SUPPORTING DOCUMENT A

Government Regulations and Criteria Applicable to the Project, Project Objectives and Design Standards

Government Regulations and Criteria Applicable to the Project

A. Federal

Canadian Environmental Assessment Act

This Act requires all projects involving a federal proponent, money, land and specific regulatory approvals to undergo an environmental assessment, through either a screening, comprehensive study or public review by a panel or mediator.

This document is a comprehensive study report, prepared in accordance with the requirements of the Act.

Canada Marine Act

The *Canada Marine Act* provides a system for making Canadian ports competitive, efficient and commercially oriented. The Act establishes port authorities and divests of certain harbours and ports, for the commercialization of the St. Lawrence Seaway, ferry services and other matter related to maritime trade and transport.

Canada Shipping Act

The *Canada Shipping Act* deals with shipping and navigation and amends the *Shipping Conferences Exemption Act*, 1987 and other Acts.

Fisheries Act

The *Fisheries Act* is a piece of legislation which protects fish and fish habitat. The release of a deleterious substance to waters inhabited by fish is prohibited. Where habitat is lost or expected to be lost, Fisheries and Oceans Canada requires appropriate compensation to ensure no net loss of habitat productive capacity before they will issue an authorization under the Act.

Navigable Waters Protection Act

The *Navigable Waters Protection Act* aims to promote safe navigation and environmental protection of navigable waters. This Act requires that authorization be obtained for any marine works that may substantially interfere with the public right to navigation.

Marine Liability Act

The *Marine Liability Act* outlines the liability of ship owners and ship operators in relation to passengers, cargo, pollution and property damage.

Migratory Birds Convention Act

This Act protects migratory birds and their nests and eggs. It is an offence to harm a migratory bird (other than by permit). Harming migratory birds has been interpreted to also include creating any disturbance which prevents or interferes with nesting. The Act is enforced by Environment Canada's Canadian Wildlife Service.

Species at Risk Act

The *Species at Risk Act* (SARA) aims to prevent wildlife species from becoming extinct, and to help species at risk recover. The Act, as well as complementary provincial and territorial legislation as provided for under the Accord for the Protection of Species at Risk, is intended to protect all wildlife species at risk in Canada. SARA provides a framework for actions to ensure the survival of wildlife species and the protection of natural heritage. It sets out how to decide which species are a priority for action and what to do to protect a species. It identifies ways governments, organizations and individuals can work together, and it establishes penalties for a failure to obey the law.

Canadian Environmental Protection Act

The *Canadian Environmental Protection Act* gives the federal government the means to better protect human health and the environment from the risks posed by toxic substances and other pollutants. The *Act* embodies an ecosystem approach by focusing on pollution problems in water, on land and through all layers of the atmosphere. It establishes a comprehensive regime to control toxic substances at each stage of their life cycle from development and manufacture through transport, disturbance, use and storage, to their safe, ultimate disposal as wastes. The *Act* applies to all phases of the project.

B. Provincial

Guidelines for the Protection and Management of Aquatic Sediment Quality in Ontario

These guidelines apply to the sediment in Hamilton Harbour while it is under water. The guidelines give numeric objectives for sediment quality: the "Severe Effect Levels" and the "Lowest Effect Levels". The guidelines also give flexibility to those considering remediation of sediment. A risk assessment or toxicity based approach can be used to develop site specific cleanup criteria.

Ontario Provincial Water Quality Objectives

The *Ontario Provincial Water Quality Objectives* (PWQO) are a set of criteria for fresh water in Ontario. The criteria given are desirable levels for nutrients, physical parameters (such as temperature) and toxic compounds. The guidelines are used to set discharge limits for activities in water and discharges to water. Although they are guidelines, they can be enforced under powers in the *Ontario Water Resources Act*.

Ontario Environmental Protection Act (EPA) and the Waste Management Regulation made under the EPA

The Waste Management Regulation, O. Reg. 347 defines hazardous, industrial and municipal wastes and regulates their generation, handling and disposal. Approvals are required to generate hazardous or industrial waste, to handle, transport and/or dispose of it.

Hazardous waste, under this regulation, can be transported by an approved hazardous waste hauler to an approved hazardous waste facility. It may also be conditioned on site without any approvals under this regulation. Once conditioned, the material will either be an industrial waste or will be de-listed as a waste (meaning it can be re-used). If it is considered an industrial waste, it must be disposed of in a licensed industrial waste facility.

Ontario Environmental Protection Act (EPA) and the General Air Regulation made under the EPA

In Ontario, air emissions are regulated under the Environmental Protection Act (EPA). Ontario Regulation 419/05, the Air Pollution-Local Air Quality Regulation, came into effect on November 30, 2005 and revokes the previous Air Quality Regulation, Regulation 346. Regulation 419/05 was most recently amended on August 31, 2007. This regulation prescribes new and/or updated air standards for 54 contaminants.

Air quality standards serve to protect Ontario communities. Regulation 419/05 prescribes requirements for industrial and commercial sources of air pollution to assess, report to the ministry and manage emissions.

Regulation 419/05 is used in the approval process to assess compliance with air standards. The Ministry of the Environment (MOE), through the Environmental Assessment and Approvals Branch (EAAB), is responsible for reviewing applications to emit a contaminant to the atmosphere under Section 9 of the EPA. The main criteria are demonstrating compliance with Regulation 419/05 under the EPA and MOE's published Sound Level Limits for Stationary Sources (1995). Other regulations and guidelines, such as specific performance requirements for equipment, are also applied as required. Where warranted, applicants are required to demonstrate that the odour impact from their facility will not result in an adverse effect.

During the technical review of the application MOE staff ensure that the proponent has provided a properly prepared proposal supported by technical documentation demonstrating that the emissions to the environment will meet Ministry requirements. The EPA provides for a general prohibition against emitting a contaminant into the environment that causes an adverse effect.

Sound or vibration are considered contaminants that may cause an adverse effect under the EPA. The noise criteria for assessing adverse effects are contained in the Ministry's publication entitled Sound Level Limits for Stationary Sources (1995).

Under the EPA, odour is also considered to be a contaminant that may cause an adverse effect.

Many phases of the project will create air emissions. An air approval will be required if any additional discharge points are created by the process and if the project takes place on land not federally designated.

Ontario Occupational Health and Safety Air Quality Standards

These standards protect worker health by setting limits for the amount of chemical contaminant that workers can be exposed to from air emissions. The standards require that if the limits are exceeded, the employer must either make modifications to the workplace or provide protective equipment.

C. Municipal

Municipal Sewer Use Bylaws

The majority of municipalities in Ontario have implemented sewer use by-laws to regulate indirect discharges to municipal sewer systems and to control inputs coming into the local sewage treatment plants. In the Hamilton Harbour area, both the Cities of Hamilton and Burlington have sewer use by-laws in place. The by-laws include general prohibitions and limit-specific prohibitions to control the quality and, in some cases, the quantity of sewage being discharged to the municipal system.

The by-laws in these municipalities allow for over strength agreements for a number of conventional parameters where the sewage treatment plant has the capacity for treatment of the discharge. The municipality may establish an agreement with the indirect discharger in order to negotiate the amount of material to be treated and to cover the costs for the treatment that is being provided by the municipal sewage treatment plant. These over strength agreements may address one or more of the following parameters: solvent extractable matter of animal or vegetable origin; biochemical oxygen demand; suspended solids; phosphorus; Kjeldahl nitrogen; and phenolic compounds.

Table A.1: Project Objectives Developed by the Project Advisory Group (2002)

1. Project Objective	
a.	Diminish the extent to which highly contaminated PAH's (> 800 ug/g less naphthalene) found within a sediment volume of approximately 20,000 m^3 in the Randle Reef Cleanup Area, can move into the water column or across the bottom of the Harbour, and can therefore constitute a source of continuing contamination within the local ecosystem.
2. Project "Generic" Management Objectives	
a.	Select a preferred alternative that is both cost effective and consistent with the various partners' funding programs, policies and interests.
b.	Satisfy federal/partner tendering processes.
c.	Select a preferred alternative that is technically and scientifically defensible.
d.	Meet all applicable federal, provincial and municipal regulatory requirements.
e.	Ensure compliance with applicable environmental assessment legislation, which includes conducting an appropriate and mutually satisfactory public consultation process.
f.	Fill a gap in the governmental environmental regulatory regime.
g.	Preferred option should have a contingency plan so that, as in the case of a batch removal approach, an alternative plan is implemented without delays.
h.	Meets Hamilton Harbour RAP Goals and Objectives.
3. Performance Objectives	
a.	Ensure that the health and safety of workers are protected during all stages of the project. Ensure that the health and safety of citizens are protected during all stages of the project.
b.	Minimize local and downwind airborne emissions during remediation process.
c.	Ensure safe transportation of hazardous materials through residential areas, if disposal to be located in an out of area site.
d.	Ensure a safe location and minimal environmental effect if the disposal site is to be located within the Harbour area.
e.	Maximize general environmental benefits to the Harbour, e.g., clean up more than one priority site, remediate contaminated sediment zones beyond initial target of <800 ug/g less naphthalene, enhancement of Harbour uses and environment.
f.	Complete a Randle Reef area contaminated sediment management strategy by April 2002 (i.e., PAG workplan).
g.	Initiate remedial actions for PAH/metals-contaminated sediment at Randle Reef, as soon as possible.
h.	Complete remedial measures in a timely manner.
i.	Avoid high risk alternatives that could result in technology failures, cost overruns and protracted implementation schedules.
j.	Long-term benefits must outweigh any short-term impacts.
k.	Realize beneficial uses for the material, including a future marine terminal (essentially replacing Pier 8 which was conveyed to Parks Canada and the City of Hamilton), environmental enhancements, public access, cultural interpretation, etc.
l.	Project recognizes and enhances Port Authority's very significant (approximately $25 million) financial investment in Pier 15.
m.	Limit the dispersal of toxic sediments around the Harbour and threatening human water

	contact uses.
3. Performance Objectives (continued)	
n.	Reduce the impacts of toxic sediments on living organisms in the Harbour.
o.	Prevent contaminated bay water entering the Stelco (now U.S. Steel) water intake and cross media dissemination of contaminants.
p.	Return any areas used for staging and remedial operations to an environmentally safe and useful condition as specified in an implementation agreement,
q.	Engage in funding partnerships including in-kind contributions to the project.
r.	No loss of navigation routes.
s.	The remediation option should allow sufficient access for ships to the Hilton Works dock.
t.	No net loss of fish habitat productive capacity.
u.	Treated water must be suitable for discharge.
v.	Sediment must be acceptable to receiver of sediment.
w.	Permanent solution/long-term sustainability.
x.	Prevent uptake of contaminants to waterfowl.

Table A.2: Objectives and Key Issues – Conceptual Design Study

Objectives and Key Issues – Final, October 4, 2002				
Category	**Objectives**	**"Essential"**	**"Desirable"**	**Key Issues**
Environmental	Containment of majority of sediment contaminated with >800 ppm PAH less naphthalene.	✓		
	Incorporation of contaminated sediments that cause acute toxicity (est. 200 to 800 ppm PAH less naphthalene) into containment structure (from Randle Reef area and other areas around Hamilton Harbour).		✓	Potentially an additional 200,000 to 400,000 m^3 of contaminated sediment (primarily from around Randle Reef area, possibly from Windermere Arm and Ottawa St slip).
	Minimize risk to human health and the environment both during implementation and in the long-term.	✓		Long-term use of land created by containment (e.g., industrial, natural habitat, etc.).
	Minimize risk to worker health and safety, both during implementation and in long-term.	✓		Potential for odour and volatiles.
	Minimize size of containment structure.	✓		
	Area and volume compensation within Hamilton Harbour.		✓	
	Fish habitat compensation within Hamilton Harbour.	✓		More favourable locations for fish habitat compensation elsewhere in Harbour (wetland habitat preferable – compensation ratio to be determined).
	Minimize potential release of contaminants to the environment, both during implementation (e.g., dredging and disturbance) and during long-term.	✓		

Objectives and Key Issues – Final, October 4, 2002				
Category	**Objectives**	**"Essential"**	**"Desirable"**	**Key Issues**
	Long-term security and performance of containment.	✓		Use 100-yr design life. Consider wave and current magnitudes, seismic effects, ship impact, etc.
	Meet all applicable regulatory requirements/permits.	✓		
	Compliance with applicable environmental assessment legislation, including public consultation.	✓		
	Minimize local and downwind airborne emissions.	✓		
	Potential to minimize wave and current activity on sediments.		✓	
	Potential for "green-scaping" of Harbour lands.		✓	Potential for linkage with Sherman Creek remnant.
	Project as a model of integrated approach (remediation, port facilities, environmental benefits, etc.).		✓	
Technical	U.S. Steel cooling water intake and outfall • continued operation, either at present or new location • minimize potential for fish impingement/entrainment (Note: U.S. Steel's use of diversion nets would not be affected by the project).	 ✓ ✓		No flow restriction during implementation or over long-term. Disturbance of sediments • turbidity of raw water • impact on MISA compliance (net loadings more representative than gross loadings) • approach velocities must not be excessive • proximity of marine traffic. Security of intake if at new location (U.S.

Objectives and Key Issues – Final, October 4, 2002				
Category	**Objectives**	**"Essential"**	**"Desirable"**	**Key Issues**
				Steel to maintain control of access). Winter operation and icing. Ease of maintenance. Do not attract fish.
	Ship access to Pier 16 to be reviewed and, if necessary, modified.	✓		
	Minimize impact to U.S. Steel operations, during both implementation and in long-term.	✓		No process interruption, either due to impacts on intake/outfall or shipping traffic.
	Minimize impact to City sewer outfalls.	✓		Birch Ave CSO tank (10,000 m^3) planned to be constructed at Sherman St outfall in next 2 to 3 years.
	Ability to phase construction (i.e., Randle Reef to be addressed as soon as possible).	✓		
	Implementation to commence Fall 2003.	✓		
	Minimize duration of remediation.	✓		To minimize environmental and operational disruption during construction phase of the facility.
	Ability to coordinate with other dredging projects in Hamilton Harbour.		✓	
	Allow for future access of the contained sediment if feasible sediment remediation technology becomes available.		✓	
	Avoidance of high-risk alternatives and	✓		

Objectives and Key Issues – Final, October 4, 2002				
Category	**Objectives**	**"Essential"**	**"Desirable"**	**Key Issues**
	unproven technologies.			
	Accommodate groundwater considerations at adjacent piers.	✓		To prevent migration of contaminants from existing piers to new facility and/or Harbour.
	Ability to monitor long-term performance and implement appropriate control measures, if necessary.	✓		Potential contaminant migration from facility into Harbour.
	Incorporate features to minimize long-term maintenance and facilitate maintenance when necessary.	✓		
Socio-economic	Addition of aesthetic enhancements and naturalized features.		✓	Will new habitat be beneficial (potential uptake of contamination, nuisance species, non-optimum location, etc.)? Aesthetics more important than habitat.
	Minimize impacts to local neighbourhood and residents during implementation.	✓		
	Organization willing to assume ownership of the containment after completion.	✓		Long-term maintenance, monitoring, responsibility and liability, and protection. Long-term land use. Security and liability concerns relating to shore access route to containment.
	No net loss of pier length.	✓		To ensure that wharf alignment and length is sufficient to maximize the cargo handling potential of Pier 15.

Objectives and Key Issues – Final, October 4, 2002				
Category	**Objectives**	**"Essential"**	**"Desirable"**	**Key Issues**
	Minimize disturbance to port activities and loss of navigations routes.	✓		
	Enhancement of port activities.		✓	If possible, should not interfere with potential reconfiguration of Pier15. Potential increase of depth in Sherman Inlet to Great Lakes draught.
	Maximize benefits to local economy.		✓	
Financial	Minimize costs of implementation and long-term maintenance.		✓	
	Maximize potential for partnerships.	✓		Government agencies are not prepared to fully fund this project.
	Synergies with City of Hamilton's Windermere Basin dredging project, and possibly others.		✓	135,000 to 210,000 m^3 of dredged material anticipated.
	Phase project to optimize overall costs.		✓	

Table A.3: Design Standards

Design Parameter	Reference	Design Standard or Requirement
Horizontal datum	(Acres, 2003)	NAD83
Vertical datum	(Acres, 2003)	International Great Lakes Datum, 1985 (Chart Datum=IGLD 1985-74.2 m)
Wind and wave characteristics	(Acres, 2003)	Harbour surge level is 0.5 to 1.0 m; significant wave height is 1.2 to 1.3 m; maximum wave energy direction is northeast, dominant wind direction is west
Basal rock	(Acres, 2003)	Queenston shale approximately 30 m below site
Climate trends for design standard consideration	(Acres, 2003)	Qualitative description- water temperature increase is likely; lower water levels are predicted
Construction windows	Not available	To be determined (TBD)
Construction sequence and duration	Present Study	SUPPORTING DOCUMENT F
Sediment physical and chemical characteristics	Present Study	Basis of Design (BOD) reports
Sediment and upland soil geotechnical	TBD	May 2005 design team soil borings at U.S. Steel, December 2004, 2004 monitoring wells, and July 2003 AMEC monitoring wells
Hydrology characteristics and contaminant mobility issues	Present Study and TBD	Present Study and TBD; hydrology analysis and civil design for 5 year stormwater flows TBD
Short-term water quality monitoring	TBD	TBD
Short-term water quality criteria	TBD	Criteria for TSS, turbidity, dissolved oxygen, temperature, chemical parameters
Site boundary, dredge limits	Acres, 2003 and TBD	Initial boundaries in conceptual design, final design boundaries TBD - Sediment characterized into Priority categories
Dredge sediment design volume	Present Study and TBD	TBD
Dredge configuration	Present Study and TBD	BOD
Minimum practical dredge thickness	Present Study	0.5 m and TBD
Debris management	Present Study	TBD through debris survey
Re-suspension control	Present Study	Current velocities expected to be less than 10 cm/second for the modeled conditions - control structures may be used
NAPL and sheens control	Present Study	TBD - Visible sheens
Air quality criteria	Not available	TBD
Residual contaminant criteria	Not available	TBD for dredge verification program

Design Parameter	Reference	Design Standard or Requirement
Acceptable production range	Present study	100 to 200 m^3/hr (hydraulic); 50 to 100 m^3/hr (mechanical)
Acceptable solids content range	Present study	5% to >10% (hydraulic), in-situ% (mechanical)
Acceptable overdredge/overcap limit	Present study	0.3 m - TBD
Dredge verification program	TBD	Dredge verification program including hydrographic surveys and sampling/analytical testing
Design Life Standard	Acres, 2003	200 years
Low/average/high lake water level, maximum height of contaminated sediment	CHS, www. Charts.gc.ca	Lake level above elevation 0 m Chart datum approximately 95% of the time, average lake level of 0.55 m Chart Datum (74.5 m IGLD 1985), 0.5 used for BOD
Maximum elevation for primary ECF	Acres, 2003	Chart datum = 3.0 m (77.2 m IGLD 1985) - TBD
ECF footprint	AMEC, 2003 and present study	TBD
ECF fill zoning, embankment material	Present study	0.5 m Chart Datum (74.7 m IGLD 1985) elevation of top of contaminated sediment in primary ECF based on lake levels, cap and configuration, Secondary ECF may contain Priority 3 and 4 sediment
Allowable deflection of facility walls	TBD	TBD
Lateral load capacity for ice loading, vessel impact loading (non-facility sides), hard berthing (facility side)	TBD	TBD
Seismic zoning/seismic design	Acres, 2003	Za Zone 1 with horizontal acceleration of 0.04 to 0.08 g at 10% probability in 50 years; Zv Zone 0 with horizontal ground velocity 0.0 to 0.04 m/second at 10% probability in 50 years
Structural steel	Present study	BOD text
ECF volumetric capacity	Present study	Footprint adjusted – see BOD - maximum fill height modified to 0.5 m (74.7 IGLD 1985) for increased capacity
ECF effluent water quality criteria	Present study	BOD text
Maximum factors of safety for slope stability of containment berms and sheet pile wall design	Present study	Allowable factors of safety (F.S.) for long-term/drained conditions for global slope stability will be 1.3 to 1.5 and 1.1. for pseudostatic/seismic. U.S. EPA factors of safety to be considered for risk. Sheetpile wall design by conventional methods

Design Parameter	Reference	Design Standard or Requirement
		would require F.S = 1.5 for material bending, material shear, embedment, and overturning
Long-term engineering monitoring program	Present study	TBD, use of inclinometers along sheetpile wall segments and pore pressure transducers below embankment
Long-term environmental monitoring program	Not available	Addresses installation of monitoring of groundwater wells, cap monitoring and surface water quality monitoring
Elevation of surrounding piers	Acres 2003	76.2 m IGLD 1985
Water service	HPA, 2003	25 cm (10 inch) minimum diameter PVC domestic line, 15 cm (6 inch) diameter PVC fire line
Sanitary sewer	HPA, 2003	300 mm minimum diameter PVC line
Storm sewer	HPA, 2003	Storm water systems remains on-site; catch basins/piping design for 5-year storm
Electrical supply	HPA, 2003	13.8 kV underground service to on-site substation
Lighting service	HPA,2003	Along roadway, 50 mete spacing (250 wall minimum fixtures); dock lighting as required
Gas service	HPA, 2003	150 mm "Yellow jacket", 60 psi maximum operating pressure
Telephone service	HPA, 2003	4,100 mm diameter concrete encased ductbank
Dock loads	HPA, 2003	50 kPa (100 psf) within 12 m (40 ft) of wall (i.e., 0 - 40 ft) 100kPa (2000 psf) beyond 12 m (40 ft) from wall
Dock surface	HPA, 2003	Asphalt or concrete over suitable granular base
Vessel design draught	HPA, 2003	10.7 m below IGLD1985
Channel configuration b/w primary/secondary ECFs	Acres, 2003	Seaway draught and double berth requirements 9 m (300 ft) for double berth, Seaway vessel can have maximum dimensions of 222.5, overall length, 23.2 m extreme breadth, and 7.92 m (25.97 ft) draught
Roads/rail minimum requirement	HPA, 2003	One 10 m wide minimum roadway to site, one rail accessing from HPA's Pier 15 rail siding
Buildings provision	HPA, 2003	75,000 ft^2 minimum warehouse with office, 3 or 4, 45 m (150 ft) diameter domes
Pipeline provision	HPA, 2003	Allow for 250 mm diameter pipeline for liquid project
Dock structure type and layout	Present study	TBD with HPA for specific bulkhead and dock configuration
Port facility timing of use	Present study	TBD with development of design elements
Port facility layout/configuration	Acres, 2003	5 ha of Primary minimum for port, TBD
Steel corrosion protection	Not available	TBD
Port facility landscaping	HPA, 2003	Entrance features and roadway features TBD
Lateral loads (berthing loads)	Not available	TBD
Development standards	Not available	TBD consistent with local codes, consistent with City

Design Parameter	Reference	Design Standard or Requirement
		of Hamilton Official Plan
Adopted building code	Not selected	TBD - Provincial standard code or International Building Code 200 (or later) for structural and civil engineering components, seismic design, etc.
Settling agent criteria	Present study	TBD - BOD
Dewatering infrastructure configuration	Present study	TBD
ECF internal cells configuration for settling effluent clarification	Present study	TBD
Effluent discharge capacity	Present study	TBD
Maximum thickness of ECF cap	Present study	TBD - prevent infiltration - subject to ECF elevation, use and cap
Infiltration controls for ECF cap	Present study	TBD
Accommodate utilities in ECF cap	Present study	TBD
Surface water collection, conveyance and discharge	Present study	TBD
Engineering controls on ECF	Present study	TBD
U.S. Steel - general design standards/requirements	Acres, 2003	Minimum sediment re-suspension, mitigation of fish impingement/entrainment (Note: U.S. Steel's use of diversion nets would not be affected by the project), ice collection/management, no impacts to surface water discharge at West Side Open Cut
U.S. Steel - General hydraulics design standards/requirements	Acres, 2003	TBD - Adequate hydraulic circulation within channel between ECF and U.S. Steel dock pier/Pier 16
U.S. Steel - Accommodate current inflow rate and future flow requirements	Acres, 2003	TBD - current rated capacity of 255,000 U.S. gallons/minute (gal/min), or if modified/relocates sized for 3000,000 U.S. gal/min
U.S. Steel - Accommodate site condition	Acres, 2003	West Side Open Cut located 110 m (364 ft) north of south end of US Steel Pier/Pier 16, WSOC invert elevation 9 m (30 ft) below ground level of pier, historical average flow of 15,000 U.S. gallons/minute and average discharge rate 4,500 U.S. gallons/minute
U.S. Steel - Accommodate agreeable future infrastructure needs	Acres, 2003	TBD - future 210 cm (84 inch) diameter storm sewer at Chainage 20+58

Design Parameter	Reference	Design Standard or Requirement
U.S. Steel - Sediment cap	Palermo et. al, 1996	TBD - use guidance for cap thickness
Modifications to adjacent facilities	Acres, 2003	Sheet pile wall at west end of Pier 15 may need repair
U.S. Steel intakes and outfall modifications	Acres, 2003	Maintain water supply
Sherman channel modifications with respect to sedimentation	Present study	TBD
Local provincial, federal standards/requirements	Present study	BOD – Section 7 - TBD

SUPPORTING DOCUMENT B

Existing Environmental Conditions Information
Fish Community and Habitat Report

Table B.1: Climate Normals – 1971 to 2000 – Hamilton A*, Ontario

Latitude: 43° 10.200' N **Longitude**: 79° 55.800' W **Elevation**: 237.70 m
Climate ID: 6153194 **WMO ID**: 71263 **TC ID**: YHM

*** This station meets WMO standards WMO standards for temperature and precipitation.**

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year	Code*
Temperature:														
Daily Average (°C)	-6	-5.2	-0.3	6.3	12.9	18	20.8	19.8	15.5	9.1	3.3	-2.7	7.6	A
Standard Deviation	2.8	2.7	2.2	1.5	1.9	1.2	1.1	1.2	1.1	1.6	1.6	2.7	0.7	A
Daily Maximum (°C)	-2.2	-1.2	4	11.2	18.5	23.7	26.3	25.1	20.7	13.8	7	0.9	12.3	A
Daily Minimum (°C)	-9.7	-9.1	-4.5	1.2	7.3	12.4	15.1	14.5	10.2	4.4	-0.4	-6.2	2.9	A
Extreme Maximum (°C)	15.6	15.8	25	29.7	32.8	35	**37.4**	36.4	34.4	28.9	24.4	20.7		
Date (yyyy/dd)	1995/14	1997/21	1998/31	1990/25	1962/17	1988/25	**1988/07**	2001/08	1973/03	1971/02	1961/03	1982/03		
Extreme Minimum (°C)	**-28**	-26.7	-22	-12.8	-3.9	1.1	5.6	1.1	-2.2	-7.8	-19.3	-26.8		
Date (yyyy/dd)	**1994/19**	1994/10	1980/02	1972/07	1966/10	1998/06	1961/05	1965/30	1974/23	1965/29	2000/23	1980/25		
Precipitation:														
Rainfall (mm)	29.5	25.7	48.6	69.6	75	83.9	86.5	80.6	82.1	71.6	68.1	43.7	764.8	A
Snowfall (cm)	43.2	35.2	25.8	8.6	0.5	0	0	0	0	0.6	11	36.8	161.8	A
Precipitation (mm)	65.8	55.3	74.8	78	75.6	83.9	86.5	80.6	82.1	72.5	78.6	76.6	910.1	A
Average Snow Depth (cm)	9	9	4	0	0	0	0	0	0	0	1	4	2	A
Median Snow Depth (cm)	8	8	2	0	0	0	0	0	0	0	0	3	2	A
Snow Depth at Month-end (cm)	9	6	1	0	0	0	0	0	0	0	1	6	2	A

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year	Code*
Extreme Daily Rainfall (mm)	39.3	54.1	35.9	45.2	39.9	66.6	**107**	90.8	59.4	91	58.8	56.8		
Date (yyyy/dd)	1995/15	1990/22	1991/27	1996/13	1969/18+	1984/17	**1989/26**	1981/08	1996/07	1995/05	1999/02	1990/29		
Extreme Daily Snowfall (cm)	**43.2**	27.4	28	29.2	11	0	0	0	0	23.6	16.4	35.6		
Date (yyyy/dd)	**1966/22**	1984/28	1999/06	1979/09	1989/07	1960/01+	1960/01+	1960/01+	1960/01+	1962/25	1986/20	1969/23		
Extreme Daily Precipitation (mm)	44.6	54.1	41.4	45.2	39.9	66.6	**107**	90.8	59.4	91	58.8	56.8		
Date (yyyy/dd)	1982/31	1990/22	1985/04	1996/13	1969/18+	1984/17	**1989/26**	1981/08	1996/07	1995/05	1999/02	1990/29		
Extreme Snow Depth (cm)	59	**64**	37	25	3	0	0	0	0	2	17	50		
Date (yyyy/dd)	2001/05	**1978/07**	1993/06	1987/01	1989/07	1970/01+	1970/01+	1970/01+	1970/01+	1989/21	1986/21	2000/31		
Days with Maximum Temperature:														
<= 0 °C	19.4	16.1	8.1	0.77	0	0	0	0	0	0	2.5	12.8	59.8	A
> 0 °C	11.6	12.2	22.9	29.2	31	30	31	31	30	31	27.5	18.2	305.5	A
> 10 °C	0.63	0.67	5.2	15.9	28.9	30	31	31	29.9	23.2	8.1	1.9	206.4	A
> 20 °C	0	0	0.57	2.5	11.4	23.8	30	28.5	16.5	3.7	0.17	0.03	117.1	A
> 30 °C	0	0	0	0	0.4	2	4.3	1.9	0.53	0	0	0	9.1	A
> 35 °C	0	0	0	0	0	0	0.13	0.03	0	0	0	0	0.16	A
Days with Minimum Temperature:														
> 0 °C	1.8	2.1	6	17.9	30.1	30	31	31	29.8	26.5	13	3.9	223.2	A
<= 2 °C	30.4	27.7	28.3	17.5	3.2	0.1	0	0	0.97	9.6	22	29.6	169.5	A
<= 0 °C	29.2	26.2	25	12.1	0.87	0	0	0	0.17	4.5	17	27.1	142.1	A
< -2 °C	26.6	23.2	19.8	6.3	0.03	0	0	0	0.03	1.6	10.6	22.2	110.4	A
< -10 °C	14.5	12.5	5.2	0.23	0	0	0	0	0	0	0.37	7.7	40.5	A
< -20 °C	1.8	1.1	0.1	0	0	0	0	0	0	0	0	0.37	3.4	A

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year	Code*
< - 30 °C	0	0	0	0	0	0	0	0	0	0	0	0	0	A
Days with Rainfall:														
>= 0.2 mm	5.3	5	8.6	11.9	12.2	11.1	10.6	10.4	11.6	12.4	11	7.7	117.7	A
>= 5 mm	2	1.5	3.2	4.4	5.3	5.1	4.2	4	4.5	4.5	4.4	2.8	46	A
>= 10 mm	1.1	0.67	1.6	2.5	2.8	3	3.1	2.5	2.8	2.4	2	1.5	26.1	A
>= 25 mm	0.17	0.1	0.2	0.33	0.2	0.7	0.87	0.83	0.83	0.27	0.4	0.2	5.1	A
Days With Snowfall:														
>= 0.2 cm	15.2	11.4	8.4	2.8	0.1	0	0	0	0	0.37	5.2	12.2	55.7	A
>= 5 cm	2.7	2	1.6	0.53	0.03	0	0	0	0	0.03	0.57	2.5	9.9	A
>= 10 cm	0.93	0.8	0.57	0.17	0.03	0	0	0	0	0	0.13	0.7	3.3	A
>= 25 cm	0.07	0.1	0.03	0.03	0	0	0	0	0	0	0	0.03	0.26	A
Days with Precipitation:														
>= 0.2 mm	17.1	14	14.4	13.5	12.2	11.1	10.6	10.4	11.6	12.5	14.6	15.8	157.7	A
>= 5 mm	4.2	3.2	4.8	5	5.4	5.1	4.2	4	4.5	4.7	4.8	5	54.9	A
>= 10 mm	1.9	1.4	2.2	2.8	2.9	3	3.1	2.5	2.8	2.4	2.3	2.3	29.8	A
>= 25 mm	0.27	0.17	0.43	0.4	0.2	0.7	0.87	0.83	0.83	0.27	0.4	0.33	5.7	A
Days with Snow Depth:														
>= 1 cm	23.6	21.8	13.4	1.7	0.03	0	0	0	0	0.03	3.8	17.3	81.6	A
>= 5 cm	18.4	16	8	0.67	0	0	0	0	0	0	1.8	8.8	53.7	A
>= 10	10.6	10.3	4.1	0.33	0	0	0	0	0	0	0.7	3.7	29.7	A

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year	Code*
>= 20	3.6	3.6	1.4	0.1	0	0	0	0	0	0	0	1.7	10.3	A
Wind:														
Speed (km/h)	21.2	19.3	19.7	19.3	16.3	14.8	13.1	12.4	13.7	16.1	18.5	19.4	17	A
Most Frequent Direction	SW	SW	NE	NE	NE	SW	SW	SW	SW	SW	SW	SW	SW	A
Maximum Hourly Speed	89	85	78	89	70	74	56	50	52	67	**93**	81		
Date (yyyy/dd)	1978/26	1997/27	1998/28	1979/06	1990/10+	1992/17	1977/31+	1983/11	2000/21	1990/18	**1998/11**	1982/28+		
Maximum Gust Speed	**133**	122	126	119	105	102	106	96	80	96	115	109		
Date (yyyy/dd)	**1978/26**	1997/27	1973/15	1979/06	1973/16	1992/17	1989/26	1990/27	1990/14	1983/13	1998/11	1982/28		
Direction of Maximum Gust	S	SW	SW	W	SW	W	W	W	SW	SW	SW	SW	S	
Days with Winds >= 52 km/hr	5.3	3.1	4.3	3.4	2.2	1.4	0.8	0.7	1.1	2.4	3.9	4.6		A
Days with Winds >= 63 km/hr	2	1	1.3	1.2	1	0.6	0.4	0.4	0.3	1	1.4	1.6		A
Degree Days:														
Above 24 °C	0	0	0	0	0.1	1.6	6.8	2.8	1	0	0	0	12.3	A
Above 18 °C	0	0	0	1.1	12.2	46	93.5	73.2	22.7	0.9	0	0	249.6	A
Above 15 °C	0	0	0.4	3.8	33.7	104.5	179	152.1	58.7	5.5	0.1	0.1	537.8	A
Above 10 °C	0.1	0	3.6	19.8	111.6	241.4	333.4	304.7	169.6	42.9	5.7	0.7	1233.3	A
Above 5 °C	1.7	1.1	18.2	76.4	246.2	390.9	488.4	459.7	314.6	137.9	35.7	5.8	2176.6	A
Above 0 °C	14.2	16	64.5	193.8	400.5	540.9	643.4	614.7	464.6	283.4	117.2	30.6	3383.7	A
Below 0 °C	199.1	161.7	73.4	6.1	0	0	0	0	0	0.2	18.3	112.8	571.5	A
Below 5 °C	341.6	288.1	182.1	38.7	0.8	0	0	0	0.1	9.6	86.7	243.1	1190.7	A
Below 10 °C	494.9	428.4	322.6	132.1	21.1	0.5	0	0	5	69.6	206.7	392.9	2073.8	A
Below 15 °C	649.9	569.7	474.3	266.1	98.2	13.6	0.5	2.4	44.2	187.3	351.1	547.3	3204.6	A

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year	Code*
Below 18 °C	742.9	654.5	567	353.4	169.7	45.1	8.1	16.5	98.1	275.7	441.1	640.2	4012.2	A
Humidex:														
Extreme Humidex	16.9	16.5	27.7	33.4	39	43.7	**49.1**	47.2	40.6	34	25.1	24.5		
Date (yyyy/dd)	1995/14	1997/21	1998/30	1990/25	1987/30	1981/15	**1995/14**	1988/02	1973/02	1971/02	1974/01	1982/03		
Wind Chill:														
Extreme Wind Chill	**-43**	-37	-30.7	-22.5	-8	-1.6	4.1	-0.1	-4.6	-10.9	-21.1	-33.9		
Date (yyyy/dd)	**1994/19**	1976/02	1989/07	1972/07	1978/01	1998/04	2001/02	1982/29	1974/23	1976/27	1976/30	1980/25		
Humidity:														
Average Relative Humidity - 0600LST (%)	82.9	82.7	82.7	82	82.3	85.7	88.7	92.2	92.2	89.7	86.2	85.7		A
Average Relative Humidity - 1500LST (%)	75	71.9	67.1	58.9	56.5	57.3	57.3	60.6	62.3	65.4	73.4	77	65.2	A

Normals for some elements are derived from less than 30 years of record. The minimum number of years used are indicated by a "code" defined as:

- "A": No more than 3 consecutive or 5 total missing years between 1971 to 2000;
- "B": At least 25 years of record between 1971 and 2000;
- "C": At least 20 years of record between 1971 and 2000; and
- "D": At least 15 years of record between 1971 and 2000.

A "+" beside an extreme date indicates that this date is the first occurrence of the extreme value. Values and dates in bold indicate all-time extremes for the location.

Note: Data used in the calculation of these Normals may be subject to further quality assurance checks. This may result in minor changes to some values presented in this table.

Figure B.1: Primary ECF Section A-A

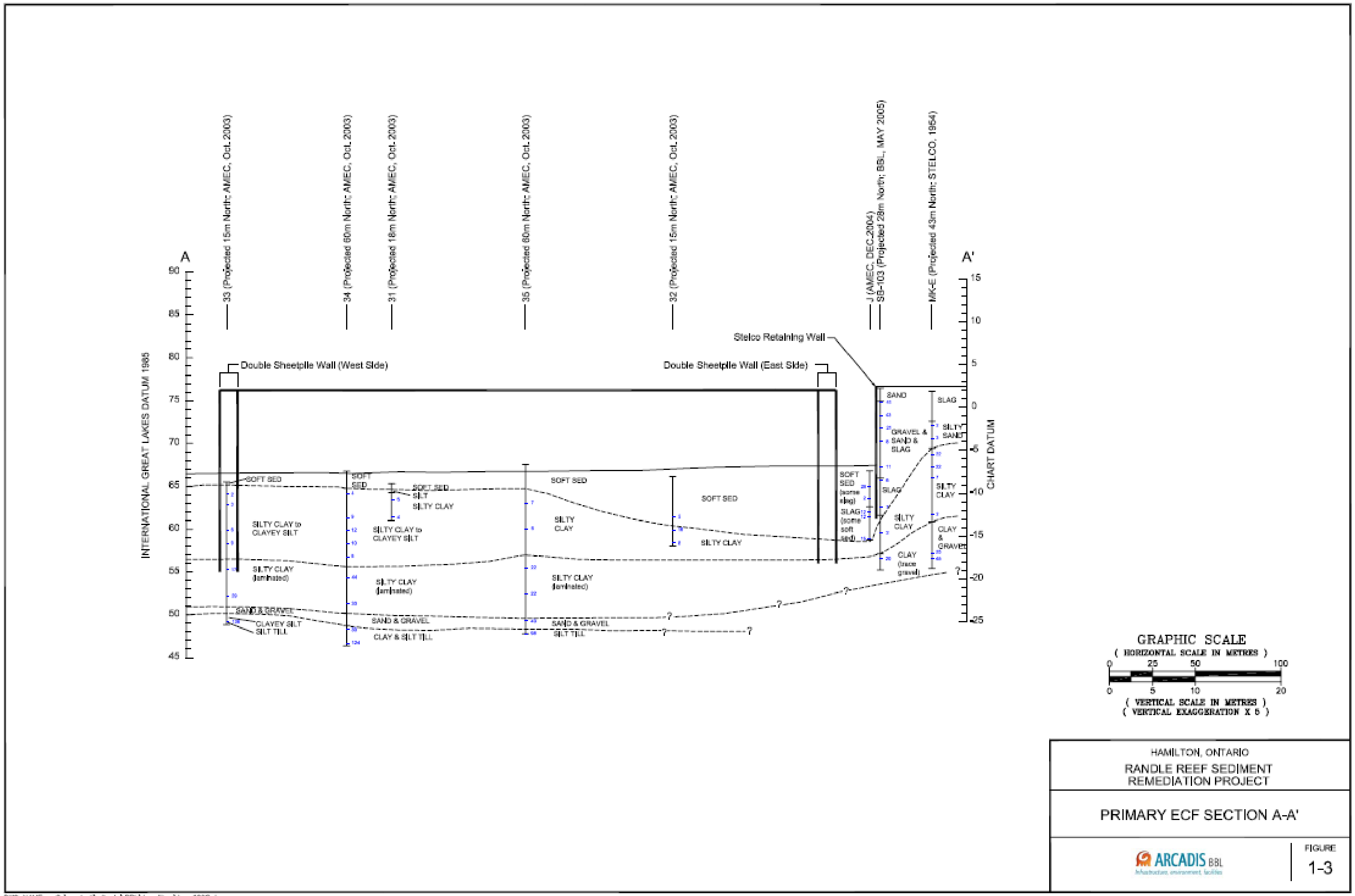

Figure B.2: Primary ECF Section B-B

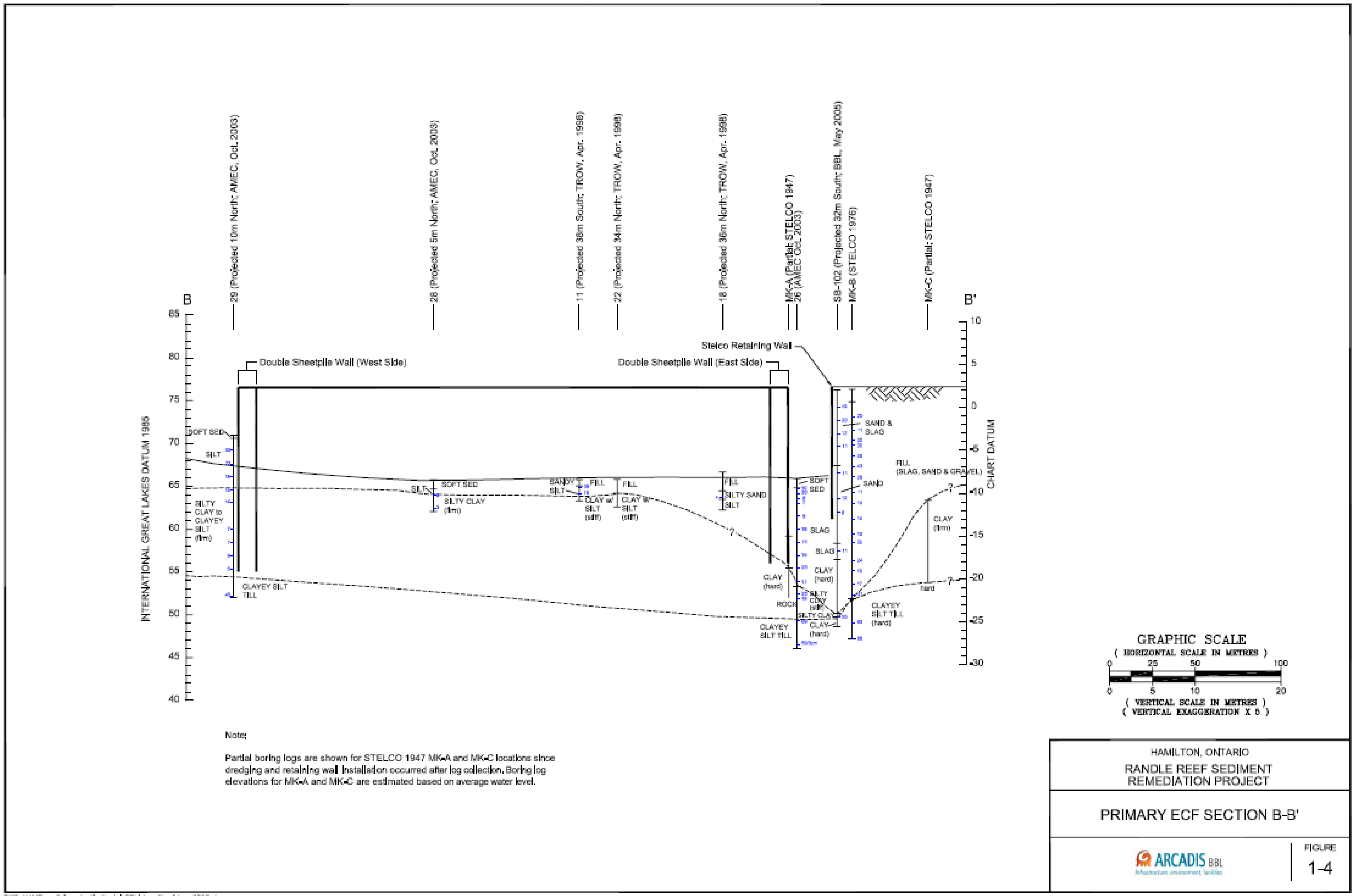

Figure B.3: Primary ECF Section C-C

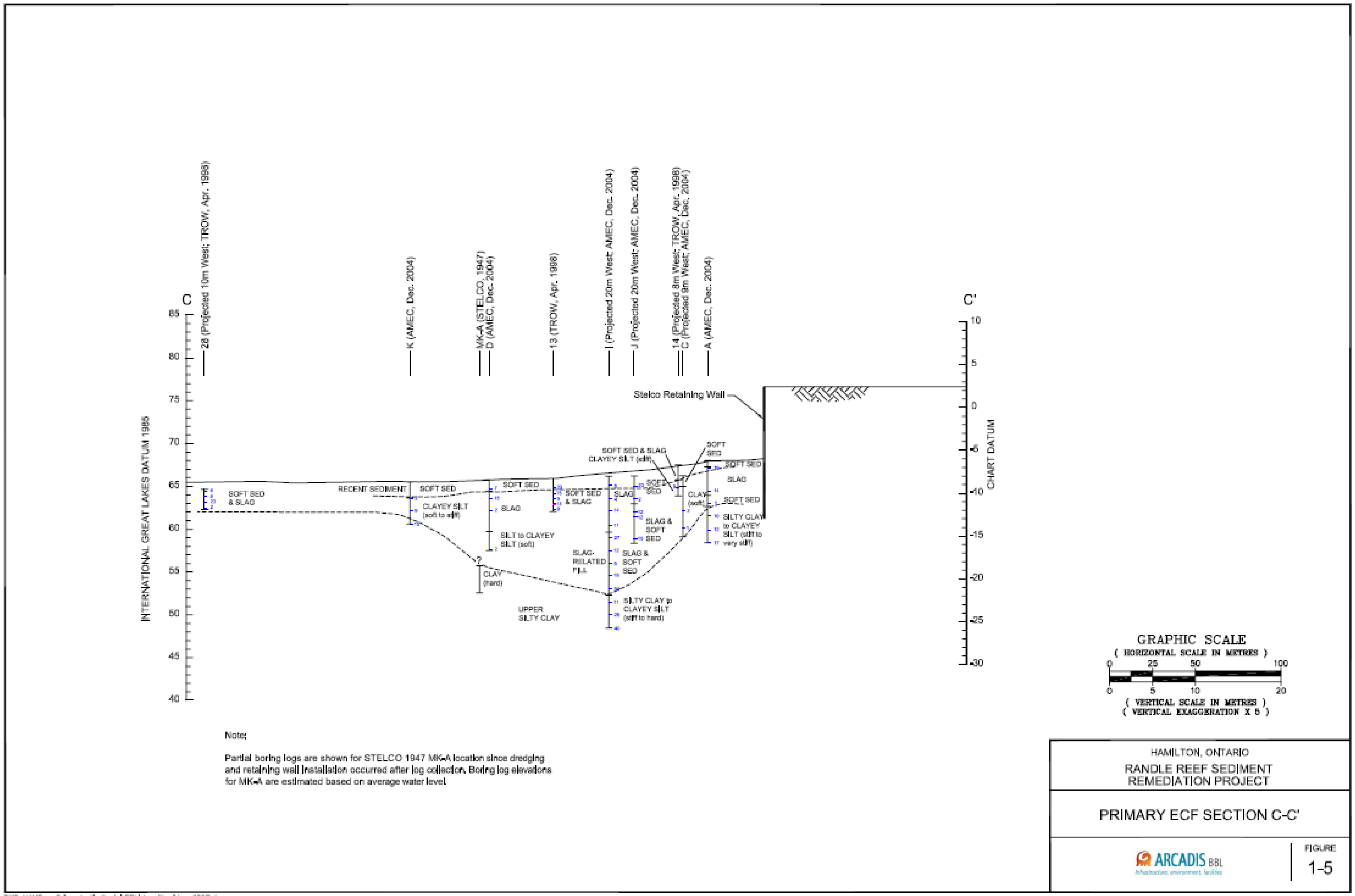

Figure B.4: Hydrogeologic Cross Section Location Map

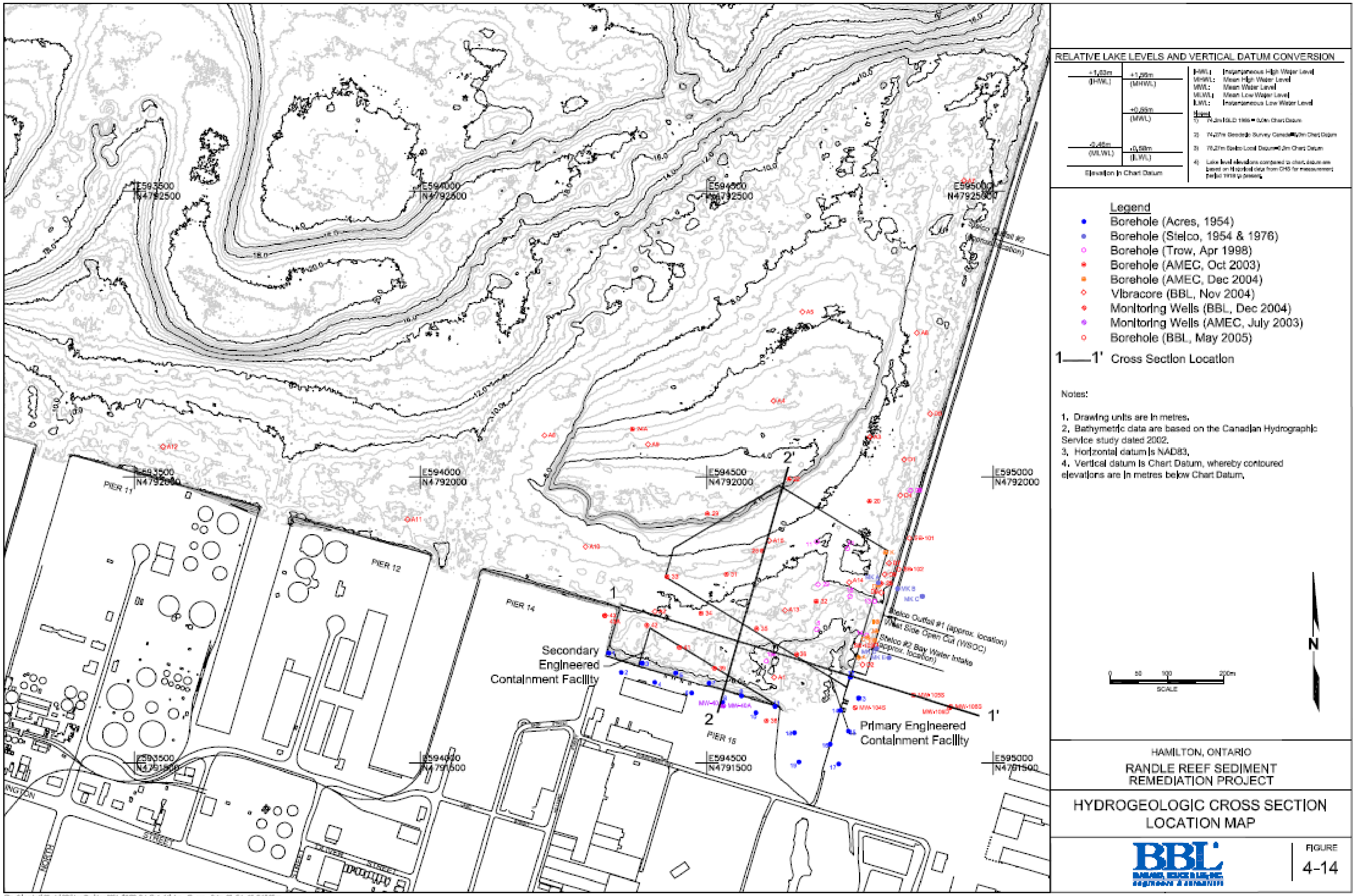

Figure B.5: Hydrogeologic Cross Section 1-1

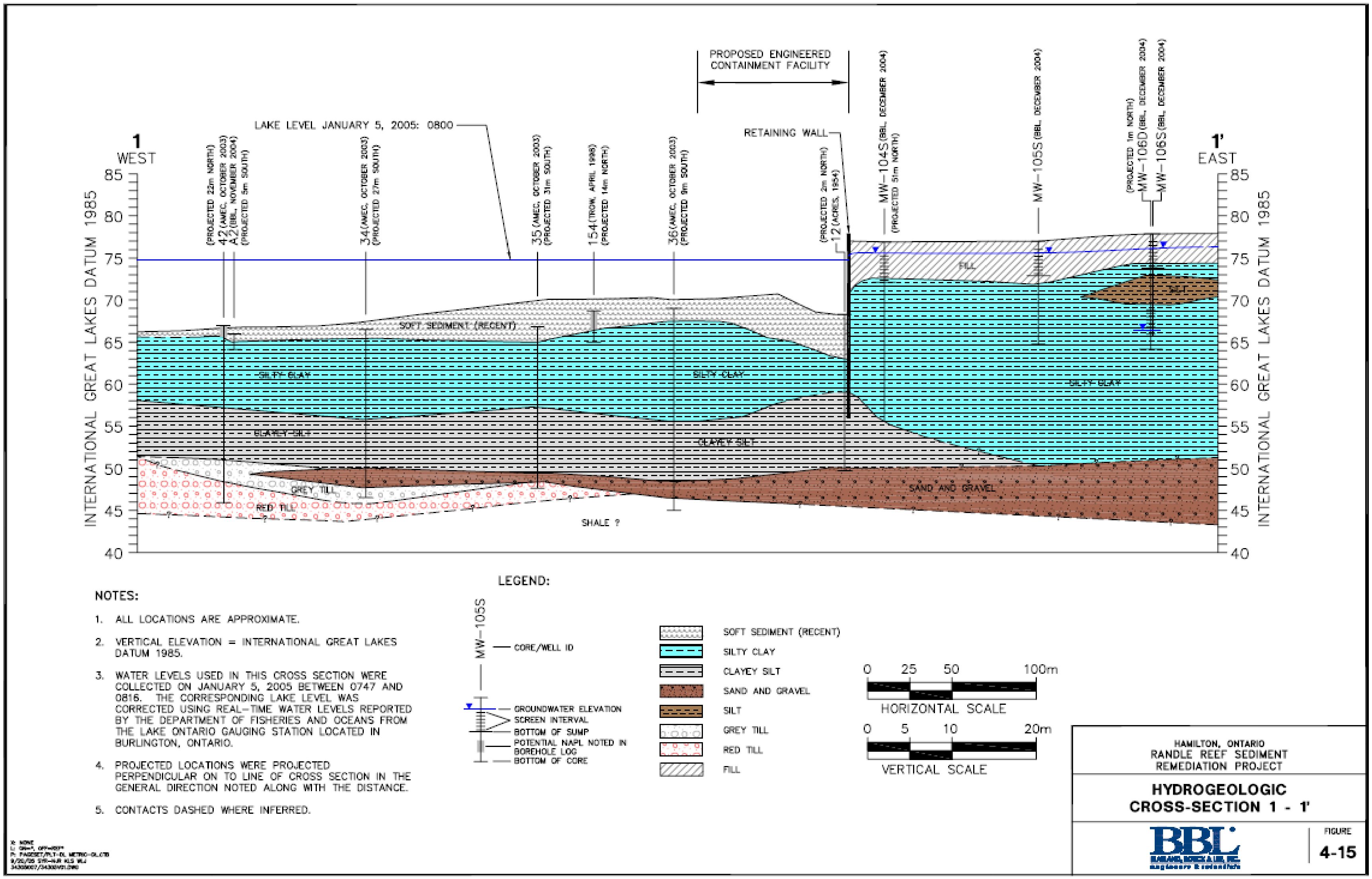

Figure B.6: Hydrogeologic Cross Section 2 -2

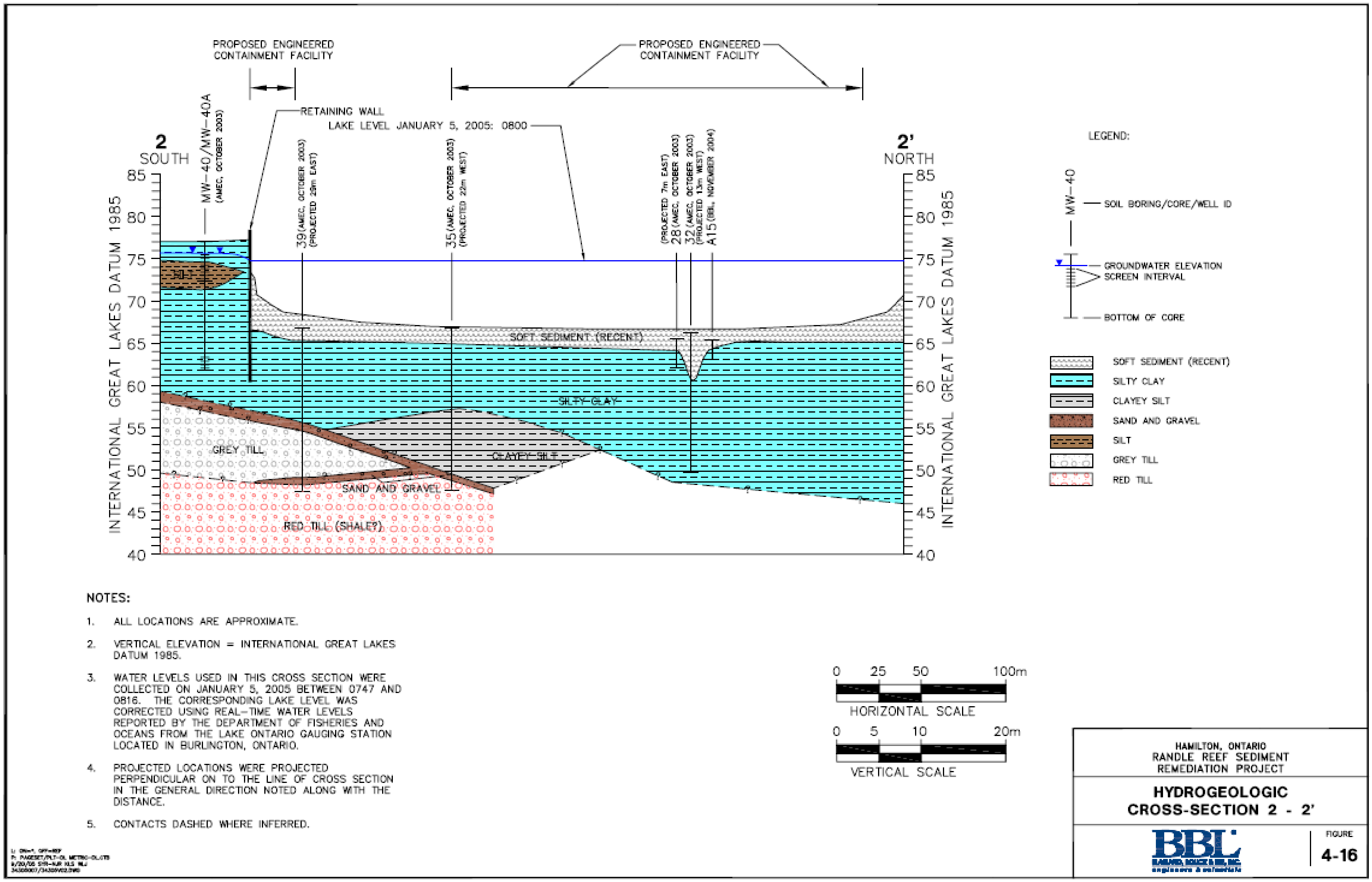

Table B.2: PAH Mass Distribution By Subarea

Subarea	Priority Designation	Mass of PAHs for a Subarea (kg)	Percentage of PAHs in a Subarea Compared to the Site (%)	Cumulative Percentage of PAH (%)
1	1	1,160,227	71.6	71.6
2	1	9,856	0.6	72.2
3	1	199,434	12.3	84.5
4	1	13,535	0.8	85.3
5	1	5,072	0.3	85.6
6	1	49,054	3.0	88.7
7	1	3,888	0.2	88.9
8	1	10,804	0.7	89.6
9	2	106,102	6.5	96.1
10	2	1,915	0.1	96.2
11	2	1,986	0.1	96.4
12	2	5,450	0.3	96.7
13	2	897	0.1	96.7
14	2	243	0.0	96.8
15	2	480	0.0	96.8
16	3	14,370	0.9	97.7
17	3	28,429	1.8	99.4
18	3	2,975	0.2	99.6
19	3	4,222	0.3	99.9
20	3	1,205	0.1	99.9
21	4	620	0.0	100.0
22	4	217	0.0	100.0
23	4	15	0.0	100.0
Total		1,620,996	100.0	

Table B.3: Arsenic Mass Distribution By Subarea

Subarea	Priority Designation	Mass of Arsenic for a Subarea (kg)	Percentage of Arsenic in a Subarea Compared to the Site (%)	Cumulative Percentage of Arsenic (%)
1	1	2,139	23.0	23.0
2	1	322	3.5	26.5
3	1	1,143	12.3	38.8
4	1	881	9.5	48.2
5	1	633	6.8	55.0
6	1	143	1.5	56.6
7	1	390	4.2	60.8
8	1	250	2.7	63.4
9	2	128	1.4	64.8
10	2	84	0.9	65.7
11	2	400	4.3	70.0
12	2	707	7.6	77.6
13	2	66	0.7	78.3
14	2	61	0.7	79.0
15	2	64	0.7	79.7
16	3	176	1.9	81.6
17	3	398	4.3	85.9
18	3	342	3.7	89.5
19	3	525	5.6	95.2
20	3	161	1.7	96.9
21	4	156	1.7	98.6
22	4	123	1.3	99.9
23	4	8	0.1	100.0
Total		9,300	100.0	

Table B.4: Chromium Mass Distribution By Subarea

Subarea	Priority Designation	Mass of Chromium for a Subarea (kg)	Percentage of Chromium in a Subarea Compared to the Site (%)	Cumulative Percentage of Chromium (%)
1	1	15,186	25.6	25.6
2	1	1,827	3.1	28.7
3	1	3,726	6.3	35.0
4	1	2,369	4.0	39.0
5	1	1,796	3.0	42.0
6	1	1,000	1.7	43.7
7	1	1,146	1.9	45.6
8	1	2,147	3.6	49.3
9	2	3,507	5.9	55.2
10	2	693	1.2	56.3
11	2	2,244	3.8	60.1
12	2	4,438	7.5	67.6
13	2	221	0.4	68.0
14	2	553	0.9	68.9
15	2	472	0.8	69.7
16	3	2,393	4.0	73.8
17	3	5,135	8.7	82.4
18	3	2,713	4.6	87.0
19	3	3,556	6.0	93.0
20	3	1,083	1.8	94.8
21	4	1,756	3.0	97.8
22	4	1,184	2.0	99.8
23	4	134	0.2	100.0
Total		59,278	100.0	

Table B.5: Copper Mass Distribution By Subarea

Subarea	Priority Designation	Mass of Copper for a Subarea (kg)	Percentage of Copper in a Subarea Compared to the Site (%)	Cumulative Percentage of Copper (%)
1	1	9,077	17.0	17.0
2	1	1,342	2.5	19.6
3	1	3,726	7.0	26.5
4	1	3,664	6.9	33.4
5	1	2,911	5.5	38.9
6	1	865	1.6	40.5
7	1	1,538	2.9	43.4
8	1	1,971	3.7	47.1
9	2	2,289	4.3	51.4
10	2	329	0.6	52.0
11	2	5,845	11.0	63.0
12	2	4,133	7.8	70.7
13	2	220	0.4	71.1
14	2	519	1.0	72.1
15	2	483	0.9	73.0
16	3	1,442	2.7	75.7
17	3	3,486	6.5	82.3
18	3	2,147	4.0	86.3
19	3	3,094	5.8	92.1
20	3	1,204	2.3	94.4
21	4	1,815	3.4	97.8
22	4	1,045	2.0	99.7
23	4	148	0.3	100.0
Total		53,293	100.0	

Table B.6: Iron Mass Distribution By Subarea

Subarea	Priority Designation	Mass of Iron for a Subarea (kg)	Percentage of Iron in a Subarea Compared to the Site (%)	Cumulative Percentage of Iron (%)
1	1	20,813,731	32.4	32.4
2	1	1,783,910	2.8	35.2
3	1	9,524,715	14.8	50.0
4	1	3,198,254	5.0	55.0
5	1	3,676,246	5.7	60.7
6	1	1,003,545	1.6	62.2
7	1	2,334,963	3.6	65.9
8	1	1,894,744	2.9	68.8
9	2	1,611,879	2.5	71.3
10	2	243,637	0.4	71.7
11	2	2,048,268	3.2	74.9
12	2	4,032,117	6.3	81.2
13	2	292,800	0.5	81.6
14	2	307,940	0.5	82.1
15	2	232,444	0.4	82.5
16	3	967,732	1.5	84.0
17	3	3,224,474	5.0	89.0
18	3	2,073,680	3.2	92.2
19	3	2,655,565	4.1	96.3
20	3	912,609	1.4	97.8
21	4	879,084	1.4	99.1
22	4	477,781	0.7	99.9
23	4	77,038	0.1	100.0
Total		64,267,156	100.0	

Table B.7: Lead Mass Distribution By Subarea

Subarea	Priority Designation	Mass of Lead for a Subarea (kg)	Percentage of Lead in a Subarea Compared to the Site (%)	Cumulative Percentage of Lead (%)
1	1	80,795	32.2	32.2
2	1	5,187	2.1	34.3
3	1	33,556	13.4	47.7
4	1	16,622	6.6	54.3
5	1	15,835	6.3	60.6
6	1	5,088	2.0	62.7
7	1	9,547	3.8	66.5
8	1	8,738	3.5	70.0
9	2	5,924	2.4	72.3
10	2	407	0.2	72.5
11	2	9,466	3.8	76.3
12	2	17,842	7.1	83.4
13	2	750	0.3	83.7
14	2	1,294	0.5	84.2
15	2	980	0.4	84.6
16	3	2,113	0.8	85.4
17	3	10,271	4.1	89.5
18	3	7,307	2.9	92.5
19	3	9,913	4.0	96.4
20	3	3,690	1.5	97.9
21	4	3,239	1.3	99.2
22	4	1,865	0.7	99.9
23	4	190	0.1	100.0
Total		250,620	100.0	

Table B.8: Nickel Mass Distribution By Subarea

Subarea	Priority Designation	Mass of Nickel for a Subarea (kg)	Percentage of Nickel in a Subarea Compared to the Site (%)	Cumulative Percentage of Nickel (%)
1	1	1,900	9.3	9.3
2	1	270	1.3	10.7
3	1	1,304	6.4	17.1
4	1	1,508	7.4	24.5
5	1	904	4.4	29.0
6	1	275	1.4	30.3
7	1	553	2.7	33.0
8	1	821	4.0	37.1
9	2	428	2.1	39.2
10	2	88	0.4	39.6
11	2	3,436	16.9	56.5
12	2	2,045	10.1	66.6
13	2	119	0.6	67.1
14	2	226	1.1	68.3
15	2	147	0.7	69.0
16	3	300	1.5	70.5
17	3	1,689	8.3	78.8
18	3	1,081	5.3	84.1
19	3	1,484	7.3	91.4
20	3	528	2.6	94.0
21	4	759	3.7	97.7
22	4	424	2.1	99.8
23	4	41	0.2	100.0
Total		20,328	100.0	

Table B.9: Zinc Mass Distribution By Subarea

Subarea	Priority Designation	Mass of Zinc for a Subarea (kg)	Percentage of Zinc in a Subarea Compared to the Site (%)	Cumulative Percentage of Zinc (%)
1	1	506,273	34.7	34.7
2	1	36,425	2.5	37.2
3	1	179,880	12.3	49.5
4	1	84,070	5.8	55.3
5	1	74,643	5.1	60.4
6	1	31,313	2.1	62.5
7	1	48,627	3.3	65.8
8	1	51,368	3.5	69.4
9	2	31,079	2.1	71.5
10	2	2,158	0.1	71.6
11	2	46,614	3.2	74.8
12	2	102,412	7.0	81.8
13	2	3,679	0.3	82.1
14	2	8,669	0.6	82.7
15	2	5,007	0.3	83.0
16	3	12,145	0.8	83.9
17	3	73,358	5.0	88.9
18	3	47,605	3.3	92.1
19	3	67,256	4.6	96.8
20	3	20,679	1.4	98.2
21	4	15,662	1.1	99.2
22	4	10,234	0.7	99.9
23	4	787	0.1	100.0
Total		1,459,942	100.0	

Fisheries and Oceans Canada's (DFO) contribution to the Randle Reef, Hamilton Harbour Comprehensive Study Report (CSR) (Environment Canada)

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Introduction

This summary report was prepared at the request of Environment Canada (EC) to provide information on the historical and current fish community and habitats (e.g. substrate and aquatic vegetation) in Hamilton Harbour. The information is a contribution to the Comprehensive Study Report for the Randle Reef Sediment Remediation Project and will aid the Responsible Authorities (EC and DFO) for the project in evaluating the remediation's contribution towards fish and fish habitat improvements in Hamilton Harbour. Both historical (1859-1970) and recent information (1985 to present) from studies conducted by DFO and others were summarized to provide EC with the status of the fish community and habitats outside of the industrialized south shore of Hamilton Harbour. For example, the current information available was not collected in the vicinity of Randle Reef but came as close as Pier 4 to the west and the Skyway Bridge area to the east. Monitoring studies conducted by DFO in the Harbour were initiated in 1988 to evaluate the fish community and associated biotic and abiotic factors that comprise habitat before (1988 and 1990) and after (1995-2007) various habitat restoration projects. Data collected by DFO is also used to determine status towards delisting of the beneficial use impairments (BUI) pertaining to fish and fish habitat in Hamilton Harbour. Funding for DFO projects was provided by the Great Lakes Action Plan through Environment Canada.

Objectives set for the summary report included:

- a summary of current substrate information
- a summary of past and current submerged aquatic vegetation (SAV) surveys
- a summary of historical and recent fish surveys

- comments on the current status of beneficial use impairments (BUIs) and their delisting targets for the fish community based on an Index of Biotic Integrity (IBI)
- information on current work underway being conducted by DFO Science on fish and fish habitat in the Harbour

Habitat Survey & Classification

The focus of fish habitat-based field surveys conducted in Hamilton Harbour in 2006 and 2007 was to supplement existing physical information and to fill gaps in spatial coverage. Preliminary work focused on gathering historical information and data from partners (Environment Canada-EC, Canadian Hydrographic Service-CHS) on depth, elevation, vegetation and substrate. Field surveys concentrated on substrate type and SAV distributions. The information will be used in the classification of fish habitats throughout the Harbour and spatial modelling where necessary to fill gaps (Hamilton Harbour 2007 RAP Report contribution: Doka et al. 2007).

Substrate (2002-2007)

Existing information on substrate types is being compiled through recent nearshore and offshore surveys (both acoustic and point sample). Sampling points from previous studies (both DFO and EC) are shown throughout the Harbour in Fig. 1. The majority of offshore survey points are soft sediments (sand/silt/clay). All these pieces of information will complete a current map of substrates types for the entire Harbour from the deep hole up to coastal elevations.

Several surveys were conducted in the shallow nearshore (<5 m water depth) to address spatial data gaps in substrate composition, as most existing information is for depths >5m. A detailed shoreline survey was conducted in 2006 to get an accurate picture of substrate type and slope around the shoreline (Fig.1). Sampling points for substrate quantification in the extreme nearshore (1 m water depth) were then selected based on shoreline type and in early May 2007, substrate and water chemistry samples were taken at 45 points (Fig. 1). Substrate sampling consisted of Ponar grabs and underwater video while water column properties included dissolved oxygen, conductivity, pH and temperature measured with Hydrolab probes.

At deeper depths, hydroacoustic surveys between 1.5 and 5 m depths were conducted along the non-industrialized areas of the Harbour and backscatter data will be analyzed to classify substrates into broad categories; validation samples were taken at the same time to train backscatter classifications. Some of this information will be used to validate a classification of backscatter data collected during CHS bathymetric cruises of the Harbour in 2002. These data are currently being processed and validated.

2006 Submerged Aquatic Vegetation (SAV) Survey

Percent Cover and Bed Extent: Echosounding using a BioSonics DTX system and a 430 kHz transducer was conducted along thirty-two reference transects that have been surveyed since 1992 (Fig. 2). Initial results of the 2006 survey are illustrated in Fig. 3, a more detailed examination of this survey can be found in Leisti et al. (2008). In general, the most extensive SAV beds were found along the north shore of Hamilton Harbour, with the widest bed extending 210-m offshore at transect 5. SAV cover was moderate (20 to 70%) to dense (> 70%) along the north shore. Although moderate to dense cover was also found along the west and southwest shores, the SAV beds were substantially smaller at less than 50-m in width. Sparse (1 to 19%) cover was encountered on the eastern shore with bed extents typically less than 50-m offshore.

Species Composition and Biomass: In conjunction with the hydroacoustics survey conducted along 32 reference transects (Doka et al. 2007), quadrat sampling for SAV species composition and biomass were conducted at a subset of 13 transects (Fig. 4). Using three 0.25 m^2 quadrats at each sample point, divers harvested above-ground biomass at four to seven points per transect. The sample points were located at depths of 0.5, 1.0, 1.5, 2.0, 2.5, 3.0 and 4.0 m, but some transects were too steep to sample at every depth. The SAV were rinsed; the majority of the plants were sorted to species, spun-dry and the wet weights were recorded.

Transect 19 recorded the highest mean biomass for the Harbour (Fig. 4), although this may be misleading since reduced visibility may have caused the diver to harvest beyond the confines of the quadrat. Additionally, winds and water currents may have concentrated and trapped loose fragments of SAV in this location. For the remaining transects, mean biomass was generally higher along the north shore and at Bayfront Park.

A maximum of six species were recorded during the survey, assuming that a narrow-leaf *Potamogeton* sp. category is one species. Species included *Vallisneria* *americana*, *Myriophyllum spicatum*, *Elodea canadensis*, *Ceratophyllum demersum* and *Potamogeton richardsonii*. All six species were recorded at Bayfront Park while four species were found at transects 3, 6 and 19. Six of 13 transects recorded only one or two species and these transects were scattered throughout the Harbour.

The six plant species had varying distributions throughout the Harbour. *V. americana* dominated nine of 13 transects, and represented more than 90% of the total mean biomass on eight transects. It was absent or found in small amounts in the southwest corner of the Harbour, with the exception of Bayfront Park. *M. spicatum* generally dominated in the southwest, contributing greater than 72% of the total biomass on three transects. Elsewhere in the Harbour it was either absent or contributed less than 8% of the biomass. *E. canadensis* was only found in the southwest corner and represented 84% of the biomass of transect 19, but contributed less than 3% to the biomass on transects 21 and 25. *P. richardsonii* was scattered throughout the Harbour but contributed less than 3% of total biomass on seven transects with the exception of 29% on transect 31. *C. demersum* was only found on transects 25 and 26, and contributed between 0.2 and 14% of the total mean biomass, respectively. A narrow-leaf *Potamogeton* sp., assumed to be one species, was found on five transects, but contributed to less than 2% of the total biomass.

Historical Aquatic Vegetation

Historically, Hamilton Harbour had an complex wetland system estimated at 500 hectares that once supported both a coldwater and a warmwater fishery (RAP 1992; Holmes and Whillans 1984; Smokorowski et al. 1998). A map from 1915 produced by the Canadian Hydrographic Service, Fig. 5, showed extensive marsh areas along the southern, eastern and northeastern shore. In the mid to late 1800’s, Kerr and Kerr noted emergent vegetation extending along the entire south shore, in the mouth and upper reaches of Grindstone Creek and in the northeast corner at Brant’s Pond (RAP 1992). These areas provided excellent spawning, nursery and adult habitat for warmwater fishes. Infilling of the Harbour has resulted in the irreversible loss of 450 ha of wetland area, based on 1992 figures (Smokorowski et al. 1998).

Past Submersed Aquatic Vegetation (SAV) Survey Methodology: A total of seventeen SAV surveys have been conducted in Hamilton Harbour through the Great Lakes Laboratory for Fisheries and Aquatic Sciences (GLLFAS), DFO since 1987. Some of the surveys were specifically designed for SAV assessment while others were used to support the electrofishing program. Through this time series of surveys, there were changes in the protocols used to assess SAV as equipment became more sophisticated. Locations also varied, with some surveys using the 100-m long, 1.5-m deep electrofishing transects in defined areas (Fig. 6), while others used transects perpendicular to the shoreline (Fig. 2).

SAV-specific surveys to determine distribution and relative abundance were conducted in 1987, annually from 1990 to 1996, and again in 2006, using hydroacoustics, SCUBA divers, or both. In 1987, echosounding was used along the 1.3-m contour of the Harbour and at 22 transects perpendicular to shore (RAP 1992). Divers were used during this survey to determine species richness and density at a subset of these locations. Using a different protocol, Minns et al. (1993) used divers in 1990 and 1991 to determine species composition, plant height, stem density and percent cover along a subset of electrofishing transects. From 1992 to 1996, paper traces from a Lowrance X-16 echosounder were analyzed from 33 transects that ran perpendicular to the shoreline (Fig. 2). These same transects were re-surveyed in 2006 (Leisti et al. 2008) and divers were used to determine wet biomass and species composition on thirteen of the 33 transects. As part of the electrofishing program, visual assessment of SAV cover and composition was conducted in 1992, 1993, 1995, 1997, 2001, 2002 and 2006 from the electrofishing boat. Protocols for these surveys are described in Valere (1996) and Brousseau et al. (2005). Sampling effort varied over the years with some years recorded discrete values of percent cover while other years cover was assigned by category. In 1993, both visual assessment and echosounding was conducted on a subset of electrofishing transects.

Percent Cover using, Echosounding: In 1987, the only location that had dense SAV (400 plants/m^2) was LaSalle Marina (RAP 1992). Moderate densities (63 plants/m^2) were found along the north shore, with the exception of the mouth of Indian Creek, which had sparse SAV (3 plants/m^2). A patch of moderate density SAV was found just south of the Desjardins Canal while sparse SAV was located in Macassa Bay. SAV was absent along the south shore, east of the Royal Hamilton Yacht Club and along the eastern shore. SAV was rarely found at depths greater than 2-m and was entirely absent at depths greater than 2.5-m.

Table 1 summarizes changes in mean percent cover and maximum depth of colonization from the SAV surveys between 1992 and 2006. While methods were consistent between 1992 and 1996, some caution should be used when comparing these results with the 2006 data as changes occurred in the equipment and the analytical procedure. However, the two echosounders were previously compared along nine transects by Leisti et al. (2006) in the Bay of Quinte in 2004 and mean cover values did not vary by more than 13%.

SAV were typically sparse (1 to 19% cover) along the eastern shore and in Carroll's Bay throughout the sampling period. SAV was always absent on transect 31 while transect 32 only recorded very sparse growth in 2006. In the north-east corner of the Harbour, transects 3 and 4 were typically sparse from 1992 to 1996, but increased substantially in 2006 to dense (>70%) cover. Along the north shore, SAV was generally moderate in the earlier years and dense in 2006, although transects 6 and 14 were consistently recorded as moderate cover. On the western shore, cover was generally sparse to moderate, but dense SAV was found on transect 21 in 1993 and transect 19 in 2006. Along the southern shoreline, SAV ranged from sparse to dense through the sampling period.

Percent Cover, Visual Assessment: Table 2 contains the results from the visual and echosounding assessments of SAV cover along the electrofishing transects. From 1990 to 2001, SAV along the eastern shoreline and the northeast bays were either absent or sparse. In 2002 and 2006, the majority of the transects on the eastern shore recorded moderate SAV, although 23% of the transects had none or sparse growth in 2002. The north shore generally had moderate to dense cover throughout the sampling period with the exception of 2001 where SAV was either sparse or absent on 75% of transects. SAV was predominantly absent and occasionally sparse on transects near the mouth of Grindstone Creek throughout the sample period.

Along the western shore, sparse SAV was typically encountered until 2001 and subsequently increased to moderate density. Sampling along the south shore was very limited until 1993. Transects 37 to 39 in Straughan Channel typically recorded moderate SAV until 2001 and then increased to dense in 2002 and 2006. Closer to the boat ramp in that same area, SAV densities were consistently sparse until 1998, absent in 2001 and dense thereafter. In the Bayfront Park area, SAV was sparse up to 2001 and then generally increased to moderate densities. In the Macassa Bay/Pier 4 area, SAV was typically moderate to dense when sampled, then decreased to sparse on two of the transects in 2006.

There will be differences between percent cover values from the electrofishing transects which run parallel to shore at a constant 1.5 m depth and the SAV transects which are perpendicular to the shoreline and survey into deeper waters. When comparing the two types of surveys using the nearest locations during the same year, there is some agreement. In 31% of the cases, both echosounding and visual assessment reported SAV within the same density category. Differences greater than two categories (i.e. one method reported sparse, the other reported dense) were found in 21% of the cases. These differences typically occurred along the steeper sections of the south shore with echosounding consistently reporting higher values than visual assessment. High wave energy along the steeper, hardened shoreline may inhibit growth in shallower areas.

Echosounding, Maximum Depth of Colonization: Table 1 records the deepest depth where SAV was found (Z_c) from 1992 to 2006. In 1992, the mean Z_c was 2.4 m and decreased to 2.1 m for the years 1993 to 1995. Mean Z_c increased slightly in 1996 to 2.1 m with an additional increase in 2006 to 2.6 m. When transects are examined individually, the minimum Z_c was consistently recorded along the eastern shoreline. The minimum Z_c for all survey years was 1.0 m and was recorded both in 1993 and 1996. In 2006, the minimum Z_c was 1.1 m and in 1995, 1.2 m. The maximum Z_c was recorded in

1992 at a depth of 1.8 m, while in 1994 it was 1.5 m. Transects that recorded the deepest Z_c were typically located on the southern shoreline, although in 1992, the deepest location for SAV was in Carroll's Bay. All surveys recorded Z_c depths in excess of 3.1 m (in 1992) with the deepest depth of 4.3 m found in 1993. A maximum Z_c of 3.5 m was recorded in 1994, 1996 and 2006, while in 1995 it was 4.1 m.

Across transects, Z_c varied from year to year, but there were trends across transects between years. Between 1992 and 1993, the Z_c decreased on 82% of the transects while in 1994, the transects where Z_c increased was equal to the number where Z_c decreased. In 1995, depths decreased on 70% of transects relative to 1994 and increased on 68% of transects in 1996 relative to 1995. Depths increased again in 2006 on 78% of the transects.

Zebra mussels became established in the Harbour in late 1991 (Dermott et al. 2007). In other locations (Skubinna et al. 1995; Knapton and Petrie 1999; Leisti et al. 2006, Zhu et al. 2006), SAV distribution and density increased after invasion by zebra mussels which has been generally attributed to increased water clarity. However, Hamilton Harbour did not experience a substantial overall increase in Secchi depth post-zebra mussel invasion (Charlton and Le Sage 1996) as did other locations (Zhu et al. 2006; Stuckey and Moore 1995). Charlton and Le Sage (1996) did report transient clearing of the waters immediately adjacent to a pier where zebra mussels had attached, but found no significant difference in Secchi depths between a series of stations moving further offshore. The authors believed that the supply of particles in the Harbour relative to the zebra mussel population overwhelmed their ability to completely clear the water.

There was a response in the SAV community between the 1987 and 1992 surveys which may be a result of localized increases in water clarity. In 1987, SAV was rarely found deeper than 2.0 m and entirely absent beyond 2.5 m (RAP 1992) while in 1992 the mean maximum depth of colonization was 2.4 m with SAV found to 3.1 m depth. The post-zebra mussel period saw the re-establishment of SAV along the eastern shoreline and expansion on the southern and western shores. Densities increased to such a degree in some of the marina areas of the southern shore, that plant control measures were undertaken in 2001 (Theysmeyer and Cleveland 2001). However, density comparison pre- and post- invasion are difficult due to the use of different metrics to describe SAV abundance. Stem density was used in the 1987 survey, while percent cover was used post-zebra mussel invasion.

Historical Species Presence: Due to the variable nature of sampling protocols, locations, and inconsistencies in sampling effort, only species presence is provided in Table 3 compared across sampling years. Between 1987 and 2006, GLLFAS conducted eight surveys over six years that examined species composition in Hamilton Harbour (RAP 1992; Minns et al. 1993; Brousseau et al. 2005; Theysmeyer and Cleveland 2001 ; Leisti et al. 2008). Some surveys identified SAV to genus, while others recorded to species. Protocols varied from diver surveys (1987, 1990, 1991, 2006) to visual assessment from the boat (2001, 2001b, 2002 and 2006b) supplemented with grab samples (2001b). Sampling locations also varied with the 1990, 1991, 2001, 2002 and 2003 surveys conducted along electrofishing transects. Different subsets of the electrofishing transects were sampled every year with only two transects consistently sampled over the five surveys. The 2001 survey examined the efficacy of methods of SAV control and sampling took place at LaSalle Marina, Macassa Bay, Royal Hamilton Yacht Club and the Hamilton Port Authority.

Eleven species have been found in the Harbour, Table 3, in addition to *Chara sp*. and *Najas sp*. Present in every survey was the species *Vallisneria americana* and the genera *Myriophyllum sp*. and *Potamogeton sp*. *Elodea canadensis* was recorded in every survey year, but was absent on the 2001b survey. *Ceratophyllum demersum* was absent in 1987 and 1991 and *Zosterella dubia* (formerly *Heteranthera dubia*) was not recorded in 1991 and 2006. All other species were present on less than 37% of the surveys.

Most of the SAV found in the Harbour are common, widely distributed, and able to tolerate low light conditions and higher levels of turbidity (Borman et al. 2001). Only *Potamogeton amplifolius* was noted to be sensitive to increasing turbidity and was found in the Harbour for just two years, in 1990 and 1991. Two invasive submersed SAV species were present in the Harbour: *Potamogeton crispus* and *Myriophyllum spicatum*. *P. crispus* is able to grow in turbid conditions but was only found on 37% of the surveys.

This species senesces in mid-summer therefore surveys conducted later in the year will not detect its presence. *M. spicatum* is one of the most widely distributed non-indigenous aquatic plants and was found on all the surveys that reported species information. *M. spicatum* is tolerant of degraded conditions and is particularly problematic in disturbed water bodies that have experienced nutrient loading, intense SAV management, or heavy motor boat use. This species has been known to begin growth under the ice in February (Crowder and Bristow 1986) and can quickly form a dense canopy which overtops and shades native SAV, thus reducing native plant abundance and diversity (Smith and Barko 1990; Eichler et al. 1999). Several studies have noted that *M. spicatum* expands rapidly, reaches a peak in 5 to 10 years, then subsequently declines (Trebitz et al. 1993; Knapton and Petrie 1999).

Habitat Summary

SAV is a valuable component of a healthy ecosystem and can affect many ecosystem processes (Carpenter and Lodge 1986). SAV presence can alter light, nutrient and temperature dynamics, anchor sediments and slow water velocity (Madson et al. 2001). SAV provides a substrate for epiphytes, habitat for invertebrates (Keast 1984; Eklov 1997) and influences phytoplankton and zooplankton populations. Fish use SAV for spawning, nursery and adult habitat (Lane et al. 1996, 1996b). Randall et al. (1996) found fish density and richness was significantly greater in areas of high macrophyte density than in areas where SAV was sparse or absent. Several factors influence SAV abundance including light availability (Barko and Smart 1981), nutrients (Carnigan and Kalff 1980), exposure (Hudon et al. 2000), temperature, ice scour, water levels, substrate characteristics and basin morphometry (Duarte and Kalff, 1990).

With the infilling of the south shore of the Harbour, there was an irreversible loss of 85% of the original vegetated shoreline and basin morphometry restricts the remaining littoral habitat (less than 3 m depth) to 220 ha (determined using a shoreline elevation of 75.1 m). In recent history, the north shore of the Harbour dominated in terms of SAV density and areal extent. SAV continues to remain absent or sparse at the mouth of Grindstone and Indian Creeks and this may be due to increased localized turbidity from storm events. Percent cover was variable along the western and southern shorelines, but the areal extent is relatively low. SAV has re-established along the eastern shoreline at sparse densities. SAV species richness and composition in the Harbour continues to be indicative of degraded environments. Reduced light availability from factors including suspended sediments and algal blooms and the lack of protected, shallow-slope shoreline remain problematic for the submerged aquatic vegetation community of Hamilton Harbour.

Historical Fish Community

Historically, Hamilton Harbour was one of the most productive areas on Lake Ontario supporting both cold and warm water commercial fisheries. The coldwater fishery was dominated by lake trout, lake herring and lake whitefish. Northern pike, smallmouth bass and largemouth bass dominated both the recreational and commercial warm water fisheries. Fisheries overseers for Hamilton Harbour in the mid- to late 1800s documented large feeding migrations of lake trout and whitefish in June and July followed by spawning migrations in October and November (Whillans 1979; Holmes and Whillans 1984; HHRAP 1992). Millions of herring and whitefish were observed spawning on the rocky shoals of the north shore (Holmes and Whillans 1984). In addition to Cootes Paradise, the south (now industrialized) and west shores of the Harbour were characterized by shallow water marshes that provided spawning, nursery and adult habitat for a wide variety of warm water species (e.g. smallmouth bass, COA 1992). In addition to pike and bass, the warm water fishery was comprised of yellow perch, sunfish, muskellunge, walleye, freshwater drum, burbot, brown bullhead, channel catfish and white sucker (Holmes and Whillans 1984). Detailed accounts of the commercial and sport fisheries in Hamilton Harbour were found in Whillans (1979) and Holmes and Whillans (1984). A list of 63 species and their status from the 1800s to the late 1970s was adapted from Holmes and Whillans 1984 (Table 4).

At the turn of the 20th century, the coldwater fishery had already been diminished as a result of heavy exploitation, loss of habitat through development and exotic species. The addition of industrial and municipal pollution added to the demise of the coldwater commercial fishery that fully disappeared by 1959 (COA 1992); the decline of the warm water fishery followed shortly after (Holmes and Whillans 1984).

Whillans (1979) in his historical review of three Great Lakes' bays documented key transformations in the Harbour fish community over a century (1859-1970), highlighting the changes to individual species and factors contributing to the change. The results of Whillans' review are summarized in Table 5.

Current Fish Community

Leslie and Timmins (1992) captured 34 species of fish during larval fish surveys conducted between 1985 and 1987. Most fishes were caught in or adjacent to turbid, low gradient waters near submerged aquatic vegetation (SAV). In 1988, they found that alewife, a non-native species belonging to the family Clupeidae, comprised more than 70% of the larval fish population in the main body of the Harbour. Including the native gizzard shad, clupeids in total represented 85% of the larval fish catch. Leslie and Timmins (1992) also found 12 species of native cyprinids (minnows) but this group of fishes comprised less than 5% of the catch. The cyprinids were found in restricted areas and the authors suggested that uncommon cyprinids in the Harbour may be close to extinction. In the western section of the Harbour, Leslie and Timmins (1992) found sunfish (e.g. pumpkinseeds) to comprise between 5% and 26% of the larval catch amongst submerged vegetation.

Between 1988 and 1990, Randall et al. (1993) studied the relationship between macrohabitat conditions and fish in Hamilton Harbour and two other Areas of Concern (AOCs), the Bay of Quinte and Severn Sound. They found that fish biomass within the three AOCs were positively correlated with total phosphorus concentrations and suggested that eutrophication may be linked to fish biomass. Of the three areas, Hamilton Harbour had the highest biomass largely due to high abundance of common carp compared to low biomass in Matchedash Bay, Severn Sound. Despite habitat degradation, the nearshore zone in Hamilton Harbour was productive but the energy was being utilized by non-native and warmwater offshore species (Randall et al. 1993). Also, the structure of the fish community was most altered in the more degraded habitats; the number of top predators contributing to total biomass was lowest, the total number of species was low, and the percentage of non-native species contributing to total biomass was highest in Hamilton Harbour (Randall et al. 1993). Conversely, the percentage of total fish biomass comprised of top predators and native fish species was highest in the least degraded sites (e.g. Severn Sound). In Hamilton Harbour, alewife, carp and bullheads dominated the catch compared to yellow perch, pumpkinseed sunfish, and top predators in the Bay of Quinte and Severn Sound (Randall et al. 1993).

Randall et al. (1996) examined the relationship between fish production and SAV measured by percent cover in the littoral zones of Hamilton Harbour, the Bay of Quinte and three bays in Severn Sound. Fish production was found to be highest in littoral areas with abundant SAV compared to those with low percent cover. The frequency of fish in the catch that utilize submerged macrophytes during part of their life cycle was significantly lower in Hamilton Harbour, which had low macrophyte abundance compared to the other AOCs. Species that were found more frequently in the Bay of Quinte and Severn Sound than in Hamilton Harbour included yellow perch, pumpkinseed sunfish, bluegill sunfish, rock bass, black crappie, largemouth bass, golden shiner, and northern pike (Randall et al. 1996).

Near Shore Fish Community Monitoring

As part of the restoration program, DFO conducted a nearshore electrofishing survey and monitoring program in Hamilton Harbour between 1988 and 2006 following the protocols outlined in Valere (1996) and Brousseau et al. (2005). The field program was initiated in 1988 (Randall et al. 1993; Minns et al. 1994; Smokorowski et al. 1998) and involved sampling of the fish community, physical habitat and water quality parameters before (1988 and 1990) and after (1992-2006) habitat restoration projects at specific sites (Fig. 7). Smokorowski et al. (1998) summarized the results of the survey program for the period 1988 to 1997, and identified delisting targets for the fish community based on an Index of Biotic Integrity (IBI; Table7). Delisting targets for Hamilton Harbour are conservative and were based on values from four other less degraded AOCs (Minns et al. 1994; Smokorowski et al. 1998). Brousseau and Randall

(2008) reported on more recent survey data (1998-2006) including species-specific trends, assessment of long-term trends in the littoral zone, and AOC IBI comparisons.

The IBI developed for Great Lakes' littoral fish assemblages integrates the effects of four main factors, non-native fishes, water quality, physical habitat supply and the abundance of piscivores (Minns et al. 1994). IBI scores were calculated from 12 separate assemblage metrics based on the diversity and trophic characteristics of the fish community (Table 7). IBI metrics were standardized and summed to produce an IBI score that ranged between 0 and 100 and was indicative of ecosystem health (Minns et al. 1994) and habitat quality (Randall and Minns 2002). IBI scores were rated as very poor (0-20), poor (20-40), fair (40-60), good (60-80) and excellent (>80). Detailed information on the development of the Great Lakes IBI can be found in Minns et al. (1994).

Sampling occurred at 33 transects at eleven areas around the Harbour (Fig. 7) at varying annual intensity except along the industrialized south shore (e.g. Randle Reef) and Windermere Arm/Basin where the presence of contaminated sediments precluded sampling. Fish surveys were designed to determine fish community composition, abundance, biomass (kg) and species richness per transect. A Smith-Root SR20E electrofishing boat (length=6.1 m, beam=1.9m) generating 8 amperes of electricity sampled fishes at a 1.5-m depth parallel to the shoreline (Brousseau et al. 2005).

Fish Catches

Cumulatively (1988-2006), 46 species of fishes were captured by electrofishing in the Harbour, but the number of species (NSP) captured in any one year was less (e.g., 27 species in 2002, Table 6). Average NSP, which includes non-native species, at transects varied significantly (refers to statistical significance) among years (Brousseau and Randall 2008). In 2006, a NSP value of 5.5 was just under the delisting target of 6 to 7 species per 100 m transect. Native species richness was not as high and varied over time (Brousseau and Randall 2008). Mean native species richness dropped to three species per transect in 2002 but increased to four species per transect in 2006 (Table 7). The highest mean value for native species richness was 4.3 in 1998.

Two species of fish currently found in Hamilton are currently designated as species at risk (SAR); the American eel and bigmouth buffalo. The American eel has been listed with the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) as a species of Special Concern but with the implementation of the new Species at Risk Act in Ontario (2007), the Committee on the Status of Species at Risk in Ontario (COSSARO) has designated the species as Endangered (COSEWIC 2006; hhtp://www.mnr.gov.on.ca/mnr/speciesatrisk/review_overview.html). The current status of the American eel in the Harbour is unknown; eels were captured electrofishing in each year between 1988 and 1998 but they were not captured in 2002 and 2006. The American eel is currently not listed under the federal *Species at Risk Act* (SARA) but an assessment is underway. The status of the bigmouth buffalo is currently being assessed under Schedule 3 of the federal SARA and this species is listed as one of Special Concern (hhtp://www.cosewic.gc.ca; hhtp://www.sararegistry.gc.ca/status/status_e.cfm). Bigmouth buffalo were caught in the Harbour in 2002 and 2006 by DFO. This species is thought to be extending its range in the Great Lakes and the extent of the population in the Harbour remains unknown.

Mean total biomass and numbers per transect varied among years; numbers were at a minimum in 2002 and 2006 (Table 7) but total biomass (kg) exceeded delisting targets in 1988, 1990, 1996, 1997 and 2006; biomass was lowest in 1995. The spike in total biomass observed in 1996 and 1997 was directly related to common carp and was coincident with the opening and operation of the Cootes Paradise fishway. Common carp that resided or moved into Cootes Paradise were held at the barrier and returned to the Harbour. Mean total biomass (kg) declined after 1997 and currently, it is close to the delisting target. Biomass (kg) of individual fish species are listed in Table 8. Native fish biomass has increased since 1988 and was higher in 2002 and 2006 than the previous four surveys (Table 7). Native species that have made greater contributions to total biomass since 2002 include brown bullhead and gizzard shad. The mean percent biomass of native fishes in 2002 and 2006 was greater than 60% compared to 35% and 25% in 1988 and 1990, respectively.

In contrast to biomass, mean total numbers of fish per transect have decreased significantly both temporally and spatially (Brousseau and Randall 2008). Average catches in 2002 and 2006 were significantly lower than what they were in 1988 and 1990 (Table 7). Numerical catches of individual fish species are listed in Table 9. Individual species that contributed to the decline in total numbers in particular were alewife (Fig. 12), but also largemouth bass, carp, brown bullhead, emerald shiner, yellow perch, logperch and pumpkinseed sunfish (Table 9). Numbers of native fish also declined significantly after 1998 (Brousseau and Randall 2008). The average catch per transect ranged from 19 to 36 between 1988 and 1998; after 1998, native fish catches per transect averaged between 13 and 14 fishes. Examples of native fishes that declined in numbers in 2002 and 2006 were logperch (Fig. 14) and pumpkinseed sunfish (Fig. 13). Other species such as emerald shiners and largemouth bass also declined but to a lesser extent. Declines in small fishes may be related to cormorant predation (Brousseau and Randall 2008).

IBI Scores

The IBI score in Hamilton Harbour has changed significantly over time, and in general has increased (Fig. 8). In 2006, an IBI score of 40 (still a poor rating) was the highest average IBI score to date; the IBI score was significantly higher than it was in 1988 (30) and 1990 (30). Similarly, the IBI score adjusted for offshore fish species (IBI*) increased over time (Fig. 9); IBI* scores were higher in post-restoration years (1996-2006) than early years (Table 7). Since 1988, IBI scores have improved significantly, indicating that conditions in the Harbour have improved but average IBI values remain relatively low (Brousseau and Randall 2008).

Species groups

*Centrarchids***:** The number of centrarchid or sunfish species in the Harbour has varied significantly over time (Brousseau and Randall 2008). An increase in centrarchids since the mid-1990s may be the result of restoration efforts around Bayfront Park (1992), LaSalle Park (1996) and the Northeast shoreline/wildlife islands (1996) which have increased underwater physical habitat structure and macrophyte abundance for this type of species (Brousseau and Randall 2008). Pumpkinseed sunfish was the dominant, non-predatory centrarchid but catches of this species have declined significantly since 1998 (Fig. 13). The decrease in average centrarchid species richness per transect in recent years (Table 7) was in part, due to the decline in pumpkinseeds. For predatory centrarchids, largemouth bass were dominant ; however, numbers of largemouth bass declined significantly in 2006 but biomass reached a maximum (Fig. 10) (Brousseau and Randall 2008). Smallmouth bass biomass peaked in 1992 and since 1995 this species has rarely been caught electrofishing (Fig. 10). Other common centrarchid species included bluegill sunfish and rock bass. Rock bass were common in the catch but contributions to total biomass on average were less than 1% (Table 8). In 1995, bluegill began to appear frequently in the samples (Tables 8-9). Other centrarchids, black crappie and green sunfish were rare. At a larger scale and based on 2006 Near Shore Community Index Netting (NSCIN) surveys, Bowlby et al. (2007) found numbers of centrarchids (sunfish) to be relatively low compared to the Bay of Quinte and other inland lakes.

Native Cyprinid and Turbidity Intolerant Species: The number of native cyprinid (minnows) and turbidity intolerant (i.e. prefer clear water) species both varied significantly during the survey period (Brousseau and Randall 2008). In general, both the number of turbidity intolerant and native cyprinid species averaged less than one species per transect (Table 7). Native cyprinids are a small but important component of the Hamilton Harbour food web. Although, six species of cyprinids were caught by electrofishing between 1988 and 2006 they were still underrepresented with only two common species, emerald and spottail shiners. Emerald shiner abundance averaged from 1% to 23% of the total catch annually (Fig. 15); numbers averaged 11.9 per transect in 1990 but have since declined in abundance (Table 9). Spottail shiners were not as abundant and contributed from less than 1% to 5% (1998) of the total annual catch. The mean catch of turbidity intolerant species per transect has increased since 1996. In 2006, a marked increase in turbidity intolerant species was found at LaSalle Park and Carrolls Point due to higher catches of spottail shiners (Brousseau and Randall 2008).

Piscivores: Piscivores or top predators have made small contributions to total mean biomass in the Harbour (2.5 to 12.1%) annually (Table 7). The percentage of piscivore biomass in the catch changed significantly during the survey period (Brousseau and Randall 2008) but has remained below the delisting targets of 20-25%.; percent piscivores was highest in 1995 and lowest in 1988. Piscivores averaged only 5% of the total biomass per transect in 2006. Minns et al. (1994) suggested that piscivores should contribute to at least 20% of the total biomass in a balanced system. Most piscivores were caught in the west end of the Harbour where macrophytes were most abundant (Brousseau and Randall 2008).

Largemouth bass and northern pike were the key contributors to mean piscivore biomass and numbers in most years (Fig. 10). Largemouth bass were rare prior to 1995 but became more abundant in later years and may be related to increased macrophyte abundance resulting from habitat modifications or temperature changes. Numerically, largemouth bass have been the Harbour's top predator comprising between 4% and 13% of total catch in any year; in biomass, largemouth bass comprised between 5% and 6 %; 0.3 kg to 0.4 kg/transect annually (Table 8). Northern pike comprised about 4% of total biomass in 1990 (0.3 kg) but were less in other years. Smallmouth bass biomass has declined in the Harbour since the mid-1990s and other predators were rare in the catch or, like the American eel, have completely disappeared from the Harbour (Fig. 10). Based on the 2006 NSCIN trap net surveys, Bowlby et al. (2007) found the catch of northern pike encouraging but numbers of other piscivores (i.e. largemouth bass, smallmouth bass and walleye) were low compared to the Bay of Quinte (OMNR 2007).

Generalist: Generalist species biomass (e.g. omnivores like carp and bullhead) in the Harbour is high and exceeded the delisting targets of 10-30% in every year (Table 7). The percentage of generalists in the catch varied significantly among years and an average of 60% generalist biomass in recent years is not different from what it was in

1988 at the onset of the monitoring program (Table 7; Brousseau and Randall 2008). Generalist biomass was strongly linked with common carp biomass that contributed between 73% and 84% of total mean biomass in peak years (1996-7). The peak in the mid-1990s was concurrent with the establishment of the carp barrier to Cootes Paradise, which displaced carp from the wetland to Hamilton Harbour (Fig. 11). Despite a significant decline from the peak years to recent years (2002- 2006), carp still remain the key contributor to total biomass (Brousseau and Randall 2008). Goldfish, another non-native cyprinid, comprised less than 1% of total biomass in most years, but increased numerically in 2006 (Fig. 11).

Brown bullhead, sometimes referred to as catfish, were the other key contributors to generalist biomass. Bullhead biomass averaged between 0.4 kg (1995) and 2.8 kg (1988) per transect (Fig 11). Biomass (kg) was significantly higher in 2002 and 2006 than in previous years, forming between 17% and 23 % of the total catch (Brousseau and Randall 2008). Trap net surveys carried out concurrently with electrofishing surveys in 2006 found bullheads to be the dominant species forming 78% of the catch (Bowlby et al. 2007). Randall et al. (1993) found that the biomass of generalists was highest in the most degraded environments (e.g. Hamilton Harbour) affected by eutrophication.

Specialists: Specialists are fishes with specialized feeding habits and are classified as planktivores, invertivores, or insectivores. Non-native and offshore species (e.g., alewife, gizzard shad and white perch) form the largest percentage of specialist biomass in the Harbour compared to native, nearshore specialists like white sucker, yellow perch and sunfish (e.g. pumpkinseed, rock bass). The average percentage of specialists in the catch remained below the delisting targets of 50-60% in recent surveys (Table 7).

The percentage of specialists in the Harbour catch has decreased significantly since 1995 (Table 7) concurrent with a decline in alewife (Fig. 12). However, an increase in percent specialists was noted in 2006 (Brousseau and Randall 2008), mainly due to an increase in gizzard shad, a native offshore specialist, that comprised close to 20% of total biomass (Fig. 12). White perch was the other key, offshore specialist in the electrofishing catch (Fig. 12). Numerically, white perch was the third most abundant fish in the 2006 OMNR trap surveys (Bowlby et al. 2007) and also comprised a large proportion of offshore trawl catches in the Harbour in 2006 (Doka et al. 2007). Collectively, alewife, gizzard shad and white perch, made up the largest contribution to offshore biomass in the harbour averaging between 31% and 63% in any given year. The high proportion of offshore, native species is not found in any other areas surveyed by DFO using the electrofishing protocol described in Brousseau et al. (2005).

Yellow perch, the dominant percid in the near shore zone, and logperch are native specialists. Numbers and biomass of yellow perch were significantly higher in the period between 1998 and 2006 than before, forming between 4% and 13% of the total catch (Tables 8-9). Since 1995, logperch have been a key component of the catch but due to their small size contribute only a small percentage (<1%) to total biomass. Both percid species peaked in numbers and biomass in 1998 (Fig. 14). NSCIN surveys conducted in 2006 found yellow perch to be virtually absent from Hamilton Harbour unlike the Bay of Quinte, Toronto Harbour and other inland lakes (Bowlby et al. 2007; OMNR 2007).

Non-native species : The number of non-native species in the catch changed significantly during the survey period (Brousseau and Randall 2008). In Hamilton Harbour, non-native or invasive fish species included the common carp, goldfish, alewife, white perch, rainbow smelt, round goby, sea lamprey, rudd and several introduced salmonids (Table 6). On average, the number of non-indigenous species per transect was between 1.5 and 2.2 (Table 7) forming between 32% and 68% of the catch in any given year. Both percent number and biomass (Table 7) of non-indigenous fish have decreased significantly over time (Brousseau and Randall 2008). Between 1988 and 1998, the biomass of non-native species was higher (57% and 68%) than the more recent catches (about 36%). Although carp continue to be the key contributor to total biomass at Hamilton, they were rarely caught electrofishing by DFO (2002-2007) in other areas (Brousseau and Randall 2008). Goldfish catches in the Harbour were higher in 2006 than in any other year (Fig. 11).

Habitat Restoration

Despite restoration of fish habitat at many locations in the Harbour, no differences were found in the IBI scores between the restoration (1996-2006) and unaltered (1988, 1990) habitats (Fig. 16). The IBI and IBI* scores were not significantly different between the two habitat types (Brousseau and Randall 2008). Most metric scores from both unaltered and restored areas increased over time; positive changes in IBI scores from both types of habitat between 1988 and 2006 were significant (Brousseau and Randall 2008).

For the years immediately following restoration efforts (1996 and 1997), IBI scores and individual metrics increased at the restoration sites (Fig. 16). However, the values declined again in the two subsequent surveys before increasing again in 2006. In an earlier report (Smokorowski et al. 1998), a significant increase in IBI scores between pre- and post-restoration periods was attributed to changes in native and centrarchid species richness, piscivores, generalists, native fish biomass, and percent non-indigenous fish by numbers and biomass. Since then, centrarchid species richness, the proportion of piscivores, and abundance of native species have declined; some metrics have declined back to pre-restoration values. Native species richness and percent generalists remained stable with similar values in 2006 to post construction (1996 and 1997) values. In 2006, there were only three metrics distinctly different between the two areas; percent generalists were notably higher at the non-altered sites, while specialists (positive) and the number of turbidity intolerant species (positive) were higher at the restoration sites. Metrics that showed similar patterns among years regardless of habitat type included non-indigenous species richness, and native cyprinid species richness. Prior to the creation of the wildlife islands, there were no macrophytes along the sand-silt shoreline that was frequently disrupted by wind turbulence. The creation of islands and increased habitat diversity and shelter may be responsible for the increase in specialists at restoration sites.

Fish Summary

After 15 years of restoration activities, the state of the fishery in Hamilton Harbour has improved but IBI scores are still lower than at other AOCs and the fish community continues to reflect an unhealthy ecosystem. The current structure of the fish assemblage reflects a shortage of high quality habitat in the littoral zone (Minns et al. 2004) containing a diversity of substrate and macrophytes; the percentage of littoral piscivores, native cyprinids, centrarchids and percids was lower than elsewhere. Comparison of IBI metrics to those from other AOCs, examination of trends over time in individual species and the results of the OMNR's NSCIN program also indicated that the state of the fish community was poor. The composition of the offshore component of the IBI score was found to be mainly comprised of non-native species. For this reason, the current IBI score adjusted for offshore species (IBI*) was a better measure of the status of the Harbour's fish community.

Increases in macrophyte growth and diversity may create more spawning and nursery habitat for certain native species. For many species, like native cyprinids and centrarchids, there is still relatively little suitable habitat. Poor water quality persists and significant improvements are required before physical and environmental habitat conditions will be suitable to improve conditions for native fishes. The capping of Randle Reef, to commence in the near future, will reduce the leakage of toxic chemicals into the Harbour but the effect on the fish community is unknown. None of the other Canadian AOCs studied by GLLFAS within DFO have been exposed to the same degree of industrial disturbance and contamination. It is unknown how eutrophication problems associated with waste water treatment facilities will be resolved in the near future but plans for enhanced treatment at local WWTP are encouraging.

Other Relevant Work and Conclusions

There are several ongoing projects of relevance to assessments of habitat and fishes in Hamilton Harbour that are funded by the Great Lakes Action Plan (GLAP), in addition to the work reported above on SAV and nearshore fish surveys (Doka *et al.*

2007). These projects include an acoustic assessment of fish in the Harbour, describing the trophic structure and development of an ecosystem model, classification and supply analysis of fish habitat, and fish habitat-population modelling. The latter two projects may be of particular interest to recommendations that arise from this comprehensive study report.

Relevant features of the Hamilton Harbour physical environment such as substrate, vegetation, and water depths have classically been used in habitat supply estimates for fish guilds and populations (Minns *et al.* 1996, W.F. Baird Associates 1996). Work on fish habitat mapping and supply has already been mentioned with regard to substrate distributions and SAV surveys. This basic approach will be extended to include relevant features about the spatial and temporal dynamics of oxygen and temperature in the Harbour as well. Statistical analysis and predictive models will be used to generate spatial layers representing the current physical status of the Harbour. These layers will be used in classifying habitat suitability for different fish guilds that use the area (e.g. warmwater piscivores with similar life histories). In this way, habitat supply can be quantified and comparisons between different habitat restoration scenarios (e.g. capping of Randle Reef) can be evaluated for their relative contribution to overall habitat availability in the system. Time permitting, an evaluation of the current situation against historic habitat availability will allow a comparison of relative gains with overall historic losses for perspective.

Selected population models have been developed that expand on the initial work by Minns *et al.* (1996, Doka 2004, Chu *et al.* 2005). The models will be modified to respond to key factors and habitat availability in the Harbour so that habitat supply estimates can be scaled up to gauge population level impacts. In this way the delisting criteria that are set for water quality (e.g. dissolved oxygen) and for SAV targets can be evaluated against their impact on sport fish populations.

Both submerged aquatic vegetation and fish community trends are positive for Hamilton Harbour. Using an adaptive management approach and the results of projects currently underway, it is theoretically possible to triage different management strategies proposed for continuing to improve the quality of aquatic habitat based on their relative impact to the whole system. With continued monitoring, predictions can be validated, improved, and the efficacy of habitat restoration can be evaluated. In this way, Hamilton Harbour would be an excellent case study to be used for other AOCs around the Great Lakes.

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Table 1. Mean bottom cover and maximum depth of colonization when bottom cover is >0 from echosounding surveys 1992 to 2006.

	Mean Bottom % Cover						Max.Depth for Bottom Cover >0, m					
Transect	1992	1993	1994	1995	1996	2006*	1992	1993	1994	1995	1996	2006*
1	10	3	6		6	21	1.9	1.7	2.0		2.0	1.7
2	15	25	0	1	1	1	2.0	1.0		1.2	1.4	1.1
3	12	2	20	28	22	72	2.5	1.3	1.9	1.8	2.3	2.6
4	23	1	4	8	19	71	2.8	2.0	1.8	2.0	2.3	2.7
5	53	54	32	49	48	81	1.8	1.9	1.8	1.8	1.9	2.9
6	30	24	57	38	44	55	1.9	1.9	2.0	1.7	3.3	3.3
7	38	43	46	24	65	79	2.2	2.0	1.9	1.9	2.5	3.4
8	50	81	59	72	73	79	2.8	2.5	2.2	2.3	2.9	3.2
9	52	49	69	69	68	76	2.6	2.2	2.9	2.3	2.7	3.1
10		83	77	70	76	87		2.9	2.5	2.0	2.8	2.8
11	34	66	86	48	84	69	2.7	1.1	2.3	2.0	2.0	2.1
12	58	68	30	12	42	75	2.3	1.6	2.3	1.3	1.8	2.8
13	15	20	16	27	26	51	2.8	2.1	2.5	2.1	1.8	3.0
14		54	42	57	60	64		2.2	2.1	1.9	2.0	2.8
15	68	70	0	79	89	59	2.1	2.3		1.7	2.0	1.9
16	5	2	9	7	8	0	3.1	1.4	1.5	1.4	2.5	0.0
18	0	0	54	0	0	25			1.9	2.3		2.2
18_2	0	2	0	21	0			2.9	2.5	1.6	2.4	
19	39	21	15	6	3	79	2.7	2.1	2.2	1.6	1.2	3.3
20	35	18	24	28	19	68	2.5	2.3	2.7	2.5	1.7	3.1
21		80	12	3	7	0		4.3	1.8	3.3	3.5	0.0
23	30	54		95	80		3.0	2.1		2.7	3.4	
24		0	47	17	29	74			3.5	3.3	3.0	2.1
25		0	8	23	58	36			1.9	2.3	2.2	3.0
26	74	15		86	83	63	2.9	2.1		2.4	3.4	2.7
28	27	16		30	28	54	2.7	3.3		4.1	1.1	3.5
29		0		0	0	95						2.6
30	0	0		0	0	0						0.0
31	54	2	4	4	49	16	2.0	3.4	1.5	1.5	1.3	2.0
32	0	0	0	0	0	3						2.8
33	13	0		0	4	8	1.9				1.0	2.5
34	10	0	1	2	0	23	1.8		1.5	1.5		2.3
35	0	5	20	5	6	24		2.0	1.9	2.0	1.6	2.4

* echosounding equipment and analysis procedures had changed by the 2006 survey

Table 2. SAV percent cover from electrofishing transects in Hamilton Harbour, 1990 to 2006. Codes are N = none, S = sparse (1 to 19%), M = moderate (20 to 70%) and D = dense (>70%). The A transects are those that were added after restoration activities in the area.

Transect	1990	1991	1992	1993*	1993	1995	1997	1998	2001	2002	2006
1						5	S		S		
2	5	2		23	0					M	M
3			N			0			S		
4	0			0	0					M	M
5			S			0			N		
6	1	0		11	0					M	D
7						0	N		N		
8	0			0	0					M	M
9						0			S	S	M
10	2			0	0					M	M
10A										S	
11									S	M	M
11A										M	
12	0			0	0					N	M
12A										M	
13			N			0			N		
14	0			0	0				S	M	M
15						0	S		S		
16	0			17	5				N	M	M
17										D	M
18	27	95		100	92				M	D	S
19						42			M	M	M
20	79				85					D	M
21			M			47			S		
22	3	28		96	89					M	M
23						36	M		N		
24	5			21	3				N	M	M
25						83	D		S		
26	35	89		100	90					M	S
27			D			81			N		
28	27	60		100	72				S	M	D
29						1	S		S		
30	0			0	0					N	N
31						2			S		
32	0			2	0				N	N	N
33						0	N		M		
34/34A	7			5	9			S		M	M
35			S			15			M		
36/36A	5	0			22			M	S	M	M
37						61			M	D	D
38	23				27					D	D
39						100			M	D	D
40	6	2	S								
41A									D		
41B					12			S	N	D	D
42/42A				0	0	0			M	D	S
42B					18				M	M	M
43/43A				0	0	0			M		
43B					38					M	S
44				71	26				M	D	D
45									M	M	S

* echogram interpretation

Table 3. Submerged SAV presence in Hamilton Harbour, 1987 to 2006.

Species or Genus	Common Name	1987	1990	1991	2001a	2001b	2002	2006	2006b
Chara sp.	Musk Grass		P						
Nymphaea odorata	White Waterlily				P				
Vallisneria americana	Tape Grass	P	P	P	P	P	P	P	P
Elodea canadensis	Waterweed	P	P	P		P	P	P	P
Zosterella dubia	Mud-plantain	P	P		P		P		
Naja sp.	Water-nymph						P		P
Potamogeton amphifolius	Big-leaf Pondweed		P	P					
Potamogeton crispus	Curly-leaf Pondweed		P	P		P			
Potamogeton gramineus	Variable Pondweed		P						
Potamogeton richardsonii	Clasping-leaf Pondweed		P			P		P	
Potamogeton sp.	Pondweeds			P	P		P		P
Broadleaf Potamogeton	Pondweeds						P		P
Narrowleaf Potamogeton	Pondweeds							P	P
Stuckenia pectinata	Sago Pondweed	P	P			P			
Ceratophyllum demersum	Coontail		P		P	P	P	P	P
Myriophyllum spicatum	Eurasian milfoil	P	P	P	P	P	P	P	P
Myriophyllum sp.	Milfoil				P		P		P
Unknown			P	P					P

Sources:
1987: Stage 1 RAP Report
1990, 1991: Minns et al., 1993
2001a, 2002, 2006b: electrofishing dataset
2001b: Thÿsmeÿer and Cleveland, 2001
2006: Leisti, 2008

Table 4. List of 63 species found in Hamilton Harbour and status from 1859 to the time of publication (adapted from Whillans and Holmes 1984)

Scientific name	Common name	Historic status
Petromyzon marinus	sea lamprey	rare
Acipenser fulvescens	lake sturgeon	extirpated (common 1860s)
Lepisosteus osseus	longnose gar	rare
Amia calva	bowfin	rare (common 1890s)
Alosa pseudoharangus	alewife	abundant
Dorosoma cepedianum	gizzard shad	abundant
Coregonus alpenae	longjaw cisco	extirpated
Coregonus artedi	lake herring (cisco)	rare (abundant 1900)
Coregonus hoyi	bloater	extirpated
Coregonus kiyi	kiyi	extirpated
Coregonus nigripinnis	blackfin cisco	extirpated
Coregonus reighardi	shortnose cisco	extirpated
Coregonus zenithicus	shortjaw cisco	extirpated
Coregonus clupeaformis	lake whitefish	extirpated (abundant 1860-80s)
Prosopium cylindraceum	round whitefish	extirpated
Oncorhynchus kisutch	coho salmon	rare
Oncorhynchus mykiss (Salmo gairdneri)	rainbow trout	very low
Salmo salar	Atlantic salmon	extirpated (abundant 1810-30s)
Salvelinus fontinalis	brook trout	rare
Salvelinus namaycush	lake trout	rare (common 1860s)
Osmerus mordax	rainbow smelt	abundant
Hiodon tergisus	mooneye	extirpated (low 1890s)
Esox lucius	northern pike	common (abundant 1800-70s)
Esox masquinongy	muskellunge	rare (abundant 1860-70s)
Carpiodes cyprinus	quillback	rare
Catastomus commersoni	white sucker	common (abundant 1860-80s)
Moxostoma macrolepidotum	shorthead redhorse	low
*Cyprinella spiloptera (*formerly *Notropis spilopgteus)*	spotfin shiner	common
Carassius auratus	goldfish	abundant
Cyprinus carpio	carp	abundant
C. carpio x *C. auratus*	carp/goldfish hybrid	abundant
*Phoxinus eos (*formerly *Chrosomus)*	northern redbelly dace	low
Clinostomus elongatus	redside dace	low
Notemigonus crysoleucas	golden shiner	common
Notropis atherinoides	emerald shiner	common
*Luxilus cornutus (*formerly *Notropis)*	common shiner	low
Notropis heterodon	blackchin shiner	rare
Notropis heterolepis	blacknose shiner	common
Notropis hudsonius	spottail shiner	common
Notropis stramineus	sand shiner	rare
Notropis volucellus	mimic shiner	low
Pimephales notatus	bluntnose minnow	common
Pimephales promelas	fathead minnow	low
Rhinichthys atratulus	blacknose dace	low
Rhinichthys cataractae	longnose dace	low
*Ameiurus nebulosus (*formerly *Ictalurus)*	brown bullhead	low (abundant 1800s)

Scientific name	Common name	Historic status
Ictalurus punctatus	channel catfish	low (abundant 1800s)
Noturus flavus	stonecat	rare
Noturus gyrinus	tadpole madtom	rare
Anguilla rostrata	American eel	extirpated? (abundant 1860-70s)
Fundulus diaphanus	banded killifish	extirpated?
Lota lota	burbot	rare (abundant 1860s)
Culaea inconstans	brook stickleback	rare
Gasterosteus aculeatus	threespine stickleback	rare
Percopsis omiscomaycus	trout-perch	no status
Morone americana	white perch	abundant
Morone chrysops	white bass	common
Morone saxatilus	striped bass	extirpated (last seen in 1881)
Ambloplites rupestris	rock bass	rare (common 1890s)
Lepomis gibbosus	pumpkinseed	common (abundant 1870s)
Lepomis macrochirus	bluegill sunfish	common (abundant 1870s)
Micropterus dolomieu	smallmouth bass	common (1850-60s)
Micropterus salmoides	largemouth bass	rare (1850-60s)
Pomoxis annularis	white crappie	low
Pomoxis nigromaculatus	Black crappie	low (common 1890s)
Perca flavescens	yellow perch	common (abundant 1860s)
*Sander vitreus (*formerly *Stizostedion vitreum)*	walleye	rare (abundant 1860s)
*Sander vitreus glaucus (*formerly *S. vitreum glaucum)*	blue pike	extirpated ? (abundant 1860s)
Sander canadense	sauger	extirpated ? (abundant 1860s)
Etheostoma nigrum	johnny darter	low
Etheostoma microperca	least darter	low
Percina caprodes	logperch	low
Labidesthes sicculus	brook silverside	low
Aplodinotus grunniens	freshwater drum	rare (abundant 1890s)
Cottus cognatus	slimy sculpin	rare

Table 5. Transformations in the Hamilton Harbour fish community and factors contributing to the changes between 1859 and 1970 (Whillans 1979).

Period	Transformation	Factors
1959-1877	• Change in six species; decline in four offshore migrants (herring, lake whitefish, lake trout and lake sturgeon), increase in alewife an non-native species and decline in one near shore species (northern pike)	• Loss of spawning and adult habitat through shoreline alterations, removal of substrates, deforestation and damning of rivers • Heavy exploitation for subsistence and commercial fisheries using gill and seine nets • Introduction of a non-native species
1878-1892	• Disappearance of Atlantic salmon • Further decline of offshore migrants: herring, lake whitefish, trout and sturgeon • Decline of four near shore species; smallmouth bass, largemouth bass, northern pike and rock bass	• Heavy exploitation of both the cold and warm water fisheries • Loss of an important prey item for lake whitefish, *Ponteporeia affinis* • Discontinuation of Atlantic salmon stocking • Water pollution (municipal sewage)
1892-1898	• Further decline of herring, lake whitefish and trout • Increases in brown bullhead, American eel, yellow perch, largemouth bass, smallmouth bass, bowfin and freshwater drum	• Heavy exploitation of offshore migrants • Increase in near shore predators may have resulted from the decline in offshore predators and/or eutrophication creating more favourable conditions for near shore species • Usually warm temperatures in 1894 and 1898 may have produced strong year classes
1906-1943	• Introduction of common carp • Decline in smallmouth bass • Increase in northern pike • Decrease in walleye, rock bass, white sucker and largemouth bass	• Introduction of a non-native species • Major restructuring along the south shore destroys a large area of smallmouth bass habitat • Intense sport fishery for smallmouth bass • Habitat degradation due to urban runoff, dredging, increase water depth and fluctuations (subsequent reduction in macrophytes), thermal pollution and eutrophication
1938-1955 (overlaps with	• Increase in abundance of three exotic species (rainbow smelt, rainbow trout and carp) and	• Increase in water turbidity due to the spawning and foraging activities of carp and water fluctuations led to a significant reduction in emergent

Period	Transformation	Factors
previous period	white sucker • Decline in bullheads, American eel, yellow perch, pumpkinseed sunfish and black crappie	macrophyte coverage • Increase in water quality in Cootes Paradise offset by decrease in water quality in the Harbour (industrial and municipal impacts)
1960-1961	• Disappearance of coldwater fishery • Significant decline in bullheads, yellow perch, bowfin, black crappie and common carp • Increase in goldfish and white bass	• Significant decrease in water levels and subsequent decline in submerged macrophyte coverage • Increase in non-native species
1962-1970 (approximate)	• Decrease in white bass • Improved status of northern pike, bullheads, yellow perch, smallmouth bass, pumpkinseed, black crappie, white perch, carp, and carp/goldfish hybrid	• Increased water levels • Increased eutrophication of Cootes Paradise

Table 6. List of 49 species captured in Hamilton Harbour (x) boat electrofishing (1988-2006) with the addition of multiple gear types in 2006. Species status was indicated as native (N), invasive/non-native (INV), introduced (I) or species at risk (SAR).

Scientific name	Common name	Status	1988	1990	1992	1995	1996	1997	1998	2002	2006*
Petromyzon marinus	sea lamprey	INV									x
Lepisosteus osseus	longnose gar	N	x	x							x
Amia calva	bowfin	N	x			x	x	x	x	x	x
Alosa pseudoharangus	alewife	INV	x	x	x	x	x	x	x	x	x
Dorosoma cepedianum	gizzard shad	N	x	x	x	x	x	x	x	x	x
Oncorhynchus tshawytscha	Chinook salmon	I	x	x	x	x	x	x	x		x
Oncorhynchus mykiss	rainbow trout	I		x	x	x	x		x	x	x
Salmo trutta	brown trout	I		x	x	x	x		x	x	
Salvelinus namaycush	lake trout	N	x	x		x			x		x
Osmerus mordax	rainbow smelt	INV	x	x	x	x		x			x
Esox lucius	northern pike	N	x	x	x	x	x	x	x	x	x
Catostomus commersoni	white sucker	N	x	x	x	x	x	x	x	x	x
Ictiobus cyprinellus	bigmouth buffalo	N, SAR								x	x
Moxostoma anisurum	silver redhorse	N							x		
Moxostoma macrolepidotum	shorthead redhorse	N									x
Carassius auratus	goldfish	INV	x	x	x	x	x	x	x	x	x
Cyprinus carpio	common carp	INV	x	x	x	x	x	x	x	x	x
Notemigonus crysoleucas	golden shiner	N								x	x
Notropis atherinoides	emerald shiner	N	x	x	x	x	x	x	x	x	x
Luxilus cornutus	common shiner	N								x	
Notropis hudsonius	spottail shiner	N	x	x	x	x	x	x	x	x	x
Pimephales notatus	bluntnose minnow	N					x		x	x	x
Pimephales promelas	fathead minnow	N						x			x
Rhinichthys atratulus	blacknose dace	N									x
Scardinius erythrophthalmus	rudd	INV									x
Ameiurus melas	black bullhead	N								x	x
Ameiurus nebulosus	brown bullhead	N	x	x	x	x	x	x	x	x	x

Scientific name	Common name	Status	1988	1990	1992	1995	1996	1997	1998	2002	2006*
Ictalurus punctatus	channel catfish	N								x	x
Noturus gyrinus	tadpole madtom	N									x
Anguilla rostrata	American eel	N, SAR	x	x	x	x	x	x	x		
Culaea inconstans	brook stickleback	N									x
Gasterosteus aculeatus	threespine stickleback	N				x	x	x		x	x
Percopsis omiscomaycus	trout-perch	N			x			x	x		x
Morone americana	white perch	INV	x	x	x	x	x	x	x	x	x
Morone chrysops	white bass	N	x	x				x			x
Ambloplites rupestris	rock bass	N	x		x	x	x	x	x	x	x
Lepomis cyanellus	green sunfish	N									x
Lepomis gibbosus	pumpkinseed	N	x	x	x	x	x	x	x	x	x
Lepomis macrochirus	bluegill sunfish	N			x	x	x	x	x	x	x
Micropterus dolomieu	smallmouth bass	N	x	x	x	x	x	x	x	x	x
Micropterus salmoides	largemouth bass	N	x	x	x	x	x	x	x	x	x
Pomoxis nigromaculatus	black crappie	N	x	x	x	x	x	x	x	x	x
Perca flavescens	yellow perch	N	x	x	x	x	x	x	x	x	x
Sander vitreus	walleye	N			x				x		x
Etheostoma nigrum	johnny darter	N	x				x	x	x		
Percina caprodes	logperch	N			x	x	x	x	x	x	x
Labidesthes sicculus	brook silverside	N				x					x
Neogobius melanostomus	round goby	INV								x	x
Aplodinotus grunniens	freshwater drum	N	x	x	x	x	x	x	x	x	x

Table 7. Average biomass, catch in numbers, species richness and metrics of IBI by year of survey.

Metric name	Influence on IBI	Target	1988	1990	1992	1995	1996	1997	1998	2002	2006
Biomass (kg)		6-7 kg	11.4	9.0	6.4	5.1	10.4	9.5	7.7	6.1	7.5
Numbers			79.6	55.1	27.5	49.8	46.5	32.8	55.3	28.4	20.5
Species richness		6-7 species	5.0	4.0	4.8	5.0	5.9	5.4	6.0	4.5	5.6
Native species richness	Positive		2.8	2.1	2.9	3.3	3.8	4.0	4.3	3.0	4.0
Centrarchid species richness	Positive		0.5	0.4	0.8	1.3	1.5	1.2	1.3	1.1	1.0
Turbidity intolerant species richness	Positive		0.2	0.0	0.3	0.2	0.6	0.5	0.4	0.3	0.5
Non-indigenous species richness	Negative		2.2	1.9	1.9	1.7	2.0	1.4	1.7	1.5	1.6
Native cyprinid species richness	Positive		0.6	0.5	0.8	0.5	0.7	1.0	0.7	0.2	0.6
Percent piscivore biomass	Positive	20-25%	2.5	9.0	12.1	12.1	8.9	7.4	4.5	5.9	5.0
Percent generalist biomass	Negative	10-30%	53.5	45.0	42.4	34.3	59.2	56.9	59.7	57.8	55.6
Percent specialist biomass	Positive	50-60%	42.4	44.4	43.7	51.7	31.9	31.8	32.5	32.0	39.4
Number of native individuals	Positive		22.7	21.7	8.8	19.5	19.4	20.5	36.3	12.7	13.9
Biomass of natives (kg)	Positive		3.7	3.1	1.6	1.4	1.9	1.3	1.6	2.7	3.3
Percent non-indigenous species by number	Negative		65.7	58.5	54.1	56.2	49.4	33.4	32.0	41.8	31.8
Percent non-indigenous species by biomass	Negative		64.3	62.1	61.9	61.1	70.3	58.0	57.2	36.0	35.6
Percent offshore species by number			62.7	49.2	44.4	60.2	43.7	31.4	46.2	36.0	36.8
Percent offshore species by number			35.4	34.7	29.8	43.2	19.6	14.9	23.4	17.9	25.2
IBI		55-60	29.6	29.7	33.4	36.0	35.6	37.1	37.7	34.1	40.1
Adjusted IBI*		50-60	15.0	17.4	20.5	18.9	25.2	28.2	24.2	25.2	27.1
Sample size			189	64	53	55	89	75	89	94	62

Table 8. Mean biomass and standard error (SE) of fish (kg) by species and year captured at transects electrofishing in Hamilton Harbour.

	1988		1990		1992		1995		1996		1997		1998		2002		2006	
Scientific name	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Petromyzon marinus	0.000		0.000		0.000		0.000		0.000		0.000		0.000		0.000		0.001	0.00
Lepisosteus osseus	0.004	0.00	0.009	0.01	0.000		0.000		0.000		0.000		0.000		0.000		0.000	
Amia calva	0.015	0.01	0.000		0.000		0.009	0.01	0.033	0.02	0.064	0.05	0.044	0.03	0.045	0.03	0.042	0.04
Alosa pseudoharangus	0.999	0.10	0.670	0.12	0.353	0.09	0.738	0.13	0.534	0.11	0.150	0.05	0.367	0.06	0.293	0.06	0.055	0.02
Dorosoma cepedianum	0.313	0.05	0.163	0.06	0.040	0.02	0.106	0.04	0.101	0.07	0.015	0.01	0.044	0.02	0.257	0.08	1.332	0.39
Oncorhynchus tshawytscha	0.002	0.00	0.001	0.00	0.001	0.00	0.000	0.00	0.001	0.00	0.000	0.00	0.000	0.00	0.000		0.000	
Oncorhynchus mykiss	0.000		0.001	0.00	0.001	0.00	0.003	0.00	0.030	0.03	0.000		0.009	0.01	0.001	0.00	0.000	
Salmo trutta	0.000		0.001	0.00	0.244	0.09	0.058	0.05	0.049	0.03	0.000	0.00	0.003	0.00	0.001	0.00	0.000	
Salvelinus namaycush	0.014	0.01	0.046	0.05	0.000		0.043	0.04	0.000		0.000		0.035	0.03	0.000		0.000	
Osmerus mordax	0.000	0.00	0.002	0.00	0.001	0.00	0.001	0.00	0.000		0.000	0.00	0.000		0.000		0.000	
Esox lucius	0.041	0.03	0.321	0.19	0.099	0.06	0.032	0.03	0.110	0.05	0.093	0.07	0.066	0.05	0.007	0.01	0.019	0.02
Catastomus commersoni	0.168	0.04	0.333	0.13	0.577	0.18	0.215	0.06	0.286	0.08	0.137	0.10	0.073	0.03	0.187	0.10	0.103	0.03
Ictiobus cyprinellus	0.000		0.000		0.000		0.000		0.000		0.000		0.000		0.055	0.05	0.000	
Moxostoma anisurum	0.000		0.000		0.000		0.000		0.000		0.000		0.014	0.01	0.000		0.000	
Moxostoma macrolepidotum	0.000		0.000		0.000		0.000		0.000		0.000		0.000		0.000		0.000	
Carassius auratus	0.171	0.04	0.084	0.03	0.047	0.03	0.017	0.02	0.023	0.02	0.012	0.01	0.031	0.02	0.039	0.02	0.262	0.08
Cyprinus carpio	5.997	0.64	4.938	1.10	3.763	0.89	2.751	0.76	7.626	0.90	7.956	1.63	5.513	0.88	2.862	0.61	3.676	0.79
Notemigonus crysoleucas	0.000		0.000		0.000		0.000		0.000		0.000		0.000		0.000		0.000	0.00
Notropis atherinoides	0.018	0.00	0.052	0.01	0.020	0.01	0.005	0.00	0.006	0.00	0.013	0.00	0.006	0.00	0.001	0.00	0.003	0.00
Luxilus cornutus	0.000		0.000		0.000		0.000		0.000		0.000		0.000		0.000		0.000	
Notropis hudsonius	0.003	0.00	0.000	0.00	0.007	0.00	0.001	0.00	0.007	0.00	0.004	0.00	0.015	0.01	0.001	0.00	0.004	0.00
Pimephales notatus	0.000		0.000		0.000		0.000		0.000		0.000		0.000	0.00	0.000		0.000	
Pimephales promelas	0.000		0.000		0.000		0.000		0.000		0.000		0.000		0.000		0.000	
Ameiurus melas	0.000		0.000		0.000		0.000		0.000		0.000		0.000		0.008	0.01	0.000	
Ameiurus nebulosus	2.770	0.37	1.902	0.64	0.283	0.06	0.353	0.09	0.546	0.10	0.499	0.10	0.729	0.12	1.424	0.16	1.261	0.17
Ictalurus punctatus	0.000		0.000		0.000		0.000		0.000		0.000		0.000		0.014	0.01	0.000	
Noturus gyrinus	0.000		0.000		0.000		0.000		0.000		0.000		0.000		0.000		0.000	

	1988		1990		1992		1995		1996		1997		1998		2002		2006	
Scientific name	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Anguilla rostrata	0.049	0.02	0.059	0.03	0.062	0.04	0.086	0.05	0.306	0.10	0.073	0.03	0.067	0.04	0.000		0.000	
Gasterosteus aculeatus	0.000		0.000		0.000		0.000	0.00	0.001	0.00	0.000	0.00	0.000		0.000	0.00	0.000	
Percopsis omiscomaycus	0.000	0.00	0.000		0.000	0.00	0.000		0.000		0.000	0.00	0.000		0.000		0.000	
Morone americana	0.461	0.07	0.186	0.05	0.297	0.10	0.118	0.03	0.199	0.04	0.172	0.04	0.130	0.02	0.161	0.04	0.139	0.03
Morone chrysops	0.046	0.02	0.004	0.00	0.000		0.000		0.000		0.006	0.01	0.000		0.000		0.000	
Ambloplites rupestris	0.002	0.00	0.000		0.011	0.01	0.032	0.01	0.029	0.01	0.033	0.01	0.023	0.01	0.049	0.01	0.035	0.01
Lepomis cyanellus	0.000		0.000		0.000		0.000		0.000		0.000		0.000		0.000		0.000	
Lepomis gibbosus	0.048	0.01	0.029	0.01	0.058	0.02	0.210	0.05	0.143	0.03	0.104	0.02	0.142	0.03	0.061	0.02	0.008	0.00
Lepomis macrochirus	0.000		0.000		0.000		0.004	0.00	0.003	0.00	0.003	0.00	0.007	0.00	0.023	0.01	0.013	0.01
Micropterus dolomieu	0.056	0.02	0.017	0.01	0.150	0.09	0.079	0.07	0.019	0.01	0.000		0.002	0.00	0.001	0.00	0.000	
Micropterus salmoides	0.051	0.02	0.074	0.05	0.074	0.04	0.116	0.05	0.073	0.02	0.134	0.04	0.088	0.04	0.344	0.10	0.359	0.11
Pomoxis nigromaculatus	0.003	0.00	0.000		0.004	0.00	0.012	0.01	0.002	0.00	0.002	0.00	0.000	0.00	0.005	0.00	0.000	
Perca flavescens	0.083	0.02	0.006	0.00	0.008	0.00	0.034	0.01	0.032	0.01	0.017	0.01	0.135	0.03	0.058	0.01	0.076	0.01
Sander vitreus	0.000		0.000		0.014	0.01	0.000		0.000		0.000		0.006	0.01	0.000		0.000	
Etheostoma nigrum	0.000	0.00	0.000		0.000	0.00	0.000		0.000	0.00	0.000	0.00	0.000	0.00	0.000		0.000	
Percina caprodes	0.000		0.000		0.001	0.00	0.009	0.00	0.017	0.00	0.014	0.00	0.086	0.02	0.001	0.00	0.009	0.00
Labidesthes sicculus	0.000		0.000		0.000		0.000		0.000		0.000		0.000		0.000		0.000	
Neogobius melanostomus	0.000		0.000		0.000		0.000		0.000		0.000		0.000		0.003	0.00	0.001	0.00
Aplodinotus grunniens	0.054	0.02	0.110	0.06	0.152	0.09	0.027	0.02	0.213	0.09	0.106	0.06	0.033	0.02	0.190	0.06	0.069	0.04
Sample size	189		64		53		55		89		75		89		94		63	
Number of species	26		23		26		27		26		27		29		27		21	
Total mean biomass (kg)	11.4	0.8	9.0	1.5	6.4	1.0	5.1	0.8	10.4	0.9	9.6	1.6	7.7	0.9	6.1	0.6	7.5	1.0

Table 9. Mean number and standard error (SE) of fish by species and year captured at transects electrofishing in Hamilton Harbour.

	1988		1990		1992		1995		1996		1997		1998		2002		2006	
Scientific name	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Petromyzon marinus	0.000		0.000		0.000		0.000		0.000		0.000		0.000		0.000		0.016	0.02
Lepisosteus osseus	0.005	0.01	0.016	0.02	0.000		0.000		0.000		0.000		0.000		0.000		0.000	
Amia calva	0.005	0.01	0.000		0.000		0.018	0.02	0.022	0.02	0.027	0.02	0.022	0.02	0.032	0.02	0.016	0.02
Alosa pseudoharangus	48.97	4.34	29.30	4.98	12.96	3.16	27.80	5.07	20.93	4.43	6.413	1.92	14.73	2.52	12.56	2.77	1.581	0.46
Dorosoma cepedianum	0.503	0.07	0.203	0.07	0.396	0.21	2.727	1.84	0.292	0.16	0.253	0.11	0.180	0.07	0.500	0.13	1.806	0.47
Oncorhynchus tshawytscha	0.185	0.05	0.094	0.05	0.094	0.05	0.036	0.03	0.067	0.04	0.027	0.02	0.034	0.03	0.000		0.000	
Oncorhynchus mykiss	0.000		0.141	0.11	0.019	0.02	0.073	0.06	0.056	0.03	0.000		0.101	0.04	0.032	0.02	0.000	
Salmo trutta	0.000		0.016	0.02	0.170	0.07	0.091	0.05	0.034	0.02	0.013	0.01	0.056	0.03	0.021	0.02	0.000	
Salvelinus namaycush	0.005	0.02	0.016	0.02	0.000		0.018	0.02	0.000		0.000		0.011	0.01	0.000		0.000	
Osmerus mordax	0.021	0.01	0.156	0.07	0.094	0.06	0.073	0.04	0.000		0.027	0.02	0.000		0.000		0.000	
Esox lucius	0.016	0.01	0.094	0.05	0.057	0.03	0.018	0.02	0.067	0.03	0.053	0.03	0.022	0.02	0.011	0.01	0.016	0.02
Catastomus commersoni	0.392	0.09	0.469	0.14	0.906	0.26	0.509	0.13	0.506	0.12	0.280	0.14	0.180	0.06	0.245	0.10	0.661	0.22
Ictiobus cyprinellus	0.000		0.000		0.000		0.000		0.000		0.000		0.000		0.032	0.02	0.000	
Moxostoma anisurum	0.000		0.000		0.000		0.000		0.000		0.000		0.011	0.01	0.000		0.000	
Moxostoma macrolepidotum	0.000		0.000		0.000		0.000		0.000		0.000		0.000		0.000		0.000	
Carassius auratus	0.190	0.04	0.125	0.05	0.057	0.04	0.018	0.02	0.034	0.02	0.013	0.01	0.034	0.02	0.032	0.02	0.484	0.13
Cyprinus carpio	2.048	0.21	1.375	0.26	1.170	0.31	0.582	0.13	1.899	0.23	2.560	0.53	1.742	0.26	0.691	0.13	0.968	0.22
Notemigonus crysoleucas	0.000		0.000		0.000		0.000		0.000		0.000		0.000		0.000		0.016	0.02
Notropis atherinoides	3.169	0.65	11.91	3.17	3.283	0.74	1.618	0.42	2.404	0.84	7.253	1.89	2.202	0.57	0.117	0.05	1.016	0.30
Luxilus cornutus	0.000		0.000		0.000		0.000		0.000		0.000		0.000		0.000		0.000	
Notropis hudsonius	0.455	0.10	0.062	0.06	0.717	0.23	0.636	0.42	1.337	0.38	1.080	0.30	2.685	1.72	0.181	0.07	0.597	0.18
Pimephales notatus	0.000		0.000		0.000		0.000		0.000		0.000		0.011	0.01	0.000		0.000	
Pimephales promelas	0.000		0.000		0.000		0.000		0.000		0.000		0.000		0.000		0.000	
Ameiurus melas	0.000		0.000		0.000		0.000		0.000		0.000		0.000		0.021	0.01	0.000	
Ameiurus nebulosus	15.33	2.12	7.844	2.64	1.226	0.26	1.709	0.44	2.337	0.44	2.040	0.39	4.494	0.73	5.436	0.70	4.032	0.60
Ictalurus punctatus	0.000		0.000		0.000		0.000		0.000		0.000		0.000		0.011	0.01	0.000	
Noturus gyrinus	0.000		0.000		0.000		0.000		0.000		0.000		0.000		0.000		0.000	

	1988		1990		1992		1995		1996		1997		1998		2002		2006	
Scientific name	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Anguilla rostrata	0.037	0.01	0.078	0.03	0.038	0.03	0.073	0.04	0.270	0.10	0.080	0.03	0.045	0.02	0.000		0.000	
Gasterosteus aculeatus	0.000		0.000		0.000		0.018	0.02	0.270	0.11	0.080	0.04	0.000		0.021	0.01	0.000	
Percopsis omiscomaycus	0.005	0.01	0.000		0.019	0.02	0.000		0.000		0.040	0.02	0.000		0.000		0.000	
Morone americana	5.487	0.94	2.328	0.52	4.170	1.37	1.691	0.38	4.045	0.78	3.400	0.66	2.371	0.42	2.074	0.47	3.548	0.75
Morone chrysops	0.190	0.06	0.016	0.02	0.000		0.000		0.000		0.013	0.01	0.000		0.000		0.000	
Ambloplites rupestris	0.021	0.01	0.000		0.094	0.06	0.218	0.09	0.326	0.09	0.333	0.10	0.191	0.06	0.340	0.07	0.258	0.07
Lepomis cyanellus	0.000		0.000		0.000		0.000		0.000		0.000		0.000		0.000		0.000	
Lepomis gibbosus	1.042	0.24	0.516	0.20	1.094	0.29	7.582	2.00	6.764	1.23	3.867	0.87	10.764	2.46	1.989	0.46	0.565	0.25
Lepomis macrochirus	0.000		0.000		0.019	0.02	0.200	0.08	0.213	0.07	0.133	0.06	0.225	0.10	0.745	0.20	0.484	0.16
Micropterus dolomieu	0.132	0.04	0.031	0.02	0.283	0.13	0.127	0.09	0.090	0.06	0.000		0.011	0.01	0.021	0.02	0.000	
Micropterus salmoides	0.090	0.03	0.125	0.05	0.189	0.05	2.618	1.01	2.281	0.52	1.307	0.37	1.618	0.30	1.521	0.34	0.726	0.24
Pomoxis nigromaculatus	0.011	0.01	0.000		0.038	0.03	0.073	0.06	0.011	0.01	0.027	0.02	0.011	0.01	0.043	0.02	0.000	
Perca flavescens	1.159	0.23	0.078	0.04	0.132	0.06	0.564	0.18	0.461	0.14	0.573	0.19	3.910	0.83	1.255	0.23	2.758	0.51
Sander vitreus	0.000		0.000		0.038	0.04	0.000		0.000		0.000		0.011	0.01	0.000		0.000	
Etheostoma nigrum	0.005	0.01	0.000		0.000		0.000		0.112	0.05	0.013	0.01	0.022	0.02	0.000		0.000	
Percina caprodes	0.000		0.000		0.057	0.04	0.636	0.26	1.506	0.44	2.600	0.87	9.618	2.19	0.106	0.05	0.855	0.25
Labidesthes sicculus	0.000		0.000		0.000		0.000		0.000		0.000		0.000		0.000		0.000	
Neogobius melanostomus	0.000		0.000		0.000		0.000		0.000		0.000		0.000		0.287	0.11	0.081	0.04
Aplodinotus grunniens	0.074	0.02	0.062	0.03	0.094	0.05	0.036	0.03	0.101	0.04	0.080	0.04	0.022	0.02	0.096	0.03	0.048	0.03
Sample size	189		64		53		55		89		75		89		94		62	
Number of species	26		23		26		27		26		27		29		27		21	
Total mean numbers	79.6	5.2	55.1	6.4	27.5	4.4	49.8	5.4	46.5	4.9	32.6	3.5	55.4	5.3	28.5	2.9	20.5	1.5

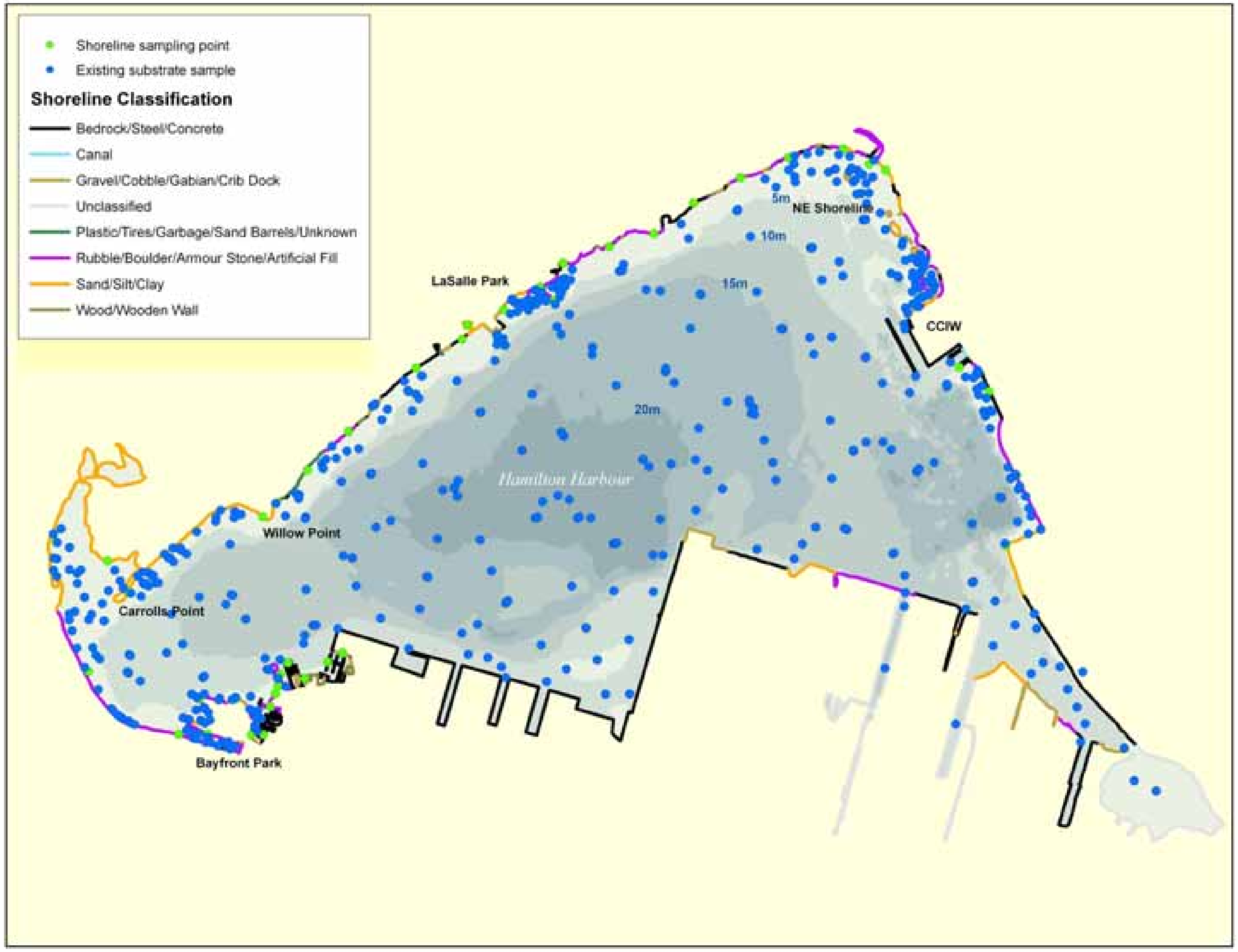


Figure 1. Shoreline survey results, shoreline sample points and historic substrate sample points for Hamilton Harbour. Historic substrate sites throughout the bay will be used to validate multi-beam information from partners.

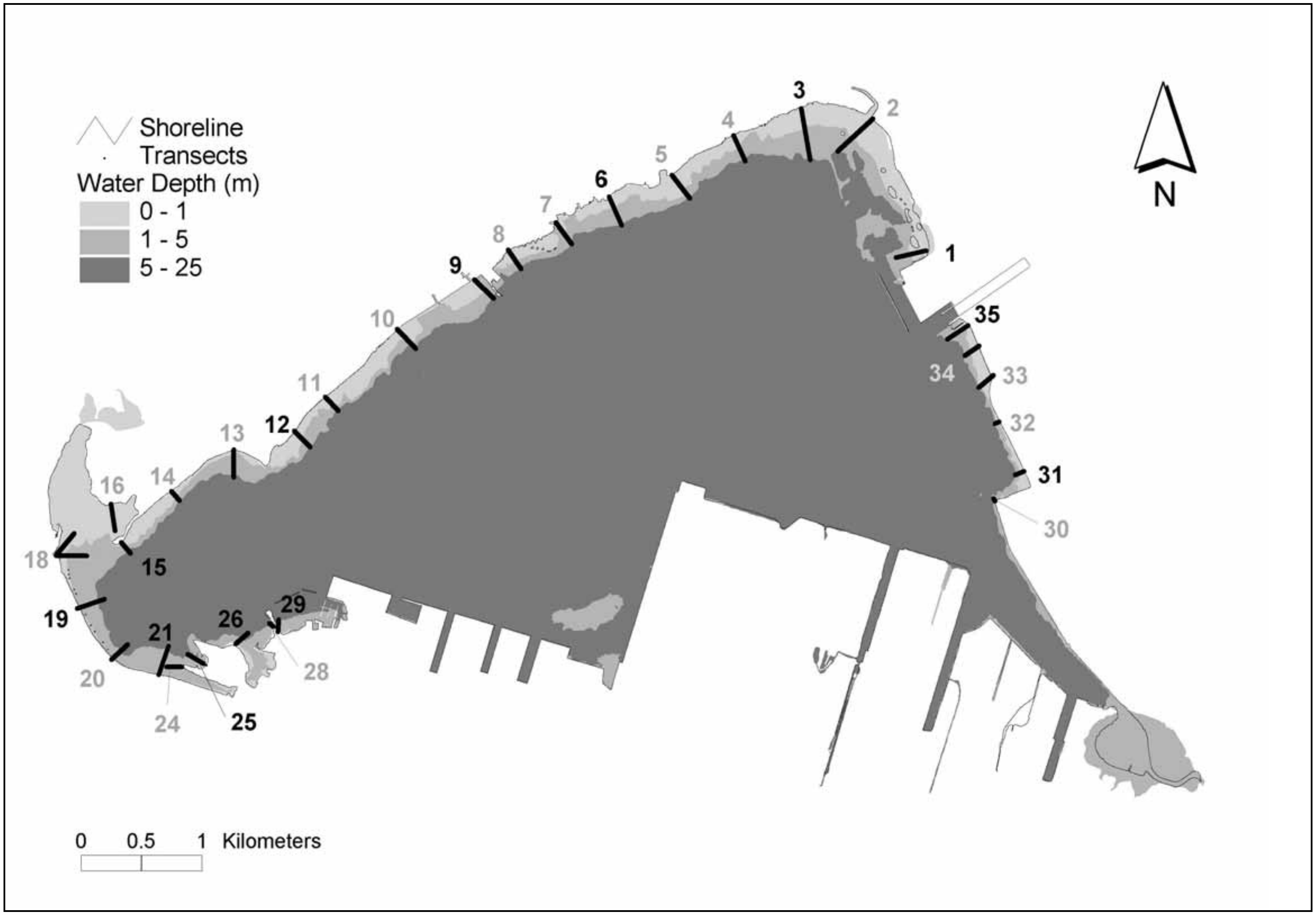


Figure 2. Hamilton Harbour SAV echosounding transects for the 1992 to 2006 surveys. Transect numbers in black represent those transects sampled by divers for biomass and species composition in 2006.

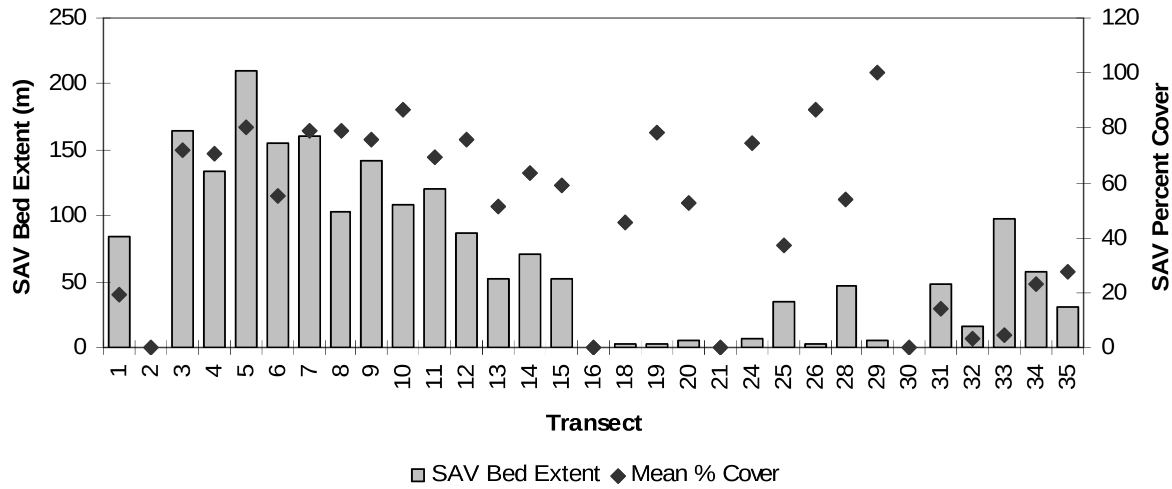


Figure 3. Percent cover and SAV bed extent from the 2006 echosounding survey.

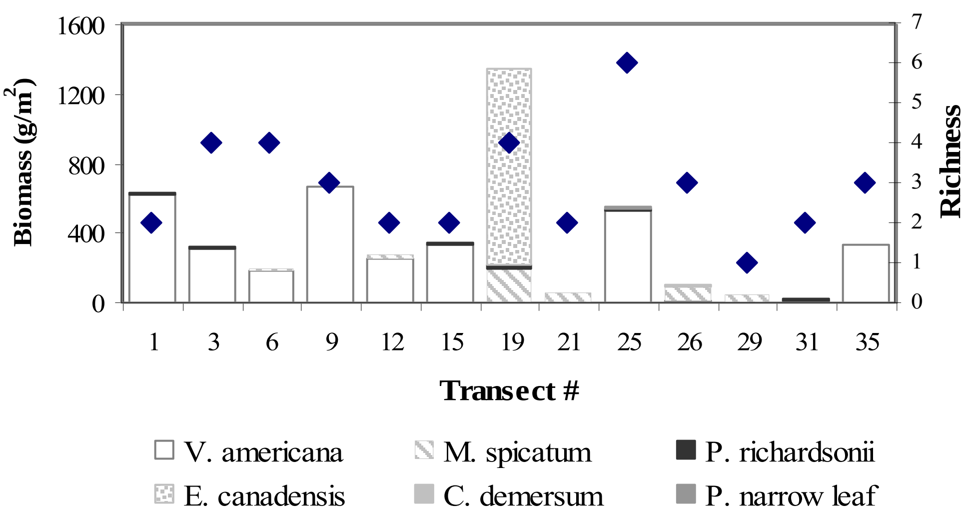


Figure 4. 2006 mean SAV biomass by species for reference transects. Diamond points show richness by transect.

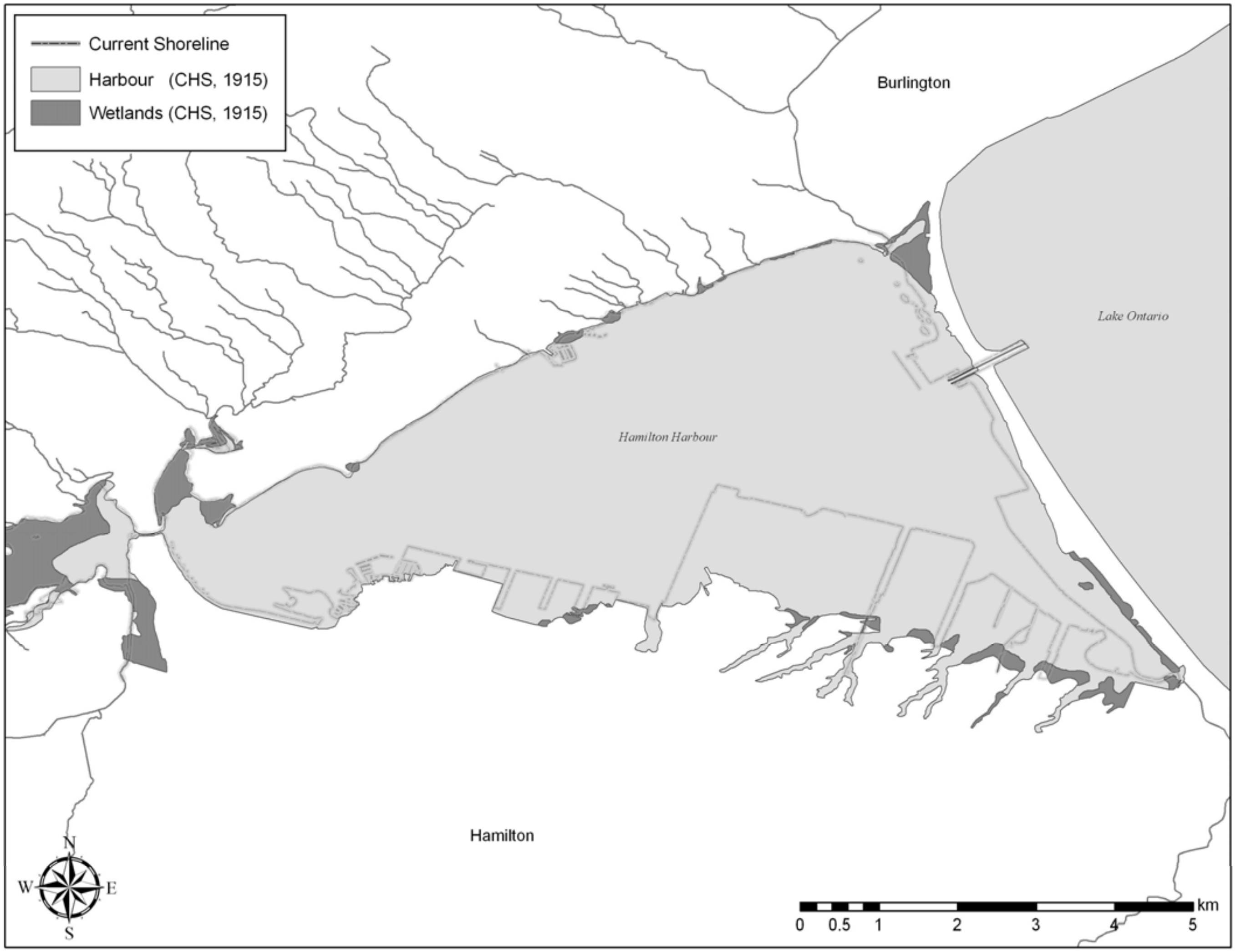


Figure 5. Hamilton Harbour shoreline and wetland map based on the Canadian Hydrographic Services 1915 map. The current shoreline is also shown to illustrate Harbour infilling.

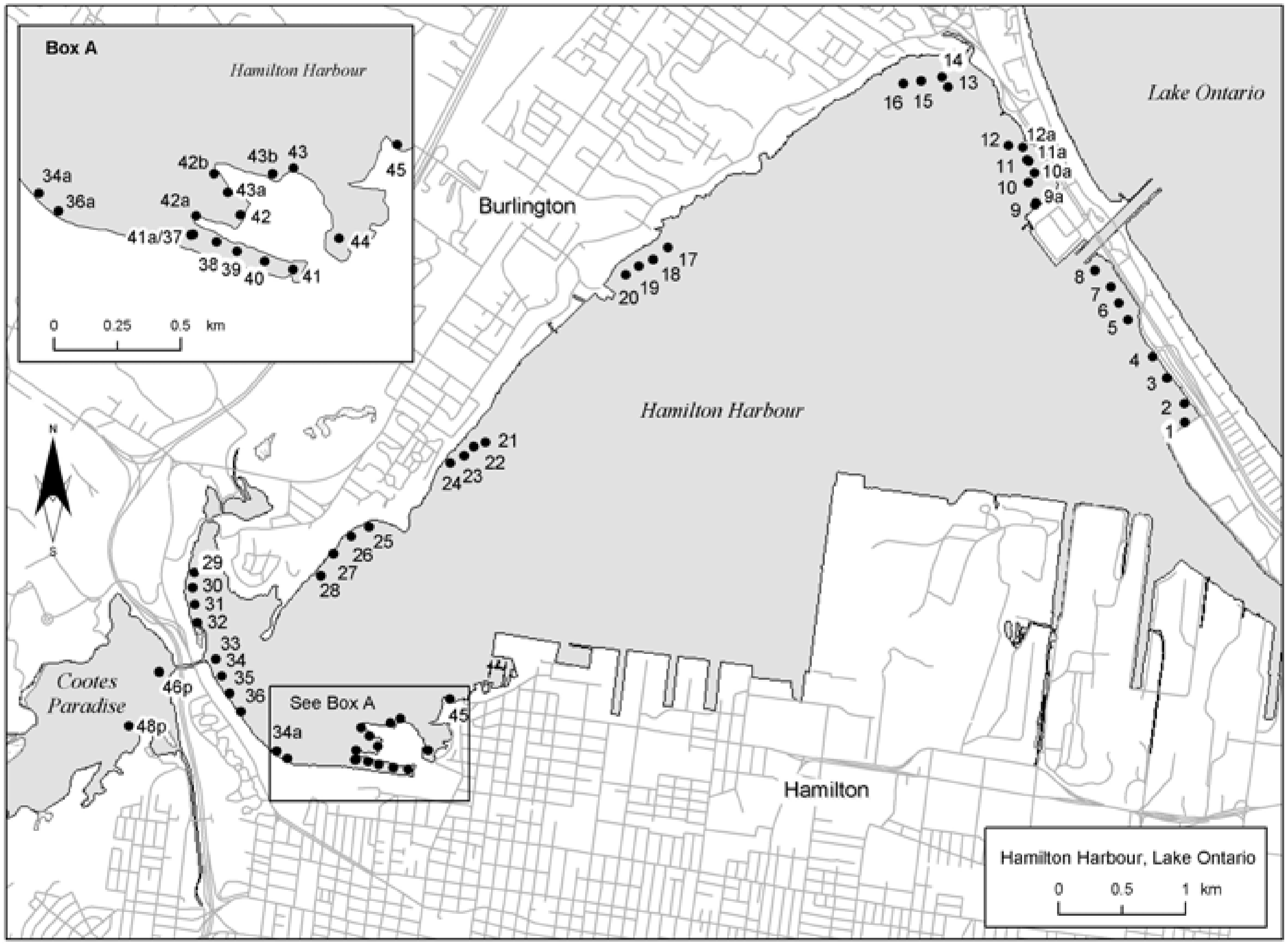


Figure 6. Electrofishing transect locations where visual assessment of SAV cover was conducted.

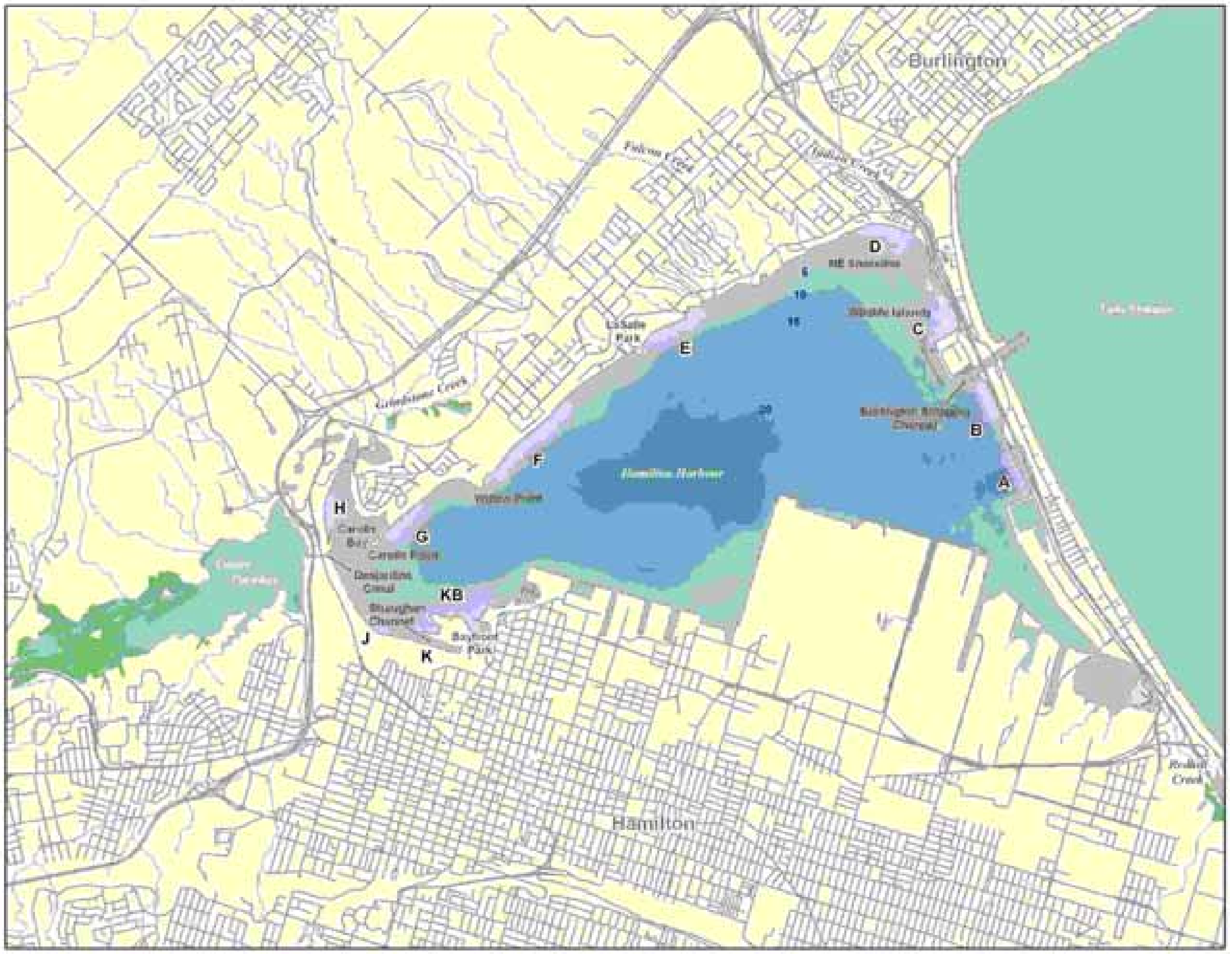


Figure 7. Electrofishing survey areas (A through KB) in Hamilton Harbour. Restoration sites, in order of chronology, were Bayfront Park (area KB), wildlife islands (area C), LaSalle Park (area E) and West Harbour Waterfront Trail (area J).

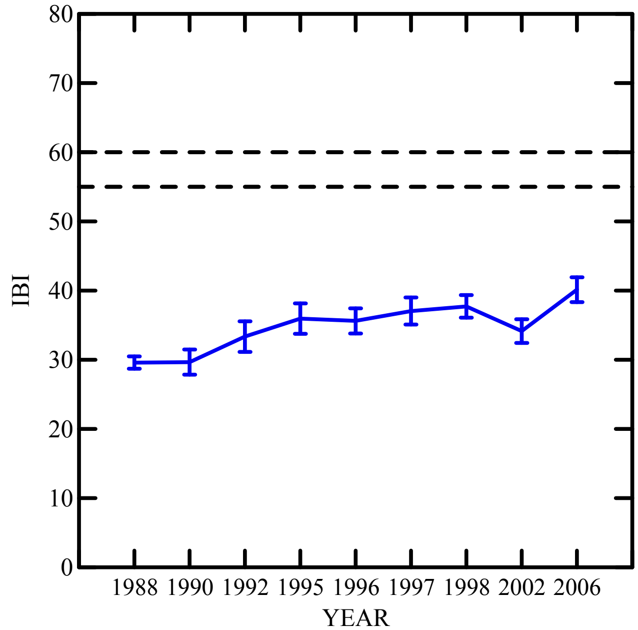


Figure 8. Average IBI score in Hamilton Harbour (± SE) for the survey years 1988 to 2006 representing an average for all transects. Horizontal reference lines (dashed) in this and following figures indicate delisting targets for Hamilton Harbour (see Table 4).

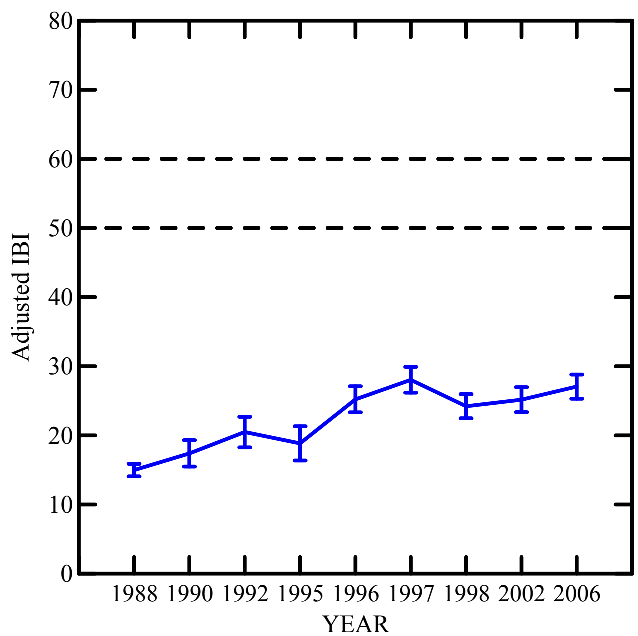


Figure 9. Average adjusted IBI score in Hamilton Harbour (± SE) for the survey years 1988 to 2006 representing an average for all transects.

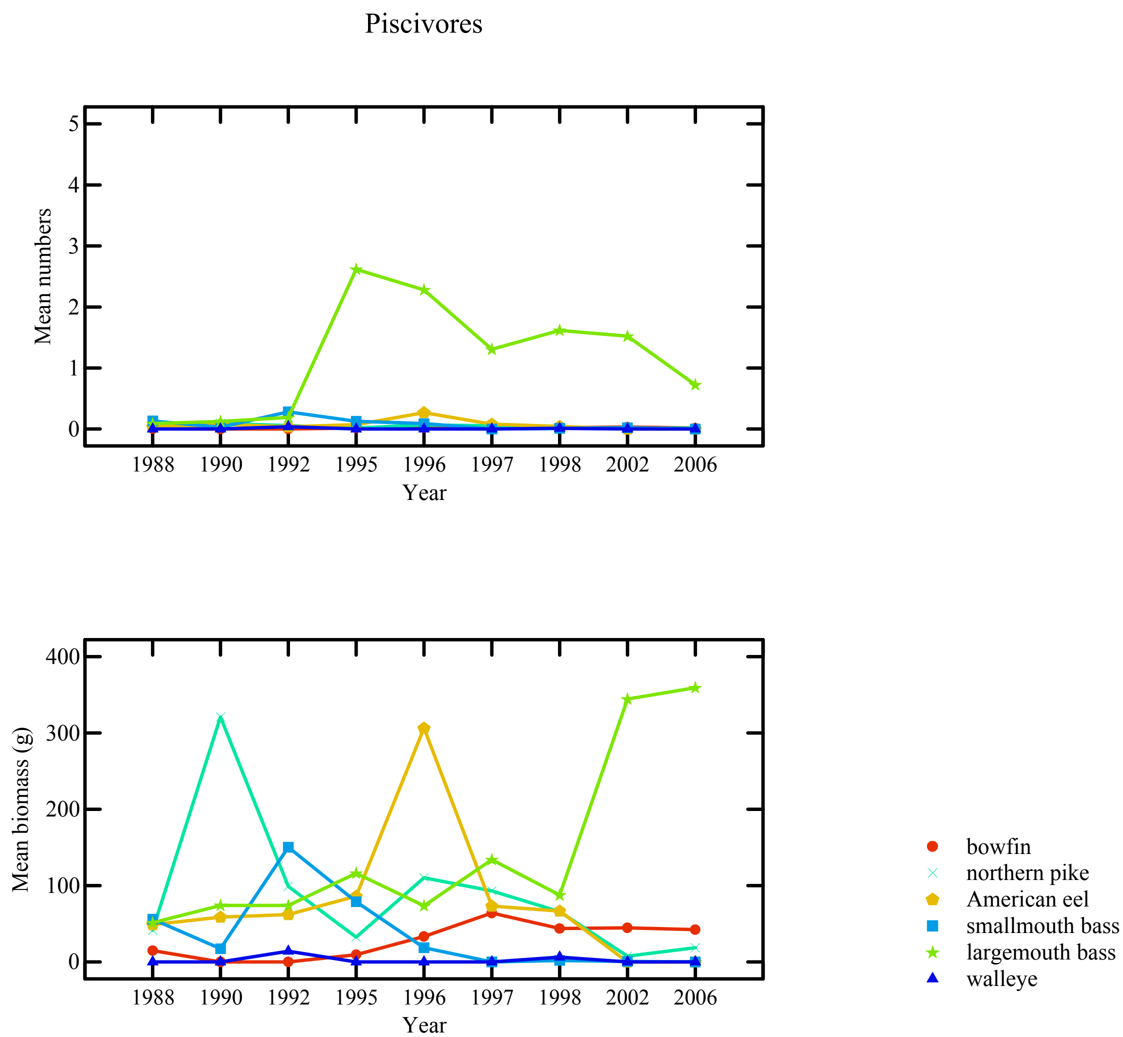


Figure 10. Trends in mean piscivore numbers (top) and biomass, grams (bottom) per transect over time. Piscivores, excluding those belonging to Salmonidae, included bowfin, northern pike, American eel, smallmouth bass, largemouth bass and walleye.

Generalists

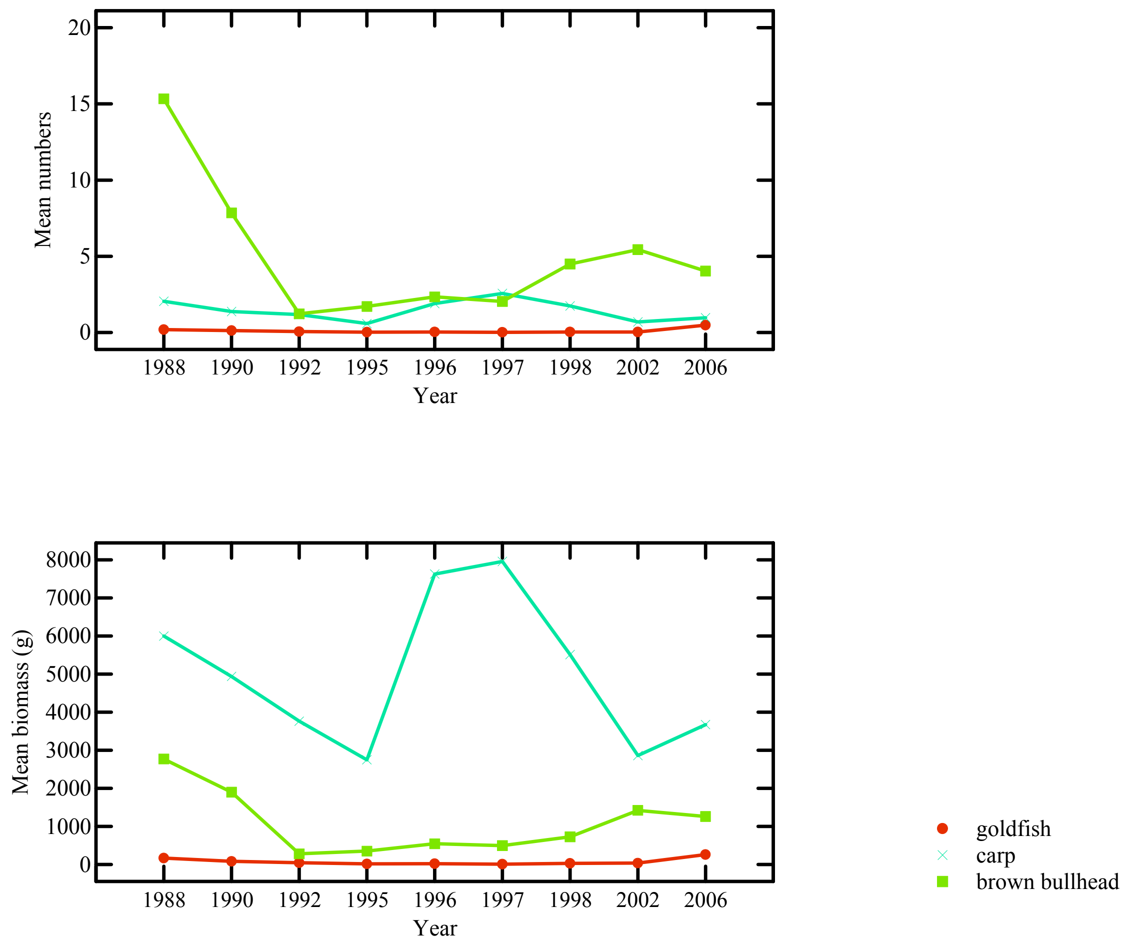
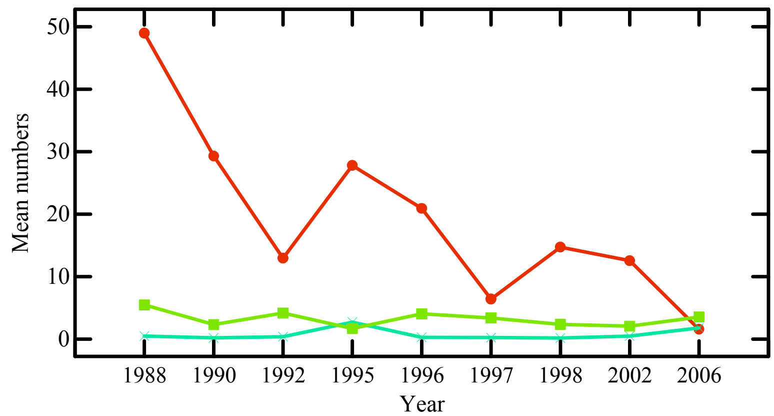


Figure 11. Trends in common generalist numbers (top) and biomass, grams (bottom) per transect over time. Species included are goldfish, carp and brown bullhead.

Offshore species



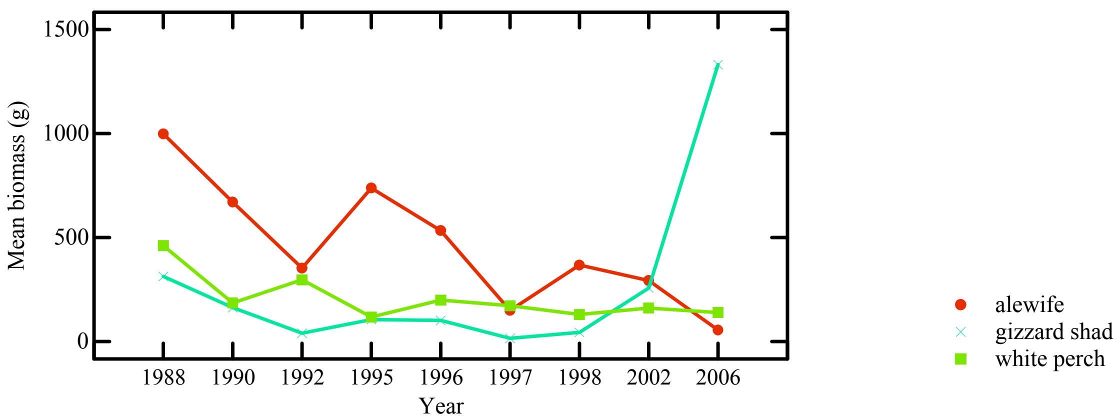


Figure 12. Trends in mean offshore species numbers (top) and biomass, grams (bottom) per transect over time. Common species included alewife, gizzard shad and white perch.

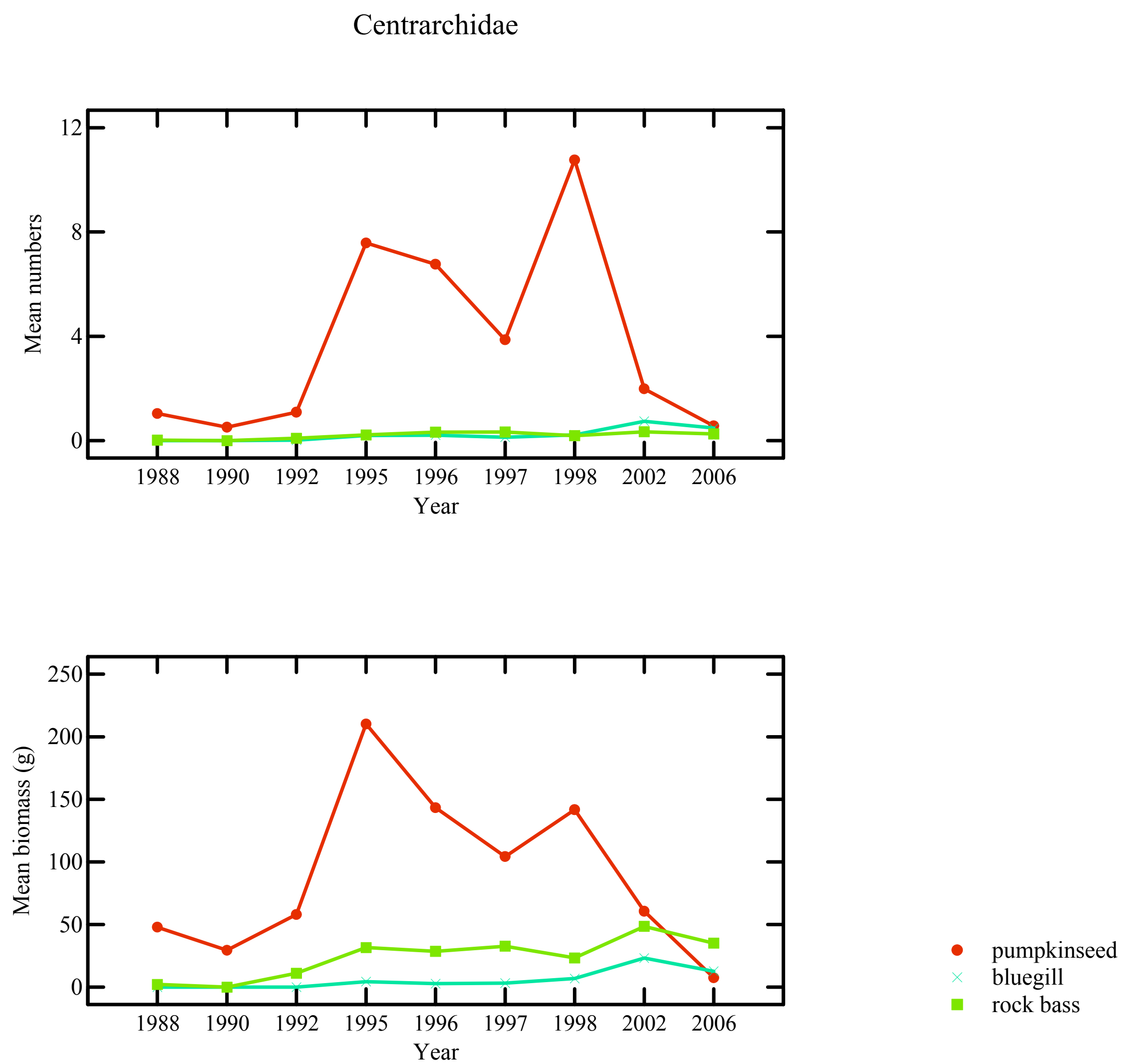


Figure 13. Trends in common centrarchid species numbers (top) and biomass, grams (bottom) per transect over time. Common species included pumpkinseed, rock bass and bluegill.

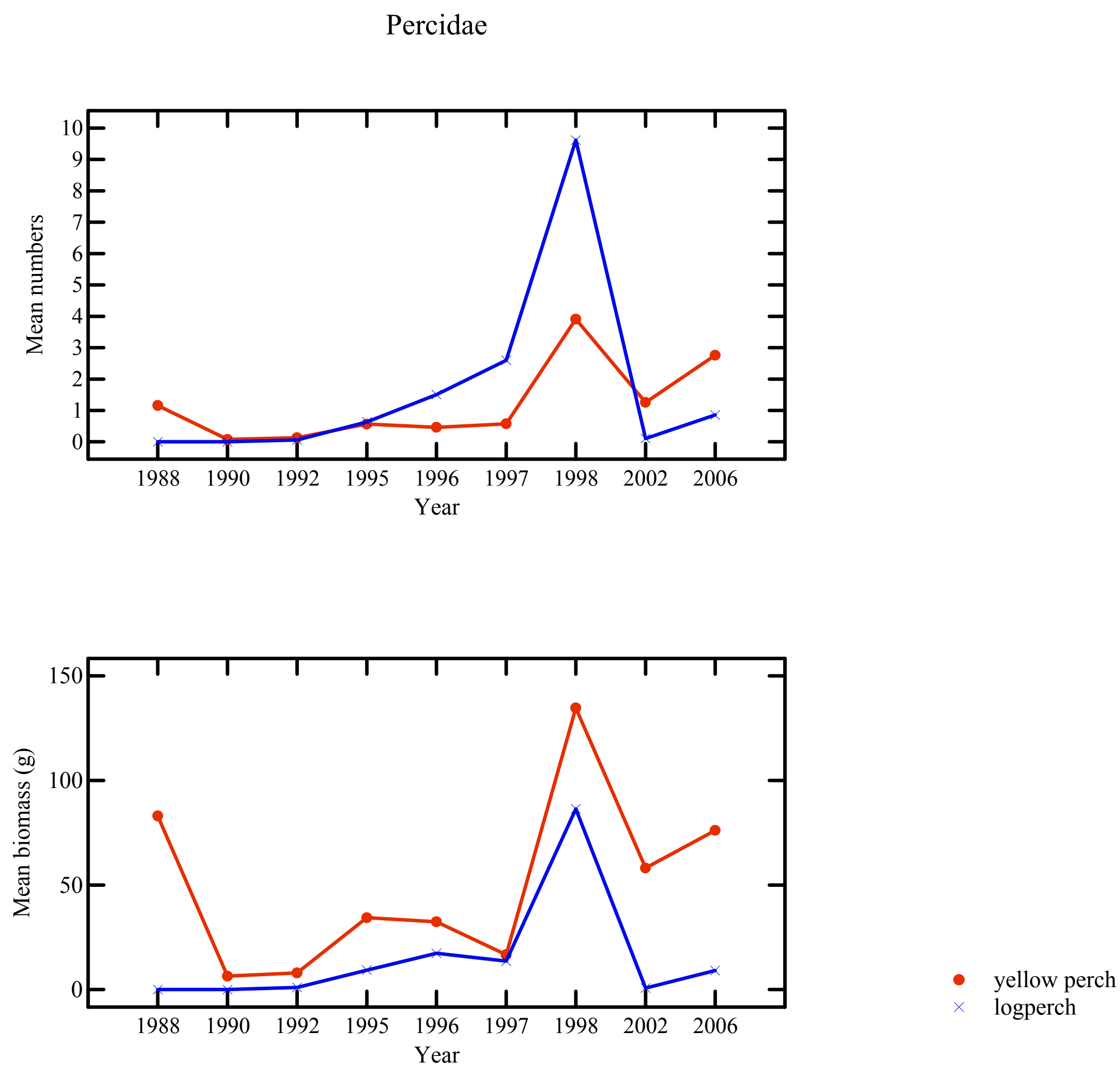


Figure 14. Trends in the two most common percid species (yellow perch, logperch) numbers (top) and biomass, grams (bottom) per transect over time.

Native cyprinidae

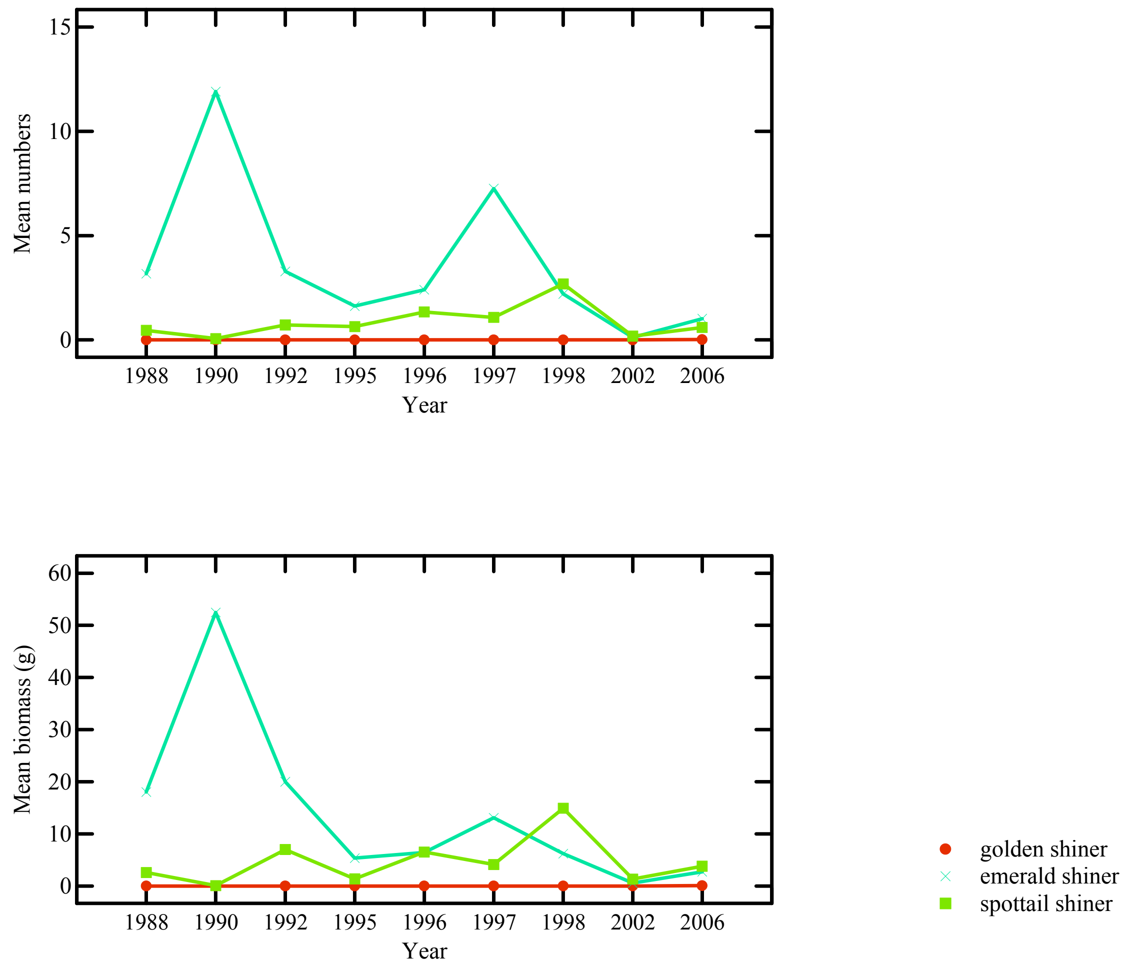


Figure 15. Trends in mean native cyprinid species numbers (top) and biomass, grams (bottom) per transect over time. Species included golden shiner, emerald shiner and spottail shiner.

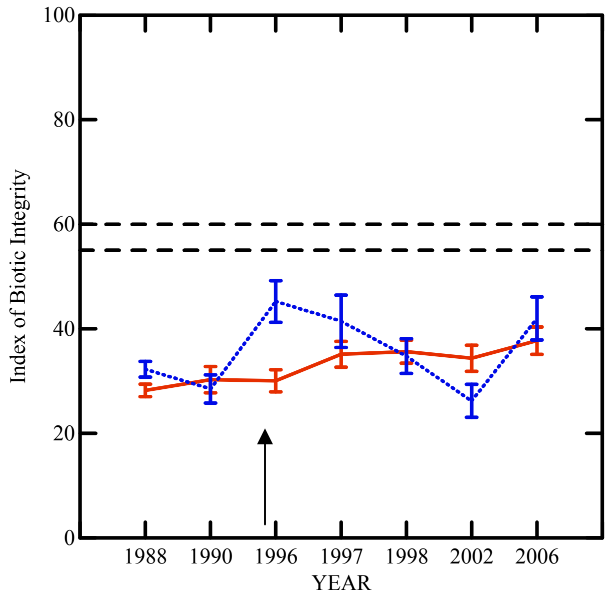


Figure 16. Comparison of Index of Biotic Integrity scores (annual mean ± SE) at restoration sites (dashed line, Sites C- wildlife islands and E- LaSalle Park only), and unaltered sites (solid line) before and after (↑) completion of physical habitat restoration work in Hamilton Harbour.

SUPPORTING DOCUMENT C

Review of Alternatives to the Project

Review of Alternatives to the Project

C.1 Conceptual Stage Alternatives

C.1.1 Description of Alternatives

At the conceptual stage in 1996, six categories of alternatives to the *Randle Reef Sediment Remediation Project* were identified as:

- inaction;
- no immediate action;
- in-situ capping;
- in-situ treatment;
- contain entire zone; and
- removal/treatment/disposal.

Each of these alternatives is described below.

- Inaction

With the inaction alternative (i.e., do nothing), the PAHs would continue to spread along the Harbour floor and re-circulate into the water column attached to sediment particles. The zone of lethality to benthic organisms could be expected to enlarge. Eventually (i.e., perhaps after 5 to 10 decades), the rate of export of PAHs from the site could decrease and the low level deposits in the Harbour bottom would be slowly buried by natural sedimentation of eroding soils from the watershed.

- No Immediate Action

This alternative was identical to the inaction alternative with the exception that after some period of time, one of the subsequent actions would be invoked. This would only occur if there were some reason to believe that a new and cheaper technical component of one of the subsequent alternatives would soon appear.

- In-situ Capping

In-situ capping involved the controlled and accurate placement of clean material laid over top of in-place contaminated sediment. The material must be considered as "clean" and acceptable for unrestricted open water disposal. The objective is to isolate the contamination from the overlying water columns.

- In-situ Treatment

Treatment of contaminants can occur under water, where the sediment lies in place. There are four types of in-situ treatment – chemical, biological, biological/chemical and immobilization.

- Contain Entire Zone

In-situ containment is a non-removal technology which encloses a zone and isolates the entire section from the waterway. This alternative would involve the use of physical barriers (i.e., sheetpiling, rubble mound and/or earthen dikes) to contain the entire Randle Reef area, including the Sherman Inlet area.

- Removal/Treatment/Disposal

Removal of the sediment would involve dredging technologies which raise material from the bottom of a water column to the surface where it can be transported elsewhere. This alternative involves the use of a dredge to remove the contaminated sediment. One of three types of dredges could be used for this alternative – mechanical dredge, hybrid dredge or hydraulic dredge.

C.1.2 Evaluation of Alternatives

Decision-making criteria were developed in order to eliminate those alternatives that were clearly not suitable. These criteria were:

- is the alternative capable of meeting the project's environmental objectives [1];
- is the alternative capable of meeting all environmental or other legislated requirements of both the federal and provincial governments; and
- will the property owner exercise legal entitlement to exclude the alternative (this action would preclude the alternative from consideration).

These criteria were applied to the six alternatives identified at the conceptual stage, in order to identify what alternatives would be carried forward for further study. In applying the exclusionary criteria, if any one criterion was not met, the alternative was eliminated from further consideration.

C.1.3 Conclusions

The "inaction", "no immediate action" and "treat in-situ" alternatives were eliminated from further consideration because they were not consistent with the environmental objectives of the project. The environmental objectives include diminishing the extent to which highly concentrated PAHs found within the 14.6 ha priority zone in the Randle Reef area can move into the water column or across the bottom of the Harbour and can, therefore, constitute a source of continuing contamination within the local ecosystem. Another objective is to take early action so that the exposure time is reduced. The cost

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[1] The objective of the project is to diminish the extent to which highly concentrated PAHs found within sediment in the Randle Reef area, can move into the water column or across the bottom of the Harbour and can, therefore, constitute a source of continuing contamination within the local ecosystem.

effectiveness of the solution is also an important consideration so that the optimum clean-up is achieved. Another goal of the selected remedial solution is that it should also not transfer the contamination to another location (e.g., disposal of the contaminants in another municipality or transfer to another media, such as air).

The "inaction" and "no immediate action" alternatives would not diminish the on-going contamination of the local ecosystem from the Randle Reef site. The inaction alternative would result in the further spread of contamination and would prevent the success of the Hamilton Harbour RAP. The current use of the area would continue to be limited and future use for deep draught barge operations would be impossible. There might also be indirect and intangible costs to local businesses if the concerted attempt to restore the Harbour through the RAP were to end in failure.

It was concluded that the "in-situ treatment" alternative might have application in other locations in Hamilton Harbour, but could not be relied upon to produce the desired reduction in exposure to PAHs in the aquatic environment as long as the location remained in active use for shipping and navigation (considered to be a necessary use).

The contain entire zone and cap alternatives were not acceptable because both would preclude the use of Piers 14 and 15. This would affect the mandate of the Hamilton Port Authority to develop and operate the Harbour for the purposes of shipping.

Based on the application of the exclusionary criteria, only the removal/treatment/disposal alternative remained for further consideration.

C.2 Alternatives Means for Removal/Treatment/Disposal

C.2.1 Description of Alternative Means

The evaluation of conceptual alternatives, as described in Section C.1, resulted in the removal/treatment/disposal alternative being retained for further more detailed consideration. Removal of the sediments necessitates their disposal. Depending on how they are disposed of, they require varying levels of pre-treatment (dewatering) and treatment. It was recognized that variations (i.e., alternative means) of the removal alternative could be developed for consideration. Table C.1 presents the 20 alternative means that were developed for more detailed evaluation. It also provides the various stages of the alternative.

C.2.2 Evaluation of Alternative Means

These 20 alternative means were compared and impact tables were prepared for each. These impact tables contained primarily descriptive (i.e., qualitative) information and are provided as Attachment C1.

The descriptive data was translated into ordinal data that reflected the relative preference of alternatives for each criteria (i.e., highly preferred alternative, moderately preferred alternative or less preferred alternative). Table C.2 presents the ratings assigned to each of the alternatives by criteria.

The results of the concordance analysis were reviewed with the Randle Reef Sediment Remediation Committee. The purpose of this qualitative review was to position the concordance analysis results along with what had been learned through public consultation and along with the collective experience of Committee members, to decide which alternatives were more preferred.

C.2.3 Conclusions

Overall the preferred alternative was: the removal of sediments to a location adjacent to the removal site; treatment by thermal, organic or biological methods; and re-use. If re-use is not feasible, then the material may be disposed of in a licenced industrial landfill after treatment for volatility and corrosivity. This alternative was viewed as a partial

Table C.1: Alternative Means Developed for Evaluation

Alternative		Stage of Alternative
A	Disposal at Hazardous Waste Facility	Removal (Dredging) → Transport to Shore → Storage or Equalization Storage → Pre-treatment → Transport to Hazardous Waste Facility → Disposal in Hazardous Waste Facility
B	Biological Treatment, Inorganic Extraction, Placement in ECF	Removal (Dredging) → Transport to Shore → Storage or Equalization Storage → Pre-treatment → Biological Treatment → Inorganic Extraction → Placement in ECF
C	Organic Extraction, Inorganic Extraction, Placement in ECF	Removal (Dredging) → Transport to Shore → Storage or Equalization Storage → Pre-treatment → Organic Extraction → Inorganic Extraction → Placement in ECF
D	Thermal Treatment, Inorganic Extraction, Placement in ECF	Removal (Dredging) → Transport to Shore → Storage or Equalization Storage → Pre-treatment → Thermal Treatment → Inorganic Extraction → Placement in ECF
E	Biological Treatment, Disposal in Landfill	Removal (Dredging) → Transport to Shore → Storage or Equalization Storage → Pre-treatment → Biological Treatment → Disposal in Landfill
F	Organic Extraction, Disposal in Landfill	Removal (Dredging) → Transport to Shore → Storage or Equalization Storage → Pre-treatment → Organic Extraction → Disposal in Landfill
G	Thermal Treatment, Disposal in Landfill	Removal (Dredging) → Transport to Shore → Storage or Equalization Storage → Pre-treatment → Thermal Treatment → Disposal in Landfill
H	Biological Treatment, Inorganic Extraction, Re-use on Commercial/Industrial Land	Removal (Dredging) → Transport to Shore → Storage or Equalization Storage → Pre-treatment → Biological Treatment → Inorganic Extraction → Re-use on Land
I	Organic Extraction, Inorganic Extraction, Re-use on Commercial/Industrial Land	Removal (Dredging) → Transport to Shore → Storage or Equalization Storage → Pre-treatment → Organic Extraction → Inorganic Extraction → Re-use on Land
J	Thermal Treatment, Inorganic Extraction, Re-use on	Removal (Dredging) → Transport to Shore → Storage or

Alternative		Stage of Alternative
	Commercial/Industrial Land	Equalization Storage → Pre-treatment → Thermal Treatment → Inorganic Extraction → Re-use on Land
K [1]	Thermal Treatment, Inorganic Extraction, Re-use on Residential or Parkland	Removal (Dredging) → Transport to Shore → Storage or Equalization Storage → Pre-treatment → Thermal Treatment → Inorganic Extraction → Re-use on Land
K [2]	Organic Extraction, Inorganic Extraction, Re-use on Residential or Parkland	Removal (Dredging) → Transport to Shore → Storage or Equalization Storage → Pre-treatment → Organic Extraction → Inorganic Extraction → Re-use on Land
L	Thermal Treatment, Inorganic Extraction, Disposal in Water	Removal (Dredging) → Transport to Shore → Storage or Equalization Storage → Pre-treatment → Thermal Treatment → Inorganic Extraction → Disposal in Water
M	Biological Treatment, Inorganic Extraction, Cap in Area Adjacent to Pier 15	Removal (Dredging) → Transport to Shore → Storage or Equalization Storage → Pre-treatment → Biological Treatment → Inorganic Extraction → Construct Containment Berm and Dispose of Sediment
N	Organic Extraction, Inorganic Extraction, Cap in Area Adjacent to Pier 15	Removal (Dredging) → Transport to Shore → Storage or Equalization Storage → Pre-treatment → Organic Extraction → Inorganic Extraction → Construct Containment Berm and Dispose of Sediment
O	Thermal Treatment, Inorganic Extraction, Cap in Area Adjacent to Pier 15	Removal (Dredging) → Transport to Shore → Storage or Equalization Storage → Pre-treatment → Thermal Treatment → Inorganic Extraction → Construct Containment Berm and Dispose of Sediment
Q	Thermal Treatment, Inorganic Extraction, Any Land-Based Application	Removal (Dredging) → Transport to Shore → Storage or Equalization Storage → Pre-treatment → Thermal Treatment → Inorganic Extraction → Re-use on Land
R	Thermal Treatment, Inorganic Extraction, Re-use as Landfill Cover	Removal (Dredging) → Transport to Shore → Storage or Equalization Storage → Pre-treatment → Thermal Treatment → Inorganic Extraction → Re-use as Landfill Cover
S	Organic Extraction, Inorganic Extraction, Re-use as Landfill	Removal (Dredging) → Transport to Shore → Storage or

Alternative		Stage of Alternative
	Cover	Equalization Storage → Pre-treatment → Organic Extraction → Inorganic Extraction → Re-use as Landfill Cover
T	Biological Treatment, Inorganic Extraction, Re-use as Landfill Cover	Removal (Dredging) → Transport to Shore → Storage or Equalization Storage → Pre-treatment → Biological Treatment → Inorganic Extraction → Re-use as Landfill Cover

Note: A more detailed description of each of these alternatives is found in:

Environment Canada. 1997. Hamilton Harbour Remedial Action Plan: Randle Reef Sediment Remediation Project. Analysis of Alternatives Report Under the Canadian Environmental Assessment Act. August 1997.

Table C.2: Evaluation of Alternatives

Criteria	A	B	C	D	E	F	G	H	I	J	K-l	L	M	N	O	Q	R	S	T	K-2
1. Level of confidence associated with ability to carry out alternative	H	L	M	M-H	M-H	M-H	M-H	L	L-M	M-H	M	L	L	M	M-H	L-M	M-H	L-M	L	L-M
2. Certainty with which cost of alternatives can be predicted	H	M	M	M	M	M	M	L	L	M-H	M	M	M	M	M	M	M-H	L	L	L-M
3. Impact on post remediation value of properties where material is disposed	H	M	M	M	H	H	H	M	M	M	M	H	M	M	M	M	H	H	H	M
4. Risk to public health and safety: • Risk associated with transportation	L	H	H	H	M	M	M	H	H	H	M	H	H	H	H	M	M	M	M	M
5. Risk to public health and safety: • Risk associated with technology	H	H	H	M	H	H	M	H	H	M	M	M	H	H	M	M	M	H	H	H
6. Risk to worker health and safety	H	M	H	M	M	H	M	M	H	M	M	M	M	H	M	M	M	H	M	H
7. Potential for impact on aquatic biota during implementation	M	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H	H	H	H	H
8. Potential for impact on aquatic biota following implementation	L	M	M	M	M	M	M	H	H	H	H	M	H	H	H	H	H	H	H	H
9. Potential for impact on terrestrial biota during implementation	M	L	L	L	H	H	H	H	H	H	H	H	M	M	M	H	H	H	H	H
10 Potential for impact on terrestrial biota following implementation	L	M	M	M	M	M	M	H	H	H	H	H	H	H	H	H	H	H	H	H
11. Potential for impact on water column during implementation	M	L	H	H	L	H	H	L	H	H	H	H	L	M	M	H	H	H	L	H

Criteria	A	B	C	D	E	F	G	H	I	J	K-l	L	M	N	O	Q	R	S	T	K-2
12. Potential for impact on water column following implementation	L	M	M	M	M	M	M	H	H	H	H	H	H	H	H	H	H	H	H	H
13. Potential for impact on air quality during implementation	M	H	H	L	H	H	L	H	H	L	L	L	H	H	L	L	L	H	H	H
14. Potential for impact on air quality following implementation	H	M	M	M	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H
15. Potential for impact on land quality during implementation	M	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H
16. Potential for impact on land quality following implementation	H	M	M	M	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H
17. Potential for noise or other loss of aesthetic value during implementation	H	L	M	M	L	H	H	L	H	H	H	H	L	H	H	H	H	H	L	H
18. Potential for disruption to recreation during implementation	H	M	M	M	H	H	H	H	H	H	M	H	H	H	H	H	H	H	H	M
19. Potential for disruption to recreation following implementation	H	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H	H	H	H	H
20. Potential for disruption to businesses	H	H	H	H	H	H	H	H	H	H	H	H	M	M	M	H	H	H	H	H
21. Potential for impact on ground water	M	H	H	H	H	H	H	H	H	H	H	H	M	M	M	H	H	H	H	H
22. Potential for contaminated residual material	L	H	M	M	H	M	M	H	M	M	M	M	H	M	M	H	M	M	H	M
23. Extent of sediment remediation	L	M	M	M	L-M	L-M	L- M	M	M	M	M-H	H	M	M	M	H	M	M	M	M-H

solution for Randle Reef, given that a significant amount of contaminated sediment would remain after the removal of the 20,000 m^3 of the most highly contaminated toxic sediments. Further work to delineate the volume and extent of the most highly contaminated area was also recommended in order to better understand the extent to which the proposed remedial alternative would address PAH contamination in the Harbour.

This preferred alternative was not one listed in Table C.1. During the review of these alternatives, it was decided to allow for a selection to be made from among the alternatives which were most preferred after applying the concordance method. These were alternatives for which some re-use of the material could be found. A primary reason for retaining this flexibility was the desire to leave room for innovation. Innovation could be helpful not only in terms of keeping costs down, but in finding an end use for the sediments that might avoid taking up limited space in disposal sites.

C.3 Sinter Plant Alternative

C.3.1 Description of Alternative

A sinter plant alternative was developed as a result of discussions among former members of the Randle Reef Sediment Remediation Committee, including representatives from Environment Canada, MOE, Hamilton Port Authority and U.S. Steel. The sinter plant was an "alternative to" the project, as per CEAA (see Section 2.4).

In May 1999, a Pre-Engineering Technical Evaluation report was prepared for Stelco (now U.S. Steel). This report assessed background information, reviewed technologies for implementing the project, proposed monitoring and operational requirements and presented budgetary evaluations for the various project elements. The proposed works and activities warranted a screening level of environmental assessment under CEAA and, in December 1999, an environmental screening report was prepared by Environment Canada.

The proposed project involved dredging approximately 20,000 m^3 of sediment from the highly contaminated area in the Harbour around Randle Reef and transporting it to the Hamilton Port Authority's property where it would be screened for coarse materials. The dredged material would be de-watered and stored, as required. The material would be conditioned to meet feedstock quality for Stelco's sinter plant specifications, and to ensure worker health and safety. The conditioning of the sediment included an initial pre-treatment to reduce the contaminant levels to levels that met the sinter plant feedstock, and which met all applicable levels for worker health and safety. The higher metal levels in the sediment were acceptable given the ability to recover and reuse the metals in the sediment within the treatment process. Two bioremediation options were examined for the pre-treatment stage.

Treatability studies related to the chemical quality of the water were also reviewed and an analysis was conducted to assess any additional pre-treatment needs for the decant water from the various stages of the treatment processes. Volatile emissions would be collected by an air containment system and the volatiles would be removed from the air by a treatment system. Once conditioned, the material would be transported to Stelco where it would be fed into the sinter plant and then into the blast furnace. The end products would be iron and blast furnace slag.

All screening, de-watering, storage and conditioning operations would occur in a controlled environment. The treated decant water would be returned to the Harbour, or discharged to the Region's combined sewer system in accordance with applicable regulatory criteria.

As a contingency measure, a limited amount of material would be conditioned only for volatility/corrosivity and placed in a licenced industrial landfill in the event that it did not meet Stelco's sinter plant specifications. In this scenario, only the material that had been removed and analyzed for specification acceptability would be landfilled. Dredging would be terminated if the sinter plan specifications could not be met.

C.3.2 Evaluation of the Alternatives

Table C.3 summarizes the evaluation of the sinter plant project, including potential environmental effects for each phase of the project and mitigation and monitoring measures.

The evaluation of the sinter plant alternative included a review with the public at a December 1999 environmental assessment meeting chaired by the Bay Area Restoration Council (BARC). Representatives from the Stelco Steelworkers Union, Local 1005, expressed health and safety related concerns. General concerns regarding overall air quality were also raised.

C.3.3 Conclusions

The potential environmental effects of the sinter plant project, including cumulative effects, were assessed in the December 1999 environmental screening report. Taking into consideration the mitigation measures considered, it was concluded that there would be no significant adverse environmental effects associated with the sinter plant project.

However, given concerns from the public expressed during the consultation undertaken for the sinter plant alternative, it was decided not to proceed but to re-examine some of the other feasible options that had been previously evaluated (see Section C.2).

Table C.3: Evaluation of Sinter Plant Project

Phase of Project	Potential Environment Effects	Monitoring	Possible Mitigation
Removal (Dredging)	Water quality impairment due to migration of suspended solids and contaminants away from dredge site in water column.	Water sampling.	Halt or alter dredging. Install silt curtain. Improve dredge operational performance.
	Noise from dredge and barge engines.	Noise monitoring.	Muffle sound or change hours of operation.
	Air emissions from dredged sediment and engine exhaust.	Ambient and downwind air monitoring.	Install wind barriers or cover specific operations and treat air. If necessary, avoid dredging when winds are light and northeast.
	Worker exposure to contaminants.	Personal air monitors on workers.	Change working conditions. Have workers wear protective equipment.
	Disruption and/or contamination of aquatic life and birds.	Sampling and observation of representative organisms.	Operate only in areas and at times approved by CWS and OMNR. Keep organisms away from project areas with barriers and other mechanisms.
Transport	Water quality impairment due to spillage of sediment due to equipment failure and/or human error.	Pressure gauges on pipelines. Observers in boats and at loading points to look for major releases. Water sampling to check for leaks and small spills.	Emergency response teams standing by. Minimize environmental damage by strategic placement of transport. Maintain and repair pipelines. Change operating procedures.
	Air quality impairment.	Air monitoring.	Change operating procedures. Keep dust down with water and other dust suppressants.

Phase of Project	Potential Environment Effects	Monitoring	Possible Mitigation
	Disruption and/ or contamination of aquatic life and birds.	Sampling and observation of representative organisms.	Operate only in areas and at times approved. by CWS and OMNR. Keep organisms away from project areas with barriers and other mechanisms.
Storage and Conditioning	Water quality impairment.	Water levels sensors. Leak detection sensors. Modeling and monitoring of decant water pre/post bio-remediation and prior to discharge.	Feedback systems to stop filling if level too high. Have emergency storage available. Have secondary containment built in. Implement various de-watering options (settling ponds, etc.), investigate water treatment options (coagulants/flocculant additions), utilize land farming or bio-slurry remediation to pre-treat dredged sediment.
	Air quality impairment.	Air emission controls/treatment and monitoring.	Keep volatile releases down by covering with 0.5m layer of water or cover with temporary roof. Air emission controls implemented – treatment and operational controls (e.g., flare the gases at the site, utilize a bio-reactor).

Source: Environment Canada. 1999. Draft. Randle Reef Sediment Remediation Project Environmental Screening Report. December 1999.

C.4 Re-examination of Disposal and Reuse Alternatives

C.4.1 Description of Alternatives

The alternatives under consideration prior to 2001 were:

Disposal Alternatives:

1(a) Dredge and dewater the sediment and dispose as a hazardous waste at an existing (upland) hazardous waste facility

1(b) Dredge and dewater the sediment, treat it to meet industrial waste criteria and dispose as an industrial waste in an existing industrial landfill

1(c) Dredge and dewater the sediment, treat it to meet industrial waste criteria and dispose in a new semi-aquatic confined disposal facility in Hamilton Harbour

These were “alternatives to” the project, as per CEAA (see Section 2.4).

Reuse Alternatives:

2(a) Dredge and dewater the sediment, treat it to meet industrial land criteria and use as fill at an industrial property

2(b) Dredge and dewater the sediment, treat it to meet residential/parkland criteria and use as fill at a residential/parkland property

All of the alternatives assumed the use of mechanical dredging to remove the sediment for purposes of the comparison and costing, although it was recognized that both mechanical and hydraulic dredging could be used.

All of the alternatives involved coarse screening to remove objects greater than approximately 2.5 cm in diameter, dewatering to reduce the water content of the dredged material to approximately 30% (by weight), treatment of the water fraction to remove solids and chemical compounds, storage of the dewatered solids until either disposal or treatment, and collection and treatment of the off-gases from the sediment.

Table C.4 provides further information on the alternatives.

C.4.2 Evaluation of the Alternatives

The purpose of this review was not to choose a preferred alternative. The intent was to review the alternatives to determine which alternative may be the most likely to be implemented.

Table C.4: Description of Alternatives

Alternative		Description of Alternative
1(a)	Dredge and dewater the sediment and dispose as a hazardous waste at an existing (upland) hazardous waste facility	This is the simplest option in terms of technical complexity. Under this option the sediment would be dredged, coarse screened, dewatered and then sent to a hazardous waste landfill site. The supernatant water would be treated as in the other options. Off-gases from the screening and dewatering processes would be collected and treated as with the other options.
1(b)	Dredge and dewater the sediment, treat it to meet industrial waste criteria and dispose as an industrial waste in an existing industrial landfill	This option has the same process steps leading up to the treatment of organics as for Option 1(a). However, the objective of a treatment phase would be to reduce the toxicity of the sediment so that the sediment could be re-classified as an "industrial waste". As an industrial waste the sediment could then be sent to an industrial landfill at considerably less cost than a hazardous waste landfill.
1(c)	Dredge and dewater the sediment, treat it to meet industrial waste criteria and dispose in a new semi-aquatic confined containment facility in Hamilton Harbour	This option is exactly the same as Option 1b except that instead of using an existing upland industrial landfill, a semi-aquatic confined containment facility is used to dispose of the treated sediment. A semi-aquatic ECF is a containment facility, usually for navigational dredged material, that is located partly in water and partly above water. For this option it is presumed that a new ECF would be designed specifically to contain material that has been classified as industrial waste. This new ECF would have to have extra containment features to ensure that contaminants could not leach out and harm the environment.
2(a) 2(b)	Dredge and dewater the sediment, treat it to meet industrial land criteria and use as fill at an industrial property Dredge and dewater the sediment, treat it to meet residential/parkland criteria and use as fill at a residential/parkland property	These two options (2a and 2b) involve "cleaning" the sediment to an acceptable level for use as fill at either a residential/parkland site or at a commercial/industrial site. The chemical criteria for fill at commercial industrial sites are slightly less stringent for commercial industrial sites than for residential/parkland sites. The first steps in the remediation process (dredging, coarse screening, dewatering, water treatment, off-gas collection/treatment) are the same as for all other options. However, after dewatering the sediment is treated for organics and metals, followed by temporary storage and reuse as industrial or residential fill.

C.4.3 Conclusions

The alternatives were not scored or ranked at this stage. The alternatives were simply presented for discussion and consideration – all alternatives were seen as feasible and none should be excluded from further consideration.

It was recognized that the main item to consider was the space for staging the land-based operations (screening, dewatering, water treatment, sediment treatment, etc.) in order to address the 20,000 m^3 of contaminated sediment. Considerable space may likely be needed for both dewatering and treatment options for this volume of material.

Attachment C1

Alternative A – Dredge and Place into Hazardous Waste Facility

Criteria	Potential Environmental Effects
1. Level of confidence associated with ability to carry out alternative	High level of confidence associated with ability to carry out alternative based on available technologies and expertise. There are a number of hazardous waste facilities available for the disposal of the material. The closest facility is Tricil in Sarnia.
2. Certainty with which cost of alternatives can be predicted	The cost of the alternative can be predicted with a high level of certainty based on past activities in other jurisdictions.
3. Impact on post remediation value of properties where material is disposed	The disposal of Randle Reef sediments at the hazardous waste facility is not expected to impact on the value of the disposal site property, since it will continue to be a hazardous waste facility regardless of whether or not these materials are disposed at the facility.
4. Risk to public health and safety	There is little concern that during the dredging operation public health will be at risk. Although sediments will be stirred up, these sediments are currently in the water and are already exposed to energy that causes some dispersion. Pre-treatment can be conducted in an enclosed environment before the sediment is transported to the hazardous waste facility, therefore, the exposure will be minimal. The risk associated with the transportation of material to the receiving facility will be directly related to the distance the material will travel. This alternative will involve the longest travel distance and, therefore, has the greatest public health and safety risk.
5. Risk to worker health and safety	This alternative will involve potential exposure to on-site workers, transportation workers and workers at the hazardous waste facility. All workers handling sediment (either at dredge site or hazardous waste facility) should employ appropriate health and safety measures.
6. Potential for impact on aquatic biota during implementation	During removal, there will be a temporary impact on aquatic biota as sediments are disturbed and dispersed. During the transportation of the hazardous material to the hazardous waste facility there is potentially a higher risk for an accident which could impact the aquatic environment should a spill occur in the vicinity of a watercourse or water body. This alternative will involve the longest travel distance and, therefore, has the greatest potential for impact on the aquatic biota.

Criteria	Potential Environmental Effects
7. Potential for impact on aquatic biota following implementation	Immediately following implementation, one might expect to see an increase in uptake by biota because of the physical disturbance. In the long-term, however, exposure of biota to PAHs in the sediment will decrease at Randle Reef and around it. The hazardous waste facility where the material is disposed with this alternative is designed to contain the material and isolate it from the environment. Therefore, effects on the aquatic environment around the hazardous waste facility following the implementation of this alternative are expected to be minimal. However, relative to the other alternatives, this has the greatest potential for impact should the containment system at the facility fail, since the contaminants may not have been treated.
8. Potential for impact on terrestrial biota during implementation	During dredging and pre-treatment, there may be an opportunity to expose terrestrial biota to the contaminated sediments, however, this potential exposure can be mitigated. During the transportation of the hazardous material to the hazardous waste facility there is potentially a risk for a spill which could impact the terrestrial environment.
9. Potential for impact on terrestrial biota following implementation	No significant impact on terrestrial biota resulting from this alternative is expected. The same potential for impact exists for all alternatives. The hazardous waste facility where the material is disposed with this alternative is designed to contain the material and isolate it from the environment. However, relative to the other alternatives, this has the greatest potential for impact should the containment system at the facility fail, since the contaminants will not have been treated.
10. Potential for impact on water column during implementation	There is some potential for a temporary impact on the water column during removal. Operation performance standards can be implemented to minimize impacts. During the transportation of the hazardous material to the hazardous waste facility there is potentially a higher risk for an accident which could impact on the water column environment should a spill occur in the vicinity of a watercourse or water body.
11. Potential for impact on water column following implementation	There is minimal potential for impact on the water column following the implementation of this alternative. Equilibrium or ambient conditions at the dredging are expected to return within 48 hours based on previous pilot projects. Hazardous waste facilities at the dredging site are designed to contain the material and isolate it from the environment. However, relative to the other alternatives, this has the greatest potential for impact should the containment system at the facility fail, since the contaminants may not have been treated.
12. Potential for impact on air quality during implementation	There is some potential for the volatilization of the material during pre-treatment, however, it is expected that this can be mitigated. During the transportation of the hazardous material to the hazardous waste facility there is potentially a risk for an accident which could result in the volatilization of contaminants should a spill occur.
13. Potential for impact on air quality following implementation	There is low potential for impact on air quality following implementation.

Criteria	Potential Environmental Effects
14. Potential for impact on land quality during implementation	There is some potential for impact on land quality during implementation during the pre-treatment stage. This is common for all alternatives. During the transportation of the hazardous material to the hazardous waste facility there is potentially a higher risk for an accident which could result in an impact on land quality.
15. Potential for impact on land quality following implementation	The lands associated with the hazardous waste facility will be degraded, however, this would have occurred irrespective of whether or not the Hamilton Harbour sediments were disposed of there.
16. Potential for noise or other loss of aesthetic value during implementation	There is some potential for loss of aesthetic value during the implementation of this removal alternative. Since the operation will be in an existing industrial area, it is expected that it will be absorbed into the surrounding landscape. Noise impacts are expected to be minimal. Since there will be no treatment operation beyond dewatering the aesthetic impact will be less for this alternative compared to alternatives requiring treatment due to the shorter time period.
17. Potential for disruption to recreation during implementation	Some disruption to recreation during implementation may occur, since the access to the site will need to b restricted for the duration of the removal operation.
18. Potential for disruption to recreation following implementation	No disruption to recreation following implementation of this alternative is expected, since the contaminate material will not be placed in a recreational area.
19. Potential for disruption to businesses	Short term potential for disruption to water-based businesses (i.e., limited to duration of removal activity) due to the temporary disruption.
20. Potential for impact on ground water	Any hazardous waste facility used for the disposal of this material will be designed to protect ground water. However, relative to the other alternatives, this has the greatest potential for impact should the containment system at the facility fail, since the contaminants will not have been treated.
21. Potential for impact on cultural heritage resources	No impact on cultural heritage resources is expected.
22. Potential for contaminated residual material	No treatment, therefore, material remains contaminated.

Alternative B – Dredge, Pre-treatment, Biological Treatment, Inorganic Extraction and Placement in Engineered Disposal Facility

Criteria	Potential Environmental Effects
1. Level of confidence associated with ability to carry out alternative	Low level of confidence associated with ability to carry out alternative due to past performance of technology with Hamilton Harbour sediment in context of Randle Reef Industrial Fill Criteria.
2. Certainty with which cost of alternatives can be predicted	The cost of the alternative can be predicted with a moderate level of certainty based on past demonstration costs and subsequent commercial practices. The uncertainty relates to the ability of the technology to achieve the Randle Reef Industrial Fill Criteria.
3. Impact on post remediation value of properties where material is disposed	The impact on the value of the ECF should be minimal, since the material will have been cleaned up to appropriate guidelines. There may, however, be implications associated with perceived risk that result in a decrease in property value should the Harbour Commission [now Hamilton Port Authority] choose to sell it for industrial land once it is filled and capped.
4. Risk to public health and safety	There is little concern that during the dredging operation public health will be at risk. Although sediments will be stirred up, these sediments are currently in the water and are already exposed to energy mat causes some dispersion. During the temporary storage of materials (if required), provisions will be required to ensure the public is not exposed to the material. Pre-treatment and treatment can be conducted in a controlled environment before the sediment is transported to the ECF. The risk associated with the transportation of material to the receiving facility will be directly related to the distance the material will travel. This alternative will involve the shortest travel distance and, therefore, has the least risk to public health and safety risk.
5. Risk to worker health and safety	Depending on the type of biological treatment, a separate temporary storage facility may be required. During the temporary storage of materials, workers will need to take precautions to avoid exposure. Biological technologies expose workers to the materials for much longer periods of time than either thermal or organic technologies. Consequently, there is a greater risk to worker health and safety because of the time and type of exposure. The risk can be mitigated with protective equipment.
6. Potential for impact on aquatic biota during implementation	During removal, there will be a temporary impact on aquatic biota as sediments are disturbed and dispersed. During the temporary storage (if required) and treatment of the material there is the potential for contaminants to reenter the Harbour, although this will be offset with mitigation and contingency measures.

Criteria	Potential Environmental Effects
7. Potential for impact on aquatic biota following implementation	Immediately following implementation, one might expect to see an increase in uptake by biota because of the physical disturbance. In the long-term, however, exposure of biota to PAHs in the sediment will decrease at Randle Reef and around it. The remediated material may still contain contaminant levels higher than typically found in other ECFs on the Great Lakes. Consequently, a risk assessment study will be required to assess potential ecosystem effects.
8. Potential for impact on terrestrial biota during implementation	During dredging, temporary storage (if required), pre-treatment and treatment, there may be an opportunity to expose terrestrial biota to the contaminated sediments, however, this potential exposure can be mitigated. Until the ECF is capped, there will be some opportunity for exposure of terrestrial biota to the treated material. Because the material will be treated, it is expected that the effects of the exposure will be minimal. During placement of the material in the ECF, birds nesting in the area could be disturbed temporarily.
9. Potential for impact on terrestrial biota following implementation	The remediated material may still contain contaminant levels higher than typically found in other ECFs on the Great Lakes. Consequently, a risk assessment study will be required to assess potential ecosystem effects.
10. Potential for impact on water column during implementation	There is some potential for a temporary impact on the water column during dredging, temporary storage (if required), pre-treatment and treatment. Operation performance standards and mitigation measures can be implemented to minimize impacts. The potential impact associated with this alternative is, in part, a function of the amount of time required to implement the alternative. It will take approximately 6 months to 5 years to implement the alternative.
11. Potential for impact on water column following implementation	The remediated material may still contain contaminant levels higher than typically found in other ECFs on the Great Lakes. Consequently, a risk assessment study will be required to assess potential ecosystem effects.
12. Potential for impact on air quality during implementation	There is some potential for the volatilization of the material during temporary storage (if required), pre-treatment and treatment, however, it is expected that this can be mitigated.
13. Potential for impact on air quality following implementation	The remediated material may still contain contaminant levels higher than typically found in other ECFs on the Great Lakes. Consequently, a risk assessment study will be required to assess potential ecosystem effects.
14. Potential for impact on land quality during implementation	During temporary storage (if required), pre-treatment and treatment there is some potential for impact on land quality, however, it is expected it can be mitigated.

Criteria	Potential Environmental Effects
IS. Potential for impact on land quality following implementation	The remediated material may still contain contaminant levels higher than typically found in other ECFs on the Great Lakes. Consequently, a risk assessment study will be required to assess potential ecosystem effects.
16. Potential for noise or other loss of aesthetic value during implementation	There is some potential for loss of aesthetic value during the implementation of this removal alternative. Since the operation will be in an existing industrial area, it is expected that it will be absorbed into the surrounding landscape. Noise impacts are expected to be minimal. The potential impact associated with this alternative is, in part, a function of the amount of time required to implement the alternative. It will take approximately 6 months to 5 years to implement the alternative.
17. Potential for disruption to recreation during implementation	Some disruption to recreation during implementation may occur, since the access to the site will need to be restricted for the duration of the removal operation. The placement of the treated material in the ECF could potentially impact temporarily on the birds using the ECF. This, in turn, could impact on bird watching.
18. Potential for disruption to recreation following implementation	No disruption to recreation following implementation of this alternative is expected, since the disposed material will not be placed in a recreational area.
19. Potential for disruption to businesses	Potential for short-term disruption to water-based businesses (limited to duration of removal activity) during dredging.
20. Potential for impact on ground water	In the long term, no potential for impact on the ground water is expected. Depending on the type of biological treatment, there may be a need for temporary storage. During temporary storage there may be potential for impact on ground water, however, mitigation measures can be developed to minimize this risk.
21. Potential for impact on cultural heritage resources	No impact on cultural heritage resources is expected.
22. Potential for contaminated residual material	Treatment will produce minimal contaminated residuals. Depending on the type of biological treatment, there may be a need for temporary storage. Any equipment used to temporarily store material will have to be disposed of.

Alternative C – Dredge, Pre-treatment, Organic and Inorganic Extraction and Placement in Engineered Containment Facility

Criteria	Potential Environmental Effects
1. Level of confidence associated with ability to carry out alternative	Moderate level of confidence associated with ability to carry out alternative due to past performance of technology with Great Lakes sediment in context of Randle Reef Industrial Fill Criteria.
2. Certainty with which cost of alternatives can be predicted	The cost of the alternative can be predicted with a moderate level of certainty based on past demonstration costs and subsequent commercial practices. This uncertainty relates to the ability of the technology to achieve the Randle Reef Industrial Fill Criteria.
3. Impact on post remediation value of properties where material is disposed	The impact on the value of the ECF should be minimal, since the material will have been cleaned up to appropriate guidelines. There may, however, be implications associated with perceived risk that result in a decrease in property value should the Harbour Commission [now Hamilton Port Authority] choose to sell it for industrial land once it is filled and capped.
4. Risk to public health and safety	There is little concern that during the dredging operation public health will be at risk. Although sediments will be stirred up, these sediments are currently in the water and are already exposed to energy that causes some dispersion. During the temporary storage of materials, provisions will be required to ensure the public is not exposed to the material. Pre-treatment and treatment can be conducted in a controlled environment before the sediment is transported to the ECF. The risk associated with the transportation of material to the receiving facility will be directly related to the distance the material will travel. This alternative will involve the shortest travel distance and, therefore, has the least risk to public health and safety risk.
5. Risk to worker health and safety	During the temporary storage of materials, workers will need to take precautions to avoid exposure. Organic technologies have less potential for risk to worker health and safety than either biological or thermal technologies because of the nature of worker exposure to the contaminated sediment and the potential for accidents. The potential risk, however, will be a function of the toxicity of the solvents that are used to extract the contaminants.
6. Potential for impact on aquatic biota during implementation	During removal, there will be a temporary impact on aquatic biota as sediments are disturbed and dispersed. During the temporary storage and treatment of the material there is the potential for contaminants to reenter the Harbour, although this will be offset with mitigation and contingency measures.

Criteria	Potential Environmental Effects
7. Potential for impact on aquatic biota following implementation	Immediately following implementation, one might expect to see an increase in uptake by biota because of the physical disturbance. In the long-term, however, exposure of biota to PAHs in the sediment will decrease at Randle Reef and around it. The remediated material may still contain contaminant levels higher than typically found in other ECFs on the Great Lakes. Consequently, a risk assessment study will be required to assess potential ecosystem effects.
8. Potential for impact on terrestrial biota during implementation	During dredging, temporary storage (if required), pre-treatment and treatment, there may be an opportunity to expose terrestrial biota to the contaminated sediments, however, this potential exposure can be mitigated. Until the ECF is capped, there will be some opportunity for exposure of terrestrial biota to the treated material. Because the material will be treated, it is expected that the effects of the exposure will be minimal. During placement of the material in the ECF, birds nesting in the area could be disturbed temporarily.
9. Potential for impact on terrestrial biota following implementation	The remediated material may still contain contaminant levels higher than typically found in other ECFs on the Great Lakes. Consequently, a risk assessment study will be required to assess potential ecosystem effects.
10. Potential for impact on water column during implementation	There is some potential for a temporary impact on the water column during dredging, temporary storage, pre-treatment and treatment. Operation performance standards and mitigation measures can be implemented to minimize impacts. The potential impact associated with this alternative is, in part, a function of the amount of time required to implement the alternative. It will take approximately 3 to 5 months to implement the alternative.
11. Potential for impact on water column following implementation	The remediated material may still contain contaminant levels higher than typically found in other ECFs on the Great Lakes. Consequently, a risk assessment study will be required to assess potential ecosystem effects.
12. Potential for impact on air quality during implementation	There is some potential for the volatilization of the material during temporary storage, pre-treatment and treatment, however, it is expected that this can be mitigated.
13. Potential for impact on air quality following implementation	The remediated material may still contain contaminant levels higher than typically found in other ECFs on the Great Lakes. Consequently, a risk assessment study will be required to assess potential ecosystem effects.
14. Potential for impact on land quality during implementation	During temporary storage, pre-treatment and treatment there is some potential for impact on land quality, however, it is expected it can be mitigated.

Criteria	Potential Environmental Effects
I5. Potential for impact on land quality following implementation	The remediated material may still contain contaminant levels higher than typically found in other ECFs on the Great Lakes. Consequently, a risk assessment study will be required to assess potential ecosystem effects.
16. Potential for noise or other loss of aesthetic value during implementation	There is some potential for loss of aesthetic value during the implementation of this removal alternative. Since the operation will be in an existing industrial area, it is expected that it will be absorbed into the surrounding landscape. Noise impacts are expected to be minimal. The potential impact associated with this alternative is, in part, a function of the amount of time required to implement the alternative. It will take approximately 3 to 5 months to implement the alternative.
17. Potential for disruption to recreation during implementation	Some disruption to recreation during implementation may occur, since the access to the site will need to be restricted for the duration of the removal operation. The placement of the treated material in the ECF could potentially impact temporarily on the birds using the ECF. This, in turn, could impact on bird watching.
18. Potential for disruption to recreation following implementation	No disruption to recreation following implementation of this alternative is expected, since the disposed material will not be placed in a recreational area.
19. Potential for disruption to businesses	Potential for short-term disruption to water-based businesses (limited to duration of removal activity) during dredging.
20. Potential for impact on ground water	No long term potential for impact on the ground water is expected. During temporary storage there may be potential for impact on ground water, however, mitigation measures can be developed to minimize this risk.
21. Potential for impact on cultural heritage resources	No impact on cultural heritage resources is expected.
22. Potential for contaminated residual material	Some contaminated residual material is expected from the organic extraction process. Any equipment used to temporarily store material will have to be disposed of.

Alternative D – Dredge, Pre-treatment, Thermal Treatment, Inorganic Extraction and Placement into Engineered Containment Facility

Criteria	Potential Environmental Effects
1. Level of confidence associated with ability to carry out alternative	Moderate to high level of confidence associated with ability to carry out alternative due to past performance of technology with Hamilton Harbour sediment. The uncertainty relates to the inorganic extraction.
2. Certainty with which cost of alternatives can be predicted	The cost of the alternative can be predicted with a moderate level of certainty based on past demonstration costs and subsequent commercial practices. The uncertainty relates to the inorganic extraction.
3. Impact on post remediation value of properties where material is disposed	The impact on the value of the ECF should be minimal, since the material will have been cleaned up to appropriate guidelines. There may, however, be implications associated with perceived risk that result in a decrease in property value should the Harbour Commission [now Hamilton Port Authority] choose to sell it for industrial land once it is filled and capped.
4. Risk to public health and safety	There is little concern that during the dredging operation public health will be at risk. Although sediments will be stirred up, these sediments are currently in the water and are already exposed to energy that causes some dispersion. During the temporary storage of materials, provisions will be required to ensure the public is not exposed to the material. Pre-treatment can be conducted in a controlled environment. Some thermal technologies use high temperatures in the presence of explosive substances. Therefore, should there be a system failure, a thermal technology could pose a greater risk to the public than organic or biological technologies. The risk associated with the transportation of material to the receiving facility will be directly related to the distance the material will travel. This alternative will involve the shortest travel distance and, therefore, has the least risk to public health and safety from a transportation perspective.
5. Risk to worker health and safety	During the temporary storage of materials, workers will need to take precautions to avoid exposure. Thermal technologies use high temperatures in the presence of explosive substances. Therefore, should there be a system failure, a thermal technology could pose a greater accident risk to the worker health and safety than organic or biological technologies.
6. Potential for impact on aquatic biota during implementation	During removal, there will be a temporary impact on aquatic biota as sediments are disturbed and dispersed. During the temporary storage and treatment of the material there is the potential for contaminants to reenter the Harbour, although this will be offset with mitigation and contingency measures.

Criteria	Potential Environmental Effects
7. Potential for impact on aquatic biota following implementation	Immediately following implementation, one might expect to see an increase in uptake by biota because of the physical disturbance. In the long-term, however, exposure of biota to PAHs in the sediment will decrease at Randle Reef and around it. The remediated material may still contain contaminant levels higher than typically found in other ECFs on the Great Lakes. Consequently, a risk assessment study will be required to assess potential ecosystem effects.
8. Potential for impact on terrestrial biota during implementation	During dredging, temporary storage, pre-treatment and treatment, there may be an opportunity to expose terrestrial biota to the contaminated sediments, however, this potential exposure can be mitigated. Until the ECF is capped, there will be some opportunity for exposure of terrestrial biota to the treated material. Because the material will be treated, it is expected that the effects of the exposure will be minimal. During placement of the material in the ECF, birds nesting in the area could be disturbed temporarily.
9. Potential for impact on terrestrial biota following implementation	The remediated material may still contain contaminant levels higher than typically found in other ECFs on the Great Lakes. Consequently, a risk assessment study will be required to assess potential ecosystem effects.
10. Potential for impact on water column during implementation	There is some potential for a temporary impact on the water column during dredging, temporary storage, pre-treatment and treatment. Operation performance standards and mitigation measures can be implemented to minimize impacts. The potential impact associated with this alternative is, in part, a function of the amount of time required to implement the alternative. It will take approximately 3 to 5 months to implement the alternative.
11. Potential for impact on water column following implementation	The remediated material may still contain contaminant levels higher than typically found in other ECFs on the Great Lakes. Consequently, a risk assessment study will be required to assess potential ecosystem effects.
12. Potential for impact on air quality during implementation	There is some potential for the volatilization of the material during temporary storage, pre-treatment and treatment, however, it is expected that this can be mitigated. Although all alternatives will need to meet Provincial Air Quality Emission standards, should process or equipment failure occur, the thermal treatment technology is more likely to have an impact on the environment than the biological or organic technologies.
13. Potential for impact on air quality following implementation	The remediated material may still contain contaminant levels higher than typically found in other ECFs on the Great Lakes. Consequently, a risk assessment study will be required to assess potential ecosystem effects.

Criteria	Potential Environmental Effects
14. Potential for impact on land quality during implementation	During temporary storage, pre-treatment and treatment there is some potential for impact on land quality, however, it is expected it can be mitigated.
I5. Potential for impact on land quality following implementation	The remediated material may still contain contaminant levels higher than typically found in other ECFs on the Great Lakes. Consequently, a risk assessment study will be required to assess potential ecosystem effects.
16. Potential for noise or other loss of aesthetic value during implementation	There is some potential for loss of aesthetic value during the implementation of this removal alternative. Since the operation will be in an existing industrial area, it is expected that it will be absorbed into the surrounding landscape. Noise impacts are expected to be minimal. The potential impact associated with this alternative is, in part, a function of the amount of time required to implement the alternative. It will take approximately 3 to 5 months to implement the alternative.
17. Potential for disruption to recreation during implementation	Some disruption to recreation during implementation may occur since the access to the site will need to be restricted for the duration of the removal operation. The placement of the treated material in the ECF could potentially impact temporarily on the birds using the ECF. This, in turn, could impact on bird watching.
18. Potential for disruption to recreation following implementation	No disruption to recreation following implementation of this alternative is expected, since the disposal material will not be placed in a recreational area.
19. Potential for disruption to businesses	Potential for short-term disruption to water-based businesses (limited to duration of removal activity) during dredging.
20. Potential for impact on ground water	No long term potential for impact on the ground water is expected. During temporary storage there may be potential for impact on ground water, however, mitigation measures can be developed to minimize this risk.
21. Potential for impact on cultural heritage resources	No impact on cultural heritage resources is expected.

Criteria	Potential Environmental Effects
22. Potential for contaminated residual material	Some contaminated residual material may be generated by the thermal treatment process. Any equipment used to temporarily store material will have to be disposed of.

Alternative E – Dredge, Pre-treatment, Biological Treatment, Inorganic Extraction and Placement in Industrial Landfill

Criteria	Potential Environmental Effects
1. Level of confidence associated with ability to carry out alternative	Moderate to high level of confidence associated with ability to carry out alternative based on available technologies, expertise and criteria.
2. Certainty with which cost of alternatives can be predicted	The cost of the alternative can be predicted with a moderate level of certainty based on lack of experience with Randle Reef Volatility Criteria.
3. Impact on post remediation value of properties where material is disposed	The disposal of Randle Reef sediments at the industrial landfill is not expected to impact on the value of the site, since it will continue to be an industrial landfill regardless of whether or not these materials are disposed at the facility.
4. Risk to public health and safety	There is little concern that during the dredging operation public health will be at risk. Although sediment will be stirred up, these sediments are currently in the water and are already exposed to energy that cause some dispersion. During the temporary storage of materials, provisions will be required to ensure the public is not exposed to the material. Pre-treatment can be conducted in an enclosed environment before the sediment is transported to the hazardous waste facility, therefore, the exposure will be minimal. Depending on the type of biological treatment, a separate storage facility may be required. The risk associated with the transportation of material to the receiving facility will be directly related to the distance the material will travel. If we assume that an industrial landfill site can be found within 100 km of the site, this will involve a moderate travel distance.
5. Risk to worker health and safety	Depending on the type of biological treatment, a separate storage facility may be required. During the temporary storage of materials, workers will need to take precautions to avoid exposure. Biological technologies expose workers to the materials for much longer periods of time than either thermal or organic technologies. Consequently, there is a greater risk to worker health and safety because of the time and type of exposure. This risk can be mitigated with protective equipment.

Criteria	Potential Environmental Effects
6. Potential for impact on aquatic biota during implementation	During removal, there will be a temporary impact on aquatic biota as sediments are disturbed and dispersed. During the temporary storage (if required) and treatment of the material there is the potential for contaminants to reenter the Harbour, although this will be offset with mitigation and contingency measures.
7. Potential for impact on aquatic biota following implementation	Immediately following implementation, one might expect to see an increase in uptake by biota because of the physical disturbance. In the long-term, however, exposure of biota to PAHs in the sediment will decrease at Randle Reef and around it. The removed material will have been remediated to a point that contaminant levels are not hazardous. The industrial landfill where the material is disposed with this alternative is designed to contain the material and isolate it from the environment. However, since the sediments will still have some degree of contamination even after treatment, there could be some potential for groundwater impacts if the containment system failed. This failure could potentially lead to surface water impacts and aquatic biota impacts.
8. Potential for impact on terrestrial biota during implementation	During dredging, temporary storage (if required), pre-treatment and treatment, there may be an opportunity to expose terrestrial biota to the contaminated sediments, however, this potential exposure can be mitigated.
9. Potential for impact on terrestrial biota following implementation	No significant impact on terrestrial biota resulting from this alternative is expected. The industrial landfill facility where the material is disposed with this alternative is designed to contain the material and isolate it from the environment. However, since the sediments will still have some degree of contamination even after treatment, there could be some potential for impact on terrestrial biota should the containment system fail.
10. Potential for impact on water column during implementation	There is some potential for a temporary impact on the water column during dredging, temporary storage (if required), pre-treatment and treatment. Operation performance standards and mitigation measures can be implemented to minimize impacts. The potential impact associated with this alternative is, in part, a function of the amount of time required to implement the alternative. It will take approximately 6 months to 5 years to implement the alternative.
11. Potential for impact on water column following implementation	There is minimal potential for impact on the water column following the implementation of this alternative. Equilibrium or ambient conditions are expected to return within 48 hours based on previous pilot projects. Industrial landfill facilities are designed to contain the material and isolate it from the environment. However, since the sediments will still have some degree of contamination even after treatment, there could be some potential for impact on groundwater if the containment system failed. This failure could potentially lead to surface water impacts.
12. Potential for impact on air quality during implementation	There is some potential for the volatilization of the material during temporary storage (if required), pre-treatment and treatment, however, it is expected that this can be mitigated.
13. Potential for impact on air quality following implementation	There is a low potential for impact on air quality following implementation.

Criteria	Potential Environmental Effects
14. Potential for impact on land quality during implementation	During temporary storage (if required), pre-treatment and treatment there is some potential for impact on land quality, however, it is expected it can be mitigated.
15. Potential for impact on land quality following implementation	The lands associated with the industrial landfill will be degraded, however, this would have occurred irrespective of whether or not the Hamilton Harbour sediments were disposed of there.
16. Potential for noise or other loss of aesthetic value during implementation	There is some potential for loss of aesthetic value during the implementation of this removal alternative. Since the operation will be in an existing industrial area, it is expected that it will be absorbed into the surrounding landscape. Noise impacts are expected to be minimal. The potential impact associated with this alternative is, in part, a function of the amount of time required to implement the alternative. It will take approximately 6 months to 5 years to implement the alternative.
17. Potential for disruption to recreation during implementation	Some disruption to recreation during implementation may occur, since the access to the site will need to be restricted for the duration of the removal operation.
18. Potential for disruption to recreation following implementation	No disruption to recreation following implementation of this alternative is expected, since the disposed material will not be placed in a recreational area.
19. Potential for disruption to businesses	Short term potential for disruption to water-based businesses (i.e., limited to duration of removal activity) due to temporary disruption.
20. Potential for impact on ground water	Depending on the type of biological treatment, there may be a need for temporary storage. During temporary storage there may be potential for impact on ground water, however, mitigation measures can be developed to minimize this risk. Any industrial landfill facility used for the disposal of this material will be designed to protect ground water. However, since the sediments will still have some degree of contamination, even after treatment, there could be some potential for impact on groundwater if the containment system failed.
21. Potential for impact on cultural heritage resources	No impact on cultural heritage resources is expected.
22. Potential for contaminated residual material	Treatment will produce minimal contaminated residuals. However, minimal remediation will have occurred, therefore, sediments still have elevated levels of contaminants. Depending on the type of biological treatment, there may be a need for temporary storage. Any equipment used to temporarily store material will have to be disposed of.

Alternative F – Dredge, Pre-treatment, Organic and Inorganic Extraction and Placement into Industrial Landfill

Criteria	Potential Environmental Effects
1. Level of confidence associated with ability to carry out alternative	Moderate to high level of confidence associated with ability to carry out alternative based on available technologies, expertise and criteria.
2. Certainty with which cost of alternatives can be predicted	The cost of the alternative can be predicted with a moderate level of certainty based on lack of experience with Randle Reef Volatility Criteria.
3. Impact on post remediation value of properties where material is disposed	The disposal of Randle Reef sediments at the industrial landfill is not expected to impact on the value of the site, since it will continue to be an industrial landfill regardless of whether or not these materials are disposed at the facility.
4. Risk to public health and safety	There is little concern that during the dredging operation public health will be at risk. Although sediments will be stirred up, these sediments are currently in the water and are already exposed to energy that causes some dispersion. During the temporary storage of materials, provisions will be required to ensure the public is not exposed to the material. Pre-treatment can be conducted in an enclosed environment before the sediment is transported to the hazardous waste facility, therefore, the exposure will be minimal. The risk associated with the transportation of material to the receiving facility will be directly related to the distance the material will travel. If we assume that an industrial landfill site can be found within 100 km of the site, this will involve a moderate travel distance.
5. Risk to worker health and safety	During the temporary storage of materials, workers will need to take precautions to avoid exposure. Organic technologies have less potential for risk to worker health and safety than either biological or thermal technologies because of the nature of worker exposure to the contaminated sediment and the potential for accidents. The potential risk, however, will be a function of the toxicity of the solvents that are used to extract the contaminants.
6. Potential for impact on aquatic biota during implementation	During removal, there will be a temporary impact on aquatic biota as sediments are disturbed and dispersed. During the temporary storage and treatment of the material there is the potential for contaminants to reenter the Harbour, although this will be offset with mitigation and contingency measures.

Criteria	Potential Environmental Effects
7. Potential for impact on aquatic biota following implementation	Immediately following implementation, one might expect to see an increase in uptake by biota because of the physical disturbance. In the long-term, however, exposure of biota to PAHs in the sediment will decrease at Randle Reef and around it. The removed material will have been remediated to a point that contaminant levels are not hazardous. The industrial landfill where the material is disposed with this alternative is designed to contain the material and isolate it from the environment. However, since the sediments will still have some degree of contamination even after treatment, there could be some potential for groundwater impacts if the containment system failed. This failure could potentially lead to surface water impacts and aquatic biota impacts.
8. Potential for impact on terrestrial biota during implementation	During dredging, temporary storage, pre-treatment and treatment, there may be an opportunity to expose terrestrial biota to the contaminated sediments, however, this potential exposure can be mitigated.
9. Potential for impact on terrestrial biota following implementation	No significant impact on terrestrial biota resulting from this alternative is expected. The industrial landfill facility where the material is disposed with this alternative is designed to contain the material and isolate it from the environment. However, since the sediments will still have some degree of contamination even after treatment, there could be some potential for impact on terrestrial biota should the containment system fail.
10. Potential for impact on water column during implementation	There is some potential for a temporary impact on the water column during dredging, temporary storage, pre-treatment and treatment. Operation performance standards and mitigation measures can be implemented to minimize impacts. The potential impact associated with this alternative is, in part, a function of the amount of time required to implement the alternative. It will take approximately 3 to 5 months to implement the alternative.
11. Potential for impact on water column following implementation	There is minimal potential for impact on the water column following the implementation of this alternative. Equilibrium or ambient conditions are expected to return within 48 hours based on previous pilot projects. Industrial landfill facilities are designed to contain the material and isolate it from the environment. However, since the sediments will still have some degree of contamination even after treatment, there could be some potential for impact on groundwater if the containment system failed. This failure could potentially lead to surface water impacts.
12. Potential for impact on air quality during implementation	There is some potential for the volatilization of the material during temporary storage, pre-treatment and treatment, however, it is expected that this can be mitigated.
13. Potential for impact on air quality following implementation	There is a low potential for impact on air quality following implementation.

Criteria	Potential Environmental Effects
14. Potential for impact on land quality during implementation	During temporary storage, pre-treatment and treatment there is some potential for impact on land quality, however, it is expected it can be mitigated.
15. Potential for impact on land quality following implementation	The lands associated with the industrial landfill will be degraded, however, this would have occurred irrespective of whether or not the Hamilton Harbour sediments were disposed of there.
16. Potential for noise or other loss of aesthetic value during implementation	There is some potential for loss of aesthetic value during the implementation of this removal alternative. Since the operation will be in an existing industrial area, it is expected that it will be absorbed into the surrounding landscape. Noise impacts are expected to be minimal. The potential impact associated with this alternative is, in part, a function of the amount of time required to implement the alternative. It will take approximately 3 to 5 months to implement the alternative.
17. Potential for disruption to recreation during implementation	Some disruption to recreation during implementation may occur, since the access to the site will need to be restricted for the duration of the removal operation.
18. Potential for disruption to recreation following implementation	No disruption to recreation following implementation of this alternative is expected, since the disposed material will not be placed in a recreational area.
19. Potential for disruption to businesses	Short term potential for disruption to water-based businesses (i.e., limited to duration of removal activity) due to the temporary disruption.
20. Potential for impact on ground water	During temporary storage there may be potential for impact on ground water, however, mitigation measures can be developed to minimize this risk. Any industrial landfill facility used for the disposal of this material will be designed to protect ground water. However, since the sediments will still have some degree of contamination, even after treatment, there could be some potential for impact on groundwater if the containment system failed.
21. Potential for impact on cultural heritage resources	No impact on cultural heritage resources is expected.
22. Potential for contaminated residual material	Some contaminated residual material is expected from the organic extraction process. In addition, minimal remediation will have occurred, therefore, sediments will still have elevated levels of contaminants. Any equipment used to temporarily store material will have to be disposed of.

Alternative G – Dredge, Pre-treatment, Thermal Treatment, Inorganic Extraction and Placement into Industrial Landfill

Criteria	Potential Environmental Effects
1. Level of confidence associated with ability to carry out alternative	Moderate to high level of confidence associated with ability to carry out alternative based on available technologies, expertise and criteria.
2. Certainty with which cost of alternatives can be predicted	The cost of the alternative can be predicted with a moderate level of certainty based on lack of experience with Randle Reef Volatility Criteria.
3. Impact on post remediation value of properties where material is disposed	The disposal of Randle Reef sediments at the industrial landfill is not expected to impact on the value of the site, since it will continue to be an industrial landfill regardless of whether or not these materials are disposed at the facility.
4. Risk to public health and safety	There is little concern that during the dredging operation public health will be at risk. Although sediment will be stirred up, these sediments are currently in the water and are already exposed to energy that cause some dispersion. During the temporary storage of materials, provisions will be required to ensure the public is not exposed to the material. Pre-treatment can be conducted in a controlled environment. Some thermal technologies use high temperatures in the presence of explosive substances. Therefore, should there be a system failure, a thermal technology could pose a greater risk to the public than organic or biological technologies. The risk associated with the transportation of material to the receiving facility will be directly related to the distance the material will travel. If we assume that an industrial landfill site can be found within 100 km of the site, this will involve a moderate travel distance.
5. Risk to worker health and safety	During the temporary storage of materials, workers will need to take precautions to avoid exposure. Some thermal technologies use high temperatures in the presence of explosive substances. Therefore, should there be a system failure, a thermal technology could pose a greater accident risk to the worker health and safety than organic or biological technologies.
6. Potential for impact on aquatic biota during implementation	During removal, there will be a temporary impact on aquatic biota as sediments arc disturbed and dispersed. During the temporary storage and treatment of the material there is the potential for contaminants to reenter the Harbour, although this will be offset with mitigation and contingency measures.

Criteria	Potential Environmental Effects
7. Potential for impact on aquatic biota following implementation	Immediately following implementation, one might expect to see an increase in uptake by biota because of the physical disturbance. In the long-term, however, exposure of biota to PAHs in the sediment will decrease at Randle Reef and around it. The removed material will have been remediated to a point that contaminant levels are not hazardous. The industrial landfill where the material is disposed with this alternative is designed to contain the material an isolate it from the environment. However, since the sediments will still have some degree of contaminate even after treatment, there could be some potential for groundwater impacts if the containment system failed. This failure could potentially lead to surface water impacts and aquatic biota impacts.
8. Potential for impact on terrestrial biota during implementation	During dredging, temporary storage, pre-treatment and treatment, there may be an opportunity to expose terrestrial biota to the contaminated sediments, however, this potential exposure can be mitigated.
9. Potential for impact on terrestrial biota following implementation	No significant impact on terrestrial biota resulting from this alternative is expected. The industrial landfill facility where the material is disposed with this alternative is designed to contain the material and isolate it from the environment. However, since the sediments will still have some degree of contamination even after treatment, there could be some potential for impact on terrestrial biota should the containment system fail.
10. Potential for impact on water column during implementation	There is some potential for a temporary impact on the water column during dredging, temporary storage, pre-treatment and treatment. Operation performance standards and mitigation measures can be implemented to minimize impacts. The potential impact associated with this alternative is, in part, a function of the amount of time required to implement the alternative. It will take approximately 3 to 5 months to implement the alternative.
11. Potential for impact on water column following implementation	There is minimal potential for impact on the water column following the implementation of this alternative. Equilibrium or ambient conditions are expected to return within 48 hours based on previous pilot projects. Industrial landfill facilities are designed to contain the material and isolate it from the environment. However, since the sediments will still have some degree of contamination even after treatment, there could be some potential for impact on groundwater if the containment system failed. This failure could potentially lead to surface water impacts.
12. Potential for impact on air quality during implementation	There is some potential for the volatilization of the material during temporary storage, pre-treatment and treatment, however, it is expected that this can be mitigated. Although all alternatives will need to meet Provincial Air Quality Emission standards, should process or equipment failure occur, the thermal treatment technology is more likely to have an impact on the environment than the biological or organic technologies.
13. Potential for impact on air quality following implementation	There is a low potential for impact on air quality following implementation.

Criteria	Potential Environmental Effects
14. Potential for impact on land quality during implementation	During temporary storage, pre-treatment and treatment there is some potential for impact on land quality, however, it is expected it can be mitigated.
15. Potential for impact on land quality following implementation	The lands associated with the industrial landfill will be degraded, however, this would have occurred irrespective of whether or not the Hamilton Harbour sediments were disposed of there.
16. Potential for noise or other loss of aesthetic value during implementation	There is some potential for loss of aesthetic value during the implementation of this removal alternative. Since the operation will be in an existing industrial area, it is expected that it will be absorbed into the surrounding landscape. Noise impacts are expected to be minimal. The potential impact associated with this alternative is, in part, a function of the amount of time required to implement the alternative. It will take approximately 3 to 5 months to implement the alternative.
17. Potential for disruption to recreation during implementation	Some disruption to recreation during implementation may occur, since the access to the site will need to be restricted for the duration of the removal operation.
18. Potential for disruption to recreation following implementation	No disruption to recreation following implementation of this alternative is expected, since the disposed material will not be placed in a recreational area.
19. Potential for disruption to businesses	Short term potential for disruption to water-based businesses (i.e., limited to duration of removal activity) due to the temporary disruption.
20. Potential for impact on ground water	During temporary storage there may be potential for impact on ground water, however, mitigation measures can be developed to minimize this risk. Any industrial landfill facility used for the disposal of this material will be designed to protect ground water. However, since the sediments will still have some degree of contamination, even after treatment, there could be some potential for impact on groundwater if the containment system failed.
21. Potential for impact on cultural heritage resources	No impact on cultural heritage resources is expected.
22. Potential for contaminated residual material	Some contaminated residual material may be generated by the thermal treatment process. In addition, minimal remediation will have occurred, therefore, sediments still have elevated levels of contaminants. Any equipment used to temporarily store material will have to be disposed of.

Alternative H – Dredge, Pre-treatment, Biological Treatment and Inorganic Extraction and Placement on Commercial or Industrial Land

Criteria	Potential Environmental Effects
1. Level of confidence associated with ability to carry out alternative	Low level of confidence associated with ability to carry out alternative due to rigour of the criteria. Biological treatment may or may not be able to treat to industrial criteria.
2. Certainty with which cost of alternatives can be predicted	The cost of the alternative can be predicted with a low level of certainty based on rigour of the criteria.
3. Impact on post remediation value of properties where material is disposed	The impact on the value of the industrial or commercial land should be minimal since the material will have been cleaned up to appropriate guidelines.
4. Risk to public health and safety	There is little concern that during the dredging operation public health will be at risk. Although sediments will be stirred up, these sediments are currently in the water and are already exposed to energy that causes some dispersion. During the temporary storage of materials, provisions will be required to ensure the public is not exposed to the material. Pre-treatment and treatment can be conducted in an enclosed environment before the sediment is cleaned up and transported to the industrial or commercial location. The risk associated with the transportation of material to the receiving lands will be directly related to the distance the material will travel. If we assume that commercial or industrial land can be found within the Harbour, this alternative will involve the shortest travel distance and, therefore, will have the least impact to public health and safety from a transportation perspective.
5. Risk to worker health and safety	Depending on the type of biological treatment, a separate storage facility may be required. During the temporary storage of materials, workers will need to take precautions to avoid exposure. Biological technologies expose workers to the materials for much longer periods of time than either thermal or organic technologies. Consequently, there is a greater risk to worker health and safety because of the time and type of exposure. This risk can be mitigated with protective equipment.
6. Potential for impact on aquatic biota during implementation	During removal, there will be a temporary impact on aquatic biota as sediments are disturbed and dispersed. During the temporary storage (if required) and treatment of the material there is the potential for contaminants to reenter the Harbour, although this will be offset with mitigation and contingency measures.

Criteria	Potential Environmental Effects
7. Potential for impact on aquatic biota following implementation	Immediately following implementation, one might expect to see an increase in uptake by biota because of the physical disturbance. In the long-term, however, exposure of biota to PAHs in the sediment will decrease at Randle Reef and around it. The removed material will have been remediated to a point that contaminant levels are consistent with those already found on the industrial lands. If material is placed on industrial/commercial lands in a manner that won't result in reentry to the Harbour, impacts will likely be minimal.
8. Potential for impact on terrestrial biota during implementation	During dredging, temporary storage (if required), pre-treatment and treatment, there may be an opportunity to expose terrestrial biota to the contaminated sediments, however, this potential exposure be mitigated.
9. Potential for impact on terrestrial biota following implementation	The impacts on terrestrial biota resulting from this alternative are expected to be negligible because the material will be consistent with soils already found on commercial or industrial lands.
10. Potential for impact on water column during implementation	There is some potential for a temporary impact on the water column during dredging, temporary storage (if required), pre-treatment and treatment. Operation performance standards and mitigation measures can be implemented to minimize impacts. The potential impact associated with this alternative is, in part, a function of the amount of time required to implement the alternative. It will take approximately 6 months to 5 years to implement the alternative.
11. Potential for impact on water column following implementation	Following the implementation of this alternative, there is no anticipated potential for impact on the water column.
12. Potential for impact on air quality during implementation	There is some potential for the volatilization of the material during temporary storage (if required), pre-treatment and treatment, however, it is expected that this can be mitigated.
13. Potential for impact on air quality following implementation	There is a low potential for impact on air quality following implementation.
14. Potential for impact on land quality during implementation	During temporary storage (if required), pre-treatment and treatment there is some potential for impact on land quality, however, it is expected it can be mitigated.
15. Potential for impact on land Quality following implementation	Low impact on land quality following implementation, since the material will be treated to a level consistent with CCME guidelines and will, therefore, potentially be as clean as soils already in the disposal location.
16. Potential for noise or other loss of aesthetic value during implementation	There is some potential for loss of aesthetic value during the implementation of this removal alternative. Since the operation will be in an existing industrial area, it is expected that it will be absorbed into the surrounding landscape. Noise impacts are expected to be minimal. The potential impact associated with this alternative is, in part, a function of the amount of time required to implement the alternative. It will take

Criteria	Potential Environmental Effects
	approximately 6 months to 5 years to implement the alternative.
17. Potential for disruption to recreation during implementation	Some disruption to recreation during dredging may occur since the access to the site will need to be restricted for the duration of the removal operation.
18. Potential for disruption to recreation following implementation	No disruption to recreation following implementation of this alternative is expected, since the contaminated material will not be placed in a recreational area.
19. Potential for disruption to businesses	Potential for short-term disruption to water-based businesses. Limited to duration of removal activity) during dredging.
20. Potential for impact on ground water	In the long term, the potential for impact on ground water quality is negligible given that the material would be clean and likely similar in character to material already at the disposal location. Depending on the type of biological treatment, there may be a need for temporary storage. During temporary storage there may be potential for impact on ground water, however, mitigation measures can be developed to minimize this risk.
21. Potential for impact on cultural heritage resources	No impact on cultural heritage resources is expected.
22. Potential for contaminated residual material	Treatment will produce minimal contaminated residual material. Depending on the type of biological treatment, there may be a need for temporary storage. Any equipment used to temporarily store material will have to be disposed of.

Alternative I – Dredge, Pre-treatment, Organic and Inorganic Extraction and Placement on Commercial or Industrial Land

Criteria	Potential Environmental Effects
1. Level of confidence associated with ability to carry out alternative	Low to moderate level of confidence associated with ability to carry out alternative due to the rigour of the criteria. The organic extraction treatment may or may not be able to treat to these criteria levels.
2. Certainty with which cost of alternatives can be predicted	The cost of the alternative can be predicted with a low level of certainty based on rigour of the criteria.

Criteria	Potential Environmental Effects
3. Impact on post remediation value of properties where material is disposed	The impact on the value of the industrial or commercial land should be minimal since the material will have been cleaned up to appropriate guidelines.
4. Risk to public health and safety	There is little concern that during the dredging operation public health will be at risk. Although sediments will be stirred up, these sediments are currently in the water and are already exposed to energy that causes some dispersion. During the temporary storage of materials, provisions will be required to ensure the public is not exposed to the material. Pre-treatment and treatment can be conducted in an enclosed environment before the sediment is cleaned up and transported to the industrial or commercial location. The risk associated with the transportation of material to the receiving lands will be directly related to the distance the material will travel. If we assume that commercial or industrial land can be found within the Harbour, this alternative will involve the shortest travel distance and, therefore, will have the least impact to public health and safety from a transportation perspective.
5. Risk to worker health and safety	During the temporary storage of materials, workers will need to take precautions to avoid exposure. Organic technologies have less potential for risk to worker health and safety than either biological or thermal technologies because of the nature of worker exposure to the contaminated sediment and the potential for accidents. The potential risk, however, will be a function of the toxicity of the solvents that are used to extract the contaminants.
6. Potential for impact on aquatic biota during implementation	During removal, there will be a temporary impact on aquatic biota as sediments are disturbed and dispersed. During the temporary storage and treatment of the material there is the potential for contaminants to reenter the Harbour, although this will be offset with mitigation and contingency measures.
7. Potential for impact on aquatic biota following implementation	Immediately following implementation, one might expect to see an increase in uptake by biota because of the physical disturbance. In the long-term, however, exposure of biota to PAHs in the sediment will decrease at Randle Reef and around it. The removed material will have been remediated to a point that contaminant levels are consistent with those already found on the industrial lands. If material is placed on industrial/commercial lands in a manner that won't result in reentry to the Harbour, impacts will likely be minimal.
8. Potential for impact on terrestrial biota during implementation	During dredging, temporary storage, pre-treatment and treatment, there may be an opportunity to expose terrestrial biota to the contaminated sediments, however, this potential exposure can be mitigated.
9. Potential for impact on terrestrial biota following implementation	The impacts on terrestrial biota resulting from this alternative are expected to be negligible because the material will be consistent with soils already found on commercial or industrial lands.

Criteria	Potential Environmental Effects
10. Potential for impact on water column during implementation	There is some potential for a temporary impact on the water column during dredging, temporary storage, pre-treatment and treatment. Operation performance standards and mitigation measures can be implemented to minimize impacts. The potential impact associated with this alternative is, in part, a function of the amount of time required to implement the alternative. It will take approximately 3 to 5 months to implement the alternative.
11. Potential for impact on water column following implementation	Following the implementation of this alternative, there is no anticipated potential for impact on the water column. The removed material will have been remediated to a point that contaminant levels are consistent with those already found on industrial lands. If the material is placed on industrial/commercial lands in a manner that will not result in reentry to the Harbour, impacts will likely be minimal.
12. Potential for impact on air quality during implementation	There is some potential for the volatilization of the material during temporary storage, pre-treatment and treatment, however, it is expected that this can be mitigated.
13. Potential for impact on air quality following implementation	There is a low potential for impact on air quality following implementation.
14. Potential for impact on land quality during implementation	During temporary storage, pre-treatment and treatment there is some potential for impact on land quality, however, it is expected it can be mitigated.
I5. Potential for impact on land quality following implementation	Low impact on land quality following implementation, since the material will be treated to a level consistent with guidelines and will, therefore, potentially be as clean as soils already in the disposal location.
16. Potential for noise or other loss of aesthetic value during implementation	There is some potential for loss of aesthetic value during the implementation of this removal alternative. Since the operation will be in an existing industrial area, it is expected that it will be absorbed into the surrounding landscape. Noise impacts are expected to be minimal. The potential impact associated with this alternative is, in part, a function of the amount of time required to implement the alternative. It will take approximately 3 to 5 months to implement the alternative.
17. Potential for disruption to recreation during implementation	Some disruption to recreation during dredging may occur since the access to the site will need to be restricted for the duration of the removal operation.
18. Potential for disruption to recreation following implementation	No disruption to recreation following implementation of this alternative is expected, since the contaminated material will not be placed in a recreational area.
19. Potential for disruption to businesses	Potential for short-term disruption to water-based businesses (limited to duration of removal activity) during dredging.

Criteria	Potential Environmental Effects
20. Potential for impact on ground water	During temporary storage there may be potential for impact on ground water, however, mitigation measures can be developed to minimize this risk. In the long term, the potential for impact on ground water quality is negligible given that the material would be clean and likely similar in character to material already at the disposal location.
21. Potential for impact on cultural heritage resources	No impact on cultural heritage resources is expected.
22. Potential for contaminated residual material	Some contaminated residual material is expected from the organic extraction process. Any equipment used to temporarily store material will have to be disposed of.

Alternative J – Dredge, Pre-treatment, Thermal Treatment and Inorganic Extraction and Placement on Commercial or Industrial Land

Criteria	Potential Environmental Effects
1. Level of confidence associated with ability to carry out alternative	Moderate to high level of confidence associated with ability to carry out alternative due to past performance of technologies with Hamilton Harbour sediment or similar material. The uncertainty relates to the organic extraction. It is expected that the thermal treatment will be able to meet criteria levels.
2. Certainty with which cost of alternatives can be predicted	The cost of the alternative can be predicted with a moderately-high level of certainty based on past activities in other jurisdictions.
3. Impact on post remediation value of properties where material is disposed	The impact on the value of the industrial or commercial land should be minimal since the material will have been cleaned up to appropriate guidelines.

Criteria	Potential Environmental Effects
4. Risk to public health and safety	There is little concern that during the dredging operation public health will be at risk. Although sediments will be stirred up, these sediments are currently in the water and are already exposed to energy that causes their dispersion. During the temporary storage of materials, provisions will be required to ensure the public is not exposed to the material. Pre-treatment can be conducted in a controlled environment. Some thermal technologies use high temperatures in the presence of explosive substances. Therefore, should there be a system failure, a thermal technology could pose a greater risk to the public than organic or biological technologies. The risk associated with the transportation of material to the receiving lands will be directly related to the distance the material will travel. If we assume that commercial or industrial land can be found within the Harbour, this alternative will involve the shortest travel distance and, therefore, will have the least impact to public health and safety from a transportation perspective.
5. Risk to worker health and safety	During the temporary storage of materials, workers will need to take precautions to avoid exposure. Some thermal technologies use high temperatures in the presence of explosive substances. Therefore, should there be a system failure, a thermal technology could pose a greater accident risk to the worker health and safety than organic or biological technologies.
6. Potential for impact on aquatic biota during implementation	During removal, there will be a temporary impact on aquatic biota as sediments are disturbed and dispersed. During the temporary storage and treatment of the material there is the potential for contaminants to reentei the Harbour, although this will be offset with mitigation and contingency measures.
7. Potential for impact on aquatic biota following implementation	Immediately following implementation, one might expect to see an increase in uptake by biota because of the physical disturbance. In the long-term, however, exposure of biota to PAHs in the sediment will decrease at Randle Reef and around it. The removed material will have been remediated to a point that contaminant levels are consistent with those already found on the industrial lands. If material is placed on industrial/commercial lands in a manner that won't result in reentry to the Harbour, impacts will likely be minimal.
8. Potential for impact on terrestrial biota during implementation	During dredging, temporary storage, pre-treatment and treatment, there may be an opportunity to expose terrestrial biota to the contaminated sediments, however, this potential exposure can be mitigated.
9. Potential for impact on terrestrial biota following implementation	The impacts on terrestrial biota resulting from this alternative are expected to be negligible because the material will be consistent with soils already found on commercial or industrial lands.

Criteria	Potential Environmental Effects
10. Potential for impact on water column during implementation	There is some potential for a temporary impact on the water column during dredging, temporary storage, pre-treatment and treatment. Operation performance standards and mitigation measures can be implemented to minimize impacts. The potential impact associated with this alternative is, in part, a function of the amount of time required to implement the alternative. It will take approximately 3 to 5 months to implement the alternative.
11. Potential for impact on water column following implementation	Following the implementation of this alternative, there is no anticipated potential for impact on the water column. The removed material will have been remediated to a point that contaminant levels are consistent with those already found on industrial lands. If the material is placed on industrial/commercial lands in a manner that will not result in reentry to the Harbour, impacts will likely be minimal.
12. Potential for impact on air quality during implementation	There is some potential for the volatilization of the material during temporary storage, pre-treatment and treatment, however, it is expected that this can be mitigated. Although all alternatives will need to meet Provincial Air Quality Emission standards, should process or equipment failure occur, the thermal treatment technology is more likely to have an impact on the environment than the biological or organic technologies.
13. Potential for impact on air quality following implementation	There is a low potential for impact on air quality following implementation.
14. Potential for impact on land quality during implementation	During temporary storage, pre-treatment and treatment there is some potential for impact on land quality, however, it is expected it can be mitigated.
15. Potential for impact on land Quality following implementation	Low impact on land quality following implementation, since the material will be treated to a level consistent with CCME guidelines and will, therefore, potentially be as clean as soils already in the disposal location.
16. Potential for noise or other loss of aesthetic value during implementation	There is some potential for loss of aesthetic value during the implementation of this removal alternative. Since the operation will be in an existing industrial area, it is expected that it will be absorbed into the surrounding landscape. Noise impacts are expected to be minimal. The potential impact associated with this alternative is, in part, a function of the amount of time required to implement the alternative. It will take approximately 3 to 5 months to implement the alternative.
17. Potential for disruption to recreation during implementation	Some disruption to recreation during dredging may occur since the access to the site will need to be restricted for the duration of the removal operation.
18. Potential for disruption to recreation following implementation	No disruption to recreation following implementation of this alternative is expected, since the contaminated material will not be placed in a recreational area.

Criteria	Potential Environmental Effects
19. Potential for disruption to businesses	Potential for short-term disruption to water-based businesses (limited to duration of removal activity) during dredging.
20. Potential for impact on ground water	During temporary storage there may be potential for impact on ground water, however, mitigation measures can be developed to minimize this risk. In the long term, the potential for impact on ground water quality is negligible given that the material would be clean and likely similar in character to material already at the disposal location.
21. Potential for impact on cultural heritage resources	No impact on cultural heritage resources is expected.
22. Potential for contaminated residual material	Some contaminated residual material may be generated by the thermal treatment process. Any equipment used to temporarily store material will have to be disposed of.

Alternative K-1 – Dredge, Treat Using a Thermal Technology and Inorganic Extraction and Placement on Residential or Park Land

Criteria	Potential Environmental Effects
1. Level of confidence associated with ability to carry out alternative	Moderate level of confidence associated with ability to carry out alternative due to past performance of technologies with Hamilton Harbour sediment or similar material. The uncertainty relates to the inorganic extraction and the thermal treatments ability to meet more restrictive criteria.
2. Certainty with which cost of alternatives can be predicted	The cost of the alternative can be predicted with a moderate level certainty because of rigour of criteria.
3. Impact on post remediation value of properties where material is disposed	The impact on the value of the residential area or parkland should be minimal since the material will have been cleaned up to appropriate guidelines. There may, however, potentially be implications associated with perceived risk.

Criteria	Potential Environmental Effects
4. Risk to public health and safety	There is little concern that during the dredging operation public health will be at risk. Although sediments will be stirred up, these sediments are currently in the water and are already exposed to energy that causes their dispersion. During temporary storage of materials, provisions will be required to ensure the public is not exposed to the material. Pre-treatment can be conducted in a controlled environment. Some thermal technologies use high temperatures in the presence of explosive substances. Therefore, should there be a system failure, a thermal technology could pose a greater risk to the public than organic or biological technologies. The risk associated with the transportation of material to the receiving facility will be directly related to the distance the material will travel. If we assume that residential or park land can be found within 100 km of the site, this will involve a moderate travel distance.
5. Risk to worker health and safety	Some thermal technologies use high temperatures in the presence of explosive substances. Therefore, should there be a system failure, a thermal technology could pose a greater accident risk to the worker health and safety than organic or biological technologies. During the temporary storage of materials, workers will need to take precautions to avoid exposure.
6. Potential for impact on aquatic biota during implementation	During removal, there will be a temporary impact on aquatic biota as sediments are disturbed and dispersed. During the temporary storage and treatment of the material, there is the potential for contaminants to reenter the Harbour, although this will be offset with mitigation and contingency measures.
7. Potential for impact on aquatic biota following implementation	Immediately following implementation, one might expect to see an increase in uptake by biota because of the physical disturbance. In the long-term, however, exposure of biota to PAHs in the sediment will decrease at Randle Reef and around it. The removed material will have been remediated to a point that containment levels are consistent with those already found in residential areas or on park lands.
8. Potential for impact on terrestrial biota during implementation	During dredging, temporary storage, pre-treatment and treatment, there may be an opportunity to expose terrestrial biota to the contaminated sediments, however, this potential exposure can be mitigated.
9. Potential for impact on terrestrial biota following implementation	The impacts on terrestrial biota resulting from this alternative are expected to be negligible because the material will be consistent with soils already found on residential or park lands.
10. Potential for impact on water column during implementation	There is some potential for a temporary impact on the water column during dredging, temporary storage, pre-treatment and treatment. Operation performance standards and mitigation measures can be implemented to minimize impacts. The potential impact associated with this alternative is, in part, a function

Criteria	Potential Environmental Effects
	of the amount of time required to implement the alternative. It will take approximately 3 to 5 months to implement the alternative.
11. Potential for impact on water column following implementation	Following the implementation of this alternative, there is no anticipated potential for impact on the water column. The removed material will have been remediated to a point that containment levels are consistent with those already found in residential areas or on park lands.
12. Potential for impact on air quality during implementation	There is some potential for the volatilization of the material during temporary storage, pre-treatment and treatment, however, it is expected that this can be mitigated. Although all alternatives will need to meet Provincial Air Quality Emission standards, should process or equipment failure occur, the thermal treatment technology is more likely to have an impact on the environment than the biological or organic technologies.
13. Potential for impact on air quality following implementation	There is a low potential for impact on air quality following implementation.
14. Potential for impact on land quality during implementation	During temporary storage, pre-treatment and treatment there is some potential for impact on land quality, however, it is expected it can be mitigated.
15. Potential for impact on land quality following implementation	Low impact on land quality following implementation, since the material will be treated to a level consistent with CCME guidelines and will, therefore, potentially be as clean as soils already in the disposal location.
16. Potential for noise or other loss of aesthetic value during implementation	There is some potential for loss of aesthetic value during the implementation of this removal alternative. Since the operation will be in an existing industrial area, it is expected that it will be absorbed into the surrounding landscape. Noise impacts are expected to be minimal. The potential impact associated with this alternative is, in part, a function of the amount of time required to implement the alternative. It will take approximately 3 to 5 months to implement the alternative.
17. Potential for disruption to recreation during implementation	Some disruption to recreation during dredging may occur since the access to the site will need to be restricted for the duration of the removal operation. During the placement of the treated material there may be some temporary disruption depending on the location where the material is disposed.
18. Potential for disruption to recreation following implementation	Following the implementation of this alternative there could potentially be a positive impact to recreation if the clean material was put to a beneficial use.
19. Potential for disruption to businesses	Potential for short-term disruption to water-based businesses (limited to duration of removal activity) during dredging.

Criteria	Potential Environmental Effects
20. Potential for impact on ground water	During temporary storage there may be potential for impact on ground water, however, mitigative measures can be developed to minimize this risk. The potential for impact on ground water quality is negligible given that the material would be clean and likely similar in character to material already at the disposal location.
21. Potential for impact on cultural heritage resources	No impact on cultural heritage resources is expected.
22. Potential for contaminated residual material	Some contaminated residual material may be generated by the thermal treatment process. Any equipment used to temporarily store material will have to be disposed of.

Alternative K-2 – Dredge, Treat Using Organic and Inorganic Extraction and Placement on Residential or Park Land

Criteria	Potential Environmental Effects
1. Level of confidence associated with ability to carry out alternative	Low to moderate level of confidence associated with ability to carry out alternative due to the uncertainty associated with organic and inorganic extraction and the ability to meet more restrictive criteria.
2. Certainty with which cost of alternatives can be predicted	The cost of the alternative can be predicted with a low to moderate level of certainty because of rigour of criteria and lack of experience achieving these levels.
3. Impact on post remediation value of properties where material is disposed	The impact on the value of the residential area or parkland should be minimal since the material will have been cleaned up to appropriate guidelines. There may, however, potentially be implications associated with perceived risk.
4. Risk to public health and safety	There is little concern that during the dredging operation public health will be at risk. Although sediments will be stirred up, these sediments are currently in the water and are already exposed to energy that causes their dispersion. During the temporary storage of materials, provisions will be required to ensure the public is not exposed to the material. Pre-treatment and treatment can be conducted in a controlled environment before the sediment is cleaned up and transported to the residential or park land location. The risk associated with the transportation of material to the receiving lands will be directly related to the distance the material will travel. If we assume that residential or park land can be found within 100 km of the site, this will involve a moderate travel distance.

Criteria	Potential Environmental Effects
5. Risk to worker health and safety	Organic technologies have less potential for risk to worker health and safety than either biological or thermal technologies because of the nature of worker exposure to the contaminated sediment and the potential for accidents. The potential risk, however, will be a function of the toxicity of the solvents that are used to extract the contaminants. During the temporary storage of materials, workers will need to take precautions to avoid exposure.
6. Potential for impact on aquatic biota during implementation	During removal, there will be a temporary impact on aquatic biota as sediments are disturbed and dispersed. During the temporary storage and treatment of the material, there is the potential for contaminants to reenter the Harbour, although this will be offset with mitigation and contingency measures.
7. Potential for impact on aquatic biota following implementation	Immediately following implementation, one might expect to see an increase in uptake by biota because of the physical disturbance. In the long-term, however, exposure of biota to PAHs in the sediment will decrease at Randle Reef and around it. The removed material will have been remediated to a point that containment levels are consistent with those already found in residential areas or on park lands.
8. Potential for impact on terrestrial biota during implementation	During dredging, temporary storage, pre-treatment and treatment, there may be an opportunity to expose terrestrial biota to the contaminated sediments, however, this potential exposure can be mitigated.
9. Potential for impact on terrestrial biota following implementation	The impacts on terrestrial biota resulting from this alternative are expected to be negligible because the material will be consistent with soils already found on residential or park lands.
10. Potential for impact on water column during implementation	There is some potential for a temporary impact on the water column during dredging, temporary storage, pre-treatment and treatment. Operation performance standards and mitigation measures can be implemented to minimize impacts. The potential impact associated with this alternative is, in part, a function of the amount of time required to implement the alternative. It will take approximately 3 to 5 months to implement the alternative.
11. Potential for impact on water column following implementation	Following the implementation of this alternative, there is no anticipated potential for impact on the water column. The removed material will have been remediated to a point that containment levels are consistent with those already found in residential areas or on park lands.
12. Potential for impact on air Quality during implementation	There is some potential for the volatilization of the material during temporary storage, pre-treatment and treatment, however, it is expected that this can be mitigated.
13. Potential for impact on air quality following implementation	There is a low potential for impact on air quality following implementation.

Criteria	Potential Environmental Effects
14. Potential for impact on land quality during implementation	During temporary storage, pre-treatment and treatment there is some potential for impact on land quality, however, it is expected it can be mitigated.
15. Potential for impact on land quality following implementation	Low impact on land quality following implementation, since the material will be remediated to a point that contaminant levels are consistent with those already found in residential areas or on park lands.
16. Potential for noise or other loss of aesthetic value during implementation	There is some potential for loss of aesthetic value during the implementation of this removal alternative. Since the operation will be in an existing industrial area, it is expected that it will be absorbed into the surrounding landscape. Noise impacts are expected to be minimal. The potential impact associated with this alternative is, in part, a function of the amount of time required to implement the alternative. It will take approximately 3 to 5 months to implement the alternative.
17. Potential for disruption to recreation during implementation	Some disruption to recreation during dredging may occur since the access to the site will need to be restricted for the duration of the removal operation. During the placement of the treated material there may be some temporary disruption depending on the location where the material is disposed.
18. Potential for disruption to recreation following implementation	Following the implementation of this alternative there could potentially be a positive impact to recreation if the clean material was put to a beneficial use.
19. Potential for disruption to businesses	Potential for short-term disruption to water-based businesses (limited to duration of removal activity) during dredging.
20. Potential for impact on ground water	The potential for impact on ground water quality is negligible given that the material would be clean and likely similar in character to material already at the disposal location. During temporary storage there may be potential for impact on ground water, however, mitigative measures can be developed to minimize this risk.
21. Potential for impact on cultural heritage resources	No impact on cultural heritage resources is expected.
22. Potential for contaminated residual material	Some contaminated residual material may be generated from the organic extraction process. Any equipment used to temporarily store material will have to be disposed of.

Alternative L – Dredge, Pre-treatment, Thermal Treatment and Inorganic Extraction and Placement into Water

Criteria	Potential Environmental Effects
1. Level of confidence associated with ability to carry out alternative	Low level of confidence associated with ability to carry out alternative due to the extent of contaminant treatment required to meet criteria.
2. Certainty with which cost of alternatives can be predicted	The cost of the alternative can be predicted with moderate certainty because of rigour of criteria.
3. Impact on post remediation value of properties where material is disposed	No impact on property values is expected since the material will have been cleaned up to appropriate guidelines.
4. Risk to public health and safety	There is little concern that during the dredging operation public health will be at risk. Although sediments will be stirred up, these sediments are currently in the water and are already exposed to energy that causes their dispersion. During temporary storage of materials, provisions will be required to ensure the public is not exposed to the material. Pre-treatment can be conducted in a controlled environment. Some thermal technologies use high temperatures in the presence of explosive substances. Therefore, should there be a system failure, a thermal technology could pose a greater risk to the public than organic or biological technologies. Once the sediments are treated they might be cleaner than the materials already in place in the disposal location, therefore, no impact is expected.
5. Risk to worker health and safety	Some thermal technologies use high temperatures in the presence of explosive substances. Therefore, should there be a system failure, a thermal technology could pose a greater accident risk to the worker health and safety than organic or biological technologies. During the temporary storage of material, workers will need to take precautions to avoid exposure.
6. Potential for impact on aquatic biota during implementation	During removal, there will be a temporary impact on aquatic biota as sediments are disturbed and dispersed. During the temporary storage and treatment of the material there is the potential for contaminants to reenter the Harbour, although this will be offset with mitigation and contingency measures. If material was placed into water there could potentially be negative impacts on aquatic biota from suspended sediments.
7. Potential for impact on aquatic biota following implementation	Immediately following implementation, one might expect to see an increase in uptake by biota because of the physical disturbance. In the long-term, however, exposure of biota to PAHs in the sediment will decrease at Randle Reef and around it. The removed material will have been remediated to a point that containment levels will be consistent with or better than the sediment at the disposal location. There is the potential for a negative effect on the benthic community at the disposal site.

Criteria	Potential Environmental Effects
8. Potential for impact on terrestrial biota during implementation	During dredging, temporary storage, pre-treatment and treatment, there may be an opportunity to expose terrestrial biota to the contaminated sediments, however, this potential exposure can be mitigated.
9. Potential for impact on terrestrial biota following implementation	The impacts on terrestrial biota resulting from this alternative are expected to be negligible because the material will be consistent with sediments already in the disposal location or better.
10. Potential for impact on water column during implementation	There is some potential for a temporary impact on the water column during dredging, temporary storage, pre-treatment and treatment. Operation performance standards and mitigation measures can be implemented to minimize impacts. The potential impact associated with this alternative is, in part, a function of the amount of time required to implement the alternative. It will take approximately 3 to 5 months to implement the alternative. During the disposal of the remediated sediment in the water column, elevated levels of suspended sediment will be observed in the water column.
11. Potential for impact on water column following implementation	Following the implementation of this alternative, there is no anticipated potential for impact on the water column. The removed material will have been remediated to a point that containment levels are consistent or better than the sediments at the disposal location.
12. Potential for impact on air quality during implementation	There is some potential for the volatilization of the material during temporary storage, pre-treatment and treatment, however, it is expected that this can be mitigated. Although all alternatives will need to meet Provincial Air Quality Emission standards, should process or equipment failure occur, the thermal treatment technology is more likely to have an impact on the environment than the biological or organic technologies.
13. Potential for impact on air quality following implementation	There is a low potential for impact on air quality following implementation.
14. Potential for impact on land quality during implementation	During temporary storage, pre-treatment and treatment there is some potential for impact on land quality, however, it is expected it can be mitigated.
IS. Potential for impact on land quality following implementation	No impact on land quality is expected following the implementation of this alternative.
16. Potential for noise or other loss of aesthetic value during implementation	There is some potential for loss of aesthetic value during the implementation of this removal alternative. Since the operation will be in an existing industrial area, it is expected that it will be absorbed into the surrounding landscape. Noise impacts are expected to be minimal. The potential impact associated with this alternative is, in part, a function of the amount of time required to implement the alternative. It will take approximately 3 to 5 months to implement the alternative.

Criteria	Potential Environmental Effects
17. Potential for disruption to recreation during implementation	Some disruption to recreation during dredging may occur since the access to the dredge and disposal site will need to be restricted.
18. Potential for disruption to recreation following implementation	Some disruption to recreation may occur since the access to recreation areas may be effected depending on the selected disposal location.
19. Potential for disruption to businesses	Potential for short-term disruption to water-based businesses (limited to duration of removal activity) during dredging.
20. Potential for impact on ground water	During temporary storage, there may be potential for impact on ground water, however, mitigation measures can be developed to minimize this risk. The potential for impact on ground water quality is negligible.
21. Potential for impact on cultural heritage resources	No impact on cultural heritage resources is expected.
22. Potential for contaminated residual material	Some contaminated residual material may be generated by the thermal treatment process. Any equipment used to temporarily store material will have to be disposed of.

Alternative M – Dredge, Pre-treatment, Biological Treatment and Metals Stabilization and Disposal Behind Containment Berm at Pier 15

Criteria	Potential Environmental Effects
1. Level of confidence associated with ability to carry out alternative	Low level of confidence based on similar studies conducted at other sites and past performance of technology with Hamilton Harbour sediment in context of Randle Reef Industrial Fill Criteria.
2. Certainty with which cost of alternatives can be predicted	The cost of the alternative can be predicted with a moderate level of certainty based on past demonstration costs and subsequent commercial practices. The uncertainty relates to the ability of the technology to achieve the Randle Reef Industrial Fill Criteria. In addition, feasibility studies would have to be conducted to determine the appropriate design for such a facility.

Criteria	Potential Environmental Effects
3. Impact on post remediation value of properties where material is disposed	The impact on the property would be an increase in size of the present lot. The material will have been cleaned up to meet appropriate guidelines. There may, however, be implications associated with perceived risk that result in a decrease in property value should the Harbour Commission [now Hamilton Port Authority] choose to sell it for industrial land once it is filled and capped.
4. Risk to public health and safety	There is little concern that during the dredging operation public health will be at risk. Although sediments will be stirred up, these sediments are currently in the water and are already exposed to energy that causes some dispersion. During the temporary storage of materials, provisions will be required to ensure the public is not exposed to the material. Pre-treatment and treatment can be conducted in a controlled environment before the sediment is transported to the ECF. Depending on the type of biological treatment, a separate temporary storage facility may be required. The risk associated with the transportation of material to the receiving facility will be directly related to the distance the material will travel. This alternative will involve the shortest travel distance and, therefore, has the least risk to public health and safety risk.
5. Risk to worker health and safety	During construction of the containment facility, caution should be taken to ensure the stability of the structure. Depending on the type of biological treatment, a separate temporary storage facility may be required. During the temporary storage of materials, workers will need to take precautions to avoid exposure. Biological technologies expose workers to the materials for much longer periods of time than either thermal or organic technologies. Consequently, there is a greater risk to worker health and safety because of the time and type of exposure. The risk can be mitigated with protective equipment.
6. Potential for impact on aquatic biota during implementation	During removal, there will be a temporary impact on aquatic biota as sediments are disturbed and dispersed. During the temporary storage (if required) and treatment of the material there is the potential for contaminants to reenter the Harbour, although this will be offset with mitigation and contingency measures.
7. Potential for impact on aquatic biota following implementation	Immediately following implementation, one might expect to see an increase in uptake by biota because of the physical disturbance. In the long-term, however, exposure of biota to PAHs in the sediment will decrease at Randle Reef and around it. The removed material will have been remediated to a point that contaminant levels are well below those outside of the berm structure. The design of the structure should prevent migration of any low level contaminants.

Criteria	Potential Environmental Effects
8. Potential for impact on terrestrial biota during implementation	During dredging, temporary storage (if required), pre-treatment and treatment, there may be an opportunity to expose terrestrial biota to the contaminated sediments, however, this potential exposure can be mitigated. During the construction of the containment structure, there may be an opportunity to expose terrestrial biota to the treated sediments, however, this potential exposure can be mitigated. Until the containment berm is covered, there will be some opportunity for exposure of terrestrial biota to the treated material. Because the material will be treated, it is expected that the effects of the exposure will be minimal.
9. Potential for impact on terrestrial biota following implementation	Once the bermed area is covered with clean fill, the potential impact should be minimal.
10. Potential for impact on water column during implementation	There is some potential for a temporary impact on the water column during dredging, temporary storage (if required) to clear a pathway for the berm. Operation performance standards and mitigation measures can be implemented to minimize impacts. The potential impact associated with this alternative is, in part, a function of the amount of time required to implement the alternative. It will take approximately 6 months to 5 years to implement the alternative.
11. Potential for impact on water column following implementation	Following implementation of this alternative, there is minimal potential for impact on the water column.
12. Potential for impact on air quality during implementation	There is some potential for the volatilization of the material during temporary storage (if required), pre-treatment and treatment, however, it is expected that this can be mitigated.
13. Potential for impact on air quality following implementation	There is low potential for impact on air quality following implementation.
14. Potential for impact on land quality during implementation	During temporary storage (if required), pre-treatment and treatment there is some potential for impact on land quality, however, it is expected it can be mitigated.
15. Potential for impact on land quality following implementation	It is expected that there will be a low impact on land quality following implementation.
16. Potential for noise or other loss of aesthetic value during implementation	There is some potential for loss of aesthetic value during the berm construction. Since the operation will be in an existing industrial area, it is expected that it will be absorbed into the surrounding landscape. Noise impacts are expected to be minimal. The potential impact associated with this alternative is, in part, a function of the amount of time required to implement the alternative. It will take approximately 6 months to 5 years to implement the alternative.
17. Potential for disruption to recreation during implementation	Some disruption to recreation during implementation may occur since the access to the site will need to be restricted for the duration of the construction activities.

Criteria	Potential Environmental Effects
18. Potential for disruption to recreation following implementation	No disruption to recreation following implementation of this alternative is expected since the treated material will not be placed in a recreational area.
19. Potential for disruption to businesses	During construction of the berm, the adjacent land would be used as a staging area for the construction operation. There could be limitations to access adjacent to the immediate work site.
20. Potential for impact on ground water	A site feasibility study is required to ensure no impacts to the ground water. Depending on the type of biological treatment, there may be a need for temporary storage. During temporary storage there may be potential for impact on ground water, however, mitigation measures can be developed to minimize this risk.
21. Potential for impact on cultural heritage resources	No impact on cultural heritage resources is expected.
22. Potential for contaminated residual material	Treatment will produce minimal contaminated residuals. Depending on the type of biological treatment, there may be a need for temporary storage. Any equipment used to temporarily store material will have to be disposed of.

Alternative N – Dredge, Pre-treatment, Organic and Inorganic Extraction and Disposal Behind Containment Berm at Pier 15

Criteria	Potential Environmental Effects
1. Level of confidence associated with ability to carry out alternative	Moderate level of confidence associated with ability to carry out alternative due to past performance of technology with Great Lakes sediment in context of Randle Reef Industrial Fill Criteria.
2. Certainty with which cost of alternatives can be predicted	The cost of the alternative can be predicted with a moderate level of certainty based on past demonstration costs and subsequent commercial practices. This uncertainty relates to the ability of the technology to achieve Randle Reef Industrial Fill Criteria. In addition, feasibility studies would have to be conducted to determine the appropriate design for such an area.
3. Impact on post remediation value of properties where material is disposed	The impact on the property would be an increase in the size of the present lot. The material will have been cleaned up to meet appropriate guidelines. There may, however, be implications associated with perceived risk that result in a decrease in property value should the Harbour Commission [now Hamilton Port Authority] choose to sell it for industrial land once it is filled and capped.

Criteria	Potential Environmental Effects
4. Risk to public health and safety	There is little concern that during the dredging operation public health will be at risk. Although sediments will be stirred up, these sediments are currently in the water and are already exposed to energy that causes some dispersion. During the temporary storage of materials, provisions will be required to ensure the public is not exposed to the material. Pre-treatment and treatment can be conducted in a controlled environment before the sediment is transported to the ECF. The risk associated with the transportation of material to the receiving facility will be directly related to the distance the material will travel. This alternative will involve the shortest travel distance and, therefore, has the least risk to public health and safety risk.
5. Risk to worker health and safety	During construction of the containment facility, caution should be taken to ensure the stability of the structure. Organic technologies have less potential for risk to worker health and safety than either biological or thermal technologies because of the nature of worker exposure to the contaminated sediment and the potential for accidents. The potential risk, however, will be a function of the toxicity of the solvents that are used to extract the contaminants. During the temporary storage of materials, workers will need to take precautions to avoid exposure.
6. Potential for impact on aquatic biota during implementation	During removal and berm construction, there will be a temporary impact on aquatic biota as sediments are disturbed and dispersed. During the temporary storage and treatment of the material there is the potential for contaminants to reenter the Harbour, although this will be offset with mitigation and contingency measures.
7. Potential for impact on aquatic biota following implementation	Immediately following implementation, one might expect to see an increase in uptake by biota because of the physical disturbance. In the long-term, however, exposure of biota to PAHs in the sediment will decrease at Randle Reef and around it. The removed material will have been remediated to a point that contaminant levels are well below those outside of the berm structure. The design of the structure should prevent migration of any low level contaminants.
8. Potential for impact on terrestrial biota during implementation	During dredging, temporary storage, pre-treatment and treatment, there may be an opportunity to expose terrestrial biota to the contaminated sediments, however, this potential exposure can be mitigated. During the construction of the containment structure, there may be an opportunity to expose terrestrial biota to the treated sediments, however, this potential exposure can be mitigated. Until the containment berm is covered, there will be some opportunity for exposure of terrestrial biota to the treated material. Because the material will be treated, it is expected that the effects of the exposure will be minimal.

Criteria	Potential Environmental Effects
9. Potential for impact on terrestrial biota following implementation	Once the bermed area is covered with clean fill, the potential impact should be minimal.
10. Potential for impact on water column during implementation	There is some potential for a temporary impact on the water column during sediment removal to clear a pathway for the berm. There is some potential for a temporary impact on the water column during dredging, temporary storage, pre-treatment and treatment. Operation performance standards and mitigation measures can be implemented to minimize impacts. The potential impact associated with this alternative is, in part, a function of the amount of time required to implement the alternative. It will take approximately 5 to 7 months to implement the alternative.
11. Potential for impact on water column following implementation	Following the implementation of this alternative, there is minimal potential for impact on the water column.
12. Potential for impact on air quality during implementation	There is some potential for the volatilization of the material during temporary storage, pre-treatment and treatment, however, it is expected that this can be mitigated.
13. Potential for impact on air quality following implementation	There is low potential for impact on air quality following implementation.
14. Potential for impact on land quality during implementation	During temporary storage, pre-treatment and treatment there is some potential for impact on land quality, however, it is expected it can be mitigated.
15. Potential for impact on land quality following implementation	It is expected there will be a low impact on land quality following implementation.
16. Potential for noise or other loss of aesthetic value during implementation	There is some potential for loss of aesthetic value during berm construction. Since the operation will be in an existing industrial area, it is expected that it will be absorbed into the surrounding landscape. Noise impacts are expected to be minimal. The potential impact associated with this alternative is, in part, a function of the amount of time required to implement the alternative. It will take approximately 5 to 7 months to implement the alternative.
17. Potential for disruption to recreation during implementation	Some disruption to recreation during implementation may occur, since the access to the site will need to be restricted for the duration of the construction activities.
18. Potential for disruption to recreation following implementation	No disruption to recreation following implementation of this alternative is expected, since the treated material will not be placed in a recreational area.
19. Potential for disruption to businesses	During construction of the berm, the adjacent land would be used as a staging area for the construction operation. There could be limitations to access adjacent to the immediate work site. Potential for short-term

Criteria	Potential Environmental Effects
	disruption to water-based businesses is, therefore, expected.
20. Potential for impact on ground water	A site feasibility study is required to ensure no impacts to the ground water from the new facility. During temporary storage there may be potential for impact on ground water, however, mitigation measures can be developed to minimize this risk.
21. Potential for impact on cultural heritage resources	No impact on cultural heritage resources is expected.
22. Potential for contaminated residual material	Some contaminated residual material is expected from the organic extraction process. Any equipment used to temporarily store material will have to be disposed of.

Alternative O – Dredge, Pre-treatment, Thermal Treatment and Inorganic Extraction and Disposal Behind Containment Berm at Pier 15

Criteria	Potential Environmental Effects
1. Level of confidence associated with ability to carry out alternative	Moderate to high level of confidence associated with ability to carry out alternative due to past performance of technology with Hamilton Harbour sediment. The uncertainty relates to the inorganic extraction.
2. Certainty with which cost of alternatives can be predicted	The cost of the alternative can be predicted with a moderate level of certainty based on past demonstration costs and subsequent commercial practices. This uncertainty relates to the ability of the technology to achieve Randle Reef Industrial Fill Criteria. In addition, feasibility studies would have to be conducted to determine the appropriate design for such an area.
3. Impact on post remediation value of properties where material is disposed	The impact on the property would be an increase in the size of the present lot. The material will have been cleaned-up to meet appropriate guidelines. There may, however, be implications associated with perceived risk that result in a decrease in property value should the Harbour Commission [now Hamilton Port Authority] choose to sell it for industrial land once it is filled and capped.
4. Risk to public health and safety	There is little concern that during the dredging operation public health will be at risk. Although sediments will be stirred up, these sediments are currently in the water and are already exposed to energy that causes some dispersion. During temporary storage of materials, provisions will be required to ensure the public is not exposed to the material. Pre-treatment can be conducted in a controlled environment. Some thermal technologies use high temperatures in the presence of explosive substances. Therefore, should there be a system failure, a thermal technology could pose a greater risk to the public than organic or biological technologies. The risk associated with the transportation of material to the receiving facility will be directly related to the distance the material will travel. This alternative will involve the shortest travel distance and, therefore, has the least risk to public health and safety from a transportation perspective.
5. Risk to worker health and safety	During construction of the containment facility caution should be taken to ensure the stability of the structure. Some thermal technologies use high temperatures in the presence of explosive substances. Therefore, should there be a system failure, a thermal technology could pose a greater accident risk to the worker health and safety than organic or biological technologies. During the temporary storage of material, workers will need to take precautions to avoid exposure.

Criteria	Potential Environmental Effects
6. Potential for impact on aquatic biota during implementation	During removal and berm construction, there will be a temporary impact on aquatic biota as sediments are disturbed and dispersed. During the temporary storage and treatment of the material there is the potential for contaminants to reenter the Harbour, although this will be offset with mitigation and contingency measures.
7. Potential for impact on aquatic biota following implementation	Immediately following implementation, one might expect to see an increase in uptake by biota because of the physical disturbance. In the long-term, however, exposure of biota to PAHs in the sediment will decrease at Handle Reef and around it. The removed material will have been remediated to a point that contaminant levels are well below those outside of the berm structure. The design of the structure should prevent mitigation of any low level contaminants.
8. Potential for impact on terrestrial biota during implementation	During dredging, temporary storage, pre-treatment and treatment, there may be an opportunity to expose terrestrial biota to the contaminated sediments, however, this potential exposure can be mitigated. During the construction of the containment structure there may be an opportunity to expose terrestrial biota to the treated sediments, however, this potential exposure can be mitigated. Until the containment berm is covered, there will be some opportunity for exposure of terrestrial biota to the treated material. Because the material will be treated, it is expected that the effects of the exposure will be minimal.
9. Potential for impact on terrestrial biota following implementation	Once the bermed area is covered with clean fill the potential impact should be minimal.
10. Potential for impact on water column during implementation	There is some potential for a temporary impact on the water column during sediment removal to clear a pathway for the berm. In addition, there is some potential for temporary impact on the water column during dredging, temporary storage, pre-treatment and treatment. Operation performance standards and mitigation measures can be implemented to minimize impacts. The potential impact associated with this alternative is, in part, a function of the amount of time required to implement the alternative. It will take approximately 5 to 7 months to implement the alternative.
11. Potential for impact on water column following implementation	Following the implementation of this alternative, there is minimal potential for impact on the water column.
12. Potential for impact on air quality during implementation	There is some potential for the volatilization of the material during temporary storage, pre-treatment and treatment, however, it is expected that this can be mitigated. Although all alternatives will need to meet Provincial Air Quality Emission standards, should process or equipment failure occur, the thermal treatment technology is more likely to have an impact on the environment than the biological or organic technologies.

Criteria	Potential Environmental Effects
13. Potential for impact on air quality following implementation	There is low potential for impact on air quality following implementation.
14. Potential for impact on land quality during implementation	During temporary storage, pre-treatment and treatment there is some potential for impact on land quality, however, it is expected it can be mitigated.
15. Potential for impact on land quality following implementation	It is expected that there will be a low impact on land quality following implementation.
16. Potential for noise or other loss of aesthetic value during implementation	There is some potential for loss of aesthetic value during berm construction. Since the operation will be in an existing industrial area, it is expected that it will be absorbed into the surrounding landscape. Noise impacts are expected to be minimal. The potential impact associated with this alternative is, in part, a function of the amount of time required to implement the alternative. It will take approximately 5 to 7 months to implement the alternative.
17. Potential for disruption to recreation during implementation	Some disruption to recreation during implementation may occur, since the access to the site will need to be restricted for the duration of the construction activities.
18. Potential for disruption to recreation following implementation	No disruption to recreation following implementation of this alternative is expected, since the treated material will not be placed in a recreational area.
19. Potential for disruption to businesses	During construction of the berm, the adjacent land would be used as a staging area for the construction operation. There could be limitations to assess adjacent to the immediate work site. Potential for short-term disruption to water-based businesses is, therefore, expected.
20. Potential for impact on ground water	During temporary storage there may be potential for impact on ground water, however, mitigative measure! can be developed to minimize this risk.
21. Potential for impact on cultural heritage resources	No impact on cultural heritage resources is expected.
22. Potential for contaminated residual material	Some contaminated residual material may be generated by the thermal treatment process. Any equipment used to temporarily store material will have to be disposed of.

Alternative Q – Dredge, Pre-treatment, Thermal Treatment and Inorganic Extraction for Unrestricted Land Use

Criteria	Potential Environmental Effects
1. Level of confidence associated with ability to carry out alternative	Low to moderate level of confidence associated with ability to carry out alternative due to the uncertainty associated with the inorganic extraction techniques ability to meet criteria.
2. Certainty with which cost of alternatives can be predicted	The cost of the alternative can be predicted with a moderate level of certainty because of rigour of criteria and lack of experience achieving these levels.
3. Impact on post remediation value of properties where material is disposed	The impact on the value of the land where the material is disposed of should be minimal due to its high level of remediation. There may, however, potentially be implications associated with perceived risk.
4. Risk to public health and safety	There is little concern that during the dredging operation public health will be at risk. Although sediments will be stirred up, these sediments are currently in the water and are already exposed to energy that causes their dispersion. During temporary storage of materials, provisions will be required to ensure the public is not exposed to the material. Pre-treatment can be conducted in a controlled environment. Some thermal technologies use high temperatures in the presence of explosive substances. Therefore, should there be a system failure, a thermal technology could pose a greater risk to the public than organic or biological technologies. The risk associated with the transportation of material to the receiving facility will be directly related to the distance the material will travel. If we assume that a disposal location can be found within 100 km of the site, this will involve a moderate travel distance.
5. Risk to worker health and safety	Some thermal technologies use high temperatures in the presence of explosive substances. Therefore, should there be a system failure, a thermal technology could pose a greater accident risk to the worker health and safety than organic or biological technologies. During the temporary storage of materials, workers will need to take precautions to avoid exposure.
6. Potential for impact on aquatic biota during implementation	During removal, there will be a temporary impact on aquatic biota as sediments are disturbed and dispersed. During the temporary storage and treatment of the material, there is the potential for contaminants to reenter the Harbour, although this will be offset with mitigation and contingency measures.

Criteria	Potential Environmental Effects
7. Potential for impact on aquatic biota following implementation	Immediately following implementation, one might expect to see an increase in uptake by biota because of the physical disturbance. In the long-term, however, exposure of biota to PAHs in the sediment will decrease at Handle Reef and around it. The removed material will have been remediated to a point that the material is considered clean fill, therefore, no long term aquatic impact is expected.
8. Potential for impact on terrestrial biota during implementation	During dredging, temporary storage, pre-treatment and treatment, there may be an opportunity to expose terrestrial biota to the contaminated sediments, however, this potential exposure can be mitigated.
9. Potential for impact on terrestrial biota following implementation	The impacts on terrestrial biota resulting from this alternative are expected to be negligible because the material will be considered clean fill.
10. Potential for impact on water column during implementation	There is some potential for a temporary impact on the water column during dredging, temporary storage, pre-treatment and treatment. Operation performance standards and mitigation measures can be implemented to minimize impacts. The potential impact associated with this alternative is, in part, a function of the amount of time required to implement the alternative. It will take approximately 3 to 5 months to implement the alternative.
11. Potential for impact on water column following implementation	Following the implementation of this alternative, there is no anticipated potential for impact on the water column. The removed material will have been remediated to a point that the material is considered clean fill, therefore, no long term impact is expected.
12. Potential for impact on air quality during implementation	There is some potential for the volatilization of the material during temporary storage, pre-treatment and treatment, however, it is expected that this can be mitigated. Although all alternatives will need to meet Provincial Air Quality Emission standards, should process or equipment failure occur, the thermal treatment technology is more likely to have an impact on the environment than the biological or organic technologies.
13. Potential for impact on air quality following implementation	There is a low potential for impact on air quality following implementation.
14. Potential for impact on land quality during implementation	During temporary storage, pre-treatment and treatment there is some potential for impact on land quality, however, it is expected it can be mitigated.
15. Potential for impact on land quality following implementation	There will be a low potential for impact on land quality following implementation, since the material will be treated to a level consistent with clean fill.

Criteria	Potential Environmental Effects
16. Potential for noise or other loss of aesthetic value during implementation	There is some potential for loss of aesthetic value during the implementation of this removal alternative. Since the operation will be in an existing industrial area, it is expected that it will be absorbed into the surrounding landscape. Noise impacts are expected to be minimal. The potential impact associated with this alternative is, in part, a function of the amount of time required to implement the alternative. It will take approximately 3 to 5 months to implement the alternative.
17. Potential for disruption to recreation during implementation	Some disruption to recreation during dredging may occur since the access to the site will need to be restricted for the duration of the removal operation. During the placement of the treated material there may be some temporary disruption depending on the location where the material is disposed.
18. Potential for disruption to recreation following implementation	There will be a low potential for impact on recreation since the material will be treated to a level consistent with clean fill. Potentially the clean fill could be used to enhance recreation areas.
19. Potential for disruption to businesses	Potential for short-term disruption to water-based businesses (limited to duration of removal activity) during dredging.
20. Potential for impact on ground water	During temporary storage there may be potential for impact on ground water, however, mitigative measures can be developed to minimize this risk. In the long term, the potential for impact on ground water quality is negligible given that the material would be clean fill.
21. Potential for impact on cultural heritage resources	No impact on cultural heritage resources is expected.
22. Potential for contaminated residual material	Some contaminated residual material may be generated by the thermal treatment process. In addition, any equipment used to temporarily store material will have to be disposed of.

Alternative R – Dredge, Pre-treatment, Thermal Treatment and Inorganic Extraction and Placement as Cover at a Landfill

Criteria	Potential Environmental Effects
1. Level of confidence associated with ability to carry out alternative	Moderate to high level of confidence associated with ability to carry out alternative based on available technologies and expertise.
2. Certainty with which cost of alternatives can be predicted	The cost of the alternative can be predicted with a moderate to high level of certainty based on past activities in other jurisdictions.

Criteria	Potential Environmental Effects
3. Impact on post remediation value of properties where material is disposed	The disposal of Randle Reef sediments at the landfill is not expected to impact on the value of the site.
4. Risk to public health and safety	There is little concern that during the dredging operation public health will be at risk. Although sediments will be stirred up, these sediments are currently in the water and are already exposed to energy that causes some dispersion. During the temporary storage of materials, provisions will be required to ensure the public is not exposed to the material. Pre-treatment can be conducted in a controlled environment. Some thermal technologies use high temperatures in the presence of explosive substances. Therefore, should there be a system failure, a thermal technology could pose a greater risk to the public than organic or biological technologies. The risk associated with the transportation of material to the receiving facility will be directly related to the distance the material will travel. If we assume that an industrial landfill site can be found within 100 km of the site, this will involve a moderate travel distance.
5. Risk to worker health and safety	Some thermal technologies use high temperatures in the presence of explosive substances. Therefore, should there be a system failure, a thermal technology could pose a greater accident risk to the worker health and safety than organic or biological technologies. During the temporary storage of materials, workers will need to take precautions to avoid exposure.
6. Potential for impact on aquatic biota during implementation	During removal, there will be a temporary impact on aquatic biota as sediments are disturbed and dispersed. During the temporary storage and treatment of the material there is the potential for contaminants to reenter the Harbour, although this will be offset with mitigation and contingency measures.
7. Potential for impact on aquatic biota following implementation	Immediately following implementation, one might expect to see an increase in uptake by biota because of the physical disturbance. In the long-term, however, exposure of biota to PAHs in the sediment will decrease at Randle Reef and around it. The removed material will have been remediated to a point that contaminant levels are consistent with those used for cover material at a landfill.
8. Potential for impact on terrestrial biota during implementation	During dredging, temporary storage, pre-treatment and treatment, there may be an opportunity to expose terrestrial biota to the contaminated sediments, however, this potential exposure can be mitigated.
9. Potential for impact on terrestrial biota following implementation	No significant impact on terrestrial biota resulting from this alternative is expected. The removed material will have been remediated to a point that contaminant levels are consistent with those used for cover material at a landfill.

Criteria	Potential Environmental Effects
10. Potential for impact on water column during implementation	There is some potential for a temporary impact on the water column during dredging, temporary storage, pre-treatment and treatment. Operation performance standards and mitigation measures can be implemented to minimize impacts. The potential impact associated with this alternative is, in part, a function of the amount of time required to implement the alternative. It will take approximately 3 to 5 months to implement the alternative.
11. Potential for impact on water column following implementation	There is minimal potential for impact on the water column following the implementation of this alternative. Equilibrium or ambient conditions are expected to return within 48 hours based on previous pilot projects. Industrial landfill facilities are designed to contain the material and isolate it from the environment. However, since the sediments will still have some degree of contamination even after treatment, there could be some potential for impact on the water column should the containment system fail.
12. Potential for impact on air quality during implementation	There is some potential for the volatilization of the material during temporary storage, pre-treatment and treatment, however, it is expected that this can be mitigated. Although all alternatives will need to meet Provincial Air Quality Emission standards, should process or equipment failure occur, the thermal treatment technology is more likely to have an impact on the environment than the biological or organic technologies.
13. Potential for impact on air quality following implementation	There is a low potential for impact on air quality following implementation.
14. Potential for impact on land quality during implementation	During temporary storage, pre-treatment and treatment there is some potential for impact on land quality, however, it is expected it can be mitigated.
15. Potential for impact on land quality following implementation	Although the use of the sediment as cover material will have a positive effect, this would occur whether or not Randle Reef sediments were used.
16. Potential for noise or other loss of aesthetic value during implementation	There is some potential for loss of aesthetic value during the implementation of this removal alternative. Since the operation will be in an existing industrial area, it is expected that it will be absorbed into the surrounding landscape. Noise impacts are expected to be minimal. The potential impact associated with this alternative is, in part, a function of the amount of time required to implement the alternative. It will take approximately 3 to 5 months to implement the alternative.
17. Potential for disruption to recreation during implementation	Some disruption to recreation during implementation may occur, since the access to the site will need to be restricted for the duration of the removal operation.
18. Potential for disruption to recreation following implementation	No disruption to recreation following implementation of this alternative is expected, since the disposed material will not be placed in a recreational area.

Criteria	Potential Environmental Effects
19. Potential for disruption to businesses	Short term potential for disruption to water-based businesses (i.e., limited to duration of removal activity) due to the temporary disruption.
20. Potential for impact on ground water	During temporary storage there may be potential for impact on ground water, however, mitigation measures can be developed to minimize the risk.
21* Potential for impact on cultural heritage resources	No impact on cultural heritage resources is expected.
22. Potential for contaminated residual material	Some contaminated residual material may be generated by the thermal treatment process. Any equipment used to temporarily store material will have to be disposed.

Alternative S – Dredge, Pre-treatment, Organic and Inorganic Extraction and Placement as a Cover at a Landfill

Criteria	Potential Environmental Effects
1. Level of confidence associated with ability to carry out alternative	Low to moderate level of confidence associated with ability to carry out alternative based on available technologies and expertise.
2. Certainty with which cost of alternatives can be predicted	The cost of the alternative can be predicted with a low level of certainty based on past activities in other jurisdictions.
3. Impact on post remediation value of properties where material is disposed	The disposal of Randle Reef sediments at the industrial landfill is not expected to impact on the value of the site.
4. Risk to public health and safety	There is little concern that during the dredging operation public health will be at risk. Although sediments will be stirred up, these sediments are currently in the water and are already exposed to energy that causes some dispersion. During the temporary storage of materials, provisions will be required to ensure the public is not exposed to the material. Pre-treatment can be conducted in an enclosed environment before the sediment is transported to the hazardous waste facility, therefore, the exposure will be minimal. The risk associated with the transportation of material to the receiving facility will be directly related to the distance the material will travel. If we assume that an industrial landfill site can be found within 100 km of the site, this will involve a moderate travel distance.

Criteria	Potential Environmental Effects
5. Risk to worker health and safety	Organic technologies have less potential for risk to worker health and safety than either biological or thermal technologies because of the nature of worker exposure to the contaminated sediment and the potential for accidents. The potential risk, however, will be a function of the toxicity of the solvents that are used to extract the contaminants. During the temporary storage of materials, workers will need to take precautions to avoid exposure.
6. Potential for impact on aquatic biota during implementation	During removal, there will be a temporary impact on aquatic biota as sediments are disturbed and dispersed. During the temporary storage and treatment of the material there is the potential for contaminants to reenter the Harbour, although this will be offset with mitigation and contingency measures.
7. Potential for impact on aquatic biota following implementation	Immediately following implementation, one might expect to see an increase in uptake by biota because of the physical disturbance. In the long-term, however, exposure of biota to PAHs in the sediment will decrease at Randle Reef and around it. The removed material will have been remediated to a point that contaminant levels are consistent with those used for cover material at a landfill.
8. Potential for impact on terrestrial biota during implementation	During dredging, temporary storage, pre-treatment and treatment, there may be an opportunity to expose terrestrial biota to the contaminated sediments, however, this potential exposure can be mitigated.
9. Potential for impact on terrestrial biota following implementation	No significant impact on terrestrial biota resulting from this alternative is expected. The removed material will have been remediated to a point that contaminant levels are consistent with those used for cover material at a landfill.
10. Potential for impact on water column during implementation	There is some potential for a temporary impact on the water column during dredging, temporary storage, pre-treatment and treatment. Operation performance standards and mitigation measures can be implemented to minimize impacts. The potential impact associated with this alternative is, in part, a function of the amount of time required to implement the alternative. It will take approximately 3 to 5 months to implement the alternative.
11. Potential for impact on water column following implementation	There is minimal potential for impact on the water column following the implementation of this alternative. Equilibrium or ambient conditions are expected to return within 48 hours based on previous pilot projects. Industrial landfill facilities are designed to contain the material and isolate it from the environment. However, since the sediments will still have some degree of contamination even after treatment, there could be some potential for impact on the water column should the containment system fail.
12. Potential for impact on air quality during implementation	There is some potential for the volatilization of the material during temporary storage, pre-treatment and treatment, however, it is expected that this can be mitigated.
13. Potential for impact on air quality following implementation	There is a low potential for impact on air quality following implementation.

Criteria	Potential Environmental Effects
14. Potential for impact on land quality during implementation	During temporary storage, pre-treatment and treatment there is some potential for impact on land quality, however, it is expected it can be mitigated.
15. Potential for impact on land quality following implementation	Although the use of the sediment as cover material will have a positive effect, this would occur whether or not Randle Reef sediments were used.
16. Potential for noise or other loss of aesthetic value during implementation	There is some potential for loss of aesthetic value during the implementation of this removal alternative. Since the operation will be in an existing industrial area, it is expected that it will be absorbed into the surrounding landscape. Noise impacts are expected to be minimal. The potential impact associated with this alternative is, in part, a function of the amount of time required to implement the alternative. It will take approximately 3 to 5 months to implement the alternative.
17. Potential for disruption to recreation during implementation	Some disruption to recreation during implementation may occur, since the access to the site will need to be restricted for the duration of the removal operation.
18. Potential for disruption to recreation following implementation	No disruption to recreation following implementation of this alternative is expected, since the disposed material will not be placed in a recreational area.
19. Potential for disruption to businesses	Short term potential for disruption to water-based businesses (i.e., limited to duration of removal activity) due to the temporary disruption.
20. Potential for impact on ground water	Any industrial landfill facility used for the disposal of this material will be designed to protect ground water. During temporary storage there may be potential for impact on ground water, however, mitigation measures can be developed to minimize this risk.
21. Potential for impact on cultural heritage resources	No impact on cultural heritage resources is expected.
22. Potential for contaminated residual material	Some contaminated residual material is expected from the organic extraction process. Any equipment used to temporarily store material will have to be disposed of.

Alternative T – Dredge, Pre-treatment, Biological Treatment and Inorganic Extraction and Placement as a Cover at a Landfill

Criteria	Potential Environmental Effects
1. Level of confidence associated with ability to carry out alternative	Low level of confidence associated with ability to carry out alternative due to rigour of the criteria. Biological treatment may or may not be able to treat to industrial criteria.
2. Certainty with which cost of alternatives can be predicted	The cost of the alternative can be predicted with a moderate to low level of certainty based on past activities in other jurisdictions.
3. Impact on post remediation value of properties where material is disposed	The disposal of Randle Reef sediments at the landfill is not expected to impact on the value of the site.
4. Risk to public health and safety	There is little concern that during the dredging operation public health will be at risk. Although sediments will be stirred up, these sediments are currently in the water and are already exposed to energy that causes some dispersion. During the temporary storage of materials, provisions will be required to ensure the public is not exposed to the material. Pre-treatment can be conducted in a controlled environment. Some thermal technologies use high temperatures in the presence of explosive substances. Therefore, should there be a system failure, a thermal technology could pose a greater risk to the public than organic or biological technologies. The risk associated with the transportation of material to the receiving facility will be directly related to the distance the material will travel. If we assume that an industrial landfill site can be found within 100 km of the site, this will involve a moderate travel distance.
5. Risk to worker health and safety	Depending on the type of biological treatment, a separate storage facility may be required. During the temporary storage of materials, workers will need to take precautions to avoid exposure. Biological technologies expose workers to the materials for much longer periods of time than either thermal or organic technologies. Consequently, there is a greater risk to worker health and safety because of the time and type of exposure. This risk can be mitigated with protective equipment.
6. Potential for impact on aquatic biota during implementation	During removal, there will be a temporary impact on aquatic biota as sediments are disturbed and dispersed. During the temporary storage and treatment of the material there is the potential for contaminants to reenter the Harbour, although this will be offset with mitigation and contingency measures.

Criteria	Potential Environmental Effects
7. Potential for impact on aquatic biota following implementation	Immediately following implementation, one might expect to see an increase in uptake by biota because of the physical disturbance. In the long-term, however, exposure of biota to PAHs in the sediment will decrease at Randle Reef and around it. The removed material will have been remediated to a point that contaminant levels are consistent with those used for cover material at a landfill.
8. Potential for impact on terrestrial biota during implementation	During dredging, temporary storage, pre-treatment and treatment, there may be an opportunity to expose terrestrial biota to the contaminated sediments, however, this potential exposure can be mitigated.
9. Potential for impact on terrestrial biota following implementation	No significant impact on terrestrial biota resulting from this alternative is expected. The removed material will have been remediated to a point that contaminant levels are consistent with those used for cover material at a landfill.
10. Potential for impact on water column during implementation	There is some potential for a temporary impact on the water column during dredging, temporary storage, (if required) pre-treatment and treatment. Operation performance standards and mitigation measures can be implemented to minimize impacts. The potential impact associated with this alternative is, in part, a function of the amount of time required to implement the alternative. It will take approximately 6 months 5 years to implement the alternative.
11. Potential for impact on water column following implementation	There is minimal potential for impact on the water column following the implementation of this alternative. Equilibrium or ambient conditions are expected to return within 48 hours based on previous pilot projects. Industrial landfill facilities are designed to contain the material and isolate it from the environment. However, since the sediments will still have some degree of contamination even after treatment, there could be some potential for impact on the water column should the containment system fail.
12. Potential for impact on air quality during implementation	There is some potential for the volatilization of the material during temporary storage (if required), pre-treatment and treatment, however, it is expected that this can be mitigated.
13. Potential for impact on air quality following implementation	There is a low potential for impact on air quality following implementation.
14. Potential for impact on land quality during implementation	During temporary storage (if required), pre-treatment and treatment there is some potential for impact on land quality, however, it is expected it can be mitigated.
15. Potential for impact on land quality following implementation	Although the use of the sediment as cover material will have a positive effect, this would occur whether or not Randle Reef sediments were used.

Criteria	Potential Environmental Effects
16. Potential for noise or other loss of aesthetic value during implementation	There is some potential for loss of aesthetic value during the implementation of this removal alternative. Since the operation will be in an existing industrial area, it is expected that it will be absorbed into the surrounding landscape. Noise impacts are expected to be minimal. The potential impact associated with this alternative is, in part, a function of the amount of time required to implement the alternative. It will take approximately 6 months to 5 years to implement the alternative.
17. Potential for disruption to recreation during implementation	Some disruption to recreation during implementation may occur, since the access to the site will need to be restricted for the duration of the removal operation.
18. Potential for disruption to recreation following implementation	No disruption to recreation following implementation of this alternative is expected, since the disposed material will not be placed in a recreational area.
19. Potential for disruption to businesses	Short term potential for disruption to water-based businesses (i.e., limited to duration of removal activity) due to the temporary disruption.
20. Potential for impact on ground water	Depending on the type of biological treatment, there may be a need for temporary storage. During temporary storage there may be potential for impact on ground water, however, mitigation measures can be developed to minimize the risk.
21. Potential for impact on cultural heritage resources	No impact on cultural heritage resources is expected.
22. Potential for contaminated residual material	Minimal contaminated residual material is expected. Depending on the type of biological treatment there may be a need for temporary storage. Any equipment used to temporarily store material will have to be disposed of.

SUPPORTING DOCUMENT D

Identification and Evaluation of Design Elements and Options

ISOLATION STRUCTURE DESIGN OPTIONS

D.1 Isolation Structure Options

D.1.1 Initial Screening

D.1.1.1 Introduction

The ECF will cover and contain contaminated sediment and dredged sediment that is placed in the ECF. The ECF isolation structures address how this material will be contained. The ECF will be created by constructing isolation structure(s) with the following objectives:

- provide a physically stable isolation structure;
- incorporate HPA planned facility uses;
- prevent contaminant transport from the ECF to Hamilton Harbour; and
- be compatible with one or more options for capping, which may be implemented when sediment placement is complete.

Based on the preliminary configuration of the site and proposed long-term use for operations adjacent to the proposed ECF, a single isolation structure may not be applicable for the entire facility. As shown in Figure D.1, the east side of the containment facility will be bounded by a channel that provides access for the U.S. Steel outfall and water intake structures. On the south side, the HPA plans to develop the edge of the ECF for berthing access. On the north and west sides, the ECF is open to the Harbour with limited or no navigational restrictions or future use requirements. The structure selected for the south side (i.e., port facilities – see Section D.6) may not be the most desirable structure for the north and west sides. Therefore, in evaluating the isolation structures options for the project, each of these three areas is assessed independently.

The service or design life for this component of the project is 200 years and is based on the estimated amount of time the structure will be operational, once constructed. It is anticipated that maintenance of the isolation structures will be necessary during the long-term monitoring of the project.

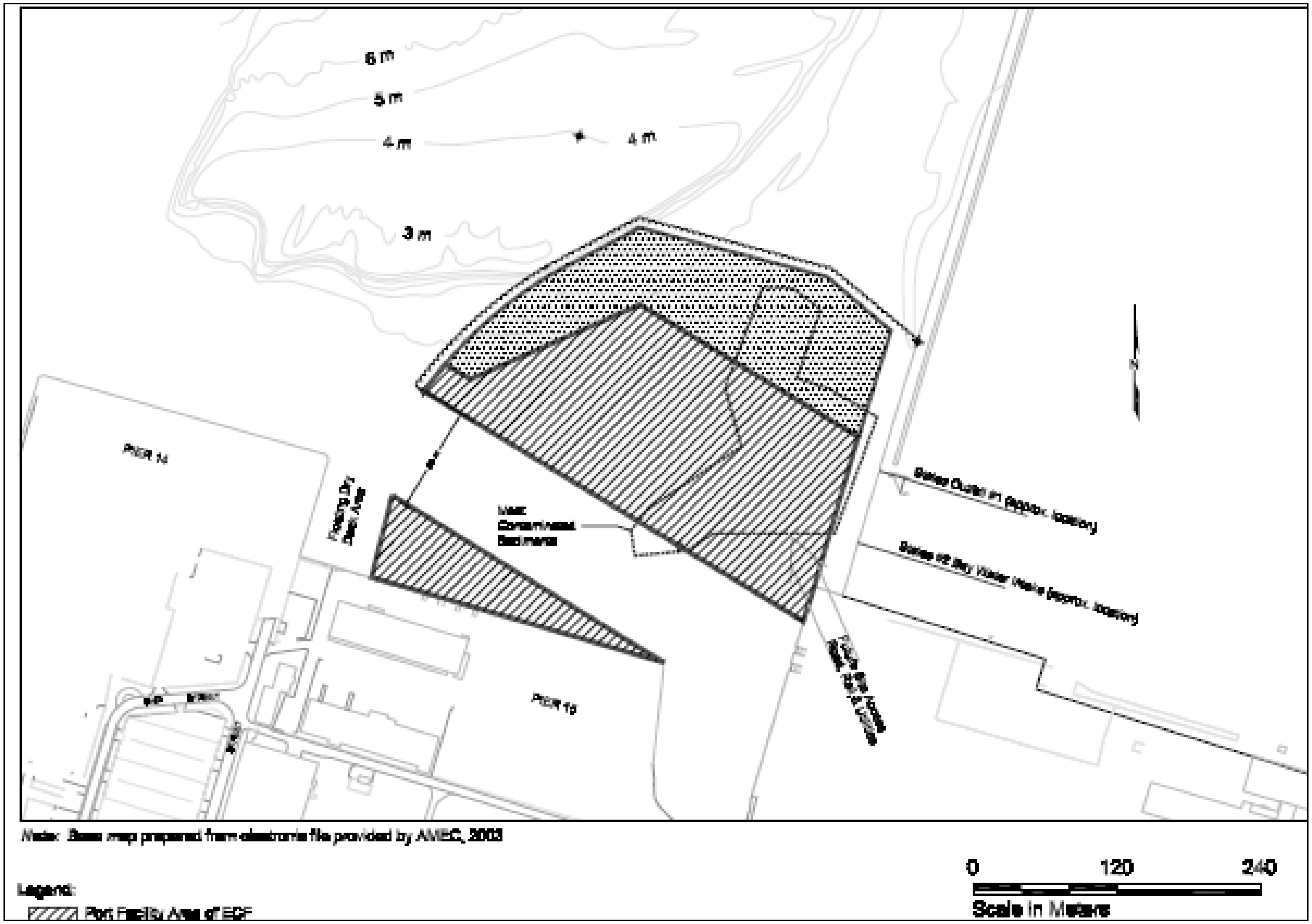
This section provides information on the evaluation of the isolation structure options. The key assumptions relating to the evaluation of isolation structure options are provided in Attachment D.1.

D.1.1.2 Identification of Options

The following isolation structure options were examined for the Randle Reef project:

- Option 1 - Sheetpile Wall Systems with Sealed Interlocks;
- Option 2 - Standard Sheetpile Wall Systems;
- Option 3 - Concrete Caisson Wall;

Figure D.1: ECF Site Plan



- Option 4 - Cellular Steel Sheetpile Wall;
- Option 5 - Earthen Containment Berm;
- Option 6 - Treatment Trenches/Walls; and
- Option 7 - Hybrid Containment Structures.

These options are described in Table D.1. Illustrations of a standard sheetpile wall system, concrete caisson wall, cellular steel sheetpile wall, typical earthen berm, treatment trench and hybrid containment structures are provided following Attachment D.1.

D.1.1.3 Evaluation Criteria

The following general criteria were used to evaluate the isolation structure options:

- service criteria;
- technical criteria;
- environmental impacts;
- cost; and
- prior application.

Attachment D.2 provides a description of the specific criteria or sub-criteria used for the evaluation of isolation structure options.

D.1.1.4 Evaluation of Isolation Structure Options

Table D.2 presents the evaluation of the isolation structure options. This evaluation was based on the evaluation criteria noted in Section D.1.1.3.

Each isolation structure option was evaluated against the criteria and assigned a rating of "high", "moderate", "low" or "unknown". In addition, some "low to moderate" and "moderate to high" rating ranges were used. A "high" rating was the most desirable and a "low" rating was least desirable. An "unknown" rating reflected uncertainty.

In addition, Attachment D.3 provides the advantages and disadvantages of the isolation structure options.

D.1.1.5 Results of Evaluation of Isolation Structure Options

All options were considered suitable for use in constructing the ECF at Randle Reef. As results from the contaminant fate and transport analyses and site specific geotechnical analyses become available (as part of the more detailed engineering work), refinements to the selection of the alternatives can be made.

Table D.1: Description of Isolation Structure Options

Option	Description	Construction Sequence
Option 1 – Sheetpile Wall with Sealed Interlocks	Steel sheetpiles with sealed interlocks are designed to limit seepage through the interlocks of the piles while providing the structural support of typical steel sheetpiles. There are generally two types of systems: (1) conventional, unmodified sheetpiles with sealant applied before sheetpile installation; and (2) conventional sheetpiles with modified interlocks with sealant applied following sheetpile installation. The interlocks of conventional sheetpiles can be treated with sealant prior to pile driving using bituminous or water-swelling products. Applying the sealant prior to pile driving has two disadvantages: (1) it is difficult to ensure continuously sealed interlocks; and (2) piles treated with water-swelling sealant (used for permanent applications) must be driven to their design tip elevations within two hours. Advantages over modified sheetpiles include availability and lower cost. In addition, conventional sheetpiles can be fairly easily combined with king piles and other structural components. Two systems were examined for potential use at Randle Reef - the Waterloo Barrier and the Sevenson system. The Waterloo Barrier system uses conventional sheetpiles with modified interlocks, which eliminate the two disadvantages mentioned for the conventional sheetpiles with regular interlocks. However, it may be difficult to strengthen the wall using king piles. Combining this system with batter piles or anchors should be possible. The modified interlocks of the Waterloo Barrier system allow the injection of sealant starting at the bottom of the interlocks. Once the piles are installed, the interlocks can be jetted clean and inspected prior to injecting the sealant. A variety of sealants are available and can be selected based on factors such as sealant/contaminant compatibility, the presence of unusual water chemistry,	The construction sequence for sheetpile walls with sealant is generally the same as general sheetpile walls described above, with the exception of applying sealant to the interlocks prior to pile driving or after pile installation depending on the selected system. Once the sheetpile wall is in place and the interlocks are sealed, the construction of the retaining structure and filling behind the wall can begin.

Option	Description	Construction Sequence
	permeability characteristics, thermal expansion characteristics, effects of freeze/thaw cycles on grout integrity, design life of the system and cost. The Sevenson system uses conventional sheetpiles with conventional interlocks. However, an angle iron is welded to the piles prior to driving, which covers the interlock and provides a space in which sealant is applied prior to pile installation. The sealant is covered with a "sealant release plate", which is removed after the sheetpile is installed.	
Option 2 - Standard Sheetpile Wall	Standard sheetpile walls without sealed interlocks may be adequate to serve as isolation structures, depending on the results of the fate and transport modeling, and can be constructed using widely available, conventional pile sections. Seepage of contaminated water through the unsealed interlocks may be influenced to a certain extent by selecting sections with fairly tight interlocks such as the Larssen interlocks. Other options include welding several sections together and driving them as a unit thereby reducing the number of unsealed interlocks. Standard sheet piling may also be applicable if sediments with lower chemical concentrations or mobility characteristics are placed adjacent to the outer boundary, or if an interior treatment trench/wall is considered.	Sheetpiles are installed using either impact or vibratory pile hammers. Each sheet of steel is installed to the required design embedment depth. Installation may require a construction berm to be placed prior to sheetpile installation. However, to avoid impact of such a berm on ECF capacity, it may be beneficial to install sheetpiles from a barge. If cantilever piles are not feasible due to excessive deflection of the wall system, additional lateral support would be required. Additional lateral support can be achieved by a number of different methods.
Option 3 - Concrete Caisson Wall	Concrete caissons are individual concrete cribs, which are slip formed and launched into the water for completion of the wall. Generally, the individual caissons would be 30 m long and 12 m high and 10 m wide. The cribs would be ballasted and set on a prepared stone mattress and backfilled. A concrete parapet is added on top along the face of the caisson. The cribs are set end to end to form the length of the terminal and a key is placed between caissons to seal the space between abutting cribs. Concrete caisson walls can be very effective in preventing or limiting contaminant transport above their base elevation, but	Concrete caisson walls have not been used extensively for port applications primarily because of the complex construction process. The concrete caissons, consisting of individual concrete cribs are slip-formed on land and launched into the water. The cribs are ballasted and set on a prepared stone mattress and backfilled. A fair amount of dredging is required prior to caisson installation to prepare the foundation, which requires interim storage of the contaminated dredged sediments.

Option	Description	Construction Sequence
	it has a fairly large footprint, which reduces the ECF capacity in comparison to sheetpile.	
Option 4 - Cellular Steel Pile Wall	A cellular steel sheetpile wall consists of flat web piling driven in a circular shape with each cell interconnected by arcs of the same piling. Preliminary sizing of the system indicates that the cell would be 20 m in diameter with the centre-to-centre distance between cells of 25 m. The cells are backfilled and act as a gravity structure. The height of the structure is estimated to be 18 m, based on preliminary soils information. A concrete parapet on top would be necessary to provide a flush face wall for berthing.	The cellular steel pile wall consists of a number of flat-web sheetpiles driven into the ground in a circular shape. Each cell would be approximately 20 m in diameter and would be interconnected with arcs also made of flat-web sheets. The cells are backfilled and act as gravity structures. The construction of cellular sheetpile walls is fairly complex and requires precise driving of the individual sheets. As a result, they are not widely used.
Option 5 - Earthen Containment Berm	The earthen containment berm alternative is a proven method for ECF construction. There are a number of examples of ECFs in the U.S. that have been constructed using this method. Low-permeability core material can be used to further decrease contaminant mobility through the berm. A small percentage of carbon in the core material can also act to improve retention of contaminants through adsorption.	The soft contaminated sediments are dredged before placement of the berm material and clean, firm foundation soils are exposed. It may be necessary or beneficial to over-excavate the foundation soils along the toe of the slopes to provide improved stability. It may be necessary to construct the berm in stages, if this option is preferred. This would be determined based on stability analyses. Some contractors find it convenient to construct earthen berms in vertical stages using training terraces or dikes. For each lift, the training terraces on each side of the berm are constructed first before filling the area in between with structural fill. This process is repeated up to the crest of the berm. The use of training terraces is effective at improving the slope stability by loading the foundation soils gradually and allowing the foundation soils to gain strength during pore water pressure dissipation/consolidation prior to placement of the next lift or level. This method also helps contain and protect the core material from erosion and sloughing. The armouring of the slopes would consist of quarry run material and/or rip rap for erosion resistance and to enhance stability of the berm.

Option	Description	Construction Sequence
Option 6 - Treatment Trenches/Walls	Isolation of the upper threshold (highly contaminated) sediments via slurry cutoff trenches and/or treatment walls may be needed to effectively contain contaminant migration. This could either be within an earthen containment berm, as trenches installed during or after berm construction, or adjacent to sheetpile walls.	
Option 7 - Hybrid Containment Structures	Based on the project objectives, it is possible that some combination of the systems described above would provide the most implementable and cost-effective alternative. Additional hybrid containment structure systems could be identified based on the results of the fate and transport analyses. The following hybrid systems were considered feasible for the Randle Reef project: • earthen containment berm with treatment trench incorporated in core of berm; • earthen containment berm with steel or plastic sheetpiles (sealed or standard) through core; • earthen containment berm with low-permeability core consisting of geotextile tubes or pre-fabricated bins; and • funnel and gate (or permeable reactive barrier) technology which utilizes nonpermeable barriers, such as cement bentonite cutoff walls, to force contaminant transport into a remediation gate; the gate is filled with a permeable reactive media to treat the contaminated pore water as it passes through.	

Table D.2: Evaluation of Isolation Structure Options

Criteria /Sub-criteria	Alternative						
	Option 1 - Sheetpile Wall with Sealed Interlocks	**Option 2 - Standard Sheetpile Wall**	**Option 3 - Concrete Caisson Wall**	**Option 4 - Cellular Steel Sheetpile Wall**	**Option 5 - Earthen Containment Berm**	**Option 6 - Treatment Trenches/Walls**	**Option 7 - Hybrid Containment**
Service - Required Effectiveness	• high • low permeability of the sealed sheetpile wall limits leakage of sediment pore water	• moderate • sheets are permeable and leakage of sediment pore water through sheetpile is likely	• high • there are no pathways for leakage through the wall • sediment pore water pathway exists below wall	• moderate to high • while leakage could potentially occur through the interlocks, the individual cells can be backfilled with low permeability material	• moderate • low permeability materials in the core of the berm reduce contaminant transport through the structure	• high • permeable trench/wall would be used with other less permeable structures • pore water constituents are treated prior to surface water exposure	• moderate to high • depends on configuration
Service – Optimization of the Containment Volume	• high (if no construction berm is required)	• high (if no construction berm is required)	• moderate • the preliminary width of the wall is 10 m	• low • the preliminary footprint of the structure is 20 m wide	• low – south and east sides • moderate – north and west sides • footprint of berm could take as much as 50 m^2 per m length of the ECF • boundaries on south and east sides are fixed, whereas the boundaries of the	• high • little or no effect on volume	• moderate to high • depends on configuration

Criteria /Sub-criteria	Alternative						
	Option 1 - Sheetpile Wall with Sealed Interlocks	Option 2 - Standard Sheetpile Wall	Option 3 - Concrete Caisson Wall	Option 4 - Cellular Steel Sheetpile Wall	Option 5 - Earthen Containment Berm	Option 6 - Treatment Trenches/Walls	Option 7 - Hybrid Containment
					ECF on the north and west sides are more flexible		
Service – Compatibility with HPA Facility Requirements	• high	• high	• high	• high	• low	• moderate • could impact structural design of port facilities if used adjacent to sheetpile bulkhead	• moderate to high • depends on configuration
Technical – Constructability	• low • sealed sheets require precise driving	• moderate	• low • fairly complex construction technique • requires dredging prior to installation	• low • circular shaped cells require precise driving of flat web sheets	• moderate	• moderate • construction of treatment trenches would need to occur either within an earthen berm or built between two sheetpile walls	• moderate • depends on configuration
Technical – Compatibility	• high – south and east sides • low – north and west sides	• high – south and east sides • low – north and west sides	• high – south and east sides • low – north and west sides	• high – south and east sides • low – north and west sides	• high – south and east sides • low – north and west sides	• moderate • works well with other containment structures (sheetpile walls and earthen berms) • would not work as a stand alone structure	• high • would be designed to be compatible and cost-effective

Criteria /Sub-criteria	Alternative						
	Option 1 - Sheetpile Wall with Sealed Interlocks	**Option 2 - Standard Sheetpile Wall**	**Option 3 - Concrete Caisson Wall**	**Option 4 - Cellular Steel Sheetpile Wall**	**Option 5 - Earthen Containment Berm**	**Option 6 - Treatment Trenches/Walls**	**Option 7 - Hybrid Containment**
Environmental Impacts	• low • minor disruption of surface sediments during pile driving	• low • minor disruption of surface sediments during pile driving	• low • some pre-installation dredging required to prepare foundation	• low • minor disruption of surface sediments during pile driving	• moderate • turbidity and disruption of surface sediments during placement of earthen materials	• none • trench/wall would not be installed through the water column	• low to moderate • dependent on configuration
Cost	• high • requires specialized steel sheets and/or use of specialty contractor	• moderate	• high	• moderate to high	• low	• moderate	• unknown • likely moderate to high
Prior Application	• moderate • used at the new Bedford Harbour project in Massachusetts to contain soil with 4,000 to 200,000 ppm PCBs	• high • also used at the New Bedford Harbour project in Massachusetts to contain PCBs • used extensively for standard bulkheads	• not widely used • last commercial wharf built using this technique was Goderich in 1986	• limited use in the Great Lakes region • last large-scale structure was constructed at Long Point in 1987	• moderate • used in several sediment remediation projects in Puget Sound, Washington	• moderate • no prior applications with sediments • used extensively for upland remediation of groundwater	• unknown

The following options were considered the most advantageous at this point in the engineering process and were carried forward for further evaluation:

- Standard Sheetpile Wall for the eastern side of the ECF;
- Standard Sheetpile Wall for the southern side of the ECF; and
- Earthen Containment Berm for the northern and western sides of the ECF.

The standard sheetpile wall was selected based on the following main advantages:

- compatibility with the HPA facility requirements as well as with the outfall structure and water intake structure along the U.S. Steel property;

- the small footprint of the structure is compatible with space requirements associated with the ship channel and maximum capacity of the ECF;

- standard sheetpile walls have been used extensively for port facilities and there is a fair amount of engineering and construction experience available; and

- sheetpile interlocks can be sealed, if necessary, to achieve a highly impermeable barrier.

While the sheetpile option is appropriate for the eastern and southern sides of the ECF, an earthen containment berm is better suited for the seaward edges of the ECF because of its more natural appearance in this environment. Other advantages of the earthen berm include:

- it can be designed to be very effective in containing contaminants and sediment pore water;

- it is likely less expensive than sheetpile walls; and

- if necessary, a berm can be combined with several other alternatives such as geotextile tubes, sheetpiles (can be plastic and with sealed interlocks), treatment trench, etc. to form a highly effective barrier.

The main disadvantage of the berm option is that its relatively large cross section reduces the capacity of the ECF.

The remaining options were eliminated from further consideration based on the following:

Option	Reasons for Elimination
Option 1 - Sheetpile Wall with Sealed Interlocks	• while more impermeable than a standard sheetpile wall, it is more costly for both the procurement of the materials and the installation of the sheets • it is also more difficult to install than standard sheetpiles due to the interlocking feature • it has not been demonstrated at this stage that the added expense of this alternative is warranted • if the risk posed by migration of contaminants through the walls is deemed unacceptable, this alternative would be re-assessed
Option 6 - Treatment Trenches/Walls	• not suitable as a stand alone option for the ECF • could be used either in conjunction with a sheetpile wall or earthen containment berm to increase the effectiveness of the overall isolation structure or within the interior of the ECF to contain specific dredge material contaminants • the applicability of this option may be re-considered based on the results of the future modeling of contaminant fate and transport • at this time, the need for a treatment system has not been determined

It was concluded that further consideration of hybrid containment structures was not warranted. Both the sheetpile wall and the earthen berm can be combined with special elements such as treatment trenches to form hybrid containment structures.

The following strategy was developed to finalize the isolation structure selection:

- perform fate and transport modeling based on the options recommended at the initial screening stage (i.e., assume that conventional techniques consisting of earthen containment berms and standard sheetpile walls are viable); if contaminant transport cannot be controlled using conventional techniques based on future fate and transport modeling, consider other techniques, including sheetpiles with sealed interlocks, treatment trenches, and hybrid structures;

- perform preliminary design and analyses of isolation structures including slope stability analyses of the earthen berm and structural design and analysis of the sheetpile alternative; other alternatives may have to be analyzed based on the results of the future fate and transport modeling; and

- re-assess feasibility of options and finalize design as part of the more detailed engineering for the project.

D.1.2 Detailed Evaluation – 30 Percent Design

D.1.2.1 Introduction

Several studies were completed to further development of the 30 percent design of the isolation structures. The ECF isolation structures design work required information from an analysis of the strength and compressibility of the sediment and a geotechnical evaluation of the ECF (see Section 4.1.7; Basis of Design Report (Arcadis BBL, 2006); (Technical Memorandum – Task 2.1.1 – Geotechnical Design Analysis, Arcadis BBL, 2008). In addition, a bench scale treatability/fate and transport testing/model (see SUPPORTING DOCUMENT E) was undertaken. A review of the total PAH and metals and mass containment relative to the isolation structures was also incorporated.

The evaluation of the isolation structures also included analyzing the compatibility of the proposed option with the other design elements (e.g., sediment management, dredging, U.S. Steel Intake/Outfall accommodation designs, etc.).

In order to limit contaminant transport to Hamilton Harbour, and based on fate and transport modeling of the sediment contaminants, the ECF isolation structure will require containment using an impermeable barrier [2]. ECF isolation structures generally refer to the environmental containment structure, with the exception of the port facility walls which are a separate design element (see Section D.6). The two walls (i.e., double sheetpile wall) both serve an environmental containment function, as well as a structural function. The primary function of the interior wall is environmental containment. The primary function of the exterior wall is structural.

D.1.2.2 Identification of Options

As the results from the contaminant fate and transport modeling and site specific geotechnical analyses became available, refinements to the isolation structure options were made. This resulted in two isolation structure options being eliminated from further consideration for the 30 percent design (see Section D.1.2.4).

The options that were assessed at the detailed 30 percent design level were:

- a double steel sheetpile wall;
- a standard steel sheetpile wall;
- a cellular steel sheetpile wall;
- an earthen (sand and gravel) containment berm;

[2] A structure that does not allow fluids to pass through. For the purposes of the engineering design, this translates to a hydraulic conductivity of $< 1.0 \times 10^{-8}$ cm/s.

- an earthen (sand and gravel) containment berm with sealed steel sheetpile through centre; and
- an earthen (sand and gravel) containment berm with reinforced high-density polyethylene (HDPE) liner on side face.

Certain options were considered to be more applicable for specific sides of the ECF. Table D.3 outlines the design options considered for the north, east and west sides of the ECF. Isolation structures for the south side of the primary ECF are noted as part of the port facilities design element due to differences in wall type/size for accommodating port design standards and requirements (see Section D.6).

D.1.2.3 Evaluation Criteria

The following general criteria were used to evaluate the isolation structure options at the 30 percent design level:

- effectiveness;
- implementability; and
- cost.

Attachment D.4 provides a description of the specific criteria or sub-criteria used for the evaluation of isolation structure options.

D.1.2.4 Evaluation of Options

The results of the fate and transport modeling led to the conclusion that the ECF isolation structure must provide an effective seal around the contained dredged sediment to prevent migration of dissolved contaminants via groundwater, including sealable interlocks for interior sheetpile walls. Based on this, the isolation structure options were re-examined.

It was concluded that the standard (single) steel sheetpile wall with tension anchors should be eliminated from further consideration for the following reasons:

- the point of compliance for the Ontario PWQOs (and/or CWQGs) is immediately adjacent to the sealed interlock and, therefore, the risk of unacceptable impacts associated with the release of dissolved constituents due to damaged interlocks or sealant is much greater than with the double steel sheetpile wall which has sealed interlocks along the interior wall;

- the mitigation of lost containment is less feasible than with the double steel sheetpile wall or containment berm options (an injection grouting remediation between double steel sheetpile wall or providing additional cutoff within the containment berm is more feasible than with the standard sheetpile wall);

Table D.3: Description of Isolation Structure Design Options

Isolation Structure Option	Isolation Structure Side	Description
Double Steel Sheetpile and Sealed Steel Sheetpile Wall (see illustrations following Attachment D.1)	North, South[3] , East and West	• in this design option, the exterior wall comprises the structural component • the interior wall comprises a sealable interlock sheetpile wall • the interior wall will be driven 3 m (10 ft) into clay • the area between the double sheetpile walls has internal bracing and gravel backfill (i.e., “gabion stone”) for structural stability
Standard Steel Sheetpile Wall (see illustrations following Attachment D.1)		• may be adequate to serve as isolation structures, depending on the results of the fate and transport modeling, and can be constructed using widely available, conventional pile sections • seepage of contaminated water through the unsealed interlocks may be influenced to a certain extent by selecting sections with fairly tight interlocks such as the Larsen interlocks • standard sheet piling may also be applicable if sediments with lower chemical concentrations or mobility characteristics are placed adjacent to the outer boundary, or if an interior treatment trench/wall is considered
Cellular Steel Sheetpile Wall (see illustrations following Attachment D.1)	North, South, East and West	• the space between the sheetpiles is backfilled using a suitable granular material • cofferdams also act as sheetpile/gravity wall hybrid systems
Earthen (sand and gravel) Containment Berm (see illustrations following Attachment D.1)	North and West	• this design option is comprised of a sand and gravel berm placed by clamshell dredge or other equipment • the aggregate is skillfully and precisely placed by qualified personnel with minimal disturbance of the water column • the berm can be constructed using riprap stepped terraces, approximately 2 m in height, with filling occurring between terraces

[3] The south wall is included here and with the cellular steel sheetpile wall option due to its environmental containment function.

Isolation Structure Option	Isolation Structure Side	Description
		• other than the sorption capacity of the earthen materials, no cut-off of migrating contaminants would be provided for in this option
Earthen (sand and gravel) Containment Berm with Sealed Steel Sheetpile through Centre (see illustrations following Attachment D.1)	North and West	• in this design option, sand and gravel fill is preferred to provide sorption capacity for migrating contaminants, which would eventually encounter the sealed interlock sheetpile wall, which is intended to be driven about 3 m (10 ft) into the clay bottom • sand and gravel side slopes are envisioned at about 2H:1V (horizontal to vertical) and the exterior slope would be armoured against storm waves with 1 tonne riprap
Earthen (sand and gravel) Containment Berm with Reinforced HDPE Liner on Side Face (see illustrations following Attachment D.1)	North and West	• in this design option, the interior face of the containment berm is lined with a specialty liner identified for this project based on experience with similar marine-related construction • the product is unlike typical HDPE (high density polyethylene), which floats on water; it is heavier than water due to a reinforcing component in the liner, permitting submerged construction • dredging to clay at the toe of the interior side of the containment berm creates an effective seal due to the close contact between the liner and low permeability clay • further, an anchor trench in the top of the containment berm is constructed to support the liner from above • sand and gravel fill is placed on top of the liner for stability during ECF filling

- the structural steel for the single wall is thicker, which could result in increased material costs and may limit availability from vendors that could provide acceptable sealable products; and

- the long-term reliability for the 200 year design life is considerably lower than with the double steel sheetpile wall.

The requirement to limit the transport of contaminants to the surrounding surface water or groundwater also eliminated the cellular steel sheetpile wall option from further consideration since the straight sheetpiles are in tension at the interlocks and a sealing product is not currently available (to the knowledge of the engineering design team).

As a result of the fate and transport modeling, it was determined that a reactive core would be required within an earthen containment berm, in order to prevent the migration of contaminants. Therefore, an earthen berm without a reactive core was eliminated from further consideration.

Reactive cores are materials which are placed within the berms to passively treat/attenuate contaminants migrating through the berms. A reactive core could be achieved by placing a sealed steel sheetpile through the centre of reinforced HDPE liner on the side face in order to adequately limit the transport of contaminants to the surrounding surface water or groundwater. Both design options could be milled locally with adequate structural capacity.

With the elimination of the standard steel sheetpile wall, the cellular steel sheetpile wall and the earthen containment berm without a reactive core, the following options remained for further consideration at the 30 percent design level:

- a double steel sheetpile wall;
- an earthen containment berm with sealed steel sheetpile through centre; and
- an earthen containment berm with reinforced high-density HDPE liner on side face.

Table D.4 presents the evaluation of these options. Each option was assigned a score by criteria, reflecting a ranking of +1 for preferred, 0 for neutral or -1 for not preferred or not meeting criteria. Where all options were assigned a "0" for a particular criterion, this indicated that there were no differences among the options for that criterion. The ranking by criteria were then summed with the highest score assigned to the most preferred option. The criteria were weighted equally.

In addition, Attachment D.5 provides the advantages and disadvantages of these options.

D.1.2.5 Results of Evaluation of Options

Based on the evaluation of the options, the options were ranked from most preferred to least preferred, as follows:

- double steel sheetpile with sealed interlocks (score = 8);
- earthen (sand and gravel) containment berm with sealed steel sheetpile through centre (score = -3); and
- earthen (sand and gravel) containment berm with reinforced HDPE liner on side face (score = -7).

Table D.4: Evaluation of Isolation Structures Options – 30 Percent Design Level

Criteria / Sub-criteria	Double Wall (SSP and Sealed SSP Walls)	Containment Berm with Sealed SSP Wall through Centre	Containment Berm with Reinforced HDPE Liner
Effectiveness			
Overall Protectiveness – Risk of Exposure to Public or Environment (short term)	1	-1	-1
Overall Protectiveness – Risk of Exposure to Public or Environment (long term)	1	1	0
Compliance with Design Standards and Other Requirements	0	0	0
Long-term Effectiveness and Performance - Risk Presented by Residuals and Contained Sediment	1	1	0
Long-term Effectiveness and Performance - Reliability of Technical Components / Controls	0	0	0
Short-term Effectiveness - Protection of Workers, Community During Construction	1	-1	-1
Short-term Effectiveness – Protection of the Environment During Construction	1	-1	-1
Short-term Effectiveness - Scheduled Duration of Design Elements/Time to Execute Design Option	0	0	0
Reduction of Mass/Volume, Toxicity, and Mobility of Contaminants - Degree of Dissolved Chemical and/or NAPL Mobility Control and Magnitude of Contaminant Mass Reduction	0	0	0
Reduction of Mass/Volume, Toxicity, and Mobility of Contaminants – Magnitude of Contaminant Mass Reduction	0	0	0
Implementability			
Technical Feasibility - Ease of Construction and Operating the Option in a Cost-Effective Manner	1	0	-1
Technical Feasibility - Reliability of Design Option	0	0	0
Technical Feasibility - Compatibility	0	0	0

Criteria / Sub-criteria	Double Wall (SSP and Sealed SSP Walls)	Containment Berm with Sealed SSP Wall through Centre	Containment Berm with Reinforced HDPE Liner
with other Design Options			
Technical Feasibility - Technical Complexity of Design Option	0	0	0
Technical Feasibility - Facilitation of Future Actions for Remediation or Repairs	-1	-1	-1
Administrative Feasibility – Facilitates Coordination with Local/Provincial/Federal Government Agencies to Both Identify and Comply with Jurisdictional Regulations	0	0	0
Administrative Feasibility - Ease of Obtaining Permits Waivers, Easements, Other Releases to Facilitate Implementation of Design Components Comprising Option	1	0	0
Administrative Feasibility - Acceptance by Stakeholders	0	0	-1
Availability - Availability of Equipment, Materials, Services, etc. to Implement, Verify and Monitor Effectiveness of Design Option	1	0	-1
Local/Provincial/Federal Government Standards and Stakeholder Input-Relative Probability of Design Option to Generate Issues or Concerns	0	0	-1
Local/Provincial/Federal Government Standards and Community Input-Incorporation of Input from the Community Based on Perceived Issues or Concerns, Relative Risk of Heightened Public Concern	0	0	0
Cost			
Cost - Capital and Periodic Costs	1	-1	0
Cost - Financial Risk	0	0	1

Based on the detailed evaluation at a 30 percent design level, it was decided that all three options were feasible and should be retained for further consideration at the 100 percent design level.

It was decided that a greater level of detail (i.e., 100 percent design) was required before a final decision could be made on a preferred option.

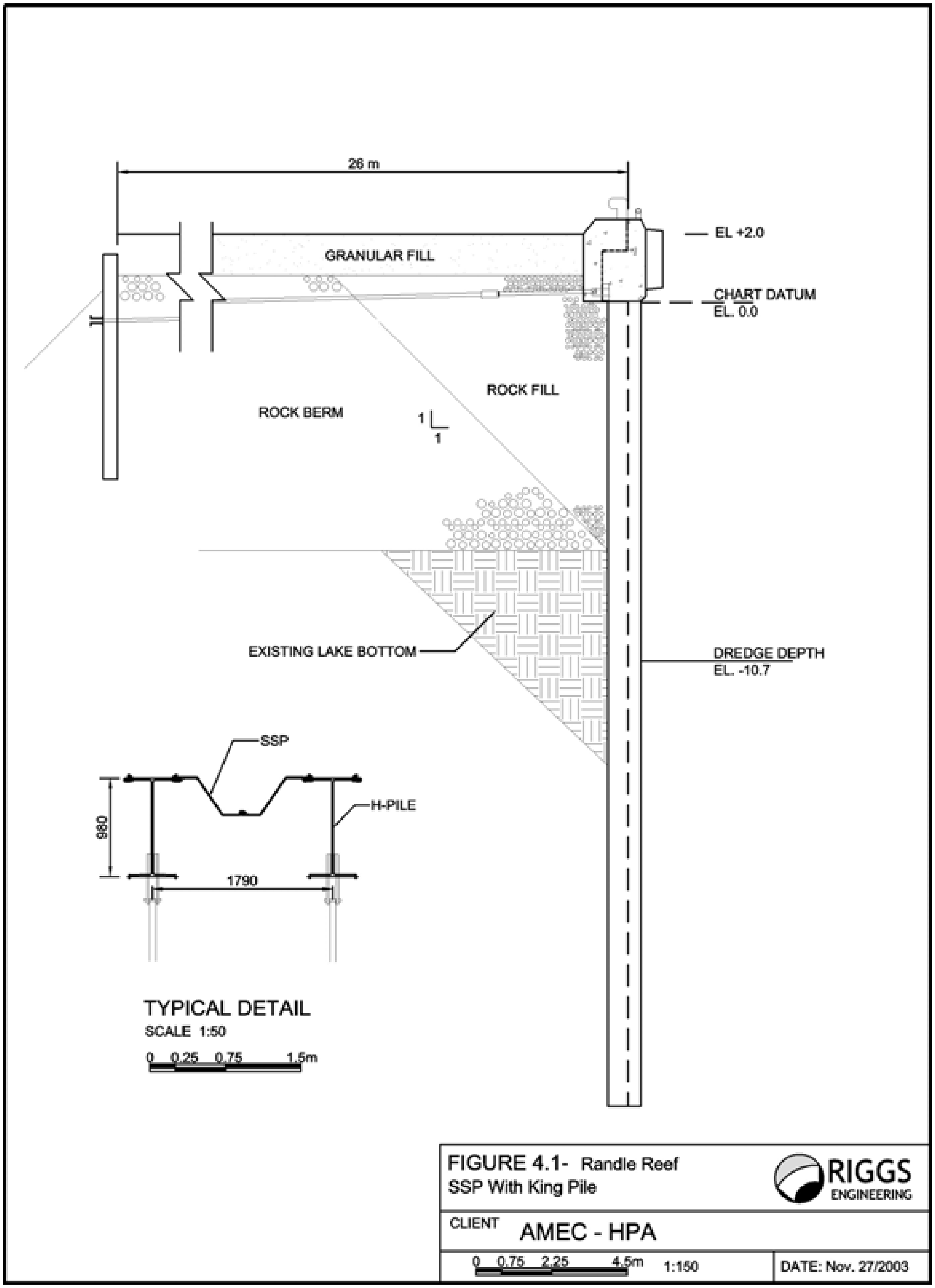
D.1.3 Detailed Evaluation – 100 Percent Design

The development of the 100 percent design for the isolation structures was largely addressed in conjunction with the 100 percent design development for the port facilities, as well as through the development of the fate and transport studies work done to support sediment management studies, capping, groundwater and stormwater management. Sections D.2.3 (dredging) and D.6.3 (port facilities) should be referred to for information pertaining to the design for the isolation structures.

Attachment D.1: Isolation Structure Options: Initial Screening Assumptions

Item	Assumptions
Subsurface Geotechnical Conditions	Based on preliminary assessment of the geotechnical data for the proposed footprint of the ECF, the foundation soils generally consist of firm (medium stiff), cohesive material. Very stiff to hard cohesive soils were encountered at depth. It is likely that surficial sediments will require dredging prior to construction of an earthen berm structure to expose higher strength foundation material. While the construction of an earthen berm should generally be feasible, it may be necessary to build the berm in stages to allow for consolidation of the foundation soils. This will likely be a matter of construction sequencing and should not affect the overall construction schedule significantly. Slope stability analyses will be performed at a later stage to assess overall berm stability and requirements for staged construction. Based on the geotechnical and port facilities design work, the construction of bulkhead walls including sheetpile solutions was considered generally feasible. A preliminary evaluation of the area of the known slag deposit indicates that the deposit is unlikely to adversely impact the constructability of any of the isolation structure alternatives. For example, driving steel sheetpile through the deposit is feasible. However, potential implications of the deposit on the effectiveness of the isolation structures to retain contaminants will be reviewed after the structures are selected and as fate and transport modeling progresses.
Availability of Construction Materials	Sealable steel sheetpile is available through Canadian Metal Rolling Mills (CMRM) in Cambridge, Ontario. CMRM manufactures the Waterloo Barrier® system under license and also distributes the Hoesch Interlock Sealing System ®, which is manufactured in Germany. Conventional sheetpiles with sealable interlocks are manufactured by Arbed in Europe and distributed by SkyLine Steel of Parsippany, New Jersey. Another patented system is installed by Sevenson of Niagara Falls, New York, and uses modified conventional sheetpiles. Sealable polyethylene and fiber-reinforced plastic sheetpiles are also available from Skyline Steel of Parsippany, New Jersey, U.S.A. and from Crane Materials International (CMI) in Atlanta, Georgia. Standard Sheetpile is available through a number of distributors. For example, standard steel sheetpile (e.g., Arbed products) is distributed in Canada by Skyline Steel of Parsippany, New Jersey, U.S.A. Hoesch sections are available through Salzgitter International. Earthen berm materials are readily available from regional quarries and are likely to include a

Item	Assumptions
	combination of sand, gravel, quarry spalls and rip rap materials. The use of slag may be feasible, however, environmental impacts would have to be evaluated.
Fate and Transport Analysis	It was assumed that the results of fate and transport studies are comparable to other contaminated dredge projects with sediments containing elevated levels of metals, PAHs and PCBs (e.g., the Eagle Harbor Superfund Project and the Commencement Bay Nearshore/Tideflats Superfund Project). At these projects, the fate and transport modeling predicted that contaminant transport through the isolation structure can be effectively controlled or minimized using conventional techniques, such as earthen containment berms and sheetpile walls. It was assumed that conventional techniques would be adequate to control contaminant transport.
Multi-year, Multi-stage Construction Life Cycle	It was assumed that construction of the isolation structure may take place in stages, over a period of years. For example, the first containment cell may require the use of temporary construction techniques due to the need for pre-construction containment structure footprint capacity. Additionally, the logical construction sequence may require an open water cell to correspond to certain dredging locations and/or methods, and a closed cell with treatment plant infrastructure for other dredge materials. Another factor affecting the construction life cycle is the rate at which material can be dredged and transported to the site, and the rate of processing for the return water, if necessary.
Site Use is a Combination of Port Facilities and Natural Area	It was assumed that the final land/sea transition structures for the ECF would include a combination of port facilities on the southern edge of the site and a natural area on the northern and western edges of the site in accordance with the conceptual design (see Section 6.0). In addition, while the boundaries of the ECF on the southern and eastern edges of the site are fixed to provide channel access, the northern and western edges of the site could be optimized depending on analysis of the capacity requirements of the site. On the eastern edge of the site, U.S. Steel operates an outfall and water intake structure. The property owners in this area have indicated that a channel access corridor needs to be maintained and that extending and burying the piping system for the structures to the northern edge of the ECF is not an option at this time.



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GRANULAR FILL
CHART DATUM
EL. 0.0
ROCK FILL
ROCK BERM
1
1
EXISTING LAKE BOTTOM
DREDGE DEPTH
EL. -10.7
SSP
H-PILE
980
1790
TYPICAL DETAIL
SCALE 1:50
0 0.25 0.75 1.5m
FIGURE 4.1- Randle Reef
SSP With King Pile
RIGGS ENGINEERING
CLIENT AMEC - HPA
0 0.75 2.25 4.5m 1:150
DATE: Nov. 27/2003

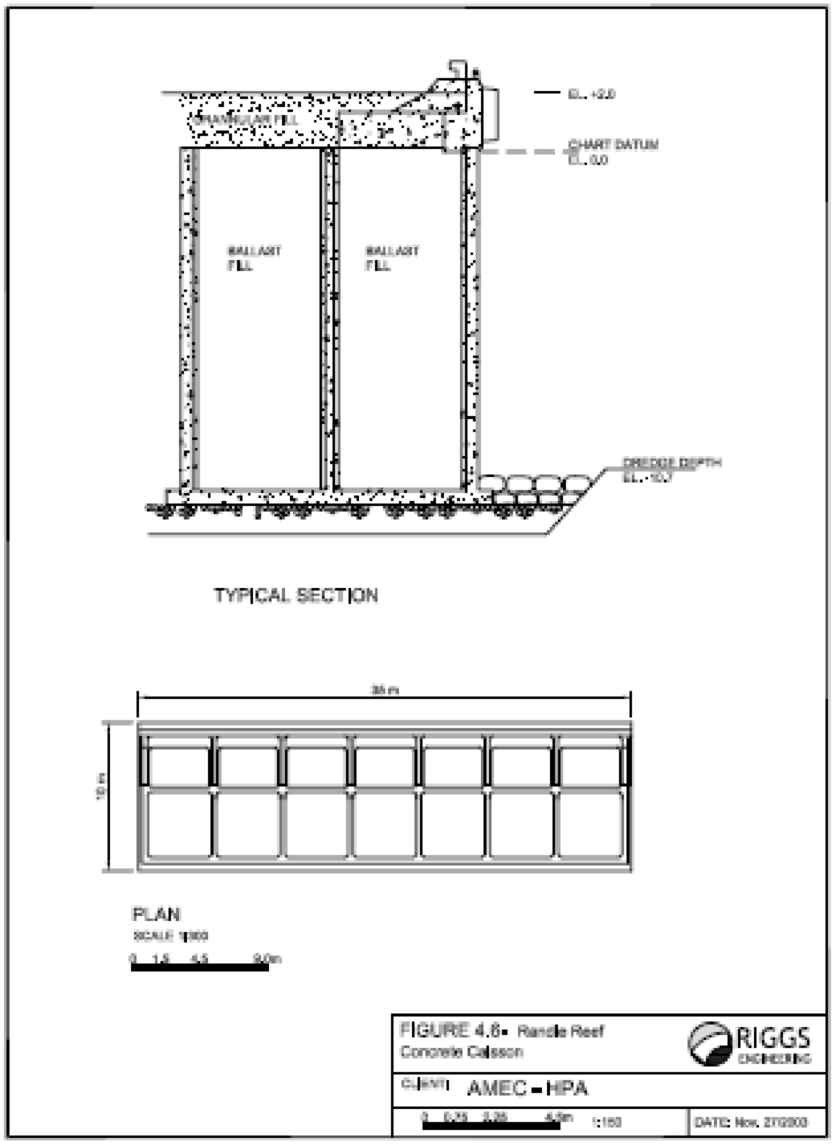
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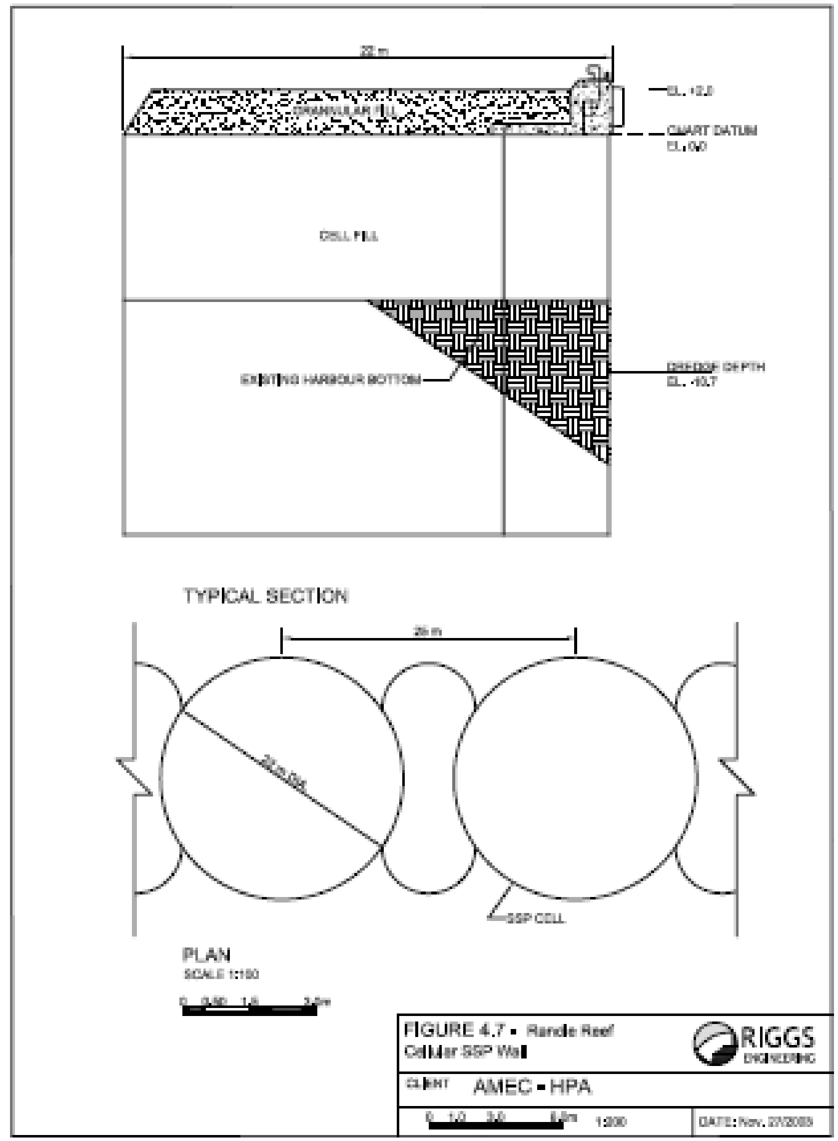
CHART DATUM
EL. 0.0
BALLAST FILL
BALLAST FILL
DREDGE DEPTH
EL. -10.7
TYPICAL SECTION
PLAN
FIGURE 4.6 - Randle Reef
Concrete Caisson
RIGGS ENGINEERING
CLIENT AMEC - HPA
1:150
DATE: Nov. 27/2003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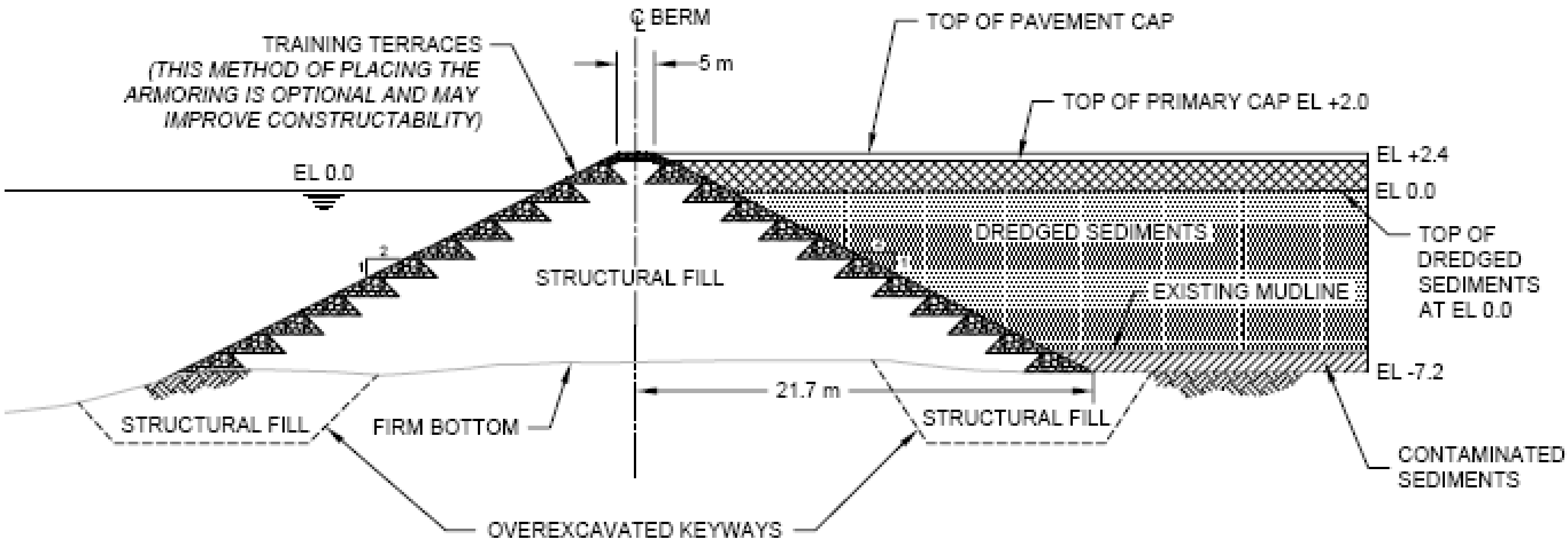
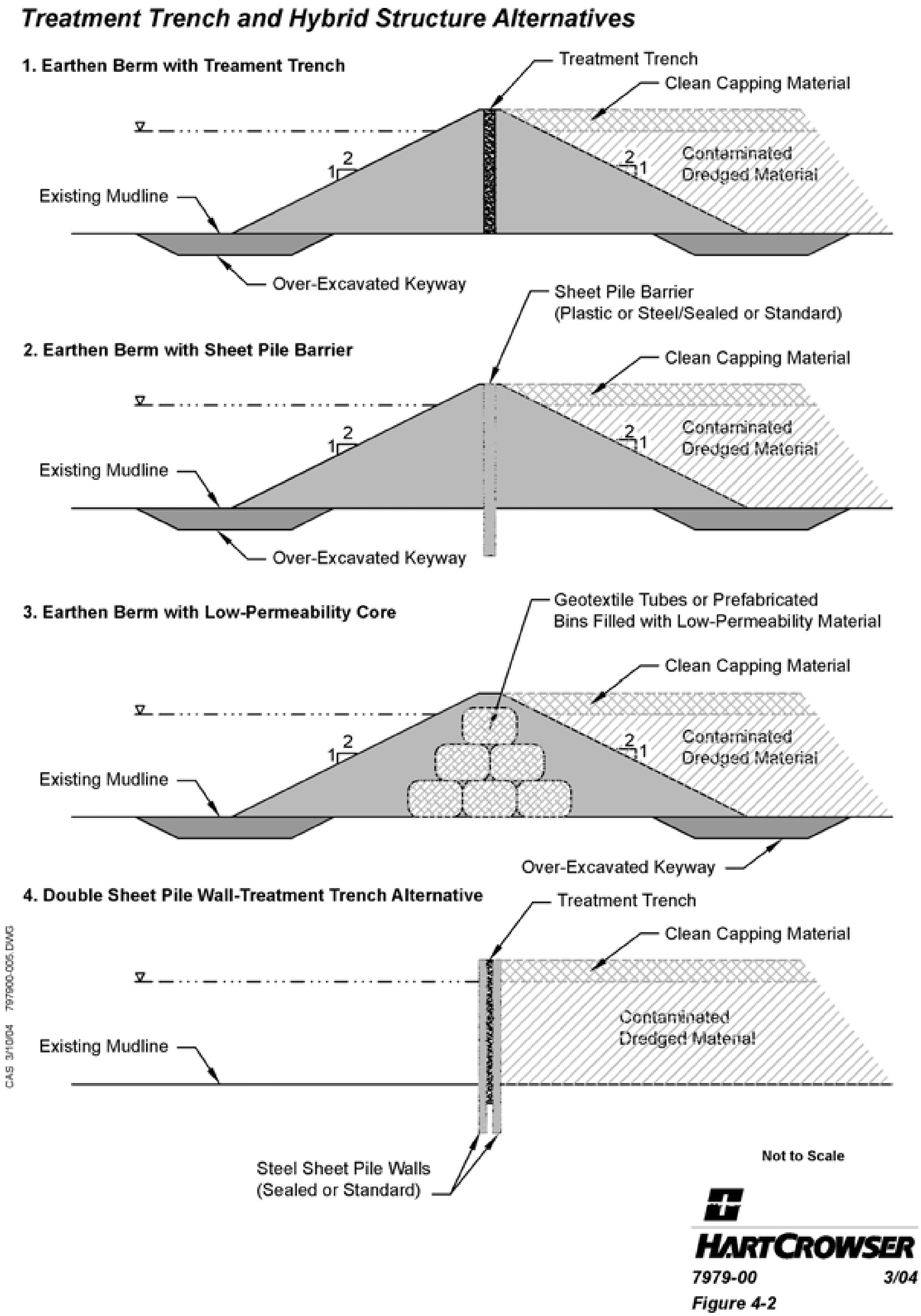
EL. 0.0
CELL FILL
EXISTING HARBOUR BOTTOM
DREDGE DEPTH
EL. -10.7
TYPICAL SECTION
26 m
SSP CELL
PLAN
SCALE 1:150
FIGURE 4.7 - Randle Reef
Cellular SSP Wall
RIGGS ENGINEERING
CLIENT AMEC - HPA
1:200
DATE: Nov. 27/2003

Isolation Structures Evaluation - Typical Earthen Berm
Randle Reef Project



Not to scale



(Sealed or Standard)

Attachment D.2: Isolation Structure Options: Description of Initial Screening Evaluation Criteria or Sub-criteria

Criteria	Sub-criteria	Criteria or Sub-criteria Description
Service Criteria	Required Effectiveness	This refers to the required effectiveness of the isolation structure to confine and limit movement of contaminants within the ECF. The performance requirements will be based on the mobility of the contaminants, which is determined from laboratory leachability tests. Based on the testing results there will be at least two possible scenarios, as follows: • the contaminants in the dredge sediment are highly mobile; the performance criteria in this case would be full containment of the sediment and associated porewater following construction; and • the contaminants in the dredge sediment are less mobile and tend to naturally attenuate as they pass through the ECF and the isolation structure to the adjacent surface waters; the performance criteria in this case would be to limit the hydraulic conductivity and movement of the porewater from the ECF to the adjacent surface waters.
	Optimization of the Containment Volume	The ECF structures would be optimized not only with respect to placement of contaminated sediments based on relative contamination, but also in terms of the use of the various containment structure design components. A primary goal of the facility is to provide excess capacity for contaminated sediments to limit the potential for exceeding the capacity of the containment site, thereby requiring an alternative containment location.
	Compatibility with HPA Facility Requirements	Requirements for ship berthing and associated loading conditions will be developed during ongoing coordination with HPA.
Technical Criteria	Constructability	The constructability or feasibility of implementation of the isolation structure is based on the complexity of the structure itself, the availability of materials and the existing site conditions.
	Compatibility	The compatibility of the isolation structure with other components of the project, as well as the long-term site use, is based on the following:

Criteria	Sub-criteria	Criteria or Sub-criteria Description
		• estimated dredged material volumes; • dewatering requirements particular to the dredged material; • expected physical and chemical characteristics of the specific dredged material volumes; • site conditions and constraints; and • compatibility of the environmental remedy with long-term site use. Compatibility with HPA requirements is a requirement for the southern edge of the site; the eastern edge must be compatible with the U.S. Steel outfall and water intake structures. On the northern and western boundaries of the ECF, the selected alternative should be compatible with the natural environment, to the extent practical.
Environmental Impacts		The primary environmental concern for the project involves impacts to water quality in Hamilton Harbour. Both short-term impacts from construction and long-term impacts of the ECF were evaluated through contaminant fate and transport modeling. Evaluation of the long-term impacts includes modeling to evaluate the flux of naphthalene and other PAH compounds through the ECF isolation structures to determine the appropriate containment structure requirements. The use of slurry walls, reactive treatment walls (including various carbon sources for sorption of residual aqueous phase PAHs) and specialized sheetpile walls were reassessed based on fate and transport modeling results. This includes modeling groundwater flow within the containment structure to determine the flow pattern through the ECF and potentially modeling the transient exchange of the ECF water with the Harbour given seasonal and other cyclical water level variations, prevailing currents and other factors.
Cost		The primary costs associated with the isolation structures will be the short-term capital costs for the procurement of materials, delivery to the site, and equipment and labor costs for the installation and construction. Long-term monitoring of the ECF and periodic restoration will result in maintenance costs over the service life of the facility.
Prior Application		Considerable experience and project examples for the isolation

Criteria	Sub-criteria	Criteria or Sub-criteria Description
		structure options are reflected in the literature. The most applicable of these previous project examples, in terms of site conditions and functions, was considered for the evaluation.

Attachment D.3: Advantages and Disadvantages of Isolation Structure Options – Initial Screening

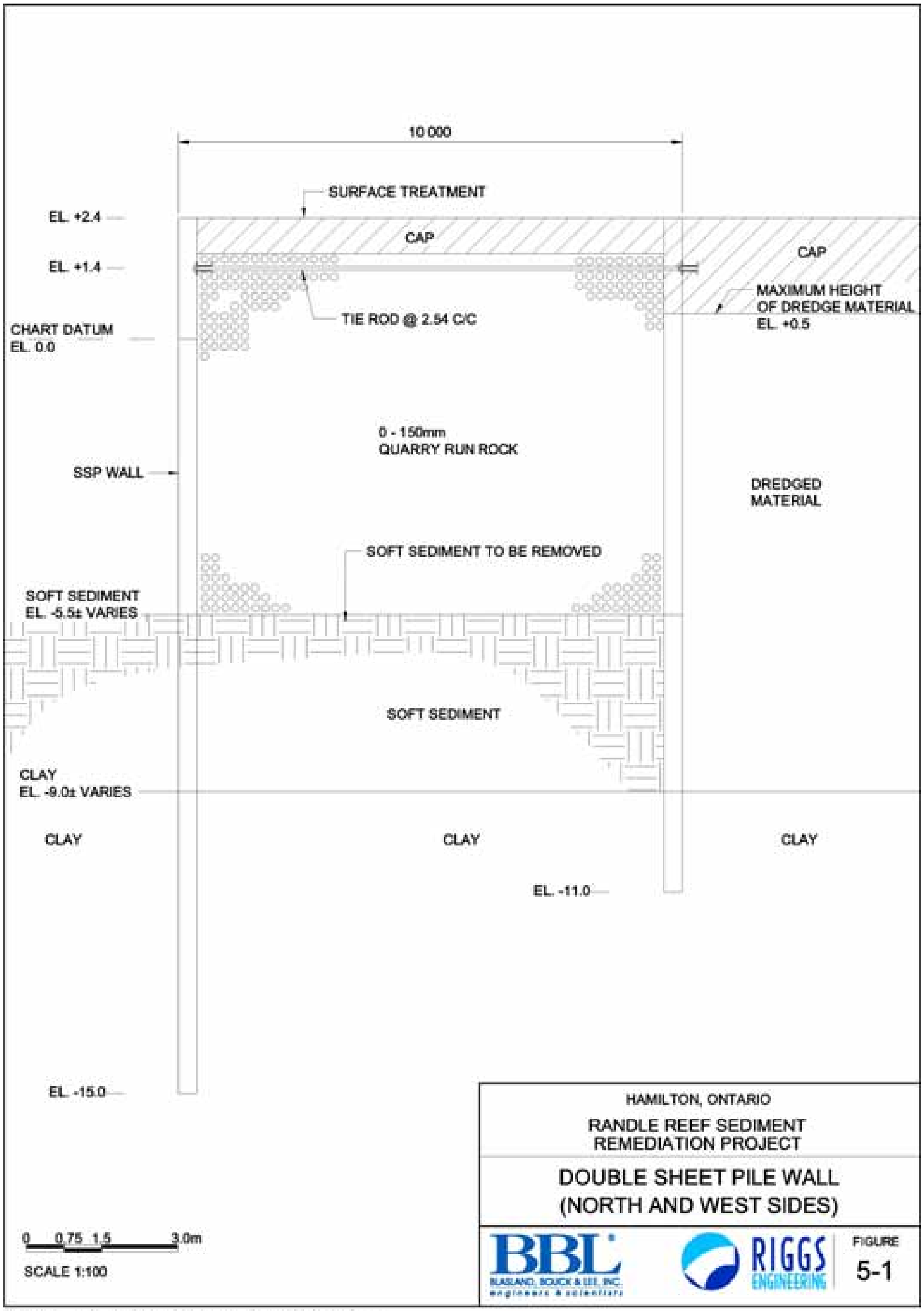
Alternative	Advantages	Disadvantages
Option 1 - Sheetpile Wall with Sealed Interlocks	• the most effective at containing contaminants and sediment pore water; however, unless all sides of the ECF are constructed using sealed sheetpile walls, the pore water generated during sediment consolidation would tend to migrate toward the most permeable isolation structure • the small footprint of the structure provides increased capacity for the ECF without increasing the perimeter of the site (size of footprint depends on construction method) • can be constructed to be compatible with the HPA facility requirements • the most applicable structure for the eastern edge of the ECF along the U.S. Steel property; the sheetpile wall would be constructed to provide an appropriate offset from the outfall structure and the water intake structure	• the least compatible alternative for the seaward edges of the ECF in that they form a vertical bulkhead, which is unnatural in this environment • costly to procure and installation takes longer than standard steel sheetpile to ensure interlocking of the sheets
Option 2 - Standard Sheetpile Wall	• small footprint of the structure provides increased capacity for the ECF without increasing the perimeter of the site • can be constructed to be compatible with the HPA facility requirements • the most applicable structure for the eastern edge of the ECF along the U.S. Steel property; the sheetpile wall would be constructed to provide an appropriate offset from the outfall structure and the water intake structure • less costly than sheets with sealed interlocks, but are likely more expensive than locally available earthen materials	• less effective at containing contaminants and sediment pore water than the sealed sheetpiles, but still provides a low level of permeability through the sheets as fine-grained sediments wedge themselves in the spaces between sheets; alternatively, a filtration fabric could be placed along the interior of the wall to reduce piping through the sheet interlocks; carbon impregnated filtration fabrics are manufactured which could be employed • the least compatible alternative for the seaward edges of the ECF in that they form a vertical bulkhead, which is unnatural in this environment

Alternative	Advantages	Disadvantages
	• installation of sheetpile walls is common practice and should be relatively quick compared to the other alternatives	
Option 3 - Concrete Caisson Wall	• sediment pore water pathway exists below wall • can be constructed to be compatible with the HPA facility requirements	• the larger footprint of the structure reduces the capacity for the ECF; the footprint of the ECF cannot be adjusted along the south and east edge of the ECF because of space limitations associated with the ship channel and the U.S. Steel property • least compatible alternative for the seaward edges of the ECF in that they form a vertical bulkhead, which is unnatural in this environment • likely the most expensive isolation structure and there will likely be a limited number of bidders that have the experience to install this system
Option 4 - Cellular Steel Pile Wall	• very effective at containing contaminants and sediment pore water • can be constructed to be compatible with the HPA facility requirements	• the larger footprint of the structure reduces the capacity for the ECF; the footprint of the ECF cannot be adjusted along the south and east edge of the ECF to compensate for the lost capacity because of space limitations associated with the ship channel and the U.S. Steel property • the least compatible alternative for the seaward edges of the ECF in that they form a vertical bulkhead, which is unnatural in this environment • may be moderately expensive compared to standard sheetpile and concrete caisson walls • not widely used and there will likely be a limited number of bidders that have the experience to install this system
Option 5 -	• can be as effective in containing contaminants and sediment	• not compatible with the HPA facility requirements due to

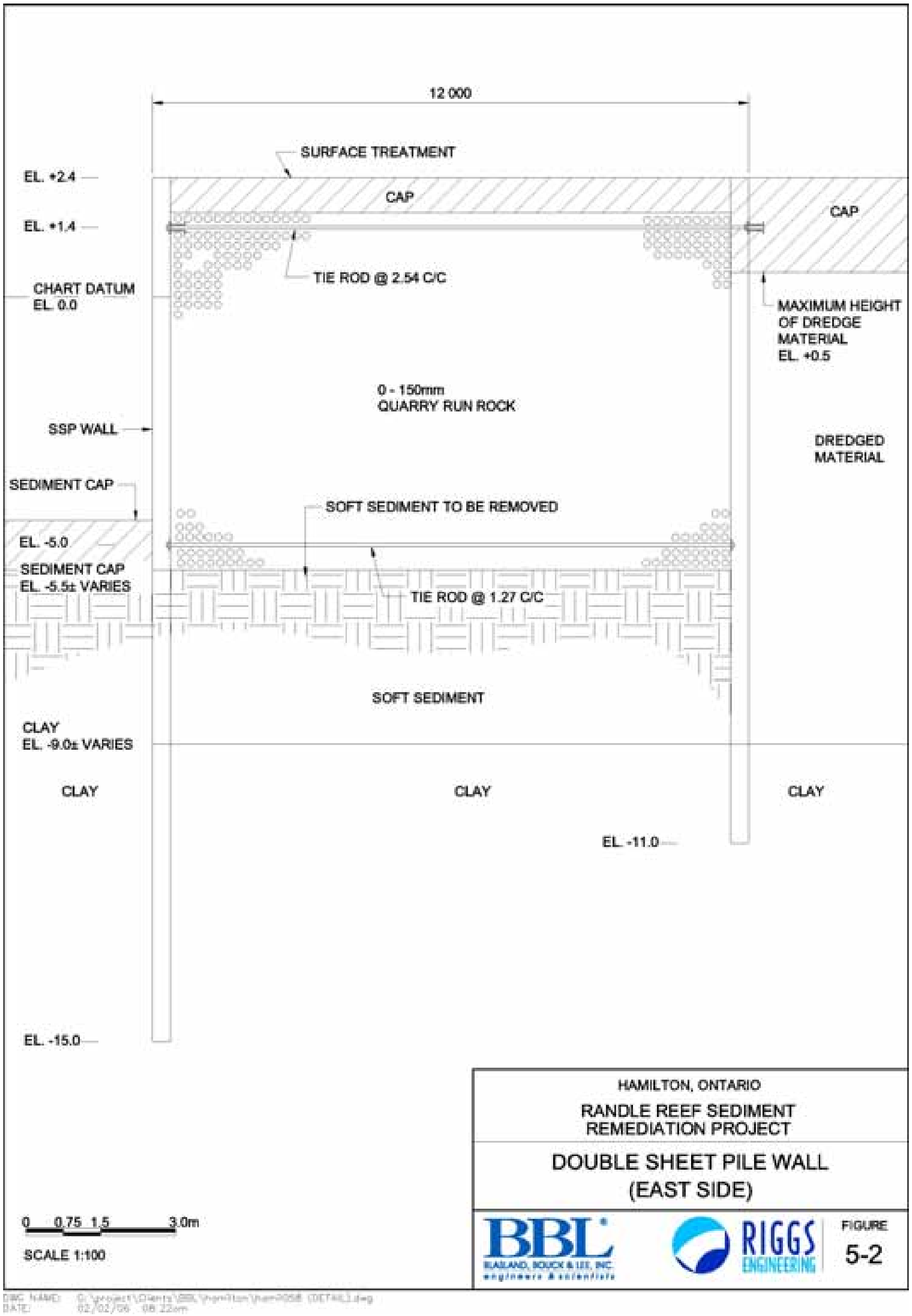
Alternative	Advantages	Disadvantages
Earthen Containment Berm	pore water as sealed sheetpiles depending on the permeability of the core materials; however, more permeable core materials (coarser grained) can still be effective depending on the pore water concentrations in the dredged sediments • the larger footprint of the earthen structure reduces the capacity of the ECF unless the footprint of the site is modified; based on the assumption that the northern and western boundaries of the site are flexible, the earthen berm alternative would still allow for adequate site capacity • the most compatible alternative for the seaward edges of the ECF in that it provides a relatively natural slope as opposed to a vertical bulkhead; the outboard slope of the berm would require armouring against wave forces • earthen materials for construction of the berm are likely less expensive than steel sheetpiles and are readily available from local sources; in addition, there is a potential that local slag could be used to construct the containment berm, further reducing cost	the vertical bulkhead requirement for construction of the wharf facility • not compatible with the U.S. Steel property outfall and water intake structures as the slopes necessary for the berm would impact the access channel and potentially the structures themselves
Option 6 - Treatment Trenches/Walls	• highly effective in containing/ treating contaminants and sediment pore water as treatment trenches/walls are commonly used for groundwater remediation projects • the footprint of the treatment wall would have minimal impact on the capacity of the ECF; if used within the containment berm or adjacent to a sheetpile wall, the footprint would be minimal • will have little effect on a sheetpile wall constructed adjacent to the U.S. Steel property outfall and water intake structures	• the treatment trench/wall could have an impact on the design of a sheetpile wall to meet the HPA facility requirements since it impacts both the earth pressure distribution adjacent to the wall and the ability for direct loading above the treatment trench/wall • treatment trenches/walls must be used in conjunction with another isolation structure alternative; they may be used independently within the interior of the ECF, but the outer boundaries require additional structural support

Alternative	Advantages	Disadvantages
	• moderate level of cost associated with procurement of treatment materials and installation of the trench/wall	
Option 7 - Hybrid Containment Structures	This alternative, if developed, would be a combination of the other alternatives presented. Advantages and disadvantages of hybrid containment structure alternatives would be evaluated and presented at that time.	

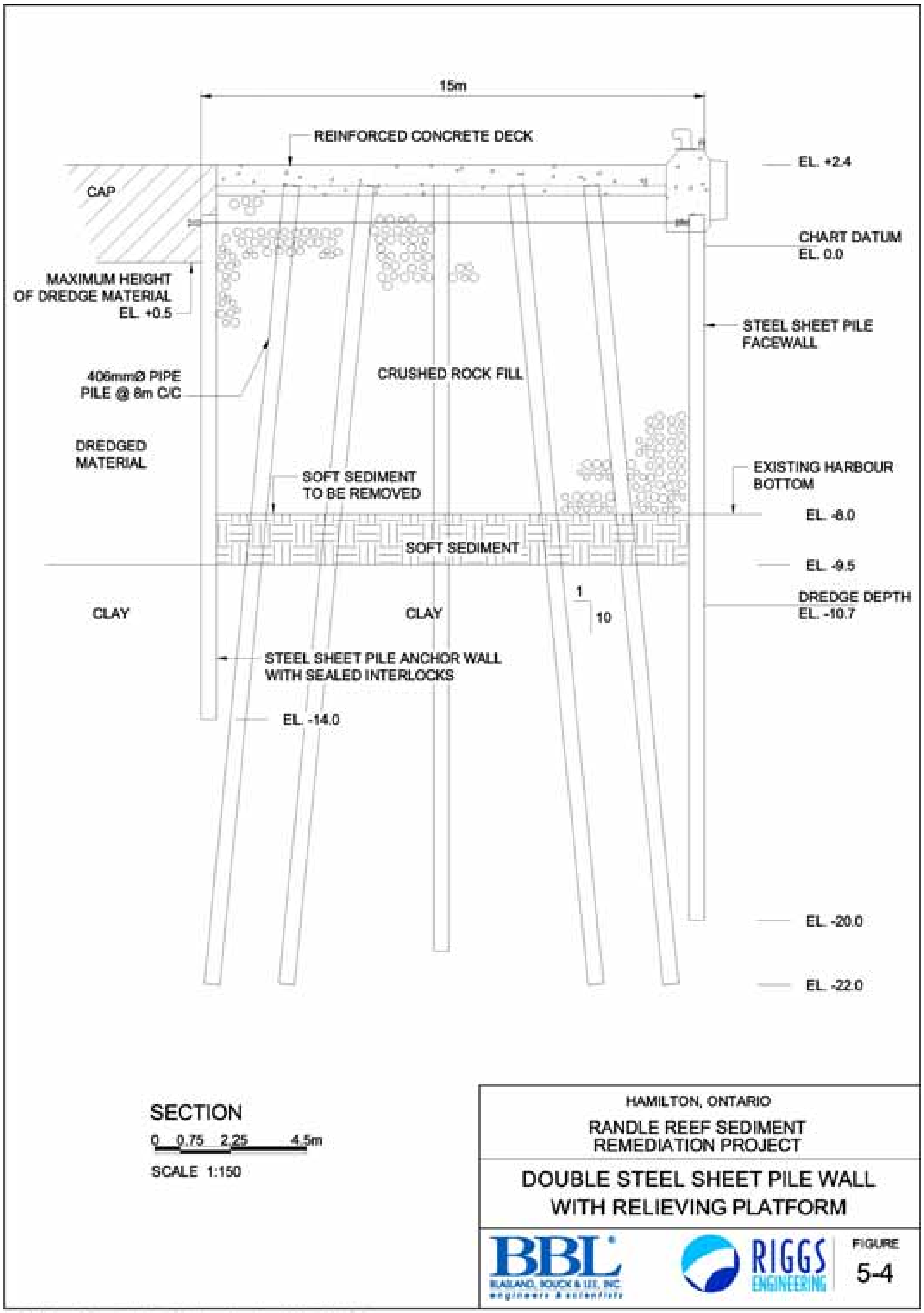
Double Steel Sheetpile and Sealed Steel Sheetpile Wall



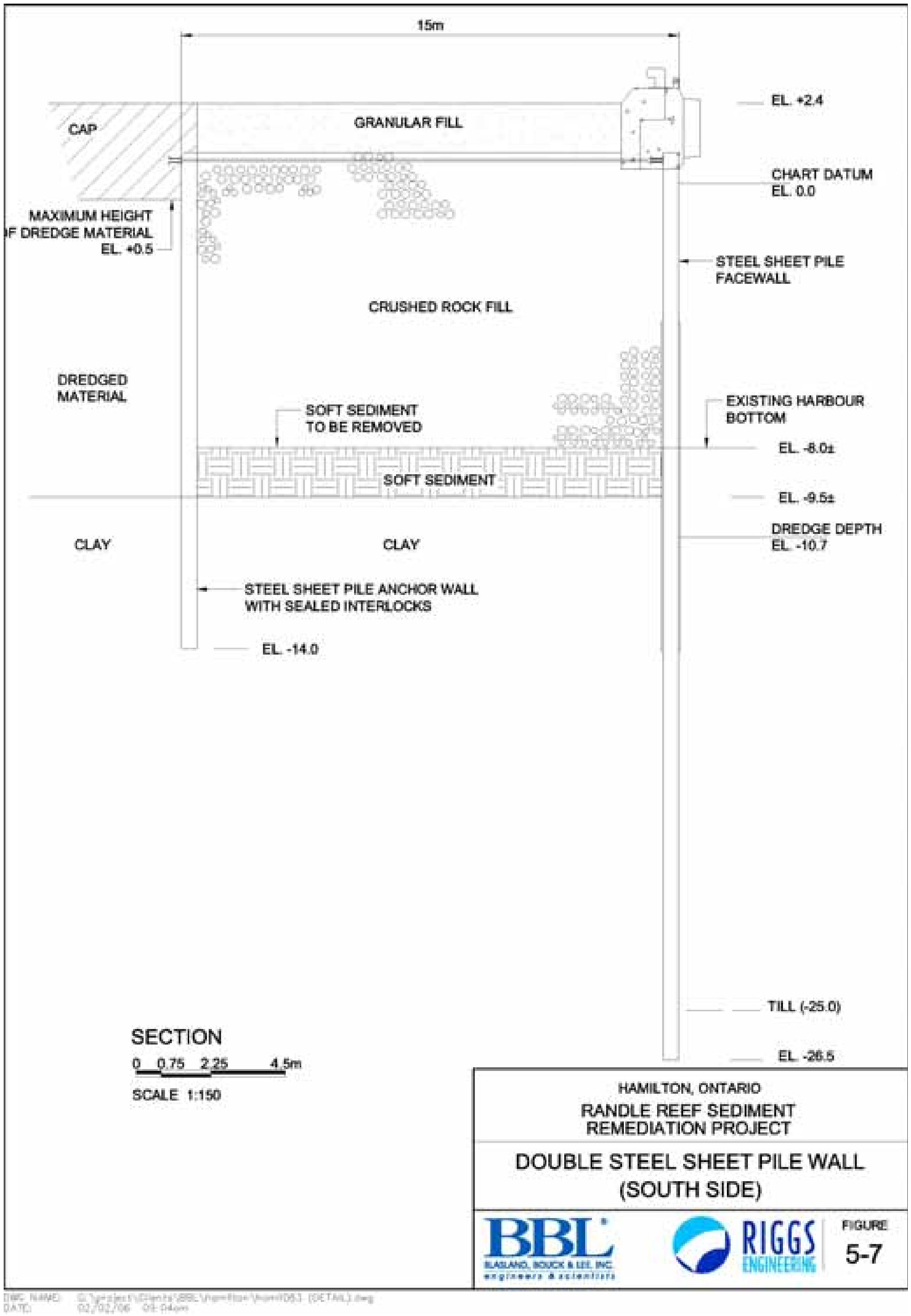
Double Steel Sheetpile and Sealed Steel Sheetpile Wall



Double Steel Sheetpile and Sealed Steel Sheetpile Wall



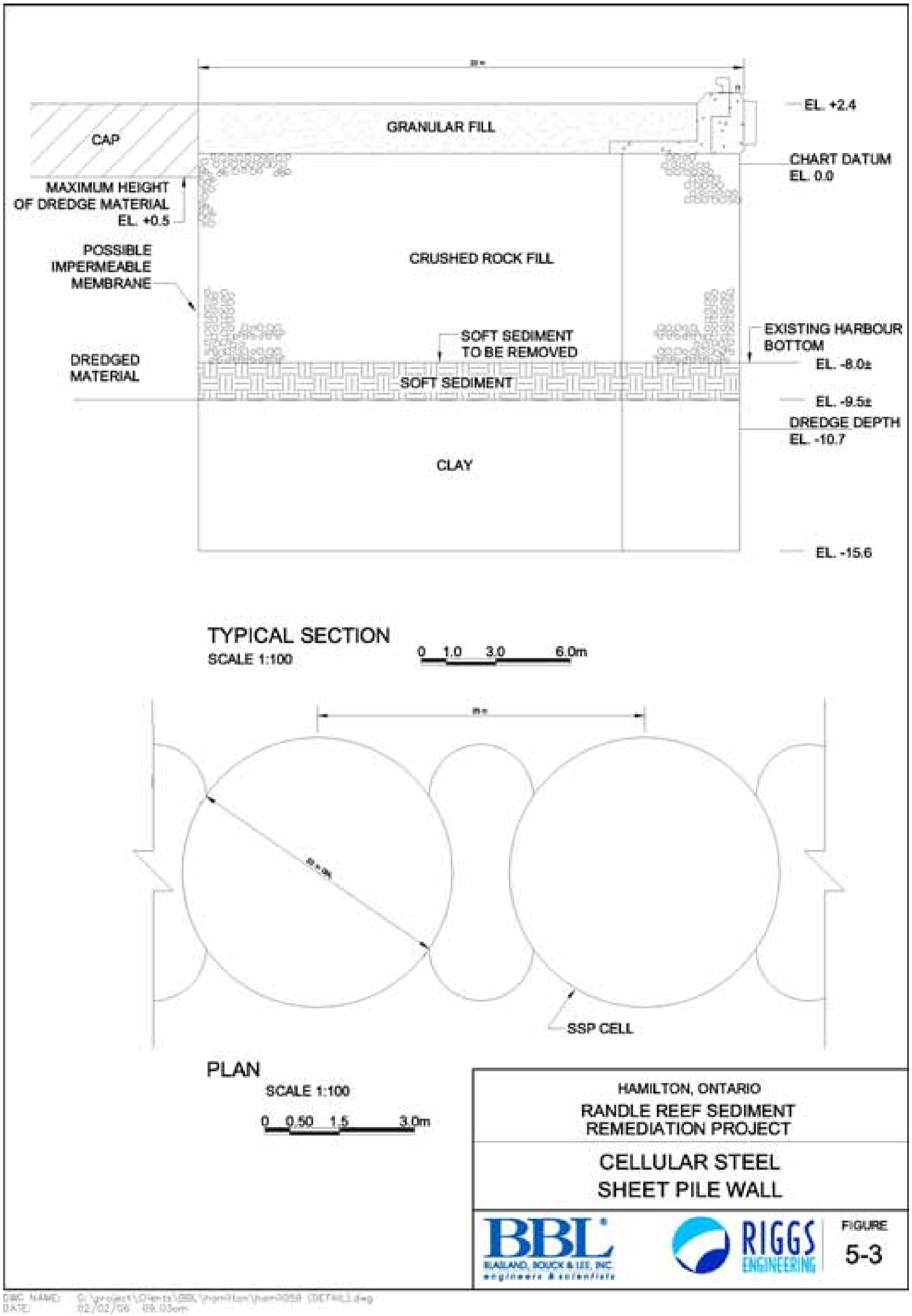
Double Steel Sheetpile and Sealed Steel Sheetpile Wall



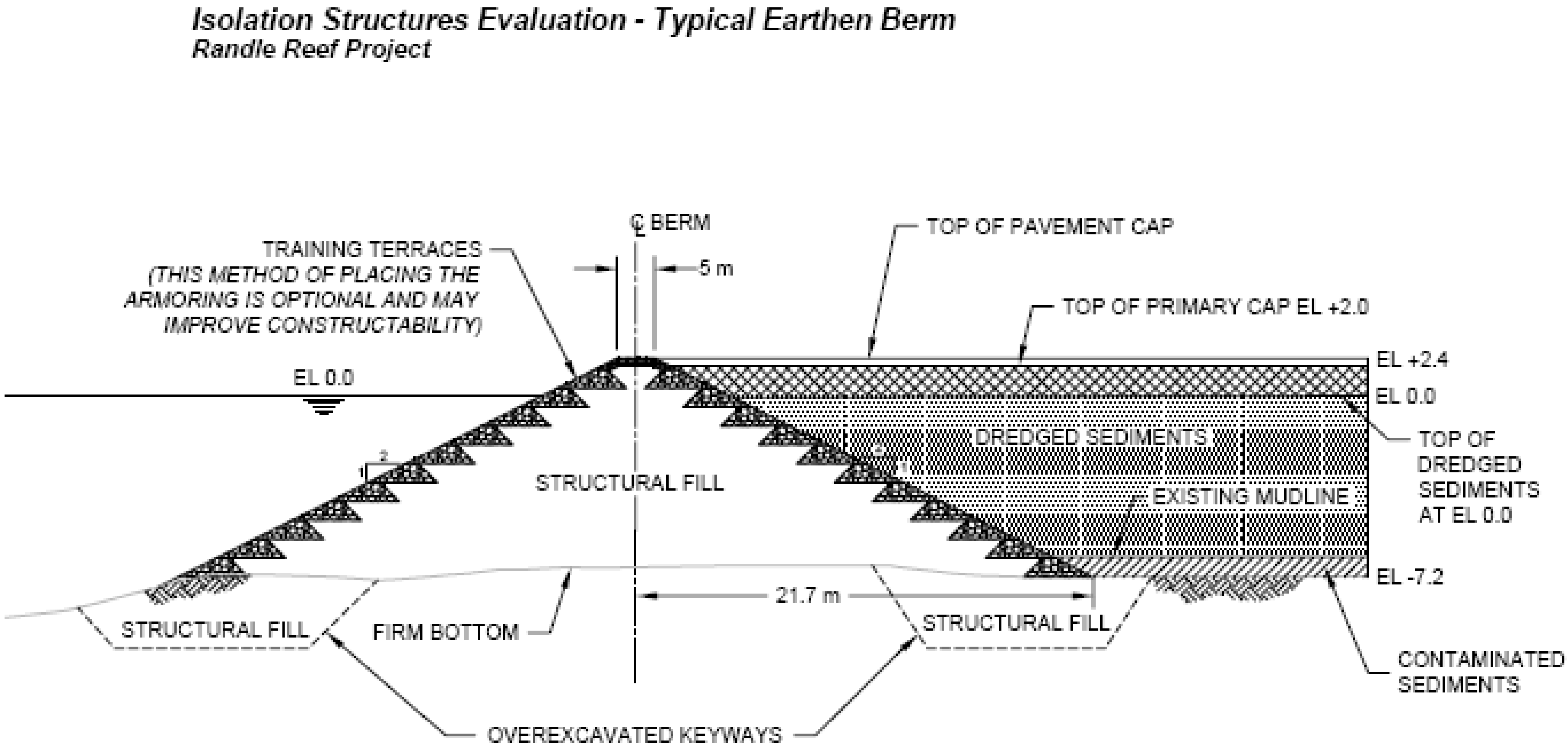
Standard Steel Sheetpile Wall

Please see Options 1, 2 and 3 – Port Facility Design Options

Cellular Steel Sheetpile Wall

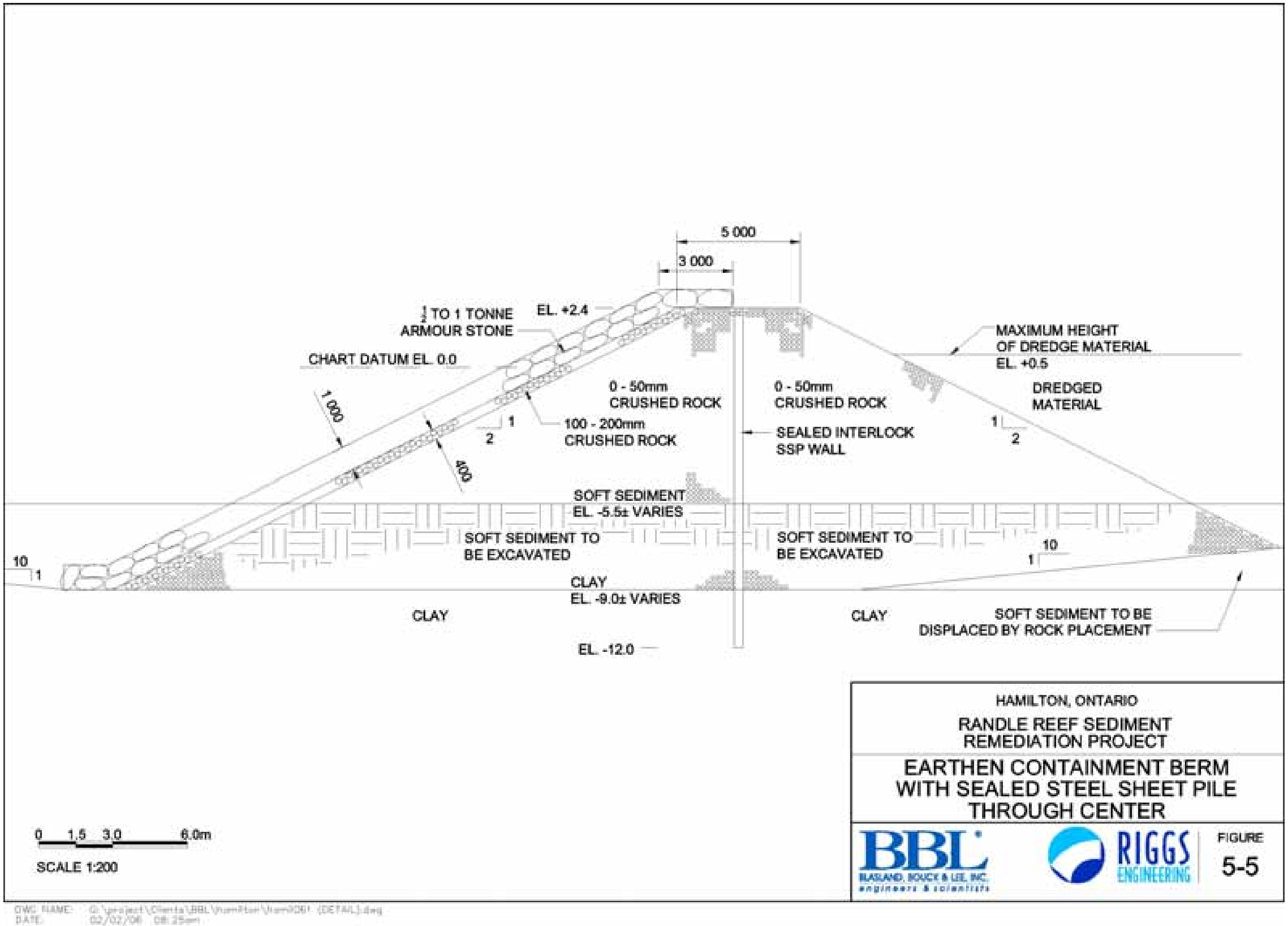


Earthen (sand and gravel) Containment Berm

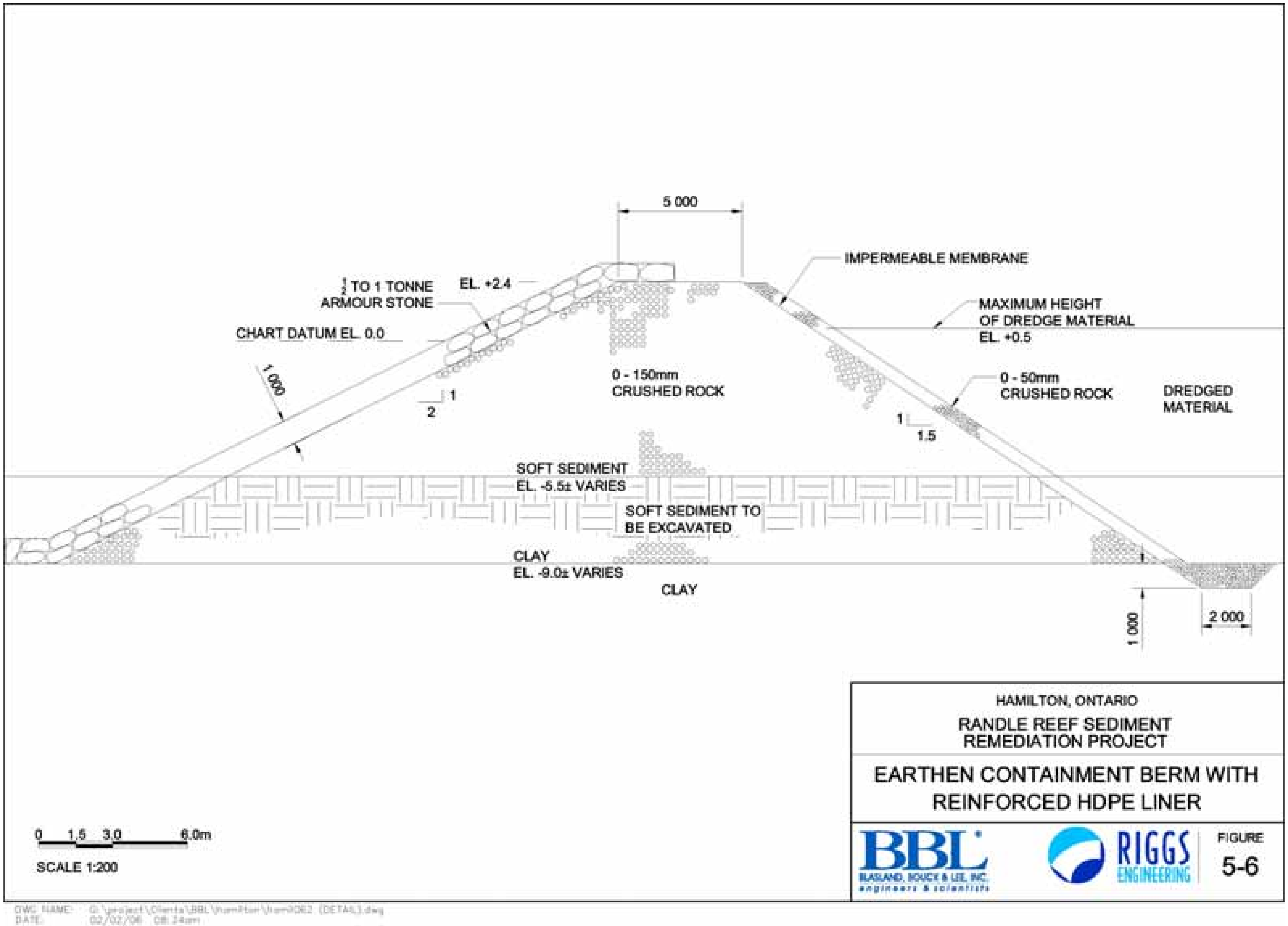


Not to scale

Earthen (sand and gravel) Containment Berm with Sealed Steel Sheetpile through Centre



Earthen (sand and gravel) Containment Berm with Reinforced HDPE Liner on Side Face



Attachment D.4: Isolation Structure Options: Description of 30 Percent Design Evaluation Criteria or Sub-criteria

Criteria	Sub-criteria	Criteria or Sub-criteria Description
Effectiveness	Overall Protectiveness	This refers to the required effectiveness of the isolation structure to prevent the risk of exposure to public or the environment both in the short term and the long-term. This addresses long-term operations and maintenance associated with the isolation structure and the 200 year design life.
	Compliance with Design Standards and Other Requirements	The ECF isolation structures would have to meet the requirement of providing an impermeable barrier, based on fate and transport requirements, to prevent the movement of contaminants to the surrounding surface and groundwater. The isolation structures would also have to be compatible with the other facility components. For the east side of the facility, this necessitates compatibility with the design standards and requirements to accommodate the U.S. Steel Intake/Outfall and other U.S. Steel requirements for maintaining hydraulic flow, water quality, etc. The isolation structures also needed to be compatible with port facility requirements. This was a particular requirement for the south side of the ECF.
	Long-term Effectiveness and Performance	This criteria considers whether the option minimizes the risk presented by residuals (contamination left following the construction project) and the contaminants contained within the ECF.
	Short-term Effectiveness	The ability of the design option to: protect worker health and safety and the adjacent community; protect the environment during construction; meet the appropriate schedule duration/timing of the construction project; and harmonize the schedule with the other design elements.
	Reduction of Mass/Volume, Toxicity and Mobility of Contaminants	The ability of the design element to optimize the PAH and metals mass captured and to reduce the impacts of volume, toxicity and mobility of contaminants during and post-construction. For example, because of the spatial requirements associated with berms, less available storage

Criteria	Sub-criteria	Criteria or Sub-criteria Description
		capacity for contaminated dredged material may be realized versus sheetpile wall structures, which require less surface area when used as part of the containment.
Implementability	Technical Feasibility	This criteria included a consideration of: the ease of constructing and operating the option in a cost-effective manner; the reliability of the option; the technical complexity of the option; compatibility with other design options; and the ease of future actions for remediation and repairs.
	Administrative Feasibility	The design option must be compatible with the legislative, policy and program requirements of the local, provincial and federal government agencies. This criteria also refers to the ease of obtaining permits and other approvals, and acceptance by stakeholders.
	Availability	This criteria refers to the availability of equipment, materials, services, etc. to implement, verify and monitor the effectiveness of the design alternative.
	Local/Provincial/Federal Government Standards and Stakeholder Input	This criteria includes a consideration of the relative probability of a design alternative to generate issues or concerns from participating government agencies due to one or more design elements.
Cost		The design option was evaluated relative to capital and periodic costs and financial risk.

Attachment D.5: Advantages and Disadvantages of Detailed 30 Percent Isolation Structure Options

Alternative	Advantages	Disadvantages
Double Steel Sheetpile Wall (SSP) with Sealed Interlocks	• less impact likely related to short-term water quality issues since sheetpile wall would be driven prior to dredging in-between the walls • complies with design standards • long term protectiveness is expected to be greater for options with a sealed SSP wall • ability of the SSP wall to provide long-term isolation depends on quality and long-term reliability of an interlock seal • SSP can withstand effects of corrosion with appropriate maintenance, as well as occasional hard berthing that may impart loads on the port facility walls • the most applicable structure for the eastern edge of the ECF along the U.S. Steel property; the sheetpile wall would be constructed to provide an appropriate offset from the outfall structure and the water intake structure • installation of sheetpile walls is common practice and should be relatively quick compared to the other alternatives • least costly at $11.8 M Note: An evaluation (including a consideration of availability) of the various vendor products for sealed sheetpile walls with interlocks was undertaken. The Waterloo Barrier™, Hoesch™,	• construction of this option is complex • hard shoreline option for north and west sides of the facility rather than a naturalized, aesthetically pleasing shoreline

Alternative	Advantages	Disadvantages
	Sevenson's Seal Wall system™ products were evaluated. The Waterloo Barrier was preferred because of the controlled installation of the sealant and associated high reliability of the seal. Sevenson may still be considered if a cost effective sealant system is identified.	
Earthen Containment Berm with Sealed SSP wall through Centre	• complies with design standards • generally less complex than SSP with interlocks • materials available locally	• more likely to result in short term water quality impacts associated with initial dredging below the footprint • most expensive of the three design options at approximately $16.9 Million • larger footprint and, therefore, reduced containment capacity
Earthen Containment Berm with Reinforced HDPE liner	• complies with design standards • generally less complex than SSP with interlocks • materials available locally	• more likely to result in short term water quality impacts associated with initial dredging below the footprint • dissolved contaminant migration below the reinforced liner at the point of contact between liner and clay is considered a greater risk • technically complex relative to constructability • risk that the reinforced liner would be less effective at cutting off flow of dissolved constituents because of the clay compared to the embedment into the clay of the SSP wall • larger footprint and, therefore, reduced containment capacity • mid-range costs at approximately $14.8 Million • stakeholders may perceive this design option as having the highest risk

DREDGING DESIGN OPTIONS

D.2 Dredging Design Options

D.2.1 Initial Screening

D.2.1.1 Introduction

The *Randle Reef Sediment Remediation Project* involves environmental dredging to remove contaminated sediments (see Section 1.8) to be immediately placed and contained in the ECF. The following three major components related to dredging were evaluated: environmental dredging equipment; suspended sediment control; and transportation of dredged material. Within each of these three components, a range of options that may be applicable for use for the Randle Reef project were identified and evaluated.

This section provides information on the evaluation of the environmental dredging components. The key assumptions relating to the evaluation of the environmental dredging components are provided in Attachment D.6.

D.2.1.2 Identification of Options and Alternatives

Introduction

As noted above, the following three major components of environmental dredging were evaluated:

- environmental dredging equipment;
- suspended sediment control; and
- transportation of dredged material.

Within each of these three components, there exist numerous technologies or options that may be applicable for use for the Randle Reef project. The universe of available options within each component of the environmental dredging process was identified and evaluated to identify potentially viable options for use on the Randle Reef project. Component options with obvious deficiencies or limitations (e.g., not available in Canada or size limitations) were eliminated from further consideration in this initial screening.

Subsequent to their evaluation, individual options from each dredging component were combined to form environmental dredging alternatives. These alternatives were then evaluated and, based on the results of this evaluation, a decision was made regarding which alternatives would be carried forward for more detailed examination in the subsequent engineering work (see Section D.2.2 and D.2.3).

Figure D.2 illustrates the relationship between the dredging components, options and alternatives considered.

Options

Environmental dredging equipment can generally be classified as mechanical, hydraulic, or pneumatic, depending on the basic method of removing the dredged material from the site. Additionally, numerous specialty dredge technologies have been developed, which combine particular features of the basic dredge methods. Within each of these general categories, numerous technologies are available, some of which are proven and have been used extensively throughout the world, while other technologies have recently been developed or improved, but are not yet proven on a full scale project. Table D.5 describes mechanical, hydraulic and pneumatic or specialty dredges.

The options that were considered for each of these three dredging equipment types are provided in Figure D.2. A description of each of these options is provided in Attachment D.7. In addition, photographs for some of these options are provided following Attachment D.7.

Release of **suspended sediments** during dredging, which results in turbidity, is a side effect of nearly all dredging technologies. However, the degree of turbidity generated during dredging varies considerably among the various dredge types, sediment properties and site conditions. Turbidity associated with contaminated sediment dredging can significantly impact the successful implementation of the remedial action, if not controlled. The following turbidity control technologies were identified for potential use for the *Randle Reef Sediment Remediation Project*:

- textile barriers (i.e. "silt screens" and "silt curtains");
- sheetpiles;
- moon pools;
- air (bubble) curtains; and
- modifications to dredging rates and equipment.

A description of each of these options is provided in Attachment D.7.

Figure D.2: Dredging Components, Options and Alternatives

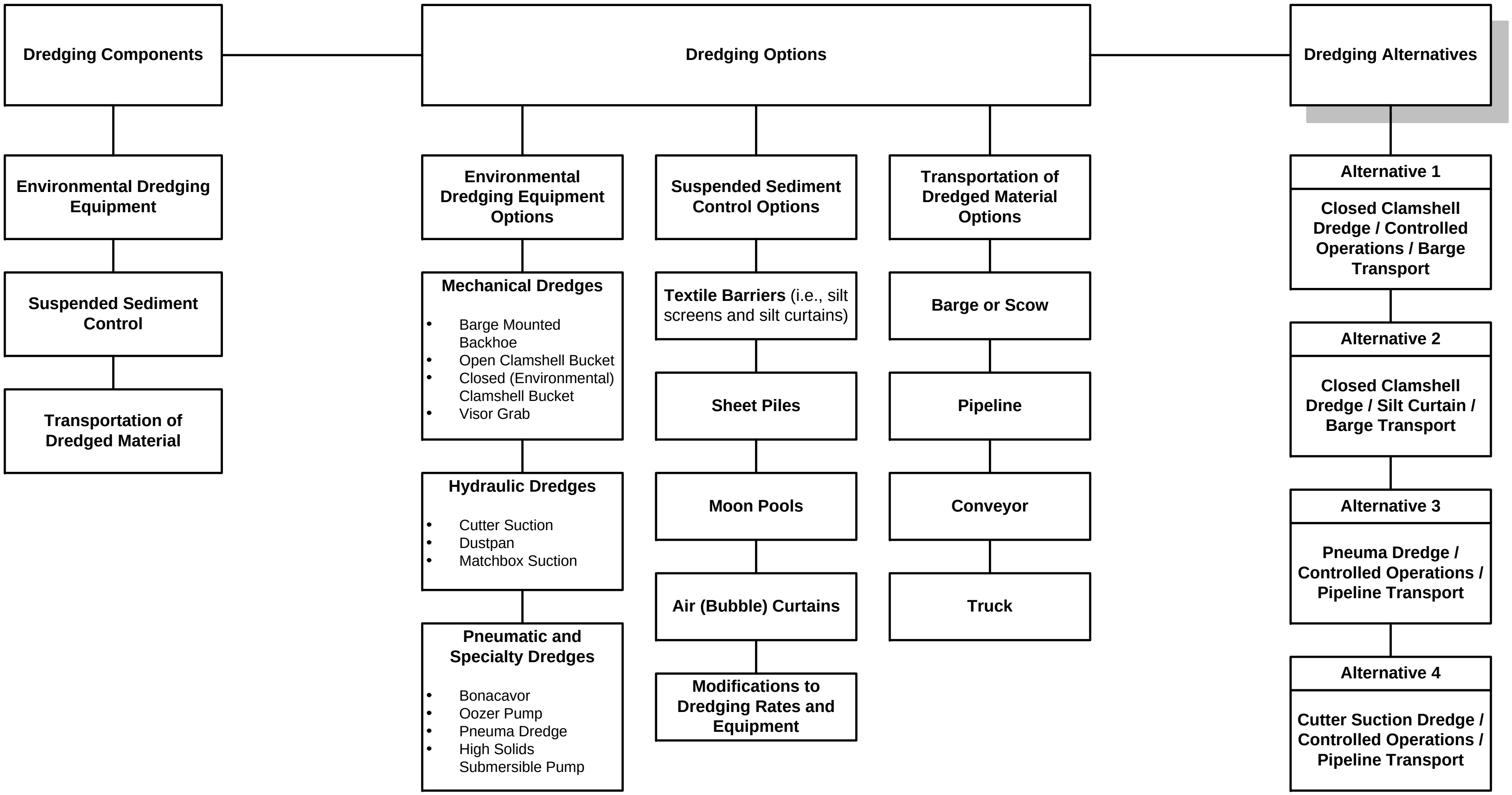


Table D.5: Description of Mechanical, Hydraulic and Pneumatic or Specialty Dredges

Dredge Type	Description
Mechanical	Mechanical dredges remove bottom sediment through the direct application of a bucket, scraper, or scoop to dislodge and remove, or dredge, the material near in-situ density (i.e., with limited added water). Dredged material is then typically placed in a hopper or scow for transport to a containment or transloading facility. Mechanical dredges typically re-suspend more sediment into the water column as a result of dredging than do hydraulic dredges. Re-suspension rates (i.e., percent of total mass re-suspended) for mechanical dredges are estimated to range from 1 to 7%, depending on numerous variables including the sediment characteristics, type and size of the bucket, cycle time, depth of cut, presence of debris and operator control.
Hydraulic	Hydraulic dredges remove and transport sediments in the form of a slurry. Key components of a hydraulic dredge include the dredgehead, the hydraulic pump and the pipeline that carries the sediment slurry. Hydraulic dredges typically create lower levels of suspended sediments (estimated at 0.5 to 2%) than do mechanical dredges for two principal reasons: (1) sediments dredged by mechanical means are exposed to the water column for a longer period, creating more opportunity for sediment losses and re-suspension; and (2) hydraulic dredges rely on suction, which means that sediments released at the point of dredging are more likely to be suctioned back into the dredging system; sediments released during mechanical dredging are not recovered. However, hydraulic dredges add 4 to 20 times to the total volume of material moved as a result of the water slurrying process. Hydraulic dredges employ a dredge pump to create suction in a hose or pipe, which is extended from the floating vessel to the mudline. The suction pipe is typically supported by a "ladder", which is used to raise/lower and position the dredge head (except in the case of the plain suction dredge where a flexible hose can be controlled by a diver). Most hydraulic dredges utilize some type of agitation device at the dredgehead (i.e., water jets, cutterhead, augers, etc.) to loosen the sediment prior to removal. An important consideration in the design of hydraulic dredges is the configuration of the dredge pump relative to the water surface and dredge head. Previous designs focused on positioning of the dredge pump at the lowest point within the hull of the vessel to minimize the head differential between the pump and the dredge head. However, recent developments include the positioning of a submersible pump on the ladder near the dredge head. The use of the submersible pump reduces the chance of pump cavitation and allows for greater dredging depths with smaller pumps.
Pneumatic or Specialty Dredges	A pneumatic dredge typically consists of a cylinder or a series of cylinders and a piston-type pump to produce a vacuum by changing the air pressure inside the cylinder(s), thereby causing high density sediment slurry to be sucked through the suction inlet by water pressure and atmospheric pressure. Specialty dredges include various types of innovative technologies, which are often improvements of more commonly used technologies, including combinations of features from more than one dredge.

After being removed from its location, dredged sediments may be **transported** either directly to the containment site or to an interim treatment/processing facility. In mechanical dredging, sediments are typically placed into scows or barges at the point of dredging and then transported directly to the containment site. However, when barge transport directly to the containment facility is not feasible, dredged sediments may be transported by barge to a shore-based transloading facility and transferred to another means of land-based transport. Hydraulic dredging typically utilizes direct pipeline transport from the dredge area to the containment site. The following methods for transporting contaminated sediments were identified for potential use for the *Randle Reef Sediment Remediation Project*:

- barge or scow;
- pipeline;
- conveyor; and
- truck.

A description of each of these options is provided in Attachment D.7.

Alternatives

As noted above, based on the evaluation of the options, individual options were combined to form environmental dredging alternatives. The four alternatives that were developed were:

- Alternative 1 – Closed Clamshell Dredge/Controlled Operations/Barge Transport;

- Alternative 2 – Closed Clamshell Dredge/Silt Curtain/Barge Transport;

- Alternative 3 – Pneuma Dredge/Controlled Operations/Pipeline Transport; and

- Alternative 4 – Cutter Suction Dredge/Controlled Operations/Pipeline Transport.

Table D.6 provides a description of these alternatives.

Controlled operations could include reduced bucket ascent and descent velocity, ensuring complete closure of bucket prior to ascent, and/or rinsing of the bucket before each descent.

Table D.6: Description of Dredging Alternatives

Dredging Alternative	Description of Dredging Alternative
Alternative 1 – Closed Clamshell Dredge [Mechanical]/Controlled Operations/Barge Transport	This alternative would consist of a closed (environmental) clamshell bucket dredge to remove sediment at near in-situ density. The dredged sediment would be placed into barges or scows and transported to the ECF for placement. Assuming that earthen berms were used to construct the containment structures forming the ECF, a barge access channel could be maintained to allow offloading within the ECF by bottom dumping or side casting, so that re-handling over the containment structure is not necessary as long as minimum water quality criteria is maintained. At some point during placement of the dredged material, either the dredged fill elevation in the ECF or water quality impacts may necessitate closure of the barge access. In this case, continued placement in the ECF would require "double-handling" of dredged sediment over the completed containment structures. In addition to requirements at the ECF, minimum water quality criteria would need to be maintained at the dredge location. This would be achieved through controlled equipment operations, such as reduced bucket ascent and descent velocity, ensuring complete closure of bucket prior to ascent, and/or rinsing of the bucket before each descent.
Alternative 2 – Closed Clamshell Dredge [Mechanical]/Silt Curtain/Barge Transport	Similar to Alternative 1, this alternative would consist of a closed (environmental) clamshell bucket dredge to remove sediment with transport to the ECF in barges or scows. A similar scenario with a barge access channel would apply to this alternative. However, additional physical suspended sediment controls (i.e., silt curtains) would be employed across the barge access channel to limit the release of turbid effluent water from the ECF. In contrast to Alternative 1, a silt curtain would be deployed around the dredge area during removal to physically contain the suspended sediment and to ensure compliance with water quality criteria. Alternative suspended sediment control configurations could include multiple tiers of silt curtains or a "moon pool" approach, where only the actual bucket is surrounded by a silt curtain, creating a small excavation cell (10 m by 10 m) that would be moved with the equipment.

Dredging Alternative	Description of Dredging Alternative
Alternative 3 – Pneuma Dredge/Controlled Operations/Pipeline Transport	This alternative would consist of a pneuma dredge to remove contaminated sediments from the Randle Reef site. The dredged sediments would be transported via hydraulic pipeline to the ECF, where a system of overflow weirs would be used to decant the effluent from the enclosed containment facility. In the event that effluent treatment is necessary prior to discharge from the ECF, a treatment system could be installed at the over flow weir(s). Considering the relatively low re-suspension potential of this type of environmental dredging equipment, water quality at the dredge location would be maintained through controlled equipment operation. However, due to the nature of the industrial operations on the adjacent upland properties, it is expected that the Randle Reef site contains a significant amount of debris on or below the mud line, potentially having a significant adverse effects on the Pneuma dredge (increased re-suspension and potential breakdown due to clogging).
Alternative 4 – Cutter Suction Dredge [Hydraulic]/Controlled Operations/Pipeline Transport	This alternative would consist of a hydraulic cutter-suction dredge to remove contaminated sediments from the Randle Reef site. The dredged sediments would be transported via hydraulic pipeline to the ECF where a system of overflow weirs would be used to decant effluent from the enclosed containment facility. In the event that effluent treatment is necessary prior to discharge from the ECF, a treatment system could be installed at the over flow weir(s). Similar to Alternative 3, there would be a volume of water associated with this type of environmental dredging equipment. Therefore, if effluent treatment were necessary this alternative would require additional evaluation. Considering the relatively low re-suspension potential of this type of environmental dredging equipment, water quality at the dredge location would be maintained through controlled equipment operation. Although not as sensitive to the presence of debris as the pneuma dredge, large amounts of debris may have adverse effects on the cutter suction dredge, causing increased re-suspension.

D.2.1.3 Evaluation Criteria

The following general criteria were used to evaluate the environmental dredging options and alternatives:

- service criteria (i.e., effectiveness);
- technical criteria (i.e., implementability);
- regulatory criteria;
- environmental impacts;
- cost; and
- prior application.

Attachment D.8 provides a description of the specific criteria or sub-criteria used for the evaluation of environmental dredging options and alternatives.

D.2..1.4 Evaluation of Dredging Options and Alternatives

Options

Attachment D.9 outlines the advantages and disadvantages of the dredging options. Suspended sediment control options and transportation options are fundamentally related to the type of dredging equipment being used. For example, hydraulic dredging typically involves pipeline transport of the material, whereas mechanical dredging typically necessitates transportation of the dredgeate using a barge or a scow. Sediment control options are selected in relation to the type of dredging and the amount of suspended sediment potentially generated with each type of equipment, and the ability of the selected control to minimize the impact for generating suspended sediments with the selected equipment.

Given the close linkage to the selected dredging equipment, suspended sediment control options and transportation options were evaluated in combination with the dredge equipment options.

The evaluation of advantages and disadvantages was used to develop dredging alternatives that could achieve the project objectives. Since a combination of the options were required for the Randle Reef project, individual options from each dredging component were combined to form environmental dredging alternatives (see below).

Alternatives

Table D.7 presents the evaluation of the dredging alternatives. This evaluation is based on the evaluation criteria noted in Section D.2.1.3. Each criterion was weighted from one

Table D.7: Evaluation of Dredging Alternatives

Environmental Dredging Alternative	Service Criteria (Effectiveness)		Technical Criteria (Implementability)		Regulatory Criteria/Environmental Impacts		Cost Criteria		Prior Application		Total
Weighting Factor (1 – 3)	3		2		1		2		3		
Alternative 1 – Closed Clamshell Dredged/Controlled Operations/Barge Transport	**4**	Equipment is highly compatible with site and suitable for placement in ECF. Short barge distance to ECF will limit number of barges required. High solids content achieved by clamshell is compatible with limited ECF capacity. Controlled operations may be effective at controlling turbidity. Clamshell dredge is suitable for handling debris, if present.	**5**	Relatively low complexity. Alternative is compatible with ECF containment and potential sediment or effluent treatment techniques. Production rate will be slower than Alternative 2, due to controlled operations.	**3**	Equipment is locally available in Ontario and has been used for similar project. Re-suspension with closed clamshell will meet regulatory water quality criteria. Potential barge leakage could impact environment.	**4**	Controlled operation and slower production rate will increase cost.	**3**	In 1992, Cable Arm Inc. demonstrated in Toronto Harbour a specially designed environmental bucket to meet demonstration requirements of the Remedial Technologies Program (RTP) of Environment Canada's Great Lakes 2000 Cleanup Fund. Other manufacturers used extensively in U.S.	**42**
Alternative 2 – Closed Clamshell Dredged/Silt Curtain/Barge Transport	**5**	Equipment is highly compatible with site and suitable for placement in ECF. Short barge distance to ECF will limit number of barges required. High solids content achieved by clamshell is compatible with limited ECF capacity. Water current velocities are	**4**	Moderate complexity. Installation of silt curtains adds complexity and will likely reduce production rate. Alternative is compatible with ECF containment and potential sediment or effluent treatment techniques.	**4**	Equipment is locally available in Ontario and has been used for similar project. Re-suspension with closed clamshell will likely meet regulatory water quality criteria. Use of silt curtain will greatly improve water quality. Potential barge leakage could impact	**4**	Installation and maintenance of silt curtain will increase costs, but production rate will increase, driving costs down.	**3**	In 1992, Cable Arm Inc. demonstrated in Toronto Harbour a specially designed environmental bucket to meet demonstration requirements of the RTP of Environment Canada's Great Lakes 2000 Cleanup Fund. Other manufacturers used extensively in U.S.	**44**

Environmental Dredging Alternative	Service Criteria (Effectiveness)		Technical Criteria (Implementability)		Regulatory Criteria/Environmental Impacts		Cost Criteria		Prior Application		Total
Weighting Factor (1 – 3)	**3**		**2**		**1**		**2**		**3**		
		sufficiently low for use of silt curtains, which are effective at controlling turbidity. Clamshell dredge is suitable for handling debris, if present.				environment.					
Alternative 3 – Pneuma Dredge/Controlled Operations/Pipeline Transport	**3**	Pneuma Dredge will be compatible with site conditions given wide range of operating depths. Lower solids content than Alternatives 1 and 2. Dredge will be impacted by presence of debris. Pipeline transport will be effective over relatively short distance to ECF from dredging site.	**4**	Moderate to high complexity compared to mechanical dredging. Assuming that effluent water treatment is not required, alternative is compatible with ECF. Production rate may be decreased by presence of debris.	**2**	Potential pipeline leakage could adversely impact environment. Presence of debris can cause clogging and lead to water quality impacts. Use of hydraulic dredge may require additional permitting above and beyond that for mechanical dredging. Air emissions may be less than mechanical dredging.	**2**	Downtime due to clogging from debris will increase costs significantly. Production rate is less than for other alternatives.	**3**	Used on Collingwood Harbour project.	**29**
Alternative 4 – Cutter Suction Dredge/Controlled Operations/Pipeline Transport	**4**	Cutter suction will be compatible with site conditions given wide range of operating depths. Lower solids content than Alternatives 1 and 2. Pipeline transport will be effective over relatively short distance to ECF from dredging site.	**5**	Moderate complexity compared to mechanical dredging. Assuming that effluent water treatment is not required, alternative is compatible with ECF. Potential clogging with debris, but less than with Pneuma Dredge.	**3**	Potential pipeline leakage could adversely impact environment. Use of hydraulic dredge may require additional permitting above and beyond that for mechanical dredging. Air emissions may be less than mechanical	**3**	Downtime due to clogging from debris could increase costs.	**3**	Used extensively in U.S. and Canada.	**40**

Environmental Dredging Alternative	Service Criteria (Effectiveness)	Technical Criteria (Implementability)	Regulatory Criteria/Environmental Impacts	Cost Criteria	Prior Application	Total
Weighting Factor (1 – 3)	**3**	**2**	**1**	**2**	**3**	
			dredged.			

Notes: 1 = Poor
5 = Excellent

Selection of recommended alternative was based on total score. Judgment was used where multiple alternatives scored within 1 to 2 points of each other.

to three. Each alternative was then assigned a score from one to five, with five being very effective for the Randle Reef project. The total score was the sum of the individual products of effectiveness and weighting factor. Since this was a subjective method of scoring, the results were viewed as a general ranking of the alternatives.

D.2.1.5 Results of Evaluation of Dredging Alternatives

Based on the evaluation of alternatives presented in the previous section, the following environmental dredging alternatives were retained for further detailed engineering evaluation:

- **Alternative 2** - Closed (environmental) clamshell bucket dredge to remove contaminated sediment with transport of those sediments to the ECF by barge or scow for placement in the ECF. It is recommended that silt curtains be employed to control suspended sediments both at the dredge location and at the containment facility (assuming a barge access channel is used). Silt curtains could be configured to encompass the entire site or small excavation cells (i.e., moon pools); and

- **Alternative 4** - Cutter suction dredge to remove contaminated sediment with transport of the dredged sediment to the ECF via hydraulic pipeline. It is recommended that silt curtains be employed to control suspended sediments both at the dredge location and at the containment facility. Silt curtains could be configured to encompass the entire site or small excavation cells.

D.2.2 Detailed Evaluation – 30 Percent Design

D.2.2.1 Introduction

Hydraulic and mechanical dredges and high solids pumps were considered for the 30 percent design. The evaluation for the 30 percent design largely related to the different stages of dredging (i.e., initial dredging, production dredging, and finish/final dredging). Initial dredging involves dredging in the footprint of the ECF between the double walls. Production dredging refers to the removal of sediment outside the ECF perimeter and away from sensitive structures such as the U.S. Steel dock wall. Final dredging involves dredging near structures or in areas where access is difficult. In addition, this includes the final dredging required to fill the ECF to the contaminated sediment final grade, which will preferably place sediments with a high solids content to facilitate a more rapid transition to cap construction.

In general, the dredges can all be used for production dredging. The evaluation at the 30 percent largely related to production dredging. Additional measures may be necessary for mechanical dredges for maintaining short-term water quality and air emission control. Initial dredging in limited access areas (e.g., between the double steel sheetpile walls) may require the use of a clamshell bucket dredge or a crane-operated high solids pump.

D.2.2.2 Identification of Options

The following hydraulic dredges were considered:

- a 40 cm (16 inch) cutterhead;
- a 35 cm (14 inch) cutterhead (with modifications and/or customization); and
- a high solids pump.

The dredge size is in reference to the diameter of the discharge pipe.

The mechanical dredge considered was an enclosed clamshell level-cut bucket. Based on the recent experience of the design consultant on other projects with a high solids pump, and as a result of communications with suppliers, the option for a high solids pump was re-introduced at the 30 percent design stage as being technically feasible. Other reasons for re-introducing this option included the potential for a contractor to customize a hydraulic dredge to meet specific project needs.

The type of sediment re-suspension controls considered with the dredge equipment were:

- controlled operations;
- hood or shroud; and
- silt curtain.

Due to the large volume of sediment to be dredged and the associated sediment contaminant concentrations, more complex re-suspension controls were not considered during the 30 percent design. The hood or shroud was not evaluated during the initial screening, but was added as a dredging option at the 30 percent design level to enhance short-term water quality. Silt curtains may be required to maintain control of disturbed NAPL and sediment re-suspension.

The design options for transportation which were considered with the dredge equipment included:

- pipeline transport with submerged discharge;
- split-hull scow with bottom dump; and
- hopper/scow with mechanical dredge removal.

The split-hull scow and hopper/scow are associated with mechanical dredge types. The split-hull scow may require an access channel if the ECF walls are constructed before the dredging occurs. The hopper/scow may be required during initial and final dredging if a barge cannot access the ECF for disposal using the split-hull scow, or if a land-based method cannot be used.

No additional evaluation for sediment re-suspension controls or transport design options was performed for the 30 percent design. Both will be a function of the type of dredge used.

Controlled operations and pipeline transport with submerged discharge are most compatible with hydraulic dredging, since that type of dredging is usually associated with low sediment re-suspension. A hood or shroud may be not be required but may be used to further reduce re-suspension effects. Silt curtains are recommended to be used in conjunction with mechanical dredging to minimize sediment re-suspension. Hopper/scows are typically used with mechanical dredging with split-hull scows being preferable to others since the costs are lower, production rates tend to be higher and there is less double handling of the dredged sediments.

Further design standards were derived from studies conducted during the 30 percent design, as well as the requirements established during the development of the dredge plan. The development of the dredge plan will influence the selection of the dredge type since it imposes the following constraints related to dredging:

- large area to dredge (approximately 61 ha (150 acres));
- majority of the dredge area will require a dredge that is capable of making shallow cuts (0.5 m to 1.0 m);
- is cost-effective in terms of being mobilized during the various construction sequences and phases;
- applicable to the different types of dredging required at the different stages of the project (initial, production, finish/final dredging); and
- addresses potential air emissions concerns.

D.2.2.3 Evaluation Criteria

The following general criteria were used to evaluate the dredging design options at the 30 percent design level:

- effectiveness;
- implementability; and
- cost.

Attachment D.10 provides a description of the specific criteria or sub-criteria used for the evaluation of dredging design options.

D.2.2.4 Evaluation of Options

Table D.8 presents the evaluation of the dredging design options. Each option was assigned a score by criteria, reflecting a ranking of +1 for preferred, 0 for neutral or -1 for not preferred or not meeting criteria. Where all options were assigned a “0” for particular criteria, this indicated that there were no differences among the options for

Table D.8: Evaluation of Dredging Design Options – 30 Percent Design Level

Criteria/Sub-criteria	16 Inch Hydraulic Cutterhead Dredge w/ Pipeline	14 Inch Hydraulic Cutterhead Dredge w/ Pipeline	Enclosed Clamshell Level Cut Bucket, Large Footprint/ Thin Thickness Removal	High Solids Pump
Effectiveness				
Overall Protectiveness – Risk of Exposure to Public or Environment (short term)	1	1	0	0
Compliance with Design Standards and Other Requirements	0	1	0	0
Long-term Effectiveness and Performance - Risk Presented by Residuals and Contained Sediment	0	0	0	-1
Short-term Effectiveness - Protection of Workers, Community During Construction	1	1	0	1
Short-term Effectiveness – Protection of the Environment During Construction	1	1	0	1
Short-term Effectiveness - Scheduled Duration of Design Elements/Time to Execute Design Option	1	0	0	-1
Reduction of Mass/Volume, Toxicity, and Mobility of Contaminants – Magnitude of Contaminant Mass Reduction	0	0	0	0
Implementability				
Technical Feasibility - Ease of Construction and Operating the Option in a Cost-Effective Manner	-1	0	1	-1
Technical Feasibility - Compatibility with other Design Options	0	1	1	0
Technical Feasibility - Technical Complexity of Design Option	0	0	0	0
Administrative Feasibility - Ease of Obtaining Permits Waivers, Easements, Other Releases to Facilitate	0	0	0	0

Criteria/Sub-criteria	16 Inch Hydraulic Cutterhead Dredge w/ Pipeline	14 Inch Hydraulic Cutterhead Dredge w/ Pipeline	Enclosed Clamshell Level Cut Bucket, Large Footprint/ Thin Thickness Removal	High Solids Pump
Implementation of Design Components Comprising Option				
Administrative Feasibility - Acceptance by Stakeholders	1	1	0	1
Availability - Availability of Equipment, Materials, Services, etc. to Implement, Verify and Monitor Effectiveness of Design Option	-1	0	1	-1
Local/Provincial/Federal Government Standards and Stakeholder Input- Relative Probability of Design Option to Generate Issues or Concerns	0	0	-1	0
Cost				
Cost - Capital and Periodic Costs	0	0	0	-1

Legend:

+1 – Preferred 0 - Neutral -1 - Not preferred or not meeting criteria the criteria. The ranking by criteria were then summed with the highest score assigned to the most preferred option. The criteria were weighted equally.

D.2.2.5 Results of Evaluation of Options

Based on the evaluation and the identification of potential re-suspension and transport controls, a combination that included the 35 cm (14 inch) cutterhead hydraulic dredge with modifications, controlled operations and pipeline transport was preferred. During the later stages of design (i.e., 100 percent design), other dredge types and sizes were considered in light of responses from regional contractors and other considerations such as various customizations, improved methods and value engineering that may be applied to the tender documents. The 100 percent design stage emphasized performance criteria rather than limiting the design to a particular dredge type.

The following summarizes the rankings and scores of the various dredges (from most preferred to least preferred):

- 35 cm (14 inch) cutterhead hydraulic dredge (score = 6);
- 40 cm (16 inch) cutterhead hydraulic dredge (score = 3);
- enclosed clamshell level-cut bucket (score = 2); and
- high solids pumps (crane-operated) (score=-2).

Based on other evaluations (Herbich, 2000), a 40 cm (16 inch) hydraulic dredge is most compatible with the dredging depths for the Randle Reef project, as well as the pipeline distance. However, discussions with marine contractors in the Hamilton area suggest that a 35 cm (14 inch) cutterhead may also work if the required precision can be attained, and a booster pump may address the pipeline distance required. These will be assessed at the 100 percent design stage.

High solids pumps may be suitable for initial dredging between double sheetpile walls while a larger hydraulic dredge may be required within the ECF footprint. Mechanical dredging may be necessary for some aspects of construction, along with engineering controls for air emissions and sediment re-suspension. This may be required for initial dredging between the sheetpile walls, and final/finish dredging, and will be developed during later stages of design.

D.2.3 Detailed Evaluation – 100 Percent Design

D.2.3.1 Introduction

The 100 percent design carried forward the equipment options from the 30 percent dredging design. Based on a comparison of the dredging techniques in the 30 percent design and an evaluation of the clay surface, the following actions were recommended to be completed for the 100 percent design to confirm the feasibility of the 30 percent options:

- re-evaluate the dredge surface to support the objective of dredging to the clay surface in Priority 1 and 2 subareas;

- perform more detailed design work to refine and optimize the dredge plan with the available data; and
- re-evaluate the overdredge allowance, given the importance of maximizing containment of the contaminants in the ECF.

D.2.3.2 Identification of Options

The preferred design alternative uses two types of dredges – mechanical and hydraulic.

Initial dredging, which is the dredging of Priority 1 sediment between the two double walls will be completed using a combination of a high solids pump and a mechanical dredge.

Production dredging of Priority 1, 2 and potentially Priority 3 sediments will be conducted using a cutter suction hydraulic dredge (cutterhead dredge) approximately 35 cm (14 inch) in size or an equivalent customized hydraulic dredge, as ECF capacity allows.

Final finish dredging may be accomplished using mechanical dredging, which will bring the ECF to grade. Mechanical dredging has the potential to reduce effluent treatment and increase solids content of sediment immediately below the cap. Drawbacks include considerable re-handling of sediment in a difficult access situation and concerns for worker health and safety.

D.2.3.3 Review of Objectives and Studies

Further design was completed by:

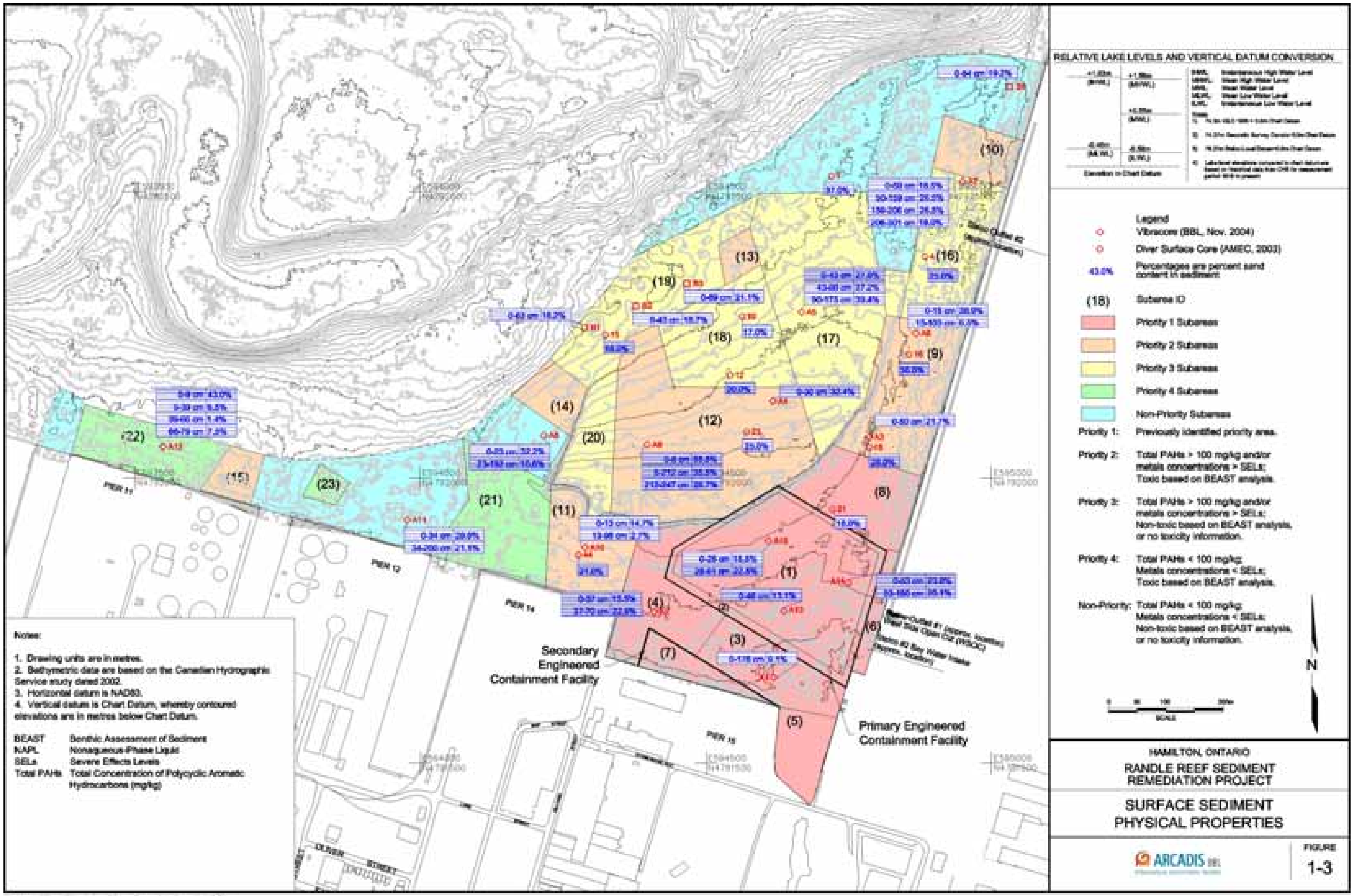
- evaluating the dredging options against various objectives;
- assessing the options against different requirements; and
- comparing the options with the recommendations from other studies related to the dredge design.

Issues which may arise during dredging were identified and the design option was reviewed for its ability to address the issue assessed.

The dredging objectives for the project were identified for optimizing the removal of contaminated sediment from the most to the least effective, and for optimizing the mass removed. Section 4.1.8 provides details on the development of the priority dredging subareas.

The sediment physical characteristics influence the dredging method, sediment transport method and consolidation behaviour. The gradation and plasticity of the sediment are especially relevant to the change in density and volume as the material consolidates in the primary ECF. The initial storage of the sediment will be impacted by the degree of volume bulking that occurs. This is in large part related to sand content (coarse-grained material), where the greater the sand content, the less volume bulking and the better the engineering behaviour of the dredged material during consolidation. The content can range from 1 to 56% in site sediments, with the most frequent range between 15 to 30%, as illustrated in Figure D.3. Plasticity of the fine grained sediment is important relative to the engineering behaviour of the sediment. The recently deposited soft

Figure D.3: Surface Sediment Physical Properties



sediments generally consist of silt or elastic silt of low plasticity. In most areas of the site, a layer of firm to stiff silty clay is beneath the recent sediment layer. This firm to stiff silty clay is described as the clay layer or upper clay layer and is the target for the dredging depth in Priority 1 and 2 areas. A review of the clay surface elevation was completed as part of the dredge plan design work.

Dredging objectives related to both dredging operations and filling of the ECF were identified and the proposed dredging option was reviewed for its ability to meet these objectives. These included the following sediment removal and ECF dredging/filling objectives:

- the post-dredge surface should have PAH concentrations < 100 mg/kg in the upper 10 cm (4 inches);
- Priority 1 and 2 areas should be fully contained/capped within the ECF, while sediment from Priority 3 and 4 should be contained as space allows;
- dredging design requires tight tolerances to minimize overdredge of uncontaminated material and will need to meet an overdredge allowance – this means advanced positioning capabilities for both horizontal and vertical positioning;
- dredging design is compatible with transport and disposal options, although numerous movements and equipment relocations are necessary for Priority 2 subareas;
- dredging is coordinated and compatible with other design elements such as sediment management;
- dredging design reduces sediment re-suspension, reduces transport of suspended sediments around the dredge head and reduces sediment exposure to air;
- dredging design limits residual contamination, either through the selection of the dredge technique or through the dredging process (incorporating second-pass dredging) - the specifications will need to identify that second-pass dredging equipment can achieve less than .5 m (1.7 ft) of removal; and
- placement of dredged material in the ECF should be managed to facilitate gravity settling of coarser sediments within the port facility area of the ECF footprint.

Some of these objectives translated into certain design standards or performance criteria which the dredging will need to meet, including:

- 0.15 m (0.5 ft) overdredge allowance;
- limitations on turbidity resulting from dredging; and
- meeting chemical criteria for residual contamination.

Further criteria and specifications will be developed when tender drawings and specifications are completed.

D.2.3.4 Evaluation of Options

For initial dredging, the combined mechanical dredging and high solids pumps were reviewed against the proposed design requirements criteria to determine if they were met.

For production dredging, the cutterhead hydraulic dredge was evaluated against the design objectives. A number of issues were reviewed to determine if the equipment option could address the following potential issues:

- variability in subsurface conditions;
- wind conditions and water column currents;
- presence and abundance of debris;
- wave conditions;
- dredging near HPA piers and U.S. Steel's dock wall;
- dredging near the ECF double sheetpile walls; and
- dredging slopes.

The impact of the above on dredging rates was evaluated for each subarea. Each factor was rated as having a high, medium or low impact, relative to the potential for concern in a given subarea. The ratings were combined to estimate an overall dredging efficiency for each subarea and to derive a production rate. A production rate range of 85 to 299 m^3/hr was calculated based on a range of efficiency factors from 41 to 95%. These rates will be evaluated with sediment management design criteria (see Table D.9). The evaluation of certain factors also led to recommendations for the design drawing and specifications to implement the 100 percent design.

D.2.3.5 Results of Evaluation of Options and Recommendations

For initial dredging, it was determined that dredging between the double walls could be performed consistent with design objectives using one of two (mechanical or high solids pump) or both approaches. Final dredging may be accomplished by mechanical dredging and will be reviewed during the final stages of design.

For production dredging, the hydraulic cutterhead was evaluated to determine whether the equipment was suitable for the various site conditions. A number of constraints and limitations were identified for consideration in the development of construction specifications, as follows:

- implement re-suspension controls during dredging;
- include provisions that describe the presence of a hard bottom as a site condition;
- provide dredge pump arrangements that minimize cavitation (cavities at the sediment interface);
- pumps should be able to pass some occasional coarse material and slag to avoid down-time and slower production rates;
- include methods for moving the cutterhead dredge to optimize production efficiency and manoeuvrability;
- structure the tender to address the ability to expand availability of the dredge equipment components;
- meet production rates that allow for sediment management and supernatant treatment designs;

Table D.9: Estimated Dredging Production Rates by Subarea

Priority Area	Priority Subarea	Subsurface Conditions	Wind Conditions and Water-column Currents	Dredging near HPA Piers and SDW	Dredging near ECF	Dredging Slopes	Long Discharge Line	Overdredge Concerns	Overall Efficiency	Production Rate (m^3/hr)
1	3	Medium	Low	High	High	Low	Low	Low	58%	121
1	4	Medium	Medium	High	High	Medium	Low	Low	41%	86
1	5	Medium	Low	High	Low	Low	Low	Low	50%	104
1	7	Medium	Low	High	Low	Low	Low	Low	59%	123
1	8	Medium	Medium	High	High	Medium	Low	Low	41%	86
2	9	Medium	Low	High	Low	Medium	Low	Low	47%	99
2	10	Medium	Low	High	Low	Medium	High	Low	43%	89
2	11	Medium	Medium	High	Low	Medium	Low	Low	45%	94
2	12	Medium	Medium	Low	Low	High	Low	Low	46%	97
2	13	Medium	Medium	Low	Low	High	Medium	Low	41%	85
2	14	Medium	Medium	Low	Low	High	Low	Low	43%	90
2	15	Medium	Low	High	Low	Medium	High	Low	52%	108
3	16	Low	Low	High	Low	Low	High	Medium	73%	153
3	17	Low	Low	Low	Low	Low	Medium	Medium	90%	190
3	18	Low	Medium	Low	Low	Low	Low	Medium	90%	190
3	19	Low	Low	Low	Low	Low	Medium	Medium	90%	190
3	20	Low	Low	Low	Low	Low	Low	Medium	95%	200
4	21	Low	Low	High	Low	Low	Low	Medium	81%	170
4	22	Low	Low	High	Low	Low	High	Medium	73%	153
4	23	Low	Low	Low	Low	Low	High	Medium	86%	180

- specifications to require the contractor to submit a construction work plan describing the survey method, method of debris removal and method of verifying that the debris has been removed prior to hydraulic dredging;
- dredging near the HPA piers and U.S. Steel dock wall will require an offset and will be sloped; the specifications will explicitly state that the contractor will be responsible for damages to the structures resulting from dredging operations;
- construction windows for fish and winter shut-down periods are in effect - associated constraints with the effluent treatment system;
- noise, light and nuisance ordinances are applicable to the site;
- tenant operations may need to be accommodated;
- coordination with navigation requirements must be addressed; and
- meet water quality requirements during construction activities.

Dredging, transport and filling options will be further developed during the development of drawings and specifications. Construction monitoring, verification sampling and sustainability opportunities will be developed under separate design elements (e.g., sediment management, port facilities) or during further design development within the drawings and specifications. The 100 percent design recommends the use of the cutter suction hydraulic dredge or specialized/customized hydraulic dredge.

Attachment D.6: Environmental Dredging - Initial Screening Assumptions

Item	Assumptions
Volume	Sediments within Randle Reef having concentrations greater than 200 ppm TPAH will be dredged, an approximate area of 275,600 m^2 with a volume of 310,00 m^3. If the dredge line is expanded to dredge sediments contaminated with greater than 50 ppm TPAH, the dredge area will be increased to 440,000 m^2 and have a volume of 476,000 m^3. It is also anticipated that sediments with free phase coal tar will be encountered. Estimates indicate that an area of 122,300 m^2 and a volume of 160,000 m^3 will have free phase coal tar present. It was assumed that the ECF may be created by encircling the most highly contaminated sediments at the site within a series of interconnected containment structures (i.e., earthen berms or sheetpile walls).
Current Velocities	The Randle Reef site covers approximately 350,000 m^2 (35 ha) with water depths ranging from approximately 4 to more than 10 m. Based on the review of the previously completed modeling, current velocities at the Randle Reef site are predicted to be low (less than 10 cm per second for the modeled conditions). Therefore, silt curtains, screens or sheetpile walls may be used for suspended sediment control.
Dredged Material Characteristics	The need to dredge is principally driven by the presence of polycyclic aromatic hydrocarbons (PAHs) in the sediments. Other contaminants include various metals and polychlorinated biphenyls. Even the most concentrated PAH (naphthalene) was found in relatively low concentrations, as compared to bulk chemical content. The presence of these contaminants does not affect the basic physical function of dredge equipment, that is, the removal of sediments from the bottom and transferal to appropriate transportation equipment. However, some small portions of these contaminants may be released to the water column and to the air during dredging. In particular, there may be a need to control air emissions of PAHs during dredging. The area to be dredged at the Randle Reef site is covered by a layer of unconsolidated soft sediments ranging in thickness from 0.8 to 3.4 m. Across most of the site, the soft sediment is underlain by a layer of clay that ranges in consistency from very soft to very stiff, with undrained shear strengths as high as 115 kilopascals.
Containment and Treatment	For the purposes of evaluating the various environmental dredging component options, it is assumed that dredged sediments could be placed directly into the ECF and that effluent would require treatment. If costly effluent treatment is required, economic considerations may favour a dredging method that results in higher solids content.

Attachment D.7: Description of Environmental Dredging Options

A. Environmental Dredging Equipment Options

Mechanical Dredges	
Equipment Option	**Description**
Barge Mounted Backhoe	The barge-mounted backhoe dredge is a land-based hydraulic backhoe excavator mounted on any suitable pontoon or barge. Operational water depth is limited only by the draft of the barge. Bucket sizes range from approximately 15 to 20 cm. The sediment re-suspension of backhoe dredges is estimated to be comparable to typical open-top clamshell or grab dredges. Production rates may range from 15 to over 120 m^3/hr depending on the size of the bucket and the operational procedures.
Open Clamshell Bucket	A bucket dredge is a mechanical device that utilizes a bucket to excavate sediment at or near in-situ densities (i.e., without entraining excessive free water). Buckets range in capacity from ½ to 20 m^3 or more and are often referred to as "clamshell buckets" due to their shape and closure method. The bucket is typically suspended from a crane. The dredge operates by lowering the bucket through the water column in the open position until it penetrates the bottom. The bucket is then closed by the crane operator through the use of wire cables, shearing the bottom sediments. The bucket is then raised to the surface and once in position above the dump scow or hopper barge, the bucket is opened and the sediment is released. Clamshell buckets typically excavate a heaped bucket of sediment, which tends to overflow the edges of the open top bucket as it is raised to the surface and subsequently swung open to the receiving vessel. This spillage creates turbidity in the water surrounding the dredge operation and contributes to the loss of material. However, "watertight" or "closed" clamshell dredges have been designed to limit the release of materials.
Closed Clamshell Bucket	The closed clamshell bucket is a modification of the typical open clamshell in which the top of the closed bucket is covered by steel plates and the sides of the bucket form a tight seal by overlapping or using rubber gaskets to prevent leaking. Typically, the top covering is equipped with vents to allow water to pass through during the descent phase of the bucket dredge. These modifications do not significantly adversely impact the performance of the closed clamshell as compared to the open clamshell.
Visor Grab	The shape of the visor grab is similar to a shovel with a sliding cover (visor flap) that is closed by two hydraulic cylinders. The shuttered grab is handled in the usual way by a mechanical excavator (i.e., backhoe). When the grab has been filled, the visor is closed before being raised to empty its contents into a transport barge. The visor grab's closing system avoids the bed material becoming compressed, which can make emptying the grab difficult. A rubber strip along the edge of the visor is intended to provide a watertight closure.

Hydraulic Dredges	
Equipment Option	**Description**
Cutter Suction	Cutter suction dredges operate under the same principles as conventional suction dredges with a rotating cutterhead. Several

Equipment Option	Description
	types of cutterheads may be employed depending on the type of material to be dredged. Sediments are broken down and drawn into a centrifugal or sludge (modified axial) dredge pump where they are transported through pipelines to a treatment and/or containment location. The dredge "walks" using a combination of winches and spuds or it can be self-propelled. Use of a ladder pump can increase the concentration of dredged slurry in the pipeline and dredge in deeper water depths. The production rate is dependent on the pump power and the size (diameter) of the intake pipe, which are typically 30 cm or smaller for remedial dredging.
Dustpan	The dustpan dredge uses a widely flared dredge head (similar to a large vacuum cleaner) with high pressure water jets positioned along its length. The water jets loosen the bed sediments which are then captured within the dredge head as it is winched into the excavation. Dustpan dredges are used primarily for dredging sandy sediments on inland rivers where the dredged sediment is pumped a relatively short distance (typically less than 300 m) and discharged in nearby open waters outside of the navigation channel.
Matchbox Suction	The matchbox suction dredge was designed to replace the cutterhead dredge. A plate over the top of the suction head prevents escape of gas bubbles. The angle between the suction head and the ladder is adjustable to optimize the position of the dredge head independent of the dredge depth.

Pneumatic and Specialty Dredges

Equipment Option	Description
Amphibious Excavator	Amphibious excavators are typically small, versatile, pontoon-mounted, multipurpose dredges equipped with both mechanical and hydraulic capabilities. Many of these amphibious excavators are portable (i.e., transportable on public roads) and capable of loading/unloading and launching themselves without additional equipment. Furthermore, most are self-propelled on land and in water but can be adapted to use land anchors and winches for positioning in water. Most amphibious excavators are equipped with interchangeable mechanical backhoe excavators and hydraulic cutterhead suction dredge attachments. Additionally, other attachments are available for sludge pumping, raking, cutting and debris removal.
Bonacavor	The bonacavor is a hybrid dredge (mechanical excavation/hydraulic transport). Sediments are dredged with a mechanical barge-mounted backhoe excavator and transported hydraulically using a Slurry Processing Unit (SPU). Excavated sediments are placed on a screen over the SPU hopper bin. Large debris are separated out and transported via containment barge to the treatment site. The desired slurry density and/or velocity of the slurry is controlled by the SPU which automatically injects the necessary amount of water to maintain the pre-defined slurry density and velocity.
Oozer Pump	The Oozer Pump is a pneumatic dredge designed to produce a vacuum inside the pump by changing the air pressure inside a system of cylinders, thereby causing high density sediment slurry to be sucked through the suction inlet by water and atmospheric pressure. The sediment in the pump is then discharged by compressed air. The Oozer pump operates on a similar principal to the pneuma pump, except that two cylinders are used rather than three. The two cylinders alternately suck in and discharge sediment, continuously performing high density sediment dredging. A centrifugal vacuum is also

Equipment Option	Description
	applied to increase the efficiency of the system. The Oozer Pump makes if possible to dredge thin layer, high density bottom sediment.
Pneuma Dredge	The pneuma is a hydraulic (pneumatic) dredge plant with a piston-type pump. It uses a combination of hydrostatic heads to create a vacuum and compressed air as a piston to move material into and out of a cylinder, similar to the oozer dredge. The pistons operate in sequence, providing continuous output at up to 60% solids concentration depending on sediment conditions and type. The system is effective in deep and very shallow waters with numerous assembly options and methods of use including pontoons, barges, in-tow or using a "dipping" method. When used in-tow, various intake configurations (e.g., plows) are available to adjust to conditions. The absence of rotating cutters provides for excellent environmental results and very low maintenance requirements.
High Solids Submersible Pump (i.e., the TOYO Submersible Agitator Pump)	The TOYO pump is a combination of an excavator and a pump that includes a built in agitator attached directly to the pump shaft. The pump digs itself into position just below the mud line and as the inward curved agitator blades rotate, the surrounding material is mixed with fluid into a highly concentrated slurry which is then fed to the impeller and transported to the containment facility. The system can be outfitted with GPS and other equipment to accurately place and monitor the position of the pump and ultimately improve accuracy.

B. Suspended Sediment Control Options

Release of suspended sediments during dredging, which results in turbidity, occurs with nearly all dredging technologies. However, the degree of turbidity generated during dredging varies considerably by dredge type, sediment properties and site conditions. Turbidity associated with contaminated sediment dredging can impact the successful implementation of the remedial action, if not controlled.

Suspended Sediment Control Options	Description
Textile Barriers (i.e., silt screens and silt curtains)	Textile barriers are used to reduce sedimentation caused by water flow and other activities such as dredging. Textile barriers, such as silt screens and silt curtains, are made from natural or man-made woven fabric designed to prevent sediment from passing from the dredge site to the remaining water body. Silt curtains are designed to contain or deflect suspended sediments or turbidity in the water column. Consequently, silt curtains are considered an integral and necessary part of the regulatory strategy for many dredging projects. Silt curtains are commonly used to protect specific areas (e.g., sensitive habitats, water intakes or recreational areas) from suspended sediment and particle-associated contamination as they can be installed and maintained in a manner that avoids the entry of equipment into the water body.
Sheetpiles	Sheetpile walls can be made out of steel, vinyl, fibreglass or plastic sheeting, which is driven into the ground to create a barrier to restrict water flow or to create an enclosure to isolate work activities. Steel sheetpiling consists of a series of rolled trough sections with interlocking grooves along each edge of the section. Each steel pile is secured groove to groove, and driven into the ground to as close to the same depth as possible to form a continuous, impervious barrier. Steel sheetpile

Suspended Sediment Control Options	Description
	walls are often used for in-water works due to their strength and durability.
Moon Pools	A moon pool is an enclosed "pool-like" area where only the bucket is surrounded by silt curtains, creating a small excavation cell that isolates the dredging machinery and moves with the machinery to each area to be dredged.
Air (Bubble) Curtains	Air bubble curtains are created by using pneumatic pumps to create compressed air flow though a submerged perforated pipe which is placed along the bottom surface. The air escapes through special nozzles on the pipe and rise to the surface forming a vertical current in the water column. At the water surface, the vertical current is transformed into a horizontal current which acts as a barrier.
Modifications to Dredging Rates and Equipment	Changing the rate at which sediment is removed and modifying the dredging equipment can minimize the re-suspension of contaminated sediment while maximizing the solids content of the dredgeate. Changing the rate could include a reduction in the bucket ascent and descent velocity, ensuring complete closure of the bucket prior to ascent, and/or rinsing of the bucket before each descent. Modifying equipment such as removing the auger head shroud or adjusting engine speed can impact on sediment re-suspension and on dredge productivity.

C. Transportation of Dredged Material Options

After the sediment has been excavated, it is transported from the dredging site to the placement site or disposal area. This transport operation, in many cases, is accomplished by the dredge itself or by using additional equipment such as barges, scows and pipelines with booster pumps.

Transportation of Dredged Material Options	Description
Barge or Scow	Barges and scows are often used in conjunction with mechanical dredges and have been one of the most widely used methods of transporting large quantities of dredged material over long distances as these vessels are either self propelled or can be placed on board larger vessels. The use of barges or scows is common when conducting offshore or near shore dredging.
Pipeline	Pipeline transport is the method most compatible with hydraulic dredging (i.e., cutterhead, dustpan and other hydraulic dredges) where a flexible hose is used to transport the dredged material from the dredge site to a disposal area on shore (such as the ECF). Pipelines can be lengthy to allow for longer distances between the dredge and the designated disposal site but may require the use of booster pumps to provide greater suction of the material through the pipeline.
Conveyor	A conveyor provides the means to transport dredged material from one location (i.e., the area in which dredge material has been collected/stored) to a dedicated sediment processing area. Conveyors can be used to transport sediment over land (not water) where trucks may be impractical due to the short distance between the dredge collection/storage area and the processing site.

Transportation of Dredged Material Options	Description
Truck	When barge transport directly to a containment facility is not feasible, dredged sediments may be transported to a shore-based transloading facility where the sediment is then loaded into large dump trucks and transported over land to the appropriate facility for treatment.

Photographs

A. Dredging Equipment

Mechanical Dredges

Barge Mounted Backhoe

The barge-mounted backhoe dredge is a land-based hydraulic backhoe excavator mounted on any suitable pontoon or barge. It is ideal for working along shorelines and in other aquatic environments that traditional excavation equipment cannot access.

Visor Grab

A visor grab contains a sliding cover (visor flap) that hydraulically close to contain the sediment within the bucket. A rubber strip along the edge of the visor creates a watertight closure.

Photo: Environment Canada

Open Clamshell Bucket

The open clamshell bucket is lowered into the water until it sinks into the bottom surface. The raising of the bucket closes the jaws of the bucket. The sides of this clamshell are open thereby allowing excess sediment to spill from the bucket as it is raised through the water column causing turbidity in the water surrounding the dredge activity.

Army Engineer Research and Development Center
U.S. http://el.erdc.usace.army.mil/resbrief/drbucket/bkt-type.html

Closed Clamshell Bucket

Unlike the open clamshell, the closed clamshell bucket is enclosed as the top is covered by steel plates and the sides either overlap or have rubber gaskets to create a tight seal. Re-suspension of sediment is significantly less with the closed clamshell bucket making it preferable for performing environmentally sensitive dredging operations than the open clamshell.

Army Engineer Research and Development Center
U.S. http://el.erdc.usace.army.mil/resbrief/drbucket/bkt-type.html

Hydraulic Dredges

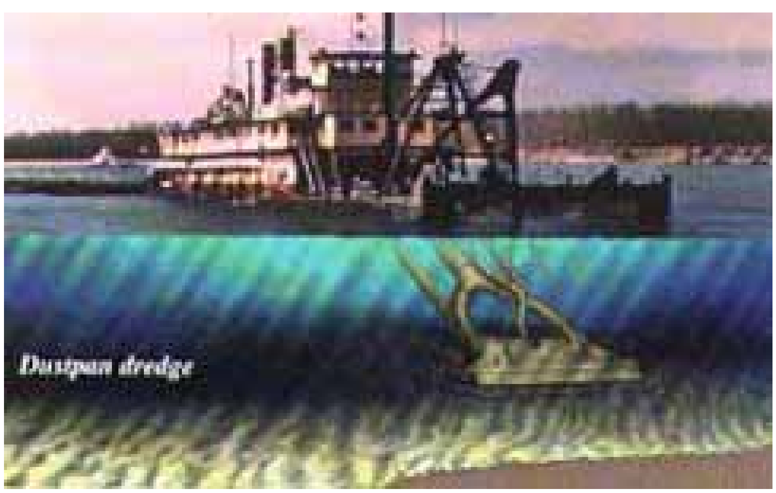
Cutter Suction Dredge

Cutter suction dredges operate under the same principles as conventional suction dredges. The dredge includes a rotating cutterhead with teeth that churns up the surface. The sediment and water is then suctioned up a long tube and transferred to a containment site.

DredgeBrokers © 2005

Dustpan Dredge

The dustpan dredge uses a widely flared dredge head (similar to a large vacuum cleaner) with high pressure water jets positioned along its length. The high velocity water jets loosen the bed sediments which are then captured within the dredge head and drawn up by pump through the dredge pipe and into a floating pipeline where the material is transported to the treatment site, containment site or to a transfer location.



http://www.globalsecurity.org/military/systems/ship/dredge-dustpan.htm

Pneumatic and Specialty Dredges

High Solids Pump (TOYO Submersible Agitator Pump)

The TOYO pump is a combination of an excavator and a pump. The pump includes a built in agitator attached directly to the pump shaft. The pump digs itself into position just below the mud line and as the inward curved agitator blades rotate, the surrounding material is mixed with fluid into a highly concentrated slurry. The pump can also be equipped with high pressure water jets to loosen sediment for removal.

Photo: Environment Canada

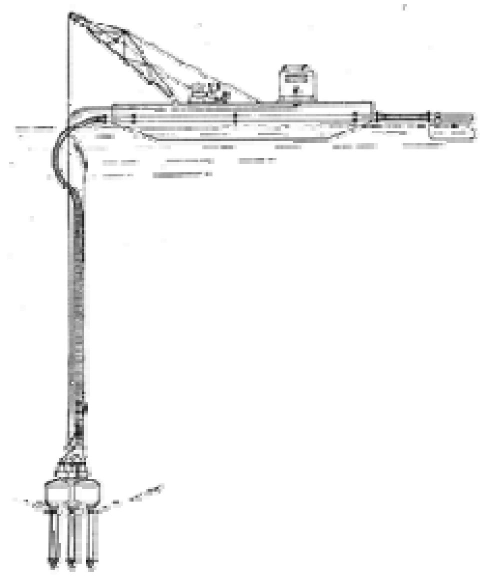
Amphibious Excavator (Amphibex)

Amphibious excavators are typically small, versatile, pontoon-mounted, multi-purpose dredges equipped with both mechanical and hydraulic capabilities. Most are self-propelled on land and in the water but can be adapted to use land anchors and winches for positioning in water.

Photo: Environment Canada

The Pneuma Dredging System

The pneuma is a hydraulic (pneumatic) dredge plant with a piston-type pump using a combination of hydrostatic heads to create a vacuum and compressed air as a piston which moves material into and out of a cylinder.



http://www.pneuma.it/dredging_of_dams_deep.html

B. Suspended Sediment Control

Textile Barriers – Silt Curtain

Textile barriers, such as silt screens and silt curtains, are made from natural or man-made woven fabric designed to prevent sediment from passing from the dredge site to the remaining water body.

Air (Bubble) Curtain

Air bubble curtains are created by compressed air flow though a submerged perforated pipe placed along the bottom surface. The air escapes through special nozzles on the pipe and rise to the surface forming a vertical current in the water column and a horizontal current at the surface which acts as a barrier.

Sheetpile

Steel sheetpiling consists of a series of rolled trough sections with interlocking grooves along each edge of the section. Each steel pile is secured groove to groove and driven into the ground to form a continuous, impervious barrier.

Moon Pool

A moon pool is an enclosed "pool-like" area where only the bucket is surrounded by silt curtains, creating a small excavation cell that isolates the dredging machinery and moves with the machinery to each area to be dredged.

C. Transportation Options

Barge / Scow

Barges and scows are often used in conjunction with mechanical dredges and have been one of the most widely used methods of transporting large quantities of dredged material over long distances as these vessels are either self propelled or can be placed on board larger vessels and transferred to the processing facility.

Conveyor

Conveyors can be used to transport sediment over land (not water) where trucks may be impractical due to the short distance between the dredge collection/storage area and the processing site.

Illinois Department of Natural Resources

Truck

Sediment is loaded into large dump trucks and transported over land to the appropriate facility for treatment.

Attachment D.8: Environmental Dredging Components: Description of Initial Screening Evaluation Criteria or Sub-criteria

Criteria	Sub-criteria	Criteria or Sub-criteria Description
Environmental Dredging Equipment		
Service Criteria (Effectiveness)	Site Compatibility	The dredging equipment must be capable of operating in the site conditions expected for this project and removing the required sediment volumes. Water depths (in excess of 12 m for this project) and channel widths can limit the size of suitable dredge equipment. The distance that material must be transported from the dredge area to the containment (or transfer) site may also affect dredge selection. In addition, the dredging equipment must be capable of removing the targeted sediments (considering grain size, moisture content, and other physical factors). Obstructions, such as logs, and debris can reduce removal efficiencies. Therefore, the selected equipment option must be capable of handling the expected obstructions for this project with minimal down time.
	Solids Content	The solids content (i.e., percent solids) is a measure of the amount of water entrained by the dredging process. The amount of water entrained in dredged sediment depends not only on the dredging process, but also on the amount of water in the sediment prior to removal. Hydraulic dredges typically entrain more water than mechanical dredges. The volume of water entrained during the dredging process will affect the subsequent dewatering and water treatment processes. The more water in the dredge material, the more that has to be removed and treated later.
Technical Criteria (Implementability)	Complexity	Equipment options that are technically complex tend to have a higher potential for breakdown and/or failure. Therefore, less complex options are more desirable.
	Compatibility with Other Options and Tasks	The dredging equipment must be compatible with other components of the environmental dredging process (e.g., suspended sediment control and transportation), as well as with other tasks of the project (e.g., sediment handling, dewatering and water treatment).
	Production Rate	Each of the various types of dredge equipment may be capable of different sediment removal rates. Depending on the total volume of dredged material and project schedule, this may have an impact on

Criteria	Sub-criteria	Criteria or Sub-criteria Description
		equipment selection. Typically, the more specialized dredge equipment options have lower production rates as compared to traditional equipment, due to their smaller size and slower operational speed, which are related to their abilities to decrease re-suspension and improve precision. Precision of sediment removal is the sum of dredging precision and positional precision. It is principally a function of operational procedures and instrumentation. It is less dependent on the type of dredging equipment.
Regulatory Criteria	Permitting	If hydraulic dredging equipment is specified, approval beyond the requirements for mechanical equipment may apply (i.e., A Permit to Take Water is required under section 34 of the Ontario Water Resources Act) (OWRA)).
	Sediment Re-suspension	Finer-grained materials, such as those proposed for dredging from Hamilton Harbour, tend to re-suspend easier and be transported farther from the point of dredging than coarser grained materials. Therefore, the grain size of the material to be removed can affect equipment selection. Although suspended sediment control technologies would likely be implemented for the project, selection of a dredge that limits re-suspension is crucial. The dredging equipment must limit or contain re-suspension in the water column where the material to be dredged does not exceed the applicable guidelines/standards/objectives set by MOE or Environment Canada.
	Dredge Availability	The dredging equipment (i.e., floating plant) must be Canadian registered and have a specific Canadian content in its manufacture.
Environmental Impacts	Sediment Re-suspension	See Regulatory Criteria above.
	Air Emissions	Releases of contaminants to the atmosphere must also be considered. Naphthalene, the most volatile of the class of PAHs, is present in the sediment and may be released to the air during dredging. Dredging (and transport) equipment that tends to reduce air emissions and accompanying odors may be appropriate. However, given the uncertainties in sediment concentrations and process emission rates, it is not possible to estimate the magnitude of emissions. Therefore, this factor can only be addressed qualitatively, at this stage.
Cost	Capital Cost	If equipment purchase is required, probable capital costs must be

Criteria	Sub-criteria	Criteria or Sub-criteria Description
		considered.
	Operating Cost	Wherever available, a range of probable costs for each equipment option, including mobilization, maintenance and operation costs, was estimated.
Prior Application	Past Performance	The success of previous use(s) of each option on similar projects was considered.
Suspended Sediment Control		
Service Criteria (Effectiveness)	Site Compatibility	The use of suspended sediment control devices is impacted by water depth, wind-induced currents, wave action, subsurface characteristics of existing sediments and deployment/installation.
	Effectiveness at Retaining Re-suspended Solids	Due to the fine grained nature of the sediments in Hamilton Harbour, some options would be more effective than others at retaining the re-suspended solids.
Technical Criteria (Implementability)	Complexity	Options that are technically complex tend to have a higher potential for breakdown and/or failure. Therefore, less complex options are more desirable.
	Compatibility with Other Options and Tasks	The suspended sediment control option must be compatible with other components of the environmental dredging process (e.g., dredging equipment and transportation) as well as with other tasks of the project (e.g., sediment handling, dewatering and water treatment).
Regulatory Criteria	Sediment Re-suspension	The suspended sediment control option must limit or contain suspended sediment generated by dredging or other remedial actions where the material to be dredged exceeds the lowest effect level of the applicable guidelines set by MOE or Environment Canada. The selected option must control turbidity such that the water quality criteria set by the appropriate agencies is maintained.
Environmental Impacts		The technologies were evaluated for the purpose of reducing environmental impacts from re-suspension of sediments during dredging.
Cost	Capital Cost	If equipment purchase is required, probable capital costs must be considered.
	Operating Cost	Wherever available, a range of probable costs for each equipment option, including mobilization, maintenance and operation costs, was

Criteria	Sub-criteria	Criteria or Sub-criteria Description
		estimated.
Prior Application	Past Performance	The success of previous use(s) of each option on similar projects was considered.
Transportation		
Service Criteria (Effectiveness)	Site Compatibility	The accessibility of the site is a major factor in selecting the appropriate transportation option. This includes consideration of potential pipeline routes, truck routes and barge draft limitations.
	Distance to Containment Site	The distance between the removal area and the containment area may limit the use of particular transportation options. For instance, the distance over which slurried sediments can be transported through a pipeline is limited by the size of the pump(s), length of pipeline and the difference in hydrostatic head between the entrance and discharge of the pipeline.
Technical Criteria (Implementability)	Complexity	Options that are technically complex tend to have a higher potential for breakdown and/or failure. Therefore, less complex options are more desirable.
	Compatibility with Other Options and Tasks	The transportation option must be compatible with other components of the environmental dredging process (e.g., dredging equipment and suspended sediment control) as well as with other tasks of the project (e.g., sediment handling, dewatering and water treatment). This is especially important with the dredge equipment, where the general type of removal equipment (i.e., mechanical, hydraulic or pneumatic) may dictate the selection of the transportation option. For example, hydraulically dredged sediments are typically transported in slurry form through a pipeline. The transportation option must also be compatible with the suspended sediment control option, including consideration of necessary interactions between the two (e.g., barge loading on sheetpile wall or barge passage through silt curtain).
Regulatory Criteria		While there are regulatory criteria relevant to dredging, handling and treatment of dredged material, transportation alone does not trigger any specific requirements. Best management practices should be followed during transportation to prevent discharge of dredged material.

Criteria	Sub-criteria	Criteria or Sub-criteria Description
Environmental Impacts		The impact on surrounding areas (e.g., increased traffic and potential for spills and leaks) as a result of the transportation method must be considered in the screening of transportation options. In addition, releases of contaminants to the atmosphere must also be considered, as naphthalene, the most volatile of the class of PAHs is present in the sediments.
Cost	Capital Cost	If purchase is required, probable capital costs must be considered.
	Operating Cost	Wherever available, a range of probable costs for each option was estimated, including mobilization, operation, maintenance and repair.
Prior Application	Past Performance	The success of previous use(s) of each option on similar projects was considered.

Attachment D.9: Advantages and Disadvantages of Dredging Equipment Options – Initial Screening

Mechanical Dredges			
Equipment Option	**Advantages**	**Disadvantages**	**Costs**
Barge Mounted Backhoe	• dredge wide range of sediments and materials including debris • operate in confined spaces • good accuracy in positioning (approximately 1 m) and depth of dredge (< 1 ft) • dredge depths between 0 (if operated from upland) and 25 m • can be operated from land to access shallow areas or other hard to reach areas • faster cycle time than typical grab bucket dredges • sediments are dredged at near in-situ densities (i.e., in-situ solids content)	• large re-suspension potential for uncovered buckets • final dredged surface is uneven	• mobilization costs for backhoe are not significant as they are typically leased from local dealer • mobilization costs for the barge to support the backhoe would depend on the size and type of barge required • portable barges may be suitable • approximate unit costs for dredging range from $10 to $20 per cm depending on size of bucket and operational limitations (i.e., slowed speed to limit re-suspension)
Visor Grab	• high solids content (i.e., near in-situ density) • low TSS concentrations and low levels of water entrainment • minimizes volume of sediments dredged • operation in typical locations as well as in locations with poor access such as quays	• limited to shallow sites • sensitive to debris	• the unit cost for navigational dredging is approximately $4 per m^3 • contaminated sediment dredging would likely result in considerably higher unit costs
Open Clamshell Bucket	• capable of excavating most types of sediment • excavates sediment at near in-situ density	• relatively slow production rate compared to hydraulic dredges but similar to other mechanical dredges; wide range of rates depending on	• unit costs for dredging with an open-top clamshell range from approximately $5 to $10 per m^3 for maintenance dredging but are rarely

Equipment Option	Advantages	Disadvantages	Costs
	• effective at working near bridges, docks, wharfs, pipelines, piers or breakwater structures due to accurate control	bucket size, water depth, debris and contamination (10 to over 230 m^3/hr) • not typically used for contaminated sediment dredging due to high level of re-suspension from bucket overflow and leakage • requires high overhead clearance	used for remedial work
Closed Clamshell Bucket	• typically re-suspend 30 to 70% less sediment than open clamshells • capable of excavating most types of sediment • excavate sediment at or near in-situ density • clamshell bucket can be mounted on any appropriately sized derrick barge • effective at working near bridges, docks, wharfs, pipelines, piers or breakwater structures due to accurate control	• entrains more water than open-top clamshells due to sealed side walls and covered top • designs that do not produce a level cut may leave uneven surfaces after dredging (i.e., craters)	• unit costs for closed clamshell dredging are typically higher than open-top clamshell dredging due to slower production

Hydraulic Dredges

Equipment Option	Advantages	Disadvantages
Cutter Suction	• can be operated by cable or swing ladder with no cable • lower re-suspension than typical mechanical (bucket) dredges • production rate for 15 to 30 cm diameter cutterhead typically ranges from 15 to 120 m^3/hr • navigational dredging with larger dredge may reach up to 2,300 m^3/hr	• when dredge has difficulty dredging, turbidity would increase substantially • 10 to 30% solids by weight • final dredged surface may resemble windrows • use of global positioning system (GPS) to precisely guide the operation can greatly reduce the presence of windrows
Dustpan	• very little mixing with undisturbed subsurface layer • dredge depths between 1.5 and 15 m	• does not operate well around obstacles or for slope dredging

Equipment Option	Advantages	Disadvantages
	• able to remove thin layers of loose material over large areas • production rates as high as 3,800 m^3/hr • often used for navigational channel dredging and mining sand in sheltered areas	• cannot be used in estuaries or bays with significant wave action, only sheltered waters • lower solids content (5 to 10% by weight) than hydraulic cutterhead dredges • the lack of a mechanical cutting mechanism limits the dredging of compacted sediments • not suitable for dredging fine-grained sediments • susceptible to clogging in the presence of debris • not well-suited for transportation of dredged material over long distances to upland containment sites; pumping distances are limited to about 300 m without the use of a booster pump
Matchbox Suction	• a large plate covers the top of the dredge head to prevent the inflow of water and escape of gas bubbles • openings on both sides of the dredge head improve production	• suitable for small removal volumes or cleanup jobs only • solids content of 5 to 15% by weight • production rate (20 to 60 m^3/hr) may be considerably slower than even small (15 cm) hydraulic cutterhead dredge (25 to 100 m^3/hr) • ineffective in debris or compacted sediments

Pneumatic and Specialty Dredges

Equipment Option	Advantages	Disadvantages	Costs
Amphibious Excavator	• interchangeable excavator attachments assist to excavate, pump, rake, drill or hammer, and lift • small size and easily transported by road; able to work in restricted areas such as narrow or shallow waterways • traverses into and out of water using the excavator arm and stabilizers; for moving longer	• four hydraulic spuds used for positioning cause sediment disturbance but can be fitted with land anchors and winches	• Normrock Industries Inc. reports costs of \$18 to \$26 per m^3 for use of their equipment to remove contaminated sediments; these costs include rental, transport, and site setup and cleanup • additional costs are presumed for operation of the equipment • other manufacturers may have varying costs

Equipment Option	Advantages	Disadvantages	Costs
	distances in water a propulsion system is used • hydraulic dredging depth of up to 5.8 m, height of 6 m, and minimum rotation of 180 degrees, some up to 360 degrees • mechanical excavation depth of 6 m with a working width of 12.8 m (a longer dipper stick may be applied) • pumping bucket, cutter pump or a conventional excavation bucket on the excavator arm • solids production for the pumping bucket varies from 50 to 120 m^3/hr • maximum pumping distance of 500 m for the pumping bucket and 1,000 m for the cutter pump • suitable for removal of debris • capable of operating in inaccessible areas such as lakes, swamps, bogs, etc. where typical equipment cannot operate		
Bonacavor	• bucket capacity of approximately 4 m^3 and a dredge reach limit of 23 m vertical and 15 m horizontal • precision dredging which removes sediments with minimal overdredge • removes sediments at near in-situ conditions using a backhoe	• production rate roughly 75 m^3/hr, based on a six hour day; exceeded 400 m^3/hr on some days for a project in the U.S.	• cost calculations are site-specific and could range from $6 to $87 per m^3 or more with an average of $47 per m^3

Equipment Option	Advantages	Disadvantages	Costs
	excavator which minimizes the volume of water to be treated • the excavator is mounted on top of a turret, on a spud-supported jack-up barge, providing a stable platform from which to operate • the slurry processing unit (SPU) eliminates 60 to 80% of the water that would normally be introduced by conventional pumping methods; this reduces the volume of water to be treated • lower level of contaminant exposure to crew and possibility of spillage since there would be fewer barge trips to shore since only larger debris would be transported by barge • minimal dispersion, although silt curtains may be required on certain sites		
Oozer Pump	• can be used for high-density (60 to 80% solids content by weight), thin-layer sediment dredging; however, some publications report lower solids contents of 25 to 40% by weight • dredge depth up to 18 m • the system provides for a uniform and continuous flow • does not agitate the bottom	• not capable of removing consolidated sediments unless equipped with cutter units, which would increase re-suspension • susceptible to clogging from debris, which increases re-suspension • capable of removing small cobbles, tin cans and bottles, but larger items such as steel plates and	• standard unit cost for dredging is approximately \$43 to \$68 per m^3 • unit price would change depending on site conditions such as sediment physical properties, water depth, the discharge distance and the volume of sediments • in addition, obstacles encountered during dredging and treatment of

Equipment Option	Advantages	Disadvantages	Costs
	sediment, thus preventing sediment from spreading during dredging • vertical accuracy of approximately 30 cm • has a production rate of approximately 250 to 600 m^3/hr	timber tend to get stuck in the cylinders	return water may increase unit costs
Pneuma Dredge	• capable of operating in shallow water (1.5 to 3 m) • potentially high solids content (25 to 80% by weight) compared to conventional hydraulic dredges • dredge production capacity ranging from 40 to 2,000 m^3/hr • available for use in Canada • maximum dredging depths over 10 m, depending on the unit selected	• does not operate on hard bottom materials (i.e., boulder field or compacted clay) • susceptible to clogging from debris, which increases re-suspension	• unit costs for dredging range from less than $17 up to $117 per m^3
High Solids Submersible Pump	• product literature states material up to 70% solids by weight can be moved • capable of operating in a large range of water depths (up to 45 m) • dredge production capacity up to 380 m^3/hr, however remedial dredging is typically significantly slower • easily transported resulting in low mobilization costs • can be used on several types of equipment which allow for	• solids content may be considerably less than maximum depending on site conditions and operational techniques • production rates on remedial projects are typically much lower than the maximum rate for navigational dredging or sediment transfer	• can be rented on a daily basis for short-term projects, or at a set price per cubic metre for larger projects

Equipment Option	Advantages	Disadvantages	Costs
	dredging in difficult access areas (i.e., docks, piers, marinas, etc.) • reduced turbidity because the pump operates submerged in the material • large open passages, replaceable top and bottom wear plates and heavy duty shaft/bearing configuration makes the pump suitable for dredging small rocks and debris		

Attachment D.10: Dredging Design Options: Description of Evaluation Criteria or Sub-criteria – 30 Percent

Criteria	Sub-criteria	Criteria or Sub-criteria Description
Effectiveness	Overall Protectiveness	This refers to the required effectiveness of the isolation structure to prevent the risk of exposure to public or the environment both in the short term and the long-term. This addresses long-term operations and maintenance associated with the isolation structure and the 200 year design life.
	Compliance with Design Standards and Other Requirements	The ECF isolation structures would have to meet the requirement of providing an impermeable barrier, based on fate and transport requirements, to prevent the movement of contaminants to the surrounding surface and groundwater. The isolation structures would also have to be compatible with the other facility components. For the east side of the facility, this necessitates compatibility with the design standards and requirements to accommodate the U.S. Steel Intake/Outfall and other U.S. Steel requirements for maintaining hydraulic flow, water quality, etc. The isolation structures also needed to be compatible with port facility requirements. This was a particular requirement for the south side of the ECF.
	Long-term Effectiveness and Performance	This criteria considers whether the option minimizes the risk presented by residuals (contamination left following the construction project) and the contaminants contained within the ECF.
	Short-term Effectiveness	The ability of the design option to: protect worker health and safety and the adjacent community; protect the environment during construction; meet the appropriate schedule duration/timing of the construction project; and harmonize the schedule with the other design elements.
	Reduction of Mass/Volume, Toxicity	The ability of the design element to optimize the PAH and metals mass

Criteria	Sub-criteria	Criteria or Sub-criteria Description
	and Mobility of Contaminants	captured and to reduce the impacts of volume, toxicity and mobility of contaminants during and post-construction. For example, because of the spatial requirements associated with berms, less available storage capacity for contaminated dredged material may be realized versus sheetpile wall structures, which require less surface area when used as part of the containment.
Implementability	Technical Feasibility	This criteria included a consideration of: the ease of constructing and operating the option in a cost-effective manner; the reliability of the option; the technical complexity of the option; compatibility with other design options; and the ease of future actions for remediation and repairs.
	Administrative Feasibility	The design option must be compatible with the legislative, policy and program requirements of the local, provincial and federal government agencies. This criteria also refers to the ease of obtaining permits and other approvals, and acceptance by stakeholders.
	Availability	This criteria refers to the availability of equipment, materials, services, etc. to implement, verify and monitor the effectiveness of the design alternative.
	Local/Provincial/Federal Government Standards and Stakeholder Input	This criteria includes a consideration of the relative probability of a design alternative to generate issues or concerns from participating government agencies due to one or more design elements.
Cost		The design option was evaluated relative to capital and periodic costs.

SEDIMENT MANAGEMENT DESIGN OPTIONS

D.3 Sediment Management/Dewatering/Water Treatment/Effluent Discharge/Air Emission Control Options

D.3.1 Initial Screening

D.3.1.1 Introduction

Subsequent to the environmental dredging to remove contaminated sediments (see Sections 1.10 and D.2), there are a number of other key project components that must be addressed (i.e., post-dredging components). Processes associated with sediment handling and management, dewatering and effluent water treatment require a careful evaluation of site conditions. In addition, sediment quality, estimated effluent concentrations, potential discharge requirements and treatability are all important considerations.

The following important objectives were considered at this stage in the overall design and engineering of the project:

- placing the sediment in the ECF using a method that minimizes discharges to the air, surface water and ground water;
- managing the sediment within the ECF in such a way as to minimize downstream effluent treatment requirements;
- dewatering the sediment using a method that minimizes discharges to the environment; and
- treating effluent water so that the water can be discharged in an environmentally sound and cost-effective manner.

The compatibility of post dredging components with other project components was also an important consideration. For example, the final design of sediment handling, dewatering and water treatment options was dependent on the selected dredging and transportation method, the expected water content of the sediment to be placed in the ECF and the level and type of contaminants present. The final selection of sediment dewatering and water treatment options needs to be coordinated with the design and the selected construction method for the ECF. The design of the containment system may consider measures to assist with dewatering and water treatment. For instance, the number and layout of ECF cells and the position and type of inlets and outlets will affect effluent quality.

This section provides information on the evaluation of options for sediment management, dewatering, water treatment, effluent discharge and air emission control. The following was assumed in the identification and evaluation of these options:

- the ECF will be constructed with a footprint that encircles and overlies the majority of the highest contaminated sediments; for the most part, sediment to be dredged and placed in the ECF will have lower PAH concentrations, in accordance with the sediment quality data available to date;

- sufficient space and time will be available for gravity dewatering within the ECF; the maximum volume of contaminated sediments to be dredged from the Randle Reef area and placed in the ECF will be 476,000 m^3;

- the ECF will be constructed using multiple cells in a multi-year, multi-stage construction life cycle;

- the Effluent Elutriate Test (EET) data are an acceptable indicator of projected effluent water quality from filling and dewatering of the proposed ECF; these data indicate:

  - ⇒ PAHs will be present at significant levels and will control treatability considerations
  - ⇒ PCBs will be present at very low levels in the effluent
  - ⇒ metals will be present at low levels in the effluent;

- direct discharge to both Hamilton Harbour and the local sanitary sewer are viable disposal options with appropriate on-site treatment to meet required discharge criteria.

Attachment D.11 provides an overview of issues and challenges relative to the options for sediment management, dewatering, water treatment, effluent discharge and air emission control.

D.3.1.2 Identification of Options and Alternatives

The following key facility components were evaluated:

- Sediment Management and Handling – Cell Configuration;
- Sediment Placement;

- Dewatering;
- Effluent Treatment;
- Effluent Discharge; and
- Air Emission Control.

Within each of these components, there exist numerous technologies or options that may be applicable for use for the Randle Reef project. Available options within each component were identified and evaluated relative to their potential use for the Randle Reef project.

Table D.10 outlines the options that were examined for the Randle Reef project for the facility components noted above. In addition, Attachment D.12 provides a detailed description of the options.

These options were evaluated and four alternatives were developed (see Section D.3.1.4). Figure D.4 illustrates the relationship between the facility components, options and alternatives.

D.3.1.3 Evaluation Criteria

The following general criteria were used to evaluate options for sediment management, dewatering, water treatment, effluent discharge and air emission control:

- service criteria (i.e., effectiveness);
- technical criteria (i.e., implementability); and
- cost.

Attachment D.13 provides a description of the specific criteria used for the evaluation of options for sediment management, dewatering, water treatment, effluent discharge and air emission control.

Table D.10: Sediment Management, Dewatering, Water Treatment, Effluent Discharge and Air Emission Control Options

Facility Component	Options
Sediment Management and Handling Options – Cell Configuration	• segregate and manage sediments in multiple containment cells based on sediment physical/chemical conditions (zoned ECF) • segregate and manage sediments in single containment cell based on sediment physical/chemical conditions • group all sediments and manage in separate containment cells, for effluent treatment processes • group all sediments and manage uniformly in a single containment cell

Facility Component	Options
Sediment Placement Options	• place dredge material directly into ECF using a long reach excavator • dump directly out of split hull scow into ECF • clamshell out of hopper or scow into ECF pump material out of hopper or scow in slurry form using a high solids pump • hydraulically pump directly into ECF • pump into holding tanks for later processing or to regulate flow
Dewatering Options	• in-place dewatering (unaided settling) • in-place dewatering with flocculant addition • in-place dewatering/sedimentation via multiple interior cells • in-place dewatering with bulking agents • in-place dewatering with bioremediation agents • lined dewatering basin • geotextile tubes • mechanical dewatering ⇒ centrifugation ⇒ filtration – belt filter press, plate and frame press ⇒ trenching
Effluent Treatment Options	• in-place gravity sedimentation • in-place filtration • in-place oil adsorbent booms and skimmers • oil water separator • dissolved air flotation • flocculation/clarification • filtration - gravity or pressure filter • adsorption – activated carbon or other media • bioremediation (bioreactor) • chemical precipitation
Effluent Discharge Options	• discharge to sanitary sewer • discharge directly to Hamilton Harbour • discharge to barge mounted treatment system
Air Emission Control Options	• minimize sediment exposure to air • minimize TSS in ponded water • treatment of dredged material to reduce volatile releases • impermeable floating cover • permeable treatment floating cover • temporary vapor control structure • miscellaneous controls

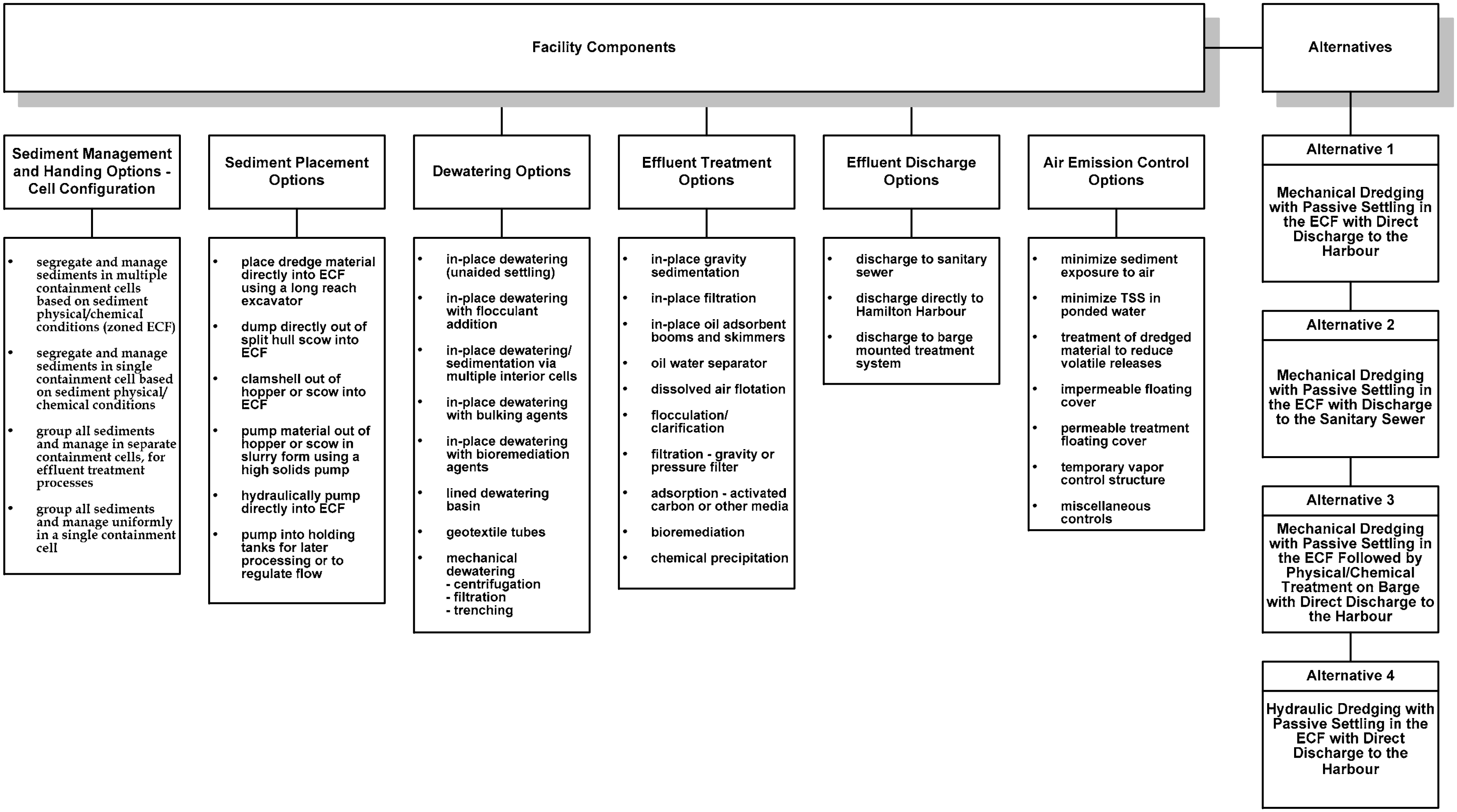
D.3.1.4 Evaluation of Options for Sediment Management, Dewatering, Water Treatment, Effluent Discharge and Air Emission Control

Options

Attachment D.14 presents the evaluation of options for sediment management, dewatering, water treatment, effluent discharge and air emission control. This evaluation was based on the evaluation criteria noted in Section D.3.1.3. Based on this evaluation, the following were retained:

Sediment Management and Handling Options – Cell Configuration	• segregate and manage sediments in multiple containment cells based on sediment physical/chemical conditions (zoned ECF) • segregate and manage sediments in single containment cell based on sediment physical/chemical conditions • group all sediments and manage uniformly in a single containment cell
Sediment Placement Options	• dump directly out of split hull scow into ECF • clamshell out of hopper or scow into ECF • hydraulically pump directly into ECF
Dewatering Options	• in-place dewatering (unaided settling) • in-place dewatering with flocculant addition • in-place dewatering/sedimentation via multiple interior cells • in-place dewatering with bioremediation agents • mechanical dewatering trenching
Effluent Treatment Options	• in-place gravity sedimentation • in-place oil adsorbent booms and skimmers • oil water separator • filtration - gravity or pressure filter • adsorption – activated carbon or other media • bioremediation (bioreactor) • chemical precipitation
Effluent Discharge Options	• discharge to sanitary sewer • discharge directly to Hamilton Harbour • discharge to barge mounted treatment system
Air Emission Control Options	• minimize sediment exposure to air • minimize TSS in ponded water • impermeable floating cover • temporary vapor control structure

Figure D.4: Relationship between Facility Components, Options and Alternatives



From these retained options, four alternatives were developed as possible scenarios for the Randle Reef project.

Alternatives

The following alternatives were developed:

- Alternative 1 - Mechanical dredge/ environmental clamshell out of hopper into ECF/ in-place dewatering in the ECF (with or without flocculants)/discharge effluent over a weir with an overflow pipe to an outfall/diffuser in Hamilton Harbour;

- Alternative 2 - Mechanical dredge/ environmental clamshell out of hopper into ECF/ in-place dewatering in the ECF (with or without flocculants)/discharge effluent water to the Woodward Avenue Waste Water Treatment Plant;

- Alternative 3 - Mechanical dredge/ environmental clamshell out of hopper into ECF/ in-place dewatering in the ECF (with or without flocculants)/pump effluent to a physical/chemical/biological treatment plant on a barge/ discharge effluent to the Harbour; and

- Alternative 4 - Hydraulic dredge directly into ECF / in-place dewatering in the ECF (with or without flocculants)/discharge effluent over a weir with an overflow pipe to an outfall/diffuser in Hamilton Harbour.

These recommended combined alternatives are described in greater detail in Table D.11.

Air emission control options are incorporated into these options. For example, the hydraulic dredging alternative incorporates air emission control features by minimizing exposure of sediments to the air since sediments are transferred inside a pipeline and do not have direct contact with the air in the transfer (particularly it is a submerged discharge of the sediment into the ECF). The addition of flocculants will also serve an air emission control function in that this further reduces the total suspended solids.

Air emission controls were also further considered in the detailed evaluation of sediment management options. The results of air emission modeling studies were available for the detailed evaluation.

D.3.1.5 Results of Evaluation of Alternatives for Sediment Management, Dewatering, Water Treatment, Effluent Discharge and Air Emission Control

The alternatives noted in Table D.11 represented the range of possible approaches that may be appropriate for the Randle Reef project, based on the outcomes of ongoing effluent elutriate testing (EET). Alternatives 1, 2 and 3 assumed mechanical dredging

Table D.11: Recommended Combined Alternatives

Alternative	Description of Alternative
Alternative 1 - Mechanical Dredging with Passive Settling in the ECF with Direct Discharge to the Harbour	Sediment would be removed using mechanical dredging and then the sediment would be offloaded from barges or scows and placed into the interior cell of the multi-cell ECF using a clamshell bucket. Sediments would be placed in the outer cell of the ECF either by direct barge disposal (i.e., bottom dumping) or by rehandling using a clamshell bucket. Passive dewatering and solids settling would take place in the ECF. Interior cell walls would be constructed with overflow weirs, so that sequential treatment of the decant water takes place. If possible, based on the dredging plan, sediments would be segregated and the highest concentration sediments would be placed in the centre cell of the ECF to reduce long-term migration of contaminants. This would further reduce contaminant levels in the effluent at the outlet of the ECF. Discharge of effluent from the ECF would be through a discharge box with an adjustable weir and an outfall/diffuser. The use of the discharge box with an adjustable weir would provide better hydraulic control and more uniform effluent quality. The use of the outfall/diffuser would provide better mixing of the effluent and receiving water and reduce the potential for environmental impact due to the discharge. A properly designed diffuser in a harbour setting may achieve a dilution of greater than 100-fold.
Alternative 2 - Mechanical Dredging with Passive Settling in the ECF with Discharge to the Sanitary Sewer	Alternative 2 would be selected if Alternative 1 were eliminated due to regulatory, treatability or other concerns. Sediment would be removed using mechanical dredging and then the sediment would be placed into the multi-cell ECF using a clamshell bucket. Sediments would be placed in the outer cell of the ECF either by direct barge disposal (i.e., bottom dumping) or by rehandling using a clamshell bucket. Passive dewatering and solids settling would take place in the ECF. The interior cell wall would be constructed with overflow weirs, so that sequential treatment of the decant water takes place. If possible based on the dredging plan, sediments would be segregated and the more highly contaminated sediments would be placed in the center cell of the ECF to reduce long-term migration of contaminants. This would further reduce contaminant levels in the effluent at the

Alternative	Description of Alternative
	outlet of the ECF. Discharge of effluent from the ECF would be through a floating pump intake on the surface of the ECF to the local sanitary sewer. A skid-mounted pump station would be leased and located upland of the ECF. The effluent would pass through the existing sanitary sewer system and be treated at the Woodward Avenue Wastewater Treatment Plant. Prior to discharge to the sewer, the following conditions would apply: • approval of discharge point into the sewer system; and • discharge would be limited to dry weather to prevent overflow of sewers to the Harbour.
Alternative 3 - Mechanical Dredging with Passive Settling in the ECF Followed by Physical/Chemical Treatment on Barge with Direct Discharge to the Harbour	Sediment would be removed using mechanical dredging and then the sediment would be placed into the multi-cell ECF using a clamshell bucket. Sediments would be placed in the outer cell of the ECF either by direct barge disposal (i.e., bottom dumping) or by re-handling using a clamshell bucket. Passive dewatering and solids settling would take place in the ECF. The interior cell walls would be constructed with overflow weirs, so that sequential treatment of the decant water takes place. If possible, based on the dredging plan, sediments would be segregated and the more highly contaminated sediments would be placed in the center cell of the ECF to reduce long-term migration of contaminants. This would further reduce contaminant levels in the effluent at the outlet of the ECF. Discharge of effluent from the ECF would be through a floating pump intake on the surface of the ECF to a flocculation tank located on a barge. The effluent would pass through a series of unit processes, such as clarification, filtration and carbon adsorption, to remove the contaminants as required for discharge to the Harbour.
Alternative 4 - Hydraulic Dredging with Passive Settling in the ECF with Direct Discharge to the Harbour	Contaminated sediments would be dredged from Randle Reef using a hydraulic dredge such as a pneuma pump or cutter suction dredge. Material would be pumped directly from the dredge to the ECF via a pipeline. Passive dewatering and solids settling would take place in the ECF. Interior containment cell(s) would be constructed with overflow weirs, so that sequential treatment of the decant water takes place. If possible, based on the dredging plan, sediments would be segregated and the more highly contaminated sediments would be placed in the interior cell of the ECF to

Alternative	Description of Alternative
	reduce long-term contaminant migration. This would further reduce contaminant levels in the effluent at the outlet of the ECF. Discharge of effluent from the ECF would be through a discharge box with an adjustable weir and an outfall/diffuser. The use of the discharge box with an adjustable weir would provide better hydraulic control and more uniform effluent quality. The use of the outfall/diffuser would provide better mixing of the effluent and receiving water and reduce the potential for environmental impact due to the discharge. A properly designed diffuser in a harbour setting may achieve a dilution of greater than 100-fold.

while Alternative 4 assumed hydraulic dredging. All of the alternatives assumed that the sediment would be placed in multiple cells. These assumptions were based on the current project status and would need to be confirmed in the detailed evaluation stage.

Alternative 1 is probably the least costly approach for handling the dewatering effluent water. However, the discharged water would likely not meet the PWQOs (and/or CWQGs) at the edge of the mixing zone. Based on the 95-percentile effluent estimate concentrations and a best-case dilution ratio of 100, naphthalene would still exceed the PWQO by an order of magnitude and some metals and PAHs would exceed by several orders of magnitude. Therefore, Alternative 1 has a low probability of meeting all the regulatory requirements. However, Alternative 1 is retained for comparison purposes as the lowest cost alternative. The actual effectiveness will be confirmed through EET and Bench-Scale Treatability Testing.

Alternative 2 is probably the second least costly approach for dewatering the dredged sediment. Alternative 2 would have a higher probability of meeting all regulatory requirements than Alternative 1. Under this alternative the discharged water would have to meet the Hamilton sewer use by-law limits. Based on the 95-percentile effluent estimate concentrations, only copper and zinc would exceed the sewer use by-law limits. The magnitude of the exceedences would be less than an order of magnitude. Actual effectiveness will be confirmed through EET and Bench-Scale Treatability Testing.

Alternative 3 is the most costly of the four alternatives presented for dewatering dredged sediment. It is likely that alternative 3 would be selected only if Alternatives 1 and 2 were eliminated due to regulatory, treatability or other concerns.

Alternative 4 provides a faster production rate than Alternatives 1, 2 and 3. However, dredge and pipeline mobilization and maintenance may increase production costs. Also, due to the large volume of water added to the process via hydraulic dredging, more volumetric capacity is required in the design of the ECF during filling operations. The dredged material tends to have a higher moisture content and, therefore, the treatment of more decant water is expected.

All alternatives were carried forward to the detailed evaluation.

D.3.2 Detailed Evaluation – 30 Percent Design

D.3.2.1 Introduction

Sediment management options were further developed through the 30 percent design level analysis. The analysis was based on a review which utilized the comprehensive data set (the data set of all the historical and recent environmental sampling completed for Randle Reef), bench scale treatability testing, bench scale fate and transport testing and air modeling results. Various options were analysed for each of five sediment management sub-elements: sediment management and handling; sediment placement; sediment dewatering; effluent treatment; effluent discharge; and air emissions control.

The analysis of the comprehensive data set provided the necessary information to prioritize subareas for sediment remediation, calculate contaminant mass to be removed in each subarea dredged, and to develop horizontal and vertical dredge limits to optimize the reduction of chemically impacted and toxic sediments in the project area (see Section 4.1.7). These provided the required information to assess the various options to address the contaminant levels to be dredged and the associated volumes of material to be dredged, as well as estimate the potential discharges. The bench-scale treatability studies and bench-scale fate and transport work was completed to determine treatability, characteristics of the post-dredging sediment and the ECF effluent. Bench–scale fate and transport testing was done to determine sediment leachate characteristics both in place and during dredging. The results from the air emissions modeling and other studies (e.g., non-aqueous phase liquid (NAPL)) were used to determine the appropriate options to carry forward for the 100 percent design. Details of the bench-scale treatability options and fate and transport are provided in SUPPORTING DOCUMENT E.

Details of the NAPL survey are provided in SUPPORTING DOCUMENT E. The determination of the presence of NAPL raises certain issues that require consideration during design. For instance, during dredging, NAPL sheens and droplets can float to the surface of the water in the dredged material receiving area or can be released to the water column during dredging. During dredging, the sheens or droplets can be managed by dredging within enclosures and/or mobilizing a clean up crew, vessel and equipment (i.e., skimmers, absorbents) to stand by during dredging. Similarly, for sediment management, the presence of NAPL can be managed by enclosing the receiving area in smaller cells, allowing for collection and/or removal treatment.

Another technical consideration to address as part of sediment management is to ensure that efficient consolidation to support proposed end uses can be achieved with the selected option. For this project, this means that the facility will be subdivided or evaluated appropriately for placement of dredged material, that sediment dewatering promotes consolidation and increased strength of the sediment, and that the settling and polishing of the effluent to remove solids and sediment contaminants meets discharge requirements and manages potential air emissions.

D.3.2.2 Identification of Options

The recommended options from the initial screening were retained and carried forward for the sub-elements of the sediment management design (i.e., ECF sub-division, sediment dewatering, effluent treatment, effluent discharge and air emissions control).

For the ECF subdivision, four internal cell configurations were evaluated with respect to the expected effluent water quality and TSS removal (see Figure D.5). These cell configurations were:

- Alternative 1 – two internal cells;

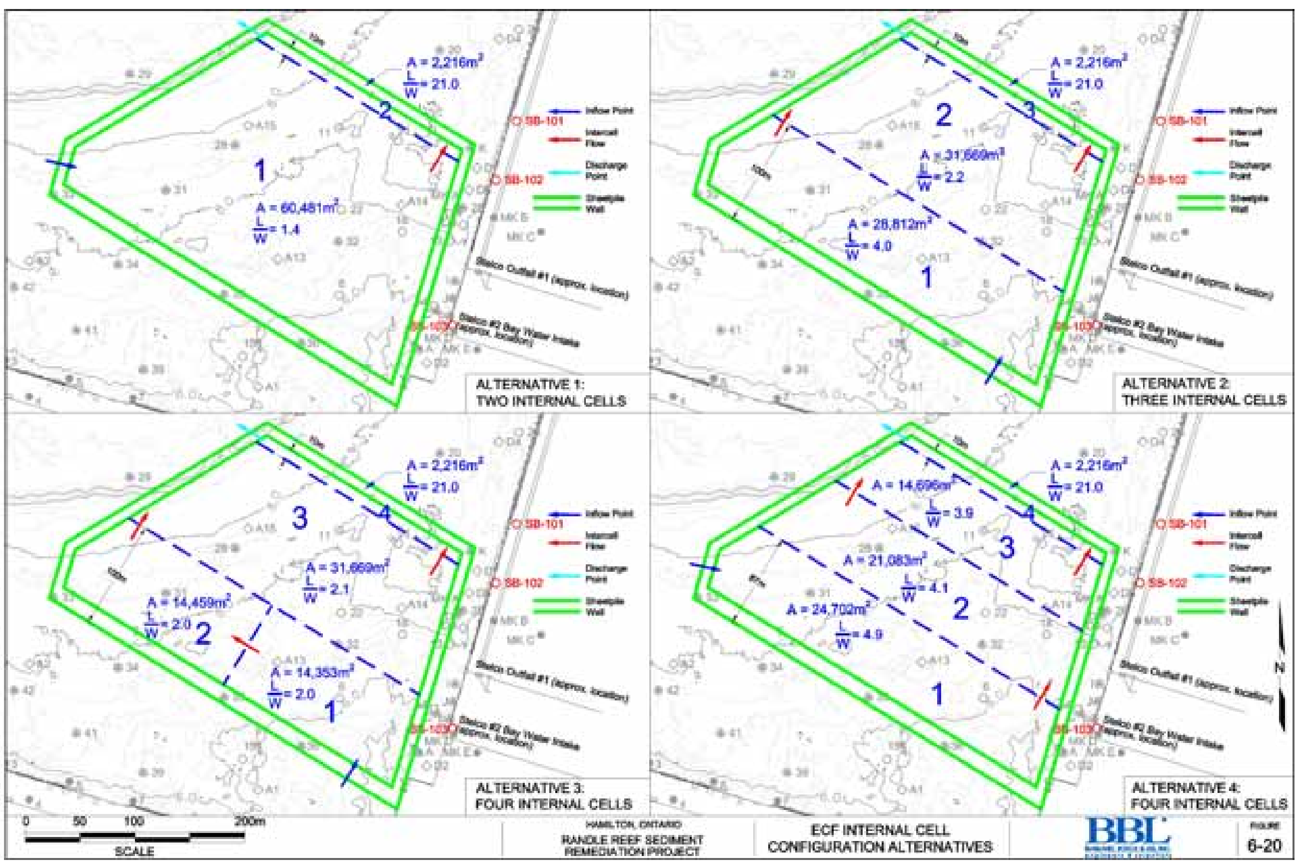
- Alternative 2 – three internal cells;
- Alternative 3 – four internal cells; and
- Alternative 4 – four internal cells.

For the sediment dewatering, the initial options were reviewed against some of the study outcomes. Certain options were then eliminated. Based on the column settling test (CST), the addition of flocculants directly to bulk sediment was shown to not be cost-effective and, therefore, the option with in-place dewatering with flocculant addition was eliminated. Passive in-place dewatering with bioremediation agents was also eliminated as one of the initial design options considered during production dredging given its incompatibility with NAPL.

The remaining two options that were retained for the 30 percent design for sediment dewatering were:

- in-place dewatering (unaided settling); and
- in-place dewatering/sedimentation via multiple interior cells.

Figure D.5: Cell Configurations



For effluent treatment, the following were considered:

- in-place gravity sedimentation;
- polymer-assisted gravity sedimentation in a polishing cell;
- in-place oil adsorbent booms and skimmers; and
- mechanical treatment plant (which may consist of one or more of the following process options – oil-water separation, filtration, activated carbon adsorption and chemical precipitation).

For effluent discharge, discharge to sanitary sewer and discharge directly to Hamilton Harbour were reviewed.

For air emissions control, the following were considered:

- minimize sediment exposure to air;
- minimize TSS in ponded water;
- employ an impermeable floating cover; and
- employ a temporary vapor-control structure.

D.3.2.3 Evaluation Criteria

The options were evaluated considering the results of various studies, the various data analyses completed and the design standards, objectives and requirements that were developed in relation to these reviews.

D.3.2.4 Evaluation of Options

For the design analysis at 30 percent, the following were considered:

- short-term water quality during dredging;
- the fate and transport of groundwater discharging from the U.S. Steel property;
- the fate and transport of groundwater discharging from the ECF;
- water quality characteristics of the ECF effluent; and
- air emissions.

Details on the design analysis are provided in the Basis of Design report (Arcadis BBL, 2006). The conclusions from these analyses were used to evaluate the options.

For the air emissions component, the potential for discharges to air during sediment management activities was evaluated using a United States Army Corps of Engineering (USACE) methodology. The USACE Tier I- Tier IV Approach (USACE, 2003) evaluation was completed and a review of a previous Hamilton Harbour dredging pilot test (Unkerskov, 1993) and other studies (MDA, 1998) was done. Based on the Tier I analysis, it was determined that further evaluation was required to reach a decision regarding volatile emissions and a Tier II analysis was recommended. All of the air emission control options were carried forward to the 100 percent design.

D.3.2.5 Results of Evaluation of Options

Based on the expected effluent water quality and TSS removal from the four alternative configurations for the ECF subdivision, the results indicate that the use of internal cells will not have a significant effect on effluent water quality. Segregation and placement of the higher concentration sediments into the ECF first, to maximize settling efficiency and contaminant removal, will be effective at controlling effluent water quality.

For ECF subdivision, an analysis with respect to the expected effluent water quality and TSS removal indicated that the use of internal cells will not have a significant effect on effluent water quality. Segregation and placement of the higher concentration sediments into the ECF first, to maximize settling efficiency and contaminant removal, will be effective at controlling effluent water quality. Based on these results, the following slightly modified design options were retained:

- segregate and manage sediments in a single containment cell (similar to Alternative 1) and place Priority 1 and 2 sediments into the ECF first; and
- segregate and manage sediments in two internal containment cells (similar to Alternative 2) and place Priority 1 and 2 sediments into the ECF first.

Other benefits to Alternative 2 were identified, including:

- provides greater certainty that the highly contaminated sediment is isolated in a specific area within the ECF;
- reduces the potential for short-circuiting of high TSS supernatant to the polishing cell by having a physical control on the discharge location; and
- allows sediment placed in the port facility area to undergo consolidation earlier in the filling process and more rapidly than a single cell.

Given the analysis and the above advantages, the preferred design option is to segregate and manage sediments in two internal containment cells (similar to Alternative 2) and to place Priority 1 and 2 sediments into the ECF first.

For sediment dewatering, in-place dewatering will be used throughout the production dredging phase. Other methods (e.g., trenching, liquid removal by pumping, wick drains) to accelerate dewatering at the end of dredging can be considered at the 100 percent stage of design. Of the two options retained for the 30 percent design, the in-place dewatering/sedimentation via multiple interior cells is an extension of in-place dewatering (unaided settling) that constrains the discharge flow to improve hydraulic parameters and, therefore, increases TSS removal. This design option is preferred because of the improvement it offers, as well as for reducing the risk that dredge discharge is short-circuited to the effluent discharge point. The preferred design option for sediment dewatering is in-place dewatering/sedimentation via multiple interior cells.

The water quality evaluation shows that in-place gravity sedimentation alone will not achieve the PWQOs (and/or CWQGs) for direct discharge to Hamilton Harbour. The effluent treatability tests show that addition of flocculants is very effective at reducing TSS but that the effluent may not meet all PWQOs. Test results also indicate that effluent polishing with granulated activated carbon (GAC) was effective at removing dissolved contaminants and could meet PWQOs (and/or CWQGs). All of the design options for effluent treatment were retained for future assessment (i.e., at the 100 percent design stage) since they are all likely to be used at different stages of the process.

The option to discharge effluent to the sanitary sewer was eliminated because the flow to the sewer during dredging would be in excess of 5 million gallons per day, which would exceed the sewer capacity. This option could potentially be reintroduced at a later stage of design if the capacity of the sewer were to be increased or the effluent could be routed to a trunk sewer (larger size). Therefore, direct discharge to Hamilton Harbour was the preferred design option.

For air emissions controls, all of the design options were retained since further modeling studies are required to develop the design standards and criteria, and the associated requirements before an assessment of the air emission control options can be completed. Further consideration of air emission control options was undertaken at the 100 percent design stage.

D.3.3 Detailed Evaluation – 100 Percent Design

D.3.3.1 Introduction

Further evaluation for the 100 percent design for sediment management included completing more detailed design work on the configuration of the ECF and evaluating the flow, placement and treatment of the dredged material and the effluent throughout the initial, production and final dredging stages. The 100 percent design included an analysis of the effluent water quality during the filling and treatment process, an analysis of the conditions and features of the ECF during filling and treatment, and the development of the proposed discharge limitations for discharge from the ECF to Hamilton Harbour. The monitoring requirements associated with sediment management were also outlined for start-up, construction and compliance. Costs were also developed.

D.3.3.2 Identification of Options

The further development of the ECF cell configuration, the placement of dredged material in the ECF and the freeboard requirements were identified as part of the development of the 100 percent design. Freeboard is the distance between the surface of the water column and the top of the inner steel sheetpile wall. A minimum freeboard distance is necessary to keep the decant water from overtopping the sides and spilling into the space between the double walls.

Development of the effluent discharge limitations was completed by considering the PWQOs, CWQGs and analytical detection limits. The proposed discharge limits (outlined in Table D.12) are set at the PWQOs or CWQGs with the exception of constituents having analytical detection limits greater than the PWQOs or CWQGs. In those cases, the proposed discharge limit is the analytical detection limit. A further review of the analytical detection limits used to establish background water quality and appropriate discharge criteria will be completed during the final stages of the 100 percent design. At that point, the proposed discharge limits for TSS and pH are based on typical Certificates of Approval issued by the Ministry of the Environment. Neither of these two parameters is expected to be the limiting factor for treatment performance. The proposed discharge limits will be met by conducting weekly monitoring of ECF effluent quality during production dredging. In addition to the limits, the effluent should not contain oil at concentrations that: (1) can be detected as a visible film, sheen or discoloration on the surface; (2) can be detected by odour; (3) can cause tainting of edible aquatic organisms; (4) can form deposits on shorelines and bottom sediments that are detectable by sight or odour; or (5) are deleterious to resident aquatic organisms.

The internal configuration of the three cells in the ECF is shown in Figure D.6. Two internal cells will be constructed within a partial wall that has a top elevation approximately 6 m (20 ft) below the water level. Cell 1 will be constructed under the footprint of the port facility along the south side of the ECF and Cell 2 will be constructed adjacent to Cell 1 to the north. A final settling cell will be used to facilitate polymer-assisted removal of suspended solids prior to mechanical treatment. The final settling cell will be placed between the double walls along the north side and the section of the west side of the ECF that borders Cell 2. The internal wall will be constructed of steel sheetpile to an approximate elevation of -5.5 m Chart Datum, and will extend 0.5 m (1.5 ft) to 3 m (10 ft) above the existing sediment surface. The wall will be temporarily in place until after completion of the ECF. The volume of Cell 1 up to -5.5 m Chart Datum is 51, 860 m^3 and for Cell 2, to -5.5 m Chart datum with a volume of 77,458 m^3. The surface area of the ECF is 62,250 m^2. Once the ECF walls are constructed, water that is approximately equal to the lake level outside will remain within the walls, at an estimated elevation of +0.5 m Chart Datum.

During initial dredging, Subarea 2 dredged material will be placed by pumping or side-casting the material. The pump outlet or the bucket will be submerged during the release of the dredged materials to reduce air emissions.

The sequence of dredging and the placement of the dredged material were determined in conjunction with the development of the dredge plan. Cell 1 will contain the sediments with the highest contaminant concentrations. After the placement of material

Table D.12: Proposed Limits for Discharge to Hamilton Harbour

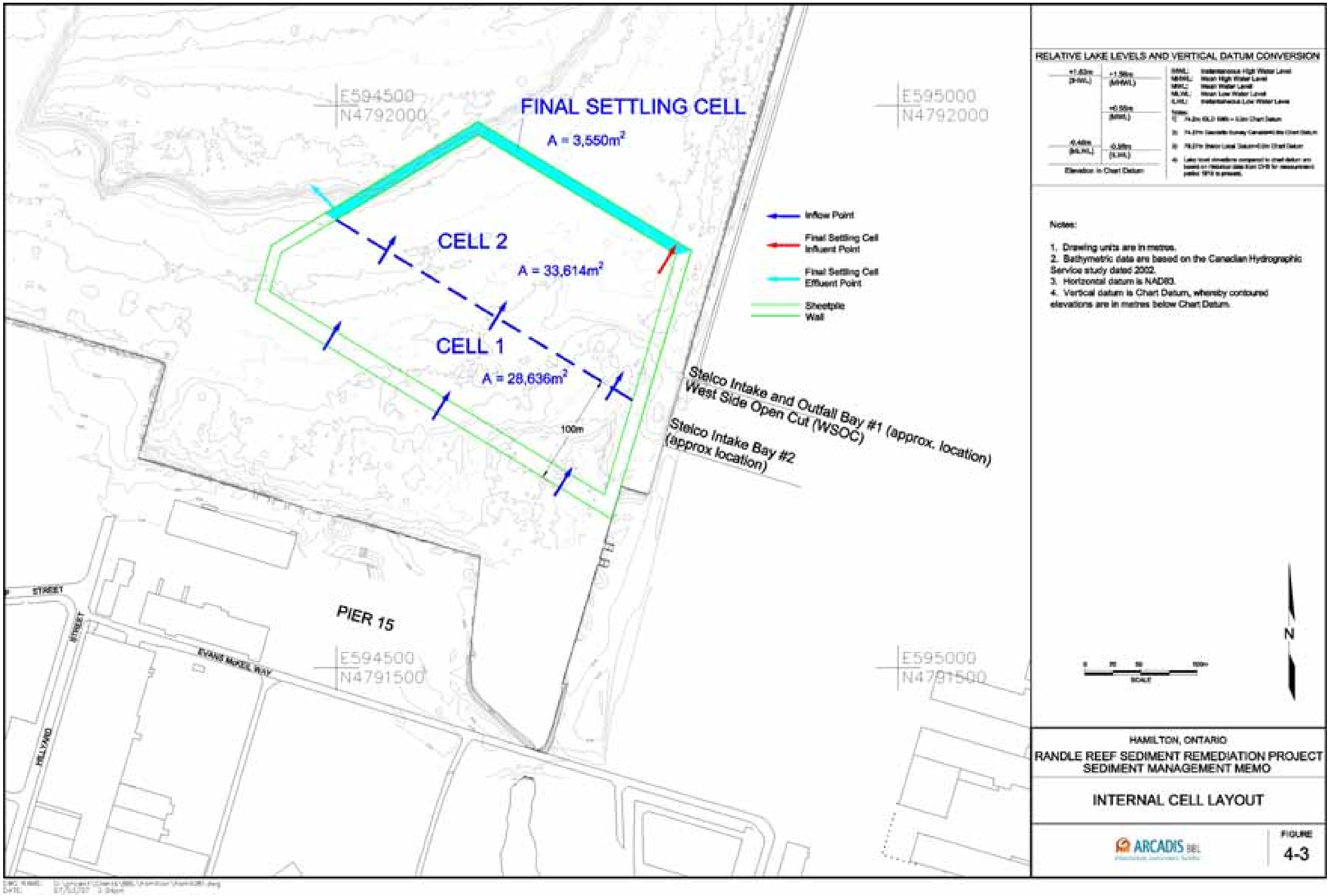
TABLE 2-2
PROPOSED LIMITS FOR DISCHARGE TO HAMILTON HARBOUR

TASK 2.1.4 SEDIMENT MANAGEMENT
RANDLE REEF SEDIMENT REMEDIATION PROJECT
HAMILTON HARBOUR

	Ontario Provincial Water Quality Objectives (PWQOs)	Hamilton Harbour Background Water Quality[1]		Method Detection Limit[2]	Proposed Discharge Limit
Conventionals in mg/L, except pH					
TSS	NA	5	S	2	25
pH	6.5 - 8.5	NA		NA	6.0 - 9.0
Total Metals in µg/L					
Aluminum	75	29	H	2.1	NA
Arsenic	100	ND	H	0.7	100
Beryllium	1,100	ND	H	0.7	1,100
Boron	200	58	H	3	200
Cadmium	0.2	1.2	S	0.07	0.2
Chromium	8.9	4.2	S	0.8	8.9
Cobalt	0.9	1.4	H	0.5	0.9
Copper	5	2	H	1.5	5
Iron	300	160	S	5.5	300
Lead	25	5	S	1.1	25
Molybdenum	40	5	H	0.7	40
Nickel	25	2	H	0.5	25
Silver	0.1	ND	H	0.1	0.1
Vanadium	6	ND	H	0.5	6
Zinc	30	27	S	2.5	30
Semivolatiles in µg/L					
1-Methylnaphthalene	2	ND	H	0.1	2
2-Methylnaphthalene	2	ND	H	0.1	2
Acenaphthene[3]	5.8	ND	H	0.05	5.8
Acenaphthylene	NA	ND	H	0.05	NA
Anthracene	0.0008	ND	H	**0.05**	**0.05**
Benz(a)anthracene	0.0004	ND	H	**0.05**	**0.05**
Benzo(a)pyrene[3]	0.015	0.061	S	0.01	0.015
Benzo(b)fluoranthene	NA	ND	H	0.05	NA
Benzo(ghi)perylene	0.00002	ND	H	**0.1**	**0.1**
Benzo(k)fluoranthene	0.0002	ND	H	**0.05**	**0.05**
Chrysene	0.0001	ND	H	**0.05**	**0.05**
Dibenz(a,h)anthracene	0.002	ND	H	**0.1**	**0.1**
Fluoranthene	0.0008	ND	H	**0.05**	**0.05**
Fluorene	0.2	ND	H	0.05	0.2
Indeno(1,2,3-cd)pyrene	NA	ND	H	0.1	NA
Naphthalene	7	0.22	S	0.05	7
Perylene	0.00007	ND	H	**0.05**	**0.05**
Phenanthrene	0.03	ND	H	**0.05**	**0.05**
Pyrene[3]	0.025	ND	H	**0.05**	**0.05**

Notes:
1. Source of data is indicated by "S" or "H"
H = Lake Ontario surface water data from December 3, 2004 grab samples, from BOD (BBL 2006) Appendix H, Table H-4
S = Average Stelco influent concentrations for 1992 to 2004 at Bayshore Pumphouse #2, except for cadmium which is average from 2003
2. Laboratory detection limits were reported by Maxxam Analytics, Inc. in Mississauga, Ontario.
3. There is not a PWQO for this compound; therefore, the applicable Canadian Water Quality Guideline (CWQG) is listed.
mg/L = milligrams per litre
µg/L = micrograms per litre
TOC = total organic carbon
TSS = total suspended solids
ND = Non-detect
NA = not available or no limit established
Bold indicates detection limit/proposed discharge limit is greater than or equal to PWQO/CWQG.

Figure D.6: Internal Cell Layout



from Subarea two, Cells 1 and 2 will be filled to the top of the internal cell wall in the following order:

- Subarea 5 will be placed into Cell 2;
- Subarea 7 will be placed into Cell 2; and
- Subarea 3 (with the highest overall contaminant concentrations) will be placed into Cell 1.

After the elevation of the dredged material reaches the top of the internal cell wall in Cell 2, dredged material will be placed to encourage even distributions of sediments as well as to keep the higher contaminant concentrations within the footprint of Cell 1. Dredged materials will be placed either along the north wall of the ECF using multiple submerged dredge slurry inlets or along the general location of the internal cell wall. This will allow sediments to accumulate more evenly across the entire ECF and reduce the potential for differential settlement, according to the recommendations from the geotechnical evaluation. In general, the placement of the slurry, sequence and location is as follows:

- Subareas 4 and 9 will be placed into the Cell 1 footprint;
- Subareas 9, 10, and 11 will be placed into the Cell 2 footprint;
- Subareas 12 and 13 will be placed into the Cell 1 footprint;
- Subareas 14, 15 and 16 will be placed into the Cell 2 footprint; and
- the remaining subareas will be placed across the entire ECF.

The freeboard for the different stages of the project was analysed. A minimum freeboard is required to be maintained to keep the decant water from overtopping the sides of the inner steel sheetpile wall and spilling into the areas between the double walls. The distance between the walls in the direction of the predominant wind speed is limited to less than 500 m for a westerly wind, defined as the fetch. In the Harbour, under extreme conditions, wind-induced waves could reach a height of 1.0 m (3 ft). Given the fetch, the maximum wave height is estimated to be less than 0.6 m (2 ft). As a conservative estimate, the assumed minimum freeboard is 1.0 m.

During the majority of the dredging, the water level within the ECF is estimated to be similar to the lake (i.e., +0.5 m Chart Datum). The top of the ECF sheetpile wall is +3.0 m Chart Datum, the associated freeboard for the majority of the project is 2.5 m (8 ft). The minimum freeboard will be critical during the initial and final dredging. Initial dredging will raise the water levels, and the water level will be at a maximum of +1.5 m Chart Datum, leaving +1.5 m of freeboard. It will be necessary to monitor the water level during the filling. When the elevation of placed dredged material reaches -0.5 m Chart Datum, the water level will be raised to +2.0 m Chart Datum. This maintains the minimum freeboard. There are two conditions to decrease the requirements. These include having sufficient controls in place to prevent overtopping during production dredging and for controls during the final stages of filling to achieve the end design.

Dredging of Subarea 2 is not considered intrusive in-water work and, therefore, can begin prior to July 16 of the first dredging season. The decant water treatment system will be required to start up when the minimum freeboard within the ECF is reached.

During production dredging, the cutterhead hydraulic dredge will be used. Possible flow rates were reviewed for some Ontario-based dredging contractors, and a conservative dredge pump flow rate was estimated based on the information (i.e., 1,250 m^3/hr and an in-situ sediment production rate of 145 m^3/hr, with an associated solids content of approximately 15% by weight). The window for production dredging and the evaluation was determined to be from July 16 to November 12 (to account for the fish window, when the Harbour is frozen over, and during extreme weather).

Climate data were reviewed to verify the schedule for decant water treatment and to consider times when cold weather would need to be considered or times when frost protection could be required.

Following treatment in the ECF and final polishing in the final settling cell, the decant water will be pumped to a mechanical treatment plant consisting of sand filters and granular activated carbon (GAC) treatment. Treated effluent will be discharged directly to Hamilton Harbour.

D.3.3.3 Review of Objectives and Studies

Further work was completed to determine the required levels of effluent treatment for different parts of the treatment train. Confirmation tests were conducted to determine the appropriate polymer and dosage for full-scale operation for effluent treatment. GAC filtration and adsorption tests were conducted to determine the effectiveness of filtration/adsorption media at polishing the ECF effluent.

As part of the effluent quality analysis, decant water treatment for the three principal water treatment processes for the project (i.e., passive settling in the ECF, polymer-assisted settling in the final settling cell, and mechanical treatment using sand filtration and GAC absorption) was modeled in a three step process. The three steps included:

- identifying the dredging characteristics, the ECF characteristics and contaminants of interest;
- estimating the TSS concentrations at each of the major stages of the filling; and
- estimating the effluent contaminant concentrations.

The dredging volumes, rates and sequence were identified for initial dredging and production dredging. The model was not used to predict decant water quality during final dredging. Final dredging refers to the filling of dredged material in the ECF above the final target level of +0.5m chart Datum. Final dredging will require modifications to the sediment management approach for production dredging.

During initial dredging, either a crane-mounted high-solids pump or a mechanical dredge will be used. The dredged materials will be placed into the ECF, with the expected increase in water level of approximately 0.5 to 1.0 m for the high-solids pump, and or less than 0.5 m for the mechanical dredge. This rise in water level can be accommodated in the ECF without water treatment during the first stage of initial dredging. After the final settling cell and mechanical treatment systems are brought on line, this water will be treated.

For production dredging, a hydraulic cutterhead will likely be used. A conservative dredge pump flow rate of 1,250 m^3/hr and an in-situ sediment production rate of 145 m^3/hr, with an associated solids content of approximately 15% by weight were used as model inputs.

The TSS concentration in the ECF effluent was estimated based on the hydraulic residence time and column settling test results. TSS concentrations in the final settling cell and the sand filter were estimated based on percent removals obtained during treatability testing. In the GAC effluent, TSS concentration is assumed to be equal to zero or non-detectable, based on adsorption characteristics of the GAC.

The contaminant concentrations in the ECF, final settling cell and sand filter effluent were estimated based on the contaminant concentration/TSS fraction in the supernatant water. The equation used to estimate this was modified since the particulate and dissolved forms were not differentiated from the dissolved forms. The effects of volatilization and biodegradation on contaminant concentration were considered negligible and were not included in the modeling.

The contaminant concentration in the GAC effluent was estimated using percent removals from the treatability tests. The GAC effluent chemical concentrations were then compared to the proposed discharge limits to evaluate whether a given ECF cell configuration and processing train will result in ECF effluent water that meets discharge limits, assuming no mixing zone at the point of discharge.

The hydraulic residence time was reviewed to determine if the appropriate settling is achieved throughout dredging. The ponded water volume available for solids settling decreases with the filling of the ECF. The methodology for assessing the hydraulic residence time and the hydraulic efficiency factor used at the 30 percent was determined to not be applicable to the 100 percent design level. Estimating the effective ponded volume between the dredge slurry inlet and the effluent outlet was determined to be more appropriate to assess the potential for inefficiencies and dead zones within the ECF. During placement of dredged materials within the Cell 1 footprint, the effective ponded water volume will be 80% of the total volume. During placement of material in the Cell 2 footprint, the effective ponded volume will be 40% of the total volume. The calculated residence time will range from 240 hours near the beginning of production dredging to 30 hours when the minimum ponded depth of 1.5 m has been reached. Near the end of filling, the ponded volume will be insufficient for effective passive settling, based on maintaining a required 1.5 m of ponded depth at all times.

A final settling cell will be used to settle out low levels of TSS that remain in the decant water after it passes through the internal ECF cells to reduce the extent of subsequent mechanical treatment. The final settling cell will extend along the north and west sides of the ECF, in the space between the double steel sheetpile walls. After initial dredging of Subarea 2, the space between the walls will be backfilled with quarry rock or a similar material, leaving 3 m (10 ft) of water column above the backfill. The top of the water column in the settling cell will be 0.5 m less than the level of the Harbour. A hydraulic analysis was done to determine whether the available volume in the settling cell is sufficient. Based on the expected influent rates (1250 m^3/hr) and the size of the cells, a velocity of 42 m/hr was calculated. This velocity is significantly below the maximum allowable velocity of 3.3 m/hr for polymer assisted settling to occur. The residence time was estimated at 8.5 hours, based on the total calculated ponded volume of 10,650 m^3/hr.

In estimating TSS concentrations, the settling characteristics within the cells in the ECF and within the mechanical treatment system were determined using different contaminant concentrations, based on the worst case (Composite II) concentrations. The polymer confirmation tests indicated that in the final settling cell, the nominal TSS removal effectiveness will be 90%, with a minimum TSS concentration of 5 mg/L. The effectiveness of the sand filters for TSS removal efficiency was estimated at 80%, and predicts the TSS leaving the GAC unit will be non-detectable.

Contaminant concentrations for each contaminant were computed as the arithmetic mean of all chemical data for subareas, as developed during the dredging design, except for the following:

- cadmium was estimated using the arithmetic average of the other metals in each subarea since cadmium concentrations by subarea were not available;
- for subarea 7, numbers were extrapolated from the adjacent subareas for metals; and
- for subarea 9, the PAH extrapolation factor was calculated using the median of the data rather than the arithmetic mean, given some of the extreme values in the data set.

The GAC effluent contaminant concentrations were calculated based on removal efficiencies calculated from the bench scale test during the 30 percent design.

Based on the discharge analysis between discharge to Hamilton Harbour and discharge to the wastewater treatment plant, it was concluded that treatment would be required for either option. Based on discussions between the engineering design consultant and the City of Hamilton, discharge to the Harbour was determined to be the preferred option because of the limited wastewater treatment plant capacity, and the associated possibility of combined sewer overflow events.

D.3.3.4 Evaluation of Options

The results of the TSS and chemical concentrations modeled for the initial dredging process predicts that the TSS in the primary settling cell effluent will be approximately 20 mg/L and will reduce to 5 mg/L in the final settling cell effluent. TSS in the sand filter and GAC effluent is predicted to be non-detectable. Several metals and PAHs are predicted to exceed the proposed discharge limits in the ECF Cell 2 and the final settling cell effluent. Only PAHs are predicted to exceed proposed discharge limits in the sand filter effluent. All modeled contaminants are predicted to be non-detectable in the GAC effluent. The model results show that water quality during initial dredging will meet the proposed discharge limits.

For production dredging, effluent TSS concentrations were modeled for each stage in the water treatment system and by each subarea. The TSS concentration of the GAC effluent is non-detectable. The modeled TSS concentration in the ECF effluent ranges from 22 mg/L near the beginning of ECF filling to 133 mg/L near the end of filling. The modeled TSS concentration in the final settling cells reduces significantly as a result of polymer addition, and is predicted to be approximately 5 mg/L for the first two dredging seasons, rising to approximately 13 mg/L during the third dredging season. The sand filter is predicted to reduce the TSS to non-detectable levels for the majority of the dredging operations. The effluent chemical concentrations were modeled for production dredging for the subareas and during each stage of the effluent treatment. In the ECF Cell 2 effluent, all metals concentrations exceeded the proposed discharge limits. In the final settling cell effluent, copper exhibited one exceedance, and iron and zinc had multiple exceedances. After sand filtration, none of the modeled metals concentrations exceeded the proposed discharge limits. Most of the PAHs in the ECF Cell 2 and final settling cell exceeded proposed discharge limits at least once for all subareas, some exceeded limits throughout the production dredging sequence. The highest predicted PAH concentrations in the ECF 2 cell will occur during dredging subareas 3 and 9. After sand filtration, 12 PAHs exceeded the proposed limits at least once, and one PAH (phenanathrene) exceeded the proposed discharge limits.

D.3.3.5 Results of Evaluation of Options

The analysis of the 100 percent sediment management treatment train, the determination of the proposed discharge limitations, and the analysis of the treated effluent throughout the treatment confirmed the treatment elements required and the feasibility of the design. The treatment of decant water will consist of gravity settling in the ECF, followed by polymer-assisted settling in a final settling cell, followed by sand filtration and GAC adsorption. The treatment system effluent will be discharged directly to Hamilton Harbour. A diffuser will not be needed since a mixing zone was not assumed.

The decant water flow regime promotes solids settling in the ECF prior to transfer of the decant water to the final settling cell. Following the placement of Subarea 2 dredged materials into the ECF, Cells 1 and 2 will be filled to the top of the internal cell wall according to contaminant concentrations. Decant water will flow from Cell 1 to Cell 2 or will flow from the influent point of Cell 2 to the final settling cell influent point. Once Cell 2 is filled to the top of the internal wall, dredged material will be placed throughout the ECF, and it will function as one cell. The ECF supernatant will be transferred to the final settling cell using three overflow structures and pumping. The polymer and associated equipment will be located on a small floating platform inside the ECF. The polymer will be mixed with the ECF supernatant using a static mixer.

Polymer test results showed that the most effective polymer for use in the final settling cell is a coagulant polymer named Krysalis CI2471H. The use of both a coagulant along with a flocculant polymer, such as Krysalis FC2406D, was shown to be able to provide more rapid settling. However, the use of a two stage process, coagulant followed by a flocculant, was not considered to be suitable to continuous treatment in the final settling cell, but will be retained for possible use during the final dredging and filling process, when greater TSS removal will be required. Polymer addition (Krysalis CI2471H) will be at a rate of 50 ppm. The MSDS sheets for the polymer will be provided in future tender specification documents. Given the daily maximum flow rate of 1,250 m^3/hr, the minimum detention time in the final settling cell will be 8.5 hours. This detention time will be sufficient to produce an effluent TSS concentration of 5 mg/L up to a maximum of 13 mg/L.

The final settling cell effluent will flow into an overflow structure and be pumped to the mechanical treatment system via a plastic pipe. The mechanical treatment system will be located on HPA property southwest of the ECF. Effluent from the final settling cell will flow in parallel through sand filters for pre-treatment prior to being treated in parallel carbon vessels. There will be twenty-two 11 cm- sand filter vessels, each with a capacity of 57 m^3/hr. The sand filters will be equipped with a backpressure-controlled automatic backwash system that will reverse the flow across the filter beds, removing solids that have collected on the filter media beds. The backwash water will be cycled back to either the ECF or into a holding tank and then into bag filters, and then again through the treatment system. The sand filters are expected to achieve 80% TSS removal for filter performance. The average TSS concentrations of the sand filter effluent will be less than 2 mg/L.

The sand filtered effluent will then flow into the GAC vessels. Chemical mass loading on the GAC vessels will be very low. Breakthrough of the carbon is not expected to occur during the life of the project. The GAC vessels are expected to be maintained on-line for the duration of the project as a safety factor. Given the average TSS concentration of the sand filtered effluent will be less than 2 mg/L, backwashing of the GAC units is expected to be required approximately every two weeks to prevent medial plugging. The carbon vessels will come equipped with pressure gauges to track pressure drops and a piping manifold with backwash connections. If backwashing is required, the wash water will be piped back to the head of the sand filters for treatment. The GAC filters are predicted to last for the entire duration of the project. At the end of the project, the activated carbon will be packaged and shipped to a permitted facility for reactivation and recycling.

The results of the decant water analysis show that the final settling cell will significantly decrease TSS and other contaminant concentrations. The studies showed that due to TSS and other contaminants, additional treatment is required following the final setting cell. The additional treatment will include sand filters followed by GAC. The modeled final settling cell effluent concentrations of iron, zinc, most of the PAHs were greater than the proposed discharge limits for initial and production dredging. The final settling cell effluent had at least two PAH exceedances for each subarea.

The final settling cell effluent will be treated with sand filters to reduce the TSS concentrations. The initial and production dredging model results show that the concentrations of metals in the sand filtered effluent will be less than the proposed discharge limits. There will be between 1 and 12 PAH (Subarea 3) exceedances in each subarea. Thus, additional treatment after sand filtration is required to reduce the PAHs.

The sand filtered effluent will be treated with GAC to reduce the concentrations of metals and PAHs. The modeled concentrations of metals and PAHs in the GAC effluent will be non-detectable for initial dredging and during production dredging with the exception of Subarea 3. The only exceedance for the GAC effluent model results is phenanthrene during dredging of Subarea 3. Monitoring results for this subarea may be used to determine whether adjustments, such as slower dredging rates, may be needed to stay in compliance.

The placement of dredged material into the ECF will use methods that reduce velocity and scour. A moveable inlet structure will distribute the material at an appropriate location. Material will be placed in a submerged condition to promote effective settling and to minimize air emissions. Stormwater will also be collected and treated in the same manner as decant water.

During final filling, when there is less than 1.5 m (5 ft) of ponded volume, the ECF detention time will be less than 20 hours, and the decant management approach may need to be modified using some of the following methods:

- decreasing ECF influent flow rates (by decreasing dredging rate, or mechanically dredging); and
- providing additional treatment to reduce TSS prior to GAC (by increasing the number of sand filters, and/or converting the polymer-assisted settling to a two stage process).

Effluent quality monitoring will be conducted for start-up, performance and compliance purposes. The results for start-up will be used to confirm the treatability test and modeling results. Samples will be collected from the ECF Cell 2, final settling cell, sand filter, and GAC effluent and will be analyzed for pH, TSS, turbidity, total metals and PAHs with PWQOs (and/or CWQGs). The concentrations of total metals and PAHs will then be correlate to TSS and the correlation to turbidity established.

Criterion for turbidity will be developed for performance monitoring. Performance monitoring will be conducted to collect ongoing data to optimize dredging operations, water management and recontamination control. Turbidity will be continuously measured at the final settling cell effluent point, the sand filter effluent point and the GAC effluent point using in-line turbidity meters. Observations regarding the presence of films, sheens, discolouration or odour will also be made. Grab samples for laboratory analysis will also be collected as required. Compliance sampling will be completed weekly to confirm that treated decant water released to the Harbour meets water quality requirements during initial and production dredging. PWQO (and/or CWQG) compliance samples will be collected from the GAC effluent and analysed for pH, TSS, turbidity, total metals and PAHs.

Costs for decant water management were estimated for certain elements of the treatment (i.e., GAC treatment system, sand filters, pumps, polymer product and equipment, turbidity metres, etc.) and are provided in Table D.13.

Table D.13: Decant Water Management Costs

Description	Unit	Unit Cost
Purchase of GAC treatment system	LS	$ 675,000
One GAC vessel change-out	LS	$ 22,000
Sand filters (22 vessels, 1,250 m^3/hr total capacity)	month	$ 22,500
One 20.3 cm x 20.3 cm pump	month	$ 3,750
One 20.3 cm x 20.3 cm standby pump	month	$ 1,560
Polymer product and equipment	season	$ 237,000
Flexifloat rental (9 m x 9 m)	day	$ 168
Inline turbidity meter	each	$ 12,000

All costs are in U.S. $ 2007.

Attachment D.11: Issues and Challenges Associated with Sediment Management, Dewatering, Water Treatment, Effluent Discharge and Air Emission Control Options

Issue	Description
Sediment Quality and Quantity	Sediment samples collected from 80 sites within the Randle Reef study area were considered to be representative of sediment quality in the potential dredge area and were used to develop and evaluate potential options for sediment management, dewatering and effluent treatment. The data indicated a high level of heterogeneity of the sediment quality (i.e., over two order of magnitude between the mean and the maximum concentration of the total PAH (tPAH)), and relatively low concentrations of total PCBs, generally lower than 1 ppm. These data include samples from the priority zone that are outside the footprint of the ECF, such as the highest concentrations of PAHs detected near the U.S. Steel wall at RR60. Data from within the footprint of the ECF were not included since those samples were not in the area to be dredged. The potential health risk associated with vapor transport was evaluated in the context of sediment dredging, transportation and placement in the ECF. Based on this assessment, the need to mitigate vapor migration and exposure will be driven by naphthalene. The management, dewatering and effluent treatment technologies will, therefore, need to effectively control airborne emissions of naphthalene. Several different types of dredge material are expected to be encountered during the Randle Reef remediation project. If it is decided to dredge Randle Reef to remove all sediments at concentrations greater than 200 ppm PAH, an approximate area of 275,600m^2 with a volume of 310,00 m^3 is expected to be dredged. If the dredge line is expanded to dredge sediments contaminated with greater than 50 ppm PAH, the dredge area will be increased to 440,000 m^2 and have a volume of 476,000 m^3. It is also likely that sediments with free phase coal tar will be encountered. Estimations indicate that an area of 122,300 m^2 and a volume of 160,000 m^3 will have free phase coal tar present. This volume is included in the 310,000m^3 referenced above. Sediments containing greater than 200 ppm and greater than 50 ppm naphthalene will likely be predominantly fine-grained, sandy dredge material. These sediments most likely will not require treatment before being placed into the ECF. If it is determined that dredgeate containing free phase coal tar can reach standards for construction of the ECF without treatment, then this material can be placed directly into the ECF. Potential methods for treating this sediment include flocculation, segregation and a number of possible amendments.
Effluent Quality	The projected water quality of the effluent from filling and dewatering of the proposed ECF was measured using the Effluent Elutriate Test (EET). The projected average and maximum concentrations of PAHs, PCBs, metals and TSS were derived.

Issue	Description
	The EET is designed to account for the settling processes and geochemical changes occurring in the ECF supernatant water during active disposal operations. Three composite samples of Randle Reef sediment were tested. The selection of samples for this testing was based on previous sediment characterization and core specific chemistry data. EET sediment sample PAH concentrations were lower than for samples collected previously from the same vicinity. However, variability of this magnitude was considered to be typical for sediment, particularly for coal tar-based contaminants, and is attributable to intrinsic sediment heterogeneity, e.g., NAPL droplets and carbonaceous material.
Comparison to Potential Discharge Requirements	Potential discharge options for effluent from filling and dewatering of the proposed ECF include direct discharge to the Harbour and/or discharge to the Woodward Avenue Wastewater Treatment Plant. The potential requirements for effluent discharges would be based on: • Ontario Provincial Water Quality Objectives (PWQO); • background water quality; and • sanitary sewer discharge limits **Ontario Provincial Water Quality Objectives** Discharges of decant water from the ECF to the surface waters of Ontario will need to meet PWQOs. PWQOs are ambient surface water quality criteria that are applicable to all waters of the province. In addition, oil should not be present in concentrations that: • can be detected as visible film, sheen, or discoloration on the surface; • can be detected by odor; • can cause tainting of edible aquatic organisms; and/or • can form deposits on shorelines and bottom sediments that are detectable by sight or odour, or are deleterious to resident aquatic organisms. In terms of discharge to the Harbour, it is anticipated that direct discharge of decant water from a treatment system may require a Certificate of Approval under Section 53 of the Ontario Water Resources Act. Water quality objectives that need to be met at the point of discharge are typically specified by the Certificate of Approval in accordance with Procedure B-1-5, Deriving Receiving Water Based Point Source Discharge Limits for Ontario Waters. The policy recognizes the concept of “mixing zones”, which are defined as areas of water contiguous to a

Issue	Description
	point of discharge that do comply with one of more PWQOs. While the intent of the policy is to minimize the size of the mixing zone, for direct discharge to the Great Lakes, a mixing zone that provides for 20-fold dilution of the effluent is typically specified. Under such a scenario, initial effluent quality would be set a 20 times the PWQO for each parameter of concern. The policy also provides guidance for those situations where the effluent quality cannot be met due to technical considerations. While it is anticipated that discharge limits will be determined in consultation with the MOE as part of the Certificate of Approval, a limit of twenty times the PWQO to account for dilution within the mixing zone was used for the initial evaluation. The *Randle Reef Sediment Remediation Project* will be conducted in accordance with the Fish Habitat Protection and Pollution Prevention section of the federal *Fisheries Act* which contains the regulations and outlines offences pertaining to deposit, dumping and submission of deleterious substances to fish habitats or to areas near fish habitats (i.e., shores, beaches). **Background Water Quality** Background water quality within the Harbour should be assessed when reviewing the potential surface water discharge criteria. Mixing zones are typically not granted in cases where ambient water quality standards are already exceeded. A comprehensive data base for background water quality in Hamilton Harbour does not exist. In the absence of a comprehensive database, the data collected at the U.S. Steel water intake were reviewed. Based on this limited data set, the following was concluded: • the background concentration for naphthalene (and probably the other PAHs) is below the PWQO; and • the background concentrations for some metals (cadmium, copper, lead and zinc) are at or just below the PWQO. The Stage 2 RAP update-Section on Toxic Substances (June 2003) also contains information regarding background water quality in Hamilton Harbour. According to the Stage 2 RAP update, chemicals and chemical classes of contaminants of concern are assigned to one of two lists. The "A" list of chemicals includes compounds that are prevalent in Hamilton Harbour at levels that pose a serious risk to fish and wildlife. Levels of these compounds exceed provincial and/or federal water, sediment, or tissue guidelines designed for the protection of aquatic biota, and significantly exceed ambient levels in Lake Ontario. Hamilton Harbour "A" list contaminants include: • Polycyclic Aromatic Hydrocarbons (PAHs); • Polychlorinated Biphenyls (PCBs);

Issue	Description
	• Toxic Metals (arsenic, cadmium, iron, lead and zinc); and • Mercury. The "B" list of contaminants in Hamilton Harbour include compounds that are highly toxic, but have not been demonstrated to be present in Hamilton Harbour at levels that pose a serious risk to fish and wildlife. Hamilton Harbour "B" list contaminants include: • dioxins and furans; • organochlorine pesticides (e.g., DDT; • current use pesticides (e.g., 2,4-D); • endocrine-disrupting compounds (EDC); and • ammonia. **Discharge to Sanitary Sewer** An alternative to discharge to surface water would be to discharge to the sanitary sewer. Discharges of decant water from the ECF to the sanitary sewer will need to meet Hamilton sewer use by-law limits. The recommendation to discharge to the sewer was dependent upon the following conditions: • approval of a discharge point into the sewer system; • discharge limited to dry weather to prevent overflow of sewers to the Harbour; • decant water does not upset treatment process at wastewater plant; • decant water will not be allowed to adversely affect quality of WWTP sludge for land application; and • ECF operators submit verification samples before discharge.
Comparison to Worst Case Effluent Concentrations	Effluent concentrations have also been estimated from sediment concentrations using the water-sediment equilibrium partitioning approach. The parameter known as the partition (or distribution) coefficient (Kd) is one of the most important parameters used in estimating the migration potential of contaminants present in aqueous solutions in contact with surface, subsurface and suspended solids. In all cases, the estimated concentrations are greater than the measured concentrations. This is as expected since the partitioning approach assumes equilibrium which is rarely achieved in the environment. The Kd values for organic constituents were calculated as the product of Total Organic Carbon (TOC) and the organic carbon partition coefficient (Koc). It is important to note that use of the generic or default partition

Issue	Description
	coefficient values found in the literature can result in significant errors when used to predict the absolute impacts of contaminant migration or site-remediation options. This is especially true for the metal constituents, whose Kd values are a function of pH, redox conditions and other chemical constituents present, and can range over several orders of magnitude. Accordingly, one of the major recommendations of the USEPA is that for site-specific calculations, partition coefficient values measured at site-specific conditions are absolutely essential. Site-specific Kd values were measured using the Sequential Batch Leaching Test (SBLT). Two replicate samples (SBLT-1 and SBLT-2) of one composite sample of Randle Reef sediment samples were tested. The selection of samples for this testing was based on previous sediment characterization and core-specific chemistry data. SBLT sediment sample PAH concentrations were lower than for samples collected previously from the same vicinity. However, variability of this magnitude was considered to be typical for sediment, particularly for coal tar-based contaminants, and is attributable to intrinsic sediment heterogeneity, e.g., NAPL droplets, carbonaceous material.
Treatability Considerations	The estimated effluent concentrations and potential discharge requirements listed in the previous sections lead to the following conclusions: • PAH concentrations in the EET effluent samples were generally greater than the PWQO criteria with a 20 to 1 dilution zone; therefore, PAHs will likely be present at significant levels in the effluent and are primary contaminants for treatability considerations; • PCB concentrations in the EET effluent samples and the site water were nondetect; therefore, although PCBs will likely not be present at significant levels in the effluent, they should be included in treatability considerations as a secondary contaminant; and • copper, lead and zinc concentrations in the EET effluent samples were lower than the PWQO criteria with a 20 to 1 dilution zone; however, these metals should be included in treatability considerations as secondary contaminants; other metals of secondary concern that should be considered during treatability testing are arsenic, cadmium, mercury and nickel.

Attachment D.12: Detailed Description of Sediment Management, Dewatering, Water Treatment, Effluent Discharge and Air Emission Control Options

Sediment Management and Handling Options – Cell Configuration

Option	Description
Segregate and Manage Sediments in Multiple Containment Cells Based on Sediment Physical/Chemical Conditions (zoned ECF)	There are two scenarios where multiple containment cells may be utilized. In the case of pre-dredging for building the isolation structure, small volumes of dredged material must be contained prior to building the final ECF. After the ECF is finalized, this pre-dredge cell may be emptied (re-handled) and refilled with highly contaminated sediment, or dismantled. The second scenario is a zoned ECF. The interior design of a zoned ECF may allow segregation of dredged materials (i.e., PAH and PCB contaminated sediments) or may facilitate sedimentation of fine-grained particles, prior to release of decant water. Construction of internal berms allows for previously delineated contaminant “hot spots” to be dredged first and placed in containment cells furthest from the overflow weir. Supernatant water would become diluted each time it overflows an internal cell wall (overflow weir). Increased retention time of effluent water may reduce contaminant concentrations to a level at which it could be discharged directly into Hamilton Harbour without additional treatment.
Segregate and Manage Sediments in Single Containment Cell Based on Sediment Physical/Chemical Conditions	With this option, the entire ECF is one large sedimentation basin. With hydraulic pumping, heavier sediments fall out of suspension near the dredge discharge pipe while water flows toward the weir. This arrangement typically requires more vertical containment capacity to allow greater retention time to meet water quality discharge limits. Dredging contaminant “hotspots” first and placing material an adequate distance from the overflow weir can allow for sufficient dilution of contaminant concentrations.
Group All Sediments and Manage in Separate Containment Cells, for Effluent Treatment Purposes	Constructing a zoned ECF with multiple internal containment cells, without regard for previously delineated “hotspots,” would allow for treatment of effluent water by retention and discharge through overflow weirs. However, if dredging is not performed with knowledge of contaminant “hotspot” locations, there is a risk of placing highly contaminated material close to the overflow weir. This could lead to effluent with high contaminant concentrations.
Group All Sediments and Manage Uniformly in a Single Containment Cell	The least costly method of managing Randle Reef sediments is to group all sediments into a single cell ECF without taking into consideration the physical or chemical conditions of the sediment. This method is effective on a time and cost basis, but dredging sediments without knowledge of contaminant hotspots could lead to effluent water with high concentrations of contaminants.

Sediment Placement Options

Option	Description
Place Dredge Material directly into ECF Using Long Reach Excavator	Using a long reach excavator to mechanically place material into the ECF is a feasible option for locations immediately adjacent to the isolation structure. Moderate production rates and reduced mobility associated with excavators in this scenario may lead to increased cost. Single handling of the material, however, is cost effective. It is likely that more naphthalene and other odours, as well as higher rates of turbidity, would be associated with this option.
Dump Directly Out of a Split Hull Scow into ECF	Dredged material could be mechanically placed into a split hull scow or barge to be placed directly into the ECF. Draft limitations could limit the amount of material that can be placed in the ECF. Minimal re-handling of the material is cost effective. To reduce naphthalene and other odours, a temporary cap on the barge could be employed. High turbidity within the ECF would be associated with this option, however, this could be controlled through the use of silt curtains.
Clamshell Out of Hopper or Scow into ECF	An environmental clamshell bucket could also be used to remove material from a hopper, barge or scow and placed into the ECF. Using a clamshell bucket would provide a more controlled placement of material into the ECF, but is also associated with a slower production rate. It is likely that more naphthalene and other odours, as well as slightly increased turbidity, would be associated with this option. Double handling increases the cost.
Pump Material Out of Hopper or Scow in Slurry Form Using a High Solids Pump	Material mechanically placed in a barge, hopper or scow could be pumped into the ECF via a high solids pump (i.e., Toyo pump or equivalent). Double handling of material (mechanically into dredge followed by hydraulically into ECF) would lead to increased cost, however, this method would have the least increased turbidity. If the pipeline discharge were below the water level, odours could be controlled. Otherwise high odour and naphthalene volatilization would be associated with this option.
Hydraulically Pump Directly into ECF	If the chosen method of environmental dredging is hydraulic, then material could be directly pumped into the ECF. Sufficient length of pipeline would be necessary to pump sediment from the dredge site to the ECF and a booster pump may be necessary, depending on the distance between the ECF and furthest dredging extent. Single handling and high production rates make this a cost effective option. If the pipeline discharge were below the water level, odours could be controlled, otherwise high odour and naphthalene volatilization would be associated with this option at the point of discharge.
Pump into Holding Tanks for Later Processing or to Regulate Flow	Dredge material could be hydraulically pumped into holding tanks to regulate the flow rate of material entering the ECF or for later processing. Large tanks would be required on a solid platform or large barge. Sedimentation in the tanks would create a maintenance issue. This option would greatly decrease dredging production rates.

Dewatering Options

Option	Description
In-Place Dewatering (unaided settling)	The most widely used method to dewater large volumes of sediment is lagunation. The efficiency of this method depends in part on the design of the drainage system and the initial solids content of the dredged material. Careful construction of the underlying drainage layer can increase dewatering rates, but for deep fills, dewatering occurs primarily through evaporation and self-weight consolidation. This can result in a very slow dewatering process, requiring trenching or other labour-intensive accelerating techniques.
In-Place Dewatering with Flocculant Addition	Flocculation is the action of very small, suspended particles coming into contact and bonding together. The process of flocculation promotes more rapid settling, as the resulting mass of the bonded particles has a higher density and is subjected to less impeding action from the water viscosity than the single, unflocculated particles. The flocculation process can be accelerated through the addition of chemical polymers. These materials can be thoroughly mixed with the dredged sediment by injecting them into a hydraulic pipeline, transporting the dredged material prior to discharge in the ECF. This option does not lend itself to mechanical dredging, with one exception. A well can be installed near the weir to allow flocculation of any remaining suspended solids in the decant water.
In-Place Dewatering/Sedimentation Via Multiple Interior Cells	The interior design of a zoned ECF may allow segregation of dredged materials or may facilitate sedimentation of fine-grained particles prior to the release of decant water. Construction of internal berms allows for previously delineated contaminant "hot spots" to be dredged first and placed in containment cells furthest from the overflow weir. Increased residence time allows improved reduction of suspended solids.
In-Place Dewatering with Bulking Agents	Bulking agents can be added to dredged sediments to provide porosity, decrease the moisture content and add to the overall strength of the mixture. Wood chips, sawdust, leaves, shredded paper, hay and corncobs are organic materials that have previously been used as bulking agents. Other materials include fly ash, Portland cement, cement kiln dust and automobile shredder fluff. A pug mill or other machinery would be required to mix the bulking agent with the sediment. Certain bulking agents can bind contaminants into a less mobile or bio-available form. A disadvantage to bulking agents is that it takes up valuable capacity in the ECF, and adds to the cost and energy usage on site.
In-Place Dewatering with Bioremediation Agents	For PAH contaminated sediments, a bioremediation agent such as "OCR Advanced" could be added to the dredge slurry at a rate of 1 pound per cubic yard for concentrations of 50 ppm. ORC Advanced would add oxygen to the soil, promoting the biodegradation of the PAHs. It is estimated that, within 12 months, there would be a 60% reduction in low molecular weight PAHs and 20%

Option	Description
	reduction in high molecular weight PAHs.
Lined Dewatering Basin	Material could be placed in a temporary upland dewatering basin lined with an impermeable fabric and graded so the effluent would drain to a series of sump pumps. Once the effluent was collected in the sump pumps, it would be discharged, as necessary. Dewatered sediment would then be transferred to the ECF for disposal. This option is very expensive due to the need for an upland site, geomembrane installation, and multiple handling/transportation of the dredged material.
Geotextile Tubes	Geotextile tubes are a more recent innovation for on-site dewatering. They are manufactured of high strength permeable geotextiles designed to retain sediments while allowing the draining of water. For this application, large tubes with circumferences of several metres would be positioned on upland space (if available) and pumped full with dredged material either directly from a hydraulic dredge, or from a high solids content pump. Excess water would drain from the small pores in the geotextiles resulting in dewatering and reduction of the volume of the contained material. This volume reduction would allow repeated filling of the tubes until maximum solids content was achieved. Dewatering in large tubes has been shown to be faster that langunation, however the tubes represent an added cost to the project. The addition of polymers to the sediment slurry before being pumped into the tubes is often used to enhance dewatering. This technology is among the newer applications, but has been used successfully for dewatering of industrial waste, sludge from the treatment of municipal wastewater and dredged sediments. To employ geotextile tube technology, a large dewatering staging area would be required. Large areas would not likely be available until the ECF were completed. An alternative would be to fill tubes underwater within the ECF. This option could have an added benefit of increasing geotechnical strength to the sediments within the ECF, however, sub-aqueous filling of tubes is more complex.
Mechanical Dewatering	There are a number of technologies available for mechanical dewatering of sediments including: centrifugation; filtration (belt filter press and plate and frame press); and trenching. Centrifugation and filtration require pre-conditioning of the sediment with polymers and are considered batch processes. Trenching uses low ground pressure vehicles to dig trenches in the surface of the dredged sediment. **<u>Centrifugation</u>** Centrifuges work by rapidly spinning a slurry of particulates and water, thus inducing forces on the particles and causing them to separate from the water. As new wet slurry is pushed through dewatered solids, the dewatered material act as a filter and further assists with the dewatering by

Option	Description
	providing a resistance to the pushing action. This material is called a "plug." Preconditioned slurry is added to one end of a large, hollow metal cylinder or "bowl " that is being spun at a high rate of speed along its longitudinal axis. Once in the bowl, the solids in the slurry begin to rapidly separate away from the water. Also inside the bowl, a screw auger or "conveyor " is driven at a lower speed than the bowl to scrape the separated solids to a small area where the "plug " forms and further dewatering occurs as the auger directs pushes the solids towards the bowl exit point. The plug reaches an equilibrium point where the rate of partially dewatered solids arriving at the plug point is matched by the rate of dewatered solids leaving through the exit point. The dewatered solids discharged through the exit point fall into a hopper or onto a conveyor system. **<u>Filtration</u>** **Plate and Frame Filter Press** Plate and frame filter presses operate by containing the sediment within two plates having a porous cloth and applying pressure to force water out. A filter press is comprised of a series of recessed metal or heavy plastic plates fitted with filter cloth and hung on a railed frame. The sediment slurry is pumped into the recesses between the plates. When the slurry occupies these spaces, a hydraulic ram is activated, pushing the plates together and forcing water out through the filter cloth. After a given duration of applying pressure, the ram is withdrawn, the plates are separated and the filter "cake" of dewatered sediment drops into a hopper or onto a conveyor. This is a batch process, not a continuous one. Often, a large surge tank is employed to keep the incoming batches more uniform. **Belt Filter Press** Belt filter presses also use porous materials and apply pressure to remove water. However, in the belt filter system, rollers and belt tensioning are used to create the pressure. Therefore, they can operate continuously, albeit low flow rates. Belt filters are typically comprised of two, continuous, porous belts, typically from 1 to 3 m wide, a series of rollers, a belt drive system and peripheral equipment. The pre-conditioned slurry is first distributed across the width of the first belt. This belt then travels across a gravity drainage section where a portion of the water freely drains from the slurry. Once the belt passes by the gravity section, the second belt is lowered down on top of the slurry "sandwiching" the slurry between the two belts. This sandwich then travels around a series of rollers that apply pressure to the slurry and produce a shearing action. These two mechanisms combine to force water from the slurry and out

Option	Description
	through the belts. Once the "sandwich " has passed through the rollers, the top belt is removed and the bottom belt is passed over a last roller with a scraper that separates the dewatered solids from the belt, depositing the dewatered cake into a hopper. Belt filter systems are somewhat limited as to the dryness of the cake that can be produced, have somewhat limited unit capacity, and are relatively labour intensive. The effluent is less clear than that from a plate and frame press and significant quantities of clean water are consumed during cleaning of the belts. **Trenching** Trenching uses low ground pressure vehicles (e.g., Louisiana Marsh Buggies) to dig trenches in the surface of the dredged sediment. This breaks the surface layer, which tends to desiccate and prevents dewatering at lower depths. The trench also provides a conduit for water to leave the site.

Effluent Treatment Options

Option	Description
In-Place Gravity Sedimentation	Sedimentation, also known as settling, is widely employed to remove suspended solids from wastewaters. Settling is the separation of particles from a fluid via gravity. Settling rates depend on the densities and sizes of the particles, as well as their tendency to agglomerate. Sedimentation does nothing for dissolved contaminants. The process is recognized to involve one or more physical mechanisms as follows: • discrete settling – individual particles; • flocculant settling – agglomeration of particles; • zone settling – particles settling as a blanket; • compression – compaction and squeezing out of fluid (often in conjunction with wick drains). Relatively quiescent conditions are necessary for settling to occur. That is, any flow of the fluid must be slow with little turbulence.
In-Place Filtration	An innovative idea for treating effluent water is to allow effluent water to flow through the ECF berm as opposed to over the berm. The addition of chemical filters, such as activated carbon, would allow for effluent to be filtered as it passes through the berm and is discharged to the Harbour.

Option	Description
In-Place Adsorbent Booms and Skimmers	Booms are widely used as a passive method for removal of floating oily waste from water. They consist of long cylinders of cloth filled with an absorbent material. They are floated on the water surface until adsorbent capacity is reached, at which time they are removed and discarded. Adsorbents include polypropylene or natural material such as sphagnum moss. Various skimmers are also available for active removal of floating oil. These use polypropylene ropes, tubes, belts or discs, which are moved through the water and then scraped or wiped to remove the adsorbed oil. Oily waste is deposited in a container.
Oil/Water Separator	This flow-through technology is used to remove free oil from wastewater. Emulsified oils are not affected by this technology. Within the separator, oil rises to the surface due to the density difference with water. Some units include inclined parallel plates to provide surfaces for oil globules to collect and agglomerate. Oily waste flows to a container for removal.
Dissolved Air Flotation	In the flotation process, waste liquid is pressurized to 40 to 60 psi, in the presence of air, and then released to atmospheric pressure in the treatment tank. The liquid is mixed vigorously in the tank and air bubbles coming out of solution attach to suspended particles, which then rise to the surface. The suspended solids are thus concentrated at the surface, where they are scraped off. Effluent is removed from the bottom of the tank. The addition of polymers to the influent may increase the capture of solids and improve the clarity of the effluent. This process can be used for removal of oily waste as well as suspended solids.
Flocculation/Clarification	Settling can be accelerated by the addition of chemical flocculants in the form of polymers. Their use for treatment of effluent in well controlled process equipment is much more effective and efficient than bulk addition to raw dredged material. Process equipment to be used in this application would include a flocculent injection pump and a clarifier. The overall process of aggregation of colloidal particles to hasten settling (coagulation) includes transportation of the particles to promote inter-particle contact (flocculation) and destabilization to permit attachment of particles. Materials that have been used to produce such effects to treat water include alum (aluminum sulfate), ferric chloride and other iron salts, lime, soda ash, chitosan (derived from crab shells) and synthetic polymers.
Filtration	**Gravity Filters** Gravity filters are used to remove particles by allowing water to flow by gravity through a granular medium, such as sand. This technology is most commonly used in water supply treatment. Filtration through granular media (e.g., sand) is a common process for removing particles from fluids. Surface effects cause particles to attach to the grains of the medium, thus removing them

Option	Description
	from the fluid. **Pressure Filters** Plate-and-frame filter presses can also be used to remove solids from more dilute solutions, such as dewatering effluent. Filter presses operate by containing the solids within a porous cloth while applying pressure to force water out. A filter press is comprised of a series of recessed metal or heavy plastic plates fitted with filter cloth and hung on a railed frame. Addition of polymers is usually required.
Adsorption	**Activated Carbon** Granular activated carbon is widely used to remove dissolved organic contaminants from water. The process requires some form of vessel where the water contacts the carbon. As the adsorptive capacity of the carbon is exhausted, the carbon must be replaced. Adsorption is the accumulation of substances at an interface or surface. Material in the adsorbate (in this case, the effluent) is adsorbed onto the surface of the adsorbent (in this case, activated carbon). The removal efficiency depends on the chemistry and concentration of the material to be removed. Carbon is effective in removing a variety of dissolved organic compounds. **Other Media** While activated carbon is the most widely used adsorbent, other materials have been used for specific applications. Proprietary adsorption media are available for removal of oils, greases and other high molecular weight, low solubility organics. These adsorbents are sometimes used as a pre-treatment prior to carbon adsorption, since these materials can “blind” carbon and reduce its useful cycle time. Metal-oxide based adsorbents are used for removal of certain metals from wastewater streams. Another example is activated alumina, which is used for removal of fluoride and arsenic.
Bioremediation (bioreactor)	A liquid phase bioreactor operates by culturing naturally occurring and/or augmented micro-organisms to remove organic compounds from the effluent water. It has been found that micro-organisms readily colonize surfaces that are in regular contact with organic wastes, utilizing the effluent stream as a food source. Once the PAHs have been present at a location for a period of time, robust, complex communities of micro-organisms establish a biofilm on the bioreactor media. This biofilm is then brought into contact with the dredge water effluent. The biofilm continuously digests any PAHs and other impurities from the water.

Option	Description
	Biological treatment can be accomplished under aerobic or anaerobic conditions using either suspended or fixed growth systems. Process selection requires additional engineering to be done, however, the following example of an aerobic, fixed film bioreactor may be most applicable for treating effluent from the ECF. The bioreactor would utilize a custom configured, floating pelleted plastic media to provide an enormous surface area for culturing the micro-organisms. An innovative revolving injector system regularly and uniformly distributes the effluent through the filter bed. The injected effluent fluidizes (stirs) only a narrow zone of media at any given time, which conserves energy. The fluidization shears off excess biofilm which promotes growth of a stable healthy colony for optimum PAH removal. The injector system is powered simply by the flow of incoming effluent. The Bioreactor design is much more compact than conventional waste water systems because of its unique media. Oxygen is added in the aeration chamber on a continuous basis as part of the process. Additionally, the cone-bottomed base of the cylindrical bioreactor is designed to collect and concentrate particulate wastes and excess sheared biofilm from where they are periodically removed through a valved outlet.
Chemical Precipitation	This process is commonly used to remove dissolved metals from wastewater. The pH of the solution is adjusted to a range where the metals of concern are precipitated. The water is then directed to a clarifier to promote settling of the precipitate.

Effluent Discharge Options

Option	Description
Sanitary Sewer	A possible option for effluent discharge is to the Woodward Avenue Waste Water Treatment Plant.
Discharge to Hamilton Harbour	If effluent water meets Ontario water quality standards, it can be discharged directly to Hamilton Harbour.
Discharge to Barge Mounted Treatment System	Effluent is pumped to a barge where treatment, likely via sand filters and/or granular activated carbon, is provided prior to discharge to Hamilton Harbour.

Air Emission Control Options

Option	Description
Minimize Sediment Exposure to Air	The highest volatile contaminant transfer condition occurs when the sediment surface is exposed. Therefore, the simplest and most cost-effective way to minimize air emissions would be to prevent direct sediment exposure to the air, and discharging below surface within the ECF. One way to do this would be to utilize hydraulic dredging and to prevent the sediment from drying out once it is

Option	Description
	placed in the ECF. During the dewatering process, the top of the sediment layer may become exposed. These locales could then be capped with the final cover.
Minimize TSS in Ponded Water	Turbulent dredge water having high TSS concentrations can also have high naphthalene emission rates. To prevent high TSS concentrations in the overlying water column of the ECF, it will be necessary to place the dredged sediment at the bottom of the ECF without producing a lot of mixing. This can more easily be accomplished using hydraulic dredging, but may also be done using mechanical dredging by using careful placement techniques. In-place dewatering with flocculants would help minimize TSS in the ponded water. Smaller interior cells in a zoned ECF will reduce wind driven waves from generating and stirring up sediments.
Treatment of the Dredged Material to Reduce Volatile Releases	A variety of methods are available to treat the volatile contaminants in the sediments prior to placement in the ECF. These include active methods such as the slurry bioreactor treatment, thermal treatment and chemical stabilization, as well as passive methods such as amendment with organic substrates to reduce the leachability, hence the volatility of contaminants such as naphthalene. These methods would be expensive and would require pilot testing to confirm treatment performance. This approach would be least compatible with the ECF concept, which relies on containment rather than treatment.
Impermeable Floating Cover	An impermeable floating cover could be placed on top of the filled ECF to control air emissions. The prevention of vapour emissions would require a floating cover of very low permeability, such as a flexible membrane. For effective operation, the floating cover must provide a seal at the edge of the ECF cell, with provisions to remove rainwater. The cost for a flexible membrane would be high and this option may not be easily or reliably implemented at the ECF. Complete coverage of the ECF may not be possible if mechanical dredging is selected with sediment placement from barges. No full-scale applications using this approach at sediment containment sites have been identified in the literature, although floating flexible membrane covers are used to control emission of organic hazardous air pollutants from surface impoundments at chemical manufacturing facilities.
Permeable treatment floating cover	A new experimental technology, the permeable treatment floating cover would float on the surface of the filled ECF and treat vapour emissions before they escape to the atmosphere. No applications using this approach at sediment containment sites have been identified in the literature. This method would require pilot testing to select the appropriate treatment agent and to confirm treatment performance. Potential treatment agents are activated carbon, zeolite and organo-clay. As with the impermeable cover, complete coverage of the ECF may not be possible if mechanical dredging is selected with sediment placement from barges.
Temporary Vapour Control Structure	Temporary vapour control structures can be either self-supported or air-supported structures. Self-supported structures consist of a rigid frame covered with an all-weather outer skin. Self-supported structures are generally operated under negative pressure, which prevents emissions via

Option	Description
	entrances/exits. Another widely used vapour control structure at waste management facilities is the air-supported structure, which uses fans to maintain a positive pressure to inflate the structure. Because air-supported structures are under positive pressure, entrances/exits may need to be provided with air locks to prevent emissions. For efficient control, the air vented from either type of structure must be sent to a control device, such as a carbon adsorber. While most applications of this technology are at relatively small facilities, this approach could be used at the EFC by constructing a modular vapour control structure and moving it to the active cell while utilizing other vapour control options at cells undergoing dewatering.
Miscellaneous Controls	A number of miscellaneous controls could theoretically be used to control vapour emissions at the ECF. Emissions could be controlled using a floating blanket of hollow plastic objects (e.g., Euro-matic Bird Balls), which have been used for control of birds, heat loss, evaporative loss and odours. Documentation for organic vapour emission control using this method is not available. Other potential methods include foam, a layer of oil and blankets of nitrogen or other inert gasses. The use of these types of controls would be experimental and would require field-scale testing prior to implementation.

Attachment D.13: Sediment Management, Dewatering, Water Treatment, Effluent Discharge and Air Emission Control Options: Description of Evaluation Criteria or Sub-criteria

Criteria	Sub-criteria	Criteria or Sub-criteria Description
Service (i.e., effectiveness)	Effectiveness in Meeting Discharge Requirements	Supernatant water from the dewatering/treatment process must meet standards set by regulatory (MOE or Environment Canada) or other government agencies before being returned to Hamilton Harbour or discharged to the sewer.
	Effectiveness in Meeting Dredged Material Geotechnical Requirements at Depth	Required ECF subsurface geotechnical conditions (i.e., post-capped bearing capacity) may affect the requirements for onsite dewatering.
	Reliability	Equipment options will be screened according to their reliability to successfully perform the tasks of this project in the existing work environment without risk of failure.
Technical Criteria (i.e., implementability)	Complexity	Equipment options that are technically complex tend to have a higher potential for breakdown and/or failure. Therefore, less complex options are more desirable.
	Compatibility with Other Project Elements	The sediment handling option must be compatible with other components of the sediment and effluent treatment process (i.e., dewatering and water treatment options), as well as with other tasks of the project (i.e., environmental dredging).
	Constructability/Time to Implement	Options for sediment management, dewatering and water treatment options must be executed in a timely manner that meets the project schedule and time restraints.
Cost	Capital Cost	If equipment purchase is required, probable capital costs must be considered.
	Operating Cost	Wherever available, a range of probable costs for each equipment option, including mobilization, maintenance and operation costs was estimated.

Attachment D.14: Evaluation of Sediment Management, Dewatering, Water Treatment, Effluent Discharge and Air Emission Control Options

Sediment Management and Handling Options – Cell Configuration

Technology	Service Criteria	Technical Criteria	Cost	Retained/Eliminated
Segregate and Manage Sediments in Multiple Containment Cells Based on Sediment Physical/Chemical Conditions (zoned ECF)	• High – containment and effluent performance	• Moderate	• High cost	• Retained
Segregate and Manage Sediments in Single Containment Cell Based on Sediment Physical/Chemical Conditions	• Moderate – high containment and effluent performance	• Moderate	• Moderate cost	• Retained
Group All Sediments and Manage in Separate Containment Cells, for Effluent Treatment Processes	• Moderate – high containment and effluent performance	• Moderate	• High cost	• Eliminated
Group all Sediments and Manage Uniformly in a Single Containment Cell	• Low – containment and effluent performance	• High	• Low cost	• Retained

Sediment Placement Options

Technology	Service Criteria	Technical Criteria	Cost	Retained/Eliminated
Place Dredge Material Directly into ECF Using a Long Reach Excavator	• Moderate – long reach excavator would have to be long enough to reach the deepest extents of the dredging project • a land-based excavator would have a limited area to work	• relatively slow production rate • low complexity, however, restricted mobility and area of applicability	• Moderate cost - due to slow production rate • special equipment not needed	• Eliminated
Dump Directly Out of Split Hull Scow into ECF	• Moderate – draft limitations would limit the amount of material that could be accommodated and/or size of the split hull scow that could be used for the project • ECF would need an entry and exit for the scow	• high production rate; loading of scow is time consuming; unloading is relatively quick • moderate complexity; tugboat necessary to transport barges	• Moderate cost – relatively quick process but more marine equipment results in moderate cost • specialized equipment is necessary	• Retained
Clamshell Out of Hopper or Scow into ECF	• High – option not dependent upon the ECF configuration	• relatively slow production rate • moderate complexity; tugboat necessary to transport barges	• Moderate cost – double handling leads to increased cost	• Retained
Pump Material Out of Hopper or Scow in Slurry Form Using a High Solids Pump	• High – hopper can unload from inside or outside of the ECF; draft limitations would limit the size of the hopper or scow that could	• high production rate; up to 380 cm/hr; may require additional controls at disposal facility to accommodate slightly	• Moderate cost – double handling leads to increased cost	• Eliminated

Technology	Service Criteria	Technical Criteria	Cost	Retained/Eliminated
	be used inside the ECF • option not necessarily dependant upon the ECF configuration	increased volume of water added by pumping • moderate complexity		
Hydraulically Pump Directly Into ECF	• Moderate – extended lengths of pipeline may be necessary to reach furthest reaches of dredging area • option not necessarily dependent upon the ECF configuration	• high production rate; may require additional controls at disposal facility to accommodate large volume of water added by hydraulic dredging • moderate complexity	• Low cost – faster production rate	• Retained
Pump into Holding Tanks for Later Processing or to Regulate Flow	• Low – extra space requirements would be necessary to accommodate holding tanks • ECF would need extra space or previously filled/consolidated region to accommodate the holding tanks	• slow production rate • high complexity; holding tanks necessitate an additional step in the handling process	• High cost – rental and permitting of on-site storage tanks increase cost	• Eliminated

Dewatering

Technology	Service Criteria	Technical Criteria	Cost	Retained/Eliminated
In-place Dewatering (unaided settling)	• Moderate – large fraction of particulate contaminants would be removed from settling alone although some would remain in effluent water	• High – very compatible; dewatering occurs inside the ECF • gravity settling of dredge material would take longer when no settling agents are added and may	• Low cost	• Retained

Technology	Service Criteria	Technical Criteria	Cost	Retained/Eliminated
	• may achieve up to 60% by weight solids content for fine-grained sediment after a long duration	be hindered by dry crust		
In-place Dewatering with Flocculant Addition	• High – larger percentage of contaminants would be removed when settling agents are added	• Moderate – dewatering occurs inside the ECF • settling agents can be included during the hydraulic dredging process • settling of dredge material would be quicker when settling agents are added	• Moderate cost	• Retained
In-place Dewatering/ Sedimentation via Multiple Interior Cells	• High – having multiple interior cells increases the retention time of effluent water and further reduces contaminant concentrations	• High – very compatible • dewatering occurs inside the ECF	• Moderate cost	• Retained
In-place Dewatering with Bioremediation Agents	• High – can achieve up to 60% reduction in low molecular weight PAHs and a 20% reduction in high molecular weight PAHs in 12 months	• High – very compatible • the powder would be slurried and injected into the dredge discharge	• High cost	• Retained
In-place Dewatering with Bulking Agents	• High – larger percentage of contaminants would be bound when bulking agents are added • bulking agents would enhance the subsurface	• Moderate – less compatible than simple settling • pre-dewatering would be required prior to placement in the ECF	• High cost	• Eliminated

Technology	Service Criteria	Technical Criteria	Cost	Retained/Eliminated
	geotechnical properties of the contained sediment	• bulking agent staging and mixing areas required		
Lined Dewatering Basin	• Low – no more effective for inorganic dredged materials than ECF	• Moderate – ECF would need extra space or previously filled/consolidated region to accommodate the basin	• Very high cost	• Eliminated
Geotextile Tubes	• High – proper design of tubes would ensure a high rate of solids removal • could also be used as internal berms in zoned ECF	• Moderate – ECF would need extra space or previously filled/consolidated region to accommodate the tubes • settling using geotubes can take a long time • flocculants would greatly reduce the time it takes for the material to dewater	• High cost	• Eliminated
Mechanical Dewatering • Centrifugation	• High – very high rate of particulate contaminant removal through mechanical dewatering • achieves up to 80% by weight solids content for fine-grained sediment • complex – centrifugation requires polymer addition and careful control	• Moderate – most compatible with oily solids • extra space or a barge required to accommodate the plant • method quicker than passive dewatering	• Very high cost	• Eliminated
• Filtration – belt filter press,	• High – very high rate of particulate removal	• Low – less compatible with oily solids	• High cost	• Eliminated

Technology	Service Criteria	Technical Criteria	Cost	Retained/Eliminated
plate and frame press	through mechanical dewatering • achieves up to 80% by weight solids content for fine-grained sediment • complex – filtration requires homogenous feed and careful control	• extra space or a barge required to accommodate the plant • method quicker than passive dewatering		
• Trenching	• Moderate – effectiveness is impacted by sediment characteristics, time and rain	• Moderate – highly compatible with material placement in ECF cells; some sediments may not respond to trenching	• Moderate cost due to labour	• Retained

Effluent Treatment Options

Technology	Service Criteria	Technical Criteria	Cost	Retained/Eliminated
In-place Gravity Sedimentation	• Moderate - effluent with less than 100 to 200 mg/L TSS can be achieved • flocculants can achieve 5 to 10 mg/L TSS • dissolved contaminants would not be removed	• Moderate – compatible, dewatering occurs inside the ECF • time consuming process that may conflict with time and schedule restraints • flocculants would decrease the time required to achieve a given TSS concentration • process widely used	• Low cost	• Retained
In-place Filtration	• High - proper design could achieve less than 30 mg/L TSS, but high influent concentrations (greater than 300 mg/L TSS) may result in clogging • dissolved contaminants could be removed depending on the media used	• Moderate – compatible, filtration occurs inside the ECF • time consuming process that may conflict with time and schedule restraints • flocculants would decrease the time required to achieve a given TSS concentration • not as widely used as passive sedimentation	• Moderate cost	• Eliminated

Technology	Service Criteria	Technical Criteria	Cost	Retained/Eliminated
In-place Oil Adsorbent Booms and Skimmers	• Moderate - effective in capturing oil from the water surface in the ECF, but not as reliable as an oil water separator (OWS)	• High – compatible, oil removal occurs inside the ECF	• Low cost	• Retained
Oil Water Separator	• High- very effective in capturing oil from the water • effluents of less than 15 mg/L oil and grease are common	• Moderate – a process plant would be required downstream of the ECF, or installed within the ECF	• Moderate cost	• Retained
Dissolved Air Flotation	• High – very effective in capturing oil from the water • pre-treatment using OWS and chemical addition required	• Low – process plant would be required downstream of the ECF	• High cost	• Eliminated
Flocculation/ Clarification	• High – effluent less than 5 to 10 mg/L TSS can be achieved • dissolved contaminants would not be removed	• Low – process plant would be required downstream of the ECF	• High cost	• Eliminated
Filtration - Gravity Filter - Pressure Filter	• High – effluent with less than 5 to 10 mg/L TSS can be achieved • some fraction of dissolved contaminants would be removed	• Low – a process plant would be required downstream of the ECF	• Moderate cost	• Retained
Adsorption - Activated Carbon - Other Media	• High – effective in removing dissolved organics	• Low – a process plant would be required downstream of the ECF	• High cost	• Retained

Technology	Service Criteria	Technical Criteria	Cost	Retained/Eliminated
	• would require pre-treatment for oil and grease	• process would produce a spent carbon for off-site disposal or regeneration		
Bioremediation (bioreactor)	• High – effective for removing PAHs	• Low – a process plant would be required downstream of the ECF • process would produce a solid waste stream that would require further processing and off-site disposal	• High cost	• Retained
Chemical Precipitation	• High – effective in removing metals • additional removal of dissolved metals may require ion exchange or ultrafiltration • would require pre-treatment for oil and grease	• Low – a process plant would be required downstream of the ECF • requires purchase of significant tankage and mechanical equipment • process likely to produce a hazardous sludge requiring off-site disposal	• High cost	• Retained

Effluent Discharge Options

Technology	Service Criteria	Technical Criteria	Cost	Retained/Eliminated
Discharge to Sanitary Sewer	• High - contaminants would be effectively treated at the off-site wastewater treatment plant • pre-discharge metals reduction may be required	• Compatible – local sanitary sewer readily available • contaminants may need to be treated prior to discharge to meet the sewer by-law limits	• Moderate to High cost - depending on rate charged by the WWTP	• Retained

Technology	Service Criteria	Technical Criteria	Cost	Retained/Eliminated
	and downtime during rain events is likely			
Discharge Directly to Hamilton Harbour	• Low – contaminants would need to be treated prior to discharge to meet water quality standards	• Very compatible	• Low cost	• Retained
Discharge to Barge Mounted Treatment System	• Moderate – contaminants would be treated in the treatment system on the barge	• Compatible – contaminants may need to be treated prior to discharge	• Moderate to High cost – depending on treatment selected and discharge criteria	• Retained

Air Emission Control Options

Technology	Service Criteria	Technical Criteria	Cost	Retained/Eliminated
Minimize Sediment Exposure to Air	• Low- air emission control efficiency may be on the order of 50% • actual performance would need to be confirmed through bench-scale testing	• High – use of hydraulic dredging and prompt capping of surface can be readily implemented	• Low cost – use of hydraulic dredging and prompt capping of surface can be done cost effectively	• Retained
Minimize TSS in Ponded Water	• Low- air emission control efficiency may be on the order of 50 % • actual performance would need to be confirmed through bench-scale testing	• High – minimization of turbidity in the ponded water can be readily implemented	• Low cost - minimization of turbidity in the ponded water can be done cost effectively	• Retained
Treatment of Dredged Material to Reduce Volatile Releases	• Moderate to High – air emission control efficiency would be a function of the sediment treatment method selected • actual performance would need to be confirmed through bench-scale testing	• Low – a separate sediment treatment train would be needed, requiring additional pilot testing, design, permitting and construction	• High cost – additional cost for pilot testing, design, permitting, construction and operations	• Eliminated
Impermeable Floating Cover	• High – assuming that the cover is designed and constructed with a 2.5 mm thickness or greater HDPE and with a good seal at	• Moderate – this option would be compatible with the ECF approach during the dewatering and consolidation stages of the	• Moderate to High cost – additional cost for design, materials, construction and inspection of cover • a vapor control and	• Retained

Technology	Service Criteria	Technical Criteria	Cost	Retained/Eliminated
	the edges	project, although complete ECF coverage would not be possible if sediment placement is done with barges	treatment devise would not be needed	
Permeable Floating Cover	• Moderate to High – air emission control efficiency would be a function of the off-gas treatment method selected • actual performance would need to be confirmed through bench-scale testing	• Low – this option is experimental and would require proof of concept and pilot testing prior to design	• Moderate to High cost – additional cost for design, materials, construction and inspection of cover	• Eliminated
Temporary Vapor Control Structure	• High – air emission control efficiency could be on the order of 100% for a properly designed system	• High – temporary vapor control structures are commercially available and can be readily implemented at the site	• High cost – additional cost for siting, leasing and erecting the building, and designing, constructing and operating the vapor control and treatment device	• Retained
Miscellaneous Controls	• Low- air emission control efficiency may be on the order of 50% • actual performance would need to be confirmed through bench-scale testing	• Low – this option is experimental and would require proof of concept and pilot testing prior to design	• Low cost – most of these options can be done cost effectively	• Eliminated

COVER AND CONTAINMENT DESIGN OPTIONS

D.4 Containment and Cover Options

D.4.1 Initial Screening

D.4.1.1 Introduction

This section provides information on the identification and evaluation of containment and cover options. There were a number of issues and challenges considered in the assessment of these options, including:

- long term isolation;
- contaminant flux;
- groundwater level;
- accommodating utilities;
- surface water runoff;
- geotechnical stability; and
- Harbour water level.

Attachment D.15 describes these issues and challenges.

The following was assumed in the identification and evaluation of containment and cover options:

- the design Harbour high water level is +1.3 m and the low water level is -0.2 m;
- the design pier elevation for the port facilities is 76.2 m;
- pre-consolidation of the underlying dredged material will be required and, if necessary, the pre-consolidation loads could be applied to the cover or portions of the cover;
- the cover or components susceptible to damage by settlement, if any, will be constructed after pre-consolidation of the underlying dredged material is complete;
- the material used for pre-consolidation loads would be suitable as a sub-base for the cover and a portion of the material used for pre-consolidation loads could be left in place and graded or prepared as a sub-base for the cover;
- more than one cover design may be used on the facility (e.g., different cover designs may be used over green spaces and/or hot cells);
- suitable granular (e.g., sand, gravel, clear stone), fine-grained soils (e.g., clay) and top soil are available within a reasonable distance and at a reasonable cost (to be confirmed during detailed design); and
- the cover will be constructed of clean material.

D.4.1.2 Identification of Options

The following containment and cover options were examined for the Randle Reef project:

- Option 1 – Soil Cover;
- Option 2 – Concrete Cover;
- Option 3 – Synthetic Liner;
- Option 4 – Underdrain;
- Option 5 – Top Drain;
- Option 6 – Top and Bottom Drained; and
- Option 7 – Drained, Low Permeability Soil.

These options are described in Table D.14. Illustrations of these options are provided following Attachment D.15.

D.4.1.3 Evaluation Criteria

The following general criteria were used to evaluate the containment and cover options:

- service criteria;
- technical criteria;
- regulatory criteria;
- environmental impacts;
- cost; and
- prior application.

Attachment D16 provides a description of the specific criteria or sub-criteria used for the evaluation of containment and cover options.

D.4.1.4 Evaluation of Containment and Cover Options

Table D.15 presents the evaluation of containment and cover options. This evaluation was based on the evaluation criteria noted in Section D.4.1.3.

D.4.1.5 Results of Evaluation of Containment and Cover Alternatives

Based on evaluation of the options, Options 1 (Soil Cover) and 2 (Concrete Cover) were preferred (note: Option 1 would only be suitable for green space since it will not meet the port facility surface pavement requirements). The main outstanding issue to be resolved with respect to these options was adequate environmental performance. It was uncertain if these cover system options combined with the lateral containment options would adequately contain contaminants to acceptable environmental levels. This can only be determined through fate and transport modeling.

Table D.14: Description of Containment and Cover Options

Option	Description	Capital Cost	Operating and Maintenance Requirements	Service Life	Chance of Success
Option 1 – Soil Cover	A soil cover of about 2 m of fine grained barrier soil covered with topsoil and vegetated. The barrier soil would be advanced across the contained sediment in one or two lifts. The primary methods of compaction would be from construction equipment during placement. The surface would be graded to promote runoff and reduce infiltration. This option does not meet HPA requirements for an asphalt or concrete final surface over the port facility area, however, it may be suitable for green space. Within the green space area, the topsoil layer could be much thicker and include select fills to facilitate landscaping.	The estimated capital cost is about $34/m². The capital cost would increase if the cover was thickened for engineering purposes or for landscaping.	The initial maintenance period could be specified in the construction contract to assist in the firm establishment of vegetation. After the vegetation is well established, the operating and maintenance requirements would consist of: • inspections and repairs of erosion and differential settlement that may affect the performance; • inspection and spraying for noxious weeds, as required; and • inspection and maintenance/removal of wildlife which may damage the cover (e.g., groundhogs).	After the vegetative cover is established, the vegetative mat should re-generate and the service life was considered to be very long and meet the 200 year design criterion. The cover is readily accessible and could be reconstructed, repaired or replaced, as necessary.	Soil covers have typically been used with good success at contained dredge facilities, landfills and other facilities containing contaminants where the ground water/leachate level is below the cover. There is a small possibility that the contaminants from the contained sediment could migrate upwards. The chance of success would be further improved with increased distance between the ground water level in the ECF and the cover surface.
Option 2 – Concrete Cover	A barrier soil of approximately 1.5 m deep would be placed over the contained sediment and compacted. A granular base would then be added and the top surface would be concrete or asphalt, designed to meet the HPA's loading requirements. The surface would be graded to promote surface runoff. It was assumed that the granular	The capital cost is estimated to be $81/m².	There are no special operating requirements although the cover will need to be inspected and undergo routine maintenance measures on an annual basis. Routine maintenance would include repairing and/or sealing cracks in the concrete.	Barrier soils and granular materials are commonly used in cover designs and are considered to have a long service life. The concrete surface would require inspection and maintenance but it is readily accessible and can be replaced as required. The service life of this option was considered to meet the 200 year design criterion.	Concrete and asphalt covers have been used with good success at contained dredge facilities. There is a small possibility that the contaminants from the contained sediment could migrate upwards towards the surface. The chance of success would be improved with an increased distance between the ground water level in the

Option	Description	Capital Cost	Operating and Maintenance Requirements	Service Life	Chance of Success
	would be free draining to the Harbour or surface water management system but would require the following: • that the water draining into the granular be suitable for discharge although (to be confirmed); • a drainage pathway would be available through the lateral containment; and • the hydraulic transmissivity of the granular base would be suitable.				ECF and the cover surface.
Option 3 – Synthetic Liner	Similar to Option 2, this option incorporates a synthetic liner to isolate the contained sediment. The purpose of the synthetic liner is to provide a barrier to the upward movement of contaminants.	The capital cost is estimated to be $98/m^2$.	There are no special operating requirements although the cover would need to be routinely inspected and maintained on a regular basis. Routine maintenance would include repairing and/or sealing cracks in the asphalt.	Barrier soils and granular drainage materials are commonly used in cover designs and these elements are considered to have a suitably long service life. The asphalt surface will require inspection and maintenance but it is readily accessible and can be replaced, as required. Geomembranes also have suitably long service lives. This option was considered to meet the 200 year design criterion.	The geomembrane would provide an effective advection and diffusion barrier isolating the contaminants from the surface and the upper cover elements, minimizing the possibility for contaminant impact on the surface components of the cover or on surface runoff. Soil covers are typically used with good success at contained dredge facilities, landfills and other facilities containing contaminants where the water level is below the cover. HDPE liners have been employed where dredged sediments are contaminated

Option	Description	Capital Cost	Operating and Maintenance Requirements	Service Life	Chance of Success
					with PAHs and PCBs at levels that have exceeded applicable concentration thresholds. There is some concern that rising ground water levels due to deep ground water discharge, rising Harbour water levels or a build up of methane gas underneath the geomembrane could result in a build up of pressure under the geomembrane. As with Option 2, water discharged from the top of the geomembrane would have to be conveyed to the surface water system or Harbour.
Option 4 - Underdrain	To address concerns regarding fluctuating water levels, a drainage layer or geodrain would be placed on top of the contained sediment for the collection of water from underneath the geomembrane. Drainage pipes would be placed within the drainage layer to facilitate drainage of water (e.g., pore water from consolidation, upward groundwater seepage, inward seepage from the Harbour) from under the geomembrane. The drainage	The capital cost is estimated to be $122/m^2. Additional costs include: • the provision of service access points for maintenance of the installed drainage pipe network; • a pump station; and • water treatment for water collected from under the drain system.	The following operating and maintenance items would be required: • regular visual inspection; • repairing and/or sealing cracks in the asphalt; • water samples collected; • maintenance of the water treatment systems • operation, inspection, maintenance, rebuild, etc. of the pump station and related equipment.	Granular drainage materials are commonly used in cover designs and leachate collection systems at many waste management facilities. The elements of this cover option are, therefore, considered to have a suitably long service life. The asphalt surface would require inspection and maintenance but it is readily accessible and can be replaced, as required. HDPE pipes have been used for leachate collection systems in waste management facilities	Similar to Option 3, contaminants are isolated from the surface and the upper cover elements by using the geomembrane which minimizes the possibility for upward contaminant movement. The under drain will control the upward migration of water to and through the geomembrane. It may also be feasible to place drainage pipes (of the under drain) at an elevation below Harbour water levels which

Option	Description	Capital Cost	Operating and Maintenance Requirements	Service Life	Chance of Success
	layer would also facilitate venting of any vapours. A geomembrane would be placed over the drain to provide a barrier between the contained sediment and the upper layers (the protective soil, granular and concrete). A protective soil or geotextile would be placed immediately above the geomembrane and a granular soil would be placed above the geomembrane for drainage and to provide a base for the asphalt surface.			and, therefore, the service life of the geomembrane and pipes are considered to be acceptable. The mechanical components consisting of the pump station and water treatment system are considered to be replaceable and, therefore, the service lives are considered suitable. This option was considered to meet the 200 year design criterion.	would result in ground water flowing into the ECF. This would result in ground water flow into the ECF. This would significantly reduce the potential contaminant flux from the ECF, however, it does result in additional water being collected which may require treatment.
Option 5 – Top Drain	This option is similar to Option 3 but includes drainage pipes above the geomembrane liner to facilitate drainage of water infiltrating through the asphalt before it infiltrates the geomembrane and contacts the contained sediment. The top drain addresses any concerns related to the transmissivity of the granular base to adequately convey water infiltrating the asphalt to a discharge point. It also allows the water to be collected at a discrete location(s) prior to discharge which would facilitate sampling and performance monitoring.	The capital cost is estimated to be $\$101/m^2$. Additional capital costs include service access points for maintenance of the installed drainage pipe network and collection of samples for performance monitoring. Since the water is being collected above the geomembrane, it is assumed to be suitable for direct discharge to the Harbour without the requirement for pumping and treatment. Therefore, no allowance is made for a pump station or treatment.	The following operating and maintenance items would be required: • regular visual inspection; • repairing and/or sealing cracks in the asphalt; • inspection of the pipes; and • sampling and analysis of the water collected.	Granular drainage materials are commonly used in cover designs and leachate collection systems at many waste management facilities. These elements of this option are considered to have a suitably long service life. The asphalt surface would require inspection and maintenance but it is readily accessible and can be replaced, as required. HDPE pipes have been used for leachate collection systems in waste management facilities and, therefore, the service life of the geomembrane and the pipes are considered to be acceptable. This option was considered to	Similar to Option 3, contaminants are isolated from the surface and upper cover elements by the geomembrane which minimizes the possibility for upward contaminant movement. The top drain minimizes mounding of water on top of the geomembrane and therefore should reduce infiltration. Infiltration through the concrete or asphalt surface is not considered to be a significant issue at this time. Similar to Option 3, this option does not address the issue of water levels or methane gas increasing below the

Option	Description	Capital Cost	Operating and Maintenance Requirements	Service Life	Chance of Success
				meet the 200 year design criterion.	geomembrane. It does, however, allow for monitoring of water quality above the geomembrane.
Option 6 – Top and Bottom Drained	This option is similar to Options 4 and 5, but includes drainage pipes above and below the geomembrane to facilitate drainage. The under drain prevents a build up of pore pressure underneath the geomembrane. It also offers the opportunity to maintain the ground water level within the ECF below the Harbour water level, thus maintaining an inward hydraulic gradient (hydraulic trap). The top drain minimizes infiltration through the geomembrane, as well as offers a location for performance monitoring. Due to its location above the geomembrane, water collected in the top drain is expected to be "clean".	The capital cost for this liner option is estimated to be $128/m². Additional capital costs include: • provision of service access points for maintenance of the installed drainage pipe network (top and bottom drain); • a pumping station; and • water treatment is likely necessary for the water collected in the under drain.	The following operating and maintenance items would be required: • regular visual inspection of the asphalt surface; • repairing and/or sealing cracks in the asphalt; • inspection of the pipes (top and under drain). • sampling of the water collected (top and under drain); • a water treatment system (considered to be likely for water collected in the under drain); and • operation, inspection, maintenance, rebuild, etc. of the pump station and related equipment.	Granular drainage materials are commonly used in cover designs and leachate collection systems at many waste management facilities. These elements are considered to have suitably long service lives. The asphalt surface would require inspection and maintenance but it is readily accessible and can be replaced, as required. HDPE pipes have been used for leachate collection systems in waste management facilities and, therefore, the service lives of the geomembrane and the pipes are considered to be acceptable. The mechanical components such as the pump station and water treatment facilities are considered to be accessible and replaceable. This option was considered to meet the 200 year design criterion.	Similar to Option 3, contaminants are isolated from the surface and the upper cover elements by the geomembrane which minimizes the possibility for upward contaminant movement. The under drain will control the upward migration of water to and through the geomembrane. It may be feasible to place the under drain pipes at an elevation below the normal Harbour water level which would result in water seeping into the ECF. The main advantage would be in an inward advective flow, minimizing the migration of contaminants out of the ECF. This would significantly reduce the potential contaminant flux out of the ECF, however it does result in additional water being collected and possibly requiring treatment. Therefore, the increased chance of achieving environmental objectives is at

Option	Description	Capital Cost	Operating and Maintenance Requirements	Service Life	Chance of Success
					least partially off set by the increased chance of technical complications due to the engineering components. Also, operating and maintenance requirements are increased due to the increased level of complexity. The addition of the top drainage system does not appear to significantly increase the chance of success, unless drainage below the asphalt surface is shown to be a concern at future design stages. In general, Option 6 contains more engineered elements than Options 1-5 making it more complex. However, it also allows the most control over infiltration and the groundwater levels within the ECF.
Option 7 – Drained – Low Permeability Soil	This option is similar to Option 6 but uses a barrier soil in place of the geomembrane. For construction purposes, a minimum 1.0 m thick barrier soil layer was selected. To provide for a 1.0 m thickness of barrier soil, the top elevation of the contained sediment would be lowered to approximately 73.8 m.	The capital cost for this liner option is estimated to be $113/m^2$. Additional capital costs include: • provision of service access points for maintenance of the installed drainage pipe network (top and bottom drain); • a pump station; and • water treatment is	The following operating and maintenance items would be required: • regular visual inspection of the asphalt surface; • repairing and/or sealing cracks in the asphalt; • inspection of the pipes (top and under drain). • Sampling of the water collected (top and under	Granular drainage materials and compacted soil liners are commonly used in cover designs and leachate collection systems at many waste management facilities. Therefore, these elements are considered to have suitably long service lives. The asphalt surface would require maintenance but it is readily accessible and can be replaced, as required. HDPE pipes have	In general, the chance of success for Option 6 is applicable to Option 7, however the main differences are: • utilizing a barrier soil consisting of a natural material (e.g., clay) reduces the uncertainty with respect to the service life of the geomembrane; and • a barrier soil may be more

Option	Description	Capital Cost	Operating and Maintenance Requirements	Service Life	Chance of Success
		considered likely to be necessary for the water collected in the under drain.	drain); • water treatment is considered to be likely for water collected under the drain; and • operation, inspection, maintenance, rebuild, etc. of the pump station and related equipment.	been used for leachate collection systems in several waste management facilities and, therefore, the service lives of the pipes are considered to be acceptable. Although the service life of an HDPE geomembrane utilized in the previous options is considered suitable, natural soil barriers are generally considered to have longer service lives than synthetic liners. This option was considered to meet the 200 year criterion.	robust with respect to future construction; for example, driving piles for foundations may be simplified if a soil barrier is used. Somewhat offsetting these benefits is the generally improved performance of geomembranes with respect to contaminant transport.

Table D.15: Evaluation of Containment and Cover Options

Criteria	Sub-criteria	Evaluation
Service Criteria	Performance	All of the options were considered to satisfactorily isolate the contained sediment from the environment and the final users. The main difference was the ability to deal with pore water and infiltration contacting the contained sediment. Options with the greatest ability to control infiltration and pore water are also more complex. The more complex options also tend to require more monitoring and maintenance which has greater potential to impact on the final use of the facility. The degree of control over the infiltration and pore water required to meet contaminant containment requirements will be determined in concert with the fate and transport modeling. Therefore, no minimum performance requirements were identified. Option 1 relies on the separation distance between the contained sediment and the surface to isolate the pore water from the surface environment. The inclusion of asphalt or concrete cover for Option 2 reduces the potential infiltration rate and prevents burrowing animals from reaching the contained sediment. In addition, it would meet the port facility end use requirements. Option 3 contains a geomembrane to provide a barrier to the movement of contaminants. The inclusion of a geomembrane is an improvement over Option 2 with respect to minimizing potential advective and diffusive contaminant migration. Option 4 is an enhancement of Option 3 by including an under drain. In addition to the physical barriers to contaminant migration provided in Options 1 and 2, the under drain controls the upward hydraulic gradient of ground water. The inclusion of a top drain in Option 5 would reduce the water on top of the geomembrane to reduce the infiltration rate. It also allows for the collection of water infiltrating the port facility surface (asphalt or concrete) and as such would facilitate performance monitoring. Option 6 controls the upward hydraulic ingredient by including an under drain and a top drain for performance monitoring. Option 7 is similar to Option 6, except with a clay liner – only the materials differ.
	Service Life	All of the options were considered likely to achieve the required service life of 200 years with proper maintenance and repair/replacement, where necessary and possible.
Technical Criteria	Complexity	Option 1 is the least complex, however, it is not suitable for the port facilities since an asphalt or concrete top surface is required. It may be suitable for green space areas. Option 2 is the least complex option that meets the port facility requirements for surface pavement. Option 3 incorporates a synthetic barrier component and, therefore, is considered to be more complex. The synthetic barrier component is assumed to be an HDPE geomembrane. The incorporation of a HDPE geomembrane complicates the construction of structures (which may

Criteria	Sub-criteria	Evaluation
		require pile foundations) and the installation of utilities in this area. While these issues can be adequately addressed through additional design measures, the design is considered to be more complex. The next cover option in increased complexity over Option 3 is Option 5, which incorporates a top drain. In addition to the issues associated with Option 3, Option 5 contains drainage pipes which must be cleaned, maintained and inspected. The next level of complexity over Option 5 is Option 4 which incorporates an under drain. Water collected within the under drain is assumed to be contaminated and would likely require pumping for treatment. At a minimum, this requires a pump station to convey the water to a sanitary sewer. However, an on-site water treatment system or a detention system may also be required. Options 6 and 7 were considered to be the most complex because they incorporate the most elements. Both include a top drain, a bottom drain, pump station and possibly an on-site water treatment system. Option 6 is considered slightly more complex due to the use of a geomembrane.
	Compatibility	None of the options are considered to be exclusive of options considered for any of the other components, therefore, compatibility is not considered to be a differentiating factor. Nonetheless, it was recognized that some of the options may integrate more effectively with options considered for other engineering components of the ECF.
	Constructability	Constructability essentially mirrors complexity. There are contractors in southern Ontario experienced with the construction of all of the elements considered in all of the options. All of the required materials should be available within reasonable proximity of Hamilton Harbour.
Regulatory Criteria		No significant regulatory issues were anticipated that would differentiate between the options.
Environmental Impacts		No significant differences between the options.
Cost	Capital Cost	Option 1 is significantly less expensive than the other options. Options 4, 6 and 7 would be the most expensive due to the requirement for pump stations and water treatment.
	Operating Cost	The operating and maintenance requirements generally reflect the complexity of each option. Consequently, Options 4, 6 and 7 have the highest operating costs and Options 1,2 and 3 have the lowest operating costs.
Prior Application		The vast majority of prior applications identified were variations of Options 1 and 2. This appears to represent the current design standard for ECFs. One ECF was identified which included a geomembrane cover. This same facility also had drainage pipes incorporated into a basal liner. This application is somewhat analogous to Option 3. It is well known and accepted that HDPE geomembrane covers have been used extensively at waste management/landfill facilities. No ECF designs similar to Options 4, 5, 6 or 7 were identified. Similar cover designs have been used at other waste management facilities.

Criteria	Sub-criteria	Evaluation
		The main difference is the loading requirements of the HPA port facility. While no direct prior applications for these options were identified, the main design issue is ensuring compatibility when incorporating the loading requirements for the HPA port facility with the selected option for cover and containment.

If acceptable environmental performance cannot be achieved with these options, then Options 3, 4, 5 and 6 should be considered. The order of preference for the other options was:

- Option 3 (Synthetic Liner) (subject to satisfactorily addressing concerns regarding an underlying rise in the ground water level within the ECF);
- Option 4 (Underdrain); and
- Option 6 (Top and Bottom Drained).

In general, this order represents an increasing level of complexity and cost, and decreasing frequency of prior application with respect to ECFs.

Based on the above, the following was recommended at this stage of the engineering work:

- no further work on Option 5 (Top Drain) was recommended because the increased level of complexity and cost does not appear justified when considering the accompanying increased chance of success;

- no further work on Option 7 (Drained, Low Permeability Soil) was recommended because of the volume lost within the ECF; and

- fate and transport modeling should be undertaken to determine the required hydraulic regime to provide adequate environmental containment for the contaminants of concern.

D.4..2 Detailed Evaluation – 30 Percent Design

D.4.2.1 Introduction

The evaluation of ECF cover and containment options considered the design of both ECF end uses, with approximately two-thirds of the primary ECF (a minimum 5 ha) being designed for port facility use and the remaining one-third for a greenway (i.e., soil cover).

Capping is required to limit the infiltration of precipitation and runoff to the dredged material within the primary ECF, and to minimize the potential for discharges of contaminants to surface water from the ECF. Another purpose of capping is to create a suitable surface for the planned end uses. This requires achieving the necessary material strength to support port and greenway end uses, as well as providing the ability to monitor the ECF performance over time.

Options 3 to 7 were carried forward from the initial screening to the 30 percent design and were incorporated into one or both of the two drainage and utility plans (see Section D.4.2.2) developed at this stage of the engineering and design work.

The secondary ECF is planned to contain lower priority sediments (Priority 3 and 4) and, therefore, will not likely require recharge-limiting components within the cap, but will require similar structural fill materials to support port usage design loads.

The results of fate and transport modeling and groundwater modeling were used to establish the requirements for the containment and cover options. In addition, there were a number of design requirements for the containment and cover options, as outlined in Table D.16.

The evaluation of the containment and cover options was largely deferred to the 100 percent design stage. The detailed evaluation of the containment and cover options was dependent on the more detailed development of the facility design standards and the more detailed technical studies.

Table D.16: Design Requirements for Containment and Cover Options

Item	Design Requirement
General	• an asphalt cap graded with appropriate drainage and designed to withstand port facilities end uses (e.g., no cracking given repeated traffic loading) • use of a high-strength geotextile to provide an appropriate barrier between the contaminated sediment and the capping material, and which helps to provide structural stability for initial cap construction • surcharging of the underlying sediment and use of wick drains to expedite consolidation • structural fill to provide suitable bearing capacity • accommodations for a utility corridor • system to collect, control and/or convey potential volatile emissions • possible groundwater extraction and treatment system for groundwater rise in the cap • stormwater system and possible extraction system depending on achievable grades for gravity drainage
Drainage Plan	• rapid conveyance of surface water off the facility, minimize ponding to reduce the potential for infiltration through the cap into the contained sediment, thereby reducing long-term fate and transport related issues • design storm is the five-year storm event • ECF surface cap is divided into two distinct catchment areas: (1) port facility area in which water would be collected and tight-lined for discharge into the municipal stormwater discharge system, including oil-water separation and other municipal elements typically required for the municipal system; and (2) the greenway system); future design will consider the possibility of an infiltration system from a portion of the paved facility into the layer above the liner, in-ground stormwater treatment and discharge directly into the Harbour

Item	Design Requirement
	• the final grades of the ECF will be between elevation 2.0 to 3.0 m (6.5 and 10 ft) Chart Datum (i.e., 76.2 m (250 ft) and 77.2 m (253 ft) IGLD 1985); if needed, the drainage plan will examine a maximum elevation greater than 3.0 m Chart Datum to facilitate gravity drainage and avoid a pump system; current design options for the 30 percent design show an elevation between 2.5 and 3.0 m Chart Datum for the port side and between 2.0 and 2.5 m for the greenway side to facilitate sloped drainage on the greenway by swales and rapid runoff of overtopping storm waves • a perimeter of riprap is assumed on the ECF greenway for erosion protection and overtopping storm wave energy dissipation • minimum cap thickness to be determined during later stages of design – modifications may be required to grading and elevation contingent on long-term cap stability and an assessment of cost-benefit versus long-term maintenance cost for the cap pavement • drainage conveyance will be maximized with surface collection; minimize penetration of the ECF cap • surface swales in the greenway area and surface drainage features (e.g., grated guttering) in the port facility area to be maximized to limit buried utilities in the ECF cap • future utility needs on the port facility side to be accommodated using a generic "multi-use" concrete utility corridor as a buried feature behind the heavily loaded section of the port facility • buried storm drain line to be included, contained in a utility corridor or equivalent encapsulation to prevent leaks from adding to re-charge potential and impacting contained sediment; the storm drain line is proposed to be located at the margin between the lower 50kPa and 100kPa load areas; later stages of design could consider locating the storm drain between the port facility double walls • limited vertical distance to grade for gravity drainage is available- this element needs to be harmonized with minimizing cap thickness and ECF volume capacity • design should provide a time of concentration for peak discharge off the facility so that infiltration is minimized
Naturalized Area	• a readily available and low cost capping medium with low permeability • use of surcharge material from the port facility area as capping material • geomembrane liner or geosynthetic clay liner materials

Item	Design Requirement
	• drainage swales to facilitate overland flow and discharge of runoff • a layer of non-structural, low-permeability asphalt • designed media which facilitates infiltration, treatment and discharge of the stormwater from the port facility area

D.4.2.2 Identification of Options

The capping and closure design was dictated by the design standards and the more detailed studies conducted during the 30 percent design work. The 100 percent design work further identified and evaluated specific design options.

For purposes of the 30 percent design, two options which incorporate some or all of the design standards are presented in Figures D.7 and D.8.

Options 1 (Soil Cover) and 2 (Concrete Cover) are similar in design for most components (i.e., combination of greenspace and pavement, presence of a utility corridor, diversion berms, possible granular filter media, etc.). Option 1 includes a channel with a surface grate or equivalent surface collection/conveyance channel sized for a five-year storm. Option 2 omits the channel but includes grading for surface swales in the green space adjacent to the pavement. In addition, Figure D.9 illustrates the cross sections for the port facility and greenspace for the 30 percent design.

D.4.2.3 Evaluation Criteria

A detailed evaluation of the containment and cover options was not completed at the 30 percent design stage. Therefore, the criteria that were used to evaluate options for some of the other facility elements were not used at this stage. A detailed assessment of the options was dependent on the further development of design standards and the results of more detailed studies at the 100 percent design level.

D.4.2.4 Evaluation of Options

As noted above, a detailed evaluation of the containment and cover options was not conducted at the 30 percent design stage. Much of the evaluation of the containment and cover options was deferred to the 100 percent design stage.

Figure D.7: Option 1(Soil Cover) - Drainage and Utility Plan

Figure D.8: Option 2 (Concrete Cover) – Drainage and Utility Plan

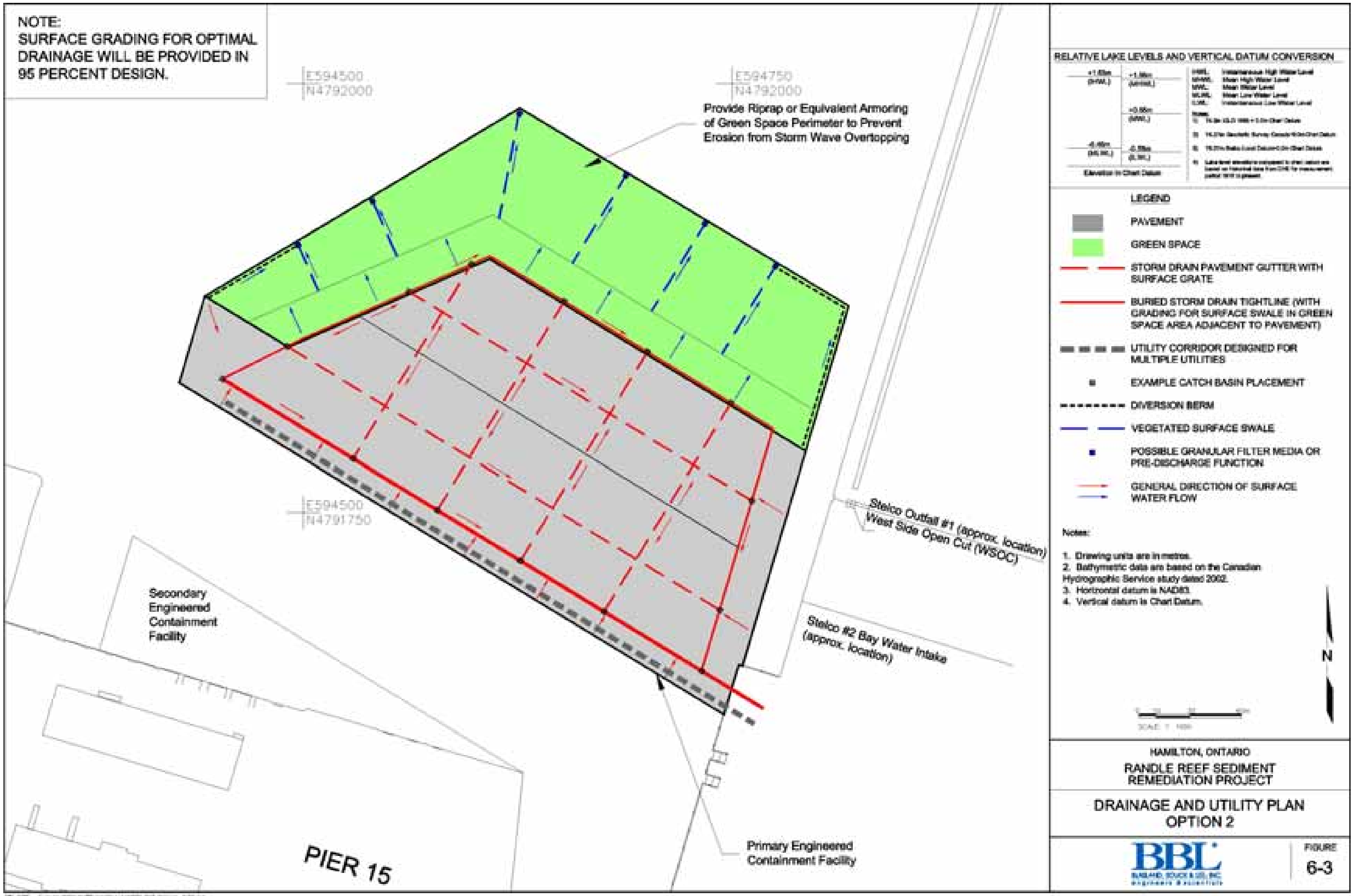
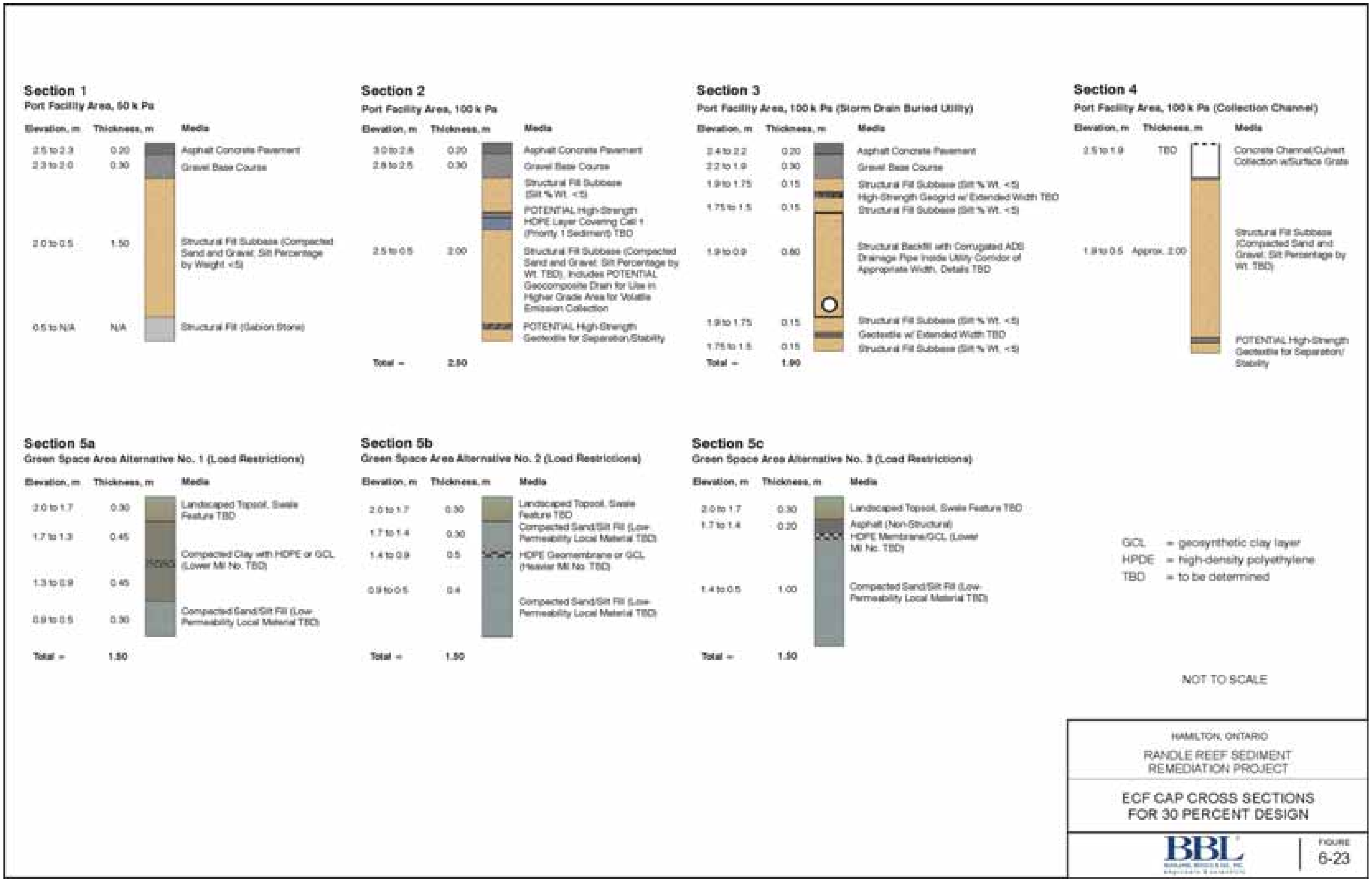


Figure D.9: Cross Section for Pavement and Greenspace Designs



However, the advantages and disadvantages of the two drainage and utility options were examined and are provided in Table D.17. Areas where there are similarities between the two options are also noted. Preliminary recommendations were made based on the comparison of the two options.

Table D.17: Advantages and Disadvantages of 30 Percent Design Containment and Cover Options

	Option 1 (Soil Cover) – Drainage and Utility Plan	Option 2 (Concrete Cover) – Drainage and Utility Plan
Advantages	• minimizes the use of buried utilities and subsurface structures including pipelines, manholes and treatment structures • able to limit/address infiltration * • long-term maintenance requirements and costs are lower than Option 2	• more flexible use of the ECF surface • less requirements for site grading • can be increased in capacity during design to handle larger storms, if desired • lower ability to limit/address infiltration • may be designed for a higher level of stormwater treatment
Disadvantages	• limitations on surface grading • constraints on vertical space	• more complex • more expensive than Option 1
Similarities Between Options	• both options provide overall protectiveness if appropriate design elements are met for fate and transport • both options meet overall design standards and requirements • well-graded structural fill compacted to a high performance specification (i.e., achieving 50 kPa for 12 m and 100kPa for the remainder within the available vertical space) • geotextile to provide working medium above dredged material and to maintain separation during long-term consolidation • ability to use low cost wick drains to facilitate consolidation • adequate pre-load/surcharge of the cap to achieve bearing capacity and/or allowable settlement • equipment, materials, services, etc. would be available to implement, verify and monitor the effectiveness of the design option - details to be determined at 100 percent design level • to limit infiltration, a liner/GCL is proposed for both options; an	

	Option 1 (Soil Cover) – Drainage and Utility Plan	Option 2 (Concrete Cover) – Drainage and Utility Plan
	emergency pump-out below the liner would provide a mechanism for preventing groundwater rise from contaminating the cap; a collection trench is proposed along the asphalt edge to remove infiltrated water above the liner/GCL • later stages of design will also consider in-ground treatment of infiltration stormwater prior to discharge to the Harbour • end or interim use will depend on construction schedule, capital expenses and opportunities to secure tenants • both options have the ability to convey the five-year storm and anticipated effects of larger storm event • both options are compatible with port services (e.g., rail service – accommodating Cooper E-380 rail loading)	

D.4.2.5 Results of Evaluation of Options

The results of the evaluation indicated that Option 1 was preferred. However, Option 2 was retained until further design criteria were developed since design requirements for elements such as surface grading may require the additional design features identified in Option 2 (e.g., inclusion of a pump station).

D.4.3 Detailed Evaluation – 100 Percent Design

It is important to note that the engineering design for the secondary facility was carried forward until part way through the 100% design stage. At this point, it was removed from the final design due to technical and cost considerations. The 30% design options for the secondary ECF focused on a need for sealed environmental containment to address potential issues of contaminant fate and transport, primarily because of the presence of Priority 1 sediment within the proposed footprint of the secondary ECF. This resulted in the requirement for a double-walled structure. During the 100% design stage, the cost of the double-walled system, the isolation of lower priority sediments and the port facility structural requirements were determined to be prohibitive (almost four times the cost per unit volume of the primary ECF). The secondary site was ultimately eliminated from the 100% design as a component of the remediation project.

D.4.3.1 Introduction

The 100 percent design for the containment and cover developed the final design details for the capping system, grading and stormwater management systems. The design of the capping system will accommodate port facility loads, limit surface water infiltration and resulting ground water recharge to contaminated sediment, and provide effective stormwater drainage.

Once it is filled and capped, the primary facility will comprise a minimum 5 ha port facility and a 2.6 ha greenway. The port facility incorporates optimized paved area (to accommodate multiple end uses and anticipated tenant needs), rail access and Cooper E-80 rail loads, a multi-use utility corridor, dockside connections and detailing that facilitates the berthing of design vessels. A possible dry dock west of the secondary ECF and a barge or Ro-Ro dock (i.e., roll-on/roll-off dock used for transporting wheeled cargo) on the west side were considered as potential end uses for the port facility on the secondary ECF. The design load requirements for the port facility range from 50 kilopascals (1,000 pounds per square foot (psf)) to 100 kilopascals (2,000 psf). For the greenway, the vegetative cover system includes features that are capable of sustaining native growth and improving aesthetics. Opportunities for a naturalized shoreline and provision of various types of habitat, as appropriate, will be examined. The higher slopes of the greenway will provide protection from wave action and assist with stormwater management.

The 100 percent design included a review of the various standards and guidance for the development of the design for the ECF cap and stormwater management systems, and application of the standards and guidance to the proposed design. Design considerations for the ECF capping system, grading and stormwater management developed during the 30 percent basis of design and during the geotechnical design and the groundwater fate and transport studies completed for the 100 percent design, were applied to the design of the various options for the port facility and the greenway. Construction monitoring, preliminary costing data and the construction scheduling and sequencing were also developed for the 100 percent design.

D.4.3.2 Identification of Options

The following options for the capping system were reviewed and design considerations were applied to develop the design for the capping system:

- foundation layer;
- underliner drainage system;
- gas venting layer;
- hydraulic barrier layer;
- overliner drainage system;
- surface drainage layer; and
- protection and erosion control layers.

The design details for stormwater management, grading and utilities differ for some of the elements for the port facility area and the greenway. Design concepts and approaches for the port facility include calculation of stormwater runoff, review and application of site limitations, development of stormwater management features and the development of site grading and utility corridors. For the greenway, the design concepts and approaches that were applied include calculation of erosion control and stormwater runoff, review and application of site limitations, development of stormwater management features and grading and drainage.

D.4.3.3 Review of Objectives and Studies

A number of design considerations were developed and carried forward from the 30 percent level of design to support the 100 percent design. The following are examples of some of the conclusions that were applied to the 100 percent design from the Basis of Design work (Arcadis BBL, 2006):

- a minimum cap thickness should range from 2.0 to 2.5 m (6.6 to 8.2 ft) for a heavy load area, live loads and traffic routes that cross the facility;

- port facility dockside areas must be set at or near the elevations of the surrounding piers to avoid the need for and associated cost of additional components for vessel loading and unloading;

- stormwater detention ponds and on-site stormwater detention in general are to be avoided; and

- high-strength geosynthetics should be used to reinforce cap material at the interface of dredged material disposed in the ECF and the cap.

In addition, the review and applicability of various regulatory requirements, guidelines and standards were assessed for the ECF capping system, including minimum thickness requirements, infiltration rates, gas generation, end use and final slope consideration. Similarly stormwater management reviews and comparisons to typical landfill cover systems were used to develop the design of the capping system, stormwater system and grades.

These reviews identified the following:

- the minimum thickness requirements for the capping systems above the geomembrane will range from approximately 2 to 3 m (6.6 to 9.8 ft);
- infiltration rates through the ECF capping system will be controlled primarily by a stormwater collection and conveyance system;
- air modeling results for the capped sediments within the ECF system indicate that a gas venting system is not required;
- the paved and green-way areas provide for the various end-uses;
- the ECF slopes should provide slope stability and promote runoff before infiltration where applicable. The ECF capping system has slopes of less than 5%, which is below the minimum to prevent ponding on the surface but does not have slopes that exceed the maximum. These slopes are necessary for the future uses in the port facility area which will use pavement and a sub-

surface stormwater collection, treatment and conveyance system for runoff control. For the greenway, the slopes range from 1 to 9%;

- to reduce the potential for surface water ponding, surface slopes in high-use areas (port facility) have been limited to no less than 1% to promote positive drainage to on-site stormwater collection and conveyance features (e.g., trench drains, stormwater catch basins, storm sewer piping). Further design may increase these slopes to maintain positive drainage under maximum anticipated differential settlement conditions;
- erosion and general soil loss will be controlled by the use of final surface cover materials, including asphalt pavement in the port facility areas, a minimum of 15 cm (6 inches) of topsoil vegetated with local plant and grass species for the majority of the greenway, and likely rock riprap where there is potential for erosive wave action near the perimeter;
- reducing the quantity of stormwater runoff from the site will not be an issue;
- for the port facility area, standard engineering practices for the design of municipal storm sewer systems will be used to size appropriate stormwater collection and conveyance features using the five year, 24 hour design storm event and/or the maximum five year rainfall intensity; and
- for the greenway, erosion control practices will be designed in accordance with appropriate guidelines (i.e., Ontario Ministry of Transportation *Environmental Guide for Erosion and Sediment Control During Construction of Highway Project).*

Further design considerations relate to those that were developed based on the groundwater fate and transport study. Napthalene, zinc and boron were selected for the modeling based on their mobility and since they have lower Ontario PWQOs. For instance, naphthalene may occur at dissolved concentrations as high as 9,300 micrograms per litre. Modeling identified recharge as a major driving force for solute transport. The results showed that all recharge into the ECF from groundwater surface mounding will require removal by drains to maintain water mass balance. The modeling results show that most or all of the water that infiltrates through the cap will likely remain within the sealed sheetpile walls.

Subgrade design considerations will consider the installation of wick drains, surcharge placement and preloading to promote consolidation within the ECF. To reduce costs, components of the ECF capping system will be constructed prior to the placement of preload. To facilitate wick drain installation, the capping system will require a foundation layer followed by a lower drainage layer to remove pore water from within the ECF during consolidation.

Materials used for the capping system will need to withstand the total and differential settlement. Current total settlement after the preload is removed is estimated to be 121 cm (4 ft) for the port facility and 32 cm (1 ft) for the greenway, with a differential settlement of 89 cm (3 ft) in the transition zone between the two areas. This settlement is expected to occur within the ECF. Once settlement is complete in the underlying foundation soils, the total settlement is estimated to be 136 cm (4.5 ft) for the port facility and 98 cm (3.2 ft) for the greenway, with a differential settlement of 38 cm (1.3 ft).

The total amount of settlement within the ECF is the most important component of settlement since it affects termination of geosynthetics at the sheetpile wall and differential settlement between the port facility and greenway areas. Settlement plates will be used to monitor settlement.

The amount of settling that will occur after the preload is removed may have an impact on final grading of the paved surface for the port facility, as well as placement of stormwater piping outlets.

D.4.3.4 Evaluation of Options

The design for each layer of the capping system from lowest to the uppermost layers was evaluated by considering the technical properties for the material selection for each layer and developing the required specifications. The layers which were considered include:

- the foundation layer (consisting of a geotextile separation layer and a geogrid system);
- the underliner drainage system;
- gas venting layer;
- hydraulic barrier layer;
- overliner drainage system;
- surface drainage layer; and
- protection and erosion control layers.

The foundation layer was selected based on providing a stable surface for the overlying layers and to facilitate the installation of wick drains. The selection of the separation geotextile is based on its ability to serve as a separation layer between the dredged material and the overlying layers, helping to maintain the drainage capability of the stone in the overlying layer. This eliminates the need and cost of sacrificial stones or aggregate, some of which would normally be lost in the underlying dredged material. The geotextile was evaluated for burst resistance, tensile strength, puncture resistance and impact tear resistance. The design calculations indicate that approximately 62 kilopascals is required for burst resistance, 0.11 kilonewtons for tensile strength, 400 newtons for puncture resistance and an opening size of 0.21 mm. Seam strength was also considered and a recommendation of overlap for seaming, thread type, thread tension, stitch density and number of rows of stitching were recommended. Factory assembly was used in the current design. Placement methods were outlined (winching the material across the dredged sediment using a cable system, using a marsh excavator or equivalent equipment capable of navigating the subgrade, or using a sectional barge). The design assumes placement by winching the material across the dredged sediment using a cable system.

The geogrid system will provide bearing capacity for the gabion stone layer and for the equipment used during construction of the lower cap and installation of the wick drains. The system should reduce differential settlement of the cap, distribute destabilizing forces from preloading or design loads deeper into the more consolidated dredged material and aid in the control of mud waves. In general, the system will contribute to the overall strength and stability of the cap during construction of the cap, the preloading phase and the long-term design loading on the cap.

Factors of safety to be applied for the selection of the geogrid system include installation damage, creep, chemical degradation, biological degradation and joints. Methods to size the geogrid for the cap were also employed. Modeling confirmed the need for the underlying dredged material to have consolidated to a shear strength of approximately 29 kilopascals during cap construction before the preload is constructed or there is a risk of a bearing-capacity-type failure.

An analysis of the porewater volume generated during consolidation provided recommendations for treatment requirements. The potential for upwelling control and groundwater management was analysed and it was concluded that the need to remove and treat groundwater is minimal and, therefore, an on-site treatment system is not proposed.

Using air modeling results, a gas venting layer is not a required component for the design.

For the hydraulic barrier layer, different materials were evaluated for use as the geomembrane, including high density polyethylene (HDPE), polyvinyl chloride (PVC), linear low-density polyethylene (LLDPE) and a geosynthetic clay liner (GCL). PVC was eliminated due to chemical incompatibility for naphthalene, one of the primary PAH congeners of concern. Use of GCL was also eliminated due to the costs associated with larger than standard overlaps of material required to withstand settlement and the associated higher costs for more material. It also has the potential to develop higher hydraulic conductivity if damaged during settlement. The HDPE geomembrane was found to have a few disadvantages compared to one made of LLDPE.

The surface drainage layer for the primary ECF was developed using design elements specific to the port facility area at the primary ECF. The secondary ECF was projected to have similar design elements, which were proposed to be further developed once the future uses of the secondary facility had been determined. For this element, a stormwater management system was developed. The “normal protection” level was selected for the design of water quality management features (as per the Ministry of Environment’s Stormwater Management Planning and Design Manual, MOE 2003). The required water quality storage volume was developed, along with a review of the site limitations (i.e., geographic location, fluctuating lake levels). These were considered along with the features for the system and site grading. The design implications were reviewed and the final grades, runoff controls systems, means to manage water storage volumes and methods to reduce infiltration into underlying layers were examined.

Similar considerations were taken into account for the greenway, although no stormwater quality control practices are proposed.

The protection and erosion control layer for the port facility will require a paved surface capable of supporting the design load of 100 kilopascal. The system will consist of sub-grade, subbase, crushed rock and asphalt layers. The subgrade of the pavement system will be placed directly above the overliner drainage systems. The greenway will use the same subgrade material as the protection layer, with stormwater management features installed within the subgrade. The greenway's erosion control layer will include topsoil and vegetation as well as riprap to serve as wave protection along the northern and northwestern perimeter of the ECF. Landscaping will include native, noninvasive plant species. Further development of the landscape design will be completed with the final drawings and specifications.

D.4.3.5 Results of Evaluation of Options

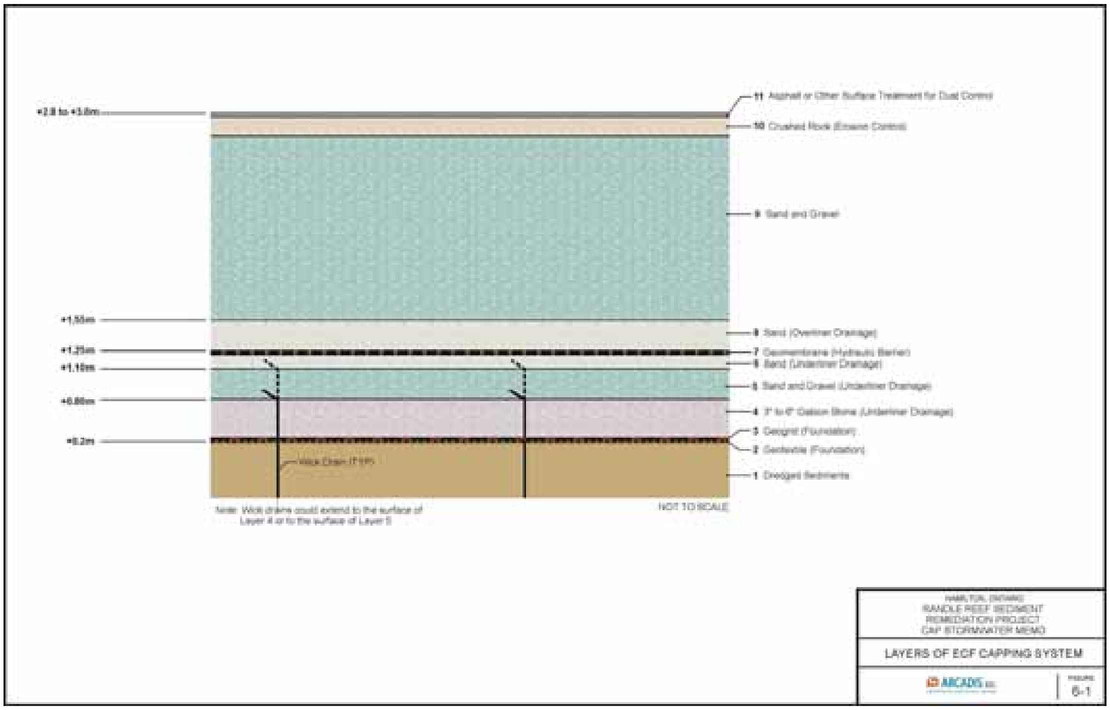
The overall design of the ECF capping system is presented in Figure D.10.

The foundation layer will consist of a separation woven geotextile placed directly on the surface of the dredged material, followed by placement of a high-strength geogrid. The foundation layer will be placed after self-consolidation of the sediments. Any large depressions on the surface of the dredged material will be smoothed out prior to placement of the geosynthetics.

The geogrid design includes one layer of a high-strength bioaxial geogrid with high modulus. A layer of nonwoven geotextile will be placed adjacent to the geogrid to provide separation. Geogrid seams will be overlapped approximately 0.3 m and tied.

Modeling results showed that the shear strength in the dredged material must increase to a certain level before the preload is applied. The shear strength will need to be verified during cap construction, using for instance, settlement plates to monitor the conditions or by using pore pressure transducers to monitor deformation behaviour and pore pressure decline.

Figure D.10: Layers of ECF Capping System



The underliner drainage system will remove pore water during consolidation and control groundwater upwelling after consolidation. The system will allow for lateral drainage of pore water/groundwater to a horizontal subsurface trench system around the internal perimeter of the
facility. Vertical risers connected to the trench system will be used to monitor pore water generated from consolidation as well as groundwater that may mound in the facility.

Design calculations for pore water generation indicated that during consolidation, a temporary onsite treatment system will be necessary to extract, treat and manage porewater.

The underliner drainage system will be constructed using gabion stone, wick drains, a transition layer of sand and gravel and a filter sand layer. The gabion stone layer will range from 7.6 to 15 cm in size and will be placed in lifts of less than 0.3 m to an approximate depth of 0.6 m. Once the gabion stone is placed, a tracked vehicle will be used to install the wick drains. A transition layer of 30 cm of sand and gravel will be used. A 15 cm lift of filter sand will be placed over the transition layer and gravel as a final filtering medium for fines, to provide a smooth installation surface, and as additional cushion to the hydraulic barrier.

A geomembrane was recommended as the material for the hydraulic barrier layer. A smooth textured LLDPE is considered to be the most appropriate material for the capping system, with a thickness of 40 mils (1 mm). Soil placement specifications will require soil to be free of debris before placement of the geomembrane. The liner will be cushioned with sand above and below. The design specifications for the material render it practically impermeable. Seaming of the liner will be completed in the field. The recommended seaming method is a dual-track hot wedge seam. A construction quality control plan for seaming, seam testing and seam repairs will be included with the specifications.

Termination of the geomembrane at the interior sheetpile wall will allow for total settlement. The design consists of a layer of nonwoven geotextile as a separation barrier beneath the liner. A wedge of soil and bentonite will be used on top of the geotextile and the liner will be placed on top of this wedge of material. Another layer of the soil/bentonite mixture will be placed on top of the liner to seal the edges of the capping system. This termination system will extend approximately 1 m from the edge of the sheetpile wall.

An overliner drainage system (essentially a monitoring layer) consisting of a 0.3 m thick layer of filter sand and filter wrapped HDPE piping ranging from 10 to 15 cm in diameter will be used. The filter sand will be well-graded sand with greater than 30% coarse material and less than 5% fines. A series of horizontal, filter-wrapped, perforated 10 cm diameter piping will be installed connected to vertical risers made of 15 cm diameter wrapped HDPE. The piping will be accessible at the surface of the capping system for monitoring purposes and can remove, as needed, any water that accumulates on the geomembrane.

A surface drainage layer that treats stormwater prior to its runoff to the area between the sheetpile walls or the Harbour will be installed. The stormwater management system will use filtration as a method for treatment prior to discharge. The system will separate grit and oil and have a 24 hour storage capacity for a five year storm event. Stormwater will travel across the surface of the port facility area and enter the stormwater management system through linear, open-grate trenches. Stormwater will then pass through catch basins and into filtration chambers. Once filtered, it will travel through a series of manholes and discharge between the sheetpile walls. Water in excess of the storage capacity will travel through large diameter pipes from the catch basin and discharge directly to the bay.

The stormwater runoff from the southern edge of the greenway will be managed using a French drain system. A stone-filled trench approximately 0.6 to 1 m in depth with a perforated drain pipe will be constructed along the boundary between the two areas and will capture clean stormwater running off the back slope of the greenway before it enters the port facility area, and will discharge the run-off between the sheetpile walls. To the extent practical, the proposed greenway will be graded to convey the surface runoff directly into the Harbour. Since much of the surface runoff will likely infiltrate into the space between the sheetpile walls, weepholes may be required and will be considered during the final design and specifications.

The protection and erosion control layer for the port facility will be a paved layer and a vegetated landscaped cover for the greenway. Placement of the protection layer will occur with the initial placement of the cap materials. Preload will be placed over the protection layer to facilitate consolidation. Once the preload is removed, the utilities and final stormwater management systems and the erosion control layers will be constructed.

The use and configuration of utility corridors is contingent on the final end use of the port facility. The details will be further developed when the exact uses are determined, likely post ECF construction. To support the potential needs, two utility corridors will be installed between the ECF double walls, likely to be placed just inside the interior and exterior walls above the tie-rod elevation of +1.0 m above Chart Datum and below the surface of the paved facility. Utilities may be designed to convey utilities separately (i.e., one corridor may be designated for electrical and mechanical utilities and the second for gas utilities). Size constraints for the corridors will need to be further examined contingent on the uses and final design.

As part of the tendering process, construction monitoring will be prepared for the following:

- subgrade and preload layers;
- sand layers;
- gabion and aggregate base course;
- asphalt layer;
- LLDPE liner;
- geogrid;
- geotextiles; and
- other best management practices to manage stormwater during construction.

Operations, maintenance and long-term monitoring will include the following:

- maintenance of the vegetative cover in the greenway;
- maintenance of the paved surface in the port facility area; and,
- inspection of the stormwater management system.

Preliminary costs are provided in Table D.18.

Table D.18: Estimated Range of Unit Costs

Item Number	Cost Item	Unit	Unit Cost		
			Low	Med	High
1	Installation of Separation Geotextile	m^2	5	6	7
2	Installation of High-Strength Geogrid	m^2	4	4	5
3	Construction of Underliner Drainage System				
	Placement of Gabion Stone	m^3	47	50	55
	Installation of Separation Geotextile	m^2	3	3	4
	Installation of Perimeter Trench Drain System				
	Piping	m	11	13	15
	Earth Materials	m^3	55	62	63
	Installation of Wick Drains	m	2	2	3
	Installation of Filter Sand	m^3	44	45	46
4	Installation of LLDPE Liner	m^2	9	10	12
5	Temporary System for Treatment of Porewater	l	2	3	3
6	Installation of Sand Cushion Layer and Overliner Drainage System				
	Piping	m	16	18	21
	Earth Materials	m^3	44	45	46
7	Installation of Settlement Plates	ea	3000	5000	6000
8	Placement of Subgrade	m^3	36	41	42
9	Placement of Subbase	m^3	39	41	42
10	Placement of Preload	m^3	39	41	42
11	Removal of Preload Material and Settlement Plates (Cost Savings for Recycling Preload)	m^3	-16	-18	-21
12	Installed Stormwater Drainage System and Utility Corridor				
	Piping	m	156	173	208
	Manholes/Catch Basins	ea	2116	2352	2822
	Materials	m^3	55	62	63
	Liner (Under Greenway)	m^2	7	7	9
13	Install Crushed Rock, Port Facility Area	m^3	39	40	42
14	Install Asphalt on Port Facility Area	m^2	18	20	24
15	Install Vegetative Cover in Greenway	m^3	44	45	42

Attachment D.15: Issues and Challenges Associated with Containment and Cover Options

Issue	Description
Long Term Isolation	The cap provides a physical barrier between the contained sediment and the environment. Wildlife management will have to address burrowing animals such as muskrats and groundhogs which may penetrate and compromise the integrity of the cover. Wildlife management could include design features, maintenance and inspection. Since this issue can be largely addressed though maintenance and inspection, it is not considered to significantly differentiate between design options.
Contaminant Flux	The contaminant pathways through the cap are as follows: • **Advective flow of pore water**, possibly increased by consolidation of the underlying soils. The advective flow must be small enough that the water can drain without becoming a structural concern. In addition, the contaminant flux must be small enough to not adversely affect the water quality of the Harbour, pose an environmental or health and safety concern at the port facility or affect the intended final use of the facility; • **Chemical diffusion -** concentration gradients may be sufficient to move contaminants through the cover. However, the contaminant flux must be small enough to not adversely affect the water quality of the Harbour or pose an environmental or health concern; and • **Pore gas** - volatile contaminants such as naphthalene may migrate through the cover as a vapour. The movement of vapours is a potential a concern if structures are built on-site as the vapours may accumulate at concentrations posing a health and/or safety concern. Vapours may also accumulate in and migrate along utility trenches (typically filled with permeable material).
Groundwater Level	The primary concerns with respect to high groundwater levels within the ECF and the cover are: • flooding of engineered components within the ECF including utility trenches and components of the cover such that their performance is compromised; and • contaminant migration off site via seepage and groundwater levels overtopping the lateral containment, utility trenches, storm water drainage facilities, etc. Factors influencing the groundwater levels within the ECF include: • **Groundwater – Upward Seepage** The Harbour is considered to be a likely groundwater discharge area. As such, upward

Issue	Description
	groundwater gradients are expected between the bedrock and the Harbour. If a low permeability design is employed for the lateral containment resulting in low lateral seepage out of the facility, there is a concern that the facility could flood from the bottom up. Groundwater level measurements at the bedrock interface will be taken as part of this design project to evaluate this issue. • **Shallow Groundwater** Shallow groundwater through the surficial soils and fill material likely discharges to the Harbour from adjacent properties. If a low permeability design is employed for the lateral containment of the ECF and shallow groundwater from adjacent properties reports to the ECF, then this groundwater must be managed, including prevention of adverse effects on adjacent properties. If groundwater flow into the ECF is restricted, for example, by the construction of a low permeability lateral containment between the ECF and the adjacent properties, drainage must be provided for the adjacent properties to ensure that groundwater conditions on the adjacent properties are not adversely affected. • **Changes in Harbour Water Levels** The Harbour water level fluctuates over time and seasonally. As the Harbour water level increases, it may create an inward hydraulic gradient across the lateral containment. This has the potential to cause water to seep into the ECF from the Harbour. As the seepage direction would be into the ECF, there would be no concern with respect to advective transport of contaminants into the Harbour through the lateral containment. However, if the water level within the ECF is allowed to increase, there may be a concern with respect to flooding of utility trenches and the adequacy of subsurface drainage. Conversely, a decrease in the Harbour water level could result in a temporary increase in the outward hydraulic gradient between the ECF and the Harbour across the lateral containment. Although temporary, this increased outward gradient could result in an increase in the advective contaminant flux into the Harbour which may not be acceptable. • **Infiltration Rate** The infiltration rate will be a key component of the water balance for the ECF. Any water which infiltrates the ECF must discharge at another location potentially: • laterally through the containment structure to the Harbour; • to the Harbour via the foundation soils; • to deep groundwater, if downward gradients are present; and/or

Issue	Description
	• to a collection system, if any. It was assumed that water infiltrating the cover and contacting the contained sediment will be contaminated.
Accommodate Utilities	The following utilities and services need to be accommodated in the design of the cover: • sanitary sewer; • water; • electrical; • communications; and • gas The electrical, communications and gas services need to be physically protected (e.g., crushing, shear, etc.), while the sewer and water need to be physically protected and protected from frost. For current purposes, a minimum 1.2 m cover soil is assumed for frost protection. Routing utilities through contained sediments represents a potential contaminant pathway off-site and, therefore, is considered to be undesirable. In addition, installation, maintenance and/or repair could be complicated because the water from dewatering the work area would likely require treatment (originate from the contaminated sediment) and there would likely be health and safety considerations for the workers. The most likely location for these utilities is within the proposed green space. It was assumed that the green space will contain screening berms. Locating these utilities within the green space allows them to be covered with sufficient soil (possibly within screening berms) and removes them from the high traffic and loads anticipated within the port facility area. It was assumed that utilities would be extended to the ECF across the land connection at the south west corner. The utility corridor could then run along the east, north and west perimeter of the ECF. This would require a slight change to the conceptual design to incorporate green space along the east perimeter of the ECF. The sanitary sewer requires either a gravity flow or a force main with a pump station. A force main will likely be required given there is likely limited elevation within the ECF and between the ECF and local sewers to maintain gravity flow for a sanitary sewer. In addition, based on early discussions with U.S. Steel, there will likely be a channel along the eastern side of the northern ECF and the use of a force main is considered more flexible for conveying the sanitary sewer across the channel.
Surface Water Runoff	While desirable to route all surface runoff through a storm water management pond(s), this may not be practical

<table>
<tr><th>Issue</th><th>Description</th></tr>
<tr><td></td><td>due to site limitations. During the final stages of design, reasonable attempts will be made to route surface runoff to storm water management ponds. Implementation of a catch basin and storm sewer system would require storm sewers to pass through the contained sediments to maintain gravity drainage. Since storm sewers through the contained sediment could function as a drain conveying pore water from the contained sediment through the lateral containment structure, they represent a potential contaminant pathway off site and, therefore, could be less desirable. However, it may not be practical to direct all surface runoff overland and therefore, some shallow storm water drains may be required.</td></tr>
<tr><td>Geotechnical Stability</td><td>Unless located on slopes where sliding is a concern, geotechnical stability is generally not a concern with respect to cover systems. Differential movements due to foundation soils, dredged material or failure of the lateral containment could potentially adversely affect performance of the cover. Therefore, the performance criteria for these items will be carefully reviewed to ensure that displacements would not adversely affect the performance of the cover. It is considered likely that the performance criteria with respect to acceptable displacements for the other engineered components will govern (e.g., structural considerations for the final end use) rather than the cover requirements.

The HPA requirements for loading are:

<table>
<tr><th rowspan="2">Distance from Dock Wall (m)</th><th colspan="2">Loading</th></tr>
<tr><th>(psf)</th><th>(kPa) *</th></tr>
<tr><td>12</td><td>1,000</td><td>50</td></tr>
<tr><td>> 12</td><td>2,000</td><td>100</td></tr>
</table>

* Values are rounded. Conversion: 1 psf = 0.0479 kPa

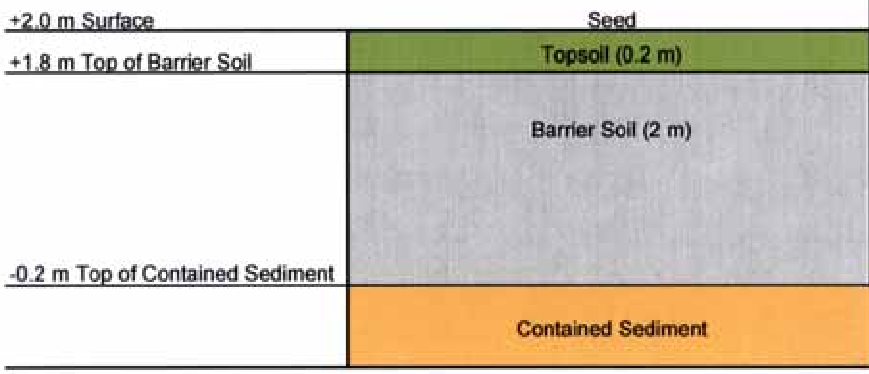
With respect to the cover, this will require that any drainage pipes or utility trenches incorporated into the cover design be sufficient to withstand these loadings plus the weight of the cover system. While point or linear loadings may locally exceed the values noted above, the asphalt or a concrete finished surface can be designed to distribute the loading.</td></tr>
<tr><td>Harbour Water Level</td><td>The predicted Harbour high water levels for specified return periods are:</td></tr>
</table>

<table>
<tr><th>Issue</th><th>Description</th></tr>
<tr><td></td><td>
<table>
<tr><th>Return Period (years)</th><th>Mean Annual Water Level (m)</th><th>Maximum Instantaneous Water Level (m)</th><th>Storm Surge (m)</th></tr>
<tr><td>2</td><td>75.00 (+0.80)</td><td>75.36 (+1.16)</td><td>0.33</td></tr>
<tr><td>10</td><td>75.28 (+1.08)</td><td>75.69 (+1.49)</td><td>0.53</td></tr>
<tr><td>25</td><td>75.39 (+1.19)</td><td>75.83 (+1.63)</td><td>0.67</td></tr>
<tr><td>50</td><td>75.47 (+1.27)</td><td>75.92 (+1.72)</td><td>0.79</td></tr>
<tr><td>100</td><td>75.54 (+1.34)</td><td>76.01 (+1.81)</td><td>0.94</td></tr>
<tr><td>200</td><td>75.61 (+1.41)</td><td>76.10 (+1.90)</td><td>1.12</td></tr>
</table>

Based on review of these water levels, and in considering a final pier elevation of about 76.2 m (IGLD), the Harbour water level will be within one metre of the surface of the pier a significant amount of the time.
</td></tr>
</table>

Illustrations

Option 1 – Soil Cover

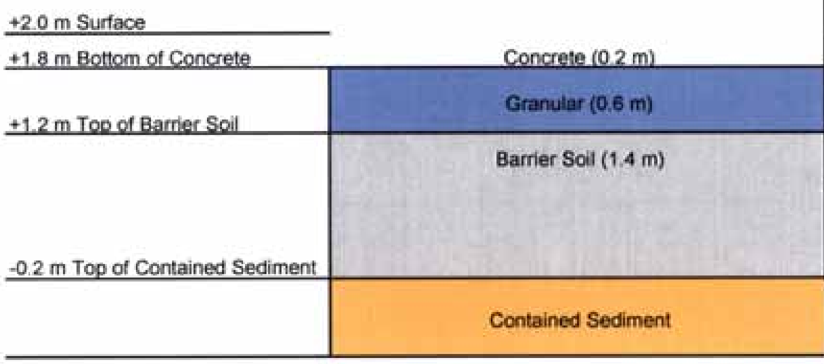


Units	Unit Cost	Quantity[a]	Cost[a]
m^2	$ 0.50	1	$0.50
m^3	$ 33.77	0.2	$6.75
m^3	$ 13.07	2	$26.14
Total[b]			$33.39

a Per square metre of cover.

b Does not include items common to other alternatives.

Option 2 – Concrete Cover

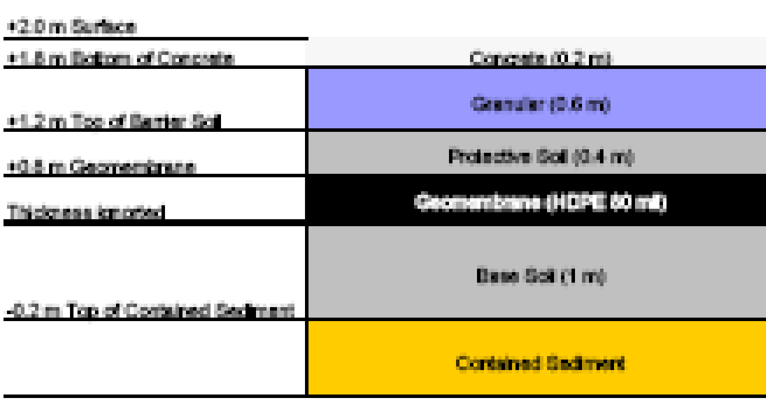


Units	Unit Cost	Quantity	Cost[a]
m^2	$ 41.70	1	$41.70
m^3	$ 34.48	0.6	$20.69
m^3	$ 13.07	1.4	$18.30
Total[b]			$80.68

a Per square metre of cover.

b Does not include items common to other alternatives.

Option 3 – Synthetic Liner

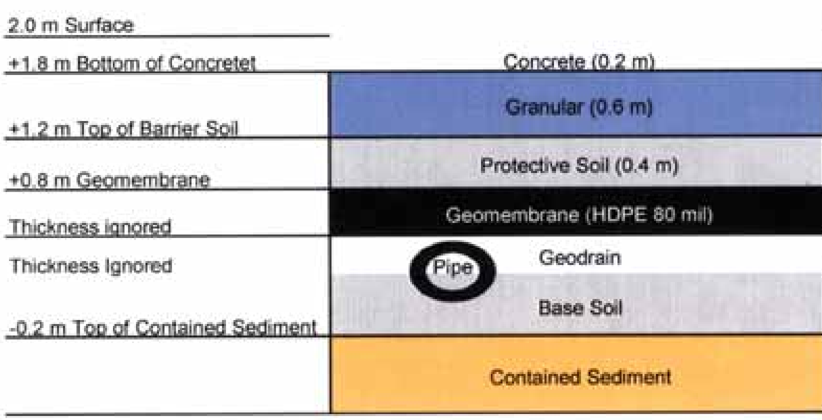


Units	Unit Cost	Quantity[a]	Cost[a]
m^2	$ 41.70	1	$41.70
m^3	$ 36.15	0.6	$21.69
m^3	$ 23.82	0.4	$9.53
m^2	$ 12.00	1	$12.00
m^3	$ 13.07	1	$13.07
Total[b]			$97.99

a Per square metre of cover.

b Does not include items common to other alternatives.

Option 4 - Underdrain

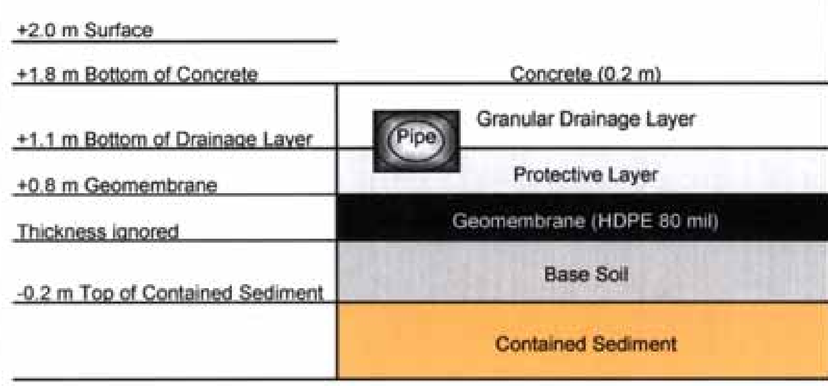


Units	Unit Cost	Quantity[a]	Cost[a]
m^2	$ 41.70	1	$41.70
m^3	$ 36.15	0.6	$21.69
m^3	$ 23.82	0.4	$9.53
m^2	$ 12.00	1	$12.00
m^2	$ 18.75	1	$18.75
m^3	$ 13.07	1	$13.07
m (Pipe)	$ 100.00	0.05	$5.00
Total[b]			$121.74

a Per square metre of cover.

b Does not include items common to other alternatives.

Option 5 - Top Drain

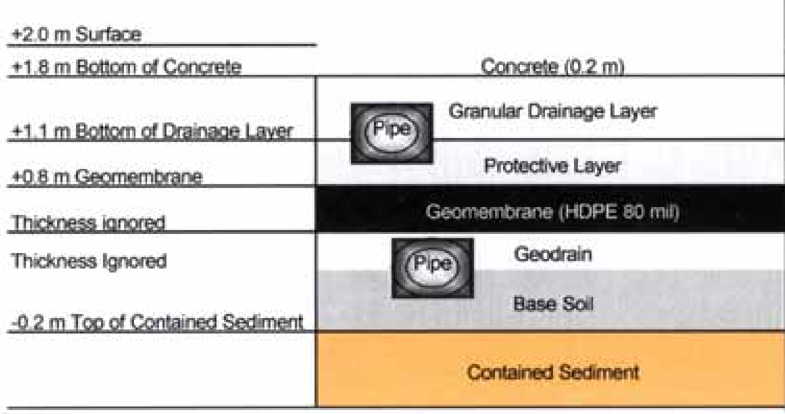


Units	Unit Cost	Quantity[a]	Cost[a]
m2	$ 41.70	1	$41.70
m^3	$ 36.15	0.7	$25.31
m^3	$ 23.82	0.3	$7.15
m^2	$ 8.25	1	$8.25
m^3	$ 13.07	1	$13.07
m (Pipe)	$ 100.00	0.05	$5.00
Total[b]			$100.47

a Per square metre of cover.

b Does not include items common to other alternatives.

Option 6 – Top and Bottom Drain

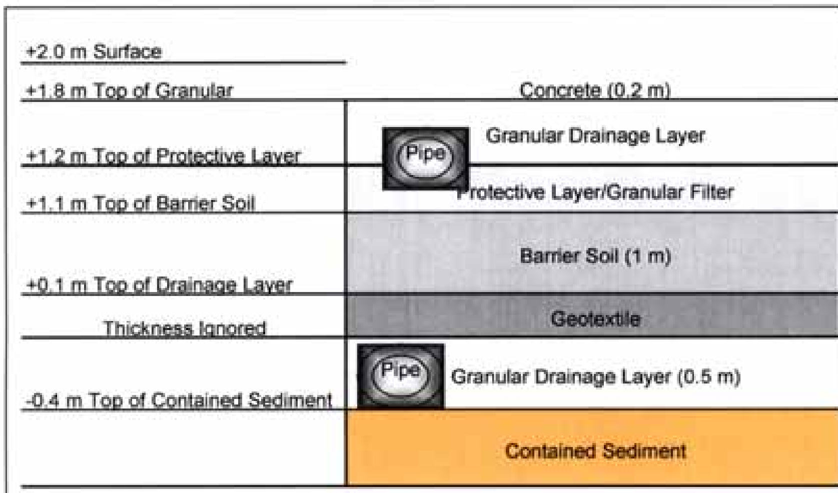


Units	Unit Cost	Quantity[a]	Cost[a]
m^2	$ 41.70	1	$41.70
m^3	$ 36.15	0.7	$25.31
m^3	$ 23.82	0.3	$7.15
m^2	$ 12.00	1	$12.00
m^2	$ 18.75	1	$18.75
m^3	$ 13.07	1	$13.07
m (Pipe)	$ 100.00	0.1	$10.00
Total[b]			$127.97

a Per square metre of cover.

b Does not include items common to other alternatives.

Option 7 – Drained, Low Permeability Soil



Units	Unit Cost	Quantity[a]	Cost[a]
m^2	$ 41.70	1	$41.70
m^3	$ 36.15	0.4	$14.46
m^3	$ 23.82	0.3	$7.15
m^2	$ 13.07	1	$13.07
m^2	$ 8.25	1	$8.25
m^3	$ 36.15	0.5	$18.08
m (Pipe)	$ 100.00	0.1	$10.00
Total[b]			$112.70

a Per square metre of cover.

b Does not include items common to other alternatives.

Attachment D.16: Containment and Capping Options: Description of Evaluation Criteria or Sub-criteria

Criteria	Sub-criteria	Criteria or Sub-criteria Description
Service Criteria	Performance	Performance of the cover options is evaluated taking into account the following: • isolation of the contained sediments from the environment; • isolation of the contained sediments from the final users; • function as part of the overall system to meet contaminant containment requirements (for example possibly limiting infiltration); • compatibility with the final use of the facility. Specific infiltration and/or permeability criteria have not been established at this stage. These need to be developed in concert with the fate and transport modeling.
	Service Life	For current purposes, it is assumed that engineered components related to contaminant containment should have a minimum service life of 200 years with appropriate allowance for replacement and/or maintenance where necessary and possible to achieve this service life. The service life is evaluated assuming that no exceptional events surpassing the design criteria occur (e.g., earthquake exceeding the design event).
Technical Criteria	Complexity	Complexity refers to the number of elements incorporated in the design and their function. Generally, the greater the number of elements, or the greater the number of mechanical components (e.g., pump stations), the more susceptible the system will be to upset conditions. Options with fewer elements or with passive elements were preferred.
	Compatibility	During the next design stage of the project, it will be necessary to combine options from the different engineering components into complete ECF design alternatives. Therefore, cover alternatives that are compatible with options considered for other components are preferred. Compatibility is a subjective evaluation of any restrictions

Criteria	Sub-criteria	Criteria or Sub-criteria Description
		the options may impose on the design of other components of the ECF.
	Constructability	Constructability differs from complexity in that it refers to the ability to construct. Complexity refers to design and operations and maintenance. Options which local contractors are more likely to be experienced with are preferred. Options which require construction in unusual or difficult conditions (e.g., significant dewatering) were considered to be less preferred.
Regulatory Criteria		This criterion relates to the ability of the option to satisfactorily meet applicable regulatory criteria. Other than overall requirements for the ECF, no specific regulatory criteria are expected to apply to the cover. It is expected that local municipal regulations, not necessarily specific to the cover, will apply and will have to be respected during construction.
Environmental Impacts		This criterion relates to any adverse environmental impacts caused by the cover. The cover will be constructed of non-contaminated material and is a passive component of the ECF. It is designed to isolate the contained sediments from the environment and be protective of future uses of the ECF. No detrimental environmental impacts are expected.
Cost	Capital Cost	This criterion refers to the expected relative capital cost to construct the options. The estimated costs are relative and are generally presented on a unit cost basis (e.g., per square metre). For simplicity, the relative cost estimates are not inclusive and omit costs items common to all of the options. Therefore, the relative cost estimates are not suitable for planning or construction cost estimating. Some cost items which could not be estimated at this stage (e.g., pump stations, water treatment) were not included.
	Operating Cost	This criterion evaluates the expected operating and maintenance requirements. This includes inspection, monitoring and expected maintenance. Costs are not estimated in absolute dollar terms, but rather options with lower or fewer operating and maintenance requirements are preferred. There are operating and maintenance requirements that are common to all options. The common items such as monitoring the water level

Criteria	Sub-criteria	Criteria or Sub-criteria Description
		within the ECF were not considered since they do not differentiate between the options. Operating and maintenance requirements such as operating pump stations and inspecting collection systems are considered.
Prior Application		Experience at other sites and similar applications were considered. Options with prior applications were considered to have a greater chance of success and were, therefore, preferred. Professional judgement was exercised in evaluating the applicability of prior applications.

U.S. STEEL INTAKE / OUTFALL DESIGN OPTIONS

D.5 U.S. Steel Intake / Outfall (I/O) Options

D.5.1 Initial Screening

D.5.1.1 Introduction

The proposed ECF will be located in the vicinity of the existing pumphouse and water intakes as well as the west side open cut (WSOC) outfall located on the U.S. Steel property. Due to the proximity of the proposed ECF to the U.S. Steel property, the project design and its implementation must not interrupt the supply or affect the quality of water entering the pump station.

There are a number of issues associated with development of the ECF in the vicinity of the existing U.S. Steel process water intake and the outfall from the WSOC. The key issues include:

- guarantee of uninterrupted operation of the intake during construction;
- subsequent operation of the ECF and its impact on U.S. Steel operation; and
- maintenance of the water quality during construction and operations of the ECF.

An island with an open channel running parallel to the existing U.S. Steel Pier 16 between the eastern boundary of the ECF and the pier was considered as the primary source for intake supply (see Section 6.0). In this scenario water entering the pumphouse could flow either from the northeast along the new channel or from the Sherman Inlet south of the pumphouse. It was concluded during early discussions with U.S. Steel that the quality of water in the Sherman Inlet would likely be unacceptable during periods of high runoff owing to elevated levels of suspended solids and possibly other contaminants. Future operation of tugs or shipping at Pier 15 was also raised as a possible cause for water quality issues owing to re-suspension of sediments.

This section examines the integration of the proposed ECF structure with U.S. Steel's water intakes in a manner that protects U.S. Steel's water supply and quality and achieves the project objectives. It provides information on the evaluation of the U.S. Steel I/O options. The key assumptions relating to the evaluation of the U.S. Steel I/O options are provided in Attachment D.17.

D.5.1.2 Identification of Options

Four options were identified, two of which were developed into general concepts. The four options, which are described in Table D.19, were:

- Option 1 – Piped I/O;
- Option 2 – Open Channel;
- Option 3 – Open Channel Wider than Option 2;

- Option 4 - Relocation of Pumphouse Intake Structure.

Table D.19: Description of U.S. Steel I/O Options

Option	Description
Option 1 – Piped I/O	• the ECF boundary would be contiguous with U.S. Steel's east pier (Pier 16) • a large forebay would be constructed to enclose the existing water intake structure • approximately 250 m of twin 2.5 m diameter pipes would be installed underground below the ECF and running northeast parallel to Pier 16 to open water beyond the ECF • access to the ECF would be via a road running close to the southwest corner of the proposed forebay • a backup water supply would be provided from the Sherman Inlet
Option 2 – Open Channel	• the ECF would be separated from U.S. Steel property by a 22 m wide, open water channel • access to the ECF island would be via a short causeway located just beyond U.S. Steel property southwest of the pumphouse • a concrete channel and gate structure would be incorporated into the causeway design to provide a backup water supply for U.S. Steel
Option 3 – Open Channel Wider than Option 2	• a channel wider than 22 m would separate the ECF from the U.S. Steel property • this approach would place a portion of the most contaminated area, referred in the project documents as the "fish tail area", outside the ECF • the material would need to be dredged and placed inside the containment rather than being left in-situ, which would increase the project cost and risk unnecessarily
Option 4 – Relocation of Pumphouse Intake Structure	• the relocation/reconstruction may involve redesign of U.S. Steel's existing pumphouse piping system

Options 3 and 4 were considered but ruled out as being undesirable for technical reasons, or as being unnecessarily complex.

Attachment D.18 provides a more detailed description of Options 1 and 2.

D.5.1.3 Evaluation Criteria

The following general criteria were used to evaluate the U.S. Steel I/O options:

- service and performance criteria;
- technical criteria;
- regulatory criteria;
- environmental impacts;
- cost; and

- prior application.

Attachment D.19 provides a description of the specific criteria or sub-criteria used for the evaluation of U.S. Steel I/O options.

D.5.1.4 Evaluation of U.S. Steel Intake/Outfall Options

Table D.20 provides a summary evaluation of the U.S. Steel I/O options, based on the evaluation criteria noted in Section D.5.1.3.

Options 1 (Piped I/O) and 2 (Open Channel) are both technically feasible and can meet the design criteria set for the water intake and WSOC outfall. There are, however, significant differences between the options when examining operation and maintenance issues. For example, Option 1 includes new structures such as the pipelines and control gates that need annual inspection and maintenance. In particular, measures are needed to control biofouling in general and zebra mussel growth in particular on the surfaces of the intake pipes, the gates and the forebay walls in addition to the existing structures, screens and pumping systems. This is undesirable as it would increase the annual maintenance cost for the water supply system.

Table D.21 provides a detailed evaluation of the U.S. Steel I/O options.

D.5.1.5 Results of Evaluation of U.S. Steel Intake/Outfall Options

Option 2 (Open Channel) is the preferable option for several reasons. Construction is less complex, thus reducing risk to water quality during the construction activities. Option 2 is less costly to implement and provides less disruption to U.S. Steel's operation of the water intake and outfall than Option 1 (Piped I/O). Construction would be simpler and would need to be staged in order to maintain acceptable raw water intake quality and possibly protect the stability of the existing Pier 16.

Option 1 would introduce several maintenance issues and annual costs that are undesirable. These include maintenance of sluice gates, protection against biofouling and zebra mussel growth in the pipes, annual cleaning and concerns for ice formation that might restrict water flow. There is also greater uncertainty regarding environmental approvals for the pipeline option (Option 1) as the design may be considered as a new marine intake because of its location.

However, both options were recommended for further consideration in the more detailed engineering work, especially since Option 1 has the potential to be less harmful to U.S. Steel operations during construction of the ECF.

Table D.20: Summary Evaluation of U.S. Steel Intake/Outfall Options

Criteria	Sub-criteria or Design Consideration	Evaluation	
		Option 1 (Piped I/O)	Option 2 (Open Channel)
Service and Performance	• Provides 15,000 USgpm Normal Flow; 300,000 USgpm Design • Provides Backup Supply • Provides Raw Water Quality Protection • Service Life and Maintenance	• yes • yes • yes • meets service life requirement • maintenance of four sluice gates • costs for chemical and mechanical cleaning in pipeline/forebay	• yes • yes • yes • meets service life requirement • may improve cleaning procedures by allowing chemical cleaning to replace some mechanical cleaning
Technical Criteria	Complexity	• more complex than Option 2	• less complex than Option 1
	Compatibility with Other Elements	• acceptable	• acceptable
	Constructability/Time to Implement	• longer time requirement than Option 2	• shorter time requirement than Option 1
Regulatory		• navigation within channel - not applicable • navigation inside Sherman Inlet - no impact on water quality to U.S. Steel	• navigation within channel - must be restricted to authorized vessels only • navigation inside Sherman Inlet - no impact on water quality to U.S. Steel
Environmental Impacts		• fish impingement - existing seasonal use of diversion nets still practical* • entrainment issues - little change from present except location of entrance* *Note: U.S. Steel's use of diversion nets would	• fish impingement - existing seasonal use of diversion nets still practical* • entrainment issues - little change from present* *Note: U.S. Steel's use of diversion nets would not be affected by the project.

Criteria	Sub-criteria or Design Consideration	Evaluation	
		Option 1 (Piped I/O)	**Option 2 (Open Channel)**
		not be affected by the project.	
Cost		• higher capital costs than Option 2 • higher operating costs than Option 2	• lower capital costs than Option 1 • lower operating costs than Option 1
Prior Application		• conventional design	• conventional design

Table D.21: Evaluation of U.S. Steel Intake/Outfall Options

Item	Evaluation
General	Implementing either Option 1 or Option 2 would allow U.S. Steel for the first time to consider chemical procedures for controlling growth of mollusks on the outer portions of the intake structures around the pumphouse. The customary procedure to date is an annual mechanical cleaning involving divers, which is awkward and costly. Chemicals have not been used in the past as not all of the water in the vicinity of the intakes necessarily enters the pump station because of natural currents in the Harbour and a large recycle back to the intake area from barometric condensers. Adding chemicals might result in a toxic release into the Harbour. The configuration proposed in Option 2 would channel all of the water near the entrance to the intakes into the pumphouse and would, therefore, remove the risk that chemicals added for control of zebra mussels of other biota could escape into the general Harbour. Option 1 includes new structures such as the pipelines and control gates that need annual inspection and maintenance. In particular, measures are needed to control biofouling in general and zebra mussel growth in particular on the surfaces of the intake pipes, the gates and the forebay walls in addition to the existing structures, screens and pumping systems. This is undesirable as it would increase the annual maintenance cost for the water supply system. It would appear that both options can be designed and constructed using relatively conventional techniques that do not add extraordinary risk. The buried pipe approach in Option 1 has more construction elements, and there is more work required very close to the existing water intakes. This means a more complex construction project and a longer construction schedule. The two options are fairly similar from the standpoint of regulatory and environmental issues. The issue of regulatory jurisdiction and control of access in the proposed intake channel needs to be addressed if Option 2 is pursued. The seasonal procedures involving the setting of diversion nets that U.S. Steel currently uses to eliminate excessive fish impingement on the intake screens can still be used with either option. The location for net placement will change but otherwise there should be little change from current practice. (Note: U.S. Steel's use of diversion nets would not be affected by the project). The conceptual designs for both Options 1 and 2 have focused on taking water from the Harbour at a location where there will be natural circulation similar to or better than the current location such that localized water quality impairment will not be a significant issue to water quality. It can be argued that any work completed in this project that affects the water intake at U.S. Steel represents maintenance of an existing system in which case

Item	Evaluation
	controls to minimize the entrainment of phytoplankton and zooplankton would not be raised (subject to verification).
Icing Issue	U.S. Steel has indicated some anxiety about the submerged inlet pipeline option owing to the potential for icing that could restrict flow. Both Option 1 and Option 2 provide protection against icing problems. The pipelines in Option 1 are more than 7.5 m below the datum, which is well below the maximum ice thickness at minimum water elevation. There is more than ample cross sectional area in the channel for Option 2 to guarantee appropriate approach velocities even with 1 m of ice cover, and assuming the ECF includes a support berm on the east facing of the ECF wall. Worst case ice conditions in all cases could involve "rafting", a condition occurring when high winds push successive sheets of flow ice on top of one another along shore. Ice thickness of several metres could develop. This has not been reported as a problem at U.S. Steel's present water intake and the risk of this occurring appears no greater in the future for either Options 1 or 2. The cross sectional area of the pipeline intake in Option 1 is smaller than the channel for Option 2 and would be more vulnerable to blockage if severe ice rafting were ever to occur.
Construction Methods	Specifying proper construction procedures and sequencing will be important for both Options 1 and 2 to protect the raw water quality at the intake during construction. The potential risk of impacting the intake water quality may be greater for Option 2 as the duration of construction activities in areas adjacent to the intake water flow will be longer than for the pipeline option. These activities include the time to construct about 300 m of the ECF barrier wall. This could be followed by a second activity that would see placement of supporting berm rock and cobble against the ECF in the intake channel. Material placement may be slowed by the need to minimize disturbance of the sediments in the channel. Option 1 requires careful driving of sheetpile walls close to the present intake as part of the forebay construction. However, once this is completed, it will be easier to isolate the area affected by installing the ECF barrier wall and dredging, bedding placement and pipe laying from the water entering the intake. The intake structure for Option 1 is located within the containment area. There should be little or no reason to dredge and relocate contaminated sediment for environmental reasons for the intake construction. The small amount of sediment excavation required for the pipe bedding and intake pipe placement can be dealt with by controlled side-casting without removing the material from the water column. The construction of Option 2 may be accomplished without dredging at all. If dredging is deemed necessary for environmental reasons, the process would be more complex as the material needs to be removed and then placed inside the ECF without allowing suspended sediment to be entrained into the water intake structure.

Item	Evaluation
Cost	<u>Option 1 – Total Construction Cost - $6.0 Million</u> • provide forebay including control gates for each pipe • level area for pipe base and allowance for bedding material • place main intake and outfall including precast manhole pipes • install piping internal to main pipes for biofouling and zebra mussel control • place back-up intake and outfall including precast concrete risers at each end pipes • annual maintenance costs are not included in the above budget estimate; an allowance of $50,000 per year is suggested for these activities <u>Option 2 – Total Construction Cost - $1.4 Million</u> • level area for channel base and allowance for bedding material • construct concrete channel 35 m long through the cross section of the access causeway to the ECF • provide removable steel gate(s) in channel • cost effectiveness of alternative design scheme with pipes or culverts will be considered during next phase of engineering Cost benefits of either option must be established within the overall project cost estimate. Relatively high cost of Option 1 may be offset by ECF cost reduction due to decreased length of sheet piling and volume of rock backfill on the east side of containment.

D.5.2 Detailed Evaluation – 30 Percent Design

D.5.2.1 Introduction

The review of the conceptual design work, historical drawings and pre-design activities completed as part of the initial screening were considered in the development of the 30 percent design. The 30 percent design reviewed the previous work and expanded on other areas which required review to further develop feasible options to address the U.S. Steel I/O structure.

The conceptual design recommended the following:

- further engineering studies should be performed to confirm the integration of the ECF with the U.S. Steel I/O and piers;
- the impact of currents and waves on the ECF as well as changes in the currents and waves as a result of the ECF need to be analysed;
- the design should incorporate long-term plans for the Harbour;
- the design should provide for continuation of U.S. Steel operations during and after construction;
- vessel access to Pier 16 should be maintained; and
- adverse impacts on groundwater at piers adjacent to the ECFs should be minimized.

Additional design considerations to be considered at the 30 percent design stage included:

- minimizing impacts to stakeholders and tenants;
- maintaining adequate water quality and quantity;
- addressing geotechnical and structural requirements for the port facility, including accommodating long-term settlement and developing minimum requirements for soil-bearing capacity;
- isolating the ECF from potentially contaminated groundwater in adjacent piers;
- accommodating combined sewer outfalls and the U.S. Steel west side open cut outfall;
- undertaking investigations and establishing construction sequencing for work in an active port; and
- addressing the potential for slag and other debris to interfere with construction of the ECF walls and for creating pathways for transport of contaminants.

Other information was developed during the initial screening that was carried forward for consideration in the 30 percent design, including:

- the need for a barrier to be maintained between the Sherman Outlet and the U.S. Steel intake, particularly to address the potential adverse impact of poor water quality coming from high stream flow/runoff periods and vessel traffic affecting water quality in the area;
- the same barrier would need to be removable to address backup capacity for water in the event of an emergency;
- freezing conditions associated with I/O pipes;
- the top of the ECF would be similar to U.S. Steel's top-of-pier elevation;
- design parameters describing the permitted intake capacity of the existing pumping facility, the normal operating rates, expected flows and design flows were determined for design purposes;
- discharge rates from the West Side Open Cut (WSOC) were determined along with the historical averages;
- a minimal capacity for the backup supply was outlined based on minimal supply still being available from a primary source, the permissible maximum mean channel velocities, pipeline intake pipe velocities and intake minimum water quality standards;
- entrainment of some or all of the discharge from the WSOC into the intake stream is acceptable to U.S. Steel given it is largely once-through cooling water;
- a redundant intake source for backup would be required if the ECF were sited in the presently proposed location; the redundant supply would need to controlled;
- operation of the pumphouse during construction;
- suspended sediment control measures will be implemented to prevent degradation of water quality during construction;
- maintenance of debris screens and methods to address fish entrainment are maintained using for instance, diversion nets around the intakes (Note: U.S. Steel's use of diversion nets would not be affected by the project);
- relocation of the existing intake structure is unacceptable to U.S. Steel because of cost and disruption of its operations;
- potential ground movements resulting from adjacent filling need to be addressed;
- design of a forebay, ECF structures or buried pipelines will include the requirement for a surcharge as specified by HPA for operating areas; and
- design considerations related to the pumphouse, intake wells and locations of the inverts need to be considered.

Available drawings were used to approximate arrangements and measurements of the sheetpile walls, intakes and outfalls. Some of the preliminary geotechnical work provided general information around the deposition of slag. Drawings were also used to examine the U.S. Steel dockwall construction and evaluate its current conditions, as well as the U.S. Steel pumphouse. Historical and current information was also reviewed to collect information about the sediments in the adjacent areas and to develop further information regarding the slag in the area of the U.S. Steel I/O and along the wall.

Further geotechnical studies and structural evaluations of the pier walls were carried out in the 30 percent design to establish design standards/parameters. Other information was reviewed to provide an assessment of the feasibility of the different options for the U.S. Steel I/O structure, including water quality/water quantity issues and operational/construction needs. The structural evaluation of the U.S. Steel dock wall indicates that the dock wall is in poor condition. Inclinometer readings indicate the steel is strained to approach its flexural yield point. Geotechnical characteristics of the underlying slag fill are highly unpredictable and have contributed to settlement and deflection of the dockwall after its construction.

D.5.2.2 Identification of Options

Two types of design options were developed to accommodate U.S. Steel's I/O. The options were either stand-alone options, in which interactions between the ECF's eastern wall and the U.S. Steel's dock wall are minimized, or options where the ECF's eastern wall and the U.S. Steel's dock wall are attached in order to brace the two structures. Five options were identified, as described below.

Option 1A (Open Channel), as illustrated in Figure D.11, consisted of an open channel between the ECF's eastern wall and the U.S. Steel dock wall. The channel width is 10 m (33 ft). Discharge flows are separated from intake flows in a separate channel formed from a non-structural sheetpile wall, with outfall flows discharged to the north. Sediments in the open channel are capped.

Option 1B (Open Channel with Piped Discharge to South), as illustrated in Figure D.12, consisted of an open channel between the ECF's eastern wall and the U.S. Steel dock wall. The channel width is 10 m (33 ft). Discharge flows are separated from intake flows in a pipe located in the channel, with outfall flows discharged to the south (i.e., Sherman Inlet). Sediments in the open channel are capped.

Option 2A (Piped Intake), as illustrated in Figure D.13, contained intake and footfall flows in pipes located in a clean utility corridor between the ECF's eastern wall and the U.S. Steel dock wall. The pipes are placed on a gravel bedding layer over a poured concrete layer. Clean fill is placed in the utility corridor around and over the pipes.

Option 2B (Pile-Supported Culvert), as illustrated in Figure D.14, contained intake and outfall flows in a pile-supported culvert. The outfall flows are directed in a concrete culvert (cross bracing or a cover may be included at the top of the culvert). With this option, an ECF eastern wall is not likely to be necessary.

Option 2C (Open Channel with Cross-Bracing), as illustrated in Figure D.15, was the same as Option 1A with the exception that cross bracing is installed between the ECF's eastern wall and the U.S. Steel dock wall.

Figure D.11: Option 1A (Open Channel)

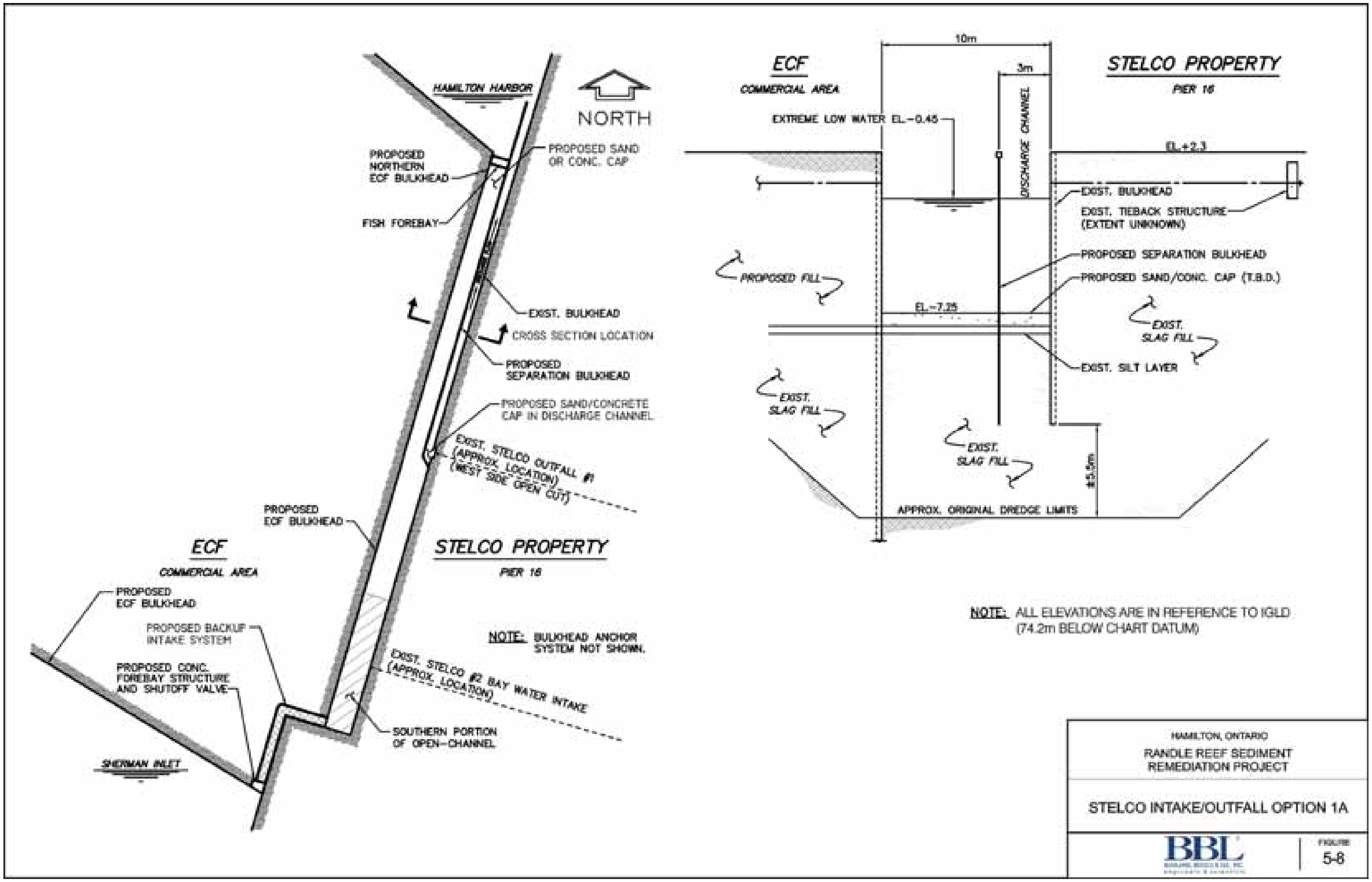


Figure D.12: Option 1B (Open Channel with Piped Discharge to South)

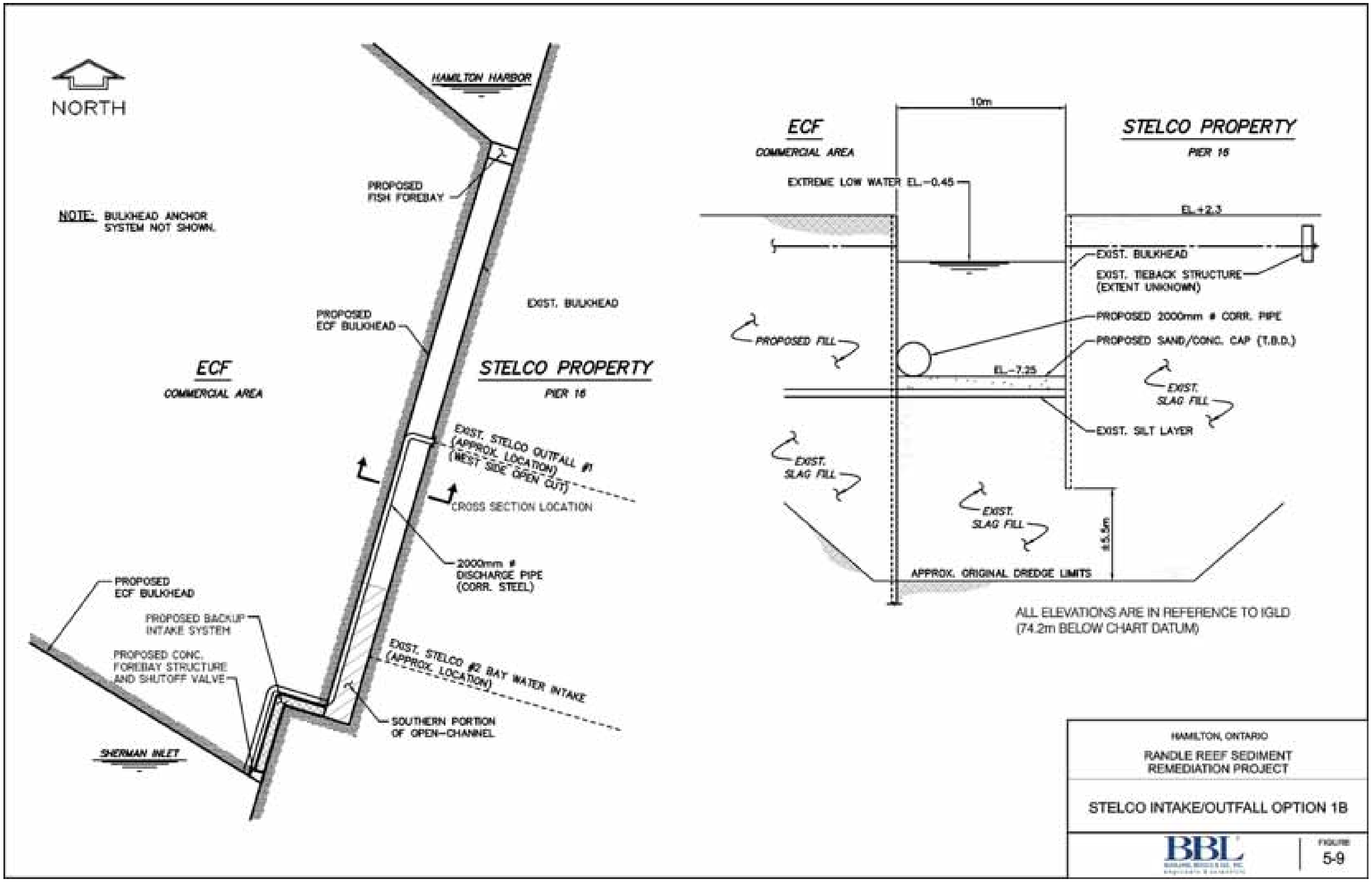


Figure D.13: Option 2A (Piped Intake)

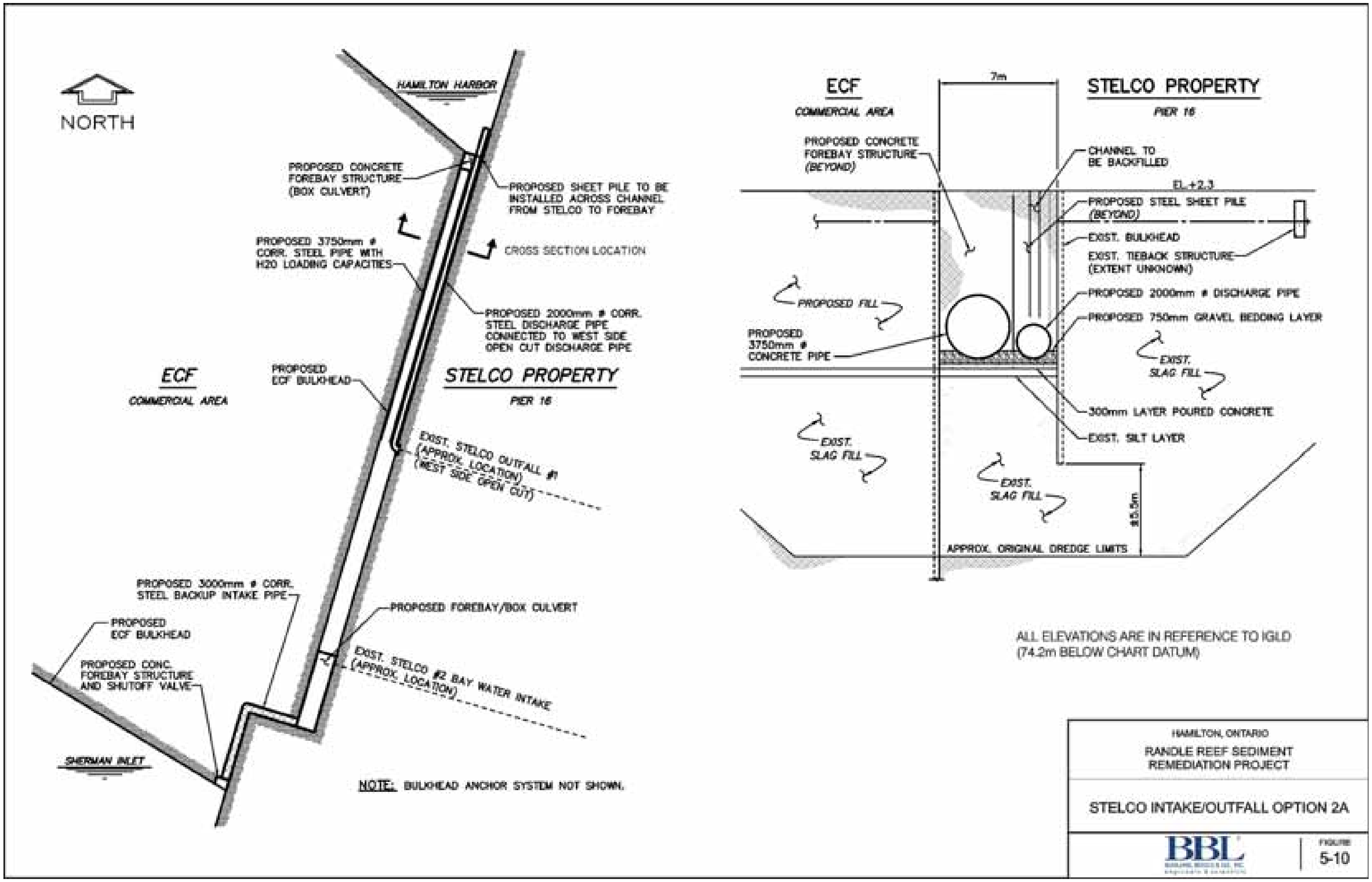


Figure D.14: Option 2B (Pile-Supported Culvert)

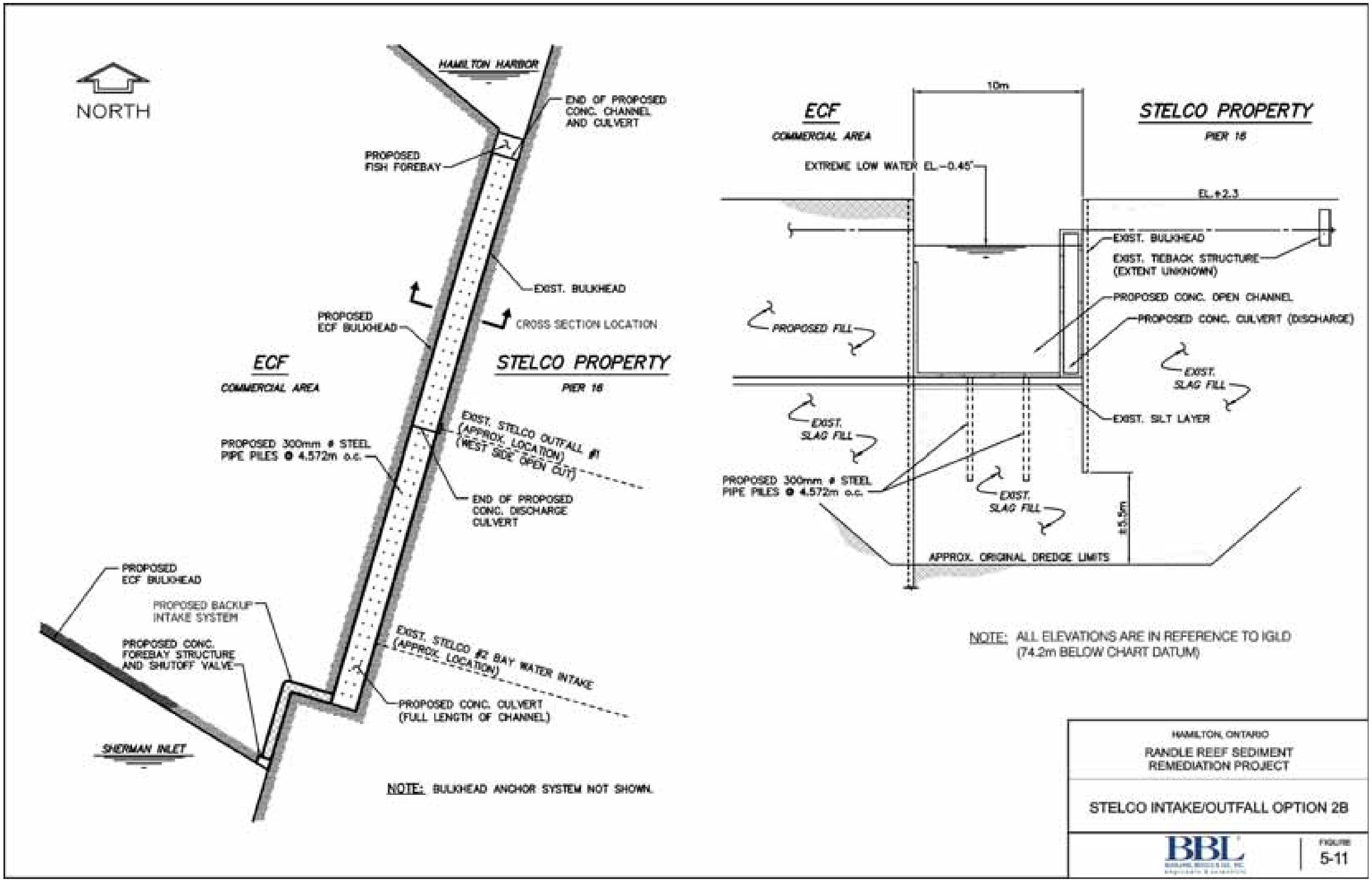
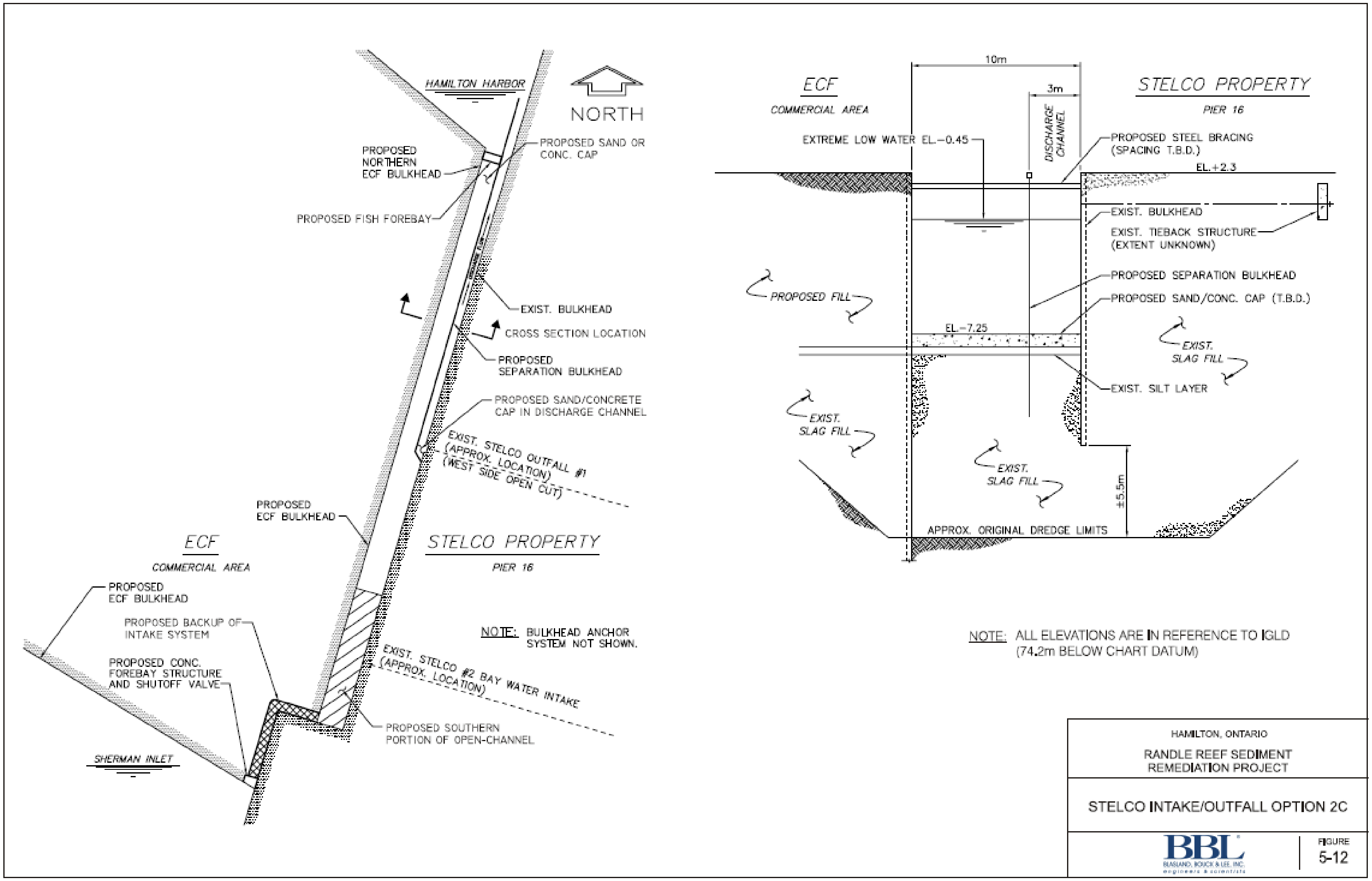


Figure D.15: Option 2C (Open Channel with Cross-Bracing)



D.5.2.3 Evaluation Criteria

The following general criteria were used to evaluate the options at the 30 percent design level:

- effectiveness;
- implementability; and
- cost.

The sub-criteria that were developed for the evaluation of the U.S. Steel I/O accommodation, as contained in Table D.22, varied from the sub-criteria developed for the evaluation of the other design elements.

D.5.2.4 Evaluation of Options

An evaluation of the five options is presented in Table D.22. Each sub-criteria was assigned a weight from one to three, with a three having the most importance and a one having the least importance. A rating from one to three was then assigned to each option by sub-criteria, with a three being the most desirable, preferred rating and a one being the least desirable/lower rating. The ratings were then multiplied by the sub-criteria weight and summed to derive an overall score for each option.

No new design-level data related to the I/O accommodation were generated at this stage. A review of the hydraulics information related to the I/O was undertaken. An analysis of the sediment cap thickness, chemical isolation, accommodation of commercial vessels, structural considerations of the U.S. Steel dock wall, ECF perimeter containment, and geotechnical considerations for the U.S. Steel dock wall was conducted to support the selection of the options.

The design was based on the requirements for a subaqueous cap. The components of cap thickness and media were selected based on the following design requirements:

- erosion protection (i.e., armour layer) or sacrificial erosion thickness (surface layer that is likely to be lost to erosion);
- bioturbation thickness (surface layer impacted by organisms in the sediment);
- cap consolidation thickness; and
- chemical isolation thickness.

For the 30 percent design, the analysis was based on presumed readily available capping media consisting of fine to medium sand or a silt/sand mixture. The resulting required thicknesses for the sand and sand/silt mixture are 1.5 m (5 ft) and 1.25 m (4 ft), respectively. The design thicknesses for these layers, along with scour protection and overcap allowance, are shown on Figure D.16. These will be further developed

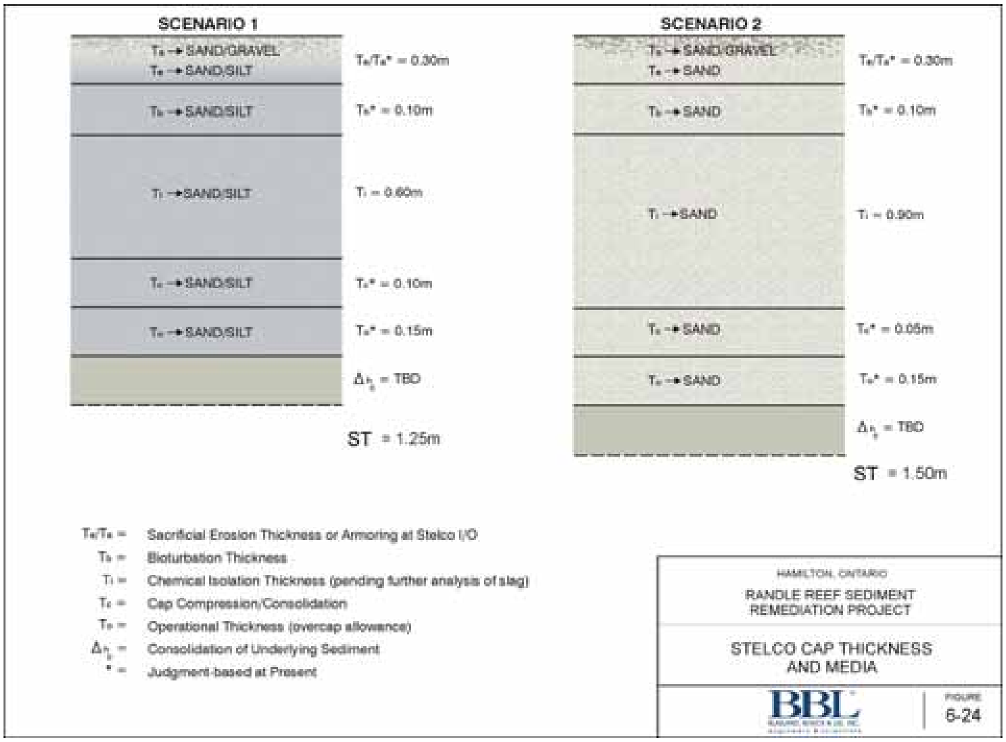
Table D.22: Evaluation of U.S. Steel I/O Options – 30 Percent Design Level

Criteria/Sub-criteria and Weighting Factor	Option 1A-Open Channel	Option 1B-Open Channel with Piped Discharge to South	Option 2A-Piped Intake	Option 2B-Pile-Supported Culvert	Option 2C-Open Channel with Cross-Bracing
Effectiveness					
Compliance with Related Design Standards - 3	3 - Will maintain adequate water intake. Low risk for water quality related disruptions. Acceptable water velocities at intakes.	3 - Will maintain adequate water intake. Low risk for water quality related disruptions. Acceptable water velocities at intakes.	1 - Will maintain adequate water intake. Higher risk for water quality related disruptions during and post construction.	2 - Will maintain adequate water intake. Higher risk for water quality related disruptions during construction from driving piles.	3 - Will maintain adequate water intake. Low risk for water quality related disruptions. Acceptable water velocities at intakes.
Site Compatibility - 2	3 – Highly compatible. Will require disruption of U.S. Steel's operations during construction and fishtail capping.	2 - Compatible. Will require disruption of U.S. Steel's operations for installation of southern discharge pipe.	1 - Less compatible. Will require disruption of U.S. Steel's operations during installation of new intake/outflow pipes.	1 - Less compatible. Will require disruption of U.S. Steel's operations during piling installation and construction of culvert.	2 - Highly compatible. Will require fewer disruptions of U.S. Steel's operations during construction and fishtail capping. Bracing is a site access issue.
Reliability - 2	3 – Once settlement has occurred, design is highly reliable.	2 - Once settlement has occurred, design is highly reliable. Requires periodic maintenance of cap. Submerged infrastructure will be difficult to modify or maintain.	1 - Surcharge on pipes and settlement of dredge/fill material must be accounted for. Submerged infrastructure difficult and costly to modify/ maintain.	2 - Reliable design. Concrete subject to deterioration over time.	3 - Once settlement has occurred, design is highly reliable. Bracing to add geotechnical stability of ECF and U.S. Steel's walls.
Implementability					
Compliance to Implementabili	3 - Most feasible option.	2 - Moderate feasibility.	1 - Difficult to build.	1 - Difficult to build.	3 - Feasible. Requires fewer

Criteria/Sub-criteria and Weighting Factor	Option 1A-Open Channel	Option 1B-Open Channel with Piped Discharge to South	Option 2A-Piped Intake	Option 2B-Pile-Supported Culvert	Option 2C-Open Channel with Cross-Bracing
ty-related Design Standards - 3	Fewer interruptions to U.S. Steel's normal operating routines.	Will require disruptions to U.S. Steel during installation of southern discharge pipe.	Requires extensive disruptions to U.S. Steel's operations for pipe installation. Option requires three forebays.	Requires extensive disruptions to U.S. Steel's operations for installation of concrete culvert.	disruptions to U.S. Steel's operations and bracing leads to better geotechnical stability of ECF and dock walls.
Availability of Construction Materials - 1	3 - Required material available and experienced contractors available locally.	2 - Requires connection to existing West Side Open Cut (WSOC) outfall.	1 - Questionable availability of material. Option requires long lengths of large intake pipes. Requires installation using heavy machinery.	1 - Questionable availability of material. Option requires large pre-cast concrete culvert structures which may or may not be readily available. Requires installation using heavy machinery.	3 - Material and contractor experience required for option readily available.
Compatibility with Other Design Standards - 3	3 - Non-permeable ECF wall structure limits contaminant mobility and provides geotechnical stability. Least connectivity between U.S. Steel and ECF walls.	3 - Non-permeable ECF wall structure limits contaminant mobility and provides geotechnical stability. Least connectivity between U.S. Steel and ECF walls.	1 - Connected options present potential for contaminant mobility between ECF and U.S. Steel walls. Fill material increases risk for poor geotechnical stability of ECF and U.S. Steel walls.	2 - Connected options present potential for contaminant mobility between ECF and U.S. Steel walls. Concrete fill lowers geotechnical stability of walls.	3 - Non-permeable sealed wall structure and steel bracing provides geotechnical stability. Less connectivity between U.S. Steel and ECF walls limiting contaminant mobility.
Risks - 3	2 - Option	2 - Good water	2 - Short term	1 - Short term	2 - Good water

Criteria/Sub-criteria and Weighting Factor	Option 1A-Open Channel	Option 1B-Open Channel with Piped Discharge to South	Option 2A-Piped Intake	Option 2B-Pile-Supported Culvert	Option 2C-Open Channel with Cross-Bracing
	provides best water quality during construction period. Open channels may be more vulnerable to frazil ice. Unlikely to have long term risks to geotechnical stability.	quality during construction period. Open channels may be more vulnerable to frazil ice. Unlikely to have long term risks to geotechnical stability.	risks to water quality. Less susceptible to frazil ice. Long term risks include geotechnical stability to ECF and U.S. Steel walls.	risks to water quality. Open channel more susceptible to frazil ice. Long term risks include geotechnical stability to ECF and U.S. Steel walls.	quality during construction period. Open channels may be more vulnerable to frazil ice. Unlikely to have long term risks to geotechnical stability.
Permitting - 1	2 - Does not provide improved circulation/ mixing with Sherman Outlet.	3 - Piped discharge to Sherman Outlet allows for increased circulation to areas otherwise segregated by the construction of the ECF.	1 - Does not provide improved circulation/mixing with Sherman Outlet. Closed option requires more filling of waterways.	1 - Does not provide improved circulation/ mixing with Sherman Outlet. Closed option requires more filling of waterways.	2 - Does not provide improved circulation /mixing with Sherman Outlet.
Cost					
Cost - 1	2 - Slightly more expensive than 1B. This option includes driving sheetpile wall to separate outflow water.	3 - Least expensive option. Least amount of earthwork and material.	1 - Most expensive option. Requires time, material and experience to design and install buried intake/outflow pipes.	1 - Expensive. Requires large pre-cast concrete structures and heavy construction equipment.	2 - Expensive. Requires driving sheetpile wall and steel bracing.
Total Score	**52**	**45**	**22**	**27**	**50**

Figure D.16: Cap Thickness and Media



during later stages of design, with a view to reducing cap thickness while controlling costs by using either more precise input assumptions or alternative capping media such as mixing in granular activated carbon or utilizing a lightweight sealing cap such as a bentonite-coated granular medium.

Modeling was conducted to evaluate the potential performance of a 0.9 m (3 ft) thick sand cap and a 0.6 m (2 ft) thick sand and silt cap for chemical isolation. Bioturbation was assumed to be negligible. Modeling results indicated that the PWQOs for naphthalene and zinc, selected because of their elevated concentrations in project sediment, relatively high mobility, and low PWQOs, were not exceeded at the cap water interface under most conditions considered. However, at high seepage velocities, contaminant concentrations at the cap-water interface approached predicted pore-water contaminant concentrations, which exceeded PWQOs. Modeled results were sensitive to groundwater seepage velocity and will need to be further characterized during later stages of design.

Construction of the ECF will render the southern 250 m (820 ft) of the U.S. Steel wharf inaccessible to commercial vessels. The northern portion may continue to serve as a commercial berth. The conditions related to berthing and unberthing are of concern with respect to the cap design. The velocity of water produced by the main propeller of a boat and the bow thruster are of primary concern. The commercial operations and the marginal stability of the wharf will have a major impact on the design to address the contaminants in this area. Dredging in proximity to the wall may adversely affect the stability of the wall. The surface elevation of capped sediments will need to maintain a minimum depth of 8.2 m (27 ft) below datum to provide access for commercial vessels, as well as the cap being designed to withstand the potential scour from commercial vessels.

Structural considerations for the dock wall are both long and short-term. The location of the east wall will be dictated by the design element and partly relate to the consolidation of the sediments, as well as reflect the nature of the underlying sediments. The underlying sediments are a significant structural consideration since there were large scale modifications to the lake bottom during the construction of the existing U.S. Steel wall, and large-scale placement of slag as fill. Structural issues with the wall have been noted since its initial construction.

Perimeter containment in this area may require a different design than the north and west ECF perimeters, given the highly variable and weak soils found in the U.S. Steel dock wall area. The geotechnical investigation also estimated the amount of settlement that may be induced on U.S. Steel property, given construction and filling of the ECF. Maximizing the distance between the two facilities will minimize settlement.

D.5.2.5 Results of Evaluation of Options

Based on the preliminary ranking, Option 1A (open channel) and Option 2C (braced open channel) ranked the highest. Both options were retained for consideration during the 100 percent design. However, Option 1A was preferred if further design development indicates that minimizing interactions with the dock wall and mobility of contaminants between the two sites is a significant consideration. Considering structural requirements and associated costs for the ECF's eastern wall, Option 2C provides cost savings of up to approximately $2 million over Option 1A. Option 1A is the second least expensive design option.

The benefits of Option 1A (Open Channel) included:

- reduced potential impacts to U.S. Steel's operations during and after construction;
- consistency with project design standards;
- long-term reliability;
- ability to limit the mobility of contaminants between the ECF and U.S. Steel property;
- service life comparable to the ECF (i.e., 200 years), assuming periodic maintenance;
- least potential to impact the U.S. Steel dock wall; and
- lower risk of impacts to both design and construction schedules.

The disadvantages of Option 1A included:

- may be subject to frazil ice under cold conditions;
- requires periodic cap maintenance; and
- will not enhance circulation in Sherman Inlet.

D.5..3 Detailed Evaluation – 100 Percent Design

D.5.3.1 Introduction

The 100 percent design for the U.S. Steel I/O accommodation addressed the following:

- further development of the design for the 25 m wide channel (expanded from 10 m to address U.S. Steel concerns for water quantity and water quality, and back-up flow requirements) between the east side of the primary ECF wall and the dock wall (Pier 16);
- further development of the design for the cap features for the area between the two structures to address isolation of the contaminants, including occasional vessel traffic;
- the design/construction features associated with dredging/building adjacent to the dock wall;
- the need for a flow separation wall to address intake/outfall water quality and quantity; and
- the potential benefits of a hydraulic connection between the channel and the Sherman Inlet area.

D.5.3.2 Identification of Options

The basic channel configuration was confirmed and revised through discussions with U.S. Steel and through further work on other elements of the channel design (e.g., hydraulics, cap, flow separator wall). Thus, the preferred option put forward from the 30 percent design was changed and resulted in expanding the channel width to 25 m from a 10 m width.

Selection of the channel remedial option included a review of dredging, capping and in-situ stabilization/solidification with Portland cement. Development of the cap design was completed for the capping option using the U.S. Army Corps of Engineers procedures.

Modeling was conducted to identify the areas for capping and to determine the type of cap required. Further review of the earlier geotechnical studies (the one-dimensional consolidation analysis conducted during the 30 percent design), and ongoing review of the flow considerations (volume and water quality) evaluated the potential for sediment re-suspension and transport of suspended sediment, as well as the resistance of capping materials to erosion.

Methods for cap material preparation and installation were also evaluated and developed. Cap construction includes the following general steps:

- mixing the materials to the required grain size, organic content and homogeneity;
- delivering the capping materials to the capping location; and
- placing the cap materials to the required thickness.

An analysis was conducted and recommendations were made to address the armouring and the construction and placement of armouring material. The channel entrance area will require armouring material to be delivered to the location for placement. The area in front of the intakes will require placing reactive core mats (RCMs) and armour mats. Additional quality control measures will be in place during construction to minimize impacts to U.S. Steel and the environment.

The need for an outfall flow separation wall was reviewed as part of the hydraulic modeling completed for the assessment of hydraulic conditions with the ECF in place. Additional review by U.S. Steel and consideration of any water quality/water quantity requirements was completed and incorporated in the decision on the need and/or design requirements related to a separation wall.

A review to determine the effectiveness/relevance of providing a hydraulic connector between the intake/outfall channel and the Sherman Inlet was undertaken.

The need for fish reduction screens was also reviewed. The I/O channel is not expected to increase fish habitat, compared to existing conditions. Therefore, upgrades to the fish screens at U.S. Steel are not part of the project. However, the turbidity control structure proposed for cap construction may remain in place after construction and be used by U.S. Steel to support fish impingement screens in the vicinity of the intakes.

D.5.3.3 Evaluation of Options

The review of options for the remediation of the sediment in the channel were considered for dredging, capping and in-situ stabilization/solidification.

Option 1 (Dredging)

The review of the dredging option identified that due to the limitations associated with dredging adjacent to the dock wall and its instability, dredging would also include capping of the areas adjacent to the wall. In addition, the unpredictable nature of the slag below the sediment in this area would likely require some restoration capping for the sediments. Dredging within this area would also require additional re-suspension controls in order to protect the intakes. Given the complexity of the dredging in this area and the need for restoration capping regardless of dredging some areas, this option was determined to be unnecessarily expensive and complex in comparison to options for capping alone.

A review of in-situ stabilization/solidification identified the following issues with the option:

- controls for re-suspension and protecting water quality at the intakes would be required;
- there may be issues with ensuring proper mixing of the cement and the slag with the sediment, given the variation in sizes/types of slag;
- further bench-scale testing would be required and would not necessarily represent later field conditions; and

- the presence of the stabilized sediment may interfere with future work on the dock wall.

Option 2 (Capping)

Capping was reviewed as an option, with the following noted:

- controls will be required to protect for the intake and turbidity but are more manageable than those required with dredging or in-situ stabilization/solidification;
- the process for capping will be less complex than dredging or in-situ stabilization/solidification;
- future maintenance/replacement of the dock wall may be undertaken by removing the cap material and subsequently replacing it.

The design of the layers of the cap considered the following components for cap media and thickness:

- chemical isolation thickness;
- bioturbation thickness;
- erosion protection; and
- consolidation and slope stability.

Sediment contaminant containment was evaluated using an advective-diffusive-reactive model formulation. The design objective for containment within the cap limits contaminant concentrations in water at the cap/water interface to levels below the PWQOs (and/or CWQGs). Contaminant concentrations in the pore water in the cap-water interface must be maintained below PWQOs (and/or CWQGs) during the service life of the cap. In addition, the cap will also limit water quality impacts to the intakes and flow capacity during and after construction, and minimize interference with navigation, including:

- the top of cap elevations should be at or below the intakes invert elevation;
- increased flow velocity near the intakes will need to be considered for additional erosion protection/armouring;
- navigation within the channel should be minimized to limit the need for additional armouring; and
- turbidity controls will be required during cap installation.

The evaluation for the remedial options for the dock wall offset areas was based on an analysis of the dimensions of the area involved, an assessment of the sediment characterization and mass of contaminants, a review of the bathymetry, and a limited analysis of the physical nature of the material. Capping and in-situ stabilization/solidification was reviewed based on costs and benefits.

The hydraulic modeling related to the evaluation of the need for and/or design for the outfall flow separation wall provided the following information:

- the 3 m discharge channel did not alter the hydraulic conditions in the intake/outfall channel significantly;
- further analysis related to water quality and temperature, given the separation of the outfall flow is required; and
- conclusions were drawn with respect to current flows based on the presence of a separation wall under different wind conditions.

The review of the hydraulic connector was done to assess the following elements:

- the hydraulic capacity of the connector;
- the need for a back up water supply if the channel becomes blocked or there is a dock wall failure;
- the potential effects on local hydraulic conditions; and
- opportunities to improve water quality and circulation in the Sherman Inlet area.

D.5.3.4 Results of Evaluation of Options

The design basis for the 25 m wide channel was confirmed for various elements of the design.

The cap's ability to withstand hydraulic and erosive forces, such as flow and waves, vessel traffic and ice effects was evaluated. The most significant effect was attributed to the occasional vessel traffic, particularly near the channel entrance and shipping berths, as well as vessel traffic associated with channel maintenance. This impact was, therefore, used to model armouring requirements. Modeling in the vicinity of the intake pipes, the entrance to the U.S. Steel I/O channel and the remainder of the U.S. Steel I/O channel results indicated that armouring would be required for each of these areas with 5 to 7.6 cm stones with a median grain size of D50. To provide geotechnical stability, a geotextile was recommended as a filter layer under the armour stone. The alternative approach that was proposed requires limiting navigation in the U.S. Steel channel, as follows:

- only vessels required to maintain the dock wall, intake/outfall structures and the ECF would be allowed to enter the channel;
- the channel would be maintained as a low-speed, no-wake zone;
- no spudding or bottom anchoring would be allowed; and
- entrance markers/buoys would not be maintained at the entrance to the channel.

Consolidation and slope stability evaluation indicated that the settlement within the cap due to self-weight is expected to be minimal and to occur during placement. The cap is expected to be relatively stable in the areas adjacent to the dock wall.

The cap modeling was completed using different capping components (alone and in various combinations), including sand, silt layers, sand and silt enriched with total organic carbon (TOC), organoclay RCMs and granular activated carbon reactive core mat. Based on the comparative performance for the initial screening modeling, a cap that included sand and silt enriched with TOC was carried forward to the next, more detailed modeling step. Since sand and silt enriched with TOC had similar performance to the RCM-based caps, with easier installation and lower procurement costs, the recommended approach is to use the silt and sand enriched with TOC, and limit use of RCMs. RCMs may be more useful in certain areas and for certain conditions (e.g., near the intakes) where thinner layers of RCM will be more applicable than a soil-based cap. Additional analyses of a pilot test capping in Hamilton Harbour was also reviewed for applicability to the cap design with respect to use and effectiveness of a sand cap.

Further modeling of the sand and silt with enriched TOC was conducted to determine its effectiveness. The results indicated that for the recommended 30 cm thick layer of sand and silt with TOC cap, the PWQOs (and/or CWQGs) in cap porewater at the cap-surface water interface will not be exceeded except for zinc, and that Provincial Sediment Quality Guidelines (PSQG) SELs will not be exceeded for any of the compounds.

The review of the bioturbation thickness recommends that 20 cm thick bioturbation zone that includes a 10 cm surficial layer of presumed active bioturbation and an additional underlying 10 cm zone for biodiffusion is needed. Due to constraints with cap thickness, the use of the upper 20 cm of the cap should be considered available for the bioturbation zone, and pore water in that zone should be monitored. If needed, future installation of a 20 cm bioturbation layer can be included as part of ongoing cap operation, maintenance and monitoring.

Mixing of sand and silt with enriched TOC can occur on-site, or off-site and transported. Armour stone may be stockpiled on site and transported to the capping site or can be transported to the capping location by barge. The design includes placing the capping material from a clamshell bucket within a maximum 0.9 m drop height at the top of the cap. The approach is proposed to limit turbidity/TSS. Approximately 230 m^3 of armor stone will be required.

The RCMs are proposed for use in the vicinity of the intakes and should be stored on-site in accordance with the manufacturer's recommendation. A minimum overlap of 0.3 m between adjacent RCM sections is recommended. Approximately 502 m^2 of RCMs are required to cover the 418 m^2 area.

Armour mattresses should also be stored on-site in accordance with the manufacturer's recommendations. A maximum spacing of 7.6 cm is recommended. The manufacturer typically provides layout instructions for fabricating a lifting frame. The mats are placed with a crane and guided into place using divers and/or risers on the lifting frame. Approximately 418 m^2 of armour mattresses are required to cover the area.

Additional considerations for cap installation include consideration of filter mattresses, which combine armour mats and RCMs into a single product, as an acceptable alternative to armour mats and RCMs. As well, the recommended approach for the transitional area between the armour mat/RCM portion of the cap and the soil cap is to lay the outer row of armour mats and RCM up over the edge of the soil cap, rather than slope the soil cap down to the RCMs, allowing for the full thickness of the soil cap in the transitional area.

Quality control methods which are recommended include:

- validation of soil cap material for compliance with grain size, TOC content, organics and metals content (about one sample per 1,000 m^3);
- armour stone should be tested for grain size distribution and organics;
- manufacturer's certificates for armour mats, RCMS, and/or filter mattresses should be reviewed and the materials inspected prior to installation;
- confirmation of soil cap thickness should be verified using settlement monitoring plates for the area near the ECF and dock walls;
- bathymetric surveys combined with settlement monitoring plates are recommended near the channel midline, away from the dock walls and ECF to monitor cap thickness; and
- armour stone thickness will be checked using settlement monitoring plates and the overlap between the RCM and armour mats should be measured by an underwater camera guided by divers and/or by remotely operated vehicles.

Recommended control structures for the installation of the capping materials include a structure that will consist of H-piles to support turbidity barriers. The turbidity barriers will be attached to the structure and, if needed, combined with stop logs to stabilize, manage flow and reduce TSS/turbidity. The turbidity barrier will extend from the water surface to within 12 inches (30.48 cm) of the channel bottom. Methods for installation (vibratory pile driver) location, number of piles and configuration are also recommended along with embedment and lengths.

The analysis to select either capping or in-situ stabilization/solidification in the dock wall offset area identified that there was limited feasibility for installing and maintaining a cap or completing the in-situ stabilization/solidification. Both were determined to be constrained by navigational requirements, the steep slopes and hard materials that comprise the bottom materials in the area, and the considerations for future repair/replacement for the dock wall. The recommendation for the dock wall offset area, based on it comprising a low percentage of the total potential affected contaminant mass (less than 1% of the total sediment contaminant mass for all sediment contaminants), is to transition to the dredge areas in adjacent subareas with no active remediation proposed for the offset area.

The assessment of the hydraulic connector concluded that:

- under most wind conditions, the water quality in the Sherman outlet channel will improve and there will be no adverse effects on water quality in the intake/outfall channel except under very strong winds from the south west;
- under all cases except the strong south west winds, the surface and bottom layer water flows from the intake/outfall channel to the Sherman outlet channel; and
- under conditions for the south west winds, the TSS plume from the Sherman outlet can increase TSS for the intake conditions; further modeling is recommended if the frequency of this occurrence requires further detail.

Further conclusions and review with U.S. Steel confirmed that a hydraulic connection was not required as a back-up water supply given the width of the channel. Conclusions regarding the need for a hydraulic connection will require further analysis during the development of detailed design drawings and specifications.

Further analysis for the flow separator channel will likewise be completed during the development of the detailed design drawings and specifications.

The presence of the channel is not expected to increase fish habitat compared to existing conditions and, therefore, upgrades to the existing fish screens are not proposed as part of the Randle Reef project. U.s. Steel may chose to utilize the turbidity control structures to support fish impingement screens in the vicinity of the intakes.

Construction monitoring needs are also outlined for the construction of the cap. The total estimated costs for cap ranges between CAN $900,000 and CAN $1,200,000 with a mid-range cost of CAN $1,050,000, not including operation, maintenance and monitoring costs. Hydrographic surveys, settlement monitoring, cap material settlement, cap thickness and water quality monitoring will be completed and will be specified in the construction monitoring plan that will accompany the detailed design drawings and specifications. Additionally, the operation, maintenance and monitoring plan will include activities related to hydrographic surveys and cap monitoring (i.e., measuring settlement, porewater concentrations of sediment, NAPL intrusion, potential for bioturbation and erosion/scour). A cap maintenance plan that responds to the findings from the operations, maintenance and monitoring plan will also be required.

Attachment D.17: U.S. Steel Intake/Outfall Options - Initial Screening Assumptions

Assumptions
The top of the ECF new island elevation would be similar to U.S. Steel's top of pier elevation.
The intake capacity of the existing pumping facility is 300,000 USgpm and the combined pumping capacity is 255,000 USgpm. Normal operating rates were indicated by U.S. Steel to be 100,000 – 150,000 USgpm with a general downward trend arising from ongoing process modifications. The expected flow would be 150,000 USgpm and the design flow would be 300,000 USgpm for any structures that may affect water supply.
Discharge from the west side open cut (WSOC) is 4,500 USgpm (recent average) although the historical average has been 15,000 USgpm.
The WSOC is largely "once through" cooling water and U.S. Steel suggested that entrainment of some or all of this discharge into the intake stream is acceptable.
A redundant intake source for back-up water would be required, and it can be drawn from Sherman Outlet. At present, reduced water quality is experienced during periods of disturbance due to vessel activity in the Sherman Outlet area. The redundant supply would need to be controlled so that the intake from Sherman Outlet would occur only in exceptional circumstances. Required capacity for back-up supply is minimum 100,000 USgpm (assuming 50,000 USgpm available from primary source).
Permissible maximum "Mean Channel Velocities" for open channel design varies between 0.61 mps to 1.83 mps. A value 0.61 mps was used for the purposes of this report.
Pipeline/Intake pipe velocities considered in this review varied from .9 m/s as a minimum to prevent silt build-up and 2.1 m/s to prevent excessive friction head.
U.S. Steel will provide minimum water quality standards for incorporation into design and construction contract documents.
U.S. Steel will be operating the pumphouse during construction.
The lake bottom areas adjacent to Pier 16 are covered with soft sediments and slag. There will be a consistent mild current toward the pumphouse intakes. Any construction activity, whether placing of bulk fill material or driving sheetpiles, would create elevated suspended solids in the water column. Temporary measures such as silt curtains and/or construction constraints based on wind and wave action would be required in the contract documents to prevent out of spec. water quality at the pumphouse intake.
The existing pumphouse intake screens are considered to be sufficient to capture refuse and trapped fish and other debris.
There is a seasonal risk/history of excessive fish impingement at the screens. U.S. Steel's normal practice to avoid problems has been to set diversion nets that form a semi-circle around the water intakes. The ability to use this type of procedure in the future is to be maintained.
Relocation of the existing intake structure away from the existing location would be unacceptable from the standpoint of cost and disruption to U.S. Steel operations.
Information gathered from the boreholes shows clay to be the main substrate material with slag deposits in some areas. Potential ground movements due to adjacent filling need to be addressed.
Design of a forebay, buried pipelines or other structures would include the requirement for a surcharge of 2000 psf as specified by the HPA for operating areas.
Existing No. 2 Bay Water Pump House, including its extension, has eight intake wells located along the western face of U.S. Steel property. Invert of intake openings is at approximate elevation of 65'-0"(based on existing drawings). Total wall length of the pump house in this area is 41m. Intakes are equipped with stationary and traveling screens.

Attachment D.18: Detailed Description of U.S. Steel Intake/Outfall Options 1 and 2

Option 1 – Piped Intake	
Overall Scheme	The overall intake/outfall system would consist of the following four main components: 1) primary inlet pipeline to main Harbour; 2) inlet forebay; 3) backup inlet pipeline to Sherman Inlet; and 4) west side open cut (WSOC) outfall intercept well. This option is based on construction of the ECF against the existing U.S. Steel pier. The plan includes two water supply inlets - the primary inlet from the open bay at the end of the channel separating Pier 16 from the ECF and a back-up water source from Sherman Outlet. A rectangular forebay would be constructed attached to the existing powerhouse intakes. The primary water intake would be provided by two 2.5 m diameter concrete pipelines extending from the forebay 250 m northward to the open Harbour in a line parallel to Pier 16. The backup water supply would be provided by twin 2.5 m diameter pipes connecting the forebay with the Sherman Outlet. The existing outfall flow from the WSOC area would be discharged into the primary intake pipes from a baffled concrete structure.
Primary Intake	Primary intake pipes would be in continuous service, except during rare maintenance inspections and annual cleaning. The flow velocity in the 2.5 m diameter lines would be 1.04 m/s at 150,000 USgpm and 2.07 m/s at the design flow of 300,000 USgpm. Each line would be 250 m long, with a control gate located in the forebay. Pipe invert elevations would be below the existing U.S. Steel intakes. While the intake invert elevation at the pumphouse and the discharge invert elevation at the WSOC are approximately 6.5 m below datum, the pipeline invert elevation at the forebay would be set at 7.5 m below datum with a grade downward toward the north. A series of 2 m diameter access manholes, located at 50 m intervals has been included as a provision so that divers can enter the pipes for inspection, and to assist with quick and convenient removal of accumulated sediments, zebra mussels or other debris. Separate molluscacide dosing systems would be installed in each pipe. Small diameter solution dosing lines would run from the pumphouse inside each 2.5 m diameter pipe and terminate in a ring diffuser at the pipe entrance so that the dosing agent can impinge against the entire internal pipe circumference. It was assumed that sodium

Option 1 – Piped Intake	
	hypochlorite or similar biofouling control agent would be used intermittently when the water temperature is above 10-12 degrees C. It was assumed that the new chemical storage tanks, safety equipment and/or metering pumps would be installed in or adjacent to the existing pumphouse. This chemical control facility should reduce the rate of biofouling and mussel growth currently observed in the intake and forebay areas. The frequency and annual cost of mechanical cleaning required at present by U.S. Steel should decrease. The control gates to each pipeline at the forebay would allow either pipeline to be taken out of service at any time for inspection, cleaning or emergency repairs without disrupting the flow in the second line. One pipe would have the ability to supply the normal water demand of 150,000 USgpm, flow velocity of .07 m/s, without relying on the back-up source from Sherman Inlet.
Back-up System	Two 2.5 m diameter, 50 m long concrete pipes would connect the Sherman Inlet to the proposed channel for back-up supply. A 5.5 m riser would be placed over the Sherman Inlet side to place the water intake well above the bottom. Control gates would be installed at the entrance to these pipes at the forebay to prevent flow during normal operation. The gates would be opened only when necessary.
Placing of Primary Intake Pipe	Before placing the 2.5 m diameter pipeline underwater, a leveled granular bedding would be placed. Due to the weight of the concrete pipes, they would settle and design of the connections between pipes would accommodate movement. The manholes can be prefabricated. The pipes would be reinforced to accommodate the 2,000 psf surcharge from pier loads.
Forebay	The forebay would be a rectangular structure 50 m long x 15 m wide. The four control gates for primary and back-up pipelines would be incorporated inside the forebay to allow the intake pipes to be closed for servicing. Construction of the forebay would be with steel sheetpiles. The existing trash racks at the pumphouse intake were considered adequate to deal with debris and trash removal and to avoid problems associated with "frazil ice" in freezing winter conditions.
WSOC Discharge	A rectangular outfall well would connect the WSOC discharge to the main pipelines. This would be made of prefabricated reinforced concrete elements. It would be used as an access manhole for maintenance of the primary intake pipelines and the inlet configuration would be designed with weirs and gates, as necessary, so that all of the flow can be directed to either pipe or both pipes together. This is needed in order to isolate one line for inspection purposes without affecting U.S. Steel's operations. It would also allow the WSOC flow to be directed to the Harbour by directing all of the flow to one pipe and then closing the gate for that pipe in the event of a spill or other mishap causing contamination in the WSOC.
Construction	Construction of the pipelines would commence with the removal or other remediation of any existing contaminated

Option 1 – Piped Intake	
	sediments in the installation zone. Removal of material from the area along the steel sheetpile wall of Pier 16 may require replacement with clean material to maintain stability of the wall. Dredging may need to be staged in this area to allow for fill replacement. Proven methods of construction would be used in order to keep the quality of intake water up to the standards acceptable for U.S. Steel's pumphouse operations. Depending on the level of U.S. Steel activity along Pier 16, the proposed pipelines may be installed from land, thereby reducing the need for floating equipment and greatly reducing the capital costs for this part of the operation. Pipes would be placed to grade and backfilled, with the fill forming part of the eastern side of the ECF containment structure.

Option 2 - Open Water Channel	
Primary Supply	This option is based on the concept presented in the conceptual design (see Section 6.0). During conceptual design, a 22 m wide, open channel was proposed between the easterly wall of the ECF and Pier 16.
Flow Velocity in the Channel	The finished elevation at the ECF was assumed to be similar to the existing elevation at Pier 16 on U.S. Steel's property. The conceptual hydraulic design considered worst conditions, which include a 1 m ice cover in the Harbour and the ECF berm with a 2 horizontal to 1 vertical slope. The channel approach velocity at a flow of 300,000 USgpm would be 0.5 m/s, which is less than the scouring velocity for fine sand. Therefore, scouring and erosion in the channel would not be a problem even with the smallest possible channel cross section.
Dredging for Existing Contaminants in the Channel	Construction of the open channel would require existing contaminated sediment to be removed or otherwise remediated. This may involve removal of the most contaminated sediment and capping of remaining sediment. Removal of material from the area along the steel sheetpile wall on Pier 16 may require replacement with clean material to maintain stability of the wall. Dredging may need to be staged in this area to allow for fill replacement. Precautions would be taken during dredging in order not to damage the existing pier.
Back-up Supply	The backup water supply would use a 35 m long by 2 m wide concrete channel bisecting the causeway that joins the ECF to the mainland. The channel base would be at an elevation suitable to provide 3 m of water depth (2 m water, 1 m ice) at the design low water level. A removable gate, possibly 2 or 3 sections of steel plate, would provide a barrier to flow under normal conditions. The gate would not be designed to withstand hydrostatic pressure, as the water elevations would always be the same on either side of the channel. The design would need to consider methods of removing the gate in both summer and winter. Air curtain/bubbler systems may be

Option 2 - Open Water Channel	
	considered to help minimize ice development. Precast concrete panels would cover the channel for the road access onto the ECF. The channel structure may be supported on piles, and would be designed for truck and train loading. Space would be allocated for various utilities that would be required for port operations.
Access Berm to ECF	The location of the entry to the ECF island from the mainland will be important. If entry to the pumphouse were closed, then a berm solution with 1:1 slope would not be possible. Sheet piling with anchors would be considered on one side (toward the pumphouse) and a berm with a 1:1 slope on the other side (Sherman Inlet).

Attachment D.19: U.S. Steel Intake/Outfall Options: Description of Evaluation Criteria or Sub-criteria

Criteria	Sub-criteria	Criteria or Sub-criteria Description
Service and Performance		The following are important considerations relative to service and performance: • provide 300,000 USgpm Design capacity, (100,000-150,000 USgpm normal); • during construction and operations raw intake water quality to be maintained within acceptable limits; • redundant intake source to be available both during construction and operations; • minimum disruption to ongoing U.S. Steel operations; and • long term service life and ease of maintenance required.
Technical Criteria	Complexity	During construction, U.S. Steel's continuous water requirement creates the need to keep the lake water quality up to the standards acceptable for U.S. Steel. Construction should use proven methods and employ water quality monitoring as part of the construction process.
	Compatibility with Other Elements	The proposed primary and secondary intake supply must accommodate the containment facility structure and the proposed future use of the ECF. Structures should be able to withstand potential ground movement induced by the presence of the ECF.
	Constructability/Time to Implement	Creating an intake pipe corridor will require measures to remove or otherwise remediate existing contaminated sediments along the alignment. This will require coordination of construction scheduling with the rest of the ECF facility. Construction may not be possible during winter months. Pre-fabricated concrete pipes, manholes and other structural elements will be used to the maximum degree possible.
Regulatory		The following are important regulatory considerations: • ease of acquiring a permit; • sediment removal, displacement and infill quality;

Criteria	Sub-criteria	Criteria or Sub-criteria Description
		• access and security; and • navigation restrictions.
Environmental Impacts		The following are important considerations relative to potential environmental impacts: • fish impingement; • control procedures for biofouling and zebra mussels; • change of local currents due to the presence of the new ECF; • construction period impacts such as sediment re-suspension; • timing of construction activity to satisfy seasonal restrictions (e.g., spawning periods); • icing conditions; and • potential sediment build-up.
Cost		Cost considerations include capital and maintenance costs.
Prior Application		Proven, conventional design and construction methods will be used to the greatest extent possible to minimize the risks to water (supply and quality), structural integrity and maintenance requirements.

PORT FACILITY DESIGN OPTIONS

D.6 Port Facility Options

D.6.1 Initial Screening

D.6.1.1 Introduction

Port facilities will be incorporated into the overall design of the ECF. HPA's requirements for the port facilities include high surcharge capacity with two deep draft berths. The main technical challenge in the design of the port facilities is to satisfy the need for a high design surcharge and deep ultimate dredged depth in an area with relatively weak soils. This must be accomplished, along with secure containment of dredged materials, at an affordable cost.

An important consideration for the design of the port facilities is the integration with the existing structures. The proposed ECF, including related port facilities, will be constructed on the north side of Pier 15. The existing wharf in this area was originally constructed by the International Harvester Company of Canada. The original wharf construction includes the east-west berth that is now referred to as Pier 15 and the north-south wall that extends to the U.S. Steel wharf (Pier 16).

This section provides information on the evaluation of the port facility options. The key assumptions relating to the evaluation of port facility options are provided in Attachment D.20.

D.6.1.2 Identification of Options

The following options were examined for the port facilities at Randle Reef:

- Option 1 - Steel Sheetpile Bulkhead with Kingpiles and Discontinuous Concrete Anchorages;
- Option 2 - Steel Sheetpile Bulkhead Reinforced with Plates and Discontinous Concrete Anchorages;
- Option 3 - Steel Sheetpile Bulkhead with Angled Tension Anchors to Rock or Till;
- Option 4 - Double Wall Steel Sheetpile Wall;
- Option 5 - Steel Sheetpile Wall with Relieving Platform;
- Option 6 - Concrete Caisson Wall; and
- Option 7 - Cellular Steel Sheetpile Wall.

These options are described in Table D.23. Illustrations of these options are provided following Attachment D.20.

Table D.23: Description of Port Facility Options

Option	Description of Option
Option 1 - Steel Sheetpile Bulkhead with Kingpiles and Discontinuous Concrete Anchorages Option 2 - Steel Sheetpile Bulkhead Reinforced with Plates and Discontinuous Concrete Anchorages	The steel sheetpile bulkhead design concept consists of a steel sheetpile face wall anchored near the low water level with tie rods to a continuous steel sheetpile anchor wall. A reinforced concrete parapet would be situated on top of the piling. Preliminary sizing of piling is based on free earth soil analysis. One major parameter, which impacts the design of this wall, is the soft sediments in the upper layer of in-situ material. This soft material is anticipated to continue down to a depth of ±18 m below chart datum, after which a denser stratum of material should be encountered. The combined 50/100 kPa surcharge with the 10.7 m dredge depth yield a piling section modulus that is not a standard section. The total height of wall is approximately 23 m. Two options are available to increase the strength of the piling. The first option is a combined wall which is a hybrid of steel sheet piling and deep section H-piles. The second involves reinforcing a standard sheetpile section with steel plates welded to the piling in zones where additional moment capacity is needed. Tie rods in reinforced steel sheetpile would be needed at every second inpan, which are generally every 2.5 m. On the hybrid system a tie rod would be needed at every H-pile location, which is generally every 1.8 m. In both options, the anchor wall would be the same and would be approximately 7 m in height and located 25 m back from the face wall.
Option 3 - Steel Sheetpile Bulkhead with Angled Tension Anchors to Rock or Till	This option includes a conventional bulkhead facewall with tension pile anchors, eliminating the need for deadman anchors offset from the facewall. There are two methods of anchoring the facewall. The first method uses grouted pre-stressed tendon anchors. Preliminary calculations suggest a 20 m bonded length would be required. A second method would be to use driven spin-fin piles. Steel plates would be welded to pipe piles near the tip to increase the pull-out capacity of the driven pile.
Option 4 - Double Wall Steel Sheetpile Wall	A parallel wall system of steel sheet piling is an alternative to a conventional anchored bulkhead. This system would be anchored together with tie rods at low water level. Preliminary sizing indicates that the face wall would be the same height as the bulkhead wall, but with the anchor wall set closer at 15 m from the face. The anchor wall would be approximately 15 m in height.
Option 5 - Steel Sheetpile Wall with	This option is a modification of steel sheetpile bulkhead wall where the 50 KPa surcharge load is

Option	Description of Option
Relieving Platform	carried by a reinforced concrete platform supported on bearing piles and steel sheetpile face wall. The platform is monolithic with the parapet, and is expected to extend 12 m back from the face wall to relieve the 50 KPa surcharge. The sheet piling would be reduced in weight and is expected to be a standard available sheetpile section. The bearing capacity of the piles supporting the platform would dictate the spacing and concrete platform dimensions. Tie back anchorage would be required to support the steel sheetpile face wall, and may be provided through anchor blocks or tension and compression pile at the back edge of the relieving platform.
Option 6 - Concrete Caisson Wall	Concrete caissons are individual concrete cribs, which are slip formed and launched into the water for completion of the wall. Generally, the individual caissons would be 30 m long, 12 m high and 10 m wide. The cribs would be ballasted and set on a prepared stone mattress and backfilled. A concrete parapet would be added on top, along the face of the caisson. The crib would be set end to end to form the length of the terminal.
Option 7 - Cellular Steel Sheetpile Wall	A cellular steel sheetpile wall consists of flat web piling driven in a circular shape with each cell interconnected by arcs of the same piling. Preliminary sizing of the system indicates that the cell would be 20 m in diameter with the centre-to-centre distance between cells of 25 m. The cells would be backfilled and act as a gravity structure. The height of the structure would be less in this concept and is estimated to be 18 m, based on preliminary soils information. A concrete parapet on top would be necessary to provide a flush face wall for berthing.

D.6.1.3 Evaluation Criteria

The following general criteria were used to evaluate the port facility options:

- service criteria;
- technical criteria;
- regulatory criteria
- environmental impacts;
- cost; and
- prior application.

Attachment D.21 provides a description of the specific criteria or sub-criteria used for the evaluation of port facility options.

Relative to the service criteria, the port facility structures must satisfy the National Building Code ultimate limit states design (strength and stability design - i.e., condition of a structure where it ceases to fulfill the function for which it was designed), as follows:

- loss of equilibrium of the global structure;
- failure by rotation or translation;
- failure by lack of vertical equilibrium;
- failure of a structural element or connection;
- failure caused by excessive movement; and
- failure caused by time dependent effects.

In addition, the following serviceability limit states (deflection and use design) were considered:

- unacceptable wall deflections and associated ground movements;
- unacceptable leakage through or beneath the structure; and
- unacceptable transport of soil grains through or beneath the structure.

D.6.1.4 Evaluation of Port Facility Options

Table D.24 presents the evaluation of port facility options. This evaluation was based on the evaluation criteria noted in Section D.6.1.3.

In some cases, a rating of "high", "moderate" or "low" was assigned. For example, a high rating for the Environmental Impact criterion indicates that the option has a greater environmental impact than an option assigned a moderate or low rating.

For the Prior Application criterion, an indication of whether the option is in common usage, moderate usage or seldom used was provided.

Table D.24: Evaluation of Port Facility Options

Criteria /Sub-criteria	Option						
	Option 1 - Steel Sheetpile Bulkhead with Kingpiles and Discontinuous Concrete Anchorages	**Option 2 - Steel Sheetpile Bulkhead Reinforced with Plates and Discontinuous Concrete Anchorages**	**Option 3 - Steel Sheetpile Bulkhead with Angled Tension Anchors to Rock or Till**	**Option 4 - Double Wall Steel Sheetpile Wall**	**Option 5 - Steel Sheetpile Wall with Relieving Platform**	**Option 6 - Concrete Caisson Wall**	**Option 7 - Cellular Steel Sheetpile Wall**
Service - Performance	• represents the most conventional method of wharf construction • the discontinuous concrete anchorages for these structures do not offer features that would assist with the containment of dredged material; separate containment elements would be required	• represents the most conventional method of wharf construction • the discontinuous concrete anchorages for these structures do not offer features that would assist with the containment of dredged material; separate containment elements would be required	• the facewall would be proportioned in the same manner and with the same confidence as Options 1 and 2 • the anchors rely on pullout resistance from the native sub-surface soils; capacity tests suggest that the ultimate capacity can be achieved; the anchors may creep with time, however, a significant over design may be required • vertical equilibrium of the facewall must be checked once the soil properties are better defined	• the facewall would be proportioned in the same manner and with the same confidence as Options 1 and 2 • the anchor wall would be constructed as a continuous wall, offset from the facewall; will satisfy the limit states • the continuous anchor wall embedded in the native clay substrate offers an opportunity to prevent the passage of both soil grains and water through the structure	• the facewall and anchor wall are proportioned similarly to Options 1, 2, 3 and 4 • this option would be preferred if the soils are too weak to carry the design surcharge loads • the anchorage system may be as in Options 1 and 2 or as in Option 4	• the dimensions of the caissons designed to provide adequate safety factors against overturning and sliding • the structure will inherently prevent the passage of soil grains and water through the individual cribs • the opportunity exists for the passage of soil and water below the structure and between the individual cribs • special details would have to be developed to eliminate this	• the diameter of the cells, the interlock strength of the sheets and the penetration of the sheets will be proportioned to satisfy the limit states design • a concrete superstructure would be required to provide for the operational needs of a commercial berth • the structure will inherently prevent the passage of soil grains and

Criteria /Sub-criteria	Option						
	Option 1 - Steel Sheetpile Bulkhead with Kingpiles and Discontinuous Concrete Anchorages	**Option 2 - Steel Sheetpile Bulkhead Reinforced with Plates and Discontinuous Concrete Anchorages**	**Option 3 - Steel Sheetpile Bulkhead with Angled Tension Anchors to Rock or Till**	**Option 4 - Double Wall Steel Sheetpile Wall**	**Option 5 - Steel Sheetpile Wall with Relieving Platform**	**Option 6 - Concrete Caisson Wall**	**Option 7 - Cellular Steel Sheetpile Wall**
			• these anchorages do not offer features that will assist with the containment of dredged materials; separate containment elements would be required • the potential for movements of the anchors over time may have an adverse impact on the containment elements			pathway	water through or below the structure
Service – Service Life	• proper engineering design principles will achieve Ultimate Limit States design; feasibility to be confirmed with geotechnical investigation • not all Serviceability Limit	• proper engineering design principles will achieve Ultimate Limit States design; feasibility to be confirmed with geotechnical investigation • not all Serviceability Limit	• proper engineering design principles will achieve Ultimate Limit States design; feasibility to be confirmed with geotechnical investigation • not all Serviceability Limit	• proper engineering design principles will achieve Ultimate Limit States design; feasibility to be confirmed with geotechnical investigation • design meets Serviceability	• proper engineering design principles will achieve Ultimate Limit States design; feasibility to be confirmed with geotechnical investigation • design meets	• proper engineering design principles will achieve Ultimate Limit States design; feasibility to be confirmed with geotechnical investigation • not all	• proper engineering design principles will achieve Ultimate Limit States design; feasibility to be confirmed with geotechnical

Criteria /Sub-criteria	Option						
	Option 1 - Steel Sheetpile Bulkhead with Kingpiles and Discontinuous Concrete Anchorages	**Option 2 - Steel Sheetpile Bulkhead Reinforced with Plates and Discontinuous Concrete Anchorages**	**Option 3 - Steel Sheetpile Bulkhead with Angled Tension Anchors to Rock or Till**	**Option 4 - Double Wall Steel Sheetpile Wall**	**Option 5 - Steel Sheetpile Wall with Relieving Platform**	**Option 6 - Concrete Caisson Wall**	**Option 7 - Cellular Steel Sheetpile Wall**
	States met; additional containment required	States met; additional containment required	States met; additional containment required	Limit States	Serviceability Limit States	Serviceability Limit States met; additional containment required	investigation • design meets Serviceability Limit States
Technical - Complexity	• low • represents conventional method of wharf construction and the necessary skills are available in the contracting community • both the equipment and materials are readily available	• low • represents conventional method of wharf construction and the necessary skills are available in the contracting community • both the equipment and materials are readily available	• moderate • higher level of complexity associated with the installation of tension anchors	• low • represents conventional method of wharf construction and the necessary skills are available in the contracting community • both the equipment and materials are readily available	• low • represents conventional method of wharf construction and the necessary skills are available in the contracting community • both the equipment and materials are readily available	• high • have been historically used where soils conditions prevent the economic use of steel sheetpiles; last commercial wharf built in this fashion was in Goderich in 1986 • this method requires specialized skills and competition among bidders may be limited	• high • cellular structures have seen limited use on the Great Lakes • the last large scale structure was constructed at Long Point in 1987 • the installation procedure is complex; the sheets must form a perfect circle for the final driven sheet to close the cell
Regulatory – Environmental	• sediment controls during pile	• sediment controls during pile	• sediment controls during pile	• sediment controls during pile	• sediment controls during pile	• would require dredging before	• sediment controls

Criteria /Sub-criteria	Option						
	Option 1 - Steel Sheetpile Bulkhead with Kingpiles and Discontinuous Concrete Anchorages	**Option 2 - Steel Sheetpile Bulkhead Reinforced with Plates and Discontinuous Concrete Anchorages**	**Option 3 - Steel Sheetpile Bulkhead with Angled Tension Anchors to Rock or Till**	**Option 4 - Double Wall Steel Sheetpile Wall**	**Option 5 - Steel Sheetpile Wall with Relieving Platform**	**Option 6 - Concrete Caisson Wall**	**Option 7 - Cellular Steel Sheetpile Wall**
Constraints	installation would be minor • piling noise	installation would be minor • piling noise	installation would be minor • piling and drilling noise (relatively quiet) during drilling for tension anchor installation	installation would be minor • piling noise	installation would be minor • piling noise • option would have highest noise levels during H-Pile or Pipe Pile driving	installation of the caissons and would require moderate sediment control and temporary dredge material storage accommodation • dredging noise	during pile installation would be minor • piling noise
Environmental Impacts	• moderate • the nature of the port facilities construction will have an impact on the overall size of the ECF; conventional bulkheads require a footprint of 25 to 30 m wide for overall stability	• moderate • the nature of the port facilities construction will have an impact on the overall size of the ECF; conventional bulkheads require a footprint of 25 to 30 m wide for overall stability	• low • the nature of the port facilities construction will have an impact on the overall size of the ECF; conventional bulkheads require a footprint of 25 to 30 m wide for overall stability	• low • this option has a narrower footprint and, thus, the overall size of the ECF is smaller	• low • the nature of the port facilities construction will have an impact on the overall size of the ECF; conventional bulkheads require a footprint of 25 to 30 m wide for overall stability	• low • this option has a narrow footprint	• moderate • this option has a moderate footprint

Criteria /Sub-criteria	Option						
	Option 1 - Steel Sheetpile Bulkhead with Kingpiles and Discontinuous Concrete Anchorages	**Option 2 - Steel Sheetpile Bulkhead Reinforced with Plates and Discontinuous Concrete Anchorages**	**Option 3 - Steel Sheetpile Bulkhead with Angled Tension Anchors to Rock or Till**	**Option 4 - Double Wall Steel Sheetpile Wall**	**Option 5 - Steel Sheetpile Wall with Relieving Platform**	**Option 6 - Concrete Caisson Wall**	**Option 7 - Cellular Steel Sheetpile Wall**
Cost (rank) Capital Cost Operating Cost	5 $28,228 – unit cost per m	4 $28,130 – unit cost per m	2 $23,113 – unit cost per m	1 $22,761 – unit cost per m	6 $29,854 – unit cost per m	7 $32,345 – unit cost per m	3 $27,176 – unit cost per m
Prior Application	• common usage	• common usage	• moderate usage	• common usage	• common usage	• seldom used	• seldom used

D.6.1.5 Results of Evaluation of Port Facility Options

Option 6 (Concrete Caisson Wall) has the highest unit cost, even with the cost of the pre-installation dredging excluded from the cost estimate.

Options 1 (Steel Sheetpile Bulkhead with Kingpiles and Discontinuous Concrete Anchorages) and 2 (Steel Sheetpile Bulkhead Reinforced with Plates and Discontinuous Concrete Anchorages) have the widest footprint and have high unit costs associated with the wide construction.

Option 3 (Steel Sheetpile Bulkhead with Angled Tension Anchors to Rock or Till) has the second lowest per unit cost and the potential for the narrowest footprint. Further design refinement is required to establish the feasibility of this option. The soil conditions may not support the vertical loads induced by the battered anchors and additional bearing piles may be required.

Option 5 (Steel Sheetpile Wall with Relieving Platform) has high unit costs (based on a conventional anchorage). A relieving platform in combination with the features of Options 3 and 4 (Double Wall Steel Sheetpile Wall) may warrant further consideration, depending on soil conditions.

The environmental constraints related to the method of construction require further investigation (i.e., pile driving and suspended sediment controls, noise, etc.).

The selection of steel sheetpile will ultimately be made by the successful bidder. As the design is refined, a performance specification will be developed identifying the minimum structural requirements. Market forces on supply cost and the contractor's familiarity with installation will determine the choice between the various steel sheetpile products.

The following options were recommended for further evaluation in the next stage of the engineering work (see Section D.6.2):

- Option 3 - Steel Sheetpile Wall with Angled Tension Anchors to Rock or Till;
- Option 4 - Double Wall Steel Sheetpile Wall;
- Option 5 - Steel Sheetpile Wall with Relieving Platform; and
- Option 7 - Cellular Steel Sheetpile Wall.

D.6.2 Detailed Evaluation – 30 Percent Design

D.6.2.1 Introduction

The port facility design element includes design options for the port facility walls on both the primary and secondary ECFs. This element overlaps with the ECF isolation structures and further addresses the need to provide adequate structural and geotechnical stability for the design dredge depth of the port facility, while providing an element of containment for contaminants. Additionally, this design element includes facility services components for the primary ECF to accommodate the likely range of port uses. Port facility services will be refined during later stages of design.

The secondary ECF was intended to contain lower priority sediment (i.e., Priorities 3 and 4) and will consist of design options that may be different in nature to those for the primary ECF (e.g., no sealed interlocks for sheetpile walls). The requirements for the secondary isolation features and port walls were to be based on the fate and transport modeling specific to the less contaminated sediments and to achieving structural design requirements for the port walls, site conditions and port facility uses.

D.6.2.2 Identification of Options

The following recommended design options were carried forward from the initial screening for the port facility walls:

- double steel sheetpile wall (north, south, east and west);
- cellular sheetpile wall (north, south, east and west);
- steel sheetpile wall with tension anchors (south); and
- steel sheetpile wall with relieving platform (south).

During the 30 percent design stage, it was determined that differences between perimeter containment on the north, west and east walls are related to the increased additional structural integrity required to accommodate the design dredge elevation and port loading requirements. Contaminant isolation features are incorporated as part of the structural design development for the port facilities.

The double steel sheetpile wall under consideration for the south side is similar to the double wall previously examined in the initial screening, with the exception that the exterior wall is embedded more deeply for stability and to accommodate a design requirement for a design berth draft elevation of 10.7 m (35 ft) below Chart Datum.

In addition, the following port services were identified at the 30 percent level of design:

- conceptual rail access/alignment and rail service;
- conceptual road access/alignment and road service;
- utility services (dockside) for the primary ECF; and
- other miscellaneous services.

Provisions (e.g., design criteria for loads, potential options to provide utility corridors) that would accommodate the installation of these port facility uses were included in the proposed designs. These include some of the design standards addressed within the 30 percent design, as well as future design standards to be addressed as part of the 100 percent design.

D.6.2.3 Evaluation Criteria

The following general criteria were used to evaluate port facility options at the 30 percent design level:

- effectiveness;
- implementability; and
- cost.

D.6.2.4 Evaluation of Options

The findings of the geotechnical evaluation were used to support development of the requirements for the port facility and to assess the slope stability of the port facility walls. Loading requirements were established for the port facility and the preliminary geotechnical design recommendations were developed considering the loading requirements.

The four design options from the initial screening were reviewed against the requirements of the geotechnical conditions and compatibility with other design elements (isolations structures and fate and transport study results) relevant to the port facilities. Two design options were considered appropriate for further evaluation against the design standards. If the design options met the design standards, evaluation criteria were applied to an analysis of the design option. In some cases, as for the secondary facility, the options were retained for the later stage of design (i.e., 100 percent design stage) given the benefits of providing some flexibility in the selection of the design elements that might result in cost savings for the project.

Due to the interaction of the port facility design element with the isolations structure design element, the evaluation of the port facility design element was completed taking into account the results of the initial phase of the fate and transport modeling completed at the 30 percent level of design. This work concluded that the port facility walls design option must provide an effective seal around the contaminants, including sealable interlocks for interior sheetpile walls. The cellular steel sheetpile wall design option was, therefore, eliminated since the straight sheetpiles could not be sealed cost effectively. The double steel sheetpile wall with tension anchor was eliminated for the following reasons:

- the point of compliance for Ontario Provincial Water Quality Objectives is immediately adjacent to the sealed interlock and the risk of unacceptable impacts due to damaged interlocks or sealant is much greater than the double steel sheetpile option with sealed interlocks along the inner wall;
- mitigation of lost containment is less feasible than the double steel sheetpile wall or containment berm options;

- the structural steel for the single wall is thicker, which may limit acceptable sealable vendor products and influence material cost;
- deflections of the single wall option would likely exceed the double steel sheetpile wall option; and
- the long-term reliability of this design option over a 200 year design life for effective containment is much lower than the double wall option.

The double steel sheetpile wall connected with tie rods (assumed to be placed 2 m (6.5 ft) below the top wall) and filled with gabion stone was evaluated to determine the applicability for the north, west and eastern side of the ECF. For the eastern side, the design loads of 50 and 100 kPa area loads (i.e., surcharge pressures) are the required design loads. The global slope stability was examined. The factor of safety was determined for the double steel sheetpile wall and foundation soils under the required loading conditions using three scenarios for different factors of safety (short term loading, long term loading and seismic loading). It was determined that no post liquefication analyses were needed since the liquefication analyses showed that the site soils will not liquefy during the design-level seismic events.

Therefore, due to the incompatibility of some of the options with the requirements of the isolation structures, and the findings of the geotechnical studies and the first phase of the fate and transport work, only two of the options from the initial screening were retained and evaluated for the port facility walls at the 30 percent design level. The two options were the double steel sheetpile wall with sealed interlocks and the double steel sheetpile wall with sealed interlocks and relieving platform.

Table D.25 presents the evaluation of these options. Each option was assigned a score by criteria, reflecting a ranking of +1 for preferred, 0 for neutral and -1 for not preferred or not meeting criteria. Where both options were assigned a “0” for a particular criterion, this indicated that there were no differences between the options for that criterion. The ranking by criteria were then summed with the highest score assigned to the most preferred option. The criteria were weighted equally.

D.6.2.5 Results of Evaluation of Options

The results of the evaluation indicate that the double steel sheetpile wall with sealed interlocks was preferred with a score of eight (8), and the double steel sheetpile wall with sealed interlocks and relieving platform was somewhat less preferred with a score of six (6). The relieving platform option may be determined to be more cost effective during later stages of design. Both options were, therefore, retained for further consideration during the 100 percent design level.

Table D.25: Evaluation of Port Facility Wall Options – 30 Percent Design Level

Criteria/Sub-criteria	Double Wall (SSP and Sealed SSP Walls)	Double Wall (SSP and Sealed SSP Walls) with Relieving Platform
Effectiveness		
Overall Protectiveness – Risk of Exposure to Public or Environment (short-term)	1	1
Overall Protectiveness – Risk of Exposure to Public or Environment (long-term)	1	1
Compliance with Design Standards and Other Requirements	0	0
Long-term Effectiveness and Performance - Risk Presented by Residuals and Contained Sediment	1	1
Long-term Effectiveness and Performance - Reliability of Technical Components / Controls	0	0
Short-term Effectiveness - Protection of Workers, Community During Construction	1	1
Short-term Effectiveness – Protection of the Environment During Construction	1	1
Short-term Effectiveness - Scheduled Duration of Design Elements/Time to Execute Design Option	1	0
Reduction of Mass/Volume, Toxicity, and Mobility of Contaminants - Degree of Dissolved Chemical and/or NAPL Mobility Control and Magnitude of Contaminant Mass Reduction	0	0
Reduction of Mass/Volume, Toxicity, and Mobility of Contaminants – Magnitude of Contaminant Mass Reduction	0	0
Implementability		
Technical Feasibility - Ease of Construction and Operating the Option in a Cost-Effective Manner	0	0
Technical Feasibility - Reliability of Design Option	0	1
Technical Feasibility - Compatibility with other Design Options	0	0
Technical Feasibility - Technical Complexity of Design Option	0	-1
Technical Feasibility - Facilitation of		

Criteria/Sub-criteria	Double Wall (SSP and Sealed SSP Walls)	Double Wall (SSP and Sealed SSP Walls) with Relieving Platform
Future Actions for Remediation or Repairs	-1	-1
Administrative Feasibility – Facilitates Coordination with Local/Provincial/Federal Government Agencies to Both Identify and Comply with Jurisdictional Regulations	0	0
Administrative Feasibility - Ease of Obtaining Permits Waivers, Easements, Other Releases to Facilitate Implementation of Design Components Comprising Option	1	1
Administrative Feasibility - Acceptance by Stakeholders	0	0
Availability - Availability of Equipment, Materials, Services, etc. to Implement, Verify and Monitor Effectiveness of Design Option	1	1
Local/Provincial/Federal Government Standards and Stakeholder Input-Relative Probability of Design Option to Generate Issues or Concerns	0	0
Local/Provincial/Federal Government Standards and Community Input-Incorporation of Input from the Community Based on Perceived Issues or Concerns, Relative Risk of Heightened Public Concern	0	0
Cost		
Cost - Capital and Periodic Costs	1	-1
Cost - Financial Risk	0	1

Legend:+1 – Preferred 0 - Neutral -1 - Not preferred or not meeting criteria

For the secondary facility it was concluded that, the port facility wall design options would be further reviewed (i.e., at the 100 percent design level) once the dredge plan is modified and the outcomes of the more sophisticated fate and transport modeling work for the secondary facility were known. It is possible that previously examined design options, such as the single wall with tension anchors, may become more cost-effective, once further information becomes available at the 100 percent design stage.

D.6.3 Detailed Evaluation – 100 Percent Design

D.6.3.1 Introduction

Further geotechnical analyses were completed to develop the structural requirements and review the site conditions for the design of the walls during the 100 percent design stage. The results of these analyses were then applied to the design for the port facility walls, for both the primary and secondary facilities.

D.6.3.2 Identification of Options

The 100 percent structural design was completed for the double steel sheetpile wall option carried forward from the 30 percent design stage.

D.6.3.3 Review Objectives and Studies

The objective of the review was to apply the geotechnical parameters and requirements for dredge grade depths and loading requirements to the design option. The design option was also analysed to validate its structural feasibility by conducting a fixed earth analysis and a free earth-undrained analysis. The anchorage capacity of the anchor wall was determined and a finite element analysis of the anchor wall was also completed. An analysis related to the vessel design, berthing and mooring, and corrosion protection of the walls was also undertaken. Costs were also developed.

D.6.3.4 Evaluation of Options

The geotechnical parameters developed during the 30 percent design and the soil layer elevations determined during the 100 percent geotechnical design work were used for the structural design of the perimeter walls for the primary ECF. The minimum steel sheetpile toe elevations required to satisfy global stability concerns were also applied to the final design of the perimeter walls. The top-of–wall elevations were designed, as per the findings of the capping, grading and stormwater management design for the walls of the primary and secondary facilities.

The design grade depths on the exterior of the ECF are based on the depths developed in the dredging plan developed for the 100 percent design. The plan also provides dredge grade depths for the removal of contaminated sediments between the exterior ECF facewall and interior wall.

Analysis of various data sources provided the means to establish design water levels, wind velocities for the 30 year and 100 year storm return periods, current speeds for the 30 year and 100 year return periods, values for static ice loading, live loads, design vessel for determination of the berthing and mooring loads, and future uses of the new port facility which include accommodation for container ships.

The anchor wall was modeled using finite element structural software.

The design of the facewall for the secondary ECF was developed based on the soil properties in the vicinity of the primary ECF. Details regarding the stabilization of Pier 15 to deal with stability concerns will be addressed during the development of the construction specifications. Fendering, mooring design and arrangement, and modeling of the parapet wall were also assessed for the 100 percent design. Service life considerations related to corrosion, tie-rod corrosion protection and methods for protecting steel piling were also assessed.

Once an option was recommended, the associated costs were also developed.

D.6.3.5 Results of Evaluation of Options and Recommendations

The design of the port walls are summarized in the Figures D.17 to D.19. Dredge grade depths walls (see Figure D.20) are as established for Priority 1 sediment removal and the future dredge grade depth of 10.67 m below Chart Datum at the port facility. A top-of-dock elevation of 3.0 m (9.8 ft) on the port facility wall and a top elevation of 2.0 m above Chart Datum on the remaining ECF walls with a design low water level of 0.3 m below Chart Datum were used in the analysis. Live loads of 50 kilopascals (kPa) (1,000 psf) within 12.2 m (40 ft) of the port facility face and 100 kPa (2,000 psf) beyond 12.2 m (40 ft) are as established at the 30 percent design level.

To optimize costs and design conditions for the walls, fixed earth analysis was completed. However, the results showed that a depth of piling for fixivity is significantly deeper than the recommended depth for global stability that would be required. Free earth-undrained analysis was found to govern the design loads on the walls and ultimate determination of sheetpiling section modulus. The results showed that a combination wall would be necessary to satisfy the strength requirements. The potential steel sheetpiling wall system is shown below in Figure D.21. To address the results of the fate and transport modeling and the requirement for a sealed steel sheetpile wall, the anchor wall may be constructed from Waterloo Barrier ® or have similar properties to the Waterloo Barrier ®. The steel sheetpiling will be specified with a low-alloy corrosion resistant steel and will have reserve thickness.

Two methods were assessed to reduce loads on the south wall: replacement of the weak upper silty clay between the sheetpile walls; and a double tie-rod system. The analysis showed that the two-tie-rod system does not reduce the bending moments as effectively as the clay replacement method. Therefore, the clay replacement method is recommended for the facewalls in those areas where bending moment reduction is required to achieve an economical sheetpile selection. The 100 percent design considers the cost for clay replacement to an average depth of 12 m below Chart Datum along the full length of the south face and at the southwest and northwest corners of the primary ECF and the secondary ECF wall.

Figure D.17: Primary ECF West Face Elevation and Dredge Limits

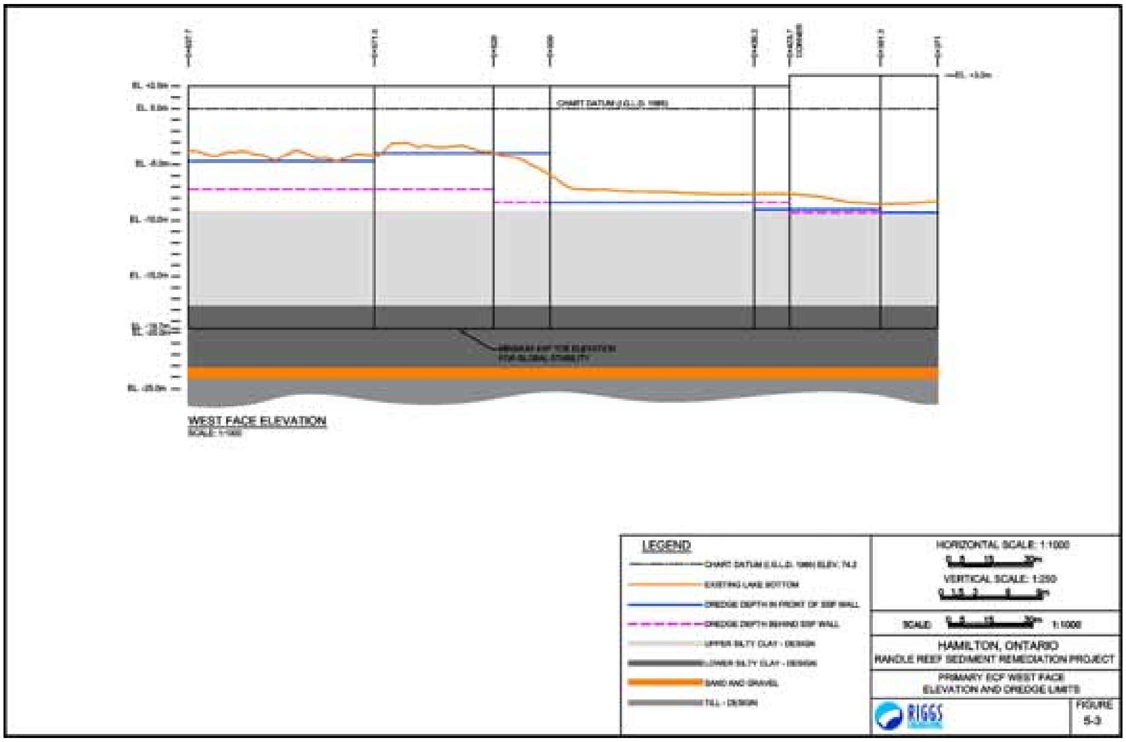


Figure D.18: Primary ECF North Face Elevation and Dredge Limits

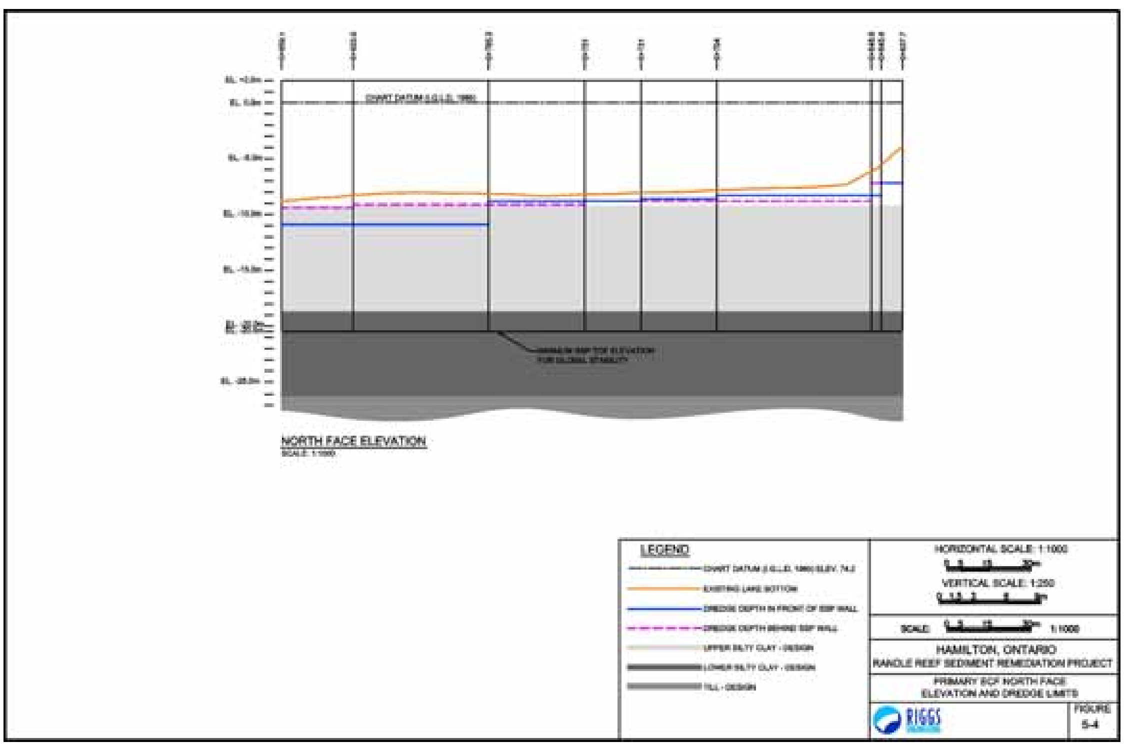
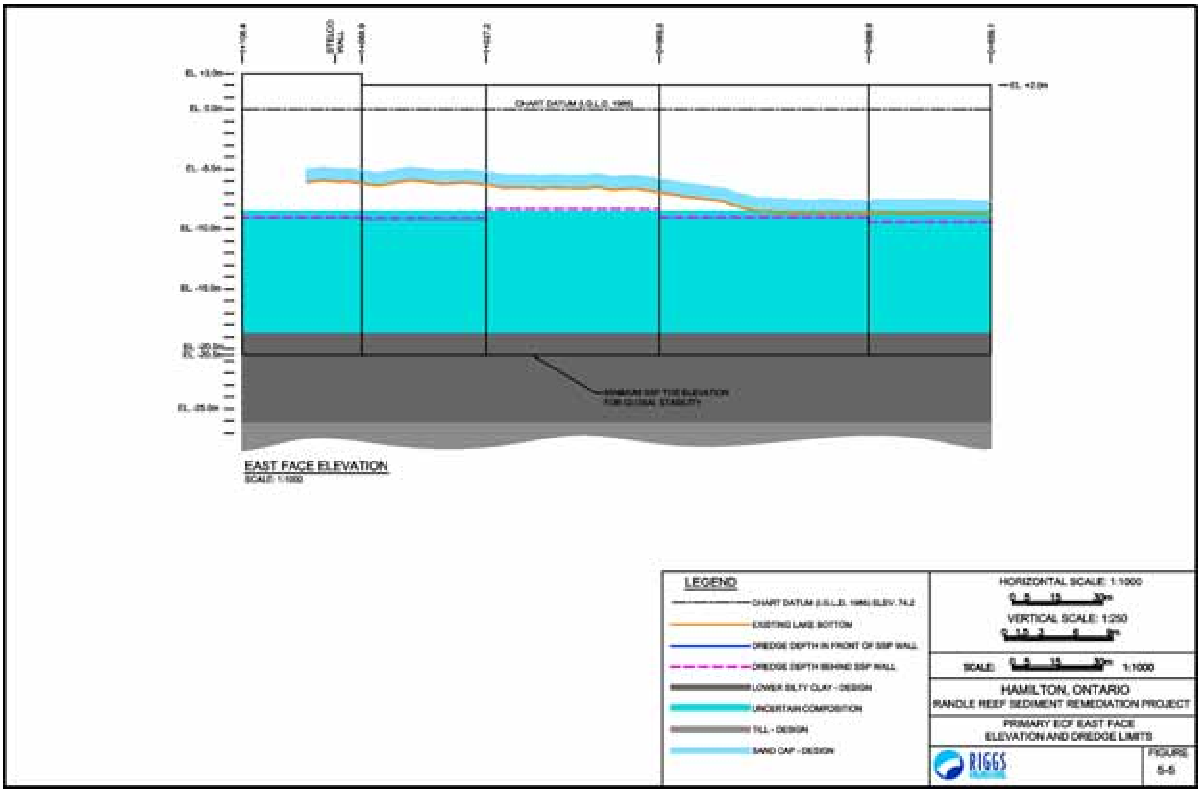


Figure D.19: Primary ECF East Face Elevation and Dredge Limits



The anchorage capacity of the anchor wall was determined. The limiting design case occurs with a full 100 kPa (200 psf) surcharge on the back side of the anchor wall and no surcharge on the face of the anchor wall. Finite element analysis of the anchor wall revealed deflection in the order of 60 millimetres (2.4 inches) within the upper silty clay layer.

The design details for the secondary ECF are similar to those for the south face of the primary ECF.

The berthing energy requirements were determined for the design vessel and are in the order of 54 to 68 tonne-metres for the design vessel displacement of 101,485 tonnes. Stand-alone bollards rated for loads of 1,000 kilonewtons (kN) are recommended with bollards rated at 500 kN recommended along the wall.

The parapet was modeled for various directions of line pull from the wall-mounted bollard and also from the reaction produced from a compressed fender and recommendations made on the most applicable parapet. A concrete parapet is recommended for the south wall of the ECF.

Figure D.20: Design Dredge Depths

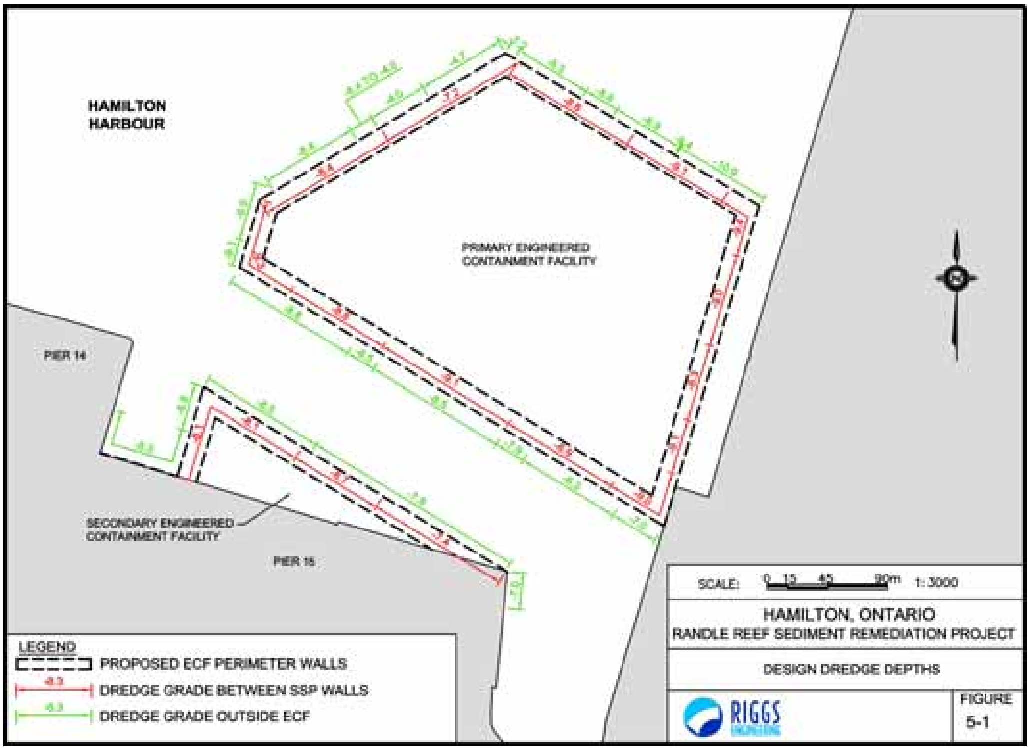
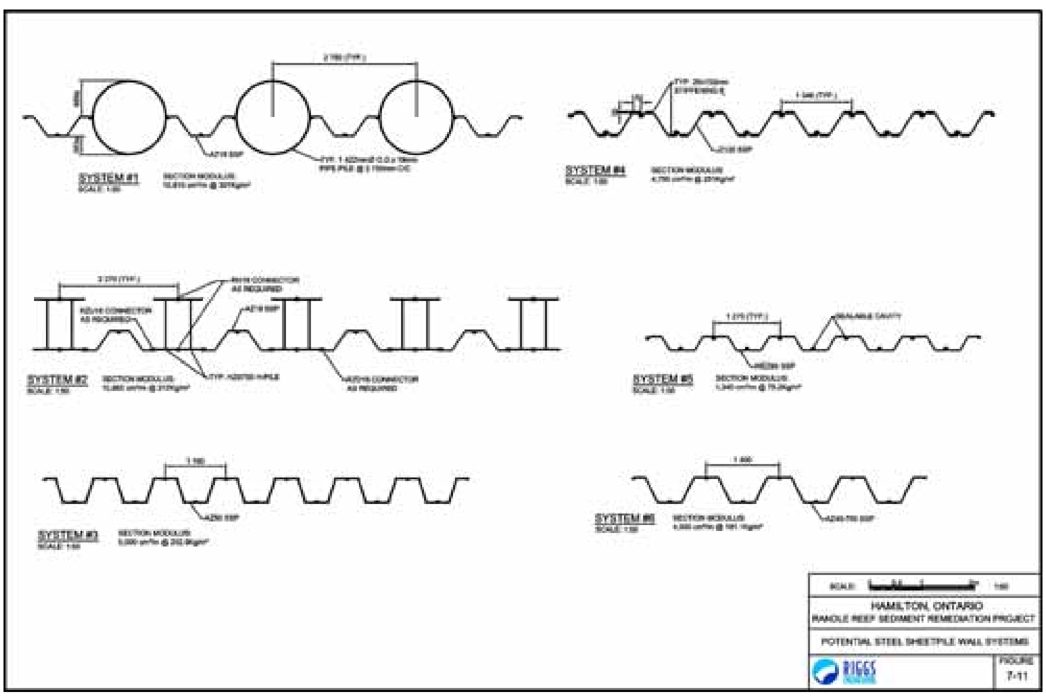


Figure D.21: Potential Steel Sheetpile Wall Systems



The interim recommendation for fenders are to use hanging tubular fenders supported on chains until the use of the port facility is more fully known.

Potential means of corrosion protection were evaluated and a steel sheetpile facewall coating system is recommended. This is expected to provide some protection against accelerated corrosion and will likely extend the service life of the facewall in excess of 30 years. A high-quality epoxy coating is recommended on the upper 10 m of the exterior face of the piling.

Three methods of corrosion protection are proposed for the tie-rods as follows:

- encapsulate the wale (i.e., a horizontal bracing member) and tie-rod connections at the facewall in the concrete parapet;
- specify a double corrosion–protection system for the tie-rods in the port facility berths; and
- modestly oversize the tie-rods in the remainder of the facility to provide a corrosion allowance in the steel.

The estimated cost for construction of the primary ECF perimeter structures is CAN $36,353,695.

Attachment D.20: Port Facility Options: Initial Screening Assumptions

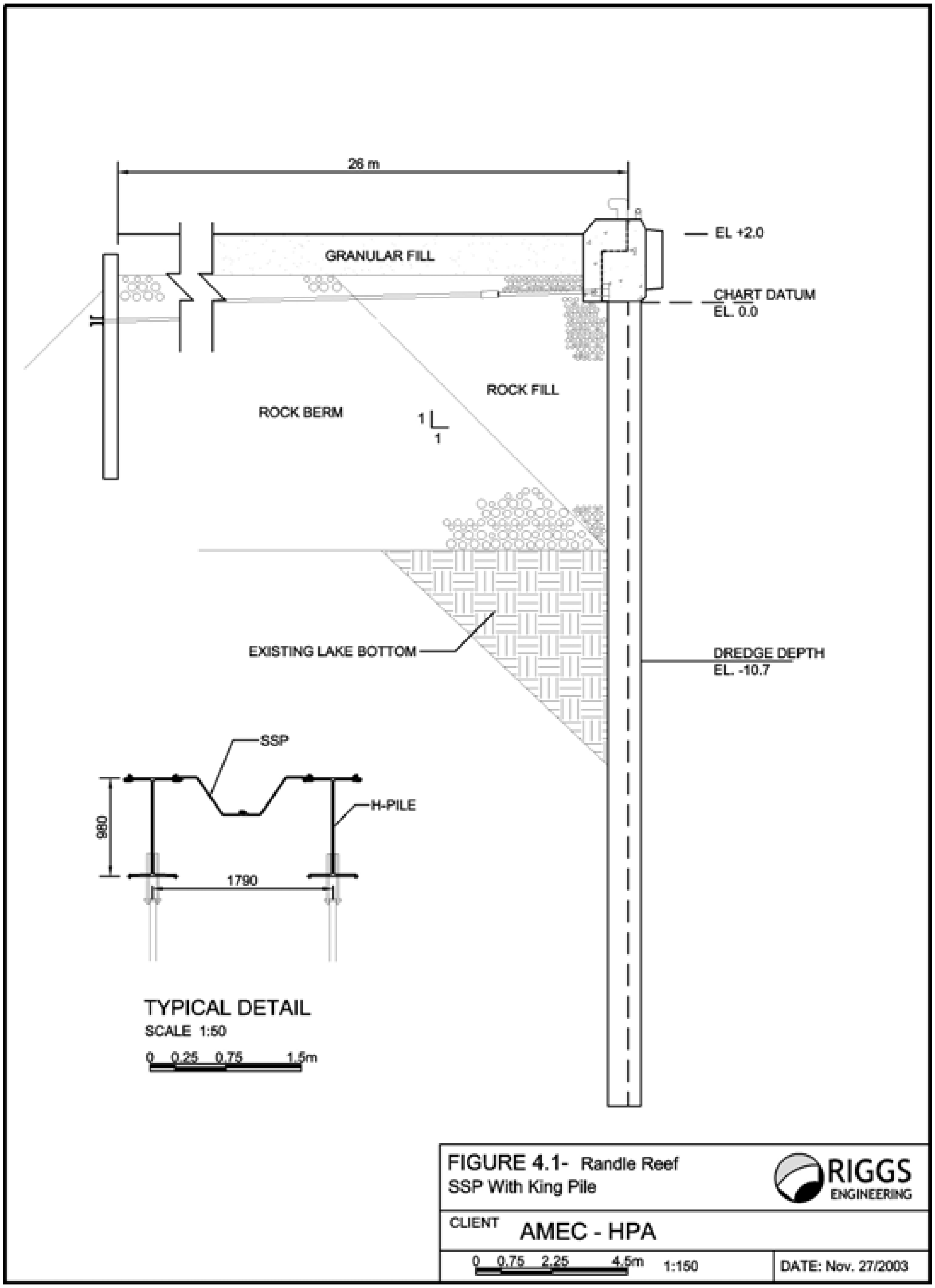
Item	Assumptions
Owner's Operational Requirements	The following parameters have been established as the operational requirements for the proposed berths: Top height of structure: +2.0 m (minimum) above chart datum IGLD Dredge Depth: 10.7 m below chart datum IGLD Surcharge: 50 KPa within 12.2 m of the wharf face and 100 KPa beyond The top elevation of the structure is considered a minimum elevation and a recommended elevation will be determined from other factors such as surface water run-off requirements, and capping and containment issues. It is anticipated that these issues will be further defined in subsequent engineering stages of the project.
Design Vessel	The United States Army Corps of Engineers has completed a reconnaissance report examining issues related to the feasibility of deepening the St. Lawrence Seaway. The proposed design depth for this project anticipates that the navigation system will be significantly overhauled in the future. A class of vessel that does not currently exist on the Great Lakes would most probably evolve in the same fashion that the current fleet has evolved around the limitations of the existing locks. The mooring and fendering requirements are not sufficiently defined to propose physical details for these vessels. The port facilities currently under consideration will have to be retrofitted for these elements, should the need evolve. The maximum length of vessel, based on future lock chambers, will be considered as the overall layout of the ECF is refined.
Mooring Requirements	A ship from the current Great Lakes Fleet normally relies on four main wires when laid up. These include one aft and one forward and two spring lines. The lines normally come off the vessel at the cargo deck level. The spring lines are secured to bollards on the dock face. This permits clearance for any vehicles required to access the vessel. At times, there may be a breasting lines, which are perpendicular to the vessel. These hold the vessel close to the dock. Other lines, which may come off the vessel, are the windless lines that are normally fibre lines and are turned out from a gear. Bollards should be constructed at intervals in the order of 20 m along the face of the dock to permit shifting of vessels at static loaders. A horizontal design pull of 250 kN would be an appropriate design

Item	Assumptions
	force. This force would be distributed by the parapet structure over a number of anchorages and would not impact on structural design option considerations. Larger capacity bollards set back from the facewall are recommended for the fore and aft lines of the vessels. These bollards should be designed for a 1000 kN line pull with a maximum angle from horizontal of 30 degrees. Independent anchorages for bollards of this capacity are typically required and consequently would not have an impact on the selection of wharf design option.
Existing Geotechnical Information and Backfill Properties	The initial value of the in-situ silty clay was estimated from a review of existing borehole information at Pier 15. Backfill materials: Granular fill $\gamma = 17.2\ kN/m^3$ $\gamma sub = 10.3\ kN/m^3$ $\varphi = 40°$ Rock fill: $\gamma = 17.2\ kN/m^3$ $\gamma sub = 9.8\ kN/m^3$ $\varphi = 45°$ In-situ soils: Silty Clay $\gamma = 20.6\ kN/m^3$ $\gamma sub = 10.8\ kN/m^3$ $\varphi = 27°$ $c' = 0$
Integration with Existing Structures	The proposed ECF, including related port facilities, will be constructed on the north side of Pier 15. The existing wharf in this area was originally constructed by the International Harvester Company of Canada. The original wharf construction includes the east-west berth that is now referred to as Pier 15 and the north-south wall that extends to the U.S. Steel Wharf (Pier 16). The structure includes a pile-supported concrete relieving platform and a steel sheetpile facewall. A stability analysis was carried out and confirmed that the structure is adequate for a dredged depth of 8.3 m relative to IGLD. With the surcharge loads carried by the relieving platform, the toe penetration of the steel sheetpile wall has a safety factor approaching 2. The existing structure does not have sufficient capacity to increase the dredge depth to the proposed 10.7 m. A transition from the proposed grade depth of 10.7 m to the design grade of 8.3 m of the existing structures will have to be defined. This has an impact on the undertaking in three areas as follows:

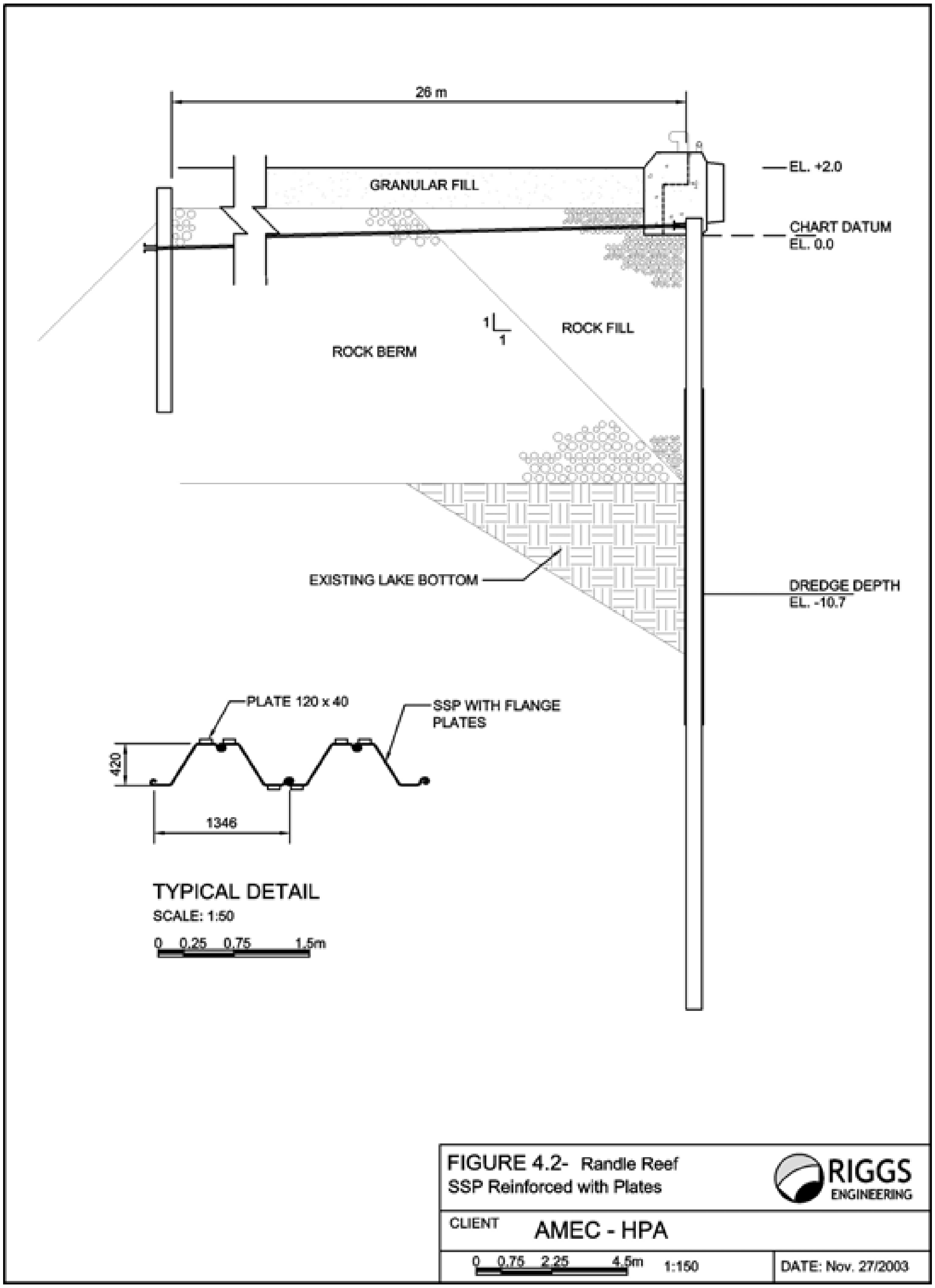
Item	Assumptions
	• <u>West Limit of Pier 15</u> The requirements are refined to include a slipway at the east end of the proposed south berth to provide space for a floating drydock. • <u>East Limit of Pier 15</u> If the proposed dredged depth extends to the west limit of the south berth, then the return wall into the inlet will be undermined. The return wall will have to be underpinned or replaced if the dredge limit extends to the east limit of the new south berth. • <u>North Limit of International Harvester Wharf</u> The primary ECF and the north berth will be constructed in the offshore area north of Pier 15 and west of Pier 16. Access to this area will be over the existing wharf at the north limit of the original International Harvester Wharf. The east limit of the dredging for the north berth may be selected to eliminate the need for underpinning or reconstruction of this wharf. Depending on the final layout, scour protection in this area may be required.

Illustrations

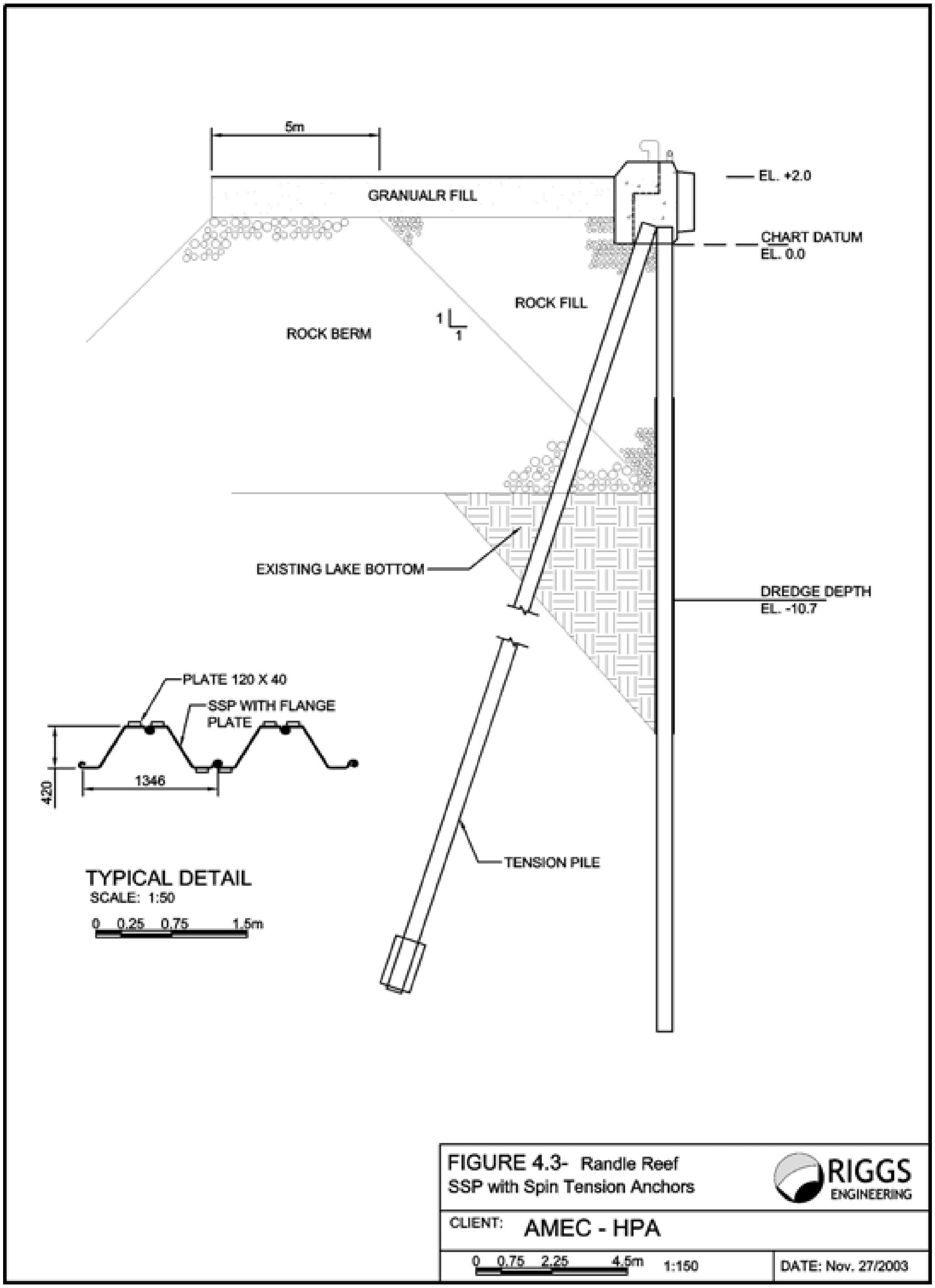
Option 1 – Steel Sheetpile Bulkhead with Kingpiles and Discontinuous Concrete Anchorages



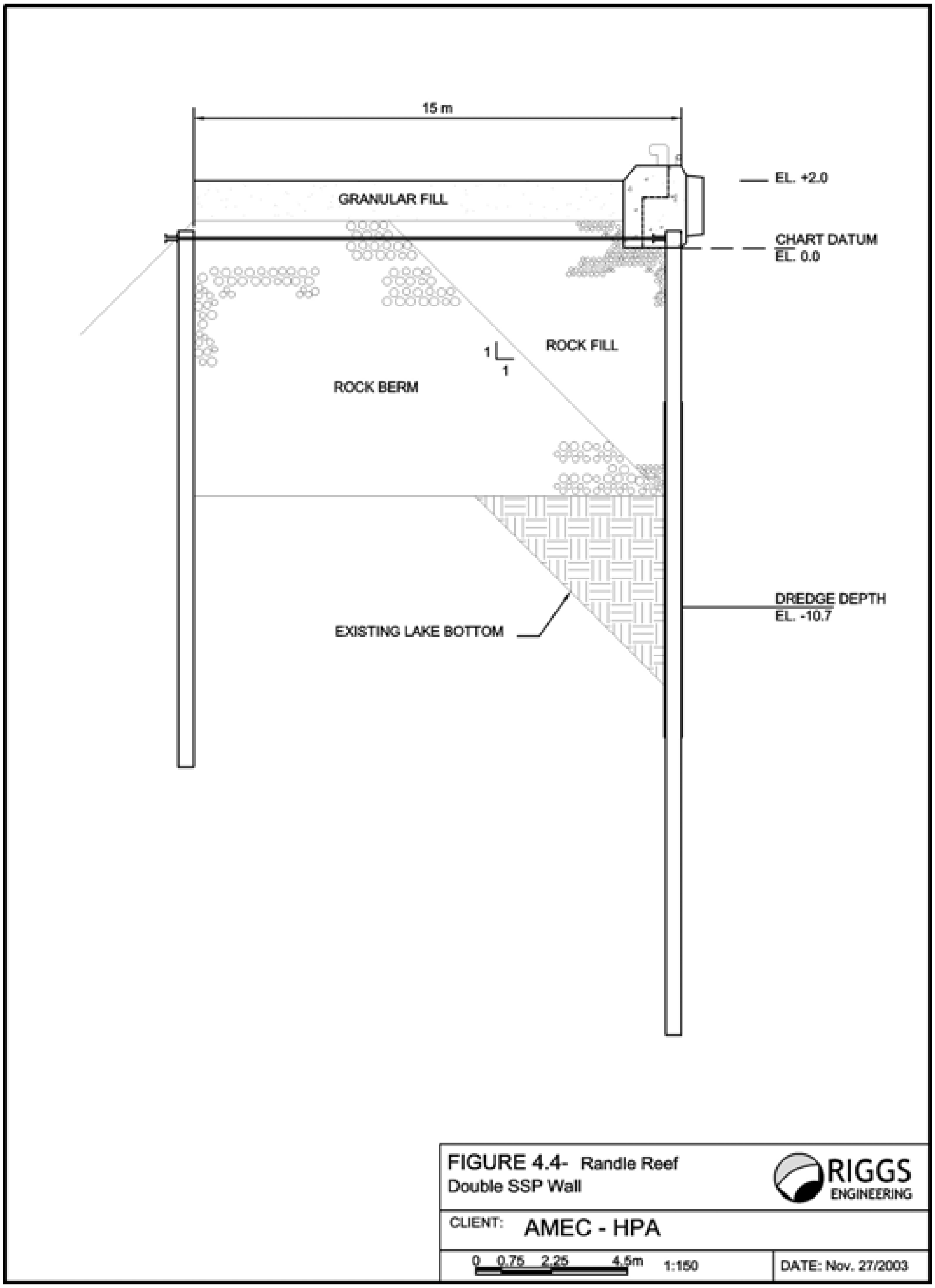
Option 2 – Steel Sheetpile Bulkhead Reinforced with Plates and Discontinuous Concrete Anchorages



Option 3 – Steel Sheetpile Bulkhead with Angled Tension Anchors to Rock or Till



Option 4 – Double Wall Steel Sheetpile Wall



Option 5 – Steel Sheetpile Wall with Relieving Platform

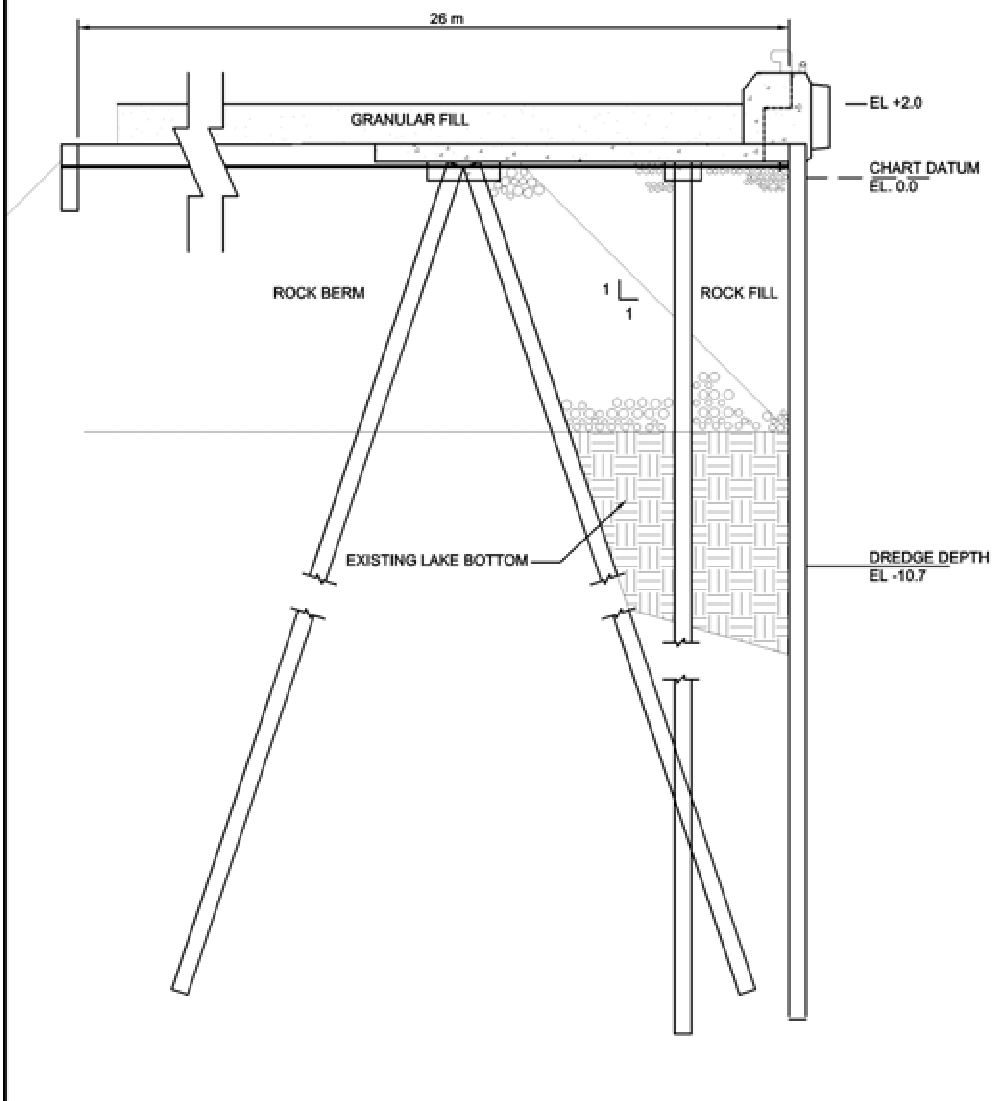


FIGURE 4.5- Randle Reef Relieving Platform

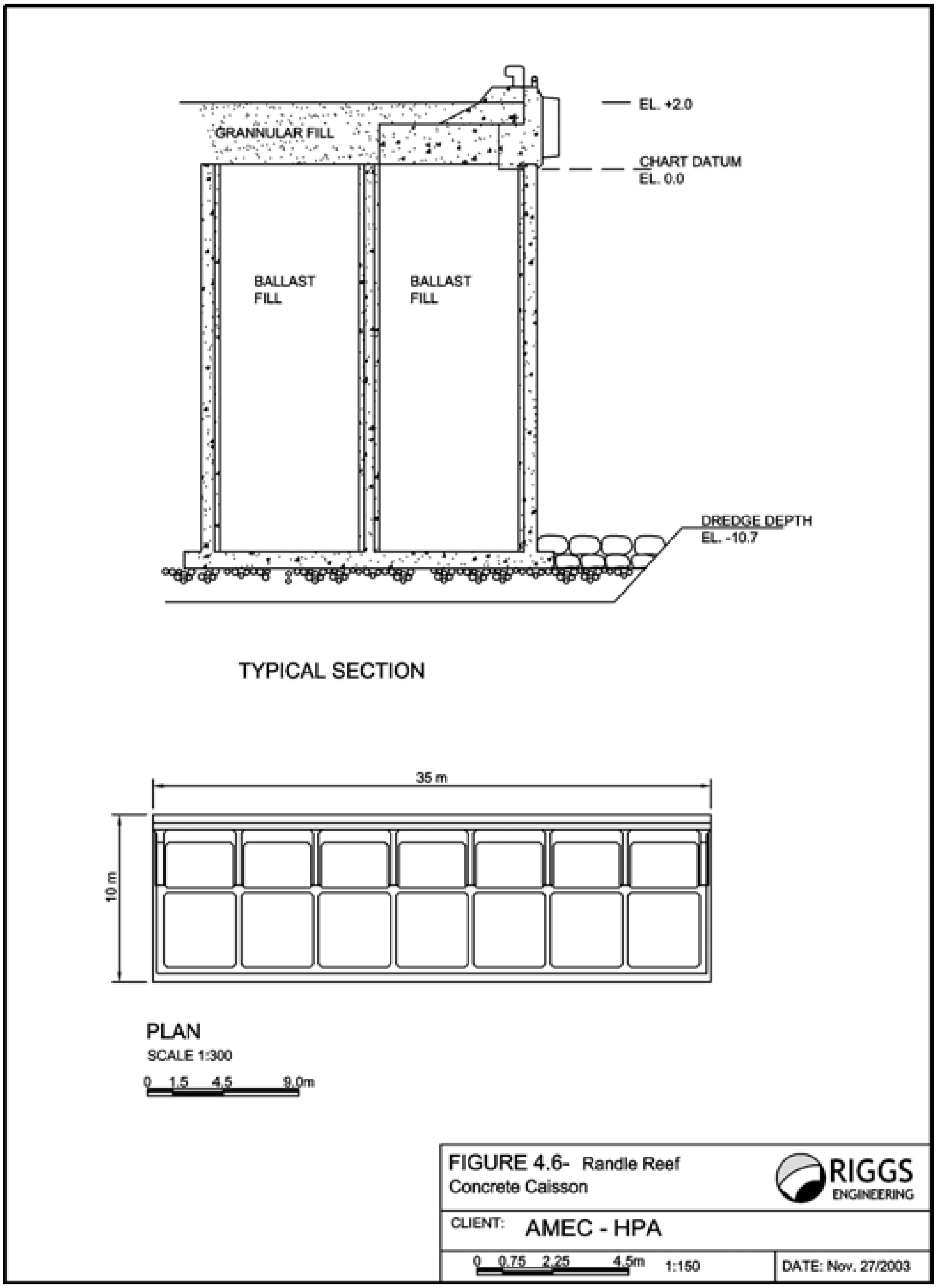
RIGGS ENGINEERING

CLIENT: AMEC - HPA

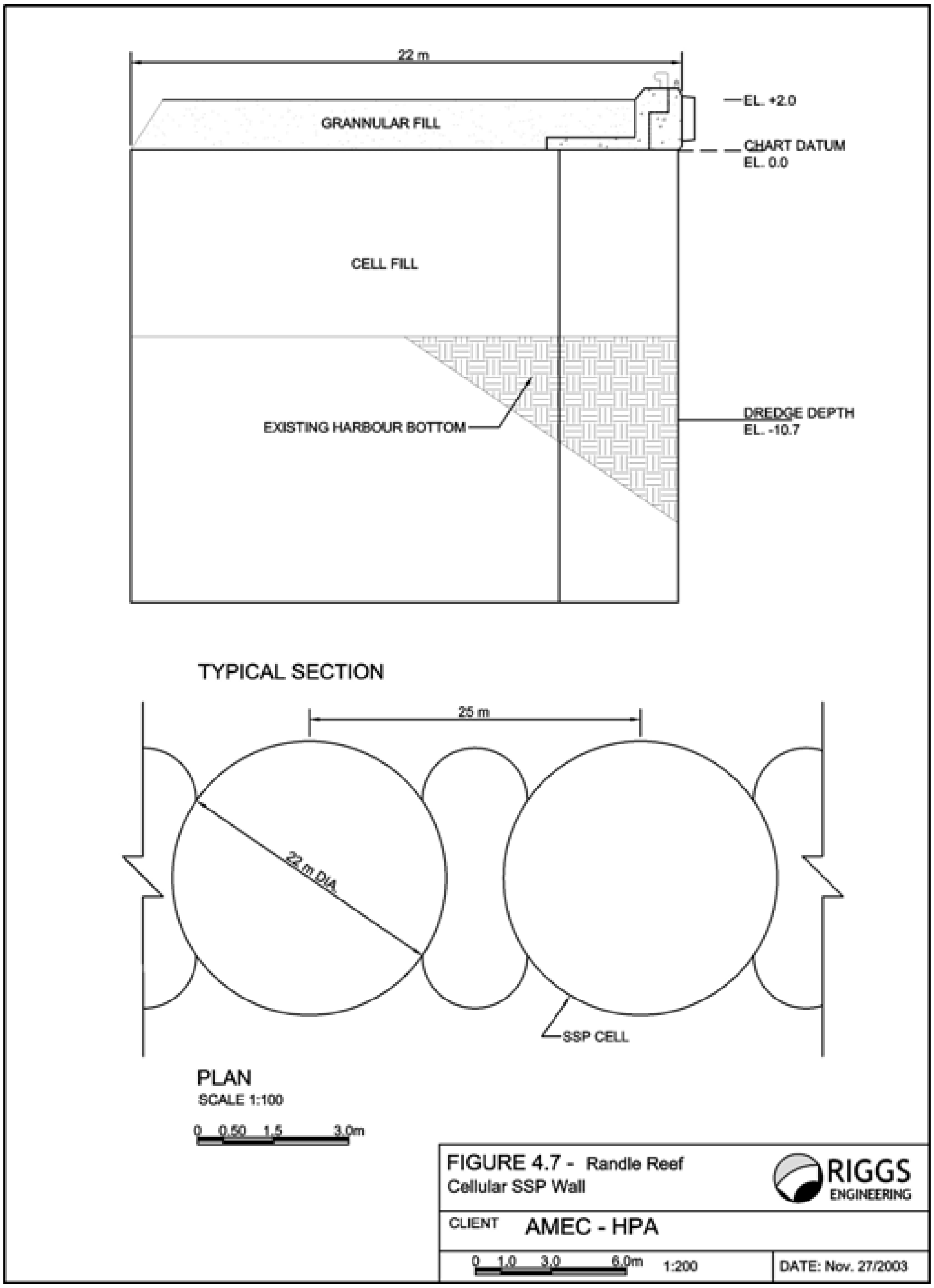
0 0.75 2.25 4.5m 1:150

DATE: Nov. 27/2003

Option 6 – Concrete Caisson Wall



Option 7 – Cellular Steel Sheetpile Wall



Attachment D.21: Port Facility Options: Description of Initial Screening Evaluation Criteria or Sub-criteria

Criteria	Sub-criteria	Criteria or Sub-criteria Description
Service Criteria (i.e., effectiveness)	Performance	The port facility structures must satisfy the ultimate limit states as follows: • loss of equilibrium of the global structure; • failure by rotation or translation; • failure by lack of vertical equilibrium; • failure of a structural element or connection; • failure caused by excessive movement; and • failure caused by time dependent effects. The serviceability limit states are equally important, particularly in light of the requirement for environmental containment. The following states will be considered: • unacceptable wall deflections and associated ground movements; • unacceptable leakage through or beneath the structure; and • unacceptable transport of soil grains through or beneath the structure.
	Service Life	The service life of the ECF is of critical environmental significance. Elements of the port facilities that cannot be replaced without affecting the integrity of the contained dredged material must be addressed with close attention to detail. Wherever possible, options should be selected that can be maintained without an impact on containment.
Technical Criteria (i.e., implementability)	Complexity	The complexity of the construction method relates to the familiarity and expertise of the construction industry.
Regulatory Criteria	Environmental Constraints	The most common environmental constraints in marine construction include timing restrictions on in-water works and measures to control or eliminate re-suspension of sediments. The nature of contaminants at this site may require more stringent application of these principles.
Environmental Impacts		The extent of infilling to create the port facilities will be reviewed together with the overall ECF. Structure types that require a smaller width for overall stability will help maximize the volume available for containment.
Cost	Capital Cost	The capital cost of the proposed port facilities.
	Operating Cost	This is not expected to be a factor in the evaluation of port facilities design components.

Criteria	Sub-criteria	Criteria or Sub-criteria Description
Prior Application		A history of successful prior application is necessary to produce reliable budget figures and to have confidence in the eventual success of the undertaking.

SUPPORTING DOCUMENT E

Summaries of Detailed Evaluation Technical Studies

Bench-Scale Treatability, Fate and Transport Testing/Model

As part of the early design-level data analysis, Hart Crowser performed laboratory investigations of sediment samples. Bench-scale treatability testing was conducted to determine treatability characteristics of the post-dredging sediment and ECF effluent. Bench-scale fate and transport testing was conducted to determine sediment leachate characteristics, both in place and during dredging.

Samples which represented the various levels of contaminated sediment expected during the remediation were used (i.e., samples from within the ECF footprint, relatively highly contaminated sediment and relatively low contaminated sediment).

PAHs were found in high concentrations in the different effluent elutriate tests and were confirmed as the primary considerations for treatability of the sediments. Although copper, lead, and zinc concentrations in the Effluent Elutriate Test (EET) samples were below the Provincial Water Quality Objectives (PWQOs), it was recommended that they be considered for treatability as secondary contaminants. Polychorlinated biphenyls (PCBs), on the other hand, were not detected in the EET samples or in the site water, and, therefore, it is unnecessary to consider these chemicals further for treatability.

Sequential batch leaching tests (SBLT) were also completed to confirm the contaminants of concern and to determine the expected behaviour during different phases of treatment (i.e., whether there was a correlation between treatment phases and the contaminants observed).

The results of the SBLT indicated that leachate from the sediment would likely contain concentrations of copper, lead, and zinc and PAHs that exceed the PWQOs. The desorption isotherms developed from the SBLT were not typical (i.e., a typical isotherm would have decreasing leachate concentrations with decreasing solid-phase concentrations). Non-constant partitioning was observed and was considered to be related to the low ionic strength of the leachate used in the test (i.e., deoxygenated distilled-de-ionized water) and the presence of nonaqueous-phase liquid (NAPL) in the sample. The effect is an increase in dissolved organic carbon concentrations in the aqueous phase, which mobilizes metals and organic contaminants bound to colloidal matter. As a result, single-point estimates for partition coefficients were developed.

I. Bench-Scale Treatability Studies

Five treatability tests were completed: 1) flocculation jar test; 2) column settling test (CST); 3) elutriate test; 4) column media filtration test; and 5) batch media adsorption test. More detailed information is provided in the Basis of Design report (Arcadis BBL, 2006).

1) Flocculation Jar Test

Purpose: The flocculation jar tests were conducted to evaluate the effectiveness of various flocculants and coagulants at increasing the settling rate and removing suspended solids from the ECF effluent. These tests provided information on the most effective flocculant, the optimum dosage, the effects of dosage on removal efficiencies and the effects of settling time on the removal of suspended solids. The optimum polymer as determined from the flocculation jar tests was then used in the column settling test.

Results: Krysalis CF2406D, manufactured by Ciba Chemicals, was selected as the best-performing polymer based on its performance at removing TSS, water clarity and the manufacturer's designated use for the polymer.

2) Column Settling Test

Purpose: The Column Settling Test (CST) provides quantitative data on the settling characteristics of sediment, information that is useful for preparing the dredging plan and designing the ECF.

Results: The CST results indicated that the polymer was effective at improving settling rates. Sediment with polymer settled slightly faster than the sediment without polymer.

3) Modified Elutriate Test

Purpose: The Modified Elutriate Test (MET) was primarily performed to prepare water for use in the column media filtration and batch media adsorption tests. In addition, information about analyte concentrations in the supernatant can be combined with CST results to predict water quality impacts associated with dredged material disposal.

Results: Concentrations of a number of metals and semi-volatile organic carbons in the supernatant were above Ontario PWQOs.

4) Column Media Filtration Test

Purpose: The column media filtration test determines the effectiveness of filtration/adsorption media at removing dissolved chemicals from ECF effluent.

Results: Based on the results of the column media filtration tests, granular activate carbon (GAC) exhibits the best performance of the three media tested. Sand and organic carbon (OC) also performed well for metals and semi-volatile organic carbons, respectively. All three media were retained for future evaluation of cost and performance based on expected influent and effluent characteristics.

5) Batch Media Adsorption Test

Purpose: The batch media adsorption tests determine the adsorption capacity of GAC and OC at removing dissolved organic chemicals from the ECF effluent.

Results: GAC was twice as effective as OC at removing semi-volatile organic carbons. There was a nearly linear removal of phenanthrene compared to the amount of medium added for both.

6) Bench-Scale Treatability Test Conclusions

The following conclusions were developed based on the results for the five bench-scale treatability tests:

- The flocculation jar test results show that polymer is very effective at reducing TSS. Krysalis CF2406D, manufactured by Ciba Chemicals, was the best-performing polymer.
- The CST results show that Composite II sediment with polymer added settles slightly faster than does Composite II sediment without polymer added. However, the results show that the effect of the polymer is significantly less under zone-settling conditions compared to what was observed for the flocculation jar tests. Therefore, polymer-assisted settling should be accomplished in a final effluent polishing cell rather than in the bulk sediment containment cells.
- Composite III sediment settled faster and more completely than did Composite II sediment.
- Concentrations of a number of metals and SVOCs in the MET elutriates were above the Ontario PWQOs. Therefore, effluent treatment will be required prior to the effluent's discharge to surface water.
- The column media filtration test results show that GAC performs better than the other media tested. Sand and OC also performed well for metals and SVOCs, respectively. All three media were retained for future evaluation as to cost and performance based on expected influent and effluent characteristics.

<u>II. Bench-Scale Fate and Transport Testing/ Fate and Transport Model</u>

Three fate and transport tests were completed: 1) thin-layer column leaching test (TCLT); 2) dredge elutriate test (DRET); and 3) pore-water extraction. More detailed information is provided in the Basis of Design report (Arcadis BBL, 2006).

1) Thin-Layer Column Leaching Test

<u>Purpose</u>: The Thin-Layer Column Leaching Test (TCLT) serves as a laboratory-scale physical model of contaminant leaching from dredged material confined in an ECF. The leaching is promoted by groundwater flowing though the ECF if it is under the water table. Sediments are assumed to be under anaerobic and reducing conditions at the time of dredging.

<u>Results</u>: Of the semi-volatile organic carbons, phenanthrene, acenaphthene and fluorene were detected at the highest concentrations in the leachate samples (i.e., around 1 µg /L). Leachate concentrations of a number of SVOCs exceeded the PWQOs in all three composites of sediment analyzed.

Of the VOCs, benzene, toluene, ethylbenzene and xylenes (BTEX) were detected at the highest concentrations in the leachate samples. Leachate concentrations of a number of VOCs exceeded the PWQOs.

Initially, naphthalene was analyzed in the SVOC fraction. However, evaluation of the analytical results indicated that the laboratory appeared to experience significant losses of naphthalene during sample extraction and preparation. Therefore, naphthalene was also analyzed in the VOC fraction. The maximum concentration of naphthalene encountered in the leachates fluctuated around 9,000 µg/L.

A number of metals (e.g., arsenic and copper) displayed similar characteristics in leachates from all three sediment composites. Beryllium, chromium, mercury, silver and vanadium were typically not detected in the leachates. Molybdenum and nickel concentrations generally decreased with increasing pore water volumes. Leachate concentrations of a number of metals exceeded the PWQOs.

2) Dredge Elutriate Test

Purpose: The Dredge Elutriate Test (DRET) simulates the release of sediment-bound and pore-water constituents into the receiving water column at the point of dredging.

Results: A number of SVOCs and VOCs were detected in elutriates at concentrations above PWQOs. Concentrations of many total metals were above the concentrations found in Lake Ontario surface water samples, but concentrations of dissolved metals tended to be similar to the concentrations found in the Harbour surface water sample used. The concentrations of cadmium, cobalt, copper, iron, silver and zinc exceeded PWQOs.

3) Pore-Water Extraction

Purpose: The objective of the pore-water extraction test is to extract pore (i.e., interstitial) water from sediments and analyze it to determine the concentrations of chemicals in equilibrium with sediment.

Results: Concentrations in the pore water of most SVOCs, three VOCs and several of the total metals exceeded PWQOs.

4) **Bench-Scale Fate and Transport Test Conclusions**

- The TCLT, DRET and pore-water extraction were completed to determine sediment characteristics during dredging and leachate characteristics of the in-place sediment.

- The TCLT results were used in groundwater modeling to evaluate chemical concentrations at the ECF/Harbour boundary.

- The DRET results were used to evaluate surface water quality during dredging.

- Pore-water extraction was performed to evaluate chemical concentrations in equilibrium with sediment and the results were used in fate and transport and treatability evaluations.

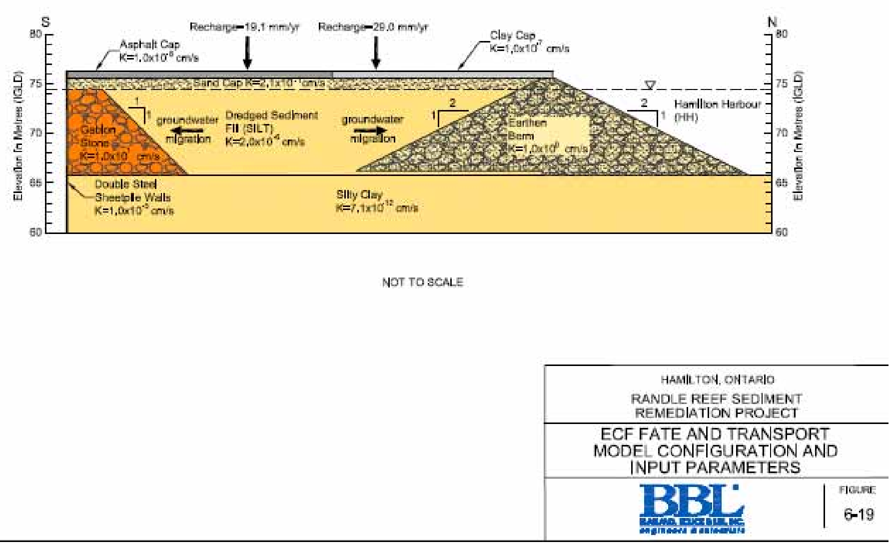
5) **Fate and Transport Model**

- The fate and transport model was used to: (1) evaluate the transport of chemicals contained in sediments that will be placed in the ECF; and (2) estimate groundwater concentrations for those chemicals at the outside edges of the ECF berm and structural wall adjacent to the Harbour. The main goal of this modeling exercise was to assess the feasibility of using an ECF to sequester dredged sediments by estimating the transport of chemicals from emplaced sediments to potential surface water receptors.

- Figure D.1 illustrates the fate and transport model configuration and input parameters.

- Fate and transport modeling will be performed at the 100 percent stage of design to take into account the results of other analyses for design options (e.g., updating the model to incorporate double steel sheetpile walls surrounding the facility, affects of sealing interlocks and revising sediment quality assumptions).

Figure D.1: ECF Fate and Transport Model Configuration and Input Parameters



NAPL Delineation Survey

To delineate the extent of sheens and mobile non-aqueous phase liquid (free-phase NAPL) in the vicinity of the proposed ECF, 63 cores (with core lengths ranging from 0.06 to 1.22 m) were collected along nine C-series transects using gravity coring techniques.

Gravity Coring

1.5 m long, 10 cm diameter Cellulose Acetate Butyrate (CAB) sampling tubes were mounted to a gravity coring device for sampling. The CCGS *Shark* was equipped with an A-frame and winch, which was used to lower the sampling unit over the side of the boat. The gravity corer was then allowed to free fall on the winch into the sediment. The unit was then hoisted back on board the vessel. Once the gravity core had been recovered, the bottom of the tube was capped. Depending on the length of recovered sediment, the tube was cut to length, labeled and capped. The cores were stored in an upright position until processed.

Selection of Sampling Locations

The initial core in each transect was advanced approximately at the edge of the region where, based on the historical data, sediments containing >800 mg/kg total PAHs were anticipated. The length of C-series transects was determined by the presence or absence of NAPL in sediment in each core. If NAPL was not observed in a core, a subsequent gravity core was advanced along the transect, 25 m closer to the sediments with the highest PAH concentrations. If NAPL was observed in a core, a subsequent gravity core was advanced along the transect, 25 m farther from the sediments with the highest PAH concentrations. The process was continued until the extent of NAPL-containing sediments was established to within 25 m. Figure D.2 illustrates the core locations and summarizes the observations made for each core.

Core Processing

Cores were processed on the vessel on a dedicated core-splitting table. Any excess water overlying the sediment was drained. The barrels were placed horizontally in a jig. The CAB barrels were cut lengthwise on both sides with a circular saw, which was set to a depth that cut down to, but did not penetrate, the sediment. The core was then moved to a plastic-covered work area where the core was split in half lengthwise. The core was photographed alongside a measuring tape and label. A photoionization detector (PID) was moved along the length of exposed sediment and the measurements were recorded in the field notebook. The lithology of the core was then logged (see Figure D.3 for an example of a borehole log); a key to the logs is provided in Figure D.4. The core was then screened for the presence of NAPL. If needed, jar tests were collected, using the procedures described below. Once the core was processed, sediment that was visibly

Figure D.2: NAPL Delineation Results

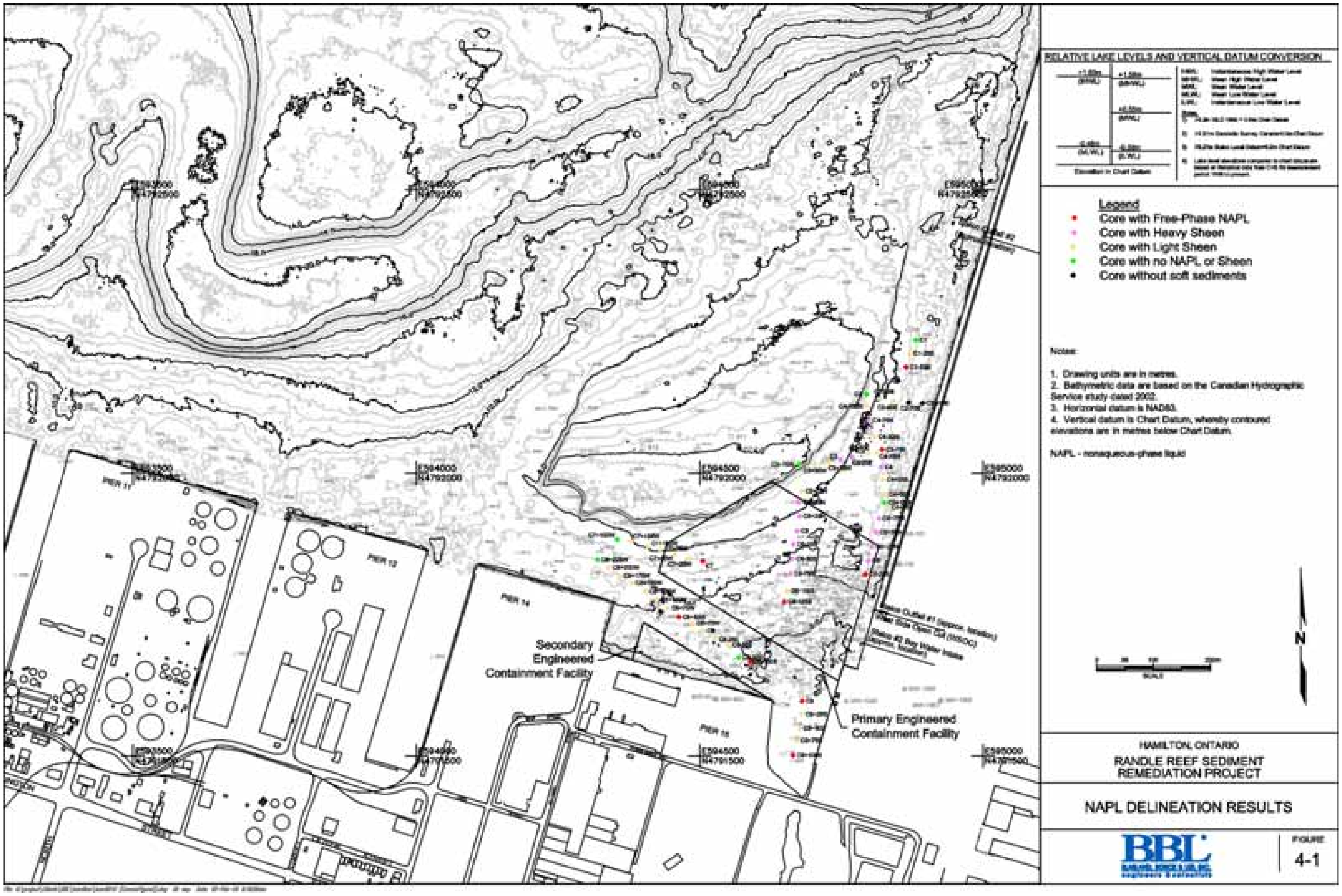


Figure D.3: Example of an Exploration Log for a Randle Reef Core

Date Start: November 18, 2004	**Northing:** 4791920.3		e
Coring Company: Environment Canada	**Easting:** 594815.8		
Coring Method: Gravity Core	**Penetration:** NA		**Core ID: C5+75N**
	Recovery: 0.40 m		**Client:** Hamilton Port Authority
	Water Depth: 9.00 m		**Location:** Hamilton Harbour
	Approximate Mudline Elevation: -8.69 m		Randle Reef
	Descriptions by: B. Thibault		Hamilton, Ontario

Depth (m bss)	Elevation (m)	Sample ID and Analyses	PID Above Core (ppm)	Geologic Column	Stratigraphic Description
0.0					Dark grayish brown SILT, some coarse Sand and fine Gravel, (very soft), wet, faint sheen.
					Very dark grayish brown SILT, little fine Sand and gray Clay, (soft), wet, moderate sheen.
-0.2		NA	0.0		Grayish brown SILTY CLAY, some fine Sand, Clay, and Vegetation, (medium stiff), slightly laminated.
					Very dark grayish brown SILT, some fine Sand, trace fine Gravel, (soft), wet, moderate coal tar odour. JAR TEST at 0.26 m bss: brown cloudy water, smooth sediment on bottom of jar, moderate coal tar odour.
	-9.0				Grayish brown SILTY CLAY, some fine Sand, Shells, and Vegetation, (medium stiff), moist, laminated.

contaminated was placed in a 200 litre drum for offsite disposal. Sediment that was visibly clean was placed in 20 litre buckets and later returned to the Harbour.

Jar Test

The jar test has been used on many projects where NAPL is present in sediments. To perform the test approximately 15 ml of sediment was placed in a 150 ml wide-mouth clear glass jar with a sealable lid. Approximately 75 ml of lake water was added to the sediment and the jar was shaken for 30 seconds. The jar was labeled and set aside. After 30 minutes, the jar was visually inspected for the presence of NAPL. The visual observations were recorded on the borehole logs.

NAPL Observations

Visual evidence of NAPL was defined as the presence of NAPL in the sediment pore fluids/spaces and/or on the sediment solid particles in a sufficient volume that the NAPL had coalesced to form droplets and/or a continuous coalesced phase that approached the NAPL native color and texture. If sheen was visible in the sediment pore fluid/spaces and/or on the sediment solid particles, then the degree of sheen was recorded on the borehole log and advancement along the transect continued until a core was recovered that did not have any NAPL or sheen. In a few instances, a transect was terminated where it intersected a previously completed transect and/or the edge of the Harbour.

Figure D.4: Key to Exploration Logs

SOIL DESCRIPTION

Soil descriptions on the exploration logs are based on visual observations in general accordance with ASTM D 2488.

Soil descriptions generally consist of the following:
Color, MAJOR CONSTITUENT, minor constituents, density/consistency, moisture, additional observations

MINOR CONSTITUENTS

Description	Estimated Percentage
Trace	Less than 5%
Few	5 to 10%
Little	10 to 15%
Some	30 to 45%

MOISTURE

Dry	Little perceptible moisture
Damp	Below optimum moisture for compaction
Moist	Likely near optimum moisture content
Wet	Likely wet of optimum moisture content

DENSITY/CONSISTENCY

Soil density/consistency descriptions on boring logs are primarily based on visual observation and are provided in parentheses. Density/consistency descriptions based on Standard Penetration Resistance (N-values) do not have parentheses.

Granular Soils Density	Standard Penetration Resistance (N) in Blows/Foot	Cohesive Soils Consistency	Standard Penetration Resistance(N) in Blows/Foot
Very loose	0 to 4	Very soft	0 to 2
Loose	4 to 10	Soft	2 to 4
Medium dense	10 to 30	Medium stiff	4 to 8
Dense	30 to 50	Stiff	8 to 15
Very dense	>50	Very stiff	15 to 30
		Hard	>30

SOIL TYPE SYMBOLS

- CLAY
- SILT
- SILTY CLAY, CLAYEY SILT, or SILT and CLAY
- SAND
- SAND and CLAY
- SANDY SILT, SILTY SAND, or SAND and SILT
- SLAG
- SILT and SLAG
- SHELLS
- SAND, SILT, and COAL TAR
- SAND and GRAVEL
- GRAVEL
- SLAG and GRAVEL, or SLAG and GRAVEL

HAMILTON, ONTARIO
RANDLE REEF SEDIMENT REMEDIATION PROJECT

KEY TO EXPLORATION LOGS

BBL
BLASLAND, BOUCK & LEE, INC.
engineers & scientists

FIGURE
D-1

DATE:
DWG NAME:

The results of the NAPL delineation were combined with visual observations of NAPL and sheen recorded in the July and November 2004 sediment core logs. In the July and November 2004 logs (as opposed to the logs for the NAPL delineation cores), light sheens were not distinguished from heavy sheens; however, the presence or absence of NAPL and/or sheen could be distinguished. The combined data set is plotted on Figure D.5. Figure D.5 illustrates the heterogeneity of sediments with respect to the presence of NAPL and/or sheens. Free-phase NAPL was identified in isolated areas in conjunction with high total PAH concentrations (on the order of 1,000 to 9,000 mg/kg) in samples collected under or near the proposed ECF and near the SDW. However, at the same time, nearby cores may have light sheens or no sheens at all. In contrast, three B-series cores collected from the northern edge of Randle Reef contained free-phase NAPL despite their relatively modest total PAH concentrations (78 to 209 mg/kg).

As stated above, some of the sediment samples were "jar-tested" for the presence of NAPL. Sheens were observed in some Randle Reef sediment samples using this test.

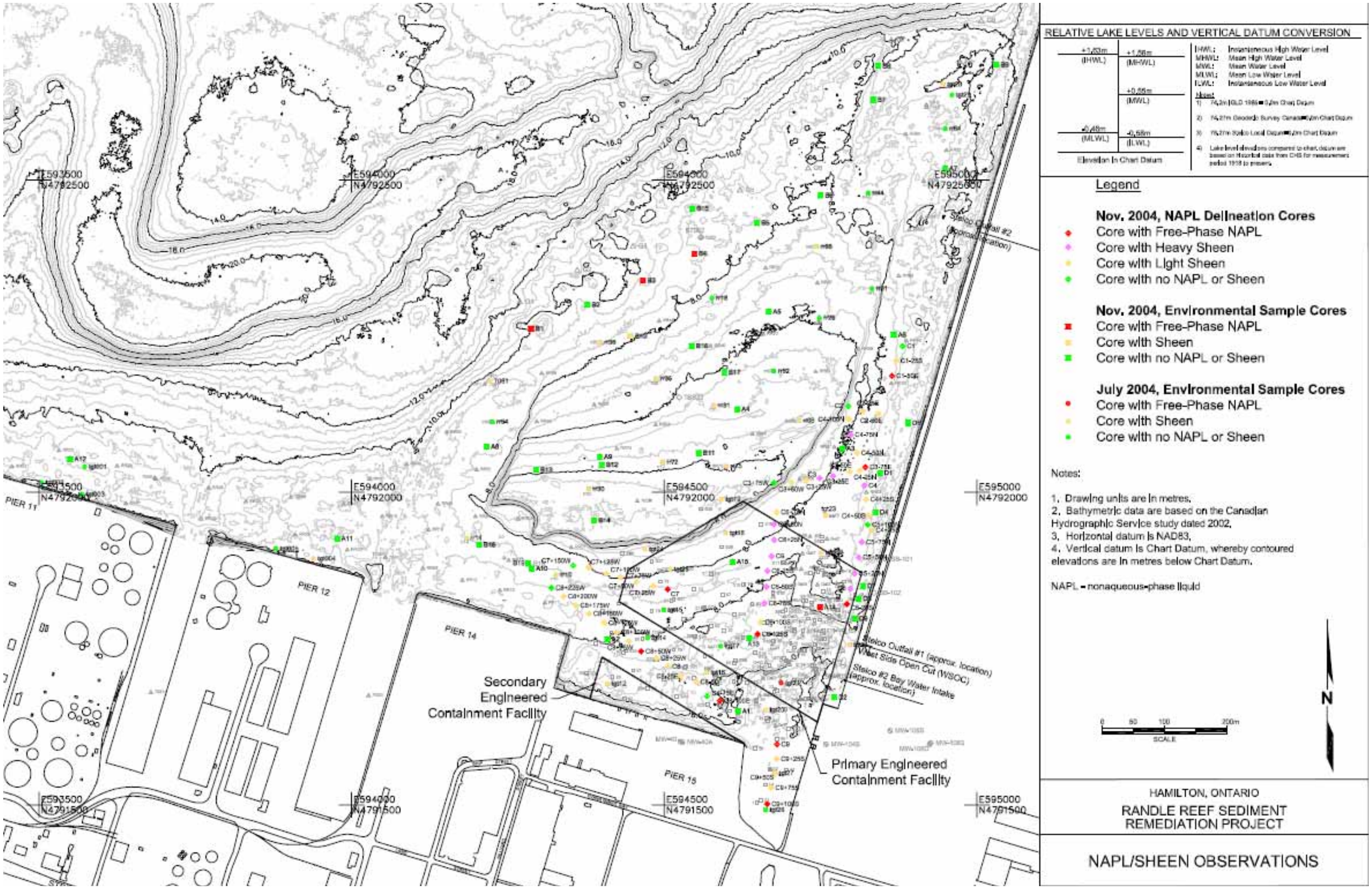
Some of the apparent heterogeneity may arise from the different methods used to identify NAPL and/or sheens during different sampling events. The NAPL-delineation (C-series) cores were examined immediately after collection with a focus on identifying NAPL and sheens. The A-Series, B-series and D-series cores collected in November 2004 were logged one to ten days after collection, although by the same field personnel who logged the C-series cores. The July 2004 cores were not logged until several weeks after collection and were logged by different field personnel.

Despite these differences, the data suggest that NAPL and sheens may be present throughout the area and may not always correlate with high total PAH concentrations. In general, the volume of NAPL observed in the sediment samples during jar testing and in direct observation of sediment cores was less than is typically observed in sediment collected near facilities that generated coal tar (e.g., coking facilities, manufactured gas plants, wood treatment facilities).

However, the presence of NAPL in Randle Reef sediment, even in smaller quantities than has been typically observed at similar facilities, does require consideration during design. NAPL presents potential design issues during dredging and sediment management, when NAPL sheens and droplets can float to the surface of the water in the dredged material receiving area, and NAPL sheens and droplets can be released to the water column during dredging.

NAPL release to the water column is typically managed by dredging within enclosures and/or mobilizing a cleanup crew, vessel, and equipment (e.g., skimmers, absorbents) to stand by during dredging. In the case of sediment management, the issue is typically managed by enclosing the receiving area in smaller cells, allowing the NAPL to be contained and removed from the surface water. NAPL could be removed by pumping the water through a treatment system and returning the water to the receiving area or by

Figure D.5: NAPL Sheen Observations



skimming the water in the receiving area. Additionally, the sediment could be stabilized by mixing it with an additive (e.g., Portland cement) as it is added to the receiving area.

NAPL release to the water column is typically managed by dredging within enclosures and/or mobilizing a cleanup crew, vessel, and equipment (e.g., skimmers, absorbents) to stand by during dredging. In the case of sediment management, the issue is typically managed by enclosing the receiving area in smaller cells, allowing the NAPL to be contained and removed from the surface water. NAPL could be removed by pumping the water through a treatment system and returning the water to the receiving area or by skimming the water in the receiving area. Additionally, the sediment could be stabilized by mixing it with an additive (e.g., Portland cement) as it is added to the receiving area.

In cases where there is a large volume of sediment with a high volumetric percentage of NAPL, mechanical dredging with an environmental clamshell, followed by stabilization of the dredged material and then isolation of the dredged material in an internal cell within the containment area, may be required. Based on the NAPL observed in sediment samples in the Randle Reef vicinity, it is not likely that dredged material will need to be handled in this manner on a large scale. If necessary at all, extra measures such as these are likely to be confined to a relatively small volume of sediment.

SUPPORTING DOCUMENT F

Detailed Project Description

F.0 PROJECT DESCRIPTION

F.1 Sediment Remediation Phases and Activities

There are six major design elements that form the sediment remediation plan:

- ECF Isolation Structures;
- Dredging Design;
- Sediment Management;
- Containment and Cover;
- U.S. Steel I/O Accommodation; and
- Port Facilities.

These design elements can be broken down into three phases: (1) the construction phase; (2) the operation phase; and (3) the decommissioning phase.

The construction phase encompasses the actual remediation of the contaminated sediments. All of the design elements listed above are included in the construction phase. The ECF walls will be constructed first, followed by dredging the contaminated sediments and placing them inside the ECF. During this time, contaminated water from the dredging process will be treated before being discharged back into the Harbour. The area in close proximity to the U.S. Steel intake/outfall will be capped. Once the ECF is filled, it will also be capped. Two thirds of the surface of the ECF will be paved to accommodate future commercial port activities and the other third of the surface will be landscaped.

The operation of the facility includes use of the paved area for typical port activities such as loading/unloading bulk materials. The facility will also support vessel mooring. The landscaped area will be capable of sustaining native growth and providing various types of habitat. The operation phase also includes a long-term monitoring and maintenance plan to ensure the ECF's continued effectiveness.

The ECF will have a 200 year life span and, therefore, development of a detailed decommissioning plan for this facility is not applicable at this time.

F.2 Remediation Criteria, Performance Objectives and Standards

<u>Sediment Clean-Up Target</u>

The PAG recommended construction of a facility that optimized containing in place, the majority of highly contaminated sediments (>800 ppm PAHs) in the area of Randle Reef. It also recommended placing moderately contaminated sediment (200 - 800 ppm PAHs) from the surrounding area of Randle Reef within the containment facility.

Air Quality Criteria

Air quality criteria include point-of-impingement limits (for acute exposure) and ambient air quality criteria (AAQC) (for chronic exposure). Limits for air discharges will be in accordance with Ontario Regulation 419/05, Air Pollution – Local Air Quality. Monitoring will consist of real-time naphthalene data to measure acute exposure and laboratory samples analyzed for polycyclic aromatic hydrocarbons and benzene, toluene, ethylbenzene and xylene to measure chronic exposure. Construction workers will be subject to The Occupational Health and Safety Act (Revised Regulations of Ontario [R.R.O.] 1990.

ECF Effluent, Surface Water and Ground Water Quality Criteria

Criteria are recommended for ECF effluent, storm water and groundwater. It is currently proposed that all three meet the MOE PWQOs (and/or CWQGs) as all three will ultimately discharge to Hamilton Harbour. It should be noted, however, that using Hamilton Harbour background water quality as the water quality criteria for this project is currently under review. If it is determined that the background water quality criteria is acceptable, this will be incorporated into the appropriate water quality criteria for the project. Regardless of the selected criteria, the discharges are expected to comply with all other applicable legislation and regulations.

Water Quality Criteria During Construction

During construction, water quality monitoring will be conducted during installation of sheetpile, dredging, capping and other in-water construction activities to confirm that water quality meets the surface water criteria outside the immediate vicinity of the construction activity. Water quality parameters will be monitored at specified sampling frequencies, locations and depths. Although localized disturbances cannot be avoided, one purpose of water quality monitoring is to demonstrate that these disturbances are not extensive and are below specified threshold levels. Water quality monitoring will be performed in accordance with MOE's *Evaluating Construction Activities Impacting on Water Resources Part III B* (1994a) and to ensure compliance with PWQOs/background criteria.

Stormwater Quality Criteria

Stormwater collected in the vicinity of the ECF during the construction phase will ultimately form part of the ECF effluent and will, therefore, be treated as such and discharged using the water quality criteria outlined above. Stormwater collected in the vicinity of the staging areas on land is not anticipated to be contaminated, as only clean materials will be stockpiled in this area. Stormwater collected on land and conveyed to a municipal sewer will be subject to the City of Hamilton Sewer Use By-Law.

Imported Soil Quality Criteria

Soil material imported to the site for capping/construction purposes will be clean, native soil.

F.3 Proposed Sediment Remediation

The goal of the *Randle Reef Sediment Remediation Project* is to contain the most severely contaminated sediment in place by constructing an engineered containment facility of approximately 7.5 ha in size around it/on top of it. Surrounding contaminated sediment outside the ECF will be dredged, placed in the facility and capped. The final use of the site will include port facilities and a greenway for naturalization.

F.4 Construction Phase

The construction phase includes the following activities: sheetpile installation; dredging; ECF effluent quality treatment; consolidation monitoring; ECF cap placement and construction; U.S. Steel I/O channel capping; and habitat area construction.

The Quality Control (QC) Plan will include compliance and performance monitoring during construction. The survey section of the QC Plan will include hydrographic survey techniques of the dredge area and inside the ECF during filling, topographic survey and elevation control during earthwork, and performance monitoring of settlement plates and containment structures and other project components that will be monitored during construction for deformation using survey techniques.

The Sediment Verification Field Sampling Plan (FSP)/Quality Assurance Project Plan (QAPP) will describe the methods and procedures that will be used by the Contractor to collect and analyze sediment to verify samples during dredging to ensure that the final remedy complies with the sediment criteria.

The Import Material FSP/QAPP will describe the methods and procedures that will be used by the Contractor to collect and analyze import material samples to ensure the material complies with the contract Specifications. The Borrow Site Characterization Report will include identification of the source of the material (including a map documenting the origin of the material) and material sample and characterization (physical and chemical testing, as specified in the contract Specifications) to ensure that the import material will meet the contract Specifications.

The Water Quality Monitoring FSP/QAPP will describe the specific methods and procedures to be used by the Contractor to collect and analyze surface water samples during construction to ensure compliance with water quality standards.

The Environmental Protection Plan will also include a Fish Salvage Plan that will be implemented during closure of the ECF sheetpile wall. This plan will describe the fish protection strategy that will be employed once the sheetpile wall is closed to remove trapped fish.

The Contractor will submit a Settlement Monitoring Plan that describes procedures, personnel and record keeping methods for installing geotechnical and settlement monitoring equipment and for monitoring settlements (and lateral movements) on existing structures adjoining the remedial action areas. The intent of this monitoring is to ensure that adjacent structures do not undergo excessive movement or structural damage associated with earthwork activities.

F.4.1 Debris Removal

The contractor will be required to perform a pre-dredge debris survey over a designated area and to remove debris using mechanical dredging techniques. Debris will be disposed of in accordance with local and provincial regulations.

F.4.2 Turbidity Control Structure at U.S. Steel Intake Pipes

The three-sided turbidity control structure will be installed at the U.S. Steel dock wall (SDW) in the vicinity of the intakes. The structure will run parallel to the SDW and will enclose the intake pipes. The control structure will consist of H-piles that will be used to support turbidity barriers. Turbidity barriers will be attached to the structure, if needed, to reduce TSS/turbidity in water flowing to the intakes. If needed, stop logs can be combined with turbidity barriers to stabilize the structure, manage flow and further reduce TSS/turbidity. The turbidity barrier is proposed to extend from the water surface to the channel bottom.

It is expected that the H-piles will be installed using a vibratory pile driver, rather than an impact driver, to minimize potential effects on the SDW. H-piles will be installed at 3 m (10ft) intervals along the length of the structure. Accordingly, seven H-piles and two corner piles will be required for the turbidity control structure. Given the 7.5 m (25 ft) water depth, the embedment depth for the H-piles will be about 15.2 m (50 ft), requiring a total pile length of about 22.9 m (75 ft). Piles will extend about 1.5 m (5 ft) above the water surface to support navigation warning markers attached to the tops of the H-piles.

The difference in water elevation inside and outside the turbidity control structure is expected to be minimal, and the hydraulic head across the structure will, therefore, be small. Based on the dimensions of the turbidity structure and the intake flows, flow velocities in the vicinity of the turbidity structure are expected to be less than 0.25 m/s (about 0.5 knot, or 0.8 ft per second).

The structure may be reused and modified as necessary by U.S. Steel after construction for water quality control and/or to support fish impingement screens.

F.4.3 ECF Containment Walls

The ECF isolation structures are proposed to be constructed prior to any dredging activities. A double steel sheetpile wall (outer structural and inner environmental) will form the ECF (Figure F.1). The primary elements of the structure include (from the inside working outward): the dredged material; the sealed interior sheetpile wall; the quarry rock between the interior and exterior sheetpile walls; and the exterior structural sheetpile wall.

The double steel sheetpile wall serves two purposes: (1) to isolate in-situ contaminated sediments, including containment of contaminated dredged material placed inside the ECF; and (2) to provide port facility walls on the south face of the primary ECF. The design elevations for the top of the perimeter structures are 3 m above Chart Datum in the commercial port facility areas and 2 m above Chart Datum in the greenway area.

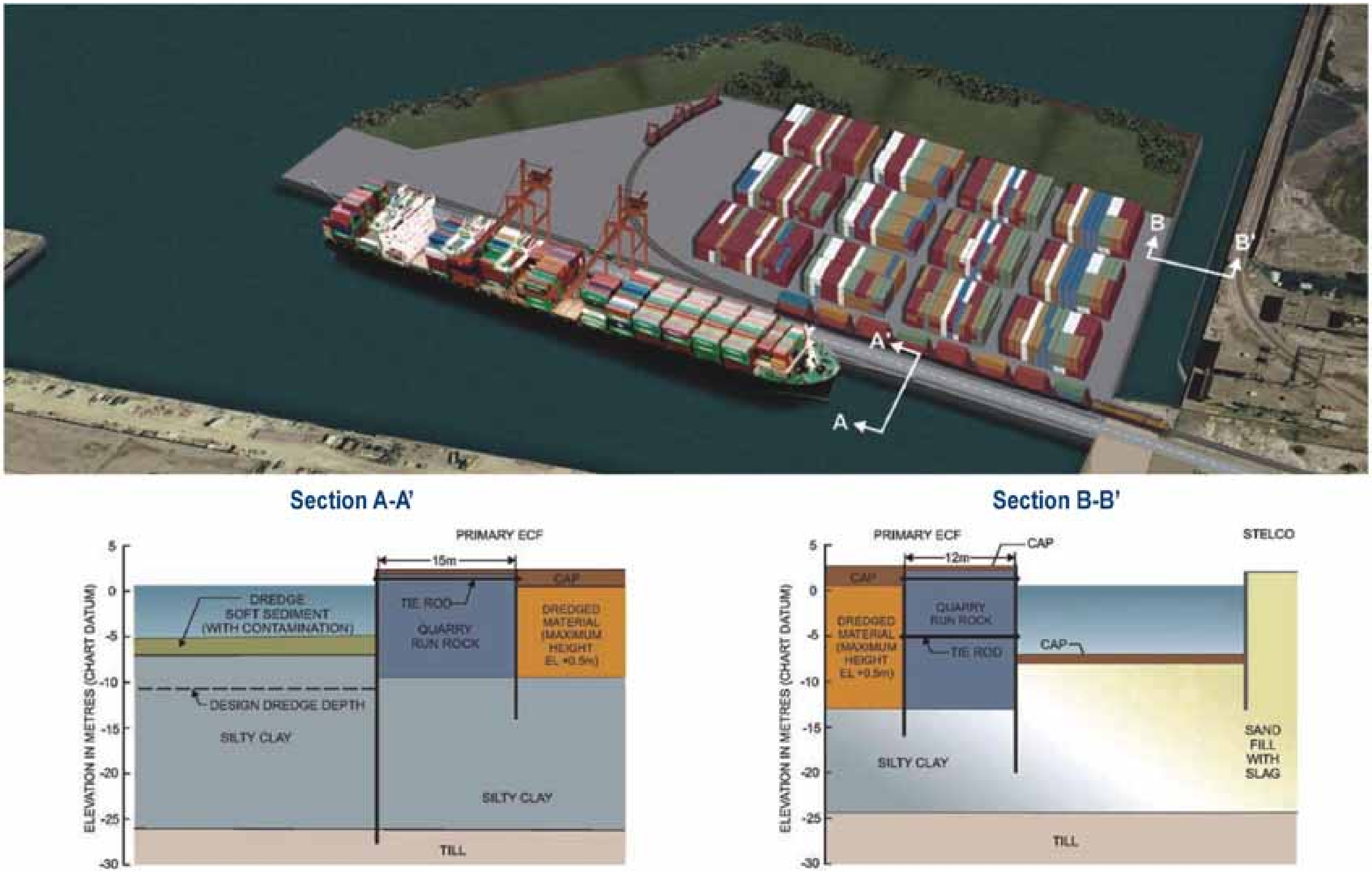
As the exterior sheetpile wall is exposed to the elements, a minimum service life of 75 years is expected, which can possibly be extended to 100 years with the detailing and prudent oversizing of the wale and anchor connections. The exterior containment structure can be completely replaced at the end of its service life, whenever that is, without disturbing the contaminated dredged material contained within the ECF.

F.4.3.1 Facewall and Anchorwall Construction

The double steel sheetpile wall consists of two parallel sheetpile walls. The exterior wall acts as a facewall. It is anchored with one or more levels of tie-rods connected to the interior wall, which acts primarily as an anchor wall.

The interior and exterior walls will be separated by backfilled quarry rock.

Figure F.1: 30 Percent Design Rendering



The anchor wall serves two primary purposes: (1) to provide a wall to isolate the contaminated dredged material; and (2) to stabilize the top of the exterior wall by providing anchorage. The anchor wall interlocks will be sealed to provide a relatively impermeable barrier.

The facewall and anchor wall will be installed at the same time. Priority 1 dredged sediments are to be removed from between the facewall and anchor wall prior to installing the connecting tie-rods. Backfilling between the walls with quarried rock fill will commence after installation of the connecting tie-rods.

F.4.3.2 Dredging Between Walls, Backfill and Concrete Parapet

Dredging will be accomplished using a combination of a mechanical dredge to "side-cast" sediment into the ECF and a crane-mounted high-solids pump to remove additional materials in proximity to the steel sheetpile walls. As the area being dredged is contained between two sheetpile walls, it is anticipated that there will be no negative environmental effects to the surrounding surface water area. Air emissions resulting from the dredging during this phase are covered under Section F.14.1. The estimated amount of sediment to be dredged from between the walls is approximately 23,500 m^3.

The area between the walls on the north and west sides of the ECF will be used as a final settling cell where water from the production dredging is treated prior to discharge to the Harbour. Backfilling between the walls on the north side will be conducted such that approximately 3 m of water column will be left above the backfill for final settling. Dredging underneath the final settling cell footprint will be conducted first so that treatment of decant water within the final settling cell can begin as soon as possible. In order to accomplish this, the following construction sequence will take place in the final settling cell area:

- construct the double walls for the entire ECF;
- dredge within the footprint of the final settling cell;
- backfill with quarry rock where dredging has occurred (such that approximately 3 m of water column will be left above the backfill), while dredging in other areas is ongoing;
- install temporary structural bracing; and
- install temporary geomembrane against the inside of the exterior wall.

Further details regarding the final settling cell are provided under Section F.4.5.2.

Inclinometers will initially be placed along the port facility walls and the U.S. Steel-facing wall. They will be surveyed initially to set the top-of-casing elevation to Chart Datum. A concrete parapet will be included along the south face of the primary ECF. This is the area of the ECF where vessel mooring will take place.

F.4.4 Pier 15 Wall Stability

The existing walls at Pier 15 will require replacement and/or strengthening before dredging in this area can occur. Part of the wall will be encapsulated with a new steel sheetpile wall and part will be strengthened to allow environmental dredging to take place in the area adjacent to the wall. It is proposed to dredge to the depth required for wall replacement/strengthening and subsequently install a post dredging stone mattress, where required, at the base of the wall, up to the design ship draft level.

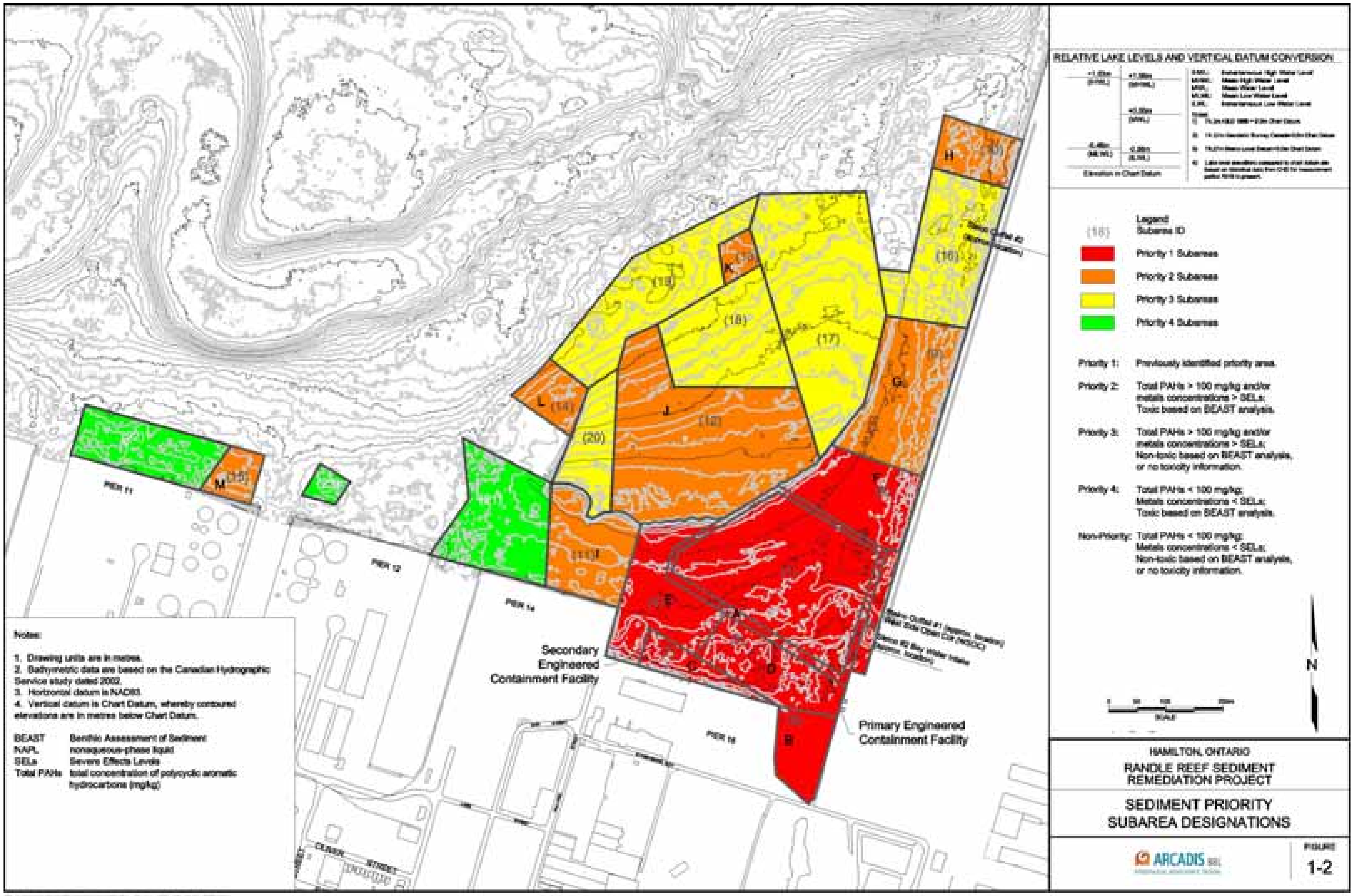
It is likely that some of the existing soil present at Pier 15 will be excavated as part of this construction component. The Pier 15 soil meets MOE industrial/commercial soil guidelines, with the exception of electrical conductivity and sodium absorption ratio. These exceedances do not pose a concern for management of these soils. A health and safety plan covering handling of this soil by workers will be prepared along with suitable soil disposal/management options. The amount of excess soil to be managed as a result of this work is anticipated to be minimal.

F.4.5 In-Water Production Dredging

Although the capacity of an ECF can be somewhat altered by how they are constructed, for the most part, ECF capacity is limited by the available area. Because of that limitation, contaminated sediments to be dredged in the vicinity of Randle Reef have been prioritized for dredging and isolation in the ECF according to their chemistry and toxicity (see Figure F.2). The definition for each priority category is outlined below:

- **Priority 1:** Previously identified as a priority area in earlier studies (identified as containing significant concentrations of PAHs and metals, as well as showing demonstrated toxicity);

Figure F.2: Sediment Priority Subarea Designations



- **Priority 2:** Total PAH > 100 mg/kg and/or metals concentrations > Severe Effect Levels (SELs); toxic based on Benthic Assessment of Sediment (BEAST) analysis;

- **Priority 3:** Total PAH > 100 mg/kg and/or metals concentrations > SELs; non-toxic based on BEAST analysis or no toxicity information;

- **Priority 4:** Total PAH < 100 mg/kg; metals concentrations < SELs; toxic based on BEAST analysis; and

- **Non-Priority:** Total PAH < 100 mg/kg; metals concentrations < SELs; non-toxic based on BEAST analysis or no toxicity information.

The dredging design for the limits of dredging addresses an in-situ volume of approximately 598,000 m^3. This in-situ volume increases with an overdredge allowance of 0.15 m to approximately 659,000 m^3. The sediment will undergo changes in density and moisture content during dredging and placement that will initially increase the total sediment volume, which will then decrease through consolidation.

Production dredging, estimated to last approximately 28 months, will be conducted using a hydraulic dredge outside the ECF exterior wall and within the limits of dredging.

There are four important components of the dredge configuration. These components are as follows:

- the suction line, which is the intake pipeline that transports dredged material under suction to the dredge pump;
- the cutter, which is the machinery at the end of the intake pipe that excavates bottom material;
- the dredge pump, which provides the power to suction bottom materials and transport them into the discharge line; and
- advancement considerations, which encompass two options for advancing the dredge during operations.

The discharge pipeline will be equipped with floats to facilitate access for moves and to allow inspection for leaks. Typical floating discharge pipelines are made of a flexible plastic material. The discharge pipeline will extend from the dredge pump to the ECF, which will range in direct approximate distances of up to 1,000 m (3,300 ft). The pipeline outlet will be submerged in the ECF to reduce the potential for volatile air emissions. The design of the pipeline outlet will facilitate the movement of the outlet point so that dredged material can be spread throughout the footprint of the ECF.

F.4.5.1 Dredging Sequence

Contaminated sediment from Priority 1 and 2 areas will be fully contained within the ECF, while sediment dredged from Priority 3 areas will be contained as space allows. The dredging design for activities outside the footprint of the ECF will include the following steps:

- dredge Priority 1 and 2 subareas to the clay surface with appropriate offsets from existing structures and dredging as close as is practical to the ECF walls. It is proposed that Priority 1 sediments will be dredged within a physically contained (i.e., steel sheetpile walls) area of the Harbour;

- complete hydrographic surveys to confirm dredging and conduct verification sampling and analysis to identify whether additional focused dredging is necessary in Priority 1 and 2 subareas before dredging in Priority 3 subareas;

- dredge Priority 3 subareas having volumes that can be accommodated within the ECF and fill the facility to an elevation of approximately 1.5 m above Chart Datum. Priority 3 areas will be dredged to the depth of interpreted contamination, which is not necessarily the full depth of the soft sediment layer; and

- place a thin layer cover of sand to backfill areas with PAH concentrations at or above 100 ppm and provide a thin layer cap of approximately 16 cm or less in remaining Priority 3 and 4 subareas to enhance natural recovery within the dredging limits. Capping would occur in two separate layers of approximately 8 cm each.

F.4.5.2 Sediment Management

Sediment management will consist of gravity settling of decant water within the ECF, followed by polymer-assisted settling in a final settling cell and additional treatment of effluent using sand filtration and granular activated carbon (GAC) adsorption. Effluent quality will be a function of dredged material flow rate and solids content, ECF configuration and volume, and expected treatment performance. Treated effluent will be discharged directly to Hamilton Harbour.

Dewatering of the dredged material and initial treatment of the decant water will occur within the ECF footprint. Within the ECF, two internal cells will be constructed with a partial steel sheetpile wall having a top elevation approximately 5.5 m below the water level. Cell 1 will be constructed under the footprint of the port facility along the south side of the ECF. Cell 2 will be constructed adjacent to Cell 1 to the north. The wall will separate Cell 1 from Cell 2 and will remain in place throughout the filling process and upon completion of the ECF. The alignment of the wall is shown on Figure F.3. Filling will begin in Cell 1. Once Cell 1 is filled, a controlled overflow will allow filling of Cell 2. Once Cell 2 is filled, the ECF will be filled throughout the entire footprint. In general, the placement of the slurry into the ECF will be as follows:

- Subareas 4, 8, 12 and 13 will be placed into the Cell 1 footprint;
- Subareas 9, 10, 11, 14, 15 and 16 will be placed into the Cell 2 footprint; and
- the remaining subareas will be evenly placed across the entire ECF.

Effluent from the ECF will be pumped to the final settling cell for additional removal of suspended solids. The final settling cell will extend along the north and west sides of the ECF, in the space between the double steel sheetpile walls. The total concentration of the suspended solids in the final settling cell supernatant is expected to be approximately 5 mg/L or less during most of the project duration, rising to a maximum of approximately 13 mg/L near the end of filling.

For the majority of the dredging operation, the water level within the ECF will remain similar to the lake level. All dredged material will be placed in a submerged condition to retain a ponded water column to control air emissions. The ponded water volume will allow for solids settling within the internal cells as dredged material is placed and for the settling of TSS and associated contaminant concentrations in the decant water that passes to the final settling cell.

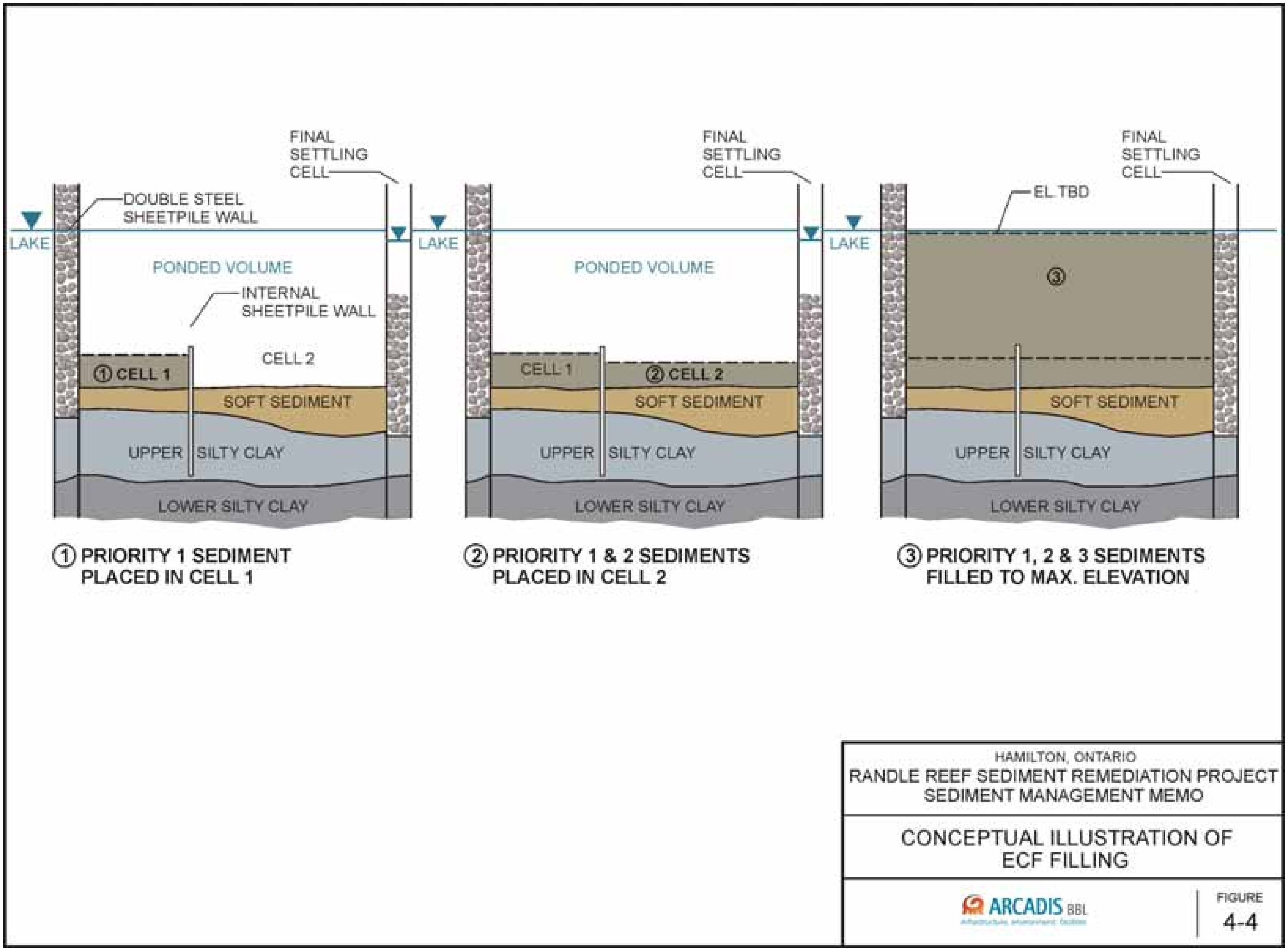
The ECF supernatant will be transferred to the final settling cell using overflow structures and pumping. Three overflow structures along the inside north wall of the ECF will each consist of a vertical pipe secured to the bottom and side of the ECF. The vertical pipe will be screened at the top end and sealed at the bottom end. The supernatant will flow into the top of the overflow structure and be pumped out via a suction hose attached to the pipe, approximately 1 to 2 m (3 to 7 ft) below the top of the overflow structure. The water will be discharged from aplastic pipe into the influent point of the final settling cell.

The polymer and associated equipment will be located on a small floating platform inside the ECF. Polymer will be injected into the ECF supernatant; the volume of polymer added will be based on continuous TSS readings. The polymer will be mixed with the ECF supernatant using a static mixer.

The final settling cell effluent will flow into an overflow structure and be pumped to the mechanical treatment system. The mechanical treatment system will be located on HPA property southeast of the ECF (Figure F.4). It is expected that there will be one overflow structure along the inside north wall of the ECF. The overflow structure will consist of a vertical pipe secured to the bottom and side of the ECF. The vertical pipe will be screened at the top end and sealed at the bottom end. The supernatant will flow into the top of the overflow structure and be pumped out via a suction hose attached to the pipe below the top of the overflow structure.

Effluent from the final settling cell will flow in parallel through sand filters for pre-treatment prior to being treated in parallel carbon vessels. The treatment system is planned to be located on land. After sand filtration and GAC adsorption, PAHs and metals will meet proposed discharge limits.

Figure F.3: Conceptual Illustration of ECF Filling



Stormwater that accumulates in the ECF during active operations will be treated in the same manner as decant water. The ECF water elevation will be lowered before periods of non-operation, when stormwater will be allowed to accumulate in the ECF.

F.4.5.3 Re-suspension Control

Re-suspension of sediment occurs during hydraulic dredging when the cutterhead and suction action disturb sediments that are not subsequently captured by the dredge. These sediments are then dispersed throughout the surrounding water column. Re-suspension can re-contaminate previously dredged areas or transport contaminated materials to non-priority areas. Re-suspension from hydraulic dredge heads is generally low compared to other dredging methods.

To mitigate re-suspension and its impacts, engineering controls (such as hydraulic dredge heads with hoods or shrouds) or operational controls (such as dredging from higher to lower elevations and from higher to lower priority areas) can be employed. When re-suspension presents a water quality concern, dredge areas can be segregated with sheetpiles so that the dredging occurs within an enclosed environment.

Silt curtains or screens can be used to reduce turbidity at certain distances from the dredge but they are generally limited in their performance. General experience in the industry indicates that hydraulic dredging produces low turbidity around the dredge head. Because the presence of silt curtains results in reduced dredging rates and increased downtime for the dredging operation (due to repositioning of the silt curtain for each move), these measures would be employed only if necessary.

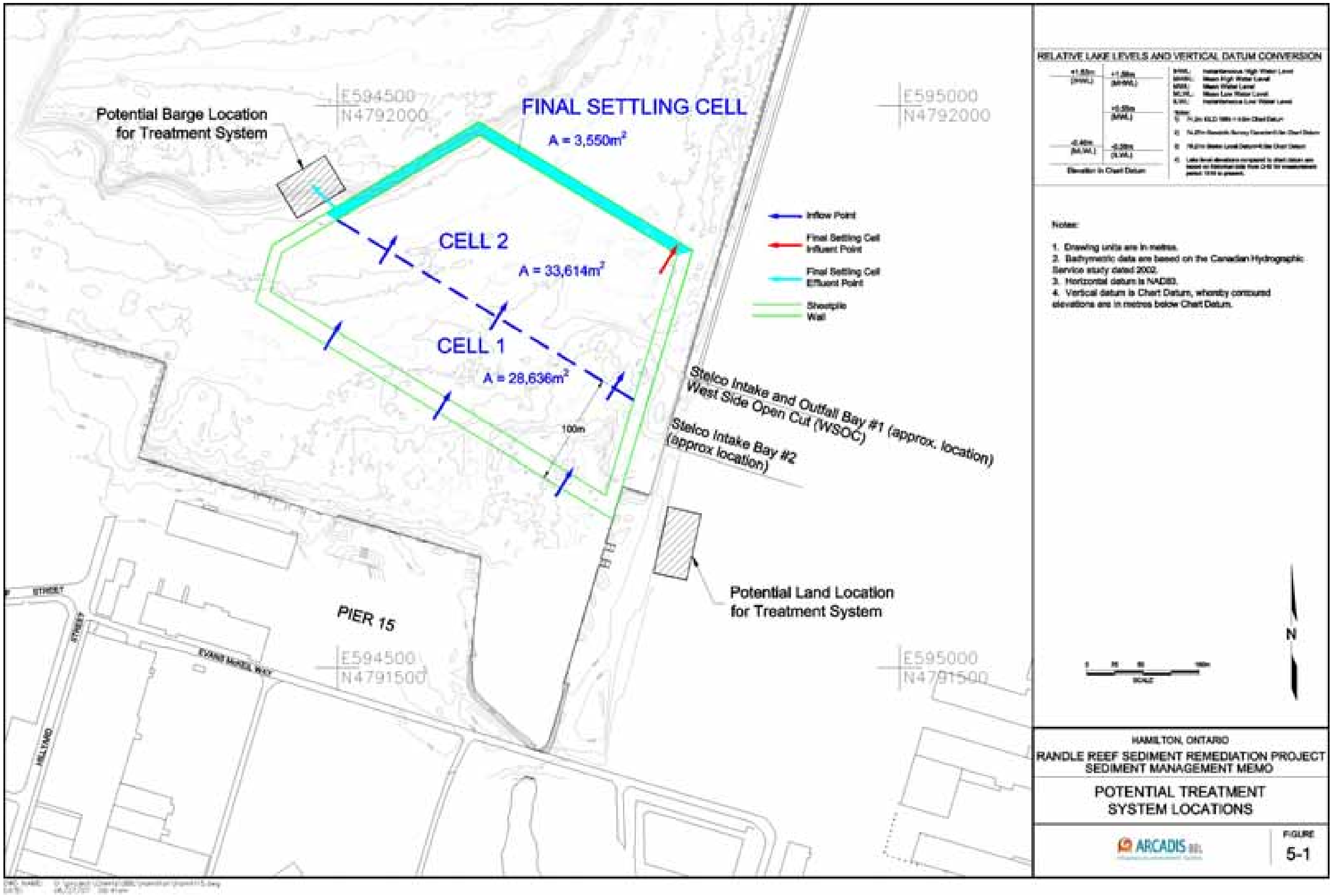
Preferably, the dredging equipment can be fitted with a hood or shroud to reduce turbidity. This, and other factors such as controlling the rate of dredging and rotation of the cutter, are intended to be the primary methods of managing sediment re-suspension at the dredge head.

For dredging in areas adjacent to the U.S. Steel intake and the initial dredging on the east side of the ECF between the sheetpile walls, engineering controls such as silt curtains may be needed to prevent suspended sediments from entering the intake.

F.4.5.4 Dredge Verification

Dredging will not remove 100% of the contaminant mass, therefore, a certain amount of contaminated sediment will remain in the sediment bed. To address this issue, post-dredging monitoring will be performed to determine whether the dredge criteria were met and measures will be taken if they were not.

Figure F.4: Potential Treatment System Locations



A combination of hydrographic surveys and verification sampling and analysis will be used to confirm contaminant removal. The amount of residual sediment and residual contaminant mass not removed during dredging will depend on a number of factors. The residual sediment will comprise either relatively undisturbed sediment or disturbed sediment that has resettled or mixed with clay, slag or other subsurface materials. The former represents sediment that is missed during dredging because of limitations of the dredging design typically associated with data distribution and density, complexity of the stratigraphic conditions and practical limitations inherent in dredging near structures and slopes. The latter is caused by activities at the dredge head that disturb the sediment without capturing it in the dredge pump intake or dredge bucket. Recent studies suggest that residual disturbed sediment can range from 2 to 10% of the dredged mass and is typically 1 to 10 cm (0.4 to 4 inches) in thickness over the surface of the dredge area.

Removal accuracy will be monitored during dredging. In addition, dredging progress will be evaluated through hydrographic surveys ("progress surveys") conducted at regular intervals. Dredging completion will be confirmed by hydrographic survey after the first-pass dredging of individual priority areas and again after the second-pass dredging is complete. Verification of the accuracy of dredging to design dredge elevations will be confirmed through these hydrographic surveys. If design dredge elevations are not met, additional dredging will be performed to complete construction to the design specifications. If verification sampling indicates that additional dredging will be required, a second set of regular hydrographic surveys in conjunction with ongoing second-pass dredging, as well as a final confirmation survey, will be completed.

Two rounds of verification sampling will be conducted: the first will identify residual contaminated sediment remaining after the first-pass dredging is complete; and the second will confirm that residual contaminated sediment and exposed native sediment surfaces meet sediment quality compliance criteria.

First round of verification sampling - Following first-pass dredging and the associated hydrographic survey in each dredge unit, verification sampling will be performed to visually confirm the absence of overlying soft sediments designated for removal and to collect surface sediment samples for laboratory analysis for compliance verification. Results of this interim verification sampling will be used to establish that additional dredging is not needed within the dredge area or to guide design requirements for either second-pass dredging or backfilling.

Second round of verification sampling - A second round of verification sampling will be conducted if second-pass dredging is required. Verification sampling will confirm that contaminated sediments were successfully removed during second-pass dredging and that no additional dredging or backfilling is necessary for exposed surface sediments to meet compliance criteria.

All verification samples will be collected using sediment coring methods. Sediment cores will capture residual surface sediments and must penetrate into the underlying clay layer in order to show the residual sediment thickness and allow for collection of a surface sediment sample for laboratory analysis.

F.4.6 Final Dredging

Final dredging to bring the sediment to grade in the primary ECF will be by mechanical means. Dredged material will be filled above the desired final elevation of approximately +0.5 m Chart Datum in anticipation of consolidation under the weight of the cap and preload.

During final ECF filling, when there is less than approximately 1.5 m (5 ft) of ponded volume, the ECF supernatant detention time will be less than approximately 20 hours and the decant management approach may need to be modified to maintain effluent quality. Possible modifications to decant water management include:

- decreasing ECF influent flow rates (for example, decrease dredging rate and/or mechanically dredge); and
- providing additional treatment to reduce TSS prior to GAC (for example, increase number of sand filters and/or convert the polymer-assisted settling to a two-stage process (coagulant followed by flocculant) in the final settling cell).

The final approach for ensuring acceptable effluent water quality during final ECF filling will be determined during the production dredging stage of the project, when actual full-scale performance data will be available for analysis and recommendation.

F.4.7 Backfilling/Thin Layer Cap

Following dredging, backfilling with a sand cover is recommended in two lifts of approximately 8 cm (3 inch) layers. The first lift will undergo some mixing with the underlying sediment, while the second should provide predominantly sand backfill with PAH < 100 mg/kg. Methods for placing the sand to reduce sediment re-suspension and contaminated sediment entrainment in backfill will be specified by the contractor and could include mechanical placement with a bucket, washing sand off a barge, "sand box" vibratory screens, or submerged diffuser placement.

F.4.8 U.S. Steel Channel Sediment Capping

An approximate 25 m wide channel, referred to as the U.S. Steel I/O channel, separates the ECF structure from the U.S. Steel facility. Contaminated sediment is up to an estimated 1.5 m (5 ft) thick in this area and is typically underlain by slag. The channel is designed to limit potential impacts associated with the ECF on U.S. Steel facilities. The channel will also provide access for maintenance and repairs to the I/O and U.S. Steel dock wall.

The overall design objectives for the U.S. Steel I/O accommodation are to:

- accommodate U.S. Steel's I/O requirements, which include maintaining present water flow rates and water quality properties during and after ECF construction and in the long term following construction;
- reduce disruption to U.S. Steel's Harbour access for shipping; and
- reduce impacts to the SDW, which is reportedly nearing the end of its useful service life.

Because of the reportedly deteriorated condition of the SDW, dredging was not considered a remedial option for this area, as removing material via dredging could have a destabilizing effect near the base of the SDW. Additionally, due to the nature of the hard material (presumably slag) in this area, navigation draft requirements and associated propeller/thruster wash, erosional flows and the steep slope beside the SDW, capping of this area is considered problematic.

The sediment cap in the U.S. Steel I/O channel will consist of a layer of sand with silt and enriched total organic carbon (TOC). To protect against vessel traffic at the U.S. Steel berths a length of the cap located at the channel entrance near the U.S. Steel berths will be armoured with stone, placed over a geotextile and the sand/silt/enriched TOC layer. As there is a restriction on cap thickness in a small area adjacent to the U.S. Steel intake pipes reactive core mats (RCMs) and armour mats will be used to provide the dual functions of sediment contaminant containment and scour protection. RCMs have a higher capacity to contain contaminants, per unit thickness than a soil-based cap. As a result, a cap with RCMs is thinner than a soil-based cap. A turbidity control structure will be installed around the intakes prior to cap construction.

Cap construction includes the following general tasks:

- mixing the cap materials to the specified grain size, organic content and homogeneity;
- delivering the capping materials to the capping location; and
- placing the capping materials to achieve the required uniform cap thickness.

The area proposed for armouring at the channel entrance requires the additional step of delivering armour stone to this location and placing it. The area in front of the intakes where armouring is necessary requires placing the RCM and armour mats.

Cap modeling results indicate that, except for zinc, PWQOs (and/or CWQGs) will not be exceeded and Severe Effect Levels (SELs) in the cap will not be exceeded for any of the compounds modeled. Containment of zinc will be expensive and has not been accomplished via full-scale sub-aqueous capping. Additionally, background zinc concentrations are elevated. Accordingly, extraordinary measures to contain zinc are not included in this cap design.

There is a SDW offset area consisting of approximately 5 m which is not part of this remediation project. The mass of sediment contaminants present in the SDW offset area is estimated to be less than 1% of the total mass of sediment contaminants located in Randle Reef, assuming that there are fine-grained sediments in the area with thickness and contaminant concentrations comparable to other nearby areas. Remediation in the SDW offset area would therefore not significantly contribute to the overall project objective of reducing sediment contaminant mass in Randle Reef sediment.

F.4.8.1 Construction Sequencing

Except for the turbidity control structure area, cap construction will commence after the ECF has been constructed and dredging in the priority areas located north of the ECF has been substantially completed. This sequencing is recommended to limit recontamination potential associated with suspension and redeposition of sediment contaminants during dredging. The general sequencing for cap construction is described below:

- construct turbidity control structure around intakes prior to ECF construction or dredging;
- after the ECF has been constructed and dredging in the priority areas located north of the ECF has been substantially completed, construct the sand with silt and enriched TOC cap;
- place Armour stone over the sand with silt and enriched TOC cap at U.S. Steel I/O channel entrance; and
- construct the RCM/Armour mat cap in the vicinity of the intakes.

It is presently expected that 10 settlement plates will be installed in five pairs evenly spaced along the length of the cap area. Each pair will have a settlement plate located about 6 m (19.7 ft) west and east of the channel centerline. Five seepage meters will also be installed along the centerline of the cap length between the five settlement plate pairs.

F.4.8.2 U.S. Steel I/O Channel Cap

The cap in the majority of the U.S. Steel I/O Channel will consist of a mixture of sand and silt with enriched TOC. The cap materials will be delivered to the site and temporarily stockpiled. The specifications will call for field testing of the appropriate mix of cap materials to achieve the requisite grain size characteristics, TOC content and homogeneity. The cap materials will be mixed on-site. Once a homogeneous mixture is achieved, the cap material can be installed by pumping the cap materials through a pipe.

F.4.8.3 Cap in Vicinity of U.S. Steel I/O Channel Entrance

Placing armour stone over the cap materials is proposed for the channel entrance, in an area running the full channel width. Armouring of the cap in this area is considered necessary to protect against vessel traffic in the U.S. Steel berths.

Armour stone proposed for armouring the cap at the U.S. Steel I/O channel entrance may be stockpiled on site and transported to the capping site or transported directly to the capping location by barge. Approximately 230 m^3 (300 $yards^3$) of armour stone are required.

F.4.8.4 Cap in Vicinity of U.S. Steel Intake Pipes

As there is a restriction on cap thickness in the area of the intake pipes (i.e., there is an approximately 0.6 m (2 ft) difference in elevation between the existing sediment bed and the intake invert), RCMs will be used in this area. RCMs have a higher capacity to contain contaminants, per unit thickness than a soil-based cap. As a result, a cap with RCMs is thinner than a soil-based cap.

In this area, armour mats overlying RCMs will also be used. This combination provides erosion protection (i.e., the armour mats) and chemical containment (i.e., the RCMs). The armour mats overlying RCMs are proposed to be laid in a configuration that extends along the length of the pumphouse and from the SDW/pumphouse to the approximate midline in the channel. To provide geotechnical stability, a geotextile will be used as a filter layer under the armour stone.

RCMs proposed for capping in the vicinity of the intakes will be stored on site in accordance with the manufacturer's recommendations. Overlaps for RCMs are not typically seamed or welded.

Armour mattresses proposed for armouring the RCMs in the vicinity of the intakes should be stored on site in accordance with the manufacturer's recommendations. The manufacturer typically provides layout instructions for fabricating a lifting frame. The mats will be placed with a crane and guided into place using divers and/or risers on the lifting frame.

A transition is required from the armour mat/RCM portion of the cap to the sand with silt and enriched TOC portion of the cap. The preferred approach for this transition is to lay the outer row of armour mats and RCM up over the edge of the soil cap, rather than slope the soil cap down to the RCMs. This approach allows for the full thickness of the soil cap in the transitional area.

F.4.9 ECF Capping

The ECF capping system will consist of a foundation layer, an underliner drainage system, a hydraulic barrier layer, an overliner drainage system, paved surface (in the port facility area), vegetative cover (in the greenway area) and stormwater management systems. The hydraulic barrier will be used in the system to reduce infiltration into the underlying sediments and to reduce upwelling of either pore water or groundwater into the cap materials. The post-consolidated surface of the interface between the top of dredged material fill and the bottom of the ECF cap has a target elevation approximately +0.5 m Chart Datum.

Because the ECF is a minimal flow system, most or all of the water that passes through the cap will likely remain within the sealed sheet pile walls. If a sufficient amount of water accumulates under the cap, excessive upward pressure could be exerted on any low-permeability layers in the cap, and cap failure may occur without engineering controls for this in place. For this reason, a drain system beneath the cap that is capable of providing pressure relief will be installed. The ECF cap design includes perimeter collection trenches for this purpose that are hydraulically connected to the drainage layer to drain the portion of cap below the geomembrane/geosynthetic clay liner (GCL).

A foundation layer will be installed to provide a stable surface on which to begin placement of overlying materials and installation of wick drains. The foundation layer will consist of two layers of geosynthetics: a separation geotextile; and a high-strength geogrid. The separation geotextile will be placed directly on the surface of the dredged material by winching it across the facility with cables. This geotextile will be delivered to the site in large, pre-seamed panels that will be sewn together in the field. The high-strength geogrid will consist of one layer of a biaxial high-strength geogrid. The geogrid will be placed in rolls and panels will be overlapped.

An underliner drainage system will be constructed to manage pore water during consolidation and aid in controlling groundwater upwelling after consolidation. The underliner drainage system consists of gabion stone. The gabion stone will be placed directly on the high-strength geogrid. A perimeter trench system (with horizontal and vertical piping) will be installed around the interior sheetpile wall. Once the gabion stone has been placed, wick drains will be installed to aid in expediting consolidation. A separation geotextile will be used on top of the gabion stone to retain the overlying sand layer that also serves as a cushion to the hydraulic barrier.

A hydraulic barrier will be used in the system to reduce infiltration into the underlying sediments and to reduce upwelling of either pore water or groundwater into the cap materials. The hydraulic barrier will consist of a linear low-density polyethylene (LLDPE) geomembrane. The LLDPE liner will be delivered to the site in rolls and seamed in the field using dual-track hot wedge seams.

An overliner drainage system will be constructed on the geomembrane and will consist of filter sand combined with horizontal and vertical piping. This system will be used to monitor, analyze, collect, and, if necessary, remove any water that has accumulated on the geomembrane.

Grading of the ECF capping system is designed to facilitate future uses while reducing surface ponding and infiltration through the cover system.

The general ECF cap construction sequence is listed below:

Foundation Layer
- level dredging surface, if needed;
- installation of high-strength geotextile;
- installation of high-strength geogrid;

Underliner Drainage System
- placement of gabion stone;
- installation of wick drains;
- installation of sand and gravel transition layer;
- installation of perimeter trench drainage system;
- construction of filter sand layer;

Hydraulic Barrier
- installation of LLDPE liner, including installation of LLDPE termination system;

Overliner Drainage System
- installation of sand cushion layer and overliner drainage system;

Settlement Monitoring System
- installation of settlement plates;

Subgrade Layer
- placement and compaction of subgrade (port facility and greenway areas);
- placement and compaction of first subbase layer;
- installation of biaxial geogrid in subbase layer;
- placement and compaction of remaining subbase layer;

Preload
- placement and compaction of preload material;
- removal of preload material and abandonment of settlement plates;

Stormwater Drainage System
- rough grading of subbase layer;
- installation of stormwater drainage system in the port facility area;
- installation of stormwater drainage system in the greenway area;
- installation of utility corridor trench;
- final grading of top subbase layer;

- installation of biaxial geogrid layer on top of subbase;

Installation of Pavement

- installation and compaction of flexible pavement base course material on the port facility area;
- installation of asphalt on port facility area;
- installation of vegetative cover; and
- installation of vegetative cover in greenway.

In general, the earthwork will be required to proceed in uniform thin lifts and stockpiling of materials on the cap during construction will be subject to some requirements.

F.4.9.1 Foundation Layer

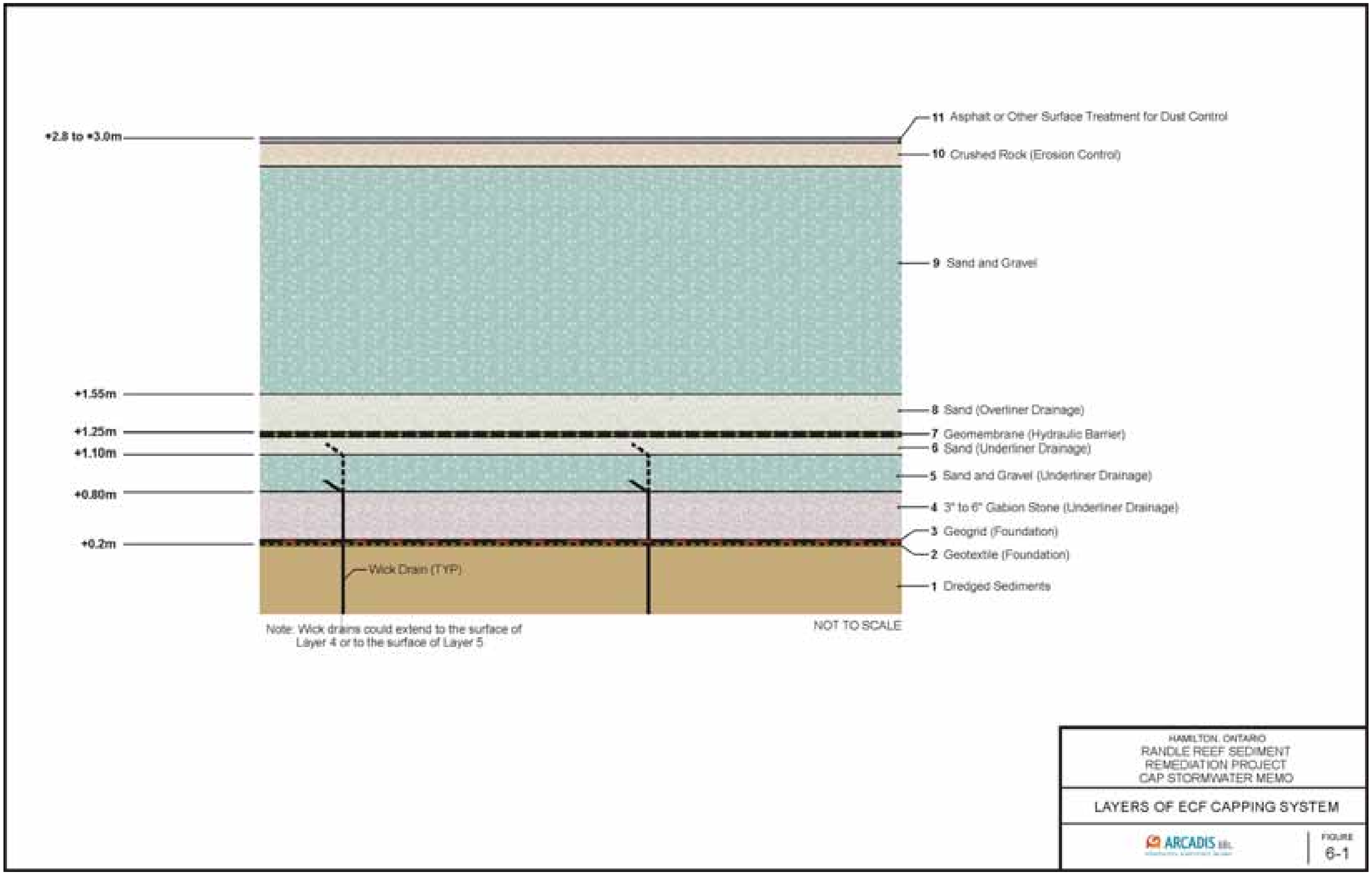
The primary purposes of the foundation layer are to provide a stable surface on which to construct the overlying layers and to facilitate the installation of wick drains. The proposed foundation layer consists of a separation, woven geotextile (Layer 2 on Figure F.5) placed directly on the surface of the dredged material (Layer 1), followed by the placement of a high-strength geogrid (Layer 3).

The foundation layer will be placed once the sediments have consolidated under their own weight and as much water as is feasible has been decanted from the surface of the sediments. If large depressions exist on the surface of the dredged material, the surface will be smoothed as required prior to placement of the geosynthetics (Koerner, 2005).

Geotextile is used to provide separation, reinforcement, filtration, and drainage. The primary purpose of this geotextile layer is to serve as a separation layer between the dredged material and the overlying layers, aiding in maintaining the drainage capability of the stone (Layer 4 on Figure F.5) in the overlying layer. The material selected for this geotextile separation layer is a medium-weight non-woven geotextile. The geotextile will be placed by winching the material across the dredged sediment using a cable system.

Seam strength is an important consideration for this material. The geotextile material will be sewn at the factory in custom-sized panels to decrease the need for field seams and increase seaming efficiency. Panels of pre-seamed fabric will be delivered to the site, aiding in deployment of the material over the dredged material surface and reducing field seams.

Figure F.5: Layers of ECF Capping System



Given the nature of the dredged material, a high-strength geogrid (Layer 3 on Figure F.5) will be placed above the separation geotextile. The use of a geogrid system is intended to:

- provide bearing capacity for the gabion stone layer and equipment used during construction of the lower cap and installation of the wick drains;
- reduce differential settlement of the cap;
- distribute destabilizing forces from preloading or design loads deeper into the more consolidated dredged material, where resistance is higher; and
- aid in control of mud waves.

The geogrid layer also contributes to the overall strength and stability of the cap during construction of the cap, the preloading phase and ultimately the long-term design loading on the cap.

Geogrids are matrix-like materials with large open spaces called apertures, typically 10 to 100 mm (0.4 to 4 inches) between longitudinal and transverse ribs. The primary function of geogrids is reinforcement, which can be one-directional (uniaxial) or two-directional (biaxial). For the foundation layer of the ECF capping system, the design includes one layer of a high-strength biaxial geogrid. Geogrid seaming typically consists of overlapping the material and anchoring with ties or staples. A layer of nonwoven geotextile will be placed adjacent to the geogrid to provide separation.

Heavy equipment cannot be used on the geogrid or the subgrade until a significant portion of the overlying stones associated with the underliner drainage system has been placed. This means that it may be necessary to place the overlying stone using a conveyor system or similar method. Placement of the stone also must be done with care, because coarse soil impingement can damage the geogrid material.

F.4.9.2 Underliner Drainage System

The underliner drainage system (i.e., Layers 4, 5 and 6 on Figure F.5) is critical for the removal of pore water during consolidation and for the control of groundwater upwelling after consolidation. This system will allow for lateral drainage of pore water/groundwater to a horizontal subsurface trench system around the internal perimeter of the facility. This subsurface trench system will be connected to vertical risers that can be used to monitor, analyze, and extract pore water generated from consolidation as well as groundwater that may mound within the facility.

The need to control groundwater upwelling within the system is based on the need to maintain a mass balance of water between the system and the average lake level, as well as on the need to reduce pressure on the underside of the hydraulic barrier layer. On an annual basis, the need to remove and treat groundwater mounded in the facility is minimal and an on-site treatment system for this component is not currently proposed. As a result, any extracted water will be treated at an off-site facility. Groundwater upwelling after consolidation is not expected to generate a significant amount of water requiring extraction and treatment.

Pore water removal during consolidation is the primary driver for the design of the underliner drainage system. During consolidation, a temporary on-site treatment system will be necessary to extract, treat, and manage removed pore water. This system will be operated as part of the post-construction operation and maintenance program. It is envisioned that a readily available trailer-mounted modular unit will be used that can be specified based on the expected flow rate and contaminant concentrations. Once the generation of pore water has stabilized or production of pore water has significantly decreased, the treatment system will be removed and water will be sent off site for treatment.

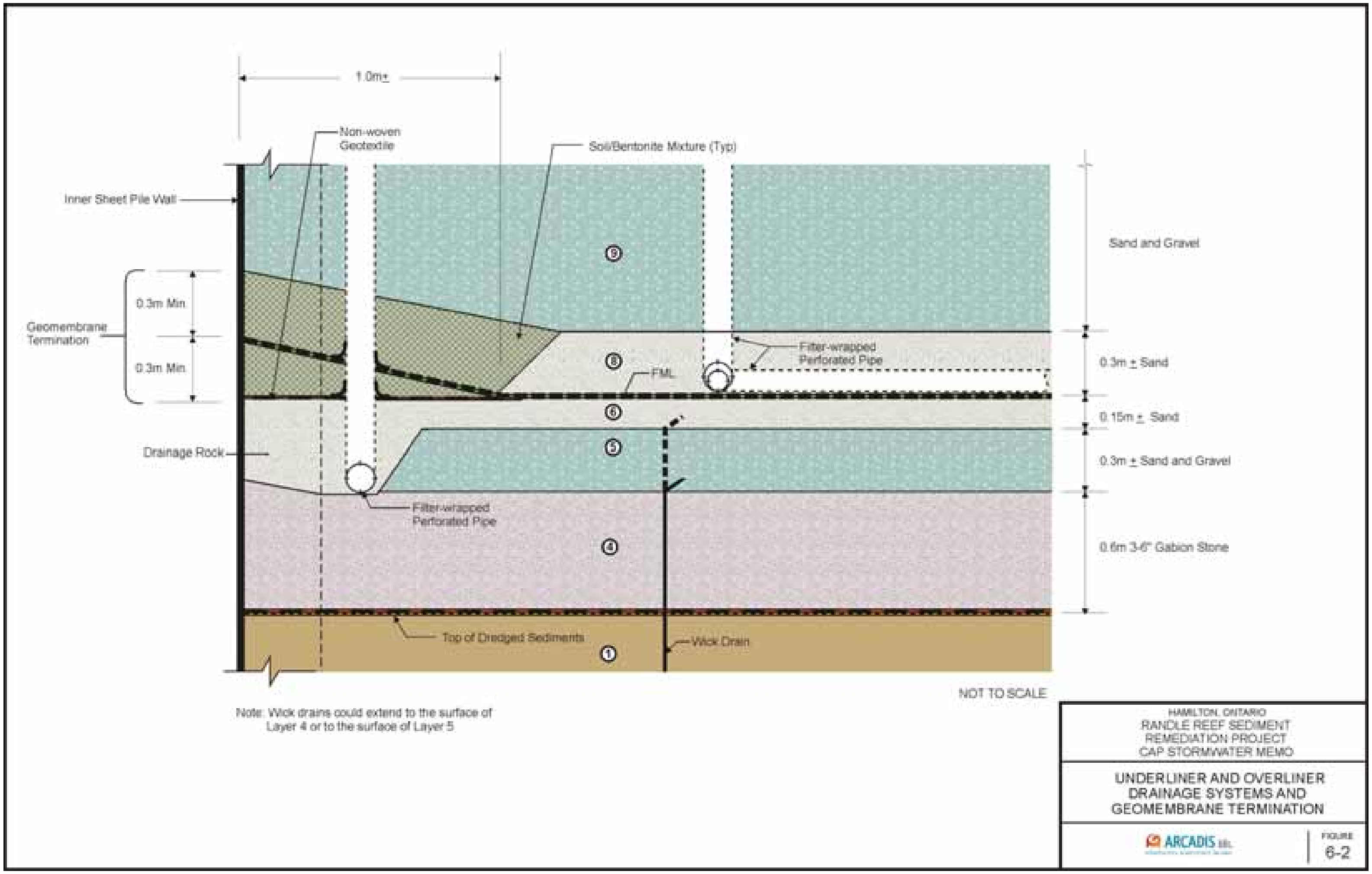
Because of the flow rates expected during pore-water removal, the underliner drainage system will be constructed using gabion stone, wick drains, a transition layer of sand and gravel, and a filter sand layer. The gabion stone (Layer 4 on Figure F.5) will be placed in lifts of less than approximately 0.3 m (1 ft) to an approximate depth of 0.6 m (2 ft). This placement method will reduce the potential of creating mud waves or damaging the underlying geosynthetics, and gabion stone in the specified size will allow for lateral movement of pore water through the pore spaces in the stone to a collection trench constructed along the interior perimeter of the ECF.

Once the gabion stone is placed, a tracked vehicle will be used to install the wick drains. Once wick drains are installed, a transition layer of sand and gravel (Layer 5 on Figure F.5) will be used to prevent the overlying sand layer from infiltrating into the gabion stone. This layer will be the same material used in the top portion of the cap.

Alift of filter sand (Layer 6 on Figure F.5) will be placed over the transition layer of sand and gravel as a final filtering medium for fines, to provide a smooth installation surface, and as additional cushion to the hydraulic barrier. In general, the material consists of well-graded sand with greater than 30% coarse material and minimal fines. Figure F.6 illustrates the design for the underliner drainage system.

The gabion stone will be sloped or trenched and the separation geotextile will wrap around the trench. Inside the wrapped trench, a smaller drainage rock will be used along with filter-wrapped high-density polyethylene (HDPE) pipe. The pipe will be placed horizontally along the internal perimeter of the facility and vertically to penetrate through the liner system to the surface, allowing access for monitoring, sampling, and removal of any upwelled water.

Figure F.6: Underliner and Overliner Drainage Systems and Geomembrane Termination



F.4.9.3 Installation of Wick Drains

Wick drains will be required in the port facility and the port facility-to-greenway transition areas to increase the rate of consolidation and shorten the necessary preload duration. Installing wick drains promotes radial consolidation and reduces the length of the drainage path that excess pore water under pressure needs to travel to be removed from the dredged material, thereby accelerating the rate of consolidation. Wick drains are thin strips of composite drainage material wrapped in permeable geosynthetics and driven into the soil using a crawler excavator and hydraulically pressed steel mandrel.

Wick drain spacing with a port facility preload is designed to yield 99% consolidation after approximately four months. Approximately 12,000 wick drains are to be installed.

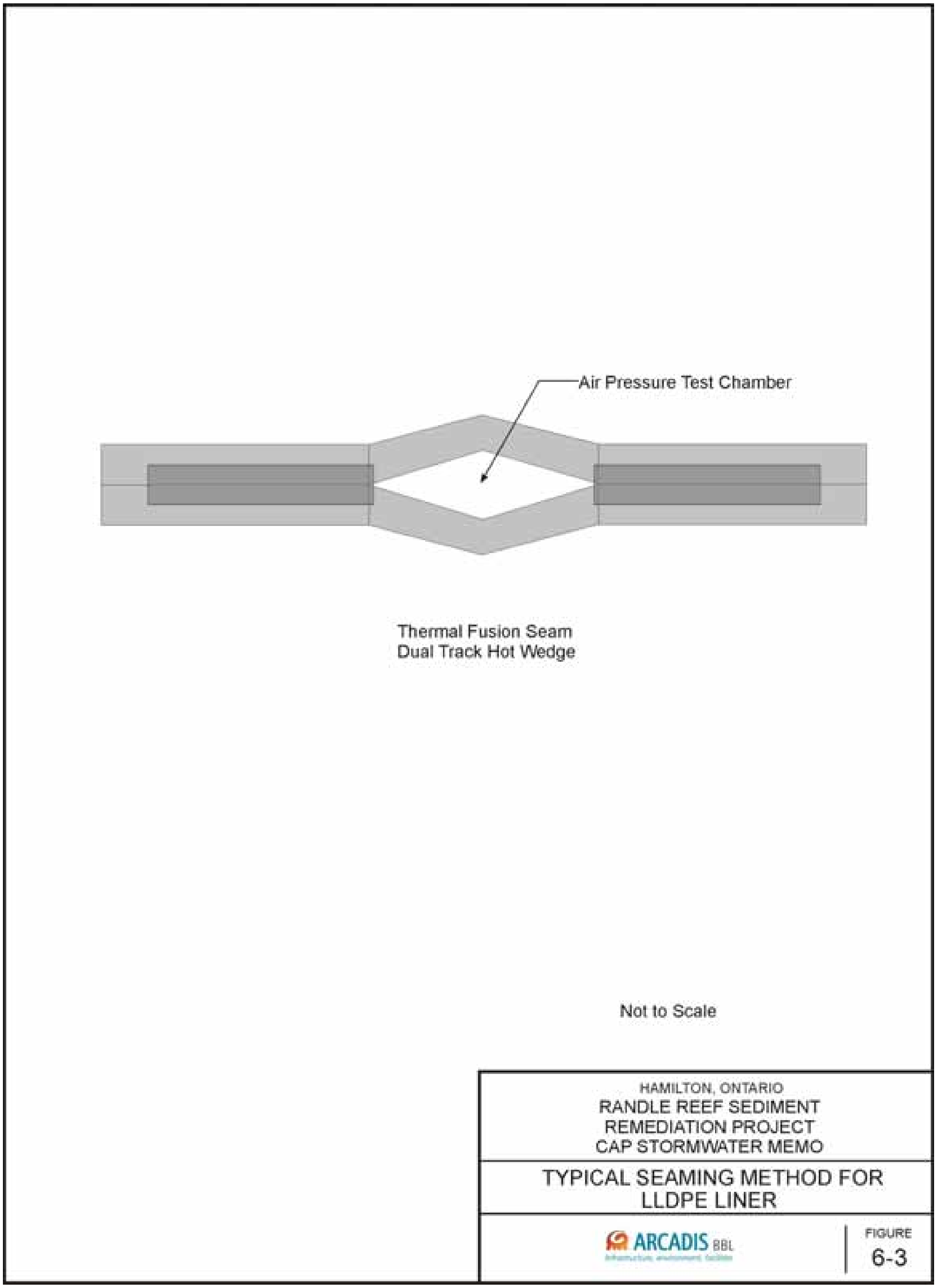
F.4.9.4 Hydraulic Barrier Layer

The purposes of the hydraulic barrier layer (Layer 7 on Figure F.5) are to reduce the infiltration of water through the cover system into the dredged material and to control the rise of pore water/groundwater into the overlying cap materials. A geomembrane has been selected as the material for the hydraulic barrier layer.

Linear low-density polyethylene (LLDPE) is considered to be the most appropriate material for the geomembrane. It is typically extruded as flat sheets and is available in a variety of thicknesses. For the ECF capping system, a smooth-textured LLDPE will be appropriate, given that slopes are minimal to nonexistent at this layer.

LLDPE liners will be delivered to the site in rolls that are then field-seamed into panels. The seaming method will consist of thermal, dual-track hot wedge fusion welding. A typical cross section of this seam is illustrated on Figure F.7. The dual-track hot wedge seam is considered the premier seaming method for all thermoplastic geomembranes. During the development of specifications, a construction quality control plan for seaming, seam testing, and seam repairs will be prepared. The specifications will contain details on requirements for experienced installers.

Figure F.7: Typical Seaming Method for LLDPE Liner



LLDPE liner placed on, or backfilled with, soil that contains stones, sticks, or hard debris is vulnerable to puncture during and after loads are placed. Soil placement specifications will require soil to be free of such debris. The LLDPE liner will be cushioned with sand both above and below for protection.

Geomembranes are typically penetrated by such features as monitoring wells, gas vent pipes or settlement monitoring devices. Penetrations through the geomembrane used in the ECF capping system will be limited to the extent practical. Vertical pipe risers for monitoring, sampling, and collecting pore water and, potentially, groundwater will penetrate the geomembrane, as illustrated on Figure F.6. Boots of the same material can be welded around the vertical pipe risers to seal around the penetration.

The geomembrane will be terminated at the interior sheetpile wall in a manner that allows for total settlement expectations within the facility. Figure F.6 illustrates the termination of the geomembrane. To seal the edges of the geomembrane as well as allow the material to move vertically within the ECF, a layer of nonwoven geotextile (similar to that in the *Foundation Layer*) will be placed as a separation barrier beneath the liner. A wedge of material consisting of a mixture of soil and bentonite will be used on top of the geotextile, and the liner will be placed on top of this wedge. Another layer of the soil/bentonite mixture will then be placed on top of the liner to seal the edges of the capping system.

F.4.9.5 Overliner Drainage System

Although the majority of the ECF capping system will be paved and a stormwater management system will control infiltration of water through the capping system, it is important to incorporate a method of monitoring for water that could accumulate on top of the geomembrane. This monitoring layer is termed the overliner drainage system (Layer 8 on Figure F.5). Materials selected for the overliner drainage system include a thick layer of filter sand and filter-wrapped HDPE piping. The filter sand also serves as a cushion layer over the geomembrane to protect it during placement of the settlement plates and overlaying cap material.

Within the layer of filter sand, a series of horizontal, filter-wrapped, perforated piping will be installed connected to vertical risers made of filter-wrapped HDPE. The piping, which will be accessible at the surface of the ECF capping system, will be used to monitor, sample, and remove (as necessary) water that accumulates on the geomembrane.

F.4.9.6 Settlement Monitoring System

The increased shear strength of the sediments will need to be verified using appropriate techniques during cap construction. This can be assessed using the results of settlement plate monitoring, controlled to some degree by the requirements of preload slope configuration, and using pore pressure transducers or other instrumentation placed within the dredged material to monitor the deformation behaviour and pore pressure decline and, therefore, the accompanying shear strength increase.

The settlement plates will be installed with the ECF cap as soon as a suitable, stable base is achieved and after important ECF cap components that should not be penetrated by the settlement plate vertical pipe segment have been constructed. Doing so will facilitate the ability to monitor the actual magnitude of consolidation occurring with time and compare that to the model predictions. Settlement plates will be abandoned after the preload material is removed and before installation of the final ECF capping system components.

F.4.9.7 Subgrade Layer

The subgrade layer (Layer 9 on Figure F.5) of the port facility and greenway areas will be placed directly above the overliner drainage system and will consist of a structural fill material, a sand and gravel mix, placed in lifts and compacted.

F.4.9.8 Preload

The purpose of placing a preload onto the ECF is to allow consolidation to occur within the sediments and foundation soils prior to any future loading of the ECF. It is anticipated that the preload will be in place for four months.

Once the subgrade layer is in place, the preload will be placed in the port facility area. The preload in the greenway is expected to consist of the same material

It is anticipated that the dredged material in the port facility area will be 99% consolidated at the time the preload is removed. In the greenway area, however, it is anticipated that the dredged material will be only 30% consolidated at the time the preload is removed. Remaining consolidation of the sediment in the greenway area will take approximately six to seven years if the preload is removed at the same time as the port facility preload. The preload in the greenway should stay in place as long as practical to maximize consolidation, depending on the landscape schedule.

Because the silty clay foundation soils located beneath the in-situ recent sediment will take much longer to consolidate, total settlement of the facility will continue over time. In the port facility area, the foundation soils are anticipated to be only 25% consolidated at the time the preload is removed. With no further loading, total settlement of the port facility is estimated to take on the order of 12 to 13 years to complete.

In the greenway area, approximately 12% of the expected consolidation of the foundation soils is predicted at the time the preload is removed. Remaining consolidation of the foundation soils is estimated to take on the order of 50 years to complete in the greenway area. Additional consolidation will occur in the dredged material fill and underlying in-situ recent sediment after the preload is removed due to the weight of the cap.

A preload transition area from the port facility to the greenway is incorporated into the design to allow for a smooth transition between the final grades of both areas, to reduce the stresses in the cap components from differential settlement that would otherwise be relatively dramatic at the northern edge of the port facility, and to provide for some consolidation (and, therefore, shear strength gain) in the dredged material on the greenway side for overall stability of the ECF fill, as well as to support landscape grading contours.

Settlement plate monitoring will be terminated following preloading. The settlement structures will be abandoned in place by removing the pipe and grouting the hole during extraction.

Once the preload is removed, utilities, final stormwater management systems and the erosion control layers will be constructed.

F.4.9.9 Stormwater Drainage Features

Port Facility

The primary objectives for stormwater management within the port facility area are to:

- develop final grades that accommodate the proposed end use;
- avoid direct runoff from paved surfaces into the lake wherever practical;
- remove runoff from the surface of high-use areas as quickly as possible and practical;
- manage the water quality and quantity in accordance with applicable legislation; and
- reduce, to the extent practical, infiltration of stormwater runoff into underlying capping layers.

Figures F.8 and F.10 show the grading and drainage plans, respectively. In general, final grades are laid out to direct stormwater runoff toward the interior of the site rather than allow direct discharge to the Harbour. However, because of the proposed crown in the port facility access road, the outer lane of the access road will shed stormwater runoff directly into the Harbour. This represents approximately 6% of the total paved area of the site.

A stormwater management system that uses filtration as a method for treatment prior to discharge will be used for the port facility. This system allows for separation of grit and oil from the water prior to discharge. The system will have a 24 hour storage capacity for a five-year storm event. Stormwater will travel across the surface of the port facility area and enter the stormwater management system through linear, open grate trenches. Stormwater will then pass through catch basins and into filtration chambers. Once filtered, stormwater will travel through a series of manholes and discharge between the exterior and interior sheet pile walls. Water in excess of the storage capacity will travel through large-diameter piping from the catch basins and discharge directly to the lake. In cases where stormwater exceeds the storage capacity, the system is designed to catch the "first flush" and still allow for some oil/water separation prior to discharge to the lake.

Final surface grades within the port facility are designed to sheet stormwater runoff northward and southward across the site, with trench drains oriented within valleys in the east-west direction to collect and convey concentrated flows to stormwater collection manholes. The trench drains consist of prefabricated, pre-sloped trench sections (i.e., the bottoms of the trench drain sections are fabricated with slopes relative to their top surfaces) with open, grated tops. Prefabricated, pre-sloped trench drain systems will be used.

The stormwater collection manholes (Figure F.9) are positioned at the downgradient ends of the trench drains. The manholes will route stormwater flows from small storm events and the early stages of larger storm events (i.e., the "first flush" of runoff) into a subsurface stormwater detention system which will provide treatment (i.e., 24 hour retention/drawdown) of the water quality storage volume. Stormwater flows exceeding the capacity of the subsurface detention system will spill over an internal weir within the stormwater collection manhole and discharge directly to the lake through a stormwater bypass pipe.

The subsurface stormwater detention system typically consists of a series of arched chambers with open bottoms placed inside an envelope of granular drainage medium. The open void created by the chambers creates additional storage volume that would not otherwise be available in a solid envelope of granular drainage medium, thereby reducing the minimum required footprint of the subsurface stormwater detention system. The system is designed to fill with stormwater that will then gradually infiltrate into a surrounding granular medium (e.g., drainage stone or sand) (Figure F.10). To reduce the potential that infiltrated water could make its way down into the cap system, ultimately building up on top of the flexible membrane liner (FML), the granular medium surrounding the subsurface chambers will be enclosed within a geomembrane.

Figure F.8: Grading Plan, Primary ECF

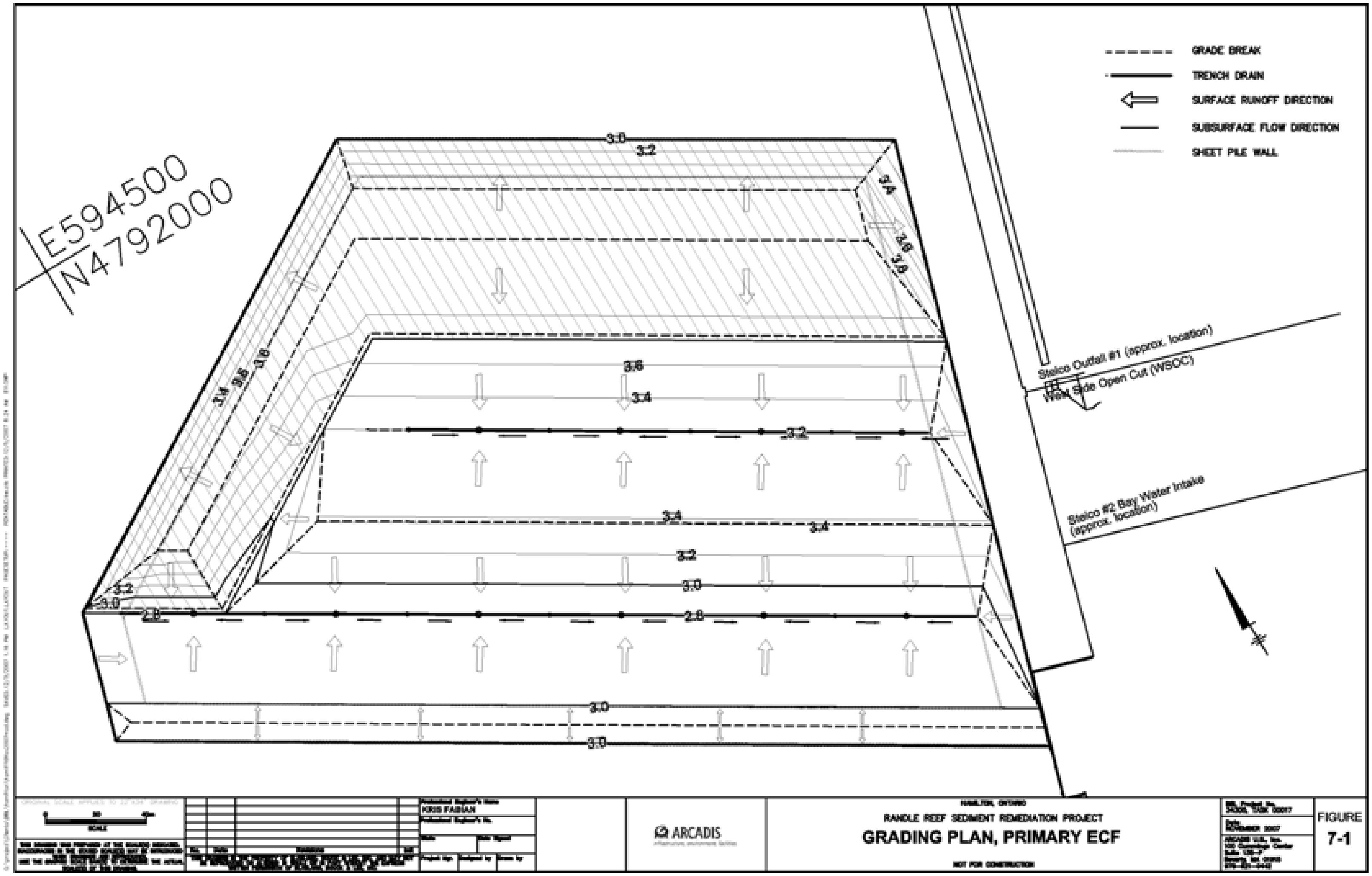
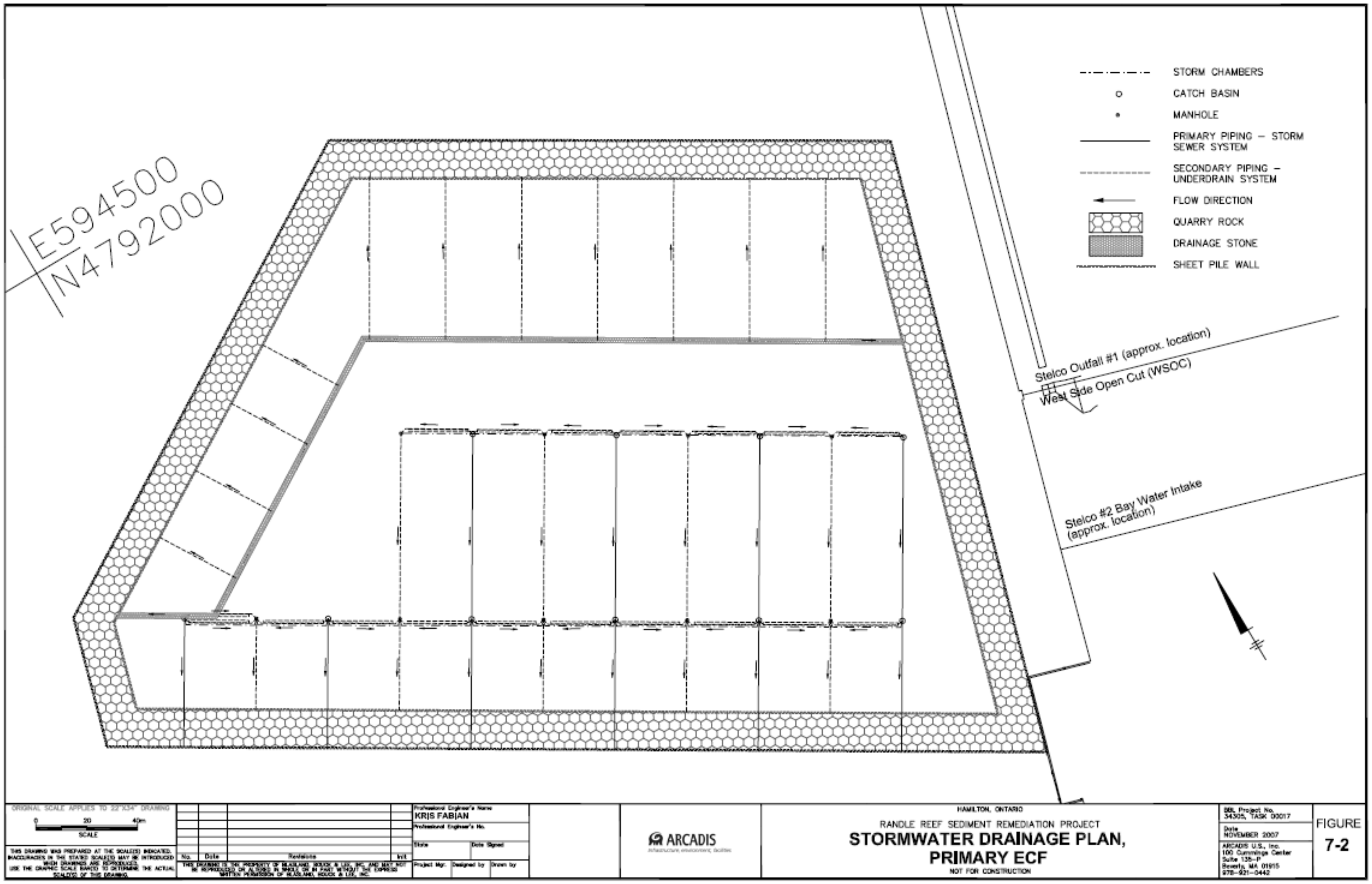


Figure F.9: Stormwater Drainage Plan, Primary ECF



After stormwater has passed through the granular medium, it will enter a perforated underdrain pipe that will convey the treated stormwater into a nearby underdrain manhole. The perforated underdrain pipe that conveys infiltrated stormwater to the underdrain manhole will transition to a solid, dual-wall pipe before passing through the geomembrane. The penetration through the geomembrane will form a watertight seal around the pipe. An outlet pipe from the underdrain manhole will then convey the treated stormwater to the rock-filled space between the interior and exterior sheetpile walls surrounding the ECF.

Greenway

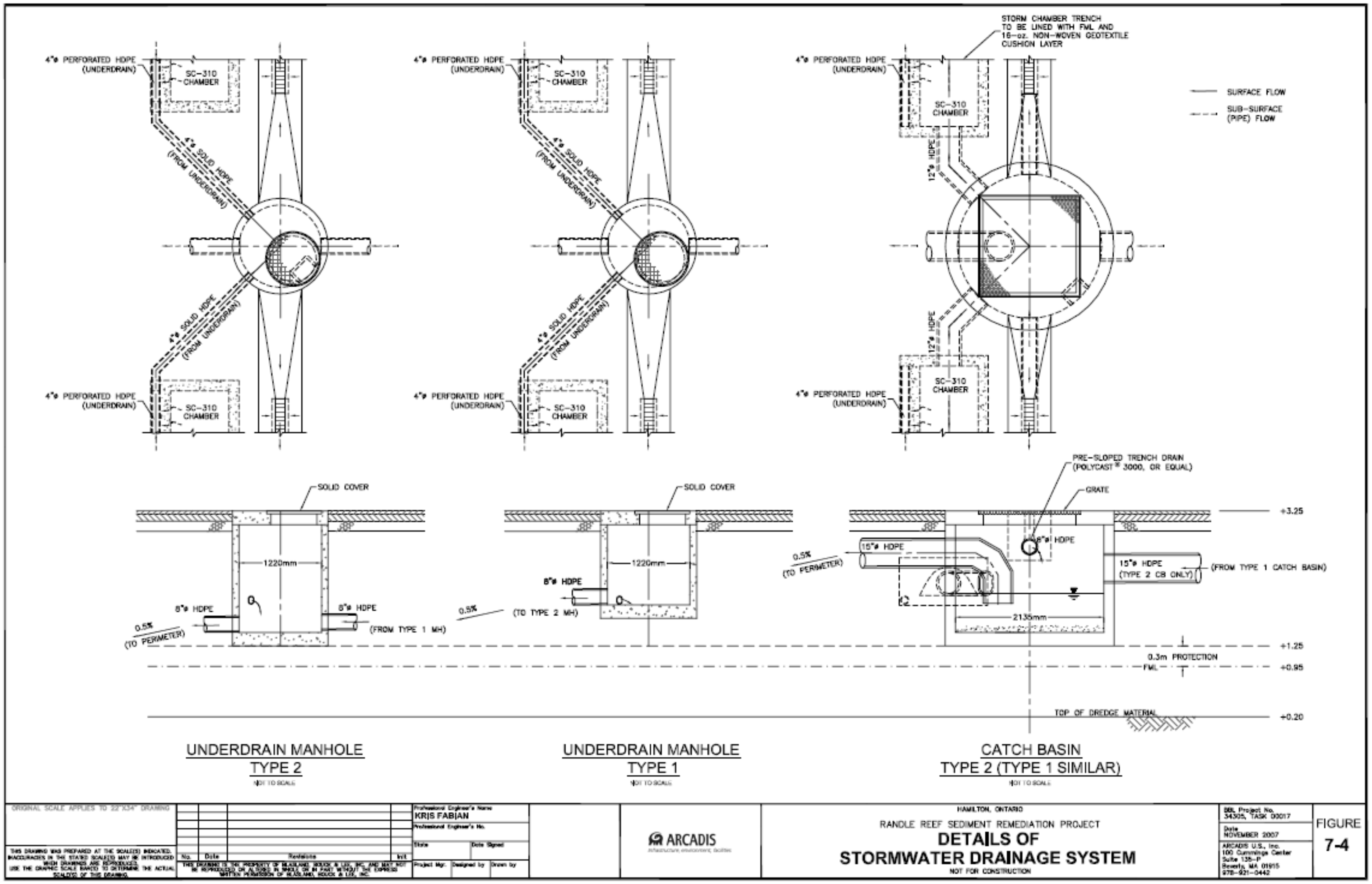
In the greenway, stormwater will flow over slopes either directly to the lake or to a French drain system installed between the port facility and greenway areas. This French drain will capture clean stormwater running off the back slope of the greenway before it enters the port facility area. Stormwater entering the French drain system will be directed under the greenway through a filter-wrapped pipe, drained to the rock between the interior and exterior sheetpile walls, and then discharged to the lake through the exterior sheetpile.

Given the pervious nature of the proposed greenway surface, a second geomembrane layer will be installed beneath the greenway to inhibit the downward movement of infiltrated stormwater and reduce the potential for buildup of infiltrated water on the lower FML. This upper geomembrane layer will be draped over the top of the interior wall to allow infiltrated water to run laterally through the cover soils and across the top of the geomembrane, ultimately emptying into the rock-filled space between the sheetpile walls. An adequate approach slope will be constructed within the cap backfill material approaching the interior sheetpile wall to reduce the potential loss of positive drainage across the upper geomembrane surface as a result of cap settlement.

To the extent practical, the proposed greenway will be graded to convey surface runoff directly into the lake. However, due to the proposed riprap wave protection, much of the surface runoff will likely infiltrate into the rock-filled space between the interior and exterior sheetpile walls surrounding the primary ECF.

Because no impervious surfaces are currently proposed for the greenway, no stormwater quality control practices (other than a vegetated final surface) are proposed at this time.

Figure F.10: Details of Stormwater Drainage System



F.4.9.10 Utilities and Flexible Pavement Construction

To support the utility needs of the port facility end use, two utility corridors will be installed between the ECF double walls, each ideally placed just inside the interior and exterior walls above the tie-rod elevation of +1.0 m above Chart Datum and below the surface of the paved facility. A concrete pavement may be necessary to limit the potential for projection cracking above the concrete corridor "hard spots" that may be experienced with flexible pavement. In this approach, one utility corridor might be used for electrical and mechanical utilities, while the second corridor might be used for gas utilities.

Once placement of the subbase and grading is completed, a layer of crushed rock (Layer 10 on Figure F.5) will be placed. Asphalt pavement (Layer 11 on Figure F.5) will be placed over the crushed rock in two lifts consisting of alayer of a dense binder and a layer of wearing course.

Assessment of final fender requirements will likely be postponed until the use of the port facility is more fully determined. For the interim, fenders in the form of hanging tubular fenders supported on chains will be used to protect the concrete parapet from damage until such time as the design vessel is capable of accessing the facility and the area is dredged to the design dredge depth.

F.4.9.11 Vegetative Cover/Landscaping

The desired future condition for the greenway is a vegetative cover system capable of sustaining native growth and providing various types of habitat as appropriate, providing terrestrial and wildlife opportunities and improving aesthetics. Landscaping will be based on regional references and include native, non-invasive plant species. Soil types will be based on the native lacustrine plant communities around western Lake Ontario. The higher slopes of the greenway will provide protection from wave action as well as assist in the management of stormwater.

The same subgrade material used beneath the port facility will also be used beneath the greenway as the protection layer; stormwater management features will be installed within this layer. The greenway's erosion control layer will include topsoil and vegetation as well as riprap to serve as wave protection along the northern and northwestern perimeter of the ECF.

Stormwater is intended to be conveyed overland through broad, shallow bioswales to a series of vernal pools located between the inner/outer ECF walls. These pools will provide amphibian habitat and will be planted with a variety of native emergent and wetland fringe species.

The conceptual landform and contouring for the greenway (Figure F.11) emulate the local, natural character and are intended to provide visual relief and buffering of the industrial port lands. The creation of the landform provides increased soil depth overtop the protective cap of the ECF, allowing for the installation of larger, native tree species.

The species selected for the recommended landscape plan (Figure F.12) are indigenous to the Deciduous Forest Region and the western end of Lake Ontario. This combination of species creates important ecological diversity and will support terrestrial and avian habitat. Over the next several decades, as plant species mature and natural processes evolve, a more complex natural landscape is anticipated to develop.

The recommended landscape plan provides a degree of visual relief from the mass of the industrial uses at the Harbour. The combination of landform, understory trees and shrubs, and taller deciduous trees will provide a significant screen at eye level and will visually block the taller, industrial structures.

F.5 Operation Phase

Port Facility

The detailed end use of the port facility has not yet been determined beyond its use as an area for loading/unloading bulk materials. To accommodate possible future uses, the proposed port facility may meet the following minimum specifications:

- Steel sheet pile wall able to accommodate design vessel draft;
- Water services (domestic and fire);
- Sanitary sewer;
- Storm sewer;
- Electrical supply;
- Gas;
- Telephone;
- Lighting along roadway and dock lighting as required;
- Provision for a future 250mm diameter pipeline (liquid product) to site;
- Meet specified dock load limits (50 kPa within 12.2 m of the port facility face and 100 kPa beyond 12.2 m);
- Buildings (minimum 7,000 m^2 warehouse with office, suitable foundation and 3-4 domes);
- Dock surface (asphalt or concrete throughout);
- Minimum 10 m wide roadway to site;
- One rail siding onto site from HPA's main Pier 15 rail siding; and
- Landscaping to include treatments along access road and entrance features to site.

Figure F.11: Landscape – Landform Concept

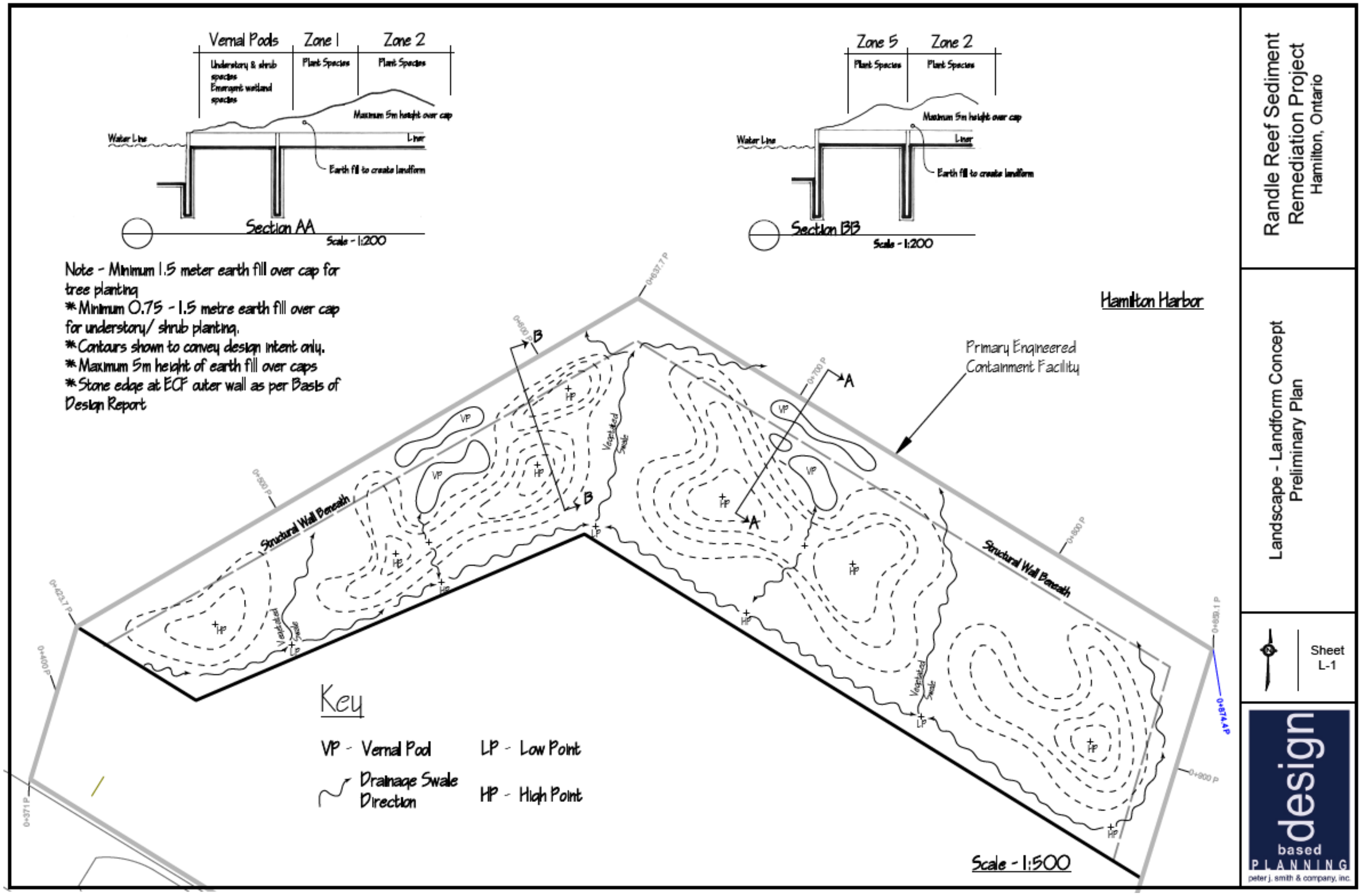
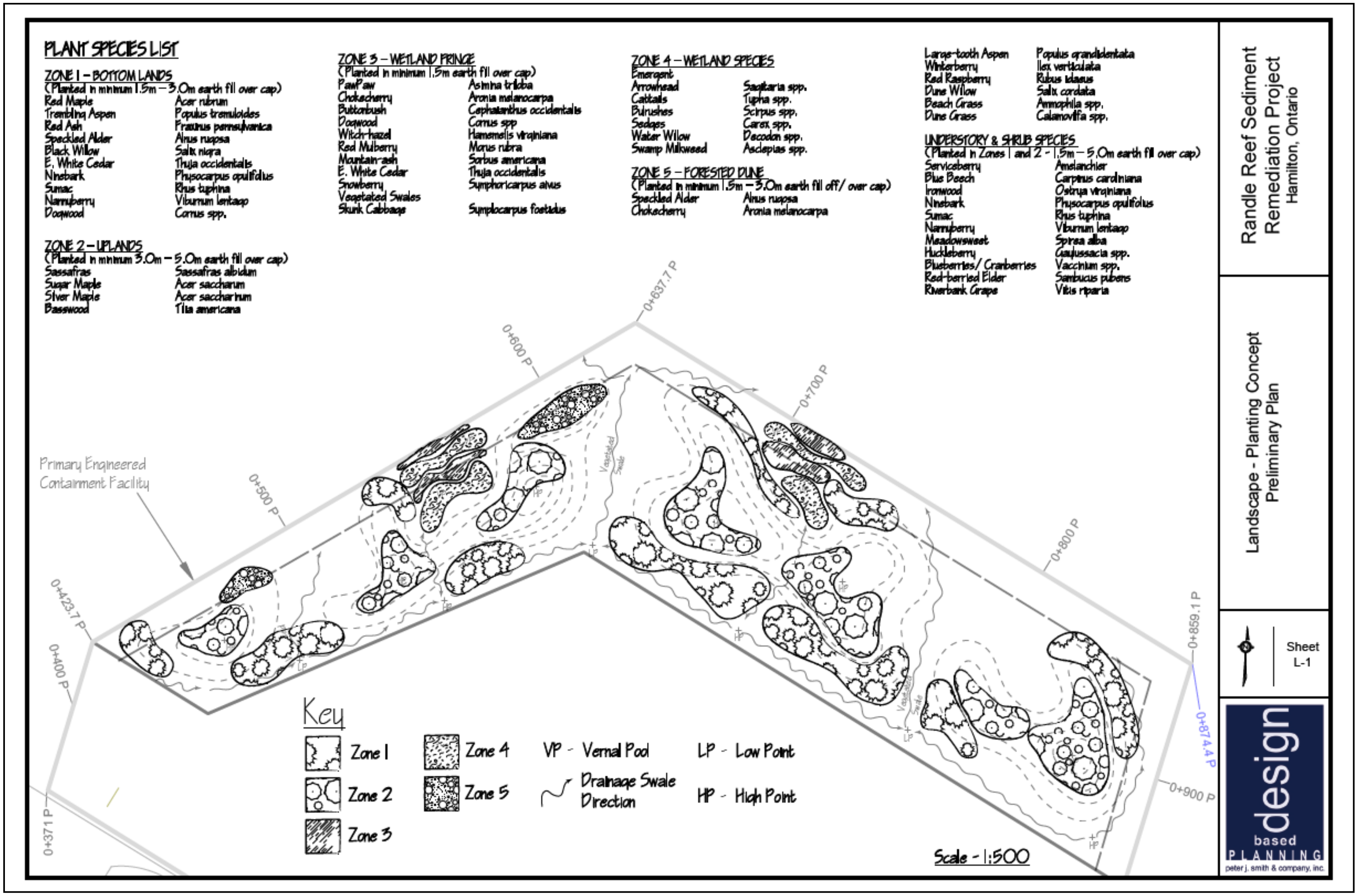


Figure F.12: Landscape Planting Concept



Placement of off-loaded or stored goods directly on the surface features of stormwater drainage system components such as catch basins should be avoided. These specifications will also accommodate the additional ECF consolidation predicted to be 0.15 m over 12 to 13 years.

Greenway

The greenway is designed to support a vegetative cover. As such, this area will not be used for port operations. Equipment within this area will be limited to that needed for maintenance of the cover. For safety, foot traffic will be limited to authorized personnel, and guard rails will be placed along the bayside perimeter at the edge of the vegetative cover to prevent foot traffic onto the riprap.

U.S. Steel I/O Channel

In order to protect the U.S. Steel I/O cap from erosion, as well as further limit potential impacts to water quality by reducing the potential for turbidity associated with vessel traffic and cap erosion, navigation in the channel will be limited as follows:

- only vessels required to maintain the SDW, U.S. Steel I/O structures, sediment cap and the ECF will be allowed to enter the channel;
- the channel will be maintained as a low-speed, no-wake zone;
- downward direction of propellers and/or thrusters will be prohibited;
- no spudding or bottom anchoring of vessels will be allowed;
- vessels will be required to fender and tie off to the SDW or ECF, depending on their purpose for entering the channel; and
- "no entrance" markers/buoys will be maintained at the entrance to the channel.

F.4.1 Use of the Marine Terminal

HPA has a mandate to develop and maintain the Port of Hamilton for shipping and navigation purposes. It invests in the development of facilities and vessel berths to facilitate cargo movement. The HPA and its tenants need to respond to the dynamic nature of the shipping market, and as a result, port properties are often used for handling/shipping various commodities in the course of any given year. Typical cargo handled on HPA properties includes liquid and dry bulk, various forms of steel (slabs, billets, rod, beams, plate, channels etc.), and project cargo (wind turbine parts, specialty plant equipment, etc.). Future operation of the HPA facility will be guided by the HPA Land Use Plan (2002) and is expected to be compatible with and typical of port operations in Hamilton Harbour. Upon completion of the ECF construction, HPA will operate the ECF as a marine terminal.

The development of the ECF is divided into two areas: (1) 5 ha marine terminal; and (2) 2.5 ha green space. The 5 ha marine terminal is intended for one or more of the following potential uses (stand-alone or in combination):

- open storage area for various port cargo;
- container terminal;
- staging area for railcars, trucks;
- berthing for marine equipment and vessels (tugs, barges, ships, ferries, etc.);
- loading/unloading of marine cargo; and/or
- other uses consistent with the above as may arise from time to time, consistent with the HPA Land Use Plan.

The 2.5 ha green space is designed to support a vegetative cover only. For more information on the maintenance and use of this green space is provided in Section F.4.

The potential environmental effects arising from such use of this marine terminal are predictable and easily mitigated by the established best management practices and the standard operating procedures in place at all HPA terminals. As with other operations within the HPA property, the operation of the ECF will comply with the environmental policies and regulations set forth by the federal and provincial governments. As a Canadian Port Authority (CPA), HPA expects a high standard of environmental management from its tenants. The HPA Land Use Plan not only speaks to the commitment of maintaining compliance with environmental regulations but that "it [HPA] will cooperate and consult with environmental agencies, including Environment Canada, Fisheries and Oceans Canada, the Ontario Ministry of Environment and local conservation authorities, when deemed appropriate or necessary". For further details on HPA policies on environmental management, refer to the HPA Land Use Plan which is available at: http://www.hamiltonport.ca/corporate/landuseplan.aspx.
The HPA's Draft Environmental Code of Practice is contained within the HPA Land Use Plan.

Based on the implementation of standard operating practices and established mitigation measures in place by HPA and its future tenants, the operation of this terminal as described will not likely have significant environmental effects on the surrounding areas.

Currently under CEAA, an EA is triggered by leasing of properties managed by a Canadian port authority. Once the end use and the potential land leases are sufficiently understood to identify a specific project, HPA, following its current practice, conducts a screening level assessment in accordance with the Canada Port Authority EA Regulations. This EA requires a clear definition of environmental effects specific to the proposed end use and the mitigation measures required to address such effects. It is anticipated that this practice will apply to future developments on the new marine terminal; however, future changes to CEAA and its associated regulatory processes may impose other review and approval requirements on these developments (i.e., when the leasing of properties is being contemplated). HPA will abide by the regulatory process in place at the time of the project under review.

International Maritime Organization, The International Convention for the Prevention of Pollution from Ships, 1973 (modified 1978), and the *Canada Marine Act* ensure that precautions are in place to prevent spills, and dictate the 'first response' to a spill. In the event of spill to Hamilton Harbour, the Canadian Coast Guard has delegated the responsibility of spill monitoring and reporting to the HPA (HPA, 2002). In addition, all spills are reported to the MOE Spills Action Centre. HPA is also a stakeholder to the Hamilton Harbour Remedial Action Plan (HHRAP) and supports the HHRAP's objective to "bring about sustainable natural ecosystems in Hamilton Harbour and its entire watershed, and to improve the potential for more extensive recreational uses while maintaining the Harbour's and the watershed's essential economic function." (Hamilton Harbour RAP Stakeholder Forum, 2002)

In addition, future leaseholders, depending on the proposed activity and the materials being handled, will be subject to Environmental Emergency (E2) Regulations under Part 8 of *Canadian Environmental Protection Act*, 1999. The E2 Regulations require implementation of environmental emergency plans prior to management of hazardous substances. Therefore, the proposed future uses of the facility will be assessed in relation to the management of substances that are covered by the E2 Regulations.

The ECF monitoring (see Section 11.0) will detect structural stability issues and/or containment concerns from the contaminated sediment within the ECF.

F.6 Maintenance and Repair

As the facility will be designed for a 200 year lifespan, a maintenance and repair program will be essential to maintaining the effectiveness of the ECF.

F.6.1 U.S. Steel Cap Maintenance Plan

Generally, no maintenance is expected to be required for the U.S. Steel I/O channel cap beyond the potential response actions resulting from a need to repair cap instability and/or contaminant containment issues associated with the cap. In the event the comparison of bathymetric data indicates significant changes in bathymetry are present, an additional follow-up hydrographic survey will be performed focusing on the area of concern. Significant changes in bathymetric elevation include more than 0.3 m (1 ft) of accretion (i.e., an increase in cap elevation) or a 0.15 m (6 inch) erosion of cap material, with accretion/erosion compared to the original post-construction cap bathymetry. After the follow-up survey, the data evaluation process will be repeated. If the follow-up hydrographic survey confirms the initial findings of significant changes in bathymetry, the following corrective actions will be implemented:

- in the event of accretion of sediment, no additional corrective actions are anticipated. Accretion of additional sediment will likely prolong cap service life by adding natural cap material over the sediment cap. Given the water depth, considerable sediment accretion would be required to impact the U.S.

Steel dockwall (SDW) and navigation for maintenance purposes in the U.S. Steel I/O channel;

- settlement monitoring platforms will be checked to evaluate the possibility that additional consolidation is responsible for the change in bathymetry, indicating potential erosion. If additional consolidation is not responsible for the erosional change in bathymetry, a volume estimate of the material required to restore the cap to the original post-construction bathymetry will be performed and original specifications and design drawings for the cap will be used to place additional cap material in the eroded area; and

- an assessment of potential causes of the erosion will be performed. The assessment will include review of U.S. Steel I/O flow records, review of navigation in the U.S. Steel I/O channel and an assessment of storm, wind, wave, ice and current conditions. Armour stone will be placed over the restored cap material if erosion is expected to recur based on the assessment of potential causes.

In the event NAPL indicators are observed in pore-water samples, or the pore-water contaminant concentrations exceed the predicted concentration by a factor of more than two and are within one-half the value of the associated PWQO (and/or CWQG), the following response actions will be implemented:

- field and laboratory documentation and QA records will be evaluated for possible bias in the analysis results;
- field measurements of pH, temperature and DO will be compared to previous measurements for possible changes in environmental conditions that could cause the increased pore-water concentrations;
- hydrographic survey and settlement monitoring data will be assessed to evaluate cap instability (e.g., erosion, more consolidation than expected in cap material or underlying native sediment) as a potential cause of increased pore-water contaminant concentrations/NAPL indicators;
- if these response actions do not resolve the issue, resampling and testing of porewater samples will be performed within 12 weeks of initial sampling (i.e., where problematic results were observed); and
- if these response actions do not resolve the issue, additional, more intrusive response actions will be implemented. These include collecting sediment cores and potentially modelling the cap conditions to determine the most effective way to mitigate the issue.

F.6.2 ECF Maintenance Plan

Groundwater

If elevated concentrations of constituents of interest are identified in groundwater between the steel sheetpile walls, mitigation measures would be implemented that would involve any or a combination of the following:

- temporarily increasing the frequency of monitoring to assess the mass flux of contaminants to the Harbour to quantify the degree of impact;
- identifying the source of the mass flux, likely through inadequate seals, and repairing by jet grouting or another method; and
- adding a source of solid sorbent carbon to enhance adsorption between the walls and further stimulate degradation of polycyclic aromatic hydrocarbons (PAHs).

If statistically significant increases in chemical concentrations or exceedances of PWQOs (and/or CWQGs) are observed during compliance groundwater quality monitoring, remedial actions to reduce the exceedances will be taken based on but not be limited to:

- re-sampling the well where the increase was observed to confirm the analytical results;
- increase the frequency of sampling of the well where the increase was observed;
- perform predictive groundwater modeling for the chemical of concern to evaluate the potential for exceedance of PWQOs (and/or CWQGs) at the point of compliance; and
- complete biological toxicity testing to evaluate the potential for environmental impacts to surface receptors.

If water elevations above the performance standards are observed during water-level monitoring, potential response actions could include but not be limited to:

- increase the frequency of pressure transducer water elevation recordings;
- perform predictive groundwater modeling for water elevations to evaluate the potential for exceedances of the performance standards to impact the ECF cap; and
- implement remediation techniques to prevent impacts to the cap.

If exceedances of PWQOs (an/or CWQGs) are observed during underdrain water quality monitoring, remedial actions to reduce the exceedances will be taken based on but not be limited to:

- re-sampling the underdrain sampling point where the increase was observed to confirm the analytical results;
- increase the frequency of sampling at the sampling point where the increase was observed;
- perform predictive groundwater modeling for the chemical of concern to evaluate the potential for exceedance of PWQOs (and/or CWQGs) at the point of compliance; and
- complete biological toxicity testing to evaluate the potential for environmental impacts to surface receptors.

Containment Walls

If survey/inclinometer monitoring indicates vertical movement of survey points on the exterior wall, response actions will include but not be limited to:

- for movement of 3 cm to less than 5 cm (1.2 to less than 2 inches): Inclinometer casing will be installed at additional locations near the locations where the deflection was measured for additional deflection monitoring of the walls that is not included in the initial inclinometer monitoring activities; and
- for movement equal to or in excess of 5 cm (2 inches): Structural and geotechnical engineers will review the data, determine a revised monitoring plan and develop a contingency plan, including potential rehabilitation alternatives to secure the wall before unacceptable deflections occur. Potential rehabilitation alternatives include rehabilitation of the sheetpile wall, restriction of surcharge loads, strengthening of passive support by buttressing, or other alternatives as defined in the contingency plan.

Depending on the extent of any steel corrosion, response actions are likely to involve repair (e.g., encapsulation) than replacement because corrosion is a gradual process.

ECF Cap

An aggressive pavement maintenance and repair schedule, including repairing defects when they occur, will be developed to keep the facility pavement from degrading beyond initial surface deflections and undergoing excessive damage.

If vegetation monitoring indicates that project standards have not been met, the following potential response actions may be implemented:

- replace plants that did not survive with a similar or hardier species; and
- perform non-chemical weed control.

F.7 Decommissioning Phase

As this facility will be operating indefinitely, decommissioning activities are not anticipated.

F.8 Project Schedule

The construction schedule is estimated to be approximately 10 years, from 2012 to 2021. The operational phase will continue indefinitely and it is not anticipated that the facility will be decommissioned.

Activity	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2021 and Beyond
Construction Phase											
Monitoring	■	■	■	■	■	■	■	■	■	■	
ECF Containment Walls	■	■	■	■							
In-Water Production Dredging				■	■	■					
U.S. Steel Sediment Cap						■					
ECF Capping						■	■	■	■	■	
Operation Phase											
Long-Term Monitoring											■
Maintenance and Repair											■
Decommissioning Phase											
None Anticipated											

F.9 Project Cost

The approximate total cost of the project is estimated to be $105 million. Table F.1 provides a breakdown of the estimated cost.

Table F.1: Project Cost

	APPROXIMATE COST
ECF Containment Structure	$39 M
Dredging & Sediment Management	$23 M
ECF Capping, Stelco cap and landscaping	$24 M
Project Management and Contracting	$15 M
Monitoring	$4 M
APPROXIMATE TOTAL COST	**$105 M**

F.10 Materials Used for Construction and Operation

A partial list of the resources and materials that will be used during the project is provided below:

- granular materials such as sand, silt, enriched total organic carbon, gravel, stone, reactive core mats, armour mats will be used for subaqueous capping;

- materials such as geotextile, geogrid and geomembranes will be used to prevent erosion, water seepage and to prevent cross contamination of materials;
- HDPE pipe will be used for cap drainage and well casings;
- soil, aggregate or taconite will be used for preload of the ECF cap;
- topsoil, plantings and riprap will be used for landscaping;
- asphalt will be used for paving;
- fuel will be used for vehicles and equipment;
- steel sheet piles will be used to construct the ECF walls;
- wick drains will be used to dewater the sediments placed within the ECF;
- sand, polymer, coagulant and granulated activated carbon will be used to treat the effluent from the ECF; and
- equipment for the ECF cap placement will include front-end loaders, bulldozers, graders, backhoes, skid steers, compactors, low ground pressure equipment and dump trucks.

F.11 Malfunction and Accident Scenarios

Potential short-term risks include accidental discharges of sediment contaminants during construction. As with any marine construction project, an additional consideration is accidental leaks of petroleum products during equipment fueling and maintenance. These risks will be mitigated by requiring that the contractor prepare a contingency plan before the work begins, by regular inspections of equipment and procedures, and by onsite deployment of a cleanup crew with personnel and equipment necessary to manage spills and leaks.

An additional short-term consideration is inadequate capacity for dredged material during construction. Inadequate capacity might result from under predicting the volume of dredged material or underestimating the time necessary for consolidation of sediment within the ECF. For both cases, contingency plans will be developed to address processing, transport and offsite disposal of excess dredged material, as well as temporary storage of dredged material while awaiting the consolidation of material already placed within the ECF. Frequent checks of dredged material volume in comparison to available ECF capacity will be made during design and construction to minimize the need for excess dredged material management.

Potential long-term risks associated with malfunctions and accidents primarily have to do with damage to the ECF and resultant adverse environmental impacts from releases of sediment contaminants. Damage to the ECF could result from heavy site use and harsh environmental conditions. Risks are also associated with larger-scale catastrophic events, such as seismic events and a rising lake level. Further, there are long-term risks of facility failure resulting from long-term “wear and tear” and structural fatigue.

Potential facility malfunctions that could result in releases of sediment contaminants to the environment and associated mitigation measures include:

- **Cap failure:** A breach of the cap would result in infiltration of precipitation and increased hydraulic head within the ECF, which in turn could result in an increased tendency for contaminants to migrate from sediment to surface water via available pathways. Annual cap inspections will be completed to evaluate any cap breaches and to determine the appropriate actions to mitigate this risk;

- **Sheetpile wall failure**: A breach of the sealed inner sheetpile wall because of corrosion or a more general structural failure would be expected to result in contaminant release. The sheetpile walls are being designed to withstand high loads typical of a port facility. The Operations Maintenance and Monitoring Plan will incorporate strict requirements to minimize the potential that port facility walls could be overloaded, with resultant structural damage. Annual sampling and laboratory testing of groundwater monitoring wells installed in the clean fill between the inner sealed sheetpile wall and the outer structural sheetpile wall will be used to evaluate the integrity of the inner wall. Additionally, periodic inspections of the ECF will include visual inspection of the outer structural sheetpile wall; and

- **Bottom confining layer failure:** Contaminants could migrate through the clay layer beneath the ECF and into the sediment and surface water outside the ECF. The monitoring wells installed around the ECF will include deeper wells screened in the clay. Corrective measures (e.g., a groundwater pump-and-treat system within the ECF) will be implemented if contaminants are detected and verified in the clay layer.

Potential accidents that could result in the release of sediment contaminants within the ECF to the environment include:

- **Navigation accidents, including ship impacts:** Port facilities associated with the ECF are hardened to withstand significant loads and impacts. Navigational aids will be developed and constructed to minimize potential vessel impacts;

- **Potential ice damage:** Hamilton Harbour ices over for the winter months. The facility will be designed to withstand ice impacts. Regular inspections of the exterior structural sheetpile walls will verify minimal ice damage;

- **Potential seismic damage:** The facility will be designed and constructed in accordance with Canadian seismic codes;

- **Waves – overtopping and structural damage:** The facility will be constructed to minimize overtopping damage associated with storm waves. The facility will be large enough to withstand storm wave damage to the exterior sheetpile wall; and

- **Changing lake level:** Increasing lake levels will be considered in the design. However, practical considerations require that the cap elevation be approximately equal to surrounding piers. Therefore, inundation of the facility will occur concurrently with inundation of surrounding piers.

F.12 Health, Safety and Environmental Protection

Within 15 calendar days following the Notice to Proceed, the Contractor will be required to submit a Remedial Action Work Plan (RAWP). The RAWP will contain the following elements:

- Project Work Plan;
- Contractor QC Plan (including a Sediment Verification Field Sampling Plan/Quality Assurance Project Plan (FSP/QAPP), an Import Material FSP/QAPP, a Structure Tolerances Report and a Borrow Site Characterization Report);
- Remedial Action Health and Safety Plan (including a Health and Safety Training Program and a Health and Safety Awareness Program);
- Environmental Protection Plan (including a Water Quality Monitoring FSP/QAPP, a Background Water Quality Monitoring Report, a Fish Salvage Plan, an Air Quality Monitoring Plan and Contingency Plan);
- Dredging and Disposal Plan;
- Project Construction Schedule; and
- Settlement Monitoring Plan.

During the construction phase, the following documentation will be submitted:

- Daily QC Report (including Daily Dredging and Disposal Report, Daily Filling and Capping Report, Daily Material Quantities and List of Utilized Equipment);
- Weekly QA Report;
- Sheetpile Wall Closure Report and As-built Drawing;
- Monthly Water Quality Monitoring Report;
- Monthly Air Quality Monitoring Report;
- Hydrographic and Topographic Survey Report; and
- Post-Dredging Verification Sampling Report.

After completion of construction activities, the Contractor will be required to submit the following items:

- As-Built Drawings, Manuals, and Certificates; and
- Pre-Final Punch List (i.e., consolidated list of items to be completed or corrected after inspection).

F.13 Construction Phase Monitoring

Monitoring for environmental parameters, in addition to construction-related parameters, will be conducted throughout the project. In some cases, background/site specific criteria will be used to determine compliance and in others, regulatory criteria will be used. This section is broken down into the four main types of monitoring that will be conducted during the construction phase of this project:

- Air Quality Monitoring;
- Water Quality Monitoring;
- Other Environmental Quality Monitoring; and
- Construction Monitoring.

F.13.1 Air Quality Monitoring

The purpose of the air quality monitoring program is to provide an ongoing assessment of the air quality during construction activities. The objectives of the air quality monitoring program are:

- to document ambient conditions (background) prior to construction activities and during construction activities;
- to confirm that air quality parameters (i.e., polycyclic aromatic hydrocarbons [PAHs] and benzene, toluene, ethylbenzene and xylene [BTEX]) in the vicinity of the construction site do not exceed prescribed limits; and
- to guide the contractor in modifying construction activities, as necessary, to protect the receiving air environment.

The results for the above parameters will be compared to the point of impingement (POI) limits for acute exposure and ambient air quality criteria (AAQC) for chronic exposure provided in *Ontario Regulation 419/05, Air Pollution – Local Air Quality*. Monitoring will also ensure compliance with worker exposure limits as outlined in the *Ontario Occupational Health and Safety Act.*

Air quality monitoring during construction will occur at the following locations:

- at background points outside the active work zone to establish current background conditions; and
- at off-site points downwind of the construction area.

Proposed monitoring zones will be oriented radially around each construction activity and will migrate with the activity. The radial monitoring point distances are under development at this stage, however, at each monitoring location, air quality parameters will be measured at 1.8 m (6 ft) from the ground surface.

The air quality parameter naphthalene will be measured in situ. Naphthalene samples will be collected by a real-time monitoring analyzer. The real-time monitoring analyzer will be used to measure naphthalene for comparison to the action levels and POI limits.

Air quality parameters will be collected every minute, stored on the analyzer and transmitted hourly to a webpage or database.

Air samples will also be collected for analysis of PAHs and benzene, toluene, ethylbenzene and xylenes (BTEX) for comparison to AAQC. These samples will be collected once a week.

Background conditions will be established on a regular basis by measuring field air quality parameters at a location outside of the construction area. Collection of background data will begin one week before the start of in-water construction activities and will continue to the end of gravity settling of decant water in the ECF. Compliance monitoring will occur at the off-site points at the start of dredging and will continue through capping of the ECF.

F.13.2 Water Quality Monitoring

The objectives of the water quality monitoring program are:

- to document ambient conditions (background) prior to construction activities and during construction activities;
- to confirm that turbidity (a water quality parameter) in the vicinity of the construction site does not exceed prescribed limits;
- to guide the Contractor in modifying construction activities, as necessary, to protect the receiving water environment;
- to provide continuous visual monitoring during construction for the presence of sheens and distressed or dying fish or wildlife; and
- to ensure effluent being discharged from the ECF meets the applicable criteria for discharge directly to the Harbour (compliance monitoring).

General water quality monitoring during construction will occur at the following locations:

- at background points outside the active work zone to establish current background conditions;
- at sentinel points within the zone of expected construction impact (downstream/downgradient of the construction area); these locations will be approximately half the distance between the construction and the compliance point; and
- at compliance points within the zone of expected construction impact.

Water quality monitoring during in-water construction activities will be conducted to confirm that water quality meets the surface water criteria outside the immediate vicinity of the construction activity. Although localized disturbances cannot be avoided, one purpose of water quality monitoring is to demonstrate that these disturbances are not extensive and are below specified threshold levels. General water quality monitoring will be performed in accordance with MOE's *Evaluating Construction Activities Impacting on Water Resources Part III B* (1994a).

Water quality monitoring will consist of the following elements:

- startup monitoring;
- performance monitoring; and
- compliance monitoring.

Water quality parameters will be collected by sondes deployed at sampling stations.

Startup Monitoring

Startup monitoring will be performed to verify consistency of actual effluent parameters with the values predicted by the model and bench-scale testing and to confirm that effluent quality meets the discharge goals. Startup monitoring samples will be analyzed for the following parameters: pH; total suspended solids (TSS); turbidity; total metals (arsenic, cadmium, chromium, copper, lead, nickel, silver, and zinc); and PAHs. Startup monitoring samples will be collected from ECF Cell 2, the final settling cell, the sand filter effluent and the granular activated carbon (GAC) effluent.

Performance Monitoring

The purpose of performance monitoring is to collect ongoing data to optimize water management and recontamination control. Monitoring will be conducted using real-time monitoring for turbidity. Generally, monitoring during construction will occur at background points outside the active work zone to establish current background conditions and at sentinel points within the zone of expected construction impact (downstream/downgradient of the construction area). Background conditions will be established on a regular basis by measuring field water quality parameters at a location outside of the construction area. Collection of background data will begin one week before the start of in-water construction activities and will continue to the end of in-water construction activities.

Sentinel points will be located approximately half the distance between the construction and the compliance point. Water quality parameters measured at the sentinel point are not required to meet compliance criteria but will be used by the Contractor to evaluate the effects of the construction activities on water quality, so that adjustments can be made before consequences become widespread.

Monitoring zones will be oriented radially around each construction activity and will migrate with the activity. The radial monitoring point distances are currently under development, however, at each monitoring location, water quality parameters will be measured within 1.8 m (6 ft) of the sediment surface. Visual inspections will also be conducted for the presence of NAPL, oils, slicks and sheens at the surface and mitigation measures will be employed (oil booms, skimmers, etc.) during construction and dredging. Depending on the placement methods selected, water quality monitoring may also be required at shallower depths during placement of the subaqueous cap in the U.S. Steel I/O channel.

During performance monitoring, turbidity will also be continuously measured at the final settling cell effluent point, the sand filter effluent point and the GAC effluent point using in-line turbidity meters. The ECF and final settling cells will also be observed for presence of films, sheen and discoloration or odour. In addition to turbidity measurements, during dredging of the most contaminated sediments or during final filling, surface water grab samples may be collected for analysis of pH, TSS, turbidity, total metals and PAHs.

Compliance Monitoring

Compliance monitoring will be performed to confirm that treated effluent released into Hamilton Harbour meets water quality requirements during both initial and production dredging.

Compliance samples from the ECF effluent will be analyzed for the following parameters: pH; TSS; turbidity; total metals (arsenic, cadmium, chromium, copper, lead, nickel, silver and zinc); and PAHs. These parameters will be compared to the Ontario PWQOs. It should be noted, however, that background water quality conditions for Hamilton Harbour are currently being established and may replace the PWQO criteria if deemed appropriate. Compliance samples will be collected from the GAC effluent and will be performed on a weekly basis for the duration of treated effluent discharge.

Compliance monitoring will also occur at the sentinel and compliance points at the start of sheetpile driving and will continue through completion of sheetpile driving. The compliance point is required to meet applicable water quality compliance criteria at all times during construction.

F.13.3 Other Environmental Quality Monitoring

Additional environmental quality monitoring proposed during construction is described below:

During Dredging Operations

Post-dredging verification sampling will be performed to confirm that residual contaminated sediment and exposed native sediment surfaces meet sediment quality compliance criteria. If verification sampling after first-pass dredging indicates the sediment criteria have not been met, second-pass dredging will occur; sediment samples will be collected from 0 to 10 cm (0 to 4 inches) below sediment surface (bss) and there will be at least one sample per 0.25 ha (1/2 acre).

Sediment removal accuracy will be monitored during dredging using hydrographic surveys conducted at regular intervals, at a minimum of every two weeks.

The hydraulic pipeline will be monitored for leakage by monitoring unexpected pressure drops along the line and by periodically inspecting the pipeline (at least twice per day) along both floating and submerged sections for leaks or damage.

Any barges or scows transporting or storing contaminated materials will be monitored for leakage.

Capping U.S. Steel I/O Channel

The chemical and physical characteristics of the capping material must be verified as appropriate for its intended use. Documentation certifying compliance with grain size and TOC content will be required. One sample per 1,000 m^3 (1,300 cy), about five samples total, is recommended for grain size analysis/curves and TOC measurement. Additionally, the material should be certified as non-detect for organic sediment contaminants and concentrations of metals in cap soils should be provided. The monitoring and detection levels for the organics and metals in the cap will be outlined in future specification documents (i.e., Construction and Maintenance Monitoring Plan and Operations and Maintenance Monitoring Plans).

In general, the Environmental Protection Plan will contain separate sections addressing contamination prevention, containment and cleanup, erosion and turbidity control, sound level control, air pollution and dust control, water quality monitoring and contingency plans as they pertain to the following construction activities:

- installation of sheetpiles;
- dredging;
- transportation of dredged sediment;
- disposal of dredged sediment;
- Stelco I/O channel capping;
- ECF capping; and
- habitat area construction.

F.13.4 Additional Construction Monitoring

Proposed additional construction monitoring is described below:

Perimeter Double Sheetpile Wall Construction

Materials specification testing and inspection both during and after installation of the sheetpiling, support system (e.g., tie-rods) and quarry rock fill. Typical topics include monitoring and survey control, installation and placement documentation, integrity and seep testing, visual inspections and deflection monitoring for the sheetpiling using inclinometers and survey techniques.

During Dredging Operations

The real-time flow rate of dredged material in the hydraulic pipeline will be monitored over the duration of the project. The flow rate of material into the ECF is critical to the ECF sediment management and effluent management.

Inclinometer monitoring will be combined with survey techniques to monitor any movements of adjacent structures during either dredging in proximity to existing structures or filling near structures.

Placement of Dredged Material in ECF

The Contractor will perform a pre-filling hydrographic survey. Filling progress and elevation accuracy will be evaluated through hydrographic surveys conducted at regular intervals. Verification of the placement of dredged sediment to the design elevation will be confirmed through these hydrographic surveys.

Hydrographic surveys will also be performed within the ECF at the end of each dredging season.

It is proposed that pore pressure transducers or other instrumentation will be installed during filling. These piezometers will allow measurement of changing elevations or changing fluid pressure as the ECF and underlying sediment undergo consolidation and settlement.

Capping U.S. Steel I/O Channel

Pre-cap and post-cap hydrographic surveys will be performed to monitor placement accuracy during capping. The surveys will be performed before and after each lift of capping material is placed to establish the cap thicknesses and extent.

As a check, the volume of cap material and extent of the capping area over which the capping material is distributed will be recorded and compared to the volume calculated via hydrographic survey.

Bearing Layer Installation (for Wick Drains)

The bearing layer installation includes material specifications testing, material delivery, handling and storage and installation testing and inspection for the geotextile, geogrid and earth material to be used. Visual inspection and survey control will also be required. Post-installation testing will be required to verify design thicknesses and load capacities prior to wick drain installation.

Wick Drain Installation

Wick drain installation includes material specifications testing, material delivery and handling and storage for the vertical wick drains to be used. Installation testing and inspection and survey control will also be required to verify that the wick drains are installed at the specified locations and required depths.

ECF Cap Installation

ECF cap installation includes material specifications testing, material delivery and handling and storage of the geosynthetics and earth material. Installation and post-installation testing and inspection and survey control will also be required to verify that the cap location and thickness and field seaming of the geosynthetics are per the requirements of the ECF cap design. This also includes initial monitoring data from settlement plates, which will be available during construction.

Pre-cap and post-cap topographic surveys will be performed. Placement accuracy will be monitored during placement of material layers. Topographic surveys will be performed before and after each lift of capping material is placed to establish the cap thicknesses and extent. Verification of the accuracy of placement to design elevations will be confirmed through these surveys.

Settlement plates will be installed relatively early in ECF cap construction and will undergo survey monitoring daily during ECF cap construction.

Preload Placement, Removal and Final Grading

Preload placement, removal and final grading includes material specifications testing for the earth material to be used and installation testing and inspection to verify that sub-grade preparation and material placement and compaction requirements are met. In addition, post-installation testing and inspection will be required for survey control to verify thicknesses, elevations and dimensions for the transition from the port facility to the greenway. After preload removal, survey control will also be required to verify final design grades.

Habitat Area

Hydrographic and topographic surveys will be performed in addition to utilizing specialized equipment controls to ensure that habitat materials are satisfactorily placed to the elevation and thickness specified in the contract Plans. Surveys will be completed for hydrographic in-water areas and topographic areas above the waterline.

The chemical and physical characteristics of the fill material must be verified as appropriate for its intended use. If placement of fill occurs in water, water quality monitoring will be performed as described previously.

F.14 Long-Term Monitoring

As this project involves creation of an engineered containment facility, the facility itself will need to be monitored to ensure it is functioning properly. Similarly, the U.S. Steel cap will also require monitoring over the long term. Any dredged areas where a thin layer sand cap was implemented will also be monitored to confirm natural recovery is taking place.

F.14.1 U.S. Steel Cap Monitoring

The proposed long-term monitoring for the U.S. Steel Cap consists of the following:

Hydrographic surveys: Hydrographic surveys will be conducted following construction at years 1, 3, 5, 10 and 15 to evaluate the cap's overall stability. Additional hydrographic surveys will be performed after storms that include 100 year (or greater) return frequency for wind speed and wave height in addition to accidents/mishaps, (e.g., unauthorized navigation in the U.S. Steel I/O channel that could result in scour/erosion of cap materials). Monitoring would be performed as soon as is safe and practical after extreme events.

Settlement monitoring: Cap settlement monitoring will be used to evaluate differential settlement and the potential for damage to the cap. Settlement monitoring will be based on measurements at settlement monitoring plates installed in sediment underlying the cap and in the sand with silt and enriched total organic carbon layer. Data from the hydrographic surveys will be used in combination with settlement plate data to evaluate cap settlement. Settlement monitoring measurements will be collected immediately after construction, six months after construction and at years 1 and 2 after construction.

If these measurements indicate consolidation/settlement is continuing at two years after construction, the need for additional settlement monitoring will be evaluated.

Porewater concentrations of sediment contaminants: Pore-water sampling and analysis will be used to evaluate the effectiveness of the cap for containing sediment contaminants and limiting the migration of the sediment contaminants through the cap to surface water. Porewater concentrations of sediment contaminants will be sampled by collecting samples from seepage meters installed in the cap. It is expected that divers will install the seepage meters, purge water from the meters prior to each sampling round, and collect the samples. Seepage meters will target porewater collection from an intermediate depth in the cap (approximately 30 cm (ft)) and from near the cap surface, to compare intermediate and shallow depths cap porewater chemistry. Pore-water samples will be collected immediately following construction completion to establish baseline conditions, then yearly following construction for years 1 to 5 and every two years for years 7 to 15. Samples will be collected in April, following ice melt. Based on observed results following years 1 to 15, sampling will occur every five years until year 50. The schedule for additional monitoring will be evaluated following year 50, based on monitoring results collected to that point.

NAPL intrusion: The presence of NAPL will be evaluated by visually inspecting samples withdrawn from seepage meters for NAPL, including immiscible layers, droplets, and/or sheens. Additionally, pore-water sampling trips will include a visual assessment of surface water in the U.S. Steel I/O channel for indications of NAPL. This will take place on the same schedule as that described in *Porewater concentrations of sediment contaminants* above.

F.14.2 ECF Monitoring

Maintenance and monitoring related to capping, grading, and stormwater management include the following:

<u>Surface</u>

Habitat area monitoring: Habitat area monitoring will consist of surveying import material elevation and plant monitoring. Plant monitoring will be conducted to ensure adequate growth and continued cover of the ECF habitat area. The plant monitoring includes a once-a-year, one day visit by a qualified biologist/technician to the habitat area in years 1, 2, 3, and 5. These visits will begin immediately following completion of the habitat area construction. Erosion should be repaired as quickly as possible. The riprap placed for wave protection should be inspected after major storm events.

Paved surface monitoring: The paved surface will be monitored for settlement using periodic surveys. While proper design can reduce the need for maintenance and repairs, these activities will still be necessary.

Inspection of the stormwater management system: Catch basins and storm chambers will need to be evaluated for sediment buildup within the system. Periodic removal of sediments may be needed to maintain the infiltration treatment aspect of the system.

Monitoring the sheetpile structures for deformation: The deformation of the sheetpile wall will be measured as settlement, deflection (rotation about a fixed point on the sheetpile wall cross section), or a combination of both. Deformation monitoring of the sheetpile wall structure will be accomplished using surveying techniques and vertical inclinometers. Inclinometers will initially be placed along the port facility walls and U.S. Steel-facing wall at a spacing of 50 m (165 ft). It is likely that the frequency of monitoring will transition from quarterly to annually over time, as long as the data show no signs of deflection.

Monitoring the sheetpile structures for corrosion: The structural condition of the ECF exterior walls will be based on visual inspection with qualitative descriptions of steel corrosion or strength loss (minor, moderate, major, and severe). The structural conditions assessment will include diver inspection of the submerged zone of the exterior wall at the following frequency, beginning with completed wall construction: years 1, 3, 5, 10, 15, 20, 25 and 30, with a re-evaluation of the recommended inspection frequency after each inspection, and particularly at year 30.

Monitoring movement of adjacent structures and settlement of ECF cap: This includes monitoring for potential settlement or horizontal movement of existing structures adjacent to the construction activities. Surveys will be performed by a licensed Ontario Land Surveyor in accordance with accepted standards and in accordance with the Plans and Specifications. The frequency of survey monitoring will likely be quarterly for the first years of operation and then decrease if trends continue to show little to no movement.

Monitoring of Existing Structures: Depending on the end use of the port facility, structures will be constructed to meet the HPA's commercial needs for the port operations. This will require structures such as warehouses, storage areas, rail lines, and other features. These structures will undergo survey monitoring at the foundations as part of the survey program. Critical structures will undergo periodic structural conditions assessment or focused structural inspection, depending on the particular structure and its function. Monitoring parameters, monitoring locations, monitoring schedule, data evaluation, potential response action, and documentation will be determined once the end use of the port facility is decided.

<u>Subsurface</u>

Groundwater contaminant monitoring: Four groundwater wells located between the double walls, both at the midpoint and close to the walls, will provide early detection in the event of contaminant migration from dredged materials in the ECF to pore water in the space between the walls. Monitoring is likely to occur at years 1, 2, 5, 10 and 20, and will then be re-evaluated for future monitoring needs.

Groundwater level monitoring: The objective of water-level monitoring is to evaluate if water levels in the ECF have risen to the point of impacting the ECF cap. Ten piezometers installed in the dredged materials will be used to monitor groundwater levels within the inner ECF walls. Pressure transducers will be installed in the monitoring wells and will record data every half hour. These data will be downloaded monthly.

Under-drain water quality monitoring: The objective of underdrain water quality monitoring is to protect water quality in adjacent surface water from contaminants that could potentially migrate in underdrain water from the ECF. The program includes the collection, analysis, and interpretation of underdrain water quality data from four underdrain sampling points installed in the ECF. Underdrain water quality samples will be collected annually.

F.14.3 General Environmental Monitoring

Seven studies have been identified and initiated to assess the effectiveness of the clean up of Randle Reef. These studies have been conducted before remediation and some will be conducted during remediation. These studies will be conducted again after the construction of the ECF and dredging are completed. It is anticipated that these studies will demonstrate that the remediation of Randle Reef has been successful.

The studies include the following:

Evaluation of Chemical and Stable Isotope Tracers: The objective of this study is to provide a measure of the quality of particulate in the water column and sources of contamination. Contamination arising from re-suspended coal tar-contaminated sediments (such as those found at Randle Reef) can be distinguished from contamination entering the Harbour from other sources, such as the air. Stable isotopes will differentiate the sources of PAHs through characteristic isotope fingerprints.

Characterization of Sediment Toxicity and Benthic Invertebrate Communities: The objective of this study is to examine the spatial extent of contamination initially, and to determine: (a) impacts of Randle Reef sediment removal; and (b) recovery of benthic conditions (e.g., to conditions meeting delisting criteria). This study provides an overall assessment of sediment contamination based on biological sediment guidelines according to Environment Canada's BEAST methodology. This assessment may use species level and not family level identification to document benthic recovery using the BACI (before after control impact) design.

Quantitation of Haemocytic Leukemia in Caged Bivalves: The objective of this study is to assess potential long term problems, as well as to document eventual health improvements. This study is based on findings from previous studies where strong correlations were found between anthropogenic inputs, such as pulp mill effluent, municipal wastewater and steel plant effluents with the incidence of Haemocytic leukemia.

Assessment of Embryo-larval Deformities in Caged and Laboratory Fish: The objective of this study is to determine the potency of the Randle Reef sediments prior to, during, and after site remediation. Spinal curvature and heart edema are found in larval fathead minnows exposed at egg stage to PAH-contaminated sediments. Chemical analysis of sediments and SPMD extracts will relate the patterns and concentrations of PAHs and PCBs present to effects on fish embryos.

Genetic and Reproductive Endpoints for Caged Fish and Second Generation Inherited Effects: This objective of this study is to link sub-cellular changes at the DNA and chromosome levels with meaningful, whole organism effects. It will also determine whether the types of damage observed might have adverse consequences for the next generation of fish. Contrast with the fish health data from the post clean-up phase will reveal the benefits for fish health of the remedial action.

Evaluation of Wild Fish Health: The objective of this study is to evaluate the effects of Randle Reef sediments on the health of indigenous fish prior to and post remediation.

Fish Tumor Study: The objective of this study is to evaluate tumor incidence in fish within the Hamilton Harbour AOC. It is proposed that the follow-up studies will evaluate the success of the project in terms of tumour incidence.

SUPPORTING DOCUMENT G

Public, Agency and Aboriginal Engagement and Consultation Materials

Table G.1: Project Advisory Group Meetings

Meeting #, Date and Location	Purpose of Meeting	Items Discussed	Key Comments / Discussion
Meeting # 1 October 17, 2001 City of Hamilton Parks Department Boardroom	• to establish the PAG and review logistics, to identify roles and commitments and to outline a draft work plan with intended accomplishments • PAG will assist in identifying and reaching consensus on a preferred remedial option in conjunction with public review and environmental assessment	• purpose of the meeting • project background (including summary of remedial options developed in 1996) • objectives of the PAG • PAG role • business conduct • work plan • other business • next meeting dates	• members requested a clear definition of the PAG role in order to provide focus • where the group fits into the process beyond the environmental assessment was an item to be further discussed
Meeting # 2 November 19, 2001 Macassa Bay Yacht Club, Hamilton	• to present information on the history of the project, project overview, remedial alternatives and environmental assessment	• meeting summary (October 17, 2001) • project history and objectives • remedial alternatives • environmental assessment process • PAG workplan update • stakeholder objectives • other business • next meeting date and location	• membership and roles were reviewed and confirmed • technical advisors will be asked to participate in specific sessions • questions raised included: ⇒ what is the distance or depth required to reach clean sediment? ⇒ why does an uneven bottom exist ⇒ regarding previous objections to the sinter plant option, has any review or study been completed to follow-up on the legitimacy of oppositions ⇒ to assist in the selection remedial options, is there a feasibility index to indicate levels of success or achievement ⇒ what are the budgetary limits? • options for dealing with contaminated sediments were described under three categories: in-situ; ex-situ; and natural recovery
Meeting # 3 January 14, 2002	• to review and confirm the objectives of each of the stakeholder groups and to explain in more detail	• meeting summary (November 19, 2001) • stakeholder objectives	• project objectives and performance objectives for the project were reviewed

Meeting #, Date and Location	Purpose of Meeting	Items Discussed	Key Comments / Discussion
Macassa Bay Yacht Club, Hamilton	what each of the proposed remedial alternatives involves • to learn more about the characteristics of the target sediment zone and the status of sediment surveys and analysis undertaken by the Ontario Ministry of the Environment	• characterization and description of the targeted sediments • MOE sediment survey – status • dredging and de-watering sediments • disposal and treatment options ⇒ dispose of sediments as a hazardous waste ⇒ treat sediments and dispose as a non-hazardous waste ⇒ treat sediments and process through sinter plant ⇒ treat sediments for re-use as commercial/industrial fill • in-situ option – contained dyke facility • work plan • short-term control options • other business • next meeting date and location	• stakeholders provided objectives prior to the meeting • objectives from BARC, the Hamilton Beach Preservation Committee and the Hamilton Port Authority were reviewed, along with additional project and performance objectives that were identified • characterization and description of the targeted sediments – it was noted that areas with PAH-Naphthalene concentrations of 700 ppm to 800 ppm will be critical for costing; additional sampling may be required in the outlying areas • MOE sediment survey – it was noted that further testing will also be conducted on dredged sediments to determine appropriate steps and procedures for reuse, treatment and/or disposal; the results will impact some of the management options • disposal and treatment options – worker safety, monitoring, environmental protection at the conditioning site and ambient levels of off-gases were raised; air concentrations will be monitored; dust control will also need to be addressed; it was noted that it appeared that the sintering process was profiled in greater detail than any other option and that the other options presented should have included similar levels of detail; specifications for the control of emissions and their capture are needed • total estimated costs were queried for dyking, moving, dredging, removing, treating and containing the sediments at the Northern Wood Preservers site

Meeting #, Date and Location	Purpose of Meeting	Items Discussed	Key Comments / Discussion
Meeting # 4 February 11, 2002 Macassa Bay Yacht Club, Hamilton	• to update the list of stakeholder objectives and to review and assess the following remedial alternatives: remove and dispose of sediments as a hazardous waste; remove and treat sediments and dispose as a non-hazardous waste; remove and treat sediments and process through sinter plant; remove and treat sediments for re-use as commercial/industrial fill; in-situ alternative – contained dyke facility	• meeting summary (January 14, 2002) • short-term control measures • MOE sediment survey – status • remedial options • stakeholder objectives • assessment of remedial options ⇒ remove and dispose of sediments as a hazardous waste ⇒ remove and treat sediments and dispose as a non-hazardous waste ⇒ remove and treat sediments and process through sinter plant ⇒ remove and treat sediments for re-use as commercial/industrial fill ⇒ in-situ options – contained dyke facility • other business • next meeting date and location	• an assessment of the remedial options against the project objective, project "generic" management objectives and performance objectives was reviewed
Meeting # 5 February 18, 2002 Macassa Bay Yacht Club, Hamilton	• to continue to compare remedial alternatives, while considering stakeholder objectives	• meeting summary (February 11, 2002) • remedial option – contained dyke facility update • compare remedial options and stakeholder objectives • next steps • other business	• an assessment of the remedial options against the project objective, project "generic" management objectives and performance objectives was reviewed • another objective was added → meets RAP goals and objectives
Meetings # 6 and 7 April 8 and 9, 2002 Macassa Bay Yacht Club, Hamilton	• to discuss the pros and cons of the five remediation alternatives and to narrow down the remediation alternatives to one or two preferred alternatives	• meeting summary (February 18, 2002) • update overview of remediation options • written responses from stakeholders • selecting an option ⇒ proposed approach ⇒ pros and cons of remediation options ⇒ narrowing down the options • next steps • other business	• the pros and cons of the following options were discussed and analysed: ⇒ dredge, de-water and direct disposal in hazardous landfill ⇒ dredge, de-water, treatment and disposal in industrial landfill ⇒ dredge, de-water, treatment to industrial/commercial land criteria (MOE) and disposal or re-use as industrial fill

Meeting #, Date and Location	Purpose of Meeting	Items Discussed	Key Comments / Discussion
			⇒ dredge, de-water, treatment and recycling in sinter plant ⇒ confined disposal facility, sediment isolation • written responses from stakeholders were reviewed → Hamilton Beach Preservation Committee, Bay Area Restoration Council, Hamilton Conservation Authority, Local 1005 (United Steelworkers of America), City of Hamilton, Great Lakes United, Central/North End West Neighbourhood and North End Neighbourhood Association, Hamilton Port Authority, City of Burlington, Stelco and Department of Fisheries and Oceans • the pros and cons of the remediation options were reviewed • further comments on sediment removal and sediment containment were noted • based on the comments and the range of options, there was little support for the sinter plant option • the sinter plant as a process was considered a viable re-use option from technical and scientific viewpoints but health, safety and handling concerns were raised by Local 1005 • the containment option appeared to be favoured • infilling was considered a sensitive issue to be balanced with a compensatory approach • preferences for the other three sediment removal options (hazardous waste landfill, non-hazardous waste landfill, industrial fill re-use) fluctuated from most to least preferred
Meeting # 8 April 24, 2002	• continuation of discussions from April 8 and 9, 2002	• meeting summaries (April 8-9, 2002) • closing discussion of preferred option	• a chart of stakeholder preferences was distributed for review – stakeholder groups were asked to

Meeting #, Date and Location	Purpose of Meeting	Items Discussed	Key Comments / Discussion
Macassa Bay Yacht Club, Hamilton	• to narrow down the list of options to one or two preferred options	⇒ review of stakeholder preferences ⇒ updates from stakeholders ⇒ consensus for preferred option • next steps • other business	verify the status of their preferred options • closing discussions were undertaken to continue the process of identifying a preferred option • stakeholders presented updates to their perspectives on the options • the majority of the PAG stakeholder groups reached consensus on recommending containment and a confined disposal facility (about 7.5 ha) as the preferred option – it was favoured by a number of stakeholder groups and acceptable by others • Great Lakes United could not support the decision due to an earlier resolution against the establishment of confined disposal facilities in the Great Lakes basin – however, in-situ containment may be acceptable to Great Lakes United • it was clearly stated that PAG wants to deal with all materials greater than 200 ppm as a whole Harbour solution • engineering and design details will need to be undertaken to optimize containment in the smallest footprint possible
Meeting # 9 December 9, 2002 Macassa Bay Yacht Club, Hamilton	• to present the conceptual designs for the containment/ECF alternative for discussion, comment and suggestions so that a preferred design may be selected	• project status as of PAG meeting April 24, 2002 • Harbour sediment assessment – update • containment facility – conceptual design options ⇒ conceptual designs ⇒ design features • whole Harbour context – compensation opportunities • next steps • other business	• since the last PAG meeting, Acres and Associates Limited was contracted to develop the conceptual design with the PIT • from three options that were developed for the all-natural and mixed-use alternatives, variations of the multi-use concept were further analyzed • the recommended conceptual design consists of a peninsula attached to Pier 16 (Stelco dock) in addition to a triangular extension to Pier 15 (McKeil Marine) for a total area of about 9.5 ha • it was noted that about 5 ha of the proposed

Meeting #, Date and Location	Purpose of Meeting	Items Discussed	Key Comments / Discussion
			peninsula structure would be required for a commercial port facility, along with the triangular extension of Pier 15 • opportunities to compensate for area and volume displacement were presented
Meeting # 10 June 12, 2007 Hamilton Chamber of Commerce **Meeting of PAG and PIT**	• to provide a project update, as well as an update on the engineering design work, the comprehensive study report and the schedule	• project update • comprehensive study report update and proposed schedule • engineering design update • Sydney Tar Ponds animation video • questions and answers	• engineering design work is currently underway and will be completed by May 2008 • environmental assessment work and partnership negotiations that are underway must be completed prior to tendering and construction, which is anticipated in 2008/09 • sections of the comprehensive study report have been prepared – additional input will be incorporated • opportunities for public comment will be provided both prior to and after submission of the comprehensive study report to the Canadian Environmental Assessment Agency • the engineering design chronology includes the Basis of Design Report (completed May 2006), final design, drawings and specifications and tender documents • design tasks focus on various geotechnical, structural, dredging, groundwater, air, capping, Stelco channel, hydraulics and landscaping components • air emission modeling, testing and analysis are being conducted to ensure worker safety and public safety • it was noted that an animation video will be prepared for the Randle Reef project • specific questions raised and responses provided

Meeting #, Date and Location	Purpose of Meeting	Items Discussed	Key Comments / Discussion
			are documented in Table 10.2
Meeting # 11 October 28, 2008 Hamilton Chamber of Commerce	• to provide an update on the status of the Randle Reef project and to provide details on engineering and environmental assessment work • to prepare for the public open house scheduled for November 18, 2008 – comments from the PAG will be used to refine public open house presentations and display panels	• introduction/opening remarks • project overview • CEAA process overview • EA overview • engineering design overview • environmental effects and mitigation measures overview • comments, questions and answers	• a web site hotline would permit people to stay connected to the project (response: a framework has been established; in the short-term, some pages will be posted on the HPA web site) • if some disaster were to strike (i.e., ramming structure by a freighter), would the rock be the final stop between the contaminants (response: yes) • will the EA report be provided to the public? (response: a public open house will be held in November 2008 as an opportunity for the public to provide comments on the project; once the EA report is submitted to the Canadian Environmental Assessment Agency, there will be an opportunity for public comment) • various comments/suggestions were made on the presentations regarding how to improve, what to include and what to emphasize • various comments/suggestions were also made on the display panels which were available for viewing at the PAG meeting

Table G.2: Questions Raised and Responses Provided – June 12, 2007 PAG and PIT Meeting

Item	Question Raised	Response Provided
Randle Reef Animation Video	Has a target audience been identified?	An animation video is planned to be produced at a basic level intended to inform the general public. The video could also be used as an educational piece for students or as a briefing item for senior management and other interest groups. As an additional resource, the video will complement various fact sheets.
	Will the Sydney Tar Ponds animation video or another similar version be used for Randle Reef?	A separate video will be produced specifically for Randle Reef.
Environmental Assessment	Is there a clear step-by-step process for determining what Certificates of Approval are required under provincial legislation?	Reviews were conducted to determine whether there is a legislative requirement to issue Certificates of Approval under either the *Environmental Protection Act* or the *Ontario Water Resources Act* for various aspects of the project. The review assessed whether the proposed project design triggers any legislative requirements for C of As. There will be a subsequent review conducted if the final design for the project differs from the proposed design such that the legislation would then trigger requirements for a C of A.
	When does the need arise for a provincial environmental assessment?	The need for a provincial environmental assessment is project-specific and outlined in legislation. For the Randle Reef project, a MOE review was conducted to determine whether a provincial EA would be required. It was determined that a provincial EA was not required, given the exemption provided for remedial or clean-up activities carried out by MOE. Depending on the final design, another provincial review may be carried out to re-assess whether any new or different elements of final design for the project would require a provincial EA.
	Why does this project not need a provincial	The process and the project have been reviewed by

Item	Question Raised	Response Provided
	environmental assessment?	MOE. There is no current legislative requirement for a provincial EA for this project. The project is subject to a federal EA as per federal legislative requirements. Future reviews may be conducted to re-confirm if any new or different project elements outlined in the final engineering design would require a provincial EA.
Engineering Design	How high will the facility measure from below the surface to above the Harbour?	The structure will be approximately 35 to 40 ft at its deepest location. The finished grade will be similar to adjacent lands. The length of the sheet pile walls will vary in length. The longest one will measure approximately 75 ft. The range of depth from the mud to the top of the pier ranges from 8 to 30 ft. Where the sheet pile wall is in the clay, it will measure a depth of approximately 70 ft.
	After capping, who will own and operate the land?	The Hamilton Port Authority will be the long-term manager of the facility and 9.5 ha site.
	Why limit greenspace to only a third of the property?	Through the consultation process, there were multiple objectives. One objective was to have a greenspace and a mixed-use facility. The new area may also help to compensate for loss of fish habitat.
	Why not have more port lands or slips? Perhaps the greenspace should be utilized for more cargo space in order to increase revenue for the HPA. Comments?	Through the consultation process, there were multiple objectives. One objective was to have a greenspace and mixed-use facility. The new port lands will create opportunities for partnerships and funding.
	Is it possible for greenspace to thrive in an industrial area?	The main objective was to deal with multiple interests, which explains why one third of the design focused on a naturalized component. Through the consultation process, greenspace was considered an attribute and as an item of interest needed to be addressed.
	Will public access be available and, if so, has security been considered?	In light of current security measures under strict directives, the greenspace will not be accessible by

Item	Question Raised	Response Provided
		the public.
	I seem to recall that public access would be provided. Comments?	That is one recollection. Potential for public access will need to be properly defined and rationalized. Previous comments on public access will be followed-up on through the RAP Office. It is important to note that the PAG started before the 9-11 tragedy and since that time security around the Harbour has changed significantly.
	If public access is denied, perhaps it may be useful to consider eliminating the greenspace and downsizing the ECF. Comments?	Alternatives for sizing were considered. Economy of scale was a factor. Potential for public access in terms of a vista may have been discussed but as the project design evolved, the most appropriate considerations for access, practicality and security were incorporated. Separately at Sherman Inlet, the Hamilton Conservation Authority and the Hamilton Port Authority are leading an initiative to examine opportunities for naturalization and public access.
	What is the projected service life?	A 200 year service life was identified through the PAG process, which is typically the timeframe desired.
	Has an emergency plan been developed?	Yes. An on-going monitoring and maintenance plan and a risk management plan have been developed as part of the engineering design to prevent and respond to emergencies.
	The $ 90 million price tag accounts for structural requirements and for stabilizing materials but is the cost dependent on the final use?	Yes, costs differ depending on final use but are not a significant factor.
	Will any of the dredged material be exposed to air during the dredging process?	Dredge material may be exposed to the air for a very brief period of time. The majority of the dredging will occur through a pumping process underwater (hydraulic dredging). Concerns can be managed. No

Item	Question Raised	Response Provided
		problems are anticipated.
	To what extent will [surface water] current modeling affect the structure?	Expert staff at the National Water Research Institute considers the structure to be so small that any impacts would be minimal. Modeling will continue.
	How confident is the cost estimate considering it is based on a 30 percent design? Is there a contingency?	At 30 percent design, a range exists around that number. The number was developed a couple of years ago based on experience from comparable projects. Cost reductions may be possible through optimization. Dredging projects are usually calculated with unit costs, which are fairly accurate. The comfort level with costs is good but wild cards do exist, such as steel costs. A 20% contingency was factored in.

Table G.3: Summary of PIT Meetings

Meeting #, Date and Location	Purpose of Meeting	Items Discussed	Key Comments / Discussion
November 13, 2003 Hamilton Port Authority Boardroom	• to provide an update of the advancement of the project and to introduce key players	• welcome and introductions • detailed engineering design study (introduction of team, study phases and status, study schedule) • comprehensive study report (scoping document, schedule) • DFO – fish compensation • other items • closing remarks	Detailed Engineering Design Study • a great deal of public concern has been expressed for the Randle Reef project; BARC would be interested in examples of other projects and information on the movement of contaminants within the facility • work has started to determine dredge locations • on October 16, 2003, the Hamilton Conservation Authority passed a resolution to support the Randle Reef project Comprehensive Study Report • confirmation that the provincial *Environmental Assessment Act* does not apply to this project is needed • press coverage on the Randle Reef project will be documented in the comprehensive study report • potential effects on fish habitat as a result of the project will be evaluated through a series of four steps – no major issues are expected DFO Fish Habitat Compensation • in terms of the fish compensation ratio, the model will look at the situation with no contamination and then discount values
November 17, 2004 Ontario Ministry of the Environment Boardroom, Hamilton	• to provide an update on the various components of the project	• welcome and introductory remarks • preliminary engineering study (facility design, project schedule) • benefits study • comprehensive study report • DFO fish habitat compensation • other business	Facility Design • PAH figures reported apply to the Randle Reef study area only; total Harbour wide PAH numbers are not consolidated but may be useful to the community • water circulation patterns will be taken into account to ensure significant changes do not occur,

Meeting #, Date and Location	Purpose of Meeting	Items Discussed	Key Comments / Discussion
		• closing remarks	to ensure fish are prevented from entering Stelco's water intake, to utilize any opportunities for improving fish habitat and to identify potential benefits for other project enhancements • the Basis for Design Report will be used to receive feedback on design alternatives; a comprehensive set of evaluation criteria will be developed, and is essential for development and selection of a preferred alternative • analysis for environmental risk, service-life and design-life are standard requirements; water quality objectives are also considered • examples of positive experiences in the U.S. in terms of long-term integrity of facilities of this nature will be provided for public reference <u>Benefits Study</u> • cost savings, infrastructure and image are categories of interest where accurate measurement will be difficult to quantify • assessing the impact of Hamilton's image is important; project impact must be considered; the cleanup of Hamilton Harbour sediments and delisting of the Area of Concern will deserve international attention once complete; promotion is imperative if Hamilton's image is to change • for comparison, impacts and outcomes of cleanup efforts in other locations will be examined <u>Comprehensive Study Report</u> • a provincial EA is not required • a presentation was made to the First Nations and a letter of support has been received • engineering tendering documents will follow the

Meeting #, Date and Location	Purpose of Meeting	Items Discussed	Key Comments / Discussion
			Minister's decision • a Great Lakes funding initiative intended to support cleanup efforts is under review • the opportunity for public input at the conceptual stage is essential • it will be important to share success stories with the public to build integrity • the Comprehensive Study Report scoping document is posted on the GLSF and HPA websites at www.sustainabilityfund.gc.ca and www.hamiltonport.ca; it will be sent to BARC to post as general information on the BARC website DFO Fish Habitat Compensation • a great variety of fish has been observed recently at the Stelco outfall area
February 16, 2006 Ontario Ministry of the Environment Boardroom, Hamilton	• to provide an update on the status of the project with a presentation and discussion of the on-going detailed engineering study • updates on fish compensation opportunities, the economic benefits study and indicator studies were also provided	• welcome and introductory remarks • preliminary engineering study (facility design, next steps, project schedule) • indicators study • DFO fish compensation • benefits study • Sydney Tar Ponds – areas of mutual interest • other business	Costs • escalated costs of $90M are expected to raise public concern; cost effectiveness and appropriate spending of the $90M estimate will likely be queried; cost comparisons will be needed to satisfy public interest • initial estimates focused on a much smaller sediment volume of 20,000 m^3 versus current 600,000 m^3 • less than $5M deals with Stelco accommodations; the only accommodation regards the offset from the wall, which is a matter of respecting Stelco operating requirements • costs are itemized between primary and secondary containment cells and dredging; estimates include contingencies; cost effectiveness of building a secondary ECF versus enhancements to the primary ECF are being considered; design

Meeting #, Date and Location	Purpose of Meeting	Items Discussed	Key Comments / Discussion
			efficiency elements for optimization opportunities are being explored so costs will vary • each stage will require a review of cost effectiveness due to the project span • large-scale project costs of Randle Reef are comparable with similar projects • the potential for Stelco to provide steel through in-kind contributions should be considered Public Concern • public interest expected to focus on escalated costs • public inquiry is anticipated on the relation of PAH burdens to the entire Harbour versus the Randle Reef project site; since the scale of the project has increased dramatically from the original proposal concerning 20,000 m^3 of sediment, impacts to delisting will be of interest; completion of the Randle Reef project solely will not provide entire delisting status • local residents were concerned previously on transporting contaminants through local neighbourhoods Stelco Concern • previous concerns expressed by Stelco workers at the sintering plant focused on air quality; potential air quality impacts will need to be communicated with Stelco union representatives to ensure that ample information is available to Stelco workers; a project update and comparison of options by BBL should be provided to PAG members for information Water Flow

Meeting #, Date and Location	Purpose of Meeting	Items Discussed	Key Comments / Discussion
			• a hydrodynamic model is important in the preliminary design stage for examining water flow, circulation, stagnation and Stelco requirements; wave climate, water circulation and velocity do impact opportunities for habitat modification and will be reviewed; opportunities to calm wave climate will be considered depending on the design and shoreline profile <u>Lifespan</u> • the design life is planned for 200 years <u>ECF Floor</u> • concerning a floor in the containment facility, the worst contaminated sediments are located within the footprint and will not have to be dredged; contaminated sediments within the Randle Reef study area will be placed within the ECF and capped; a sufficient barrier addresses any groundwater contamination concerns; a layer of clay underlying the site will further limit migration <u>Capping</u> • the cap is intended to shed water; a composite of materials will include asphalt, gravel and fill; asphalt is considered the best surface for intended long-term use; storm drains will be incorporated; a membrane at the upper surface will require annual maintenance and monitoring; construction of the cap is intended for diverse long-term uses <u>Monitoring</u> • groundwater monitoring wells will be included; frequency will be determined and reviewed as

Meeting #, Date and Location	Purpose of Meeting	Items Discussed	Key Comments / Discussion
			necessity stipulates Intermediate Design • at the intermediate design phase, satisfactory completion of the environmental study report will be required before moving forward Secondary ECF • the intent of the secondary ECF is to contain lower concentrations of contaminated sediments Maintenance • maintenance will be required over the entire 200-year lifespan; HPA will be responsible for maintaining the general area, however, new responsibility for maintenance of additional uses will need to be addressed; ideally, natural maintenance should be encouraged in terms of regeneration; revenue generation to cover maintenance costs will be an item of interest to the HPA Options • a landfill option is extremely costly so would be difficult to consider due to volume DFO Fish Habitat Compensation • a naturalized shoreline will be important for creating fish habitat • habitat compensation options will vary; in addition to terrestrial ideas, accommodations for beach or wetland interests can be incorporated but would significantly increase complexity and costs; wetlands require hydrated soils; beaches require

Meeting #, Date and Location	Purpose of Meeting	Items Discussed	Key Comments / Discussion
			special coastal and slope stability considerations; expert advice from a landscape specialist on the design aspects of a naturalized shoreline should perhaps be explored; opportunities to optimize community interests should be considered • dimensions and surface area of the containment configuration will be required by DFO to run a habitat modeling exercise; calculations on habitat losses and compensatory estimates will be necessary for detailing naturalization plans; further design details pertaining to environmental ecological restoration are still to be completed <u>Benefits Study</u> • it will be important to identify indicators that can be measured over time in order to ground-truth the model

Table G.4: Summary of Comments - June 11, 2003 Public Open House

Item	Comments	Action in Response to Comments
General Comments	• great presentation – well done • the posters were very informative and easily accessed; they contained just enough information; hope that another open house will be held when the project is further along • presentations and presenters were excellent; wish there was a new technology (like radiation)	• no action required
Comments in Favour of the Project	• appreciate the efforts to reach agreement on this project; approve of the partnership, commercial use and naturalization; a very positive step to solve the long-term worrisome situation; congratulations to all involved • in favour of cleaning up Randle Reef and making it open green space and environmentally clean; do not oppose any commercialization; keep up the good work with the Remedial Action Plan • believe that this is the best solution with the least disruption • poster boards very good; this is a very large project and it will be interesting to see if the many affected parties can come together and raise the required funding; there were a number of senior government representatives present, which lends significant moral support to the project; the proposed final remediated area design is attractive and should be a win for all parties • on the whole, the advantages outweigh the disadvantages – just get it done! • very interesting project, well worthwhile; think the funding issues need to be addressed soon or all this work will be for nothing	• no action required

Item	Comments	Action in Response to Comments
	• proposed solution is innovative and well thought out; hope that we can attract political support to make it happen • the project selected seems to be the most viable and realistic option; personally think it to be the best choice; make sure the contaminated sediment can be cleaned up later and the natural structure and form of the Harbour can be restored • like the concept; keeps all the contaminated material in the Harbour; appears to be well contained; equipment for additional dredging appears to be state of the art; more economical and just as effective as other options; combining greening of shoreline with commercial use is excellent land use practice for the Harbour • agree with the idea of stabilizing contaminants in-situ rather than relocating; like the green potential; should consider soil mixing of the site to solidify the sediments and entomb then in cement on location; good momentum, just keep pressing forward • essential to the health of Hamilton Harbour to remediate Randle Reef contaminated sediment site; eager to see a solution to the problem; the preferred capping option will isolate the contamination and have a larger footprint, and allow a more complete solution; filling in the Harbour at this site will improve the environmental health of the Harbour; that the preferred option will combine environmental improvements and provide a commercial use is another example of how Harbour stakeholders work through a difficult problem and find win-win solutions; expecting senior levels of	

Item	Comments	Action in Response to Comments
	government and local partners to fund this key project • project has merit and deserves support from all levels of government • congratulations; it is a worthwhile project; thank you for your efforts to take care of our environment; success with your project! • informative; questions were answered; making the right choice as to what process to use in cleaning up the Harbour; wish they could do it sooner • notion of "contain and cap in place" shows potential if the harmful carcinogens can be effectively isolated; risks associated with handling contaminated sediment above (and below) the waterline will at least be minimized by moving the relatively less-contaminated material and depositing it in the containment area, reducing the number of steps involved; proposed peninsula could have certain commercial and even aesthetic advantages • plan appears reasonable, financially viable and realistic; also provides an opportunity for the Port Authority to participate in a manner which provides a revenue-producing pier to offset the substantial cost to contain the toxic materials; simply dredging the site does not seem to be truly possible; congratulations to all involved groups for a job well-done	
Comments Against the Project	• excellent displays; hopefully you will excavate (dredge) and remove • totally against any infilling of Harbour areas • Great Lakes United cannot support the containment and ECF option	• no action required • position of Great Lakes United noted • Sections 5.0 to 7.0 provide detailed documentation regarding the consideration of alternatives and the development of the preferred alternatives for the

Item	Comments	Action in Response to Comments
		project • the majority of the PAG stakeholder groups reached consensus on recommending containment and a engineered containment facility as the preferred option
Other	• some concerns remain as to the mixture of contaminated sediments and dispersal during the transfer into the containment area or discharge back into the Bay • please address the issues that "could" occur to residents on Northshore Blvd. West; please pass on information to proper authorities that Stelco (and probably others) continue to pollute (air pollution) during the night time hours when no contact can be made with the Ministry of the Environment to report this • if the taxpayer is paying for all or most of clean-up, then all the area should be open to the public; pursue those who contaminated the Bay – it is not an accident that the two toxic hot spots are beside the coke oven and by-product areas of Stelco and Dofasco • final assessment should include criteria and evidence about the cumulative impacts of the proposal on water quality (e.g., assimilative capacity) and aquatic life in the Bay (e.g., cold water fish species) given the consistent infilling of the Bay over time; final assessment should include criteria and evidence to demonstrate that the current proposal is safer to human health than the removal, treatment and destruction of PAHs	• potential effects on water quality and aquatic life, as well as potential cumulative effects, are addressed in Section 9.0 • relative to access, public access is something not suitable for HPA property due to concerns for public health and safety; there are no plans to incorporate public access as part of the project • the governments of Canada and Ontario promote the "polluter-pays-principle" as a priority; in the case of Hamilton, the pollution can be traced back over 100 years to businesses operating legally at the time and/or to companies that no longer exist; this is why it is important for federal, provincial and municipal governments, along with community members and local industry, to work together to clean up the site; appropriate environmental monitoring will continue into the future to ensure the site is not re-contaminated; there are currently no on-going sources to the area which would prevent moving forward with remediation at this site

Table G.5: Summary of Comments - November 18, 2008 Public Open House

Item	Comments	Action in Response to Comments
General Comments	• strong support with the proposed solution in an expedient manner; while the proposed solution is not perfect, believe that there is no perfect solution that can be practically accomplished within the desired delisting timeframe	• no action required
	• very supportive of the project but feels that the steel industry needs to be pushed hard to contribute and to take action on air pollution	• no action required
	• impressed by information presented	• no action required
	• is this migration of tar residue continuing to be fed by the steel companies?	• no
	• in 1949, I fished for pike in the Harbour; could catch fish up to four feet; there was a lot of turbulence around Stelco [now U.S. Steel]; after dropping an anchor, the anchor came up black; what is the highest peak of the three hills of Randle Reef?; how deep are the contaminants?	• the bathymetry is very detailed and recent; many cores were taken in close proximity to the intakes in the Priority 1 area; the borings were deep, although exact depth and location could not be provided at the meeting, it is believed that the contaminants are a couple of metres down
	• where is the steel coming from?; can it be shipped in or trucked in?; can the rock be trucked or shipped in?	• steel for the inner wall will be Waterloo barrier • steel can be shipped • rock may also be shipped to reduce truck traffic
	• what do you expect will be required after the 200 years?	• advances beyond the 200 year life of the facility can be anticipated • sheets can be replaced if corroded; other measures can be taken to construct a new structure, if required • a monitoring and maintenance plan will be implemented to extend the service life of the facility as much as possible
	• when are comments due?	• December 31, 2008
Timeline	• remain concerned about having this project completed in time to meet the delisting target of	• no action required

Item	Comments	Action in Response to Comments
	2015; with that in mind, request that every effort be made to accelerate the project such as performance incentives for contractors	
	• if the project is to be completed by 2019, does this mean that delisting would be postponed	• by 2015, approximately 95% of the targeted sediments will be removed and contained within the ECF • from 2015 to 2019, activities will include capping and green space and port facility construction
	• will there be performance clauses to ensure contractors do not fall behind timelines to ensure delisting is achieved	• it is expected that Public Works and Government Services Canada will implement a measure such as this
	• were other schedules and equipment examined to optimize the timeline	• an optimized timeline has been developed • a contractor may make other suggestions to expedite the timeline
Funding	• previous feedback from the HPA and Mayor suggested that funding agreements would be in place this month; timeline now shows April 2009 for completion; please explain this delay and what can be done about it	• no action required • the timeline presented at the Public Open House is the most realistic view on funding, at this time
	• would be surprised if the funding mentioned in the meeting will be forthcoming in the current financial climate	• no action required
	• why is so much public money going into remediating a situation created by an industry that is entirely responsible for this condition?	• the site is a priority for remediation in the Hamilton Harbour RAP and under the Canada-Ontario Agreement Respecting the Great Lakes Basin Ecosystem
	• what certainty can be provided to ensure that funding will be available from all levels of government?	• a committee has been formed to address funding • Environment Canada has committed $30M, MOE has committed $30M and $7M will come from the HPA • the HPA and the City of Hamilton will lead an exercise to acquire the remaining funding from local stakeholders

Item	Comments	Action in Response to Comments
		• groups being approached include U.S. Steel for in-kind steel, the City of Burlington and other local stakeholder groups are also being approached for funding or in-kind
	• how old is the budget?; how current is the $90M figure?	• the cost estimate was prepared in June 2008; there will be a number of factors affecting the final cost, including the price of steel and fuel • the cost estimate will be revisited when the project moves towards implementation
Leakage Monitoring	• how will the ECF be monitored for leaks?	• ECF monitoring will include monitoring the sheetpile structures for deformation and corrosion • deformation monitoring will be accomplished using survey techniques and vertical inclinometers • monitoring of the structural condition of the ECF exterior walls will be based on visual inspection with qualitative descriptions of steel corrosion or strength loss (minor, moderate, major and severe) • the structural conditions assessment will include diver inspection of the submerged zone of the exterior wall • monitoring wells will be installed between the double walls to provide early detection of any contaminant migration • piezometers will be installed in the dredge material to evaluate if water levels in the ECF have risen to the point of impacting the ECF cap • water quality from the under drain system will be monitored to protect water quality in adjacent surface water from contaminants that could migrate from the ECF
Safety of Dredging	• concerned about the safety of the dredging of contaminated sediment from around the area; will this not create an air emissions hazard when the	• an air quality monitoring program will be in place to provide an on-going assessment of the air quality during construction

Item	Comments	Action in Response to Comments
	sediment is exposed to air?; this would affect the workers at the site especially, but also the general public; what specific safety measures are in place to prevent this from happening?	• the objectives of the air quality monitoring program are: to document ambient conditions prior to construction activities and during construction activities; to confirm that the air quality parameters in the vicinity of the construction site do not exceed prescribed limits; and to guide the contractor in modifying construction activities, as necessary, to protect the receiving air environment
Provision for Reopening	• should that "silver bullet" actually surface in the form of an effective, safe way to treat the sediment, can the ECF be opened for this purpose?; the project team should continue to be open to solutions such as that proposed by Envirofix, but should not derail or slow down the current project by doing so	• yes, there is provision for the consideration of future technologies
Blind Channel	• a concern was raised in earlier years about the creation of a blind channel and a fish trap in the area of the steel company water intake; has any design come forward to alleviate that concern?	• a plan is currently being developed, and will be implemented as part of the project, to address this issue
Migration Rates	• what sort of migration rates of organics or metals will occur through the thin cap layer?	• contaminant concentrations in the area are low (less than 100 ppm PAH), so migration through the cap is not a concern
Access	• how long will construction affect access to Pier 14 and possibly Pier 15?; ship repairs need to continue; will there be limited access?; will there be a major or minor effect and for how long?	• measures will be taken to minimize impacts • work will proceed within a specific timeframe to protect fish spawning and migration • areas may be closed off to prolong the construction season • work will proceed in consultation with harbour officials to minimize navigational impacts during construction
Dredging	• will major dredging occur on the east face of Pier 14	• there will be some dredging at this location

Item	Comments	Action in Response to Comments
Opposed to Project	• the project, as presented, is a colossal waste of money; it is nothing more than an expensive engineering solution designed by an American company to fill in 7.5 ha of Hamilton Harbour; this will create more docking space for ships and a sports field close to the U.S. Steel site; in terms of docking space, there is plenty which has not been used for years, and in terms of sports fields, there are larger areas of abandoned lands closer to the city core which could be converted more easily; the $90 million which this project is anticipated to cost could be much better spent on the city's infrastructure • this project will do nothing to improve water quality in the Harbour, which is primarily a problem of bacterial contamination from combined sewers; the reef could easily be covered with loose rock, slag from the steel mills, and similar materials at a fraction of the cost; over the last 150 years or so, approximately 500 ha, or one third of the Harbour area, have already been filled in at little or no cost to the public purse; such infills continue at present along other parts of the Harbour shore, especially the east side; no improvement of the water quality has come from such infills, more likely than not, the opposite is true	• no action required

You are invited to the...

Randle Reef
Sediment Remediation Project

OPEN HOUSE

WEDNESDAY, JUNE 11, 2003
2 to 5 p.m. and 6 to 8 p.m.

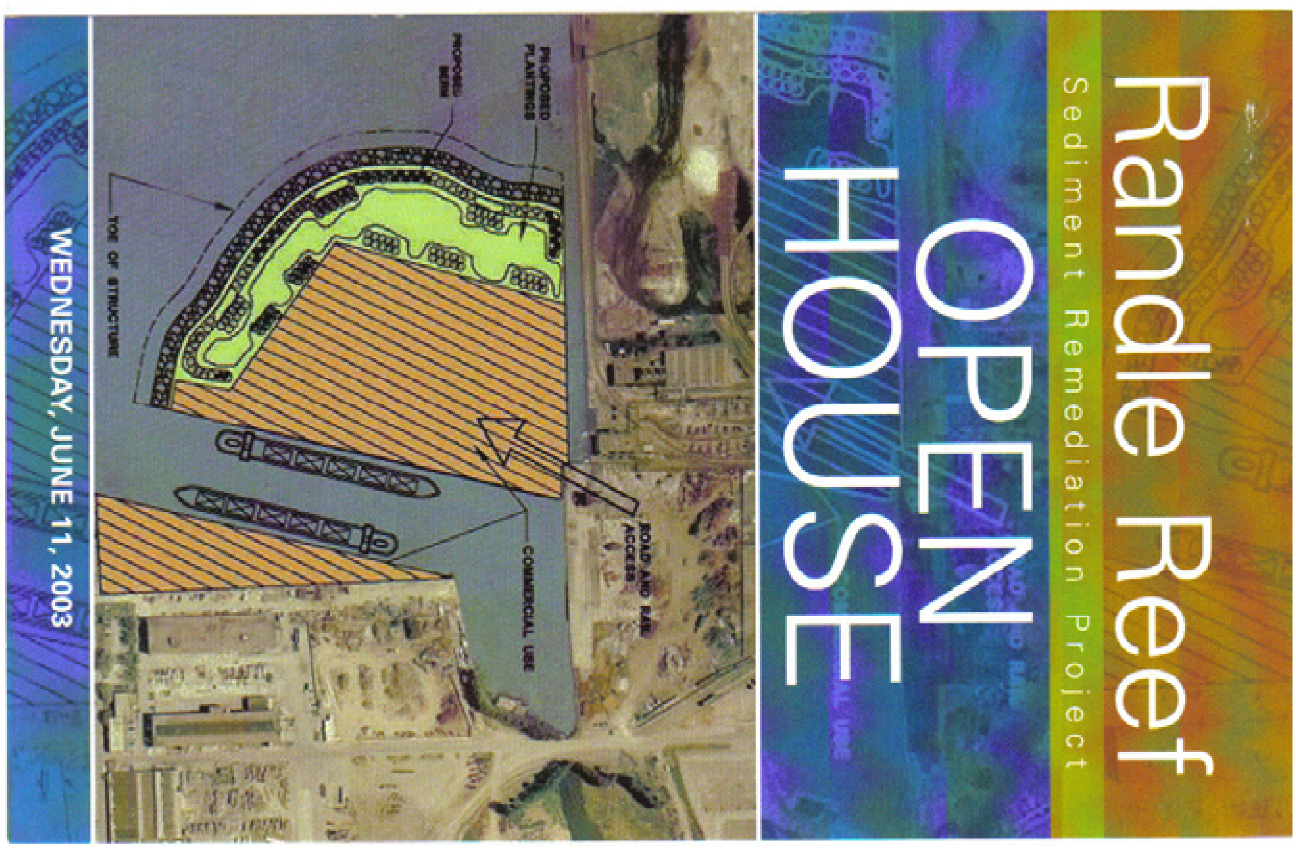
LIUNA STATION
360 James Street North, Hamilton

Learn more about the preferred option to solve the contaminated sediment problem near the south shore of Hamilton Harbour at Randle Reef.

This project is a key component of the Hamilton Harbour Remedial Action Plan. For more information, call (905) 527-7111

www.hamiltonharbour.ca

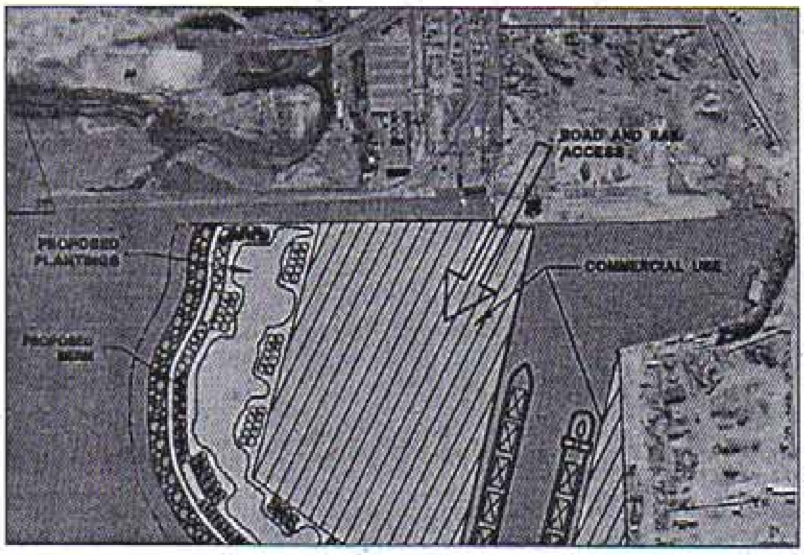
Bay Area Restoration Council
Life Sciences Building - B130F
1280 Main Street West
Hamilton ON L8S 4K1



PUBLIC NOTICE

Randle Reef Sediment Remediation Project

OPEN HOUSE



Members of the public are invited to learn more about the preferred option to solve the contaminated sediment problem near the south shore of Hamilton Harbour at Randle Reef.

The Open House will take place on Wednesday, June 11, 2003 at the Liuna Station, 360 James Street North, Hamilton, Ontario. The Open House times are 2 to 5 p.m. and 6 to 8 p.m.

Information about the scope and time-line of the preferred option, the conceptual design of the engineered containment solution, the habitat compensation proposals, and environmental assessment process will be available for viewing.

For more information about the open house, please contact the Bay Area Restoration Council at (905) 527-7111.

SPORTS NEWS

TO SUGGEST A STORY FOR THIS PAGE, CONTACT MARK CRIPPS AT 905-664-8800 EXT. 230

29 • WEDNESDAY, JUNE 11, 2003 • STONEY CREEK NEWS

PUBLIC NOTICE

Randle Reef Sediment Remediation Project: Open House

Members of the public are invited to learn more about the preferred option to solve the contaminated sediment problem near the south shore of Hamilton Harbour at Randle Reef.

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For more information about the open house, please contact the
Bay Area Restoration Council at (905) 527-7111

Too Good to Miss

June 10, 2003

D8

For events taking place in Hamilton, submit items in writing to Linda Ricciardi, The Spectator, 44 Frid St., Hamilton L8N 3G3, e-mail lricciardi@thespec.com or fax 905-521-8986. Deadline is one week prior to publication.

Good Causes

Participation House is looking for volunteer gardeners to assist adults with physical disabilities in the greenhouse, and help with indoor and outdoor gardens. Call Volunteer Hamilton 905-523-4444.

Al-Anon meetings are available seven days a week throughout Hamilton, Burlington, Stoney Creek, Dundas, Ancaster and Flamborough. Share experience, strength and hope in dealing with alcoholism. Visit the Web site at http://al-anon.alateen.on.ca or call 905-522-1733.

Canadian Calorie Counters, Branch 763, will meet from 6:30 to 8 p.m. tomorrow at Millgrove United Church, 370 5th Concession Rd. W. Millgrove. Visitors welcome. Call 905-689-8244.

Canadian Calorie Counters, Branch 561, meets from 6 to 8 p.m. tomorrow at Stoney Creek Baptist Church, 79 Collegiate Ave. Visitors and new members welcome. Call 905-549-0384.

Chedoke Amputee Peer Support group meets at 7 p.m. tomorrow at Chedoke Hospital, Holbrook Building, room C179. Call 905-521-2100, ext. 74630.

Friends in Grief, Inc., support groups for bereaved adults, is holding a drop-in from 7 to 8:30 p.m. tomorrow at 1030 Upper James St., Suite 207. Call 905-318-0059.

Randle Reef Public Open House Sediment Remediation Project drop-in takes place from 2 to 5 p.m. and 6 to 8 p.m. tomorrow at Liuna Station, 360 James St. N. Call 905-527-7111.

PUBLIC NOTICE

Randle Reef Sediment Remediation Project
OPEN HOUSE

Wednesday
June 11, 2003
2-5 pm & 6-8 pm

Liuna Station,
360 James St. N., Hamilton

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Randle Reef Sediment Remediation Project Open House

Wednesday, June 11th, 2003
360 James St. N, Hamilton

Comment Sheet

Please Print Neatly. Your comments are appreciated and will be taken into consideration.

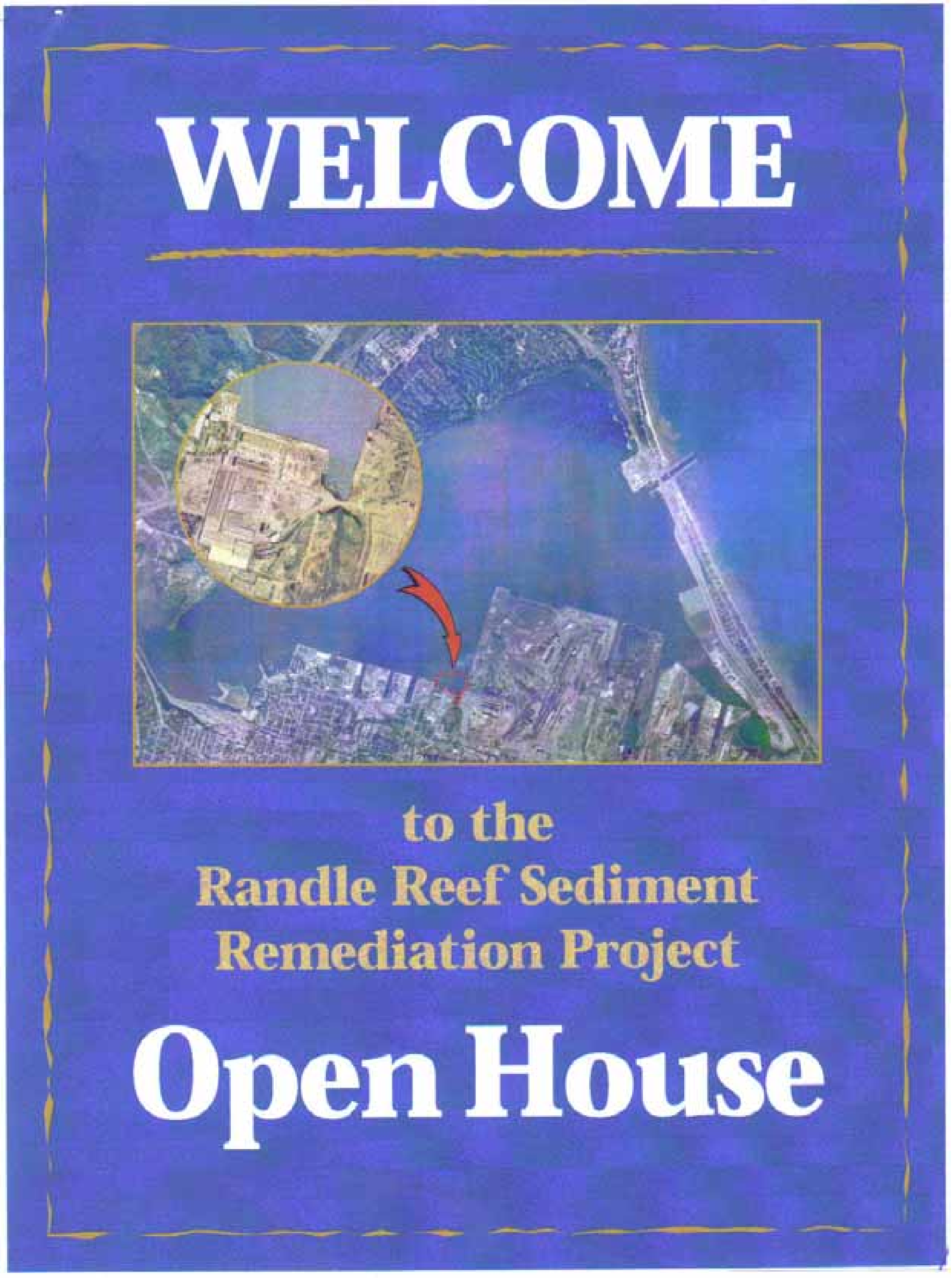
Please leave your completed comment sheet in the drop box provided.

Name and address (optional)

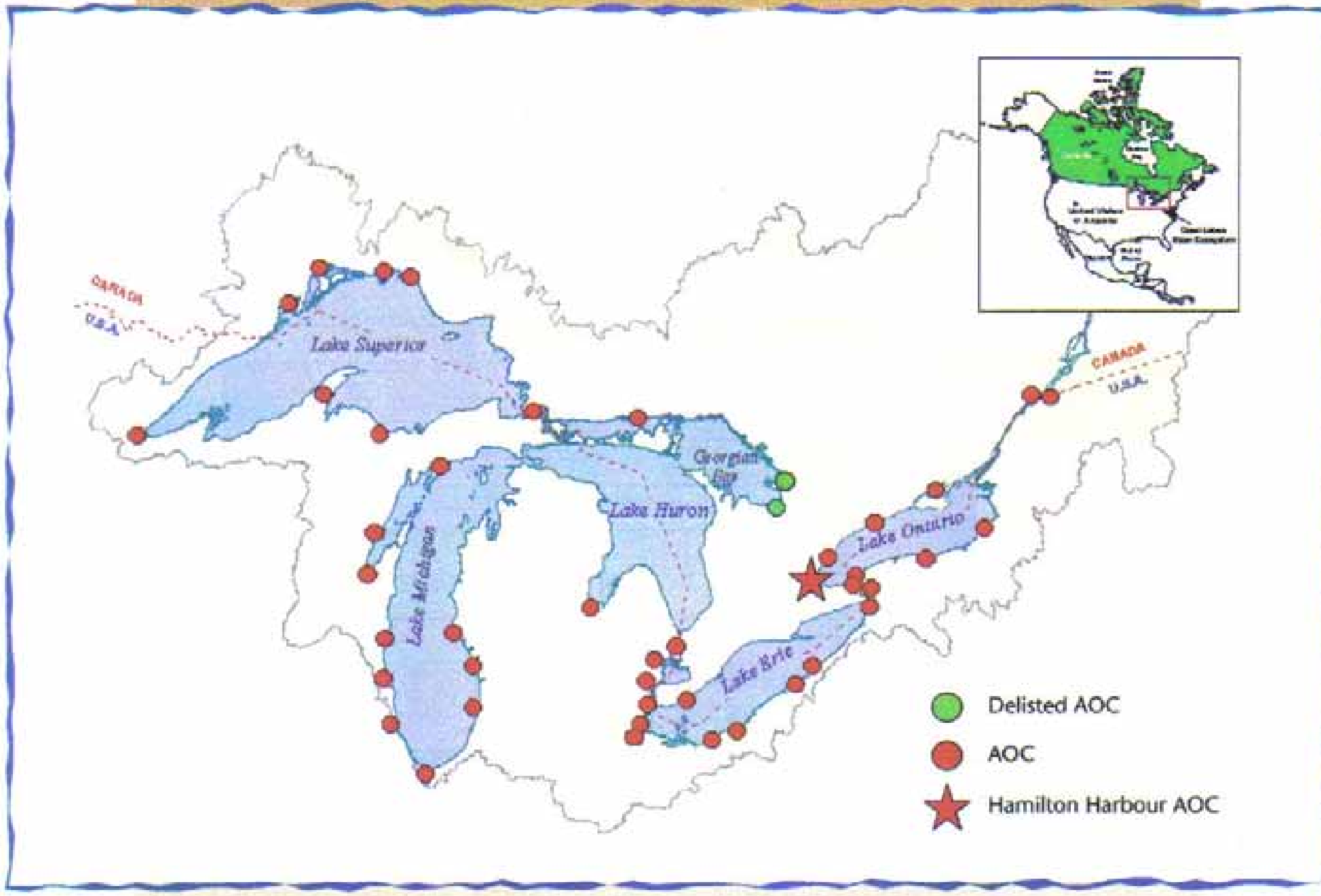
Name:

Address: P.C.:

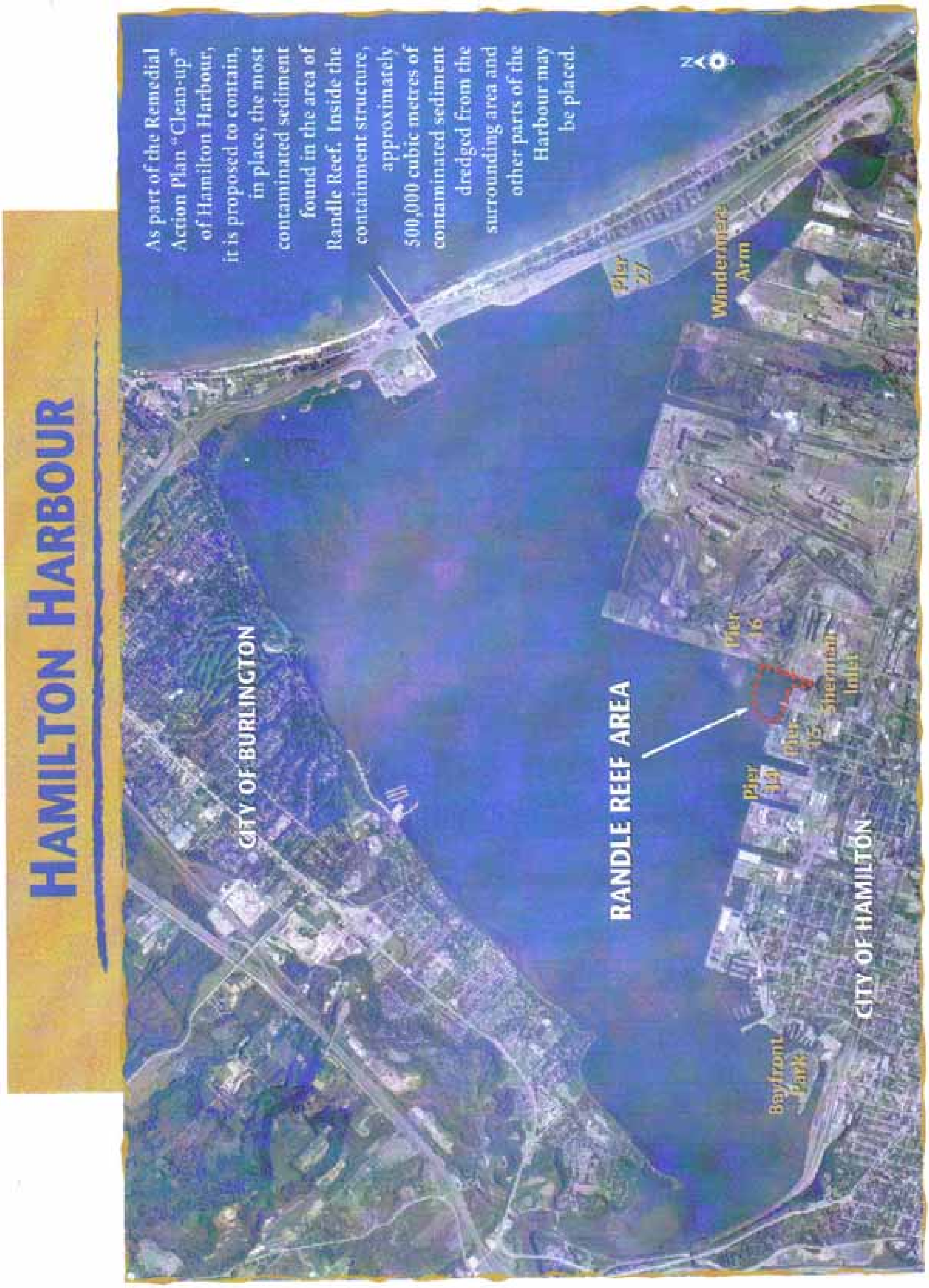
Telephone number: Email:


WELCOME
to the
Randle Reef Sediment
Remediation Project
Open House

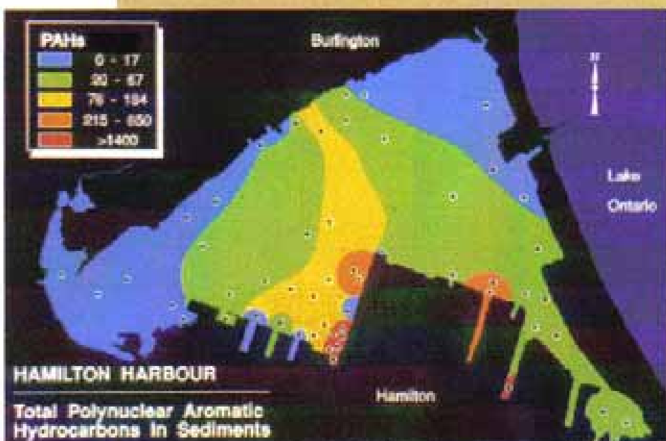
REMEDIAL ACTION PLAN



Hamilton Harbour is one of 43 "Areas of Concern" (AOC) identified in the Great Lakes Water Quality Agreement between Canada and the United States. The Remedial Action Plan (commonly called the "RAP") is a detailed strategy to clean-up the Harbour, which would result in the "delisting" of the Harbour as an "Area of Concern." The RAP was updated in 2002 by a group of stakeholders representing a cross section of government, business, environmental and recreational interests.


HAMILTON HARBOUR
As part of the Remedial Action Plan "Clean-up" of Hamilton Harbour, it is proposed to contain, in place, the most contaminated sediment found in the area of Randle Reef. Inside the containment structure, approximately 500,000 cubic metres of contaminated sediment dredged from the surrounding area and other parts of the Harbour may be placed.
N
Pier 27
Windermere Arm
CITY OF BURLINGTON
RANDLE REEF AREA
Pier 16
Sherman Inlet
Pier 15
Pier 14
CITY OF HAMILTON
Bayfront Park

HARBOUR CONTAMINATED SEDIMENTS



The historical distribution of PAHs are illustrated on this 1989 map.

Polycyclic Aromatic Hydrocarbons (PAHs)

Polycyclic aromatic hydrocarbons (PAHs) are the contaminants of greatest concern in the sediments in the area of Randle Reef. They are known to be persistent and toxic, and bioaccumulative to a limited extent. Concentrations are very high in this part of the Harbour. The Randle Reef area contains the highest levels of PAH on the Canadian side of the Great Lakes.

PAHs of sufficient concentration and exposure periods are carcinogenic and have the potential to harm a wide variety of life forms, including humans. Clearly, cautious and safe work routines are required in the handling of these materials.

PAH contamination is likely a legacy from a variety of past industrial processes and no ongoing sources are known to exist that would re-contaminate the site.

The Hamilton Harbour RAP planning for sediment clean-up has primarily focused on Polycyclic Aromatic Hydrocarbons, PAHs, defining three levels of contamination. *(Note: Levels are measured in parts per million or ppm.)*

"Hot Spots", High Contamination:

- greater than 800 ppm total PAH less naphthalene, and
- other areas of high toxicity such as the Dofasco boat slip (PAHs/PCBs/metals)

Medium Contamination:

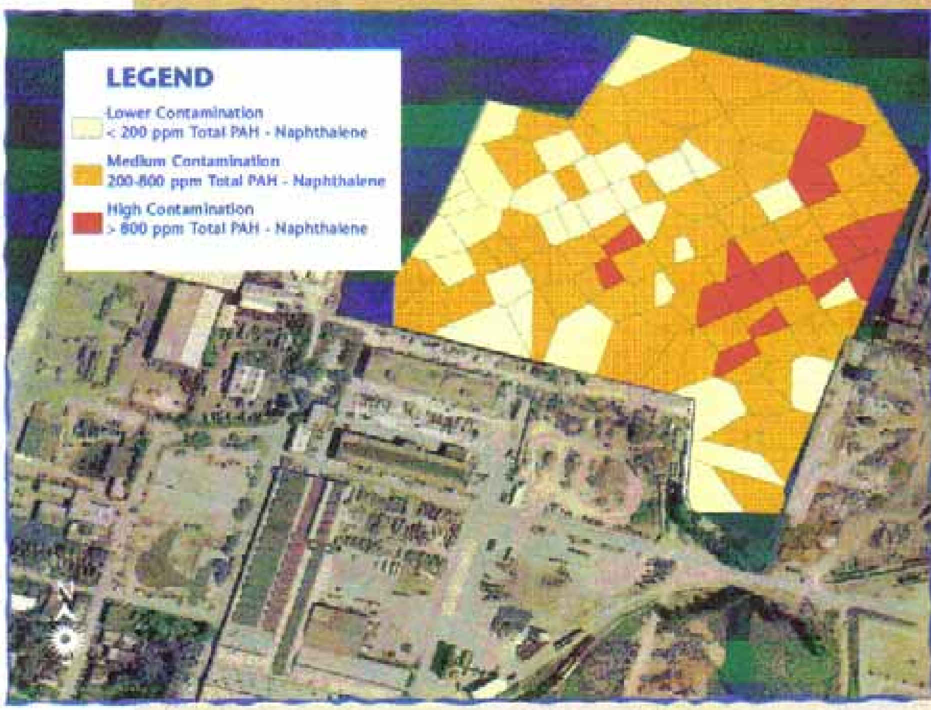
- between 200 and 800 ppm total PAH less naphthalene

Lower Contamination:

- less than 200 ppm total PAH less naphthalene

The highly contaminated sediments or "hot spots" should be removed from contact with the Harbour environment; medium contaminated sediments should be removed from biological contact or remediated in place to lower toxicity; and lower contaminated sediments should be left in place and allowed to degrade naturally over time.

AREA OF CONTAMINATION AT RANDLE REEF



Once identified as a potential area of high contamination "hot spot," more detailed sampling of the sediment was carried out.

What Contaminants are in the Sediment?

Polycyclic Aromatic Hydrocarbons (PAH)

The map above shows levels of contamination for polycyclic aromatic hydrocarbons (PAHs). Total PAH concentrations at Randle Reef range from non-detectable to 57,000 ppm within the Randle Reef study area.

Scientists determined that a simpler picture of PAH contamination was provided if one of the PAH types, naphthalene (N) was subtracted from the sediment analysis.

While other contaminants are present in the Randle Reef study area and include elevated concentrations of iron, manganese, lead, zinc, chromium and copper, PAHs are the priority for remediation.

SELECTING A REMEDIAL OPTION

Stakeholder Project Advisory Group 2001 – 2003

Project Advisory Group (PAG) formed

- Bay Area Restoration Council
- Canadian Coast Guard *(correspondence participation only)*
- Central North End West Neighbourhood Association
- City of Burlington
- City of Hamilton
- Clean Air Hamilton
- Environment Canada
- Fisheries and Oceans Canada
- Great Lakes United
- Hamilton Beach Preservation Committee
- Hamilton Industrial Environmental Association Citizen Liaison Group
- Hamilton Conservation Authority
- Hamilton Port Authority
- Landsdale Neighbourhood Group *(correspondence participation only)*
- North Central Community Council *(correspondence participation only)*
- Ontario Ministry of Environment
- Ontario Ministry of Labour
- RAP Coordinator
- Stelco Hamilton
- Strathcona Community Council *(correspondence participation only)*
- United Steelworkers of America

In 2001, a cross-section of stakeholders from government, environmental groups and the local community held a series of meetings.

Acting on the PAG recommendation for developing a sediment containment facility, a smaller project implementation team was formed to take the concept through the steps necessary for design and construction.

The PAG reviewed:

- sediment and contaminant characteristics
- treatment options, including approximately 24 previous options
- issues of concern

The PAG identified key project objectives

- Maximize containment/removal of acutely toxic sediments in the Harbour.
- Ensure that the health and safety of workers & citizens are protected during all stages of the project.
- Minimize local and downwind airborne emissions during remediation process.
- Ensure safe transportation of hazardous materials through residential areas, if disposal to be located in an out of area site.
- Avoid high risk alternatives that could result in technology failures, cost overruns and protracted implementation schedules.
- No net loss of fish habitat.
- No loss of navigation routes.
- Prevent uptake of contaminants by waterfowl.
- Permanent solution/long term sustainability.

The PAG recommended:

- construction of a facility that optimized containing, in place, the majority of highly contaminated sediments (>800 ppm PAH-N) in the area of Randle Reef and placing within the containment facility, moderately contaminated sediment (200-800 ppm PAH-N) from the surrounding area of Randle Reef and other parts of the Harbour.

It was clearly stated that the PAG wants to deal with all PAH contaminated sediment greater than 200 ppm less naphthalene as a whole Harbour solution.

Project Implementation Team 2002 – ongoing

The Project Implementation Team was formed to move the project forward and includes:

- Bay Area Restoration Council (observer)
- City of Hamilton
- Clean Air Hamilton
- Environment Canada
- Fisheries and Oceans Canada
- Hamilton Conservation Authority
- Hamilton Port Authority
- Ontario Ministry of Environment
- RAP Coordinator
- Stelco Hamilton

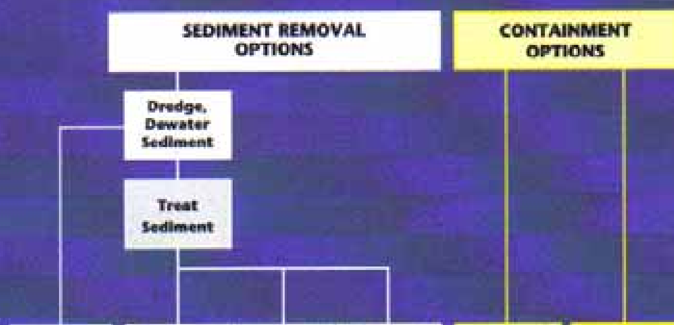
Project Implementation Team (PIT) formed

An independent consultant was engaged to prepare a conceptual design study for the "containment" facility. At the same time, Environment Canada and the Ontario Ministry of Environment assessed the volume of contaminated material and determined that approximately 500,000 cubic meters of sediment may be appropriate for containment.

The containment conceptual design was presented to the PAG on December 9, 2002 and the PAG recommended proceeding to detailed design.

OPTIONS FOR REMEDIATION CONSIDERED

RANDLE REEF PROJECT
Sediment Remediation Options – Hamilton Harbour



	OPTION 1 Hazardous Waste Landfill Disposal	OPTION 2 Non-Hazardous Waste Landfill Disposal	OPTION 3 Sinter Plant Re-Use	OPTION 4 Industrial Fill Re-Use	OPTION 5 (a) Containment 5 ha	OPTION 5 (b) Containment 9.5 ha
Total PAHs (-) Naphthalene	>800 ppm	>800 ppm	>800 ppm	>800 ppm	>800 ppm	>200 ppm
Estimated Remediated Quantity (thousands cubic metres)	20	20	20	20	65	630
Estimated Cost (millions)	$10	$8.4	$7.6	$17.1	$15	$31
Estimated Cost/cubic metre	$500	$420	$380	$855	$230	$49 (with dredging)
Estimated tonnes total PAHs	710	710	710	710	1070	1660

COMPARISON of Key Project Objectives	REMOVAL OPTIONS	CONTAINMENT OPTIONS
Maximize containment/removal of acutely toxic sediments in the Harbour.	-	✓
Ensure that the health and safety of workers & citizens are protected during all stages of the project.	✓	✓
Minimize local and downwind airborne emissions during remediation process.	✓	✓
Ensure safe transportation of hazardous material through residential areas, if disposal is to be located at an out of area site.		✓
Avoid high risk alternatives that could result in technology failures, cost overruns and protracted implementation schedules.		✓
No net loss of fish habitat.	✓	✓
No loss of navigation routes.	✓	✓
Prevent uptake of contaminants by waterfowl.	✓	✓
Permanent solution/long term sustainability.		✓
PLUS... ...accelerates the process for the delisting of contaminated sediment as an impairment to Hamilton Harbour		✓

CONCEPTUAL DESIGN OPTIONS

The Project Advisory Group (PAG) recommended:

- construction of a facility that optimized containing, in place, the majority of highly contaminated sediments (>800 ppm PAH-N) in the area of Randle Reef and placing within the containment facility moderately contaminated sediment (200-800 ppm PAH-N) from the surrounding area of Randle Reef and other parts of the Harbour.

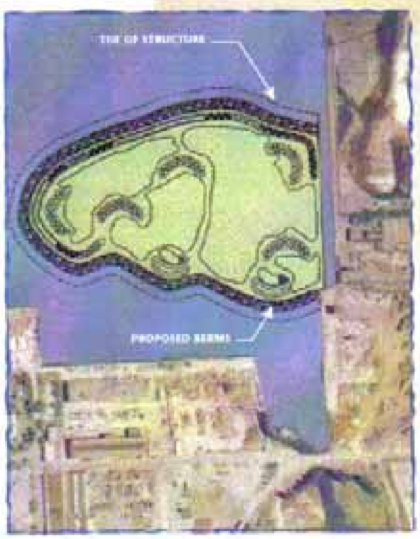
It was clearly stated that the PAG wanted to deal with all PAH contaminated sediment greater than 200 ppm less naphthalene as a whole Harbour solution.

As a result of the PAG's input three options were considered:

- A fully naturalized island
- A fully naturalized peninsula
- A mixed use peninsula or a facility directly connected to the Stelco Hamilton dock

The naturalized island option was rejected after initial consideration. In order to function as an island and not interfere with navigation, the containment structure would have to be located off shore directly over Randle Reef. Such an offshore location would be located outside the "hot spot" and hence could not serve as a containment structure.

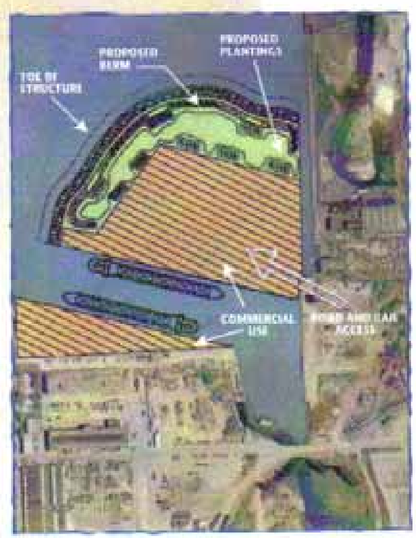
OPTIONS OF FULLY NATURALIZED AND MIXED USE PENINSULAS



Fully Naturalized Peninsula

COMPARISON

All Natural	Natural-Commercial Mix
Configuration	**Configuration**
▸ Obstructs harbour operations, unless island located on Randle Reef ▸ If located on Reef • Larger facility • Requires complete dredging of priority zone	▸ Peninsula attached to Pier 16 ▸ Commercial use on south side (about 5 ha) ▸ Northern and western sides naturalized ▸ Minimizes dredging of priority zone
Potential Partners	**Potential Partners**
▸ Funding • Environment Canada • Ontario Ministry of Environment • City of Hamilton ▸ In-kind • Stelco Hamilton • Hamilton Conservation Authority	▸ Funding • Hamilton Port Authority • Environment Canada • Ontario Ministry of Environment • City of Hamilton ▸ In-kind • Stelco Hamilton • Hamilton Conservation Authority • Hamilton Port Authority
Proposed Owner	**Proposed Owner**
▸ None	▸ Hamilton Port Authority

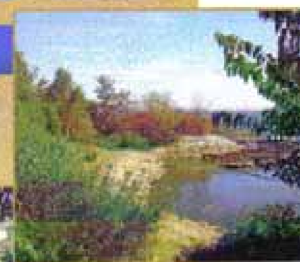


Mixed Use Peninsula

PREFERRED CONCEPTUAL DESIGN OPTION

Natural Shoreline

Approximately 5ha along the shoreline facing the Harbour will be naturalized. Some examples of various naturalized shoreline areas in the Harbour are shown on the left.



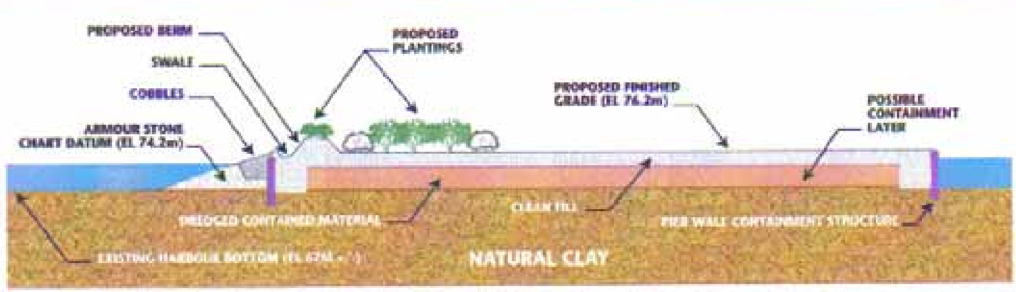
Port Components

Hamilton is one of the busiest ports in Canada... 700 ships a year... making it an important element both to local industry and national economy. New docking berths will replace existing docks. The area for unloading ships will be approximately 5ha in size.

Containment Design

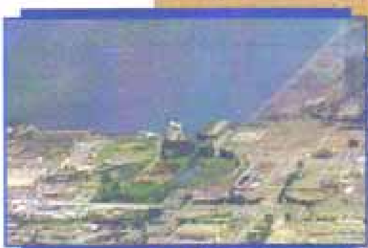
Example of Silt Curtain

- The peninsula is located over the majority of the "hot spot" sediments to minimize dredging or disturbance of these materials.
- During any dredging activities undertaken with this project, measures will be taken, such as using a silt curtain, to protect the local environment.
- A containment element will be selected based on engineering, environmental considerations, constructability and cost.
- A risk assessment will be carried out to ensure the long term integrity of containment. The containment design will allow for long term monitoring of the performance of the facility.



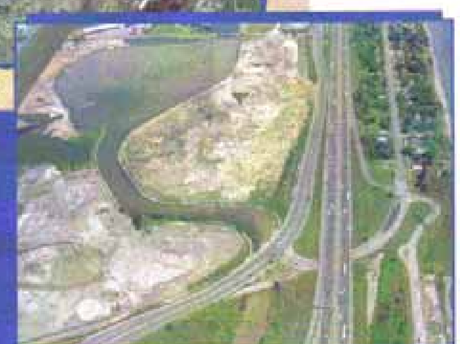
Schematic of a Cross-Section of Peninsula Design (Not to Scale)

ENVIRONMENTAL ENHANCEMENT OPPORTUNITIES



Sherman Inlet
potential for
1 hectare
of wetland

Pier 27
potential for
1 - 2 hectares
of wetland



Windermere
potential for
2 - 4 hectares
of wetland

Fish Habitat Compensation:

Fisheries and Oceans Canada requires that there be "no net loss" in the productive capacity of fish habitat. Any in-water works that result in the loss of fish habitat, require compensation. Approximately 3ha to 5ha of wetlands may be established in the areas of Windermere Basin, Sherman Inlet and Pier 27. These initiatives will create a net increase in productive fish habitat.

Volume compensation for Harbour infilling:

There is no significant change in Harbour volume because the vast majority of fill is taken from the Harbour as contaminated sediment to be placed in the containment structure. The Remedial Action Plan attempts to keep Harbour infilling to a minimum and endorses infilling only if for the purpose of implementing remedial actions. For example, infilling was permitted to create fish habitat and wildlife islands.

Associated Naturalization Projects:

The Hamilton Conservation Authority asked that the project attempt to compensate, to the extent possible, for surface area lost in the Harbour by cutting back areas from land surrounding the Harbour. As a result of this request, portions of shoreline, as outlined on the map, are being considered for naturalization along the east and south sides of the Harbour. Also, the wetlands proposed for fish compensation will provide surface area compensation if configured appropriately.

Comprehensive Environmental Assessment Study

Engineering Study

Securing Funding and Partnerships

Construction and Dredging

NEXT STEPS

More about...

ENVIRONMENTAL ASSESSMENT

A Comprehensive Study will be conducted under the Canadian Environmental Assessment Act to ensure sound environmental decisions are made about the Randle Reef Remediation Project.

The Study is triggered by:

- partnership funding by Environment Canada and the Hamilton Port Authority
- use of Hamilton Port Authority lands
- authorization under the *Fisheries Act* and *Navigable Waters Protection Act*

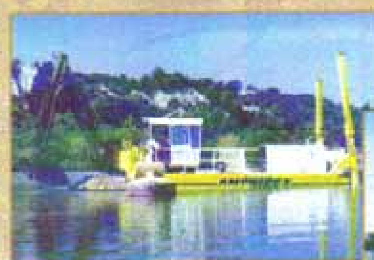
The Comprehensive Study will assess:

- the purpose of the project
- alternative means of carrying out the project
- the environmental effects of the project
- effects on sustainable use of renewable resources
- the significance of effects
- all public comments
- any effects requiring further study
- proposed mitigation measures
- any other matters deemed relevant by the Responsible Authorities
- the need for and requirements of any follow-up

The Comprehensive Study review and approval involve:

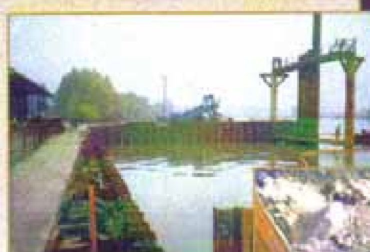
- meetings with stakeholder groups (ongoing)
- open house (June 2003)
- report submission to the Canadian Environmental Assessment Agency (January 2004)
- 30 to 45 day public review of final report (January-February 2004)
- response to public comment (March 2004)
- approval of the report by the federal Minister of the Environment
- project proceeds

IMPLEMENTATION

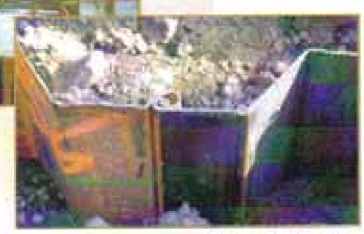


Hydraulic Dredge

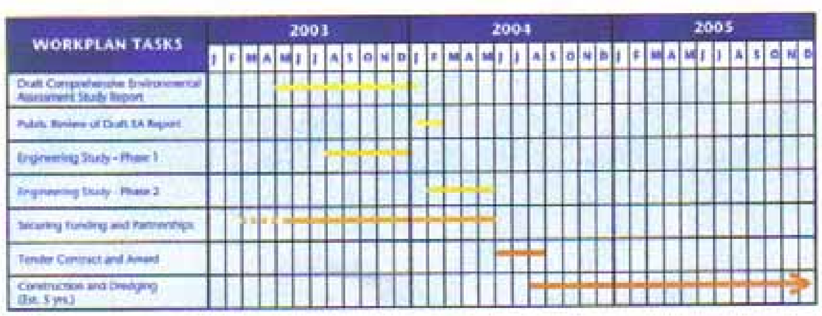
Cable Arm Sediment Removal Bucket



Steel Sheet Pile Barrier



Waterloo Sealed Steel Sheet Pile Barrier



Public Notice

Randle Reef Sediment Remediation Project
Public Meeting

Members of the public are invited to learn more about the plans for the clean-up of contaminated sediment near the south shore of Hamilton Harbour at Randle Reef. The Randle Reef Sediment Remediation Project is a key project aimed at achieving the goals and objectives of the Hamilton Harbour Remedial Action Plan (RAP).

Learn more about:

- What the clean-up involves
- Environmental, social and economic benefits
- Preliminary environmental assessment results
- Next steps
- Opportunities for you to comment

When: Tuesday, November 18, 2008
1-7 pm – View displays and speak with the project team
7-8 pm – Formal presentations
8-9 pm – Questions and answers

Where: Hamilton Chamber of Commerce
555 Bay Street North
Hamilton, Ontario

For more information about the public meeting, please contact:
Kathy Trotter,
Hamilton Harbour Remedial Action Plan (RAP)
(905) 336-6279 or
Kathy.Trotter@ec.gc.ca

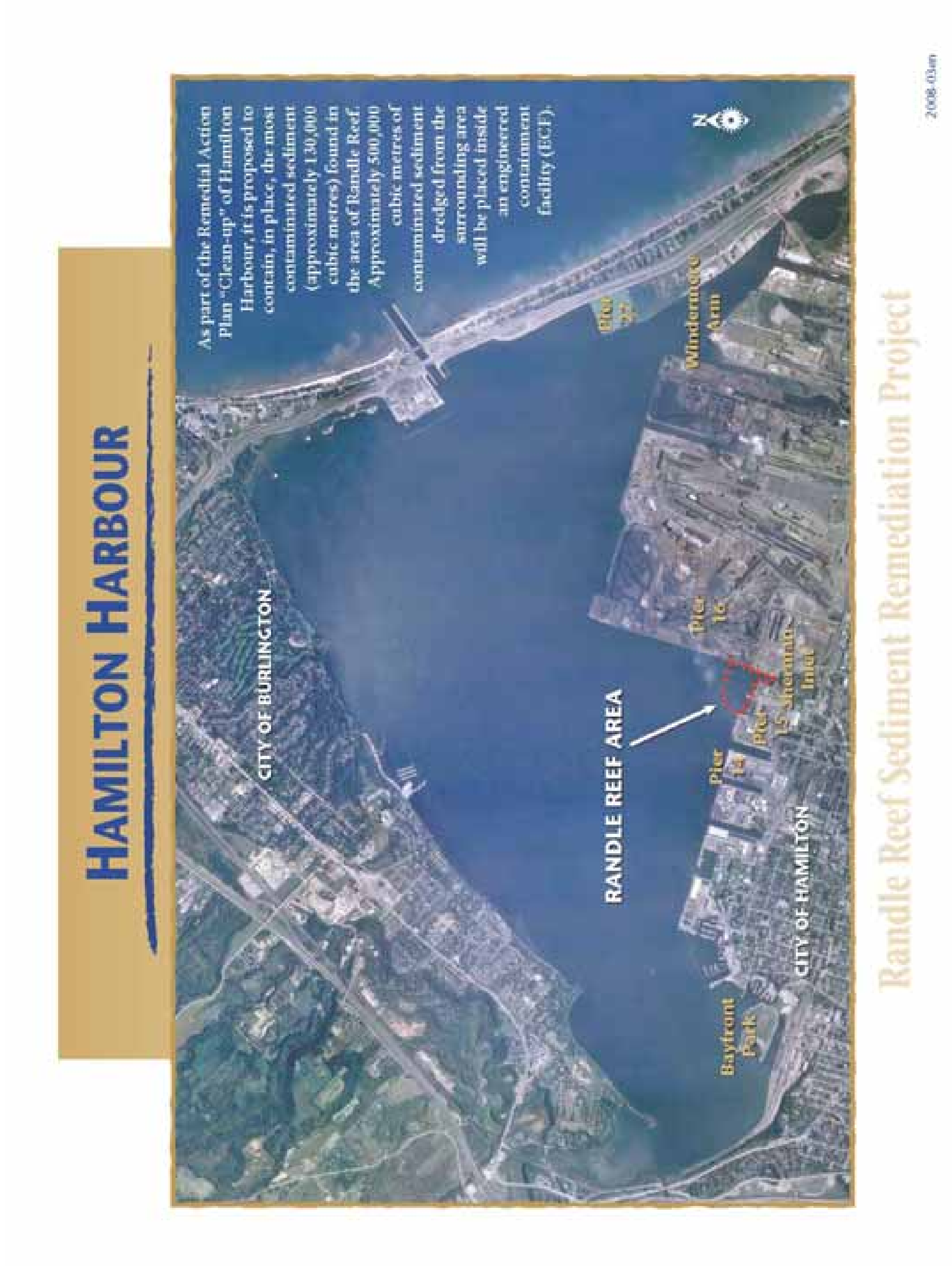
R001258485

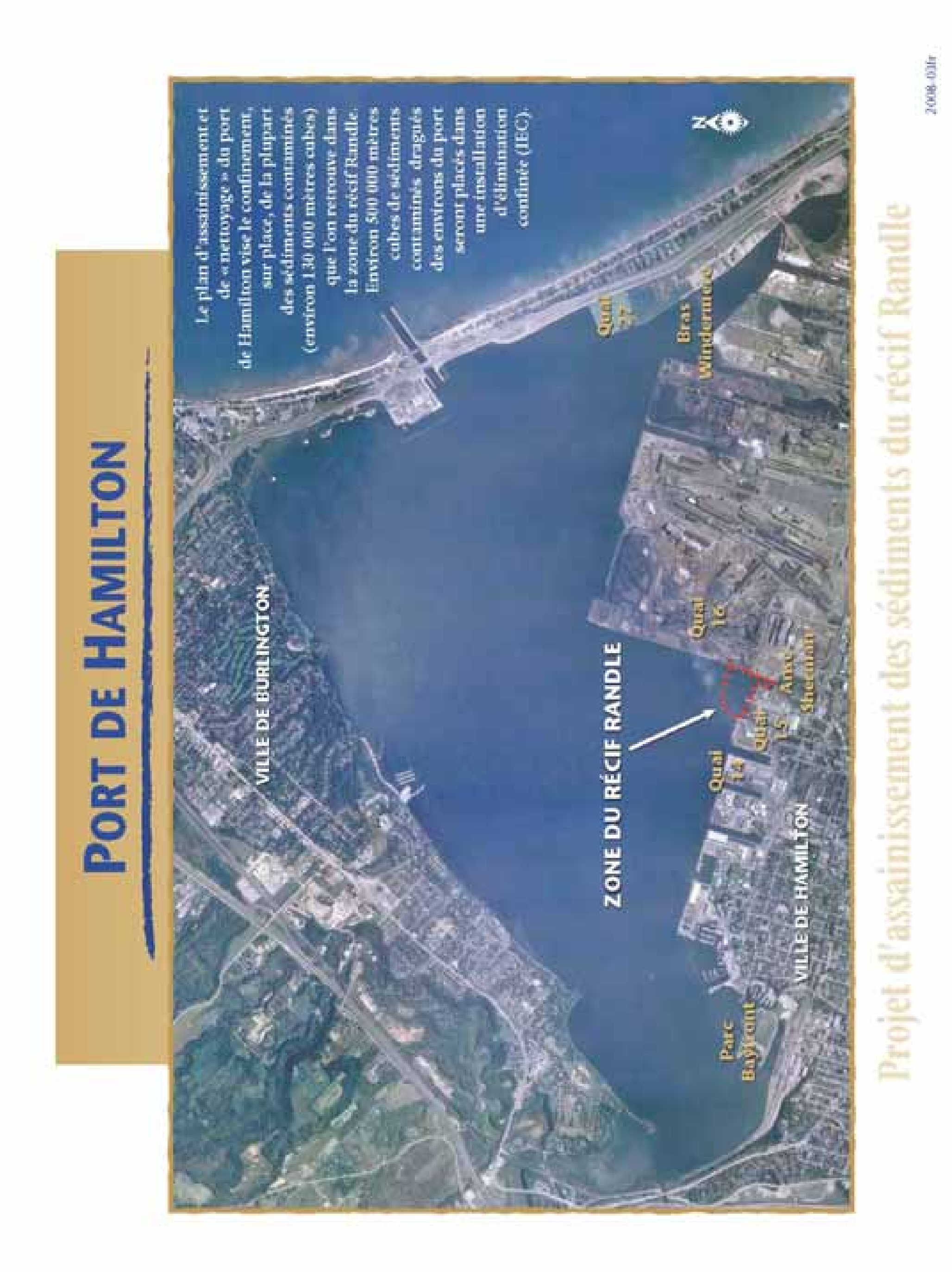
REMEDIAL ACTION PLAN

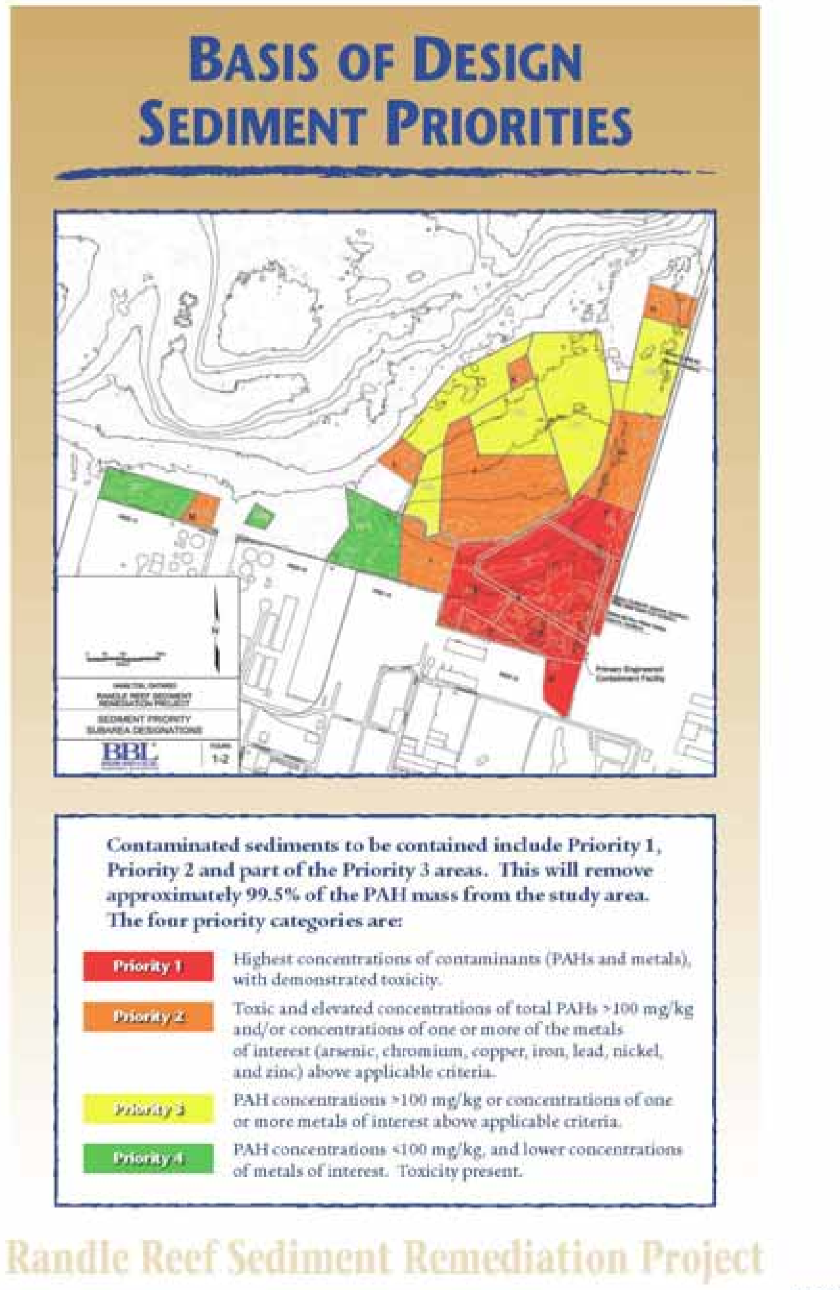
- Hamilton Harbour is one of 43 Areas of Concern identified in international (U.S-Canadian) and Federal- Provincial Agreements which call for protection and restoration of the Great Lakes.
- The Great Lakes are an important environmental and economic resource:
  - largest fresh, surface water system on earth - roughly 18% of the world supply;
  - home to more than 1/10 of the U.S. and 1/4 of the Canadian populations; and
  - provides water for essential uses - consumption, transportation, power, etc.
- The Remedial Action Plan (RAP) is the local community's solution to clean-up and de-list the harbour as a toxic hot spot in the Great Lakes.

Randle Reef Sediment Remediation Project

2008-02


HAMILTON HARBOUR
As part of the Remedial Action Plan "Clean-up" of Hamilton Harbour, it is proposed to contain, in place, the most contaminated sediment (approximately 130,000 cubic metres) found in the area of Randle Reef. Approximately 500,000 cubic metres of contaminated sediment dredged from the surrounding area will be placed inside an engineered containment facility (ECF).
CITY OF BURLINGTON
RANDLE REEF AREA
CITY OF HAMILTON
Pier 22
Windermere Arm
Pier 16
Sherman Inlet
Pier 15
Pier 14
Bayfront Park
N
Randle Reef Sediment Remediation Project
2008-03en


PORT DE HAMILTON
Le plan d'assainissement et de « nettoyage » du port de Hamilton vise le confinement, sur place, de la plupart des sédiments contaminés (environ 130 000 mètres cubes) que l'on retrouve dans la zone du récif Randle. Environ 500 000 mètres cubes de sédiments contaminés dragués des environs du port seront placés dans une installation d'élimination confinée (IEC).
VILLE DE BURLINGTON
ZONE DU RÉCIF RANDLE
Quai 27
Bras Windermere
Quai 16
Anse Sherman
Quai 15
Quai 14
VILLE DE HAMILTON
Parc Bayfront
Projet d'assainissement des sédiments du récif Randle
2008-03fr


BASIS OF DESIGN
SEDIMENT PRIORITIES
Primary Engineered Containment Facility
SEDIMENT PRIORITY SUBAREA DESIGNATIONS
BBL
1-2
Contaminated sediments to be contained include Priority 1, Priority 2 and part of the Priority 3 areas. This will remove approximately 99.5% of the PAH mass from the study area. The four priority categories are:
Priority 1
Highest concentrations of contaminants (PAHs and metals), with demonstrated toxicity.
Priority 2
Toxic and elevated concentrations of total PAHs >100 mg/kg and/or concentrations of one or more of the metals of interest (arsenic, chromium, copper, iron, lead, nickel, and zinc) above applicable criteria.
Priority 3
PAH concentrations >100 mg/kg or concentrations of one or more metals of interest above applicable criteria.
Priority 4
PAH concentrations <100 mg/kg, and lower concentrations of metals of interest. Toxicity present.
Randle Reef Sediment Remediation Project
2008-04

SELECTING A REMEDIAL OPTION

Who Was Involved?

Stakeholder Project Advisory Group (PAG)

- Bay Area Restoration Council
- Canadian Coast Guard
  (*correspondence participation only*)
- Central/North End West Neighbourhood Association
- City of Burlington
- City of Hamilton
- Clean Air Hamilton
- Environment Canada
- Fisheries and Oceans Canada
- Great Lakes United
- Hamilton Beach Preservation Committee
- Hamilton Industrial Environmental Association
  Citizen Liaison Group
- Hamilton Conservation Authority
- Hamilton Port Authority
- Landsdale Neighbourhood Group
  (*correspondence participation only*)
- North Central Community Council
  (*correspondence participation only*)
- Ontario Ministry of Environment
- Ontario Ministry of Labour
- RAP Coordinator
- U. S. Steel Canada (*formerly Stelco*)

What Was Done?

The PAG reviewed:

- sediment and contaminant characteristics
- approximately 24 remedial options
- issues of concern

The PAG recommended:

- construction of a facility that optimized containing, in place, the majority of highly contaminated sediments (>800 ppm PAH-N) in the area of Randle Reef and dredging and placing other contaminated sediment (200-800 ppm PAH-N) from the surrounding area of Randle Reef and potentially other parts of the Harbour in the facility

PAG's goal is to deal with all PAH-contaminated sediment greater than 200 ppm less naphthalene as a whole harbour solution.

Randle Reef Sediment Remediation Project

2008-05

ENVIRONMENTAL ASSESSMENT

A Comprehensive Study will be conducted under the *Canadian Environmental Assessment Act* to ensure sound environmental decisions are made about the Randle Reef Remediation Project.

The EA Study is triggered by:

- partnership funding by Environment Canada and the Hamilton Port Authority (HPA)
- use of HPA lands
- authorization under the *Fisheries Act* and *Navigable Waters Protection Act*

The Comprehensive Study will assess:

- what can be impacted by the project
- what the impact is and its significance
- how to prevent or minimize the impact
- other public concerns
- requirements for follow-up
- requirements for monitoring

Public Comment Period:

- a 30-45 day public review and comment period for the Comprehensive Study Report will commence in April 2009
- advertised in local newspapers and provided at local venues (e.g. library)
- Federal Minister reviews report and announces decision (Summer 2009)
- ongoing project updates to the public

Randle Reef Sediment Remediation Project

2008-06a

Environmental Effects Assessment

Potential Measures To Reduce or Eliminate These Impacts:

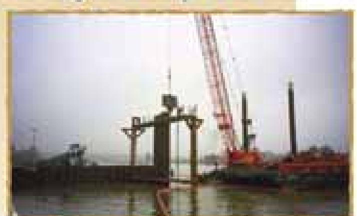
- restrict where, when and how work is conducted
- comply with residential noise by-law
- use of specialized sheet pile installation techniques to minimize noise and vibration
- avoid trucking near residential areas as much as possible
- work with local residents to design acceptable truck haul routes and establish safety measures (e.g. crossing guards)

Minimizing The Impact To The Community

Residential Areas Adjacent to Pier 14 and along Haul Routes May be Impacted by:

- truck traffic
- construction impacts (i.e. nuisance – noise, vibration, dust)

Installing Steel Sheetpile Wall



Surface Water May Be Impacted By:

- construction activities in the water
- construction activities around shoreline areas

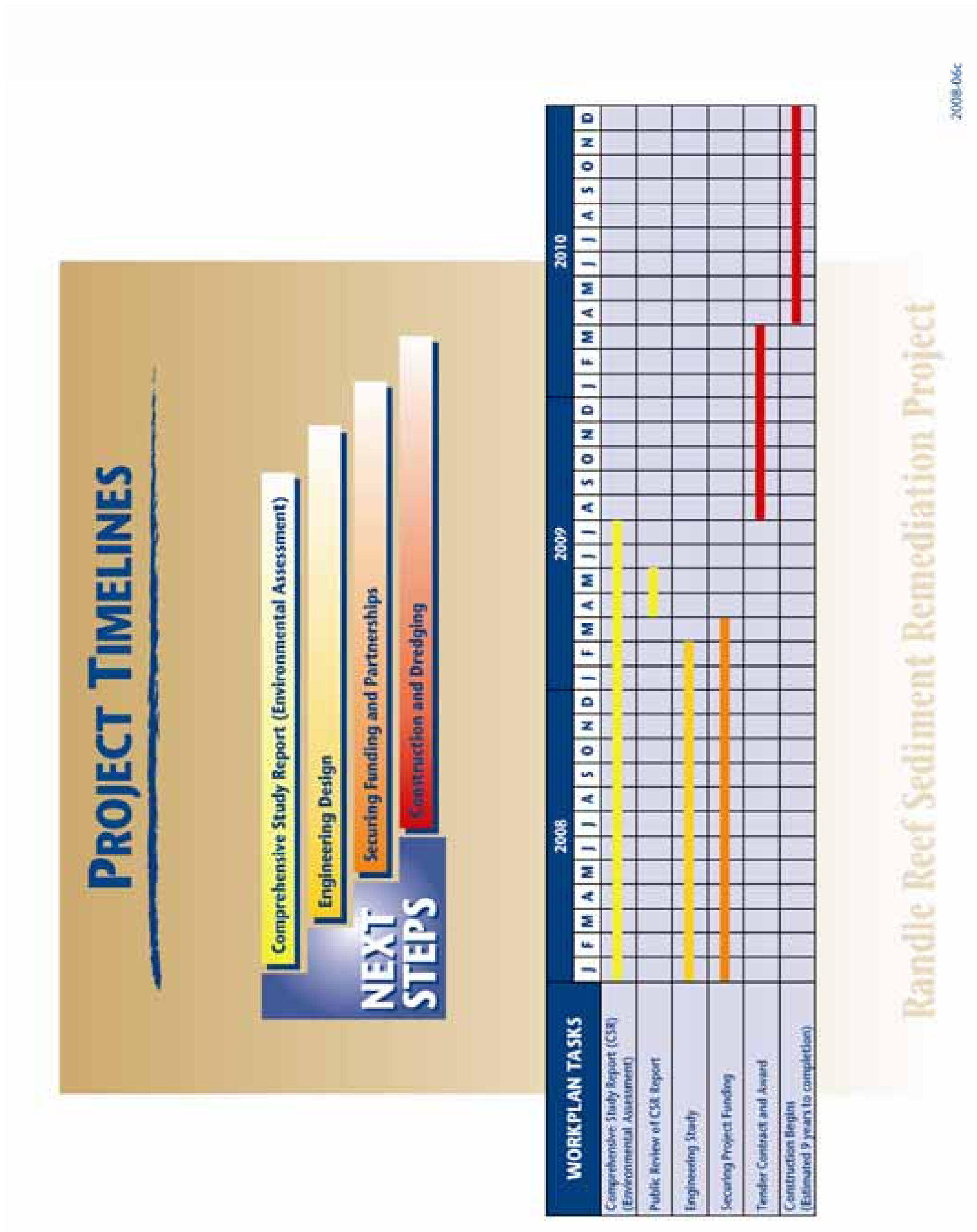
Potential Measures to Reduce or Eliminate These Impacts:

- isolate in-water construction zones with silt curtains/sheetpile walls
- minimize re-suspension from dredging (e.g. use of specialized equipment)
- slow down dredging production rate
- use a stormwater management system around the staging area
- monitor and follow up on effluent discharges to water

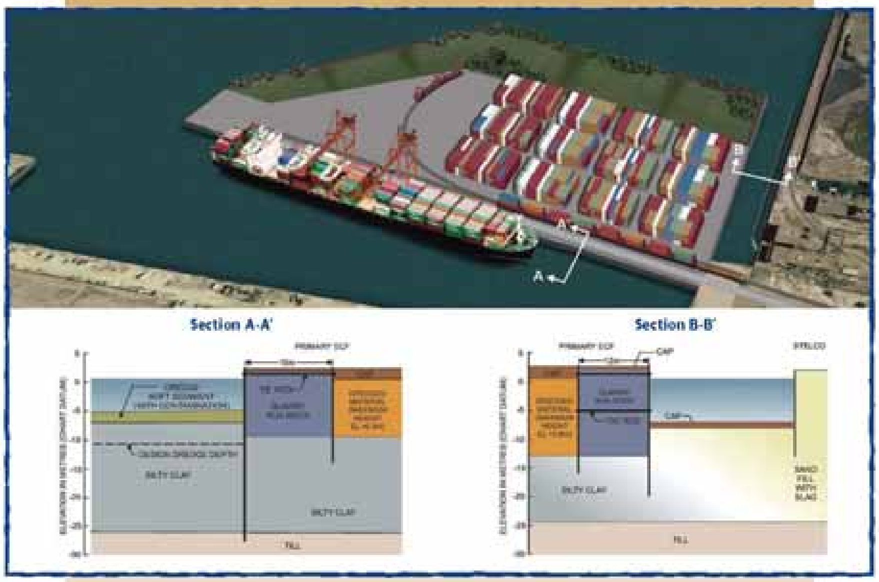
Steel Sheetpile and Silt Curtains Providing Containment

Randle Reef Sediment Remediation Project

2008-06b


PROJECT TIMELINES
Comprehensive Study Report (Environmental Assessment)
Engineering Design
Securing Funding and Partnerships
Construction and Dredging
NEXT STEPS
WORKPLAN TASKS
2008
2009
2010
J F M A M J J A S O N D
Comprehensive Study Report (CSR) (Environmental Assessment)
Public Review of CSR Report
Engineering Study
Securing Project Funding
Tender Contract and Award
Construction Begins (Estimated 9 years to completion)
Randle Reef Sediment Remediation Project
2008-06c

Design Rendering



Engineered Containment Facility

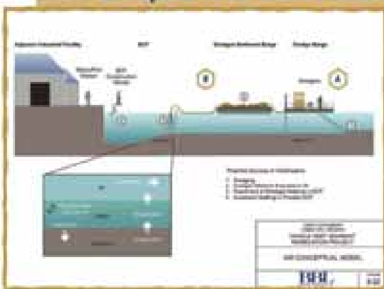
The proposed remediation of Randle Reef involves the construction of an engineered containment facility (ECF) about 7.5 ha (18.5 acres) in size. A double steel sheet pile wall (outer structural, inner environmental) will form the ECF. The ECF will cover in place about 130,000 m^3 of contaminated sediments, and contain about 500,000 m^3 of PAH-contaminated sediments dredged from the Randle Reef surrounding area. The total volume of sediment would fill three major sporting arenas. Its proposed end use will be a mix of about 2/3 port activities and 1/3 naturalized open space. Long term monitoring will be undertaken over the 200 year life span of the facility.

Randle Reef Sediment Remediation Project

2008-07

DESIGN ELEMENTS

Conceptual VOC Emission Scenario



Air emissions resulting from the volatilization of sediment contaminants is a major design issue impacting both dredging and transport operations. The sediment in Priority 1 and 2 areas contain relatively high levels of Polycydic Aromatic Hydrocarbons (PAHs) as well as other volatile organic compounds (VOCs). This resulted in a preference for design options requiring minimal disturbance, minimal handling and minimal exposure of sediment to the atmosphere.

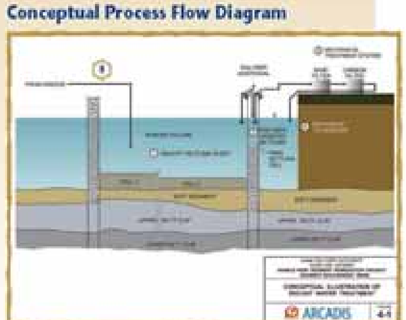
The greatest risk of volatilization is from mechanical dredging, because this method will expose sediment to the atmosphere during removal and placement in the ECF. Therefore, mechanical dredging will be minimized and will account for approximately 4% of the total sediment to be dredged.

The majority of the dredging will be conducted by hydraulic means. Hydraulic dredging has less potential for contaminant volatilization because the sediment is removed into a pipeline at the dredge head, then transported directly to the ECF via the pipeline and discharged into the ECF below water.

Conceptual Process Flow for Hydraulic Dredging

- **A** Dredging will be accomplished using hydraulic and mechanical operations.
- **B** The dredged sediment will be transported by pipeline to the ECF.
- **1** The dredged sediment will be dewatered through unaided settling in internal cells that subdivide the ECF.
- **2** Polymers are added to the effluent to aid in further settling in a polishing cell.
- **3** Additional treatment of effluent will involve sand filters and activated carbon adsorption.
- **4** Final effluent will be discharged to Hamilton Harbour.

Conceptual Process Flow Diagram



Randle Reef Sediment Remediation Project

2008-08

ASSESSING THE EFFECTIVENESS OF RANDLE REEF REMEDIATION

Collecting Suspended Sediment

Baseline studies (prior to remediation) have been conducted from 2005 to 2008.

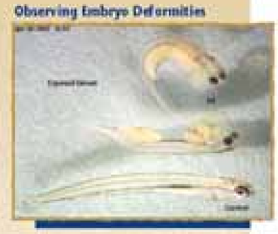
- to be compared with studies undertaken during and post remediation

The studies will provide solid baselines for monitoring changes to the environment and aquatic organisms during construction and after remediation as a result of the Randle Reef Sediment Remediation Project.

Deploying Caged Mussels

Sub-sampling for Benthic Community

Observing Embryo Deformities



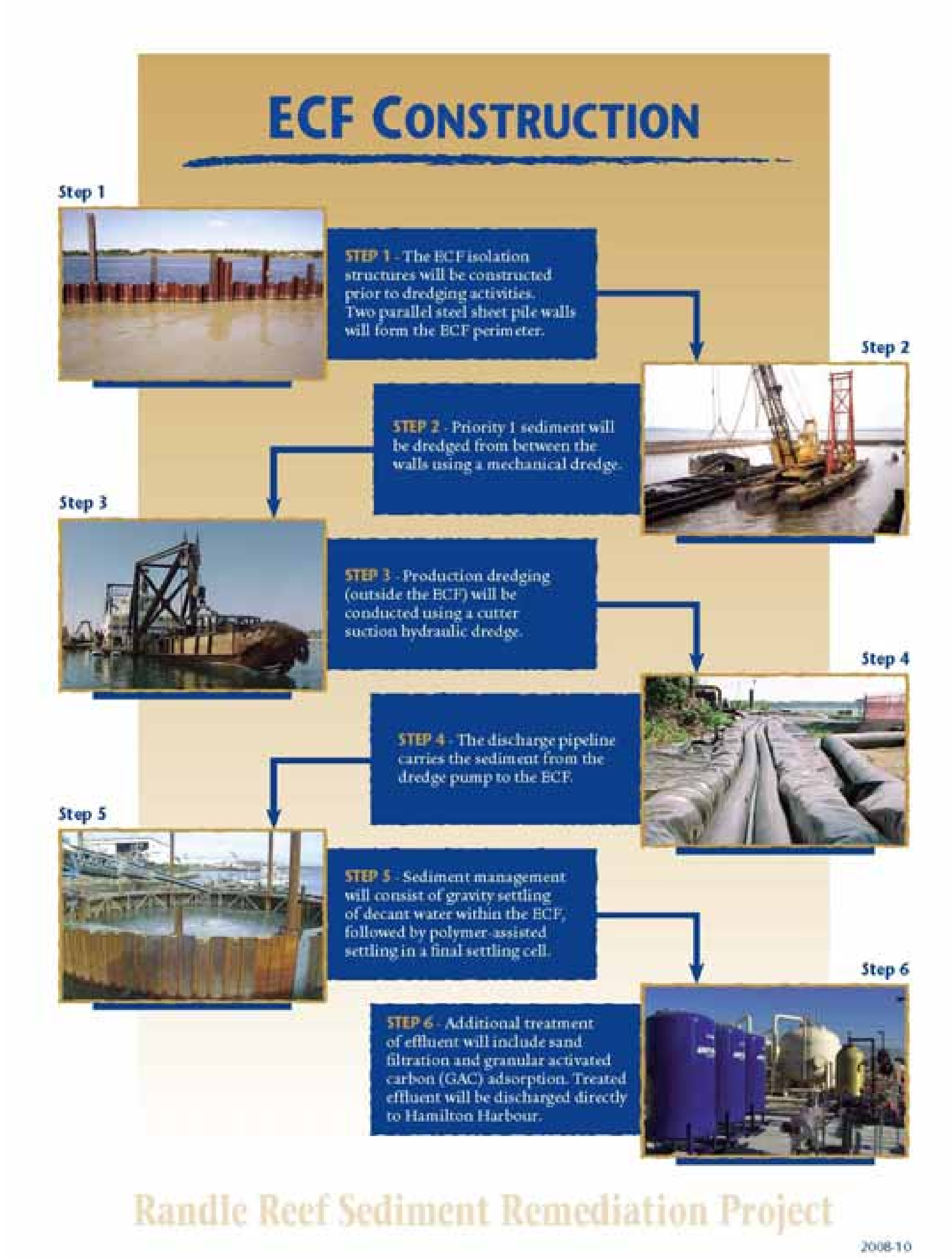
Collecting Wild Fish

List of Studies

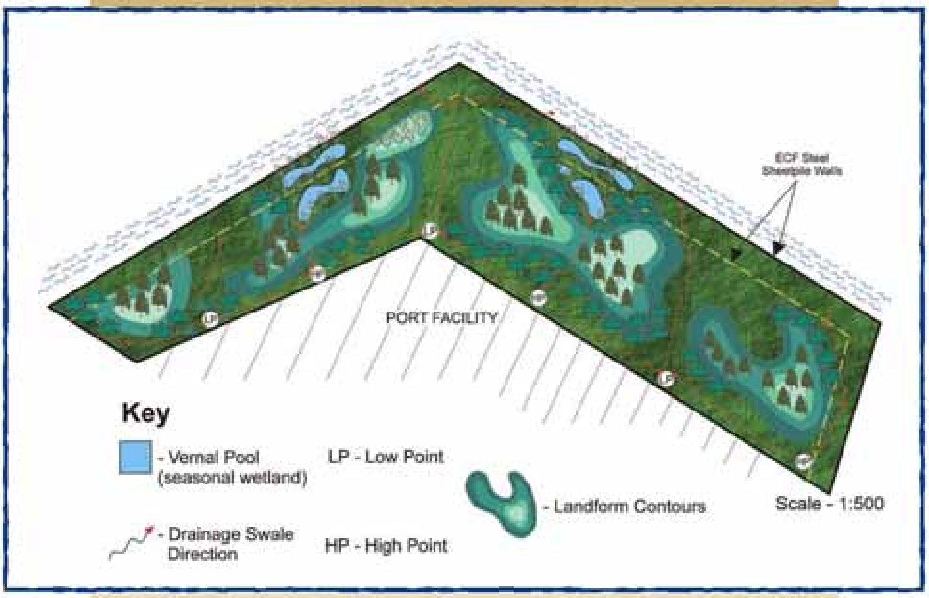
- PAH concentrations and profiles in suspended sediments
- sediment toxicity and benthic invertebrate community structure
- Toxicity Identification and Evaluation (TIE)
- Haemocytic leukemia in caged bivalves
- larval and embryo deformities in fish exposed to PAHs
- genetic and reproductive endpoints for caged fish and second generation inherited effects
- wild fish health endpoints
- tumours and external abnormalities in wild fish
- geo-referenced database

Randle Reef Sediment Remediation Project

2008-09


ECF CONSTRUCTION
Step 1
STEP 1 - The ECF isolation structures will be constructed prior to dredging activities. Two parallel steel sheet pile walls will form the ECF perimeter.
Step 2
STEP 2 - Priority 1 sediment will be dredged from between the walls using a mechanical dredge.
Step 3
STEP 3 - Production dredging (outside the ECF) will be conducted using a cutter suction hydraulic dredge.
Step 4
STEP 4 - The discharge pipeline carries the sediment from the dredge pump to the ECF.
Step 5
STEP 5 - Sediment management will consist of gravity settling of decant water within the ECF, followed by polymer-assisted settling in a final settling cell.
Step 6
STEP 6 - Additional treatment of effluent will include sand filtration and granular activated carbon (GAC) adsorption. Treated effluent will be discharged directly to Hamilton Harbour.
Randle Reef Sediment Remediation Project
2008-10

LANDSCAPE DESIGN



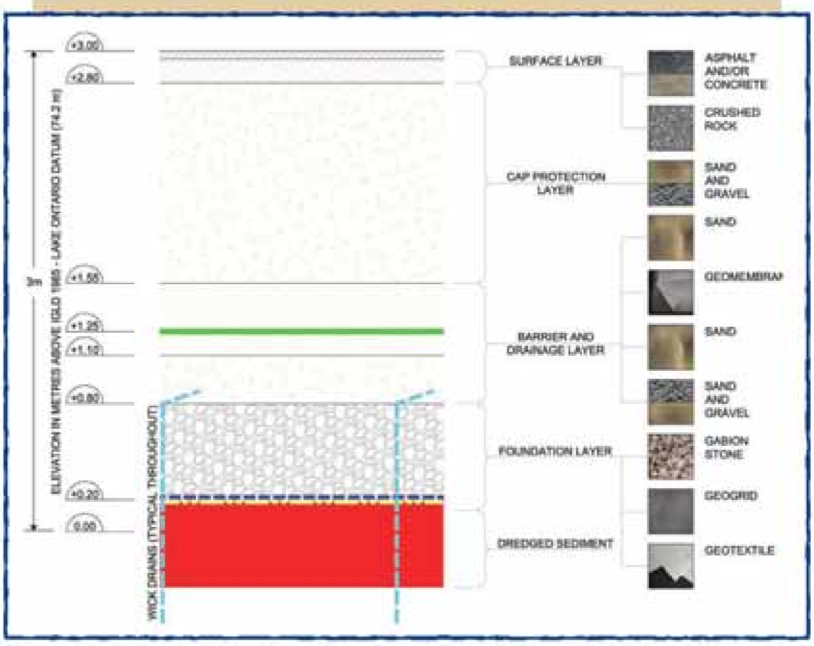
The desired future condition for the greenway is a vegetative cover system capable of sustaining native growth and providing various types of habitat as appropriate, providing terrestrial and wildlife opportunities, improving aesthetics and incorporating opportunities for a naturalized shoreline. The combination of landforms, understory trees and shrubs, and taller deciduous trees will provide a degree of visual relief from the views of the industrial facilities and activities in the harbour.

Randle Reef Sediment Remediation Project

2008-11

ECF CAP

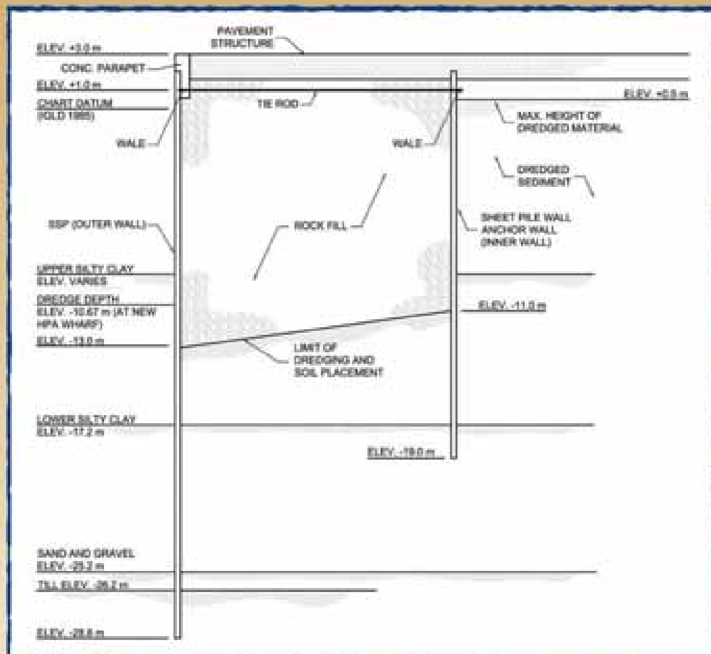
- This shows a section of the engineered containment facility cap. Cap materials to be used include aggregates of various sizes, geo-textile and geo-grid, wick drains, and surface materials (asphalt and/or concrete).
- Cap construction will follow completion of environmental dredging. The cap materials will be placed sequentially from the bottom up, and induced consolidation will take place in advance of final surfacing with asphalt and/or concrete.
- A combination of self-weight consolidation and induced consolidation will lower the contaminated dredge material elevation from +1.5 m to between +0.2 m and +0.5 m.
- The layers in the cap serve various functions, including isolation of the contaminated dredged sediment from the environment, a base foundation for the surface, and the structural ability of the area to provide end uses for both the port facility and the greenway.



Randle Reef Sediment Remediation Project

2008-12

ECF Structure - Section



This shows a section through the parallel double wall of the ECF.
The ECF will be constructed using various structural components.
Some of these components are:

- **Steel Sheetpile Facewall (Outer Wall)**
  This is the outer steel sheetpile wall forming the parallel double wall system that defines the perimeter of the ECF. It is also referred to as the structural wall. The south face of the ECF is the location where vessel berthing would take place for port use.

- **Steel Sheetpile Anchorwall With Sealed Interlocks (Inner Wall)**
  This is the inner steel sheetpile wall forming the double wall system of the ECF. It is also referred to as the environmental wall. This wall serves as the anchorage for the outer steel sheetpile wall.

- **Tie Rods**
  Tie rods are the long round steel bars that connect the two parallel steel sheetpile walls (outer and inner walls). Typically tie rods are spaced 6 to 8 feet apart, and act in tension to hold the double wall system together.

Randle Reef Sediment Remediation Project

2008-13

WHAT ALTERNATIVES WERE CONSIDERED?

- no action
- wait / no action now
- leave in place and cap (*in-situ* capping)
- leave in place and treat* (*in-situ* treatment)
- dredge and dispose at off-site waste facility
- dredge, treat* and reuse
- containment
- combinations of the above (24 options)

**biological, organic & inorganic extraction, thermal*

Selected Option

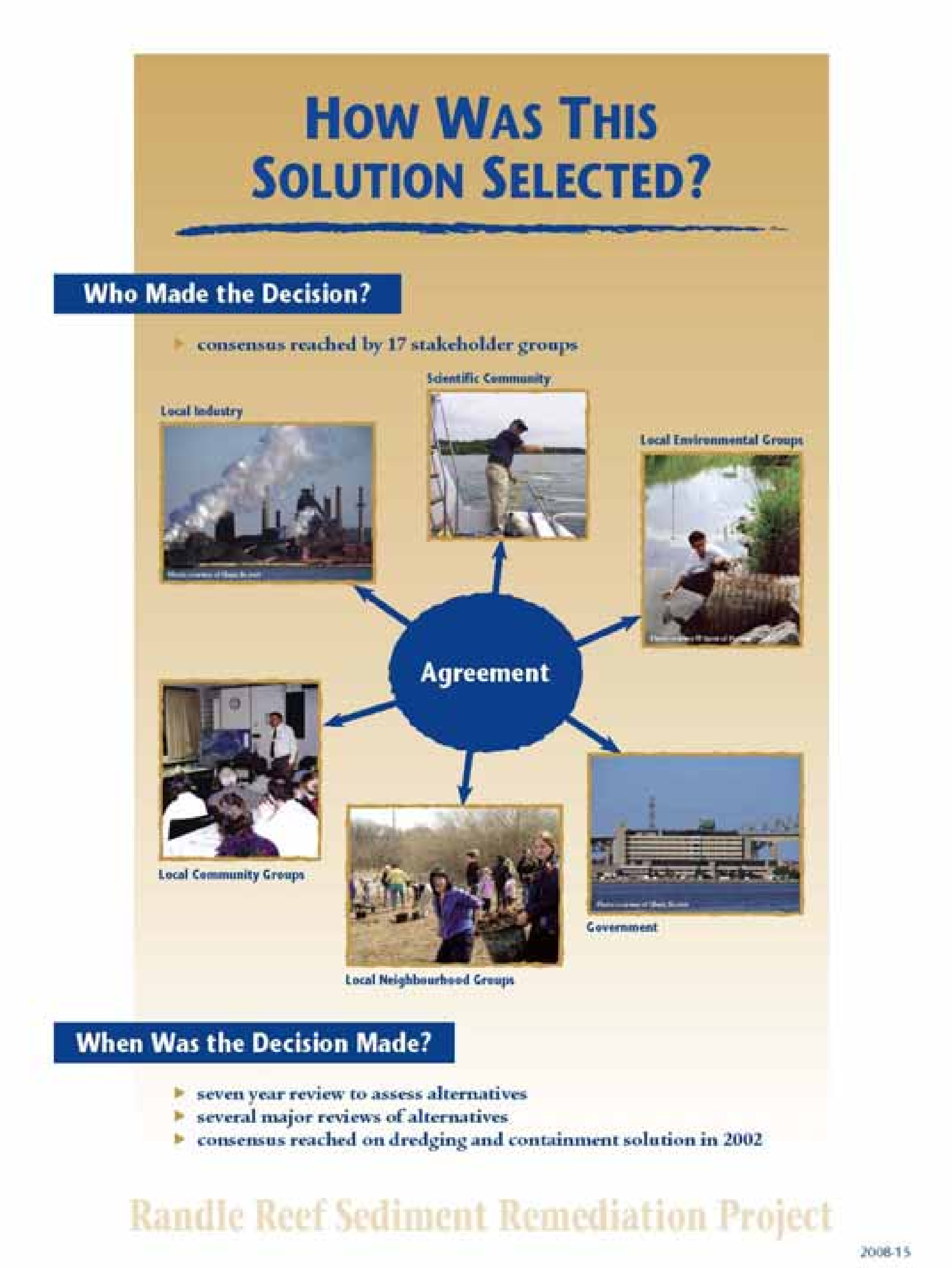
Environmental Dredging and Containment Within a State of the Art Engineered Containment Facility

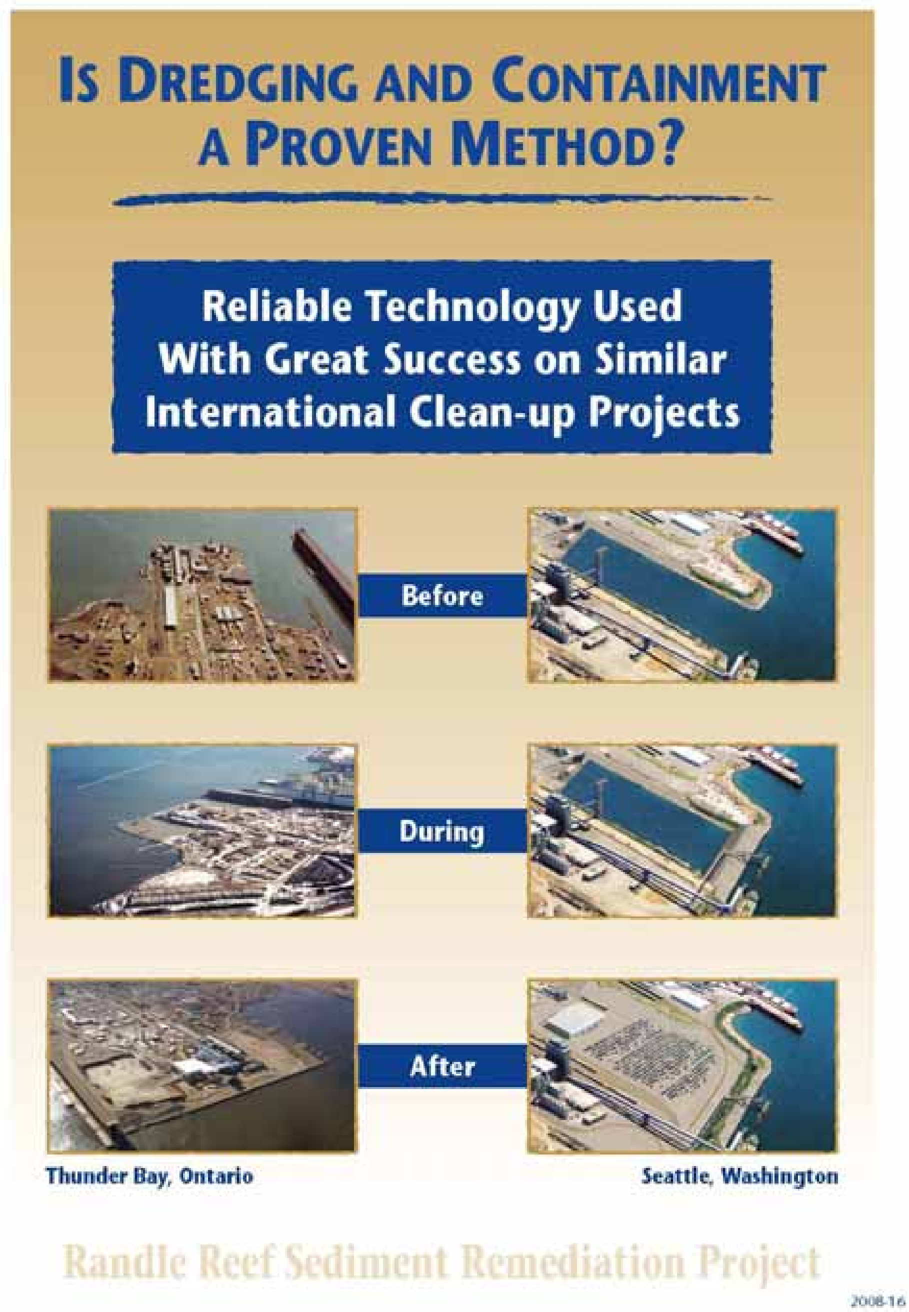
This Option is Best Suited Because It:

- offers a whole harbour solution – addresses over 90% of PAH contamination in the harbour
- utilizes a proven technology
- ensures a long-term solution
- meets timeline and budget requirements
- improves fish and wildlife habitats
- minimizes airborne emissions during construction
- ensures health and safety of public
- maintains shipping routes
- is cost-effective
- provides an opportunity for funding, ownership and maintenance partnerships

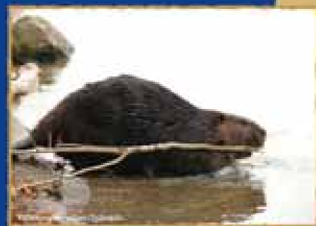
Randle Reef Sediment Remediation Project

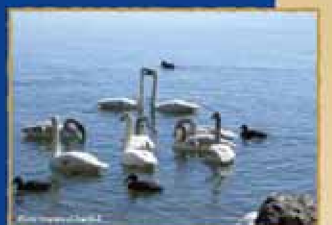
2008-14


HOW WAS THIS SOLUTION SELECTED?
Who Made the Decision?
consensus reached by 17 stakeholder groups
Scientific Community
Local Industry
Local Environmental Groups
Agreement
Local Community Groups
Government
Local Neighbourhood Groups
When Was the Decision Made?
seven year review to assess alternatives
several major reviews of alternatives
consensus reached on dredging and containment solution in 2002
Randle Reef Sediment Remediation Project
2008-15


IS DREDGING AND CONTAINMENT A PROVEN METHOD?
Reliable Technology Used With Great Success on Similar International Clean-up Projects
Before
During
After
Thunder Bay, Ontario
Seattle, Washington
Randle Reef Sediment Remediation Project
2008-16

WHY CLEAN UP?

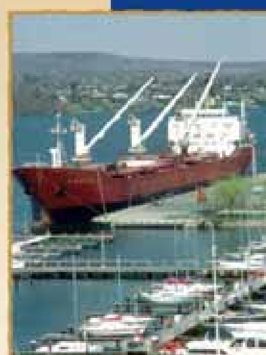




Stops the "spill in slow motion"

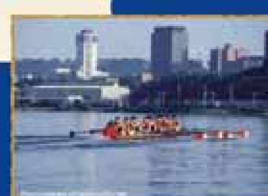
Environmental Benefits:

- preserve health of harbour
- improve fish and wildlife habitat
- reduce spread of contaminants through the harbour
- essential to delisting Hamilton Harbour as an Area of Concern



Economical and Social Benefits:

- estimate of $126M in economic impact to the community (job creation, business development, tourism)
- enhances recreational opportunities (beaches, boating, fishing)
- enhances shipping and port facilities
- promotes a positive image of the harbour and community as a place to live and work



Randle Reef Sediment Remediation Project

2008-17

Randle Reef Sediment Remediation Project
Public Meeting

Tuesday, November 18, 2008
1:00 p.m. - 9:00 p.m.
Hamilton Chamber of Commerce
555 Bay Street N., 2nd Floor

Meeting Overview

1:00 – 7:00 Opportunity to view displays and speak with the project team

7:00 – 8:00 Formal Presentations

- Welcome and Opening Remarks
  Brian McCarry, *McMaster University and Member of Project Advisory Group*
- Remediation Project Overview
  Roger Santiago, *Environment Canada*
- Engineering Design Overview
  Mark Mahoney, *Arcadis*
- Environmental Assessment Overview
  Dianne Damman, *D.C. Damman and Associates*

8:00 – 9:00 Question and Answer Session

- Facilitator, John Hall, *Hamilton Harbour Remedial Action Plan Coordinator*

Comment Form

If you have any comments on the *Randle Reef Sediment Remediation Project*, please feel free to use the back of this sheet and hand them in today.
If you prefer, please send comments to:
John Hall, Hamilton Harbour Remedial Action Plan Coordinator.
Phone: (905) 336 6465
Email: John.Hall@ec.gc.ca
Fax: (905) 336 4906
867 Lakeshore Road, Burlington, ON L7R 4A6

Comment Form

Please add notes or comments here:

Randle Reef Sediment Remediation Project
Contact Information

If you would like further information about the *Randle Reef Sediment Remediation Project* please see the Bay Area Restoration Council (BARC) website.

www.hamiltonharbour.ca

If you wish to speak to someone regarding project details please contact one of the members of the project steering committee:

Roger Santiago
Environment Canada
416 739 5876
Roger.santiago@ec.gc.ca

Wally Rozenberg
Ontario Ministry of the Environment
905 521 7700
Wally.Rozenberg@ontario.ca

Bill Fitzgerald
Hamilton Port Authority
905 525 4330 ext 208
bfitzgerald@hamiltonport.ca

Randle Reef Newspaper Articles – 1994 to 2008

	HEADLINE	NEWSPAPER	DATE	FOCUS OF ARTICLE	MENTIONED IN ARTICLE
1994					
1.	Maintaining Momentum – Harbour cleanup Group Has a New Coordinator	Hamilton Spectator	September 21		√
2.	A Toxic Dilemma	Hamilton Spectator	September 28	√	
1995					
3.	Bay's 'Hot Spot' Spreading Toxins – Randle Reef Source of Contamination	Hamilton Spectator	March 4	√	
4.	Life Around Lake Ontario – Hamilton's Renewable Water Resource	Toronto Star	October 1		√
1996					
5.	The Harbour is Now Cleaner But There's Still More to Be Done	Hamilton Spectator	June 26		√
6.	Legal Notices	Hamilton Spectator	July 16	√	
7.	Randle Reef a 'Toxic Hotspot'	Hamilton Spectator	July 31	√	
8.	Invest in the Cleanup	Hamilton Spectator	August 9	√	
1997					
9.	Province to Aid Harbour Cleanup	Hamilton Spectator	February 12	√	
10.	Zebra Mussels Used to Track Toxics	Hamilton Spectator	February 14		√
11.	Modest Million for Bay Cleanup	Hamilton Spectator	April 1	√	
12.	Hamilton Harbour: There's a Better Balance	Hamilton Spectator	May 9		√
13.	Harbour Frights	Hamilton Spectator	May 10	√	
14.	Randle Reef An Environmental Hot Spot	Hamilton Spectator	May 12	√	
15.	Stelco Must Face Cleanup Costs	Hamilton Spectator	May 14	√	
16.	Time for Stelco to Pay for Hotspot: Sterling	Hamilton Spectator	May 15	√	
17.	Stelco Has Cash for Big Ad Campaign, But Not Cleanup	Hamilton Spectator	May 16		√
18.	No More Games	Hamilton Spectator	May 23	√	
19.	Harbour Cleanup May Be Cut Back	Hamilton Spectator	May 28		√
20.	Cleanup Threatened (letter to Editor)	Hamilton Spectator	June 4		√

HEADLINE		NEWSPAPER	DATE	FOCUS OF ARTICLE	MENTIONED IN ARTICLE
21.	Scientist Back as Volunteer	Hamilton Spectator	August 15		√
22.	Forging Ahead On The Harbour	Hamilton Spectator	August 15		√
1998					
23.	What Can We Do For Hamilton Area?	Hamilton Spectator	March 31		√
24.	Toxic Cleanup Deal	Hamilton Spectator	July 24	√	
25.	Harbour Cleanup At Crossroads	Hamilton Spectator	September 2		√
26.	Hamilton Harbour A 'Toxic Hot Spot'	Hamilton Spectator	September 18		√
27.	Harbour Cleanup Lagging	Hamilton Spectator	September 18		√
28.	Cleaning Up This Town	Hamilton Spectator	September 18		√
1999					
29.	Reef Cleanup Would Emit Dioxins	Hamilton Spectator	June 1	√	
30.	Time to Make a Commitment To Our Harbour	Hamilton Spectator	June 21		√
31.	A Toxic Dilemma	Hamilton Spectator	June 21	√	
32.	Stelco Should Help Pay for Safe Cleanup of Randle Reef: Union	Hamilton Spectator	December 17	√	
2000					
33.	Our Harbour Dreams Are Closer To Reality	Hamilton Spectator	June 6		√
34.	Warnings On Lake Fish Urged	Hamilton Spectator	July 25		√
35.	Health Fears Stall Harbour Cleanup	Hamilton Spectator	July 26	√	
36.	Inertia Unacceptable On Harbour Cleanup	Hamilton Spectator	July 28	√	
37.	Toxic 'Torpedo' Hunts Harbour Pollution	Hamilton Spectator	August 29		√
38.	Harbour Report is Environmental Good News	Hamilton Spectator	August 29		√
2001					
39.	Bay Report Shows Success, Failings	Hamilton Spectator	January 31		√
40.	Black Slicks Spotted in Harbour	Hamilton Spectator	September 6		√
41.	Harbour Blob's Undergo Chemical 'Fingerprinting'	Hamilton Spectator	September8		√
42.	Reef Marks Harvey T.'s Role In Harbour History	Hamilton Spectator	October 25	√	

HEADLINE	NEWSPAPER	DATE	FOCUS OF ARTICLE	MENTIONED IN ARTICLE
43. Harbouring Hope	Hamilton Spectator	December 5		√
44. Clean Up of Randle Reef May Require Legal Action	Hamilton Spectator	December 5	√	
45. International Spotlight on Hamilton Harbour	Hamilton Spectator	December 5	√	
46. Hamilton Harbour Rebirth for Real At Last	Hamilton Spectator	December 5		√
47. Harbour Authority Setting The Right Tone	Hamilton Spectator	December 5		√
2002				
48. Solution for Toxic Hot Spot	Hamilton Spectator	March 4	√	
49. Hamilton Harbour Vision Vast, Friendly	Hamilton Spectator	March 5		√
50. Port Authority Offers Top-Rate Harbour Plan	Hamilton Spectator	March 6		√
51. Time to Pick Cleanup Plan for Harbour's Toxic Hot Spot	Hamilton Spectator	April 8	√	
52. No Perfect Solution	Hamilton Spectator	April 8	√	
53. Group Favours Toxic Reef Cap	Hamilton Spectator	April 11	√	
54. Will Our Harbour Be Clean At Long Last?	Hamilton Spectator	April 24	√	
55. Harbour stakeholders agree to cap hot spot	Hamilton Spectator	April 25	√	
56. Everything you wanted to know about Randle Reef	Hamilton Spectator	April 27	√	
57. Randle Reef: Key Stakeholders Agree	Hamilton Spectator	April 27	√	
58. Spec stories on harbour cleanup spawn award	Hamilton Spectator	June 12	√	
59. Start Posting Chemical Warnings	Hamilton Spectator	August 6		√
60. Harbour Action Names Stelco, Port Authority	Hamilton Spectator	September 18	√	
61. Randle Reef Cleanup Plan is Protested	Hamilton Spectator	September 19	√	
62. Harbour Cleanup Bill: $640m	Hamilton Spectator	September 20		√
63. Cleanup: Support from business, government crucial	Hamilton Spectator	September 21		√
64. Hamilton Harbour: What's Good, What's Not so Good	Hamilton Spectator	November 23		
65. Finding Redemption One Fish at a Time	Hamilton Spectator	November 25		√

HEADLINE	NEWSPAPER	DATE	FOCUS OF ARTICLE	MENTIONED IN ARTICLE
66. Bathers Kept in the Dark	Hamilton Spectator	November 28		√
67. City Can't Go It Alone on Harbour Renewal	Hamilton Spectator	November 29		√
68. Harbour threat plain to eye amid renewed cleanup vows	Mountain News	September 25		√
69. Bringing Back the Bay (Weeklong Series)	Hamilton Spectator	November	√	
70. Repairing Randle Reef	Hamilton Spectator	November 29	√	
71. Success Story in Progress IJC Says of Harbour	Hamilton Spectator	November 29		√
72. Science Gets to Bottom of Problem	Hamilton Spectator	November 29		√
73. Windermere Will Wait	Hamilton Spectator	November 30		√
74. Harbour in the Home Stretch	Hamilton Spectator	November 30		√
75. Ancient River Snakes Along Harbour Bottom	Hamilton Spectator	November 30		√
76. Toxins Occur as Complex Mixtures	Hamilton Spectator	December 10		√
77. Plans for Harbour Open to View	Hamilton Spectator	December 10		√
78. Copps Committed to Randle Reef cleanup	Hamilton Spectator	December 10	√	
79. New Threats Worrisome as Lakes' cleanup pace lags	Hamilton Spectator	December 10		√
80. Progress on Harbour is Worth Celebrating	Hamilton Spectator	December 10		√
81. 'Cap' on Randle Reef is a practical solution	Hamilton Spectator	December 10	√	
82. Harbour Hot Spot could be in line for funds	Hamilton Spectator	December 10	√	
83. Toxic stakes too high for stakeholder approach	Hamilton Spectator	December 10	√	
84. The Port Authority's Balancing Act	Hamilton Spectator	December 10		√
2003				
85. Public Notice – Randle Reef Sediment Remediation Project Open House	Hamilton Spectator		√	
86. Time to Make a Commitment to Our Harbour	Hamilton Spectator			√
87. Expressway Decision must Benefit Majority	Hamilton Spectator			√
88. Great Lakes Cleanup Slow, But City's Progress Praised	Hamilton Spectator			√

HEADLINE		NEWSPAPER	DATE	FOCUS OF ARTICLE	MENTIONED IN ARTICLE
89.	New Pier Plan Goes Public	Hamilton Spectator	June 9	√	
90.	Reef cleanup wins kudos	Hamilton Spectator		√	
	2004				
91.	Steward of our Harbour?	Hamilton Spectator			√
92.	Earth Day is Every Day	Hamilton Spectator			√
93.	Seeds of a Nature Reserve	Hamilton Spectator			√
94.	City Hopes Harbour Cleanup Gets Three-Pronged Attack	Hamilton Spectator	February 2		√
95.	Environmentalists Report Harbour is on the Mend	Hamilton Spectator	September 27		√
96.	Maligned Body of Water Reborn	Toronto Star	November 27		√
	2005				
97.	Group Reviewing Dated Great Lakes Treaty	Hamilton Spectator			√
98.	Where Water Lilies Once Congregated	Hamilton Spectator			√
99.	Cash Buoys Harbour Plans	Hamilton Spectator			√
100.	Randle Reef Cleanup "Big Problem"	Hamilton Spectator	February 25	√	
101.	Design Underway for Randle Reef	Hamilton Spectator	March 29	√	
102.	Find the Cash, Clean the Reef	Hamilton Spectator	March 30	√	
103.	A Family's Long Love Affair With Our Harbour	Hamilton Spectator	May 30		√
104.	Water Quality Commitment	Hamilton Spectator	October 25		√
105.	Harbour's Cleaner and Greener	Hamilton Spectator	November 8		√
	2006				
106.	Harbour Water Quality Showing Many Signs of Improvement	Flamborough Review	June 16		√
107.	…and Then There was Light; McMaster Scientists are Working on a Revolutionary Light Bulb in the Tiny, Tiny…	Hamilton Spectator	November 17		√
108.	Bay Cleanup Costs Run Deep	Hamilton Spectator	December 5		√
109.	An Investment in our Future	Hamilton Spectator	December 6		√
110.	Public Input Key to Governments Protecting Great Lakes	Hamilton Spectator	December 28		√
	2007				

HEADLINE	NEWSPAPER	DATE	FOCUS OF ARTICLE	MENTIONED IN ARTICLE
111. A Billion Reasons for Cleaning Up Our Harbour	Hamilton Spectator	January 18		√
112. Randle Reef Cleanup Could Bring $126 Million in Benefits, Study Says		January 19	√	
113. Fix Randle Reef and Perception	Hamilton Spectator	January 19	√	
114. Randle Reef Cleanup	Hamilton Spectator	January 20	√	
115. Shoring Up Support; City Wants Ottawa, Province to Kick in $60m for Randle Reef	Hamilton Spectator	January 20	√	
116. Randle Reef Cleanup is a Top Priority: Mayor	Hamilton Spectator	January 22	√	
117. Mayor Fred Goes to Ottawa	Hamilton Spectator	January 22		√
118. Mayor Won’t Play ‘Blame Game’ Just Wants Randle Reef Cleaned Up	Hamilton Spectator	January 29	√	
119. City Can’t Afford Reef Cleanup: MPP	Hamilton Spectator	January 31	√	
120. Mayor Offers PM a Deal: No Lawsuit if you Fund Us	Hamilton Spectator	February 7		√
121. Mayor and PM ‘Build a Relationship’	Hamilton Spectator	February 8		√
122. Who Gave Eisenberger Right to Deal?	Hamilton Spectator	February 12		√
123. Randle Reef: What’s Stelco’s Role?	Hamilton Spectator	February 13	√	
124. The Ugly Side of Environmental Justice; The Remedial Action Plan for Hamilton’s Harbour Ignores the Cause of Issues Like Randle Reef	Hamilton Spectator	February 19		√
125. Global Issues First	Hamilton Spectator	February 19		√
126. Hamilton Says 1 Cent Translates into $100m; Eisenberger Hopes Budge Will Deliver	Hamilton Spectator	March 19		√
127. Harbour Cleanup Setback: Hopes for Randle Reef Sink as Province Offers Trickle of Cash	Hamilton Spectator	March 23	√	
128. Budget Hits & Misses	Hamilton Spectator	March 23		√
129. Budget Has City Waiting, Hoping	Hamilton Spectator	March 23		√
130. Bridge “Will Be An Icon” for City	Hamilton Spectator	April 3		√
131. Councillors Want Leadership from Mayor Fred	Hamilton Spectator	April 13		√
132. Sea Change	Hamilton Spectator	May 3		√

HEADLINE	NEWSPAPER	DATE	FOCUS OF ARTICLE	MENTIONED IN ARTICLE
133. HPA Turns Attention to Harbour's Health	Hamilton Spectator	May 3		√
134. Port's Bold Move	Hamilton Spectator	May 7		√
135. Awards for Eco-Warriors	Hamilton Spectator	June 5		√
136. Harbour Report Card	Hamilton Spectator	June 6		√
137. Dalton McGuinty to Hamilton: Tell Me What You Want	Hamilton Spectator	June 7		√
138. Keeping Moving on the Waterfront	Hamilton Spectator	June 7		√
139. Have Your Say	Hamilton Spectator	June 8		√
140. Get While the Getting's Good	Hamilton Spectator	June 8		√
141. Voter's Don't Trust Dalton, Says Rivals	Hamilton Spectator	June 11		√
142. Premier Dalton McGuinty Rolled Into Hamilton Last Week to Ask Hamiltonians What He Should Do to Help the Area	Hamilton Spectator	June 11		√
143. The Shipping News	Hamilton Spectator	June 25		√
144. There's More to Dalton Than Broken Promises	Hamilton Spectator	July 4		√
145. Minister Mum on Randle Reef	Hamilton Spectator	July 12	√	
146. Ex-harbour commissioners damaged fish habitat at Sherman Inlet: report	Hamilton Spectator	July 16		√
147. Minister visiting Randle Reef	Hamilton Spectator	July 17	√	
148. Filling of Sherman Inlet hurt Fish Habitats	Hamilton Spectator	July 17		√
149. Will Minister Dig Deep for Toxic Reef?	Hamilton Spectator	July 18	√	
150. Standing up for the Harbour	Hamilton Spectator	July 18		√
151. No Charges for Illegal Filling of Sherman Inlet	Hamilton Spectator	July 19		√
152. DFO Holds Back on Filled Inlet Charges	Hamilton Spectator	July 20		√
153. Ontario Committed to the Great Lakes	Hamilton Spectator	July 21	√	
154. Hamilton's Waterfront is a Source of Pride	Hamilton Spectator	July 30		√
155. Harbour Tour Full of Surprises and Sunshine	Hamilton Spectator	August 11		√
156. Liberals Announce $30-million for	Globe and Mail	August 15	√	

HEADLINE	NEWSPAPER	DATE	FOCUS OF ARTICLE	MENTIONED IN ARTICLE
Randle Reef Cleanup				
157. Ontario to Invest $30 million Towards Hamilton Harbour Cleanup	Hamilton Spectator	August 15	√	
158. Province Gives $30-million to Clean Up Randle Reef	Hamilton Spectator	August 16	√	
159. A Reef Called Randle	Hamilton Spectator	August 16	√	
160. Big-Spender McGuinty: We Can Manage	Toronto Star	August 16		√
161. Future Use of Randle Reef is Questionable	Hamilton Spectator	August 17	√	
162. Harbour Cleanup Could Net City $914 m in Benefits	Hamilton Spectator	August 17	√	
163. Randle Reef Fix: Key to Cleaning Up City's Image	Hamilton Spectator	August 17	√	
164. Reef Cleanup is a Serious Issue	Hamilton Spectator	August 17	√	
165. Randle Reef Solution Near as Funds Appear	Hamilton Spectator	August 18	√	
166. McGuinty to Announce Innovation Project at Dofasco	Hamilton Spectator	August 24		√
167. Hamilton a Must-Win Target for the Liberals	Hamilton Spectator	September 8		√
168. McGuinty Warns Hamilton Will Lose if Conservatives Win	Hamilton Spectator			√
169. No Comment	Hamilton Spectator	September 13		√
170. Mayor Says Lister, Randle Cash 'Will Flow'	Hamilton Spectator	September 14		√
171. Local Firm Has Low-Cost Plan to Clean Randle Reef	Hamilton Spectator		√	
172. Don't Bury Randle Mess, We'll Reuse it, Firm Says	Hamilton Spectator	September 29	√	
173. A Walk Through the Future	Hamilton Spectator	September 29		√
174. Hamilton, the Ambitious City Once More	Hamilton Spectator	October 3		√
175. Too Late to Change Plan for Randle Coal Tar?	Hamilton Spectator	October 4	√	
176. Mayor Fred Puts the Cart Before the Horse	Hamilton Spectator	October 5		√
177. Voting for Dollars	Hamilton Spectator	October 6		√
178. Promises, Promises!	Hamilton Spectator	October 6		√
179. Grits Deserve Second Term	Hamilton Spectator	October 6		√

HEADLINE	NEWSPAPER	DATE	FOCUS OF ARTICLE	MENTIONED IN ARTICLE
180. Let's Hope This is Not a Wasted Exercise	Hamilton Spectator	October 11	√	
181. Our Future Begins Now	Hamilton Spectator	October 11		√
182. Baird Coming with Cash for Randle Reef Cleanup	Hamilton Spectator	November 8	√	
183. Government of Canada to Make Announcement on Hamilton Harbour	Media Advisory – Environment Canada	November 8	√	
184. Ottawa Delivers $30m to Complete Randle Reef Puzzle	Hamilton Spectator		√	
185. Randle Reef 101	Hamilton Spectator	November 10	√	
186. Hamilton Closer to Cleaning up its Image	Hamilton Spectator	November 10	√	
187. A Legacy on the Waterfront	Hamilton Spectator	November 10	√	
188. Hamilton's Turn to Step Up	Hamilton Spectator	November 12	√	
189. Clean Up Randle Reef Mess Properly	Hamilton Spectator	November 15	√	
190. Spectator Stance on Randle Reef Troubling(Opinion Section)	Hamilton Spectator	November 15	√	
191. Let Local Company Give Its New Process a Crack at Cleaning Up Randle Reef	Hamilton Spectator	November 21	√	
192. Taking Issue With Liberals	Hamilton Spectator	November 27		√
193. City Log	Hamilton Spectator	December 3		√
194. Inlet Toxic to Fish, So Fill-In Didn't Matter: Port Boxx	Hamilton Spectator	December 4		√
195. Ministry Cool to Decontamination for Toxic Mud	Hamilton Spectator	December 8		√
196. Opposition Runs Deep	Hamilton Spectator	December 18		√
197. Year in Review	Hamilton Spectator	December 31		√
2008				
198. Year In Review	Hamilton Spectator	January 3		√
199. City Should Not be Footing Any of Randle Reef Bill	Hamilton Mountain News/Stoney Creek News (Letter to Editor)	January 4	√	
200. Great Lakes Focus Has Tanked: Report	Hamilton Spectator	February 2		√
201. Hobson Pond Will Remain Untouched	Hamilton Spectator	February 2		√

HEADLINE	NEWSPAPER	DATE	FOCUS OF ARTICLE	MENTIONED IN ARTICLE
202. Amalgamation Doesn't Work	Hamilton Spectator	February 20		√
203. Federal Government is Working on GO Transit	Hamilton Spectator	March 6		√
204. MP's Censorship Try Inappropriate	Hamilton Spectator	March 10		√
205. City Log	Hamilton Spectator	March 17	√	
206. Red Hill Parkway Legal Fight Still On, Says, Council	Hamilton Spectator	March 26		√
207. McMeekin Talks Up Biosphere Park	Hamilton Spectator	March 29		√
208. Hamilton Next	Hamilton Spectator	May 16		√
209. Health of Bay Tied to Health of Community	Hamilton Spectator	June 14		√
210. 'We're on the Move,' Says Mayor	Hamilton Spectator	July 23		√
211. The $48-million Question	Hamilton Spectator	August 27		√
212. Making Plans for Randle: $90M Cleanup Strategy Being Floated for Public Input in November	Hamilton Spectator	August 29	√	
213. Rotary Puts Spotlight on Water	Hamilton Spectator	October 6		√
214. Simple or Smooth—You Choose	Hamilton Spectator	October 6		√
215. Put Hamilton At The Table, Harper Urges	Hamilton Spectator	October 8		√
216. Beyond the View from the Bridge	Hamilton Spectator	October 30		√
217. Learn More About $ 90M Harbour Cleanup Plan	Hamilton Spectator	November 15	√	
218. Randle Reef Team Seeks $ 23M	Hamilton Spectator	November 19	√	
219. Randle Reef Not City's Problem	Hamilton Spectator	November 21	√	
2009				
220. Will Steel Slump Hurt Reef Cleanup?	Hamilton Spectator	March 18		√
221. Hamilton Harbour Remains One of the Most Severely Polluted Water Bodies in Ontario	Hamilton Spectator	April 23		√
222. Reef cleanup bogged down	Hamilton Spectator	November 24	√	
223. Randle Reef frustration	Hamilton Spectator	November 26	√	
2010				
224. Stelco called cleanup saboteur; New book says it tried to derail harbour upgrade	Hamilton Spectator	February 17		√

	HEADLINE	NEWSPAPER	DATE	FOCUS OF ARTICLE	MENTIONED IN ARTICLE
225.	Effort to cap toxic stew awaits only city funding	Hamilton Spectator	February 16	√	
226.	Randle Reef quagmire	Hamilton Spectator	February 18	√	
227.	HAVE YOUR SAY	Hamilton Spectator	February 18	√	
228.	'Solid leadership' sought; Two MPs ask feds for help with Randle Reef cleanup	Hamilton Spectator	February 27	√	
229.	Space? Money? Let's build the stadium on harbour's Randle Reef	Hamilton Spectator	March 1	√	
230.	The shame of Randle Reef; Politics derail cleanup of the harbour	Hamilton Spectator	March 15	√	
231.	Fixing Randle Reef	Hamilton Spectator	March 19	√	
232.	Waterway clean up may cost city $2M	InsideHalton.com	April 7	√	
233.	Toxic cleanup bill keeps rising	Hamilton Spectator	April 19	√	
234.	Cities sludge it out	The Bay Observer	May	√	
235.	City increases commitment to clean up Randle Reef	Ancaster News	May 6	√	

SIX NATIONS COUNCIL
www.sixnations.ca
(519) 445-2201 P.O. Box 5000, Ohsweken, Ontario Canada N0A 1M0 Fax: (519) 445-4208

May 31' 2004

John Shaw, Manager
Great Lakes Sustainability Fund Environment Canada 867 Lakeshore Road Burlington, ON L7R 4A6

Re: Randle Reef Contamjnated Sediment Remediation Project Hamilton Harbour

Dear Mr. Shaw:

Six Nations of the Grand River appreciated your presentation that provided information on the proposed Randle Reef Contaminated Sediment Remediation Project planned for Hamilton Harbour.

Issues of environment within our traditional territory are of importance. To that end, Six Nations Council would like to see the maximum amount of contaminants contained by the proposed project reflecting the construction of the 9.5 hectare structure. Six Nations has not identified any other issues relating to the Randle Reef Remediation Project.

Please keep us informed of the Projects progress and any changes that may arise.

Respectfully Yours,

[redacted]

SIX NATIONS OF THE GRAND RIVER