes are home, office, and workplace for them. Preservation and protection of precious Great Lakes water resources, whether used for navigation, drinking water, power generation, fish or wildlife, or recreation, is our shared concern. Cargo sweepings, a *de minimis* quantity of dust and dry cargo that is spilled or becomes air-borne during the cargo loading and discharging operations on Great Lakes vessels that cannot be retrieved, is hose washed over the side of the vessel in approved locations in the Great Lakes. The U.S. Coast Guard Ninth District 1993 Enforcement Policy for Cargo Residues on the Great Lakes (and subsequent editions) was developed after much consultation with industry and environmental experts. This policy, which indicates where washdowns may take place, is in effect today and is followed by every Lake vessel navigating the Great Lakes.

We have reviewed the questions you proposed to us on March 19, 2002, via e-mail. We have attached a response to those questions. If there is further information needed, please contact the undersigned.

Sincerely,

RW Harkins

Richard W. Harkins
Vice President - Operations

RWH:lca
Attachment
g:\harkins\wordoc\letter\020409-tebeau-letter.doc

cc w/att: Members – LCA Advisory Committee
Members – LCA Fleet Engineers Committee
Members – LCA Navigation Committee
Donald N. Morrison – Canadian Shipowners Association

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QUESTIONS AND SUGGESTIONS POSED BY POTOMAC MANAGEMENT GROUP REGARDING CARGO RESIDUE PRACTICES AND PROCEDURES

INCLUDING

LAKE CARRIERS' ASSOCIATION MEMBERS CARGO RESIDUE PRACTICE AND PROCEDURE IMPROVEMENTS FOR SAFETY AND EFFICIENCY SINCE THE 1993 ENFORCEMENT POLICY FOR CARGO RESIDUES

GENERAL STATEMENT

Environment protection and stewardship continues to be one of the priorities for all Lake Carriers' Association member companies. The Great Lakes are home, office, and workplace for them. Preservation and protection of precious Great Lakes water resources, whether used for navigation, drinking water, power generation, fish or wildlife, or recreation, is our shared concern. Cargo sweepings, a *de minimis* quantity of dust and dry cargo that is spilled or becomes airborne during the cargo loading and discharging operations on Great Lakes vessels that cannot be retrieved, is hose washed over the side of the vessel in approved locations in the Great Lakes. The U.S. Coast Guard Ninth District 1993 Enforcement Policy for Cargo Residues (and subsequent editions) was developed after much consultation with industry and environmental experts. That policy, which indicates where wash downs may take place, is in effect today and is followed by every Lake vessel navigating the Great Lakes.

LAKE CARRIERS' ASSOCIATION POSITION ON CARGO RESIDUE

Since 1993, the members of Lake Carriers' Association have assiduously worked to reduce the deck and tunnel spillage during cargo-handling operations. Our members adhere to practices outlined in the Enforcement Policy for Cargo Residues. The *de minimis* amount of non-hazardous, non-toxic, dry-bulk minerals and agricultural products that remain on the deck and the tunnel poses no environmental harm when washed over the side of the vessel into the waters of the Great Lakes in the designated washdown areas. There is no need for any requirement to retrofit vessels to further minimize or completely eliminate the *de minimis* amount of material placed into the open Lakes. The ship operators have investigated all manners of technical innovation and, as indicated in response to these questions, have found them not feasible. We look forward to the completion of this study and a report filed with Congress so as the U.S. Coast Guard can proceed to publish regulations that will formalize the current Enforcement Policy.

QUESTION 1 – FROM POTOMAC MANAGEMENT:

COULD COMPLETE SWEEP DOWN OF THE DECKS AND DISPOSAL OF THE MATERIAL ASHORE BE DONE? HOW MANY EXTRA MAN HOURS (MAYBE 8 PER TRIP), HOW MANY HOURS DELAY IN SAILING TIME (HALF-HOUR PER TRIP), AND WHAT IS THE COST OF DUMPSTER FOR DISPOSAL ASHORE?

LCA approached the Duluth Seaway Port Authority (with 613 U.S.-Flag, 246 Canadian-Flag, and 168 overseas commercial vessel arrivals in 2001) with this question and their response is included as Attachment A. Their response indicated if shore gangs were even possible in all the locations and in the numbers needed to support the bulk cargo trade, a minimum of four hours of manpower would cost about $5,600. However, added to that would be the cost of a dumpster and crane, as well as shifting the vessel to another dock to complete the clean-up operations, and that would drive the cost to $7,580 for a Lake vessel and $10,780 for an ocean ship. For a typical 50-trip season, this equates to approximately $380,000 per vessel, or $3.8 million for a 10-vessel fleet. This assumes that nighttime, freezing weather, snow on the deck, and other weather factors permit the cleanup to be promptly done. And these estimates do not include the cost to the vessel owner for the delays, lost cargo, and extra crew time. An estimated delay cost to the vessel owner would be up to $8,000 for four hours, for an additional $400,000 per year per vessel or $4 million for a 10-vessel fleet. These estimates only consider the removal of sweepings from the main deck to the dock. It is significantly more complex and labor intensive to remove sweepings from the tunnel that is accessible only by a series of ladders leading from these confined spaces.

QUESTIONS AND SUGGESTIONS POSED BY POTOMAC MANAGEMENT GROUP
REGARDING CARGO RESIDUE PRACTICES AND PROCEDURES

INCLUDING

LAKE CARRIERS' ASSOCIATION MEMBERS CARGO RESIDUE PRACTICE AND PROCEDURE IMPROVEMENTS
FOR SAFETY AND EFFICIENCY SINCE THE 1993 ENFORCEMENT POLICY FOR CARGO RESIDUES

DISCUSSION FROM LCA

Using shoreside "gangs" at every loading dock is not practical. There are 24 iron ore, stone, and coal loading ports west of the Welland Canal and nearly 70 discharging ports on the U.S. side of the Great Lakes. Many of these ports, such as Duluth-Superior, Detroit and vicinity, Toledo, Cleveland, and others have facilities spread throughout the port area and, therefore, load or discharge many vessels simultaneously. There are at least 250 terminals at U.S. Great Lakes ports. Shoreside crews would be required to be available 24 hours per day, 7 days per week from early-April until late-December (longer at the iron ore ports) and in multiple sets with at least one crew for each ship being worked. Hiring and training large numbers of workers, often unfamiliar with shipboard operations for clean-up operations to be available in all kinds of weather on short notice at the scores of separate locations, would impose an extraordinary expense on every ship operator and would likely lead to delays. Those workers would not be seamen and, for personal injury and death claims purposes, would fall into the jurisdiction of the Longshore and Harbor Workers Act — a regime that is complex and much more expensive than the individual State Workers' Compensation regimes.

CAUSES AND MEASURES TO REDUCE DECK SPILLAGE

Almost all modern dry-bulk loading facilities on the Great Lakes use conveyor belt loading systems in order to load vessels quickly. Many of these installations have troughed conveyor belts, dust covers over the belts, dust collection and control systems, side boards and skirt boards to keep the cargo trained on the center of the belt, and telescoping chutes that guide the cargo into the hold of a ship. Some gravity-loading chute systems are still used. In either case, it is critically important for the dockowner and the ship's crew to minimize any spillage onto the deck that will require any cleanup. The officer on the ship who is in-charge of the loading operations is always on deck and always in continuous communication with the shoreside loading operator to assure the proper amount of cargo is loaded and is loaded in a sequence that minimizes hull stress and trim of the vessel. If there is any difficulty whatsoever, including spillage on deck, the vessel's loading officer will stop the loading process.

There are other ways that cargo can spill onto the deck of a vessel. The vessel may move without warning due to heavy wind gusts or a passing vessel. Small pieces of cargo may be jolted loose when the loading rig moves to another location on the ship. When cargo is wet or when loading in the rain, some moisture sticks to the loading rig belt and there may be drips of water that fall off the belt onto the deck where the belt returns. At times, when frozen cargo is loaded, some particles may get thrown off or bounce off the belts onto the deck of the ship.

In some loading ports, some fugitive dust gets airborne and deposited on the deck of the vessel. This poses a sanitation problem of tracking dirt into the vessel's crew's quarters and a concern for equipment maintenance, so rinsing down this dust deposit is often required. If a vessel departs during periods of darkness, the rinse down is delayed until daylight hours when the crew can work safely on deck — if weather, wind and sea conditions, and conditions of freezing permit the activity. In cases of severe weather or freezing weather, no water washing may be attempted at all. In many cases, only the area surrounding the crew's cabins is rinsed down when there is not sufficient reason to rinse down the entire weather deck of the ship. The weather deck of the ship, which can measure some 95,000 square feet (over two acres) on a 1,000-foot–long vessel, has many obstructions, such as hatch openings, safety railings, lighting fixtures, deck cranes, mooring winches, tank vents, hatch rails for the crane to remove hatches, and many other structural items. The deck is not a smooth flat surface and is covered with a "non-skid" paint that contains sand-like particles in order to provide safe and sure footing for crew members on painted steel surfaces. This abrasive deck covering and the complexity of the deck obstructions make water the only feasible means of cleanup of this fugitive dust and minor spillage.

QUESTIONS AND SUGGESTIONS POSED BY POTOMAC MANAGEMENT GROUP
REGARDING CARGO RESIDUE PRACTICES AND PROCEDURES

INCLUDING

LAKE CARRIERS' ASSOCIATION MEMBERS CARGO RESIDUE PRACTICE AND PROCEDURE IMPROVEMENTS
FOR SAFETY AND EFFICIENCY SINCE THE 1993 ENFORCEMENT POLICY FOR CARGO RESIDUES

VACUUMING DECKS

Any attempt to vacuum the entire exposed area of the deck with vessel crew is infeasible. As indicated above, the surface area on a 1,000-foot vessel is over two acres (95,000 square feet) and filled with nooks created by the steel structure of hatch reinforcements, doubler plates, rails for the hatch cover lifting device, and gunnel plates. This time- and labor-intensive task covering the large surface area of the main deck could not be completed in the time that it takes to load the ship. Furthermore, cleaning operations at nighttime or in high winds or freezing weather or snow and ice-covered decks would make the vacuum task impossible to perform. For these reasons, there has been no serious attempt to develop any such vacuum system for use on the deck of a large vessel.

On occasion, there may be a quantity of cargo that is spilled locally onto the deck in sufficient quantity to have the crew called out prior to departure to shovel any spillage back into the cargo hold prior to putting the hatch covers back on. When the crew does undertake cleanup of the deck, after the vessel is loaded, the hatch covers put back on, and the deck made safe for sea and the vessel is underway, only those portions of the deck where there is spillage are rinsed. The hatch covers cannot be removed after the vessel departs port until the vessel is safely in the next port. All of these factors point to the very intense pressure on ship operators and crews to have the most efficient and spill-free loading operation take place every time.

It is in the best interest of the vessel to minimize any fugitive dust or spillage. Any spillage will require the limited crew time to be expended and will take away from their other required shipboard duties and maintenance tasks.

QUESTION 2 – FROM POTOMAC MANAGEMENT:

INSTALLING COMBINGS ON DECK AND A SUMP FOR CAPTURING LARGER PIECES OF CARGO POSSIBLY UTILIZING A BALLAST TANK (MAYBE A WEEK OR TWO IN SHIPYARD – LOST TIME AND SEVERAL HUNDRED THOUSAND DOLLARS)?

AND *(BECAUSE IT IS CLOSELY RELATED)*

QUESTION 3 – FROM POTOMAC MANAGEMENT:

INSTALLATION OF DECK SUMP AND SUMP IN THE TUNNEL WITH PUMPS TO HOLDING TANK ONBOARD (ESSENTIALLY THE "NO DISCHARGE" OPTION). PERHAPS REQUIRING A MAJOR SHIP OVERHAUL, SEVERAL MONTHS OF LOST TIME, SEVERAL MILLIONS OF DOLLARS IN CONSTRUCTION COST?

Containment of all deck sweepings and water has been looked at and is not possible on most Great Lakes vessels because they have sheer deck edges and no gunnel bars fitted on the outboard edges running the length of the vessel to keep the water from running over the side. Technically, fitting gunnel bars on these vessels to collect water and deck sweepings could be done at an estimated cost of $300,000 to $400,000 per vessel, based on an 8-inch wide by ¾-inch thick plate welded to the entire length of the vessel on both sides. However, Great Lakes Load Line Regulations would not permit this because containing that water would add to the deck height and reduce the vessel's stability. Additionally, free surface effects and freezing and holding that water would also negatively impact stability and strength and would not be permitted by the U.S. Coast Guard and Classification Society.

The additional difficulty is that trying to contain all the water and sweepings from the deck would require installation of several collection sumps on the weather deck with associated pumps, electrical installations, piping systems, and controls along both sides of the vessel for the entire length of the deck, as well as holding tanks to collect the water. The sumps and holding tanks would be required on each side of the ship because the deck is cambered and highest in the middle and water would gravitate to the outside edges of the ship.

These deck sump penetrations, at least four on each side of the vessel, would have to be made in the highest stressed members of the hull girder (weather deck plating is specialty steel and up to 1¾" thick), and these penetrations would cause stress risers and would not be permitted by the Classification Society. The potential cost of at least $500,000 per vessel would be needed if these modifications were even technically possible.

If the water and sweepings could be contained on the deck, the slurry would have to be piped or funneled into some sort of holding tanks so that it could be collected and made ready to pump ashore. These tanks could possibly be built into an existing ballast tank, but would be subject to a safety evaluation for free surface and stability impacts, as well as the impact on the reduction in cargo carrying capacity for the vessel. It is highly unlikely that the U.S. Coast Guard and the Classification Society would approve the placement of tanks that would be subject to changes in stability and trim caused by the free surface movement of liquids.

CAUSES AND MEASURES TO REDUCE TUNNEL SPILLAGE

All but one of the 56 vessels enrolled in LCA are self-unloaders and, thus, do not require shoreside infrastructure for unloading the cargo to the consignee's terminal. Current practice is for the customer to have a stockpile area adjacent to where the vessel berths. The vessel ties up and swings its unloading boom (250-foot average length) over the dock and unloads the cargo onto a pile.

Cargo spillage during unloading can occur when small pieces of cargo strike the rubber conveyor belt in such a way as to fall off the belt and into the unloading tunnel. Another way for cargo to spill into the unloading tunnel is when it sticks or hangs up in the hold and then breaks free and flows rapidly onto the belt. Yet another way is when the cargo is wet and water actually drips into the unloading tunnel and gets carried past belt cleaning (scraper) systems and falls onto the tunnel deck. Mechanical failure and operational errors (belt overloading) can also occur. However, all vessels have continuous communication with the unloading operators. Radio systems are used. Furthermore, there are indicator light systems that tell the unloading gate operator how much cargo is loaded on the belt. These adjustable loading indicators are set by the deck officer and have a margin of safety that assures conveyor belt overloading does not take pace. In many instances, vessels have reduced the unloading rate to minimize the potential of any spillage in the unloading tunnel.

During cargo loading operations, the cargo itself may contain significant water. Washed limestone, rain or snow covered cargo, and even dust control water will cause water slurry to drain from the cargo hold into the unloading tunnel while the vessel is in transit to the unloading port. Often, the quantity of water in the tunnel must be pumped out in approved locations during the transit in order to prevent damage to tunnel belt rollers and to prevent tunnel belts from slipping when they are started.

Many improvements have been made to the unloading system and equipment to reduce airborne dust and cargo spillage. Fine-mist water sprays have been installed to prevent dust from becoming airborne where it may be generated at unloading gates and cargo transfer areas. Also, at points where cargo is placed onto the belt, guiding skirts and lips have been installed to train the cargo onto the center of the belt. Where cargo transfer takes place, skirt boards and side scrapers are installed to keep all cargo on the belt. To reduce cargo from sticking to the conveyor belt and carrying back to drop off onto the tunnel deck, finely-tuned scraping systems have been installed to effectively clean the belt surface. To prevent sticking of the cargo in the holds, some ships have lined their cargo holds with Teflon sheets that prevent the material from sticking. Other ships have vibrators installed in the cargo hold area to cause the cargo to flow smoothly to the unloading gates.

Cleanup procedures for unloading tunnels have taken a drastic change in recent years. Cleaning up spillage is a labor-intensive and time-consuming job because of the complex structure where the unloading belts are located. The massive weight of the cargo in the cargo hold is supported by complex structure in the unloading tunnel. This complex structure makes access to all areas in the tunnel difficult or impossible to access. The conveyor belt itself is continuous for the entire length of the vessel (some vessels have three tunnel conveyors) and is supported on rollers spaced 18 inches apart, raised just inches above the unloading tunnel deck. Water hoses are the only means to flush out any debris or slurry from under the belt(s).

Another practice that has been incorporated since the 1993 Enforcement Policy is to only hose down parts of the unloading tunnel as needed and defer a complete cleanup for several trips, or weeks, or longer until needed. Crew safety is critical and hosing operations will take place on the half of the tunnel where the operator is stationed during unloading and only if there is spillage. With limited crew and available crew maintenance hours, every effort is made to prevent spillage since cleanup takes away from necessary shipboard work. The fact that vessels no longer need to do a complete cleanup attests to the fact that cargo spillage is kept to a bare minimum.

The possibility of containing and collecting all cargo sweepings and water in the unloading tunnel is less difficult than the containing and collecting it on deck primarily because the tunnel itself provides natural containment by the nature of the structural requirement for watertight integrity and watertight compartmentation. Sumps are currently installed on self-unloading vessels and pumps capable of pumping the water and sweepings to outside the hull are currently installed. However, those pumps do not have the power, pressure, or capability of pumping the water and sweepings to a deck-mounted shore connection or to a tank installed ashore. As in the case of the deck problem, the slurry must be pumped into some sort of holding tanks within the vessel prior to being pumped ashore. This would require tanks within the ballast tank, as previously noted, and would require additional higher capacity pumps and piping systems to take the water ashore. A tank within the tank has the same difficulty on stability (free surface effect) and potential reduction of cargo carried.

SHORESIDE DISPOSAL CONSIDERATIONS

Currently, there are no methods or means aboard any ship to offload large volumes of water ashore. If this water and sweepings were to be pumped ashore, it would have to be done while the vessel was either loading or unloading cargo — when crew members are already involved in the operation going on. Both loading and unloading operations often require the vessel to be shifted along the dock during the process. Any shore connection would have to be flexible in order to allow the vessel to move at the dock. In addition, the vessel can approach the dock from either the port or starboard side, so pumping off capability would be required on both sides of the vessel. Additional crew involvement would be mandated to hook up, monitor, and control any water offloading process.

Shoreside infrastructure and receiving facilities are not available in any port within the Great Lakes to handle any volumes of colored water and cargo sweepings. Getting the contained water and sweepings ashore will pose many challenges and problems to the vast number of different loading and unloading facilities vessels visit and in all kinds of weather conditions, including freezing. In a few cases, it may be possible to locate shoreside piping and holding tanks fairly close to the dock with fixed piping systems that are large enough in size and capable of withstanding abrasive materials. In some cases, the dock is built away from land and offshore in deep water to allow the loading or discharge operation to take place in water deep enough for the vessel. In other cases, especially at unloading locations, the vessel may not be near the dock and may be 20 to 50 feet or more away from any shoreside structure or land and there may not be a dock facility at all. Getting heavy and long flexible hosing to extend from the ship to the dock, land area, or fixed shoreside piping locations will require cranes and lifting devices both on the ship and ashore. All flexible and portable piping will have to be certified by either U.S. Coast Guard or State regulatory officials. Also, the flexible hoses will have to be large enough in diameter to not plug with occasional rocks, pellets, and muddy slurry (at least 6 inches in diameter), will have to be resistant to abrasion from these elements, and able to withstand the pressure required to pump the slurry to a shoreside tank. Long flexible hose that meet these requirements and can withstand subzero temperatures are not known to exist. Because the handling and operations of this slurry will have to be conducted in subzero temperatures at times, necessary heaters and devices to keep men, machinery, and piping warm and safe will be required.

The number and size of shoreside holding tanks will vary depending on the frequency of vessel visits. Some docks have a continuous lineup of vessels and the loading or unloading operation proceeds around the clock; while at other locations, there may be only one vessel call in a week or two. Shoreside tankage must be sized and built accordingly and also will be required to be insulated and heated for subzero climates. Any shoreside installation will have to undergo State and Local regulatory and permit review. Once provided to a shore facility, if they existed, the water and sweepings would have to be disposed of in an environmentally-sound manner.

For all the above reasons, shoreside disposal of slurry and water from operating vessels is not feasible.

FACTORS WHEN CHANGING CARGOS

The most efficient way to operate a vessel is to load the same cargo at the same dock and discharge that cargo at the same dock and repeat that process throughout the entire season. Vessel crews can develop patterns and efficiencies and tune the operation to make it very efficient with repeated operations. Operators attempt to keep a vessel in the same trade pattern with the same cargo as much a possible. Unfortunately, in the bulk cargo trade on the Great Lakes this scenario is not always possible. A vessel schedule may call for a repeat trip only to find before arrival that there has been a shoreside mechanical breakdown of the loading equipment or that there are other vessels waiting to load at the same dock (that would cause a considerable delay). Thus, a vessel may be redirected or unexpectedly diverted to another loading facility with the possibly of a different type of cargo to be delivered to a different unloading port. Changing cargos often requires the residual previous cargo to be removed from the cargo hold to prevent contamination of the next cargo.

When a vessel returns to the same loading dock to load the same type of iron ore, coal, or stone, cleaning any residual cargo out of the hold is unnecessary. However, if a different kind of cargo is to be loaded, then cargo contamination can be an issue. Power plants do not want limestone or iron ore in their steam coal. When a change in cargo type is known prior to discharging the existing cargo (which is almost always the case), the practice at the unloading dock is to have the crew turn out at the end of the unloading process to hose out the cargo holds with high pressure water hoses and rinse that cargo and water onto the conveyor belt. That water and cargo is placed on the tunnel conveyor belt and discharged ashore with all the remainder of the cargo. The sequence for discharging the cargo allows the crew to progressively clean holds as they become empty. Thus, when the cargo discharge is complete, the entire cargo hold has been rinsed clean and the vessel is ready for a different type of cargo.

For vessels that are prone to change cargos frequently or on short notice, some companies have a policy to rinse the cargo hold at each unload — just in case. In many cases, if the next cargo is uncertain or unknown, the cargo hold will be rinsed out at the unloading dock to prevent having to take a delay to rinse out the cargo hold prior to loading the next cargo.

Attachment
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SENT VIA FAX

March 28, 2002

TO: George Ryan, President
Lake Carriers' Association
Cleveland

RE: Cargo Residue Removal

MEMO

In response to your inquiry about the cost of removing cargo residue from a ship's deck, the following is based on estimates by Lake Superior Warehousing Co., Inc., the Port Authority's terminal operator and stevedoring contractor, and the writer's 40-plus years in the maritime industry:

Depending on the type and amount of cargo cleaned and removed from deck, a minimum gang of 12 longshoremen (contractually, an "extra labor gang") would be required for a guaranteed minimum of four hours. The cost of the gang, including fringe benefits, stevedoring supervision and administrative expense, would be about $1,400 per hour. Thus the four-hour minimum labor cost would be about $5,600.

One must assume that the residue would need to be placed in a metal container, such as a "Dumpster," for which the rental cost---including transportation to a disposal site---would be about $600.

Because most ships do not have deck cranes, a shore crane of about 40 tons capacity would be required to lift aboard and later remove the Dumpster. Using a portal-to-portal rate of about $180 for a crane and operator times a minimum of six hours (one hour travel to the dock, waiting time, one hour travel return to base), the cost would be about $1,080.

In the event that the ship would be required to depart the loading berth to allow another ship to load (a common requirement in this port), the ship would need to shift to another berth. A domestic or Canadian lake vessel would presumably shift without tug assistance to a berth costing about $300 per day. (The hourly cost of the laker itself would need to be calculated by others.)

An ocean ship required to shift berths routinely employs two tugs, a pilot and linehandlers to shift from one berth to another. In this case, the average cost of such a shift is about $3,200. (The hourly cost of the ocean ship would need to be calculated by others.)

To summarize, the estimated cost for removing cargo residue from a lake vessel would be at least $7,580 and for an ocean ship would be at least $10,780.

Please recognize that in reality, the costs would almost inevitably be much higher because there would be a wide variance in time and cost depending on the type of cargo (iron pellets, coal, grain, other bulk products), volume of residue, type of ship, dock location, time of day the services are performed (straight time, time and one-half or double time) and other factors---plus the ship's operating expense.

As you know, perhaps the oldest maxim in the maritime industry is that the only time a ship can pay for itself is when its under way. Thus, any time taken from an outbound voyage would need to be factored into a cost analysis.

Davis Helberg, Executive Director

DH/amm