Hog Is. Remediation
Newton Creek

Interim Remedial Action Options Report

Hog Island Inlet

City of Superior, Douglas County, Wisconsin

SEH No. WIDNR9905.02

November 2003

SEH

SHORT ELLIOTT HENDRICKSON INC
Multidisciplined.
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architecture • engineering • environmental • transportation

November 5, 2003

RE: Hog Island Inlet
Interim Remedial Action Options Report
Superior, Wisconsin
SEH No. WIDNR9905.02

Mr. James A. Hosch
Hydrogeologist/Project Manager
WDNR Bureau of Remediation and Redevelopment
1401 Tower Avenue
Superior, WI 54880

Dear Mr. Hosch:

Short Elliott Hendrickson Inc.® (SEH) is submitting the enclosed report titled "Interim Remedial Action Options Report – Hog Island Inlet" for the Wisconsin Department of Natural Resources Bureau of Remediation and Redevelopment. The report outlines the technical and economical feasibility of interim remediation alternatives to reduce risks associated with sediment contamination in Hog Island Inlet and the final 600 feet of Newton Creek (Segment L) upstream of the inlet.

If you have any questions pertaining to this or any phase of the project, please contact me.

Sincerely,

Mark J. Broses, PE
Project Manager

MJB/TJ/JH/ls/KA
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Interim Remedial Action Options Report

Hog Island Inlet
City of Superior, Douglas County, Wisconsin

Prepared for:
Wisconsin Department of Natural Resources
Superior, Wisconsin

Prepared by:
Short Elliott Hendrickson Inc.
421 Frenette Drive
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I, Mark J. Broses, hereby certify that I am a registered professional engineer in the State of Wisconsin, registered in accordance with the requirements of ch. A-E 4, Wis. Adm. Code; that this document has been prepared in accordance with the Rules of Professional Conduct in ch. A-E 8, Wis. Adm. Code; and that, to the best of my knowledge, all information contained in this document is correct and the document was prepared in compliance with all applicable requirements in chs. NR 700 to 726, Wis. Adm. Code.

[signature]	31176	11-5-03
Mark J. Broses, PE Project Manager	PE Number	Date

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Conclusion

Option 1 did scored poorly in comparison to the other options primarily because it would not reduce risks to human health and/or the environment in a reasonable time frame. Overall, Options 2 and 3 received the same score. SEH recommends that the WDNR further consider each of these options for implementation at the site. Pending further discussion, SEH recommends Option 2 because it is less expensive (by approximately $1 million) and is a proven technology. Option 3 is an innovative technology that would not disturb the site as much as Option 2, but it is unproven and appears to be more expensive, including costs that would be associated with cost cap guarantees or performance bonding.

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Interim Remedial Action Options Report

Hog Island Inlet

Prepared for Wisconsin Department of Natural Resources
Bureau of Remediation and Redevelopment

1.0 Introduction

Newton Creek begins near the Murphy Oil USA Refinery (Murphy) in Superior, Wisconsin, and ends at its mouth located at Hog Island Inlet, which is located in the southeast end of Superior Bay, Lake Superior. In previous studies, the Wisconsin Department of Natural Resources (WDNR) determined that potential ecological risks to Newton Creek and Hog Island Inlet are high.

Contaminated sediments (at concentrations above severe effects levels) in the first 700 feet of Newton Creek (Segment A, adjacent to the Murphy outfall impoundment) were removed in 1997 (by Murphy). The WDNR implemented an interim remedial action for Segments B through K of Newton Creek during the summer of 2003. Because it is believed that a large portion of Newton Creek Segment L is influenced by interactions between Lake Superior and the inlet, Segment L will be addressed at the same time as Hog Island Inlet. The current work scope is focused on evaluating potential remedial actions for Hog Island Inlet and Newton Creek Segment L.

This remedial action options report (RAOR) evaluation was prepared by Short Elliott Hendrickson Inc. (SEH) on behalf of the WDNR Bureau of Remediation and Redevelopment, per WDNR contract 02RRSU dated June 13, 2002 (which authorized work to begin on July 1, 2002). The RAOR was prepared in general accordance with ch. NR 722, Wisconsin Administrative Code, WDNR's February 28, 2002 revised scope of work, and the tasks described in SEH's April 10, 2002 proposal.

1.1 Project Contacts

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1.2 Purpose

This report provides the information needed to select an interim remedy to remediate contaminated sediments within Hog Island Inlet and Newton Creek Segment L. Several remediation technologies were considered including natural attenuation, capping, in situ treatment, and/or removal with ex situ treatment or disposal. As discussed herein, remediation goals will be based on chronic protection of ecological receptors.

Remedial action options were evaluated with respect to criteria defined in ch. NR 722 Wis. Adm. Code including technical feasibility (long-term effectiveness, short-term effectiveness, implementability, and restoration time frame), and economic feasibility (costs). The report includes a side-by-side comparison of each of the options with respect to technical and economic feasibility.

The report evaluates the following options in detail:

- Option 1 – No Action/Monitoring/Institutional Controls;
- Option 2 –Removal of Contaminated Sediment to Chronic Sediment Quality Targets with Off Site Treatment and/or Landfill Disposal; and
- Option 3 – In-situ Electrochemical Treatment of Contaminated Sediment to Chronic Sediment Quality Targets.

1.3 Site Location and Description

The Newton Creek / Hog Island Inlet system are located in the City of Superior, Douglas County, Wisconsin. Figure 1, "Site Location Map" illustrates the general location of the system.

The Newton Creek / Hog Island system is defined by the WDNR as including the surface water environment encompassing Newton Creek Impoundment, Newton Creek, Hog Island Inlet, the inlet mouth to

Superior Bay, and all floodplain, overflow areas, and wetlands associated with these water bodies. The Newton Creek/Hog Island system receives storm water through overland flow and storm water outfalls. The primary non-storm water source of surface water to the Newton Creek/Hog Island system is the Murphy Refinery treated process wastewater outfall (permitted as Outfall #1 in WPDES Permit No. WI-0003085-6).

Under normal conditions (without runoff from seasonal thaws or precipitation events), creek flows from the Murphy impoundment at a rate of approximately one cubic foot per second (cfs). Normal creek width is approximately three feet and creek water depth varies from six inches to one foot. However, storm events significantly increase creek flow for short periods.

According to s. NR 104.10(3)(b) Wis. Adm. Code: "Newton Creek in the City of Superior, from the headwaters to its mouth into Hog Island Inlet of Superior Bay [is] classified as a non-continuous stream and [is also] classified for fish and aquatic life uses with the subcategory of limited forage fish communities. Hog Island Inlet and Superior Bay [are] classified for fish and other aquatic life uses with the subcategory of Great Lakes communities."

The Newton Creek/Hog Island system and its contiguous wetlands encompass approximately 60 acres with the total length of the system extending approximately 1.5 miles. Newton Creek flows through numerous culverts and under bridges that exist where the creek intersects roadways and a railroad line. It flows through industrial, commercial, and residential areas in the City of Superior before reaching Hog Island Inlet. Newton Creek is generally accessible to the public, along its entire length.

Adjacent properties in the Segment L area are a mixture of undeveloped/vacant land with nearby residential areas. The Osaugee Recreational Trail runs parallel to the Hog Island Inlet shore and crosses Newton Creek via a pedestrian bridge. In the Hog Island Inlet area, the surrounding land use is a mixture of undeveloped and vacant industrial properties.

Additional descriptive information is provided below for Segment L and the Hog Island Inlet.

1.3.1 Segment L

Segment L begins where the creek emerges from beneath Highway 2, on the northeast side of the highway. Segment L extends approximately 600 feet from the highway, and discharges directly into the Hog Island Inlet.

Property on both sides of Segment L, are owned by the City of Superior. The land is undeveloped. Tracks of the Burlington Northern Santa Fe Railroad bound the City parcels to the north and south. There are no residences located along Newton Creek in Segment L.

The Segment L floodplain is heavily vegetated with invasive wetland vegetation, primarily grasses and forbs, with a few alders and poplar trees.

Normal flow into Newton Creek Segment L is from Murphy's treated wastewater discharge upstream, via the upstream creek segments. During storm events, storm water also flows into the creek from approximately ten upstream storm water outfalls, minor drainage-ways and overland flow.

1.3.2 Hog Island Inlet

Hog Island and Hog Island inlet together form an approximately 90-acre embayment in Superior Bay. Hog Island is approximately 55 acres and is connected to the mainland shore by a 20 acre (approximately) submerged wetland isthmus. Hog Island Inlet covers approximately 17 acres. An approximately 50-foot wide channel in the northwest corner of the embayment opens into Superior Bay. Hog Island Inlet's mouth is approximately 1.4 miles from the Superior Bay entry in Lake Superior.

Hog Island was formed by the historic deposition of dredge materials from the adjacent shipping channel of Superior Bay. The dredge materials have been largely undisturbed and now support a diverse wetland ecosystem along the southwestern side of the island. The central part of the island would be considered upland without plants or soils characteristic of wetlands.

Hog Island Inlet is bordered by Hog Island, the Lakehead Pier, the Hog Island wetland isthmus, and the mainland shore. Hog Island and the isthmus are undeveloped. The Lakehead Pier was developed at one time but is currently vacant. The pier may have been used for transfer and storage of various materials including iron, coal, and/or oil. A series of parallel railroad tracks lie along the southwest side of the Inlet. State Highway 2 runs parallel to the railroad tracks and mainland shore at higher elevations.

Water depths in Hog Island Inlet range from less than one foot to seven feet. The shallowest water depths occur in the east end of the inlet and the deepest near the inlet opening to Superior Bay. Water level changes in Superior Bay produce short term variations in water level up to 0.5 feet or more in the inlet due to Lake seiche effect. As water levels fall in Lake Superior, water flows out of Hog Island Inlet into Superior Bay. As water levels rise, water flows into Hog Island Inlet from Superior Bay.

The surface water elevation of Lake Superior currently varies between approximately 601 and 602 feet above mean sea level (MSL). The elevation of the lake varies seasonally with lower elevations in February to March and higher elevations in August to September. The recent annual surface water elevation is approximately seven inches lower than its long-term average.

Based on bottom probing, soft sediment in the inlet is less than one foot thick through most of the eastern half of the inlet and near shore around most of the western half of the inlet. Sediments greater than two feet thick cover approximately one half of the western portion of the inlet. In a few relatively small areas, the soft sediment thickness exceeds five feet.

There are no residences adjacent to the Hog Island Inlet. Several residences are located approximately 300 feet to the south of Segment L with commercial establishments to the west along Hwy 2. Local residents use the island and wetland isthmus areas for recreation.

According to the 1993-1994 wetland survey (Reed, 1994) and the WDNR (WDNR, 1994), the dominant vegetation encountered around the southwestern side of Hog Island Inlet is classified as an emergent plant community. The dominant plant species included Burreed (*Sparganium sp.)*, Lake sedge *(Carex lacustris)*, and Broad-leaved cattail. *(Typha latifolia)*. The wetland isthmus and Hog Island perimeter wetland vegetation is characteristic of emergent marsh, sedge meadow and shrub-carr/alder thicket with scattered lowland hardwoods. Submergent and floating leaf aquatic plant species are present in the open waters of the inlet beyond the emergent vegetation stands.

Hog Island and the nearby Ogdensburg Pier (also called Lakehead Pier) serve to protect the Hog Island Inlet from wave action, creating an aquatic environment that supports a diverse aquatic community.

Hog Island Inlet has a high functional value for aesthetics, recreation, education, and science. Although the ecosystem of Hog Island Inlet is the result of dredge spoil deposition, the area has been allowed to develop naturally. The area hosts a wide diversity of plant species and has future potential as an educational study site or outdoor laboratory.

The Inlet is already used by the United States Environmental Protection Agency (USEPA) and others for scientific study. All wetlands within the project area including those in Hog Island Inlet are part of the Lake Superior Areas of Special Natural Resource Interest (ASNRI) as listed in s. NR 103.04 Wis. Adm. Code. ASNRI are recognized by the state or federal government as possessing special ecological, cultural, aesthetic, educational, recreational, or scientific qualities.

Hog Island Inlet is part of the "nearshore zone area" of Lake Superior that serves important functions in maintaining the biodiversity of the Lake system. Nearshore areas like Hog Island Inlet represent only 5% of the total area of Lake Superior. Virtually all species of Great Lakes fish use the nearshore waters for one or more of their critical life stages or functions (e.g., permanent residence; migratory pathway for anadromous fish; temporary nursery and feeding grounds; and refuges for young-of-the year fish).

Researchers with USEPA have identified a wide variety of species, various life stages (young-of-the-year, yearling, and adult) and an abundance of fish in the Inlet. Twenty-four species of fish were collected in the Inlet in fyke nets by USEPA. Seventeen of the twenty four were in the young-of-the year life stage. Game fish collected included yellow perch, walleye, northern pike, small mouth bass, bluegill, and rock bass. WDNR fisheries staff observations are that the Inlet appears to support northern pike spawning habitat, and both adult and young of the year pike have been observed.

2.0 Project History

The Newton Creek / Hog Island Inlet system have been the focus of WDNR investigations for several years. Previous summary reports regarding Newton Creek that were reviewed by SEH in preparation of this report are listed below in chronological order:

- Identification of Pollutants of Concern, Further Needed Site Assessments, and Estimated Remediation Costs for Contaminated Sediments in Newton Creek, Hog Island Inlet, and Potentially, Superior Harbor, WDNR, April 6, 1992;
- Newton Creek/Hog Island Inlet Investigative Survey, Eder Associates Consulting Engineers (for Murphy), November 1993;
- Evaluation of Sediment Contamination at Newton Creek and Hog Island Inlet, ENSR Consulting Engineers (for Murphy), December 1993;
- Human Health Risk Assessment for Newton Creek and Hog Island Inlet, ENSR (for Murphy), August 1994;

- Assessment of Wetland Habitats Associated with the Newton Creek System, Don Reed (for WDNR), November 23, 1994;
- Characterization of Sediment Contamination in the Newton Creek System, WDNR, December 15, 1994;
- DRAFT RCRA 3008(h) Consent Order to Murphy Oil USA, Inc., Superior, Wisconsin Facility. USEPA ID No. WID 816 194 336. USEPA, March 01, 1995 DRAFT;
- Summary of Investigation Activities Associated with the WDNR Newton Creek Feasibility Study Supplementary Site Characterization, Burns & McDonnell (for Murphy), March 1995;
- Remedial Alternatives Array Document for Newton Creek System, RMT (for WDNR), April 1995;
- Feasibility Study Report for Newton Creek System, RMT (for WDNR), October 1995;
- Newton Creek System Sediment Contamination Site Characterization Report, WDNR, December 1, 1995;
- Results of Aerobic Biodegradation Screening Treatability Study for the Newton Creek System, RMT (for WDNR), January 1996;
- Closure/Post-Closure Plan for Wastewater Treatment Ponds Nos. 1 & 6, Wisconsin Petroleum Refinery, Murphy Oil USA, Inc., Burns & McDonnell (for Murphy), June 1996;
- Superior Refinery Pond Closure Project Final Workplan for Newton Creek Remediation, Roy F. Weston (for Murphy), August 1997;
- Site Investigation Report - Newton Creek Segments B and C, SEH (for WDNR), September 2000;
- Preliminary Engineering Report – Newton Creek Remediation, SEH (for WDNR), November 2001;
- Site Investigation Work Plan– Newton Creek and Hog Island Inlet, SEH (for WDNR), August 2002;
- Remedial Investigation Report – Newton Creek Segments B-K SEH (for WDNR), February 2003;
- Remedial Action Options Report – Newton Creek, SEH (for WDNR), April 2003;
- Remedial Design Report – Newton Creek, SEH (for WDNR), April 2003; and
- Site Investigation Report – Hog Island Inlet, SEH (for WDNR), September 2003.

interim action being taken and any solid or hazardous waste and contaminated environmental media that is being generated, treated, stored or disposed as part of the interim action.

- Use recycling or treatment to the extent practicable.
- Be consistent with the final remedial action that is likely to be selected for that pathway of exposure or contaminated environmental media that is being addressed by the interim action.
- Comply with the following requirements when disposal of contaminated soil, sediment or other granular material such as fill, not including debris, is proposed: Volumes of contaminated soil, sediment or other granular material, not including debris, that exceed 100 cubic yards may be disposed of in a licensed landfill with a department-approved composite liner, or a liner that is equivalent to a composite liner in terms of environmental protection, as determined by the department, in compliance with the landfill's approved plan of operation.

3.2 Sediment Cleanup Goals

Sediment quality cleanup goals based on protection from chronic effects were determined by calculating the midpoint concentration between the "no observed adverse effects level (NOAEL) concentrations" and "lowest observed adverse effects level (LOAEL) concentrations" presented in the Site Investigation Report (SEH, September 2003). According to the USEPA 1998. "Guidelines for Ecological Risk Assessment", the midpoint concentration (or maximum acceptable toxicant concentration) is an estimated threshold concentration of the chemical within the range defined by the NOAEL and LOAEL values.

Sediment cleanup goals based on <u>chronic criteria</u> are listed below:

DRO = 10 mg /kg (NOAEL <6.8 mg/kg; LOAEL = 13 mg/kg)
TEH = 9 mg /kg (NOAEL 5.7 mg/kg; LOAEL = 11.3 mg/kg)
TPAH = 2.6 mg/kg (NOAEL 2.3 mg/kg; LOAEL = 2.9 mg/kg)

Sediment quality cleanup goals based on protection from acute effects (toxicity test survival impacts) were determined by calculating the midpoint concentration between concentrations at HI-27 (sediment sampling location highest concentration without survival impacts) and HI-13 (sediment sampling location lowest concentration with survival impacts) presented in the Site Investigation Report (SEH, September 2003).

Sediment cleanup goals based on <u>acute criteria</u> are listed below:

DRO = 36 mg/kg (HI-27 = 21 mg/kg; HI-13 = 50 mg/kg)

TEH = 62 mg/kg (HI-27 = 23 mg/kg; HI-13 = 101 mg/kg)
TPAH = 7.5 mg/kg (HI-27 = 4.3 mg/kg; HI-13 = 10.7 mg/kg)

Approximately 20,000 cubic yards of sediments would require remediation to meet acute criteria. Approximately 50,000 cubic yards of sediments across 15 acres of the inlet would require remediation to meet chronic criteria. Calculations are included in Appendix A "Design Calculations".

Chronic protection goals were selected because Hog Island Inlet is part of the "nearshore zone area" of Lake Superior that serves important functions in maintaining the biodiversity of the Lake system. Nearshore areas like Hog Island Inlet represent only 5% of the total area of Lake Superior. Remediation goals based on chronic protection of ecological receptors should also meet sediment quality needs for future recreational use of the site by the public.

3.3 ARARs

A brief summary of the applicable or relevant and appropriate requirements (ARARs) that may apply to remediation activities at the site is included in this section. The summary below includes descriptions of chemical-specific requirements, location-specific requirments, and action-specific requirements for the proposed remediation options. These requirements are summarized in Table 1, "Review of ARARs and Information To Be Considered."

3.3.1 Chemical-Specific Requirements

Chemical-specific ARARs are requirements that regulate the release or presence of specific chemical constituents in the environment. These requirements generally establish risk-based concentration levels or discharge limits for specific chemicals. The concentration levels generally are determined based on human health and ecological risks.

Water treatment levels will be based on the point of discharge. Discharges to the sanitary sewer will be required to meet the requirements of the City of Superior. Discharges to Lake Superior, will require a temporary WPDES permit from the WDNR. The Federal Clean Water Act may also have specific requirements.

Chemical specific cleanup levels may also be required for remediation residuals, including off-gases and water. Off-gases will be required to meet air emissions requirements listed in ch. NR 400 Wis. Adm. Code.

3.3.2 Location-Specific Requirements

Location-specific ARARs are requirements that relate to the geographic location or features of the site. These requirements may affect the remedial action choices or may impose constraints on specific remedial alternatives.

Hog Island Inlet is classified for fish and other aquatic life uses with the subcategory of Great Lakes communities. Newton Creek is considered a non-continuous stream in accordance with ch. NR 104 Wis. Adm. Code. The site is subject to laws pertaining to waters of the State of Wisconsin and regulations pertaining to the Coastal Zone Management Act, Clean Water Act, Fish and Wildlife Coordination Act, and Rivers and Harbors Act.

Newton Creek and Hog Island Inlet are near residential and recreational use areas. Local ordinances may dictate maximum working noise levels, hours of operation, and traffic patterns. Local building or grading permits may be required for excavation work.

Newton Creek flows under several railroads in Segment L. Construction activities conducted within the railroad right-of-way may also be subject to specific requirements of the railroad and the Federal Railroad Administration.

3.3.3 Action-Specific Requirements

Specific remedial activities selected to accomplish site cleanup are regulated or controlled by action-specific ARARs. Action-specific requirements regulate how a selected alternative must be accomplished. Example action-specific ARARs are discussed herein as they may pertain to possible remedial alternatives.

The Federal Occupation Safety and Health Act (OSHA) includes several regulations regarding remediation, excavation, and construction activities. State and Federal DOT regulations apply to transportation of solid wastes over public highways.

Several State of Wisconsin Administrative Code regulations may apply to specific actions potentially implemented at this site, particularly those enforced by the WDNR and the Wisconsin Department of Commerce (DCOM). These regulations include, but are not limited to, the ch. NR 100 Wis. Adm. Code series on water quality, the ch. NR 200 Wis. Adm. Code series on the Wisconsin Pollution Discharge Elimination System, the ch. NR 400 Wis. Adm. Code series on air quality, the ch. NR 500 Wis. Adm. Code series for solid waste handling, the ch. NR 700 Wis. Adm. Code series on environmental remediation, and DCOM safety requirements.

4.0 Identification and Screening of Potential Remedial Technologies

Wis. Adm. Code s. NR 708.11 indicates that Interim Actions may include any of the following:

- Restricting public access to the site or facility.
- Conducting source removal, such as excavation and treatment of highly contaminated soils, to prevent or limit further movement of the contamination.
- Constructing a temporary engineering control.

General response actions that satisfy the remedial action objectives are identified and described. Table 2, "General Response Action - Technology Screening" presents a list of technologies under each general response action and documents the preliminary screening.

4.1 General Response Actions

General response actions are broad categories of activities and technologies that may be applied alone or in combination in order to accomplish the remedial action objectives. The general response actions may be applicable to one or more media at the site. Some general response actions are required only in combination with other general response actions. Therefore, not all remediation alternatives will include all of the identified general response actions. Specific activities and technologies within each general response action category are identified for evaluation and assembly into potential remedial actions. The general response actions for this project may include:

- Institutional Controls
- Access Restrictions
- Engineering Controls (Capping)
- In Situ Treatment
- Physical Removal (Excavation, Dredging)
- Solids Dewatering/Stabilization
- Transportation
- Ex Situ Solids Treatment
- Solids Disposal
- Water Treatment
- Water Disposal

4.1.1 Institutional Controls

Institutional controls include deed restrictions and ordinances to prevent site disturbance, restrict site usage, and discourage trespassing.

4.1.2 Access Restrictions

Access restrictions include physical restrictions to limit access to the site by unauthorized personnel, and may include posted warnings, security fences, security personnel, and video surveillance.

4.1.3 Engineering Controls (Capping)

Engineering controls include technologies to prevent contact with, leaching, or migration of contaminants. Sediment capping technologies could include permeable caps, treatment caps, or impermeable caps.

4.1.4 In situ Treatment

In situ treatment of the sediments could include chemical oxidation, electrical oxidation, or enhanced biological remediation.

4.1.5 Physical Removal (Excavation, Dredging)

Physical removal of contaminated sediment from its current location may involve a mechanical or hydraulic dredging. Alternatively, the inlet could be temporarily dewatered to allow for "dry" excavation.

4.1.6 Solids Dewatering/Stabilization

Wet sediments should pass paint filter tests prior to transport and disposal. A bench scale sediment stabilization study was performed with sediments from Newton Creek, which are similar in composition to Hog Island Inlet sediments. Results of the study provide physical and chemical data on sediments, appropriate mixing reagents to meet paint filter tests, and data on freshwater leaching of contaminants from the stabilized sediments. Details of the study and results are provided in Appendix C of the Interim Remedial Action Options Report for Newton Creek (SEH, April 2003).

4.1.7 Transportation

Transportation of excavated materials off-site to treatment or disposal areas may include a variety of methods including railcars or trucks.

4.1.8 Ex Situ Solids Treatment

A variety of ex situ treatment technologies are available for contaminant destruction, extraction, or mobility reduction including thermal oxidation, stabilization, bioreactors, soil washing, landspreading, and phytoremediation. Treated sediments could have a beneficial reuse.

4.1.9 Disposal

Excavated materials may be transported off site to engineered landfills. Materials may require pretreatment prior to disposal.

4.1.10 Water Treatment

Soils dewatering and/or treatment, and hydraulic controls may generate contaminated water that will require treatment. Selected treatment technologies would be required to meet applicable discharge requirements and be approved as best available technology.

4.1.11 Water Disposal

Treated water may potentially be discharged to the municipal sanitary or storm sewer or to Lake Superior.

4.2 Preliminary Screening

While several of the technologies identified under each general response action may be applicable to the site remediation, only a limited number can be evaluated as part of a combined remedial action. Therefore the technologies in each general response action were screened in Table 2.

SEH prepared a preliminary list of retained options with preliminary cost estimates to discuss with the WDNR. A brief description of each is provided below. Preliminary costs were assembled for remediation volumes to meet acute cleanup criteria (20,000 cubic yards) or chronic cleanup criteria (50,000 cubic yards). Based on identified implementability and/or cost related issues, some of the technologies were not retained for further consideration.

4.2.1 In-place treatment via Electrical Oxidation

This option would be directed at treating the sediments in place. Following the placement of anodes and cathodes into the sediments, low voltage electricity would be run through the sediments. The electric current would cause organic contaminants in the sediments to oxidize to carbon dioxide and water. Treatment would occur from one to three years. Range of costs for this option was estimated to be from approximately \$3 million to \$6 million dollars, dependant on the volume of sediments being addressed.

This technology has been used with success on PAH contaminated sediments in Germany in recent years. A 6-month technology demonstration project was recently conducted by NRRI with sediments from the Erie Pier at the Duluth CDF. The results of the demonstration had only limited success in part due the short time frame.

This technology is not yet a proven technology. NRRI is currently testing this technology on sediments from Newton Creek at their facility in Coleraine, Minnesota.

4.2.2 Partial Removal of Upper Soft Sediments and Placement of Sand Cap

Capping without removal of the contaminated sediments as an engineering control was not retained in the technology screening process. However, the combined approach of partial removal and backfilling over remaining contaminated sediments with a clean sand cap was considered.

This option would involve dredging a maximum 2 feet thickness of contaminated soft sediments. The removal thickness would be less than 2 feet where soft sediments are not as thick. Dredged sediments would be dewatered, stabilized, and transported off site for disposal in a solid waste facility. Clean sand would be used to cap areas where contamination would remain. Long term monitoring would be required to evaluate the effectiveness of the cap. Range of costs for this option is from approximately $4 million to $6 million dollars, dependant on the volume of sediments being addressed.

The cap could be damaged from ice heaving due to winter freeze up, which could cause underlying contaminants to be exposed.

4.2.3 Complete Removal of Contaminated Sediments with 50% Off-Site Disposal to a Landfill and 50% Land-farming

This option would involve dredging the entire thickness of contaminated soft sediments. Dredged sediments would be dewatered and stabilized. Sediments with lead concentrations greater than 50 mg/kg would be transported off site for disposal in a solid waste facility. Sediments with lead concentrations less than 50 mg/kg would be transported off site for treatment/disposal via land-farming or phytoremediation. The 50 mg/kg lead limit is based on the requirements of s. NR 718.09 Wis. Adm. Code which prohibits landspreading of materials exceeding ch. NR 720 Wis. Adm. Code residual contaminant levels (RCLs) for metals. Long term monitoring would be required to evaluate the effectiveness of the treatment. Range of costs for this option is from approximately $3 million to $5 million dollars, dependant on the volume of sediments being addressed.

4.2.4 Complete Removal of Contaminated Sediments with Off-Site Disposal to a Landfill

This option would involve dredging the entire thickness of contaminated soft sediments. Dredged sediments would be dewatered and stabilized. Sediments would be transported off site for disposal in a solid waste facility. Range of costs for this option is from approximately $3 million to $6 million dollars, dependant on the volume of sediments being addressed.

4.2.5 Complete Removal of Contaminated Sediments with On-Site Treatment via Segregation

This option would involve dredging the entire thickness of contaminated soft sediments. Dredged sediments would be processed to segregate the highly contaminated fine-grained soils from the less contaminated coarse-grained soils. The highly contaminated fine-grained soils would be transported off site for disposal in a solid waste facility. The less contaminated coarse-grained soils would be transported off site for beneficial reuse (assuming a location could be identified). Range of costs for this option is from approximately $3 million to $6 million dollars, dependant on the volume of sediments being addressed.

4.2.6 Complete Removal of Contaminated Sediments with On-Site Treatment via Segregation & Soil Washing

This option would involve dredging the entire thickness of contaminated soft sediments. Dredged sediments would be processed to segregate the highly contaminated fine-grained soils from the less contaminated coarse-grained soils. The highly contaminated fine-grained soils would be further treated with surfactants and/or oxidizing agents to remove and/or destroy organic contaminants. The treated fines and less contaminated coarse-grained soils would be transported off site for beneficial reuse (assuming a location could be identified). Range of costs for this option is from approximately $5 million to $10 million dollars, dependant on the volume of sediments being addressed.

4.2.7 Selection of Remedial Action Options for Detailed Analysis

SEH and WDNR met to discuss each of the options. Each option was conceptually evaluated for technical effectiveness and economic feasibility. Sediment capping was not retained because of the potential for damage from ice heaving and shallow water nature of the inlet. Dredging with segregation and soil washing was not retained because it appeared to be much more expensive than the other options. It was decided to proceed with detailed analysis of the options presented in the next section to meet cleanup goals based on chronic protection criteria.

Chronic protection goals were selected because Hog Island Inlet is part of the "nearshore zone area" of Lake Superior that serves important functions in maintaining the biodiversity of the Lake system. Nearshore areas like Hog Island Inlet represent only 5% of the total area of Lake Superior. Remediation goals based on chronic protection of ecological receptors should also meet sediment quality needs for future recreational use of the site by the public.

5.0 Interim Remedial Action Options

Following the review of preliminary options, the WDNR selected three remedial action options potentially feasible to meet the remedial action objectives. The options below presented include various orders of complexity, site disturbance, and economic impact:

- Option 1 – No Action/Monitoring/Institutional Controls;
- Option 2 – Removal of Contaminated Sediment to Chronic Sediment Quality Targets with Off Site Treatment and/or Landfill Disposal; and
- Option 3 – In-situ Electrochemical Treatment of Contaminated Sediment to Chronic Sediment Quality Targets.

This section presents a summary of various assumptions necessary to create the options and then provides a description of each option. Figure 4, "Conceptual Sediment Remediation Options Flow Diagram" also presents each option from a process perspective.

Remedial action options are evaluated according to the technical and economic feasibility criteria outlined in s. NR 722.07(4) Wis. Adm. Code.

The technical feasibility of an option is evaluated according to the following criteria:

- Long-term effectiveness
- Short-term effectiveness
- Implementability
- Restoration Time Frame

The economic feasibility of an option is evaluated according to the following criteria:

- Costs (Initial Capital Costs, Annual OMM Costs, and 10 year Present Worth)

5.1 Option 1 – No Action, Monitoring, Institutional Controls

Option 1 would be directed at minimizing human contact with contaminated sediment and surface water within the Newton Creek Segment L and Hog Island Inlet. Warning signs cautioning the general public of the apparent risks associated with the sediments would be posted along the shoreline.

Ongoing, long-term monitoring would be conducted to evaluate potential changes in contamination levels. Surface water and sediment sampling would be conducted on a annual basis and an annual report would be submitted to the WDNR with an evaluation of the results and recommendations for future actions and/or a change in the monitoring program, if necessary.

5.1.1 Long-Term Effectiveness – Option 1

This option would have no affect on the reduction of toxicity, mobility, or volume of the contamination. Long-term human health impacts from exposure to the contaminants would be reduced if the public heeded the sign warnings. This likelihood is uncertain.

Long-term ecological risks would not be reduced.

5.1.2 Short-Term Effectiveness – Option 1

Implementation of this option would result in only limited disturbance and exposure to contamination during sampling events.

5.1.3 Implementability – Option 1

This option would not satisfy the State of Wisconsin's regulatory requirements for protection of human health and the environment, and more specifically protection of surface water.

Additionally, it may not be reasonable to assume that posted warnings would limit adolescents from playing in the creek or inlet.

5.1.4 Restoration Time Frame – Option 1

The restoration time frame for this option would be relatively long in comparison to the other options. Monitoring of the sediments has occurred for more than 10 years with very little change in PAH contaminant concentrations noted. It is likely that the restoration timeframe would be several decades and that human and ecological risks would not be abated in a reasonable time frame.

5.1.5 Costs – Option 1

The preliminary projection of capital costs for this option is approximately $29,000 for installation of warning signs and public information meetings. Annual OMM costs are approximately $17,000 and include annual sampling of the sediment and surface water and preparing annual reports. The 5-year present worth cost is approximately $81,000. Cost estimate details are provided in Appendix B.

5.2 Option 2 – Removal of Contaminated Sediment to Chronic Sediment Quality Targets with Off Site Treatment and/or Landfill Disposal

Option 2 would be directed at removal of contaminated sediments with concentrations greater than the chronic sediment quality targets (approximately 50,000 cubic yards). This would minimize current and future exposures.

Sediments in Newton Creek Segment L and Hog Island Inlet would be removed using common excavation and mechanical dredging equipment.

A temporary facility could be constructed at Lakehead Pier for equipment, sediment dewatering and stabilization, water treatment, and other operations. A silt curtain would be installed at the outlet of the inlet into Lake Superior, as well as along the shore of the wetland isthmus. Contaminated sediment would be dewatered and stabilized prior to off-site disposal. Stabilizing material would likely consist of wood flour or similar materials.

Stabilized sediment with lead concentrations below the ch. NR 720 Wis. Adm. Code RCL of 50 mg/kg would be transported to an off site location for landspreading. Sediment with lead concentrations exceeding the ch. NR 720 Wis. Adm. Code RCL of 50 mg/kg would be transported to a permitted solid waste landfill for disposal.

Residual water from the sediment dewatering would be continuously collected and treated prior to disposal to Lake Superior or the City of Superior sanitary sewer system. Water treatment could include screening, flocculation, settling, and filtration. Carbon adsorption would be used for final polishing prior to discharge.

The dredged area of the inlet would not be backfilled, except for the purposes of stabilizing slopes along the shoreline. Backfill in Segment L and along the inlet shoreline would consist of clean granular or rock material. Figure 5, "Conceptual Hog Island Sediment Removal Cross Section" illustrates the potential removal and restoration. Discussions with WDNR Fishery staff indicate that the post-excavation depths would provide suitable habitat for resident fish.

Additional activities relating to Option 2 include: access road construction, temporary construction controls, staging and stabilization facilities, installation of a temporary water treatment facility, personnel and vehicle/equipment decontamination facilities, and coordination with local utility companies and railroads.

Monitoring of contaminant levels at the landspreading location would occur for approximately two years, or until sufficient contaminant reduction was confirmed pursuant to the provisions of ch. NR 718 Wis. Adm. Code.

Property Access Permission would be required from Enbridge Energy (for access to Lakehead Pier), BNSF Railroad, the City of Superior, and Douglas County. Other property owners in the vicinity of the site would also be contacted to communicate the proposed activities. Figure 6, "Property Ownership" illustrates the various property owners in the vicinity of the site.

Permit requirements could include:

- Environmental Assessment (EA) to meet NEPA requirements
- WDNR Chapter 30 Permit
- Permission from the US Army Corps of Engineers
- WDNR Chapter 283 WPDES permit for discharge of treated water
- WDNR permit for landspreading of contaminated sediments
- WDNR notification form for landfill disposal
- City of Superior Permits for use of Right of Ways and Streets

It is unlikely that an air permit would be required, however this should be confirmed.

5.2.1 Long Term Effectiveness – Option 2, Removal

This option would reduce the mobility and volume of the contamination as well as eliminate the source of exposure. The volume and toxicity of sediments placed in a landfill would not be reduced. After completion of the remedy, human health and environmental exposures would be significantly reduced.

5.2.2 Short-Term Effectiveness – Option 2, Removal

Short-term risks to human health and the environment would be increased during implementation of this remedy due to physical hazards and increased potential for exposure to the contaminants. Engineering controls and safety measures would be utilized to limit the potential for increased exposures for both workers and the community.

5.2.3 Implementability – Option 2, Removal

There are no significant concerns regarding constructability, ease of undertaking further remedial action, or monitoring. There are no known endangered or threatened species present in the proposed project area; however, as identified in Section 1.3.2 above, all wetlands within the project area including those in Hog Island Inlet are part of the Lake Superior Areas of Special Resource Interest (ASNRI) as listed in s. NR 103.04 Wis. Adm. Code. ASNRI are recognized as possessing special ecological, cultural, aesthetic, educational, recreational, or scientific qualities. An updated plant survey of the work area would be conducted by the WDNR as a component of the EA.

5.2.4 Restoration Time Frame – Option 2, Removal

Restoration of the site is focused on the interim remedial action goal of reducing immediate risks to human health and the environment. This option would restore the site within one year.

5.2.5 Costs – Option 2, Removal

The preliminary projection of capital costs for this option is approximately $5,208,000. Annual post remediation monitoring costs are approximately $17,000. The 5-year present worth cost is approximately $5,280,000. Cost estimate details are provided in Appendix B.

5.3 Option 3 – In-situ Electrochemical Treatment of Contaminated Sediment to Chronic Sediment Quality Targets

This option would be directed at treating the sediments in place. Following the placement of electrodes (anodes and cathodes) into the sediments, low voltage electricity would be run through the sediments. The electric current would cause organic contaminants in the sediments to oxidize to carbon dioxide and water. Treatment would occur from one to three years until sediment concentrations meet the chronic sediment quality targets.

A network (approximate 30 foot spacing) of electrodes (anodes and cathodes) would be placed into the sediments at approximate depths of 4 feet into the sediment across the 17 acre inlet, and in the 600 foot length of Newton Creek Segment L. Electrodes would be constructed of either metallic sheet pile material, rods, or other conductive material.

Direct electrical current would be imposed on the sediments via the in-situ electrodes. When the electric current passed through the sediments, the sediments become polarized. The polarized sediments discharge electricity inducing redox reactions, which destroy organics. Appendix C, " Electrochemical Remediation Documentation" provides further details on this innovative technology.

Various humic organic materials in the sediments would be destroyed along with the PAHs. The developer of this process (EPI) has considered this phenomena in their proposal (included in Appendix C). As detailed in their proposal, treatment would occur across the inlet in four phases and should be complete within two years. EPI's proposal in Appendix C outlines the phasing approach.

There is a potential that metals in the sediments could be mobilized and migrate toward the electrodes. Sediment sampling would be required prior to system shutdown to determine if sediment metal concentrations have increased in the vicinity of the electrodes.

Sediments would be sampled periodically to determine the effectiveness of sediment treatment. Sediment would be sampled for select metals, DRO, PAHs, and TEH. Monitoring results would be evaluated to optimize efficiency of the treatment cells and determine when cleanup goals for chronic protection have been achieved.

Property Access Permission would be required from Enbridge Energy (for access to Lakehead Pier), BNSF Railroad, the City of Superior, and Douglas County.

Permit requirements could include:

- Environmental Assessment (EA) to meet NEPA requirements
- WDNR Chapter 30 Permit for installation of electrode structures
- Permission from the US Army Corps of Engineers

It is unlikely that an air permit would be required, however this should be confirmed. Coordination with Fish and Wildlife personnel is recommended to explore potential concerns regarding short term low voltage impacts on fish, and if there is a specific window of time that should be avoided (e.g. spawning season).

5.3.1 Long-Term Effectiveness – Option 3

If successful, this option would reduce the toxicity, mobility, and volume of the contamination as well as eliminating the route of exposure, as contaminants would be destroyed via oxidation. After completion of the remedy, human health and environmental exposures would be significantly reduced.

5.3.2 Short-Term Effectiveness – Option 3

Short-term risks to human health and the environment would not be significantly increased during implementation of this remedy due to the in-situ treatment approach.

Electrical current would be low voltage and should not present a risk to humans. However, the potential short term risks from the low voltage current and/or production of carbon dioxide gases is not well understood at this time.

5.3.3 Implementability – Option 3

There are no known endangered or threatened species present in the proposed project area, however as identified in Section 1.3.2 above, all wetlands within the project area including those in Hog Island Inlet are part of the Lake Superior Areas of Special Resource Interest (ASNRI) as listed in s. NR 103.04 Wis. Adm. Code. ASNRI are recognized as possessing special ecological, cultural, aesthetic, educational, recreational, or scientific qualities. An updated plant survey of the work area would be conducted by the WDNR as a component of the EA.

This technology is not yet considered a proven technology and EPI is not certain the cleanup goals based on chronic criteria can be met. Therefore it is recommended that performance guarantees, bonding, or cost cap insurance be considered a component of this option, if selected. It is uncertain whether or not bonding or cost cap insurance would be available for this application.

5.3.4 Restoration Time Frame – Option 3

Restoration of the site is focused on the interim remedial action goal of reducing immediate risks to human health and the environment. This option, if successful, would restore the site within two years.

5.3.5 Costs – Option 3

The preliminary projection of capital costs for this option is approximately $6,154,000. Annual post remediation monitoring costs are approximately $17,000. The 5-year present worth cost is approximately $6,227,00. Cost estimate details are provided in Appendix B

Costs for this option include an estimate of $290,000 for performance bonding or cost cap insurance to provide protection in the event that the innovative technology would not be effective.

5.4 Comparison of Interim Remedial Action Options

Table 3, "Comparison of Remedial Action Options" summarizes the evaluation of each interim action option and utilizes a numerical scoring system for each evaluation criteria. The scoring system provides a balanced system to give equal weight to the technical and economic criteria described in the previous section. Rating for each criteria category was based upon the previous discussion for each option.

Scoring was based upon each option's relative rating when compared to the other options. A score of 1 to 5 was possible for each criteria. Low scoring indicates the best options in the criteria category.

Overall, Options 2 and 3 received the same score as summarized in Table 3. SEH recommends that the WDNR further consider these two options for implementation at the site. Option 2 is less expensive (by approximately $1 million) but Option 3 would cause less disturbance to the site and would destroy the contaminants insitu.

5.4.1 Long-Term Effectiveness Comparison

Options 1 would not reduce the toxicity, mobility, and volume of the contamination nor eliminate the route of exposure. Option 2 would reduce the mobility of contamination and would eliminate the route of exposure. However sediment contaminants placed in a landfill would not be reduced in volume. Option 3 would destroy the contaminants in place and would thus reduce the toxicity, mobility, and volume of the contamination and would eliminate the route of exposure.

5.4.2 Short-Term Effectiveness Comparison

Short term risks for Option 1 would not increase. Short term risks for Option 3 would not increase significantly because the technology is implemented in situ and would cause little disturbance beyond installation of the probes. Short term risks for Option 2 could increase due to the physical disturbance of the site over a 6 month period, however engineering controls would be utilized to minimize potential releases. Potential releases of suspended contaminants beyond the silt curtains could occur.

5.4.3 Implementability Comparison

Option 3 appears to be easier to implement than Option 2 since there would be much less site work, property disturbance and apparently less permitting requirements. However, since Option 3 is an unproven innovative technology there would be the need to obtain cost cap insurance or performance surety products, which may also limit potential funding opportunities.

5.4.4 Restoration Time Frame Comparison

Option 1 would not restore the site. Both Options 2 and 3 would restore the site in approximately the same time period of 1 to 3 years.

5.4.5 Cost Comparison

Option 1 is the least expensive since very little action would be implemented. Regarding remediation options, Option 2 appears to be less expensive than Option 3, primarily due to performance bonding or cost-cap insurance that would likely be required due to the innovative yet unproven nature of the in situ treatment method.

6.0 Project Schedule

A conceptual schedule for the remedial action is as follows:

Task	Estimated Timeline for Completion
Public Meeting to Present Option	November 2003
WDNR Select Option	December 2003
Complete Remedial Design Report, Submit Permit Applications, and Negotiate Property Access Agreements	February 2004
Complete Remedial Design Contract Documents and Identify Landspreading Location	March 2004
Contract Award to Remediation Contractor	May 2004
Receive Permit Approvals	July 2004
Install Electrochemical Treatment Equipment **or** Commence Dredging	July 2004
Treatment (In situ Electrochemical Oxidation **or** Landspreading of Dredged Sediments) and Quarterly Monitoring	August 2004 – October 2006
Final Acceptance (contingent on results)	December 2006

7.0 Standard of Care

The conclusions and recommendations contained in this report were arrived at in accordance with generally accepted professional engineering practice at this time and location. Other than this, no warranty is implied or intended.

MJB/TJ/JH/ls/KA/KA

TABLES

Tables

Table 1 (Continued)
Review of ARARs and Information to be Considered
Hog Island Inlet Interim Remedial Action

Standard, Requirement, Criteria, or Limitation	Citation	Description	Comments
Fish and Wildlife Coordination Act	FWCA 1964	Requires federal agencies to take into consideration the effect that water related projects would have on fish and wildlife resources; take action to prevent loss or damage to these resources; and provide for the development and improvement of these resources.	Potential action and location specific ARAR.
EXECUTIVE ORDER ON PROTECTION OF WETLANDS	Executive Order 11990	Requires federal agencies to take action to minimize the destruction, loss, or degradation of wetlands and enhance the natural and beneficial values of wetlands.	Potential action and location specific ARAR.
EXECUTIVE ORDER ON PROTECTION OF FLOODPLAINS	Executive Order 11988 40 CFR 6, Appendix A	Requires federal agencies to take action to avoid adversely impacting floodplains, to minimize floodplain destruction, and to preserve the value of floodplains.	Potential action and location specific ARAR.
NATIONAL HISTORICAL PRESERVATION ACT	16 USCA 469a-1 36 CFR 800	Requires any federal construction project or federally approved project to preserve significant scientific, prehistoric, or archeological data.	Potential action and location specific ARAR.
ENDANGERED SPECIES ACT	16 USCA Sections 1531 – 144 59 CFR 17, 81, 222, 225,402, 50-453	Action to conserve endangered species or threatened species	Potential action and location specific ARAR.
EXECUTIVE ORDER ON PROTECTION OF CHILDREN FROM ENVIRONMENTAL HEALTH RISKS AND SAFETY RISKS	Executive Order 13045		Potential action and location specific ARAR

Table 1 (Continued)
Review of ARARs and Information to be Considered
Hog Island Inlet Interim Remedial Action

Standard, Requirement, Criteria, or Limitation	Citation	Description	Comments
Wisconsin City and Village Shoreland-Wetland Protection Program	WAC NR 117	Establishes minimum standards to accomplish State shoreland protection objectives.	Potential action and location specific ARAR.
WISCONSIN ENVIRONMENTAL POLICY ACT	WAC NR 150	Evaluation criteria to ascertain the effects of major projects on the environment.	Potential action and location specific ARAR.
WISCONSIN STATE ENVIRONMENTAL PROTECTION – WATER REGULATION	WAC NR 300-	Provides definitions, submittal requirements, exemptions and other general information relating to projects conducted in waters of the state.	Potential action and location specific ARAR.
Sediment Sampling, Analysis, Monitoring and Disposal	WAC NR 347	Provides definitions, sediment sampling and analysis requirements, disposal criteria and monitoring requirements for dredging projects that are subject to regulation under s. 144.04, 144.43 to 144.47, 144.60 to 144.74, and ch. 147 Wisc. Stats.	Potential action and location specific ARAR for dredging in State waterway.
WISCONSIN STATE ENVIRONMENTAL PROTECTION – AIR POLLUTION CONTROL REGULATIONS	WAC NR 400-	Establishes concentration levels, by chemical, for new sources.	Potential action-specific ARAR for removal, treatment, and disposal of VOC, PAH, metals, contaminated sediments, soil, and groundwater.
WISCONSIN STATE ENVIRONMENTAL PROTECTION – SOLID AND HAZARDOUS WASTE MANAGEMENT	WAC NR 500-	Provides definitions, submittal requirements, exemptions and other general information relating to solid waste facilities that are subject to regulations under s. 289.01 to 289.97 Wis. Stats.	Potential action-specific ARAR.
Beneficial Use of Industrial Products	WAC NR 538	Establishes standards and procedures that allow for the beneficial reuse of non-hazardous industrial by-products.	Potential action-specific ARAR.
WISCONSIN STATE	WAC NR 700-	Establishes standards and procedures that allow	Potential action and location

Table 1 (Continued)
Review of ARARs and Information to be Considered
Hog Island Inlet Interim Remedial Action

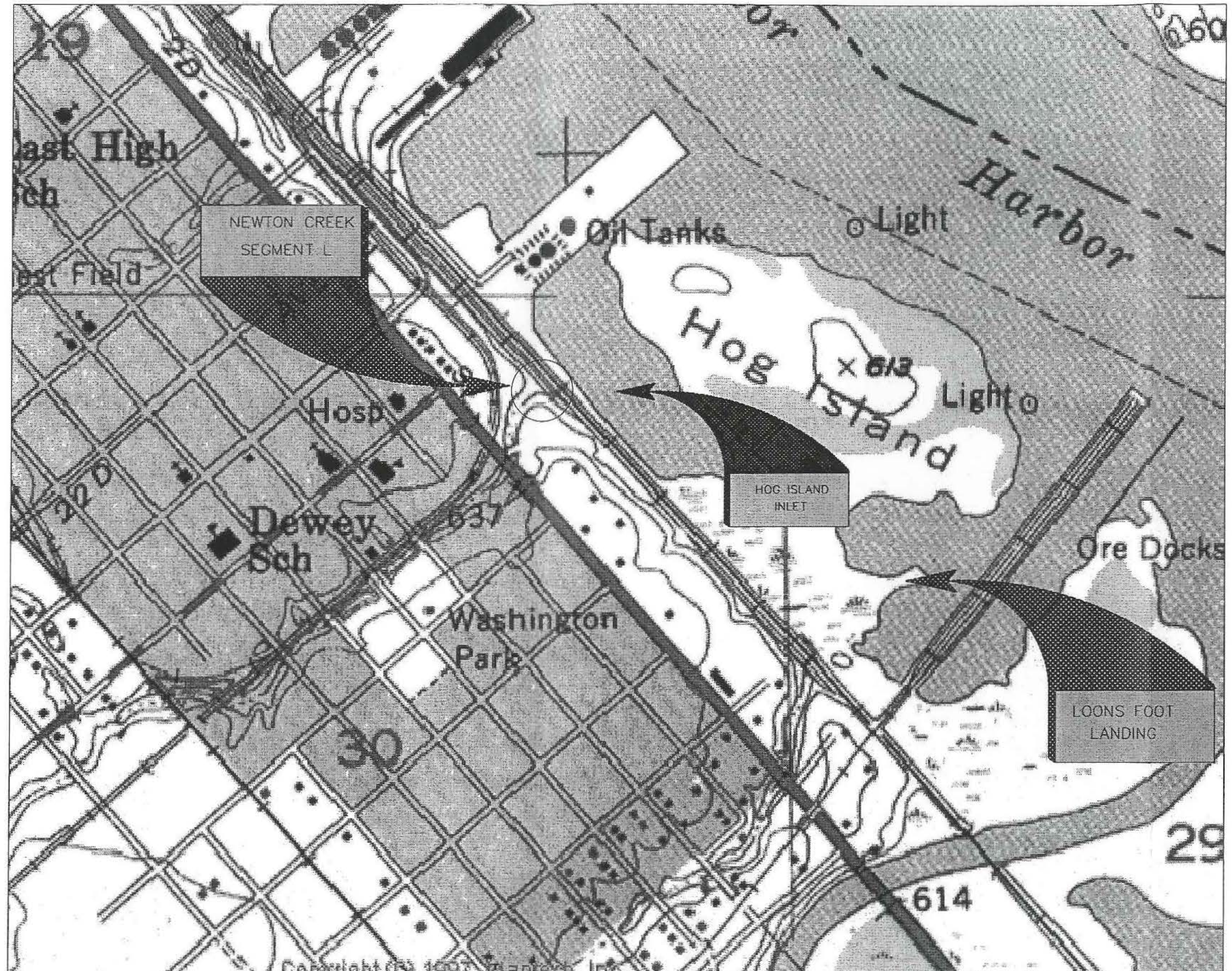
Standard, Requirement, Criteria, or Limitation	Citation	Description	Comments
ENVIRONMENTAL PROTECTION – INVESTIGATION AND REMEDIATION		for site-specific flexibility, pertaining to the identification, investigation, and remediation of sites and facilities which are subject to regulation under s. 292.11, 292.15, 292.31, or 292.41 Wis. Stats.	specific ARAR.
Soil Cleanup Standards	WAC NR 720	Establishes residual contaminant levels based on protection of groundwater and protection of human health from direct contact with contaminated soil.	Potential ARAR for contaminated soils.
Interim Guidance for Soil Cleanup levels for Polycyclic Aromatic Hydrocarbons (PAHs)	WDNR PUBL RR-519-97	Provides interim guidance on suggested soil cleanup levels for PAHs.	Potential ARAR for contaminated soils.
Standards for Selecting Remedial Actions	WAC NR 722	Establishes minimum standards for identifying and evaluating remedial action options and selecting remedial actions.	Potential ARAR.
Navigable Waters, Harbors, and Navigation	Chapter 30 – Wisconsin Statutes	Regulates permits to place structures in navigable waters, diversion of water from lakes and streams, changing stream courses, enlargement and protection of waterways, and removal of material from the beds of navigable lakes and streams.	
Fish and Game	Chapter 29.29(3) – Wisconsin Statutes	Regulates deposit of deleterious substances such as sand or stone into navigable waters.	
CITY REQUIREMENTS			
City of Superior Ordinances		Noise , Zoning, Wetlands, City Streets, Traffic Diversion, and Right of Way Access Ordinances	Potential action-specific ARAR.

FIGURES

Figures

HOG ISLAND INLET
REMEDIAL ACTION OPTIONS REPORT
SUPERIOR, WISCONSIN

COUNTY LOCATION MAP



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REPRODUCED FROM
USGS SUPERIOR QUADRANGLE
WISCONSIN – DOUGLAS CO. 7.5 MINUTE SERIES
1954– PHOTOREVISED 1983

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1	10/10/03	REMEDIAL ACTION OPTIONS REPORT	RJH	10/03	MJB	10/03			MJB	11/03

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HOG ISLAND INLET - SUPERIOR, WISCONSIN
REMEDIAL ACTION OPTIONS REPORT

FIGURE 1
SITE LOCATION MAP

PROJ. NO. WIDNR990502
DATE 10/10/03

1

NO	DATE	ISSUE/REVISIONS	DRAWN BY		DESIGN		FIELD REVIEW		QC CHECK	
1	10/10/03	Remedial Action Options Report	RJH	10/03	MJB	10/03				

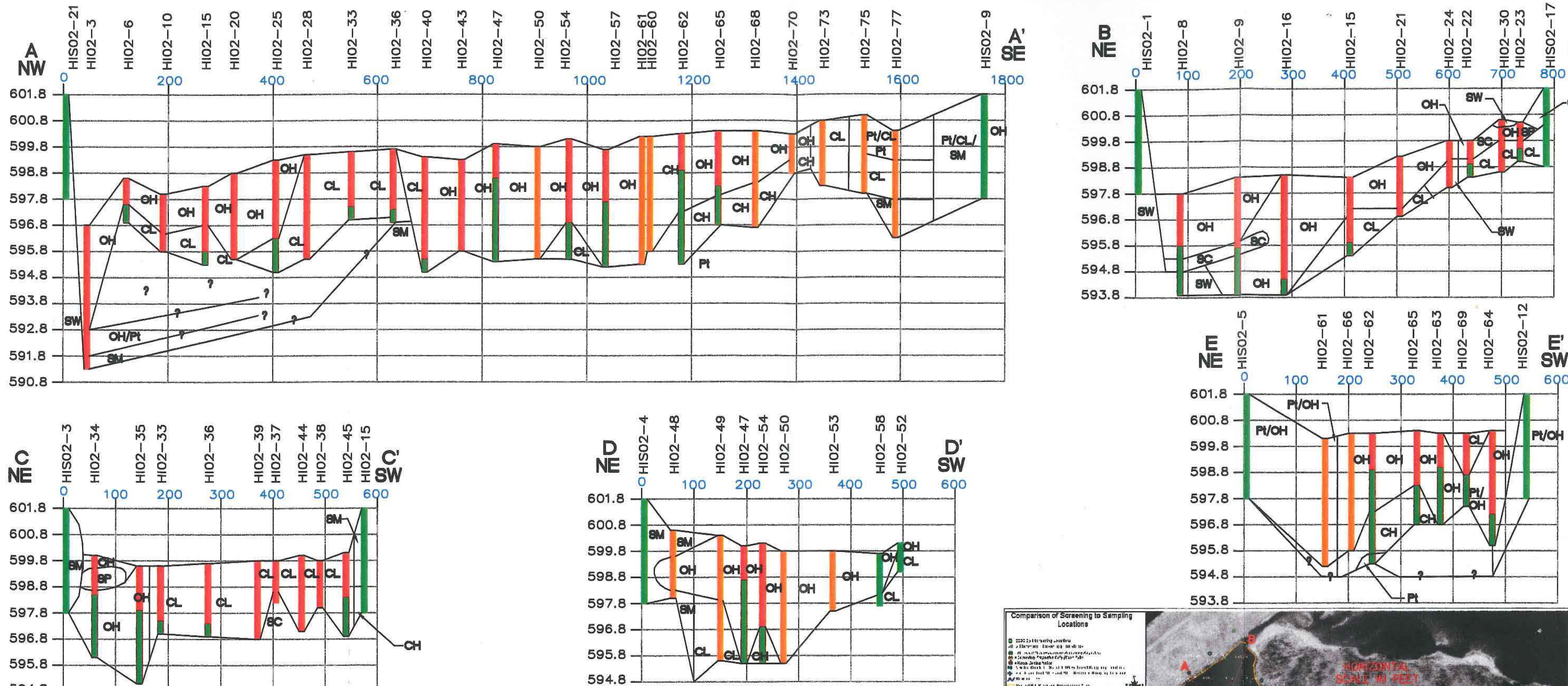
SEH

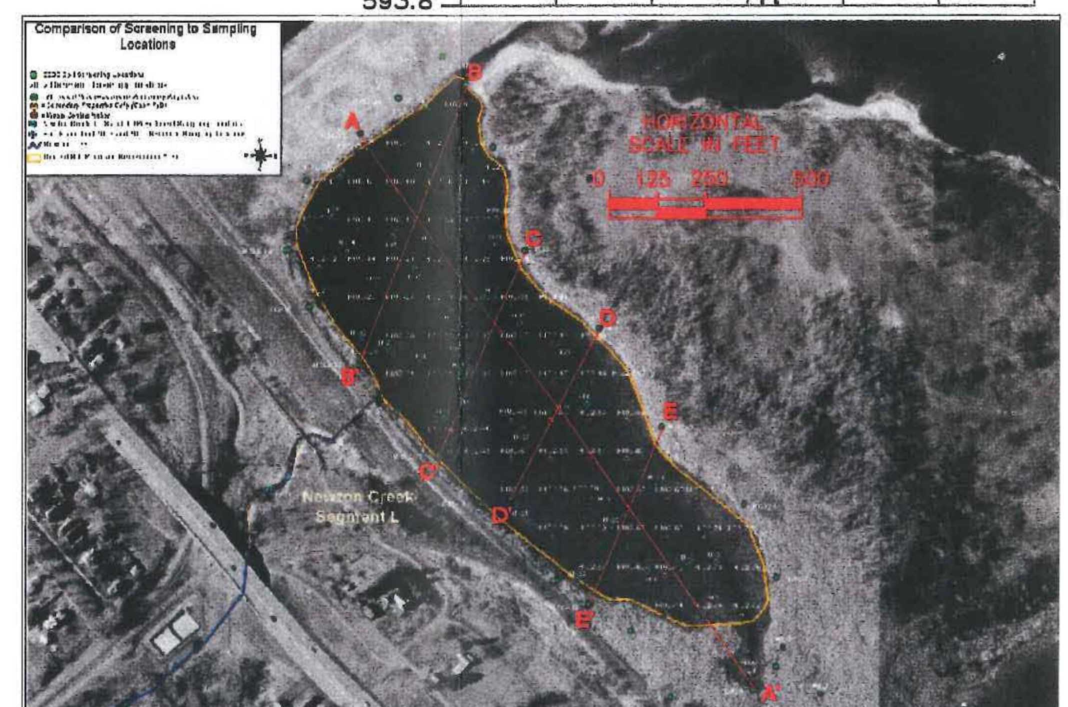
HOG ISLAND INLET - SUPERIOR, WISCONSIN
REMEDIAL ACTION OPTIONS REPORT

FIGURE 2
REMEDIAL ACTION BOUNDARIES

PROJ NO. WIDNR9905.00
10/10/03

2





LEGEND:

- = VISUAL CONTAMINATION (red)
- = SECONDARY PROPERTIES ONLY (ODOR, FID) (orange)
- = NO VISUAL CONTAMINATION OR SECONDARY PROPERTIES (green)

Pt = PEAT
SW = WELL GRADED SANDS
SM = SILTY SANDS
CL = LEAN CLAYS
CH = FAT CLAYS
OH = ORGANIC CLAYS
SC = CLAYEY FINE SANDS
GW = WELL GRADED GRAVELS

HORIZONTAL SCALE IN FEET
0 50 100 200

VERTICAL SCALE IN FEET
0 1 2 4

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1	10/13/03	REMEDIAL ACTION OPTIONS REPORT	RJH	10/03	BAL	10/03			MJB	10/03

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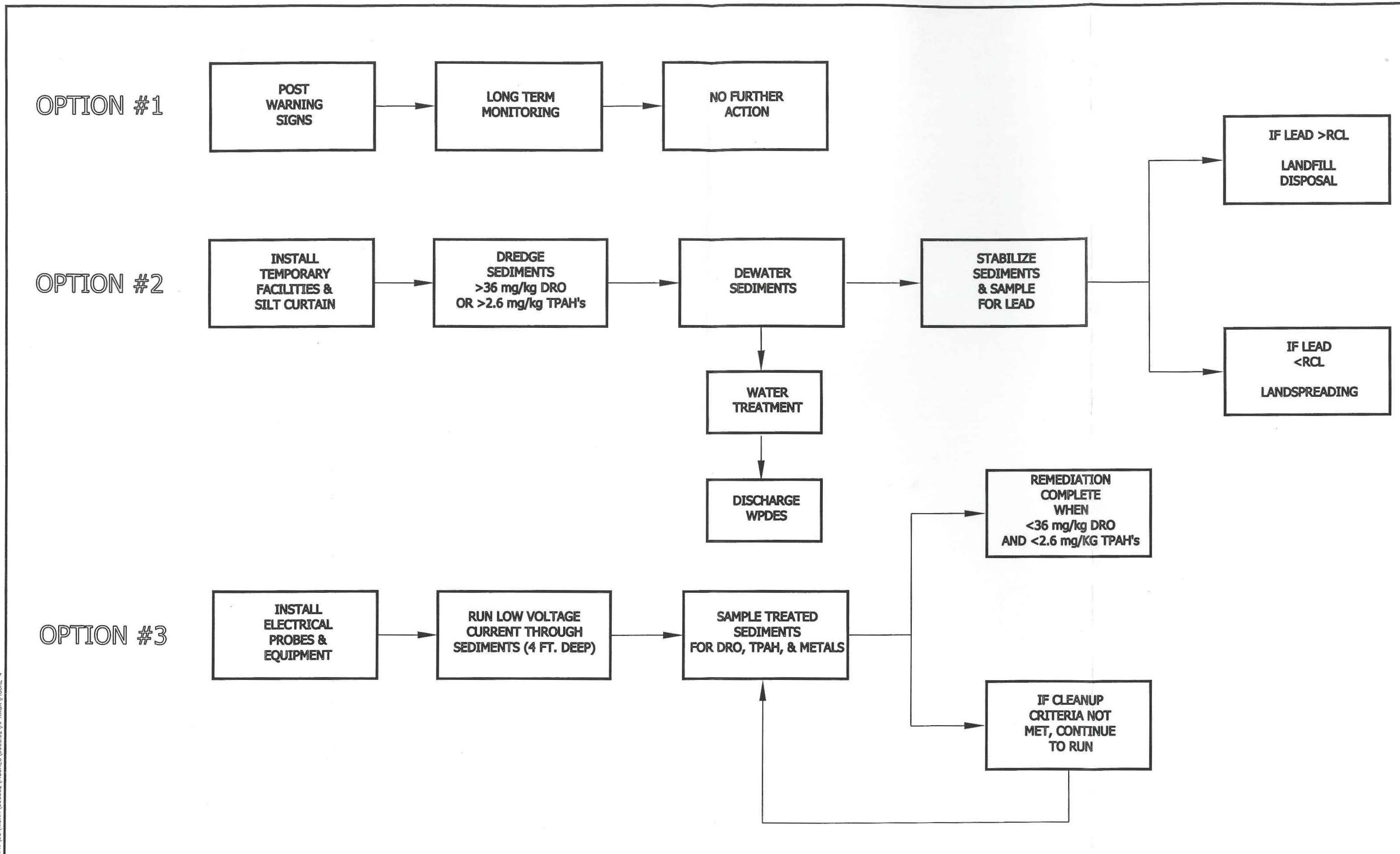
HOG ISLAND INLET - SUPERIOR, WISCONSIN
REMEDIAL ACTION OPTIONS REPORT

FIGURE 3
HOG ISLAND INLET
CONTAMINATED SEDIMENT
CROSS SECTION

PROJ. NO. WDNR9905.02
DATE 10/13/03
3



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1	10/10/03	REMEDIAL ACTION OPTIONS REPORT	RJH	10/03	MJB	10/03			MJB	10/03

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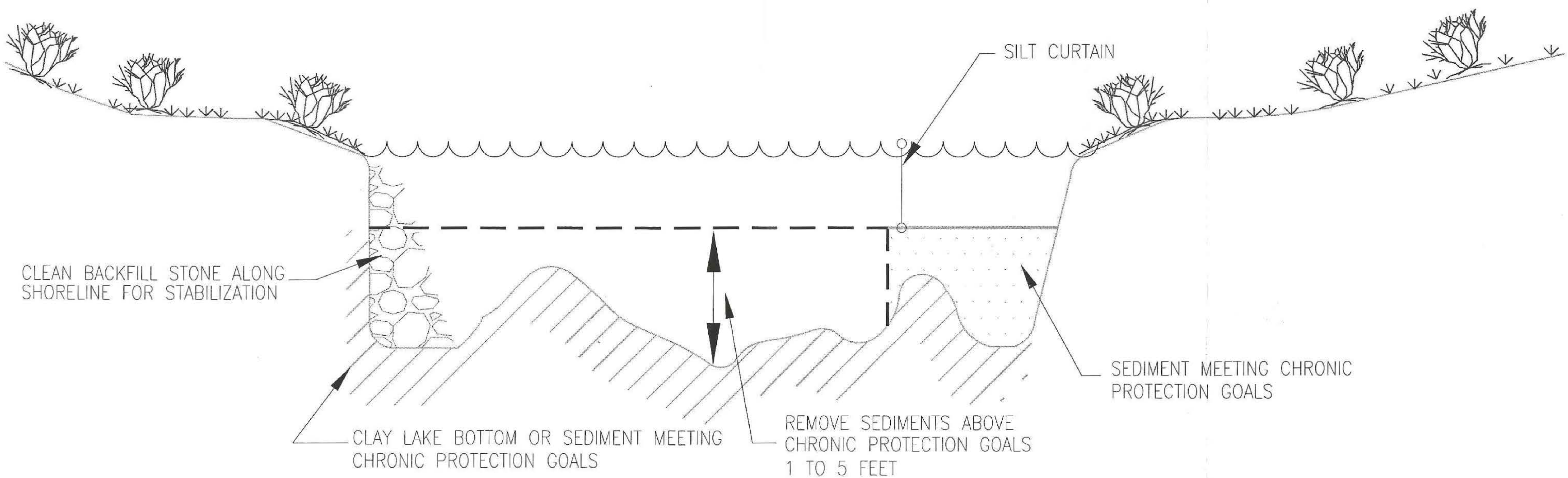
HOG ISLAND INLET - SUPERIOR, WISCONSIN
REMEDIAL ACTION OPTIONS REPORT

FIGURE 4
CONCEPTUAL SEDIMENT REMEDIATION OPTIONS FLOW DIAGRAM

PROJ. NO. WIDNR9905.02
DATE 10/10/03

4



DRAWING FILENAME: FIGURE 5
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1	10/13/03	REMEDIAL ACTION OPTIONS REPORT	RJH	10/03	MJB	10/03			MJB	11/03

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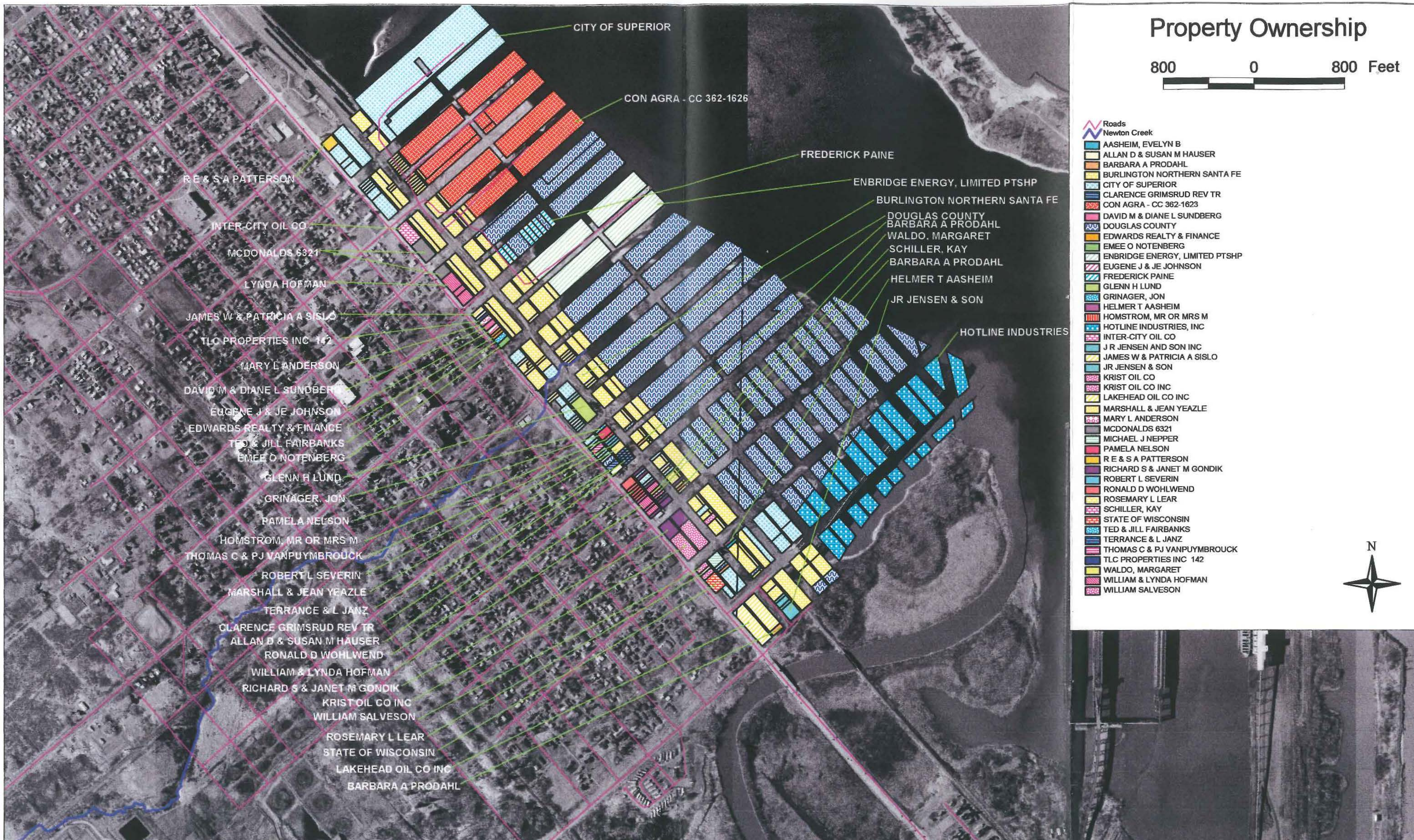
HOG ISLAND INLET - SUPERIOR, WISCONSIN
REMEDIAL ACTION OPTIONS REPORT

FIGURE 5
CONCEPTUAL HOG ISLAND INLET SEDIMENT REMEDIATION CROSS SECTION

PROJ. NO. WIDNR9905.02
DATE 10/13/03

5



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1	10/26/03	Remedial Action Options Report	RJH	10/03	MJB	10/03		

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HOG ISLAND INLET - SUPERIOR, WISCONSIN
REMEDIAL ACTION OPTIONS REPORT

FIGURE 6
PROPERTY OWNERSHIP

PROJ NO. WIDNR9905.02
10/27/03

6

APPENDIX

Appendix A

Design Calculations

Hog Island Inlet
- Estimate of Contaminated Sediments based on Field Observations

Screening sample ID	Approx Water Depth (ft)	Top of Interval Depth (ft)	Bottom of Interval Depth (ft)	Core Thickness (ft)	Visual or Secondary Contam thickness (ft)	Representative of Plan View Surface Area (sft)	Volume of Contam Seds (cy)	Soil Description	Oil or Sheen	FID reading	Odor Description	Comments
Newton Creek Segment L:												
L1sed1	1	1.0	2.5	1.5	1.5	1200	67	gray clayey sand and gravel seds	slight staining	1900	odor	
L2sed1	1	1.0	2.5	1.5	1.5	2400	133	soft brown to black organic silt	some sheening	1000	odor	cat tails
Hog Island Inlet Sediments												
HI02-2	2.2	2.2	7.9	5.7	4	10000	1481	Top 3.0' clean sand, 3.0 to 4.0' silty to clayey sand and gravel, 4.0 to 5.5' soft brown organic clay, underlain by soft reddish-brown clay	sheen at sand and gravel interval	165	odor	sand becomes cleaner near surface
HI02-3	5.0	5.0	10.3	5.3	4	5000	741	Top 4.0' soft brown clay, 4.0-5.1' soft brown organic clay and peat, 5.1-5.3' sand and silt	Stained from 2 to 4'	62	odor to 4.0'	Very soft for top 0.5', clean to 2'
HI02-4	3.0	3.0	5.6	2.6	1.5	5000	278	Top 1.5' soft brown clay with gravel, 1.5-2.5' soft organic clay and peat, underlain by stiff reddish-brown clay	Slight staining near top	103	slight odor	
HI02-5	2.7	2.7	4.4	1.7	1.7	10000	630	Top 0.9' very soft brown lean clay, 0.9-1.0' fibrous peat, 1.0-1.7' stiff reddish-brown clay	none	88	slight odor	
HI02-6	3.2	3.2	4.8	1.6	1	10000	370	Top 1.0 ft. soft brown clay, 1.0-1.2' sand, 1.2-1.6' stiff reddish-brown clay	Top 1.0' stained	9	odor	2" clean soft clay on top
HI02-7	4.2	4.2	10.5	6.3	5.5	10000	2037	Top 5.5' soft brown clay with chunks of wood, underlain by stiff reddish-brown clay	slight staining in upper 5.5' (increases with depth)	771	odor	wood in tip
HI02-8	4.0	4.0	7.9	3.9	3	10000	1111	Top 2.5' soft brown organic clay; 2.5 to 3.0' layers of clayey sand; 3.0 to 3.9' dense sand	slight staining on top of sand layer	9	slight odor in upper 2'	2' sand on top, hard bottom
HI02-9	3.4	3.4	7.8	4.4	3	10000	1111	Top 2.5' soft brown organic clay, 2.5-3.0 brown clayey sand, 3.0-4.4' soft brown organic clay, some wood	slight staining on top of sand layer	141	slight odor	2"sand on top, soft beneath
HI02-10	3.8	3.8	6.0	2.2	1.5	10000	556	Top 1.5' soft brown clay, underlain by stiff reddish-brown clay	staining and sheening near surface	116	odor	sheen on water surface while sampling
HI02-11	2.8	2.8	4.9	2.1	1.6	10000	593	Top 1.6' soft brown clay, underlain by stiff reddish-brown clay	Top 1.6' stained	459	odor	2" clean soft clay on top
HI02-12	2.4	2.4	3.3	0.9	0.9	5000	167	Top 0.5' brown clayey sand with numerous wood chips, 0.5-0.9' stiff reddish-brown clay	none	22	slight odor	
HI02-13	1.2	1.2	2.4	1.2	0.8	5000	148	Top 0.8' dark brown sandy organic clay with numerous wood chips, underlain by stiff reddish-brown clay	none	260	slight odor	in cattails
HI02-14	2.2	2.2	4.0	1.8	1.2	10000	444	Top 1.2' soft brown clay, 1.2-1.5' clayey wood and organics, 1.5-1.8' stiff reddish-brown clay	Top 1.2' stained	40	odor	4" clean soft clay on top
HI02-15	3.4	3.4	6.3	2.9	1.5	10000	556	Top 1.5' soft brown clay with wood chunks, underlain by stiff reddish-brown clay	staining and sheening near surface	1260	odor	Top 2" clean, sheen on water surface during sampling
HI02-16	3.3	3.3	8.0	4.7	4	10000	1481	Top 4.0' soft brown clay underlain by very soft reddish-brown clay	slight staining in upper 4'	28	slight odor in upper 4', increases with depth	
HI02-17	2.6	2.6	6.1	3.5	1	10000	370	Top 4" sand, Soft dark brown lean clay mixed with organics	none	12	very slight to slight odor	odor increases near surface, sand likely clean
HI02-18	2.1	2.1	5.6	3.5	0.7	10000	259	Top 0.2' soft brown clay, 0.2-1.2', gray fine sand, little clay, 1.5-3.9' soft brown organic clay	Slight staining from 0.2 to 0.7'	64	odor	
HI02-19	2.2	2.2	6.5	4.3	4.3	10000	1593	Soft dark brown lean clay, some organics	none	125	slight odor, gets stronger near surface	stiffer at bottom, odor stronger near surface
HI02-20	3.0	3.0	6.3	3.3	3.3	10000	1222	Soft brown clay, wood in tip	stained gray	6	strong odor	stiff on bottom, wood in tip, top 2" clean
HI02-21	2.7	2.7	4.9	2.2	2	10000	741	Top 2.0' soft brown clay with chunks of wood, underlain by stiff reddish-brown clay	staining and sheening, increases near surface	16	odor	2" clean soft clay on top, sheen on water surface during sampling
HI02-22	2.0	2.0	3.3	1.3	0.8	10000	296	Top 0.8' clayey sand and gravel, some organics, underlain by stiff reddish-brown clay	Little staining in top 0.8'	7	odor	thin layer of soft silt/clay on top
HI02-23	1.3	1.3	2.8	1.5	1	5000	185	Top 1.0' organic sand and gravel, 1.0 to 1.5' stiff reddish-brown clay	Top 1.0' stained	11	odor	lots of logs (near shoreline), sheen on water surface during sampling
HI02-24	2.0	2.0	3.8	1.8	1.8	10000	667	Top 1.0' soft brown clay underlain by sand to 1.8' (no recovery of sand)	stained black below 0.2'	52	strong odor	
HI02-25	2.6	2.6	6.7	4.1	3	10000	1111	Top 3.0' soft brown clay underlain by stiff reddish-brown clay	top 3.0' stained, sheen	557	odor	top 3" clean, staining increases with depth
HI02-26	2.4	2.4	6.4	4.0	3	10000	1111	Soft brown lean clay, some organics	none	560	slight odor, gets stronger near surface	
HI02-27	1.9	1.9	5.8	3.9	1.5	5000	278	Top 1.5' brownish-gray fine sand, little clay, 1.5-3.9' soft brown organic clay	none	58	odor	
HI02-28	2.4	2.4	6.2	3.8	3.8	10000	1407	Soft brown lean clay, some organics	slight sheen	22	odor	stiff at bottom
HI02-29	2.4	2.4	5.3	2.9	2.9	10000	1074	Top 1.4' soft brown clay underlain by sand and gravel	stained black	7	odor	bottom is silty sand and gravel
HI02-30	1.2	1.2	3.1	1.9	1.9	10000	704	Top 0.2' brown sand and gravel, soft brown clay from 0.2 to 1.0', underlain by clayey sand	stained gray and black below 0.2'	30	odor	
HI02-31	1.2	1.2	3.2	2.0	2	10000	741	Brown clayey sand, little gravel	stained black	109	odor	
HI02-32	1.8	1.8	3.8	2.0	1	10000	370	Top 6-8" silty underlain by clayey sand and gravel	slight staining	6	slight odor	top silty
HI02-33	2.2	2.2	4.8	2.6	2.6	10000	963	Soft brown lean clay, some organics	staining (dissipates with depth)	41	odor	refusal
HI02-34	1.8	1.8	5.6	3.8	1.2	5000	222	Top 0.2' very soft brown clay, 0.2-1.2' gray fine sand, little clay, 1.2-3.8' soft brown organic clay	Stained from 0.2 to 1.2'	51	odor	
HI02-35	2.2	2.2	7.7	5.5	1.5	10000	556	Top 5.5' soft brown clay	possible staining	95	odor to 1.5'	
HI02-36	2.1	2.1	4.9	2.8	1	10000	370	Soft reddish-brown lean clay, becomes sandy near bottom	possible staining	6	slight odor near top	bottom is stiffer and sandier
HI02-37	2.0	2.0	3.5	1.5	1.5	10000	556	Brown lean clay overlying black clayey sand and gravel	stained black	7	odor	stiff bottom, sand and gravel
HI02-38	2.0	2.0	3.8	1.8	1.8	10000	667	Stiff brown clay, some organics	staining	56	odor	harder bottom
HI02-39	2.0	2.0	4.9	2.9	2.9	10000	1074	Black to reddish-brown soft lean clay, sandier near bottom	bottom stained black, some staining above	160	odor	bottom sandy/silty clay on top of sand
HI02-40	2.4	2.4	6.7	4.3	1	10000	370	Top 4.3' soft brown clay	staining from 0.2 to 1.0'	11	slight odor (increases with depth)	very soft for first 0.2'
HI02-41	1.4	1.4	6.6	5.2	1	5000	185	Top 1.0' soft sandy organic clay, 1.0-5.2' soft brown organic clay	none		odor (stronger near top)	
HI02-42	1.8	1.8	7.1	5.3	0.5	10000	185	Top 5.3' soft brown organic clay	Possible slight staining in top 6"		odor (stronger near top)	
HI02-43	2.4	2.4	6.0	3.6	3.6	10000	1333	Top 3.6' soft brown clay	Stained below 1.5'	10	odor	
HI02-44	1.8	1.8	4.6	2.8	2.8	10000	1037	Soft reddish-brown lean clay	slight staining	19	odor	probable sand at bottom (no recovery)
HI02-45	1.7	1.7	4.9	3.2	1	10000	370	Soft reddish-brown lean clay	slight staining toward top	32	slight odor	refusal (probable wood), sand at bottom
HI02-46	2.3	2.3	5.5	3.2	3.2	10000	1185	Top 3.2' soft brown clay	none	43	odor (increses with depth)	surface very soft, refusal at bottom
HI02-47	1.9	1.9	6.5	4.6	0.5	10000	185	Top 4.6' soft brown organic clay	Possible slight staining in top 6"		odor (stronger near top)	refusal (probable wood)
HI02-48	1.2	1.2	3.8	2.6	1	5000	185	Top 1.0' brown silty sand, 1.0-2.3' soft brown organic clay, 2.3-2.6' dense brown silty sand	none		slight odor	
HI02-49	1.4	1.4	6.8	5.4	2.5	10000	926	Top 2.5' soft brown organic clay, 2.5-5.4' brown lean clay, trace organics	none		slight odor	clayier and less organic with depth
HI02-50	2.0	2.0	6.2	4.2	1	10000	370	Top 4.2' soft brown organic clay	none		odor	very soft (liquidy) for top 2"
HI02-51	2.0	2.0	4.7	2.7	2.7	10000	1000	Top 2.7' soft brown clay	none	28	odor	refusal at bottom
HI02-53	2.0	2.0	4.3	2.3	2	10000	741	Top 2.0' soft brown clay, 2.0-2.3' semi-soft reddish-brown clay	none	35	odor	
HI02-54	1.8	1.8	6.4	4.6	3	10000	1111	Top 3.0' soft brown organic clay, 3.0-4.6' reddish-brown fat clay	Possible slight staining in top 3.0'		odor in top 3.0'	very soft (liquidy) for top 2"
HI02-55	1.2	1.2	5.5	4.3	4.3	5000	796	Top 4.3' brown organic clay	none		odor	very soft (liquidy) for top 2"
HI02-56	1.5	1.5	3.8	2.3	2.3	5000	426	Top 2.0' brown organic clay, 2.0-2.3' brown silty sand	none		odor	
HI02-57	2.1	2.1	6.5	4.4	2	5000	370	Top 4.4' soft brown organic clay	Possible very slight staining		odor (stronger near top)	very soft (liquidy) for top 3"
HI02-59	1.7	1.7	3.7	2.0	2	10000	741	Top 2.0' soft brown clay	none	95	moderate odor	refusal (wood in tip)
HI02-60	1.7	1.7	6.0	4.3	1	10000	370	Top 4.3' soft brown lean to fat clay, trace organics	none		slight odor (stronger near top)	
HI02-61	1.7	1.7	6.5	4.8	1	10000	370	Brown organic clay, some peat near bottom	none		slight odor	
HI02-62	1.5	1.5	6.5	5.0	3	10000	1111	Top 3.0' soft brown organic clay, 3.0-5.0' soft reddish-brown lean to fat clay, peat layer at bottom	Possible very slight staining near top		odor	
HI02-63	1.6	1.6	5.0	3.4	3	10000	1111	Top 3.4' soft brown organic clay	Possible very slight staining near top		odor	
HI02-64	1.4	1.4	5.8	4.4	2.9	5000	537	Top 2.9' soft brown organic clay, 2.9-4.4' brown organic clay and peat, occasional sand seams	Possible very slight staining		odor	refusal (log)
HI02-65	1.4	1.4	5.0	3.6	2.5	10000	926	Top 2.5' soft brown organic clay, 2.5-3.5' reddish-brown fat clay	Possible very slight staining near top		odor in top 2.5'	
HI02-66	1.6	1.6	6.0	4.4	1	10000	370	Brown organic clay, numerous wood chips, occasional sand seams	none		slight odor	
HI02-67	1.0	1.0	4.5	3.5	3.5	5000	648	Alternating layers of silty sand and brown lean clay	none		odor	
HI02-68	1.4	1.4	5.1	3.7	1	10000	370	Top 2.0' brown soft organic clay, 2.0-3.7' soft reddish-brown fat clay	none		slight odor	
HI02-69	1.4	1.4	4.2	2.8	1.5	10000	556	Top 1.5' soft brown lean clay, sand seam at 1.5', 1.5-2.8' brown peat and organic clay	Possible very slight staining in top 1.5'		odor	logs
HI02-70	1.5	1.5	3.0	1.5	1	10000	370	Top 1.0' brown organic clay, 1.0-1.5' reddish-brown fat clay, trace organics	none		odor	refusal (likely wood)
HI02-71	1.2	1.2	5.5	4.3	1	10000	370	Brown organic clay	none		odor	very soft (liquidy) organics over top
HI02-72	0.9	0.9	4.5	3.6	1	5000	185	Brown lean clay, little organics	Possible very slight staining near top		odor	
HI02-73	1.0	1.0	3.5	2.5	1	10000	370	Brown lean to fat clay, little to some organics	none		odor	wood at bottom
HI02-74	1.5	1.5	7.0	5.5	1	5000	185	Brown organic clay, blacker and more organic near top	none		odor	
HI02-75	0.8	0.8	3.8	3.0	1	5000	185	Alternating layers of peat and brown lean clay	none		odor	very soft (liquidy) for top 4"
HI02-76	1.0	1.0	5.5	4.5	1	10000	370	Brown lean clay, little organics	Possible very slight staining near top		odor	
						648600 sft	48367 cy					
						15 acres						

APPENDIX

Appendix B

Cost Estimate Detail

Preliminary Engineer's Cost Projection-Option 1: No Action/Monitoring/Institutional Controls

Capital Costs							
Access Control		$	26,000				
Subtotal:				$	26,000		
Contingency:	10%				2,600		
Subtotal, Initial Capital Costs:						**$**	**28,600**
Long-Term Operations, Maintenance, and Monitoring Costs:							
Monitoring		$	9,040				
Maintenance		$	2,000				
Subtotal:				$	11,040		
Contingency	10%			$	1,104		
Subtotal Annual OM&M Costs:						**$**	**12,144**

Capitalized Costs		
Long Term Operation Period, n (years)		**5 years**
Average Net Interest Rate, i		5%
Present Worth Factor (i, n)		4.329
Annual OM&M Costs:	$	12,144
Present Worth Long Term OM&M Costs		$52,577
Initial Capital Costs:	$	28,600
Capitalized Total Costs:		**$81,177**

Details

Capital Costs

Item	Quantity	Unit	Unit Price	Total Price	
Access Control					
Warning/Caution Signs	60 ea		$ 100.00	$ 6,000.00	
Public Information Meetings	1 ls		$ 20,000.00	$ 20,000.00	
Subtotal, Access Control					$ 26,000.00

Long Term Costs

Item	Quantity	Unit	Unit Cost	Total	
Monitoring					
Annual Sedmiment Sampling - 5 locations	12 hr		$ 70.00	$ 840.00	
Annual Sedmiment Analysis (PAH, metals, DRO, O&G)	5 ea		$ 500.00	$ 2,500.00	
Annual Surface Water Sampling - 4 locations	10 hr		$ 70.00	$ 700.00	
Annual Surface Water Analysis (PAH, metals, DRO, O&G)	4 ea		$ 500.00	$ 2,000.00	
Annual Report	1 ls		$ 3,000.00	$ 3,000.00	
Subtotal Monitoring:					$ 9,040.00
Maintenance					
Maintenance of Signs	1 ls		$ 2,000.00	$ 2,000.00	
Subtotal Maintenance					$ 2,000.00

Preliminary Engineer's Cost Projection-Option 2: Sediment Removal & Disposal via Landfill and Landspreading

Capital Costs							
Site Preparation		$	208,000				
Removal of Contaminated Sediment		$	1,103,196				
Disposal of Contaminated Sediment and Soil Disposal		$	2,350,000				
Restoration		$	284,000				
Subtotal:				$	3,945,196		
Engineering	5%	$	3,945,196	$	197,259.8		
Permits	2%	$	3,945,196	$	78,903.9		
Const Oversite	5%	$	3,945,196	$	197,259.8		
Contingency:	20%	$	3,945,196	$	789,039.2		
Subtotal, Initial Capital Costs:						$	5,207,659
Long-Term Operations, Maintenance, and Monitoring Costs:							
Monitoring		$	13,540				
Maintenance		$	500				
Subtotal:				$	14,040		
Contingency	20%			$	2,808		
Subtotal Annual OM&M Costs:						$	16,848

Capitalized Costs		
Long Term Operation Period, n (years)		5 years
Average Net Interest Rate, i		5%
Present Worth Factor (i, n)		4.329
Annual OM&M Costs:	$	16,848
Present Worth Long Term OM&M Costs		$72,943
Initial Capital Costs:	$	5,207,659
Capitalized Total Costs:		$5,280,602

Details

Capital Costs

Site Preparation

Item	Quantity	Unit		Unit Cost		Total		
Mobilization	1 ls		$	40,000.00	$	40,000.00		
Trailer Office	6 mos		$	500.00	$	3,000.00		
Temporary Fence	2000 lf		$	5.00	$	10,000.00		
Decontamination Facilities	1 ls		$	10,000.00	$	10,000.00		
Water Treatment System	6 mos		$	20,000.00	$	120,000.00		
Clearing	1 ls		$	5,000.00	$	5,000.00		
Temporary Access Road Placement and Removal	1 ls		$	10,000.00	$	10,000.00		
Repair Existing Roads	1 ls		$	10,000.00	$	10,000.00		
Subtotal, Site Preparation							$	208,000.00

Removal of Contaminated Sediment

Item	Quantity	Unit		Unit Cost		Total		
Silt Curtain	1000 lf		$	25.00	$	25,000.00		
Surface Water Monitoring	180 samples		$	100.00	$	18,000.00		
Sediment Analysis	1000 samples		$	50.00	$	50,000.00		
Mechanical Dredging	50000 cy		$	10.00	$	500,000.00		
Sediment Dewatering	50000 cy		$	5.00	$	250,000.00		
Water Treatment	10098 mgal		$	2.00	$	20,196.00		
Sediment Stabilization and Handling	50000 cy		$	2.00	$	100,000.00		
Stabilization Materials	3000 ton		$	30.00	$	90,000.00		
Sediment Transfer to Transport Trucks	50000 cy		$	1.00	$	50,000.00		
Subtotal Removal							$	1,103,196.00

Disposal of Contaminated Sediment and Soil Disposal

Item	Quantity	Unit		Unit Cost		Total		
Laboratory Analysis for Disposal	100 ea		$	100.00	$	10,000.00		
Transport Sediment to Landspreading Location	54000 ton		$	10.00	$	540,000.00		
Landspreading	54000 ton		$	10.00	$	540,000.00		
Transport Sediment to Landfill (80 miles)	36000 ton		$	10.00	$	360,000.00		
Sediment Disposal / Tipping Fees	36000 ton		$	25.00	$	900,000.00		
Subtotal Disposal							$	2,350,000.00

Restoration

Item	Quantity	Unit		Unit Cost		Total		
Backfilling Segment L with Gravel & Streambed Stone	200 tons		$	20.00	$	4,000.00		
Medium Random Riprap to stablize shoreline in inlet	10000 tons		$	20.00	$	200,000.00		
Coir Roll along shore	5000 lf		$	12.00	$	60,000.00		
Regevetation Repair (12 mos)	1 LS		$	20,000.00	$	20,000.00		
Subtotal Stream Restoration							$	284,000.00

Long Term Costs

Item	Quantity	Unit		Unit Cost		Total		
Monitoring								
Annual Sedmiment Sampling - 5 locations	12 hr		$	70.00	$	840.00		
Annual Sedmiment Analysis (PAH, metals, DRO, O&G)	5 ea		$	1,000.00	$	5,000.00		
Annual Surface Water Sampling - 4 locations	10 hr		$	70.00	$	700.00		
Annual Surface Water Analysis (PAH, metals, DRO, O&G)	4 ea		$	1,000.00	$	4,000.00		
Annual Report	1 ls		$	3,000.00	$	3,000.00		
Subtotal Monitoring:							$	13,540.00
Maintenance								
Maintenance of Vegetation	1 ls		$	500.00	$	500.00		
Subtotal Maintenance							$	500.00

Preliminary Engineer's Cost Projection-Option 3: In Situ Sediment ElectroChemical Oxidation

Capital Costs							
Site Preparation		$	112,000				
ElectroChemical Treatment		$	4,677,400				
Subtotal:				$	4,789,400		
Engineering	1%	$	4,789,400	$	47,894.0		
Permits	0.5%	$	4,789,400	$	23,947.0		
Oversite	1%	$	4,789,400	$	47,894.0		
Performance Bonding	6%	$	4,789,400	$	287,364.0		
Contingency:	20%	$	4,789,400	$	957,880.0		
Subtotal, Initial Capital Costs:						**$**	**6,154,379**
Long-Term Operations, Maintenance, and Monitoring Costs:							
Monitoring		$	13,540				
Maintenance		$	500				
Subtotal:				$	14,040		
Contingency	20%			$	2,808		
Subtotal Annual OM&M Costs:						**$**	**16,848**

Capitalized Costs		
Long Term Operation Period, n (years)		**5 years**
Average Net Interest Rate, i		5%
Present Worth Factor (i, n)		4.329
Annual OM&M Costs:	$	16,848
Present Worth Long Term OM&M Costs		$72,943
Initial Capital Costs:	$	6,154,379
Capitalized Total Costs:		**$6,227,322**

Details

Capital Costs

Site Preparation

Item	Quantity	Unit		Unit Cost		Total		
Mobilization	1	ls	$	40,000.00	$	40,000.00		
Trailer Office	24	mos	$	500.00	$	12,000.00		
Temporary Access Road Placement and Removal	1	ls	$	10,000.00	$	10,000.00		
Local Power Upgrade	1	ls	$	50,000.00	$	50,000.00		
Subtotal, Site Preparation							$	112,000.00

ElectroChemical Treatment

Item	Quantity	Unit		Unit Cost		Total		
Silt Curtain	200	lf	$	25.00	$	5,000.00		
Surface Water Monitoring	30	samples	$	100.00	$	3,000.00		
Sediment Analysis	100	samples	$	500.00	$	50,000.00		
ElectroChemical Treatment, 4 ft deep	16	acres	$	288,712.50	$	4,619,400.00		
Subtotal Removal							$	4,677,400.00

Long Term Costs

Item	Quantity	Unit		Unit Cost		Total		
Monitoring								
Annual Sedmiment Sampling - 5 locations	12	hr	$	70.00	$	840.00		
Annual Sedmiment Analysis (PAH, metals, DRO, O&G)	5	ea	$	1,000.00	$	5,000.00		
Annual Surface Water Sampling - 4 locations	10	hr	$	70.00	$	700.00		
Annual Surface Water Analysis (PAH, metals, DRO, O&G)	4	ea	$	1,000.00	$	4,000.00		
Annual Report	1	ls	$	3,000.00	$	3,000.00		
Subtotal Monitoring:							$	13,540.00
Maintenance								
Maintenance of Vegetation	1	ls	$	500.00	$	500.00		
Subtotal Maintenance							$	500.00

APPENDIX

Appendix C

Electrochemical Remediation Documentation

ELECTRO-PETROLEUM, INC.
996 Old Eagle School Road
Suite 1118
Wayne, PA 19087
Telephone (610) 687-9070
Fax (610) 964-8570
www.electropetroleum.com
Kwittle@electropetroleum.com

November 5, 2003

Mr. Mark J. Broses, P. E.
Short Elliott Hendrickson Inc.
421 Frenette Drive
Chippewa Falls, WI 54729
mbroses@sehinc.com

Proposal for the Hog Island Inlet

Dear Mark:

Electro-Petroleum, Inc. (EPI) and electrochemical processes, llc. (ecp) are pleased to propose the following budget proposal for treatment of the Hog Island Site in Wisconsin. This proposal is based on information provided to EPI in the Site Investigation Report, Hog Island Inlet, dated September 2003. The project duration is planned to last no longer than 24 months at a projected cost of $ 4,619,400 to treat the projected 144,720 tons at a cost of $32/ton.

We propose that the site which is approximately 540 meters long with an average width of 156 meters and an average depth of 1.20 meters be divided into four equal sections and each section remediated in turn.

The standard lot would be comprised of about 198 electrodes arranged in 22 rows or 11 pairs of electrodes, each row having 9 electrodes @ 15 m length.

The electrode grid: The spacing (for the time being) is 3m between anodes and anodes, and 3m between cathodes and cathodes. The distance between a pair of electrodes (anode-cathode) is 10 m; the distance between 2 electrode pairs (anode row and the next cathode row) is 3 m.

We would require 99 converters and associated equipment. The electrodes would be driven into the sediment from a barge to a depth of approximately 1 meter.

Each electrode of 15 m length comprises of 8 steel plates, 1 x 1 m, about 5 mm thickness, in total 1,584 sub-electrodes. After 4 months, the treatment would be shifted to the next lot. We calculate to retrieve about 50% of the cables and steel plates in each move. Three moves would be required to complete the project. If the project would be completed all at one time, the cost of the project would increase to more than $6,500,000.

We propose that if the process does not meet the required TPAH level the material could be dredged, heaped and treated exsitu.

As we discussed, the insitu treatment of sediments is a new innovative treatment technology and the use in high Humic Substance containing sediments is being evaluated at the Erie Pier CDF. The results of this test program have not yet been completed at this time.

Note 1.
Clean-Up levels
The clean-up level for TPAH as indicated by the site characterization report of 2 - 3 mg TPAH/kg is low bearing in mind that PAH present themselves as a part of the total humate substances in the sediment and may be considered to be a sub-constituent of HS. Dependent on the mass of HS, we have reached in Vordinborg (Denmark) at 22.3% of HS in the sediments a baseline of 21 mg/kg (TPAH) which seems to be the absolute baseline ("noise") of TPAH. In discussions with Mark Broses, this target is for the 18 PAHs required by Wisconsin.

Note 2.
As far as DRO are concerned, we should advise you that TPH greater than C15 are an intermediate by-product of the decomposition of PAH. The present concentrations are very small and of no major concern. Heavy metals are not required to be remedied. Iron and manganese are no pollutant and are available in concentrations in the range of the natural background of these metals in the soils.

Note 3.
This proposal does not include any analytical costs.

Note 4.
This proposal does not include the cost of cap insurance on the project.

Note 5.

This proposal assumes that the required power will be available in close proximity to the site without undue utility expense.

Open Questions:

Where do we have access to electricity of what maximum out-put - can we place there or next to it a container carrying our 99 converters?

Do we have to consider any special operation window (fishing, tourism, etc)?

Thank you for the opportunity to submit this proposal to your company. We look forward to hearing from you.

Sincerely,

J. Kenneth Wittle, Ph. D.
Vice President
Electro-Petroleum, Inc.

JKW/bw

ELECTROCHEMICAL REMEDIATION TECHNOLOGIES FOR SOIL, SEDIMENT AND GROUND WATER

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ABSTRACT

ElectroChemical Remediation Technologies (ECRTs) are phenomena related to colloid electrochemistry and belong to the class of Direct Current Technologies (DCTs) where DC electricity is passed between two electrodes. The primary distinctions between ECRTs and traditional electrokinetics are the (1) operative mechanisms, (2) energy input, (3) nature of the direct current, and (4) resulting outcome. Employing low-energy, proprietary AC/DC current, ECRTs are patented in the United States and Europe. They generate reduction-oxidation reactions at the pore scale and, through the Induced Complexation (IC) process, mobilize and remove metals in soil, sediments and ground water, and through the ElectroChemical GeoOxidation (ECGO) process, destroy organics in soil and sediments. ECRTs are successful both *in-situ* and *ex-situ*. Among the contaminants remediated to below regulatory standards are VOCs, CVOCs, SVOCs, PAHs, PCBs, phenols, fuels, other hydrocarbons, explosives, mercury, cadmium and lead. In many of the more than 50 successful projects, multiple contaminants have been removed with a single system, including combinations of metals and organics. ECRT projects are documented, ISO 9001-certified and insurable. ECRTs work rapidly, on the order of months, at costs well below excavation and disposal. Site data are presented below.

Technical Basis and Benefits of ECRTs

ECRTs use a proprietary AC/DC current passed through soil between electrode pairs to create an induced polarization field. In this field, soil particles behave as capacitors and discharge electricity many times per second, creating redox reactions that mineralize organic molecules to carbon dioxide and water. Neither pumping nor chemical additives are used in either the ECGO or IC processes. The reaction rates are inversely proportional to grain size, such that ECRTs remediate faster in clays and silts than in sands and gravels.

Metals remediation occurs when the redox reactions create ionic complexes that are much more mobile in soil and ground water than simple metal ions or free metals. These complex ions move to the electrodes under the electric field and are electrochemically plated on. When remediation goals are achieved, the electrodes are removed for metals recycling/disposal.

ECRTs achieve rapid cleanup, on the order of months, require less energy than electrokinetic methods, and cost less than conventional remediation such as excavation. A wide range of contaminants of concern, including metals and organics, may be treated with a single system. ECRTs work *in-situ* or *ex-situ*, in all soil types, generally produce no regulated waste streams, are safe, quiet, and do not interfere with surface activities. The projects are well documented, ISO 9001-certified, and insurable. Two case histories taken from the many successful projects are presented below.

IC Case History (Metals Remediation)

IC removed mercury from sediments in the Union Canal in Scotland. The canal contains brackish water (total dissolved solids = 3,500 mg/l) and is 10 m wide x 1.1 m deep, with a silt bottom containing both elemental and organic mercury from an upstream detonator factory. The area remediated was 220 m^3. Two electrode pairs were placed within the silt at the canal banks; six locations were sampled within the remediation cell and one outside the cell.

The initial mercury concentration within the cell ranged from 33 to 1570 mg/kg, and averaged 243 mg/kg. After 12 days of remediation, the concentration ranged from 9 to 417 mg/kg and averaged 119 mg/kg; after 26 days, the concentration ranged from 0.7 to 11 mg/kg and averaged 6 mg/kg. A total of 76 kg (168 lbs) of mercury was plated on the electrodes during the 26 days of remediation. The cleanup objective was 20 mg/kg. A mass balance calculation showed good agreement between the plated-on mercury and the concentration reduction in the sediments.

ECGO–PAH Case History (Organics Remediation)

In Enns, Austria, 500 tons of silt and fine sand from a former manufactured gas plant site contaminated with poly-aromatic hydrocarbons (PAHs) and their derivatives were piled for *ex-situ* remediation. The pile measured 12 m x 14 m x 3 m high.

Table 1. "Official" Regulator Approved Chemical Analysis Results

Days	1	36	70
Naphthalene	80.7	81.3	17.29
Acenaphtylene	35.2	44.1	0.98
Acenaphthene	9.8	22.2	0.6
Fluorene	38.6	503.1	1.13
Phenanthrene	326.8	83.7	7.35
Anthracene	47.8	11.9	1.45
Fluoranthene	107.5	23.4	2.98
Pyrene	230.2	81	8.38
Benzo(a)anthracene	71.3	17.6	1.48
Chrysen	81.8	17.9	2.04
Benzo(b)fluoranthene	50.7	9.6	2.09
Benzo(k)fluoranthene	47.3	4.2	1.21
Benzo(a)pyrene	110.3	17.9	3.75
Indeno(123-cd)pyrene	47.8	26.2	1.09
Dibenz(ah)anthracene	9.5	25.6	2.98
Benzo(ghi)perylen	59.5	37.9	0.54
Total PAHs (1-16)	1354.8	1007.6	55.33

Note: All concentrations are in milligrams per kilogram (mg/kg)

Soil sampling by the local regulators showed a maximum concentration of US-EPA 1-16 PAHs (Method 8270) at approximately 11,000 mg/kg. The average PAH concentration from a separate, composite soil sample was 1,354 mg/kg.

Two electrode arrays at an average distance of 6.2 m were installed in the pile. Each consisted of three steel pipes, 8 m x 192 mm (OD), laid above each other at 0.5 m, 1 m, and 1.7 m above ground. An irrigation system humidified the pile. Soil samples for chemical analysis were composited from three cores taken from varying depths at eight different locations. The regulator and the technology developer each received a 30-gram aliquot. The regulator used an independent chemical laboratory for analysis in compliance with the German Standard Method DIN 38407, T.8. The results are shown in Table 1. The remediation was completed in 70 days when the "official" chemical analysis indicated that the average total PAHs (1-16) concentration in the pile was 55 mg/kg. The cleanup objective was 100 mg/kg.

The technology developer analyzed the split samples with qualitative gas chromatography-mass spectroscopy (GC-MS), using an internal standard of 1,3-dibromopropane. The results are shown in Figure 1. At 36 days of remediation (Figure 1b), the high-molecular-weight compounds have disappeared and lower weight compounds are forming.

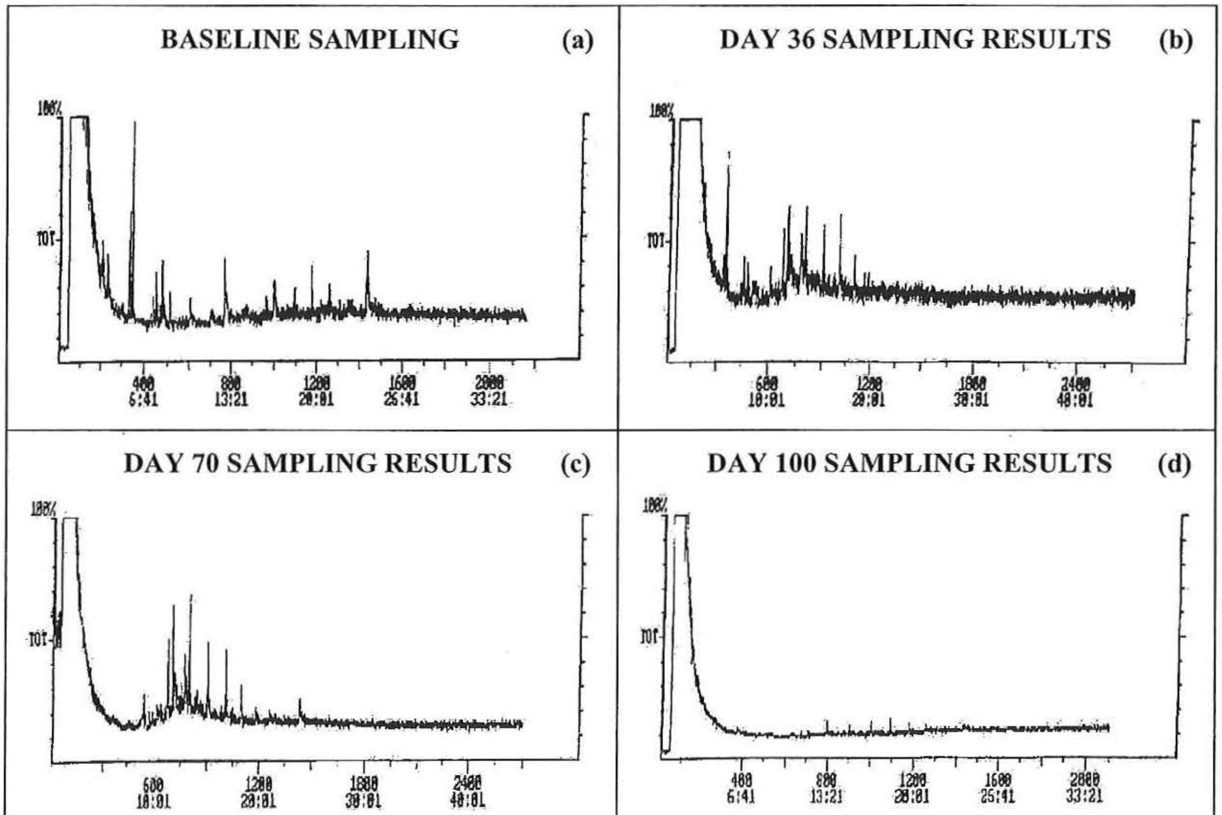

Figure 1. GC-MS Chromatograms for Official Regulator Chemical Analysis Indicate a Total Average PAH (1-16) Concentration of (a) 1354 mg/kg, (b) 1000 mg/kg, (c) 55 mg/kg, and (d) Not Quantified. See Table 1 for "Official" Analysis.

By remediation day 70, the objective of reducing the total average PAH (1-16) concentration to 100 mg/kg was achieved (Table 1). However, the technology developer obtained permission to continue for another 30 days to validate the postulation that ECGO would mineralize the organic contaminants to carbon dioxide and water. Figure 1d presents the GC-MS chromatogram for soil samples collected by the regulator at 100 days of remediation, showing that all compounds were reduced to near detection limits. The PAHs were at or near not-quantifiable concentrations and only organic acids, ketones, and esters were detected.

Conclusion

ECRT redox reactions, induced by electrochemical means, have been shown to be effective for metals remediation with the IC process, and organics remediation with the ECGO process, meeting site cleanup objectives in a matter of months.

Manufactured Gas Plants

ElectroChemical Remediation Technologies

ecp
electrochemical
processes

OVERVIEW

Electro-Petroleum Inc. (EPI) in Wayne, PA, has developed a number of remediation technologies. EPI and the technology developer, Electrochemical Processes, llc. (ecp) in Stuttgart, Germany, have over 20 years experience in the field of environmental R&D and in the successful field application of innovative technology. EPI and ecp are offering a patented electrochemical technology that is innovative, cost-effective, and rapid for treating MGP sites.

ElectroChemical Remediation Technologies (ECRTs) have remediated *in-situ* over two million metric tons of soil sediments and ground water in Europe. Contaminants remediated to below the local clean-up standard are organics and metals. ECRTs are considered the next generation in electrochemical remediation, and its benefits are that it:

1. can destroy organics *in-situ* in the vadose zone and ground water aquifers using the ElectroChemical GeoOxidation (ECGO) process;
2. enhances the mobilization of metals and precipitates them onto the electrodes through the Induced Complexation (IC) process which also utilizes the three major electro-kinetic mechanisms of (a) electro-osmosis, (b) electro-migration and (c) electro-phoresis;
3. typically complete the remediation in less than six months and;
4. general preliminary engineering cost estimates are $100 per cubic yard for volumes in excess of 3,000 cubic yards to $25 per cubic yard for volumes over 100,000 cubic yards.

ECRTs are based on imposing a direct electrical current via *in-situ* electrodes (referred to as a proprietary electrical current) that would take advantage of the electrical capacitance property of the soil particles. When the electrical current described above is passed through the soil, the soil particles become polarized. These polarized soil particles discharge electricity inducing redox reactions, which perform the remediation benefits described above.

The working depth of the technology is only limited by available drilling technology to install the electrodes. A typical field configuration consists of:

1. at least one electrode pair;
2. electrodes placed either vertically or horizontally, at distances of approximately 10 meters and;
3. a source of direct electrical current connected to the electrodes.

No surface treatment system is necessary for soil remediation. Ground water treatment is required for dissolved organics in a coarse-grained aquifer.

TECHNOLOGY MECHANISMS

Field data collected by the technology developer at numerous sites indicate that redox reactions are occurring within the region to be remediated in both the near field and far field relative to the electrodes. The electrochemical reactions are occurring at any and all interfaces in the soil-ground water-contaminant system. The majority of the reactions are believed to take place at the double-layer, which exists on all soil particles.

When the proprietary electrical current is passed through the soil, the soil particles become polarized and induce redox reactions, which decompose organic contaminants and provide enhanced mobilization of metals.

The effectiveness of the technology for different types of contaminants in the vadose zone and ground water is shown in Table 1. The soil particle surface area and the soil-to-water ratio are key parameters in determining the effectiveness of the technology.

FIELD EXPERIENCE

The ECRT process has been applied at over 50 locations in Europe and several in the United States. In addition to the European activity, EPI and ecp have six projects that are ongoing in the United States and Japan: one full-scale remediation project for xylene and chlorinated pesticides and four demonstration

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projects which include (a) PCBs in soil and fresh water sediments, (b) Hg, PAHs and phenols in marine sediments, (c) chlorinated volatile organic compounds in soil and ground water at two sites and (d) PAHs in fresh water sediments.

Table 1. ECRTs Effectiveness

Contaminant	Vadose Zone	Ground Water
Metals	Yes	Yes
Radionuclides	Yes[1]	Yes[1]
Dissolved Organics	Yes	Yes[2]
Free-Phase Organics	Yes	Yes

1 Radionuclides have not been remediated with the ECRTs, however for those radionuclides that are metals, the ECRTs should be applicable.

2 Rate of redox reactions depends on the grain size in the aquifer. As the amount of fine-grained material in the aquifer increases, the technology effectiveness increases.

ECRTs have been applied at sites containing metals and organics such as (1) MTBE, (2) chlorinated volatile hydrocarbons, (3) phenols, (4) TPH, (5) PAHs and (6) derivatives of TNT.

Application to Manufactured Gas Plant (MGP) Sites

ECGO, the ECRTs process that destroys organics, has been successfully applied to eight MGP sites in Europe. A brief synopsis of the eight sites treated and the results follow.

Site 1—Lignite Carbonizing Plant, Deuben, Germany

In one of the most polluted areas of the plant, a pump house (Photo 1), a remediation test using ECGO was conducted in an area 10 m x 20 m.

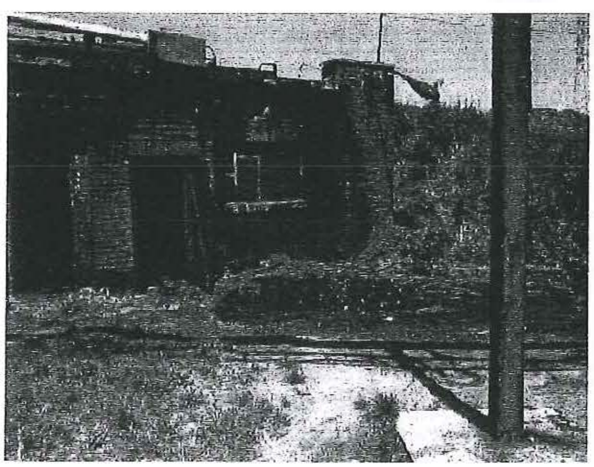

Photo 1. Pump House Site, Deuben, Germany

The principal pollutants at the treatment site were phenols, EOX (halogenated hydrocarbons) and petroleum hydrocarbons. Treatment was conducted to a depth of 28.8 m.

Table 2 shows the chemical results of the cleanup at the start and after 73 days of treatment.

Table 2. Remediation Results (mg/kg), Deuben, Germany

Sample Depth (mbgs[1])	Baseline (Pre-Treatment)			After 73 Days of Treatment		
	Phenols	TPH	EOX	Phenols	TPH	EOX
0-0.6	212.1	243.8	5.7	n.d.	15.3	n.d.
0.6-2.0	330.9	438.6	12.2	n.d.	14.7	n.d.
2.0-4.6	282.7	353.2	16.3	1.55	11.2	n.d.
4.6-6.6	178.7	239.1	15.8	1.06	1.7	n.d.
6.6-10.6	109.6	135.4	23.1	n.d.	23.5	n.d.
10.6-14.2	122.7	n.a.	16.1	n.d.	9.8	n.d.
14.2-18	159.7	n.a.	11.6	n.d.	15.0	0.76
18-23	174.8	n.a.	12.5	n.d.	29.0	1.2
23-23.9	65.1	n.a.	10.2	n.d.	23.8	1.9
23.9-24.8	36.4	n.a.	9.1	n.d.	40.6	5.2
24.8-28.8	35.5	n.a.	12.6	n.d.	n.a.	n.a.

n.a. not analyzed

n.d. not detected

[1] Meters below ground surface

The regulator (Office of Mining in Halle, Germany) has accepted the results of this test and the ECGO process has been recommended to remediate the entire Deuben site.

Site 2—Remediation of Heaped Soil, Austria

Approximately 500 tons of soil polluted by polycyclic aromatic hydrocarbons (PAHs) from a MGP site was treated in Austria. The soil had been excavated and was sieved to remove coarse material. The final pile measured approximately 12 m x 14 m x 3 m. A schematic of the site is shown in Figure 1.

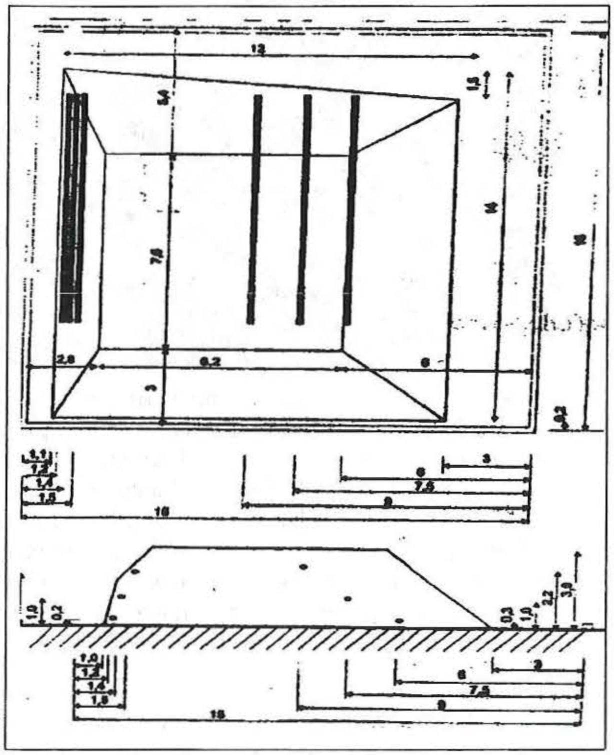

Figure 1. Plan View (top) and Cross Section of the Heap in Austria

This pile was treated for 70 days and total US EPA 1-16 PAHs were reduced from an initial value of 1,355 mg/kg to 55 mg/kg. The regulatory clean up objective for this remediation was 100 mg/kg. The heap was then treated for an additional 30 days until the metabolites of the PAHs had been safely decomposed. The gas chromatogram of soil samples collected 100 days after remediation startup is shown in Figure 2.

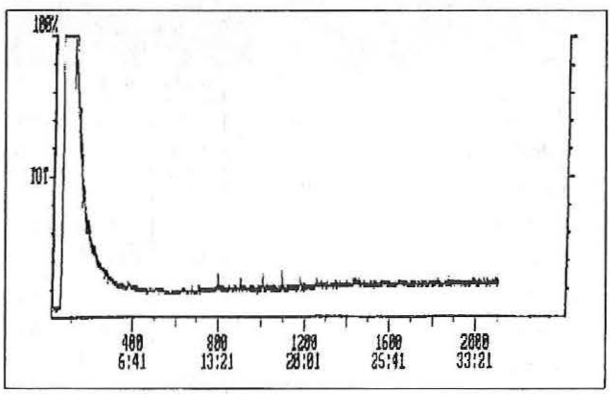

Figure 2. GC-Chromatogram at 100 Days

Sampling and Chemical Analysis

Extensive sampling and analysis was conducted during this remediation. Special geoprobes were used to collect 30 samples at ten different locations in the heap at three depth intervals for compositing prior to analysis. An accredited Austrian Laboratory, who reported the results directly to the regulators (Table 3), performed analyses using gas chromatography-mass spectroscopy (GC-MS), according to quality assurance procedures provided in ISO-9001.

Table 3. "Regulator" Chemical Analysis (mg/kg) for Remediation in Austria

Contaminant	Day 1	Day 36	Day 70
Naphthalene	80.7	81.3	17.29
Acenaphtylene	35.2	44.1	0.98
Acenaphthene	9.8	22.2	0.6
Fluorene	38.6	503.1	1.13
Phenanthrene	326.8	83.7	7.35
Anthracene	47.8	11.9	1.45
Fluoranthene	107.5	23.4	2.98
Pyrene	230.2	81	8.38
Benzo(a)anthracene	71.3	17.6	1.48
Chrysene	81.8	17.9	2.04
Benzo(b)fluoranthene	50.7	9.6	2.09
Benzo(k)fluoranthene	47.3	4.2	1.21
Benzo(a)pyrene	110.3	17.9	3.75
Indeno(123-cd)pyrene	47.8	26.2	1.09
Dibenz(ah)anthracene	9.5	25.6	2.98
Benzo(ghi)perylene	59.5	37.9	0.54
Total USEPA 1-16 PAHs	1,354.8	1007.6	55.33
Carcinogenic PAHs (6)	423.1	119.2	14.1

Site 3—Luxembourg

A volume of approximately 140,000 cubic yards of soil was contaminated with tar from a MGP operated on the site from 1899 to 1965. The site remediation was complicated by the age of the contamination and a number of high-pressure gas pipelines running through the site that required cathodic protection. The cleanup levels for soil were: 16 PAH (EPA): 50 mg/kg, BTEX: 25 mg/kg (benzene: 1 mg/kg), phenols 5 mg/kg, TPH: 1000 mg/kg.

Targeted remediation goals were met at most of the soil sampling locations after 70 days of treatment.

Recontamination became an issue at certain locations within the remediation area. This soil recontamination was found to be due to previously unidentified tar pits, which were located and removed. Additional treatment was necessary for hot spots. Ground water monitoring for Chemical Oxygen Demand (COD) demonstrated substantial reduction of ground water contaminants during treatment (Table 4).

Table 4. Ground Water Chemical Oxygen Demand ($mg\ O_2/L$), Esch, Luxembourg

Well ID	Before Treatment	After Treatment
P1	265	10
P2	>1,000	10
P3	>1,000	10
6	15	22
7	480	12
10	435	10
11	>1,000	n.d.
13	265	10
15	492	10
24	315	34
38	365	10
42	442	10

Site 4—Count Moltke Coal Mine Town, Gas Manufacturing Site, Germany

The coal mine "Count Moltke" represented a special case since the location had been used to generate town gas and a coke production facility that produced chemical by-products such as benzene and phenols. The site was abandoned in 1965, graded and covered with a clay layer. In 1992, the first attempt at site remediation was performed using bioremediation. The process reduced the total PAHs present but did not provide for a reduction in the carcinogenic PAHs, such as benzo(a)pyrene. In addition to soil, the site subsurface typically contained debris as shown in Photo 2.

Photo 2. Debris in the Subsoil at Count Moltke Site

An ECGO test over an area measuring 25m x 30m x 2m was conducted over a 46-week period. The test remediation results for PAHs are shown in Figure 3. Metabolites were analyzed by GC-MS scanning methods; phenols, phenol derivatives and carboxylic acids were detected at non-quantifiable levels; piperidine and pyridine were monitored but not officially reported.

Site 5—Confluence MGP Site, Lyon, France

This former MGP site was located close to a residential area in the center of the city. The site covers 8 m x 8 m x 6 m. A controlled, small-scale ECGO field test was conducted on a section of the contaminated material and the results are presented in Table 5.

The test was judged to be successful after 75 days although it had been planned to continue for 120 days.

Table 5. Remediation Results (mg/kg), Lyon, France

Contaminant	Baseline (Pre-Treatment)	Day 40	Day 75	Percent Decrease
Benzene	0.031	0.025	0.01	67.7
Toluene	2.51	0.46	0.017	99.3
Ethylbenzene	0.01	0.01	0.01	0
p,m Xylene	0.015	0.033	0.01	33.3
o-Xylene	0.023	0.03	0.01	56.5
BTEX	2.58	0.55	0.017	99.3
TPH	380	459	316	16.8
Naphthalene	186	284	11.8	93.7
Acenaphtylene	162	218	8.9	94.5
Acenaphtene	151	70.7	7.9	94.8
Fluorene	315	339	15.5	95.1
Phenanthrene	683	717	27.9	95.9
Anthracene	330	246	11.5	96.5

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Fluoranthene*	706	643	31.5	95.5	Benzo(a)pyrene*	135	82.9	9.3	93.1
Pyrene	417	350	14	96.6	Diben(a,h)anthracene	12	51	5.1	57.5
Benz(a)antrhacene	217	162	11.8	94.6	Benzo(ghi)perylene*	38	23.1	2.8	92.6
Chrysene	186	117	9.7	94.8	Indeno(1,2,3cd)pyrene*	54	35.3	3.7	93.1
Benzo(b)fluoranthene*	106	69.3	4.8	95.5	PAH tot.	3769	3395.7	179.8	95.2
Benzo(k)fluoranthene*	71	38.4	3.6	94.9	PAH carcinogen.	1110	902	55.7	95.0

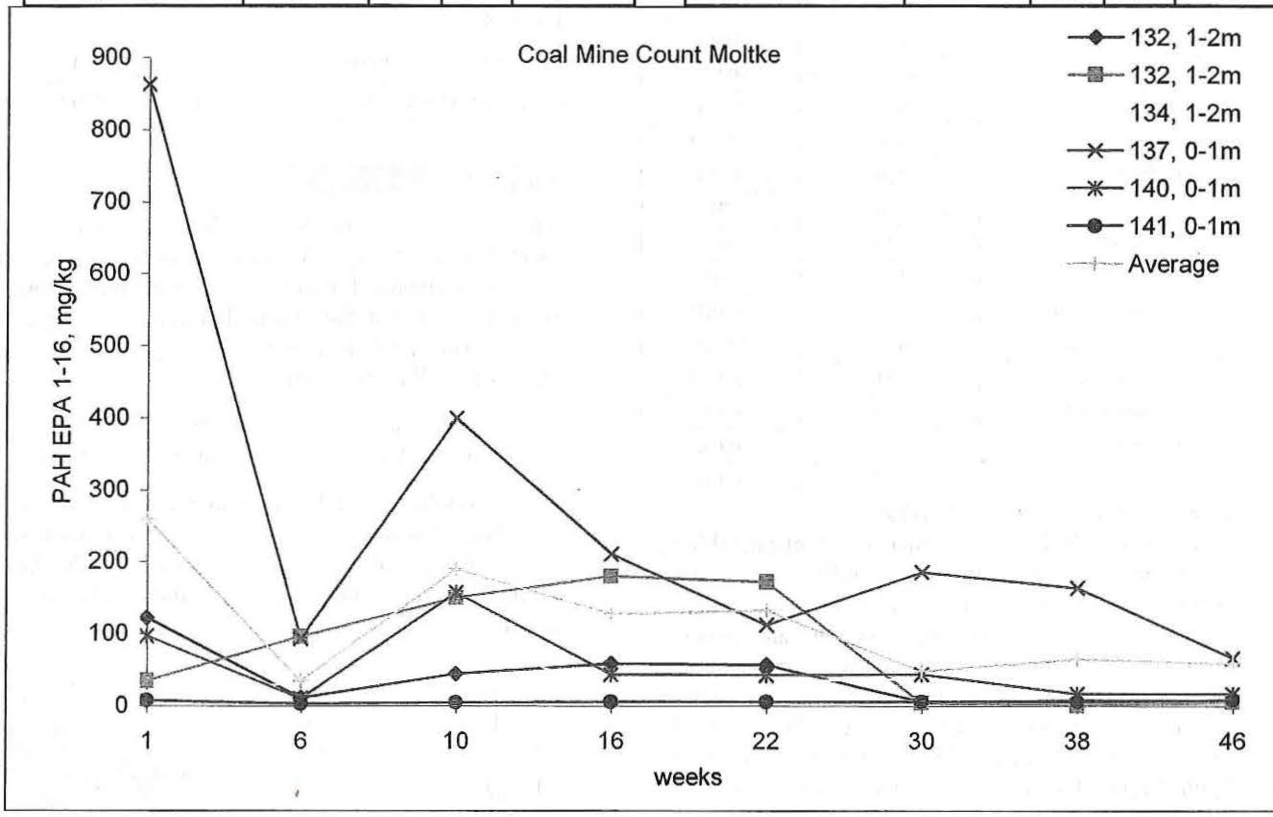

Figure 3. Remediation Trend of Total PAH per Selected Sampling Locations, Count Moltke Site

Site 6—MGP Site of Eberswalse, Greater Berlin, Germany

Approximately 500 tons of soil excavated close to a tar pit contained PAHs making it suitable only for disposal in a hazardous landfill. The ECRT process was selected as a treatment process to remove the hazardous PAHs. The heap, approximately 17 m x 15 m x 1.5 m, was treated for 35 days. Results of this remediation project are provided in Table 6. At the end of the ECGO treatment, the soil was suitable for disposal.

Site 7—MGP City of Westerland, Germany

The town gas site was abandoned three decades prior to remediation. Approximately 1,425 tons of contaminated soils were treated at the site by ECGO. During remediation the site was sold for industrial use and the project was prematurely terminated. Nevertheless, the German clean-up target of 50 mg/kg was reached. Contaminants were reduced from an initial concentration of 338.6 mg/kg.

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Table 6. Remediation Results (mg/kg) from Eberswalde, Germany

Contaminant	Baseline (Pre-Treatment)	After 35 Days of Treatment
Naphthalene	0.48	<0.015
Cenaphtylene	0.36	<0.015
Acenaphtene	n.d.	<0.010
Fluorene	n.d.	<0.010
Phenanthrene	0.56	<0.020
Anthracene	n.d.	<0.010
Fluoranthene	2.30	<0.020
Pyrene	2.30	0.016
Benzo(a)anthracene	1.00	0.008
Chrysene	1.20	0.005
Benzo(b)fluoranthene	0.83	<0.010
Benzo(k)fluoranthene	0.72	<0.010
Benzo(a)pyrene	2.00	<0.010
Dibenzo(a,h)anthracene	0.20	<0.005
Benzo(g,h,i)perylene	1.40	<0.005
Indeno(1,2,3-c,d)pyrene	1.50	<0.010

Site 8. Angermuende, Germany

Sediments in Mills Creek adjacent to an abandoned MGP plant were treated using ECGO in 1998. The creek sediments were contaminated to a depth of two feet by a black substance having an intense, unpleasant odor. The test was conducted for a period of 65 days. The reduction in PAHs shown in Table 7 has been recorded by the City of Angermuende Environmental Office. Prior to the test, an agreed upon target for a 50% reduction in PAHs was established. This goal was met.

Table 7. Remediation Results (mg/kg), Angermuende, Germany

Contaminant	Baseline (before treatment)	After 65 Days of Treatment
Naphthalene	130	1.1
Acenaphtylene	220	1.7
Acenaphthene	110	1.5
Fluorene	290	2.8
Phenanthrene	950	21
Anthracene	390	14
Fluoranthene*	740	54
Pyrene	310	23
Benzo(a)anthracene	230	26
Chrysene	210	18
Benzo(b)fluoranthene*	120	16
Benzo(k)fluoranthene*	75	12
Benzo(a)pyrene*	160	25
Dibenzo(a,h)anthracene	24	3.8
Benzo(g,h.i)perylene*	64	6.8
Indeno(1,2,3-c,d)pyrene*	85	1.2
Σ of PAH (EPA 1-16)	4,111	227.9

FIELD DEPLOYMENT

The electrodes can be installed as either sheet electrodes for sites with shallow contamination, or as tubular electrodes for sites where wells/boreholes are required to reach the contamination. The depth of application of the technology is only limited by the available drilling technology.

Typical electrical direct currents, at safe voltage levels, are applied to electrodes installed at the site

The technology has been deployed successfully in operating gasoline service stations and at industrial sites. A typical deployment scheme is shown in Figure 4, along with before and after soil sampling results.

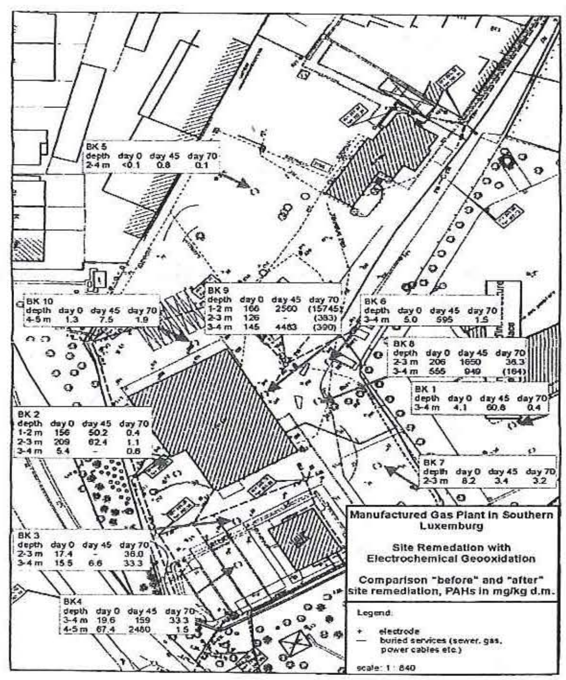

Figure 4. An Illustration of a Possible ECRT

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CLOSING

ECGO has been shown to be an effective remediation technology for MGP sites in Europe, remediating both soil and ground water.

Please contact one of our offices for additional information on remediating MGP sites and visit our web sites for more ECRTs information.

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