18912 North Creek Parkway, Suite 101
Bothell, Washington 98011
(425) 482-3325

Final Technical Memorandum

TO:	Mark Edens / Rick Thomas, Washington State Department of Ecology, Toxics Cleanup Program	**DATE:**	June 22, 2009
FROM:	Tom Dubé, LHG	**REF:**	Work Assignment SAIC #23, Task 5
CC:	Dan Cargill, Washington State Department of Ecology, Toxics Cleanup Program		
SUBJECT:	Lower Duwamish Waterway, South Park Marina, Sediment Recontamination Assessment		

1.0 Introduction

South Park Marina (SPM) is located at 8604 Dallas Avenue South in Seattle, Washington (Figure 1). The facility lies along the Lower Duwamish Waterway (LDW) at River Mile 3.5, and is located immediately northwest of the Terminal 117 Early Action Area (EAA). Under contract to the Washington State Department of Ecology (Ecology), Science Applications International Corporation (SAIC) developed a *Summary of Existing Information and Identification of Data Gaps* report and a *Site Reconnaissance Plan*. These reports summarized information relevant to the potential for sediment recontamination from the SPM site, identified several data gaps, and proposed a plan for characterizing the site.

SAIC subsequently collected soil, sediment, and groundwater samples at the SPM site between September 2007 and July 2008 (SAIC 2008a, 2008b). Sampling focused on a portion of the site adjacent to the LDW where a former disposal pond was located. A number of exceedances of the Model Toxics Control Act (MTCA) cleanup levels and draft soil-to-sediment and groundwater-to-sediment protective screening levels (SAIC 2006) were identified during the sampling events for contaminants of concern (COCs) at the SPM site, particularly in soil of the former disposal pond area. However, the pathway for these COCs to reach the LDW was not clearly established. Groundwater showed only limited exceedances of COC cleanup levels or screening levels. River bank soil samples also showed a number of exceedances, but the link between these COCs and those in the intertidal sediment samples was uncertain. To resolve some of these uncertainties, this sediment recontamination assessment task was conducted.

This task consisted of developing a multi-tiered modeling scheme utilizing available data to perform the following:

- Assess the potential for the COCs found at SPM above screening levels to migrate to the LDW,
- Assess the potential for these chemicals to partition into sediments and accumulate to levels above Sediment Quality Standards (SQS), and
- If concentrations are predicted to exceed SQS, estimate the time needed to exceed SQS.

The recontamination assessment modeling scheme was applied to two scenarios:

- Current site conditions, and
- Terminal 117 excavation and development into intertidal habitat.

2.0 Site Scenarios

2.1 Current Site Conditions

Previous uses of the SPM upland property include the A&B Barrel Company, a drum reconditioning facility. A&B Barrel operated between 1946 and 1961 in the southeastern portion of what is now the SPM property (Figure 2). Between the mid-1950s and 1961, the operation included a waste disposal pond near the waterway and an outdoor yard area, apparently used for storage. Oils, grease, and sodium hydroxide were reportedly discharged to the pond. In 1961 the site was completely vacated, the pond was filled in, and the area was regraded. The site was later occupied by SPM, which has been in operation since 1970 and currently includes boat repair and maintenance facilities, upland boat storage, boat haul-out services, a boat launch ramp, and moorage slips in the LDW. Currently, the SPM site is covered with buildings, boats, and equipment, and the site is largely paved.

Adjacent to the southeast property line of SPM is the Terminal 117 EAA. Until 1993 the Terminal 117 site had been used for asphalt manufacturing operations, including the use of oils that contained polychlorinated biphenyls (PCBs). Historically, the U.S. Army Corps of Engineers may have used the Terminal 117 shoreline area to deposit LDW-generated dredged material that may have contained heavy metals and other COCs (URS 1994).

Sampling results from past Terminal 117 inspections indicated high levels of PCBs in soil, groundwater, and sediments. In 1999, the Port of Seattle conducted a Comprehensive Environmental Response Compensation and Liability Act (CERCLA) Removal Action that included the removal and treatment of impounded stormwater, excavation and disposal of more than 2,000 tons of PCB-contaminated soil, backfilling the excavation, installation of storm drain improvements, and paving the site, including areas where there had been limited or no characterization and removal. The completion of this work resulted in the present-day configuration of the Terminal 117 property.

Both the SPM and Terminal 117 shore areas generally consist of intertidal zone from near the top of the shoreline bank (+13 feet) to -4 feet mean lower low water (MLLW), and a subtidal zone from -4 feet MLLW to the slope of the navigation channel at -9 feet MLLW. The riverbank

along the SPM shoreline is steep, consisting of intermittently placed riprap in-filled with sediment.

2.2 Terminal 117 Remediation Plan

The proposed remediation and development plan for the Terminal 117 EAA consists of upland soil removal and sediment excavation/dredging, possibly combined with capping (Windward 2008). Where practical, intertidal bank materials and mudflat sediment would be excavated using conventional shore-based earth-moving equipment. Remaining sediment would be removed using over-water mechanical dredging. Capping would be used instead of excavation or dredging to contain contaminated sediment at locations where capping can be applied without unacceptable shallowing and/or constricting of the river channel (Figure 3). Actual limitations on cap placement relative to the channel would be established during removal action design by undertaking a localized flood routing study. This alternative includes completion of the Terminal 117 Upland Area by backfilling to a finished grade just above elevation +14 feet MLLW.

The proposed Terminal 117 remediation alternative includes the excavation of intertidal and subtidal sediment along the entirety of Terminal 117 property and a small portion of the southeastern SPM property (Figure 3). The proposed sediment cap would infill the southern and central excavated portions of the Terminal 117 site. The sediment cap is not proposed to extend northward to infill the excavated areas of the northern Terminal 117 or SPM property, in order to avoid interfering with navigation depths in the Marina.

The overall change in Terminal 117 morphology due to the redevelopment is likely to have minimal impacts on the local groundwater flow direction. Because the final grade of Terminal 117 is proposed to be approximately 4 feet below that of SPM (Windward 2008), shallow groundwater in the area of SPM adjacent to Terminal 117 may be redirected eastward. Although groundwater flow near the former disposal pond is still expected to maintain a net flow generally toward the northeast, discharging to the LDW, a component of groundwater flow near the property boundary would likely flow radially with an eastward component toward Terminal 117.

3.0 Contaminant Modeling

For both (a) current conditions, and (b) Terminal 117 excavation and development, separate models were used to evaluate the two probable LDW sediment recontamination pathways:

- Groundwater leaching of soil contaminants, and
- Erosional input of contaminated soil or sediment.

Modeling these pathways involved multiple steps that are summarized below. The cumulative results of these models are used to predict whether surface sediments in the vicinity of SPM and Terminal 117 will become contaminated above regulatory standards due exclusively to COC loading from the SPM site.

3.1 Groundwater Leaching of Soil Contaminants

Groundwater at SPM was sampled in three monitoring events (last one only for mercury) for three wells onsite. Only two of these wells are considered to be located in a net downgradient position from the disposal pond (MW-2 and MW-3). COC concentrations in this small number of groundwater samples showed only limited exceedances of screening levels; however, numerous soil samples from the site, representing a greater spatial coverage area, did show results exceed screening levels at overall higher multiple factors of the screening levels (SAIC 2008a). These soil-bound COCs may cause recontamination of LDW sediments if these contaminants are leached from the soil by groundwater, transported and discharged to the LDW in dissolved form, and then partitioned onto suspended or deposited sediment particles in the LDW. As described below, dissolution and transport of COCs were first quantitatively assessed using a coupled groundwater flow/solute transport model. The results of this transport modeling were then employed in a sediment recovery model in order to evaluate the partitioning and accumulation of COCs in LDW surface sediments.

3.1.1 Leaching of Contaminants from Soil

Groundwater Flow Model

The groundwater flux can be calculated at this site using the Darcy equation, as described in MTCA, using Equation 747-4 [WAC 173-340-747(5)(f)(i)]:

$$Q = K \times I \times A$$

where:
Q = the flow rate (liters/day or ft^3/day)
K = hydraulic conductivity (cm/sec or ft/day)
I = horizontal hydraulic gradient (ft/ft, unitless)
A = flow cross-sectional area (ft^2)

Groundwater passing through the site is an interaction between an upgradient flux on the upland area (from the southwest) and tidal effects from the waterway (to the northeast). Onsite recharge is expected to be limited because virtually the entire SPM surface is covered by pavement or buildings. The extreme range of measured hydraulic gradients in SPM groundwater between MW-3 (nearest the disposal pond) and LDW surface water is from 0.15 at very low tidal levels to -0.02 during a rising high tide (negative because flow direction is inland from LDW at high tide). A short-term (7-hour) tidal survey was conducted at SPM using the three onsite wells, which are located in a row parallel to the shoreline; due to the short duration and well configuration, these data are of limited usefulness for determination of hydraulic gradients. A 24-hour tidal survey at Terminal 117 was conducted March 4 and 5, 2008, which included a tidally averaged gradient determination (Windward 2008). The mean gradient from this latter survey is approximately 0.016 (based on a location adjacent to the SPM property boundary), with a flow direction toward the LDW (to the northeast). Because hydrogeologic data from SPM were limited, the mean gradient from the Terminal 117 survey was used for the SPM groundwater model, as the best overall tidally weighted representation of groundwater movement.

Even though several seeps were observed along the bank of the Terminal 117 site, no seeps were seen at the SPM site regardless of tidal height (SAIC 2008a), suggesting that the majority discharge of groundwater occurs as non-channelized, subsurface flow to the waterway. Tidal data collected from Terminal 117 wells suggest that mean groundwater flow is approximately parallel to the SPM / Terminal 117 property line, and therefore migration from the SPM to the Terminal 117 Upland Area is unlikely (Windward 2008).

Soils in the vicinity of the SPM site generally consist of 3 to 10 feet of sand-rich fill that overlies up to 95 feet of alluvium, found as discontinuous silt units with interbedded sands, silty sands, and some gravel (Windward 2008). The aquifer soils near the former disposal pond at SPM include an upper thin zone of sand and silty sand (fill material wet only at high tidal groundwater levels), underlain by 4 to 13 feet of silt grading to silty sand, underlain by sand (SAIC 2008a). A number of published hydraulic conductivity values for silty sand units typically range from 10^{-2} to 10^{-5} cm/sec; silt-rich units typically have hydraulic conductivities ranging from 10^{-3} to 10^{-6} cm/sec. For this model the average hydraulic conductivity used is 10^{-3} cm/sec, based on the average value of this portion of the regional LDW aquifer (Fabritz et al. 1998). Considering the high silt content of the shallow portion of the site aquifer, the value of 10^{-3} cm/sec is a conservative representation of aquifer permeability.

The former disposal pond is approximately 25 feet wide. Even though the aquifer may be up to 95 feet thick, the section containing the COCs that has the potential to release contaminants to the LDW is likely less than 20 feet thick (derived from the vertical extent for PCB detection both at SPM and Terminal 117). This information suggests the cross-sectional area of the COC release from the site is limited to approximately 1,000 ft^2. The calculated groundwater flux rate through this zone is 45 ft^3/day (1,300 liters/day).

Solute Transport Model

Two analytical calculations were performed to model upper-bound contaminant loads to LDW surface water. These calculations are based on the groundwater flux and potential COC concentrations in groundwater. Method 1 is used for the COCs with positive detections in groundwater, and Method 2 is for COCs with only soil detections (Table 1) (SAIC 2008a).

Method 1: Estimate loading based on dissolved concentration

For soluble constituents with positive detection, a conservative estimate of the discharge mass (M) was calculated using the average groundwater flux (Q_{avg}) and the highest detected dissolved concentration (C_{diss}):

$$M = C_{diss} \times Q_{avg}$$

Method 2: Estimate loading based on soil/water equilibrium concentration

Numerous COCs were detected in the SPM soil from the disposal pond and have the potential to leach to groundwater, but were not detected in groundwater samples. Equilibrium COC concentrations potentially present in groundwater were estimated based on the maximum soil concentrations (S_{max}), fraction of organic carbon (f_{oc}), and organic carbon-water partitioning coefficients (K_{oc}):

$$C_{diss} = S_{max} / (f_{oc} \times K_{oc})$$

$$M = C_{diss} \times Q_{avg}$$

The fraction of organic carbon was based on the default value from MTCA [WAC 173-340-747(4-6)], of 0.001 g/g (0.1% f_{oc}). K_{oc} values for SMS COCs were derived from the "best estimate" values from SAIC (2006). These "best estimate" K_{oc} values were developed in conjunction with Ecology for evaluating sediment recontamination risk for LDW drainage areas (SAIC 2006). K_{oc} values for COCs not included in SAIC (2006) were derived from data compiled by Ohio EPA (2005).

3.1.2 Partitioning of Dissolved Contaminants to Sediments

Sediment Recovery Model

The adsorption of organic compounds to sediments is primarily determined by the molecular weight, the f_{oc}, and the K_{oc} of the organic compound. As the organic carbon content of the sediment and the K_{oc} (and usually the molecular weight) of the compound increase, so does the adsorption of the compound to the sediment matrix.

The software program RECOVERY, available for download from the U.S. Army Corps of Engineers, was used for modeling the transfer of solids and partitioning of COCs between the overlying water column and sediment bed (Boyer et al. 1994; Ruiz et al. 2000). This model has previously been applied in the LDW to predict the vertical migration of COCs through sediments (Ruiz and Schroeder 2001).

Parameterization of the RECOVERY model includes defining the morphology and hydrology of the SPM/LDW site, physical and chemical properties of the surface sediment mixed layer and underlying sediment, and chemical properties and loading quantities of individual COCs (Table 2 and Attachment 1). A schematic of the RECOVERY model is shown in Figure 4. The model design is optimized for a well-mixed surface water layer underlain by a vertically stratified sediment column. The sediment is assumed to be well-mixed horizontally but segmented vertically into a well-mixed surface layer and deep sediment. Fundamental assumptions of the RECOVERY model are that:

- The water body is well mixed,
- The surface sediment layer is well mixed,
- COCs follow a linear reversible equilibrium sorption mechanism,
- LDW surface water flow-through is constant, and
- Movement of individual COCs are independent.

COC loading rate results from the Solute Transport Model (Section 3.1.1) and the Erosional Input Model (Section 3.2) were treated as contaminant point sources to the LDW in the RECOVERY model. Additionally, background loadings of COCs sorbed to newly deposited sediment particles at the site are included in the model. Because little COC data exist for LDW

suspended sediments, two different baseline loadings were considered in the RECOVERY model. The "upstream" background loading values, representing relatively "clean" suspended sediments, are derived from average surface concentrations from sediments analyzed upstream of LDW River Mile 5.0 (Windward 2007). The "site" baseline concentrations are derived from average surface sediment concentrations at the SPM site (SAIC 2008a), and are generally greater than the "upstream" background loadings (Table 3). In cases where compounds were not detected, the greatest reporting limit was used for the baseline concentration.

3.2 Erosional Input of Contaminated Soil/Sediment

COCs sorbed to soil/sediment of the SPM site may cause recontamination of LDW sediment if these particles are eroded and transported to the waterway. Only the intertidal bank of SPM is considered to be susceptible to erosion because almost the entire upland zone is paved or covered with buildings (Figure 5). Although the SPM intertidal region has previously been classified as net depositional (Windward 2008), this may include episodes of resuspension of some portion of the sediment bed due to physical disturbances such as increased river velocity, wind/wave-generated currents, and/or propeller wash scour from vessels. Therefore a bank erosion "best-case" scenario consists of only deposition with no erosion. The "worst-case" scenario, which is used for the erosional input model, consists of an intermittently erosive bank.

In order to determine the quantity of COCs stored on the SPM property, three-dimensional models of soil/sediment contaminant concentrations were created using data collected at the SPM site (SAIC 2008a). For modeling purposes, a "worst-case" erosion rate of 1 cm/yr for the entire SPM intertidal zone was used to determine the erosional COC loading to the LDW. This erosion rate is less than the estimated sedimentation rate of 3 cm/yr for SPM (Windward 2008). The erosional COC loadings to the LDW were included in the RECOVERY model as a particle-associated contaminant source that does not undergo partitioning to the dissolved phase.

4.0 Modeling Results

Dissolved loadings from the Solute Transport Model and particulate loadings from the Erosional Model are summarized in Table 4. These loadings represent a "worst-case" scenario because they are derived from maximum soil/groundwater concentrations and assume maximum bank erosion of SPM. The RECOVERY model was employed to combine both the dissolved and particulate COC loadings to determine their partitioning to surface sediments in the vicinity of SPM. Model runs include both "upstream" background and "site" baseline concentrations as initial surface sediment concentrations, representing the probable concentration range of newly deposited particles at SPM (Table 3).

RECOVERY model results are summarized in Tables 5 and 6, and results are used to assess the potential for contaminants to accumulate to levels above SQS in surface sediments adjacent to SPM. Table 5 represents the "worst-case" scenario where both groundwater and erosional loadings are considered, while Table 6 considers only groundwater loading. Because there is no temporal change in the loading flux, RECOVERY model results indicate that the surface sediment COC concentrations initially increase before reaching steady-state values in 10 to 15

years, depending upon the compound. Three representative examples are presented in Figure 6. After this equilibrium period, surface sediment concentrations are not expected to increase further. The modeling results are discussed first for current site conditions (Section 4.1), and then for the proposed Terminal 117 EAA excavation and development plan (Section 4.2).

4.1 Current Site Conditions

Groundwater and Erosional Loading

After the 10- to 15-year accumulation and equilibrium period, surface sediments in the vicinity of SPM are expected to exceed Sediment Management Standards (SMS) criteria for total PCBs regardless of the initial particulate background concentration (Table 5). Butylbenzylphthalate may also be expected to exceed SMS criteria, but only if "site" baseline concentrations occur.

Groundwater Loading Only

Total PCBs are expected to exceed SMS criteria, but only if "site" baseline concentrations occur (Table 6).

4.2 Terminal 117 Excavation and Development

The proposed excavation and development plan for the Terminal 117 EAA is expected to have effects on the site's morphology and the loading of COCs to the LDW. However, the redevelopment plan is expected to have only small localized effects on groundwater flow through SPM, and therefore will not affect dissolved loadings to the LDW from SPM. Compared to current conditions at the site, the proposed excavation and development plan is expected to:

- Increase the depth of the active depositional area,
- Increase the flow-through volume, and
- Decrease erosional COC loading.

Groundwater and Erosional Loading

After the 10- to 15-year accumulation and equilibrium period, surface sediments in the vicinity of SPM are expected to exceed SMS criteria for total PCBs and butylbenzylphthalate if "site" baseline concentrations occur (Table 5).

Groundwater Loading Only

Total PCBs are expected to exceed SMS criteria, but only if "site" baseline concentrations occur (Table 6).

5.0 Conclusions

Although surface sediments collected at SPM were found to be in exceedance of SMS criteria for total PCBs (SAIC 2008a), SPM-sourced COCs may not have been responsible for this contamination, nor are SPM-sourced COCs expected to cause additional future exceedances.

The integrated modeling scheme applied in this study determined that the dominant factor controlling future sediment COC concentrations are the initial background concentrations of surface sediment particles, rather than contaminant loading derived from upland SPM sources.

The differences in COC concentrations between the "upstream" background and "site" baseline conditions (Table 3) suggest that particles accumulate contaminants in the LDW either during transport before deposition or while residing in surface sediments in the vicinity of SPM. However, when sediments with "upstream" background concentrations are subjected to SPM-derived loadings under the modeled conditions, they do not accumulate COCs to levels comparable to the "site." This suggests that, under current conditions, SPM-sourced COCs alone are not responsible for the measured surface sediment concentrations. Therefore, using "site" rather than "upstream" concentrations as sediment baseline values is more appropriate for predicting future sediment concentrations. When using these "site" baseline concentrations in the modeling framework, the derived future sediment COC concentrations likely represent maximum values.

Although this modeling work does not predict a temporal peak in COC loading from SPM, surface sediment concentrations are expected to increase to a steady value within a 10- to 15-year period. When applying "site" baseline concentrations and both erosional and groundwater loadings, surface sediment equilibrium concentrations of total PCBs and butylbenzylphthalate are expected to exceed SMS criteria. SMS exceedance for total PCBs is inevitable due to the "site" baseline concentration exceedance of total PCBs. The SMS exceedance of butylbenzylphthalate is dominantly due to the modeled erosional input of this compound, which is found in high concentrations in the bank soil. However, because SPM's intertidal bank is likely net depositional, significant erosional loading is unlikely. When only groundwater loadings are considered, total PCBs are the only SMS criteria exceedance.

Terminal 117 EAA excavation and development modifies local site conditions by causing a small decrease in erosional loading, but no predicted change to groundwater loading from SPM. However, cleanup of Terminal 117 EAA may effectively remove a COC loading source to the LDW and surface sediments in the vicinity of SPM. Therefore, "upstream" background concentrations may be a more appropriate initial condition than "site" baseline concentrations for newly deposited sediment after Terminal 117 cleanup. Under these conditions, COC loading from SPM is not expected to cause any future SMS exceedances at any locations on either SPM or Terminal 117 that have undergone cleanup.

6.0 References

Boyer, J.M., S.C. Chapra, C.E. Ruiz, and M.S. Dortch. 1994. RECOVERY, A Mathematical Model to Predict the Temporal Response of Surface Water to Contaminated Sediments. Technical Report W-94-4, U.S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi.

DiToro, D.M. 1985. A Particle Interaction Model of Reversible Organic Chemical Sorption. *Chemosphere*. Vol. 14, pp. 1503-1538.

Fabritz, J., J. Massman, and D.B. Booth. 1998. Development of a three-dimensional, numerical groundwater flow model for the Duwamish River Basin. Center for Urban Water Resources Management, University of Washington, Seattle.

Ohio Environmental Protection Agency (Ohio EPA). 2005. Table of chemical and physical parameters for a number of toxic chemicals; website last updated September 2005, accessed in May 2009 (http://www.epa.state.oh.us/dhwm/pdf/Chem_Phys_Tox.PDF).

Ruiz, C.E., P.R. Schroeder, and N.M. Aziz. 2000. RECOVERY: A Contaminated Sediment-water Interaction Model. ERDC/EL SR-D-00-1, U.S. Army Engineer Research and Development Center, Waterways Experiment Station, Vicksburg, Mississippi.

Ruiz, C.E., and P.R. Schroeder. 2001. Assessment of contaminant isolation at Duwamish, Wash., capping site verifies RECOVERY prediction strength. Dredging Research. Vol. 4, No. 1:1-4. (Bulletin of the Environmental Laboratory of the U.S. Army Engineer Research and Development Center.)

SAIC. 2006. Soil and Groundwater Screening Criteria, Source Control Action Plan, Slip 4, Lower Duwamish Waterway, Draft. Prepared for Washington State Department of Ecology by SAIC, Bothell, Washington; August 2006 (Revised February 2007).

SAIC. 2008a. South Park Marina, Seattle, Washington, Additional Site Characterization Activities Data Report, Final. Prepared for Toxics Cleanup Program, Washington State Department of Ecology. SAIC, Bothell, Washington; June 30, 2008.

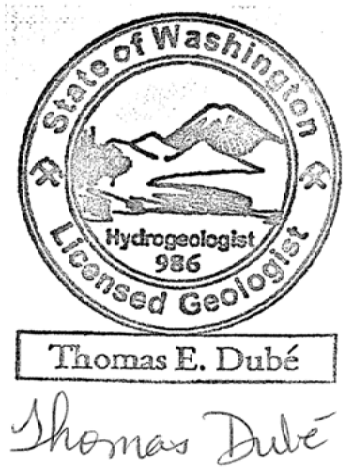
SAIC. 2008b. Transmittal of Low-Level Mercury Results, July 2008 Groundwater Sampling Round, South Park Marina Site, Seattle, Washington; Final Technical Memorandum to Washington State Department of Ecology from SAIC, Bothell, Washington; December 31, 2008.

URS. 1994. Site inspection report for the Malarkey Asphalt Company, Seattle, Washington. Prepared for the U.S. Environmental Protection Agency, Region 10. URS Consultants, Seattle, Washington.

USGS. 2003. Surface-Water Quality of the Skokomish, Nooksack, and Green-Duwamish Rivers and Thornton Creek, Puget Sound Basin, Washington, 1995-98. U.S. Geological Survey, National Water-Quality Assessment Program, Tacoma, Washington.

Windward. 2007. Lower Duwamish Waterway Remedial Investigation; Baseline Ecological Risk Assessment. Prepared for Lower Duwamish Waterway Group, by Windward Environmental LLC; Seattle, Washington.

Windward. 2008. Lower Duwamish Waterway Superfund Site, Terminal 117 Early Action Area, Revised Engineering Evaluation/Cost Analysis, Draft. Prepared for the Port of Seattle and the City of Seattle, for submittal to the USEPA Region 10, by Windward Environmental LLC and others; Seattle, Washington; July 30, 2008.



Thomas E. Dubé
WA Licensed Geologist/Hydrogeologist
No. 986, expires 11/17/09

Figures

Figure 1. Site Regional Vicinity Map
Figure 2. South Park Marina Site Map
Figure 3. Terminal 117 Excavation Plan
Figure 4. RECOVERY Model Schematic
Figure 5. Erosional and Depositional Areas Near South Park Marina
Figure 6. Modeled Surface Sediment Chemical Concentrations

Tables

Table 1. Estimated contaminant mass load to LDW through the former disposal pond
Table 2. Physical properties used in the RECOVERY model
Table 3. Surface sediment chemical concentrations used as model background values
Table 4. Chemical loadings to the LDW used in the RECOVERY model
Table 5. Predicted equilibrium surface sediment chemical concentrations due to groundwater and erosional loading
Table 6. Predicted equilibrium surface sediment chemical concentrations due to groundwater loading only

Attachment

Attachment 1. Example of RECOVERY input parameters for Aroclor 1254

Figures

N
W E
S

0 0.25 0.5 Kilometers

0 0.25 0.5 Miles

Figure 1. Site Regional Vicinity Map

SAIC
From Science to Solutions

:\LDW\gis\projects\SouthPark\VicinityMap061908.mxd June 25, 2008

0 25 50 Feet

Figure 2. South Park Marina Site Map

SAIC
From Science to Solutions

N
W E
S

0 25 50 100 150
Feet

Figure 3. Terminal 117 Excavation Plan

SAIC
From Science to Solutions

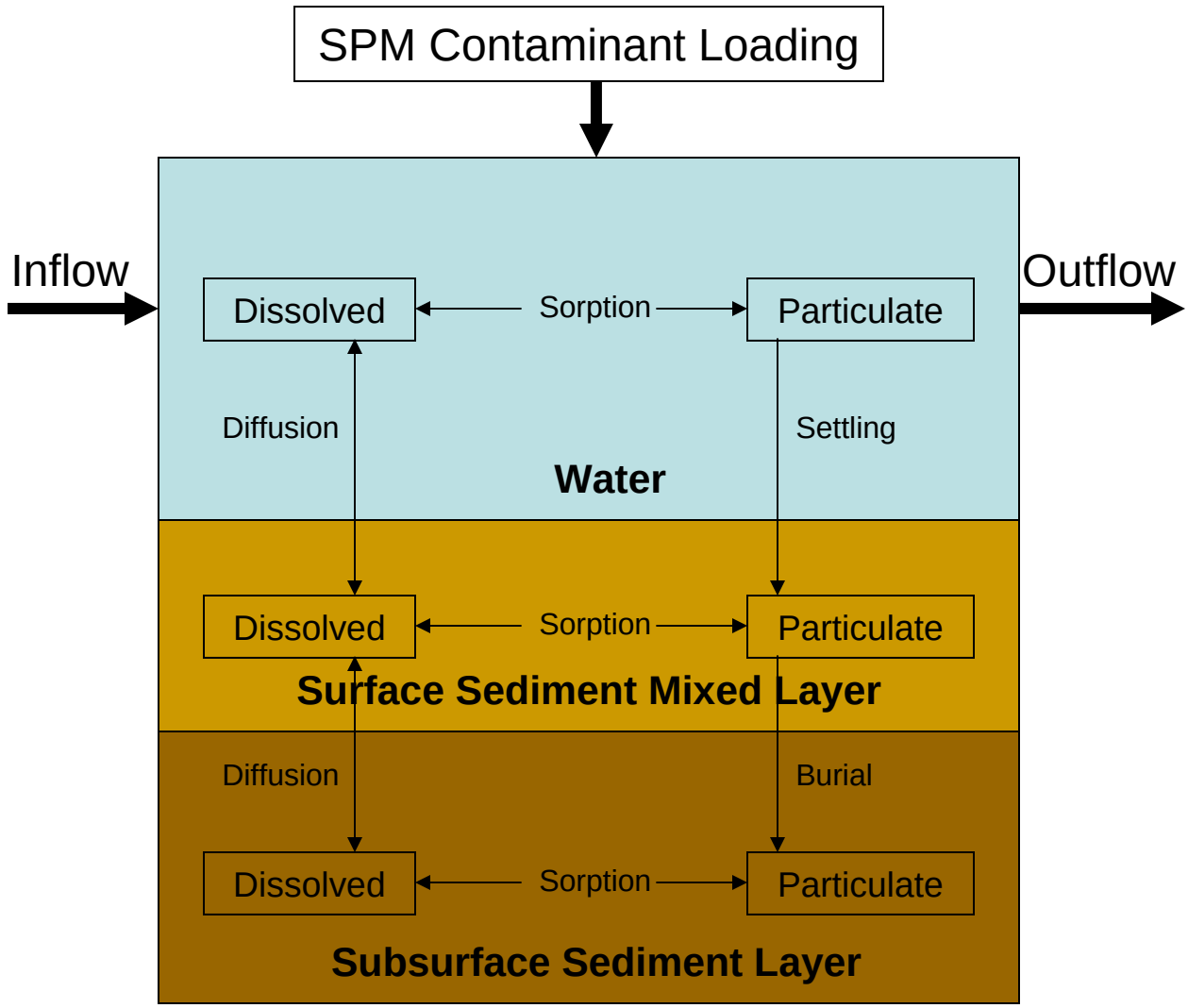
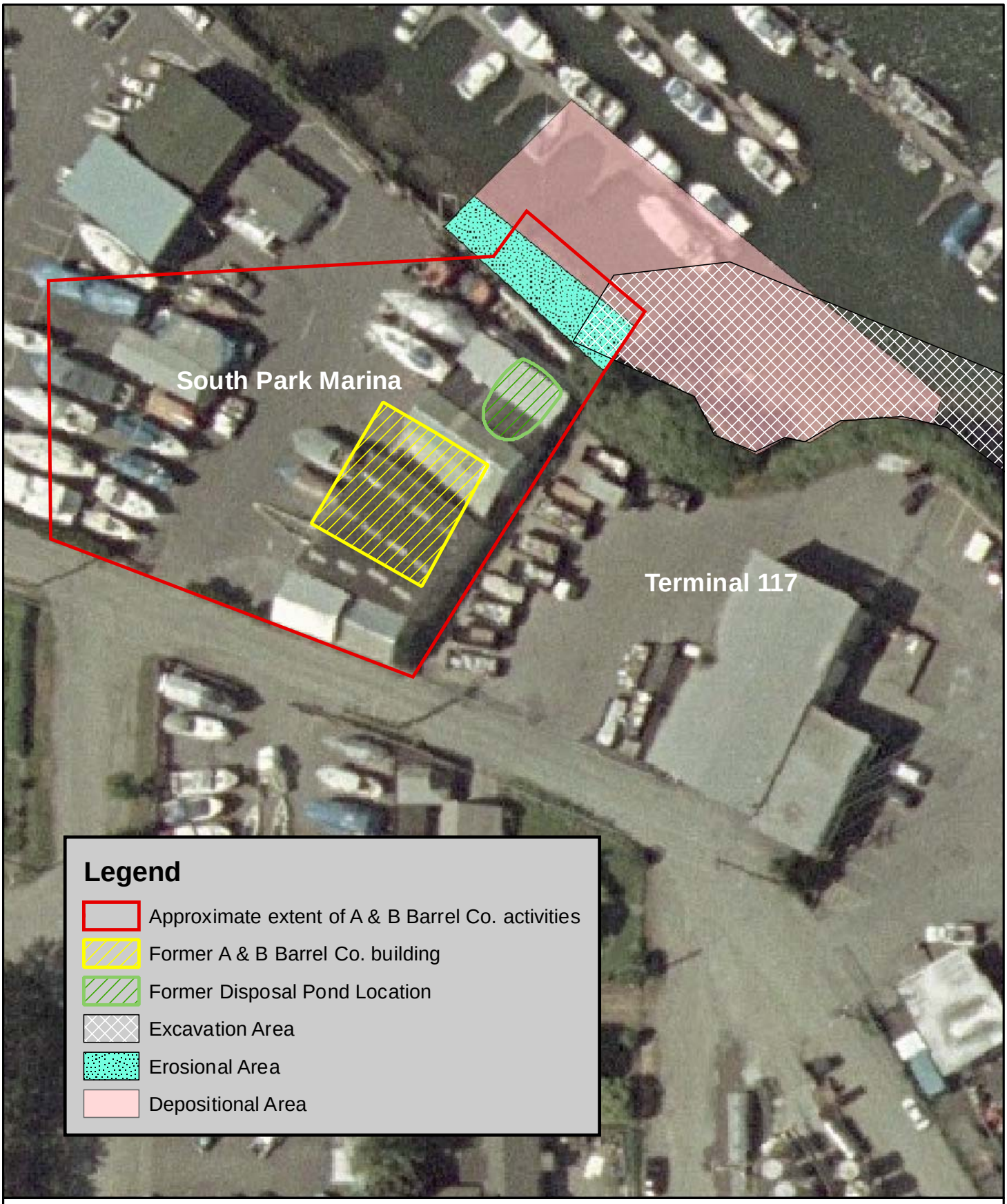


Figure 4. RECOVERY Model Schematic

SAIC
From Science to Solutions



N
W E
S

Figure 5. Erosional and Depositional Areas Near South Park Marina

0 25 50 100 150 Feet

SAIC
From Science to Solutions

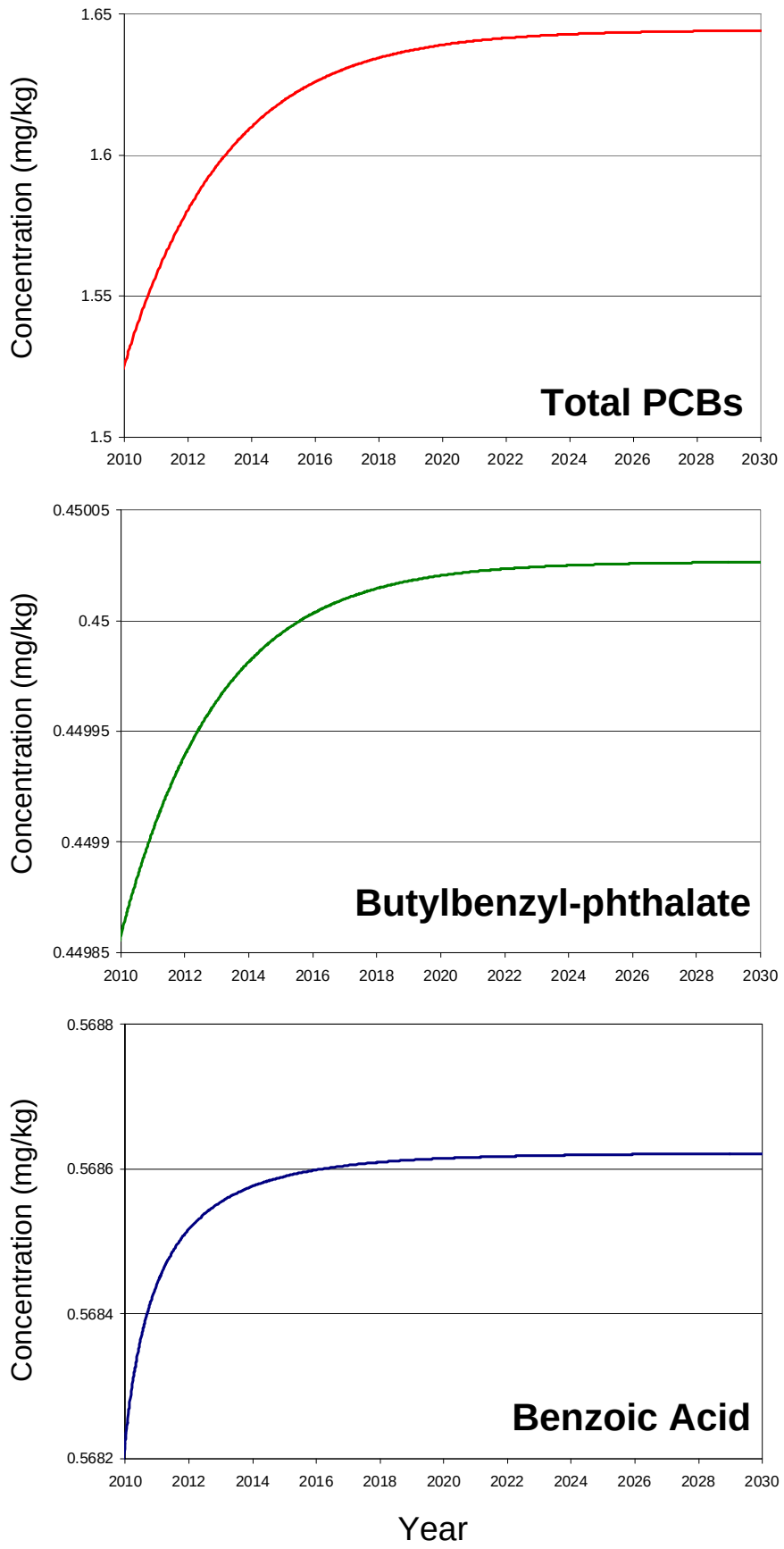


Figure 6. Modeled Surface Sediment Chemical Concentrations

SAIC
From Science to Solutions

Tables

Table 1. Estimated contaminant mass load to LDW through the former disposal pond

Group	Parameter	Maximum Concentration in GW (µg/L)‡	Method 1 Daily Discharge (mg)	Maximum Concentration in Soil (mg/kg)	Koc (L/kg)	Equilibrium Concentration at foc=0.1 (mg/L)	Method 2 Daily Discharge (mg)	Maximum Daily Discharge (mg)
Metals	Arsenic	8.07	10.4	9.4	--	--	--	10.4
	Cadmium	0.091	0.117	31.4	--	--	--	0.117
	Chromium	40.4	51.9	465	--	--	--	51.9
	Copper	9.83	12.6	198	--	--	--	12.6
	Lead	0.519	0.666	3180	--	--	--	0.666
	Mercury	0.00169	0.00217	29.5	--	--	--	0.00217
	Silver	0.005	0.00642	0.299	--	--	--	0.00642
	Zinc	5.2	6.68	1510	--	--	--	6.68
PCBs	PCB-Aroclor 1248	U	U	U	43900†	U	U	U
	PCB-Aroclor 1254	U	U	36	75600†	0.476	611	611
	PCB-Aroclor 1260	U	U	5.1	207000†	0.0246	31.6	31.6
	Total PCBs	U	U	36	44800†	0.804	1030	1030
Pesticides	2,4'-DDD	U	U	U	1000000*	U	U	U
	2,4'-DDT	0.0013	0.00167	1.3	2630000*	0.000494	0.635	0.635
	4,4'-DDD	U	U	0.8	1000000*	0.0008	1.03	1.03
	4,4'-DDE	U	U	0.0021	4470000*	0.00000047	0.000603	0.000603
	4,4'-DDT	0.0014	0.0018	0.6	2630000*	0.000228	0.293	0.293
	Aldrin	0.0015	0.00193	9.4	48700*	0.193	248	248
	Dieldrin	0.041	0.0526	0.92	21400*	0.043	55.2	55.2
	Heptachlor	U	U	0.00056	1140000*	0.000000491	0.000631	0.000631
SVOCs	Acenaphthene	U	U	0.51	6120†	0.0833	107	107
	Anthracene	U	U	1.2	20400†	0.0588	75.5	75.5
	Benzo(a)anthracene	U	U	0.24	426600†	0.000563	0.722	0.722
	Benzo(a)pyrene	U	U	0.0075	786800†	0.00000953	0.0122	0.0122
	Benzo(b)fluoranthene	U	U	0.13	803000†	0.000162	0.208	0.208
	Benzo(k)fluoranthene	U	U	0.0036	787000†	0.00000457	0.00587	0.00587
	Benzo(ghi)perylene	U	U	0.13	2676000†	0.0000486	0.0624	0.0624
	Benzoic Acid	U	U	0.19	14.49†	13.1	16800	16800
	Benzyl Alcohol	U	U	0.0077	15.66†	0.492	631	631
	Bis(2-Ethylhexyl) Phthalate	U	U	7	165000†	0.0424	54.5	54.5
	Butylbenzylphthalate	U	U	2.2	9360†	0.235	302	302
	Chrysene	U	U	0.53	236000†	0.00225	2.88	2.88
	Dibenzo(a,h)anthracene	U	U	0.0022	2620000†	0.00000084	0.00108	0.00108
	Dibenzofuran	U	U	0.6	11300†	0.0531	68.2	68.2
	1,2-Dichlorobenzene	U	U	0.11	443†	0.248	319	319
	Dimethylphthalate	U	U	0.23	371†	0.62	796	796
	Di-N-Butylphthalate	U	U	1.3	1460†	0.89	1140	1140
	Di-N-Octyl Phthalate	U	U	U	196000†	U	U	U
	Fluoranthene	U	U	0.88	70900†	0.0124	15.9	15.9
	Fluorene	U	U	1	11300†	0.0885	114	114
	Indeno(1,2,3-cd)pyrene	U	U	0.1	2680000†	0.0000373	0.0479	0.0479
	2-Methylnaphthalene	U	U	4.5	2090†	2.15	2760	2760
	2-Methylphenol	U	U	U	443†	U	U	U
	4-Methylphenol	U	U	0.0022	434†	0.00507	6.51	6.51
	Naphthalene	U	U	1.9	1840†	1.03	1330	1330
	Pentachlorophenol	U	U	2.8	3380†	0.828	1060	1060
	Phenanthrene	U	U	2.4	20800†	0.115	148	148
	Phenol	U	U	U	268†	U	U	U
	Pyrene	0.021	0.027	0.99	69400†	0.0143	18.3	18.3
TPH	Gasoline Range Organics	U	U	U	720*	U	U	U
	Diesel Range Organics	U	U	23	7240*	3.18	4080	4080
	Residual Range Organics	U	U	21	7240*	2.9	3720	3720
VOCs	Acetone	U	U	0.048	0.575*	83.5	107000	107000
	Benzene	U	U	0.078	58.9*	1.32	1700	1700
	n-Butylbenzene	U	U	2	2830*	0.707	907	907
	Sec-Butylbenzene	U	U	1.2	2150*	0.558	717	717
	Carbon Disulfide	U	U	0.00012	45.7*	0.00263	3.37	3.37
	Chlorobenzene	U	U	0.046	219*	0.21	270	270
	1,2-Dichlorobenzene	U	U	0.31	617*	0.502	645	645
	1,4-Dichlorobenzene	U	U	0.038	617*	0.0616	79.1	79.1
	1,1-Dichloroethane	U	U	0.00031	31.6*	0.00981	12.6	12.6
	Cis-1,2-Dichloroethene	U	U	11	35.5*	310	398000	398000
	Trans-1,2-Dichloroethene	U	U	0.21	52.5*	4	5140	5140
	Ethylbenzene	U	U	9.3	363*	25.6	32900	32900
	Isopropylbenzene (Cumene)	U	U	1.7	820*	2.07	2660	2660
	p-Isopropyltoluene	U	U	2.6	4050*	0.642	824	824
	Naphthalene	U	U	2.5	2000*	1.25	1610	1610
	n-Propylbenzene	U	U	1.8	676*	2.66	3420	3420
	Styrene	U	U	0.037	776*	0.0477	61.2	61.2
	Tert-Butylbenzene	U	U	0.087	2200*	0.0395	50.8	50.8
	Tetrachloroethene	0.2	0.257	0.17	794*	0.214	275	275
	Toluene	0.18	0.231	7.2	182*	39.6	50800	50800
	Trichloroethene	U	U	0.17	166*	1.02	1310	1310
	1,2,4-Trimethylbenzene	U	U	17	720*	23.6	30300	30300
	1,3,5-Trimethylbenzene	U	U	6.6	660*	10	12800	12800
	Vinyl Chloride	U	U	0.87	18.6*	46.8	60100	60100
	m,p-Xylene	U	U	44	400*	110	141000	141000
	o-Xylene	U	U	24	363*	66.1	84900	84900

Table includes all parameters modeled in the study. U = undetected analyte.

‡ Maximum groundwater concentrations are expressed in µg/L to be consistent with SAIC (2008a, 2008b).

† Koc "best estimate" data developed with Ecology (SAIC 2006)

* Koc data from Ohio EPA (2005) website

foc value from MTCA Method B soil default value (0.1%)

Table 2. Physical properties used in the RECOVERY model

	Parameter	Current Conditions	Terminal 117 Remediated
Morphology and Hydrology	Suspended Solids Concentration (mg/L)[‡]	31.0	31.0
	Suspended Solids Total Organic Carbon (wt%)[‡]	1.95	1.95
	Depositional Surface Area (m^2)*	1170	1170
	Average Water Depth (m)*	3.1	4.6
	Side-slope Current Speed (cm/s)*	5.1	5.1
	Flow-Through (m^3/yr)	1.04E+08	1.62E+08
Surface Sediment Mixed Layer	Sedimentation Rate (cm/yr)*	3	3
	Contaminated Sediment Depth (m)	1	1
	Depth of Mixed Sediment Layer (m)	0.1	0.1
	Porosity (%)	80	80
	Particle Specific Gravity (g/cm^3)	2.36	2.36
	Total Organic Carbon (wt%)[†]	2	2
Subsurface Sediment Layer	Porosity (%)	50	50
	Particle Specific Gravity (g/cm^3)	2.36	2.36
	Total Organic Carbon (wt%)[†]	2	2

[‡] Median conditions outlined in USGS (2003)

* Conditions outlined in Windward (2008)

[†] Average LDW site conditions in SAIC (2006)

Table 3. Surface sediment chemical concentrations used as model background values

Group	Parameter	Concentration (mg/kg)			
		Upstream Background*		Site‡	
Metals	Arsenic	6.0		16	
	Cadmium	0.15		0.26	
	Chromium	13		27	
	Copper	16		55	
	Lead	5.2		44	
	Mercury	0.057		0.23	
	Silver	0.03		0.75	
	Zinc	49		94	
PCBs	PCB-Aroclor 1248	0.0084	U	0.033	
	PCB-Aroclor 1254	0.0022	U	0.059	U
	PCB-Aroclor 1260	0.0027		1.2	
	Total PCBs	0.013		1.3	
Pesticides	2,4'-DDD	0.0020	U	0.046	
	2,4'-DDT	0.0020	U	0.049	U
	4,4'-DDD	0.0020	U	0.0014	
	4,4'-DDE	0.0014	U	0.0034	U
	4,4'-DDT	0.0020	U	0.16	U
	Aldrin	0.0012	U	0.046	
	Dieldrin	0.002	U	0.0018	U
	Heptachlor	0.0012	U	0.0014	U
SVOCs	Acenaphthene	0.0024		0.0055	
	Anthracene	0.0030		0.033	
	Benzo(a)anthracene	0.013		0.091	
	Benzo(a)pyrene	0.013		0.097	
	Benzo(b)fluoranthene	0.021		0.17	
	Benzo(k)fluoranthene	0.0071		0.058	
	Benzo(ghi)perylene	0.010		0.072	
	Benzoic Acid	0.54		0.28	U
	Benzyl Alcohol	0.012		0.087	
	Bis(2-Ethylhexyl) Phthalate	0.12		0.16	
	Butylbenzylphthalate	0.025		0.43	
	Chrysene	0.016		0.18	
	Dibenzo(a,h)anthracene	0.005		0.018	
	Dibenzofuran	0.0063	U	0.0047	
	1,2-Dichlorobenzene	0.0062	U	0.014	U
	Dimethylphthalate	0.0035		0.10	
	Di-N-Butylphthalate	0.014		0.03	
	Di-N-Octyl Phthalate	0.066		0.014	U
	Fluoranthene	0.034		0.21	
	Fluorene	0.0016		0.0089	
	Indeno(1,2,3-cd)pyrene	0.0094		0.082	
	2-Methylnaphthalene	0.002		0.007	
	2-Methylphenol	0.010	U	0.0023	
	4-Methylphenol	0.11		0.0071	
	Naphthalene	0.0024		0.0085	
	Pentachlorophenol	0.012		0.14	U
	Phenanthrene	0.014		0.092	
	Phenol	0.013		0.017	
	Pyrene	0.028		0.18	
	Total cPAHs	0.085		0.68	
TPH	Gasoline Range Organics	--		20	U
	Diesel Range Organics	--		93	
	Residual Range Organics	--		530	

* Average surface sediment concentrations upstream of LDW river mile 5.0

‡ Average surface sediment concentrations at SPM site (SAIC 2008)

U = Parameter not detected at the stated reporting level.

Table 4. Chemical loadings to the LDW used in the RECOVERY model

Group	Parameter	Current Conditions		Terminal 117 Remediated	
		Particulate Erosional Loading (kg/yr)	Dissolved Groundwater Loading (kg/yr)	Particulate Erosional Loading (kg/yr)	Dissolved Groundwater Loading (kg/yr)
Metals	Arsenic	0.019	0.0038	0.016	0.0038
	Cadmium	0.0022	0.000043	0.0017	0.000043
	Chromium	0.08	0.019	0.06	0.019
	Copper	0.5	0.0046	0.4	0.0046
	Lead	0.24	0.00024	0.17	0.00024
	Mercury	0.0011	0.00000079	0.0007	0.00000079
	Silver	0.0005	0.0000023	0.0004	0.0000023
	Zinc	0.4	0.0024	0.32	0.0024
PCBs	PCB-Aroclor 1248	0.00012	U	0.00008	U
	PCB-Aroclor 1254	0.0021	0.22	0.0014	0.22
	PCB-Aroclor 1260	0.0014	0.012	0.0010	0.012
	Total PCBs	0.004	0.38	0.0025	0.38
Pesticides	2,4'-DDD	0.00006	U	0.00004	U
	2,4'-DDT	0.00024	0.00023	0.00017	0.00023
	4,4'-DDD	0.00004	0.00037	0.000026	0.00037
	4,4'-DDE	0.00006	0.00000022	0.00005	0.00000022
	4,4'-DDT	0.0004	0.00011	0.00027	0.00011
	Aldrin	0.0011	0.09	0.00097	0.09
	Dieldrin	0.000019	0.02	0.000015	0.02
	Heptachlor	0.000011	0.00000023	0.000007	0.00000023
SVOCs	Acenaphthene	0.00017	0.039	0.00013	0.039
	Anthracene	0.00026	0.028	0.00020	0.028
	Benzo(a)anthracene	0.00033	0.00026	0.00026	0.00026
	Benzo(a)pyrene	0.0004	0.0000045	0.00028	0.0000045
	Benzo(b)fluoranthene	0.0005	0.000076	0.0004	0.000076
	Benzo(k)fluoranthene	0.00031	0.0000021	0.00023	0.0000021
	Benzo(ghi)perylene	0.00037	0.000023	0.00029	0.000023
	Benzoic Acid	0.0047	6.1	0.0037	6.1
	Benzyl Alcohol	0.00077	0.23	0.0006	0.23
	Bis(2-Ethylhexyl) Phthalate	0.0015	0.02	0.0012	0.02
	Butylbenzylphthalate	0.0004	0.11	0.00031	0.11
	Chrysene	0.00043	0.0011	0.00033	0.0011
	Dibenzo(a,h)anthracene	0.00024	0.00000039	0.00018	0.00000039
	Dibenzofuran	0.00017	0.025	0.00012	0.025
	1,2-Dichlorobenzene	0.00024	0.12	0.00018	0.12
	Dimethylphthalate	0.0017	0.29	0.0013	0.29
	Di-N-Butylphthalate	0.0006	0.42	0.00047	0.42
	Di-N-Octyl Phthalate	0.00023	U	0.00018	U
	Fluoranthene	0.00047	0.0058	0.00037	0.0058
	Fluorene	0.00019	0.041	0.00015	0.041
	Indeno(1,2,3-cd)pyrene	0.0004	0.000017	0.00030	0.000017
	2-Methylnaphthalene	0.00063	1	0.00053	1
	2-Methylphenol	0.00037	U	0.0003	U
	4-Methylphenol	0.00023	0.0024	0.00018	0.0024
	Naphthalene	0.00016	0.48	0.00012	0.48
	Pentachlorophenol	0.0025	0.39	0.0019	0.39
	Phenanthrene	0.0005	0.054	0.0004	0.054
	Phenol	0.0007	U	0.00053	U
	Pyrene	0.00047	0.0067	0.00037	0.0067
	Total cPAHs	0.0026	0.00146	0.002	0.00146
TPH	Gasoline Range Organics	0.18	U	0.12	U
	Diesel Range Organics	1.6	1.5	1.1	1.5
	Residual Range Organics	4	1.4	3.0	1.4
VOCs	Acetone		39		39
	Benzene		0.62		0.62
	n-Butylbenzene		0.33		0.33
	Sec-Butylbenzene		0.26		0.26
	Carbon Disulfide		0.0012		0.0012
	Chlorobenzene		0.098		0.098
	1,2-Dichlorobenzene		0.24		0.24
	1,4-Dichlorobenzene		0.029		0.029
	1,1-Dichloroethane		0.0046		0.0046
	Cis-1,2-Dichloroethene		150		150
	Trans-1,2-Dichloroethene		1.9		1.9
	Ethylbenzene		12		12
	Isopropylbenzene (Cumene)		0.97		0.97
	p-Isopropyltoluene		0.3		0.3
	Naphthalene		0.59		0.59
	n-Propylbenzene		1.2		1.2
	Styrene		0.022		0.022
	Tert-Butylbenzene		0.019		0.019
	Tetrachloroethene		0.1		0.1
	Toluene		19		19
	Trichloroethene		0.48		0.48
	1,2,4-Trimethylbenzene		11		11
	1,3,5-Trimethylbenzene		4.7		4.7
	Vinyl Chloride		22		22
	m,p-Xylene		52		52
	o-Xylene		31		31

Table includes all parameters modeled in the study. U = undetected analyte.

Table 5. Predicted equilibrium surface sediment chemical concentrations due to groundwater and erosional loading

Group	Parameter	Surface Sediment Concentration (mg/kg)				Organic Carbon Normalized Surface Sediment Concentration (mg/kg TOC)				Sediment Management Standards (mg/kg)		Sediment Management Standards (mg/kg TOC)	
		Current Conditions		Terminal 117 Remediated		Current Conditions		Terminal 117 Remediated					
		Upstream Background	Site	Upstream Background	Site	Upstream Background	Site	Upstream Background	Site	SQS	CSL	SQS	CSL
Metals	Arsenic	7.2	17	6.9	17					57	93	--	--
	Cadmium	0.29	0.39	0.26	0.36					5.1	6.7	--	--
	Chromium	17	32	16	31					260	270	--	--
	Copper	46	85	40	78					390	390	--	--
	Lead	20	59	15	54					450	530	--	--
	Mercury	0.12	0.29	0.097	0.27					0.41	0.59	--	--
	Silver	0.06	0.78	0.054	0.78					6.1	6.1	--	--
	Zinc	75	120	68	110					410	960	--	--
PCBs	PCB-Aroclor 1248	0.016	0.04	0.013	0.038					--	--	--	--
	PCB-Aroclor 1254	0.2	0.25	0.13	0.19					--	--	--	--
	PCB-Aroclor 1260	0.092	1.3	0.07	1.2					--	--	--	--
	Total PCBs	0.3	1.6	0.21	1.4	**15**	**80**	11	**72**	--	--	12	65
Pesticides	2,4'-DDD	0.0058	0.049	0.0044	0.048					--	--	--	--
	2,4'-DDT	0.017	0.064	0.012	0.059					--	--	--	--
	4,4'-DDD	0.0043	0.0037	0.0036	0.003					--	--	--	--
	4,4'-DDE	0.005	0.007	0.0043	0.0063					--	--	--	--
	4,4'-DDT	0.025	0.18	0.018	0.18					--	--	--	--
	Aldrin	0.072	0.12	0.061	0.11					--	--	--	--
	Dieldrin	0.0032	0.003	0.0029	0.0027					--	--	--	--
	Heptachlor	0.0019	0.002	0.0017	0.0018					--	--	--	--
SVOCs	Acenaphthene	0.013	0.016	0.01	0.013	0.67	0.82	0.51	0.67	--	--	16	57
	Anthracene	0.019	0.048	0.015	0.045	0.97	2.5	0.77	2.3	--	--	220	1200
	Benzo(a)anthracene	0.033	0.11	0.028	0.11	1.7	5.6	1.4	5.6	--	--	110	270
	Benzo(a)pyrene	0.036	0.12	0.03	0.11	1.8	6.2	1.5	5.6	--	--	99	210
	Benzo(b)fluoranthene	0.052	0.2	0.045	0.19	4	13.9	3.4	13.4	--	--	230	450
	Benzo(k)fluoranthene	0.026	0.076	0.021	0.072								
	Benzo(ghi)perylene	0.033	0.095	0.028	0.089	1.7	4.9	1.4	4.6	--	--	31	78
	Benzoic Acid	0.83	0.57	0.76	0.5					0.65	0.65	--	--
	Benzyl Alcohol	0.058	0.13	0.048	0.12					0.057	0.73	--	--
	Bis(2-Ethylhexyl) Phthalate	0.21	0.25	0.19	0.23	11	13	9.7	12	--	--	47	78
	Butylbenzylphthalate	0.05	0.45	0.044	0.44	2.6	**23**	2.3	**23**	--	--	4.9	64
	Chrysene	0.043	0.2	0.036	0.19	2.2	10	1.8	9.7	--	--	110	460
	Dibenzo(a,h)anthracene	0.02	0.032	0.016	0.029	1	1.6	0.82	1.5	--	--	12	33
	Dibenzofuran	0.017	0.015	0.014	0.012	0.87	0.77	0.72	0.62	--	--	15	58
	1,2-Dichlorobenzene	0.02	0.028	0.017	0.025	1	1.4	0.87	1.3	--	--	2.3	2.3
	Dimethylphthalate	0.1	0.2	0.082	0.18	5.1	10	4.2	9.2	--	--	53	53
	Di-N-Butylphthalate	0.051	0.067	0.042	0.059	2.6	3.4	2.2	3	--	--	220	1700
	Di-N-Octyl Phthalate	0.081	0.028	0.077	0.025	4.2	1.4	3.9	1.3	--	--	58	4500
	Fluoranthene	0.061	0.23	0.055	0.23	3.1	12	2.8	12	--	--	160	1200
	Fluorene	0.013	0.02	0.011	0.018	0.67	1	0.56	0.92	--	--	23	79
	Indeno(1,2,3-cd)pyrene	0.033	0.11	0.027	0.1	1.7	5.6	1.4	5.1	--	--	34	88
	2-Methylnaphthalene	0.042	0.047	0.034	0.039	2.2	2.4	1.7	2	--	--	38	64
	2-Methylphenol	0.032	0.024	0.031	0.023					0.063	0.063	--	--
	4-Methylphenol	0.12	0.021	0.12	0.018					0.67	0.67	--	--

Table 5. Predicted equilibrium surface sediment chemical concentrations due to groundwater and erosional loading

Group	Parameter	Surface Sediment Concentration (mg/kg)				Organic Carbon Normalized Surface Sediment Concentration (mg/kg TOC)				Sediment Management Standards (mg/kg)		Sediment Management Standards (mg/kg TOC)	
		Current Conditions		Terminal 117 Remediated		Current Conditions		Terminal 117 Remediated					
		Upstream Background	Site	Upstream Background	Site	Upstream Background	Site	Upstream Background	Site	SQS	CSL	SQS	CSL
SVOCs	Naphthalene	0.02	0.026	0.0097	0.016	1	1.3	0.5	0.82	--	--	99	170
	Pentachlorophenol	0.16	0.29	0.16	0.29					0.36	0.69	--	--
	Phenanthrene	0.044	0.12	0.038	0.12	2.3	6.2	1.9	6.2	--	--	100	480
	Phenol	0.056	0.06	0.045	0.05					0.42	1.2	--	--
	Pyrene	0.056	0.2	0.05	0.2	2.9	10	2.6	10	--	--	1000	1400
	Total cPAHs	0.16	0.16	0.12	0.12					--	--	--	--
TPH	Gasoline Range Organics	11	31	7.5	27					--	--	--	--
	Diesel Range Organics	95	190	68	160					--	--	--	--
	Residual Range Organics	250	780	180	710					--	--	--	--
VOCs	Benzene	0.000037	0.000037	0.000024	0.000024					--	--	--	--
	1,2-Dichlorobenzene	0.0064	0.0002	0.0063	0.00013					--	--	--	--
	1,4-Dichlorobenzene	0.0028	0.000025	0.0028	0.000016					--	--	--	--
	Ethylbenzene	0.0038	0.0038	0.0025	0.0025					--	--	--	--
	Naphthalene	0.00022	0.00022	0.00014	0.00014					--	--	--	--
	Styrene	0.0000048	0.0000048	0.0000031	0.0000031					--	--	--	--
	Toluene	0.0026	0.0026	0.0017	0.0017					--	--	--	--
	Trichloroethene	0.000039	0.000039	0.0000029	0.0000029					--	--	--	--
	1,2,4-Trimethylbenzene	0.0088	0.0088	0.000076	0.000076					--	--	--	--
	1,3,5-Trimethylbenzene	0.0088	0.0088	0.000076	0.000076					--	--	--	--
	Vinyl Chloride	0.00081	0.00081	0.00052	0.00052					--	--	--	--
	m,p-Xylene	0.033	0.033	0.021	0.021					--	--	--	--
	o-Xylene	0.033	0.033	0.021	0.021					--	--	--	--

Table includes all parameters modeled in the study.
VOC concentrations do not include background values.
Bold text are data that exceeded SMS (SQS or CSL) values.

Table 6. Predicted equilibrium surface sediment chemical concentrations due to groundwater loading only

Group	Parameter	Surface Sediment Concentration (mg/kg)				Organic Carbon Normalized Surface Sediment Concentration (mg/kg TOC)				Sediment Management Standards (mg/kg)		Sediment Management Standards (mg/kg TOC)	
		Current Conditions		Terminal 117 Remediated		Current Conditions		Terminal 117 Remediated					
		Upstream Background	Site	Upstream Background	Site	Upstream Background	Site	Upstream Background	Site	SQS	CSL	SQS	CSL
Metals	Arsenic	6	16	6	16					57	93	--	--
	Cadmium	0.15	0.26	0.15	0.26					5.1	6.7	--	--
	Chromium	13	27	13	27					260	270	--	--
	Copper	16	55	16	55					390	390	--	--
	Lead	5.2	44	5.2	44					450	530	--	--
	Mercury	0.057	0.23	0.057	0.23					0.41	0.59	--	--
	Silver	0.03	0.75	0.03	0.75					6.1	6.1	--	--
	Zinc	49	94	49	94					410	960	--	--
PCBs	PCB-Aroclor 1248	0.0084	0.033	0.0084	0.033					--	--	--	--
	PCB-Aroclor 1254	0.073	0.13	0.048	0.1					--	--	--	--
	PCB-Aroclor 1260	0.0086	1.2	0.0065	1.2					--	--	--	--
	Total PCBs	0.084	1.3	0.057	1.2	4.3	**67**	2.9	**62**	--	--	12	65
Pesticides	2,4'-DDD	0.002	0.046	0.002	0.046					--	--	--	--
	2,4'-DDT	0.002	0.049	0.002	0.049					--	--	--	--
	4,4'-DDD	0.0021	0.0015	0.0021	0.0015					--	--	--	--
	4,4'-DDE	0.0014	0.0034	0.0014	0.0034					--	--	--	--
	4,4'-DDT	0.0021	0.16	0.002	0.16					--	--	--	--
	Aldrin	0.0051	0.05	0.0037	0.048					--	--	--	--
	Dieldrin	0.002	0.0018	0.002	0.0018					--	--	--	--
	Heptachlor	0.0012	0.0014	0.0012	0.0014					--	--	--	--
SVOCs	Acenaphthene	0.0024	0.0056	0.0024	0.0055	0.12	0.29	0.12	0.28	--	--	16	57
	Anthracene	0.0031	0.033	0.0031	0.033	0.16	1.7	0.16	1.7	--	--	220	1200
	Benzo(a)anthracene	0.013	0.091	0.013	0.091	0.67	4.7	0.67	4.7	--	--	110	270
	Benzo(a)pyrene	0.013	0.097	0.013	0.097	0.67	5	0.67	5	--	--	99	210
	Benzo(b)fluoranthene	0.021	0.17	0.021	0.17	1.4	12	1.4	12	--	--	230	450
	Benzo(k)fluoranthene	0.0071	0.058	0.0071	0.058								
	Benzo(ghi)perylene	0.011	0.072	0.011	0.072	0.56	3.7	0.56	3.7	--	--	31	78
	Benzoic Acid	0.55	0.29	0.55	0.28					0.65	0.65	--	--
	Benzyl Alcohol	0.012	0.087	0.012	0.087					0.057	0.73	--	--
	Bis(2-Ethylhexyl) Phthalate	0.12	0.16	0.12	0.16	6.2	8.2	6.2	8.2	--	--	47	78
	Butylbenzylphthalate	0.025	0.43	0.025	0.43	1.3	22	1.3	22	--	--	4.9	64
	Chrysene	0.017	0.18	0.017	0.18	0.87	9.2	0.87	9.2	--	--	110	460
	Dibenzo(a,h)anthracene	0.005	0.018	0.005	0.018	0.26	0.92	0.26	0.92	--	--	12	33
	Dibenzofuran	0.0063	0.0047	0.0063	0.0047	0.32	0.24	0.32	0.24	--	--	15	58
	1,2-Dichlorobenzene	0.0063	0.014	0.0062	0.014	0.32	0.72	0.32	0.72	--	--	2.3	2.3
	Dimethylphthalate	0.0036	0.1	0.0036	0.1	0.18	5.1	0.18	5.1	--	--	53	53
	Di-N-Butylphthalate	0.015	0.031	0.014	0.031	0.77	1.6	0.72	1.6	--	--	220	1700
	Di-N-Octyl Phthalate	0.066	0.014	0.066	0.014	3.4	0.72	3.4	0.72	--	--	58	4500
	Fluoranthene	0.034	0.21	0.034	0.21	1.7	11	1.7	11	--	--	160	1200
	Fluorene	0.0017	0.009	0.0016	0.009	0.087	0.46	0.082	0.46	--	--	23	79
	Indeno(1,2,3-cd)pyrene	0.0094	0.082	0.0094	0.082	0.48	4.2	0.48	4.2	--	--	34	88
	2-Methylnaphthalene	0.0027	0.0077	0.0025	0.0074	0.14	0.39	0.13	0.38	--	--	38	64
	2-Methylphenol	0.01	0.0023	0.01	0.0023					0.063	0.063	--	--
	4-Methylphenol	0.11	0.0073	0.11	0.0071					0.67	0.67	--	--

Table 6. Predicted equilibrium surface sediment chemical concentrations due to groundwater loading only

Group	Parameter	Surface Sediment Concentration (mg/kg)				Organic Carbon Normalized Surface Sediment Concentration (mg/kg TOC)				Sediment Management Standards (mg/kg)		Sediment Management Standards (mg/kg TOC)	
		Current Conditions		Terminal 117 Remediated		Current Conditions		Terminal 117 Remediated					
		Upstream Background	Site	Upstream Background	Site	Upstream Background	Site	Upstream Background	Site	SQS	CSL	SQS	CSL
SVOCs	Naphthalene	0.0097	0.016	0.0025	0.0086	0.5	0.82	0.13	0.44	--	--	99	170
	Pentachlorophenol	0.012	0.14	0.043	0.17					0.36	0.69	--	--
	Phenanthrene	0.014	0.092	0.014	0.092	0.72	4.7	0.72	4.7	--	--	100	480
	Phenol	0.013	0.017	0.013	0.017					0.42	1.2	--	--
	Pyrene	0.028	0.18	0.028	0.18	1.4	9.2	1.4	9.2	--	--	1000	1400
	Total cPAHs	0.086	0.7	0.086	0.7					--	--	--	--
TPH	Gasoline Range Organics	--	20	--	20					--	--	--	--
	Diesel Range Organics	--	93	--	93					--	--	--	--
	Residual Range Organics	--	530	--	530					--	--	--	--
VOCs	Benzene	0.000037	0.000037	0.000024	0.000024					--	--	--	--
	1,2-Dichlorobenzene	0.0064	0.0002	0.0063	0.00013					--	--	--	--
	1,4-Dichlorobenzene	0.0028	0.000025	0.0028	0.000016					--	--	--	--
	Ethylbenzene	0.0038	0.0038	0.0025	0.0025					--	--	--	--
	Naphthalene	0.00022	0.00022	0.00014	0.00014					--	--	--	--
	Styrene	0.0000048	0.0000048	0.0000031	0.0000031					--	--	--	--
	Toluene	0.0026	0.0026	0.0017	0.0017					--	--	--	--
	Trichloroethene	0.000039	0.000039	0.0000029	0.0000029					--	--	--	--
	1,2,4-Trimethylbenzene	0.0088	0.0088	0.000076	0.000076					--	--	--	--
	1,3,5-Trimethylbenzene	0.0088	0.0088	0.000076	0.000076					--	--	--	--
	Vinyl Chloride	0.00081	0.00081	0.00052	0.00052					--	--	--	--
	m,p-Xylene	0.033	0.033	0.021	0.021					--	--	--	--
	o-Xylene	0.033	0.033	0.021	0.021					--	--	--	--

Table includes all parameters modeled in the study.
VOC concentrations do not include background values.
Bold text are data that exceeded SMS (SQS or CSL) values.
All results are in mg/kg, except those that have been organic carbon normalized.

Attachment

Attachment 1: Example of RECOVERY input parameters for Aroclor 1254

Water		
Initial concentration of chemical	4.5×10^{-5}	µg/L
External loadings	223	g/yr
Water surface area	1166	m^2
Water depth	3.05	m
Flow-through	1.04×10^{8}	m^3/yr
Residence time	3.4×10^{-5}*	yr
Sediment		
Contaminated sediment depth	1	m
Depth of mixed layer	0.1	m
Mixed layer surface area	1166	m^2
Initial concentration – mixed layer	0.059	mg/kg
Initial concentration – deep contaminated sediments	0.059	mg/kg
System Properties		
Suspended solids concentration in water	31	mg/L
Mixed sediment porosity	0.8	
Deep sediment porosity	0.5	
Mixed sediment particle specific gravity	2.36	g/cm^3
Deep sediment particle specific gravity	2.36	g/cm^3
Wind speed	0.001	m/sec
Weight fraction carbon in solid – suspended	0.0195	
Weight fraction carbon in solid – mixed layer	0.02	
Weight fraction carbon in solid – deep	0.02	
Resuspension velocity	0.001	m/yr
Burial velocity	0.03	m/yr
Settling velocity	472*	m/yr
Enhanced diffusion	0	cm^2/sec
Enhanced mixing depth	0	cm
Chemical Properties		
Molecular diffusivity	5×10^{-6}	cm^2/sec
Decay coefficients – dissolved contaminant:		
water	0	1/yr
mixed layer	0	1/yr
deep sediments	0	1/yr
Decay coefficients – particulate contaminant:		
water	0	1/yr
mixed layer	0	1/yr
deep sediments	0	1/yr
Henry's constant	0.0083	atm-m^3/gmole
Molecular weight	328	g/mole
Organic carbon-water partition coefficient (K_{oc})	75600†	L/kg
Octanol-water partition coefficient (K_{ow})	91750‡	(mg/m^3 octanol)/(mg/m^3 water)

Notes:

* values calculated by RECOVERY program

† K_{oc} "best estimate" data developed with Ecology (SAIC 2006)

‡ log K_{ow} = [(log K_{oc} – 0.00028) / 0.983], (DiToro 1985), where K_{oc} = "best estimate" data (SAIC 2006)