Tables

Table 2-1a. Documented Occurrences and Listed Status of Rare Animals Within the Saginaw Bay Watershed (Midland, Saginaw, Bay Counties)

Common Name[a]	Scientific Name	Federal Status	State Status	County(ies) of Documented Occurrence[a]	Natural Community Associations[b]	Likely Exposure to Segment 1 Sediments?
Birds						
Henslow's Sparrow	*Ammodramus henslowii*	--	E	Bay, Sag	LWMP, HILP, MSP, MP	No
Red-shouldered Hawk	*Buteo lineatus*	--	T	Mid	DMNF, DMSF, MNF, MSF	No
Peregrine falcon	*Falco peregrinus*	--	E	Bay	SLC, VLC, GLC, LLC, VC, GV, SC	No
Least Bittern	*Ixobrychus exilis*	--	T	Bay	EM, GLM	No
King Rail	*Rallus elegans*	--	E	Sag, Bay	EM, GLM, LWP, LWMP, SWM	No
Caspian Tern	*Sterna caspia*	--	T	Bay	sand/gravel beach	No
Forster's Tern	*Sterna forsteri*	--	T	Bay	GLM	No
Common Tern	*Sterna hirundo*	--	T	Bay, Mid	sand/gravel beach	No
Fishes						
Channel Darter	*Percina copelandi*	--	E	Sag	Inland lakes, streams, rivers	No
River Darter	*Percina shumardi*	--	E	Sag	Lake Huron, Inland lakes, streams, rivers	No
Sauger	*Sander canadensis*	--	T	Bay[H]	Lake Huron, rivers	No
Insects						
Persius Duskywing	*Erynnis persius persius*	--	T	Bay	OO, OPB	No
Frosted Elfin	*Incisalia irus*	--	T	Bay	OB, OPB	No
Mollusks						
Slippershell	*Alasmidonta viridis*	--	T	Mid	HSRIFF, HSRUN, MSRIFF, MSRUN, INLLB	Potentially[c]
Northern riffleshell	*Epioblasma torulosa rangiana*	E	E	Bay	MSRIFF, RIRIFF	No
Snuffbox	*Epioblasma triquetra*	--	E	Sag, Mid	streams	No
Easter pondmussel	*Ligumia nasuta*	--	E	Bay	No data	No
Reptiles						
Spotted Turtle	*Clemmys guttata*	--	T	Sag	B, EM, GLM, DMSF, MSF, PF, IMW, SWM, WMP, OB, RCS	No
Eastern Fox Snake	*Pantherophis gloydi*	--	T	Sag	GLM, EM, MSF, LOO, LWMP, LWP	No

Notes:

a. Counties of documented occurrence and natural community associations as identified by the Michigan Natural Features Inventory (MNFI) Rare Species Explorer animal lists at http://web4.msue.msu.edu/mnfi/explorer/index.cfm accessed on March 15, 2011. Status and distribution of many listed species and their natural habitats is uncertain because systematic surveys have not yet been completed.

b. These habitat associations are uncertain based on best professional judgment and known use of this species of palustrine forested wetlands and palustrine herbaceous wetlands identified in the Comprehensive Report Species – Cryptotis parva downloaded from the Nature Serve website at http://www.natureserve.org/explorer on December 13, 2007; this species may also occur in a number of other terrestrial forested habitats within the Basin such as MSF, MNF, DMNF, and DMSF.

c. There are not documented occurrences of this species in Setment 1 The habitat for this species is marginal in Segment 1, as it is typically found in creeks and headwaters of rivers, though it has been reported in larger rivers and in lakes and therefore, cannot be ruled out. . In fall 2010, a benthic survey was performed in Segment 1. The survey found no evidence of the slippershell mollusk in Segment 1.

* - Natural communities followed by an asterisk are not known to be within the Saginaw Bay Basin.

[H] - Historic occurrence; element not recorded in over 50 years.

Status Codes:
E: Endangered
T: Threatened
--: Not Listed
LE: Listed Endangered

Counties:
Bay: Bay
Mid: Midland
Sag: Saginaw

Natural Communities:
B: bog
DMNF: dry-mesic northern forest
DMSF: dry-mesic southern forest
EM: emergent marsh
GLM: Great Lakes marsh
HSRIFF: Headwater stream - riffle
HSRUN: Headwater stream - run
HILP: Hillside prairie
IMW: intermittent wetland
INLLB: Inland lake - littoral benthic
LOO: lakeplain oak openings
LWMP: lakeplain wet-mesic prairie
LWP: lakeplain wet prairie
MSRIFF: mainstream stream - riffle
MSRUN: mainstream stream - run
MP: mesic prairie
MNF: mesic northern forest
MSF: mesic southern forest

Natural Communities Cont:
MSP: mesic sand prairie
OO: oak openings
OB: oak barrens
OPB: oak-pine barrrens
PF: prairie fen
RCS: rich conifer swamp
RIRIFF river - riffle
SWM: southern wet meadow
WMP: wet-mesic prairie
WMSP: wet-mesic sand prairie
SLC: sandstone lakeshore cliff
VLC: volcanic lakeshore cliff
GLC: granite lakeshore cliff
LLC: limestone lakeshore cliff
VC; volcanic cliff
SC: sandstone cliff

Table 2-1b. Documented Occurrences and Listed Status of Rare Plants Within Bay, Midland, and Saginaw Counties

Common Name	Scientific Name	Federal Status	State Status	County(ies) of Documented Occurrence[a]	Natural Community Associations[a]	Likely Exposure to Segment 1 Sediments?
Three-awned Grass	*Aristida longespica*	--	T	Mid	LWP	No
Tall Green Milkweed	*Asclepias hirtella*	--	T	Bay	LWP	No
Forked Aster	*Aster furcatus*	--	T	Mid[H]	SFF*	No
Slough Grass	*Beckmannia syzigachne*	--	T	Bay	EM	No
False Hop Sedge	*Carex lupuliformis*	--	T	Bay	SFF*	No
Weak Stellate Sedge	*Carex seorsa*	--	T	Mid[H]	HCS*, SHS*	No
Beak Grass	*Diarrhena americana*	--	T	Mid	SFF*	No
Showy orchis	*Galearis spectabilis*	--	T	Sag, Bay[H]	MNF, MSF	No
Whorled pogonia	*Isotria verticillata*	--	T	Sag	B, DMNF	No
Orange or Yellow Fringed Orchid	*Platanthera ciliaris*	--	E	Bay[H]	B	No
Eastern Prairie white-fringed Orchid	*Platanthera leucophaea*	T	E	Sag, Bay[H]	B, LWP, LWMP	No
Hairy Mountain-mint	*Pycnanthemum pilosum*	--	T	Sag[H]	OO	No
Fire Pink	*Silene virginica*	--	E	Bay[H]	DMSF, OB	No

Notes:

a. Counties of documented occurrence and natural community associations as identified by Michigan Natural Features Inventory (MNFI) Rare Species Explorer animal lists at http://web4.msue.msu.edu/mnfi/explorer/index.cfm accessed onMarch 15, 2011. Status and distribution of many listed species and their natural habitats is uncertain because systematic surveys have not yet been completed.

b. These habitat associations are uncertain based on best professional judgment and known use of this species of palustrine forested wetlands and palustrine herbaceous wetlands identified in the Comprehensive Report Species – Cryptotis parva downloaded from the Nature Serve website at http://www.natureserve.org/explorer on December 13, 2007; this species may also occur in a number of other terrestrial forested habitats within the Basin such as MSF, MNF, DMNF, and DMSF.

* - Natural communities followed by an asterisk are not known to be within the Saginaw Bay Basin.

H - Historic occurrence; element not recorded in over 50 years

Status Codes:
E: Endangered
T: Threatened
--: Not Listed

Counties:
Bay: Bay
Mid: Midland
Sag: Saginaw

Natural Communites:
B: bog
DMNF: dry-mesic northern forest
DMSF: dry-mesic southern forest
EM: emergent marsh
HCS: hardwood-conifer swamp
LWMP: lakeplain wet-mesic prairie
LWP: lakeplain wet prairie
MNF: mesic northern forest
MSF: mesic southern forest
OO: oak openings
OB: oak barrens
SFF: southern floodplain forest
SHS: Southern hardwood swamp

Table 3-1 Existing Reports Contributing to Characterization of Segment 1

Geology, Geomorphology, and Sediment Transport
ATS. 2006, 2007, 2008, 2009, 2010. Segment 1 Multi-beam Bathymetric Surveys. Ann Arbor Technical Services, Inc. Ann Arbor, Michigan
ATS. 2009. Final GeoMorph® Pilot Site Characterization Report, Upper Tittabawassee River and Floodplain Soils Midland, Michigan, Volumes III and IV. Ann Arbor Technical Services, Inc. Ann Arbor, Michigan. June.
ENVRION International and LimnoTech In. 2008. Riverbank Stabilization Pilot Corrective Action Project for the Tittabawassee River. Prepared for The Dow Chemical Company. January.
McDowell and Associates. 2000. Final Report, Hydrogeological Study and Design, 2001 RGIS Upgrade Project Lift Station #5 to Station 69+25. Mildand, MI. February.
Radian International. 1998. Reventment Groundwater Interception System Hydraulic Loading and Flow Study. Prepared for The Dow Chemical Company. April.
Radian International. 2000. Identification and Description of Glacial Till Sand Units in Areas Along the Tittabawassee River. Prepared for The Dow Chemical Company. April.
Sediment Chemistry
ATS. 2009. Final GeoMorph® Pilot Site Characterization Report, Upper Tittabawassee River and Floodplain Soils Midland, Michigan, Volumes I, II, and V. Ann Arbor Technical Services, Inc. Ann Arbor, Michigan. June.
URS. 2010. Compliance Schedule Task H-12 Historic Outfall Investigation Summary Report, Sections 4.1-4.2. January.
Sediment Toxicity
Currie, R.J., J.W. Davis, and S.C. Lucas. 2008. Evaluation of Sediment Toxicity in Tittabawassee River Sediments Using the Midge, *Chironomus dilutus* and the Amphipod, *Hyalella azteca* . The Dow Chemical Company, Midland, MI. October 29th, 2008.
Currie, R.J., J.W. Davis, and S.C. Lucas. 2008. Evaluation of Sediment Toxicity in Tittabawassee River Sediments Using the Midge, *Chironomus dilutus* and the Amphipod, *Hyalella azteca* . The Dow Chemical Company, Midland, MI. October 29th, 2008.
ERM. 2008. Sediment Toxicity Test Results, *Hyalella azteca* and *Chironomus dilutus* 10 Day Survival and Growth Tests. 5-15 December 2008. Environmental Resources Management, Holland, MI.
ERM. 2009. Sediment Toxicity Test Report, *Hyalella azteca* and *Chironomus dilutus* 10 Day Survival and Growth Tests. 13-23 March 2009. Environmental Resources Management, Holland, MI.
ERM. 2009. Sediment Toxicity Test Report, *Hyalella azteca* and *Chironomus dilutus* 10 Day Survival and Growth Tests. 12-22 June 2009. Environmental Resources Management, Holland, MI.
ERM. 2009. Sediment Toxicity Test Report, *Hyalella azteca* and *Chironomus dilutus* 10 Day Survival and Growth Tests. 2-12 October 2009. Environmental Resources Management, Holland, MI.
ERM. 2009. Sediment Toxicity Test Report, *Hyalella azteca* and *Chironomus dilutus* 10 Day Survival and Growth Tests. 24 November-4 December 2009. Environmental Resources Management, Holland, MI.
GLEC. 2009. Final Report: *Chironomus dilutus* and *Hyalella azteca* 10-Day Whole Sediment Toxicity Testing Results for Midland Dow Sediment Samples. January 26, 2009. Great Lakes Environmental Center, Traverse City, MI.

Table 3-1 Existing Reports Contributing to Characterization of Segment 1

GLEC. 2009. Final Report: *Chironomus dilutus* and *Hyalella azteca* 10-Day Whole Sediment Toxicity Testing Results for Midland Dow Sediment Samples. August 10, 2009. Great Lakes Environmental Center, Traverse City, MI.

GLEC. 2009. Final Report: *Chironomus dilutus* and *Hyalella azteca* 10-Day Whole Sediment Toxicity Testing Results for Midland Dow Sediment Samples. December 2, 2009. Great Lakes Environmental Center, Traverse City, MI

Bioaccumulation

Davis, J.W., S.C. Lucas, and G.D. Martin, 2008. Monitoring of Chemical Residues in the Tittabawassee River (Reach D) using Semi-Permeable Membrane Devices (SPMDs): June-July 2007. Dow Chemical Company, Midland, MI. November 13.

Davis, J.W., M. Crook, S.C. Lucas, and G.D. Martin. 2009. Monitoring of 2,3,7,8-Substituted Polychlorinated Dibenzo-P-dioxins and Dibenzofurans in the Tittabawassee River using Semi-Permeable Membrane Devices (SPMDs): Former 47 Building Site: June-July 2008. Dow Chemical Company, Midland, MI. January 27.

Dow Chemical Company, 1999. 1998 Native Fish Monitoring Survey of the Tittabawassee River.

Dow Chemical Company, 2002. 2001 Native Fish Monitoring Survey of the Tittabawassee River.Dow. 2005. NPDES Permit MI 0000868: Submittal of Analyses Related to Wild Fish Monitoring Study.

Dow. 2007. NPDES Permit MI 0000868: Submittal of Analyses Related to Wild Fish Monitoring Study.

ENTRIX. 2007. Analytical Report for Fish Sampled from the Tittabawassee and Saginaw Rivers in Support of Human Health Risk Assessment. ENTRIX, Incorporated. December 17.MDNR. 1984. Fish Contaminant Monitoring in Michigan - 1984. Surface Water Quality Division, Michigan Department of Natural Resources. Report #MI/DNR/SWQ-89/071.

MDNR 1987. Fish Contaminant Monitoring Program 1987 Annual Report. Surface Water Quality Division, Michigan Department of Natural Resources. Report # MI/DNR/SWQ-87

MDNR. 1992. Fish Contaminant Monitoring Program 1992 Annual Report. Surface Water Quality Division, Michigan Department of Natural Resources. Report # MI/DNR/SWQ-92/292.

MDNR. 1995. Fish Contaminant Monitoring Program 1995 Annual Report. Surface Water Quality Division, Michigan Department of Natural Resources. Report # MI/DNR/SWQ-95/.

MDNRE. 1999. Fish Contaminant Monitoring Program 1999 Annual Report. Surface Water Quality Division, Michigan Department of Natural Resources. Report # MI/DNR/SWQ-99

MDNRE. 2000. Fish Contaminant Monitoring Program 2000 Annual Report. Surface Water Quality Division, Michigan Department of Natural Resources. Report # MI/DNR/SWQ-00

Woodburn, KB, AJ Clark, HD Kirk, LL Lamparaski, B Landenberger, TL Peters, and DL Rick. 1998. Caged Catfish Biouptake Study on the Tittabawassee and Chippewa Rivers. The Dow Chemical Company, Midland, MI. February 16.

Woodburn, KB, D Myers, and L McFadden. 2003. 2001 Caged Catfish Biouptake Study on the Tittabawassee and Chippewa Rivers: Chlorobenzene, Chlorophenol, and DDD Residues in Fish. The Dow Chemical Company, Midland, MI. October 10.

Table 3-2a 2006-2007 Site Investigation Sediment Analytes

Chlorobenzene	
634-66-2	1,2,3,4-TETRACHLOROBENZENE
87-61-6	1,2,3-TRICHLOROBENZENE
95-94-3	1,2,4,5-TETRACHLOROBENZENE
120-82-1	1,2,4-TRICHLOROBENZENE
95-50-1	1,2-DICHLOROBENZENE
541-73-1	1,3-DICHLOROBENZENE
106-46-7	1,4-DICHLOROBENZENE
108-90-7	CHLOROBENZENE
118-74-1	HEXACHLOROBENZENE
608-93-5	PENTACHLOROBENZENE
82-68-8	PENTACHLORONITROBENZENE
Chlorophenol	
58-90-2	2,3,4,6-TETRACHLOROPHENOL
95-95-4	2,4,5-TRICHLOROPHENOL
88-06-2	2,4,6-TRICHLOROPHENOL
120-83-2	2,4-DICHLOROPHENOL
87-65-0	2,6-DICHLOROPHENOL
95-57-8	2-CHLOROPHENOL
59-50-7	4-CHLORO-3-METHYL-PHENOL
87-86-5	PENTACHLOROPHENOL
Chlorinated Aliphatic	
630-20-6	1,1,1,2-TETRACHLOROETHANE
71-55-6	1,1,1-TRICHLOROETHANE
79-34-5	1,1,2,2-TETRACHLOROETHANE
79-00-5	1,1,2-TRICHLOROETHANE
75-35-4	1,1-DICHLOROETHENE
96-18-4	1,2,3-TRICHLOROPROPANE
78-87-5	1,2-DICHLOROPROPANE
99-35-4	1,3,5-TRINITROBENZENE
99-65-0	1,3-DINITROBENZENE
126-99-8	2-CHLORO-1,3-BUTADIENE
111-91-1	BIS(2-CHLOROETHOXY) METHANE
111-44-4	BIS(2-CHLOROETHYL) ETHER
108-60-1	BIS(2-CHLOROISOPROPYL) ETHER
56-23-5	CARBON TETRACHLORIDE
75-00-3	CHLOROETHANE
67-66-3	CHLOROFORM
74-87-3	CHLOROMETHANE
10061-01-5	CIS-1,3-DICHLOROPROPENE
77-47-4	HEXACHLORO-1,3-CYCLOPENTADIENE
67-72-1	HEXACHLOROETHANE
76-01-7	PENTACHLOROETHANE
156-60-5	TRANS-1,2-DICHLOROETHENE

Table 3-2a   2006-2007 Site Investigation Sediment Analytes

10061-02-6	TRANS-1,3-DICHLOROPROPENE
110-57-6	TRANS-1,4-DICHLORO-2-BUTENE
Dioxin/Furan	
35822-46-9	1,2,3,4,6,7,8-HPCDD
67562-39-4	1,2,3,4,6,7,8-HPCDF
55673-89-7	1,2,3,4,7,8,9-HPCDF
39227-28-6	1,2,3,4,7,8-HXCDD
70648-26-9	1,2,3,4,7,8-HXCDF
57653-85-7	1,2,3,6,7,8-HXCDD
57117-44-9	1,2,3,6,7,8-HXCDF
19408-74-3	1,2,3,7,8,9-HXCDD
72918-21-9	1,2,3,7,8,9-HXCDF
40321-76-4	1,2,3,7,8-PECDD
57117-41-6	1,2,3,7,8-PECDF
57117-41-6	1,2,3,7,8-PENTACHLORODIBENZOFURAN
60851-34-5	2,3,4,6,7,8-HXCDF
57117-31-4	2,3,4,7,8-PECDF
57117-31-4	2,3,4,7,8-PENTACHLORODIBENZOFURAN
1746-01-6	2,3,7,8-TCDD
51207-31-9	2,3,7,8-TCDF
51207-31-9	2,3,7,8-TETRACHLORODIBENZOFURAN
ETEQ	ETEQ
3268-87-9	OCDD
39001-02-0	OCDF
37871-00-4	TOTAL HPCDD
38998-75-3	TOTAL HPCDF
34465-46-8	TOTAL HXCDD
55684-94-1	TOTAL HXCDF
36088-22-9	TOTAL PECDD
30402-15-4	TOTAL PECDF
41903-57-5	TOTAL TCDD
55722-27-5	TOTAL TCDF
Halogenated Aliphatic	
75-34-3	1,1-DICHLOROETHANE
96-12-8	1,2-DIBROMO-3-CHLOROPROPANE
106-93-4	1,2-DIBROMOETHANE
107-06-2	1,2-DICHLOROETHANE
101-55-3	4-BROMOPHENYL PHENYL ETHER
75-27-4	BROMODICHLOROMETHANE
75-25-2	BROMOFORM
74-83-9	BROMOMETHANE
124-48-1	DIBROMOCHLOROMETHANE
74-95-3	DIBROMOMETHANE
75-71-8	DICHLORODIFLUOROMETHANE

Table 3-2a 2006-2007 Site Investigation Sediment Analytes

87-68-3	HEXACHLORO-1,3-BUTADIENE
75-09-2	METHYLENE CHLORIDE
127-18-4	TETRACHLOROETHENE
79-01-6	TRICHLOROETHENE
75-69-4	TRICHLOROFLUOROMETHANE
75-01-4	VINYL CHLORIDE
Herbicide	
94-74-6	2-METHYL-4-CHLOROPHENOXYACETIC ACID (MCPA)
75-99-0	DALAPON
1918-00-9	DICAMBA
Metal	
7429-90-5	ALUMINUM
7440-36-0	ANTIMONY
7440-38-2	ARSENIC
7440-39-3	BARIUM
7440-41-7	BERYLLIUM
7440-42-8	BORON
7440-43-9	CADMIUM
7440-70-2	CALCIUM
7440-47-3	CHROMIUM
7440-48-4	COBALT
7440-50-8	COPPER
7440-57-5	GOLD
7439-89-6	IRON
7439-92-1	LEAD
7439-93-2	LITHIUM
7439-95-4	MAGNESIUM
7439-96-5	MANGANESE
7439-97-6	MERCURY
7440-02-0	NICKEL
7440-09-7	POTASSIUM
7782-49-2	SELENIUM
7440-22-4	SILVER
7440-23-5	SODIUM
7440-24-6	STRONTIUM
7440-28-0	THALLIUM
7440-31-5	TIN
7440-32-6	TITANIUM
7440-62-2	VANADIUM
7440-66-6	ZINC
Nitrophenol	
51-28-5	2,4-DINITROPHENOL
534-52-1	2-METHYL-4,6-DINITROPHENOL
88-75-5	2-NITROPHENOL

Table 3-2a 2006-2007 Site Investigation Sediment Analytes

100-02-7	4-NITROPHENOL
PAH	
91-57-6	2-METHYLNAPHTHALENE
83-32-9	ACENAPHTHENE
208-96-8	ACENAPHTHYLENE
120-12-7	ANTHRACENE
205-99-2	BENZO(B)FLUORANTHENE
191-24-2	BENZO(G,H,I)PERYLENE
207-08-9	BENZO(K)FLUORANTHENE
56-55-3	BENZO[A]ANTHRACENE
50-32-8	BENZO[A]PYRENE
218-01-9	CHRYSENE
53-70-3	DIBENZO[A,H]ANTHRACENE
206-44-0	FLUORANTHENE
86-73-7	FLUORENE
193-39-5	INDENO(1,2,3-C,D)PYRENE
91-20-3	NAPHTHALENE
85-01-8	PHENANTHRENE
129-00-0	PYRENE
Pesticide	
90301-92-1	(E)-BETA-2,3,4,5,6-HEXACHLOROSTYRENE
88-85-7	2-(1-METHYLPROPYL)-4,6-DINITROPHENOL
93-72-1	2-(2,4,5-TRICHLOROPHENOXY)PROPIONIC ACID
93-76-5	2,4,5-T (TRICHLOROPHENOXYACETIC ACID)
94-75-7	2,4-D (DICHLOROPHENOXYACETIC ACID)
72-54-8	4,4-DDD
72-55-9	4,4-DDE
50-29-3	4,4-DDT
309-00-2	ALDRIN
319-84-6	ALPHA-BHC
319-85-7	BETA-BHC
2921-88-2	CHLORPYRIFOS
5103-71-9	CIS-CHLORDANE
5103-73-1	CIS-NONACHLOR
319-86-8	DELTA-BHC
2303-16-4	DIALLATE
60-57-1	DIELDRIN
60-51-5	DIMETHOATE
298-04-4	DISULFOTON
959-98-8	ENDOSULFAN I
33213-65-9	ENDOSULFAN II
1031-07-8	ENDOSULFAN SULFATE
72-20-8	ENDRIN
7421-93-4	ENDRIN ALDEHYDE

Table 3-2a 2006-2007 Site Investigation Sediment Analytes

52-85-7	FAMPHUR
76-44-8	HEPTACHLOR
1024-57-3	HEPTACHLOR EPOXIDE
465-73-6	ISODRIN
143-50-0	KEPONE
58-89-9	LINDANE
72-43-5	METHOXYCHLOR
5598-13-0	METHYL CHLORPYRIFOS
298-00-0	METHYL PARATHION
2385-85-5	MIREX
126-68-1	O,O,O-TRIETHYL PHOSPHOROTHIOATE
53-19-0	O,P'-DDD
29082-74-4	OCTACHLOROSTYRENE
27304-13-8	OXYCHLORDANE
298-02-2	PHORATE
67774-32-7	POLYBROMINATED BIPHENYLS
23950-58-5	PRONAMIDE
1918-16-7	PROPACHLOR
299-84-3	RONNEL
57-74-9	TECHNICAL CHLORDANE
3689-24-5	TETRAETHYL DITHIOPYROPHOSPHATE
297-97-2	THIONAZIN
140-57-8	TOTAL ARAMITE
8001-35-2	TOXAPHENE
5103-74-2	TRANS-CHLORDANE
39765-80-5	TRANS-NONACHLOR
Phenol	
98-54-4	4-TERT-BUTYLPHENOL
108-95-2	PHENOL
Phthalate	
117-81-7	BIS(2-ETHYLHEXYL) PHTHALATE
84-66-2	DIETHYL PHTHALATE
131-11-3	DIMETHYL PHTHALATE
84-74-2	DI-N-BUTYL PHTHALATE
117-84-0	DI-N-OCTYL PHTHALATE
PCB	
11104-28-2	AROCLOR 1221
11141-16-5	AROCLOR 1232
12672-29-6	AROCLOR 1248
11097-69-1	AROCLOR 1254
11096-82-5	AROCLOR 1260
12674-11-2	PCB-1016 (AROCLOR 1016)
53469-21-9	PCB-1242 (AROCLOR 1242)

Table 3-2a 2006-2007 Site Investigation Sediment Analytes

Styrene	
29086-38-2	(E)-ALPHA,BETA-2,3,4,5,6-HEPTACHLOROSTYRENE
29086-39-3	(Z)-ALPHA,BETA-2,3,4,5,6-HEPTACHLOROSTYRENE
90301-93-2	(Z)-BETA-2,3,4,5,6-HEXACHLOROSTYRENE
14992-81-5	2,3,4,5,6-PENTACHLOROSTYRENE
68705-15-7	ALPHA-2,3,4,5,6-HEXACHLOROSTYRENE
29082-75-5	BETA,BETA-2,3,4,5,6-HEPTACHLOROSTYRENE
Other SVOC	
123-91-1	1,4-DIOXANE
130-15-4	1,4-NAPHTHOQUINONE
134-32-7	1-NAPHTHYLAMINE
121-14-2	2,4-DINITROTOLUENE
606-20-2	2,6-DINITROTOLUENE
91-59-8	2-AMINONAPHTHALENE (BETA NAPHTHYLAMINE)
91-58-7	2-CHLORONAPHTHALENE
99-55-8	2-METHYL-5-NITROANILINE
95-48-7	2-METHYLPHENOL
88-74-4	2-NITROANILINE
109-06-8	2-PICOLINE (ALPHA-PICOLINE)
91-94-1	3,3'-DICHLOROBENZIDINE
119-93-7	3,3'-DIMETHYLBENZIDINE
56-49-5	3-METHYLCHOLANTHRENE
108-39-4	3-METHYLPHENOL
99-09-2	3-NITROANILINE
92-67-1	4-AMINOBIPHENYL
106-47-8	4-CHLOROANILINE
7005-72-3	4-CHLOROPHENYL PHENYL ETHER
106-44-5	4-METHYLPHENOL
100-01-6	4-NITROANILINE
56-57-5	4-NITROQUINOLINE-N-OXIDE
57-97-6	7,12-DIMETHYLBENZ[A]ANTHRACENE
122-09-8	A,A-DIMETHYLPHENETHYLAMINE
98-86-2	ACETOPHENONE
62-53-3	ANILINE
103-33-3	AZOBENZENE
92-87-5	BENZIDINE
100-51-6	BENZYL ALCOHOL
80-05-7	BISPHENOL-A
85-68-7	BUTYL BENZYL PHTHALATE
86-74-8	CARBAZOLE
510-15-6	CHLOROBENZILATE
122-39-4	DIPHENYLAMINE
62-50-0	ETHYL METHANESULFONATE
1888-71-7	HEXACHLOROPROPENE

Table 3-2a 2006-2007 Site Investigation Sediment Analytes

78-59-1	ISOPHORONE
120-58-1	ISOSAFROLE
91-80-5	METHAPYRILENE
66-27-3	METHYL METHANESULFONATE
924-16-3	N-BUTYL-N-NITROSO-1-BUTANAMINE
98-95-3	NITROBENZENE
10595-95-6	NITROSOMETHYLETHYLAMINE
55-18-5	N-NITROSODIETHYLAMINE
62-75-9	N-NITROSODIMETHYLAMINE
621-64-7	N-NITROSO-DI-N-PROPYLAMINE
59-89-2	N-NITROSOMORPHOLINE
621-64-7	N-NITROSO-N-PROPYL-1-PROPANAMINE
100-75-4	N-NITROSOPIPERIDINE
930-55-2	N-NITROSOPYRROLIDINE
95-53-4	O-TOLUIDINE
60-11-7	P-DIMETHYLAMINOAZOBENZENE
62-44-2	PHENACETIN
106-50-3	P-PHENYLENEDIAMINE
110-86-1	PYRIDINE
94-59-7	SAFROLE
Other VOC	
53-96-3	2-ACETYLAMINOFLUORENE
78-93-3	2-BUTANONE (MEK)
591-78-6	2-HEXANONE
108-10-1	4-METHYL-2-PENTANONE (MIBK)
67-64-1	ACETONE
75-05-8	ACETONITRILE
107-02-8	ACROLEIN
107-13-1	ACRYLONITRILE
107-05-1	ALLYL CHLORIDE (3-CHLOROPROPENE)
71-43-2	BENZENE
75-15-0	CARBON DISULFIDE
97-63-2	ETHYL METHACRYLATE
100-41-4	ETHYLBENZENE
74-88-4	IODOMETHANE
78-83-1	ISOBUTANOL
80-62-6	METHYL METHACRYLATE
126-98-7	METHYLACRYLONITRILE
107-12-0	PROPANE NITRILE (PROPIONITRILE)
100-42-5	STYRENE
108-88-3	TOLUENE
1330-20-7	TOTAL XYLENES
108-05-4	VINYL ACETATE

Table 3-2a   2006-2007 Site Investigation Sediment Analytes

Other	
105-67-9	2,4-DIMETHYLPHENOL
57-12-5	CYANIDE
132-64-9	DIBENZOFURAN
56-38-2	ETHYL PARATHION
86-30-6	N-NITROSODIPHENYLAMINE
90-43-7	O-PHENYLPHENOL
18496-25-8	SULFIDE
TOC	TOTAL ORGANIC CARBON

Table 3-2b   Analytes for Additional 2007 Reach B-D Sediment Samples

SCOIs	
120-82-1	1,2,4-TRICHLOROBENZENE
95-94-3	1,2,4,5-TETRACHLOROBENZENE
95-50-1	1,2-DICHLOROBENZENE
541-73-1	1,3-DICHLOROBENZENE
106-46-7	1,4-DICHLOROBENZENE
108-90-7	CHLOROBENZENE
118-74-1	HEXACHLOROBENZENE
87-68-3	HEXACHLORO-1,3-BUTADIENE
127-18-4	TETRACHLOROETHENE
71-43-2	BENZENE
PCOIs - Dioxin/Furan	
70648-26-9	1,2,3,4,7,8-HXCDF
57653-85-7	1,2,3,6,7,8-HXCDD
57117-41-6	1,2,3,7,8-PECDF
57117-31-4	2,3,4,7,8-PECDF
1746-01-6	2,3,7,8-TCDD
51207-31-9	2,3,7,8-TCDF
ETEQ	ETEQ

Table 3-2c H-12 Outfall Investigation Target Analytes

Chlorobenzene	
634-66-2	1,2,3,4-TETRACHLOROBENZENE
87-61-6	1,2,3-TRICHLOROBENZENE
120-82-1	1,2,4-TRICHLOROBENZENE
95-50-1	1,2-DICHLOROBENZENE
541-73-1	1,3-DICHLOROBENZENE
106-46-7	1,4-DICHLOROBENZENE
108-90-7	CHLOROBENZENE
118-74-1	HEXACHLOROBENZENE
608-93-5	PENTACHLOROBENZENE
Chlorophenol	
58-90-2	2,3,4,6-TETRACHLOROPHENOL
95-95-4	2,4,5-TRICHLOROPHENOL
88-06-2	2,4,6-TRICHLOROPHENOL
120-83-2	2,4-DICHLOROPHENOL
87-65-0	2,6-DICHLOROPHENOL
95-57-8	2-CHLOROPHENOL
59-50-7	4-CHLORO-3-METHYL-PHENOL
87-86-5	PENTACHLOROPHENOL
Halogenated Aliphatic	
75-34-3	1,1-DICHLOROETHANE
106-93-4	1,2-DIBROMOETHANE
107-06-2	1,2-DICHLOROETHANE
74-97-5	BROMOCHLOROMETHANE
156-59-2	CIS-1,2-DICHLOROETHENE
74-95-3	DIBROMOMETHANE
75-09-2	DICHLOROMETHANE
87-68-3	HEXACHLORO-1,3-BUTADIENE
127-18-4	TETRACHLOROETHENE
79-01-6	TRICHLOROETHENE
75-01-4	VINYL CHLORIDE
Metal	
7440-38-2	ARSENIC
7440-39-3	BARIUM
7440-47-3	CHROMIUM
7440-48-4	COBALT
7440-50-8	COPPER
7439-89-6	IRON
7439-92-1	LEAD
7439-93-2	LITHIUM
7440-02-0	NICKEL
7782-49-2	SELENIUM
7440-22-4	SILVER
PAH	
91-57-6	2-METHYLNAPHTHALENE
83-32-9	ACENAPHTHENE
56-55-3	BENZO[A]ANTHRACENE
50-32-8	BENZO[A]PYRENE
207-08-9	BENZO[K]FLUORANTHENE
218-01-9	CHRYSENE
206-44-0	FLUORANTHENE
86-73-7	FLUORENE

Table 3-2c   H-12 Outfall Investigation Target Analytes

91-20-3	NAPHTHALENE
85-01-8	PHENANTHRENE
129-00-0	PYRENE
Pesticide	
93-76-5	2,4,5-T
94-75-7	2,4-D
309-00-2	ALDRIN
60-57-1	DIELDRIN
298-04-4	DISULFOTON
72-20-8	ENDRIN
58-89-9	LINDANE
319-85-7	B-BHC
319-86-8	Δ-BHC
Phenol	
98-54-4	4-TERT-BUTYLPHENOL
108-95-2	PHENOL
Phthalate	
84-66-2	DIETHYL PHTHALATE
84-74-2	DI-N-BUTYL PHTHALATE
Other	
132-64-9	DIBENZOFURAN
56-38-2	ETHYL PARATHION
86-30-6	N-NITROSODIPHENYLAMINE
90-43-7	O-PHENYLPHENOL

Table 3-3 Segment 1 Sediment TEQ SWACs

	Pre-Reach B/D Remediation	Current Conditions
Segment 1	**183**	**68**
Reaches A-D, above Dow Dam	330	8
Dow Dam to Station 110+30 (1-mile interval)	135	135
Station 110+30 to 163+10 (1-mile interval)	70	70

SWAC: Surface-Weighted Average Concentration
TEQ: Toxic Equivalents

Table 3-4 Segments 1 and 2 Bed Pin Survey Dates

Reach	# Transects	Installation Date	Follow-up Surveys		
			2008	2009	2010
Segment 1					
E, F, and H	3	August 2009			May, Sept.
Segment 2					
J and K	4	August 2008	Sept., Oct., Nov.	Aug., Sept., Oct., Nov.	Jun., Sept.
L	3	October 2007		Aug.	Jul., Sept.
L	7	August 2008		Aug.	Jul., Sept.
M, N, and Q	6	October 2008		Aug.	Jul., Sept.
P	1	October 2008		Aug.	May, Sept.

Table 3-5 Maximum Depth of Active Bed Layer in Segment 1 SMAs During 10-Year Simulation Period

Area	Number of Grid Cells in SMA	Maximum Active Bed Depth: Average (ft)	Maximum Active Bed Depth: Range (ft)
SMA-1	5	0.7	0.5 – 0.9
SMA-2	2	0.6	0.6 – 0.7
SMA-3	2	0.4	0.3 – 0.5
SMA-4	2	0.5	0.4 – 0.7
SMA-5	4	0.8	0.6 – 1.0
SMA-6	5	0.7	0.4 – 0.9

SMA: Sediment Management Area

Table 3-6 Dry Weight and Organic Carbon Normalized Risk Zone Values

Dry Weight Risk Zone Values (units in mg/kg)						
Zones and Associated Criteria (a)	**Total PAHs**	**Total Chlorobenzenes**	**Arsenic**	**Ethyl parathion**	**oPP**	**Total Chlorophenols**
Ambient	<1	ND	<3	ND	ND	ND
No Significant Risk (NSR)	15.11 (J195)	<33.3 (D1)	<150	<0.36	<92	ND-25.7
Potential for Low Exposure /Risk (PLER)	17.4 (J195)	33.3 (D1)	150 (D1)	0.36 (RJ195)	92 (RD-54+75)	25.7 (RF82+50)
Potential for Exposure/Risk (PER)	>17.4 (Lingle)	>39.7 (D2)	Not Available	Not Available	Not Available	Not Available

Organic-Carbon Normalized Risk Zone Values (units in µg/gOC)						
Zones and Associated Criteria (b)	**Total PAHs**	**Total Chlorobenzenes**	**Arsenic**	**Ethyl parathion**	**oPP**	**Total Chlorophenols**
No Significant Risk (NSR)	1373 (J195)	-	Not Applicable	33 (J195)	-	-
Potential for Low Exposure /Risk (PLER)	NA	1525 (D1)	Not Applicable	NA	4381 (RD-54+75)	1835.7 (RF-82+50)

mg/kg: Milligrams per kilogram
NA: Not available
ND: Not detected
µg/gOC: Micrograms per gram of organic carbon
oPP: o-PhenylPhenol
PAH: Polycyclic aromatic hydrocarbon
(a) Dry weight risk zone values are derived in Appendix A2. The dry weight PLERs were used for the designation of sediment management areas, as described in Section 3.5 of the Response Proposal.

(b) The organic carbon-normalized PLERs are derived and described in Appendix B1. These values were used to confirm that the designation of sediment management areas using dry weight values was appropriate.

(#) Names in parantheses reflect the sediment toxicity testing sample ID with which the risk zone value is based.

< Less than
> Greater than

Table 3-7 Comparison of Target SCOI PLERs and ESBs Derived Based on EPA EqP and SSDs

SCOI Group	Analyte	SSSL PLER (a) (mg/kg)	Independently Derived Benchmarks at 2% OC (mg/kg) (b, c, d)	SSSL PLER (a) (µg/g OC)	Independently Derived TOC-normalized Benchmarks Value (µg/g OC) (b, c, d)
PAHs		15		1,373	
	Acenaphthene		10		491
	Acenaphthylene		9.0		452
	Anthracene		12		594
	Benzo[a]anthracene		17		841
	Benzo[a]pyrene		19		965
	Benzo[b]fluoranthene		20		979
	Benzo[ghi]perylene		22		1,095
	Benzo[k]fluoranthene		20		981
	Chrysene		17		844
	Dibenzo[a,h]anthracene		22		1,123
	Fluoranthene		14		707
	Fluorene		11		538
	Indeno[1,2,3-cd]pyrene		22		1,115
	Naphthalene		7.7		385
	Phenanthrene		12		596
	Pyrene		14		697
Chlorobenzenes	1,2,3,4-Tetrachlorobenzene	33	28	1,525	1,272
	1,2,3-Trichlorobenzene		19		1,021
	1,2,4,5-Tetrachlorobenzene		28		1,279
	1,2,4-Trichlorobenzene		20		1,015
	1,2-Dichlorobenzene		16		780
	1,3-Dichlorobenzene		16		780
	1,4-Dichlorobenzene		16		780
	Chlorobenzene		11		570
	Hexachlorobenzene		43		1,849
	Pentachlorobenzene		32		1,600
Chlorophenols	2,3,4,6-Tetrachlorophenol	26	29	1,836	1,341
	2,4,5-Trichlorophenol		25		1,090
	2,4,6-Trichlorophenol		23		1,086
	2,4-Dichlorophenol		17		847
	2,6-Dichlorophenol		17		814
	2-Chlorophenol		12		609
	4-Chloro-3-methyl-phenol		16		745
	Pentachlorophenol		37		1,638
o-Phenylphenol	o-Phenylphenol	92	17	4,381	888
Ethyl Parathion (b)	Ethyl parathion	0.36	33	33	1,630
Ethyl Parathion (c)	Ethyl parathion	0.36	0.43	33	21.3

(a) PLERs were developed as described in Appendix B2.
(b) EqP based benchmarks developed as described in Appendix B3
(c) SSD based benchmark for ethyl parathion as described in Appendix B3
(d) 2% OC was considered appropriate for this comparison because this is the average OC
%: percent
EPA: Environmental Protection Agency
EqP: equilibrium partitioning
ESB: environmental sediment benchmark
µg/g OC: micrograms per kilogram of organic carbon
mg/kg: milligrams per kilogram
OC: sediment organic carbon
PAH: polycyclic aromatic hydrocarbon
PLER: Potential low exposure/risk value
SCOI: secondary chemical of interest
SSDs: Study sensitivity distributions
SSSL: Site-specific screening level

Table 3-8 Summary of Segment 1 Sediment Management Areas

Sediment Management Area	Approximate Area, sq ft	Surface Sediment SCOIs > PLER	Max Surface Concentration (0-2 ft)	Location IDs for Surface Sediment SCOIs > PLER	Core IDs With Notations of Sheen or Brown Liquid Above Till	Maximum Subsurface Total Chlorobenze Concentration, mg/kg	Till Depth, ft
1	8,000	Arsenic Total PAHs	310 mg/kg 25.4 mg/kg	RE-61+50-IC98 RE-61+50-IC37, RE-62+00-IC60	--	8.3	5.7-9.0
2	7,000	Total Chlorobenzenes Total Chlorophenols	2,653 mg/kg 68.6 mg/kg	RE-73+50-IC30 RE-73+50-IC30	RE-73+50-IC30	11,310	3.3
3	21,000	Total Chlorobenzenes Total Chlorophenols Total PAHs oPP	13,570 mg/kg 978 mg/kg 126 mg/kg 220 mg/kg	RF-83+00-IC33 RF-83+00-IC33 RF-83+00-IC33 RF-83+00-IC33	RF-82+50-IC75 RF-83+00-IC33 RF-83+00-IC69	13,580	4.2-6.2
4	5,000	None	--	--	RG-137+50-IC71 RG-137+50-IC114 RG-138+00-IC115	818	4.3-6.5
5	11,000	None	--	--	RH-145+00-IC118	2,530	3.1
6	30,000	Ethyl parathion	520 mg/kg	RH-151+50-IC33	RH-150+00-IC34 RH-150+00-IC108 RH-151+00-IC144 RH-151+50-IC33 RH-151+50-IC92	404	7.2-9.3

mg/kg: milligram/kilogram
SCOI: secondary constituent of interest
sq ft: square feet

Table 3-9 Total Chlorobenzene Interpolation Input Parameters

Parameter[1]	Value / Setting	Description/Explanation[2]
Geology Kriging Parameters [3,4,5]		
Search Distance	16,367 ft	The search distance input field defines the radial distance (in feet) from any given model node that the kriging module will look for data points to be included in the estimation of the model parameter at that node.
Points	20	The Points parameter defines the maximum number of data points (within the specified search distance) that will be considered for the parameter estimation at a model node.
Quadrant Search Enabled	Max 40 points per quadrant, use all data points	The Quadrant Search toggle changes the method by which data sample points are selected for inclusion in the kriging matrix. If this is on, the "Points" parameter switches to "Max Points in Quadrant".
X Res / Y Res	295 / 213 nodes (results in approx. 30 ft^2 grid)	The X Res and Y Res parameters specify the number of grid nodes that will be included within the X and Y axes of the model domain.
Convex Hull Offset	1%	The Convex Hull Boundary Offset parameter sets the distance in user units that the convex hull for the kriging domain will be set outside of the actual convex hull of the data. This parameter allows the user to specify the distance outside of the actual data in which the parameter values will be extrapolated.
Ordinary Kriging Pair Search Range	16,367 ft	The Pair Search Range specifies the radial distance from any input data point that will be searched to assemble the data pairs that are used in the variance analysis.
Ordinary Kriging Minimum Range	2,728 ft	The Minimum Range parameter defines the smallest distance between data pairs at which the semivariogram procedure can set the sill of the semivariogram. In essence, this parameter constrains the minimum distance between data points beyond which the best-fit algorithms will consider all points to have an equal and minimum influence on the kriged model node value.
Ordinary Kriging Semivariogram Symmetry	1	The Semivariogram Symmetry parameter describes the degree to which the algorithm's expert system is allowed to distort the geometry of the semivariogram in calculating the best fit to the data. 1 = no distortion, or spherical symmetry.
Sand Layer Semivariogram Output Parameters		
Top of Sand Surface – **Range:** **Sill:** **Nugget:**	 2,728 ft 57.3 ft^2 0 ft^2	**Range** - the approximate distance at which spatial autocorrelation between data point pairs ceases or the distance at which the sill is attained **Sill**- the semivariance value at which the variogram model levels out (plateau) **Nugget** – intercept of the semivariace model – kriging software utilizes a nugget of zero, which cannot be changed, and which forces the estimated value to be equal to the known value of data points that fall exactly on a grid point in the modeled domain, thus honoring actual data points.

Table 3-9 Total Chlorobenzene Interpolation Input Parameters

Parameter[1]	Value / Setting	Description/Explanation[2]
Bottom of Sand Surface Range: Sill: Nugget:	2,728 ft 41.9 ft^2 0 ft^2	**Range** - the approximate distance at which spatial autocorrelation between data point pairs ceases or the distance at which the sill is attained **Sill**- the semivariance value at which the variogram model levels out (plateau) **Nugget** – intercept of the semivariace model – kriging software utilizes a nugget of zero, which cannot be changed, and which forces the estimated value to be equal to the known value of data points that fall exactly on a grid point in the modeled domain, thus honoring actual data points.
Proportional Gridding	Active	Proportional Gridding – the number of nodes specified for the Z Resolution will be distributed (proportionately) over the geologic layers in a manner that is approximately proportional to the fractional thickness of each layer relative to the total thickness of the geologic domain.
Min Cells Per Layer	5	Min Cells per layer - establishes a minimum number of cells (in the Z direction) per layer.
Minimum Layer Thickness	0.0001 ft	Minimum Layer Thickness forces layers thinner than the specified value to have a minimum thickness and therefore not pinch-out completely.
Adaptive Gridding	Active	The adaptive grid will result in a kriged parameter distribution that honors all of the measured data points exactly.
Total Chlorobenzenes in Sand Layer Ordinary Kriging Parameters [6,7]		
Krig 3D Chemistry Input	Total Chlorobenzenes[8]	Total chlorobenzene concentrations were kriged in the sand sediment overlying the till unit.
Statistical Method	Kriging Ordinary	
Octant Search Enabled	Max 80 points per quadrant, use all data points	The Octant Search toggle changes the method by which data sample points are selected for inclusion in the kriging matrix. The "Points" parameter switches to "Max Points in Octant". Searching is performed for each of the eight Octants surrounding the point to be kriged. Within each octant a maximum number of points (up to one-fourth of the total points) are selected. Then, points are taken sequentially from each octant up to the maximum number of total points or until all octant's points have been used.
Anisotropy	100	The Horiz./Vert. Anisotropy Ratio parameter allows the user to consider the effects of anisotropy in the conductivity of soil matrices to fluid flow. The Horiz./Vert. Anisotropy Ratio tells the kriging algorithm what multiplication factor should be used to apply biased weighting on data points in horizontal and vertical directions away from a given model node. A typical value for the Anisotropy Ratio in sediment is 10; a conservative value of 100 was used.
Ordinary Kriging Pair Search Range	7,113 ft	
Ordinary Kriging Minimum Range	4,064 ft	

Table 3-9 Total Chlorobenzene Interpolation Input Parameters

Parameter[1]	Value / Setting	Description/Explanation[2]
Ordinary Kriging Min Z Range	1 ft	Parameter defines the smallest distance in the Z axis of the data at which the semivariogram procedure can set the sill of the semivariogram.
Ordinary Kriging Semivariogram Symmetry	1	
X/Y Resolution	Passed from geology	The X / Y / Z Resolution parameters specify the number of grid nodes that will be included within the model domain. If Indicator_Geology is being passed a model domain from Krig_3D_Geology, then the x-y values are not used.
Z Resolution	35 nodes	
Min cells per layer	5	
Min layer thickness	0.5 ft	
Total Chlorobenzenes in Sand Layer Output Parameters		
Semivariogram **Range :** **Sill:** **Nugget:**	4,064 ft: 1.1 mg/kg^2 0 mg/kg^2	**Range** - the approximate distance at which spatial autocorrelation between data point pairs ceases or the distance at which the sill is attained **Sill**- the semivariance value at which the variogram model levels out (plateau) **Nugget** – intercept of the semivariace model – kriging software utilizes a nugget of zero, which cannot be changed, and which forces the estimated value to be equal to the known value of data points that fall exactly on a grid point in the modeled domain, thus honoring actual data points.

Notes:

1. Input parameters for kriging software (Environmental Visualization System Pro 9.42 [EVS-Pro C-Tech 2010])
2. Parameter descriptions adapted from "C Tech Help System For EVS & MVS 9.4" by C Tech Development Corp.
3. Geology kriging was done for three predominant geologic layers (Sand Sediment, Lacustrine Clay, Till).
4. Vertical measures for the cores, which were originally presented as National Geodetic Vertical Datum 1929 (NGVD29 - Feet), were transformed to North American Vertical Datum 1988 (NAVD88 - Feet) using VERTCON from the National Geodetic Survey online web application (http://www.ngs.noaa.gov/cgi-bin/VERTCON/vert_con.prl).
5. The core top elevations were all adjusted to the elevation from the most appropriate elevation source and date. Cores which were extracted on a given date were related back to the most relevant bathymetry or topography surface for that time period and the elevation from the shared XY coordinate was used as the bathymetry or topography corrected core-top elevation.
6. Log data transformations are performed internally in EVS, the results are back transformed by EVS and displayed in their native units.
7. EVS managed anisotropy internally, therefore no bandwidth or lag space parameters are set, on the choice of quadrants, octants are made by user.
8. Total chlorobenzenes were calculated as the sum of reportable results from the following chemicals: Chlorobenzene; 1,2-Dichlorobenzene; 1,3-Dichlorobenzene; 1,4-Dichlorobenzene; 1,2,3-Trichlorobenzene; 1,2,4-Trichlorobenzene; 1,2,3,4-Tetrachlorobenzene; Pentachlorobenzene; and Hexachlorobenzene. Where non-detected results were reported, ½ of the method detection limit (MDL) was used as a surrogate concentration. In the event that field duplicates were encountered, the average of the results was used.

Table 3-10 Estimated Segment 1 Sediment TEQ SWACs under Post-Response (

	Current Conditions (ppt)	Estimated Post-Response Conditions, SMAs 1-6 (ppt)
Segment 1	**68**	**< 50**
Reaches A-D, above Dow Dam (1-mile interval)	9	9
Dow Dam to Station 110+30 (1-mile interval)	135	< 80
Station 110+30 to 163+10 (1-mile interval)	70	< 60

ppt: parts per trillion
SWAC: Surface-Weighted Average Concentration
TEQ: Toxic Equivalents

Table 4-1 Potential Chemical-Specific ARARs for Segment 1 of the Tittabawassee River

Medium	Standard or Requirement	Regulatory Citation			Comments
		Federal	State	Local	
Sediments	Sediment cleanup criteria	None	None	None	Sediment cleanup criteria for response actions under CERCLA are based on site-specific risk evaluations.

Notes:

ARAR = applicable or relevant and appropriate requirement; CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act

Table 4-2 Potential Action-Specific ARARs for Segment 1 of the Tittabawassee River

Action	Standard or Requirement	Regulatory Citation			Comments
		Federal	State	Local	
Dredge/Fill Activities	Requirements for the discharge of dredged/fill material into navigable waters or wetlands	Clean Water Act (33 USC 1251et seq.; 40 CFR 230 and 231; 33 CFR 320-330) Rivers and Harbors Act (33 USC 401 et seq.)	Part 91 of NREPA (Soil Erosion and Sedimentation Control; MCL 324.9101 et seq.) Part 301 of NREPA (Inland Lakes and Streams; MCL 324.30101 et seq) Part 303 of NREPA (Wetlands Protection; MCL 324.30301 et seq.)		May be applicable to any remedy that involves dredging or filling
	Design and operating standards for treatment and storage of hazardous waste	Resource Conservation and Recovery Act (42 USC6901 et seq.; 40 CFR 264)	Part 111 of NREPA (Hazardous Waste Management; MCL 324.11101 et seq.)		May be applicable if excavated sediments are designated as hazardous waste
Capping/Cover/Filling Activities	Requirements for applying cap or cover materials into navigable waters or wetlands	Clean Water Act (33 USC 1251 et seq.; 40 CFR 230 and 231; 33 CFR 320-330) Rivers and Harbors Act (33 USC 401 et seq.)	Part 91 of NREPA (Soil Erosion and Sedimentation Control; MCL 324.9101 et seq.) Part 301 of NREPA (Inland Lakes and Streams; MCL 324.30101 et seq) Part 303 of NREPA (Wetlands Protection; MCL 324.30301 et seq.)		May be applicable to any remedy that involves capping, covering, or filling

Table 4-2 Potential Action-Specific ARARs for Segment 1 of the Tittabawassee River

Action	Standard or Requirement	Regulatory Citation			Comments
		Federal	State	Local	
Treatment of Excavated Sediments	Requirements for the management of hazardous waste	Resource Conservation and Recovery Act (42 USC6901 et seq.; 40 CFR 262, 264)	Part 111 of NREPA (Hazardous Waste Management; MCL 324.11101 et seq.)		May be applicable if excavated sediments are designated as hazardous waste
Land Disposal of Excavated Sediments	Requirements for hazardous waste disposal	Resource Conservation and Recovery Act Land Disposal Restrictions (42 USC 6901 et seq.; 40 CFR 268)	Part 111 of NREPA (Hazardous Waste Management; MCL 324.11101 et seq.)		May be applicable to disposal if excavated sediments are designated as hazardous waste
	Requirements for solid waste management and disposal	Solid Waste Disposal Act (42 USC 6901 et seq.; 40 CFR 257, 258)	Part 115 of NREPA (Solid Waste Management; MCL 324.11501 et seq.)		May be applicable to the disposal of non-hazardous solid materials generated during the remedy
Discharges to Surface Water	Wastewater treatment prior to discharge		Part 31 of NREPA (Water Resources Protection; MCL 324.3101 et seq.)		May be applicable if the selected remedy involves creation of point source discharges of wastewater to surface waters
	Surface water quality standards	Ambient Water Quality Criteria established under Section 304(a) of the Clean Water Act (33 USC 1251 et seq.)	Part 31 of NREPA (Water Resources Protection; MCL 324.3101 et seq.)		May be applicable for discharges to surface water, depending on the selected remedy

Notes:

ARAR = applicable or relevant and appropriate requirement; CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act; CFR = Code of Federal Regulations; MCL = Michigan Compiled Laws; USC = United States Code

Table 4-3 Potential Location-Specific ARARs for Segment 1 of the Tittabawassee River

Location	Standard or Requirement	Regulatory Citation			Comments
		Federal	State	Local	
Within Floodplain	Requirements for design, operation and maintenance of hazardous waste treatment, storage, and disposal facilities	Resource Conservation and Recovery Act (42 USC 6901 et seq.; 40 CFR 264)	Part 111 of NREPA (Hazardous Waste Management, MCL 324.11101 et seq.)		May be applicable if sediments or treatment residuals exceed the criteria for designation as hazardous waste
	Requirements for occupying, filling or grading the floodplain		Part 31 of NREPA (Water Resources Protection, MCL 324.3101 et seq.) Part 91 (Soil Erosion and Sedimentation Control, MCL 324.9101 et seq.)		May be applicable to selected remedy if it involves construction activities within a floodplain.
Within/Adjacent to Wetlands	Requirements for dredging or filling a regulated wetland	Clean Water Act (33 USC 1251 et seq.)	Part 91 of NREPA (Soil Erosion and Sedimentation Control, MCL 324.9101 et seq.) Part 303 of NREPA (Wetland Protection, MCL 324.30301 et seq.)		May be applicable if selected remedy involves activities in or adjacent to wetlands

Table 4-3 Potential Location-Specific ARARs for Segment 1 of the Tittabawassee River

Location	Standard or Requirement	Regulatory Citation			Comments
		Federal	State	Local	
Within Navigable or State Surface Waters	Standards for dredging and construction	Clean Water Act (33 USC 1251 et seq.)	Part 301 of NREPA (Inland Lakes and Streams, MCL 324.30101 et seq.)		May be applicable to in-water construction activities, including any dredge or fill operations
	Requirements for activities that may obstruct or alter a navigable waterway	Section 10 of the Rivers and Harbors Act (33 USC 403)	Part 301 of NREPA (Inland Lakes and Streams, MCL 324.30101 et seq.)		May be applicable to in-water construction activities
Historic Sites or Structures	Avoidance, minimization, or mitigation of impacts to historic sites or structures	National Historic Preservation Act (16 USC 470f; 36 CFR Parts 60, 63 and 800)			May be applicable if the selected remedy may impact a historical site or structure

Notes:

ARAR= applicable or relevant and appropriate requirement; CFR = Code of Federal Regulations; MCL = Michigan Compiled Laws; USC = United States Code

Table 5-1 Screening of Segment 1 Remedial Technologies

General Response Action	Potentially Applicable Remedial Technology	Description	Effectiveness	Implementability			Cost	Screening
			Applicable to Site COCs/Media	Segment 1-Specific Considerations	Available and Demonstrated	Innovative		
Removal and Disposal/ Treatment	Sediment removal; process options include: • Excavation ("in the dry") • Mechanical dredging • Hydraulic dredging	**Excavation:** Excavators, backhoes, and other conventional earth moving equipment may be used during an excavation to remove contaminated sediment after water has been diverted or drained (i.e. "in the dry" removal); Excavation area dewatering may be facilitated through the installation of sheet pile walls, temporary cofferdams, or other water management structures and the subsequent lowering of the local groundwater table.	Removal is effective in mass removal, but resuspension of contaminants and post-removal residuals limit overall effectiveness	Reach distance from shore may limit application to near shore areas; once SMA is dewatered, equipment can be positioned within or adjacent to excavation area	Well demonstrated (including on-site)	No	High	Retained for SMAs 1, 2, 3, and 6
		Dredging: Dredging may be used to remove sediments in submerged conditions; dredging is generally accomplished with two main technologies: hydraulic (a method that generally involves pumping material, resulting in a slurry-like material) and mechanical (typically involving the use of a clamshell bucket on a derrick barge).		Floating dredging equipment requires minimum water depth (typically 18 to 24 inches), however water depths in Segment 1 are often shallower than this minimum; Hydraulic dredging will require more staging areas for dewatering than mechanical methods.	Well demonstrated (including on-site in areas with suitable water depth)	No	High	
	Removal of recoverable product	Removal of recoverable product would involve installation of a well(s) screened within the recoverable product deposit; well(s) would be pumped and recovered product and/or groundwater would be treated.	Applicable to areas where product could be pumped; subject to field testing/verification during remedial design	Wells often installed in conjunction with other flow controls to prevent transport within the sediment layers; horizontal wells may be feasible in localized areas.	Well demonstrated for upland site and some aquatic sites	No	Medium	Retained for SMAs 2, 3, and 6
In Situ Treatment	Reactive engineered cap	A permeable cap may be placed above contaminated sediments, and a material such as organoclay or activated carbon placed within the sediment cap to sorb dissolved-phase contaminants potentially also facilitating further biodegradation, and limiting migration into overlying sediment porewater and surface water.	Potentially applicable to areas with relatively high subsurface sediment concentrations where in situ containment alone may not be fully effective; reactive caps can be designed to permanently treat some contaminants	Placement of reactive media through water may be difficult; cap armoring is based on site-specific erosion evaluation	Several projects have been implemented successfully	Yes	Medium	Retained for SMAs 2, 3, and 6
	In situ stabilization	In situ stabilization/treatment options for sediment contaminants include injection and mixing of zero valent iron, sodium persulfate, permanganate, and/or cement	Effectiveness uncertain for these site-specific conditions		Only bench-scale demonstrations have been completed,	Yes	Medium to High	Not retained
In Situ Containment	Lateral containment	A barrier may be used to enclose/isolate the targeted sediments. The barrier would be installed from the top of sediment down into the till unit preventing lateral movement of contaminants outside of the contained area.	Applicable to areas of potential product migration or for hydraulic controls	Could be combined with a low permeability cap placed on top of the impacted sediments within the hydraulic containment to provide enhanced contaminant and hydraulic controls.	Well demonstrated	No	Medium	Retained for SMAs 2, 3, and 6

General Response Action	Potentially Applicable Remedial Technology	Description	Effectiveness	Implementability			Cost	Screening
			Applicable to Site COCs/Media	Segment 1-Specific Considerations	Available and Demonstrated	Innovative		
In Situ Containment	Vertical containment; process options include: • Sediment cap • Low permeability cap	A sediment cap may be designed to effectively contain and isolate contaminated sediments from the biologically active surface zone. Capping materials may include sand, gravel, or rock or natural sedimentation within geocells placed on existing river bottom.	Applicable to site contaminants; thickness will be dependent on contaminant transport modeling	Chemical isolation requirements and cap armoring would be based on SMA-specific erosion evaluation.	Well demonstrated (including on-site)	No	Medium	Retained for all SMAs
		Low-permeability caps may be constructed of natural materials such as clay, synthetic materials such as HDPE, or combinations such a geosynthetic clay liners.	Applicable to areas of where hydraulic containment needs to be achieved	Could be used in conjunction with lateral containment and/or other hydraulic controls. Cap armoring would be based on site-specific erosion evaluation	Several projects have been implemented successfully	Partially	Medium	Retained for SMAs 2, 3, and 6
	Hydraulic control (pumping)	Hydraulic control involves installation of a hydraulic well (likely within a laterally and/or vertically contained area) to extract groundwater flow, creating a slight negative pressure within the area	Applicable to areas where hydrostatic influence is necessary to reduce groundwater transport out of deposit	Could be used in conjunction with lateral and/or vertical containment and could be integrated with existing DOW RGIS system	Several projects have been implemented successfully	No	Medium to High	Retained for SMAs 2, 3, and 6
Monitored Natural Recovery	Natural sedimentation and mixing	Monitoring to document that presence and effectiveness of natural sedimentation and mixing processes in reducing and maintaining surface sediment concentrations such that unacceptable risks do not exist.	Applicable to relatively stable and low surface sediment concentrations	OU 1 sediment transport model can assess location-specific sediment deposition and mixing	Range of monitoring tools are readily available to verify model predictions; well demonstrated	No	Low	Retained for SMAs 1, 4, 5, and 6
Institutional Controls	Administrative and/or legal controls	Institutional controls are non-engineered instruments, such as administrative and legal controls, that may be included as part of a response action to minimize the potential for human health or ecological exposure to sediment contamination and ensure the long-term integrity of the remedy • Land use restrictions and maintenance agreements • Enforcement and permit devices • Permit conditions for future actions • Informational devices including signage and fish consumption advisories		Existing fish consumption advisory in effect	Well demonstrated	No	Low	Retained for all SMAs

Table 6-1 Summary of Assembled Alternatives

SMA	Alterative 1	Alternative 2	Alternative 3
SMA 1	Monitored natural recovery	In situ containment (Figure 6-1): • Chemical and physical isolation cap (8,000 sf)	Removal of sediment (Figure 6-2): • Temporary flow controls • 1,600 cy sediment removal • Backfill for post-dredge residuals management
SMA 2 and SMA 3	In situ containment with hydraulic control (Figures 6-3 and 6-4): • Lateral containment with barrier wall • Passive hydraulic control through existing RGIS • Vertical containment with low-permeability cap ○ 7,000 sf in SMA 2 ○ 21,000 sf in SMA 3	Removal of recoverable product/treatment and In situ containment with hydraulic control (Figures 6-5 and 6-6): • Product recovery well(s) • Lateral containment with barrier wall • Active hydraulic control • Vertical containment with low-permeability cap ○ 7,000 sf in SMA 2 ○ 21,000 sf in SMA 3	Removal of sediment and post-dredge in situ containment (Figures 6-7 and 6-8): • Temporary enclosure for turbidity control • Sediment removal ○ 2,300 cy in SMA 2 ○ 5,700 cy in SMA 3 • Reactive cap for post-dredge residuals management
SMA 4 and SMA 5	Monitored natural recovery	In situ containment (Figures 6-9 and 6-10): • Physical isolation cap ○ 5,000 sf in SMA 4 ○ 11,000 sf in SMA 5	Removal of sediment (Figures 6-11 and 6-12): • Temporary enclosure for turbidity control • Sediment removal ○ 1,500 cy in SMA 4 ○ 2,000 cy in SMA 5 • Backfill for post-dredge residuals management
SMA 6	Removal/treatment of recoverable product, removal of nearshore ethyl parathion-impacted sediments and MNR (Figure 6-13): • Product recovery well(s) • Temporary flow controls • 500 cy sediment removal • Backfill for post-dredge residuals management (7,000 sf) • MNR	Removal/treatment of recoverable product, removal of nearshore ethyl parathion-impacted sediments and in situ containment with hydraulic control (Figure 6-14): • Product recovery well(s) • Lateral containment with barrier wall • Active hydraulic control • Temporary flow controls • 500 cy sediment removal • 30,000 sf low permeability cap	Removal of sediment (Figure 6-15): • Temporary enclosure for turbidity control • 15,500 cy sediment removal • Cap/backfill for post-dredge residuals management (30,000 sf)

Table 7-1 Response Alternative Evaluation Criteria

Segment 1 EE/CA Criteria
Effectiveness
Protection of Human Health and Environment
Compliance with ARARs
Short-term Effectiveness
Long-term Effectiveness and Permanence
Reduction of Toxicity, Mobility, or Volume
Implementability
Cost

Table 8-1 Segment 1 Response Alternative Cost Comparisons

Alternative	Construction Cost	O&M Cost [a]	Total Cost
SMA 1			
Alt 1 – MNR	$0	$30,000	$30,000
Alt 2 – In Situ Containment	$210,000	$40,000	$250,000
Alt 3 – Removal of Sediment	$490,000	$0	$490,000
SMAs 2 and 3			
Alt 1 - In Situ Containment with Hydraulic Control	$1,100,000	$90,000	$1,200,000
Alt 2 - Removal of Recoverable Product/Treatment and In Situ Containment with Hydraulic Control	$1,700,000	$130,000	$1,800,000
Alt 3 - Sediment Removal/Post-Dredge In Situ Containment	$2,200,000 to $7,300,000 [b]	$70,000	$2,300,000 to $7,400,000 [b]
SMAs 4 and 5			
Alt 1 – MNR	$0	$60,000	$60,000
Alt 2 – In Situ Containment	$520,000	$80,000	$600,000
Alt 3 – Removal of Sediment	$1,700,000	$0	$1,700,000
SMA 6			
Alt 1 – Removal of Near Shore Ethyl Parathion Deposit/MNR	$2,100,000	$100,000	$2,200,000
Alt 2 – Removal of Near Shore Ethyl Parathion Deposit/In Situ Containment	$2,500,000	$160,000	$3,100,000
Alt 3 – Removal of Sediment	$3,800,000 to $8,700,000 [b]	$40,000	$3,800,000 to $8,700,000 [b]

a. Long-Term monitoring for all alternatives will be performed as detailed in the Site Wide Monitoring Plan.

b. Range of costs provided for alternatives that include sediment removal where removed sediment may require treatment for volatile organic compounds (VOCs) prior to disposal. Volumes and treatment methods are subject to refinement during remedial design based on a site-specific waste characterization.