Appendix A
Interim Rule for Dry Cargo Residue Discharges in the Great Lakes, September 29, 2008

applicable here because, pursuant to 5 U.S.C. 804(3)(C), this final rule ''does not substantially affect the rights or obligations of non-agency parties.''

List of Subjects

29 CFR Part 2200

Administrative practice and procedure.

29 CFR Part 2203

Sunshine Act.

Signed at Washington, DC, on the 23rd day of September, 2008.

Horace A. Thompson III,

Chairman.

Thomasina V. Rogers,

Commissioner.

■ Accordingly, 29 CFR parts 2200 and 2203 are corrected by making the following amendments:

PART 2200—RULES OF PROCEDURE

■ 1. The authority citation for part 2200 continues to read as follows:

Authority: 29 U.S.C. 661(g), unless otherwise noted. Section 2200.96 is also issued under 28 U.S.C. 2112(a).

■ 2. In § 2200.57, paragraph (a), in the third sentence, remove the ZIP code suffix ''3419'' and add, in its place, ''3457''.

■ 3. In § 2200.63, paragraph (b), correct ''zequesten¢'' to read ''requested''.

■ 4. In § 2200.91, paragraph (c), in the fourth sentence, remove the number ''20'' and add, in its place, ''10''.

■ 5. In § 2200.96, in the first sentence, remove the ZIP code suffix ''3419'' and add, in its place, ''3457''.

■ 6. In § 2200.209, paragraph (g), in the last sentence, remove the phrase ''21 day'' and add, in its place, ''11-day''.

PART 2203—REGULATIONS IMPLEMENTING THE GOVERNMENT IN THE SUNSHINE ACT

■ 7. The authority citation for part 2203 continues to read as follows:

Authority: 29 U.S.C. 661(g); 5 U.S.C. 552b(d)(4); 5 U.S.C. 552b(g).

■ 8. In § 2203.2, in the definition of ''Regularly-scheduled meetings,'' remove the time ''10:00 a.m.'' and add, in its place, ''10:30 a.m.''

■ 9. In § 2203.4, paragraph (c), in the first sentence, remove the time ''10:00 a.m.'' and add, in its place, ''10:30 a.m.''

■ 10. In § 2203.4, paragraph (c), in the first sentence, remove the ZIP code suffix ''3419'' and add, in its place, ''3457''.

■ 11. In § 2203.7, paragraph (b), in the third sentence, remove the ZIP code suffix ''3419'' and add, in its place, ''3457''.

[FR Doc. E8–22783 Filed 9–26–08; 8:45 am]

BILLING CODE 7600–01–P

DEPARTMENT OF HOMELAND SECURITY

Coast Guard

33 CFR Part 151

[Docket No. USCG–2004–19621]

RIN 1625–AA89

Dry Cargo Residue Discharges in the Great Lakes

AGENCY: Coast Guard, DHS

ACTION: Interim rule; request for comments.

SUMMARY: The Coast Guard is amending its regulations to allow the discharge of bulk dry cargo residue (DCR) in limited areas of the Great Lakes by self-propelled vessels and by any barge that is part of an integrated tug and barge unit. DCR is the residue of non-toxic and non-hazardous bulk dry cargo like limestone, iron ore, and coal. These regulations also add new recordkeeping and reporting requirements and encourage carriers to adopt voluntary control measures for reducing discharges. Discharges are now prohibited in certain protected and sensitive areas where, previously, they were allowed. The Coast Guard also requests public comments on the need for and feasibility of additional conditions that might be imposed on discharges in the future, such as mandatory use of control measures, or further adjustments to the areas where discharges are allowed or prohibited.

DATES: This interim rule takes effect September 29, 2008. Initial reports under amended 33 CFR 151.66(c)(4) are due January 15, 2009. Comments and related material submitted in response to the request for comments must reach the Docket Management Facility on or before January 15, 2009.

ADDRESSES: Comments and material received from the public, as well as documents mentioned in this preamble as being available in the docket, are part of docket USCG–2004–19621 and are available for inspection or copying at the Docket Management Facility (M–30), U.S. Department of Transportation, West Building Ground Floor, Room W12–140, 1200 New Jersey Avenue, SE., Washington, DC 20590, between 9 a.m. and 5 p.m., Monday through Friday, except Federal holidays. You may also find this docket on the Internet at *http://www.regulations.gov*.

We encourage you to submit comments identified by Coast Guard docket number USCG–2004–19621 to the Docket Management Facility at the U.S. Department of Transportation. To avoid duplication, please use only one of the following methods:

(1) *Online: http://www.regulations.gov.*

(2) *Mail:* Docket Management Facility (M–30), U.S. Department of Transportation, West Building Ground Floor, Room W12–140, 1200 New Jersey Avenue, SE., Washington, DC 20590–0001.

(3) *Hand delivery:* Same as mail address above, between 9 a.m. and 5 p.m., Monday through Friday, except Federal holidays. The telephone number is 202–366–9329.

(4) *Fax:* 202–493–2251.

Anyone can search the electronic form of all comments received into any of our dockets by the name of the individual submitting the comment (or signing the comment, if submitted on behalf of an association, business, labor union, etc.). You may review a Privacy Act system of records notice regarding our public dockets in the January 17, 2008 issue of the **Federal Register** (73 FR 3316).

FOR FURTHER INFORMATION CONTACT: If you have questions on this interim rule, call LT Heather St. Pierre, U.S. Coast Guard, telephone 202–372–1432 or e-mail *Heather.J.St.Pierre@uscg.mil.* If you have questions on viewing or submitting material to the docket, call Ms. Renee V. Wright, Program Manager, Docket Operations, telephone 202–366–9826.

SUPPLEMENTARY INFORMATION:

Table of Contents

I. Acronyms

APA Administrative Procedure Act
DCR Dry Cargo Residue

DEIS Draft Environmental Impact Statement
FEIS Final Environmental Impact Statement
IEP Interim Enforcement Policy
NPRM Notice of Proposed Rulemaking
ROD Record of Decision

II. Regulatory History and Good Cause for Immediate Effectiveness

In the **Federal Register** on May 23, 2008, we published a notice of proposed rulemaking (NPRM) and a notice of availability for the accompanying Draft Environmental Impact Statement (DEIS) (73 FR 30014). We received written comments on the proposed rule from 55 sources, and heard from 3 commenters at public meetings. The public meetings were announced in the **Federal Register** on June 6, 2008 (73 FR 32273) and held in Duluth, MN, and Cleveland, OH, on July 15 and 17, 2008, respectively. Availability of the Final Environmental Impact Statement (FEIS) was announced on August 22, 2008, by the Environmental Protection Agency (73 FR 49667) and by the Coast Guard (73 FR 49694), and the Record of Decision (ROD) adopting the findings of the FEIS was signed on [DATE].

This interim rule takes effect immediately upon its publication in the **Federal Register**. Under the Administrative Procedure Act (APA), 5 U.S.C. 553(d), a substantive rule such as this must be published not less than 30 days before its effective date, unless the agency finds good cause for an earlier effective date and publishes that finding with the rule. As we subsequently discuss in more detail, this rule generally allows the continuation of existing practices in the Great Lakes. Those practices have been sanctioned by Congress and, although they have minor indirect adverse impacts on the Great Lakes environment, their discontinuation could impose a substantial economic burden on Great Lakes maritime commerce. Congressional sanction for the existing practices expires on September 30, 2008, and it was Congress's intent that the Coast Guard review existing practices and issue new regulations governing those practices by that date. If the APA's 30-day provision were given effect, then there would be a period of up to a month during which existing practices would be prohibited, and the resulting burden on Great Lakes maritime commerce would be significant in relation to the duration of the prohibition and the potential environmental benefits of such a short prohibition. The Coast Guard has concluded the APA's 30-day provision is unnecessary and contrary to the public interest due to the disruption entailed by so short a period of prohibition. Therefore, the Coast Guard finds good cause for this interim rule to take effect upon publication in the **Federal Register**.

III. Background, Purpose, and Discussion of Rule

This interim rule adopts the regulatory text proposed in our May 2008 NPRM, with only minor changes. For a fuller discussion of the background and purpose of this rulemaking, please consult the NPRM.

A substantial portion of Great Lakes shipping involves ''bulk dry cargos:'' principally limestone, iron ore, and coal, but also lesser quantities of other substances like cement and salt. During ship loading or unloading operations, small portions of these cargos often fall on ship decks or within ship unloading tunnels. This fallen dry cargo residue (DCR) can contaminate other cargos or cause crew members to slip or otherwise injure themselves on a ship's deck. Traditionally, Great Lakes carriers have managed DCR by periodically washing both the deck and cargo unloading tunnels with water in a practice commonly known as ''cargo sweeping.'' In order to reduce costs and minimize in-port time, ships typically conduct this cargo sweeping underway while transiting between ports.

Prior to the adoption of this interim rule, Coast Guard regulations that implement the Act to Prevent Pollution from Ships (APPS), 33 U.S.C. 1901 *et seq.*, have treated DCR as an operational waste, which constitutes garbage. The discharge of any garbage, anywhere on the navigable waters of the United States, was prohibited. Strict enforcement of this regulatory scheme on the Great Lakes would have put an end to the practice of cargo sweeping. However, in recognition of the special characteristics of Great Lakes dry cargo shipping, an ''interim enforcement policy'' (IEP) allowed ''incidental discharges'' of non-toxic and non-hazardous DCR on the Great Lakes from 1993 until 2008. The IEP was originally adopted by the Coast Guard's Ninth District, and then mandated by Congress in 1998, 2000, and 2004 (Pub. L. 105–383, sec. 415; Pub. L. 106–554, sec. 1117; Pub. L. 108–293, sec. 623). The IEP allowed cargo sweeping only in defined waters, most of which are relatively deep and far from shore. Additionally, it prohibited or restricted discharges in special areas that are considered environmentally sensitive. The congressionally mandated enforcement of the IEP expires September 30, 2008, or upon the promulgation of new regulations, whichever date comes first.

The 2004 legislation gave the Coast Guard authority to regulate the discharge of DCR on the Great Lakes, notwithstanding any other law (Pub. L. 108–293, sec. 623(b)). The Coast Guard interprets this authority to allow regulation on the Great Lakes, on water or on shore, of any operation related to the loading, transfer, or unloading of dry bulk cargo, or to cargo sweeping or other discharge of dry bulk cargo residue. All of these operations relate to and are part and parcel of the discharge of dry bulk cargo, as contemplated by Congress in the 2004 legislation. House Report 108–617, the conference report prepared in support of the 2004 legislation, states:

> It is expected that the [IEP] will be made permanent or replaced with an alternative regime that appropriately balances the needs of maritime commerce and environmental protection.

This interim rule amends Coast Guard regulations so that DCR discharges may continue in the U.S. waters of the Great Lakes, so long as those discharges are in compliance with regulatory conditions that derive, with modifications, from the IEP. One modification is non-substantive: We are clarifying the current policy but not changing it, to exclude non-self propelled barges that are not part of an integrated tug and barge unit. Integrated tugs and barges remain included because they are designed and operated similarly to self propelled vessels of the same size and service. We are substantively modifying the IEP to add new recordkeeping and reporting requirements for dry cargo carriers. We are adding, to the list of locations in the Great Lakes where DCR discharges will not be allowed, additional areas that the Final Environmental Impact Study designates as protected and sensitive. Finally, we are strongly encouraging carriers to voluntarily adopt control measures for reducing the amount of DCR that accumulates on or within vessels and that would ultimately be discharged into the Great Lakes.

Based on our Final Environmental Impact Statement, we have concluded that continued discharges of DCR will have only a minor indirect impact on most areas within the Great Lakes environment. The FEIS indicated that unconstrained discharges could have a direct significant adverse impact on protected and sensitive areas. We will mitigate that impact by prohibiting most discharges in those areas, and within three miles of land-based protected and sensitive areas. Only discharges under certain conditions and in specified areas will be allowed in the Western Basin of Lake Erie, in order to avoid the adverse economic impact that the FEIS indicates could accompany the complete prohibition of discharges in that area. Vessels operating exclusively in the Western Basin will be allowed to discharge limestone, clean stone, coal, iron ore, and salt in dredged navigation channels between Toledo Harbor Light and Detroit River Light, where environmental conditions are already disturbed frequently due to dredging.

IV. Discussion of Comments

We received 55 comments during the public comment period on our May 2008 NPRM, as well as comments from 3 individuals at our two public meetings. Few, if any, commenters distinguished between the DEIS and NPRM in their comment, and therefore all comments were considered for both documents. We have addressed the comments in detail in the FEIS, which was made available to the public on August 22, 2008. In response to public comments, we are extending the areas where DCR discharges are prohibited to include waters within three miles of shore at the following sites: Indiana Dunes and Sleeping Bear National Lakeshores on Lake Michigan and Grand Portage National Monument and Apostle Islands and Pictured Rocks National Lakeshores on Lake Superior. Otherwise, we are adopting the regulatory text we proposed in the NPRM without substantive change.

A table presenting the substance of each comment received, and the Coast Guard's response, appears in the FEIS which can be found in the docket at *http://www.regulations.gov*. The comments, and our responses, are summarized in the following discussion. During the drafting of this interim rule, we received late comments which did not raise new substantive issues and did not affect the following discussion.

Comments in favor of prohibiting continued DCR discharges. Forty-six commenters favored prohibiting continued DCR discharges in the Great Lakes. We agree with these commenters that our environmental analysis shows that prohibition could minimize the potential for adverse environmental impacts, but disagree that DCR discharges should be completely prohibited. In giving the Coast Guard permanent regulatory authority over Great Lakes DCR discharges, Congress expected us to strike an appropriate balance between maritime commercial and environmental protection needs. By balancing the adverse environmental impact of continued DCR discharges in the Great Lakes against the potentially substantial economic cost of prohibiting discharges anywhere in the Great Lakes, we believe this interim rule best achieves Congress' intent.

Comments on the toxicity of DCR. Fifteen commenters expressed concern regarding toxic chemicals in DCR and their effects on humans, animals, and plants. As recounted in detail in the FEIS, we have carefully evaluated the toxic potential of DCR. In general, we found that any toxic components of DCR deposits in the Great Lakes do not exist in concentrations known to be toxic to organisms. In those few instances where a cargo's residue concentration can be found near or above potentially harmful levels, natural sedimentation lowers the concentration to well below potentially harmful levels. There is little or no potential for any fish with toxic concentrations in their tissues to enter the food chain. Moreover, the inclusion of mandatory recordkeeping in our interim rule will enable us to track future DCR discharges, and should environmental conditions change significantly in the future, we retain the regulatory authority needed to address those changed conditions.

Comments on the impact of DCR on invasive mussels and the aquatic environment. Eight commenters expressed concern regarding invasive mussels and the aquatic environment. The FEIS contains detailed information about how we evaluated the impact of DCR on the aquatic environment, especially with respect to invasive mussels. We found minor adverse effects on sediment physical structure, the benthic community, and invasive species. Except in portions of Lakes Michigan and Huron where the potential impact is minor, the discharge of DCR will not change the distribution or density of mussels in most of the Great Lakes, either because mussels are already ubiquitous (e.g., in Lakes Erie and Ontario) or because water depth, temperature, and calcium levels limit mussel distribution and density (e.g., in Lake Superior). Once again, we believe our interim rule best achieves the legislative intention behind our regulatory authority by balancing the minor adverse impact of continued DCR discharges on sediment physical structure, the benthic community, and invasive species against the potential economic cost of prohibiting those discharges.

Comments on the legality of the Coast Guard's proposal. Thirty-six commenters objected to the continued allowance of DCR discharge on the grounds that it is already illegal under U.S. or international laws, treaties, or agreements. Among the authorities listed by these commenters are the International Convention for the Prevention of Pollution from Ships (MARPOL), APPS, the Great Lakes Water Quality Agreement (GLWQA), and State laws in Michigan, Minnesota, and Pennsylvania. We discuss the possible interplay between this interim rule and State law more fully in ''Federalism,'' Part V.E. of this preamble.

This interim rule replaces the IEP with new regulations. We initially adopted the IEP in response to concerns that strict enforcement of existing authorities such as APPS would prohibit continued DCR discharge in the Great Lakes. Congress subsequently addressed that same concern by passing legislation in 1998, 2000, and 2004 that required the Coast Guard to implement and enforce the IEP on the Great Lakes. In 2004, Congress also gave the Coast Guard authority ''notwithstanding any other law'' to regulate the discharge of DCR in the Great Lakes. The legislative history of the 2004 legislation shows that Congress expected the Coast Guard to make the IEP permanent or replace the IEP with an alternative regime that appropriately balances maritime commercial and environmental protection needs. The 2004 legislation is the latest expression of Congress's intentions with respect to regulating Great Lakes DCR discharge, and the basis for the Coast Guard's rulemaking.

Comments relating to recordkeeping and reporting. Seventeen commenters either opposed mandatory recordkeeping and reporting as unnecessary, or asked for modifications in the record form or in the frequency of reporting. We agree that some minor modifications to the reporting form are appropriate which will be reflected in Form CG–33. However, we disagree that the quarterly reporting schedule requires excessively frequent reporting. We have found through the numerous rules and programs we administer that recordkeeping is an integral and important part of ensuring regulatory compliance. The Coast Guard is not requiring the recording or reporting of any data that constitutes trade secrets or privileged and confidential commercial or financial information. We consider the economic cost of our new recordkeeping and reporting requirements to be reasonable, especially considering the value of comprehensive DCR practice data and its potential relationship with natural resources. Data reported to the Coast Guard will be useful as we evaluate the costs and benefits of DCR control measures. Quarterly reporting ensures that data is assembled quickly. Once our data collection needs are satisfied, we will likely retain the recordkeeping requirement, but may modify or eliminate the reporting requirement.

We have removed the facsimile of Form CG–33 from the regulation, but included information on how to obtain the form itself in the regulatory text.

V. Request for Additional Comments

In our May 2008 NPRM, we promised to open a new rulemaking to begin a new phase of DCR study, simultaneously with publication of the final rule for the present rulemaking. The new phase would consider what additional conditions, if any, should be imposed on DCR discharges in order to offset any long term impacts they might have.

We have decided to conduct this new phase as part of the present rulemaking rather than as a separate project. Therefore, in this interim rule we announce the opening of the new phase, and strongly encourage you to submit public comments to assist us. We want to determine if, in the long term, the optimal balancing of commercial and environmental interests requires the mandatory use of DCR control measures, the adjustment of the geographical boundaries within which discharges are currently allowed, or other regulatory changes.

The outcome of this new phase is not predetermined. We might find a clear case for imposing new DCR control measure requirements and altering geographical boundaries. Alternatively, we might find that the costs of any new regulatory measures outweigh the environmental benefits the new measures would provide, and leave our regulations unchanged. In determining the regulatory outcome, we intend to be guided by data on DCR discharges and on DCR control measures that are already in voluntary use, and by careful consideration of public comments. The DCR control measures we have identified for analysis are listed in the Table below.

TABLE—POTENTIAL DRY CARGO RESIDUE CONTROL MEASURES

Shipboard measures:
Enclosed conveyor.
Troughed conveyor.
Conveyor skirts.
Belt scrapers.
Water mist for dust control.
Conveyor capacity indicators.
Deck remote controls for conveyors.
Stop conveyor while ship or belt is repositioned.
Delay loading/unloading during high wind.
Radio communication between deck and loader.
Crew training on procedures to reduce DCR.
Limit vertical angle of conveyor boom.
Broom & shovel.
Tarps to collect DCR.
Cargo hold vibrator.
Watertight gate seal.
Cargo hold lining.
Minimize hatch removal during poor weather.
Careful cargo hold gate operation.
Shoreside measures:
Enclosed conveyor.
Troughed conveyor.
Conveyor skirts.
Belt scrapers.
Water mist for dust control.
Conveyor capacity indicators.
Deck remote controls for conveyors.
Stop conveyor while ship or belt is repositioned.
Delay loading/unloading during high wind.
Radio communication between deck and loader.
Crew training on procedures to reduce DCR.
Limit vertical angle of conveyor boom.
Flow feeder.
Loading chute, including telescoping or conveyors.
Chemical surfactants.
Suction pumped cargo, slurry transport, pneumatic or screw conveyors.

To better focus our efforts, we invite you to respond to the following questions:

1. Is there a control measure, other than those listed in the Table, that we should study?

2. Do you have data on the cost of installing, operating and maintaining control measures or their effectiveness in reducing the volume of DCR discharged? Can you identify a data source we should consult?

3. If control measures were to be required, are you in favor of a phase-in, and if so, how might the phase-in be structured?

4. Are you in favor of limiting the areas in which control measures should be required, and if so, what are the areas where those requirements should apply?

5. Are there other changes the Coast Guard should make in order to regulate the long term discharge of DCR in the Great Lakes in a way that is both economically and environmentally sustainable?

Please see the **ADDRESSES** section of this document for information on how you can share your responses to these questions with us.

VI. Regulatory Evaluation

A. Executive Order 12866

This rule is not a ''significant regulatory action'' under section 3(f) of Executive Order 12866, Regulatory Planning and Review, and does not require an assessment of potential costs and benefits under section 6(a)(3) of that Order. The Office of Management and Budget has not reviewed it under that Order.

Public comments on the NPRM are summarized in Part IV of this preamble. We received no public comments that would alter our assessment of impacts in the NPRM. We have adopted the assessment in the NPRM as final. See the ''Regulatory Evaluation'' section of the NPRM for the complete analysis. A summary of the assessment follows.

The recordkeeping provisions in this rule require owners and operators of self propelled vessels to maintain records and report information on dry cargo operations. This rule does not require the use of control measures to reduce the amount of residue swept into the Great Lakes.

There are minimal costs involved in requiring owners and operators of vessels to keep records of their bulk dry cargo residue sweeping operations and to make those records available to the Coast Guard. Moreover, many vessel operators already record this information voluntarily. We identified 55 U.S., 33 Canadian, and 186 non-Canadian foreign vessels operating on the Great Lakes affected by the recordkeeping and reporting requirements of this rule.

We estimate the annual recurring cost of this rule to industry, both U.S. and foreign, to be $88,828 (non-discounted). The total combined U.S. and foreign 10-year (2009–2018) present value cost of this rule is $623,891 discounted at 7 percent and $757,721 discounted at 3 percent.

We estimate the annual recurring cost of this rule to U.S. industry to be $60,077 (non-discounted). The total U.S. 10-year (2009–2018) present value cost of this rule is $421,956 discounted at 7 percent and $512,469 discounted at 3 percent. See the ''Regulatory Evaluation'' section of the NPRM for additional details of the population and cost estimates.

This rule will increase the Coast Guard's ability to understand the practice of dry cargo sweeping, monitor the practice, and, if necessary, subject the practice of dry cargo sweeping to further controls in the future.

B. Small Entities

Under the Regulatory Flexibility Act (5 U.S.C. 601–612), we have considered whether this rule would have a significant economic impact on a substantial number of small entities. The term ''small entities'' comprises small businesses, not-for-profit organizations that are independently owned and operated and are not dominant in their fields, and governmental jurisdictions with populations of less than 50,000.

In the NPRM, we certified under 5 U.S.C. 605(b) that the proposed rule would not have a significant economic impact on a substantial number of small entities and we requested public comments on this certification. We received no comments on this certification and adopt it as final.

In the NPRM, we identified 13 small entities affected by this rule involving inland water freight transportation, marine cargo handling, packaging and labeling services, and other navigation related industries. We estimated the per vessel annual cost impact of this rulemaking on small entities to be about $1,092. We determined that the cost of the recordkeeping and reporting requirements would not significantly impact the annual operating revenues of the affected small entities. See the ''Small Entities'' section of the NPRM for more details.

Therefore, the Coast Guard certifies under 5 U.S.C. 605(b) that this interim rule will not have a significant economic impact on a substantial number of small entities.

C. Assistance for Small Business

Under section 213(a) of the Small Business Regulatory Enforcement Fairness Act of 1996 (Pub. L. 104–121), we offered to assist small entities in understanding the rule so that they could better evaluate its effects on them and participate in the rulemaking. If the rule would affect your small business, organization, or governmental jurisdiction and you have questions concerning its provisions or options for compliance; please consult Lt St. Pierre (see **FOR FURTHER INFORMATION CONTACT**).

Small businesses may send comments on the actions of Federal employees who enforce, or otherwise determine compliance with, Federal regulations to the Small Business and Agriculture Regulatory Enforcement Ombudsman and the Regional Small Business Regulatory Fairness Boards. The Ombudsman evaluates these actions annually and rates each agency's responsiveness to small business. If you wish to comment on actions by employees of the Coast Guard, call 1–888–REG–FAIR (1–888–734–3247). The Coast Guard will not retaliate against small entities that question or complain about this rule or any policy or action of the Coast Guard.

D. Collection of Information

This rule calls for a new collection of information under the Paperwork Reduction Act of 1995 (44 U.S.C. 3501–3520). As defined in 5 CFR 1320.3(c), ''collection of information'' comprises reporting, recordkeeping, monitoring, posting, labeling, and other, similar actions. A summary of the title and description of the information collection, a description of those who must collect the information, and an estimate of the total annual burden follow. This information has not changed from the NPRM. The estimate covers the time for reviewing instructions, searching existing sources of data, gathering and maintaining the data needed, and completing and reviewing the collection. See the ''Collection of Information'' section of the NPRM for additional details.

Title: Dry Cargo Residue Sweepings in the Great Lakes.

Summary of the Collection of Information: These DCR recordkeeping provisions will require vessel operators to maintain a DCR log to document what dry cargos are loaded, unloaded, and swept, when they are swept, how they are swept, how much is swept, what control measures, if any, are in place, and where, when, and how fast the vessel is traveling when the sweepings take place.

Need for Information: By making DCR recordkeeping mandatory, we will greatly increase our ability to understand the practice of dry cargo sweeping, monitor the practice, and if necessary, subject the practice of DCR sweeping to further controls in the future.

Proposed Use of Information: The DCR recordkeeping and reporting requirements will provide additional data to support Coast Guard analysis of policies to reduce DCR discharges over the long term, beyond the next 6 to 10 years.

Description of the Respondents: The respondents are owners and operators of U.S., Canadian, and foreign flag vessels carrying dry-bulk cargos operated on the Great Lakes. The respondents will conduct DCR recordkeeping and handle the submissions.

Number of Respondents: Based on estimates from the NPRM, the total number of vessels that handle Great Lakes dry bulk cargo shipments is 274 (= 55 U.S. vessels + 33 Canadian vessels

+ 186 non-Canadian foreign vessels). We estimate the number of respondents equal the number of vessels since there will be crew on each vessel recording the information.

Frequency of Response: Based on estimates from the NPRM, the annual frequency of response is 10,615 for U.S. vessels and 5,153 for foreign vessels.

Burden of Response: Based on estimates from the NPRM, the total annual burden hours for this rule are 886 hours for U.S. vessel operators and 448 hours for foreign vessel operators. We estimate the annual costs of this burden to be $60,077 (non-discounted) for U.S. operators and $28,751 for foreign operators.

During public hearings, one commenter questioned the usefulness of collecting man hour data stating that recording man hours can vary greatly by interpretation and that the data will be unusable. The Coast Guard disagrees with the commenter. The man hour data provided by vessel masters will enable the Coast Guard to better estimate the burden of implementing DCR control measures. The information will provide a benchmark for measuring DCR-related man hours for the different alternatives under consideration. We have provided instructions and guidance for recording man hours. As discussed in the NPRM, we found many vessel operators already record this information voluntarily.

As required by 44 U.S.C. 3507(d), we submitted a copy of the proposed rule to the Office of Management and Budget for its review of the collection of information. OMB approved the collection for 33 CFR part 151 and Form CG–33 on September 4, 2008, and the corresponding approval number from OMB is OMB Control Number 1625–0072, which expires on September 11, 2011.

E. Federalism

A rule has implications for federalism under Executive Order 13132, Federalism, if it has a substantial direct effect on State or local governments and would either preempt State law or impose a substantial direct cost of compliance on them. The Coast Guard received 10 comments in response to our NPRM regarding the possible interplay between Coast Guard regulations and State laws that may relate to DCR discharges. We understand that at least some States in the Great Lakes region already have legislation that may prohibit certain solid waste discharges in their Great Lakes waters, and that certain of those States take the position that DCR may be or at least may contain solid waste. However, we do not agree with the commenters that the Federal regulation either expressly preempts or necessarily conflicts with those laws. Rather, and to clarify our Federalism statement in accordance with the responsibilities and the principles contained in EO 13132 regarding Federalism, the Coast Guard states that this regulation does not expressly preempt those State laws. Nor does the Coast Guard by promulgating this regulation take the position that such State laws facially frustrate an over-riding federal purpose. However, the ultimate question regarding preemption of State laws is a legal question that is subject to court interpretation and decision based on the application of particular facts to those individual laws. Because no court has ruled on the questions raised, the Coast Guard cautions carriers that they must comply with all applicable Federal and State laws regulating DCR discharges. We will work with States and carriers to make sure carriers are informed of any State laws that could impose more restrictions on DCR discharges than we have proposed.

F. Unfunded Mandates Reform Act

The Unfunded Mandates Reform Act of 1995 (2 U.S.C. 1531–1538) requires Federal agencies to assess the effects of their discretionary regulatory actions. In particular, the Act addresses actions that may result in the expenditure by a State, local, or tribal government, in the aggregate, or by the private sector of $100,000,000 or more in any one year. This rule will not result in such expenditure.

G. Taking of Private Property

This rule will not affect a taking of private property or otherwise have taking implications under Executive Order 12630, Governmental Actions and Interference with Constitutionally Protected Property Rights.

H. Civil Justice Reform

This rule meets applicable standards in sections 3(a) and 3(b)(2) of Executive Order 12988, Civil Justice Reform, to minimize litigation, eliminate ambiguity, and reduce burden.

I. Protection of Children

We have analyzed this rule under Executive Order 13045, Protection of Children from Environmental Health Risks and Safety Risks. This rule is not an economically significant rule and will not create an environmental risk to health or risk to safety that might disproportionately affect children.

J. Indian Tribal Governments

This rule does not have tribal implications under Executive Order 13175, Consultation and Coordination with Indian Tribal Governments, because it will not have a substantial direct effect on one or more Indian tribes, on the relationship between the Federal Government and Indian tribes, or on the distribution of power and responsibilities between the Federal Government and Indian tribes.

K. Energy Effects

We have analyzed this rule under Executive Order 13211, Actions Concerning Regulations That Significantly Affect Energy Supply, Distribution, or Use. We have determined that it is not a ''significant energy action'' under that order because it is not a ''significant regulatory action'' under Executive Order 12866 and is not likely to have a significant adverse effect on the supply, distribution, or use of energy. The Administrator of the Office of Information and Regulatory Affairs has not designated it as a significant energy action. Therefore, it does not require a Statement of Energy Effects under Executive Order 13211.

L. Technical Standards

The National Technology Transfer and Advancement Act (NTTAA) (15 U.S.C. 272 note) directs agencies to use voluntary consensus standards in their regulatory activities unless the agency provides Congress, through the Office of Management and Budget, with an explanation of why using these standards would be inconsistent with applicable law or otherwise impractical. Voluntary consensus standards are technical standards (e.g., specifications of materials, performance, design, or operation; test methods; sampling procedures; and related management systems practices) that are developed or adopted by voluntary consensus standards bodies. This rule does not use technical standards. Therefore, we did not consider the use of voluntary consensus standards.

M. Environment

We have analyzed this rule under Department of Homeland Security Management Directive 5100.1 and Commandant Instruction M16475.lD, which guide the Coast Guard in complying with the National Environmental Policy Act of 1969 (NEPA) (42 U.S.C. 4321–4370f). The Final Environmental Impact Statement and Record of Decision appear in the docket.

List of Subjects in 33 CFR Part 151

Administrative practice and procedure, Oil pollution, Penalties, Reporting and recordkeeping requirements, Water pollution control.

■ For the reasons discussed in the preamble, the Coast Guard amends 33 CFR part 151 as follows:

PART 151—VESSELS CARRYING OIL, NOXIOUS LIQUID SUBSTANCES, GARBAGE, MUNICIPAL OR COMMERCIAL WASTE, AND BALLAST WATER

■ 1. The authority citation for part 151 is revised to read as follows:

Authority: 33 U.S.C. 1321, 1902, 1903, 1908; 46 U.S.C. 6101; Pub. L. 104–227 (110 Stat. 3034); Pub. L. 108–293 (118 Stat. 1063), § 623; E.O. 12777, 3 CFR, 1991 Comp. p. 351; DHS Delegation No. 0170.1, sec. 2(77).

Subpart A—Implementation of MARPOL 73/78 and the Protocol on Environmental Protection to the Antarctic Treaty as it pertains to Pollution From Ships

■ 2. Revise § 151.66 to read as follows:

§ 151.66 Operating requirements: Discharge of garbage in the Great Lakes and other navigable waters.

(a) Except as otherwise provided in this section, no person on board any ship may discharge garbage into the navigable waters of the United States.

(b) On the United States' waters of the Great Lakes, commercial ships, excluding non-self propelled barges that are not part of an integrated tug and barge unit, may discharge bulk dry cargo residues in accordance with this paragraph and paragraph (c) of this section. Owners and operators of ships to which these paragraphs apply are encouraged to minimize the volume of dry cargo residues discharged through the use of suitable residue control measures onboard and by loading and unloading cargo at facilities that use suitable shoreside residue control measures. As used in this paragraph and paragraph (c) of this section:

Apostle Islands National Lakeshore means the site on or near Lake Superior administered by the National Park Service, less Madeline Island, and including the Wisconsin shoreline of Bayfield Peninsula from the point of land at 46°57′19.7″ N, 90°52′51.0″ W southwest along the shoreline to a point of land at 46°52′56.4″ N, 91°3′3.1″ W.

Bulk dry cargo residues means non-hazardous and non-toxic residues of dry cargo carried in bulk, including limestone and other clean stone, iron ore, coal, salt, and cement. It does not include residues of any substance known to be toxic or hazardous, such as, nickel, copper, zinc, lead, or materials classified as hazardous in provisions of law or treaty;

Caribou Island and Southwest Bank Protection Area means the area enclosed by rhumb lines connecting the following coordinates, beginning on the northernmost point and proceeding clockwise:

47°30.0′ N	85°50.0′ W
47°24.2′ N	85°38.5′ W
47°04.0′ N	85°49.0′ W
47°05.7′ N	85°59.0′ W
47°18.1′ N	86°05.0′ W

Detroit River International Wildlife Refuge means the U.S. waters of the Detroit River bound by the area extending from the Michigan shore at the southern outlet of the Rouge River to 41°54′ N, 083°06′ W along the U.S.-Canada boundary southward and clockwise connecting points:

42°02′ N	083°08′ W
41°54′ N	083°06′ W
41°50′ N	083°10′ W
41°44.52 N	083°22′ W
41°44.19 N	083°27′ W

Grand Portage National Monument means the site on or near Lake Superior, administered by the National Park Service, from a southwest corner of the monument point of land, 47°57.521′ 89°41.245′, to the northeast corner of the monument point of land, 47°57.888′ 89°40.725′.

Indiana Dunes National Lakeshore means the site on or near Lake Michigan, administered by the National Park Service, from a point of land near Gary, Indiana at 41°42′59.4″ N 086°54′59.9″ W eastward along the shoreline to 41°37′08.8″ N 087°17′18.8″ W near Michigan City, Indiana.

Integrated tug and barge unit means any tug barge combination which, through the use of special design features or a specially designed connection system, has increased seakeeping capabilities relative to a tug and barge in the conventional pushing mode;

Isle Royale National Park means the site on or near Lake Superior, administered by the National Park Service, where the boundary includes any submerged lands within the territorial jurisdiction of the United States within four and one-half miles of the shoreline of Isle Royale and the surrounding islands, including Passage Island and Gull Island.

Mile means a statute mile, and refers to the distance from the nearest land or island;

Milwaukee Mid-Lake Special Protection Area means the area enclosed by rhumb lines connecting the following coordinates, beginning on the northernmost point and proceeding clockwise:

43°27.0′ N	87°14.0′ W
43°21.2′ N	87°02.3′ W
43°03.3′ N	87°04.8′ W
42°57.5′ N	87°21.0′ W
43°16.0′ N	87°39.8′ W

Northern Refuge means the area enclosed by rhumb lines connecting the coordinates, beginning on the northernmost point and proceeding clockwise:

45°45′ N	86°00′ W,

western shore of High Island, southern shore of Beaver Island:

45°30′ N	85°30′ W
45°30′ N	85°15′ W
45°25′ N	85°15′ W
45°25′ N	85°20′ W
45°20′ N	85°20′ W
45°20′ N	85°40′ W
45°15′ N	85°40′ W
45°15′ N	85°50′ W
45°10′ N	85°50′ W
45°10′ N	86°00′ W

Pictured Rocks National Lakeshore means the site on or near Lake Superior, administered by the National Park Service, from a point of land at 46°26′21.3″ N 086°36′43.2″ W eastward along the Michigan shoreline to 46°40′22.2″ N 085°59′58.1″ W.

Six Fathom Scarp Mid-Lake Special Protection Area means the area enclosed by rhumb lines connecting the following coordinates, beginning on the northernmost point and proceeding clockwise:

44°55′ N	82°33′ W
44°47′ N	82°18′ W
44°39′ N	82°13′ W
44°27′ N	82°13′ W
44°27′ N	82°20′ W
44°17′ N	82°25′ W
44°17′ N	82°30′ W
44°28′ N	82°40′ W
44°51′ N	82°44′ W
44°53′ N	82°44′ W
44°54′ N	82°40′ W

Sleeping Bear Dunes National Lakeshore means the site on or near Lake Michigan, administered by the National Park Service, that includes North Manitou Island, South Manitou Island and the Michigan shoreline from a point of land at 44°42′45.1″ N 086°12′18.1″ W north and eastward along the shoreline to 44°57′12.0″ N 085°48′12.8″ W.

Stannard Rock Protection Area means the area within a 6 mile radius from Stannard Rock Light, at 47°10′57″ N 87°13′34″ W;

Superior Shoal Protection Area means the area within a 6 mile radius from the center of Superior Shoal, at 48°03.2′ N 87°06.3′ W;

Thunder Bay National Marine Sanctuary means the site on or near Lake Huron designated by the National Oceanic and Atmospheric Administration as the boundary that forms an approximately rectangular area by extending along the ordinary high water mark between the northern and southern boundaries of Alpena County, cutting across the mouths of rivers and streams, and lakeward from those points along latitude lines to longitude 83 degrees west. The coordinates of the boundary are:

45°12′25.5″ N	83°23′18.6″ W
45°12′25.5″ N	83°00′00″ W
44°51′30.5″ N	83°00′00″ W
44°51′30.5″ N	83°19′17.3″ W

Waukegan Special Protection Area means the area enclosed by rhumb lines connecting the following coordinates, beginning on the northernmost point and proceeding clockwise:

42°24.3′ N	87°29.3′ W
42°13.0′ N	87°25.1′ W
42°12.2′ N	87°29.1′ W
42°18.1′ N	87°33.1′ W
42°24.1′ N	87°32.0′ W; and

Western Basin means that portion of Lake Erie west of a line due south from Point Pelee.

TABLE 151.66(b)—BULK DRY CARGO RESIDUE DISCHARGES ALLOWED ON THE GREAT LAKES

Location	Cargo	Discharge allowed except as noted
Tributaries, their connecting rivers, and St. Lawrence River.	Limestone and other clean stone ..	Prohibited where there is an apparent impact on wetlands, fish spawning areas, and potable water intakes.
	All other cargos	Prohibited.
Lake Ontario	Limestone and other clean stone ..	Prohibited where there is an apparent impact on wetlands, fish spawning areas, and potable water intakes.
	Iron ore	Prohibited within 6 miles from shore.
	All other cargos	Prohibited within 13.8 miles from shore.
Lake Erie	Limestone and other clean stone ..	Prohibited where there is an apparent impact on wetlands, fish spawning areas, and potable water intakes; prohibited in the Detroit River International Wildlife Refuge; prohibited in Western Basin, except that a vessel operating exclusively within Western Basin may discharge limestone or clean stone cargo residues over the dredged navigation channels between Toledo Harbor Light and Detroit River Light.
	Iron ore	Prohibited within 6 miles from shore; prohibited in the Detroit River International Wildlife Refuge; prohibited in Western Basin, except that a vessel may discharge residue over the dredged navigation channels between Toledo Harbor Light and Detroit River Light if it unloads in Toledo or Detroit and immediately thereafter loads new cargo in Toledo, Detroit, or Windsor.
	Coal, salt	Prohibited within 13.8 miles from shore; prohibited in the Detroit River International Wildlife Refuge; prohibited in Western Basin, except that a vessel may discharge residue over the dredged navigation channels between Toledo Harbor Light and Detroit River Light if it unloads in Toledo or Detroit and immediately thereafter loads new cargo in Toledo, Detroit, or Windsor.
	All other cargos	Prohibited within 13.8 miles from shore; prohibited in the Detroit River International Wildlife Refuge; prohibited in Western Basin.
Lake St. Clair	Limestone and other clean stone ..	Prohibited where there is an apparent impact on wetlands, fish spawning areas, and potable water intakes.
	All other cargos	Prohibited.
Lake Huron except Six Fathom Scarp Mid-Lake Special Protection Area.	Limestone and other clean stone ..	Prohibited where there is an apparent impact on wetlands, fish spawning areas, and potable water intakes; prohibited in the Thunder Bay National Marine Sanctuary.
	Iron ore	Prohibited within 6 miles from shore and in Saginaw Bay; prohibited in the Thunder Bay National Marine Sanctuary; prohibited for vessels up bound along the Michigan thumb as follows: (1) Between 5.8 miles northeast of entrance buoys 11 and 12 to the track line turn abeam of Harbor Beach, prohibited within 3 miles from shore; and (2) For vessels bound for Saginaw Bay only, between the track line turn abeam of Harbor Beach and 4 nautical miles northeast of Point Aux Barques Light, prohibited within 4 miles from shore and not less than 10 fathoms of depth.
	Coal, salt	Prohibited within 13.8 miles from shore and in Saginaw Bay; prohibited in the Thunder Bay National Marine Sanctuary; prohibited for vessels up bound from Alpena into ports along the Michigan shore south of Forty Mile Point within 4 miles from shore and not less than 10 fathoms of depth.
	All other cargos	Prohibited within 13.8 miles from shore and in Saginaw Bay; prohibited in the Thunder Bay National Marine Sanctuary.
Lake Michigan	Limestone and other clean stone ..	Prohibited where there is an apparent impact on wetlands, fish spawning areas, and potable water intakes; prohibited within the Milwaukee Mid-Lake and Waukegan Special Protection Areas; prohibited within the Northern Refuge; prohibited within 3 miles of the shore of the Indiana Dunes and Sleeping Bear National Lakeshores; prohibited within Green Bay.

TABLE 151.66(b)—BULK DRY CARGO RESIDUE DISCHARGES ALLOWED ON THE GREAT LAKES—Continued

Location	Cargo	Discharge allowed except as noted
	Iron ore	Prohibited in the Northern Refuge; north of 45° N, prohibited within 12 miles from shore and in Green Bay; south of 45° N, prohibited within 6 miles from shore, and prohibited within the Milwaukee Mid-Lake and Waukegan Special Protection Areas, in Green Bay, and within 3 miles of the shore of Indiana Dunes and Sleeping Bear National Lakeshores; except that discharges are allowed at: (1) 4.75 miles off Big Sable Point Betsie, along established Lake Carriers Association (LCA) track lines; and (2) Along 056.25° LCA track line between due east of Poverty Island to a point due south of Port Inland Light.
	Coal	Prohibited in the Northern Refuge; prohibited within 13.8 miles from shore and prohibited within the Milwaukee Mid-Lake and Waukegan Special Protection Areas, in Green Bay, and within 3 miles of the shore of Indiana Dunes and Sleeping Bear National Lakeshores; except that discharges are allowed: (1) Along 013.5° LCA track line between 45° N and Boulder Reef, and along 022.5° LCA track running 23.25 miles between Boulder Reef and the charted position of Red Buoy #2; (2) Along 037° LCA track line between 45°20′ N and 45°42′ N; (3) Along 056.25° LCA track line between points due east of Poverty Island to a point due south of Port Inland Light; and (4) At 3 miles from shore for coal carried between Manistee and Ludington along customary routes.
	Salt	Prohibited in the Northern Refuge; prohibited within 13.8 miles from shore and prohibited within the Milwaukee Mid-Lake and Waukegan Special Protection Areas, in Green Bay, and within 3 miles of the shore of Indiana Dunes and Sleeping Bear National Lakeshores, and in Green Bay.
	All other cargos	Prohibited in the Northern Refuge; prohibited within 13.8 miles from shore and prohibited within the Milwaukee Mid-Lake and Waukegan Special Protection Areas, in Green Bay, and within 3 miles of the shore of Indiana Dunes and Sleeping Bear National Lakeshores.
Lake Superior	Limestone and other clean stone	Prohibited where there is an apparent impact on wetlands, fish spawning areas, and potable water intakes; and prohibited within Isle Royal National Park and the Caribou Island and Southwest Bank, Stannard Rock, and Superior Shoal Protection Areas, and within 3 miles of the shore of the Apostle Islands and Pictured Rocks National Lakeshores or the Grand Portage National Monument.
	Iron ore	Prohibited within 6 miles from shore (within 3 miles off northwestern shore between Duluth and Grand Marais); and prohibited within Isle Royal National Park and the Caribou Island and Southwest Bank, Stannard Rock, and Superior Shoal Protection Areas, and within 3 miles of the shore of the Apostle Islands and Pictured Rocks National Lakeshores or the Grand Portage National Monument.
	Coal, salt	Prohibited within 13.8 miles from shore (within 3 miles off northwestern shore between Duluth and Grand Marais); and prohibited within Isle Royal National Park and the Caribou Island and Southwest Bank, Stannard Rock, and Superior Shoal Protection Areas, and within 3 miles of the shore of the Apostle Islands and Pictured Rocks National Lakeshores or the Grand Portage National Monument.
	Cement	Prohibited within 13.8 miles from shore (within 3 miles offshore west of a line due north from Bark Point); and prohibited within Isle Royal National Park and the Caribou Island and Southwest Bank, Stannard Rock, and Superior Shoal Protection Areas, and within 3 miles of the shore of the Apostle Islands and Pictured Rocks National Lakeshores or the Grand Portage National Monument.
	All other cargos	Prohibited within 13.8 miles from shore; and prohibited within Isle Royal National Park and the Caribou Island and Southwest Bank, Stannard Rock, and Superior Shoal Protection Areas, and within 3 miles of the shore of the Apostle Islands and Pictured Rocks National Lakeshores or the Grand Portage National Monument.

(c)(1) The master, owner, operator, or person in charge of any commercial ship loading, unloading, or discharging bulk dry cargo in the United States' waters of the Great Lakes and the master, owner, operator, or person in charge of a U.S. commercial ship transporting bulk dry cargo and operating anywhere on the Great Lakes, excluding non-self propelled barges that are not part of an integrated tug and barge unit, must ensure that a written record is maintained on the ship that fully and accurately records information on:

(i) Each loading or unloading operation on the United States' waters of the Great Lakes, or in the case of U.S. commercial ships on any waters of the Great Lakes, involving bulk dry cargo; and

(ii) Each discharge of bulk dry cargo residue that takes place in United States' waters of the Great Lakes, or in the case of U.S. commercial ships on any waters of the Great Lakes.

(2) For each loading or unloading operation, the record must describe:

(i) The date of the operation;

(ii) Whether the operation involved loading or unloading;

(iii) The name of the loading or unloading facility;

(iv) The type of bulk dry cargo loaded or unloaded;

(v) The method or methods used to control the amount of bulk dry cargo residue, either onboard the ship or at the facility;

(vi) The time spent to implement methods for controlling the amount of bulk dry cargo residue; and

(vii) The estimated volume of bulk dry cargo residue created by the loading or unloading operation that is to be discharged.

(3) For each discharge, the record must describe:

(i) The date and time the discharge started, and the date and time the discharge ended;

(ii) The ship's position, in latitude and longitude, when the discharge started and when the discharge ended; and

(iii) The ship's speed during the discharge.

(iv) Records must be kept on Coast Guard Form CG–33, which can be found at *http://www.uscg.mil/hq/cg5/cg522/cg5224/dry_cargo.asp*. The records must be certified by the master, owner, operator, or person in charge and kept in written form onboard the ship for at least two years. Copies of the records must be forwarded to the Coast Guard at least once each quarter, no later than the 15th day of January, April, July, and October. The record copies must be provided to the Coast Guard using only one of the following means:

(A) E-mail to *DCRRecordkeeping@USCG.mil*;

(B) Fax to (202) 372–1926, ATTN: DCR RECORDKEEPING; or

(C) Mail to U.S. Coast Guard: Commandant (CG–522), ATTN: DCR RECORDKEEPING, CGHQ Room 1210, 2100 Second Street, SW, Washington, DC 20593–0001.

Dated: September 23, 2008.

J.G. Lantz,

Acting Assistant Commandant for Marine Safety, Security and Stewardship, United States Coast Guard.

[FR Doc. E8–22670 Filed 9–26–08; 8:45 am]

BILLING CODE 4910–15–P

POSTAL SERVICE

39 CFR Part 111

Postage Payment for Bound Printed Matter Limited to Permit Imprint

AGENCY: Postal Service™.

ACTION: Final rule.

SUMMARY: In this final rule, the Postal Service is revising mailing standards for all Bound Printed Matter (BPM). In March we filed a notice with the Postal Regulatory Commission for a classification change requiring all mailings of Bound Printed Matter be paid by permit only. The Commission agreed, and we are moving forward with the change.

Postage payment for BPM mailings: carrier route, presorted, and nonpresorted (single-piece) flats and parcels, regardless of volume, are limited to permit imprint. Mailers can no longer affix postage by adhesive stamps, postage meter, or PC Postage®. BPM will not be accepted at retail counters, in collection boxes, or by carriers and must be deposited and accepted at the Post Office™ facility that issued the permit. Merchandise Return Service (MRS) permit holders may continue to pay nonpresorted BPM prices on eligible items returned with a MRS label.

DATES: This rule is effective September 29, 2008, and is applicable beginning September 11, 2008.

FOR FURTHER INFORMATION CONTACT: Carol A. Lunkins at 202–268–7262.

SUPPLEMENTARY INFORMATION: Mailers who are presently authorized to pay postage via permit imprint may use their existing permit to mail BPM at the Post Office™ where the permit is held. Mailers who wish to obtain a new authorization to pay postage via permit imprint must complete an application and pay a one-time application fee at each office of mailing to mail BPM on or after September 11, 2008. Authorization is obtained by submitting PS Form 3615, *Mailing Permit Application and Customer Profile,* and the applicable fee to the Post Office where mailings are to be deposited. As long as a permit remains active, there is no additional fee for use of a permit imprint indicia, but other fees (e.g., an annual destination entry mailing fee) may be due depending on where the mail is deposited.

Payment for postage must be made for each mailing through an advance deposit account before the mailing can be released for processing. Funds to pay postage must be deposited as directed by the USPS®.

Nonpresorted BPM mailings, except discount mailings (e.g., barcode discounts), will be exempt from the general minimum volume requirement for a permit imprint mailing of at least 200 pieces or 50 pounds of mail and will not have a minimum volume requirement. However, the current requirements for all other commercial nonpresorted and presorted minimum volumes will remain (e.g., nonpresorted barcoded—50 pieces and presorted—300 pieces).

As a reminder, prices for BPM pieces vary by weight and zone of destination. Supporting documentation of postage is required for all nonidentical-weight pieces and for identical-weight pieces that are not separated by price and zone.

This requirement, which limits the payment of postage for all BPM to permit imprint, is effective September 11, 2008.

The Postal Service adopts the following changes to *Mailing Standards of the United States Postal Service,* Domestic Mail Manual (DMM), which is incorporated by reference in the *Code of Federal Regulations.* See 39 CFR 111.1.

List of Subjects in 39 CFR Part 111

Administrative practice and procedure, Postal Service.

■ Accordingly, 39 CFR part 111 is amended as follows:

PART 111—[AMENDED]

■ 1. The authority citation for 39 CFR part 111 continues to read as follows:

Authority: 5 U.S.C. 552(a); 39 U.S.C. 101, 401, 403, 404, 414, 416, 3001–3011, 3201–3219, 3403–3406, 3621, 3622, 3626, 3632, 3633, and 5001.

■ 2. Revise the following sections of the *Mailing Standards of the United States Postal Service,* Domestic Mail Manual (DMM) as follows:

* * * * *

300 Commercial Flats

* * * * *

Appendix B
Notice for EIS Preparation, Including Public Scoping Meeting Announcement, and Summary of Comments Received

Dated: December 18, 2008.

Jeffrey Shuren,

Associate Commissioner for Policy and Planning.

[FR Doc. E8–30839 Filed 12–24–08; 8:45 am]

BILLING CODE 4160–01–S

DEPARTMENT OF HOMELAND SECURITY

Coast Guard

[Docket No. USCG–2008–1229]

Chemical Transportation Advisory Committee

AGENCY: Coast Guard, DHS.

ACTION: Notice seeking public comments on MARPOL Reception Facilities.

SUMMARY: The Chemical Transportation Advisory Committee (CTAC), through its Working Group on the International Convention for the Prevention of Pollution from Ships (MARPOL) Annex, has been tasked with providing comment and recommendations to the U.S. Coast Guard for optimizing domestic MARPOL port reception facilities. CTAC is a committee formed under the authority of the Federal Advisory Committee Act (FACA), 5 U.S.C. App. (Pub. L. 92–463). To assist and complement CTAC's efforts, the Coast Guard is hereby seeking comments from the public on MARPOL reception facilities in the U.S. The Coast Guard is specifically interested in identifying all issues that negatively impact MARPOL implementing regulations for port reception facilities; and recommendations to address those issues.

CTAC Tasking: The original Task Statement that was provided to CTAC at the April 24, 2008 meeting in Washington, DC, included the following:

1. Provide comments and recommendations as necessary on: (To be completed by the Spring of 2009)

• Impact, if any, on MARPOL compliance caused by a variance in disposal costs;

• Impact, if any, on MARPOL compliance caused by vessels having to shift berths to complete transfers;

• Plan to document MARPOL reception facility services required and received through an advanced notice of arrival and departure report;

• Disposal of residues at other than those facilities receiving the cargo related to those residues. Vessels currently have limited information on availability of Annex I and Annex II facilities at subsequent ports of call;

• Level of consistency in disposal procedures in fulfillment of federal, state and local MARPOL waste disposal requirements as well as operational variances among facilities. For example, in fulfillment of state requirements, some facilities may request pre-identification of constituents in Annex I as well as Annex II residues. Additionally, facilities themselves have differing disposal procedures; and,

• Feasibility of simultaneous MARPOL and cargo transfers at every facility. According to vessel operators, some facilities prohibit simultaneous discharge of MARPOL residues and cargo transfers thereby causing delays.

2. Provide a final report in items listed above, a recommended way-ahead to implement any recommendations (e.g., proposed changes to MARPOL and/or domestic regulations) and the corresponding implementing language. (To be completed by the fall of 2009)

Seeking Public Comment: Possible areas of concern for stakeholders may include:

• Conflicts with other regulations;

• Disposal cost issues at ports/terminals;

• Requirement for lab analysis of Annex I or II wastes;

• Segregation of Annex V wastes; and

• Additional burden, if any, of adopting standardized Advance Notice Forms (ANF) and/or Waste Delivery Receipt (WDR) forms adopted by the International Maritime Organization.

Public comments that are received will assist and complement CTAC's efforts. CTAC's MARPOL Annex working group is scheduled to meet in February 2009. Comments must be received by January 31, 2009 in order to be considered.

ADDRESSES: The public may address comments via USPS, e-mail or FAX, to Mr. James Prazak, CTAC Chairman, C/O The Dow Chemical Company, 2301 N. Brazosport Blvd., B–122, Freeport, TX 77541–3257. FAX (979) 238–9737, E-mail: *jprazak@dow.com*. The Coast Guard requests that copies of comments be sent HQ, U.S. Coast Guard, CG–5442, ATTN: Commander Michael Roldan, 2100 Second Street, SW., Washington, DC 20593–0001. Fax: 202–372–1906, E-mail: *luis.m.roldan@uscg.mil*.

FOR FURTHER INFORMATION CONTACT: Commander Michael Roldan, telephone 202–372–1130, e-mail: *luis.m.roldan@uscg.mil*, or David Condino, MARPOL COA Project Manager, telephone 202–372–1145, e-mail: *david.a.condino@uscg.mil*.

SUPPLEMENTARY INFORMATION: Notice seeking public comment is given under the Federal Advisory Committee Act, 5 U.S.C. App. (Pub. L. 92–463).

Public Meeting: A separate Notice will be given regarding the next CTAC meeting at which time the Coast Guard will seek to discuss such public comments and the recommendations of CTAC. This will be a public meeting and instructions will be provided for those wishing to make oral presentations at the meeting and/or wishing to provide written comments.

Dated: December 19, 2008.

J. Lantz,

Director of Commercial Regulations and Standards.

[FR Doc. E8–30805 Filed 12–24–08; 8:45 am]

BILLING CODE 4910–15–P

DEPARTMENT OF HOMELAND SECURITY

Coast Guard

[USCG–2004–19621]

Dry Cargo Residue Discharges in the Great Lakes; Preparation of Environmental Impact Statement

AGENCY: Coast Guard, DHS.

ACTION: Notice of intent; request for comments; notice of public scoping meeting.

SUMMARY: The Coast Guard announces its intent to prepare a new Environmental Impact Statement (EIS) for the next phase of this rulemaking. The new EIS will tier off the first EIS, which was prepared in support of the interim rule published in September 2008. Under the interim rule, the discharge of bulk dry cargo residue is allowed to continue in limited areas of the Great Lakes and under certain conditions. The Coast Guard plans to issue a final rule that may modify the interim rule and add new conditions for discharges. The new EIS will support the final rule. This notice requests public comments and begins a public scoping process to help determine the scope of issues to be addressed in the new EIS.

DATES: Comments and related material must either be submitted to our online docket via *http://www.regulations.gov* on or before March 30, 2009 or reach the Docket Management Facility by that date. The public scoping meeting will be held on January 28, 2009, from 1 p.m. to 5 p.m. Comments and related material must reach the Docket Management Facility on or before March 30, 2009.

ADDRESSES: The public scoping meeting will be held at the Hotel Blake, 500 South Dearborn, Chicago, IL 60605. The contact telephone number for the Hotel Blake is (312) 986–1234.

In addition to submitting written statements or making verbal comments at the public scoping meeting, you may submit comments identified by docket number USCG–2004–19621 using any one of the following methods:

(1) *Federal eRulemaking Portal: http://www.regulations.gov.*

(2) *Fax:* 202–493–2251.

(3) *Mail:* Docket Management Facility (M–30), U.S. Department of Transportation, West Building Ground Floor, Room W12–140, 1200 New Jersey Avenue, SE., Washington, DC 20590–0001.

(4) *Hand delivery:* Same as mail address above, between 9 a.m. and 5 p.m., Monday through Friday, except Federal holidays. The telephone number is 202–366–9329.

To avoid duplication, please use only one of these methods. For instructions on submitting comments, see the ''Public Participation and Request for Comments'' portion of the **SUPPLEMENTARY INFORMATION** section below.

FOR FURTHER INFORMATION CONTACT: If you have questions regarding this notice, please contact Mr. Greg Kirkbride, U.S. Coast Guard, telephone 202–372–1479, e-mail *Gregory.B.Kirkbride@uscg.mil.* If you have questions on viewing or submitting material to the docket, call Ms. Renee V. Wright, Program Manager, Docket Operations, telephone 202–366–9826.

SUPPLEMENTARY INFORMATION:

Public Participation and Request for Comments

We encourage you to submit comments and related material during the public scoping process. All comments received will be posted, without change, to *http://www.regulations.gov* and will include any personal information you have provided.

Submitting comments: If you submit a comment, please include the docket number for this notice (USCG–2004–19621) and provide a reason for each suggestion or recommendation. You may submit your comments and material online, or by fax, mail or hand delivery, but please use only one of these means.

To submit your comment online, go to *http://www.regulations.gov,* select the Advanced Docket Search option on the right side of the screen, insert ''USCG–2004–19621'' in the Docket ID box, press Enter, and then click on the balloon shape in the Actions column. If you submit your comments by mail or hand delivery, submit them in an unbound format, no larger than 8½ by 11 inches, suitable for copying and electronic filing. If you submit them by mail and would like to know that they reached the Facility, please enclose a stamped, self-addressed postcard or envelope. We will consider all comments and material received during the comment period.

Viewing the comments: To view the comments go to *http://www.regulations.gov,* select the Advanced Docket Search option on the right side of the screen, insert USCG–2004–19621 in the Docket ID box, press Enter, and then click on the item in the Docket ID column. If you do not have access to the internet, you may view the docket online by visiting the Docket Management Facility in Room W12–140 on the ground floor of the Department of Transportation West Building, 1200 New Jersey Avenue SE., Washington, DC 20590, between 9 a.m. and 5 p.m., Monday through Friday, except Federal holidays. We have an agreement with the Department of Transportation to use the Docket Management Facility.

Privacy Act: Anyone can search the electronic form of comments received into any of our dockets by the name of the individual submitting the comment (or signing the comment, if submitted on behalf of an association, business, labor union, etc.). You may review a Privacy Act, system of records notice regarding our public dockets in the January 17, 2008 issue of the **Federal Register** (73 FR 3316).

Public Scoping Meeting

If you need special arrangements, please use the contact information in **FOR FURTHER INFORMATION CONTACT**. The meeting will start with an overview presentation, followed by a formal public comment period. Following the formal public comment period, we will hold an informal open house. At the open house, Coast Guard personnel will be available to provide more information about the National Environmental Policy Act (NEPA), Coast Guard rulemaking processes, and dry cargo residue discharges. A court reporter will be present during both the formal public comment period and the informal open house to record verbal comments from the public. The public will also be able to submit written comments related to this rulemaking at any time during the meeting. Verbal comments will be recorded and transcribed, and the transcription will be placed in the public docket along with any written statements that may be submitted during the meeting. These comments and statements will be addressed by the Coast Guard as part of the tiered Environmental Impact Statement.

Background and Purpose

Bulk dry cargo vessels on the Great Lakes sometimes wash the residue of non-hazardous and non-toxic cargo, like taconite (iron ore) pellets, coal, and grain, overboard. This ''sweeping,'' or discharge, of dry cargo residue (DCR) is allowed, under certain conditions, by 33 CFR 151.66, as amended by an interim rule published on September 29, 2008 (73 FR 56492), which was supported by an EIS (the ''first EIS'').

The interim rule also announced the Coast Guard's intent to conduct a second phase of this rulemaking before issuing a final rule. In the second phase, we want to determine what additional regulatory changes, if any, should be imposed on DCR discharges to offset any potential long term impacts from this practice. Those additional changes could include, among other possible measures, the mandatory use of DCR control measures or adjustment to the geographical boundaries within which discharges are currently allowed. A tiered EIS (40 CFR 1508.28; hereinafter referred to as the ''second EIS'') will allow the Coast Guard to focus on these specific issues, while excluding those that were decided in the first phase of the rulemaking, in order to determine whether further adjustments to the interim rule are needed.

As required by 40 CFR 1501.7, a Council on Environmental Quality regulation that implements NEPA, this notice begins an early and open public ''scoping process'' for determining the scope of issues to be addressed in the second EIS. We invite public comment on our current plan for preparing the second EIS. Currently, we intend to:

• Conduct an inventory of shoreside facilities for types of control measures used when loading and unloading dry cargo to and from vessels and types of dry cargo handled.

• Conduct an inventory of vessels that carry DCR for types of control measures used on board the vessel when loading and unloading.

• Quantify the current amount of cargo residues on vessels, with and without control measures.

• Review and analyze vessel DCR reporting forms in order to quantify DCR discharge amounts by cargo type, vessel class, and control measure.

• Evaluate costs for implementing, operating, and maintaining vessel and shoreside DCR control measures.

• Update previous impact analyses of DCR discharge on water quality changes and DCR disposition.

We may modify this plan in light of public comment received during the scoping process. This information will be used as a basis for selecting the proposed action from alternatives under consideration. Analysis of this information may also be used to develop additional alternatives not listed below that can be considered.

Possible Alternatives

Alternatives currently being considered for future Coast Guard action include:

- Adopting the interim rule as a final rule without changes. This will allow the current level of DCR discharges to continue in limited areas of the Great Lakes and under certain conditions. For the purposes of our environmental review in this second EIS, this represents the ''no-action'' alternative;
- Adopting a final rule based on the interim rule, but with changes designed to reduce the potential environmental impact of DCR discharges. Possible changes would be specified and could include:
  - Adoption of the mandatory use of DCR control measures;
- Control measures on vessels, and/or
- Control measures at the loading and unloading facilities;
  - DCR quantity discharge limits;
- DCR quantity limits could be scaled according to vessel class, size and/or route length;
  - Cargo type discharge limits; or
  - Additional restrictions on DCR discharge locations;
- Prohibit all DCR discharges in the Western Basin
- Zero-Discharge Alternative.

This is not an exhaustive list of alternatives. We intend to be guided by data on DCR discharges and DCR control measures and by consideration of all public comments.

Scoping Process

Public scoping is an early and open process for determining the scope of issues to be addressed in this second EIS and for identifying the issues related to the proposed action that may have a significant effect on the Great Lakes environment. The scoping process begins with publication of this notice and ends after the Coast Guard has:

- Invited the participation of Federal, State, and local agencies, any affected Indian tribe, and other interested persons;
  - The Coast Guard has requested the Environmental Protection Agency, the United States Fish and Wildlife Service, the National Marine Fisheries Service, the National Park Service, and the United States Army Corps of Engineers to serve as cooperating agencies in the preparation of this second EIS. With this Notice of Intent, we are asking Federal, State, and local agencies with jurisdiction or special expertise with respect to environmental issues in the Great Lakes region, in addition to those we have already contacted, to formally cooperate with us in the preparation of this tiered EIS.
- Determined the scope and the issues to be analyzed in depth in the second EIS;
  - From our first EIS, we have identified this preliminary list of environmental resources to receive attention in the second EIS:
- Sediment physical structure
- Protected and Sensitive Areas
- Benthic Community
- Invasive Species
- Socioeconomic Resources
- Identified and eliminated from detailed study those issues that are not significant or that have been covered elsewhere (for example, we do not anticipate detailed study of the following environmental resources that we determined, in the first EIS, to have ''no impact'' from DCR discharges: fish and other pelagic organisms, waterfowl, and recreational or commercial fishing);
- Allocated responsibility for preparing the tiered EIS components;
- Indicated any related environmental assessments or environmental impact statements that are not part of the tiered EIS;
- Identified other relevant environmental review and consultation requirements, such as Coastal Zone Management Act consistency determinations, and threatened and endangered species and habitat impacts;
- Indicated the relationship between timing of the environmental review and other aspects of the application process; and
- Exercised our option under 40 CFR 1501.7(b) to hold the public scoping meeting announced in this notice.

Once the scoping process is complete, the Coast Guard will prepare a draft second EIS, and we will publish a **Federal Register** notice announcing its public availability. If you wish to be mailed or e-mailed the announcement of the second EIS's notice of availability, please contact the person named in **FOR FURTHER INFORMATION CONTACT** or send a request to be added to our contact mailing list along with your name and mailing address or an e-mail address online, by fax, mail, or hand delivery according to the *Submitting Comments* instructions above. If you provide comments on this notice, we will automatically add your contact information to our contact mailing list and you will automatically be sent an announcement of the draft second EIS's notice of availability. We will provide the public with an opportunity to review and comment on the draft second EIS. After the Coast Guard considers those comments, we will prepare the final second EIS and similarly announce its availability and solicit public review and comment.

Dated: December 19, 2008.

Jeffery G. Lantz,

Director of Commercial Regulations and Standards, U.S. Coast Guard.

[FR Doc. E8–30804 Filed 12–24–08; 8:45 am]

BILLING CODE 4910–15–P

DEPARTMENT OF HOMELAND SECURITY

Transportation Security Administration

Extension of Agency Information Collection Activity Under OMB Review: Aircraft Operator Security

AGENCY: Transportation Security Administration, DHS.

ACTION: 30-day Notice.

SUMMARY: This notice announces that the Transportation Security Administration (TSA) has forwarded the Information Collection Request (ICR), OMB control number 1652–0003, abstracted below to the Office of Management and Budget (OMB) for review and approval of an extension of the currently approved collection under the Paperwork Reduction Act. The ICR describes the nature of the information collection and its expected burden. TSA published a **Federal Register** notice, with a 60-day comment period soliciting comments, of the following collection of information on October 10, 2008, 73 FR 60310. TSA has implemented aircraft operator security standards at 49 CFR part 1544, which require each aircraft operator to which this part applies to adopt and implement a security program.

DATES: Send your comments by January 28, 2009. A comment to OMB is most effective if OMB receives it within 30 days of publication.

ADDRESSES: Interested persons are invited to submit written comments on the proposed information collection to the Office of Information and Regulatory Affairs, Office of Management and Budget. Comments should be addressed to Desk Officer, Department of Homeland Security/TSA, and sent via electronic mail to *oira_submission@omb.eop.gov* or faxed to (202) 395–6974.

Appendix B Summary of Scoping Meeting Comments

No.	Comment on	Summary and Points	CH2M HILL Response
001	September 29th Rule Published in FR	It is my recommendation no changes be made to the current dry cargo sweeping requirements. There clearly is no ecological damage being done and requiring the shippers and in the end, public to bear an additional cost to good purpose is without merit.	Comment acknowledged. This alternative is included in the Draft Tiered EIS as the No Action Alternative
002	September 29th Rule Published in FR	I don't think any foreign substance should be allowed to be dumped in any fresh water source, especially one that people rely on for means of living. It shouldn't matter whether it costs the shipping companies money, don't they have enough that they can afford the extra cost.	The alternative of no discharged was evaluated in the Phase I Final EIS and found to not meet the purpose and need because it threaten the economic viability of the shipping industry. This conclusion was reevaluated in the Draft Tiered EIS in Chapter 2, and found to still be valid. Thus the no discharge alternative was considered but screened out.
003	September 29th Rule Published in FR	Commenter stated that he disagrees with the interim policy and supports No Action, as described in Phase I EIS (no discharge). Commenter does not believe the discharges have no effect on the ecosystem as there is much evidence to refute these claims. Believes that protecting only sensitive areas and not remainder of ecosystem is a function of protecting only what we understand, rather than other potential sensitive areas. Concerned with the alteration of the topography of the lake bottoms within the shipping lanes where "dumping" is concentrated. Believes more research on sweeping within the Great Lakes ecosystem is needed, particularly to understand effects at greater depths. (Summary)	The No Action alternative as identified in the Phase I EIS was determined to have a significant economic impact on the shipping industry. In the subsequent Tiered EIS, alternatives with greater reductions in DCR discharge than the interim rule were identified (Chapter 2) based on additional vessel monitoring and evaluated (Chapter 4).
004	Final EIS Dated August 2008	Comment on Cargo Sweeping into the Great Lakes. It is the cumulative affect of permitting cargo sweeping by freighters in the Great Lakes that is bound to be detrimental to the water quality. This affects not only wildlife but also to the health of the people in both Canada and the USA who consume water taken from the Great Lakes. Cargo sweeping should be treated in the same way as the discharge of effluent from main sewage holding tanks, that is it should not be permitted.	The environmental effects of permitted DCR discharges are described in Chapter 4 of the Tiered EIS.As described in the IEP, if material is hazardous or toxic then its discharge is not permitted. Thus, by definition DCR is non-hazardous and non-toxic. Any material found to be toxic or hazardous by studies conducted in support of the EIS (as reported in Appendix H sweepings characterization, chemical) or any other investigation, the discharge of such materials would be banned.
005	September 29th Rule Published in FR	Noted importance of PA's water and ports to the Commonwealth's environment, economy, and nation. Resubmitted comments given July 2008 on DEIS, as they still maintain those concerns as they relate to the rulemaking. The July 2008 document stated the Water Planning Office (WPO) opposes selection of alternatives allowing continued sweeping with recordkeeping on the basis of DCR discharge to Lake Erie being contrary to the PA Clean Streams Law, inconsistent with the federal Clean Water Act, and inconsistent with NPDES Vessel General Permit issued by USEPA. Supports mandatory requirements of controls and management practices on all carriers and at port facilitates to reduce or eliminate DCR. Requests list of all international agreements, Canadian laws, federal and state (U.S. laws) that regulate discharges and discussion on whether they prohibit DCR discharge. Believes potential for shipping to disperse invasive species carried within the dry bulk cargo, cargo holds, ship decks and cargo handling equipment, as non-native aquatic organisms are known to persist in the sludge of reportedly dewatered ballast tanks. States that ecologically and recreationally important fish species may be affected where the species are known to spawn on rocky substrate in the nearshore zone due to DCR. Believes that the discharges of clean stones should not be allowed to continue within 3 statute miles of shore. (Summary)	Compliance with referenced regulations is discussed in the regulatory framework section of Chapter 1. Chapter 1 of the Phase I Final EIS lists and summarizes all relevant international agreements and laws. Mandatory controls are incorporated into alternatives considered in Chapter 2. Both environmental consequences and cost implications are addressed by analysis of the Proposed Action and Alternatives (Chapters 2 and 4). Eliminating all DCR discharge within 3 miles was evaluated in the Draft Tiered EIS as a mitigation measure. The potential to spread invasive species associated with cargo was evaluated in the Phase I Final EIS and found not to be a concern because the storage of the cargo on the lake shore would have already introduced any species included in the cargo so shipping the cargo could not introduce new species.
006	September 29th Rule Published in FR	Expressed their support of the adoption of the Interim Rule as the basis of permanent regulations. The reporting requirements are relatively easy to fulfill, though unsure of the benefit from it. Concerned about the quarterly requirement considering some vessels might be in the Great Lakes less than every quarter and spend more of their time overseas, which may result in mistakes in reporting due to timing, and potential change in management, crew and ownership; suggested requirement changes for foreign-flag vessels to reporting when ships exit the St. Lawrence Seaway which will be more accurate and efficient. (Summary)	The comment is acknowledged. Continuation of the Interim Rule is considered as an alternative in Chapters 2 and 4. They non Canadian foreign vessels represent less than 0.5 percent of DCR so any uncertainty with this vessels was deemed inconsequential

No.	Comment on	Summary and Points	CH2M HILL Response
007	December 2008 Rule Making Announcement in FR	Stated that DCR has been thoroughly research for the last 10 years, and has been deemed insignificant. Expressed there is no need for further investigation and questioned the necessity of the additional record keeping. Said no knowledge of other control measures that should be studied. The cost of installing, operating, and maintaining DCR control systems has been answered in the EIS. These costs far exceed the industry's financial capabilities. In addition, it is good business practice to minimize DCR, If some system or practice was found to be beneficial and cost-effective, vessel operators should be given a reasonable period of time to procure equipment and/or train crew on a new procedure.	The environmental and cost implications of the Proposed Action and Alternatives are addressed by the analysis provided in Chapter 4 of the Tiered EIS.
		Expressed they would be surprised if any environmentally-sensitive areas have gone undetected. They envision no changes in the No Discharge Zones and would not endorse any new prohibitions without the most compelling evidence of need. There are other environmental issues then DCR on the Great Lakes that need to be addressed and therefore, need to move past this issue. (Summary)	Potential no discharge zones were evaluated in Chapters 2 and 4 of the Draft Tiered EIS and the Phase I Final EIS.
008	December 2008 Rule Making Announcement in FR	Several of the "potential" control measures indicated in the Federal Register notice should be requirements, rather than options. Reasonable requirements include shipboard conveyor skirts, broom and shovel usage and shore-side loading conveyor stoppages while the ship or belt is repositioned during loading. Appendix F assumed that deck sweeping and tunnel washing would take an estimated 3.5 hours at $1,700 per vessel hour. This assumes that vessels remain at dock an additional 3.5 hours solely for deck sweeping/tunnel washing purposes. It is reasonable to conduct dry deck sweeping simultaneously with vessel loading (since it requires several hours to load or unload a ship). There is a concern that the sediment alteration resulting from DCR discharge is creating more favorable conditions that may lead to invasive species eventual adaptation to the Lake Superior	Mandatory controls are incorporated into alternatives considered in Chapter 2. The potential for colonization of invasive species is addressed in Chapter 4. The costs for cleaning decks before leaving port were evaluated as part of the Draft Tiered EIS (Appendix E).
		Issuance of the Interim Rule was in direct conflict with the authority provided under Section 307 of CZMA. The agency requests that the USGC voluntarily extend the period for comments and for state consultation within the framework of CZMA. This extension would provide additional time for state consultation and an opportunity to review the first data submissions required as per the recordkeeping provisions of the DCR. of Minnesota takes the position that discharging DCR into Lake Superior is in direct violation of at least two state laws. (Summary)	This comment is acknowledged. The state CZM agencies were contacted and responded as part of the Phase I Final EIS. This Draft Tiered EIS provides the opportunity for extending the comment period.
009	September 29th Rule Published in FR	Describes several additional control measures to study. The Canadian Ship owners Association (CSA) would favor a phase-in that would allow sufficient time for the planning of capital expenditures. We have the following specific comments regarding the reporting form: • The reporting form requires documenting information for not only the vessel but also the control measures used and the • "Estimated residue to be swept into water" – This information is recorded in the "For Cargo Loading and Unloading Operations" section of the reporting form as proposed. However, as discharge of DCR is prohibited in port, the column "estimated residue to be swept into water" should be moved to the "For Residue Sweeping Operations Only" section of the reporting form. • The form uses the term "residue sweeping operations". A definition of "residue sweepings" is not included and should be added. The CSA is encouraged by the proposed rulemaking which acknowledges the minimal environmental impact of these discharges; the will continue to employ and refine their management practices to minimize quantities of DCR. (Summary)	The comment is acknowledged and phasing in of the rule will be considered as part of implementation. The reporting requirements were reevaluated in the Draft Tiered EIS and alternatives considered (Chapter 2)

No.	Comment on	Summary and Points	CH2M HILL Response
010	September 29th Rule Published in FR	Definition of cargo sweepings: Would suggest replacing the expression “cargo sweeping” with “cargo disposal”. In the Canadian regulations, disposal of cargo residues may either be in the form of sweepings or washings, which may cause confusion between American and Canadian regulations. Record-Keeping Procedures: While we would have preferred that the reporting form be consistent with international practices under MARPOL Annex V, the CG-33 Bulk Dry Cargo Residue Reporting Form does not present any reporting difficulty. However, the quarterly reporting requirement may present a difficulty for foreign-flagged ships that do not trade regularly in the Great Lakes. With a view to avoiding situations in which reporting deadlines may be missed, we would suggest that records be e-mailed either when leaving the Great Lakes, or submitted to the U.S Coast Guard at Massena. Request for Additional Comments: We believe that it is important to promote and encourage the implementation and recognition of voluntary environmental programs like the Green Marine’s Environmental Program of the St. Lawrence and Great Lakes Marine Industry and the Green Award. (Summary)	The comment is acknowledged. The term "DCR discharge" is now used generically because of the different methods of DCR removal. See response to comment 6 regarding foreign vessels.
011	DCR Discharges in the Great Lakes; Preparation of EIS (FR Dec 08)	I am concerned that the U.S. Congress revised and upheld a policy that will continue to allow freighters to dump traces of cargo such as iron ore, wood chips and limestone into the Great Lakes. Although cargo sweeping is illegal in U.S. waters it seems that carriers on the Great Lakes are now operating under an Interim Enforcement Policy since 1993 which allows for the incidental of dry cargo residues. Freighters, I am told, dump nearly 500 tonnes of waste into the Great Lakes water system annually. I have major concerns about the long-term effects of such practices. Much of the waste, especially iron ore and taconite, contains toxic metals such as mercury that have the potential to contaminate wildlife as well as people. One act of cargo sweeping or one act of discharging ballast water is responsible for the decline of the Great Lakes but collectively, these acts are ravaging the entire ecosystem. As long as the U.S. Coast Guard sanctions the practice of sweeping waste into the Great Lakes, we cannot be confident that our lakes are protected. I feel that the USCG’s interim rule is out of step with existing environmental protections for the lakes in the United States and Canada, and internationally. Please consider my request for you to take steps necessary to stop this practice altogether. Other industries must treat wastes in plants designed for that purpose and I don't see that this situation is any different. Please protect our precious Great Lakes. Thank you.	Based on additional vessel monitoring, alternatives have been refined, and both environmental consequences and cost implications are addressed by analysis of the Proposed Action and Alternatives (Chapter 4). This includes no discharge and significantly reduced discharge.
012	U.S. DHS/USCG - Advanced Notice of Proposed Rulemaking; Request for Information	The Lake Carrier's Association (LCA) questions the need for further study since the first EIS was based on more of a decade of research and results were not suggested as preliminary or speculative. LCA believes the Final Rule will achieve protection of the Great Lakes and allow to maintain an efficient way to move large quantity of materials. The commenter states that self regulation has limited discharge to de minimis amounts, and further reduction should not be regulated under regulatory requirements as it is in the interest of the shipping companies from a business perspective to reduce DCR. No additional No Discharge Zones should be added to the list as this list was based on a decade-plus of studies unless further study was conducted. The Zero Discharge Alternative should be rejected. Due to fuel efficiency, vessels are better for the environment than trucks and freight trains. (Summary)	The comment is acknowledged.
013	DCR Discharges in the Great Lakes; Preparation of EIS (FR Dec 08)	The Coast Guard funded a $10 million study with arguably the best environmental research company in the nation to determine what, if any, negative impact cargo sweeping had on the Great Lakes. The study targeted routes traveled by thousands of ships for nearly a century, and the "worst" area identified, off Sandusky, Ohio found an amount of cargo residue equivalent to 3 cups of material spread evenly over the area of a football field. The study examined areas that were traversed by many, many ships over the years. At one time there were over 600 US flagged ships sailing on the lakes. Currently, there are only 62 US flagged ships operating on the Great Lakes. Advances in technology, employing best management practices, and the acute environmental awareness of today's professional mariner have reduced the amount of cargo residue to negligible levels, as evidenced by the	The comment is acknowledged.

No.	Comment on	Summary and Points	CH2M HILL Response
		current DCR reporting requirements. Much of that residue consists of natural material, particularly limestone, which has beneficial properties for fish habitat and the health of the lakes. As a professional mariner, and more importantly, an avid Great Lakes fisherman, It think anyone would dispute the fact that the Great Lakes are cleaner now than they were 40 years ago. My friends in the shipping industry live, work and play in our Great Lakes waters. They have a vested interest in the long term health of the lakes, and they are committed to reducing ANY harmful discharges into our waters. The studies have been done, and good science has determined that there has been no negative impact from "cargo sweeping" on our Great Lakes to date, and the amount of cargo entering the water is only a fraction of that discharged historically. There is no scientific basis to prohibit the continued practice of cargo sweeping as it exists today.	
014	DCR Discharges in the Great Lakes; Preparation of EIS (FR Dec 08)	We do not concur that these materials are “nontoxic” and “non-hazardous.” Studies have demonstrated that these materials can have human health impacts over long-term exposure periods. The potential impacts to the Great Lakes environment are not fully understood but we do know that there are impurities in coal, such as PAHs (polycyclic aromatic hydrocarbons) and selenium, and in taconite, chromium. Controlling contaminant sources to Lake Michigan and Lake Superior are key components of the Lakewide Management Plans (LaMP-Lake Michigan 2008; LaMP-Lake Superior 2008). Lake Superior is identified as a demonstration lake by the states of Minnesota, Michigan and Wisconsin and the Province of Ontario for the virtual elimination of potentially toxic, bioaccumulative pollutants. A Pollution-Prevention approach is consistent with the Lake Superior Binational Program Zero Discharge Demonstration Project and is the preferred management approach when potential human and environmental impacts are not fully understood. Controlling the dry cargo residue by means other than washing it overboard is a reasonable expectation and a responsibility of the shipping industry.	As described in the IEP, if material is hazardous or toxic then it is not regulated as cargo sweepings (i.e. DCR). Thus, by definition DCR is non-hazardous and non-toxic. Any material found to be toxic or hazardous by chemical and toxicity studies conducted in support of the EIS (as reported in Appendix H sweepings characterization, chemical) or any other investigation, the discharge of such materials would be banned.
		1. Allowing the discharge of dry cargo, as is proposes under the USCG “Dry Cargo Residue Discharge into the Great Lakes” rule in 33 CFR 151.66, is in direct conflict with the U.S. EPA proposed NPDES vessel General Permit. Section 2.2.1 of the EPA general permit states “Vessel owner/operators must clear their vessels’ decks of debris, garbage, residue and spills prior to conducting deck washdowns and prior to departing from port to prevent these constituents from entering any waste stream.” Inclusion of this best management practice requirement in EPA’s permit constitutes a technology-based effluent limit to prevent the discharge of substances that may adversely impact water quality. We agree with the EPA and believe the cleaning of material off the deck prior to washdown is an appropriate preventative measure to keep cargo residues out of the Great Lakes.	Section 2.2.1 of the 5 Feb. 2009 Vessel General permit does not include the cited language. The Section does include the following "Vessel owner/operators must minimize the introduction of on-deck debris, garbage, residue and spill into deck washdown and runoff discharges." The minimize DCR alternative evaluated in the Draft Tiered EIS includes the same requirement.
		2. The DNR believes that discharges provide potential substrate for invasive and/or exotic species. Hard residues washed overboard creates desirable substrate for mussel colonization that otherwise is absent in some areas. This could lead to increased infestations of zebra and quagga mussels. Dry cargo residue discharge could have a negative impact on the benthic organisms. The EIS identifies a degree of uncertainty about the magnitude of this impact. The environmental and economic consequences of the potential for increased invasive mussel populations must be given important consideration.	In Chapter 4 and Appendix K , the analysis of the Alternatives as they relate to invasive species is addressed.
		3. The proposed approach to dry cargo residue management is inconsistent with Wisconsin Statues and rules. It is also inconsistent with Wisconsin’s approved Coastal Zone Management (CZM) plan. Under s. NR 102.04(a), Wis. Adm. Code, it states…. “Substances that will cause objectionable deposits on the shore or in the bed of a body of water, shall not be present in such amounts as to interfere with the public rights in waters of the state.” Under S. 30.12, Wisconsin Statutes, the fill or deposition of material in navigable waters is prohibited.	The Phase I Final EIS and Chapter 1 of the Draft Tiered EIS addresses the issue of compliance with state laws and regulations. As stated in the documents the DCR rule does not preempt state law.

No.	Comment on	Summary and Points	CH2M HILL Response
015	DCR Discharges in the Great Lakes; Preparation of EIS (FR Dec 08)	The Minnesota Pollution Control Agency (MPCA) believes the Zero Discharge Alternative is technically and economically feasible for commercial ships within Great Lakes waters. Suggested solutions for a Zero Discharge Alternative include reasonable requirements, cost control measures (on-board storage of tunnel wash water while under way), and alternative loading considerations for shore facilities and shipboard actions. The MPCA believes further issues should receive in-depth analysis in the second EIS, which are using Lake Superior as a demonstration lake for Zero Discharge of persistent, bio-accumulative substances, DCR discharges providing potential substrate for invasive/exotic species, and DCR effects on the benthic community. It is believed by the MPCA that discharging of DCR into Lake Superior is in violation of state law. (Summary)	The Phase I Final EIS concluded that no discharge of DCR would threaten the continued economic viability of the shipping industry and the Draft Tiered EIS reexamined the question and reached the same conclusion. The issue of invasive species was thoroughly evaluated as reported in Appendix K. Response to comments 14 addresses compliance with state law.
016	DCR Discharges in the Great Lakes; Preparation of EIS (FR Dec 08)	The National Wildlife Federation (NWF) states dry cargo residue discharges into the Great Lakes are prohibited by Federal and International law. The NWF supports the Zero Discharge alternative as it is consistent with these laws and it protects the Great Lakes from deleterious impacts of DCR. If the Zero Discharge alternative is not selected, the NWF believes improvements are needed such as establishing achievable improvements to existing practices and an increase on restrictions of discharge areas. NWF supports an expanded scope of the second EIS which would include a further evaluation of restrictions and technologies, and further study of the toxicity of dry cargo residue. (Summary)	Compliance with referenced regulations is discussed in the regulatory framework section of Chapter 1 of the Phase I Final EIS. Alternatives suggested are described in Chapter 2 and their impacts evaluated in Chapter 4 of the Draft Tiered EIS.
017	DCR Discharges in the Great Lakes; Preparation of EIS (FR Dec 08)	Shipping Federation of Canada (SFC) supports the USCG approach to develop a second EIS. SFC suggests the assessment of types of control measures includes best management practices and technology measures, since both can result in reductions of DCR. If the Interim Rule is to be implemented successfully regulatory requirements must be manageable from an operations standpoint, particularly for foreign-flagged vessels, which could include submitting records by means of e-mail when leaving the Great Lakes, or by submitting the form to the U.S. Coast Guard at Massena. (Summary)	Alternative 4 in the Phase I Final EIS (the Proposed Action with DCR Control Measures on Ships) would propose to adopt the IEP with recordkeeping and require DCR control measures on all ships carrying DCR. A modified version of Alternative 4 is described in Chapter 2 of the Tiered EIS, and the analysis of this alternative is provided in Chapters 4 and 5 of the Tiered EIS.
018	DCR Discharges in the Great Lakes; Preparation of EIS (FR Dec 08)	Coastal States Organization (CSO) states under the Coastal Zone Management Act a federal agency wishing to take action that is inconsistent with state law must show cause as to why it is moving forward with a rule that is inconsistent with state law. The proposed continued discharge of DCR is inconsistent with state laws, rules and Coastal Management Plans. It is the opinion of CSO that adopting a rule in conflict with state law creates regulatory confusion for the shipping industry and places unreasonable enforcement burdens on the states. DCR can be dramatically reduced in a practical and economically feasible way, and it is in the opinion of CSO that the first EIS was insufficient in providing consideration to alternatives to sweeping. It is recommended shoreside control measures such as dock loading and unloading be considered as it provides sufficient time to clear the deck of dry residue and, while in dock, the washings can be treated on land.	The issue of relation to state law is addressed in Response to comment 14 and in Chapter 1 of the Phase I Final EIS. Methods for reducing DCR are identified and evaluated in Chapters 2 and Appendix D of the Draft Tiered EIS.
019	DCR Discharges in the Great Lakes; Preparation of EIS (FR Dec 08)	Expressed their concern about impacts of allowing discharge of DCR, and the conflict with the Wisconsin Department of Natural Resources' federally-approved policies.	The issue of relation to state law is addressed in Response to comment 14 and in Chapter 1 of the Phase I Final EIS.
020	DCR Discharges in the Great Lakes; Preparation of EIS (FR Dec 08)	I support the NWF in trying to clean up the great lakes from dry cargo residue. It is clear that the coast guard is allowing too permissive a regulation, which negatively impacts life for all on earth. The coast guard is out of line here and not operating in the best interests of all American citizens, who want clean water. The great lakes have been subject to siege from foreign shippers. That needs to stop.	The comment is acknowledged

No.	Comment on	Summary and Points	CH2M HILL Response
021	U.S. DHS/USCG - Advanced Notice of Proposed Rulemaking; Request for Information	The Michigan Department of Environmental Quality (DEQ) stated based on the permitting criteria, adverse impacts to coastal resources are anticipated from the proposed DCR Rule, therefore, the rule must be determined to be inconsistent with Michigan's Coastal Management Program (CMP). A letter dated July 10, 2006 stated the current practice and proposed DCR rule would be a violation of State law.	The issue of relation to state law is addressed in Response to comment 14 and in Chapter 1 of the Phase I Final EIS.
022	U.S. DHS/USCG - Advanced Notice of Proposed Rulemaking; Request for Information	As a member of the Coastal States Organization (CSO),The Pennsylvania DEP Water Planning Office expressed support for CSO comments, which they reviewed, helped develop and support.	This comment is acknowledged.

Dry Cargo Residue Reporting Form Evaluation for Shipping Activity from Sept. 29, 2008, to Jan. 15, 2009

PREPARED FOR: U.S. Coast Guard

PREPARED BY: CH2M HILL

DATE: November, 2009

Introduction

The U.S. Coast Guard is preparing a tiered Environmental Impact Statement (EIS) for the second phase of rulemaking for nonhazardous and nontoxic dry cargo residue (DCR) discharges from bulk cargo ships on the Great Lakes. An interim rule published on September 29, 2008 (73 FR 56492), regulates the discharge of DCR in the Great Lakes. Under the interim rule, nonhazardous and nontoxic DCR discharge can continue in limited areas of the Great Lakes and under certain conditions. The interim rule added new recordkeeping and reporting requirements and encouraged carriers to adopt voluntary control measures for reducing DCR discharges. A facsimile of the reporting form (form CG-33), which shows the required recordkeeping information, is shown in Figures 1 and 2.

This memorandum documents and evaluates the last quarter of recordkeeping data for the 2008 shipping season, which represents the reporting period between September 29, 2008, and January 15, 2009. This evaluation will provide input in the preparation of the tiered EIS, which will support the development of the final rule regulating DCR discharges in the Great Lakes.

The objectives of this memorandum are to

- Develop an inventory of U.S., Canadian, and foreign vessels carrying dry bulk cargo on the Great Lakes
- Quantify DCR sweepings as reported by the bulk cargo carriers and compare these quantities with those used in the first EIS
- Develop a database of installed control measures for each bulk cargo vessel as determined from the recordkeeping information
- Determine the usefulness of the recordkeeping data in analyzing the effectiveness of various control measures at reducing the amount of DCR generated during the loading and unloading of bulk cargo
- Provide recommendations to improve the usefulness of the data

Methods

Vessel DCR records submitted to the USCG in hard copy by the shippers were manually entered into a Microsoft Excel database. The database was structured to allow for data analysis and query and for future use within a Geographical Information System (GIS) and for future tasks beyond the vessel records analysis. The procedures for developing the database included the following:

1. Entering data as it appeared on the vessel record form (Data on the DCR reporting forms were entered into the electronic database so that each row on the DCR forms corresponded to a separate line in the DCR database.)
2. Converting the DCR quantity to consistent units of cubic feet and pounds (Reported units greatly varied, from cubic meters, cubic yards, pounds, tons, etc.)
3. Converting the discharge location to a consistent latitude and longitude format for future use in a GIS
4. Converting the vessel speed to a consistent unit (Reported units varied between knots and mph.)
5. Performing a random check of approximately 17 percent of the database entries for quality control

The database includes all of the information recorded on the DCR sheets, additional general information on the individual ships and facilities, and information that would allow for future retrieval. The information within the database was entered exactly as it was reported on the vessel records, except when explicit, easily correctable errors were observed (spelling errors, consistent ship names, etc). Additional general information regarding the individual ships was obtained mostly from *Know Your 2008 Ships* (Marine Publishing, 2008), www.boatnerd.com, and from vessel company Web sites. Additional facility information was obtained from the U.S. Army Corp of Engineers (ACOE, 2009) and through Internet searches. In total, 44 key items of information were included as fields in the database. Table 1 summarizes the information included in the database for each loading and unloading event recorded on the vessel records and the preferred units.

Overall, the primary assumption about the database was that the data reported on the DCR datasheet was correct. There was no reason to assume that any of the data were incorrect, unless a given entry was significantly different from the rest of the entries for a similar situation. The only exception to this was when there was an obvious inconsistency with similar records for the same ship facility, or with any other records with similar information. When obviously inconsistent data were omitted from the data sheet and similar data did not provide insight on the missing data, the corresponding line on the vessel form was left blank as if nothing had been reported on the vessel form.

Data Discrepancies and Corrective Action Taken During Database Development

Discrepancies in the vessel records required some manual corrections of obvious errors. There were, however, examples of data discrepancies identified when data queries revealed that vessel recordkeeping was not consistent between records or when the vessel records were not completed according to the reporting form instructions. These discrepancies were generally not corrected because of the size of the database, i.e., manual entry-by-entry check was not possible for the more than 2,500 entries. In addition, some of the entries could not be corrected because the intent of the vessel record was not clear. A summary of some of the significant discrepancies are as follows:

- Multiple rows were used to record a single unloading or loading event and subsequent DCR-sweeping event. To account for the use of multiple rows for a single event, records were removed from the data analysis if unloading or loading had not been specified or if no DCR volume had been specified. It is estimated thatfor this reason, about 16 percent of the usable data was removed from the statistical analysis. In order to have used these data, the entries would have to be evaluated individually and professional judgment made on what was meant by each data entry.

- Facility names were inconsistent or incorrect, and many required internet searches to verify or correct the names. Often there was not enough information to determine the actual facility referred to on the DCR reporting form to make the database consistent. Several facilities that were candidates for the direct observation investigation were researched to determine correct facility names. Otherwise the entries were not corrected due to number of discrepancies.

- Based on internet searches and industry knowledge of the shoreside facilities, the facility control measures were found to be incorrect on many of the reporting forms, likely because a vessel's crew was not familiar with facility control measures. For example, a DCR reporting form may have indicated that a certain facility did not use troughed conveyors for loading cargo, when previous visits by team members confirmed they exist at the facility. The entries were not corrected due to the large number of discrepancies.

- The DCR volume and vessel speed were recorded with inconsistent units or no units. These records were corrected by converting the values into a common unit, or assuming that a value recorded without a unit was provided in the unit requested on the form (cubic meters for DCR volume and knots for vessel speed).

These numerous and substantive inconsistencies and errors in the reporting forms create considerable uncertainty in the database. The number of flaws we have discovered and checked indicates the reliability of the information in the forms may be suspect, particularly for that which cannot be checked (e.g., quantity of DCR). In addition, the database cannot distinguish between deck and tunnel DCR. Past observations indicate that DCR quantity from these two sources can be very different, and variation due to source of DCR (deck or tunnel) can be large compared to variation resulting from control measures. This high degree of uncertainty in the database constrains a rigorous statistical and quantitative analysis of the data.

Dry Cargo Residue Densities and Corrective Action

The densities of limestone and taconite provided on the DCR reporting form were found to be inaccurate subsequent to preparation of this memorandum. The limestone density provided on the form is 150 lbs/ft^3 and the taconite density on the form is 222 lbs/ft^3. The density of coal of the form (50 lbs/ft^3) was accurate, so no adjustment was necessary for coal. Samples of limestone and taconite collected in June 2009 during the direct observation program ranged from approximately 94 to 103 lbs/ ft^3 and 125 to 130 lbs/ft^3, for limestone and taconite respectively. These values agree reasonably well with literature values for the two cargos, which range from 85 to 110 lbs/ft^3 for limestone and from 107 to 175 lbs/ft^3 for taconite (see Table 2 of "Dry Cargo Residue Reporting Form Evaluation for Shipping

Activity from January 16, 2009, to July 15, 2009". To account for the incorrect densities on the reporting form, the reported DCR volumes for these cargos were corrected in the database using a density of 100 lbs/ft^3 for limestone and a density of 130 lbs/ft^3 for taconite. To be conservative, it was assumed that all reported DCR volumes were estimated using the incorrect densities on the DCR reporting form, and therefore all reported volumes were adjusted using the correct densities. This assumption likely overestimates the volumes for those records that were reported based solely on a visual estimate of volume, but accounts for those records that were reported based on an estimated mass of DCR that was converted using the densities on the form. This approach provides a conservative upper bound of DCR volumes in order to assess impacts of the practice of discharging DCR to the Great Lakes. Because of the incorrect densities on the reporting form, the summary statistics in this memorandum were corrected for limestone and taconite in Tables 2 and 3.

Statistical Analysis

To evaluate the significance of the various control measures on DCR quantities, analysis of variance (ANOVA) techniques were applied. ANOVA is a family of methods that partition the total variation in a data set into components that can be attributed to potential sources of variation (as opposed to performing separate two-sample comparisons of the data with and without each control measure). With the DCR data, these potential sources were the 17 facility control measures for the loading operation and the 20 vessel control measures for the unloading operation. The control measures were treated as indicator factors, using a value of 0 or 1 depending on whether the control measure was present or not. Separate ANOVAs were completed for the three different cargo types (e.g., limestone, coal, and taconite).

Since the data were survey data (as opposed to a controlled experiment where the combination levels of each control measure could be planned), the data were unbalanced. This means not only that some control measures were present more than others, but that the various combinations of control measures were present in various quantities (and some not present at all). However, considering the rather large data set (which provided the opportunity for most control measures to be represented alongside a variety of other control measures), the unbalanced nature of the data is not thought to be a serious impediment to acquiring insight into most control measures as to whether they are significant factors in predicting DCR quantity (except for the control measures so weakly represented in the data set that only a small number of cases existed where they were present).

An ANOVA probability was calculated for each control measure. Each probability represents the likelihood that the observed effects of the control measure on DCR quantity could be due to random noise in the data. Thus, the lower the probability, the stronger the indication that the control measure is a significant factor. Often a significance level is chosen to compare to the probabilities. For instance, with a significance level of 0.1, any probability less than 0.1 would be considered an indication of a significant control measure based on the expectation that the observed effect of the control measure in the data would be expected to occur randomly only one in 10 times.

The ANOVAs were run with both raw data and rank-transformed data. The former is a traditional approach, but technically its probabilities depend on an assumption that the scatter in the data, or the spread of data points for the various control measures is normally distributed (an assumption not generally valid). Using rank-transformed data provides a nonparametric approach that does not depend on any given statistical distribution. In practical terms, the ANOVA with raw data is more heavily influenced by outlying (extreme) values than is the rank-transformed ANOVA. Both approaches can offer useful insights.

The conclusion that a control measure is a significant factor based on the probability's relationship to the significance level can lead to occasional false positives. For instance, using a significance level of 0.1, one might expect approximately 10 percent false indications of significance (just as one would expect approximately 5 percent such false indications with a significance level of 0.05). ANOVA is a two-sided test, in that either lower or higher DCR quantity values in association with given control measures will lead to a significant conclusion. If one does not expect given control measures to promote higher DCR quantities, yet there are a few significant cases (based on low calculated probabilities) where the control measure appears to be promoting greater DCR quantity, the explanation may be that these were false positive conclusions.

Results

The data evaluation included only those data entries that contained a load or unload event, identified the cargo type, and reported a DCR quantity, including a value of zero. If the DCR quantity on a record was blank, the entry was not included in the evaluation because it was unknown if the DCR quantity was zero, a value greater than zero, but not recorded, or if the DCR quantity was included as part of a subsequent entry. By using only entries with at least these three parameters, the evaluation considered only the higher quality data.

The results of the vessel DCR reporting are summarized in Tables 2 through 4. Summary statistics for the volume of DCR reported for coal, limestone/stone, and taconite are shown in Table 2, broken down by loading and unloading events combined and separately. Table 3 presents summary statistics for the corresponding masses of DCR, and Table 4 presents the total time spent discharging for each DCR type. The values presented in Tables 2 and 3 represent a summary of DCR reported for loading and unloading events but do not represent only DCR discharge events. Some records reported DCR volumes for a given event but did not include an associated discharge for the event. Therefore, the summary statistics describe the DCR quantities generated by loading and unloading events, but include both discharge and nondischarge events.

DCR Amounts and Discharge Time for Loading and Unloading Operations

The DCR records data indicate that on a volume basis for all loading and unloading events, the average volume of taconite residue, at 32.9 ft^3, is greater than coal residue or limestone/stone residue—17.5 ft^3 and 19.0 ft^3, respectively (Table 2). However, the average volume can be biased by a few extreme events; therefore, examining the median value, or the number separating the higher half of the data set from the lower half of the data set (i.e., the 50th percentile) can provide a more representative value for the most common DCR volume per event.

The median volume of coal residue from all loading and unloading events (4.0 ft^3) is higher than the median value for limestone/stone (3.0 ft^3), but the same as that of taconite (4.0 ft^3) (Table 2). The median volume of taconite is about eight times less than the average, the median volume of coal was about four times less than the average, and the median volume of limestone/stone was about six times less than the average amount. This would indicate that some large spillage events or gross overestimates of volume heavily influenced the average amount of taconite residue and to a lesser extent, the average amounts of coal and limestone/stone residues. The large differences in maximum residue volumes support this observation. The maximum volume of taconite residue reported is 1,812 ft^3, which is much greater than the maximum residues reported for coal and limestone/stone (106 ft^3 and 530 ft^3, respectively).

On a mass basis for all events, the average mass of taconite residue is 4,271 lbs, which is greater than the mass of coal residue or limestone/stone residue—1,363 lbs and 1,904 lbs, respectively (Table 3). However, the median taconite residue from both loading and unloading events is about eight times smaller, at 525 lbs. The differences between average and median masses of coal and limestone/stone are not as great. The median mass of coal from loading and unloading is 200 lbs, or about four times less than the average amount, and the median mass of limestone/stone is 300 lbs, or about six times less than the average amount.

Table 4 presents the summary statistics for the time spent sweeping DCR for each cargo type. The average time spent sweeping coal and limestone/stone residue, about 150 minutes, is very similar for combined loading and unloading operations. The average time spent sweeping taconite residue, 192 minutes, is greater. There is not as much variation in the reported time for sweeping DCR as evidenced by the median time for each cargo. The median time required is about 14 to 30 percent less than the average times reported.

DCR Amounts and Discharge Time for Unloading Operations

The DCR records data indicate that on a volume basis, the average volume of taconite residue from unloading operations (32.9 ft^3) is greater than that of coal residue or limestone/stone residue—17.4 ft^3 and 13.2 ft^3, respectively (Table 2). However, the median coal residue is about twice as high (approximately 2 ft^3 more) as the median residue for limestone/stone. On a mass basis, the median taconite residue (597 lbs) is about three times higher than the median coal residue (200 lbs). The median mass of limestone/stone residue from unloading (265 lbs) is similar to that of coal (Table 3).

The time spent discharging DCR after unloading operations is similar among the three cargo types, with taconite residue requiring slightly more time to sweep. Taconite residue requires a median time of 145 minutes to sweep, whereas coal and limestone/stone are very similar, with median times of 127 and 128 minutes, respectively (Table 4).

DCR Amounts and Discharge Time for Loading Operations

The DCR records data indicate that on a volume basis, the average volume of limestone/stone residue from loading operations (26.8 ft^3) is greater than that of coal (17.5 ft^3), but similar to that of taconite (27.9 ft^3) (Table 2). The median volumes of DCR generated from loading operations are similar among the three cargoes and similar to the median volumes from unloading operations as well.

On a mass basis, the median mass of limestone/stone and taconite residue for loading events is similar—400 lbs and 445 lbs, respectively (Table 3). The median mass of coal residue resulting from loading operations, 212 lbs, is considerably less than that of the other two cargos.

The time spent discharging DCR after loading operations varies considerably among the three cargo types (Table 4). The median time required to sweep taconite residue after loading events is 180 minutes. In contrast, the time required for sweeping limestone/stone residue after loading events is only one-half this amount, or 90 minutes. The time required to sweep coal residue after loading operations is 120 minutes.

Comparison of DCR Amounts between Loading and Unloading Operations

The median DCR volume for coal for unloading events is similar to that reported for loading events (Table 2). This suggests that the unloading operations and control measures used on the ships for this cargo generally generate similar DCR as the loading operations, based on the vessel reporting forms. The median DCR volume reported for limestone/stone unloading events is considerably less than that reported for loading events. However, the data for taconite suggest the opposite trend where loading operations have a lower median DCR volume than unloading events (Table 2). This suggests that taconite loading operations and control measures generate less DCR than ship operations and control measures during unloading events.

Comparison of DCR Amounts Between Phase I and Phase II

Tables 5 and 6 compare the DCR amounts used in the first EIS (Phase I), with those determined from an analysis of the vessel DCR records from the last quarter of the 2008 shipping season (Phase II). The Phase I amounts were based on data from voluntary reporting by the Great Lakes shipping industry.

Table 5 presents a comparison of summary statistics for the three cargos of primary interest (coal, taconite, and limestone/stone) for all data reported during the first quarter of mandatory reporting with the Phase I data used in the first EIS. The statistics for Phase I do not include data points where the mass reported was greater than 10 tons. This comparison shows that the average mass of all three cargo types appears to be greater than the average masses used in the Phase I investigation. However, the average value can be biased by a few extreme events; therefore, examining the median value can provided a more representative value for the most common DCR value. The median masses of coal and limestone/stone are similar between Phase I and Phase II, but the median mass of taconite in Phase II appears to be about twice the value of that in Phase I, at least without values greater than 10 tons removed from the data set.

To provide a more direct comparison between Phase I and II DCR quantities, values greater than 10 tons were removed from the Phase II data set and the summary statistics of this revised data set were compared with the Phase I data in Table 6. This evaluation did not change the average or median values for coal residue. The average mass of limestone/stone decreased for Phase II from 1,906 lbs to 1,494 lbs, but the median value did not change. The average mass of taconite decreased from 4,266 lbs to 1,602 lbs, and the median value decreased from 524 lbs to 470 lbs. Therefore, the median mass of taconite residue reported during the last quarter of the 2008 shipping season (470 lbs) is greater than the median mass identified in Phase I (282 lbs). However, the median masses of coal and limestone/stone are slightly less than the values calculated in Phase I.

To evaluate reporting variability among individual vessels, the two ships for which the most records were available from both phases were selected and compared (Table 7). This comparison showed that the amounts of DCR reported by one ship (Vessel 56) are very different from the amounts reported during Phase I. The median masses of DCR for all three cargo types are consistently greater in the Phase II data then they are in the Phase I data for this vessel. In contrast, the data for the other ship (Vessel 7) were more consistent between Phases I and II. The median mass of taconite reported by this vessel is the same for both phases (100 lbs). Although the median mass of limestone/stone for Phase II is twice as high as that during Phase I, the difference is much less than that observed for Vessel A. Similarly, the median mass of coal is greater for the Phase II data, but the difference is much less than for the other ship, and there was only one record in Phase II, compared to eight records in Phase I. The reasons for the differences between Phase I and II amounts and the large difference between the ships is unknown, but it may be related to reporting errors during either phase of reporting, and the number of records for each ship between Phases I and II.

Vessel DCR Amounts and Control Measures

Table 8 presents a summary of the reporting data for all vessels that reported DCR during the first mandatory reporting period for the last quarter of the 2008 shipping season, between September 29, 2008, and January 15, 2009. The data represents an inventory of all vessels that reported and identified the control measures used during each reporting event. Table 8 presents summary DCR statistics for each vessel and identifies the control measures reported at least once, as well as the country of origin, the year constructed, and the length of the vessel. Vessels highlighted in the table are ones that had 10 or more entries in the database. These vessels could be targeted for direct observations, if the vessel records are indications of ship utilization frequencies.

DCR Amounts. Of the vessels with more than 10 records for taconite during the first mandatory reporting period, *Vessel 34* had the lowest median DCR volume reported, with a median of 0 ft^3 of taconite residue reported. In contrast, *Vessel 7* had a median volume of 35.3 ft^3 of taconite residue. The median DCR volume for all vessels reporting taconite residue was 2.68 ft^3.

Of the vessels with more than 10 records for coal during the first mandatory reporting period, *Vessel 13* has the lowest median DCR volume reported, with a median of 1.77 ft^3 of coal residue reported. In contrast, *Vessel 15* has a median volume of 35.3 ft^3 of coal residue. The median DCR volume for all vessels reporting coal residue is 4.0 ft^3.

Of the vessels with more than 10 records for limestone/stone during the first mandatory reporting period, the *Vessel 56* has the lowest median DCR volume reported, with a median of 0.67 ft^3 of limestone/stone residue. In contrast, the *Vessel 45* has a median volume of 35.3 ft^3 of limestone/stone residue. The median DCR volume for all vessels reporting limestone/stone residue is 1.77 ft^3.

Control Measure Effectiveness. Table 9 presents the ANOVA results for determining which vessel control measures showed a significant effect on DCR volumes. Control measures considered to have a significant effect on DCR volume at an alpha level of 0.2 are indicated in the table, along with the direction of the effect (i.e., the mean DCR amount was either less or greater when the control measure was used). The table presents ANOVA results separately for coal, limestone/stone, and taconite, and for all three cargos together. The table also presents ANOVA results for the raw data and for the rank transformed data set to allow a nonparametric analysis of the data.

The results indicate that several vessel control measures show a significant effect on DCR amounts, but the effect varies by cargo type and in some cases the results show a significant effect in the positive direction (i.e., a greater mean DCR amount when a given control measure is reported). Variability in the estimated DCR quantities and possible reporting errors for which control measures are associated with a given unloading event might explain these apparently contradictory results.

Table 10 summarizes those control measures found to have a significant effect on DCR quantity and associated with a mean DCR amount that is less than the mean without the control measure. Several control measures show a significant effect for coal, but only a couple do for limestone/stone and taconite, when considering the raw data alone. Additional control measures show a significant effect on all three cargo types when the rank-transformed data are considered, which tends to lessen the effect of extreme values on the statistical test. The only two control measures that show a significant effect for all three cargo types are tarps to collect residue and a watertight gate seal. However, fewer than 30 observations are available for events with these control measures; therefore, the results should be viewed with caution. Thirty is the minimum number of observations preferred for this type of statistical analysis.

Composition of Bulk Dry Cargo Fleet. Table 11 compares DCR volume generated by U.S. vessels with that from foreign vessels from unloading coal, limestone/stone, and taconite. Most of the foreign vessels carrying coal, limestone/stone, and taconite on the Great Lakes were Canadian vessels; only two non-Canadian vessels—one from Germany and one from Switzerland—reported taconite residue during the reporting period.

The median volume of each cargo generated during unloading is larger for foreign vessels than it is for U.S. vessels. The largest difference is for coal, where Canadian vessels have a median volume of 8.83 ft^3 and U.S. vessels have a median volume of 3.00 ft^3. The median volume of limestone/stone is slightly less for U.S. vessels, at 1.67 ft^3, than for Canadian vessels, at 2.24 ft^3. The median volume of taconite is larger for foreign vessels (3.53 ft^3) than for U.S. vessels (2.50 ft^3); however, the variance in the data is greater for U.S. vessels, so the average for U.S. vessels is greater, at 22.3 ft^3, than for foreign vessels, at 18.2 ft^3.

Facility DCR Amounts and Control Measures

Table 12 summarizes the reporting data for each facility as reported by the vessels that loaded at the facilities during the first mandatory reporting period and presents summary statistics for DCR generated during loading events at each facility as reported by the vessels. The summary statistics presented include data for only coal, taconite, and limestone/stone, but data for other cargoes were reported as well. Table 12 also identifies control measures reported in the vessel records at least once for each facility.

DCR Amounts. Of the port facilities with more than 10 records for taconite during the first mandatory reporting period, Taconite Facility No. 23 had the lowest median DCR volume of taconite reported, 0.68 ft^3; Taconite Facility No. 47 had the highest, 8.12 ft^3. The median volume for all facilities with taconite residue is 1.77 ft^3.

Of the port facilities with more than 10 records for coal during the first mandatory reporting period, Coal Facility No. 30 had the lowest median DCR volume of coal residue reported, 2.07ft^3; Coal Facility No. 22, had the highest, 14.13 ft^3. Although only six records were available for Coal Facility No. 10 of note is the relatively high median coal residue for this facility: 52.97 ft^3. The median volume for all facilities with coal residue is 4.24 ft^3.

Of the limestone/stone port facilities with more than 10 records during the first mandatory reporting period, Limestone Facility No. 30 had the lowest median DCR volume reported, 0.67 ft^3; Limestone Facility No. 22 had the highest at 4.00 ft^3. Although only eight records were available for Limestone Facility No. 22 of note is the relatively high median limestone/stone residue for this facility: 28.49 ft^3. The median volume for all facilities for limestone/stone residue is 2.67 ft^3.

Control Measure Effectiveness. Table 13 presents the ANOVA results for determining which facility control measures showed a significant effect on DCR volumes. Control measures considered to have a significant effect on DCR volume at an alpha level of 0.2 are indicated in the table, along with the direction of the effect (i.e., the mean DCR amount was either less or greater when the control measure was used). The table presents ANOVA results for coal, limestone/stone, and taconite separately and for all three cargos together. The table also presents ANOVA results for the raw data and for the rank-transformed data set to allow a nonparametric analysis of the data.

The results indicate that several facility control measures show a significant effect on DCR amounts, but the effect varies by cargo type and in some cases the measure shows a significant effect in the positive direction (i.e., a greater mean DCR amount when a given control measure was reported). Based on the raw data, none of the facility control measures shows a significant effect in the less-DCR direction for limestone/stone or taconite residue. Variability in the estimated DCR quantities and possible reporting errors for which control measures are associated with a given loading event might explain these apparently contradictory results.

Table 14 presents a summary of those control measures found to result in a significant effect on DCR quantity and associated with a mean DCR amount that was less than the mean without the control measure. Several facility control measures show a significant effect for coal, but none does for limestone/stone and taconite when considering the raw data alone. A couple of control measures show a significant effect on all three cargo types when the rank-transformed data are considered, which tends to lessen the effect of extreme values on the statistical test. The only facility control measures that showed a significant effect for all three cargo types was limiting the vertical angle of the conveyor boom. However, fewer than 30 observations were available for events with this control measure; therefore, the results should be viewed with caution. Thirty is the minimum number of observations preferred for this type of statistical analysis.

DCR Amounts by Vessel and Facility. Table 15 presents a compilation of summary statistics for individual vessels grouped by the facility where they unloaded their cargo for each event. Most of the records show a vessel visiting a particular port facility only once during the reporting period. However, a few of the vessels did make repeated deliveries at a particular facility.

Conclusions

The analysis of the mandatory vessel DCR recordkeeping from the last quarter of the 2008 shipping season is inconclusive as to the effectiveness of individual control measures, either for facility or for vessel. The variability and uncertainty in the reporting data prevent a clear understanding of statistically significant effects of the control measures. However, the reporting of DCR quantities generated an abundant amount of data for characterizing the DCR quantities generated during the loading and unloading of the dry cargo.

DCR Quantities

Based on the first quarter of reporting data, the median volume of coal residue generated during bulk cargo shipments on the Great Lakes is about twice as high as the median volume of limestone/stone and taconite residue. There is little difference between the median volume of residue generated during coal loading and that generated during unloading. However, for limestone/stone, unloading operations seem to generate about 50 percent more residue than do loading operations. In contrast, unloading operations for taconite seem to generate 25 percent less residue than do loading operations.

Although there is considerable variability in the recordkeeping data, the median mass values of DCR reported during the 2008 shipping season reporting agree well with the median values used in Phase I for coal and limestone/stone. The median mass of each cargo is slightly lower in the Phase II data than it is in the Phase I data for these cargos, with outlying values (over 10 tons) removed from both data sets. However, the median mass of taconite residue reported in Phase II is about 1.7 times larger than the median mass used in the Phase I investigation.

Control Measure Effectiveness

The statistical analysis of the vessel and facility control measure effectiveness revealed a few control measures that were identified as having a significant effect on DCR amounts. However, none of the control measures were found with certainty to have a significant effect on reducing DCR for each of the three main cargo types. Three control measures—two vessel control measures (tarps to collect residue and a watertight gate seal) and one shoreside facility control measure (limiting the vertical angle of the conveyor boom)—are associated with decreased DCR. However, there are fewer observations for each of these control measures than would be preferred for this type of analysis to ensure a statistically sound conclusion.

The uncertainty and variability in the reporting data contributed to the lack of finding many control measures to be significantly effective at reducing DCR quantities. A major uncertainty surrounds the reliability of the recordkeeping for shoreside facility control measures, because the ship personnel responsible for completing the recordkeeping forms may not be fully familiar with the shoreside control measures. Another limitation of the data set is the lack of consistency in the recordkeeping. For example, some of the structural control measures that cannot be shut off or not used (e.g., a troughed conveyor) were not reported for all the events for a given facility or vessel when they should have been. This created erroneous data points that were associated with DCR quantities in the absence of a given control measure, when in fact those data points should have been associated with a given control measure. The effect of this error is to dampen the statistical power and prevent the test from discerning true differences in the control measure effectiveness.

Although the variability in the data constrains the statistical evaluation of control measures, there are some qualitative observations that are useful. Events employing a number of control measures have a mean of DCR well below events without these measures, and these same control measures have lower mean DCR volumes for multiple cargos. These control measures include the following:

- Enclosed conveyor belts
- Loading chutes
- Stopping the conveyor while ship is loading
- Troughed conveyors
- Belt scrapers
- Tarps
- Brooms and shovels

The events employing these measures generally have mean DCR volumes at least 50 percent less than events not employing the measures. They are also measures that on the basis of observation and engineering judgment should be the most effective.

Recommendations for Improved Data Quality

Our primary recommendation for improving the evaluation of DCR quantities and control measure effectiveness is to implement a rigorous observation program. A standardized observation protocol would provide higher quality data with possibly less variability in estimates of DCR quantities and a more consistent indication of which control measures are associated with a given event. As mentioned above, the variability in the recordkeeping data constrained the statistical evaluation, but qualitative evaluation of the data suggests that a number of control measures likely reduce DCR quantities. A rigorous observation program would yield valuable information to help us better understand the vessel record database, allow some validation of the range of DCR discharges reported in the vessel records, provide strong qualitative evidence regarding the effectiveness of multiple control measures, and assist with identifying the effectiveness of the industry standards (i.e., baseline) of control measures used to move bulk dry cargo. A statistical evaluation of DCR control measure effectiveness would be possible if a sufficient number of observations could be collected, but this is not recommended because there is no assurance that the observation program would provide significant statistical evidence on each individual control measure.

Clarification of the instruction for completing the reporting forms could improve the data quality. Possible clarifications or supplemental guidance for completing the reporting forms are summarized below:

- Complete the form in its entirety.
- Use a single row for each material loaded/unloaded and its associated sweeping event
- When multiple cargos are unloaded or loaded, record each material on separate row and estimate a DCR quantity for each material

- Report a DCR quantity for each entry, event if a sweeping event does not occur immediately after the load/unload event; if the DCR quantity is zero, enter a zero instead of leaving the space blank
- Provide the correct units (cubic meters) for the DCR quantity, or at a minimum, specify which units are reported
- Report deck DCR and tunnel DCR quantities separately for each event if the reporting form can be changed. If the reporting form cannot be changed, the DCR quantity should be specified as the total DCR for the event, inclusive of the deck and tunnel, and should include only the DCR quantity and not the water used to sweep the material
- Record shoreside facility control measures thoroughly, with input from the shoreside facility if needed; if the ship crew does not know which control measures are used by the facility, crew should ask the facility
- Maintain consistent facility names by providing a list of possible unloading and loading facilities
- Provide remarks on any atypical occurrences during loading, such as an equipment failure

References

Army Corps of Engineers (ACOE) Navigation Data Center. 2009. U.S. Waterway Data: Port and Waterway Facilities. http://www.iwr.usace.army.mil/ndc/data/datapwd.htm. Site accessed February 25, 2009.

Marine Publishing Co. Inc. 2008. *Know Your 2008 Ships: Guide to Boats and Boatwatching, Great Lakes and St. Lawrence Seaway*. 49th ed.

TABLE 1
Summary of the Type of Data Within Vessel Records Database

Type	Source
Date	Vessel DCR Reporting Forms
Ship official number	
Ship IMO number	
Vessel name	
Cargo involved	
Operation (load/unload)	
Facility name	
Port (name, city, state, province, country)	
Facility control measures implemented (type, number)	
Vessel control measures implemented (type, number)	
Time spent implementing control measures (minutes)	
Estimated residue to be discharged (cubic feet)	
Discharge start (date, time, longitude—decimal deg. and direction, latitude—decimal deg. and direction)	
Discharge stop (date, time, longitude—decimal deg. and direction, latitude—decimal deg. and direction)	
Fleet name	*Know Your Ships 2008* (Marine Publishing 2008)
City of owning company	
Fleet (state, province, country)	
Year Built	
Cargo capacity (long tons)	
Overall length (feet)	
Breadth (feet)	
Depth (feet)	
Vessel notes	

TABLE 2
Summary Statistics for Volume of DCR

Unloading and Loading Events
Total DCR Volume (ft^3)

Statistical Value	Material		
	Coal	**Stone/Limestone**	**Taconite**
Number of Records with DCR Value	273	402	398
Average	17.5	19.0	32.9
Standard Deviation	27.3	48.5	146.9
Median	4.00	3.00	4.04
Minimum	0.00	0.00	0.00
Maximum	106	530	1,812
95th Percentile	84.8	105.9	120.8

Unloading Events
Total DCR Volume (ft^3)

Statistical Value	Material		
	Coal	**Stone/Limestone**	**Taconite**
Number of Records with DCR Value	136	230	233
Average	17.4	13.2	36.4
Standard Deviation	28.4	28.5	174.6
Median	4.00	2.7	4.6
Minimum	0.00	0	0
Maximum	106	159	1,812.0
95th Percentile	101	79.5	120.8

Loading Events
Total DCR Volume (ft^3)

Statistical Value	Material		
	Coal	**Stone/Limestone**	**Taconite**
Number of Records with DCR Value	137	172	165
Average	17.5	26.8	27.9
Standard Deviation	4.24	65.8	95.2
Median	4.24	4	3.4
Minimum	0.00	0	0
Maximum	106	530	725
95th Percentile	72.5	158.9	60.4

TABLE 3
Summary Statistics for Mass of DCR

Unloading and Loading Events
Total DCR Mass (pounds)

Statistical Value	Material		
	Coal	**Stone/Limestone**	**Taconite**
Number of Records with DCR Value	273	402	398
Average	873	1,904	4,271
Standard Deviation	1,363	4,850	19,097
Median	200	300	525
Minimum	0.00	0.00	0.00
Maximum	5,297	52,970	235,505
95^{th} Percentile	4,238	10,594	15,700

Unloading Events
Total DCR Mass (pounds)

Statistical Value	Material		
	Coal	**Stone/Limestone**	**Taconite**
Number of Records with DCR Value	136	230	233
Average	871	1,322	4,727
Standard Deviation	1,420	2,845	22,703
Median	200	265	597
Minimum	0.00	0	0
Maximum	5,297	15,892	235,505
95^{th} Percentile	5,074	7,946	15,700

Loading Events
Total DCR Mass (pounds)

Statistical Value	Material		
	Coal	**Stone/Limestone**	**Taconite**
Number of Records with DCR Value	137	172	165
Average	875	2,682	3,628
Standard Deviation	212	6,576	12,371
Median	212	400	445
Minimum	0.00	0	0
Maximum	5297	52,970	94,202
95^{th} Percentile	3625	15,891	7,850

TABLE 4
Summary Statistics for Time Spent Discharging DCR

Unloading and Loading Events
Total Time Spent Sweeping Discharge (min)

Statistical Value	Material		
	Coal	Stone/Limestone	Taconite
Number of Records with DCR Value	202	238	288
Average	150	153	192
Standard Deviation	119	149	134
Median	120	105	165
Minimum	3.00	0.00	2.00
Maximum	852	810	830
95th Percentile	359	440	429

Unloading Events
Total Time Spent Sweeping Discharge (min)

Statistical Value	Material		
	Coal	Stone/Limestone	Taconite
Number of Records with DCR Value	107	129	171
Average	152	151	187
Standard Deviation	107	128	148
Median	127	128	145
Minimum	3.00	1.00	3.00
Maximum	445	640	1,059
95th Percentile	381	393	438

Loading Events
Total Time Spent Sweeping Discharge (min)

Statistical Value	Material		
	Coal	Stone/Limestone	Taconite
Number of Records with DCR Value	95	109	117
Average	148	156	201
Standard Deviation	120	90.0	180
Median	120	90.0	180
Minimum	3.00	0.00	2.00
Maximum	852	810	580
95th Percentile	334	528	375

TABLE 5

Comparison between Phase I and Phase II DCR Mass. Outliers Removed from Phase I (≥10 Tons) only.

Total DCR Mass (pounds)						
	Coal		Limestone/Stone		Taconite	
Statistical Value	**Phase I**	**Phase II**	**Phase I**	**Phase II**	**Phase I**	**Phase II**
Number of Records with DCR Value	758	273	528	402	1,203	398
Average	191	873	248	1,904	247	4,271
Standard Deviation	150	1,363	175	4,850	200	19,097
Median	240	200	332	300	282	525
Minimum	0	0	0	0	0	0
Maximum	2,500	5,297	2,500	52,970	5,000	235,505
95th Percentile	500	4,238	765	10,594	600	15,700

*Phase I did not include records when DCR was greater than or equal to 10 tons.

**Phase II Results from vessel DCR record keeping.

TABLE 6

Comparison between Phase I and Phase II DCR Mass. Outliers Removed from Phase I (≥10 Tons) and Phase II (≥10 Tons).

Total DCR Mass (pounds)						
	Coal		Limestone/Stone		Taconite	
Statistical Value	**Phase I**	**Phase II**	**Phase I**	**Phase II**	**Phase I**	**Phase II**
Number of Events	758	273	528	395	1,203	383
Average	191	873	248	1,494	247	1,602
Standard Deviation	150	1,363	175	3,275	200	2,670
Median	240	200	332	300	282	470
Minimum	0	0.00	0	0.00	0	0.00
Maximum	2,500	5,297	2,500	15,892	5,000	15,679
95th Percentile	500	4,238	765	10,178	600	7,839

*Phase I did not include records when DCR was greater than or equal to 10 tons.

**Phase II Results from vessel DCR record keeping. Records were not included when DCR was greater or equal to 10 tons.

TABLE 7

Comparison between Phase I and Phase II DCR Mass for two Ships.

Vessel 56 DCR Mass (pounds)						
Statistical Value	Coal		Limestone/Stone		Taconite	
	Phase I	Phase II	Phase I	Phase II	Phase I	Phase II
Number of Records with DCR Value	1	6	112	13	20	4
Average	200	2,693	208	5,452	258	3,794
Standard Deviation	-	1,863	167	4,646	151	4,183
Median	200	3,090	188	7,840	238	3,840
Minimum	200	265	30	3	50	79
Maximum	200	5,297	1,500	15,679	600	7,416
95th Percentile	-	4,856	400	10,975	505	7,416

Vessel 7 DCR Mass (pounds)						
Statistical Value	Coal		Limestone/Stone		Taconite	
	Phase I	Phase II	Phase I	Phase II	Phase I	Phase II
Number of Records with DCR Value	8	1	9	4	17	26
Average	72	150	94	106	421	163
Standard Deviation	61	-	94	31	1,186	234
Median	35	150	50	100	100	100
Minimum	25	150	17	75	27	50
Maximum	175	150	250	150	5,000	1,250
95th Percentile	166	150	230	143	1,400	325

TABLE 8
DCR Discharge by Vessel
(highlighted rows indicate vessels with 10 or more records)

					DCR Quantity Generated by Vessel (data from vessel records) (data sorted by median DCR quantity) (cubic feet)							Vessel Control Measures (reported on vessel records)																			
Material	Vessel ID	Country of Fleet	Year Built	Overall Length (ft)	Number of Records with a DCR Value Recorded	Average	Standard Deviation	Median	Minimum	Maximum	95th Percentile	Enclosed Conveyor	Troughed Conveyor	Skirts on Conveyor	Belt Scrapers	Water/Mist	Capacity Indicators	Remote Controls	Stop Conveyor	Wind Delay	Radio Communications	Crew Training	Limit Angle of Conveyor	Broom & Shovel	Tarps	Vibrator	Gate Seal	Cargo Hold Lining	Minimize Hatch Removal	Careful Cargo Hold Gate Operation	Other
Unloading Taconite Database Statistics					**231**	**21.42**	**102.55**	**2.68**	**0.00**	**1059.40**	**70.63**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
Taconite[1]	Vessel - 1	Canada	1985	736.6	2	0.00	0.00	0.00	0.00	0.00	0.00	X		X	X		X					X				X		X		X	
	Vessel - 57	United States	1973	630.0	1	0.00	-	0.00	0.00	0.00	0.00		X	X	X	X	X	X	X		X	X	X			X				X	
	Vessel - 58	United States	1981	634.8	3	0.24	0.41	0.00	0.00	0.71	0.71		X	X	X	X	X	X			X	X				X	X			X	
	Vessel - 59	Canada	1967	730.0	3	2.94	5.10	0.00	0.00	8.83	8.83	X	X	X	X		X	X			X	X	X	X	X		X		X	X	
	Vessel - 60	United States	1944	706.5	11	2.87	4.92	0.00	0.00	11.41	11.41		X		X	X	X	X	X		X	X							X		
	Vessel - 61	United States	1959	806.0	3	0.02	0.01	0.02	0.00	0.02	0.02			X	X	X	X				X	X	X			X				X	
	Vessel - 62	United States	1973	680.0	7	0.42	0.24	0.25	0.25	0.74	0.74		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	
	Vessel - 6	United States	1978	634.8	3	0.41	0.22	0.28	0.28	0.67	0.67	X	X	X	X	X		X	X		X	X	X			X	X	X	X	X	
	Vessel - 7	United States	1953	690.0	5	0.46	0.19	0.32	0.32	0.67	0.67	X				X	X		X	X			X							X	X
	Vessel - 63	United States	1979	636.0	7	0.50	0.19	0.35	0.35	0.71	0.71		X	X	X	X	X	X	X	X	X	X	X	X							
	Vessel - 8	United States	1949	678	4	0.48	0.14	0.45	0.34	0.68	0.68		X	X	X		X		X		X			X						X	
	Vessel - 64	Canada	1959	730.0	8	9.16	16.15	0.45	0.09	35.31	35.31													X							
	Vessel - 9	United States	1942	826.0	8	0.71	0.83	0.57	0.00	2.48	2.48				X	X					X	X		X							
	Vessel - 10	Canada	1962	730.0	1	0.67	-	0.67	0.67	0.67	0.67																				
	Vessel - 5	United States	1959	690.0	1	0.68	-	0.68	0.68	0.68	0.68					X						X	X					X		X	
	Vessel - 48	United States	1976	1,004.0	9	1.40	0.95	0.68	0.35	2.68	2.68	X		X	X	X	X				X									X	
	Vessel - 65	United States	1978	1,000.0	2	0.71	0.50	0.71	0.35	1.06	1.06		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
	Vessel - 12	United States	1979	1,000.0	1	0.71	-	0.71	0.71	0.71	0.71	X	X		X	X							X								
	Vessel - 13	United States	1972	1,000.0	8	0.84	0.10	0.90	0.68	0.90	0.90		X			X					X								X		
	Vessel - 66	Canada	1983	730.1	6	1.47	0.93	1.24	0.71	3.18	3.18											X		X					X		
	Vessel - 67	United States	1960	730.0	5	2.12	0.79	1.77	1.77	3.53	3.53																				X
	Vessel - 68	United States	1976	770.0	8	2.21	1.16	1.77	0.88	3.53	3.53	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
	Vessel - 18	Canada	1983	730.0	5	1.64	0.91	1.80	0.23	2.55	2.55	X	X			X				X					X	X		X			
	Vessel - 21	Canada	1981	740.0	1	2.12	-	2.12	2.12	2.12	2.12	X	X	X	X							X	X	X		X	X	X		X	
	Vessel - 69	Switzerland	2000	419.5	1	2.12	-	2.12	2.12	2.12	2.12									X	X	X		X	X				X	X	
	Vessel - 70	United States	1953	606.0	3	2.17	1.04	2.50	1.00	3.00	3.00		X	X	X	X	X		X		X	X	X			X				X	
	Vessel - 26	United States	1952	767.0	2	2.83	0.00	2.83	2.83	2.83	2.83		X		X		X				X		X							X	
	Vessel - 27	Canada	1953	639.3	6	19.02	28.61	3.06	0.90	70.63	70.63		X	X	X		X	X	X		X		X	X		X		X		X	
	Vessel - 29	Canada	1968	730.0	2	3.53	0.00	3.53	3.53	3.53	3.53				X								X	X	X	X					
	Vessel - 30	Canada	1963	730.2	1	3.53	.	3.53	3.53	3.53	3.53	X		X	X	X		X		X	X	X	X	X		X			X	X	
	Vessel - 31	United States	1978	1,004.0	13	3.94	1.51	3.53	0.35	6.71	6.71		X		X	X	X	X	X		X		X	X		X				X	
	Vessel - 34	United States	1953	767.0	11	4.01	1.14	3.53	3.53	7.06	7.06	X	X	X	X	X	X	X			X									X	
	Vessel - 35	United States	1929	603.0	2	4.41	3.75	4.41	1.77	7.06	7.06	X	X	X	X	X					X	X				X				X	
	Vessel - 36	Canada	1980	729.8	2	5.30	2.50	5.30	3.53	7.06	7.06													X						X	
	Vessel - 44	Canada	1973	739.1	2	5.83	0.75	5.83	5.30	6.36	6.36	X	X	X	X	X	X		X	X		X	X	X		X		X	X	X	
	Vessel - 46	Canada	1984	736.6	4	6.62	3.64	6.18	3.53	10.59	10.59	X	X	X	X	X	X		X	X		X	X	X		X		X	X	X	
	Vessel - 71	United States	1977	1,004.0	5	6.03	4.46	7.06	0.20	10.21	10.21	X		X	X	X	X		X		X	X		X					X	X	
	Vessel - 49	Canada	1967	728.9	1	7.06	-	7.06	7.06	7.06	7.06		X		X	X															
	Vessel - 72	United States	1976	728.0	7	32.24	40.87	13.42	8.83	123.60	123.60	X	X	X	X	X	X	X	X		X	X	X	X		X	X			X	
	Vessel - 73	Canada	1968	729.8	3	30.60	35.38	17.64	3.53	70.63	70.63	X			X		X				X	X	X	X		X			X	X	
	Vessel - 74	United States	1972	858.0	13	17.66	0.00	17.66	17.66	17.66	17.66				X	X	X				X	X	X						X		
	Vessel - 75	United States	1980	1,000.0	17	166.99	347.34	21.19	0.71	1,059.40	1,059.40		X	X	X	X	X	X	X	X	X	X	X	X			X		X	X	
	Vessel - 52	Canada	1972	739.8	1	35.31	.	35.31	35.31	35.31	35.31	X	X	X	X	X	X						X		X	X		X		X	
	Vessel - 76	United States	1980	730.0	13	24.56	20.93	35.31	0.01	70.63	70.63		X	X	X	X		X	X		X		X						X		
	Vessel - 77	Canada	1960	730.0	4	38.84	36.70	38.84	7.06	70.63	70.63					X				X	X	X		X							
	Vessel - 78	Germany	2005	606.9	1	52.97	-	52.97	52.97	52.97	52.97													X							
	Vessel - 79	Canada	1963	730.0	1	70.63	-	70.63	70.63	70.63	70.63													X							
	Vessel - 56	Canada	1966	730.0	4	99.58	62.07	123.60	9.89	141.25	141.25																				

*Records that had no DCR value reported are not included in the table.

TABLE 8
DCR Discharge by Vessel
(highlighted rows indicate vessels with 10 or more records)

					DCR Quantity Generated by Vessel (data from vessel records) (data sorted by median DCR quantity) (cubic feet)							Vessel Control Measures (reported on vessel records)																			
Material	Vessel ID	Country of Fleet	Year Built	Overall Length (ft)	Number of Records with a DCR Value Recorded	Average	Standard Deviation	Median	Minimum	Maximum	95th Percentile	Enclosed Conveyor	Troughed Conveyor	Skirts on Conveyor	Belt Scrapers	Water/Mist	Capacity Indicators	Remote Controls	Stop Conveyor	Wind Delay	Radio Communications	Crew Training	Limit Angle of Conveyor	Broom & Shovel	Tarps	Vibrator	Gate Seal	Cargo Hold Lining	Minimize Hatch Removal	Careful Cargo Hold Gate Operation	Other
Unloading Coal Database Statistics					136	17.43	28.41	4.00	0.00	105.94	105.94	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Coal	Vessel - 63	United States	1981	634.8	2	0.00	0.00	0.00	0.00	0.00	0.00		X	X	X	X	X	X			X	X				X	X			X	
Coal	Vessel - 80	Canada	1976	730.0	1	0.00	.	0.00	0.00	0.00	0.00	X	X		X		X				X									X	
Coal	Vessel - 81	Norway	1985	584.7	1	0.00	.	0.00	0.00	0.00	0.00									X	X	X		X	X				X	X	
Coal	Vessel - 43	United States	1943	620.5	3	35.31	61.16	0.00	0.00	105.94	105.94		X		X		X	X	X		X	X	X	X	X	X			X	X	
Coal	Vessel - 65	United States	1978	634.8	1	0.32	.	0.32	0.32	0.32	0.32	X		X	X	X					X		X					X			
Coal	Vessel - 74	Canada	1963	730.2	3	1.31	1.93	0.35	0.04	3.53	3.53	X		X	X	X		X		X	X	X	X	X		X			X	X	
Coal	Vessel - 53	United States	1975	634.8	4	0.84	0.34	0.67	0.67	1.34	1.34	X	X	X	X							X		X							
Coal	Vessel - 27	United States	1979	1,000.0	6	0.93	0.58	0.71	0.67	2.12	2.12	X	X	X	X	X	X	X	X	X	X			X		X			X	X	
Coal	Vessel - 1	Norway	1973	680.0	2	1.70	1.90	1.70	0.35	3.04	3.04		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	
Coal	Vessel - 55	United States	1977	1,000.0	6	1.74	1.08	1.73	0.00	2.83	2.83	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X		X	X	X
Coal	Vessel - 13	United States	1929	603.0	11	2.05	1.61	1.77	0.53	5.30	5.30	X	X	X	X	X	X	X			X	X		X		X			X	X	
Coal	Vessel - 44	United States	1926	371.3	2	2.00	2.83	2.00	0.00	4.00	4.00	X	X	X	X	X	X	X		X	X	X	X			X	X			X	
Coal	Vessel - 36	United States	1942	826.0	3	2.50	1.15	2.40	1.40	3.70	3.70				X	X					X	X		X							
Coal	Vessel - 29	United States	1976	1,004.0	11	2.71	1.70	2.83	0.67	6.71	6.71	X		X	X	X	X				X									X	
Coal	Vessel - 56	United States	1949	678.0	1	3.00	.	3.00	3.00	3.00	3.00		X								X			X							
Coal	Vessel - 46	United States	1977	1,004.0	4	3.58	2.80	3.53	0.20	7.06	7.06	X		X	X				X			X		X							
Coal	Vessel - 61	United States	1979	636.0	4	3.97	2.22	3.53	1.77	7.06	7.06		X	X	X	X	X	X	X	X	X	X	X		X						
Coal	Vessel - 11	United States	1953	606.0	1	4.00	.	4.00	4.00	4.00	4.00		X	X	X	X	X		X		X	X	X			X				X	
Coal	Vessel - 52	Canada	1953	639.3	6	14.63	27.48	4.50	1.13	70.63	70.63		X	X	X		X	X	X		X		X	X		X		X		X	
Coal	Vessel - 30	Canada	1983	730.0	3	4.67	2.31	6.00	2.00	6.00	6.00	X	X							X	X	X		X	X	X		X			
Coal	Vessel - 26	United States	1959	690.0	2	6.25	4.02	6.25	3.41	9.09	9.09																				
Coal	Vessel - 6	Norway	1978	1000	2	7.06	0.00	7.06	7.06	7.06	7.06	X	X	X	X	X	X	X			X	X		X						X	
Coal	Vessel - 9	United States	1952	767.0	1	7.06	.	7.06	7.06	7.06	7.06		X		X		X						X							X	
Coal	Vessel - 82	Canada	1943	620.5	3	7.30	6.71	7.06	0.71	14.13	14.13		X		X	X	X	X			X	X				X		X		X	
Coal	Vessel - 67	Canada	1968	730.0	8	8.17	1.31	7.95	7.06	10.59	10.59	X		X	X	X	X		X				X	X	X	X			X		
Coal	Vessel - 5	Canada	1984	736.6	1	10.59	.	10.59	10.59	10.59	10.59	X	X	X	X		X					X	X	X		X		X	X	X	
Coal	Vessel - 71	Canada	1980	729.8	1	10.59	.	10.59	10.59	10.59	10.59				X																
Coal	Vessel - 35	United States	1976	728.0	2	14.13	0.00	14.13	14.13	14.13	14.13		X	X	X	X	X				X	X	X		X	X					
Coal	Vessel - 78	United States	1976	770.0	5	17.66	17.63	14.13	0.71	42.38	42.38	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
Coal	Vessel - 83	United States	1945	579.2	7	26.40	33.87	15.00	2.30	100.00	100.00			X	X			X	X	X	X	X		X		X		X	X	X	
Coal	Vessel - 84	Canada	1974	730.0	4	30.02	10.59	28.25	21.19	42.38	42.38					X			X		X	X				X		X	X	X	
Coal	Vessel - 15	Canada	1979	730.0	14	59.78	36.34	35.31	21.19	105.94	105.94	X	X	X	X	X	X		X		X	X	X	X	X	X			X	X	
Coal	Vessel - 60	Canada	1981	740.0	2	42.38	9.99	42.38	35.31	49.44	49.44	X			X	X					X	X	X	X		X			X		
Coal	Vessel - 85	Canada	2000	656.2	1	49.44	.	49.44	49.44	49.44	49.44									X	X	X									
Coal	Vessel - 7	United States	1980	730.0	6	53.85	37.27	61.80	5.30	105.94	105.94				X	X					X		X			X					
Coal	Vessel - 45	United States	1929	604.0	2	88.29	0.00	88.29	88.28	88.29	88.29		X	X	X		X	X	X			X	X			X				X	

*Records that had no DCR value reported are not included in the table.

TABLE 8
DCR Discharge by Vessel
(highlighted rows indicate vessels with 10 or more records)

Material	Vessel ID	Country of Fleet	Year Built	Overall Length (ft)	DCR Quantity Generated by Vessel (data from vessel records) (data sorted by median DCR quantity) (cubic feet): Number of Records with a DCR Value Recorded	Average	Standard Deviation	Median	Minimum	Maximum	95th Percentile	Vessel Control Measures (reported on vessel records): Enclosed Conveyor	Troughed Conveyor	Skirts on Conveyor	Belt Scrapers	Water/Mist	Capacity Indicators	Remote Controls	Stop Conveyor	Wind Delay	Radio Communications	Crew Training	Limit Angle of Conveyor	Broom & Shovel	Tarps	Vibrator	Gate Seal	Cargo Hold Lining	Minimize Hatch Removal	Careful Cargo Hold Gate Operation	Other
Unloading Limestone Database Statistics					**230**	**8.81**	**18.97**	**1.77**	**0.00**	**105.94**	**52.97**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
Limestone/stone[1]	Vessel - 63	United States	1981	634.8	1	0.00	.	0.00	0.00	0.00	0.00		X	X	X	X	X	X			X	X				X	X			X	
	Vessel - 44	United States	1926	371.3	3	0.00	0.00	0.00	0.00	0.00	0.00	X	X	X	X	X	X	X		X	X	X	X			X	X			X	
	Vessel - 43	United States	1943	620.5	8	4.41	12.49	0.00	0.00	35.31	35.31		X		X		X	X	X		X	X	X	X	X	X			X	X	
	Vessel - 65	United States	1978	634.8	5	0.39	0.16	0.32	0.32	0.67	0.67	X	X	X	X	X		X	X		X	X	X			X		X	X	X	
	Vessel - 1	United States	1973	680.0	3	0.47	0.20	0.35	0.35	0.71	0.71		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	
	Vessel - 82	Canada	1943	620.5	8	1.27	1.63	0.35	0.00	4.06	4.06		X		X	X	X	X			X	X				X		X		X	
	Vessel - 86	Canada	1943	650.5	6	0.77	0.82	0.53	0.00	1.77	1.77			X	X	X			X	X	X	X	X	X		X		X	X	X	
	Vessel - 56	United States	1949	678.0	26	1.09	1.56	0.67	0.33	8.33	2.33		X	X	X		X		X		X	X		X						X	
	Vessel - 87	United States	1942	730.0	1	0.67	.	0.67	0.67	0.67	0.67	X	X		X	X	X	X				X	X	X							
	Vessel - 88	Canada	1952	663.5	9	0.67	0.00	0.67	0.67	0.67	0.67	X	X		X			X			X	X	X	X		X	X	X	X	X	
	Vessel - 53	United States	1975	634.8	6	1.42	1.01	1.01	0.67	3.18	3.18	X	X	X	X	X			X		X	X									
	Vessel - 31	Canada	1967	730.0	1	1.20	.	1.20	1.20	1.20	1.20	X	X	X	X		X		X		X	X	X	X	X				X	X	
	Vessel - 30	Canada	1983	730.0	3	1.74	0.70	1.33	1.33	2.55	2.55	X													X	X		X			
	Vessel - 37	United States	1952	698.0	9	1.63	0.68	1.33	1.00	3.33	3.33		X	X	X		X									X				X	
	Vessel - 13	United States	1929	603.0	13	1.52	1.00	1.33	0.30	3.53	3.53	X	X	X	X		X	X	X		X	X		X		X				X	
	Vessel - 61	United States	1979	636.0	3	1.18	0.74	1.41	0.35	1.77	1.77		X	X	X	X	X	X	X	X	X										
	Vessel - 9	United States	1952	767.0	1	1.77	.	1.77	1.77	1.77	1.77		X		X		X	X					X							X	
	Vessel - 89	Canada	1982	730.0	1	2.00	.	2.00	2.00	2.00	2.00	X	X	X	X		X	X	X		X	X				X		X		X	
	Vessel - 11	United States	1953	606.0	31	2.26	1.27	2.00	0.50	8.00	3.00		X	X	X	X	X		X		X	X	X	X		X				X	
	Vessel - 35	United States	1976	728.0	8	3.95	4.25	2.47	0.67	14.13	14.13		X	X	X	X	X		X		X	X	X	X		X	X			X	
	Vessel - 90	Canada	1968	640.5	14	22.79	33.26	4.41	1.77	105.94	105.94		X	X	X	X	X	X	X	X	X	X	X	X		X		X	X	X	
	Vessel - 59	Canada	1966	729.9	1	4.94	.	4.94	4.94	4.94	4.94																				
	Vessel - 52	Canada	1953	639.3	5	24.39	45.60	5.00	3.00	105.94	105.94		X	X	X		X	X	X		X		X	X		X		X		X	
	Vessel - 83	United States	1945	579.2	10	18.49	28.18	5.15	0.00	80.00	80.00			X	X			X	X	X	X	X		X		X			X	X	
	Vessel - 91	Canada	1979	658.0	2	6.34	2.36	6.34	4.67	8.01	8.01	X		X	X		X	X			X	X	X			X		X	X	X	
	Vessel - 34	United States	1944	706.5	12	4.53	4.48	4.70	0.00	10.06	10.06		X		X	X	X	X	X		X	X							X		
	Vessel - 57	Canada	1968	729.8	1	10.59	.	10.59	10.59	10.59	10.59	X			X		X				X	X	X			X			X	X	
	Vessel - 92	Canada	1972	650.0	8	14.02	8.44	11.02	7.35	26.67	26.67	X		X	X						X			X					X		
	Vessel - 74	Canada	1963	730.2	1	14.13	.	14.13	14.13	14.13	14.13	X		X	X	X		X		X	X	X	X	X		X			X	X	
	Vessel - 2	Canada	1970	647.0	15	23.31	25.17	17.66	0.71	70.63	70.63		X	X	X	X			X		X	X	X			X		X		X	X
	Vessel - 7	United States	1980	730.0	4	25.29	27.89	25.60	0.53	49.44	49.44	X		X	X			X			X		X								
	Vessel - 45	United States	1929	604.0	11	44.94	27.77	35.31	17.66	105.94	105.94		X	X	X		X	X	X			X	X			X				X	

[1] DCR summary statistics are based on values recorded on the reporting forms and are not adjusted for the densities of taconite and limestone provided on the reporting form. The data combined for all records reported in Tables 1 and 2 reflect adjustments based on corrected densities.

*Records that had no DCR value reported are not included in the table.

TABLE 9

Analysis of Variance Results Using Vessel Control Measures as Indicator Parameters

Dry Cargo Residue Data - Reporting Period (September 29, 2008 through January 15, 2009)

Control Measure Description	Limestone / Coal / Taconite			Limestone			Coal			Taconite		
	Probability	Conclusion	Count #	Probability	Conclusion	Count #	Probability	Conclusion	Count #	Probability	Conclusion	Count #
Raw Data												
1 Enclosed conveyor	0.255	NS	154	0.246	NS	42	0.361	NS	62	0.205	NS	50
2 Troughed conveyor	0.087	Less with CM	323	0.452	NS	153	0.650	NS	68	0.203	NS	102
3 Conveyor skirts	0.633	NS	312	0.119	Greater with CM	149	0.827	NS	75	0.924	NS	88
4 Belt Scrapers	0.684	NS	434	0.823	NS	182	0.280	NS	109	0.621	NS	143
5 Water/mist for dust control	0.923	NS	300	0.002	Less with CM	90	0.000	Less with CM	71	0.330	NS	139
6 Conveyor capacity indicators	0.832	NS	321	0.968	NS	126	0.016	Greater with CM	67	0.747	NS	128
7 Deck remote controls of conveyors	0.988	NS	200	0.033	Greater with CM	86	0.081	Less with CM	46	0.704	NS	68
8 Stop conveyor while ship or belt is repositioned	0.141	Greater with CM	213	0.197	Greater with CM	118	0.819	NS	41	0.469	NS	54
9 Delay loading/unloading during high wind	0.422	NS	106	0.810	NS	31	0.877	NS	31	0.596	NS	44
10 Radio Communication between deck and loader	0.375	NS	415	0.027	Less with CM	176	0.193	Less with CM	97	0.237	NS	142
11 Crew training on procedures to reduce residue	0.846	NS	302	0.962	NS	133	0.000	Greater with CM	69	0.474	NS	100
12 Limit vertical angle of conveyor boom	0.009	Greater with CM	217	0.148	Greater with CM	104	0.051	Greater with CM	49	0.053	Greater with CM	64
13 Broom & shovel (to return to hold or shore)	0.585	NS	201	0.499	NS	75	0.002	Less with CM	47	0.088	Greater with CM	79
14 Tarps to collect residue(to return to hold or shore)	0.001	Less with CM	52	0.311	NS	13*	0.069	Less with CM	20*	0.003	Less with CM	19*
15 Cargo hold vibrator	0.003	Less with CM	252	0.841	NS	126	0.310	NS	69	0.002	Less with CM	57
16 Watertight gate seal	0.000	Greater with CM	60	0.445	NS	18*	0.193	Less with CM	13*	0.000	Greater with CM	29*
17 Cargo hold lining (teflon or kevlar)	0.497	NS	91	0.191	Greater with CM	56	0.608	NS	14*	0.907	NS	21*
18 Minimize hatch removal during poor weather	0.413	NS	154	0.787	NS	53	0.006	Greater with CM	40	0.726	NS	61
19 Careful cargo hold gate operation	0.364	NS	331	0.362	NS	162	0.006	Less with CM	69	0.354	NS	100
Rank Transformed Data												
1 Enclosed conveyor	0.098	Less with CM	154	0.724	NS	42	0.085	Less with CM	62	0.280	NS	50
2 Troughed conveyor	0.000	Less with CM	323	0.043	Less with CM	153	0.077	Less with CM	68	0.612	NS	102
3 Conveyor skirts	0.047	Less with CM	312	0.080	Greater with CM	149	0.914	NS	75	0.912	NS	88
4 Belt Scrapers	0.945	NS	434	0.012	Less with CM	182	0.352	NS	109	0.899	NS	143
5 Water/mist for dust control	0.027	Less with CM	300	0.015	Less with CM	90	0.042	Less with CM	71	0.391	NS	139
6 Conveyor capacity indicators	0.066	Less with CM	321	0.208	NS	126	0.006	Less with CM	67	0.072	Less with CM	128
7 Deck remote controls of conveyors	0.297	NS	200	0.675	NS	86	0.043	Less with CM	46	0.359	NS	68
8 Stop conveyor while ship or belt is repositioned	0.640	NS	213	0.124	Greater with CM	118	0.527	NS	41	0.017	Less with CM	54
9 Delay loading/unloading during high wind	0.804	NS	106	0.702	NS	31	0.701	NS	31	0.243	NS	44
10 Radio Communication between deck and loader	0.020	Less with CM	415	0.005	Less with CM	176	0.681	NS	97	0.027	Less with CM	142
11 Crew training on procedures to reduce residue	0.245	NS	302	0.284	NS	133	0.001	Less with CM	69	0.183	Less with CM	100
12 Limit vertical angle of conveyor boom	0.001	Greater with CM	217	0.008	Greater with CM	104	0.004	Greater with CM	49	0.023	Less with CM	64
13 Broom & shovel (to return to hold or shore)	0.953	NS	201	0.056	Less with CM	75	0.030	Less with CM	47	0.705	NS	79
14 Tarps to collect residue(to return to hold or shore)	0.001	Less with CM	52	0.000	Less with CM	13*	0.154	Less with CM	20*	0.040	Less with CM	19*
15 Cargo hold vibrator	0.031	Less with CM	252	0.001	Greater with CM	126	0.652	NS	69	0.019	Less with CM	57
16 Watertight gate seal	0.134	Less with CM	60	0.047	Less with CM	18*	0.002	Less with CM	13*	0.104	Less with CM	29*
17 Cargo hold lining (teflon or kevlar)	0.871	NS	91	0.890	NS	56	0.326	NS	14*	0.668	NS	21*
18 Minimize hatch removal during poor weather	0.179	Less with CM	154	0.750	NS	53	0.090	Greater with CM	40	0.651	NS	61
19 Careful cargo hold gate operation	0.008	Less with CM	331	0.433	NS	162	0.002	Less with CM	69	0.449	NS	100

NS - mean DCR amount with control measure not significantly different than mean DCR amount without control measure, at alpha level of 0.20.

Conclusion - if the mean of the discharge amounts or mean of the ranks for tranformed data are significantly different, the direction of the difference for the mean with the control measure is indicated.

* number of observations is less than 30, thus result should be viewed with caution.

TABLE 10

Vessel Control Measures Associated with Significant Differences in Mean DCR Amount Reported (alpha level of 0.2)

Dry Cargo Residue Data - Reporting Period (September 29, 2008 through January 15, 2009)

Control Measure	Control Measure Description	Limestone / Coal / Taconite	Limestone	Coal	Taconite
Raw Data					
2	Troughed conveyor	X			
5	Water/mist for dust control		X	X	
7	Deck remote controls of conveyors			X	
10	Radio Communication between deck and loader		X	X	
13	Broom & shovel (to return to hold or shore)			X	
14	Tarps to collect residue (to return to hold or shore)	X		X*	X*
15	Cargo hold vibrator	X			X
16	Watertight gate seal			X*	
19	Careful cargo hold gate operation			X	
Rank Transformed Data					
1	Enclosed conveyor	X		X	
2	Troughed conveyor	X	X	X	
3	Conveyor skirts	X			
4	Belt Scrapers		X		
5	Water/mist for dust control	X	X	X	
6	Conveyor capacity indicators	X		X	X
7	Deck remote controls of conveyors			X	
8	Stop conveyor while ship or belt is repositioned				X
10	Radio Communication between deck and loader	X	X		X
11	Crew training on procedures to reduce residue			X	X
12	Limit vertical angle of conveyor boom				X
13	Broom & shovel (to return to hold or shore)		X	X	
14	Tarps to collect residue(to return to hold or shore)	X	X*	X*	X*
15	Cargo hold vibrator	X			X
16	Watertight gate seal	X	X*	X*	X*
18	Minimize hatch removal during poor weather	X			
19	Careful cargo hold gate operation	X		X	

X - mean of DCR reported or mean of the ranks for tranformed data were significantly different from mean when control measure was not used.
(only significant results where the mean DCR amount was less when the control measure was reported are shown)
* number of observations is less than 30, thus conclusion should be viewed with caution.

TABLE 11
Comparison between DCR Mass of U.S. and Foreign Vessels during Unloading Events.

Statistical Value	DCR Volume (cubic feet)					
	Coal		Limestone/Stone		Taconite	
	U.S.	Canadian	U.S.	Canadian	US	Foreign*
Number of Records with DCR Value	81	55	148	82	173	60
Average	13.0	24.0	7.04	12.0	22.3	18.2
Standard Deviation	25.8	31.0	16.6	22.4	117	33.2
Median	3.00	8.83	1.67	2.24	2.50	3.53
Minimum	0.0	0.0	0.0	0.0	0.0	0.0
Maximum	106	106	106	106	1,059	141
95th Percentile	88.3	106	44.5	66.4	35.3	72.4

*Includes one vessel from Germany and one vessel from Switzerland; all others were Canadian vessels.

TABLE 12

DCR Discharge by Facility (Loading Records Only)

Material	Facility ID	DCR Quantity Generated by Facility (data from vessel records) (data sorted by median DCR quantity) (cubic feet)							Facility Control Measure (reported on vessel records)																
		Number of Records with a DCR Value Recorded	Average	Standard Deviation	Median	Minimum	Maximum	95th Percentile	Enclosed Conveyor	Troughed Conveyor	Skirts on Conveyor	Belt Scrapers	Water/Mist	Capacity Indicators	Remote Controls	Stop Conveyor	Wind Delay	Radio Communications	Crew Training	Limit Angle of Conveyor	Plow Feed	Loading Chute	Chemical Surfactants	Suction Pumped Cargo	Other
Facility Taconite Database Statistics		163	16.48	55.98	1.77	0.00	423.76	35.31	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X
Taconite[1]	Taconite - 23	22	55.42	135.91	0.68	0.25	423.76	388.13	X	X	X	X	X	X	X	X	X	X	X	X		X	X		
	Taconite - 21	13	1.38	1.33	0.88	0.00	4.24	4.24	X	X	X	X	X	X		X	X	X	X		X	X			
	Taconite - 18	11	1.63	1.44	1.00	0.45	4.50	4.50			X	X				X		X				X			
	Taconite - 39	1	1.35	-	1.35	1.35	1.35	1.35								X		X				X			
	Taconite - 40	1	1.35	-	1.35	1.35	1.35	1.35	X	X	X	X						X							
	Taconite - 35	6	2.47	2.25	1.59	0.28	5.30	5.30										X				X			
	Taconite - 41	1	1.77	-	1.77	1.77	1.77	1.77										X				X			
	Taconite - 42	1	1.77	-	1.77	1.77	1.77	1.77										X	X						
	Taconite - 43	1	2.00	-	2.00	2.00	2.00	2.00								X		X				X			
	Taconite - 5	20	4.40	6.36	2.13	0.29	21.19	19.42				X	X	X	X	X	X	X	X	X		X	X		
	Taconite - 32	12	14.82	30.33	3.00	0.68	105.94	105.94									X	X				X			X
	Taconite - 44	1	3.53	-	3.53	3.53	3.53	3.53																	
	Taconite - 45	1	3.53	-	3.53	3.53	3.53	3.53																	
	Taconite - 46	42	13.01	26.43	4.86	0.67	169.50	35.31	X	X	X	X	X	X	X	X	X	X	X	X		X			
	Taconite - 47	24	10.43	10.34	8.12	0.28	35.31	24.72	X	X	X	X	X	X		X	X	X	X	X		X			
	Taconite - 48	1	17.66	-	17.66	17.66	17.66	17.66	X	X															
	Taconite - 49	2	18.54	23.72	18.54	1.77	35.31	35.31	X	X							X	X	X						
	Taconite - 50	3	94.52	80.94	141.25	1.06	141.25	141.25																	
Facility Coal Database Statistics		137	17.51	26.17	4.24	0.00	105.94	80.00	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
Coal	Coal - 30	38	10.87	21.75	2.07	0.00	70.63	70.63	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
	Coal - 42	1	3.00	-	3.00	3.00	3.00	3.00	X	X	X	X			X	X		X				X			
	Coal - 37	16	19.36	32.36	3.28	0.00	105.94	105.94	X	X		X	X	X		X	X	X	X	X		X			
	Coal - 11	12	12.47	29.51	3.88	1.00	105.94	105.94	X	X	X	X	X		X	X	X	X	X			X			
	Coal - 43	1	3.98	-	3.98	3.98	3.98	3.98				X													
	Coal - 44	1	4.94	-	4.94	4.94	4.94	4.94				X	X					X	X						
	Coal - 18	5	12.97	20.55	5.00	0.00	49.44	49.44	X	X	X	X		X	X	X		X	X			X			
	Coal - 42	2	5.00	4.24	5.00	2.00	8.00	8.00	X	X		X				X		X				X			
	Coal - 45	4	6.18	3.38	5.30	3.53	10.59	10.59								X	X	X							
	Coal - 46	1	7.06	-	7.06	7.06	7.06	7.06																	
	Coal - 2	20	12.77	12.93	8.83	0.00	35.31	35.31	X	X	X	X		X		X	X	X				X			
	Coal - 47	2	11.48	3.75	11.48	8.83	14.13	14.13							X	X	X	X							
	Coal - 22	23	26.58	28.57	14.13	0.00	84.75	84.75	X	X	X	X		X	X	X	X	X	X	X		X			
	Coal - 48	1	30.00	-	30.00	30.00	30.00	30.00	X	X	X					X	X	X				X	X		
	Coal - 49	2	30.02	32.46	30.02	7.06	52.97	52.97						X	X			X	X			X			
	Coal - 10	6	47.71	41.94	52.97	1.77	105.94	105.94	X	X	X	X		X	X	X		X	X			X			
	Coal - 50	1	70.63	-	70.63	70.63	70.63	70.63																	
	Coal - 31	1	70.63	-	70.63	70.63	70.63	70.63	X	X				X	X							X			

*Records that had no DCR reported were not included in the table.

TABLE 12
DCR Discharge by Facility (Loading Records Only)

Material	Facility ID	DCR Quantity Generated by Facility (data from vessel records) (data sorted by median DCR quantity) (cubic feet)							Facility Control Measure (reported on vessel records)																
		Number of Records with a DCR Value Recorded	Average	Standard Deviation	Median	Minimum	Maximum	95th Percentile	Enclosed Conveyor	Troughed Conveyor	Skirts on Conveyor	Belt Scrapers	Water/Mist	Capacity Indicators	Remote Controls	Stop Conveyor	Wind Delay	Radio Communications	Crew Training	Limit Angle of Conveyor	Plow Feed	Loading Chute	Chemical Surfactants	Suction Pumped Cargo	Other
Facility Limestone Database Statistics		171	17.97	43.96	2.67	0.00	353.13	105.94	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X
Limestone[1]	Limestone - 54	2	0.00	0.00	0.00	0.00	0.00	0.00						X		X		X	X						
	Limestone - 30	29	5.30	19.37	0.67	0.00	105.00	14.13	X	X	X	X	X	X	X	X	X	X	X			X			
	Limestone - 52	1	0.67	-	0.67	0.67	0.67	0.67	X	X		X				X		X	X	X					
	Limestone - 55	1	1.00	-	1.00	1.00	1.00	1.00								X		X							
	Limestone - 43	1	1.34	-	1.34	1.34	1.34	1.34								X		X							
	Limestone - 3	24	13.51	26.09	1.54	0.00	80.00	80.00	X	X	X	X		X		X	X	X	X	X		X	X		
	Limestone - 56	2	1.55	0.30	1.55	1.34	1.77	1.77							X	X		X				X			
	Limestone - 28	3	2.24	2.51	1.77	0.00	4.94	4.94				X	X	X		X		X	X			X			X
	Limestone - 49	8	7.08	15.72	2.01	0.35	45.91	45.91	X	X	X	X	X	X	X	X	X	X	X	X		X			
	Limestone - 25	12	3.99	4.87	2.01	0.32	17.66	17.66	X	X	X		X	X	X	X	X	X	X	X		X			
	Limestone - 28	1	2.47	-	2.47	2.47	2.47	2.47								X		X							
	Limestone - 33	33	28.05	47.85	3.00	0.00	160.00	141.26	X	X	X	X	X	X	X	X	X	X	X	X	X	X			
	Limestone - 57	4	3.92	2.08	3.00	2.67	7.00	7.00	X	X	X	X	X			X		X				X			
	Limestone - 58	1	3.53	-	3.53	3.53	3.53	3.53						X				X	X						
	Limestone - 22	22	32.51	58.24	4.00	0.35	194.22	170.00	X	X	X	X	X	X		X	X	X	X		X	X			
	Limestone - 48	10	38.97	110.42	4.14	0.35	353.13	353.13	X		X					X		X	X			X			
	Limestone - 59	9	8.83	0.00	8.83	8.83	8.83	8.83	X	X	X	X	X	X		X		X	X						
	Limestone - 16	8	43.15	46.87	28.49	0.71	105.94	105.94	X	X	X	X	X	X		X		X	X	X			X		

[1] DCR summary statistics are based on values recorded on the reporting forms and are not adjusted for the densities of taconite and limestone provided on the reporting form. The data combined for all records reported in Tables 1 and 2 reflect adjustments based on corrected densities.

*Records that had no DCR reported were not included in the table.

TABLE 13

Analysis of Variance Results Using Facility Control Measures as Indicator Parameters

Dry Cargo Residue Data - Reporting Period (September 29, 2008 through January 15, 2009

Control Measure Description	Limestone / Coal / Taconite			Limestone			Coal			Taconite		
	Probability	Conclusion	Count #	Probability	Conclusion	Count #	Probability	Conclusion	Count #	Probability	Conclusion	Count #
Raw Data												
A Enclosed conveyor	0.422	NS	97	0.970	NS	42	0.182	Greater with CM	43	.	-	12*
B Troughed conveyor	0.496	NS	95	0.872	NS	41	0.131	Less with CM	42	.	-	12*
C Conveyor skirts	0.431	NS	84	0.335	NS	40	0.233	NS	27*	0.404	NS	17*
D Belt Scrapers	0.510	NS	127	0.545	NS	66	0.409	NS	43	0.544	NS	18*
E Water/mist for dust control	0.544	NS	50	0.193	Greater with CM	25*	0.899	NS	14*	0.974	NS	11*
F Conveyor capacity indicators	0.259	NS	150	0.205	NS	72	0.112	Greater with CM	35	0.577	NS	43
G Deck remote controls of conveyors	0.675	NS	48	0.719	NS	6*	0.248	NS	39	0.858	NS	3*
H Stop conveyor while ship or belt is repositioned	0.087	Less with CM	252	0.407	NS	132	0.785	NS	57	0.319	NS	63
I Delay loading/unloading during high wind	0.377	NS	66	0.288	NS	28*	0.038	Greater with CM	16*	0.716	NS	22*
J Radio Communication between deck and loader	0.874	NS	335	0.786	NS	152	0.069	Less with CM	57	0.729	NS	126
K Crew training on procedures to reduce residue	0.398	NS	114	0.760	NS	64	0.352	NS	21*	0.987	NS	29*
L Limit vertical angle of conveyor boom	0.210	NS	45	0.994	NS	9*	0.005	Less with CM	22*	0.937	NS	14*
M Plow feeder	0.351	NS	17*	0.803	NS	2*	0.601	NS	14*	0.962	NS	1*
N Loading chute, incl. Telescoping or conveyors	0.397	NS	178	0.695	NS	71	0.431	NS	66	0.349	NS	41
O Chemical surfactants	0.542	NS	6*	0.198	Greater with CM	3*	0.917	NS	1*	0.743	NS	2*
P Suction pumped cargo, slurry transport, pneumatic or screw conveyors	.	-	0	.	-	0	.	-	0	.	-	0
Rank Transformed Data												
A Enclosed conveyor	0.262	NS	97	0.474	NS	42	0.448	NS	43	.	-	12*
B Troughed conveyor	0.382	NS	95	0.872	NS	41	0.393	NS	42	.	-	12*
C Conveyor skirts	0.181	Greater with CM	84	0.146	Greater with CM	40	0.174	Less with CM	27*	0.432	NS	17*
D Belt Scrapers	0.456	NS	127	0.108	Greater with CM	66	0.970	NS	43	0.500	NS	18*
E Water/mist for dust control	0.265	NS	50	0.418	NS	25*	0.914	NS	14*	0.389	NS	11*
F Conveyor capacity indicators	0.000	Greater with CM	150	0.000	Greater with CM	72	0.820	NS	35	0.898	NS	43
G Deck remote controls of conveyors	0.566	NS	48	0.281	NS	6*	0.055	Less with CM	39	0.759	NS	3*
H Stop conveyor while ship or belt is repositioned	0.266	NS	252	0.479	NS	132	0.212	NS	57	0.891	NS	63
I Delay loading/unloading during high wind	0.006	Greater with CM	66	0.222	NS	28*	0.001	Greater with CM	16*	0.889	NS	22*
J Radio Communication between deck and loader	0.000	Less with CM	335	0.598	NS	152	0.013	Less with CM	57	0.001	Less with CM	126
K Crew training on procedures to reduce residue	0.960	NS	114	0.183	Less with CM	64	0.697	NS	21*	0.030	Greater with CM	29*
L Limit vertical angle of conveyor boom	0.000	Less with CM	45	0.038	Less with CM	9*	0.041	Less with CM	22*	0.076	Less with CM	14*
M Plow feeder	0.263	NS	17*	0.276	NS	2*	0.045	Less with CM	14*	0.571	NS	1*
N Loading chute, incl. Telescoping or conveyors	0.328	NS	178	0.452	NS	71	0.186	Less with CM	66	0.711	NS	41
O Chemical surfactants	0.448	NS	6*	0.031	Greater with CM	3*	0.786	NS	1*	0.121	Less with CM	2*
P Suction pumped cargo, slurry transport, pneumatic or screw conveyors	.	-	0	.	-	0	.	-	0	.	-	0

NS - mean DCR amount with control measure not significantly different than mean DCR amount without control measure, at alpha level of 0.20.

Conclusion - if the mean of the discharge amounts or mean of the ranks for tranformed data are significantly different, the direction of the difference for the mean with the control measure is indicated.

* number of observations is less than 30, thus result should be viewed with caution.

TABLE 14

Facility Control Measures Associated with Significant Differences in Mean DCR Amount Reported (alpha level of 0.2)

Dry Cargo Residue Data - Reporting Period (September 29, 2008 through January 15, 2009)

Control Measure	Control Measure Description	Limestone / Coal / Taconite	Limestone	Coal	Taconite
Raw Data					
B	Troughed conveyor			X	
H	Stop conveyor while ship or belt is repositioned	X			
J	Radio Communication between deck and loader			X	
L	Limit vertical angle of conveyor boom			X*	
Rank Transformed Data					
C	Conveyor skirts			X	
G	Deck remote controls of conveyors			X	
J	Radio Communication between deck and loader	X		X	X
K	Crew training on procedures to reduce residue		X		
L	Limit vertical angle of conveyor boom	X	X*	X*	X*
M	Plow feeder			X*	
N	Loading chute, incl. telescoping or conveyors			X	
O	Chemical surfactants				X*

X - mean of DCR reported or mean of the ranks for tranformed data were significantly different from mean when control measure was not used.

(only significant results where the mean DCR amount was less when the control measure was reported are shown)

* number of observations is less than 30, thus conclusion should be viewed with caution.

TABLE 15
DCR Volume by Vessel and Facility (Unloading Records Only)

Material	Vessel ID	Facility ID	DCR Quantity Generated by Vessel (data sorted by median DCR quantity) (cubic feet)						
			Number of Records with a DCR Value Recorded	Average	Standard Deviation	Median	Minimum	Maximum	95th Percentile
Unloading Taconite Vessels Database Statistics			227	21.77	103.42	2.68	0.00	1059.40	70.63
Taconite[1]	Vessel - 34	Taconite-40	1	0.00	-	0.00	0.00	0.00	0.00
	Vessel - 63	Taconite-22	1	0.00	-	0.00	0.00	0.00	0.00
	Vessel - 31	Taconite-22	1	0.00	-	0.00	0.00	0.00	0.00
	Vessel - 31	Taconite-3	1	0.00	-	0.00	0.00	0.00	0.00
	Vessel - 34	Taconite-16	5	0.00	0.00	0.00	0.00	0.00	0.00
	Vessel - 63	Taconite-41	1	0.00	-	0.00	0.00	0.00	0.00
	Vessel - 10	Taconite-20	1	0.00	-	0.00	0.00	0.00	0.00
	Vessel - 44	Taconite-42	1	0.00	-	0.00	0.00	0.00	0.00
	Vessel - 34	Taconite-43	1	0.00	-	0.00	0.00	0.00	0.00
	Vessel - 18	Taconite-44	1	0.00	-	0.00	0.00	0.00	0.00
	Vessel - 10	Taconite-12	1	0.00	-	0.00	0.00	0.00	0.00
	Vessel - 18	Taconite-22	2	0.02	0.00	0.02	0.02	0.02	0.02
	Vessel - 1	Taconite-45	1	0.25	-	0.25	0.25	0.25	0.25
	Vessel - 1	Taconite-20	1	0.25	-	0.25	0.25	0.25	0.25
	Vessel - 65	Taconite-26	1	0.28	-	0.28	0.28	0.28	0.28
	Vessel - 62	Taconite-41	3	0.32	0.00	0.32	0.32	0.32	0.32
	Vessel - 61	Taconite-46	4	0.35	0.00	0.35	0.35	0.35	0.35
	Vessel - 1	Taconite-47	2	0.37	0.17	0.37	0.25	0.49	0.49
	Vessel - 56	Taconite-22	2	0.39	0.08	0.39	0.34	0.45	0.45
	Vessel - 65	Taconite-22	2	0.48	0.27	0.48	0.28	0.67	0.67
	Vessel - 36	Taconite-20	2	0.51	0.72	0.51	0.00	1.01	1.01
	Vessel - 29	Taconite-48	2	0.51	0.22	0.51	0.35	0.67	0.67
	Vessel - 56	Taconite-16	2	0.56	0.16	0.56	0.45	0.68	0.68
	Vessel - 1	Taconite-16	3	0.58	0.29	0.74	0.25	0.74	0.74
	Vessel - 68	Taconite-49	4	0.59	0.53	0.45	0.11	1.35	1.35
	Vessel - 62	Taconite-50	2	0.67	0.00	0.67	0.67	0.67	0.67
	Vessel - 77	Taconite-15	1	0.67	-	0.67	0.67	0.67	0.67
	Vessel - 26	Taconite-26	1	0.68	-	0.68	0.68	0.68	0.68
	Vessel - 29	Taconite-51	3	0.68	0.00	0.68	0.68	0.68	0.68
	Vessel - 6	Taconite-52	2	0.71	0.50	0.71	0.35	1.06	1.06
	Vessel - 63	Taconite-26	1	0.71	-	0.71	0.71	0.71	0.71
	Vessel - 27	Taconite-22	1	0.71	-	0.71	0.71	0.71	0.71
	Vessel - 61	Taconite-16	3	0.71	0.00	0.71	0.71	0.71	0.71
	Vessel - 36	Taconite-22	6	0.77	0.92	0.57	0.00	2.48	2.48
	Vessel - 30	Taconite-20	2	0.79	0.80	0.79	0.23	1.35	1.35
	Vessel - 79	Taconite-22	7	0.84	0.11	0.90	0.68	0.90	0.90
	Vessel - 78	Taconite-49	1	0.88	-	0.88	0.88	0.88	0.88
	Vessel - 79	Taconite-26	1	0.90	-	0.90	0.90	0.90	0.90
	Vessel - 76	Taconite-26	1	1.06	-	1.06	1.06	1.06	1.06
	Vessel - 78	Taconite-53	2	1.32	0.62	1.32	0.88	1.77	1.77
	Vessel - 76	Taconite-54	1	1.41	-	1.41	1.41	1.41	1.41
	Vessel - 76	Taconite-53	4	1.59	1.17	1.24	0.71	3.18	3.18
	Vessel - 69	Taconite-22	1	1.77	-	1.77	1.77	1.77	1.77
	Vessel - 78	Taconite-22	1	1.77	-	1.77	1.77	1.77	1.77
	Vessel - 69	Taconite-14	2	1.77	0.00	1.77	1.77	1.77	1.77
	Vessel - 69	Taconite-26	1	1.77	-	1.77	1.77	1.77	1.77
	Vessel - 30	Taconite-22	1	1.80	-	1.80	1.80	1.80	1.80
	Vessel - 11	#N/A	2	2.00	1.41	2.00	1.00	3.00	3.00
	Vessel - 29	Taconite-22	2	2.12	0.00	2.12	2.12	2.12	2.12
	Vessel - 60	Taconite-12	1	2.12	-	2.12	2.12	2.12	2.12
	Vessel - 75	Taconite-53	1	2.12	-	2.12	2.12	2.12	2.12
	Vessel - 30	Taconite-3	1	2.25	-	2.25	2.25	2.25	2.25
	Vessel - 11	Taconite-20	1	2.50	-	2.50	2.50	2.50	2.50
	Vessel - 30	Taconite-26	1	2.55	-	2.55	2.55	2.55	2.55
	Vessel - 29	Taconite-16	2	2.63	0.07	2.63	2.58	2.68	2.68
	Vessel - 46	Taconite-58	1	2.68	-	2.68	2.68	2.68	2.68
	Vessel - 9	Taconite-59	1	2.83	-	2.83	2.83	2.83	2.83
	Vessel - 9	Taconite-12	1	2.83	-	2.83	2.83	2.83	2.83
	Vessel - 78	Taconite-60	4	3.09	0.88	3.53	1.77	3.53	3.53
	Vessel - 57	Taconite-22	1	3.53	-	3.53	3.53	3.53	3.53
	Vessel - 8	Taconite-57	4	3.53	2.59	3.53	0.35	6.71	6.71
	Vessel - 8	Taconite-13	3	3.53	0.00	3.53	3.53	3.53	3.53
	Vessel - 8	Taconite-49	3	3.53	0.00	3.53	3.53	3.53	3.53
	Vessel - 64	Taconite-16	1	3.53	-	3.53	3.53	3.53	3.53
	Vessel - 74	Taconite-61	1	3.53	-	3.53	3.53	3.53	3.53
	Vessel - 69	Taconite-62	1	3.53	-	3.53	3.53	3.53	3.53
	Vessel - 64	Taconite-63	3	3.53	0.00	3.53	3.53	3.53	3.53
	Vessel - 64	Taconite-44	2	3.53	0.00	3.53	3.53	3.53	3.53
	Vessel - 67	Taconite-64	1	3.53	-	3.53	3.53	3.53	3.53
	Vessel - 67	Taconite-48	1	3.53	-	3.53	3.53	3.53	3.53
	Vessel - 64	Taconite-50	4	4.41	1.77	3.53	3.53	7.06	7.06
	Vessel - 13	Taconite-26	2	4.41	3.75	4.41	1.77	7.06	7.06
	Vessel - 64	Taconite-26	1	5.30	-	5.30	5.30	5.30	5.30
	Vessel - 8	Taconite-45	3	5.30	0.00	5.30	5.30	5.30	5.30
	Vessel - 5	Taconite-20	3	5.30	3.06	3.53	3.53	8.83	8.83
	Vessel - 71	Taconite-65	2	5.30	2.50	5.30	3.53	7.06	7.06
	Vessel - 73	Taconite-20	2	5.83	0.75	5.83	5.30	6.36	6.36
	Vessel - 46	Taconite-26	4	6.86	4.67	8.53	0.20	10.21	10.21
	Vessel - 66	Taconite-20	1	7.06	-	7.06	7.06	7.06	7.06
	Vessel - 34	Taconite-26	4	7.88	5.29	10.06	0.00	11.41	11.41
	Vessel - 12	Taconite-22	3	7.89	4.69	10.59	2.47	10.59	10.59
	Vessel - 31	Taconite-20	1	8.83	-	8.83	8.83	8.83	8.83
	Vessel - 12	Taconite-26	2	8.83	2.50	8.83	7.06	10.59	10.59
	Vessel - 59	Taconite-44	1	9.89	-	9.89	9.89	9.89	9.89
	Vessel - 5	Taconite-12	1	10.59	-	10.59	10.59	10.59	10.59
	Vessel - 12	Taconite-16	2	10.95	14.48	10.95	0.71	21.19	21.19
	Vessel - 68	Taconite-53	3	11.88	20.30	0.23	0.09	35.31	35.31
	Vessel - 57	Taconite-26	1	17.64	-	17.64	17.64	17.64	17.64
	Vessel - 7	Taconite-22	1	17.66	-	17.66	17.66	17.66	17.66
	Vessel - 72	Taconite-55	1	17.66	-	17.66	17.66	17.66	17.66
	Vessel - 72	Taconite-56	6	17.66	0.00	17.66	17.66	17.66	17.66
	Vessel - 72	Taconite-57	1	17.66	-	17.66	17.66	17.66	17.66
	Vessel - 72	Taconite-66	1	17.66	-	17.66	17.66	17.66	17.66
	Vessel - 72	Taconite-47	4	17.66	0.00	17.66	17.66	17.66	17.66
	Vessel - 7	Taconite-41	4	17.84	35.19	0.35	0.01	70.63	70.63
	Vessel - 52	Taconite-26	6	19.02	28.61	3.06	0.90	70.63	70.63
	Vessel - 12	Taconite-49	1	21.19	-	21.19	21.19	21.19	21.19
	Vessel - 35	Taconite-26	1	26.49	-	26.49	26.49	26.49	26.49
	Vessel - 35	Taconite-16	1	26.49	-	26.49	26.49	26.49	26.49
	Vessel - 7	Taconite-16	7	27.85	13.66	35.31	0.71	35.31	35.31
	Vessel - 35	Taconite-22	5	34.54	49.83	13.42	8.83	123.60	123.60
	Vessel - 21	Taconite-20	1	35.31	-	35.31	35.31	35.31	35.31
	Vessel - 68	Taconite-26	1	35.31	-	35.31	35.31	35.31	35.31
	Vessel - 7	Taconite-12	1	35.31	-	35.31	35.31	35.31	35.31
	Vessel - 58	Taconite-67	4	38.84	36.70	38.84	7.06	70.63	70.63
	Vessel - 70	Taconite-68	1	52.97	-	52.97	52.97	52.97	52.97
	Vessel - 49	Taconite-15	1	70.63	-	70.63	70.63	70.63	70.63
	Vessel - 57	Taconite-12	1	70.63	-	70.63	70.63	70.63	70.63
	Vessel - 59	Taconite-20	2	123.60	24.97	123.60	105.94	141.25	141.25
	Vessel - 59	Taconite-26	1	141.25	.	141.25	141.25	141.25	141.25
	Vessel - 12	Taconite-3	9	306.05	441.60	28.25	7.06	1,059.40	1,059.40

*Records with no DCR value reported are not included in the table.

TABLE 15
DCR Volume by Vessel and Facility (Unloading Records Only)

Material	Vessel ID	Facility ID	DCR Quantity Generated by Vessel (data sorted by median DCR quantity) (cubic feet)						
			Number of Records with a DCR Value Recorded	Average	Standard Deviation	Median	Minimum	Maximum	95th Percentile
Unloading Coal Vessels Database Statistics			**135**	**17.54**	**28.48**	**4.00**	**0.00**	**105.94**	**105.94**
Coal	Vessel - 80	Coal-49	1	0.00	-	0.00	0.00	0.00	0.00
	Vessel - 81	Coal-61	1	0.00	-	0.00	0.00	0.00	0.00
	Vessel - 63	Coal-46	1	0.00	-	0.00	0.00	0.00	0.00
	Vessel - 63	Coal-62	1	0.00	-	0.00	0.00	0.00	0.00
	Vessel - 43	Coal-37	1	0.00	-	0.00	0.00	0.00	0.00
	Vessel - 44	Coal-63	1	0.00	-	0.00	0.00	0.00	0.00
	Vessel - 55	Coal-64	1	0.00	-	0.00	0.00	0.00	0.00
	Vessel - 43	Coal-65	1	0.00	-	0.00	0.00	0.00	0.00
	Vessel - 65	Coal-66	1	0.32	-	0.32	0.32	0.32	0.32
	Vessel - 74	Coal-49	3	1.31	1.93	0.35	0.04	3.53	3.53
	Vessel - 13	Coal-67	1	0.53	-	0.53	0.53	0.53	0.53
	Vessel - 53	Coal-49	4	0.84	0.34	0.67	0.67	1.34	1.34
	Vessel - 27	Coal-90	2	0.67	0.00	0.67	0.67	0.67	0.67
	Vessel - 13	Coal-37	2	0.71	0.00	0.71	0.71	0.71	0.71
	Vessel - 78	Coal-62	1	0.71	-	0.71	0.71	0.71	0.71
	Vessel - 27	Coal-33	3	1.18	0.82	0.71	0.71	2.12	2.12
	Vessel - 27	Coal-64	1	0.71	-	0.71	0.71	0.71	0.71
	Vessel - 55	Coal-33	3	1.60	0.45	1.34	1.34	2.12	2.12
	Vessel - 1	Coal-68	2	1.70	1.90	1.70	0.35	3.04	3.04
	Vessel - 13	Coal-49	5	2.97	1.99	1.77	1.06	5.30	5.30
	Vessel - 13	Coal-36	1	1.77	-	1.77	1.77	1.77	1.77
	Vessel - 13	Coal-9	1	2.01	-	2.01	2.01	2.01	2.01
	Vessel - 13	Coal-69	1	2.01	-	2.01	2.01	2.01	2.01
	Vessel - 36	Coal-48	3	2.50	1.15	2.40	1.40	3.70	3.70
	Vessel - 29	Coal-36	4	3.05	2.69	2.40	0.67	6.71	6.71
	Vessel - 29	Coal-39	6	2.37	1.03	2.42	0.67	3.35	3.35
	Vessel - 83	Coal-66	1	2.50	-	2.50	2.50	2.50	2.50
	Vessel - 61	Coal-70	2	2.65	1.25	2.65	1.77	3.53	3.53
	Vessel - 55	Coal-49	2	2.83	0.00	2.83	2.83	2.83	2.83
	Vessel - 78	Coal-71	1	2.83	-	2.83	2.83	2.83	2.83
	Vessel - 56	Coal-6	1	3.00	-	3.00	3.00	3.00	3.00
	Vessel - 29	Coal-24	1	3.46	-	3.46	3.46	3.46	3.46
	Vessel - 46	Coal-49	4	3.58	2.80	3.53	0.20	7.06	7.06
	Vessel - 82	Coal-49	2	3.88	4.49	3.88	0.71	7.06	7.06
	Vessel - 11	Coal-49	1	4.00	-	4.00	4.00	4.00	4.00
	Vessel - 44	Coal-72	1	4.00	-	4.00	4.00	4.00	4.00
	Vessel - 30	Coal-34	2	4.00	2.83	4.00	2.00	6.00	6.00
	Vessel - 52	Coal-49	6	14.63	27.48	4.50	1.13	70.63	70.63
	Vessel - 7	Coal-73	1	5.30	-	5.30	5.30	5.30	5.30
	Vessel - 61	Coal-12	2	5.30	2.50	5.30	3.53	7.06	7.06
	Vessel - 30	Coal-74	1	6.00	-	6.00	6.00	6.00	6.00
	Vessel - 26	Coal-49	2	6.25	4.02	6.25	3.41	9.09	9.09
	Vessel - 9	Coal-75	1	7.06	-	7.06	7.06	7.06	7.06
	Vessel - 6	Coal-4	2	7.06	0.00	7.06	7.06	7.06	7.06
	Vessel - 67	Coal-76	1	7.06	-	7.06	7.06	7.06	7.06
	Vessel - 67	Coal-33	2	7.06	0.00	7.06	7.06	7.06	7.06
	Vessel - 67	Coal-77	1	7.06	-	7.06	7.06	7.06	7.06
	Vessel - 67	Coal-78	1	8.83	-	8.83	8.83	8.83	8.83
	Vessel - 67	Coal-79	1	8.83	-	8.83	8.83	8.83	8.83
	Vessel - 67	Coal-80	1	8.83	-	8.83	8.83	8.83	8.83
	Vessel - 67	Coal-81	1	10.59	-	10.59	10.59	10.59	10.59
	Vessel - 71	Coal-2	1	10.59	-	10.59	10.59	10.59	10.59
	Vessel - 5	Coal-82	1	10.59	-	10.59	10.59	10.59	10.59
	Vessel - 35	Coal-83	1	14.13	-	14.13	14.13	14.13	14.13
	Vessel - 35	Coal-23	1	14.13	-	14.13	14.13	14.13	14.13
	Vessel - 82	Coal-1	1	14.13	-	14.13	14.13	14.13	14.13
	Vessel - 83	Coal-91	1	15.00	-	15.00	15.00	15.00	15.00
	Vessel - 83	Coal-84	2	16.15	19.59	16.15	2.30	30.00	30.00
	Vessel - 83	Coal-84	2	17.50	3.54	17.50	15.00	20.00	20.00
	Vessel - 84	Coal-76	4	30.02	10.59	28.25	21.19	42.38	42.38
	Vessel - 15	Coal-40	3	30.60	4.08	28.25	28.25	35.31	35.31
	Vessel - 78	Coal-33	3	28.25	14.13	28.25	14.13	42.38	42.38
	Vessel - 15	Coal-76	1	35.31	-	35.31	35.31	35.31	35.31
	Vessel - 15	Coal-33	2	35.31	0.00	35.31	35.31	35.31	35.31
	Vessel - 15	Coal-33	3	54.15	45.41	35.31	21.19	105.94	105.94
	Vessel - 60	Coal-33	1	35.31	-	35.31	35.31	35.31	35.31
	Vessel - 60	Coal-76	1	49.44	-	49.44	49.44	49.44	49.44
	Vessel - 85	Coal-85	1	49.44	-	49.44	49.44	49.44	49.44
	Vessel - 7	Coal-70	5	63.56	32.08	70.63	17.66	105.94	105.94
	Vessel - 15	Coal-86	2	79.46	37.46	79.46	52.97	105.94	105.94
	Vessel - 45	Coal-87	1	88.28	-	88.28	88.28	88.28	88.28
	Vessel - 45	Coal-65	1	88.29	-	88.29	88.29	88.29	88.29
	Vessel - 83	Coal-88	1	100.00	-	100.00	100.00	100.00	100.00
	Vessel - 43	Coal-72	1	105.94	-	105.94	105.94	105.94	105.94
	Vessel - 15	Coal-89	3	105.94	0.00	105.94	105.94	105.94	105.94

*Records with no DCR value reported are not included in the table.

TABLE 15
DCR Volume by Vessel and Facility (Unloading Records Only)

Material	Vessel ID	Facility ID	DCR Quantity Generated by Vessel (data sorted by median DCR quantity) (cubic feet)						
			Number of Records with a DCR Value Recorded	Average	Standard Deviation	Median	Minimum	Maximum	95th Percentile
Unloading Limestone Vessels Database Statistics			229	8.84	19.01	1.77	0.00	105.94	52.97
Limestone	Vessel - 43	Limestone-84	1	0.00	-	0.00	0.00	0.00	0.00
	Vessel - 44	Limestone-84	1	0.00	-	0.00	0.00	0.00	0.00
	Vessel - 83	Limestone-93	1	0.00	-	0.00	0.00	0.00	0.00
	Vessel - 43	Limestone-94	1	0.00	-	0.00	0.00	0.00	0.00
	Vessel - 34	Limestone-95	1	0.00	-	0.00	0.00	0.00	0.00
	Vessel - 86	Limestone-96	1	0.00	-	0.00	0.00	0.00	0.00
	Vessel - 43	Limestone-97	1	0.00	-	0.00	0.00	0.00	0.00
	Vessel - 34	Limestone-98	3	0.00	0.00	0.00	0.00	0.00	0.00
	Vessel - 86	Limestone-99	1	0.00	-	0.00	0.00	0.00	0.00
	Vessel - 83	Limestone-100	1	0.00	-	0.00	0.00	0.00	0.00
	Vessel - 44	Limestone-101	1	0.00	-	0.00	0.00	0.00	0.00
	Vessel - 43	Limestone-102	1	0.00	-	0.00	0.00	0.00	0.00
	Vessel - 34	Limestone-103	1	0.00	-	0.00	0.00	0.00	0.00
	Vessel - 63	Limestone-104	1	0.00	-	0.00	0.00	0.00	0.00
	Vessel - 43	Limestone-105	1	0.00	-	0.00	0.00	0.00	0.00
	Vessel - 82	Limestone-106	3	0.24	0.41	0.00	0.00	0.71	0.71
	Vessel - 44	Limestone-107	1	0.00	-	0.00	0.00	0.00	0.00
	Vessel - 43	Limestone-66	2	0.00	0.00	0.00	0.00	0.00	0.00
	Vessel - 13	Limestone-108	1	0.30	-	0.30	0.30	0.30	0.30
	Vessel - 65	Limestone-47	1	0.32	-	0.32	0.32	0.32	0.32
	Vessel - 65	Limestone-109	1	0.32	-	0.32	0.32	0.32	0.32
	Vessel - 65	Limestone-110	1	0.32	-	0.32	0.32	0.32	0.32
	Vessel - 65	Limestone-111	1	0.32	-	0.32	0.32	0.32	0.32
	Vessel - 56	Limestone-112	1	0.33	-	0.33	0.33	0.33	0.33
	Vessel - 13	Limestone-113	1	0.33	-	0.33	0.33	0.33	0.33
	Vessel - 86	Limestone-114	1	0.35	-	0.35	0.35	0.35	0.35
	Vessel - 1	Limestone-115	1	0.35	-	0.35	0.35	0.35	0.35
	Vessel - 61	Limestone-116	1	0.35	-	0.35	0.35	0.35	0.35
	Vessel - 1	Limestone-117	1	0.35	-	0.35	0.35	0.35	0.35
	Vessel - 56	Limestone-118	6	0.86	0.76	0.50	0.33	2.33	2.33
	Vessel - 56	Limestone-119	2	0.50	0.00	0.50	0.50	0.50	0.50
	Vessel - 7	Limestone-120	1	0.53	-	0.53	0.53	0.53	0.53
	Vessel - 56	Limestone-121	1	0.67	-	0.67	0.67	0.67	0.67
	Vessel - 56	Limestone-122	6	0.80	0.44	0.67	0.45	1.67	1.67
	Vessel - 56	Limestone-123	3	0.56	0.19	0.67	0.33	0.67	0.67
	Vessel - 56	Limestone-113	4	0.92	0.50	0.67	0.67	1.67	1.67
	Vessel - 65	Limestone-125	1	0.67	-	0.67	0.67	0.67	0.67
	Vessel - 53	Limestone-126	1	0.67	-	0.67	0.67	0.67	0.67
	Vessel - 87	Limestone-127	1	0.67	-	0.67	0.67	0.67	0.67
	Vessel - 53	Limestone-48	1	0.67	-	0.67	0.67	0.67	0.67
	Vessel - 88	Limestone-128	9	0.67	0.00	0.67	0.67	0.67	0.67
	Vessel - 35	Limestone-129	1	0.67	-	0.67	0.67	0.67	0.67
	Vessel - 13	Limestone-67	1	0.71	-	0.71	0.71	0.71	0.71
	Vessel - 1	Limestone-112	1	0.71	-	0.71	0.71	0.71	0.71
	Vessel - 86	Limestone-131	1	0.71	-	0.71	0.71	0.71	0.71
	Vessel - 11	Limestone-132	1	1.00	-	1.00	1.00	1.00	1.00
	Vessel - 11	Limestone-133	1	1.00	-	1.00	1.00	1.00	1.00
	Vessel - 13	Limestone-119	1	1.06	-	1.06	1.06	1.06	1.06
	Vessel - 2	Limestone-135	1	1.06	-	1.06	1.06	1.06	1.06
	Vessel - 31	Limestone-136	1	1.20	-	1.20	1.20	1.20	1.20
	Vessel - 37	Limestone-84	3	1.33	0.33	1.33	1.00	1.67	1.67
	Vessel - 37	Limestone-119	1	1.33	-	1.33	1.33	1.33	1.33
	Vessel - 30	Limestone-84	3	1.74	0.70	1.33	1.33	2.55	2.55
	Vessel - 37	Limestone-137	1	1.33	-	1.33	1.33	1.33	1.33
	Vessel - 13	Limestone-84	3	1.97	1.35	1.33	1.06	3.53	3.53
	Vessel - 56	Limestone-138	2	1.33	0.47	1.33	1.00	1.67	1.67
	Vessel - 13	Limestone-34	1	1.41	-	1.41	1.41	1.41	1.41
	Vessel - 61	Limestone-84	2	1.59	0.25	1.59	1.41	1.77	1.77
	Vessel - 13	Limestone-139	2	1.59	1.25	1.59	0.71	2.47	2.47
	Vessel - 37	Limestone-140	3	1.56	0.19	1.67	1.33	1.67	1.67
	Vessel - 53	Limestone-84	4	1.80	1.07	1.68	0.67	3.18	3.18
	Vessel - 86	Limestone-84	1	1.77	-	1.77	1.77	1.77	1.77
	Vessel - 86	Limestone-141	1	1.77	-	1.77	1.77	1.77	1.77
	Vessel - 7	Limestone-142	1	1.77	-	1.77	1.77	1.77	1.77
	Vessel - 9	Limestone-127	1	1.77	-	1.77	1.77	1.77	1.77
	Vessel - 13	Limestone-66	1	1.77	-	1.77	1.77	1.77	1.77
	Vessel - 90	Limestone-15	1	1.77	-	1.77	1.77	1.77	1.77
	Vessel - 90	Limestone-67	1	1.77	-	1.77	1.77	1.77	1.77
	Vessel - 90	Limestone-143	2	1.77	0.00	1.77	1.77	1.77	1.77
	Vessel - 90	Limestone-93	1	1.77	-	1.77	1.77	1.77	1.77
	Vessel - 90	Limestone-80	2	1.77	0.00	1.77	1.77	1.77	1.77
	Vessel - 2	Limestone-14	1	1.77	-	1.77	1.77	1.77	1.77
	Vessel - 11	Limestone-84	5	1.70	0.76	2.00	0.50	2.50	2.50
	Vessel - 11	Limestone-27	1	2.00	-	2.00	2.00	2.00	2.00
	Vessel - 11	Limestone-47	1	2.00	-	2.00	2.00	2.00	2.00
	Vessel - 11	Limestone-52	5	1.80	0.84	2.00	1.00	3.00	3.00
	Vessel - 89	Limestone-80	1	2.00	-	2.00	2.00	2.00	2.00
	Vessel - 11	Limestone-145	1	2.00	-	2.00	2.00	2.00	2.00
	Vessel - 11	Limestone-14	1	2.00	-	2.00	2.00	2.00	2.00
	Vessel - 34	Limestone-144	1	2.01	-	2.01	2.01	2.01	2.01
	Vessel - 2	Limestone-141	2	2.12	2.00	2.12	0.71	3.53	3.53
	Vessel - 11	Limestone-15	4	2.38	0.48	2.25	2.00	3.00	3.00
	Vessel - 11	Limestone-58	2	2.25	1.06	2.25	1.50	3.00	3.00
	Vessel - 11	Limestone-102	2	2.25	0.35	2.25	2.00	2.50	2.50
	Vessel - 83	Limestone-146	1	2.30	-	2.30	2.30	2.30	2.30
	Vessel - 83	Limestone-119	1	2.30	-	2.30	2.30	2.30	2.30
	Vessel - 35	Limestone-144	3	3.12	1.28	2.47	2.30	4.60	4.60
	Vessel - 35	Limestone-147	3	2.47	0.00	2.47	2.47	2.47	2.47
	Vessel - 13	Limestone-148	1	2.47	-	2.47	2.47	2.47	2.47
	Vessel - 11	Limestone-114	2	2.50	0.71	2.50	2.00	3.00	3.00
	Vessel - 82	Limestone-84	5	1.89	1.81	2.54	0.00	4.06	4.06
	Vessel - 13	Limestone-149	1	2.67	-	2.67	2.67	2.67	2.67
	Vessel - 11	Limestone-49	3	4.33	3.21	3.00	2.00	8.00	8.00
	Vessel - 11	Limestone-150	1	3.00	-	3.00	3.00	3.00	3.00
	Vessel - 52	Limestone-139	1	3.00	-	3.00	3.00	3.00	3.00
	Vessel - 11	Limestone-151	1	3.00	-	3.00	3.00	3.00	3.00
	Vessel - 37	Limestone-152	1	3.33	-	3.33	3.33	3.33	3.33
	Vessel - 59	Limestone-84	1	4.94	-	4.94	4.94	4.94	4.94
	Vessel - 52	Limestone-84	3	37.98	58.86	5.00	3.00	105.94	105.94
	Vessel - 83	Limestone-153	1	5.00	-	5.00	5.00	5.00	5.00
	Vessel - 52	Limestone-146	1	5.00	-	5.00	5.00	5.00	5.00
	Vessel - 83	Limestone-49	1	5.30	-	5.30	5.30	5.30	5.30
	Vessel - 91	Limestone-154	2	6.34	2.36	6.34	4.67	8.01	8.01
	Vessel - 92	Limestone-120	1	7.35	-	7.35	7.35	7.35	7.35
	Vessel - 92	Limestone-84	5	12.68	8.44	7.35	7.35	26.67	26.67
	Vessel - 56	Limestone-147	1	8.33	-	8.33	8.33	8.33	8.33
	Vessel - 34	Limestone-84	6	8.72	1.12	9.06	7.38	10.06	10.06
	Vessel - 83	Limestone-155	1	10.00	-	10.00	10.00	10.00	10.00
	Vessel - 57	Limestone-80	1	10.59	-	10.59	10.59	10.59	10.59

*Records with no DCR value reported are not included in the table.

TABLE 15
DCR Volume by Vessel and Facility (Unloading Records Only)

Material	Vessel ID	Facility ID	DCR Quantity Generated by Vessel (data sorted by median DCR quantity) (cubic feet)						
			Number of Records with a DCR Value Recorded	Average	Standard Deviation	Median	Minimum	Maximum	95th Percentile
Limestone[1]	Vessel - 2	Limestone-80	2	11.12	14.23	11.12	1.06	21.19	21.19
	Vessel - 35	Limestone-118	1	14.13	-	14.13	14.13	14.13	14.13
	Vessel - 74	Limestone-156	1	14.13	-	14.13	14.13	14.13	14.13
	Vessel - 92	Limestone-157	1	14.70	-	14.70	14.70	14.70	14.70
	Vessel - 45	Limestone-158	1	17.66	-	17.66	17.66	17.66	17.66
	Vessel - 2	Limestone-143	3	24.72	25.46	17.66	3.53	52.97	52.97
	Vessel - 83	Limestone-151	1	20.00	-	20.00	20.00	20.00	20.00
	Vessel - 92	Limestone-159	1	26.67	-	26.67	26.67	26.67	26.67
	Vessel - 90	Limestone-84	7	43.82	36.95	26.67	7.06	105.94	105.94
	Vessel - 2	Limestone-160	3	37.67	13.37	31.78	28.25	52.97	52.97
	Vessel - 45	Limestone-52	1	35.31	-	35.31	35.31	35.31	35.31
	Vessel - 45	Limestone-14	3	41.20	26.97	35.31	17.66	70.63	70.63
	Vessel - 45	Limestone-102	2	35.31	0.00	35.31	35.31	35.31	35.31
	Vessel - 43	Limestone-161	1	35.31	-	35.31	35.31	35.31	35.31
	Vessel - 2	Limestone-162	2	35.67	49.44	35.67	0.71	70.63	70.63
	Vessel - 7	Limestone-115	1	49.44	-	49.44	49.44	49.44	49.44
	Vessel - 7	Limestone-117	1	49.44	-	49.44	49.44	49.44	49.44
	Vessel - 45	Limestone-163	1	52.97	-	52.97	52.97	52.97	52.97
	Vessel - 83	Limestone-164	1	60.00	-	60.00	60.00	60.00	60.00
	Vessel - 2	Limestone-165	1	61.80	-	61.80	61.80	61.80	61.80
	Vessel - 45	Limestone-166	2	61.80	62.43	61.80	17.66	105.94	105.94
	Vessel - 45	Limestone-167	1	70.63	-	70.63	70.63	70.63	70.63
	Vessel - 83	Limestone-52	1	80.00	-	80.00	80.00	80.00	80.00

[1] DCR summary statistics are based on values recorded on the reporting forms and are not adjusted for the densities of taconite and limestone provided on the reporting form. The data combined for all records reported in Tables 1 and 2 reflect adjustments based on corrected densities.

*Records with no DCR value reported are not included in the table.

Attachment A
Facsimile of U.S. Coast Guard Bulk Dry Cargo Residue Reporting Form (Form CG-33)

U.S. DEPARTMENT OF HOMELAND SECURITY U.S. COAST GUARD CG-33 Rev. (02-08)	**BULK DRY CARGO RESIDUE REPORTING FORM**	**OMB Number 1625-0072 Expires:**
		OFFICIAL/IMO NO.
MASTER'S CERTIFICATION:		**VESSEL NAME:**

For Cargo Loading & Unloading Operations									*For Residue Discharge Operations Only*		
Date	**Cargo Involved**[1]	**Operation** *(check one)*		**Facility Name**	**Control Measures Used**[2] *(see list of codes)*		**Time Spent to Implement Control Measure** *(hrs)*	**Estimated Residue to be Discharged**[3] *(m^3)*	**Discharge Start**	**Discharge Stop**	**Vessel Speed (kts)**
		Load	*Unload*		Facility	Vessel			*Date/Time(D/T) Ship's Position (Lat/Long)*	*Date/Time(D/T) Ship's Position (Lat/Long)*	
									D/T: Lat: Long:	D/T: Lat: Long:	
									D/T: Lat: Long:	D/T: Lat: Long:	
									D/T: Lat: Long:	D/T: Lat: Long:	
									D/T: Lat: Long:	D/T: Lat: Long:	
									D/T: Lat: Long:	D/T: Lat: Long:	
									D/T: Lat: Long:	D/T: Lat: Long:	
									D/T: Lat: Long:	D/T: Lat: Long:	

Please see footnotes on next page

Remarks:

Reset

NOTES:

[1] **Cargo Involved:** Provide the common name of the cargo (e.g., coal, taconite, sand, limestone, grain, salt, etc.) When multiple cargo types are discharged, please create a separate entry for each type

[2] **Control Measures:** Enter the code(s) below for each dry cargo residue control measure(s) used during cargo handling operations, for both cargo facilities (if known), and for your vessel.

[3] Estimated residue after loading and unloading operations to be discharged in accordance with 33 CFR 151.66

Return to Form

Cargo Involved	Facility Control Measures: Code	Facility Control Measures: Measure	Vessel Control Measures: Code	Vessel Control Measures: Measure
	A	Enclosed conveyor	1	Enclosed conveyor
iron ore	B	Troughed conveyor	2	Troughed conveyor
taconite	C	Conveyor skirts	3	Conveyor skirts
scale	D	Belt Scrapers	4	Belt Scrapers
coal/coke	E	Water/mist for dust control	5	Water/mist for dust control
grain	F	Conveyor capacity indicators	6	Conveyor capacity indicators
seed	G	Deck remote controls of conveyors	7	Deck remote controls of conveyors
wood pulp	H	Stop conveyor while ship or belt is repositioned	8	Stop conveyor while ship or belt is repositioned
potash	I	Delay loading/unloading during high wind	9	Delay loading/unloading during high wind
fertilizer	J	Radio Communication between deck and loader	10	Radio Communication between deck and loader
limestone	K	Crew training on procedures to reduce residue	11	Crew training on procedures to reduce residue
sand/gravel	L	Limit vertical angle of conveyor boom	12	Limit vertical angle of conveyor boom
dolomite	M	Plow feeder	13	Broom & shovel (to return to hold or shore)
clay	N	Loading chute, incl. Telescoping or conveyors	14	Tarps to collect residue(to return to hold or shore)
aggregates	O	Chemical surfactants	15	Cargo hold vibrator
salt	P	Suction pumped cargo, slurry transport,	16	Watertight gate seal
gypsum		pneumatic or screw conveyors	17	Cargo hold lining (teflon or kevlar)
cement	Q	Other (describe measure on "Remarks" line	18	Minimize hatch removal during poor weather
Other		on front of form)	19	Careful cargo hold gate operation
			20	Other (describe measure on "Remarks" line on front of form)

Equivalence Table for estimating residue

Cargo	Density (lbs/ft^3)	Equivalent Volume for 350 lbs of DCR	Volume in m^3
Coal	50	7 ft^3	0.2
Limestone	150	2.3 ft^3	0.07
Taconite	222	1.6 ft^3	0.05

Note: One 5 gallon bucket is equivalent to 0.019 m^3

1 cubic ft = 0.0283 m^3

EXHIBIT 2
Page 2 of Recordkeeping Form
DCR Records Analysis Memorandum

Appendix C
Dry Cargo Residue Reporting Form Evaluation for Shipping Activity

Dry Cargo Residue Records Evaluation for Shipping Activity from January 16, 2009, to July 15, 2009

PREPARED FOR: U.S. Coast Guard

PREPARED BY: CH2M HILL

DATE: November, 2009

Introduction

The U.S. Coast Guard is preparing a tiered Environmental Impact Statement (EIS) for the second phase of rulemaking for nonhazardous and nontoxic dry cargo residue (DCR) discharges from bulk cargo ships on the Great Lakes. An interim rule published on September 29, 2008 (73 FR 56492), regulates the discharge of DCR in the Great Lakes. Under the interim rule, nonhazardous and nontoxic DCR discharge can continue in limited areas of the Great Lakes and under certain conditions. The interim rule added new recordkeeping and reporting requirements and encouraged carriers to adopt voluntary control measures for reducing DCR discharges. A facsimile of the reporting form (form CG-33), which shows the required recordkeeping information, is included as Attachment A.[1]

This memorandum documents and evaluates the recordkeeping data collected for the period between January 16, 2009, and July 15, 2009. A previous memorandum did so for the recordkeeping data collected for the period between September 29, 2008, and January 15, 2009 (CH2M HILL, 2009). The evaluation will provide input for the preparation of the tiered EIS, which will support the development of the final rule regulating DCR discharges in the Great Lakes. Recordkeeping forms received after August 4, 2009, were not included in the analysis because they were received too late to be included in the data analysis due to time constraints. An additional 583 recordkeeping forms, received late for the September 29, 2008, to January 15, 2009, reporting period, were also not included in the analysis presented here.

[1] Original, interactive form is available at http://www.uscg.mil/hq/cg5/cg522/cg5224/docs/CG33.pdf.

The objectives of this memorandum are to

- Quantify DCR sweepings as reported by the bulk cargo carriers for the second and third quarters (i.e. January 16, 2009 to July 15, 2009) of mandatory reporting and compare these quantities with those used in the Phase I EIS and those reported in the first quarter of reporting (September 29, 2008 to January 15, 2009)
- Determine the usefulness of the recordkeeping data in analyzing the effectiveness of various control measures at reducing the amount of DCR generated during the loading and unloading of bulk cargo

Methods

Vessel DCR records submitted to the Coast Guard in hard copy by the shippers were manually entered into a Microsoft Excel database. The database was structured to allow for data analysis, query, and for future use within a geographic information system (GIS) and for future tasks beyond the vessel records analysis. The procedures for developing the database included the following:

1. Entering data as it appeared on the vessel record form (Data on the DCR reporting forms were entered into the electronic database so that each row on the DCR forms corresponded to a separate line in the DCR database.)
2. Converting DCR quantities to consistent units of cubic feet and pounds (Reported units greatly varied, from cubic meters, cubic yards, pounds, tons, etc.)
3. Converting discharge locations to a consistent latitude and longitude format for future use in a GIS
4. Converting vessel speeds to a consistent unit (Reported units varied between knots and mph.)
5. Randomly checking approximately 50 percent of the database entries for quality control

The database includes all of the information recorded on the DCR sheets, additional general information on the individual ships and facilities, and information that would allow for future retrieval. The information within the database was entered exactly as it was reported on the vessel records, except when explicit, easily correctable errors were observed (spelling errors, inconsistent ship names, etc.). Missing data fields were left as blank entries in the database. Additional general information regarding the individual ships was obtained mostly from *Know Your 2008 Ships* (Marine Publishing, 2008), www.boatnerd.com, and from vessel company Web sites. Additional facility information was obtained from the U.S. Army Corp of Engineers (2009) and through Internet searches. In total, 44 key items of information were included as fields in the database. Table 1 summarizes the information included in the database for each loading and unloading event recorded on the vessel records and the preferred units.

Overall, the primary assumption was that the data reported on each DCR reporting form were correct. There was no reason to assume that any of the data were incorrect, unless a given entry was significantly different from the rest of the entries for a similar situation. When obviously inconsistent data were omitted from the data sheet and similar data did not provide insight on the missing data, the corresponding line on the vessel form was left blank as if nothing had been reported on the vessel form.

Data Discrepancies and Corrective Action Taken During Database Development

Discrepancies in the vessel records required some manual corrections of obvious errors. There were, however, examples of data discrepancies identified when data queries revealed that vessel recordkeeping was not consistent between records for the same vessel or when the vessel records were not completed according to the reporting form instructions which was estimated at approximately 36 percent of the records for coal, limestone, and taconite. These discrepancies were generally not corrected because of the size of the database; that is, manual entry-by-entry checking was not possible for the approximately 2,500 entries. In addition, some of the entries could not be corrected because the intent of the data recorder was not clear. A summary of some of the significant discrepancies are as follows:

- Multiple rows were used to record a single unloading or loading event and corresponding DCR-sweeping event. To account for the use of multiple rows for a single event, records were removed from the data analysis if unloading or loading had not been specified or if no DCR volume had been specified. It is estimated that for this reason, about 18 percent of the usable data was removed from the statistical summary.

In order to have used these data, the entries would have to be evaluated individually and professional judgment made on what was meant by each data entry.

- Facility names were inconsistent or incorrect, and many required Internet searches to verify or correct the names. Often there was not enough information to determine the actual facility referred to on the DCR reporting form to make the database consistent. The entries were not corrected due to the large number of discrepancies.
- Based on Internet searches and industry knowledge of the shoreside facilities, the facility control measures were found to be incorrect on many of the reporting forms, likely because a vessel's crew was not familiar with facility control measures. For example, a DCR reporting form may have indicated that a certain facility does not use troughed conveyors for loading cargo, when previous visits by team members confirmed they exist at the facility. The entries were not corrected due to the large number of discrepancies.
- Some of the DCR volume and vessel speed records were reported in units that differed from those requested on the reporting form. These values were converted to allow them to be compared with the rest of the records.

These numerous and substantive inconsistencies and errors in the reporting forms create considerable uncertainty in the database. For example, some control measures that are part of a vessel's infrastructure, such as a troughed conveyor, were reported for some unloading events, but not for others for a given vessel. Potential reasons for other discrepancies in the vessel records are discussed in the DCR Loading and Unloading Observations Technical Memorandum (CH2M HILL, 2009b). The number of inconsistencies discovered and checked indicates the reliability of the information in the forms may be suspect, particularly for that which cannot be checked (e.g., quantity of DCR). In addition, the database cannot distinguish between deck DCR and tunnel DCR. Past observations indicate that DCR quantity from these two sources can be very different, and variation due to source of DCR (deck or tunnel) can be large compared to variation resulting from control measures. This high degree of uncertainty in the database constrains a rigorous statistical and quantitative analysis of the data.

Dry Cargo Residue Densities and Corrective Action

The densities of limestone and taconite provided on the DCR reporting form were found to be inaccurate subsequent to preparation of the memorandum documenting the data for the period between September 29, 2008, and January 15, 2009 (CH2M HILL, 2009). The limestone density provided on the form is 150 lbs/ft^3 and the taconite density on the form is 222 lbs/ft^3. Samples of these cargos collected in June 2009 during the direct observation program ranged from approximately 94 to 103 lbs/ ft^3 and 125 to 130 lbs/ft^3, respectively. These values agree reasonably well with literature values for the two cargos, which range from 85 to 110 lbs/ft^3 for limestone and from 107 to 175 lbs/ft^3 for taconite (Table 2). To account for the incorrect densities on the reporting form, the reported DCR volumes for these cargos were corrected in the database using a density of 100 lbs/ft^3 for limestone and a density of 130 lbs/ft^3 for taconite. To be conservative, it was assumed that all reported DCR volumes were estimated using the incorrect densities on the DCR reporting form, and therefore all reported volumes were adjusted using the correct densities. This assumption likely overestimates the volumes for those records that were reported based solely on a visual estimate of volume, but accounts for those records that were reported based on an estimated mass of DCR that was converted using the densities on the form. This approach provides a conservative upper bound of DCR volumes in order to assess impacts of the practice of discharging DCR to the Great Lakes.

Because of the incorrect densities on the reporting form, the summary statistics presented in the technical memorandum documenting the first reporting period (CH2M HILL, 2009) were incorrect for limestone and taconite. The corrected summary statistics for the first reporting period (2008 vessel records) are presented in Table 3 for volume and Table 4 for mass.

Results

The data evaluation included only those data entries that contained a load or unload event (and indicated which), identified the cargo type, and reported a DCR quantity, including a value of zero. If the DCR quantity on a record was blank, the entry was not included in the evaluation because it was unknown if the DCR quantity was zero, a value greater than zero but not recorded, or if it was included as part of a subsequent entry. A total of 1,178 useable data entries were included in the data summary for the three primary cargos, which included 383 entries (32 percent) for coal, 396 entries (34 percent) for limestone, and 399 (34 percent) entries for taconite.

Summary statistics for reported volumes for coal, limestone, and taconite DCR are shown in Table 3, broken down by loading and unloading events. Table 4 presents summary statistics for the corresponding masses of DCR, and Table 5 presents the total time spent discharging DCR for each cargo type. The values presented in Tables 3 and 4 represent a summary of DCR reported for loading and unloading events but do not represent only DCR discharge events. Some records reported DCR volumes for a given event but did not include an associated discharge for the event. Therefore, the summary statistics describe the DCR quantities generated by loading and unloading events, but include both discharge and nondischarge events.

DCR Amounts and Discharge Time for Loading Operations

The 2009 DCR vessel records data indicate that the mean volumes of limestone and taconite residue reported from loading operations were similar, at 12.6 ft^3 and 12.0 ft^3, respectively (Table 3). The mean volume of coal residue reported was considerably less, at 7.5 ft^3. However, the mean volume can be biased by a few extreme events; therefore, examining the median value, or the number separating the higher half of the data set from the lower half of the data set (i.e., the 50th percentile) can provide a more representative value for the most common DCR volume per event. An examination of the distributions of loading and unloading data revealed that the distributions are skewed toward the lower end of the scale (see Figures 1 and 2 for examples). Therefore, the median value is likely more informative of the central tendency of the data than is the mean.

Although mean volumes of limestone and taconite were greater than the mean value for coal, the median taconite volume (2.4 ft^3) was more similar to the median coal volume (1.8 ft^3) for loading events. The median limestone volume for loading events was 3.6 ft^3, suggesting that limestone loading results in about twice as much residue as coal loading does, regardless of whether the mean or median values are considered (Table 3).

FIGURE 1
Limestone Loading Events (2009 Vessel Records)

Inset figure represents a close-up view of the 0-27 ft³ range of the graph

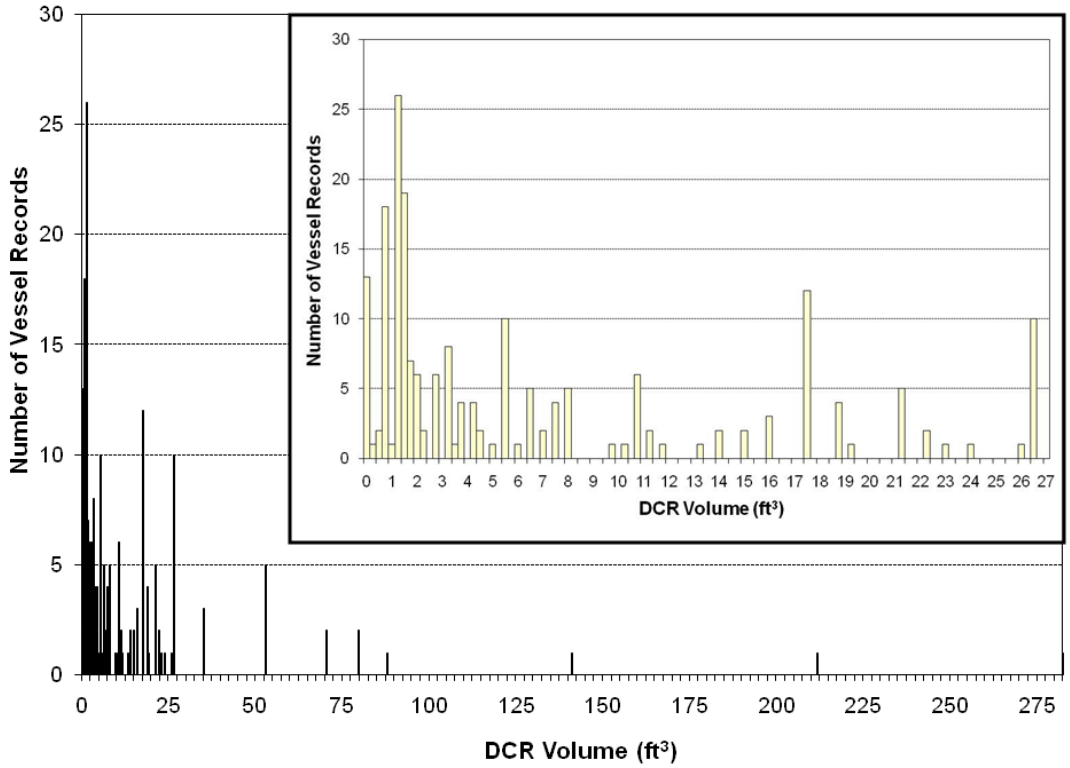
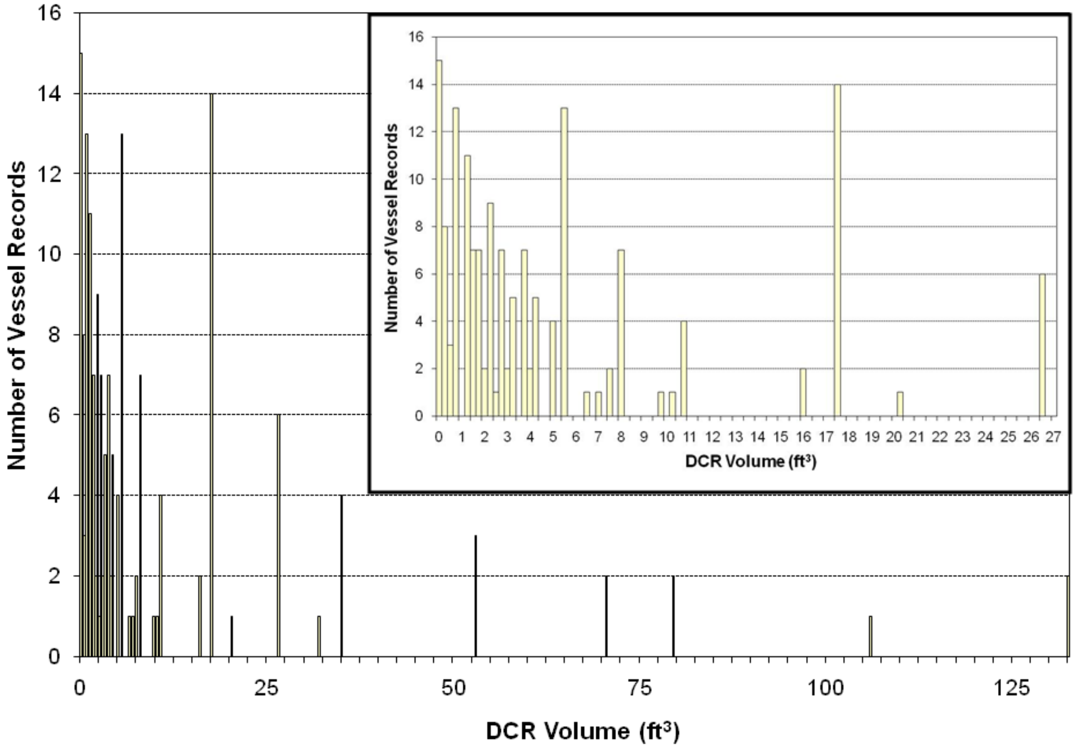


FIGURE 2
Limestone Unloading Events (2009 Vessel Records)
Inset figure represents a close-up view of the 0-27 ft³ range of graph



On a mass basis, the mean and median amounts of limestone and taconite residue reported for loading events was much larger than that reported for coal. Taconite loading events were associated with the largest mean DCR generated: 1,564 lbs per event (median of 313 lbs). Mean amount of limestone DCR was 1,260 lbs per event. However, the median amount of DCR generated by limestone loadings (360 lbs) was higher than the median for taconite (313 lbs). The median mass of coal residue from loading operations, 88 lbs (mean of 374 lbs), was considerably less than the median masses of the other two cargos.

The times spent discharging DCR after loading operations vary considerably among the three cargo types (Table 5). The median time required to wash taconite residue off the deck after loading events was 175 minutes (mean of 213 minutes). In contrast, the median time required for washing limestone residue off the deck after loading events was 135 minutes (mean of 203 minutes), and for coal residue, 120 minutes (mean of 162 minutes).

DCR Amounts and Discharge Time for Unloading Operations

The 2009 DCR vessel records data indicate that on a volume basis, the median volume of residue reported for unloading operations was 2.4 ft^3 (mean 14.2 ft^3) for taconite, 3.5 ft^3 (mean 13.2 ft^3) for coal, and 3.2 ft^3 (mean 10.5 ft^3) for limestone (Table 2). Although the mean volume of taconite was greater, the median taconite volume from unloading was about 1 ft^3 less than the median values for coal and limestone.

On a mass basis, the amount of taconite residue reported for unloading events was much higher than coal or limestone. The mean amount of taconite residue reported was 1,849 lbs per event. In contrast, the mean limestone residue reported for unloading events was 1,052 lbs, and the mean for coal-unloading events was 662 lbs (Table 4). Although the mean amount of taconite residue per loading event was much higher than the mean amount of limestone, the median values for both cargos were similar, at 313 lbs and 318 lbs, respectively. The median coal (177 lbs) residue reported per unloading event was much lower than the median for either taconite or coal. The mean values of taconite and limestone are much larger than their median values because a few large discharge events can substantially increase the mean value in a data set; where as the median value is not affected by disproportionately large values or outliers.

Based on the results of the direct observations of unloading operations (CH2M HILL, 2009b), it is likely that there is uncertainty in many of the DCR volumes reported for unloading events. The median DCR volumes reported by the vessels for the unloading events directly observed were significantly less than the DCR volumes estimated during the observations. Because loading events primarily generate DCR on the vessel deck and unloading events primarily generate DCR in the vessel tunnel, it appears that at least for some vessels, only the deck DCR is estimated for unloading events and the tunnel DCR is either ignored or inaccurately estimated.

Factors that could cause differences between the DCR volumes from the direct observations and the vessel records could include the following:

- Mates or others who complete the vessel reporting form may not inspect the deck or tunnel to estimate DCR. Instead, they may estimate a quantity based the duration of washing the deck or tunnel (e.g., longer sweeping time indicates more DCR), or the quantity is estimated based on historical loading and unloading DCR of the cargo or facility.

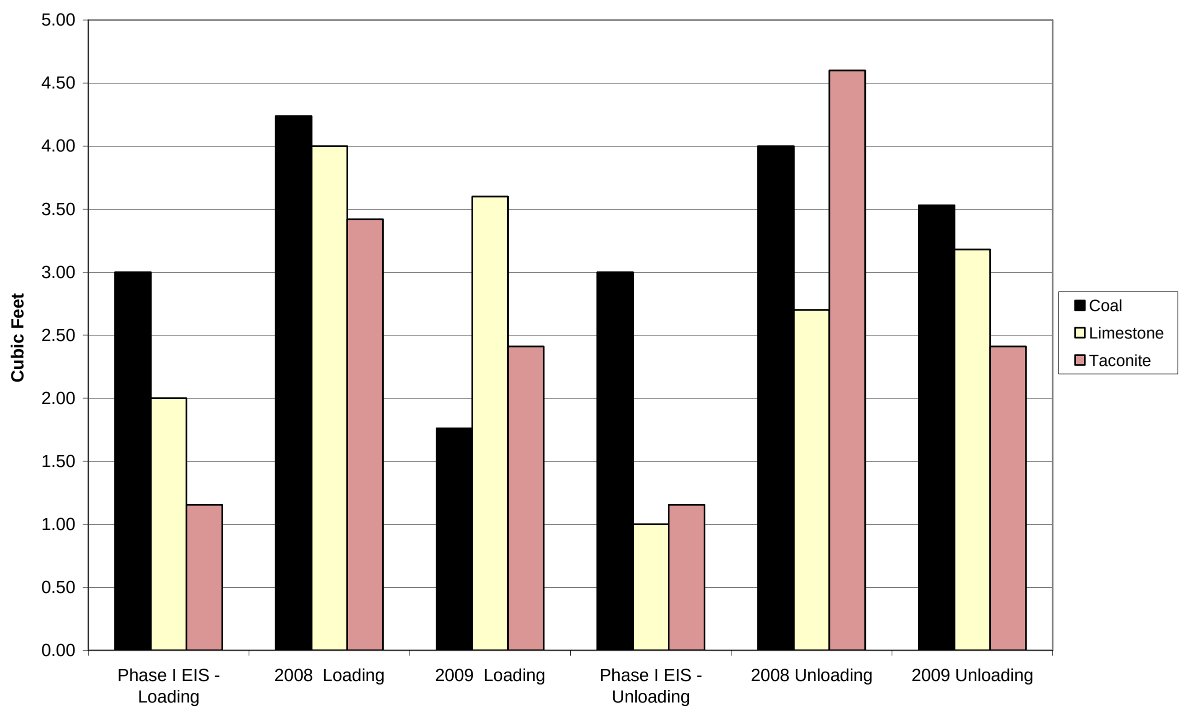
- The DCR volumes reported are estimates, because the crew does not collect and measure DCR for reporting.
- The total DCR quantity may not be reported for the vessel (i.e., only deck DCR may be reported but not tunnel DCR).
- DCR quantities are typically reported if it is product, but not dust. Many vessel crews did not view dust as DCR and therefore dust is likely not estimated for reporting. Instead, the crew defined DCR as spilled product, such as a taconite pellet, or a piece of coal or a stone.

The times reported for discharging DCR after unloading operations were similar among the three cargo types, with taconite residue requiring slightly more time to sweep. Taconite residue required a mean time of 259 minutes (median time of 204 minutes) to sweep, whereas coal and limestone were similar, with mean times of 219 minutes (median times of 165 minutes) and 179 minutes (median time of 139 minutes), respectively (Table 5).

Comparison of DCR among the 2008 and 2009 Records and the Phase I EIS Estimates

All the median DCR volumes reported for loading events in 2009 were less than the median volumes reported in the 2008 records (Figure 1). Reported DCR volumes for unloading events showed the same trend; with the exception of limestone, where the median value reported was about 0.5 ft^3 greater in 2009. The 2009 data show that more DCR associated with unloading events for coal, about 1.8 ft^3, was reported in contrast to the 2008 records, where the median values for loading and unloading were very similar. The median DCR amounts reported for limestone and taconite were very similar between the loading and unloading events (Figure 2).

FIGURE 3
Comparison of Median Volumes of DCR from 2008 and 2009 Vessel Records and Phase I EIS



There was less variability in the 2009 records for limestone and taconite as demonstrated by the smaller standard deviations of these data sets, which decreased considerably from 2008 to 2009 (Table 3). In contrast, the variability in the reported coal residue associated with loading events increased considerably from 2008 to 2009, with the standard deviation increasing from 4.2 ft^3 to 15.9 ft^3.

Table 3 compares the DCR volumes used in the Phase I EIS with those determined from analyzing the vessel DCR records from the last quarter of the 2008 shipping season and the first two quarters of the 2009 shipping season. The Phase I amounts were based on data from voluntary reporting by the Great Lakes shipping industry. The statistics for Phase I do not include data points where the mass reported was greater than 10 tons because these records were considered to be outliers. This comparison shows that the mean reported volume of all three cargo types is greater than the mean volumes used in the Phase I EIS. However, the average value can be biased by a few extreme events; therefore, the median values are compared in Figure 1. The median volume of coal reported in the 2008 records for loading events was higher than the Phase I volume, but the median volume for 2009 was lower. Therefore, the median coal volume used in the Phase I EIS agrees reasonably well with the volumes reported for coal loadings in the 2008– 2009 vessel records. In contrast, the median volumes reported for limestone and taconite in the 2008 and 2009 vessel records were consistently higher than the median volumes used in the Phase I EIS. The median reported volumes for all three cargos for unloading events were consistently higher in the 2008 and 2009 vessel records than the volumes used in Phase I.

Summary of DCR and Reported Control Measures for each Vessel

Table 6 summarizes the reporting data for all vessels that reported DCR for the period of January 16, 2009, to July 15, 2009. Table 6 presents summary DCR statistics for each vessel and identifies the control measures reported at least once as well as the country of origin, the year constructed, and the length of the vessel. Most vessels reported using at least one-half of the listed control measures at least once on the reporting forms and all of the listed control measures were reported at least once in the vessel records for each cargo, although several vessels did not report using any of the control measures. The reporting forms that reported no control measures used for a given event are most likely erroneous because some of the control measures are part of the vessel's infrastructure.

Summary of DCR and Reported Control Measures for each Loading Facility

Table 7 summarizes the reporting data and presents descriptive statistics for DCR generated during loading at each facility as reported by the vessels that loaded at the facilities during the reporting period. The summary statistics presented in Table 7 include data for only coal, limestone, and taconite, but the data set includes DCR data for all cargos reported. Table 7 also identifies control measures reported in the vessel records at least once for each facility. Most of the control measures were reported at least once for at least some of the facilities. However, three control measures (plow feeder, chemical surfactants, and suction-pumped cargo) were not listed for any of the facilities loading limestone or taconite. Plow feed and suction-pumped cargo were reported for two facilities loading coal, and chemical surfactants were reported for one facility loading coal, although the name was not provided for this facility on the reporting form. Control measures used nearly universally included: troughed conveyors, skirting, belt scrappers, stopping the loading conveyor between cargo holds, and communications and crew training. Water misting was also used nearly universally for coal and limestone loading operations and loading chutes were used for coal loading operations.

DCR Amounts by Vessel and Facility

Table 8 compiles summary statistics for individual vessels grouped by the facility where they unloaded their cargo for each event. Most of the records show a vessel visiting a particular port facility only once during the reporting period. However, a few of the vessels did make repeated deliveries at a particular facility.

Composition of Bulk Dry Cargo Fleet

Table 9 compares DCR volume generated by U.S. vessels with that from foreign vessels for unloading of coal, limestone, and taconite during the January 16, 2009, to July 15, 2009 reporting period. All of the foreign vessels carrying coal, limestone, and taconite on the Great Lakes during this period were Canadian vessels.

The median volume of coal and limestone residue generated during unloading was larger for Canadian vessels than it was for U.S. vessels. The largest difference was for limestone: Canadian vessels had a median volume of 6.0 ft^3 (mean of 20.5 ft^3), whereas U.S. vessels had a median volume of 2.4 ft^3 (mean of 7.1 ft^3). The median reported volume of coal residue was slightly less for U.S. vessels, at 3.4 ft^3 (mean of 13.0 ft^3), than for Canadian vessels, at 4.2 ft^3 (mean of 13.8 ft^3). The median volume of taconite residue was larger for U.S. vessels at 3.7 ft^3 (mean of 12.4 ft^3) than for Canadian vessels at 1.1 ft^3 (mean of 7.1 ft^3). Individual large volume DCR discharge events were not excluded from the summary statistics presented in Table 9; therefore, the median values may provide a better comparison as they are not affected by a few large events, unlike the mean values that can be biased by a few large events.

Conclusions

The analysis of the 2009 vessel records from the first two quarters of the 2009 shipping season shows that the reporting data are generally consistent with the 2008 reporting data, although there was a general trend of less median quantities of DCR reported in 2009 for coal and taconite. The median quantities of limestone reported for loading and unloading events were similar to those reported in the 2008 records. The variability and uncertainty in the reporting data prevent a meaningful analysis and understanding of statistically significant effects of the control measures. However, the reporting of DCR quantities generated an abundant amount of data for characterizing the DCR quantities generated during the loading and unloading of the dry cargo. With the exception of DCR reported for coal-loading events, the median DCR quantities reported were greater than the values used in the Phase I EIS.

Control Measure Effectiveness

The uncertainty and variability in the 2008 vessel records data made it impossible to assess whether individual control measures were significantly effective at reducing DCR quantities. A major uncertainty surrounds the reliability of the recordkeeping for shoreside facility control measures, because the ship personnel responsible for completing the recordkeeping forms were likely not fully familiar with the shoreside control measures. Another limitation of the data set is the lack of consistency in the recordkeeping. For example, some of the structural control measures that cannot be shut off or not used (e.g., a troughed conveyor) were not reported for all the events for a given facility or vessel when they should have been. This created erroneous data points that were associated with DCR quantities in the absence of a given control measure, when in fact those data points should have been associated with a given control measure. Problems with the data prevent their use in any statistical analysis of control measure effectiveness. Therefore, this type of analysis was not attempted for the 2009 vessel records data set.

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CH2M HILL. 2009. DCR Records Evaluation (Sept. 29, 2008, to Jan. 15, 2009)

CH2M HILL. 2009b. DCR Loading and Unloading Observations.

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U.S. Army Corps of Engineers. 2009. U.S. Waterway Data: Port and Waterway Facilities. Navigation Data Center. Available from http://www.iwr.usace.army.mil/ndc/data/datapwd.htm. Site accessed February 25, 2009.

TABLE 1
Summary of the Type of Data Within Vessel Records Database

Type	Source
Date	Vessel DCR Reporting Forms
Ship official number	
Ship IMO number	
Vessel name	
Cargo involved	
Operation (load/unload)	
Facility name	
Port (name, city, state, province, country)	
Facility control measures implemented (type, number)	
Vessel control measures implemented (type, number)	
Time spent implementing control measures (minutes)	
Estimated residue to be discharged (cubic feet)	
Discharge start (date, time, longitude—decimal deg. and direction, latitude—decimal deg. and direction)	
Discharge stop (date, time, longitude—decimal deg. and direction, latitude—decimal deg. and direction)	
Fleet name	*Know Your Ships 2008* (Marine Publishing 2008)
City of owning company	
Fleet (state, province, country)	
Year Built	
Cargo capacity (long tons)	
Overall length (feet)	
Breadth (feet)	
Depth (feet)	
Vessel notes	

TABLE 2
Summary of Density Values for Coal, Limestone, and Taconite

Cargo	Density (lbs/ft^3)	Type	Source
Coal	52	Bituminous, broken	SImetric (http://www.SImetric.co.uk)
	45–55	Bituminous, sized	Tapco Inc. (http://www.tapcoinc.com)
	45–55	Bituminous, sized	SME Mining Reference Handbook (Society for Mining, Metallurgy, and Exploration)
Limestone	97	Broken	SImetric (http://www.SImetric.co.uk)
	55–95	Dust	Tapco Inc. (http://www.tapcoinc.com)
	85–90	Crushed	SME Mining Reference Handbook (Society for Mining, Metallurgy, and Exploration)
	110	Solid (Type I)	American Society for Testing and Materials (ASTM) C-568
Taconite	175	Taconite	SImetric (http://www.SImetric.co.uk)
	116–130	Taconite pellets	Tapco Inc. (http://www.tapcoinc.com)
	116–130	Iron ore pellets	SME *Mining Reference Handbook* (Society for Mining, Metallurgy, and Exploration)
	107–143	Iron ore, taconite	

TABLE 3
Comparison of DCR Volumes between Vessel Records and Phase I EIS Estimates

Statistical Value	Coal (ft3) 2008 Vessel Records	Coal (ft3) 2009 Vessel Records	Coal (ft3) Phase I EIS Estimate[a]	Limestone (ft3) 2008 Vessel Records	Limestone (ft3) 2009 Vessel Records	Limestone (ft3) Phase I EIS Estimate[a]	Taconite (ft3) 2008 Vessel Records	Taconite (ft3) 2009 Vessel Records	Taconite (ft3) Phase I EIS Estimate[a]
Loading									
Mean	17.5	7.48	3.01	26.8	12.6	2.69	27.9	12.0	1.79
Std deviation	4.2	15.9	2.35	65.8	28.6	2.41	95.2	34.2	2.81
Median	4.2	1.76	3.00	4.0	3.60	2.00	3.4	2.41	1.15
Minimum	0	0	0.20	0	0	0.15	0	0	0.12
Maximum	106.0	141	20.0	530.0	282	10.0	725.0	241	38.5
95th percentile	72.5	35.3	6.00	158.9	52.9	8.00	60.4	48.3	6.15
No. of Records	137	198	154	172	220	74	165	197	239
Unloading									
Mean	17.4	13.2	3.30	13.2	10.5	1.23	36.4	14.2	1.45
Std deviation	28.4	30.8	2.28	28.5	20.7	0.76	174.6	27.8	1.83
Median	4.0	3.53	3.00	2.7	3.18	1.00	4.6	2.41	1.15
Minimum	0	0	0.30	0	0	0.10	0	0	0.04
Maximum	106	159	12.0	159.0	132	3.00	1,812.0	181	23.1
95th percentile	101	70.6	8.00	79.5	52.9	2.30	120.8	60.3	3.85
No. of Records	136	185	115	230	176	35	233	202	192

[a]The vessel records supporting the first EIS separated DCR estimates by the deck and tunnel, but did not specify loading or unloading events. Therefore, deck estimates were assumed to be loading events and tunnel estimates were assumed to be unloading events.

TABLE 4
Comparison of Mass of DCR between Vessel Records and Phase I EIS Estimates

Statistical Value	Coal (lbs) 2008 Vessel Records	Coal (lbs) 2009 Vessel Records	Coal (lbs) Phase I EIS Estimate[a]	Limestone (lbs) 2008 Vessel Records	Limestone (lbs) 2009 Vessel Records	Limestone (lbs) Phase I EIS Estimate[a]	Taconite (lbs) 2008 Vessel Records	Taconite (lbs) 2009 Vessel Records	Taconite (lbs) Phase I EIS Estimate[a]
Loading									
Mean	875	374	150	2,682	1,260	269	3,628	1,564	233
Std deviation	212	796	118	6,576	2,861	241	12,371	4,441	365
Median	212	88.0	150	400	360	200	445	313	150
Minimum	0	0	10.0	0	0	15.0	0	0	15.0
Maximum	5,297	7,058	1,000	52,970	28,212	1,000	94,202	31,378	5,000
95th percentile	3,625	1,765	300	15,891	5,293	800	7,850	6,275	800
No. of Records	137	198	154	172	220	74	165	197	239
Unloading									
Mean	871	662	165	1,322	1,052	123	4,727	1,849	188
Std deviation	1,420	1,540	114	2,845	2,072	76.0	22,703	3,608	238
Median	200	177	150	265	318	100	597	313	150
Minimum	0	0	15.0	0	0	10.0	0	0	5.0
Maximum	5,297	7,940	600	15,892	13,233	300	235,505	23,534	3,000
95th percentile	5,074	3,529	400	7,946	5,293	230	15,700	7,844	500
No. of Records	136	185	115	230	176	35	233	202	192

[a]The vessel records supporting the first EIS separated DCR estimates by the deck and tunnel, but did not specify loading or unloading events. Therefore, deck estimates were assumed to be loading events and tunnel estimates were assumed to be unloading events.

TABLE 5
Comparison of Total Time Spent Discharging DCR between Vessel Records and Phase I EIS Estimates

	Coal (min)			Limestone (min)			Taconite (min)		
Statistical Value	**2008 Vessel Records**	**2009 Vessel Records**	**Phase I EIS Estimate[a]**	**2008 Vessel Records**	**2009 Vessel Records**	**Phase I EIS Estimate[a]**	**2008 Vessel Records**	**2009 Vessel Records**	**Phase I EIS Estimate[a]**
Loading									
Mean	148	162	171	156	203	199	201	213	245
Std deviation	120	169	141	90.0	236	109	180	189	133
Median	120	120	133	90.0	135	180	180	175	240
Minimum	3.00	3	18	0.00	2	30	2.00	9	10
Maximum	852	1,050	1430	810	1,440	480	580	1,440	1,065
95th percentile	334	404	374	528	655	421	375	450	434
No. of Records	95	137	154	109	133	74	117	153	239
Unloading									
Mean	152	219	176	151	179	149	187	259	201
Std deviation	107	244	66	128	159	65	148	253	161
Median	127	165	175	128	139	145	145	204	165
Minimum	3.00	5	30	1.00	3	40	3.00	1	5
Maximum	445	1,425	344	640	816	345	1,059	1,440	1,351
95th percentile	381	670	300	393	543	243	438	752	420
No. of Records	107	145	115	129	116	35	171	168	193

[a]The vessel records supporting the first EIS separated DCR estimates by the deck and tunnel, but did not specify loading or unloading events. Therefore, deck estimates were assumed to be loading events and tunnel estimates were assumed to be unloading events.

TABLE 6
DCR Discharge by Vessel (Unloading Records Only)

Material	Vessel Identification	Country of Fleet	Year Built	Overall Length (ft)	DCR Quantity Generated by Vessel (ft^3)							Vessel Control Measures																			
					Number of Records with a DCR Value Recorded	Average	Standard Deviation	Median	Minimum	Maximum	95th Percentile	Enclosed Conveyor	Troughed Conveyor	Skirts on Conveyor	Belt Scrapers	Water/Mist	Capacity Indicators	Remote Controls	Stop Conveyor	Wind Delay	Radio Communications	Crew Training	Limit Angle of Conveyor	Broom & Shovel	Tarps	Vibrator	Gate Seal	Cargo Hold Lining	Minimize Hatch Removal	Careful Cargo Hold Gate Operation	Other
Unloading Taconite Database Statistics					**202**	**14.22**	**27.75**	**2.41**	**0.00**	**181.03**	**60.34**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
Taconite	Vessel Name Not Provided	Country Not Reported	-	-	3	140.80	34.84	120.68	120.68	181.03	181.03										X	X		X							
	Vessel - 1	Canada	1967	729	3	2.01	2.51	1.21	0.00	4.83	4.83													X							X
	Vessel - 2	Canada	1977	730	2	6.03	0.00	6.03	6.03	6.03	6.03	X	X	X	X	X	X			X		X			X						
	Vessel - 3	Canada	1984	736.6	2	0.00	0.00	0.00	0.00	0.00	0.00	X	X	X	X	X	X		X	X		X	X	X		X		X	X	X	
	Vessel - 4	United States	1980	730.0	7	50.86	37.82	30.17	6.03	90.51	90.51	X	X			X															
	Vessel - 5	United States	1978	1,004.0	4	0.48	0.14	0.48	0.36	0.60	0.60		X	X	X		X	X	X		X		X	X	X					X	
	Vessel - 6	Canada	1952	767.0	1	1.21	-	1.21	1.21	1.21	1.21		X		X		X	X			X	X		X						X	
	Vessel - 7	Canada	1985	736.6	4	0.00	0.00	0.00	0.00	0.00	0.00	X		X	X		X					X				X		X		X	
	Vessel - 8	United States	1980	1,000.0	12	4.12	2.07	4.53	1.21	6.03	6.03																				
	Vessel - 9	Canada	1979	730.0	1	18.10	-	18.10	18.10	18.10	18.10								X		X	X		X					X		
	Vessel - 10	Canada	1952	767.0	10	13.82	14.47	15.09	1.21	48.27	48.27		X		X	X	X		X		X	X	X	X		X				X	
	Vessel - 11	United States	1959	806.0	10	18.30	29.01	0.40	0.00	60.34	60.34										X	X		X							
	Vessel - 12	Canada	1977	739.8	2	0.00	0.00	0.00	0.00	0.00	0.00										X	X						X	X		
	Vessel - 13	Canada	1972	739.9	3	60.34	0.00	60.34	60.34	60.34	60.34	X	X	X	X	X	X	X			X	X	X		X	X		X		X	
	Vessel - 14	United States	1980	1,004.0	11	2.00	0.72	2.41	0.60	2.41	2.41		X	X	X	X	X				X	X		X						X	
	Vessel - 15	Canada	1979	767.0	2	12.07	0.00	12.07	12.07	12.07	12.07			X	X	X	X	X	X		X	X	X	X	X	X				X	
	Vessel - 16	United States	2000	740.0	5	7.24	1.65	6.03	6.03	9.05	9.05		X		X	X	X				X	X	X							X	
	Vessel - 17	United States	1974	704.0	4	0.98	0.57	0.75	0.60	1.81	1.81	X	X	X	X	X	X	X	X		X	X	X	X			X		X	X	
	Vessel - 18	United States	1959	690.0	7	1.53	0.92	1.00	0.58	3.08	3.08		X	X	X	X	X	X			X	X	X	X		X		X		X	
	Vessel - 19	United States	1979	1,000.0	1	1.21	-	1.21	1.21	1.21	1.21	X	X		X	X	X	X			X	X	X	X							
	Vessel - 20	United States	1976	1,004.0	1	10.86	-	10.86	10.86	10.86	10.86	X		X	X	X	X				X									X	
	Vessel - 21	Canada	1967	730.0	2	0.00	0.00	0.00	0.00	0.00	0.00	X	X	X	X	X	X	X	X		X	X	X	X	X				X	X	
	Vessel - 22	United States	1952	768.3	3	3.22	2.51	2.41	1.21	6.03	6.03																				
	Vessel - 23	United States	1973	680.0	4	0.56	0.64	0.27	0.18	1.51	1.51	X	X	X	X	X	X	X					X			X					
	Vessel - 24	United States	1976	728.0	38	3.87	3.94	3.02	0.60	15.09	15.09																				
	Vessel - 25	United States	1942	826.0	6	1.23	2.37	0.33	0.00	6.03	6.03				X	X	X	X			X	X	X	X		X				X	
	Vessel - 26	Canada	1963	730	1	6.03	-	6.03	6.03	6.03	6.03													X					X		
	Vessel - 14	Canada	1980	1,004.0	4	1.81	0.74	1.96	0.91	2.41	2.41		X	X	X	X	X				X	X		X						X	
	Vessel - 28	Canada	1968	729.6	4	0.62	0.68	0.63	0.00	1.21	1.21																				
	Vessel - 29	Canada	1973	974.5	20	39.73	25.38	30.17	2.05	120.68	90.51		X		X		X				X										
	Vessel - 30	United States	1977	1,004.0	4	2.77	2.38	2.33	0.38	6.03	6.03										X	X		X							
	Vessel Name Reported as Missing	Country Not Reported	-	-	2	8.45	0.85	8.45	7.84	9.05	9.05										X	X		X							
	Vessel - 31	Canada	1963	730.0	4	68.46	61.37	75.43	2.29	120.68	120.68																				
	Vessel - 22	Canada	1952	768.2	3	13.28	14.68	6.03	3.62	30.17	30.17		X	X	X	X	X	X			X	X	X	X						X	
	Vessel - 33	Canada	1953	639.3	1	60.34	-	60.34	60.34	60.34	60.34		X	X	X		X	X	X		X		X	X					X		
	Vessel - 34	United States	1975	634.8	1	0.60	-	0.60	0.60	0.60	0.60	X	X	X	X	X	X	X			X					X				X	
	Vessel - 35	Canada	1967	728.3	8	1.43	1.91	0.91	0.00	6.03	6.03					X					X	X		X							
	Vessel - 36	United States	1949	678.0	2	1.54	0.54	1.54	1.15	1.92	1.92		X	X	X						X	X		X						X	

*Records that had no DCR value reported are not included in the table.

TABLE 6

DCR Discharge by Vessel (Unloading Records Only)

Material	Vessel Identification	Country of Fleet	Year Built	Overall Length (ft)	DCR Quantity Generated by Vessel (ft^3): Number of Records with a DCR Value Recorded	Average	Standard Deviation	Median	Minimum	Maximum	95th Percentile	Vessel Control Measures: Enclosed Conveyor	Troughed Conveyor	Skirts on Conveyor	Belt Scrapers	Water/Mist	Capacity Indicators	Remote Controls	Stop Conveyor	Wind Delay	Radio Communications	Crew Training	Limit Angle of Conveyor	Broom & Shovel	Tarps	Vibrator	Gate Seal	Cargo Hold Lining	Minimize Hatch Removal	Careful Cargo Hold Gate Operation	Other
Unloading Coal Database Statistics					**185**	**13.24**	**30.80**	**3.53**	**0.00**	**158.79**	**70.58**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
Coal	Vessel Name Not Provided	Country Not Reported	-	-	1	35.29	-	35.29	35.29	35.29	35.29	X		X	X	X	X	X	X		X	X			X	X	X		X	X	
	Vessel - 2	Canada	1977	730.0	4	7.06	0.00	7.06	7.06	7.06	7.06																				
	Vessel - 37	United States	1978	1,000.0	23	12.22	15.78	9.53	0.35	70.58	29.01																				
	Vessel - 4	United States	1980	730.0	9	102.37	73.47	158.79	0.35	158.79	158.79	X	X			X															
	Vessel - 6	Canada	1952	767.0	1	1.06	-	1.06	1.06	1.06	1.06																				
	Vessel - 38	United States	1953	606.0	3	15.53	6.72	11.64	11.64	23.29	23.29		X	X	X	X	X		X		X	X	X	X		X			X	X	
	Vessel - 39	Country Not Reported	1973	630.0	1	1.76	-	1.76	1.76	1.76	1.76																				
	Vessel - 39	United States	1973	630.0	1	5.29	-	5.29	5.29	5.29	5.29		X	X	X	X	X	X	X	X	X	X	X							X	
	Vessel - 9	Canada	1979	730.0	2	17.64	14.97	17.64	7.06	28.23	28.23	X	X	X	X		X	X			X	X								X	
	Vessel - 57	Canada	1979	730.0	2	88.22	74.86	88.22	35.29	141.15	141.15	X	X	X	X	X	X					X	X						X	X	
	Vessel - 40	Canada	1981	730.0	2	0.00	0.00	0.00	0.00	0.00	0.00	X	X	X	X		X	X		X	X	X	X		X	X		X	X	X	
	Vessel - 10	Canada	1952	767.0	6	5.12	2.13	5.29	3.00	7.06	7.06				X		X				X	X	X	X		X				X	
	Vessel - 11	United States	1959	806.0	2	1.08	1.02	1.08	0.35	1.80	1.80								X		X	X		X							
	Vessel - 41	Canada	1977	739.9	1	35.29	-	35.29	35.29	35.29	35.29																				
	Vessel - 13	Canada	1972	739.9	1	52.93	-	52.93	52.93	52.93	52.93																				
	Vessel - 16	United States	2000	740.0	1	0.00	-	0.00	0.00	0.00	0.00		X		X	X	X				X	X	X							X	
	Vessel - 17	United States	1974	704.0	3	4.88	8.00	0.35	0.18	14.12	14.12																				
	Vessel - 18	United States	1959	690.0	4	6.13	6.66	3.50	1.50	16.00	16.00		X	X	X	X	X	X	X		X	X	X	X		X		X			
	Vessel - 19	United States	1979	1,000.0	12	0.47	0.31	0.35	0.35	1.41	1.41																				
	Vessel - 20	United States	1976	1,004.0	18	4.60	3.12	3.93	0.95	13.41	13.41	X		X	X	X	X				X									X	
	Vessel - 42	Canada	1983	730.0	2	6.53	0.75	6.53	6.00	7.06	7.06								X		X	X		X							
	Vessel - 21	Canada	1967	730.0	13	5.70	19.52	0.00	0.00	70.58	70.58	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X		X	X	X
	Vessel - 22	United States	1952	768.3	3	3.76	0.41	3.53	3.53	4.23	4.23		X		X	X			X		X	X	X	X		X				X	
	Vessel - 23	United States	1973	680.0	2	0.88	0.00	0.88	0.88	0.88	0.88	X	X	X	X	X	X	X			X		X			X					
	Vessel - 25	United States	1942	826.0	5	1.55	1.81	0.35	0.00	3.53	3.53										X	X		X							
	Vessel - 2	Canada	1977	730	4	4.85	0.88	5.29	3.53	5.29	5.29	X	X	X	X	X	X			X		X			X						
	Vessel - 39	United States	1973	630.0	7	5.13	4.72	3.53	0.71	14.12	14.12								X	X		X									
	Vessel - 28	Canada	1968	729.6	1	70.58	-	70.58	70.58	70.58	70.58																				
	Vessel - 44	United States	1981	1,013.5	15	1.43	0.39	1.50	1.00	2.20	2.20	X	X	X	X	X	X				X	X		X					X	X	
	Vessel - 45	United States	1973	630.0	11	4.16	4.26	3.53	0.00	13.06	13.06	X	X	X	X	X	X	X		X	X	X	X	X		X	X			X	
	Vessel - 46	United States	1929	604.8	2	74.10	44.91	74.10	42.35	105.86	105.86		X	X	X		X	X	X			X	X			X				X	
	Vessel - 30	United States	1977	1,004.0	7	5.57	2.44	7.00	2.00	7.00	7.00																				
	Vessel - 38	United States	1953	606.2	3	11.64	0.00	11.64	11.64	11.64	11.64		X		X	X	X		X		X	X	X	X						X	
	Vessel - 48	Canada	1974	630.0	2	2.00	0.00	2.00	2.00	2.00	2.00																				
	Vessel - 22	Canada	1952	768.2	6	4.88	2.53	3.88	2.12	8.82	8.82										X	X		X							
	Vessel - 33	Canada	1953	639.3	2	52.93	24.95	52.93	35.29	70.58	70.58		X	X	X		X	X	X		X		X	X					X		
	Vessel - 34	United States	1975	634.8	1	0.04	-	0.04	0.04	0.04	0.04	X		X	X	X										X	X				
	Vessel - 49	United States	1977	1,000.0	2	3.00	2.74	3.00	1.06	4.94	4.94																				

*Records that had no DCR value reported are not included in the table.

TABLE 6

DCR Discharge by Vessel (Unloading Records Only)

					DCR Quantity Generated by Vessel (ft³)							Vessel Control Measures																			
Material	Vessel Identification	Country of Fleet	Year Built	Overall Length (ft)	Number of Records with a DCR Value Recorded	Average	Standard Deviation	Median	Minimum	Maximum	95th Percentile	Enclosed Conveyor	Troughed Conveyor	Skirts on Conveyor	Belt Scrapers	Water/Mist	Capacity Indicators	Remote Controls	Stop Conveyor	Wind Delay	Radio Communications	Crew Training	Limit Angle of Conveyor	Broom & Shovel	Tarps	Vibrator	Gate Seal	Cargo Hold Lining	Minimize Hatch Removal	Careful Cargo Hold Gate Operation	Other
Unloading Limestone Database Statistics					**176**	**10.52**	**20.72**	**3.18**	**0.00**	**132.33**	**52.93**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
Limestone	Vessel - 50	United States	1973	680.0	3	0.62	0.40	0.53	0.26	1.06	1.06	X	X	X	X	X	X		X		X				X					X	
	Vessel - 51	Canada	1970	647.0	19	3.27	2.97	3.71	0.05	10.06	10.06	X	X	X	X	X	X		X	X	X	X	X			X		X	X	X	X
	Vessel - 4	United States	1980	730.0	2	132.33	0.00	132.33	132.33	132.33	132.33	X	X		X		X		X	X	X	X	X								
	Vessel - 38	United States	1953	606.0	7	37.58	23.74	34.93	17.47	70.40	70.40																				
	Vessel - 39	Country Not Reported	1973	630.0	2	5.03	0.37	5.03	4.76	5.29	5.29																				
	Vessel - 39	United States	1973	630.0	6	5.82	1.74	5.29	3.71	7.94	7.94	X	X	X	X	X	X	X	X	X	X	X	X	X		X				X	
	Vessel - 40	Canada	1981	730.0	12	0.00	0.00	0.00	0.00	0.00	0.00	X	X	X	X	X	X	X	X		X	X	X			X	X	X	X	X	
	Vessel - 10	Canada	1952	767.0	5	3.88	1.84	4.76	1.06	5.29	5.29				X	X	X		X		X	X	X	X		X				X	
	Vessel - 17	United States	1974	704.0	2	1.59	0.00	1.59	1.59	1.59	1.59	X	X	X	X	X	X	X	X		X	X	X	X		X			X	X	
	Vessel - 18	United States	1959	690.0	5	2.05	1.24	2.00	0.75	4.00	4.00		X	X	X	X	X		X	X	X	X	X	X		X		X		X	
	Vessel - 52	United States	1953	767.0	4	1.27	0.00	1.27	1.27	1.27	1.27																				
	Vessel - 22	United States	1952	768.3	5	3.71	2.57	2.65	1.59	7.94	7.94		X	X	X	X	X			X	X	X	X	X						X	
	Vessel - 23	United States	1973	680.0	1	4.23	-	4.23	4.23	4.23	4.23	X	X	X	X	X	X	X			X		X								
	Vessel - 53	United States	1944	706.5	4	0.56	0.71	0.37	0.00	1.48	1.48																				
	Vessel - 24	United States	1976	728.0	6	4.59	4.71	2.38	0.53	10.59	10.59		X	X	X		X				X	X		X		X	X			X	
	Vessel -54	United States	1952	698.0	7	4.97	6.79	3.02	0.00	20.11	20.11						X		X		X	X									
	Vessel -39	United States	1973	630.0	23	4.31	3.75	2.65	1.06	15.88	10.59																				
	Vessel -28	Canada	1968	729.6	4	20.38	39.35	0.79	0.53	79.40	79.40																				
	Vessel - 55	United States	1943	620.5	1	2.01	-	2.01	2.01	2.01	2.01		X	X	X	X	X		X		X	X	X			X				X	
	Vessel -45	United States	1973	630.0	5	6.86	5.47	4.23	2.01	15.88	15.88	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X		X	X	
	Vessel - 46	United States	1929	604.8	9	35.88	18.48	26.47	26.47	79.40	79.40		X	X	X		X	X	X			X	X			X				X	
	Vessel - 56	Canada	1952	698.0	2	0.66	0.56	0.66	0.26	1.06	1.06	X	X	X	X	X	X	X	X	X	X	X	X	X		X			X		
	Vessel Name Reported as Missing	Country Not Reported	-	-	4	8.34	0.79	7.94	7.94	9.53	9.53	X	X	X	X	X	X	X	X	X	X	X	X	X		X			X		
	Vessel -38	United States	1953	606.2	13	20.15	6.56	17.47	17.47	34.93	34.93										X	X		X							
	Vessel - 48	Canada	1974	630.0	5	0.94	0.96	0.53	0.45	2.65	2.65	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			X	X	
	Vessel - 22	Canada	1952	768.2	5	3.71	1.18	3.71	2.12	5.29	5.29		X	X	X	X	X				X	X	X	X							
	Vessel - 33	Canada	1953	639.3	5	43.05	43.45	52.93	1.50	105.86	105.86		X	X	X		X	X	X		X		X	X					X		
	Vessel - 34	United States	1975	634.8	9	1.45	1.85	0.25	0.05	5.29	5.29	X	X	X	X	X	X	X	X		X	X	X			X	X		X	X	
	Vessel - 36	United States	1949	678.0	1	1.50	-	1.50	1.50	1.50	1.50		X	X	X						X	X		X						X	

*Records that had no DCR value reported are not included in the table.

TABLE 7
DCR Discharge by Facility (Loading Records Only)

		DCR Quantity Generated by Facility (ft^3)							Facility Control Measure																
Material	Facility Identification	Number of Records with a DCR Value Recorded	Average	Standard Deviation	Median	Minimum	Maximum	95th Percentile	Enclosed Conveyor	Troughed Conveyor	Skirts on Conveyor	Belt Scrapers	Water/Mist	Capacity Indicators	Remote Controls	Stop Conveyor	Wind Delay	Radio Communications	Crew Training	Limit Angle of Conveyor	Plow Feed	Loading Chute	Chemical Surfactants	Suction Pumped Cargo	Other
Facility Taconite Database Statistics		**197**	**12.03**	**34.16**	**2.41**	**0.00**	**241.37**	**48.27**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**		**X**			
Taconite	Taconite - 1	2	12.07	0.00	12.07	12.07	12.07	12.07										X	X	X					
	Taconite - 2	2	10.56	2.13	10.56	9.05	12.07	12.07										X							
	Taconite - 3	24	13.34	17.12	2.41	0.00	60.34	48.27										X							
	Taconite - 4	1	9.05	-	9.05	9.05	9.05	9.05										X	X	X					
	Taconite - 5	7	2.07	1.25	3.02	0.00	3.02	3.02		X		X		X		X		X	X						
	Taconite - 6	2	1.71	0.00	1.71	1.71	1.71	1.71		X	X	X	X			X		X	X	X					
	Taconite - 7	5	39.22	47.80	18.10	3.02	120.68	120.68	X		X	X	X			X		X				X			
	Taconite - 8	2	0.44	0.19	0.44	0.31	0.58	0.58																	
	Taconite - 9	2	12.07	0.00	12.07	12.07	12.07	12.07										X	X	X					
	Taconite - 10	17	3.48	2.86	3.02	0.60	12.07	12.07		X	X	X				X		X	X						
	Taconite - 11	12	11.94	12.25	7.54	0.36	30.17	30.17		X	X	X				X		X	X						
	Taconite - 12	1	181.03	-	181.03	181.03	181.03	181.03										X							
	Taconite - 13	8	4.90	6.75	0.60	0.60	18.10	18.10		X		X						X							
	Taconite - 14	1	2.17	-	2.17	2.17	2.17	2.17	X									X							
	Taconite - 15	1	3.02	-	3.02	3.02	3.02	3.02		X					X	X		X				X			
	Taconite - 16	1	3.02	-	3.02	3.02	3.02	3.02								X		X	X			X			
	Taconite - 17	24	1.43	1.14	1.21	0.38	6.15	3.02										X	X			X			
	Taconite - 18	6	3.44	2.71	3.62	0.31	6.64	6.64										X		X					
	Taconite - 19	1	0.00	-	0.00	0.00	0.00	0.00																	
	Taconite - 20	1	9.05	-	9.05	9.05	9.05	9.05		X		X	X			X	X	X		X					
	Taconite - 21	2	2.66	0.51	2.66	2.29	3.02	3.02		X		X	X			X	X	X		X					
	Taconite - 22	1	18.10	-	18.10	18.10	18.10	18.10				X				X		X	X			X			
	Taconite - 23	7	4.40	3.68	3.02	1.21	12.07	12.07								X		X				X			
	Taconite - 24	3	10.76	16.82	1.51	0.60	30.17	30.17																	
	Taconite - 25	1	12.07	-	12.07	12.07	12.07	12.07				X							X			X			
	Taconite - 26	5	98.42	130.51	6.03	1.51	241.37	241.37				X				X		X							
	Taconite - 27	13	12.53	17.51	3.02	1.35	60.34	60.34		X	X	X		X		X		X				X			
	Taconite - 28	7	44.35	88.56	1.81	1.21	241.37	241.37	X	X	X	X				X	X	X	X			X			
	Taconite - 29	3	16.69	27.35	1.21	0.60	48.27	48.27	X	X	X	X		X		X	X	X	X			X			
	Taconite - 30	1	12.07	-	12.07	12.07	12.07	12.07	X	X	X	X		X		X	X	X	X			X			
	Taconite - 31	1	12.07	-	12.07	12.07	12.07	12.07	X	X	X	X		X		X	X	X	X			X			
	Taconite - 32	19	5.52	13.43	1.21	0.24	60.34	60.34				X				X		X	X			X			
	Taconite - 33	1	1.21	-	1.21	1.21	1.21	1.21		X	X	X		X		X		X							
	Taconite - 34	4	0.55	0.19	0.56	0.36	0.73	0.73		X	X	X				X		X							
	Taconite - 35	4	1.55	1.00	1.21	0.77	3.02	3.02				X				X		X	X			X			
	Taconite - 36	2	2.41	0.00	2.41	2.41	2.41	2.41		X	X	X				X		X	X	X					
	Taconite - 37	2	1.81	1.71	1.81	0.60	3.02	3.02																	
	Taconite - 38	1	0.00	-	0.00	0.00	0.00	0.00										X							

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TABLE 7
DCR Discharge by Facility (Loading Records Only)

Material	Facility Identification	DCR Quantity Generated by Facility (ft³): Number of Records with a DCR Value Recorded	Average	Standard Deviation	Median	Minimum	Maximum	95th Percentile	Facility Control Measure: Enclosed Conveyor	Troughed Conveyor	Skirts on Conveyor	Belt Scrapers	Water/Mist	Capacity Indicators	Remote Controls	Stop Conveyor	Wind Delay	Radio Communications	Crew Training	Limit Angle of Conveyor	Plow Feed	Loading Chute	Chemical Surfactants	Suction Pumped Cargo	Other
Facility Coal Database Statistics		**198**	**7.48**	**15.92**	**1.76**	**0.00**	**141.15**	**35.29**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	
Coal	Coal - 1	1	0.00	-	0.00	0.00	0.00	0.00		X								X		X					
	Coal - 2	13	2.14	4.01	0.00	0.00	10.59	10.59			X	X		X		X				X		X			
	Coal - 3	2	0.00	0.00	0.00	0.00	0.00	0.00			X	X		X		X				X		X			
	Coal - 4	2	52.93	24.95	52.93	35.29	70.58	70.58	X	X	X	X	X	X		X		X	X			X			
	Coal - 5	7	8.07	1.39	7.06	7.06	10.59	10.59	X		X				X	X			X						
	Coal - 6	5	3.74	6.21	0.71	0.71	14.82	14.82	X	X	X	X	X	X		X		X	X	X					
	Coal - 7	1	5.29	-	5.29	5.29	5.29	5.29					X			X		X							
	Coal - 8	1	1.34	-	1.34	1.34	1.34	1.34		X	X	X	X	X	X	X		X	X						
	Coal - 9	1	35.29	-	35.29	35.29	35.29	35.29	X	X	X	X		X		X		X	X	X					
	Coal - 10	5	9.32	14.65	4.23	0.88	35.29	35.29		X	X	X	X	X	X	X		X	X						
	Coal - 11	1	0.00	-	0.00	0.00	0.00	0.00	X	X	X	X	X	X	X	X		X	X	X		X			
	Coal - 12	5	2.96	2.79	3.53	0.35	7.06	7.06	X	X	X					X		X				X			
	Coal - 13	1	1.00	-	1.00	1.00	1.00	1.00	X	X	X	X	X	X				X							
	Coal - 14	1	3.53	-	3.53	3.53	3.53	3.53	X	X			X	X				X							
	Coal - 15	2	4.59	1.00	4.59	3.88	5.29	5.29		X	X	X	X	X		X		X	X	X		X			
	Coal - 16	1	7.06	-	7.06	7.06	7.06	7.06	X	X					X										
	Coal - 17	1	0.88	-	0.88	0.88	0.88	0.88	X	X					X										
	Coal - 18	8	4.54	6.43	1.06	0.00	17.64	17.64	X	X		X	X					X							
	Coal - 19	6	10.65	3.74	12.00	3.53	14.12	14.12					X			X		X							
	Coal - 20	1	1.06	-	1.06	1.06	1.06	1.06										X				X			
	Coal - 21	1	1.76	-	1.76	1.76	1.76	1.76																	
	Coal - 22	19	6.26	9.25	2.47	0.00	35.29	35.29		X			X			X		X	X			X			
	Coal - 23	2	0.00	0.00	0.00	0.00	0.00	0.00					X			X		X							
	Coal - 24	1	8.82	-	8.82	8.82	8.82	8.82								X		X							
	Coal - 25	2	64.58	58.39	64.58	23.29	105.86	105.86																	
	Coal - 26	2	7.76	5.49	7.76	3.88	11.64	11.64																	
	Coal - 27	1	18.00	-	18.00	18.00	18.00	18.00	X	X	X	X	X	X		X	X	X	X			X			
	Coal - 28	3	24.41	18.85	35.29	2.65	35.29	35.29	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
	Coal - 29	4	0.22	0.44	0.00	0.00	0.88	0.88	X			X					X	X	X			X			
	Coal - 30	29	3.65	7.29	1.52	0.00	35.29	21.17	X		X	X	X	X	X					X		X		X	
	Coal - 31	1	3.53	-	3.53	3.53	3.53	3.53	X	X	X	X	X	X	X	X	X	X	X	X	X	X			
	Coal - 32	9	0.59	1.76	0.00	0.00	5.29	5.29			X	X		X		X				X		X			
	Coal - 33	33	5.74	9.50	1.50	0.00	35.29	35.29																	
	Coal - 34	2	11.64	0.00	11.64	11.64	11.64	11.64									X	X	X						
	Coal - 35	3	4.82	3.87	7.06	0.35	7.06	7.06	X				X			X			X			X			
	Coal - 36	1	4.41	-	4.41	4.41	4.41	4.41	X	X	X	X	X	X		X	X	X	X	X		X			
	Coal - 37	5	33.59	60.34	11.64	0.35	141.15	141.15		X						X		X	X	X		X			
	Coal - 38	12	7.57	7.53	4.12	1.00	24.00	24.00		X		X	X			X	X	X		X					
	Coal - 39	1	1.60	-	1.60	1.60	1.60	1.60	X	X		X	X					X							
	Coal - 40	1	70.58	-	70.58	70.58	70.58	70.58	X		X	X				X		X							
	Coal - 41	1	1.50	-	1.50	1.50	1.50	1.50		X															

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TABLE 7
DCR Discharge by Facility (Loading Records Only)

Material	Facility Identification	DCR Quantity Generated by Facility (ft^3): Number of Records with a DCR Value Recorded	Average	Standard Deviation	Median	Minimum	Maximum	95th Percentile	Facility Control Measure: Enclosed Conveyor	Troughed Conveyor	Skirts on Conveyor	Belt Scrapers	Water/Mist	Capacity Indicators	Remote Controls	Stop Conveyor	Wind Delay	Radio Communications	Crew Training	Limit Angle of Conveyor	Plow Feed	Loading Chute	Chemical Surfactants	Suction Pumped Cargo	Other
Facility Limestone Database Statistics		**220**	**12.60**	**28.61**	**3.60**	**0.00**	**282.12**	**52.93**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**		**X**			
Limestone	Limestone - 1	1	52.93	-	52.93	52.93	52.93	52.93		X	X	X	X	X	X	X		X	X						
	Limestone - 2	4	12.31	9.97	10.85	3.71	23.82	23.82		X		X				X									
	Limestone - 3	8	3.82	4.36	2.12	0.53	13.23	13.23	X	X	X	X	X	X		X		X	X	X		X			
	Limestone - 4	1	52.93	-	52.93	52.93	52.93	52.93	X	X	X	X	X	X		X		X	X	X		X			
	Limestone - 5	20	4.16	6.31	1.27	0.56	22.23	19.06		X	X	X		X		X	X	X	X						
	Limestone - 6	1	5.29	-	5.29	5.29	5.29	5.29		X		X				X									
	Limestone - 7	1	26.47	-	26.47	26.47	26.47	26.47			X	X				X	X	X	X						
	Limestone - 8	3	1.06	0.00	1.06	1.06	1.06	1.06	X	X	X	X	X	X		X		X							
	Limestone - 9	4	2.38	2.65	1.06	1.06	6.35	6.35		X	X														
	Limestone - 10	6	6.21	9.80	1.96	1.06	25.94	25.94		X	X														
	Limestone - 11	1	10.59	-	10.59	10.59	10.59	10.59	X	X	X	X	X	X		X	X	X	X	X		X			
	Limestone - 12	1	0.53	-	0.53	0.53	0.53	0.53		X	X	X	X	X		X	X	X	X	X		X			
	Limestone - 13	1	19.06	-	19.06	19.06	19.06	19.06																	
	Limestone - 14	1	18.53	-	18.53	18.53	18.53	18.53	X	X	X	X	X	X		X	X	X	X			X			
	Limestone - 15	3	17.29	8.14	21.17	7.94	22.76	22.76	X	X	X	X	X			X		X	X	X					
	Limestone - 16	1	10.06	-	10.06	10.06	10.06	10.06																	
	Limestone - 17	4	3.75	2.31	4.21	0.75	5.82	5.82		X		X				X		X	X						
	Limestone - 18	1	10.59	-	10.59	10.59	10.59	10.59										X	X	X					
	Limestone - 19	1	26.47	-	26.47	26.47	26.47	26.47		X	X	X	X	X		X		X	X	X					
	Limestone - 20	1	6.35	-	6.35	6.35	6.35	6.35	X	X	X	X				X		X	X	X		X			
	Limestone - 21	1	22.23	-	22.23	22.23	22.23	22.23		X	X	X			X		X	X	X			X			
	Limestone - 22	11	47.76	58.97	26.47	0.53	211.73	211.73		X	X	X	X	X		X	X	X	X			X			
	Limestone - 23	12	68.90	76.78	34.93	17.47	282.12	282.12		X	X	X	X	X		X	X	X	X			X			
	Limestone - 24	4	0.32	0.64	0.00	0.00	1.27	1.27																	
	Limestone - 25	19	2.72	2.90	0.53	0.00	7.94	7.94		X		X	X			X	X	X		X					
	Limestone - 26	1	2.22	-	2.22	2.22	2.22	2.22	X	X	X	X	X	X		X		X	X						
	Limestone - 27	1	4.23	-	4.23	4.23	4.23	4.23		X	X	X				X		X	X	X					
	Limestone - 28	2	2.51	2.81	2.51	0.53	4.50	4.50		X	X	X				X		X	X	X					
	Limestone - 29	1	52.93	-	52.93	52.93	52.93	52.93				X				X		X							
	Limestone - 30	6	3.94	2.64	3.18	1.01	7.41	7.41		X	X	X		X		X		X	X						
	Limestone - 31	9	10.58	25.88	1.06	0.00	79.40	79.40				X				X		X							
	Limestone - 32	1	7.94	-	7.94	7.94	7.94	7.94				X				X		X							
	Limestone - 33	1	7.41	-	7.41	7.41	7.41	7.41		X	X	X		X		X		X	X						
	Limestone - 34	15	11.07	9.82	11.12	0.50	34.93	34.93					X					X							
	Limestone - 35	4	19.72	4.50	17.47	17.47	26.47	26.47		X	X	X		X		X		X	X						
	Limestone - 36	1	1.06	-	1.06	1.06	1.06	1.06		X	X	X	X	X		X	X	X	X	X					
	Limestone - 37	2	13.76	0.00	13.76	13.76	13.76	13.76		X	X	X		X		X		X				X			
	Limestone - 38	6	10.72	9.75	9.45	0.42	21.17	21.17				X				X		X							
	Limestone - 39	1	11.12	-	11.12	11.12	11.12	11.12				X				X		X							
	Limestone - 40	1	1.06	-	1.06	1.06	1.06	1.06		X		X		X		X		X							
	Limestone - 41	1	1.06	-	1.06	1.06	1.06	1.06		X		X	X			X		X							

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TABLE 7

DCR Discharge by Facility (Loading Records Only)

		DCR Quantity Generated by Facility (ft^3)							Facility Control Measure																
Material	Facility Identification	Number of Records with a DCR Value Recorded	Average	Standard Deviation	Median	Minimum	Maximum	95th Percentile	Enclosed Conveyor	Troughed Conveyor	Skirts on Conveyor	Belt Scrapers	Water/Mist	Capacity Indicators	Remote Controls	Stop Conveyor	Wind Delay	Radio Communications	Crew Training	Limit Angle of Conveyor	Plow Feed	Loading Chute	Chemical Surfactants	Suction Pumped Cargo	Other
	Limestone - 42	22	5.62	6.00	2.51	1.01	21.17	18.53		X		X	X			X	X	X		X					
	Limestone - 43	1	5.29	-	5.29	5.29	5.29	5.29	X	X	X	X	X	X	X	X	X	X	X	X		X			
	Limestone - 44	9	1.01	2.02	0.00	0.00	5.29	5.29	X	X	X	X	X			X	X	X	X			X			
	Limestone - 45	1	5.29	-	5.29	5.29	5.29	5.29		X	X	X	X	X	X			X	X	X					
	Limestone - 46	1	10.59	-	10.59	10.59	10.59	10.59			X	X				X	X	X	X			X			
	Limestone - 47	1	2.12	-	2.12	2.12	2.12	2.12																	
	Limestone - 48	11	2.22	1.43	1.27	1.27	4.76	4.76				X				X		X							
	Limestone - 49	1	1.06	-	1.06	1.06	1.06	1.06																	
	Limestone - 50	5	12.92	10.84	15.88	1.06	26.47	26.47									X	X	X			X			
	Limestone - 51	1	21.17	-	21.17	21.17	21.17	21.17																	
	Limestone - 52	1	1.59	-	1.59	1.59	1.59	1.59	X	X	X	X	X			X	X		X			X			
	Limestone - 53	2	3.02	0.00	3.02	3.02	3.02	3.02																	

*Records that had no DCR reported were not included in the table.

TABLE 8
DCR Volume by Vessel and Facility (Unloading Records Only)

Material	Vessel ID	Facility ID	DCR Quantity Generated by Vessel						
			Number of Records with a DCR Value Recorded	Average	Standard Deviation	Median	Minimum	Maximum	95th Percentile
Unloading Taconite Vessels Database Statistics			202	14.22	27.75	2.41	0.00	181.03	60.34
Taconite	Vessel - 12	Taconite-1	1	0.00	-	0.00	0.00	0.00	0.00
	Vessel - 21	Taconite-2	1	0.00	-	0.00	0.00	0.00	0.00
	Vessel - 24	Taconite-3	1	12.07	-	12.07	12.07	12.07	12.07
	Vessel - 21	Taconite-3	1	0.00	-	0.00	0.00	0.00	0.00
	Vessel - 8	Taconite-3	8	4.45	2.26	6.03	1.21	6.03	6.03
	Vessel - 23	Taconite-4	1	1.51	-	1.51	1.51	1.51	1.51
	Vessel - 6	Taconite-4	1	1.21	-	1.21	1.21	1.21	1.21
	Vessel - 10	Taconite-4	5	19.62	17.39	18.10	1.54	48.27	48.27
	Vessel - 14	Taconite-4	1	2.41	-	2.41	2.41	2.41	2.41
	Vessel - 22	Taconite-4	1	2.41	-	2.41	2.41	2.41	2.41
	Vessel - 29	Taconite-4	7	37.93	11.40	30.17	30.17	60.34	60.34
	Vessel - 32	Taconite-4	1	6.03	-	6.03	6.03	6.03	6.03
	Vessel - 10	Taconite-5	1	18.10	-	18.10	18.10	18.10	18.10
	Vessel - 29	Taconite-6	2	84.48	51.20	84.48	48.27	120.68	120.68
	Vessel - 11	Taconite-7	3	0.06	0.06	0.08	0.00	0.12	0.12
	Vessel - 18	Taconite-8	4	1.96	1.05	2.10	0.58	3.08	3.08
	Vessel - 14	Taconite-9	1	2.11	-	2.11	2.11	2.11	2.11
	Vessel - 10	Taconite-10	1	18.10	-	18.10	18.10	18.10	18.10
	Vessel - 4	Taconite-11	5	63.96	36.36	90.51	24.14	90.51	90.51
	Vessel - 5	Taconite-11	1	0.60	-	0.60	0.60	0.60	0.60
	Vessel - 23	Taconite-11	1	0.18	-	0.18	0.18	0.18	0.18
	Vessel - 23	Taconite-11	1	0.30	-	0.30	0.30	0.30	0.30
	Vessel - 5	Taconite-12	3	0.44	0.14	0.36	0.36	0.60	0.60
	Vessel - 7	Taconite-12	1	0.00	-	0.00	0.00	0.00	0.00
	Vessel - 10	Taconite-12	3	1.32	0.19	1.21	1.21	1.54	1.54
	Vessel - 14	Taconite-12	9	1.94	0.79	2.41	0.60	2.41	2.41
	Vessel - 15	Taconite-12	2	12.07	0.00	12.07	12.07	12.07	12.07
	Vessel - 17	Taconite-12	3	1.11	0.63	0.91	0.60	1.81	1.81
	Vessel - 22	Taconite-12	1	6.03	-	6.03	6.03	6.03	6.03
	Vessel - 14	Taconite-12	4	1.81	0.74	1.96	0.91	2.41	2.41
	Vessel - 28	Taconite-12	1	0.00	-	0.00	0.00	0.00	0.00
	Vessel - 29	Taconite-12	9	39.56	15.71	30.17	24.14	60.34	60.34
	Vessel - 32	Taconite-12	2	16.90	18.77	16.90	3.62	30.17	30.17
	Vessel - 29	Taconite-13	2	2.05	0.00	2.05	2.05	2.05	2.05
	Vessel - 2	Taconite-14	2	6.03	0.00	6.03	6.03	6.03	6.03
	Vessel - 1	Taconite-14	1	0.00	-	0.00	0.00	0.00	0.00
	Vessel - 26	Taconite-14	1	6.03	-	6.03	6.03	6.03	6.03
	Vessel - 31	Taconite-15	1	120.68	-	120.68	120.68	120.68	120.68
	Vessel - 16	Taconite-16	3	8.05	1.74	9.05	6.03	9.05	9.05
	Vessel - 24	Taconite-16	11	3.46	3.96	3.02	1.21	15.09	15.09
	Vessel - 24	Taconite-16	25	3.77	3.81	3.02	0.60	15.09	12.07
	Vessel - 34	Taconite-16	1	0.60	-	0.60	0.60	0.60	0.60
	Vessel - 30	Taconite-16	3	1.68	1.19	1.92	0.38	2.74	2.74
	Missing	Taconite-16	2	8.45	0.85	8.45	7.84	9.05	9.05
	Vessel - 36	Taconite-16	2	1.54	0.54	1.54	1.15	1.92	1.92
	Vessel - 11	Taconite-17	1	0.38	-	0.38	0.38	0.38	0.38
	Vessel - 1	Taconite-18	1	1.21	-	1.21	1.21	1.21	1.21
	Vessel - 35	Taconite-19	8	1.43	1.91	0.91	0.00	6.03	6.03
	Vessel - 3	Taconite-20	1	0.00	-	0.00	0.00	0.00	0.00
	Vessel - 7	Taconite-20	1	0.00	-	0.00	0.00	0.00	0.00
	Vessel - 12	Taconite-20	1	0.00	-	0.00	0.00	0.00	0.00
	Vessel Name Not Provided	Taconite-20	2	150.85	42.67	150.85	120.68	181.03	181.03
	Vessel - 7	Taconite-20	2	0.00	0.00	0.00	0.00	0.00	0.00
	Vessel - 11	Taconite-20	1	0.08	-	0.08	0.08	0.08	0.08
	Vessel - 16	Taconite-20	2	6.03	0.00	6.03	6.03	6.03	6.03
	Vessel - 9	Taconite-21	1	18.10	-	18.10	18.10	18.10	18.10
	Vessel - 13	Taconite-21	2	60.34	0.00	60.34	60.34	60.34	60.34
	Vessel - 17	Taconite-21	1	0.60	-	0.60	0.60	0.60	0.60
	Vessel - 18	Taconite-21	3	0.95	0.04	0.92	0.92	1.00	1.00
	Vessel - 11	Taconite-22	1	0.42	-	0.42	0.42	0.42	0.42
	Vessel - 24	Taconite-23	1	3.02	-	3.02	3.02	3.02	3.02
	Vessel - 1	Taconite-24	1	4.83	-	4.83	4.83	4.83	4.83
	Vessel - 13	Taconite-25	1	60.34	-	60.34	60.34	60.34	60.34
	Vessel - 3	Taconite-26	1	0.00	-	0.00	0.00	0.00	0.00
	Vessel - 4	Taconite-27	2	18.10	17.07	18.10	6.03	30.17	30.17
	Vessel - 8	Taconite-28	4	3.47	1.73	2.72	2.41	6.03	6.03
	Vessel - 11	Taconite-29	4	45.49	29.71	60.34	0.92	60.34	60.34
	Vessel - 19	Taconite-30	1	1.21	-	1.21	1.21	1.21	1.21
	Vessel - 20	Taconite-31	1	10.86	-	10.86	10.86	10.86	10.86
	Vessel - 22	Taconite-32	1	1.21	-	1.21	1.21	1.21	1.21
	Vessel - 23	Taconite-33	1	0.24	-	0.24	0.24	0.24	0.24
	Vessel - 25	Taconite-34	6	1.23	2.37	0.33	0.00	6.03	6.03
	Vessel - 28	Taconite-35	3	0.82	0.66	1.21	0.06	1.21	1.21
	Vessel - 30	Taconite-36	1	6.03	-	6.03	6.03	6.03	6.03
	Vessel - 31	Taconite-37	3	51.05	61.90	30.17	2.29	120.68	120.68
	Vessel - 33	Taconite-38	1	60.34	-	60.34	60.34	60.34	60.34
	Vessel Name Not Provided	Taconite-39	1	120.68	-	120.68	120.68	120.68	120.68
Unloading Coal Vessels Database Statistics			185	13.24	30.80	3.53	0.00	158.79	70.58
Coal	Vessel - 39	Coal-1	1	5.29	-	5.29	5.29	5.29	5.29
	Vessel - 11	Coal-2	1	0.35	-	0.35	0.35	0.35	0.35
	Vessel - 6	Coal-3	1	1.06	-	1.06	1.06	1.06	1.06
	Vessel - 19	Coal-4	4	0.35	0.00	0.35	0.35	0.35	0.35
	Vessel - 30	Coal-4	4	4.50	2.89	4.50	2.00	7.00	7.00
	Vessel - 44	Coal-4	12	1.35	0.38	1.37	1.00	2.20	2.20
	Vessel - 18	Coal-5	2	2.25	1.06	2.25	1.50	3.00	3.00
	Vessel - 22	Coal-6	2	3.53	0.00	3.53	3.53	3.53	3.53
	Vessel - 10	Coal-6	5	5.43	2.22	7.06	3.00	7.06	7.06
	Vessel - 16	Coal-6	1	0.00	-	0.00	0.00	0.00	0.00
	Vessel - 46	Coal-7	1	42.35	-	42.35	42.35	42.35	42.35
	Vessel - 23	Coal-8	1	0.88	-	0.88	0.88	0.88	0.88
	Vessel - 39	Coal-9	3	2.32	1.09	2.01	1.41	3.53	3.53
	Vessel - 45	Coal-9	2	7.94	1.25	7.94	7.06	8.82	8.82
	Vessel - 22	Coal-10	1	8.82	-	8.82	8.82	8.82	8.82
	Vessel - 38	Coal-11	1	11.64	-	11.64	11.64	11.64	11.64
	Vessel - 22	Coal-11	1	3.53	-	3.53	3.53	3.53	3.53
	Vessel - 22	Coal-11	2	4.59	3.49	4.59	2.12	7.06	7.06
	Vessel - 39	Coal-12	1	1.76	-	1.76	1.76	1.76	1.76
	Vessel - 45	Coal-12	1	3.53	-	3.53	3.53	3.53	3.53
	Vessel - 34	Coal-12	1	0.04	-	0.04	0.04	0.04	0.04
	Vessel - 21	Coal-13	2	0.00	0.00	0.00	0.00	0.00	0.00
	Vessel - 57	Coal-13	2	88.22	74.86	88.22	35.29	141.15	141.15
	Vessel - 38	Coal-14	1	11.64	-	11.64	11.64	11.64	11.64
	Vessel - 18	Coal-15	2	10.00	8.49	10.00	4.00	16.00	16.00

*Records with no DCR value reported are not included in the table.

TABLE 8
DCR Volume by Vessel and Facility (Unloading Records Only)

Material	Vessel ID	Facility ID	DCR Quantity Generated by Vessel: Number of Records with a DCR Value Recorded	Average	Standard Deviation	Median	Minimum	Maximum	95th Percentile
Coal	Vessel - 38	Coal-16	2	17.47	8.23	17.47	11.64	23.29	23.29
	Vessel - 45	Coal-17	2	8.03	7.11	8.03	3.00	13.06	13.06
	Vessel - 23	Coal-18	1	0.88	-	0.88	0.88	0.88	0.88
	Vessel - 4	Coal-19	1	10.59	-	10.59	10.59	10.59	10.59
	Vessel - 46	Coal-20	1	105.86	-	105.86	105.86	105.86	105.86
	Vessel - 45	Coal-21	1	5.29	-	5.29	5.29	5.29	5.29
	Vessel - 45	Coal-22	1	4.94	-	4.94	4.94	4.94	4.94
	Vessel - 38	Coal-23	1	11.64	-	11.64	11.64	11.64	11.64
	Vessel - 39	Coal-23	1	7.06	-	7.06	7.06	7.06	7.06
	Vessel - 20	Coal-24	3	3.26	1.58	4.02	1.45	4.31	4.31
	Vessel - 44	Coal-24	1	1.50	-	1.50	1.50	1.50	1.50
	Vessel - 22	Coal-24	1	4.23	-	4.23	4.23	4.23	4.23
	Vessel - 23	Coal-25	4	1.85	1.94	1.94	0.00	3.53	3.53
	Vessel - 44	Coal-25	2	1.90	0.14	1.90	1.80	2.00	2.00
	Vessel - 30	Coal-25	1	7.00	-	7.00	7.00	7.00	7.00
	Vessel - 17	Coal-26	1	0.35	-	0.35	0.35	0.35	0.35
	Vessel - 17	Coal-27	1	0.18	-	0.18	0.18	0.18	0.18
	Vessel - 4	Coal-28	2	132.33	37.43	132.33	105.86	158.79	158.79
	Vessel - 20	Coal-29	1	2.15	-	2.15	2.15	2.15	2.15
	Vessel - 37	Coal-30	20	13.96	16.25	9.67	0.35	70.58	49.79
	Vessel - 38	Coal-31	1	11.64	-	11.64	11.64	11.64	11.64
	Vessel - 17	Coal-32	1	14.12	-	14.12	14.12	14.12	14.12
	Vessel - 2	Coal-33	2	4.41	1.25	4.41	3.53	5.29	5.29
	Vessel Name Not Provided	Coal-33	1	35.29	-	35.29	35.29	35.29	35.29
	Vessel - 2	Coal-33	2	7.06	0.00	7.06	7.06	7.06	7.06
	Vessel - 9	Coal-33	2	17.64	14.97	17.64	7.06	28.23	28.23
	Vessel - 40	Coal-33	1	0.00	-	0.00	0.00	0.00	0.00
	Vessel - 21	Coal-33	8	9.26	24.80	0.00	0.00	70.58	70.58
	Vessel - 49	Coal-33	1	1.06	-	1.06	1.06	1.06	1.06
	Vessel - 42	Coal-34	2	6.53	0.75	6.53	6.00	7.06	7.06
	Vessel - 20	Coal-35	1	3.81	-	3.81	3.81	3.81	3.81
	Vessel - 20	Coal-36	2	6.00	1.00	6.00	5.29	6.70	6.70
	Vessel - 39	Coal-37	2	7.41	9.48	7.41	0.71	14.12	14.12
	Vessel - 2	Coal-38	2	7.06	0.00	7.06	7.06	7.06	7.06
	Vessel - 40	Coal-38	1	0.00	-	0.00	0.00	0.00	0.00
	Vessel - 19	Coal-39	7	0.55	0.40	0.35	0.35	1.41	1.41
	Vessel - 20	Coal-39	10	4.64	3.77	3.60	0.95	13.41	13.41
	Vessel - 37	Coal-39	3	0.62	0.08	0.67	0.53	0.67	0.67
	Vessel - 2	Coal-40	2	5.29	0.00	5.29	5.29	5.29	5.29
	Vessel - 10	Coal-41	1	3.53	-	3.53	3.53	3.53	3.53
	Vessel - 22	Coal-41	1	3.53	-	3.53	3.53	3.53	3.53
	Vessel - 22	Coal-42	1	4.23	-	4.23	4.23	4.23	4.23
	Vessel - 20	Coal-43	1	8.61	-	8.61	8.61	8.61	8.61
	Vessel - 21	Coal-44	2	0.00	0.00	0.00	0.00	0.00	0.00
	Vessel - 21	Coal-45	1	0.00	-	0.00	0.00	0.00	0.00
	Vessel - 4	Coal-46	1	158.79	-	158.79	158.79	158.79	158.79
	Vessel - 4	Coal-47	1	158.79	-	158.79	158.79	158.79	158.79
	Vessel - 11	Coal-48	1	1.80	-	1.80	1.80	1.80	1.80
	Vessel - 4	Coal-49	4	82.13	88.62	84.69	0.35	158.79	158.79
	Vessel - 41	Coal-50	1	35.29	-	35.29	35.29	35.29	35.29
	Vessel - 13	Coal-51	1	52.93	-	52.93	52.93	52.93	52.93
	Vessel - 19	Coal-52	1	0.35	-	0.35	0.35	0.35	0.35
	Vessel - 23	Coal-53	1	0.35	-	0.35	0.35	0.35	0.35
	Vessel - 39	Coal-54	1	7.06	-	7.06	7.06	7.06	7.06
	Vessel - 28	Coal-55	1	70.58	-	70.58	70.58	70.58	70.58
	Vessel - 45	Coal-56	4	0.02	0.02	0.02	0.00	0.04	0.04
	Vessel - 30	Coal-57	2	7.00	0.00	7.00	7.00	7.00	7.00
	Vessel - 48	Coal-58	2	2.00	0.00	2.00	2.00	2.00	2.00
	Vessel - 33	Coal-59	2	52.93	24.95	52.93	35.29	70.58	70.58
	Vessel - 49	Coal-60	1	4.94	-	4.94	4.94	4.94	4.94
Unloading Limestone Vessels Database Statistics			**176**	**10.52**	**20.72**	**3.18**	**0.00**	**132.33**	**52.93**
Limestone	Vessel - 39	Limestone-1	1	2.49	-	2.49	2.49	2.49	2.49
	Vessel - 39	Limestone-2	1	2.65	-	2.65	2.65	2.65	2.65
	Vessel - 39	Limestone-3	1	3.71	-	3.71	3.71	3.71	3.71
	Vessel - 34	Limestone-3	1	0.25	-	0.25	0.25	0.25	0.25
	Vessel - 34	Limestone-4	1	2.65	-	2.65	2.65	2.65	2.65
	Vessel - 48	Limestone-4	1	0.53	-	0.53	0.53	0.53	0.53
	Vessel - 17	Limestone-5	1	1.59	-	1.59	1.59	1.59	1.59
	Missing	Limestone-6	2	8.73	1.12	8.73	7.94	9.53	9.53
	Vessel - 22	Limestone-7	1	7.94	-	7.94	7.94	7.94	7.94
	Vessel - 10	Limestone-7	1	3.00	-	3.00	3.00	3.00	3.00
	Vessel - 22	Limestone-7	1	2.65	-	2.65	2.65	2.65	2.65
	Missing	Limestone-7	2	7.94	0.00	7.94	7.94	7.94	7.94
	Vessel - 22	Limestone-7	1	5.29	-	5.29	5.29	5.29	5.29
	Vessel - 45	Limestone-8	1	2.01	-	2.01	2.01	2.01	2.01
	Vessel - 28	Limestone-9	1	79.40	-	79.40	79.40	79.40	79.40
	Vessel - 39	Limestone-10	1	2.65	-	2.65	2.65	2.65	2.65
	Vessel - 55	Limestone-11	1	2.01	-	2.01	2.01	2.01	2.01
	Vessel - 51	Limestone-11	1	5.29	-	5.29	5.29	5.29	5.29
	Vessel - 51	Limestone-12	2	2.91	3.37	2.91	0.53	5.29	5.29
	Vessel - 46	Limestone-13	1	26.47	-	26.47	26.47	26.47	26.47
	Vessel - 38	Limestone-13	2	17.47	0.00	17.47	17.47	17.47	17.47
	Vessel - 39	Limestone-13	1	4.76	-	4.76	4.76	4.76	4.76
	Vessel - 39	Limestone-14	1	5.29	-	5.29	5.29	5.29	5.29
	Vessel - 39	Limestone-15	3	5.77	4.19	3.71	3.02	10.59	10.59
	Vessel - 46	Limestone-16	1	52.93	-	52.93	52.93	52.93	52.93
	Vessel - 38	Limestone-17	1	34.93	-	34.93	34.93	34.93	34.93
	Vessel - 52	Limestone-18	1	1.27	-	1.27	1.27	1.27	1.27
	Vessel - 10	Limestone-19	2	5.29	0.00	5.29	5.29	5.29	5.29
	Vessel - 51	Limestone-20	2	2.91	3.37	2.91	0.53	5.29	5.29
	Vessel - 51	Limestone-21	1	3.71	-	3.71	3.71	3.71	3.71
	Vessel - 40	Limestone-22	1	0.00	-	0.00	0.00	0.00	0.00
	Vessel - 51	Limestone-23	2	5.29	6.74	5.29	0.53	10.06	10.06
	Vessel - 39	Limestone-23	2	1.59	0.75	1.59	1.06	2.12	2.12
	Vessel - 50	Limestone-24	1	0.53	-	0.53	0.53	0.53	0.53
	Vessel -54	Limestone-25	1	2.01	-	2.01	2.01	2.01	2.01
	Vessel -54	Limestone-25	1	20.11	-	20.11	20.11	20.11	20.11
	Vessel - 22	Limestone-26	1	4.23	-	4.23	4.23	4.23	4.23
	Vessel - 45	Limestone-27	2	4.23	0.00	4.23	4.23	4.23	4.23
	Vessel - 38	Limestone-28	4	17.47	0.00	17.47	17.47	17.47	17.47
	Vessel - 48	Limestone-29	1	0.53	-	0.53	0.53	0.53	0.53
	Vessel - 22	Limestone-30	2	3.44	0.37	3.44	3.18	3.71	3.71
	Vessel - 22	Limestone-30	1	2.12	-	2.12	2.12	2.12	2.12
	Vessel - 24	Limestone-31	2	5.56	7.11	5.56	0.53	10.59	10.59

*Records with no DCR value reported are not included in the table.

TABLE 8
DCR Volume by Vessel and Facility (Unloading Records Only)

Material	Vessel ID	Facility ID	DCR Quantity Generated by Vessel: Number of Records with a DCR Value Recorded	Average	Standard Deviation	Median	Minimum	Maximum	95th Percentile
Limestone	Vessel - 39	Limestone-32	1	5.29	-	5.29	5.29	5.29	5.29
	Vessel - 34	Limestone-33	3	0.16	0.09	0.21	0.05	0.21	0.21
	Vessel - 23	Limestone-34	1	4.23	-	4.23	4.23	4.23	4.23
	Vessel - 53	Limestone-35	2	0.00	0.00	0.00	0.00	0.00	0.00
	Vessel - 46	Limestone-35	2	26.47	0.00	26.47	26.47	26.47	26.47
	Vessel - 46	Limestone-36	3	28.23	3.06	26.47	26.47	31.76	31.76
	Vessel - 10	Limestone-37	1	4.76	-	4.76	4.76	4.76	4.76
	Vessel - 39	Limestone-38	2	1.54	0.67	1.54	1.06	2.01	2.01
	Vessel - 45	Limestone-38	1	15.88	-	15.88	15.88	15.88	15.88
	Vessel -54	Limestone-39	1	0.00	-	0.00	0.00	0.00	0.00
	Vessel - 22	Limestone-40	1	4.23	-	4.23	4.23	4.23	4.23
	Vessel - 39	Limestone-41	2	1.75	0.00	1.75	1.75	1.75	1.75
	Vessel - 22	Limestone-42	1	1.59	-	1.59	1.59	1.59	1.59
	Vessel - 24	Limestone-43	2	6.62	5.61	6.62	2.65	10.59	10.59
	Vessel - 36	Limestone-44	1	1.50	.	1.50	1.50	1.50	1.50
	Vessel - 46	Limestone-45	1	79.40	-	79.40	79.40	79.40	79.40
	Vessel - 38	Limestone-46	5	20.96	7.81	17.47	17.47	34.93	34.93
	Vessel - 38	Limestone-47	1	70.40	-	70.40	70.40	70.40	70.40
	Vessel -54	Limestone-48	1	2.75	-	2.75	2.75	2.75	2.75
	Vessel - 38	Limestone-49	3	40.93	26.97	34.93	17.47	70.40	70.40
	Vessel - 39	Limestone-49	1	7.94	-	7.94	7.94	7.94	7.94
	Vessel - 39	Limestone-50	2	4.23	4.49	4.23	1.06	7.41	7.41
	Vessel - 51	Limestone-51	1	3.71	-	3.71	3.71	3.71	3.71
	Vessel - 51	Limestone-52	1	0.05	-	0.05	0.05	0.05	0.05
	Vessel - 40	Limestone-53	1	0.00	-	0.00	0.00	0.00	0.00
	Vessel - 38	Limestone-54	1	17.47	-	17.47	17.47	17.47	17.47
	Vessel - 18	Limestone-55	3	2.50	1.39	2.25	1.25	4.00	4.00
	Vessel - 38	Limestone-56	1	17.47	-	17.47	17.47	17.47	17.47
	Vessel - 40	Limestone-57	1	0.00	-	0.00	0.00	0.00	0.00
	Vessel - 39	Limestone-57	2	8.73	10.11	8.73	1.59	15.88	15.88
	Vessel - 34	Limestone-57	1	3.18	-	3.18	3.18	3.18	3.18
	Vessel - 46	Limestone-57	1	26.47	-	26.47	26.47	26.47	26.47
	Vessel - 40	Limestone-58	1	0.00	-	0.00	0.00	0.00	0.00
	Vessel - 18	Limestone-59	1	0.75	-	0.75	0.75	0.75	0.75
	Vessel - 38	Limestone-59	2	26.20	12.35	26.20	17.47	34.93	34.93
	Vessel -54	Limestone-60	1	3.71	-	3.71	3.71	3.71	3.71
	Vessel - 24	Limestone-61	1	2.12	-	2.12	2.12	2.12	2.12
	Vessel - 51	Limestone-62	1	0.05	-	0.05	0.05	0.05	0.05
	Vessel - 39	Limestone-63	2	6.62	1.87	6.62	5.29	7.94	7.94
	Vessel - 48	Limestone-64	1	2.65	-	2.65	2.65	2.65	2.65
	Vessel - 39	Limestone-65	1	7.41	-	7.41	7.41	7.41	7.41
	Vessel -54	Limestone-66	2	3.10	0.11	3.10	3.02	3.18	3.18
	Vessel - 39	Limestone-66	1	3.97	-	3.97	3.97	3.97	3.97
	Vessel - 45	Limestone-66	1	7.94	-	7.94	7.94	7.94	7.94
	Vessel - 18	Limestone-67	1	2.00	-	2.00	2.00	2.00	2.00
	Vessel - 34	Limestone-68	1	1.06	-	1.06	1.06	1.06	1.06
	Vessel - 51	Limestone-69	1	0.05	-	0.05	0.05	0.05	0.05
	Vessel - 51	Limestone-70	5	3.81	2.58	5.29	0.53	6.35	6.35
	Vessel - 39	Limestone-71	1	10.59	-	10.59	10.59	10.59	10.59
	Vessel - 39	Limestone-72	1	2.65	-	2.65	2.65	2.65	2.65
	Vessel - 39	Limestone-72	1	3.71	-	3.71	3.71	3.71	3.71
	Vessel - 34	Limestone-73	1	0.16	-	0.16	0.16	0.16	0.16
	Vessel - 24	Limestone-74	1	1.06	-	1.06	1.06	1.06	1.06
	Vessel - 22	Limestone-75	1	2.12	-	2.12	2.12	2.12	2.12
	Vessel - 4	Limestone-76	2	132.33	0.00	132.33	132.33	132.33	132.33
	Vessel - 40	Limestone-77	3	0.00	0.00	0.00	0.00	0.00	0.00
	Vessel - 40	Limestone-78	1	0.00	-	0.00	0.00	0.00	0.00
	Vessel - 10	Limestone-78	1	1.06	-	1.06	1.06	1.06	1.06
	Vessel - 40	Limestone-79	1	0.00	-	0.00	0.00	0.00	0.00
	Vessel - 51	Limestone-80	1	1.06	-	1.06	1.06	1.06	1.06
	Vessel - 40	Limestone-80	3	0.00	0.00	0.00	0.00	0.00	0.00
	Vessel - 51	Limestone-81	1	6.88	-	6.88	6.88	6.88	6.88
	Vessel - 17	Limestone-82	1	1.59	-	1.59	1.59	1.59	1.59
	Vessel - 39	Limestone-83	1	5.29	-	5.29	5.29	5.29	5.29
	Vessel - 56	Limestone-83	2	0.66	0.56	0.66	0.26	1.06	1.06
	Vessel - 50	Limestone-84	2	0.66	0.56	0.66	0.26	1.06	1.06
	Vessel - 39	Limestone-85	1	4.76	-	4.76	4.76	4.76	4.76
	Vessel - 52	Limestone-86	3	1.27	0.00	1.27	1.27	1.27	1.27
	Vessel - 53	Limestone-87	2	1.11	0.52	1.11	0.74	1.48	1.48
	Vessel - 39	Limestone-88	1	4.76	-	4.76	4.76	4.76	4.76
	Vessel - 28	Limestone-89	3	0.71	0.31	0.53	0.53	1.06	1.06
	Vessel - 48	Limestone-90	2	0.49	0.06	0.49	0.45	0.53	0.53

*Records with no DCR value reported are not included in the table.

TABLE 9

Comparison between DCR Volume of U.S. and Foreign Vessels during Unloading Events.

Statistical Value	DCR Volume (cubic feet)					
	Coal		Limestone/Stone		Taconite	
	U.S.	Canadian	U.S.	Canadian	US	Canadian
Number of Records	134	49	120	77	113	57
Average	13.0	13.8	7.14	20.5	12.4	7.07
Standard Deviation	32.5	26.5	16.8	28.5	21.8	19.3
Median	3.4	4.2	2.4	6.0	3.7	1.1
Minimum	0	0	0	0	0	0
Maximum	159	141	90.5	121	132	106
95th Percentile	106	70.6	45.3	60.3	52.9	52.9

There were 13 records that did not report country of origin for the vessel.

Attachment A
Facsimile of U.S. Coast Guard Bulk Dry Cargo Residue Reporting Form (Form CG-33)

U.S. DEPARTMENT OF HOMELAND SECURITY U.S. COAST GUARD CG-33 Rev. (02-08)	**BULK DRY CARGO RESIDUE REPORTING FORM**	**OMB Number 1625-0072 Expires:**
		OFFICIAL/IMO NO.
MASTER'S CERTIFICATION:		**VESSEL NAME:**

For Cargo Loading & Unloading Operations									*For Residue Discharge Operations Only*		
Date	**Cargo Involved**[1]	**Operation** *(check one)*		**Facility Name**	**Control Measures Used**[2] *(see list of codes)* Facility Vessel		**Time Spent to Implement Control Measure** *(hrs)*	**Estimated Residue to be Discharged**[3] *(m^3)*	**Discharge Start** *Date/Time(D/T) Ship's Position (Lat/Long)*	**Discharge Stop** *Date/Time(D/T) Ship's Position (Lat/Long)*	**Vessel Speed (kts)**
		Load	*Unload*		*Facility*	*Vessel*					
									D/T: Lat: Long:	D/T: Lat: Long:	
									D/T: Lat: Long:	D/T: Lat: Long:	
									D/T: Lat: Long:	D/T: Lat: Long:	
									D/T: Lat: Long:	D/T: Lat: Long:	
									D/T: Lat: Long:	D/T: Lat: Long:	
									D/T: Lat: Long:	D/T: Lat: Long:	
									D/T: Lat: Long:	D/T: Lat: Long:	

Please see footnotes on next page

Remarks:

An agency may not conduct or sponsor, and a person is not required to respond to a collection of information unless it displays a valid OMB control number. The Coast Guard estimates that the average burden for this report is 15 minutes. You may submit any comments concerning the accuracy of this estimate or any suggestions for reducing the burden to: Commandant (CG-5232), U.S. Coast Guard Room 1400, 2100 Second Street SW, Washington, D.C. 20593-0001

Reset

NOTES:

[1] **Cargo Involved:** Provide the common name of the cargo (e.g., coal, taconite, sand, limestone, grain, salt, etc.)
When multiple cargo types are discharged, please create a separate entry for each type

[2] **Control Measures:** Enter the code(s) below for each dry cargo residue control measure(s) used during cargo handling operations, for both cargo facilities (if known), and for your vessel.

Return to Form

[3] Estimated residue after loading and unloading operations to be discharged in accordance with 33 CFR 151.66

Cargo Involved	Facility Control Measures Code	Facility Control Measures Measure	Vessel Control Measures Code	Vessel Control Measures Measure
	A	Enclosed conveyor	1	Enclosed conveyor
iron ore	B	Troughed conveyor	2	Troughed conveyor
taconite	C	Conveyor skirts	3	Conveyor skirts
scale	D	Belt Scrapers	4	Belt Scrapers
coal/coke	E	Water/mist for dust control	5	Water/mist for dust control
grain	F	Conveyor capacity indicators	6	Conveyor capacity indicators
seed	G	Deck remote controls of conveyors	7	Deck remote controls of conveyors
wood pulp	H	Stop conveyor while ship or belt is repositioned	8	Stop conveyor while ship or belt is repositioned
potash	I	Delay loading/unloading during high wind	9	Delay loading/unloading during high wind
fertilizer	J	Radio Communication between deck and loader	10	Radio Communication between deck and loader
limestone	K	Crew training on procedures to reduce residue	11	Crew training on procedures to reduce residue
sand/gravel	L	Limit vertical angle of conveyor boom	12	Limit vertical angle of conveyor boom
dolomite	M	Plow feeder	13	Broom & shovel (to return to hold or shore)
clay	N	Loading chute, incl. Telescoping or conveyors	14	Tarps to collect residue(to return to hold or shore)
aggregates	O	Chemical surfactants	15	Cargo hold vibrator
salt	P	Suction pumped cargo, slurry transport,	16	Watertight gate seal
gypsum		pneumatic or screw conveyors	17	Cargo hold lining (teflon or kevlar)
cement	Q	Other (describe measure on "Remarks" line	18	Minimize hatch removal during poor weather
Other		on front of form)	19	Careful cargo hold gate operation
			20	Other (describe measure on "Remarks" line on front of form)

Equivalence Table for estimating residue

Cargo	Density (lbs/ft^3)	Equivalent Volume for 350 lbs of DCR	Volume in m^3
Coal	50	7 ft^3	0.2
Limestone	150	2.3 ft^3	0.07
Taconite	222	1.6 ft^3	0.05

Note: One 5 gallon bucket is equivalent to 0.019 m^3

1 cubic ft = 0.0283 m^3

Estimated Cost of Alternatives Evaluated in Detail in the Tiered Draft EIS

PREPARED FOR: U.S. Coast Guard

PREPARED BY: CH2M HILL

DATE: September 7, 2011

1. Introduction

The U.S. Coast Guard is preparing a Tiered Draft Environmental Impact Statement (EIS) to further support the rulemaking for management of bulk dry cargo residue (DCR) discharges to the Great Lakes. The Tiered Draft EIS is based on additional information obtained through direct observation of loading and unloading events of the three major cargoes—coal, taconite, and limestone—and through vessel DCR recordkeeping analysis (CH2M HILL, 2009). The direct observations were completed in spring and summer 2009 and consisted of 30 loading and unloading events. (One additional taconite-loading facility was visited, but no loading operations were observed because no vessels were scheduled during the observation program.)

This memorandum summarizes cost estimates for the alternatives that remained following screening in the Tiered Draft EIS. The cost estimates from the Phase I Final EIS were used for this memorandum and refined based on direct observations and additional industry knowledge gained during development of the Tiered Draft EIS. Cost estimates were developed for the following alternatives:

- **Alternative 1: No Action—**The No Action alternative is required to be evaluated by the National Environmental Policy Act (NEPA). This alternative would continue the current DCR interim rule's approach, and the interim rule would become a final rule, without substantive changes. Dry bulk cargo transport would continue, following current patterns and practices. This alternative would continue to require each dry bulk cargo vessel to complete DCR Reporting Form CG-33 every time that vessel loads or unloads such cargo, washes its deck or tunnel, and discharges DCR. The completed forms are submitted quarterly.

- **Alternative 2: Performance Requirement to Minimize DCR Discharges—**This alternative would require that the amount of DCR discharged overboard be minimized by reducing or eliminating it to the extent achievable, using control measures and best management practices that are available, economically practicable, and achievable in light of best marine practices.

  The DCR discharge minimization could be achieved through prevention, such as proactive operations and maintenance of structural control measures, and operational procedures that the shoreside facility and vessel owners and operators determine provide a high level of DCR control. DCR discharges minimization could also be achieved by collecting concentrated areas of DCR on the deck and in the tunnel.

Under this alternative, the U.S. Coast Guard would establish a "broom-clean" standard for the deck and would require each vessel owner/operator to develop and implement a management plan that minimizes DCR discharges from the deck and tunnel.

This alternative would not delay a vessel while in port, and it would require recordkeeping to quantify the DCR discharged, a practice similar to using the existing DCR Reporting Form CG-33, but submitting the form on a regular basis would not be required. This alternative also includes the exclusion zones for DCR discharges included in the existing interim rule.

- **Alternative 3: Prescriptive Requirement for Baseline Control Measures—**This alternative would require that all vessels and shoreside loading facilities have the control measures described below, or their equivalent, and maintain them so that they operate as designed to control DCR. Observations of dry-cargo-loading and -unloading operations revealed a number of common measures that when implemented, operated, and maintained properly, were effective at controlling DCR. Through observations, review of DCR reporting forms, and interviews with vessel and shoreside facility personnel, a list of measures that met the criteria of effectiveness and presence throughout the industry was developed. These baseline control measures or their equivalent were present for each cargo type, vessel, and shoreside facility. This alternative would not delay a vessel while in port, and it would require recordkeeping to quantify the DCR discharged, similar to the existing practice with DCR Reporting Form CG-33. Submitting the form on a regular basis would not be required. This alternative also includes the exclusion zones for DCR discharges included in the existing interim rule.

2. Estimated Cost Summary

The methodology used for estimating costs in the Phase I Final EIS alternatives (Appendix F in the Phase I Final EIS) was used as a basis for these estimates and refined based on additional information obtained from the direct observations, industry communication, and research. The Phase I estimates were developed for the DCR control measures using traditional cost-estimating techniques, communication with Lake Carrier Association member companies, and engineering judgment, and through direct contact with manufacturers of control measures. Costs were separated into capital, installation, operations and maintenance, and delay to capture the total cost each alternative may have on the shipping industry. The cost estimates prepared in the Phase I Final EIS were reported in 2007 U.S. dollars using construction cost index (CCI) 8045, but all estimates completed for the Tiered Draft EIS were converted to 2009 U.S. dollars using a 2009 producer price index (PPI). Costs were estimated for the Great Lakes fleet, which includes U.S. vessels and ports and Canadian vessels that would be affected by a new rule. The cost estimates were not developed for individual companies, vessels, or shoreside facilities. Foreign, non-Canadian vessels, were not included in the cost estimates because there are very few foreign, non-Canadian vessels that operate in U.S. waters and at U.S. shoreside facilities for coal, limestone, and taconite cargoes (less than 0.5 percent as determined by 2006 shipment tonnages on the Great Lakes (USACE, 2006)).

Cost estimates were developed separately for loading and unloading operations to recognize the differences in DCR sources. Loading primarily generates DCR on the deck, while unloading primarily generates DCR in the tunnel and on the deck. For the alternatives that require DCR collection during loading operations, the vessels and shoreside loading facilities are expected to each have shared responsibility for preventing or collecting DCR. In some loading operations, the DCR control is entirely with the shoreside facility operation (e.g., when a vessel does not shift during loading and the shoreside facility shiploader is positioned), while in some loading operations the vessels share responsibility with the facility to prevent DCR (e.g., when a vessel is required to shift during loading and the shifting could generate DCR). For the purpose of estimating the cost of alternatives, it is assumed that DCR control is managed by the vessels (i.e., facility costs are not estimated because of the variability between shoreside facilities and their loading equipment, and to maintain a consistent cost estimating methodology between alternatives). This results in a cost to the vessels for each loading event and does not calculate a cost to the shoreside loading facilities. In practice, the cost is expected to be shared between the vessels and facilities, because they share responsibility to reduce DCR during loading operations. Although the costs are calculated for the vessels, the costs are expected to be also shared among the shoreside facilities and not borne solely by the vessels.

In contrast, the DCR generated during unloading operations is caused only by the equipment and operations of the vessel. Therefore, the vessel would most likely incur the costs during unloading operations.

Whether loading or unloading, the cost of minimizing or eliminating DCR could be calculated by either preventing or collecting DCR. This means that the cost of implementing certain control measures to prevent DCR would be equivalent in cost to the labor and time required to collect the DCR if the control measures were not implemented. For the purposes of the cost estimates, the costs of collecting DCR were estimated with “high” and “low” bounds to bracket the range of potential costs to the Great Lakes shipping industry. These cost estimates are detailed below.

Each alternative includes several assumptions that describe the possible operational procedures and equipment that could be used to achieve the objectives of the alternative. These assumptions are similar to those used in the Phase I Final EIS and they were generally observed during the observation program (CH2M HILL, 2009). These assumptions are not requirements of the alternative, but instead they are used to bound and define details of how the industry could comply with the alternative for cost-estimating purposes. These assumptions are discussed below and within the cost estimate for each alternative.

2.1 Vessel Trips

The Phase I Final EIS defined a vessel trip as an event that includes one cargo loading, one unloading, and a deck and tunnel washdown (at selected times as described below) to discharge DCR. A vessel could have a split unloading (i.e., a vessel travels to two ports to complete its unloading), but this was assumed to be a very small percentage of the total vessels and vessel trips and were included with the vessel trip estimates.

The Phase I Final EIS identified that not all trips would result in the need to washdown the deck or tunnel at the end of a trip. A washdown may not occur for each trip because not all loadings or unloadings produce enough DCR to present a safety or equipment operational hazard, not all vessels practice washdown during each trip, and vessels do not always leave an exclusion zone to allow for a washdown. Based on these reasons and the direct observations, the Phase I Final EIS assumed that 75 percent of trips involve a washdown. This assumption was therefore also used in the cost estimates for the alternatives in the Tiered Draft EIS.

Each U.S. and Canadian vessel was assumed to make 60 trips in a typical year, which is based on communication with the Great Lakes shipping industry during the Phase I Final EIS (LCA, 2007). Based on communication with the Canadian shipping industry as part of the Tiered Draft EIS, approximately 75 percent of the Canadian trips are to U.S. ports for either a loading or an unloading event (Anderson, 2009; Porter, 2009). Because the Merchant Marine Act of 1920 (Jones Act) prevents foreign vessels from loading and unloading during a trip between U.S. ports, the remaining 25 percent of the Canadian trips would not be impacted by a U.S. regulation. Therefore, cost estimates for each alternative were developed for U.S. vessels completing an average of 60 trips per year and the Canadian vessels completing an average of 45 trips per year (75 percent of 60 trips per year as discussed above) to or from U.S. ports. Because these trip estimates were developed when demand for shipped commodities was typical of a long-term average, they were used within the cost estimates to reflect a typical year.

In contrast, the Lake Carriers' Association reported that U.S. vessels have carried 42.5 percent less cargo in 2009 than during the previous year (Nekvasil, 2009). Because this reduced shipping represents the most recent economic period, the number of vessel trips was estimated for this time and was used to reflect a period when there is decreased demand for the dry bulk cargo commodities (compared to the typical year discussed above). The 2008 and 2009 vessel records and 2003 through 2008 monthly shipping tonnages were evaluated to determine the average number of vessel trips. The U.S. vessel trips were estimated by counting the number of reported loading and unloading events (from the vessel records) for each reporting vessel and using the maximum of the two to define the total number of trips for that vessel during the reporting period. These values were then averaged to determine the total average number of trips for each reporting vessel of the U.S. fleet for the 2008 and 2009 period of analysis.

The Canadian vessel trips were estimated by adding the reported loading and unloading events for each vessel from the vessel records. The Canadian vessel records were added to estimate the total number of trips for that vessel because the Jones Act does not allow a Canadian vessel to load and unload the same cargo during a single trip; therefore a Canadian loading event must be a different trip than a Canadian unloading event. These values were then averaged to determine the total average number of trips for each reporting vessel in the Canadian fleet. The 2008 and 2009 vessel records did not include records for the entire 2008 and 2009 shipping seasons, but the number of loading and unloading events recorded for each vessel was extrapolated to estimate the total number of trips in a shipping season. These events were extrapolated using the percent of total annual shipping for the missing months using 2003 through 2008 monthly shipping tonnages from the Lake Carriers' Association. The number of trips calculated in the 2008 and 2009 vessel records were extrapolated between 56 and 69 percent for U.S. vessels and between 59 and 69 percent for Canadian vessels (i.e., between 56 and 69 percent of the total annual tonnage is historically shipped during dates for which vessel records were not available). The average

U.S. vessel trips using the 2008 and 2009 vessel records and extrapolating to an entire shipping season was 41 trips per year. Similarly for Canadian vessels, the 2008 and 2009 vessel records extrapolated to an entire shipping season averaged 32 trips per year.

2.2 Number and Distribution of Vessels

The Phase I Final EIS inventoried the Great Lakes bulk dry cargo fleet that consisted of 55 U.S. vessels and 70 Canadian vessels, which includes the active vessels when demand for shipped commodities was typical of a long-term average. These numbers of vessels were therefore used within the cost estimates to reflect a typical year. The vessels were categorized in two classes that represent different lengths to recognize the variation within U.S. and Canadian fleets and that larger vessels will require more time to collect DCR. Vessel Class V-VIII consists of vessels between 600 and 850 feet long, and Class IX-X vessels are between 850 and 1,100 feet (LeLievre, 2008). Based on information provided by the U.S. and Canadian shipping industry and the Phase I Final EIS, 100 percent and 75 percent of the Canadian vessels and U.S. vessels are Class V–VIII, respectively, and the remaining 25 percent of U.S. vessels are Class IX–X (Anderson, 2009; Porter, 2009).

As discussed above for the estimated number of vessel trips, the 2008 and 2009 vessel records were also used to estimate the number of U.S. and Canadian vessels in use during the most recent shipping seasons and during a period when the shipping tonnages are less than previous years (Nekvasil, 2009). The number of U.S. vessels ranged between 33 and 38 for the two periods of record, and the Canadian vessel count ranged between 34 and 50. When the 2008 and 2009 records were combined, the U.S. vessels in service during the two periods totaled 47 vessels (out of a possible total of 55) and the Canadian vessels totaled 63 (out of a possible 70). Combining the 2008 and 2009 vessel records represented almost an entire shipping season. Though vessel records were not available for 2.5 months of a 12-month calendar year (records were not available from mid-July through the end of September), the missing 2.5 months are not expected to significantly change the total number of vessels operating. It is unlikely that additional vessels are used only during those months. Therefore, using the most recent 2008 and 2009 vessel records, there were 47 U.S. vessels in service and 63 Canadian vessels, where these numbers were used to reflect a period when there is decreased demand for the dry bulk cargo commodities (compared to the typical year discussed above).

2.3 Impact of Alternatives on Canadian Vessels

U.S. regulations apply to Canadian (and foreign) vessels when they operate at U.S. ports or in U.S. waters. The Minimize DCR Discharges and Baseline Control Measures alternatives do not require the vessels to control tunnel-derived DCR *while in port or in U.S. waters* because it is possible for foreign vessels (non-U.S. flag vessels) to delay washdown and DCR discharges from portions of the vessel until the vessel is outside U.S. waters. DCR from the vessel tunnel can be discharged only when pumped from the tunnel sump pumps, so it is possible for foreign vessels (non-U.S. flag vessels) to delay all tunnel DCR discharges until the vessels are outside of U.S. waters. Therefore, the DCR generated in the tunnel is not included in the estimated costs for Canadian vessels.

Deck DCR, however, can be inadvertently discharged in U.S. waters without washdown by the vessel crew and would not meet the intent of the Minimize DCR Discharges or Baseline Control Measures alternatives. Deck DCR could be discharged by foul weather, wind, or waves washing over the deck and washing DCR overboard. In addition, the Minimize DCR Discharges alternative includes a broom-clean standard for the deck of all vessels whenever the vessel is in transit. Because deck DCR could be discharged without a crew washdown of the deck, the alternatives include Canadian vessels for DCR control from the vessel deck.

2.4 DCR Collection on Vessel Deck

Based on the average number of hatches for the different class vessels, DCR collection is assumed to be required over some of the vessel deck. DCR is not generated uniformly over the vessel deck, and therefore collection of DCR would not be required over the entire vessel deck. Based on communication with the Great Lakes shipping industry during the Phase I Final EIS and from direct observations, DCR collection is assumed to be required around 75 percent of the hatches. This is to recognize that some hatches will not require DCR collection because the DCR volumes are small or are unrecoverable using best marine practices.

Based on the direct observations and an inventory of Great Lakes vessels (LeLievre, 2008; Boatnerd, 2009) Class V-VIII vessels have an average of about 19 hatch openings, and Class IX-X vessels have an average of about 28 hatch openings. The total number of hatches estimated in the U.S. fleet is 1,169 (75% × 55 vessels × 19 hatches per vessel + 25% × 55 vessels × 28 hatches per vessel). The total number of hatches estimated in the Canadian fleet is 1,330 (70 vessels × 19 hatches per vessel). As discussed below in the details of each alternative cost estimate, the hatch openings for the two classes of vessels are used to estimate the costs to collect DCR on the different sized vessels during loading events.

2.5 Crew Labor Rates

Crew labor rates are used in the cost estimates to determine the financial burden to the shipping industry. The rates used in the estimates were based on the 2009 East Coast Salary Chart, which reports salary rates of civilian employees set by the Military Sealift Command. For the purpose of the cost estimates, the salaried rates were converted to raw (unburdened) hourly labor rates by assuming the salaries are paid over a 52-week year and a 40-hour workweek. The unburdened labor rates of a deckhand was based on an Able Seaman (M), which yields $19 per hour, and the hourly rate of a maintenance crew member was based on a Deck Engineer Mechanic (D), which yields $22 per hour. The unburdened hourly labor rates were adjusted to estimate the burdened hourly rates, to include the benefits. Escalating the unburdened hourly rates by 40 percent (BLS, 2009) yields a burdened hourly rate of $27 per hour for a deckhand and $31 per hour for a maintenance crewmember.

2.6 Recordkeeping

Recordkeeping is required by the existing interim rule, and therefore the shipping industry has borne the cost of the existing recordkeeping requirement. The Minimize DCR Discharges and Baseline Control Measures alternatives also require recordkeeping, but less stringent reporting requirements are included in the alternatives compared to the No Action alternative. Because Alternatives 2 and 3 require some form of recordkeeping that is either the same as or less burdensome than the existing requirements (Alternative 1), it is assumed that the costs for recordkeeping would not create additional financial burden.

The cost savings for the vessels no longer having to complete Master Certification or having to complete quarterly submission of reporting forms to the U.S. Coast Guard was estimated in the Regulatory Analysis Section VI of the SNPRM (USCG 2011). These cost savings were calculated from the recordkeeping cost estimates completed as part of the Interim Rule RA, which totaled $13,794 ($12,672 Master certification + $1,122 submission; 2006 dollars) (USCG, 2008). These costs, for the NEPA analysis, are then converted from 2006 dollars to 2009 dollars using the PPI and applied as a cost savings in Alternatives 2 and 3 because these requirements would no longer be required. Cost savings for the U.S. fleet was estimated to total $14,603 (2009 dollars).

Canadian vessels would also realize a cost savings. From the Interim Rule RA, 33 Canadian vessels traveling 42 trips per year had a cost impact of $4,158 ($3,485 Master certification + $673 submission). Adjusting the cost for 70 vessels and 60 trips used for Alternatives 2 and 3 and converting the cost to 2009 dollars yields a total cost savings to Canadian vessels of $13,339 (2009 dollars).

Using the 2008/2009 vessel records of 41 trips and 47 vessels for the U.S. fleet and 32 trips and 63 vessels for the Canadian fleet, the cost savings total $8,527 for the U.S. fleet and $6,403 for the Canadian fleet (2009 dollars).

3. No Action Cost Estimate

The No Action alternative is a continuation of the current Great Lakes shipping industry practices for DCR discharges control and therefore there are no additional costs for this alternative.

4. Performance Requirement to Minimize DCR Discharges Cost Estimate

This alternative would require that the amount of DCR discharged overboard be minimized by reducing or eliminating it to the extent achievable using control measures and best management practices that are available, economically practicable, and achievable in light of best marine practice. It reflects the observations of DCR loading and unloading, which revealed that significant reduction in DCR discharges can be achieved by careful attention to operations and implementation of readily available control measures. It also accommodates variation in equipment and operating procedures among vessels and shoreside facilities and encourages vessel owners and operators and shoreside facilities to use their own experience and innovation to determine the most efficient and effective approach to controlling DCR discharges on their vessel or at their shoreside facility. This alternative addresses a performance result (minimizing DCR discharges) but is not prescriptive to the vessel owner or operator or shoreside facility on how to achieve the result.

The DCR discharges minimization could be achieved through prevention, such as proactive operations and maintenance of structural control measures, and operational procedures that the shoreside facility and vessel owners and operators determine provide a high level of DCR control. DCR discharges minimization could also be achieved by collecting concentrated areas of DCR on the deck and in the tunnel. This alternative requires each vessel owner or operator to prepare and maintain a DCR Management Plan with vessel-specific elements describing DCR control equipment, provisions, and operating procedures best suited to their vessel to minimize DCR discharges to the Great Lakes. Preparation of the plan also requires the owner/operator to evaluate their vessel and procedures periodically to identify DCR control opportunities and update the plan as new technologies or procedures are developed.

For cost-estimating purposes, it is assumed that the currently installed control measures on the vessels and shoreside loading facilities are maintained and functionally operating (i.e., no additional control measure capital, operation, or maintenance costs), but that DCR is manually collected by the vessel crew (i.e., facility costs are not estimated). While collecting DCR will require additional time by the vessel crew, it is not expected to delay the vessel from leaving port because DCR could be collected during the loading and unloading operations.

Cost estimates for this alternative are completed separately for loading and unloading operations and are summarized below in separate subsections.

4.1 Management Plan Costs

The management plan costs were developed in the Supplemental Notice of Proposed Rule Making (SNPRM) (USCG, 2011) and totaled $24,920 for the U.S. fleet and $14,280 for the 70 vessels included in the Canadian fleet[1]. In addition, the U.S. fleet would also incur annual costs ranging from $14,203 to $53,263 for implementation of the broom clean standard, and the foreign vessel fleet would incur costs ranging from $12,120 to $45,120. The management plan costs using the vessel count from the 2008/2009 vessel records (47 U.S. vessels and 63 foreign vessels) totaled $21,295 for the U.S. fleet and $12,852 for the Canadian fleet[2].

4.2 Options under Minimization for Loading Operations

Based on the direct observations, when DCR is generated during loading operations, it will likely be concentrated on the vessel deck under the loading booms or adjacent to the hatch openings. In this scenario, DCR discharges would be minimized by collecting DCR from those areas of concentrated accumulation, but not collecting all DCR, such as light dusting that may be spread over much of the vessel deck. Collecting the concentrated DCR would not delay the vessel in port, because it is assumed that the crew can collect DCR during the loading operation or the vessel could mobilize the crew at the end of the operation to collect the deck DCR. Both practices were seen during the observation program and were effective at minimizing DCR discharges when employed.

Cost estimates for loading operations to minimize DCR discharges are summarized below

4.2.1 Lower-Range Cost

The details of the example lower-range cost estimate to achieve the objectives of this alternative are summarized below. The cost estimate includes specific assumptions that describe a possible scenario to achieve the objectives of this alternative. The assumptions are

[1] In determining the cost of the Management Plan, the SNPRM considers the foreign fleet to be Canadian and foreign Non-Canadian vessels that enter into U.S, navigable waters. The DEIS, on the other hand, looks only at Canadian flag vessels when estimating cost for foreign vessels.

[2] The SNPRM only considers the total number of U.S. vessels that permanently operate on the Great Lakes, while the DPEIS considers both the vessel population that permanently operates on the Great Lakes and the population of vessels that operated during the 2008/2009 shipping season,

necessary to estimate a cost for this alternative, but as discussed above, the assumptions are not a requirement of the alternative.

Capital Costs

There are no additional capital costs for this alternative.

Operations and Maintenance Cost

Throughout the loading sequence, the vessel would utilize crew on deck to collect the deck DCR. This practice would not require additional crewmembers and would allow the crew to collect DCR during normal loading operations (i.e., this operation would not delay the vessel in port). Based on the direct observations, at the end of the loading event, the vessel would mobilize two additional crewmembers for 1 minute (0.017 hour) (2 minutes total) to collect DCR for each of the three remaining hatches. The number of crew and time required to collect the DCR for this alternative would prevent a vessel delay while in port, which was seen during the observations program. To estimate the operations and maintenance cost for this alternative, the following calculations are completed:

First, the total number of hatches that will be swept for the U.S. fleet is calculated:

$$\text{Total U.S. Fleet Swept Hatches} = 55 \text{ vessels} \times 3 \frac{\text{hatches}}{\text{vessels}} = 165 \text{ hatches}$$

Next, a similar calculation is completed for the Canadian fleet:

$$\text{Total Canadian Fleet Swept Hatches} = 70 \text{ vessels} \times 3 \frac{\text{hatches}}{\text{vessels}} = 210 \text{ hatches}$$

Next, the total labor time is calculated for the total U.S. and Canadian fleet:

$$\text{Total U.S. Fleet Time} = 75\% \times 60 \frac{\text{trips}}{\text{yr}} \times 0.017 \frac{\text{hrs}}{\text{crew - hatch - trip}} \times 165 \text{ hatches} \times 2 \text{ crew} = 253 \, {}^{\text{hrs}}\!/_{\text{yr}}$$

$$\text{Total Canadian Fleet Time} = 75\% \times 45 \frac{\text{trips}}{\text{yr}} \times 0.017 \frac{\text{hrs}}{\text{crew - hatch - trip}} \times 210 \text{ hatches} \times 2 \text{ crew} = 241 \, {}^{\text{hrs}}\!/_{\text{yr}}$$

Using the labor times calculated above, the total U.S. and Canadian labor costs are calculated by multiplying by the hourly labor costs. These costs are for the entire Great Lakes shipping industry, not for individual vessels:

$$\text{Total U.S. Fleet Labor Costs} = 253 \frac{\text{hrs}}{\text{yr}} \times \frac{\$27}{\text{hr}} = {}^{\$6{,}831}\!/_{\text{yr}}$$

$$\text{Total Canadian Fleet Labor Costs} = 241 \frac{\text{hrs}}{\text{yr}} \times \frac{\$27}{\text{hr}} = {}^{\$6{,}507}\!/_{\text{yr}}$$

$$\text{Total Great Lakes Fleet Labor Costs} = \$6{,}831 + \$6{,}507 = {}^{\$13{,}338}\!/_{\text{yr}}$$

4.2.2 Cost Estimates Based on 2008 and 2009 Vessel Records

As discussed above, the 2008 and 2009 vessel records were evaluated to estimate the annual number of trips and vessels for the U.S. and Canadian vessels during this recent period of record, and for a period when there was a decrease in demand for shipped commodities. Using an average of 41 trips per year for 47 U.S. vessels and 32 trips per year for 63 Canadian vessels, the cost estimates of this alternative are the following:

Higher-Range Cost Estimate Based on Vessel Records

Capital Costs: None.

Operations and Maintenance Costs:

$$\text{U.S. Fleet Class V - VIII Vessels} = 75\% \times 47 \text{ vessels} = 35.25 \text{ vessels}$$

$$\text{U.S. Fleet Class IX - X Vessels} = 25\% \times 47 \text{ vessels} = 11.75 \text{ vessels}$$

$$\text{Canadian Fleet Class V - VIII Vessels} = 100\% \times 63 \text{ vessels} = 63 \text{ vessels}$$

$$\text{Total Swept Hatches}_{\text{U.S. Fleet: Class V - VIII Vessel}} = 75\% \times 35.25 \text{ vessels} \times 19 \frac{\text{hatches}}{\text{vessels}} = 502 \text{ hatches}$$

$$\text{Total Swept Hatches}_{\text{U.S. Fleet: Class IX - X Vessel}} = 75\% \times 11.75 \text{ vessels} \times 28 \frac{\text{hatches}}{\text{vessels}} = 247 \text{ hatches}$$

$$\text{Total Swept Hatches}_{\text{Total U.S. Fleet}} = 502 \text{ hatches} + 247 \text{ hatches} = 749 \text{ hatches}$$

$$\text{Total Swept Hatches}_{\text{Canadian Fleet: Class V - VIII Vessel}} = 75\% \times 63 \text{ vessels} \times 19 \frac{\text{hatches}}{\text{vessels}} = 898 \text{ hatches}$$

$$\text{Total U.S. Fleet Time} = 75\% \times 41 \frac{\text{trips}}{\text{yr}} \times 0.083 \frac{\text{hrs}}{\text{crew - hatch - trip}} \times 749 \text{ hatches} \times 4 \text{ crew} = 7{,}647 \text{ hrs/yr}$$

$$\text{Total Canadian Fleet Time} = 75\% \times 32 \frac{\text{trips}}{\text{yr}} \times 0.083 \frac{\text{hrs}}{\text{crew - hatch - trip}} \times 898 \text{ hatches} \times 4 \text{ crew} = 7{,}155 \text{ hrs/yr}$$

$$\text{Total U.S. Fleet Labor Costs} = 7{,}647 \frac{\text{hrs}}{\text{yr}} \times \frac{\$27}{\text{hr}} = \$206{,}469/\text{yr}$$

$$\text{Total Canadian Fleet Labor Costs} = 7{,}155 \frac{\text{hrs}}{\text{yr}} \times \frac{\$27}{\text{hr}} = \$193{,}185/\text{yr}$$

$$\text{Total Great Lakes Fleet Labor Costs} = \$206{,}469 + \$193{,}185 = \$399{,}654/\text{yr}$$

Lower-Range Cost Estimate Based on Vessel Records

Capital Costs: None.

Operations and Maintenance Costs:

$$\text{Total U.S. Fleet Swept Hatches} = 47 \text{ vessels} \times 3 \frac{\text{hatches}}{\text{vessels}} = 141 \text{ hatches}$$

$$\text{Total Canadian Fleet Swept Hatches} = 63 \text{ vessels} \times 3 \frac{\text{hatches}}{\text{vessels}} = 189 \text{ hatches}$$

$$\text{Total U.S. Fleet Time} = 75\% \times 41\ \frac{\text{trips}}{\text{yr}} \times 0.017\ \frac{\text{hrs}}{\text{crew - hatch - trip}} \times 141\ \text{hatches} \times 2\ \text{crew} = 147\ \text{hrs}/\text{yr}$$

$$\text{Total Canadian Fleet Time} = 75\% \times 32\ \frac{\text{trips}}{\text{yr}} \times 0.017\ \frac{\text{hrs}}{\text{crew - hatch - trip}} \times 189\ \text{hatches} \times 2\ \text{crew} = 154\ \text{hrs}/\text{yr}$$

$$\text{Total U.S. Fleet Labor Costs} = 147\ \frac{\text{hrs}}{\text{yr}} \times \frac{\$27}{\text{hr}} = \$3{,}969/\text{yr}$$

$$\text{Total Canadian Fleet Labor Costs} = 154\ \frac{\text{hrs}}{\text{yr}} \times \frac{\$27}{\text{hr}} = \$4{,}158/\text{yr}$$

$$\text{Total Great Lakes Fleet Labor Costs} = \$3{,}969 + \$4{,}158 = \$8{,}127/\text{yr}$$

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4.2.3 Higher-Range Cost

The details of the example higher-range cost estimate to achieve the objectives of this alternative are summarized below. The cost estimate includes specific assumptions that describe a possible scenario to achieve the objectives of this alternative. The assumptions are necessary to estimate a cost for this alternative, but as discussed above, the assumptions are not a requirement of the alternative.

Capital Costs

There are no additional capital costs for this alternative.

Operations and Maintenance Cost

Toward the end of the loading event, it is assumed that the vessel would mobilize four crewmembers for a total of 5 minutes (0.083 hour) per hatch. The number of crew and time required to collect the DCR for this alternative was based on the direct observations. To estimate the operations and maintenance cost for this alternative, the following calculations are completed:

First, the number of U.S. vessels in each vessel class is calculated based on the number of vessels and distribution of vessel classes, as discussed above:

$$\text{U.S. Fleet Class V - VIII Vessels} = 75\% \times 55\ \text{vessels} = 41.25\ \text{vessels}$$
$$\text{U.S. Fleet Class IX - X Vessels} = 25\% \times 55\ \text{vessels} = 13.75\ \text{vessels}$$

The total number of hatches estimated in the U.S. fleet is 1,169 (75% × 55 vessels × 19 hatches per vessel + 25% × 55 vessels × 28 hatches per vessel).

Next, the number of Canadian vessels is calculated in each vessel class using the number of vessels and distribution, as discussed above:

$$\text{Canadian Fleet Class V - VIII Vessels} = 100\% \times 70\ \text{vessels} = 70\ \text{vessels}$$

The total number of hatches estimated in the Canadian fleet is 1,330 (70 vessels × 19 hatches per vessel).

Next, using the number of vessels calculated above, the total number of hatches that would be swept for the U.S. fleet is calculated by using the number of vessels, hatches, and the percent of hatches that would require sweeping:

$$\text{Total Swept Hatches}_{\text{U.S. Fleet: Class V - VIII Vessel}} = 75\% \times 41.25 \text{ vessels} \times 19 \frac{\text{hatches}}{\text{vessels}} = 588 \text{ hatches}$$

$$\text{Total Swept Hatches}_{\text{U.S. Fleet: Class IX - X Vessel}} = 75\% \times 13.75 \text{ vessels} \times 28 \frac{\text{hatches}}{\text{vessels}} = 289 \text{ hatches}$$

$$\text{Total Swept Hatches}_{\text{Total U.S. Fleet}} = 588 \text{ hatches} + 289 \text{ hatches} = 877 \text{ hatches}$$

A similar calculation was completed for the Canadian fleet:

$$\text{Total Swept Hatches}_{\text{Canadian Fleet: Class V - VIII Vessel}} = 75\% \times 70 \text{ vessels} \times 19 \frac{\text{hatches}}{\text{vessels}} = 998 \text{ hatches}$$

To calculate the total U.S. and Canadian labor times to collect deck DCR, the total number of hatches calculated above is multiplied by the time required for the crew to collect DCR at those hatches. As discussed above, 75 percent of the trips are expected to include DCR in concentrated areas that would require collection in this alternative:

$$\text{Total U.S. Fleet Time} = 75\% \times 60 \frac{\text{trips}}{\text{yr}} \times 0.083 \frac{\text{hrs}}{\text{crew - hatch - trip}} \times 877 \text{ hatches} \times 4 \text{ crew} = 13{,}103 \, {}^{\text{hrs}}\!/\!_{\text{yr}}$$

$$\text{Total Canadian Fleet Time} = 75\% \times 45 \frac{\text{trips}}{\text{yr}} \times 0.083 \frac{\text{hrs}}{\text{crew - hatch - trip}} \times 998 \text{ hatches} \times 4 \text{ crew} = 11{,}183 \, {}^{\text{hrs}}\!/\!_{\text{yr}}$$

Finally, the total number of crew are converted to total U.S. and Canadian labor costs to collect deck DCR by multiplying the total fleet labor demands by the labor rate. These costs are for the entire Great Lakes shipping industry, not for individual vessels:

$$\text{Total U.S. Fleet Labor Costs} = 13{,}103 \frac{\text{hrs}}{\text{yr}} \times \frac{\$27}{\text{hr}} = \$353{,}781\!/\!_{\text{yr}}$$

$$\text{Total Canadian Fleet Labor Costs} = 11{,}183 \frac{\text{hrs}}{\text{yr}} \times \frac{\$27}{\text{hr}} = \$301{,}941\!/\!_{\text{yr}}$$

$$\text{Total Great Lakes Fleet Labor Costs} = \$353{,}781 + \$301{,}941 = \$655{,}722\!/\!_{\text{yr}}$$

4.3 Options under Minimization for Unloading Operations

During unloading operations, DCR was observed to be generated in the vessel tunnel and on the vessel deck. Although the majority of the DCR was observed to be generated in the vessel tunnel, DCR discharges must be minimized from both locations by collecting concentrated areas of DCR in the vessel tunnel and on the vessel deck. DCR generated on the deck was observed under the unloading boom or directly adjacent to it, and DCR in the tunnel was observed along the length of the tunnel at cargo hold gates and at conveyor belt transfer locations. To develop cost estimates for this alternative, the following assumptions were made for minimizing DCR discharges from the vessel tunnel and deck during unloading operations.

Minimizing DCR discharges is assumed to be accomplished by manually collecting concentrated areas of DCR, by washing parts of the tunnel where DCR is the most concentrated (such as sections where cargo hold gate operation is completed, transfer belt areas in the vessel tunnel, pinch belt elevator) and pumping the DCR and washwater onto the unloading conveyor belt for offloading to the shoreside facility. Larger DCR that cannot be pumped would be manually collected and placed on the unloading conveyor belt. These operations would be completed toward the end of the unloading operations to minimize DCR discharges and to prevent the vessel from being delayed in port. Because only portions of the tunnel could be washed during unloading (to prevent interfering with cargo hold gate operations), the concentrated areas of DCR in the portion of the tunnel not yet washed would be shoveled and placed on the unloading conveyor belt. Then, while the vessel is in transit, the crew would wash down the remaining portion of tunnel and discharge the washwater overboard with tunnel sump pumps (pumps in the vessel tunnel that discharge water and DCR overboard), similar to the vessels' observed operation. During the washdown, any DCR retained on the sump grating (screens that prevent DCR from entering the sump pumps) would be shoveled onto the conveyor belt for offloading at the next shoreside facility.

Minimizing DCR discharges on the vessel deck would include collecting concentrated areas of DCR. DCR could be collected with a shovel and offloaded to the shoreside facility or stored on the vessel for disposal at the next shoreside facility.

To prevent the vessel from being delayed while in port to collect DCR, the vessel could mobilize additional crew to collect DCR, and DCR could be collected on the deck and in the tunnel simultaneously. As discussed above, the remaining DCR not collected during the unloading operations could be collected while the vessel is in transit, as part of the vessels' observed operation.

Cost estimates for this alternative are completed separately for loading and unloading operations. Cost estimates for loading operations to minimize DCR discharges are summarized below.

4.3.1 Lower-Range Cost

The details of the example lower-range cost estimate to achieve the objectives of this alternative are summarized below. The cost estimate includes specific assumptions that describe a possible scenario to achieve the objectives of this alternative. The assumptions are necessary to estimate a cost for this alternative, but as discussed above, the assumptions are not a requirement of the alternative.

Capital and Operations and Maintenance Costs

Some vessels and unloading operations were observed to minimize DCR discharges during unloading by washing portions of the tunnel, utilizing existing crew to collect DCR, maintaining control measures to proactively prevent DCR, or other methods that meet the objectives of this alternative. Similarly, some vessels were observed to dispose DCR to the shoreside facility without incurring additional costs. Because some unloading operations were able to minimize DCR discharges, this alternative assumes operations currently practiced by some could be practiced by all. Therefore, DCR would be collected by the existing crew during existing unloading operations and would not require additional cost.

4.3.2 Cost Estimates Based on 2008 and 2009 Vessel Records

As discussed above, the 2008 and 2009 vessel records were evaluated to estimate the annual number of trips and vessels for the U.S. and Canadian vessels during this recent period of record, and for a period when there was a decrease in demand for shipped commodities. Using an average of 41 trips per year for 47 U.S. vessels and 32 trips per year for 63 Canadian vessels, the cost estimates of this alternative are the following:

Higher-Range Cost Estimate Based on Vessel Records

Capital Costs:

$$\text{Total U.S Fleet Plumbing Mod. Capital Cost} = \$23{,}388/\text{vessels} \times 50\% \times 47 \text{ vessels} = \$549{,}618$$

$$\text{Total U.S Fleet Sump Grating Capital Cost} = \$1{,}080/\text{grate} \times 3 \text{ grates}/\text{vessel} \times 47 \text{ vessels} = \$152{,}280$$

$$\text{Total U.S. Fleet Capital Cost of Alternative} = \$549{,}618 + \$152{,}280 = \$701{,}898$$

Operations and Maintenance Costs:

$$\text{Total U.S. Fleet Time} = 75\% \times 41 \frac{\text{trips}}{\text{yr}} \times 47 \text{ vessels} \times 0.083 \frac{\text{hrs}}{\text{crew - hatch - trip}} \times 1 \frac{\text{crew}}{\text{vessel}} \times 2 \text{ hatches} = 240\ \text{hrs}/\text{yr}$$

$$\text{Total Canadian Fleet Time} = 75\% \times 32 \frac{\text{trips}}{\text{yr}} \times 63 \text{ vessels} \times 0.083 \frac{\text{hrs}}{\text{crew - hatch - trip}} \times 1 \frac{\text{crew}}{\text{vessel}} \times 2 \text{ hatches} = 251\ \text{hrs}/\text{yr}$$

$$\text{Total U.S. Fleet Labor Cost} = 240 \frac{\text{hrs}}{\text{yr}} \times \frac{\$27}{\text{hr}} = \$6{,}480/\text{yr}$$

$$\text{Total Canadian Fleet Labor Cost} = 251 \frac{\text{hrs}}{\text{yr}} \times \frac{\$27}{\text{hr}} = \$6{,}777/\text{yr}$$

$$\text{Total Great Lakes Fleet Labor Cost} = \$6{,}480 + \$6{,}777 = \$13{,}257/\text{yr}$$

$$\text{Total U.S. Fleet Time} = 75\% \times 41 \frac{\text{trips}}{\text{yr}} \times 47 \text{ vessels} \times 0.33 \frac{\text{hrs}}{\text{crew - trip}} \times 2 \frac{\text{crew}}{\text{vessel}} = 954\ \text{hrs}/\text{yr}$$

$$\text{Total U.S. Fleet Labor Cost} = 954 \frac{\text{hrs}}{\text{yr}} \times \frac{\$27}{\text{hr}} = \$25{,}758/\text{yr}$$

$$\text{Total U.S. Fleet DCR Disposal Volume} = 75\% \times 41 \frac{\text{trips}}{\text{vessel - yr}} \times 47 \text{ vessels} \times 3.5 \frac{\text{cu ft DCR}}{\text{trip}} = 5{,}058 \frac{\text{cu ft DCR}}{\text{yr}}$$

$$\text{Total U.S. Fleet DCR Disposal Cost} = 5{,}058 \frac{\text{cu ft DCR}}{\text{yr}} \times \frac{\$12}{\text{cu ft DCR}} = \$60{,}696/\text{yr}$$

$$\text{Total U.S. Fleet Operations and Maintenance Costs} = \$92{,}934/\text{yr}$$

$$\text{Total Canadian Fleet Operations and Maintenance Costs} = \$6{,}777/\text{yr}$$

$$\text{Total Great Lakes Fleet Operations and Maintenance Costs} = \$99{,}711/\text{yr}$$

Lower-Range Cost Estimate Based on Vessel Records

Capital and Operations and Maintenance Costs:

None.

4.3.3 Higher-Range Cost

The details of the example higher-range cost estimate to achieve the objectives of this alternative are summarized below. The cost estimate includes specific assumptions that describe a possible scenario to achieve the objectives of this alternative. The assumptions are necessary to estimate a cost for this alternative, but as discussed above, the assumptions are not a requirement of the alternative.

Capital Costs

In order to meet the requirements of this alternative, collection or prevention of concentrated areas of DCR in the tunnel resulting from unloading operations would be necessary. A possible operational scenario was developed (not a requirement) that vessel owner/operators may use for accomplishing this minimization requirement. The cost estimate is based on observations and discussions with vessel owner/operators The scenario, as described below, is not a requirement of this alternative, but it represents an approach that can be used for minimizing DCR discharges during unloading operations. The scenario used for cost estimating consists of modifying the sump pump plumbing in the vessel tunnel to allow the sump pumps to pump washwater and DCR slurry onto the unloading conveyor belt. The actual sump pumps would remain unchanged, but the discharge piping from the tunnel pumps would be modified to allow discharge on the conveyor belt. It was assumed that only the U.S. fleet would be making this modification because as discussed above, foreign vessels could delay tunnel washdown until they were outside of U.S. waters. Based on the observation program and communication with the shipping industry, several vessels in the U.S. fleet already have the plumbing modification (to allow tunnel washwater to discharge onto the unloading conveyor belt) and/or practice other methods (e.g., shoveling) to minimize DCR discharges from the tunnel (Peterson, 2009). Of the 24 vessels observed during the observation program (CH2M HILL, 2009), approximately half had the plumbing modification. One of the U.S. fleet operators confirmed that at least half of their fleet had (or are scheduled to have) the plumbing modification (Peterson, 2009).

The capital costs for this scenario represent plumbing modification to the remaining U.S. vessels. For cost estimating proposes, 50 percent of the U.S. fleet was assumed to need the plumbing modification. The plumbing modification cost was estimated in the Phase I Final EIS alternatives cost estimate, and it was refined with material quantities specific for this scenario. Table 1 summarizes the modifications that were made to the Phase I Final EIS cost estimate. This estimate assumes that there are three tunnel sump pumps in each vessel that would be modified, and it includes materials, labor, and equipment costs.

TABLE 1
Plumbing Modification Cost Estimate as Compared to Phase I Final EIS (Cost per Modified Vessel)

			Phase I		Phase II	
Line Item	Unit	Unit Cost	Quantity	Cost Estimate	Quantity	Cost Estimate

Tunnel (Near Cargo Hold Gates)						
4-inch flanged steel pipe	LF	141	150	$21,141	50	$7,048
90-degree elbows	EA	523	12	$6,277	6	$3,138
4-inch gate valves	EA	2,703	4	$10,812	2	$5,406
Tunnel (Near Transfer Conveyors, Pinch Belt, Cargo Elevators, etc.)						
4-inch flanged steel pipe	LF	141	100	$14,094	25	$3,524
90-degree elbows	EA	523	6	$3,139	3	$1,569
4-inch gate valves	EA	2,703	2	$5,406	1	$2,703
Total				**$60,869**		**$23,388**

1. All costs in 2009 PPI using unit costs obtained from Reed Construction Data 2007.
2. Extended costs differ because the unit costs were rounded to the nearest dollar.

The costs in Table 1 were converted from the Phase I Final EIS (CCI 8045) to 2009 PPI. Replacement costs were not included because the plumbing modifications are expected to have a service life in excess of 20 years, which is a common design life expectancy for this type of equipment.

The following calculations were completed to estimate the capital expenditure by the U.S. fleet for making the plumbing modification. The vessel cost was multiplied by the total number of vessels requiring the plumbing modification:

$$\text{Total U.S Fleet Plumbing Mod. Capital Cost} = \$23{,}388 / \text{vessels} \times 50\% \times 55 \text{ vessels} = \$643{,}170$$

Most vessels were observed to have grating over the sump pumps to protect the tunnel pumps from larger DCR, but the grating was typically in poor condition or had large openings that would not allow DCR to be retained on the grating and collected (i.e., minimized). Therefore, in this scenario, each vessel was assumed to need three new gratings for three sump pump locations. To be consistent with grating material observed in the vessels' tunnels, the grating was assumed to be ¼-inch metal, 4 feet by 4 feet. Material costs were estimated to be $450 for each grate (McMaster, 2009), where installation and markups used during the Phase I Final EIS resulted in a total cost of $1,080 for each grate. Replacement costs were not included because the grating is expected to have a service life in excess of 20 years, which is a common design life expectancy for this type of equipment.

$$\text{Total U.S Fleet Sump Grating Capital Cost} = \$1{,}080 / \text{grate} \times 3 \text{ grates} / \text{vessel} \times 55 \text{ vessels} = \$178{,}200$$

The total U.S. fleet capital cost to replace the sump grating and the tunnel sump pumps is calculated by adding the two above costs:

$$\text{Total U.S. Fleet Capital Cost of Alternative} = \$643{,}170 + \$178{,}200 = \$821{,}370$$

Operations and Maintenance Cost

Deck: During the direct observations, it was observed that deck DCR generated during unloading was concentrated primarily under or adjacent to the unloading conveyor boom, in an area equivalent to about two hatches. These areas did not have concentrated DCR over the entire area, but this alternative would require crew to collect the concentrated areas. For this alternative, the vessel would mobilize one additional crewmember for 5 minutes (0.083 hour) per hatch, for an area equivalent to two hatches to collect deck DCR, which is also consistent with the direct observations. To estimate the operations and maintenance cost for minimizing deck DCR discharges for this alternative, the following calculations were completed:

First, the total U.S. and Canadian labor times to collect deck DCR were calculated using the trip frequency requiring DCR collection, the number of trips and vessels, and the time and area required to collect the DCR, as discussed above:

$$\text{Total U.S. Fleet Time} = 75\% \times 60\,\frac{\text{trips}}{\text{yr}} \times 55\text{ vessels} \times 0.083\,\frac{\text{hrs}}{\text{crew - hatch - trip}} \times 1\,\frac{\text{crew}}{\text{vessel}} \times 2\text{ hatches} = 411\,{}^{\text{hrs}}\!/_{\text{yr}}$$

$$\text{Total Canadian Fleet Time} = 75\% \times 45\,\frac{\text{trips}}{\text{yr}} \times 70\text{ vessels} \times 0.083\,\frac{\text{hrs}}{\text{crew - hatch - trip}} \times 1\,\frac{\text{crew}}{\text{vessel}} \times 2\text{ hatches} = 393\,{}^{\text{hrs}}\!/_{\text{yr}}$$

Next, the labor costs for collecting deck DCR are calculated by multiplying the labor times by the hourly labor costs:

$$\text{Total U.S. Fleet Labor Cost} = 411\frac{\text{hrs}}{\text{yr}} \times \frac{\$27}{\text{hr}} = {}^{\$11{,}097}\!/_{\text{yr}}$$

$$\text{Total Canadian Fleet Labor Cost} = 393\frac{\text{hrs}}{\text{yr}} \times \frac{\$27}{\text{hr}} = {}^{\$10{,}611}\!/_{\text{yr}}$$

$$\text{Total Great Lakes Fleet Labor Cost} = \$11{,}097 + \$10{,}611 = {}^{\$21{,}708}\!/_{\text{yr}}$$

Tunnel: During the observations program, vessel crews were observed washing portions of the tunnel towards the end of the unloading operation. Washing the tunnel during unloading allowed some DCR to be collected and unloaded with the cargo, and it allowed the crew to minimize DCR discharges from the tunnel. To estimate the cost of this alternative, this observed operation was assumed to be implemented by the U.S. vessels (but was not applied to Canadian vessels because tunnel discharges could be delayed to areas within Canadian waters).

Based on the direct observations, towards the end of the unloading, the vessel would mobilize two additional crewmembers for 20 minutes (0.33 hour) each (40 minutes total) to wash down portions of the tunnel where DCR is the most concentrated and where washdown would not interfere with unloading operations. For the portions of the tunnel that are not washed during unloading, these areas would be washed and DCR collected and placed on the unloading conveyor belt while the vessel is underway, similar to existing tunnel washdown operations (no additional time for washing the remaining portion of tunnel would be needed for this cost estimate because this is part of the industry's current practice). To estimate the operations and maintenance cost for minimizing tunnel DCR for this alternative, the following calculations were completed:

First, the total U.S. fleet labor times to minimize tunnel DCR discharges were calculated using the trip frequency requiring tunnel washdown, the number of trips and vessels, and the time required to wash down portions of the tunnel, as discussed above:

$$\text{Total U.S. Fleet Time} = 75\% \times 60\ \frac{\text{trips}}{\text{yr}} \times 55\ \text{vessels} \times 0.33\ \frac{\text{hrs}}{\text{crew - trip}} \times 2\ \frac{\text{crew}}{\text{vessel}} = 1{,}634\ \text{hrs}/\text{yr}$$

Next, the labor costs are calculated by multiplying the labor times by the hourly labor costs:

$$\text{Total U.S. Fleet Labor Cost} = 1{,}634\ \frac{\text{hrs}}{\text{yr}} \times \frac{\$27}{\text{hr}} = \$44{,}118/\text{yr}$$

Because portions of the tunnel will be washed while the vessel is underway, tunnel DCR could be retained on the sump pump grating. This DCR would be shoveled from the grating onto the unloading conveyor belt for disposal at the next shoreside facility. While some facilities were observed to accept the DCR for no cost, it is assumed that there is a cost for the DCR disposal. Based on the median tunnel DCR volume from all of the unloading observations completed during the observations program, 3.5 cubic feet of tunnel DCR would be offloaded and landfilled at the shoreside facility. The direct observations showed that about 25 percent of the total tunnel DCR is retained on the sump pump grating and requires disposal. Using a disposal cost of $12 per cubic foot (Reed Construction Data, 2006; 2009 PPI; average of typical construction debris (steel, concrete, and masonry)) the following calculations were completed to estimate the operations and maintenance cost for disposing of the tunnel DCR.

First, the total U.S. fleet DCR volume for disposal was calculated using the trip frequency requiring tunnel disposal, the number of trips and vessels, and the disposal volume, as discussed above:

$$\text{Total U.S. Fleet DCR Disposal Volume} = 75\% \times 60\ \frac{\text{trips}}{\text{vessel - yr}} \times 55\ \text{vessels} \times 3.5\ \frac{\text{cu ft DCR}}{\text{trip}} = 8{,}663\ \frac{\text{cu ft DCR}}{\text{yr}}$$

Next, the total U.S. fleet cost to dispose of the tunnel DCR was calculated by multiplying the total disposal volume by the disposal cost:

$$\text{Total U.S. Fleet DCR Disposal Cost} = 8{,}663\frac{\text{cu ft DCR}}{\text{yr}} \times \frac{\$12}{\text{cu ft DCR}} = \$103{,}956/\text{yr}$$

Adding the above costs, the total U.S. and Canadian fleet operations and maintenance cost of this alternative are $159,171 and $10,611, respectively. The total Great Lakes fleet operations and maintenance cost of this alternative is $169,782.

5. Prescriptive Requirement for Baseline Control Measures Cost Estimate

This alternative would require that all vessels and shoreside loading facilities have the control measures described below, or their equivalent, and maintain them so that they operate as designed to control DCR discharges. Observations of dry cargo loading and unloading operations revealed a number of common measures that if implemented, operated, and maintained properly, were effective at controlling DCR discharges (CH2M HILL, 2009). Through observations, review of DCR reporting forms, and interviews with vessel and shoreside facility personnel, a list of measures that met the criteria of effectiveness and presence throughout the industry was developed (Table 2). These baseline control measures or their equivalent were present for each cargo type, vessel, and shoreside facility.

TABLE 2
Baseline Control Measures

Control Measure	Coal	Taconite	Limestone
Shoreside Loading Facility			
Troughed conveyor	X	X	X
Skirting	X	X	X
Belt scrapers	X	X	X
Water/mist	X	—	X
Stop conveyor	X	X	X
Communications	X	X	X
Crew training	X	X	X
Loading chute	X	—	—
Vessel			
Troughed conveyor	X	X	X
Skirting	X	X	X
Belt scrapers	X	X	X
Water/mist	X	X	X
Capacity indicators	X	X	X
Communications	X	X	X
Crew training	X	X	X
Broom and shovel	X	X	X
Cargo hold vibrators	X	—	X
Careful gate operation	X	X	X

X, control measure required; —, control measure not required.

Because all of the vessels and facilities have the baseline control measures (or their equivalents), there are no capital costs associated with the installation and implementation of the baseline control measures. Similarly, replacement of the baseline control measures would be considered current baseline operations and would require no additional costs. This alternative differs from the No Action alternative in that the vessels and shoreside facilities must keep the control measures they currently have (or equivalent) and provide additional maintenance and training to allow the control measures (structural and operational) to function as they were designed and intended.

This alternative assumes that all shoreside loading facilities conform to specific industry rules and regulations (facilities have necessary equipment to meet regulatory requirements for shipping food products, explosion protection, etc).

5.1 Loading Operations

Shoreside loading facilities that maintain and implement the baseline control measures were observed to generate significantly less DCR than facilities that did not (CH2M HILL, 2009). The costs for providing a level of DCR control equivalent to maintaining and implementing the baseline control measures could be calculated by either estimating the facility costs to prevent the DCR, or by the vessel crew time to collect the DCR generated by improperly maintained or implemented control measures. To maintain consistency with the cost estimates of other alternatives, this cost estimate assumes that the DCR is collected by the vessel crew (i.e., facility costs are not estimated), although the cost of this alternative would likely be shared between the vessels and the shoreside facilities, as discussed above. Increased maintenance or improved operation of the shoreside loading facility control measures could reduce the time required by vessels to collect the DCR, which would reduce the cost of this alternative to the vessel and possibly to the entire Great Lakes shipping industry.

Because this alternative has estimated a cost for the vessels, and because the observations program demonstrated that properly maintained and implemented baseline control measures can minimize DCR discharges, the cost estimates for this alternative would have the same assumptions and numerical values as the Minimize DCR Discharges alternative. The cost estimates for this alternative (and the Minimize DCR Discharges alternative) are summarized below.

5.1.1 Higher-Range Cost

The estimated costs to the total U.S. and Canadian fleet are $353,781 per year and $301,941 per year, respectively, in operations and maintenance costs. The estimated cost to the entire Great Lakes fleet is $655,722 per year.

5.1.2 Lower-Range Cost

The estimated costs to the total U.S. and Canadian fleet are $6,831 per year and $6,507 per year, respectively, in operations and maintenance costs. The estimated cost to the entire Great Lakes fleet is $13,338 per year.

5.1.3 Cost Estimates Based on 2008 and 2009 Vessel Records

As discussed above, the 2008 and 2009 vessel records were evaluated to estimate the annual number of trips and vessels for the U.S. and Canadian vessels during this recent period of record, and for a period when there was a decrease in demand for shipped commodities. Using an average of 41 trips per year for 47 U.S. vessels and 32 trips per year for 63 Canadian vessels, the cost estimates of this alternative are the following:

Higher-Range Cost Estimate Based on Vessel Records

Capital Costs:

None.

Operations and Maintenance Costs:

$$\text{Total U.S. Fleet Operations and Maintenance Costs} = \$206{,}469 \big/ \text{yr}$$

$$\text{Total Canadian Fleet Operations and Maintenance Costs} = \$193{,}185 \big/ \text{yr}$$

$$\text{Total Great Lakes Fleet Operations and Maintenance Costs} = \$399{,}654 \big/ \text{yr}$$

Lower-Range Cost Estimate Based on Vessel Records

Capital Costs:

None.

Operations and Maintenance Costs:

$$\text{Total U.S. Fleet Operations and Maintenance Costs} = \$3{,}969 \big/ \text{yr}$$

$$\text{Total Canadian Fleet Operations and Maintenance Costs} = \$4{,}158 \big/ \text{yr}$$

$$\text{Total Great Lakes Fleet Operations and Maintenance Costs} = \$8{,}127 \big/ \text{yr}$$

5.2 Unloading Operation

The unloading operation of this alternative assumes all vessels currently have all baseline control measures or equivalent methods of DCR control and that all baseline control measures equipment and procedures are functioning as designed to control DCR discharges. Each vessel was observed to perform some maintenance of vessel control measures, but this alternative includes only the additional costs for increased maintenance of the existing control measures. Some DCR would still need to be collected because control measures like belt scrapers often only concentrate DCR in the tunnel, but do not eliminate DCR. This estimate assumes that the DCR remaining would be collected throughout the unloading operations using existing vessel operations, because it was observed that for vessels with properly maintained and implemented control measures, crews required less time to collect DCR than for vessels on which control measures were not maintained or implemented as designed to control DCR.

5.2.1 Higher-Range Cost

The details of the example higher-range cost estimate to achieve the objectives of this alternative are summarized below. The cost estimate includes specific assumptions that describe a possible scenario to achieve the objectives of this alternative. The assumptions are necessary to estimate a cost for this alternative, but as discussed above, the assumptions are not a requirement of the alternative.

Capital Costs

There are no additional capital costs for this alternative.

Operations and Maintenance Cost

The vessels observed during the observation program required additional maintenance to allow the control measures to function as they were designed. Based on the observations, this alternative consists of an additional 4 hours for two crew members per month (8 hours total per month) of increased vessel control measure maintenance. Because the typical shipping season occurs between April and December, this cost was applied over a 9-month period, when additional maintenance would be completed. The labor rate used in this estimate was taken as the average fully burdened labor costs of the maintenance crewmember ($31 per hour) and the Able Seaman/Deckhand ($27 per hour), which is $29 per hour, because the observations program saw both types of crew performing maintenance. Because some deck DCR can be generated during unloading, this cost estimate alternative includes Canadian vessels. This cost estimate, however, assumes a smaller number of hours for maintenance and training for the Canadian vessels, to reduce only the deck DCR during unloading. The observations revealed that about 10 percent of the total unloading DCR is generated on the deck, and therefore it is assumed that 10 percent of the time burden will be required for maintenance and training for the Canadian crews. To estimate the operations and maintenance cost for this alternative, the following calculations were completed:

First, the maintenance time burdens to the U.S and Canadian fleets were calculated:

$$\text{Total U.S. Fleet Maint. Burden} = 4\,\frac{\text{hrs}}{\text{month - crew}} \times 2\text{ crew} \times 55\text{ vessels} \times 9\,\frac{\text{months}}{\text{yr}} = 3{,}960\ {}^{\text{hrs}}\!/_{\text{yr}}$$

$$\text{Total Canadian Fleet Maint. Burden} = \left(10\% \times 4\,\frac{\text{hrs}}{\text{month - crew}}\right) \times 2\text{ crew} \times 70\text{ vessels} \times 9\,\frac{\text{months}}{\text{yr}} = 504\ {}^{\text{hrs}}\!/_{\text{yr}}$$

Next, to calculate the maintenance cost to the total U.S. and Canadian fleets, the maintenance time burdens are multiplied by the hourly labor cost:

$$\text{Total U.S. Fleet Maintenance Cost} = 3{,}960\,\frac{\text{hrs}}{\text{yr}} \times \frac{\$29}{\text{hr}} = {}^{\$114{,}840}\!/_{\text{yr}}$$

$$\text{Total Canadian Fleet Maintenance Cost} = 504\,\frac{\text{hrs}}{\text{yr}} \times \frac{\$29}{\text{hr}} = {}^{\$14{,}616}\!/_{\text{yr}}$$

$$\text{Total Great Lakes Fleet Maintenance Cost} = {}^{\$114{,}840}\!/_{\text{yr}} + {}^{\$14{,}616}\!/_{\text{yr}} = {}^{\$129{,}456}\!/_{\text{yr}}$$

In addition to increased control measure maintenance, this cost estimate includes 4 hours of refresher training for 6 crew members once every season because the observations program observed some crew members that were less skilled than others operating and maintaining the control measures. The training estimate duration, frequency, and crew size were based on the direct observations and professional judgment. As discussed above, Canadian vessels are assumed to require 10 percent of the labor hours compared to U.S. vessels. To estimate the operations and maintenance cost for this alternative, the following calculations were completed:

First, the training time burden to the U.S. and Canadian fleet was calculated, where the Canadian fleet required less training because there is less deck DCR (as discussed above):

$$\text{Total U.S. Fleet Training Burden} = 4\,\frac{\text{hrs}}{\text{session - crew}} \times 6\ \text{crew} \times 55\ \text{vessels} \times 1\,\frac{\text{session}}{\text{yr}} = 1{,}320\ \text{hrs}/\text{yr}$$

$$\text{Total Canadian Feet Training Burden} = \left(10\% \times 4\,\frac{\text{hrs}}{\text{session - crew}}\right) \times 6\ \text{crew} \times 70\ \text{vessels} \times 1\,\frac{\text{session}}{\text{yr}} = 168\ \text{hrs}/\text{yr}$$

Next, to calculate the training cost to the total U.S. and Canadian fleets, the training time burdens are multiplied by the hourly labor cost:

$$\text{Total U.S. Fleet Training Cost} = 1{,}320\,\frac{\text{hrs}}{\text{yr}} \times \frac{\$29}{\text{hr}} = \$38{,}280/\text{yr}$$

$$\text{Total Canadian Fleet Training Cost} = 168\,\frac{\text{hrs}}{\text{yr}} \times \frac{\$29}{\text{hr}} = \$4{,}872/\text{yr}$$

$$\text{Total Great Lakes Fleet Training Cost} = \$38{,}280/\text{yr} + \$4{,}872/\text{yr} = \$43{,}152/\text{yr}$$

The estimated unloading operations cost to the total U.S. and Canadian fleet are $153,120 per year and $19,488 per year, respectively. The estimated unloading operations cost to the entire Great Lakes fleet for this alternative is $172,608 per year.

5.2.2 Lower-Range Cost

The details of the example lower-range cost estimate to achieve the objectives of this alternative are summarized below. The cost estimate includes specific assumptions that describe a possible scenario to achieve the objectives of this alternative. The assumptions are necessary to estimate a cost for this alternative, but as discussed above, the assumptions are not a requirement of the alternative.

Capital Costs

There are no additional capital costs for this alternative.

Operations and Maintenance Cost

This cost estimate is the same as the higher-range cost estimate except that 1 hour of increased vessel control measure maintenance was assumed for one crew member per month. This reduced amount of maintenance time was observed during the observation program for some vessels that needed only a short time of additional maintenance to allow control measures to function as they were intended. Because some vessels were observed to require this lesser amount of additional maintenance, this cost estimate assumes that all the vessels need only this lesser amount, to estimate a lower-range cost. This cost estimate uses the same 9-month shipping season and average maintenance crew labor rate of $29 per hour. To estimate the operations and maintenance cost for this alternative, the following calculations were completed:

First, the maintenance time burdens to the U.S and Canadian fleets were calculated:

$$\text{Total U.S. Fleet Maint. Burden} = 1\,\frac{\text{hr}}{\text{month - crew}} \times 1\text{ crew} \times 55\text{ vessels} \times 9\,\frac{\text{months}}{\text{yr}} = 495\,{}^{\text{hrs}}\!/_{\text{yr}}$$

$$\text{Total Canadian Fleet Maint. Burden} = \left(10\% \times 1\,\frac{\text{hr}}{\text{month - crew}}\right) \times 1\text{ crew} \times 70\text{ vessels} \times 9\,\frac{\text{months}}{\text{yr}} = 63\,{}^{\text{hrs}}\!/_{\text{yr}}$$

Next, to calculate the maintenance costs to the total U.S. and Canadian fleets, the maintenance time burdens are multiplied by the hourly labor cost:

$$\text{Total U.S. Fleet Maintenance Cost} = 495\,\frac{\text{hrs}}{\text{yr}} \times \frac{\$29}{\text{hr}} = {}^{\$14{,}355}\!/_{\text{yr}}$$

$$\text{Total Canadian Fleet Maintenance Cost} = 63\,\frac{\text{hrs}}{\text{yr}} \times \frac{\$29}{\text{hr}} = {}^{\$1{,}827}\!/_{\text{yr}}$$

$$\text{Total Great Lakes Fleet Maintenance Cost} = {}^{\$14{,}355}\!/_{\text{yr}} + {}^{\$1{,}827}\!/_{\text{yr}} = {}^{\$16{,}182}\!/_{\text{yr}}$$

In addition to increased control measure maintenance, this cost estimate includes 1 hour of refresher training for 6 crew members once every season because during the observations program some crew members less skilled than others were observed operating and maintaining the control measures. To estimate the operations and maintenance cost for this alternative, the following calculations were completed:

First, the training time burdens to the U.S. and Canadian fleets were calculated, where the Canadian fleet required less training because there is less deck DCR (as discussed above):

$$\text{Total U.S. Fleet Training Burden} = 1\,\frac{\text{hr}}{\text{session - crew}} \times 6\text{ crew} \times 55\text{ vessels} \times 1\,\frac{\text{session}}{\text{yr}} = 330\,{}^{\text{hrs}}\!/_{\text{yr}}$$

$$\text{Total Canadian Fleet Training Burden} = \left(10\% \times 1\,\frac{\text{hr}}{\text{session - crew}}\right) \times 6\text{ crew} \times 70\text{ vessels} \times 1\,\frac{\text{session}}{\text{yr}} = 42\,{}^{\text{hrs}}\!/_{\text{yr}}$$

Next, to calculate the training cost to the total U.S. and Canadian fleets, the training time burdens are multiplied by the hourly labor cost:

$$\text{Total U.S. Fleet Training Cost} = 330\,\frac{\text{hrs}}{\text{yr}} \times \frac{\$29}{\text{hr}} = {}^{\$9{,}570}\!/_{\text{yr}}$$

$$\text{Total Canadian Fleet Training Cost} = 42\,\frac{\text{hrs}}{\text{yr}} \times \frac{\$29}{\text{hr}} = {}^{\$1{,}218}\!/_{\text{yr}}$$

$$\text{Total Great Lakes Fleet Training Cost} = {}^{\$9{,}570}\!/_{\text{yr}} + {}^{\$1{,}218}\!/_{\text{yr}} = {}^{\$10{,}788}\!/_{\text{yr}}$$

The estimated unloading operations costs to the total U.S. and Canadian fleets are $23,925 per year and $3,045 per year, respectively. The estimated unloading operations cost for the entire Great Lakes fleet for this alternative is $26,970 per year.

5.2.3 Cost Estimates Based on 2008 and 2009 Vessel Records

As discussed above, the 2008 and 2009 vessel records were evaluated to estimate the annual number of trips and vessels for the U.S. and Canadian vessels during this recent period of record, and for a period when there was a decrease in demand for shipped commodities.

Using an average of 41 trips per year for 47 U.S. vessels and 32 trips per year for 63 Canadian vessels, the cost estimates of this alternative are the following:

Higher-Range Cost Estimate Based on Vessel Records

Capital Costs:

None.

Operations and Maintenance Costs:

$$\text{Total U.S. Fleet Maint. Burden} = 4\ \frac{\text{hrs}}{\text{month - crew}} \times 2\ \text{crew} \times 47\ \text{vessels} \times 9\ \frac{\text{months}}{\text{yr}} = 3{,}384\ \text{hrs}/\text{yr}$$

$$\text{Total Canadian Fleet Maint. Burden} = \left(10\% \times 4\ \frac{\text{hrs}}{\text{month - crew}}\right) \times 2\ \text{crew} \times 63\ \text{vessels} \times 9\ \frac{\text{months}}{\text{yr}} = 454\ \text{hrs}/\text{yr}$$

$$\text{Total U.S. Fleet Maintenance Cost} = 3{,}384\frac{\text{hrs}}{\text{yr}} \times \frac{\$29}{\text{hr}} = \$98{,}136/\text{yr}$$

$$\text{Total Canadian Fleet Maintenance Cost} = 454\frac{\text{hrs}}{\text{yr}} \times \frac{\$29}{\text{hr}} = \$13{,}166/\text{yr}$$

$$\text{Total Great Lakes Fleet Maintenance Cost} = \$98{,}136/\text{yr} + \$13{,}166/\text{yr} = \$111{,}302/\text{yr}$$

$$\text{Total U.S. Fleet Training Burden} = 4\ \frac{\text{hrs}}{\text{session - crew}} \times 6\ \text{crew} \times 47\ \text{vessels} \times 1\frac{\text{session}}{\text{yr}} = 1{,}128\ \text{hrs}/\text{yr}$$

$$\text{Total Canadian Feet Training Burden} = \left(10\% \times 4\ \frac{\text{hrs}}{\text{session - crew}}\right) \times 6\ \text{crew} \times 63\ \text{vessels} \times 1\frac{\text{session}}{\text{yr}} = 151\ \text{hrs}/\text{yr}$$

$$\text{Total U.S. Fleet Training Cost} = 1{,}128\frac{\text{hrs}}{\text{yr}} \times \frac{\$29}{\text{hr}} = \$32{,}712/\text{yr}$$

$$\text{Total Canadian Fleet Training Cost} = 151\frac{\text{hrs}}{\text{yr}} \times \frac{\$29}{\text{hr}} = \$4{,}379/\text{yr}$$

$$\text{Total Great Lakes Fleet Training Cost} = \$32{,}712/\text{yr} + \$4{,}379/\text{yr} = \$37{,}091/\text{yr}$$

$$\text{Total U.S. Fleet Operations and Maintenance Costs} = \$130{,}848/\text{yr}$$

$$\text{Total Canadian Fleet Operations and Maintenance Costs} = \$17{,}545/\text{yr}$$

$$\text{Total Great Lakes Fleet Operations and Maintenance Costs} = \$148{,}393/\text{yr}$$

Lower-Range Cost Estimate Based on Vessel Records

Capital Costs:

None.

Operations and Maintenance Costs:

$$\text{Total U.S. Fleet Maint. Burden} = 1\,\frac{\text{hr}}{\text{month - crew}} \times 1\text{ crew} \times 47\text{ vessels} \times 9\,\frac{\text{months}}{\text{yr}} = 423\,{}^{\text{hrs}}\!/_{\text{yr}}$$

$$\text{Total Canadian Fleet Maint. Burden} = \left(10\% \times 1\,\frac{\text{hr}}{\text{month - crew}}\right) \times 1\text{ crew} \times 63\text{ vessels} \times 9\,\frac{\text{months}}{\text{yr}} = 57\,{}^{\text{hrs}}\!/_{\text{yr}}$$

$$\text{Total U.S. Fleet Maintenance Cost} = 423\,\frac{\text{hrs}}{\text{yr}} \times \frac{\$29}{\text{hr}} = {}^{\$12{,}267}\!/_{\text{yr}}$$

$$\text{Total Canadian Fleet Maintenance Cost} = 57\,\frac{\text{hrs}}{\text{yr}} \times \frac{\$29}{\text{hr}} = {}^{\$1{,}653}\!/_{\text{yr}}$$

$$\text{Total Great Lakes Fleet Maintenance Cost} = {}^{\$12{,}267}\!/_{\text{yr}} + {}^{\$1{,}653}\!/_{\text{yr}} = {}^{\$13{,}920}\!/_{\text{yr}}$$

$$\text{Total U.S. Fleet Training Burden} = 1\,\frac{\text{hr}}{\text{session - crew}} \times 6\text{ crew} \times 47\text{ vessels} \times 1\,\frac{\text{session}}{\text{yr}} = 282\,{}^{\text{hrs}}\!/_{\text{yr}}$$

$$\text{Total Canadian Fleet Training Burden} = \left(10\% \times 1\,\frac{\text{hr}}{\text{session - crew}}\right) \times 6\text{ crew} \times 63\text{ vessels} \times 1\,\frac{\text{session}}{\text{yr}} = 38\,{}^{\text{hrs}}\!/_{\text{yr}}$$

$$\text{Total U.S. Fleet Training Cost} = 282\,\frac{\text{hrs}}{\text{yr}} \times \frac{\$29}{\text{hr}} = {}^{\$8{,}178}\!/_{\text{yr}}$$

$$\text{Total Canadian Fleet Training Cost} = 38\,\frac{\text{hrs}}{\text{yr}} \times \frac{\$29}{\text{hr}} = {}^{\$1{,}102}\!/_{\text{yr}}$$

$$\text{Total Great Lakes Fleet Training Cost} = {}^{\$8{,}178}\!/_{\text{yr}} + {}^{\$1{,}102}\!/_{\text{yr}} = {}^{\$9{,}280}\!/_{\text{yr}}$$

$$\text{Total U.S. Fleet Operations and Maintenance Costs} = {}^{\$20{,}445}\!/_{\text{yr}}$$

$$\text{Total Canadian Fleet Operations and Maintenance Costs} = {}^{\$2{,}755}\!/_{\text{yr}}$$

$$\text{Total Great Lakes Fleet Operations and Maintenance Costs} = {}^{\$23{,}200}\!/_{\text{yr}}$$

6. Summary

A summary of the cost estimates for each alternative is shown in Table 3.

TABLE 3
Summary of Estimated Total Costs for the Entire U.S. and Canadian Bulk Dry Cargo Fleets (2009 U.S. Dollars)

	Capital Costs ($)			Operations and Maintenance Costs ($/yr)		
Alternative	U.S.	Canadian	Total	U.S.	Canadian	Total
No Action[a]	—	—	—	—	—	—
Performance Requirement to Minimize DCR						
Management Plan	24,920	14,280	39,200	—	—	—
Record Keeping Cost Savings	—	—	—	(14,603)	(13,339)	(27,942)
Broom Clean Standard (Avg)	—	—	—	33,733	28,620	62,353
Options						
Load: Higher Range	—	—	—	353,781	301,941	655,722
Unload: Higher Range	821,370	—	821,370	159,171	10,611	169,782
Total Higher Range Cost	**846,290**	**14,280**	**860,570**	**532,082**	**327,833**	**859,915**
Management Plan	24,920	14,280	39,200	—	—	—
Record Keeping Cost Savings	—	—	—	(14,603)	(13,339)	(27,942)
Broom Clean Standard (Avg)	—	—	—	33,733	28,620	62,353
Options						
Load: Lower Range	—	—	—	6,831	6,507	13,338
Unload: Lower Range	—	—	—	—	—	—
Total Lower Range Cost	**24,920**	**14,280**	**39,200**	**25,961**	**21,788**	**47,749**
	Cost Estimates Using 2008/2009 Vessel Records					
Management Plan	21,295	12,852	34,147	—	—	—
Record Keeping Cost Savings	—	—	—	(8,527)	(6,403)	(14,930)
Broom Clean Standard (Avg)	—	—	—	33,733	28,620	62,353
Options						
Load: Higher Range	—	—	—	206,469	193,185	399,654
Unload: Higher Range	701,898	—	701,898	92,934	6,777	99,711
Total Higher Range Cost	**723,193**	**12,852**	**736,045**	**324,609**	**222,179**	**546,788**
Management Plan	21,295	12,852	34,147	—	—	—
Record Keeping Cost Savings	—	—	—	(8,527)	(6,403)	(14,930)
Broom Clean Standard (Avg)	—	—	—	33,733	28,620	62,353
Options						
Load: Lower Range	—	—	—	3,969	4,158	8,127
Unload: Lower Range	—	—	—	—	—	—

TABLE 3
Summary of Estimated Total Costs for the Entire U.S. and Canadian Bulk Dry Cargo Fleets (2009 U.S. Dollars)

	Capital Costs ($)			Operations and Maintenance Costs ($/yr)		
Alternative	U.S.	Canadian	Total	U.S.	Canadian	Total
Total Lower Range Cost	**21,295**	**12,852**	**34,147**	**29,175**	**26,375**	**55,550**
Prescriptive Requirement for Baseline Control Measures						
Load: Higher Range	—	—	—	353,781	301,941	655,722
Unload: Higher Range	—	—	—	153,120	19,488	172,608
Record Keeping Cost Savings	—	—	—	(14,603)	(13,339)	(27,942)
Total Higher Range Cost	**—**	**—**	**—**	**492,298**	**308,090**	**800,388**
Load: Lower Range	—	—	—	6,831	6,507	13,338
Unload: Lower Range	—	—	—	23,925	3,045	26,970
Record Keeping Cost Savings	—	—	—	(14,603)	(13,339)	(27,942)
Total Lower Range Cost	**—**	**—**	**—**	**16,153**	**(3,787)**	**12,366**
	Cost Estimates Using 2008/2009 Vessel Records					
Load: Higher Range	—	—	—	206,469	193,185	399,654
Unload: Higher Range	—	—	—	130,848	17,545	148,393
Record Keeping Cost Savings	—	—	—	(8,527)	(6,403)	(14,930)
Total Higher Range Cost	**—**	**—**	**—**	**328,790**	**204,327**	**533,117**
Load: Lower Range	—	—	—	3,969	4,158	8,127
Unload: Lower Range	—	—	—	20,445	2,755	23,200
Record Keeping Cost Savings	—	—	—	(8,527)	(6,403)	(14,930)
Total Lower Range Cost	**—**	**—**	**—**	**15,887**	**510**	**16,397**

[a] No additional cost for this alternative because the No Action alternative is the current rule.

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Attachment A
Economic Analysis of Alternatives

The purpose of this attachment is to analyze the economic effects of each of the alternatives to make a determination on economic significance as defined in Chapter 4 of the Tiered EIS. This analysis involves comparing the detailed cost information presented in Appendix E of the Tiered EIS to the revenues earned by the waterborne dry bulk carrier industry. As explained in Appendix E, a plausible set of assumptions was made to place reasonable bounds on costs to support robust conclusions about the economic significance of impacts.

Alternative 1: No Action

The No Action alternative is a continuation of the interim rule. DCR management practices would remain the same as the current practices with some recordkeeping requirements, and no incremental costs, beyond what are currently expended, are anticipated. Thus, future conditions and impacts would be the same as those of existing DCR operations.

In the Phase I Final EIS, based on the historic average number of vessels and trips as of 2007, this alternative was found to have no impacts on the waterborne dry bulk carrier industry and other industries directly dependent on Great Lakes waterborne dry bulk shipping because the estimated economic costs would be negligible, consisting of recordkeeping by the shipping companies. In the Phase I Final EIS, the total annual cost for the U.S. Great Lakes dry bulk carrier industry (not per vessel) was estimated to be $60,000; for all Canadian vessels, $17,000; and for foreign non-Canadian vessels, $12,000. In the Tiered EIS these costs are used as current costs and implementation of No Action would not result in a change in costs.

The No Action would be a continuation of existing conditions. The cumulative effect of the No Action combined with foreseeable future actions affecting the operating costs and competitive factors for the waterborne dry bulk carrier industry and related industries is expected to be similar to, or perhaps slightly more intense than, the existing conditions, due to higher operating costs (primarily fuel) for vessels, decreased efficiencies from light loading due to shallow channel depths from lower lake levels and dredging practices, and possibly greater competition from other modes of transportation such as rail and trucking.

Alternative 2: Performance Requirement to Minimize DCR Discharges

This alternative would require that the amount of DCR discharged overboard be minimized. This would be accomplished through maintaining a “broom-clean” standard for the deck, and would require each vessel owner/operator to develop and implement a management plan that minimizes DCR discharge from the deck and tunnel. There are no specific requirements for equipment or procedures as part of this alternative as it allows the vessel owners or operators to determine the most effective and efficient way to minimize DCR on their specific vessels.

The costs to the industry of complying with this alternative were estimated and appear in Table A-1.

TABLE A-1
Summary of Estimated Total Incremental Costs for the Entire U.S. and Canadian Fleet (2009 U.S. Dollars)

	Annualized Costs[a]		
Alternative	**U.S. Fleet**	**Canadian Fleet**	**Total**
No Action	0	0	0
Minimize DCR Discharges			
High end of range	541,000	300,000	841,000
Low end of range	(6,700)	(6,200)	(12,900)
Baseline Control Measures			
High end of range	492,000	308,000	800,000
Low end of range	16,200	(3,800)	12,400

Note: Undiscounted annualized costs include amortized capital costs using straight-line depreciation assuming a useful life of capital of 20 years. High-end-of-range costs for both alternatives reflect higher end DCR volumes observed and historic number of vessels and trips. Low-end-of-range costs for both alternatives reflect lower end DCR volumes observed and historical number of vessels and trips.
[a]Rounded to the nearest thousand for five- and six-digit amounts; to nearest hundred for four-digit amounts.

Costs were estimated for a high (representing historic number of vessels and trips, and the high end of observed DCR volume) and low (representing historic number of vessels and trips, and low end of observed DCR volume) range to account for uncertainty. It is expected the costs for an alternative would most likely fall within that range. Undiscounted costs were annualized using straight-line depreciation to amortize capital costs. Annualized costs to the fleet of U.S. vessels are estimated to range from approximately $(6,700) to $541,000, and for Canadian vessels, from approximately $(6,200) to $300,000. Total costs to the Great Lakes fleet are estimated to range from $(12,900) per year to $841,000 per year.

In 2008, approximately 70 percent of the U.S. Great Lakes shipping companies generated over $470 million dollars in revenues. This information is based upon annual 10K reports for the publicly traded companies and Dun and Bradstreet Business Reports for the nonpublic companies.

One percent of these revenues is $4.7 million, and 3 percent is $14.2 million. Using the significance criteria described in Section 4.2 of the Tiered EIS indicates the range of costs to the U.S. fleet for this alternative (-$12,900 to $541,000) falls into the "no impact" category. Annual revenues can change by up to 25 percent, as reflected in the collected financial data cited in the Tiered EIS. However, even with these revenue changes the impact to the U.S. fleet would still be in the "no impact" category.

The cumulative effect of the Performance Requirement to Minimize DCR Discharges alternative combined with foreseeable future actions affecting the cost and competitive factors for the waterborne dry bulk carrier industry and related industries is expected to be similar to, or perhaps slightly more intense than, the existing conditions, due to higher operating costs (primarily fuel) for vessels, decreased efficiencies from light loading if the current trend of lower lake levels continues, and possibly greater competition from other modes of transportation such as rail and trucking.

Alternative 3: Prescriptive Requirement for Baseline Control Measures

This alternative assumes all vessels and shoreside facilities have all baseline control measures, which were determined from the direct observation program to be available for all vessels (Appendix D in the Tiered EIS), or equivalent methods of DCR control, and that all baseline control measure equipment and procedures are functioning as designed. It requires that vessels and facilities keep the control measures they currently have (or equivalent) and provide maintenance to allow the control measures (structural and operational) to function as they were designed and intended. As with the Minimize DCR Discharges alternative, this alternative would not cause a vessel delay in port, would require recordkeeping, and would maintain exclusion areas required in the interim rule.

Based on the high and low ranges of cost assumptions described above for Alternative 2, annualized costs to the fleet of U.S. vessels are estimated to range from approximately $16,200 per year to $492,000 per year. Undiscounted costs to the Canadian fleet are estimated to range from approximately $(3,800) per year to $308,000 per year. Total costs to the Great Lakes fleet are estimated to range from $12,400 per year to $800,000 per year. (See Table A-1.) Using the significance criteria described in Section 4.2 of the Tiered EIS indicates the range of costs ($16,200 to $492,000) to the U.S. fleet for this alternative falls into the "no impact" category. As previously noted, annual revenues can change by up to 25 percent as indicated by the range in financial data collected for the Tiered EIS. However, even with these revenue changes, the impact to the U.S. fleet would still be in the "no impact" range.

The cumulative effect of the Baseline Control Measures alternative combined with foreseeable future actions emphasizing the cost and competitive factors for the waterborne dry bulk carrier industry and related industries is expected to be similar to, or perhaps slightly more intense than, the existing conditions, due to higher operating costs (primarily fuel) for vessels, decreased efficiencies from light loading in response to the continued current trend of lower lake levels, and possibly greater competition from other transportation modes.

DCR Discharge Exclusion Areas Specified in the Interim Rule

PREPARED FOR: U.S. Coast Guard

PREPARED BY: CH2M HILL

DATE: November 6, 2009

In 1993, the U.S. Coast Guard's (Coast Guard) Ninth District adopted an Interim Enforcement Policy (IEP) which regulated and allowed for the discharge of non-toxic and non-hazardous dry cargo residues (DCR) to the Great Lakes. This memorandum highlights the establishment and modifications to DCR exclusion areas (areas within which DCR discharge is not permitted) over time, and areas where DCR discharge currently is prohibited.

The 1993 IEP, as with all regulations following it, sought to reasonably balance commercial requirements with necessary safeguards for Great Lakes environmental protection. The IEP provided for the discharging of DCR in defined portions of the Great Lakes that are relatively far from the shore and that avoid environmentally sensitive areas, which are generally at least 3 miles from shore. It excluded discharges from other areas. The IEP applies only to dry cargo residues, and does not alter the strict prohibition of any discharge of oily waste, untreated sewage, plastics, dunnage (packing materials), or other items commonly understood to be "garbage," from vessels on the Great Lakes. The Ninth District periodically reissued the IEP through 1997.

In 1994, the Coast Guard recognized that the general designation of exclusion areas was an initial resource protection effort and asked the National Oceanic and Atmospheric Administration (NOAA) and Great Lakes Environmental Research Laboratory (GLERL) to form an ad hoc scientific steering committee to review available information and to advise them on the environmental implications and effectiveness of the interim regulations. Part of the steering committee's action was to convene a workshop to review the IEP in general and the exclusion areas specifically (Reid and Meadows, 1999). The workshop was held in 1994 and attended by NOAA, other Great Lakes scientists, and representatives of the Great Lakes shipping industry. The committee recommended several modifications to the exclusion areas, which are summarized in the Phase I Final EIS (Section 1.6).

Beginning in 1998, Congress legislatively authorized continuation of the IEP and renewed this authorization again in 2000 and 2004. In 2004, Congress also authorized the Coast Guard to begin environmental assessment activities necessary to support new regulatory action. Environmental assessment activities were completed in 2008, prior to the expiration of the IEP, with the release of the Phase I Final EIS in August 2008.

The Phase I Final EIS predicted impacts to several designated, managed, or otherwise sensitive areas. Those impacts could be mitigated by eliminating DCR discharges within the borders of designated, managed or sensitive areas. The mitigation measures, which were incorporated to the preferred alternative, included the following, with figures drawn from various environmental documents and included following this memorandum for ease of reference:

- **Detroit River International Wildlife Refuge.** Prohibit all DCR discharges within the boundaries of the refuge (Figure 1-1, Phase I Final EIS; Figure 3-1, Tiered EIS).
- **Northern Lake Michigan Lake Trout Refuge (Northern Refuge).** Prohibit all DCR discharges within the boundaries of the refuge (Figure 1-2, Phase I Final EIS; Figure 3-1, Tiered EIS).
- **Thunder Bay National Marine Sanctuary.** Prohibit all DCR discharges within the boundaries of the sanctuary (Figure 1-3, Phase I Final EIS; Figure 3-1, Tiered EIS).
- **Isle Royale National Park.** Prohibit all DCR discharges within the boundaries of the park (Figure 1-4, Phase I Final EIS; Figure 3-1, Tiered EIS).
- **Green Bay.** Allow discharge of limestone and clean stone only for ships loading and unloading in Green Bay (Figure 1-5, Phase I Final EIS; Figure 3-1, Tiered EIS).
- **Western Basin of Lake Erie.** Allow discharge of limestone and clean stone only for ships loading and unloading in the Western Basin of Lake Erie. Retain the IEP's limited exception for coal, taconite, and salt discharges within dredged navigation channels

between Toledo Harbor Light and Detroit River Light (Figure 1-6, Phase I Final EIS; Figure 3-1, Tiered EIS).

In addition, the preferred alternative included a prohibition on DCR discharges within 3 miles of the shore of the following land-based protected areas:

- **Indiana Dunes National Lake Shore.** Lake Michigan; location H in Figure 3-1, Tiered EIS.
- **Sleeping Bear Dunes National Lakeshore.** Lake Michigan; location G in Figure 3-1, Tiered EIS.
- **Pictured Rocks Lake Shore.** Lake Superior; location E in Figure 3-1, Tiered EIS.
- **Apostle Islands National Lake Shore.** Lake Superior, location B in Figure 3-1, Tiered EIS.
- **Grand Portage National Monument.** Lake Superior.

Discharges to protected and sensitive areas would only be allowed to continue for limestone and clean stone to the Western Basin of Lake Erie and Green Bay (only ships loading and unloading within the areas); coal, taconite, and salt in the dredged channels of the Western Basin of Lake Erie; and limestone and clean stone to Green Bay in Lake Michigan. Allowed discharges in all of these areas would be limited to ships transporting dry cargo totally within the area and thus the ships cannot sweep DCR outside the area during transit.

In September 2008, the Coast Guard issued the Interim Rule for Dry Cargo Residue Discharges in the Great Lakes (interim rule), which adopted the preferred alternative identified the Phase I EIS and detailed the future management of DCR. The interim rule incorporated discharge limitations established in the IEP (2004) and added mitigation areas identified in the Phase I Final EIS. Relevant pages of the interim rule (Federal Register, September 20, 2008) which describe where DCR discharge is permitted, are provided below.

Sensitive Areas Figures

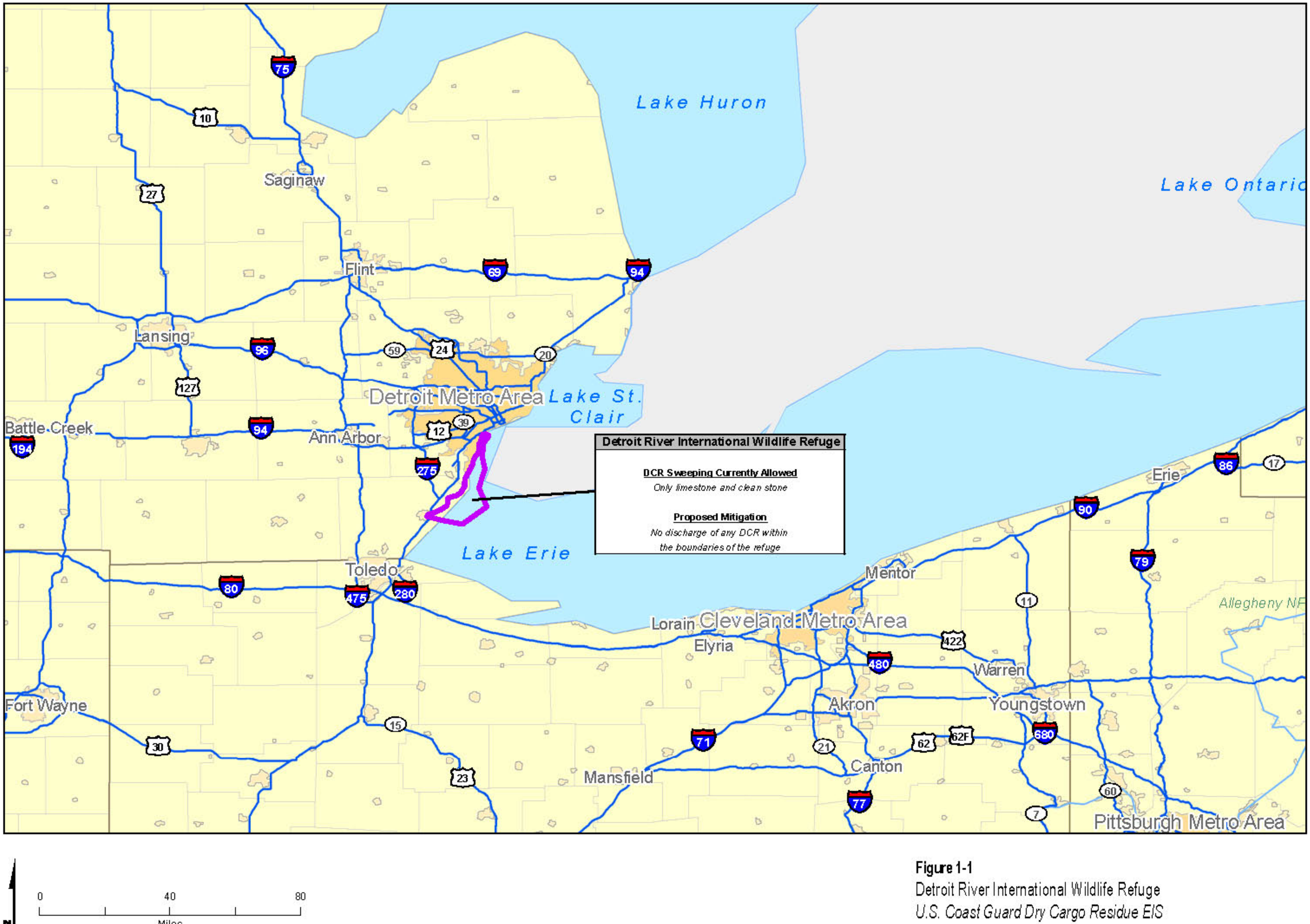

Figure 1-1
Detroit River International Wildlife Refuge
U.S. Coast Guard Dry Cargo Residue EIS

CH2MHILL

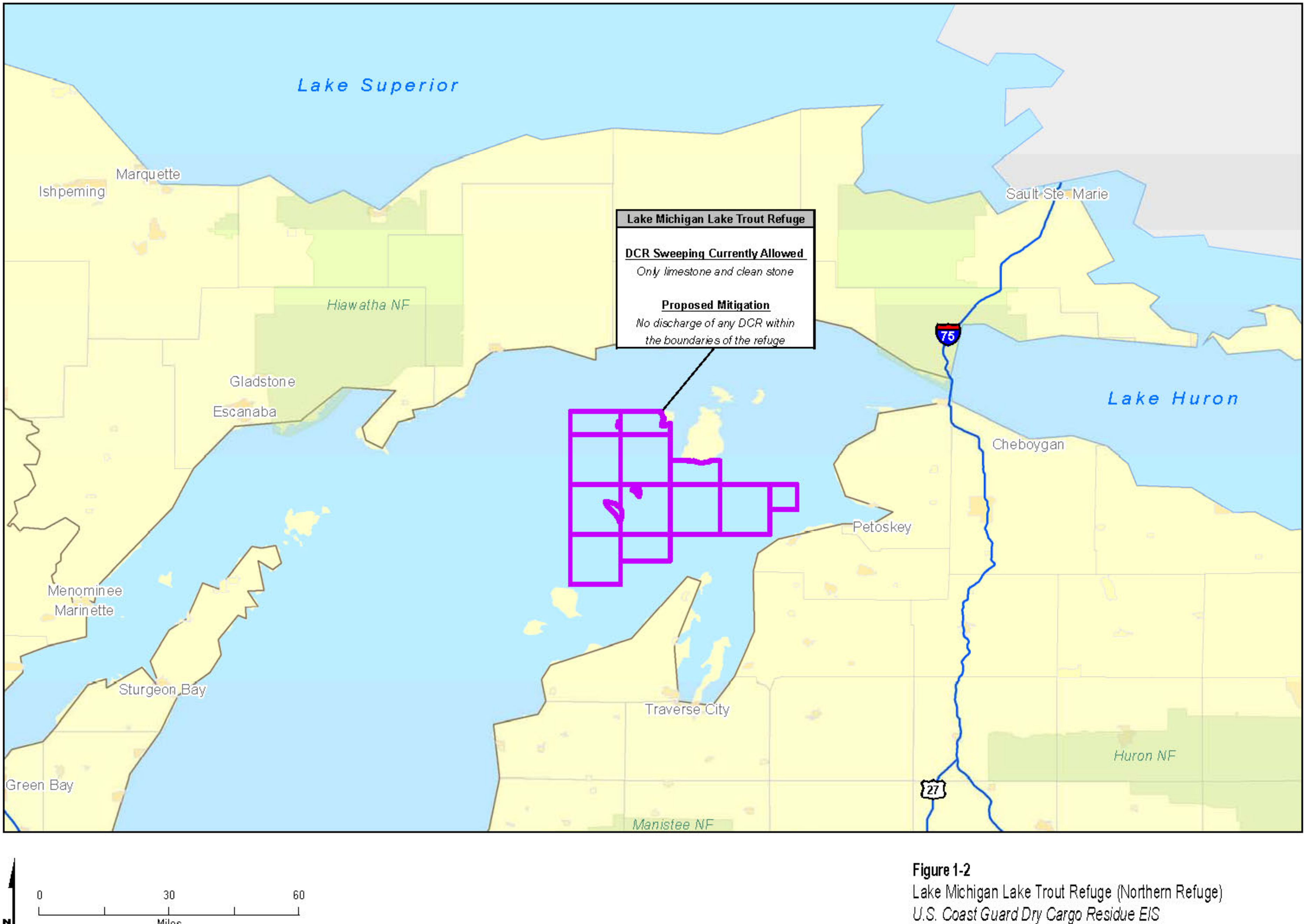

Figure 1-2
Lake Michigan Lake Trout Refuge (Northern Refuge)
U.S. Coast Guard Dry Cargo Residue EIS

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MKE \\WAVE\PROJ\GIS\USCOASTGUARD\DRYCARGOEIS\MAPFILES\FIGURE 01-04 - LAKE MICHIGAN LAKE TROUT REFUGE.MXD 8/1/2008 15:41:15

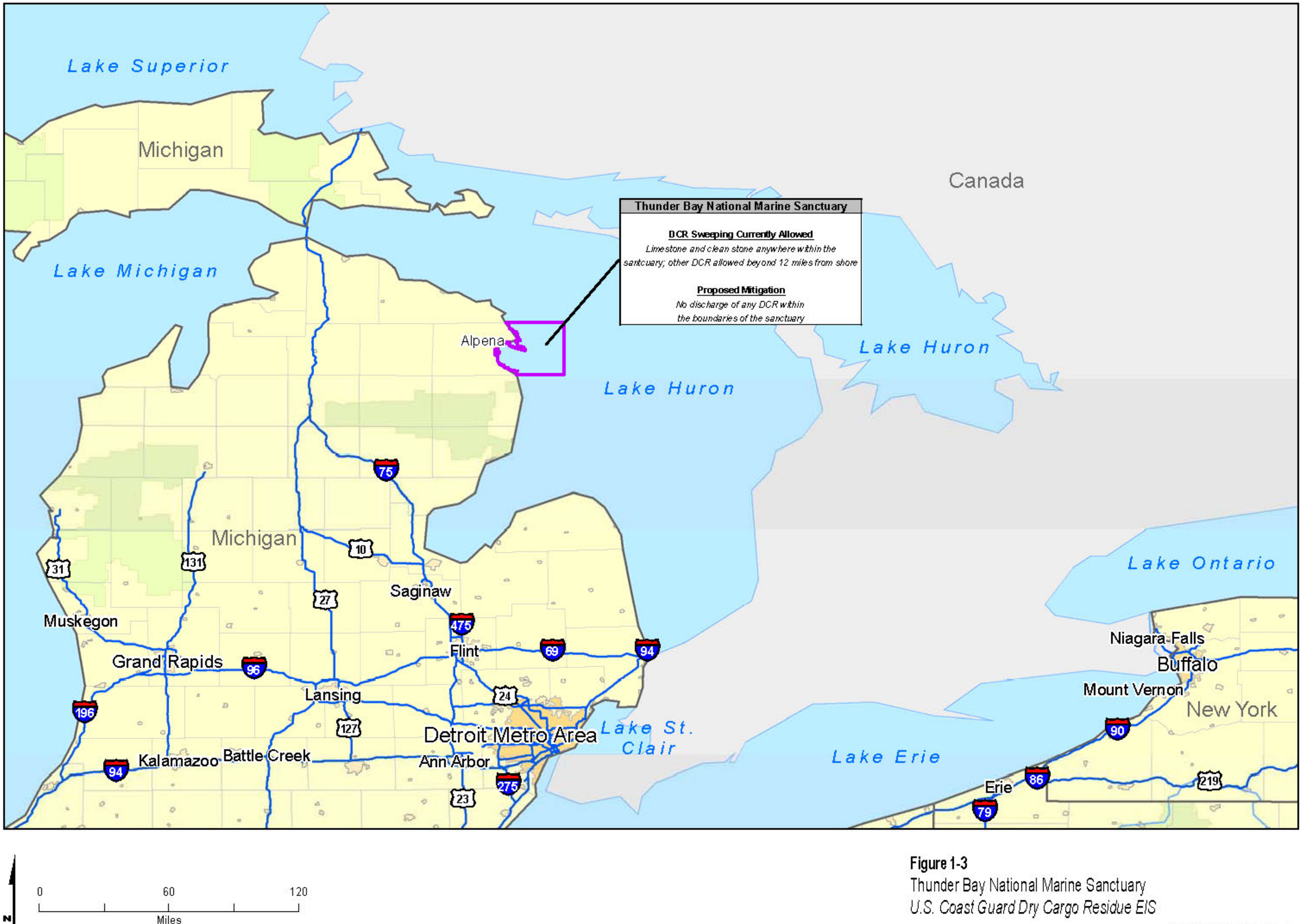

Figure 1-3
Thunder Bay National Marine Sanctuary
U.S. Coast Guard Dry Cargo Residue EIS

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MKE \\WAVE\PROJ\GIS\USCOASTGUARD\DRYCARGOEIS\MAPFILES\FIGURE 01-05 - THUNDER BAY NATIONAL MARINE SANCTUARY.MXD 7/30/2008 09:03:23

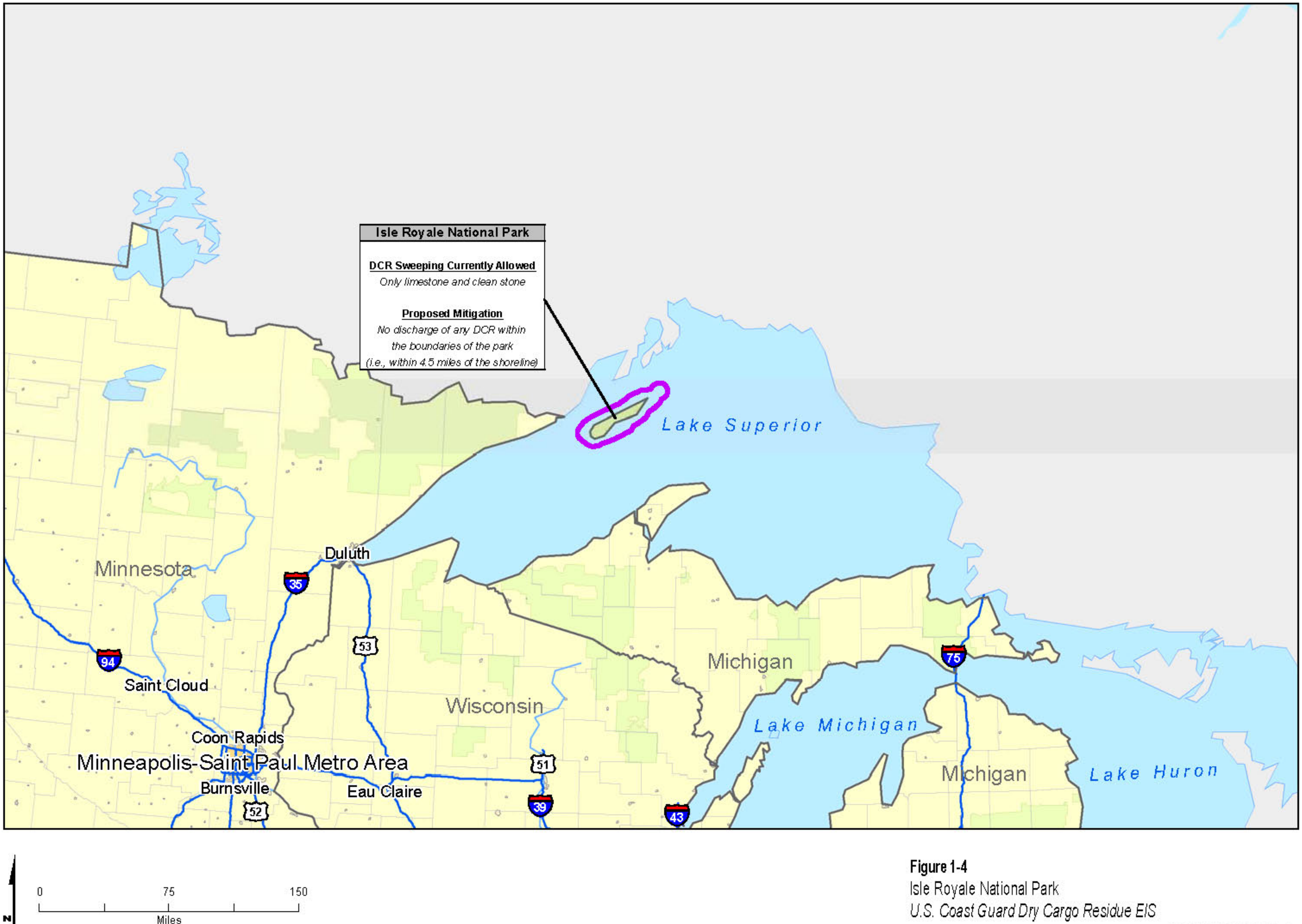

Figure 1-4
Isle Royale National Park
U.S. Coast Guard Dry Cargo Residue EIS

CH2MHILL

MKE \\WAVE\PROJ\GIS\USCOASTGUARD\DRYCARGOEIS\MAPFILES\FIGURE 01-02 - ISLE ROYALE NATIONAL PARK.MXD 7/30/2008 08:21:45

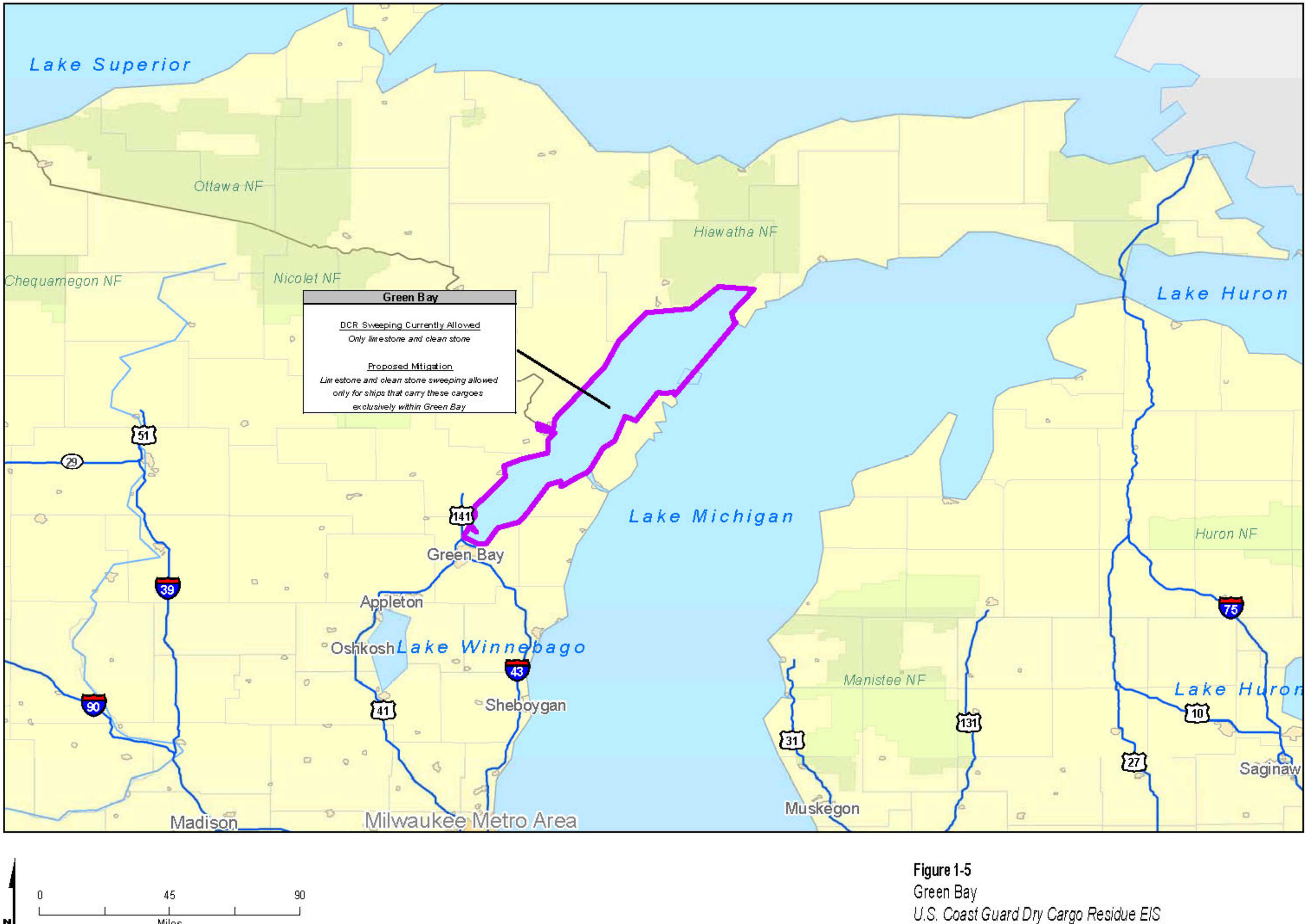

Figure 1-5
Green Bay
U.S. Coast Guard Dry Cargo Residue EIS

CH2MHILL

MKE \\WAVE\PROJ\GIS\USCOASTGUARD\DRYCARGOEIS\MAPFILES\FIGURE 01-06 - GREENBAY.MXD 7/30/2008 09:15:40

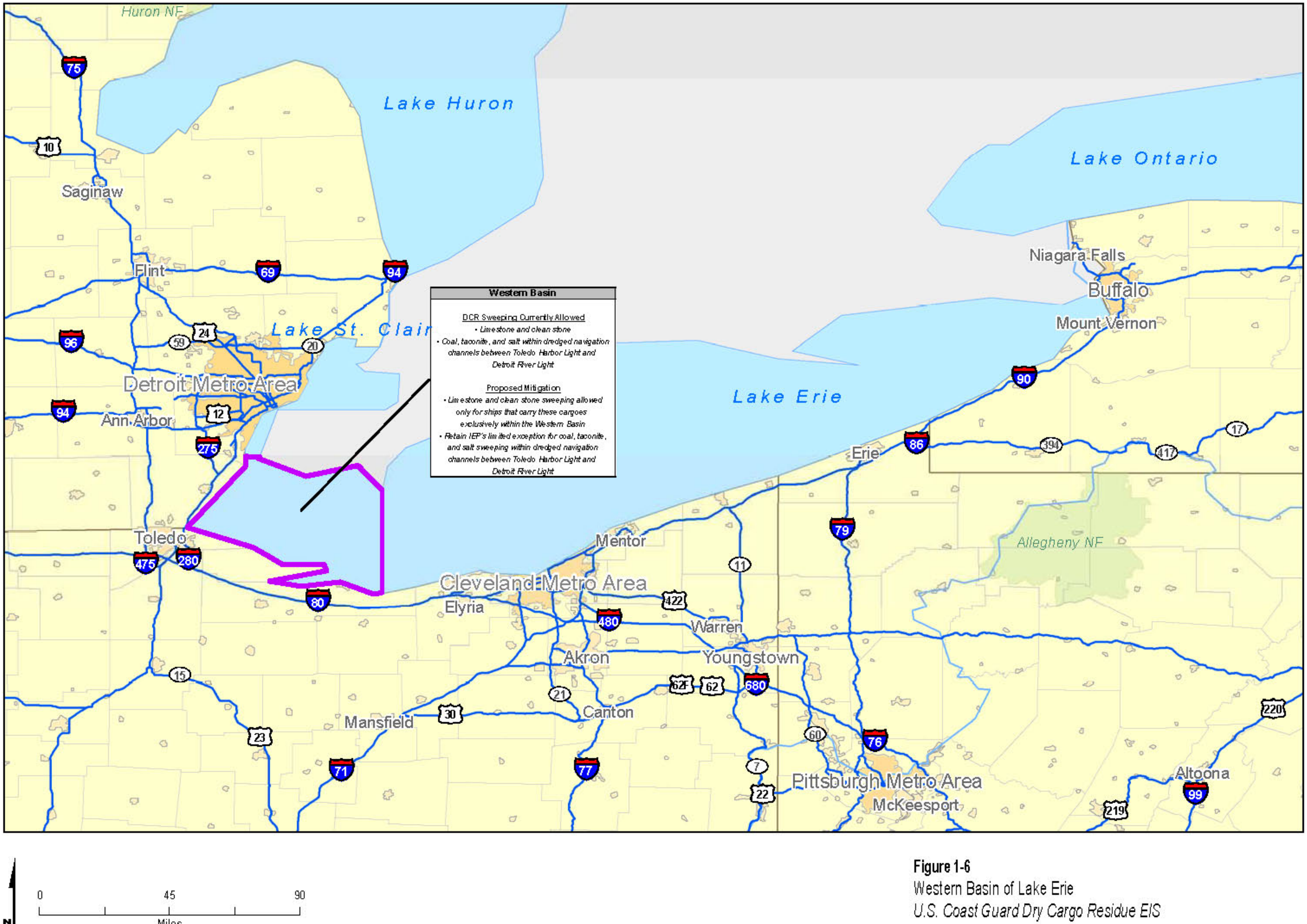

Figure 1-6
Western Basin of Lake Erie
U.S. Coast Guard Dry Cargo Residue EIS

CH2MHILL

MKE \\WAVE\PROJ\GIS\USCOASTGUARD\DRYCARGOEIS\MAPFILES\FIGURE 01-07 - WESTERN BASIN.MXD 7/30/2008 09:20:24

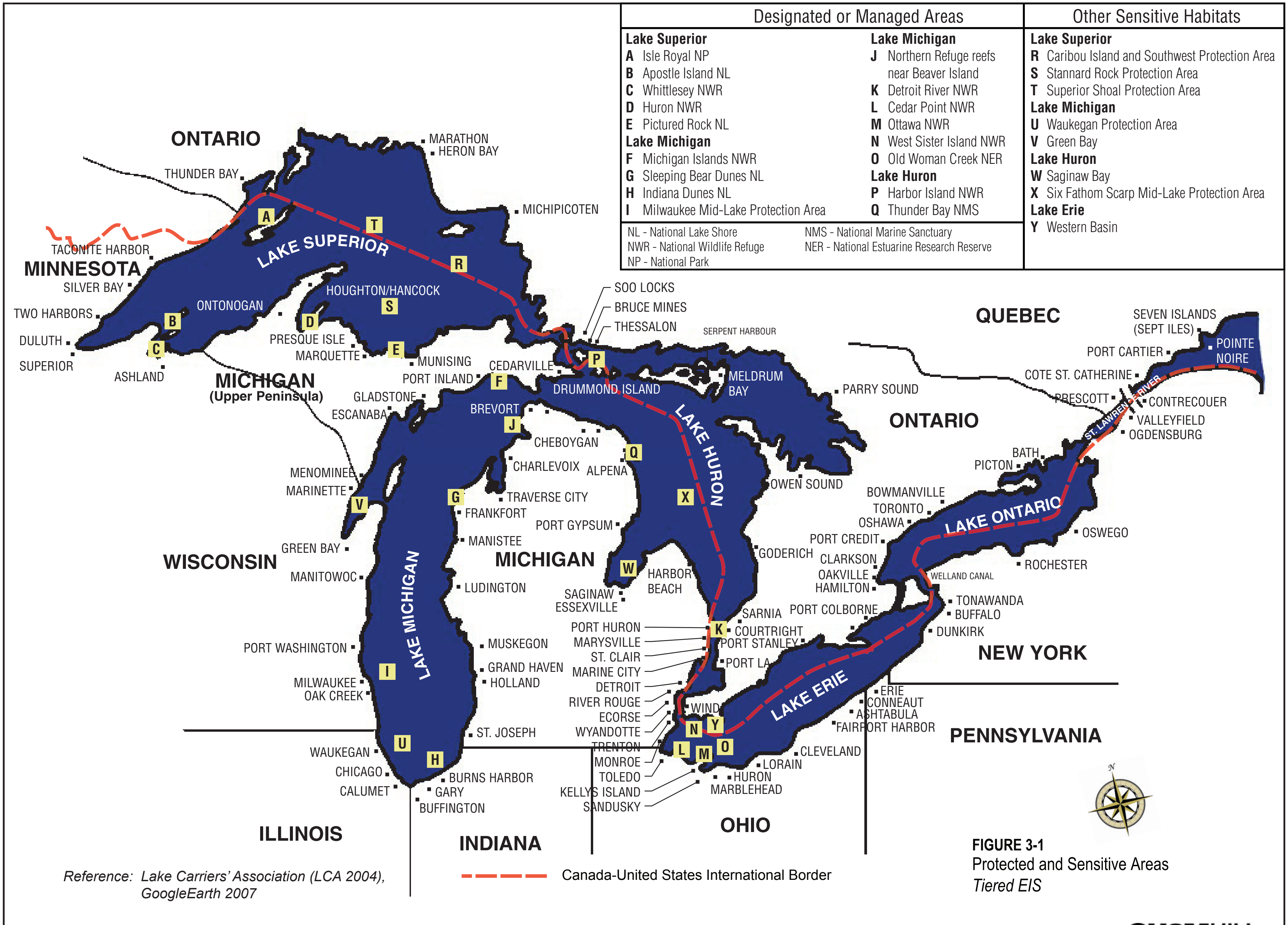

FIGURE 3-1
Protected and Sensitive Areas
Tiered EIS

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Interim Rule

List of Subjects in 33 CFR Part 151

Administrative practice and procedure, Oil pollution, Penalties, Reporting and recordkeeping requirements, Water pollution control.

■ For the reasons discussed in the preamble, the Coast Guard amends 33 CFR part 151 as follows:

PART 151—VESSELS CARRYING OIL, NOXIOUS LIQUID SUBSTANCES, GARBAGE, MUNICIPAL OR COMMERCIAL WASTE, AND BALLAST WATER

■ 1. The authority citation for part 151 is revised to read as follows:

Authority: 33 U.S.C. 1321, 1902, 1903, 1908; 46 U.S.C. 6101; Pub. L. 104–227 (110 Stat. 3034); Pub. L. 108–293 (118 Stat. 1063), § 623; E.O. 12777, 3 CFR, 1991 Comp. p. 351; DHS Delegation No. 0170.1, sec. 2(77).

Subpart A—Implementation of MARPOL 73/78 and the Protocol on Environmental Protection to the Antarctic Treaty as it pertains to Pollution From Ships

■ 2. Revise § 151.66 to read as follows:

§ 151.66 Operating requirements: Discharge of garbage in the Great Lakes and other navigable waters.

(a) Except as otherwise provided in this section, no person on board any ship may discharge garbage into the navigable waters of the United States.

(b) On the United States' waters of the Great Lakes, commercial ships, excluding non-self propelled barges that are not part of an integrated tug and barge unit, may discharge bulk dry cargo residues in accordance with this paragraph and paragraph (c) of this section. Owners and operators of ships to which these paragraphs apply are encouraged to minimize the volume of dry cargo residues discharged through the use of suitable residue control measures onboard and by loading and unloading cargo at facilities that use suitable shoreside residue control measures. As used in this paragraph and paragraph (c) of this section:

Apostle Islands National Lakeshore means the site on or near Lake Superior administered by the National Park Service, less Madeline Island, and including the Wisconsin shoreline of Bayfield Peninsula from the point of land at 46°57′19.7″ N, 90°52′51.0″ W southwest along the shoreline to a point of land at 46°52′56.4″ N, 91°3′3.1″ W.

Bulk dry cargo residues means non-hazardous and non-toxic residues of dry cargo carried in bulk, including limestone and other clean stone, iron ore, coal, salt, and cement. It does not include residues of any substance known to be toxic or hazardous, such as, nickel, copper, zinc, lead, or materials classified as hazardous in provisions of law or treaty;

Caribou Island and Southwest Bank Protection Area means the area enclosed by rhumb lines connecting the following coordinates, beginning on the northernmost point and proceeding clockwise:

47°30.0′ N	85°50.0′ W
47°24.2′ N	85°38.5′ W
47°04.0′ N	85°49.0′ W
47°05.7′ N	85°59.0′ W
47°18.1′ N	86°05.0′ W

Detroit River International Wildlife Refuge means the U.S. waters of the Detroit River bound by the area extending from the Michigan shore at the southern outlet of the Rouge River to 41°54′ N, 083°06′ W along the U.S.-Canada boundary southward and clockwise connecting points:

42°02′ N	083°08′ W
41°54′ N	083°06′ W
41°50′ N	083°10′ W
41°44.52 N	083°22′ W
41°44.19 N	083°27′ W

Grand Portage National Monument means the site on or near Lake Superior, administered by the National Park Service, from a southwest corner of the monument point of land, 47°57.521′ 89°41.245′, to the northeast corner of the monument point of land, 47°57.888′ 89°40.725′.

Indiana Dunes National Lakeshore means the site on or near Lake Michigan, administered by the National Park Service, from a point of land near Gary, Indiana at 41°42′59.4″ N 086°54′59.9″ W eastward along the shoreline to 41°37′08.8″ N 087°17′18.8″ W near Michigan City, Indiana.

Integrated tug and barge unit means any tug barge combination which, through the use of special design features or a specially designed connection system, has increased seakeeping capabilities relative to a tug and barge in the conventional pushing mode;

Isle Royale National Park means the site on or near Lake Superior, administered by the National Park Service, where the boundary includes any submerged lands within the territorial jurisdiction of the United States within four and one-half miles of the shoreline of Isle Royale and the surrounding islands, including Passage Island and Gull Island.

Mile means a statute mile, and refers to the distance from the nearest land or island;

Milwaukee Mid-Lake Special Protection Area means the area enclosed by rhumb lines connecting the following coordinates, beginning on the northernmost point and proceeding clockwise:

43°27.0′ N	87°14.0′ W
43°21.2′ N	87°02.3′ W
43°03.3′ N	87°04.8′ W
42°57.5′ N	87°21.0′ W
43°16.0′ N	87°39.8′ W

Northern Refuge means the area enclosed by rhumb lines connecting the coordinates, beginning on the northernmost point and proceeding clockwise:

45°45′ N 86°00′ W,

western shore of High Island, southern shore of Beaver Island:

45°30′ N	85°30′ W
45°30′ N	85°15′ W
45°25′ N	85°15′ W
45°25′ N	85°20′ W
45°20′ N	85°20′ W
45°20′ N	85°40′ W
45°15′ N	85°40′ W
45°15′ N	85°50′ W
45°10′ N	85°50′ W
45°10′ N	86°00′ W

Pictured Rocks National Lakeshore means the site on or near Lake Superior, administered by the National Park Service, from a point of land at 46°26′21.3″ N 086°36′43.2″ W eastward along the Michigan shoreline to 46°40′22.2″ N 085°59′58.1″ W.

Six Fathom Scarp Mid-Lake Special Protection Area means the area enclosed by rhumb lines connecting the following coordinates, beginning on the northernmost point and proceeding clockwise:

44°55′ N	82°33′ W
44°47′ N	82°18′ W
44°39′ N	82°13′ W
44°27′ N	82°13′ W
44°27′ N	82°20′ W
44°17′ N	82°25′ W
44°17′ N	82°30′ W
44°28′ N	82°40′ W
44°51′ N	82°44′ W
44°53′ N	82°44′ W
44°54′ N	82°40′ W

Sleeping Bear Dunes National Lakeshore means the site on or near Lake Michigan, administered by the National Park Service, that includes North Manitou Island, South Manitou Island and the Michigan shoreline from a point of land at 44°42′45.1″ N 086°12′18.1″ W north and eastward along the shoreline to 44°57′12.0″ N 085°48′12.8″ W.

Stannard Rock Protection Area means the area within a 6 mile radius from Stannard Rock Light, at 47°10′57″ N 87°13′34″ W;

Superior Shoal Protection Area means the area within a 6 mile radius from the center of Superior Shoal, at 48°03.2′ N 87°06.3′ W;

Thunder Bay National Marine Sanctuary means the site on or near Lake Huron designated by the National Oceanic and Atmospheric Administration as the boundary that forms an approximately rectangular area by extending along the ordinary high water mark between the northern and southern boundaries of Alpena County, cutting across the mouths of rivers and streams, and lakeward from those points along latitude lines to longitude 83 degrees west. The coordinates of the boundary are:

45°12′25.5″ N	83°23′18.6″ W
45°12′25.5″ N	83°00′00″ W
44°51′30.5″ N	83°00′00″ W
44°51′30.5″ N	83°19′17.3″ W

Waukegan Special Protection Area means the area enclosed by rhumb lines connecting the following coordinates, beginning on the northernmost point and proceeding clockwise:

42°24.3′ N	87°29.3′ W
42°13.0′ N	87°25.1′ W
42°12.2′ N	87°29.1′ W
42°18.1′ N	87°33.1′ W
42°24.1′ N	87°32.0′ W; and

Western Basin means that portion of Lake Erie west of a line due south from Point Pelee.

TABLE 151.66(b)—BULK DRY CARGO RESIDUE DISCHARGES ALLOWED ON THE GREAT LAKES

Location	Cargo	Discharge allowed except as noted
Tributaries, their connecting rivers, and St. Lawrence River.	Limestone and other clean stone	Prohibited where there is an apparent impact on wetlands, fish spawning areas, and potable water intakes.
	All other cargos	Prohibited.
Lake Ontario	Limestone and other clean stone	Prohibited where there is an apparent impact on wetlands, fish spawning areas, and potable water intakes.
	Iron ore	Prohibited within 6 miles from shore.
	All other cargos	Prohibited within 13.8 miles from shore.
Lake Erie	Limestone and other clean stone	Prohibited where there is an apparent impact on wetlands, fish spawning areas, and potable water intakes; prohibited in the Detroit River International Wildlife Refuge; prohibited in Western Basin, except that a vessel operating exclusively within Western Basin may discharge limestone or clean stone cargo residues over the dredged navigation channels between Toledo Harbor Light and Detroit River Light.
	Iron ore	Prohibited within 6 miles from shore; prohibited in the Detroit River International Wildlife Refuge; prohibited in Western Basin, except that a vessel may discharge residue over the dredged navigation channels between Toledo Harbor Light and Detroit River Light if it unloads in Toledo or Detroit and immediately thereafter loads new cargo in Toledo, Detroit, or Windsor.
	Coal, salt	Prohibited within 13.8 miles from shore; prohibited in the Detroit River International Wildlife Refuge; prohibited in Western Basin, except that a vessel may discharge residue over the dredged navigation channels between Toledo Harbor Light and Detroit River Light if it unloads in Toledo or Detroit and immediately thereafter loads new cargo in Toledo, Detroit, or Windsor.
	All other cargos	Prohibited within 13.8 miles from shore; prohibited in the Detroit River International Wildlife Refuge; prohibited in Western Basin.
Lake St. Clair	Limestone and other clean stone	Prohibited where there is an apparent impact on wetlands, fish spawning areas, and potable water intakes.
	All other cargos	Prohibited.
Lake Huron except Six Fathom Scarp Mid-Lake Special Protection Area.	Limestone and other clean stone	Prohibited where there is an apparent impact on wetlands, fish spawning areas, and potable water intakes; prohibited in the Thunder Bay National Marine Sanctuary.
	Iron ore	Prohibited within 6 miles from shore and in Saginaw Bay; prohibited in the Thunder Bay National Marine Sanctuary; prohibited for vessels up bound along the Michigan thumb as follows: (1) Between 5.8 miles northeast of entrance buoys 11 and 12 to the track line turn abeam of Harbor Beach, prohibited within 3 miles from shore; and (2) For vessels bound for Saginaw Bay only, between the track line turn abeam of Harbor Beach and 4 nautical miles northeast of Point Aux Barques Light, prohibited within 4 miles from shore and not less than 10 fathoms of depth.
	Coal, salt	Prohibited within 13.8 miles from shore and in Saginaw Bay; prohibited in the Thunder Bay National Marine Sanctuary; prohibited for vessels up bound from Alpena into ports along the Michigan shore south of Forty Mile Point within 4 miles from shore and not less than 10 fathoms of depth.
	All other cargos	Prohibited within 13.8 miles from shore and in Saginaw Bay; prohibited in the Thunder Bay National Marine Sanctuary.
Lake Michigan	Limestone and other clean stone	Prohibited where there is an apparent impact on wetlands, fish spawning areas, and potable water intakes; prohibited within the Milwaukee Mid-Lake and Waukegan Special Protection Areas; prohibited within the Northern Refuge; prohibited within 3 miles of the shore of the Indiana Dunes and Sleeping Bear National Lakeshores; prohibited within Green Bay.

TABLE 151.66(b)—BULK DRY CARGO RESIDUE DISCHARGES ALLOWED ON THE GREAT LAKES—Continued

Location	Cargo	Discharge allowed except as noted
	Iron ore	Prohibited in the Northern Refuge; north of 45° N, prohibited within 12 miles from shore and in Green Bay; south of 45° N, prohibited within 6 miles from shore, and prohibited within the Milwaukee Mid-Lake and Waukegan Special Protection Areas, in Green Bay, and within 3 miles of the shore of Indiana Dunes and Sleeping Bear National Lakeshores; except that discharges are allowed at: (1) 4.75 miles off Big Sable Point Betsie, along established Lake Carriers Association (LCA) track lines; and (2) Along 056.25° LCA track line between due east of Poverty Island to a point due south of Port Inland Light.
	Coal	Prohibited in the Northern Refuge; prohibited within 13.8 miles from shore and prohibited within the Milwaukee Mid-Lake and Waukegan Special Protection Areas, in Green Bay, and within 3 miles of the shore of Indiana Dunes and Sleeping Bear National Lakeshores; except that discharges are allowed: (1) Along 013.5° LCA track line between 45° N and Boulder Reef, and along 022.5° LCA track running 23.25 miles between Boulder Reef and the charted position of Red Buoy #2; (2) Along 037° LCA track line between 45°20′ N and 45°42′ N; (3) Along 056.25° LCA track line between points due east of Poverty Island to a point due south of Port Inland Light; and (4) At 3 miles from shore for coal carried between Manistee and Ludington along customary routes.
	Salt	Prohibited in the Northern Refuge; prohibited within 13.8 miles from shore and prohibited within the Milwaukee Mid-Lake and Waukegan Special Protection Areas, in Green Bay, and within 3 miles of the shore of Indiana Dunes and Sleeping Bear National Lakeshores, and in Green Bay.
	All other cargos	Prohibited in the Northern Refuge; prohibited within 13.8 miles from shore and prohibited within the Milwaukee Mid-Lake and Waukegan Special Protection Areas, in Green Bay, and within 3 miles of the shore of Indiana Dunes and Sleeping Bear National Lakeshores.
Lake Superior	Limestone and other clean stone	Prohibited where there is an apparent impact on wetlands, fish spawning areas, and potable water intakes; and prohibited within Isle Royal National Park and the Caribou Island and Southwest Bank, Stannard Rock, and Superior Shoal Protection Areas, and within 3 miles of the shore of the Apostle Islands and Pictured Rocks National Lakeshores or the Grand Portage National Monument.
	Iron ore	Prohibited within 6 miles from shore (within 3 miles off northwestern shore between Duluth and Grand Marais); and prohibited within Isle Royal National Park and the Caribou Island and Southwest Bank, Stannard Rock, and Superior Shoal Protection Areas, and within 3 miles of the shore of the Apostle Islands and Pictured Rocks National Lakeshores or the Grand Portage National Monument.
	Coal, salt	Prohibited within 13.8 miles from shore (within 3 miles off northwestern shore between Duluth and Grand Marais); and prohibited within Isle Royal National Park and the Caribou Island and Southwest Bank, Stannard Rock, and Superior Shoal Protection Areas, and within 3 miles of the shore of the Apostle Islands and Pictured Rocks National Lakeshores or the Grand Portage National Monument.
	Cement	Prohibited within 13.8 miles from shore (within 3 miles offshore west of a line due north from Bark Point); and prohibited within Isle Royal National Park and the Caribou Island and Southwest Bank, Stannard Rock, and Superior Shoal Protection Areas, and within 3 miles of the shore of the Apostle Islands and Pictured Rocks National Lakeshores or the Grand Portage National Monument.
	All other cargos	Prohibited within 13.8 miles from shore; and prohibited within Isle Royal National Park and the Caribou Island and Southwest Bank, Stannard Rock, and Superior Shoal Protection Areas, and within 3 miles of the shore of the Apostle Islands and Pictured Rocks National Lakeshores or the Grand Portage National Monument.

(c)(1) The master, owner, operator, or person in charge of any commercial ship loading, unloading, or discharging bulk dry cargo in the United States' waters of the Great Lakes and the master, owner, operator, or person in charge of a U.S. commercial ship transporting bulk dry cargo and operating anywhere on the Great Lakes, excluding non-self

Predicted Dry Cargo Residue Volumes of Alternatives

PREPARED FOR: U.S. Coast Guard

PREPARED BY: CH2M HILL

DATE: October 13, 2011

Introduction

This technical memorandum (TM) presents the results of predicting volumes of discharged cargo residue (DCR) under the Performance Requirement to Minimize DCR (Minimize DCR) Alternative and the Prescriptive Requirement for Baseline Control Measures (Baseline Control Measures) Alternative. It also documents the methods and assumptions used to do so. These alternatives, along with No Action, were those identified for detailed analysis after being screened in the Tiered Environmental Impact Statement (EIS). The predicted DCR volumes were those expected to be achieved under the conditions of each alternative. The alternatives do not, however, limit the amount of DCR that can be discharged during a given event. Each scenario's implied maximum DCR volume was used only to determine the environmental impact of each alternative and to aid in the selection of one alternative for a U.S. Coast Guard rule to regulate DCR.

This TM presents 12 distinct calculations: loading and unloading DCR volumes for coal, for limestone, and for taconite for each of the two action alternatives. This TM is divided into two main sections—loading and unloading—because of the different methods used to determine the DCR volumes. Vessel records from October 2008 to July 2009 were used to determine the predicted loading DCR volumes, and direct observation by CH2M HILL staff during 2009 was used to determine the predicted unloading DCR volumes. As determined in a separate, direct observations TM (CH2M HILL, 2009; included as Appendix D to the Tiered EIS), the loading DCR volumes reported on the vessel records were representative of the volumes observed directly during loading events. However, the DCR volumes generated during unloading as reported on the vessel recording forms (CG-33) were not comparable to the observed unloading events, and the completeness of the DCR quantification methods used for the vessel records was questionable (CH2M HILL, 2009).

For both the predicted loading and unloading DCR volumes, the mean and median volumes for each primary cargo (i.e., coal, limestone, and taconite) were calculated. The impacts anticipated from the implementation of the alternatives are a result of the total volume of DCR discharged over a given period, and the mean is proportional to that total volume, whereas the 50th percentile value is not; therefore, the mean, when reliable, can be useful for evaluating impacts of DCR discharges.

As a basis for comparison, the assumptions made and the values predicted for the No Action Alternative are discussed briefly in the next section. The sections afterward further describe the methods and assumptions used to estimate the predicted DCR volumes resulting from the Minimize DCR and Baseline Control Measures Alternatives.

No Action Alternative

For the No Action Alternative, the predicted loading DCR volumes were compiled from the 2008 and 2009 vessel records. Because coal, limestone, and taconite represent over 90 percent of Great Lakes bulk dry cargo, only the vessel records for those cargos were used in this evaluation (CH2M HILL, 2009).

The unloading DCR volumes were calculated from the direct observation DCR estimates from unloading events. These values were used to most accurately reflect current practices of the Great Lakes shipping industry with the available information. By definition, direct observations represent the No Action Alternative. Table 1 summarizes the predicted DCR volumes for this alternative.

TABLE 1
Predicted DCR Volumes for the No Action Alternative

	Loading Volume (ft^3)		Unloading Volume (ft^3)	
Cargo	**Median DCR**	**Mean DCR**	**Median DCR**	**Mean DCR**
Coal	3.4	11.6	41.1	48.9
Limestone	3.7	18.8	25.1	241.2
Taconite	3.0	19.3	9.3	9.3

Predicted Loading DCR Volumes

The 2008 and 2009 vessel records were used to predict the loading DCR volumes of the Minimize DCR and Baseline Control Measures Alternatives.

Cumulative volume distribution graphs (Figures 1, 2, and 3) for each cargo type were used to determine the predicted conservative (i.e., large) but realistic DCR volumes for each alternative. The graphs were constructed using the vessel record data, and the figures show that at or near the 10th and 20th percentiles of DCR volume, there are plateaus in the percentages for each cargo. Such a pattern in the cargo data records, which contain at least 300 events for each cargo type, suggests a natural divide between high and low DCR volumes. DCR events that added to the cargoes' cumulative volume total beyond the 10th and 20th percentile of total DCR volume are considered large events that occurred infrequently, compared with the rest of the reported events. Ultimately, a small number of large discharge events accounted for an overwhelming majority of the total DCR discharge volume for each cargo type. The values that indicated the threshold for high-volume discharges, identified in Figures 1 through 3 by the blue and red boxes, were selected as the maximum DCR volumes that would be expected under the conditions of the two alternatives. This would serve to target the reduction of the largest DCR discharge

TABLE 2
Maximum DCR Volumes for Each Alternative

Cargo	Minimize DCR Alternative (ft^3)	Baseline Control Measures Alternative (ft^3)
Coal	7	12.5
Limestone	10	15
Taconite	10	30

Values are used for environmental impact purposes only.

events, which would satisfy the stated goal of each alternative. The Minimize DCR Alternative was assigned the more restrictive maximum expected volume (i.e., 10th percentile volume) because the Baseline Control Measures Alternative (which, in turn, was assigned the 20th percentile volume) does not require the vessel or facility crew to reclaim any DCR generated during loading operations. Table 2 summarizes the maximum expected volumes for both alternatives.

For each alternative, values in the data set greater than the expected maximum volume were reduced to that maximum value. This assumes that the implementation of the alternative would be expected to reduce the greatest volumes down to the maximum volumes. The mean was calculated for each modified data set and served as the estimated DCR volume expected for each alternative. The median for each cargo type in the modified data set remained constant because the expected maximum volume affected only a small number of high-volume discharge events. Thus, the median was not used as the predicted DCR volume for the alternatives.

FIGURE 1
Profile of Coal DCR Discharges during Loading Events

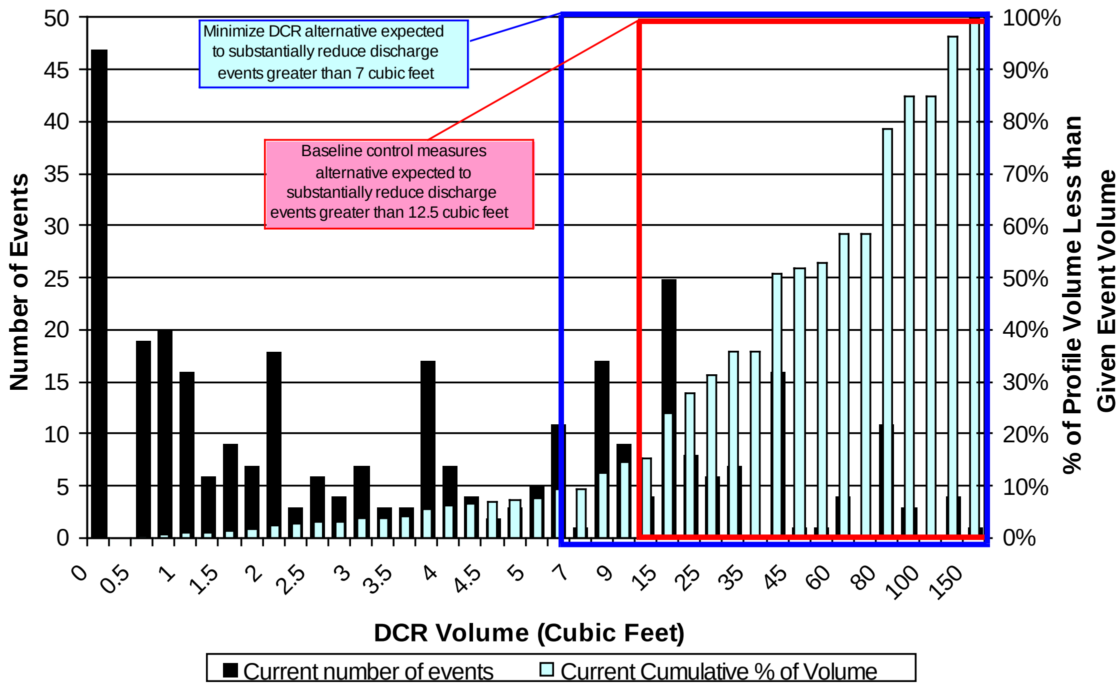


FIGURE 2
Profile of Limestone DCR Discharges during Loading Events

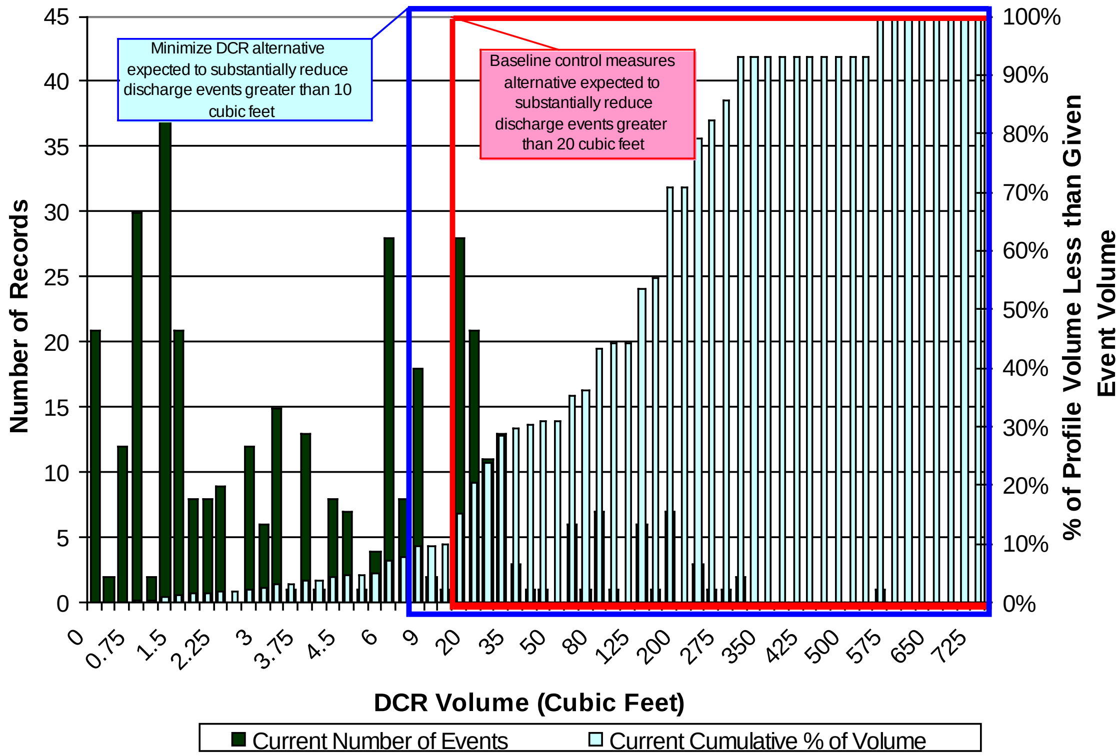
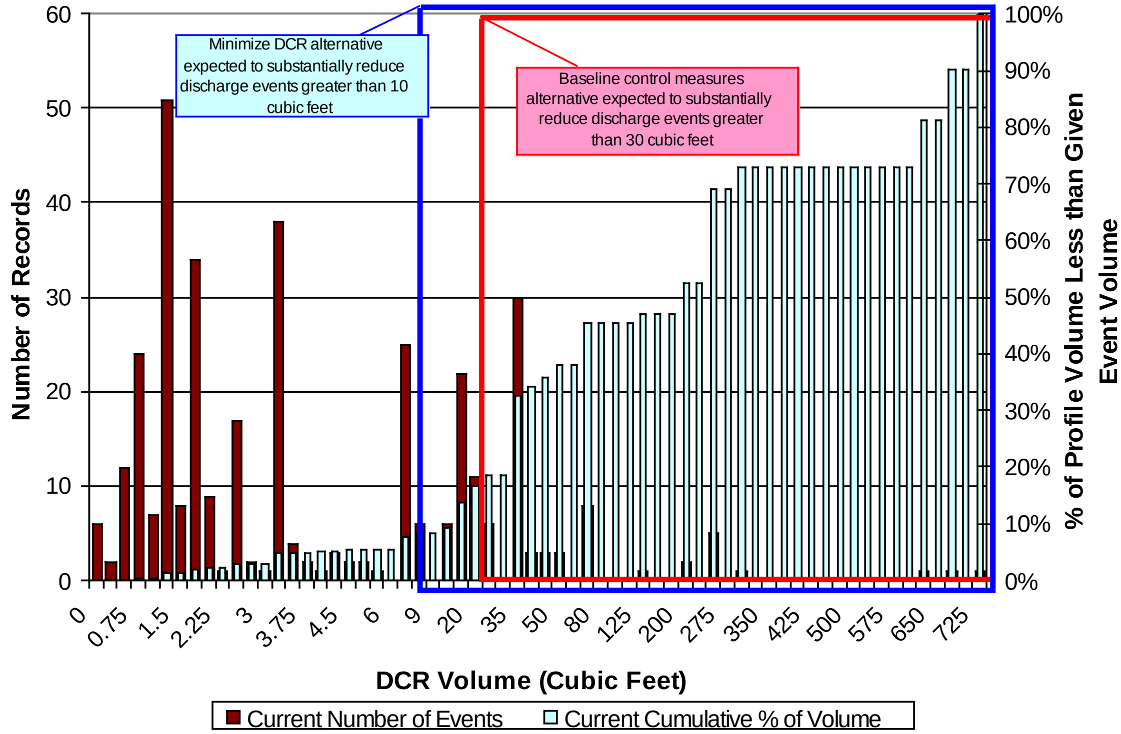


FIGURE 3
Profile of Taconite DCR Discharges during Loading Events



Minimize DCR Alternative

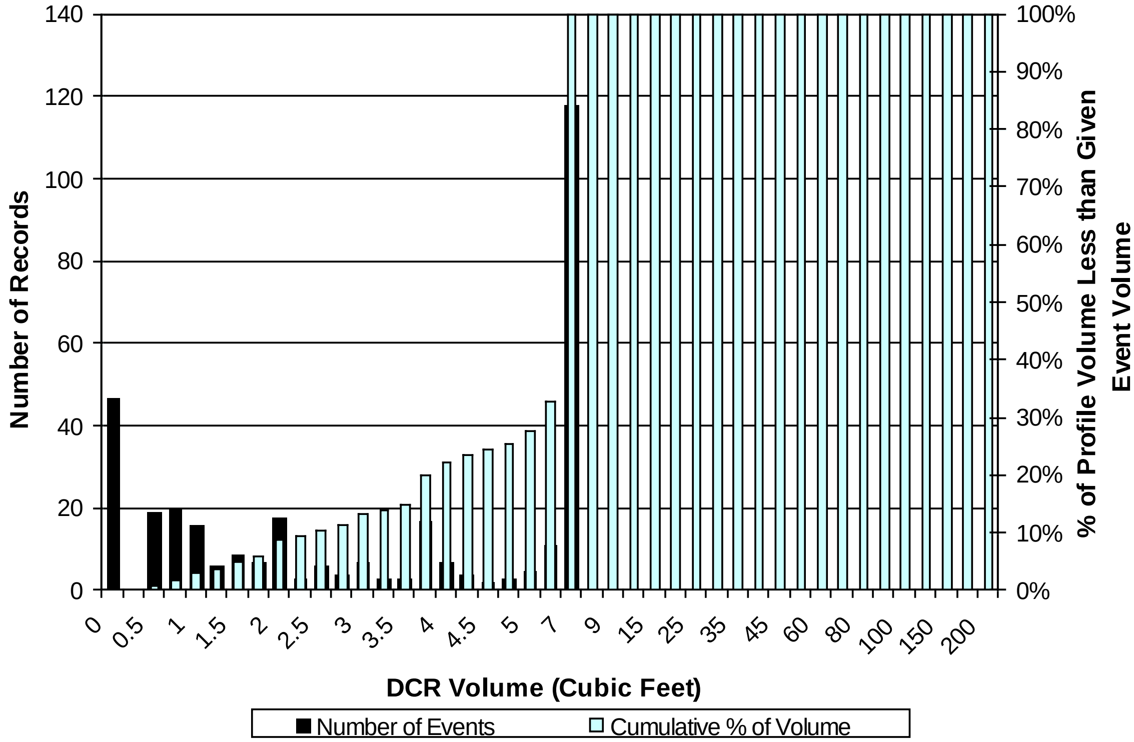
To obtain the predicted loading DCR volumes for the Minimize DCR Alternative, the vessel record volumes were adjusted with the respective values shown in Table 2.

Coal. Figure 4 shows the adjusted data with DCR values not exceeding 7 cubic feet (ft^3) (52 gallons). The mean of the adjusted data was calculated to be 3.6 ft^3. The median value before and after adjustment was 3.4 ft^3 (25 gallons). Compared with the mean of the No Action Alternative (11.6 ft^3, or 87 gallons), the mean of the Minimize DCR Alternative represents a 69 percent reduction in DCR.

Limestone. Figure 5 shows the adjusted data with DCR values not exceeding 10 ft^3 (75 gallons). The mean of the adjusted data was calculated to be 4.9 ft^3 (37 gallons). The median value before and after adjustment was 3.7 ft^3 (28 gallons). Compared with the mean of the No Action Alternative (18.8 ft^3, or 141 gallons), the mean of the Minimize DCR Alternative represents a 74 percent reduction in DCR.

Taconite. Figure 6 shows the adjusted data with DCR volumes not exceeding 10 ft^3 (75 gallons). The mean of the adjusted data was calculated to be 4.5 ft^3 (34 gallons). The median value before and after adjustment was 3.0 ft^3 (22 gallons). Compared with the mean of the No Action Alternative (19.3 ft^3, or 144 gallons), the mean of the Minimize DCR Alternative represents a 77 percent reduction in DCR.

FIGURE 4
Profile of Coal DCR Discharge during Loading Events if Minimize DCR Alternative Is Employed



105

FIGURE 5
Profile of Limestone DCR Discharge during Loading Events if Minimize DCR Alternative Is Employed

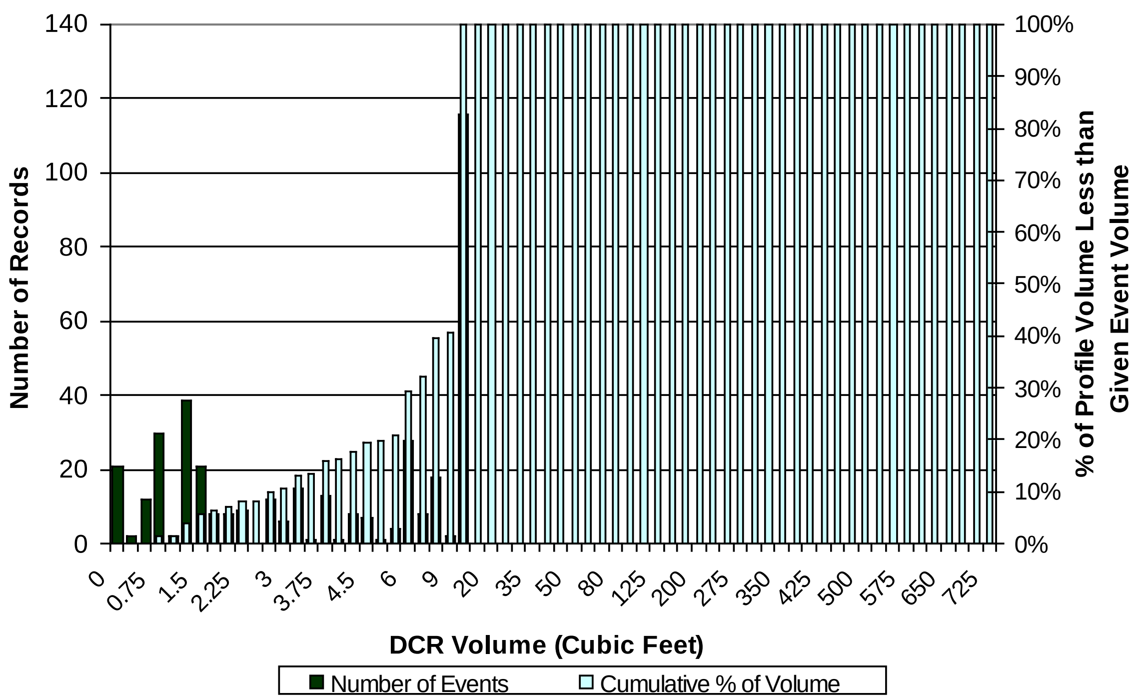
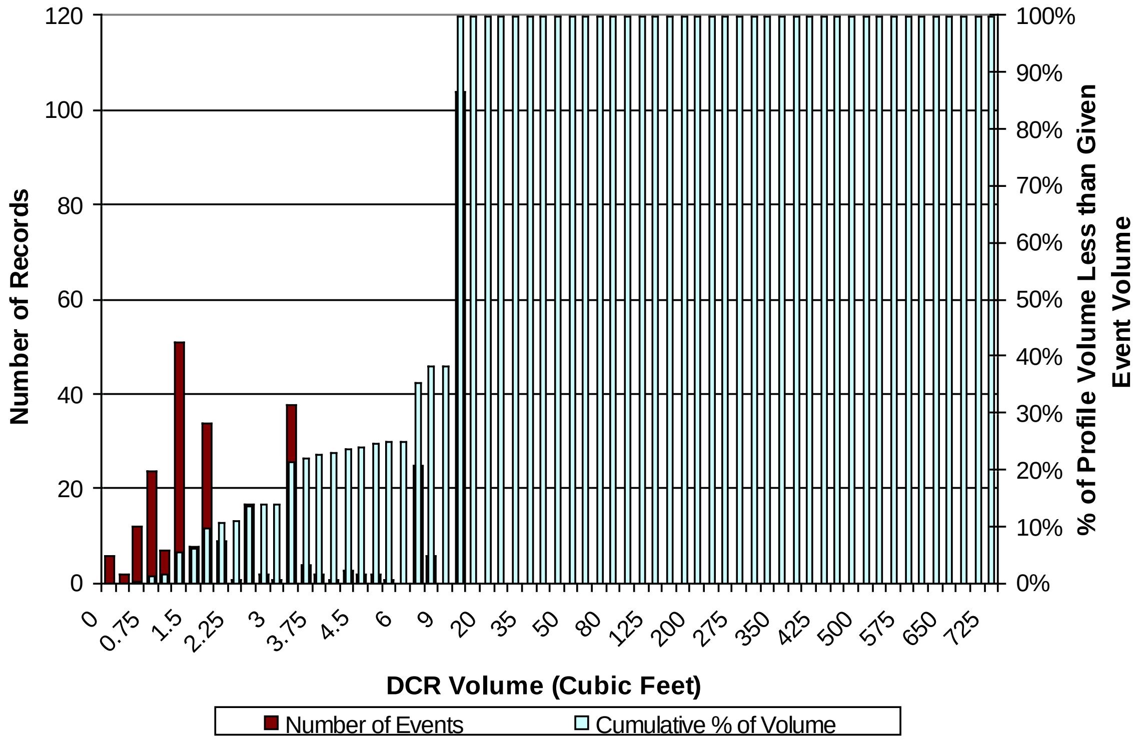


FIGURE 6
Profile of Taconite DCR Discharge during Loading Events if Minimize DCR Alternative Is Employed



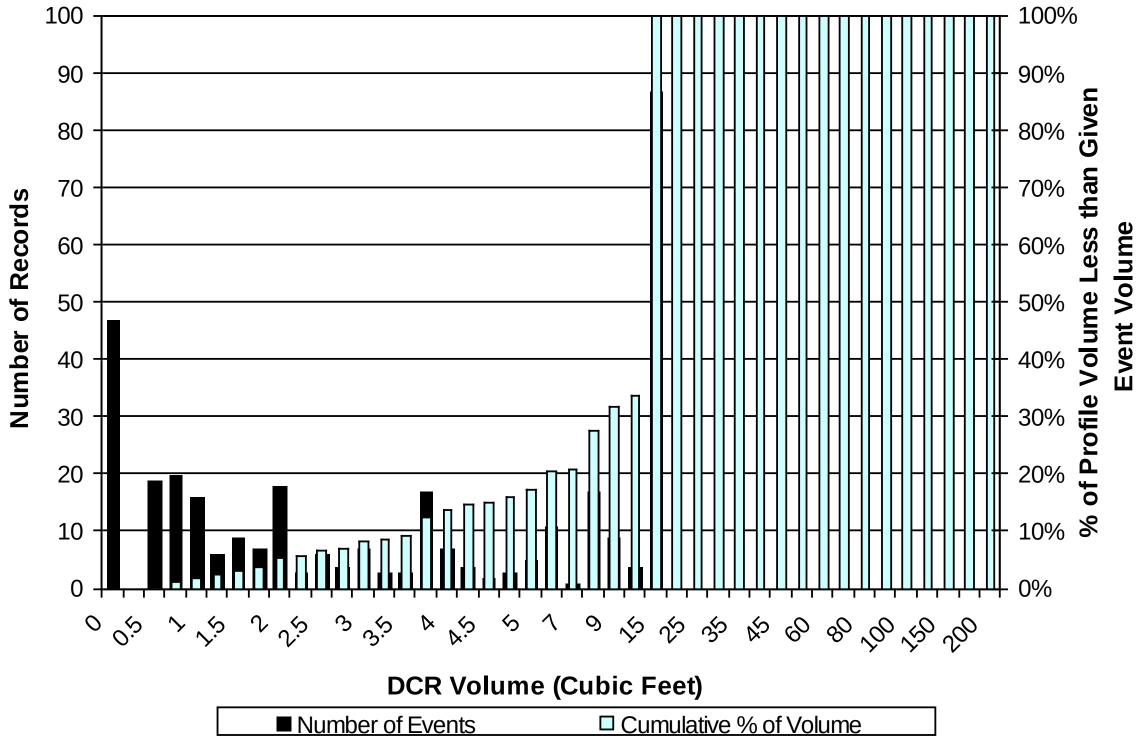
Baseline Control Measures Alternative

As with the Minimize DCR Alternative, the predicted loading DCR volumes for the Baseline Control Measures Alternative were calculated by reducing the values in the vessel record data set that were greater than the expected maximum DCR discharge volume to the expected maximum DCR volume. The expected maximum DCR discharge volume for each cargo is listed in Table 2.

Coal. Figure 7 shows the adjusted data with DCR values not exceeding 12.5 ft^3 (94 gallons). The mean of the adjusted data was calculated to be 5.1 ft^3 (38 gallons). The median value before and after adjustment was 3.4 ft^3 (25 gallons). Compared with the mean of the No Action Alternative (11.6 ft^3, or 87 gallons), the mean of the Baseline Control Measure Alternative represents a 56 percent reduction in DCR.

Limestone. Figure 8 shows the adjusted data with DCR values not exceeding 15 ft^3 (112 gallons). The mean of the adjusted data was calculated to be 7.1 ft^3. The median value before and after adjustment was 3.7 ft^3 (28 gallons). Compared with the mean of the No Action Alternative (18.8 ft^3, or 141 gallons), the mean of the Baseline Control Measure Alternative represents a 62 percent reduction in DCR.

FIGURE 7
Profile of Coal DCR Discharges during Loading Events if Baseline Control Measure Alternative Is Employed



125

FIGURE 8
Profile of Limestone DCR Discharges during Loading Events if Baseline Control Measure Alternative Is Employed

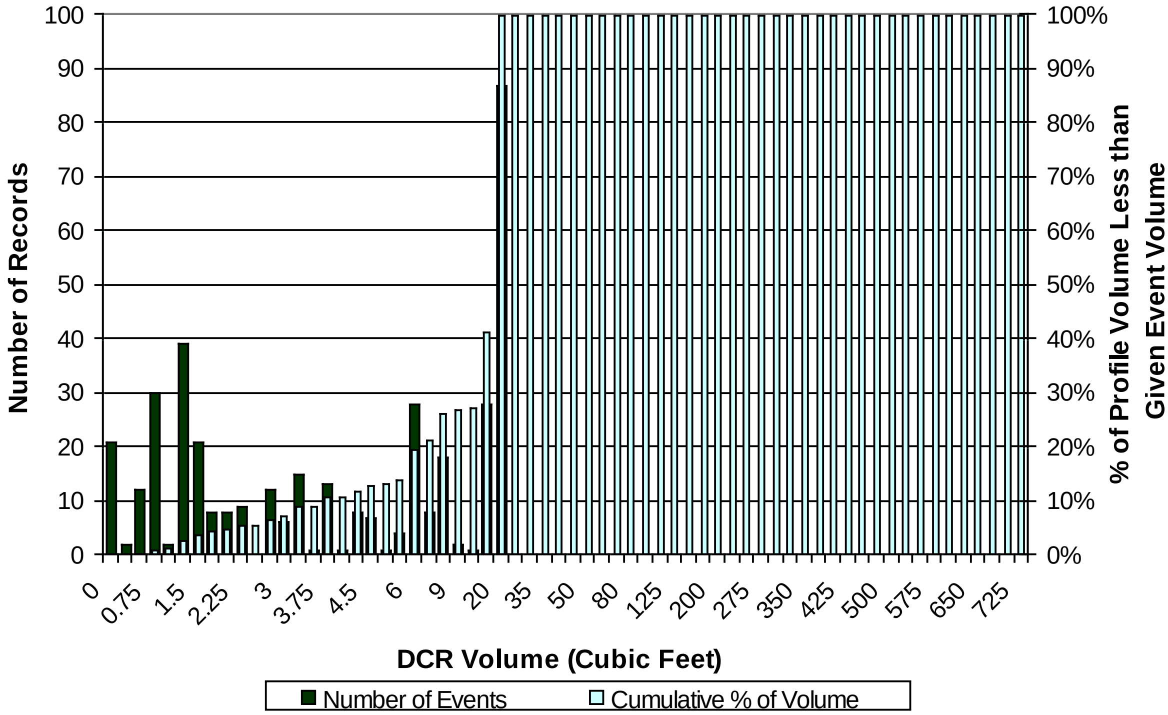
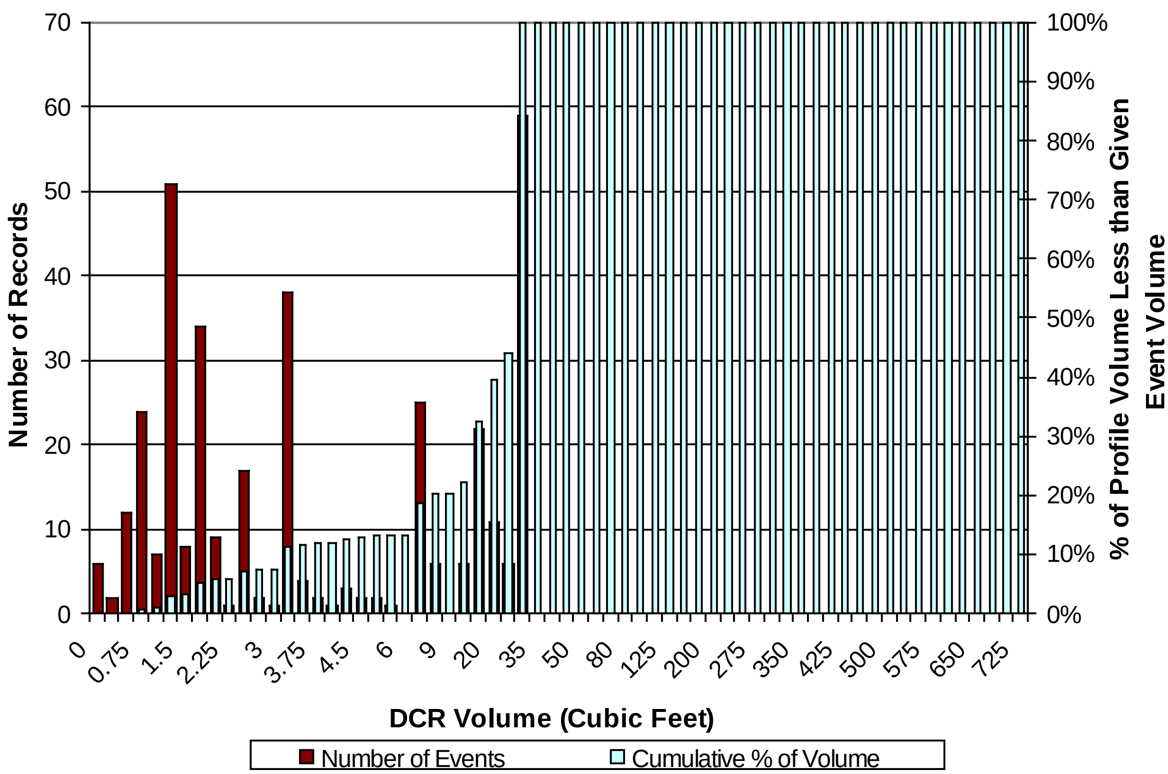


FIGURE 9
Profile of Taconite DCR Discharges during Loading Events if Baseline Control Measure Alternative Is Employed



Taconite. Figure 9 shows the adjusted data with DCR values not exceeding 30 ft^3 (224 gallons). The mean of the adjusted data was calculated to be 8.3 ft^3 (62 gallons). The median value before and after adjustment was 3.0 ft^3 (22 gallons). Compared with the mean of the No Action Alternative (19.3 ft^3, or 144 gallons), the mean of the Baseline Control Measure Alternative represents a 57 percent reduction in DCR.

Predicted Unloading DCR Volumes

Direct observations of unloading events during spring and summer 2009 were used to estimate the predicted unloading DCR volumes of the alternatives. The unloading vessel records compiled during the 2008 and 2009 shipping seasons were deemed inconsistent when compared with the values obtained from the direct observations. Fourteen unloading operations were observed at 11 shoreside unloading facilities. The observations included 12 vessels: four that unloaded coal, five that unloaded limestone, and five that unloaded taconite. Two vessels were observed twice, but for different cargos for each observation.

Minimize DCR Alternative

The Minimize DCR Alternative is performance based and requires the vessel or facility to minimize DCR but does not prescribe any methods for achieving this. It is up to the vessel owner or operator to determine the most appropriate approach and method for each vessel. In order to predict impacts in this Draft Tiered EIS, the volume of DCR discharged to the Great Lakes under this alternative was estimate by the project team that conducted the dry cargo loading and unloading observations. To estimate the predicted DCR volumes for the Minimize DCR Alternative, the direct observations that best reflected the alternative were first identified. Although none of the observed practices was completely consistent with the definition of the Minimize DCR Alternative, several observations embodied aspects of the Minimize Alternative. By combining results from all observations, it was possible to predict the remaining DCR volume if all the conditions of the Minimize DCR alternative were met. Adjustments were made by first noting concentrated areas of DCR. For each of these concentrated areas, the likely reduction in volume was estimated if the conditions of the Minimize DCR Alternative were met. This estimate was based on observations of similar operations or equipment on other vessels or similar locations on the same vessel where Minimize DCR conditions were met. These estimated reductions under optimum conditions were 75 percent.

Observations of dry cargo unloading indicated that under less-than-ideal conditions (e.g., inclement weather, cargo condition, and human and equipment variability) DCR volumes could be greater. Therefore, a 50 percent reduction of the original estimated DCR discharge volume was applied for this scenario, instead of 75 percent because observations of collecting DCR in concentrated areas indicated this was the range of effectiveness using methods consistent with the definition of minimize DCR. . Mean and median values of DCR volume were determined for each reduction scenario and each cargo type. Thus, the scenario representing the greatest DCR volume discharged (i.e., only a 50 percent reduction of the DCR volume observed, as the closest approximation to the Minimize DCR Alternative conditions) was selected for comparison with the No Action Alternative to take into account variability that would likely occur during actual unloading events.

Coal. The coal-unloading event in Milwaukee, Wisconsin, was chosen as the sole observation to estimate DCR for coal unloading under the Minimize DCR Alternative (12.57 ft^3, or 94 gallons). Deck and tunnel DCR from that event could have been reduced by collecting the concentrated DCR on the deck with a shovel and by washing down the tunnel as described for the Minimize DCR Alternative. Based on the observation, to follow the intent of the Minimize DCR Alternative, the DCR that remained in the vessel tunnel and on deck could have been reduced, resulting in a lower total DCR volume. If the DCR had been reduced by 75 percent, the resulting DCR volume would have been 3.1 ft^3 (24 gallons). If the DCR had been reduced by 50 percent, the resulting DCR volume would have been 6.3 ft^3 (47 gallons).

The coal-unloading event in Manitowoc, Wisconsin, generated a large quantity of DCR because of a misaligned tunnel conveyor belt, missing belt scrapers, and missing cargo hold gate skirts and because the unloading boom, which was overloaded, deposited coal on the vessel deck. Neither this event nor the two coal unloading events in St. Clair, Michigan, represent the Minimize DCR Alternative because no parts of the tunnel were washed during the unloading. There was no additional attempt to reduce the amount of DCR after it had been generated.

<u>To summarize:</u>

Original DCR estimate = 12.57 ft^3 (24 gallons)
Minimize DCR estimate (75 percent reduction) = 3.1 ft^3; mean = median = 3.1 ft^3 (24 gallons)
Minimize DCR estimate (50 percent reduction) = 6.3 ft^3; mean = median = 6.3 ft^3 (47 gallons)

Limestone. DCR discharges for two of the five limestone-unloading events could have been reduced by applying the Minimize DCR Alternative. These two DCR discharge events were estimated at 5.75 ft^3 (43 gallons) and 13.02 ft^3 (97 gallons). The total vessel DCR volumes in both cases could have been reduced to meet the intent of the Minimize DCR Alternative had the tunnel washdown procedures discussed in the Minimize DCR Alternative been used and had concentrated areas of DCR on the vessel deck been collected. Reducing the original DCR estimates by 75 percent results in an estimated average and median DCR volume for limestone unloading to be 2.4 ft^3 (18 gallons). With a reduction of 50 percent, the mean and median DCR volumes would both be 4.7 ft^3 (35 gallons).

<u>To summarize:</u>

Original DCR estimates = 5.75 ft^3 (43 gallons), 13.02 ft^3 (97 gallons)
Minimize DCR estimates (75 percent reduction) = 1.4 ft^3, 3.3 ft^3; mean = median = 2.4 ft^3 (18 gallons)
Minimize DCR estimates (50 percent reduction) = 2.9 ft^3, 6.5 ft^3; mean = median = 4.7 ft^3 (35 gallons)

Taconite. DCR volumes for four of the five taconite-unloading events directly observed (the events observed at the Toledo, Ohio, facility; both observations at the Indiana Harbor facility; and the second observation at the Gary, Indiana, facility) could have been reduced by applying the Minimize DCR Alternative. These four events were estimated at 9.28 ft^3 (69 gallons), 7.95 ft^3 (60 gallons), 4.67 ft^3 (35 gallons), and 9.48 ft^3 (71 gallons). Each event's DCR discharge volume could have been reduced by using the tunnel washdown procedures discussed in the Minimize DCR Alternative. In one case, closing two doors from the tunnel could have eliminated deck DCR. In each of the four cases, DCR that would comply with the Minimize DCR Alternative was calculated by reducing tunnel DCR from the transfer (or loop) belt areas by 75 percent, and in the one instance where the doors to the tunnel were left open, eliminating deck DCR. This results in the same mean and median estimated DCR volumes for taconite unloading of 2.7 ft^3 (20 gallons). Reducing the original DCR estimate by 50 percent to account for variability results in a mean DCR volume for taconite unloading of 3.9 ft^3 (29 gallons) and median volume of 4.3 ft^3 (32 gallons).

The first taconite unloading observation at the Gary, Indiana, facility was excluded from this alternative because excessive DCR was generated from cargo hold gates, conveyor skirts, and transfer locations and also within the rotary elevator, due mostly to poor operations, maintenance, or installation of equipment.

<u>To summarize:</u>

Original DCR estimates = 9.28, 7.95, 4.67, and 9.48 ft^3 (69, 60, 35, and 71 gallons, respectively)

Minimize DCR estimates (75 percent reduction of tunnel DCR only) = 2.9, 2.4, 1.2, and 4.2 ft^3; mean = 2.7 ft^3 (20 gallons)
median = 2.7 ft^3 (20 gallons)

Minimize DCR estimates (50 percent reduction of all DCR) = 4.6, 4.0, 2.3, and 4.7 ft^3; mean = 3.9 ft^3 (29 gallons), median = 4.3 ft^3 (32 gallons)

Baseline Control Measures Alternative

To estimate the predicted loading DCR volumes for the Baseline Control Measures Alternative, direct observations of what appeared to be properly installed and maintained baseline control measures, as identified in the direct observations TM, were selected. Once one or several observations were selected, the values were averaged, and the median for each data set was calculated from this subset of records to obtain the unloading DCR volume for each cargo type under the Baseline Control Measures Alternative.

It was assumed that the baseline control measures required of vessels were independent of whether the vessel was loading or unloading when the control measure was applicable to the respective loading or unloading operation. For example, when a vessel was loaded, it was assumed that the use of broom and shovels on the vessel was a required baseline control measure but that use of a cargo hold vibrator was not applicable. It is important to note that the baseline control measures identified in the direct observations TM were for vessels (both loading and unloading operations) and shoreside loading facilities.

During unloading events, some vessels and shoreside loading facilities implemented control measures that were not part of the baseline. For example, some vessels have enclosed conveyors, and some shoreside loading facilities used capacity indicators and remote controls. These measures reduce DCR, and it was assumed that the vessels and facilities would continue to use them under the Baseline Control Measures Alternative, even though their use would not be required. The DCR estimates below include estimates of DCR with the implementation of the baseline control measures applied only to unloading events. No attempt was made to quantify the DCR that would be discharged without the use of vessel or shoreside loading facility control measures not required under the alternative. In this manner, the estimate is most likely to be representative of the implementation of baseline control measures applied to the entire Great Lakes fleet.

Coal. Baseline control measures were applied to three of the four coal-unloading events that were directly observed. These events were estimated at 34 ft^3 (256 gallons), 48 ft^3 (359 gallons), and 13 ft^3 (97 gallons), respectively. The baseline control measures of all three vessels generally were working properly, and the DCR generated on the deck and in the tunnel was a result of normal unloading operations. The average DCR volume generated by the vessels was 32 ft^3 (236 gallons), and the median was 34 ft^3 (256 gallons).

Although baseline control measures were used for the unloading event in Manitowoc, Wisconsin, it was the only event excluded as an example of the alternative because of a misaligned tunnel conveyor belt, missing belt scrapers, and missing cargo hold gate skirts, and because the overloaded unloading boom deposited coal on the vessel deck.

<u>To summarize:</u>

Original DCR estimates = 34, 48, and 13 ft^3
Mean = 32 ft^3
Median = 34 ft^3

Limestone. Two limestone-unloading events effectively applied baseline control measures and were selected for inclusion in the alternative calculation. These events were estimated at 5.8 ft^3 (43 gallons) and 25 ft^3 (188 gallons) of DCR. The mean and median DCR volume of these two observations was 15 ft^3 (115 gallons).

The remaining limestone unloading observations were excluded because of improper maintenance and use of baseline control measures, and the inability to use these observations to estimate DCR volumes for this alternative because estimating the DCR by correcting those deficient control measures was not possible.

<u>To summarize:</u>

Original DCR estimates = 5.8 and 25 ft^3 (43 and 188 gallons, respectively)
Mean = median = 15 ft^3 (115 gallons)

Taconite. The first taconite-unloading event observed at the Indiana Harbor facility, the event at Toledo, Ohio, and the two events at the Gary, Indiana, facility had, by definition, all the baseline control measures. However, not all were used while the vessels were at port. In none of these four unloading events were using a broom and shovel to reclaim DCR observed, and this limited the ability to quantify the DCR generated based solely on the baseline control measures.

The second taconite-unloading event that was observed at the Indiana Harbor facility was the only unloading event that, in addition to having the baseline control measures present, used all the control measures during the event, including using the broom and shovel to reclaim some of the DCR. The quantity of DCR generated during the event was 4.7 ft^3 (35 gallons).

<u>To summarize:</u>

Selected Baseline Control Measure records DCR = 4.7 ft^3 (35 gallons)

Mean = 4.7 ft^3 (35 gallons); Median = 4.7 ft^3 (35 gallons)

Summary

Table 3 summarizes the predicted DCR volumes for the No Action, Minimize DCR, and Baseline Control Measures Alternatives.

TABLE 3
Predicted Reduction in DCR Discharge Volume per Discharge Event for Each Alternative

	No Action		Minimize DCR			Baseline Control Measures		
	Median (ft^3)	Mean (ft^3)	Median (ft^3)	Mean (ft^3)	Estimated DCR Reduction Compared with No Action (%)	Median (ft^3)	Mean (ft^3)	Estimated DCR Reduction Compared with No Action (%)
Loading[a]								
Coal	3.4	11.6	3.4	3.6	69	3.4	5.1	56
Limestone	3.7	18.8	3.7	4.9	74	3.7	7.1	62
Taconite	3.0	19.3	3.0	4.5	77	3.0	8.3	57
Unloading[b]								
Coal	41.1	48.9	6.3	6.3	85	34.0	32.0	17
Limestone	25.1	241.2	4.7	4.7	81	15.0	15.0	40
Taconite	9.3	9.3	4.3	3.9	54	4.7	4.7	49

[a]Reductions calculated with means because of large data set and median not valid because values were adjusted to lower highest values.
[b]Reductions calculated with median because of small data set.

References

CH2M HILL. 2009. "DCR Loading and Unloading Observations." Technical Memorandum Prepared for U.S. Coast Guard. November 6.

Appendix H
Summary of EPA NPDES Vessel General Permit for Discharges Incidental to the Normal Operation as Related to U.S. Coast Guard DCR Rule

Summary of EPA NPDES Vessel General Permit for Discharges Incidental to the Normal Operation as Related to U.S. Coast Guard DCR Rule

PREPARED FOR: U.S. Coast Guard

PREPARED BY: CH2M HILL

DATE: November 5, 2009

The EPA has recently issued requirements for National Pollution Discharge Elimination System (NPDES) permits for discharges incidental to the normal operation of ships (http://cfpub.epa.gov/npdes/home.cfm?program_id=350). The requirement was initially prompted by concern over introducing non-native invasive species through discharging ballast water, but the resulting regulations cover all forms of pollutants, with specified exceptions, including dry cargo residue (DCR). The intent of the permits is to control discharge of pollutants and prevent violation of water quality standards.

Summary of Vessel General Permit

The basic requirement of the VGP promulgated by EPA is that vessel operators must minimize the discharge of pollutants from the incidental operations of ships covered by the VGP. EPA defines "minimize" as "reducing and/or eliminating to the extent achievable using control measures (including best management practices) that are technologically available and economically practicable and achievable in light of best marine practice." In some cases the permit requires specific actions to minimize the discharge, such as the following:

- Treated bilge water must be discharged when vessels are underway (sailing at speeds greater than 6 knots), unless doing so would threaten the safety and stability of the ship.
- Vessels with ballast water tanks must maintain a ballast water management plan developed specifically for the vessel.
- All tank barges must have spill rails and must plug their scuppers before any cargo operations if required by the vessel class society.

- If any spills result during loading or unloading of cargo, vessel owner/operators must completely clean up spills or residue before scuppers are unplugged (this and the above condition apply to dry cargo barges).
- Saltwater flushing for vessels with empty ballast water tanks is mandatory.
- Where feasible, machinery on deck must have coamings or drip pans to collect any oily water from machinery and to prevent spills.

The VGP establishes requirements for numerous specific discharge categories, including deck washdown, bilgewater, discharges of ballast water, boiler/economizer blowdown, etc. There are recommendations and sometimes requirements specific to each category, but all include the minimization of pollutant discharge requirement. The requirements for the two categories relevant to DCR are copied below.

Deck Sweepings:

> Vessel owner/operators must minimize the introduction of on-deck debris, garbage, residue and spill into deck washdown and runoff discharges. When required by their class societies (e.g., oil tankers), their flag Administrations, or the U.S. Coast Guard, vessels must be fitted with and use perimeter spill rails and scuppers to collect the runoff for treatment…. The presence of floating solids, visible foam, halogenated phenol compounds, and dispersants, or surfactants in deck washdowns must be minimized. Vessel operators must minimize deck washdowns while in port.

Tunnel Discharge:

> All vessels must minimize the discharge of bilgewater into waters subject to this permit. This can be done by minimizing the production of bilgewater, disposing of bilgewater on shore where adequate facilities exist, or discharging into waters not subject to this permit (i.e., more than 3 nautical miles (nm) from shore) for vessels that regularly travel into such waters.

In the permit and supporting documentation, EPA goes to great length to explain and justify the somewhat qualitative and subjective nature of many aspects of the requirements. They have determined that "it is infeasible to calculate numeric water quality based effluent limits for vessels at this time." Similarly, they find that "it is infeasible to set specific numeric effluent limits for discharges of deck runoff due to variation in vessel size and associated deck surface area, types of equipment operated on the deck, and limitations on space for treatment equipment." In the absence of numerical limits, they "require permittees to engage in specific behaviors or best management practices (BMPs)." They use similar logic for permit limitations that are based on the best professional judgment of the permit writer.

Inspection, monitoring, recordkeeping, and reporting requirements are also included in the VGP. The specific recordkeeping requirements relevant to a DCR rule are the following:

- Records must be kept on the vessel
- The basic vessel information must be included
- Documentation of violation of effluent limit and Corrective Action Assessment
- Log of deficiencies and problems found during required inspections
- Dates, estimated volume, and location of bilgewater discharges
- Record of training, completed as required by permit

Relation of VGP to DCR Rule and EIS

EPA seems to have reached conclusions that there is not sufficient information to develop numerical discharge limits that are achievable and protective of the environment. Similarly, the variation among ships and cargo make the universal requirement of equipment or operating procedures impractical. Although they address specific equipment and/or procedures to control discharge, the cases where they do in fact impose specific requirements are the exception rather than the rule. They do, however, frequently provide suggested equipment or procedures to control discharge of pollutants.

Appendix I
Dry Cargo Residue Discharge Analysis for the U.S. Coast Guard

Dry Cargo Residue Discharge Analysis for the U.S. Coast Guard

PREPARED FOR: U.S. Coast Guard

PREPARED BY: CH2M HILL

DATE: December 10, 2009

Executive Summary

The U.S. Coast Guard is conducting a study of dry cargo residue (DCR) discharges from bulk cargo ships on the Great Lakes to understand the potential environmental influence of the discharges and to support policy development on the issue. This memorandum documents an analysis of potential water quality and sediment impact of the DCR and is an update of the analysis conducted in support of the Phase I Final EIS (U.S. Coast Guard, 2008), being based upon more recently available DCR data. The analysis employed focused mathematical modeling to simulate water quality impacts and deposition rates and used those results to make conclusions regarding water quality associated with the discharge and the accumulation of DCR material over time. The conclusions of this updated analysis are similar to those reached in the technical memorandum on DCR discharge (CH2M HILL, 2008) in support of the Phase I Final EIS.

During the first analysis, liquid and solid samples were collected from the decks and sumps of eight bulk dry cargo vessels (CH2M HILL, 2007a). Analytical results were compared to chronic and acute water quality criteria obtained from the Great Lakes Initiative and the U.S. Environmental Protection Agency (EPA) for the protection of aquatic life and human health. This comparison did not take into account the dilution that would occur during DCR discharges. This was a useful comparison from a screening perspective, however, because discharge parameters that meet criteria even without consideration of applicable dilution can be regarded as parameters that do not require further impact assessment. There were only three instances in which chronic water quality criteria were exceeded in undiluted samples by more than a factor of 10, and the highest exceedance of acute water quality criteria was by a factor of 1.9.

Solids sampled from the sumps and decks of the vessels demonstrated that limestone and taconite solids did not exceed any sediment criteria. Again, the sample results did not take into account dilution, dispersion and attenuation that would occur as the solids integrate into lake bottom sediments. The comparison of undiluted samples to sediment criteria again provides a defensible basis to screen out parameters that do not require further assessment. Coal DCR collected from ship decks generally exceeded criteria for polycyclic aromatic hydrocarbons (PAHs), such as naphthalene and pyrene, by a factor of up to 5 in some individual undiluted samples. Only one vessel had sump solids that exceeded sediment criteria. The sump solids collected from that ship showed elevated levels of metals. The exceedance of metals criteria on this single ship seems to be the result of incorporation of foreign metallic materials, such as wire or metal shavings, because none of the DCR materials themselves exceeded any metals criterion. More extensive sampling would be required to determine the true nature of DCR on Great Lakes sediment. However, preliminary results indicate that most of the undiluted samples collected meet most water quality and sediment criteria.

DCR was directly observed during loading and unloading operations on 30 vessels from May 27 to July 1, 2009. The direct observations included loading and unloading of coal, limestone, and taconite and occurred in Lake Superior, Lake Michigan, and Lake Erie. These direct observations supplemented vessel DCR reporting form data supplied by the shipping industry during portions of 2008 and 2009. Comparisons of the 2009 directly observed data to data utilized for the Phase I Final EIS and data reported for 2008 and 2009 was analyzed in detail (CH2M HILL, 2009) and utilized for this updated discharge analysis. The discharge data was used in this analysis and represents current DCR discharge conditions (the No Action alternative in the Tiered Draft EIS in support of DCR rulemaking). The data show that the typical DCR discharge is larger than what was estimated during work on the Phase I Final EIS, but is still a relatively small amount of material distributed over a relatively large section of lake. An estimation based on collected data determined that DCR accounts for 0.006 percent of the total amount of cargo transported through the Great Lakes (Potomac Management Group, 2003).

A review of computer modeling software packages determined that few modeling applications would apply to DCR on the Great Lakes. To analyze water quality impacts, a Simple Dilution Model was used. None of the evaluated modeling programs was applicable to the sediment quality modeling; therefore, a spreadsheet model was developed specifically for this analysis.

The Simple Dilution Model used to estimate dilution of DCR discharges was created to predict dilution of discharged wastewater from cruise ships in Alaskan seas (Loehr et al., 2003). The model proved to be the most useful and applicable of all those evaluated. It demonstrates that dilution factors from 27,000:1 to 62,000:1 can be expected for DCR from moving bulk cargo vessels on the Great Lakes. These dilution factors are due to the large displacement of water and wash from large propellers, which create a wide swath of turbulence and mixing behind moving ships. The dilution factors are achieved within 15 minutes of discharge (Alaska DEC, 2001), ensuring that the discharge of DCR has an insignificant impact on water quality.

Naphthalene (present in coal DCR) was the chemical parameter of highest average concentration in the discharged solids in relation to the sediment quality criteria. Using conservative assumptions, it was found that if all the coal DCR discharged to Lake Superior in a given year is spread uniformly over an area 10 miles by 6,091 feet (1,857 m), sediment criteria will be met with a safety factor through natural sedimentation processes alone. If natural sedimentation is considered negligible and dilution is assumed to occur through mixing with the top 2 inches of existing sediment, coal discharged over 100 years evenly spread over an area of 10 miles by 2,398 feet (731 m) meets sediment criteria with a safety factor. In reality, coal DCR discharges are spread over an area much larger than 10 miles by 6,091 feet (1,857 m), indicating no significant impact on sediments.

Because of the small mass of the discharges and the relatively benign nature of the material, there is no significant impact to the lake sediments from an evenly dispersed discharge of DCR. Even a single, large coal discharge event (586 pounds/mile) is required to be spread out over a width of only 44.5 feet (13.6 m) in order to be diluted to meet sediment criteria by natural sedimentation. In reality, coal DCR discharged from a moving cargo vessel will be spread out much more than 44.5 feet (13.6 m) because of wake turbulence. A large cargo vessel can be up to 98 feet (30 m) in width with the wake and turbulent zones behind the vessel about 2.5 times greater than the width of the vessel (Loehr et al., 2003). This sediment analysis also assumes conservative sedimentation rates for the central basin of Lake Superior and includes a safety factor of 10.

A single large discharge of coal was estimated to be the 95th percentile obtained from the vessel DCR reporting form 2008 database. Only 5 percent of discharges in this database were denser than 586 pounds/mile. The 95th percentile in the 2009 vessel DCR reporting form database was also examined and found to be 221 pounds/mile. The higher number from the 2008 database was used as a conservative approach. The 2008 95th percentile discharge must be spread over a width of 44.5 feet (13.6 m) in order to be diluted by natural sedimentation to meet sediment criteria with a safety factor.

The coal is spread over a wider area due to mixing; therefore, the DCR meet sediment criteria by either natural sedimentation or mixing with the top two inches of sediment.

An analysis of the volume of historical DCR using sonar data (Mackey, 2006) determined that some of the DCR sonar images cover a relatively large area and are not likely the result of current typical DCR discharges. The loading and unloading of cargo has improved in recent times, and the amount of DCR that is swept overboard has been reduced from historical levels. DCR is typically discharged in very small amounts over vast areas of the lake. The 95th percentile discharge for coal is only 586 lbs/mile (see DCR discharge Data). This would equate to a 5-gallon bucket of coal DCR every football field length over the course of 1 mile. The coal would likely be spread out at least one ship width (over 68 feet) as the turbulent mixing zone is considered to be 2.5 times the width of the vessel (Loehr et al., 2003). The largest current recorded DCR events represent relatively small amounts of material discharged over large areas; therefore, it is assumed that most of the deposits observed during the sidescan sonar study are not typical of current DCR practices. However, further research and field verification are required to determine the origin of deposits observed during the sidescan sonar study.

Conservative assumptions were employed throughout the water and sediment quality analyses. The water and sediment analyses confirm that DCR discharges are diluted to the point that water and sediment quality criteria are met and no significant adverse impacts on water or sediment quality are expected.

Introduction

This memorandum is an update, using more recent data, of the dry cargo residue discharge analysis performed for the U.S. Coast Guard in 2007 (CH2M HILL, 2008) in support of the Phase I Final EIS (U.S. Coast Guard, 2008). Throughout this memorandum, the 2007 analysis is referred to as the "Phase I" effort.

The Great Lakes dry bulk carrier industry normally transports more than 150 million tons of dry bulk cargo on the Great Lakes each year. Dry cargo includes iron, coal, limestone, grain, salt, gypsum and other materials; however, iron, coal, and limestone account for most of the transported material. A small amount of material is inadvertently deposited on the decks and in the below-deck conveyor tunnels of the cargo vessels during loading and unloading operations. Historically, nonhazardous, nontoxic spilled material is discharged into the lake to eliminate unsafe conditions onboard. Material accumulating on the ship deck is washed overboard after each unloading operation, and DCR in the tunnels is washed every two to three trips. The tunnel material is collected in a sump that discharges out the side of the ship. About 0.006 percent of the total transported cargo material is discharged to the Great Lakes as DCR during vessel washdown operations. In 2001, 165 million tons of cargo was transported on the Great Lakes, and 494 tons of cargo was discharged as DCR (Potomac Management Group 2003).

Prior to September 30, 2008, the Interim Enforcement Policy (IEP) governed discharge of DCR on the Great Lakes. The U.S. Coast Guard has since issued an interim rule that imposed new limitations on the discharge of the DCR, mandated recordkeeping and reporting requirements, and encouraged carriers to adopt voluntary control measures to reduce DCR discharge. The Coast Guard is continuing its study of DCR discharges from bulk cargo ships on the Great Lakes based upon new records collected in 2008 and 2009 and direct observations of loading and unloading operations in 2009 since the new rule was issued to better understand the potential environmental and economic implications of the DCR practices and to support a potential new DCR rule. This memorandum documents an analysis of potential water quality and sediment impact of the DCR discharges. The objective of the DCR discharge analysis was to use focused mathematical modeling to simulate water and sediment quality impacts associated with the DCR.

The type of mathematical model most appropriate for the analysis depends upon whether the DCR can significantly affect the water column water quality, the substrate, water quality through chemical reaction, or a combination.

The number of possible combinations of material, location, substrate type, etc., is extensive. This study prioritized the analysis based upon the comprehensive information gathered on DCR discharge locations, materials, etc., during previous tasks. Following this approach focused the modeling analysis in areas where actual impacts may be occurring.

Information gained from prior analysis guided model selection and model inputs. Efforts previously undertaken include conducting a sophisticated sonar study in several study areas on Lakes Superior, Michigan, and Erie (S D Mackey, 2006); collecting and characterizing extensive samples of deck DCR and sump slurries of coal, limestone, and taconite (CH2M HILL, 2007a); and collection of toxicological and nutrient enrichment data from DCR samples (CH2M HILL, 2007b, c). The information gained from these efforts was considered and included in the prior modeling analysis (CH2M HILL, 2008). The data used in this updated analysis is based upon DCR reported during portions of 2008 and 2009 from the shipping industry and direct observations of loading and unloading events observed in 2009 (CH2M HILL, 2009). The water quality analysis utilized data from 2009 direct observations and the data from the Phase I Final EIS. The sediment quality analysis utilized the data from 2009 direct observations and the 2008 and 2009 Vessel DCR Reporting Forms.

Modeling Objective

The modeling used chemical analysis, DCR grain size distribution, physical lake data, and DCR discharge data in conjunction with modeling software and calculation approaches to predict chemical concentrations in the water column in comparison to water quality standards. The modeling task also determined information on coverage and buildup of DCR material over time to determine effects on sediment quality.

Evaluation of Modeling Software

Liquid and solids samples were collected from the decks and sumps of eight bulk dry cargo vessels. Analytical results were compared to chronic and acute water quality criteria determined by the Great Lakes Initiative and the EPA criterion for the protection of aquatic life and human health concerns. The DCR characterization chemical analysis data (CH2M HILL, 2007a) show that there are few chemical parameters for which the sump slurries exceed acute water quality benchmark criteria. Modeling can determine the extent of mixing and estimate chemical concentrations over time in the affected water column.

The effect that mixing has upon the chemical concentration depends upon the DCR chemical concentrations in the discharge, background concentrations in the receiving water, and a host of other factors.

There are mathematical models for modeling plume discharges and for modeling ship wakes, but the two models have not been combined. There is sparse documentation directed specifically at determining dilution of discharges from moving ships (CH2M HILL, 2007b). However, one study generated a Simple Dilution Model and validated the model in order to determine dilution of wastewater discharged from moving cruise ships in Alaskan seas. Table 1 lists the nine models evaluated for potential application for modeling DCR.

The Simple Dilution Model was published in OCEANS 2003 Proceedings (Loehr et al., 2003). The model was developed by an independent Science Advisory Panel to assist the Alaska Department of Environmental Conservation in evaluating the effects of wastewater discharges from cruise ships in Alaskan waters.

Visual Plumes (Frick et al., 2001) is a modeling program that simulates surface water jets and plumes in order to determine water quality impacts due to a liquid discharge. Cormix (Jirka et al., 1996) is able to model submerged single-port and multiport diffuser discharges as well as surface discharge sources and is useful for modeling the impact of liquid discharges on receiving waters (i.e., treated wastewater outfall into a river). These two models are designed specifically for liquid discharges.

TABLE 1
Discharge Models Evaluated for Potential Application for Modeling of DCR Discharge

Model	Contact	Purpose	Status
Simple Dilution Model	See Loehr et al., 2003	Evaluate dilution of wastewater discharges from cruise ships in Alaskan waters.	Published 2003
Visual Plumes	EPA	Assists in the preparation of mixing zone analyses, total maximum daily loads, and other water quality applications.	Available from EPA
Cormix	EPA	Provides documented water quality modeling, NPDES regulatory decision support, visualization of regulatory mixing zones, and tools for outfall specification and design.	Available from EPA
STFATE (Short Term Fate)	USACE	Short term fate of discrete disposal of dredged material, water column impact, and deposition	Available from USACE
CDFATE (Continuous Disposal Fate)	USACE	Water column impact due to continuous disposal of dredged material; Also able to model discrete dumps	Available from USACE
OOC (Offshore Operators' Committee)	Offshore Operators' Committee	Water column impact and deposition due to offshore drilling	Not Available
CD-Cormix	EPA	Extends the CORMIX expert system to water quality prediction from continuous dredge disposal sources; DOS based program	Available from EPA and USACE
D-Cormix	EPA	Extends the CORMIX expert system to water quality prediction from continuous dredge disposal sources; Windows Based Program	Under development in cooperation with EPA and USACE
MDFATE (Multiple Disposal Fate)	USACE	Models bathymetry changes due to multiple disposals in a specific area	Available from USACE

Models created to simulate discharged liquid are insufficient to model the discharge of DCR slurries. No models exist to predict the dilution and dispersion of discharged DCR slurries. However, models have been created to simulate the dilution and dispersion of dredged material at open water dredged material disposal sites as well as offshore drilling sites (Table 1).

The U.S. Army Corps of Engineers (USACE) maintains a suite of dredged material disposal–modeling software in order to predict many aspects of dredged material disposal including water quality impacts, sediment accumulation, and release of chemical parameters from disposed material in sediments. This modeling software suite is known as ADDAMS (Automated Dredging and Disposal Alternatives Modeling System). STFATE (EPA, 1995), CDFATE (Chase, 1994), and MDFATE (Moritz, 1994) are components of ADDAMS.

A modeling program known as the Offshore Operators Committee Model (OOC model) (MBC, 1983) is able to simulate a variety of offshore oil field discharges characterized by unsteady, three dimensional behavior. Discharges are assumed to originate from a single port outfall. The OOC model predicts the distribution of discharged materials in the water column and the deposition of materials on the sea floor. This model can be applied to mud, cuttings and produced water discharges. The model was developed by Brandsma and Sauer (MBC, 1983) under sponsorship of the Offshore Operators' Committee (OOC). The model has been used by government and industry to estimate the likely behavior and fate of drilling mud and cuttings discharged in the marine environment. However, the model is not publicly available or available for purchase. OOC modeling work must be performed by Brandsma Engineering of Durango, CO.

Additionally, CD-Cormix (Jirka et al., 1996) is available to model continuous dredge disposals. This is a DOS-based program that uses Cormix methodology to predict water column impacts resulting from continuous dredged material disposal. CD-Cormix is fairly difficult to use because it is available only in DOS format, and the programming does not allow easy transition between modules. However, MixZon Inc. is developing D-Cormix (Doneker and Jirka 1997) in cooperation with the USACE and the EPA. D-Cormix is a Windows-based modeling program that extends the CORMIX system to water quality prediction from continuous dredge disposal sources. It models water column characteristics resulting from sources of suspended sediment in continuous pipeline dredging operations often referred to as “flow lane” or “in-water” disposal.

Model Selection

CH2M HILL continued to utilize the water and sediment quality models selected during Phase I. The model selection process is detailed in the 2007 discharge analysis for the U.S. Coast Guard (CH2M HILL, 2008).

Vessels Underway

Detailed Water Quality Model Description—Vessels Underway

A Simple Dilution Model was published in OCEANS 2003 Proceedings (Loehr et al., 2003). This model was developed by an independent Science Advisory Panel to assist the Alaska Department of Environmental Conservation in evaluating the effects of wastewater discharges from cruise ships in Alaskan waters. The cruise ships discharge wastewater above the water surface while moving; much like the DCR discharges from cargo vessels in the Great Lakes.

The panel reviewed several pertinent previous studies and concluded the following:

- The water displaced by a moving ship creates turbulent mixing upon its return astern of the ship.
- Large propellers on ships enhance mixing.
- Dilution is rapid and significant and depends on the size and speed of the vessel and the discharge rate.
- The cross-sectional mixing area behind a vessel rapidly expands to four times the cross-sectional area (beam × draft) of the submerged part of the vessel.

Simple Dilution Model: Dilution Factor = 4 × (width × draft × speed)/(discharge rate)

The cruise ships analyzed in the referenced paper had a beam of about 100 feet (30.5 m), a draft of 25 feet (7.6 m), and speeds ranging from 9 to 19 knots. The cruise ships are very similar in physical dimensions and speed to the large cargo vessels traveling on the Great Lakes. Great Lakes cargo vessels generally have 70 to 100 foot (21 to 30.5 m) beams, 30 feet (9 m) of draft or less, and can travel at speeds up to 17 knots (Great Lakes, 2007). Wastewater discharge rates for cruise ships range from 250 to 500 gallons per minute (0.95 to 1.9 m^3/min), which is similar to the 300 gallons per minute (1.1 m^3/min) flow from a typical washdown hose on board a cargo vessel (CH2M HILL, 2007a).

In August 2001, the EPA conducted a dye study of the discharges of four cruise ships. The Simple Dilution Model proved to be a conservative model. It underpredicted the dilution factors that were actually observed by the EPA. The actual observed dilution factors were greater than that predicted by the model but were not more than 40 percent greater than that predicted by the model. Research on wastewater discharges from cruise ships has shown that a dilution factor of at least 12,000 can be expected within 15 minutes behind a large cruise ship (that is, a discharge of 12,000 mg/L copper would be diluted to 1 mg/L within 15 minutes) (Alaska DEC, 2001).

Detailed Sediment Quality Model Description—Vessels Underway

The sediment quality model, developed by CH2M HILL specifically for this analysis, is a spreadsheet model that assumes discharged DCR is diluted via natural deposition or mixing with existing sediments. This model determines the required area over which DCR must be uniformly distributed in order to dilute the DCR sufficiently to meet sediment criteria. This modeling approach thus provides a comparison of the depositional area needed relative to the likely depositional area that actually occurs for DCR.

Vessels in Port

Under the interim rule, no DCR material discharges can occur in ports or near shore areas except for limestone. Consequently, water quality and sediment models were developed to simulate discharge water quality and DCR buildup for limestone DCR discharge in port and near shore areas.

Detailed Water Quality Model Description—Vessels in Port

To simulate water quality from a stationary limestone DCR discharge in port and nearshore areas, a spreadsheet model was used to analyze mixing from either sump or deck discharges. Discharge modeling was developed to analyze mixing between water volumes from the vessel tunnel or deck discharge with water from around the vessel.

Detailed Sediment Quantity Model Description—Vessels in Port and Nearshore Areas

To simulate sediment buildup from a stationary limestone DCR discharge in port and near shore areas, a spreadsheet model was used to analyze limestone buildup from deck or sump DCR discharge.

DCR discharge Data

Tables 2 through 6 summarize the data collected from direct observations during loading and unloading operations on 30 vessels during the period from May 27 to July 1, 2009. The data include weight of discharged DCR and are divided into loading and unloading events. For loading events, DCR is confined to the ship deck. For unloading events, DCR occurs on both the deck and the ship tunnel with generally over 90 percent of the DCR from the tunnel. Deck DCR is hosed off while tunnel DCR is washed into a sump and then pumped out of the ship.

TABLE 2
Summary of DCR Loading Direct Observations (2009)

	Coal DCR Weight (lb)	Limestone DCR Weight (lb)	Taconite DCR Weight (lb)
Mean	363	634	518
Median	207	535	539
Maximum	1,307	1,003	782
95th percentile	1,040	997	740

Note: 16 loading events were observed.

TABLE 3
Summary of DCR Unloading Direct Observations (2009)

	Coal DCR Weight (lb)	Limestone DCR Weight (lb)[a]	Taconite DCR Weight (lb)
Mean	2,443	24,120	1,203
Median	2,054	2,506	1,206
Maximum	5,036	108,001	1,936
95th percentile	4,640	88,043	1,796

[a]Limestone DCR include a vessel that had a one-time large quantity DCR discharge.
Note: 14 unloading events were observed.

TABLE 4
Summary of DCR Loading 2009 Database (2009)

	Coal DCR Weight (lb)	Limestone DCR Weight (lb)	Taconite DCR Weight (lb)
Mean	374	1,260	1,564
Median	88	360	313
Maximum	7,058	28,212	31,378
95th percentile	1,765	5,293	6,275

Note: 618 loading events were reported.

TABLE 5
Summary of DCR Unloading Vessel DCR Reporting Form Database (2009)

	Coal DCR Weight (lb)	Limestone DCR Weight (lb)	Taconite DCR Weight (lb)
Mean	662	1,052	1,849
Median	177	318	313
Maximum	7,940	13,233	23,533
95th percentile	3,529	5,293	7,844

Note: 565 unloading events were reported.

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TABLE 6
Deck DCR Discharge Comparison (2009 Direct Observation Loading Events with All Phase I Deck DCR Events)

	Phase I Mean (lb)	2009 Direct Observations Mean (lb)	Ratio of Direct Observations to Phase I
Coal	150.4	363	2.4
Limestone	269.4	634	2.4
Taconite	233.3	518	2.2

From the tables, it is apparent that unloading events generally have higher DCR volumes than loading events. The direct observation loading discharges ranged from 33 pounds to 1,307 pounds and the unloading discharges ranged from 575 pounds to 108,001 pounds. For unloading events, less than 23 percent of the DCR discharges were greater than 1,500 pounds and only 4 out of 30 discharges exceeded 5,000 pounds. The largest discharge, 108,001 pounds, was limestone and was due to extenuating circumstances. The observed loading events did not have discharges greater than 1,500 pounds.

DCR discharges for the 2009 vessel DCR reporting form database for loading ranged from zero to 31,378 pounds and the unloading discharges ranged from zero to 23,533 pounds. The loading events had less than 15 percent of the DCR discharges greater than 1,500 pounds with 26 out of 619 discharges exceeding 5,000 pounds. The unloading events experienced less than 12 percent of the DCR discharges greater than 1,500 pounds with 42 out of 569 discharges exceeding 5,000 pounds.

A review of the data indicates the direct observations trended higher than other reporting data. Deck DCR discharge can come from either loading or unloading events. Direct observation in 2009 indicated that loading events generally had higher deck DCR quantities than unloading events. To be conservative, the highest deck DCR numbers were used from 2009 direct observations for comparison with all Phase I deck discharges.

A comparison of the 2009 vessel DCR reporting form data with the direct observations indicates direct observation data was generally higher than what was reported on the Vessel Reporting Form for the same event. The discharge analysis chose to use conservative DCR values applicable whether from the direct discharge observations or the 2009 vessel reporting form database. The direct observation data was used to update the Phase I water quality calculations. The mean and median discharge masses obtained from the direct observations are quite small in relation to the dilution available, especially when considering the distance of the discharge. For example, the median loading discharge mass is 207 pounds, or 4.1 ft^3 of coal. Coal is the lightest of the DCR materials and consequently has the highest volume per unit weight. If the median discharge of 4.1 ft^3 was spread out over the 2009 vessel DCR reporting form median discharge distance of 37 miles, one would expect to see only a trace of the discharged material on the bottom of the lake.

The discharge density was calculated to identify discharges with the greatest DCR discharge density (i.e., the largest discharge mass over the smallest area). The median discharge density for coal was 4 pounds/mile. Less than 5 percent of coal discharges had densities greater than 586 pounds/mile in 2008.

The 2009 vessel DCR reporting form database found that taconite constitutes 44 percent of the mass of DCR discharges (Table 7), while coal and limestone accounted for 22 percent and 34 percent, respectively, of the total discharged DCR mass. These values vary by no more than seven percent compared to the 2003 PMG report.

TABLE 7
DCR Distribution

Material	% of Total Discharged Mass
Coal	22
Stone	34
Iron	44

Note: Data obtained from the 2009 vessel DCR reporting form database

Chemical Analysis Review

Water Quality

Samples of both liquids and solids were collected from the decks and sumps of eight bulk dry cargo vessels. The analytical results of these samples were compared to chronic and acute water quality criteria that were determined by the Great Lakes Initiative (EPA, 2005) and the EPA (2007) for the protection of aquatic life and human health concerns.

Table 8 shows the chemical analysis data in terms of exceedance ratios for chronic water quality criteria as well as sediment criteria. Samples of DCR from the deck and the sump were tested individually, and within each of these samples, the solid and liquid portions were also tested separately. The exceedance ratio is calculated as follows:

$$\text{Exceedance Ratio} = \frac{\text{Analyte Concentration in Sample}}{\text{Chronic Water Quality Criteria or Sediment Criteria}}$$

The highest exceedance of chronic water quality criteria was observed in a sample of liquid collected from the sump of a vessel carrying western coal. The sample exceeded the chronic water quality criterion for pyrene by a factor of 31.4 and the aluminum criterion by a factor of 11. The third highest water quality exceedance was a liquid sample collected from a limestone vessel sump that exceeded the aluminum criterion by a factor of 10.9. These three are the only instances in which water quality criteria were exceeded by more than a factor of 10. Table 9 lists all values that exceeded the chronic water quality criteria and includes the sample analysis value (result), the chronic water criteria, and the exceedance ratio (analyte result: water criteria ratio). The results are listed by cargo type. Appendix A of the dry cargo residue discharge analysis (CH2M HILL, 2008) contains a key to the sample IDs in Table 9.

The set of more detailed sampling data for the chemical parameters that shows the highest exceedances of water quality (CH2M HILL, 2008, Appendix B) shows that only one sample had an extremely high value for pyrene. All of the liquid and solid samples that were collected exceeded pyrene water quality criteria by less than a factor of 6, except the lone sump liquid sample which exceeded criteria by a factor of 31.4. The exceedance of 31.4 does not appear to be representative of a typical sump discharge from a coal vessel. Further sampling would be required to determine a consistent average pyrene concentration in the sump liquid. If the exceedance ratio of 31.4 is discarded as an outlier, then all liquids that were sampled would be within a factor of 11 of the chronic water quality criteria.

To compare the dry deck DCR with the sump slurry, the dry deck DCR was mixed with lake water. This mixture of dry deck DCR and lake water simulated the slurry that is washed overboard during discharge events. Tables 8 and 9 show that the sump slurries had greater chemical parameter concentrations and a greater number of water quality criteria exceedances than did the deck DCR slurries. The deck DCR that are washed overboard have less contact time with water and are more distributed and dilute than the sump slurry discharge.

Mixing Zone Regulations Review

The water quality data obtained from sampling liquid from cargo vessel sumps and from mixing DCR with lake water showed that, for the most part, the discharged liquid meets water quality criteria. Water quality criteria are met when the exceedance ratio is less than 1.0. However, Table 9 shows that there are 30 instances when chronic water quality criteria were exceeded and eight instances for which acute water quality criteria were exceeded during Phase I. There are only three instances in which chronic water quality criteria were exceeded by more than a factor of 10. The highest exceedance of acute water quality criteria was by a factor of 1.9 (see Chemical Analysis Review). The dilution factor is a parameter that determines, for a specific sample, how much dilution would be necessary to reach the acceptable water quality criteria. EPA guidelines allow dilution factors of 10 as a default value for most discharges to surface water (EPA, 1991). The Great Lake Initiative allows dilution factors of 10 or greater (EPA, 2005).

TABLE 8
Exceedance Ratios

						Taconite				Eastern Coal				Western Coal				Limestone			
						Deck DCR		Sump		Deck DCR		Sump		Deck DCR		Sump		Deck DCR		Sump	
Analyte	Chronic Water Quality Criteria	Acute Water Quality Criteria	Units	Sediment Criteria	Units	Solids	Liquid	Solids	Liquid	Solids	Liquid	Solids	Liquid	Solids	Liquid	Solids	Liquid	Solids	Liquid	Solids	Liquid
Aluminum	0.087	0.750	mg/L	—	—	—	—	—	—	—	7.4	—	—	—	6.2	—	**11**	—	—	—	**10.9**
Anthracene	0.73	13	µg/L	57.2	µg/kg	—	—	—	—	—	—	—	—	1.5	—	—	—	—	—	—	—
Arsenic	0.15	0.34	mg/L	9.79	mg/kg	—	—	—	—	1.3	—	—	—	—	—	3.0	—	—	—	—	—
Benzo(a)anthracene	0.027	0.49	µg/L	108	µg/kg	—	—	—	—	1.4	—	—	—	1.2	—	—	3.4	—	—	—	—
Benzo(a)pyrene	0.014	0.24	µg/L	—	—	—	—	—	—	—	1.4	—	—	—	1.4	—	2.6	—	—	—	—
Cadmium	0.00025	0.0045	mg/L	0.99	mg/kg	—	—	—	2.4	—	—	—	—	—	—	1.1	—	—	—	—	8.9
Cadmium, dissolved	0.00021	0.00384	mg/L	—	—	—	—	—	1.8	—	—	—	—	—	—	—	—	—	—	—	7.2
Chromium	0.011	0.016	mg/L	43.4	mg/kg	—	—	—	—	—	—	—	—	—	—	4.9	—	—	—	—	—
Chrysene	0.014	0.24	µg/L	166	µg/kg	—	—	—		1.7	3.6	—	—	—	1.4	—	7.1	—	—	—	—
Copper	0.009	0.014	mg/L	31.6	mg/kg	—	—	—	**2.9**	—	—	—	—	—	—	**61.4**[a]	—	—	—	—	**1.5**
Copper, dissolved	0.009	0.013	mg/L	—	—	—	—	—	**2.2**	—	—	—	—	—	—	—	—	—	—	—	1.4
Fluoranthene	6.16	33.6	µg/L	480	µg/kg	—	—	—	—	—	—	—	—	1.1	—	—	—	—	—	—	—
Fluorene	3.9	70	µg/L	180	µg/kg	—	—	—	—	2.3	—	—	—	—	—	—	—	—	—	—	—
Iron	1.000	—	mg/L	—	—	—	1.3	—	6.2	—	—	—	—	—	—	—	9.8	—	—	—	1.6
Lead	0.003	0.082	mg/L	35.8	mg/kg	—	—	—	2.3	—	—	—	—	—	—	6.6	—	—	—	—	2.5
Lead, dissolved	0.003	0.065	mg/L	—	—	—	—	—	1.2	—	—	—	—	—	—	—	—	—	—	—	1.2
Naphthalene	12	190	µg/L	176	µg/kg	—	—	—	—	17.6	—	—	—	2.0	—	—	—	—	—	—	—
Nickel	0.052	0.47	mg/L	22.7	mg/kg	—	—	—	—	1.0	—	—	—	—	—	5.2	—	—	—	—	—
Phenanthrene	6.3	30	µg/L	204	µg/kg	—	—	—	—	4.6	—	—	—	1.4	—	—	—	—	—	—	—
Pyrene	0.014	0.24	µg/L	195	µg/kg	—	—	—	—	1.6	3.2	—	—	3.7	5.6	—	**31.4**	—	—	—	—
Selenium	0.005	0.024	mg/L	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1.9
Selenium, dissolved	0.005	0.022	mg/L	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2.4
Zinc	0.120	0.120	mg/L	121	mg/kg	—	—	—	1.2	2.4	—	—	—	—	—	1.7	—	—	—	—	1.6

Note: **Bold** numbers also exceed acute water quality criteria.
[a]The value of copper is not representative of the typical copper values and is most likely due to contamination from foreign objects.

TABLE 9
Samples That Exceeded Chronic Water Quality Standards

Cargo	Vessel Name	Sample ID	Analyte	Result	Units	Water Chronic Criteria	Water Acute Criteria	Matrix	Exceedance Ratio (with chronic criteria)
Limestone	Earl W. Oglebay	CLELV2-LS-1	Cadmium	0.0022	mg/L	0.000246	0.0045	Water	8.9
Limestone	Earl W. Oglebay	CLELV2-LS-1	Cadmium, dissolved	0.0015	mg/L	0.000209	0.00384	Water	7.2
Limestone	Earl W. Oglebay	CLELV2-LS-1	Copper	0.0139	mg/L	0.0093	0.014	Water	1.5
Limestone	Earl W. Oglebay	CLELV2-LS-1	Iron	1.49	mg/L	1		Water	1.5
Limestone	Earl W. Oglebay	CLELV2-LS-1	Lead	0.0079	mg/L	0.0032	0.082	Water	2.5
Limestone	Earl W. Oglebay	CLELV2-LS-1	Lead, dissolved	0.0030	mg/L	0.0025	0.065	Water	1.2
Limestone	Earl W. Oglebay	CLELV2-LS-1	Selenium	0.0093	mg/L	0.005	0.024	Water	1.9
Limestone	Earl W. Oglebay	CLELV2-LS-1	Selenium, dissolved	0.0109	mg/L	0.0046	0.022	Water	2.4
Limestone	Earl W. Oglebay	CLELV2-LS-1	Zinc	0.191	mg/L	0.12	0.12	Water	1.6
Limestone	PathFinder	CLELV1-LS-1	Aluminum	0.951	mg/L	0.087	0.75	Water	10.9
Limestone	PathFinder	CLELV1-LS-1	Iron	1.60	mg/L	1		Water	1.6
Limestone	PathFinder	CLELV1-LS-1-D	Copper, dissolved	0.0130	mg/L	0.009	0.013	Water	1.4
Limestone	PathFinder	CLELV1-LS-1-D	Iron	1.52	mg/L	1		Water	1.5
Taconite	Edwin R. Gott	DLHTV1-LS-1	Cadmium	0.00059	mg/L	0.000246	0.0045	Water	2.4
Taconite	Edwin R. Gott	DLHTV1-LS-1	Cadmium, dissolved	0.00037	mg/L	0.000209	0.00384	Water	1.8
Taconite	Edwin R. Gott	DLHTV1-LS-1	Copper	0.0271	mg/L	0.0093	0.014	Water	2.9
Taconite	Edwin R. Gott	DLHTV1-LS-1	Copper, dissolved	0.0198	mg/L	0.009	0.013	Water	2.2
Taconite	Edwin R. Gott	DLHTV1-LS-1	Iron	6.22	mg/L	1		Water	6.2
Taconite	Edwin R. Gott	DLHTV1-LS-1	Lead	0.0075	mg/L	0.0032	0.082	Water	2.3
Taconite	Edwin R. Gott	DLHTV1-LS-1	Lead, dissolved	0.0029	mg/L	0.0025	0.065	Water	1.2

TABLE 9
Samples That Exceeded Chronic Water Quality Standards

Cargo	Vessel Name	Sample ID	Analyte	Result	Units	Water Chronic Criteria	Water Acute Criteria	Matrix	Exceedance Ratio (with chronic criteria)
Taconite	Edwin R. Gott	DLHTV1-LS-1	Zinc	0.143	mg/L	0.12	0.12	Water	1.2
W. Coal	American Integrity	DLHCV2-LS-1	Aluminum	0.955	mg/L	0.087	0.75	Water	11
W. Coal	American Integrity	DLHCV2-LS-1	Benzo(a)anthracene	0.091	µg/L	0.027	0.49	Water	3.4
W. Coal	American Integrity	DLHCV2-LS-1	Benzo(a)pyrene	0.037	µg/L	0.014	0.24	Water	2.6
W. Coal	American Integrity	DLHCV2-LS-1	Chrysene	0.10	µg/L	0.014	0.24	Water	7.1
W. Coal	American Integrity	DLHCV2-LS-1	Iron	9.79	mg/L	1		Water	9.8
W. Coal	American Integrity	DLHCV2-LS-1	Pyrene	0.44	µg/L	0.014	0.24	Water	31.4
W. Coal	American Spirit	DLHCV1-LS-1	Pyrene	0.047	µg/L	0.014	0.24	Water	3.4
W. Coal	American Spirit	DLHCV1-LS-1-D	Pyrene	0.048	µg/L	0.014	0.24	Water	3.4
W. Coal	American Spirit	DLHCV1-LS-1RE	Pyrene	0.023	µg/L	0.014	0.24	Water	1.6

The Technical Support Document for Water Quality-Based Toxics Control (TSD) (U.S. EPA 1991) published by the EPA provides states and regions with guidance for analyzing adverse water quality impacts caused by toxic discharges to the surface waters of the United States.

The EPA TSD states that it is not always necessary to meet all water quality criteria within the discharge pipe to protect the integrity of the water body as a whole. Regulatory agencies generally allow small areas, known as mixing zones, near outfalls to exceed water quality criteria. The EPA TSD also states that acute criteria may be exceeded if an analysis indicates that organisms drifting through the plume along the path of maximum exposure would not be exposed to concentrations exceeding the acute criteria when averaged over 1-hour (or appropriate site-specific) averaging period for acute criteria. Then, lethality to swimming or drifting organisms ordinarily should not be expected even for rather fast-acting toxicants. The EPA TSD states that if a drifting organism travels through a plume for less than 15 minutes, a 1-hour average exposure would not be expected to exceed the acute criterion. Significant dilution due to wake turbulence is expected to occur in less than 15 minutes (Alaska DEC 2001) ensuring that DCR discharges will not exceed acute criteria and will not cause lethality to passing organisms.

Most states allow mixing zones but provide spatial dimensions to limit their size. Mixing zones for lakes are usually specified by surface area, width, cross-sectional area, and volume. The EPA TSD provides four methods to determine appropriate regulations to ensure that discharged liquid that exceeds acute water quality criteria will not cause lethality to aquatic organisms.

1. Meet acute water quality criteria prior to discharge.
2. Discharge liquid at a velocity of 3 m/s or greater, and establish a regulatory mixing zone spatial limitation of 50 times the discharge length scale (square root of the cross-sectional area of the discharge pipe).
3. Meet the most restrictive of the following:
   a. Meet the acute water quality criteria within 10 percent of the distance of the outfall to the edge of the specified regulatory mixing zone.
   b. Meet the acute water quality criteria within a distance of 50 times the discharge length scale in any spatial direction. This restriction will ensure a dilution factor of at least 10 within this distance.
   c. The acute water quality criteria within a distance of five times the local water depth in any horizontal direction from the outfall.
4. Provide data to the state regulatory agency showing that a drifting organism would not be exposed to 1-hour average concentrations exceeding the acute water quality criteria.

DCR discharge is performed while the vessel is under way. Typical ship speeds are around 12 knots, or 6 m/s (Great Lakes 2007). DCR discharges fall and accelerate due to gravity before entering the water. Assuming discharged DCR fall 16 feet (5 m), the discharged liquid will have a downward velocity of 32 feet per second (9.8 meters per second) immediately before entering the water.

The relative infrequency of criteria exceedance, coupled with the intense dilution expected because of the momentum of the discharged liquid, will ensure that discharged liquid is diluted to a concentration below acute water quality criteria almost instantaneously, and no aquatic life will be exposed to lethal concentrations.

The Great Lakes Initiative (GLI) (U.S. EPA 2005) also provides guidance on mixing zones. It allows mixing zones if the discharger can demonstrate the following:

1. Show that the mixing zone does not interfere with or block passage of fish or aquatic life
2. Show that the mixing zone will be allowed only to the extent that the level of the pollutant permitted in the water body would not likely jeopardize the continued existence of any endangered or threatened species listed under section 4 of the ESA or result in the destruction or adverse modification of such species' critical habitat
3. Show that the mixing zone does not extend to drinking water intakes
4. Show that the mixing zone would not otherwise interfere with the designated or existing uses of the receiving water or downstream waters
5. Show that the mixing zone does not promote undesirable aquatic life or result in a dominance of nuisance species
6. Provide that by allowing additional mixing/dilution substances will not settle to form objectionable deposits; floating debris, oil, scum, and other matter in concentrations that form nuisances will not be produced; and objectionable color, odor, taste or turbidity will not be produced

Because of the relatively benign discharge characteristics (see Chemical Analysis Review), small quantities, and highly dispersed and rapidly mixed nature of the discharges, it is reasonable to believe that DCR discharges meet all the above criteria provided by the GLI, with one possible exception. Depending on the definition of “objectionable deposits,” the DCR discharges may meet the criteria stated in item 6. However, the DCR discharges should not be considered “objectionable” because they are relatively benign materials and are dispersed in small amounts over vast areas of the lake. These deposits are released in such small quantities that natural sedimentation processes are able to dilute the deposits to concentrations below sediment criteria (see Sediment Quality Analysis, below).

Sediment Quality

DCR samples were collected from the decks and sumps of vessels carrying coal, taconite, and limestone. The samples were evaluated for chemical concentrations in the DCR discharge characterization technical memorandum (CH2M HILL, 2007a)), which is included in the dry cargo residue discharge analysis (CH2M HILL, 2008, Appendix C). The data obtained from the chemical analysis were compared directly to sediment guideline values. There are no separate parameters for chronic and acute contaminants. The measured values and sediment criteria for each analyte are listed in Table 10.

TABLE 10
Samples That Exceeded Sediment Criteria

Cargo	Vessel Name	Field ID	Analyte	Result	Units	Sediment Criteria	Matrix	Exceedance Ratio
E. Coal	American Courage	CLECV3-DS-1	Arsenic	11.3	mg/kg	9.79	SOIL	1.2
E. Coal	American Courage	CLECV3-DS-1	Chrysene	290	µg/kg	166	SOIL	1.7
E. Coal	American Courage	CLECV3-DS-1	Naphthalene	400	µg/kg	176	SOIL	2.3
E. Coal	American Courage	CLECV3-DS-1	Phenanthrene	580	µg/kg	204	SOIL	2.8
E. Coal	American Courage	CLECV3-DS-1-D	Arsenic	12.4	mg/kg	9.79	SOIL	1.3
E. Coal	American Courage	CLECV3-DS-1-D	Chrysene	240	µg/kg	166	SOIL	1.4
E. Coal	American Courage	CLECV3-DS-1-D	Naphthalene	430	µg/kg	176	SOIL	2.4
E. Coal	American Courage	CLECV3-DS-1-D	Nickel	23.2	mg/kg	22.7	SOIL	1.0
E. Coal	American Courage	CLECV3-DS-1-D	Phenanthrene	630	µg/kg	204	SOIL	3.1
E. Coal	American Courage	CLECV3-DS-1-D	Pyrene	200	µg/kg	195	SOIL	1.0
E. Coal	American Courage	CLECV3-DS-1-D	Zinc	295	mg/kg	121	SOIL	2.4
E. Coal	American Courage	CLECV3-DS-1DL	Chrysene	170	µg/kg	166	SOIL	1.0
E. Coal	American Courage	CLECV3-DS-1DL	Naphthalene	270	µg/kg	176	SOIL	1.5
E. Coal	American Courage	CLECV3-DS-1DL	Phenanthrene	420	µg/kg	204	SOIL	2.1
E. Coal	American Courage	CLECV3-DS-1DL	Pyrene	310	µg/kg	195	SOIL	1.6
E. Coal	American Republic	CLECV4-DS-1	Benzo(a)anthracene	150	µg/kg	108	SOIL	1.4
E. Coal	American Republic	CLECV4-DS-1	Chrysene	180	µg/kg	166	SOIL	1.1
E. Coal	American Republic	CLECV4-DS-1	Fluorene	180	µg/kg	77.4	SOIL	2.3
E. Coal	American Republic	CLECV4-DS-1	Naphthalene	3100	µg/kg	176	SOIL	17.6
E. Coal	American Republic	CLECV4-DS-1	Phenanthrene	930	µg/kg	204	SOIL	4.6
E. Coal	American Republic	CLECV4-DS-1	Pyrene	280	µg/kg	195	SOIL	1.4
W. Coal	American Integrity	DLHCV2-DS-1	Anthracene	88	µg/kg	57.2	SOIL	1.5
W. Coal	American Integrity	DLHCV2-DS-1	Benzo(a)anthracene	110	µg/kg	108	SOIL	1.0
W. Coal	American Integrity	DLHCV2-DS-1	Fluoranthene	480	µg/kg	423	SOIL	1.1
W. Coal	American Integrity	DLHCV2-DS-1	Naphthalene	360	µg/kg	176	SOIL	2.0

TABLE 10
Samples That Exceeded Sediment Criteria

Cargo	Vessel Name	Field ID	Analyte	Result	Units	Sediment Criteria	Matrix	Exceedance Ratio
W. Coal	American Integrity	DLHCV2-DS-1	Phenanthrene	220	µg/kg	204	SOIL	1.1
W. Coal	American Integrity	DLHCV2-DS-1	Pyrene	720	µg/kg	195	SOIL	3.7
W. Coal	American Spirit	DLHCV1-DS-1	Anthracene	72	µg/kg	57.2	SOIL	1.3
W. Coal	American Spirit	DLHCV1-DS-1	Phenanthrene	210	µg/kg	204	SOIL	1.0
W. Coal	American Spirit	DLHCV1-DS-1	Pyrene	380	µg/kg	195	SOIL	1.9
W. Coal	American Spirit	DLHCV1-DS-1-D	Anthracene	79	µg/kg	57.2	SOIL	1.4
W. Coal	American Spirit	DLHCV1-DS-1-D	Benzo(a)anthracene	130	µg/kg	108	SOIL	1.2
W. Coal	American Spirit	DLHCV1-DS-1-D	Phenanthrene	280	µg/kg	204	SOIL	1.4
W. Coal	American Spirit	DLHCV1-DS-1-D	Pyrene	670	µg/kg	195	SOIL	3.4
W. Coal	American Spirit	DLHCV1-SS-1	Arsenic	19.0	mg/kg	9.79	SOIL	1.9
W. Coal	American Spirit	DLHCV1-SS-1	Chromium	206	mg/kg	43.4	SOIL	4.7
W. Coal	American Spirit	DLHCV1-SS-1	Copper	135	mg/kg	31.6	SOIL	4.3
W. Coal	American Spirit	DLHCV1-SS-1	Nickel	94.5	mg/kg	22.7	SOIL	4.2
W. Coal	American Spirit	DLHCV1-SS-1-D	Arsenic	23.5	mg/kg	9.79	SOIL	2.4
W. Coal	American Spirit	DLHCV1-SS-1-D	Cadmium	1.11	mg/kg	0.99	SOIL	1.1
W. Coal	American Spirit	DLHCV1-SS-1-D	Chromium	213	mg/kg	43.4	SOIL	4.9
W. Coal	American Spirit	DLHCV1-SS-1-D	Copper	1540	mg/kg	31.6	SOIL	48.7
W. Coal	American Spirit	DLHCV1-SS-1-D	Lead	237	mg/kg	35.8	SOIL	6.6
W. Coal	American Spirit	DLHCV1-SS-1-D	Nickel	111	mg/kg	22.7	SOIL	4.9
W. Coal	American Spirit	DLHCV1-SS-1-D	Zinc	201	mg/kg	121	SOIL	1.7
W. Coal	American Spirit	DLHCV1-SS-2	Arsenic	28.9	mg/kg	9.79	SOIL	3.0
W. Coal	American Spirit	DLHCV1-SS-2	Chromium	144	mg/kg	43.4	SOIL	3.3
W. Coal	American Spirit	DLHCV1-SS-2	Copper	1940	mg/kg	31.6	SOIL	61.4
W. Coal	American Spirit	DLHCV1-SS-2	Lead	91.6	mg/kg	35.8	SOIL	2.6
W. Coal	American Spirit	DLHCV1-SS-2	Nickel	119	mg/kg	22.7	SOIL	5.2

Sample Analysis

Chemical analysis of the solid DCR obtained from the sumps and decks of various ships showed that only the coal DCR exceeded sediment criteria. The results of the chemical analysis for sediment samples are shown in Table 10. Chemical concentrations in the taconite and limestone DCR were below the sediment criteria for all analytes. As previously shown in Table 8, the highest exceedance of sediment criteria was in a sample of sump solids obtained from a vessel hauling western coal. This sample exceeded the copper sediment criteria by a factor of 61.4. Table 10 provides more details for the samples that exceeded sediment criteria. A key to the sample IDs in Table 10 is provided in Appendix A of the dry cargo residue discharge analysis (CH2M HILL, 2008).

Most of the sediment exceedances were found in samples of coal deck DCR for polycyclic aromatic hydrocarbons (PAHs) such as naphthalene and chrysene. PAHs are organic compounds formed primarily by incomplete combustion of carbon-containing fuels such as coal. The deck DCR from all four coal vessels had sample results that exceeded the benchmark criteria for PAHs. The highest exceedance ratio was in a sample of deck DCR from an eastern coal vessel (CV4) that exceeded the naphthalene criteria by a factor of 17.6.

As seen in Table 10, there were only three instances in which a DCR solids sample exceeded the sediment criteria by more than a factor of 10. Two of the values were copper samples collected from two different sumps on the same western coal vessel (CV1). The third exceedance was the naphthalene exceedance on CV4. The two copper exceedances are not representative of typical DCR discharges. The samples of sump solids from CV1 appear to be high in overall metals because of the potential inclusion of foreign metallic objects. CV1 exceeded several metals criteria including cadmium, chromium, and copper while samples of sump and deck solids from the other three vessels did not exceed any metals criteria (CH2M HILL, 2008, Appendix D). All other sediment exceedances were found in samples of deck DCR (Table 10). Additional chemical parameters that had the highest sediment exceedance ratios are documented in Appendix D of the dry cargo residue discharge analysis (CH2M HILL, 2008).

In addition to the high copper values that were found in some sump samples, Table 10 indicates that the naphthalene exceedance ratio of 17.6 on CV4 is atypical. The naphthalene concentrations on other coal vessels all had exceedance ratios less than 2.6.

Modeling Parameters

To provide a representative chemical parameter value for the sediment analysis, an average value was used to calculate the exceedance ratio and dilution factor. The dilution factor is a comparison of the concentrations (based on mass balance) to determine the amount of clean sediment that would need to be added to the sample so that the sediment and DCR mixture meets the sediment criteria. The dilution factor is based on mass balance and is defined as:

$$\text{Dilution Factor} = (C_d - C)/(C - C_s)$$

Where:

C_d = Concentration of Parameter in DCR (mg/kg)

C_s = Concentration of Parameter in Sediment (mg/kg)

C = Desired Concentration (mg/kg)

The average recorded sample values were used to determine which parameter had the largest exceedance factor. This parameter, along with the calculated dilution factor was used in the sediment dilution modeling. Table 11 summarizes the average recorded sample values. The values were broken into two subsets, one for the deck DCR samples and one for the sump solid samples. Some chemical parameters were not found in both types of samples and are therefore marked "n/a."

TABLE 11
Average Values of Sample Results and Average Exceedance Ratios

	Average Result				Exceedance Ratio	
Analyte	Deck DCR	Sump Solids	Solids Criteria	Units	Deck DCR	Sump Solids
Anthracene	87.9	n/a	57.2	µg/kg	1.54	n/a
Arsenic	11.6	22.6	9.79	mg/kg	1.19	2.31
Benzo(a)anthracene	126.3	n/a	108	µg/kg	1.17	n/a
Cadmium	n/a	1.1	0.99	mg/kg	n/a	1.12
Chromium	n/a	181.3	43.4	mg/kg	n/a	4.18
Chrysene	233.3	n/a	166	µg/kg	1.41	n/a
Copper	n/a	931.8	31.6	mg/kg	n/a	29.49
Dibenz(a,h)anthracene	38.0	n/a	33	µg/kg	1.15	n/a
Fluoranthene	480.0	n/a	423	µg/kg	1.13	n/a
Fluorene	133.0	n/a	77.4	µg/kg	1.72	n/a
Lead	n/a	177.2	35.8	mg/kg	n/a	4.95
Mercury	0.3	n/a	0.18	mg/kg	1.71	n/a
Naphthalene	637.8	n/a	176	µg/kg	3.62	n/a
Nickel	25.4	99.1	22.7	mg/kg	1.12	4.36
Phenanthrene	417.5	n/a	204	µg/kg	2.05	n/a
Pyrene	487.3	n/a	195	µg/kg	2.50	n/a
Zinc	295.0	299.0	121	mg/kg	2.44	2.47

As previously noted, the samples from one sump contained metal results unrepresentative of DCR, and consequently, the metal values from that sump were not included in the analysis. The next highest average exceedance ratio was for naphthalene, and so naphthalene was selected as the main chemical of concern. The average naphthalene concentration was 637.8 µg/kg, which exceeded the sediment criterion of 176 µg/kg by a factor 3.6. The average naphthalene value along with the sediment quality criteria was used to determine the dilution factor. The calculated dilution factor, 2.62, was then used in the above equation to determine the mass of sediment required to dilute coal DCR to meet sediment criteria.

Modeling Results

Water Quality Analysis—Vessels Underway

The greatest dilution required to meet water quality criteria for any DCR discharge was that of the sump containing coal. The coal sump slurry concentration of 0.44 µg/L of pyrene was 31.4 times greater than the chronic water quality criterion of 0.014 µg/L, but this concentration was atypical.

Generally most chemical concentrations were within a factor of 10 of the chronic water quality criteria (see Chemical Analysis Review).

The Simple Dilution Model was used to predict chemical parameter concentrations in the water column due to DCR discharges (Table 12). The mass of discharged deck DCR was taken as the average discharge obtained from the direct observations (CH2M HILL, 2009). Discharge volumes of deck DCR were then calculated based on ratios of water to deck DCR (CH2M HILL, 2007a). Because the sweepings slurry simulation technical memorandum (CH2M HILL, 2007a) had utilized an average mass of DCR material from decks, an adjustment was made to account for potentially higher concentrations associated with higher average DCR volumes as documented in the direct observations. The ratio of the average DCR in the Phase I analysis to the average DCR material from direct observations determined the adjustment factor (Table 6).

The largest sump on the studied coal vessels was roughly 12 yd^3 (2,424 gallons) and the largest sump on the studied taconite vessels was 1.2 yd^3 (242 gallons). The sample from the limestone sumps did not show any water quality exceedances; therefore, dilution is not required to discharge this material. Volumes larger than the sump volume are also discharged when the tunnels are flooded during washdown events. Discharge rates are limited by sump pump capacity. The discharge rate of the sump slurry was assumed to be equal to 400 gpm. Data from the 2009 direct observations indicated that volume of DCR material in the tunnel sumps is higher than what was utilized during Phase I (CH2M HILL, 2009). However, the limiting factor for discharging material from the tunnel is the sump pumping rate. No information gained during the 2009 direct observations indicated that the 400 gpm sump discharge rate was inaccurate. Consequently, the revised tunnel sump discharge analysis will produce the same dilution factors as Phase I.

The Simple Dilution Model requires the following inputs:

- Vessel draft
- Vessel width (beam)
- Vessel speed
- Discharge flow rate

The draft was assumed 10 feet (3 m) for an empty vessel. This is a very conservative assumption as the draft of a fully loaded ship is generally 30 feet (9.1 m). The width of the vessel is assumed 68 feet (20.7 m), which is the width of the smallest vessel that was sampled. Maximum vessel speeds are around 14 to 15 knots (Great Lakes 2007). A typical cruising speed was assumed to be 12 knots during discharge, although some cargo vessels can travel at 17 knots. The entire volume of discharged material was assumed to enter the water in 10 minutes. Shorter discharge duration results in a higher discharge rate and lower dilution factor. These are very conservative estimates because the data show that discharges on average occur over 54 miles over the course of 4 hours. The discharge flow rate is calculated based on the discharge volume and duration of discharge. The discharge flow rate is then entered into the Simple Dilution Model along with vessel speed, width, and draft. Even with these conservative assumptions, the dilution factors calculated with the Simple Dilution Model ranged from 27,000 to 62,000 for the various scenarios, which are much greater than that required to meet water quality standards.

TABLE 12
Modeling Results (Water Quality)

DCR Material	Coal (Deck)	Taconite (Deck)	Limestone (Deck)	Coal (Sump)	Taconite (Sump)	Limestone (Sump)
Parameter of concern	Aluminum	Iron	No exceed-ance	Pyrene	Iron	Aluminum
Initial parameter concentration (µg/L)	641	1,250	—	0.44	6,200	951
Revised initial concentration (µg/L)	1,547	2,775				
Chronic water quality criteria (µg/L)	87	1,000	—	0.0144	1,000	87
Acute water quality criteria (µg/L)	750	—	—	—	—	—
Dilution factor required to meet criteria	7.4	1.3	—	30.6	6.22	10.9
Revised dilution factor required to meet criteria	17.8	2.8	—	—	—	—
Mass of DCR discharge (lb)	363	518	—	—	—	—
Water to DCR ratio (gal./lb)	18	18	—	—	—	—
Volume of discharge (gallons)	6,534	9,324	—	4,000	4,000	4,000
Duration of discharge (s)	600	600	—	600	600	600
Vessel speed (knots)	12	12	—	12	12	12
Vessel width (ft)	68	68	—	68	68	68
Vessel draft (ft)	10.00	10.00	—	10.00	10.00	10.00
Distance of discharge (ft)	12,152	12,152	—	12,152	12,152	12,152
Rate of DCR discharge (gpm)	653	932	—	400	400	400
Estimated dilution factor	38,000	27,000	—	62,000	62,000	62,000
Est. parameter concentration behind vessel (µg/L)	2E-02	5E-02	—	7E-06	1E-01	2E-02

Frequency of Ship Discharges

The chronic water quality criteria generally are considered the maximum allowable concentration of a chemical parameter that will not have detrimental effects on organisms that are exposed indefinitely (EPA, 1991). An analysis of shipping frequency by port was performed on 2004 DCR data (E2M, 2005) to determine the applicability of chronic water quality criteria to the DCR discharges. A summary of the number of ships arriving or departing from a port or an area of the Great Lakes in any four-day period from January 2004 through December 2006 is shown in Table 13. The maximum number of coal carrying ships was 8 from the ports of Duluth/Superior with the highest number of overall shipping being from taconite in the port of Cleveland (Table 13).

TABLE 13
Shipping Frequency by Port

	Material	Maximum Shipping Frequency[a]
Duluth/Superior	Coal	8
Duluth/Superior	Taconite	6
Duluth/Superior	Limestone	N/A
Silver Bay	Coal	1
Silver Bay	Taconite	7
Silver Bay	Limestone	N/A
Southern Lake Michigan (includes several ports)	Coal	7
Southern Lake Michigan (includes several ports)	Taconite	7
Southern Lake Michigan (includes several ports)	Limestone	2
Cleveland	Coal	1
Cleveland	Taconite	9
Cleveland	Limestone	2
Ashtabula	Coal	2
Ashtabula	Taconite	4
Ashtabula	Limestone	N/A
Marble Head/Sandusky	Coal	4
Marble Head/Sandusky	Taconite	N/A
Marble Head/Sandusky	Limestone	3

[a]Maximum number of arrivals and departures in a 4-day period.

Table 13 shows that maximum number of coal DCR discharges in a given area did not exceed eight discharges in 4 days during the 2004 shipping season. Because dilution occurs within 15 minutes and the highest frequency of ships from a port over a 4-day period is one every 12 hours, the chronic effects from these discharges are not significant.

Water Quality Analysis—Vessels in Port and Near Shore Areas

Tunnel DCR

The water quality analysis from stationary vessels in port and near shore areas assumed discharge volume and water quality parameters thought to be conservative based upon the sump and deck discharge data obtained during the Phase I EIS. The discharged volume was estimated by assuming the tunnel of the vessel contains one foot of water that must be pumped out. This water was assumed to have an Aluminum concentration that is 10.9 times greater than the water quality chronic standard. Aluminum was chosen for this analysis because Phase I data showed that Aluminum had the highest sump concentration relative to the chronic criteria, requiring dilution of 10.9 times to meet water quality chronic standards (see Table 8 in the Phase I EIS report). The discharge volume was assumed to mix with water over a surface area equal to the area of the ship. The resulting water quality was then compared with chronic criteria. The analysis indicated that the resulting water quality will not exceed the chronic criteria.

Deck DCR

For deck discharge, there were no instances of water quality exceeding chronic or acute criteria for limestone DCR (see Table 8). Consequently, no water quality impacts exceeding water quality criteria are expected from limestone deck DCR.

Water Quality Analysis Conclusions

The Simple Dilution Model has shown that significant mixing and dilution can be expected behind large moving vessels. Therefore, the chemical parameter concentrations in the DCR discharges will be rapidly diluted below water quality criteria. The discharge of DCR from a moving cargo vessel does not have any significant adverse impact on the water column because the turbulence created by the displacement of water by the massive cargo ships and the jetting caused by the large propellers mix the discharged DCR with a large amount of water in a very short time. Significant dilution factors can be expected due to this mixing within 15 minutes of discharge (Alaska DEC, 2001).

Discharge of limestone DCR from stationary vessels in port is not expected to exceed water quality criteria based upon simple dilution of DCR discharge with water from under the vessel.

Sediment Quality Analysis—Vessels Underway

The high copper and naphthalene concentrations seen in the chemical analysis data are atypical of DCR discharges. There were no limestone or taconite solids samples, from the decks and sumps of bulk dry cargo vessels, which exceeded any sediment criteria. With the exception of the CV1 sumps, which appear to have been contaminated with foreign metallic substances, the only sediment criteria exceedances occurred in coal deck DCR, which generally exceeded criteria for PAHs by a factor of less than 5. The highest average sediment exceedance was a naphthalene exceedance of 3.6 in coal deck DCR. This exceedance ratio will be used to analyze potential sediment DCR concentrations from DCR discharges (see Chemical Analysis Review). All the following sediment analyses include a safety factor of 10. The value of the safety factor was derived to protect against future increases in shipping cargo and any uncertainty with the data. A safety factor of 10 provides very conservative estimates for the calculated area required for DCR dilution. Mass data of DCR discharges were obtained from the PMG report (Potomac Management Group 2003) for the 2000–2001 shipping season and were adjusted upward by comparing the ratio of 2009 DCR direct observations with vessel DCR reporting form information.

The following three sediment analyses were performed:

- Long-term sediment impact assuming dilution of coal DCR discharges due to natural sedimentation only
- Long-term sediment impact assuming coal DCR discharges are diluted by mixing with the top 2 inches of existing sediment. Natural sedimentation rates are assumed to be negligible
- Short-term (1-year) impact due to the largest discharged mass over a conservative distance

Long-Term Sediment Analysis: Natural Sedimentation

CH2M HILL developed a spreadsheet analysis to determine the long-term impact on sediments due to the discharge of DCR in the Great Lakes. This analysis assumes that DCR discharges will be diluted only by natural sedimentation. Sedimentation rates are generally lower in the central basin because there is little suspended sediment from wind or river sources.

- **Lake Erie—**Reported sedimentation rates for Lake Erie range from 0.2 to 6.3 mm/yr (200 to 10,000 g/m^2/yr). A value of 0.3 mm/yr was chosen as a conservative estimate of natural sedimentation in areas of DCR discharge.

- **Lake Michigan—**Reported sedimentation rates for Lake Michigan range from 60 to 2,500 g/m²/yr. A value of 0.3 mm/yr (500 g/m²/yr) was chosen as an estimate of natural sedimentation in areas of DCR discharge (Eadie et al., 2000; Robbins et al., 2001).
- **Lake Superior—**Reported sedimentation rates for Lake Superior range from 25 to 3,040 g/m²/yr. Values of 0.1 to 0.3 mm/yr were reported for the central basin of Lake Superior (Baker et al., 1991; Evans et al., 1981). This report stated a maximum sedimentation rate of 3.2 mm/yr. However, Klump et al. (1989) also report some areas of Lake Superior that receive virtually zero net long-term accumulation due to seasonal bottom currents that effectively scour the bottom. A value of 0.2 mm/yr (320 g/m²/yr) was chosen as a conservative estimate of natural sedimentation in areas of DCR discharge.

A spreadsheet model was created to determine how much area would be needed when DCR is evenly distributed to dilute by natural sedimentation so as to meet the sediment criteria. The largest required area for dilution of coal occurs in Lake Superior, because the highest mass of coal is discharged in Lake Superior and because of the relatively low rate of natural sedimentation that occurs there in comparison to the other lakes. The modeling determined that in order to dilute the average observed naphthalene values, all coal DCR discharged into Lake Superior would need to be spread for 10 miles over a 6,091-feet width (1,857-meter) (Table 14) to become diluted enough to meet sediment criteria by natural sedimentation. This assumes that DCR discharge (coal) for the entire lake would be distributed uniformly over the given area.

The area determined in the analysis included the conservative safety factor of 10. In reality, coal DCR are spread over an area much larger than 11.5 square miles (10 miles long by 6,091 feet wide) (see CH2M HILL, 2008, Appendix E); therefore the concentration of naphthalene in the sediments is much less than the sediment criterion of 176 mg/kg. Figures E-1, E-2, and E-3 show study areas that are about 1 mile wide (S D Mackey, 2006). The figures show tracklines for documented DCR discharges to the Great Lakes. It is clear that the DCR discharges are spread out over an area much larger than 11.5 square miles.

Also, some mixing of coal DCR with existing sediments can be expected, which would further reduce the concentration of naphthalene. The analysis is representative of a long-term (100-year) period in which the DCR evenly mix with naturally depositing sediment in a steady state condition. The analysis assumed discharge rates representative of 2000–2001 data (Potomac Management Group 2003) and adjusted to account for differences in DCR 2009 direct observations and Phase I data (Table 14), as well as a safety factor of 10. The factor of safety ensured a conservative value which accounts for uncertainty in future coal hauling trends and data uncertainty. It also assumes that the naturally depositing sediment has a chemical parameter concentration of zero.

Lake Erie has the largest impact because of coal DCR relative to its surface area. However, the required deposition area is only about 0.072 percent of the total surface area of Lake Erie, indicating that the discharge of coal DCR does not have a significant impact on the Lake.

TABLE 14
Sediment Analysis: Natural Sedimentation

	Total Coal Discharged (lb/yr)	Mass of Sediment Required for Dilution (lb/yr)	Deposition Area Reqd. for Dilution with Safety Factor (m^2)	% of Total Lake Area with Safety Factor	Width Reqd. for a 10-Mile-Long Discharge Zone (m)
Lake Erie	775,830	2,035,672	18,506,110	0.07188	1,150
Lake Michigan	400,665	1,051,290	9,557,185	0.01647	594
Lake Superior	801,865	2,103,984	29,886,142	0.03626	1,857

Notes: Mass of discharged coal data (2000-2001) obtained from PMG report (Potomac Management Group 2003). Updated calculations include increasing the DCR mass by a ratio of 5 due to the mass of coal from the direct observations being on average 5 times larger than the data used in Phase I.

Long-Term Sediment Analysis: Mixing with Existing Sediments

DCR discharges can slowly mix over time with existing sediments. The mechanisms that can induce mixing include the movement of organisms that live in or near the top 2 inches of existing sediment and possible strong currents due to storms or density currents.

If a sample of the top 2 inches of sediment (conservatively, the most biologically active) (EPA 2001) is collected, only a small fraction of this sample will contain DCR and the average concentration of DCR that aquatic organisms experience within this biologically active zone will meet sediment criteria. Even if there is no sediment and DCR mixing, the composite of the biologically active zone will not exceed sediment criteria. The DCR discharges should have little effect on organisms living in the top 2 inches of sediments. Klump et al. hypothesize that in some cases storms during isothermal conditions generate sufficient bottom currents at depth to scour the bottom very effectively.

A spreadsheet model was created to determine how much area would be needed to dilute the DCR chemical parameter by mixing with existing sediment to meet the sediment criterion. The analysis assumes the existing sediment is clean and has a chemical parameter concentration of zero. The largest required area for dilution of coal occurs in Lake Superior because it has the highest value of coal discharged. The modeling analysis simulated all the coal, discharged over 100 years in Lake Superior, evenly distributed over one location. From the modeling results, in order to dilute the highest average DCR chemical parameter (naphthalene), coal DCR would need to be spread for 10 miles over a 731-meter width (4.5 square miles) (Table 15) to become diluted enough to meet the sediment criterion.

In reality, coal DCR is spread over an area much larger than 4.5 square miles (see CH2M HILL, 2008,Appendix E); therefore, the concentration of naphthalene in the sediments is much less than the sediment criterion of 176 mg/kg. Figures E-1, E-2, and E-3 (CH2M HILL, 2008,Appendix E) show study areas in yellow that are generally about 1 mile wide (S D Mackey, 2006). The figures show tracklines for documented DCR discharges to the Great Lakes.

The analysis assumed a 100-year period of DCR discharge at discharge rates representative of 2000–2001 data (Potomac Management Group 2003) (Table 15) updated with a ratio of 5 to reflect potentially higher historical DCR discharge when comparing the DCR direct observations to historical results. The analysis also includes a factor of safety of 10 to account for uncertainty in future coal hauling trends, data uncertainty, and to be conservative.

Lake Erie has the largest impact from coal DCR relative to its surface area. However, the required deposition area is only about 0.04 percent of the total surface area of Lake Erie, indicating that the discharge of coal DCR does not have a significant impact on the lake.

TABLE 15
Sediment Analysis: Mixing with Existing Sediment

	Total Coal Discharged Over 100 yr (lb)	Mass of Sediment Required for Dilution (lb)	Area of Sediment Required for Dilution (m^2)	% of Total Lake Area	Width Required for a 10-Mile-Long Discharge Zone (m)
Lake Erie	77,583,000	203,567,213	11,384,172	0.04422	707
Lake Michigan	40,066,500	105,129,032	5,879,174	0.01013	365
Lake Superior	80,186,500	210,398,441	11,766,198	0.01428	731

Note: Updated calculations include a ratio of 5 due to the mass of coal from the direct observations being 5 times larger than the data used in Phase I.

Short-Term Sediment Analysis: Single Worst Discharge

A spreadsheet model was used to determine the area needed to dilute the single largest discharge of coal by natural sedimentation. A single large discharge of coal was taken as 586 lb/mile, which is the 95th percentile (that is, only 5 percent of discharges were denser) of all the coal DCR discharges in the reviewed 2008 vessel DCR report form data (see DCR Discharge Data). The largest required area for dilution of coal occurs in Lake Superior because of the relatively low rate of sedimentation. The modeling determined that to dilute the highest chemical parameter concentration (naphthalene) by natural sedimentation over the course of 1 year, the discharge of 586 pounds would need to be spread for 1 mile over a 44.5 feet (13.6 meter) width (Table 16) to be diluted enough to meet sediment criteria through 1 year of natural sediment deposition. This assumes that the DCR discharge (coal) would be distributed uniformly over the given area and that no other DCR discharges will settle on the same location for 1 year. It also assumes that the naturally depositing sediment has a chemical parameter concentration of zero.

TABLE 16
Sediment Analysis: 95th Percentile Single Discharge (Natural Sedimentation)

Parameter	Value
Parameter of concern	Naphthalene
Parameter concentration (mg/kg)	638
Sediment quality criteria (mg/kg)	176
Lake Erie sedimentation rate ($g/m^2/yr$)	500
Lake Michigan sedimentation rate ($g/m^2/yr$)	500
Lake Superior sedimentation rate ($g/m^2/yr$)	320
Mass of coal deck discharge (lb)	586
Safety factor	10
Length of discharge (miles)	1
Width required for 1-mile-long depositional zone—Lake Erie (m)	8.7
Width required for 1-mile-long depositional zone—Lake Michigan (m)	8.7
Width required for 1-mile-long depositional zone—Lake Superior (m)	13.6

In reality, coal DCR is spread over an area much wider than 44.5 feet (13.6 m). Figures E-1, E-2, and E-3 show study areas that are generally about 1 mile wide (S D Mackey, 2006). The figures show tracklines for documented DCR discharges to the Great Lakes.

This analysis assumes that the discharged coal DCR is uniformly distributed along the entire length of DCR discharge because of a lack of more specific information on the discharge. It is unlikely that the DCR will be distributed uniformly along the entire length for a single DCR discharge event; rather, there will be lengths with no discharge at all, and other segments with large discharges. However, a safety factor of 10 was included in the analysis to account for this uncertainty and others.

It is reasonable to believe that the coal discharges would in fact spread out more than 44.5 feet (13.6 m) in width, because the turbulent mixing zone created behind a moving cargo vessel is likely greater than the vessel's width (65.6 to 98 feet or 20 to 30 m). In fact, studies suggest that mixing turbulence behind a moving vessel occurs in a vertical area 2.5 times the vessel width and 3 times the draft (Loehr et al., 2003). Coal is light with a specific gravity not much different from water and, therefore, may have a tendency to become entrained in the turbulent mixing zone behind the moving vessel and become distributed uniformly across a 98-foot (30-meter) width or larger. However, larger chunks of coal have higher settling velocities and may not become entrained. Overall, the DCR coal discharge would be expected to be at least 44.5 feet (13.6 m) wide.

At a speed of 12 knots (20 ft/s), a coal particle discharged at the midpoint of the ship would be at its stern within 25 seconds assuming it is 1,000 feet (305 m) long. If it is assumed that a particle that has fallen 15 feet (4.6 m) or less within 25 seconds would become entrained and mixed in the turbulent mixing zone behind the vessel, the particles with settling velocities less than 0.6 ft/s (0.183 m/s) would become entrained. Grain size data are available for the solids samples that were collected for the sweepings characterization memorandum (CH2M HILL, 2007a). Table F-3 of Appendix F (CH2M HILL, 2008) shows that all but the three largest grain sizes of coal settle at a velocity less than or equal to 0.2 m/s. More than 85 percent of the mass of Eastern Coal deck DCR and more than 75 percent of the mass of Western Coal deck DCR settles at less than 0.2 m/s. However, about 60 percent of the mass of the Western Coal sump solids has settling velocities greater than 0.2 m/s. Consequently, a significant percentage of the coal DCR material would be dispersed across an area equal to or greater than the width of the ship wake-generated mixing zone.

Sediment Quality Analysis—Vessels in Port and Nearshore Areas

Limestone DCR is the only material that can be discharged in port and near shore areas under the interim rule. Based upon the limestone solids chemical analysis, there are no chemical exceedances in limestone material. Consequently, the DCR discharge of limestone in port focused upon limestone buildup of material over time.

Limestone buildup was estimated assuming a mean volume of limestone DCR per event based upon the vessel DCR reporting form 2009 database which has 10.5 and 12.6 cubic feet for loading and unloading limestone DCR on average (CH2M HILL, 2009). The Great Lakes shipping season is generally limited to spring through fall operation. Consequently, 200 vessel visits a year at one limestone facility, each with a loading and unloading event appears to be a conservative assumption. Because a vessel is generally docked in port within the same general area, the buildup of limestone was assumed to consistently occur over 25 percent of a vessel area. Based upon these assumptions, the limestone DCR buildup totals 4,620 cubic feet which results in up to 0.32 feet (9.75 cm) per year or a total of 6.49 feet (210 cm) over 20 years.

Having 200 limestone DCR loading and unloading events resulting in 0.32 feet (9.75 cm) per year of limestone buildup would be greater than the naturally occurring sediment deposition of 0.016 feet (0.5 cm) per year in the nearshore higher depositional areas in Lake Erie; however, background sediment deposition in a port could be higher than the open lake.

The buildup of limestone DCR due to average discharges does not appear to be significant. However, large discharges can have more significant impact. For example, during the 2009 DCR direct observations, there was a limestone DCR observation that totaled 108,001 pounds or 1,080 cubic feet. The discharge of this much limestone from just one event over an area equal to 25 percent of the vessel footprint would result in 0.08 feet (2.5 cm) of limestone buildup from that one event. Just four discharges of this size would exceed 200 average loading and unloading events. It should be noted that this event was an extreme outlier. The median unloading event resulted in a limestone discharge of 318 pounds of DCR while the median loading event resulted in a discharge of 360 pounds of DCR.

Sediment Quality Analysis Conclusions

All the coal discharged to Lake Superior—the lake with the highest amount of coal discharge—in a given year when spread uniformly over a 10-mile by 1,857-m area will meet sediment criteria when DCR and sediment dilution occurs because of natural sedimentation only even when including a safety factor of 10. If natural sedimentation is considered negligible and dilution is assumed to occur through mixing with the top 2 inches of existing sediment, the same mass of coal must be spread over an area of 10 miles by 731 m to meet sediment criteria.

A single large discharge of coal was chosen to be the 95th percentile obtained from the vessel DCR reporting form 2008 database. Only 5 percent of discharges in this database were denser than 586 lb/mile. The 95th percentile in 2009 was 221 pounds/mile. Consequently, the 2008 value is a more conservative number to use. This density of DCR discharge must be spread over a width of 13.6 m in Lake Superior in order to be diluted by natural sedimentation to meet sediment criteria within 1 year. As previously stated, coal DCR is spread over an area much wider than 44.5 feet (13.6 m).

Limestone and taconite solids do not exceed any sediment criteria. The required areas for dilution of discharged coal are much smaller than the areas that actually receive DCR discharges; therefore, the DCR discharges meet sediment criteria either by natural sedimentation or mixing with the top 2 inches of sediment.

Sediment quality impacts do not occur from vessels in port with limestone DCR based upon a chemical analysis of limestone. Typical limestone DCR volumes do not result in significant limestone buildup. However, large limestone DCR events can be many times greater than the average event and can result in much faster limestone buildup.

Mass Estimates of Sonar Images

In late 2006, DCR in the Great Lakes were analyzed using sidescan sonar data acquisition (S D Mackey, 2006). The sonar work identified a subset of potential DCR deposits on the lake bottom as potential sites for sediment sampling attempts. Sediment sampling confirmed the presence of DCR, such as taconite and coal, at several of these locations.

The sediment quality analysis above indicated that, in many instances, the average amount of DCR reaching the lake bottom would be negligible. A review of the DCR mass typically discharged indicates that a relatively small volume of DCR is discharged and would not be visible with a sonar investigation unless discharged in one location. Consequently, an analysis was conducted to determine a range of DCR mass needed to obtain the DCR sonar images that were observed.

Sonar images of select larger sites were used to estimate an approximate area that the DCR covered. The sonar study was conducted in areas of relatively high DCR activity. Although the sonar image reflects the area that the DCR cover, direct sampling of these areas determined that the DCR is not a continuous cover. DCR deck discharge observations indicate material would be spread out over the entire discharge area. Data from sediment samples indicate that the actual amount of DCR could make up as little as 5 percent of the area that the sonar images show as having a strong acoustic response. Two coal samples provided coverage results of 5 and 30 percent. An estimated DCR thickness of 0.25 inch at both 5 and 100 percent coverage was used to determine an estimated volume range of DCR for a series of sonar images.

TABLE 17
Volume and Weight of Potential Materials from Sampling Areas

				5% Area (ft^2)					100% Area (ft^2)			
Lake	Site	Sonar Sample ID	Total DCR Discharge Area (ft^2)	5% Area (ft^2)	Volume with 0.25" Thickness (ft^3)	Weight of Coal (tons)	Weight of limestone (tons)	Weight of Taconite (tons)	Volume with 0.25" Thickness (ft^3)	Weight of Coal (tons)	Weight of limestone (tons)	Weight of Taconite (tons)
Superior	Duluth	1	224890	11240	234	7.1	11.4	20.5	4685	142	227	410
		2	30560	1530	332	1.0	1.5	2.8	637	19	31	56
		3	22870	1140	24	0.7	1.2	2.1	476	14	23	42
		4	22870	1140	24	0.7	1.2	2.1	476	14	23	42
Superior	Silver Bay	1	53050	2650	55	1.7	2.7	4.8	1105	33	54	97
		2	35510	1775	37	1.1	1.8	3.2	740	22	36	65
		3	32170	1610	34	1.0	1.6	2.9	670	20	33	59
Michigan		1A	5270	265	5	0.2	0.3	0.5	110	3	5	10
		1B	8560	430	9	0.3	0.4	0.8	178	5	9	16
		2	31740	1590	33	1.0	1.6	2.9	661	20	32	58
		3	36150	1810	38	1.1	1.8	3.3	753	23	37	66
		4	7750	390	8	0.2	0.4	0.7	161	5	8	14
Erie	Marblehead	1	16140	810	17	0.5	0.8	1.5	336	10	16	29
		2	21890	1095	23	0.7	1.1	2.0	456	14	22	40
			154030	7700	160	4.9	7.8	14.0	3209	97	156	281
			27060	1350	28	0.9	1.4	2.5	564	17	27	49
			19370	970	20	0.6	1.0	1.8	404	12	20	35
		3	21060	1050	22	0.7	1.1	1.9	439	13	21	38
			7640	380	8	0.2	0.4	0.7	159	5	8	14
			18400	920	19	0.6	0.9	1.7	383	12	19	34
Erie	Cleveland	1A	8070	400	8	0.3	0.4	0.7	168	5	8	15
		1B	8610	430	9	0.3	0.4	0.8	179	5	9	16
		2	9680	480	10	0.3	0.5	0.9	202	6	10	18
		3	140420	7020	146	4.4	7.1	12.8	2925	89	142	256

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The ability of the side-scan sonar to detect acoustic anomalies depends upon the type of bottom background material, type of DCR, and coverage of DCR on the lake bottom. For example, coverage of one taconite pellet every square meter would not likely be visible, but coverage of taconite pellets of 10 percent or more of a reasonably sized area likely would be visible. The actual distribution of DCR on the lake bottom is unknown and, consequently, a range of coverages that would be expected to produce an acoustic anomaly was estimated.

The densities of coal, limestone, and taconite were used to calculate the potential weight of material that could have been deposited in the DCR discharge. The average density of anthracite coal (68.98 pounds/ft^3, or 1,105 kg/m^3) and bituminous coal (52.0 pounds/ft^{3}or 833 kg/m^3) was used to determine the weight of coal. Some sites had multiple DCR images that the sonar detected, and depending on the orientation and size of the DCR images, they were considered either part of the same discharge or different DCR images. Consequently, the same site may have several discharge areas listed. Table 17 lists the results of this analysis.

Some sonar images show deposits characterized as "subcircular rings" and "amorphous masses" that appear to be caused by large discrete discharges that would be unlikely caused by current DCR discharges based upon mass estimates, which are generally continuous and of small amounts of material.

The largest mass of DCR from the 2009 vessel DCR reporting form database was 7,058 pounds (3.53 tons), 28,212 pounds (14.11 tons), and 31,378 pounds (15.69 tons) for loading and 7,940 pounds (3.97 tons), 13,233 pounds (6.62 tons), and 23,533 pounds (11.77 tons) for unloading for coal, limestone, and taconite respectively. The average mass of DCR from the 2009 vessel DCR reporting form database was 374 pounds (0.19 tons), 1,249 pounds (0.62 tons), 1,558 pounds (0.78 tons) for loading and 646 pounds (0.32 tons), 1,046 pounds (0.52 tons), and 1,838 pounds (0.92 tons) for unloading for coal, limestone, and taconite respectively. The 95th percentile discharge for all DCR materials equates to 207 pounds per mile. This would equate to about six 5-gallon buckets of coal DCR spread over a length of 1 mile.

The coal would likely be spread out at least one ship width (over 68 feet) as the turbulent mixing zone is considered to be 2.5 times the width of the vessel (Loehr et al., 2003). It may be possible that the "linear" features observed on the sonar images represent the largest 1 percent of all DCR discharges. However, the typical DCR deck discharge likely would leave only a trace on a side-scan sonar image and may not be detectable at all due to the procedure used to discharge the material. Further research and field verification are required to determine the origin of deposits observed during the sidescan sonar study.

Many of the large discrete deposits observed during the sonar study (S D Mackey, 2006) are likely due to historical DCR discharges, but some may also be due to dredged material discharge, or other unknown sources. Verification sampling confirmed the presence of DCR at some of these sites, but most sites were not sampled. The mass of discharges was greater in the past, before the technology and the motivation to minimize discharges became commonplace. The Potomac Management Group report states that "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" (Potomac Management Group, 2003). It is possible that many of the images observed during side-scan sonar were created from DCR discharges in the past. Indeed, images from high frequency sonar have indicated that, in some instances, the surface of the lake bottom is smooth, whereas low frequency sonar has indicated the presence of many DCR deposits just below the surface (S D Mackey, 2006). The side-scan sonar report hypothesized that historical DCR deposits are likely the source of acoustic backscatter in areas where numerous complex patterns are observed in the low frequency sonar images.

The results (shown in Table 17) of the volume and weight calculations from the sampling areas range in values from 0.2 tons to 7.1 tons for coal for 5 percent coverage of the area, and from 3 tons to 142 tons for coal for 100 percent coverage. The average weights from the sonar analysis are 1.3 tons of coal, 2.0 tons of limestone, and 3.7 tons of taconite for 5 percent coverage, and 25.3 tons of coal, 40.6 tons of limestone, and 73.2 tons of taconite for 100 percent coverage. It is unlikely that many of the evaluated DCR images are recent due to the estimated mass needed to produce the sonar images. The DCR volume has decreased over time because of refined loading and unloading methods. The estimated amount of DCR detected by sonar is much larger than what would be expected from a typical discharge. Most of the large deposits are likely historical discharges, but the larger current discharges may be responsible for some of the sonar images.

Bioavailability

The chemical parameter concentration in the DCR material is not equivalent to the exposure that aquatic organisms would experience in the lake bottom sediment because not all the chemical parameter is generally bioavailable. Bioavailability refers to the amount of material that can be exposed to and ingested by aquatic organisms compared to the total amount of material. For example, when a chemical constituent is within a solid, it is not available to an aquatic organism. Chunks of DCR will not have all the chemical parameters immediately bioavailable since much of the chemical mass will be inside chunks and large pieces of the DCR.

The sediment concentration calculations used conservative analyses, such as assuming a factor of safety, demonstrating that actual DCR discharges occur over a much larger area than is needed to dilute DCR discharges through natural deposition or sediment mixing, and by assuming natural sediment deposition rates that are lower than the average depositional rates for the lakes. The concentrations of chemical parameters contained within the DCR in the lake bottom sediment are not entirely bioavailable, making the results of the sediment concentration analysis even more conservative.

If the chemical parameter in the combined DCR and sediment exceeds the sediment criterion, it does not mean that the amount of bioavailable chemical parameter exceeds the criterion. While the sediment quality analysis indicates sediment criteria should be met, testing organisms collected from sediment samples containing DCR deposits is an important step in assessing bioavailability to determine whether the chemical parameters at the concentrations present have an effect on aquatic organisms. Aquatic organism testing has been completed and is reported in the Phase I EIS. The conclusion indicated no chemical toxicity or bioaccumulation associated with DCR material.

Conclusions

The analysis of DCR and their effect on water quality and sediment quality took into account previously collected data, sonar images, and modeling. First, historical models were reviewed to determine if modeling software were available to perform the required analysis. The Simple Dilution Model was used for the water quality analysis, and a spreadsheet model was used to analyze potential sediment impacts. Next, information on the number of historical DCR discharges, maximum discharge mass, distance traveled during discharge, and the DCR grain size distribution was reviewed. The historical information was organized by lake (Lake Superior, Lake Michigan, or Lake Erie) and by type of material discharged.

The water quality analysis concluded that the Simple Dilution Model has shown that significant mixing and dilution can be expected behind large moving vessels, and the concentrations of dissolved chemical parameters in the DCR discharges will be rapidly diluted to concentrations below water quality criteria. The discharge of DCR from a moving cargo vessel does not adversely affect the water column because turbulence created by the displacement of water by massive cargo ships and jetting caused by the large propellers mix discharged DCR with a large amount of water in a very short time.

Several DCR samples of deck and sump solids captured from different vessels were used to analyze for composition of coal, taconite, and limestone. The measured concentrations of the chemical parameters within the samples were compared to sediment criteria. The comparison was considered the exceedance ratio, a way of determining which chemical parameters appear in the samples in the largest amounts relative to established criteria. A value greater than 1 indicated that a criterion had been exceeded. For chemical parameters with values greater than 1, the analysis also calculated a required dilution factor to determine the width of lake needed for DCR discharge to meet criteria through dilution by natural sedimentation. Limestone and taconite materials always met sediment criteria. Naphthalene in coal was found to have the highest average exceedance ratio, but coal DCR would meet sediment criteria through mixing with natural sedimentation when evenly distributed over an area 10 miles long by 6,091 feet (1,857 m) for proper dilution, even when including a factor of safety of 10.

The volume of historical DCR was analyzed to compare observed potential sonar DCR images. The analysis determined that some of the historical DCR observable through the sonar study is relatively large and most likely not attributable to recently documented typical DCR amounts. However, the largest of recent DCR events could be of comparable magnitude to observed sonar DCR images. The loading and unloading of cargo has improved in recent times and the amount of DCR that is swept overboard has been reduced. DCR is typically discharged in very small amounts over vast areas of the lake. The 95th percentile discharge for coal in 2008 is 586 lbs/mile (see DCR discharge Data). This would equate to a 5-gallon bucket of coal DCR every football field length over the course of 1 mile. The coal would likely be spread out at least one ship width (over 68 feet) as the turbulent mixing zone is considered to be 2.5 times the width of the vessel (Loehr et al., 2003). However, further research and field verification are required to determine the origin of deposits observed during the sidescan sonar study.

Overall, the analyses determined that the current level of DCR discharges occurring in the Great Lakes should meet water and sediment quality criteria.

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Appendix J
Impact Analysis of Ongoing Dry Cargo Residue Practices

Impact Analysis of Ongoing Dry Cargo Residue Practices

PREPARED FOR: U.S. Coast Guard

PREPARED BY: CH2M HILL

DATE: October 2009

Introduction

The U.S. Coast Guard has investigated the impact of dry cargo residue (DCR) discharges on ecological conditions in the Great Lakes since the promulgation of the Interim Enforcement Policy (IEP). These investigations have included the following:

- "Proceedings of the Workshop: The Environmental Implications of Cargo Sweepings in the Great Lakes" (Reid and Meadows, 1999)
- "A Study of Dry Cargo Residue Discharges in the Great Lakes" (PMG, 2002)
- "Study of Incidental Dry Cargo Residue Discharges in the Great Lakes" (e^2M, 2005)
- "Scientific Approach for Dry Cargo Sweepings Impact Analysis" (Volpe National Transportation System Center et al., 2006a) and "Scientific Plan for Dry Cargo Sweepings Impact Analysis" (Volpe National Transportation System Center et al., 2006b)
- DCR studies conducted by CH2M HILL in fall 2006: "USCG Dry Cargo Sweepings Scientific Investigation: Sweepings Characterization—Chemical Analyses" (CH2M HILL, 2007a) and "*USCG Dry Cargo Sweepings Scientific Investigation: Sweepings Characterization – Toxicological Analyses*" (CH2M HILL, 2007b), "*USCG Dry Cargo Sweepings Scientific Investigation: Biological Characterization – Nutrient Enrichment* " (CH2M HILL, 2007c), and "*USCG Dry Cargo Sweepings Scientific Investigation: Identification of Sonar Investigation Sites* " (CH2M HILL, 2007d)
- DCR studies conducted by CH2M HILL in spring 2007: "*Dry Cargo Residue Discharge Analysis for the U.S. Coast Guard* " (CH2M HILL, 2007e), which was updated in 2009 (CH2M HILL 2009a), and "*USCG Dry Cargo Residue Spring 2007 Scientific Investigation: Depositional Area Characterization*" (CH2M HILL, 2007f)
- "*DCR Records Evaluation (Sept. 29, 2008 to Jan. 15, 2009)" and "Dry Cargo Residue Records Evaluation for Shipping Activity from January 16, 2009, to July 15, 2009*" (CH2M HILL 2009b, c)
- "*DCR Loading and Unloading Observations* " (CH2M HILL 2009d)

These studies have described existing DCR practices and procedures and documented ecological conditions in the areas of DCR discharge. However, only qualitatively have they evaluated the effects of DCR discharge on various segments of the Great Lakes ecosystem.

The purpose of this technical memorandum is to relate changes in ecosystem parameters to DCR discharge as measured or predicted as part of the U.S. Coast Guard's investigations. A similar memorandum was prepared in support of the Phase I Environmental Impact Statement (EIS) (Appendix N to the Phase I EIS). This memorandum represents an update of the previous one, incorporating the findings and evaluations done in 2009 on DCR (CH2M HILL, 2009a–d). The impacts from past and ongoing DCR practices are documented for the segments of the ecosystem that, as explained below, were determined to be potentially influenced by the discharge of DCR:

- Water quality
  - Chemistry
  - Nutrient enrichment
  - Dissolved oxygen
- Sediment quality
  - Chemistry
  - Physical structure
  - Deposition rate
- Biological resources
  - Fish and other pelagic (residing in the water column) organisms
  - Benthic (residing in the sediments) community
  - Waterfowl

The impacts from DCR practices identified in this memorandum will be incorporated into the Draft Tiered Environmental Impact Statement (EIS) currently under preparation by the U.S. Coast Guard as part of the DCR management Phase II rulemaking. Specifically, the results identified in this memorandum will be used to describe the impacts associated with the Draft Tiered EIS No Action alternative of continuing the existing Interim Rule, because the measurements used here were taken during a period preceded by over 15 years of adherence to a policy materially identical to the Interim Rule (the IEP, as described in the Phase I EIS). The results will also be used to predict impacts of alternative methods of managing DCR evaluated in the Draft Tiered EIS. Since the other alternatives are similar to the Interim Rule in that they would result in lessened discharges of DCR, the predicted impacts of these other alternatives will be modifications of the impacts measured for adherence to the existing Interim Rule. For example, if an alternative would result in reduced discharge of DCR, the predicted impact for the alternative would be proportionately less than that measured and reported in this memorandum.

Impact Conceptual Model

The first step in impact prediction is to conceptualize the practice under evaluation. This conceptualization is used to identify potential pathways and mechanisms associated with the practice that could alter components of the ecosystem. Through review of past studies, discussions with Great Lakes scientists, discussions with Lake carrier operators, and observations of DCR practices, a conceptual model of how the discharge of DCR could interact with ecological resources was developed (Figure 1).

The potential interaction between DCR and the ecosystem begins with DCR discharged from the ship, from either sweeping of the deck or pumping of the sump (low -lying wet sumps in tunnels under the cargo holds collect cargo residue and washdown water and are typically 100-200 gallons each; the total number of sumps depends on the design of the individual vessel). This material then enters the water column, where it can potentially alter the chemical characteristics of the water, affecting the dissolved oxygen concentration, nutrient concentrations, or contaminant concentrations. After a relatively short residence time in the water column, the DCR solids settle to the lake bottom and become incorporated into the sediments. The settling can alter the sediments physically by adding hard particles to the typically soft mud on the lake floor. The DCR can also add contaminants and thus change the chemistry of the sediments or otherwise change the habitat by increasing the rate of solids deposition on the bottom.

The physical, chemical, or enrichment alterations of the water column or sediments can in turn affect the biological resources residing in the water column or sediments (Figure 1). This can change the characteristics of the benthic organisms or pelagic communities. The changes can result either from changes in physical habitat or from the addition of contaminants that could be toxic to the biological resources. The alterations could also move through the system and affect organisms, such as waterfowl, dependent on either the pelagic or benthic community.

Scientific investigations were designed (Volpe National Transportation System Center et al., 2006a) and conducted (CH2M HILL, 2007a-f) to determine if the potential impacts identified in the impact conceptual model (Figure 1) are occurring. Virtually all scientific investigations are limited in spatial and temporal coverage and thus represent just a "snapshot" of the conditions of interest. The DCR investigations are no exception, and thus there is some degree of uncertainty in applying the results to broader geographic coverage and duration. In order to minimize the uncertainty, more than one investigation was designed to assess each potential area of impact, thus constituting a multiple-lines-of - evidence approach (Figure 2). If each line of evidence yields the same conclusion regarding the existence or degree of impact, there is more certainty and confidence in the prediction.

Although there are numerous types of DCR and discharges occurring in all the Great Lakes, previous studies (Reid and Meadows, 1999; PMG, 2002; e^{2}M, 2005) have indicated that the extent and intensity of impact is not the same for all DCR materials or for each lake. Most (84–99 percent) of the bulk cargo shipped on the lakes comprises iron ore (i.e., taconite), coal, and limestone (Table 1). Cement and grain are the only other materials composing 3 percent or more of the cargo shipped, and the percents of these commodities are much less when only U.S.-flagged ships are considered (1998–2004 data from e^{2}M [2005]; Table 1]). In addition, these materials reflect a much lower percent of the discharge than they do of the cargo because of the handling practices of grain and cement. Grain and cement are loaded and unloaded using totally enclosed pumping systems, so there is little if any spillage and thus very little DCR discharged during deck- or tunnel-cleaning operations. In recent years, commodities other than iron ore, coal, and limestone—such as salt, grain, coke, cement, milliscale, slag, sand, and potash —have accounted for less than 1 percent to 16 percent of the total cargo shipped annually (Table 1).

A review of the chemical characteristics of DCR (PMG, 2002) revealed that if any type of DCR had metal concentrations that could affect water quality or cause toxicity, it would be iron ore (taconite). Similarly, if organic chemical contaminants were present in DCR at concentrations that could affect water quality or toxicity, it would be in coal DCR, and if physical alteration of the sediment were present from particularly large, dense particles in soft mud, it would be greatest with limestone DCR. Thus if current DCR practices had an impact, they would be greatest from iron ore, coal, and limestone, and DCR management methods to control impacts from these materials would also control impacts from other types of DCR. The workshop held by NOAA (Reid and Meadows, 1999) reached a similar conclusion: that if DCR discharged to the lake had an impact; it would be most noticeable from these materials.

Two areas where DCR impacts could be greater from materials other than iron ore, coal, and limestone were considered. One is enrichment from discharge of material high in organic content, such as grain or forest products. However, as presented above, grain is handled in an enclosed environment with little or no spillage, and the volume of forest products shipped and discharged is very low (it does not appear in quantifiable amounts in ships' records from 2001 or 2004). Thus, these materials were not studied in detail.

The second area of potential impacts that might not be fully addressed by examining iron ore, coal, and limestone is localized change in water chemistry from the discharge of salt. Salt is carried primarily on Canadian vessels, and for all the Great Lakes can be as much as 41,000 pounds a year (compared to 1,805,474 pounds a year, or approximately 2% of the total, for iron ore, coal, and limestone) (PMG, 2002). Salt contamination would not be a concern in the water column because even if it dissolved completely, the dilution would be several thousand to one, and there would be no measurable rise in the water's salinity, and thus no impacts would occur. If the salt did not dissolve in the water column, it could come to rest in the sediments, where it would dissolve over time and be diluted by the water around it. If the salt crystals dissolved slowly, no impacts would occur because of dilution. If dissolution was rapid, there could be a localized issue within a few centimeters of the salt crystal. The rate of dissolution depends on the temperature, pH, and the conductivity of the water.

DCR discharge occurs in all of the lakes but at very different rates. The rate of discharge in each lake was evaluated for each DCR material, and the areas of the greatest discharge per acre were identified (PMG, 2002). This information, along with other information regarding the lakes and DCR operations, was evaluated in detail to identify the specific areas within the Great Lakes where the impact could be the greatest (Volpe National Transportation System Center et al., 2006b). This analysis took into consideration the differences in habitat among the lakes, and the areas identified with the highest discharge rates represent common habitat types within all of the Great Lakes.

The identified areas were the focus of the detailed sampling and analysis conducted to support this impact evaluation. As described below, each of the areas of greatest DCR discharge was sampled and analyzed to characterize the physical, chemical, and biological aspects of sediments. These areas were sampled because if lake sediments were affected by DCR discharge, the effects would be greatest in the areas with higher documented discharge rates. Effects in other areas from DCR discharge would be less; thus, impacts documented based on these selected areas would represent the greatest expected impacts. If no effects were detected in these areas, none would be expected in other areas. Similarly, measures to mitigate impacts from DCR discharge determined for the identified areas would be equally effective in areas with a reduced rate of discharge.

Water Quality

As described above, the first area that could be potentially impacted from DCR discharge is the water column. As the DCR mixes with the water, there is the potential for chemicals from the DCR to dissolve in the lake water and for water quality criteria to be exceeded; for water to be enriched with nutrients; or for organic manner to be added, thus increasing the oxygen demand, which can result in lower dissolved oxygen concentrations. The dilution of the DCR once it enters the lake determines the concentration of the compounds found in the DCR and their associated impact on water quality. Thus the first step in evaluating the impact in the water column was to determine the dilution of the DCR discharge. This determination was made using a mathematical simulation that is described in detail in CH2M HILL (2009a) and summarized below.

A review of modeling computer software packages determined that few complex modeling applications would apply to DCR discharge to the Great Lakes; thus, the Simple Dilution Model was used to estimate dilution of the DCR discharges with lake water. The Simple Dilution Model was developed by an independent science advisory panel to assist the Alaska Department of Environmental Conservation in evaluating the effects of wastewater discharges from cruise ships in Alaskan waters (Loehr et al., 2003). The model proved to be the most useful and applicable of all those evaluated.

The cruise ships analyzed in Loehr et al. (2003) had beams of about 100 feet, drafts of 25 feet, and speeds ranging from 9 to 19 knots, which are specifications very similar to the large cargo vessels traveling on the Great Lakes. Great Lakes cargo vessels generally have 70- to 100-foot beams, 30 feet of draft or less, and can travel at speeds up to 17 knots (Great Lakes et al., 2007). Wastewater discharge rates for cruise ships range from 250 to 500 gallons per minute (gpm), which is similar to the 300-gpm flow from a typical washdown hose onboard a cargo vessel (CH2M HILL, 2007a).

In August 2001, the U.S. Environmental Protection Agency (EPA) conducted a dye study of the discharges of four cruise ships to validate the Simple Dilution Model. The model proved a conservative model, as the actual observed dilution factors were greater by up to 40 percent than those predicted by the model were. Research on wastewater discharges from cruise ships has shown that a dilution factor of at least 12,000 can be expected within 15 minutes behind a large cruise ship (Alaska DEC, 2001).

Two types of discharge were modeled for each DCR of concern (taconite, coal, and limestone). One was the liquid collected from the sumps of lake carriers, as described by CH2M HILL (2007a). The other was deck DCR, which was simulated from solid DCR collected from the ships' deck and calculated based on ratios of water to deck DCR that were presented in CH2M HILL (2007a, 2009a).

The Simple Dilution Model was used to predict the dilution of discharge in the water column due to both DCR deck and sump discharges. The mass of discharged deck DCR was taken as the average discharge obtained from the 2004 data (e^{2}M, 2005) and applied separately for each type of DCR. The largest sump on the studied coal vessels was roughly 12 yd^3 (2,424 gallons), and the largest sump on the studied taconite vessels was 1.2 yd^3 (242 gallons); these were used as the volumes for these types of DCR. The sample from the limestone sumps did not show any water quality exceedances (see the water chemistry section, below); therefore dilution is not required to discharge this material. Volumes larger than the sump volume are also discharged when the tunnels within the hull of the vessel, used for unloading DCR, are flooded during washdown events; however, individual discharge rates are limited by sump pump capacity. The discharge rate of the sump slurry was assumed to equal 400 gpm, and the duration of pumping was conservatively estimated (i.e., the largest discharge that could realistically occur) at 10 minutes. This yielded a discharge volume of 4,000 gallons, which is much larger than the sump. The calculated dilution ranged from 26,000 to 62,000 to 1, depending on type of DCR (Table 2). These are minimum estimates of dilution because currents, substantial winds, or hull or propeller wash would increase the dilution. This means that approximately 15 minutes following the discharge, there are between 26,000to 62,000 parts of water for every one part of deck slurry or sump liquid in the water column behind the vessel.

Water Chemistry

If water chemistry is changed sufficiently by increasing the lake water concentration of chemicals found in DCR, there can be impacts to aquatic biota and other lake ecosystem components. The presence of an impact is determined by comparing the lake water concentrations to chronic and acute water quality criteria obtained from the Great Lakes Initiative and the EPA for the protection of aquatic life and human health. Criteria are established for both long-term (chronic criteria) and short-term (acute criteria) exposure. Acute criteria are generally applied for the protection of aquatic biota that might pass closely to a discharge but be exposed only for hours to days. The analytical results of liquid sump samples and simulated deck DCR that were collected from eight bulk dry cargo vessels (CH2M HILL, 2007a) were used to evaluate the change in lake water concentration, and thus water chemistry impact from DCR discharges.

The first step to evaluating the water chemistry impact was to compare the measured concentration in the sump liquid or simulated deck sweeping, before any dilution, with the most stringent water quality criteria. This was a useful comparison from a screening perspective, because discharge parameters that meet criteria even without consideration of applicable dilution can be regarded as parameters that do not require further impact assessment. The highest exceedance of acute water quality criteria in the undiluted sump liquid or simulated deck DCR was by a factor of 1.9 and most of the chemical concentrations were below the acute criteria. This means that the discharge would have to be diluted by only an equal volume of lake water (i.e., a dilution of 1) to meet the acute criteria of any chemical in the DCR discharge. Since the DCR discharge was estimated to be diluted at least 26,000 times after 15 minutes, all acute criteria would be met within seconds of discharge.

There are only three instances in which chronic water quality criteria were exceeded in undiluted samples by more than a factor of 10, and the highest exceedance was by a factor of 31 for pyrene (Table 3). The highest pyrene concentration measured in any discharge was 0.44 μg/L, or 44 parts per billion, compared to a water quality criterion of 0.014 μg/L. This concentration was adjusted to 1.06 ug/L because simulated DCR slurry was based on an average mass of DCR from decks in data from 2004 (e2M, 2005), which is lower than the average mass of DCR in direct observations in 2009 (CH2M HILL 2009d) by a factor of 2.4. If the discharge were diluted with clean water at the minimum predicted dilution (26,000 times), the resulting concentration after 15 minutes would be approximately 4.1×10^{-5} μg/L. Even if the receiving water was at 99 percent of the criterion (i.e., 0.01386 μg/L), the concentration after mixing of receiving water and discharge would be only 0.0139 μg/L, which is still below the criterion.

The discharge of DCR would not result in any exceedances of water quality criteria even for the chemical with the highest concentration in relation to criteria and even if the receiving water was already very close to the criteria. This analysis represents only limited sampling, but of the ships sampled there was only minimal variability (CH2M HILL, 2007a); thus although there is uncertainty in the analysis, it is considered representative. Since the prediction is well below the threshold of impact (approximately 26,000 times), there is little uncertainty in the concluding that discharge of DCR from the tunnel sump or deck would not have an impact on water chemistry.

Dissolved Oxygen

Organic matter in the DCR discharge can be used as food by bacteria and other microorganisms in the lake water. As the organisms use this food, they respire, which consumes the dissolved oxygen in the water. This is a natural process and indeed essential for the ecosystem to function. However, if there is an excess of organic matter, the process proceeds at an unnatural rate, and the oxygen can be depleted to levels below that required to sustain fish and other organisms present in the lake water. The potential for this impact to occur is dependent on the amount of organic matter present in the DCR and subsequently in the lake water.

Biochemical oxygen demand (BOD) and chemical oxygen demand (COD) were measured in the sump liquid and simulated DCR slurry from the eight vessels sampled (CH2M HILL, 2007a). BOD or COD was not detected in any of the simulated DCR slurry, and was detected in only one of the sump liquid samples (25 mg/L total BOD and COD, which is what might be expected in stormwater runoff). The simulated DCR slurrydeck sweepings is considered to be more reflective of DCR because the sump liquid can contain bilge water from normal tunnel operations. Although the simulated DCR slurry was based on an average mass of DCR material from decks in data from 2004 (e^2M, 2005) (a mass lower than the average mass of DCR in direct observations in 2009 (CH2M HILL 2009d) by a factor of 2.4), For the maximum concentration measured, after the minimum predicted dilution of 26,000 times, the oxygen demand in the receiving water would be well below detectable levels. Even with uncertainty associated with the limited number of samples, the low level of impact predicted on dissolved oxygen strongly indicates the absence of any impact on water quality.

Nutrient Enrichment

As described above, there is the potential for a discharge to stimulate biological activity, which can have implications on ecosystem function. Just as the addition of organic material can stimulate bacterial activity, addition of inorganic nutrients (particularly phosphorous and nitrogen) can stimulate aquatic plant growth. Plant growth is essential to ecosystem function because it forms the base of the food web. However, an excess of it can alter the ecological balance, particularly by creating so much respiration from the excess food that dissolved oxygen is severely depleted. The potential for adverse stimulation of plant growth was examined from two perspectives: increase in nutrient concentration and laboratory testing of increased aquatic plant growth. Both of these are described in detail by CH2M HILL (2007c) and summarized below.

In general, there was little difference between nutrient concentrations in simulated DCR slurry and the lake water. Of all the forms of nitrogen and phosphorous measured (NO_3, NH3, TKN, TN, OP, and TP), all the DCR analyzed (iron, eastern coal, western coal, and limestone), and both lakes tested (Superior and Erie), there were only six cases where the slurry had higher concentrations than the lake water (Table 4). Of the cases with significantly higher nutrient concentrations in slurry, only total phosphorus in western coal for Lake Erie was substantially higher (five times higher, with Lake water at 0.02 mg/L and the slurry at 0.13 mg/L). The other five cases of higher nutrient concentrations in the slurry were less than twice the lake water concentrations. As mentioned above, although simulated DCR slurry was based on an average mass of DCR from decks in data from 2004 (e^2M, 2005), which is lower than the average mass of DCR in direct observations in 2009 (CH2M HILL 2009d) by a factor of 2.4, after dilution (at least 26,000 times, as described above), there would be no measurable change in nutrient concentrations resulting from DCR discharge.

The potential for DCR discharge to stimulate aquatic plant growth was also assessed. The assessment was made by introducing phytoplankton (small, free-floating aquatic plants) into an aliquot of water from Lakes Erie and Superior and then measuring the increase of phytoplankton as indicated by increased chlorophyll concentration after 4 days. Similarly, the phytoplankton were introduced into DCR slurries simulated with water from Lake Erie and Lake Superior. The tests on simulated slurry were done with 100 percent, 50 percent, and 10 percent slurry, with the balance of the test material made up of lake water.

Minor increases in phytoplankton activity were seen in several of the slurry-type cases for both lakes (Figures 3 and 4). Western coal and limestone produced little or no response for either pure slurry or the dilutions in either lake. Eastern coal and taconite generally produced an increase of approximately 50 percent with the pure slurry and much less with the 10 percent slurry. Since neither of these materials showed an increase in primary nutrients (Table 4), it is likely that the increases observed were due to micronutrients such as iron.

Although DCR can produce slightly increased aquatic plant production when introduced at high concentrations, the effects are diminished at dilutions of even 10 to 1 (i.e., the 10 percent slurry test), and no change is expected at dilutions expected from DCR discharges (i.e., at least 26,000 to 1).

Sediment Quality

As discussed above, the residence time of DCR in the water column is short, and no measurable impacts are predicted for the water column. In contrast, the ultimate fate of most DCR discharge is the lake bottom, where there is the potential for accumulation and thus impacts to the sediment quality. DCR can have an impact on sediments by accumulating at a rate higher than that of natural sediment and by altering the physical or chemical characteristics of the sediment. The potential for each of these types of impact is addressed below.

Sediment Deposition Rate

The impact of DCR deposition is gauged by how it compares to natural sedimentation rates. The natural rate varies considerably both among and within lakes (Table 5). The lakes with larger volumes (e.g., Lake Superior) have lower natural deposition rates, and the smaller lakes with more developed shorelines (e.g., Lake Erie) have the highest rates. Within lakes, the nearshore areas receive the land-based soil particles via stormwater runoff and thus have the highest deposition rates. In contrast, the central portions of lakes have reduced land-based input and have substantially lower deposition rates.

The DCR deposited within shipping track lines was estimated from ships logs for 2001 (PMG, 2002). The estimated deposition rates for all types of DCR combined and all lakes ranged from 6.449 to 0.086 lb/acre/year, which convert to 0.72 to 0.01 $g/m^2/year$ on average in various segments of shipping track lines. This is approximately 0.2 percent, or less than the natural deposition rate (Table 5) and only a small fraction of the variation within lakes. Benthic, or sediment-dwelling, organisms have evolved to tolerate the natural sedimentation rates, and such small increases would not have an impact on the sediment environment. There are instances where this average is exceeded, and this could produce temporary impacts in small areas. However, the limited spatial and temporal nature of the effects would be insignificant in relationship to the shipping track line and of the entire lake.

Sediment Physical Structure

The physical structure of the sediments was evaluated by assessing the potential for DCR discharges to alter the composition of the sediments to the degree that the habitat for benthic organisms would be adversely affected. This impact was evaluated by comparing grain size distributions of sediments in DCR discharge and reference areas.

Sediment samples were collected from five shipping track lines (two in Lake Superior, one in Lake Michigan, and two in Lake Erie) and analyzed for chemical and physical parameters, as well as tested toxicologically. Each track line consisted of a DCR discharge area and a reference area. Large, high-intensity DCR discharge areas (approximately 10 miles long and the width of the shipping lane) were selected based on ships' logs showing the areas of greatest DCR sweeping and discharge activity. These areas were then surveyed using multibeam sonar, and precise sampling locations were determined based on the presence of acoustic anomalies, which may indicate the presence of concentrated DCR on the sediment surface (Habitat Solutions, 2006; CH2M HILL, 2007d). Acoustic anomalies varied in size and appear to have been successfully targeted for most samples in both Lake Superior track lines and one track line in Lake Erie (Marblehead). The acoustic anomalies in Lake Michigan and Lake Erie (Cleveland) may not have been as successfully targeted (CH2M HILL, 2007f). The successful targeting of the acoustic anomalies was also determined by the presence of DCR in the sediment. All DCR -discharge -area sediment samples had more DCR than did those samples from reference areas. The greatest amounts of DCR were observed in a Lake Superior (Duluth) DCR discharge area sample and a Lake Erie (Cleveland) DCR discharge area sample.

The results of the grain size analysis for sediment collected in the DCR discharge areas and reference areas are presented for each lake in Figures 5 through 9. DCR collected from the deck of cargo vessels is also shown on the figures, with types of DCR not distinguished because they all have similarly sized particles (larger than 0.05 mm). In general, the grain sizes in DCR discharge areas were similar to sediment in reference areas and not similar to the grain size of deck DCR samples (i.e., larger than 0.05 mm), with some exceptions. Lake Michigan sediment grain sizes in both DCR discharge and reference areas appear larger and more similar to deck DCR samples' grain sizes than sediment grain sizes in Lake Superior and Lake Erie. Some samples also contained a small percentage of larger particles that are similar in size to deck DCR samples. A Lake Superior (Duluth) DCR discharge area sample contained approximately 15 percent more particles within the 3.35- to 19-mm range than other samples within the Duluth track line. A Lake Erie (Marblehead) DCR discharge area sample contained approximately 20 percent more particles within the 0.6- to 1.18-mm range than other samples within the Marblehead track line. Similarly, a Lake Erie (Cleveland) DCR discharge area sample contained approximately 15 percent more particles within the 0.6- to 1.18-mm range than other samples within the Cleveland track line. As previously indicated, the greatest amount of DCR (coal) was observed in this sample. This sample also had considerably higher total organic carbon than the reference area samples.

Based on these results, impacts to sediment physical structure, defined as noticeable grain size differences among sediments from DCR discharge areas, may occur in at least some areas of intense DCR discharge. These impacts are likely to be insignificant because the increased heterogeneous grain size distribution provides increased habitat diversity relative to that of reference areas.

Sediment Chemistry

When material is added to the lake bottom, even in small amounts, there is the potential for the chemistry of the sediment to change, which can produce toxicity to the organisms in the sediment or disrupt sediment processes such as decomposing organic matter or regenerating nutrients to facilitate photosynthesis. This represents a major potential for impact because the sediment is the final resting place for the DCR, and any changes in chemistry can be cumulative. Because of the potential for significant impact from alteration of sediment chemistry, this was a major focus of the impact evaluation for DCR discharge. The evaluation consisted of three independent analyses to produce three lines of evidence, because each line has inherent uncertainty, but taken together the uncertainty is greatly reduced. The three types of analyses employed were the following:

- Mathematical calculation of sediment concentrations of concern based on DCR discharge rates
- Measurement of DCR chemistry and toxicity
- Measurement of sediment chemistry and toxicity in areas of greatest DCR discharge

Each of these analyses is discussed below.

Calculation of Sediment Concentrations of Concern. DCR discharge, both over the longterm and from single events, was evaluated using multiple approaches to estimate concentrations in sediments. One evaluation was based on the annual discharge of DCR combined with the annual natural deposition, but no mixing with in-place sediments. Another evaluation assumed mixing of DCR discharged over 100 years and the top 2 inches of sediment with no natural deposition. The final evaluation considered the single largest event over the smallest area listed in DCR discharge records (PMG, 2002). All approaches incorporated conservative assumptions so that any inaccuracies in the calculations would tend to overestimate rather than underestimate sediment concentrations. The evaluations were also based on the chemical found at the highest concentration in any deck or cargo DCR sample type relative to the criterion (naphthalene, by a factor of 17.6 times greater than the criterion for the maximum concentration and of 3.6 times greater for the average concentration). Thus the analysis is based on the worst case in the data record, and impacts from any other chemical would be less. The evaluations are described in detail by CH2M HILL (2009a) and summarized below.

The addition of naphthalene to the sediment was calculated using the total discharge of coal from the 2001 DCR record (PMG, 2002) for each lake. If all of the coal DCR for a given lake was discharged over 10 miles of shipping track line at a width of 1,857 m or greater and mixed with natural sediment deposition over one year,[1] there would be no exceedance of criterion for naphthalene. In reality, coal DCR sweeping discharges over an entire year are spread over an area much larger than 10miles by 6,091 feet (1,875 meters) because in a given year not all ships on the track line would clean the decks or sumps in the same 10 -mile linear distance or in the same location relative to the center of the track line. Individual DCR discharges from moving cargo vessels spread out because of wake turbulence. Large cargo vessels can be up to 98 feet (30 meters) in width, and the turbulent zones behind the ships are about 2.5 times greater than the ship width (Loehr et al. 2003). Thus the width of an individual discharge would be at least 245 feet and all the discharges on a track line would be over a much wider area. Since naphthalene was found at the greatest concentration relative to the criterion, no other chemicals would exceed criteria under these circumstances. Review of DCR discharge records (PMG, 2002; e^{2}M, 2005) reveal that the actual area of discharge is much greater than these dimensions, thus no exceedances of sediment criteria based on this mathematical simulation are anticipated.

A similar analysis was performed to predict concentrations in sediment assuming no natural deposition but mixing of the DCR with the top 2 inches of in-place sediments. Whereas the previous analysis was done on a yearly basis, this analysis was done over a 100-year duration. The analysis revealed that if all DCR for Lake Superior was deposited within a 10-mile -long and 731-meter -wide area or greater, this would result in sediment concentrations below criteria for all chemicals detected in any DCR type. The area required in other lakes would be even less because the greatest amount of DCR is discharged in Lake Superior. This analysis also supports the conclusion that long-time discharge of DCR would not result in sediment quality exceedances.

The above analyses addressed the potential for sediment impact based on long-term discharge of DCR but there is also the possibility of a one-time event increasing the sediment concentration above criteria in a small area. The potential for this impact was evaluated by assuming that a large single discharge of coal (i.e., 221 lbs/mile, which is the 95th percentile of all the coal DCR discharges in the reviewed 2009 Vessel DCR Reporting Form data (CH2M HILL, 2009b) occurred and combined over 1 year with the naturally deposited sediment. For the chemical in any DCR type with the highest concentration relative to criteria (i.e., naphthalene) to be below the criteria in the sediment, the width of discharge would have to be only 5.1 meters wide. Since the lake carriers are at least 20

[1]For Lake Superior; other lakes are less because the natural sedimentation rate is greater in the other lakes.

meters wide, a discharge width of at least 5.1 m is assured. Another coal discharge within a year would have to occur in the exactly same 5.1-meter-by -1-mile area for any sediment criterion to be exceeded.

Based on calculations of DCR mixing with sediments using conservative assumptions (and a safety factor of 10), no impacts on sediment chemistry are anticipated. This is due to the relative low concentrations of potentially harmful chemicals in the DCR and the low rate of DCR deposition relative to natural sedimentation. This theoretical prediction was tested by analyzing the DCR and the sediments where the DCR is deposited, as discussed below.

DCR Solids Chemistry and Toxicity. DCR samples were collected from the decks and sumps of vessels carrying coal, taconite, and limestone and analyzed chemically (CH2M HILL, 2007a). This evaluation represents a hypothetical situation, in which the sediments on the lake floor, under the discharge, are 100 percent DCR. This situation could never occur, but if the chemistry and toxicity of 100 percent DCR does not represent an impact, then there would be no impact once the DCR is mixed with in-place sediments in proportions discussed above (DCR representing 0.1 percent or less of natural deposition; see Table 5). The data obtained from the chemical analysis were compared directly to sediment guideline values. Sediment guideline values are the freshwater consensus-based threshold effects concentrations from MacDonald et al. (2000). Threshold effects concentrations are defined as the concentrations below which adverse effects are not expected.

Chemical analysis of the solid DCR obtained directly from the sumps and decks of various ships showed that only the DCR from the decks exceeded sediment criteria. Chemical concentrations in the taconite and limestone DCR were below the sediment criteria for all analytes. Most of sediment criteria exceedances were associated with samples of coal deck DCR that exceeded criteria for polycyclic aromatic hydrocarbons (PAHs) such as naphthalene and chrysene, with at least one PAH exceedance from all ships sampled. As stated above, the highest single exceedance ratio was in a sample of deck DCR from an eastern coal vessel that exceeded the naphthalene criterion by a factor of 17.6.

There were only three instances in which a DCR solids sample exceeded the sediment criteria by more than a factor of 10. Two of the values were copper samples collected from two different sumps on the same western coal vessel. The third exceedance was the naphthalene exceedance. The two copper exceedances are not representative of typical DCR discharges described above. The samples of sump solids appear to be high in overall metals because of the potential inclusion of foreign metallic objects. Observations during sampling confirmed that bolts, screws, wires, and other foreign matter were present in the sumps (CH2M HILL, 2007a). These objects are likely the cause of the high values of several metals analytes observed in the sump solids. All other sediment exceedances (below a factor of 10) were found in samples of deck DCR.

Dry deck DCR solids and the DCR diluted with clean sediment were also tested toxicologically with the midge (*Chironomus dilutus*) and the amphipod (*Hyallela azteca*) in chronic bioassays (20 days and 28 days, respectively) to conservatively simulate exposure to accumulated DCR deposits on the lake bottom (CH2M HILL, 2007b). Both species were tested with 100 percent DCR, and *H. azteca* was tested in a mixture of 10 percent and 50 percent DCR mixed with clean sediment. The purpose for testing the mixture was to determine if combining the DCR with native sediments, as would occur for an actual discharge, would alter the response of the organism in the test. Ten percent DCR was used instead of a value closer to what occurs in the lakes (i.e., 0.1 percent) to overestimate impact and because the purpose was to determine if toxicity test organism responses changed when the DCR was diluted, not to measure actual DCR concentrations. Consistent toxicity was not observed across bioassays, which may suggest sensitivity differences among the test species to the physical and chemical properties of the DCR. For chironomids, mortality was observed in taconite exposures, and growth impacts were observed in an eastern coal samples. However, no chemical constituents in the taconite sample exceeded sediment guideline values. In the eastern coal sample, there were slight exceedances of the guideline values for arsenic, chrysene, naphthalene, phenanthrene, and pyrene (all hazard quotients were less than 5.0). For the *Hyallela* bioassays, where toxicity was observed in several samples, there were also few exceedances. The lowest *Hyallela* survival was observed in western coal, but there were only slight exceedances of sediment benchmarks for benzo(a)anthracene, phenanthrene, and pyrene in this sample.

The DCR samples mixed with native sediments showed considerably less mortality or fewer growth effects than in the 100 percent DCR samples. The results of the *Hyallela* dilutions are shown in Figure 10. For all samples except an eastern coal sample, significant effects on survival as compared to the control were observed in all 100 percent DCR samples, but the effect on survival was considerably reduced at 10 percent for all samples except a limestone sample. The limestone sample had similar results for all dilutions and had no constituent that exceeded screening guidelines values, which suggests that chemical factors were not involved.

Based on these results, it does not appear that chemical constituents in DCR are associated with toxicity, as a consistent negative relationship with chemical concentration was not observed. While undiluted DCR discharge may produce toxicity from chemical exposure, under realistic dilution scenarios, the effects are similar to control sediment. Reduced performance (i.e., significant reductions from the laboratory control) in undiluted DCR is most likely the result of a combination of chemical and physical factors that are not readily distinguishable.

Sediment Chemistry and Toxicity. As described above, sediment samples were collected from five shipping track lines (two in Lake Superior, one in Lake Michigan, and two in Lake Erie) and analyzed for chemical and physical parameters and tested toxicologically. The data obtained from the chemical analyses were compared directly to sediment guideline values.

In all the lakes, sediment concentrations of inorganics and PAHs in both DCR discharge areas and reference areas were very similar. Concentrations of some inorganics were elevated above screening guideline values in both areas and in all lakes, but within the range identified by other investigators for the open water sediments in the Great Lakes (Mudroch et al., 1988) (Table 6). Sediment PAH concentrations in DCR discharge areas were rarely above criteria and were very similar to those in reference areas.

For Lake Superior, concentrations of arsenic, cadmium, copper, lead, nickel, and zinc exceeded screening guideline values in the DCR discharge and reference areas, with no observable difference between the two areas. Concentrations of PAHs were low in all samples and did not exceed guideline values in any sample. As previously mentioned, a greater amount of DCR (taconite) was observed in a Lake Superior (Duluth) DCR discharge area sample, but the presence of more DCR (taconite) in this sample did not appear to affect levels of any constituent measured, including iron.

For Lake Michigan, as for Lake Superior, concentrations of arsenic, cadmium, copper, lead, nickel, and zinc were elevated above screening guideline values in both DCR discharge and reference area samples. The highest concentrations of these constituents were observed in a DCR discharge area sample (approximately two times higher in this sample than in the reference area sample). PAHs were also higher in this sample than in the other DCR discharge area samples, but the highest levels of PAHs were observed in a reference area sample.

For Lake Erie, concentrations of arsenic, cadmium, copper, lead, nickel, and zinc exceeded screening benchmarks in both the DCR discharge and reference areas. Concentrations of PAHs were low in all samples, and were only detected slightly above benchmarks in one Lake Erie (Cleveland) DCR discharge area sample and a Lake Erie (Cleveland) reference area sample. As previously mentioned, a greater amount of DCR was observed in the Lake Erie (Cleveland) DCR discharge area sample, but the presence of more DCR (eastern coal) in this sample did not appear to affect levels of any of the constituent measured. For chemicals without screening benchmarks, only calcium, in a Lake Erie (Marblehead) DCR discharge area sample, appeared elevated, possibly due to a large number of juvenile mussels in the sample.

Clyne (2000) evaluated metals concentrations in DCR discharge areas in Lake Ontario and observed that average concentrations in sediments with DCR were significantly lower than average metal concentrations in reference area sediments. The lower metals concentrations in DCR discharge area sediments were attributed to the relatively high density of DCR particles, which had lower metals concentrations than sediments in the reference area. This conclusion is supported by comparing concentrations in the sediment samples collected by Clyne (2000) to concentrations in DCR solids collected in October 2006 (CH2M HILL, 2007a) (Table 7). For all parameters measured, sediment concentrations had higher levels than did DCR solids.

Sediment samples were also tested toxicologically with the midge (*Chironomus dilutus)* and the amphipod (*Hyallela azteca*) in chronic bioassays (20 days and 28 days, respectively) (CH2M HILL, 2007f). Survival and growth were measured for each test species at test completion. Although results from both DCR discharge areas and reference areas showed survival and growth differences significantly below the laboratory control for many samples, there were few differences between the DCR discharge area and the reference areas (Figures 11 through 14). In Lake Michigan, *Hyallela* growth was significantly reduced when compared to one of the reference area samples. However, the high level of growth in the reference area sample is most likely a result of density dependence, as this sample also had the lowest survivorship of all samples; thus more food was likely available for growth of the surviving organisms. In Lake Erie, chironomid survival in one of the Marblehead DCR discharge area samples was significantly lower than in the reference sample. In the other DCR discharge area sample from Lake Erie, growth was significantly less than in the reference area sample. In both of these Lake Erie samples, small coal fragments were observed.

Although statistically significant adverse effects were found in DCR discharge areas relative to the response of test organisms in reference areas, which suggests an impact, the effects observed do not appear to be associated with any chemical constituent. As described above, several constituents (mostly inorganics) exceeded screening criteria in both DCR discharge and reference area samples, but the magnitude of the constituent does not appear to be related to reduced growth or survival of test organisms in the toxicity testing. For DCR discharge area samples in Lake Erie (Marblehead), which had significantly lower average organism growth and survival, constituents that exceeded criteria also exceeded criteria in the reference area samples by the same or similar magnitude.

In comparison to the results from the deck DCR sample toxicity testing, *Hyallela* survival was lower in sediment from both DCR discharge and reference areas as compared to most types of DCR (coal, taconite, and limestone; the 10 percent dilutions were used for comparison). *Hyallela* growth was very similar in DCR discharge and reference area sediment and deck DCR samples, except for taconite, which was generally higher than in sediment. Chironomid survival was very similar to average survival in all types of DCR; whereas growth in sediment (both DCR discharge and reference areas) was less than in eastern coal and taconite (western coal and limestone were similar to sediment).

One way of evaluating the influence of sediment chemistry on toxicity is to compare the concentrations of potentially toxic chemicals in the sediment to the survival of organisms in the toxicity tests. The comparison is based not on the absolute chemical concentration but rather the concentration compared to the level that is expected to cause an effect. For metals, this is the probable effect concentration (PEC) quotient (MacDonald et al., 2000). For PAHs, this is the equilibrium-partitioning sediment benchmark (ESB) (EPA, 2003). An exceedance of a PEC or an ESB greater than 1.0 is more likely to be associated with effects in benthic invertebrates. The mean PEC quotient is the average of all the ratios of chemical concentration to PEC value in a sediment sample. The ESB is the sum of all the ratios of individual PAH chemical concentrations, corrected for organic carbon content in the sediment, to chronic toxicity values, multiplied by a adjustment factor to account for PAHs that were not measured. Thus, a mean PEC quotient or ESB can be calculated for each sample tested toxicologically and compared to the toxicity test responses. In situations where toxicity is suspected, a higher mean PEC quotient or ESB should be negatively associated with toxicological response (e.g., lower survival). As shown in Figures 15 and 16, mean PEC quotients and ESBs do not appear to be associated with the toxicological responses.

Based on these results, it does not appear that chemical constituents in DCR discharge areas impact sediment chemistry. Sediment chemistries in DCR discharge and in references areas are very similar, and concentrations of potentially toxic chemicals may even be less in DCR discharge areas; any observable difference in chemical composition is not likely to produce significant toxicity. While undiluted DCR discharge may produce toxicity from chemical exposure, under realistic dilution scenarios, the effects are similar to sediment in the effects are similar to effects in sediment from DCR discharge and reference areas. The overall reduced performance in toxicity testing (i.e., significant reductions in average organism growth and survival, as compared to the laboratory control) in DCR discharge and references area sediment is most likely not the result of chemical parameters.

Summary of Sediment Chemistry. The evaluation of sediment chemistry consisted of three independent analyses to produce three lines of evidence. For all three analyses, no impacts to sediment chemistry were anticipated. Some sediment toxicity was observed in DCR discharge areas when compared to reference areas, but the toxicity was not from DCR chemistry.

Biological Resources

The impacts on biological resources from DCR discharges, if any, result in changes in sediment or water quality. The measurement of the biological conditions should reflect the water and sediment quality and where changes in these characteristics from DCR discharge correlate with biological changes, the biological effects can be attributed to DCR. Two areas of biological resources (Special Status Species, and Protected and Sensitive Areas) are not addressed in this memorandum because no original data were collected in these areas as part of this program; however, they are addressed in the Draft Tiered EIS. Also, the impacts on invasive species are not addressed in this memorandum because the work was presented in separate memoranda (CH2M HILL, 2007g; CH2M HILL, 2008a; CH2M HILL, 2008b) and the impacts are addressed in the Draft Tiered EIS.

Fish and Other Pelagic Organisms

Impacts to fish and other pelagic organisms found in the open water areas of the Great Lakes were evaluated by considering the same measures used to evaluate impacts to water quality, as described above, and by using the results of laboratory toxicity studies conducted with simulated slurries of deck DCR and sump material. The presence of an impact was determined if chemicals attributable to DCR were predicted to occur in the water column, even in the mixing zone, at concentrations greater than surface water quality criteria; if depletion of dissolved oxygen would occur from DCR, even in the mixing zone; and if significant adverse effects were found on the survival or growth of test organisms exposed to simulated slurries of DCR or sump material. As described above, the discharge of DCR would not result in any exceedances of water quality criteria or impacts to dissolved oxygen. Thus from a water quality perspective, no impact on biological resources is expected.

DCR slurry and sump liquids toxicity testing was conducted with the fathead minnow (*Pimephales promelas*) and the water flea (*Daphnia magna*) in acute bioassays (48 hours) with dilutions to conservatively simulate exposure to discharged slurries in the lake water column. Daphnid and minnow survival was decreased in undiluted sump slurry samples from a taconite vessel and a limestone vessel. Survival was not decreased in the other DCR sump liquid or deck-DCR slurries. In the undiluted taconite sample slurry, aluminum, copper (total and dissolved), and zinc (total but not dissolved) concentrations exceeded acute criteria. In the undiluted limestone sample slurry, only aluminum exceeded criteria. In both samples, total iron also exceeded the chronic criterion (acute criterion are not available for iron). Although simulated DCR slurry was based on an average mass of DCR material from decks in data from 2004 (e^2M, 2005), which is lower than the average mass of DCR in direct observations in 2009 (CH2M HILL, 2009d) by a factor of 2.4; when these slurries were diluted to 1 percent, no effects on survival were observed.

Based on these results, no impacts to fish and other pelagic organisms are predicted.

Benthic Community

The benthic community comprises the interacting organisms found at or near the bottom of the Great Lakes and consists of organisms, such as worms, that generally reside in or on the upper portion of lake sediments or that spend a great deal of time in contact with lake sediments. Impacts to the benthic community were evaluated (1) by comparing the benthic invertebrate community structure or composition within areas of high -intensity DCR sweeping activities with the community structure in reference areas outside the DCR discharge zones, (2) by conducting bulk sediment toxicity with sediments from current DCR discharge zones and from reference areas, (3) by comparing toxicity of DCR with toxicity of laboratory control sediments, and (4) by comparing chemical tissue residues in benthic organisms in the DCR discharge zones with those of organisms from reference areas outside the DCR discharge zones.

Benthic Community Structure

Benthic community structure data were collected from the same sediment samples described above for chemical analysis (five shipping track lines: two in Lake Superior, one in Lake Michigan, and two in Lake Erie). Each track line consisted of a DCR discharge area and a reference area.

Data collected from Lake Superior do not suggest that the benthic community structure is impacted in DCR discharge areas relative to reference areas. Abundance (total number of organisms present and total number of organisms present within a specific taxonomic group) values were low in both DCR discharge and reference areas but similar to data collected by EPA (2007). Likewise, taxa richness (the number of taxonomic groups) was low, averaging three to six species per area, but within the range of EPA’s (2007) observations, of two to six species per sample location. The presence of the amphipod *Diporeia hoyi*, a sensitive species, in both reference and DCR discharge areas also suggests little, if any, impact.

The relationship between benthic community structure and DCR discharge areas in Lake Michigan is unclear. Metrics were both higher (abundance of freshwater clams—Family Sphaeriidae—and diversity—the number of taxa present and how evenly the density of organisms is partitioned among the taxa) and lower (total organism abundance and aquatic worm abundance) in the DCR discharge area relative to the reference area. A comparison to EPA (2007) data suggests that taxa richness is within the previously measured range, but total organism abundance, observed at more than 2,000 organisms per square meter, was higher than that observed in this study (maximum of 759 per square meter). *Diporeia hoyi* was also observed by EPA (2007) at levels higher (fewer than 1,000 per square meter) than in this study (none observed). The results of this comparison suggest that impacts unrelated to DCR discharge are occurring throughout southern Lake Michigan, but further interpretation is limited by the small sample size.

The relationship between benthic community structure and DCR discharge areas in Lake Erie is unclear, but little difference was observed between areas. The benthic community structure in Lake Erie is influenced by many factors, such as a high invasive mussel (family Dreissenidae) population, which can significantly alter the lake bottom, and the eutrophic nature of the system, so it is difficult to differentiate relationships to DCR from other potential factors. EPA (2007) data for Lake Erie indicate high taxa richness (median of 11 taxa), high abundance (fewer than 6,000 organisms per square meter), no *Diporeia* spp., and where the amphipod was absent, aquatic worms were dominant. The results of this investigation in both track lines and reference areas are consistent with EPA findings.

Further interpretation of the benthic community structure data is limited by the sample size, as well as by the potential for seasonal variations that could affect community structure. The accuracy in hitting acoustical anomalies in the DCR discharge areas increases the uncertainty in relating DCR discharge to changes in benthic community structure. Based on visual observations, the greatest amount of DCR was observed in the Lake Superior (Duluth) DCR discharge area replicate sample 3 (LS2-SD-T2-03) and Lake Erie (Cleveland) DCR discharge area replicate sample 2 (LE2-SD-T2-02). Benthic community data in LS2-SD-T2-03 are within the range of samples for DCR discharge and reference area samples for all metrics. A large number of dreissenids were observed in LE2-SD-T2-02, as well as more gastropods and chironomids and fewer oligochaetes, suggesting possible community shifts with a large amount of DCR.

Maher (1999) performed an extensive evaluation of benthic community structure in Lake Ontario and observed differences in the composition of species found in DCR discharge areas compared to reference areas. Three mechanisms were proposed for this community shift: physical disturbance, contaminant effects, and coarsening and de-enrichment of sediment. Physical disturbance would be the result of addition of DCR to the substrate that leads to an increase of early colonizing species. Contaminant effects may affect the species composition and affect the permeability of sediments. A coarsening and de-enrichment of the sediment would affect those species with grain size and organic content preferences. In this study, we found little evidence for differences in chemistry between DCR discharge areas and reference areas that would result in contaminant effects, but a coarsening and de-enrichment mechanism is possible, as we found noticeable grain size differences that may be attributable to DCR. The results of our study do not suggest a physical disturbance mechanism, but our results are limited by the small sample size and limited number of taxa collected, as compared to Maher (1999).

Based on the results of this investigation and on previous studies, DCR discharge has the potential to produce changes in the benthic community. However, these changes cannot be easily predicted, as they may be the result of several mechanisms and interactions with other factors, such as a highly invasive mussel population and the eutrophic nature of some systems. The shift in community structure is not considered impairment and may be only short term—as Soster and McCall (1990) and McCall and Soster (1990) have found that successional stages in Lake Erie were not obvious after 2–14 months—and is therefore considered insignificant.

Toxicity Testing

As discussed above, toxicity testing was performed on sediment collected from DCR discharge areas using sediment testing organisms, *Hyallela azteca* and *Chironomus dilutus*. Figures 11 through 14 present the results of the sediment toxicity testing, with reference lines showing average responses from DCR toxicity testing for comparison. Although results from both DCR discharge areas and reference areas were significantly less than the laboratory control for many samples, there were only a few differences between the DCR discharge area and the reference areas, and the effects observed do not appear to be associated with any chemical constituent.

Sediments in DCR discharge and reference areas are very similar chemically, and concentrations of potentially toxic chemicals may be even less in DCR discharge areas. Thus, differences in chemical composition are not likely to be the cause of differences in toxicity. Whereas undiluted DCR discharge may produce toxicity from chemical exposure, under realistic dilution scenarios, the effects are similar to sediment in DCR discharge areas. The overall reduced performance (i.e., significant reductions from the laboratory control) in DCR discharge and reference area sediment is most likely the result of a combination of chemical contributions from sources other than DCR and physical parameters that are not readily distinguishable.

Benthic Tissue

Benthic tissue was collected in DCR discharge and reference areas and analyzed chemically. Due to equipment malfunctions that resulted in a small tissue volume collected, a complete chemical analysis was not possible for all samples. Interpretation of these data is also limited because individual benthic species were not separated (a composite sample was required to obtain sufficient volume) or depurated prior to analysis, and only a limited number of samples was collected (a second sampling trip was undertaken to collect additional tissue samples from the DCR discharge and reference areas). Based on these limited data, it appears that chemicals in the tissue of benthic organisms from DCR discharge areas are at levels similar to those in the tissue of benthic organisms from reference areas (see Table 10). PAHs are slightly higher in the tissue collected from the Lake Michigan DCR discharge area than in that collected from the reference area, but sediment PAH concentrations appear elevated throughout southern Lake Michigan, with the highest concentrations observed in the reference area.

Waterfowl

Some species of waterfowl feed on benthic organisms at water depths that could potentially expose them to chemicals in DCR or to chemicals that have accumulated in the tissue of benthic organisms within DCR discharges areas.

Impacts to waterfowl were estimated with a food web model and benthic tissue data. For modeling purposes, the long-tailed duck (*Clangula hyemalis*) was used as a representative species that may forage in DCR discharge and reference areas. The long-tailed duck is a small duck that can submerge to deep depths, winters in the Great Lakes, and eats primarily invertebrates, such as amphipods, mollusks, and oligochaetes, as well as fish. Long-tailed duck food web exposure to chemicals in benthic tissue was estimated using the following formula (modified from EPA [1993]):

$$DI_x = \frac{[[\sum_i (FIR)(FC_{xi})(PDF_i)] + [(FIR)(SC_x)(PDS)])]]}{BW}$$

where: DI_x = Dietary intake for chemical x (mg chemical/kg body weight/day)
FIR = Food ingestion rate (kg/day, dry weight)
FC_{xi} = Concentration of chemical x in food item i (mg/kg, dry weight)
PDF_i = Proportion of diet composed of food item i (dry weight basis)
SC_x = Concentration of chemical x in sediment (mg/kg, dry weight)
PDS = Proportion of diet composed of sediment from incidental ingestion (dry weight basis)
BW = Body weight (kg, wet weight)

Conservative values (i.e., ones that overpredict impacts) specific to the long-tailed duck that were used as input variables to this equation were obtained from the scientific literature. To be consistent with a conservative approach, a minimum body weight and maximum food ingestion rate were used. To account for incidental ingestion of sediment while foraging, the maximum sediment concentration in each area was also used. In addition, it was assumed that chemicals are 100 percent bioavailable and that the duck spends 100 percent of its time feeding in the DCR discharge or reference areas. Dietary exposure estimates were derived for each bioaccumulative chemical as defined by EPA (2000). An example calculation for arsenic is presented in Table 8.

Exposure levels associated with negative effects were developed for each chemical. Toxicological information from the literature for wildlife species most closely related to waterfowl was used, when available, but was supplemented by laboratory studies of nonwildlife species (e.g., chickens) when necessary. The ingestion screening values are expressed as milligrams of the chemical per kilogram body weight of the receptor per day (mg/kg-BW/day). Growth and reproduction were emphasized as assessment endpoints because they are the most ecologically relevant to maintaining viable populations and because they are generally the most studied chronic toxicological endpoints for ecological receptors. If several chronic toxicity studies were available from the literature, the most appropriate study was selected for each receptor species based upon study design, study methodology, study duration, study endpoint, and test species. No observed adverse effect levels (NOAELs) based on growth and reproduction were used, when available, as the primary screening values. Since a chronic NOAEL was unavailable for antimony, a NOAEL estimate was extrapolated from a chronic lowest observed adverse effect level (LOAEL) using an uncertainty factor of 10. Ingestion screening values for are summarized in Table 9.

The estimated exposure concentrations or doses from each benthic tissue sample and sediment were divided by the NOAEL effects levels in Table 9 to derive hazard quotients. An example of this calculation for arsenic is also presented in Table 8. Hazard quotients exceeding one indicate the potential for risk because the constituent concentration or dose (exposure) exceeds the effects level. However, as described above, the exposure estimates and effects levels are derived using intentionally conservative assumptions so that hazard quotients greater than or equal to 1 do not necessarily indicate that risks are present or impacts are occurring. Rather, such a hazard quotient identifies constituent-pathway-receptor combinations that may require further evaluation. Hazard quotients that are less than 1 indicate that risks are very unlikely, enabling a conclusion of no significant elevated risk to be reached with high confidence.

The results of the hazard quotient calculations for each benthic tissue chemical and sample analyzed are presented in Table 10. All hazard quotients were less than 1.0, except chromium in the Lake Michigan reference sample and benzo(a)pyrene, benzo(b)fluoranthene, and chrysene in the Lake Michigan DCR discharge area. However, the food web exposures in these samples only slightly exceeded the effects levels, as all hazard quotients were less than 2.0, suggesting that even with conservative assumptions, impacts are unlikely. If less conservative assumptions were used, such as an average body weight or ingestion rate or a less-conservative effects level (in the Lake Michigan DCR discharge, hazard quotients based on the LOAL would be less than 0.2), the hazard quotients would not exceed 1.0. More importantly, because chemical constituents in sediment and benthic tissue from DCR discharge areas are similar to that in reference areas, the potential impacts from DCR discharge to waterfowl appear negligible.

The food web model analysis evaluates ingestion only through the food web and does not consider potential impacts from the gathering of grit, which can occur at deep depths. In addition to the long-tailed duck, common loons may dive to deep depths and have been recorded at depths up to 600 feet in the Great Lakes (Ehrlich et al., 1988). Franson et al. (2001) described the dimension of stones found in the stomachs of dead loons. Stones retained in sieves with mesh sizes between 4.75 mm and 8.00 mm accounted for the greatest percentage (by mass) of grit in loon stomachs. Although coal, limestone, and taconite collected from cargo vessels was predominantly within the range of 0.6 to 1.18 mm, it is possible that DCR discharge will contain particles of the sizes found in loon stomachs, even though sediment collected in DCR discharge areas typically had almost no particles in this size range. As discussed above, the chemical concentrations of DCR are lower than those of existing sediments; even if waterfowl ingest individual DCR particles, no chemical effects would occur.

Summary of Impacts

The impacts from past and ongoing DCR practices to segments of the ecosystem potentially influenced by the discharge of DCR are summarized in Table 11. The potential impacts in this analysis (no impact, insignificant impact, or significant impact) are associated with the Draft Tiered EIS No Action alternative of continuing the existing Interim Rule. The results will also be used to predict impacts of alternative methods of managing DCR evaluated in the Draft Tiered EIS.

For water quality, no impacts to water chemistry (including toxicity), dissolved oxygen, or nutrient enrichment are predicted, with little uncertainty because any effects are diminished at dilutions expected from DCR discharges (i.e., at least 26,000 to 1).

For sediment quality, no impacts from sediment deposition rate or to sediment chemistry, which consisted of three independent analyses, are predicted. Some sediment toxicity was observed in DCR discharge areas when compared to reference areas, but the toxicity does not appear to be associated with any chemical constituent. Impacts to sediment physical structure, defined as noticeable grain size differences among sediments from DCR discharge areas, may occur in at least some areas of intense DCR discharge, but these impacts are likely insignificant because the increased heterogeneous grain size distribution provides increased habitat diversity relative to that of reference areas.

For biological resources, no impacts to fish and other pelagic organisms are predicted. DCR discharge has the potential to produce changes in the benthic community because of changes to the sediment physical structure. However, these changes are not easily predicted, as they may be the result of several mechanisms and interactions with other factors. The shift in community structure is not considered impairment and may only be short term; therefore it is considered to be insignificant. Impacts to waterfowl, either through the foodweb or from grit ingestion, are not predicted.

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TABLE 1
Relative Quantities of Dry Cargo Types

	1997 to 2001 Cargo (PMG, 2002)	2001 Discharge (PMG, 2002)	1998 to 2004 Cargo (e^2M, 2005)	2004 Discharge (e^2M, 2005)
Iron ore	39.7%	36.9%	50.7%	58.8%
Coal	23.4%	27.0%	21.2%	19.7%
Limestone	22.1%	26.0%	26.5%	20.5%
Combined Iron Ore, Coal, and Limestone	***84.1%***	***89.9%***	***98.3%***	***99.1%***
Salt	4.3%	2.1%	0.9%	NR
Grain	8.9%	2.3%	0.3%	NR
Coke	NR	1.5%	NR	NR
Cement/Gypsum	3.1%	0.3%	NR	NR
Millscale	NR	0.1%	NR	NR
Slag	NR	0.9%	NR	NR
Cement	NR	0.5%	NR	NR
Sand	NR	0.2%	NR	NR
Potash	0.4%	0.2%	NR	NR

NR= not reported due to insufficient volume for analysis

TABLE 2

Modeling Results (Water Quality)

DCR DCR Material	Taconite Deck	Taconite Sump	Coal Coal (Deck)	Coal Coal (Sump)	Limestone Deck (a)
Mass of DCR discharge (lb)	518	–	363	–	634
Volume of discharge (gallons)	9,324	4,000	6,534	4,000	7,608
Duration of discharge (s)	600	600	600	600	600
Vessel speed (knots)	12	12	12	12	12
Vessel width (ft)	68	68	68	68	68
Vessel draft (ft)	10	10	10	10	10
Distance of discharge (ft)	12,152	12,152	12,152	12,152	12,152
Rate of DCR discharge (gpm)	932	400	653	400	761
Estimated dilution factor	26,000:1	62,000:1	38,000:1	62,000:1	33,000:1

(a) Dilution was not calculated for limestone sump because no compound in the limestone slurry exceed water quality criteria thus it was not necessary to apply a dilution factor to determine compliance.

TABLE 3
Exceedance Ratios

Analyte	Chronic Water Quality Criteria	Taconite		Easter Coal		Western Coal		Limestone	
		Deck	**Sump**	**Deck**	**Sump**	**Deck**	**Sump**	**Deck**	**Sump**
Aluminum	0.75 mg/L	—	—	—	—	—	11	—	10.9
Benzo(a)anthracene	0.027 µg/L	—	—	—	—	—	**3.4**	—	—
Benzo(a)pyrene	0.014 µg/L	—	—	—	—	—	**2.6**	—	—
Cadmium	0.00025 mg/L	—	**2.7**	—	—	—	—	—	**8**
Cadmium, dissolved	0.00021 mg/L	—	**1.8**	—	—	—	—	—	**7.2**
Chrysene	0.014 µg/L	—	—	**3.2**	—	—	**7.1**	—	—
Copper	0.009 mg/L	—	2.9	—	—	—	—	—	1.5
Copper, dissolved	0.009 mg/L	—	2.2	—	—	—	—	—	**1.4**
Fluorene		—	—	—	—	—	—	—	—
Iron	1 mg/L	**1.3**	**6.2**	—	—	—	**9.8**	—	**1.6**
Lead	0.003 mg/L	—	**2.3**	—	—	—	—	—	**2.5**
Lead, dissolved	0.003 mg/L	—	**1.2**	—	—	—	—	—	**1.2**
Pyrene	0.014 ug/l	—	—	**3.2**	—	**3.2**	**31.4**	—	—
Selenium	0.005 mg/L	—	—	—	—	—	—	—	**1.9**
Selenium, dissolved	0.005 mg/L	—	—	—	—	—	—	—	**2.4**
Zinc	0.12 mg/L	—	**1.2**	—	—	—	—	—	**1.6**

Note: Bold numbers also exceed acute water quality criteria.

TABLE 4

Nutrient Concentrations in Simulated DCR Slurry and Lake Water

	NO_3 (mg/L)		TKN (mg/L)		TN (mg/L)		TP (mg/L)	
	Lake Water	Simulated Slurry	Lake Water	Simulated Slurry	Lake Water	Simulated Slurry	Lake Water	Simulated Slurry
Iron								
Lake Superior	—	—	—	—	—	—	0.02	0.03
Lake Erie	—	—	—	—	—	—	—	—
Eastern Coal								
Lake Superior	—	—	—	—	—	—	—	—
Lake Erie	—	—	—	—	—	—	—	—
Western Coal								
Lake Superior	0.36	0.37	—	—	—	—	—	—
Lake Erie	—	—	0.85	1.26	0.99	1.43	0.02	0.13
Limestone								
Lake Superior	0.37	0.38	—	—	—	—	—	—
Lake Erie	—	—	—	—	—	—	—	—

Shaded cells indicate values are statistically different

Nutrients with no statistical difference are not shown

TABLE 5

Natural and DCR Deposition Rates (a)

	Range of Natural Deposition Rates ($g/m^2/yr$)		Typical Range in Track Line ($g/m^2/yr$)	Maximum DCR Deposition Rates ($g/m^2/yr$) (b)
	Lower End	**Upper End**		
Erie	180	10000	2300	3.61
Michigan	20	2500	490	3.25
Superior	25	3040	50	0.31
Ontario	85	1225	490	0.27

(a) Taken from discussions of sedimentation rates in Dry Cargo Residue Discharge Analysis for the U.S. Coast Guard Technical Memorandum (CH2M HILL, 2009) and DEIS Chapter 3.

(b) Maximum total DCR deposition rate calculated for most intense shipping in Potomac Study (PMG, 2002). Updated calculations include increasing the DCR mass by a ratio of 5 due to the mass of coal from the direct observations being on average 5 times larger than the data used in Phase 1 (CH2M HILL, 2009).

TABLE 6
Maximum Sediment Concentrations (mg/kg) in DCR Discharge and Reference Areas, with Screening Guidelines and the Ranges of Values

	Guideline	Lake Superior					Lake Michigan			Lake Erie				
Analyte	Guideline Value (MacDonald et al. 2000)	LS1	LS1-Ref	LS2	LS-2-Ref	Mudroch et al., 1988	LM1	LM1-Ref	Mudroch et al., 1988	LE1	LE1-Ref	LE2	LE2-Ref	Mudroch et al., 1988
Arsenic	9.79	18.6	20.5	51.4	28.6	Not Available	14.4	11.1	5.0–15.0	5.09	7.42	13.2	9.8	0.45–12.3
Cadmium	0.99	2.15	2.05	2.84	2.82	1.4–2.5	2.32	1.52	0.05–1.8	3.08	2.53	2.72	2.22	0.8–13.7
Chromium	43.4	61.5	52	46.2	43.6	29.5–60.2	49.4	39.9	140	53.7	52.7	68.2	60.6	12–362
Copper	31.6	128	134	81.6	83.5	113–173	49.9	36.7	54	47.1	46.6	56.3	48.6	5–207
Iron	Not Available	53,200	52,700	64,700	50,900	49,100–57,600	29,400	23,300	Not Available	33,700	35,000	44,600	49,300	11,000–77,900
Lead	35.8	63.5	69.5	44.7	50.3	74.9–138	112	65.2	10–130	47.7	46.1	64.7	52.7	6–299
Mercury	0.18	0.135	0.134	0.117	0.127	0.094–0.16	0.11	0.0942	0.030–0.380	0.352	0.399	0.17	0.208	0.045–4.8
Nickel	22.7	45.5	41	44.5	42.2	28.9–66.4	51.3	29.9	25	50.3	51	67.2	58	16–150
Zinc	121	166	174	140	145	143-195	190	143	40–350	180	180	214	240	18–536

TABLE 7

Comparison of Inorganic Concentrations in DCR and Sediment from Previous Investigations

DCR Type	Chromium (mg/kg)	Copper (mg/kg)	Lead (mg/kg)	Nickel (mg/kg)	Zinc (mg/kg)
CH2M HILL (2007a)					
Coal Deck DCR	10.65	17.13	5.98	10.45	28.88
Coal SS	9.9	14.8	2.67	4.56	15.8
Limestone Deck DCR	3.33	2.87	7.78	5.12	8.82
Limestone SS	5.69	4.32	1.12	9.73	23.38
Taconite Deck DCR	10.15	2.83	0.93	2.68	6.07
Taconite SS	9.34	4.28	4.11	3.55	30.51
Clyne (2000)					
Average Non-impacted DCR Discharge Areas	81.29	119.71	91.43	98.86	303.71
Average Impacted DCR Discharge Areas	65	105	70	91.5	264

TABLE 8
Example Food Web Calculation for Waterfowl

$$DI_x = \frac{[\sum(FIR)(FC_{xi})(PDF_i) + [(FIR)(SC_x)(PDS)]}{BW}$$

$$HQ = \frac{DI_x}{\text{Screening Value}}$$

Symbol	Value	Description	Units
DI_x	Calculated	Dietary intake for constituent x (arsenic)	mg chemical/kg body weight/day
FIR	6.19E-02	Food ingestion rate based allometric equation for wading birds (EPA, 1993) and using the maximum reported body weight of 1.1 kg for the long-tailed duck (Robertson and Savard, 2002)	kg/day (dry weight)
FC_{xi}	1.79E-01	Concentration of analyte x (arsenic) in aquatic invertebrates (benthic tissue composite)	mg/kg (dry weight)
PDF_i	9.67E-01	Proportion of diet composed of aquatic invertebrates (assumed)	(dry weight)
SC_x	51.4	Maximum concentration of analyte x (arsenic) in sediment in area	mg/kg (dry weight)
PDS	3.30E-02	Proportion of diet composed of sediment. Based on value for mallard from Beyer et al. (1994)	(dry weight)
BW	5.00E-01	Minimum long-tailed duck body weight (Robertson and Savard, 2002)	kg (wet weight)

DI_x = 0.23

NOAEL Screening Value (from Table 8) = 5.14

HQ (see Table 10) = 0.045

TABLE 9
Waterfowl Ingestion Screening Values

Analyte	Test Organism	Duration	Exposure Route	Effect/Endpoint	NOAEL (mg/kg/d)		LOAEL (mg/kg/d)		Reference
Inorganics									
Arsenic	mallard	128 days	oral in diet	survival	5.14E+00		1.28E+01		Sample et al., 1996
Cadmium	mallard	90 days	oral in diet	reproduction	1.45E+00		2.00E+01		Sample et al., 1996
Chromium	black duck	10 months	oral in diet	reproduction	1.00E+00		5.00E+00		Sample et al., 1996
Copper	chicks	10 weeks	oral in diet	growth/survival	4.70E+01		6.17E+01		Sample et al., 1996
Lead	quail	12 weeks	oral in diet	reproduction	1.13E+00		1.13E+01		Sample et al., 1996
Mercury	mallard	3 generations	oral in diet	reproduction	2.60E-02		7.80E-02		EPA, 1997
Nickel	mallard	90 days	oral in diet	growth/survival	7.74E+01		1.07E+02		Sample et al., 1996
Selenium	mallard	100 days	oral in diet	reproduction	4.00E-01		8.00E-01		Sample et al., 1996
Silver	mallard	14 days	oral in diet	survival	1.78E+01	(b)	1.78E+02	(a)	EPA, 1999
Zinc	chicken	44 weeks	oral in diet	reproduction	1.45E+01		1.31E+02		Sample et al. 1996
Polyaromatic Hydrocarbons									
Acenaphthene	chicken	35 days	oral in diet	reproduction	7.10E+00	(b)	7.10E+01	(a)	Rigdon and Neal, 1963
Acenaphthylene	chicken	35 days	oral in diet	reproduction	7.10E+00	(b)	7.10E+01	(a)	Rigdon and Neal, 1963
Anthracene	chicken	35 days	oral in diet	reproduction	7.10E+00	(b)	7.10E+01	(a)	Rigdon and Neal, 1963
Benzo(a)anthracene	chicken	35 days	oral in diet	reproduction	7.10E+00	(b)	7.10E+01	(a)	Rigdon and Neal, 1963
Benzo(a)pyrene	chicken	35 days	oral in diet	reproduction	7.10E+00	(b)	7.10E+01	(a)	Rigdon and Neal, 1963
Benzo(b)fluoranthene	chicken	35 days	oral in diet	reproduction	7.10E+00	(b)	7.10E+01	(a)	Rigdon and Neal, 1963
Benzo(g,h,i)perylene	chicken	35 days	oral in diet	reproduction	7.10E+00	(b)	7.10E+01	(a)	Rigdon and Neal, 1963
Benzo(k)fluoranthene	chicken	35 days	oral in diet	reproduction	7.10E+00	(b)	7.10E+01	(a)	Rigdon and Neal, 1963
Chrysene	chicken	35 days	oral in diet	reproduction	7.10E+00	(b)	7.10E+01	(a)	Rigdon and Neal, 1963
Dibenz(a,h)anthracene	chicken	35 days	oral in diet	reproduction	7.10E+00	(b)	7.10E+01	(a)	Rigdon and Neal, 1963
Fluoranthene	chicken	35 days	oral in diet	reproduction	7.10E+00	(b)	7.10E+01	(a)	Rigdon and Neal, 1963
Fluorene	chicken	35 days	oral in diet	reproduction	7.10E+00	(b)	7.10E+01	(a)	Rigdon and Neal, 1963
Indeno(1,2,3-cd)pyrene	chicken	35 days	oral in diet	reproduction	7.10E+00	(b)	7.10E+01	(a)	Rigdon and Neal, 1963
Phenanthrene	chicken	35 days	oral in diet	reproduction	7.10E+00	(b)	7.10E+01	(a)	Rigdon and Neal, 1963
Pyrene	chicken	35 days	oral in diet	reproduction	7.10E+00	(b)	7.10E+01	(a)	Rigdon and Neal, 1963

(a) Uncertainty factor of 10 applied for conversion between NOAEL and LOAEL
(b) Acute or subchronic to chronic uncertainty factor of 10 applied

TABLE 10
Waterfowl Foodweb Modeling Results

	LS2-TS-Sled			LE1-TS-SLED			LM2-TS-RSLED-01			LM2-TS-RSLED-02			LE2-TS-SLED			RFI-TS-SLED		
Analyte	**Maximum Sediment (mg/kg)**	**Benthic Tissue Composite (mg/kg dry)**	**Hazard Quotient**	**Maximum Sediment (mg/kg)**	**Benthic Tissue Composite (mg/kg dry)**	**Hazard Quotient**	**Maximum Sediment (mg/kg)**	**Benthic Tissue Composite (mg/kg dry)**	**Hazard Quotient**	**Maximum Sediment (mg/kg)**	**Benthic Tissue Composite (mg/kg dry)**	**Hazard Quotient**	**Maximum Sediment (mg/kg)**	**Benthic Tissue Composite (mg/kg dry)**	**Hazard Quotient**	**Maximum Sediment (mg/kg)**	**Benthic Tissue Composite (mg/kg dry)**	**Hazard Quotient**
Inorganics																		
Arsenic	51.4	0.179	0.045	5.03	0.866	0.024	14.4	0.994	0.035	11.1	2.58	0.069	13.2	0.863	0.031	7.42	0.589	0.020
Cadmium	2.84	0.0552	0.013	3.08	1.48	0.13	2.32	0.613	0.057	1.52	0.612	0.055	2.72	0.616	0.059	2.53	1.11	0.10
Chromium	46.2	0.235	0.22	53.7	3.99	0.70	49.4	3.17	0.58	39.9	10.3	1.40	68.2	2.17	0.54	52.7	3.04	0.58
Copper	81.6	11.3	0.036	47.1	9.43	0.028	49.9	10.3	0.031	36.7	8.39	0.025	56.3	6.55	0.022	46.6	10.2	0.030
Lead	44.7	0.0736	0.17	47.7	3.49	0.54	112	3.4	0.77	65.2	2.99	0.55	64.7	1.69	0.41	46.1	3.27	0.51
Mercury	0.117	0.01	0.064	0.352	0.0266	0.18	0.11	0.0104	0.07	0.0942	0.0232	0.12	0.17	0.0099	0.072	0.399	0.0206	0.16
Nickel	44.5	0.253	0.0027	50.3	3.81	0.009	51.3	5.84	0.01	29.9	3.58	0.007	67.2	2.04	0.0067	51	2.99	0.007
Selenium	1.56	0.102	0.046	*1.48*	0.619	0.20	2.14	0.903	0.29	*4.39*	0.93	0.32	*1.98*	0.464	0.16	1.45	0.372	0.13
Silver	0.704	0.167	0.0013	0.828	0.165	0.0013	*0.742*	0.163	0.0013	*0.802*	0.17	0.0013	*0.926*	0.165	0.0013	0.825	0.167	0.0013
Zinc	140	4.92	0.08	180	16.8	0.19	190	13.2	0.16	143	30.8	0.29	214	18.7	0.21	180	21.6	0.23
Polyaromatic Hydrocarbons																		
Acenaphthene	0.006	6.7	0.11	0.0045	2	0.034	0.014	6.7	0.11	0.02	6.7	0.11	0.0092	2.9	0.049			
Acenaphthylene	0.0078	3.3	0.056	0.016	1	0.017	0.012	16	0.27	0.02	3.3	0.056	0.02	1.4	0.024			
Anthracene	0.019	4.1	0.069	0.017	1	0.017	0.04	23	0.39	0.06	3.3	0.056	0.027	1.5	0.025			
Benzo(a)anthracene	0.065	6.7	0.11	0.074	2	0.034	0.13	46	0.78	0.16	14	0.24	0.1	4.4	0.074			
Benzo(a)pyrene	0.064	6.7	0.11	0.093	3.8	0.064	0.15	85	1.43	0.17	36	0.61	0.13	9.5	0.16			
Benzo(b)fluoranthene	0.12	13	0.22	0.17	4	0.068	0.25	89	1.50	0.28	28	0.47	0.26	12	0.20			
Benzo(g,h,i)perylene	0.053	10	0.17	0.087	3	0.051	0.13	57	0.96	0.14	22	0.37	0.12	4.3	0.073			
Benzo(k)fluoranthene	0.042	10	0.17	0.068	3	0.051	0.11	41	0.69	0.10	8.9	0.15	0.11	4.4	0.074			
Chrysene	0.077	4.5	0.076	0.13	4	0.068	0.18	67	1.13	0.21	20	0.34	0.18	11	0.19			
Dibenz(a,h)anthracene	0.015	10	0.17	0.023	3	0.051	0.033	19	0.32	0.038	7.4	0.12	0.03	4.3	0.073			
Fluoranthene	0.13	8.1	0.14	0.17	4.8	0.081	0.3	57	0.96	0.39	15	0.25	0.21	11	0.19			
Fluorene	0.009	6.7	0.11	0.014	2	0.034	0.018	6.7	0.11	0.027	6.7	0.11	0.016	2.9	0.049			
Indeno(1,2,3-cd)pyrene	0.051	10	0.17	0.078	3	0.051	0.12	53	0.89	0.13	17	0.29	0.11	5.9	0.10			
Phenanthrene	0.08	12	0.20	0.065	5.5	0.093	0.19	25	0.42	0.21	20	0.34	0.11	15	0.25			
Pyrene	0.11	6.7	0.11	0.16	2.8	0.047	0.27	58	0.98	0.30	19	0.32	0.21	4.7	0.079			

Blank cells indicate chemical analysis not performed
Shaded cells indicate Hazard Quotients greater than or equal to 1.0
Results in italics indicate analyte was not detected
LS2-TS-Sled = Lake Superior (Duluth) DCR Discharge Area
LM2-TS-RSLED-01 = Lake Michigan (2nd Trip) - DCR Discharge Area
LM2-TS-RSLED-02 = Lake Michigan (2nd Trip) - Reference Area
LE2-TS-Sled = Lake Erie (Cleveland) DCR Discharge Area
RFI-TS-SLED = Lake Erie Reference Area

TABLE 11
Summary of DCR Impact Analysis

Resource Area	Draft Tiered EIS No Action Alternative: Continue the Existing Interim Rule
Water Quality	
Water Chemistry	○
Nutrient Enrichment	○
Dissolved Oxygen	○
Sediment Quality	
DCR Deposition Rate	○
Physical Habitat Changes	◐
Sediment Chemistry	○
Biological Resources	
Special Status Species	NA
Protected and Sensitive Areas	NA
Fish and Other Pelagic Organisms	○
Benthic Community Structure	◐
Invasive Species	NA
Waterfowl	○

NA = Not evaluated in this memorandum

○ = No Impact

◐ = Insignificant Impact

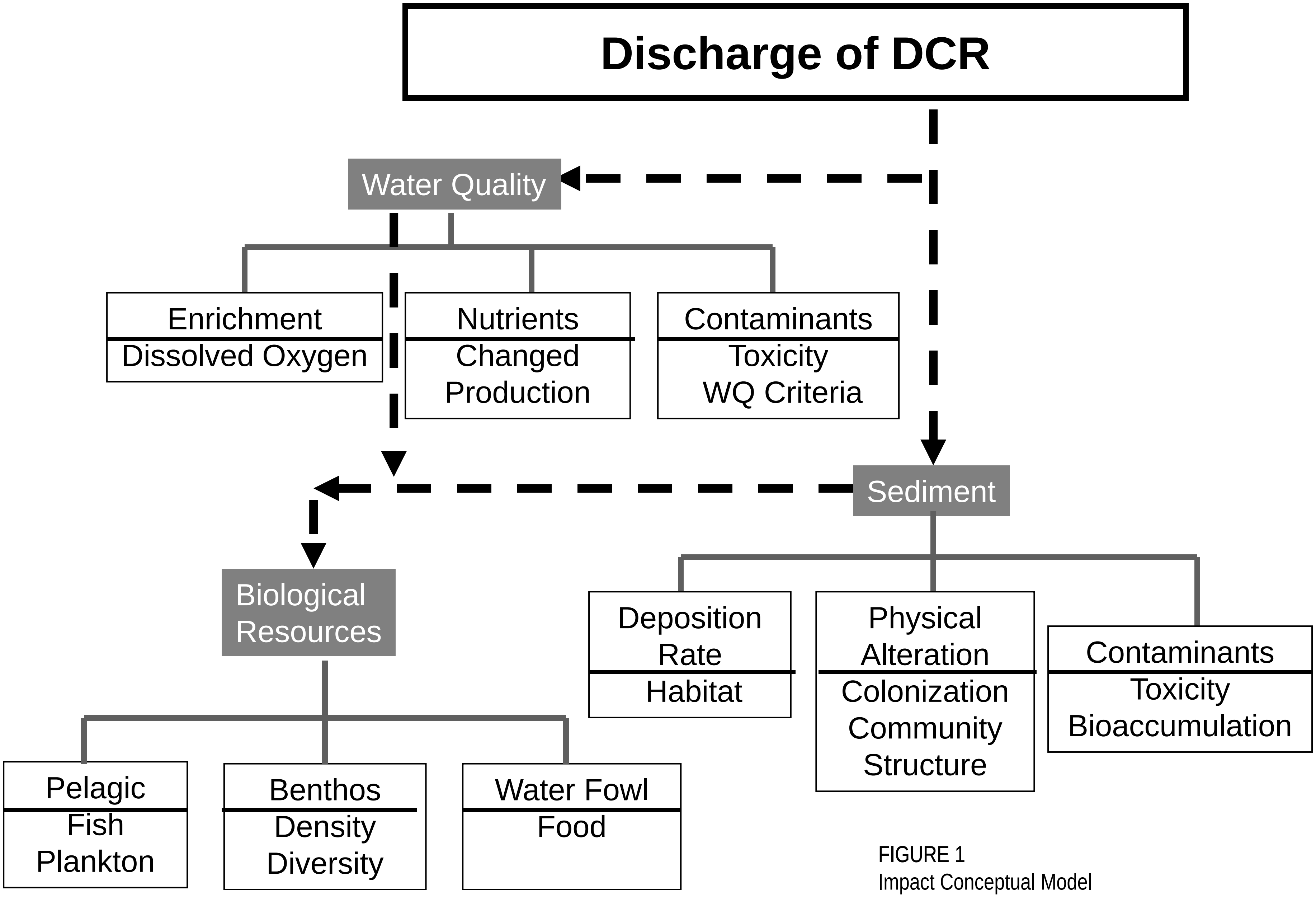

FIGURE 1
Impact Conceptual Model

	Areas of Potential Impact						
Scientific Investigations	Water Chemistry	Enrichment & Nutrients	Sediment Chemistry	Sediment Alteration & Deposition	Benthos	Pelagic Organisms	Water Fowl
Sweepings Characterization	■	■	■	■	■	■	■
Sweepings Discharge Analysis	■	■	■	■		■	
Historic Deposition Analysis				■			
Physical Characterization of Deposition Area				■	■		
Chemical Characterization of Deposition Area			■		■	■	■
Toxicity Tests			■		■	■	
Benthic Community Structure					■		
Nutrient Enrichment	■	■					

FIGURE 2
Scientific Investigation of Impacts: Multiple Lines of Evidence

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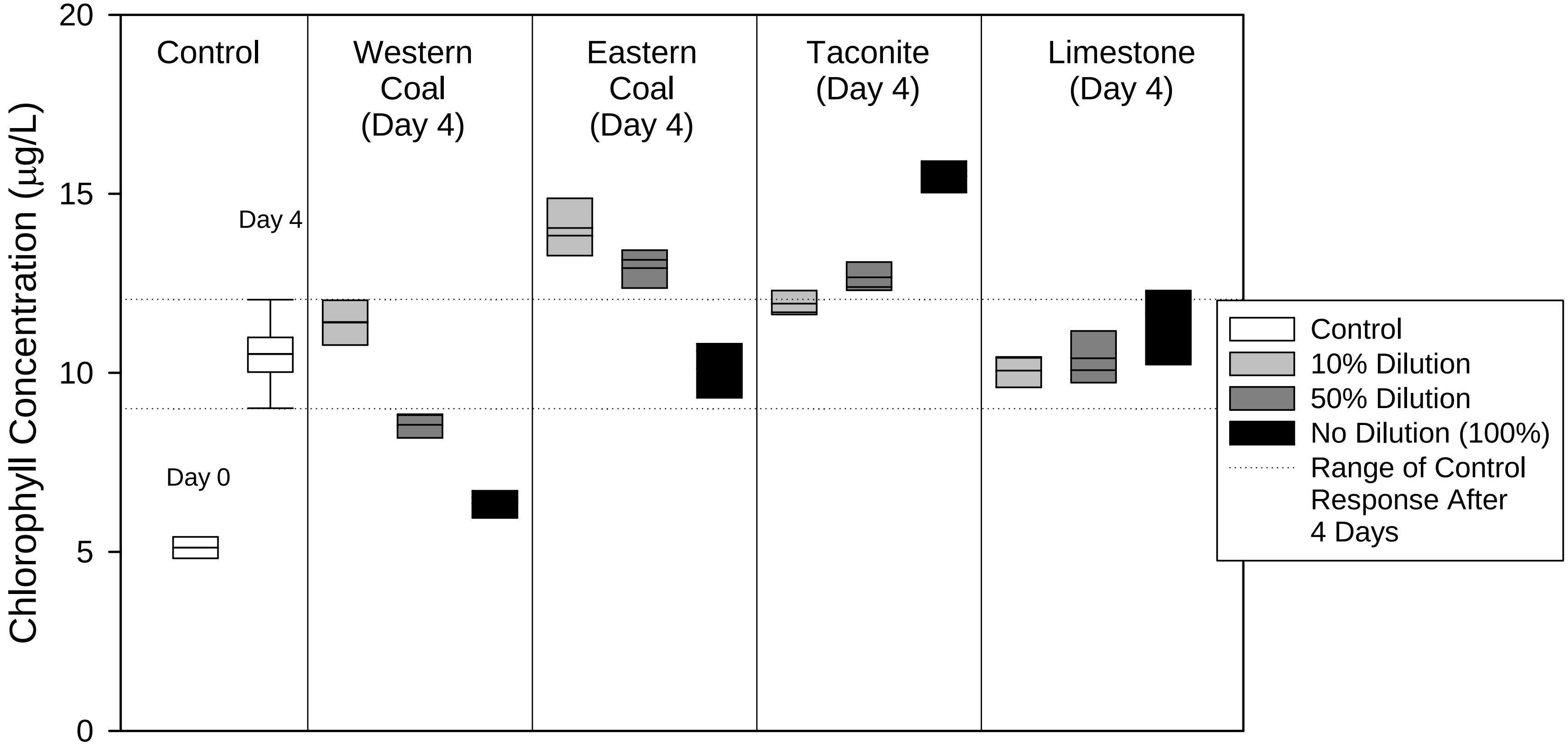

FIGURE 3
Aquatic Plant Stimulation
in Lake Erie

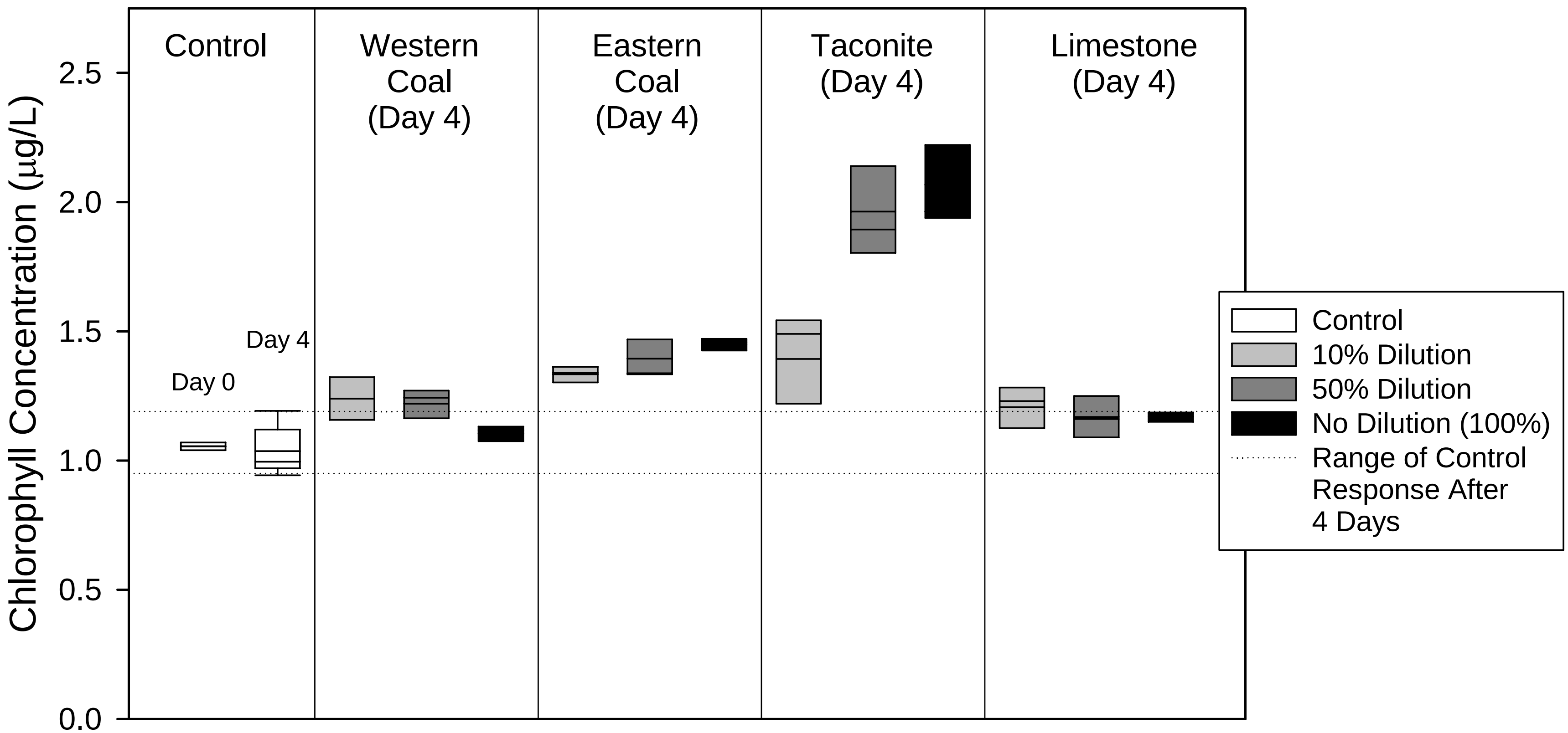

FIGURE 4
Aquatic Plant Stimulation
in Lake Superior

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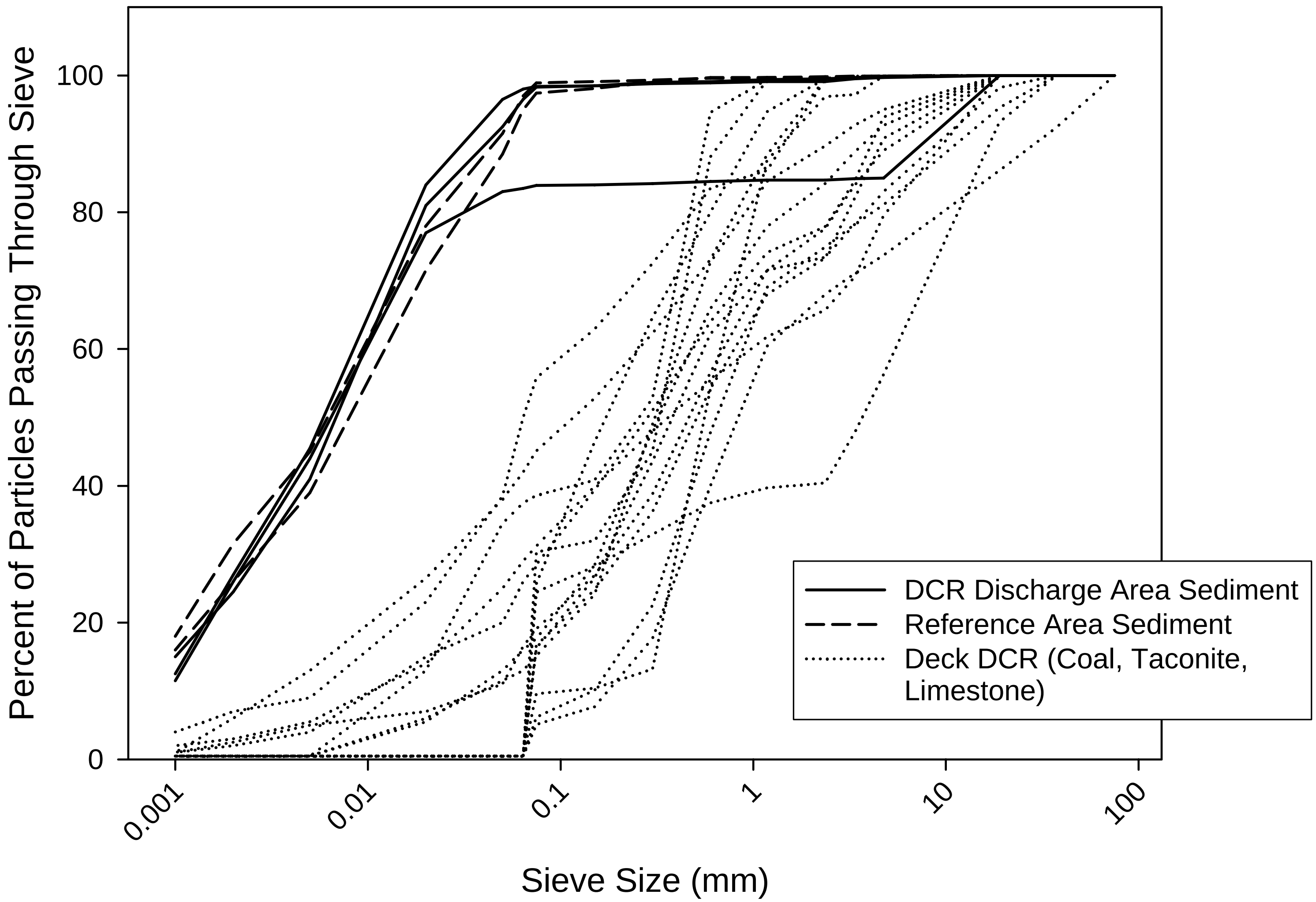

FIGURE 5
Lake Superior (Silver Bay)
Sediment and DCR Grain
Size

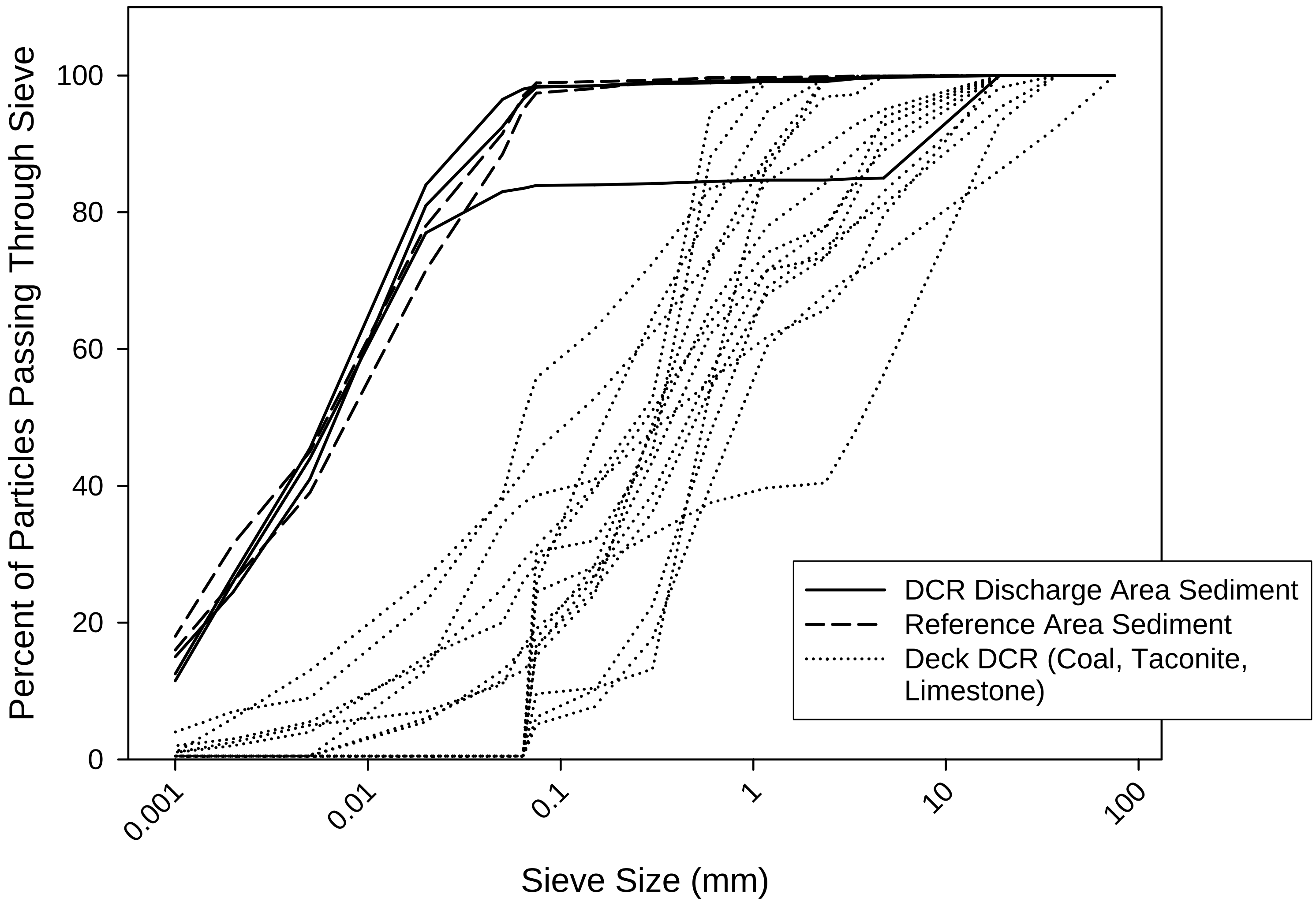

FIGURE 6
Lake Superior (Duluth) Sediment and DCR Grain Size

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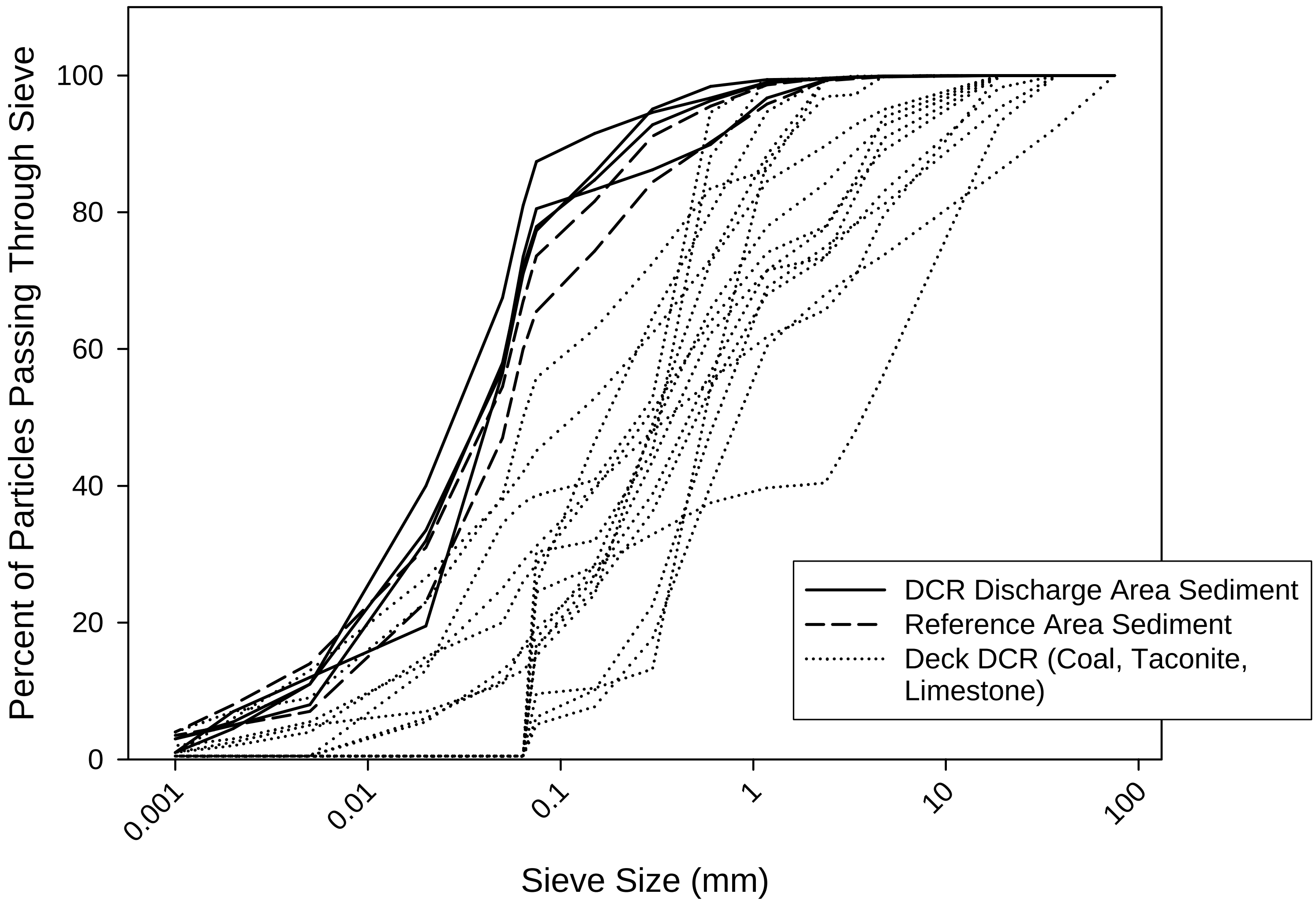

FIGURE 7
Lake Michigan Sediment
and DCR Grain Size

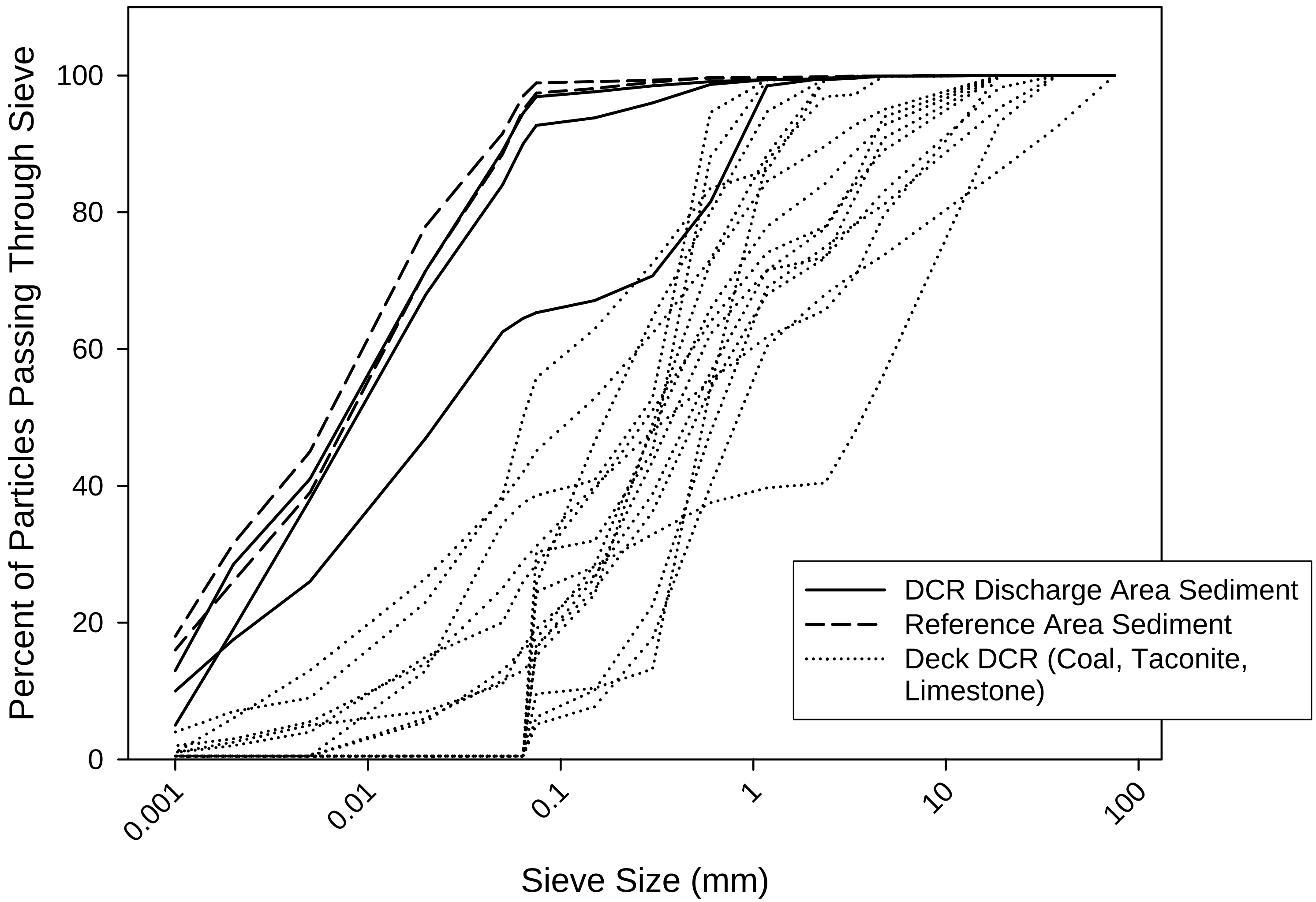

FIGURE 8
Lake Erie (Marblehead)
Sediment and DCR Grain
Size

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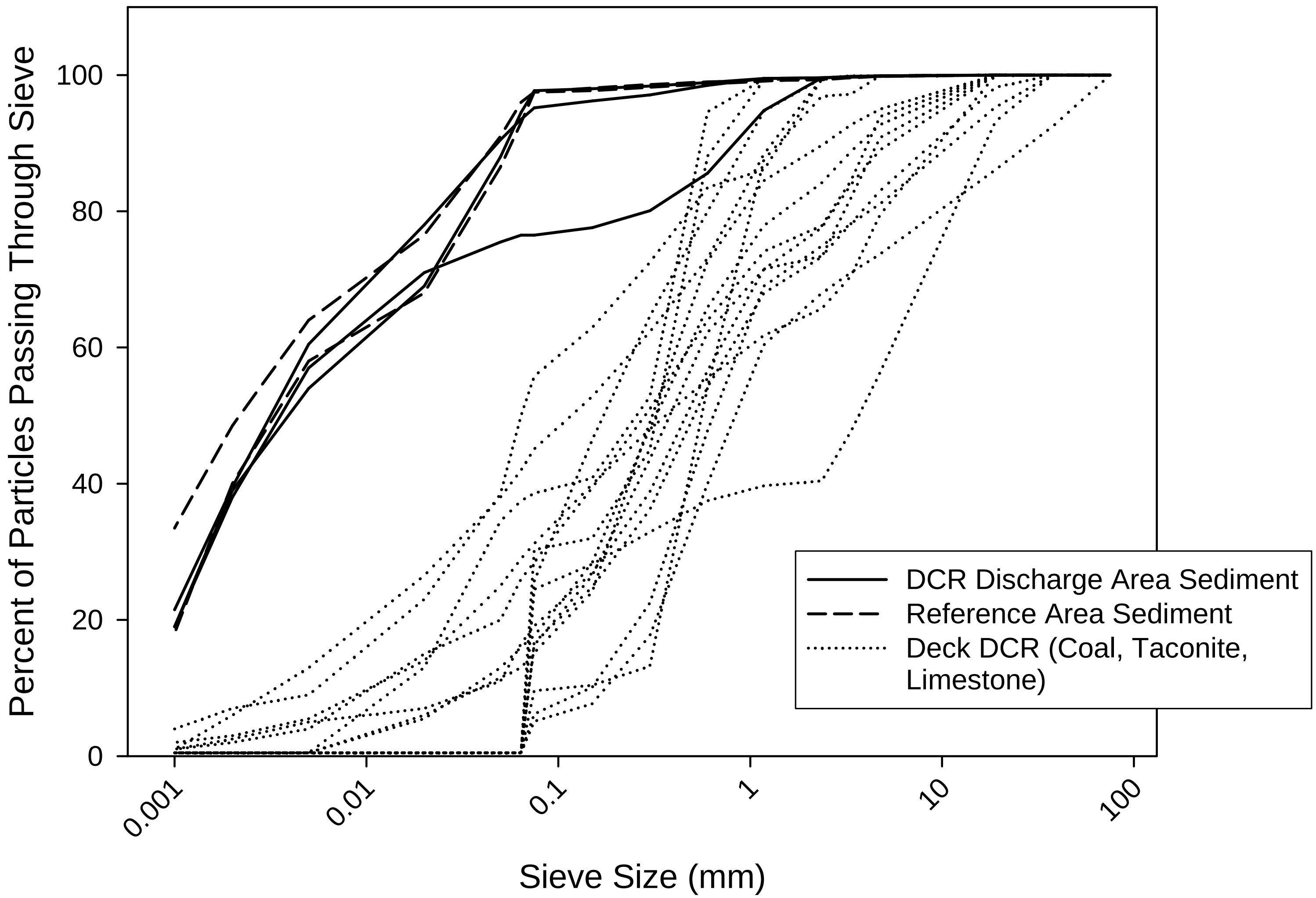

FIGURE 9
Lake Erie (Cleveland)
Sediment and DCR Grain Size

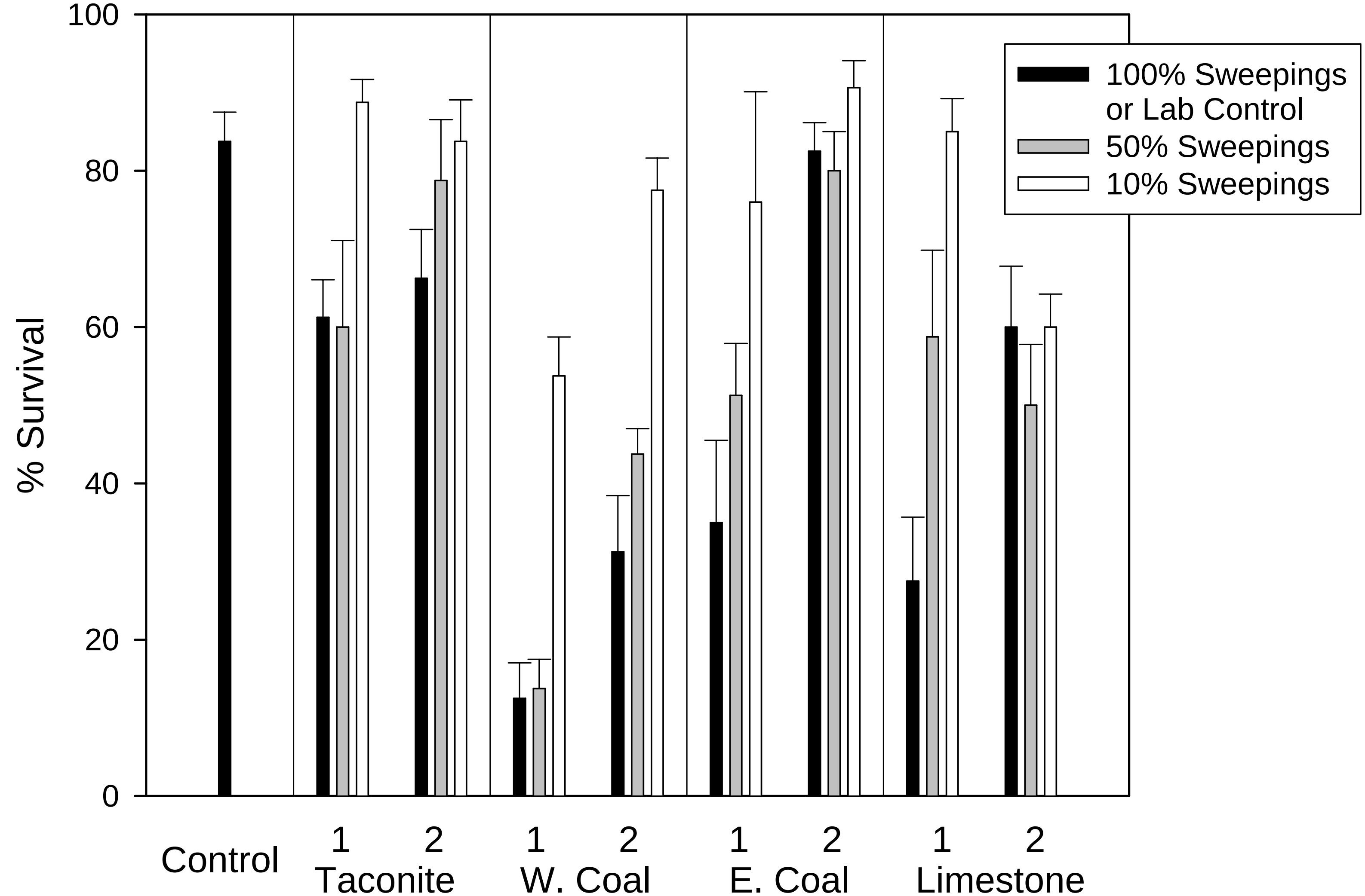

FIGURE 10
Hyallela azteca Survival in
DCR with Dilutions

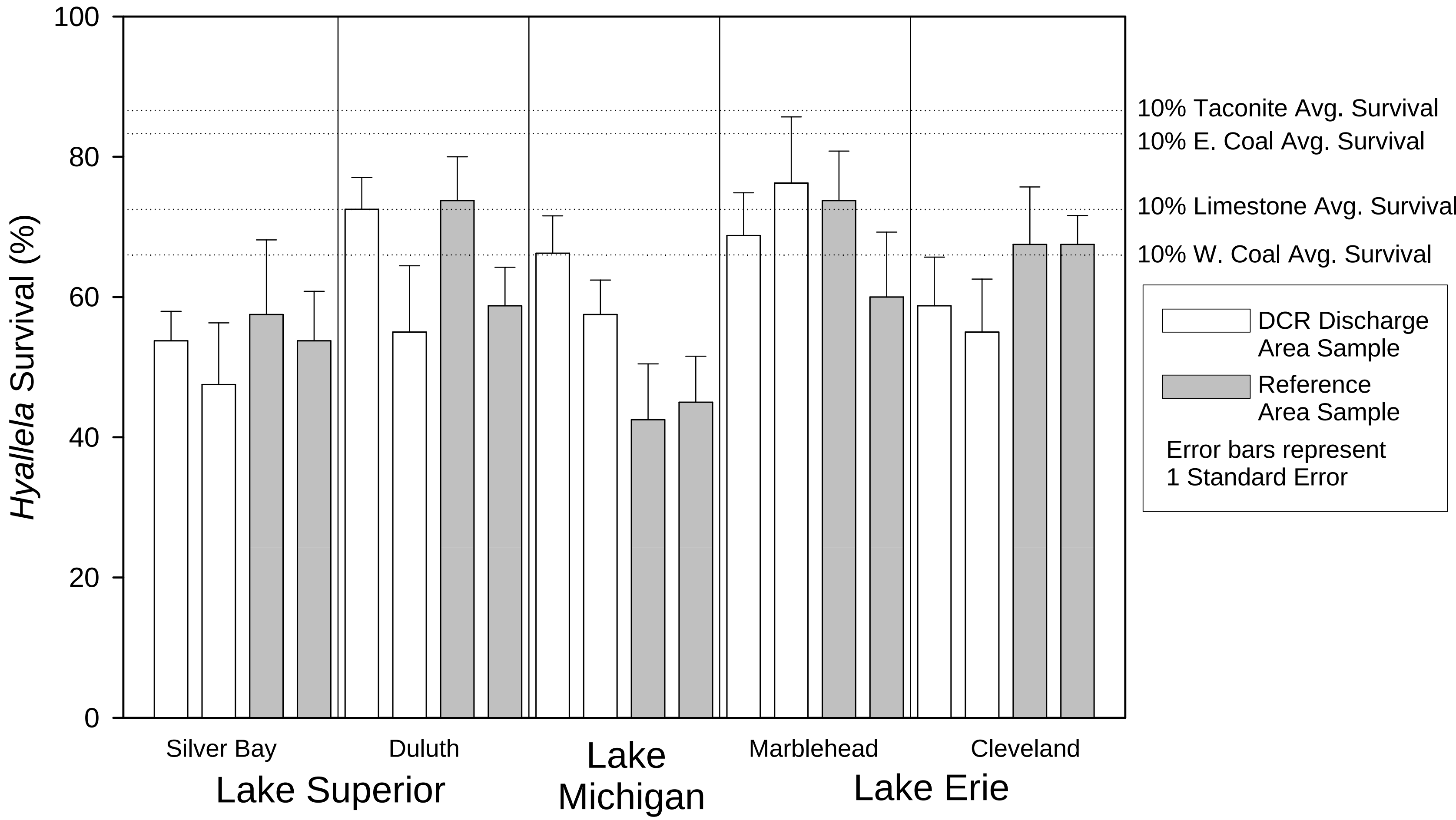

FIGURE 11
Hyallela azteca Survival in DCR Discharge and Reference Areas

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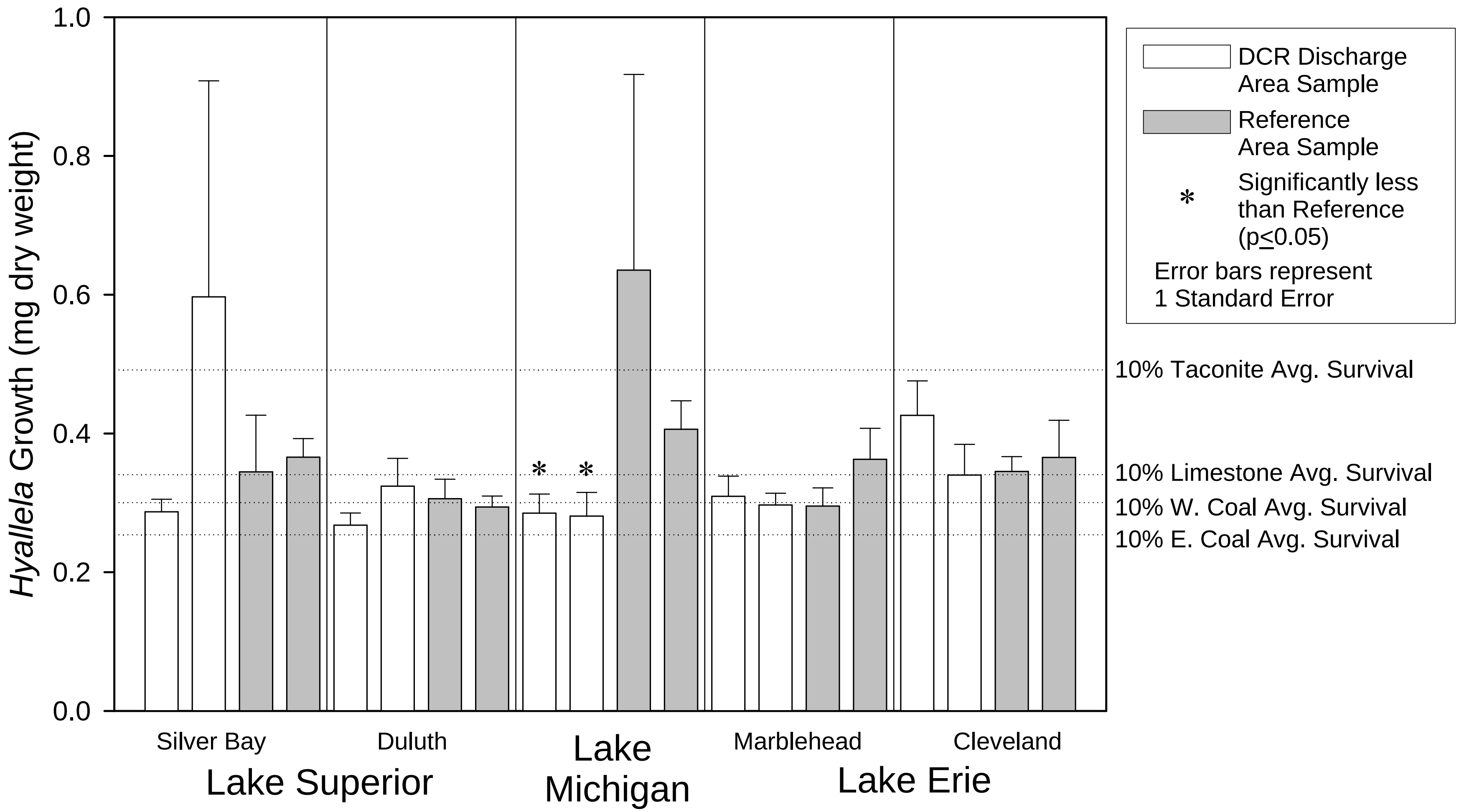

FIGURE 12
Hyallela azteca Growth in
DCR Discharge and
Reference Areas

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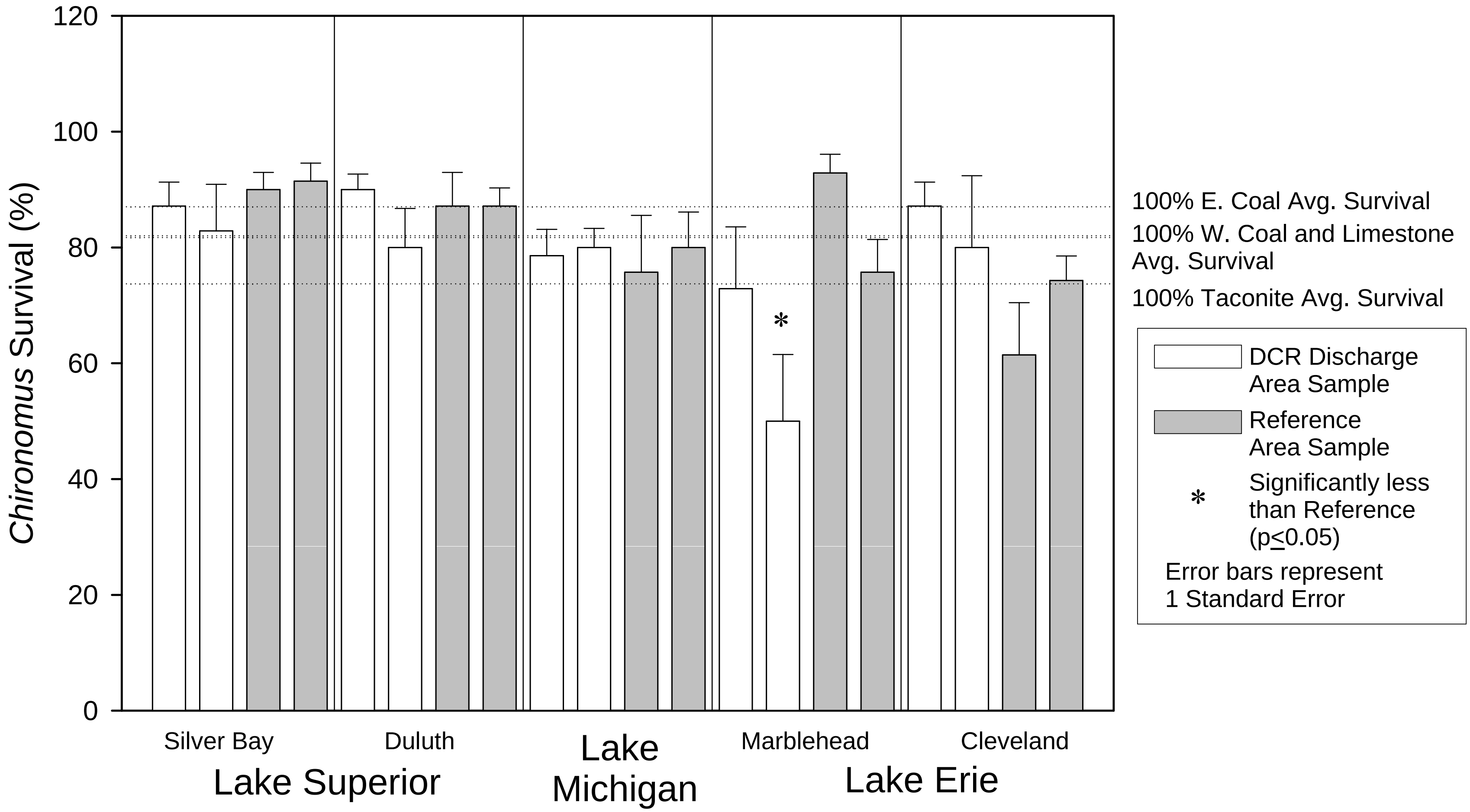

FIGURE 13
Chironomus dilutus
Survival in DCR discharge
and Reference Areas

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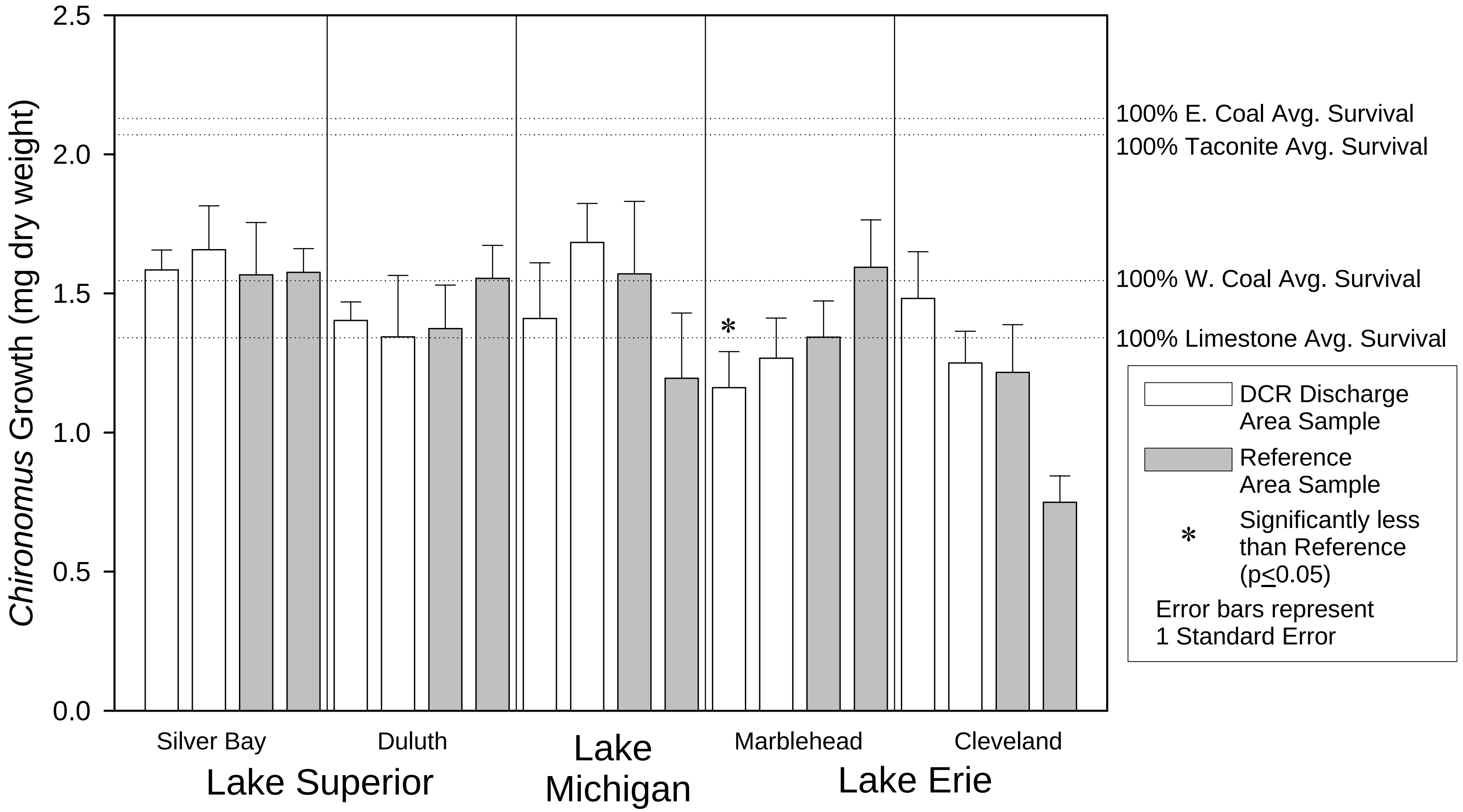

FIGURE 14
Chironomus dilutus
Growth in DCR Discharge
and Reference Areas

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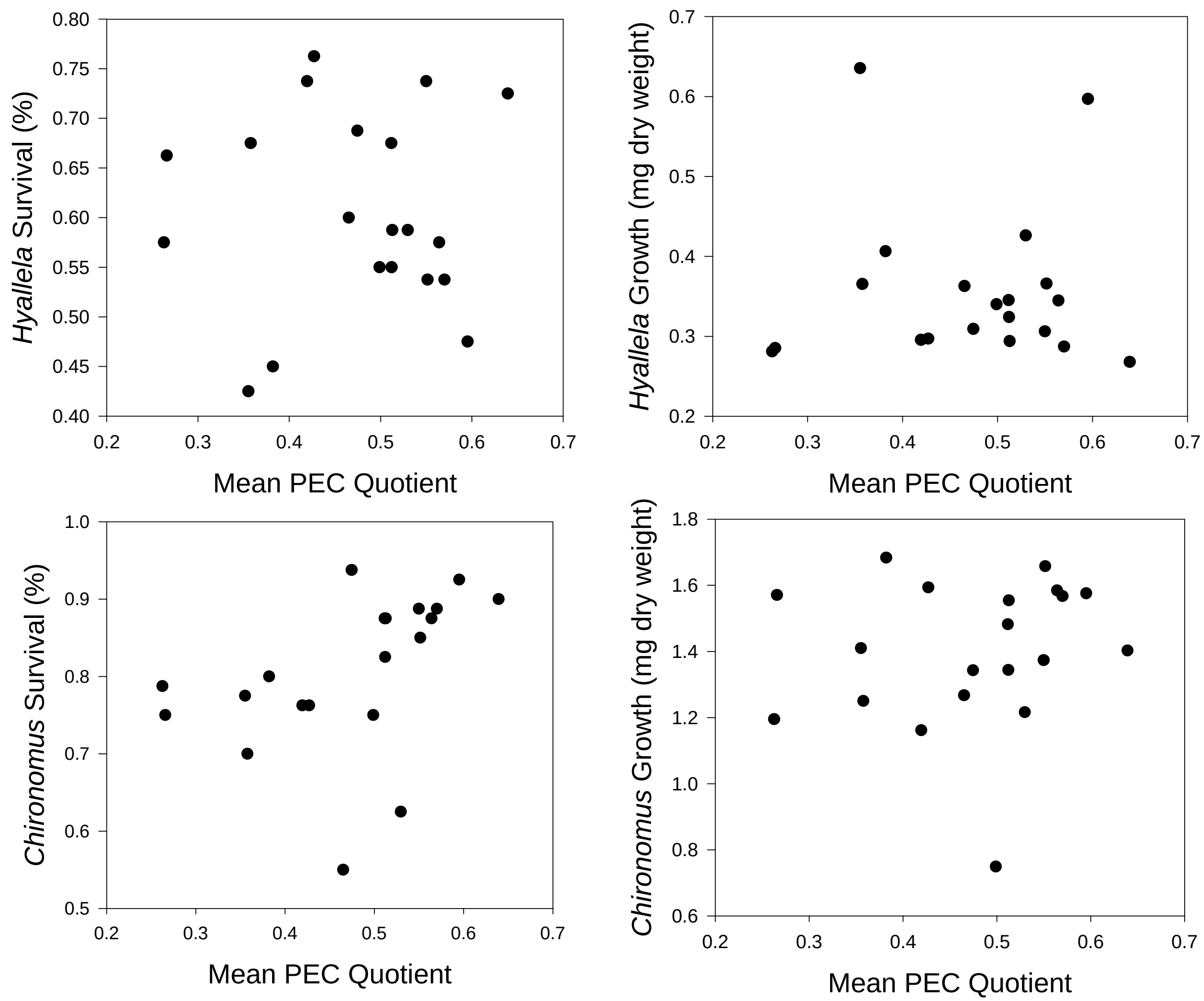

FIGURE 15
Toxicity Test Response
and Mean PEC Quotient

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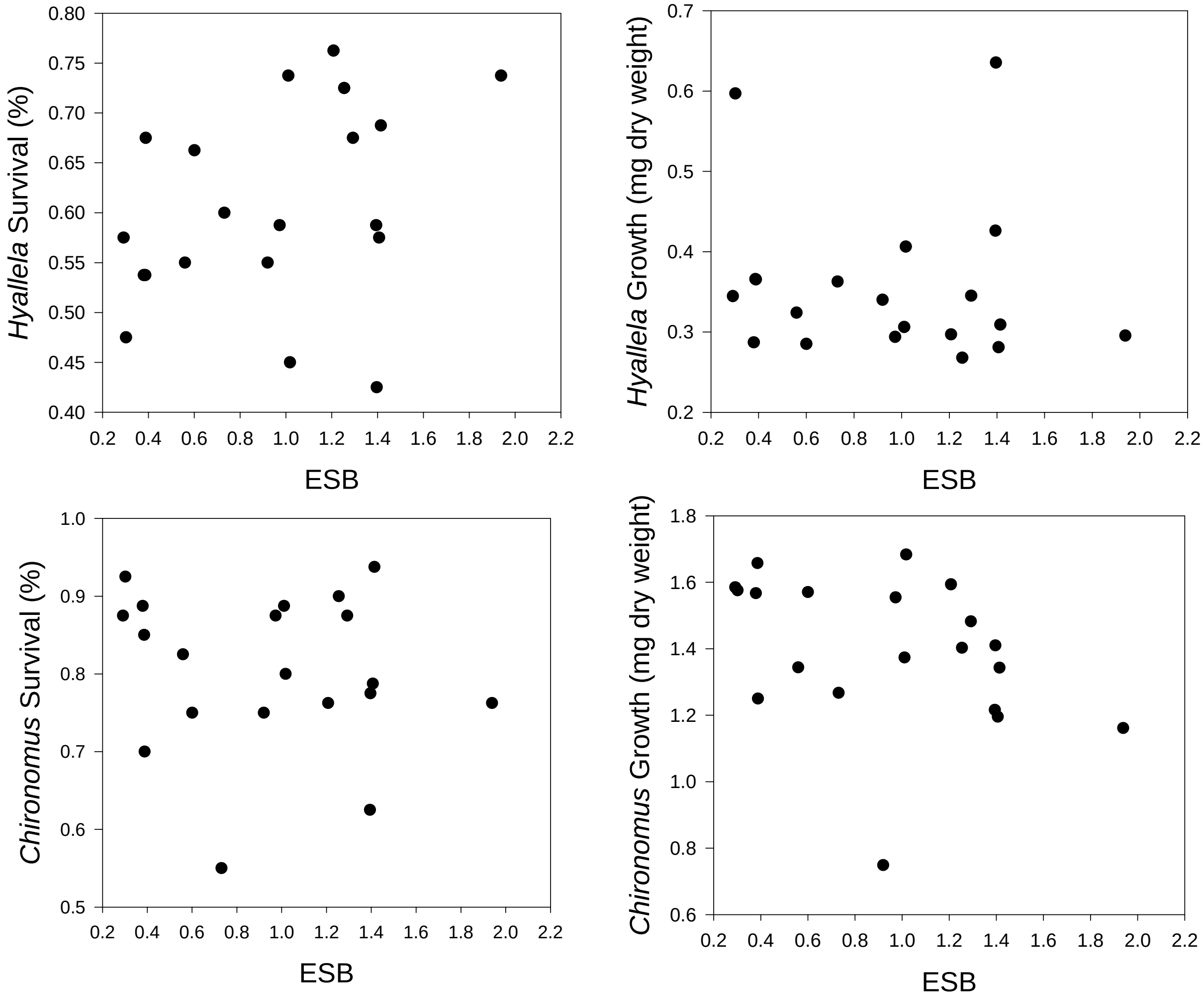

FIGURE 16
Toxicity Test Response
and ESB

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Appendix K
Great Lakes Invasive Mussel Investigations Conducted in Support of U.S. Coast Guard Dry Cargo Residue EIS

Great Lakes Invasive Mussel Investigations Conducted in Support of U.S. Coast Guard Dry Cargo Residue EIS

PREPARED FOR: U.S. Coast Guard

PREPARED BY: CH2M HILL and Aquatic Environmental Consulting

DATE: October 19, 2009

In support of the Phase I Final EIS for dry cargo residue (DCR) in the Great Lakes CH2M HILL conducted an extensive literature review and four phases of mussel attachment studies. The review and studies consisted of:

- **Literature Review:** Summary of life history, habitat, environmental requirements, and distribution within the Great lakes for zebra and quagga mussels.
- **Phase I Attachment Studies**: Comparison of adult mussels' attachment success for DCR substrate (taconite, limestone, and coal) vs. attachment to native sediment.
- **Phase II Attachment Studies**: Comparison of adult mussels' attachment success for DCR substrate (taconite, limestone, and coal) covered with various depths of natural sediment.
- **Phase III Attachment Studies**: Comparison of adult mussels' attachment success for DCR substrate (taconite, limestone, and coal) at various densities within native substrate.
- **Phase IV Attachment Studies**: Comparison of post veliger stage mussels' attachment success for DCR substrate (taconite, limestone, and coal) covered with various depths of natural sediment.

The findings of the review and each of the studies are presented in this memorandum.

Colonization of Cargo Residue in the Great Lakes by Zebra Mussel (*Dreissena polymorpha*) and Quagga Mussel (*Dreissena bugensis*)

Introduction

The U.S. Coast Guard is preparing an EIS to support rule making for management of dry cargo residue (DCR). Concern over DCR discharged to the lakes as potential substrate for the colonization of the invasive species *Dreissena polymorpha* (zebra mussel) and *Dreissena bugensis* (quagga mussel) within the Great Lakes has prompted an investigation into their attachment onto these residues. Invasion of the Great Lakes by dreissenids has caused both environmental and economic concerns. Providing additional habitat for their proliferation may increase their expansion into other areas of the lakes. This technical memorandum consists of a literature review and provides input in the EIS analysis of invasive mussel impacts in the lakes. The goals of the literature review are the following:

- Discuss life processes of *Dreissena spp*
- Document limiting factors of *Dreissena spp*, particularly substrate preferences
- Consider ecological and economic impacts of *Dreissena spp* colonization
- Find and interpret relatively recent *Dreissena polymorpha* (zebra mussel) and *Dreissena bugensis* (quagga mussel) distributions in the open waters of the Great Lakes in relation to navigational track lines of cargo ships

Origin

Zebra mussels are considered native to the Black Sea, Caspian Sea, and Ural River areas of Eurasia. Quagga mussels are indigenous to the Dneiper River drainage of Ukraine and were reported in Ukraine's Bug River in 1890 (Andrusov, 1890). Canals built in Europe have allowed both of these species to expand their ranges, and they now have expanded into most major drainages in Europe. Zebra and quagga mussels in the Great Lakes have been introduced by numerous sources in northwestern and north central Europe, from which shipping to the Great Lakes originates (Jentes, 2001). Zebra mussels were first discovered in Lake St. Clair in 1988 and quagga mussels where first noted in Lake Erie in 1989. Quagga mussels where not identified as a distinct species until 1991.

Life Processes

Reproduction and Development

Both zebra and quagga mussels are prolific breeders; this possibly contributes to their spread and abundance. *Dreissena spp* are dioecious (either male or female) with external fertilization. A fully mature female mussel is capable of producing up to one million eggs per season. Reproduction of zebra mussels usually occurs in the spring or summer, depending on water temperature. Optimal temperature for spawning is 14°C to 16°C (USGS, 2005); in waters that are warm throughout the year, spawning may occur over longer periods. Spawning for quagga mussels in profundal areas is reported to occur at 9°C (Claxton and Mackie, 1998). This lower spawning temperature may give the quagga mussel an advantage over the zebra mussel and may contribute to its invasions in the northern Great Lakes.

Dreissenid early life history evolves through the veliger, post-veliger, and adult stages. The veligers are photopositive, active swimmers using a ciliated velum (derived from the prototroch of the trocophore larva). After 10–15 days, the veligers metamorphose to the first post-veliger stage, the pediveliger. The pediveliger becomes photonegative and settles to the benthos in search for a suitable substrate for attachment. The pediveliger has a velum and a ciliated foot and uses both in substrate exploration. It is the pediveliger that is the primary life stage involved in substrate selection. Once the development proceeds to the next postveliger stage, the plantigrade, it loses its velum and can no longer swim. Once in contact with the substrate, the post-veliger attaches and completes shell development and maturation to an adult.

Dispersion Processes

Zebra and quagga mussels are dispersed by a variety of mechanisms. Generally, in the presettling stage, mussel veligers are moved by prevailing water currents. As post-veligers become photonegative, settling down the water column, they drift with currents until they encounter a suitable attachment surface.

Mussels attach to surfaces by secreting a tuft of fibers known as byssal threads (collectively forming a bysuss) from a gland near the foot of their shells. The threads have an adhesive disk at the end that attaches to surfaces by secreting a protein adhesive. To detach, the mussels secrete enzymes that break the byssal threads near the foot. Byssal threads are regenerated after detachment (Claudi and Mackie, 1994).

Adult mussels can relocate either by crawling, which can occur at rates up to several meters per day, or by moving with currents after detachment (Maryland Sea Grant, 1994). Adults will reposition themselves to a more advantageous location to obtain food. Translocation of adult mussels is most common in fall and winter months (Claudi and Mackie, 1994). To a lesser extent, waterfowl and other aquatic organisms also assist in the dispersal of these mussels.

Feeding

Both mussels are filter feeders; they use their cilia to pull water into their shell cavity where it passes through an incurrent siphon and desirable particulate matter is removed. Each adult mussel is capable of filtering one or more liters of water each day and removing phytoplankton, zooplankton, and even their own veligers (Snyder et al., 1997; USGS, 2007a). Any undesirable particulate matter is bound with mucus, known as pseudofeces, and ejected out the incurrent siphon. The particle-free water is then discharged out the excurrent siphon.

Natural Predators

European populations of diving ducks have changed their migration patterns in order to forage on beds of zebra mussels (Molloy et al., 1997). This most extreme case occurred on Germany’s Rhine River. Overwintering diving ducks and coots consumed up to 97 percent of the standing crop of mussels each year. However, high mussel reproduction rates replenished the population each summer. Molloy et al. (1997) cited 176 species involved in predation, 34 in parasitism, and 10 in competition with mussels.

In North America, the species most likely to prey on relatively deep beds of zebra and quagga mussels are scaup, canvasbacks, and old squaws. But populations of these species are quite low; in the Great Lakes, diving ducks are migrating visitors, pausing only to feed during migrations. However, Canadian researchers have documented increasing numbers of migrating ducks feeding on zebra mussels around Point Pelee in western Lake Erie. In southern Lake Michigan, zebra mussels encrusting an underwater power plant intake attracted flocks of lesser scaup. Unfortunately, some were pulled into the intake pipe and drowned. The stomachs of these dead scaup were full of zebra mussels. Mallard ducks also are frequently observed foraging on zebra mussels on shoreline rocks and shallow structures. Additionally, round goby (*Neogobius melanostomus*) and freshwater drum (*Aplodinotus grunniens*) are known to feed substantially on *Dreissena spp* (French and Love, 1995; Walsh et al., 2007). While drums may reduce population, they are not an effective biological controller because of feeding limitations based on mussel shell size (French and Love, 1995). Yellow perch (*Perca flavescens*) have been observed feeding on juveniles, particularly when they are detached and drifting.

Limiting Factors

Although zebra and quagga mussels are similar species, limiting factors vary slightly, as shown in Table 1.

Food Supply

Food availability is one of the most essential factors for *Dreissena spp* growth (Chase and Bailey, 1999). Insufficient food can compromise the structure of *Dreissena spp* byssal threads and lead to weak attachment (Clarke, 1999). Total suspended solids and phytoplankton represent the *Dreissena spp* food sources (USGS, 2007a). In Lake Huron, zebra mussel growth was affected nine times more by phytoplankton biomass (measured by chlorophyll-*a*) than by temperature (Chakraborti et al., 2002). As expected, higher nutritional quality of food aides reproduction success by increasing mussel egg mass (Wacker and Elert, 2003).

TABLE 1
Environmental Requirements for Great Lakes Invasive Mussels

Parameter	Zebra	Quagga	Reference
Preferred temperature (°C)	10–25	As low as 5	Karatayev et al. (1998), Paukstis et al. (1997), Roe and MacIsaac (1997), Claudi and Mackie (1994)
Preferred calcium level (mg/L)	44–50	Perhaps higher than for zebra mussels	Sprung (1987), Jones and Ricciardi (2005)
Preferred pH	7.4–9.3	Presumed similar to zebra mussels	Sprung (1987), Bowman and Baily (1998)
Preferred DO (% saturation)	At least 25	Perhaps lower than for zebra mussels	Karatayev et al. (1998)
Preferred depth (ft)	15–25	Up to at least 300	Mills et al. (1993, 1999), Egan (2006)
Reported extreme depths (ft)	360, Lake Ontario	540, Lake Michigan	Mills et al. (1993), Egan (2006)

Note: DO, dissolved oxygen.

Temperature

Temperature is another major factor in zebra mussel survival and reproduction (Chase and Bailey, 1999; Wacker and Elert, 2003). Zebra mussel survival temperatures range from 0°C to slightly in excess of 30°C for short periods; optimum temperatures are generally less than 25°C (Paukstis et al., 1997). The minimal temperature for growth and development is approximately 10°C (Karatayev et al., 1998). Increased temperatures usually increase feeding rates. Zebra mussel spawning (release of gametes into the water column) will generally not occur at temperatures below about 12°C (Claudi and Mackie, 1994).

Quagga mussels have been found in temperatures less than 5°C in Lake Ontario and there is evidence that quagga mussels are capable of spawning at temperatures near 5°C (Mills et al., 1993; Roe and MacIsaac, 1997). This may give them an advantage over the zebra mussel and account for their proliferating in the hypolimnion of the some Great Lakes. Claxton and Mackie (1998) found that quagga mussels spawned between 9°C and 10°C whereas zebra mussels neither spawned nor showed significant gametogenic development at these temperatures. MacIsaac (1994) reported that high water temperature in the Great Lakes would not likely affect quagga mussel distribution.

Calcium Level

The significance of calcium as a limiting factor for zebra mussels depends on the life stage of the mussel. Although adult zebra mussels can tolerate low-calcium waters, veligers are most successfully reared within a calcium level ranging from 44 to 50 mg/L, with minimum range of 12–24 mg/L (Sprung, 1987; Ram and Walker, 1993). Because veligers are highly sensitive to calcium, calcium is a critical characteristic for zebra mussel population establishment. Zebra mussels do not survive when there is prolonged low-calcium concentration in the water because calcium is an essential element in the composition of the bivalve shell. Calcium concentrations of 15 mg/L or less were found to limit the distribution of zebra mussels in the St. Lawrence River (Mellina and Rasmussen, 1994). Laboratory-based studies conducted by Hincks and Mackie (1997) reported maximum growth at 32mg/L and negative shell growth at 8.5 mg/L. Jones and Ricciardi (2005) indicated that zebra mussel populations occurred at calcium levels as low as 8 mg/L.

Quagga mussels were found to be absent below calcium concentrations of 12 mg/L, which suggests that they may have a higher calcium requirement then the zebra mussel (Jones and Ricciardi, 2005).

pH

The amount of hydrogen ions in the water—that is, pH—is critical in determining whether zebra mussels will be able to survive and reproduce in a water body. A pH of 7.4 or less inhibits larval development (Sprung, 1987). Laboratory-based studies conducted by Bowman and Baily (1998) indicated an upper tolerance limit of between 9.3 and 9.6. Hincks and Mackie (1997) reported that positive growth in juvenile zebra mussels occurred only at a pH greater than 8.3. Despite the general threshold, in laboratory studies Mikheev (1964) found that water with a pH of 6.6 and a calcium level less than 12 mg/L could host a mussel population greater than 500,000/m2. This has not been documented in the field. Information on the effects of pH on the quagga mussel is lacking, but the effects would likely be similar to those on the zebra mussel.

Dissolved Oxygen Level

In 1992, Lake Erie's area with periodic summer anoxia was the only region of the basin that was not colonized with *Dreissena spp* (Dermott and Munawar, 1993). This observation strongly suggests that dissolved oxygen is a limiting factor to population density and occurrence. Successful growth and reproduction of zebra mussels requires at least 25 percent oxygen saturation (Karatayev et al., 1998). Due to their preferred shallow water habitat, this usually is not a problem. Although zebra mussels can survive at very low concentrations for short periods of time, growth and reproduction will be limited (Woynarovich, 1961).

As with pH, there is little information on dissolved oxygen requirements for the quagga mussel. Based on its ability to colonize deeper areas of the Great Lakes, its dissolved oxygen needs may be less than those of the zebra mussel.

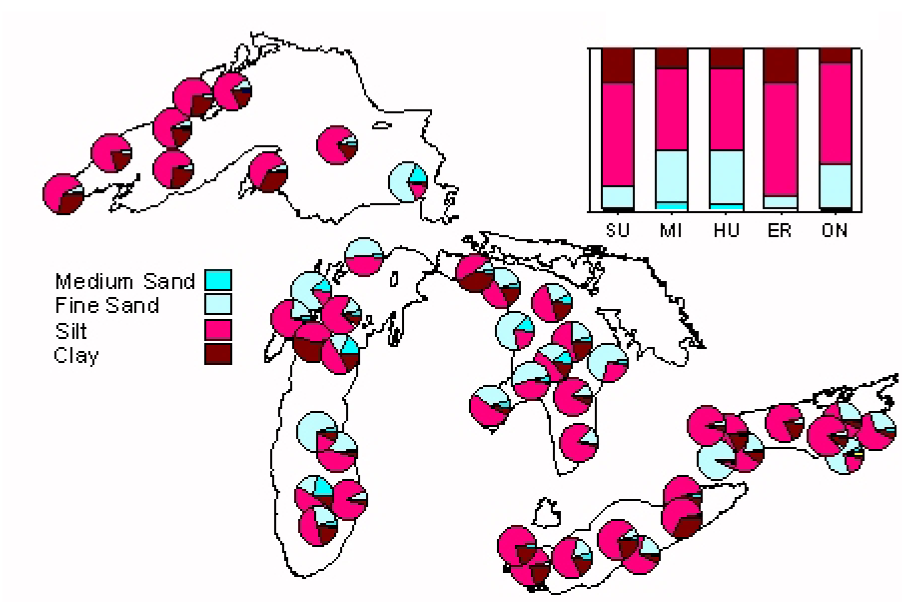
Substrate Availability

One of the most critical factors that affect the distribution and abundance of zebra mussels is substrate suitable for attachment. Juvenile and adult zebra mussels are epifaunal and generally sessile and are most abundant on rocky surfaces (Mellina and Rasmussen, 1994; Karatayev et al., 1998). The attachment of zebra and quagga mussels to hard substrates is a process that occurs when dressenid post-veliger larvae search for their initial attachment location and with mobile adults. Under normal conditions over 99 percent of veligers do not reach a successful attachment stage. High mortality is expected for post-veligers unable to locate and settle upon suitable substrate (Stańczykowska, 1977). Post-veligers prefer substrate consisting of macrophytes, mussel aggregates, and pebbles (Lewandowski, 1982). Zebra mussels will colonize on any hard surface and can reach densities of up to 30,000 to 70,000 mussels per square meter (2,800 to 6,500 mussels per square foot) under certain conditions. Zebra mussels will also colonize soft, silty lake bottoms where harder objects are deposited to serve as substrate (Ohio Sea Grant Program, 1995). However, preference for naturally occurring hard substrates may diminish over time as mussels become established in an area and juveniles colonize old shell. This can result in expansion onto adjacent soft substrates such as sand, mud, and gravel (Hunter and Bailey, 1992; Berkman et al., 2000; Czarnoeski et al., 2004).

In contrast, adult quagga mussels appear to be able to colonize both hard and soft substrates. They have formed extensive colonies on soft sediment in Lake Erie (Dermott and Munawar, 1993; Dermott and Kerec, 1997; Roe and MacIsaac, 1997). Quagga and zebra mussels have been found in western Lake Erie on soft substrates, displaying adaptation within 4 years of being introduced into the basin (Ohio Sea Grant Program, 1995; Berkman et al., 2000). In Lake Michigan they can colonize sand, clay, and pebbles, but not soft mud (Egan, 2006). As noted above, once a mussel is established on a hard or soft substrate, its shell can provide complex, hard substrate and promote colonization. Zebra mussels also will attach to one another, growing to thicknesses of up to 150 mm (6 in) (O'Neill, 1996).

The U.S. Environmental Protection Agency's (EPA) Great Lakes National Program Office reported the substrate composition of the Great Lakes for 1998 (EPA, 1998). (See Figure 1.) Silt and clay dominate the lakes, and Lake Michigan and Huron have the most sand. All substrate types in the Great Lakes could be colonized by quagga mussels because whereas substrate has been shown to affect population density and distribution, it has not been shown to restrict mussels from being present in systems due to their ability to colonize sand, mud, and hard substrate (Allen and Ramcharan, 2001).

FIGURE 1
Sediment Composition in the Great Lakes, Summer 1998



Source: EPA (1998).

Depth

Zebra mussels generally reach their highest densities in shallow water. Lake Ontario zebra mussel populations were most abundant at depths of 15 to 25 m (50 to 82 ft) (Mills et al., 1993). In Lake Erie, zebra mussels have expanded habitat into deeper, muddy substrate areas of the basin with an average depth of 10 m (33 ft) (Coakley et al., 1997). In Lake Ontario they have been reported at depths of 110 m (360 ft) (Mills et al., 1993).

In Lake Erie, zebra and quagga mussels coexist at depths of 8 to 110 m (26 to 360 ft). However, only quagga mussels are present at depths greater than 110 m (360 ft), as great as 130 m (425 ft) in Lake Ontario (Mills et al., 1993, 1999). Quagga mussels can thrive in both warm and near-freezing conditions of Lake Michigan, flourishing at depths of 300 ft and have been found as deep as 540 ft (Egan, 2006).

Colonization Effects

While low-density zebra and quagga mussel colonies may cause negligible impact, high-density colonies have led to major ecological and economic problems since their arrival in North America. Both species are prodigious water filterers, removing substantial amounts of phytoplankton and suspended particulates from the water. By removing the phytoplankton, dreissenid in turn decrease the food source for zooplankton, therefore altering the food web (USGS, 2007a, b). USGS (2007a) summarized studies showing the decreases of plankton due to large dreissenid colonies reducing zooplankton biomass through reducing phytoplankton. (See Table 2.) Zebra mussels filter small particles 90 percent more efficiently than native unionid bivalve mollusks, and dreissenid infestations have decreased unionid populations (Nalepa, 1994; USGS, 2007a). A study by the National Oceanic and Atmospheric Administration's (NOAA) Great Lakes Environmental Research Laboratory found that zebra mussels also promote and maintain *Microcystis* blooms, a potentially toxic blue-green alga, by filtering *Microcystis* out of water but eating other algae, *Microcystis*'s competitors (Vanderploeg et al., 2001).

TABLE 2
Summary of Studies Reporting Phytoplankton Decline due to Large-Scale *Dreissena spp* Invasions*

Location	Effects after *Dreissena spp* invasions	Reference
Lake Erie	Diatom declined 82–92%	Holland (1993)
	Total algae declined 62–90% from 1988 to 1990	Nichols and Hopkins (1993)
	Zooplankton declined 55–71%	MacIsaac et al. (1995)
Saginaw Bay, Lake Huron	Chlorophyll-*a* declined 60–70%; zooplankton decreased 40% from 1991 to 1992	Fahnenstiel et al. (1993)
Hudson River	Phytoplankton biomass declined 85%; zooplankton declined 70%	Caraco et al. (1997)

* From USGS (2007a) data.

Dr. Thomas Nalepa with NOAA reported that Lake Huron alewives, smelt, and bloater populations, which feed on zooplankton, have suffered greatly owing to the invasion of quagga, which severely decrease food availability for the larger fish that prey on these smaller fish. Nalepa also stated that Michigan’s coho and chinook salmon stocking rates were reduced by 50 percent in response to mussels’ negative impact on food availability (AP, 2007).

In addition to decreasing chlorophyll-*a*, the filtration of water is associated with increases in water transparency and accumulation of pseudofeces (Claxton and Mackie, 1998). Increased water clarity enhances light penetration, causing a proliferation of aquatic plants that can change species dominance. This alters entire ecosystems and creates viable substrate from plants for veligers to expand colonies. Increased water clarity can also alter thermoclines by increasing water temperature. The accumulating pseudofeces produced by high-density dreissenid colonies create a polluted environment (USGS, 2007a). The process of waste decomposing depletes oxygen, creates acidic conditions, and produces toxic byproducts (USGS, 2007b). In addition, quagga and zebra mussels accumulate organic pollutants within their tissues to levels more than 300,000 times greater than concentrations in the environment, and these pollutants are found in their pseudofeces. These bioaccumulated toxins can be passed up the food chain, thereby increasing wildlife exposure to organic pollutants (Snyder et al., 1997; USGS, 2007a).

Another major threat from high *Dreissena spp* density involves the fouling of native freshwater mussels. In addition to competing for food, zebra mussels are known to heavily colonize any hard substrata, including native mussels and other invertebrates. This can cause stress and even mortality due to feeding interference, and this fouling has severely reduced populations of native mussels.

High *Dreissena spp* density can also change habitat for other species. The *Dreissena spp* beds negatively affect blue gill, a major Great Lakes fisheries species, by decreasing their predation rates on amphipods by providing amphipods spatial refugia (González and Downing, 1999). Similar decreased foraging efficiency was reported with native mottled sculpin (*Cottus bairdi*) (McCabe and Marsden, 2001).

The ability to rapidly colonize hard surfaces causes serious economic problems. These major biofouling organisms can clog water intake structures, such as pipes and screens, therefore reducing pumping capabilities for power and water treatment plants, costing industries, companies, and communities. Recreation-based industries and activities have also been affected; docks, breakwalls, buoys, boats, and beaches have all been heavily colonized (USGS, 2007a).

Potential *Dreissena spp* colonization impacts are not completely clear owing to the relatively short time span of their presence in North America. However, it is certain from studies thus far that *Dreissena spp* have a high potential for rapid adaptation leading to significant long-term impacts in North American waters (Mills et al., 1996).

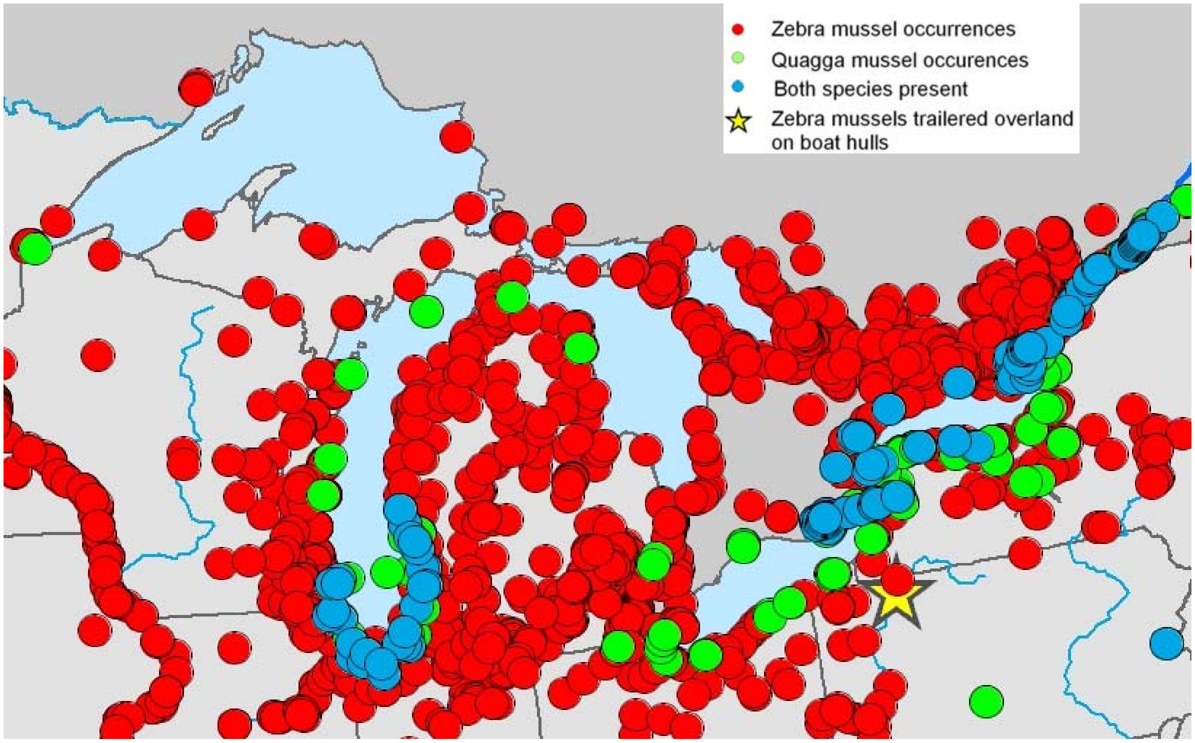
Population Distribution

A population shift has occurred within the *Dreissena spp* since the early 1990s. The large shell size and low respiration rates of quagga mussels are competitive advantages against the zebra mussel and may explain their increasing dominance between the two species (Stoeckmann, 2003). In 1992, quagga mussels greatly outnumbered zebra mussels only in the eastern basin of Lake Erie, but now the entire lake is dominated with quagga mussels (Mills et al., 1993; Patterson et al., 2002). Additionally, Patterson et al. (2002) reported that the *Dreissena spp* basin-average, shell-free dry tissue mass in Lake Erie increased nearly fourfold from 1992 to 2002. Quagga mussels dominate the *Dreissena spp* in nearshore regions of Lake Ontario as well (Wilson et al., 2006).

Currently, Lake Superior does not have a large *Dreissena spp* invasion. No quagga mussels were observed in Lake Superior in a 2002 survey; however, they were observed in 2005 and in 2007 as expected owing to their ability to spawn at temperatures lower than zebra mussels can and survive with a lower food supply (Grigorovich et al., 2003; EPA, 2007; USGS, 2007a). The current area of reproduction is in the Duluth-Superior harbor (EPA, 2007; Minnesota Sea Grant, 2007). Doug Jenson (personal communication, 2007) with the Minnesota Sea Grant attributes the isolated harbor colonization to the harbor's being less influenced by Lake Superior and by having shallower, warmer waters with higher calcium levels. Jenson also commented that despite the large magnitude of larva floating from the Duluth-Superior harbor into the western basin, no massive colonies exist in the larger lake. Due to Lake Superior's low calcium levels, Doug Jenson (personal communication, 2007) and Thomas Nalepa (AP, 2007) do not believe quagga mussel colonization will be as large scale as in the other Great Lakes.

CH2M HILL investigated the existence of up-to-date, open-water population density maps for all the Great Lakes through literature searches and personal correspondence with federal, state, and university authorities (Benson, 2007; Bunnell, 2007; Kreiger, 2007; Mayer, 2007; Mackey, 2007; Ciborowski, 2007). All resources concluded that due to the expansive scope of such a study and insufficient funding, no recent open water *Dreissena spp* distribution maps exist for the entire Great Lakes. The U.S. Geological Survey (USGS) has produced a nearshore map (see Figure 2) displaying the presence of quagga and zebra mussels in the Great Lakes for 2007 but not showing open water information or density values (USGS, 2007c). Benthic surveys performed annually by EPA can provide only mussel presence or absence data due to the provisional characteristics of the *Dreissena spp* portion of the study (EPA, 2007). (See Figure 3.)

FIGURE 2
Map of *Dreissena spp* Nearshore Distribution for 2007



Source: USGS (2007).

However, maps showing open-water distribution patterns in Lake Erie and south Lake Michigan were created for this report. To further investigate the distribution patterns of Lake Erie and south Lake Michigan, basin bathymetry and cargo ship sweep lines were included in the figures. The zebra and quagga survey maps highlight the 10-m and 100-m contours according to their respective depth preference, as previously discussed (Mills et al., 1993, 1999; Egan, 2006). The cargo ship sweep lines were produced from data from e[2]M (2005).

Lake Erie quagga and zebra mussel distribution maps (see Figures 4 and 5) were created using data from an environmental monitoring and assessment program (Ciborowski et al., 2007). Depth is not a limiting factor for the quagga mussels in Lake Erie because the maximum depth is 210 feet, within the quagga mussel preference. These figures display the dominance of quagga mussels over zebra mussels in Lake Erie and reflect the limiting effects of anoxia on dreissenid colonization reported by Dermott and Munawar (1993). Lake Erie's central basin area with periodic summer anoxia was the only region that was not colonized with *Dreissena spp*. Potential areas of concern may be areas to the east and west of this absence region, where sweeping and *Dreissena spp* presence was reported. However, because *Dreissena spp* are present throughout the lake, dry cargo residue discharged here may not promote increased *Dreissena spp* colonization any more than the existing colonies themselves promote colonization by creating their own substrate.

The southern Lake Michigan *Dreissena spp* distribution maps (see Figures 6 and 7) were created using data from NOAA (Nalepa, unpublished data, 2004. As in Lake Erie, quagga dominance is reflected here as well. A potential area of concern in southern Lake Michigan is the open water east of Chicago, where sweeping was reported. Depth is not a limiting factor in this area owing to its being less than 100 m (300 ft), and quagga mussel presence was confirmed at the sites. Any additional hard substrate here may promote increased *Dreissena spp* colonization. Near shore localized anoxia is possible in Lake Michigan and may account for the absence of *Dreissena spp* near Michigan City (Bunnell, 2007).

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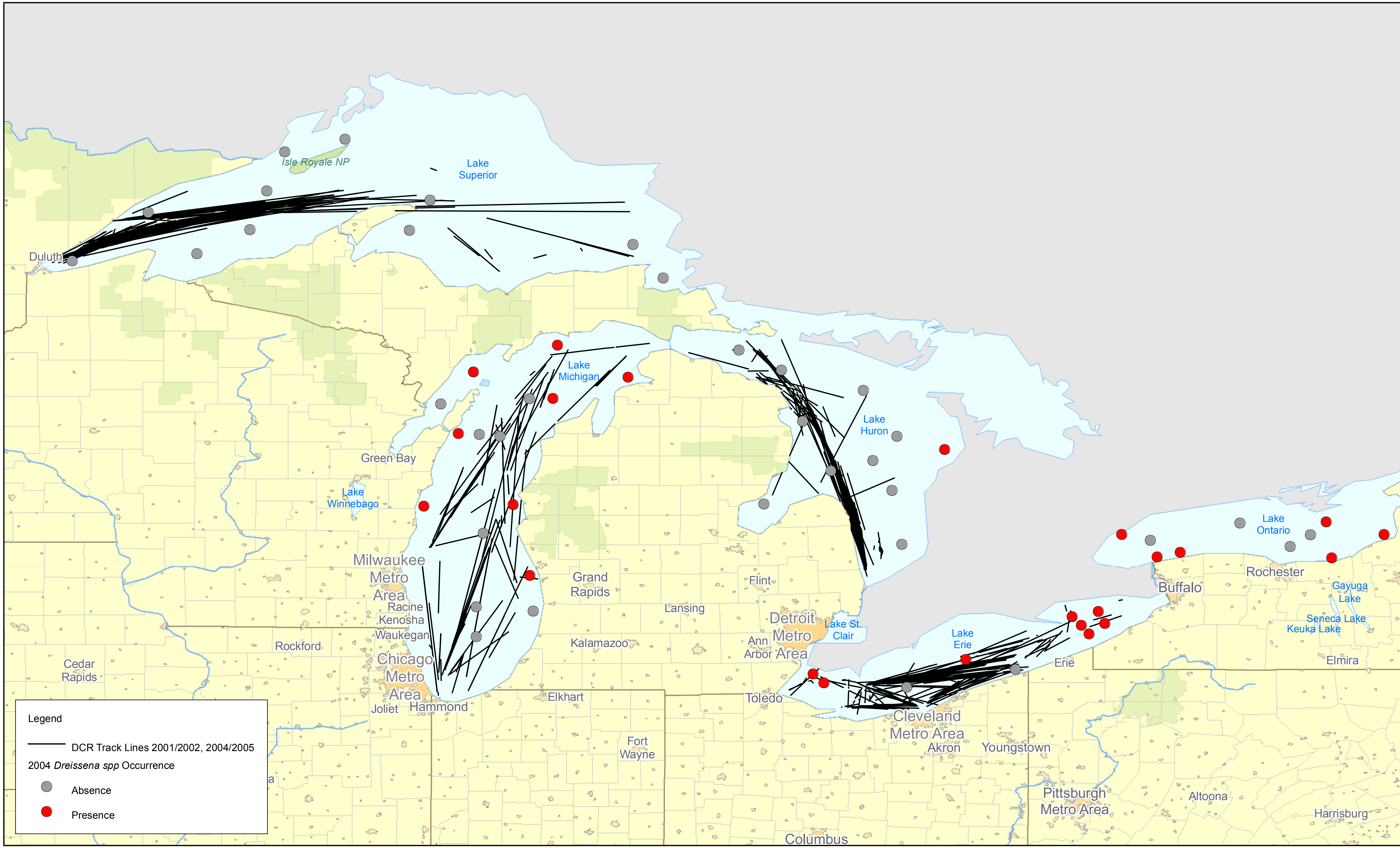

Figure 3
Dreissena spp, EPA Benthic Survey Stations
Created by CH2M HILL from EPA Great Lakes National Program Office 2004 benthic data

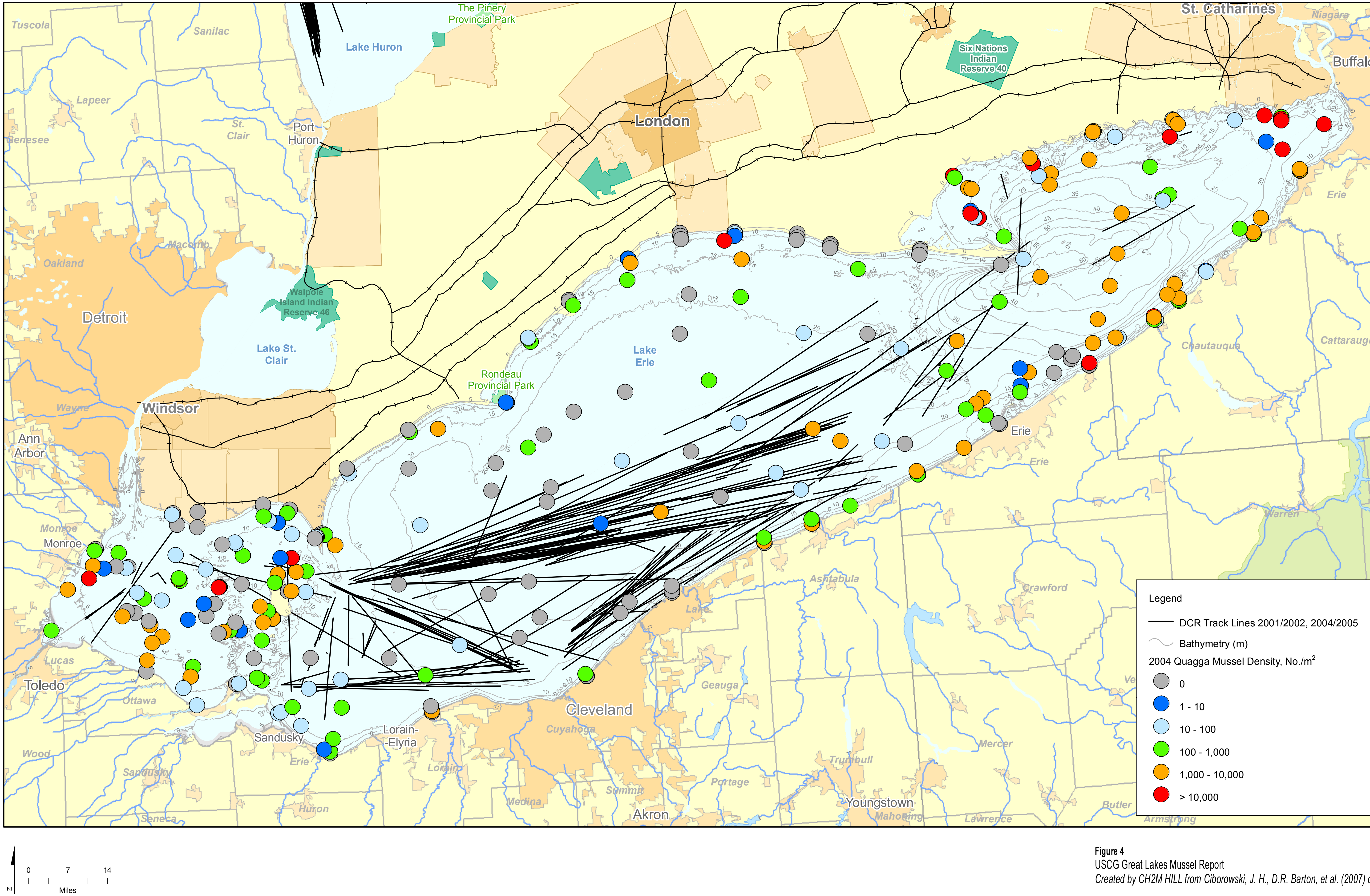

Figure 4
USCG Great Lakes Mussel Report
Created by CH2M HILL from Ciborowski, J. H., D.R. Barton, et al. (2007) data

CH2MHILL

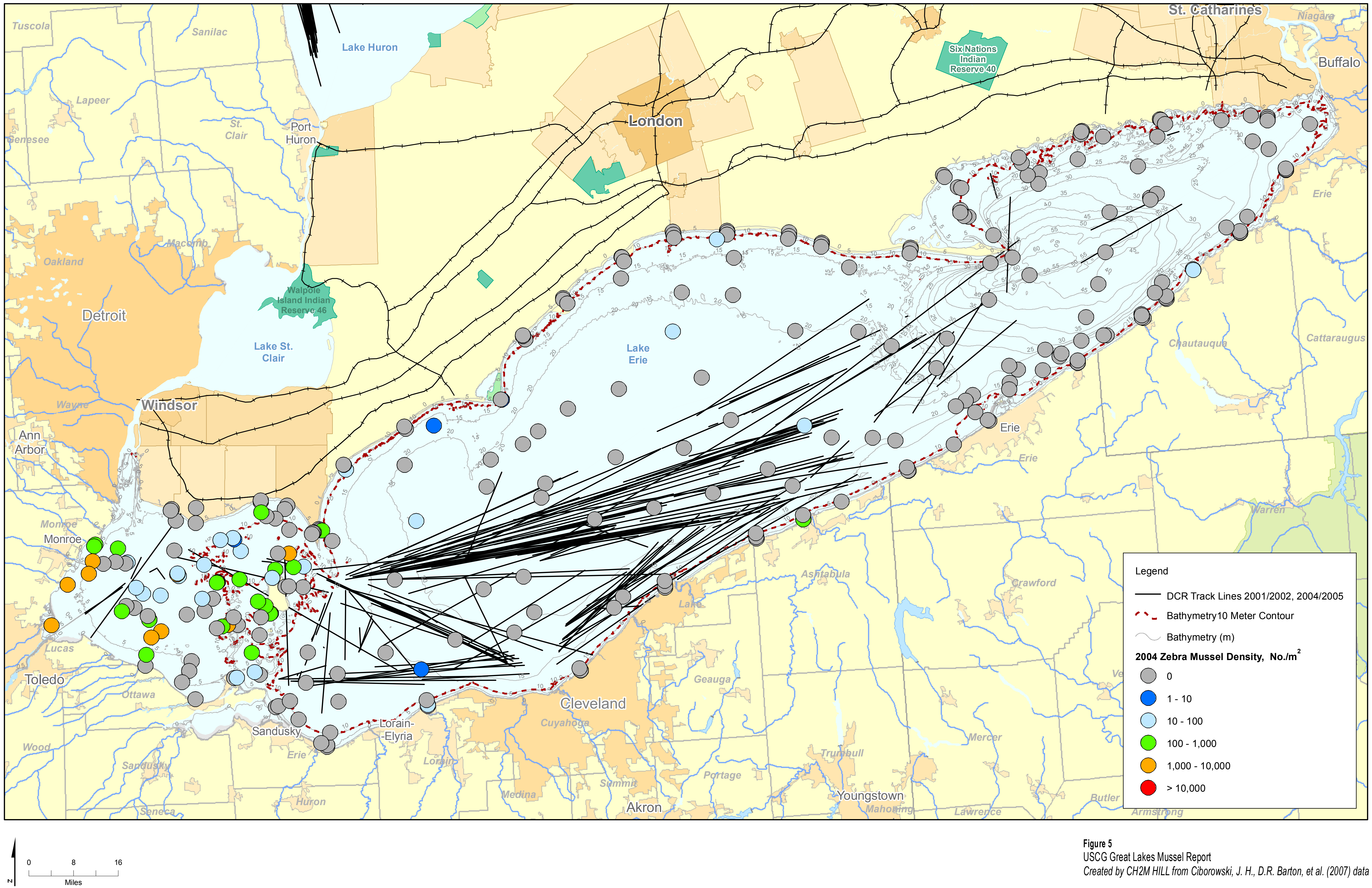

Figure 5
USCG Great Lakes Mussel Report
Created by CH2M HILL from Ciborowski, J. H., D.R. Barton, et al. (2007) data

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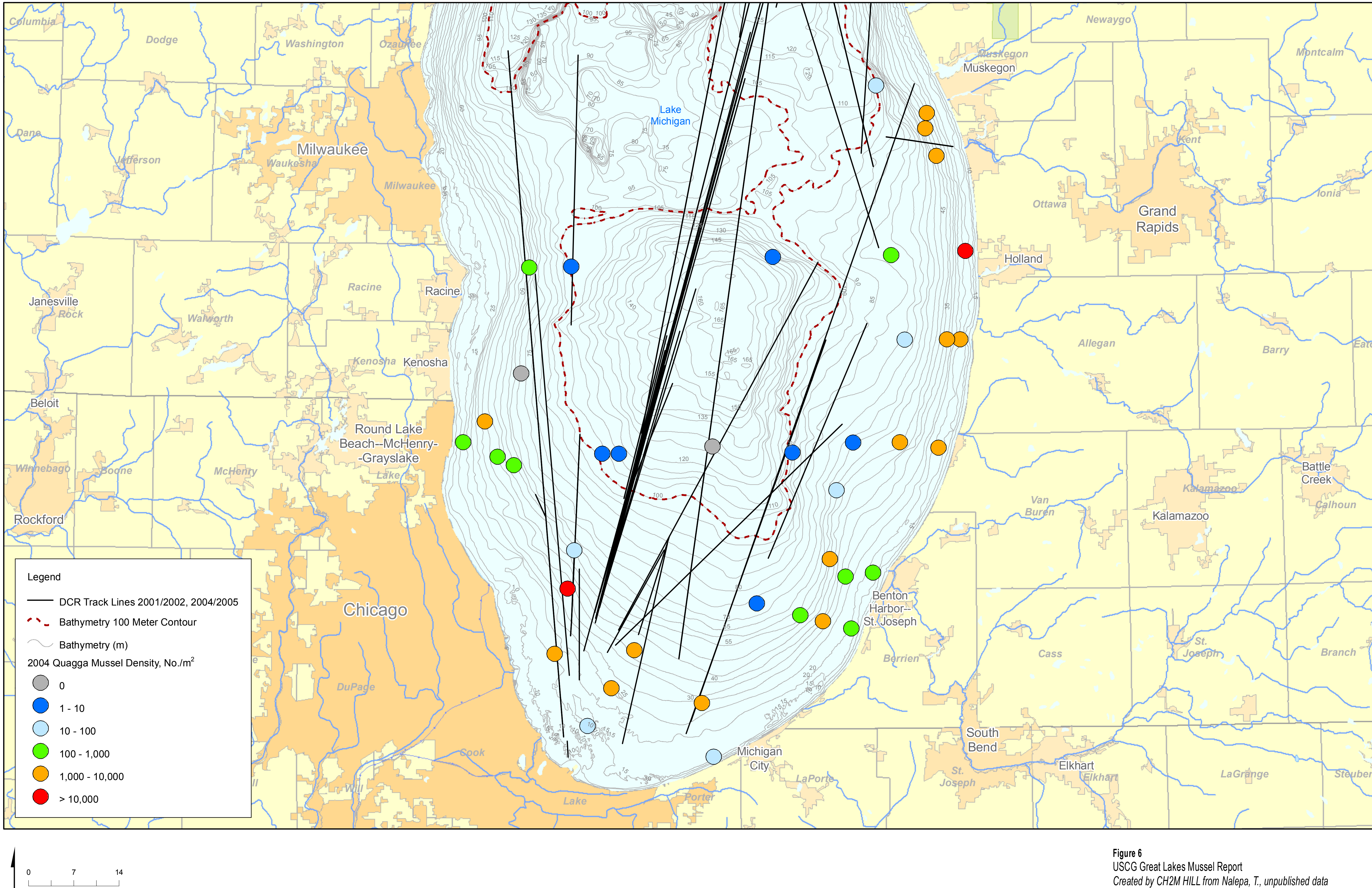


Figure 6
USCG Great Lakes Mussel Report
Created by CH2M HILL from Nalepa, T., unpublished data

CH2MHILL

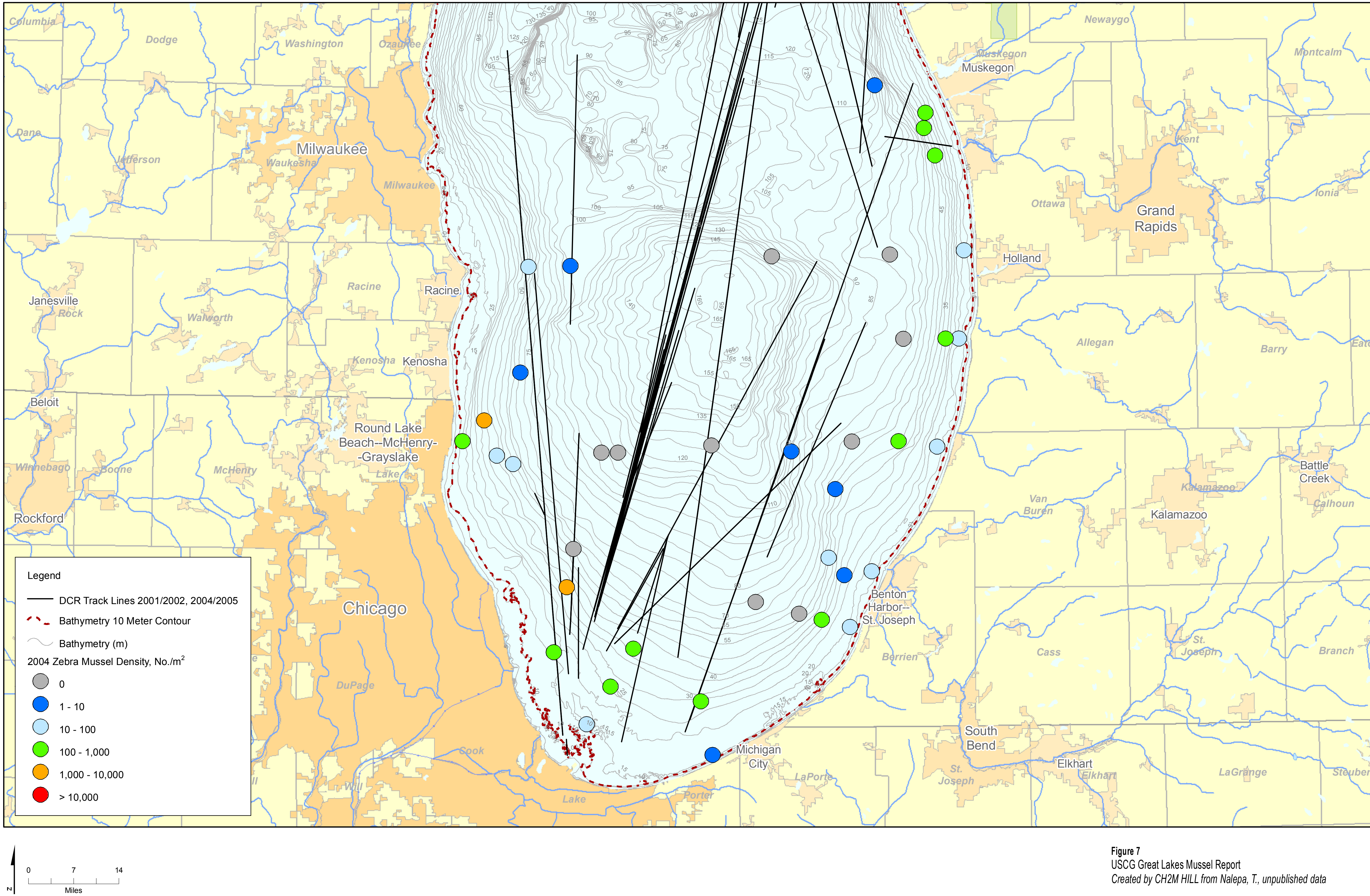


Figure 7
USCG Great Lakes Mussel Report
Created by CH2M HILL from Nalepa, T., unpublished data

CH2MHILL

Laboratory Based Attachment Study for Colonization Potential of Cargo Sweepings in the Great Lakes by Zebra Mussels (Dreissena polymorpha) and Quagga Mussels (Dreissena bugensis) Phase I: DCR Substrate

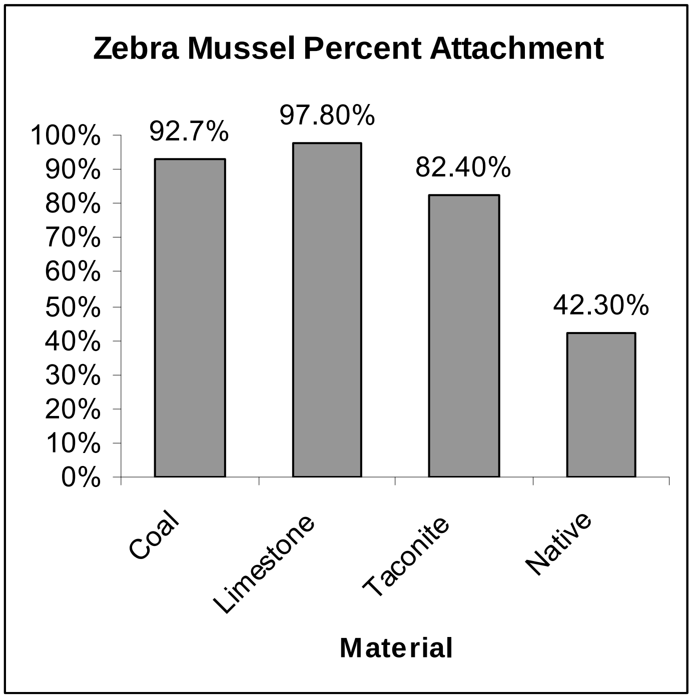
The Rapid Assay for Encrustacea Attachment was used to determine percent attachment of the zebra mussel (*Dreissena polymorpha*) and quagga mussel (*Dreissena bugensis*) mussels to cargo sweepings.

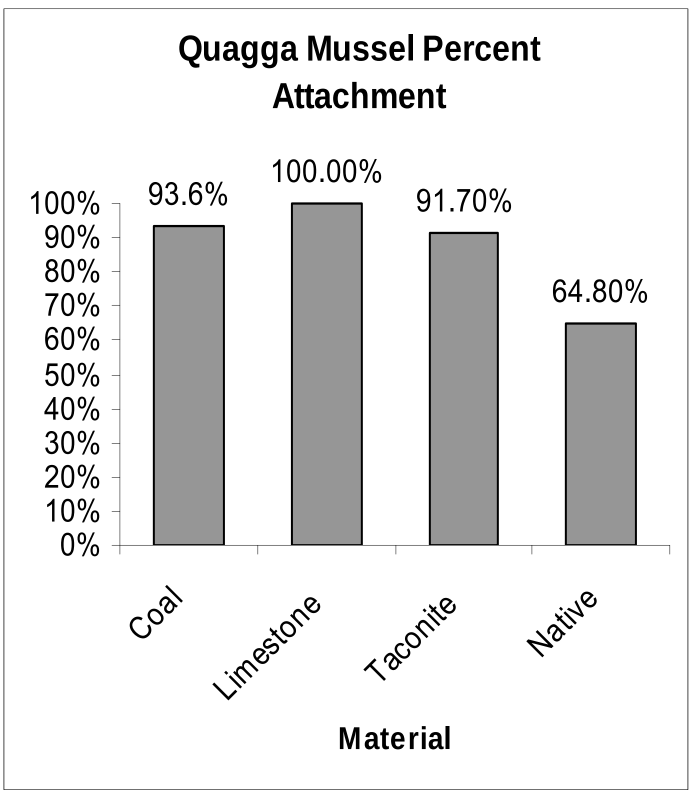
The test organisms for this study ranged between 0.8 cm and 5 cm in length and were collected from colonization substrates placed in the Milwaukee Lake Michigan inner harbor located at the Great Lakes WATER Institute, The University of Wisconsin-Milwaukee. The test materials were provided by CH2MHill and included ship sweepings of coal, limestone, taconite, and a native fine grained substrate, used as a control.

Approximate sizes of deck sweepings were: coal 10-60mm; limestone 0.01mm to 28mm; taconite 5mm to 15mm; native sediment was fine from silt to clay sized. The test conditions were: temperature 19°C; alkalinity 113 mg/l as $CaCO_3$; conductivity 264 μS/cm; pH 8.12; dissolved oxygen 8.34 mg/l.

The test material was adhered to 10 cm X 10 cm gray PVC base plates using silicon so that a solid surface of the test material will be formed. The five base plate replicates for each adhered material were placed in 10 gallon aquaria (filled with four inches of filtered Lake Michigan water) and then each of the five replicate base plates were loaded by hand with 10 mussels per replicate. The mussels were acclimated from 16°C (harbor water temperature) to 19°C (aquaria water temperature) over a two hour period.

The time interval for observation of initial attachment was 24 hours. At 24 hours neither zebra or quagga mussels attached to the the native substrates, but did attach to all other substrates. At the end of the 48 hour attachment period, the substrates were removed from the water, inverted, and attachment efficiency determined. Specimens that detach were then placed on a blank PVC substrate to determine their attachment capability. This determined that specimens that don't attach are in fact capable of attaching (not damaged) to a substrate known to facilitate attachment. All of these specimens attached. If specimens crawl off the substrate they were recorded as 'translocator' escapes. The 48 hour results are presented below in graphical and data formats.


Zebra Mussel Percent Attachment
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
92.7%
97.80%
82.40%
42.30%
Coal
Limestone
Taconite
Native
Material


Quagga Mussel Percent Attachment
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
93.6%
100.00%
91.70%
64.80%
Coal
Limestone
Taconite
Native
Material

Zebra Mussels	Replicate	Attached	Percent	Unattached	Translocator
Coal	1	10	100.0%	0	0
	2	7	77.8%	2	1
	3	9	100.0%	0	1
	4	9	100.0%	0	1
	5	6	85.7%	1	3
	Total	41		3	6
	Average	8.2	92.7%	0.6	1.2
Limestone	1	8	100.0%	0	2
	2	8	88.9%	1	1
	3	6	100.0%	0	4
	4	8	100.0%	0	2
	5	6	100.0%	0	4
	Total	36		1	13
	Average	7.2	97.8%	0.2	2.6
Taconite	1	6	85.7%	1	3
	2	8	88.9%	1	1
	3	5	100.0%	0	5
	4	7	87.5%	1	2
	5	2	50.0%	2	6
	Total	28		5	17
	Average	5.6	82.4%	1	3.4
Native	1	6	85.7%	1	3
	2	0	0.0%	10	0
	3	0	0.0%	10	0
	4	2	40.0%	3	5
	5	6	85.7%	1	3
	Total	14		25	11
	Average	2.8	42.3%	5	2.2

Quagga Mussels	Replicate	Attached	Percent	Unattached	Translocator
Coal	1	5	100.0%	0	5
	2	8	88.9%	1	1
	3	8	88.9%	1	1
	4	10	100.0%	0	0
	5	9	90.0%	1	0
	Total	40		3	7
	Average	8	93.6%	0.6	1.4
Limestone	1	8	100.0%	0	2
	2	10	100.0%	0	1
	3	8	100.0%	0	2
(2 dead specimens)	4	8	100.0%	0	0
	5	8	100.0%	0	2
	Total	42		0	7
	Average	8.4	100.0%	0	1.4
Taconite	1	8	100.0%	0	2
	2	7	87.5%	1	2
	3	4	80.0%	1	5
	4	10	100.0%	0	0
	5	10	90.9%	1	0
	Total	39		3	9
	Average	7.8	91.7%	0.6	1.8
Native	1	5	83.3%	1	4
	2	5	71.4%	2	3
	3	4	80.0%	1	5
	4	1	14.3%	6	3
	5	3	75.0%	1	6
	Total	18		11	21
	Average	3.6	64.8%	2.2	4.2

Laboratory Based Attachment Study for Colonization Potential of Cargo Sweepings in the Great Lakes by Zebra Mussels (Dreissena polymorpha) and Quagga Mussels (Dreissena bugensis), Phase II: Native Sediment

The Rapid Assay for Encrustacea Attachment was used to determine percent attachment of the zebra mussel (*Dreissena polymorpha*) and quagga mussel (*Dreissena bugensis*) mussels to cargo sweepings when covered by a thin (1.0-5.0mm) layer of native sediment.

The test organisms for this study ranged between 0.8 cm and 5 cm in length and were collected from colonization substrates placed in the Milwaukee Lake Michigan inner harbor located at the Great Lakes WATER Institute, The University of Wisconsin-Milwaukee. The test materials were provided by CH2MHill and included ship sweepings of coal, limestone, taconite, and a native fine grained substrate, used as a control.

Approximate sizes of deck sweepings were: coal 10-60mm; limestone 0.01mm to 28mm; taconite 5mm to 15mm; native sediment was fine from silt to clay sized. The mean test conditions were: temperature 19°C; alkalinity 137 mg/l as $CaCO_3$; conductivity 325 µS/cm; pH 7.77; dissolved oxygen 6.81 mg/l.

The test material was placed in five replicate 10 cm X 10 cm square containers. Added over the top of the test material was 1.0 to 5.0 mm of native fine sediment. The five container replicates loaded with test material and fine native sediment were placed in 10 gallon aquaria (filled with four inches of filtered Lake Michigan water) and then the fine sediment of each of the five replicate containers was gently mixed to allow resettling of the suspended sediment. This process insured a thin layered coating over the test material except in the crevices formed by large adjacent test material where the fine sediment was thicker. On average the thickness of the fine sediment ranged from between 1.0 to 5.0 mm, but up to 10 mm between larger particles (taconite and coal). The containers were loaded by hand with 10 mussels per replicate. In total, there were 4-Quagga aquaria and 4-zebra mussel aquaria, each containing one test material. The containers with only fine sediment to a depth of 25 mm were considered the control. The mussels were acclimated from 15°C (harbor water temperature) to 19°C (aquaria water temperature) over a three hour period.

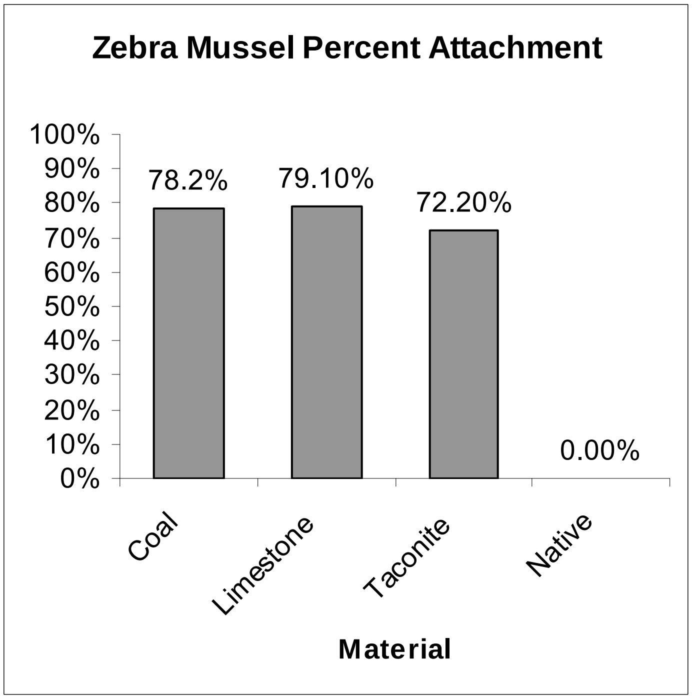
The time interval for observation of initial attachment was 48 hours. At the end of the 48 hour attachment period, the containers with test materials were removed from the water, and attachment determined by lifting the mussels with a forceps. When mussels that were attached to substrate (i.e., taconite, coal, limestone) the material was lifted with the zebra mussel. Specimens that were not attached were then placed on a blank PVC substrate to determine their attachment capability. This determined that specimens that don't attach are in fact capable of attaching (not damaged) to a substrate known to facilitate attachment. Of the 400 mussels tested, only one was dead because of shell breakage during handling. All of these specimens attached. If specimens crawl off the substrate and attached to the container walls they were recorded as 'translocator' escapes. The 48 hour results are presented below in graphical and data formats.

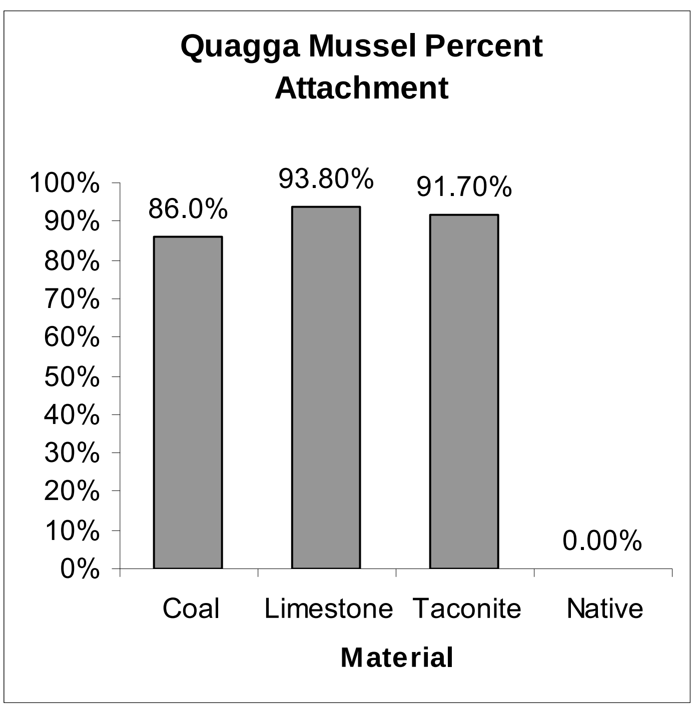
It is interesting to note that both the zebra and quagga mussels moved through the 5.0mm of fine sediment, and at times through 10mm of fine sediment at the crevices between the large pieces of test material. This suggests that in the field, both mussels will actively attach to buried hard substrates. While sedimentation rates in some of the Great Lakes can be low, >1mm/yr, bioturbation displacement by benthic invertebrates can be very high, thereby quickly covering deposited hard substrates with fine sediment. Robbins (ref below) states that "Where comparisons are possible, rates of sediment reworking by 'conveyor belt' species are comparable to or exceed sedimentation rates." Examples of literature references concerning bioturbation effects include:

Krezoski, J.R. Particle reworking in Great Lakes sediments: in-situ tracer studies using rare earth elements. OCEANS apos;88. apos; A Partnership of Marine Interestsapos;. Proceedings Volume , Issue , 31 Oct-2 Nov 1988 p437 - 441 vol.2

J.A. Robbins, Stratigraphic and dynamic effects of sediment reworking by Great Lakes zoobenthos Hydrobiologia Volume 91-92, Number 1 / July, 1982 611-622

John R. Krezoski, Samuel C. Mozley, John A. Robbins, Influence of Benthic Macroinvertebrates on Mixing of Profundal Sediments in Southeastern Lake Huron. *Limnology and Oceanography*, Vol. 23, No. 5 (Sep., 1978), pp. 1011-1016





Zebra Mussels	Replicate	Attached	Percent	Unattached	Translocator
Coal	1	9	90.0%	1	0
	2	5	55.6%	4	1
	3	9	90.0%	1	0
	4	6	66.7%	3	1
	5	8	88.9%	1	1
	Total	37		10	3
	Average	7.4	78.2%	2	0.6
Limestone	1	5	50.0%	5	2
	2	8	80.0%	2	1
	3	6	85.7%	1	3
	4	8	80.0%	2	0
	5	10	100.0%	0	0
	Total	37		10	6
	Average	7.4	79.1%	2	1.2
Taconite	1	6	66.7%	3	1
	2	5	50.0%	5	0
	3	8	88.9%	1	1
	4	7	77.8%	2	1
	5	7	77.8%	2	1
	Total	33		13	4
	Average	6.6	72.2%	2.6	0.8
Native	1	0	0.0%	10	3
	2	0	0.0%	9	1
	3	0	0.0%	10	0
	4	0	0.0%	10	0
	5	0	0.0%	10	2
	Total	0		49	6
	Average	0	0.0%	9.8	1.2

Quagga Mussels	Replicate	Attached	Percent	Unattached	Translocator
Coal	1	9	90.0%	1	0
	2	9	90.0%	1	0
	3	9	90.0%	1	0
	4	8	80.0%	2	0
	5	8	80.0%	2	0
	Total	43		7	0
	Average	8.6	86.0%	1.4	0
Limestone	1	10	100.0%	0	0
	2	9	90.0%	1	0
	3	9	100.0%	0	0
	4	8	88.9%	1	1
	5	9	90.0%	1	0
	Total	45		3	1
	Average	9	93.8%	0.6	0.2
Taconite	1	6	66.7%	3	1
	2	8	80.0%	2	0
	3	4	44.4%	5	1
	4	6	66.7%	3	1
	5	9	90.0%	1	0
	Total	33		14	3
	Average	6.6	69.6%	2.8	0.6
Native	1	0	0.0%	10	0
	2	0	0.0%	10	0
	3	0	0.0%	10	0
	4	0	0.0%	10	0
	5	0	0.0%	7	3
	Total	0		47	3
	Average	0	0.0%	9.4	0.6

Laboratory-Based Attachment Studies for Colonization Potential on Dry Cargo Residue in the Great Lakes by Zebra Mussels (*Dreissena polymorpha*) and Quagga Mussels (*Dreissena bugensis*): Phase III Covered with Native Sediment

Introduction

Concern over dry cargo residue (DCR) as a potential substrate for the colonization of the invasive species *Dreissena polymorpha* (zebra mussel) and *Dreissena bugensis* (quagga mussel) within the Great Lakes has prompted an investigation into their attachment potential onto DCR sweepings. Invasion of the Great Lakes by dreissenids has caused both environmental and economic concerns and provided additional habitat for their proliferation that may increase their expansion into other areas of the lakes.

Attachment of zebra and quagga mussels to hard substrates is well documented in the literature. Mellina and Rasmussen (1994) indicted that zebra mussels were found on hard substrates, particularly rocky surfaces, but were usually absent on softer substrates. Quagga mussels, on the other hand, appear to be able to colonize both hard and soft substrates. The bottom of Lake Erie has extensive colonies of quagga mussels on soft sediment (Dermott and Munawar 1993; Dermott and Kerec 1997; Roe and MacIsaac 1997); in Lake Michigan they will colonize sand, clay, and pebbles, but not soft mud (Egan, 2006).

A laboratory-based study was undertaken to assess the potential for attachment of zebra and quagga mussels to DCR. The Rapid Assay for Encrustacea Attachment method (Kaster, personal communication, 2007) was used as the test protocol for this study. Residue materials consisting of coal (size range 10–60 mm), limestone (0.1–28 mm), and taconite (5–15 mm) were collected from cargo ships, and native sediment (silt to clay size range) was collected from Lake Superior.

Preliminary experiments were conducted to better understand attachment processes regarding residue material and overlaying sediment. They are described by CH2M HILL (2007a). The initial Phase I assessment was conducted by submitting the test organisms directly to the sweepings material and native substrate, which had been attached to 10 cm × 10 cm PVC plates and placed in 10-gallon aquaria for 48 hours. The results of this first phase indicated that on average 91 percent of the zebra mussels and 95 percent of the quagga mussels attached to the residue material. Attachment to the native material, which was rendered semisolid because it was also attached to the PVC substrate, averaged 42 percent for zebra mussels and 65 percent for quagga mussels. The results suggested both species' significant preference for attaching to the residue material.

As a result of the outcome of the first phase, a second phase was initiated in which each residue material type was placed into 10 cm × 10 cm containers, the containers placed into aquaria, and the residue material topped with 1.0–5.0 mm of native fine sediment. Native sediment was also placed directly into sample containers to a depth of approximately 25 mm to act as a control. After 48 hours, the test was terminated and mussel attachment assessed. Average attachment for zebra mussels on coated residue sweepings was 77 percent, while that for quagga mussels was 91 percent. There were no attachments by either species to the native material controls, which would be the normal attachment expectation. In addition, attachment to native material in Phase 1 suggests that there was no toxic affect of the native sediment to prevent attachment. The results of the second phase suggested that a thin coating of sediment will not interfere with attachment to the sweepings material.

Data from the first two attachment studies indicated that both zebra and quagga mussels will attach to dry cargo residue, even if covered with a thin layer of sediment. Because of these findings, several other questions were raised regarding the depth of sediment at which these mussels can attach to DCR and the relationship of attachments to concentration of DCR.

Phase III: Attachment of Dreissenids Through Native Sediment and DCR Material

The attachment of zebra and quagga mussels directly to hard substrates is clearly recognized by both the literature and the results of Phase I. In addition, there are clearly broad implications associated with the Phase II research that tests zebra and quagga mussel attachment through a layer of soft sediment. When zebra mussels were found living on soft sediments in the early 1990s by a research team from the Great Lakes WATER Institute, University of Wisconsin-Milwaukee, two mechanisms for attachment were advanced for potential en mass colonization of soft sediments by zebra mussels. The first was the self-establishment on pieces of dead zebra mussel shells washed to deeper depths from the colonized nearshore areas. The second was the use of small fragments of materials such as sand or vegetation to seed the formation of a druss. In the mid-1990s, researchers from Ohio State University's Byrd Polar Research Institute described soft sediment attachment as being initiated by the veliger larva attaching itself to a single grain of sand. As the larva grows its byssal threads, which serve as anchors to attach the mussel to a stable surface, it continues to pick up more sand grains, thereby creating a mat of cemented sediment. More recently, the current project (Phase II) found that adult zebra and quagga mussels can explore vertically in muddy substrates using their byssus apparatus to find pockets of hard substrates.

This latter finding has several colonization implications. This behavior may help explain the rapid advancement of dreissenids throughout U.S. lake and river ecosystems, especially those with higher sedimentation rates, sediment-focusing patterns, or general-current-facilitated movement of fine sediment. For example, dreissenid mussels are regarded as freshwater riverine species because of their initial movement into the Russian rivers. This suggests their ability to colonize across fluvial plains of river deltas and along the margins of hard substrate and soft substrate zones. In lakes, that ability to seek hard substrates slightly overlaid with fine sediment would extend the colonization success of zebra and quagga mussels. The Phase III study, while having other potential ecological ramifications, specifically addressed attachment success through soft sediment to DCR.

Methodology and Results

In order to better understand the relationship between sediment depth and the depth at which DCR would be limited to dreissenid colonization, a small-scale bench-top study was conducted to preliminarily determine DCR penetration into bottom sediments. The study was used to develop an estimate of maximum velocity of the densest material (taconite) through the water column, and how deep into the sediment this material would penetrate. The assumption was that the other DCR material (coal and limestone), being less dense, reach maximum velocity sooner and penetrate a shorter distance into the sediment. Taconite pellets were passed through a column of water 1.75 m deep with a layer of sediment (Lake Superior) approximately 6 cm deep at the bottom of the column. Velocity was measured by timing the taconite drop through the water column. Depth of penetration was measured to the top of the pellet using a ruler.

TABLE 1
DCR Penetration Assessment Using Taconite (Densest Material)

	Drop					
	1	2	3	4	5	Average
Weight (g)	3.17	5.15	5.33	3.96	4.81	4.48
Velocity (cm/s)	76	73	67	63	71	70
Penetration (mm)	4	7	6	—[a]	4	5.3[b]

[a] No measurement possible due to location of test pellet in sediment.
[b] Four measurements.

The results of this brief assessment suggest that taconite will penetrate an average of 5.3 mm of sediment (Lake Superior), at an average velocity of 70 cm/s. The deepest penetration was 7 mm. Based on these preliminary results, it was assumed that the other DCR materials (coal and limestone), as described above, would not reach these velocities nor penetrate to these depths. The data from the taconite drop test was used to develop sediment depths used in Phase IIIa and Phase IIIb.

Phase IIIa: Attachment Study to Assess Sediment Depth Penetration of Dreissenid Byssal Threads

The Rapid Assay for Encrustacea Attachment was used to determine percent attachment of quagga mussels (*Dreissena bugensis*) to DCR when covered with native sediment. Since zebra and quagga mussels attach similarly to hard substrates, only one species was used. The quagga mussel was selected for this phase of the study because of its ability to exist on softer substrates, as suggested in the literature. This study phase used quagga mussels to determine the depth of native sediment through which byssal attachment was successful. The results of this assessment will establish a relationship between percent attachment and native sediment depth, thereby imparting a predictive capability.

The experimental design used four sediment depths (4, 8, 16, and 24 mm) overlying a single substrate (taconite). Taconite was the only DCR material used based on its density and the results of the velocity study. The quagga mussels used in this study ranged in length between 0.8 cm and 1.5 cm and were collected from colonization substrates placed in the Milwaukee Lake Michigan inner harbor located at the Great Lakes WATER Institute, University of Wisconsin–Milwaukee. The taconite was collected from ships and was the same material used in the first two phases of the program. Taconite deck sweepings ranged from 5 mm to 15 mm in diameter, whereas native sediment ranged in size from fine silt to clay-sized particles. Thus, four depths times five replicates equaled 20 individual tests. Each replicate was tested independently, within its dedicated experimental 10 cm × 10 cm square container. Each replicate contained 10 quagga mussels (total 200 mussels). Each test container was filled with a layer of taconite and appropriate amount of sediment (to a depth of 4, 8, 16, or 24 mm), and filled with filtered Lake Michigan water. The containers were loaded by hand with 10 mussels per replicate. The mussels were acclimated from the harbor water temperature of 16°C to the container water temperature of 19°–20°C over a 3-hour period.

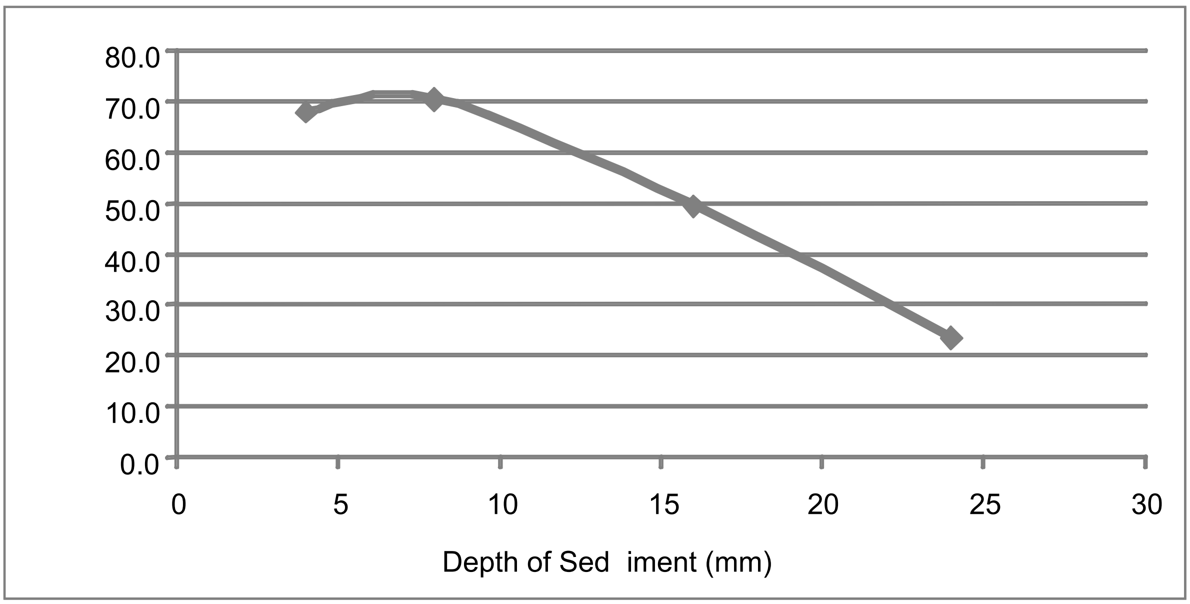
The time interval for observation of attachment was 48 hours. Attachment was determined by lifting the mussels with forceps. Mussels were indicated as attached when the taconite was lifted with the mussel. Specimens not attached were placed on a blank PVC substrate (a substrate known to facilitate attachment) within an aquarium filled with filtered Lake Michigan water to determine their attachment capability. If specimens crawled and attached to the container walls, they were recorded as “translocator” escapes.

The results indicate that as the depth of sediment on top of the DCR increases, attachment success by dreissenids to DCR decreases (Table 2 and Figure 1). There was little difference in attachment success between the 4-mm and 8-mm sediment covers, but success declined substantially at greater covering depths. In addition, as the sediment depth increased and DCR became unavailable, attachment of quagga mussels to other quagga mussels increased (Table 2).

Phase IIIb: Study to Assess Dreissenid Attachment under Low Percentages of DCR

The Phase I, II, and IIIa studies established that dreissenids will attach to bare DCR (no sediment cover) but are generally attachment limited by sediment covering DCR, as shown in Figure 1. Phase IIIa also preliminarily established that the densest DCR material (taconite) falling through the water column will penetrate sediment (disturbed Lake Superior sediments) to only approximately 7 mm (average 5.3 mm). Therefore, taconite as well as other DCR would be available, at least initially, for attachment.

FIGURE 1
Attachment Success of Quagga Mussels to DCR (Taconite) Through Overlying Sediment



However, the amount of DCR available for attachment may be quite small when compared to the total bottom area available for attachment. As documented by CH2M HILL (2007b), in areas of high DCR discharge, DCR annual discharge represents only 0.2 percent of the natural annual sediment deposition.

The second part of this study limits the amount of DCR available while holding the depth of DCR in sediment constant. The following experimental design was initiated to help assess how low-DCR substrate availability might affect attachment. To facilitate this laboratory-based study and to attempt to replicate real world conditions, the percentages of DCR used were based on mass. The test consisted of DCR–natural sediment mixtures of 1, 2, 4, and 16 percent DCR. The lowest of these percentages is substantially greater than the 0.2 percent that occurs on lake bottoms, but logistic constraints (size of containers and mass of sediment required) prohibited replicating actual average deposition mixtures. Additionally, if the geometric progression of dilutions were to provide evidence that decreases in DCR percentage lower attachment success, then projections could be made beyond the range of test conditions (that is, for less than 1 percent DCR in sediment). Table 3 lists the assumptions used for these tests.

Five replicates of each percent of each DCR material were tested. Thus, four percentages times five replicates times three DCR materials equals 60 individual tests. In addition to the above test design, a control containing only sediment (3.35 cm deep) was tested (five replicates). Each replicate was tested independently, within its dedicated experimental container. Each replicate contained 10 quagga mussels (total 650 mussels). The DCR was hand placed in the containers to a depth of 7 mm at equally spaced intervals. The quagga mussels used in this study ranged in length from 1.5 cm to 2.5 cm and were collected from colonization substrates placed in the Milwaukee Lake Michigan inner harbor located at the Great Lakes WATER Institute, University of Wisconsin–Milwaukee. Test DCR was collected from ships and was the same material used in earlier phases: ship sweepings of coal, limestone, and taconite and a native fine-grained substrate. Each test container was filled with filtered Lake Michigan water above the 3.35-cm sediment level. The containers were loaded by hand at generally equally spaced intervals with 10 mussels per replicate. The mussels were acclimated from the harbor water temperature of 15°C to the container water temperature of 19°–20°C over a 3-hour period.

TABLE 3
Test Assumptions

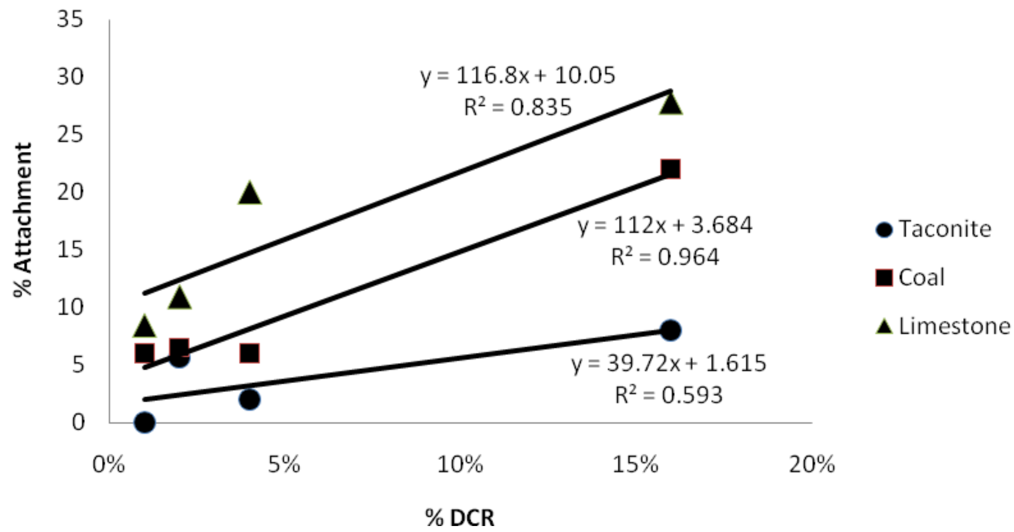
	Target Mass (g/rep)	
Percent	Of Specified DCR Material	Of Sediment
1	4.47	442.33
2	9.03	442.33
4	18.43	442.33
16	70.7	442.33

Note: Mass of DCR was based on average mass of taconite pellet. Size of test chamber used, 11 cm × 11 cm. Depth of sediment in each chamber, 3.35 cm. Depth at which DCR was placed, 7 mm (depth of estimated penetration and depth at which attachment success began to decline). DCR materials (taconite, coal, limestone) tested separately.

The time interval for observation of attachment was 48 hours. At the end of the 48-hour period, attachment was determined by lifting the mussels with forceps. Mussels were considered attached to the test material (taconite, coal, limestone) if it was lifted with the quagga mussel. Specimens not attached were placed on a blank PVC substrate (a substrate known to facilitate attachment) within an aquarium filled with filtered Lake Michigan water to determine their attachment capability. If specimens crawled to and attached to the container walls, they were recorded as “translocator” escapes.

Results of the Phase IIIb study are presented in Tables 4 through 8 and Figure 2. Table 4 shows the final concentrations of DCR used for each series of tests, by mass. For taconite, the average percent for each replicate series was 1.00, 1.98, 3.68, and 15.30, respectively. The average percent for the coal replicate series was 1.10, 1.98, 4.13, and 15.90, and for the limestone replicate series 1.02, 2.00, 4.08, and 15.36 percent.

FIGURE 2
Results of Phase IIIb Attachment Study for All Three DCR Materials



The attachment results for the control (Table 5) indicated that there were no attachments under the above test conditions. There were three attachments to other quagga mussels and no attachment to test chamber walls in the control test containers. The results for each DCR material show increasing attachment success with increasing DCR percentage (Figure 2 and Tables 6 through 8). There was a good correlation between the concentration of coal and limestone and mussel attachments. This trend was not as strong for taconite, although there was a slight upward trend.

Conclusions

Zebra mussels (*Dreissena polymorpha*) and quagga mussels (*Dreissena bugensis*) will attach to DCR materials. Reduced dreissenid attachment showed an inverse relation to increased sediment depth over DCR material. Natural sedimentation and bioturbation may act as limiting factors to colonization of DCR over time. Dreissenids actively probe sediment to locate hard substrate and will extend byssal threads to a depth greater than 20 mm to facilitate attachment, but attachment is substantially reduced at depths greater than 8 mm. The velocity-penetration study suggests that the mass of DCR is not large enough to penetrate bottom sediments deep enough to limit dreisseind colonization. Finally, as the mass concentration of DCR increases, so does the probability of attachment by dreissenids.

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Table 4. Actual DCR mass and average percentages used in Phase IIIb. DCR mass in 442.33 g of sediment at 3.35 cm deep and 11 cm squared.

	Taconite DCR Mass (g)			
Replicate	1%	2%	4%	16%
1	4.53	8.98	15.84	69.25
2	4.81	8.99	15.40	65.43
3	4.40	8.43	16.70	68.70
4	3.96	8.63	15.76	69.08
5	4.35	8.65	17.54	65.76
Mean	4.41	8.74	16.25	67.64
Mean percentage per replicate	1.00%	1.98%	3.68%	15.30%
Pieces*	1	2	4	13

	Coal DCR Mass (g)			
Replicate	1%	2%	4%	16%
1	4.48	8.42	18.41	71.22
2	4.73	8.46	17.61	71.42
3	4.68	8.96	18.43	69.22
4	4.28	9.51	18.22	69.35
5	4.25	8.51	18.58	70.12
Mean	4.48	8.77	18.25	70.27
Mean percentage per replicate	1.01%	1.98%	4.13%	15.90%
Pieces*	2	3	4	11

	Limestone DCR Mass (g)			
Replicate	1%	2%	4%	16%
1	4.24	8.85	18.40	70.15
2	4.84	8.57	16.72	63.31
3	4.48	8.65	17.94	69.07
4	4.63	9.15	18.03	66.09
5	4.41	9.09	19.12	70.9
Mean	4.52	8.86	18.04	67.90
Mean percentage per replicate	1.02%	2.00%	4.08%	15.36%
Pieces**	4	9	19	42,42,50,50,42

*Number of pieces of DCR in each mix; **Limestone 16% pieces for replicate 1-5.

Table 5. Control results for Phase IIIb assessment. Controls were sediment only at a depth of 3.35 cm, with no DCR.

	Attached (#)	Not Attached (#)	% Attached	Attached To Quagga (#)	% Attached To Quagga	Attached to Wall (#)
Control						
1	0	10	0	0	0	0
2	0	7	0	3	30	0
3	0	10	0	0	0	0
4	0	10	0	0	0	0
5	0	10	0	0	0	0
Mean		9.4	0	0.6	6	

Table 6. Results of Phase IIIb attachment study, taconite DCR.

% DCR Mix	Attached (#)	Not Attached (#)	% Attached	Attached To Quagga (#)	% Attached To Quagga	Attached to Wall (#)
1%						
1	0	10	0	0	0	0
2	0	10	0	0	0	0
3	0	10	0	0	0	0
4	0	8	0	2	20	0
5	0	10	0	0	0	0
Mean		9.6		0.4	4.0	
2%						
1	0	8	0	2	20	0
2	0	6	0	4	40	0
3	1	8	11.1	1	10	0
4	1	5	16.7	4	40	0
5	0	10	0	0	0	0
Mean	0.4	7.4	5.6	2.2	22.0	
4%						
1	1	9	10.0	0	0	0
2	0	10	0	0	0	0
3	0	10	0	0	0	0
4	0	10	0	0	0	0
5	0	10	0	0	0	0
Mean	0.2	9.8	2.0			
16%						
1	0	10	0	0	0	0
2	1	9	10.0	0	0	0
3	1	9	10.0	0	0	0
4	1	9	10.0	0	0	0
5	1	9	10.0	0	0	0
Mean	0.8	9.2	8.0			

Table 7. Results of Phase IIIb attachment study, coal DCR.

% DCR Mix	Attached	Not Attached	% Attached	Attached To Quagga	% Attached To Quagga	Attached to Wall
1%						
1	0	10	0	0	0	0
2	1	7	12.5	2	20	0
3	0	10	0	0	0	0
4	2	8	20.0	0	0	0
5	0	10	0	0	0	0
Mean	0.6	9.0	6.5	0.4	4.0	
2%						
1	0	10	0.0	0	0	0
2	0	10	0	0	0	0
3	3	7	30.0	0	0	0
4	0	10	0	0	0	0
5	0	8	0	2	20	0
Mean	0.6	9.0	6.0	0.4	4.0	
4%						
1	0	10	0	0	0	0
2	0	7	0	3	30	0
3	0	8	0	2	20	0
4	2	8	20.0	0	0	0
5	1	7	12.5	2	20	0
Mean	0.6	8.0	6.5	1.4	14	
16%						
1	2	8	20.0	0	0	0
2	2	8	20.0	0	0	0
3	3	7	30.0	0	0	0
4	2	8	20.0	0	0	0
5	2	8	20.0	0	0	0
Mean	2.2	7.8	22.0			

Table 8. Results of Phase IIIb attachment study, limestone DCR.

% DCR Mix	Attached	Not Attached	% Attached	Attached To Quagga	% Attached To Quagga	Attached to Wall
1%						
1	1	9	10.0	0	0	0
2	0	10	0	0	0	0
3	2	7	22.2	1	10	0
4	1	9	10.0	0	0	0
5	0	9	0	0	0	1
Mean	0.8	8.8	8.4	0.2	2.0	0.2
2%						
1	0	10	0	0	0	0
2	3	7	30.0	0	0	0
3	1	9	10.0	0	0	0
4	0	10	0	0	0	0
5	1	6	14.3	3	30	0
Mean	1.0	8.4	10.9	0.6	6.0	
4%						
1	3	7	30.0	0	0	0
2	4	6	40.0	0	0	0
3	2	8	20.0	0	0	0
4	0	10	0	0	0	0
5	1	9	10.0	0	0	0
Mean	2.0	8.0	20.0			
16%						
1	1	9	10.0	0	0	0
2	2	8	20.0	0	0	0
3	2	8	20.0	0	0	0
4	4	5	44.4	1	10	0
5	4	5	44.4	1	10	0
Mean	2.6	7.0	27.8	0.4	4.0	

Laboratory Based Attachment Study for Colonization Potential of Dry Cargo Residue in the Great Lakes by Zebra Mussels (Dreissena polymorpha) and Quagga Mussels (Dreissena bugensis): Phase IV: Post-Veliger Colonization

Introduction

Concern over dry cargo residue (DCR) as potential substrates for the colonization of the invasive species *Dreissena polymorpha* (zebra mussel) and *Dreissena bugensis* (quagga mussel) within the Great Lakes has prompted an investigation into their attachment onto DCR. Invasion of the Great Lakes by dreissenids has caused both environmental and economic concerns and provided additional habitat for their proliferation that may increase their expansion into other areas of the lakes.

Attachment of adult zebra and quagga mussels to hard substrates is well documented in the literature and in previous studies conducted by the authors (Phase I through III of the Attachment Studies). Mellina and Rasmussen (1994) indicted that zebra mussels were found on hard substrates, particularly rocky surfaces, but were usually absent on softer substrates. Quagga mussels on the other hand appear to be able to colonize both hard and soft substrates. The bottom of Lake Erie has extensive colonies of quagga mussels on soft sediment (Dermott and Munawar 1993; Dermott and Keroc 1997; Roe and MacIsaac 1997).

The attachment of zebra and quagga mussels to hard substrates is a process that occurs with the adult which can be actively mobile and by dressenid post-veliger larvae searching for their initial home for attachment.

As the adults reproduce their early life history unfolds with the zygote, trochophore, D-larva, veliger, and post-veliger stages. The veligers are photopositive, active swimmers by use of the ciliated velum (derived from the prototroch of the trocophore larva). After about 10-15 days, the veligers metamorphose to the first post-veliger stage, the pediveliger, it becomes photonegative and settles to the benthic zone in search of a suitable substrate for attachment. Under normal conditions, 99%+ of veligers do not reach a successful attachment stage. The pediveliger has both a velum and a ciliated foot and both are used in substrate exploration. The pediveliger is the critical life stage that explores available substrates in search of optimal attachment conditions (i.e. hard substrate, current, chemistry, etc.). The pediveliger will swim a few millimeters off the substrate, then will hover stationery over the substrate using its velum before settling and then using its foot to investigate the substrate. If it is a hard substrate the pediveliger may stay. If the substrate is soft sediment (and the pediveliger is within about a week's time window for substrate selection) it will rise off the substrate and continue to search for optimal conditions. If optimal (or near optimal) conditions are not found within about a week's time, then the pediveliger will attempt colonization of marginal attachment conditions (i.e. soft substrate, etc). Once development proceeds to the next post-veliger stage, the plantigrade, it loses its velum and thus it's swimming capability. It is the pediveliger that is the primary life stage involved in substrate selection. The plantigrade is subordinate to substrate selection, although it is active in 'fine tuning' its initial attachment location.

This study investigated pediveliger selection and plantigrade attachment success on cargo sweepings (limestone, taconite, and coal) and on native soft sediment. Two experimental designs were used: 1) bulk settlement and attachment success on clean DCR material and native sediment and 2) bulk settlement and attachment on DRC material covered with 1 mm and 3 mm's of native sediment. The study attempted to answer the following questions:

- Will post-veligers attach to uncovered DCR, and
- Will post-veligers attach to DCR covered with 1mm and 3 mm of native sediment.

Phase IVa: Post-Veliger 14-Day Colonization Study: Bulk Settlemant and Attachment on DCR Material and Native Sediment

Methodology and Results

The bulk settlement study used five replicate 700 ml chambers (12 x12 cm) for each DCR material (limestone, taconite, and coal) and a native sediment control. Post-veliger larvae were collected from the Milwaukee Lake Michigan inner harbor located at the Great Lakes WATER Institute, The University of Wisconsin-Milwaukee. A distinction was not made between zebra versus quagga veligers, however it is known that the distribution of adults, where the veligers were collected, was approximately 50/50%. Samples were concentrated as needed based on harbor *in situ* abundance densities. The density of post-veliger larvae used for the bulk settlement and attachment studies was approximately 665.5 larvae/chamber. 700 ml of raw harbor water was used in each chamber, to a depth of 6.5 cm, to cover the DCR. The post-veliger larvae were allowed to settle for a total period of 14 days. Periodic observations were made about every four days to gauge settling, and general success or failure of the experiment.

The post-veliger 14 day colonization study was conducted from June 30 through July 14, 2008. The results are listed in Table 1. The results indicate that post-veligers (pedivelgers, plantigrade veligers) will attach to DCR. An analysis of the results indicated a clear preference for the DCR material as opposed to the native sediment (Tables 2 and 3). The analysis shows that the percent attachment for each DCR type was significantly greater than the percent attachment on native sediment. The analysis also shows that the percent attachment for limestone was significantly greater than the percent attachment to coal, but not for taconite. The percent attachment between tactonite and coal was not significantly different. The data suggests a potential attachment preference of the sequence limestone>taconite>coal>native sediment (Figure 1).

TABLE 1
Results of bulk settlement and attachment by Post-Veligers on DCR material

Sample	Limestone		Taconite		Coal		Sediment*	
	No. Attached	%	No. Attached	%	No. Attached	%	No. Attached	%
1	42	6.3	49	7.4	18	3.5	0	0.0
2	51	7.7	18	2.7	2	0.3	0	0.0
3	47	7.1	31	4.7	10	1.5	0	0.0
4	34	5.1	5	0.8	11	1.7	1	0.2
5	29	4.4	26	3.9	23	3.5	0	0.0
Average	**40.6**	**6.1**	**25.8**	**3.9**	**12.8**	**2.1**	**0.2**	**0.03**

***10 mm sediment depth**

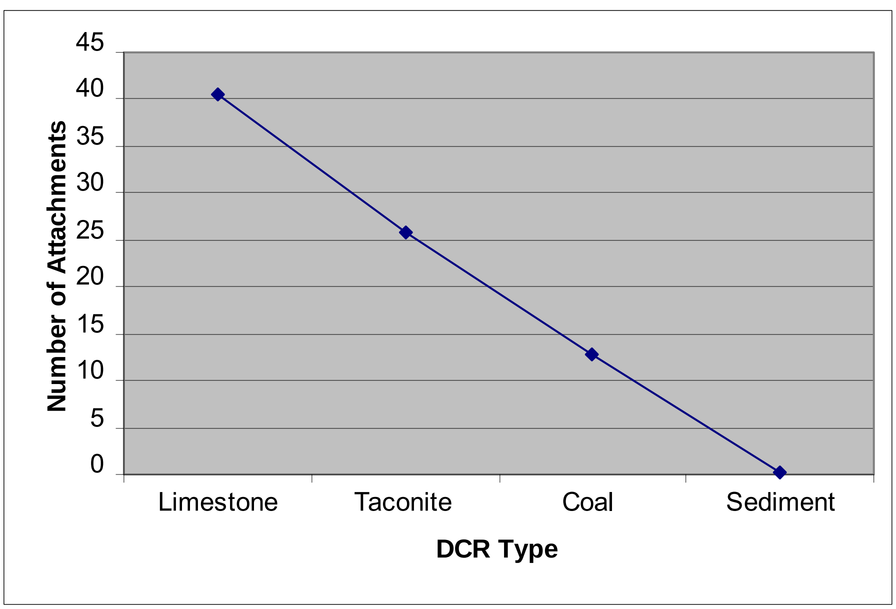
TABLE 2
Results of ANOVA Test on the Bulk Settlement and Attachment Data (log x+1 transformed data)

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square
Treatments (between columns)	3	6.860	2.287
Residuals (within columns)	16	1.086	0.06786
Total	**19**	**7.946**	
F = 33.699 = (MStreatment/MSresidual)			

TABLE 3
Results of Tukey-Kramer Multiple Comparison Test on the bulk settlement and attachment data. If the value of q is greater than 4.046 then the P value is less than 0.05

Comparison	Mean Difference	q	P value
Limestone vs Taconite	0.2719	2.334	ns p>0.05
Limestone vs Coal	0.5590	4.799	* p<0.05
Limestone vs Sediment	1.550	13.307	*** p<0.001
Taconite vs Coal	0.2871	2.465	ns
Taconite vs Sediment	1.278	10.973	*** p<0.001
Coal vs Sediment	0.9911	8.508	*** p<0.001

FIGURE 1
Post-veliger attachment preference based on the above data



Phase IVb: Post-Veliger 14-Day Colonization Study: Sediment Penetration onto DCR Material

The sediment penetration study used five replicate 700 ml chambers, 12x12cm, for each DCR material (limestone, taconite, and coal) and a native sediment control. Two test conditions were assessed, one with 1 mm depth of native sediment covering the DCR material , and one with 3 mm. Post-Veliger larvae were again collected from the Milwaukee Lake Michigan inner harbor located at the Great Lakes WATER Institute, The University of Wisconsin-Milwaukee. Samples were concentrated as needed based on harbor *in situ* abundance densities. The density of post-veligers for the sediment penetration studies was approximately 630.7 larvae/chamber. 700 ml of harbor water was used in each chamber, at a depth of 6.5 cm, to cover the DCR. The post-veligers were allowed to settle for a total period of 14 days. Observations were again made about every four days to gauge settling, and general success or failure of the experiment.

The results are presented in Tables 4 and 5. The data indicate that a minimum 1mm cover of DCR material by native sediment will curtail attachment by post-veligers to DCR. An analysis of the data indicated no significant difference (critical p-value of 0.05) in attachments between each type of DCR material and native sediment (Tables 6 and 7).

TABLE 4
Results of sediment penetration study by post-veligers on DCR material. Overyling sediment Depth: 1mm

Sample	Limestone		Taconite		Coal		Sediment*	
	No. Attached	%	No. Attached	%	No. Attached	%	No. Attached	%
1	0	0.0	1	0.2	2	0.3	0	0.0
2	2	0.3	0	0.0	0	0.0	0	0.0
3	1	0.2	1	0.2	0	0.0	0	0.0
4	0	0.0	0	0.0	1	0.2	0	0.0
5	0	0.0	0	0.0	0	0.0	0	0.0
Average	**0.6**	**0.1**	**0.4**	**0.1**	**0.6**	**0.1**	**0**	**0.0**

TABLE 5
Results of sediment penetration study by post-veligers on DCR material. Overyling sediment depth: 3mm

Sample	Limestone		Taconite		Coal		Sediment*	
	No. Attached	%	No. Attached	%	No. Attached	%	No. Attached	%
1	0	0.0	1	0.2	2	0.3	0	0.0
2	0	0.0	0	0.0	0	0.0	0	0.0
3	0	0.0	1	0.2	0	0.0	0	0.0
4	1	0.2	0	0.0	1	0.2	0	0.0
5	0	0.0	0	0.0	0	0.0	0	0.0
Average	**0.2**	**0.04**	**0.4**	**0.08**	**0.6**	**0.1**	**0**	**0.0**

TABLE 6
Results of ANOVA test on the sediment penetration, 1 mm depth (log x+1 transformed data)

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square
Treatments (between columns)	3	0.08178	0.02726
Residuals (within columns)	16	0.5031	0.03144
Total	**19**	**0.5848**	
F = 0.8670 = (MStreatment/MSresidual)			

TABLE 7
Results of ANOVA test on the sediment penetration, 3 mm depth (log x+1 transformed data)

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square
Treatments (between columns)	3	0.01359	0.004531
Residuals (within columns)	16	0.2175	0.01359
Total	**19**	**0.2311**	
F = 0.3333 = (MStreatment/MSresidual)			

Conclusions

The phase IV study was developed to answer the following questions:

- Will post-veligers attach to uncovered DCR, and
- Will post-veligers attach to DCR covered with 1 and 3 mm of native sediment.

Based on the results it appears that the post-veligers will attach to DCR material . In addition it appears that at least in this experiment there was a distinct attachment preference by post-veligers for limestone, followed by taconite and coal. The second part of the study indicated that by covering the DCR with a layer of native sediment to a depth of 1mm or more will curtain post-veliger attachment onto DCR. The addition of these data to what has been developed by the other experiments further supports the premise that Zebra Mussels (*Dreissena polymorpha*) and Quagga Mussels (*Dreissena bugensis*) will attached to exposed DCR including the post-veliger stages. In addition, if the mussels are covered with native sediment, attachment to DCR will be curtailed depending on the depth to which the material is buried. In the case of post-veligers, as little as 1 mm of sediment appears to prevent almost all attachment. It should be kept in mind that given the high reproductive capacity of adult female dressinids (500,000 veligers/mussel), even a 0.2% attachment rate would equate to 1000 attachments.

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