Duwamish Diagonal Sediment Remediation Project: 2011 and 2012 Monitoring Report

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King County

Department of Natural Resources and Parks
Water and Land Resources Division
Science and Technical Support Section
King Street Center, KSC-NR-0600
201 South Jackson Street, Suite 600
Seattle, WA 98104
206-477-4800 TTY Relay: 711
www.kingcounty.gov/EnvironmentalScience

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Prepared for:

King County Wastewater Treatment Division
Department of Natural Resources and Parks

Submitted by:

Jenée Colton
King County Water and Land Resources Division
Department of Natural Resources and Parks

King County
Department of
Natural Resources and Parks
Water and Land Resources Division

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EXECUTIVE SUMMARY

Between November 2003 and March 2004, the Elliott Bay/Duwamish Restoration Program (EBDRP) implemented the Duwamish/Diagonal Sediment Remediation Project in the vicinity of the Duwamish/Diagonal combined sewer overflow/storm drain (CSO/SD). This project involved dredging contaminated sediment and placing engineered caps in two areas to isolate the remaining contamination. Due to elevated residual PCB contamination around the caps after dredging, King County placed clean sand as an enhanced natural recovery (ENR) remediation method in a 4-acre area during February 2005. King County monitored the caps, ENR area and surrounding sediments to document changing chemistry and the stability of the caps and ENR area. Although monitoring to fulfill the original minimum monitoring plan requirements of a five-year period was completed in 2010, King County continued sediment chemistry monitoring in 2011 and 2012. This report presents results of the 2011 and 2012 annual monitoring events for the Duwamish/Diagonal CSO/SD sediment remediation project.

Sediment samples were collected in 2011 and 2012 from a total of 23 stations in four monitoring areas at the Duwamish/Diagonal site: Sediment Cap Area A, Sediment Cap Area B, the ENR Area, and from perimeter stations outside the cap and ENR areas. Samples were collected from all stations previously sampled except for Station 2C in the Perimeter Area in 2012 because of a lack of access. Samples were analyzed for conventional parameters, metals and trace organics. The specific analytes were selected to allow comparison of sediment data to the Washington State Sediment Management Standards (SMS) marine benthic chemical criteria. All analytical data were reviewed and found to meet quality assurance/quality control objectives.

In Cap Area A, concentrations of nine chemicals exceeded SMS in 2011 and one chemical exceeded SMS in 2012. None of the chemical concentrations measured at Cap Area B stations exceeded SMS in 2011. Three chemicals exceeded SMS at three stations in 2012. Transient exceedances of the SMS observed in 2011 at Station 1A are consistent with historical monitoring at this station which is located near the Diagonal Way CSO/SD outfall. Dynamic year-to-year changes in sediment chemistry and physical characteristics are expected to occur at this station due to the influence of discharges from the outfall. Exceedances observed at other Cap Area stations were limited in extent to four chemicals: bis(2-ethylhexyl)phthalate (BEHP), benzoic acid, pentachlorophenol and phenol. BEHP is ubiquitous and often seen as a background contaminant. Benzoic acid has natural sources and phenols have been previously observed at the site as transient contaminants (EBDRP 2015). Concentrations continue to be consistently below the SMS at all ENR Area stations except for several PAHs and total HPAH at Station 6C in 2012. PAH exceedances of SMS Sediment Quality Standards (SQS) at station 6C are unexplained at this point. However, given the sporadic history of other chemical exceedances at this station (EBDRP 2015), the 2012 exceedances are expected to be transient. Although still exceeding the SMS SQS, OC-normalized PCB concentrations have continued to decline at Station 8C in the Perimeter Area. At some other Perimeter Area stations, PCBs increased in 2011 (8C and 9C) and 2012 (8C-10C, 13C) to above the SMS SQS, sometimes exceeding the Cleanup Screening Level

(CSL). Seven other contaminants exceeded the SMS in the Perimeter Area in 2012, including BEHP.

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1.0 INTRODUCTION

This report presents results of the 2011 and 2012 annual monitoring events for the Duwamish/Diagonal Combined Sewer Overflow (CSO)/Storm Drain (SD) sediment remediation project. The report includes a project background, sampling and analytical methodologies, and results of sediment chemistry analyses. The fifth year of monitoring the Enhanced Natural Remediation (ENR) area occurred in 2010 and represented the last year of the 5-year minimum monitoring requirement. King County conducted the 2011 and 2012 monitoring voluntarily to supplement the monitoring data collected under the Duwamish/Diagonal Sediment Remediation Project to lengthen this continuous time series on remedy performance in the Lower Duwamish Waterway. Sampling methods employed for these events remained consistent with those contained in the Duwamish/Diagonal Sediment Remediation Dredging and Capping Operations Sediment Monitoring Sampling and Analysis Plan (SAP) (King County 2003) except for a reduction in number of grab samples per composite for perimeter samples from ten to three in 2010 (EBDRP 2015)..

This section provides project background and the station sampling history of the project. Section 2.0 includes summaries of sample collection and analytical methods, laboratory quality assurance and quality control (QA/QC) review, and deviations from the Sampling and Analysis Plan (SAP). The results of the 2011 and 2012 monitoring activities are presented in Section 3.0 and Section 4.0 provides a report summary. Appendices to the report include the King County Environmental Laboratory Quality Assurance review package, complete sediment chemistry results and data validation reports of the chemistry data.

1.1 Project Background

Between November 2003 and March 2004, the Elliott Bay/Duwamish Restoration Program (EBDRP) implemented the Duwamish/Diagonal Sediment Remediation Project in the vicinity of the Duwamish/Diagonal CSO/SD (Figure 1). The Closure Report (EBDRP 2005) describes dredging, transport, disposal, and capping methods employed for the 2003/2004 project, the objective of which was to remediate contaminated sediment within a 7-acre area immediately adjacent to the Duwamish/Diagonal CSO/SD and the old Duwamish Treatment Plant outfall (denoted in EBDRP 2005 as Areas A and B, respectively). The 2003/2004 project included removal of a minimum of three to an average of five feet of contaminated sediments from Areas A and B from November 2003 to January 2004 and placement of an effective capping layer during January-February 2004, to isolate remaining chemicals from the environment and return the site to approximately the bottom elevations that existed prior to dredging. Baseline, post-construction sediment chemistry samples were collected from eight stations on the cap in Areas A and B in June 2004. These stations are shown on Figure 1 as 1A–5A and 1B–3B.

Sediment dredging residuals are defined as contaminated sediments found at the post-dredging surface of the sediment profile, either within or around the dredging footprint

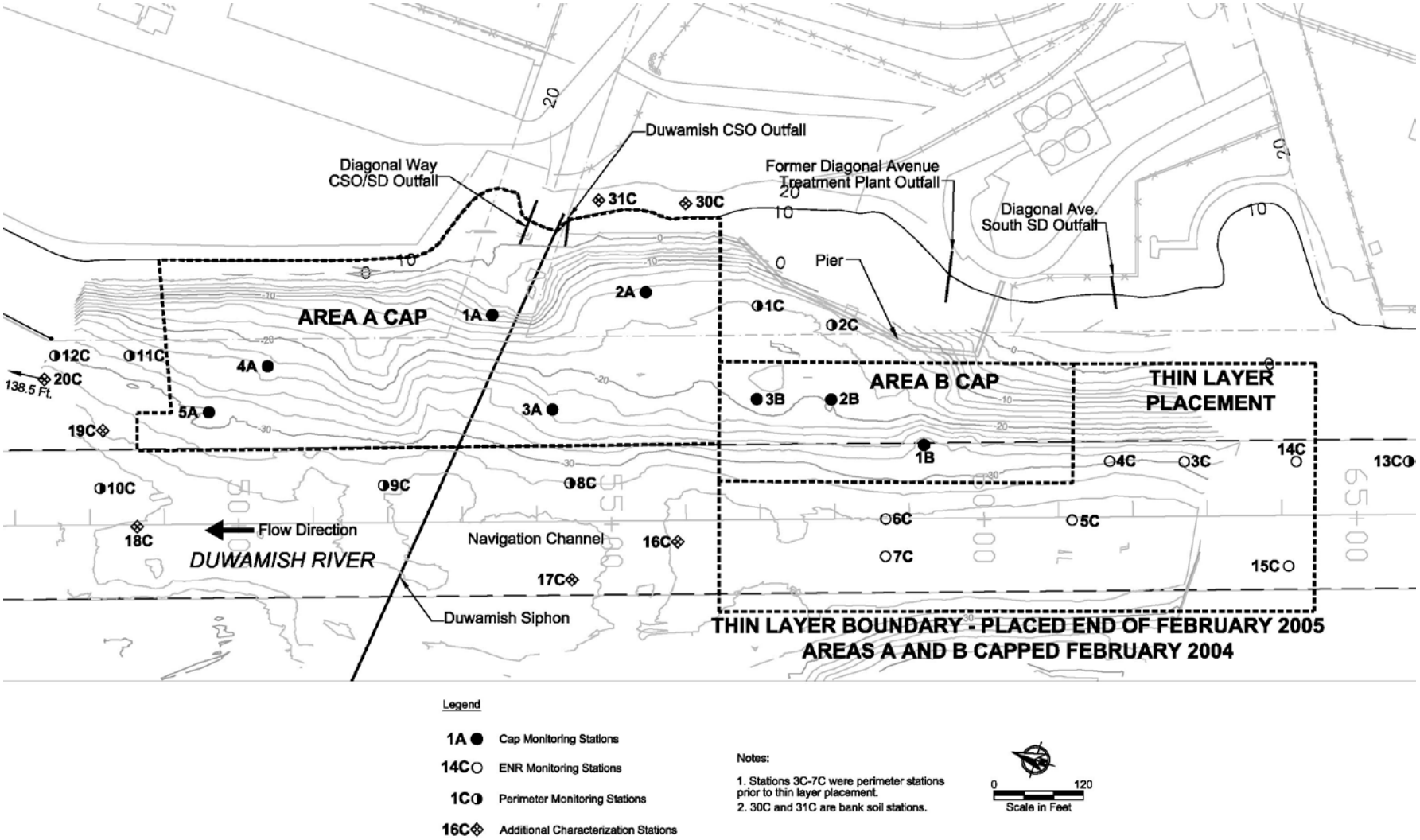


Figure 1. Duwamish Diagonal Site and Monitoring Stations

(Bridges et al. 2008). Some form of dredging residuals could be expected to occur at most sediment cleanup sites; however, the magnitude of release varies widely between projects based on a range of site-specific and operational factors (Desrosiers et al. 2005, EPA 2005, NRC 2007). Both the Washington State Department of Ecology (Ecology) and the United States Environmental Protection Agency (EPA) required King County to monitor for movement of dredging residuals beyond the site boundary by measuring the pre-construction and post-construction sediment chemistry at 12 perimeter stations outside the 2003/2004 dredging/capping project boundary, that had first been sampled in October 2003 prior to dredging (EBDRP 2005). These stations are shown in Figure 1 as 1C–12C.

Analysis of the March 2004 sampling data from the perimeter stations revealed that 2003/2004 project dredging activities had increased surface sediment concentrations of polychlorinated biphenyls (PCBs) around the margin of Area B to a higher degree than dredging residuals adjacent to Area A (Figure 2). The occurrence of a greater amount of dredging residuals near Area B was consistent with the contractor's initial operations in this area that did not consistently apply required best management practices (BMPs) to minimize spread of dredging residuals. As a result, King County examined six prospective remedial actions to reduce elevated PCB levels caused by the dredging residuals. After consultation with Ecology and EPA, King County selected the thin layer placement remedy, also known as Enhanced Natural Recovery (ENR), as the best way to reduce the elevated PCB levels within the 4-acre dredge residual area around Area B in the most expedient manner possible.

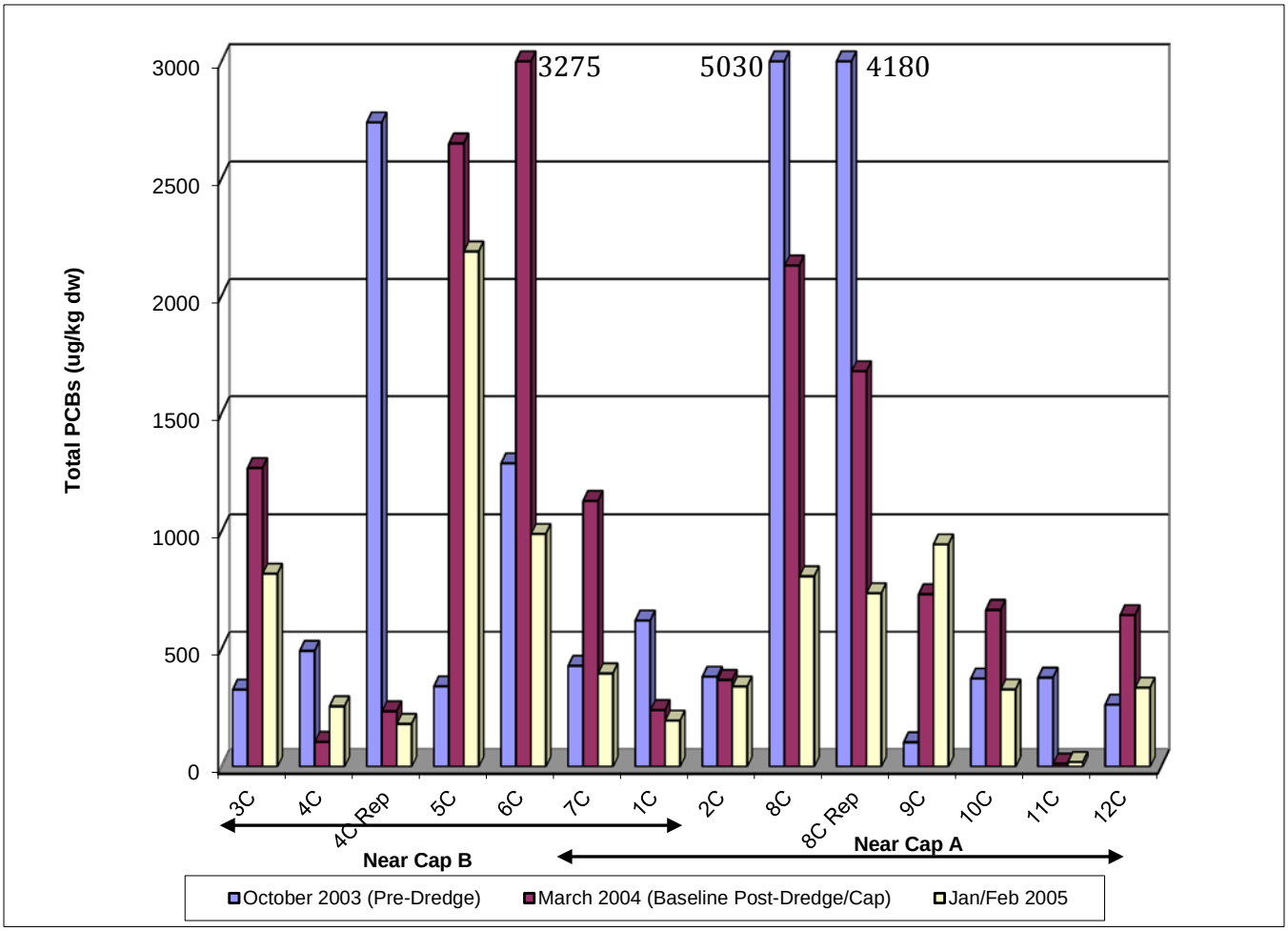


Figure 2. Changes in PCB Concentrations at Duwamish Diagonal Perimeter Stations (2003–2005)

The thin layer placement remedy involved the placement of clean sand material to a minimum thickness of six inches over a 4-acre area (Figure 1) of dredging residuals to immediately reduce exposure to elevated PCB levels and accelerate the natural recovery timeframe in this area. To ensure the minimum thickness of six inches, the design called for placing 7,100 tons of sand, which would yield an average thickness of nine inches, to help ensure that the entire 4-acre ENR area would receive at least six inches of cover material. Over time, the natural process of bioturbation is expected to mix clean sediment into underlying sediment containing PCBs. Monitoring continued to be performed to document the effectiveness of the thin-layer placement and bioturbation process and to compare it to natural recovery rates in the area surrounding Area A, which had significantly lower dredge residuals.

Placement of the ENR sand occurred between February 19 and 25, 2005. Samples were collected for Year 2005 monitoring in January, prior to placement including Perimeter Stations 1C–12C. Additional stations were added to this sampling to improve the general characterization of the area post remediation at EPA's request (13C–20C and bank stations 30C–31C – see Figure 1). Baseline sediment chemistry samples were then collected from

seven stations within the ENR area in March 2005, five of which were the pre-existing stations 3C–7C and two of which were new stations added for spatial coverage (14C–15C). The major project events are presented through 2007 on a timeline in Figure 3. Annual monitoring continued through 2012.

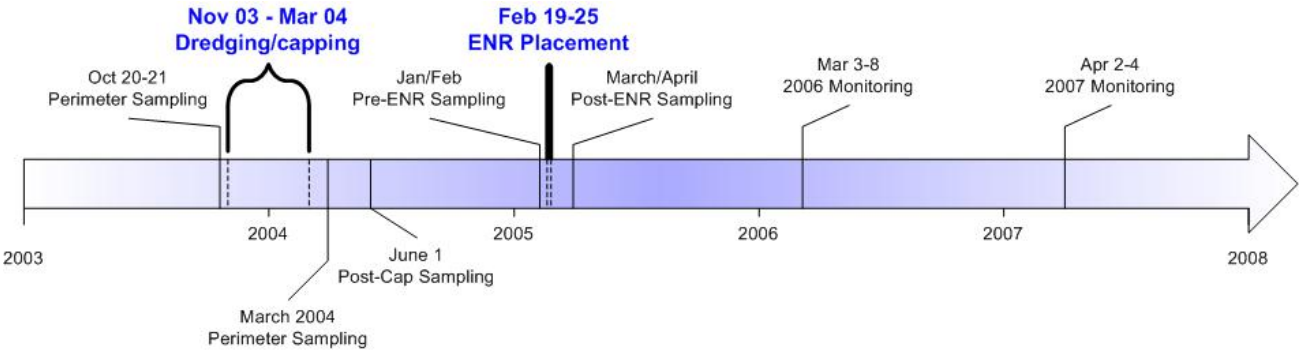


Figure 3. Duwamish Diagonal Project Timeline

Sediment monitoring requirements for the Duwamish/Diagonal Sediment Remediation Project are described in the initial SAP (King County 2003) as well as the SAP addendum prepared to cover monitoring activities for the ENR area (King County 2004). The baseline post-capping data were presented in the Duwamish/Diagonal CSO/SD Sediment Remediation Project Closure Report (EBDRP 2005), the 2005 Monitoring Report (EBDRP 2007) and the 4-Acre Residuals Interim Action Closure Report (King County 2007). Annual monitoring data have been presented in various reports available for download[1] (King County 2007, King County and Anchor Environmental 2008, King County 2010). Although monitoring to fulfill the original minimum monitoring plan requirements of a five-year period was completed in 2010, King County continued monitoring in 2011 and 2012.

1.2 Stations Sampled During the 2011/2012 Monitoring Events

Sediment samples were collected March 28 and 29, 2011, and March 28 and April 4, 2012, from a total of 23 stations in four monitoring areas at the Duwamish/Diagonal site: Sediment Cap Area A, Sediment Cap Area B, the Enhanced Natural Recovery (ENR) Area, and from perimeter stations outside the areas of remediation and ENR. Figure 1 presents the locations of the 23 monitoring stations described in the following sections.

1.2.1 Sediment Cap Area A

Samples were collected from five stations in Sediment Cap Area A in 2011 and 2012, which represents Year Seven and Year Eight of post-construction monitoring, respectively. Table 1 provides a station list and history of sample collection dates.

[1] Project website:
http://www.kingcounty.gov/environment/wastewater/SedimentManagement/Projects/DuDi/Library.aspx

Table 1. Sample Dates for Sediment Cap Area A Stations

Station	2004 – Baseline	2005 – Year 1	2006 – Year 2	2007 – Year 3	2008 – Year 4	2009 – Year 5	2010 – Year 6 [a]	2011 – Year 7[a]	2012 – Year 8 [a]
DUD_1A	6/1	4/27	3/7	4/3	3/24	4/28	3/29	3/28	3/28
DUD_2A	6/1	4/27	3/7	4/3	3/24	4/28	3/29	3/28	3/28
DUD_3A	--	4/27	3/7	4/3	3/24	4/28	3/29	3/28	3/28
DUD_4A	6/1	4/27	3/7	4/3	3/24	4/28	3/29	3/28	3/28
DUD_5A	6/1	4/27	3/7	4/3	3/24	4/28	3/29	3/28	3/28

[a] Sampling beyond Year 5 was not required in the project SAP but was collected to facilitate comparisons with the ENR area.

A baseline sediment sample was not collected from Station DUD_3A in 2004 because only coarse gravel was found during repeated attempts to sample this location; thereby precluding the ability to run sediment chemistry analyses.

1.2.2 Sediment Cap Area B

Samples were collected from three stations in Sediment Cap Area B in 2011 and 2012, which also represent Year Seven and Year Eight of post-construction monitoring, respectively. Table 2 provides a station list and history of sample collection dates.

Table 2. Sample Dates for Sediment Cap Area B Stations

Station	2004 – Baseline	2005 – Year 1	2006 – Year 2	2007 – Year 3	2008 – Year 4	2009 – Year 5	2010 – Year 6 [a]	2011 – Year 7 [a]	2012 – Year 8 [a]
DUD_1B	6/1	4/27	3/7	4/3	3/24	4/27	3/29	3/28	3/28
DUD_2B	6/1	8/17	3/7	4/3	3/24	4/27	3/29	3/28	4/4
DUD_3B	6/1	--	3/7	4/3	3/24	4/27	3/29	3/28	4/4

[a] Sampling beyond Year 5 was not required in the project SAP but was collected to facilitate comparisons with the ENR area.
Note: Coarse gravel at 2B required repeated sampling in Year One with success in August 2005

A Year One sediment sample was not collected from Station DUD_3B in 2005 because only coarse gravel was found during repeated attempts to sample this location; thereby precluding the ability to run sediment chemistry analyses.

1.2.3 Enhanced Natural Recovery (ENR) Area

Samples were collected from seven stations in the ENR Area in 2011 and 2012, which represent Year Six and Year Seven of post-construction monitoring for the thin-layer placement, respectively. Table 3 provides a station list and history of sample collection dates.

Table 3. Sample Dates for ENR Stations

Station	2005 – Baseline	2006 – Year 1	2007 – Year 2	2008 – Year 3	2009 – Year 4	2010 – Year 5	2011 – Year 6 [a]	2012 – Year 7 [a]
DUD_3C	3/16	3/10	4/03	3/25	4/28	3/30	3/28	3/28
DUD_4C	3/16	3/10	4/03	3/25	4/28	3/30	3/29	3/28
DUD_5C	3/24	3/10	4/03	3/25	4/28	3/30	3/29	3/28
DUD_6C	3/24	3/10	4/03	3/25	4/28	3/30	3/29	3/28
DUD_7C	3/24	3/10	4/04	3/25	4/28	3/30	3/29	3/28
DUD_14C	3/16	3/10	4/04	3/25	4/28	3/30	3/29	3/28
DUD_15C	3/16	3/10	4/04	3/25	4/28	3/30	3/29	3/28

[a] Sampling beyond Year 5 was not required in the project SAP but was collected to facilitate comparisons with the cap and perimeter areas.

1.2.4 Perimeter Stations

Samples were collected from eight perimeter stations in 2011 and seven perimeter stations in 2012, which represent Year Seven and Year Eight monitoring post-construction of the cap. These stations are all located outside of the remedial areas. Table 4 provides a station list and history of sample collection dates. Unlike the Cap and ENR monitoring stations, monitoring dates beginning prior to the remedial action are included in this table. Station DUD_13C was added to the monitoring program in 2005 to represent conditions upstream of the ENR Area.

Table 4. Sample Dates for Perimeter Stations

Station	2003 – Pre-Construc-tion	2004 – Base-line	2005 – Year 1	2006 – Year 2	2007 – Year 3	2008 – Year 4	2009 – Year 5	2010 – Year 6	2011 – Year 7 [a]	2012 – Year 8 [a]
DUD_1C	10/20	3/29	2/1	3/8	4/2	3/24	4/27	3/29	3/28	4/4
DUD_2C	10/20	3/29	1/31	3/8	4/2	3/24	4/27	3/29	3/28	--
DUD_8C	10/21	3/30	2/1	3/8	4/2	3/24	4/28	3/29	3/28	3/28
DUD_9C	10/21	3/30	1/31	3/8	4/2	3/24	4/29	3/29	3/28	3/28
DUD_10C	10/21	3/30	2/1	3/8	4/2	3/24	4/29	3/29	3/28	3/28
DUD_11C	10/21	3/30	2/1	3/9	4/2	3/25	4/29	3/29	3/28	3/28
DUD_12C	10/21	3/30	2/2	3/9	4/2	3/25	4/29	3/29	3/29	3/28
DUD_13C	--	--	2/2	3/9	4/4	3/25	4/29	3/29	3/29	3/28

[a] Sampling beyond Year 6 (Year 5 post-ENR) was not required in the project SAP but was collected to facilitate comparisons with the cap and ENR areas.
Note: A sample could not be collected at 2C in 2012 because a large barge was parked over the station and could not be moved to allow access.

1.3 Sample Collection

This section describes the methods employed to collect representative sediment samples from the Duwamish/Diagonal sediment remediation site and analyze them for sediment chemistry parameters. A discussion of laboratory QA/QC review and deviations from the SAP are also presented.

Including field replicates, 26 samples were collected in 2011 and 25 samples in 2012 from the locations discussed in Section 1.2. One field replicate sample was collected from each of Cap Area B, the ENR Area, and the Perimeter Area in each year. All sample collection followed methods in the project SAP, which are consistent with protocols outlined in the Puget Sound Estuary Program's (PSEP) Puget Sound Protocols (PSEP 1997, 1998). The sample collection and handling methods are summarized below and details can be found in the project SAP and SAP addendum (King County 2003, 2004).

1.3.1 Station Positioning

Sediment grab samples were collected from King County's research vessel *Liberty*, which is equipped with a differential global positioning system (DGPS). Field coordinates were recorded using DGPS for each sediment grab as the sampler contacted the sediment bed. Coordinates for each grab deployment are shown in Appendix A with a comparison to the prescribed study coordinates.

1.3.2 Sample Collection and Handling

Sediment was obtained using two modified, stainless steel, 0.1 m^2 Van Veen grab samplers deployed in tandem from King County's research vessel *Liberty*. A single deployment of the tandem Van Veen grab samplers was considered "two grabs" when both of the grabs returned an acceptable sample. Three grabs were composited for each sample from the ENR Area and Cap Areas A and B as specified in the SAP. In the Perimeter Area, three grabs were composited for each sample in accordance with a change in method that began in 2010. The number of composites was reduced from ten to three to avoid sampling of subsurface sediments. A summary of the number of grabs obtained at each station is provided in Appendix A. The details of sample collection are summarized below and described in Appendix A.

Sediment chemistry samples targeted the top 10 cm of sediment and required a minimum grab penetration depth of 11 cm to ensure that sediment touching the sides of the grab sampler was not collected. This was not always possible given the substrate in the sediment cap and ENR areas. When penetration depth was less than 10 cm, sediment was sampled to a depth of 1 cm from the bottom of the grab. Penetration depth was determined by measuring the depth of sediment within each grab by sliding a ruler vertically along the inside of the sampler's side wall after each successful cast. Penetration depths, recorded as "Sample Depth" (see Appendix A), indicate that the minimum required depth was not recovered for all samples to return a 0- to 10-cm depth stratum sample.

Undisturbed sediments in the grab were collected with a stainless steel spoon and then placed in a stainless steel bowl for homogenization. Prior to homogenization, collected sediment was stored covered with aluminum foil in coolers between grab deployments. After thorough homogenization, sediment aliquots were transferred to appropriate laboratory containers.

Head space was left in all sediment chemistry sample containers to allow further mixing at the laboratory and for expansion should the containers be stored frozen. All sample containers were stored in insulated, ice-filled coolers while in the field.

The grab samplers were decontaminated between sampling stations by scrubbing with a brush and Detergent 8 (a phosphate-free soap) followed by a thorough *in situ* rinsing. A separate pre-cleaned stainless steel bowl and spoon were dedicated to each sampling station, precluding the need for decontamination of this equipment in the field.

While in the field, all samples were under direct possession and control of King County field staff. For chain of custody (COC) purposes, the research vessel was considered a "controlled area." Each day, all sample information was recorded on a COC form. This form was completed in the field and accompanied all samples during transport and delivery to the laboratory each day. Upon arrival at the King County Environmental Laboratory (KCEL), the sample delivery person relinquished all samples to the sample login person. The date and time of sample delivery was recorded and both parties then signed off in the appropriate sections on the COC form. Once completed, original COC forms were archived in the project file. Copies of all completed COC forms are included in Appendix A.

1.4 Laboratory Analyses

Sediment chemistry analyses were selected to allow comparison of sediment data to the lowest of the SMS marine benthic chemical criteria, found in Table I of Chapter 173-204-320 WAC (Ecology 2013). Other chemicals of interest (chlorinated pesticides and additional metals), total organic carbon and sediment grain size were analyzed as well. A complete list of all parameters analyzed along with their respective detection limits is included in Appendix A. All laboratory analyses were performed by the KCEL. The following subsections summarize the analyses performed as well as QA/QC analyses.

1.4.1 Conventionals

Conventional analyses included percent solids, total organic carbon (TOC), and particle size distribution (PSD). Percent solids and TOC analyses were performed to provide data necessary to normalize sediment data to dry weight and organic carbon, respectively. Percent solids analysis was performed according to Standard Method (SM) 2540-G (APHA 1998), which is a gravimetric determination. TOC analysis was performed following EPA Method 9060 (EPA 1995), high-temperature combustion with infrared spectroscopy. PSD analysis was performed according to ASTM Method D422 (ASTM 2002), which is a combination of sieve and hydrometer analyses.

1.4.2 Metals

Metal analytes included aluminum, antimony, arsenic, beryllium, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, selenium, silver, thallium, and zinc. With the exception of mercury, all metal analyses were performed following EPA Method 3050B/6010C (EPA 2000); strong-acid digestion with inductively coupled plasma optical

emission spectroscopy (ICP-OES). Mercury was analyzed according to EPA Method 7471B (EPA 2007), cold vapor atomic absorption spectroscopy (CVAA).

1.4.3 Trace Organics

Trace organic analytes included base/neutral/acid extractable semivolatile compounds (BNAs), chlorinated pesticides, and polychlorinated biphenyls (PCBs) as Aroclors. BNA analysis was performed following EPA Method 8270D (EPA 2007), gas chromatography with mass spectroscopy (GC/MS). Chlorinated pesticides and PCBs were analyzed by EPA Method 8081B/8082A (EPA 2007), gas chromatography with electron capture detection (GC/ECD).

Beginning with the 2011 sample analysis, KCEL modified their extraction methods for EPA Method 8081B/8082A to improve chemical interference and accuracy of quantification. The extraction solvents were switched from methylene chloride and acetone to hexane and acetone. In addition, starting with the 2012 sample analysis, the chromatogram peaks used for quantitation were changed to eliminate potential for double-counting Aroclors that have overlapping peaks (e.g., Aroclor 1254 and 1260) and improve accuracy. An automated software program was also introduced in 2012 to improve quantitation consistency. To test for impacts from the extraction change, KCEL conducted independent analyses of samples and laboratory standard reference material (SRM) using the different extraction solvents. The results indicated that the change to hexane/acetone may result in slightly higher (~5%) total Aroclor concentrations. KCEL also re-quantitated the 2012 Diagonal sediment Aroclors using the quantitation method applied in previous monitoring years. Comparing total Aroclor values calculated from old versus new quantitation methods for 2012 Diagonal samples, the quantitation changes did not make a substantive difference. This conclusion is supported by the relative percent differences which ranged from +/- 0.2 to -15.6 (n=25) but most were within +/- 2.0. All but one RPD were within +/- 7.7. Considering the QC acceptance limit for PCBs in Diagonal sediment duplicates is 35% (EBDRP 2005), these RPDs are well below the acceptable analytical variability. Overall, these Aroclor method extraction and quantitation changes are not expected to make a meaningful difference in the interpretation of PCB results over time.

1.5 Quality Assurance/Quality Control Review

KCEL reviewed the 2011 and 2012 analytical data by comparing the results to reference method and SAP requirements and flagging with laboratory data qualifiers where appropriate. Chemistry data were reviewed by the laboratory quality assurance officer following QA1 guidelines (PTI 1989) and flagged with data qualifiers where appropriate. Data validation was conducted by Water and Land Resources Division Science Unit staff. This data validation review has been based, in part, on guidance found in *USEPA Contract Laboratory Program National Functional Guidelines for Superfund Organic Methods Data Review* (EPA 2008) and *USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Superfund Data Review* (EPA 2010). For the conventionals, metals, mercury, and organics validation, data anomaly forms, batch reports and analytical quality control (QC) reports were reviewed. The following QC parameters were also reviewed: holding

time, method blanks, spike blanks and duplicates, matrix spikes and duplicates, standard reference materials, laboratory replicates and surrogates.

Laboratory QA/QC practices produced chemistry data sufficient to pass QA1 review and data validation. QA1 review narratives are presented as Appendix A and data validation reports are in Appendix B. The main QA issue is method blank contamination for benzoic acid and bis(2-ethylhexyl)phthalate (BEHP) affecting select 2012 samples. All method blanks run with 2011 samples contained target analytes at less than the MDL indicating there were no blank contamination issues. Several 2012 samples were requalified during data validation as non-detect due to benzoic acid in associated method blanks. In addition, one sample was requalified as nondetect due to blank contamination with BEHP.

1.6 Deviations from Sampling Plan

There were no deviations to the SAP or SAP addendum (King County 2003, King County 2004) for sediment sampling in 2011 with one exception described below. During the sampling event in 2012, KCEL discovered two barges parked over four monitoring stations: 1C, 2C, 2B and 3B. King County contacted Island Tug and Barge and requested that the barges be moved to allow access for sampling. The smaller of the two barges was completely moved and the second, larger barge was shifted to allow access to three of the four stations. Because the large barge could not be completely moved without assistance from a tug boat and Island Tug and Barge had no plans for this to occur in the near future, sampling at 2C was not completed in 2012. A reduction in the grabs collected per composite at the perimeter stations (from 10 to 3 grabs) was implemented in 2010. This change was continued during the 2011 and 2012 sampling events.

2.0 DUWAMISH DIAGONAL SEDIMENT SAMPLING RESULTS FOR 2011 AND 2012

This section summarizes the results of the chemistry analyses for 2011 and 2012 monitoring samples for sediment Cap Areas A and B (Years 7 and 8 post-cap), the Perimeter Area (Years 7 and 8 post-cap) and the ENR (Years 6 and 7 post-thin layer placement). The complete analytical results can be found in Appendix C. Results are first summarized for all analytes by area and compared to marine benthic Sediment Management Standards (SMS) (Ecology 2013). Specifically, contaminant concentrations in surface sediments were compared to numerical chemical values of the SMS: the sediment quality standards (SQS) and the cleanup screening levels (CSL) (WAC 173-204-320 and WAC 173-204-562, respectively). Field duplicates were averaged before comparison to SMS. SMS rules were followed in the calculation of sums and handling of undetected results.

2.1 Sediment Cap Area A

The analytical chemistry results, including TOC, for the five stations in Cap Area A sampled in 2011 and 2012 can be found in Tables 5 and 6, respectively, located at the end of this section. The results are normalized to dry weight (dw) or organic carbon (OC) as appropriate for comparison to SMS marine benthic criteria. Concentrations of nine chemicals in 2011 and one chemical in 2012 exceeded SMS in two samples as discussed below.

In 2011, bis(2-ethylhexyl)phthalate (BEHP) exceeded SMS at two stations:1A and 4A. The OC-normalized BEHP concentration at 4A exceeded the SQS. The TOC content of the 1A sample was 4.3%, above the 3.0% upper end of the recommended maximum for comparison to OC-normalized standards. Therefore, at 1A the dry-weight concentrations of chemicals with OC-normalized SMS criteria were compared to the dry-weight lowest apparent effects threshold (LAET) and 2LAET; these are equivalent to the SQS and CSL SMS standards, respectively. The dry-weight BEHP concentration at 1A exceeded both the SQS and the CSL. An additional eight chemicals exceeded SMS at 1A. Dry-weight concentrations of total PCBs, phenanthrene, total LPAHs, chrysene, and butylbenzylphthalate (BBP) exceeded the SQS and fluoranthene, pyrene and total HPAHs concentrations exceeded the SQS and CSL at 1A. In 2012, dry-weight concentrations of phenol exceeded the SQS at 2A and 3A. No other chemicals exceeded SQS or CSL in Cap Area A that year.

Relative grain size composition changes were compared across the 2010, 2011, and 2012 samplings (Figure 4). Overall, substantial shifts in categorical relative grain sizes were not observed during the 2010 to 2012 period except at 1A and 4A. While in 2011, 1A showed a decrease in proportion of sand with corresponding increases in the percent gravel by about 20% and increase in total fines by about 15%, the grain size composition at 1A returned in

2012 to a similar pattern as seen in 2010. At 4A, the proportion of sand decreased about 40% while relative total fines increased compared to 2010. However, in contrast to 1A, relative grain sizes did not appreciably change at 4A between 2011 and 2012. The changes in relative grain size composition at stations 2A, 3A, and 5A were small and may reflect method and/or natural deposition variability. Generally, relative grain size at these stations appears consistent.

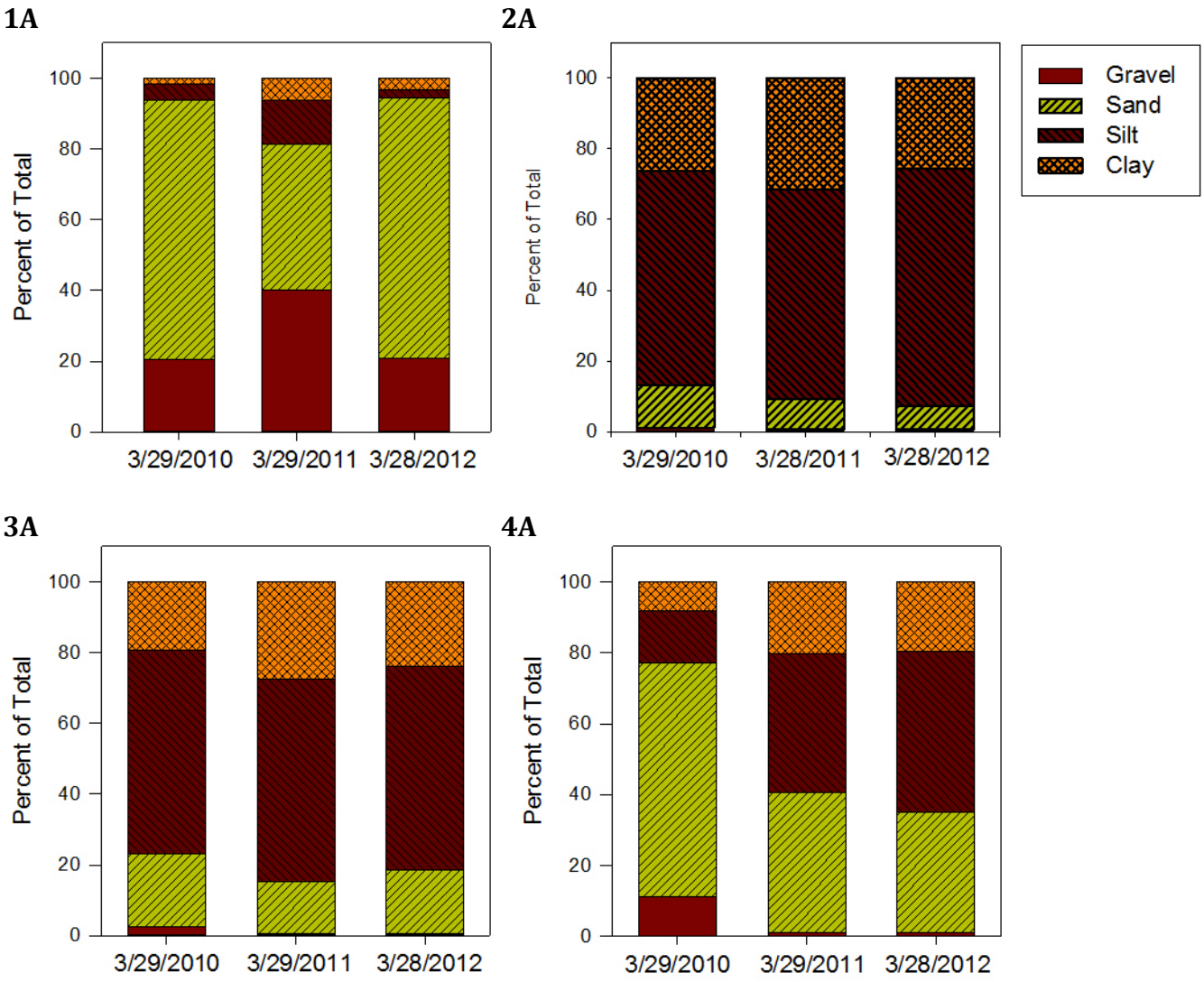


Figure 4. Changes in Grain Size on Cap A

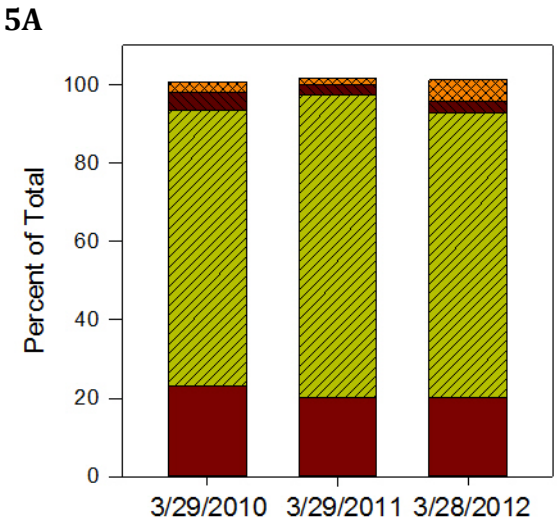


Figure 4 (cont.) Changes in Grain Size on Cap A

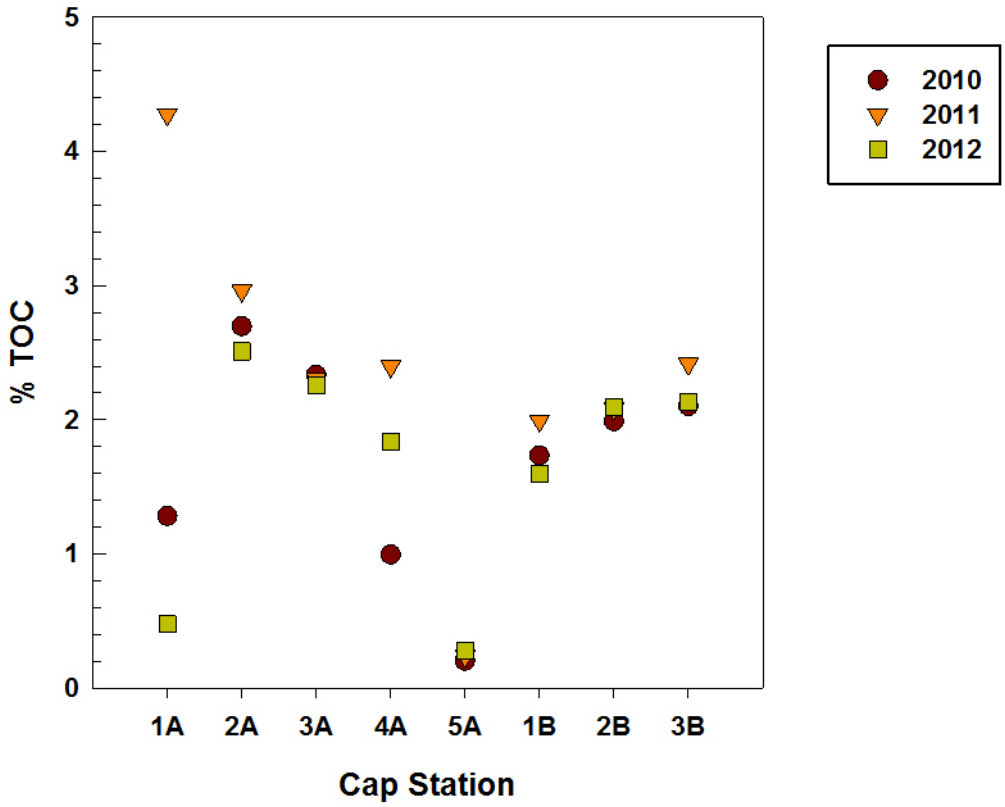


Figure 5. Percent TOC in Cap Areas A and B Samples, 2010–2012

TOC content in Cap Area A ranged from 0.2 to 4.3% in 2011 and 0.3 to 2.5% in 2012 (Figure 5). TOC composition was consistent from 2010 through 2012 at 2A, 3A, and 5A. At 1A and 4A, TOC composition increased substantially in 2011 compared to 2010. At 1A, which is located in front of the Diagonal Way combined sewer overflow (CSO)/storm drain

(SD), TOC increased to 4.3% in 2011, higher than any other station sampled that year. TOC decreased to less than 0.5% at 1A in 2012. Smaller changes were measured in TOC at 4A; TOC rose from about 1.0% to 2.4% in 2011 and declined to1.8% in 2012. The more dynamic changes in TOC at 1A are consistent with the variable flows associated with areas in front of outfalls.

2.2 Sediment Cap Area B

The analytical chemistry results, including TOC, for the three stations in Cap Area B sampled in 2011 and 2012 can be found in Tables 5 and 6, respectively. The results are normalized to dry weight (dw) or organic carbon (OC) as appropriate for comparison to SMS. None of the chemistry results in Cap Area B exceeded SMS in 2011. Concentrations of three chemicals exceeded SMS in one or more samples collected in 2012.

Dry weight concentrations of phenol exceeded the SQS at all three Cap Area B stations in 2012. In addition, pentachlorophenol was measured above SQS at 2B. Dry weight benzoic acid concentrations exceeded both the SQS and CSL (which are the same value) at 2B and 3B.

Small changes in relative grain size occurred from 2010 to 2012 (Figure 6). The proportion of fines at 1B increased by about 15% in 2011 over 2010 and then decreased in 2012 to an intermediate percentage. These changes in fines were reflected by commensurate changes in sand fractions with no impact on gravel fractions. A similar increase in fines from 2010 to 2011 was observed at 3B. Smaller changes occurred between 2011 and 2012 at this station. Small changes were also observed in all grain size categories from 2010 to 2012 at 2B.

TOC measurements in all Cap B samples ranged from 2.0 to 2.4% in 2011 and 1.6 to 2.1% in 2012. Little change occurred in relative TOC between 2010 and 2012 (see Figure 5).

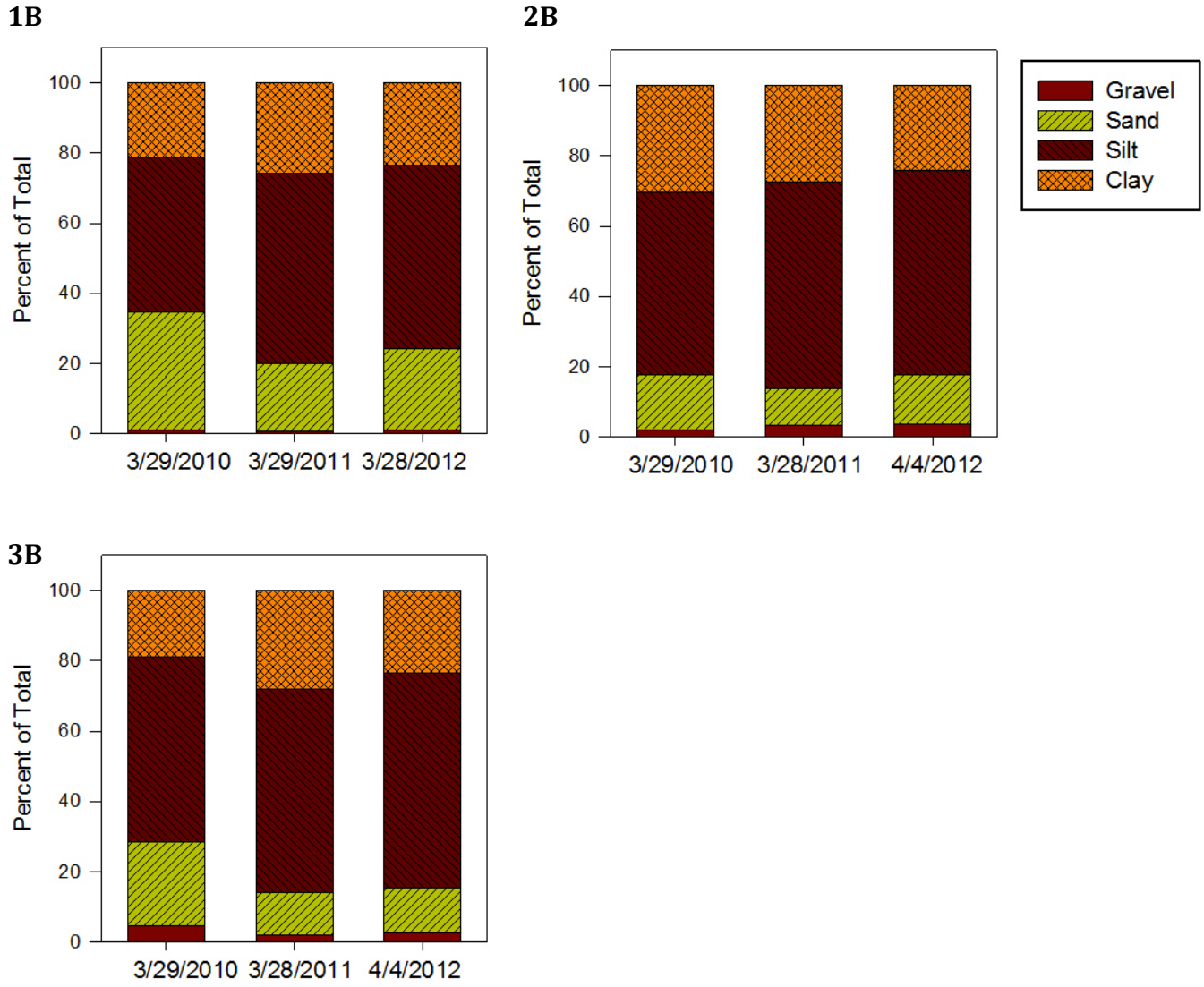


Figure 6. Changes in Grain Size on Cap B

2.3 Enhanced Natural Recovery Area

The analytical chemistry results, including TOC, for the seven stations in the Enhanced Natural Recovery (ENR) Area sampled in 2011 and 2012 can be found in Tables 5 and 6, respectively. In 2011, none of the chemicals measured in ENR Area samples exceeded SMS. In 2012, several PAHs exceeded SMS at 6C but for all other ENR Area stations, none of the chemicals measured in samples exceeded SMS. At 6C, one LPAH and six HPAHs exceeded SQS in addition to total HPAH. Large changes in grain size were not observed in 2012 (see discussion below) that would indicate a large scale disturbance near this station. This fact combined with the lack of previous chemical exceedances at this station indicates elevated PAHs at this station are unusual and may be transient.

Grain size changes over time varied considerably across ENR area stations, except at 5C. Similarities in overall composition are shared between 14C and 15C (Figure 7). At 6C or 7C, no substantial inter-annual changes in overall grain size composition were observed between 2010 and 2012. Substantial changes were observed in 2011 at four ENR stations: 3C, 4C, 14C and 15C. At 3C, 14C, and 15C, relative fines increased by approximately 20% from 2010 to 2011. In contrast, coarse grains became more prominent at 4C in 2011 compared to 2010. This trend continued at 4C in 2012 with coarse grains increasing to over 90 percent of sediments. However, at the other three stations (3C, 14C, and 15C), relative fines decreased, returning to 2010 levels at 14C and 15C.

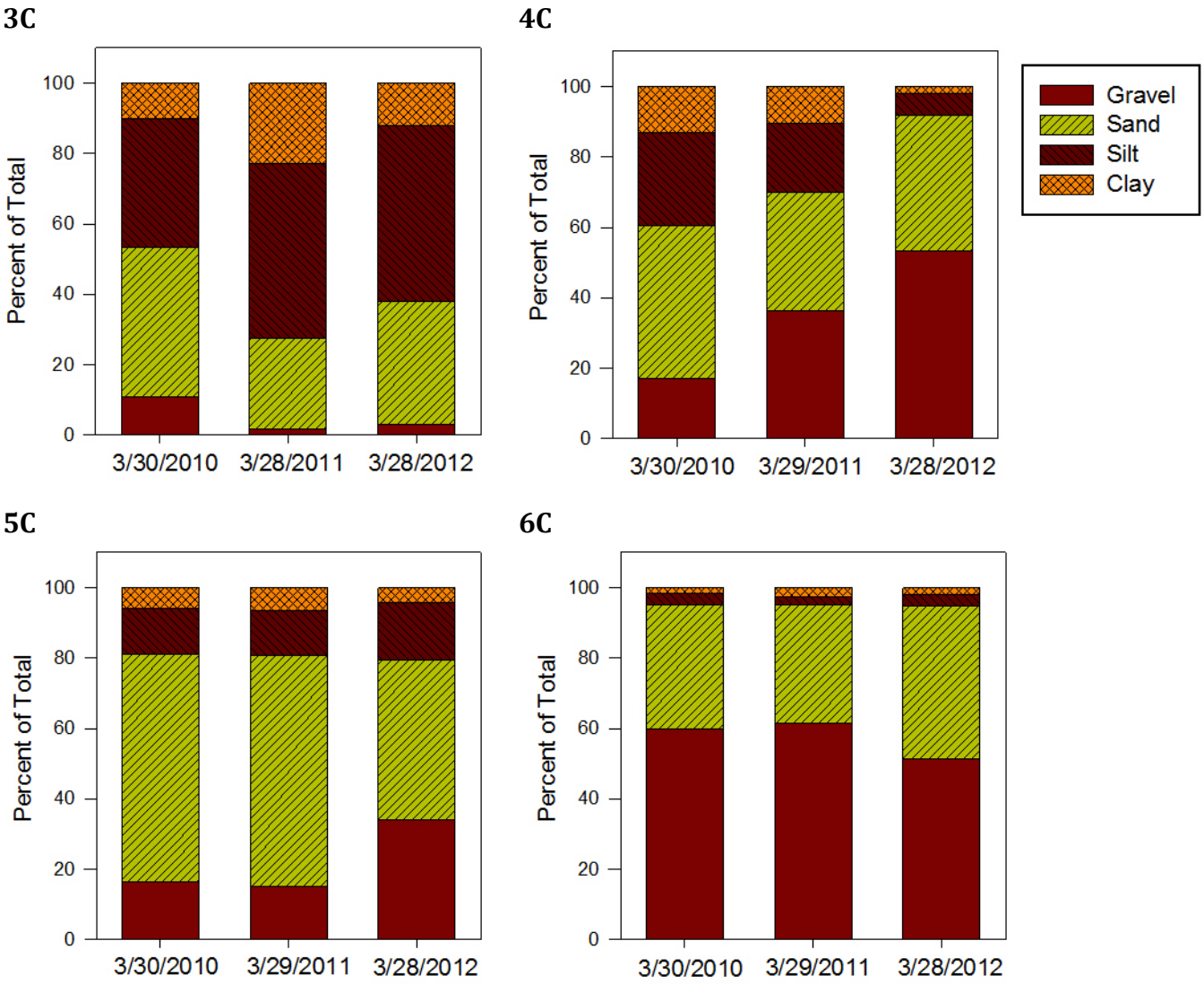


Figure 7. Changes in Grain Size at ENR Stations (Thin Layer Placement)

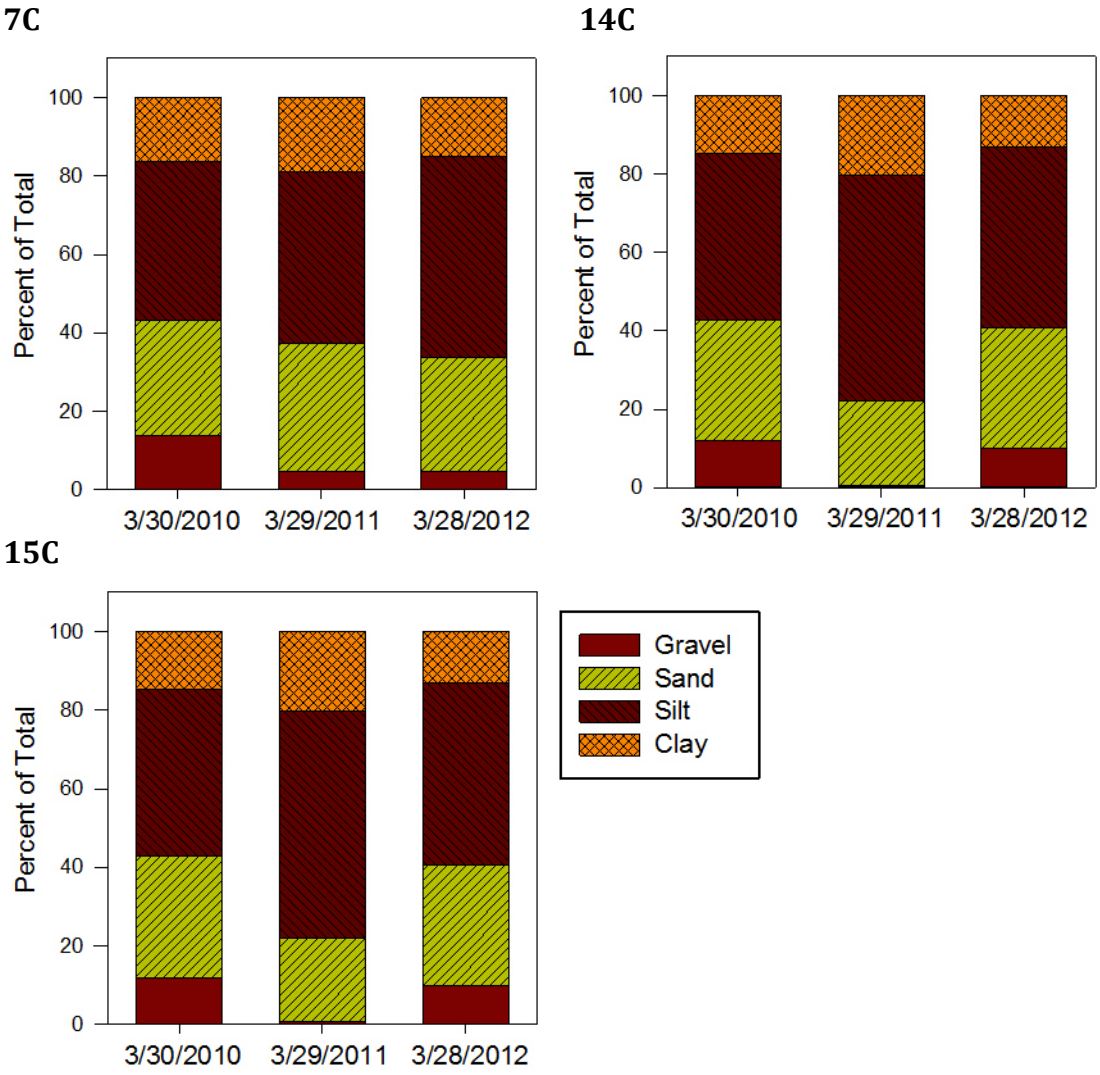


Figure 7 (cont.) Changes in Grain Size at ENR Stations (Thin Layer Placement)

TOC measurements in ENR area samples ranged from 0.2% to 1.9% in 2011 and from 0.6% to 2.3% in 2012. Relative TOC was fairly consistent between 2010 and 2012 with inter-annual differences of less than 0.5% (Figure 8).

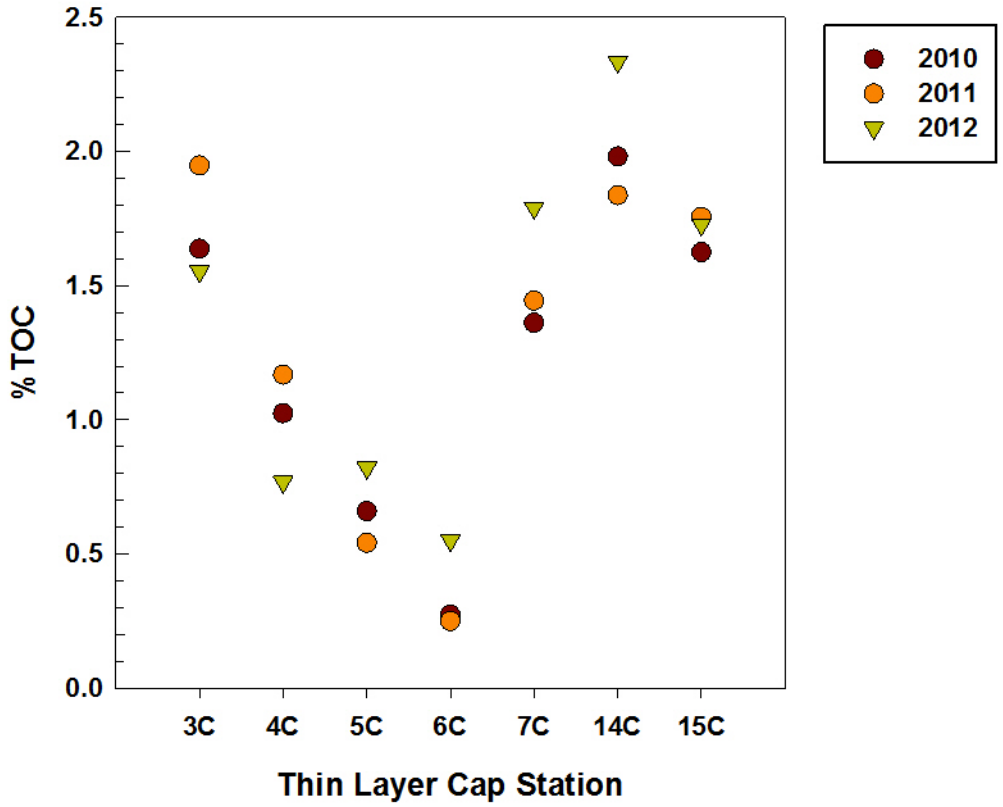


Figure 8. Percent TOC in ENR Area Samples, 2010–2012

2.4 Perimeter Area

The analytical chemistry results for the eight stations sampled in 2011 and seven stations sampled in 2012 in the Perimeter Area can be found in Tables 5 and 6, respectively. The results are normalized to dry weight (dw) or organic carbon (OC) as appropriate for comparison to SMS. The concentrations of three chemicals in 2011 and six chemicals in 2012 exceeded the SMS as discussed below.

OC-normalized total PCB concentrations exceeded SQS at 8C and 9C in 2011. The total PCB concentration at 8C also exceeded the CSL. OC-normalized concentrations of BEHP at 1C, 8C, and 11C and BBP at 1C and 10C also exceeded the SQS in 2011.

In 2012, dry-weight mercury concentration at 8C exceeded both the SQS and CSL at 8C. OC-normalized total PCB concentrations exceeded the SQS at stations 8C, 10C and 13C. OC-normalized total PCB concentrations exceeded both the SQS and CSL at 9C. At station 8C, BEHP concentrations exceeded both the SQS and CSL. The average dry-weight concentrations of field duplicates exceeded the SQS for phenol at 1C. Both the SQS and CSL for benzoic acid (which are the same value) were exceeded by the average dry weight concentration of field duplicates at 1C. At 11C, the dry weight concentration of 4-

methylphenol exceeded both the SQS and CSL. It should be noted that method blank concentrations of benzoic acid were above the method detection limit.

Interannual variability in relative grain size was generally small to moderate at perimeter stations between 2010 and 2012 (Figure 9). Small changes were observed at 2C, 10C, 12C and 13C. At 8C, shifts to more gravel and less sand was observed between 2010 and 2012. The largest changes were measured at 9C and 11C. In 2011, the total coarse grains fell from >90% to <60% at 9C; total coarse sediments was just below 70% in 2012. At 11C, total fines increased by approximately the same amount in 2011 and 2012 resulting in >50% fines in 2012. Similar to grain size results in prior years, relative grain size at 13C most closely resembles 1C and 2C with low fractions of coarse sediments. Relative grain size composition appears to be similar at stations 9C and 10C with 11C similar to these stations in 2011 but changing in 2012to be more similar to 12C.

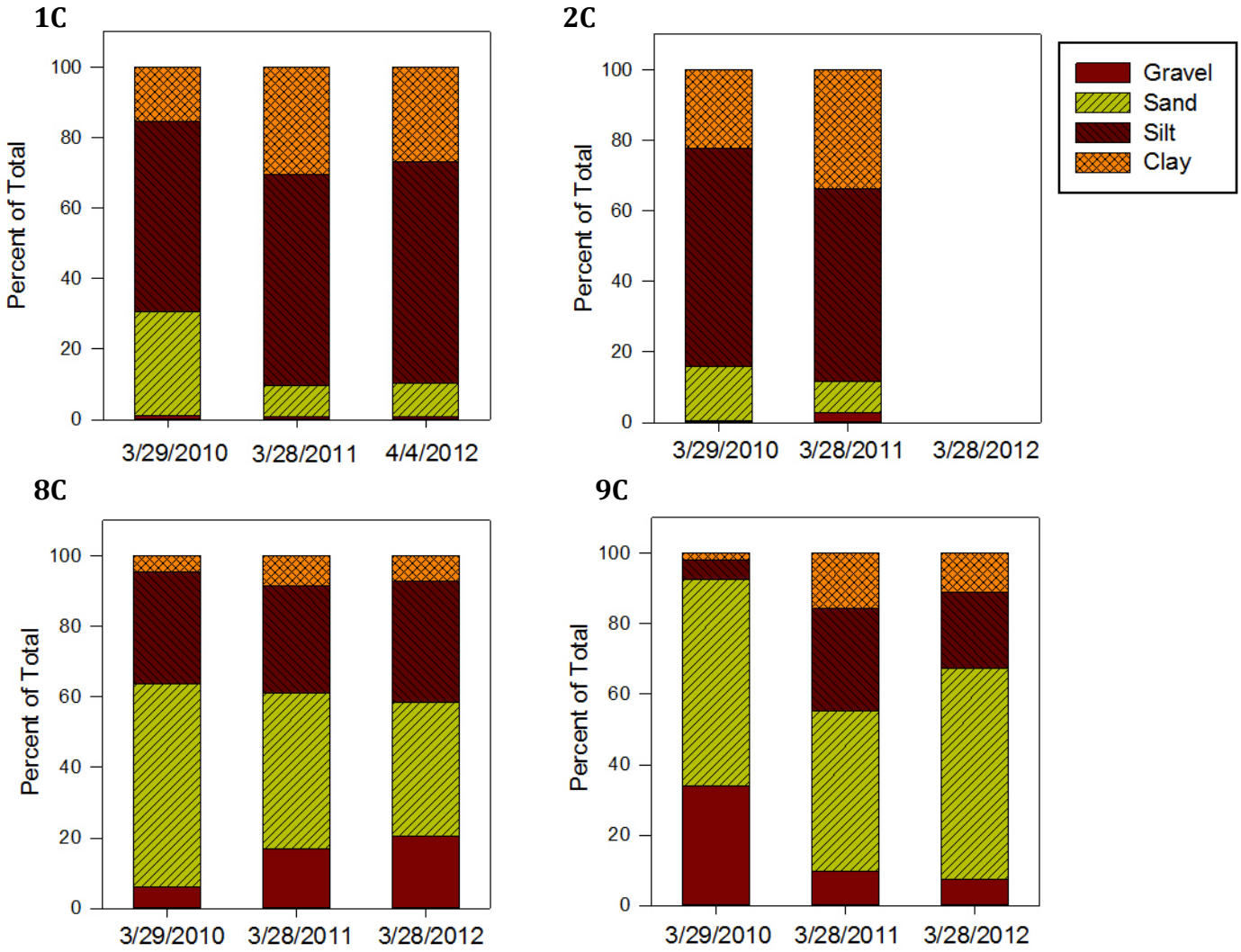
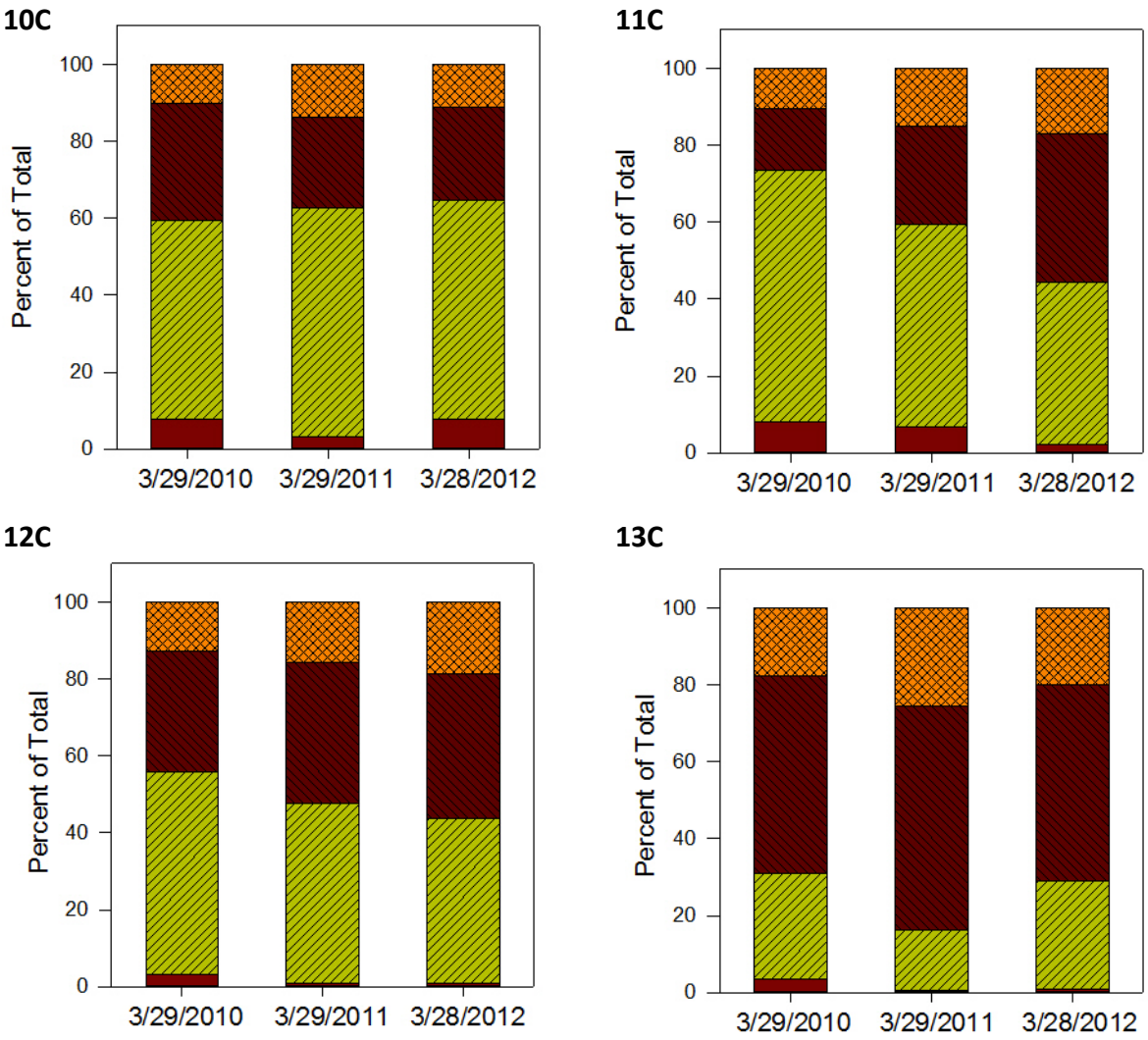


Figure 9. Changes in Grain Size at Perimeter Stations (1C, 2C, 8C–13C)



Note: Station 13C was not added until 2005

Figure 9 (continued). Changes in Grain Size at Perimeter Stations (1C, 2C, 8C–13C)

TOC composition ranged from 1.1% to 2.9% in 2011 and 0.8% to 2.7% in 2012 (Figure 10). TOC composition generally varied little (<0.5%) between 2010 and 2012 at all stations except 9C. At this station, TOC increased from 0.5% in 2010 to 1.3% in 2011 but declined again to 0.7% in 2012.

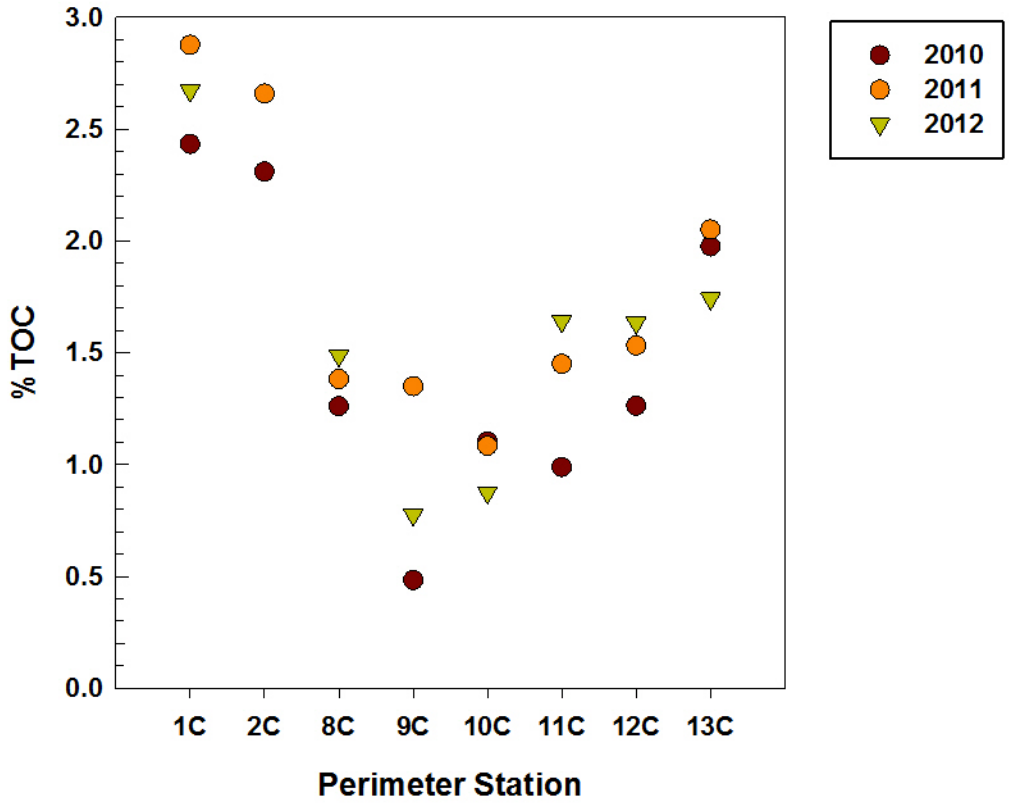


Figure 10. Percent TOC in Perimeter Area Samples, 2010–2012

Table 5. 2011 Sediment Chemistry Results – Comparison to SMS Marine Benthic Chemical Criteria

	SMS		Cap Area A					Cap Area B		
	SQS	CSL	DUD_1A	DUD_2A	DUD_3A	DUD_4A	DUD_5A	DUD_1B Avg	DUD_2B	DUD_3B
Conventionals (%)										
Total Solids	--	--	54.5	44.9	46.4	56.3	79.9	48.5	45.6	45.1
Total Organic Carbon	--	--	4.28	2.96	2.31	2.40	0.24	1.99	2.08	2.42
Metals (mg/kg)										
Arsenic	57	93	5.14 J	14.6	13.4 J	10.7 J	3.38 J	10.3 J	12.1 J	13.3 J
Cadmium	5.1	6.7	0.64 J	0.42 J	0.39 J	0.43 J	0.12 U	0.28 J	0.31 J	0.35 J
Chromium	260	270	29.0	33.2	33.0	36.1	16.8	29.7	30.3	30.6
Copper	390	390	69.4	75.3	74.6	73.9	44.3	60.2	64.0	67.6
Lead	450	530	36.3	35.4	34.1	58.3	6.92	24.0	26.8	30.6
Mercury	0.41	0.59	0.14 J	0.20 J	0.24 J	0.23 J	0.03 J	0.16 J	0.17 J	0.17 J
Silver	6.1	6.1	1.63 J	2.23 J	2.22	1.78 J	1.24 J	1.91 J	1.97 J	2.11 J
Zinc	410	960	200	147	134	155	43.6	102	116	120
PCBs (mg/kg-OC)										
Total PCBs	12	65	*3.10* *	6.82	1.23	3.63	*31.6*	5.63	7.00	8.07
LPAH (mg/kg-OC)										
2-Methylnaphthalene	38	64	*0.68*	0.40 U	0.50 U	0.39 U	*2.76 U*	0.55 U	0.56 U	0.49 U
Acenaphthene	16	57	*0.87*	0.40 U	0.50 U	0.39 U	*2.76 U*	0.55 U	0.56 U	0.49 U
Acenaphthylene	66	66	*2.24*	0.40 U	0.50 U	0.58 J	*2.76 U*	0.55 U	0.66 J	0.49 U
Anthracene	220	1200	*4.76*	2.73	2.60	2.52	*3.75 J*	1.95	3.15	3.53
Fluorene	23	79	*5.36*	0.75 J	0.63 J	0.81	*2.76 U*	0.65 J	1.05 J	1.36
Naphthalene	99	170	*0.55*	1.09	0.64 J	0.41 J	*2.76 U*	1.02 J	0.56 U	0.92 J
Phenanthrene	100	480	*110* *	4.77	5.79	7.63	*9.43*	4.32	7.40	6.55
Total LPAH	370	780	*124* *	9.34	9.64	11.9	*13.2*	7.69	12.3	12.4
HPAH (mg/kg-OC)										
Benzo(a)anthracene	110	270	*26.9*	7.05	7.62	8.30	*12.8*	5.36	8.53	7.24
Benzo(a)pyrene	99	210	*20.8*	7.11	9.09	9.33	*15.4*	6.52	10.0	8.07
Benzo(g,h,i)perylene	31	78	*13.2*	4.40	5.92	5.79	*11.5*	4.11	6.39	5.17
Chrysene	110	460	*57.5* *	11.3	11.1	11.5	*19.3*	9.12	13.5	12.8
Dibenzo(a,h)anthracene	12	33	*5.19*	1.64	2.08	2.19	*3.75 J*	1.57	2.32	1.85
Fluoranthene	160	1200	*189* **	13.8	16.4	17.3	*25.9*	10.7	18.1	14.1
Indeno(1,2,3-Cd)Pyrene	34	88	*11.7*	3.44	4.87	4.74	*9.17*	3.51	5.38	4.32
Pyrene	1000	1400	*131* **	15.2	15.7	19.6	*23.8*	10.0	18.2	12.8
Total Benzofluoranthenes	230	450	*70.4*	16.7	19.3	19.8	*32.0*	13.8	22.3	18.1
Total HPAH	960	5300	*525* **	80.6	92.1	98.6	*154*	64.7	105	84.4
Chlorobenzenes (mg/kg-OC)										
1,2,4-Trichlorobenzene	0.81	1.8	*0.02 U*	0.04 U	0.05 U	0.04 U	*0.28 U*	0.05 U	0.06 U	0.05 U
1,2-Dichlorobenzene	2.3	2.3	*0.38 U*	0.66 U	0.82 U	0.65 U	*4.58 U*	0.91 U	0.93 U	0.81 U
1,4-Dichlorobenzene	3.1	9	*0.34 U*	0.60 U	0.75 U	0.59 U	*4.17 U*	0.83 U	0.84 U	0.73 U
Hexachlorobenzene	0.38	2.3	*0.02 U*	0.04 U	0.05 U	0.04 U	*0.28 U*	0.05 U	0.06 U	0.05 U
Phthalates (mg/kg-OC)										
Bis(2-Ethylhexyl)Phthalate	47	78	*95.7* **	40.8	28.2	74.1 *	*67.2*	20.3	37.3	27.6
Butylbenzylphthalate	4.9	64	*16.4* *	2.23	2.30	2.79	*4.17 U*	1.89	1.66	2.17
Diethylphthalate	61	110	*0.47 U*	0.83 U	1.03 U	0.81 U	*5.73 U*	1.14 U	1.16 U	1.01 U
Dimethylphthalate	53	53	*0.47 U*	0.83 U	1.03 U	0.81 U	*5.73 U*	1.14 U	1.16 U	1.01 U
Di-N-Butylphthalate	220	1700	*0.47 U*	0.90 J	1.03 J	0.96 J	*5.73 U*	1.14 J	1.16 J	1.01 U
Di-N-Octylphthalate	58	4500	*0.47 U*	0.83 U	1.03 U	0.81 U	*5.73 U*	1.14 U	1.16 U	1.01 U
Ionic Organics (ug/kg dw)										
2-Methylphenol	63	63	9.72 U	11.8 U	11.4 U	9.41 U	6.63 U	10.9 U	11.6 U	11.8 U
4-Methylphenol[1]	670	670	116	60.1 U	58.2 U	48.0 U	33.8 U	55.7 U	59.2 U	59.9 U
2,4-Dimethylphenol	29	29	114	11.8 U	11.4 U	9.41 U	6.63 U	10.9 U	11.6 U	11.8 U
Benzyl Alcohol	57	73	24.4 U	29.6 U	28.7 U	23.6 U	16.6 U	27.4 U	29.2 U	29.5 U
Benzoic Acid	650	650	444	345	284	265	148	228	336	459
Pentachlorophenol	360	690	147 U	178 U	172 U	142 U	100 U	165 U	175 U	177 U
Phenol	420	1200	49.5 U	60.1 U	58.2 U	48.0 U	33.8 U	55.7 U	59.2 U	59.9 U
Miscellaneous (mg/kg-OC)										
Dibenzofuran	15	58	*2.14*	0.40 U	0.50 U	0.41 J	*2.76 U*	0.55 U	0.65 J	0.52 J
Hexachlorobutadiene	3.9	6.2	*0.12 U*	0.20 U	0.25 U	0.20 U	*1.41 U*	0.28 U	0.28 U	0.25 U
n-Nitroso-di-phenylamine	11	11	*0.57 U*	1.00 U	1.24 U	0.99 U	*6.93 U*	1.34 U	1.40 U	1.22 U

Table 5. 2011 Sediment Chemistry Results – Comparison to SMS Marine Benthic Chemical Criteria (cont.)

	SMS		Enhanced Natural Recovery Area						
Location ID	**SQS**	**CSL**	**DUD_3C**	**DUD_4C**	**DUD_5C**	**DUD_6C**	**DUD_7C Avg**	**DUD_14C**	**DUD_15C**
Conventionals (%)									
Total Solids	--	--	**49.6**	**64.1**	**72.7**	**85.9**	**57.2**	**52.8**	**50.8**
Total Organic Carbon	--	--	**1.95**	**1.17**	**0.54**	**0.25**	**1.44**	**1.84**	**1.76**
Metals (mg/kg)									
Arsenic	57	93	**11.3 J**	**7.18 J**	**4.95 J**	**2.68 J**	**8.48 J**	**11.7 J**	**10.2 J**
Cadmium	5.1	6.7	**0.28 J**	**0.22 J**	**0.13 U**	**0.11 U**	**0.24 J**	**0.32 J**	**0.26 J**
Chromium	260	270	**25.6**	**21.5**	**18.2**	**14.0**	**25.0**	**28.2**	**27.2**
Copper	390	390	**55.6**	**55.2**	**33.3**	**30.0**	**48.8**	**61.7**	**50.0**
Lead	450	530	**25.2**	**16.8**	**10.1**	**3.73 J**	**16.8**	**30.7**	**19.3**
Mercury	0.41	0.59	**0.18 J**	**0.10 J**	**0.05 J**	**0.03 J**	**0.13 J**	**0.48**	**0.13 J**
Silver	6.1	6.1	**1.69 J**	**1.45 J**	**1.18 J**	**1.07 J**	**1.69 J**	**1.69 J**	**1.73 J**
Zinc	410	960	**95.2**	**71.0**	**50.2**	**29.9**	**79.7**	**107**	**90.2**
PCBs (mg/kg-OC)									
Total PCBs	12	65	**5.36**	**5.24**	**6.30**	***5.43***	**4.56**	**7.46**	**3.58**
LPAH (mg/kg-OC)									
2-Methylnaphthalene	38	64	0.55 U	0.71 U	1.35 U	*2.47 U*	0.64 U	0.55 U	0.59 U
Acenaphthene	16	57	0.55 U	0.71 U	1.35 U	*2.47 U*	0.64 U	0.55 U	0.59 U
Acenaphthylene	66	66	0.55 U	0.71 U	1.35 U	*2.47 U*	0.64 U	0.55 U	0.59 U
Anthracene	220	1200	**0.98 J**	**1.09 J**	**2.36 J**	*2.47 U*	**1.51 J**	**1.81**	**0.78 J**
Fluorene	23	79	0.55 U	0.71 U	1.35 U	*2.47 U*	0.64 U	0.58 J	0.59 U
Naphthalene	99	170	0.55 U	0.71 U	1.35 U	*2.47 U*	0.64 U	0.55 U	0.59 U
Phenanthrene	100	480	**3.06**	**2.07**	**5.41**	***4.14 J***	**2.65**	**3.82**	**1.65**
Total LPAH	370	780	**4.05**	**3.16**	**7.77**	***4.14***	**4.16**	**6.22**	**2.43**
HPAH (mg/kg-OC)									
Benzo(a)anthracene	110	270	**2.86**	**3.02**	**7.28**	***5.12***	**2.95**	**4.47**	**1.89**
Benzo(a)pyrene	99	210	**3.36**	**3.93**	**8.40**	***5.49***	**3.57**	**5.58**	**2.34**
Benzo(g,h,i)perylene	31	78	**1.83**	**2.36**	**4.64**	***3.02 J***	**1.89**	**3.10**	**1.40**
Chrysene	110	460	**4.46**	**5.03**	**13.4**	***7.16***	**4.32**	**7.38**	**3.18**
Dibenzo(a,h)anthracene	12	33	**0.89 J**	**0.79 J**	**2.08 J**	*2.47 U*	**0.71 J**	**1.11**	0.59 U
Fluoranthene	160	1200	**7.51**	**5.75**	**14.2**	***9.91***	**5.23**	**9.35**	**4.66**
Indeno(1,2,3-Cd)Pyrene	34	88	**1.79**	**2.04**	**4.37**	***2.70 J***	**1.73**	**2.86**	**1.30**
Pyrene	1000	1400	**6.36**	**5.69**	**13.7**	***8.93***	**4.86**	**9.20**	**3.92**
Total Benzofluoranthenes	230	450	**7.17**	**8.38**	**18.0**	***11.4***	**7.19**	**11.9**	**4.93**
Total HPAH	960	5300	**36.2**	**37.0**	**86.1**	***53.8***	**32.1**	**54.9**	**23.6**
Chlorobenzenes (mg/kg-OC)									
1,2,4-Trichlorobenzene	0.81	1.8	0.05 U	0.07 U	0.13 U	*0.25 U*	0.06 U	0.05 U	0.06 U
1,2-Dichlorobenzene	2.3	2.3	0.91 U	1.17 U	2.23 U	*4.09 U*	1.07 U	0.91 U	0.99 U
1,4-Dichlorobenzene	3.1	9	0.83 U	1.07 U	2.03 U	*3.72 U*	0.97 U	0.82 U	0.90 U
Hexachlorobenzene	0.38	2.3	0.05 U	0.07 U	0.13 U	*0.25 U*	0.06 U	0.05 U	0.06 U
Phthalates (mg/kg-OC)									
Bis(2-Ethylhexyl)Phthalate	47	78	**8.15**	**13.1**	**19.0**	***10.7***	**6.93**	**11.0**	**5.12**
Butylbenzylphthalate	4.9	64	0.83 U	1.07 U	2.03 U	*3.72 U*	0.97 U	0.82 U	0.90 U
Diethylphthalate	61	110	1.14 U	1.47 U	2.79 U	*5.12 U*	1.33 U	1.13 U	1.23 U
Dimethylphthalate	53	53	1.14 U	1.47 U	2.79 U	*5.12 U*	1.33 U	1.13 U	1.23 U
Di-N-Butylphthalate	220	1700	1.14 U	1.47 U	2.79 U	*5.12 U*	1.33 U	1.13 U	1.23 U
Di-N-Octylphthalate	58	4500	1.14 U	1.47 U	2.79 U	*5.12 U*	1.33 U	1.13 U	1.23 U
Ionic Organics (ug/kg dw)									
2-Methylphenol	63	63	10.7 U	8.27 U	7.29 U	6.17 U	9.27 U	10.0 U	10.4 U
4-Methylphenol[1]	670	670	54.4 U	42.1 U	37.1 U	31.4 U	47.2 U	51.1 U	53.1 U
2,4-Dimethylphenol	29	29	10.7 U	8.27 U	7.29 U	6.17 U	9.27 U	10.0 U	10.4 U
Benzyl Alcohol	57	73	27 U	20.7 U	18.3 U	15.5 U	23.3 U	25.2 U	26.2 U
Benzoic Acid	650	650	216 U	**178**	**173**	125 U	187 U	**206**	211 U
Pentachlorophenol	360	690	161 U	125 U	110 U	93.1 U	140 U	152 U	157 U
Phenol	420	1200	54.4 U	42.1 U	37.1 U	31.4 U	47.2 U	51.1 U	53.1 U
Miscellaneous (mg/kg-OC)									
Dibenzofuran	15	58	0.55 U	0.71 U	1.35 U	*2.47 U*	0.64 U	0.55 U	0.59 U
Hexachlorobutadiene	3.9	6.2	0.28 U	0.36 U	0.69 U	*1.26 U*	0.33 U	0.28 U	0.30 U
n-Nitroso-di-phenylamine	11	11	1.38 U	1.78 U	3.38 U	*6.19 U*	1.61 U	1.37 U	1.49 U

Table 5. 2011 Sediment Chemistry Results – Comparison to SMS Marine Benthic Chemical Criteria (cont.)

	SMS		Perimeter Area							
Location ID	**SQS**	**CSL**	**DUD_1C**	**DUD_2C**	**DUD_8C**	**DUD_9C**	**DUD_10C**	**DUD_11C**	**DUD_12C**	**DUD_13C Avg**
Conventionals (%)										
Total Solids	--	--	**44.5**	**47.4**	**64.6**	**61.4**	**64.5**	**62.3**	**61.6**	**47.1**
Total Organic Carbon	--	--	**2.88**	**2.66**	**1.38**	**1.35**	**1.08**	**1.45**	**1.53**	**2.05**
Metals (mg/kg)										
Arsenic	57	93	**13.9 J**	**13.9**	**10.0**	**9.1 J**	**11.1**	**8.2 J**	**8.6 J**	**11.4 J**
Cadmium	5.1	6.7	**0.43 J**	**0.34 J**	**1.52**	**0.84**	**0.39 J**	**0.30 J**	**0.42 J**	**0.34 J**
Chromium	260	270	**34.4**	**30.4**	**52.5**	**33.1**	**26.8**	**27.1**	**31.7**	**29.9**
Copper	390	390	**79.3**	**68.8**	**63.8**	**49.8**	**52.4**	**61.6**	**75.3**	**60.1**
Lead	450	530	**38.2**	**31.9**	**40.7**	**32.1**	**47.6**	**30.5**	**47.6**	**25.4**
Mercury	0.41	0.59	**0.19 J**	**0.16 J**	**0.26 J**	**0.18 J**	**0.13 J**	**0.16 J**	**0.16 J**	**0.19 J**
Silver	6.1	6.1	**2.20 J**	**2.05 J**	**2.96**	**2.12**	**1.63**	**1.67**	**1.77**	**1.98 J**
Zinc	410	960	**152**	**124**	**104**	**90.2**	**109**	**111**	**123**	**107**
PCBs (mg/kg-OC)										
Total PCBs	12	65	**6.3**	**6.9**	**73.5 ****	**18.4 ***	**11.2**	**7.3**	**11.5**	**5.1**
LPAH (mg/kg-OC)										
2-Methylnaphthalene	38	64	**0.49 J**	**2.93**	0.59 U	0.64 U	0.76 U	0.59 U	0.56 U	0.55 U
Acenaphthene	16	57	**0.45 J**	**1.28**	0.59 U	0.64 U	0.76 U	0.59 U	0.56 U	0.55 U
Acenaphthylene	66	66	**1.49**	**12.0**	0.59 U	0.64 U	0.76 U	0.76 J	0.56 U	0.55 U
Anthracene	220	1200	**3.50**	**12.1**	**1.90**	**3.20**	**3.78**	**3.46**	**2.85**	**1.73**
Fluorene	23	79	**1.76**	**10.6**	**0.87 J**	**0.99 J**	**1.37 J**	**1.21**	**0.75 J**	0.55 U
Naphthalene	99	170	0.41 U	**0.79 J**	0.59 U	0.64 U	0.76 U	6.21	0.56 U	0.55 U
Phenanthrene	100	480	**11.1**	**51.7**	**5.72**	**7.21**	**8.71**	**11.3**	**5.61**	**3.92**
Total LPAH	370	780	**18.3**	**88.4**	**8.50**	**11.4**	**13.9**	**22.9**	**9.22**	**5.7**
HPAH (mg/kg-OC)										
Benzo(a)anthracene	110	270	**10.3**	**38.7**	**5.20**	**5.96**	**12.4**	**10.9**	**7.31**	**4.09**
Benzo(a)pyrene	99	210	**11.2**	**21.2**	**7.87**	**8.84**	**20.2**	**13.2**	**10.8**	**5.21**
Benzo(g,h,i)perylene	31	78	**7.16**	**8.73**	**4.29**	**4.91**	**8.97**	**8.50**	**6.76**	**2.92**
Chrysene	110	460	**16.4**	**40.2**	**8.12**	**8.50**	**18.7**	**16.0**	**12.2**	**7.67**
Dibenzo(a,h)anthracene	12	33	**2.17**	**3.78**	**1.68**	**1.42**	**3.85**	**3.09**	**2.39**	**1.13 J**
Fluoranthene	160	1200	**26.1**	**155**	**11.2**	**12.2**	**18.2**	**23.3**	**15.3**	**10.3**
Indeno(1,2,3-Cd)Pyrene	34	88	**5.49**	**8.33**	**3.65**	**3.99**	**8.34**	**7.16**	**5.36**	**2.52**
Pyrene	1000	1400	**26.2**	**101**	**20.7**	**18.9**	**25.8**	**23.2**	**19.3**	**9.39**
Total Benzofluoranthenes	230	450	**26.2**	**48.8**	**15.2**	**16.9**	**47.6**	**26.4**	**23.8**	**10.6**
Total HPAH	960	5300	**131**	**425**	**78.0**	**81.6**	**164**	**132**	**103**	**53.8**
Chlorobenzenes (mg/kg-OC)										
1,2,4-Trichlorobenzene	0.81	1.8	0.04 U	0.04 U	0.06 U	0.06 U	0.08 U	0.06 U	0.06 U	0.05 U
1,2-Dichlorobenzene	2.3	2.3	0.69 U	0.70 U	0.99 U	1.06 U	1.26 U	0.97 U	0.93 U	0.91 U
1,4-Dichlorobenzene	3.1	9	0.63 U	0.63 U	0.90 U	0.97 U	1.14 U	0.88 U	0.85 U	0.83 U
Hexachlorobenzene	0.38	2.3	0.04 U	0.04 U	0.06 U	0.06 U	0.08 U	0.06 U	0.06 U	0.05 U
Phthalates (mg/kg-OC)										
Bis(2-Ethylhexyl)Phthalate	47	78	**57.8 ***	**34.8**	**52.1 ***	**39.3**	**29.0**	**52.2 ***	**42.6**	**12.9**
Butylbenzylphthalate	4.9	64	**5.02 ***	**1.90**	0.90 U	**2.68**	**5.34 ***	**2.87**	**3.14**	**1.12**
Diethylphthalate	61	110	0.86 U	0.87 U	1.23 U	1.33 U	1.57 U	1.22 U	1.17 U	1.14 U
Dimethylphthalate	53	53	0.86 U	0.87 U	1.23 U	1.33 U	1.57 U	1.22 U	1.17 U	1.14 U
Di-N-Butylphthalate	220	1700	**1.85**	0.87 U	**2.41**	1.33 U	1.57 U	1.44 J	1.17 J	1.14 U
Di-N-Octylphthalate	58	4500	0.86 U	0.87 U	1.23 U	1.33 U	1.57 U	1.22 U	1.17 U	1.14 U
Ionic Organics (ug/kg dw)										
2-Methylphenol	63	63	11.9 U	11.2 U	8.20 U	8.63 U	8.22 U	8.51 U	8.60 U	11.26 U
4-Methylphenol[1]	670	670	60.7 U	57.0 U	41.8 U	44.0 U	41.9 U	43.3 U	43.8 U	57.3 U
2,4-Dimethylphenol	29	29	11.9 U	11.2 U	8.20 U	8.63 U	8.22 U	8.51 U	8.60 U	11.26 U
Benzyl Alcohol	57	73	29.9 U	28.1 U	20.6 U	21.7 U	20.6 U	21.3 U	21.6 U	28.2 U
Benzoic Acid	650	650	**319**	**308**	166 U	174 U	166 U	**297**	174 U	227 U
Pentachlorophenol	360	690	180 U	169 U	124 U	130 U	124 U	128 U	130 U	170 U
Phenol	420	1200	60.7 U	57.0 U	41.8 U	44.0 U	41.9 U	43.3 U	43.8 U	57.3 U
Miscellaneous (mg/kg-OC)										
Dibenzofuran	15	58	**1.20**	**7.15**	0.59 U	0.64 U	0.76 U	**0.69 J**	0.56 U	0.55 U
Hexachlorobutadiene	3.9	6.2	0.21 U	0.21 U	0.30 U	0.33 U	0.39 U	0.30 U	0.29 U	0.28 U
n-Nitroso-di-phenylamine	11	11	1.04 U	1.06 U	1.49 U	1.60 U	1.90 U	1.47 U	1.41 U	1.37 U

Notes:

[1] 3- and 4-methylphenol cannot be distinguished analytically so this value represents either or both chemicals.
Comparison to AETs is presented in Appendix D for OC-
normalized SMS values outside of TOC of <05% or > 3%
Heavy shading: Detected value exceeds one or both criterion
Light shading: TOC <0.5% or >3%, thus OC-normalized chemicals compared to LAET and 2LAET
dw: dry weight normalized
OC: organic carbon normalized

SMS: Sediment Management Standards (Chapter 173-204 WAC)
SQS: Sediment Quality Standard (Table I, Chapter 173-204-320 WAC)
CSL: Cleanup Screening Level (Table III, Chapter 173-204-562 WAC)
LPAHs: Low Molecular Weight Polycyclic Aromatic Hydrocarbons
HPAHs: High Molecular Weight Polycyclic Aromatic Hydrocarbons
PCBs: Polychlorinated Biphenyls

Bold: Detected
6.3 U: Italic font denotes that TOC requires comparison to LAET and 2LAET (SQS and CSL equivalent levels, respectively)
* Exceeds SMS SQS or SQS-AET criteria.
** Exceeds SMS CSL or CSL-AET criteria.
Qualifiers:
U: <MDL
J: <RDL

Table 6. 2012 Sediment Chemistry Results – Comparison to SMS Marine Benthic Chemical Criteria

	SMS		Cap Area A					Cap Area B		
	SQS	CSL	DUD_1A Avg	DUD_2A	DUD_3A	DUD_4A	DUD_5A	DUD_1B	DUD_2B	DUD_3B
Conventionals (%)										
Total Solids	--	--	83.3	46.6	49.1	55.6	79.4	51.9	48.2	48.3
Total Organic Carbon	--	--	0.48	2.51	2.26	1.83	0.28	1.60	2.10	2.13
Metals (mg/kg)										
Arsenic	57	93	2.40 J	13.1 J	10.6 J	8.99 J	2.90 J	7.90 J	11.0 J	12.0 J
Cadmium	5.1	6.7	0.38 J	0.54 J	0.53 J	0.54 J	0.18 J	0.42 J	0.50 J	0.52 J
Chromium	260	270	19.5	30.3	31.8	31.1	24.6	27.6	34.4	30.0
Copper	390	390	31.9	69.1	68.0	71.2	40.2	56.1	72.4	67.1
Lead	450	530	47.6	33.7	32.4	40.5	7.32	23.5	32.0	31.3
Mercury	0.41	0.59	0.21 J	0.16 J	0.18 J	0.15 J	0.03 J	0.15 J	0.18 J	0.23 J
Silver	6.1	6.1	0.47 J	0.97 J	0.98 J	0.79 J	0.64 J	0.87 J	1.04 J	0.97 J
Zinc	410	960	107	140	133	148	49.2	102	127	123
PCBs (mg/kg-OC)										
Total PCBs	12	65	8.13	5.36	7.78	5.80	4.57	5.55	5.79	9.69
LPAH (mg/kg-OC)										
2-Methylnaphthalene	38	64	1.34 U	0.45 U	0.48 U	0.52 U	2.38 U	0.64 U	0.52 U	0.51 U
Acenaphthene	16	57	1.34 U	0.45 U	0.48 U	0.52 U	2.38 U	0.64 U	0.52 U	0.51 U
Acenaphthylene	66	66	1.34 U	0.45 U	0.48 U	0.52 U	2.38 U	0.64 U	0.52 U	0.51 U
Anthracene	220	1200	6.48	1.43	1.33	2.58	2.47 J	1.91	2.20	3.34
Fluorene	23	79	2.50	0.45 U	0.48 U	0.76 J	2.38 U	0.64 U	0.55 J	0.94 J
Naphthalene	99	170	1.34 U	0.45 U	0.48 U	0.77 J	2.38 U	0.64 U	0.52 U	0.51 U
Phenanthrene	100	480	32.1	4.03	3.09	9.04	9.73	6.15	5.16	6.29
Total LPAH	370	780	39.6	5.46	4.42	13.2	12.2	8.06	7.91	10.6
HPAH (mg/kg-OC)										
Benzo(a)anthracene	110	270	22.2	6.14	6.85	11.6	13.7	7.33	7.60	10.8
Benzo(a)pyrene	99	210	23.1	6.75	7.67	12.5	22.9	8.65	8.61	10.3
Benzo(g,h,i)perylene	31	78	8.23	3.05	2.86	4.98	12.6	3.19	4.26	5.11
Chrysene	110	460	27.7	9.57	9.28	16.4	18.0	11.0	11.2	16.6
Dibenzo(a,h)anthracene	12	33	2.47	0.77 J	0.81 J	1.25	2.96 J	0.84 J	1.12	1.33
Fluoranthene	160	1200	55.9	18.0	10.5	23.2	25.1	12.4	15.4	17.6
Indeno(1,2,3-Cd)Pyrene	34	88	7.97	2.81	2.81	4.72	11.5	3.16	4.02	4.77
Pyrene	1000	1400	51.3	15.9	10.5	23.4	24.3	12.9	15.4	17.5
Total Benzofluoranthenes	230	450	46.0	14.8	17.0	31.4	32.3	16.4	18.8	24.6
Total HPAH	960	5300	244	77.8	68.4	129	163	75.8	86.5	108
Chlorobenzenes (mg/kg-OC)										
1,2,4-Trichlorobenzene	0.81	1.8	0.13 U	0.05 U	0.05 U	0.05 U	0.24 U	0.06 U	0.05 U	0.05 U
1,2-Dichlorobenzene	2.3	2.3	1.35 U	0.46 U	0.48 U	0.52 U	2.39 U	0.64 U	0.53 U	0.52 U
1,4-Dichlorobenzene	3.1	9	2.03 U	0.68 U	0.72 U	0.78 U	3.59 U	0.96 U	0.79 U	0.78 U
Hexachlorobenzene	0.38	2.3	0.13 U	0.05 U	0.05 U	0.05 U	0.24 U	0.06 U	0.05 U	0.05 U
Phthalates (mg/kg-OC)										
Bis(2-Ethylhexyl)Phthalate	47	78	109	26.2	17.2	93.9	32.5	14.7	20.7	26.0
Butylbenzylphthalate	4.9	64	39.4	2.16	2.34	3.68	7.49	2.21	2.36	2.56
Diethylphthalate	61	110	2.78 U	0.94 U	0.99 U	1.08 U	4.93 U	1.32 U	1.09 U	1.07 U
Dimethylphthalate	53	53	2.71 U	0.91 U	0.96 U	1.05 U	4.80 U	1.29 U	1.06 U	1.04 U
Di-N-Butylphthalate	220	1700	2.78 U	0.94 J	0.99 U	1.08 U	4.93 U	1.32 U	1.09 U	1.07 U
Di-N-Octylphthalate	58	4500	2.71 U	0.91 U	0.96 U	52.1	4.80 U	1.29 U	1.06 U	1.04 U
Ionic Organics (ug/kg dw)										
2-Methylphenol	63	63	6.36 U	11.4 U	10.8 U	9.53 U	6.68 U	10.2 U	11.0 U	11.0 U
4-Methylphenol[1]	670	670	32.4 U	309	137	160	34.0 U	459	162	133
2,4-Dimethylphenol	29	29	6.36 U	11.4 U	10.8 U	9.53 U	6.68 U	10.2 U	11.0 U	11.0 U
Benzyl Alcohol	57	73	16.0 U	28.5 U	27.1 U	23.9 U	16.8 U	25.6 U	27.6 U	27.5 U
Benzoic Acid	650	650	325	607	609	556	358	513	726 **	764 **
Pentachlorophenol	360	690	96.0 U	172 U	163 U	144 U	101 U	154 U	442 *	166 U
Phenol	420	1200	37.8 J	891 *	481 *	230	76.8 J	513 *	807 *	905 *
Miscellaneous (mg/kg-OC)										
Dibenzofuran	15	58	1.43 J	0.45 U	0.48 U	0.52 U	2.38 U	0.64 U	0.52 U	0.53 J
Hexachlorobutadiene	3.9	6.2	0.68 U	0.23 U	0.24 U	0.26 U	1.21 U	0.32 U	0.27 U	0.26 U
n-Nitroso-di-phenylamine	11	11	3.10 U	1.14 U	1.20 U	1.30 U	5.96 U	1.60 U	1.32 U	1.29 U

Table 6. 2012 Sediment Chemistry Results – Comparison to SMS Marine Benthic Chemical Criteria (cont.)

	SMS		Enhanced Natural Recovery Area						
Location ID	**SQS**	**CSL**	**DUD_3C Avg**	**DUD_4C**	**DUD_5C**	**DUD_6C**	**DUD_7C**	**DUD_14C**	**DUD_15C**
Conventionals (%)									
Total Solids	--	--	**54.7**	**82.2**	**66.3**	**73.3**	**52.9**	**51.4**	**55.6**
Total Organic Carbon	--	--	**1.55**	**0.77**	**0.82**	**0.55**	**1.79**	**2.33**	**1.73**
Metals (mg/kg)									
Arsenic	57	93	**9.69 J**	**4.14 J**	**6.33 J**	**3.96 J**	**8.88 J**	**9.14 J**	**9.89 J**
Cadmium	5.1	6.7	**0.47 J**	**0.22 J**	**0.26 J**	**0.15 J**	**0.38 J**	**0.41 J**	**0.36 J**
Chromium	260	270	**26.6**	**17.5**	**17.2**	**14.2**	**23.4**	**25.7**	**23.0**
Copper	390	390	**62.1**	**35.4**	**35.9**	**28.0**	**48.8**	**56.4**	**48.9**
Lead	450	530	**29.7**	**11.1**	**10.6**	**6.93**	**19.7**	**25.5**	**22.1**
Mercury	0.41	0.59	**0.16 J**	**0.04 J**	**0.08 J**	**0.05 J**	**0.12 J**	**0.16 J**	**0.14 J**
Silver	6.1	6.1	**0.80 J**	**0.52 J**	**0.71 J**	**0.56 J**	**0.78 J**	**0.95 J**	**0.59 J**
Zinc	410	960	**115**	**48.1**	**58.1**	**41.2**	**88.7**	**102**	**88.5**
PCBs (mg/kg-OC)									
Total PCBs	12	65	**5.65**	**4.18**	**4.02**	**7.36**	**2.33**	**4.38**	**3.08**
LPAH (mg/kg-OC)									
2-Methylnaphthalene	38	64	0.62 U	0.84 U	0.97 U	**4.03**	0.56 U	0.44 U	0.55 U
Acenaphthene	16	57	0.62 U	0.84 U	0.97 U	1.31 U	0.56 U	0.44 U	0.55 U
Acenaphthylene	66	66	0.62 U	0.84 U	0.97 U	**21.2**	0.56 U	0.44 U	0.55 U
Anthracene	220	1200	**2.93**	**1.30 J**	**2.02 J**	**55.4**	**1.57**	**2.34**	**1.77**
Fluorene	23	79	**0.74 J**	0.84 U	0.97 U	**17.0**	0.56 U	**0.62 J**	0.55 U
Naphthalene	99	170	0.62 U	0.84 U	0.97 U	1.31 U	0.56 U	0.44 U	0.55 U
Phenanthrene	100	480	**6.35**	**2.72**	**3.69**	**245 ***	**3.61**	**4.84**	**5.45**
Total LPAH	370	780	**10.0**	**4.02**	**5.71**	**339**	**5.18**	**7.80**	**7.22**
HPAH (mg/kg-OC)									
Benzo(a)anthracene	110	270	**10.3**	**5.05**	**5.38**	**135 ***	**5.30**	**7.71**	**7.08**
Benzo(a)pyrene	99	210	**12.3**	**7.71**	**8.46**	**128 ***	**7.02**	**8.26**	**8.35**
Benzo(g,h,i)perylene	31	78	**6.39**	**3.07**	**3.12**	**65.8 ***	**3.37**	**3.91**	**3.96**
Chrysene	110	460	**16.2**	**7.23**	**8.84**	**229 ***	**7.94**	**11.7**	**10.8**
Dibenzo(a,h)anthracene	12	33	**1.79**	**0.92**	**1.06 J**	**17.4 ***	**1.17**	**1.08**	**1.04 J**
Fluoranthene	160	1200	**17.5**	**8.35**	**8.28**	**140**	**9.04**	**14.3**	**13.9**
Indeno(1,2,3-Cd)Pyrene	34	88	**6.05**	**2.83**	**2.84**	**48.3 ***	**3.06**	**3.72**	**3.81**
Pyrene	1000	1400	**21.8**	**10.0**	**9.78**	**342**	**10.3**	**15.6**	**14.7**
Total Benzofluoranthenes	230	450	**29.4**	**12.6**	**12.9**	**152**	**13.8**	**19.3**	**17.9**
Total HPAH	960	5300	**122**	**57.7**	**60.6**	**1258 ***	**61.1**	**85.4**	**81.6**
Chlorobenzenes (mg/kg-OC)									
1,2,4-Trichlorobenzene	0.81	1.8	0.06 U	0.08 U	0.10 U	0.13 U	0.06 U	0.04 U	0.06 U
1,2-Dichlorobenzene	2.3	2.3	0.63 U	0.84 U	0.98 U	1.32 U	0.56 U	0.44 U	0.55 U
1,4-Dichlorobenzene	3.1	9	0.94 U	1.27 U	1.47 U	1.98 U	0.84 U	0.67 U	0.83 U
Hexachlorobenzene	0.38	2.3	0.06 U	0.08 U	0.10 U	0.13 U	0.06 U	0.04 U	0.06 U
Phthalates (mg/kg-OC)									
Bis(2-Ethylhexyl)Phthalate	47	78	**23.6**	**13.7**	**16.6**	**11.8**	**12.5**	**15.2**	**11.0**
Butylbenzylphthalate	4.9	64	**3.20**	**2.88**	**3.10**	**3.74**	**2.07**	**2.35**	**2.21**
Diethylphthalate	61	110	1.30 U	1.74 U	2.02 U	2.72 U	1.16 U	0.92 U	1.14 U
Dimethylphthalate	53	53	1.26 U	1.69 U	1.96 U	2.65 U	1.13 U	0.89 U	1.11 U
Di-N-Butylphthalate	220	1700	**2.20**	1.74 U	2.02 U	2.72 U	1.16 U	0.92 U	1.14 U
Di-N-Octylphthalate	58	4500	1.26 U	1.69 U	1.96 U	2.65 U	1.13 U	0.89 U	1.11 U
Ionic Organics (ug/kg dw)									
2-Methylphenol	63	63	9.69 U	6.45 U	7.99 U	7.23 U	10.0 U	10.3 U	9.53 U
4-Methylphenol[1]	670	670	49.4 U	32.8 U	40.7 U	36.8 U	51.0 U	52.5 U	48.6 U
2,4-Dimethylphenol	29	29	9.69 U	6.45 U	7.99 U	7.23 U	10.0 U	10.3 U	9.5 U
Benzyl Alcohol	57	73	24.3 U	16.2 U	20.1 U	18.1 U	25.1 U	25.9 U	23.9 U
Benzoic Acid	650	650	**529**	**356**	**412**	**371**	**535**	**558**	**505**
Pentachlorophenol	360	690	146 U	97.3 U	121 U	109 U	151 U	156 U	144 U
Phenol	420	1200	**179 J**	**59.6 J**	40.7 U	36.8 U	**221**	**119 J**	**198**
Miscellaneous (mg/kg-OC)									
Dibenzofuran	15	58	0.62 U	0.84 U	0.97 U	1.31 U	0.56 U	0.44 U	0.55 U
Hexachlorobutadiene	3.9	6.2	0.32 U	0.43 U	0.50 U	0.67 U	0.29 U	0.23 U	0.28 U
n-Nitroso-di-phenylamine	11	11	1.57 U	2.10 U	2.44 U	3.29 U	1.40 U	1.11 U	1.38 U

Table 6. 2012 Sediment Chemistry Results – Comparison to SMS Marine Benthic Chemical Criteria (cont.)

	SMS		Perimeter Area						
Location ID	**SQS**	**CSL**	**DUD_1C Avg**	**DUD_8C**	**DUD_9C**	**DUD_10C**	**DUD_11C**	**DUD_12C**	**DUD_13C**
Conventionals (%)									
Total Solids	--	--	**44.4**	**66.7**	**81.2**	**69.2**	**59.1**	**59.4**	**53.9**
Total Organic Carbon	--	--	**2.67**	**1.49**	**0.78**	**0.88**	**1.64**	**1.63**	**1.74**
Metals (mg/kg)									
Arsenic	57	93	**13.7 J**	**14.8**	**9.40**	**14.7**	**9.31 J**	**8.08 J**	**7.98 J**
Cadmium	5.1	6.7	**0.59 J**	**3.75**	**1.43**	**0.46 J**	**0.44 J**	**0.42 J**	**0.46 J**
Chromium	260	270	**33.5**	**83.7**	**42.9**	**27.0**	**29.6**	**30.0**	**26.9**
Copper	390	390	**76.3**	**86.2**	**62.6**	**43.9**	**64.8**	**63.1**	**53.8**
Lead	450	530	**34.1**	**77.4**	**54.2**	**37.6**	**32.5**	**36.4**	**27.3**
Mercury	0.41	0.59	**0.23 J**	**0.71 ****	**0.36**	**0.14 J**	**0.25 J**	**0.16 J**	**0.17 J**
Silver	6.1	6.1	**1.15 J**	**4.38**	**2.04**	**0.84 J**	**0.88 J**	**0.89 J**	**0.95 J**
Zinc	410	960	**149**	**172**	**102**	**89.3**	**129**	**116**	**102**
PCBs (mg/kg-OC)									
Total PCBs	12	65	**5.3**	**49.3 ***	**66.7 ****	**22.0 ***	**5.39**	**6.47**	**13.0 ***
LPAH (mg/kg-OC)									
2-Methylnaphthalene	38	64	0.45 U	**1.71**	**1.57 J**	0.87 U	0.55 U	0.55 U	0.56 U
Acenaphthene	16	57	0.45 U	**0.81 J**	0.84 U	0.87 U	0.55 U	0.55 U	0.56 U
Acenaphthylene	66	66	**0.60 J**	**1.80**	**1.14 J**	**1.24 J**	**0.60 J**	0.55 U	0.56 U
Anthracene	220	1200	**2.59**	**4.90**	**2.76**	**5.20**	**3.63**	**2.51**	**2.29**
Fluorene	23	79	**0.89 J**	**1.65**	**1.17 J**	**1.52 J**	**0.93 J**	**0.66 J**	**0.65 J**
Naphthalene	99	170	0.45 U	**2.35**	**27.5**	0.87 U	0.55 U	0.55 U	0.56 U
Phenanthrene	100	480	**7.18**	**12.0**	**8.92**	**12.7**	**8.00**	**7.26**	**5.56**
Total LPAH	370	780	**11.3**	**23.5**	**41.5**	**20.7**	**13.2**	**10.4**	**8.50**
HPAH (mg/kg-OC)									
Benzo(a)anthracene	110	270	**9.84**	**10.9**	**9.43**	**20.0**	**12.5**	**9.54**	**8.39**
Benzo(a)pyrene	99	210	**9.06**	**15.9**	**17.8**	**21.0**	**12.7**	**11.3**	**9.93**
Benzo(g,h,i)perylene	31	78	**4.63**	**6.10**	**8.05**	**11.2**	**7.57**	**5.82**	**5.46**
Chrysene	110	460	**14.6**	**16.7**	**13.2**	**24.9**	**17.6**	**13.9**	**12.2**
Dibenzo(a,h)anthracene	12	33	**1.12**	**1.36**	**2.10**	**2.99**	**1.72**	**1.56**	**1.53**
Fluoranthene	160	1200	**21.7**	**19.1**	**16.0**	**23.4**	**22.2**	**18.6**	**13.7**
Indeno(1,2,3-Cd)Pyrene	34	88	**4.05**	**5.05**	**7.11**	**10.5**	**6.70**	**5.25**	**5.06**
Pyrene	1000	1400	**21.6**	**51.9**	**50.2**	**38.6**	**27.6**	**20.9**	**18.5**
Total Benzofluoranthenes	230	450	**22.1**	**35.6**	**35.4**	**47.5**	**31.2**	**26.5**	**22.3**
Total HPAH	960	5300	**109**	**163**	**159**	**200**	**140**	**113**	**97.1**
Chlorobenzenes (mg/kg-OC)									
1,2,4-Trichlorobenzene	0.81	1.8	0.04 U	0.05 U	0.08 U	0.09 U	0.05 U	0.05 U	0.06 U
1,2-Dichlorobenzene	2.3	2.3	0.45 U	0.54 U	0.85 U	0.88 U	0.55 U	0.55 U	0.57 U
1,4-Dichlorobenzene	3.1	9	0.68 U	0.81 U	1.27 U	1.32 U	0.82 U	0.82 U	0.85 U
Hexachlorobenzene	0.38	2.3	0.04 U	0.05 U	0.08 U	0.09 U	0.05 U	0.05 U	0.06 U
Phthalates (mg/kg-OC)									
Bis(2-Ethylhexyl)Phthalate	47	78	**29.5**	**78.4 ****	**43.0**	**35.8**	**39.0**	**30.6**	**23.0**
Butylbenzylphthalate	4.9	64	**3.49**	0.81 U	1.27 U	**3.76**	**4.48**	**2.76**	**2.20**
Diethylphthalate	61	110	0.93 U	1.11 U	1.75 U	1.82 U	1.13 U	1.13 U	1.17 U
Dimethylphthalate	53	53	0.91 U	1.08 U	1.70 U	1.77 U	1.10 U	1.10 U	1.14 U
Di-N-Butylphthalate	220	1700	**0.93 J**	1.11 U	**2.70 J**	1.82 U	1.13 U	1.13 U	1.17 U
Di-N-Octylphthalate	58	4500	0.91 U	1.08 U	1.70 U	1.77 U	1.10 U	1.10 U	1.14 U
Ionic Organics (ug/kg dw)									
2-Methylphenol	63	63	12.0 U	7.95 U	6.53 U	7.66 U	8.97 U	8.92 U	9.83 U
4-Methylphenol[1]	670	670	**366**	40.5 U	33.3 U	**47.7 J**	**3367 ****	**210**	**169**
2,4-Dimethylphenol	29	29	12.0 U	7.95 U	6.53 U	7.66 U	8.97 U	8.92 U	9.83 U
Benzyl Alcohol	57	73	30.1 U	19.9 U	16.4 U	19.2 U	22.5 U	22.4 U	24.7 U
Benzoic Acid	650	650	**722 ****	**430**	**456**	**409**	**535**	**492**	**518**
Pentachlorophenol	360	690	181 U	120 U	98.5 U	116 U	135 U	135 U	148 U
Phenol	420	1200	**848 ***	40.5 U	**54.2 J**	**119**	**245**	**131 J**	**156**
Miscellaneous (mg/kg-OC)									
Dibenzofuran	15	58	**0.57 J**	**1.33**	0.84 U	**1.11 J**	**0.63 J**	0.55 U	0.56 U
Hexachlorobutadiene	3.9	6.2	0.23 U	0.27 U	0.43 U	0.45 U	0.28 U	0.28 U	0.29 U
n-Nitroso-di-phenylamine	11	11	1.13 U	1.34 U	2.11 U	2.19 U	1.37 U	1.37 U	1.42 U

Notes:

[1] 3- and 4-methylphenol cannot be distinguished analytically so this value represents either or both chemicals.
Comparison to AETs is presented in Appendix D for OC-
normalized SMS values outside of TOC of <05% or > 3%
Heavy shading: Detected value exceeds one or both criterion
Light shading: TOC <0.5% or >3%, thus OC-normalized chemicals compared to LAET and 2LAET
dw: dry weight normalized
OC: organic carbon normalized

SMS: Sediment Management Standards (Chapter 173-204 WAC)
SQS: Sediment Quality Standard (Table I, Chapter 173-204-320 WAC)
CSL: Cleanup Screening Level (Table III, Chapter 173-204-562 WAC)
LPAHs: Low Molecular Weight Polycyclic Aromatic Hydrocarbons
HPAHs: High Molecular Weight Polycyclic Aromatic Hydrocarbons
PCBs: Polychlorinated Biphenyls

Bold: Detected
6.3 U: Italic font denotes that TOC requires comparison to LAET and 2LAET (SQS and CSL equivalent levels, respectively)
* Exceeds SMS SQS or SQS-AET criteria.
** Exceeds SMS CSL or CSL-AET criteria.
Qualifiers:
U: <MDL
J: <RDL

3.0 SUMMARY

Samples were collected in 2011 and 2012 from stations in Cap Areas A and B, the ENR Area and the Perimeter Area per methods outlined in the project SAP (King County 2003; King County 2004). Samples were collected from all stations previously sampled except for 2C in the Perimeter Area in 2012 because of a lack of access. No results were rejected following QA review of the data. A summary of the overall findings are presented below.

In Cap Area A, concentrations of nine chemicals exceeded SMS in 2011 and one chemical exceeded SMS in 2012. Total PCBs, phenanthrene, total LPAH, chrysene and BBP exceeded the SQS at one Cap Area A station and BEHP exceeded the SQS at a different Cap Area A station in 2011. Fluoranthene, pyrene, total HPAH and BEHP concentrations exceeded CSL and SQS at three stations. In 2012, phenol exceeded the SQS at two Cap Area A stations.

None of the chemical concentrations measured at Cap Area B stations exceeded SMS in 2011. Three chemicals exceeded SMS at three stations in 2012. While phenol concentrations exceeded the SQS at all three Cap Area B stations in 2012, pentachlorophenol was above SQS at only one station and benzoic acid concentrations exceeded both the SQS and CSL (which are the same) at two stations.

Chemistry results indicate that SMS were not exceeded for any chemical in 2011 samples from ENR Area stations. This was also the situation in 2012 except at 6C where several PAHs exceeded the SQS. In the Perimeter Area, total PCBs exceeded SQS at one station and both the SQS and CSL at another station in 2011. BEHP also exceeded the SQS at three stations and BBP exceeded the SQS at two stations in 2011. In 2012, total PCB concentrations exceeded the SQS at three stations. Mercury, total PCBs, BEHP and benzoic acid each exceeded both the SQS and CSL at one station. Phenol exceeded the SQS and 4-methylphenol exceeded both the SQS and CSL at one station.

Substantial TOC and grain size changes occurred at 1A and 4A in 2011, but at other stations in Cap Areas A and B these parameters remained consistent between 2010 and 2012. TOC and grain size changes were either minor (<15%) or temporary in the ENR Area with the exception of grain size at 4C. At this station, coarse sediments showed an increase year-to-year of about 30 percent cumulatively. TOC at Perimeter Area stations varied within 0.5% between years except at 9C where TOC temporarily increased by nearly 1.0% in 2011. Overall, the 2011 and 2012 TOC and grain size results appear to be relatively stable across stations compared to 2010, with occasional large but temporary shifts except at two stations: 4A and 4C. At 4A, relative fines increased by almost 40% in 2011 and remained approximately the same in 2012. At 4C, relative fines have decreased over 15% each of the last two years.

The transient exceedances of SMS observed in 2011 at 1A are consistent with historical monitoring at this station, which is located near the Diagonal Way CSO/SD outfall. Dynamic year-to-year changes in sediment chemistry and physical characteristics are expected to occur at this station due to the influence of discharges from the outfall. Exceedances

observed at other Cap Area stations were limited in extent to four chemicals: BEHP, benzoic acid, pentachlorophenol and phenol. BEHP is ubiquitous and often seen outfalls. Benzoic acid has natural sources and, along with phenols, has been previously observed at the site as transient contaminants (EBDRP 2015). As of 2012, concentrations continue to be consistently below SMS at all ENR Area stations except 6C. PAH exceedances at 6C are unexplained at this point but given the monitoring history at this station (EBDRP 2015), the exceedances are expected to be transient. Although still exceeding SMS, OC-normalized PCB concentrations have continued to decline at 8C in the Perimeter Area. At some other Perimeter Area stations, PCBs have increased in 2011 (8C and 9C) and 2012 (8C-10C, 13C) to above the SMS SQS, and sometimes exceed the CSL. Some other contaminants exceeding SMS in the Perimeter Area, such as BEHP, have also been occasionally detected during previous sampling events in the Duwamish/Diagonal Sediment Monitoring Program (EBDRP 2015). Although unexplained, these 2012 exceedances may also be transient.

4.0 REFERENCES

APHA. 1998. Standard Methods for the Examination of Water and Wastewater, 20th Edition. American Public Health Association. Washington, D.C.

ASTM. 2002. Standard Test Method for Particle-Size Analysis of Soils D422-63(2002). American Society for Testing and Materials. West Conshohocken, Pennsylvania.

Bridges, T.S., S. Ells, D. Hayes, D. Mount, S.C. Nadaeu, M. R. Palermo, C. Patmount, and P. Schroeder. 2008. The Four Rs of Environmental Dredging: Resuspension, Release, Residual, and Risk. Prepared for Dredging Operations and Environmental Research Program, Army Corps of Engineers. EDRC/EL TR-08-4.

Desrosiers, R., C. Patmont, E. Appy, and P. LaRosa. 2005. Effectively Managing Dredging Residuals: Balancing Remedial Goals and Construction Costs. Proceedings of the Third International Conference on Remediation of Contaminated Sediments, January 24–27, 2005, New Orleans, Louisiana, Battelle Press.

EBDRP. 2005. Duwamish/Diagonal CSO/SD Sediment Remediation Project Closure Report Panel Publication 39. Prepared by EcoChem and Anchor Environmental, L.L.C. for the Elliott Bay/Duwamish Restoration Program. Seattle, Washington.

EBRDP. 2007. Duwamish/Diagonal Sediment Remediation Project 2005 Monitoring Report. Panel Publication 40. Prepared by Anchor Environmental, L.L.C. for the Elliott Bay/Duwamish Restoration Program. Seattle, Washington.

EBDRP. 2015. Duwamish/Diagonal Sediment Remediation Project Final 2010 Monitoring Report. Panel Publication 43. Prepared by the King County Water and Land Resourced Division for the King County Wastewater Division and the Elliott Bay/Duwamish Restoration Program.

PTI 1989. Puget Sound Dredged Disposal Analysis Guidance Manual - Data Quality Evaluation for Proposed Dredged Material Disposal Projects. Prepared for the Washington State Department of Ecology by PTI Environmental Services. Bellevue, Washington.

Ecology. 2013. Sediment Management Standards, Chapter 173-204 WAC. Washington State Department of Ecology. Olympia, Washington.

EPA. 1995. Test Methods for Evaluating Solid Waste. Laboratory Manual – Physical/Chemical Methods, SW-846, 3rd Edition, Update IIB. United States

Environmental Protection Agency, Office of Solid Waste and Emergency Response. Washington, D.C.

EPA. 2000. SW-846 Test Methods for Evaluating Solid Waste, Third Edition, Update IV, Method 6010C, Methods for determination of Metals by Inductively Coupled Plasma – Atomic Emission Spectrometry, November 2000.

EPA. 2005. Contaminated Sediment Remediation Guidance for Hazardous Waste Sites. December 2005. http://www.epa.gov/superfund/health/conmedia/sediment/documents.htm

EPA. 2007. SW-846 Test Methods for Evaluating Solid Waste, Volume 1B: Laboratory Manual Physical/Chemical Methods, February 2007. Online http://www3.epa.gov/epawaste/hazard/testmethods/sw846/online/index.htm

EPA. 2008. USEPA Contract Laboratory Program National Functional Guidelines for Superfund Organic Methods Data Review. OSWER 9240.1-48, USEPA-540-R-08-01. United States Environmental Protection Agency. Washington, D.C. June 2001.

EPA. 2010. USEPA Contract Laboratory Program National Functional Guidelines for Superfund Inorganic Data Review. OSWER 9240.1-51, USEPA-540-R-10-011. United States Environmental Protection Agency. Washington, D.C. January 2010.

King County. 2003. Duwamish/Diagonal Sediment Remediation, Dredging and Capping Operations, Sediment Monitoring Sampling and Analysis Plan. King County Department of Natural Resources and Parks. Seattle, Washington.

King County. 2004. Addendum to Surface Sediment Chemistry Monitoring for Duwamish/Diagonal Sediment Remediation Project. King County Department of Natural Resources and Parks. Seattle, Washington.

King County. 2007. Duwamish/Diagonal Sediment Remediation Project 4-Acre Residuals Interim Action Closure Report. Anchor Environmental, L.L.C. Seattle, Washington.

King County. 2010. Duwamish/Diagonal Sediment Remediation Project, 2008/2009 Monitoring Report. Prepared by King County Department of Natural Resources and Parks for Elliott Bay/Duwamish Restoration Program Panel and King County Department of Natural Resources and Parks. Panel Publication 42.

King County and Anchor Environmental. 2008. Duwamish/Diagonal Sediment Remediation Project, 2006/2007 Monitoring Report. Prepared by King County Department of Natural Resources and Parks and Anchor Environmental for Elliott

Bay/Duwamish Restoration Program Panel and King County Department of Natural Resources and Parks. Panel Publication 41.

NRC. 2007. Sediment Dredging at Superfund Megasites: Assessing the Effectiveness. National Research Council, 2007.Washington D.C.: National Academy Press.

PSEP. 1997. Recommended Guidelines for Sampling Marine Sediment, Water Column, and Tissue in Puget Sound. Prepared for the Puget Sound Estuary Program (U.S. Environmental Protection Agency Region 10) by the King County Environmental Laboratory. Seattle, Washington.

PSEP. 1998. Recommended Guidelines for Station Positioning in Puget Sound. Prepared for the Puget Sound Estuary Program (U.S. Environmental Protection Agency Region 10) by the King County Environmental Laboratory. Seattle, Washington.