FINAL REPORT

Adaptive Management Strategy 2012 Annual Report

Deltaport Third Berth, Delta, BC

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Vancouver Fraser Port Authority
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Attn: Kim Keskinen, Environmental Specialist

Dear Ms. Keskinen,

Re: FINAL – Adaptive Management Strategy 2012 Annual Report, Deltaport Third Berth, Delta, BC

Hemmera is pleased to provide you with hardcopies and an electronic copy of the final Adaptive Management Strategy 2012 Annual Report, completed as part of the Deltaport Third Berth construction project.

We appreciate the opportunity to work with you on this project and trust that this report is satisfactory to your requirements. Please feel free to contact the undersigned at 604.669.0424 regarding any questions or further information that you may require.

Regards,
Hemmera

Bonnie Marks

Bonnie Marks, M.A.Sc., P.Eng., PMP
Project Manager

EXECUTIVE SUMMARY

At the request of the Vancouver Fraser Port Authority (VFPA), Hemmera Envirochem Inc. (Hemmera), Northwest Hydraulics Consultants (NHC) and Precision Identification (Precision) are pleased to provide the Adaptive Management Strategy (AMS) 2012 Annual Report for the Deltaport Third Berth (DP3) project. The AMS is designed to provide an early warning system, so that steps can be taken to mitigate risks well before valued ecosystem components are affected. The AMS is an eight year study (2007 – 2014) focussed on the Roberts Bank inter-causeway ecosystem. This program assesses the potential for negative trends in the ecosystem from marine eutrophication and dendritic channelization linked to DP3 construction and operation.

The main AMS monitoring program components include coastal geomorphology, surface water and sediment quality, eelgrass distribution, benthic community structure, and coastal seabird/shorebird composition. It is challenging to separate specific potential effects related to DP3 from the inherent natural environmental (reference sampling sites well away from DP3 indicate high natural variability for many parameters). By monitoring physical, chemical and biological conditions, early detection of any potential negative effects from DP3 is possible. Such early detection is valuable in determining the nature of proactive response as part of an overall adaptive management approach.

Some of the major signs of eutrophication would include an increase in nutrient concentrations, primary productivity (and chlorophyll *α* concentrations) as well as a decrease in dissolved oxygen and water clarity. No such increases or decreases have been observed in the inter-causeway area since AMS data collection began in 2007.

This report summarizes and interprets the findings of the sixth year (2012) of the AMS program, and provides recommendations for the seventh year of monitoring (2013). To date, overall findings of the program do not suggest any emerging negative trends linked to DP3 construction or operation.

COASTAL GEOMORPHOLOGY

Based on recommendations made in the 2011 Annual Report (Hemmera 2012b), the following monitoring activities were discontinued as of January 1, 2012:

- Monitoring of the area around the Crest Protection Structure (Q1 and Q3).
- Erosion and deposition monitoring of the tidal flats in the immediate vicinity of DP3 (monitoring events in all quarters, Q1 – Q4).
- Sediment sample collection and analyses of grain size and organic carbon content (Q2 and Q4 sampling events).

Orthophotograph interpretation was conducted in 2012 to detect potential large-scale geomorphic adjustments to the study area (the inter-causeway area).

Two additional small investigations were conducted in 2012 based on recommendations made in the 2011 Annual Report (Hemmera 2012b). Because these are new investigations that do not fit within the standard AMS monitoring plan, each of these studies has been summarized in memorandums provided as appendices to this report. These studies include:

- Sediment sample collection and analyses of grain size distribution around select DoD rod sites to determine spatial variability within these localized areas.
- Assessment of channel changes in the 'Area of New Drainage Channels' near DP3.

The 2012 sediment sampling study was conducted at the request of the SAC in order to help understand the variation observed at rod sites during the course of the monitoring program. The results of the sampling study suggest that the differences in percent silt content observed around the rods, as measured in the May 2012 samples, indicate that changes seen over the course of the monitoring program reflect changes in the surface sediments over time, and to a lesser extent changes in grain size distribution over small distances at each rod site. The higher values of silt content measured at these sites in May as compared to during the biannual AMS monitoring program further imply that temporal changes are a significant factor. It is not possible, based on these data, to determine if these changes occur on a seasonal basis.

Construction-related activities in 2007 led to the formation of 'new' drainage channels in the mud flats adjacent to the DP3 perimeter dike. The 2012 study of the 'Area of New Drainage Channels' indicates that only very small amounts of sediment are being transported within these channels, and that the cross sectional shape of the channels has gradually flattened since their formation. Orthophoto mapping indicates the location of these new channels has remained consistent since 2008, following small adjustments immediately following their formation in 2007.

Orthophoto mapping indicates that the large system of dendritic channels (these dendritic channels originally developed during the 1980s) continues to shift laterally and extend shoreward. The amplitude of channel meanders, as determined from 2012 orthophotographs, is larger than has previously been observed, with an associated growth of point bars on the inside of meander bends. However, the increase in landward channel extension has changed less than previous years. The system of channels near the BC Ferries causeway has experienced only small changes relative to previous years prior to when the two separate channels joined together.

The 2012 orthophotographs also show a series of new sediment deposits on the tidal flats on the east side of the Deltaport causeway that appear to have formed from material originating from the East Causeway Habitat Compensation Project sites.

In general, ongoing change within the inter-causeway area has been detected through the interpretation of the orthophotos; however, this change cannot be directly attributed to the DP3 project. The exception is the formation of bars along the east side of the causeway from material lost from the nearby East Causeway Habitat Compensation Project. As there is no ongoing source of material, we would not expect these bars to continue to grow.

SURFACE WATER AND SEDIMENT QUALITY

The AMS program includes nine surface water and sediment quality monitoring stations:

- One in the ditch that drains into the inter-causeway area near the base of the BC Ferries Causeway (DP01).
- Six inter-causeway stations (DP02, DP03, DP04, DP05, DP08, and DP09).
- Two distant reference stations, located at the north end of Roberts Bank (DP06 and DP07).

All stations are located in intertidal areas, with the exception of two subtidal stations, DP05 and DP07 (they are located closest to the Strait of Georgia).

The 2012 surface water and sediment monitoring was carried out quarterly with surface water and sediment samples analyzed for nutrients quarterly and metals in Q1. Data evaluation focused on comparisons of the chemistry data to applicable regulatory guidelines and standards, as well as the assessment of temporal and spatial quality trends. Overall, metal and nutrient concentrations in surface water and sediment were within the same range as in previous years except for chlorophyll *a* as discussed below.

Other than the total boron in surface water samples collected from DP02 to DP09, there were no exceedances of the regulatory guidelines noted in Q1-2012. Total boron concentrations measured during 2012 were comparable to previous results and normal for coastal marine water in Canada. A number of metal parameters (cadmium, chromium, copper, manganese, and nickel) exceeded the regulatory guidelines in the surface water sampled collected from station DP01 (located downstream of the agricultural ditch) which is similar to previous years.

Similar to previous years, there were no metal exceedances of applicable regulatory criteria in sediment in 2012. The highest metal concentrations in sediment for 2012 were observed at the inter-causeway stations DP05 and DP09, specifically copper, and at reference station DP06. These three sediment samples had higher silt and clay content than the other samples based on the grain size data. Based on the lithium normalization technique, these metal results are considered reflective of natural background conditions.

Overall, based on the data collected to date, there is no evidence of increasing concentrations of metals or metals loading as a result of the DP3 construction or operation. It is recommended that the analysis of surface water and sediment samples for metals be discontinued.

As in previous years, nutrient concentrations were higher in sediments in the inter-causeway than at the reference stations. This likely relates to higher biological activity within the inter-causeway (as compared to the exposed location of the reference stations at the mouth of the Fraser River) and not to DP3 construction or operations.

Consistent with previous years, the highest nutrient concentrations in surface water were measured in the agricultural ditch near the base of the causeway (DP01), and are likely related to upland agricultural inputs. The highest chlorophyll *a* concentration between 2007 and 2012 was measured at DP04 in Q2-2012; however, higher concentrations have generally been detected during Q2 or Q3 sampling events due to warm water temperatures and increased light levels resulting in greater phytoplankton numbers.

Overall, nutrient concentrations in the inter-causeway area have not shown an increasing, or decreasing, trend for dissolved oxygen, in the six years of AMS monitoring (2007 – 2012). Ammonia concentrations in surface water in the inter-causeway stations appeared to have decrease between 2007 and 2009. The reference stations DP06 and DP07 have higher and more variable ammonia concentrations and appear to have decreased over the 2007 to 2012 time period. There are potential seasonal trends for organic nitrogen, TKN, and chlorophyll α in surface water with higher concentrations detected in Q2 and Q3. In addition, phosphate concentrations in surface water within both the inter-tidal causeway and the reference stations tend to be higher in Q4 sampling events (November or December).

Based on the data collected to date, there is no evidence of eutrophication occurring as a result of DP3 construction or operation.

EELGRASS

The eelgrass distribution in the new channel area and in other locations where change had been noted in 2011 were mapped on August 13, 14, and 15, 2012 to take advantage of the last good daytime low tides of 2012.

The SIMS survey was conducted on September 2, 2012. Analysis of the SIMS data revealed that the lower limit of Z. *marina* in the inter-causeway has not changed since 2003.

The assessment of epiphyte load and absence of *Beggiatoa* sp. indicate that the eelgrass habitat was healthy and functioning well.

The productivity (LAI) of *Z. marina* at most of the inter-causeway sites in 2012 was average. The similarity between the inter-annual LAI trends observed at Roberts Bank and in Boundary Bay indicates the inter-annual productivity at both locations is primarily governed by large-scale environmental factors, rather than local or site specific influences.

The development of DP3 resulted in a loss of *Z. marina* habitat in the area that was altered by sediment deposition from the new drainage channel formation adjacent to DP3 (as discussed in previous reports). The eelgrass habitat in this area increased between 2010 and 2011, however a decrease was observed in 2012.

There are no changes recommended to the eelgrass program for 2013.

COASTAL SEABIRDS / SHOREBIRD COMPOSITION

A third year of windshield surveys for Great Blue Heron (*Ardea heodias*) was conducted during June, July and August 2012. Recommendations in the 2011 Annual report (Hemmera, 2012b) advocated for continued heron surveys to verify that the low heron numbers documented in August 2011 were most likely the result of surveyor error and not indicative of a population decline.

Heron abundance and distribution within the inter-causeway in 2012 was similar to that documented prior to and after construction of DP3 (Hemmera 2005, Hemmera 2008d, Hemmera 2009, Hemmera 2010, Hemmera 2012a and Hemmera 2012b). Except for low heron numbers documented during the August 2011 survey, which are attributed to surveyor error, five years of construction and operation monitoring indicate that Great Blue Heron use of the inter-causeway has not changed from pre-construction levels.

SUMMARY OF RECOMMENDATIONS

To date, the data collected during the AMS monitoring program indicates no widespread physical nor biological change in the inter-causeway area following DP3 construction and operation.

Based on the findings to date, the following adaptations to the AMS program are recommended:

- As recommended in the 2011 annual report (Hemmera 2012b), the land-based topographic survey portion of the next ‘coastal mapping’ survey (scheduled for 2013) should cover an increased extent in the regions of the ‘trunk’ channels and the Crest Protection Structure and its adjacent channels to provide a greater area of overlap in the two datasets in order to improve confidence in the accuracy of the surface model within these areas.
- Continue to conduct orthophotograph interpretation and associated channel mapping of the inter-causeway area on an annual basis to assess the ongoing changes to the ‘area of new drainage channels’, the larger dendritic channel systems, and the newly formed sand deposits near the Deltaport Causeway (east side).
- Discontinue the annual metals analysis in surface water and sediment samples as data collected to date does not indicate increasing concentrations as a result of DP3 construction or operation.
- Discontinue the Great Blue Heron surveys in 2013 as data for herons collected from 2008 to 2012 has indicated that overall abundance and habitat use within the inter-causeway area by heron were similar to pre-construction surveys conducted from 2003 to 2004.

ACKNOWLEDGEMENTS

Hemmera gratefully acknowledges the contributions of our additional project team members:

Coastal Geomorphology:	Northwest Hydraulic Consultants Ltd. 30 Gostick Place North Vancouver, BC V7M 3G2
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In addition, Hemmera would also like to acknowledge the effort and contributions of the following individuals:

Vancouver Fraser Port Authority:	Darrell Desjardin, Director of Environment Carolina Eliasson, Environmental Specialist Carrie Brown, Environmental Specialist
Scientific Advisory Committee:	Rowland Atkins, M.Sc., P.Geo. Senior Geomorphologist, Golder Associates Ltd. Terri Sutherland, PhD Research Scientist, Science Branch, Department of Fisheries and Oceans Ron Ydenberg, PhD Department of Biological Sciences, Simon Fraser University

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GLOSSARY OF TERMS

ADCP	Acoustic Doppler Current Profiler
AWAC	Acoustic Wave and Current Meter
AMS	Adaptive Management Strategy
BC	British Columbia
BCF	BC Ferries
CCME	Canadian Council of Ministers of the Environment
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
CSR	Contaminated Sites Regulation
CWS	Canadian Wildlife Service
DF	Difference Factor
DP3	Deltaport Third Berth
DFO	Department of Fisheries and Oceans
DO	Dissolved Oxygen
DoD	Depth of Disturbance
DQO	Data Quality Objectives
EC	Environment Canada
Hs	Significant Wave Height
LAI	Leaf Area Index
MAL	Marine Aquatic Life
MEDS	Marine Environmental Data Service
NHC	Northwest Hydraulic Consultants
NTU	Nephalometric Turbidity Units
PC	Point Count
PDA	Personal Digital Assistant
PDO	Pacific Decadal Oscillation
QA/QC	Quality Assurance/Quality Control
RDL	Reported Detection Limit
RPD	Relative Percent Difference
RTK GPS	Real-Time Kinematic Global Positioning System
SAC	Scientific Advisory Committee
SARA	Species at Risk Act

$SedQC_{ss}$	Sediment Criteria for Sensitive Marine and Estuarine Sediments
SEM	Standard Error of the Mean
SIMS	Seabed Imaging and Mapping System
TFN	Tsawwassen First Nation
TKN	Total Kjeldahl Nitrogen
Tp	Wave Period
TSS	Total Suspended Solids
VFPA	Vancouver Fraser Port Authority
WHSRN	Western Hemispheric Shorebird Reserve Network
WQG	Water Quality Guidelines

1.0 INTRODUCTION

At the request of the Vancouver Fraser Port Authority (VFPA), Hemmera Envirochem Inc. (Hemmera), Northwest Hydraulics (NHC) and Precision Identification (Precision) are pleased to provide this 2012 Annual Report for the Adaptive Management Strategy (AMS) for the Deltaport Third Berth (DP3) project. This report summarizes and interprets the findings of the sixth year (2012) of the AMS program, and provides recommendations for adapting the program for the seventh year of monitoring.

Similar to previous annual reports, the document is structured as follows:

- Results section: presents the 2012 results.
- Discussion section: compares the 2012 data to previous years results.
- Conclusions and Recommendations section: includes a discussion of overall trends of the AMS program and provides recommendations for adaptations of the monitoring program.

1.1 BACKGROUND

1.1.1 DP3 Project Description

Deltaport is a marine container terminal located on Roberts Bank in Delta, BC (**Figure 1**). The DP3 project involved the construction to accommodate an additional ship berth along with approximately twenty hectares of land for an expanded container storage yard and dredging to deepen the existing ship channel and creation of an adjacent tug moorage area.

The DP3 project was subject to both the provincial *British Columbia Environmental Assessment Act* and the federal *Canadian Environmental Assessment Act*. The environmental assessment involved a large number of studies including coastal geomorphology, water quality, sediment quality, marine resources, coastal seabirds and waterfowl, vegetation and wildlife, archaeology, socio-economics, noise, visual and lighting, air quality, and road, rail and ship traffic. This report is available from the BC Environmental Assessment Office website (http://www.eao.gov.bc.ca/). As part of the acceptance of the environmental assessment by the BC Environmental Assessment Office were recommendations by Environment Canada – Canadian Wildlife Service (CWS) that an AMS be developed to provide practical advance warning of potential emerging negative ecosystem trends during project construction and operation.

A timeline of post-construction and key operation activities is presented in **Table 1.1-1**.

All terminal construction was complete in 2009, with construction of habitat compensation features completed in 2010. The terminal began operations in January 2010. There were no known activities of significance in 2012 and therefore, the timeline in **Table 1.1-1** below does not show 2012.

Table 1.1-1 Timeline of Post-construction and Operation Activities

Site Activities	Timeline									
	2009		2010				2011			
	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Marine Construction Demobilization	DCL demobilized from site in July 2009									
TSI Terminal Finishing Works (land based) including electrical, paving, drainage	On-going	Completed December 2009								
DP3 official opening and start of operations			Operations start January 2010	On-going						
East Causeway Habitat Compensation Project		Start of Construction September 2009	On-going	On-going	On-going	Construction complete September 2010				
Removal of Temporary Barge Ramp Facility (Tug Basin)										November 8 to December 5

1.1.2 AMS Project Objectives

The objectives of the AMS project are to undertake a science-based systematic approach to the monitoring of the Roberts Bank inter-causeway ecosystem to reduce uncertainty and assess the potential for negative trends in the ecosystem from marine eutrophication and dendritic channelization. This approach should:

1. Provide practical advance warning of potential emerging negative ecosystem trends during DP3 construction and operation.
2. Establish actions that VFPA would undertake to prevent or mitigate negative trends that exceed applicable thresholds and may be linked to the DP3 project.

The AMS includes monitoring methods to specifically identify and mitigate potential environmental effects in the following areas of concern (the AMS project team member completing the work is shown in brackets):

- Coastal geomorphology (NHC).
- Surface water quality (Hemmera).
- Sediment quality (Hemmera).
- Eelgrass distribution (Precision).
- Benthic community structure (Hemmera).
- Coastal seabird / shorebird composition (Hemmera).

1.2 Scope of Work

The AMS support program has been implemented to address concerns and meet requirements of stakeholders such as Environment Canada (EC), the Department of Fisheries and Oceans (DFO) and the CWS as well as other legislation, guidelines, and best management practices applicable to the work. The AMS involves the identification, management, prevention, and mitigation of environmental effects that may result from DP3 construction. The AMS program also undergoes an independent peer review by a Scientific Advisory Committee (SAC), comprised of scientists with expertise in the various study areas of the AMS, appointed by VFPA and EC.

The scope-of-work for the annual report involved completion of the following tasks:

- Analysis of orthophotograph data that were collected, in part, to support coastal geomorphology/oceanography monitoring.
- Analysis of quarterly data from surface water quality monitoring.
- Analysis of quarterly data from sediment quality monitoring.
- Analysis of eelgrass data collected between July and September 2012.

- Analysis of three windshield surveys for Great Blue Heron between June and August 2012.
- Evaluating the data relative to the objectives of the AMS program. Data evaluation included looking at both temporal and spatial trends in the data observed during the year as well as comparison to data collected from previous years, where applicable.
- Providing recommendations based on the findings to date, for adaptations to the AMS program and/or mitigation measures that may be required if adverse impacts are observed.

A detailed list of monitoring activities completed between 2007 and 2012 is presented in **Table 1**. A chronology of key adaptations to the AMS program implemented from 2007 through to 2012 is presented in **Table 2**. A summary of the rationale for the adaptations is presented in **Table 3**.

1.2.1 Coastal Geomorphology

The physical environment of the study area for the AMS monitoring program provides the basis for the ecological features and functions that define Roberts Bank. NHC has responsibility for the Coastal Geomorphology portion of the AMS monitoring program for the area defined as the inter-causeway portion of the Roberts Bank tidal flats, extending shoreward to the dikes and seaward to the delta foreslope and includes the deeper waters in the vicinity of the new terminal. The tidal flats represent the sub-aqueous top-set beds of the Fraser River Delta and at Roberts Bank the zone is generally featureless except for the development of tidal channels. Prior to the construction of the BC Ferries and Deltaport causeways, this area would have been swept by the Fraser River plume, depositing sediments and nutrients. The environment was also shaped by wind-generated waves and tidal currents from the Strait of Georgia. With the construction of the causeways, beginning in the early 1950s, the processes affecting the inter-causeway area have been modified, primarily through diversion of the Fraser plume, a reduction in wave energy, and the expansion of eelgrass beds on the tidal flats.

A comprehensive Coastal Geomorphology Study of the Roberts Bank area was completed by NHC as part of the environmental impact assessment phase of the project (NHC 2004). This document provides background and rationale that have informed the design of the present monitoring program. In particular, the Coastal Geomorphology Study provides a very detailed description of the history of the natural and human-influenced evolution of the study area, with particular emphasis on providing greater detail for the proximal portions of the study area and less detail for the distal regions. The approach taken by the Coastal Geomorphology Study was to view the inter-causeway portion of Roberts Bank as a relatively isolated zone, cut off from geomorphically significant inputs of sediment but also partially protected from the higher energy waves and currents that continue to shape the rest of the delta front.

The Coastal Geomorphology portion of the AMS monitoring program includes six primary activities:

- Monitoring of the physical conditions in the area around the Crest Protection Structure (**Figure 2**).
- Automated monitoring of turbidity in the water column on the tidal flats (**Figure 3**).

- Automated monitoring of erosion and deposition on the tidal flats in the immediate vicinity of the new terminal (**Figure 3**).
- Collection and analysis of sediment samples for analysis of grain size (**Figures 4** and **5**).
- Interpretation of orthophotographs for the purpose of detecting large-scale geomorphic adjustments to the study area.
- Coastal geomorphology mapping, consisting of hydrographic and topographic surveys.
- Wave monitoring.

Based on recommendations included in the AMS 2009 Annual Report (Hemmera, 2010), the instrumentation used to monitor both turbidity and waves was removed during the Q3-2010 monitoring period, thus marking the termination of the wave and turbidity monitoring portions of the AMS program. Based on recommendations included in the AMS 2011 Annual Report (Hemmera, 2012b), the remaining field-based components of the monitoring program - including the Crest Protection Structure monitoring, monitoring of erosion and deposition, and collection and analysis of sediment samples for grain size analysis - were discontinued as of January 1, 2012.

1.2.2 Surface Water Quality

Changes in surface water chemistry are one of the first indicators of emerging ecosystem trends. The objectives of the surface water study are to identify any early trends suggesting that eutrophication is occurring or that metal concentrations are increasing as a result of DP3 construction or operation.

In the context of the AMS, marine eutrophication has been defined as an enrichment of nutrients in the inter-causeway area surface water and sediment that affects, or has the potential to affect, the health and stability of the marine ecosystem at Roberts Bank. The primary source of nutrients from Deltaport is primarily treated sewage effluent. The sewage treatment plant was constructed as part of the initial Deltaport container terminal development in 1997 and provides secondary treatment of sewage prior to discharge. The sewage treatment plant is permitted under a Ministry of Water Land and Air Protection (MWLAP) effluent permit PE-14865 to discharge treated effluent into the Deltaport ship berth at a depth of 12 metres below mean low water. The projected increase in sewage output from the DP3 project was considered to be minimal. Other sources of nutrients to the DP3 area include agricultural inputs from the surrounding area and from the Fraser River, municipal waste discharges, upwelling from Georgia Straight, and bird and wildlife excreta.

Historical water quality data for Roberts Bank and the surrounding data were available from data compilations conducted by Triton (2001) and Swain et al. (1998).

It should be noted that the potential for large-scale eutrophication in the Straight of Georgia is considered low for two reasons. First, total primary productivity is insensitive to moderate increases or decreases in nitrogen concentrations because nitrogen concentrations in the Georgia Strait are naturally elevated (2-20 µM) (Mackas and Harrison 1997). Second, the inter-causeway area is subject to regular tidal and nutrient exchange.

If eutrophication were occurring, one would first expect to see an increase in nutrient concentrations, followed by an increase in chlorophyll *α* and a decrease in dissolved oxygen and clarity, as primary productivity increased. Nuisance algal blooms would decrease the amount of light penetrating the water column, affecting eelgrass growth and sediment chemistry. Seasonal hypoxia in summer months, resulting from increased plant growth due longer days and warmer water temperatures, would precede more widespread hypoxia and reduced water transparency. **Table 1.2-1** below describes the progression of eutrophication.

Table 1.2-1 Progression of Eutrophication

Nutrient Enrichment	Primary Symptoms	Secondary Symptoms
• Increased concentrations of nitrogen and phosphorus. • Changes in nutrient ratios.	• Increased phytoplankton primary production and biomass. • Changed phytoplankton community structure. • Harmful algal blooms. • Increased growth of short-lived nuisance macroalgae. • Increased sedimentation of organic matter.	• Reduced water transparency. • Altered distribution of long-lived submerged vegetation. • Altered benthic invertebrate communities. • Reduced bottom water oxygen concentrations. • Kills of bottom-dwelling fish and invertebrates.

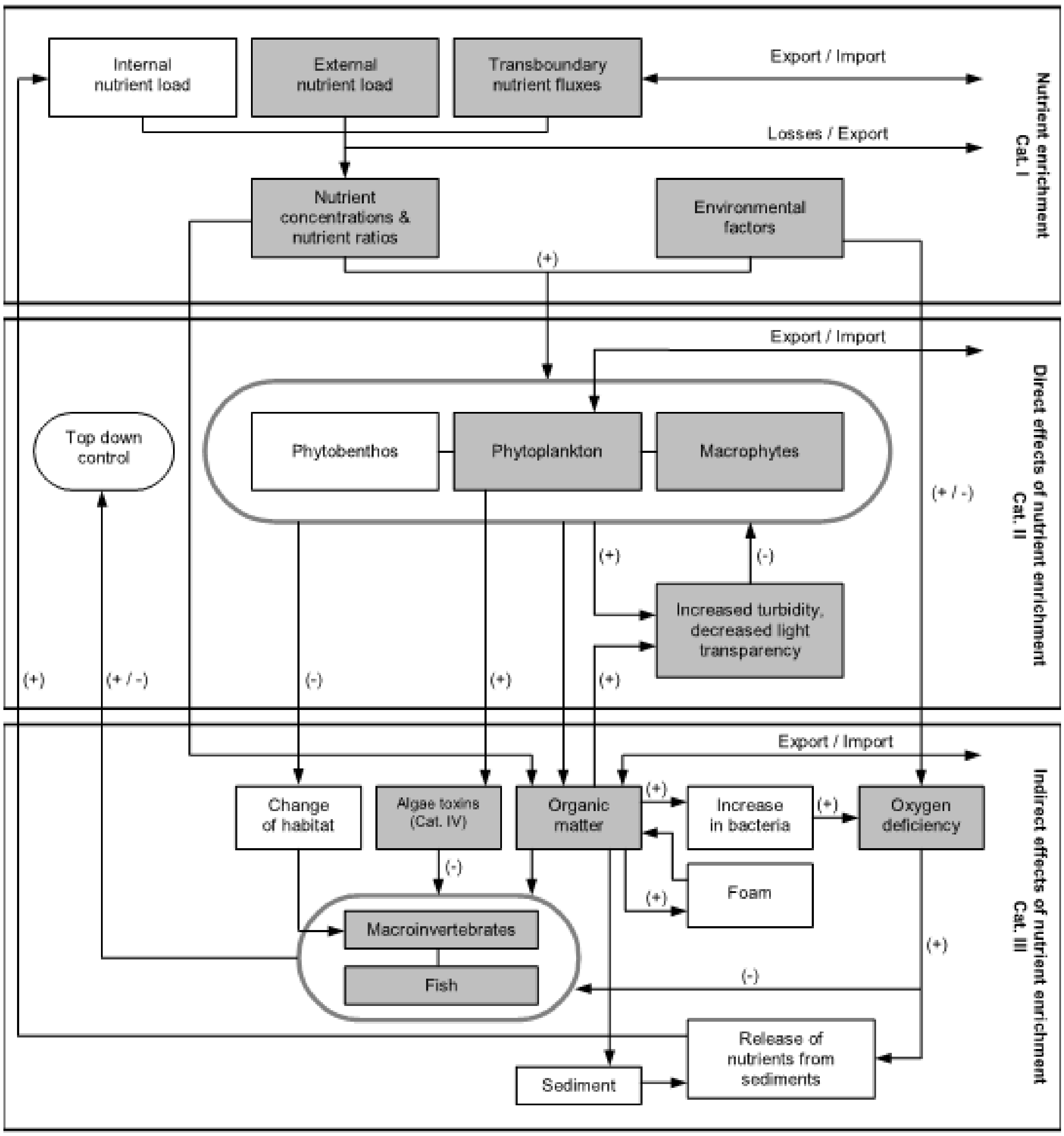
Figure 1.2-1 provides a more detailed illustration of the feedback loops involved in the eutrophication process. The illustration is taken from the Oslo Paris Commission document title ‘Ecological Quality Objectives for the Greater North Sea with Regard to Nutrients and Eutrophication Effects’ (OSPAR 2005).

As noted above, surface water chemistry is used as a first tier indicator of potential eutrophication in the inter-causeway area at Roberts Bank.

Surface water samples have been collected by Hemmera at seven fixed surface water and sediment monitoring stations since 2007 (**Figures 6** and **7**). Surface water samples were collected at two additional fixed sampling stations in the inter-causeway area beginning in 2009 that were added to enhance the benthic invertebrate sampling program as per recommendations from the SAC.

In addition to the quarterly monitoring, the waters of the upper end of the DP3 turning basin (near DP04) were also monitored continuously (every 15 minutes) for pH, temperature, and dissolved oxygen using a YSI 6600V2 buoy-mounted sonde. The sonde was damaged twice by storms during continuous deployment in 2007 and 2008 so, in 2009, to avoid damage due to storm events, the sonde was no longer deployed continuously but rather for approximately one week each quarter. Quarterly deployment of the Sonde was discontinued in 2012.

Figure 1.2-1 Generic Conceptual Framework to Assess Eutrophication (OSPAR 2005)



1.2.3 Sediment Quality

Changes in sediment chemistry are also an indicator of emerging ecosystem trends. The objectives of the sediment chemistry study are the same as for surface water: to identify any trends suggesting that eutrophication is occurring or that metal concentrations are increasing as a result of DP3 construction or operation.

An extensive sediment sampling program was conducted to the east and west of the Deltaport causeway prior to DP3 construction (Hemmera 2004). Historical sediment data for the reference area are presented in Stancil (1980).

Changes in sediment chemistry would be expected to occur after trends signalling eutrophication were noted in surface water. The decomposition of algae would lead to an increase in nutrient concentrations in sediment, a decrease in redox values, and an increase in sulphide concentrations. Metal concentrations in sediment could potentially increase as a result of co-deposition with sulphides. Sediment chemistry is also used as a first tier indicator of potential eutrophication in the inter-causeway area at Roberts Bank as changes in sediment chemistry would be expected to affect the composition of the benthic invertebrate community and the health of the eelgrass community.

1.2.4 Eelgrass

Eelgrass (*Zostera* spp.) meadows provide a variety of ecological services that assist in the maintenance of healthy estuarine and marine habitats. Eelgrass habitat is considered essential habitat because it is the basis of primary production that supports both economically and ecologically important finfish and shellfish populations (Duarte et al. 2008). Native eelgrass (*Z. marina*) meadows support numerous commercially important finfish and shellfish species (Orth and Heck 1980, Phillips 1984, Heck et al. 1989, 1995, 2003, Fredette et al. 1990, Short et al. 1993, Dean and Haldorson 2000, Beck et al. 2001).

Ducks, swans, and geese are known to forage on *Z. marina* during migration. Black brant geese are dependant of *Z. marina* as their primary food source; their migration route follows *Z. marina* meadows from Alaska to Mexico and back (Wyllie-Echeverria and Ackerman 2003). Herons are known to forage for prey extensively in *Z. marina* meadows (Essinger 2007). Baldwin and Lovvorn reported that waterfowl distribution in Boundary Bay, British Columbia was related to the presence of *Zostera* spp. (1994a), and that the expansion of *Z. japonica* habitat at that location resulted in a local increase in the abundance of dabbling ducks and brant (1994b).

Zostera species sequester large amounts of carbon and the productivity of a healthy eelgrass meadow rivals that of most oceanic and terrestrial ecosystems (Mateo et al. 2007). The eelgrass provides a substrate and habitat for numerous species epiphytes, epibenthos, and benthos which add to the overall productivity of the habitat (Fredette et al. 1990).

Eelgrass produces oxygen through photosynthesis and releases it into the water and sediment (Constanza et al. 1997, Marba et al. 2007).

Zostera species increase decomposition rates in sediments, regulate nutrient cycles, and accelerate nutrient regeneration (Short 1987, Hansen et al. 2000).

Zostera meadows act as a filter trapping and binding sediments (Fonseca 1992, Heiss et al. 2000) and removing contaminants (Lyngby and Brix 1982, Francoise et al. 1989, Hoven et al. 1999). The *Zostera* leaves baffle currents and waves reducing coastal erosion (Koch and Verduin 2001).

Roberts Bank, including the inter-causeway area, supports the largest native eelgrass (*Zostera marina*) meadow in southern British Columbia. Dramatic increases in the area colonized by native eelgrass occurred between 1967 and 2003 (Durance 2004a and 2004b, Harrison 2004).

The large increases in *Z. marina* habitat at this location are likely the result of several factors:

- The Deltaport causeway deflects the plume of the Fraser River, hence the turbidity of the water over the inter-causeway eelgrass bed has decreased since the causeway was developed. The reduction in turbidity results in increased photoperiod duration and intensity for the eelgrass, which may have stimulated growth and reproduction.
- The BC Ferry causeway may protect the eelgrass bed from severe south easterly winter storms. Eelgrass beds along the Washington and Oregon coast are often partially removed by winter storms. Although this has never been formally documented in British Columbia there is evidence that it occurs in Boundary Bay.
- The introduction and rapid mudflat colonization by *Z. japonica* may have resulted in ponding of water at higher elevations during low tide (Tarbotton and Harrison 1996). This may have enabled *Z. marina*, which is more susceptible to desiccation, to colonize areas higher than previously possible. Once established *Z. marina* could out compete (shade) the smaller *Z. japonica*.
- Studies conducted during the 1970s and 1980s along the Pacific coast determined that the successful establishment of *Z. marina* from seedlings was very rare. However, in the last decade researchers have noted the successful establishment of many seedlings in eelgrass beds from California to British Columbia (S. Wyllie-Escherverria, pers. comm.; C. Durance, pers. obs.). It is possible that the increased amount of available light accelerates seedling development, enhancing seedling survival. Billions of *Zostera* seeds are produced in the inter-causeway annually, hence even a small increase in survivorship could lead to a dramatic increase in density and distribution.

Z. japonica, an introduced species of eelgrass, was first identified in the inter-causeway area in 1976 (Harrison and Bigley 1982). The area colonized *by Z. japonica* rapidly increased to 317 hectares by 2003 (FREMP, 2003). *Z. japonica* colonized areas that were above the optimal range for *Z. marina.*

Zostera populations are declining globally; primarily due to anthropogenic stresses (Short and Wyllie-Escheverria, 1996, 2000). The specific factors responsible for declines include: increased nutrient inputs resulting in decreased light availability (Kemp et al. 1983, Moore et al 1997); increased nitrogen loading leading to increased algal abundance (den Hartog 1994, Short and Burdick, 1996, Bowen and Valiela 2001); organic enrichment resulting in sediment reducing conditions and anoxia (De Casabianca et al. 1997, Flindt et al. 1997, Terrados et al. 1999); elevated sulphide levels impacting root metabolism (Smith et al, 1988), nutrient uptake (Pregnall et al. 1984), and photosynthetic processes (Goodman et al. 1995); physical disturbance through fishing practices; and shoreline development including dredging, filling, and shoreline hardening (Moore and Short 2007).

Z. marina is often used as an indicator species to monitor and/or assess ecosystem health since changes in light availability or water quality conditions will affect the distribution, abundance, and growth of the species (Dennison et al. 1993, Short et al. 1993). Therefore, the AMS program monitors the health and vigour of *Z. marina* and the distribution of *Z. marina* and *Z. japonica* in the inter-causeway area of Roberts Bank. Changes in surface water and sediment chemistry would be expected to affect the health of the eelgrass community and thus the composition of the benthic invertebrate community; therefore eelgrass health and vigour are used as a second tier indicator.

1.2.4.1 Eelgrass Survey Objectives and Rationale

The eelgrass survey was designed to detect changes in the eelgrass habitat of the inter-causeway area and to determine whether any changes were caused directly or indirectly by the development of DP3. The specific objectives of the eelgrass monitoring plan are:

- To map the distribution of eelgrass (*Z. marina and Z. japonica*) the inter-causeway annually via remote sensing.
- To monitor the vigour and species composition of eelgrass at the nine reference stations (**Figures 8** and **9**) that were established for the Deltaport Third Berth EA, and to record the presence of epiphytes and *Beggiatoa* sp. at each of these stations annually.
- To map the lower limit of eelgrass of eelgrass distribution within the inter-causeway area using the Seabed Imaging and Mapping System (SIMS) every three years (2009, 2012).

The objectives were based on rationale provided in the literature by numerous seagrass scientists and by decades of experience studying the Roberts Bank eelgrass meadows. The rationale behind each of the objectives is explained in the following sections.

1.2.4.2 Distribution Map

The distribution of *Z. marina* and *Z. japonica* may vary inter annually due to natural factors that include: climate; mean sea level; and the timing, duration, and amplitude of low and high tides. Anthropogenic impacts that cause changes in light availability, water quality conditions, or sedimentation / erosion rates could also alter the distribution of the two *Zostera* species.

A baseline map of the eelgrass distribution was prepared in 2003 for the Deltaport Third Berth Project Marine Resources Impact Assessment (Triton 2004). The annual AMS eelgrass surveys map the current distribution of both species and use the maps to detect changes that have occurred relative to 2003 and previous AMS study years.

1.2.4.3 Eelgrass Health and Vigour

Slight changes in light availability or water quality conditions can affect the productivity of *Z. marina*. The relative productivity of *Z. marina* was estimated at eleven reference stations as part of the Deltaport Third Berth Project Marine Resources Impact Assessment (Triton 2004). Nine of the original reference stations were selected for the AMS. These stations are monitored annually to detect changes in eelgrass productivity. The stations that were selected included all those located in the inter-causeway, two west of the Deltaport Causeway, and three in Boundary Bay as shown on **Figures 8** and **9**. Changes in the inter-causeway eelgrass productivity could be related to influences other than the development of DP3, the data from stations west of the Deltaport Causeway could assist in differentiating between changes caused by the development of DP3 and other local sources such as the Fraser River plume. The Boundary Bay stations (**Figure 9**) were selected to provide data to assess effects of large scale environmental variation on eelgrass.

The eelgrass habitat at Site 1 was very similar to that at Site 2 in 2003 (**Figure 8**). Site 2 was selected due to its proximity to DP3. Site 1 was selected as a reference by which to assess changes in the eelgrass habitat adjacent to DP3 should they occur. The habitat in the vicinity of Site 1 changed from dense continuous *Z. marina* in 2003 to patchy mixed eelgrass by 2008, Site 1 was no longer suitable for comparison to Site 2, therefore a new station, Site 1B was established (**Figure 8**). The eelgrass habitat at Site 1B is very similar to that at Site 2. Site 1 was renamed Site 1A (**Figure 8**), monitoring will continue at this site as the data may provide insight into the evolution of the sand lobe.

The three reference stations in Boundary Bay were selected in 2003 to represent eelgrass habitat within a range similar to the sites included in the 2003 Roberts Bank study area. Reference site WR1 is located near the upper limit of the eelgrass bed; the *Z. marina* at this location is similar in stature and density to *Z. japonica*. The 2003 Roberts Bank study area included a site west of the Deltaport Causeway that provided habitat similar to WR1 in Boundary Bay; this site was not included in the AMS surveys due to the absence of this habitat type within the inter-causeway area. The reference site WR1 was surveyed each year while waiting for the tide to ebb providing access to WR2 and WR3; however since WR1 is not similar to any sites in the inter-causeway the data from WR1 is not assessed for the AMS. Reference site WR2 is slightly lower than site WR1 and therefore supports larger plants. Site WR3 is the deepest and supports the largest plants of the three reference sites in Boundary Bay.

The productivity of eelgrass varies seasonally, thus the annual sampling is conducted at a date comparable, within a few weeks, to the date when the 2003 data was collected.

A variety of epiphytes colonize eelgrass; these are an important food source for many organisms and add to the overall productivity of the habitat. However, there have been several instances where epiphyte populations have surpassed natural levels and smothered eelgrass to the extent the habitat was severely impacted or destroyed. Two causes for these extensive epiphyte increases have been identified; eutrophication and over fishing. Eutrophication has occurred in poorly flushed estuaries when the nutrient load, usually from upland sources, increases. The added nutrients encouraged the growth of epiphytes that smothered the eelgrass. The epiphytes comprise a lower level on many food webs. Epiphytes are consumed by small grazers (amphipods, copepods, etc.) that are then consumed by small fish; small fish are eventually consumed by larger fish. The extensive removal of large fish via commercial fishing unbalances the system. The abundance of small fish increases because fewer are consumed by large fish. The increase in small fish abundance leads to a decrease in grazer population that would have otherwise kept the epiphytes in balance.

The AMS monitors the relative abundance of epiphytes at each of the reference stations annually as an early indicator of potential degradation within the eelgrass habitat.

Beggiatoa sp. is frequently used as an indicator species to identify degraded marine habitats. The filamentous preteobacteria forms visible whitish mats in many polluted marine environments, especially those with eutrophic sediments rich in hydrogen sulphide and low in oxygen. *Beggiatoa* sp. has not been observed at Roberts Bank however the eelgrass survey team searches for evidence of it during the other field surveys, as it would indicate a decline in the health of the ecosystem. The VFPA would be notified immediately if *Beggiatoa* sp. was discovered in the inter-causeway area. A monitoring program would be immediately developed and implemented.

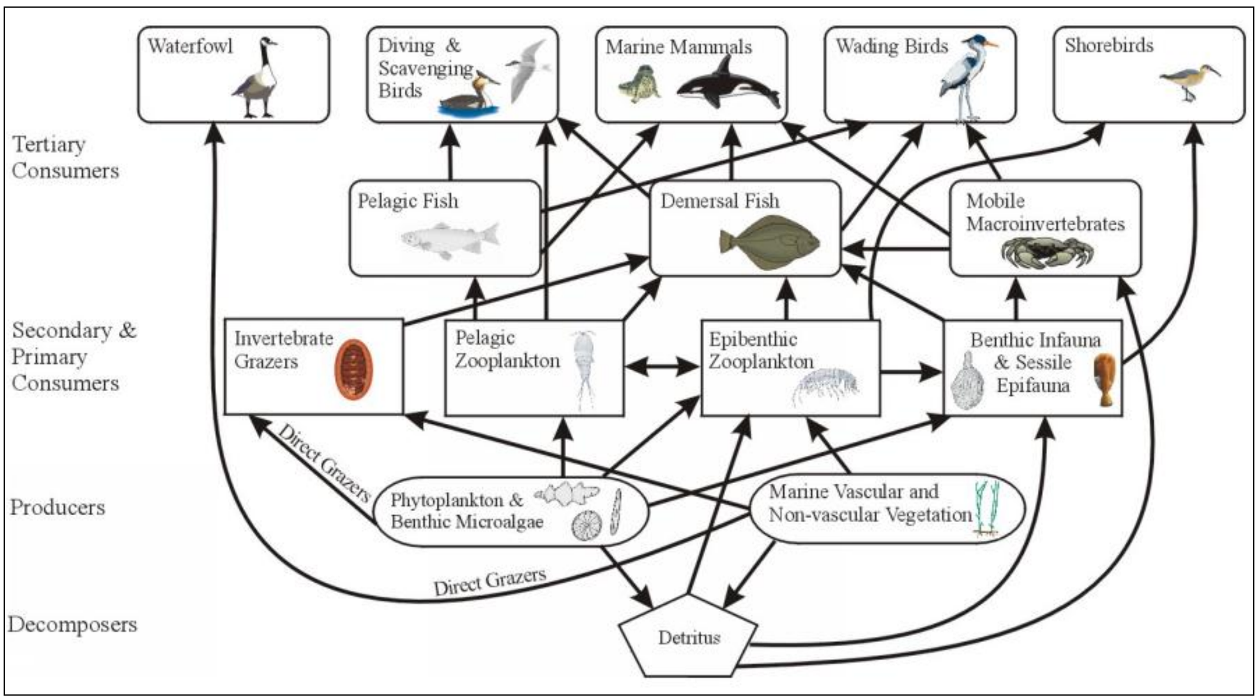
1.2.4.4 Lower Limit of Eelgrass Distribution

The lower limit of eelgrass distribution is dependant on many factors including; light penetration (turbidity), current, and substrate type. The lower limit of an established eelgrass meadow may be decreased by anthropogenic impacts that increase turbidity (e.g. suspended sediments, nutrients) or increase currents (e.g. bow thrusters, vessel traffic). The maximum depth of eelgrass distribution along highly developed portions of the eastern coast of the United States is less than one metre, while in the clear waters off of Alaska it has been recorded at depths greater than 30 metres. The lower limit of the inter-causeway eelgrass meadow is not usually visible on orthophotos due to the influence of the turbid Fraser River. The extent that is visible on the photographs is dependant not only on the turbidity at the time of filming but also on the tide height. The annual remote sensing mapping is not capable of determining the depth limit of eelgrass in the inter causeway. In order to assess whether the depth distribution of eelgrass has changed over time the lower limit of the eelgrass meadow is mapped tri-annually (2009, 2012) using an integrated remotely operated towed video camera and GPS system.

1.2.5 Benthic Community

Benthic invertebrates play a critical role in maintaining ecosystem health, as a food source for birds, fish, and macroinvertebrates (Peterson et al. 2000) (**Figure 1.2-2**).

Figure 1.2-2 Conceptual Marine Food Web for Roberts Bank (Triton 2004)



Subtidal habitats tend to be physically predictable. In contrast, intertidal habitats are characterized by greater variability in physical factors, including waves, tidal currents, erosion, slope, light, air exposure, temperature, salinity, and sediment stability. Burd et al. (1998) note that the influence of these factors, as well as biological factors, can lead to spatial heterogeneity of intertidal assemblages in what appear to be similar habitats. An earlier study by Burd et al. (1987) in the intertidal zone in Boundary Bay found that not only sediment grain size, but also the presence of eelgrass affected the species assemblage, with benthic communities in eelgrass beds structurally different and more diverse than those in nearby bare sediments.

Changes in the benthic invertebrate community linked to eutrophication would only be expected to occur after changes in surface water chemistry and/or sediment chemistry were noted. In the initial stages, benthic invertebrate abundance would be expected to increase as a result of increased nutrient availability. Benthic invertebrates can cope with oxygen depletion to varying degrees (days to month). As the amount of oxygen available in sediment decreased, the structure of the benthic invertebrate community would be expected to change, with more tolerant suspension and burrowing detritus feeders increasing in abundance. Signs of such change would include an increase in the ratio of polychaetes to amphipods and an increase in the ratio of *polychaeta sedentaria* to *polychaeta errantia*.

In cases of severe eutrophication, overall benthic invertebrate abundance would be expected to decrease significantly, with only the most tolerant species surviving. This would result from a combination of factors including excessive organic matter deposition, oxygen depletion, and the presence of high concentrations of ammonia and free sulphides in sediment pore water. For benthic habitats, much of the increased primary production is delivered directly to microbial loops (Baird et al. 2004). Higher rates of microbial decomposition can deplete dissolved oxygen near the sediment–water interface and produce hydrogen sulphide that enters pore water, and eventually the water column (Diaz & Rosenberg 1995). Organic matter deposition can also directly smother benthic invertebrates. Therefore, benthic community, like eelgrass health and vigour, is also a second tier indicator.

The goal of the benthic invertebrate community analysis of the AMS is to determine if changes in ecosystem processes and characteristics that may indicate increased nutrient loading and/or altered sediment transport regimes are evident based on especially temporal changes in the benthic invertebrate community. Natural variability in benthic invertebrate communities can make it difficult to determine if subtle changes are occurring as a result of seabed eutrophication or other causes. Site-specific factors will affect the composition of the benthic invertebrate community and its sensitivity to increased nutrient loading.

1.2.6 Birds

The Fraser River Delta provides habitat that is international in its significance for a wide variety of birds including waterfowl, shorebirds, coastal seabirds, Great Blue Herons, and raptors. Annually, approximately 1.4 million birds use the Delta during the peak of migration (Butler and Campbell 1987). The Fraser River Estuary, which includes Roberts Bank and the inter-causeway area between the Deltaport Causeway and the BC Ferries Causeway, provides critical habitat for the largest wintering concentrations of waterbirds and raptors in Canada (BC Waterfowl Society 2006).

Two listed species that use the region include the Great Blue Heron (*Ardea herodias*) and Black Brant Geese (*Branta bernicla*) (Brant). Great Blue Heron (*fannini* subspecies) are listed federally by the Committee on the Status of Endangered Wildlife (COSEWIC) under the *Species at Risk Act* (SARA, Schedule 1) as a species of ‘Special Concern’. Provincially, the coastal *fannini* subspecies is blue-listed due to declining populations attributed primarily to human development and in part to increasing disturbance from eagle populations (Gebauer and Moul 2001). Brant are also provincially blue-listed. Blue-listed organisms are indigenous species or subspecies considered to be of Special Concern in British Columbia, but whose populations are not so imperilled as to be considered threatened with, or in danger of, extirpation (i.e., red-listed).

Due to the potential for disturbance to this habitat resulting from Deltaport Third Berth construction, Hemmera monitored waterfowl and coastal seabird use of the inter-causeway from 2007 to 2009 as part of the Deltaport AMS (Hemmera 2008a, 2008b, 2008c, 2009). The main objectives of this work were to provide data towards answering a concern regarding potential marine eutrophication, changes to coastal erosion processes and the distribution and composition of local biota, including shorebirds and coastal seabirds in the inter-causeway area. The bird study data were considered one indicator of ecosystem structure and function on a relatively broad spatial-temporal scale. Ecosystem changes leading to adverse ecosystem effects (e.g., eutrophication and erosion) that might have been attributable to DP3 construction activity would likely have been first detected through monitoring at a finer scale (e.g., water quality, benthic community, and eelgrass monitoring). Therefore, bird monitoring was considered a third tier indicator of potential eutrophication.

An additional concern was that construction activities could potentially alter bird feeding and/or resting behaviours and bioenergetics. As such, monitoring bird relative abundance, distribution and behaviour in the context of the DP3 construction activity was conducted as an important indicator of construction-related effects to a valued ecosystem component.

Due to the possibility that changes to the ecosystem over time can affect key species such as Great Blue Heron, Brant, Western Sandpiper (*Calidris mauri*), and Dunlin (*Calidris alpina*), monitoring bird usage within the inter-causeway area was part of the overall strategy to monitor ecosystem structure and function in the inter-causeway area. To that end, the following bird study objectives were identified for studies conducted between 2007 and 2009:

1. Determine whether there are impacts to Brant and Great Blue Heron usage of the inter-causeway area during critical periods of construction and operation.
2. Determine whether there are impacts on coastal seabird and shorebird usage of the inter-causeway area during construction.

Construction of Deltaport Third Berth was completed in December 2009. Results for the first three years of monitoring indicated that overall bird abundance and habitat use within the inter-causeway area did not differ significantly compared to pre-construction surveys conducted from 2003-2004 (Hemmera 2005).

In 2010, after completing three years of coastal waterbird point count surveys and following consultation with Port Metro Vancouver, the scope of bird surveys was changed to focus on two species, Brant and Great Blue Heron. Then after review of the 2011 data, and in consultation with Scientific Advisory Committee (SAC), the decision was made to discontinue Brant surveys in 2012 and continue with Great Blue Heron surveys using windshield survey methodologies described in **Appendix A**.

1.3 FIELD METHODOLOGIES

The detailed field methodologies for the various survey and sampling methods are included in the Detailed Workplan document prepared for the VFPA by Hemmera (2007a) and a summary is also attached in **Appendix A** (updated to reflect 2011 changes). The following sections provide some of the basic methodology along with any methodological variations that were necessary for completion of the work.

1.3.1 Coastal Geomorphology

Monitoring for the AMS program began in April 2007 and has continued through 2012. However, the field-based components of the monitoring program were discontinued as of January 1, 2012, based on recommendations made in the 2011 AMS annual report (Hemmera, 2012b). The following sub-sections provide a summary of the methodology and timing for each monitoring activity. A detailed description of the methodology is presented in **Appendix A**.

1.3.1.1 Crest Protection Structure Monitoring

Monitoring of the Crest Protection Structure was discontinued at the end of 2011. No additional data were collected in 2012 related to this activity. **Figure 2** shows the former locations of the monitoring cross-sections as well as the monitoring points on the Crest Protection Structure.

1.3.1.2 Automated Turbidity Monitoring

Automated Turbidity Monitoring was discontinued during 2010. No additional data were collected during 2012 under this activity. The previous location of the turbidity instrument is shown in **Figure 3**.

1.3.1.3 Monitoring of Erosion and Deposition

Monitoring of erosion and deposition was discontinued as of January 1, 2012. No additional data were collected during 2012 under this activity. The previous locations of the DoD rods are shown in **Figure 4** and **Figure 5** illustrates the sequential measurements that were made to calculate maximum scour and net deposition. All DoD rods were removed from the study area in May 2012.

1.3.1.4 Sediment Samples

Collection of sediment samples was discontinued as of January 1, 2012. No additional data were collected during 2012 under this activity.

1.3.1.5 Interpretation of Orthophotographs

Orthophotographic mapping was proposed in the AMS Plan for the purpose of tracking the dendritic channelization process as well as other geomorphic features within the study area. Aerial photographs of the study area are scheduled to be taken on a yearly basis during summer low tides in July. The 2012 photos were flown on July 6 during a low tide of 0.8 m Chart Datum. Aerial photos were evaluated to assess trends and patterns of erosion and/or accretion on the tidal flats as well as changes to any other significant features such as tidal channels. This evaluation is conducted annually and covers the entire inter-causeway tidal flat area. The methodology consists of overlaying successive ortho-rectified photographs using GIS mapping techniques to delineate and identify morphological changes on the tidal flats. A set of systematic mapping protocols was developed to map geomorphic features and allow comparison between photos taken in successive years. Mapping was completed by a geomorphologist who is familiar with the physical environment of Roberts Bank. The resulting maps show the location of tidal channels, areas of erosion or sand accretion, significant geomorphic features, and changes in vegetation between successive surveys.

1.3.1.6 Coastal Geomorphology Mapping

Coastal geomorphology mapping was included as part of the AMS geomorphology monitoring to assess topographic changes due to long-term erosion or accretion of the inter-causeway tidal flats in the general vicinity of DP3. A combined bathymetric and topographic survey of the tidal flats using Real Time Kinematic (RTK) GPS positioning was carried out in 2007. This survey was repeated in 2010 during May and June using the same survey instrumentation. Data were collected along the same transects that were previously surveyed in order to generate a Digital Elevation Model (DEM) that could be compared to the 2007 DEM. This data was presented in the 2010 annual report. The next coastal mapping survey is scheduled for the summer of 2013.

1.3.1.7 Wave and Current Monitoring

The Wave and Current Monitoring activity was discontinued during 2010. No additional data were collected during 2012 under these activities. The former locations of the wave sensors are shown on **Figure 3**.

1.3.2 Surface Water Quality

Surface water samples were collected quarterly by Hemmera at the seven fixed surface water and sediment monitoring stations illustrated on **Figure 6** (DP01, DP02, DP03, DP04, DP05, DP06, and DP07). In Q1 only, surface water samples were collected at DP08 and DP09 (**Figure 6**), as per the recommendations from the SAC. The surface water samples were added to provide co-located surface water samples to enhance the interpretation benthic invertebrate sampling program results. These surface water stations were monitored for water quality only in 2012.

A representative surface water sample was collected one metre below the surface at each intertidal sampling station using a Van Dorn sampler. At subtidal sampling stations DP05 and DP07, water samples were collected at two depths: the A level (1.0 metres below the water surface) and the B level (2.0 metres above the sediment). At DP01, located in a tidally influenced drainage ditch discharging to the inter-causeway area, samples were collected from 0.5 m below surface from under the dyke bridge (**Figure 7**). Surface water sampling dates are presented in **Table 1**. The detailed methodology and the field and laboratory quality assurance and quality control (QA/QC) measures are as outlined in **Appendix A**.

The parameters analyzed for each surface water sample included:

- Temperature.
- pH.
- Hardness.
- Salinity.
- Metals (Q1 only in 2011).
- Chlorine[1].
- Turbidity and total suspended solids (TSS).
- Nutrients (Phosphate, Phosphorus, Ortho-phosphorus, Total Kjeldahl Nitrogen (TKN), Total Nitrogen, Ammonia, Nitrate, Nitrite and Organic Nitrogen).
- Clarity (via secchi disc).
- Chlorophyll *α.*

The detailed methodology and the field and laboratory quality assurance and quality control (QA/QC) measures are as outlined in **Appendix A**.

[1] Chlorine was analyzed only in the sample collected at station DP01. The purpose of this parameter relates to the presence of an immediately up-gradient recreational water park and concerns of discharge to the inter-causeway area.

The station nearest the DP3 construction area (DP04), was also monitored continuously for a number of water quality parameters (pH, temperature, conductivity, and dissolved oxygen) using a YSI 6600V2 buoy-mounted sonde operated in conjunction with the DP3 construction environmental monitoring program. Since 2010, the sonde was deployed on an intermittent basis, generally for one week period during the quarterly monitoring program, to avoid damage due to storm events. The sonde monitoring program was discontinued at the beginning of 2012 and field water quality parameters were collected at the time of sampling collection during the quarterly events.

A 20% difference between the measured parameter inter-causeway and reference station results was initially proposed to gauge the potential for impacts; however, AMS results from 2007 suggested that baseline conditions at the inter-causeway and reference stations differed by more than 20%. As such, an alternate approach to evaluating the data was adopted in 2008.

The minimum and maximum concentrations recorded during each quarterly sampling event in 2012 for each parameter of interest were noted and three categories of approximately equal range were created. The average concentration for the parameter over the four quarters was then calculated at each station and the value categorized as low, intermediate, or high, with low average values represented by small dots and high average values represented by large dots. This method facilitated the identification of spatial trends in metal and nutrient concentrations and the comparison of spatial trends in sediment and surface water data. Temporal trends for select parameters were also graphed.

1.3.3 Sediment Quality

Quarterly sediment sampling was completed by Hemmera at the same time as the surface water sampling at the stations illustrated on **Figure 6**. A representative sediment grab sample was collected from each of the nine stations using a Ponar sampler. Sediment samples were analyzed for the following parameters:

- Metals (Q1 only in 2011).
- Total nitrogen.
- Ammonia.
- Nutrients.
- Redox (Eh).
- Hydrogen sulphide (H_2S).

The detailed methodology and the field and laboratory QA/QC measures are as outlined in **Appendix A**. The sediment data was analyzed following the same procedure as the surface water data.

1.3.4 Eelgrass

1.3.4.1 Distribution and Mapping

The digital orthophotographs were not available before the last of the daytime low low tides of the year. The field survey ground truthed the eelgrass habitat distribution in the inter-causeway area focusing on areas where change has occurred over time before reviewing the orthophotographs. A handheld computer with GPS and GIS capabilities was used to confirm and/or determine the boundaries and species composition polygons that were mapped in 2011. Additional GPS data were collected while travelling to and from the monitoring stations. The distribution of eelgrass in the vicinity of the sand lobe was basely solely on orthophoto interpretation.

Digital orthophotographs (2012) were interpreted using the field survey data to develop a base layer for mapping the current distribution of eelgrass in the inter-causeway area. The criterion for minimum polygon size was 50 m by 50 m.

The results of the orthophotograph interpretation and field surveys were combined with the GIS layer developed for the Coastal Geomorphology component of this study that delineates channels in the study area to produce a map detailing the 2012 distribution of eelgrass within the study area.

The eelgrass habitat within the area that was altered by sediment deposition in area of new channel formation adjacent to DP3 was mapped at a finer scale. The Coastal Geomorphology data was reviewed by NHC to determine the boundaries of the area that was altered. The intertidal portion of the area potentially affected was surveyed at low tide to search for changes in eelgrass distribution that had occurred since 2011. The team followed the 2011 polygon boundaries and if changes were noted then additional GPS data was recorded. The team walked the upper perimeter of the area to search for new eelgrass colonization within the small channels. The subtidal portion of the area that was altered was viewed from the road adjacent to the site. The orthophotos, waypoint data, and field notes were used to map each habitat type within the area. The GIS data was used by NHC to produce a 2012 map of the area and to estimate the total area occupied by each habitat type. The area (m^2) of each habitat type was calculated then converted to hectares and reduced to two decimal places.

A Seabed Imaging and Mapping System (SIMS) was used to determine the lower edge of eelgrass distribution in the inter-causeway area. The SIMS system uses a towed underwater video camera and is positioned with a real time differential GPS. The camera, towed from a boat, follows predetermined track lines perpendicular to the deep edge of the inter-causeway eelgrass bed. The film is analyzed noting the presence, absence, and relative density of eelgrass along each track. A SIMS survey is completed tri-annually. Data from the SIMS survey was incorporated on the 2012 distribution map for areas beyond which eelgrass could be seen on the orthophotographs.

1.3.4.2 Monitoring Eelgrass Vigour and Health at the Established Stations

The survey assesses the health and growth of eelgrass at nine of the eelgrass monitoring stations that were established for the DP3 Environmental Assessment, including four stations in the inter-causeway area, two stations west of the Deltaport Causeway (**Figure 8**), and three reference stations in Boundary Bay (**Figure 9**).

The parameters that were quantified at each of the stations included total shoot density, reproductive shoot density, shoot length, and shoot width[2]. Means were calculated from 20 replicate samples at each station.

The relative productivity at each station was calculated using a Leaf Area Index (LAI) formula. The LAI is calculated as follows:

$$\text{LAI} = \text{mean density } (\#/\text{m}^2) \times \text{mean shoot length (m)} \times \text{mean shoot width (m)}$$

The data for each parameter at each station from 2003 and from 2007 to 2012 were used to create histograms to demonstrate the trends over time.

T-tests using the Bonferroni correction adjustment were used to test for significant differences between years for each parameter, except in cases where there was no variation within a data set. A standard paired two-sample, 2-tailed t-test was used in cases where the Bonferroni correction adjustment could not be applied.

The presence or absence of *Beggiatoa sp.* and relative density of epiphytes and was recorded at each of the stations. Photographs were taken at each site to document the epiphytic cover for future reference.

1.3.5 Benthic Community

Sediment samples for benthic community analysis were not collected in 2012 and no future benthic sampling events are planned.

1.3.6 Birds

As discussed in **Section 1.2.6**, Brant surveys were discontinued in 2012 and only Great Blue Heron surveys were conducted in 2012. “Windshield” peak count surveys for Great Blue Heron were conducted during the key timing window for the species (June to August). The objective of windshield surveys is to count all Great Blue Heron using the inter-causeway area at a given time. The rapid assessment methodology of this technique allows a more representative total population count of the individuals using the inter-causeway area to be collected than through point count surveys, as the short duration of surveys minimizes possible recounting of individuals.

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[2] Quadrat sampling along transects as described in *Methods for Mapping and Monitoring Eelgrass Habitat in British Columbia* (Precision 2002).

The windshield survey methodology (**Appendix A**) involves stopping at a subset of the point count stations, and at other locations with good vantage points of the inter-causeway, to count all visible Great Blue Herons, with no minimum time requirement. A single windshield survey consists of one complete assessment of the inter-causeway from points along the Deltaport and BC Ferries Causeways and Tsawwassen First Nation lands (**Figure 10**). At each observation station, biologists recorded 1) weather data, 2) the number of Great Blue Heron and their flight direction, if applicable; 3) bird behaviour; 4) the distance target species were from the shoreline, and 5) any sources of disturbance, if applicable.

Windshield surveys are conducted at the most ideal time to identify the maximum number of individuals within a short period of time. Hemmera has found that the most productive time to count Great Blue Heron is within one hour on either side of the peak low tide during the summer months, when herons hunt amongst the eelgrass beds between the Deltaport and BC Ferries Causeways.

Great Blue Heron have been documented to use the inter-causeway in greatest numbers from June to August when low tides are prevalent during the day. This period also corresponds to the heron breeding season and the fledging of heron young, which subsequently use the inter-causeway to forage.

In 2012, one windshield survey was completed each month in June, July and August (Events 64, 65 & 66). Observers used binoculars and spotting scopes to count Great Blue Heron and record distances from the point count stations/vantage points. Observers counted individuals and groups of birds and documented bird behaviour. Data was recorded into a hand-held PDA with digital forms that were consistent with those used by Port Metro Vancouver and Canadian Wildlife Service (CWS) in past bird studies. **Figure 10** outlines the inter-causeway area and survey station locations.

Observers counted birds within the following distance categories:

- 0 – 250 m from shore.
- 250 – 500 m from the shore.
- > 500 m to approximately 1 km.

Birds observed flying overhead (F/O) were also recorded.

2.0 RESULTS

The following sections provide a summary of key findings for the AMS quarterly monitoring events during 2012.

2.1 BACKGROUND INFORMATION

2.1.1 Weather, Tides and Fraser River

Winds, waves, tidal currents and Fraser River discharges provide the main driving forces for the physical processes occurring at Roberts Bank. This chapter provides a brief overview of these parameters for the duration of the 2012 monitoring period. Comparisons to historical conditions were made using statistical techniques to provide an assessment of the overall frequency and magnitude of these driving forces.

Reference stations for environmental data collected outside of the AMS program were chosen based on proximity to the site, quality of data, and length of historical record. It is recognised that conditions within the AMS Inter-causeway Area may differ somewhat from those measured at the external stations, both in terms of magnitude as well as timing but an in-depth analysis of these variations is outside the scope of the AMS. The primary purpose of presenting these data is to provide an independent evaluation of the relative wind and wave conditions compared to historical conditions in order to put the data collected for the AMS Monitoring Program into context. The wind and wave analysis based on the external stations provides a useful proxy measurement of the overall energy regime affecting the site.

2.1.2 Winds and Waves

Deltaport Terminal is exposed to waves from the northwest, west, south-west, south and south-east. **Figure 11** shows the fetch lengths measured at 10 degree intervals from a point near the offshore end of the terminal. The offshore (deepwater) wave conditions are governed by the fetch length, wind speed and wind duration. There are no continuous long-term wave or wind measurements at Deltaport. However, hourly wind data for the period from January to December 2012 were obtained from Vancouver International Airport, which has the longest continuous record in the area. Wave heights and wave periods have been recorded at Halibut Bank by Fisheries and Oceans Canada through the Marine Environmental Data Service (MEDS) program. The Halibut Bank station is located in the Strait of Georgia approximately mid-way between Nanaimo and Sechelt and 45 km northwest of Deltaport. The combination of wind and wave measurements provides a reasonable basis for characterizing the deepwater wave climate near Deltaport in 2012. The wind speed and direction data were used to hindcast the deepwater wave conditions at the site using a standard calculation relating fetch length, wind speed, and wind duration to wave height, while the measurements at Halibut Bank provided an independent check of the predictions. Knowledge of the deepwater wave conditions from the hindcast data provides a useful contextual comparison for evaluating the wave data that was previously collected at the three stations within the study area and continue to provide a context for the relative amount of wave energy that the study area is exposed to.

Wind speed and wind direction were tabulated for four periods: January-March (**Table 4**), April-June (**Table 5**), July-September (**Table 6**) and October-December (**Table 7**). The values in these tables represent the number of observations (hourly data) in each speed class and direction range. The time series of wind measurements was also reviewed to identify specific storm events over the monitoring period. In this case, a storm event was defined as having a sustained wind speed greater than 30 km/h (**Table 8**). Each storm event was analysed in terms of the factors that are most important to the geomorphic outcome: time that winds were greater than 30 km/h, corresponding tide levels, and estimated significant wave height (Hs) and wave period (Tp). An evaluation of the historical probability of occurrence for exceedence of the maximum wind speed provides additional context.

The strongest wind event of the year, regardless of direction, occurred in the January-March period and was from the west with a maximum wind speed of 69 km/h and winds that remained above 30 km/h for twenty six hours. Despite the relatively shorter fetch length from the west, this February 25/26 event had high winds over a long duration, resulting in predicted wave heights of 3.3 m. A wind event on January 9/10 that had winds of similar magnitude but lasting only thirteen hours would have generated similar wave heights. The strong wind events in this period came from nearly all cardinal directions except the north, with nine observations exceeding 40 km/h (**Table 9**). Of the fourteen storm events in this period, all but four are predicted to have generated waves of 1 m (Hs) or greater, according to hindcast calculations.

During the April-June period, there were four storms but only one observation with maximum wind speed exceeding 40 km/h (**Table 9**), which came from the west. This storm occurred on May 9 and had a maximum wind speed of 48 km/h and would have generated 1.5 m high waves; however, the duration of this 11 hour storm was shortened by a 5 hour long lull before the next storm began and lasted for 19 hours. The July-September period had only one identified storm event, which had a maximum wind speed of 44 km/h from the west and lasted for four hours to generate waves of up to 1.2 m.

The eleven storms that were identified in the October-December period had their peak winds coming from a large range of cardinal directions. There were five events with winds exceeding 40 km/h but only two of these events would have produced waves over 2 m in height. The third largest storm of the year occurred on October 1, with maximum winds reaching 61 km/h and winds exceeding 30 km/h for seventeen hours from the west, and would have generated waves up to 2.3 m.

The highest winds of the year occurred during a twenty six hour storm on February 25/26 that had maximum winds of up to 69 km and average winds of 48 km/h to generate 3.3 m high waves according to hindcast calculations. Wind direction was consistently from just north of west for the entire duration of the storm, with very little variation. The maximum wind speed for this storm has a probability of exceedence of only 0.1% on the basis of all peak hourly winds for the period from 1953 to 2006. The highest reported significant wave height (Hs) during this period at Halibut Banks was 1.6 m with a period (Tp) of 5.3 seconds. The storm was associated with a moderately high tide of 4.5 m (Chart Datum) but due to the length of the storm, a number of tidal cycles were experienced, with a minimum tide height of 1.8 m. The two values of wave height reported above for this storm event come from two different sources: measured wave height at Halibut Bank; and hindcast wave height based on wind data from the Vancouver Airport. Each of these values serves as a proxy for the actual wave conditions within the study area, which is subject to different fetch lengths, wind speeds and directions, as well as other factors, compared to the reference stations.

A frequency analysis was carried out on the wind and wave data to assess the relative magnitude of the 2012 events versus the long-term conditions. Estimates of long-term frequency and duration of wind events and wave conditions were summarized in NHC (2004). **Figure 12** shows cumulative frequency distribution (percent time exceedence) plots of wind speed for the four seasons as measured at Vancouver Airport. **Figure 13** shows similar plots for wave heights recorded at Halibut Bank. In 2012, the percent time exceedence curve for winds between 5 km/h and 50 km/h was shifted upward of the long-term curve for January to March, indicating that winds in this speed range were exceeded more often than the long-term average. For the April to June and July to September periods the percent time exceedence curve is shifted upward of the long-term record curve for winds between 5 km/h and 25 km/h. The curve for the October to December period is shifted upwards for winds between 5 km/h and 35 km/h.

2.1.2.1 Inter-annual Comparisons

A comparison of the 2012 wave data to the long-term average conditions based on the period of record (data collected from 1953 to 2006) is more complex than for the wind data. For the January to March period, the percent time wave exceedence curve for 2012 shows two departures from the long-term record; there was a greater incidence of waves up to 0.4 m in height and a lower incidence of waves between 0.4 m and 1.2 m. For both the April to June and July to September periods there was a slightly lower incidence of waves between 0.4 m and 1.0 m in height as compared to the long-term average. The October to December period showed quite a large decrease in the percent time that waves of between 0.2 m and 1.5 m were exceeded.

Overall, the wind and wave conditions in 2012 were generally less severe than the average conditions over the period of record.

2.1.3 Tides

Tide levels are predicted by the Canadian Hydrographic Service at Tsawwassen using observed levels at Point Atkinson as a reference station. Tide levels were also measured by NHC at Deltaport from June 14, 2007 using a pressure transducer and data logger. The record from this instrument contains a number of gaps caused by accidental damage and wilful tampering of the installation, and ends on July 3, 2008 when the instrument was permanently removed (**Figure 14** to **Figure 17**).

The tides are mixed, semi-diurnal, that exhibit differences in elevation between successive high waters and successive low waters. The sequence of the tides typically follows the pattern of Higher High Water to Higher Low Water to Lower High Water to Lower Low Water, although this pattern is reversed approximately 15% of the days in a tide cycle as the tides switch from spring to neap. Lower Low Water occurs in daylight hours between April and August while during the fall and winter season Lower Low Water occurs during the night time. The tide range undergoes a bi-weekly variation due to the influence of the moon. Spring tides, having the largest range, occur 15 days apart, 26 hours after a new or full moon. The maximum tidal ranges occur near the time of the summer and winter solstice. The minimum tidal range occurs around the time of the Spring and Autumn equinoxes.

The highest tide of 2012 occurred on December 16, during a calm period between storms that had winds of almost 40 km/h. The predicted High Water at Point Atkinson was 5.024 m (Chart Datum) at 15:30 h, while the highest tide level recorded at Point Atkinson was 5.447 m.

2.1.4 Fraser River Discharge and Sediment Inflow

The Fraser River hydrograph has a characteristic nival-regime, with the flow rising in late April, peaking in May and early June, then receding through the late summer and fall. The lowest annual discharge typically occurs in March.

The Fraser River adds approximately 18 million tonnes of sand, silt and clay sediment to the Strait of Georgia each year on average. Suspended sediment concentrations typically rise to between 500 mg/L to 1,000 mg/L during the May-June freshet season, then decline through the late summer and fall to between 100 to 200 mg/L. Sediment concentrations in the low flow winter season typically range between 50 to 100 mg/L (McLean and Church, 1986).

Virtually the entire sand load is deposited in the delta front off the main arm jetty near Steveston. Due to the isolated nature of the inter-causeway portion of Roberts Bank and the presence of the Deltaport Causeway, even the fine clay-sized sediment in the Fraser plume is deflected into the deep waters of the Strait of Georgia (**Figure 18**).

Information on conditions during 2012 is based on preliminary data from Water Survey of Canada and is still subject to revision. The 2012 freshet was much larger than the average annual flood, reaching a maximum discharge of 11,941 m^3/s in Hope and 13,145 m^3/s in Mission around June 22/23. By the first week of August the discharge had reduced to 6,000 m^3/s at Hope, and then continued to decrease slowly through the fall, reaching 2,000 m^3/s in the first week of November, with typical discharge fluctuations in response to local rainfall events during this period. The peak freshet was similar to a 25-year return period flood and was notable for its relatively early onset. No sediment measurements were made on the Fraser River in 2012. However, based on a comparison with previous years of observations it is very likely that the total load in 2012 was much higher than the mean annual load of around 18 million tonnes. Based on previous years observations it is expected that the highest sediment concentrations would have reached approximately 1,000 mg/L in early July, decreasing to a few hundred mg/L by mid-August.

2.1.5 Post-construction Activities

Construction activities associated with development of the terminal were completed in December 2009 and commercial operation of the terminal commenced in mid-January 2010 (**Table 1.1-1**). Post-construction activities in 2010 were related to development of the habitat compensation features along the east side of the Deltaport causeway. This activity involved replacing the existing rock rip-rap that is currently protecting the east side of the Deltaport Causeway with structures designed to create a more complex range of habitat types. The habitat compensation features were substantially completed in September, 2010. DP3 post-construction activities in 2011 were limited to the removal of the temporary barge ramp that was located in the tug basin. Removal occurred between November 8 and December 5, 2011. There were no known activities of significance in 2012.

2.2 COASTAL GEOMORPHOLOGY

2.2.1 Crest Protection Structure Monitoring

No Crest Protection Structure monitoring was conducted during 2012.

2.2.2 Automated Turbidity Monitoring

No turbidity monitoring was conducted during 2012.

2.2.3 Monitoring of Erosion and Deposition

No monitoring of erosion and deposition was conducted during 2012.

2.2.4 Sediment Samples

The regular sediment sampling portion of the monitoring program was not conducted in 2012. A one-time investigation of localized spatial distribution of grain size around select DoD rods was conducted in May 2012. The results of this investigation are presented in a memorandum in **Appendix B** of this report.

2.2.5 Interpretation of Orthophotographs

The study area for this monitoring activity includes the entire area of Roberts Bank within the inter-causeway tidal flats. **Figure 19** shows the results of the orthophotographic interpretation, which was completed using GIS mapping techniques under the direction of the project geomorphologist. Areas of disturbance, including the active channel zone, shown in light purple, are areas where channel activity or deposition is occurring, but individual bars and/or channels are too small to be mapped individually. Sand bars, either large forms near the low-tide edge of the tidal flats or smaller channel point bars, have been mapped in yellow. Tidal channels are delineated in green – a dark green colour for channels large enough to have its banks mapped with double lines and light green for smaller channels.

The main features of interest shown in **Figure 19** include:

1. New drainage channels that formed at the north-eastern margin of the perimeter dike.
2. Formation of sand bars on the tidal flats on the seaward side of the Crest Protection Structure.
3. The large system of dendritic channels draining into the turning basin.
4. The tidal channels adjacent to the BC Ferries Causeway.
5. New sand bars located along the Deltaport Causeway (east side) appearing to originate from the East Causeway Habitat Compensation Project.

Items 2 through 4 are historic features that pre-date the DP3 project and have been identified and described in detail previously (NHC, 2004).

New sand bar features were identified in the 2012 orthophotograph adjacent to the Deltaport Causeway, which appear to be caused by substrate material that was placed as part of the East Causeway Habitat Compensation Project and which may have migrated seaward.

Figure 20 shows a comparison of the area of new drainage channels as mapped in July 2011, to July 2012. On June 4, 2012, a final field inspection was conducted to assess the current conditions and processes impacting these new channels and results of this investigation are presented in a memorandum in **Appendix C** of this report. **Figure 21** shows the outline of the large dendritic channels that were digitized from the 2011 and 2012 orthophotos.

2.2.6 Coastal Geomorphology Mapping

Coastal geomorphology mapping surveys were not conducted during 2012. The next surveys are scheduled to occur in the summer of 2013.

2.2.7 Wave and Current Monitoring

No wave or current monitoring was conducted during 2012.

2.3 SURFACE WATER QUALITY

2.3.1 Quality Assurance / Quality Control

For metals in surface water, the data quality objective (DQO) for precision was to obtain a relative percent difference (RPD) of less than 20%. The DQO for completeness was 100%. For the organic parameters the DQO for precision was RPD of less than 50%. As RPDs met the DQOs, it was concluded that the data were, on the whole, reliable and met project requirements for laboratory and field duplicate QA/QC evaluation. Detailed QA/QC evaluations are presented in the quarterly reports. A summary of issues encountered is presented in **Table 9** and discussed below.

In general, the RPDs were less than 30% in 2012 except chlorophyll *a* (33%) in Q4-2012. The concentration of chlorophyll a in Q4-2012 was within the range of previously detected concentrations and the RPD was less than the organic parameter DQO of 50%. The elevated RPD is therefore not considered indicative of sampling or laboratory quality control issues.

2.3.2 Chemistry

The parameters analyzed as indicators of potential toxicity to marine organisms were compared against the BC Water Quality Guidelines (WQG) for the Protection of Marine Aquatic Life (MAL) and the Canadian Council of Ministers of the Environment (CCME) MAL WQG. The data are presented in **Table 10**.

2.3.2.1 Metals

Surface water samples were analysed only in Q1 of 2012 and data is provided on **Table 10**. Other than the total boron in surface water samples (excluding ditch station DP01), there were no exceedances of the regulatory guidelines noted in Q1-2012. Total boron concentrations measured during 2012 from these locations ranged from 3,870 to 4,850 µg/L. This is compatible with boron concentrations in coastal marine water in Canada (typically ranges from 3,700 to 4,300 µg/L) (Moss and Nagpal, 2003).

A number of metal parameters exceeded the regulatory guidelines in the surface water sampled collected from station DP01 (located downstream of the agricultural ditch). In Q1-2012, cadmium, chromium, copper, manganese and nickel exceeded the regulatory guidelines. These same metals have exceeded the regulatory guidelines in previous years.

2.3.2.2 Eutrophication-related Parameters

Surface water samples were analysed quarterly in 2012 for eutrophication parameters and data is provided on **Table 10**. Nitrate concentrations met the CCME MAL of 16 mg/L. There is no other regulatory criteria applicable to nutrients in seawater. Results of eutrophication-related parameters in the context of the potential for eutrophication are presented in the discussion section (**Section 3.2**).

2.3.2.3 Sonde

The quarterly deployment of the Sonde was discontinued in 2012. Field water quality measurements of temperature, pH, conductivity, dissolved oxygen, redox and turbidity were collected with a YSI probe at the time of surface water sampling each quarter as presented on **Table 10**. The averages for each field parameter by quarter were calculated (excluding DP01) and are summarized in the table below. Field measurements are consistent with previous year measurements using the weekly sonde deployment.

Table 2.3-1 Average Field Water Quality Measurements by Quarter

Quarter	Average				
	Temperature (ºC)	pH	Dissolved Oxygen (mg/L)	Redox (mV)	Turbidity (NTU)
Q1	6.7	7.7	10	260	0.85
Q2	11.8	8.1	9.5	174	7.5
Q3	13.2	7.8	9.2	276	1.0
Q4	7.5	7.8	9.0	345	3.7

2.4 SEDIMENT QUALITY

2.4.1 Quality Assurance / Quality Control

For sediment, the DQOs were a RPD of less than 20%. Based on all RPDs, except ORP noted below, being less than 20% in 2012, the sediment data set was considered complete and accurate based on the results of the field and laboratory QA/QC. Detailed QA/QC evaluations are presented in the quarterly reports. A summary of issues encountered is presented in **Table 9** and discussed below.

The RPD for oxidation reduction potential (ORP) for the duplicate pair collected at DP4 in Q3-2102 was 23% which is a marginal exceedance of the DQO and likely due to the heterogeneity of the sediment at station DP04. The data was considered valid.

2.4.2 Sediment Chemistry

The sediment chemistry data is presented on **Table 11**. The sediment toxicity parameters (metals) were compared against the BC Contaminated Sites Regulation (CSR), Schedule 9 Generic Numerical Sediment Criteria for sensitive marine and estuarine sediments ($SedQC_{ss}$). Similar to previous years, no exceedances of the $SedQC_{ss}$ were measured during the Q1-2012 monitoring event.

There are no regulatory criteria applicable to nutrients in sediment. Nutrient concentrations will be discussed in the context of potential eutrophication in **Section 3.3**.

2.4.3 Grain Size

Grain size samples were collected by Hemmera during the Q1-2012 monitoring event and data is provided in **Table 11**. Sediment grain size ranged from sand with trace silt to sand with some silt and clay. This is consistent with grain size results from NHC and Hemmera from previous years.

2.5 EELGRASS

2.5.1 Distribution and Mapping

2.5.1.1 Inter-causeway Area

The eelgrass distribution in the new channel area and in other locations where change had been noted in 2011 were mapped on August 13, 14, and 15, 2012 to take advantage of the last good daytime low tides. The SIMS survey was conducted on September 2, 2012. The imagery was interpreted and geo-referenced maps produced.

The air photographs were taken during low tide on July 6, 2012 and available as digital orthophotographs on September 4, 2012. The orthophotographs were interpreted using the data from the field survey. Additional data were collected for this section while monitoring Eelgrass Vigour and Health at the Roberts Bank Stations between July 29 and August 1, 2012. The data from the SIMS survey was used to map the lower limit of eelgrass that was not discernable on the orthophotos.

The 2012 and 2003 distribution of eelgrass within the study area is shown in **Figure 22**. The eelgrass distribution maps produced for the AMS between 2007 and 2011 are provided in **Appendix D**.

Z. japonica is an annual species that recruits from seeds each spring; therefore the distribution and density of this species may vary greatly between years. The base of the rip rap along the majority of the eastern edge of the DeltaPort Causeway is located at approximately 3 m (chart datum) and is near the upper limit for *Z. japonica* in the inter-causeway. The distribution and cover of *Z. japonica* in this area varies from continuous to patchy to unvegetated mud between years. The *Z. japonica* distribution and density in this area in 2012 was similar to that of 2003.

The area classified as patchy, as opposed to continuous, within the main *Z. japonica* meadow has increased annually since 2010.

The landward edge of the continuous *Z. japonica* meadow in the northeast corner of the inter-causeway retreated seaward between 2003 between and 2011. A comparison of the GIS maps from 2003 and 2011 revealed that the continuous *Z. japonica* meadow has retreated approximately 230 m since 2003 in this area. The trend reversed in 2012 as the landward edge of *Z. japonica* in this area moved landward; the distance recolonized by *Z. japonica* varied between 25 and 280 metres.

The boundaries and size of transition zone southeast of the sand lobe has varied since 2003 as it did during the 1980s; the cover has remained continuous. A sand bar developed along a drainage channel near the ferry causeway that increased in size between 2003 and 2007. Most of the sand bar was colonized by a patchy distribution of *Z. marina* and *Z. japonica* by 2008. The area continued to support a patchy distribution of both species in 2009, except for a small area where two drainage channels had connected. The current within the channel during tidal exchanges eliminated the eelgrass in its path. The density of both eelgrass species increased along the northern perimeter of the 'sand bar' by 2010 resulting in an increase in the area occupied by the continuous mixed zone and the continuous *Z. japonica* zone. The conversion of patchy habitat in this area to continuous habitat continued into 2012.

The landward boundary of continuous *Z. marina* habitat and the seaward boundary of continuous *Z. japonica* habitat southeast of the sand lobe complex both migrated seaward between 2003 and 2011. The distance that the polygon boundaries have migrated was variable; the distance midway between the sand lobe complex and the re-vegetating sandbar discussed above was measured using GIS. The continuous *Z. japonica* meadow had expanded approximately 280 m seaward while the continuous *Z. marina* meadow has retreated approximately 210 m seaward. The edge of the continuous *Z. marina* meadow was unchanged between 2011 and 2012. The continuous mixed zone that lies between the continuous *Z. japonica* and continuous *Z. marina* zones expanded shoreward between 2001 and 2012, resulting in a polygon boundary between the continuous mixed and continuous *Z. japonica* very similar to that which was mapped in 2003.

There have been eelgrass increases and losses in the vicinity of the sand lobe complex over the last year. The majority of the increases are in the northern and western areas while the majority of the losses occurred in the southern and eastern areas of the complex.

The landward border of the continuous *Z. marina* meadow between the sand lobe and the DeltaPort Causeway that was mapped in 2003 had developed areas of patchy distribution by 2007. The area of patchy *Z. marina* distribution in this location varied inter-annually between 2007 and 2010. The 2011 field survey determined that most of the patchy *Z. marina* habitat documented between 2007 and 2010 supported continuous coverage at this location. The density of *Z. marina* continued to increase over the following year and by the 2012 field survey was very similar to that of 2003.

The transition zone northwest of the sand lobe between continuous *Z. marina* and continuous *Z. japonica* habitat where the two *species* co-existed to provide continuous coverage in 2003 has changed considerably over time. This sand lobe is located in the middle of the inter-causeway area and shown as orange on **Figure 22**. The transition zone in this area had encroached into monocultures of *Z. marina* and *Z. japonica* by 2007 (**Figure D-1**). The enlarged transition zone became patchy by 2008 (**Figure D-2**). The majority of the patchy transition zone developed into patchy *Z. japonica* habitat by 2009, due to the loss of *Z. marina* in this area (**Figure D-3**). The area formerly classified as mixed transition zone, northwest of the sand lobe, continued to support patchy *Z. japonica* in 2010; however there were many *Z. marina* seedlings amongst the *Z. japonica* in the northwestern part of this polygon (**Figure D-4**). Many of the seedlings survived and multiplied; the 2011 survey documented the expansion of mixed patchy habitat into the area classified as patchy *Z. japonica* in 2010 (**Figure D-5**). The density of both eelgrass species increased in 2012 resulting in a large area in the far western part of this area being classified as Zostera mixed continuous (**Figure 22**); *Z. japonica* was the dominant cover however *Z. marina* was present throughout this polygon.

The seaward edge of the continuous *Z. japonica* habitat adjacent to the western edge of the area influenced by the sand lobe advanced into an area classified as patchy *Z. japonica* in 2011.

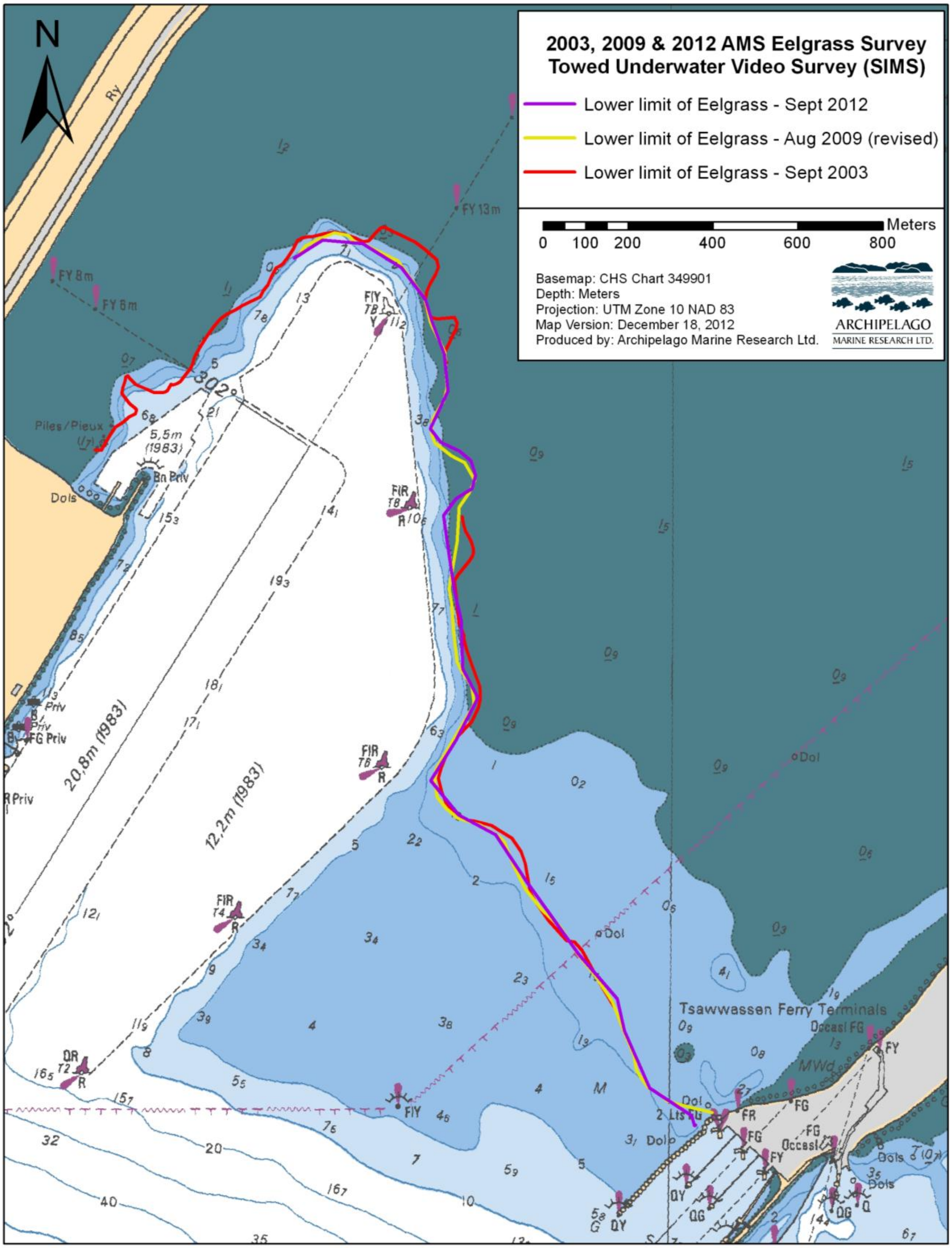
Several small sand bars developed perpendicular to the Deltaport causeway in an area that has either been patchy or continuous *Z. japonica* since 2003.

The lower limit of eelgrass distribution is in the inter-causeway has been mapped by orthophoto interpretation for most years of the AMS study. The 2012 map included data from the SIMS survey in addition to orthophoto interpretation. The results from the SIMS survey are provided in the following section.

2.5.1.2 SIMS Survey

The geo-referenced imagery from the SIMS survey was assessed to determine presence, absence, and relative shoot density along the lower limit of the eelgrass bed in the inter-causeway (**Appendix A**). The data was used to construct a shape file tracking the lower limit of eelgrass presence (>5% cover). The shape files from this survey, and those conducted in 2003 and 2009 were combined on a chart (**Figure 2.5-1**).

Figure 2.5-1 Lower Limit of Eelgrass (Z. marina) in the Inter-causeway



The SIMS survey was able to map eelgrass to a depth beyond which it is visible on orthophotos. A comparison of the survey results from 2012 with those from 2009 and 2003 indicates that the lower limit has remained very stable over this time period. The lower limit of eelgrass has increased in slightly in several areas adjacent to the tug turning basin. The lower limit of eelgrass between the tug turning basin and the Tsawwassen Ferry Causeway has remained unchanged since 2003.

The density of eelgrass has remained relatively constant in the areas adjacent to the tug turning basin since 2003; most of this area is intertidal (**Appendix A**). The density of eelgrass in the intertidal area between the tug turning basin and the Tsawwassen Ferry Causeway has also remained constant although it has varied in the subtidal areas. The 2012 densities are very similar to those assessed in 2003, while the 2009 densities are greater.

2.5.1.3 New Channel Area

Sediment deposition and drainage channel formation adjacent to the perimeter dyke in the inter-causeway area in 2007 (i.e. new channel area) altered the eelgrass distribution in that area (**Figure D-1**). The lower portion of the *Z. marina* bed and some of patches of *Z. marina* survived through 2008 (**Figure D-2**).

The area (m^2) colonized by eelgrass in 2008 in the vicinity of the area that was altered by sediment deposition from the new drainage channel formation was estimated using GIS and found to be comparable with the area occupied by eelgrass at this location in 2003. The 2009 survey found that surviving eelgrass had continued to multiply. A large portion of the area that was classified as patchy *Z. marina* in 2008 and 2009 had been colonized by *Ulva* sp. by 2010; eelgrass was absent in this area. The filamentous green algae (*Ulva*[3] sp.) that dominated this area was similar in appearance to that which was present in the "crab nursery" hummocks near Deltaport, as documented in the EA. The DP3 EA had identified "crab nursery" hummocks in the embayment area that was later filled for DP3. These *Ulva* sp. hummock areas contained a high density of crab larvae and juveniles.

The surviving portion of the main Z. *marina* bed expanded into 2011 (**Figure D-5**). The continuous *Z. marina* polygon in the south eastern end of this area had expanded into an area classified as patchy in 2010 (**Figure D-4**), and the adjacent patchy polygon had expanded into an area that was un-vegetetated in 2010 (**Figure D-4**). *Z. marina* started to colonize a large area (725 m^2) northwest of the patchy polygon in 2011; however since the density was less than one per m^2 the classification remained unvegetated. The density and distribution of *Z. marina* also increased in several of the small channels.

[3] The genus of algae identified in the EA was *Enteromorpha* sp., the taxonomic classification has since been changed to *Ulva* sp.

The 2012 survey documented a decrease in the area colonized by Z. marina, especially in the area of continuous coverage (**Figure 2.5-1**). The total area colonized by *Z. japonica* was greater than that documented in 2011 (**Table 2.5-1**); however all areas colonized by *Z. japonica* were patchy in 2012. The main losses were in the central and southern parts of the study area. There were slight increases in *Z. marina* habitat in the western corner of the study area; the eastern corner remained unchanged.

The extent of the potentially altered area, referred to as the New Channel Area, was redefined in 2010 and reduced from approximately 12 hectares to 6 hectares; including only the area closest to the perimeter dyke (**Figure 2.5-1**).

The area occupied by each habitat type in 2012, 2011, 2010, and 2003 within the redefined area was calculated using GIS (**Table 2.5-1**). The majority of the unvegetated channels in the inter-causeway are dominated by sand substrates; AMS eelgrass mapping previous to 2011 classified all unvegetated channels as ‘sand’. However, the channels near the DeltaPort Causeway are mud; therefore the unvegetated classifications have been changed from mud to mudflat and from sand to unvegetated channel.

Figure 2.5-2 Delineation and 2012 Habitat Classification of the Area that was Altered by Sediment Deposition from the New Drainage channel Formation and Assessed for Habitat Changes.

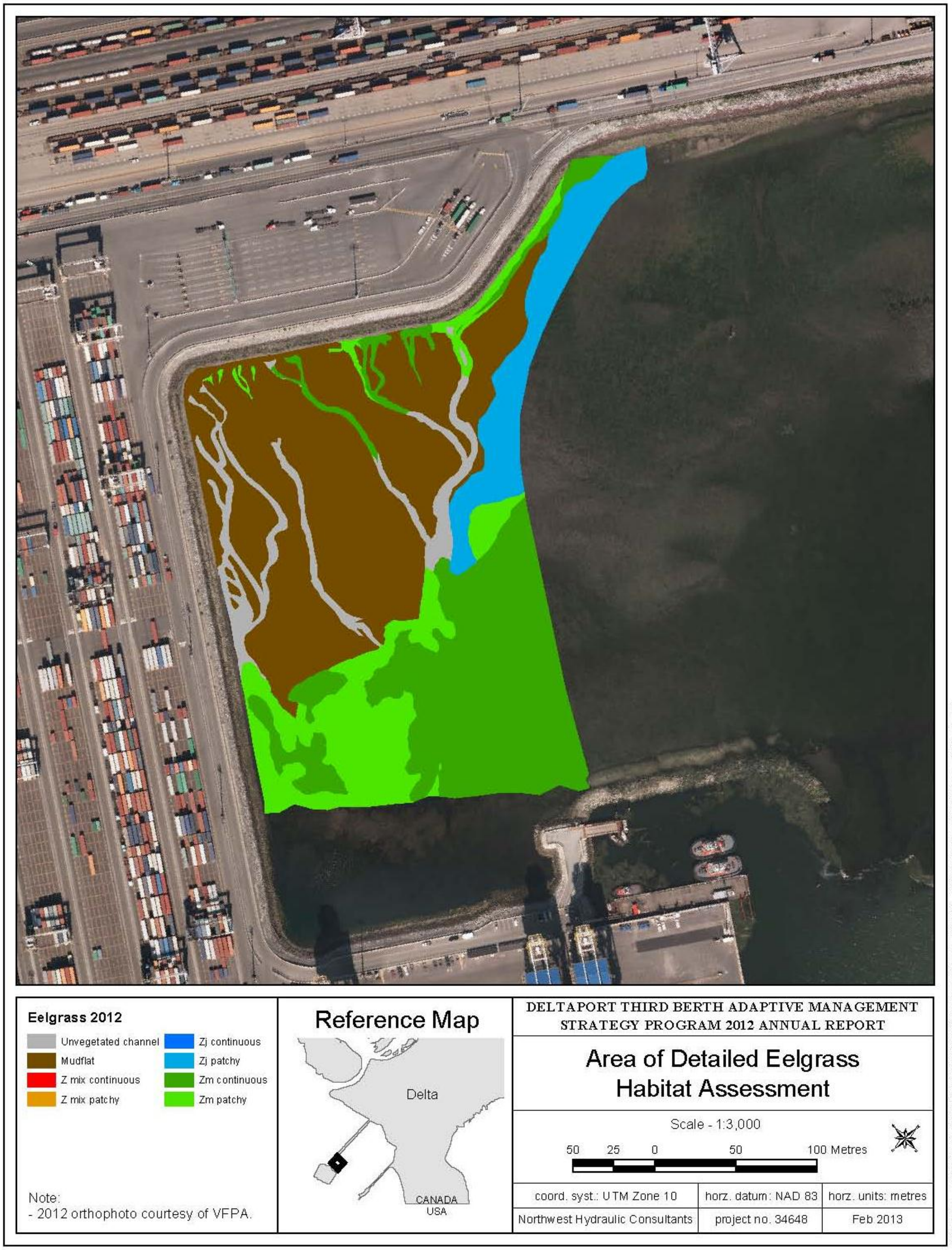


Table 2.5-1 New Channel Area Occupied by each Habitat Type in 2003, 2010, 2011, and 2012.

Habitat	Area 2003 (Ha.)	Area 2010 (Ha.)	Area 2011 (Ha.)	Area 2012 (Ha.)	Change between 2011 and 2012 (Ha.)
Z. marina continuous	4.45	2.06	2.17	1.71	-0.46
Z. marina patchy	0	0.62	0.96	0.84	-0.11
Zostera mixed continuous	0	0	0.03	0	-0.03
Zostera mixed patchy	0	0.11	0.10	0	-0.10
Total Z. marina	4.45	2.79	3.26	2.55	-0.71
Z. japonica continuous	0	0.44	0.16	0	-0.16
Z. japonica patchy	0	0.18	0.29	0.55	0.26
Total Z. japonica	0	0.62	0.45	0.55	0.10
Mudflat	1.66	2.43	2.20	2.64	0.44
Unvegetated channel	0	0.28	0.22	0.36	0.14
Total Unvegetated	1.66	2.71	2.41	3.01	0.60
Total Combined	6.11	6.11	6.12	6.11	-0.01

Studies have shown that the ponding effect of *Z. japonica* shoots often enables *Z. marina* to establish and eventually form a monoculture; therefore the area of *Zostera* mixed was included in the *Z. marina* total.

The total portion of the new channel area that was colonized by either patchy or continuous *Z. marina* decreased by 0.71 hectares between the 2011 and 2012 field surveys. The area occupied by continuous *Z. japonica* decreased over the last year while that supporting a patchy distribution of the species increased. The total unvegetated portion of the area that was altered by sediment deposition from the new drainage channel formation increased by 0.60 hectares between the 2011 and 2012 surveys.

2.5.2 Monitoring Eelgrass Vigour and Health at the Established Stations Results

The field survey was conducted from July 30 through August 2, 2012. The station originally referred to as Site 1 was renamed Site 1A in 2009, at which time Site 1B was added.

The epiphyte load at all stations was ranked as typical. *Beggiatoa sp.* was not present at any of the sites, nor was it observed when travelling to or from the sites.

The *Z. marina* distribution was classified as continuous at all Sites except Site 1A where it was patchy and coexisted with *Z. japonica* and was classified as continuous mixed. *Z. japonica* was absent from all sites except Site 1A where it was classified as dense.

The parameters that were quantified at each of the stations included total shoot density, reproductive shoot density, shoot length, and shoot width. Means were calculated from 20 samples at each station, except at Site 1A. *Z. marina* was present in only nine of the quadrat samples at Site 1A, therefore the mean shoot length and width was based on a sample size of eight. Mean values were reduced to one decimal place (**Table 2.5-2)**. Leaf Area Index values were calculated using two decimal places for each parameter in the equation (**Table 2.5-2**). The LAI calculation for Site 1A used the shoot length and width data from all 20 replicates; zeros were entered in cases where *Z. marina* was absent. A summary of the monitoring data from 2003 and the annual AMS surveys is provided in **Appendix D**.

Leaf Area Indices (LAI) integrate total density, shoot length, and shoot width to estimate relative productivity. Histograms of the LAI data are presented in **Figures 2.5-3** through **2.5-6**. The LAI data from Site 2 at Roberts Bank is compared with the data from Site WR3 in Boundary Bay (**Figure 2.5-7**). Histograms for each of the individual parameters are provided in **Appendix D**.

Table 2.5-2 Mean Eelgrass Shoot Density (Total and Reproductive), Length, and Width at Each Reference Station in 2012.

Site (#)	Total Density (#/0.25m^2)	Length (cm)	Width (mm)	Reproductive Shoot Density (#/0.25m^2)
Inter-causeway near Deltaport Causeway				
1.A	3.1	57.9	5.44	0
1.B	22.6	180.8	8.2	0.2
2	28.2	198.0	7.8	1.7
Inter-causeway area near Ferry Causeway				
5	11.8	138.3	8.2	0
6	21.3	156.3	8.1	0.8
West of Deltaport Causeway				
3	12.0	115.0	8.8	0.2
4	11.0	161.2	8.7	0.6
Boundary Bay				
WR1	67.2	38.8	4.0	0
WR2	36.6	106.2	7.4	6.8
WR3	34.1	158.4	8.1	2

T-tests using the Bonferroni correction adjustment were used to test for significant differences between years for each parameter, except in cases where there was no variation within a data set. A standard paired two-sample, 2-tailed t-test was used in cases where the Bonferroni correction adjustment could not be applied. The 2012 data from Site 1B was compared with the data from Site 1A for 2008, 2007, and 2003. The results of the analysis comparing the data from 2012 with that from previous years are summarized in **Table 2.5-3**; the p-values are provided in **Appendix D**.

Table 2.5-3 Years when the Data Were Significantly Different from that Recorded in 2012.

Site (#)	Total Density	Length	Width	LAI	Reproductive Shoot Density
Inter-causeway near Deltaport Causeway					
1A	2003, 2007, 2008	2003, 2007, 2008	2003(ins), 2007, 2008, 2009	2003, 2007, 2008	-
1B	2010, 2011	2003, 2007, 2008,	2008	2008, 2010, 2011	2009
2	2010, 2011	2003, 2007	-	2003, 2007, 2010	-
Inter-causeway Area near BC Ferries Causeway					
5	2007, 2008, 2009, 2010, 2011	2003, 2008, 2009 2010, 2011	2003	2003, 2008, 2009, 2010, 2011	*2009
6	-	-	-	2003	-
West of Deltaport Causeway					
3	2010	2010, 2011	2003	2003, 2010	2007, 2009
4	2008, 2010	-	-	2003, 2008, 2010	-
Boundary Bay					
WR1	2003	2008, 2010, 2011	2003, 2007, 2011	2010	*2003, *2008, *2010,
WR2	2003	2003, 2008, 2009, 2010, 2011	2009, 2011	2003, 2009	2003, 2007, 2009, 2010
WR3	2003, 2007, 2009, 2010	2003, 2008, 2009	2003	2003, 2007, 2010	2011

Note: * Bonferroni Correction Factor could not be applied. Standard 2- sample, 2-tailed, t-tests were used to analyze data in cases where the variance was zero within a data set and the Bonferroni Correction Factor could not be applied.

Figure 2.5-3 LAI Data from Roberts Bank, inter-causeway near Deltaport Causeway, Sites 1A, 1B, and 2

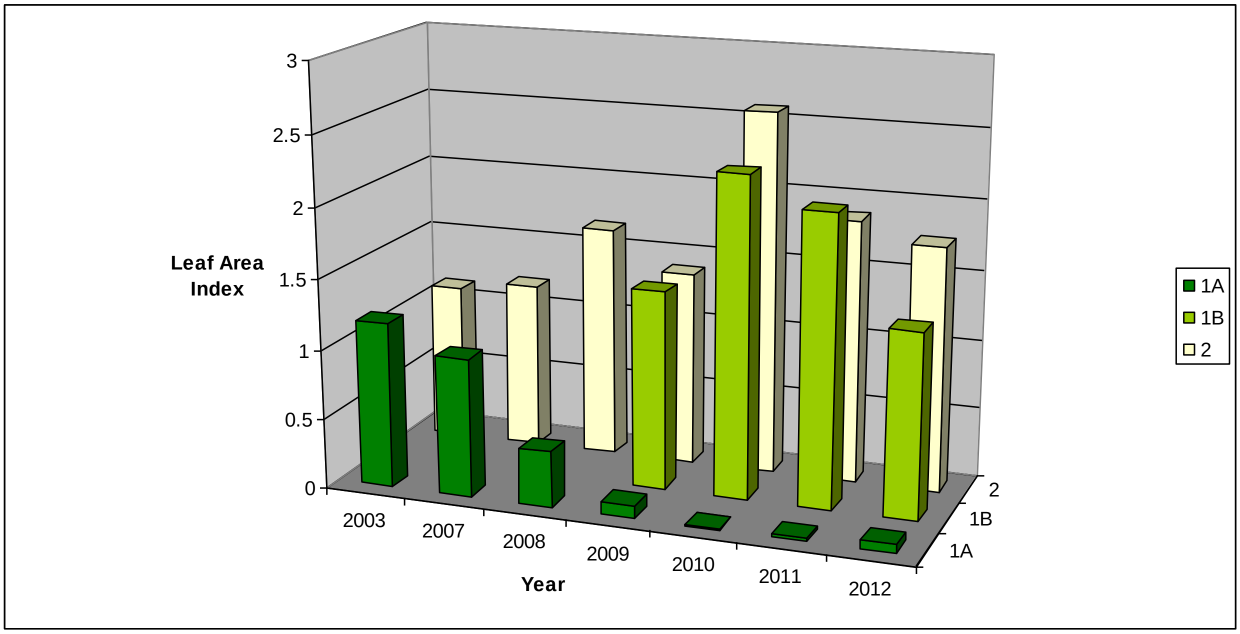


Figure 2.5-4 LAI Data from Roberts Bank, west of Deltaport Causeway, Sites 3 and 4

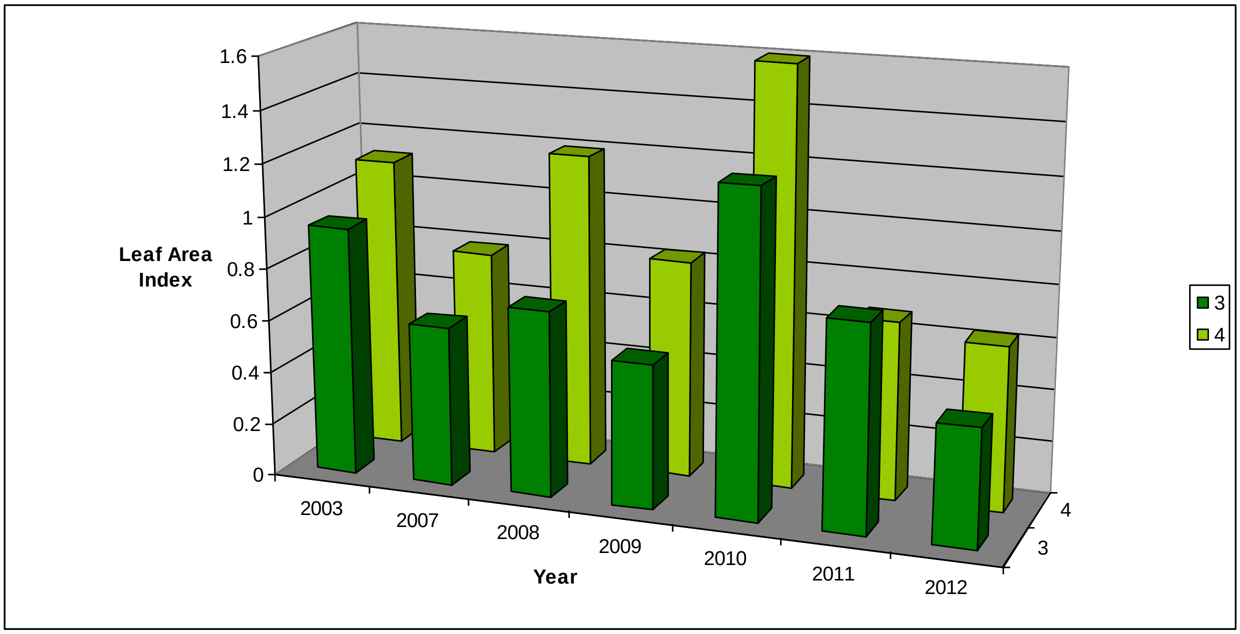


Figure 2.3-5 LAI Data from Roberts Bank, inter-causeway Area near the Ferry Causeway, Sites 5 and 6.

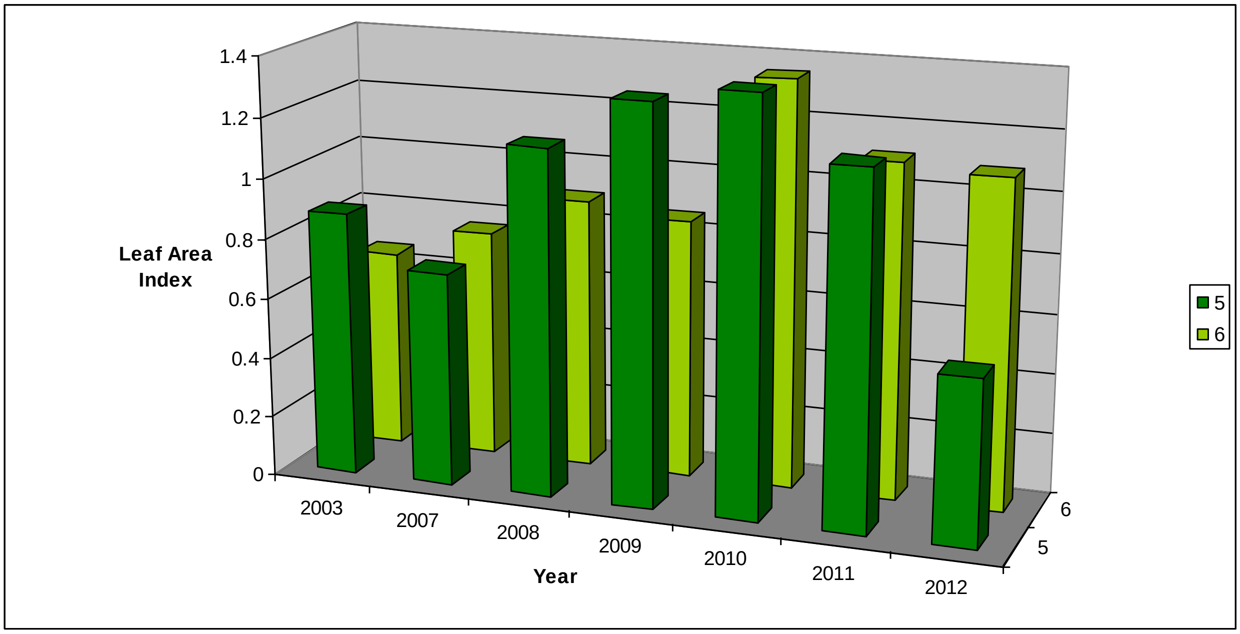


Figure 2.5-6 LAI Data from Boundary Bay, Sites WR1, WR2, and WR3.

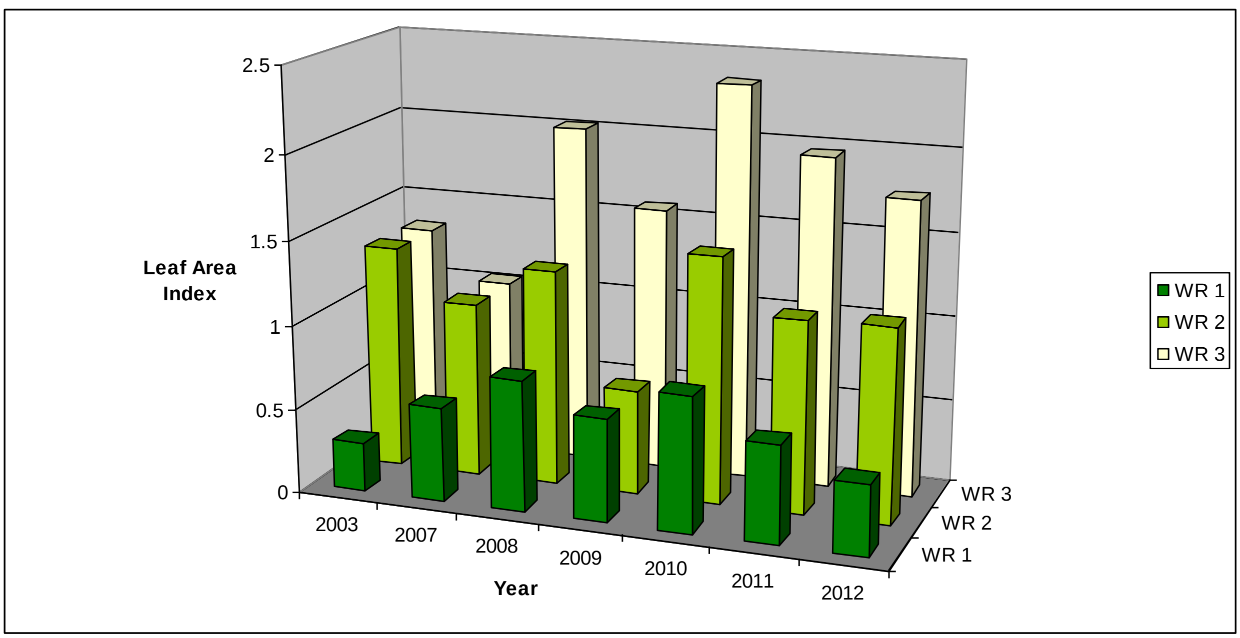
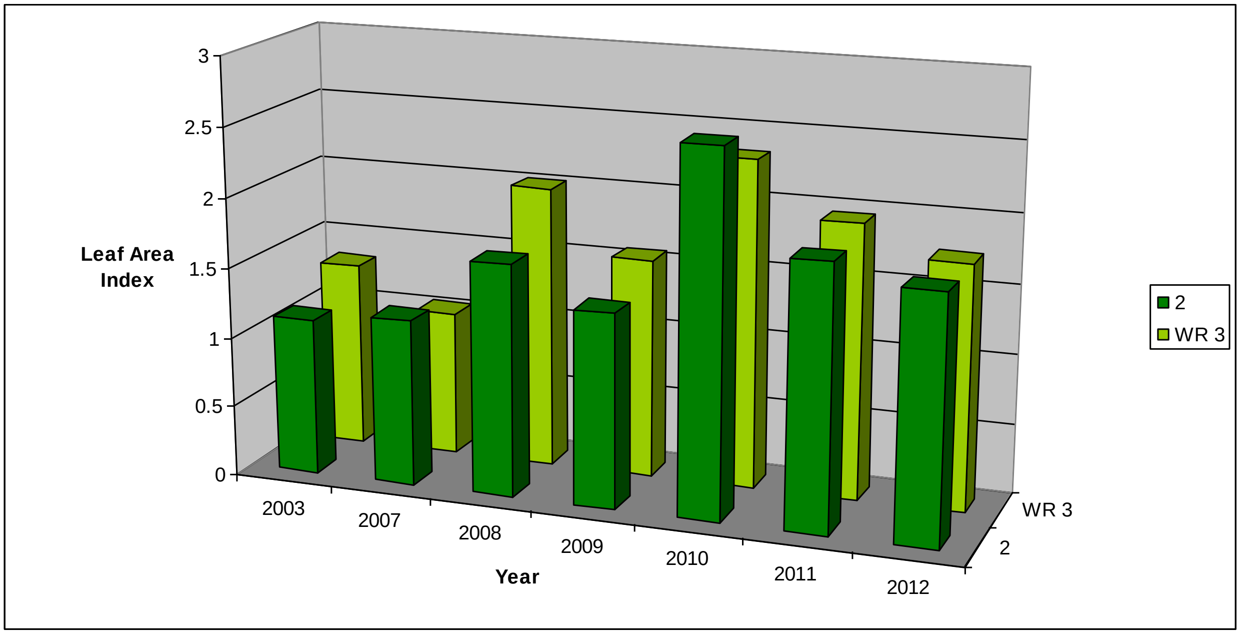


Figure 2.5-7 LAI Data from Site 2 at Roberts Bank and from Site WR3 in Boundary Bay.



2.6 BIRDS – GREAT BLUE HERON

The following data are intended to provide an estimate of the number and distribution of Great Blue Heron using the inter-causeway area. Hemmera conducted three windshield surveys for Great Blue Heron between June and August 2012 on the dates listed in **Table 2.6-1**. Great Blue Heron use and abundance was not assessed from January through May, or September through December, 2012.

The surveys were conducted during acceptable weather periods of little to no precipitation or fog, light winds (Beaufort scale: 0-4)[4] and calm sea state (Beaufort scale: 0-3)[5]. All surveys were conducted during peak low tide.

Table 2.6-1 Survey Events for Great Blue Heron in 2012

Event	Month	Day	Tide	Start	End
64	June	15	Low	12:00	13:00
65	July	16	Low	11:40	12:30
66	August	15	Low	12:06	13:20

Survey results for Great Blue Heron windshield surveys are presented in **Table 2.6-2**

4 Beaufort Scale (Land): 1 – smoke drifts (wind 2-5km/hr); 2 – leaves rustle, vane moved by wind (wind 6-12 km/hr); 3 – leaves in constant motion, light flag extended (wind 13-19 km/hr); 4 – raises dust and loose paper, small branches move (wind 20-29 km/hr).

5 Beaufort Scale (Sea): 1 – ripples without foam crests; 2 – small wavelets, crests don't break; 3 – large wavelets, perhaps scattered whitecaps; 4 – small waves, fairly frequent whitecaps.

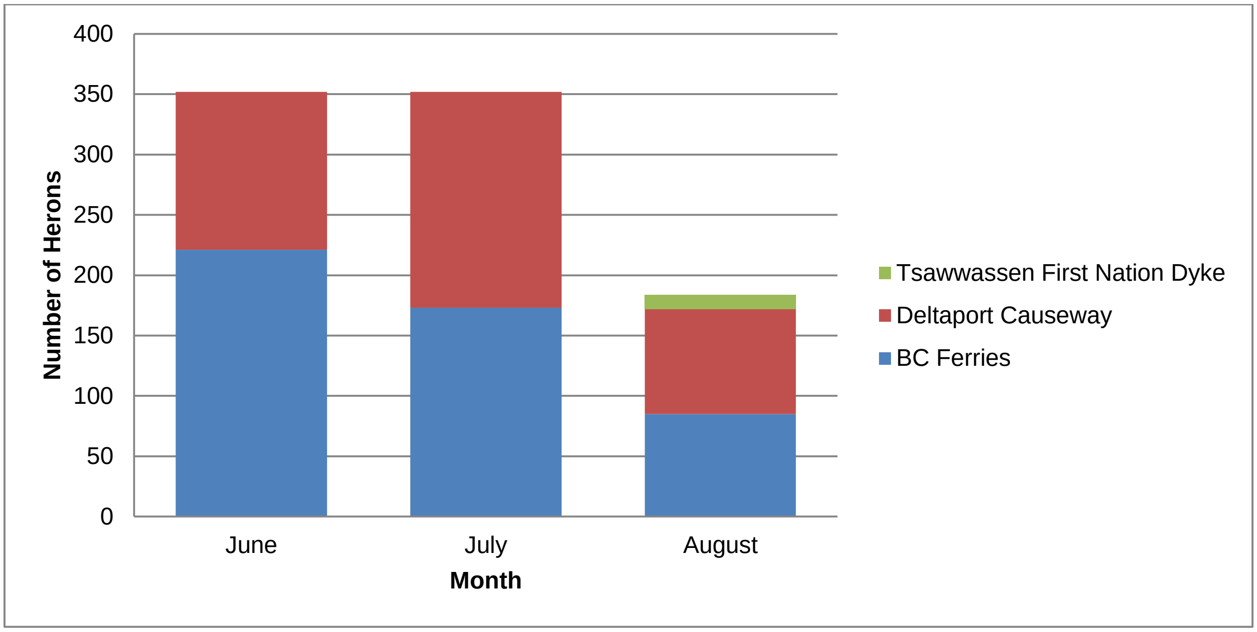
Table 2.6-2 Windshield Survey Results for Great Blue Heron by Transect and Distance (m) from Shoreline

Distance (m)	Transect			Total
	Tsawwassen First Nation Dyke	Deltaport Causeway	BC Ferries	
June				
0-250	0	91	52	143
250-500	0	40	94	134
500-1000	0	0	75	75
Total	**0**	**131**	**221**	**352**
July				
0-250	0	79	95	174
250-500	0	69	33	102
500-1000	0	31	45	76
Total	**0**	**179**	**173**	**352**
August				
-100-0	12	0	0	12
0-250	0	15	31	46
250-500	0	58	24	82
500-1000	0	14	30	44
Total	**12**	**87**	**85**	**184**
Grand Total	**12**	**397**	**479**	**888**

A total of 888 Great Blue Herons were recorded either foraging or resting within the inter-causeway between June and August (**Figure 23**). An additional 199 Great Blue Herons were observed (n=56 in June, n=26 in July and n=117 in August), foraging on the mudflats within the inter-causeway area at distances greater than 1 km, outside the area surveyed for birds. The number of herons observed decreased from June (n=352) to August (n=184) which is consistent with previous years (**Figure 2.7-4**).

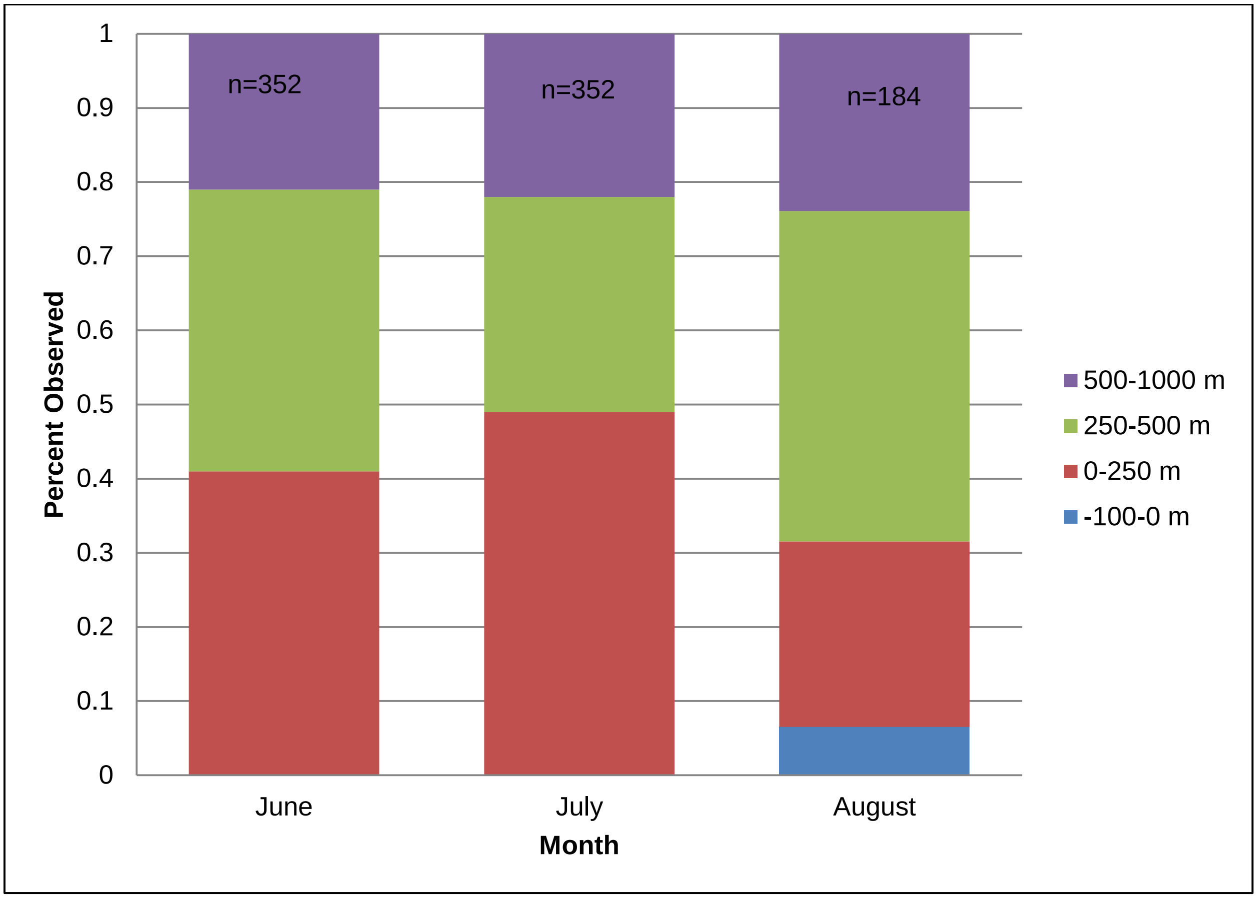
Great Blue Heron distribution was greatest along the BC Ferries transect accounting for 53.9% (479/888) of heron detections. Counts along the Deltaport Transect comprised 44.7% (397/888) of the total heron count (**Figure 2.6-1**). Heron use inland along the TFN transect was only recorded in August (n=12) (**Figure 2.6-1**).

Figure 2.6-1 Abundance of Great Blue Herons Observed at Low Tide during Windshield Surveys along All Transects from June to August 2012



During low tide, Great Blue Herons were distributed within the inter-causeway area, foraging along the tide line as eelgrass beds were exposed. While the total herons observed in June (n=352) and July (n=352) was greater than the number of herons observed in August (n=184) the majority of the herons were distributed similarly within the study area (**Figure 2.6-2** and **Figure 23**). Between June and August, heron use of eelgrass beds greater than 500 m from the shoreline changed very little with 21% (75/352) in June and 24% (44/184) in August. Similarly, the total use of the inter-causeway at distances between 0 and 500 m remained fairly consistent over the survey period with 78% (277/352) in June, 79% (276/352) in July and 70% (128/184) in August.

Figure 2.6-2 Percent Great Blue Herons within the Deltaport inter-causeway from June to August 2012

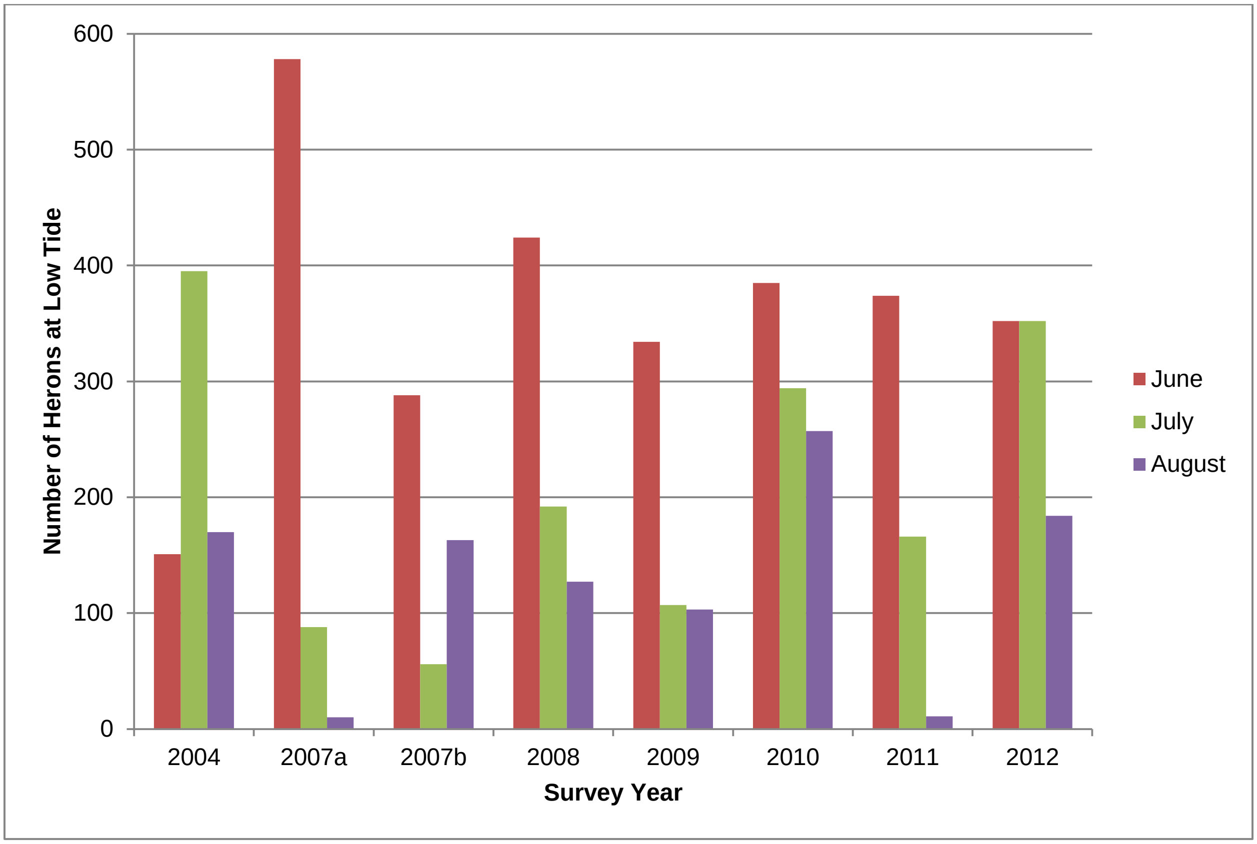


Note: Distance categories are referenced from the shoreline.

2.6.1 Comparison of Results

The total number of herons observed within the inter-causeway study area in 2012 (n=888) was consistent with the mean abundance of herons documented during June – August from 2004 to 2011 (668±139 SD) (**Figure 2.6-3**).

Figure 2.6-3 Number of Great Blue Heron Documented during Low Tide Surveys from 2004 to 2012



Note: Two surveys were conducted each month in 2007.

In 2011, the total number of herons documented (n=451) was lower than in 2010 (n=936) and in 2012 (n=888), primarily as a result of a low number of herons (n=11) observed during the August survey (**Figure 2.6-3**). While variability in heron numbers has been documented previously (n=10 in August 2007a), the 2012 results indicate that the low numbers observed in 2011 are likely the result of surveying outside of the peak low tide, and are not indicative of a change in the use of the inter-causeway.

3.0 DISCUSSION

3.1 COASTAL GEOMORPHOLOGY

One of the primary objectives of the AMS monitoring program is to make an assessment of the possible effects of the DP3 project on the surrounding physical environment of the Roberts Bank tidal flats, specifically, the inter-causeway area. Data collection for the AMS program was initiated in April 2007, after construction operations for the DP3 project had already begun, albeit in the early stages of construction. As a result, except for aerial photographs and some limited hydrographic surveys, there is no baseline data for which a comparison of the pre- and post-project conditions can be made. However, the rate of change of the processes affecting the physical environment in the vicinity of Deltaport is not rapid, and it is reasonable to expect that the parameters that are being monitored would have represented near-baseline conditions at the onset of the project. Analysis of the present data set therefore involves discussion of the existing conditions and attempting to place these existing conditions in the context of observations made in the AMS 2007 Annual Report (Hemmera 2008d).

3.1.1 Crest Protection Structure Monitoring

Monitoring of the Crest Protection Structure was not conducted during 2012. A discussion of the final results of this portion of the AMS monitoring program can be found in the 2011 Annual Report (Hemmera 2012a).

3.1.2 Automated Turbidity Monitoring

Turbidity monitoring was discontinued in 2010. There are no results related to this activity in 2012.

3.1.3 Monitoring of Erosion and Deposition

Monitoring of erosion and deposition was not conducted during 2012. All DoD rods were removed from the study area during the May 2012 sediment study (discussed below).

3.1.4 Sediment Samples

The sediment sampling program was discontinued following Q4-2011.

In the 2011 Annual Report, an additional sediment sampling study was recommended to assess the variability in observed sediment grain size at select sediment sampling sites. During the course of the AMS monitoring program, sediment samples at sites C02, D02 and E01, showed high levels of variability in percent silt content, while samples at site C03 exhibited very small changes in percent silt.

Under the original biannual AMS sediment study design it is not possible to determine if such variability is a result of:

- Seasonal variability; or
- Localized heterogeneity in the composition of the sediments.

An intensive sampling program was suggested as a means to potentially explain this observed variability. Sampling was conducted on one day (May 8, 2012) at four sites (C02, D02, E01 and C03) using the same sampling methodology as has been used previously except that in this case, the samples were collected in the eight cardinal directions around each of the rods at a distance of 2 m from the rod instead of at a single location. Care was taken to avoid introducing random error by using the same corer to collect the sediment and having the same lab conduct the analysis as was previously used in the study. As the rod at site C03 showed low variability during the AMS program, it was used here as a control, or reference, site.

The control site (C03) returned values of percent silt that were within 2 percentage points of each station around the rod, but were all slightly higher than the previous recorded maximum value reported during the AMS monitoring program. This suggests that changes observed at this rod site over the monitoring program reflect changes in the surface sediments over time, rather than changes in localized spatial distribution of sediment.

Samples collected around two of the ‘high variability’ rod sites (C02 and E01) showed consistency in levels of silt content around the rod (within 10 percentage points), but overall levels were higher than the previously recorded maximum value at each site, which suggests changes to the surface sediments over time. However, higher variability observed during the biannual AMS monitoring program indicates that localized spatial heterogeneity in sediment distribution is also a factor. At C02, a small channel near the site alternately deposits and erodes surface sediments as it migrates through the area. At site E01, the fine surface sediments deposited in this area of ‘new drainage channels’ can be easily redistributed within the area during large storms, and are likely highly stratified, such that small differences in sampling depth result in significant changes in percent silt content.

Samples collected at D02, which had the largest variability during the biannual AMS monitoring program, returned values of silt content that varied by up to 34.5 percentage points around the rod, with one of the eight samples exceeding the previous maximum value by 16 percentage points. These variations are likely related to the occurrence of small channels that redistribute sediments in the area, as well as differences in sediment composition between a nearby patch of deposited sediment and the surrounding eelgrass beds.

Based on the results it is reasonable to conclude that much of the variability in percent silt content measured during the biannual AMS monitoring program is temporal in nature. To a lesser extent, some variation is likely due to localized differences in spatial distribution of fine sediments at a given site. These localized changes are more pronounced at some sites than at others, in particular those sites that have been documented to have erosional and depositional features (such as small channels or distinct deposits of sediment) nearby.

The results and discussion of this study are discussed in more detail in a memorandum provided in **Appendix B** of this report.

3.1.5 Interpretation of Orthophotographs

The study area for this monitoring activity, as outlined in the Detailed AMS Workplan (Hemmera, 2007), includes the area of Roberts Bank within the inter-causeway portion of the tidal flats. Important changes to the physical environment have been ongoing since the initiation of construction activities for the BC Ferries Causeway and terminal in 1958. These changes have been extensively documented in the Coastal Geomorphology Study (NHC, 2004) and include formation of large systems of dendritic channels, lateral expansion of eelgrass beds, and dredging for expansion of the ship turning basin.

Aerial photographs of the study area are flown in July each year during a low tide event, and subsequently ortho-rectified to create the series of orthophotographs. The changes discussed in this section refer to those that have occurred between the July 2011 and July 2012 imaging dates.

Five main areas of geomorphic change have been identified from the interpretation and mapping of the orthophotos:

1. New drainage channels that formed at the north-eastern margin of the perimeter dike in 2007.
2. Formation of sand bars on the tidal flats on the seaward side of the Crest Protection Structure.
3. The large system of dendritic channels draining into the turning basin.
4. The tidal channels adjacent to the BC Ferries Causeway.
5. New sand bars located along Deltaport Causeway.

These features are shown in **Figure 19**. **Figure 20** shows a detailed view of the area of new drainage channels.

3.1.5.1 New Drainage Channels

The new drainage channels that first became visible in the 2007 orthophoto were initially formed by seawater leaking from the perimeter dike enclosing the DP3 footprint. The south side of the perimeter dike was sealed with sand in July 2007 and flow was observed to have decreased from the perimeter dike the next day. Some leakage of sediment-laden waters was reported within this period but the precise quantity is not known. By the time the 2008 monitoring began, the area within the DP3 footprint had been filled with sediment from dredging activities and water drainage from the dike had ceased.

The channels affected an area of approximately 3.4 hectares, roughly divided between a zone of erosion and a zone of deposition. The channels on the upper mud flats (above approximately 1.5 m (Chart Datum) elevation), which were mostly free of vegetation, initially incised into the soft sediment and carried a large amount of material into the lower tidal flats immediately shoreward of the Crest Protection Structure. The deposition zone resembles that of an alluvial fan and coincides with an area of medium to dense eelgrass beds. Areas within the eelgrass were observed to be buried under the soft sediment within the deposition zone.

These channels have not undergone appreciable lateral migration since the previous photographs taken in 2011. The footprint of the active channel zone is also largely the same; however, tide height at the time of the airphoto acquisition greatly influences the perceived lower elevation extent of the active channel zone in this area, which accounts for most of the differences in the active channel zone mapping here in recent years. Whereas the expansion of eelgrass beds observed in the 2008 photos was largely confined to the upper mud flats, according to orthophotos from 2009, 2010, 2011, eelgrass had also colonized the lower flats. In 2012, this lower region experienced a loss of eelgrass. Eelgrass distribution in this area is discussed in greater detail in **Section 3.4**.

On June 4, 2012, following recommendations made in the 2011 Annual Report, a final field inspection was conducted to assess the current conditions and processes impacting these new channels. This site visit, in combination with a variety of other desktop analyses, was used to summarize the body of knowledge related to the formation of these channels and provide an assessment of their long-term stability.

Annual orthophoto mapping has defined the lateral position of the new channels since their initial formation. Between the 2007 and 2008 orthophotos, there was some slight lateral migration of the channels, whereas since 2008, the channels have not moved by a measurable distance.

Topographic and bathymetric surveys conducted in 2007 and repeated in 2010 also indicate no measurable change to the average surface elevation in this area. However, the spatial resolution of these surveys is not sufficient to determine localized changes in elevation within the channels themselves. Both casual observations and oblique photographs have documented a gradual reduction in the angle of the banks of these channels since their initial formation. Observations made during the site visit on June 4, 2012, which corresponded with a rapidly dropping tide, indicate that these channels are not actively transporting sediment. This is supported by the observation that very fine and soft sediments have persisted in this area since the formation of the channels. The conclusion of this investigation is that no further significant changes are likely to occur to this area. Additional detail related to this investigation is presented in the 'new channels memo' included as **Appendix C** this report.

3.1.5.2 Sand Bars Seaward of the Crest Protection Structure

The portion of the tidal flats on the seaward side of the Crest Protection Structure has a much higher level of exposure to waves than the areas behind the structure. Breaking waves have often been observed in this area but never on the landward side of the structure. Sand bar features in this area appear only slightly different in 2012 than they did in 2011. These differences are attributed more too increased clarity in the 2012 orthophotos and a slightly different tide level in the image than to changes in the size and shape of the sand bars. The decreased magnitude and frequency of storms that occurred between imaging dates in 2011 and 2012 is reflected by the stable nature of the sand bars in this area over this period.

Natural modification of the sand bars in this area is expected to continue, with wave action and tidal flow moving the existing sediment along the edge of the turning basin, and some new sediment coming from the existing tidal channels. Prior to 2012, the DoD rods in this area measured some of the largest amounts of erosion and deposition within the study area, and the Crest Protection Structure monitoring cross-sections captured some of the largest changes in elevation measured on the tidal flats in close proximity to the Crest Protection Structure.

3.1.5.3 Large System of Dendritic Channels

The large system of dendritic channels shown in **Figure 21** was the focus of detailed geomorphic and hydrodynamic analysis as part of the Coastal Geomorphology Study (NHC, 2004). Historic orthophotos show that these channels evolved gradually since the ship turning basin was originally dredged in 1969 and developed further, following expansion of the turning basin and construction of the Crest Protection Structure in 1982. The system of channels and sand bars presently extends over a large area of the tidal flats. The sand bars alone covered an area of over 30 hectares in 2002. The results of previous analysis (Coastal Geomorphology Study, NHC 2004) concluded that the formation of these large channels is related to historic dredging of the ship turning basin. Given that they are relatively removed from the assumed area of influence of the new DP3, it is unlikely that they are being influenced by, or have influence on the present project.

The main features of interest in the large dendritic channels include the main trunk channel, a very large sand deposit at the shoreward end of the trunk channel, referred to as the ‘sand lobe’, and a system of smaller ‘tributary’ channels extending from the trunk channel shoreward across the tidal flats. **Figure 21** shows the outline of the channels that were digitized from the 2011 and 2012 orthophotos. The trunk channel has remained relatively stable, but the orthophoto comparison shows small changes to the rest of the system since July 2011. Shoreward extension of some of the tributary channels has continued to occur over the last year with some additional widening of these channels, while other tributary channels appear to have receded and become inactive.

Between July 2011 and July 2012, the dendritic channels have extended landward very little relative to previous years. In the northern-most arm of the dendritic channels, where there has been growth during each year of the monitoring program, there was no visible extension over the past year. The location in which there was more growth than in other areas was in the south-eastern arm (which extends toward the BC ferries causeway), which had experienced rapid growth in recent years. Change to the extent of this arm was approximately 15 meters.

In contrast to the unusually small changes seen in the extent of these channels, there was much greater change in the planform shape of some of the channels. The amplitude of channel meanders is larger in the 2012 image than has been observed previously, and the point bar features that occur on the inside bend of each meander are larger than in previous years. Similarly, the sand lobe feature appears to be more active than in previous years, with bare sand appearing to replace existing patches of eelgrass (through either erosion or deposition of that area) that had grown on parts of the sand lobe, and a small new channel forming in the middle of the sand lobe.

3.1.5.4 Channel Development along the BC Ferries Causeway

The tidal channel and its tributaries that have formed adjacent to the BC Ferries Terminal do not appear to be related to any of the activities of Deltaport but the channels fall within the study area for the interpretation of orthophotographs portion of the AMS monitoring program. These channels appear to have formed initially in response to expansion of the ferry terminal and have continued to expand shoreward over the last several decades as a result of tidal drainage, resulting in a wide trunk channel running parallel to the causeway. A small channel on the upper tidal flats, which formed in response to overland drainage from the agricultural lands east of the dikes (**Figure 19**), joined with this main trunk channel at some time between July 2008 and July 2009, as noted in the 2009 Annual Report (Hemmera, 2010). Since the connection of the main trunk channel with this smaller channel, both channels appear to have stopped their expansion.

Between July 2011 and July 2012, changes in the area surrounding the connecting point of these two channels have been quite small relative to changes in this area in previous years. This suggests that the connection of the two channels has resulted in increased stability of the channels and decreased rates of sedimentation on the tidal flats in this area. The narrower drainage channel has continued to migrate in a meandering pattern near to where it joins the trunk channel, while remaining very stable higher up the tidal flats. The trunk channel and small dendritic arms extending from it have experienced only very small changes over the past year.

3.1.5.5 Development of Sand Bars along the Deltaport Causeway

A series of small ((60 – 5,700 m^2)) sand or fine gravel deposits have been identified in the 2012 orthophotos that are located along the east side of the Deltaport Causeway. These deposits have been mapped as ‘sand bars’ in **Figure 19**. The sediment appears to have originated from the nearby East Causeway Habitat Compensation sites, where there has been an observed loss of material (*pers. comm.*, G.L. Williams). This sediment has likely been transported out of these alcoves during certain dropping tidal conditions during which there is rapid outflow of water from the alcoves. The material is then deposited very close to the causeway as it encounters the slower moving water on the tidal flats. These features are also discussed as they relate to eelgrass distribution in **Section 3.4**.

3.1.6 Coastal Geomorphology Mapping

The topographic and bathymetric surveys and subsequent digital elevation model creation which comprised this portion of the AMS program were not conducted in 2012.

3.1.7 Wave and Current Monitoring

The wave and current monitoring portion of the Coastal Geomorphology program was discontinued in 2010. The wave climate affecting the study area was assessed based on wind data collected at Vancouver Airport and compared to wave data measured at Halibut Bank (see **Section 2.1.2**).

3.2 SURFACE WATER QUALITY

The discussion of surface water quality monitoring results considered both spatial and temporal trends.

Results from stations DP02, DP03, and DP04, intertidal stations in the inter-causeway area, were compared to results from DP06, the intertidal reference station (**Figure 6**). The results from station DP05, the subtidal station in the inter-causeway area were compared to those from the subtidal reference station (DP07). The A level and B level subtidal results were also considered separately. As noted in **Section 1.3.2**, the A level samples at DP05 and DP07 were collected one metre below the surface of the water and B level samples were collected 2.0 metres above the sediment. Station DP01 was not included in this comparison as it has no associated reference station. Stations DP08 and DP09 were not included in the temporal trend analysis since they were only sampled in Q1 and were added as part of the benthic invertebrate monitoring program.

3.2.1 Spatial Trends between Inter-causeway and Reference Stations

The data collected within the inter-causeway area were compared with the results from the reference stations in **Figures 24** and **25**. Note that the values presented in **Figures 24** and **25** include only data for 2012 as they are intended to capture spatial trends in 2012. Temporal trends (2007 to 2012) are captured in **Figures 26** and **27** and on trend plots in **Appendix E** and **F**.

3.2.1.1 Metals

Figure 24 compares metal concentrations at the nine monitoring stations within the first quarter of 2012. The metals selected for **Figure 24** include arsenic, barium, cadmium, copper, lead and zinc as these metals have established regulatory guidelines, exceeded regulatory guidelines during the AMS program or have been detected consistently above their RDL. Other regulated metals parameters, including beryllium, chromium, mercury, selenium and silver, were not included as most values were less than the RDL. Uranium was not included as concentrations were typically less than 2% of the BC WQG.

The highest metal concentrations in surface water were measured at DP01 and, as discussed in **Section 2.3.2.1**, a number (cadmium, chromium, copper, manganese and nickel) exceed regulatory guidelines in Q1-2012 (similar to previous years). There were no exceedances of regulatory guidelines for metals in any of the other surface water samples in Q1-2012, except boron as discussed in **Section 2.3.2.1**. In summary, excluding DP01 data, spatial trends include:

- Arsenic concentrations were less than detection in all samples.
- Barium concentrations were generally higher at the reference sites than in the inter-causeway area.
- Boron concentrations were generally lower at the reference sites (upper samples) that in the inter-causeway area.
- Cadmium concentrations were similar across all stations with the highest at DP09.
- Copper concentrations were similar across all stations with most concentrations below the detection limit and highest concentrations at the reference site DP06.
- Lead concentrations were mainly below the method detection limit with detectable concentrations at DP05A and DP07A.
- Zinc concentrations were below the method detection limit at all stations except DP02.

Metal concentrations at the A and B levels at DP05 were more similar than metal concentrations at the A and B levels at DP07. Similar to 2010 and 2011, the pattern in metal concentrations measured at DP07A is different from concentrations of some metal at DP06, suggesting a more variable influence of Fraser River inputs.

3.2.1.2 Eutrophication-related Parameters

Figure 25 shows spatial trends in eutrophication-related parameters. As with previous years, the highest chlorophyll α, ammonia, phosphate, TKN and total nitrogen concentrations in surface water were measured at DP01. The elevated concentrations at DP01 are attributed to upland fertilizer inputs. Fertilizers are applied to agricultural land upgradient of DP01 to enhance agricultural crop growth. Excess nutrients subsequently make their way in groundwater and surface water that is conveyed to the ditch where DP01 is located.

Dissolved oxygen measurements between the inter-causeway area and the reference sites are similar (DP02 to DP05 average = 9.89 mg/L, DP06 to DP07 average =9.76 mg/L for data set 2007 to 2012). The dissolved oxygen concentrations were generally the lowest each quarter at the deeper subtidal stations DP05B and DP07B, and in the highest range at intertidal stations DP02, DP03 and DP08. The elevated dissolved concentrations measured at these intertidal stations were likely a function of the presence of eelgrass at these stations. Relatively low dissolved oxygen was expected at DP05B and DP07B, as dissolved oxygen typically decreases with depth.

Key spatial trends observed in 2012 were relatively elevated nutrient concentrations (ammonia, TKN, nitrite, total nitrogen, phosphate) at DP01 (likely a result of upland run-off) as compared with other stations and DP04 having a higher concentrations of chlorophyll *a*, organic nitrogen and TKN compared to other stations in Q2-2012 and Q3-2012.

Other spatial trends observed using the 2007 to 2012 data set include:

- The average ammonia concentrations are higher and more variable for the reference stations (0.034 mg/L) than the inter-causeway (0.022 mg/L). Generally lower concentrations of ammonia have been measured in the samples from the deeper stations (DP05B, DP07B).
- Similar phosphate (both inorganic and ortho) concentrations have been detected in the inter-causeway area sampling stations and the shallow reference stations. Generally, higher phosphate concentrations have been measured in the samples from the deeper stations (DP05B, DP07B).
- The average TKN concentrations are slightly lower for the reference stations (average = 0.17 mg/L) than the inter-causeway (average = 0.2 mg/L). Generally lower concentrations of TKN have been measured in the samples from the deeper stations (DP05B, DP07B).
- Generally, the concentrations of chlorophyll α are higher and more variable at the inter-causeway stations (average = 1.69 mg/L) then the reference stations (average = 0.67 mg/L).

The spatial analysis did not suggest a trend towards eutrophication.

3.2.2 Temporal Trends

3.2.2.1 Metals

Metal concentrations in surface water do not show clear increasing or decreasing temporal trends between quarters or consistent seasonal patterns (**Figure 26**). Both the highest metal concentrations and the greatest variability were observed at DP01.

Trend plots for metals grouped by inter-causeway stations (DP02 to DP05) and reference stations (DP06 to DP07) have been prepared using data from 2007 to 2012 and are attached as **Appendix E**. A review of the trend graphs indicate:

- Inter-causeway stations and reference stations have similar concentrations of metals with reference stations having slightly higher mean values (2007-2010) and higher variability for cadmium, copper and zinc.
- Concentrations of metals at inter-causeway stations were all less than CCME/BC WQG between 2007 and 2012, except for copper in one sample collected from DP05A in Q1-2007. Reference stations had one or more exceedances of CCME/BC WQG for cadmium, copper and zinc.
- No increasing trend in metal concentrations.

3.2.2.2 Eutrophication-related Parameters

Temporal trends (2007 to 2012) for eutrophication parameters are captured in **Figures 27** and **30**. The chlorophyll *a*, nitrate, nitrite, TKN, nitrogen, phosphorus and ammonia concentrations do not exhibit an increasing trend, or for dissolved oxygen a decreasing trend, over the course of six years of monitoring when all parameters are plotted together on a log scale by all events (**Figure 27**) or by quarter (**Figure 30**).

Trend graphs for each eutrophication parameter grouped by inter-causeway stations (DP02 to DP05) and reference stations (DP06 to DP07) are provided in **Appendix F**. A review of the trend graphs for surface water indicates:

- Dissolved oxygen measurements do not fluctuate notably over time but indicate a potential seasonal pattern with lower dissolved oxygen in Q3 and/or Q4 events.
- Ammonia concentrations in the inter-causeway stations appear to have decreased between 2007 and 2009. The reference stations DP06 and DP07 have higher and more variable ammonia concentrations and appear to have decreased over a longer time period (i.e. 2007 to 2012 as compared to the inter-causeway stations.
- Phosphate concentrations (both inorganic and ortho) do not indicate a trend over the entire 2007 to 2012 time period. There does appear to be a seasonal trend in phosphate concentrations within both the inter-causeway and the reference stations with higher concentrations (peaks on the trend graph) in Q4 sampling events (November or December).
- Nitrate, nitrite and total nitrogen concentrations have generally been less than detection limits or just above detection limit since Q2-2009 at the inter-causeway and reference sampling stations (except for total nitrogen and nitrate at DP04 in Q4 of 2011).
- TKN and organic nitrogen concentrations do not indicate a trend over the entire 2007 to 2012 time period. Higher concentrations generally occur in Q2 or Q3 sampling events which indicates a seasonal trend in the data.
- Chlorophyll α concentrations do not indicate a trend over the entire 2007 to 2012 time period. However, higher than average concentrations were measured during the majority of Q2 and Q3 sampling events at both inter-causeway and reference sampling stations.

The temporal analysis does not suggest a trend towards eutrophication.

3.2.3 Ecosystem Health and Function

Metal and nutrient concentrations in surface water have not shown an increasing trend in the six years of AMS monitoring (2007 – 2012). As such, DP3 construction and operation are not considered to have had a negative impact on water quality in the inter-causeway area. In 2010, Hemmera recommended reducing the frequency of metal monitoring to once per year and analyzing metals in surface water only in Q1. The results for metals from 2011 and 2012, plus the preparation of trend graphs (**Appendix E**), further support that DP3 construction and operation is not negatively impacting the water quality in the inter-causeway area.

Phosphorus and nitrogen are two key nutrients associated with plant growth. Increasing concentrations of either may signal an increased risk of algal blooms or eutrophication. In marine environments, nitrogen is the limiting nutrient. Nitrate accounted for the bulk of total nitrogen in the water samples (**Figure 27**). Ammonium is the form of nitrogen preferentially taken up by aquatic plants from surface waters. For phosphorus, orthophosphate, the soluble, inorganic fraction, is the form taken up by plants.

Other key parameters that may act as indicators for eutrophication include chlorophyll *α,* dissolved oxygen, and TSS. Chlorophyll *α* levels fluctuate naturally with the seasons; rainfall, warm summer water temperatures and light levels lead to greater phytoplankton numbers, and therefore higher chlorophyll *α* levels. However, long-term elevated concentrations of chlorophyll *α* can reflect an increase in nutrient loads and increasing trends can indicate eutrophication. An increase in TSS can also signal an increase in phytoplankton or detritus associated with eutrophication although inorganic particulate matter may account for a significant portion of TSS and confound any trends.

A literature review on parameters used to monitor eutrophication was conducted in 2009. Sources considered included:

- National Oceanic and Atmospheric Association.
- Australian and New Zealand Environment Conservation Council.
- European Environment Agency.
- HELCOM – Baltic Sea.
- OSPAR – North-East Atlantic;
- Canadian Council of Ministers of the Environment (CCME).

While most jurisdictions proposed gauging the potential for eutrophication by establishing local or regional baseline conditions, the CCME presented the following criteria from work by Vollenweider et al. (1998) and Bricker et al. (1999); **Tables 3.2-1** and **Table 3.2-2** respectively.

Table 3.2-1 Criteria for Evaluating Trophic Status of Marine Systems (Vollenweider et al. 1998)

Trophic Status	TN (mg/L)	TP (mg/L)	Chlorophyll α (µg/L)
Oligotrophic	< 0.26	<0.10	<1
Mesotrophic	≥0.26-0.35	≥0.10-0.30	≥1-3
Eutrophic	≥0.35-0.40	≥0.30-0.40	≥3-5
Hypereutrophic	≥0.40	≥0.40	≥5

Table 3.2-2 Trophic Status Classification Based on Nutrient and Chlorophyll (Bricker et al. 1999)

Degree of Eutrophication	TN (mg/L)	TP (mg/L)	Chlorophyll α (µg/L)
Low	0-≤0.1	0-≤0.01	0-≤5
Medium	>0.1-≤1	>0.01-≤0.1	>5-≤20
High	>1	>0.1	>20-≤60

The average nitrogen concentration in the study area over the first three years of data collection was 2.2 mg/L. While this suggests a high degree of enrichment under both classification systems, this falls within the range considered normal for the Strait of Georgia, which has naturally elevated nitrogen concentrations (Mackas and Harrison 1997). The average phosphorus concentration in the study area was 0.08 mg/L, which falls in the medium range under Bricker's classification system and oligotrophic under Vollenweider's classification system. The average chlorophyll α concentration in the study area was 1.3 µg/L, which is considered low and indicative of mesotrophic conditions.

Following discussions with VFPA and SAC in 2010, graphs showing the relationship between nitrate to ammonia and total nitrogen to total phosphorus in surface water were prepared to determine if station-specific or area-wide trends in these ratios exist which might be used as a line of evidence in evaluating ecosystem health (**Figure 28** and **Figure 29**). When present in excess, ammonia is toxic to organisms. Under eutrophic conditions, ammonia would be expected to accumulate. **Figure 28** suggests that while nitrate concentrations vary from station to station, the ammonia concentrations fall in a more restricted range (0 to 0.1 mg/L), except at DP01 (where there are nutrient inputs from upland sources and surface water in the drainage ditch is not oxygenated to the same extent as surface water in the inter-causeway area or at the reference sites).

The Redfield ratio is the atomic ratio of carbon, nitrogen, and phosphorus found in the deep ocean and named after Alfred C. Redfield who first described this ratio in a 1934 article. The Redfield ratio defines the optimal C:N:P ratio in the marine environment as 106:16:1. In particular, the N:P ratio of 16:1 is considered the optimal ratio for phytoplankton growth. Eutrophication can lead to a shift in this ratio. Given the lack of temporal trends in the inter-causeway area or the reference stations towards eutrophication, the N:P ratio for the current data set (2007-2012) presented below is considered to reflect that which naturally occurs in the study area.

To understand how the Redfield ratio compares to data within the study area (DP02 to DP07), the average N:P ratio was calculated for four time periods (2007-2012, 2007-2011, 2007-2010 and 2007-2009). The average N:P ratio in the study area over the six years (2007-2012) of the AMS program was 21:1 which is greater than the predicted Redfield ratio. The average N:P ratio in the study area was calculated at 23:1 for 2007-2011, 26:1 for 2007-2010 data set and 31:1 for 2007-2009 data set. While nitrogen concentrations in the area are naturally elevated, **Figure 29** shows several outliers, which would further bias this ratio upwards. Trend graphs were prepared for redfield ratio N:P for inter-causeway and reference stations with concentrations of total nitrogen and phosphorus converted to a molar concentrations (**Appendix F**). The trend graph shows that from 2009 to 2012 the N:P ratio using molar concentrations is close to the predicted Redfield ratio of 16:1, except for one event (DP04 in Q4-2011).

3.2.3.1 Site-specific Nutrient Thresholds

Naturally occurring nutrient concentrations vary spatially and temporally. To detect potential eutrophication (or environmental change), and account for this natural variability, site-specific criteria (or thresholds) are developed (where there is sufficient site-specific information to do so).

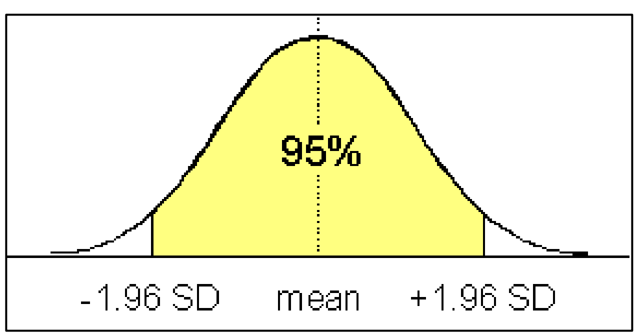
In the case of Roberts Bank sufficient information for site specific criteria, and eutrophication thresholds, have historically been unavailable. However, the AMS program was designed to provide both the site-specific information and thresholds to identify potential eutrophication at Roberts Bank. The following information relates to what the criteria, or thresholds, are and how data collected in 2012 relates to these thresholds.

3.2.3.2 Threshold Identification

The threshold for evaluating potential environmental change (e.g., eutrophication) was established in conjunction with PMV and the AMS Scientific Advisory Committee in 2012 and presented in the final 2011 annual report (Hemmera 2012b). The nutrient threshold for each parameter is the mean +/- 1.96 multiplied by the standard deviation (SD) of the mean (μ):

$$\text{Eutrophication Parameter Threshold} = \mu \pm 1.96 \times SD$$

Assuming a normal distribution, this threshold captures data or results that exceed 95% of the natural variability as shown in the graph below. Since eutrophication may lead to increases in nutrient parameters concentrations and decreases in dissolved oxygen, the threshold for dissolved oxygen has been set at the lower limit (i.e. negative) and all other nutrient thresholds has been set at the upper limit (i.e. positive).



The first four years of AMS data (2007-2010) were used to define background conditions. This is reasonable as three years of data is considered sufficient for defining background conditions by the Australian and New Zealand Environment Conservation Council.

Parameters that were observed above the nutrient thresholds in 2012 include (**Appendix F)**:

- Total phosphorus at inter-causeway stations DP02 in Q1 and DP05B in Q4. The total phosphorus at the reference station DP07B was also above the nutrient threshold in Q4 (suggesting a regional influence). The deeper sampling sites tend to have higher concentrations of phosphorus and as discussed in **Section 3.2.2.2**, higher concentrations are generally measured during Q4 sampling events.
- Organic nitrogen at inter-causeway station DP04 in Q2. While the organic nitrogen concentrations at reference station DP06 were not above the nutrient threshold in 2012, the highest concentration at DP06 occurred during Q2 event. Organic nitrogen concentrations are variable over the 2007 to 2012 period and have been above the nutrient threshold in previous sampling events.
- Chlorophyll α at inter-causeway station DP04 in Q2 (May 2012). The chlorophyll α concentrations detected at the reference stations DP06 and DP07A were slightly higher in Q2 than during the other 3 sampling events in 2012. As discussed in **Section 3.2.2.2**, higher concentrations are generally detected in Q2 and Q3 events due to warm water temperatures and increased light levels resulting in greater phytoplankton numbers. It is therefore unlikely that this elevated chlorophyll α concentration detected at DP04 is related to DP3 operation or a sign of eutrophication.

As documented in the May 2012 letter to VFPA regarding development of site-specific nutrient thresholds, an exceedance of the nutrient threshold is not necessarily indicative of eutrophication and a tiered-approach would be used to evaluate exceedances. In the context of the tiered evaluation approach, the 2012 data does not warrant additional investigation. For example, no parameters were above the nutrient thresholds for more than two sequential monitoring events or concentrations were elevated both in the inter-causeway area and at the reference stations. This parameters will continued to be monitored quarterly in 2013 and evaluated against the tiered evaluation approach.

3.3 SEDIMENT QUALITY

Similar to surface water, the discussion of sediment quality results considered both spatial and temporal trends, with particular attention given to parameters associated with eutrophication.

A lithium geonormalizing technique was applied to distinguish between metals inputs from anthropogenic sources and natural variations in background metal concentrations. Lithium occurs predominantly in several common silicate minerals where it substitutes for potassium, sodium, and magnesium and has been shown to be an effective means to normalize metals concentrations to background (Sutherland et. al. 2007).

Figure 31 shows sediment metals parameters normalized to lithium for 2007 to 2012. For most parameters, the normalized metal parameters lay close to the regression line suggesting natural background concentrations. In 2012, notable points that plotted slightly higher then the regression line include the reference station DP06 for aluminium, cobalt, copper, zinc, and DP05 and DP09 for copper based on the **Figure 31** plot. These results are consistent with previously results for copper at DP05 and DP09 and for the other metals at DP06. These three locations had higher content of silt and clay than the other samples based on the grain size data. Based on the lithium normalization, these metal results are considered reflective of natural background conditions.

3.3.1 Spatial Trends between Inter-causeway and Reference Stations

Figures 32 and **33** show a comparison of the relative variation of sediment metals and eutrophication-related parameters between the intertidal inter-causeway stations (DP02, DP03, DP04, DP05, DP08, and DP09) and their associated reference samples (DP06 and DP07).

3.3.1.1 Metals

Figure 32 shows spatial trends in metals concentrations for the CSR Schedule 9 sediment metals parameters (arsenic, chromium, copper, mercury and zinc)[6]. Similar to previous years, metal concentrations were highest at DP05 and DP09 (subtidal locations within inter-causeway), specifically copper and zinc. However, as discussed above and shown on **Figure 31A**, the copper and zinc concentrations are considered natural based on normalization to lithium. The reference station DP06 also had higher concentrations of metals in 2012 compared to the other locations, which has been noted in previous years (ex. 2009). Metal concentrations at DP01 (near agricultural ditch) appear to be higher in 2012 when compared to previous spatial trend figures in annual reports for 2008 through 2011 (Hemmera 2009, 2010, 2012a, 2012b). The other inter-causeway stations (DP02 to DP04, DP08) had metal concentrations in sediment similar to those measured at reference station DP07.

3.3.1.2 Eutrophication-related Parameters

As with surface water, phosphorus and nitrogen in sediment are two key nutrients associated with plant growth. Increasing concentrations of either may signal an increased risk of eutrophication. In sediment, nitrate is the primary nitrogen source for aquatic plants; however, both nitrite and ammonia have the potential to undergo nitrification to nitrate. Elevated TKN concentrations are usually the result of sewage and manure discharges to water bodies.

[6] Cadmium and lead were not included in the spatial trend graphs as concentrations were less than the RDL for all samples. CSR Schedule 9 sediment criteria are generally adopted by federal regulators in BC due to the extensive federal input into their development.

As in previous years, concentrations of eutrophication-related parameters in sediments at the inter-causeway stations were greater than those at the reference stations (**Figure 33**). As shown on **Figure 33**, the highest concentrations of eutrophication-related parameters at the inter-causeway stations were measured at DP05, except for total phosphorous, which is the same as previous years. Station DP05 is located in the subtidal environment within the inter-causeway area and consistently has higher concentrations than the other sampling locations (see trend graphs in **Appendix F**). The lower phosphorous concentrations at DP05 are likely related to its location outside of the eelgrass beds

The spatial analysis does not suggest a trend towards eutrophication.

3.3.2 Temporal Trends

3.3.2.1 Metals

Metal concentrations within the inter-causeway and at the reference stations in 2012 were similar to those from 2007 to 2011 (**Figure 34** and **Appendix E**). Similarly, station DP01 (located near the agricultural runoff ditch west of the BC Ferries causeway) showed the greatest variability in metal concentrations between 2007 and 2012. Reasons for this variability are likely related to seasonal or yearly changes in the quality of sediment deposited by the agricultural runoff. Given DP01's distance from DP3 and its location at the point where the agricultural ditch enters the mud flats, this variability is not likely related to DP3 construction or eutrophication.

Review of temporal metal concentration trend graphs, for the 2007 to 2012 time period, (**Appendix E**) indicate:

- Inter-causeway stations and reference stations have similar concentrations of metals with reference stations having higher variability in copper concentrations.
- Concentrations of metals at inter-causeway and reference stations were all less than the CSR sediment criteria between 2007 and 2012.
- No increasing trend in metal concentrations.

3.3.2.2 Eutrophication-related Parameters

Concentrations of eutrophication parameters within the inter-causeway and at the reference stations in 2012 were similar to those from 2007 to 2011 (**Figures 35** and **36**, **Appendix F**). Total phosphorus concentrations showed very little variation at the seven stations monitored over the full six year period (**Figure 35**). Sulphide concentrations were most variable of the eutrophication parameters, especially at DP01 (located near the agricultural runoff ditch west of the BC Ferries causeway). Short term increases in sulphide have been noted at the inter-causeway stations; however, there does not appear to be an increasing trend in sulphide concentrations over the 2007 to 2012 time period.

Review of temporal concentration trend graphs for each eutrophication parameters (**Appendix E**) indicate:

- Ammonia concentrations do not indicate a trend over time or show a distinct seasonal trend across all stations.
- Total phosphorus, TKN and sulphide concentrations do not indicate a trend over time or seasonal trend.
- Total nitrogen concentrations do not indicate a trend over time or seasonal trend except the trend graph for reference stations seems to indicate a potential trend in higher concentrations in Q3 (2007, 2008, 2009) or Q4 (2010, 2011, 2012).
- Organic nitrogen concentrations and total organic carbon do not indicate a trend over time or seasonal trend.

The temporal analysis does not suggest a trend towards eutrophication.

3.3.3 Ecosystem Health and Function

The spatial and temporal analysis of the sediment data does not show a trend towards eutrophication or increases in metal concentrations resulting from DP3 construction or operation. Given that metal concentrations in sediment have not shown an increasing trend over the six years of the AMS program, it is unlikely that metal inputs from the construction and operation of DP3 will affect the overall concentration of metals in sediments within the inter-causeway.

Following discussions with VFPA and SAC in 2010, graphs showing the relationship between total nitrogen and total phosphorus, TOC and total nitrogen, and TOC and total phosphorus in sediment were prepared to determine if station-specific or area-wide trends in these nutrient ratios exist which might be used as a line of evidence in evaluating ecosystem health (**Figures 37**, **38**, and **39**).

As noted in **Section 3.2.3,** the Redfield ratio defines the C:N:P ratio in the marine environment as 106:16:1. .Eutrophication can lead to a shift in the Redfield ratio. However, given the lack of temporal trends in the inter-causeway area or the reference stations towards eutrophication, the C:N:P ratios are considered to reflect those naturally occurring in the study area.

Neither the N:P nor the C:P ratios corresponded to the Redfield ratio but these ratios do not very widely at each station over the six year sampling period (except for DP01) as shown on **Figures 37** and **39**. As shown on **Figure 38**, the C:N ratio for sediment data is generally consistent with the Redfield ratio except DP01 and DP05 are noted as having a higher C:N ratio than other stations. The average C:N ratio for DP02 to DP07 using 2007 to 2012 data set was 7.8, falling close to the predicted ratio of 6.6. This ratio is similar to the C:N ratio calculated for the 2007 to 2011 data set of 7.6, 2007 to 2010 data set of 7.6 and 2007 to 2009 data set of 7.8. Trend graphs for the Redfield ratios in sediment were also prepared and are provided in **Appendix F**. These graphs do not indicate any notable increases or decreases in these ratios over the 2007 to 2012 monitoring period.

3.3.3.1 Site-specific Nutrient Thresholds

As discussed in **Section 3.2.3.1**, nutrient thresholds for evaluating potential environmental change (e.g., eutrophication) were set for each parameter as:

Eutrophication Parameter Threshold = μ +/- 1.96 X SD

Thresholds, based on 2007-2010 data, for the individual eutrophication parameters are shown on the trend graphs contained in **Appendix F**.

Most eutrophication parameters were not measured above the site specific nutrient thresholds. However, station DP05, in deeper waters, did show some exceedances. This station typically shows higher concentrations for all eutrophication parameters (than the other inter-causeway stations) and this is likely due to it being subtidal (as opposed to intertidal). Sulphide at DP05 was observed above the threshold limit for sediment in 2012 at the inter-causeway stations during both the Q3 and Q4 sampling events. The TOC value at DP05 was also above the threshold limit in Q2 and Q3 in 2012. The sulphide concentrations in 2012 are similar to concentrations detected previously in 2007 at this location. The sulphide concentrations at reference station DP07 were slightly higher in Q3 and Q4, however, sulphide concentrations at the reference stations are notably lower than at DP05.

3.4 EELGRASS DISCUSSION

3.4.1 Eelgrass Distribution and Mapping Discussion

The inter-causeway eelgrass meadow is composed of three main habitat types. A large *Z. marina* bed, a large *Z. japonica* bed, and a transition zone located between the two *Zostera* beds. The transition zone tends to be slightly above the optimal elevation for *Z. marina* and usually supports a mix of both species. *Z. japonica* can't compete with *Z. marina* for space but it is an opportunist and can colonize the area between *Z. marina* shoots. The size and boundaries of the transition zone was shown to vary with climate during the 1980s (Harrison, P.G. 1984). Warm dry summers resulted in desiccation of some of the *Z. marina* in this area enabling *Z. japonica* to prosper. Cool summers resulted in an increase in *Z. marina* at this location and hence a decrease in the amount of *Z. japonica.*

Z. japonica is an annual species; the shoots typically live less than one year and germinate from seed in the spring. Therefore the distribution and density of this species tends to vary considerably between years. However, there appears to trend beyond inter-annual variation occurring in the upper areas of the main *Z. japonica* meadow (adjacent to the unvegetated mudflat). An area of patchy *Z. japonica* was first noted in this meadow in 2010 (**Figure D-4**), the size of the area has increased annually since (**Figure D-5**, **Figure 22**). A second area, east of the first, developed into patchy habitat in 2011 (**Figure D-5**) and expanded into 2012 (**Figure 22**). It is possible that sediment accretion in parts the upper intertidal has occurred and resulted in an elevation that is sub-optimal for *Z. japonica* resulting in a patchy distribution.

Several small sand bars developed perpendicular to the east side of Deltaport causeway in an area that has either been patchy or continuous *Z. japonica* since 2003 (**Figure 22**); these are discussed in the Geomorphology section of this report.

The boundaries and size of transition zone northwest of the sand lobe have changed considerably since 2003. The 2008 eelgrass field surveys noted vertical rhizome growth of *Z. marina* in this area and suggested that this was a response to recent sediment deposition. It was suggested that the sediment deposition may have resulted from the evolution of the sand lobe and associated dendritic channels since the area of diminished eelgrass productivity extended to the sand lobe. The majority of the transition zone had developed into patchy *Z. japonica* habitat by 2009, although a relatively small area at the north western end of this zone continued to support both species. The 2010 field survey noted *Z. marina* seedlings in the area classified as patchy *Z. japonica* adjacent to the mixed patchy zone. The seedlings survived and multiplied by 2011 resulting in an expansion of the mixed patchy habitat. The 2012 survey found that the density of both species had increased over the last year resulting in continuous distribution; *Z. japonica* was dominant.

The 2011 AMS Annual report (Hemmera 2012b) discussed inter-annual variation in the timing and height of the lowest summer tides over the course of the AMS and suggested that this may have contributed to changes within northwest side of the transition zone. The 2010 bathymetry data was compared with that which was used for the EA (pre 2003) for the area in the vicinity of the transition zone. The comparison suggested that there may have been a 30 to 40 centimetre increase in the elevation at this location, and concluded that the reduction in *Z. marina* habitat and changes to the transition zone were the result of sediment movement and accretion caused by the continued evolution of the dendritic channels and sand lobe combined with inter-annual variation in tide height, and not related to the development of DP3.

The boundary and size of the transition zone south east of the sand lobe has also varied over time, although to a lesser extent. The landward boundary retreated in 2008 and then began advancing landward in 2010.

In an attempt to understand the losses and gains of *Z. marina* in the transition zone the annual Mean Low Low Water (MLLW) levels at Tsawwassen were examined. The slope in the vicinity of the transition zone is approximately 1:1,000, therefore a very small change in water level during low tide can result in large changes in the amount of tidal flat that is exposed.

Historical data is available from a tide prediction website that has demonstrated accuracy over the course of this project.[7] The mean low low water height over four months (April 1 to July 22) was downloaded from the site for the years between 1990 and 2025, the last year for which data is currently predicted. The dates were selected to correspond roughly from the onset of the active growing season up to the

7 http://tbone.biol.sc.edu/tide/tideshow.cgi

time when the AMS data is recorded. The mean MLLW level during this period between 1990 and 2007 was 1.18 m., with a range from 1.10 to 1.28 m. The MLLW in 2008 was 1.08 m. The MLLW levels increased to 1.11 m in 2009, and will continue to increase to a height of 1.31 m in 2014 after which they will begin a gradual decline to 1.13 m in 2025.

The review of MLLW water data revealed that over the period between 1990 and 2025 it was lowest during 2008. The 2009 MLLW was relatively low but within the range recorded for other years. However, the maximum July temperature in 2009 exceeded that for other years of the AMS. The maximum temperature record for July at the Vancouver airport in 2009 was 34.4 ^{0}C, while in the other years of the AMS it ranged from 25.8^{0}C to 28.3^{0}C. The warmer temperature combined with lower water would have lead to an increase in desiccation of the eelgrass shoots and their mortality. The higher annual MLLW levels and cooler July temperatures since 2009 are likely factors that have enhanced the ability of *Z. marina* to survive at higher elevations on the tidal flats. There have been eelgrass increases and losses in the vicinity of the sand lobe complex over the last year; the magnitude of change was less than in previous years. The majority of the increases were in the northern and western areas while the majority of the losses occurred in the southern and eastern areas of the complex.

The SIMS mapping data demonstrates that the maximum lower depth of *Z. marina* in the inter-causeway has remained unchanged since 2003, as has the intertidal percent cover in the area mapped using SIMS. The subtidal percent cover data collected in 2012 was very similar to that collected in 2003, but lower than in 2009.

The lowest tides in 2008 and 2009 were negative, while those in 2002 and 2003, and in 2010 and 2011 were positive. It is likely that the variation in height of low tides contributed to the increased density observed in 2009. The lower water levels 2008 and 2009 would have resulted in an increase in the amount of phytosynthetically active radiation (light) reaching the eelgrass and stimulating growth.

The area (m^2) colonized by *Z. marina* in 2012 in the area that was altered by sediment deposition from the new drainage channel formation was less than in 2011. Several areas in the intertidal zone that supported patchy *Z. marina* in 2011 had developed into unvegetated mudflat or patchy *Z. japonica* by the time of the 2012 survey. The *Z. marina* in the slightly subtidal southern corner of the assessment area changed from continuous *Z. marina* to patchy *Z. marina* over this time. There was also less *Z. marina* in the small channels in 2012.

The reason for these changes is unknown at present. Precision Identification, NHC, and representatives from both the PMV and the AMS Scientific Advisory Committee have planned a site visit for the first good daytime low tide on April 2, 2013 to assess the current condition of *Z. marina* in the area and to develop a work plan to investigate possible causes for these changes.

Several eelgrass habitat changes were noted adjacent to the Tsawwassen Ferry Causeway; these are due to the channel and sandbar development in that area.

3.4.2 Eelgrass Vigour and Health Discussion

Research has shown that eutrophication may lead to an elevated epiphyte load on eelgrass. The epiphyte load on the eelgrass at all stations on Roberts Bank and at the reference stations at Boundary Bay in 2012 was comparable to previous years at the time these beds were surveyed.

Beggiatoa sp. is often used as an indicator species to identify degraded marine habitats. The filamentous preteobacteria forms visible whitish mats in many polluted marine environments, especially those with sediments rich in hydrogen sulphide. *Beggiatoa* sp. was not noted at either Roberts Bank or Boundary Bay during the 2012 eelgrass surveys.

The distribution of *Zostera marina* and the absence of *Z. japonica* at all sampling stations except Site 1A was consistent with records from previous years. Site 1A is located in an area that evolved from continuous *Z. marina* in 2003 to patchy mixed zone by 2007 (**Section 2.5.1**).

The eelgrass density, shoot morphology, and relative productivity are compared between sampling dates in **Sections 3.4.2.1** through **3.4.2.6**.

3.4.2.1 Inter-causeway near Deltaport Causeway, Sites 1A, 1B, and 2

Site 2 was originally selected due to its proximity to DP3. The eelgrass habitat at Site 1 was very similar to that at Site 2 in 2003, and was selected as a reference by which to assess changes in the eelgrass habitat adjacent to DP3 should changes occur. The habitat at Site 1 changed subsequent to 2003 and was no longer suitable for comparison to Site 2, therefore a new station, Site 1B was established in 2009. The eelgrass habitat at Site 1B is very similar to that at Site 2. Site 1 was renamed Site 1A, monitoring will continue at this site as it may provide insight into the evolution of the sand lobe.

The eelgrass habitat in the vicinity of Site 1A has changed since 2003, it evolved from dense, continuous *Z. marina* to a patchy distribution of relatively sparse *Z. marina* and *Z. japonica* by 2009 and into 2010. The density of both species increased in the vicinity of Site 1A in 2011; however the area continued to have a patchy distribution. The density of both species continued to increased into 2012; the combined cover by *Z. marina* and *Z. japonica* was continuous.

There was an absence of reproductive shoots at Site 1A therefore statistical comparisons between years were not possible. There have not been any reproductive shoots noted at Site 1A since 2009. *Z. marina* seedlings rarely produce reproductive shoots before they are at least two years old; this may account for the absence at this site.

The shoot size at Site 1A decreased between 2003 and 2008, since that time it has remained relatively stable. The length and width in 2012 were significantly different from 2003, 2007, and 2008; the shoot width was also significantly different when compared to 2009. The density decreased from 2008 through 2010 and then increased from 2010 through 2012. The 2012 shoot density was significantly different from that recorded in 2003, 2007, and 2008. The LAI has increased at this site annually since 2010 however the difference is not significant. The LAI values for Site 1A in 2012 were significantly different from that site in 2009 and all previous years of this study. The were no significant differences in reproductive shoot density between 2012 and the other years.

The data from Site 1B was compared with that from Site 1A for the years 2008, 2007, and 2003.

The total shoot density at Site 1B in 2012 was less than in 2010 and 2011; these differences were significant. The total shoot density was similar to that recorded between 2003 and 2009; there were no significant differences for these comparisons. The shoot size in 2012 was similar to the three previous years. Shoot length was significantly different when compared with the years 2003, 2007, and 2008. Shoot width was only significantly different when compared with 2008. The LAI was less than in 2010 and 2011; these differences were significant. The LAI was also significantly different when compared to 2008, but not the other years. The reproductive shoot density was lower than in previous years however the difference was only significant when 2012 was compared to 2009.

The total shoot density at Site 2 was similar to that recorded between 2003 and 2009 but less than in 2010 and 2011; these differences were significant. The mean shoot length at Site 2 in 2012 was the greatest in the study; the difference was only significant when compared with the years 2003 and 2007. The mean shoot width was within the range recorded in previous years; none of the differences were significant. The LAI at Site 2 in 2012 less than in 2010 and greater than in 2003 and 2007; these differences were all significant. The reproductive shoot density was similar to that recorded previously at this site; there were no significant differences between years.

3.4.2.2 Inter-causeway Area near BC Ferries Causeway, Sites 5 and 6.

The total shoot density at Site 5 was the lowest recorded for this study; the differences were significant for all comparisons except 2003. The mean shoot width was within the range recorded between 2007 and 2011, but lower than in 2003; the difference was significant. The mean shoot width was less than in 2003 and 2007; the differences were significant. The LAI at Site 5 was the lowest recorded for this study; the differences were significant for all comparisons except 2007. There was an absence of reproductive shoots at Site 5 therefore statistical comparisons between years were not possible.

Site 6 has demonstrated minimal variation over time, the shoot size and total shoot density was not significantly in 2012 relative to all previous years of this study. The LAI was only significantly different when the 2012 data was compared with that from 2003. The reproductive shoot density was similar to that recorded previously at this site; there were no significant differences between years.

3.4.2.3 West of Deltaport Causeway, Sites 3 and 4.

The mean total shoot density at Site 3 was the lowest recorded at this site in previous years of this study; however the difference was only significant when the data was 2012 was compared with that from 2010. The mean shoot length was also less than in most other years; the differences were only significant for 2010 and 2011. The mean shoot width was similar to all other years except for 2003 when the shoots were wider; the difference was significant. The LAI at Site 3 was lower than in all previous years, but only significantly different from 2003 and 2010. The reproductive shoot density was lower than in previous years however the difference was only significant when 2012 was compared to 2007 and 2009.

The total shoot density at Site 4 was less than in previous years of this study; the differences were only significant for 2008, and 2010. The mean shoot length and width were within the ranges recorded previously at this site; none of the comparisons indicated significant differences. The LAI at this site was lower than in previous years but only significantly different when compared with data from 2003, 2008, and 2010. The reproductive shoot density was lower than in previous years however the differences were not significant.

3.4.2.4 Boundary Bay, Sites WR1, WR2, and WR3.

Site WR1 is higher than any areas supporting *Z. marina* in the inter-causeway at Roberts Bank, the plants are smaller and the habitat not comparable to any of the other sites in the AMS. The data collected at this site may be useful for future projects but is not relevant for the AMS, and therefore it will not be included in this discussion.

The total shoot density at Site WR2 was similar to that recorded from 2007 through 2011 however it was greater than that recorded in 2003; the difference was significant. The mean shoot length was lower than in all previous years except for 2009; the differences were significant between the mean shoot length in 2012 and all previous years except 2007. The mean shoot width in 2012 was greater than all previous years however the differences were only significant when the 2012 data was compared with that from 2009 and 2011. The LAI at this site was similar to most previous years although it was greater than in 2003 and 2009; these differences were significant. The density of flowering shoots was greater than in most other years; the differences were significant when 2012 was compared 2003, 2007, 2009, and 2010.

The total shoot density at WR3 was greater than in all previous years of the study with the exceptions of 2010 and 2011; the differences were significant for all comparisons except 2008 and 2011. The difference was significant for all years except 2008 and 2010. There were reproductive shoots within the samples for all years except for 2011; the reproductive shoot density in 2012 was only significantly different from 2011.

The mean shoot length at WR3 was the lowest recorded for this study however the difference was only significant when the 2011 data was compared with that from 2003, 2008, and 2009. The mean shoot width in 2011 was greater than in all previous years; the difference was only significant for 2003. The LAI was greater in 2011 than in most other years, the difference was only significant when compared with the data from 2003, 2007, and 2010. Reproductive shoot density was greater than in all other years except 2008, the difference between 2008 and 2012 was significant.

3.4.2.5 Roberts Bank Site 2 and Boundary Bay, Site WR3.

The inter-annual variation in productivity at a Roberts Bank site and at a reference site in Boundary Bay were compared (**Figure 2.5-6**). Site 2 at Roberts Bank was selected for the comparison because it is the site closest to DP3. Site WR3 in Boundary Bay was selected for comparison because the shoot length and width at this location are very similar to that at Site 2.

The trends in productivity were very similar between the two sites.

3.4.2.6 Inter Annual Variation in Productivity

The trends in productivity between years were similar for most of the inter-causeway sites. The productivity was the greatest in 2010 followed by 2011, and was the lowest in 2003 and 2007. The main exception was Site 1A where the productivity decreased from 2003 through 2010 then increased in 2011 and 2012 relative to 2010.

The productivity at the sites west of the Deltaport Causeway was also the greatest in 2010; however there was not a clear trend for the other years. These sites are more strongly influenced by the Fraser River plume than are the inter-causeway sites; this may be one of the factors that contributes to the variability in productivity at these sites.

The trends in productivity between years at the Boundary Bay sites are similar those at the inter-causeway sites.

3.5 BIRDS – GREAT BLUE HERON

In 2012, heron distribution and use of habitats within the inter-causeway was very similar to previous years (Hemmera 2008d, Hemmera 2009, Hemmera 2010, Hemmera 2012 a and Hemmera 2012b), and indicate that overall abundance and habitat use within the inter-causeway area by heron was similar to pre-construction surveys conducted from 2003 to 2004. Herons used foraging habitats distributed throughout the inter-causeway and were recorded foraging in both near- and far-shore habitats as tidal fluctuations exposed eelgrass beds. The areas of highest use were within 500 m of the shoreline along the BC Ferries transect at PCs 118 and 120, and adjacent to the Deltaport Causeway within PCs 13, 14 and 15 (**Figure 23**).

The results of the 2012 surveys verified that the lower heron numbers documented in 2011 were the result of a sampling aberration and not indicative of a change in use of the inter-causeway. The timing of the August 2011 survey was not consistent with established methods. According to protocol, surveys are to occur within an hour of a peak low tide (**Appendix A**). During the August 2011 survey, the peak low tide occurred during the early morning when it was still dark, thus the survey was conducted during the secondary low tide later in the afternoon. During secondary low tides, the mean tide height is greater and less eelgrass is available for heron use, likely resulting in less herons being documented.

4.0 CONCLUSIONS AND RECOMMENDATIONS

4.1 COASTAL GEOMORPHOLOGY

The coastal geomorphology portion of the AMS monitoring program has been ongoing for almost 69 months from its inception in April 2007 to the end of 2012. Upon review of the data that was collected and analysed in support of the AMS, the majority of the initial monitoring activities have now been discontinued. Large-scale monitoring through interpretation of orthophotographs (annual) and bathymetric and topographic surveys (planned for 2013) provide ongoing, high-level information.

To date, the most notable change within the study area was the 2007 formation of ‘new’ drainage channels on the mud flats adjacent to the DP3 perimeter dike. Observations in the field indicate that only very small amounts of sediment continue to be transported within these channels. Mapping from the orthophotographs shows that the position of the channels has not changed between the time that the 2008 and 2012 photos were taken, and the existing DoD rod data indicates a much lower level of erosion and deposition in this area than the period immediately following their formation.

No other long-term physical changes have occurred on the tidal flats that could be attributed to the construction of DP3, which is consistent with predictions made in the Coastal Geomorphology Report (NHC, 2004). It has become apparent this year that the construction activities associated with the habitat compensation project on the east side of the Deltaport Causeway may be having a direct influence on the study area as sand and/or fine gravel appears to have been washed out of the project and has deposited lower down on the mud flats.

The 2010 Annual Report made a recommendation that the next coastal mapping surveys scheduled in the AMS geomorphology work plan for 2013 be conducted with increased spatial extent and resolution of the topographic surveys. The focus of this recommendation is the topographic survey data in three key areas: 1) the new drainage channels near DP3, 2) the Crest Protection Structure and surrounding area, and 3) the “trunk” channels extending from the Crest Protection Structure toward the dendritic channels. The additional land-based topographic survey data will provide a greater area of overlap with the bathymetric survey data to improve our understanding of how the surface elevations are changing over time in regions of high density eelgrass.

Among the objectives and schedule of the AMS monitoring program is a phasing out of monitoring activities on a reasonable timeline if the field evidence supports such action. Based on the results of the AMS Coastal Geomorphology monitoring program to date, all field-based quarterly data collection has already been discontinued. A review of the need for orthophotograph interpretation of the inter-causeway area should be made following the analysis of the coastal geomorphology mapping and thus should be continued for at least one more year.

4.2 SURFACE WATER QUALITY

The 2012 surface water and sediment monitoring took place quarterly with surface water and sediment samples analyzed for nutrients quarterly and metals annual in Q1. Other than the total boron in surface water samples collected from DP02 to DP09, there were no exceedances of the regulatory guidelines noted in Q1-2012. Total boron concentrations measured during 2012 were comparable to previous results and normal for coastal marine water in Canada.

A number of metal parameters exceeded the regulatory guidelines in the surface water sampled collected from station DP01 (located downstream of the agricultural ditch). In Q1-2012, cadmium, chromium, copper, manganese and nickel exceeded the regulatory guidelines at DP01. These metals have exceeded the regulatory guidelines in previous years.

Overall, based on the data collected to date, there is no evidence of increasing concentrations of metals or metals loading as a result of the DP3 construction or operation. It is recommended that the analysis of surface water samples for metals be discontinued.

Consistent with previous years, the highest nutrient concentrations were measured in the agricultural ditch near the base of the causeway (DP01), and are likely related to upland agricultural inputs. The highest chlorophyll *a* concentration between 2007 and 2012 was measured at DP04 in Q2-2012; however, higher concentrations have generally been detected during Q2 or Q3 sampling events due to warm water temperatures and increased light levels resulting in greater phytoplankton numbers.

Overall, nutrient concentrations in the inter-causeway area have not shown an increasing, or decreasing, trend for dissolved oxygen, in the six years of AMS monitoring (2007 – 2012). Ammonia concentrations in surface water in the inter-causeway stations appeared to have decrease between 2007 and 2009. The reference stations DP06 and DP07 have higher and more variable ammonia concentrations and appear to have decreased over the 2007 to 2012 time period. There are potential seasonal trends for organic nitrogen, TKN, and chlorophyll α with higher concentrations detected in Q2 and Q3. In addition, phosphate concentrations within both the inter-tidal causeway and the reference stations tend to be higher in Q4 sampling events (November or December).

Based on the data collected to date, there is no evidence of eutrophication occurring as a result of DP3 construction or operation.

Given that naturally occurring nutrient concentrations vary significantly from one area to another it was recommended that site-specific nutrient criteria or threshold for the AMS be developed. Nutrient thresholds have been developed in conjunction with PMV and the AMS Science Advisory committee in 2012. For each nutrient parameter, the threshold is the mean +/- 1.96 SD calculated using 2007 – 2010 data set. These thresholds have been applied to the 2012 data in this report and will be applied in future quarterly and annual reports.

The eutrophication parameters observed above the developed threshold limits in the inter-causeway area in 2012 were for total phosphorus at DP02 and DP05B, and organic nitrogen and chlorophyll *a* at DP04. These elevated concentrations for these parameters at these locations in 2012 are thought to be due to seasonal fluctuations and/or deeper sample location and not related to DP3 operation or a sign of eutrophication.

4.3 SEDIMENT QUALITY

The 2012 sediment monitoring took place quarterly with samples analyzed for nutrients quarterly and metals annual in Q1.

4.3.1 Metals

Similar to previous years, there were no metal exceedances of applicable regulatory criteria in sediment in 2012. The highest metal concentrations in sediment for 2012 were observed at the inter-causeway stations DP05 and DP09, specifically copper, and at reference station DP06. These three sediment samples had higher silt and clay content than the other samples based on the grain size data. Based on the lithium normalization technique, these metal results are considered reflective of natural background conditions.

No notable temporal trends have been observed in the metals data from the sampling stations. It is recommended that the analysis of sediment samples for metals be discontinued since based on the data collected to date, there is no evidence of increasing concentrations of metals or metals loading as a result of the DP3 construction or operation.

As in previous years, nutrient concentrations were higher in sediments in the inter-causeway than at the reference stations. This likely relates to higher biological activity within the inter-causeway (as compared to the exposed location of the reference stations at the mouth of the Fraser River) and not related to DP3 construction or operations. Neither nutrients nor other eutrophication-related parameters exhibited a temporal trend in sediment.

4.3.2 Nutrients

Based on the data collected to date, no evidence of eutrophication occurring as a result of DP3 construction or operation has been observed. As discussed for surface water, nutrient thresholds have been set as the mean +/- 1.96 SD calculated using 2007-2010 data set. These benchmarks have been applied to the 2012 data in this report and will be applied in future quarterly and annual reports.

Sulphide at DP05 was observed above the threshold limit for sediment in 2012 at the inter-causeway stations during both the Q3 and Q4 sampling events. This station (DP05) typically shows higher concentrations for all eutrophication parameters (than the other inter-causeway stations) and this is likely due to it being subtidal (as opposed to intertidal). The sulphide concentrations in 2012 are similar to concentrations detected previously in 2007 at this location.

4.4 EELGRASS

The area of patchy mixed eelgrass northwest of the sand lobe, between the continuous *Z. marina* and continuous *Z. japonica* meadows, has developed into continuous mixed eelgrass habitat. The density of Z. marina in this area has increased although *Z. japonica* is dominant.

There have been habitat gains and losses along the Tsawwassen Ferry Causeway; these seem related to dendritic channel evolution in the area rather than to the development and operation of DP3.

It appears that the area colonized by *Z. marina* and *Z. japonica* on the northern and western parts of the sand lobe have increased over the last year, while those on the southern and eastern parts of the sand lobe and associated dendritic channels have decreased.

The lower limit of *Z*. *marina* in the inter-causeway mapped in 2012 has not changed since 2003. The intertidal percent cover along the lower edge has remained constant. The percent cover in the shallow subtidal is less than in 2009 but comparable to 2003. The variation between years is likely due to inter-annual variation in MLLW and therefore the amount of light available at depth.

The assessment of epiphyte load and the absence of *Beggiatoa* sp. were consistent with results from previous years and indicate that the eelgrass habitat was in good condition.

The productivity (LAI) of *Z. marina* at most of the inter-causeway sites in 2012 was average. The exceptions were Site 1A and 5. The productivity at Site 1A remains low but has tripled over the last year. The productivity at Site 5, near the Tsawwassen Ferry Causeway was lowest recorded during the AMS but not significantly different from 2007. The changes in the vicinity of Site 5 are likely due to evolution of a sand bar and channels in that area and not related to DP3. The productivity trends at the Boundary Bay sites were similar to the inter-causeway sites. The productivity (LAI) at the sites west of the Deltaport Causeway were relatively low, however the values were within the range documented in previous years.

The similarity between the inter-annual LAI trends observed at Roberts Bank and in Boundary Bay indicates the inter-annual productivity at both locations is primarily governed by large-scale environmental factors, rather than local or site specific influences.

The development of DP3 resulted in a loss of *Z. marina* habitat in the area that was altered by sediment deposition from the new drainage channel formation adjacent to DP3 (as indicated by the changes in hectares of continuous and patchy Z. marina habitat when comparing the 2003 and 2012 data). The 2010 bathymetric data demonstrated that the loss was not due to sediment accretion in the area. The eelgrass habitat in this area increased between 2010 and 2011, however a decrease was observed in 2012. A team including representatives from PMV, SAC, NHC, and Precision Identification will visit in the area in early April 2013 to determine whether the site is showing signs of recovery and to develop a work plan if additional studies are required.

There are no other indications that the development of DP3 has negatively affected the inter-causeway eelgrass habitat.

No changes to the eelgrass survey program are recommended for 2013.

4.5 BIRDS

AMS data for herons collected from 2008 to 2012 indicates that overall abundance and habitat use within the inter-causeway area by heron were similar to pre-construction surveys conducted from 2003 to 2004. Additionally, the results of the 2012 surveys verified that the low heron numbers document in August 2011 were likely the result of conducting the survey during the secondary peak low tide, and not indicative of a change in use of the inter-causeway.

No project affects have been document to affect Great Blue Heron use of the inter-causeway, thus Hemmera recommends discontinuing the heron surveys in 2013.

4.6 SUMMARY

To date, the data collected during the AMS monitoring program indicates no widespread physical or biological change in the inter-causeway area following DP3 construction and operation.

Based on the findings to date, the following adaptations to the AMS program are recommended:

- As recommended in the 2012 annual report, the land-based topographic survey portion of the next ‘coastal mapping’ survey (scheduled for 2013) should cover an increased extent in the regions of the ‘trunk’ channels and the Crest Protection Structure and its adjacent channels to provide a greater area of overlap in the two datasets in order to improve confidence in the accuracy of the surface model within these areas.
- Continue to conduct orthophotograph interpretation and associated channel mapping of the inter-causeway area on an annual basis to assess the ongoing changes to the ‘area of new drainage channels’, the larger dendritic channel systems, and the newly formed sand deposits near the Deltaport Causeway (east side of the inter-causeway area).
- Discontinue the annual metals analysis in surface water and sediment samples as data collected to date does not indicate increasing concentrations as a result of DP3 construction or operation;
- Discontinue the Great Blue Heron surveys in 2013 as data for herons collected from 2008 to 2012 has indicated that overall abundance and habitat use within the inter-causeway area by heron were similar to pre-construction surveys conducted from 2003 to 2004.

5.0 CLOSING

We trust that the information contained in this draft report meets your needs at this time. If you have any questions, please do not hesitate to contact the undersigned.

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7.0 STATEMENT OF LIMITATIONS

This report was prepared by Hemmera Envirochem Inc. (Hemmera), based on work conducted by the project team of Hemmera, Northwest Hydraulic Consultants (NHC) and Precision Identification (the Project Team) for the sole benefit and exclusive use of the Vancouver Fraser Port Authority. The material in it reflects the Project Team's best judgment in light of the information available to it at the time of preparing this report. Any use that a third party makes of this Report, or any reliance on or decision made based on it, is the responsibility of such third parties. The members of the Project Team accept no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions taken based on this report.

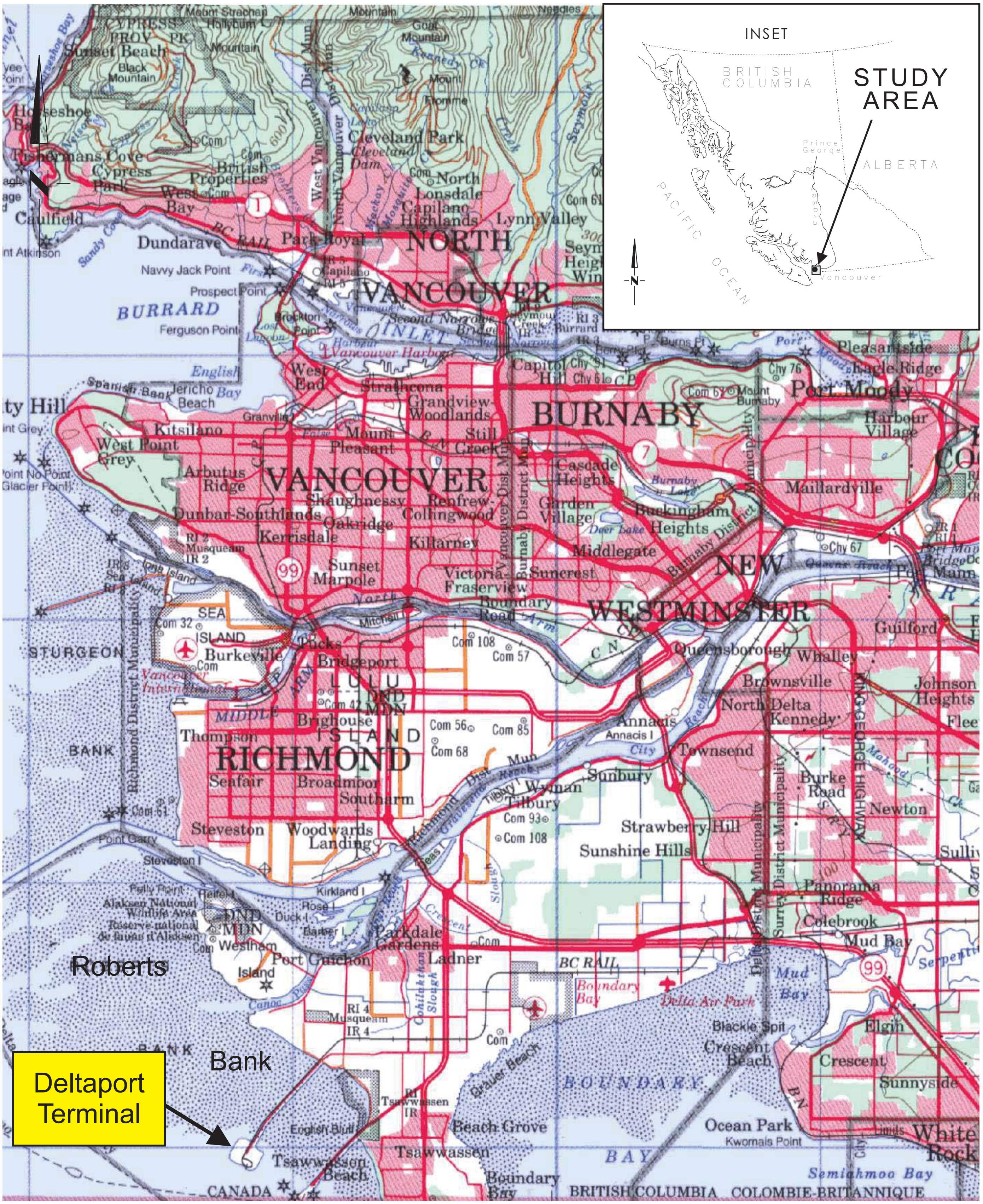
The Project Team has performed the work as described above and made the findings and conclusions set out in this report in a manner consistent with the level of care and skill normally exercised by members of the environmental science profession practicing under similar conditions at the time the work was performed.

This report represents a reasonable review of the information available to the Project Team within the established scope, work schedule and budgetary constraints. The conclusions and recommendations contained in this report are based upon applicable legislation existing at the time the report was drafted. Any changes in the legislation may alter the conclusions and/or recommendations contained in the report. Regulatory implications discussed in this report were based on the applicable legislation existing at the time this report was written.

In preparing this report, the Project Team have relied in good faith on information provided by others as noted in this report, and has assumed that the information provided by those individuals is both factual and accurate. The members of the Project Team accept no responsibility for any deficiency, mis-statement or inaccuracy in this report resulting from the information provided by those individuals.

The liability of the members of the Project Team to the Vancouver Fraser Port Authority shall be limited to injury or loss caused by the negligent acts of the Project Team. The total aggregate liability of Hemmera and the members of the Project Team related to this agreement shall not exceed the lesser of the actual damages incurred, or the total fee of the members of the Project Team for services rendered on this project.

FIGURES



HEMMERA

CLIENT:

PORT METRO vancouver

DELTAPORT THIRD BERTH - ADAPTIVE MANAGEMENT STRATEGY PROGRAM - 2012 ANNUAL REPORT

SITE LOCATION

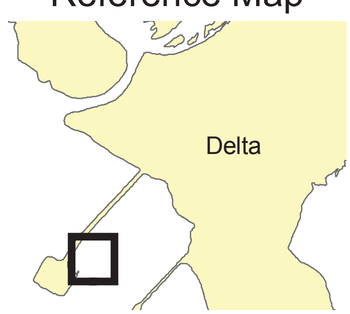
PROJECT No. 499-002.19	August 2013	FIGURE 1

Legend

- Monitoring Sites
- Topographic Sections

Note:
- July 29, 2011 orthophoto image courtesy of VFPA.

Reference Map



DELTAPORT THIRD BERTH ADAPTIVE MANAGEMENT STRATEGY PROGRAM 2012 ANNUAL REPORT

Crest Protection Structure
Monitoring Site Location Map

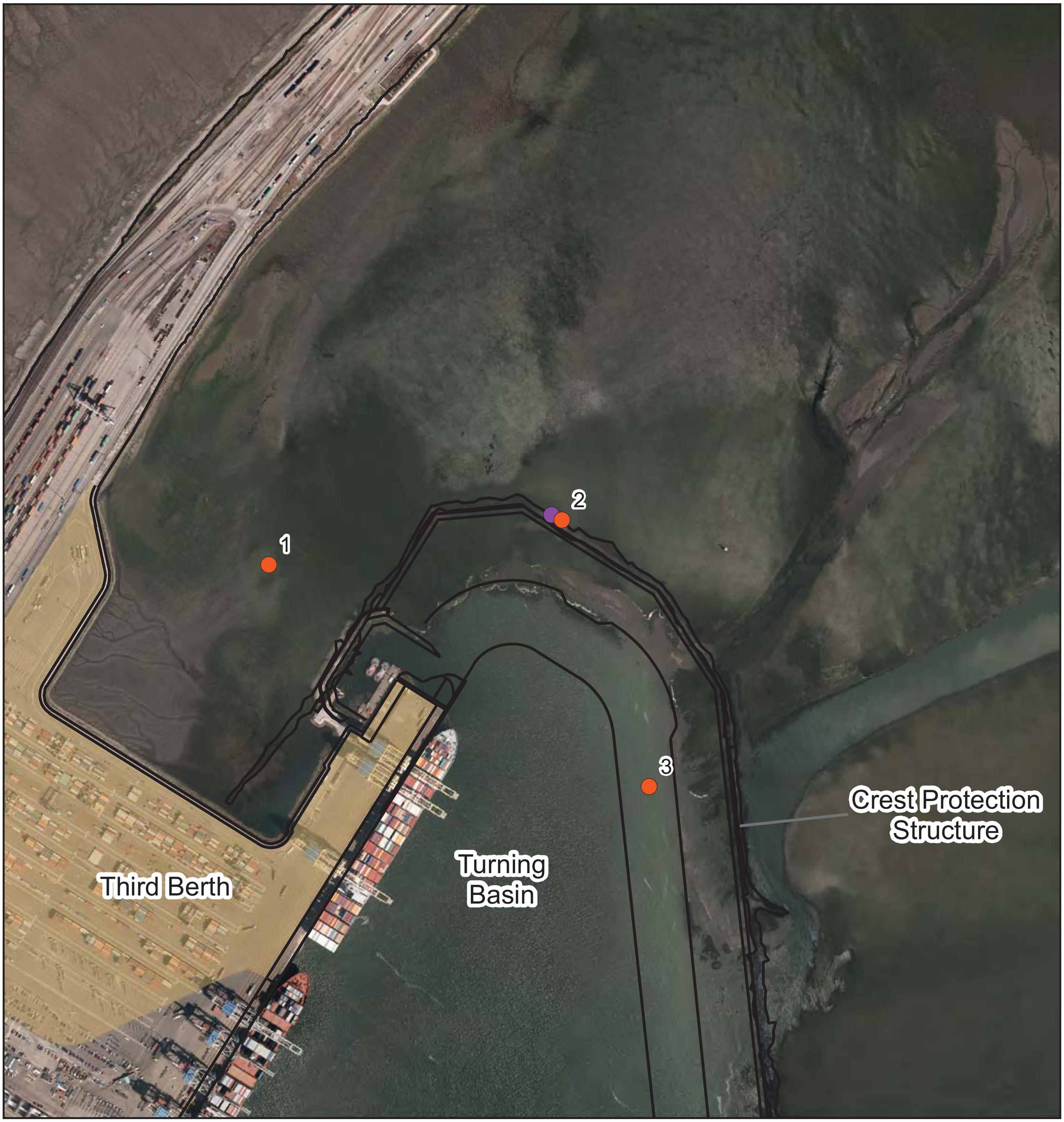
Scale - 1:7,500

100 50 0 100 200 Metres

coord. syst.: UTM Zone 10	horz. datum: NAD 83	horz. units: metres
northwest hydraulic consultants	project no. 3-4648	August 2013

MSN, 34648 Deltaport Monitoring\GIS\Fig_CrestProtectionSites.mxd

Figure 2

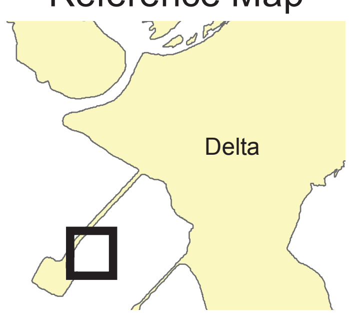


Legend

- Wave Sensor
- Turbidity Sensor 2

Note:
- July 29, 2011 orthophoto image courtesy of VFPA.

Reference Map



DELTAPORT THIRD BERTH ADAPTIVE MANAGEMENT STRATEGY PROGRAM 2012 ANNUAL REPORT

Instrumentation Site Location Map

Scale - 1:7,500

100 50 0 100 Metres

coord. syst.: UTM Zone 10	horz. datum: NAD 83	horz. units: metres
northwest hydraulic consultants	project no. 3-4648	August 2013

CM, 34648 Deltaport Monitoring\GIS\Fig_AllInstrumentSites.mxd

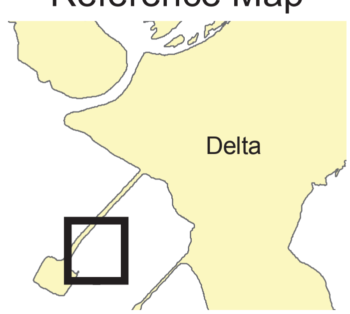
Figure 3

Legend

● Existing DOD Rod

Note:
- July 29, 2011 orthophoto image courtesy of VFPA.

Reference Map



DELTAPORT THIRD BERTH ADAPTIVE MANAGEMENT STRATEGY PROGRAM 2012 ANNUAL REPORT

Depth of Disturbance Rods Location Map

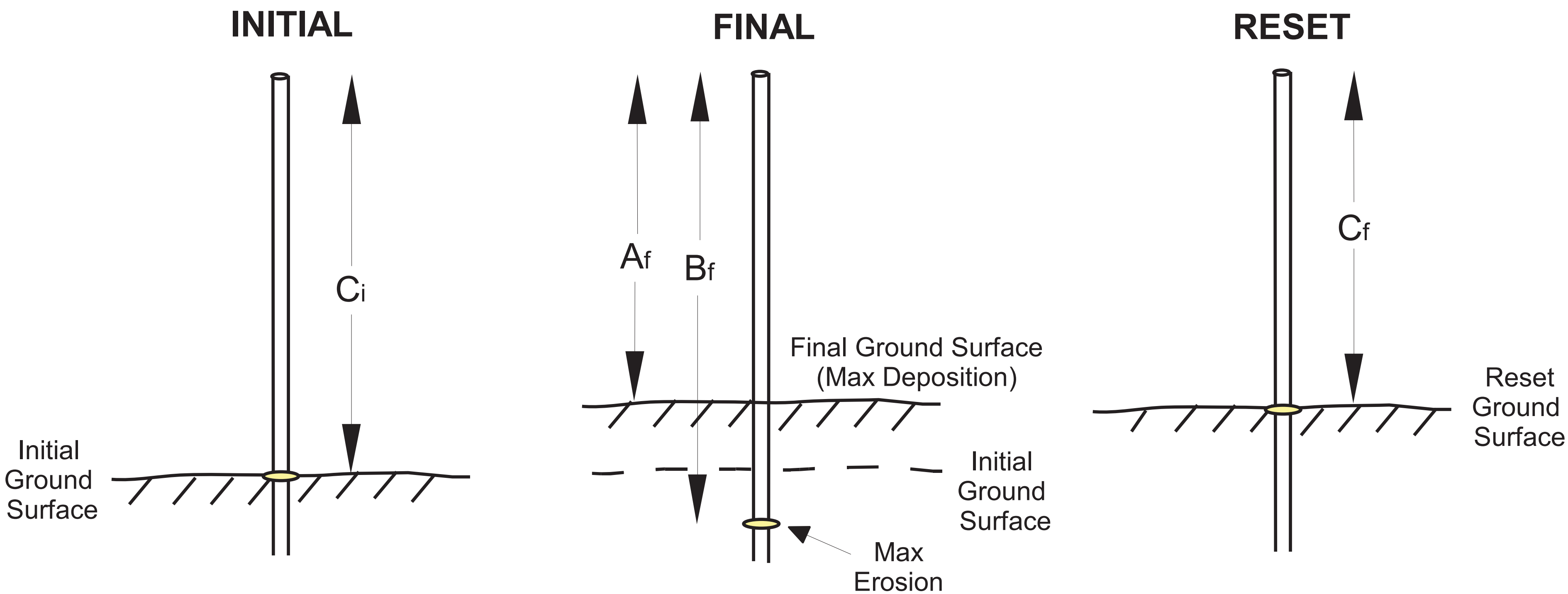
Scale - 1:10,000

100 50 0 100 200 300 Metres

coord. syst.: UTM Zone 10	horz. datum: NAD 83	horz. units: metres
northwest hydraulic consultants	project no. 3-4648	August 2013

PGH, 34648 Deltaport Monitoring\GIS\Fig_DepthOfDisturbanceSites.mxd

Figure 4

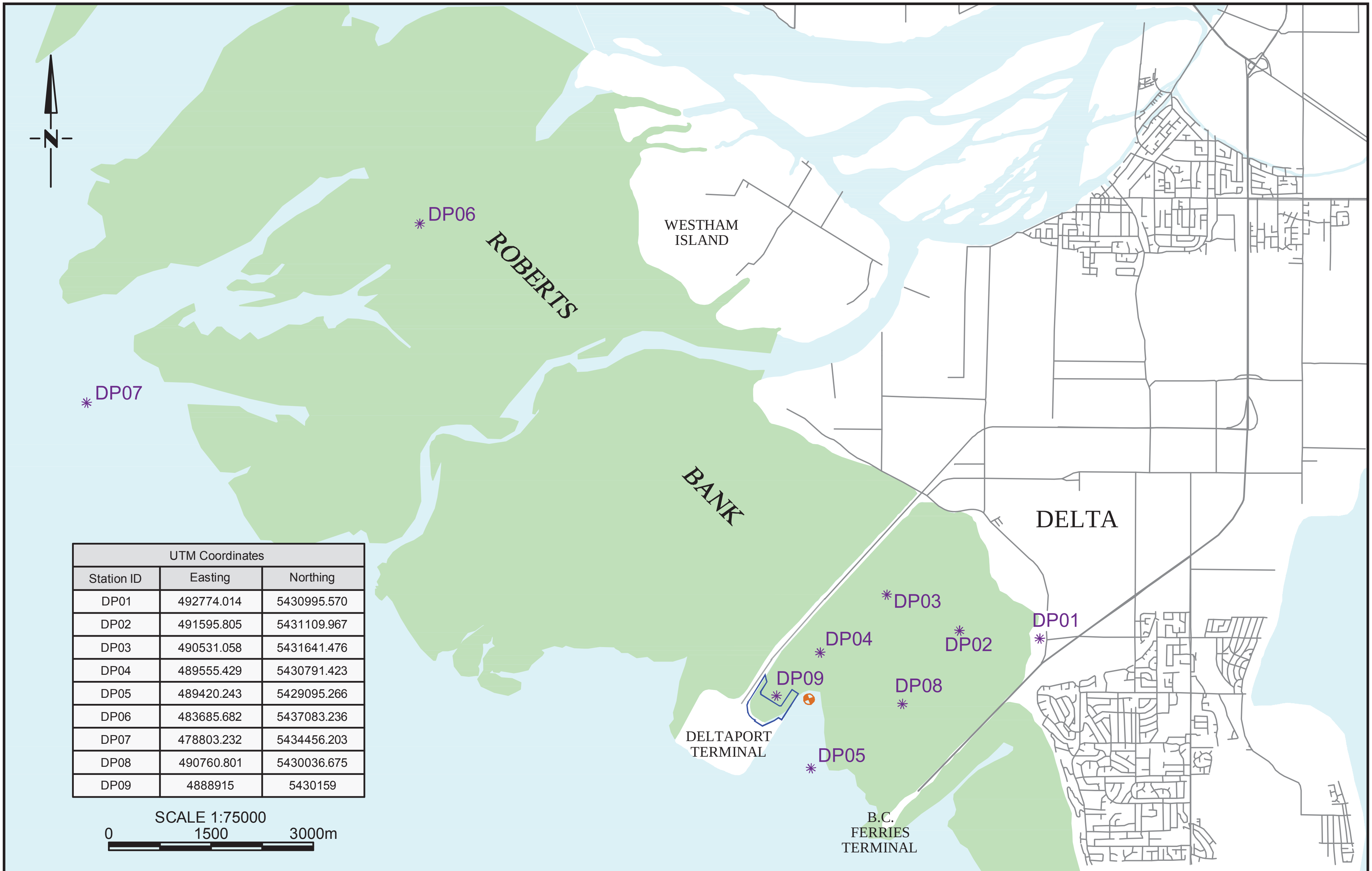


A = Height Above Ground
B = Height Above Washer
C = Reset: Height Above Ground/Washer

Deposition = $B_f - A_f$
Erosion = $B_f - C_i$ (if $B_f - C_i < 0$, then $B_f - C_i$ set to 0 to remove error)
Net Change = Deposition – Erosion

DELTAPORT THIRD BERTH ADAPTIVE MANAGEMENT STRATEGY PROGRAM 2012 ANNUA L REPORT		
Bed Level Change Computations at Depth of Disturbance Rods		
northwest hydraulic consultants	project no. 3-4648	August 2013

Figure 5



UTM Coordinates		
Station ID	Easting	Northing
DP01	492774.014	5430995.570
DP02	491595.805	5431109.967
DP03	490531.058	5431641.476
DP04	489555.429	5430791.423
DP05	489420.243	5429095.266
DP06	483685.682	5437083.236
DP07	478803.232	5434456.203
DP08	490760.801	5430036.675
DP09	4888915	5430159

LEGEND
- Water
- Tidal Mud & Sand
- Sampling Station
- YSI Sonde

Note: DP8 & DP9 are only monitored in Q1.

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DELTAPORT THIRD BERTH - ADAPTIVE MANAGEMENT STRATEGY PROGRAM - 2012 ANNUAL REPORT

SURFACE WATER, SEDIMENT & BENTHIC INVERTEBRATE MONITORING STATIONS

PROJECT No. 499-002.19	August 2013	FIGURE 6

LEGEND

Water Quality Sampling Station

SCALE 1:5,000 (metres)

0 100 200

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CLIENT: PORT METRO vancouver

DELTAPORT THIRD BERTH - ADAPTIVE MANAGEMENT STRATEGY PROGRAM - 2012 ANNUAL REPORT

DETAILED LOCATION OF SAMPLE DP01

PROJECT No. 499-002.19	August 2013	FIGURE 7

-N-

LEGEND

SAMPLE LOCATION

THIRD BERTH FOOTPRINT

SCALE 1:30,000
metres
0 600 1200

REFERENCE DRAWINGS

- Base Map Information Provided by Triton Consultants Ltd., dated Sept 2004.
- Envirowest Environmental Consultants Figure 'Appendix A', dated Nov. 1, 2004.

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CLIENT: PORT METRO vancouver

DELTAPORT THIRD BERTH - ADAPTIVE MANAGEMENT STRATEGY PROGRAM - 2012 ANNUAL REPORT

EELGRASS STATION REFERENCE LOCATIONS (DELTAPORT AREA)

PROJECT No. 499-002.19	August 2013	FIGURE 8

LEGEND

◇ Eelgrass Sampling Station (UTM Coordinates Shown)

Note: The shallow and deep station are each approximately 10 metres away from the mid station.

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DELTAPORT THIRD BERTH - ADAPTIVE MANAGEMENT STRATEGY PROGRAM - 2012 ANNUAL REPORT

EELGRASS REFERENCE STATION LOCATION (BOUNDARY BAY AREA)

PROJECT No.		
499-002.19	August 2013	FIGURE 9

Legend

100	Contour Line Label
●	Species Specific (GBHE & BRAN) "windshield" survey locations

Common Name
GBHE
Great Blue Heron
BRAN
Brant

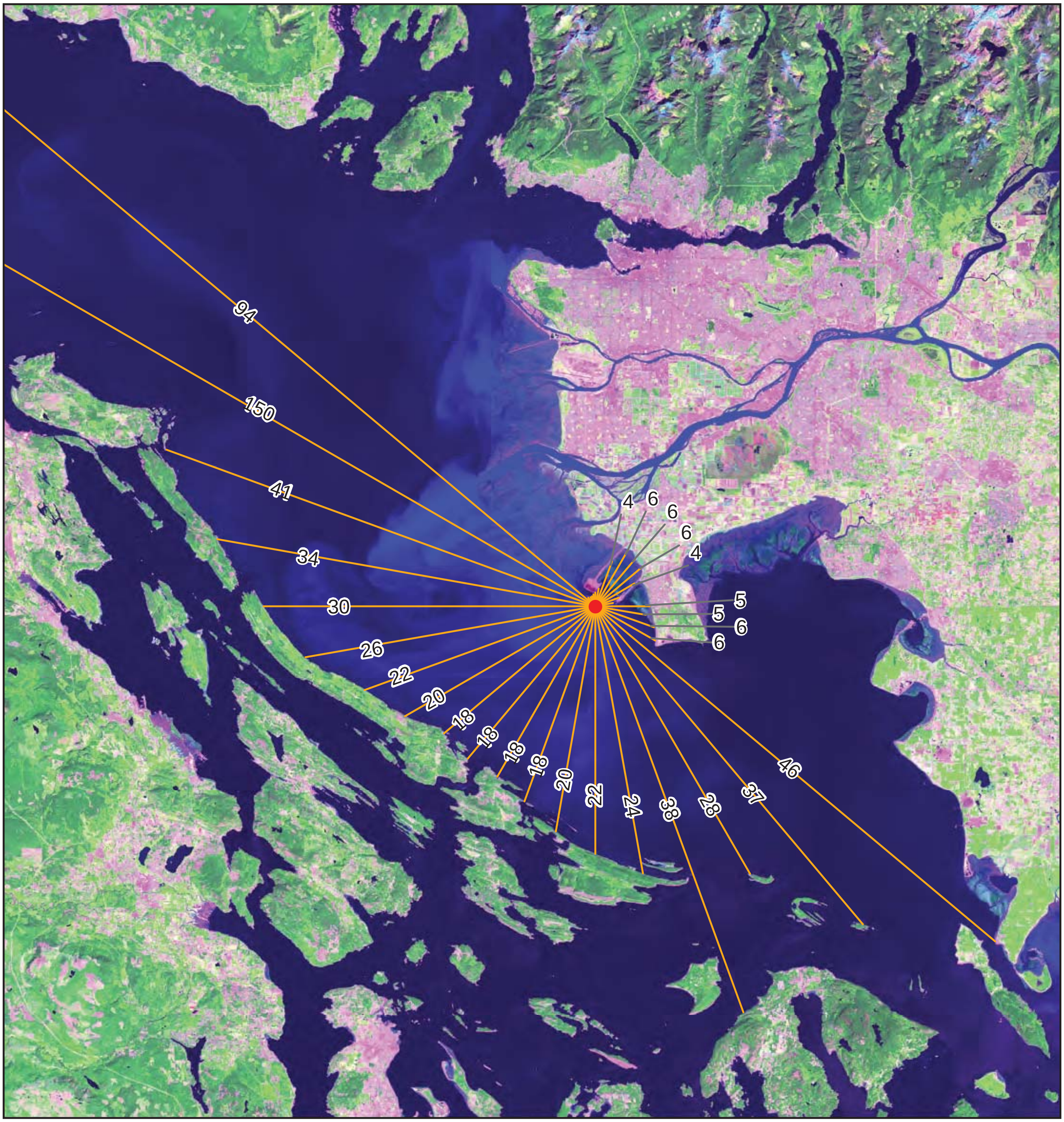
1:25,000
900 450 0 900 Meters

HEMMERA
PORT METRO vancouver

DELTAPORT THIRD BIRTH-ADAPTIVE MANAGEMENT STRATEGY PROGRAM 2012 ANNUAL REPORT

BIRD SURVEY TRANSECT LOCATIONS

PROJECT NO: 499-002.19 | August 2013 | FIGURE 10



Legend

- Reference Point
- Fetch Lengths at 10° intervals (km)

Note:
- July 30, 2000 Landsat composite image courtesy of Geogratis.

DELTAPORT THIRD BERTH ADAPTIVE MANAGEMENT STRATEGY PROGRAM 2012 ANNUAL REPORT

Fetch Lengths at Deltaport

Scale - 1:500,000

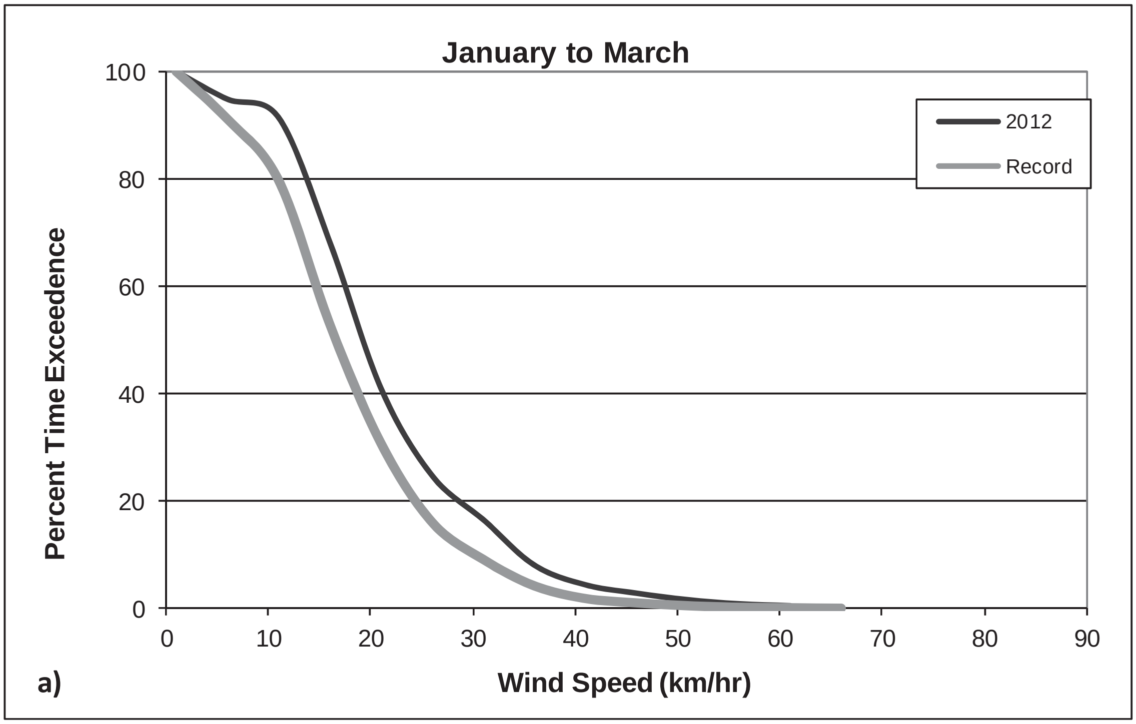
10 5 0 10 Kilometres

coord. syst.: UTM Zone 10	horz. datum: NAD 83	horz. units: metres
northwest hydraulic consultants	project no. 3-4648	August 2013

PGH/MSN, 34648 Deltaport Monitoring\GIS\Fig_FetchLength.mxd

Figure 11

Figure 12 Summary of Hourly Wind Speed Measured at Vancouver International Airport for the Period a) January to March, and b) April to June



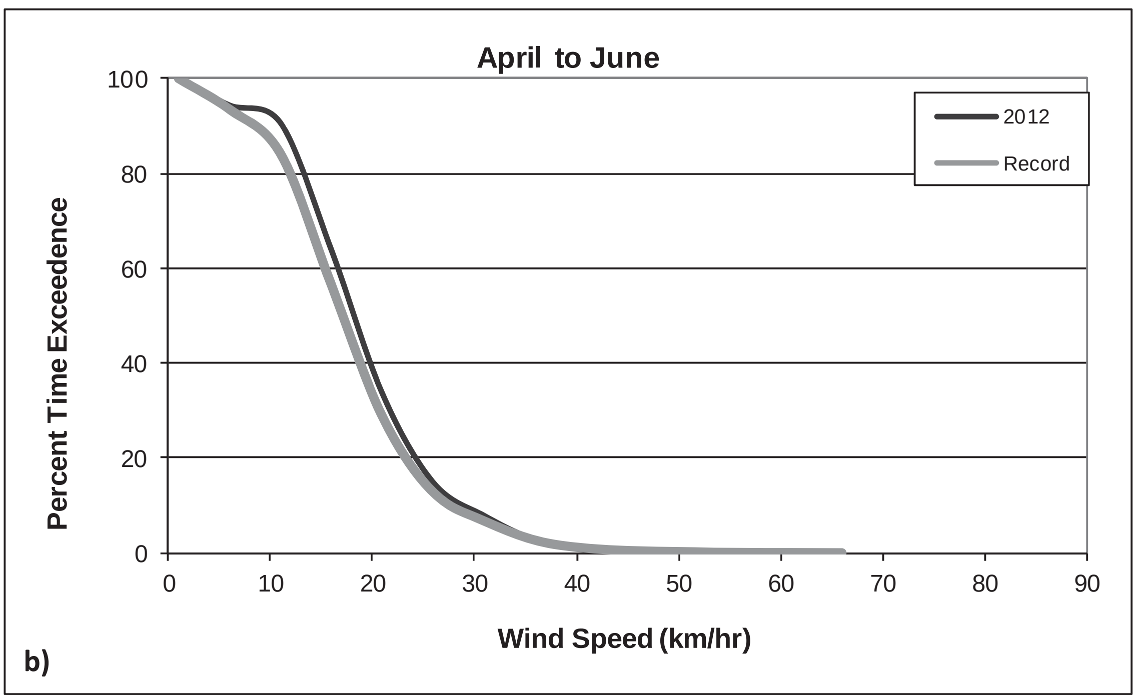
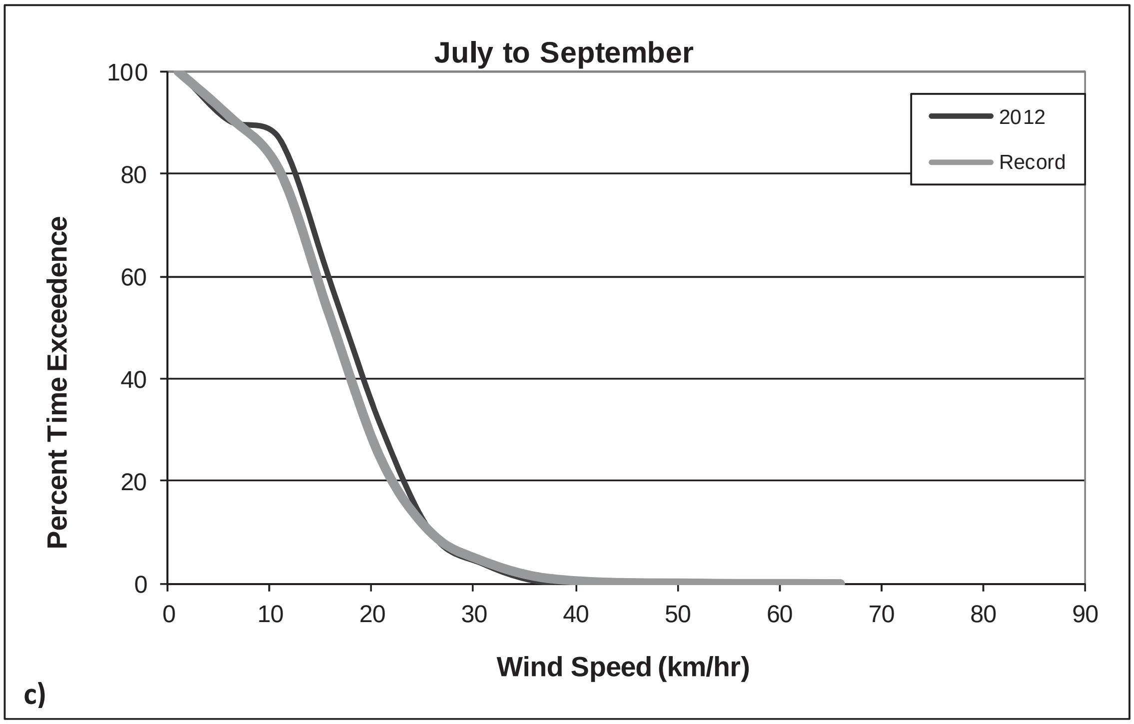


Figure 12 Summary of Hourly Wind Speed Measured at Vancouver International Airport for the Period c) July to September and d) October to December



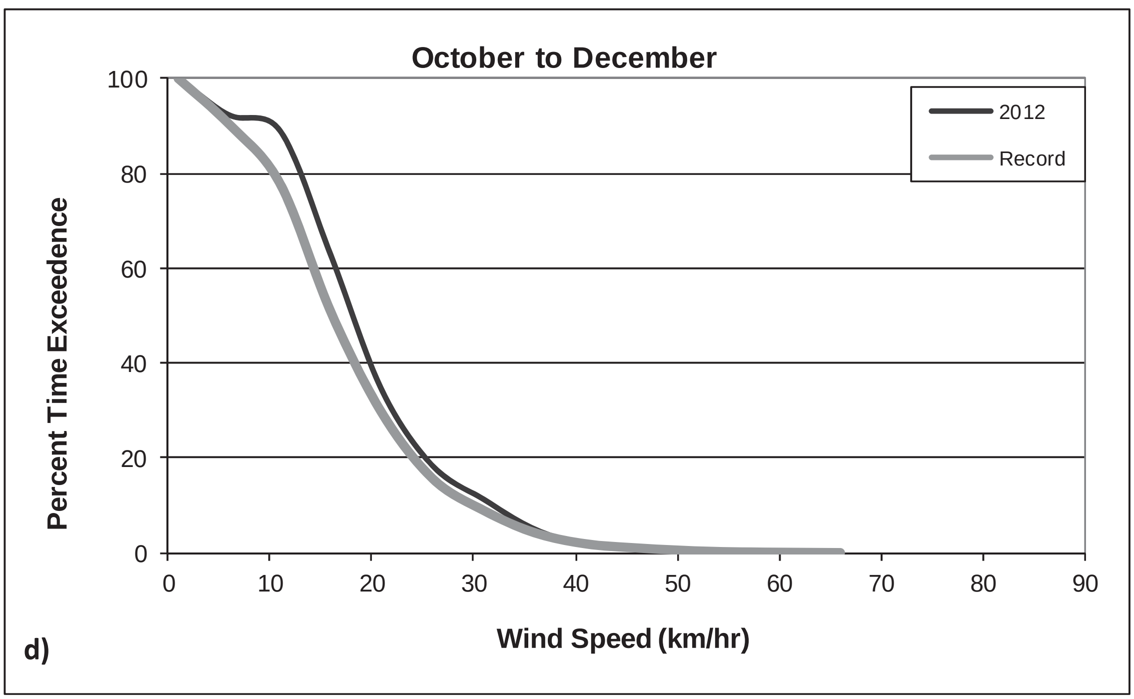


Figure 13 Summary of Wave Data from Station #46146 (Halibut Bank) for the Period a) January to March, and b) April to June

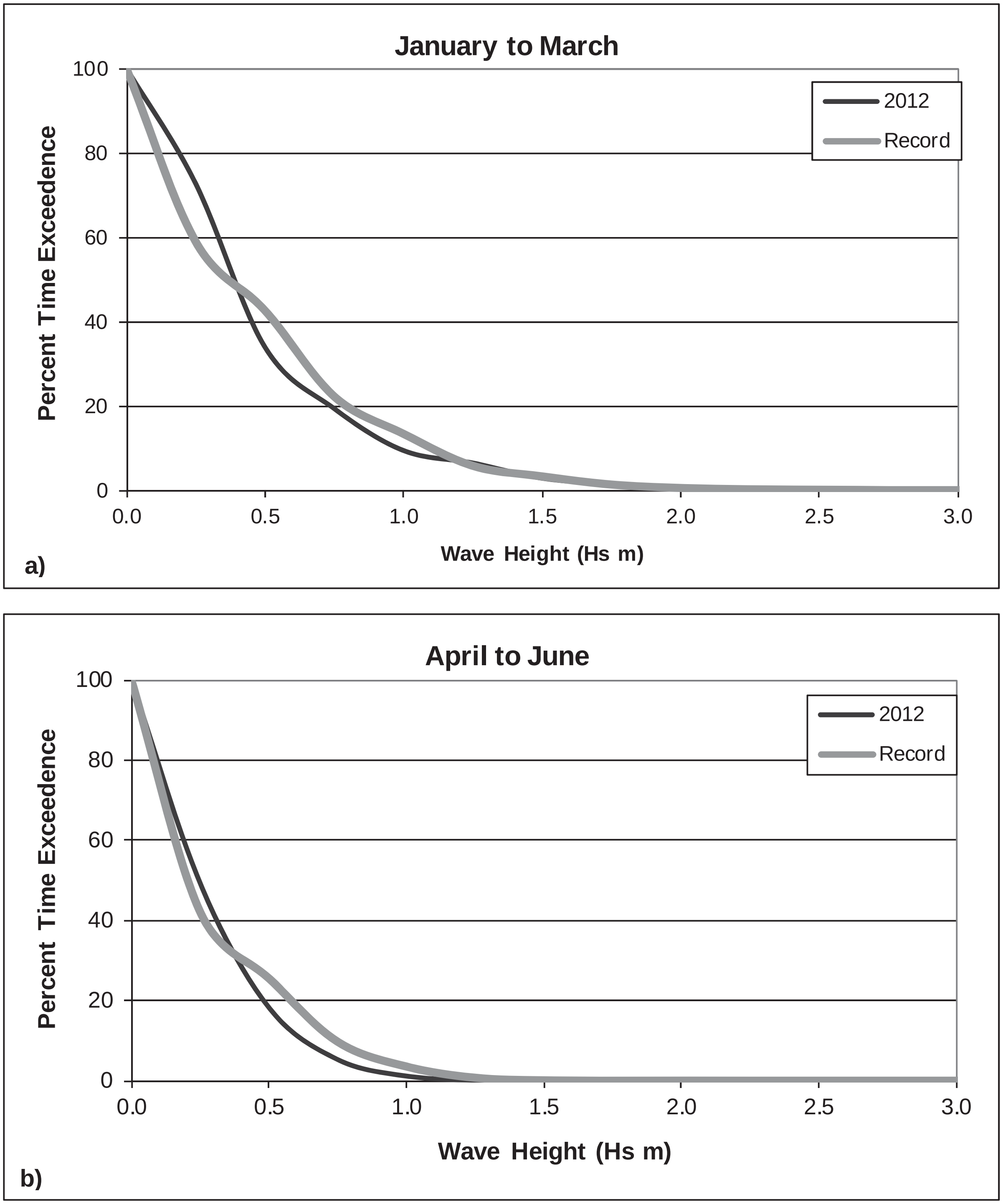
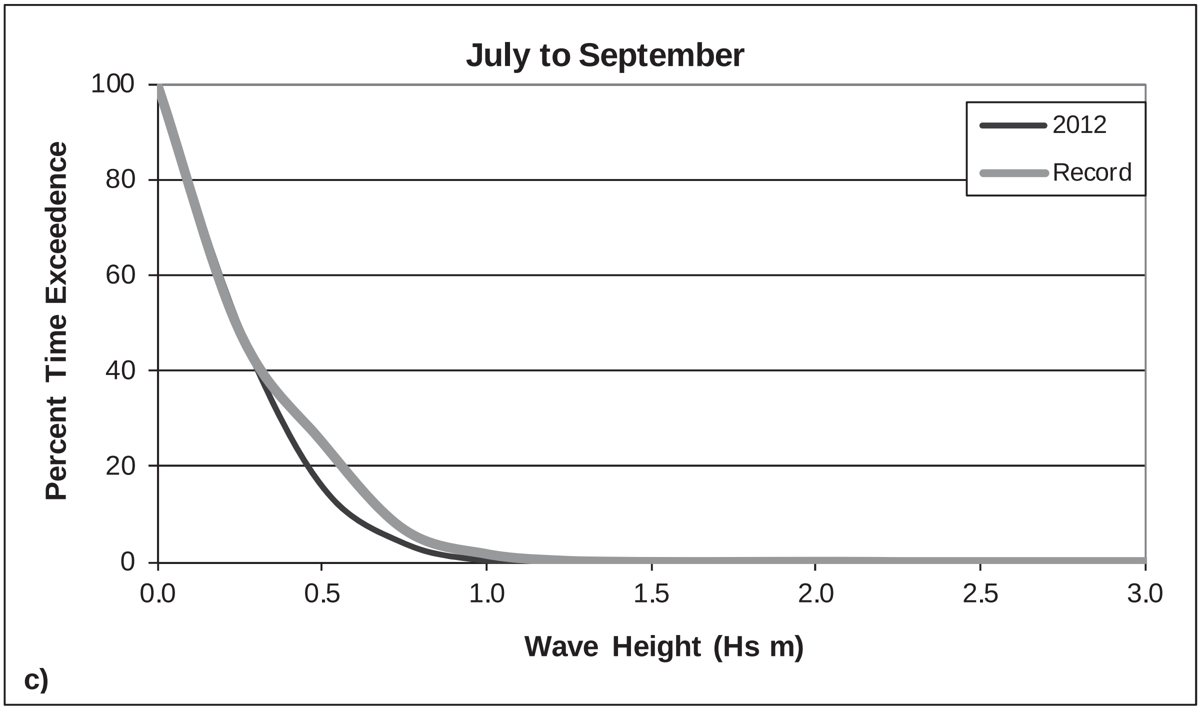


Figure 13 Summary of Wave Data from Station #46146 (Halibut Bank) for the Period c) July to September, and b) October to December



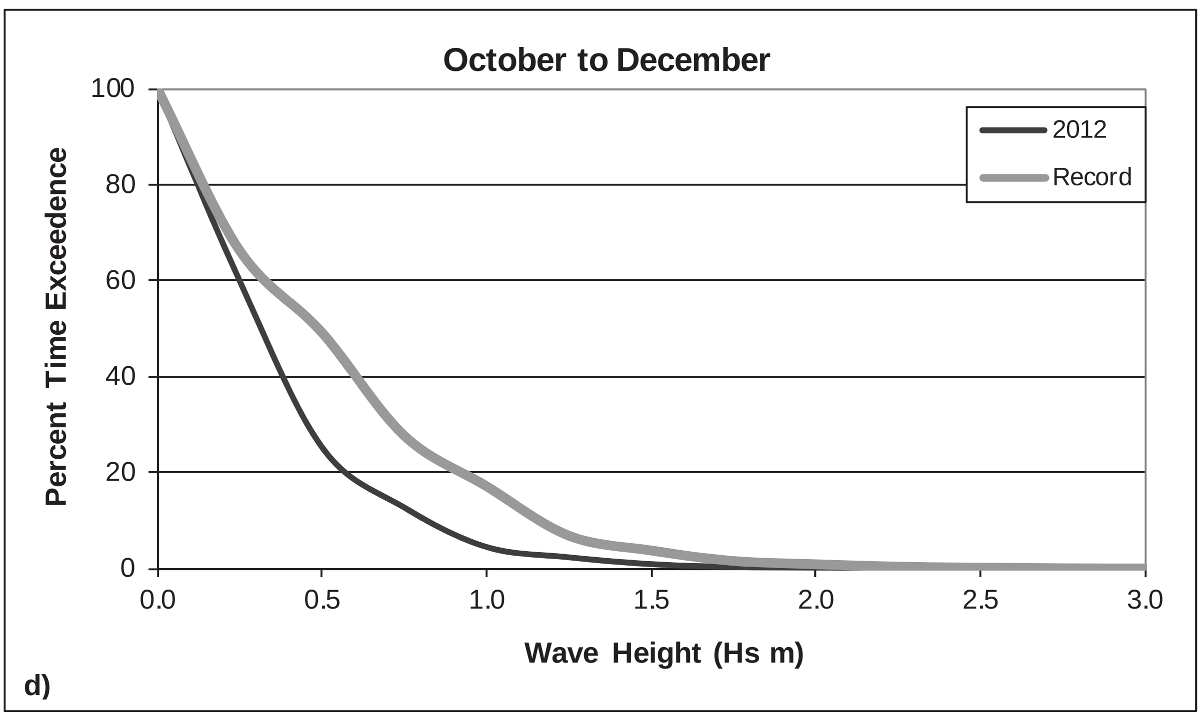


Figure 14 Observed Tide Levels at Point Atkinson, January to March 2012

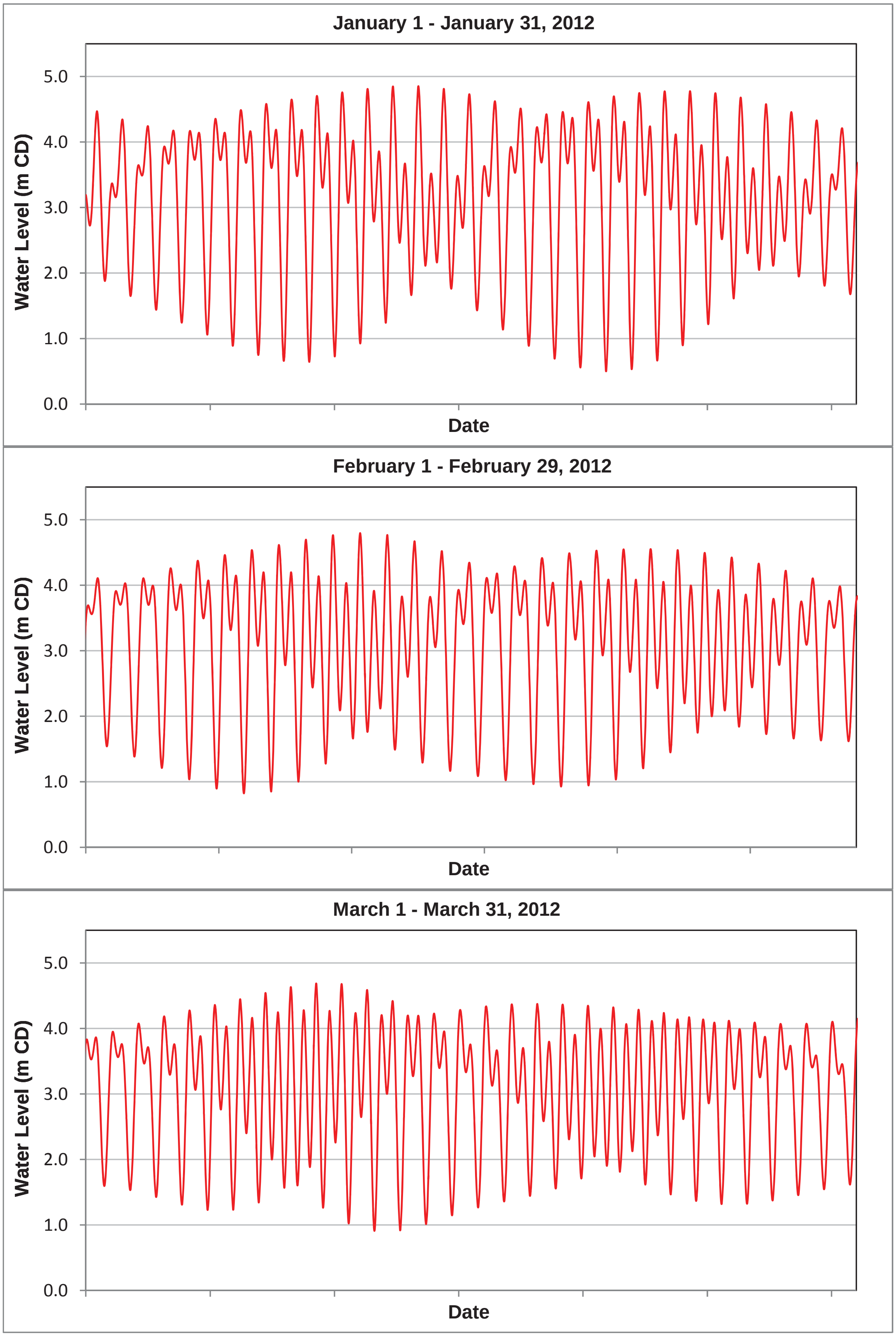


Figure 15 Observed Tide Levels at Point Atkinson, April to June 2012

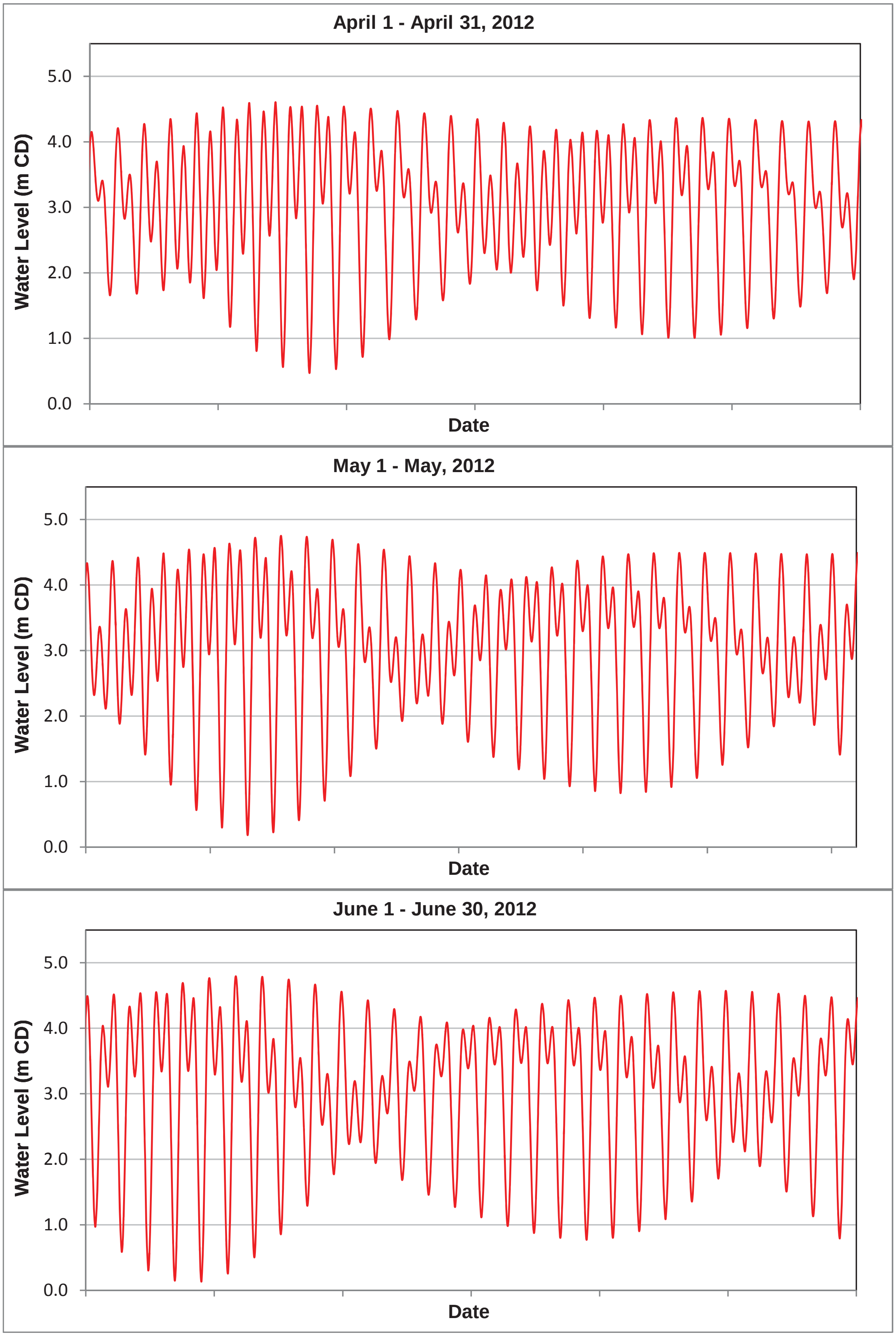


Figure 16 Observed Tide Levels at Point Atkinson, July to September 2012

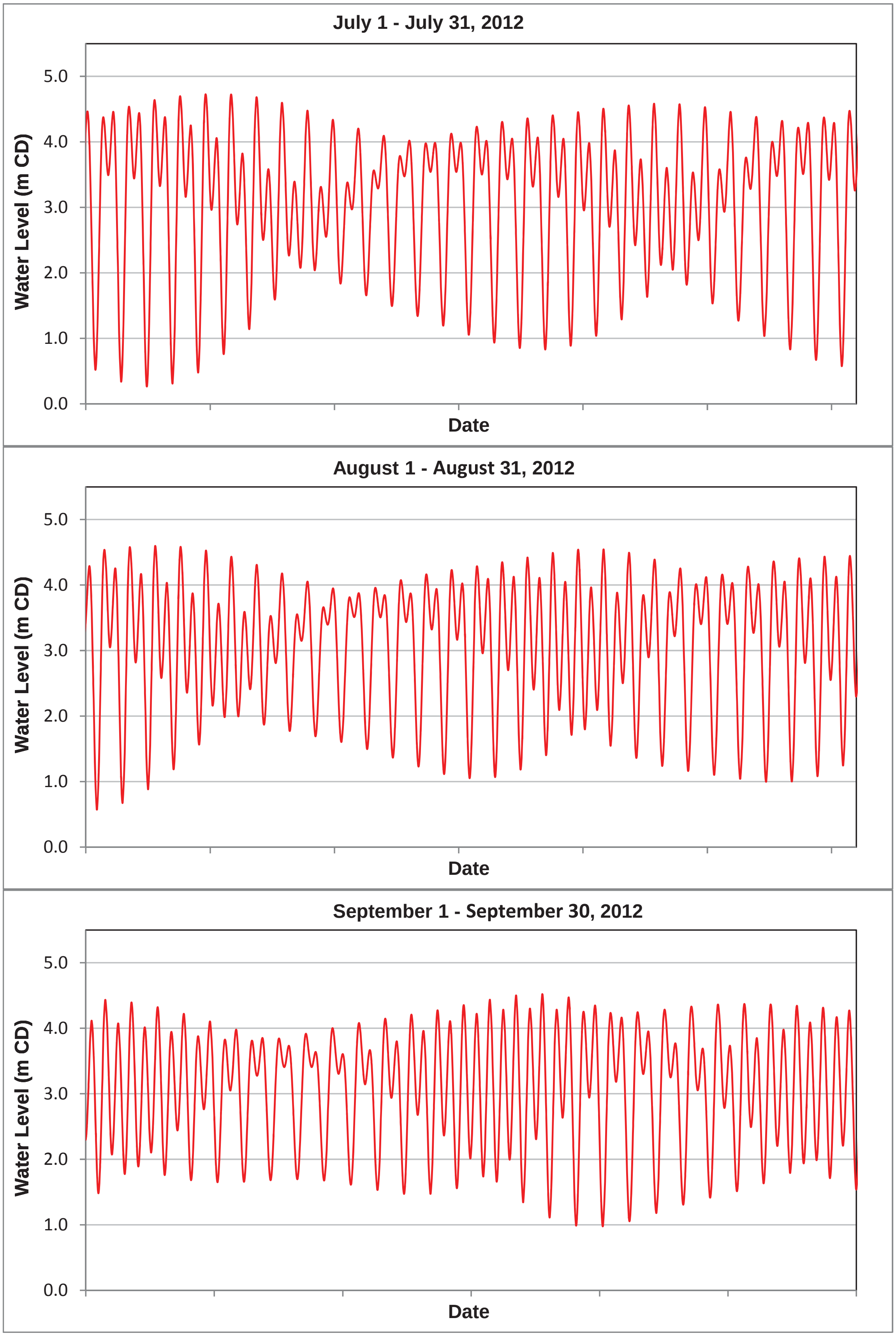
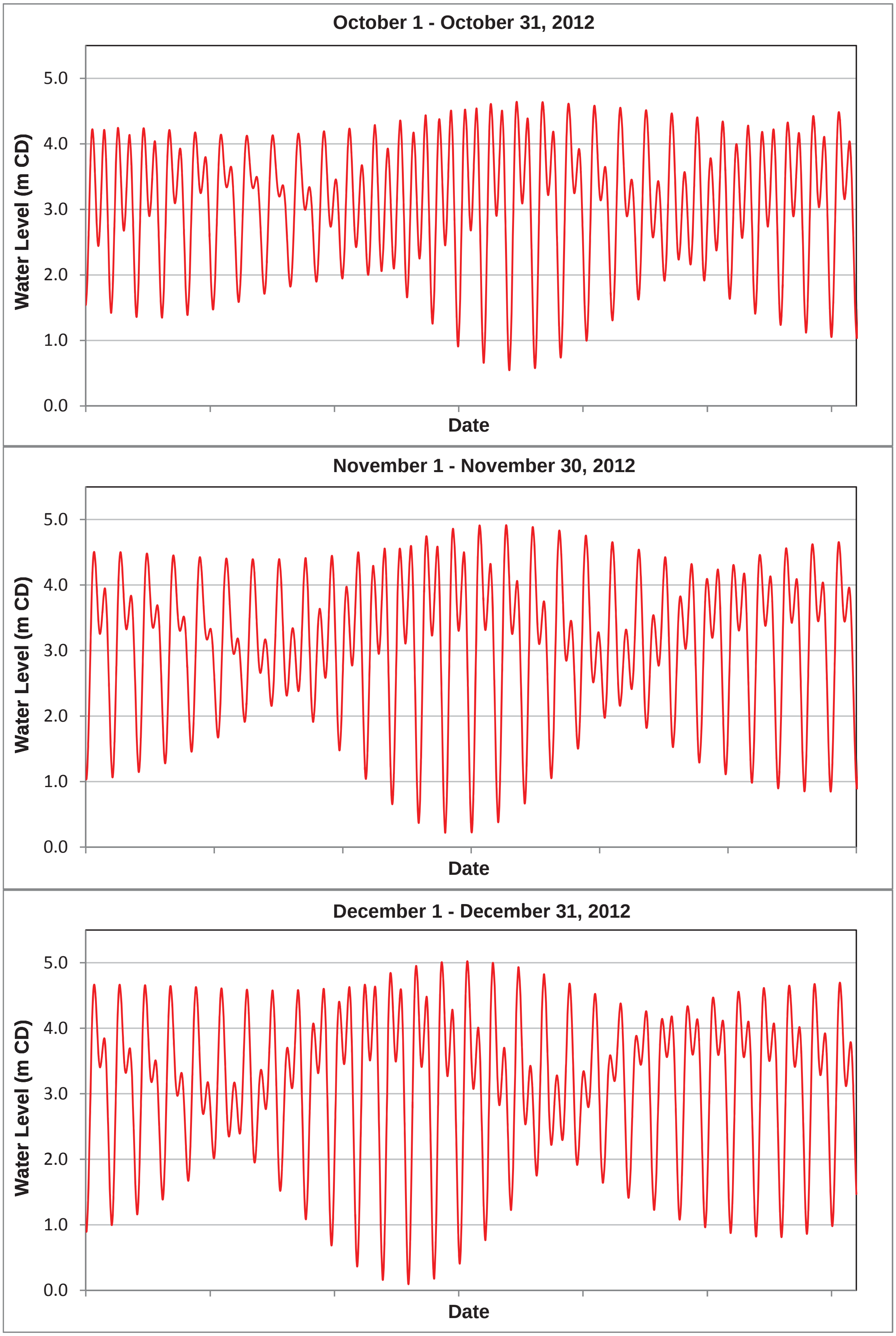


Figure 17 Observed Tide Levels at Point Atkinson, October to December 2012



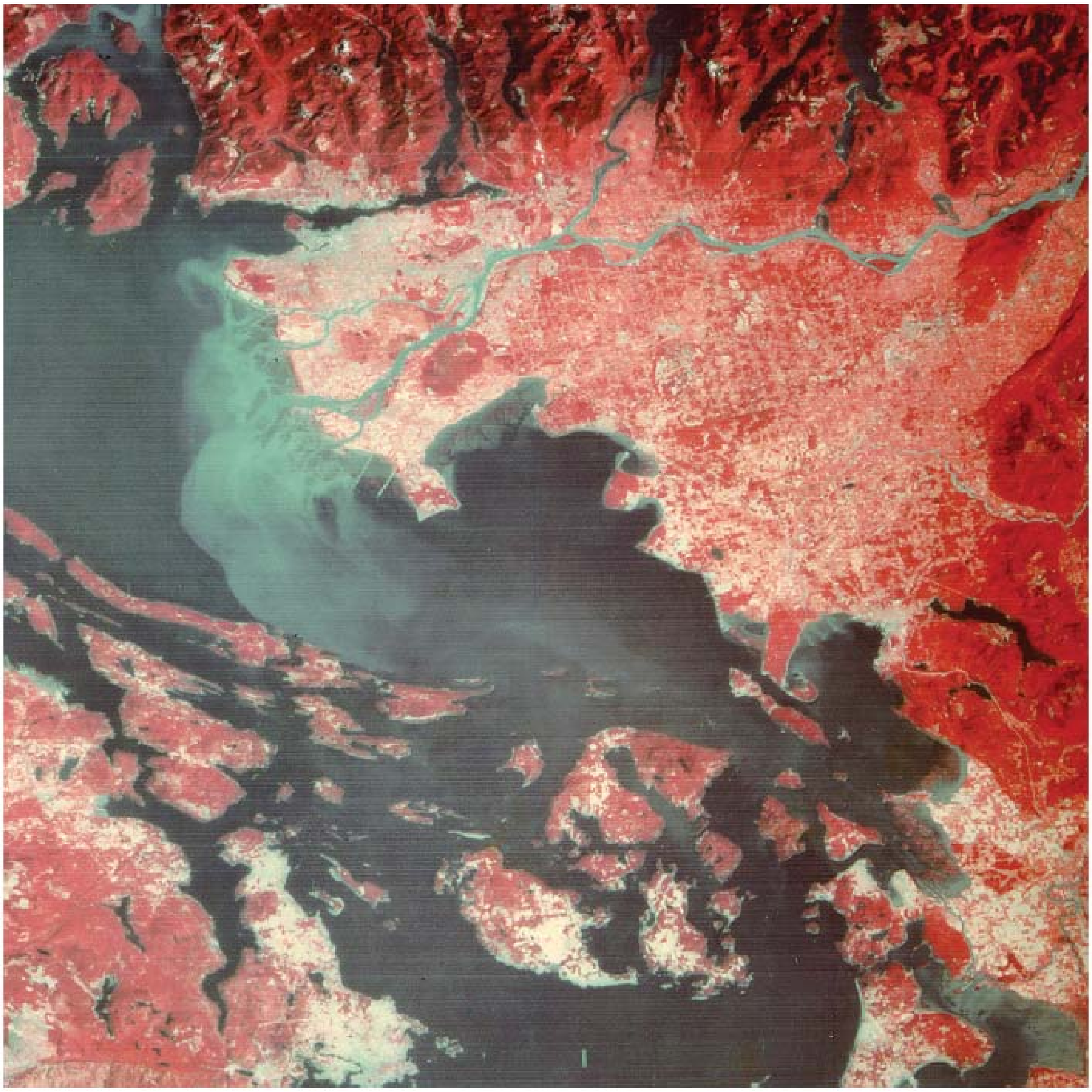
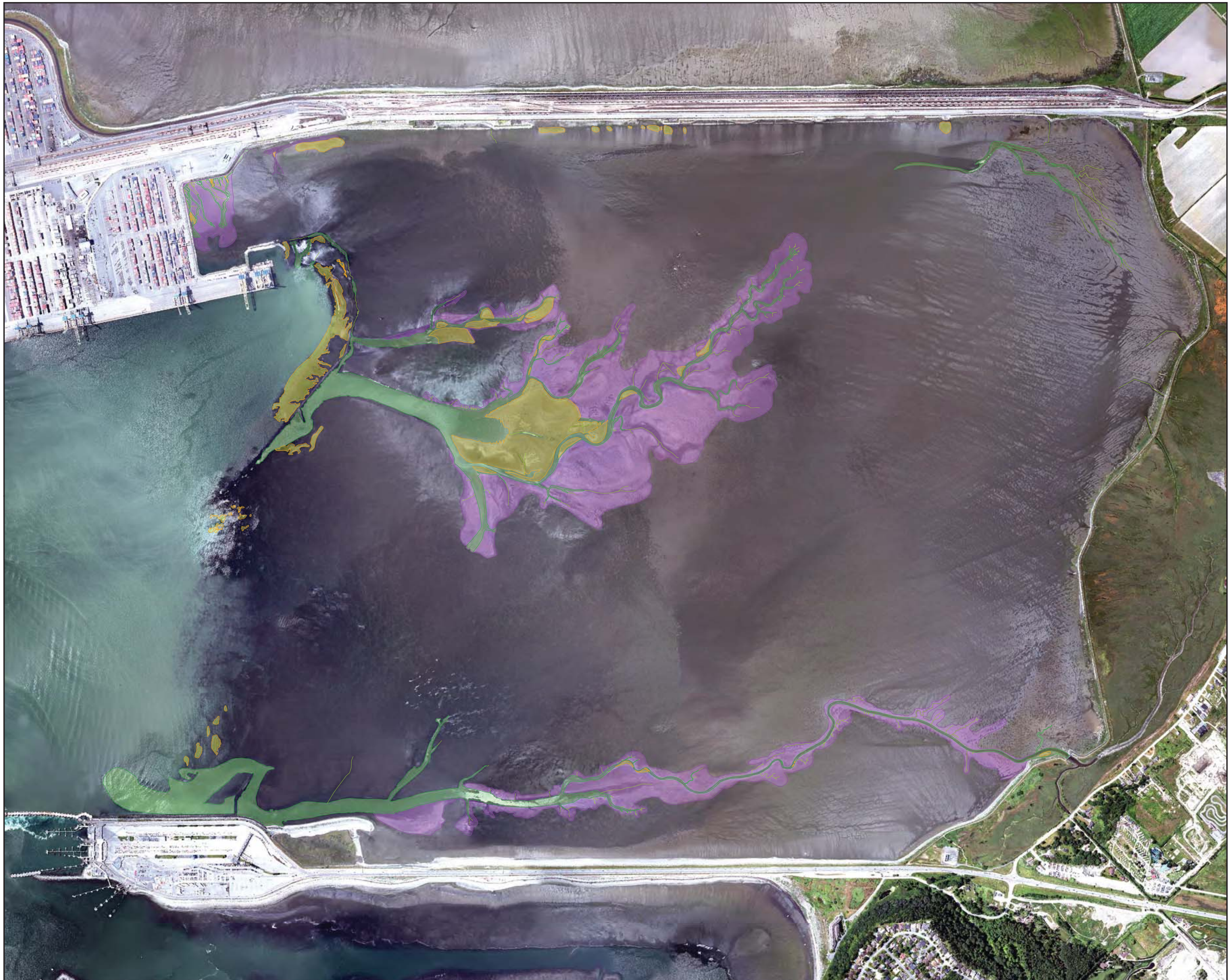


Figure 18. Fraser River Plume deflected by Roberts Bank Causeway during Ebb Tide (image 1982 Colour IR).



DELTAPORT THIRD BERTH ADAPTIVE MANAGEMENT STRATEGY PROGRAM 2012 ANNUAL REPORT

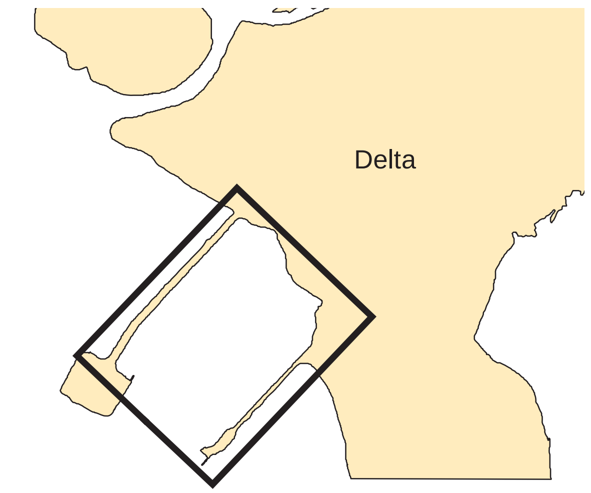
2012
Orthophoto Interpretation

Scale - 1:15,000

0 200 400 600 800 Metres

coord. syst.: UTM Zone 10	horz. datum: NAD 83	horz. units: metres
Northwest Hydraulic Consultants	project no. 34648	August 2013

Reference Map



Legend

ACTIVE CHANNEL ZONE

BAR

WIDE CHANNEL

NARROW CHANNEL

BAR

CHANNEL

ACTIVE CHANNEL ZONE

Note:
- July 6, 2012 orthophoto supplied by VFPA.

JXD, \\192.168.100.12\projects\34648 DP3 AMS\GIS\Fig_Mapping2011.mxd

Figure 19

DELTAPORT THIRD BERTH ADAPTIVE MANAGEMENT STRATEGY PROGRAM 2012 ANNUAL REPORT

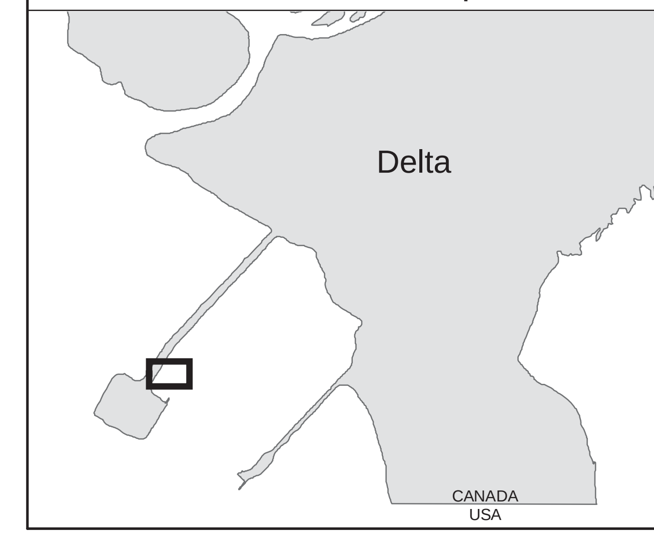
Drainage Channel Detailed Comparison, 2011 and 2012 Orthophotos

Scale - 1:4,000

100 50 0 100 Metres

coord. syst.: UTM Zone 10	horz. datum: NAD 83	horz. units: metres
Northwest Hydraulic Consultants	project no. 34648	August 2013

Reference Map



Legend

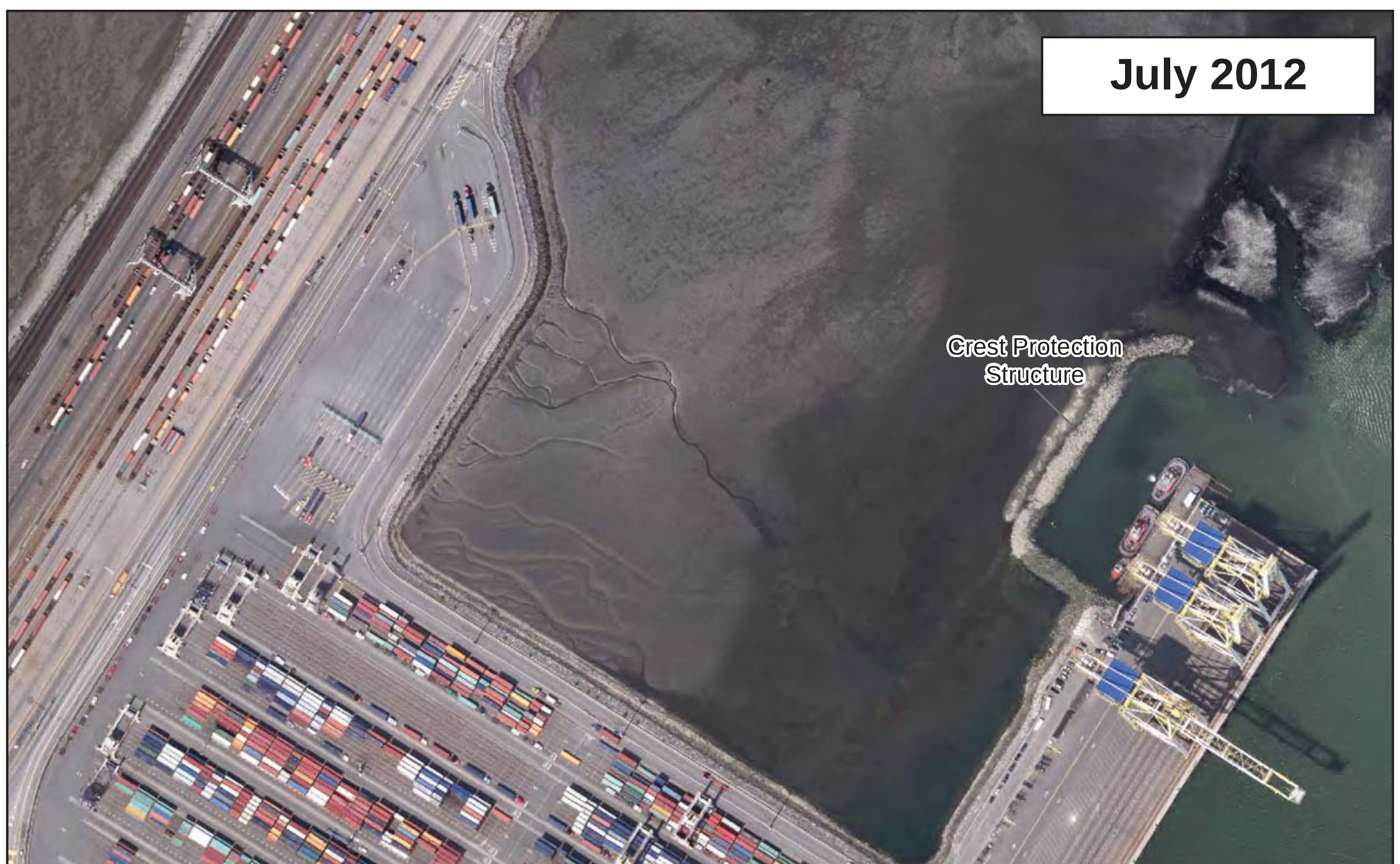
2011 Channel Mapping

- ACTIVE CHANNEL ZONE
- CHANNEL - DOUBLE LINE
- CHANNEL - SINGLE LINE

2012 Channel Mapping

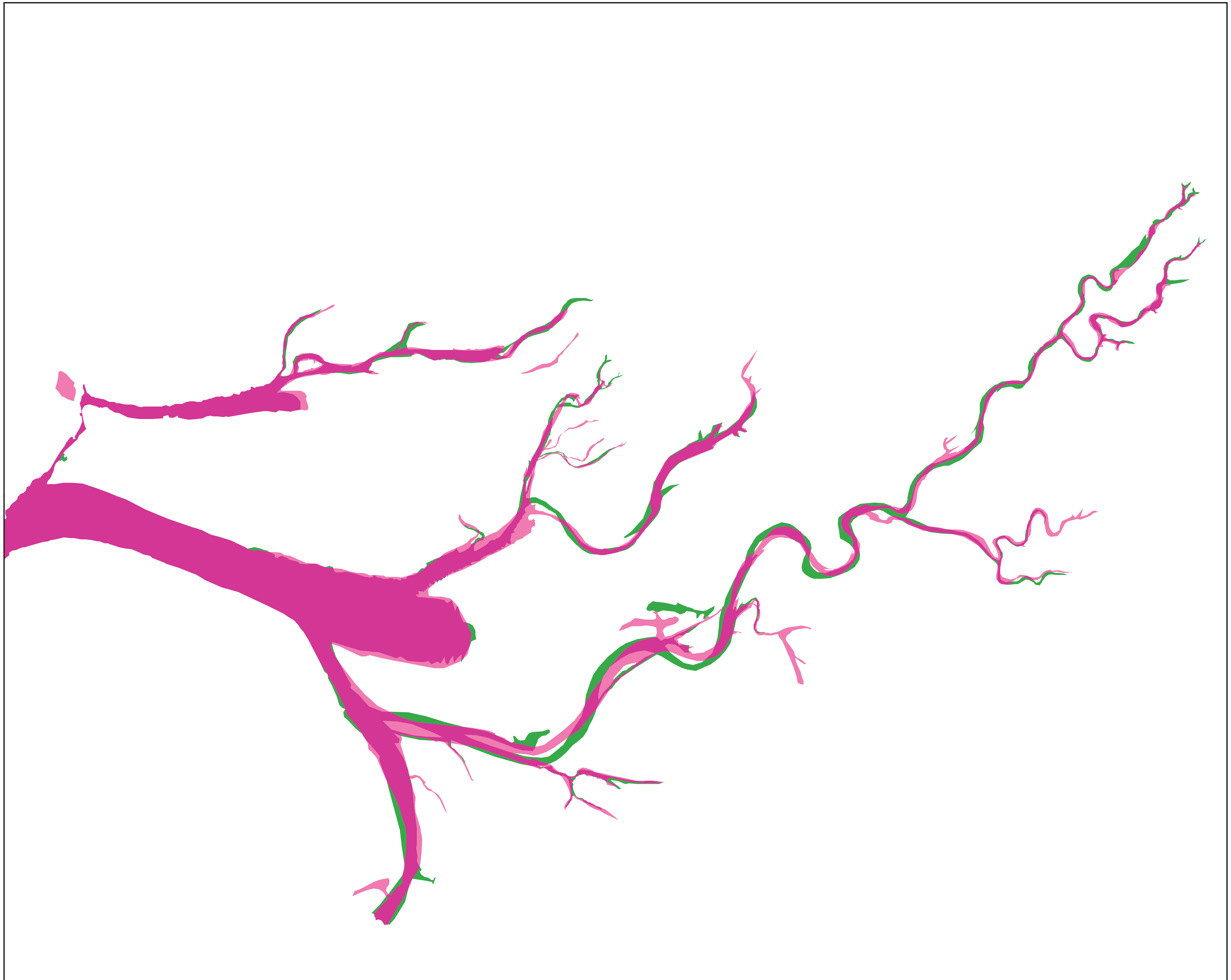
- ACTIVE CHANNEL ZONE
- CHANNEL

Note:
- 2011 and 2012 orthophotos supplied by Vancouver Fraser Port Authority.



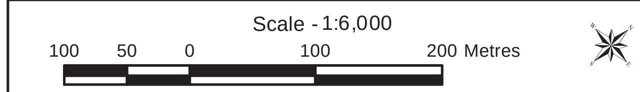
MSN & JXD, 34648 Deltaport Monitoring\GIS\Fig_New2011Channels.mxd

Figure 20



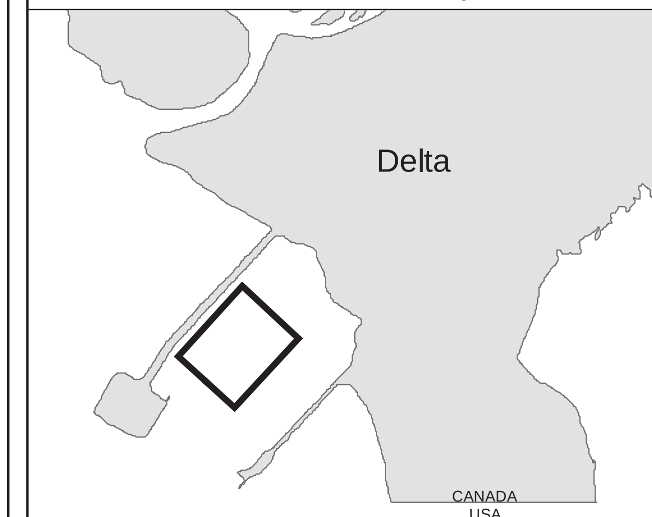
DELTAPORT THIRD BERTH ADAPTIVE MANAGEMENT STRATEGY PROGRAM 2012 ANNUAL REPORT

Mapped Channel Changes Based on 2012 and 2011 Orthophotos



coord. syst.: UTM Zone 10	horz. datum: NAD 83	horz. units: metres
Northwest Hydraulic Consultants	project no. 34648	August 2013

Reference Map



Legend

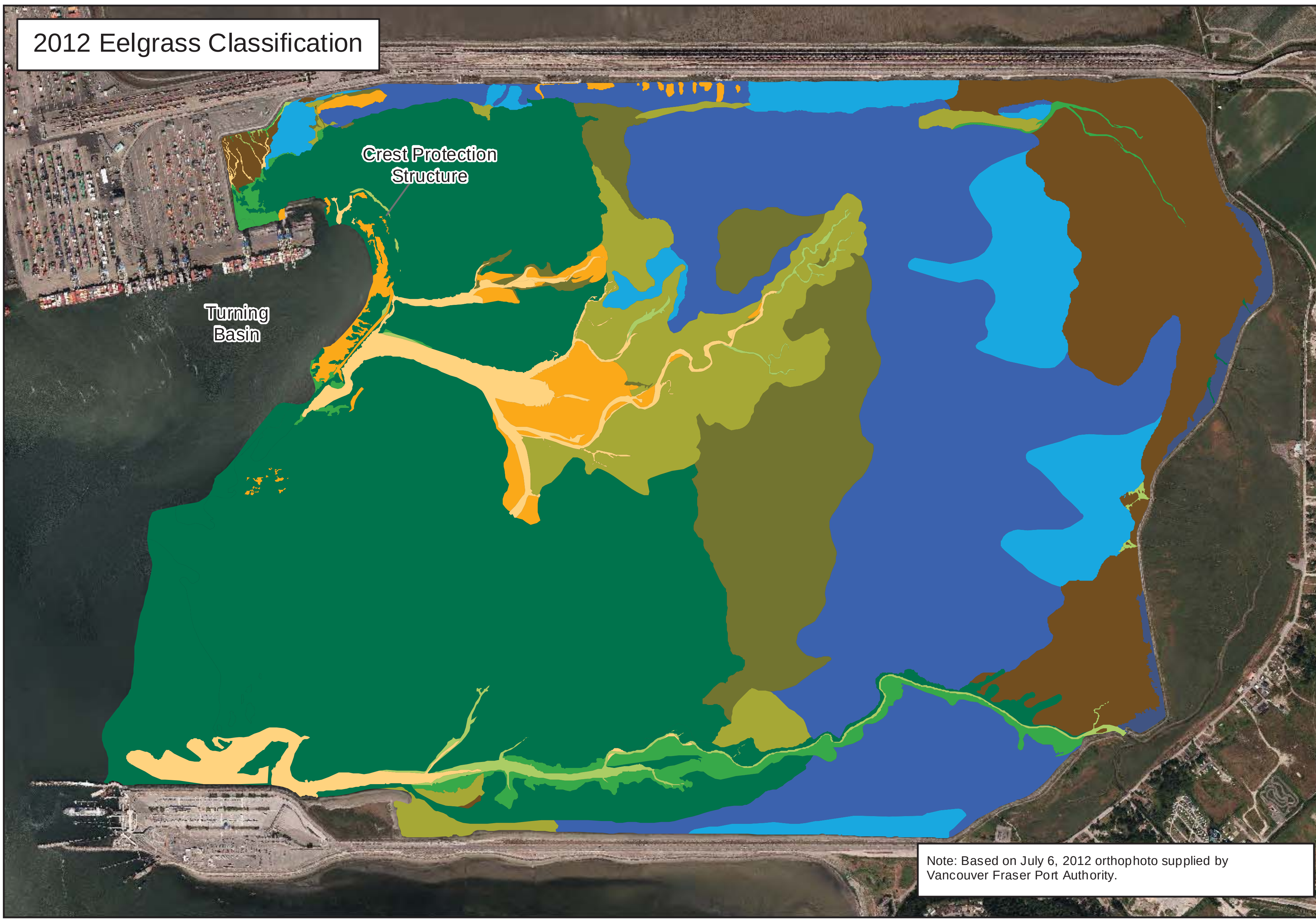
2011 to 2012

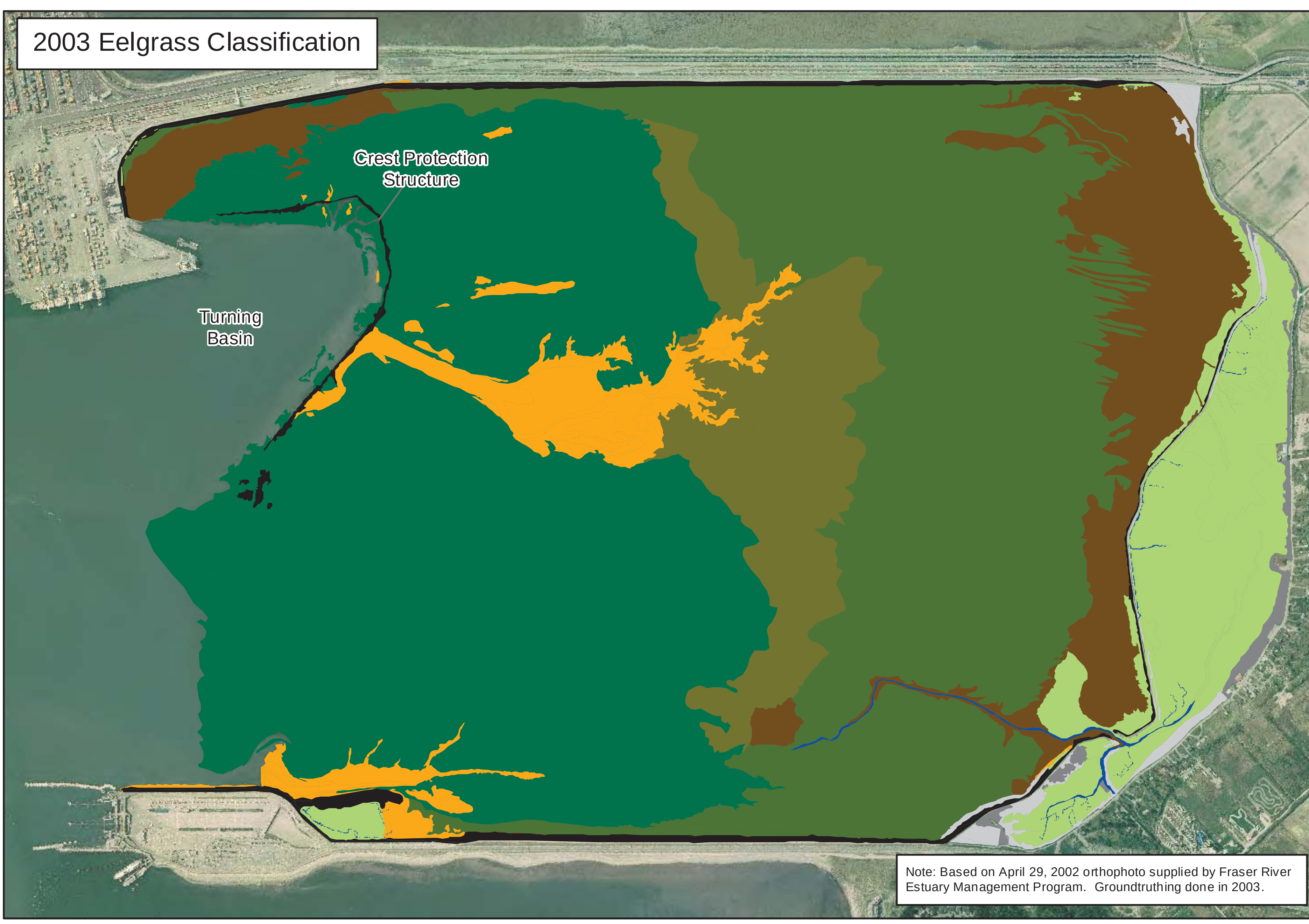
- channel in 2011 (not in 2012)
- channel in 2011 and 2012 (no change)
- channel in 2012 (not in 2011)

Note:
- Variation in conditions such as tide level, vegetation growth and water clarity may influence the accuracy of change mapping between 2011 and 2012.

MSN & JXD,\\192.168.100.12\projects\34648 DP3 AMS\GIS\Fig_Mapping2011Comp2010.mxd

Figure 21





2012 Eelgrass Classification

- Zostera marina - continuous
- Zostera marina - patchy
- Zostera mix - continuous
- Zostera mix - patchy
- Zostera marina - channel
- Z. japonica - continuous
- Z. japonica - patchy
- Unvegetated channel
- Mudflats
- Sand
- Backshore

2003 Eelgrass Classification

- Z. marina
- Zostera mixed
- Z. japonica
- Marsh
- Rocky Habitat
- Channel
- Mud
- Sand
- Shrubs
- Grass

* Transition Zone

DELTAPORT THIRD BERTH ADAPTIVE MANAGEMENT STRATEGY PROGRAM 2012 ANNUAL REPORT

Eelgrass Classification 2003 and 2012

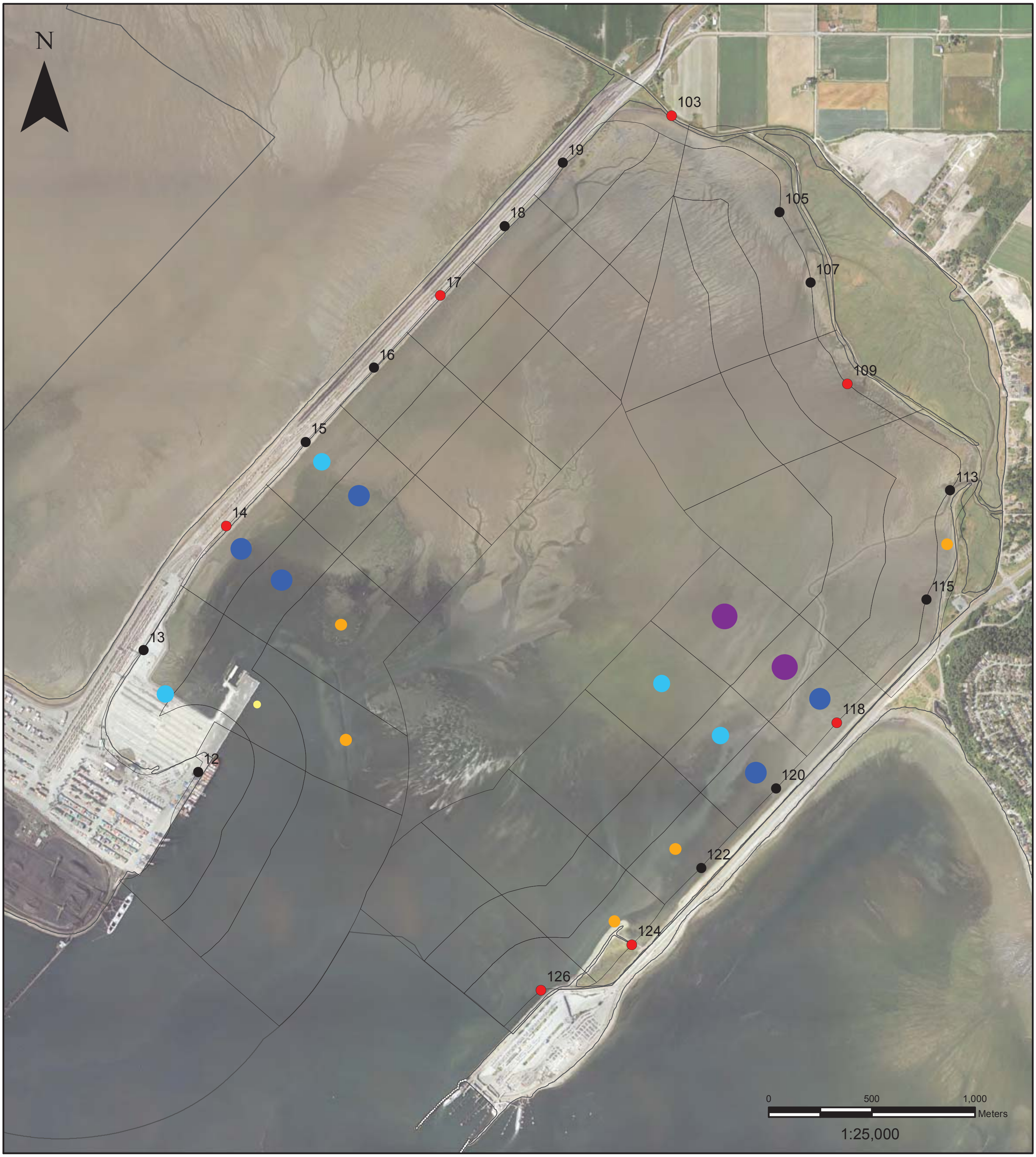
Scale - 1:20,000

500 250 0 500 Metres

coord. syst.: UTM Zone 10	horz. datum: NAD 83	horz. units: metres
Northwest Hydraulic Consultants	project no. 34648	August 2013

Figure 22

MSN & JXD, \\192.168.100.12\projects\34648 DP3 AMS\GIS\EelgrassMapping\34648_JXD_FigEelgrass2012and2003.mxd



Legend

Study Stations

- Focal species windshield survey location
- Other

Maximum Heron Count (Jun-Aug 2012)

- 1 - 10
- 10 - 25
- 25 - 50
- 50 - 100
- 100 - 150

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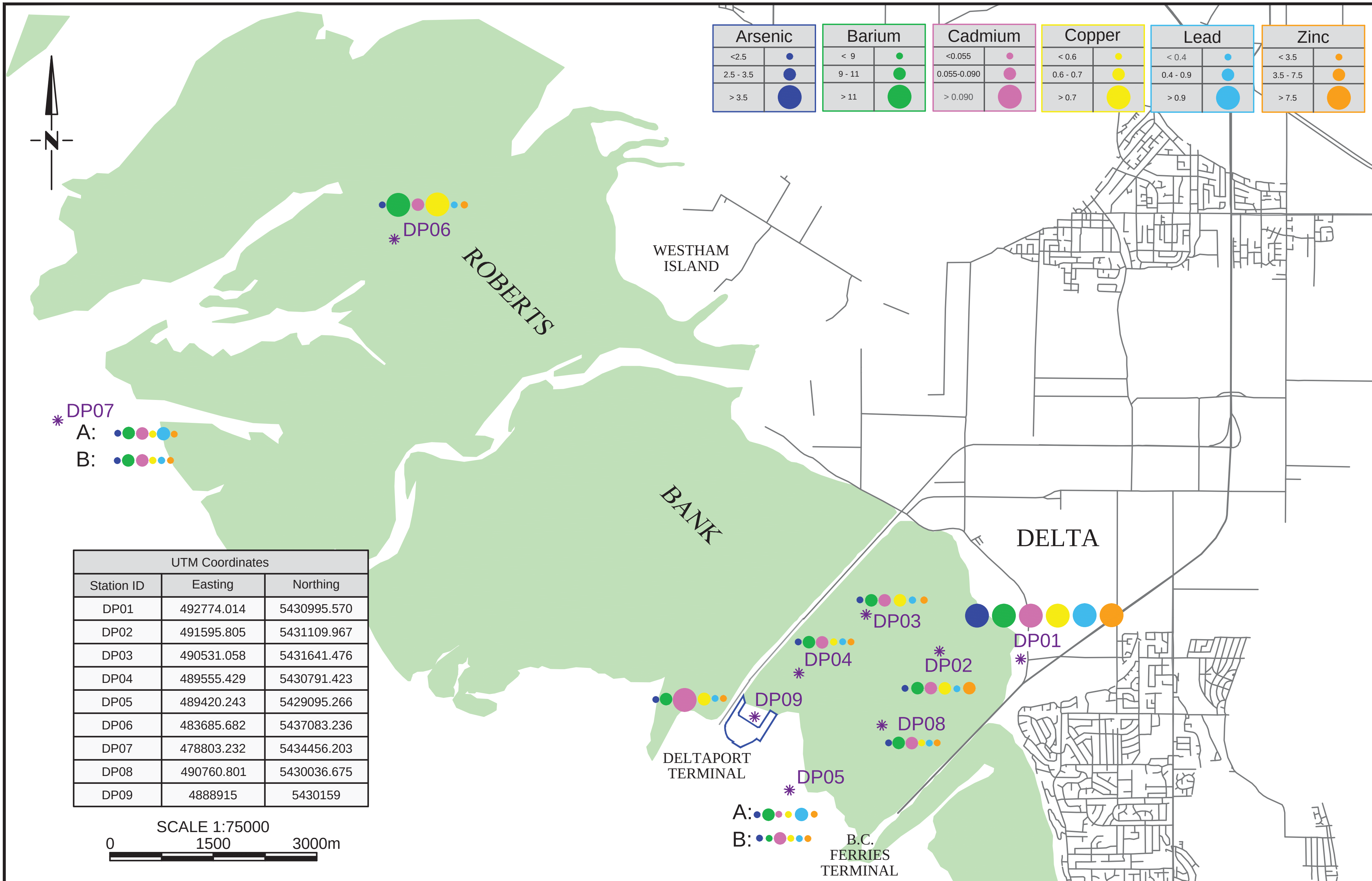
DELTAPORT THIRD BERTH - ADAPTIVE MANAGEMENT STRATEGY PROGRAM 2012 ANNUAL REPORT

Great Blue Heron Distribution and Abundance within the Inter-causeway Area during Low Tide Events, June-August 2012

PROJECT NO:		
499-002.19	August 2013	FIGURE 23



UTM Coordinates		
Station ID	Easting	Northing
DP01	492774.014	5430995.570
DP02	491595.805	5431109.967
DP03	490531.058	5431641.476
DP04	489555.429	5430791.423
DP05	489420.243	5429095.266
DP06	483685.682	5437083.236
DP07	478803.232	5434456.203
DP08	490760.801	5430036.675
DP09	4888915	5430159

LEGEND

- Water
- Tidal Mud & Sand
- ✳ Sampling Station
- A: Surface (Shallow) Station
- B: Bottom (Deep) Station

Note: Units for all parameters are µg/L, unless otherwise noted.

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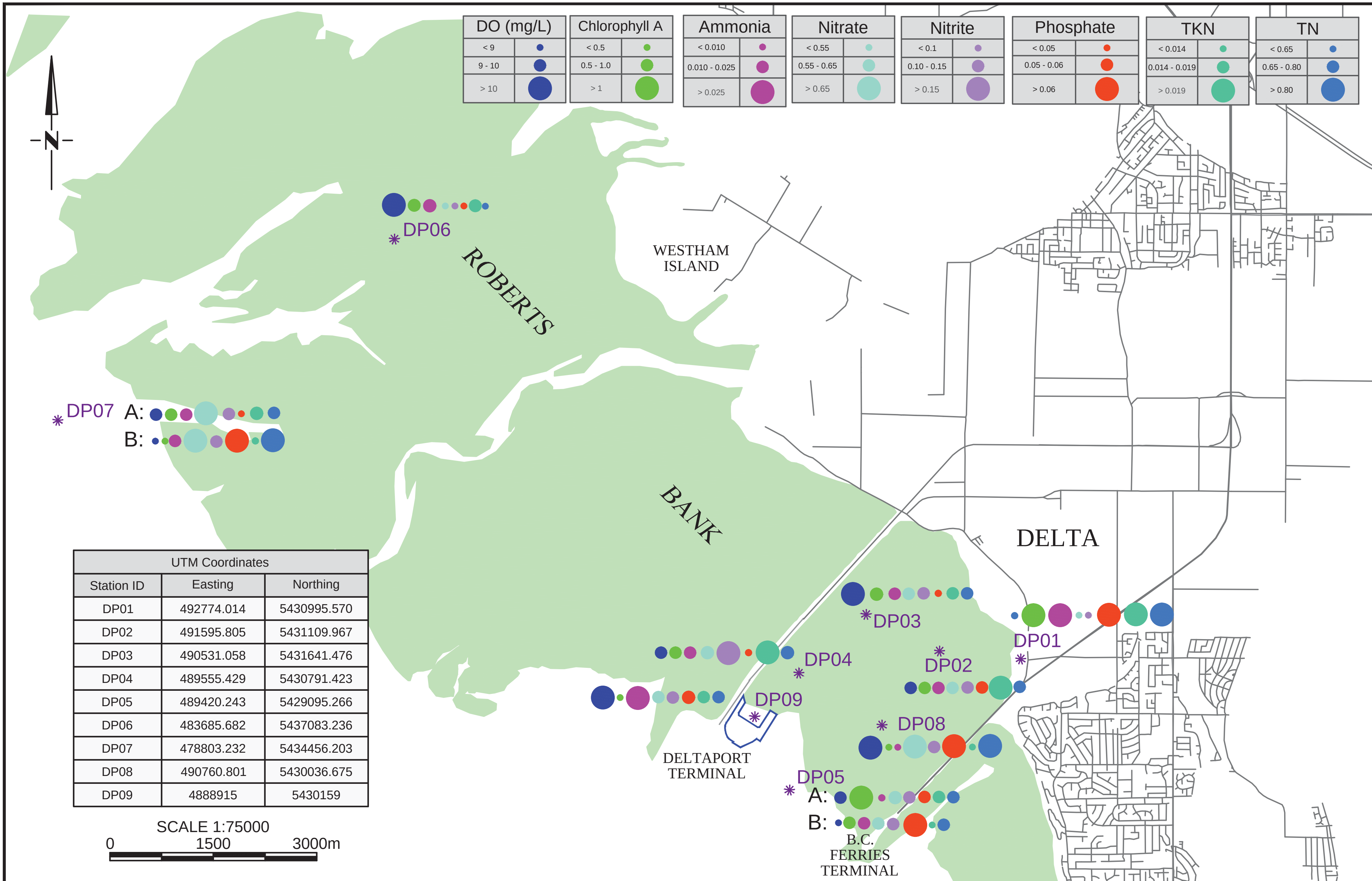
DELTAPORT THIRD BERTH - ADAPTIVE MANAGEMENT STRATEGY PROGRAM - 2012 ANNUAL REPORT

SPATIAL TRENDS OF METAL PARAMETERS IN SURFACE WATER (2012)

PROJECT No. 499-002.19	August 2013	FIGURE 24



UTM Coordinates		
Station ID	Easting	Northing
DP01	492774.014	5430995.570
DP02	491595.805	5431109.967
DP03	490531.058	5431641.476
DP04	489555.429	5430791.423
DP05	489420.243	5429095.266
DP06	483685.682	5437083.236
DP07	478803.232	5434456.203
DP08	490760.801	5430036.675
DP09	4888915	5430159

LEGEND
- Water
- Tidal Mud & Sand
- ⁕ Sampling Station
- A: Surface (Shallow) Station
- B: Bottom (Deep) Station

Note: Units for all parameters are µg/L, unless otherwise noted.

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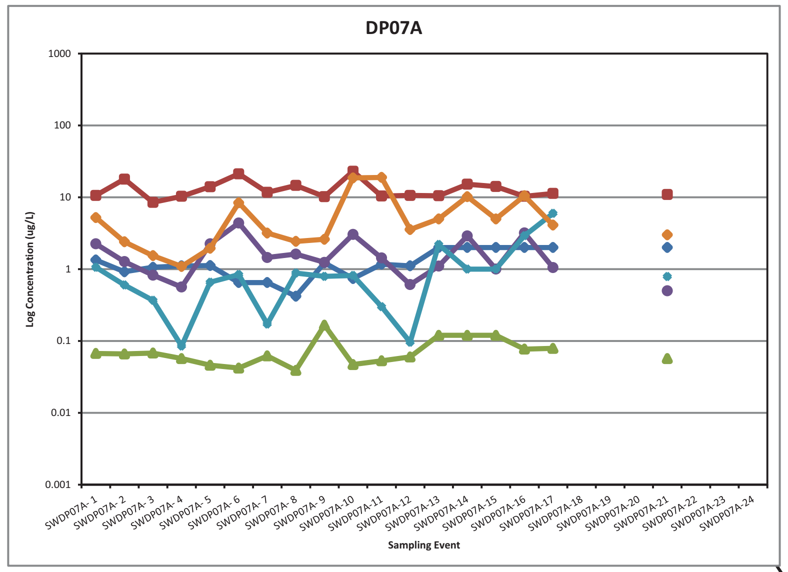
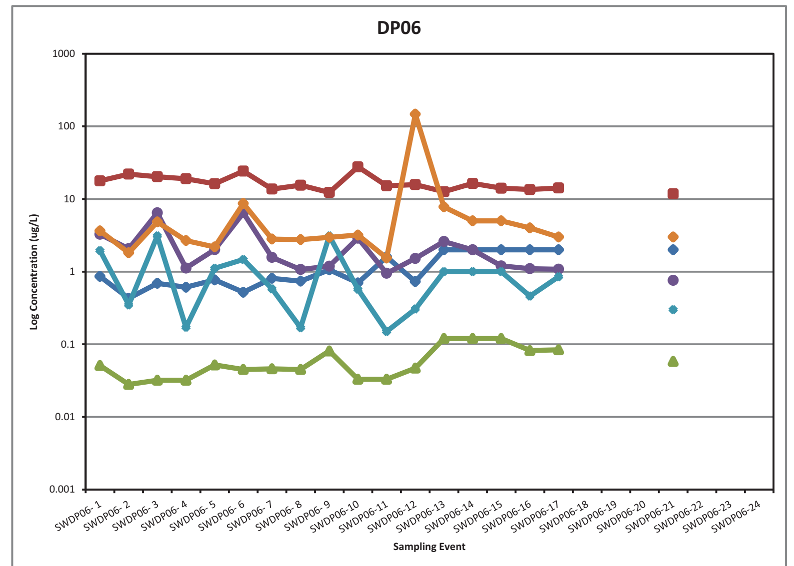
CLIENT: PORT METRO vancouver

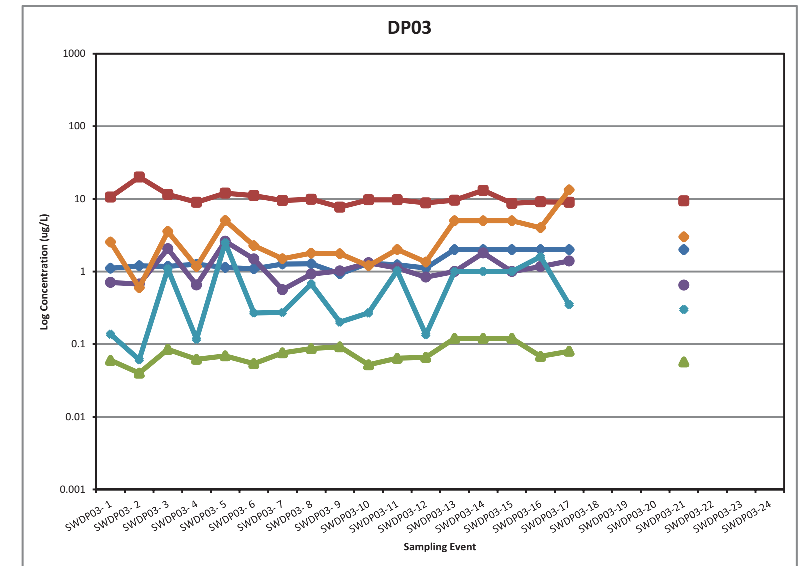
DELTAPORT THIRD BERTH - ADAPTIVE MANAGEMENT STRATEGY PROGRAM - 2012 ANNUAL REPORT

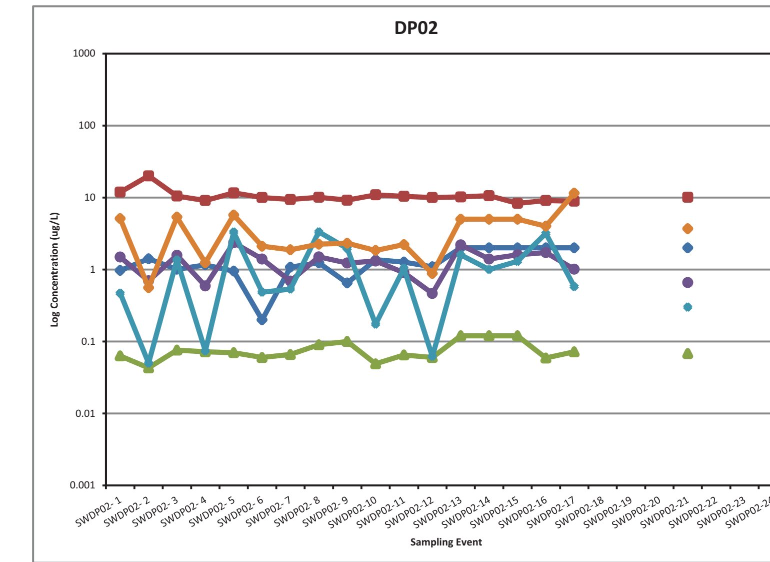
SPATIAL TRENDS OF EUTROPHICATION-RELATED PARAMETERS IN SURFACE WATER (2012)

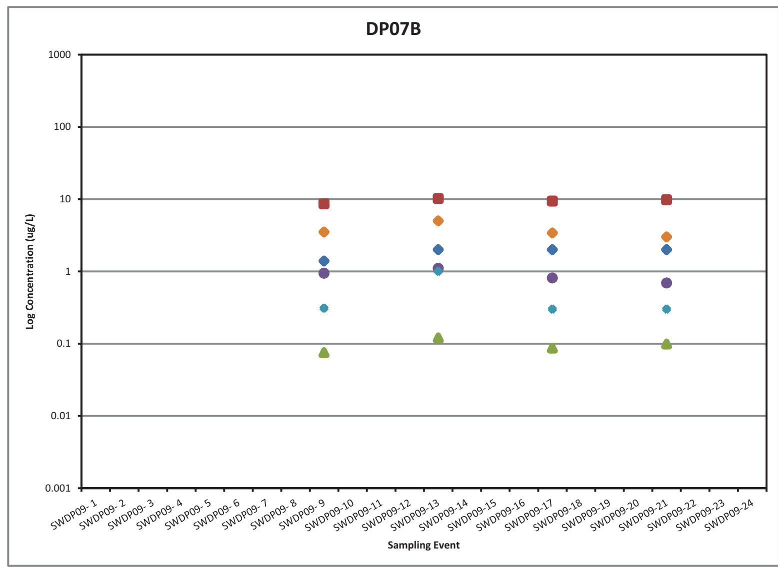
PROJECT No.	Date	Figure
499-002.19	August 2013	FIGURE 25

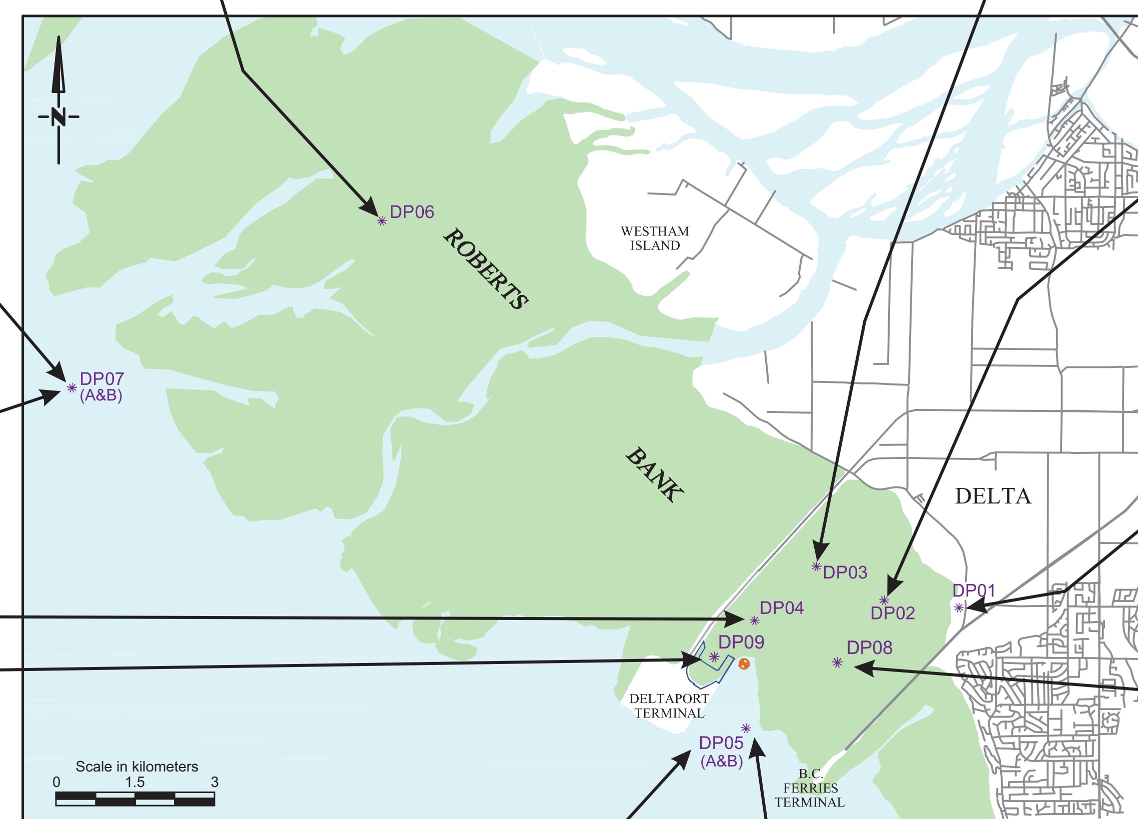


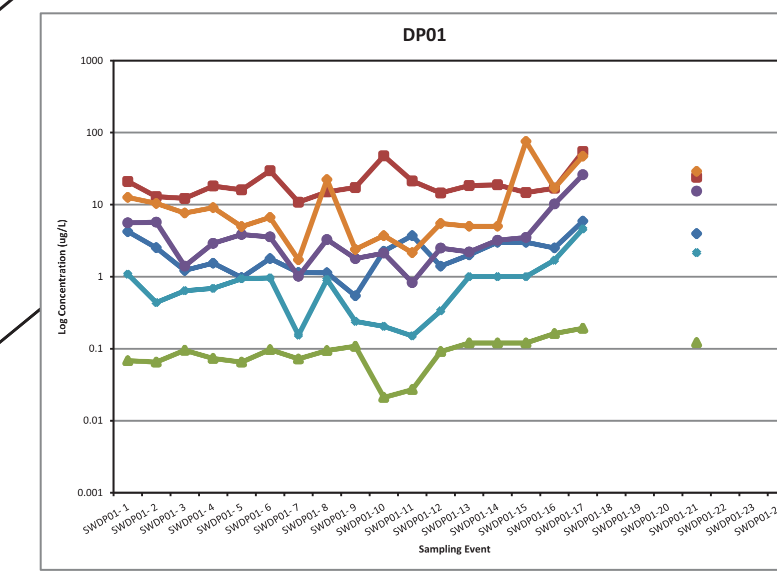


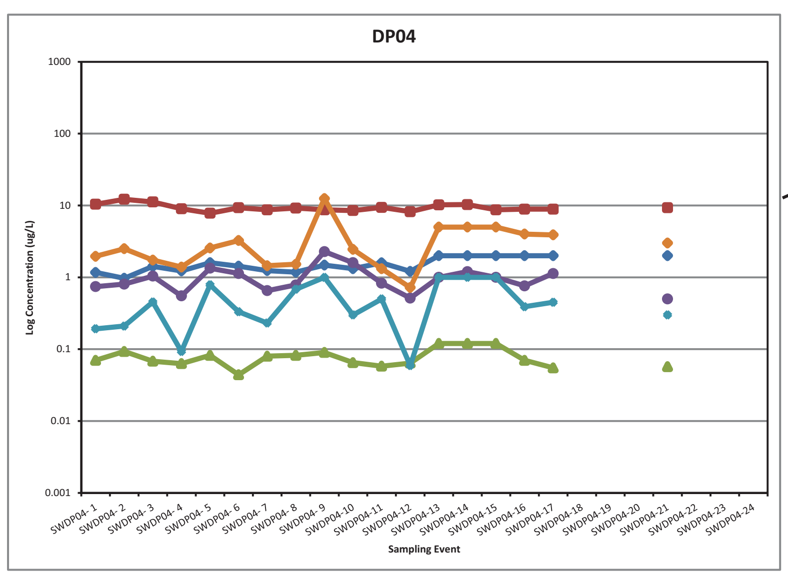


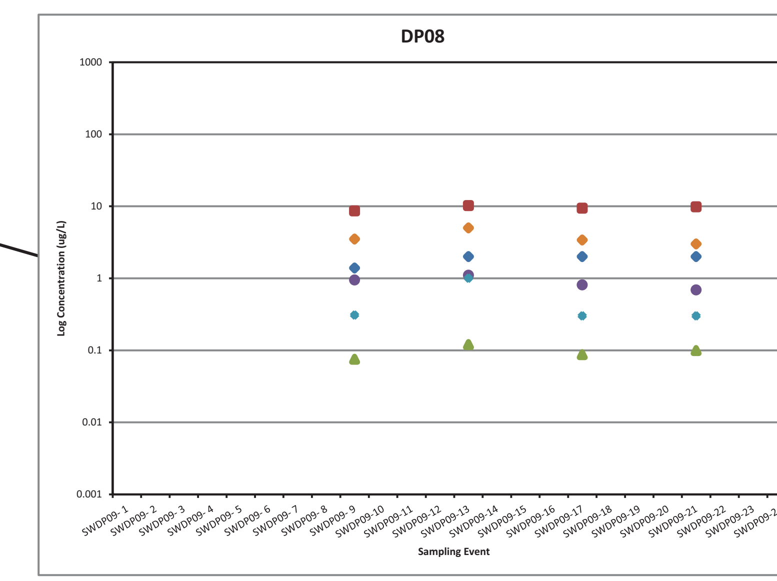


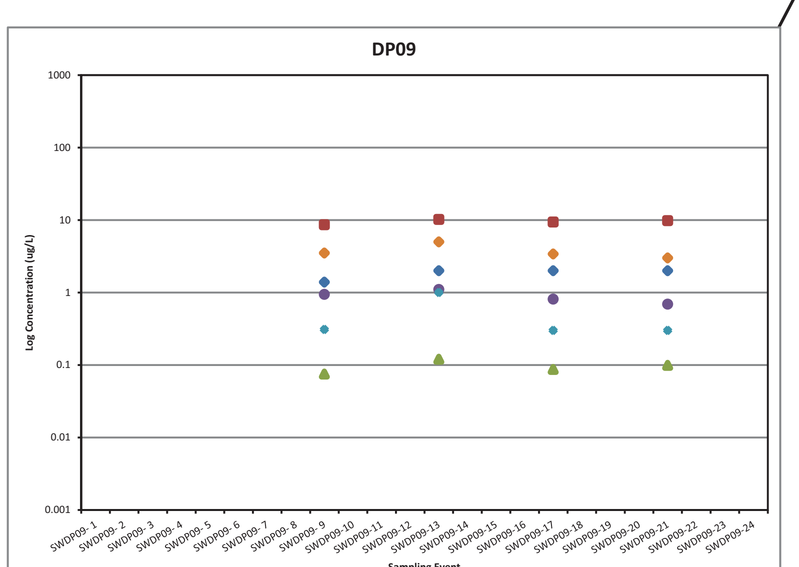


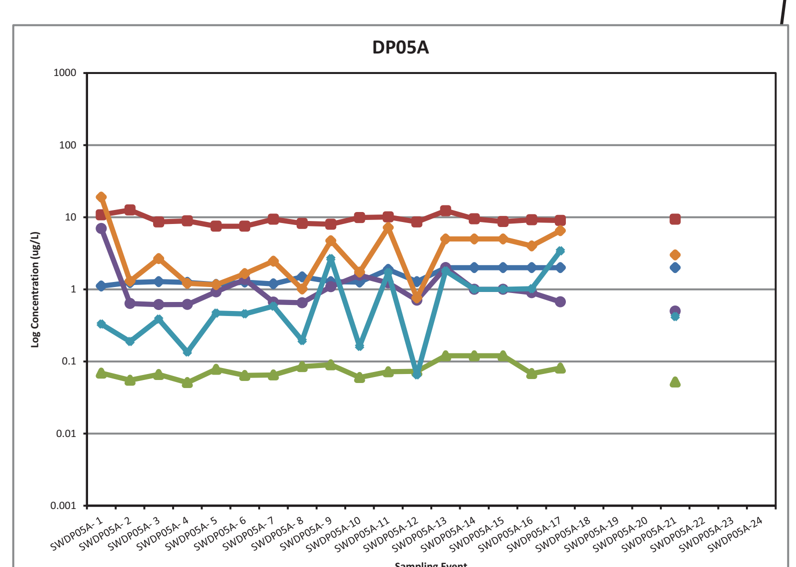


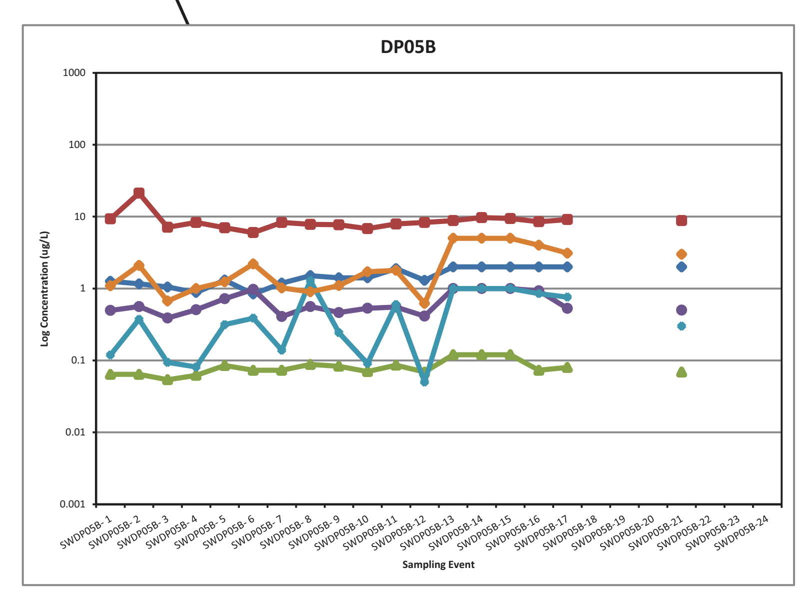












Event #'s					
1	Q1 2007	5	Q1 2008	9	Q1 2009
2	Q2 2007	6	Q2 2008	10	Q2 2009
3	Q3 2007	7	Q3 2008	11	Q3 2009
4	Q4 2007	8	Q4 2008	12	Q4 2009
Event #'s					
13	Q1 2010	17	Q1 2011	21	Q1 2012
14	Q2 2010	18	Q2 2011	22	Q2 2012
15	Q3 2010	19	Q3 2011	23	Q3 2012
16	Q4 2010	20	Q4 2011	24	Q4 2012

LEGEND
Water
Tidal Mud & Sand
Water Quality Sampling Station
YSI Sonde
SDDP04-7
Event #
Station Location
Sample Type (SD=sediment)

NOTE: All measurements are in mg/kg

Chart Legend
Surface Water / Arsenic
Surface Water / Barium
Surface Water / Cadmium
Surface Water / Copper
Surface Water / Lead
Surface Water / Zinc

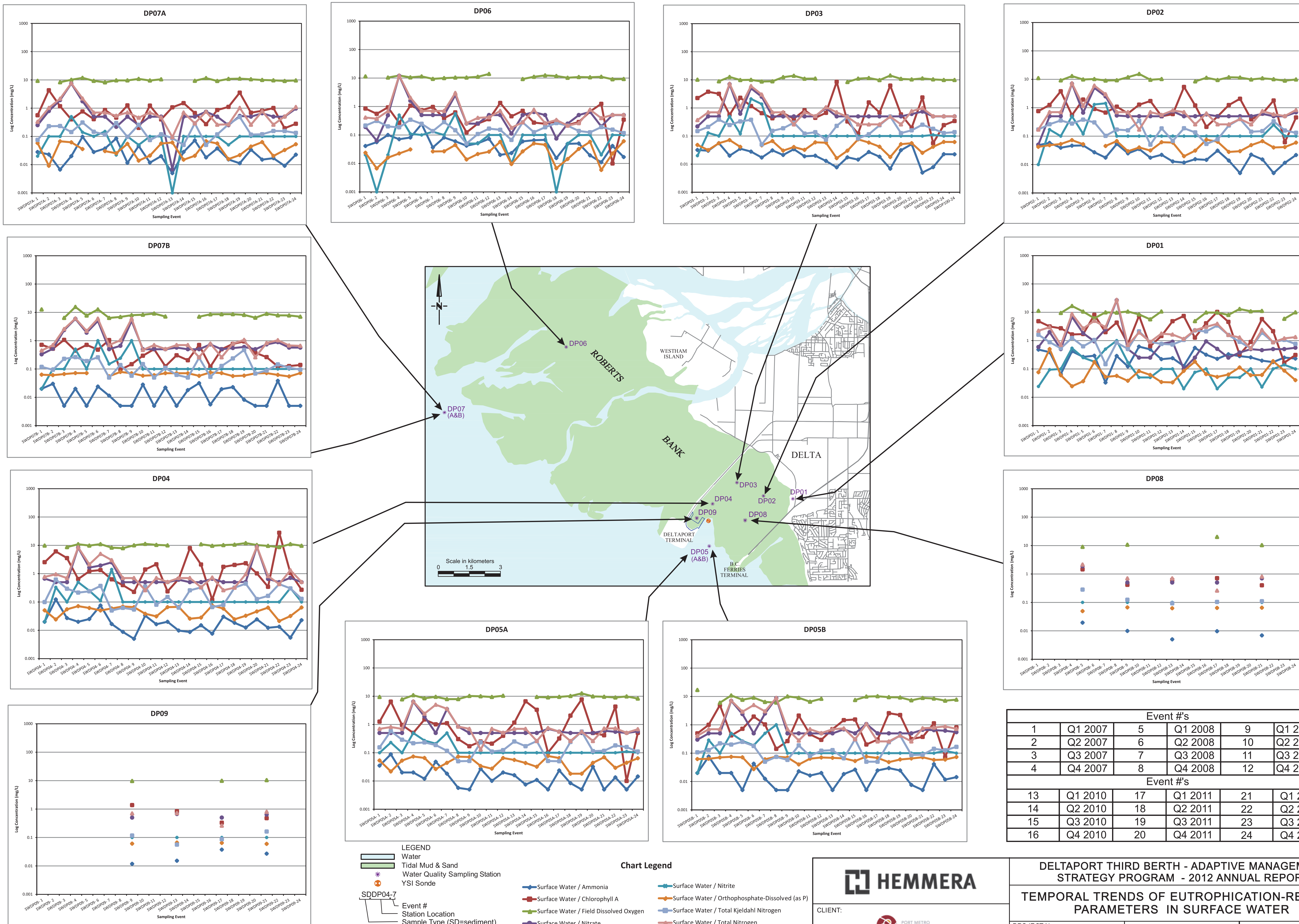
HEMMERA

CLIENT: PORT METRO vancouver

DELTAPORT THIRD BERTH - ADAPTIVE MANAGEMENT STRATEGY PROGRAM - 2012 ANNUAL REPORT

TEMPORAL TRENDS OF METALS IN SURFACE WATER

PROJECT No. 499-002.19	August 2013	FIGURE 26



Event #'s					
1	Q1 2007	5	Q1 2008	9	Q1 2009
2	Q2 2007	6	Q2 2008	10	Q2 2009
3	Q3 2007	7	Q3 2008	11	Q3 2009
4	Q4 2007	8	Q4 2008	12	Q4 2009
Event #'s					
13	Q1 2010	17	Q1 2011	21	Q1 2012
14	Q2 2010	18	Q2 2011	22	Q2 2012
15	Q3 2010	19	Q3 2011	23	Q3 2012
16	Q4 2010	20	Q4 2011	24	Q4 2012

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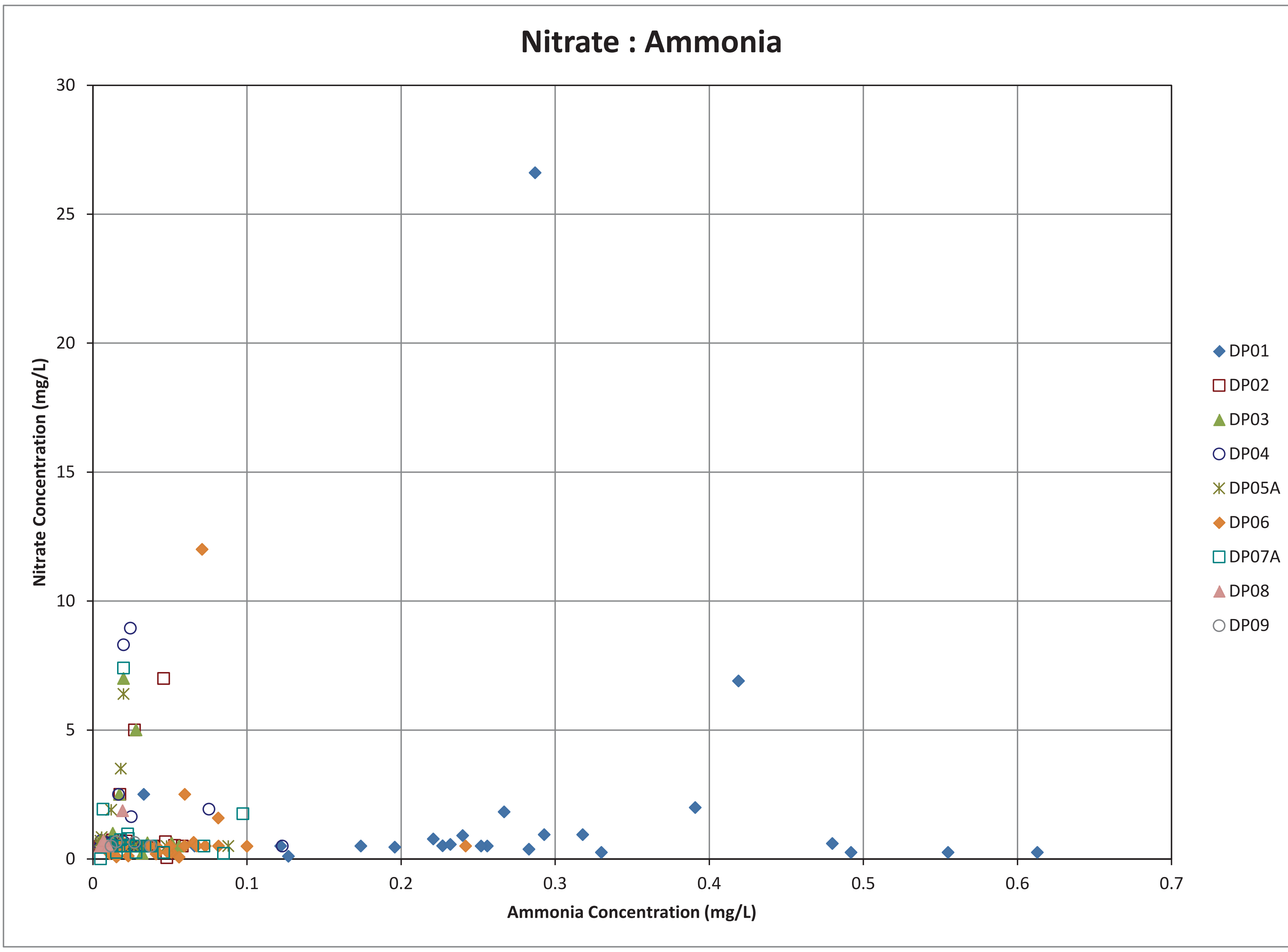
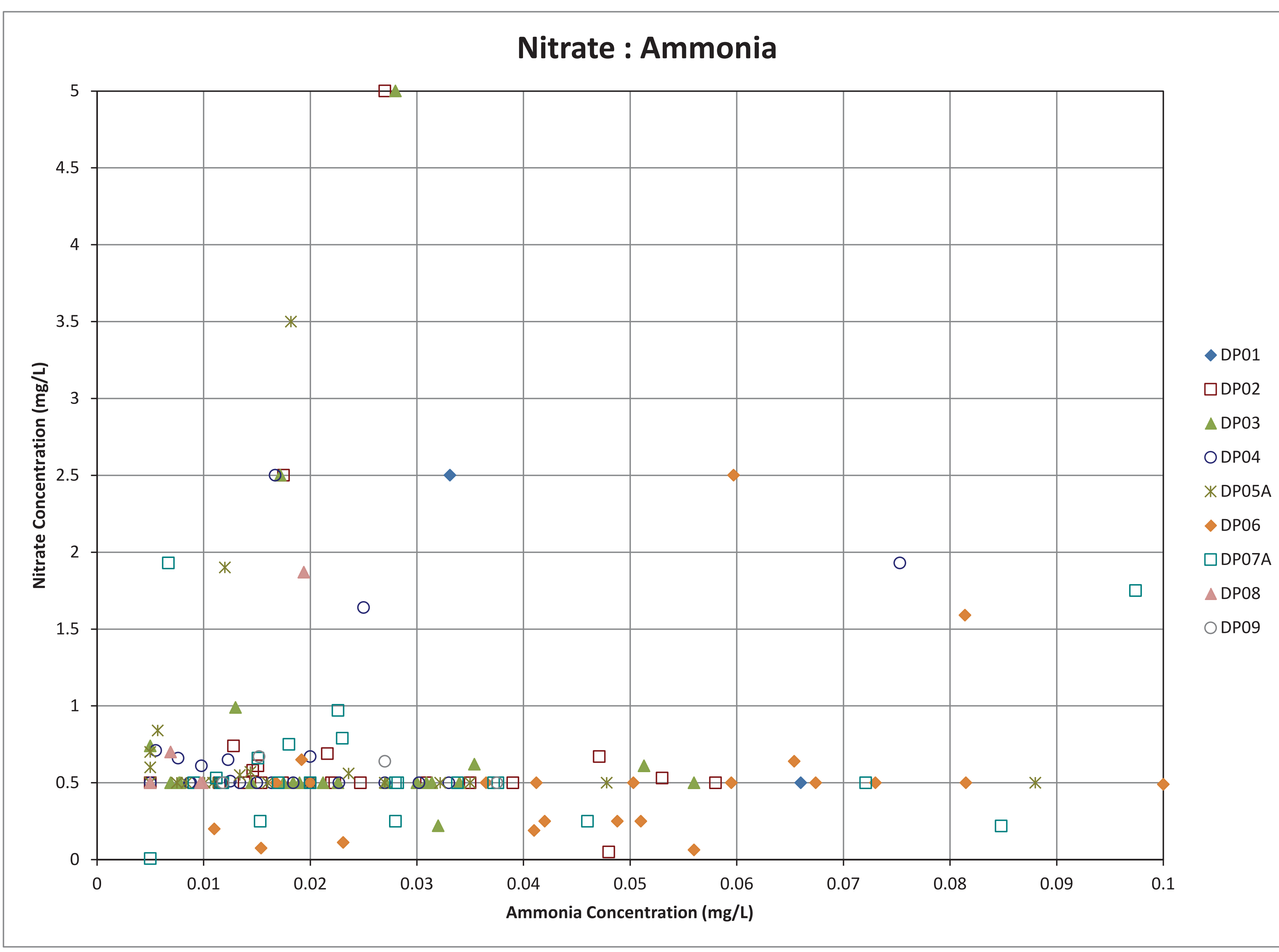
CLIENT: PORT METRO vancouver

DELTAPORT THIRD BERTH - ADAPTIVE MANAGEMENT STRATEGY PROGRAM - 2012 ANNUAL REPORT

TEMPORAL TRENDS OF EUTROPHICATION-RELATED PARAMETERS IN SURFACE WATER

PROJECT No.		
499-002.19	August 2013	FIGURE 27





Note: This graph shows a close-up view of the same lower concentration data shown above.

HEMMERA

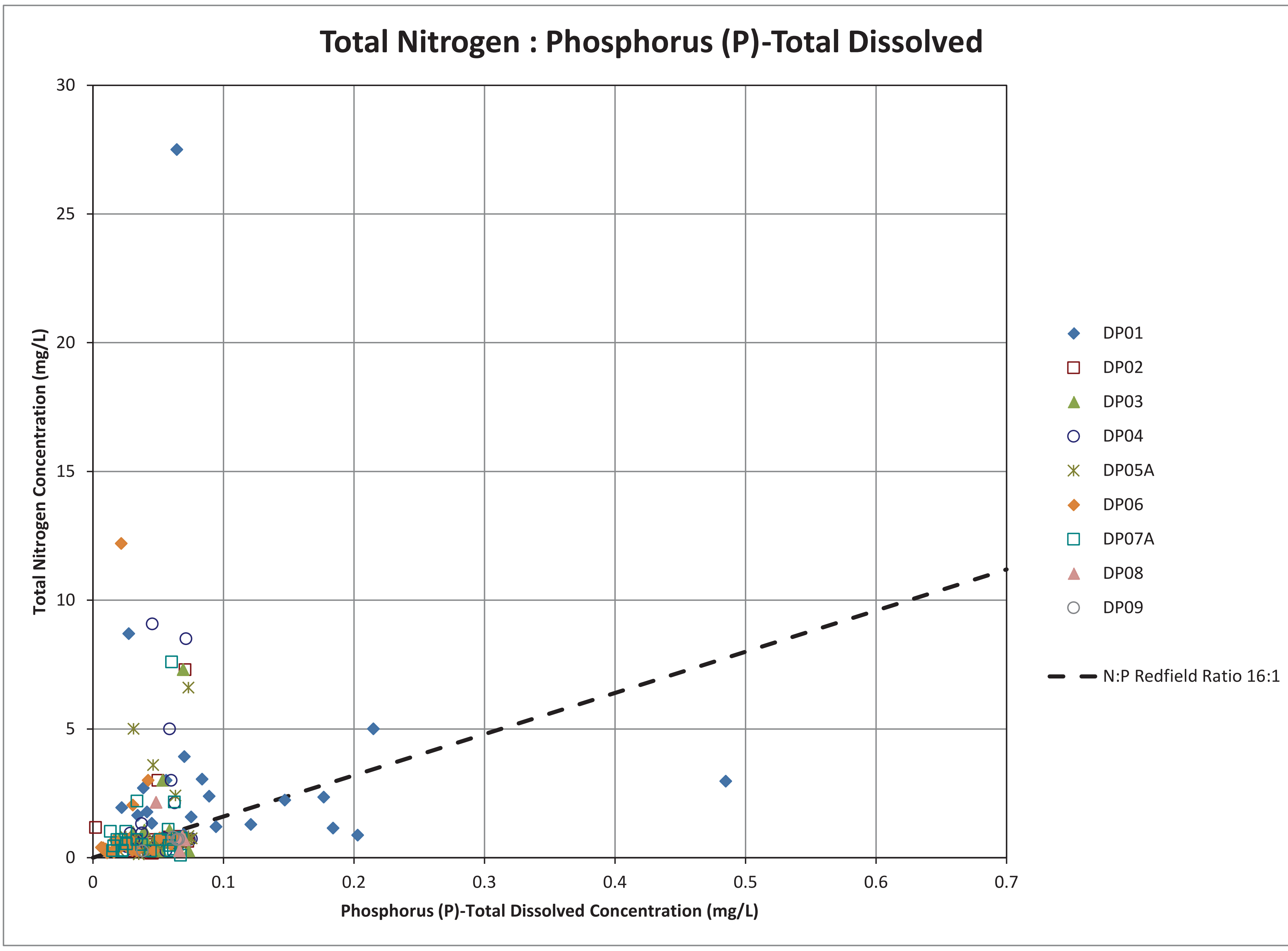
CLIENT:

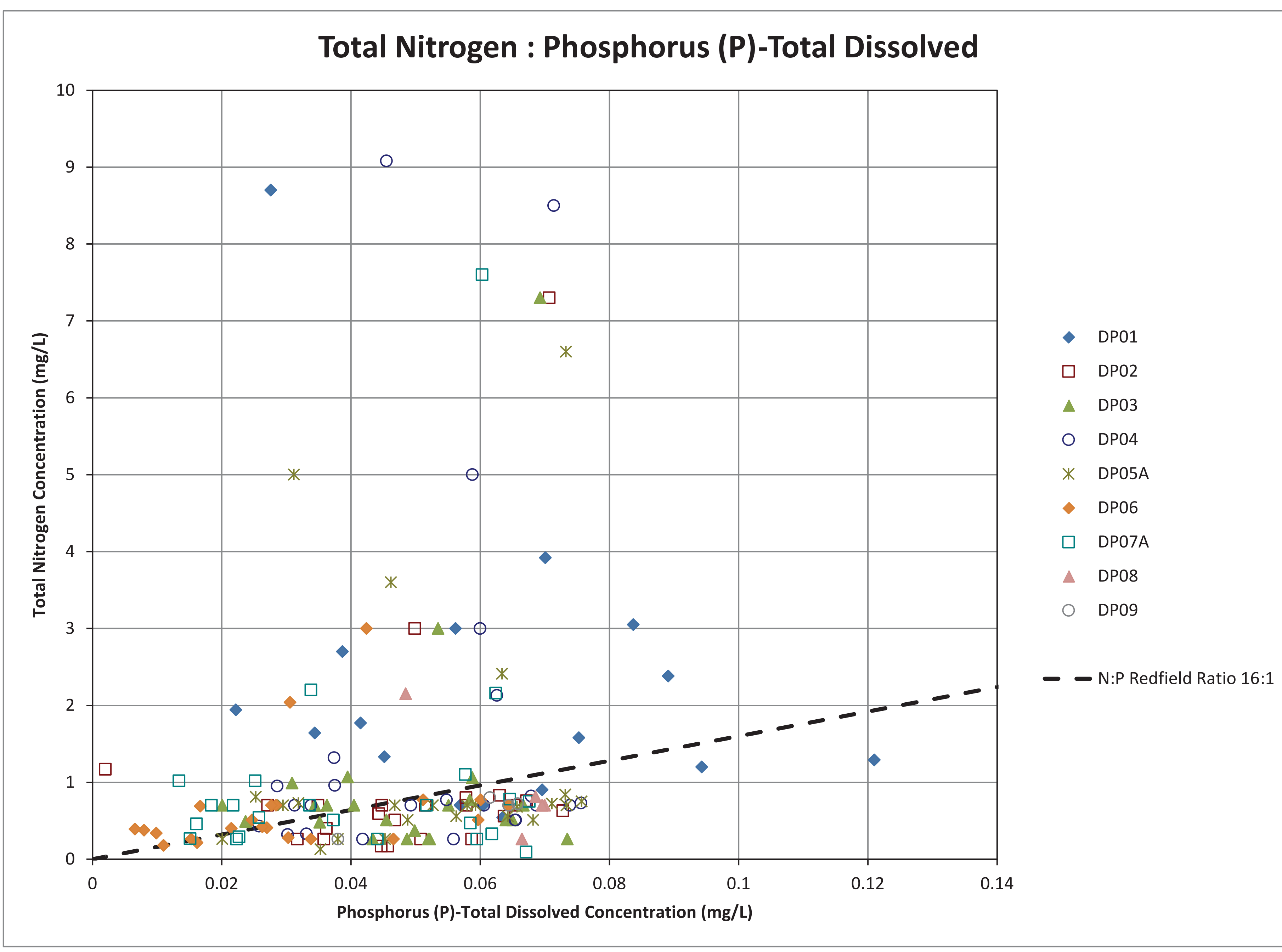
PORT METRO vancouver

DELTAPORT THIRD BERTH - ADAPTIVE MANAGEMENT STRATEGY PROGRAM - 2012 ANNUAL REPORT

RATIO OF NITRATE TO AMMONIA IN SURFACE WATER

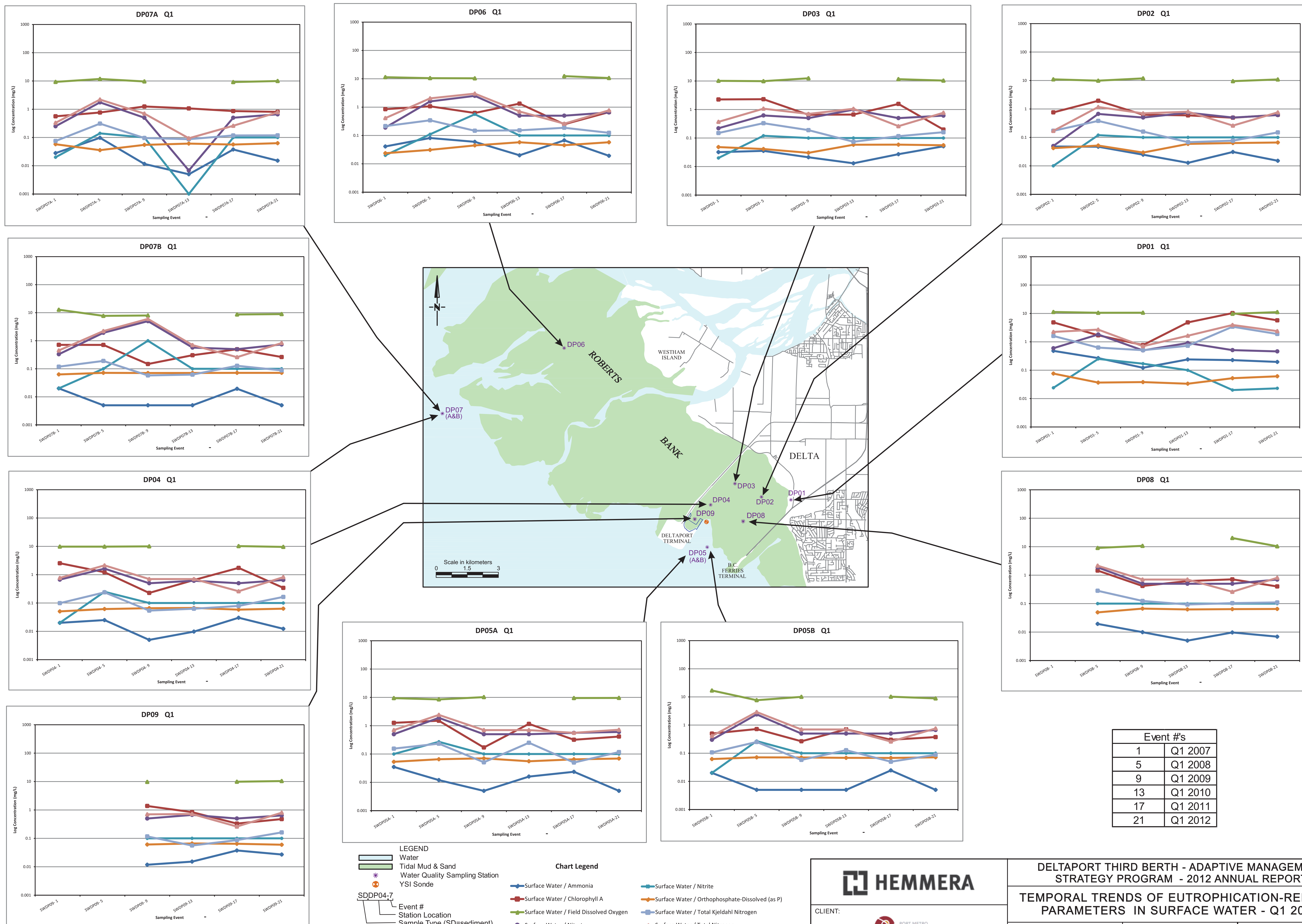
PROJECT No. 499-002.19	August 2013	FIGURE 28





Note: This graph shows a close-up view of the same lower concentration data shown above.

HEMMERA	DELTAPORT THIRD BERTH - ADAPTIVE MANAGEMENT STRATEGY PROGRAM - 2012 ANNUAL REPORT		
CLIENT: PORT METRO vancouver	RATIO OF TOTAL NITROGEN TO TOTAL PHOSPHORUS IN SURFACE WATER		
	PROJECT No. 499-002.19	August 2013	FIGURE 29



LEGEND
Water
Tidal Mud & Sand
Water Quality Sampling Station
YSI Sonde

SDDP04-7
Event #
Station Location
Sample Type (SD=sediment)

NOTE: All measurements are in mg/kg

Chart Legend

- Surface Water / Ammonia
- Surface Water / Chlorophyll A
- Surface Water / Field Dissolved Oxygen
- Surface Water / Nitrate
- Surface Water / Nitrite
- Surface Water / Orthophosphate-Dissolved (as P)
- Surface Water / Total Kjeldahl Nitrogen
- Surface Water / Total Nitrogen

Event #'s	
1	Q1 2007
5	Q1 2008
9	Q1 2009
13	Q1 2010
17	Q1 2011
21	Q1 2012

HEMMERA

CLIENT: PORT METRO vancouver

DELTAPORT THIRD BERTH - ADAPTIVE MANAGEMENT STRATEGY PROGRAM - 2012 ANNUAL REPORT

TEMPORAL TRENDS OF EUTROPHICATION-RELATED PARAMETERS IN SURFACE WATER - Q1 2012

PROJECT No. 499-002.19 | August 2013 | FIGURE 30-Q1

Event #'s	
2	Q2 2007
6	Q2 2008
10	Q2 2009
14	Q2 2010
18	Q2 2011
22	Q2 2012

LEGEND
Water
Tidal Mud & Sand
Water Quality Sampling Station
YSI Sonde

SDDP04-7
Event #
Station Location
Sample Type (SD=sediment)

NOTE: All measurements are in mg/kg

Chart Legend

- Surface Water / Ammonia
- Surface Water / Chlorophyll A
- Surface Water / Field Dissolved Oxygen
- Surface Water / Nitrate
- Surface Water / Nitrite
- Surface Water / Orthophosphate-Dissolved (as P)
- Surface Water / Total Kjeldahl Nitrogen
- Surface Water / Total Nitrogen

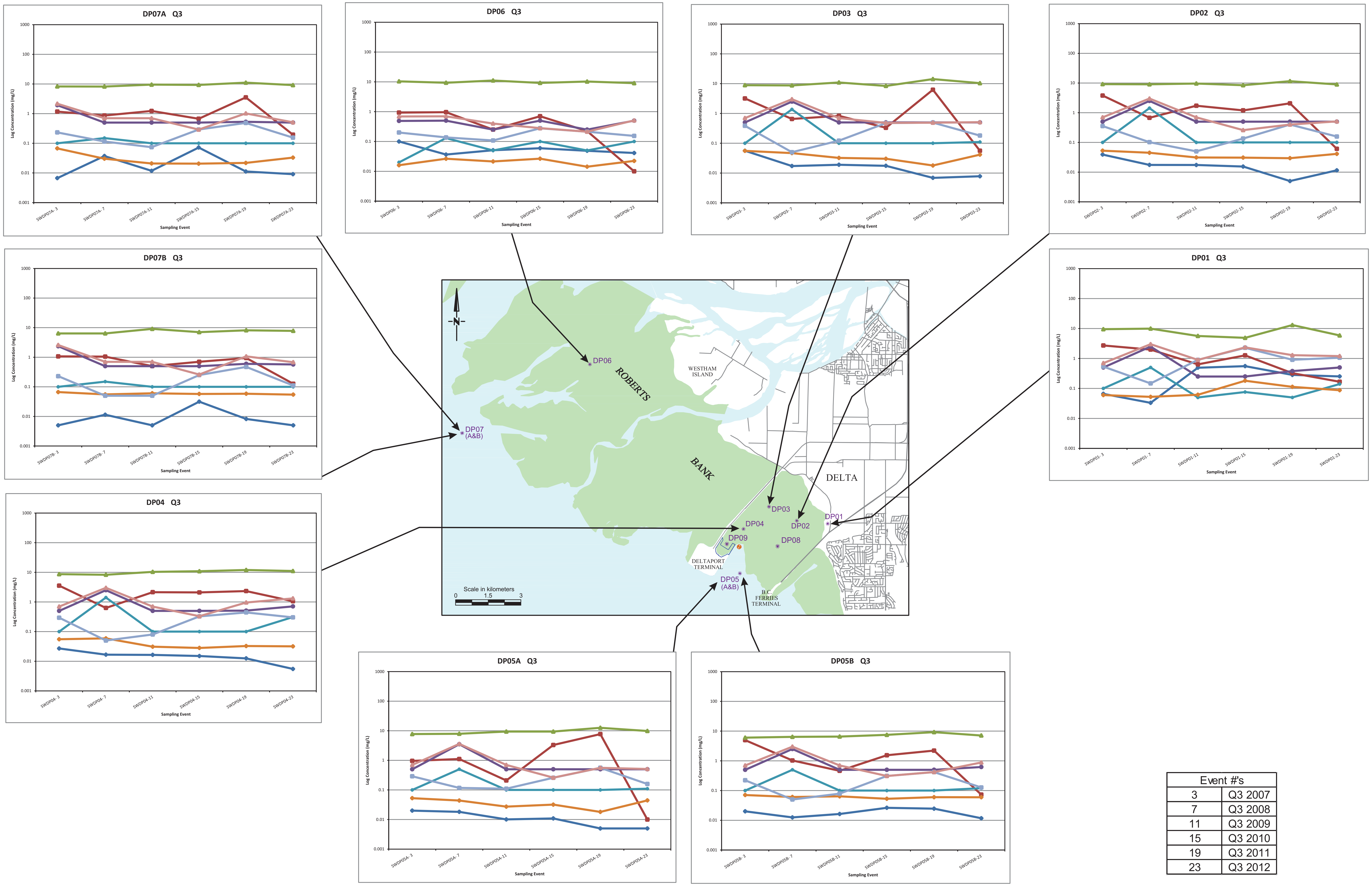
HEMMERA

CLIENT: PORT METRO vancouver

DELTAPORT THIRD BERTH - ADAPTIVE MANAGEMENT STRATEGY PROGRAM - 2012 ANNUAL REPORT

TEMPORAL TRENDS OF EUTROPHICATION-RELATED PARAMETERS IN SURFACE WATER - Q2 2012

PROJECT No.		
499-002.19	August 2013	FIGURE 30-Q2



Event #'s	
3	Q3 2007
7	Q3 2008
11	Q3 2009
15	Q3 2010
19	Q3 2011
23	Q3 2012

LEGEND
Water
Tidal Mud & Sand
Water Quality Sampling Station
YSI Sonde

SDDP04-7
Event #
Station Location
Sample Type (SD=sediment)

NOTE: All measurements are in mg/kg

Chart Legend

- Surface Water / Ammonia
- Surface Water / Chlorophyll A
- Surface Water / Field Dissolved Oxygen
- Surface Water / Nitrate
- Surface Water / Nitrite
- Surface Water / Orthophosphate-Dissolved (as P)
- Surface Water / Total Kjeldahl Nitrogen
- Surface Water / Total Nitrogen

HEMMERA

CLIENT:
PORT METRO vancouver

DELTAPORT THIRD BERTH - ADAPTIVE MANAGEMENT STRATEGY PROGRAM - 2012 ANNUAL REPORT

TEMPORAL TRENDS OF EUTROPHICATION-RELATED PARAMETERS IN SURFACE WATER - Q3 2012

PROJECT No.	Date	Figure
499-002.19	August 2013	FIGURE 30-Q3

Event #'s	
4	Q4 2007
8	Q4 2008
12	Q4 2009
16	Q4 2010
20	Q4 2011
24	Q4 2012

LEGEND
Water
Tidal Mud & Sand
Water Quality Sampling Station
YSI Sonde

SDDP04-7
Event #
Station Location
Sample Type (SD=sediment)

NOTE: All measurements are in mg/kg

Chart Legend

- Surface Water / Ammonia
- Surface Water / Chlorophyll A
- Surface Water / Field Dissolved Oxygen
- Surface Water / Nitrate
- Surface Water / Nitrite
- Surface Water / Orthophosphate-Dissolved (as P)
- Surface Water / Total Kjeldahl Nitrogen
- Surface Water / Total Nitrogen

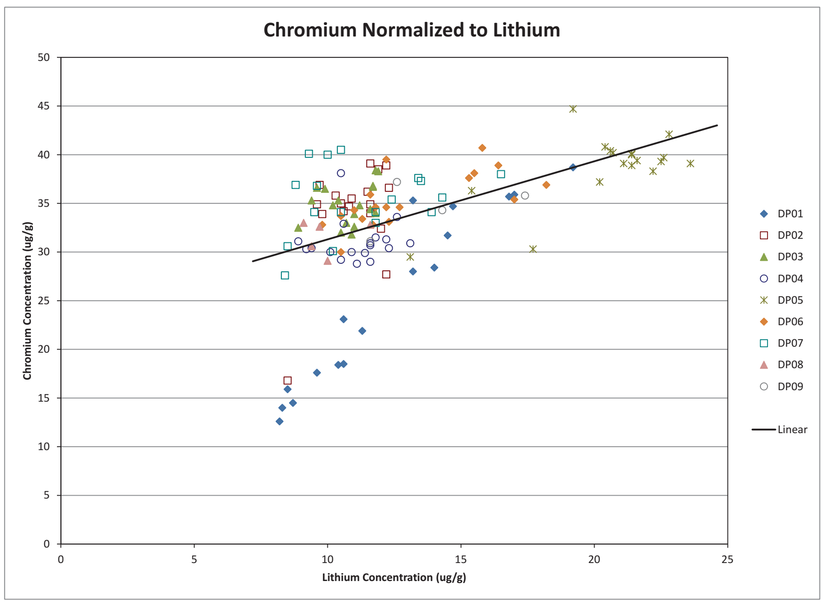
HEMMERA

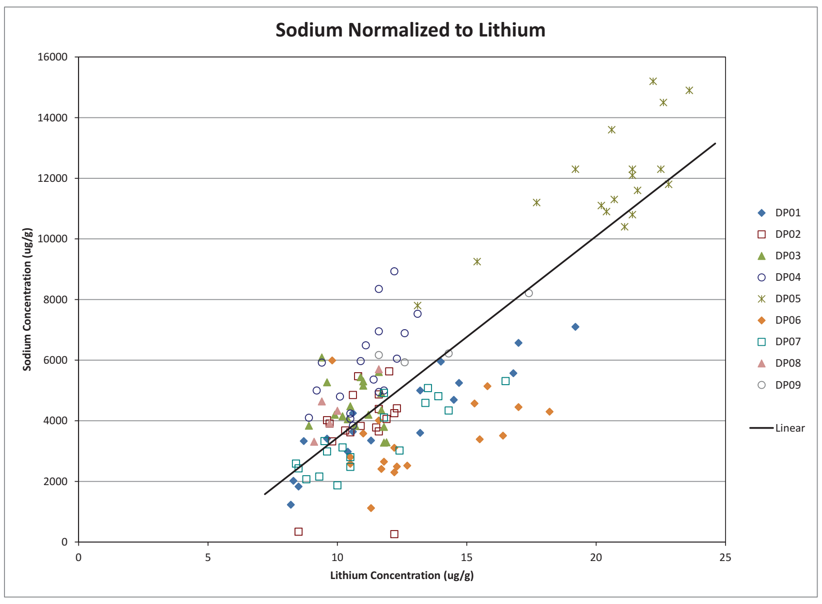
CLIENT: PORT METRO vancouver

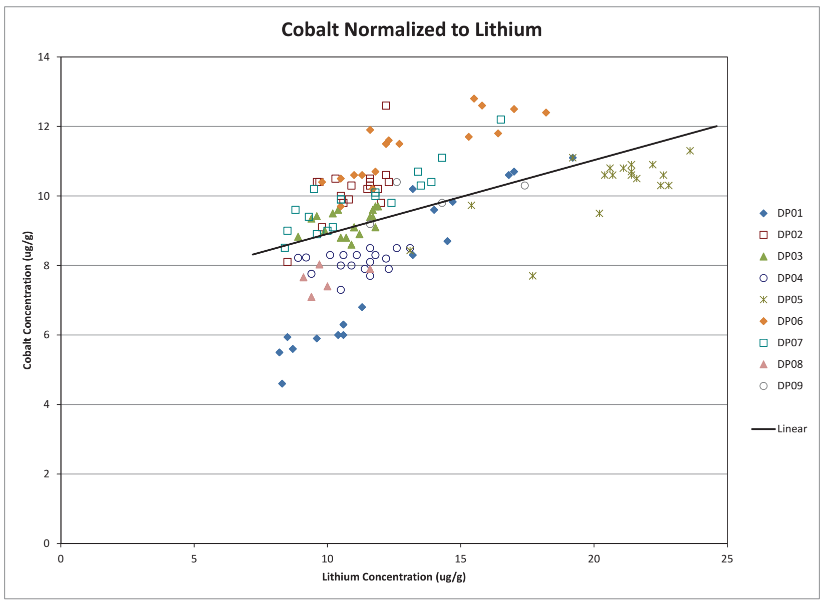
DELTAPORT THIRD BERTH - ADAPTIVE MANAGEMENT STRATEGY PROGRAM - 2012 ANNUAL REPORT

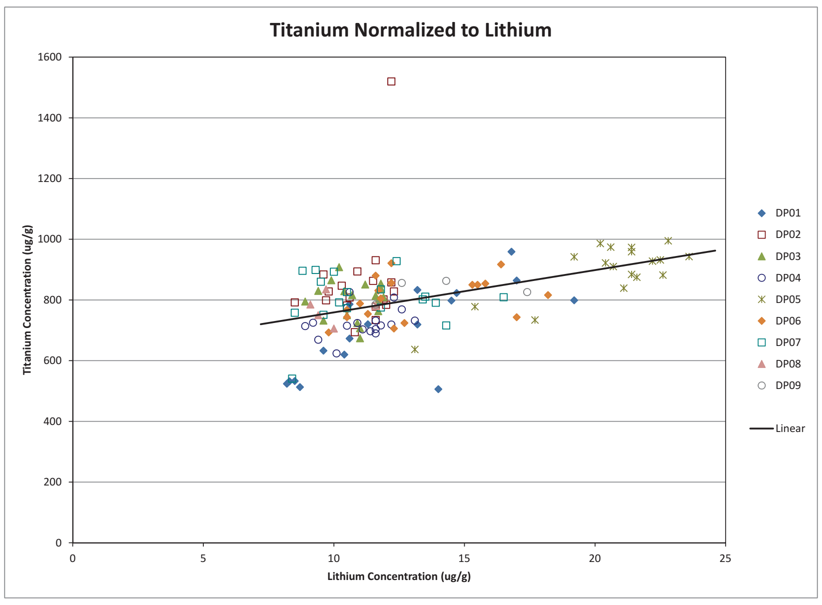
TEMPORAL TRENDS OF EUTROPHICATION-RELATED PARAMETERS IN SURFACE WATER - Q4 2012

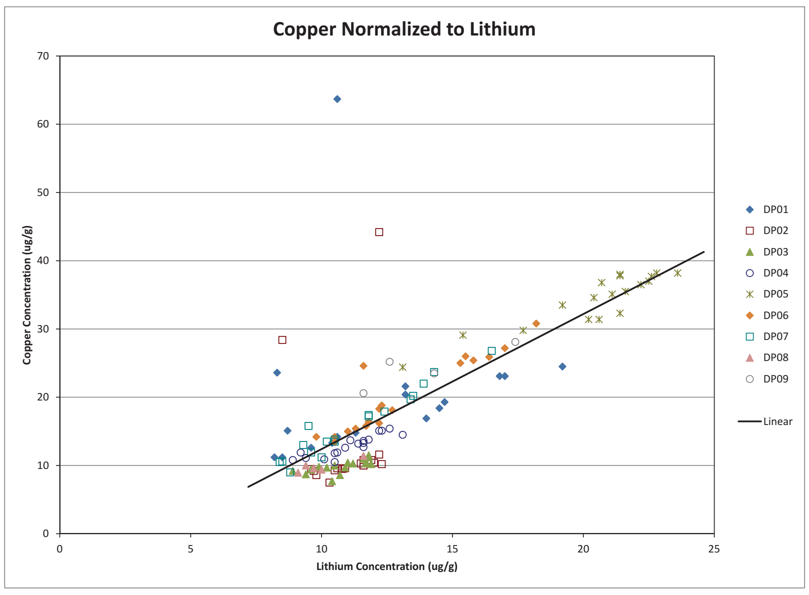
PROJECT No. 499-002.19 | August 2013 | FIGURE 30-Q4

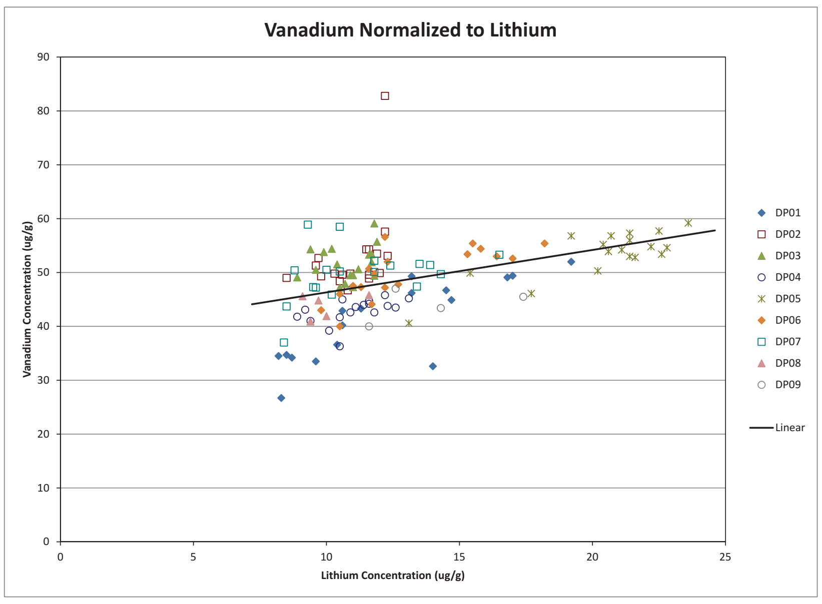


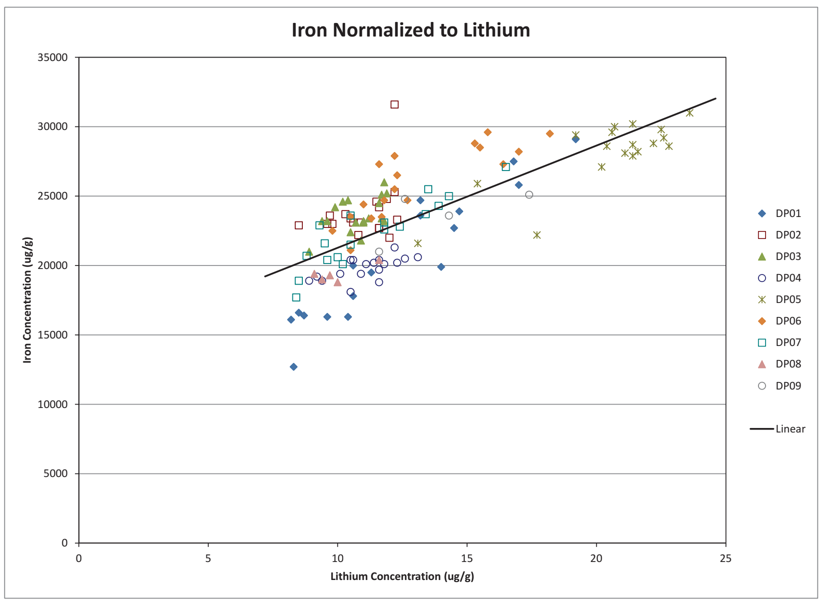


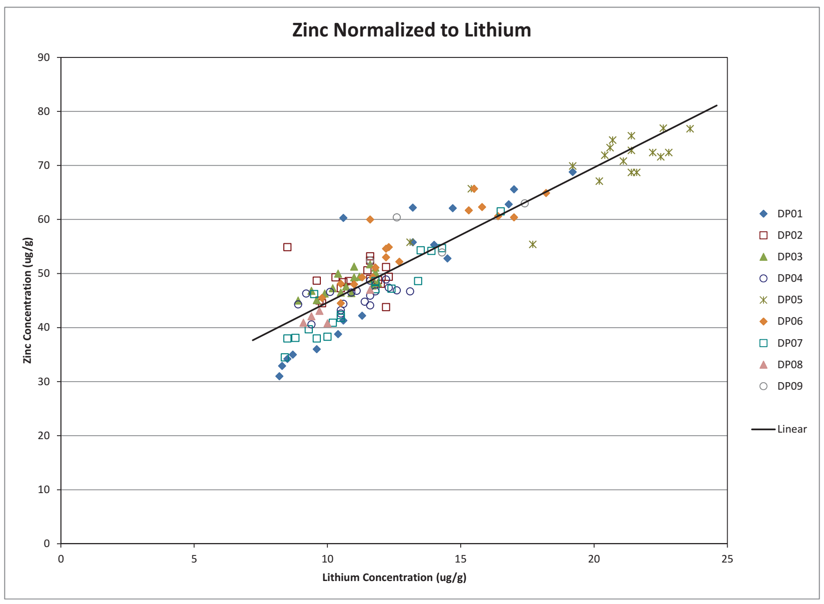












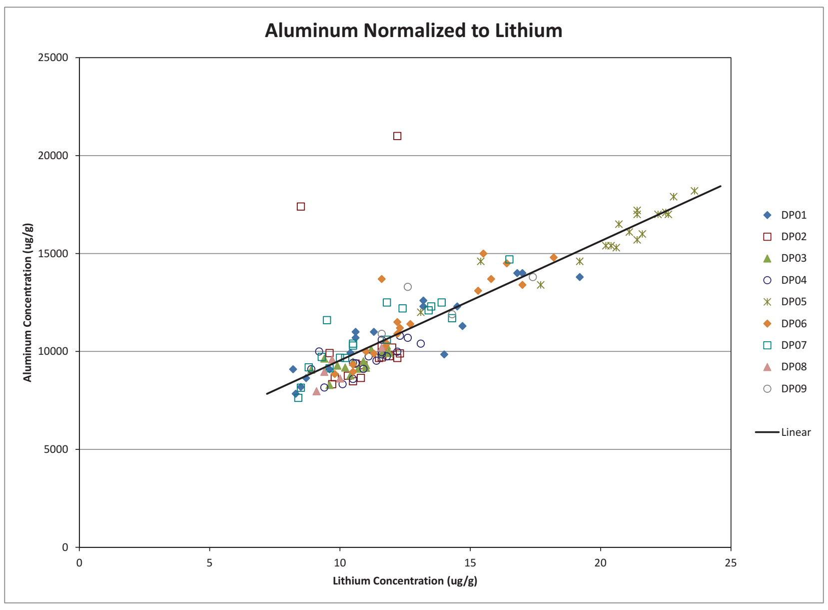
HEMMERA

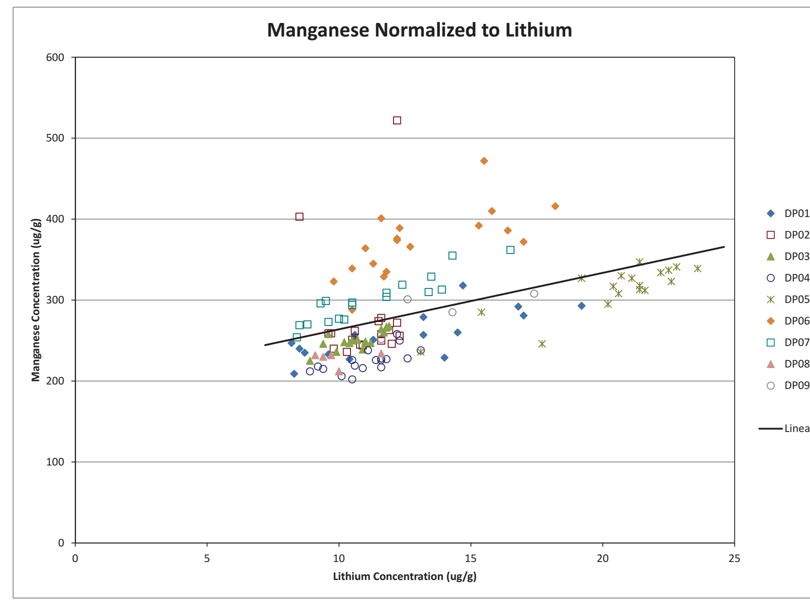
CLIENT: PORT METRO vancouver

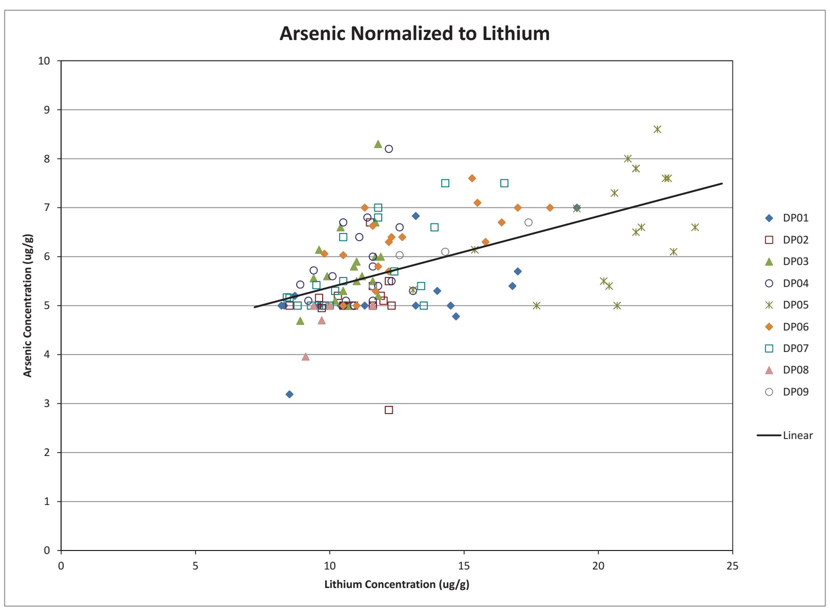
DELTAPORT THIRD BERTH - ADAPTIVE MANAGEMENT STRATEGY PROGRAM - 2012 ANNUAL REPORT

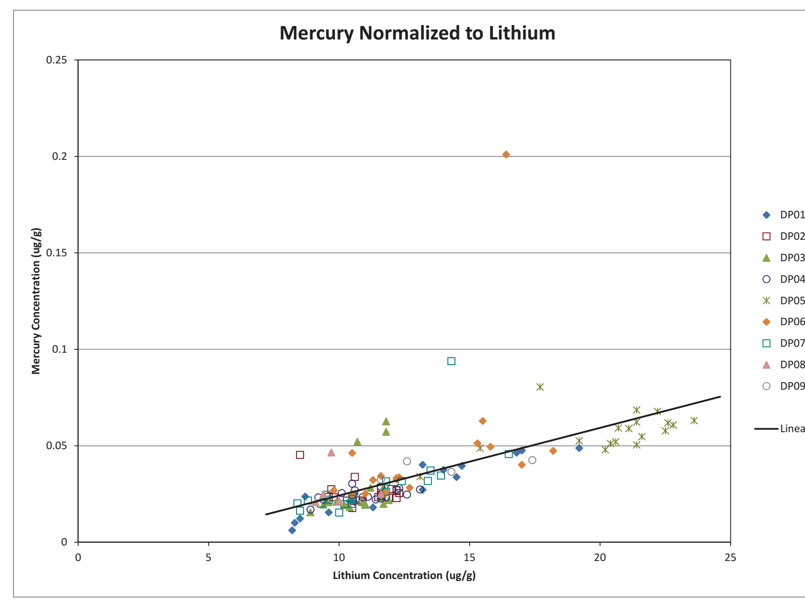
METAL CONCENTRATIONS IN SEDIMENT NORMALIZED TO LITHIUM BY STATION (ALL DATA)

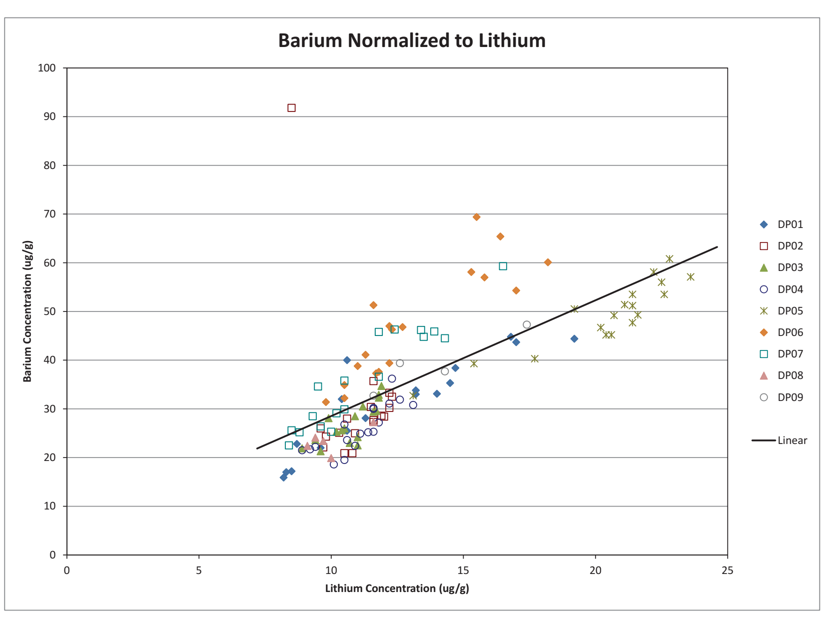
PROJECT No. 499-002.19	August 2013	FIGURE 31A

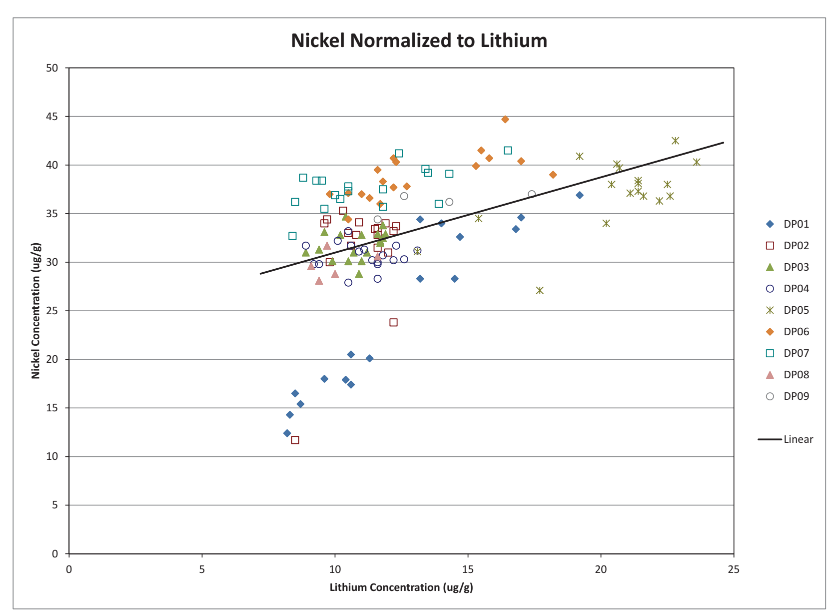


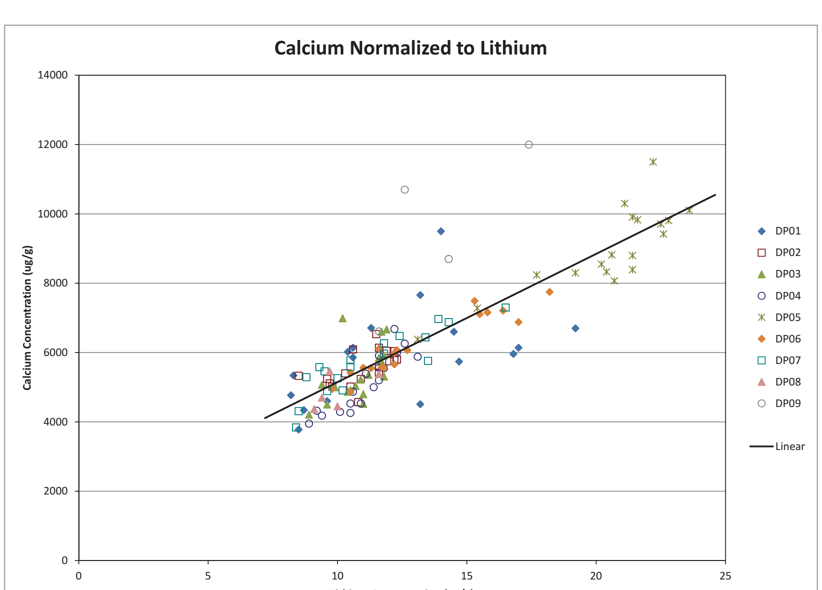


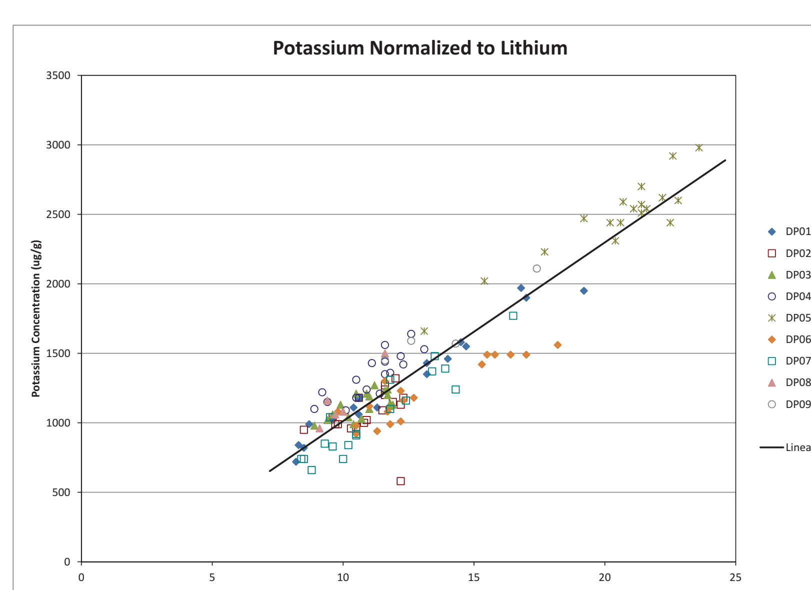












HEMMERA

CLIENT:

PORT METRO vancouver

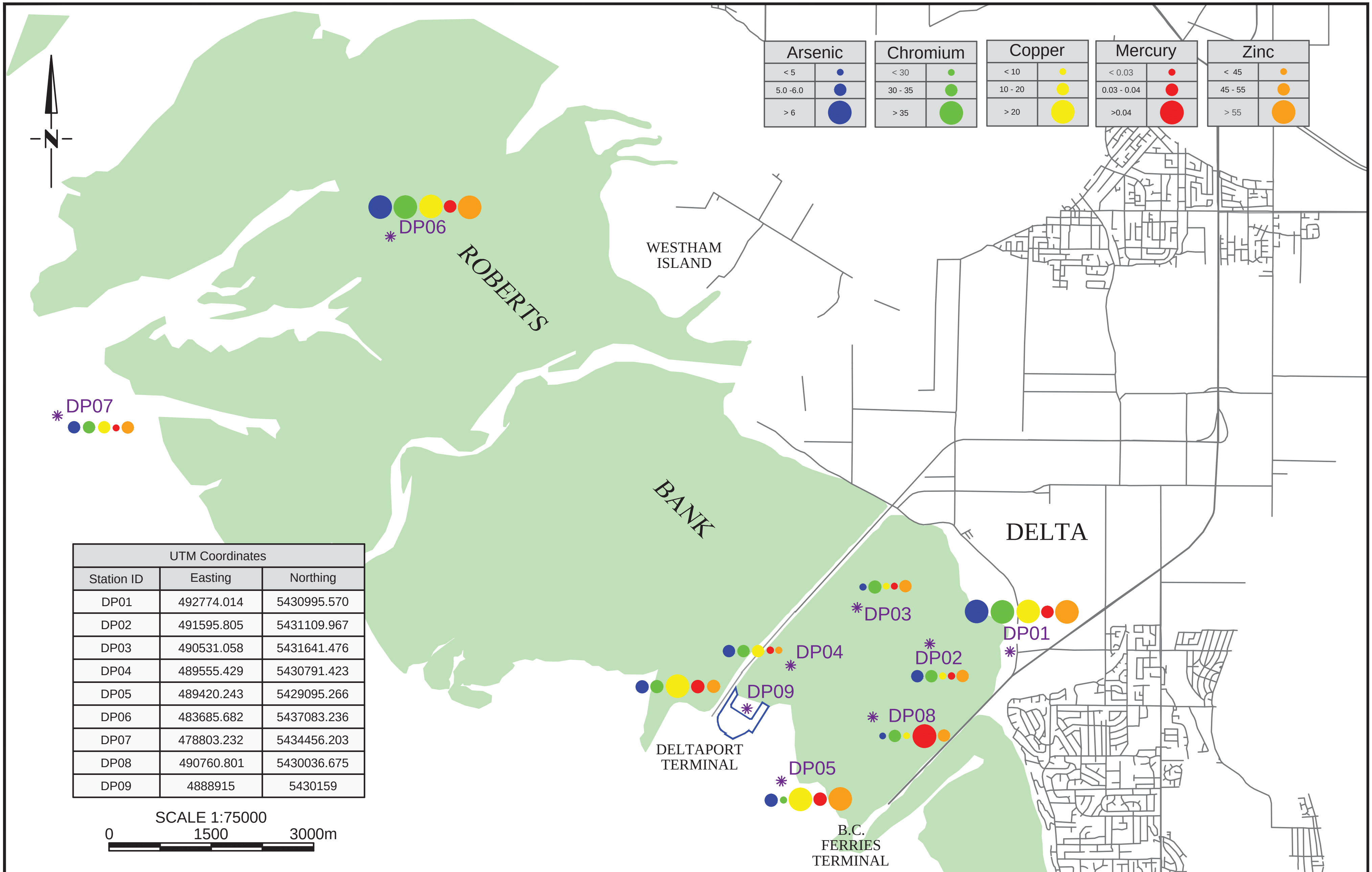
DELTAPORT THIRD BERTH - ADAPTIVE MANAGEMENT STRATEGY PROGRAM - 2012 ANNUAL REPORT

METAL CONCENTRATIONS IN SEDIMENT NORMALIZED TO LITHIUM BY STATION (ALL DATA)

PROJECT No. 499-002.19

August 2013

FIGURE 31B



UTM Coordinates		
Station ID	Easting	Northing
DP01	492774.014	5430995.570
DP02	491595.805	5431109.967
DP03	490531.058	5431641.476
DP04	489555.429	5430791.423
DP05	489420.243	5429095.266
DP06	483685.682	5437083.236
DP07	478803.232	5434456.203
DP08	490760.801	5430036.675
DP09	4888915	5430159

LEGEND
Water
Tidal Mud & Sand
Sampling Station
Note: Units for all parameters are µg/g, unless otherwise noted.

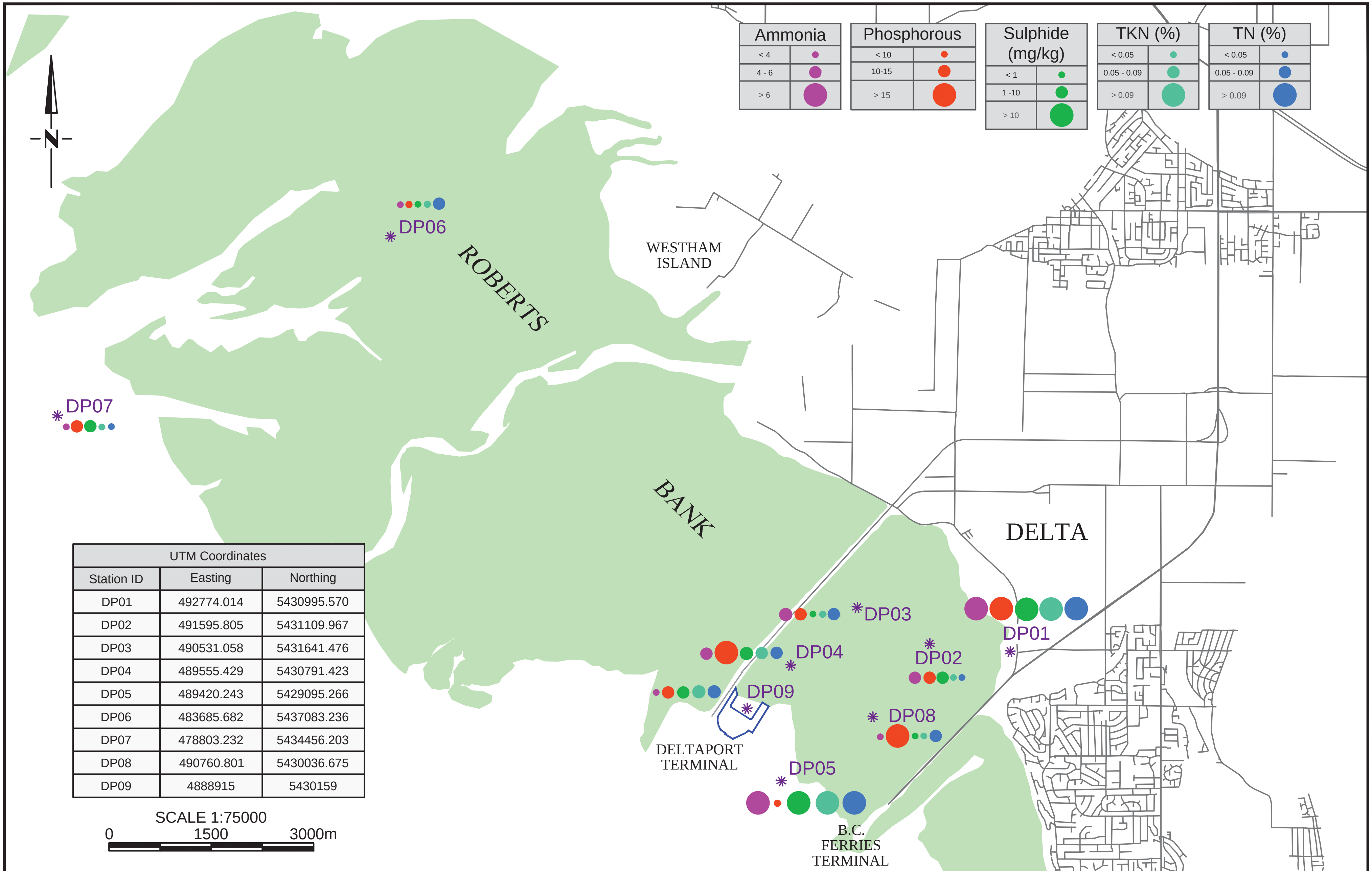
HEMMERA

CLIENT: Port Metro Vancouver

DELTAPORT THIRD BERTH - ADAPTIVE MANAGEMENT STRATEGY PROGRAM - 2012 ANNUAL REPORT

SPATIAL TRENDS OF METALS IN SEDIMENT (2012)

PROJECT No.		
499-002.19	August 2013	FIGURE 32



UTM Coordinates		
Station ID	Easting	Northing
DP01	492774.014	5430995.570
DP02	491595.805	5431109.967
DP03	490531.058	5431641.476
DP04	489555.429	5430791.423
DP05	489420.243	5429095.266
DP06	483685.682	5437083.236
DP07	478803.232	5434456.203
DP08	490760.801	5430036.675
DP09	4888915	5430159

LEGEND
Water
Tidal Mud & Sand
Sampling Station

Note: Units for all parameters are µg/g, unless otherwise noted.

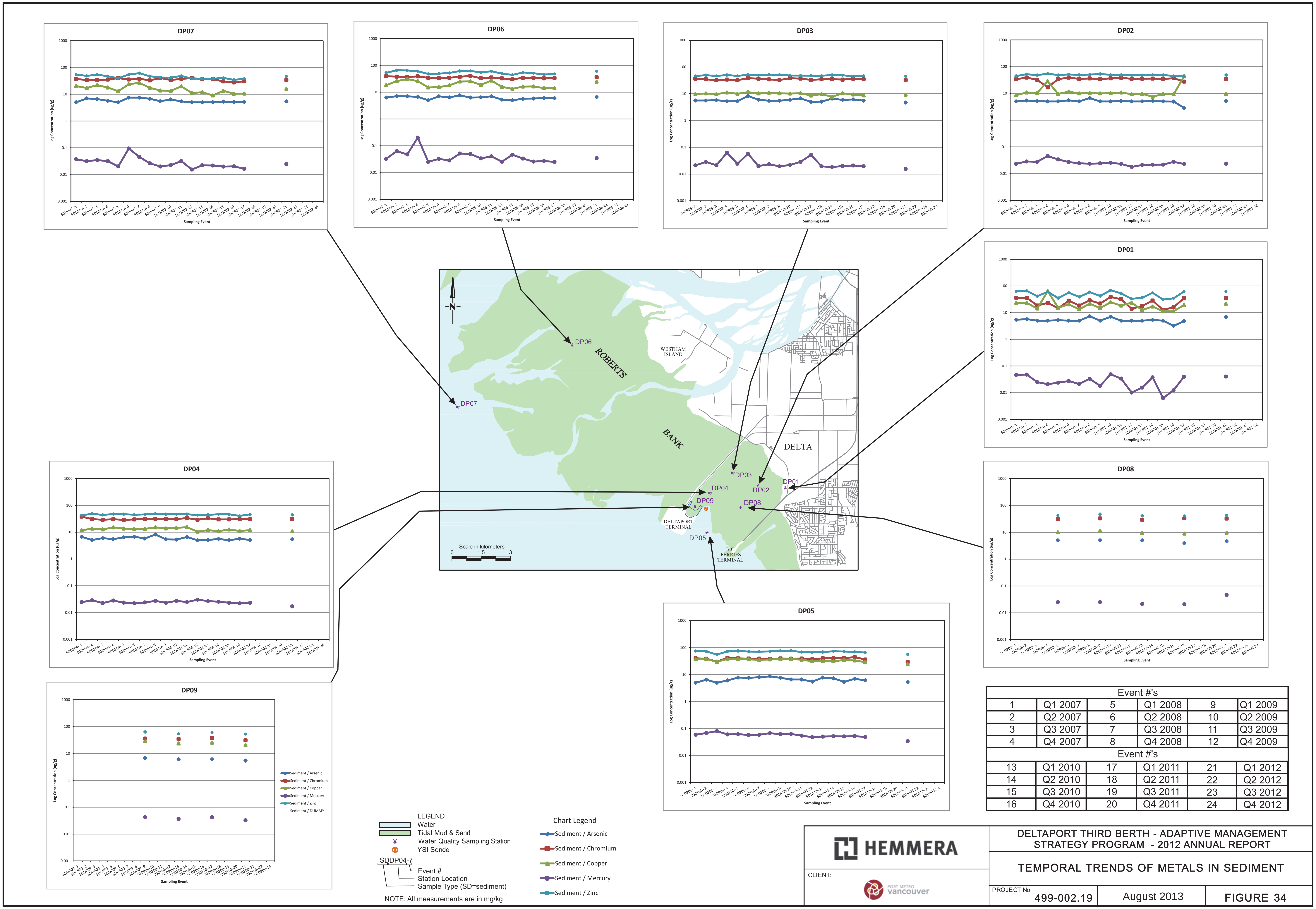
HEMMERA

CLIENT: PORT METRO vancouver

DELTAPORT THIRD BERTH - ADAPTIVE MANAGEMENT STRATEGY PROGRAM - 2013 ANNUAL REPORT

SPATIAL TRENDS OF EUTROPHICATION-RELATED PARAMETERS IN SEDIMENT (2012)

PROJECT No. 499-002.19	August 2013	FIGURE 33



Event #'s					
1	Q1 2007	5	Q1 2008	9	Q1 2009
2	Q2 2007	6	Q2 2008	10	Q2 2009
3	Q3 2007	7	Q3 2008	11	Q3 2009
4	Q4 2007	8	Q4 2008	12	Q4 2009

Event #'s					
13	Q1 2010	17	Q1 2011	21	Q1 2012
14	Q2 2010	18	Q2 2011	22	Q2 2012
15	Q3 2010	19	Q3 2011	23	Q3 2012
16	Q4 2010	20	Q4 2011	24	Q4 2012

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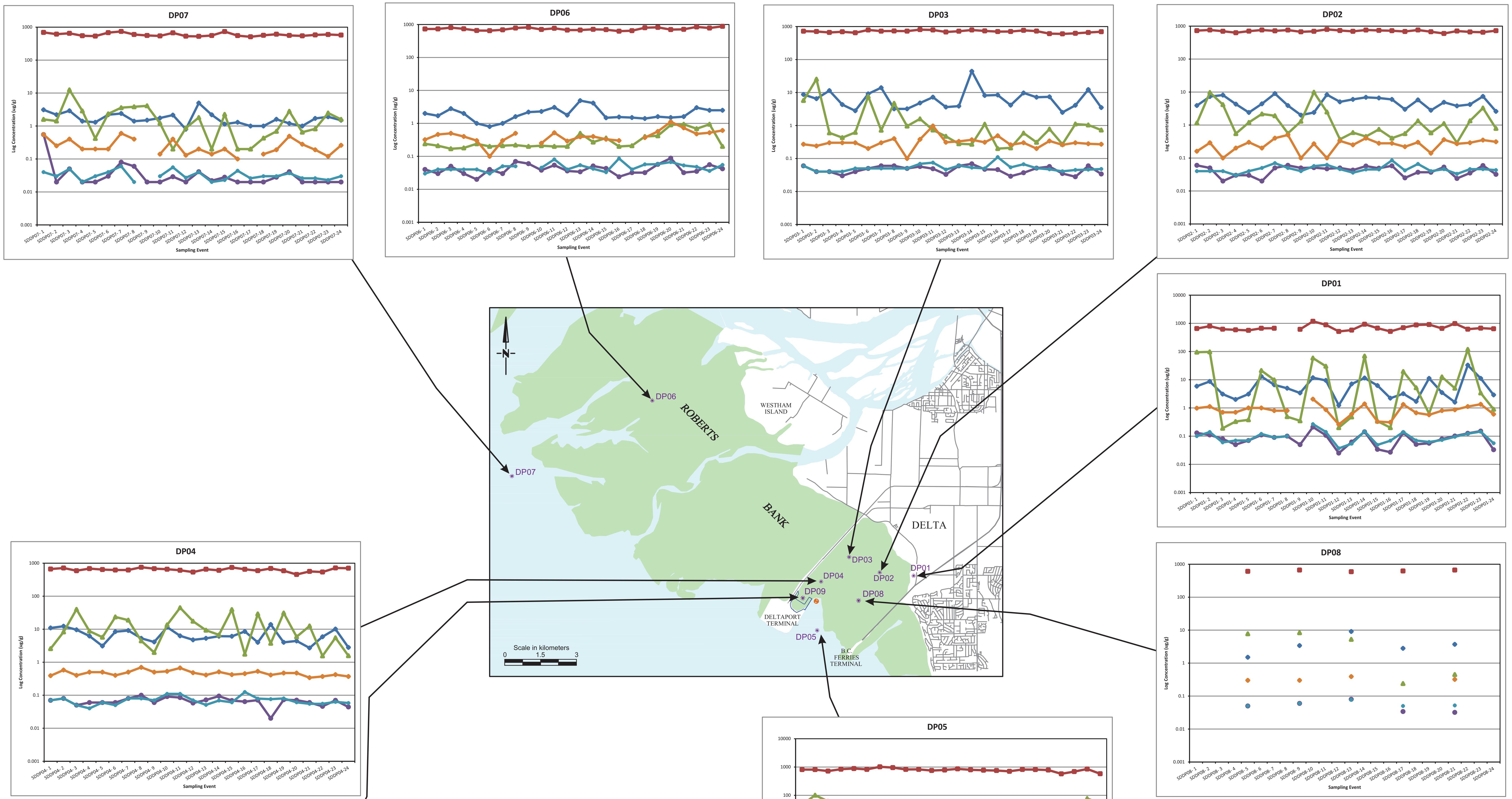
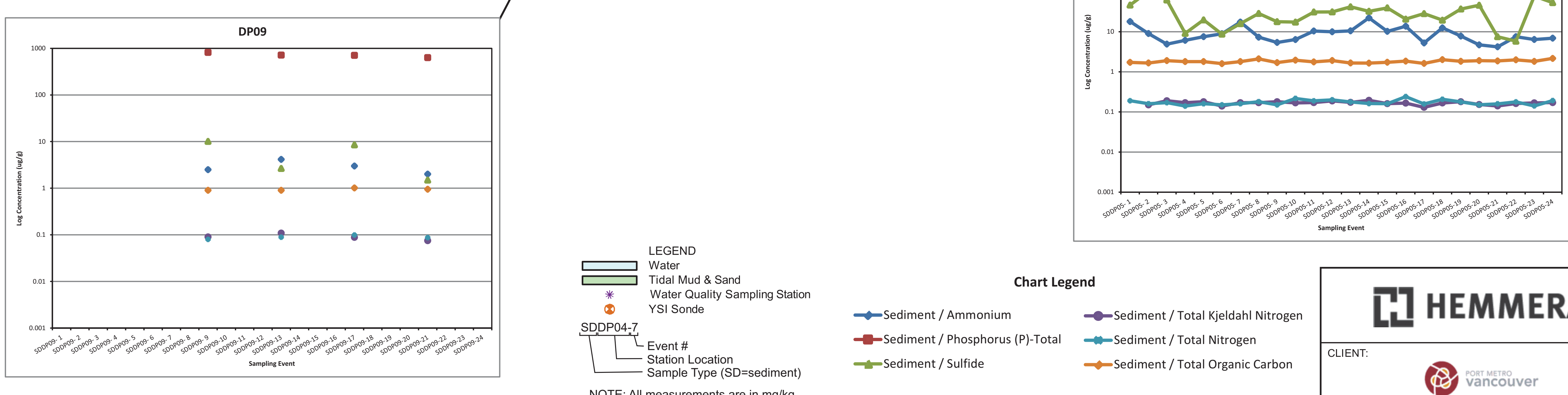
DELTAPORT THIRD BERTH - ADAPTIVE MANAGEMENT STRATEGY PROGRAM - 2012 ANNUAL REPORT

TEMPORAL TRENDS OF METALS IN SEDIMENT

PROJECT No. 499-002.19 | August 2013 | FIGURE 34





Event #'s					
1	Q1 2007	5	Q1 2008	9	Q1 2009
2	Q2 2007	6	Q2 2008	10	Q2 2009
3	Q3 2007	7	Q3 2008	11	Q3 2009
4	Q4 2007	8	Q4 2008	12	Q4 2009
Event #'s					
13	Q1 2010	17	Q1 2011	21	Q1 2012
14	Q2 2010	18	Q2 2011	22	Q2 2012
15	Q3 2010	19	Q3 2011	23	Q3 2012
16	Q4 2010	20	Q4 2011	24	Q4 2012

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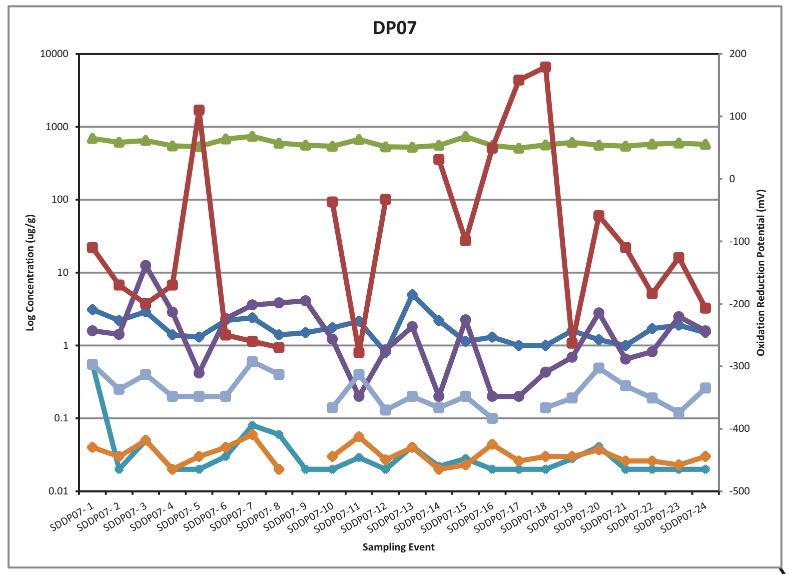
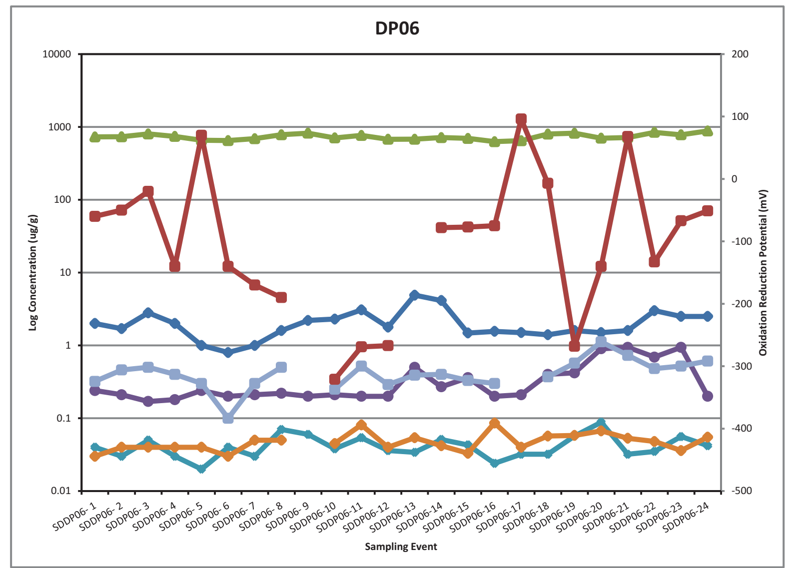
CLIENT: PORT METRO vancouver

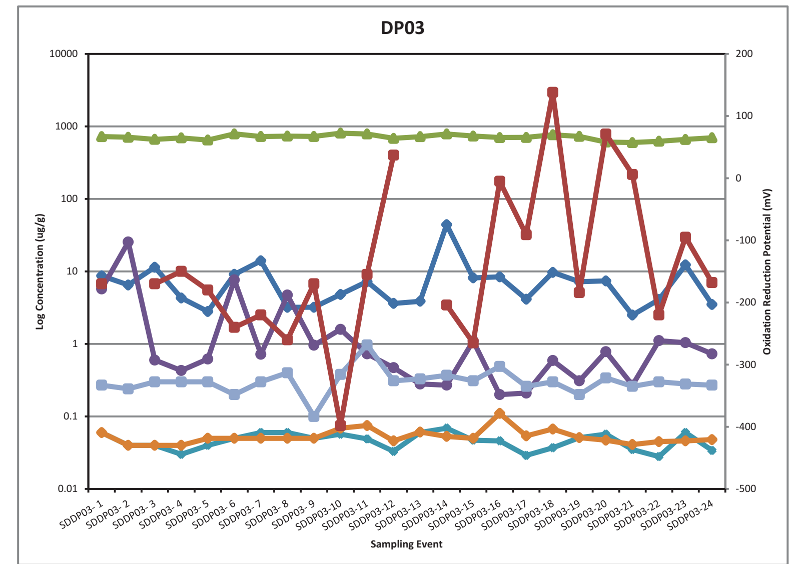
DELTAPORT THIRD BERTH - ADAPTIVE MANAGEMENT STRATEGY PROGRAM - 2012 ANNUAL REPORT

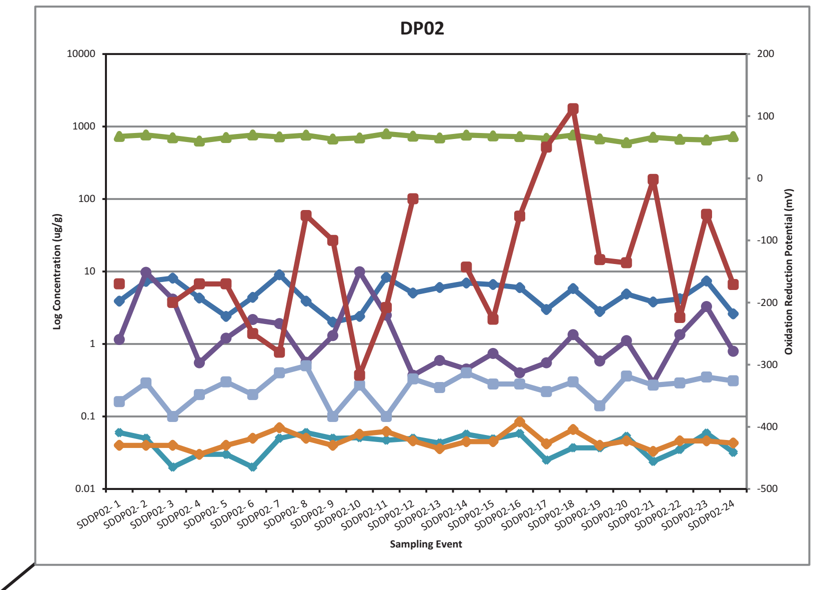
TEMPORAL TRENDS OF EUTROPHICATION-RELATED PARAMETERS IN SEDIMENT (ALL QUARTERS)

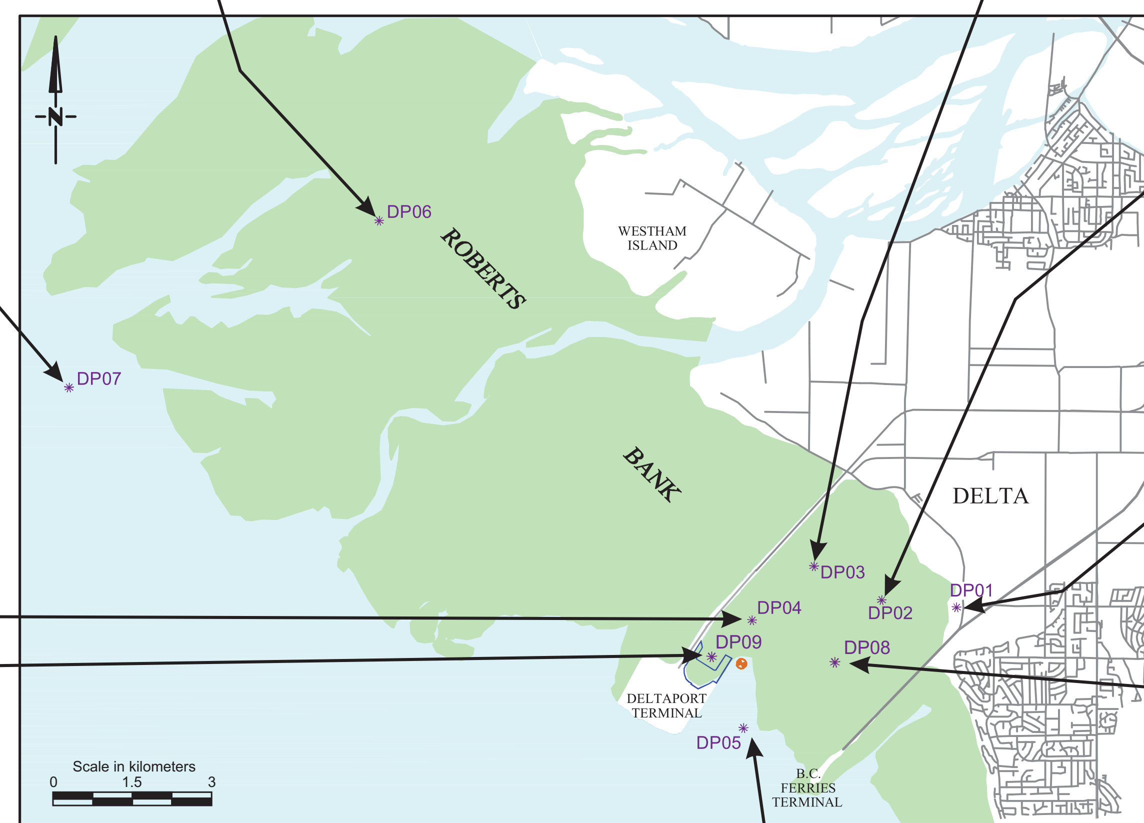
PROJECT No.		
499-002.19	August 2013	FIGURE 35A

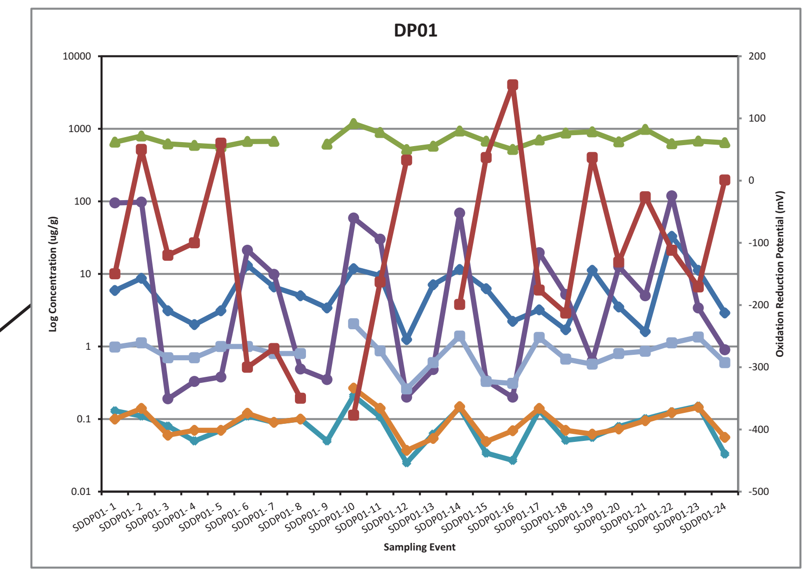


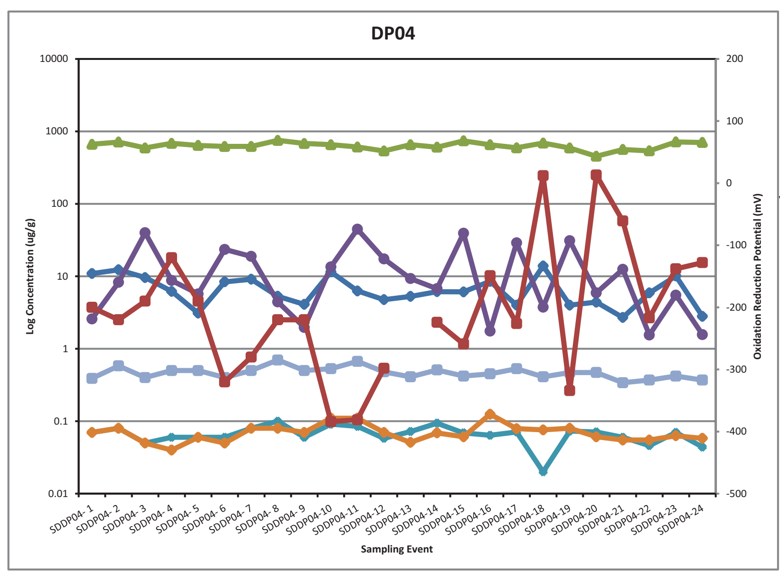


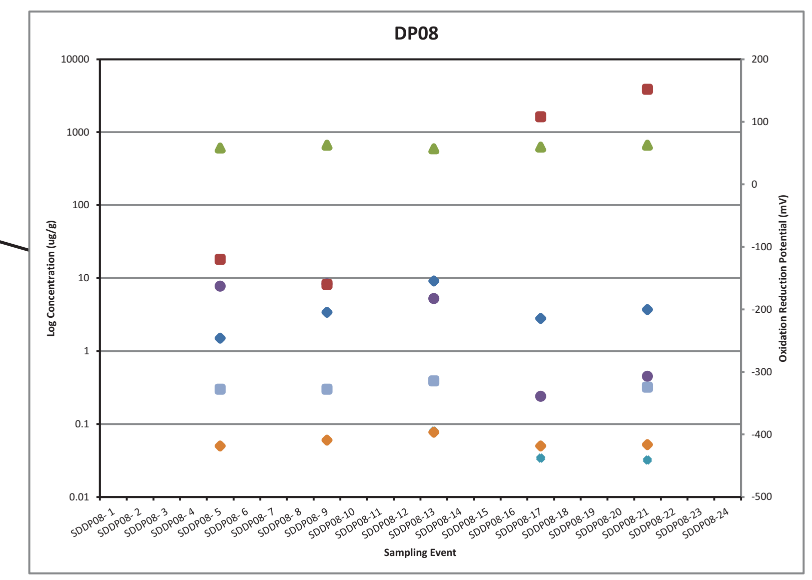


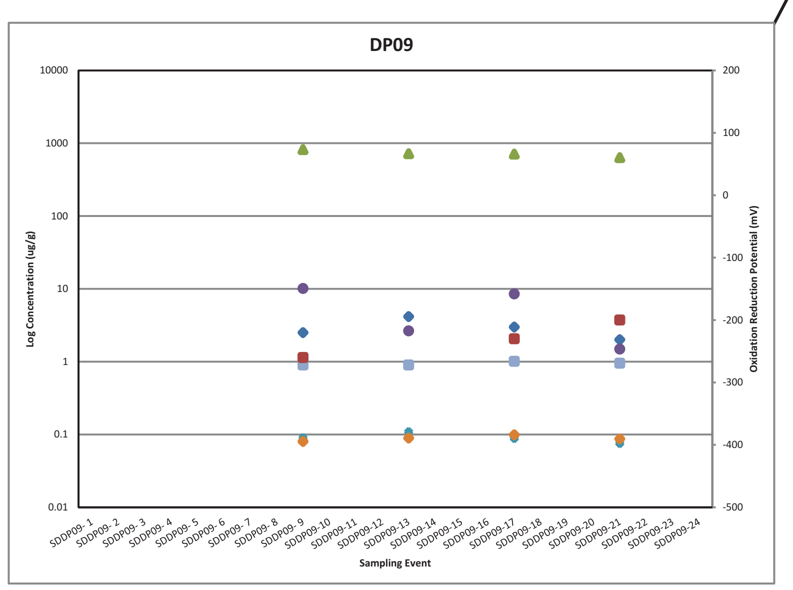


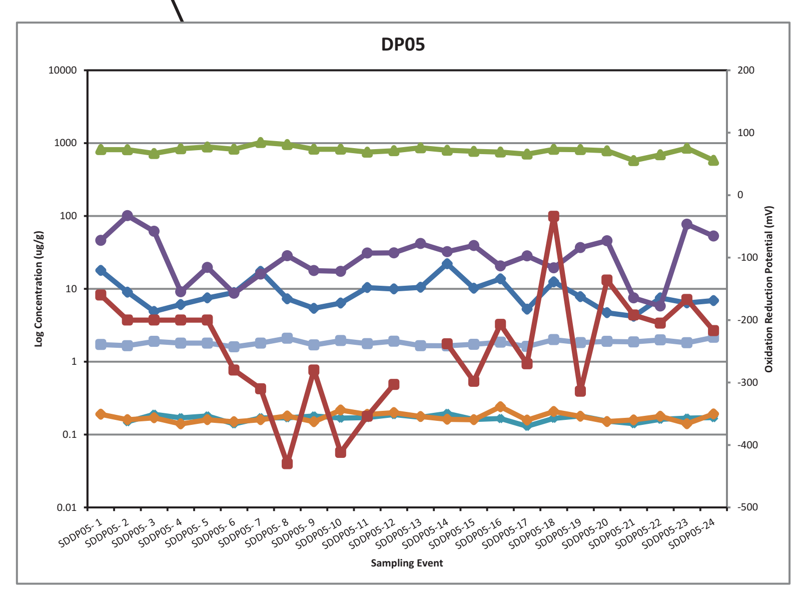












Event #'s					
1	Q1 2007	5	Q1 2008	9	Q1 2009
2	Q2 2007	6	Q2 2008	10	Q2 2009
3	Q3 2007	7	Q3 2008	11	Q3 2009
4	Q4 2007	8	Q4 2008	12	Q4 2009
Event #'s					
13	Q1 2010	17	Q1 2011	21	Q1 2012
14	Q2 2010	18	Q2 2011	22	Q2 2012
15	Q3 2010	19	Q3 2011	23	Q3 2012
16	Q4 2010	20	Q4 2011	24	Q4 2012

LEGEND
- Water
- Tidal Mud & Sand
- Water Quality Sampling Station
- YSI Sonde

SDDP04-7
- Event #
- Station Location
- Sample Type (SD=sediment)

NOTE: All measurements are in mg/kg

CHART LEGEND
- Sediment / Ammonium
- Sediment / Phosphorus (P)-Total
- Sediment / Sulfide
- Sediment / Total Kjeldahl Nitrogen
- Sediment / Total Nitrogen
- Sediment / Total Organic Carbon
- Sediment / Oxidation Reduction Potential

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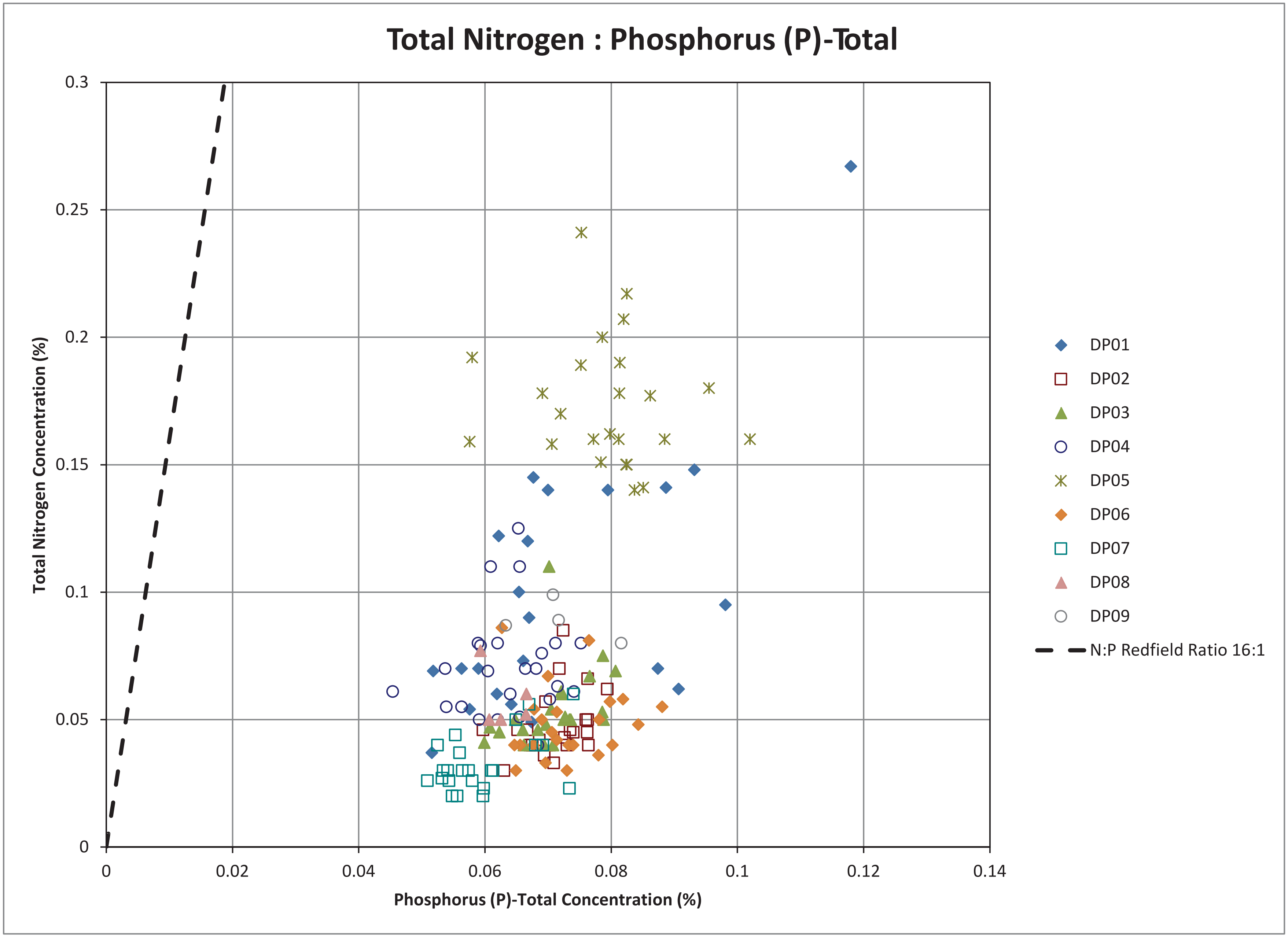
CLIENT: PORT METRO vancouver

DELTAPORT THIRD BERTH - ADAPTIVE MANAGEMENT STRATEGY PROGRAM - 2012 ANNUAL REPORT

TEMPORAL TRENDS OF EUTROPHICATION-RELATED PARAMETERS IN SEDIMENT (ALL QUARTERS)

PROJECT No. 499-002.19	August 2013	FIGURE 35B



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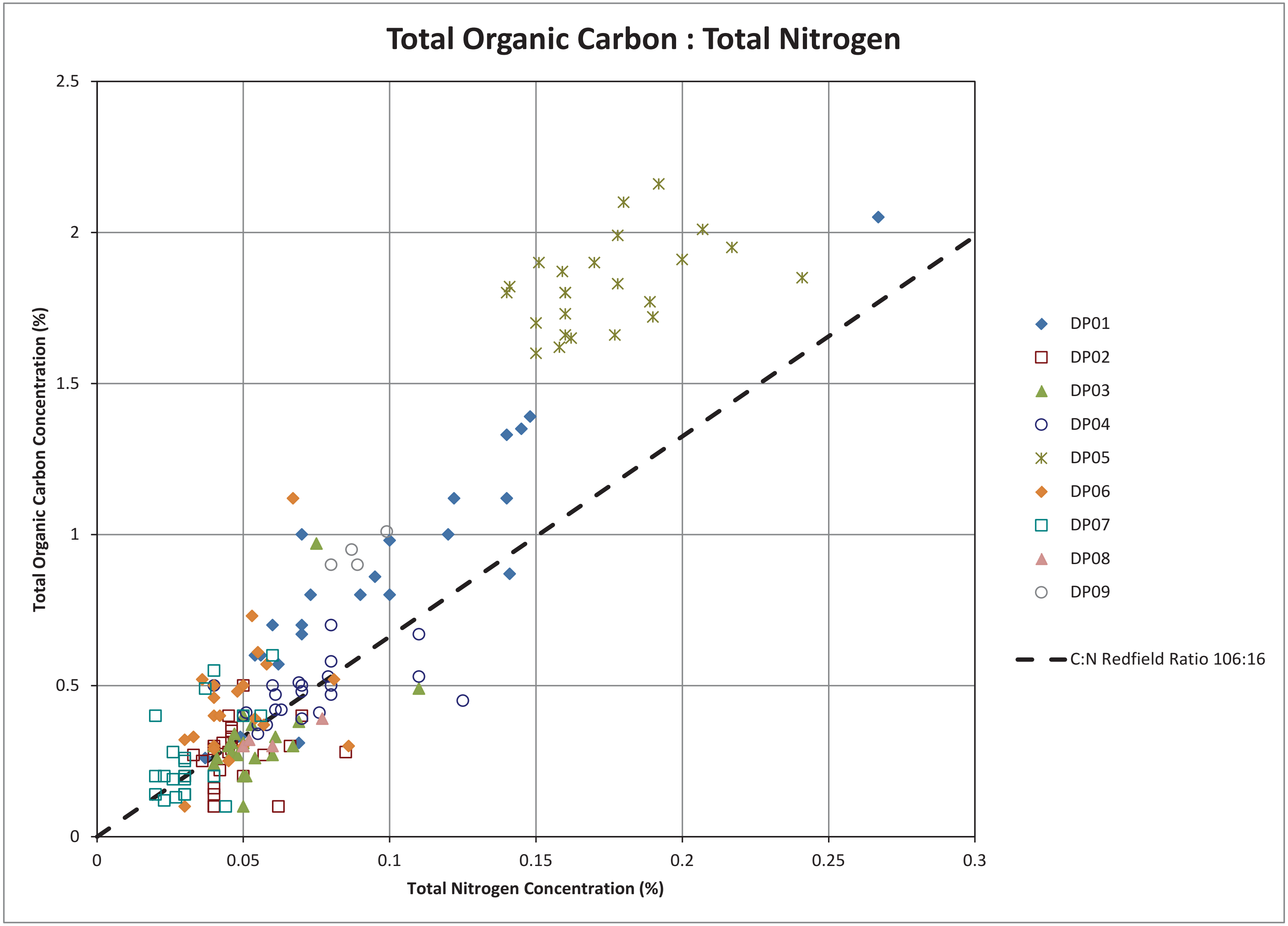
CLIENT:

PORT METRO vancouver

DELTAPORT THIRD BERTH - ADAPTIVE MANAGEMENT STRATEGY PROGRAM - 2012 ANNUAL REPORT

RATIO OF TOTAL NITROGEN TO TOTAL PHOSPHORUS IN SEDIMENT (2007 TO 2012)

PROJECT No. 499-002.19	August 2013	FIGURE 37



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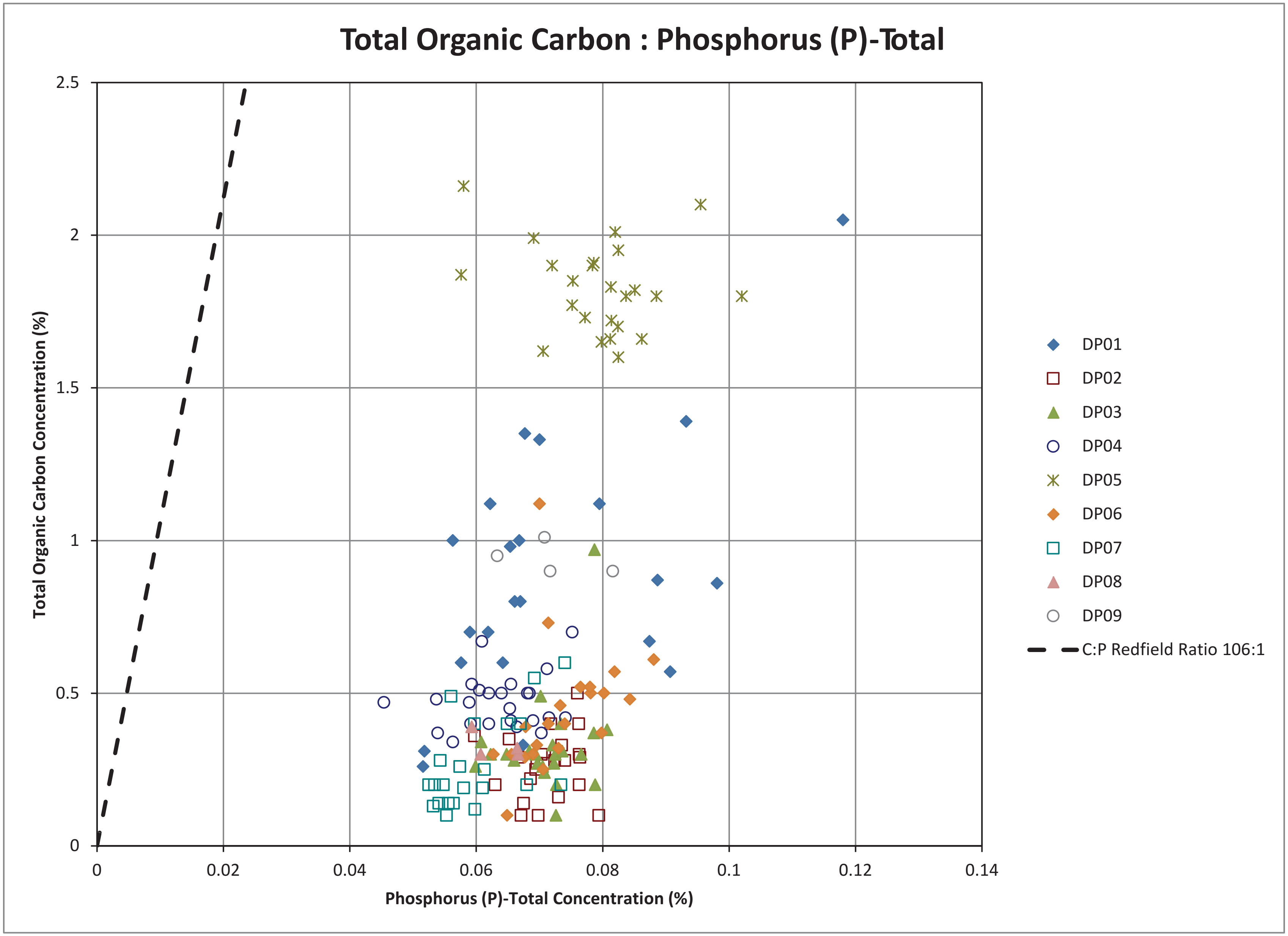
CLIENT:

PORT METRO vancouver

DELTAPORT THIRD BERTH - ADAPTIVE MANAGEMENT STRATEGY PROGRAM - 2012 ANNUAL REPORT

RATIO OF TOTAL ORGANIC CARBON TO TOTAL NITROGEN IN SEDIMENT (2007 TO 2012)

PROJECT No. 499-002.19	August 2013	FIGURE 38



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CLIENT:

PORT METRO vancouver

DELTAPORT THIRD BERTH - ADAPTIVE MANAGEMENT STRATEGY PROGRAM - 2012 ANNUAL REPORT

RATIO OF TOTAL ORGANIC CARBON TO TOTAL PHOSPHORUS IN SEDIMENT (2007 TO 2012)

PROJECT No. 499-002.19	August 2013	FIGURE 39

TABLES

Table 1: Monitoring Dates

Year	Quarter	Date	Monitoring Activity
2007	1	March 22 - 24	Sediment, Surface Water, and Benthic Invertebrate Sampling
		March 24 - 25	Bird Survey
		April 7 - 12	Bird Survey
		April 20	Install DoD Rods Sediment Samples Crest Protection Monitoring - photos only
		April 23 - 24	Bird Survey
	2	May 7 - 8	Bird Survey
		May 22 - 23	Bird Survey
		June 5 - 6	Bird Survey
		June 18 - 19	Bird Survey
		June 20 - 21	Sediment and Surface Water Quality Sampling
		July 3 - 4	Bird Survey
		July 12 - 16	Eelgrass Survey
		July 16 - 17	Bird Survey
		July 30	DoD Rods Crest Protection Monitoring - photos & surveys Turbidity Sensor Download Aerial Photographs
	3	July 30 - 31	Bird Survey
		August 17 - 18	Bird Survey
		August 30 - 31	Bird Survey
		September 14 - 15	Bird Survey
		October 1 - 2	Sediment and Surface Water Quality Sampling
		October 2	DoD Rods Sediment Samples Crest Protection Monitoring - surveys only
		October 2 - 3	Bird Survey
		October 18 - 20	Bird Survey
		October 29	Remaining DoD Rods Remaining Sediment Samples Turbidity Sensor Download
	4	November 1 - 4	Bird Survey
		November 15 - 16	Bird Survey
		November 27	DoD Rods Crest Protection Monitoring - no surveys (equipment failure) Turbidity Sensor Download - Sensor 2 only
		November 29 - 30	Bird Survey
		December 10	Sediment and Surface Water Quality Sampling
		December 15	Bird Survey
		December 28	Bird Survey

Table 1: Monitoring Dates

Year	Quarter	Date	Monitoring Activity
2008	1	January 11	Bird Survey
		January 21	DoD Rods Crest Protection Monitoring - surveys only Turbidity Sensor Download - Sensor 2 only
		January 23	Bird Survey
		February 8	Bird Survey
		February 22 - 25	Bird Survey
		March 3-5	Sediment, Surface Water, and Benthic Invertebrate Sampling
		March 10 - 12	Bird Survey
		March 27 - 29	Bird Survey
	2	April 9	DoD Rods Installation of 6 additional DoD Rods Sediment Samples Crest Protection Monitoring - photos & surveys Turbidity Sensor Download - Sensor 2 only Install Wave Sensors
		April 10 - 11	Bird Survey
		April 24 - 25	Bird Survey
		May 8 - 9	Bird Survey
		May 22 - 23	Bird Survey
		May 29 - 30	Sediment and Surface Water Quality Sampling
		June 23	Bird Survey
	3	July 3	DoD Rods Installation of 2 additional DoD Rods Crest Protection Monitoring - photos & surveys Turbidity Sensor Download - Sensor 2 only Aerial Photographs Wave Sensors Download
		July 22	Bird Survey
		August 14 - 17	Eelgrass Survey
		August 19	Bird Survey
		September 20 - 21	Bird Survey
		September 23 - 24	Sediment and Surface Water Quality Sampling
	4	October 14	Bird Survey
		October 17	DoD Rods Sediment Samples Turbidity Sensor Download - Sensor 2 only Wave Sensors Download - #1 & #2 only
		November 20	Bird Survey
		December 10	Sediment and Surface Water Quality Sampling
		December 17 - 20	Bird Survey

Table 1: Monitoring Dates

Year	Quarter	Date	Monitoring Activity
2009	1	February 7	DoD Rods Wave Sensors Download - #1 & #2 only
		March 5	Crest Protection Monitoring - surveys only Install replacement Turbidity Sensor Installed Wave Sensors - #1 & #3 only
		January 26	Bird Survey
		February 19	Bird Survey
		February 23 - 24	Sediment, Surface Water, and Benthic Invertebrate Sampling
		March 26 - 27	Bird Survey
	2	April 15 - 16	Bird Survey
		April 27	DoD Rods Sediment Samples Turbidity Sensor Download - Sensor 2 only Wave Sensors Download - #1 & #2 only
		May 4 - 7	Bird Survey
		May 20	Bird Survey
		May 20	Sediment and Surface Water Sampling
		May 20	Wave Sensors Download - #3 only
		May 26	Install replacement for Turbidity Sensor 2 (new design)
		June 12	Bird Survey
		June 23	Tidal Current Monitoring - collection of ADCP measurements
	3	July 17	Bird Survey
		July 20	DoD Rods Crest Protection Monitoring - photos & surveys Turbidity Sensor Download - Sensor 2 only Wave Sensors Download - #1 and #2 only Aerial Photographs
		August 14 - 17	Eelgrass Survey
		August 13	Bird Survey
		September 14	Bird Survey
		September 14 - 15	Sediment and Surface Water Quality Sampling
		September 15	Wave Sensors Download - #3 only
			Install replacement Wave Sensor #2
	4	October 8	Reprogram Wave Sensor #2
		October 17 - 18	Bird Survey
		November 3	DoD Rods Sediment Samples Turbidity Sensor Download - Sensor 2 only Wave Sensors - #1 & #2 only
		November 15	Bird Survey
		December 3	Sediment and Surface Water Quality Sampling
		December 13	Bird Survey

Table 1: Monitoring Dates

Year	Quarter	Date	Monitoring Activity
2010	1	January 17	Bird Survey
		January 23	Wave Sensor #3 - instrument not located
		January 28 - 30	DoD Rods Crest Protection Monitoring - surveys only Turbidity Sensor Download - Sensor #2 only Wave Sensors Download - #1 and #2 only
		February 17	Bird Survey
		March 8 - 9	Sediment, Surface Water, and Benthic Invertebrate Sampling
		March 16	Bird Survey
	2	April 5	Wave Sensor #1 removed Wave Sensor #3 reinstalled
		April 14	Bird Survey
		May 16 - 17	DoD Rods Sediment Samples Turbidity Sensor Download - Sensor #2 only Wave Sensors Downloaded - Sensors #1 and #2 only
		May 18 - 27	Topographic Surveys begin- 2 days
		June 7	Wave Sensor Download - Sensor #3 only
		June 7 - 8	Sediment and Surface Water Quality Sampling
		June 14 - 17	Bathymetric Surveys begin - 3 days
		June 15	Bird Survey
	3	July 9	Aerial Photographs
		July 9 - 12	Eelgrass Survey
		July 14	Bird Survey
		August 9	DoD Rods Crest Protection Monitoring - surveys and photos Turbidity Sensor Download - Sensor #2 only Wave Sensor Download - Sensor #2 only
		August 20	Bird Survey
		August 30 - 31	Sediment and Surface Water Quality Sampling
		August 31	Wave Sensor Removal - Sensors #2 and #3 Turbidity Sensor #2 Removal
	4	November 7 - 8	DoD Rods Sediment Samples
		December 2	Sediment and Surface Water Quality Sampling

Table 1: Monitoring Dates

Year	Quarter	Date	Monitoring Activity
2011	1	January 18	DoD Rods
			Crest Protection Monitoring - surveys only
		February 16	Bird Survey
		March 2 - 4	Sediment, Surface Water, and Benthic Invertebrate Samples
		March 6	Bird Survey
	2	April 13	Bird Survey
		April 19	DoD Rods
			Sediment Samples
		June 8 - 9	Sediment and Surface Water Quality Sampling
		June 20	Bird Survey
	3	July 13	DoD Rods
			Crest Protection Monitoring - surveys and photos
		July 19	Bird Survey
		July 28-August1	Eelgrass Survey
		August 11-12	Eelgrass Survey
		August 19	Bird Survey
		September 6 - 7	Sediment and Surface Water Quality Sampling
	4	October 29	DoD Rods
			Sediment Samples
		November 7 - 8	Sediment and Surface Water Quality Sampling
2012	1	February 20 & 21	Sediment and Surface Water Quality Sampling
	2	May 8	DoD Rods Decomissioning
			Sediment Grain Size Variability Investigation
		May 29	Sediment and Surface Water Quality Sampling
		June 15	Bird Survey
	3	July 16	Bird Survey
		July 29 - Aug 1	Eelgrass Survey
		August 13 & 15	Eelgrass Survey
		August 15	Bird Survey
		September 2	SIMS Survey
		September 5	Sediment and Surface Water Quality Sampling
	4	December 6 & 10	Sediment and Surface Water Quality Sampling

Table 2: Chronology of Adaptations to the Monitoring Programs

Activity & Sub-task	Date	Event	Description
Crest Protection Structure			
Photographs	April 19, 2007	Program Inception	Established initial photo points (CRST 01 to 14).
	July 30, 2007	Q2-2007	Establish additional photo monitoring point (CRST 15).
	July 3, 2008	Q3-2008	Last quarterly monitoring - switch to annual photos.
	January 2012	Discontinued	Discontinued annual photographs based on 6 years of monitoring results
Surveys	July 30, 2007	Q2-2007	Establish 5 monitoring cross sections.
	July 3, 2008	Q3-2008	Last quarterly monitoring - switch to bi-annual surveys (Q1 and Q3).
	January 2012	Discontinued	Discontinued bi-annual surveys based on 6 years of monitoring results
Turbidity Monitoring			
Sensors	June 14, 2007	Sensor Installation	Two sensors installed in study area.
	July 12, 2007	Move Sensor	Sensor 1 moved from tide channel to new location inside Crest Protection Structure.
	July 31, 2007	Replace Sensor	Sensor 2 malfunctioning so replaced with temporary instrument.
	Oct 30, 2007	Sensor Failure	Sensor 1 malfunctioning due to water penetration, replaced with temporary instrument.
	Mar 6, 2008	Sensor Failure	Temporary instrument failed due to water penetration, replaced with original repaired Sensor 1
	April 10, 2008	Sensor Failure	Original Sensor 1 instrument failed due to water penetration. Sensor 1 removed from site permanently.
	Feb 7, 2009	Sensor Missing	Sensor installation disturbed during abnormal weather event. Turbidity Sensor 2 missing. All data back to 17 Oct, 2008 lost with instrument.
	May 26, 2009	New Sensor Installed	Replacement for Sensor 2 installed. Re-start turbidity monitoring
	31 Aug, 2010	Sensor Removal	Completion of tubidity monitoring program.
Tide Gauge	June 14, 2007	Gauge Installation	Installation on caisson.
	Sept 6, 2007	Gauge Damaged	Gauge damaged and repaired, loss of some data.
	Oct 29, 2007	Gauge Damaged	Instrument dangling from rope, apparently tampered with.
	April 10, 2008	Gauge Damaged	Pipe housing missing.
	April 21, 2008	Gauge Repaired	Pipe housing replaced.
	July 3, 2008	Gauge Damaged	Pipe housing missing - instrument secured temporarily
	Oct 17, 2008	Gauge Damaged	Removed from site permanently. Rely on CHS gauge data.
Water Samples	May 17, 2007	Data Collection	Collection of water samples. Turbidity of samples very low.
	Nov 5, 2007	TSS Memo	NHC memo outlining methodology for relating turbidty to total suspended solids. Suspend collection of water samples.
Monitoring of Erosion and Deposition			
DoD Rods	April 19, 2007	Installation	Twenty-six rods installed.
	April 9, 2008	Installation	Additional six rods installed in area of new drainage channels
	July 3, 2008	Installation	Additional 2 rods installed in pond feature.
	January 2012	Discontinued	Decommissioned DoD rods and discontinued quartering monitoring based on 6 years of monitoring results
Sediment Samples			
Sediment Sampling	April 19, 2007	Program Inception	Samples collected at each DoD rod location on a bi-annual basis.
	January 2012	Discontinued	Discontinued bi-annual monitoring based on 6 years of monitoring results
Orthophotographic Interpretation			
Aerial Photos	July 14, 2007	Photos	Annual aerial photos of the study area flown commences (ongoing)
Coastal Geomorphology Mapping			
Bathymetric & Topographic Surveys	July 8, 2007	Surveys	Combined bathymetric and topographic surveys.
	July 13, 2007	Surveys	Topographic surveys, bathymetric surveys suspended due to rough seas.
	Nov 7, 2007	Surveys	Bathymetric surveys completed.
	May 18, 2010	Surveys	Topographic surveys
	May 19, 2010	Surveys	Topographic surveys
	Jun 14, 2010	Surveys	Bathymetric surveys begin.
	Jun 17, 2010	Surveys	Bathymetric surveys completed.

Table 2: Chronology of Adaptations to the Monitoring Programs

Activity & Sub-task	Date	Event	Description
Wave and Current Monitoring			
AWAC (work by ASL)	Feb 20, 2007	AWAC Deployed	
	April 20, 2007	AWAC Recovered	Found to have been dragged several hundred metres, pressure sensors not functioning.
	June 6, 2007	AWAC Re-Deployed	
	Sept 27, 2007	AWAC Damaged	Burial by temporary sediment placement. Recovered but damaged beyond repair.
NHC Wave Sensors	Jan 30, 2008	NHC Memo	Alternative strategy for current and wave monitoring
	April 10, 2008	Wave Sensors Installed	
	May 4, 2008	Sensor #3 Dragged	NHC contacted by Vancouver Pile and Dredge on June 19, instrument was dragged by tug boat operator.
	June 23, 2008	Sensor #3 Re-Deployed	
	Sept, 2008	Sensor #3 Removed	Sensor removed by DP3 construction worker to facilitate construction activity.
	Feb 7, 2009	Sensor #1 and #2 Dragged	Sensor #1 found to have been dragged approximately 200 metres. Sensor #2 found about 10-20 metres from original location.
	Mar 5, 2009	Sensor #3 Re-Deployment	
	April 27, 2009	Sensor #1 Removed	Sensor removed and sent to supplier for re-calibration after dragging episode.
	May 26, 2009	Sensor #1 Re-Deployed	
	July 20, 2009	Sensor #2 Removed	Sensor failed due to water penetration.
	Sep 15, 2009	New Sensor #2 Installed	
	Jan 28, 2010	Sensor #3 Missing	Instrument and data from Sep to Dec 2009 lost.
	28 Jan, 2010	Sensor #3 Missing	Instrument and data from Sep to Dec 2009 lost.
	5 Apr, 2010	Sensor location change	Sensor #1 removed. Sensor #3 reinstalled.
	31 Aug, 2010	Sensor Removal	Sensors #2 and #3 removed. Completion of wave monitoring program.
ADCP Tidal Current Measurements	June 23, 2009	Data Collection	ADCP measurments of tidal currents to verify results of NHC numerical modelling.
Sediment, Surface Water, and Benthic Invertebrate Sampling			
Quality Monitoring Program	June 20, 2007	Q2-2007	PAH and TBT dropped from sediment analytical program
			Dissolved iron added to surface water analytical program
	Dec 10, 2007	Q4-2007	Rush sulphide analysis implemented
	Mar 3, 2008	Q1-2008	Additional sampling station (DP08) added for benthic invertebrate sampling events
	Feb 23, 2009	Q1-2009	Additional sampling station (DP09) added for benthic invertebrate sampling events
	January 2009	Q1-2009	Implementation of Sonde deployment one week per quarter
	Mar 3 - 4, 2011	Q1-2011	Conducted benthic sampling in Q1 2011, instead of Q1 2012 (as per SAC comments Dec 2010)
	Mar 3 - 4, 2011	Q1-2011	Implementation of metals analysis for surface water and sediment samples only in Q1
	January 2012	Discontinued	Discontinuation of the weekly Sonde deployment
Bird Surveys			
Surveys	June 23, 2008	Q2-2008	Survey frequency reduced to monthly
			Distance categories changed to larger categories
			TFN transect discontinued
			Point count stations on TFN merged
	Nov 20, 2008	Q4-2008	Implementation of windshield surveys for focal species (great blue heron and brant)
	January 2012	Discontinued	Discontinuation of brant windshield surveys based on 6 years of monitoring data
Eelgrass Surveys			
Distribution Mapping Field Survey	Sept 7-8, 2007	Surveys	Annual surveys to ground-truth orthophoto interpretation commences (ongoing)
Eelgrass Health & Vigour	July 12-16, 2007	Surveys	Annual monitoring at nine reference stations commences
	July 19-23, 2009	Surveys	Annual monitoring at ten reference stations (ongoing)
SIMS Survey	August 25, 2009	Surveys	Triennial towed video survey to determine the lower limit of eelgrass distribution in the inter-causeway
SIMS Survey	September 2, 2012	Surveys	Triennial towed video survey to determine the lower limit of eelgrass distribution in the inter-causeway

Table 3: Rationale for Adaptations to the Adaptive Management Strategy

Change	Reason for Change	Reference
Dissolved iron analysis added for surface water	To determine if total iron exceedances were linked to particulate matter	Sec 2.2.2 (Q1-2007)
TBT not analyzed in sediment	No TBT source associated with DP3 construction, none detected in Q1-2007	Sec 1.3.1 (Q2-2007)
PAHs not analyzed in surface water	No PAH source associated with DP3 construction, none detected in Q1-2007	Sec 1.3.2 (Q2-2007)
Rush (24-hour) sulphide analysis implemented	To minimize sulphide volatilization	
Station DP08 added	To provided better spatial coverage in the inter-causeway area	Sec. 4.2 (2008 Annual report)
Station DP09 added	To evaluate the impact of new drainage channels in the inter-causeway area	Sec. 4.5 (2008 Annual report)
Addition of 8 new DoD rods	To provide greater resolution in area of new drainage channels & pond	Sec 4.1.1 (2007 Annual Report)
Removal of Turbidity Sensor 1	Turbidity levels not very high; harsh operating conditions; expensive repairs; redundancy with Turbidity Sensor 2	Sec 4.1.3 (2007 Annual Report)
Modifications to bird survey methodology	To increase the efficiency of data collection	Sec 4.6 (2007 Annual Report)
Reduction in Crest Protection surveys	Reduction to twice a year because measured very little change.	Sec 4.1.2 (2007 Annual Report)
Windshield surveys for Brant and Heron	To obtain a more accurate assessment of brant and heron numbers after reduction in point count stations at TFN and Tsawwassed Ferry transects	Sec 4.6 (2007 Annual Report)
Addition of 3 wave sensors	To replace destroyed AWAC and monitor wave height and wave period	NHC memo to VFPA of Jan 30, 2008
DP08 station added to benthic invertebrate sampling program	To provide better spatial coverage in the inter-causeway area	Sec 1.3.5 (Q1-2008)
Removal of Tide Gauge	Harsh operating conditions; developed relation between Point Atkinson station and local tide gauge	Sec 1.3.1.2 (Q3-2008)
Addition of an eelgrass reference station	Habitat changes at one of the established sites	Sec. 4.4 (2008 Annual report)
DP09 station added to benthic invertebrate sampling program	To provide better spatial coverage in the inter-causeway area	Sec 1.3.2 (2009 Annual Report)
Removal of Wave Sensors #2 and #3 and Turbidity Sensor	Completion of wave and turbidity monitoring program. DP3 not negatively affecting suspended sediment or wave heights.	Sec 4.1 (2009 Annual Report)
Wave Sensor #1 moved to location of Wave Sensor #3	Incoming wave heights more significant for determination of wave attenuation and overall wave climate.	Sec 2.2.7 (Q2-2010)
Conducted benthic sampling in Q1 2011, instead of Q1 2012	To have have a total of four years of annual benthic data (as per SAC comments Dec 2010)	Sec 5.5 (2010 Annual Report)
Conducted metals analysis of surface water and sediment in Q1 only beginning 2011	Metal concentrations to date did not exhibit a temporal trend and there is no evidence of metals loading as a result of DP3 construciton or operation	Sec 4.2 (2010 Annual Report)
Discontinued remaining field-based quarterly Coast Geomorphology monitoring program	No long-term physical changes have occurred on the tidal flats that could be attributed to the construction of DP3 (other than area of new drainage channels)	Sec 4.1 (2011 Annual Report)
Discontinue the benthic invertebrate program	No evidence of statistically significant temporal trends, or of spatial trends, that might be associated with the construction and operation of the DP3 project.	Sec 4.5 (2011 Annual Report)
Discontinued the Brant windshiled surveys	No project affects have been documented to affect Brant use of the inter-causeway;	Sec 4.6 (2011 Annual Report)

Table 4: Summary of Wind Speed and Direction January to March, 2012

Wind Speed (km/h)	N	NE	E	SE	S	SW	W	NW
0-5	6	11	17	14	9	4	5	8
5-10	34	32	230	70	30	30	45	34
10-15	4	34	342	67	42	20	33	52
15-20	4	11	177	54	41	13	27	28
20-25		6	61	45	26	13	17	11
25-30			60	39	27	20	23	16
30-35		1	24	11	15	7	14	8
35-40			11	7	3	2	7	4
40-45			2	2	3	2	18	
45-50			1	4			7	4
50-55				2			6	
55-60				2			4	
60-65				2			3	
65-70							2	1
Total	48	95	925	319	196	111	211	166

Note:

Total records =	2071	h
Total time winds calm =	113	h
Total observations =	2184	h

Hourly Wind Speed and Direction Recorded at Vancouver International Airport-January to March, 2012

Table 5: Summary of Wind Speed and Direction April to June, 2012

Wind Speed (km/h)	N	NE	E	SE	S	SW	W	NW
0-5	18	7	12	7	12	10	11	5
5-10	48	24	180	68	59	83	78	47
10-15	5	26	218	85	66	70	124	66
15-20	3	7	140	48	30	47	60	73
20-25			38	23	6	18	35	32
25-30	1		19	11	6	4	40	29
30-35			2	1		2	30	8
35-40			1			2	6	
40-45				1		1	4	
45-50							2	
50-55								
55-60								
60-65								
65-70								
Total	75	64	610	244	179	237	390	260

Note:

Total records =	2059	h
Total time winds calm =	125	h
Total observations =	2184	h

Hourly Wind Speed and Direction Recorded at Vancouver International Airport-April to June, 2012

Table 6: Summary of Wind Speed and Direction July to September, 2012

Wind Speed (km/h)	N	NE	E	SE	S	SW	W	NW
0-5	11	5	8	15	15	8	14	5
5-10	49	17	168	86	59	58	111	74
10-15	1	2	169	107	43	77	142	82
15-20			124	118	21	34	61	99
20-25			24	28		3	26	45
25-30			18	11	1	2	7	33
30-35							9	1
35-40							1	
40-45							1	
45-50								
50-55								
55-60								
60-65								
65-70								
Total	61	24	511	365	139	182	372	339

Note:

Total records =	1993	h
Total time winds calm =	215	h
Total observations =	2208	h

Hourly Wind Speed and Direction Recorded at Vancouver International Airport-July to September, 2012

Table 7: Summary of Wind Speed and Direction October to December, 2012

Wind Speed (km/h)	N	NE	E	SE	S	SW	W	NW
0-5	9	5	20	15	6	5	5	8
5-10	62	24	255	72	43	23	52	50
10-15	8	30	355	87	30	18	53	44
15-20	2	15	194	60	21	12	18	30
20-25		2	82	29	13	10	7	12
25-30			69	33	14	6	2	15
30-35			26	17	10	1	9	7
35-40			9	2	1		6	3
40-45			1	1			4	2
45-50				1			5	1
50-55							2	
55-60							1	
60-65							1	
65-70								
Total	81	76	1011	317	138	75	165	172

Note:

Total records =	2035	h
Total time winds calm =	173	h
Total observations =	2208	h

Hourly Wind Speed and Direction Recorded at Vancouver International Airport-October to December, 2012

Table 8: Storm Events during 2012 Monitoring Period

Start Date	Start time	End Date	End time	Time at	Water Level	Water Level	Water Level	Wind Speed		Probability	Wind Direction		Hs	Tp
	(LST)		(LST)	Max Speed	at Start *m*	at End *m*	at Max *m*	Maximum *km/h*	Average *km/h*	of Exceedence *(%)*	at Max *10's deg*	Average *10's deg*	m	sec
09/01/2012	16:00	01/10/2012	5:00	1:00	4.09	3.93	0.94	67	44.8	0.02%	W	W	3.25	7.19
14/01/2012	10:00	14/01/2012	14:00	12:00	4.76	2.72	3.87	39	33.6	1.67%	W	W	2.01	6.05
21/01/2012	6:00	21/01/2012	11:00	7:00	5.09	3.99	4.84	39	33.5	1.67%	S	S	0.85	3.65
22/01/2012	7:00	22/01/2012	17:00	14:00	4.74	4.65	4.44	43	37.3	0.93%	E	E	1.01	4.12
26/01/2012	5:00	26/01/2012	8:00	5:00	3.79	5.03	3.79	46	38.8	0.61%	W	W	1.34	4.65
22/02/2012	21:00	23/02/2012	7:00	23:00	2.66	4.37	1.51	52	40.9	0.24%	W	W	1.58	4.97
25/02/2012	4:00	26/02/2012	6:00	9:00	3.24	3.79	4.17	69	47.9	0.01%	W	W	3.25	7.16
28/02/2012	10:00	28/02/2012	19:00	17:00	3.88	2.65	1.88	48	35.6	0.46%	E	E	0.49	2.47
05/03/2012	8:00	05/03/2012	21:00	20:00	3.49	1.30	1.66	50	38.6	0.30%	NW	W	2.37	6.37
11/03/2012	21:00	12/03/2012	13:00	9:00	4.29	2.25	4.83	65	46.3	0.03%	SE	SE	2.43	5.98
14/03/2012	7:00	14/03/2012	12:00	9:00	4.12	3.62	4.52	39	34.0	1.67%	E	E	0.43	2.37
15/03/2012	14:00	15/03/2012	18:00	17:00	3.03	1.61	1.69	37	33.0	2.40%	SW	S	0.79	3.54
19/03/2012	22:00	20/03/2012	4:00	1:00	1.76	4.86	3.20	39	34.0	1.67%	E	SE	0.91	3.87
28/03/2012	12:00	29/03/2012	7:00	2:00	2.74	4.29	4.00	50	34.7	0.30%	SE	SE	1.67	5.13
01/04/2012	3:00	01/04/2012	6:00	3:00	4.48	3.67	4.48	39	33.5	1.67%	W	W	1.36	4.93
09/05/2012	0:00	09/05/2012	10:00	2:00	3.63	2.55	3.28	48	40.5	0.46%	W	W	1.52	4.86
09/05/2012	16:00	10/05/2012	10:00	23:00	1.32	2.94	4.27	35	31.5	3.14%	W	W	1.04	4.21
16/05/2012	22:00	17/05/2012	11:00	10:00	3.04	1.72	1.48	39	33.6	1.67%	W	W	2.01	6.05
10/09/2012	0:00	10/09/2012	4:00	2:00	3.75	2.39	3.19	44	36.2	0.81%	W	W	1.16	4.35
01/10/2012	19:00	02/10/2012	12:00	23:00	3.96	2.61	1.67	61	42.0	0.07%	W	W	2.33	6.41
16/10/2012	4:00	16/10/2012	7:00	6:00	4.02	4.60	4.75	46	40.0	0.61%	W	W	1.31	4.56
19/10/2012	0:00	19/10/2012	4:00	3:00	1.27	1.77	1.15	35	32.4	3.14%	S	SE	1.05	4.22
08/11/2012	11:00	08/11/2012	15:00	13:00	4.10	3.90	4.41	35	32.4	3.14%	NW	NW	1.93	5.93
18/11/2012	11:00	19/11/2012	2:00	1:00	4.82	1.68	2.14	48	35.8	0.46%	SE	SE	1.24	4.59
03/12/2012	23:00	04/12/2012	6:00	2:00	2.76	3.63	1.84	39	32.1	1.67%	E	E	0.40	2.30
07/12/2012	12:00	07/12/2012	22:00	14:00	4.77	2.71	4.12	48	36.7	0.46%	W	NW	2.42	6.60
15/12/2012	5:00	15/12/2012	14:00	12:00	3.79	3.59	3.65	37	33.4	2.40%	E	E	0.42	2.34
16/12/2012	16:00	17/12/2012	0:00	22:00	3.59	1.86	3.18	39	32.1	1.67%	E	E	0.36	2.15
17/12/2012	4:00	17/12/2012	9:00	8:00	2.30	5.40	5.25	50	41.3	0.30%	W	W	1.55	4.93
19/12/2012	2:00	19/12/2012	7:00	5:00	2.04	3.66	2.39	35	32.5	3.14%	E	E	0.39	2.28

Note 1: Water level data from Point Atkinson (Station #7795). Have previously shown strong correlation between PtAtkinson and local tide gauge.
Note 2: Wind data from Vancouver International Airport.
Note 3: Wave hindcasting performed at seaward end of Roberts Bank Causeway.
Note 4: Annual probability of exceedence for maximum hourly wind speed based on analysis of 1953 to 2006 hourly wind data from Vancouver International Airport.

Table 9: Summary of Quality Assurance/Quality Control Issues

Surface Water	
Q1 2012	Chloropyll A had an RPD in excess of the DQO at 29% BC Ministry of Environment DQO for organics in water is 30% and therefore the chlorophyll a data is considered valid.
Q2 2012	All RPDs below the DQO
Q3 2012	Chloropyll A had an RPD in excess of the DQO at 27% BC Ministry of Environment DQO for organics in water is 30% and therefore the chlorophyll a data is considered valid.
Q4 2012	Chloropyll A had an RPD in excess of the DQO at 33% The chlorophyll a data was within the range detected in the previous quarters and the data is considered valid.
Sediment	
Q1 2012	All RPDs below the DQO
Q2 2012	All RPDs below the DQO
Q3 2012	Oxidation Reduction Potentail slightly exceeded the DQO with an RPD of 23%.
Q4 2012	All RPDs below the DQO

Table 10: AMS Surface Water Chemistry Results

			Location ID:	DP01																							
			Sample ID:	SWDP01-1	SWDP01-2	SWDP01-3	SWDP01-4	SWDP01-5	SWDP01-6	SWDP01-7	SWDP01-8	SWDP01-9	SWDP01-10	SWDP01-11	SWDP01-12	SWDP01-13	SWDP01-14	SWDP01-15	SWDP01-16	SWDP01-17	SWDP01-18	SWDP01-19	SWDP01-20	SWDP01-21	SWDP01-22	SWDP01-23	SWDP01-24
			Date Sampled:	22/03/2007	20/06/2007	02/10/2007	10/12/2007	05/03/2008	30/05/2008	21/09/2008	27/11/2008	23/02/2009	20/05/2009	14/09/2009	03/12/2009	09/03/2010	08/06/2010	31/08/2010	02/12/2010	11/03/2011	08/06/2011	07/09/2011	08/11/2011	21/02/2012	29/05/2012	05/09/2012	10/12/2012
Parameter	***Nutrient Threshold*** [20]	**BCWQG MAL** [3,4]	**CCME MAL** [5,6]																								
Sample Info																											
Sample Depth, Below Water Surface (m)		-	-	0.3	-	0.5	0.5	0.5	0.4	0.5	0.3	0.3	0.3	0.3	0.1	0.5	0.5	0.2	0.3	0.5	0.2	0.1	0.2	0.1	0.5	0.25	0.1
Field Tests																											
Secchi Depth (m)		-	-	-	-	0.5	-	0.5	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Field Temperature (ºC)	-	-	-	7.93	-	12.4	2.73	8.14	14.8	14.8	4.4	7.58	17.73	16.95	5.48	-	-	15.47	5.55	7.5	16.31	20.8	6.93	5.97	-	19.15	5.5
Field pH	-	-	-	7.31	-	-	7.79	7.96	8.16	7.94	7.49	7.62	7.59	6.4	7.5	-	-	6.9	7.15	6.33	6.78	7.55	7.27	6.69	-	7.66	7.67
Field Conductivity (uS/cm)	-	-	-	6696	-	31208	23489	38716	11400	42835	24952	26011	9123	13321	31580	-	-	12460	26399	-	18826	10026	32999	3758	-	23840	34300
Field Dissolved Oxygen (mg/L)	6.02 [21]	-	-	11.26	-	9.48	16.67	10.56	6.14	9.92	9.7	10.63	8.42	5.64	10.69	-	-	4.88	9.83	9.73	8.07	13.05	10.83	11.14	-	5.88	9.97
Field Redox, Uncorrected (mV)	-	-	-	121.3	-	207	199	-16.6	82.1	-83	-292	-296.2	70.8	278	135.7	-	-	-3.9	167.3	140.7	319.4	278	163.6	125.5	-	222.1	197.5
Field Turbidity (NTU)	-	-	-	46.16	-	-	-	-	-	-	9.4	-	12	3	0.87	-	-	23.9	0.95	-	0.94	5.07	7.69	68.8	-	36.5	-
Physical Tests																											
Hardness, Total (CaCO3) (mg/L)	-	-	-	651	974	4740	-	3990	1460	5280	4500	4340	1160	1530	3330	-	-	1390	2780	526	-	-	-	471	-	-	-
Total Suspended Solids (mg/L)	-	-	-	22	27.2	43.7	21.5	22.2	35.9	20.7	14.4	-	24.5	11	23.8	20.7	18.7	35.3	73	203	41.1	7.6	28.2	81.3	30.6	237	49.5
Turbidity (NTU)	-	-	-	-	-	-	15.9	5.31	19.3	7.18	11.7	-	14.7	5.24	24.6	13.8	8.7	25.2	146	231	24.6	7.07	16.5	102	10.2	87.6	24.3
Dissolved Inorganics																											
Orthophosphate (as P) (mg/L)	0.087	-	-	0.0761	0.503	0.06	0.0245	0.0367	0.175	0.0524	0.057	0.0381	0.0839	0.0616	0.0345	0.0334	0.0845	0.181	0.0657	0.0522	0.0634	0.113	0.0598	0.0611	0.188	0.0873	0.0402
Phosphorus (P), Total Dissolved (mg/L)	0.087	-	-	0.147	0.485	0.0569	0.0276	0.0387	0.215	0.0562	0.0643	0.0605	0.0222	0.0696	0.0415	0.0344	0.184	0.177	0.0837	0.0701	0.0753	0.121	0.0635	0.0891	0.203	0.0943	0.0452
Inorganics																											
Ammonia (mg/L)	0.065	-	-	0.48	0.391	0.066	0.419	0.267	0.293	0.0331	0.287	0.122	0.613	0.492	0.221	0.24	0.127	0.555	0.318	0.227	0.33	0.283	0.256	0.196	0.174	0.252	0.232
Nitrate (mg/L)	5.23	-	16	0.595	1.99	<0.500	6.9	1.82	0.94	<2.500	26.6	<0.500	<0.250	<0.250	0.77	0.91	0.1	<0.250	0.94	0.51	<0.250	0.38	<0.500	0.46	<0.500	<0.500	0.56
Nitrite (mg/L)	0.978	-	-	0.024	0.094	<0.100	0.54	0.25	0.18	<0.500	<1.000	0.17	<0.050	<0.050	<0.100	<0.100	<0.020	0.076	<0.100	<0.020	<0.050	<0.050	<0.100	0.023	<0.100	0.14	<0.100
Silicon Dioxide (mg/L)	-	-	-	9.3	4.8	-	-	-	4.2	-	-	-	-	12.3	8.5	7.6	6.2	6.6	9.4	10.4	7.4	5.8	5.9	7.47	2.92	3.5	8.21
Total Inorganics																											
Chlorine (mg/L)	-	-	-	-	<0.200	<0.200	<0.200	<0.200	<0.100	<0.100	<0.100	<0.100	<0.100	-	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	-	<0.100	<0.100	<0.100	<0.100	<0.100
Phosphorus (P) (mg/L)	-	-	-	0.299	0.654	0.0948	0.203	0.0819	0.411	0.0802	0.103	0.0872	0.0951	0.102	0.177	0.132	0.305	0.309	0.531	0.921	0.273	0.184	0.123	0.522	0.292	0.427	0.188
Total Kjeldahl Nitrogen (mg/L)	0.434	-	-	1.61	0.879	0.535	1.24	0.628	1.05	0.147	0.852	0.508	2.12	0.898	0.762	0.726	1.05	2.27	2.11	3.41	1.58	0.905	0.538	1.89	0.874	1.06	0.763
Total Nitrogen (mg/L)	5.92	-	-	2.23	2.97	<0.700	8.7	2.7	<5.000	<3.000	27.5	<0.700	1.94	0.9	1.77	1.64	1.15	2.35	3.05	3.92	1.58	1.29	0.54	2.38	0.87	1.2	1.33
Organics																											
Organic Nitrogen (mg/L)	0.392	-	-	1.13	0.488	-	0.819	0.36	0.757	0.114	0.565	0.386	1.51	0.406	0.541	0.486	0.923	1.71	1.79	3.18	1.25	0.622	0.282	1.7	0.699	0.809	0.531
Microbiological Analysis																											
Chlorophyll A	5.11	-	-	4.84	3.15	2.72	1.65	1.7	8.1	1.98	4.32	0.769	7.58	0.636	1.45	4.83	7.4	1.27	4.08	10.3	4.58	0.323	0.895	5.73	2.15	0.167	0.31
Dissolved Metals																											
Iron	-	-	-	-	14	<300	10	<10	32	<10	25	12	52	56	23	53	<50	12.6	76	372	-	-	-	-	-	-	-

Table 10: AMS Surface Water Chemistry Results

Parameter	Nutrient Threshold [20]	BCWQG MAL [3,4]	CCME MAL [5,6]	SWDP01-1	SWDP01-2	SWDP01-3	SWDP01-4	SWDP01-5	SWDP01-6	SWDP01-7	SWDP01-8	SWDP01-9	SWDP01-10	SWDP01-11	SWDP01-12	SWDP01-13	SWDP01-14	SWDP01-15	SWDP01-16	SWDP01-17	SWDP01-18	SWDP01-19	SWDP01-20	SWDP01-21	SWDP01-22	SWDP01-23	SWDP01-24
			Location ID:	DP01																							
			Date Sampled:	22/03/2007	20/06/2007	02/10/2007	10/12/2007	05/03/2008	30/05/2008	21/09/2008	27/11/2008	23/02/2009	20/05/2009	14/09/2009	03/12/2009	09/03/2010	08/06/2010	31/08/2010	02/12/2010	11/03/2011	08/06/2011	07/09/2011	08/11/2011	21/02/2012	29/05/2012	05/09/2012	10/12/2012
Total Metals																											
Aluminum	-	-	-	674	<500	<500	388	110	150	<200	<300	<100	184	59	490	168	148	300	1720	8130	-	-	-	3250	-	-	-
Antimony	-	-	-	<2.0	<2	<10	<5	<10	<10	<10	<10	<10	<2	<5	<10	<0.5	<0.5	<0.5	<0.5	<0.5	-	-	-	0.347	-	-	-
Arsenic	-	12.5 [17]	12.5	4.22	2.52	1.22	1.54	0.97	1.78	1.14	1.13	0.54	2.26	3.71	1.4	<2	3	3	2.5	5.9	-	-	-	3.96	-	-	-
Barium	-	200 [8]	-	21	12.9	12.2	18.1	16	29.5	10.8	15	17.3	47.5	21.3	14.5	18.4	18.8	14.7	16.9	54.6	-	-	-	24	-	-	-
Beryllium	-	100 [9]	-	<10	<10	<50	<25	<50	<50	<50	<50	<50	<10	<25	<50	<0.5	<0.5	<0.5	<0.5	<0.5	-	-	-	0.115	-	-	-
Bismuth	-	-	-	<10	<10	<50	<25	<50	<50	<50	<50	<50	<10	<25	<50	<0.5	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.25	-	-	-
Boron	-	1200 [4]	-	610	860	**3500**	**2010**	**2800**	**2000**	**3200**	**3000**	**2800**	840	1040	**2300**	**2410**	1000	1110	**2360**	470	-	-	-	406	-	-	-
Cadmium	-	0.12 [7]	0.12	0.068	0.065	0.095	0.073	0.065	0.097	0.072	0.094	0.108	0.021	0.027	0.091	<0.12	<0.12	<0.12	**0.162**	**0.192**	-	-	-	**0.121**	-	-	-
Calcium	-	-	-	65800	79800	346000	203000	266000	110000	343000	301000	279000	105000	128000	218000	209000	102000	113000	186000	56600	-	-	-	47200	-	-	-
Cesium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5	<0.5	<0.5	<0.5	0.65	-	-	-	0.283	-	-	-
Chromium	-	1.5 [10]	1.5	**<10**	**<10**	**<50**	**<25**	**<50**	**<50**	**<50**	**<50**	**<50**	**<10**	**<25**	**<50**	<1	<1	<1	**3.98**	**16.4**	-	-	-	**7.5**	-	-	-
Cobalt	-	-	-	1.51	0.781	0.348	1.33	0.782	0.546	0.226	0.762	0.444	1.31	0.46	1.5	1.37	0.65	0.71	2.19	6.11	-	-	-	3.99	-	-	-
Copper	-	3 [18]	-	**5.59**	**5.71**	1.4	2.9	**3.85**	**3.56**	1.01	**3.27**	1.78	2.12	0.827	2.49	2.2	**3.2**	**3.5**	**10.2**	**26**	-	-	-	**15.4**	-	-	-
Gallium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5	<0.5	<0.5	<0.5	2.22	-	-	-	0.88	-	-	-
Iron	-	-	-	2070	718	451	1060	490	1080	324	590	204	962	426	1070	1340	1030	1110	2930	13400	-	-	-	6210	-	-	-
Lead	-	140 [18]	-	1.08	0.437	0.637	0.687	0.935	0.96	0.154	0.912	0.239	0.204	<0.15	0.335	<1	<1	<1	1.69	4.6	-	-	-	2.15	-	-	-
Lithium	-	-	-	<100	<100	<500	<250	<500	<500	<500	<500	<500	<100	<250	<500	92	36	44	82	20	-	-	-	17.8	-	-	-
Magnesium	-	-	-	118000	188000	1070000	576000	808000	288000	1070000	911000	885000	219000	295000	675000	608000	207000	269000	562000	93300	-	-	-	85800	-	-	-
Manganese	-	100 [11]	-	**175**	75	13.5	**135**	80.5	63.8	11.1	68.2	68.6	**246**	**293**	100	**156**	**131**	**120**	98.3	**287**	-	-	-	**160**	-	-	-
Mercury	-	-	0.016	<0.010	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	**0.017**	-	-	-	-	-	-	-
Molybdenum	-	-	-	2.6	5.8	8.2	6.1	8	6.3	8.4	8.3	6.4	2.7	<2.5	5.1	6.4	3.6	3	5.7	5.5	-	-	-	4.08	-	-	-
Nickel	-	8.3 [12]	-	8.25	5.62	1.49	5.71	4.15	2.92	1.12	6.14	2.88	6.87	1.92	5.82	7.02	4.98	3.23	**11.4**	**26.5**	-	-	-	**17.9**	-	-	-
Potassium	-	-	-	45200	64900	355000	188000	273000	92000	329000	280000	241000	62500	91000	204000	185000	64000	86000	172000	33000	-	-	-	31200	-	-	-
Rhenium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.025	-	-	-
Rubidium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	56.3	19.7	23.7	50.3	17.7	-	-	-	11.3	-	-	-
Selenium	-	-	-	<0.50	0.56	0.88	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<2	<2	<2	<2	<2	-	-	-	<1	-	-	-
Silicon	-	-	-	5070	3170	2960	7370	2680	3040	1660	4590	2600	4390	6910	6330	4960	3590	5130	13200	25300	-	-	-	10700	-	-	-
Silver	-	3 [18]	-	<0.20	<0.2	<1	<0.5	<1	<1	<1	<1	<1	<0.2	<0.5	<1	<0.2	<0.2	<0.2	<0.1	<0.1	-	-	-	<0.025	-	-	-
Sodium	-	-	-	1070000	1480000	7990000	4580000	6470000	2330000	8620000	7300000	7660000	1680000	2440000	5380000	5180000	1550000	2190000	4620000	714000	-	-	-	708000	-	-	-
Strontium	-	-	-	892	1200	6600	3270	4590	3300	5720	4880	5030	1370	1860	3820	3670	1320	1720	3270	620	-	-	-	553	-	-	-
Tellurium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.05	-	-	-
Thallium	-	-	-	<2.0	<2	<10	<5	<10	<10	<10	<10	<10	<2	<5	<10	<0.5	<0.5	<0.5	0.053	0.116	-	-	-	0.027	-	-	-
Thorium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5	<0.5	<0.5	<0.5	0.84	-	-	-	0.407	-	-	-
Tin	-	-	-	<2.0	<2	<10	<5	<10	<10	<10	<10	<10	<2	<5	<10	<1	<1	<1	<1	<1	-	-	-	<1	-	-	-
Titanium	-	-	-	21	<20	<100	<100	<100	<100	<100	<100	<100	<20	<100	<100	6.7	5.4	12	80.2	358	-	-	-	159	-	-	-
Tungsten	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<1	<1	<1	<1	<1	-	-	-	<0.05	-	-	-
Uranium	-	100 [13]	-	0.629	0.392	1.99	1.41	1.92	0.197	2.03	2.16	2.01	0.628	0.63	1.78	1.81	1.02	0.78	1.79	1.65	-	-	-	0.956	-	-	-
Vanadium	-	50 [14]	-	<20	<20	**<100**	<50	**<100**	**<100**	**<100**	**<100**	**<100**	<20	<50	**<100**	1.99	2.33	2.62	7.85	25.2	-	-	-	11.2	-	-	-
Yttrium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5	<0.5	<0.5	1.37	3.68	-	-	-	2.08	-	-	-
Zinc	-	55 [19]	-	12.6	10.4	7.64	9.08	4.96	6.66	1.71	22.3	2.39	3.71	2.15	5.48	<5	<5	75.5	17	47.1	-	-	-	29	-	-	-
Zirconium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5	<0.5	<0.5	1.12	2.7	-	-	-	1.95	-	-	-

Table 10: AMS Surface Water Chemistry Results

Parameter	*Nutrient Threshold* [20]	BCWQG MAL [3,4]	CCME MAL [5,6]																								
			Location ID:	DP02																							
			Sample ID:	SWDP02-1	SWDP02-2	SWDP02-3	SWDP02-4	SWDP02-5	SWDP02-6	SWDP02-7	SWDP02-8	SWDP02-9	SWDP02-10	SWDP02-11	SWDP02-12	SWDP02-13	SWDP02-14	SWDP02-15	SWDP02-16	SWDP02-17	SWDP02-18	SWDP02-19	SWDP02-20	SWDP02-21	SWDP02-22	SWDP02-23	SWDP02-24
			Date Sampled:	22/03/2007	21/06/2007	02/10/2007	10/12/2007	03/03/2008	29/05/2008	20/09/2008	26/11/2008	24/02/2009	20/05/2009	14/09/2009	03/12/2009	09/03/2010	07/06/2010	30/08/2010	02/12/2010	02/03/2011	08/06/2011	06/09/2011	07/11/2011	20/02/2012	29/05/2012	05/09/2012	10/12/2012
Sample Info																											
Sample Depth, Below Water Surface (m)		-	-	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	1	0.8	1.2	0.5	1	0.75	0.5	0.5
Field Tests																											
Secchi Depth (m)		-	-	-	-	1.2	-	1	-	1.9	1.1	-	-	-	-	-	-	-	2.4	-	-	-	1.5	1.4 (bottom)	0.75 (bottom)	1.2 (bottom)	1.75
Field Temperature (ºC)	-	-	-	6.94	16.1	11.4	4.95	7.31	14.98	13.27	6.78	7.84	17.5	16	6.11	-	-	14.87	7.47	5.35	12.4	17.35	7.69	6.76	15.4	15.04	6.68
Field pH	-	-	-	7.89	8.38	-	7.67	8.06	7.79	7.8	7.69	7.64	8.69	7.94	7.68	-	-	6.05	7.73	7.55	5	8.2	7.57	7.78	8.48	8.01	7.92
Field Conductivity (uS/cm)	-	-	-	32960	36600	31678	44274	40843	34500	43985	29268	29291	39001	36006	40989	-	-	36620	44858	43499	19000	36299	40469	29200	33844	33030	38520
Field Dissolved Oxygen (mg/L)	6.02 [21]	-	-	10.99	-	9.18	13.01	9.87	10.23	9.04	9.24	11.89	15.44	9.63	10.24	-	-	8.44	11.36	9.48	11.83	11.54	9.89	10.89	10.07	8.97	9.89
Field Redox, Uncorrected (mV)	-	-	-	248.7	231	214	274	-25.6	255.6	-13	-336	-348.6	168	201.2	135.1	-	-	203	242.2	394.3	335.2	258.5	240.6	266.1	179	203.9	372.6
Field Turbidity (NTU)	-	-	-	-	1.7	-	-	-	-	-	1.95	2.7	4.4	1.5	2.04	-	-	0.87	1.27	1.14	6.28	1.39	1.04	1.25	11.2	0.72	-
Physical Tests																											
Hardness, Total (CaCO3) (mg/L)	-	-	-	3550	4060	4850	-	4620	4050	5190	5540	5240	4610	4260	4710	-	-	4650	5410	5390	-	-	-	5010	-	-	-
Total Suspended Solids (mg/L)	-	-	-	12	28	21.7	8.8	13	30.7	34	21.1	-	18.5	11.7	13.8	18	14	17.3	13.7	10.2	6.6	3.9	<2.000	<2.000	24.8	2.4	<3.000
Turbidity (NTU)	-	-	-	-	-	-	1.79	1.62	2.9	1.22	3.16	-	3.29	1.31	2.5	4.08	2.89	0.96	1.47	1.08	4.08	2.13	1.53	1.93	6.89	1.11	1.99
Dissolved Inorganics																											
Orthophosphate (as P) (mg/L)	0.087	-	-	0.042	0.0479	0.0527	0.0724	0.0519	**-**	0.0449	0.0669	0.0294	0.0399	0.0312	0.0612	0.0592	0.0196	0.0308	0.0751	0.0634	0.0278	0.0295	0.0482	0.0663	0.0398	0.0412	0.0591
Phosphorus (P), Total Dissolved (mg/L)	0.087	-	-	0.0457	0.0579	0.0515	0.0707	<0.002	**-**	0.0499	0.0653	0.0448	0.0447	0.0349	0.0637	0.0578	0.0271	0.0358	0.0728	0.0587	0.0317	0.0362	0.0508	0.0672	0.0443	0.0468	0.063
Inorganics																											
Ammonia (mg/L)	0.065	-	-	0.048	0.058	0.039	0.046	0.0471	0.027	0.0175	0.053	0.0247	0.035	0.0174	0.022	0.0128	0.0117	0.0154	0.0146	0.0309	0.0138	<0.005	0.0223	0.0151	<0.005	0.0115	0.0216
Nitrate (mg/L)	5.23	-	16	<0.050	<0.500	<0.500	***7***	0.67	<5.000	<2.500	0.53	<0.500	<0.500	<0.500	<0.500	0.74	<0.500	<0.500	0.58	<0.500	<0.500	<0.500	<0.500	0.61	<0.500	<0.500	0.69
Nitrite (mg/L)	0.978	-	-	<0.010	0.17	<0.100	<0.500	0.12	***1.3***	***1.43***	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	0.25	<0.100	<0.100
Silicon Dioxide (mg/L)	-	-	-	3.1	1.5	-	-	2.4	-	-	3.4	-	-	1.8	3.3	2.4	<1.000	<1.000	3.7	2.8	2.8	<1.000	2.9	2.86	1.48	0.96	3.83
Total Inorganics																											
Chlorine (mg/L)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.100	-	<0.100	<0.100	<0.100	<0.100	-	-	-	-	-	-
Phosphorus (P) (mg/L)	-	-	-	0.0568	0.0688	0.0637	0.0735	0.0606	-	0.0588	0.0742	0.0418	0.0608	0.0448	0.0721	0.0653	0.0483	0.0514	0.079	0.0607	0.0543	0.0587	0.0569	0.076	0.097	0.0545	0.0657
Total Kjeldahl Nitrogen (mg/L)	0.434	-	-	0.171	0.262	0.355	0.276	0.381	0.304	0.102	0.17	0.16	0.347	<0.050	0.187	0.068	0.189	0.135	0.053	0.077	0.237	0.4	0.143	0.15	0.333	0.158	0.131
Total Nitrogen (mg/L)	5.92	-	-	0.17	<0.700	<0.700	***7.3***	1.17	***<6.000***	<3.000	0.7	<0.700	0.17	<0.700	0.56	0.8	<0.700	<0.260	0.63	<0.260	<0.260	0.4	<0.260	0.76	0.59	<0.510	0.83
Organics																											
Organic Nitrogen (mg/L)	0.392	-	-	0.123	-	-	0.23	0.334	0.277	0.085	0.117	0.135	0.312	<0.060	-	<0.060	0.177	0.12	<0.060	<0.060	0.223	***0.4***	0.121	0.13	0.333	0.146	0.109
Microbiological Analysis																											
Chlorophyll A	5.11	-	-	0.758	1.25	3.79	0.547	1.94	0.905	0.675	1.09	0.628	1.28	1.72	0.501	0.595	***5.39***	1.2	0.212	0.493	1.24	2.07	0.389	0.622	1.79	0.061	0.453
Dissolved Metals																											
Iron	-	-	-	-	<10	<300	<10	<10	<10	<10	<10	<10	<10	11	<10	<50	<50	<5	<10	<10	-	-	-	-	-	-	-

Table 10: AMS Surface Water Chemistry Results

Parameter	Nutrient Threshold [20]	BCWQG MAL [3,4]	CCME MAL [5,6]	SWDP02-1	SWDP02-2	SWDP02-3	SWDP02-4	SWDP02-5	SWDP02-6	SWDP02-7	SWDP02-8	SWDP02-9	SWDP02-10	SWDP02-11	SWDP02-12	SWDP02-13	SWDP02-14	SWDP02-15	SWDP02-16	SWDP02-17	SWDP02-18	SWDP02-19	SWDP02-20	SWDP02-21	SWDP02-22	SWDP02-23	SWDP02-24
Location ID:				DP02																							
Date Sampled:				22/03/2007	21/06/2007	02/10/2007	10/12/2007	03/03/2008	29/05/2008	20/09/2008	26/11/2008	24/02/2009	20/05/2009	14/09/2009	03/12/2009	09/03/2010	07/06/2010	30/08/2010	02/12/2010	02/03/2011	08/06/2011	06/09/2011	07/11/2011	20/02/2012	29/05/2012	05/09/2012	10/12/2012
Total Metals																											
Aluminum	-	-	-	<100	<200	<100	<100	<100	160	<100	<100	<100	<100	<100	<100	55	59	16.8	38	21.3	-	-	-	25.7	-	-	-
Antimony	-	-	-	<10	21	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<0.5	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-
Arsenic	-	12.5 [17]	12.5	0.97	1.41	1.01	1.16	0.95	<0.2	1.08	1.24	0.65	1.37	1.27	1.09	<2	<2	<2	<2	<2	-	-	-	<2	-	-	-
Barium	-	200 [8]	-	11.9	<20	10.5	9.1	11.6	10	9.4	10.1	9.2	10.9	10.4	10	10.2	10.6	8.3	9.1	8.9	-	-	-	10.1	-	-	-
Beryllium	-	100 [9]	-	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<0.5	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-
Bismuth	-	-	-	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<0.5	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-
Boron	-	1200 [4]	-	**2700**	**2900**	**3700**	**3600**	**3000**	**2700**	**3400**	**3500**	**4000**	**3000**	**3300**	**3300**	**3810**	**3440**	**3620**	**4470**	**4210**	-	-	-	**4310**	-	-	-
Cadmium	-	0.12 [7]	0.12	0.063	0.043	0.076	0.072	0.07	0.06	0.066	0.09	0.1	0.049	0.065	0.06	<0.12	<0.12	<0.12	0.059	0.072	-	-	-	0.068	-	-	-
Calcium	-	-	-	236000	267000	348000	340000	284000	261000	342000	353000	337000	302000	278000	305000	321000	270000	311000	357000	344000	-	-	-	318000	-	-	-
Cesium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-
Chromium	-	1.5 [10]	1.5	**<50**	**<50**	**<50**	**<50**	**<50**	**<50**	**<50**	**<50**	**<50**	**<50**	**64**	**<50**	<1	<1	<1	<0.7	<0.4	-	-	-	<0.5	-	-	-
Cobalt	-	-	-	0.136	0.092	0.1	0.112	0.06	0.158	0.071	0.085	0.151	0.167	<0.05	0.062	<0.5	<0.5	<0.5	<0.05	<0.05	-	-	-	0.098	-	-	-
Copper	-	3 [18]	-	1.49	0.696	1.58	0.591	2.36	1.4	0.69	1.5	1.23	1.31	0.905	0.465	2.2	1.4	1.6	1.72	1.01	-	-	-	0.66	-	-	-
Gallium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-
Iron	-	-	-	116	46	111	69	31	138	67	84	103	131	33	73	105	147	<50	60	36	-	-	-	52	-	-	-
Lead	-	140 [18]	-	0.469	<0.05	1.36	0.074	3.31	0.484	0.535	3.33	1.96	0.174	1.04	0.062	1.6	<1	1.3	3.18	0.58	-	-	-	<0.3	-	-	-
Lithium	-	-	-	<500	<500	<500	<500	<500	<500	<500	<500	<500	<500	<500	<500	163	130	153	157	160	-	-	-	169	-	-	-
Magnesium	-	-	-	718000	825000	1100000	1100000	950000	824000	1050000	1130000	1070000	936000	867000	959000	1020000	895000	940000	1100000	1110000	-	-	-	1020000	-	-	-
Manganese	-	100 [11]	-	11.2	6.21	7.45	8.25	6.21	13.2	5.23	8.63	13.1	11.1	6.46	5.64	7.12	8.86	3.9	3.76	2.55	-	-	-	5.58	-	-	-
Mercury	-	-	0.016	<0.010	<0.01	<0.01	<0.01	<0.01	<0.01	**0.019**	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-	-	-	-	-	-	-
Molybdenum	-	-	-	5.5	12.4	9.1	9.4	9	5.6	9.6	7.7	9.6	9.4	8.1	8.4	9.8	7	8.4	9.2	9.1	-	-	-	10	-	-	-
Nickel	-	8.3 [12]	-	0.879	0.612	0.758	0.737	0.835	0.994	0.611	0.759	0.995	0.659	0.481	0.538	0.73	0.65	0.63	<0.5	0.53	-	-	-	0.78	-	-	-
Potassium	-	-	-	242000	271000	366000	362000	281000	249000	331000	344000	305000	279000	257000	286000	309000	259000	280000	334000	323000	-	-	-	308000	-	-	-
Rhenium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-
Rubidium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	96.5	70.4	81.4	95.5	93.6	-	-	-	99.3	-	-	-
Selenium	-	-	-	<0.50	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<2	<2	<2	<2	<2	-	-	-	<2	-	-	-
Silicon	-	-	-	1650	880	1540	1930	1370	1260	1150	1920	700	770	1130	1940	1470	530	620	1690	1670	-	-	-	1660	-	-	-
Silver	-	3 [18]	-	<1.0	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<0.2	<0.2	<0.2	<0.1	<0.1	-	-	-	<0.1	-	-	-
Sodium	-	-	-	6340000	7230000	8250000	8150000	7900000	7060000	8690000	8930000	9390000	7880000	7700000	8290000	8930000	6490000	7990000	9250000	9150000	-	-	-	8820000	-	-	-
Strontium	-	-	-	4470	5060	7200	5820	5610	4520	6050	5480	6010	5000	5380	6070	5960	4650	5430	6410	6340	-	-	-	5860	-	-	-
Tellurium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-
Thallium	-	-	-	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<0.5	<0.5	<0.5	<0.05	<0.05	-	-	-	<0.05	-	-	-
Thorium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-
Tin	-	-	-	<10	<10	<10	<10	<10	<10	<10	<10	13	<10	<10	<10	<1	<1	<1	<1	<1	-	-	-	<1	-	-	-
Titanium	-	-	-	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<5	<5	<5	<5	<5	-	-	-	<5	-	-	-
Tungsten	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<1	<1	<1	<1	<1	-	-	-	<1	-	-	-
Uranium	-	100 [13]	-	1.56	0.949	2.09	2.08	1.75	1.79	2.1	2.26	2.41	1.86	1.92	1.75	2.75	1.91	2.35	2.66	2.46	-	-	-	2.63	-	-	-
Vanadium	-	50 [14]	-	**<100**	**<100**	**<100**	**<100**	**<100**	**<100**	**<100**	**<100**	**<100**	**<100**	**<100**	**<100**	1.52	1.45	1.36	1.6	1.46	-	-	-	1.74	-	-	-
Yttrium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-
Zinc	-	55 [19]	-	5.1	0.56	5.35	1.24	5.72	2.11	1.88	2.25	2.32	1.84	2.22	0.88	<5	<5	<5	<4	11.4	-	-	-	3.7	-	-	-
Zirconium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-

Table 10: AMS Surface Water Chemistry Results

Parameter	Nutrient Threshold [20]	BCWQG MAL [3,4]	CCME MAL [5,6]	SWDP03-1	SWDP03-2	SWDP03-3	SWDP03-4	SWDP03-5	SWDP03-6	SWDP03-7	SWDP03-8	SWDP03-9	SWDP03-10	SWDP03-11	SWDP03-12	SWDP03-13	SWDP03-14	SWDP03-15	SWDP03-16	SWDP03-17	SWDP03-18	SWDP03-19	SWDP03-20	SWDP03-21	SWDP03-22	SWDP03-23	SWDP03-24
			Location ID:	DP03																							
			Date Sampled:	22/03/2007	21/06/2007	02/10/2007	10/12/2007	03/03/2008	29/05/2008	20/09/2008	26/11/2008	24/02/2009	20/05/2009	14/09/2009	03/12/2009	09/03/2010	07/06/2010	30/08/2010	02/12/2010	03/03/2011	08/06/2011	06/09/2011	07/11/2011	20/02/2012	29/05/2012	05/09/2012	10/12/2012
Sample Info																											
Sample Depth, Below Water Surface (m)		-	-	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	1.8	0.5	0.5	0.5	0.5	0.5	1	1	1.2	0.4	1	0.9	0.5	0.4
Field Tests																											
Secchi Depth (m)		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.5	-	-	-	1.4	1.6 (bottom)	0.9 (bottom)	1.3 (bottom)	1.5
Field Temperature (ºC)	-	-	-	8.53	14.9	11.6	6.38	6.57	16.16	13.23	7.46	7.82	14.69	16.24	6.22	-	-	15.08	7.1	5.59	15.03	16.4	7.06	6.18	14.96	14.03	6.4
Field pH	-	-	-	7.8	8.55	-	7.73	8.01	7.88	7.8	7.76	7.7	8.5	8.03	7.73	-	-	7.4	7.76	7.74	7.94	8.26	7.54	7.81	8.39	8.05	7.92
Field Conductivity (uS/cm)	-	-	-	10089	31300	31175	44401	38157	37169	44296	30029	29101	40202	36040	40513	-	-	38190	45009	44168	20975	35404	40558	27367	33007	32370	39980
Field Dissolved Oxygen (mg/L)	6.02 [21]	-	-	10.14	-	8.87	12.65	9.85	10.01	8.72	8.86	12.47	13.98	10.97	11.11	-	-	8.39	11.04	11.6	9.8	14.26	10.85	10.34	11.26	10.39	9.89
Field Redox, Uncorrected (mV)	-	-	-	236.1	258.6	230	252	-249.2	235.2	-1	-325.9	-354.5	148.5	229.1	160	-	-	139	250.1	305.1	279	256.1	206.1	273	189.3	284	361.2
Field Turbidity (NTU)	-	-	-	1.2	5.2	-	-	-	-	-	1.72	3.9	2.5	0.9	1.02	-	-	1.07	0.32	4.94	4.51	1.22	1.15	1.71	4.2	0.78	-
Physical Tests																											
Hardness, Total (CaCO3) (mg/L)	-	-	-	4750	3440	4590	-	4170	4460	5380	5450	5200	4740	4180	4570	-	-	4580	5540	5450	-	-	-	4690	-	-	-
Total Suspended Solids (mg/L)	-	-	-	8	23.3	26.3	16.8	14.3	33.3	25.3	19.1	-	15.8	17.7	24.5	8	14	10	13	18.2	8.8	5.9	<2.000	2.2	8	2.8	<3.000
Turbidity (NTU)	-	-	-	-	-	-	1.69	1.42	3.7	1.12	2.47	-	1.55	1.22	1.64	3.05	2.11	1.25	1.78	4.89	4.94	2.42	1.39	2.55	3.46	1.21	1.57
Dissolved Inorganics																											
Orthophosphate (as P) (mg/L)	0.087	-	-	0.0482	0.0317	0.0555	0.072	0.0412	-	0.0467	0.0664	0.0303	0.0407	0.0322	0.0597	0.0581	0.0163	0.0302	0.0764	0.0587	0.0419	0.0179	0.0513	0.0558	0.0252	0.0414	0.0618
Phosphorus (P), Total Dissolved (mg/L)	0.087	-	-	0.0499	0.0405	0.0551	0.0693	0.0395	-	0.0535	0.0667	0.0363	0.0487	0.0344	0.064	0.0588	0.0201	0.0352	0.0735	0.0522	0.0434	0.0237	0.052	0.0584	0.0309	0.0455	0.065
Inorganics																											
Ammonia (mg/L)	0.065	-	-	0.032	0.03	0.056	<0.020	0.0354	0.028	0.0172	0.0309	0.0212	0.034	0.019	<0.020	0.013	0.0077	0.0175	0.0145	0.0271	0.0184	0.0069	0.0314	0.0513	<0.005	0.0078	0.0226
Nitrate (mg/L)	5.23	-	16	0.22	<0.500	<0.500	***7***	0.62	<5.000	<2.500	<0.500	<0.500	<0.500	<0.500	<0.500	0.99	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	0.61	0.74	<0.500	<0.500
Nitrite (mg/L)	0.978	-	-	<0.020	0.13	<0.100	<0.500	0.12	***2.1***	***1.37***	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	0.11	<0.100
Silicon Dioxide (mg/L)	-	-	-	2.2	1.6	-	-	2.1	-	-	3	-	-	1.8	3.2	2.5	<1.000	1.1	3.9	2.9	2.6	1.3	2.7	3.03	1.24	1.14	3.58
Total Inorganics																											
Chlorine (mg/L)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.100	-	<0.100	<0.100	<0.100	<0.100	-	-	-	-	-	-
Phosphorus (P) (mg/L)	-	-	-	0.0589	0.0641	0.0764	0.0734	0.0474	-	0.0605	0.0721	0.0436	0.0526	0.0443	0.0668	0.067	0.0391	0.0437	0.0786	0.0813	0.0578	0.0496	0.0568	0.0684	0.0506	0.0524	0.08
Total Kjeldahl Nitrogen (mg/L)	0.434	-	-	0.15	0.211	0.385	0.246	0.331	0.378	<0.050	0.153	0.189	0.298	0.122	0.137	0.074	0.23	***0.475***	0.082	0.116	0.242	***0.493***	0.127	0.16	0.253	0.181	0.128
Total Nitrogen (mg/L)	5.92	-	-	0.37	<0.700	<0.700	***7.3***	1.07	***<6.000***	<3.000	<0.700	<0.700	0.26	<0.700	0.51	1.06	<0.700	0.48	<0.260	<0.260	<0.260	0.49	<0.260	0.77	0.99	<0.510	<0.510
Organics																											
Organic Nitrogen (mg/L)	0.392	-	-	-	-	-	0.246	0.296	0.351	<0.060	0.122	0.168	0.264	0.103	-	0.061	0.222	***0.458***	0.068	0.089	0.224	***0.486***	0.096	0.11	0.253	0.173	0.105
Microbiological Analysis																											
Chlorophyll A	5.11	-	-	2.25	3.77	3.19	0.572	2.3	1.17	0.652	0.427	0.656	0.414	0.831	0.445	0.667	***8.47***	0.33	0.123	1.57	0.687	***6.24***	0.588	0.198	2.36	0.056	0.244
Dissolved Metals																											
Iron	-	-	-	-	<10	<300	<10	<10	12	<10	<10	<10	<10	<10	<10	<50	<50	<5	<10	<10	-	-	-	-	-	-	-

Table 10: AMS Surface Water Chemistry Results

			Location ID:	DP03																							
			Sample ID:	SWDP03-1	SWDP03-2	SWDP03-3	SWDP03-4	SWDP03-5	SWDP03-6	SWDP03-7	SWDP03-8	SWDP03-9	SWDP03-10	SWDP03-11	SWDP03-12	SWDP03-13	SWDP03-14	SWDP03-15	SWDP03-16	SWDP03-17	SWDP03-18	SWDP03-19	SWDP03-20	SWDP03-21	SWDP03-22	SWDP03-23	SWDP03-24
			Date Sampled:	22/03/2007	21/06/2007	02/10/2007	10/12/2007	03/03/2008	29/05/2008	20/09/2008	26/11/2008	24/02/2009	20/05/2009	14/09/2009	03/12/2009	09/03/2010	07/06/2010	30/08/2010	02/12/2010	03/03/2011	08/06/2011	06/09/2011	07/11/2011	20/02/2012	29/05/2012	05/09/2012	10/12/2012
Parameter	***Nutrient Threshold* [20]**	**BCWQG MAL [3,4]**	**CCME MAL [5,6]**																								
Total Metals																											
Aluminum	-	-	-	<100	<200	<200	<100	<100	130	<100	<100	<100	<100	<100	<100	45	41	15.8	26	107	-	-	-	27.6	-	-	-
Antimony	-	-	-	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<0.5	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-
Arsenic	-	12.5 [17]	12.5	1.11	1.2	1.18	1.26	1.14	1.09	1.27	1.28	0.93	1.3	1.24	1.12	<2	<2	<2	<2	<2	-	-	-	<2	-	-	-
Barium	-	200 [8]	-	10.6	<20	11.5	9	12	11.1	9.5	9.9	7.7	9.7	9.7	8.8	9.6	13.1	8.7	9.1	9	-	-	-	9.4	-	-	-
Beryllium	-	100 [9]	-	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<0.5	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-
Bismuth	-	-	-	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<0.5	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-
Boron	-	1200 [4]	-	**3500**	**2600**	**3700**	**3500**	**2800**	**3100**	**3400**	**3600**	**3900**	**3000**	**2800**	**3200**	**4450**	**4760**	**3690**	**4640**	**4380**	-	-	-	**4220**	-	-	-
Cadmium	-	0.12 [7]	0.12	0.06	0.04	0.085	0.062	0.069	0.054	0.076	0.087	0.092	0.052	0.064	0.066	<0.12	<0.12	<0.12	0.068	0.08	-	-	-	0.057	-	-	-
Calcium	-	-	-	305000	216000	338000	358000	258000	286000	344000	347000	335000	308000	269000	298000	331000	300000	310000	364000	347000	-	-	-	303000	-	-	-
Cesium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-
Chromium	-	1.5 [10]	1.5	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	63	<50	<1	<1	<1	<0.7	<0.4	-	-	-	<0.5	-	-	-
Cobalt	-	-	-	0.069	0.079	0.166	0.052	0.065	0.156	0.059	0.066	0.136	0.096	<0.05	0.055	<0.5	<0.5	<0.5	<0.05	0.106	-	-	-	0.113	-	-	-
Copper	-	3 [18]	-	0.709	0.672	2.06	0.652	2.61	1.49	0.562	0.921	1.02	1.32	1.12	0.839	<1	1.8	<1	1.17	1.4	-	-	-	0.65	-	-	-
Gallium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-
Iron	-	-	-	55	63	186	59	31	158	58	71	111	51	37	54	95	95	<50	52	206	-	-	-	62	-	-	-
Lead	-	140 [18]	-	0.137	0.061	1.09	0.117	2.49	0.269	0.273	0.674	0.201	0.27	1.03	0.135	<1	<1	<1	1.6	0.35	-	-	-	<0.3	-	-	-
Lithium	-	-	-	<500	<500	<500	<500	<500	<500	<500	<500	<500	<500	<500	<500	173	184	153	164	161	-	-	-	156	-	-	-
Magnesium	-	-	-	968000	703000	1080000	1160000	857000	909000	1100000	1110000	1060000	964000	852000	928000	1060000	924000	925000	1120000	1110000	-	-	-	954000	-	-	-
Manganese	-	100 [11]	-	5.88	7.13	11.4	4.16	7.7	12.9	5.44	6.07	14	6.75	6.82	5.79	6.62	8.37	3.6	3.62	5.25	-	-	-	7.34	-	-	-
Mercury	-	-	0.016	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-	-	-	-	-	-	-
Molybdenum	-	-	-	7.6	7.6	9.8	8.8	7.6	6.5	10.3	8.5	8.4	8.9	7.1	7.1	10.7	9.5	8.4	9.4	9.1	-	-	-	9.1	-	-	-
Nickel	-	8.3 [12]	-	0.528	0.536	1.01	0.446	0.675	0.943	0.465	0.612	0.83	0.402	0.521	0.56	0.81	0.84	0.59	0.66	1.63	-	-	-	0.87	-	-	-
Potassium	-	-	-	309000	226000	363000	385000	251000	275000	338000	332000	306000	284000	256000	285000	318000	271000	282000	348000	323000	-	-	-	292000	-	-	-
Rhenium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-
Rubidium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	103	99	81.3	98.1	96.5	-	-	-	90.1	-	-	-
Selenium	-	-	-	0.51	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.82	<0.5	<0.5	<0.5	<0.5	<2	<2	<2	<2	<2	-	-	-	<2	-	-	-
Silicon	-	-	-	1410	1360	1890	1860	1260	1130	1700	1680	710	760	1090	1820	1440	580	680	1700	1870	-	-	-	1760	-	-	-
Silver	-	3 [18]	-	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<0.2	<0.2	<0.2	<0.1	<0.1	-	-	-	<0.1	-	-	-
Sodium	-	-	-	7340000	5770000	8290000	8620000	7130000	7740000	8850000	8610000	9320000	8100000	7680000	8200000	9220000	6800000	8020000	9640000	9160000	-	-	-	8250000	-	-	-
Strontium	-	-	-	5970	4270	6850	5960	5220	5060	6010	5590	6110	5140	4570	5510	6110	4860	5490	6680	6320	-	-	-	5530	-	-	-
Tellurium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-
Thallium	-	-	-	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<0.5	<0.5	<0.5	<0.05	<0.05	-	-	-	<0.05	-	-	-
Thorium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-
Tin	-	-	-	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<1	<1	<1	<1	<1	-	-	-	<1	-	-	-
Titanium	-	-	-	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<5	<5	<5	<5	<5	-	-	-	<5	-	-	-
Tungsten	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<1	<1	<1	<1	<1	-	-	-	<1	-	-	-
Uranium	-	100 [13]	-	1.96	1.24	1.99	1.77	1.85	1.9	2.24	2.4	2.26	1.72	1.91	1.71	2.77	2.75	2.26	2.62	2.49	-	-	-	2.51	-	-	-
Vanadium	-	50 [14]	-	**<100**	**<100**	**<100**	**<100**	**<100**	**<100**	**<100**	**<100**	**<100**	**<100**	**<100**	**<100**	1.41	1.7	1.31	1.57	1.64	-	-	-	1.52	-	-	-
Yttrium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-
Zinc	-	55 [19]	-	2.55	0.6	3.56	1.17	5.04	2.27	1.5	1.79	1.76	1.2	2.01	1.35	<5	<5	<5	<4	13.3	-	-	-	<3	-	-	-
Zirconium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-

Table 10: AMS Surface Water Chemistry Results

Parameter	*Nutrient Threshold* [20]	BCWQG MAL [3,4]	CCME MAL [5,6]	SWDP04-1	SWDP04-2	SWDP04-3	SWDP04-4	SWDP04-5	SWDP04-6	SWDP04-7	SWDP04-8	SWDP04-9	SWDP04-10	SWDP04-11	SWDP04-12	SWDP04-13	SWDP04-14	SWDP04-15	SWDP04-16	SWDP04-17	SWDP04-18	SWDP04-19	SWDP04-20	SWDP04-21	SWDP04-22	SWDP04-23	SWDP04-24
Location ID:				DP04																							
Date Sampled:				23/03/2007	20/06/2007	02/10/2007	10/12/2007	05/03/2008	30/05/2008	20/09/2008	26/11/2008	24/02/2009	20/05/2009	14/09/2009	03/12/2009	09/03/2010	07/06/2010	30/08/2010	02/12/2010	03/03/2011	08/06/2011	06/09/2011	07/11/2011	20/02/2012	29/05/2012	05/09/2012	10/12/2012
Sample Info																											
Sample Depth, Below Water Surface (m)		-	-	0.5	-	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	1	2.4	2	0.5	1	1.5	0.5	0.5
Field Tests																											
Secchi Depth (m)		-	-	-	-	1.7	-	2.2	-	1.9	2.2	-	-	-	-	-	-	-	3	-	-	-	1.7	2.5 (bottom)	1.5 (bottom)	1.5	2
Field Temperature (ºC)	-	-	-	7.6	-	11.1	6.96	6.9	14.69	12.23	8.56	7.17	11.62	15.8	7.15	-	-	15.06	8.08	5.85	14.8	15.39	8.08	6.94	11.53	13.82	6.7
Field pH	-	-	-	7.89	-	-	7.75	7.99	7.95	7.73	7.76	7.59	8.13	8.02	7.74	-	-	7.72	7.75	7.82	8	8.06	7.59	7.78	7.84	7.93	7.89
Field Conductivity (uS/cm)	-	-	-	42603	-	32241	44592	45283	37722	45518	31575	30014	42909	35973	41659	-	-	37960	45412	44170	16626	36816	34910	27372	41907	32360	40740
Field Dissolved Oxygen (mg/L)	6.02 [21]	-	-	9.79	-	8.66	10.95	9.8	11.02	8.29	7.92	10.02	11.26	10.36	9.97	-	-	10.89	9.63	10.2	10.6	12	10.26	9.58	8.67	11.07	9.68
Field Redox, Uncorrected (mV)	-	-	-	261.2	-	242	239	-36.9	205.4	54	-325.7	-368.4	172.7	235.1	171.8	-	-	122.3	251.3	231.3	264	259	197.9	276.2	167.1	329.4	368.2
Field Turbidity (NTU)	-	-	-	0	-	-	-	-	-	-	1.37	0.9	2.3	0.8	0.8	-	-	1.12	0.04	5.44	4.3	0.64	0.94	0.79	4.6	0.7	-
Physical Tests																											
Hardness, Total (CaCO3) (mg/L)	-	-	-	5060	4280	4970	-	5140	4510	5610	5790	5450	5180	4040	4800	-	-	4730	5450	5410	-	-	-	5010	-	-	-
Total Suspended Solids (mg/L)	-	-	-	6	27.2	26.3	23.5	19.6	3.2	27.3	22.4	-	13.8	17	21.2	9.3	16.7	<3.000	15	24.2	7.2	3	<2.000	<2.000	20.2	6.7	3.3
Turbidity (NTU)	-	-	-	-	-	-	1.44	1.16	1.49	1.1	1.68	-	1.58	0.72	1.41	5.03	2.05	0.98	1.01	7.05	4.34	1.21	1.59	1.52	7.6	1.3	1.62
Dissolved Inorganics																											
Orthophosphate (as P) (mg/L)	0.087	-	-	0.0507	0.0241	0.0552	0.0712	0.0613	0.0501	0.0591	0.0695	0.0657	0.0383	0.031	0.0657	0.0671	0.0257	0.0281	0.075	0.0584	0.0245	0.0326	0.0463	0.0632	0.0212	0.0318	0.0638
Phosphorus (P), Total Dissolved (mg/L)	0.087	-	-	0.0548	0.0286	0.0493	0.0714	0.0626	0.0588	0.06	0.0687	0.0739	0.0418	0.0338	0.0654	0.0606	0.0313	0.0331	0.0756	0.0559	0.0302	0.0375	0.0455	0.0679	0.0258	0.0374	0.0655
Inorganics																											
Ammonia (mg/L)	0.065	-	-	<0.020	***0.123***	0.027	<0.020	0.025	***0.0753***	0.0167	0.0088	<0.005	0.033	0.0164	<0.020	0.0098	0.0087	0.015	0.0076	0.0302	0.0184	0.0125	0.0244	0.0123	0.0134	0.0055	0.0227
Nitrate (mg/L)	5.23	-	16	0.67	<0.500	<0.500	***8.3***	1.64	1.93	<2.500	<0.500	<0.500	<0.500	<0.500	<0.500	0.61	<0.500	<0.500	0.66	<0.500	<0.500	0.51	***8.95***	0.65	<0.500	0.71	<0.500
Nitrite (mg/L)	0.978	-	-	<0.020	0.33	<0.100	<0.500	0.25	0.11	***1.41***	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	0.31	<0.100
Silicon Dioxide (mg/L)	-	-	-	2.1	2	-	-	-	1.4	-	3	-	-	1.8	3	2.4	<1.000	1.2	3.5	2.9	1.8	1.4	3.1	2.95	1.04	0.75	3.78
Total Inorganics																											
Chlorine (mg/L)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.11	-	<0.100	<0.100	<0.100	<0.100	-	-	-	-	-	-
Phosphorus (P) (mg/L)	-	-	-	0.0612	0.0489	0.0687	0.076	0.0652	0.0666	0.0709	0.0714	0.0755	0.059	0.0407	0.0746	0.0667	0.0503	0.0438	0.0798	0.0825	0.0494	0.0517	0.0603	0.0781	0.0806	0.063	0.0704
Total Kjeldahl Nitrogen (mg/L)	0.434	-	-	0.099	***0.62***	0.294	0.214	0.238	0.369	<0.050	0.062	0.054	0.354	0.08	0.15	0.063	0.258	0.326	0.066	0.079	0.32	***0.444***	0.127	0.164	0.428	0.302	0.129
Total Nitrogen (mg/L)	5.92	-	-	0.77	0.95	<0.700	***8.5***	2.13	<5.000	<3.000	<0.700	<0.700	0.26	<0.700	0.51	<0.700	<0.700	0.33	0.73	<0.260	0.32	0.96	***9.08***	0.82	0.43	1.32	<0.510
Organics																											
Organic Nitrogen (mg/L)	0.392	-	-	-	***0.497***	-	0.214	0.213	0.294	<0.060	<0.060	<0.060	0.321	0.064	-	<0.060	0.249	0.311	<0.060	<0.060	0.302	***0.431***	0.103	0.152	***0.415***	0.297	0.106
Microbiological Analysis																											
Chlorophyll A	5.11	-	-	2.54	***6.09***	3.55	0.645	1.22	1.34	0.629	0.393	0.227	1.4	2.14	0.237	0.649	***8.01***	2.1	0.12	1.74	2.03	2.33	1.02	0.343	***27.8***	1.06	0.27
Dissolved Metals																											
Iron	-	-	-	-	<10	<300	<10	<10	23	<10	<10	<10	<10	10	<10	<50	<50	<5	<10	<10	-	-	-	-	-	-	-

Table 10: AMS Surface Water Chemistry Results

Parameter	Nutrient Threshold [20]	BCWQG MAL [3,4]	CCME MAL [5,6]	SWDP04-1	SWDP04-2	SWDP04-3	SWDP04-4	SWDP04-5	SWDP04-6	SWDP04-7	SWDP04-8	SWDP04-9	SWDP04-10	SWDP04-11	SWDP04-12	SWDP04-13	SWDP04-14	SWDP04-15	SWDP04-16	SWDP04-17	SWDP04-18	SWDP04-19	SWDP04-20	SWDP04-21	SWDP04-22	SWDP04-23	SWDP04-24
Location ID:				DP04																							
Date Sampled:				23/03/2007	20/06/2007	02/10/2007	10/12/2007	05/03/2008	30/05/2008	20/09/2008	26/11/2008	24/02/2009	20/05/2009	14/09/2009	03/12/2009	09/03/2010	07/06/2010	30/08/2010	02/12/2010	03/03/2011	08/06/2011	06/09/2011	07/11/2011	20/02/2012	29/05/2012	05/09/2012	10/12/2012
Total Metals																											
Aluminum	-	-	-	<100	<100	<100	<100	<100	110	<100	<100	<100	<100	<100	<100	67	43	16.6	25.5	99.7	-	-	-	14.1	-	-	-
Antimony	-	-	-	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<0.5	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-
Arsenic	-	12.5 [17]	12.5	1.17	0.97	1.42	1.23	1.6	1.43	1.24	1.18	1.48	1.32	1.59	1.21	<2	<2	<2	<2	<2	-	-	-	<2	-	-	-
Barium	-	200 [8]	-	10.4	12.2	11.2	9	7.8	9.3	8.7	9.2	8.7	8.5	9.4	8.2	10.2	10.3	8.7	8.9	8.9	-	-	-	9.3	-	-	-
Beryllium	-	100 [9]	-	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<0.5	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-
Bismuth	-	-	-	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<0.5	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-
Boron	-	1200 [4]	-	**3500**	**3300**	**3800**	**3600**	**3700**	**2900**	**3500**	**3700**	**4100**	**3400**	**2800**	**3200**	**4360**	**4240**	**3650**	**4640**	**4380**	-	-	-	**4560**	-	-	-
Cadmium	-	0.12 [7]	0.12	0.07	0.093	0.068	0.063	0.082	0.044	0.08	0.082	0.09	0.065	0.058	0.064	<0.12	<0.12	<0.12	0.07	0.055	-	-	-	0.057	-	-	-
Calcium	-	-	-	322000	251000	362000	359000	337000	309000	357000	372000	353000	335000	262000	314000	317000	338000	320000	359000	345000	-	-	-	318000	-	-	-
Cesium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-
Chromium	-	1.5 [10]	1.5	**<50**	**<50**	**<50**	**<50**	**<50**	**<50**	**<50**	**<50**	**<50**	**<50**	**61**	**<50**	<1	<1	<1	<0.7	<0.4	-	-	-	<0.5	-	-	-
Cobalt	-	-	-	<0.05	0.056	0.081	0.055	0.057	0.107	0.056	<0.05	<0.05	0.083	<0.05	<0.05	<0.5	<0.5	<0.5	<0.05	0.137	-	-	-	<0.05	-	-	-
Copper	-	3 [18]	-	0.743	0.804	1.04	0.552	1.34	1.13	0.652	0.784	2.28	1.6	0.828	0.514	<1	1.2	<1	0.76	1.13	-	-	-	<0.5	-	-	-
Gallium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-
Iron	-	-	-	21	17	72	52	32	80	61	44	51	42	26	43	127	84	<50	41	213	-	-	-	29	-	-	-
Lead	-	140 [18]	-	0.192	0.21	0.454	0.093	0.785	0.332	0.231	0.682	0.997	0.299	<0.5	0.059	<1	<1	<1	0.39	0.45	-	-	-	<0.3	-	-	-
Lithium	-	-	-	<500	<500	<500	<500	<500	<500	<500	<500	<500	<500	<500	<500	165	159	149	161	162	-	-	-	166	-	-	-
Magnesium	-	-	-	1030000	886000	1170000	1160000	1040000	908000	1150000	1180000	1110000	1060000	822000	975000	1030000	1040000	955000	1110000	1100000	-	-	-	1020000	-	-	-
Manganese	-	100 [11]	-	3.22	5.77	6.86	4.5	4.85	10.1	5.6	4.22	4.2	4.75	5.93	4.12	6.99	5.78	3.7	3.28	5.61	-	-	-	3.97	-	-	-
Mercury	-	-	0.016	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-	-	-	-	-	-	-
Molybdenum	-	-	-	7.5	9.1	9.4	9.9	9.7	5.6	10.3	8.5	10.6	11.1	6.1	5.8	10.2	8.7	8.3	9.4	9.4	-	-	-	10.2	-	-	-
Nickel	-	8.3 [12]	-	0.421	0.56	0.798	0.508	0.559	0.762	0.473	0.507	0.777	0.417	0.444	0.467	0.71	0.61	0.52	0.56	0.92	-	-	-	0.59	-	-	-
Potassium	-	-	-	331000	264000	387000	376000	361000	288000	357000	345000	319000	307000	248000	297000	312000	307000	294000	341000	323000	-	-	-	308000	-	-	-
Rhenium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-
Rubidium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	99.7	88.9	80.7	98.9	98.7	-	-	-	96.5	-	-	-
Selenium	-	-	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<2	<2	<2	<2	<2	-	-	-	<2	-	-	-
Silicon	-	-	-	1170	1010	1420	1920	1430	910	1930	1500	1450	860	980	1730	1560	640	830	1610	1900	-	-	-	1590	-	-	-
Silver	-	3 [18]	-	<1	<1	<1	<1	1.4	<1	<1	<1	<1	<1	<1	<1	<0.2	<0.2	<0.2	<0.1	<0.1	-	-	-	<0.1	-	-	-
Sodium	-	-	-	7840000	6840000	8790000	8450000	8440000	8000000	9410000	8900000	9770000	8800000	7480000	8530000	8970000	7670000	8290000	9450000	9140000	-	-	-	8750000	-	-	-
Strontium	-	-	-	6100	5040	7200	6250	5740	4800	6410	5690	6630	5810	4780	5800	5970	5510	5710	6530	6310	-	-	-	5810	-	-	-
Tellurium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-
Thallium	-	-	-	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<0.5	<0.5	<0.5	<0.05	<0.05	-	-	-	<0.05	-	-	-
Thorium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-
Tin	-	-	-	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<1	<1	<1	<1	<1	-	-	-	<1	-	-	-
Titanium	-	-	-	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<5	<5	<5	<5	<5	-	-	-	<5	-	-	-
Tungsten	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<1	<1	<1	<1	<1	-	-	-	<1	-	-	-
Uranium	-	100 [13]	-	1.74	1.28	1.9	1.94	2.27	1.67	2.4	2.38	2.35	1.93	1.81	1.73	2.63	2.57	2.28	2.62	2.59	-	-	-	2.6	-	-	-
Vanadium	-	50 [14]	-	**<100**	**<100**	**<100**	**<100**	**<100**	**<100**	**<100**	**<100**	**<100**	**<100**	**<100**	**<100**	1.52	1.68	1.38	2.02	1.73	-	-	-	1.75	-	-	-
Yttrium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-
Zinc	-	55 [19]	-	1.96	2.5	1.74	1.39	2.56	3.25	1.45	1.52	12.5	2.45	1.32	0.72	<5	<5	<5	<4	3.9	-	-	-	<3	-	-	-
Zirconium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-

Table 10: AMS Surface Water Chemistry Results

Parameter	*Nutrient Threshold* [20]	BCWQG MAL [3,4]	CCME MAL [5,6]	SWDP05A-1	SWDP05A-2	SWDP05A-3	SWDP05A-4	SWDP05A-5	SWDP05A-6	SWDP05A-7	SWDP05A-8	SWDP05A-9	SWDP05A-10	SWDP05A-11	SWDP05A-12
Location ID:				DP05A											
Date Sampled:				22/03/2007	20/06/2007	02/10/2007	10/12/2007	05/03/2008	30/05/2008	21/09/2008	27/11/2008	24/02/2009	20/05/2009	14/09/2009	03/12/2009
Sample Info															
Sample Depth, Below Water Surface (m)		-	-	0.5	-	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Field Tests															
Secchi Depth (m)		-	-	-	-	3.6	4.3	-	-	2.8	2	-	-	-	-
Field Temperature (ºC)	-	-	-	7.59	-	10.6	7.77	7.08	13.47	12.46	8.92	7.15	12.05	15.78	7.9
Field pH	-	-	-	7.77	-	-	7.58	7.87	7.53	791	7.69	7.45	8.09	7.94	7.73
Field Conductivity (uS/cm)	-	-	-	43311	-	32657	44533	44250	37260	40733	32678	30023	40238	35306	42330
Field Dissolved Oxygen (mg/L)	6.02 [21]	-	-	9.42	-	7.73	10.86	8.48	9.5	7.91	7.9	10.22	9.95	9.4	10.39
Field Redox, Uncorrected (mV)	-	-	-	251.9	-	253	221	-40.2	201.4	-86	-322.7	-346.8	209.8	299.4	152.3
Field Turbidity (NTU)	-	-	-	3.87	-	-	-	-	-	-	0.71	0.75	2.8	0.75	0.62
Physical Tests															
Hardness, Total (CaCO3) (mg/L)	-	-	-	4370	3750	5040	-	5250	4430	4800	5470	5460	4760	4040	4790
Total Suspended Solids (mg/L)	-	-	-	8.7	18.5	15.7	30.8	14.2	9.9	11.3	7.1	-	13.8	14.3	10.5
Turbidity (NTU)	-	-	-	-	-	-	0.88	0.58	1.66	1.87	1.17	-	1.99	1.05	1.18
Dissolved Inorganics															
Orthophosphate (as P) (mg/L)	0.087	-	-	0.0531	0.0217	0.0527	0.0735	0.0654	0.0264	0.0438	0.0727	0.0704	0.034	0.0273	0.0652
Phosphorus (P), Total Dissolved (mg/L)	0.087	-	-	0.058	0.0253	0.0527	0.0733	0.0634	0.0312	0.0462	0.0732	0.0734	0.0353	0.0295	0.0682
Inorganics															
Ammonia (mg/L)	0.065	-	-	0.035	***0.088***	<0.020	<0.020	0.012	0.0478	0.0182	0.0057	<0.005	0.027	0.0101	<0.020
Nitrate (mg/L)	5.23	-	16	<0.50	<0.500	<0.500	***6.4***	1.9	<0.500	3.5	0.84	<0.500	<0.500	<0.500	<0.500
Nitrite (mg/L)	0.978	-	-	<0.10	0.23	<0.100	<0.500	0.27	0.21	<0.500	<0.100	<0.100	<0.100	<0.100	<0.100
Silicon Dioxide (mg/L)	-	-	-	2.8	2.5	-	-	-	1.2	-	-	-	-	2	3
Total Inorganics															
Chlorine (mg/L)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Phosphorus (P) (mg/L)	-	-	-	0.0634	0.0418	0.0604	0.0766	0.0687	0.0409	0.0501	0.0811	0.0775	0.042	0.0368	0.0694
Total Kjeldahl Nitrogen (mg/L)	0.434	-	-	0.155	***0.585***	0.289	0.217	0.232	0.187	0.117	<0.050	0.051	0.236	0.11	0.123
Total Nitrogen (mg/L)	5.92	-	-	<0.70	0.81	<0.700	***6.6***	2.41	<5.000	3.6	0.84	<0.700	0.13	<0.700	0.51
Organics															
Organic Nitrogen (mg/L)	0.392	-	-	0.12	***0.497***	-	0.217	0.22	0.139	0.099	<0.060	<0.060	0.209	0.1	-
Microbiological Analysis															
Chlorophyll A	5.11	-	-	1.26	***6.42***	0.96	0.504	1.5	1.01	1.11	0.304	0.17	0.25	0.209	0.397
Dissolved Metals															
Iron	-	-	-	-	<10	<300	<10	<10	22	<10	12	<10	<10	<10	<10

Parameter	SWDP05A-13	SWDP05A-14	SWDP05A-15	SWDP05A-16	SWDP05A-17	SWDP05A-18	SWDP05A-19	SWDP05A-20	SWDP05A-21	SWDP05A-22	SWDP05A-23	SWDP05A-24
Date Sampled:	08/03/2010	07/06/2010	30/08/2010	02/12/2010	03/03/2011	08/06/2011	06/09/2011	07/11/2011	20/02/2012	29/05/2012	05/09/2012	10/12/2012
Sample Info												
Sample Depth, Below Water Surface (m)	0.5	0.5	0.5	0.5	1	0.5	0.5	0.5	1	3, 3	0.5	0.5
Field Tests												
Secchi Depth (m)	-	-	-	3	-	-	-	2	5	1.5	2	3.75
Field Temperature (ºC)	-	-	14.76	8.34	6.81	14.2	14.73	8.48	7.07	10.07	12.88	8.13
Field pH	-	-	8.1	7.72	7.79	7.95	8.14	7.66	7.7	7.66	7.82	7.7
Field Conductivity (uS/cm)	-	-	39300	45216	44945	12934	29150	32550	30950	44060	31860	41760
Field Dissolved Oxygen (mg/L)	-	-	9.4	9.1	9.49	10.16	12.6	9.87	9.59	9.01	9.84	8.26
Field Redox, Uncorrected (mV)	-	-	93.2	257.8	220.7	268.1	269.9	251.7	260.2	202.1	285.8	364.3
Field Turbidity (NTU)	-	-	0.48	0.21	1.22	4.94	0.68	0.79	0.63	1.3	0.7	-
Physical Tests												
Hardness, Total (CaCO3) (mg/L)	-	-	4960	5670	5580	-	-	-	5090	-	-	-
Total Suspended Solids (mg/L)	45.3	16	10	16.3	4.2	7.6	5.7	<2.000	<2.000	3	<2.000	<2.000
Turbidity (NTU)	25	1.18	0.86	1.01	0.78	5.21	1.62	1.88	1.31	1.66	1.16	1.36
Dissolved Inorganics												
Orthophosphate (as P) (mg/L)	0.0556	0.0433	0.0319	0.0766	0.0649	0.0181	0.0181	0.0439	0.0693	0.0291	0.0443	0.0636
Phosphorus (P), Total Dissolved (mg/L)	0.0593	0.0468	0.038	0.0757	0.0643	0.0201	0.0563	0.0453	0.0711	0.0319	0.0488	0.0657
Inorganics												
Ammonia (mg/L)	0.016	0.0075	0.0109	<0.005	0.0236	0.0084	<0.005	0.0322	<0.005	0.0134	<0.005	0.0144
Nitrate (mg/L)	<0.500	<0.500	<0.500	0.7	0.56	<0.500	<0.500	<0.500	0.6	0.55	<0.500	0.57
Nitrite (mg/L)	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	0.11	<0.100
Silicon Dioxide (mg/L)	3	1.4	1.3	3.7	2.8	3	1.7	3.1	2.75	1.47	1.72	3.29
Total Inorganics												
Chlorine (mg/L)	-	-	<0.100	<0.100	<0.100	<0.100	-	-	-	-	-	-
Phosphorus (P) (mg/L)	0.089	0.0588	0.0482	0.0759	0.0737	0.0322	0.0533	0.0493	0.0737	0.0405	0.0584	0.071
Total Kjeldahl Nitrogen (mg/L)	0.25	0.17	0.258	0.051	<0.050	0.24	***0.56***	0.114	0.117	0.181	0.159	0.11
Total Nitrogen (mg/L)	<0.700	<0.700	<0.260	0.75	0.56	<0.260	0.56	<0.260	0.72	0.73	<0.510	0.68
Organics												
Organic Nitrogen (mg/L)	0.234	0.163	0.247	<0.060	<0.060	0.232	***0.56***	0.082	0.117	0.168	0.159	0.095
Microbiological Analysis												
Chlorophyll A	1.16	***6.6***	3.3	0.101	0.319	2.05	***7.72***	0.499	0.414	4.29	<0.010	0.504
Dissolved Metals												
Iron	<50	<50	<5	<10	<10	-	-	-	-	-	-	-

Table 10: AMS Surface Water Chemistry Results

Parameter	Nutrient Threshold [20]	BCWQG MAL [3,4]	CCME MAL [5,6]	SWDP05A-1	SWDP05A-2	SWDP05A-3	SWDP05A-4	SWDP05A-5	SWDP05A-6	SWDP05A-7	SWDP05A-8	SWDP05A-9	SWDP05A-10	SWDP05A-11	SWDP05A-12	SWDP05A-13	SWDP05A-14	SWDP05A-15	SWDP05A-16	SWDP05A-17	SWDP05A-18	SWDP05A-19	SWDP05A-20	SWDP05A-21	SWDP05A-22	SWDP05A-23	SWDP05A-24
Location ID:				DP05A																							
Date Sampled:				22/03/2007	20/06/2007	02/10/2007	10/12/2007	05/03/2008	30/05/2008	21/09/2008	27/11/2008	24/02/2009	20/05/2009	14/09/2009	03/12/2009	08/03/2010	07/06/2010	30/08/2010	02/12/2010	03/03/2011	08/06/2011	06/09/2011	07/11/2011	20/02/2012	29/05/2012	05/09/2012	10/12/2012
Total Metals																											
Aluminum	-	-	-	<100	<100	<100	<100	<100	160	<100	<100	<100	<100	<100	<100	330	24	12.2	14	15.3	-	-	-	7.7	-	-	-
Antimony	-	-	-	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<0.5	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-
Arsenic	-	12.5 [17]	12.5	1.11	1.24	1.28	1.25	1.17	1.26	1.19	1.49	1.28	1.26	1.89	1.28	<2	<2	<2	<2	<2	-	-	-	<2	-	-	-
Barium	-	200 [8]	-	10.8	12.6	8.6	8.9	7.5	7.5	9.4	8.2	8	9.9	10.1	8.6	12.3	9.5	8.7	9.2	8.9	-	-	-	9.4	-	-	-
Beryllium	-	100 [9]	-	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<0.5	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-
Bismuth	-	-	-	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<0.5	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-
Boron	-	1200 [4]	-	**3300**	**3000**	**3700**	**3500**	**3500**	**2800**	**3000**	**3700**	**4000**	**2900**	**3000**	**3200**	**3570**	**4080**	**3930**	**4640**	**4550**	-	-	-	**4660**	-	-	-
Cadmium	-	0.12 [7]	0.12	0.069	0.055	0.066	0.051	0.078	0.064	0.065	0.085	0.09	0.06	0.072	0.073	<0.12	<0.12	<0.12	0.068	0.081	-	-	-	0.052	-	-	-
Calcium	-	-	-	285000	228000	359000	350000	346000	300000	312000	350000	352000	312000	263000	309000	320000	349000	336000	371000	363000	-	-	-	335000	-	-	-
Cesium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-
Chromium	-	1.5 [10]	1.5	**<50**	**<50**	**<50**	**<50**	**<50**	**<50**	**<50**	**<50**	**<50**	**<50**	**52**	**<50**	<1	<1	<1	<0.7	<0.4	-	-	-	<0.5	-	-	-
Cobalt	-	-	-	0.082	0.059	0.064	<0.05	<0.05	0.098	0.064	<0.05	<0.05	0.095	<0.05	<0.05	<0.5	<0.5	<0.5	<0.05	<0.05	-	-	-	<0.05	-	-	-
Copper	-	3 [18]	-	**6.99**	0.636	0.615	0.617	0.924	1.37	0.666	0.652	1.09	1.57	1.23	0.706	2	1	<1	0.9	0.67	-	-	-	<0.5	-	-	-
Gallium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-
Iron	-	-	-	68	18	47	23	22	81	54	41	48	50	26	68	610	<50	<50	26	28	-	-	-	13	-	-	-
Lead	-	140 [18]	-	0.33	0.189	0.386	0.135	0.468	0.457	0.585	0.195	2.67	0.162	1.71	0.065	1.8	<1	<1	1.02	3.42	-	-	-	0.42	-	-	-
Lithium	-	-	-	<500	<500	<500	<500	<500	<500	<500	<500	<500	<500	<500	<500	159	156	161	163	171	-	-	-	173	-	-	-
Magnesium	-	-	-	887000	772000	1170000	1140000	1070000	893000	978000	1120000	1110000	966000	821000	975000	1010000	1080000	1000000	1150000	1140000	-	-	-	1030000	-	-	-
Manganese	-	100 [11]	-	6.48	7.97	5.43	2.28	2.49	8.43	5.85	3.33	2.21	7.05	6.86	3.44	14.8	3.45	3.54	3.05	1.91	-	-	-	2.34	-	-	-
Mercury	-	-	0.016	<0.010	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-	-	-	-	-	-	-
Molybdenum	-	-	-	6.9	7.1	9.4	9.5	7.2	6.5	9.8	8	10.6	9.6	7.5	7.1	9	8.5	8.7	9.7	9.6	-	-	-	10.5	-	-	-
Nickel	-	8.3 [12]	-	0.593	0.568	0.582	0.356	0.59	0.941	0.546	0.493	0.562	0.51	0.61	0.47	1.53	0.51	0.51	0.58	0.52	-	-	-	<0.5	-	-	-
Potassium	-	-	-	296000	239000	384000	374000	366000	277000	306000	316000	317000	285000	250000	300000	315000	313000	306000	351000	341000	-	-	-	326000	-	-	-
Rhenium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-
Rubidium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	92.6	86.7	85.2	99.3	103	-	-	-	102	-	-	-
Selenium	-	-	-	<0.50	0.62	<0.5	0.59	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<2	<2	<2	<2	<2	-	-	-	<2	-	-	-
Silicon	-	-	-	1580	1380	1380	1750	1550	850	1350	1730	1530	1020	1220	1670	3260	650	880	1620	1690	-	-	-	1580	-	-	-
Silver	-	3 [18]	-	<1.0	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<0.2	<0.2	<0.2	<0.1	<0.1	-	-	-	<0.1	-	-	-
Sodium	-	-	-	7620000	6280000	8700000	8370000	8590000	7800000	8060000	9750000	9720000	8130000	7500000	8610000	9200000	7890000	8640000	9740000	9590000	-	-	-	9210000	-	-	-
Strontium	-	-	-	5750	4330	7050	6170	5860	4790	5250	5670	6250	5000	4900	5770	6010	5620	5920	6760	6700	-	-	-	6090	-	-	-
Tellurium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-
Thallium	-	-	-	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<0.5	<0.5	<0.5	<0.05	<0.05	-	-	-	<0.05	-	-	-
Thorium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-
Tin	-	-	-	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<1	<1	<1	<1	<1	-	-	-	<1	-	-	-
Titanium	-	-	-	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	13.5	<5	<5	<5	<5	-	-	-	<5	-	-	-
Tungsten	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<1	<1	<1	<1	<1	-	-	-	<1	-	-	-
Uranium	-	100 [13]	-	1.92	1.32	2.05	1.74	2.19	1.81	2	2.56	2.39	1.82	1.93	2.12	2.6	2.51	2.38	2.7	2.57	-	-	-	2.57	-	-	-
Vanadium	-	50 [14]	-	**<100**	**<100**	**<100**	**<100**	**<100**	**<100**	**<100**	**<100**	**<100**	**<100**	**<100**	**<100**	2.41	1.46	1.44	1.51	1.47	-	-	-	1.72	-	-	-
Yttrium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-
Zinc	-	55 [19]	-	19	1.3	2.67	1.21	1.16	1.65	2.46	1.01	4.72	1.73	7.18	0.76	<5	<5	<5	<4	<3	-	-	-	<3	-	-	-
Zirconium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-

Table 10: AMS Surface Water Chemistry Results

Parameter	Nutrient Threshold [20]	BCWQG MAL [3,4]	CCME MAL [5,6]	SWDP05B-1	SWDP05B-2	SWDP05B-3	SWDP05B-4	SWDP05B-5	SWDP05B-6	SWDP05B-7	SWDP05B-8	SWDP05B-9	SWDP05B-10	SWDP05B-11	SWDP05B-12	SWDP05B-13	SWDP05B-14	SWDP05B-15	SWDP05B-16	SWDP05B-17	SWDP05B-18	SWDP05B-19	SWDP05B-20	SWDP05B-21	SWDP05B-22	SWDP05B-23	SWDP05B-24
			Location ID:	DP05B																							
			Date Sampled:	24/03/2007	20/06/2007	02/10/2007	10/12/2007	05/03/2008	30/05/2008	21/09/2008	27/11/2008	24/02/2009	20/05/2009	14/09/2009	03/12/2009	08/03/2010	07/06/2010	30/08/2010	02/12/2010	03/03/2011	08/06/2011	06/09/2011	07/11/2011	20/02/2012	29/05/2012	05/09/2012	10/12/2012
Sample Info																											
Sample Depth, Below Water Surface (m)		-	-	10	-	0.5	0.5	14	13	0.5	14	14	13	15	15	15	14	15.5	17	15	14	13	14.5	14	14	14	14.5
Field Tests																											
Secchi Depth (m)		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	2	5	1.5	2	3.75
Field Temperature (ºC)	-	-	-	7.3	-	10.1	7.54	7.22	11.66	11.14	9.13	7	9.3	11.43	8.75	-	-	12.39	8.38	6.68	10.24	12.02	9.32	7.2	9.36	10.5	8.42
Field pH	-	-	-	7.76	-	-	7.62	7.82	7.6	7.63	7.65	7.45	7.9	7.6	7.64	-	-	8.07	7.7	7.6	7.74	7.83	7.58	7.7	7.69	7.6	7.75
Field Conductivity (uS/cm)	-	-	-	45143	-	33099	44917	46613	42172	45770	33418	30189	47097	45499	45616	-	-	42400	45886	44703	32712	32013	45978	31500	45743	31170	43090
Field Dissolved Oxygen (mg/L)	6.02 [21]	-	-	16.92	-	***6.02***	10.86	7.66	9.06	6.42	6.08	10.08	8.96	6.55	8.29	-	-	7.48	9.93	10.19	9.47	9.24	7.32	8.86	8.47	7.12	7.72
Field Redox, Uncorrected (mV)	-	-	-	227.2	-	251	230	-73.5	206.9	-66	-305.7	-351.2	210.9	258.1	145.5	-	-	93.6	259.2	220.8	275.2	276.6	242.4	254.4	199.7	282	342.5
Field Turbidity (NTU)	-	-	-	10.19	-	-	-	-	-	-	1.11	0.9	2.2	0.1	0.61	-	-	0.75	0.17	0.78	2.67	1.16	0.25	0.4	1.2	0.37	-
Physical Tests																											
Hardness, Total (CaCO3) (mg/L)	-	-	-	-	5210	5120	-	5300	4790	5500	5600	5520	5440	5310	5060	-	-	5400	5700	5660	-	-	-	5260	-	-	-
Total Suspended Solids (mg/L)	-	-	-	20.2	36.5	51.7	14.8	12.9	19.9	11.3	4.4	-	27.8	17.7	19.2	6	16.7	17.3	13	12.2	9.2	6.6	<2.000	<2.000	4.4	3.9	33.5
Turbidity (NTU)	-	-	-	-	-	-	1.46	0.72	2.04	1.07	1.32	-	2.04	0.43	1.23	0.78	0.87	0.81	1.22	0.56	3.37	3.28	1.21	1.37	1.57	1.22	10.4
Dissolved Inorganics																											
Orthophosphate (as P) (mg/L)	0.087	-	-	0.062	0.0634	0.0708	0.0745	0.0713	0.0273	0.0608	0.0754	0.0706	0.04	0.0639	0.0705	0.0685	0.0655	0.0529	0.0759	0.0679	0.0484	0.0599	0.065	0.0717	0.0578	0.0595	0.0732
Phosphorus (P), Total Dissolved (mg/L)	0.087	-	-	0.0688	0.0648	0.0683	0.067	0.0704	0.0326	0.0622	0.0777	0.074	0.0414	0.0666	0.0704	0.0755	0.0669	0.0567	0.0758	0.069	0.0488	0.0628	0.0659	0.0734	0.0576	0.0655	0.077
Inorganics																											
Ammonia (mg/L)	0.065	-	-	<0.020	***0.076***	<0.020	<0.020	<0.005	0.0426	0.0125	<0.005	<0.005	0.023	0.0163	<0.020	<0.005	0.0183	0.0263	<0.005	0.0246	0.0297	0.0246	0.0076	<0.005	0.0411	0.0117	0.0143
Nitrate (mg/L)	5.23	-	16	0.3	<0.500	<0.500	***7***	2.39	<0.500	<2.500	***8.8***	<0.500	<0.500	<0.500	<0.500	<0.500	0.69	<0.500	1.07	<0.500	<0.500	<0.500	<0.500	0.67	0.65	0.62	0.55
Nitrite (mg/L)	0.978	-	-	<0.020	0.29	<0.100	<0.500	0.27	0.19	<0.500	***<1.000***	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	0.12	<0.100
Silicon Dioxide (mg/L)	-	-	-	2.3	2.3	-	-	-	<1.000	-	-	-	-	2.2	3	2.4	2	1.7	3.5	2.8	1.4	2.3	2.6	2.76	1.94	2.15	3.72
Total Inorganics																											
Chlorine (mg/L)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.100	<0.100	<0.100	<0.100	-	-	-	-	-	-
Phosphorus (P) (mg/L)	-	-	-	0.0705	0.0716	0.0713	0.0844	0.0726	0.0435	0.0638	0.078	0.0776	0.0507	0.0697	0.0751	0.0762	0.0742	0.062	0.0804	0.0752	0.0675	0.0798	0.0695	0.0808	0.0676	0.073	0.118
Total Kjeldahl Nitrogen (mg/L)	0.434	-	-	0.107	0.128	0.222	0.201	0.251	0.179	<0.050	0.074	0.058	0.188	0.079	0.122	0.128	0.066	0.31	<0.050	<0.050	0.242	0.417	0.086	0.088	0.143	0.127	0.167
Total Nitrogen (mg/L)	5.92	-	-	0.41	<0.700	<0.700	***7.2***	2.91	<5.000	<3.000	***8.9***	<0.700	0.28	<0.700	0.51	<0.700	0.75	0.31	1.07	<0.260	<0.260	0.42	<0.260	0.76	0.8	0.88	0.72
Organics																											
Organic Nitrogen (mg/L)	0.392	-	-	-	<0.070	-	0.201	0.251	0.136	<0.060	0.074	<0.060	0.165	0.063	-	0.128	<0.060	0.284	<0.060	<0.060	0.212	***0.392***	0.078	0.088	0.102	0.116	0.153
Microbiological Analysis																											
Chlorophyll A	5.11	-	-	0.5	1	4.96	0.422	0.722	1.95	1.03	0.142	0.266	2.11	0.462	0.295	0.706	1.46	1.54	0.202	0.301	2.57	2.21	0.316	0.375	1.13	0.073	0.813
Dissolved Metals																											
Iron	-	-	-	-	<10	<300	<10	<10	22	<10	14	<10	<10	<10	<10	<50	<50	<5	<10	<10	-	-	-	-	-	-	-

Table 10: AMS Surface Water Chemistry Results

Parameter	*Nutrient Threshold* [20]	BCWQG MAL [3,4]	CCME MAL [5,6]																								
			Location ID:	DP05B																							
			Sample ID:	SWDP05B-1	SWDP05B-2	SWDP05B-3	SWDP05B-4	SWDP05B-5	SWDP05B-6	SWDP05B-7	SWDP05B-8	SWDP05B-9	SWDP05B-10	SWDP05B-11	SWDP05B-12	SWDP05B-13	SWDP05B-14	SWDP05B-15	SWDP05B-16	SWDP05B-17	SWDP05B-18	SWDP05B-19	SWDP05B-20	SWDP05B-21	SWDP05B-22	SWDP05B-23	SWDP05B-24
			Date Sampled:	24/03/2007	20/06/2007	02/10/2007	10/12/2007	05/03/2008	30/05/2008	21/09/2008	27/11/2008	24/02/2009	20/05/2009	14/09/2009	03/12/2009	08/03/2010	07/06/2010	30/08/2010	02/12/2010	03/03/2011	08/06/2011	06/09/2011	07/11/2011	20/02/2012	29/05/2012	05/09/2012	10/12/2012
Total Metals																											
Aluminum	-	-	-	<100	<300	<100	<100	<100	130	<100	<100	<100	<100	<100	<100	<10	26	14.5	25.2	14	-	-	-	10.3	-	-	-
Antimony	-	-	-	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<0.5	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-
Arsenic	-	12.5 [17]	12.5	1.26	1.16	1.05	0.88	1.31	0.84	1.19	1.51	1.41	1.41	1.89	1.3	<2	<2	<2	<2	<2	-	-	-	<2	-	-	-
Barium	-	200 [8]	-	9.3	21.2	7.1	8.3	7	6	8.3	7.8	7.7	6.8	7.9	8.3	8.8	9.7	9.4	8.5	8.8	-	-	-	8.8	-	-	-
Beryllium	-	100 [9]	-	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<0.5	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-
Bismuth	-	-	-	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<0.5	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-
Boron	-	1200 [4]	-	**3800**	**3900**	**3500**	**3500**	**3700**	**3100**	**3500**	**3600**	**4000**	**3300**	**3900**	**3500**	**4170**	**4510**	**4280**	**4700**	**4440**	-	-	-	**4700**	-	-	-
Cadmium	-	0.12 [7]	0.12	0.064	0.064	0.054	0.062	0.085	0.073	0.073	0.088	0.083	0.07	0.086	0.069	<0.12	<0.12	<0.12	0.073	0.08	-	-	-	0.069	-	-	-
Calcium	-	-	-	345000	309000	395000	359000	348000	320000	357000	364000	356000	351000	346000	327000	346000	365000	360000	378000	357000	-	-	-	339000	-	-	-
Cesium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-
Chromium	-	1.5 [10]	1.5	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	54	<50	<1	<1	<1	<0.7	<0.4	-	-	-	<0.5	-	-	-
Cobalt	-	-	-	<0.050	0.052	<0.05	<0.05	<0.05	0.086	<0.05	<0.05	<0.05	0.075	<0.05	<0.05	<0.5	<0.5	<0.5	<0.05	<0.05	-	-	-	<0.05	-	-	-
Copper	-	3 [18]	-	0.496	0.562	0.389	0.507	0.721	0.974	0.408	0.561	0.464	0.532	0.552	0.413	<1	<1	<1	0.93	0.53	-	-	-	<0.5	-	-	-
Gallium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-
Iron	-	-	-	29	51	22	38	27	109	35	46	30	45	24	38	<50	<50	<50	41	24	-	-	-	16	-	-	-
Lead	-	140 [18]	-	0.119	0.373	0.094	0.081	0.315	0.387	0.139	1.29	0.243	0.091	<0.6	<0.05	<1	<1	<1	0.85	0.76	-	-	-	<0.3	-	-	-
Lithium	-	-	-	<500	<500	<500	<500	<500	<500	<500	<500	<500	<500	<500	<500	179	169	170	165	167	-	-	-	173	-	-	-
Magnesium	-	-	-	1090000	1080000	1290000	1170000	1080000	970000	1120000	1140000	1120000	1110000	1080000	1030000	1090000	1200000	1090000	1160000	1130000	-	-	-	1070000	-	-	-
Manganese	-	100 [11]	-	2.47	3.58	2.31	2.89	1.76	7.02	3.68	2.59	1.96	2.78	3.32	3.2	2.1	2.49	3.08	2.88	1.76	-	-	-	1.86	-	-	-
Mercury	-	-	0.016	<0.010	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-	-	-	-	-	-	-
Molybdenum	-	-	-	8.9	9.4	8.2	10.5	8.7	7.8	9.8	8.5	9.7	11.2	9.5	8.4	10.2	9.4	9.9	9.4	9.5	-	-	-	10.5	-	-	-
Nickel	-	8.3 [12]	-	0.64	0.52	0.416	0.425	0.565	0.735	0.479	0.481	0.475	0.377	0.418	0.46	<0.5	<0.5	0.5	0.58	0.67	-	-	-	<0.5	-	-	-
Potassium	-	-	-	348000	329000	415000	387000	371000	298000	352000	319000	328000	325000	326000	314000	336000	350000	336000	354000	334000	-	-	-	332000	-	-	-
Rhenium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-
Rubidium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	107	95.5	91.7	100	98.1	-	-	-	104	-	-	-
Selenium	-	-	-	<0.50	<0.5	0.69	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.76	<0.5	<2	<2	<2	<2	<2	-	-	-	<2	-	-	-
Silicon	-	-	-	1340	1380	1560	1810	1530	750	1470	1630	1600	720	1340	1620	1200	1160	1140	1740	1680	-	-	-	1480	-	-	-
Silver	-	3 [18]	-	<1.0	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<0.2	<0.2	<0.2	<0.1	<0.1	-	-	-	<0.1	-	-	-
Sodium	-	-	-	8230000	8620000	9380000	8660000	8660000	8200000	9270000	9900000	9930000	9210000	9800000	8980000	9320000	9390000	9350000	9940000	9420000	-	-	-	9330000	-	-	-
Strontium	-	-	-	6680	6300	6460	6290	5700	5320	6340	5730	6420	5970	6450	6280	6520	6790	6500	6840	6530	-	-	-	6210	-	-	-
Tellurium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-
Thallium	-	-	-	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<0.5	<0.5	<0.5	<0.05	<0.05	-	-	-	<0.05	-	-	-
Thorium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-
Tin	-	-	-	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<1	<1	<1	<1	<1	-	-	-	<1	-	-	-
Titanium	-	-	-	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<5	<5	<5	<5	<5	-	-	-	<5	-	-	-
Tungsten	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<1	<1	<1	<1	<1	-	-	-	<1	-	-	-
Uranium	-	100 [13]	-	1.97	1.28	1.82	1.87	2.4	2.29	2.27	2.65	2.36	2.05	2.48	1.74	2.62	2.74	2.56	2.61	2.57	-	-	-	2.68	-	-	-
Vanadium	-	50 [14]	-	**<100**	**<100**	**<100**	**<100**	**<100**	**<100**	**<100**	**<100**	**<100**	**<100**	**<100**	**<100**	1.52	1.55	1.48	1.5	1.49	-	-	-	1.75	-	-	-
Yttrium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-
Zinc	-	55 [19]	-	1.09	2.1	0.67	1	1.24	2.2	1.02	0.9	1.1	1.71	1.79	0.62	<5	<5	<5	<4	3.1	-	-	-	<3	-	-	-
Zirconium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-

Table 10: AMS Surface Water Chemistry Results

Parameter	*Nutrient Threshold* [20]	BCWQG MAL [3,4]	CCME MAL [5,6]	SWDP06-1	SWDP06-2	SWDP06-3	SWDP06-4	SWDP06-5	SWDP06-6	SWDP06-7	SWDP06-8	SWDP06-9	SWDP06-10	SWDP06-11	SWDP06-12
Location ID:				DP06											
Date Sampled:				23/03/2007	20/06/2007	01/10/2007	10/12/2007	04/03/2008	29/05/2008	20/09/2008	26/11/2008	23/02/2009	20/05/2009	15/09/2009	03/12/2009
Sample Info															
Sample Depth, Below Water Surface (m)		-	-	0.5	-	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	3	0.5
Field Tests															
Secchi Depth (m)		-	-	-	-	0.6	0.9	0.4	-	0.5	1	-	-	-	-
Field Temperature (ºC)	-	-	-	6.4	-	12.4	3.96	6.23	6.4	13.51	7.74	6.08	14.63	17.44	5.51
Field pH	-	-	-	7.81	-	6.5	7.45	7.97	7.81	7.83	7.47	7.69	8.24	7.8	6.73
Field Conductivity (uS/cm)	-	-	-	20042	-	4877	11517	24116	20042	23071	24000	19360	10344	14450	15133
Field Dissolved Oxygen (mg/L)	6.02 [21]	-	-	11.4	-	10.4	12.26	10.55	11.4	9.35	9.95	10.39	10.38	11.09	13.94
Field Redox, Uncorrected (mV)	-	-	-	207	-	212	176	-64.9	207	-22	-273.9	265.2	168.4	167.8	189.9
Field Turbidity (NTU)	-	-	-	18.92	-	-	-	-	-	-	5.48	1.7	24	5.6	8.27
Physical Tests															
Hardness, Total (CaCO3) (mg/L)	-	-	-	1950	212	615	-	2530	139	2640	1710	3940	767	1610	1800
Total Suspended Solids (mg/L)	-	-	-	12.7	28.5	12.9	12.2	25.3	94.7	35.3	9.1	-	19.8	-	19.8
Turbidity (NTU)	-	-	-	-	-	-	8.75	14	86.3	16.5	7.93	-	25.9	7.15	10.9
Dissolved Inorganics															
Orthophosphate (as P) (mg/L)	0.087	-	-	0.0237	0.0067	0.016	0.0224	0.031	-	0.0264	0.0267	0.0446	0.0138	0.0214	0.0259
Phosphorus (P), Total Dissolved (mg/L)	0.087	-	-	0.027	0.008	0.0167	0.0218	0.0306	-	0.0284	0.0277	0.0424	0.0153	0.0215	0.0263
Inorganics															
Ammonia (mg/L)	0.065	-	-	0.041	0.056	***0.1***	***0.071***	***0.0814***	***0.242***	0.0365	***0.0815***	0.0597	0.042	0.051	***0.073***
Nitrate (mg/L)	5.23	-	16	0.19	0.0634	0.49	***12***	1.59	<0.500	<0.500	<0.500	<2.500	<0.250	<0.250	<0.500
Nitrite (mg/L)	0.978	-	-	<0.020	<0.001	<0.020	<0.500	0.11	<0.100	0.13	<0.100	0.56	<0.050	<0.050	<0.100
Silicon Dioxide (mg/L)	-	-	-	3.7	4.9	-	-	-	-	-	4.4	-	-	3	4.4
Total Inorganics															
Chlorine (mg/L)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Phosphorus (P) (mg/L)	-	-	-	0.0486	0.0477	0.0298	0.0343	0.0528	-	0.0602	0.0415	0.0523	0.0404	0.0292	0.0497
Total Kjeldahl Nitrogen (mg/L)	0.434	-	-	0.214	0.312	0.2	0.186	0.343	0.247	0.137	0.284	0.147	<0.050	0.108	0.167
Total Nitrogen (mg/L)	5.92	-	-	0.41	0.375	0.69	***12.2***	2.04	<0.700	<0.700	<0.700	<3.000	0.26	<0.400	0.42
Organics															
Organic Nitrogen (mg/L)	0.392	-	-	-	0.256	-	0.115	0.261	<0.070	0.1	0.203	0.087	<0.070	<0.070	-
Microbiological Analysis															
Chlorophyll A	5.11	-	-	0.847	0.554	0.932	0.267	1.07	0.747	0.964	0.389	0.622	0.123	0.251	0.358
Dissolved Metals															
Iron	-	-	-	-	21	-	11	<10	59	<10	19	<10	23	11	14

Parameter	SWDP06-13	SWDP06-14	SWDP06-15	SWDP06-16	SWDP06-17	SWDP06-18	SWDP06-19	SWDP06-20	SWDP06-21	SWDP06-22	SWDP06-23	SWDP06-24
Location ID:	DP06											
Date Sampled:	08/03/2010	07/06/2010	30/08/2010	02/12/2010	04/03/2011	08/06/2011	06/09/2011	07/11/2011	20/02/2012	29/05/2012	05/09/2012	06/12/2012
Sample Info												
Sample Depth, Below Water Surface (m)	0.5	0.5	0.5	0.5	1	0.25	1	0.5	1	1.9	0.5	0.5
Field Tests												
Secchi Depth (m)	-	-	-	1.1	-	-	-	1.2	2.7 (bottom)	0.25	0.75	1.5
Field Temperature (ºC)	-	-	14.98	6.02	4.47	13.66	16.98	7.75	6.5	12.78	14.47	7.75
Field pH	-	-	7.1	7.74	7.81	6.38	7.73	7.77	7.81	8.94	7.71	7.77
Field Conductivity (uS/cm)	-	-	20580	28438	29578	80300	6297	22722	25054	746	18750	31920
Field Dissolved Oxygen (mg/L)	-	-	9.23	11.06	12.39	11.78	10.24	10.87	10.64	11.08	9.05	9.25
Field Redox, Uncorrected (mV)	-	-	8.5	165.9	340	205.3	187.4	229.3	268.5	106.9	221.6	351.4
Field Turbidity (NTU)	-	-	3.55	3.43	5.03	43.8	7.87	1.87	1.31	32.8	3.54	-
Physical Tests												
Hardness, Total (CaCO3) (mg/L)	-	-	2530	3290	3470	-	-	-	4280	-	-	-
Total Suspended Solids (mg/L)	67.3	10.7	13.3	7.7	9.6	65.7	11.7	4.4	2.2	47.2	9.9	19.2
Turbidity (NTU)	23.3	13.9	4.95	4.61	5.38	53.1	10.4	4.28	2.12	30.9	7.93	6.45
Dissolved Inorganics												
Orthophosphate (as P) (mg/L)	0.0576	0.0095	0.0265	0.0504	0.0453	0.0068	0.0143	0.0324	0.0576	0.0059	0.0223	0.0603
Phosphorus (P), Total Dissolved (mg/L)	0.0644	0.011	0.0303	0.0512	0.0466	0.0099	0.0162	0.0338	0.0601	0.0066	0.0247	0.0597
Inorganics												
Ammonia (mg/L)	0.02	0.0231	0.0595	***0.0654***	***0.0674***	0.0154	0.0488	0.0503	0.0192	0.011	0.0412	0.0168
Nitrate (mg/L)	<0.500	0.112	<0.500	0.64	<0.500	0.0749	<0.250	<0.500	0.65	0.2	<0.500	<0.500
Nitrite (mg/L)	<0.100	<0.010	<0.100	<0.100	<0.100	<0.001	<0.050	<0.100	<0.100	<0.020	<0.100	<0.100
Silicon Dioxide (mg/L)	3	4.7	2.7	4.9	3.8	6.2	4	3.7	3.18	5.73	3.45	2.94
Total Inorganics												
Chlorine (mg/L)	-	-	<0.100	<0.100	<0.100	0.39	-	-	-	-	-	-
Phosphorus (P) (mg/L)	0.099	0.0264	0.0443	0.0635	0.0561	0.0714	0.0329	0.0421	0.0653	0.0579	0.0367	0.0796
Total Kjeldahl Nitrogen (mg/L)	0.152	0.067	0.277	0.125	0.187	0.262	0.213	0.138	0.124	0.189	0.154	0.117
Total Nitrogen (mg/L)	<0.700	0.18	0.28	0.77	<0.260	0.337	0.213	<0.260	0.77	0.391	<0.510	<0.510
Organics												
Organic Nitrogen (mg/L)	0.132	<0.060	0.217	<0.060	0.12	0.247	0.164	0.087	0.105	0.178	0.112	0.101
Microbiological Analysis												
Chlorophyll A	1.33	0.453	0.704	0.272	0.248	0.301	0.223	0.285	0.669	1.24	<0.010	0.346
Dissolved Metals												
Iron	<50	<50	<5	<10	<10	-	-	-	-	-	-	-

Table 10: AMS Surface Water Chemistry Results

			Location ID:	DP06																							
			Sample ID:	SWDP06-1	SWDP06-2	SWDP06-3	SWDP06-4	SWDP06-5	SWDP06-6	SWDP06-7	SWDP06-8	SWDP06-9	SWDP06-10	SWDP06-11	SWDP06-12	SWDP06-13	SWDP06-14	SWDP06-15	SWDP06-16	SWDP06-17	SWDP06-18	SWDP06-19	SWDP06-20	SWDP06-21	SWDP06-22	SWDP06-23	SWDP06-24
			Date Sampled:	23/03/2007	20/06/2007	01/10/2007	10/12/2007	04/03/2008	29/05/2008	20/09/2008	26/11/2008	23/02/2009	20/05/2009	15/09/2009	03/12/2009	08/03/2010	07/06/2010	30/08/2010	02/12/2010	04/03/2011	08/06/2011	06/09/2011	07/11/2011	20/02/2012	29/05/2012	05/09/2012	06/12/2012
Parameter	***Nutrient Threshold*** [20]	**BCWQG MAL** [3,4]	**CCME MAL** [5,6]																								
Total Metals																											
Aluminum	-	-	-	226	1110	170	200	282	1170	<500	181	<100	523	151	367	364	370	86.7	83.5	81.9	-	-	-	18.3	-	-	-
Antimony	-	-	-	<5	<0.5	<10	<2	<5	<0.2	<10	<5	<10	<2	<5	<5	<0.5	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-
Arsenic	-	12.5 [17]	12.5	0.86	0.43	0.69	0.61	0.77	0.52	0.81	0.74	1.06	0.7	1.6	0.73	<2	<2	<2	<2	<2	-	-	-	<2	-	-	-
Barium	-	200 [8]	-	17.8	22	20.3	19	16.2	24.2	13.7	15.5	12.3	27.7	15.2	15.8	12.6	16.4	14.1	13.5	14.2	-	-	-	11.8	-	-	-
Beryllium	-	100 [9]	-	<25	<2.5	<50	<10	<25	<1	<50	<25	<50	<10	<25	<25	<0.5	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-
Bismuth	-	-	-	<25	<2.5	<50	<10	<25	<1	<50	<25	<50	<10	<25	<25	<0.5	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-
Boron	-	1200 [4]	-	**1310**	129	<1000	740	**1760**	65	**1700**	1120	**2700**	490	1120	**1220**	**3480**	390	**2060**	**2890**	**2950**	-	-	-	**3870**	-	-	-
Cadmium	-	0.12 [7]	0.12	0.051	0.028	0.032	0.032	0.052	0.045	0.046	0.045	0.081	0.033	0.033	0.047	<0.12	<0.12	<0.12	0.082	0.084	-	-	-	0.058	-	-	-
Calcium	-	-	-	133000	24500	49400	79900	168000	19300	170000	111000	246000	53400	110000	117000	312000	39000	166000	213000	227000	-	-	-	277000	-	-	-
Cesium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-
Chromium	-	1.5 [10]	1.5	**<25**	**4.1**	**<50**	**<10**	**<25**	**2.2**	**<50**	**<25**	**<50**	**<10**	**<25**	**<25**	<1	<1	<1	<0.7	<0.4	-	-	-	<0.5	-	-	-
Cobalt	-	-	-	0.252	0.394	0.189	0.161	0.252	1.2	0.398	0.147	0.054	0.37	0.159	0.238	<0.5	<0.5	<0.5	0.113	0.153	-	-	-	0.052	-	-	-
Copper	-	3 [18]	-	**3.27**	2.07	**6.45**	1.12	2.01	**6.45**	1.57	1.07	1.19	2.89	0.95	1.52	2.6	2	1.2	1.1	1.08	-	-	-	0.76	-	-	-
Gallium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-
Iron	-	-	-	300	369	161	218	329	1350	599	231	53	467	159	310	737	423	133	165	168	-	-	-	39	-	-	-
Lead	-	140 [18]	-	1.95	0.349	3.1	0.171	1.11	1.47	0.58	0.169	3.11	0.571	<0.15	0.306	<1	<1	<1	0.46	0.85	-	-	-	<0.3	-	-	-
Lithium	-	-	-	<250	<25	<500	<100	<250	<10	<500	<250	<500	<100	<250	<250	156	<20	82	97	107	-	-	-	140	-	-	-
Magnesium	-	-	-	393000	36600	119000	225000	513000	22100	539000	348000	807000	154000	324000	367000	951000	87600	514000	670000	705000	-	-	-	871000	-	-	-
Manganese	-	100 [11]	-	22.8	38.8	39.1	21.9	21.3	74	23.9	18.8	11.2	27.7	21.9	28	18.9	25.6	16.1	15.8	13.4	-	-	-	7.29	-	-	-
Mercury	-	-	0.016	<0.01	<0.01	<0.01	<0.01	<0.01	0.017	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-	-	-	-	-	-	-
Molybdenum	-	-	-	2.6	1.26	<5	2.3	5.1	0.62	5.3	3.1	5.6	2.3	3	<2.5	8.8	<2	4.8	6	6.5	-	-	-	8.5	-	-	-
Nickel	-	8.3 [12]	-	1.16	1.43	0.953	0.834	1.32	4.47	1.57	0.928	0.762	1.63	0.715	1.26	2	1.23	0.77	0.93	1.09	-	-	-	0.56	-	-	-
Potassium	-	-	-	123000	12000	37000	75000	178000	7000	170000	104000	226000	44200	97000	112000	277000	25300	155000	201000	213000	-	-	-	268000	-	-	-
Rhenium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-
Rubidium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	90.4	8.2	44.1	60	64.2	-	-	-	84	-	-	-
Selenium	-	-	-	<0.5	0.61	0.8	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<2	<2	<2	<2	<2	-	-	-	<2	-	-	-
Silicon	-	-	-	2320	3330	2250	2840	2620	5340	2890	2810	1920	4810	2150	3130	2990	4280	1750	2210	2360	-	-	-	1820	-	-	-
Silver	-	3 [18]	-	<0.5	<0.05	<1	<0.2	<0.5	0.022	<1	<0.5	<1	<0.2	<0.5	<0.5	<0.2	<0.2	<0.2	<0.1	<0.1	-	-	-	<0.1	-	-	-
Sodium	-	-	-	3090000	257000	905000	1890000	4140000	162000	5040000	3140000	7120000	1200000	2720000	2910000	8360000	728000	4110000	5560000	5580000	-	-	-	7500000	-	-	-
Strontium	-	-	-	2080	253	869	1320	2860	164	3020	1860	5440	900	1850	2070	5490	554	3050	3910	4170	-	-	-	5030	-	-	-
Tellurium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-
Thallium	-	-	-	<5	<0.5	<10	<2	<5	<0.2	<10	<5	<10	<2	<5	<5	<0.5	<0.5	<0.5	<0.05	<0.05	-	-	-	<0.05	-	-	-
Thorium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-
Tin	-	-	-	<5	2.22	<10	<2	<5	<0.2	<10	<5	<10	<2	<5	<5	<1	<1	<1	<1	<1	-	-	-	<1	-	-	-
Titanium	-	-	-	<100	25	<100	<100	<100	53	<100	<100	<100	46	<100	<100	16	13.3	<5	<5	<5	-	-	-	<5	-	-	-
Tungsten	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<1	<1	<1	<1	<1	-	-	-	<1	-	-	-
Uranium	-	100 [13]	-	0.937	0.221	0.432	0.58	1.34	0.263	1.26	0.872	1.72	0.453	0.842	0.833	2.49	<0.5	1.29	1.66	1.76	-	-	-	2.15	-	-	-
Vanadium	-	50 [14]	-	<50	5	**<100**	<20	<50	3.5	**<100**	<50	**<100**	<20	<50	<50	2.33	1.23	0.98	1.18	1.18	-	-	-	1.5	-	-	-
Yttrium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-
Zinc	-	55 [19]	-	3.65	1.82	4.83	2.68	2.19	8.68	2.81	2.76	2.97	3.19	1.54	147	7.8	<5	<5	<4	<3	-	-	-	<3	-	-	-
Zirconium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-

Table 10: AMS Surface Water Chemistry Results

Parameter	Nutrient Threshold [20]	BCWQG MAL [3,4]	CCME MAL [5,6]	SWDP07A-1	SWDP07A-2	SWDP07A-3	SWDP07A-4	SWDP07A-5	SWDP07A-6	SWDP07A-7	SWDP07A-8	SWDP07A-9	SWDP07A-10	SWDP07A-11	SWDP07A-12	SWDP07A-13	SWDP07A-14	SWDP07A-15	SWDP07A-16	SWDP07A-17	SWDP07A-18	SWDP07A-19	SWDP07A-20	SWDP07A-21	SWDP07A-22	SWDP07A-23	SWDP07A-24
Location ID:				DP07A																							
Date Sampled:				24/03/2007	20/06/2007	01/10/2007	10/12/2007	04/03/2008	29/05/2008	20/09/2008	26/11/2008	23/02/2009	20/05/2009	14/09/2009	03/12/2009	08/03/2010	07/06/2010	30/08/2010	02/12/2010	04/03/2011	08/06/2011	06/09/2011	07/11/2011	20/02/2012	29/05/2012	05/09/2012	10/12/2012
Sample Info																											
Sample Depth, Below Water Surface (m)		-	-	0.5	-	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	1	0.5	0.5	0.5	2	3, 3	0.5	0.5
Field Tests																											
Secchi Depth (m)		-	-	-	-	5.2	2	1.8	-	1	1.2	-	-	-	-	-	-	-	2.1	-	-	-	2.5	4.5	0.25	1.5	0.5
Field Temperature (ºC)	-	-	-	7.85	-	10.8	6.62	6.27	12.05	13.36	8.07	7.2	10.64	16.19	7.01	-	-	16.68	7.06	6.03	13.31	15.62	8.25	6.55	11.57	14.03	7.17
Field pH	-	-	-	7.8	-	-	7.64	7.94	6.1	7.6	7.78	7.69	7.77	7.85	7.63	-	-	8.13	7.65	7.78	7.28	7.91	7.76	7.63	7.98	7.88	7.94
Field Conductivity (uS/cm)	-	-	-	43933	-	32350	39268	23905	48340	31003	25693	41521	13999	31966	30289	-	-	17400	40000	41139	19190	26236	31266	25278	38272	25150	36350
Field Dissolved Oxygen (mg/L)	6.02 [21]	-	-	9.27	-	8.27	10.1	11.81	9.27	8.2	9.6	9.62	10.85	9.52	10.51	-	-	9.3	11.59	9.16	10.86	11.08	10.52	9.96	9.67	9.16	9.58
Field Redox, Uncorrected (mV)	-	-	-	180.3	-	257	172	-74	290.5	135	-276.2	-329.4	250.1	217.6	192.5	-	-	58.2	250	267.5	233.8	302.5	224.2	230.9	175.9	310	299.8
Field Turbidity (NTU)	-	-	-	1.2	-	-	-	-	-	-	5.45	1.1	23	1.1	1.49	-	-	3.08	0.14	2.17	24.5	2.22	0.83	0.51	3.1	0.95	-
Physical Tests																											
Hardness, Total (CaCO3) (mg/L)	-	-	-	-	2140	5110	-	2510	484	3380	5840	4830	992	3590	4090	-	-	1940	4850	4310	-	-	-	4490	-	-	-
Total Suspended Solids (mg/L)	-	-	-	33.6	21.2	3.7	22.2	12.7	48.7	6	11.8	-	25.8	11.7	17.8	21.3	10.7	5.3	16.3	8.2	32	6.5	5.6	4.4	6.4	3.7	<3.000
Turbidity (NTU)	-	-	-	-	-	-	2.21	4.88	50	4.86	7.07	-	28	1.44	2.1	10.8	8.33	3.25	2.33	1.95	25.9	3.92	1.64	1.61	4.04	2.47	1.32
Dissolved Inorganics																											
Orthophosphate (as P) (mg/L)	0.087	-	-	0.0578	0.0091	0.0672	0.0618	0.0356	-	0.0302	0.0253	0.0548	0.0139	0.0209	0.056	0.0608	0.015	0.0206	0.0677	0.0563	0.0158	0.0218	0.0438	0.0629	0.0203	0.0329	0.0529
Phosphorus (P), Total Dissolved (mg/L)	0.087	-	-	0.0618	0.0134	0.0624	0.0603	0.0338	-	0.0336	0.0258	0.0517	0.0161	0.0218	0.0585	0.0671	0.0184	0.0227	0.0676	0.0595	0.0151	0.0252	0.0441	0.0646	0.0223	0.0373	0.0577
Inorganics																											
Ammonia (mg/L)	0.065	-	-	0.028	0.023	0.0067	<0.020	***0.0974***	0.028	0.0372	***0.0848***	0.0116	0.046	0.0118	<0.020	<0.005	0.0282	***0.0721***	0.018	0.0376	0.0153	0.0112	0.0338	0.0151	0.017	0.0091	0.0226
Nitrate (mg/L)	5.23	-	16	0.25	0.79	1.93	***7.4***	1.75	<0.500	<0.500	0.218	<0.500	<0.250	<0.500	<0.500	0.0068	<0.500	<0.500	0.75	<0.500	<0.250	0.53	<0.500	0.66	<0.500	<0.500	0.97
Nitrite (mg/L)	0.978	-	-	<0.020	<0.100	<0.100	<0.500	0.14	<0.100	0.15	0.022	<0.100	<0.050	<0.100	<0.100	<0.001	<0.100	<0.100	<0.100	<0.100	<0.050	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100
Silicon Dioxide (mg/L)	-	-	-	2.1	3.2	-	-	-	-	-	4.7	-	-	2	3.1	2.6	3.7	3	3.7	3.4	4.9	2.5	3.1	3.18	2.12	2.27	3.48
Total Inorganics																											
Chlorine (mg/L)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.100	<0.100	<0.100	0.2	-	-	-	-	-	-
Phosphorus (P) (mg/L)	-	-	-	0.0644	0.0352	0.0638	0.069	0.0452	-	0.0447	0.0349	0.0662	0.0447	0.0321	0.0616	0.0836	0.032	0.0293	0.0759	0.0638	0.0474	0.0383	0.0506	0.0692	0.0299	0.0445	0.062
Total Kjeldahl Nitrogen (mg/L)	0.434	-	-	0.075	0.23	0.233	0.143	0.31	0.146	0.115	0.296	0.096	0.258	0.074	0.119	0.087	<0.050	0.291	<0.050	0.118	0.267	***0.486***	0.116	0.119	0.156	0.155	0.133
Total Nitrogen (mg/L)	5.92	-	-	0.33	1.02	2.16	***7.6***	2.2	<0.700	<0.700	0.54	<0.700	0.46	<0.700	0.47	0.094	<0.700	0.29	0.75	<0.260	0.267	1.02	<0.260	0.78	<0.260	<0.510	1.1
Organics																											
Organic Nitrogen (mg/L)	0.392	-	-	-	0.207	-	0.143	0.213	0.119	0.078	0.211	0.084	0.212	0.062	-	0.087	<0.060	0.219	<0.060	0.08	0.252	***0.475***	0.082	0.104	0.139	0.146	0.11
Microbiological Analysis																											
Chlorophyll A	5.11	-	-	0.561	4.3	1.17	0.401	0.766	0.407	0.864	0.462	1.25	0.2	1.23	0.399	1.07	1.51	0.672	0.271	0.861	1.11	3.53	0.691	0.807	1.01	0.195	0.28
Dissolved Metals																											
Iron	-	-	-	-	<10	-	<10	<10	24	<10	18	<10	20	<10	<10	<50	<50	<5	<10	<10	-	-	-	-	-	-	-

Table 10: AMS Surface Water Chemistry Results

Parameter	Nutrient Threshold [20]	BCWQG MAL [3,4]	CCME MAL [5,6]	SWDP07A-1	SWDP07A-2	SWDP07A-3	SWDP07A-4	SWDP07A-5	SWDP07A-6	SWDP07A-7	SWDP07A-8	SWDP07A-9	SWDP07A-10	SWDP07A-11	SWDP07A-12	SWDP07A-13	SWDP07A-14	SWDP07A-15	SWDP07A-16	SWDP07A-17	SWDP07A-18	SWDP07A-19	SWDP07A-20	SWDP07A-21	SWDP07A-22	SWDP07A-23	SWDP07A-24
Location ID:				DP07A																							
Date Sampled:				24/03/2007	20/06/2007	01/10/2007	10/12/2007	04/03/2008	29/05/2008	20/09/2008	26/11/2008	23/02/2009	20/05/2009	14/09/2009	03/12/2009	08/03/2010	07/06/2010	30/08/2010	02/12/2010	04/03/2011	08/06/2011	06/09/2011	07/11/2011	20/02/2012	29/05/2012	05/09/2012	10/12/2012
Total Metals																											
Aluminum	-	-	-	<100	<400	<100	<100	102	723	<200	<200	<100	781	<100	<100	133	171	52.4	42.7	32.3	-	-	-	12.8	-	-	-
Antimony	-	-	-	<10	<5	<10	<10	<5	<1	<10	<10	<10	<2	<10	<10	<0.5	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-
Arsenic	-	12.5 [17]	12.5	1.34	0.92	1.06	1.11	1.12	0.65	0.65	0.42	1.22	0.74	1.17	1.11	<2	<2	<2	<2	<2	-	-	-	<2	-	-	-
Barium	-	200 [8]	-	10.6	17.9	8.5	10.3	14	21.2	11.7	14.6	10.2	23	10.4	10.6	10.5	15.2	14.1	10.3	11.3	-	-	-	10.9	-	-	-
Beryllium	-	100 [9]	-	<50	<25	<50	<50	<25	<5	<50	<50	<50	<10	<50	<50	<0.5	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-
Bismuth	-	-	-	<50	<25	<50	<50	<25	<5	<50	<50	<50	<10	<50	<50	<0.5	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-
Boron	-	1200 [4]	-	**3900**	**1560**	**4000**	**3000**	**1860**	300	**2100**	1000	**3500**	600	**2500**	**2800**	**4080**	**1500**	**1530**	**4220**	**3650**	-	-	-	**4070**	-	-	-
Cadmium	-	0.12 [7]	0.12	0.067	0.066	0.068	0.057	0.046	0.042	0.062	0.039	**0.166**	0.047	0.053	0.06	<0.12	<0.12	<0.12	0.077	0.079	-	-	-	0.057	-	-	-
Calcium	-	-	-	332000	133000	338000	296000	167000	41600	215000	371000	294000	68300	234000	257000	327000	124000	130000	321000	291000	-	-	-	295000	-	-	-
Cesium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-
Chromium	-	1.5 [10]	1.5	**<50**	**<25**	**<50**	**<50**	**<25**	**<5**	**<50**	**<50**	**<50**	**<10**	**55**	**<50**	<1	<1	<1	<0.7	<0.4	-	-	-	<0.5	-	-	-
Cobalt	-	-	-	<0.050	0.123	<0.05	0.056	0.108	0.864	0.181	0.131	<0.05	0.335	0.054	0.07	<0.5	<0.5	<0.5	0.062	0.052	-	-	-	<0.05	-	-	-
Copper	-	3 [18]	-	2.25	1.27	0.825	0.563	2.25	**4.38**	1.45	1.62	1.24	**3.04**	1.43	0.609	1.1	2.9	<1	**3.19**	1.05	-	-	-	<0.5	-	-	-
Gallium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-
Iron	-	-	-	36	92	<10	55	127	1020	240	205	28	443	29	62	275	243	76	80	67	-	-	-	24	-	-	-
Lead	-	140 [18]	-	1.06	0.601	0.368	0.085	0.657	0.841	0.172	0.882	0.792	0.816	<0.3	0.096	2.2	<1	<1	2.92	5.97	-	-	-	0.79	-	-	-
Lithium	-	-	-	<500	<250	<500	<500	<250	<50	<500	<500	<500	<100	<500	<500	174	57	62	147	137	-	-	-	147	-	-	-
Magnesium	-	-	-	1060000	439000	1040000	942000	508000	92300	690000	1190000	994000	199000	729000	838000	1070000	377000	393000	983000	870000	-	-	-	911000	-	-	-
Manganese	-	100 [11]	-	2.3	13.9	1.93	5.33	12.3	55.7	15.4	16.8	6.35	20.9	7.88	7.54	9.71	19.9	12.1	6.84	7.18	-	-	-	5.04	-	-	-
Mercury	-	-	0.016	<0.010	<0.01	<0.01	<0.01	<0.01	0.013	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-	-	-	-	-	-	-
Molybdenum	-	-	-	10.5	4.4	9.5	8.7	4.9	0.97	5.8	<5	8.7	2.9	5.2	6.1	9.4	3.6	4	8.6	7.8	-	-	-	8.9	-	-	-
Nickel	-	8.3 [12]	-	0.558	0.767	0.453	0.503	0.898	3.43	0.947	0.901	0.685	1.97	1.03	0.606	1.11	0.98	0.58	0.64	0.91	-	-	-	<0.5	-	-	-
Potassium	-	-	-	333000	137000	297000	318000	178000	28100	221000	354000	277000	56700	218000	248000	341000	113000	117000	299000	265000	-	-	-	288000	-	-	-
Rhenium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-
Rubidium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	101	32.3	33.1	89.1	79.6	-	-	-	89	-	-	-
Selenium	-	-	-	0.7	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<2	<2	<2	<2	<2	-	-	-	<2	-	-	-
Silicon	-	-	-	1120	1990	1350	1890	2180	3960	2090	1490	1640	5180	1210	1820	2020	2570	1810	1760	1960	-	-	-	1710	-	-	-
Silver	-	3 [18]	-	<1.0	<0.5	<1	<1	<0.5	<0.1	<1	<1	<1	<0.2	<1	<1	<0.2	<0.2	<0.2	<0.1	<0.1	-	-	-	<0.1	-	-	-
Sodium	-	-	-	7920000	3570000	8420000	7170000	4110000	753000	5800000	9170000	8700000	1610000	6210000	7190000	9800000	3000000	3140000	8270000	7610000	-	-	-	8110000	-	-	-
Strontium	-	-	-	6530	2520	7580	5190	2980	562	3690	1670	6780	1130	4050	4800	6360	2240	2340	5740	5120	-	-	-	5400	-	-	-
Tellurium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-
Thallium	-	-	-	<10	<5	<10	<10	<5	<1	<10	<10	<10	<2	<10	<10	<0.5	<0.5	<0.5	<0.05	<0.05	-	-	-	<0.05	-	-	-
Thorium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-
Tin	-	-	-	<10	<5	<10	<10	<5	<1	<10	<10	<10	<2	<10	<10	<1	<1	<1	<1	<1	-	-	-	<1	-	-	-
Titanium	-	-	-	<100	<50	<100	<100	<100	34	<100	<100	<100	57	<100	<100	5.1	6.4	<5	<5	<5	-	-	-	<5	-	-	-
Tungsten	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<1	<1	<1	<1	<1	-	-	-	<1	-	-	-
Uranium	-	100 [13]	-	2.08	0.762	1.94	1.76	1.25	0.399	1.52	0.783	2.05	0.512	1.62	1.59	2.53	1.05	1.02	2.39	2.15	-	-	-	2.39	-	-	-
Vanadium	-	50 [14]	-	**<100**	<50	**<100**	**<100**	<50	<10	**<100**	**<100**	**<100**	<20	**<100**	**<100**	1.71	1.12	0.89	1.35	1.23	-	-	-	1.53	-	-	-
Yttrium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-
Zinc	-	55 [19]	-	5.22	2.4	1.54	1.09	1.95	8.38	3.18	2.43	2.6	18.6	18.9	3.56	<5	10.2	<5	10.5	4.1	-	-	-	<3	-	-	-
Zirconium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-

Table 10: AMS Surface Water Chemistry Results

Parameter	*Nutrient Threshold* [20]	BCWQG MAL [3,4]	CCME MAL [5,6]	SWDP07B-1	SWDP07B-2	SWDP07B-3	SWDP07B-4	SWDP07B-5	SWDP07B-6	SWDP07B-7	SWDP07B-8	SWDP07B-9	SWDP07B-10	SWDP07B-11	SWDP07B-12	SWDP07B-13	SWDP07B-14	SWDP07B-15	SWDP07B-16	SWDP07B-17	SWDP07B-18	SWDP07B-19	SWDP07B-20	SWDP07B-21	SWDP07B-22	SWDP07B-23	SWDP07B-24
Location ID:				DP07B																							
Date Sampled:				24/03/2007	20/06/2007	01/10/2007	10/12/2007	04/03/2008	29/05/2008	20/09/2008	26/11/2008	23/02/2009	20/05/2009	14/09/2009	03/12/2009	08/03/2010	07/06/2010	30/08/2010	02/12/2010	04/03/2011	08/06/2011	06/09/2011	07/11/2011	20/02/2012	29/05/2012	05/09/2012	10/12/2012
Sample Info																											
Sample Depth, Below Water Surface (m)		-	-	13	-	0.5	0.5	22	20.5	0.5	20	20	18	20	20	-	21	21	26	28	21.2	18	20	19	20	21.5	20
Field Tests																											
Secchi Depth (m)		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.1	-	-	-	2.5	4.5	0.25	1.5	0.5
Field Temperature (ºC)	-	-	-	7.85	-	10.3	7.12	7.23	7.85	11.32	9.19	7.15	8.7	11.93	8.91	-	-	12.2	8.52	8.63	9.73	11.76	9.66	7.23	8.48	10.77	8.75
Field pH	-	-	-	7.73	-	-	7.61	7.78	7.73	7.53	7.65	7.63	7.75	7.2	7.58	-	-	7.76	7.63	7.7	7.58	7.67	7.53	7.54	7.8	7.71	7.83
Field Conductivity (uS/cm)	-	-	-	45970	-	32733	41778	46773	45970	45421	34323	30447	47732	45260	46179	-	-	41400	45686	45047	31936	32082	45750	30454	47322	30810	43460
Field Dissolved Oxygen (mg/L)	6.02 [21]	-	-	12.75	-	6.39	15.58	7.71	12.75	6.38	6.91	7.96	8.28	9.1	7.15	-	-	7.05	8.54	8.63	8.64	8.14	6.49	8.92	7.85	7.8	7.04
Field Redox, Uncorrected (mV)	-	-	-	200.2	-	255	223	-92.7	200.2	-25	-272.2	-329.9	262.2	227.2	157.6	-	-	67.7	250.2	266.1	306.1	307.6	229.6	236.5	179.7	296	299.9
Field Turbidity (NTU)	-	-	-	0.09	-	-	-	-	-	-	0.42	0.95	2.5	0.25	0.99	-	-	0.83	2.39	1.17	3.4	8.2	0.82	0.21	1.3	0.37	-
Physical Tests																											
Hardness, Total (CaCO3) (mg/L)	-	-	-	-	5130	5210	-	5420	4260	5460	6060	5520	5530	5400	5240	-	-	5380	5300	4820	-	-	-	5400	-	-	-
Total Suspended Solids (mg/L)	-	-	-	10.9	25.2	51	9.5	15.3	38	31.3	18.4	-	21.2	19.7	25.2	16	14.7	12	17	7.6	16	60.7	64.4	2.6	3	8.4	27.5
Turbidity (NTU)	-	-	-	-	-	-	1.7	0.48	4.3	5.84	0.9	-	2.3	0.75	1.75	2.37	1.89	0.8	1.29	1.23	3.25	23.2	14.5	1.23	0.78	0.44	4.79
Dissolved Inorganics																											
Orthophosphate (as P) (mg/L)	0.087	-	-	0.063	0.0606	0.0665	0.0719	0.0717	**-**	0.0554	0.0788	0.0708	0.0579	0.0605	0.0712	0.0712	0.0708	0.0575	0.0759	0.0717	0.0563	0.0585	0.0702	0.0717	0.062	0.0546	0.0716
Phosphorus (P), Total Dissolved (mg/L)	0.087	-	-	0.0656	0.0597	0.059	0.0667	0.0711	**-**	0.0588	0.0774	0.0757	0.0578	0.0665	0.0736	0.0774	0.0726	0.0612	0.0752	0.0727	0.0579	0.0615	0.0705	0.0745	0.0623	0.0616	0.0751
Inorganics																											
Ammonia (mg/L)	0.065	-	-	<0.020	0.03	<0.005	<0.020	<0.005	0.024	0.0114	<0.005	<0.005	0.028	<0.005	0.022	<0.005	0.018	0.0316	0.0056	0.0194	0.0229	0.0082	<0.005	<0.005	0.0383	<0.005	<0.005
Nitrate (mg/L)	5.23	-	16	0.33	0.52	2.36	***5.9***	1.92	<5.000	<0.500	0.66	<5.000	<0.500	<0.500	<0.500	0.57	<0.500	<0.500	0.74	<0.500	0.55	0.6	<0.500	0.74	0.89	0.57	0.57
Nitrite (mg/L)	0.978	-	-	<0.020	<0.100	<0.100	<0.500	0.1	***<1.000***	0.15	0.24	***<1.000***	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100
Silicon Dioxide (mg/L)	-	-	-	2.1	2.3	-	-	-	-	-	2.6	-	-	2.2	2.9	2.7	2.1	2	3.6	3.1	1.6	2.3	2.5	2.62	2.06	1.95	3.29
Total Inorganics																											
Chlorine (mg/L)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.100	<0.100	<0.100	<0.100	-	-	-	-	-	-
Phosphorus (P) (mg/L)	-	-	-	0.0671	0.0666	0.0678	0.0745	0.0856	-	0.0771	0.0723	0.0772	0.0638	0.0687	0.0774	0.0851	0.0747	0.0638	0.0773	0.0777	0.067	0.113	0.117	0.0741	0.0661	0.0712	0.0992
Total Kjeldahl Nitrogen (mg/L)	0.434	-	-	0.119	0.094	0.229	0.263	0.191	0.259	<0.050	0.138	0.058	0.149	<0.050	0.11	0.062	<0.050	0.25	0.053	0.128	0.236	***0.471***	0.069	0.088	0.146	0.111	0.095
Total Nitrogen (mg/L)	5.92	-	-	0.45	<0.700	2.59	***6.1***	2.21	***<6.000***	<0.700	1.04	***<6.000***	0.47	<0.700	0.51	<0.700	<0.700	<0.260	0.79	<0.260	0.79	1.07	<0.260	0.83	1.04	0.68	0.66
Organics																											
Organic Nitrogen (mg/L)	0.392	-	-	-	<0.070	-	0.263	0.191	0.235	<0.060	0.138	<0.060	0.121	<0.060	-	0.062	<0.060	0.218	<0.060	0.109	0.213	***0.463***	0.069	0.088	0.107	0.111	0.095
Microbiological Analysis																											
Chlorophyll A	5.11	-	-	0.714	0.521	1.07	0.445	0.71	0.481	1.05	0.0944	0.148	0.295	0.502	0.125	0.305	0.204	0.703	0.121	0.498	0.769	0.943	0.375	0.263	0.123	0.127	0.139
Dissolved Metals																											
Iron	-	-	-	-	<10	-	<10	<10	<10	<10	<10	<10	<10	<10	<10	<50	<50	<5	<10	<10	-	-	-	-	-	-	-

Table 10: AMS Surface Water Chemistry Results

			Location ID:	DP07B																							
			Sample ID:	SWDP07B-1	SWDP07B-2	SWDP07B-3	SWDP07B-4	SWDP07B-5	SWDP07B-6	SWDP07B-7	SWDP07B-8	SWDP07B-9	SWDP07B-10	SWDP07B-11	SWDP07B-12	SWDP07B-13	SWDP07B-14	SWDP07B-15	SWDP07B-16	SWDP07B-17	SWDP07B-18	SWDP07B-19	SWDP07B-20	SWDP07B-21	SWDP07B-22	SWDP07B-23	SWDP07B-24
			Date Sampled:	24/03/2007	20/06/2007	01/10/2007	10/12/2007	04/03/2008	29/05/2008	20/09/2008	26/11/2008	23/02/2009	20/05/2009	14/09/2009	03/12/2009	08/03/2010	07/06/2010	30/08/2010	02/12/2010	04/03/2011	08/06/2011	06/09/2011	07/11/2011	20/02/2012	29/05/2012	05/09/2012	10/12/2012
Parameter	***Nutrient Threshold*** [20]	**BCWQG MAL** [3,4]	**CCME MAL** [5,6]																								
Total Metals																											
Aluminum	-	-	-	<100	<300	<100	<100	<100	260	<300	<200	<100	<100	<100	<100	277	51	18.7	19.8	17.2	-	-	-	8.1	-	-	-
Antimony	-	-	-	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<0.5	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-
Arsenic	-	12.5 [17]	12.5	1.41	1.51	1.4	0.93	1.53	1.02	1.32	1.53	1.29	1.47	1.93	1.19	<2	<2	<2	<2	<2	-	-	-	<2	-	-	-
Barium	-	200 [8]	-	9.6	11.7	9	8.9	7.8	9.9	8.8	8.2	7.8	9	7.5	8.3	9.2	9.6	8.5	9	10.2	-	-	-	9.5	-	-	-
Beryllium	-	100 [9]	-	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<0.5	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-
Bismuth	-	-	-	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<0.5	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-
Boron	-	1200 [4]	-	**4000**	**4000**	**4000**	**3400**	**3600**	**2900**	**3500**	**3800**	**4000**	**3500**	**3700**	**3600**	**4340**	**4520**	**4210**	**4660**	**4150**	-	-	-	**4850**	-	-	-
Cadmium	-	0.12 [7]	0.12	0.06	0.073	0.056	0.056	0.084	0.064	0.078	0.089	0.091	0.07	0.119	0.072	<0.12	<0.12	<0.12	0.072	0.071	-	-	-	0.075	-	-	-
Calcium	-	-	-	346000	305000	334000	344000	364000	282000	352000	382000	334000	357000	349000	342000	354000	347000	358000	345000	323000	-	-	-	342000	-	-	-
Cesium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-
Chromium	-	1.5 [10]	1.5	**<50**	**<50**	**<50**	**<50**	**<50**	**<50**	**<50**	**<50**	**<50**	**<50**	**59**	**<50**	<1	<1	<1	<0.7	<0.4	-	-	-	<0.5	-	-	-
Cobalt	-	-	-	<0.050	0.065	<0.05	<0.05	<0.05	0.225	0.224	<0.05	<0.05	0.075	0.07	<0.05	<0.5	<0.5	<0.5	<0.05	<0.05	-	-	-	<0.05	-	-	-
Copper	-	3 [18]	-	0.887	0.539	1.04	0.396	1.41	1.42	0.868	0.584	0.516	0.495	**5.74**	0.439	<1	<1	<1	0.86	1.2	-	-	-	<0.5	-	-	-
Gallium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-
Iron	-	-	-	32	49	<10	32	17	315	363	28	29	45	115	67	65	94	<50	36	38	-	-	-	13	-	-	-
Lead	-	140 [18]	-	0.597	0.119	0.116	<0.05	0.682	0.376	0.207	2.92	0.175	0.129	20.2	0.075	<1	<1	<1	1.77	2.92	-	-	-	<0.3	-	-	-
Lithium	-	-	-	<500	<500	<500	<500	<500	<500	<500	<500	<500	<500	<500	<500	199	174	176	161	155	-	-	-	186	-	-	-
Magnesium	-	-	-	1100000	1060000	1060000	1110000	1100000	863000	1110000	1240000	1140000	1130000	1100000	1070000	1090000	1130000	1090000	1080000	974000	-	-	-	1100000	-	-	-
Manganese	-	100 [11]	-	2.03	9.46	1.86	2.87	1.68	15.5	10.4	2.32	1.85	2.93	6.25	3.52	2.89	10.2	3.85	3.77	4.34	-	-	-	1.72	-	-	-
Mercury	-	-	0.016	<0.010	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-	-	-	-	-	-	-
Molybdenum	-	-	-	9.9	9.3	9.9	8.3	10.3	6.2	10.1	9.2	9.3	12.9	7.4	7.8	11	9.5	9.6	9.2	8.8	-	-	-	10.7	-	-	-
Nickel	-	8.3 [12]	-	0.362	0.646	0.42	0.388	0.265	1.14	1.07	0.457	0.568	0.359	0.627	0.472	0.66	0.6	0.57	<0.5	0.86	-	-	-	<0.5	-	-	-
Potassium	-	-	-	351000	321000	297000	367000	379000	262000	343000	370000	319000	335000	324000	322000	320000	332000	333000	327000	299000	-	-	-	335000	-	-	-
Rhenium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-
Rubidium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	108	98	92	96.7	91.4	-	-	-	108	-	-	-
Selenium	-	-	-	<0.50	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.58	<0.5	<0.5	<0.5	<0.5	<2	<2	<2	<2	<2	-	-	-	<2	-	-	-
Silicon	-	-	-	1380	1300	1330	1770	1610	1760	1660	1540	1580	1070	1370	1630	1570	1240	1240	1580	1760	-	-	-	1540	-	-	-
Silver	-	3 [18]	-	<1.0	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<0.2	<0.2	<0.2	<0.1	<0.1	-	-	-	<0.1	-	-	-
Sodium	-	-	-	8270000	8350000	8300000	8220000	8400000	7430000	8960000	9520000	9980000	9480000	9800000	9280000	9720000	8850000	9270000	9120000	8520000	-	-	-	9410000	-	-	-
Strontium	-	-	-	6850	6130	7450	5900	5910	4750	6330	5930	7890	6270	6260	6550	6330	6400	6420	6270	5770	-	-	-	6290	-	-	-
Tellurium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-
Thallium	-	-	-	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<0.5	<0.5	<0.5	<0.05	<0.05	-	-	-	<0.05	-	-	-
Thorium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-
Tin	-	-	-	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<1	<1	<1	<1	<1	-	-	-	<1	-	-	-
Titanium	-	-	-	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<5	<5	<5	<5	<5	-	-	-	<5	-	-	-
Tungsten	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<1	<1	<1	<1	<1	-	-	-	<1	-	-	-
Uranium	-	100 [13]	-	2.01	1.44	1.79	1.8	1.86	1.87	2.35	2.5	2.35	1.83	2.37	1.74	2.78	2.89	2.53	2.51	2.37	-	-	-	2.65	-	-	-
Vanadium	-	50 [14]	-	**<100**	**<100**	**<100**	**<100**	**<100**	**<100**	**<100**	**<100**	**<100**	**<100**	**<100**	**<100**	1.46	1.78	1.55	1.36	1.27	-	-	-	1.78	-	-	-
Yttrium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-
Zinc	-	55 [19]	-	2.31	1.5	1.46	0.86	2.75	2.57	2.21	1.13	1.29	2.82	8.16	0.94	<5	<5	<5	8.3	3.5	-	-	-	<3	-	-	-
Zirconium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-

Table 10: AMS Surface Water Chemistry Results

			Location ID:	DP08					DP09			
			Sample ID:	SWDP08-5	SWDP08-9	SWDP08-13	SWDP08-17	SWDP08-21	SWDP09-9	SWDP09-13	SWDP09-17	SWDP09-21
			Date Sampled:	04/03/2008	25/02/2009	08/03/2010	04/03/2011	20/02/2012	25/02/2009	09/03/2010	03/03/2011	20/02/2012
Parameter	***Nutrient Threshold*** [20]	**BCWQG MAL** [3,4]	**CCME MAL** [5,6]									
Sample Info												
Sample Depth, Below Water Surface (m)		-	-	0.5	0.5	0.5	1	1	0.5	0.5	1	1
Field Tests												
Secchi Depth (m)		-	-	2.1	-	-	-	2.5 (bottom)	-	-	-	2
Field Temperature (ºC)	-	-	-	6.76	7.16	-	6.34	6.9	7.22	-	6.19	6.16
Field pH	-	-	-	7.94	7.49	-	7.65	7.78	7.45	-	7.81	7.84
Field Conductivity (uS/cm)	-	-	-	42599	29566	-	44770	29957	29594	-	44310	27909
Field Dissolved Oxygen (mg/L)	6.02 [21]	-	-	9.04	10.7	-	20.19	10.34	9.72	-	9.87	10.41
Field Redox, Uncorrected (mV)	-	-	-	89.7	-379.3	-	382.6	258.5	-366.8	-	180.4	272.5
Field Turbidity (NTU)	-	-	-	-	1.9	-	1.84	0.42	-	-	1.35	1.27
Physical Tests												
Hardness, Total (CaCO3) (mg/L)	-	-	-	4720	5430	-	5190	5000	5370	-	5420	4670
Total Suspended Solids (mg/L)	-	-	-	9.3	-	5.3	10.9	<2.000	-	12	17.6	2.4
Turbidity (NTU)	-	-	-	1.1	-	0.75	1.19	1.2	-	5.36	1.71	2.59
Dissolved Inorganics												
Orthophosphate (as P) (mg/L)	0.087	-	-	0.0493	0.0667	0.0624	0.0639	0.0649	0.0607	0.0661	0.0645	0.0596
Phosphorus (P), Total Dissolved (mg/L)	0.087	-	-	0.0485	0.07	0.0696	0.0665	0.0686	0.0644	0.0658	0.038	0.0615
Inorganics												
Ammonia (mg/L)	0.065	-	-	0.0194	0.0099	<0.005	0.0097	0.0069	0.0118	0.0152	0.0375	0.027
Nitrate (mg/L)	5.23	-	16	1.87	<0.500	<0.500	<0.500	0.7	<0.500	0.67	<0.500	0.64
Nitrite (mg/L)	0.978	-	-	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100
Silicon Dioxide (mg/L)	-	-	-	-	-	2.5	3	2.88	-	2.5	3	2.91
Total Inorganics												
Chlorine (mg/L)	-	-	-	-	-	-	<0.100	-	-	<0.100	<0.100	-
Phosphorus (P) (mg/L)	-	-	-	0.0531	0.0793	0.0726	0.0713	0.0718	0.0681	0.0767	0.0726	0.0718
Total Kjeldahl Nitrogen (mg/L)	0.434	-	-	0.283	0.124	0.093	0.104	0.11	0.117	0.056	0.087	0.162
Total Nitrogen (mg/L)	5.92	-	-	2.15	<0.700	<0.700	<0.260	0.81	<0.700	0.72	<0.260	0.8
Organics												
Organic Nitrogen (mg/L)	0.392	-	-	0.263	0.114	0.093	0.094	0.1	0.105	<0.060	<0.060	0.135
Microbiological Analysis												
Chlorophyll A	5.11	-	-	1.45	0.417	0.619	0.713	0.401	1.38	0.838	0.331	0.478
Dissolved Metals												
Iron	-	-	-	<10	<10	<50	<10	-	<10	<50	<10	-

Table 10: AMS Surface Water Chemistry Results

Parameter	Nutrient Threshold [20]	BCWQG MAL [3,4]	CCME MAL [5,6]	SWDP08-5	SWDP08-9	SWDP08-13	SWDP08-17	SWDP08-21	SWDP09-9	SWDP09-13	SWDP09-17	SWDP09-21
			Location ID:	DP08					DP09			
			Date Sampled:	04/03/2008	25/02/2009	08/03/2010	04/03/2011	20/02/2012	25/02/2009	09/03/2010	03/03/2011	20/02/2012
Total Metals												
Aluminum	-	-	-	<100	<100	<10	16.5	14	<100	204	24.3	24.4
Antimony	-	-	-	<10	<10	<0.5	<0.5	<0.5	<10	<0.5	<0.5	<0.5
Arsenic	-	12.5 [17]	12.5	1.13	1.23	<2	<2	<2	1.39	<2	<2	<2
Barium	-	200 [8]	-	8.3	8.2	8.5	9.1	9.8	8.6	10.2	9.2	9.8
Beryllium	-	100 [9]	-	<50	<50	<0.5	<0.5	<0.5	<50	<0.5	<0.5	<0.5
Bismuth	-	-	-	<50	<50	<0.5	<0.5	<0.5	<50	<0.5	<0.5	<0.5
Boron	-	1200 [4]	-	**3400**	**4100**	**4490**	**4480**	**4650**	**4300**	**4140**	**4410**	**4450**
Cadmium	-	0.12 [7]	0.12	0.071	0.075	<0.12	0.096	0.067	0.075	<0.12	0.087	0.099
Calcium	-	-	-	317000	336000	359000	344000	323000	330000	329000	347000	301000
Cesium	-	-	-	-	-	<0.5	<0.5	<0.5	-	<0.5	<0.5	<0.5
Chromium	-	1.5 [10]	1.5	**<50**	**<50**	<1	<0.4	<0.5	**<50**	<1	<0.4	<0.5
Cobalt	-	-	-	0.07	<0.05	<0.5	<0.05	<0.05	<0.05	<0.5	<0.05	0.074
Copper	-	3 [18]	-	2.23	0.797	<1	1.1	<0.5	0.945	1.1	0.81	0.69
Gallium	-	-	-	-	-	<0.5	<0.5	<0.5	-	<0.5	<0.5	<0.5
Iron	-	-	-	32	81	<50	33	27	87	171	57	51
Lead	-	140 [18]	-	0.728	0.214	<1	1.28	<0.3	0.309	<1	<0.3	<0.3
Lithium	-	-	-	<500	<500	196	170	177	<500	157	164	162
Magnesium	-	-	-	954000	1110000	1110000	1050000	1020000	1100000	1040000	1110000	951000
Manganese	-	100 [11]	-	5.74	3.62	2.66	2.28	3.3	3.92	7.26	3.47	6.43
Mercury	-	-	0.016	<0.01	<0.01	<0.01	<0.01	-	<0.01	<0.01	<0.01	-
Molybdenum	-	-	-	10.2	8.5	9.8	9.8	10.1	10.1	9.5	9.2	9.8
Nickel	-	8.3 [12]	-	0.422	0.512	0.66	0.74	<0.5	0.556	0.74	0.79	0.55
Potassium	-	-	-	335000	297000	332000	320000	317000	298000	313000	323000	291000
Rhenium	-	-	-	-	-	<0.5	<0.5	<0.5	-	<0.5	<0.5	<0.5
Rubidium	-	-	-	-	-	107	101	98.3	-	95	99	96.4
Selenium	-	-	-	<0.5	1.68	<2	<2	<2	0.82	<2	<2	<2
Silicon	-	-	-	1360	1530	1440	1590	1540	1530	1540	1690	1610
Silver	-	3 [18]	-	<1	<1	<0.2	<0.1	<0.1	<1	<0.2	<0.1	<0.1
Sodium	-	-	-	7440000	9340000	9970000	9060000	8880000	9330000	9100000	9070000	8140000
Strontium	-	-	-	5560	5430	6480	6170	5880	5490	6050	6310	5410
Tellurium	-	-	-	-	-	<0.5	<0.5	<0.5	-	<0.5	<0.5	<0.5
Thallium	-	-	-	<10	<10	<0.5	<0.05	<0.05	<10	<0.5	<0.05	<0.05
Thorium	-	-	-	-	-	<0.5	<0.5	<0.5	-	<0.5	<0.5	<0.5
Tin	-	-	-	<10	<10	<1	<1	<1	<10	<1	<1	<1
Titanium	-	-	-	<100	<100	<5	<5	<5	<100	<5	<5	<5
Tungsten	-	-	-	-	-	<1	<1	<1	-	<1	<1	<1
Uranium	-	100 [13]	-	2.11	2.13	2.62	2.61	2.58	2.21	2.67	2.52	2.56
Vanadium	-	50 [14]	-	**<100**	**<100**	1.31	1.48	1.69	**<100**	1.63	1.42	1.5
Yttrium	-	-	-	-	-	<0.5	<0.5	<0.5	-	<0.5	<0.5	<0.5
Zinc	-	55 [19]	-	1.84	<3.5	<5	5	<3	<3.5	<5	3.4	<3
Zirconium	-	-	-	-	-	<0.5	<0.5	<0.5	-	<0.5	<0.5	<0.5

Table 10: AMS Surface Water Chemistry Results

(1) All values are reported as µg/L unless otherwise noted
(2) - = No standard or not analyzed
(3) BCWQG = BC Water Quality Guidelines (Approved and Working), updated to January 2010
(4) BCWQG MAL = British Columbia Water Quality Guidline Marine Aquatic Life water use
(5) CCME = Canadian Council of Ministers of the Environment, Canadian Environmental Quality Guidelines, 1999, updated to November 30, 2011
(6) CCME MAL = Chapter 4, Canadian Water Quality Guidelines for the Protection of Aquatic Life, Marine, updated to November 30, 2011
(7) Working - Maximum
(8) Working - Maximum, adverse effects on bivalves, under ministry review
(9) Working - Maximum, minimal risk, under ministry review
(10) Working - Maximum, under ministry review (Unknown full reference)
(11) Working - Maximum, to protect consumers of shellfish
(12) Working - Maximum, 4 day average
(13) Working - Maximum, minimal risk
(14) Working - Maximum, 99% level of protection
(15) CCME MAL stipulates pH not < 7 and not > 8.7
(16) CCME MAL stipulates Salinity (%) not <= 10
(17) BCWQG MAL = British Columbia Water Quality Guidline for the protection of Marine Aquatic Life, interim guideline
(18) Approved - Maximum
(19) Approved - Maximum, To protect aquatic life from acute or lethal effects
(20) Nutrient Threshold value calculated using data from DP02 to DP05 from 2007 to 2010 The nutrient theshold values are not used to evaluate DP01 data.
(21) Nutrient Threshold for field dissolved oxygen is a minimum not a maximum.

Table 11: AMS Sediment Chemistry Results

		Location ID:	DP01																							
		Sample ID:	SDDP01-1	SDDP01-2	SDDP01-3	SDDP01-4	SDDP01-5	SDDP01-6	SDDP01-7	SDDP01-8	SDDP01-9	SDDP01-10	SDDP01-11	SDDP01-12	SDDP01-13	SDDP01-14	SDDP01-15	SDDP01-16	SDDP01-17	SDDP01-18	SDDP01-19	SDDP01-20	SDDP01-21	SDDP01-22	SDDP01-23	SDDP01-24
		Date Sampled:	22/03/2007	20/06/2007	02/10/2007	10/12/2007	05/03/2008	30/05/2008	21/09/2008	27/11/2008	23/02/2009	20/05/2009	14/09/2009	03/12/2009	09/03/2010	08/06/2010	31/08/2010	02/12/2010	11/03/2011	09/06/2011	07/09/2011	08/11/2011	21/02/2012	29/05/2012	05/09/2012	10/12/2012
		Sample Depth (m):	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.01	0.00-0.05	0.00-0.10	0.00-0.10	0.00-0.10	0.00-0.10	0.00-0.10	0.00-0.10	0.00-0.05	0.00-0.10	0.00-10.00	0.000.00-0.100.10	0.00-0.10	-
Parameter	***Nutrient Threshold*** [5]	**BCCSR SedQC(SS) Marine** [3,4]																								
Physical Tests																										
Moisture (%)	-	-	36.9	44	30.8	23.6	25.6	29.1	25.8	25.8	14	42.7	31.4	18.6	26.8	49.1	17.2	17.2	39.5	40	34.6	37.3	37.1	22.9	46.9	26.1
Oxidation Reduction Potential (mV)	-	-	-150	50	-120	-100	60	-300	-270	-350	-	-377	-163	33	-	-199	37	154	-176	-213	37	-131	-26	-112	-171	1
pH	-	-	8.03	7.89	8.01	7.75	8.02	8.12	7.63	7.75	8.13	7.46	8.03	8.12	7.95	7.71	8.28	7.79	7.81	-	-	-	7.19	-	-	-
Grain Size																										
Clay (<0.004 mm) (%)	-	-	10	-	-	-	-	-	-	-	2	-	-	-	1	-	2.06	1.42	8.42	-	3.89	-	9.25	-	-	-
Silt (0.004-0.063 mm) (%)	-	-	30	-	-	-	-	-	-	-	6	-	-	-	8	-	13.2	6.04	48.6	-	26	-	45.7	-	-	-
Sand (0.063-2.00 mm) (%)	-	-	57	-	-	-	-	-	-	-	28	-	-	-	59	-	84.1	41.1	41.6	-	70.1	-	44	-	-	-
Gravel (>2.00 mm) (%)	-	-	3	-	-	-	-	-	-	-	64	-	-	-	32	-	0.67	51.5	1.42	-	<0.10	-	1.13	-	-	-
Total Inorganics																										
Ammonium	19.8	-	5.9	8.7	3.1	2	3.1	13.1	6.6	5	3.4	11.8	9.48	1.24	7.09	11.5	6.24	2.22	3.2	1.7	11.2	3.5	1.6	32.9	11.2	2.9
Available Phosphate	-	-	-	6	-	-	-	-	-	-	-	-	-	-	-	-	-	12.2	3.8	6.4	21.4	13.2	15.2	49.3	5.4	13.2
Phosphorus	897	-	654	795	619	585	563	668	635	1040	614	1180	887	516	576	932	550	518	700	874	907	661	981	622	677	642
Sulfide	49.5	-	95	97.5	<0.19	0.33	0.38	21.2	9.86	0.49	0.35	58.8	30.1	<0.20	0.48	69	0.34	<0.20	19.6	5.21	0.63	12.6	5	119	3.4	<0.90
Total Kjeldahl Nitrogen (%)	0.186	-	0.13	0.11	0.08	0.05	0.07	0.11	0.09	0.1	0.05	0.21	0.107	0.025	0.062	0.143	0.034	0.027	0.132	0.051	0.056	0.079	0.101	0.126	0.151	0.033
Total Nitrogen (%)	0.197	-	0.1	0.14	0.06	0.07	0.07	0.12	0.09	0.1	-	0.267	0.141	0.037	0.054	0.148	0.049	0.069	0.14	0.07	0.062	0.073	0.095	0.122	0.145	0.056
Organics																										
Organic Nitrogen (%)	0.183	-	0.13	0.11	0.08	0.05	0.07	0.11	0.09	0.1	0.05	0.209	0.106	0.025	0.061	-	0.033	0.027	-	0.051	0.055	0.079	0.101	0.123	0.15	0.032
Total Organic Carbon (%)	1.98	-	0.98	1.12	0.7	0.7	1	1	0.8	0.8	-	2.05	0.87	0.26	0.6	1.39	0.33	0.31	1.33	0.67	0.57	0.8	0.86	1.12	1.35	0.6

Table 11: AMS Sediment Chemistry Results

		Location ID:	DP01																							
		Sample ID:	SDDP01-1	SDDP01-2	SDDP01-3	SDDP01-4	SDDP01-5	SDDP01-6	SDDP01-7	SDDP01-8	SDDP01-9	SDDP01-10	SDDP01-11	SDDP01-12	SDDP01-13	SDDP01-14	SDDP01-15	SDDP01-16	SDDP01-17	SDDP01-18	SDDP01-19	SDDP01-20	SDDP01-21	SDDP01-22	SDDP01-23	SDDP01-24
		Date Sampled:	22/03/2007	20/06/2007	02/10/2007	10/12/2007	05/03/2008	30/05/2008	21/09/2008	27/11/2008	23/02/2009	20/05/2009	14/09/2009	03/12/2009	09/03/2010	08/06/2010	31/08/2010	02/12/2010	11/03/2011	09/06/2011	07/09/2011	08/11/2011	21/02/2012	29/05/2012	05/09/2012	10/12/2012
		Sample Depth (m):	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.01	0.00-0.05	0.00-0.10	0.00-0.10	0.00-0.10	0.00-0.10	0.00-0.10	0.00-0.10	0.00-0.05	0.00-0.10	0.00-10.00	0.000.00-0.100.10	0.00-0.10	-
Parameter	***Nutrient Threshold*** [5]	**BCCSR SedQC(SS) Marine** [3,4]																								
Total Metals																										
Aluminum	-	-	14000	14000	10700	11000	8640	12300	9930	13200	11000	13800	12300	7840	9090	9850	9090	8190	11300	-	-	-	12600	-	-	-
Antimony	-	-	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	0.11	0.3	-	-	-	0.23	-	-	-
Arsenic	-	26	5.4	5.7	<5.0	<5.0	5.2	<5.0	<5.0	7.3	<5.0	7	<5.0	<5.0	<5.0	5.3	<5.0	3.19	4.78	-	-	-	6.83	-	-	-
Barium	-	-	44.8	43.7	25.5	40	22.8	33.8	32	38.9	28.1	44.4	35.3	17	22	33.1	15.9	17.2	38.4	-	-	-	33	-	-	-
Beryllium	-	-	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.20	0.26	-	-	-	0.3	-	-	-
Bismuth	-	-	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<0.20	<0.20	-	-	-	<0.20	-	-	-
Cadmium	-	2.6	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.10	0.16	-	-	-	0.129	-	-	-
Calcium	-	-	5960	6140	5860	6140	4340	7660	6020	6430	6710	6700	6600	5340	4600	9500	4770	3780	5740	-	-	-	4510	-	-	-
Chromium	-	99	35.7	35.9	18.5	23.1	14.5	28	18.4	28.8	21.9	38.7	31.7	14	17.6	28.4	12.6	15.9	34.7	-	-	-	35.3	-	-	-
Cobalt	-	-	10.6	10.7	6	6.3	5.6	8.3	6	9.3	6.8	11.1	8.7	4.6	5.9	9.6	5.5	5.94	9.83	-	-	-	10.2	-	-	-
Copper	-	67	23.1	23.1	14.2	63.7	15.1	20.4	13.3	21.6	14.8	24.5	18.4	23.6	12.6	16.9	11.2	11.2	19.3	-	-	-	21.6	-	-	-
Iron	-	-	27500	25800	17800	20000	16400	23600	16300	24900	19500	29100	22700	12700	16300	19900	16100	16600	23900	-	-	-	24700	-	-	-
Lead	-	69	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	3.02	7.64	-	-	-	6.2	-	-	-
Lithium	-	-	16.8	17	10.6	10.6	8.7	13.2	10.4	16.1	11.3	19.2	14.5	8.3	9.6	14	8.2	8.5	14.7	-	-	-	13.2	-	-	-
Magnesium	-	-	10400	10700	7080	6450	5840	8390	6490	9570	7390	11500	9090	5100	6090	9740	6100	5830	9130	-	-	-	8410	-	-	-
Manganese	-	-	292	281	257	254	235	279	227	330	251	293	260	209	233	229	247	240	318	-	-	-	257	-	-	-
Mercury	-	0.43	0.0464	0.0476	0.0249	0.0208	0.0237	0.0272	0.0212	0.033	0.0181	0.0488	0.0338	0.0101	0.0155	0.0376	0.0062	0.0123	0.0396	-	-	-	0.0402	-	-	-
Molybdenum	-	-	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<0.50	1.35	-	-	-	0.76	-	-	-
Nickel	-	-	33.4	34.6	17.4	20.5	15.4	28.3	17.9	28.2	20.1	36.9	28.3	14.3	18	34	12.4	16.5	32.6	-	-	-	34.4	-	-	-
Potassium	-	-	1970	1900	1180	1060	990	1350	1110	1770	1110	1950	1580	840	1020	1460	720	820	1550	-	-	-	1430	-	-	-
Selenium	-	-	<2.0	<3.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<0.20	0.2	-	-	-	0.21	-	-	-
Silver	-	-	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<0.10	<0.10	-	-	-	<0.10	-	-	-
Sodium	-	-	5570	6570	4250	3640	3330	5000	2980	8720	3350	7100	4690	2020	3410	5950	1230	1830	5250	-	-	-	3600	-	-	-
Strontium	-	-	42.9	41.8	28.9	38.6	29.1	37.9	28.6	45.4	33.9	43.6	37.2	32.6	28.7	58.4	23.6	20.6	37.8	-	-	-	36.5	-	-	-
Thallium	-	-	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.050	0.102	-	-	-	0.091	-	-	-
Tin	-	-	<5.0	<5.0	<5.0	<5.0	<5.0	5.1	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<2.0	<2.0	-	-	-	<2.0	-	-	-
Titanium	-	-	959	864	673	786	513	833	620	764	720	799	798	532	633	506	524	533	823	-	-	-	719	-	-	-
Vanadium	-	-	49.1	49.4	42.9	40.2	34.2	49.3	36.6	47.3	43.3	52	46.7	26.7	33.5	32.6	34.5	34.7	44.9	-	-	-	46.2	-	-	-
Zinc	-	170	62.8	65.6	41.3	60.3	35	55.8	38.8	58.6	42.2	68.8	52.8	32.9	36	55.3	31	34.2	62.1	-	-	-	62.2	-	-	-
Unknown Parameters																										
Phosphorus, total, acid digestion	897	-	610	-	580	590	440	660	670	700	450	***1050***	858	450	508	810	674	-	-	-	-	-	-	-	-	-

Table 11: AMS Sediment Chemistry Results

		Location ID:	DP02																							
		Sample ID:	SDDP02-1	SDDP02-2	SDDP02-3	SDDP02-4	SDDP02-5	SDDP02-6	SDDP02-7	SDDP02-8	SDDP02-9	SDDP02-10	SDDP02-11	SDDP02-12	SDDP02-13	SDDP02-14	SDDP02-15	SDDP02-16	SDDP02-17	SDDP02-18	SDDP02-19	SDDP02-20	SDDP02-21	SDDP02-22	SDDP02-23	SDDP02-24
		Date Sampled:	22/03/2007	21/06/2007	02/10/2007	10/12/2007	03/03/2008	29/05/2008	20/09/2008	26/11/2008	24/02/2009	20/05/2009	14/09/2009	03/12/2009	09/03/2010	07/06/2010	30/08/2010	02/12/2010	02/03/2011	08/06/2011	06/09/2011	07/11/2011	20/02/2012	29/05/2012	05/09/2012	10/12/2012
		Sample Depth (m):	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.07	0.00-0.05	0.00-0.04	0.00-0.05	0.00-0.10	0.00-0.10	0.00-0.10	0.00-0.10	0.00-0.10	0.00-0.10	0.00-0.03	0.00-0.15	0.00-4.00	0.000.00-0.050.05	0.00-0.07	-
Parameter	***Nutrient Threshold*** [5]	**BCCSR SedQC(SS) Marine** [3,4]																								
Physical Tests																										
Moisture (%)	-	-	28	32.2	33	34	30.8	33.2	33.8	34	31.1	32.3	30.1	29.5	34.7	32.1	35.5	31.8	32.1	32.8	33.3	28.6	27.9	33.2	35.8	29.7
Oxidation Reduction Potential (mV)	-	-	-170	-	<-200	-170	-170	-250	-280	-60	-100	-317	-208	-33	-	-143	-227	-61	50	112	-131	-136	-2	-224	-58	-171
pH	-	-	7.92	7.74	8.17	8.04	7.89	7.97	7.82	7.71	7.75	8.01	8.06	7.91	7.85	7.89	7.56	7.58	7.86	-	-	-	7.87	-	-	-
Grain Size																										
Clay (<0.004 mm) (%)	-	-	2	-	-	-	3	-	-	-	4	-	-	-	1	-	0.88	3.54	2.08	-	3.28	-	2.5	-	-	-
Silt (0.004-0.063 mm) (%)	-	-	3	-	-	-	4	-	-	-	6	-	-	-	6	-	16.8	8.23	15.2	-	11.8	-	12.9	-	-	-
Sand (0.063-2.00 mm) (%)	-	-	95	-	-	-	93	-	-	-	88	-	-	-	93	-	82.3	88.2	82.6	-	84.9	-	84.1	-	-	-
Gravel (>2.00 mm) (%)	-	-	<1	-	-	-	<1	-	-	-	1	-	-	-	<1.0	-	<0.10	<0.10	0.11	-	<0.10	-	0.53	-	-	-
Total Inorganics																										
Ammonium	19.8	-	3.9	7.3	8.1	4.3	2.4	4.4	9	3.9	2	2.4	8.31	5.05	6	6.93	6.6	5.99	2.99	5.8	2.8	4.9	3.8	4.2	7.4	2.6
Available Phosphate	-	-	-	15	-	-	-	-	-	-	-	-	-	-	-	-	-	14.5	13.5	16.3	13.1	14	17.1	14.8	16.1	10.6
Phosphorus	897	-	691	764	698	365	703	763	718	760	671	669	794	735	694	762	688	724	686	763	675	597	709	667	652	726
Sulfide	49.5	-	1.15	9.74	4.16	0.55	1.2	2.17	1.91	0.56	1.3	9.88	2.49	0.37	0.59	0.45	0.74	0.4	0.55	1.34	0.58	1.11	<0.29	1.34	3.28	<0.79
Total Kjeldahl Nitrogen (%)	0.186	-	0.06	0.05	<0.02	0.03	0.03	<0.02	0.05	0.06	0.05	0.051	0.047	0.05	0.043	0.057	0.049	0.058	0.025	0.037	0.037	0.053	0.024	0.035	0.059	0.032
Total Nitrogen (%)	0.197	-	0.04	0.04	0.04	0.03	0.04	0.05	0.07	0.05	0.04	0.057	0.062	0.046	0.036	0.045	0.045	0.085	0.042	0.066	0.04	0.046	0.033	0.046	0.046	0.043
Organics																										
Organic Nitrogen (%)	0.183	-	0.06	0.05	<0.02	0.03	0.03	<0.02	0.05	0.06	0.05	0.051	0.046	0.049	0.042	-	0.049	0.058	0.025	0.037	0.037	0.053	0.023	0.035	0.058	0.032
Total Organic Carbon (%)	1.98	-	0.16	0.29	0.1	0.2	0.3	0.2	0.4	0.5	0.1	0.27	<0.10	0.33	0.25	0.4	0.28	0.28	0.22	0.3	0.14	0.36	0.27	0.29	0.35	0.31

Table 11: AMS Sediment Chemistry Results

Location ID:			DP02											
Sample ID:			SDDP02-1	SDDP02-2	SDDP02-3	SDDP02-4	SDDP02-5	SDDP02-6	SDDP02-7	SDDP02-8	SDDP02-9	SDDP02-10	SDDP02-11	SDDP02-12
Date Sampled:			22/03/2007	21/06/2007	02/10/2007	10/12/2007	03/03/2008	29/05/2008	20/09/2008	26/11/2008	24/02/2009	20/05/2009	14/09/2009	03/12/2009
Sample Depth (m):			0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.07	0.00-0.05	0.00-0.04	0.00-0.05
Parameter	***Nutrient Threshold***[5]	**BCCSR SedQC(SS) Marine**[3,4]												
Total Metals														
Aluminum	-	-	8680	10300	10200	17400	9380	9670	9700	9670	9950	9900	9760	8480
Antimony	-	-	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Arsenic	-	26	<5.0	5.4	5.1	<5.0	<5.0	5.5	<5.0	6.7	<5.0	<5.0	5.2	<5.0
Barium	-	-	24.3	35.7	28.4	91.8	28	30.2	27.3	30.4	27.7	32.5	28.6	20.9
Beryllium	-	-	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Bismuth	-	-	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
Cadmium	-	2.6	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Calcium	-	-	5020	6140	5750	5330	6090	6040	5600	6530	5420	5800	6050	5020
Chromium	-	99	33.9	39.1	32.4	16.8	34.2	38.9	34.9	36.2	34	36.6	38.5	35
Cobalt	-	-	9.1	10.4	9.8	8.1	9.8	10.6	10.5	10.2	10.3	10.4	10.2	10
Copper	-	67	8.6	10.8	10.4	28.4	9.6	11.6	10	10.3	10	10.2	10.8	9.3
Iron	-	-	23000	24200	22000	22900	23100	25300	22700	24600	22700	23300	24800	23400
Lead	-	69	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30
Lithium	-	-	9.8	11.6	12	8.5	10.6	12.2	11.6	11.5	11.6	12.3	11.9	10.5
Magnesium	-	-	8020	9520	9370	4930	8510	9340	9120	8910	9120	9410	9310	8620
Manganese	-	-	240	278	246	403	262	272	258	274	250	256	263	251
Mercury	-	0.43	0.0233	0.0284	0.0276	0.0453	0.0339	0.027	0.0244	0.0234	0.0241	0.0255	0.0231	0.0178
Molybdenum	-	-	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0
Nickel	-	-	30	33.5	31	11.7	31.7	33.2	32.8	33.4	31.5	33.7	34	33
Potassium	-	-	990	1240	1320	950	1180	1130	1200	1090	1270	1180	1150	970
Selenium	-	-	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Silver	-	-	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Sodium	-	-	3320	3650	5630	340	4850	4250	4870	3780	4390	4410	4060	3620
Strontium	-	-	28.7	32.9	28.2	41.7	28.7	28.5	27.6	30.3	27.5	28.3	29.5	26.3
Thallium	-	-	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Tin	-	-	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Titanium	-	-	828	931	784	792	808	858	734	863	778	828	802	782
Vanadium	-	-	49.3	54.3	49.9	49	49.6	57.6	49.6	54.3	48.9	53.1	53.5	48.4
Zinc	-	170	44.5	52.4	48.1	54.9	48.4	51.2	49	50.6	53.2	49.4	48.8	47.3
Unknown Parameters														
Phosphorus, total, acid digestion	897	-	730	690	670	630	640	690	750	550	580	696	706	660

Location ID:	DP02											
Sample ID:	SDDP02-13	SDDP02-14	SDDP02-15	SDDP02-16	SDDP02-17	SDDP02-18	SDDP02-19	SDDP02-20	SDDP02-21	SDDP02-22	SDDP02-23	SDDP02-24
Date Sampled:	09/03/2010	07/06/2010	30/08/2010	02/12/2010	02/03/2011	08/06/2011	06/09/2011	07/11/2011	20/02/2012	29/05/2012	05/09/2012	10/12/2012
Sample Depth (m):	0.00-0.10	0.00-0.10	0.00-0.10	0.00-0.10	0.00-0.10	0.00-0.10	0.00-0.03	0.00-0.15	0.00-4.00	0.000.00-0.050.05	0.00-0.07	-
Parameter												
Total Metals												
Aluminum	9300	8760	8650	8330	21000	-	-	-	9920	-	-	-
Antimony	<10	<10	<10	0.18	0.13	-	-	-	0.2	-	-	-
Arsenic	<5.0	5.2	<5.0	4.95	2.87	-	-	-	5.16	-	-	-
Barium	25	25.1	20.9	22.1	33.3	-	-	-	26	-	-	-
Beryllium	<0.50	<0.50	<0.50	0.21	0.29	-	-	-	0.22	-	-	-
Bismuth	<20	<20	<20	<0.20	<0.20	-	-	-	<0.20	-	-	-
Cadmium	<0.50	<0.50	<0.50	<0.10	<0.10	-	-	-	0.067	-	-	-
Calcium	5240	5400	4570	5110	5780	-	-	-	5240	-	-	-
Chromium	35.5	35.8	34.7	36.9	27.7	-	-	-	34.9	-	-	-
Cobalt	10.3	10.5	9.9	10.4	12.6	-	-	-	10.4	-	-	-
Copper	9.6	7.5	9.5	9.21	44.2	-	-	-	9.46	-	-	-
Iron	23100	23700	22200	23600	31600	-	-	-	23000	-	-	-
Lead	<30	<30	<30	3.77	2	-	-	-	3.81	-	-	-
Lithium	10.9	10.3	10.8	9.7	12.2	-	-	-	9.6	-	-	-
Magnesium	8580	9010	9000	8260	11200	-	-	-	8630	-	-	-
Manganese	244	236	245	259	522	-	-	-	259	-	-	-
Mercury	0.021	0.0216	0.0217	0.0275	0.0229	-	-	-	0.0235	-	-	-
Molybdenum	<4.0	<4.0	<4.0	0.65	<0.50	-	-	-	<0.50	-	-	-
Nickel	34.1	35.3	32.8	34.4	23.8	-	-	-	34	-	-	-
Potassium	1020	960	1000	990	580	-	-	-	1040	-	-	-
Selenium	<2.0	<2.0	<2.0	<0.20	<0.20	-	-	-	<0.20	-	-	-
Silver	<2.0	<2.0	<2.0	<0.10	<0.10	-	-	-	<0.10	-	-	-
Sodium	3830	3680	5470	3910	260	-	-	-	4020	-	-	-
Strontium	27.9	29.2	27	26.5	25.2	-	-	-	28.6	-	-	-
Thallium	<1.0	<1.0	<1.0	0.078	<0.050	-	-	-	0.079	-	-	-
Tin	<5.0	<5.0	<5.0	<2.0	<2.0	-	-	-	<2.0	-	-	-
Titanium	894	847	694	799	1520	-	-	-	884	-	-	-
Vanadium	49.8	49.8	46.7	52.7	82.8	-	-	-	51.3	-	-	-
Zinc	47.5	49.3	48.6	45	43.8	-	-	-	48.7	-	-	-
Unknown Parameters												
Phosphorus, total, acid digestion	593	670	740	-	-	-	-	-	-	-	-	-

Table 11: AMS Sediment Chemistry Results

		Location ID:	DP03																							
		Sample ID:	SDDP03-1	SDDP03-2	SDDP03-3	SDDP03-4	SDDP03-5	SDDP03-6	SDDP03-7	SDDP03-8	SDDP03-9	SDDP03-10	SDDP03-11	SDDP03-12	SDDP03-13	SDDP03-14	SDDP03-15	SDDP03-16	SDDP03-17	SDDP03-18	SDDP03-19	SDDP03-20	SDDP03-21	SDDP03-22	SDDP03-23	SDDP03-24
		Date Sampled:	23/03/2007	21/06/2007	02/10/2007	10/12/2007	03/03/2008	29/05/2008	20/09/2008	26/11/2008	24/02/2009	20/05/2009	14/09/2009	03/12/2009	09/03/2010	07/06/2010	30/08/2010	02/12/2010	03/03/2011	08/06/2011	06/09/2011	07/11/2011	20/02/2012	29/05/2012	05/09/2012	10/12/2012
		Sample Depth (m):	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.08	0.00-0.05	0.00-0.04	0.00-0.05	0.00-0.10	0.00-0.10	0.00-0.10	0.00-0.10	0.00-0.10	0.00-0.10	0.00-0.03	0.00-0.10	0.00-10.00	0.000.00-0.050.05	0.00-0.06	-
Parameter	***Nutrient Threshold*** [5]	**BCCSR SedQC(SS) Marine** [3,4]																								
Physical Tests																										
Moisture (%)	-	-	25.5	31.2	30.4	29.5	32.8	30.2	30.5	34.6	35.6	27.8	25.1	26.2	31.7	34.4	37.5	33.4	29.5	35.1	31.9	28.8	28.9	32.6	34.8	26.5
Oxidation Reduction Potential (mV)	-	-	-170	-	-170	-150	-180	-240	-220	-260	-170	-398	-155	37	-	-204	-265	-5	-91	138	-184	71	6	-220	-95	-168
pH	-	-	7.99	7.9	8.13	7.83	7.96	7.96	7.94	7.81	7.91	8.04	8.01	7.9	7.92	7.92	8	7.62	7.72	-	-	-	7.69	-	-	-
Grain Size																										
Clay (<0.004 mm) (%)	-	-	3	-	-	-	3	-	-	-	3	-	-	-	1	-	2.97	2.68	1.76	-	2.3	-	2.63	-	-	-
Silt (0.004-0.063 mm) (%)	-	-	3	-	-	-	3	-	-	-	5	-	-	-	5	-	9.64	8.85	10.9	-	11.2	-	9.72	-	-	-
Sand (0.063-2.00 mm) (%)	-	-	94	-	-	-	94	-	-	-	91	-	-	-	93	-	87.4	88.5	85.5	-	86.5	-	87.6	-	-	-
Gravel (>2.00 mm) (%)	-	-	<1	-	-	-	<1	-	-	-	<1	-	-	-	2	-	<0.10	<0.10	1.79	-	<0.10	-	0.1	-	-	-
Total Inorganics																										
Ammonium	19.8	-	8.7	6.5	11.4	4.3	2.8	9.1	14	3.2	3.2	4.81	7.23	3.62	3.87	***44.1***	8.15	8.41	4.14	9.7	7.2	7.4	2.5	4.1	12.3	3.5
Available Phosphate	-	-	-	14	-	-	-	-	-	-	-	-	-	-	-	-	-	11.2	11.3	22.2	15.3	14.8	13.9	14.3	17.9	10.7
Phosphorus	897	-	723	708	662	694	648	788	725	734	726	807	787	684	721	786	736	702	705	766	727	608	599	623	660	697
Sulfide	49.5	-	5.73	25.4	0.6	0.43	0.62	7.63	0.72	4.72	0.96	1.59	0.73	0.47	0.28	0.27	1.1	<0.20	<0.21	0.59	0.31	0.78	<0.27	1.11	1.04	<0.73
Total Kjeldahl Nitrogen (%)	0.186	-	0.06	0.04	0.04	0.03	0.04	0.05	0.06	0.06	0.05	0.057	0.049	0.033	0.06	0.069	0.047	0.046	0.029	0.037	0.051	0.057	0.035	0.028	0.06	0.034
Total Nitrogen (%)	0.197	-	0.06	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.05	0.069	0.075	0.046	0.061	0.053	0.05	0.11	0.054	0.067	0.051	0.047	0.041	0.045	0.046	0.048
Organics																										
Organic Nitrogen (%)	0.183	-	0.06	0.04	0.04	0.03	0.04	0.05	0.06	0.06	0.05	0.056	0.048	0.033	0.06	-	0.046	0.045	0.028	0.037	0.05	0.056	0.035	0.028	0.059	0.034
Total Organic Carbon (%)	1.98	-	0.27	0.24	0.3	0.3	0.3	0.2	0.3	0.4	<0.1	0.38	0.97	0.31	0.33	0.37	0.31	0.49	0.26	0.3	0.2	0.34	0.26	0.3	0.28	0.27

Table 11: AMS Sediment Chemistry Results

		Location ID:	DP03																							
		Sample ID:	SDDP03-1	SDDP03-2	SDDP03-3	SDDP03-4	SDDP03-5	SDDP03-6	SDDP03-7	SDDP03-8	SDDP03-9	SDDP03-10	SDDP03-11	SDDP03-12	SDDP03-13	SDDP03-14	SDDP03-15	SDDP03-16	SDDP03-17	SDDP03-18	SDDP03-19	SDDP03-20	SDDP03-21	SDDP03-22	SDDP03-23	SDDP03-24
		Date Sampled:	23/03/2007	21/06/2007	02/10/2007	10/12/2007	03/03/2008	29/05/2008	20/09/2008	26/11/2008	24/02/2009	20/05/2009	14/09/2009	03/12/2009	09/03/2010	07/06/2010	30/08/2010	02/12/2010	03/03/2011	08/06/2011	06/09/2011	07/11/2011	20/02/2012	29/05/2012	05/09/2012	10/12/2012
		Sample Depth (m):	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.08	0.00-0.05	0.00-0.04	0.00-0.05	0.00-0.10	0.00-0.10	0.00-0.10	0.00-0.10	0.00-0.10	0.00-0.10	0.00-0.03	0.00-0.10	0.00-10.00	0.000.00-0.050.05	0.00-0.06	-
Parameter	***Nutrient Threshold*** [5]	**BCCSR SedQC(SS) Marine** [3,4]																								
Total Metals																										
Aluminum	-	-	9280	10100	9500	10300	9470	9920	10100	9900	9310	9930	9980	9120	9180	8780	9170	8290	9640	-	-	-	9070	-	-	-
Antimony	-	-	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	0.2	0.51	-	-	-	0.21	-	-	-
Arsenic	-	26	5.6	5.6	5.8	5.2	5.3	8.3	6	5.5	5.5	6	6.7	<5.0	5.1	6.6	5.9	6.14	5.56	-	-	-	4.69	-	-	-
Barium	-	-	28.1	30.5	28.5	32.9	26	32.3	29.7	29.4	24.2	34.7	29.6	23	25.3	25.6	22.5	21.3	23.6	-	-	-	21.9	-	-	-
Beryllium	-	-	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	0.22	0.21	-	-	-	0.21	-	-	-
Bismuth	-	-	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<0.20	<0.20	-	-	-	<0.20	-	-	-
Cadmium	-	2.6	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.10	<0.10	-	-	-	0.053	-	-	-
Calcium	-	-	5000	5360	5220	5310	4920	5910	5740	5850	4800	6670	6600	5040	6990	4870	4520	4500	5070	-	-	-	4210	-	-	-
Chromium	-	99	36.5	34.8	31.8	34	32	38.4	36.7	34.4	32.6	38.3	36.8	33	34.8	35.3	33.9	36.6	35.3	-	-	-	32.5	-	-	-
Cobalt	-	-	9	8.9	8.6	9.1	8.8	9.7	9.6	9.4	9.1	9.7	9.4	8.8	9.5	9.6	9.1	9.42	9.35	-	-	-	8.83	-	-	-
Copper	-	67	9.8	10.3	9.7	11.2	10	11.5	10.3	11	10.4	10.2	10.5	8.6	9.7	7.7	10.4	9.42	8.71	-	-	-	9.21	-	-	-
Iron	-	-	24200	23400	21800	23200	22400	26000	23400	24500	23100	25200	25100	23100	24600	24700	23200	23200	23200	-	-	-	21000	-	-	-
Lead	-	69	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	4.72	23.9	-	-	-	4.15	-	-	-
Lithium	-	-	9.9	11.2	10.9	11.8	10.5	11.8	11.7	11.6	11	11.9	11.7	10.7	10.2	10.4	11	9.6	9.4	-	-	-	8.9	-	-	-
Magnesium	-	-	8190	8810	8420	7960	7950	8960	8780	8780	8710	9010	8740	8210	8190	8770	8820	7890	8410	-	-	-	7660	-	-	-
Manganese	-	-	236	247	239	267	250	266	260	264	247	268	260	251	248	247	249	258	246	-	-	-	225	-	-	-
Mercury	-	0.43	0.0211	0.0283	0.0213	0.0627	0.0242	0.0573	0.0199	0.0233	0.0194	0.0219	0.0286	0.0522	0.0194	0.0183	0.0199	0.0208	0.0196	-	-	-	0.0156	-	-	-
Molybdenum	-	-	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	0.56	<0.50	-	-	-	0.53	-	-	-
Nickel	-	-	30.1	31	28.8	33.8	30.1	32.5	32.2	32.9	30.1	32.9	32	31	32.8	34.7	32.8	33.1	31.3	-	-	-	31	-	-	-
Potassium	-	-	1130	1270	1210	1140	1210	1120	1240	1230	1190	1130	1200	1030	1040	990	1100	1060	1020	-	-	-	980	-	-	-
Selenium	-	-	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<0.20	<0.20	-	-	-	<0.20	-	-	-
Silver	-	-	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<0.10	<0.10	-	-	-	<0.10	-	-	-
Sodium	-	-	4200	4200	5440	3800	4480	3280	4910	5610	5160	3290	4350	3830	4150	4050	5300	5270	6090	-	-	-	3840	-	-	-
Strontium	-	-	29.6	30.7	27.4	31.8	25.7	30	30.3	30.2	26.7	35.4	33.6	29.8	37.7	29.1	28.5	26.9	36.8	-	-	-	23.8	-	-	-
Thallium	-	-	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.050	<0.050	-	-	-	<0.050	-	-	-
Tin	-	-	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<2.0	<2.0	-	-	-	<2.0	-	-	-
Titanium	-	-	865	851	724	838	750	854	763	814	674	809	799	816	908	829	707	732	830	-	-	-	795	-	-	-
Vanadium	-	-	53.8	50.6	49.5	49.4	47.2	59.1	51.9	53.3	47.3	55.7	53.4	47.9	54.4	51.5	49.5	50.5	54.3	-	-	-	49.1	-	-	-
Zinc	-	170	46.3	49.4	46.4	50.2	46.5	51.1	49	51.7	51.3	48.3	47.8	47.6	47.3	50	49.3	45.1	46.8	-	-	-	45	-	-	-
Unknown Parameters																										
Phosphorus, total, acid digestion	897	-	690	690	630	680	570	700	690	570	570	766	629	629	639	700	567	-	-	-	-	-	-	-	-	-

Table 11: AMS Sediment Chemistry Results

		Location ID:	DP04																							
		Sample ID:	SDDP04-1	SDDP04-2	SDDP04-3	SDDP04-4	SDDP04-5	SDDP04-6	SDDP04-7	SDDP04-8	SDDP04-9	SDDP04-10	SDDP04-11	SDDP04-12	SDDP04-13	SDDP04-14	SDDP04-15	SDDP04-16	SDDP04-17	SDDP04-18	SDDP04-19	SDDP04-20	SDDP04-21	SDDP04-22	SDDP04-23	SDDP04-24
		Date Sampled:	23/03/2007	20/06/2007	02/10/2007	10/12/2007	05/03/2008	30/05/2008	20/09/2008	26/11/2008	24/02/2009	20/05/2009	14/09/2009	03/12/2009	09/03/2010	07/06/2010	30/08/2010	02/12/2010	03/03/2011	08/06/2011	06/09/2011	07/11/2011	20/02/2012	29/05/2012	05/09/2012	10/12/2012
		Sample Depth (m):	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.08	0.00-0.08	0.00-0.05	0.00-0.05	0.00-0.10	0.00-0.10	0.00-0.10	0.00-0.10	0.00-0.10	0.00-0.10	0.00-0.03	0.00-0.10	0.00-10.00	0.000.00-0.100.10	0.00-0.06	-
Parameter	***Nutrient Threshold*** [5]	**BCCSR SedQC(SS) Marine** [3,4]																								
Physical Tests																										
Moisture (%)	-	-	36.8	41.5	33.3	33.6	35.5	32.6	33.7	47.4	36.5	39.3	42.5	27.3	39.7	36.9	39.5	34.1	38.6	26.8	34	31.4	27.7	35.4	42.7	30
Oxidation Reduction Potential (mV)	-	-	<-200	-220	-190	-120	-190	-320	-280	-220	-220	-384	-381	-298	-	-224	-259	-149	-226	12	-334	13	-61	-217	-138	-128
pH	-	-	7.86	8.55	8.21	7.88	8.06	7.92	7.95	7.72	8.18	7.81	8.18	7.84	7.89	7.92	7.64	7.5	7.82	-	-	-	7.34	-	-	-
Grain Size																										
Clay (<0.004 mm) (%)	-	-	4	-	-	-	3	-	-	-	4	-	-	-	2	-	2.55	2.71	2.54	-	5.25	-	2.46	-	-	-
Silt (0.004-0.063 mm) (%)	-	-	6	-	-	-	15	-	-	-	9	-	-	-	7	-	11.7	9.01	10.1	-	10.4	-	7.28	-	-	-
Sand (0.063-2.00 mm) (%)	-	-	91	-	-	-	80	-	-	-	87	-	-	-	90	-	85.7	88.3	87.3	-	84.4	-	90.1	-	-	-
Gravel (>2.00 mm) (%)	-	-	<1	-	-	-	1	-	-	-	<1	-	-	-	<1.0	-	<0.10	<0.10	<0.10	-	<0.10	-	0.16	-	-	-
Total Inorganics																										
Ammonium	19.8	-	10.9	12.3	9.6	6.2	3.1	8.4	9.1	5.3	4.1	11.5	6.28	4.76	5.28	6.13	6.09	8.52	3.99	13.9	4	4.4	2.7	5.9	10.1	2.8
Available Phosphate	-	-	-	21	-	-	-	-	-	-	-	-	-	-	-	-	-	18.7	8.3	32.2	9.4	17.6	15.6	19.4	30	13.7
Phosphorus	897	-	664	712	591	684	640	599	620	752	681	655	609	537	655	605	587	653	593	690	589	454	563	539	715	703
Sulfide	49.5	-	2.58	8.25	39.9	8.76	5.71	23.5	18.8	4.44	1.97	13.5	44.7	17.4	9.3	6.74	39.3	1.75	29	3.74	31	5.9	12.5	1.55	5.5	1.57
Total Kjeldahl Nitrogen (%)	0.186	-	0.07	0.08	0.05	0.06	0.06	0.06	0.08	0.1	0.06	0.091	0.085	0.058	0.072	0.094	0.069	0.064	0.071	<0.020	0.073	0.071	0.06	0.046	0.07	0.044
Total Nitrogen (%)	0.197	-	0.07	0.08	0.05	0.04	0.06	0.05	0.08	0.08	0.07	0.11	0.11	0.07	0.051	0.069	0.061	0.125	0.079	0.076	0.08	0.061	0.055	0.055	0.063	0.058
Organics																										
Organic Nitrogen (%)	0.183	-	0.07	0.08	0.07	0.06	0.06	0.06	0.08	0.1	0.06	0.09	0.085	0.058	0.071	-	0.068	0.063	0.071	<0.020	0.073	0.071	0.06	0.046	0.069	0.044
Total Organic Carbon (%)	1.98	-	0.39	0.58	0.4	0.5	0.5	0.4	0.5	0.7	0.5	0.53	0.67	0.48	0.41	0.51	0.42	0.45	0.53	0.41	0.47	0.47	0.34	0.37	0.42	0.37

Table 11: AMS Sediment Chemistry Results

		Location ID:	DP04																							
		Sample ID:	SDDP04-1	SDDP04-2	SDDP04-3	SDDP04-4	SDDP04-5	SDDP04-6	SDDP04-7	SDDP04-8	SDDP04-9	SDDP04-10	SDDP04-11	SDDP04-12	SDDP04-13	SDDP04-14	SDDP04-15	SDDP04-16	SDDP04-17	SDDP04-18	SDDP04-19	SDDP04-20	SDDP04-21	SDDP04-22	SDDP04-23	SDDP04-24
		Date Sampled:	23/03/2007	20/06/2007	02/10/2007	10/12/2007	05/03/2008	30/05/2008	20/09/2008	26/11/2008	24/02/2009	20/05/2009	14/09/2009	03/12/2009	09/03/2010	07/06/2010	30/08/2010	02/12/2010	03/03/2011	08/06/2011	06/09/2011	07/11/2011	20/02/2012	29/05/2012	05/09/2012	10/12/2012
		Sample Depth (m):	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.08	0.00-0.08	0.00-0.05	0.00-0.05	0.00-0.10	0.00-0.10	0.00-0.10	0.00-0.10	0.00-0.10	0.00-0.10	0.00-0.03	0.00-0.10	0.00-10.00	0.000.00-0.100.10	0.00-0.06	-
Parameter	***Nutrient Threshold*** [5]	**BCCSR SedQC(SS) Marine** [3,4]																								
Total Metals																										
Aluminum	-	-	9420	10600	9850	10800	9750	9530	9970	9990	9750	10400	10700	8600	9400	8330	9110	8160	10000	-	-	-	9100	-	-	-
Antimony	-	-	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	0.18	0.23	-	-	-	0.19	-	-	-
Arsenic	-	26	6.7	5.1	6	5.5	6.4	6.8	5.8	8.2	5.4	5.3	6.6	<5.0	5.1	5.6	5	5.72	5.1	-	-	-	5.43	-	-	-
Barium	-	-	26.8	30	25.3	36.2	24.9	25.2	30.2	31.1	27.2	30.8	31.9	19.5	23.6	18.6	22.4	22.2	21.7	-	-	-	21.5	-	-	-
Beryllium	-	-	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	0.21	0.21	-	-	-	0.21	-	-	-
Bismuth	-	-	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<0.20	<0.20	-	-	-	<0.20	-	-	-
Cadmium	-	2.6	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	0.12	0.16	-	-	-	0.145	-	-	-
Calcium	-	-	4530	5560	5200	6000	5390	5000	5910	6680	5550	5880	6260	4260	4870	4290	4530	4180	4320	-	-	-	3950	-	-	-
Chromium	-	99	38.1	30.7	29	30.4	28.8	29.9	30.9	31.3	31.5	30.9	33.6	29.2	32.9	30	30	30.4	30.3	-	-	-	31.1	-	-	-
Cobalt	-	-	8	8.1	7.7	7.9	8.3	7.9	8.5	8.2	8.3	8.5	8.5	7.3	8.3	8.3	8	7.76	8.23	-	-	-	8.22	-	-	-
Copper	-	67	11.8	13.6	12.7	15.1	13.7	13.2	13.3	15.1	13.8	14.5	15.4	10.5	11.9	10.9	12.6	11.1	11.9	-	-	-	10.8	-	-	-
Iron	-	-	20400	20400	18800	20200	20100	20200	19700	21300	20100	20600	20500	18100	20400	19400	19400	18900	19200	-	-	-	18900	-	-	-
Lead	-	69	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	4.95	5.25	-	-	-	4.57	-	-	-
Lithium	-	-	10.5	11.6	11.6	12.3	11.1	11.4	11.6	12.2	11.8	13.1	12.6	10.5	10.6	10.1	10.9	9.4	9.2	-	-	-	8.9	-	-	-
Magnesium	-	-	7670	9040	8690	7940	8360	7960	8380	8790	8330	9260	8830	7490	8000	8340	8490	7260	8240	-	-	-	7880	-	-	-
Manganese	-	-	226	226	217	250	238	226	228	258	227	238	228	202	219	206	216	215	218	-	-	-	212	-	-	-
Mercury	-	0.43	0.0245	0.0288	0.0227	0.0281	0.0236	0.0222	0.0239	0.0274	0.0233	0.0274	0.0248	0.0304	0.0269	0.0255	0.0234	0.0221	0.0233	-	-	-	0.017	-	-	-
Molybdenum	-	-	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	0.77	1.63	-	-	-	0.83	-	-	-
Nickel	-	-	33.2	29.8	28.3	31.7	31.3	30.2	30	30.2	30.7	31.2	30.3	27.9	31.7	32.2	31.1	29.8	29.8	-	-	-	31.7	-	-	-
Potassium	-	-	1310	1560	1440	1420	1430	1210	1350	1480	1360	1530	1640	1180	1180	1090	1240	1150	1220	-	-	-	1100	-	-	-
Selenium	-	-	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.5	<2.0	<2.1	<0.20	<0.20	-	-	-	<0.20	-	-	-
Silver	-	-	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<0.10	<0.10	-	-	-	<0.10	-	-	-
Sodium	-	-	4240	8350	6950	6050	6490	5360	4950	8930	5000	7530	6890	4070	3840	4800	5970	5920	5000	-	-	-	4100	-	-	-
Strontium	-	-	30.4	34.8	27.4	38.5	29.2	27.5	29.4	35.7	28.6	33.2	32.5	25.6	27.6	24.8	27.9	26.6	28.9	-	-	-	22.9	-	-	-
Thallium	-	-	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	0.106	0.11	-	-	-	0.116	-	-	-
Tin	-	-	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<2.0	<2.0	-	-	-	<2.0	-	-	-
Titanium	-	-	774	732	690	808	703	697	704	719	716	732	769	715	826	624	724	669	725	-	-	-	714	-	-	-
Vanadium	-	-	41.7	44.7	44.2	43.8	43.6	44	44.7	45.8	42.6	45.2	43.5	36.3	45	39.2	42.6	41	43.1	-	-	-	41.8	-	-	-
Zinc	-	170	42.6	48.7	44.1	47.4	46.8	44.8	45.9	48.9	46.7	46.7	46.9	43.2	44.4	46.6	46.5	40.6	46.3	-	-	-	44.3	-	-	-
Unknown Parameters																										
Phosphorus, total, acid digestion	897	-	650	-	540	660	480	620	610	520	540	645	541	513	566	530	741	-	-	-	-	-	-	-	-	-

Table 11: AMS Sediment Chemistry Results

		Location ID:	DP05																							
		Sample ID:	SDDP05-1	SDDP05-2	SDDP05-3	SDDP05-4	SDDP05-5	SDDP05-6	SDDP05-7	SDDP05-8	SDDP05-9	SDDP05-10	SDDP05-11	SDDP05-12	SDDP05-13	SDDP05-14	SDDP05-15	SDDP05-16	SDDP05-17	SDDP05-18	SDDP05-19	SDDP05-20	SDDP05-21	SDDP05-22	SDDP05-23	SDDP05-24
		Date Sampled:	24/03/2007	20/06/2007	02/10/2007	10/12/2007	05/03/2008	30/05/2008	21/09/2008	27/11/2008	24/02/2009	20/05/2009	14/09/2009	03/12/2009	08/03/2010	07/06/2010	30/08/2010	02/12/2010	03/03/2011	08/06/2011	06/09/2011	07/11/2011	20/02/2012	29/05/2012	05/09/2012	10/12/2012
		Sample Depth (m):	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.12	0.00-0.10	0.00-0.12	0.00-0.12	0.00-0.10	0.00-0.10	0.00-0.10	0.00-0.10	0.00-0.10	0.00-0.10	0.00-0.10	0.00-0.20	0.00-15.00	0.000.00-0.300.30	0.00-0.15	-
Parameter	***Nutrient Threshold*** [5]	**BCCSR SedQC(SS) Marine** [3,4]																								
Physical Tests																										
Moisture (%)	-	-	46.7	54.4	51.5	52	51.7	49.6	54.6	54.6	52.9	54.7	48.7	50	52	54.3	50	51.6	50.7	51.1	48.8	53.8	46	50.4	53.4	52.2
Oxidation Reduction Potential (mV)	-	-	-160	-200	<-200	<-200	<-200	-280	-310	-430	-280	-412	-354	-303	-	-238	-298	-207	-270	-34	-314	-136	-192	-205	-167	-217
pH	-	-	8.17	7.98	8.1	7.86	7.83	7.89	7.71	7.91	7.83	7.76	8.04	8.19	7.88	7.86	7.7	7.64	7.83	-	-	-	7.81	-	-	-
Grain Size																										
Clay (<0.004 mm) (%)	-	-	16	-	-	-	15	-	-	-	17	-	-	-	16	-	11.8	9.68	10.9	-	14.7	-	14.3	-	-	-
Silt (0.004-0.063 mm) (%)	-	-	41	-	-	-	53	-	-	-	49	-	-	-	49	-	30.6	56.7	54.8	-	55.7	-	50.9	-	-	-
Sand (0.063-2.00 mm) (%)	-	-	44	-	-	-	33	-	-	-	34	-	-	-	35	-	57.6	33.6	34.3	-	29.6	-	34.8	-	-	-
Gravel (>2.00 mm) (%)	-	-	<1	-	-	-	<1	-	-	-	<1	-	-	-	<1.0	-	<0.10	<0.10	<0.10	-	<0.10	-	<0.10	-	-	-
Total Inorganics																										
Ammonium	19.8	-	17.9	9	4.9	6.1	7.5	8.9	17.4	7.3	5.4	6.38	10.4	9.96	10.5	***22.1***	10.2	13.7	5.25	12.5	7.8	4.7	4.2	7.5	6.4	6.9
Available Phosphate	-	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	15.7	4.4	29.7	10.8	3.9	10.7	7.3	6.9	9.8
Phosphorus	897	-	814	812	644	837	885	825	851	***955***	824	825	741	726	862	798	772	753	706	820	813	784	576	691	851	580
Sulfide	49.5	-	46.2	***101***	***61.6***	9.1	19.7	8.69	15.9	28.5	17.8	17.4	31	31.2	41.8	32.3	39.3	20.6	28.3	19.4	36.8	45.7	7.5	5.8	***77***	***53***
Total Kjeldahl Nitrogen (%)	0.186	-	-	0.15	***0.19***	0.17	0.18	0.14	0.17	0.17	0.18	0.168	0.171	***0.188***	0.173	***0.195***	0.161	0.166	0.13	0.167	0.18	0.153	0.141	0.162	0.168	0.171
Total Nitrogen (%)	0.197	-	0.19	0.16	0.17	0.14	0.16	0.15	0.16	0.18	0.15	***0.217***	0.189	***0.2***	0.177	0.162	0.16	***0.241***	0.158	***0.207***	0.178	0.151	0.159	0.178	0.141	0.192
Organics																										
Organic Nitrogen (%)	0.183	-	-	0.15	***0.19***	0.16	0.18	0.14	0.17	0.17	0.18	0.167	0.17	***0.187***	0.172	-	0.16	0.164	0.13	0.166	0.179	0.153	0.14	0.162	0.167	0.17
Total Organic Carbon (%)	1.98	-	1.72	1.66	1.9	1.8	1.8	1.6	1.8	***2.1***	1.7	1.95	1.77	1.91	1.66	1.65	1.73	1.85	1.62	***2.01***	1.83	1.9	1.87	***1.99***	1.82	***2.16***

Table 11: AMS Sediment Chemistry Results

		Location ID:	DP05																							
		Sample ID:	SDDP05-1	SDDP05-2	SDDP05-3	SDDP05-4	SDDP05-5	SDDP05-6	SDDP05-7	SDDP05-8	SDDP05-9	SDDP05-10	SDDP05-11	SDDP05-12	SDDP05-13	SDDP05-14	SDDP05-15	SDDP05-16	SDDP05-17	SDDP05-18	SDDP05-19	SDDP05-20	SDDP05-21	SDDP05-22	SDDP05-23	SDDP05-24
		Date Sampled:	24/03/2007	20/06/2007	02/10/2007	10/12/2007	05/03/2008	30/05/2008	21/09/2008	27/11/2008	24/02/2009	20/05/2009	14/09/2009	03/12/2009	08/03/2010	07/06/2010	30/08/2010	02/12/2010	03/03/2011	08/06/2011	06/09/2011	07/11/2011	20/02/2012	29/05/2012	05/09/2012	10/12/2012
		Sample Depth (m):	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.12	0.00-0.10	0.00-0.12	0.00-0.12	0.00-0.10	0.00-0.10	0.00-0.10	0.00-0.10	0.00-0.10	0.00-0.10	0.00-0.10	0.00-0.20	0.00-15.00	0.000.00-0.300.30	0.00-0.15	-
Parameter	***Nutrient Threshold*** [5]	**BCCSR SedQC(SS) Marine** [3,4]																								
Total Metals																										
Aluminum	-	-	16500	17000	13400	17900	17200	17100	16100	17000	17000	18200	16000	15400	15700	15300	15400	14600	14600	-	-	-	12000	-	-	-
Antimony	-	-	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	0.37	0.33	-	-	-	0.26	-	-	-
Arsenic	-	26	<5.0	6.5	5	6.1	7.8	7.6	8	8.6	7.6	6.6	6.6	5.5	7.8	7.3	5.4	6.98	6.14	-	-	-	5.32	-	-	-
Barium	-	-	49.2	51.2	40.3	60.8	53.5	56	51.4	58.1	53.5	57.1	49.3	46.7	47.7	45.2	45.2	50.5	39.3	-	-	-	32.7	-	-	-
Beryllium	-	-	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	0.54	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	0.36	0.29	-	-	-	0.25	-	-	-
Bismuth	-	-	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<0.20	<0.20	-	-	-	<0.20	-	-	-
Cadmium	-	2.6	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	0.91	<0.50	0.63	<0.50	0.64	<0.50	<0.50	0.35	0.31	-	-	-	0.259	-	-	-
Calcium	-	-	8070	8390	8240	9810	9910	9710	10300	11500	9420	10100	9830	8550	8800	8820	8330	8300	7280	-	-	-	6380	-	-	-
Chromium	-	99	40.2	38.9	30.3	42.1	40	39.3	39.1	38.3	39.7	39.1	39.4	37.2	40.1	40.4	40.8	44.7	36.3	-	-	-	29.5	-	-	-
Cobalt	-	-	10.6	10.6	7.7	10.3	10.9	10.3	10.8	10.9	10.6	11.3	10.5	9.5	10.7	10.8	10.6	11.1	9.73	-	-	-	8.43	-	-	-
Copper	-	67	36.8	37.8	29.8	38.2	38	37	35.1	36.5	37.7	38.2	35.5	31.4	32.3	31.4	34.6	33.5	29.1	-	-	-	24.4	-	-	-
Iron	-	-	30000	28700	22200	28600	30200	29800	28100	28800	29200	31000	28200	27100	27900	29600	28600	29400	25900	-	-	-	21600	-	-	-
Lead	-	69	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	8.73	6.58	-	-	-	5.86	-	-	-
Lithium	-	-	20.7	21.4	17.7	22.8	21.4	22.5	21.1	22.2	22.6	23.6	21.6	20.2	21.4	20.6	20.4	19.2	15.4	-	-	-	13.1	-	-	-
Magnesium	-	-	12200	12400	10200	11600	12300	12100	12500	12500	13100	13100	12200	11100	12200	12800	12200	11500	10900	-	-	-	8760	-	-	-
Manganese	-	-	330	318	246	341	347	337	327	334	323	339	312	295	313	308	317	327	285	-	-	-	236	-	-	-
Mercury	-	0.43	0.0592	0.0686	0.0805	0.0608	0.0623	0.0578	0.059	0.0678	0.0619	0.0631	0.0548	0.048	0.0505	0.0521	0.0512	0.0526	0.0488	-	-	-	0.034	-	-	-
Molybdenum	-	-	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	1.74	1.18	-	-	-	1.15	-	-	-
Nickel	-	-	39.7	37.3	27.1	42.5	38.1	38	37.1	36.3	36.8	40.3	36.8	34	38.4	40.1	38	40.9	34.5	-	-	-	31.1	-	-	-
Potassium	-	-	2590	2510	2230	2600	2700	2440	2540	2620	2920	2980	2540	2440	2570	2440	2310	2470	2020	-	-	-	1660	-	-	-
Selenium	-	-	<2.0	<2.0	<3.0	<2.0	<2.0	<3.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<0.50, <3.2	0.46	0.41	-	-	-	0.35	-	-	-
Silver	-	-	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	0.13	0.12	-	-	-	<0.10	-	-	-
Sodium	-	-	11300	10800	11200	11800	12100	12300	10400	15200	14500	14900	11600	11100	12300	13600	10900	12300	9250	-	-	-	7800	-	-	-
Strontium	-	-	47.7	49.5	41.8	58.7	54.2	53.2	51	59.7	52.5	58.1	49.6	52.2	54.3	55.3	50.4	49.7	46.6	-	-	-	38.1	-	-	-
Thallium	-	-	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	0.158	0.145	-	-	-	0.114	-	-	-
Tin	-	-	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<2.0	<2.0	-	-	-	<2.0	-	-	-
Titanium	-	-	910	884	734	995	959	932	839	928	882	943	875	986	973	974	922	942	778	-	-	-	637	-	-	-
Vanadium	-	-	56.8	56	46.1	54.6	57.3	57.7	54.2	54.8	53.4	59.2	52.8	50.3	53	53.9	55.2	56.8	49.9	-	-	-	40.6	-	-	-
Zinc	-	170	74.7	72.8	55.4	72.4	75.5	71.6	70.8	72.4	76.9	76.8	68.7	67.1	68.7	73.3	71.9	69.9	65.7	-	-	-	55.8	-	-	-
Unknown Parameters																										
Phosphorus, total, acid digestion	897	-	610	-	720	800	650	780	***1020***	700	640	793	752	786	721	760	731	-	-	-	-	-	-	-	-	-

Table 11: AMS Sediment Chemistry Results

		Location ID:	DP06																							
		Sample ID:	SDDP06-1	SDDP06-2	SDDP06-3	SDDP06-4	SDDP06-5	SDDP06-6	SDDP06-7	SDDP06-8	SDDP06-9	SDDP06-10	SDDP06-11	SDDP06-12	SDDP06-13	SDDP06-14	SDDP06-15	SDDP06-16	SDDP06-17	SDDP06-18	SDDP06-19	SDDP06-20	SDDP06-21	SDDP06-22	SDDP06-23	SDDP06-24
		Date Sampled:	23/03/2007	20/06/2007	01/10/2007	10/12/2007	04/03/2008	29/05/2008	20/09/2008	26/11/2008	23/02/2009	20/05/2009	15/09/2009	03/12/2009	08/03/2010	07/06/2010	30/08/2010	02/12/2010	04/03/2011	08/06/2011	06/09/2011	07/11/2011	20/02/2012	29/05/2012	05/09/2012	06/12/2012
		Sample Depth (m):	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.08	0.00-0.05	0.00-0.10	0.00-0.07	0.00-0.10	0.00-0.10	0.00-0.10	0.00-0.10	0.00-0.10	0.00-0.10	0.00-0.07	0.00-0.15	0.00-10.00	0.000.00-0.500.50	0.00-0.08	-
Parameter	***Nutrient Threshold*** [5]	**BCCSR SedQC(SS) Marine** [3,4]																								
Physical Tests																										
Moisture (%)	-	-	30.4	32.6	32.4	27.2	34	27.4	26.6	32.6	31.7	30.6	30	26.6	28	28.9	30.5	28.8	30	35.5	35.7	33.3	32	34.4	39.9	26.8
Oxidation Reduction Potential (mV)	-	-	-60	-50	-20	-140	70	-140	-170	-190	-	-321	-269	-267	-	-78	-77	-75	96	-7	-268	-140	68	-133	-67	-51
pH	-	-	7.87	7.92	7.99	7.95	8	8.01	7.82	7.83	7.85	7.76	7.97	7.99	7.95	7.8	7.71	7.56	7.73	-	-	-	7.87	-	-	-
Grain Size																										
Clay (<0.004 mm) (%)	-	-	7	-	-	-	3	-	-	-	8	-	-	-	6	-	4.92	2.1	4.85	-	14.1	-	11.6	-	-	-
Silt (0.004-0.063 mm) (%)	-	-	16	-	-	-	8	-	-	-	30	-	-	-	27	-	23.3	14	18.2	-	71.1	-	47.5	-	-	-
Sand (0.063-2.00 mm) (%)	-	-	78	-	-	-	88	-	-	-	59	-	-	-	66	-	71.8	83.9	77	-	14.8	-	40.8	-	-	-
Gravel (>2.00 mm) (%)	-	-	<1	-	-	-	<1	-	-	-	4	-	-	-	<1.0	-	<0.10	<0.10	<0.10	-	<0.10	-	<0.10	-	-	-
Total Inorganics																										
Ammonium	19.8	-	2	1.7	2.8	2	1	<0.8	1	1.6	2.2	2.3	3.07	1.78	4.9	4.13	1.48	1.56	1.5	1.4	<1.6	1.5	<1.6	3	2.5	2.5
Available Phosphate	-	-	-	6	-	-	-	-	-	-	-	-	-	-	-	-	-	8.5	10.1	9.2	5.4	6.5	7	8.3	8.6	6.5
Phosphorus	897	-	723	733	802	713	656	649	690	781	820	699	745	637	618	714	696	627	647	798	819	700	714	843	780	881
Sulfide	49.5	-	0.24	0.21	<0.17	<0.18	0.24	<0.20	0.21	0.22	<0.20	<0.21	<0.20	<0.20	0.5	0.27	0.36	<0.20	<0.21	0.4	0.42	0.9	0.94	<0.69	0.94	<0.20
Total Kjeldahl Nitrogen (%)	0.186	-	0.04	0.03	0.05	0.03	0.02	0.04	0.03	0.07	0.06	0.038	0.054	0.036	0.034	0.051	0.043	0.024	0.032	0.032	0.057	0.088	0.032	0.035	0.056	0.042
Total Nitrogen (%)	0.197	-	0.03	0.04	0.04	0.04	0.04	0.03	0.05	0.05	-	0.045	0.081	0.04	0.054	0.042	0.033	0.086	0.04	0.057	0.058	0.067	0.053	0.048	0.036	0.055
Organics																										
Organic Nitrogen (%)	0.183	-	0.04	0.03	0.05	0.03	0.02	0.04	0.03	0.07	0.06	0.037	0.054	0.035	0.033	-	0.043	0.024	0.032	0.032	0.057	0.088	0.032	0.035	0.056	0.042
Total Organic Carbon (%)	1.98	-	0.32	0.46	0.5	0.4	0.3	<0.1	0.3	0.5	-	0.25	0.52	0.29	0.39	0.4	0.33	0.3	-	0.37	0.57	1.12	0.73	0.48	0.52	0.61

Table 11: AMS Sediment Chemistry Results

	Location ID:		DP06																							
	Sample ID:		SDDP06-1	SDDP06-2	SDDP06-3	SDDP06-4	SDDP06-5	SDDP06-6	SDDP06-7	SDDP06-8	SDDP06-9	SDDP06-10	SDDP06-11	SDDP06-12	SDDP06-13	SDDP06-14	SDDP06-15	SDDP06-16	SDDP06-17	SDDP06-18	SDDP06-19	SDDP06-20	SDDP06-21	SDDP06-22	SDDP06-23	SDDP06-24
	Date Sampled:		23/03/2007	20/06/2007	01/10/2007	10/12/2007	04/03/2008	29/05/2008	20/09/2008	26/11/2008	23/02/2009	20/05/2009	15/09/2009	03/12/2009	08/03/2010	07/06/2010	30/08/2010	02/12/2010	04/03/2011	08/06/2011	06/09/2011	07/11/2011	20/02/2012	29/05/2012	05/09/2012	06/12/2012
	Sample Depth (m):		0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.08	0.00-0.05	0.00-0.10	0.00-0.07	0.00-0.10	0.00-0.10	0.00-0.10	0.00-0.10	0.00-0.10	0.00-0.10	0.00-0.07	0.00-0.15	0.00-10.00	0.000.00- 0.500.50	0.00-0.08	-
Parameter	***Nutrient Threshold*** [5]	**BCCSR SedQC(SS) Marine** [3,4]																								
Total Metals																										
Aluminum	-	-	11500	15000	14800	14500	10000	9890	11400	13100	13700	11200	13400	10200	9330	10900	10400	8850	8960	-	-	-	13700	-	-	-
Antimony	-	-	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	0.26	0.28	-	-	-	0.37	-	-	-
Arsenic	-	26	6.3	7.1	7	6.7	5	7	6.4	7.6	6.3	6.4	7	5.3	<5.0	5.7	5.8	6.06	6.03	-	-	-	6.63	-	-	-
Barium	-	-	47	69.4	60.1	65.4	38.8	41.1	46.8	58.1	57	46.3	54.3	37.3	34.9	39.4	37.6	31.4	32.2	-	-	-	51.3	-	-	-
Beryllium	-	-	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	0.22	0.23	-	-	-	0.27	-	-	-
Bismuth	-	-	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<0.20	<0.20	-	-	-	<0.20	-	-	-
Cadmium	-	2.6	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	0.52	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.10	<0.10	-	-	-	0.118	-	-	-
Calcium	-	-	5660	7110	7750	7210	5560	5550	6070	7490	7160	6070	6880	5580	5420	5980	5560	4950	4870	-	-	-	6110	-	-	-
Chromium	-	99	39.5	38.1	36.9	38.9	34.3	33.4	34.6	37.6	40.7	33.1	35.4	32.8	30	34.6	34.6	32.8	33.7	-	-	-	35.9	-	-	-
Cobalt	-	-	11.5	12.8	12.4	11.8	10.6	10.6	11.5	11.7	12.6	11.6	12.5	10.2	9.7	11.5	10.7	10.4	10.5	-	-	-	11.9	-	-	-
Copper	-	67	18.3	26	30.8	25.9	15	15.4	18.1	25	25.4	18.8	27.2	15.8	13.4	16.2	16.4	14.2	14.2	-	-	-	24.6	-	-	-
Iron	-	-	27900	28500	29500	27300	24400	23400	24700	28800	29600	26500	28200	23500	21100	25500	24700	22500	23500	-	-	-	27300	-	-	-
Lead	-	69	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	4.99	4.61	-	-	-	5.33	-	-	-
Lithium	-	-	12.2	15.5	18.2	16.4	11	11.3	12.7	15.3	15.8	12.3	17	11.7	10.5	12.2	11.8	9.8	10.5	-	-	-	11.6	-	-	-
Magnesium	-	-	9720	11300	11900	10100	8990	9080	9560	10500	11300	9830	10900	8960	8730	10200	9760	8530	8420	-	-	-	9950	-	-	-
Manganese	-	-	376	472	416	386	364	345	366	392	410	389	372	329	288	374	335	323	339	-	-	-	401	-	-	-
Mercury	-	0.43	0.0326	0.0629	0.0474	0.201	0.0251	0.0323	0.0283	0.0513	0.0495	0.0337	0.0402	0.0254	0.0463	0.0333	0.0256	0.0269	0.025	-	-	-	0.0344	-	-	-
Molybdenum	-	-	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	0.7	<0.50	-	-	-	0.68	-	-	-
Nickel	-	-	37.7	41.5	39	44.7	37	36.6	37.8	39.9	40.7	40.3	40.4	36	34.4	40.7	38.3	37	37.1	-	-	-	39.5	-	-	-
Potassium	-	-	1230	1490	1560	1490	1120	940	1180	1420	1490	1160	1490	1080	920	1010	990	1080	980	-	-	-	1300	-	-	-
Selenium	-	-	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<3.0	<2.0	<2.0	<2.0	<2.0	<0.20	<0.20	-	-	-	0.26	-	-	-
Silver	-	-	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<0.10	<0.10	-	-	-	<0.10	-	-	-
Sodium	-	-	3110	3390	4300	3510	3580	1120	2520	4570	5140	2490	4450	2410	2580	2300	2650	5990	2800	-	-	-	4010	-	-	-
Strontium	-	-	36.7	41.6	40.4	43.9	31.3	29	31.6	39.2	40.1	32	38.8	32.8	27.4	32.7	32.2	31.1	29.8	-	-	-	36.3	-	-	-
Thallium	-	-	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.050	<0.050	-	-	-	0.056	-	-	-
Tin	-	-	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<2.0	<2.0	-	-	-	<2.0	-	-	-
Titanium	-	-	921	850	816	917	788	754	724	850	854	706	743	831	743	856	805	693	767	-	-	-	880	-	-	-
Vanadium	-	-	56.6	55.4	55.4	53	47.5	47.3	47.8	53.4	54.4	52	52.6	44.1	40	47.2	49.7	43	46	-	-	-	50.7	-	-	-
Zinc	-	170	53	65.7	64.9	60.6	48	49.3	52.2	61.7	62.3	54.9	60.4	49.3	44.5	54.6	51.1	45.5	48.1	-	-	-	60	-	-	-
Unknown Parameters																										
Phosphorus, total, acid digestion	897	-	730	-	710	740	480	620	650	620	670	706	765	677	678	580	533	-	-	-	-	-	-	-	-	-

Table 11: AMS Sediment Chemistry Results

Parameter	Nutrient Threshold[5]	BCCSR SedQC(SS) Marine[3,4]	SDDP07-1	SDDP07-2	SDDP07-3	SDDP07-4	SDDP07-5	SDDP07-6	SDDP07-7	SDDP07-8	SDDP07-9	SDDP07-10	SDDP07-11	SDDP07-12	SDDP07-13	SDDP07-14	SDDP07-15	SDDP07-16	SDDP07-17	SDDP07-18	SDDP07-19	SDDP07-20	SDDP07-21	SDDP07-22	SDDP07-23	SDDP07-24
Location ID:			DP07																							
Date Sampled:			24/03/2007	20/06/2007	01/10/2007	10/12/2007	04/03/2008	29/05/2008	20/09/2008	26/11/2008	23/02/2009	20/05/2009	14/09/2009	03/12/2009	08/03/2010	07/06/2010	30/08/2010	02/12/2010	04/03/2011	08/06/2011	06/09/2011	07/11/2011	20/02/2012	29/05/2012	05/09/2012	10/12/2012
Sample Depth (m):			0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.07	0.00-0.08	0.00-0.08	0.00-0.10	0.00-0.10	0.00-0.10	0.00-0.10	0.00-0.10	0.00-0.10	0.00-0.10	0.00-0.07	0.00-0.20	0.00-6.00	0.000.00-0.100.10	0.00-0.06	-
Physical Tests																										
Moisture (%)	-	-	28.5	29.4	26.1	26.3	24.5	24.4	36.7	31.8	24.8	21.1	22.6	22.1	25.5	20.1	26.5	22.4	22.9	19.1	24.2	25.9	24.2	19.6	26.9	19.9
Oxidation Reduction Potential (mV)	-	-	-110	-170	<-200	-170	110	-250	-260	-270	-	-37	-278	-33	-	31	-99	49	158	179	-263	-59	-110	-184	-126	-207
pH	-	-	8.04	8.16	8.13	8.1	8.24	8.11	7.86	8	8.29	8	8.18	8.01	8.2	8.01	7.87	7.56	7.72	-	-	-	8.18	-	-	-
Grain Size																										
Clay (<0.004 mm) (%)	-	-	7	-	-	-	2	-	-	-	4	-	-	-	2	-	2.1	1.44	1.27	-	6.28	-	4.87	-	-	-
Silt (0.004-0.063 mm) (%)	-	-	15	-	-	-	4	-	-	-	6	-	-	-	5	-	4.1	2.57	5.33	-	19.9	-	16.3	-	-	-
Sand (0.063-2.00 mm) (%)	-	-	78	-	-	-	93	-	-	-	87	-	-	-	92	-	93.8	96	93.3	-	73.8	-	78.8	-	-	-
Gravel (>2.00 mm) (%)	-	-	<1	-	-	-	<1	-	-	-	2	-	-	-	<1.0	-	<0.10	<0.10	0.1	-	<0.10	-	<0.10	-	-	-
Total Inorganics																										
Ammonium	19.8	-	3.1	2.2	2.9	1.4	1.3	2.2	2.4	1.4	1.5	1.75	2.15	<0.80	4.98	2.19	1.14	1.3	<1.0	<1.0	<1.6	1.2	<1.0	1.7	1.9	1.5
Available Phosphate	-	-	-	12	-	-	-	-	-	-	-	-	-	-	-	-	-	14.2	12.5	11.1	11.5	8.5	10.1	10.5	12.7	7.8
Phosphorus	897	-	692	613	649	548	534	680	740	597	559	541	670	532	525	556	557	553	509	564	610	560	543	580	598	574
Sulfide	49.5	-	1.59	1.42	12.5	2.87	0.42	2.34	3.6	3.84	4.1	1.22	0.2	0.87	1.81	<0.20	2.25	<0.20	<0.20	0.43	0.69	2.8	0.65	0.82	2.48	1.59
Total Kjeldahl Nitrogen (%)	0.186	-	***0.55***	<0.02	0.05	0.02	<0.02	0.03	0.08	0.06	<0.02	0.02	0.029	<0.020	0.041	0.022	0.028	<0.020	<0.020	<0.020	0.028	0.041	<0.020	<0.020	<0.020	<0.020
Total Nitrogen (%)	0.197	-	0.04	0.03	0.05	<0.02	0.03	0.04	0.06	0.02	-	0.03	0.056	0.027	0.04	<0.020	0.023	0.044	0.026	0.03	0.03	0.037	0.026	0.026	0.023	0.03
Organics																										
Organic Nitrogen (%)	0.183	-	-	<0.02	0.05	0.02	<0.02	0.03	0.08	0.06	<0.02	0.02	0.028	<0.020	0.041	-	0.028	<0.020	<0.020	<0.020	0.028	0.041	<0.020	<0.020	<0.020	<0.020
Total Organic Carbon (%)	1.98	-	0.55	0.25	0.4	0.2	0.2	0.2	0.6	0.4	-	0.14	0.4	0.13	0.2	0.14	0.2	<0.10	-	0.14	0.19	0.49	0.28	0.19	0.12	0.26

Table 11: AMS Sediment Chemistry Results

		Location ID:	DP07																							
		Sample ID:	SDDP07-1	SDDP07-2	SDDP07-3	SDDP07-4	SDDP07-5	SDDP07-6	SDDP07-7	SDDP07-8	SDDP07-9	SDDP07-10	SDDP07-11	SDDP07-12	SDDP07-13	SDDP07-14	SDDP07-15	SDDP07-16	SDDP07-17	SDDP07-18	SDDP07-19	SDDP07-20	SDDP07-21	SDDP07-22	SDDP07-23	SDDP07-24
		Date Sampled:	24/03/2007	20/06/2007	01/10/2007	10/12/2007	04/03/2008	29/05/2008	20/09/2008	26/11/2008	23/02/2009	20/05/2009	14/09/2009	03/12/2009	08/03/2010	07/06/2010	30/08/2010	02/12/2010	04/03/2011	08/06/2011	06/09/2011	07/11/2011	20/02/2012	29/05/2012	05/09/2012	10/12/2012
		Sample Depth (m):	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.07	0.00-0.08	0.00-0.08	0.00-0.10	0.00-0.10	0.00-0.10	0.00-0.10	0.00-0.10	0.00-0.10	0.00-0.10	0.00-0.07	0.00-0.20	0.00-6.00	0.000.00-0.100.10	0.00-0.06	-
Parameter	***Nutrient Threshold*** [5]	**BCCSR SedQC(SS) Marine** [3,4]																								
Total Metals																										
Aluminum	-	-	12300	12500	12500	12200	9720	11700	14700	10600	10300	10400	12100	9680	9140	9190	9670	7630	8150	-	-	-	11600	-	-	-
Antimony	-	-	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	0.16	0.18	-	-	-	0.26	-	-	-
Arsenic	-	26	<5.0	7	6.6	5.7	<5.0	7.5	7.5	6.8	5.5	6.4	5.4	<5.0	<5.0	<5.0	5.3	5.17	5.16	-	-	-	5.42	-	-	-
Barium	-	-	44.8	45.8	45.9	46.3	28.5	44.5	59.3	36.6	29.9	35.8	46.2	25.3	26.4	25.2	29.1	22.5	25.6	-	-	-	34.6	-	-	-
Beryllium	-	-	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	0.5	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.20	<0.20	-	-	-	0.23	-	-	-
Bismuth	-	-	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<0.20	<0.20	-	-	-	<0.20	-	-	-
Cadmium	-	2.6	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.10	<0.10	-	-	-	0.078	-	-	-
Calcium	-	-	5760	6270	6970	6480	5580	6880	7300	5970	5780	5590	6440	5260	4890	5290	4910	3840	4310	-	-	-	5460	-	-	-
Chromium	-	99	37.3	34.1	34.1	35.4	40.1	35.6	38	33	40.5	34.1	37.6	40	36.8	36.9	30.1	27.6	30.6	-	-	-	34.1	-	-	-
Cobalt	-	-	10.3	10.1	10.4	9.8	9.4	11.1	12.2	10	9.9	9.9	10.7	9	8.9	9.6	9.1	8.51	9	-	-	-	10.2	-	-	-
Copper	-	67	20.2	17.2	22	17.9	13	23.7	26.8	17.4	13.8	13.5	19.7	11.2	11.9	9	13.5	10.5	10.6	-	-	-	15.8	-	-	-
Iron	-	-	25500	22600	24300	22800	22900	25000	27100	23100	23600	21500	23700	20600	20400	20700	20100	17700	18900	-	-	-	21600	-	-	-
Lead	-	69	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	2.75	2.7	-	-	-	3.74	-	-	-
Lithium	-	-	13.5	11.8	13.9	12.4	9.3	14.3	16.5	11.8	10.5	10.5	13.4	10	9.6	8.8	10.2	8.4	8.5	-	-	-	9.5	-	-	-
Magnesium	-	-	10300	9650	10400	9010	8890	10700	11100	9340	9250	8920	10200	8790	8620	8950	9160	7460	7960	-	-	-	8870	-	-	-
Manganese	-	-	329	309	313	319	296	355	362	304	294	297	310	277	273	270	276	254	269	-	-	-	299	-	-	-
Mercury	-	0.43	0.0372	0.0316	0.0346	0.0317	0.0201	0.0939	0.0458	0.0262	0.02	0.0225	0.0318	0.0154	0.0221	0.0217	0.0198	0.0202	0.0164	-	-	-	0.0246	-	-	-
Molybdenum	-	-	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<0.50	<0.50	-	-	-	<0.50	-	-	-
Nickel	-	-	39.2	35.7	36	41.2	38.4	39.1	41.5	37.5	37.8	37.3	39.6	36.9	35.5	38.7	36.5	32.7	36.2	-	-	-	38.4	-	-	-
Potassium	-	-	1480	1310	1390	1160	850	1240	1770	1100	910	920	1370	740	830	660	840	740	740	-	-	-	1040	-	-	-
Selenium	-	-	<2.0	<2.0	<2.0	<2.0	<3.0	<2.0	<2.0	<2.0	<4.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<0.20	<0.20	-	-	-	<0.20	-	-	-
Silver	-	-	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<0.10	<0.10	-	-	-	<0.10	-	-	-
Sodium	-	-	5080	4110	4810	3020	2160	4340	5310	4920	2800	2480	4590	1870	2990	2070	3120	2590	2430	-	-	-	3330	-	-	-
Strontium	-	-	33.8	31.4	32.3	33.9	25.6	32.9	37.2	27.6	25.8	25	31.2	23.5	23.9	22.1	24.7	20.4	23.5	-	-	-	28.3	-	-	-
Thallium	-	-	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	0.083	0.082	-	-	-	0.086	-	-	-
Tin	-	-	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<2.0	<2.0	-	-	-	<2.0	-	-	-
Titanium	-	-	811	835	791	928	899	716	809	775	826	773	802	893	751	896	792	541	758	-	-	-	860	-	-	-
Vanadium	-	-	51.6	50.1	51.4	51.3	58.9	49.7	53.3	52.2	58.5	50.2	47.4	50.5	47.2	50.4	45.9	37	43.7	-	-	-	47.3	-	-	-
Zinc	-	170	54.3	48.6	54.2	47.2	39.7	54.7	61.5	47.1	42.3	41.8	48.6	38.3	38	38.1	40.9	34.5	38	-	-	-	46.2	-	-	-
Unknown Parameters																										
Phosphorus, total, acid digestion	897	-	590	-	580	530	410	660	740	470	450	540	583	488	499	490	734	-	-	-	-	-	-	-	-	-

Table 11: AMS Sediment Chemistry Results

Parameter	Nutrient Threshold [5]	BCCSR SedQC(SS) Marine [3,4]	SDDP08-5	SDDP08-9	SDDP08-13	SDDP08-17	SDDP08-21	SDDP09-9	SDDP09-13	SDDP09-17	SDDP09-21
		Location ID:	DP08					DP09			
		Sample ID:	SDDP08-5	SDDP08-9	SDDP08-13	SDDP08-17	SDDP08-21	SDDP09-9	SDDP09-13	SDDP09-17	SDDP09-21
		Date Sampled:	04/03/2008	25/02/2009	08/03/2010	04/03/2011	20/02/2012	25/02/2009	09/03/2010	03/03/2011	20/02/2012
		Sample Depth (m):	0.00-0.05	0.00-0.08	0.00-0.10	0.00-0.10	0.00-4.00	0.00-0.07	0.00-0.10	0.00-0.10	0.00-15.00
Physical Tests											
Moisture (%)	-	-	30.2	32.3	32.5	27	25.7	39.5	40.2	36.4	37.5
Oxidation Reduction Potential (mV)	-	-	-120	-160	-	108	152	-260	-	-230	-200
pH	-	-	7.84	7.97	7.92	7.44	7.63	8.05	7.96	8.02	7.7
Grain Size											
Clay (<0.004 mm) (%)	-	-	2	3	3	3.09	1.94	7	6	6.34	6.64
Silt (0.004-0.063 mm) (%)	-	-	3	5	4	6.53	8.88	34	31	37.7	32.6
Sand (0.063-2.00 mm) (%)	-	-	94	91	93	90.4	89.2	59	63	56	60.8
Gravel (>2.00 mm) (%)	-	-	<1	<1	<1.0	<0.10	<0.10	1	<1.0	<0.10	<0.10
Total Inorganics											
Ammonium	19.8	-	1.5	3.4	9.11	2.8	3.7	2.5	4.15	2.99	2
Available Phosphate	-	-	-	-	-	24.7	28.8	-	-	7	11.3
Phosphorus	897	-	607	666	593	625	665	816	692	708	633
Sulfide	49.5	-	7.76	8.34	5.25	0.24	0.45	10.1	2.65	8.5	1.49
Total Kjeldahl Nitrogen (%)	0.186	-	0.05	0.06	0.08	0.034	0.032	0.09	0.109	0.088	0.075
Total Nitrogen (%)	0.197	-	0.05	0.06	0.077	0.05	0.052	0.08	0.089	0.099	0.087
Organics											
Organic Nitrogen (%)	0.183	-	0.05	0.06	0.079	0.034	0.032	0.09	0.108	0.087	0.075
Total Organic Carbon (%)	1.98	-	0.3	0.3	0.39	-	0.32	0.9	0.9	1.01	0.95

Table 11: AMS Sediment Chemistry Results

		Location ID:	DP08					DP09			
		Sample ID:	SDDP08-5	SDDP08-9	SDDP08-13	SDDP08-17	SDDP08-21	SDDP09-9	SDDP09-13	SDDP09-17	SDDP09-21
		Date Sampled:	04/03/2008	25/02/2009	08/03/2010	04/03/2011	20/02/2012	25/02/2009	09/03/2010	03/03/2011	20/02/2012
		Sample Depth (m):	0.00-0.05	0.00-0.08	0.00-0.10	0.00-0.10	0.00-4.00	0.00-0.07	0.00-0.10	0.00-0.10	0.00-15.00
Parameter	***Nutrient Threshold*** [5]	**BCCSR SedQC(SS) Marine** [3,4]									
Total Metals											
Aluminum	-	-	8960	10200	8620	7970	9590	13800	11900	13300	10900
Antimony	-	-	<10	<10	<10	0.18	0.2	<10	<10	0.24	0.22
Arsenic	-	26	<5.0	<5.0	<5.0	3.96	4.7	6.7	6.1	6.03	5.4
Barium	-	-	24.1	27.3	19.9	22.4	23.4	47.3	37.7	39.4	32.7
Beryllium	-	-	<0.50	<0.50	<0.50	<0.20	0.23	<0.50	<0.50	0.28	0.23
Bismuth	-	-	<20	<20	<20	<0.20	<0.20	<20	<20	<0.20	<0.20
Cadmium	-	2.6	<0.50	0.5	<0.50	<0.10	0.075	0.76	<0.50	0.27	0.207
Calcium	-	-	4700	5380	4450	4370	5460	12000	8700	10700	6610
Chromium	-	99	30.6	32.8	29.1	33	32.6	35.8	34.3	37.2	31.1
Cobalt	-	-	7.1	7.9	7.4	7.66	8.03	10.3	9.8	10.4	9.19
Copper	-	67	10	11.4	9.4	8.95	9.61	28.1	23.5	25.2	20.6
Iron	-	-	19000	20400	18800	19400	19300	25100	23600	24800	21000
Lead	-	69	<30	<30	<30	3.46	3.8	<30	<30	4.76	4.21
Lithium	-	-	9.4	11.6	10	9.1	9.7	17.4	14.3	12.6	11.6
Magnesium	-	-	7540	8890	7890	7310	8090	12100	10100	10700	9090
Manganese	-	-	230	234	212	232	232	308	285	301	252
Mercury	-	0.43	0.025	0.0251	0.0215	0.0208	0.0466	0.0426	0.0365	0.042	0.0326
Molybdenum	-	-	<4.0	<4.0	<4.0	<0.50	<0.50	<4.0	<4.0	0.59	0.53
Nickel	-	-	28.1	30.6	28.8	29.6	31.7	37	36.2	36.8	34.4
Potassium	-	-	1160	1500	1080	960	1060	2110	1570	1590	1450
Selenium	-	-	<2.0	<2.0	<2.0	<0.20	<0.20	<2.0	<2.0	0.23	0.24
Silver	-	-	<2.0	<2.0	<2.0	<0.10	<0.10	<2.0	<2.0	<0.10	<0.10
Sodium	-	-	4640	5700	4330	3310	3920	8210	6220	5930	6170
Strontium	-	-	26.5	28.8	24.2	25.4	29.2	53.7	44.6	58.4	37.4
Thallium	-	-	<1.0	<1.0	<1.0	0.11	0.117	<1.0	<1.0	0.125	0.119
Tin	-	-	<5.0	<5.0	<5.0	<2.0	<2.0	<5.0	<5.0	<2.0	<2.0
Titanium	-	-	750	780	706	785	835	826	863	856	785
Vanadium	-	-	40.9	45.8	41.9	45.6	44.8	45.5	43.4	47	40
Zinc	-	170	42.1	47	40.8	40.9	43.1	63	53.9	60.4	52.4
Unknown Parameters											
Phosphorus, total, acid digestion	897	-	470	540	583	-	-	610	717	-	-

Table 11: AMS Sediment Chemistry Results

(1) All values are reported as µg/g unless otherwise noted
(2) - = No standard or not analyzed
(3) BCCSR = BC Environmental Management Act, Contaminated Sites Regulation, B.C. Reg. 375/96, including amendments up to B.C. Reg. 6/2013; effective January 24, 2013
(4) BCCSR SedQC(SS) Marine = Schedule 9, Column IV, Marine and Estuarine Sediment, Sensitive Site
(5) Nutrient Threshold values calculated using data from DP02 to DP05 from 2007 to 2010

APPENDIX A
Methodology

A-1 GEOMORPHOLOGY

A-1.1 INVESTIGATION METHODOLOGY

The main components of the monitoring program are based on the recommendations provided in the Deltaport Third Berth (DP3) Adaptive Management Strategy (AMS). Based on this information and Northwest Hydraulic Consultants' (NHC) general understanding of the processes at Deltaport, the detailed geomorphological monitoring work plan is described below. The field based monitoring components of crest protection monitoring, erosion and deposition monitoring, and sediment sampling were discontinued at the beginning of 2012.

A-1.1.1 Crest Protection Monitoring

The purpose of crest protection monitoring is to detect channel incision, headcutting or dendritic channel formation around perimeter crest protection. The monitoring covers the entire perimeter of the crest protection structure, with particular focus in the vicinity of the tug basin and DP3 structures. Field reconnaissance and site observations are made quarterly during low tide by a qualified geomorphologist. Fixed points were established on the ground for taking repeat photography and for conducting terrestrial surveys. Ground surveys are carried out using a Real Time Kinematic (RTK) global positioning system (GPS) station to measure the dimensions of channels that are present or subsequently form.

A-1.1.2 Automated Monitoring of Erosion and Deposition

Measurements of the temporal variation in erosion and deposition at specified locations are collected using conventional erosion pins (depth of disturbance pins). The depth of disturbance (DoD) rods are monitored at three-month intervals during the course of other field investigations (Crest Protection Structure monitoring and bed sediment sampling). The DoD rods have been spaced at 150-m intervals and located on the tidal flats above 0.5 m chart datum in elevation. Conventional depth of disturbance rods consist of a length of rebar that is embedded into the tidal flats and a large flat disk with a central hole (similar to a washer) is placed over it, flush with the ground. The initial distance from the top of the rebar to the disk is recorded at the time of installation. If the ground is lowered as a result of scour, the distance from the top of the rebar to the disk will increase over time. If deposition occurs, the sediment buries the disk. Vegetation accumulation on the DoD rod may occur on a seasonal basis related to growth and die off of the various plant species found at Roberts Bank. The presence of vegetation is noted and photo-documented and the height of accumulated weed is recorded. Accumulated weed is carefully removed to expose the bare sediments underneath and allow measurement of washer burial or scour as described above. Quarterly observations are made to determine the magnitude of erosion and deposition.

A-1.1.3 Sediment Samples

Sediment samples are scheduled for collection twice yearly, once in the spring and once in the fall, post Fraser River freshet. Samples are collected at each DoD rod site using a shallow hand corer. The top 10 cm of the sample are removed from the core and stored in a freezer until analysis to ensure that biological activity does not alter the percent fines. A sampling depth of 10 cm was chosen to ensure that there is sufficient sediment to perform a robust grain size analysis and to ensure that the sample captures undisturbed sediments at depth as well as newly deposited sediments. Preliminary monitoring of the DoD rods has demonstrated that a 10 cm sampling depth is appropriate at a majority of the sites. The first set of samples was collected at a distance of 5 m to the north of each rod. To avoid re-sampling in the same hole, subsequent sampling is rotated around the rod location.

The primary purpose of the laboratory analysis is to determine the particle size distribution of the samples. Subsequent results will be compared to determine if a fining or coarsening trend is occurring. The following is a description of the methodology used to determine the organic content of the sample, analyzed by ALS Laboratories:

> The sample is introduced into a quartz tube where it undergoes combustion at 900° C in the presence of oxygen. Combustion gases are first carried through a catalyst bed in the bottom of the combustion tube, where oxidation is completed and then carried through a reducing agent (copper), where the nitrogen oxides are reduced to elemental nitrogen. This mixture of N_2, CO_2, and H_2O is then passed through an absorber column containing magnesium perchlorate to remove water. N_2 and CO_2 gases are then separated in a gas chromatographic column and detected by thermal conductivity.

The remaining sample is then put through a series of sieves and a hydrograph to provide a graph of percent finer by weight down to 0.5 mm.

A-1.1.4 Interpretation of Ortho Photographs

Aerial photographs are evaluated to assess trends and patterns of erosion and/or accretion on the tidal flats. This evaluation is conducted annually and covers the entire inter-causeway tidal flat area. The methodology consists of overlaying successive ortho-rectified photographs using GIS mapping techniques to delineate and identify morphological changes on the tidal flats. The maps show areas of erosion or sand accretion and changes in vegetation between successive surveys.

A-1.1.5 Coastal Geomorphology Mapping

This task assesses topographic changes due to long-term erosion or accretion adjacent to the terminal. An initial baseline survey was completed at the start of the study. The surveys will be repeated every three to four years. The highest resolution surveys are made near DP3. More limited surveys are made across the shallow inter-tidal flats where the relief is very low. Precise bathymetric surveying is performed using RTK GPS positioning for horizontal control and single beam digital echo sounding.

A-1.2 DATA EVALUATION

This section summarizes the geomorphological data that will be evaluated and interpreted for the monitoring components presented above. Interpretation of the DoD measurements and bathymetric survey data is straightforward, and is not included below. Results are provided only in the quarterly reports with data interpretation and discussion provided in the annual reports.

A-1.2.1 Crest Protection Monitoring

Comparisons of repeat terrestrial photographs will be performed to show seasonal and long-term changes. Comparison of ground surveys to document scour or erosion from channel formation or headcutting processes. This interpretation will be supplemented by assessment of annual aerial photography and periodic low-level over flights from a fixed wing aircraft, as described in **Section A-1.1.4**.

A-1.2.2 Sediment Samples

Measurements of short-term accretion and erosion will be correlated with met-ocean conditions (wave and tide conditions), construction activities and changes in vegetation or eelgrass. Comparisons will also be made with surveyed topographic changes along the Crest Protection and results of the photographic monitoring.

A-1.2.3 Interpretation of Ortho Photographs

Overlay maps will be interpreted to assess the key factors that are controlling morphological changes on the tidal flats. Results will be compared with other long-term assessments (as documented previously in the Coastal Geomorphology Study, NHC 2004). The results of this investigation will be integrated with other related studies on eelgrass extent and distribution in order to provide a complete understanding of any habitat changes.

A-2 SURFACE WATER

A-2.1 INVESTIGATION METHODOLOGY

Fixed surface water and sediment quality monitoring stations are established adjacent to the Deltaport facility, within the inter-causeway area and at two reference locations along Robert's Bank. The locations are described as follows:

- One station (Station DP01) in the ditch near the base of the ferry terminal causeway to monitor nutrient and sediment loading from upland sources.
- Two stations (Stations DP02 and DP03) located in the intertidal portion of the inter-causeway area within the eelgrass beds.
- One station (Station DP04) in the intertidal portion of the inter-causeway area at the head of the ship turning basin adjacent to DP3.

- One station (Station DP05) in the subtidal portion of the inter-causeway area within the ship turning basin adjacent to DP3.
- One intertidal reference station (Station DP06) located off Westham Island northwest of Deltaport.
- One subtidal reference station (Station DP07) located off Westham Island northwest of Deltaport.
- One station (Station DP08 added in 2008) in the intertidal portion of the inter-causeway area between DP02 and DP05.
- One station (Station DP09 added in 2009) in the intertidal area adjacent to DP3.

The surface water sampling methodology outlined below, including sample implement decontamination procedures, is based on the protocols developed for the Puget Sound Estuary Program (PSEP 1996). Representative surface water samples will be collected from each of the sampling stations.

A vessel equipped with a 5-litre Van Dorn sampler, constructed of clear lexan, will be used to collect surface water samples at each station. One water sample will be collected just below the surface and for the subtidal samples; one surface water sample will also be collected at a depth of two metres above the seafloor. As with the sediment sample, the surface water sampling stations will be located using a GPS. The vessel will be equipped with a depth sounder, however, to ensure that the sampler is triggered at an appropriate depth a two metre rope with a weight at the end will be attached to the base of the Van Dorn. To minimize the turbidity plume from disturbed sediment, the sampler will be lowered slowly and carefully as it approaches the bottom (based on depth sounder readings). Tripping the sampler is then delayed approximately one minute is used to allow currents at the site to transport turbidity generated by the weight out of the area of the sampler. Each recovered water sample will be examined to ensure acceptable sample quality, including no entrained sediment, and the water in the sampler decanted into laboratory prepared sample bottles. The five litre Van Dorn volume is sufficient to meet sample volume requirements. Similar to the sediment sampling process, field observations will be recorded at each station during sample collection. Field observations will include general information (e.g., station name, date, time), and a description of the site location, GPS coordinates, water depth and characteristics (e.g., colour, odour, turbidity).

As part of our quality assurance program, Hemmera will also undertake a number of measures including consistent use of the same field technicians, daily field reporting between field technicians and project manager, and submission of samples in laboratory supplied sterile sampling containers under chain of custody, following the directions provided by the analytical laboratory, etc. The required laboratory reported detection limits have been pre-determined with the laboratory so that the results can be compared to the appropriate regulatory screening levels. The detection limits and regulatory screening levels are provided in the AMS Detailed Workplan. One blind field duplicate sediment sample will also be collected during each sampling event to further assist in the evaluation of data quality. The data quality objective (DQO) for precision will be measured using the relative percent differences (RPD) between characterization and duplicate samples (to evaluate data precision) as well as percent completeness to evaluate the effectiveness of the sampling program with respect to the project objectives. Due to the limited number of samples, the DQO for completeness is 100%. The DQOs for precision will be 20% RPD for inorganic parameters and 50% RPD for organic parameters. The quality assurance program will also include review of the analytical laboratory's quality control results.

The samples will be stored in coolers on ice and transported directly to the laboratory at the end of the sampling day (approximately 1.5 hour travel time).

The waters of the upper end of the DP3 turning basin (near DP04) will be monitored continuously for a number of water quality parameters (pH, temperature, conductivity, dissolved oxygen, and turbidity) using a YSI buoy-mounted sonde. As of 2009, the sonde was no longer deployed continuously (due to damaged by storms) but rather for approximately one week each quarter during quarterly sampling programs. As of 2012, the sonde was no longer deployed weekly. Field water quality parameters were measured at the time of sample collected during each quarterly sampling program.

A-2.2 SAMPLE ANALYSES

The parameters analyzed to facilitate data interpretation include:

- Temperature.
- pH.
- Hardness.
- Salinity.

The parameters being analyzed to assess the presence/absence of toxicants include:

- Metals (analysed quarterly until the end of 2010 and annually in Q1 starting in 2011).
- Chlorine[1].

Several of the water quality parameters were also selected for their use in facilitating identification of marine eutrophication and/or construction impacts. These include:

- Turbidity, TSS, Clarity (secchi disk).
- Nutrients (Phosphate, Phosphorus, Ortho-phosphorus, Total Kjeldahl Nitrogen (TKN), Total Nitrogen, Ammonia, Nitrate, Nitrite and Organic Nitrogen N).
- Chlorophyll *a.*

These parameters are analysed quarterly at DP01 to DP07 and annually in Q1 at DP08 and DP09.

[1] Chlorine will be collected from the ditch station only. The purpose is to evaluate potential impacts from chlorine to the inter-causeway area as historical releases of water from a nearby upland water park have been documented. Polycyclic aromatic hydrocarbons (PAHs) have been dropped from the program as no exceedances were noted during the Q1-2007 event.

A-2.3 DATA EVALUATION

As indicated above, a number of the monitored surface water parameters are to support data interpretation purposes and therefore do not require action levels. The other parameters collected, as indicators of potential toxicity to marine organisms, will be compared against the applicable provincial and federal water quality screening levels:

- British Columbia Approved Water Quality Guidelines (Criteria), 1998 Edition.
- A Compendium of Working Water Quality Guidelines for British Columbia, 2001 Update.
- Canadian Council of Ministers of the Environment (CCME) Water Quality Guidelines, 2006 Update.

These analytical results will be provided in the quarterly reports with data interpretation and discussion of the sampling results provided only in the annual reports.

The remaining results will be presented in each quarterly report with evaluation for negative trends occurring within each annual report. As with the sediment sampling program, the data collected within the inter-causeway area will be tabulated, graphed, and statistically compared with the results from the relevant reference stations elsewhere along Robert's Bank. A 20-percent difference between the eutrophication parameter inter-causeway and far-field results was originally proposed as a preliminary indicator of a potential for eutrophication impacts. Since 2012, data is compared against site-specific nutrient thresholds calculated based on the mean + 1.96 x standard deviation for the 2007-2010 data set. A comparison of the analytical results against these nutrient thresholds is provided in the quarterly reports and further discussion provided within the annual report

A-3 SEDIMENT

A-3.1 INVESTIGATION METHODOLOGY

As with the surface water sampling program, representative sediment grab samples will be collected from each sampling station on a quarterly basis (four times per year). The sampling methodology outlined below, including sample implement selection and decontamination procedures, is based on the protocols developed for the Puget Sound Estuary Program (PSEP 1996)[2]. A shallow draft vessel equipped with an 8.2 L Ponar grab sampler will be used to collect the sediment samples. Field staff will work from the ditch bank to collect samples from the sediments at Station 1. Sampling stations will be located using global positioning system (GPS) coordinates. Each recovered grab sample will be examined to ensure acceptable sample quality, the supernatant water in the sampler will be decanted and the upper 5 cm of sediment will be placed in a clean stainless steel mixing bowl. Repeated grab samples may be required to

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2 Puget Sound Estuary Program (PSEP) 1996. Recommended Guidelines for Sampling Marine Sediment, Water Column, and Tissue in Puget Sound. Prepared by King County Environmental Laboratory for Puget Sound Estuary Program, U.S. Environmental Protection Agency, Region 10, Seattle, WA.

fulfill sample volume requirements. The sample will be mixed with a stainless steel spoon until homogenous in texture and colour. However, sediment for hydrogen sulphide analysis will be collected prior to mixing to minimize oxidation and volatilization. Field observations will be recorded at each station during sample collection and will include general information (e.g., station name, date, time), a description of the site location, GPS coordinates, water depth, sediment characteristics (e.g., grain size, colour, odour, debris, visual contamination), and a record of the amount of effort required for sediment collection.

Aliquots of sediment for chemical analysis will be collected in 250mL laboratory prepared glass jars with Teflon lids for submission to the project laboratory for analysis of the parameters listed in **Section A-3.2**. The sediment samples are collected and transported to the lab generally by 5:30 pm the day the samples are collected. Sediment samples are placed in jars and immediately stored in a covered cooler with ice to keep them at a cold state, at or near 4^{o}C for delivery to the laboratory. All samples are analysed within the laboratory holding time.

Sediment samples for sulphide analysis are collected prior to homogenization and are placed in jars with no headspace in order to minimize the potential for oxidation. As with the other parameters, sulphide sample jars are then placed immediately on ice. The laboratory holding time for sulphides is 24 hours to minimize potential loss through volatilization and increase the reliability of results. Sulphide analysis is via the laboratory method is described below:

- Add 8 – 12 drops of sodium hydroxide to a centrifuge tube to 5 g (based on dry weight) of sample into the tube.
- Add water.
- Shake for 20 minutes, then centrifuge.
- Filtered supernatant through a 0.45 micro filter.
- Transfer an aliquot to a test tube containing zinc acetate.
- Bulk the sample with MQ water and analyze colourimetrically.

The field sampling equipment (i.e., Ponar, bowls and spoons, etc.) will be decontaminated prior to sample collection at each station. This involves an initial rinse with site seawater, followed by washing with Alconox soap, a second rinse with site seawater, and final rinse with distilled water in accordance with the PSEP (1996) methodology.

Quality assurance measures (staff, sample handling, field duplicates and DQO) for the sediment sampling program will be the same as those outlined for the surface water sampling program (**Section A-2.1**) above. The detection limits and regulatory screening levels for sediment samples are provided in the AMS Detailed Workplan.

A-3.2 SAMPLE ANALYSES

Sediment samples are analyzed for the following parameters:

- Metals were analyzed as indicators of potential toxicity to marine organisms (Tributlytin was analyzed only during the Q1-2007 event). Metals were analysed quarterly until the end of 2010 and annually in Q1 starting in 2011.
- Parameters measured to evaluate sediment eutrophication include:
  - Total nitrogen.
  - Ammonia.
  - TKN.
  - Total organic nitrogen.
  - Phosphorous.
  - Redox (Eh).
  - Hydrogen sulphide (H_2S).
- Sediment grain size samples are collected annually in Q1.

Except as noted above, these parameters are analysed quarterly at DP01 to DP07 and annually in Q1 at DP08 and DP09.

A-3.3 DATA EVALUATION

The toxicity parameters, when sampled, will be compared against the BC Contaminated Sites Regulation, Schedule 9 Generic Numerical Sediment Criteria for sensitive marine and estuarine sediments ($SedQC_{ss}$) and the Puget Sound Dredge Disposal Analysis (PSDDA) criteria for TBT as indicated in the AMS workplan document. These analytical results will be provided in the quarterly reports. Anomalous results will be highlighted and briefly discussed. Data interpretation and discussion of the sampling results will be provided only in the annual reports

The remaining sediment quality parameters will be evaluated within each annual report for observable trends. The data collected within the inter-causeway area will be tabulated, graphed, and statistically compared with the sediment results from the reference stations and with data from previous years sampling. A 20-percent difference between the eutrophication parameter inter-causeway and far-field results or between results from year to year was originally proposed as an indicator of a potential for eutrophication impacts. Since 2012, data is compared against site-specific nutrient thresholds calculated based on the mean + 1.96 x standard deviation for the 2007-2010 data set. A comparison of the analytical results against these nutrient thresholds is provided in the quarterly reports and further discussion provided within the annual report

A-4 EELGRASS

A-4.1 INVESTIGATION METHODOLOGY

A-4.1.1 Eelgrass Distribution and Mapping

Aerial photograph interpretation will be used to develop a base layer for mapping the current distribution of eelgrass in the inter-causeway area. Aerial photograph flights used for the eelgrass monitoring program are to be flown in July 2007 and at the same time in subsequent years. The amount of cloud cover, sun angle, and season at the time when the photos are flown; and the resolution of the photos, will determine whether it is possible to distinguish between areas that support a monoculture of *Z. japonica* and areas that support a monoculture of *Zostra marina*. There is a 'transition' zone between these two habitats in the inter causeway area where the two species co-exist. It may be possible to approximate the boundaries of the transition area from the photos. Homogenous habitat types will be delineated to form polygons. We have proposed a minimum polygon size of 50 m by 50 m; however, this may be modified through discussions with Vancouver Fraser Port Authority (VFPA).

A field survey will follow the aerial photograph interpretation to confirm and/or determine the species composition of each polygon. The boundaries of the transition area will likely need to be determined on-site and mapped using a GPS. *Zostra japonica* is an annual species; although a small percentage of the shoots may survive throughout the winter. To accurately map the distribution of this species the field survey should be completed between June and early September.

The data collected during the field survey would be incorporated onto the base layer by Hemmera to create a GIS map that accurately depicts the current distribution of eelgrass in the inter-causeway area.

A-4.1.2 Monitoring Eelgrass Vigour and Health at the Established Stations

The annual eelgrass vigour and health survey will be conducted during one of the low tide cycles between mid July and mid August and will assess the health and growth of eelgrass at nine of the eelgrass monitoring stations that were established for the DP3 Environmental Assessment and one additional monitoring station that was added in 2008. The monitoring stations include four stations in the inter-causeway area, two stations west of the Westshore Coal Terminal and Deltaport Causeway, and three reference stations in Boundary Bay.

The parameters that will be monitored at each of the stations will include those assessed for the baseline study; shoot density, shoot length, and shoot width[3]. This data will be used to calculate Leaf Area Indices (LAI) at each location.

[3] Quadrat sampling along transects as described in *Methods for Mapping and Monitoring Eelgrass Habitat in British Columbia* (Precision 2002).

The distribution of *Zostra marina* at each station will be classified as patchy, continuous, or absent. The percent cover of *Zostra japonica* will be ranked according to the following scale: <1% present; 1% to 40% sparse; 41% – 75% moderate; >75% dense.

The monitoring plan includes noting the presence or absence of epiphytes at each of the stations. It would be possible for Ms. Durance, based on her 25 experience with this population of eelgrass to further classify the presence of epiphytes in the inter-causeway area as typical, less than usual, or more than usual.

The presence or absence of *Beggiatoa* sp. will also be noted. Ms. Durance has never observed *Beggiatoa* sp. at Roberts Bank. In the unlikely event that it is noted during an annual monitoring event, a strategy would need to be developed so that increases or decreases in the area covered by this species could be assessed. The location of the *Beggiatoa* sp. would be recorded using a GPS, for future reference. If there is sufficient time available the crew will map the area covered by *Beggiatoa* sp. VFPA will be notified immediately, with suggestions as to how to modify the AMS to include mapping and monitoring changes in the distribution of this species.

A-4.1.3 SIMS Survey

A Subtidal Imaging and Mapping System (SIMS) survey will be used to determine the lower limit of eelgrass in the inter-causeway during the summer of 2009 and 2012. The SIMS method and equipment is only available through Archipelago Marine Research (AMR).

SIMS is a towed video system developed to carry out systematic mapping of marine vegetation, macroinvertebrates, seafloor substrates and morphology from the intertidal zone to depths of about 40m. The field of view is approximately 1 m by 2-3 m. The acquired imagery (digital video format) is geo-referenced using differential GPS with positions and time “burned onto” the video imagery with one-second update intervals. Depth of the towfish is also shown on the image. The towfish is maintained at an elevation of 1-1.5 m above the seafloor. Tow speed for SIMS is about 1 knot (2 km/hr) yielding a line coverage of 12 to 15 km in a typical survey day. A seven metre vessel provided and operated by Arrawac Marine Services is used to conduct the survey. A laptop computer is used for pre-plotting the navigation lines and for showing the vessel track lines during the survey. The position, depth and video time data is stored in custom MS Access database format developed for the SIMS classification system.

The video imagery is classified (by a geologist and a biologist) for substrate, epiflora (macrophytes) and epifauna (including fish) using a standard substrate and biotic classification system initially developed for the Province of British Columbia. The SIMS database system allows data entry for each second of video imagery collected. The interpreted data are interfaced with ArcView for map production. Typically the survey product is a comprehensive portfolio of maps, developed in GIS format, showing sediment type, major vegetative features, macroinvertebrates and fish observations and an interpretation of valued and sensitive biophysical features.

A-4.2 DATA EVALUATION

An eelgrass distribution map will be produced annually, based on aerial photograph interpretation and confirmed by ground truthing. A brief report will accompany a map that assesses changes that were observed in a local and regional context. This information will be compiled and summarized within each annual report for consideration by the SAC.

Natural eelgrass densities may vary significantly between years due to climatic changes. Although the mean density tends to be stable over time, environmental change such as El Niňo events may lead to severe changes in density. An El Niňo winter followed by a La Niňa summer once resulted in a ten-fold density increase in at least several eelgrass beds in British Columbia and Washington State. Data (vigour and epiphyte load) from the inter-causeway would be compared with many other sites in addition to Boundary Bay to ascertain whether changes subsequent to development at Roberts Bank are due to impacts attributable to the DP3 project, other non-DP3 anthropogenic causes, or natural causes.

A-5 BENTHIC COMMUNITY

A-5.1 INVESTIGATION METHODOLOGY

Benthic community health in the inter-causeway area is linked to sediment quality and water quality; and it is anticipated that if significant changes are seen in benthic community health, effects would also be observed in surface water quality and/or sediment quality (see **Sections A-2** and **A-3**). Therefore, sediment samples for benthic community analysis will be co-located with surface water and sediment samples from six of the seven sampling stations identified for the surface water and sediment quality monitoring programs. No benthic samples will be collected for station DP-01 as this station is located in a drainage ditch discharging to the inter-causeway area. The samples for benthic invertebrate analysis will be collected separately during the sediment sampling program. Samples will be preserved and packaged in the field, as required, and shipped to Biologica Environmental Services, Ltd., who process the samples and report taxonomic results to Hemmera.

The first benthic community sampling event will be completed during the first quarterly sampling event prior to the start of dredging. The next benthic invertebrate sample collection event is scheduled to occur during the Q1-2008 sampling event in March 2008. During the March 2008 event, a fourth benthic sampling station will be sampled. The location will form the fourth corner of a rectangle created by connecting stations DP02, DP03 and DP04 and the new station. Water quality and sediment samples will be collected at this station only during the benthic community sampling event and not during subsequent quarterly monitoring events. Further benthic community sampling will be completed at the end of construction during the first post-construction quarterly sediment sampling event. To facilitate data management, a fixed naming convention will be used. For instance, DP01A-1 will denote a sample collected at DP01, with the letter distinguishing between the three benthic invertebrate samples collected at this location, and the number specifying that the sample was collected during the first benthic invertebrate sampling event.

To capture inherent variability potentially present at the stations, three replicates will be initially collected per station for the benthic community sampling (*Benthic Marine Habitats and Communities of the Southern Kaipara*, Aukland Regional Council Technical Publication 275). Should the results of statistical analysis of variance of richness and abundance in the first year's benthic community sampling indicate acceptable variance observed between the replicates, we propose to reduce the sampling to one replicate sample per station during the second event. We have proposed an acceptable level of variance as being less than 20%.

Sampling methodology will be similar to that for the sediment sampling described in **Section A-3.1** but with some modifications. For the benthic community sample, the supernatant water is not decanted. After examination of grab quality, including consistent sample volume between stations, the sediment is placed in a plastic container (Tupperware bin) and transferred to a pre-cleaned stainless steel screening station on shore. The sample contents are gently rinsed through a 1.0 mm mesh sieve using seawater strained for zooplankton using a fine nylon mesh. The sample material remaining on 1.0 mm sieves is transferred into 1 L plastic containers and preserved in a 10% solution of formalin buffered with marble chips. These samples are then transported to Biologica for taxonomic identification. Taxonomic identification of benthic invertebrates will be down to the species level, where practical, and include both the diversity (number of species) and abundance of individuals for adult, juvenile and intermediate life stages.

A-5.2 DATA INTERPRETATION

As stated in the AMS, infaunal and epifaunal benthic community results will be evaluated and the data collected within the inter-causeway area will be tabulated, graphed, and statistically compared with the benthic results from reference stations elsewhere along Robert's Bank. A 20-percent difference from elsewhere along Robert's Bank will be used as an indicator of a potential for benthic community impacts in the inter-causeway area requiring further discussion within the final annual report.

Benthic community health is linked to sediment quality and water quality; therefore, it is expected that if significant changes are seen in benthic community health, effects would also be observed in surface sediment quality and/or water quality.

The sampling results will also be compared to video observations made during the SIMS survey that is part of the Eelgrass program (**Section A-4.1.3**). As stated above, the video imagery will be used for epiflora (macrophytes) and epifauna (including demersal fish) classification using a standard system initially developed for the Province of British Columbia. The SIMS database system allows data entry for each second of video imagery collected. The interpreted data are interfaced with ArcView showing sediment type, major vegetative features, macroinvertebrates and fish observations and an interpretation of valued and sensitive biophysical features.

A-6 BIRDS

A-6.1 INVESTIGATION METHODOLOGY

Hemmera has conducted coastal seabird surveys as part of the DP3 AMS from 2007 until the present. As of May 2008, the survey methodology previously used in the DP3 AMS, DP3 supporting studies, and by CWS was modified to incorporate adaptations to the original scope of the AMS. Following input from Hemmera and discussion with the Scientific Advisory Committee (SAC) and CWS, these adaptations were implemented pursuant to SAC and CWS recommendations (see 2008, 2009, and 2010 Adaptive Management Strategy Annual Reports). Additional adaptations were implemented as of February 2010 to focus surveys exclusively on two focal species – great blue heron and brant. For these species, Hemmera conducts time effective “windshield” peak count surveys during the key timing windows. Brant surveys focus on the winter and spring migration use of the inter-causeway area during the months of February, March, and April. Great blue heron surveys focus on use of the inter-causeway area for foraging in the months of June, July, and August. The windshield survey methodology is described below. Brant surveys were discontinued in 2012.

Windshield surveys are a fast and efficient method for determining peak numbers of focal species within the inter-causeway area. The windshield survey methodology involves stopping at a subset of point count stations (PC) to count all visible individuals of the given focal species, with no minimum time requirement. Bird studies are completed along the following three transects:

- Deltaport Transect: South side of Deltaport Causeway (PC 12 – 19).
- Tsawwassen First Nation (TFN) Transect: TFN Lands (PC 103, 105, 109, and 115).
- BC Ferries Transect: BC Ferries Causeway (point count stations 118, 120, 122, 124, and 126).

There are a subset of three PC stations on the Deltaport Transect, two PC stations on the TFN Transect and three PC stations on the BC Ferries Transect. A new subset of PC stations was identified for the 2011 windshield surveys because of changes to accessibility along all three transects (see Figure 10 of 2011 annual report for the new subset of PC stations). The plot size at each PC station has an approximate area of 0.5 km^2 (0.5 km x 1 km).

Observers use binoculars and spotting scopes to identify species and record the location of brant within the inter-causeway. Observers record weather data at each station, count individuals and groups of birds and document bird behaviour. Data is recorded into a hand-held PDA with digital forms that are consistent with those used by VFPA and Canadian Wildlife Service (CWS) in past bird studies. Observers count birds within the following distance categories:

- 100 m inland to the shore (TFN Transect only).
- 0 – 250 m from shore.
- 250 – 500 m from the shore.
- > 500 m to approximately 1 km.

The distance of brant and heron are recorded from the point count station. If large numbers of birds are observed within a sample plot, then observers block off a group of individuals, count them, and extrapolate to the whole of the flock. Birds observed in flight are recorded as ‘flyovers’ and the flight direction is recorded.

Windshield surveys are conducted once a month during key timing windows for each focal species: spring for brant (February – April), and summer for great blue heron (June – August). Windshield surveys are conducted at the most ideal time to identify the maximum number of individuals within a short period of time. For brant, this is within approximately one hour on either side of the peak high tide during the winter months, when brant flock together in the middle of the inter-causeway area, making them more visible to observers. Similarly, the most productive time to count great blue heron is within one hour on either side of the peak low tide during the summer months, when herons forage in the eelgrass beds.

A-6.2 Data Evaluation

The rapid assessment methodology of the windshield survey technique allows an accurate count of great blue heron or brant using the inter-causeway area to be collected, as the short duration of surveys minimizes possible recounting of individuals. However, the short duration of windshield surveys minimizes the ability to collect data about the spatial distribution of birds. This will likely limit the ability to report on spatial distribution of birds within the inter-causeway area. Hemmera’s biologists believe that data from Years 1-3 of the AMS and baseline studies has well documented habitat use patterns within the inter-causeway area. Hemmera biologists also note that the monthly frequency and short (but efficient) duration of windshield surveys may not entirely encompass variability in bird populations or account for movement in and out of the inter-causeway area from day to day, which may obscure more accurate seasonal patterns.

Data collected will be compared to pre-construction and construction period data to determine whether operation and post-construction activities result in changes in species use of the inter-causeway. Hemmera will import the baseline data into its data management system to facilitate interpretation. Data interpretation will include comparisons between baseline monitoring, construction, and post-construction results. Possible analyses may include temporal trend analyses (e.g., linear regression) to detect positive or negative changes in focal species use of the inter-causeway. VFPA will be notified if negative trends are observed during data interpretation. Additionally, Hemmera will provide VFPA with recommendations, if necessary, to implement or modify mitigation measures to prevent or attenuate observed negative ecosystem trends. The data will be reported in event summary reports for each survey, quarterly reports and annual reports.

APPENDIX B

NHC Memorandum: Deltaport Third Berth Adaptive Management Strategy Monitoring Program Spatial Variation in Grain Size Distribution at Four DoD Rods

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northwest hydraulic consultants

MEMORANDUM

TO:	Bonnie Marks (Hemmera)	**DATE:**	March 18, 2013
FROM:	Derek Ray (NHC); Patrick Humphries (NHC)	**NO. PAGES:**	1 of 9
CC:	Kim Keskinen (PMV); Ben Wheeler (Hemmera)	**PROJECT NO.:**	34648 (NHC reference)

RE: **Deltaport Third Berth Adaptive Management Strategy Monitoring Program**
Spatial variation in grain size distribution at four DoD rods

BACKGROUND

Northwest Hydraulic Consultants (NHC), in partnership with Hemmera Envirochem (Hemmera) and Precision Identification (Precision), has been engaged by Port Metro Vancouver (PMV) to conduct ongoing monitoring in support of the Adaptive Management Strategy (AMS) for the Deltaport Third Berth (DP3) expansion project. As part of the the Coastal Geomorphology component of the AMS, NHC has been collecting sediment samples twice a year between 2007 and 2012. The samples were collected at the 28 original DoD rod locations (those installed at the inception of the program), approximately two meters from each rod in a randomly chosen quadrant so as not to resample the same location in consecutive visits. Analysis of these samples to determine grain-size distribution and organic content was performed by a commercial laboratory.

At several of these DoD rod sites, percent silt content in the samples was highly variable over time throughout the monitoring program, while at the majority of sites, the measured percent silt content remained relatively constant. The variability was thought to be caused by either a) seasonal influences, or b) natural spatial variability of the sediments. In order to develop an increased understanding of the variability at certain locations, NHC recommended in the 2011 AMS Annual Report that an additional sediment sampling trip be conducted to conduct additional samples in an attempt to determine how grain size distribution may vary spatially around a few select rods that have shown high levels of variability during the course of the monitoring program. This sampling work was conducted on May 8, 2012.

The purpose of this memo is to provide the results and analysis of data gathered during this sampling trip, and to discuss how they relate to changes in grain size distributions seen in samples collect during the DP3 AMS sediment monitoring program.

METHODOLOGY

Four sampling locations were chosen for intensive sediment sampling. Each of these has displayed a different pattern in the variability of percent silt content in samples collected throughout the monitoring program. The samples collected at C02, D02, and E01 (**Figure 1**) have all been highly variable over time (greater than 100 percent change in percent silt content from the lowest values collected at these sites), but each has exhibited a different pattern of change over the period. The fourth rod site sampled was C03, which was chosen because it has consistently exhibited very low silt content throughout the monitoring program, and so was chosen to act as a 'control' site.

In keeping with established sampling protocols for the AMS program, samples were collected using a short hand-corer to remove approximately a 10 cm long core of near-surface material. The samples were subsequently analyzed by a commercial laboratory to determine the particle grain size distribution of each sample. The samples were collected on May 8, 2012, which coincides with the typical Q2 sampling timing of late-April to early-May. Eight samples were collected at each site at a distance of 2 m from the rod location, one in each of the eight cardinal directions from the rod. Samples were labelled in the field based on the DoD rod label (ie. C02) with an additional number denoting the cardinal direction (1=N, 2=NW, 3=W, etc.).

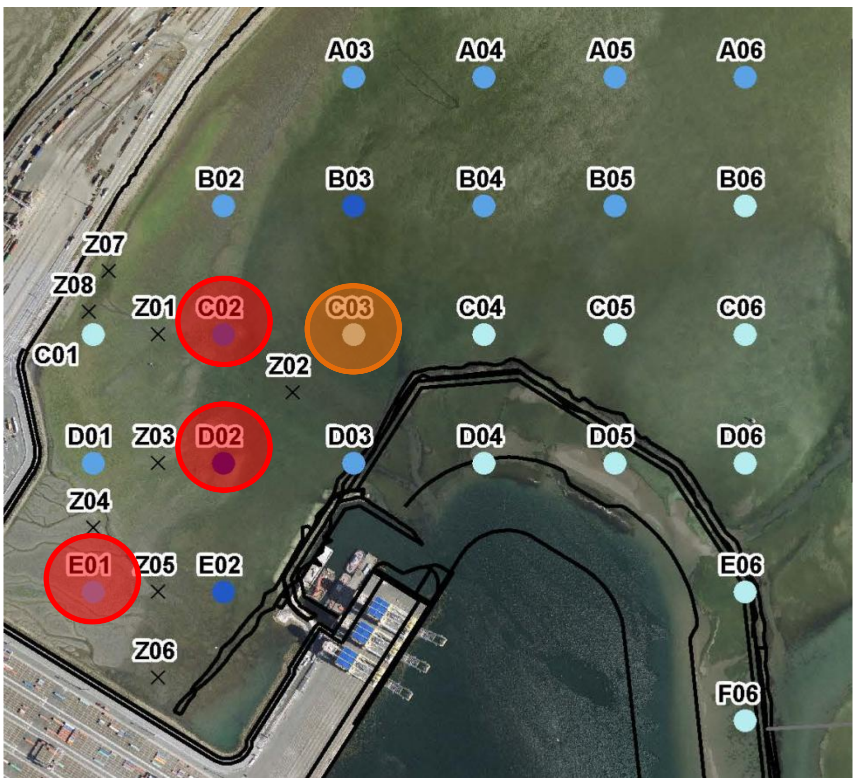

Figure 1: **Location of DoD rod sampling sites. Red circles indicate sites that historically displayed highly variable values of percent silt; yellow circle is the control site.**

Results

The percent silt content of each sample is plotted in **Figure 2** in the form of a line graph for ease of relating the various samples to the common sampling point (rather than to denote a spatial- or time-scale). For reference, the sediment grain-size analysis for each sample is also presented in tabular form in Table 1. The results at all but D02 show a remarkable consistency, particularly C03, which varies by as little as a few percentage points.

The values of percent silt for the D02 samples are generally quite consistent except for the W and SW samples, and to a lesser degree the NE sample.

The most surprising result is that all of the samples return values of percent silt that are as high or higher than the largest values ever returned previously at that site. For example, at C02 the previous maximum value was 41% silt content in Q2-2010, while all but three of the most recent samples are over 40% silt content.

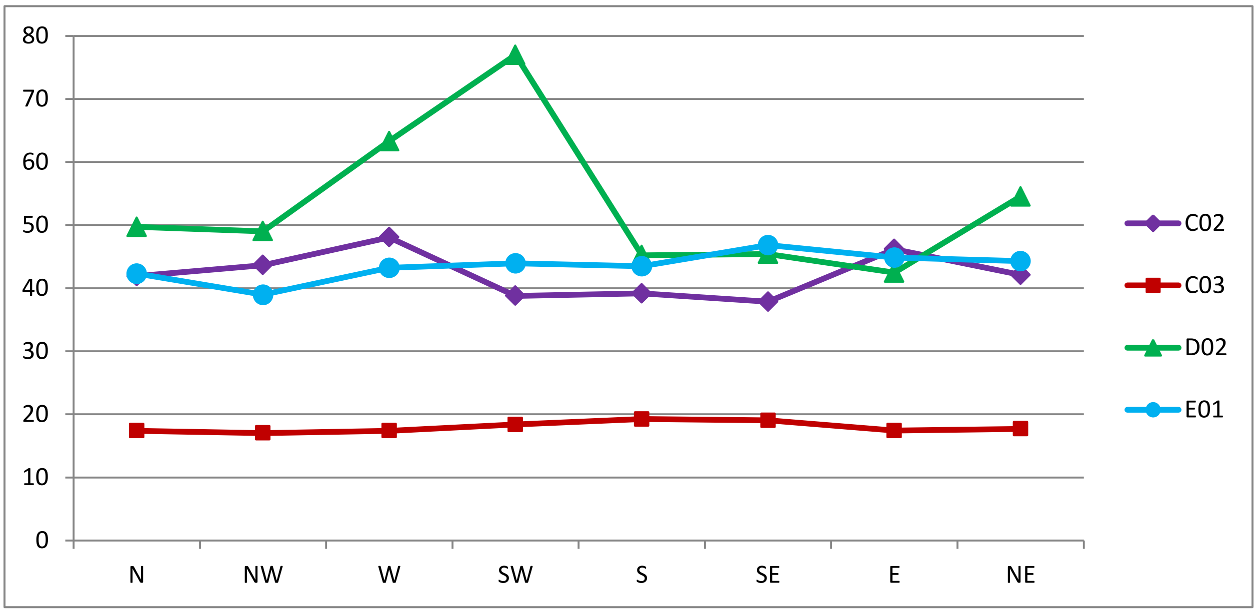

Figure 2: **Percent silt content in samples collected 2 m away from each rod in 8 octants around the rod.**

Sample Direction From Rod	N	NW	W	SW	S	SE	E	NE	N	NW	W	SW	S	SE	E	NE
Sample Name	C02-1	C02-2	C02-3	C02-4	C02-5	C02-6	C02-7	C02-8	C03-1	C03-2	C03-3	C03-4	C03-5	C03-6	C03-7	C03-8
> 2 mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2 - 0.5 mm	0.18	0.24	0.16	0.26	0.31	0.35	0.31	0.2	0.48	0.41	0.4	0.31	0.25	0.57	0.29	0.17
0.5 - 0.355 mm	1.87	1.85	1.15	1.74	2.13	1.98	1.34	1.33	9.44	7.01	8.05	7.01	5.91	6.16	6.2	6.4
0.355 - 0.25 mm	1.35	1.34	0.83	1.26	1.54	1.44	0.97	0.96	6.83	5.07	5.83	5.07	4.28	4.46	4.49	4.63
0.25 - 0.18 mm	16.05	14.43	11.07	13.37	15.34	14.22	12.05	13.6	32.25	35.08	34.24	33.9	34.21	34.42	35.74	35.33
0.18 - 0.125 mm	12.61	11.34	8.7	10.51	12.06	11.17	9.47	10.69	25.34	27.56	26.9	26.64	26.88	27.04	28.08	27.76
0.125 - 0.09 mm	14.71	15.32	16.95	19.24	16.64	18.62	16.75	17.56	4.66	4.42	4.06	4.9	5.22	4.7	4.39	4.53
0.09 - 0.063 mm	11.35	11.82	13.08	14.84	12.83	14.36	12.92	13.55	3.6	3.41	3.13	3.78	4.02	3.62	3.39	3.49
<0.063 mm	41.89	43.65	48.06	38.77	39.15	37.85	46.18	42.1	17.39	17.04	17.39	18.39	19.23	19.03	17.42	17.69
Sample Direction From Rod	N	NW	W	SW	S	SE	E	NE	N	NW	W	SW	S	SE	E	NE
Sample Name	D02-1	D02-2	D02-3	D02-4	D02-5	D02-6	D02-7	D02-8	E01-1	E01-2	E01-3	E01-4	E01-5	E01-6	E01-7	E01-8
> 2 mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2 - 0.5 mm	0.32	0.41	0.3	0.29	0.35	0.32	0.34	0.57	0.2	0.19	0.13	0.22	0.23	0.19	0.29	0.22
0.5 - 0.355 mm	5.64	6.81	3.84	2.18	6.59	5.26	5.66	4.67	1.46	0.75	0.71	0.77	0.95	0.68	1.07	0.89
0.355 - 0.25 mm	4.08	4.93	2.78	1.58	4.77	3.81	4.1	3.38	1.06	0.54	0.51	0.56	0.69	0.49	0.77	0.65
0.25 - 0.18 mm	17.75	16.79	10.57	5.59	19.38	19.28	20.41	15.61	15.36	15.76	13.77	14.21	15.1	14.27	14.18	14.2
0.18 - 0.125 mm	13.94	13.19	8.3	4.39	15.23	15.15	16.04	12.26	12.07	12.39	10.82	11.16	11.87	11.21	11.14	11.16
0.125 - 0.09 mm	4.83	4.99	6.16	5.08	4.78	6.07	6.21	5.07	15.56	17.74	17.41	16.45	15.64	14.86	15.63	16.14
0.09 - 0.063 mm	3.73	3.85	4.75	3.92	3.69	4.69	4.79	3.91	12	13.69	13.43	12.69	12.06	11.47	12.06	12.45
<0.063 mm	49.7	49.02	63.29	76.97	45.21	45.41	42.45	54.53	42.29	38.95	43.22	43.95	43.47	46.83	44.86	44.29

Table 1: Particle Grain Size Distribution by weight of the 8 samples collected at 4 rod sites.

Interpretation of Results

Figure 3 shows the percent silt content of all samples collected at the four sites during the course of the AMS monitoring program. It should be noted that in 2007 there was a truncated season whereby four 'quarterly' monitoring activities were completed between April and December, such that the seasonal timing of Q1 and Q3 in 2007 are similar to the seasonal timing of Q2 and Q4 in subsequent years. Also, all DoD rods were replaced in Q1-2011 in an effort to prevent future breakage of the corroding metal rods. The new rods were installed within 10 m of the former rod locations. Therefore, the 2011 samples shown in **Figure 3** were collected at the new rod locations, as were the samples collected for this sampling study. These new locations provided a similar variability in percent silt content as had been observed prior to the rod replacement, with no clear indication (or field observations) that the new sites differed markedly from the original locations.

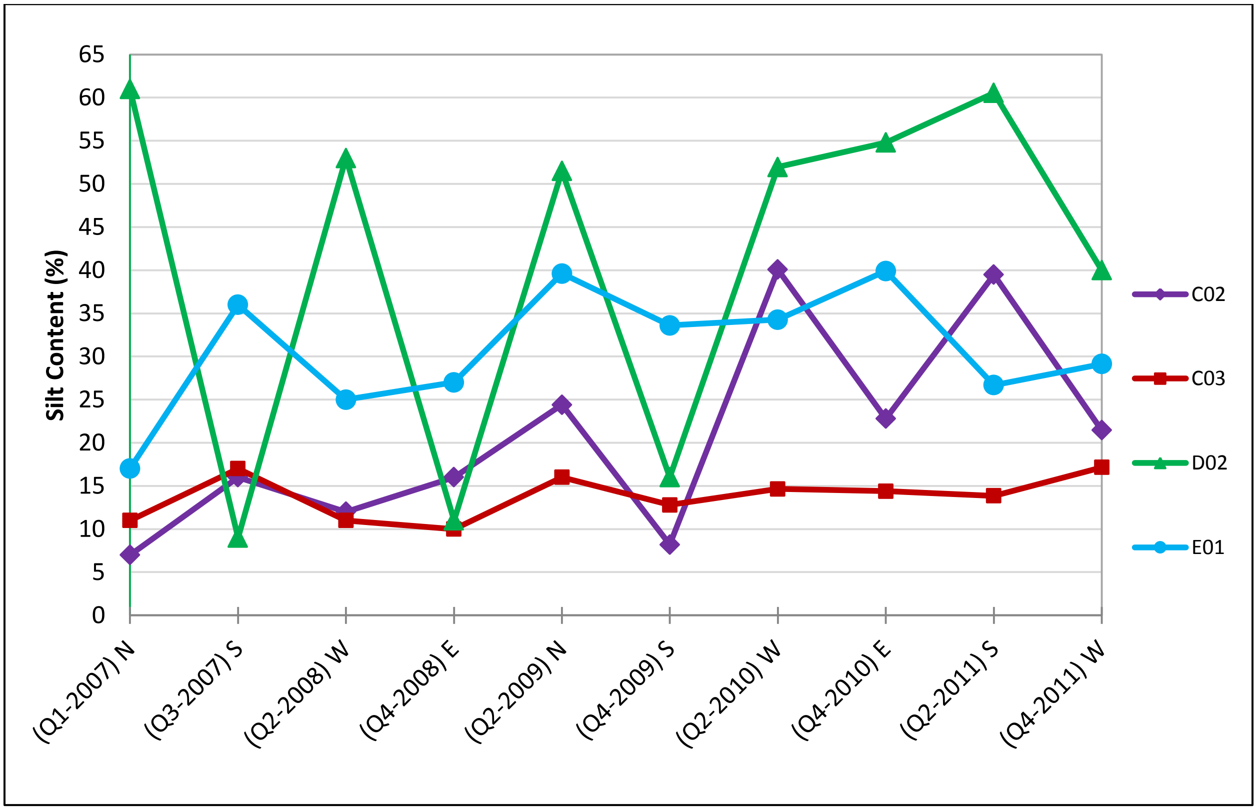

Figure 3: **Percent silt content measured at four locations during the sediment monitoring program over time. The cardinal direction of sampling is noted on the x-axis along with time of sampling (quarter and year).**

The apparently seasonal trend seen in **Figure 3** is particularly strong at the D02 location, while the C02 and E01 show similar, though less clear trends in percent silt that would appear to be seasonal patterns. The highly variable trend can also be explained spatially, as from 2007 to 2009 the very high values at D02 were collected at the N and W locations and the low value samples were collected at the S and E locations. The order of directional samples was changed in 2010 in an attempt at disproving the seasonal hypothesis but from 2010 all samples returned quite high values of percent silt, regardless of cardinal direction. During these last two years the percent silt values at C02 also saw an upward shift, with the spring (Q2) values being over 40% and the fall (Q4) values being only slightly lower than the previous maximum. In contrast, the values returned at E01 are quite variable but show no trend that can be attributed to either seasonal effects or cardinal direction. We have investigated additional factors that would cause this variability.

Field observations made throughout the monitoring program have indicated that a very small channel passes near site C02, alternately depositing and eroding surface sediments around the rod as it migrates through the area. The 2007 orthophotograph clearly shows this narrow channel passing through site C02 (**Figure 4**), originating from a small ponded area near the Deltaport Causeway. This channel has been more difficult to identify in many subsequent years, but interpretation of the 2012 orthophotos has indicated that this has become a network of smaller channels. Samples collected at this site in May 2012 vary in percent silt content between 38 and 48 percent. The maximum value previously recorded at this site was 40 percent. In the past, this site has varied up to 32 percentage points between monitoring periods and sampling directions, but also by as little as 4 percentage points. The changes seen at this site over the monitoring program may therefore reflect changes to the surrounding surface sediments over time, as well as localized spatial patterns of sediment distribution caused by the migration of small channels in the area. If this is the cause, then the consistently high percent silt content of the eight recent samples could be explained by recent channel activity.

Site C03 is located in an area of continuous eelgrass, where no physical changes to the surrounding sediment surface have been noted during the AMS monitoring program. This site has shown low values of percent silt content silt content (less than 20 percent) throughout the monitoring program without any large changes (greater than 10 percentage points) between monitoring periods. The samples collected in May 2012 vary in percent silt content around the rod between 17 and 19 percent. The previously recorded maximum value at this site was 17 percent. During the monitoring program, the maximum change between monitoring periods was 5 percentage points and the minimum change was 0.2 percentage points. However, the consistently higher values around the rod for the samples collected in May 2012 may indicate that the changes seen at this rod site over the monitoring program reflect changes in the surface sediments over time, rather than changes in localized spatial distribution of sediment.

Site E01 is located in the region of 'new channels'. Surface sediment near this rod is typically very soft mud and fine sand, with little visible variation in composition. The 8 samples collected in May 2012 at this site vary in percent silt content around the rod between 39 and 47 percent. The previous maximum value recorded at this site was 40 percent. The higher values of percent silt content around this rod as well as the low variability between these 8 samples again indicate that the record shown by the monitoring program in **Figure 3** likely represents changes to the surface sediments over time, rather than localized changes in grain size distribution around the rod. There are likely a combination of factors which influence the variability in silt content measured at this location; the abundance of fine surface sediments deposited within the area of 'new channels' is likely to be more easily redistributed within the area than more coarse sediments by the occurrence of large storm events; and it is also possible that the sediments in this area are highly stratified, such that small differences in sampling depth result in significant changes in percent silt content of the sample.

Samples taken at site D02 have shown the largest changes in percent silt content during the monitoring program, with values ranging from 9 to 61 percent. Field observations have noted another small channel in the vicinity of this rod, as well as a large patch of bare sediments to the south and east of the rod, as seen in the 2007 orthophoto (**Figure 4**). Several other similar features can also be seen nearby in **Figure 4**. These bare patches of sediment predate the construction of DP3, as they are also visible in the 2002 orthophotos. A 1979 aerial photo (**Figure 5**) shows an apron of fine sediments on either side of the causeway that were apparently placed during construction. **Figure 5** shows that by 1979 they had begun to spread outward across the tidal flats. This sediment is likely the source of the sand deposit features seen in **Figure 4**, and it is also possible that this input of fine sediments during the causeway construction has influenced surface sediment composition in all sediment samples collected during the AMS program at rod sites located in the likely area of influence (rods in the 'Shoreward Tidal Flat' group). Most of these bare patches of sediment have been covered by eelgrass in more recent years, indicating that they are more stable than in the past.

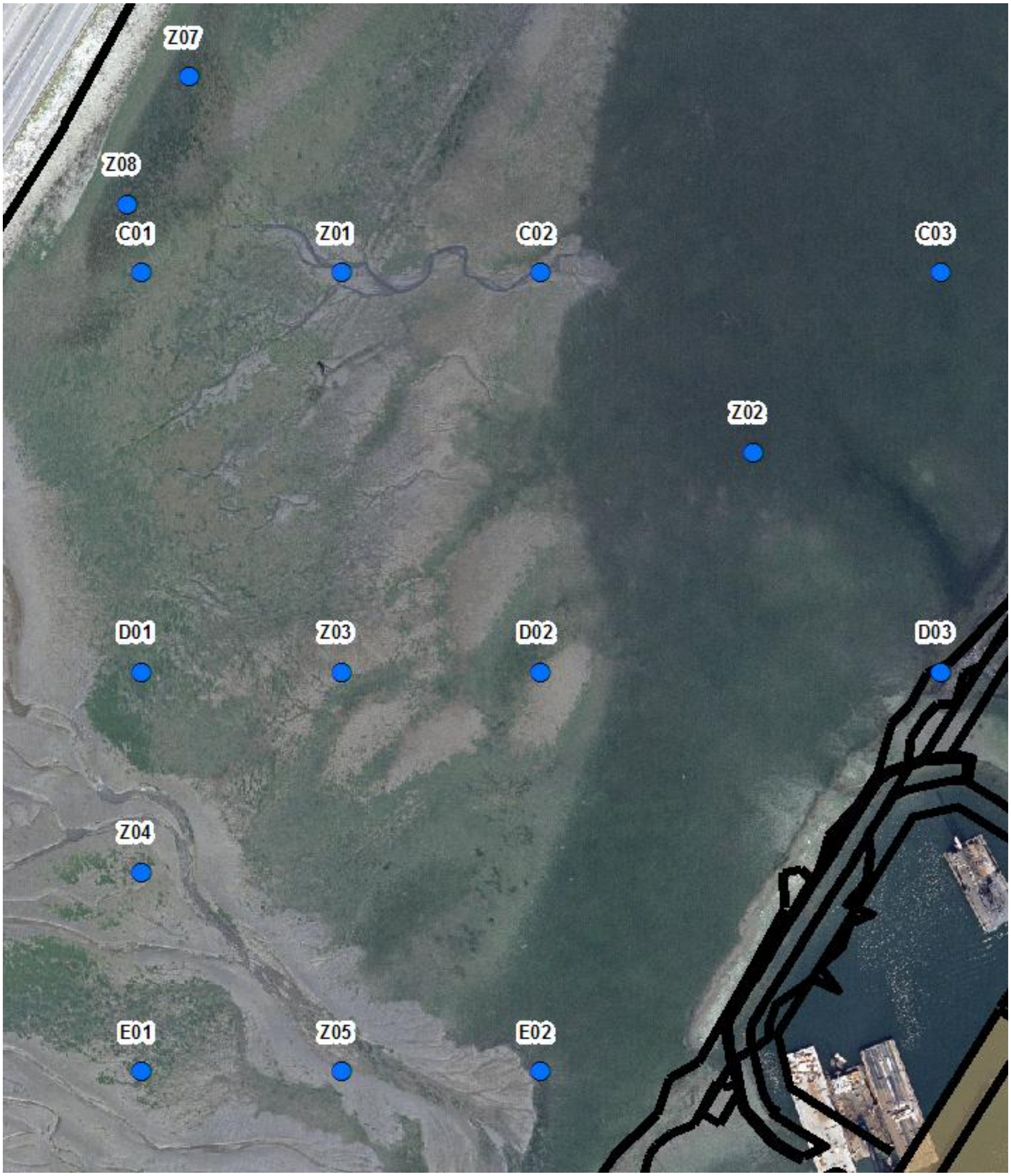

Figure 4: Sampling sites shown on the 2007 orthophoto. Features of interest include the channel passing through C02 and patches of bare sediments near D02 and E01.

Figure 5: Portion of an August 8, 1979 aerial photograph showing deposits of sediment on either side of the causeway that were apparently related to causeway construction.

Samples collected at this site in May 2012 varied from between 42 and 77 percent silt content. The samples collected to the south and southwest of the rod were 2 and 15 percentage points higher than the previously recorded maximum values, respectively. The remaining 6 samples were within 12 percentage points of each other. The wide range of values seen around this rod indicates that large changes in percent silt content do occur over small distances at this sampling location. These changes are likely related to the occurrence of small channels that redistribute sediments in the area, as well as differences in sediment composition between the patch of deposited sediment and the surrounding eelgrass beds.

CONCLUSION

At rod sites C02, C03, and E01, the small differences in percent silt content seen around the rods, as measured in the May 2012 samples, indicate that changes seen over the course of the monitoring program reflect changes in the surface sediments over time, and to a lesser extent changes in grain size distribution over small distances at each rod site. The high values of silt content measured at these sites further imply that temporal changes are a significant factor. It is not possible, based on these data, to determine if these changes occur on a seasonal basis.

Of these three rods, C02 had the largest variability in percent silt content around the rod. The presence of small channels passing through this rod site was previously thought to be the dominant factor influencing changes in the values of percent silt content measured here. While there was not as much variability measured around the rod as has been seen over the course of the monitoring program as this site, the spatial variability that was measured (12 percentage points) does indicate that these channels have some influence over localized changes in percent silt content.

The 8 samples collected at D02 had the largest variability in percent silt content of the 4 rod sites chosen for this spatial sampling study. While most of the samples at this site were quite close to each other in percent silt content, two samples were significantly different. These samples demonstrate that large changes in percent silt content can occur in surface sediments over small distances at this location. However, the spatial variability measured around this rod was not as large as the temporal variation during the monitoring program.

This sampling study indicates that the changes seen in percent silt content of samples collected during the sediment monitoring program reflect changes that have occurred to the surface sediments over time as well as differences in the sediment surface over small distances around the rod sites. Areas that are located near small erosional/depositional features such as small drainage channels or deposits of finer sediments are more likely to have large changes in grain size distribution over small distances. Also, areas that have been shown to have finer sediments tend to experience greater amounts of change in grain size distribution over small distances, as fine sediments are more easily transported. Conversely, areas that are composed of coarser sediments (more sand) or are located in more stable areas tend to have smaller changes in grain size over a similar small distance around each rod.

References

NHC, 2004. Roberts Bank Container Expansion Coastal Geomorphology Study. Prepared for Vancouver Port Authority. Prepared by Northwest Hydraulic Consultants and Triton Consultants Ltd., November, 2004, 116 pp + appendices.

APPENDIX C

NHC Memorandum: Deltaport Third Berth Adaptive Management Strategy Monitoring Program Final Field Inspection of New Drainage Channels

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northwest hydraulic consultants

MEMORANDUM

TO:	Bonnie Marks (Hemmera)	**DATE:**	March 18, 2013
FROM:	Derek Ray (NHC); Patrick Humphries (NHC)	**NO. PAGES:**	1 of 12
CC:	Kim Keskinen (PMV); Ben Wheeler (Hemmera)	**PROJECT NO.:**	34648 (NHC reference)

RE: **Deltaport Third Berth Adaptive Management Strategy Monitoring Program Final Field Inspection of New Drainage Channels**

BACKGROUND

Northwest Hydraulic Consultants (NHC), in partnership with Hemmera Envirochem (Hemmera) and Precision Identification (Precision), has been engaged by Port Metro Vancouver (PMV) to conduct ongoing monitoring in support of the Adaptive Management Strategy (AMS) for the Deltaport Third Berth (DP3) expansion project. As part of the Coastal Geomorphology component of the AMS, NHC has been monitoring the evolution of an area of 'New Drainage Channels' that initially formed in April, 2007, during a brief period in the construction phase of the DP3 project when tidal waters and supernatant were leaking from the perimeter dyke.

In keeping with the stated goals and timelines of the AMS program, on-the-ground monitoring activities relating to Coastal Geomorphology have been discontinued. However, the Scientific Advisory Committee (SAC), which provides technical oversight to the consulting team, made a recommendation that a final monitoring effort be directed to gaining a more complete understanding of the long-term behaviour of these channels. The purpose of this memo is to document the field inspections carried out in June of 2012 and to summarise the available body of information relating to these features.

APPROACH

The approach taken to describing the new channels and providing comment on future evolution relies heavily on observation and interpretation. However, information from various sources describing the area of new channels has been collected during the course of the AMS monitoring program. These include:

1. High resolution digital orthophotos of the study area that have been taken each summer during low tide conditions from 2007 to 2012;
2. Low level oblique photos taken from a fixed-wing aircraft;
3. Photographs taken at ground level at various times following channel formation;

4. An array of Depth of Disturbance (DoD) rods within the immediate study area that was supplemented with additional rods following channel formation;

5. Sediment samples collected at the original DoD rod sites, some of which are in the area of influence of new drainage channels; and

6. Topographic and bathymetric surveys of the study area, including the area of new channels, starting in 2007 and repeated in 2010 and scheduled to be repeated in 2013.

There have been a number of *ad hoc* site visits to make observations and collect photographs. These include a site visit on April 18, 2007 to inspect the newly-formed channels and a follow-up visit on June 14, 2007 to make additional observations. Casual observations were also made during the course of regular monitoring but these have not been catalogued here. Recently, on June 4, 2012, the channels were methodically inspected to provide information for the preparation of this memo.

Various methods for collecting topographic detail for the express purpose of monitoring the channels were explored. However, systematic and random survey error, which is largely unavoidable would account for a level of imprecision that would be of greater magnitude than the magnitude of change that is thought to be occurring. Sources of survey error include: vertical and horizontal error in the Real-Time Kinematic (RTK) GPS signal, the error inherent in surveying soft, unstable sediments, and the localised changes that would be induced by the physical presence of the survey crew (ie. deep footprints).

Channel Formation

The new channels initially formed in April and May of 2007, as a result of tidal waters draining through the permeable perimeter dyke that was placed to define the outline of the DP3 footprint. **Figure 1** shows an orthophoto mosaic from July 2, 2008, with the perimeter dyke highlighted in orange. The photo was taken after dredgeate was pumped into the footprint to form the new land for the terminal, which occurred in late-June, 2007.

Prior to the introduction of the fill material, the interior ground elevation of the terminal footprint was defined by the previously-existing tidal flats, and the internal dyke (also shown in **Figure 1**) formed a semi-isolated enclosure with the existing terminal as the other boundary. Because the internal dyke and the perimeter dyke were permeable, water within the terminal footprint was free to rise and fall with the tides, although water levels were out of sync because the transfer of water through the dyke was slower than the rate of rise and fall of the open ocean water levels. The time lag resulted in water levels being higher on the seaward side of the dyke during a rising tide (**Figure 2a**) but lower on a dropping tide (**Figure 2b**). During a very low tide, water stored within the containment dykes drained through the perimeter dyke and across the exposed tidal flats resulting in the formation of drainage channels.

Figure 1: July 2008 orthophotograph, during construction of DP3.

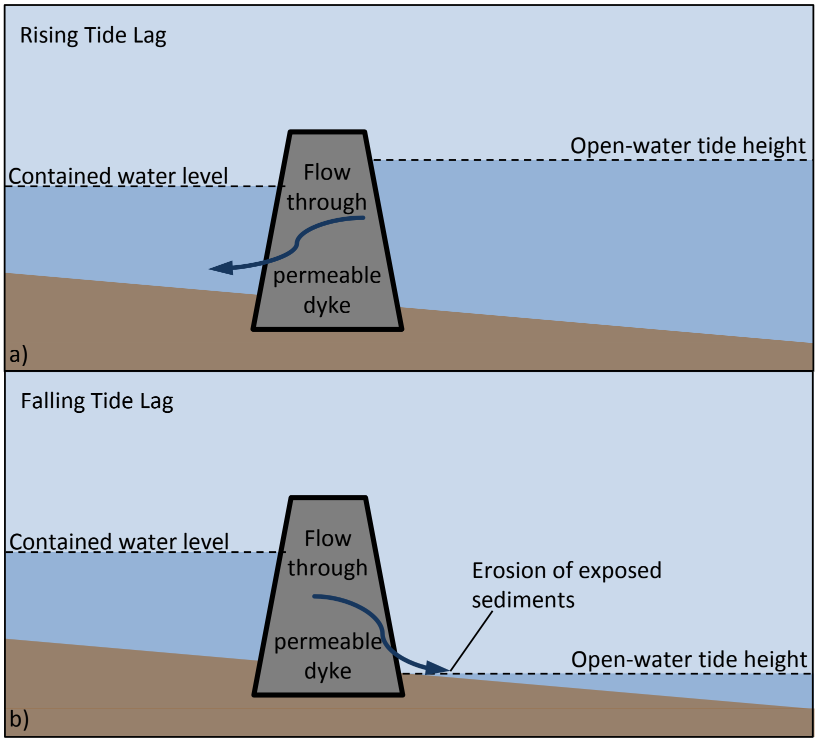


Figure 2: Schematic diagram showing water level differential between the open water and the area inside the perimeter dyke during a) rising tide, and b) dropping tide conditions.

Figure 3 shows an oblique aerial photograph of the new channels taken on March 12, 2008. Although the initial period of active channel formation had ended approximately nine months previously, the effects of those channel processes remained quite visible. The upslope portion of the channels in the left side of the photo have incised into the mud flat surface as smaller branch channels joined together, moving the eroded material through a transport 'reach' and depositing the sediments in lobes into the eelgrass beds at the downslope limit of the channels.

Based on our understanding of events at the time, the issue of water draining through the perimeter dyke persisted for many weeks until a portion of the inner enclosure could be back-filled. Dredge material was pumped into the terminal footprint to seal the permeable dyke and to displace water that would otherwise infill the footprint. While this drastically reduced the amount of water flowing across the tidal flats, for a short period of time during the back-filling operation, supernatant (sediment-laden water) also flowed out of the perimeter dyke, delivering water and fine sediment to the tidal flats. The sediment lobes visible in the right side of **Figure 3** may therefore include a certain amount of this material.

Figure 3: Oblique aerial photograph of the new channels taken on March 12, 2008.

Summary of Data and Observations

Orthophotos

High resolution orthophotos have been collected each year during a summer low tide. The area of new drainage channels has been mapped from these photos for each photo year and compared with previous years. The results, summarized from the annual AMS reports, indicate that there has been no detectable change in the lateral position of the drainage channels following some small adjustments immediately after their formation in 2007. The channels remain visible but direct field observations indicate that there is insufficient flow in the channels to initiate sediment transport, and thus lateral migration of the channels.

DoD Rods

An array of DoD rods was installed on 18 and 19 April, 2007 at the start of the AMS monitoring program. The original 26 rods were monitored on a quarterly basis for a full year, with an additional eight rods (z-series) added in the Spring of 2008 to provide greater spatial resolution. For the purposes of analysis, the population of rods was divided into three groups:

- Group 1 – Seaward of the Crest Protection Structure;
- Group 2 – Area of New Channels; and
- Group 3 – Remaining DoD rods Shoreward of Crest Protection Structure.

Figure 4 shows the location of the rods with the yellow shaded oval indicating the seven rods that were considered to be within the area of new channels. **Figure 5** shows a histogram of net change by monitoring period (quarter) for the three DoD rods that have been installed in the area of new channels since the channels first formed (D01, E01, and E02). The magnitude of net change in Q2-2007 is very large in the positive direction, indicating net deposition, particularly at E02, which is lower in elevation than the other two rods. By Q3-2007 the values for net change are slightly negative, except at E02, which shows almost 4 cm of deposition. By the winter of 2007 the values of net change have all become negative and the magnitude of net change remains relatively low for the duration of the monitoring study as compared to the initial disturbance. The results have been interpreted as demonstrating an initially large input of sediment from the channel erosion and influx of supernatant, followed by a return to the expected background levels of deposition and erosion.

Table 1 shows the summary statistics for all DoD rods from 2008 to 2011 (2007 was excluded from this table because there were no data for the z-series rods). Not surprisingly, the magnitude of change for those rods on the seaward side of the Crest Protection Structure (CPS) is much larger than for the rods on the shoreward side. Of particular note to this memo is that there is very little difference between Group 2 and Group 3, indicating that from 2008 onwards, the DoD rods in the area of new channels were experiencing similar processes as those elsewhere on the tidal flats.

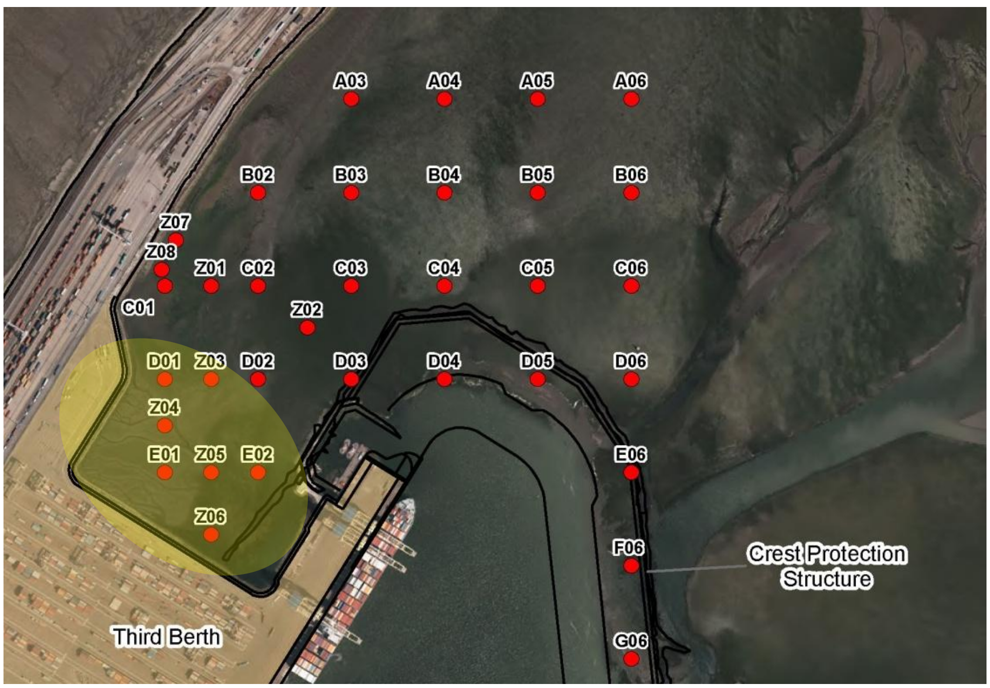


Figure 4: Location of DoD rods in area of new channels as indicated by shaded oval.

Figure 5: Histogram showing magnitude of net change over time at DoD rods D01, E01, and E02 from 2007 to 2011.

		Group 1	Group 2	Group 3
Deposition	Q1 Mean ('08,'09,'10, '11 only)	3.89	1.99	1.30
	Q2 Mean	4.77	1.97	1.39
	Q3 Mean	2.40	1.95	1.58
	Q4 Mean	3.44	0.89	1.42
	Annual Mean	3.59	1.61	1.43
Erosion	Q1 Mean ('08,'09,'10, '11 only)	-5.92	-1.87	-1.32
	Q2 Mean	-4.64	-1.00	-1.00
	Q3 Mean	-4.66	-1.77	-1.24
	Q4 Mean	-5.40	-1.71	-1.44
	Annual Mean	-5.09	-1.58	-1.25
Combined Erosion and Deposition	Min	-22.70	-9.70	-10.40
	Max	21.00	8.50	9.20
	Mean	-0.75	0.01	0.09
	Std. Dev. (σ)	5.69	2.22	2.17
	1.282 Std. Dev. (1.282σ)	7.29	2.85	2.78
	Deposition Threshold	6.54	2.86	2.87
	Erosion Threshold	-8.04	-2.83	-2.69

Table 1: DoD rod summary statistics from 2008 to 2011.

Sediment Samples

Sediment samples were collected twice yearly at each of the original 26 DoD rod sites using a short hand corer to extract a 10 cm long core. The sediment samples were analysed by a commercial lab to determine the grain size distribution and carbon content. The purpose of the sampling was to monitor for short-term changes in grain size in the near-surface sediments. **Figure 6** shows that the percent silt content at the sampling locations within the area of new drainage channels varied by several tens of percentage points throughout the duration of the AMS monitoring program. The Q1-2007 samples were collected between April 18 and 20, 2007, around the time that the channels had begun to form. D01, which is just outside the initial deposition zone shows very little increase in percent fines over time until Q2-210 when values begin to increase. E01 and E02, which are well within the deposition footprint show sharp increase in percent fines following the initial sampling, with generally elevated values since. Both the delayed increase in the D01 samples and the variability in E01 and E02 would appear to be indicative of redistribution of those fine sediments.

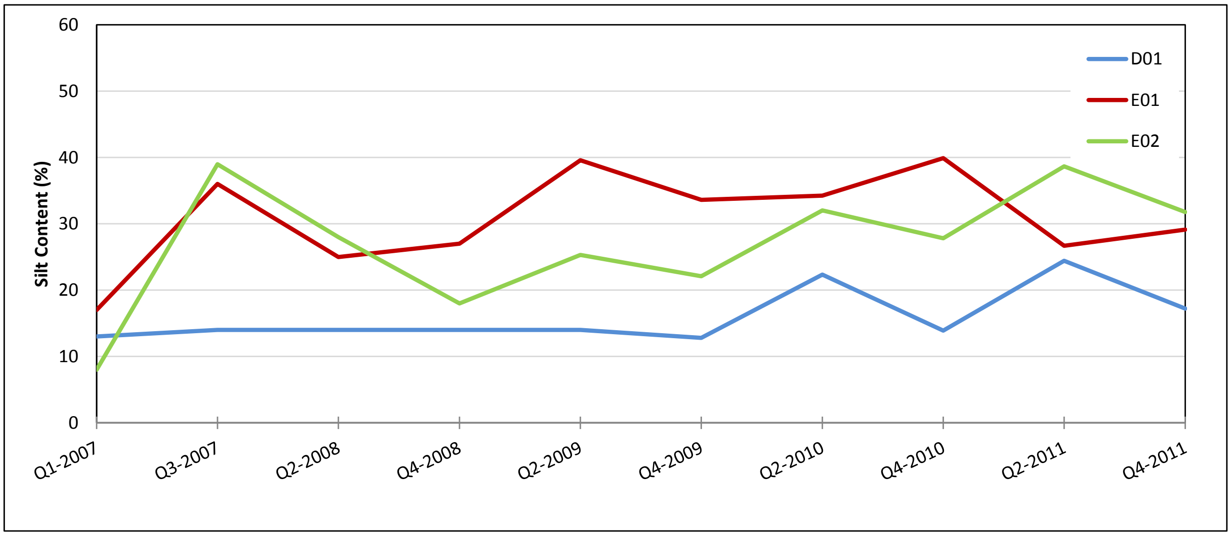


Figure 6: Percent silt content at sampling locations D01, E01, and E02 from 2007 to 2011.

Topographic and Bathymetric Surveys

A combined topographic and bathymetric survey was conducted in the summer of 2007, after the channels had formed. This survey covered the entire wider area of interest, which extends from the upper edge of the tidal flats, seaward to sub-tidal waters, and from the Deltaport Causeway laterally to the half-way point between the Deltaport and BC Ferries Causeways.

The survey techniques included a boat-mounted depth sounder, which was deployed over the sub-tidal and deeper portions of the inter-tidal areas. Ground-based surveying on foot using an RTK-GPS was used over the upper inter-tidal areas. The presence of eelgrass results in a highly variable return from an acoustic depth sounder and requires significant data cleaning and smoothing; however, the boat can rapidly cover large distances with greater spatial resolution. The ground-based survey techniques are not affected by the presence of eelgrass but are much slower and thus spatial resolution is lower.

The area of new drainage channels was surveyed using a boat-mounted depth sounder, with some ground-based data collection during both 2007 (following channel formation) and during 2010. **Map 1** shows a comparison surface created by subtracting the 2007 DEM (digital elevation model) from the 2010 DEM. This map shows that changes in this area are very small. The larger differences in elevation that are seen in this map are generally caused by differences in the DEM extents, by individual survey points that were collected in one year, but not another, or by errors in the survey data caused by eelgrass interference with the echo-sounder signal. This is most noticeable around the edges of the surface near the perimeter dyke and on the southeast side of the image where the DEM surfaces do not match precisely. Within the center of the channels there are also some larger elevation differences; this is due to one surface containing a point which was collected within the channel while the other surface does not contain this point, resulting in an apparently large difference in elevation. The remaining elevation differences are most likely related to interference with eelgrass fronds (as there are larger differences visible on this map with the areas in which eelgrass is visible), and with other inherent surveying inaccuracy. While the accuracy of this map is not ideal for this type of analysis, it does provide a picture of only very small changes occurring within the area of new channels over the three year period.

A topographic survey of the new channels was also conducted by a PMV (then Vancouver Port Authority) surveyor, during low tide on June 25 and July 3, 2007 (Sketch Plan No. S2007-177). The point data was primarily collected to show the outline of the channels (which matches very closely with the orthophoto mapping in this area). The elevations attached to the 'top of bank' points align with the average surface elevation from the 2007 and 2010 DEM surfaces. A limited number of survey points also exist for the channel bottom, but no data is available with which to compare these values.

Channel Evolution

Following the initial period of channel formation in the spring and early summer of 2007, the channels have undergone a period of slow adjustment. As mentioned above, some slight lateral migration occurred between 2007 and 2008, and there has not been any noticeable lateral migration since that time. Oblique photographs taken during repeat monitoring visits have meanwhile shown a reduction in the vertical relief of the channel banks, resulting in a lower gradient bank side slopes with a poorly defined top and bottom edge (**Figure 7**). In particular, the sharp vertical 'banks' at the outside of channel bends that typically signify active lateral migration have re-graded to shallow sloped banks.

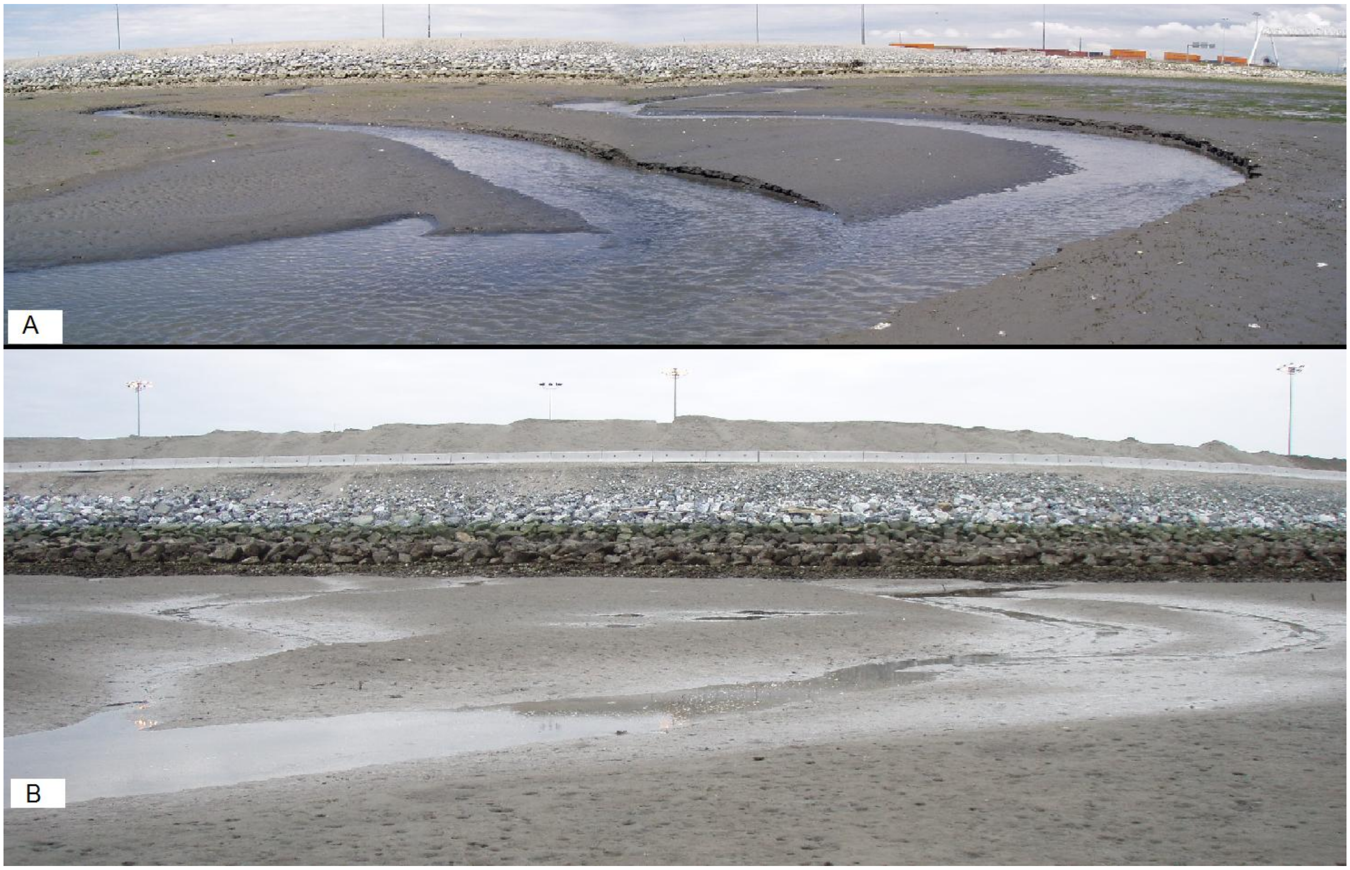


Figure 7: Ground-based photos of a portion of the channels taken from near the same location, showing how the cross sectional shape of the channel has changed between A) 2007 and B) 2012.

Field Observations

A number of observations were made during the June 4, 2012 site visit that support the conclusions of the desktop analyses described above. The site visit was conducted during a relatively large tidal swing from 4.2 m to 0.3 m, resulting in a rapidly dropping tide that would tend to exaggerate in-channel processes that were observed. Only small amounts of very fine sediments were observed to be transported within the channels during the period of greatest draining flows. In addition to the lack of erosion observed, the persistence of very soft surface sediments in the area throughout the monitoring program support the theory that there is insufficient energy in the system to reshape these channels further.

The time period during which these channels convey the most flow is after the tide level has dropped below the elevation of the surrounding ground surface. The remaining water stored in the surrounding sediments then drains directly into the channels. This occurs below an elevation of approximately 2.0 m CD at the upper edge of the new channels area. At these tide levels and below, water was observed to be draining directly from the toe of the perimeter dyke into the mouth of the channels (**Figure 8**). This source appeared to provide the majority of the flow passing through these channels at tide stages below 2.0 m, implying that the water table in the fill material immediately behind the riprap slope face is driven by the tides Based on the fact that only small quantities of water appear to drain from the riprap face, saturation of the fill material does not extend very far into the terminal footprint.

Figure 8: This image shows drainage originating from the toe of the perimeter dyke (bottom of image) flowing directly onto the tidal flats and combining to form one of the main channels in the 'area of new drainage channels'.

CONCLUSION

No erosion or significant sediment transport has been observed within the channels, and there is no evidence of active channel development. Very soft sediments have also persisted within the channels since their formation, indicating a very low energy environment. Existing survey data does not provide a detectable amount of change to surface elevations in the area, and orthophotograph mapping during the AMS program suggests that the channels have remained laterally stable following a short period of initial adjustment after their formation.

Bank side-slope gradients within the channels decreased markedly soon after their formation, from very steep sided banks to flatter, more rounded banks, and have remained at a very low gradient or decreased further in the following years.

The fastest flows within the channels occur when the tide level has dropped below the elevation of the surrounding ground surface. Under these conditions, the majority of the flow within the channels comes from water draining the saturated sediments in the edges of the terminal footprint. This drainage appears to be of insufficient volume to transport sediments other than very small amounts of fine sediments.

The channels in their present (2012) form are mainly a relict of the initial channel-forming flows. Since the initial channel formation, the features have been losing definition and would be expected to eventually become indistinct except that in such a very low energy environment, the redistribution of sediments that is required to obscure the channels is largely absent.

REFERENCES

NHC, 2004. Roberts Bank Container Expansion Coastal Geomorphology Study. Prepared for Vancouver Port Authority. Prepared by Northwest Hydraulic Consultants and Triton Consultants Ltd., November, 2004, 116 pp + appendices.

APPENDIX D

Eelgrass Distribution Maps, Graphs, Data, and Statistics

APPENDIX D: EELGRASS

Figures and tables are provided in the following order:

Figure D-1 Eelgrass distribution in the inter-causeway based on orthophoto interpretation and field surveys conducted in 2003 and 2007

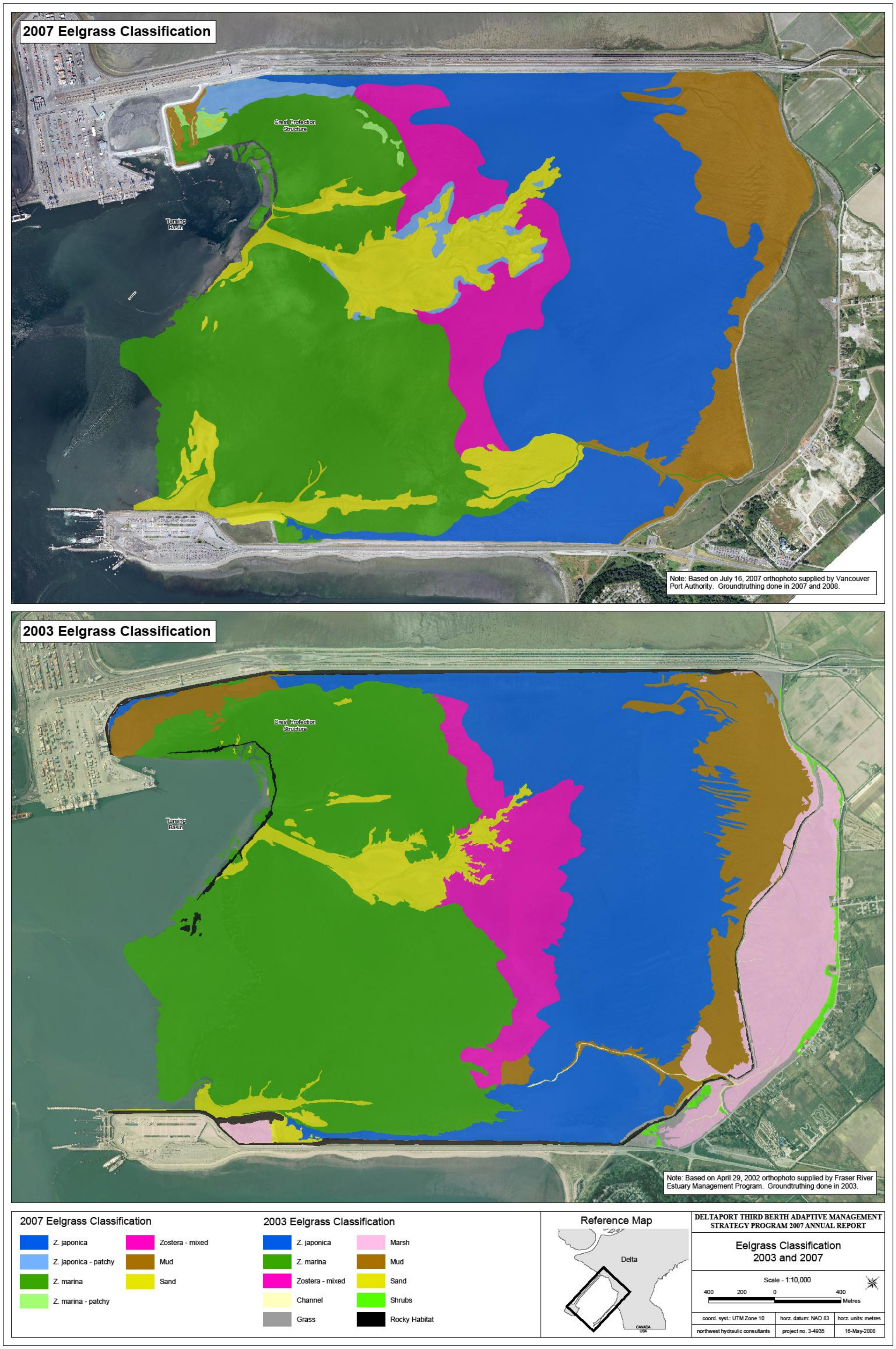


Figure X

Figure D-2 Eelgrass distribution in the inter-causeway based on orthophoto interpretation and field surveys conducted in 2008

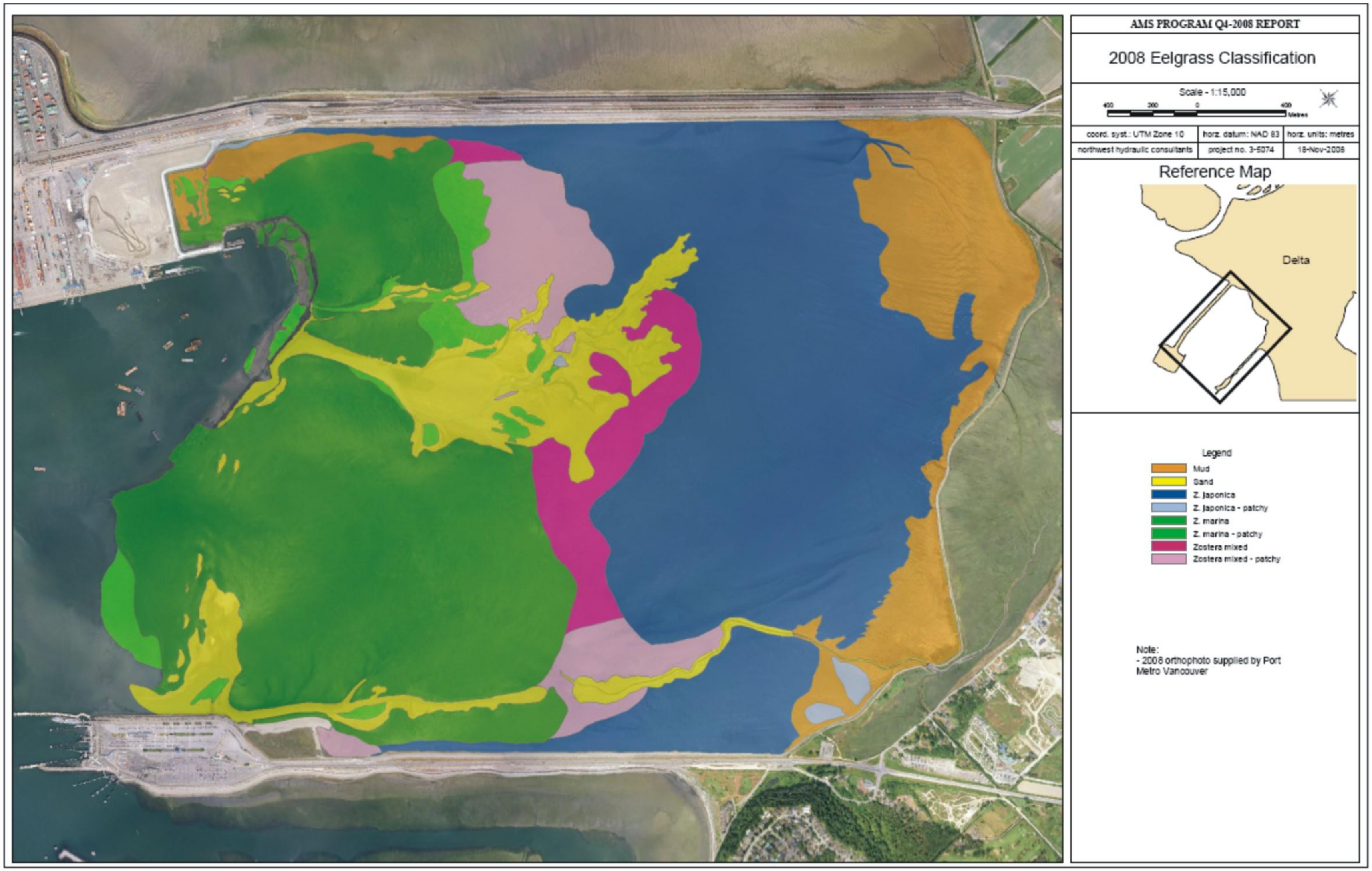


Figure D-3 Eelgrass distribution in the inter-causeway based on orthophoto interpretation and field surveys conducted in 2009

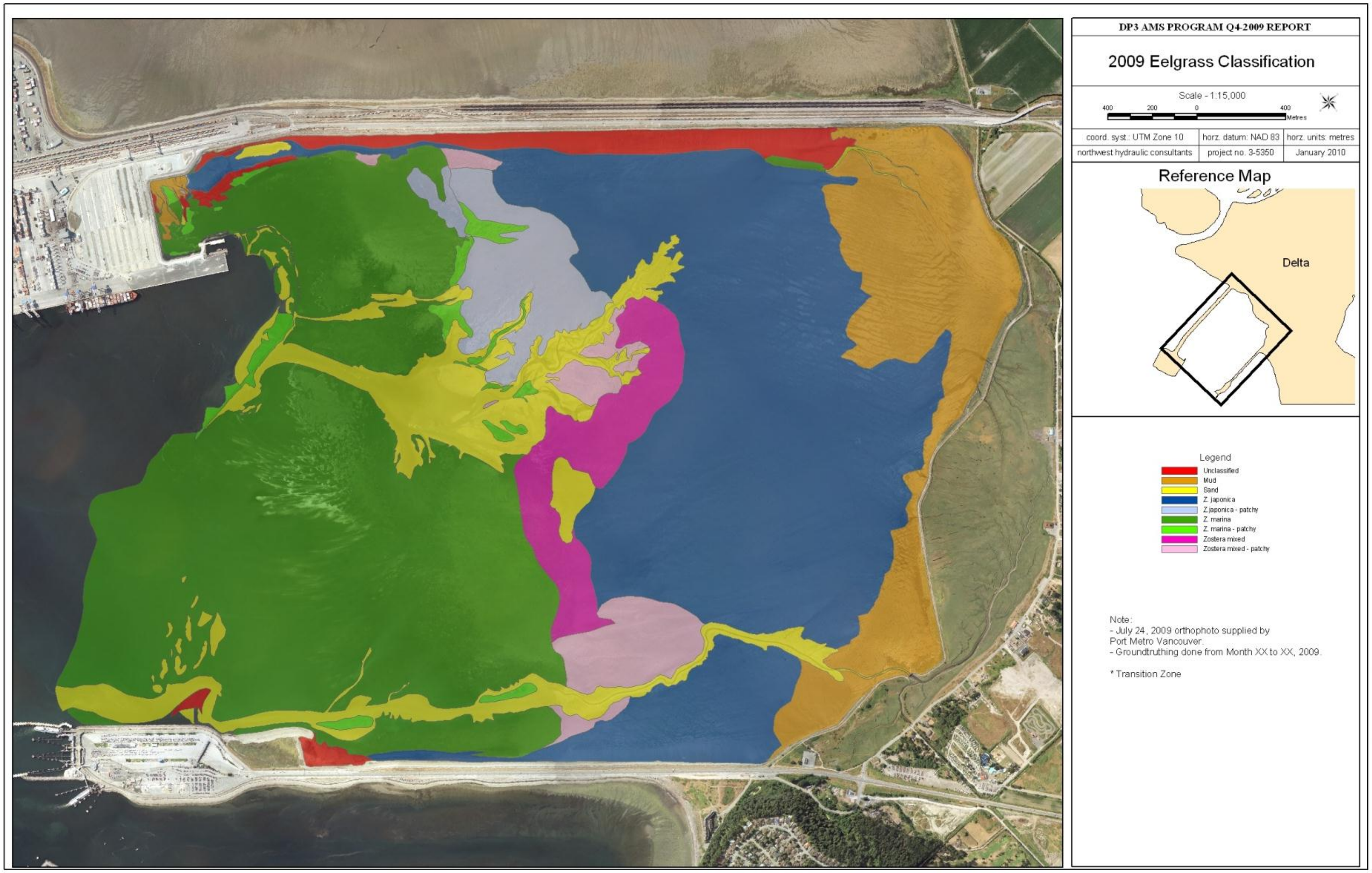


Figure D-4 **Eelgrass distribution in the inter-causeway based on orthophoto interpretation and field surveys conducted in 2010.**

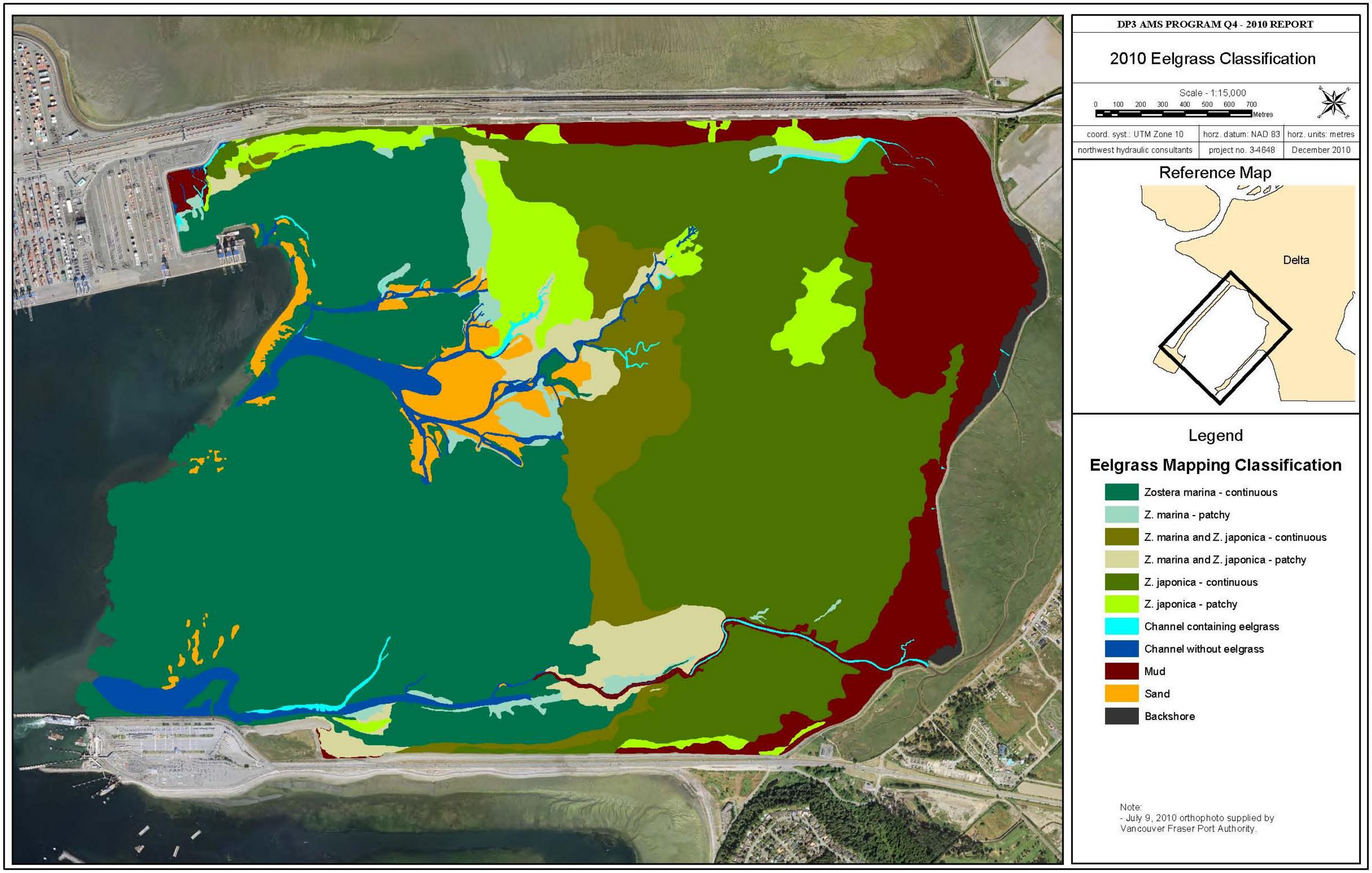


Figure D-5 Eelgrass distribution in the inter-causeway based on orthophoto interpretation and field surveys conducted in 2011.

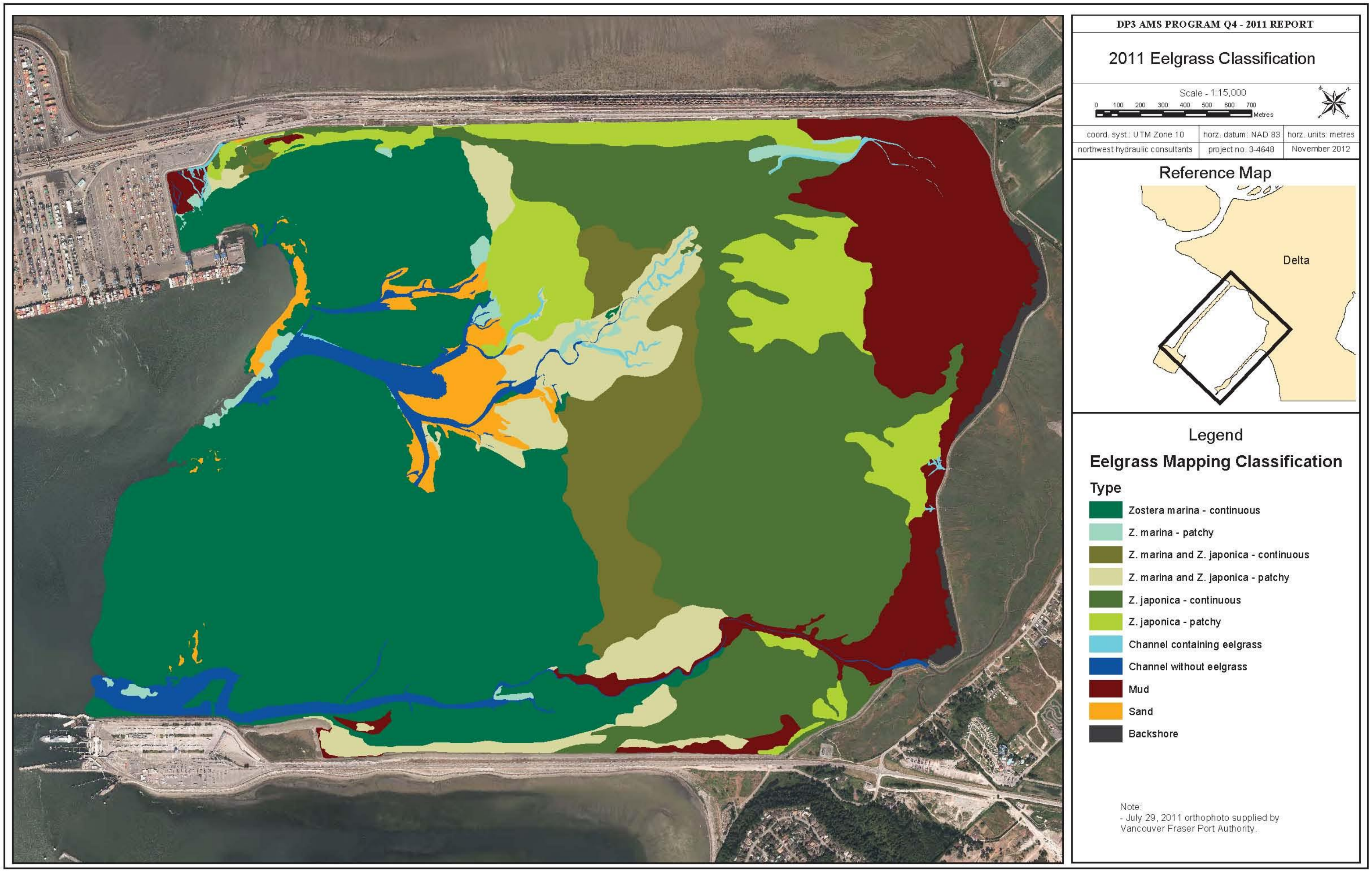


Figure D-6 **Mean eelgrass shoot density data from Roberts Bank, Inter-causeway near Deltaport Causeway, Sites 1A, 1B, and 2**

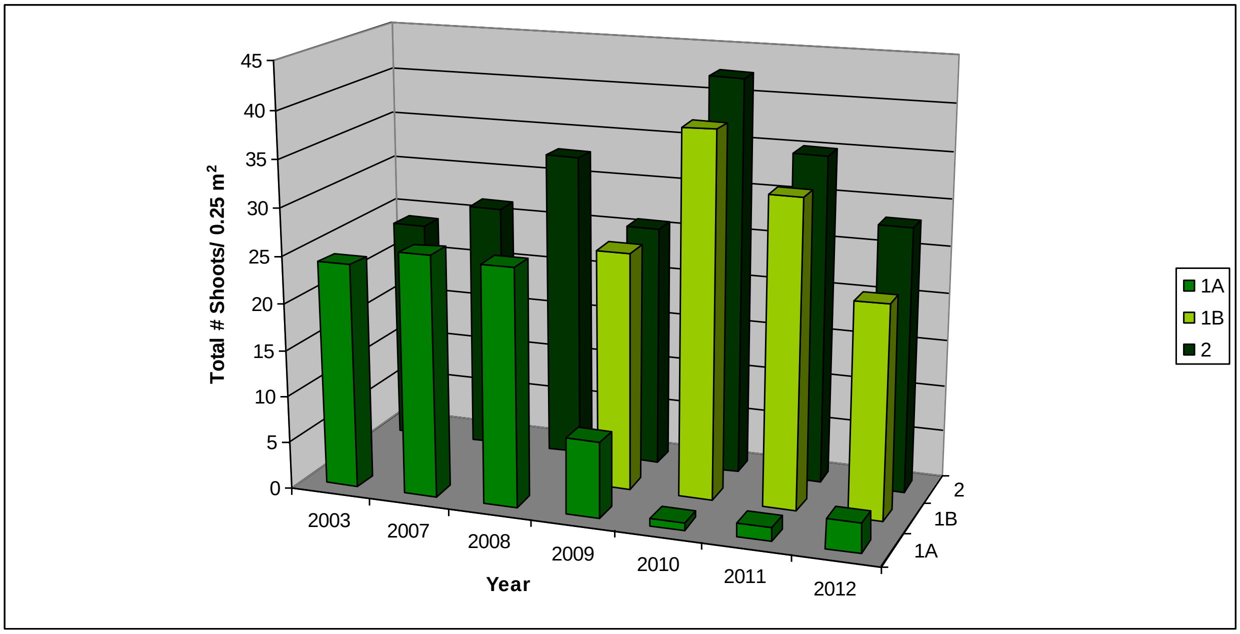


Figure D-7 **Mean eelgrass shoot density data from Roberts Bank, west of Deltaport Causeway, Sites 3 and 4**

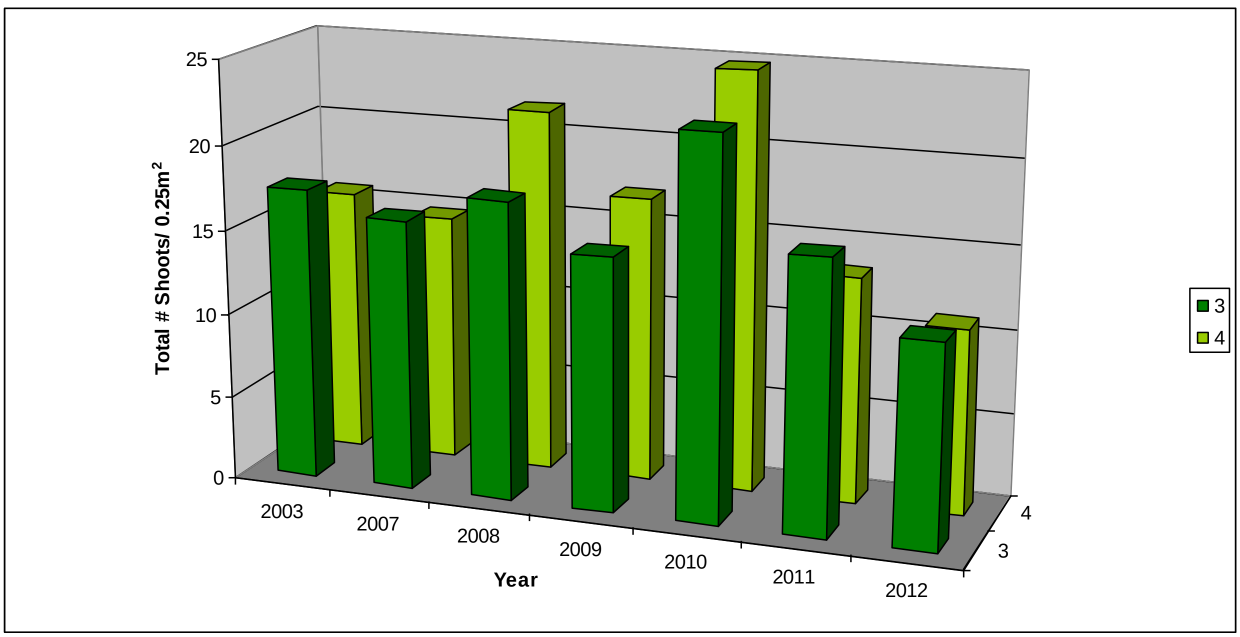


Figure D-8 Mean eelgrass shoot density data from Roberts Bank, Inter-causeway near Ferry Causeway, Sites 5 and 6

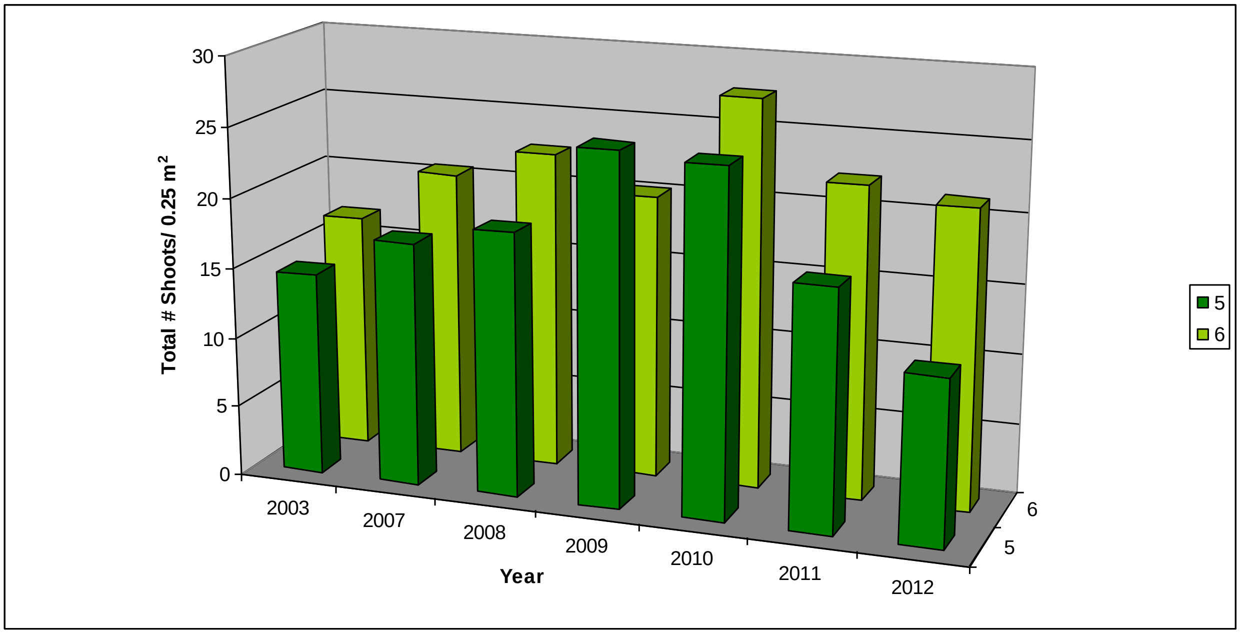


Figure D-9 Mean eelgrass shoot density data from Boundary Bay, Sites WR1, WR2, and WR3

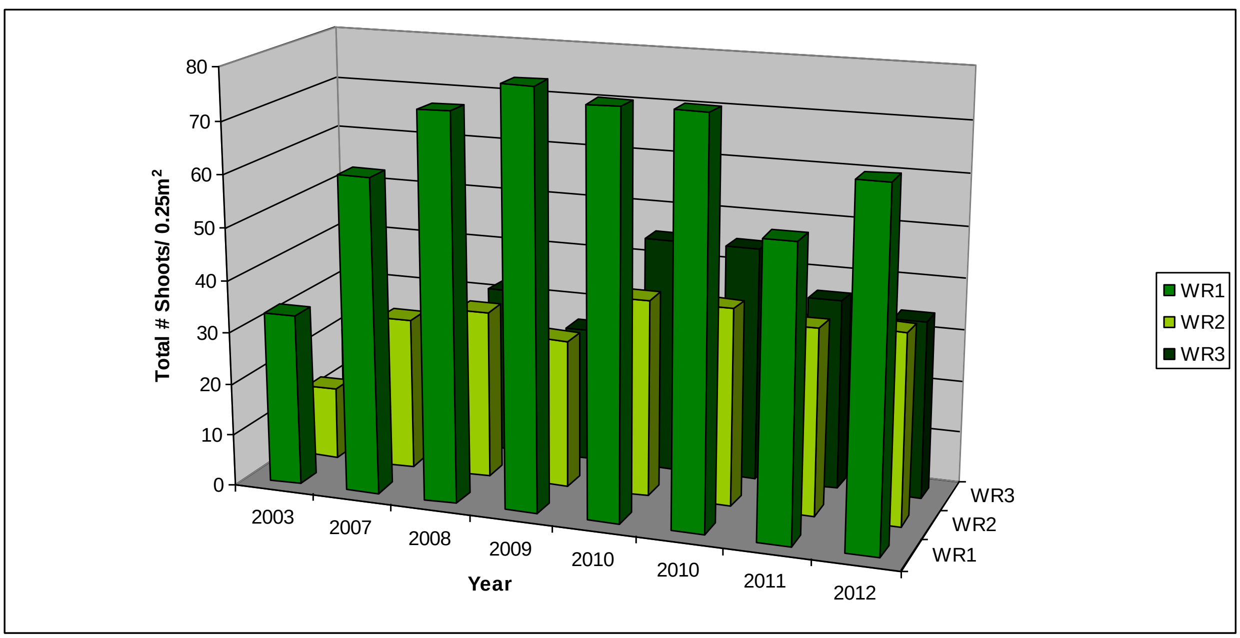


Figure D-10 Mean eelgrass shoot length data from Roberts Bank, Inter-causeway near Deltaport Causeway, Sites 1A, 1B, and 2

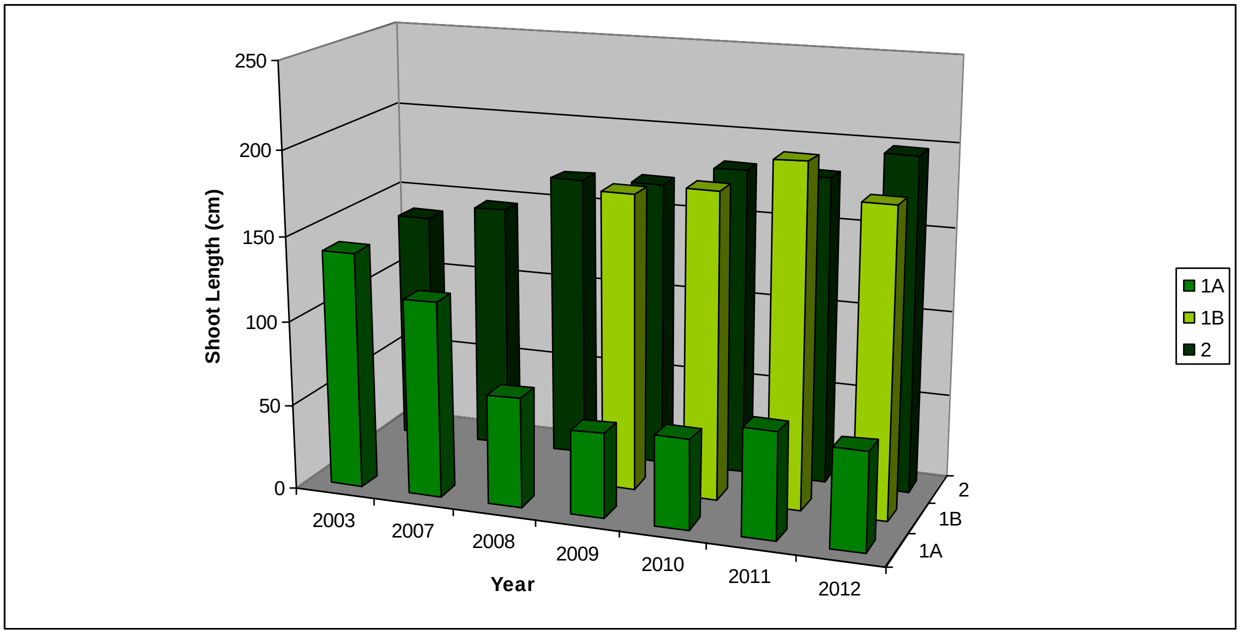


Figure D-11 Mean eelgrass shoot length data from Roberts Bank, west of Deltaport Causeway, Sites 3 and 4

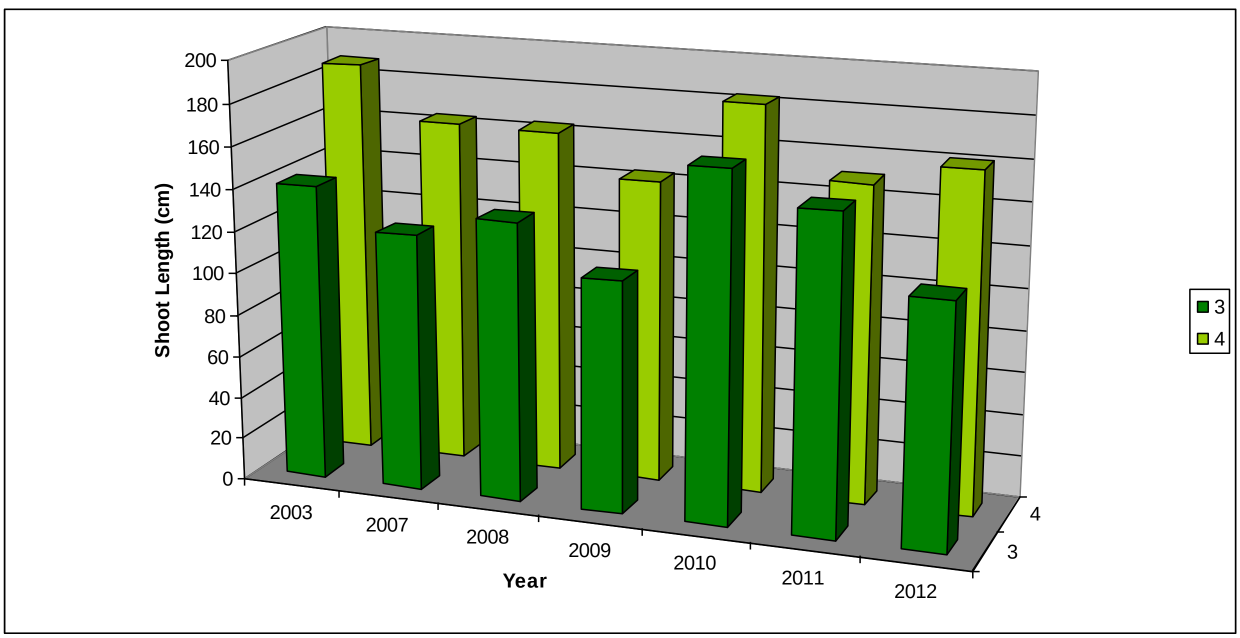


Figure D-12 Mean eelgrass shoot length data from Roberts Bank, Inter-causeway near Ferry Causeway, Sites 5 and 6

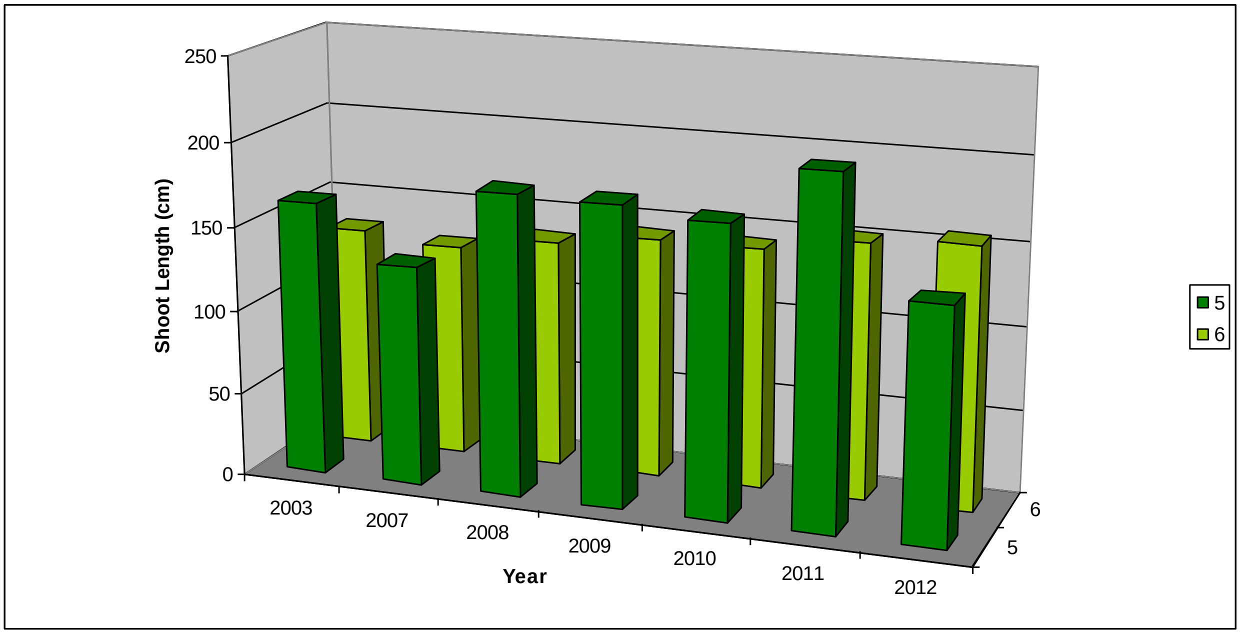


Figure D-13 Mean eelgrass shoot length data from Boundary Bay, Sites WR1, WR2, and WR3

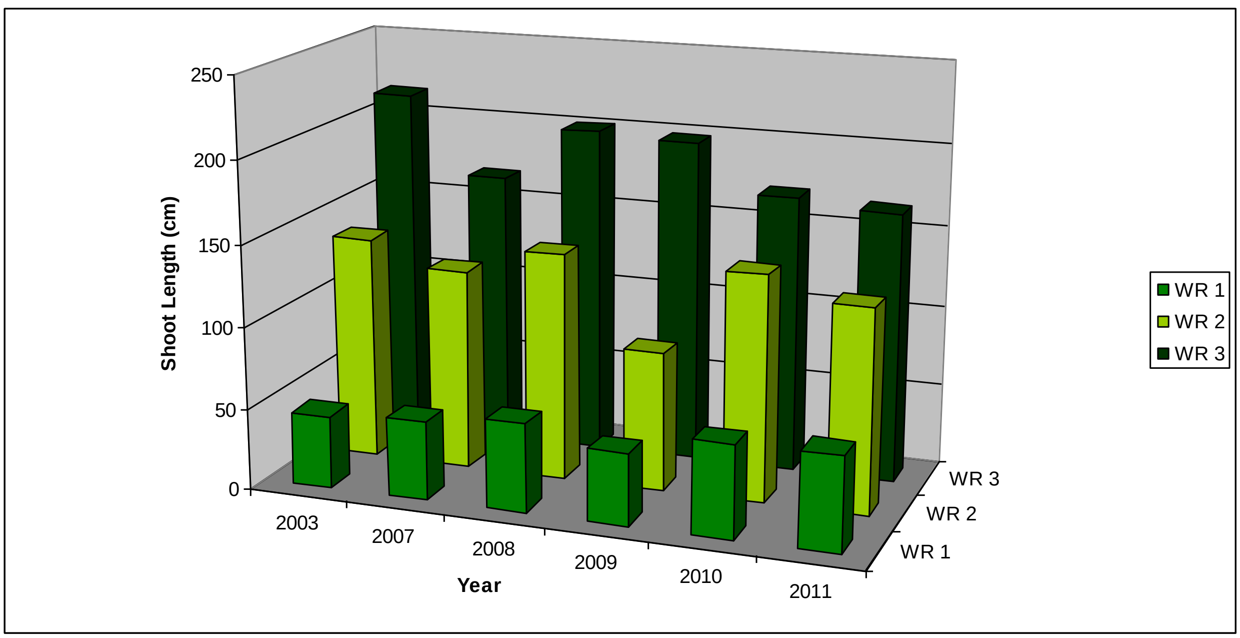


Figure D-14 Mean eelgrass shoot width data from Roberts Bank, Inter-causeway near Deltaport Causeway, Sites 1A, 1B, and 2

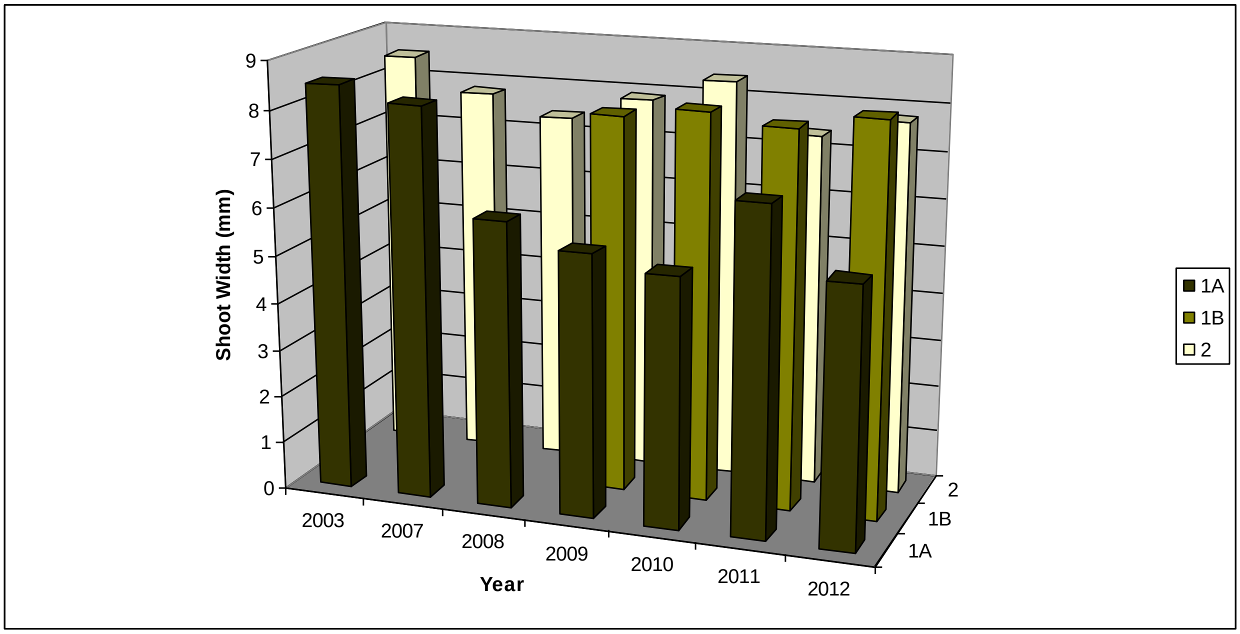


Figure D-15 Mean eelgrass shoot width data from Roberts Bank, west of Deltaport Causeway, Sites 3 and 4

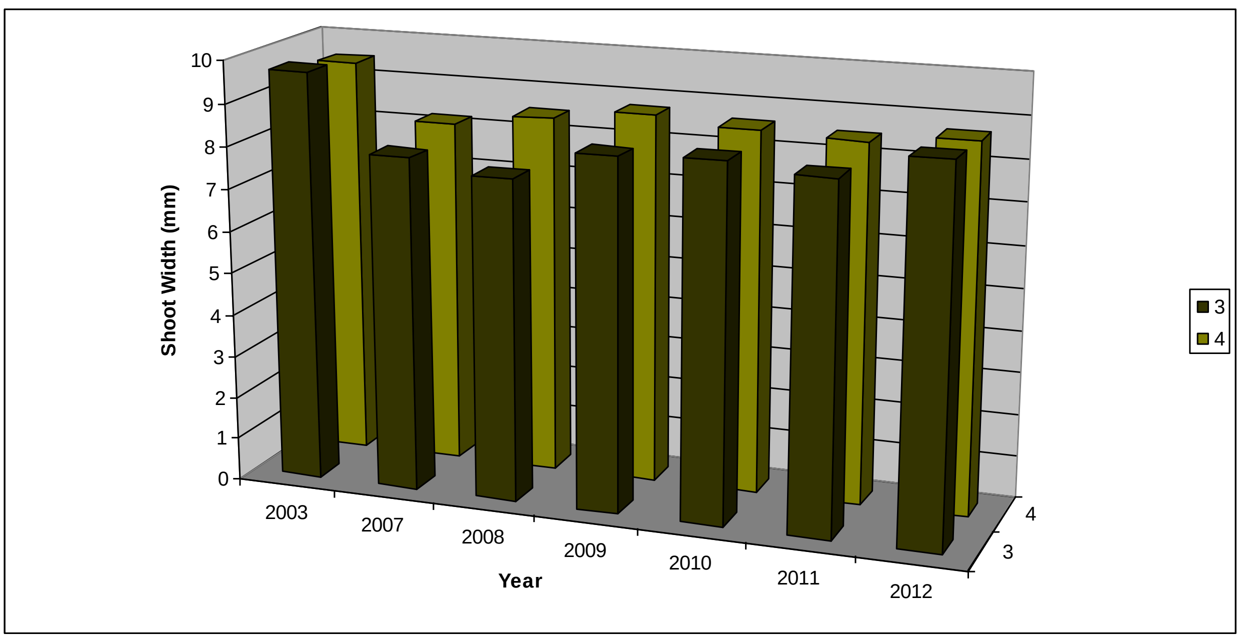


Figure D-16 Mean eelgrass shoot width data from Roberts Bank, Inter-causeway near Ferry Causeway, Sites 5 and 6

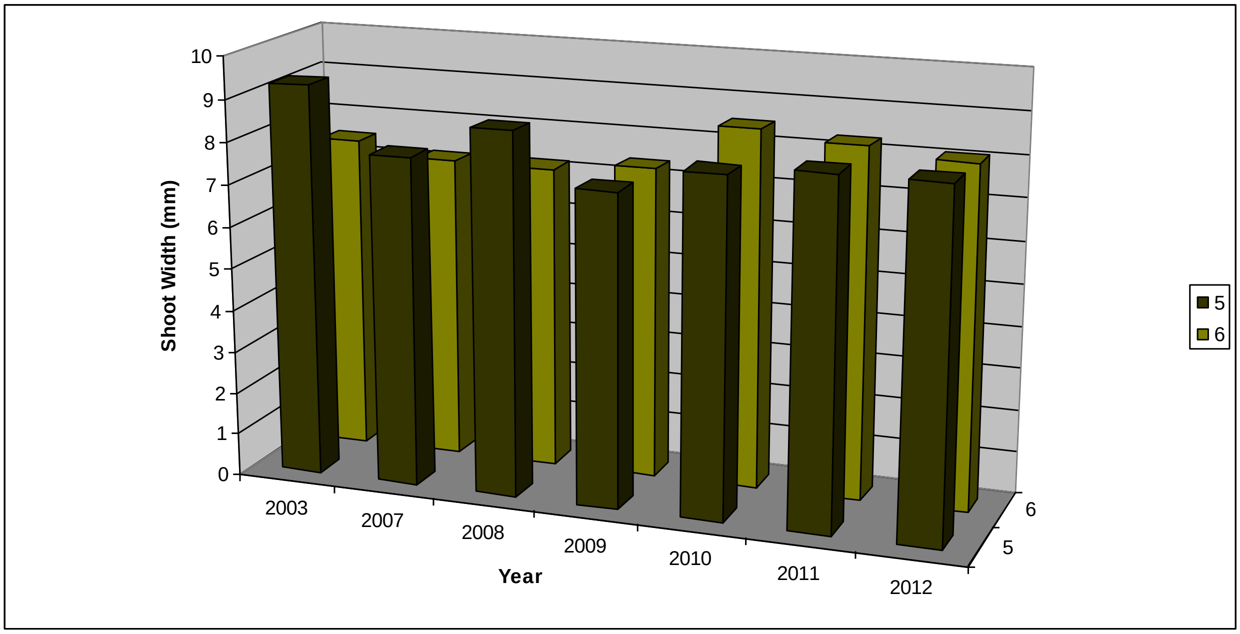


Figure D-17 Mean eelgrass shoot width data from Boundary Bay, Sites WR1, WR2, and WR3

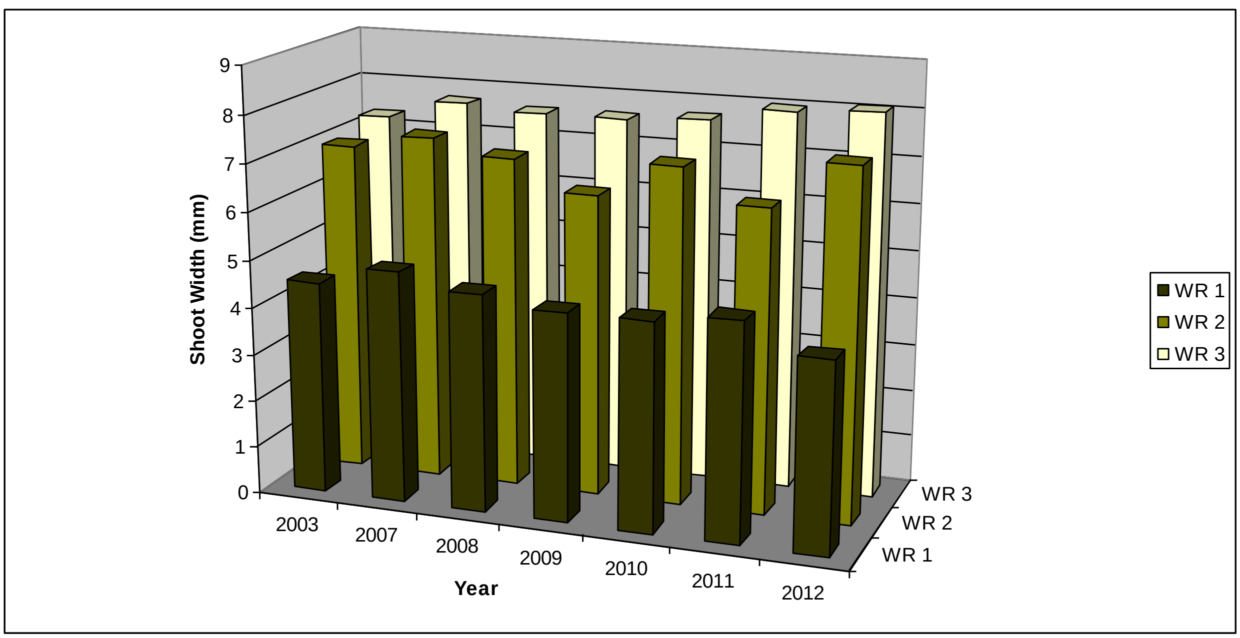


Figure D-18 Mean reproductive shoot density data from Roberts Bank, Inter-causeway near Deltaport Causeway, Sites 1A, 1B, and 2

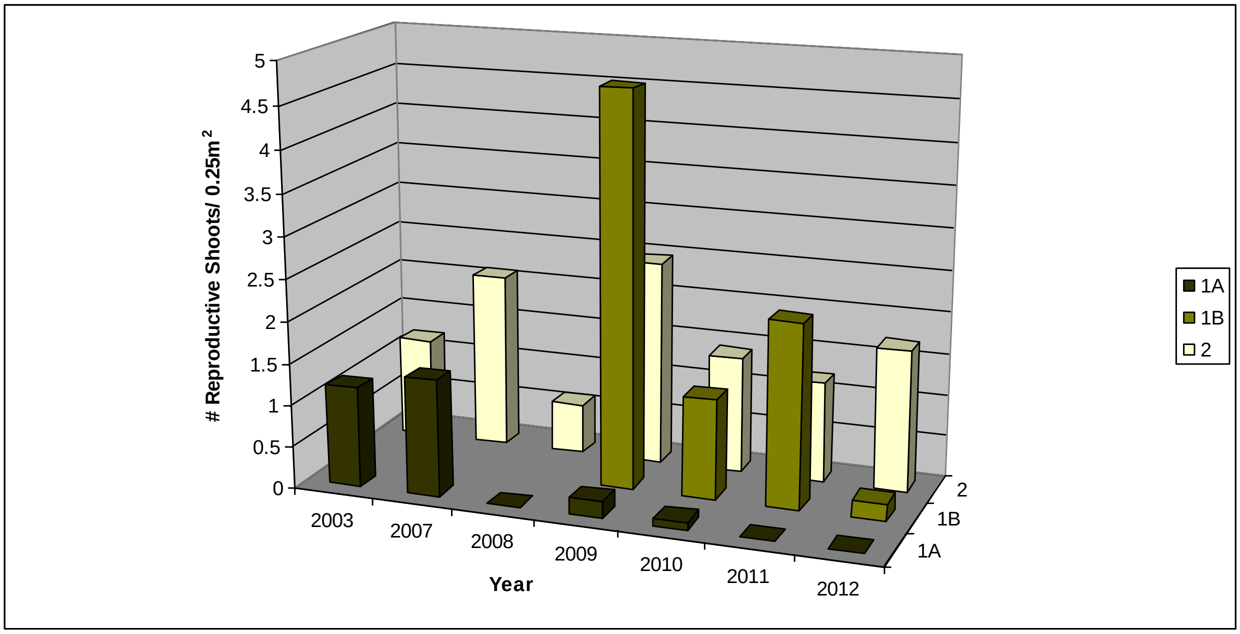


Figure D-19 Mean reproductive shoot density data from Roberts Bank, west of Deltaport Causeway, Sites 3 and 4

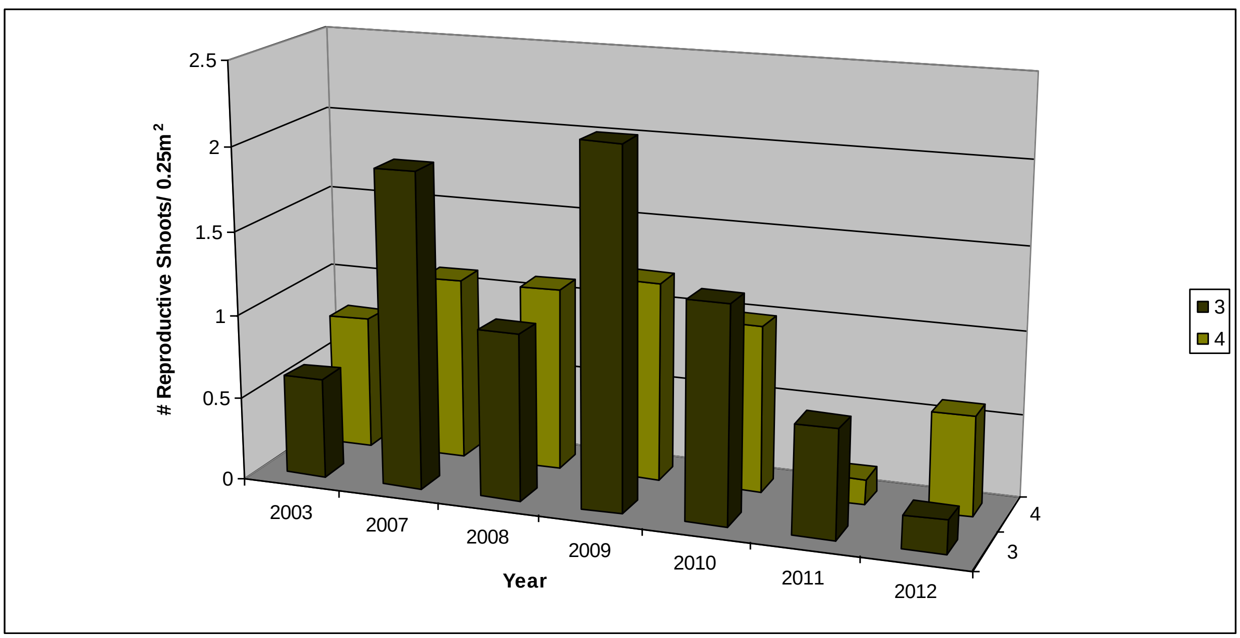


Figure D-20 Mean eelgrass reproductive shoot density data from Roberts Bank, Inter-causeway near Ferry Causeway, Sites 5 and 6

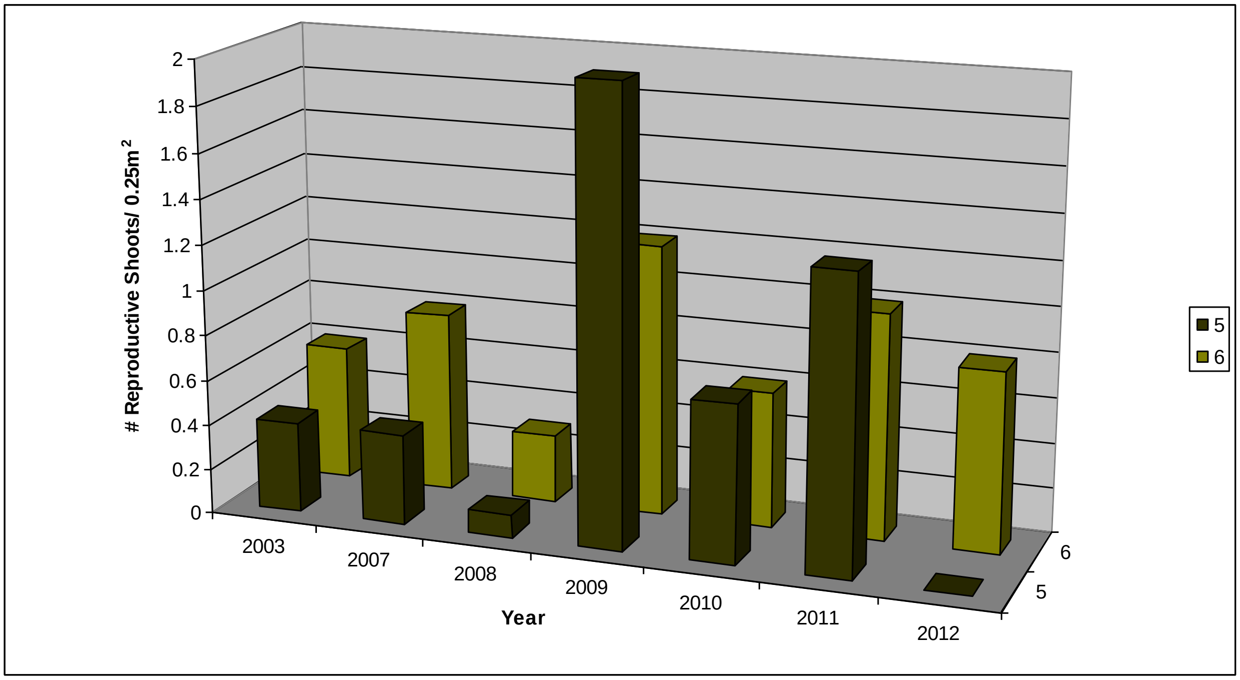


Figure D-21 Mean eelgrass reproductive shoot density data from Boundary Bay, Sites WR1, WR2, and WR3

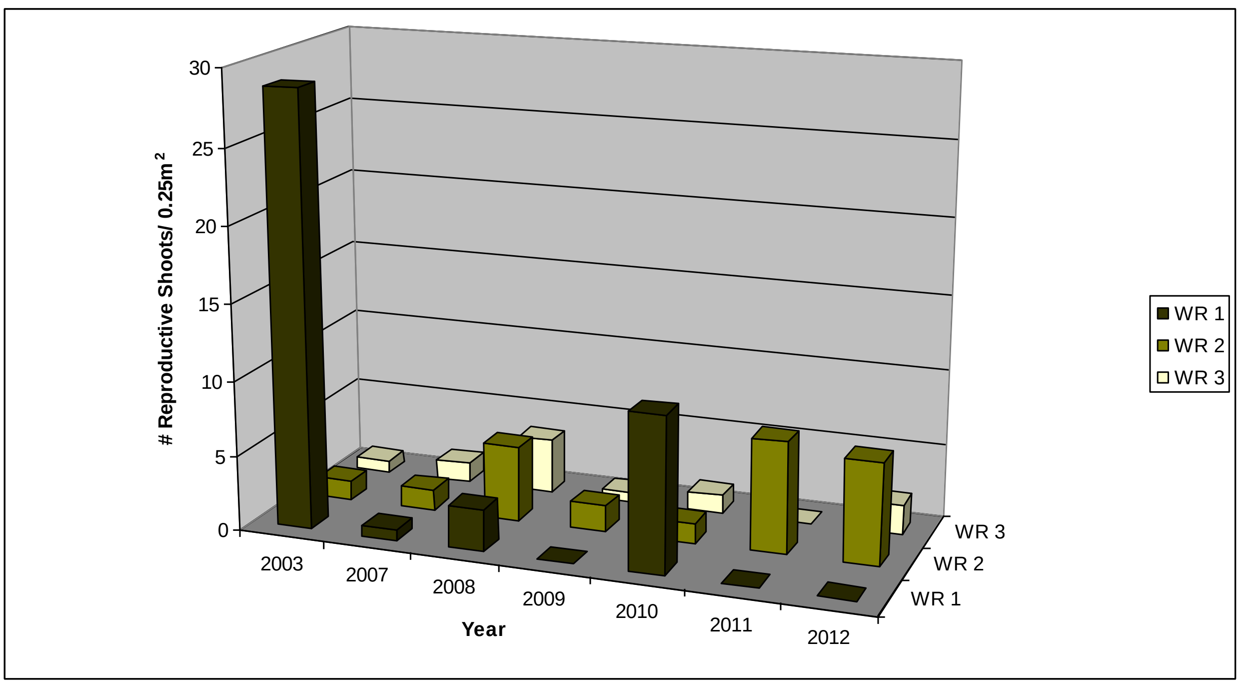
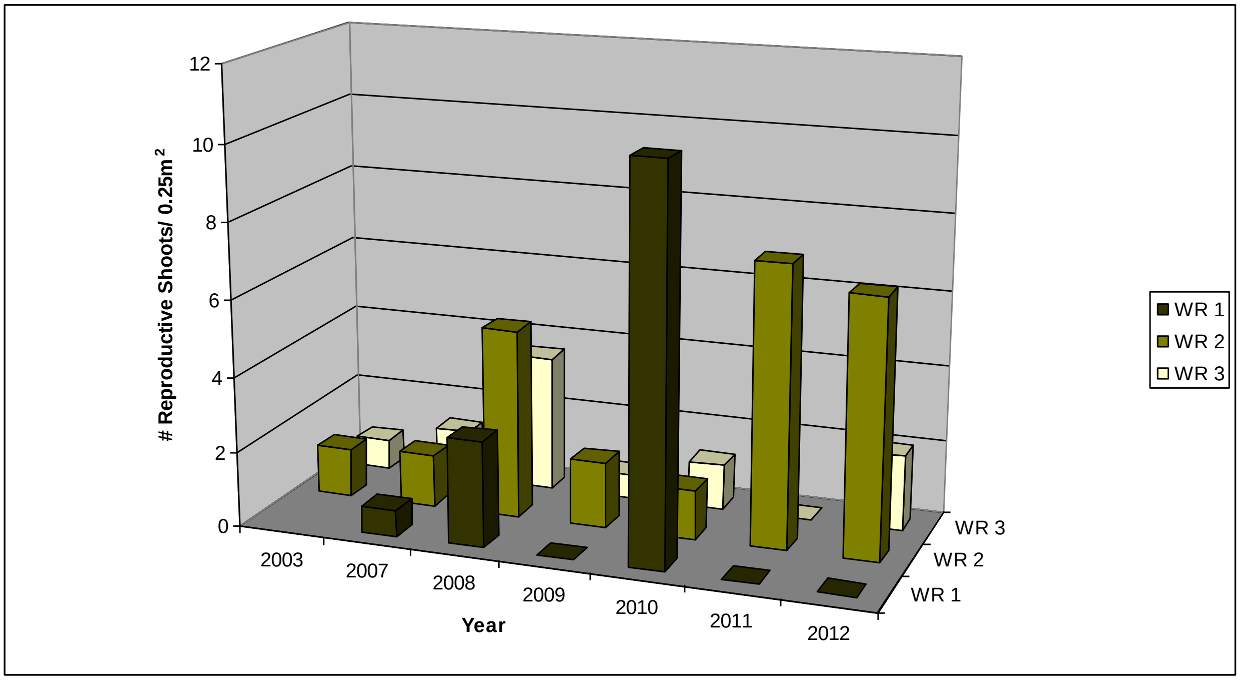


Figure D-22 **Mean eelgrass reproductive shoot density data from Boundary Bay, Sites WR1, WR2, and WR3**



Note: The data for Site WR1 in 2003 has been omitted.

Table D-1 Mean Eelgrass Shoot Density (total and reproductive) at Each Reference Station in 2003 and 2007 through 2012.

Site	Total Density (#/0.25m^2)							Reproductive Shoot Density (#/0.25m^2)						
	2012	2011	2010	2009	2008	2007	2003	2012	2011	2010	2009	2008	2007	2003
Inter-causeway area near Deltaport Causeway														
1A	3.1	1.4	0.8 (1.8)*	8.1	25.4	25.8	24	0	0	0	0.2	0	1.4	1.2
1B	22.6	32.6	38.8	25.4	-	-	-	0.2	2.2	1.2	4.7	-	-	-
2	28.2	35.0	42.4	25.8	32.8	26.5	23.9	1.7	1.2	1.4	2.45	0.6	2.1	1.2
Inter-causeway area near BC Ferries Causeway														
5	11.8	17.1	24.6	25	18.8	17.4	14.5	0	1.3	0.7	2	0.1	0.4	0.4
6	21.3	22.2	27.6	20.2	22.6	20.6	16.8	0.8	1	0.6	1.2	0.3	0.8	0.6
West of Deltaport Causeway														
3	12.0	16.1	22.5	15	17.65	16	17.3	0.2	0.65	1.3	2.15	1	1.9	0.6
4	11.0	13.4	24.8	16.9	21.6	14.7	15.7	0.6	0.15	1.0	1.2	1.1	1.1	0.8
Boundary Bay														
WR1	67.2	55.6	76.8	79.4	73.8	60.6	33	0	0	10.25	0	2.8	0.7	28.7
WR2	36.6	35.7	37.8	28.53	32.4	29.4	14	6.8	7.4	1.3	1.75	5.0	1.4	0.5
WR3	34.1	36.6	45.1	26.05	32.5	19.9	21	2	0	1.2	0.63	3.6	1.3	0.8

Notes: Means are based on a sample of twenty replicates.
* Value in parentheses includes mature shoots and seedlings.

Table D-2 Mean Eelgrass Shoot Length, Width, and LAI at Each Reference Station from 2007 through 2012, and in 2003

Site	Length (cm)							Width (mm)							LAI						
	2012	2011	2010	2009	2008	2007	2003	2012	2011	2010	2009	2008	2007	2003	2012	2011	2010	2009	2008	2007	2003
Inter-causeway area near Deltaport Causeway																					
1A	57.9	63.1	52.7	50	65	115.8	140	5.4	6.8	5.2	5.5	6	8.2	8.5	0.06	0.02	0.009	0.09	0.4	0.99	1.18
1B	180.8	201.2	180.8	175.4	-	-	-	8.2	7.9	8.1	7.9	-	-	-	1.32	2.07	2.28	1.42	-	-	-
2	198.05	181.4	182.2	170.1	168.9	146.7	137.6	7.8	7.4	8.4	7.9	7.4	7.8	8.5	1.75	1.88	2.59	1.39	1.66	1.19	1.12
Inter-causeway area near BC Ferries Causeway																					
5	138.3	206.3	172.5	178	179	130.7	163.5	8.2	8.2	8.0	7.4	8.6	7.8	9.3	0.63	1.17	1.37	1.32	1.15	0.71	0.88
6	156.3	152.0	142.95	143.15	135.8	127.3	132.4	8.1	8.3	8.5	7.4	7.2	7.2	7.5	1.09	1.11	1.35	0.86	0.9	0.76	0.66
West of Deltaport Causeway																					
3	115.0	149.8	164.5	109.5	132.15	121.8	141.1	8.8	8.2	8.4	8.3	7.6	7.9	9.7	0.45	0.79	1.24	0.55	0.71	0.61	0.95
4	161.2	150.7	183.4	144.15	163.35	164	188.8	8.7	8.5	8.6	8.75	8.5	8.2	9.5	0.63	0.68	1.60	0.83	1.2	0.79	1.12
Boundary Bay																					
WR1	38.8	57.8	56.7	44	54.4	48.4	44.4	4.0	4.6	4.4	4.4	4.6	4.9	4.5	0.42	0.58	0.80	0.61	0.78	0.56	0.29
WR2	106.15	124.9	138.4	85	139	122.7	137.4	7.4	6.4	7.1	6.3	7	7.3	7	1.15	1.14	1.46	0.62	1.28	1.04	0.54
WR3	158.4	165.0	169.4	198.35	201	167.4	215.2	8.0	8.0	7.7	7.6	7.6	7.7	7.3	1.75	1.96	2.34	1.57	2.02	1.04	1.33

Notes: Means are based on a sample of twenty replicates.

Bonferroni adjusted probability values using separate variances are provided followed by the probability values calculated using pooled variance in brackets. p-values <0.0025 were considered significant (0.05/20). The Bonferroni adjustment requires that each data set has variation; standard two-sample, 2-tailed t-tests were used to analyze data in cases where the variance was zero within one of the datasets. The reproductive shoot density was 0 at several sites on several sampling dates; these comparisons could not be analyzed statistically. NS has been used to denote comparisons of identical datasets to indicate that the identical datasets are Not Significantly different from each other.

Table D-3 Bonferroni adjusted Probability Values Attained for Each Parameter Using a Two-sample t-test Comparing Data Sets from 2012 and 2003

Site #	Total Density	Length	Width	LAI	Reproductive Density
Inter-causeway near Coal Port Causeway					
1A	0 (0)	0 (0)	1.42E-08*	0(0)	0.007(0.003)
1B	1(1)	0.001(0)	0.126*	0.616(0.606)	0.034(0.029)
2	0.007(0.006)	0(0)	0.004*	0(0)	1(1)
Inter-causeway near Ferry Causeway					
5	0.056(0.049)	0(0)	0(0)	0(0)	0.287*
6	0.040(0.039)	0.003(0.003)	0.018(0.012)	0(0)	1(0)
West of Coal Port Causeway					
3	0.033(0.025)	0.004(0.002)	0(0)	0(0)	0.169(0.155)
4	0.008(0.004)	0.257(0.243)	0.003(0.002)	0(0)	1(1)
Boundary Bay					
WR1	0(0)	0.021(0.017)	0(0)	0.010(0.010)	2.51E-09*
WR2	0(0)	0(0)	0.088(0.074)	0(0)	0(0)
WR3	0(0)	0(0)	0(0)	0.002(0.002)	0.006(0.006)

Note: * Standard t-test p-value (not adjusted)

Table D-4 Bonferroni adjusted Probability Values Attained for Each Parameter Using a Two-sample t-test Comparing Data Sets from 2012 and 2007

Site #	Total Density	Length	Width	LAI	Reproductive Density
Inter-causeway near Coal Port Causeway					
1A	0(0)	0(0)	0(0)	0(0)	0.003(0.001)
1B	0.707(0.705)	0(0)	1(1)	0.038(0.037)	0.013(0.010)
2	1(1)	0(0)	1(1)	0.002(0.002)	1(1)
Inter-causeway near Ferry Causeway					
5	0(0)	1(1)	0.784(0.784)	0.087(0.083)	0.028*
6	1(1)	0.058(0.051)	0.006(0.006)	0.019(0.019)	1(1)
West of Coal Port Causeway					
3	0.216(0.203)	1(1)	1(1)	0.488(0.481)	0(0)
4	0.091(0.087)	1(1)	0.168(0.167)	0.396(0.388)	1(1)
Boundary Bay					
WR1	1(1)	0.012(0.012)	0.001(0.000)	0.101(0.095)	0.074*
WR2	0.023(0.023)	0.188(0.169)	1(1)	1(1)	0(0)
WR3	0(0)	0.201(0.201)	0.025(0.023)	0(0)	0.728(0.726)

Note: * Standard t-test p-value (not adjusted)

Table D-5 Bonferroni adjusted Probability Values Attained for Each Parameter Using a Two-sample t-test Comparing Data Sets from 2012 and 2008

Site #	Total Density	Length	Width	LAI	Reproductive Density
Inter-causeway near Coal Port Causeway					
1A	0(0)	0(0)	0(0)	0(0)	0.162*
1B	1(1)	0(0)	0(0)	0(0)	0.214*
2	0.013(0.013)	0.011(0.007)	0.751(0.750)	1(1)	0.050(0.044)
Inter-causeway near Ferry Causeway					
5	0(0)	0(0)	0.922(0.918)	0(0)	0.330*
6	1(1)	0.014(0.014)	0.003(0.003)	0.190(0.188)	0.175(0.165)
West of Coal Port Causeway					
3	0.022(0.016)	0.424(0.424)	0.921(0.920)	0.041(0.038)	0.006(0.004)
4	0(0)	1(1)	1(1)	0(0)	1(1)
Boundary Bay					
WR1	1(1)	0.002(0.002)	0.005(0.004)	0.036(0.026)	0.001*
WR2	0.286(0.285)	0(0)	0.617(0.617)	1(1)	0.124(0.118)
WR3	1(1)	0(0)	0.058(0.055)	0.808(0.784)	0.508(0.482)

Note: * Standard t-test p-value (not adjusted)

Table D-6 Bonferroni adjusted Probability Values Attained for Each Parameter Using a Two-sample t-test Comparing Data Sets from 2012 and 2009

Site #	Total Density	Length	Width	LAI	Reproductive Density
Inter-causeway near Coal Port Causeway					
1A	0.046(0.034)	0.015(0.010)	0.001(0)	1(1)	0.809(0.797)
1B	0.511(0.509)	1(1)	0.639(0.624)	1(1)	0(0)
2	0.680(0.679)	0.013(0.008)	1(1)	0.048(0.045)	1(1)
Inter-causeway near Ferry Causeway					
5	0(0)	0(0)	0.004(0.003)	0(0)	6.1E-05*
6	1(1)	0.161(0.160)	0.010(0.008)	0.209(0.209)	1(1)
West of Coal Port Causeway					
3	0.795(0.792)	1(1)	0.339(0.338)	1(1)	0(0)
4	0.005(0.004)	0.243(0.243)	1(1)	0.171(0.165)	0.685(0.684)
Boundary Bay					
WR1	0.297(0.272)	0.250(0.239)	0.003(0.003)	0.015(0.013)	1*
WR2	0.004(0.004)	0(0)	0(0)	0(0)	0(0)
WR3	0.001(0.001)	0(0)	0.058(0.056)	1(1)	0.003(0.003)

Note: * Standard t-test p-value (not adjusted)

Table D-7 Bonferroni adjusted Probability Values Attained for Each Parameter Using a Two-sample t-test Comparing Data Sets from 2012 and 2010

Site #	Total Density	Length	Width	LAI	Reproductive Density
Inter-causeway near Coal Port Causeway					
1A	1(1)	1(1)	1(1)	1(1)	0.330*
1B	0(0)	1(1)	1(1)	0(0)	0.053(0.046)
2	0(0)	0.577(0.573)	0.242(0.242)	0(0)	1(1)
Inter-causeway near Ferry Causeway					
5	0(0)	0(0)	1(1)	0(0)	0.184*
6	0.001(0.001)	0.143(0.141)	0.931(0.931)	0.108(0.108)	1(1)
West of Coal Port Causeway					
3	0(0)	0(0)	0.310(0.308)	0(0)	0.008(0.005)
4	0(0)	0.027(0.027)	1(1)	0(0)	1(1)
Boundary Bay					
WR1	0.225(0.209)	0(0)	0.071(0.066)	0.001(0.000)	7.52E-11*
WR2	1(1)	0.002(0.001)	0.768(0.768)	0.019(0.019)	0(0)
WR3	0(0)	0.216(0.213)	0.009(0.008)	0(0)	0.761(0.757)

Note: * Standard t-test p-value (not adjusted)

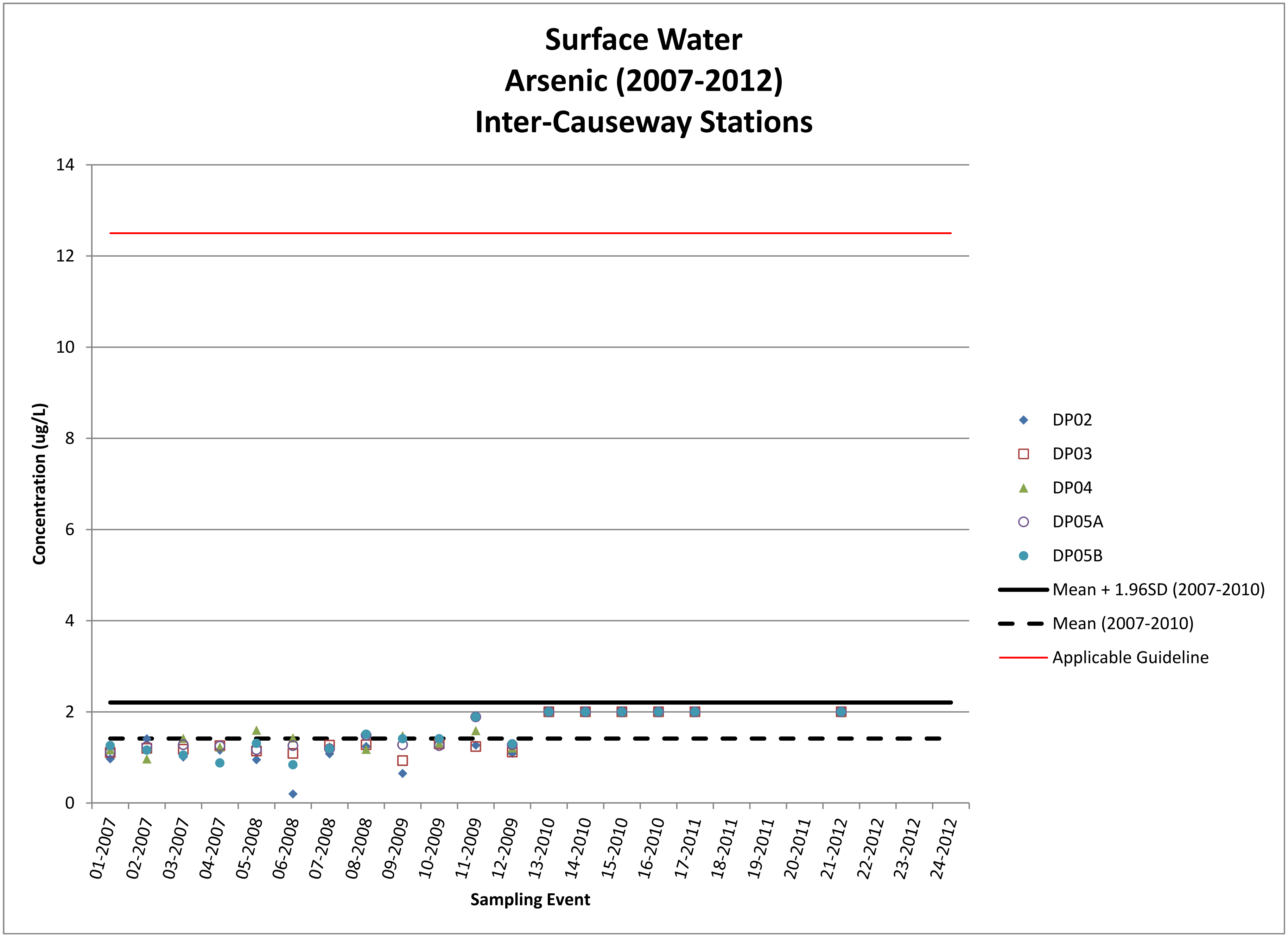
Table D-8 Bonferroni adjusted Probability Values Attained for Each Parameter Using a Two-sample t-test Comparing Data Sets from 2012 and 2011

Site #	Total Density	Length	Width	LAI	Reproductive Density
Inter-causeway near Coal Port Causeway					
1A	1(1)	1(1)	1(1)	1(1)	0.330*
1B	0(0)	0.148(0.138)	0.877(0.876)	0(0)	0.001(0.001)
2	0(0)	0.403(0.395)	0.470(0.462)	1(1)	1(1)
Inter-causeway near Ferry Causeway					
5	0(0)	0(0)	1(1)	0(0)	0.017*
6	1(1)	1(1)	1(1)	1(1)	1(1)
West of Coal Port Causeway					
3	0.240(0.234)	0(0)	0.774(0.771)	0.009(0.009)	0.132(0.118)
4	0.624(0.619)	0.766(0.762)	1(1)	1(1)	0.311(0.296)
Boundary Bay					
WR1	0.009(0.008)	0(0)	0(0)	0.003(0.003)	1*
WR2	1(1)	0(0)	0(0)	1(1)	1(1)
WR3	1(1)	0.925(0.923)	1(1)	0.741(0.726)	2.16E-06*

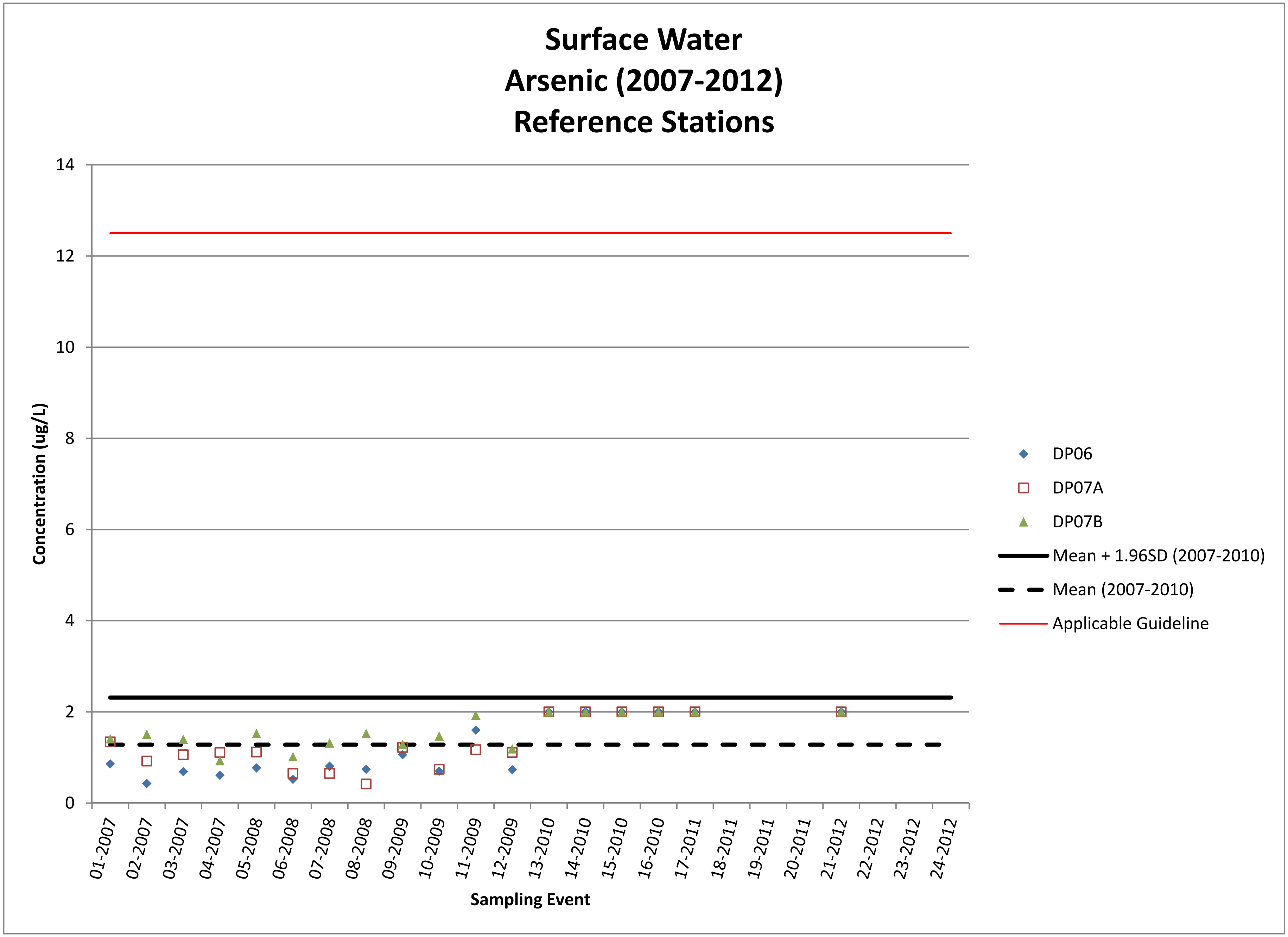
Note: * Standard t-test p-value (not adjusted)

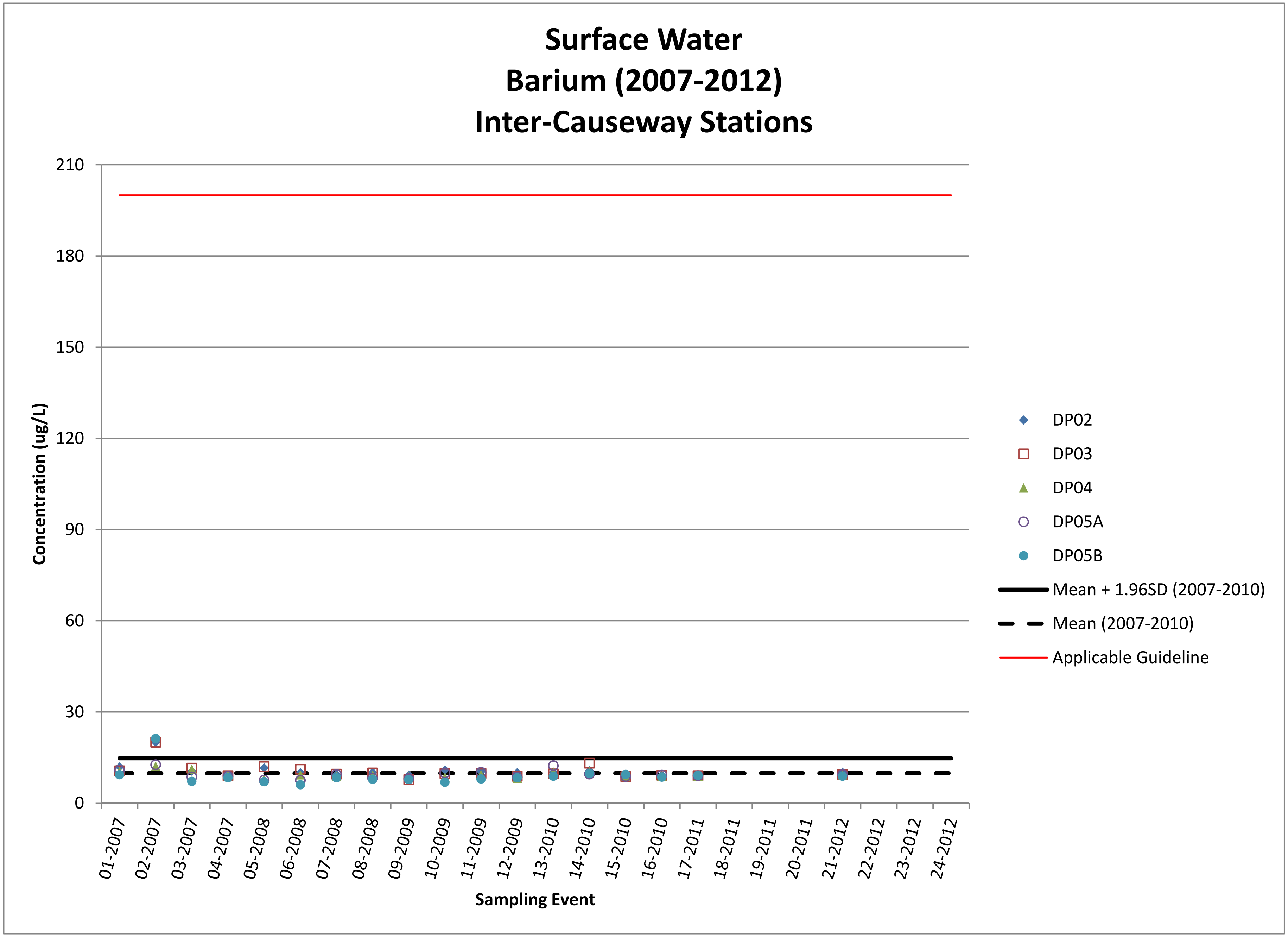
APPENDIX E

Trend Graphs for Surface Water and Sediment Chemistry – Metals

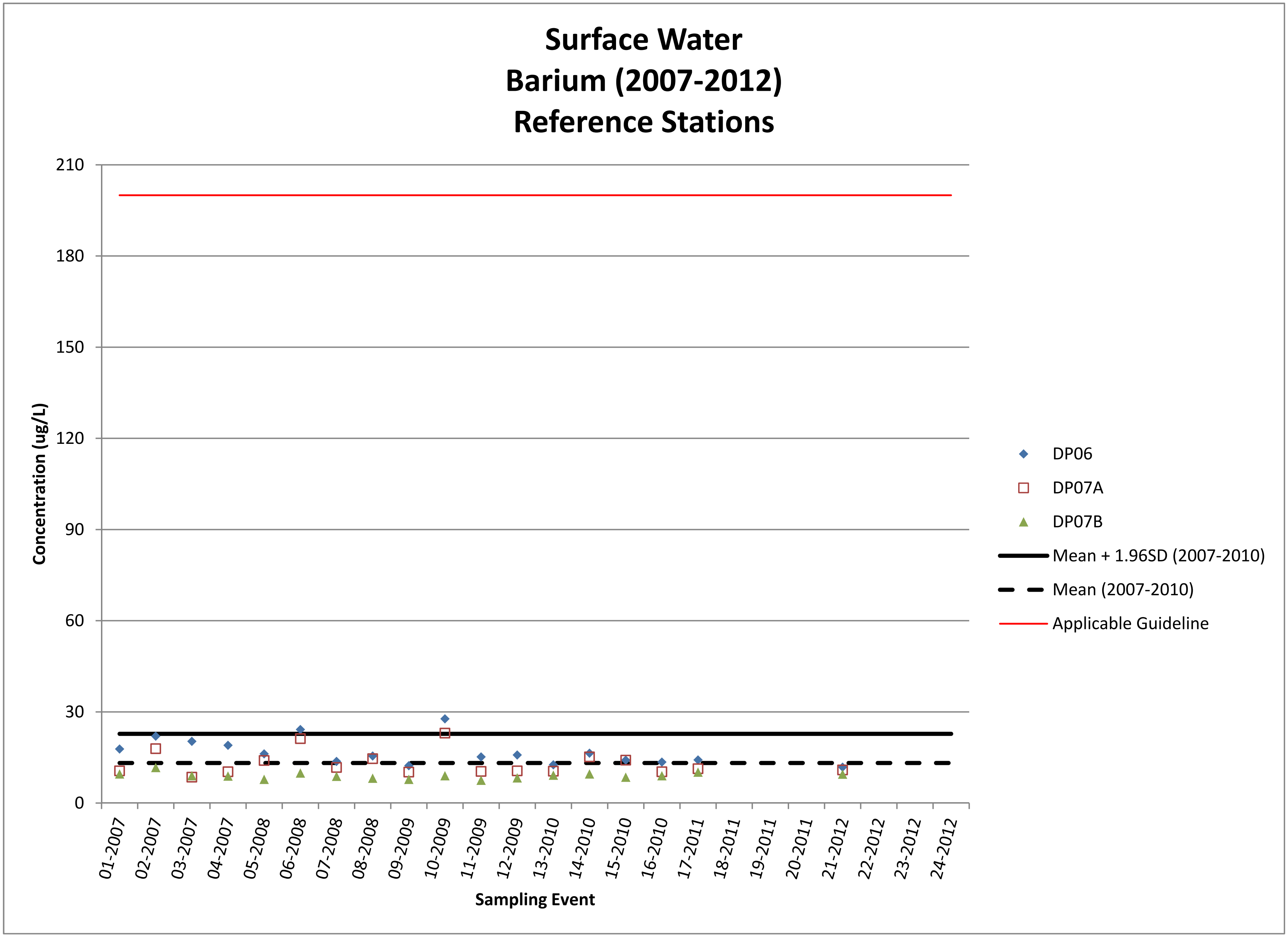


Surface Water
Arsenic (2007-2012)
Inter-Causeway Stations
Concentration (ug/L)
0
2
4
6
8
10
12
14
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
Sampling Event
DP02
DP03
DP04
DP05A
DP05B
Mean + 1.96SD (2007-2010)
Mean (2007-2010)
Applicable Guideline

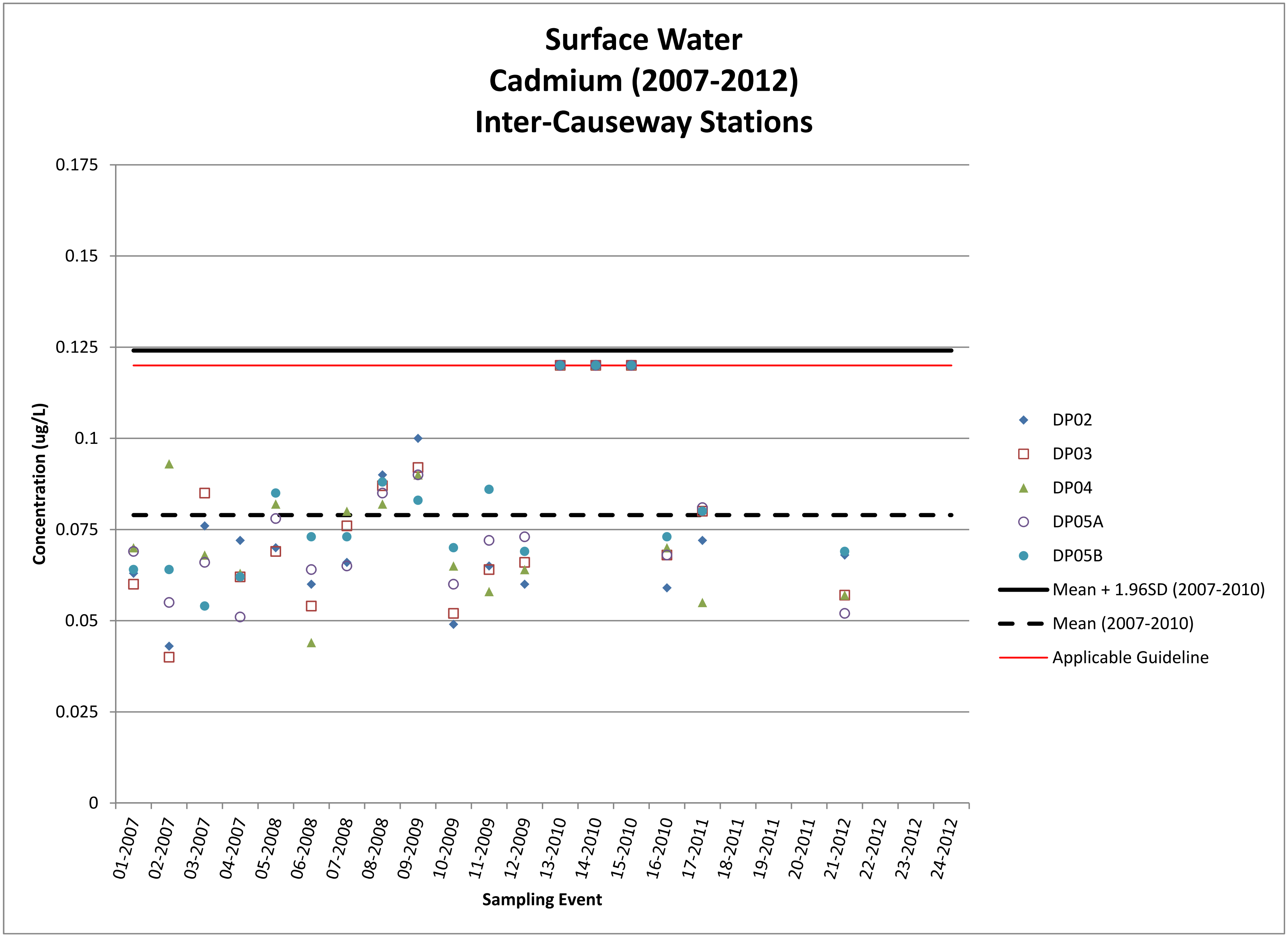

Surface Water
Arsenic (2007-2012)
Reference Stations
Concentration (ug/L)
0
2
4
6
8
10
12
14
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
Sampling Event
DP06
DP07A
DP07B
Mean + 1.96SD (2007-2010)
Mean (2007-2010)
Applicable Guideline



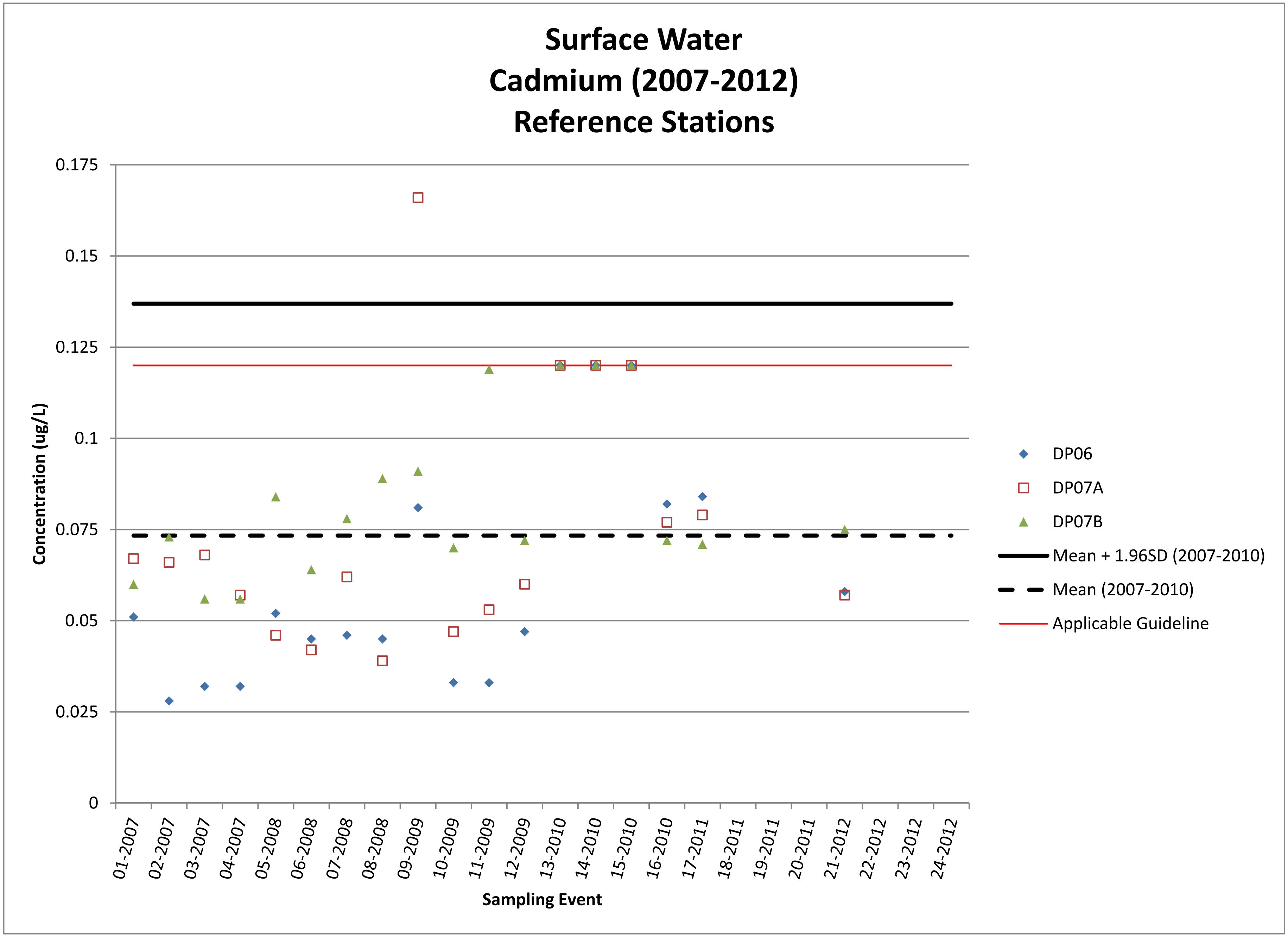
Surface Water
Barium (2007-2012)
Inter-Causeway Stations
Concentration (ug/L)
210
180
150
120
90
60
30
0
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
Sampling Event
DP02
DP03
DP04
DP05A
DP05B
Mean + 1.96SD (2007-2010)
Mean (2007-2010)
Applicable Guideline

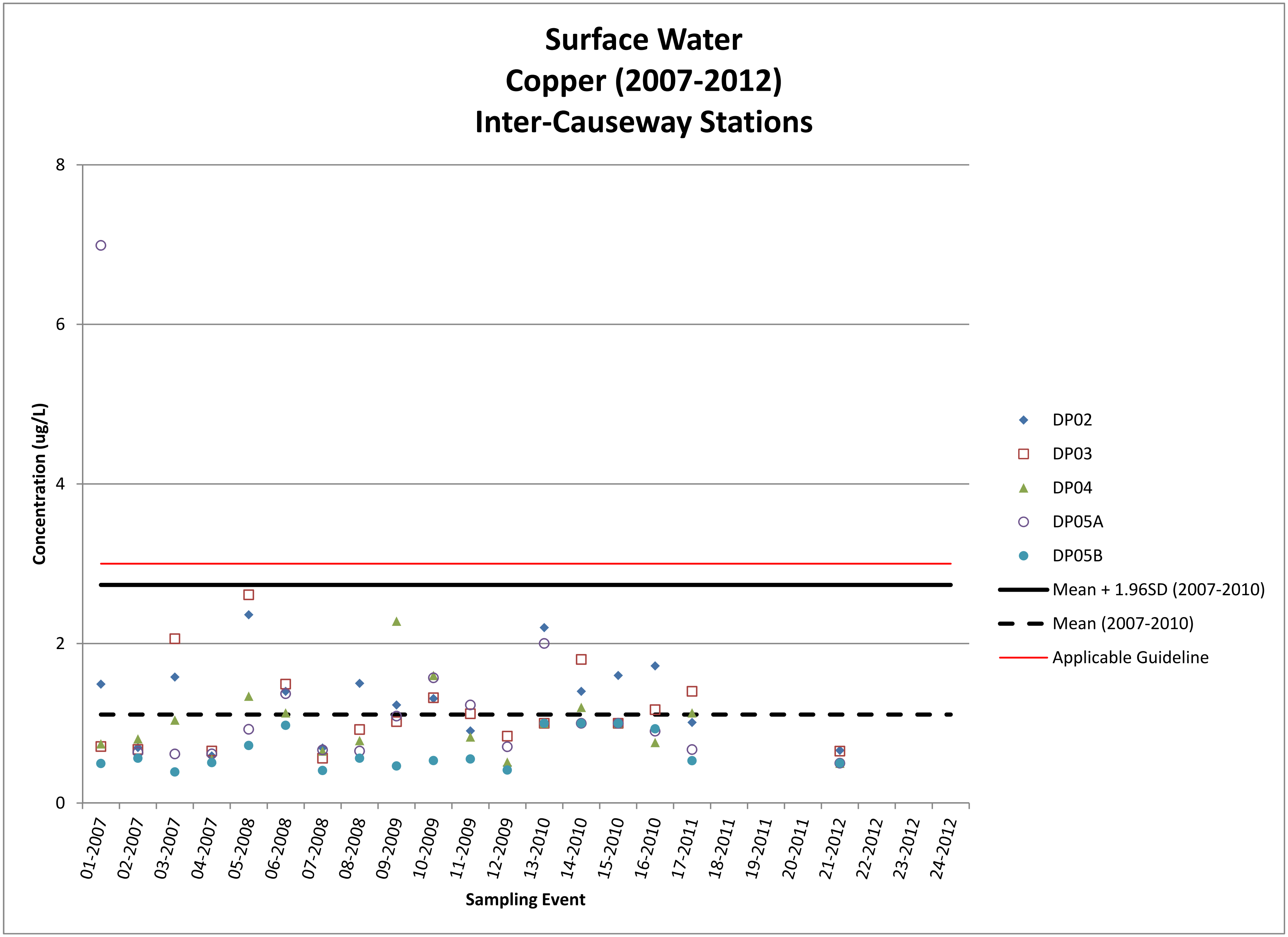


Surface Water
Barium (2007-2012)
Reference Stations
Concentration (ug/L)
210
180
150
120
90
60
30
0
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
Sampling Event
DP06
DP07A
DP07B
Mean + 1.96SD (2007-2010)
Mean (2007-2010)
Applicable Guideline

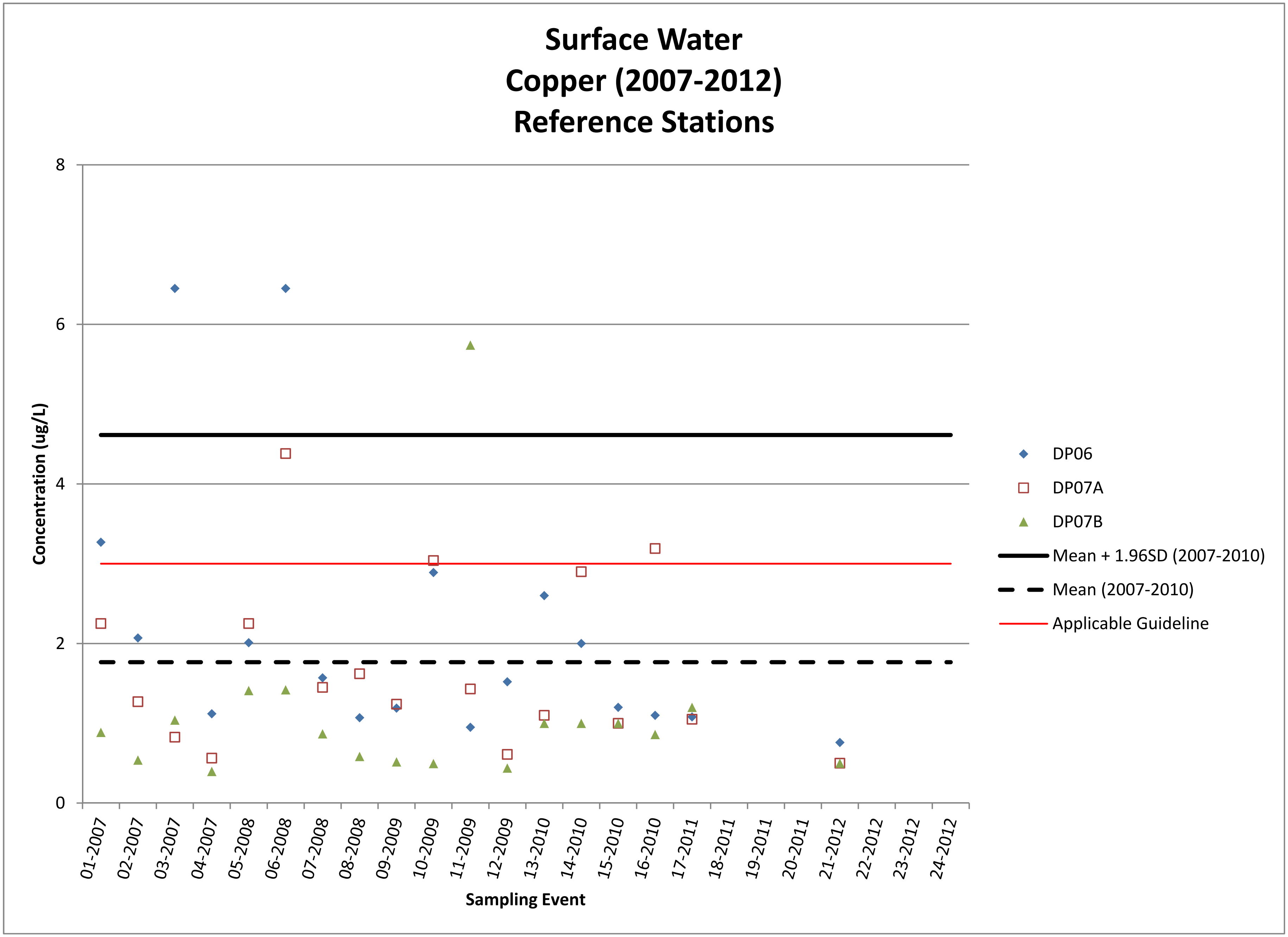


Surface Water
Cadmium (2007-2012)
Inter-Causeway Stations
Concentration (ug/L)
0.175
0.15
0.125
0.1
0.075
0.05
0.025
0
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
Sampling Event
DP02
DP03
DP04
DP05A
DP05B
Mean + 1.96SD (2007-2010)
Mean (2007-2010)
Applicable Guideline

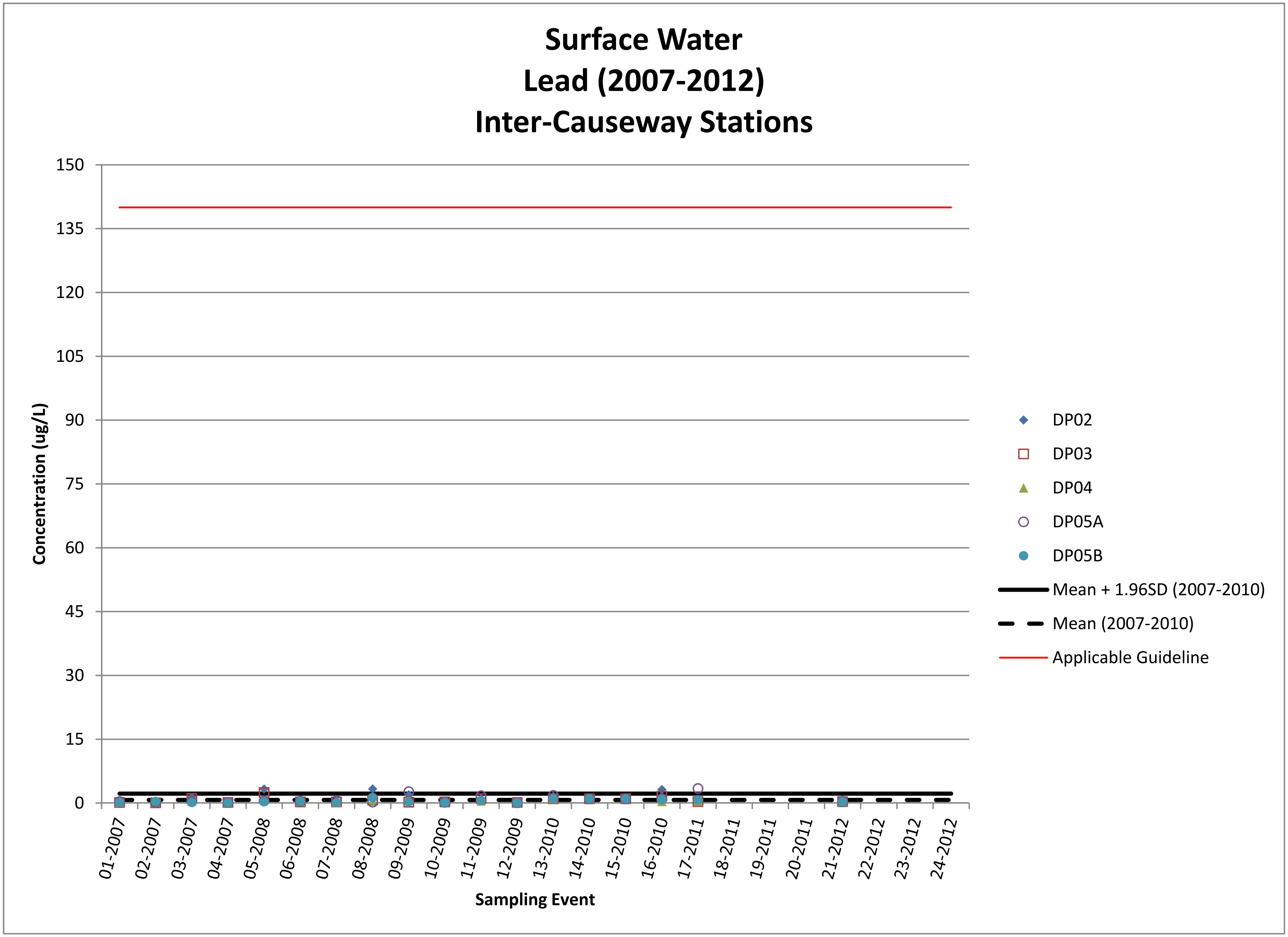

Surface Water
Cadmium (2007-2012)
Reference Stations
Concentration (ug/L)
0.175
0.15
0.125
0.1
0.075
0.05
0.025
0
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
Sampling Event
DP06
DP07A
DP07B
Mean + 1.96SD (2007-2010)
Mean (2007-2010)
Applicable Guideline

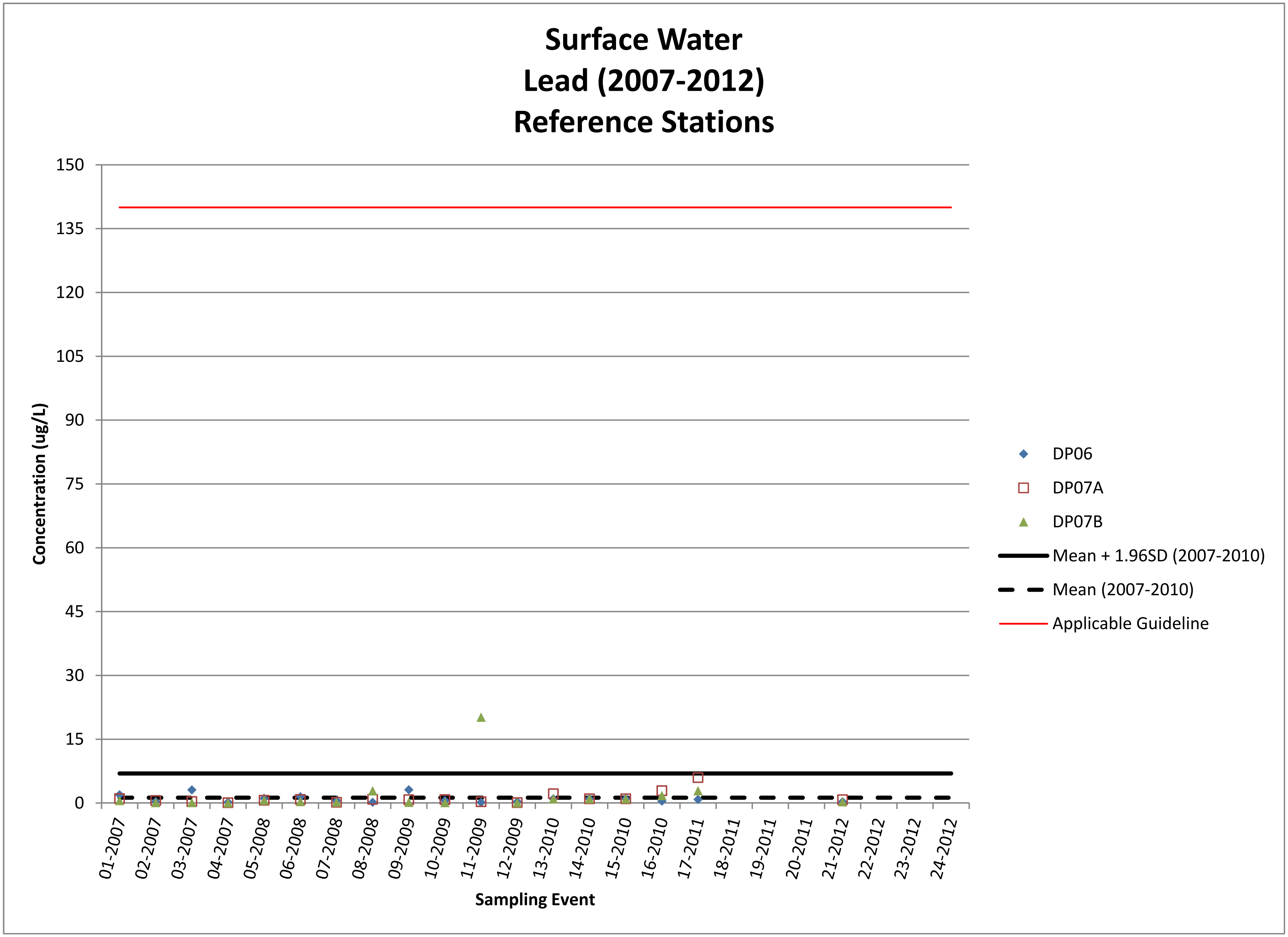


Surface Water
Copper (2007-2012)
Inter-Causeway Stations
Concentration (ug/L)
0
2
4
6
8
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
Sampling Event
DP02
DP03
DP04
DP05A
DP05B
Mean + 1.96SD (2007-2010)
Mean (2007-2010)
Applicable Guideline

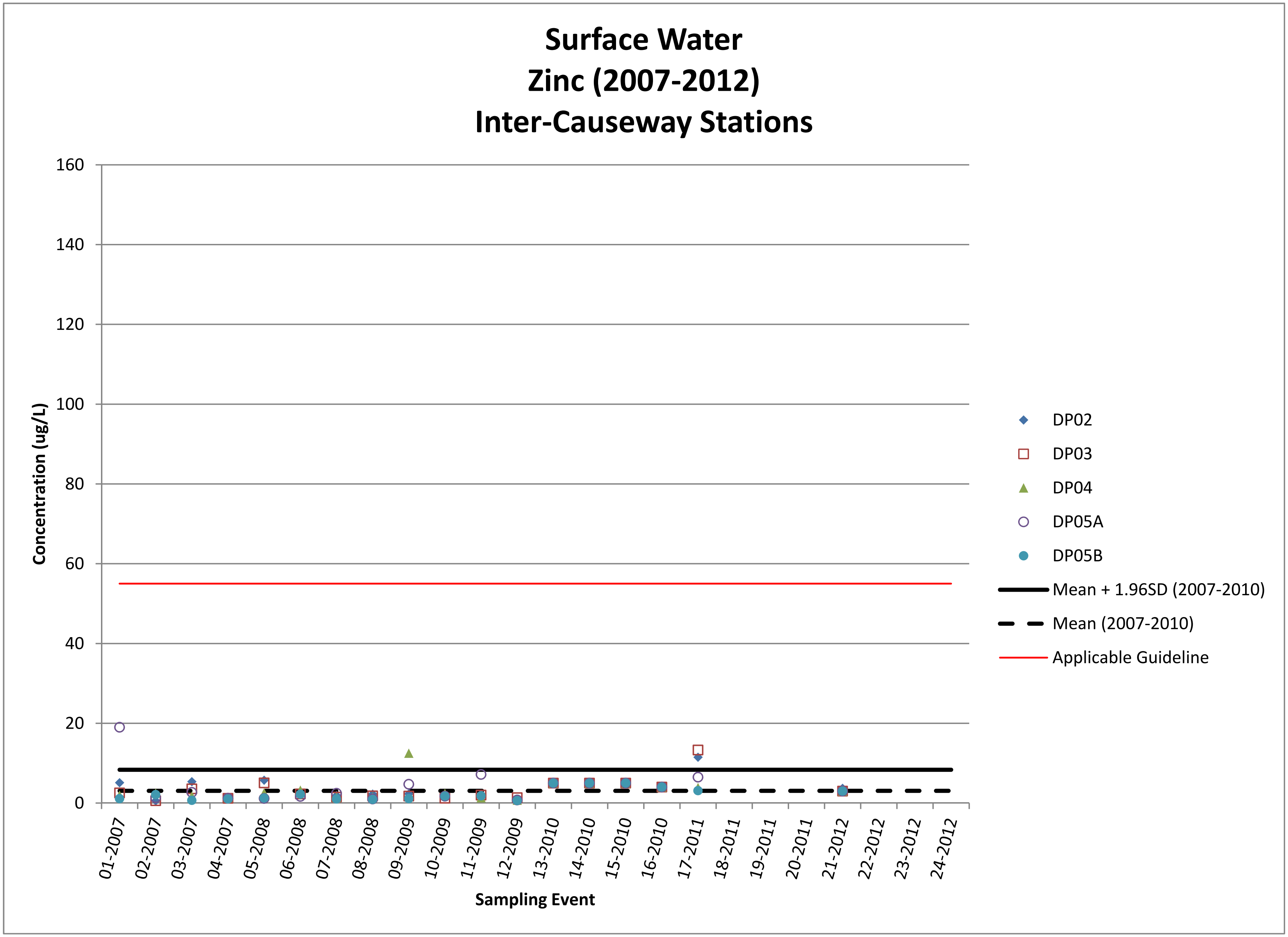


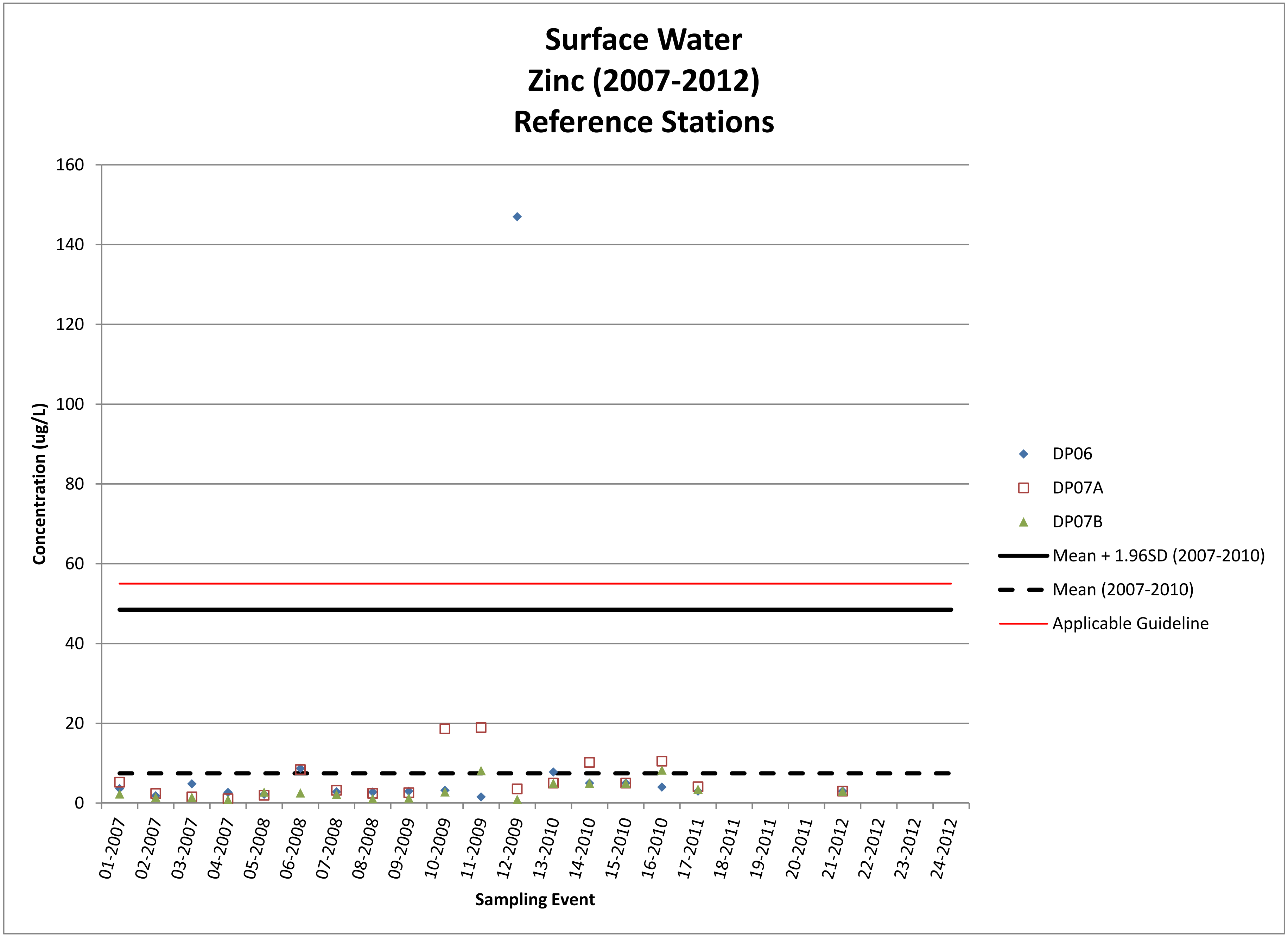
Surface Water
Copper (2007-2012)
Reference Stations
Concentration (ug/L)
0
2
4
6
8
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
Sampling Event
DP06
DP07A
DP07B
Mean + 1.96SD (2007-2010)
Mean (2007-2010)
Applicable Guideline


Surface Water
Lead (2007-2012)
Inter-Causeway Stations
Concentration (ug/L)
150
135
120
105
90
75
60
45
30
15
0
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
Sampling Event
DP02
DP03
DP04
DP05A
DP05B
Mean + 1.96SD (2007-2010)
Mean (2007-2010)
Applicable Guideline

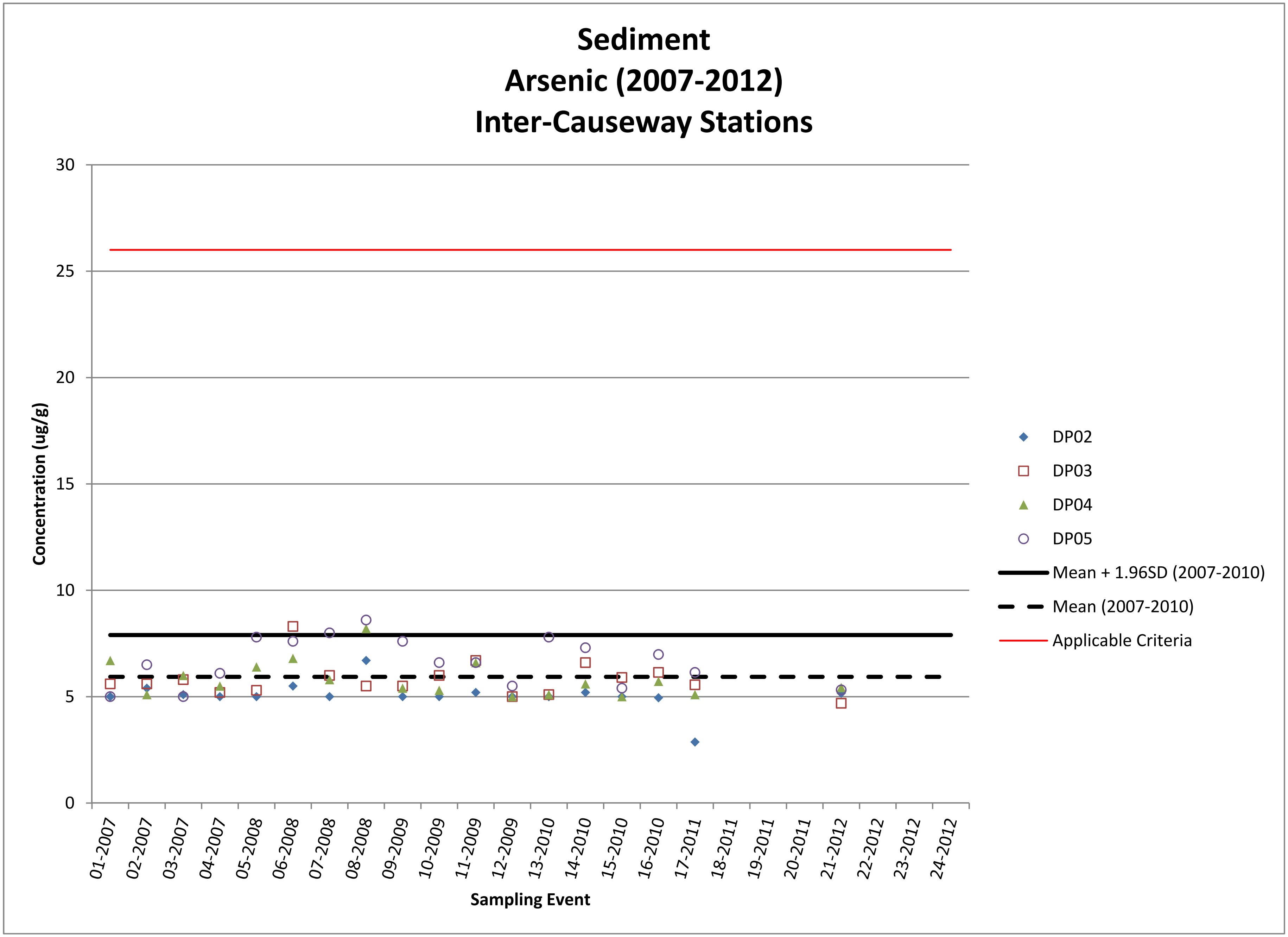


Surface Water
Lead (2007-2012)
Reference Stations
Concentration (ug/L)
150
135
120
105
90
75
60
45
30
15
0
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
Sampling Event
DP06
DP07A
DP07B
Mean + 1.96SD (2007-2010)
Mean (2007-2010)
Applicable Guideline

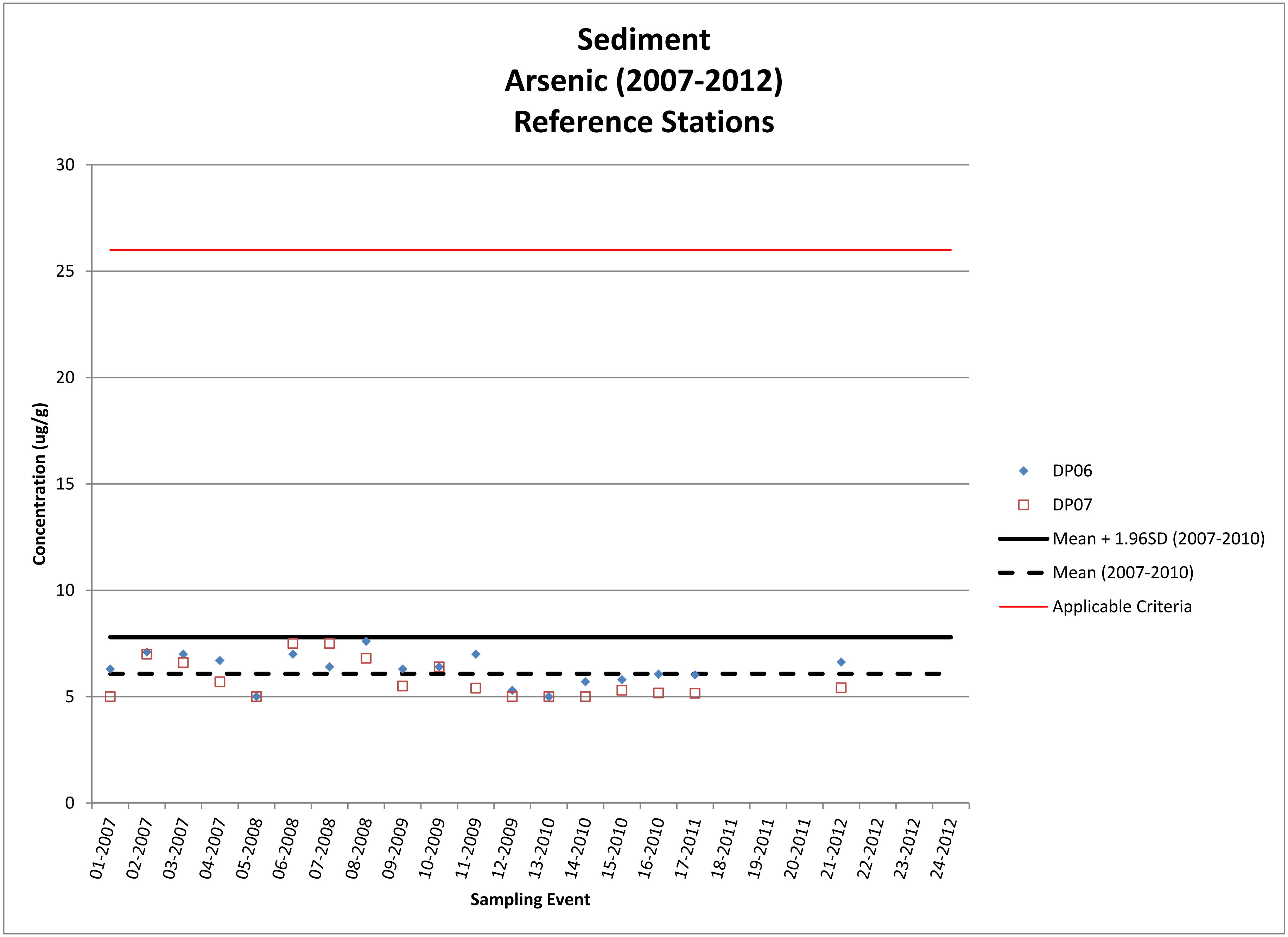

Surface Water
Zinc (2007-2012)
Inter-Causeway Stations
Concentration (ug/L)
160
140
120
100
80
60
40
20
0
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
Sampling Event
DP02
DP03
DP04
DP05A
DP05B
Mean + 1.96SD (2007-2010)
Mean (2007-2010)
Applicable Guideline



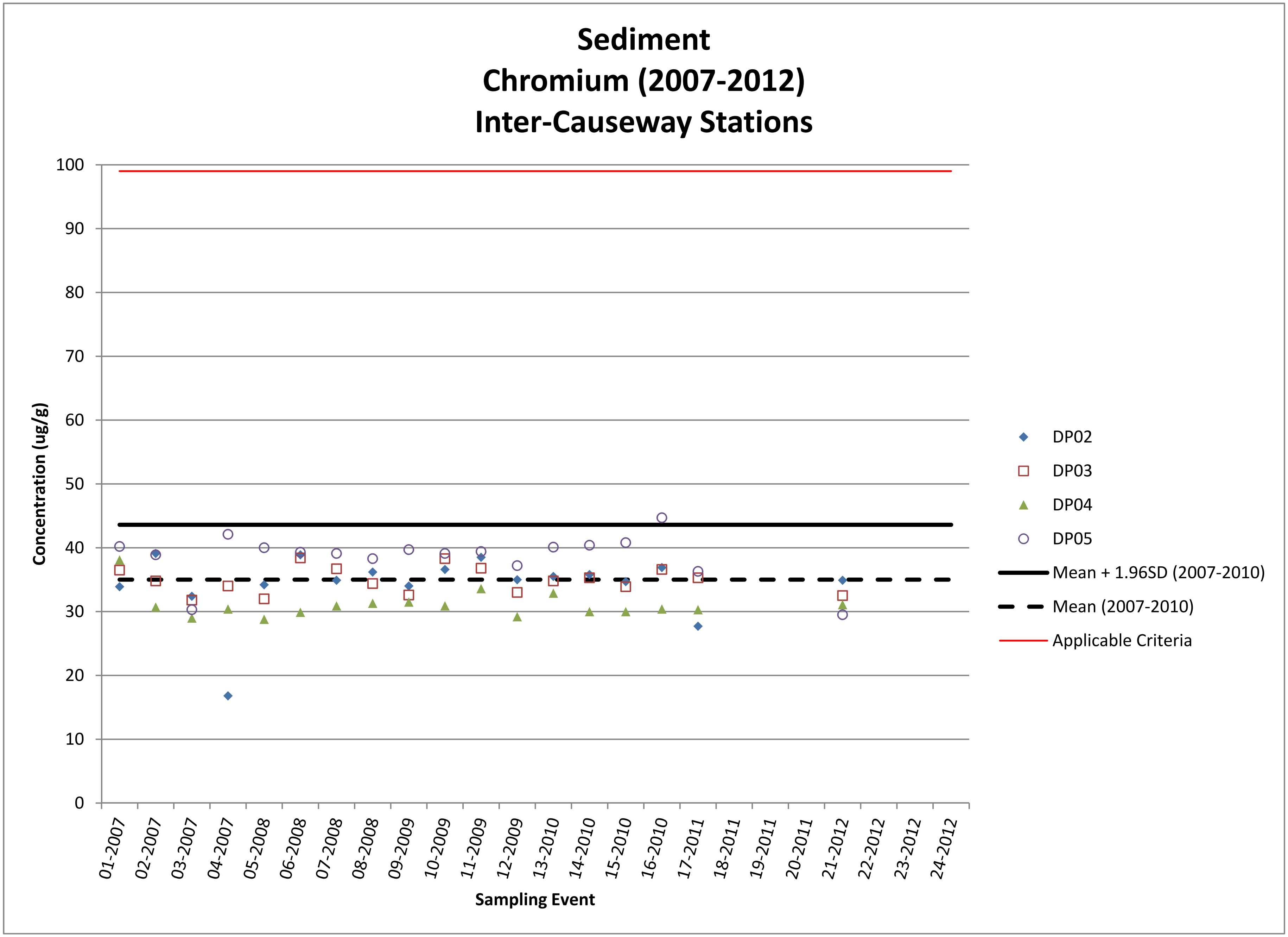
Surface Water
Zinc (2007-2012)
Reference Stations
Concentration (ug/L)
0
20
40
60
80
100
120
140
160
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
Sampling Event
DP06
DP07A
DP07B
Mean + 1.96SD (2007-2010)
Mean (2007-2010)
Applicable Guideline



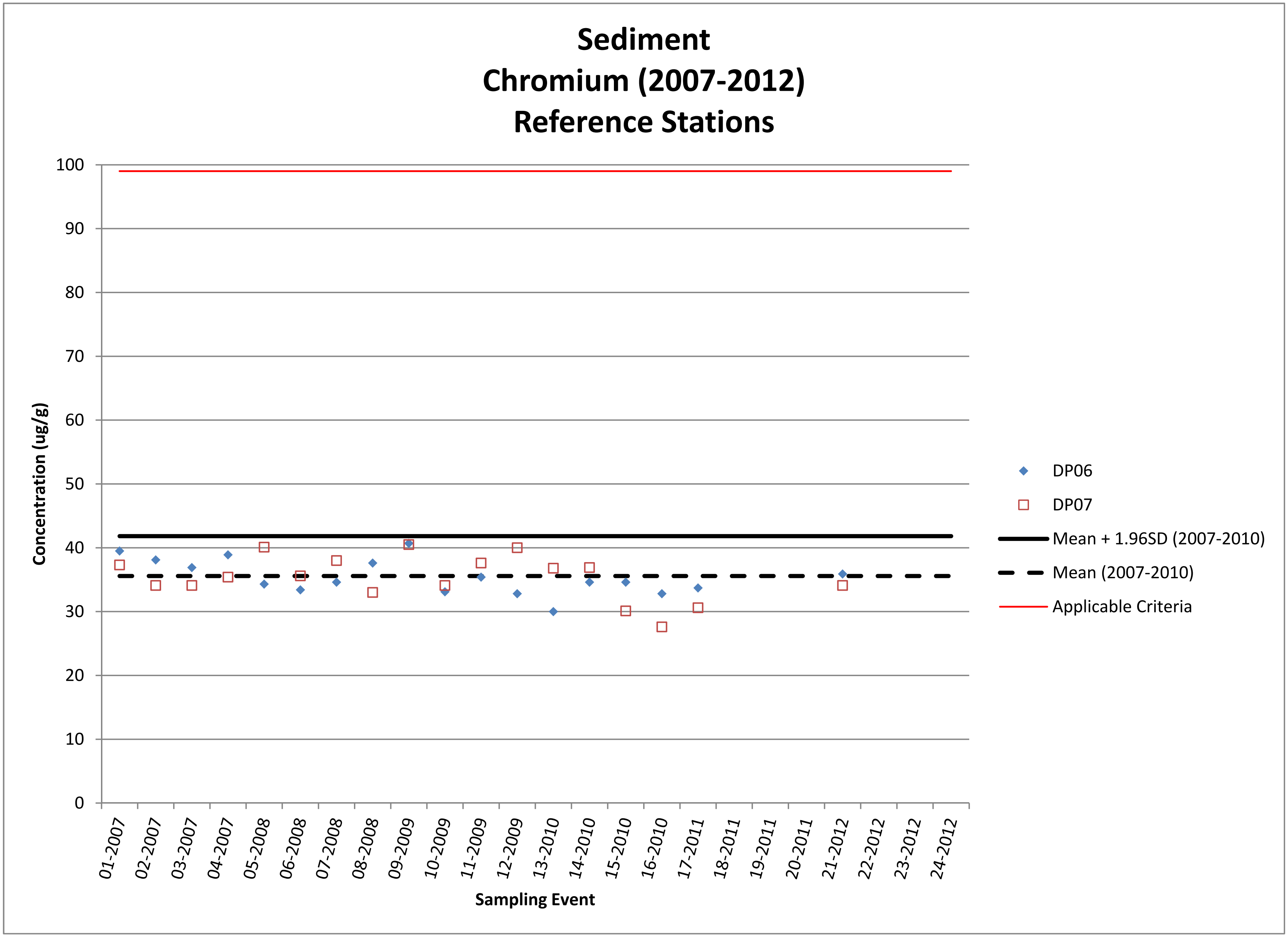
Sediment
Arsenic (2007-2012)
Inter-Causeway Stations
Concentration (ug/g)
0
5
10
15
20
25
30
Sampling Event
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
DP02
DP03
DP04
DP05
Mean + 1.96SD (2007-2010)
Mean (2007-2010)
Applicable Criteria

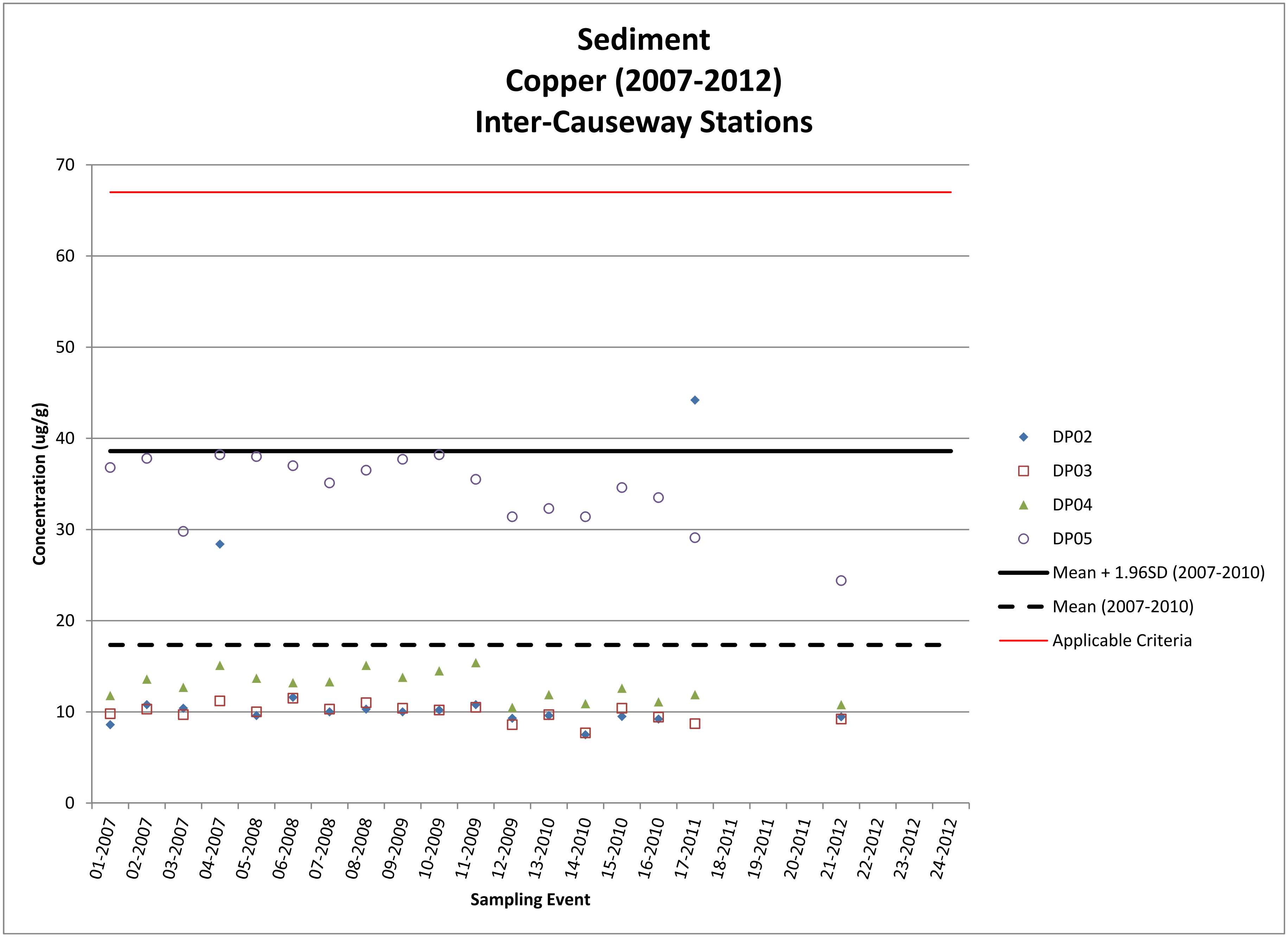


Sediment
Arsenic (2007-2012)
Reference Stations
Concentration (ug/g)
0
5
10
15
20
25
30
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
Sampling Event
DP06
DP07
Mean + 1.96SD (2007-2010)
Mean (2007-2010)
Applicable Criteria

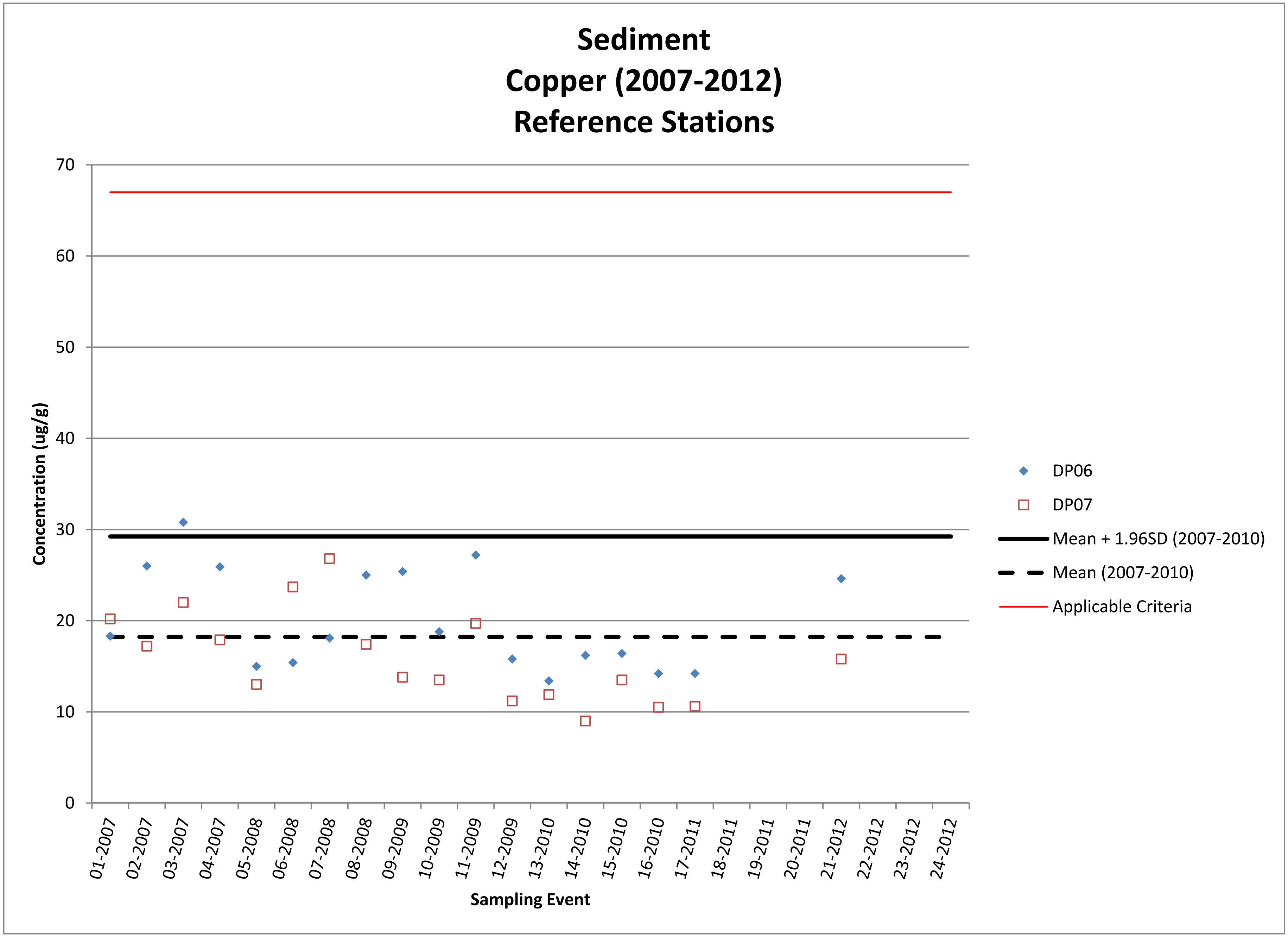


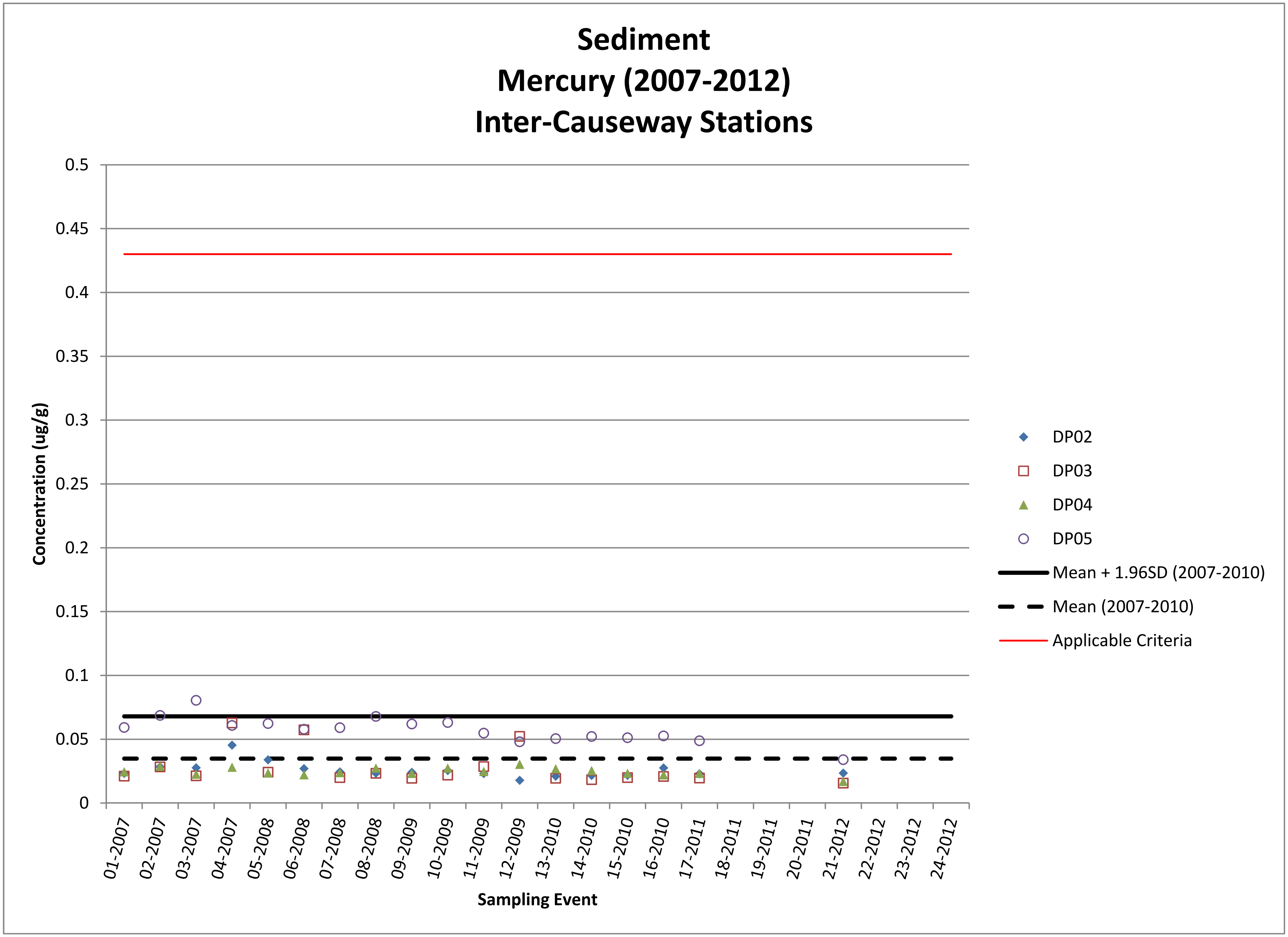
Sediment
Chromium (2007-2012)
Inter-Causeway Stations
Concentration (ug/g)
0
10
20
30
40
50
60
70
80
90
100
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
Sampling Event
DP02
DP03
DP04
DP05
Mean + 1.96SD (2007-2010)
Mean (2007-2010)
Applicable Criteria


Sediment
Chromium (2007-2012)
Reference Stations
Concentration (ug/g)
100
90
80
70
60
50
40
30
20
10
0
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
Sampling Event
DP06
DP07
Mean + 1.96SD (2007-2010)
Mean (2007-2010)
Applicable Criteria

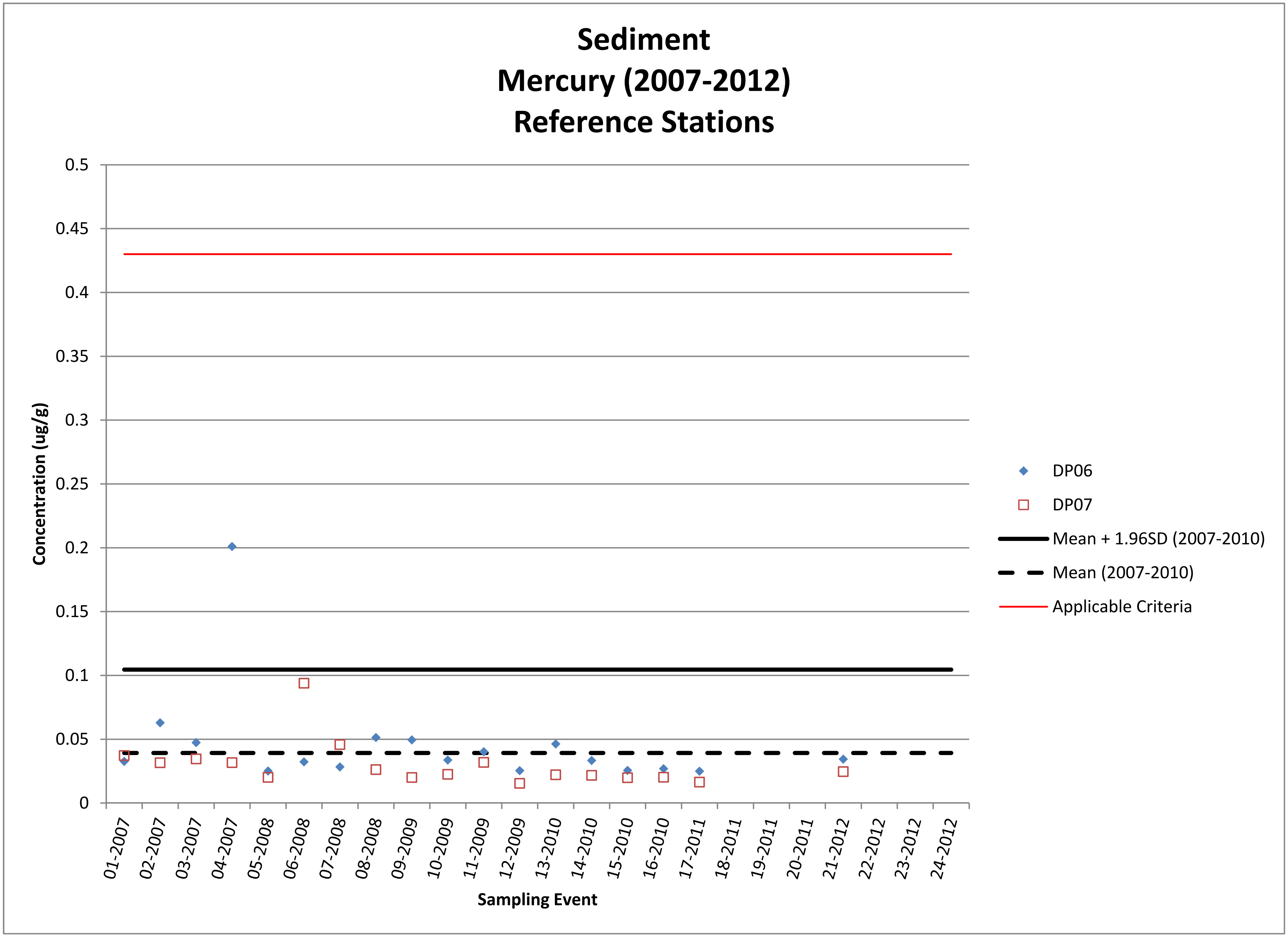


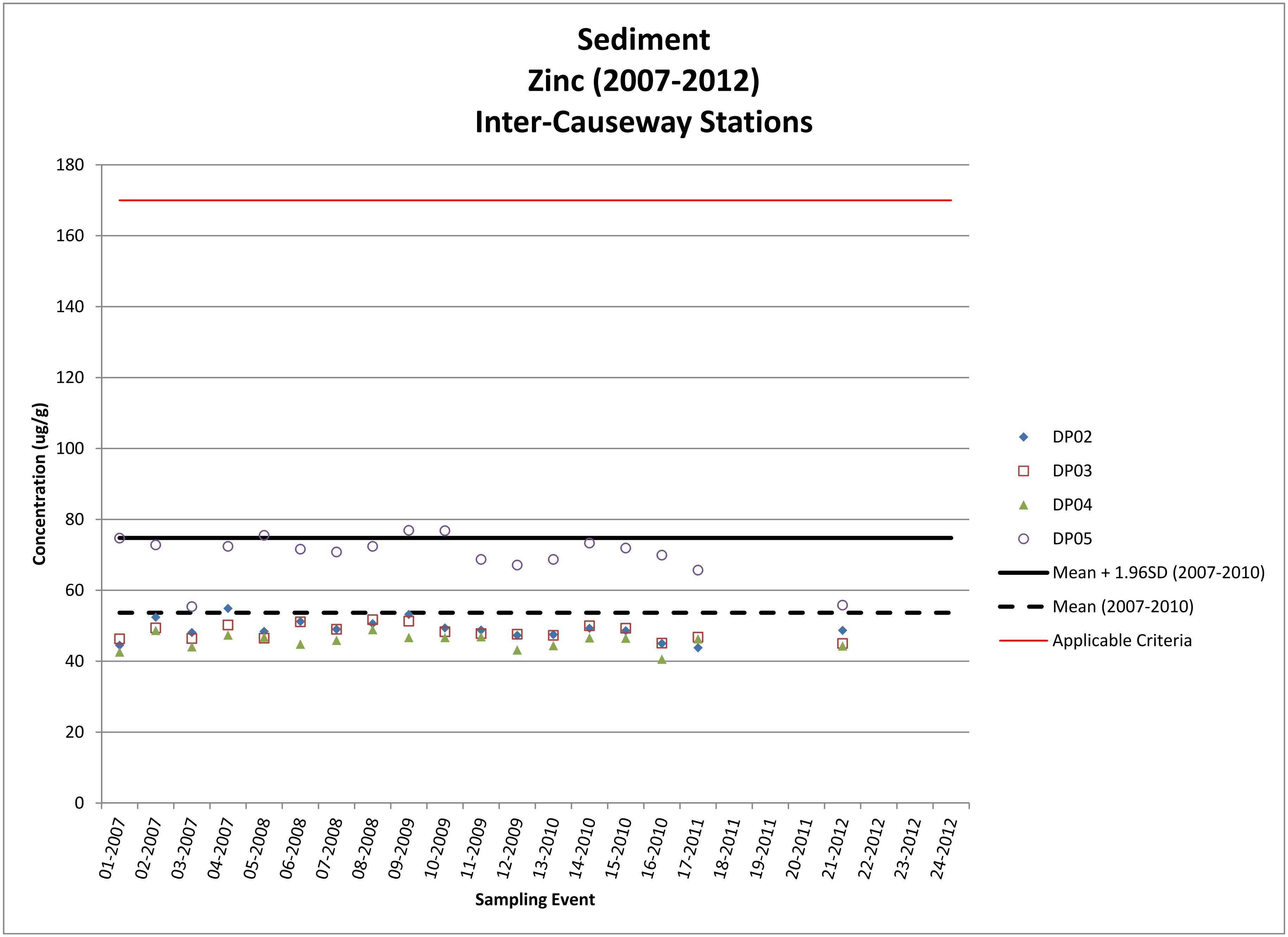
Sediment
Copper (2007-2012)
Inter-Causeway Stations
Concentration (ug/g)
0
10
20
30
40
50
60
70
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
Sampling Event
DP02
DP03
DP04
DP05
Mean + 1.96SD (2007-2010)
Mean (2007-2010)
Applicable Criteria


Sediment
Copper (2007-2012)
Reference Stations
Concentration (ug/g)
0
10
20
30
40
50
60
70
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
Sampling Event
DP06
DP07
Mean + 1.96SD (2007-2010)
Mean (2007-2010)
Applicable Criteria

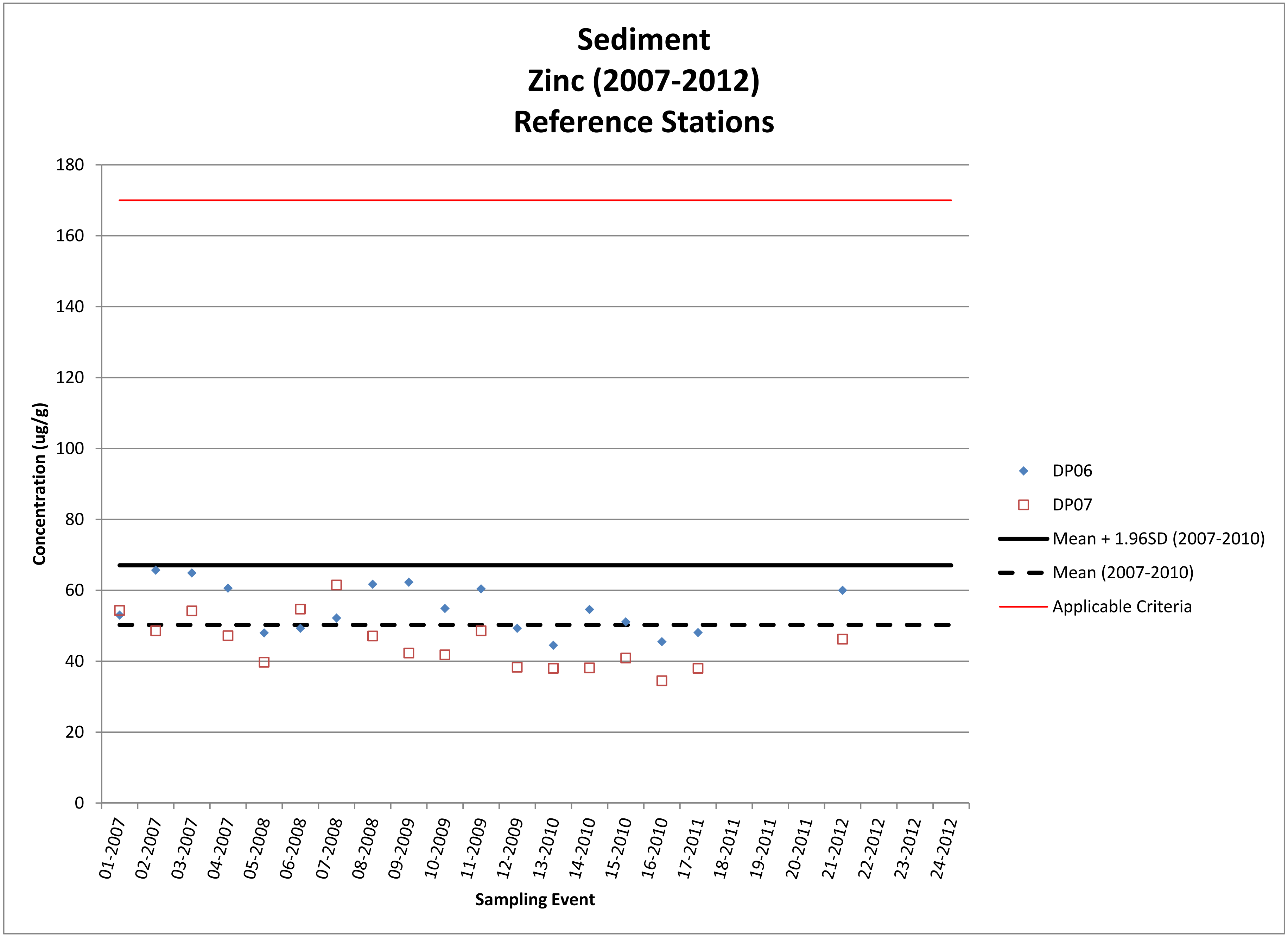


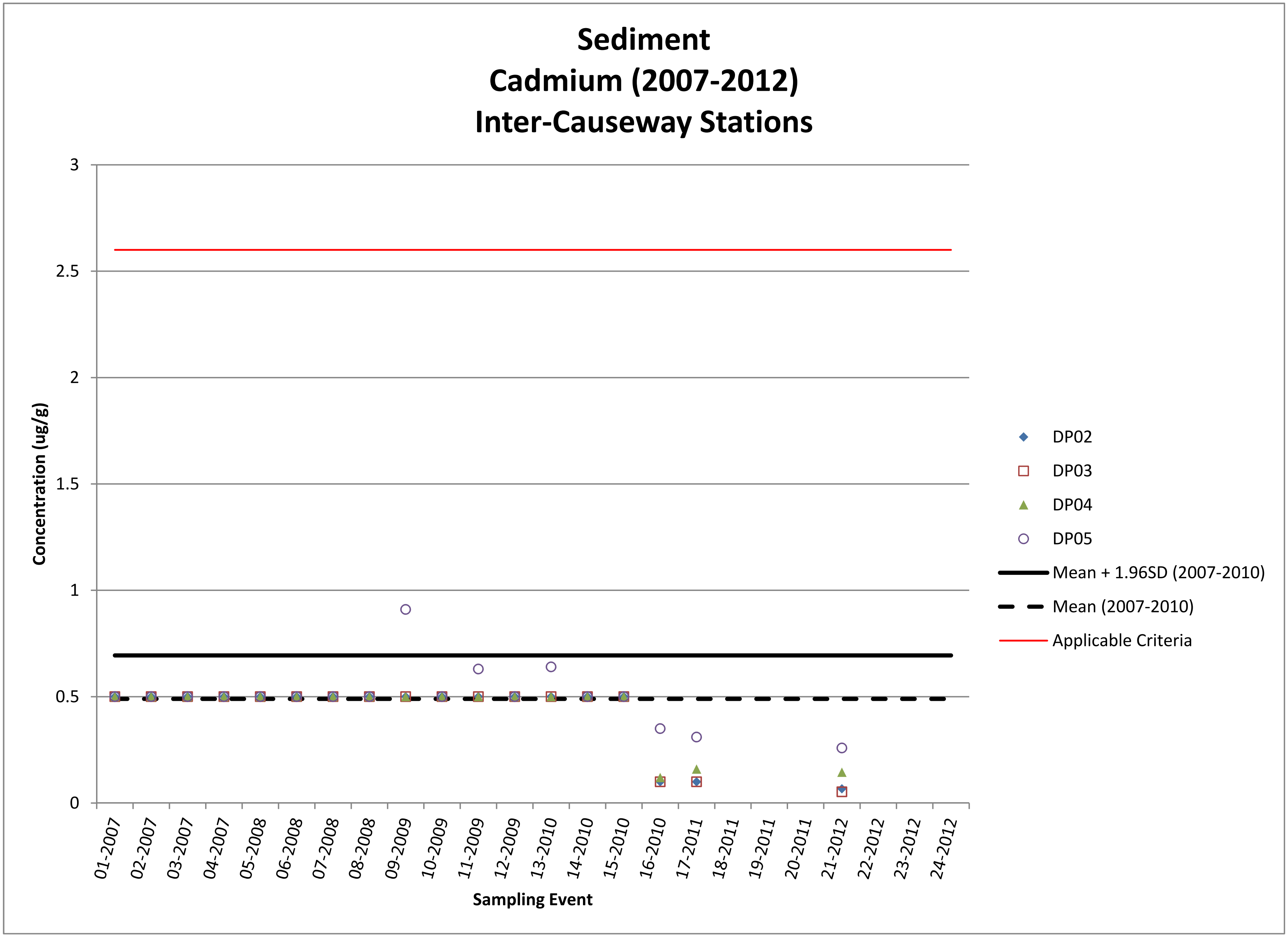
Sediment
Mercury (2007-2012)
Inter-Causeway Stations
Concentration (ug/g)
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
Sampling Event
DP02
DP03
DP04
DP05
Mean + 1.96SD (2007-2010)
Mean (2007-2010)
Applicable Criteria


Sediment
Mercury (2007-2012)
Reference Stations
Concentration (ug/g)
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
Sampling Event
DP06
DP07
Mean + 1.96SD (2007-2010)
Mean (2007-2010)
Applicable Criteria

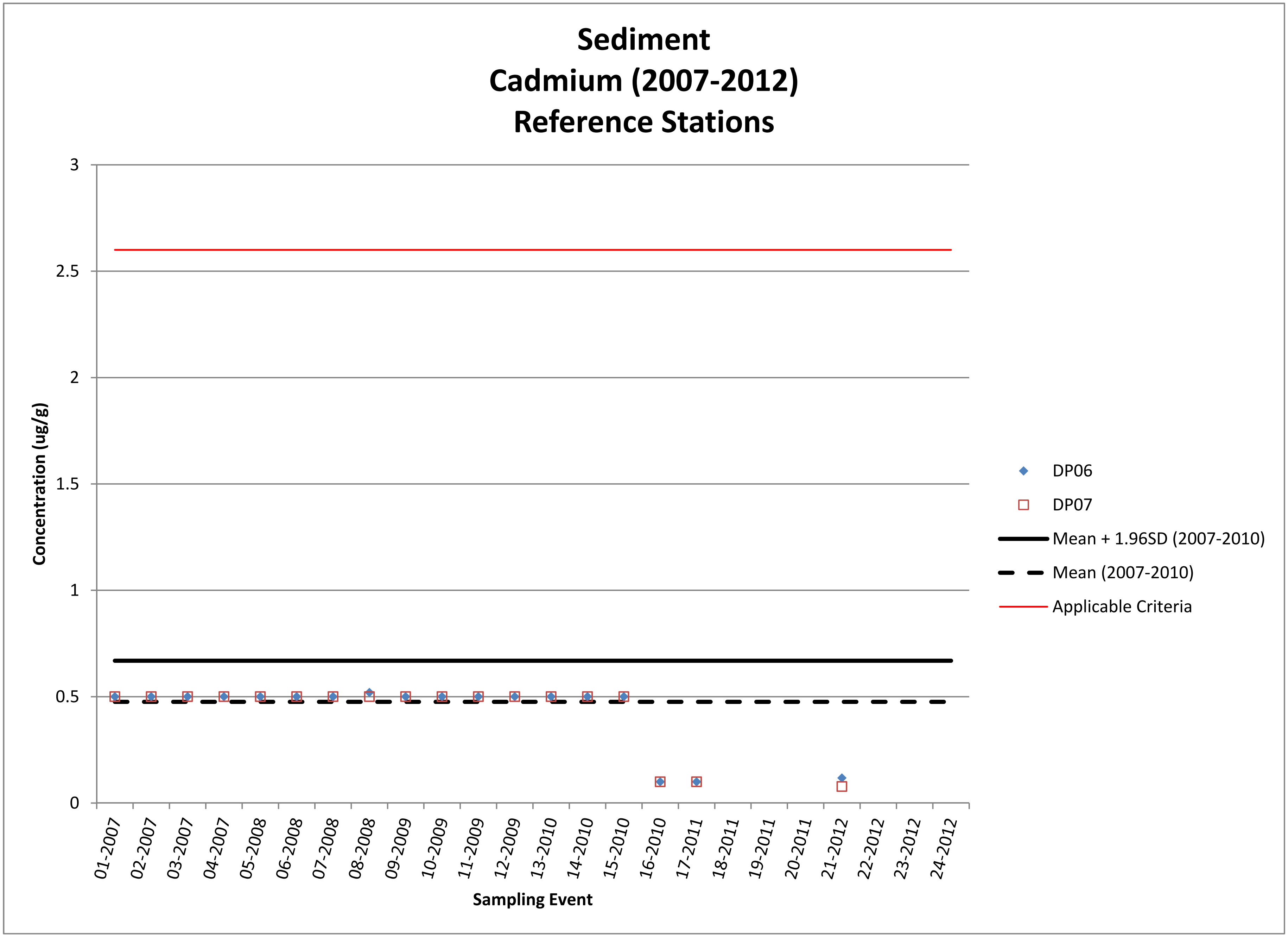


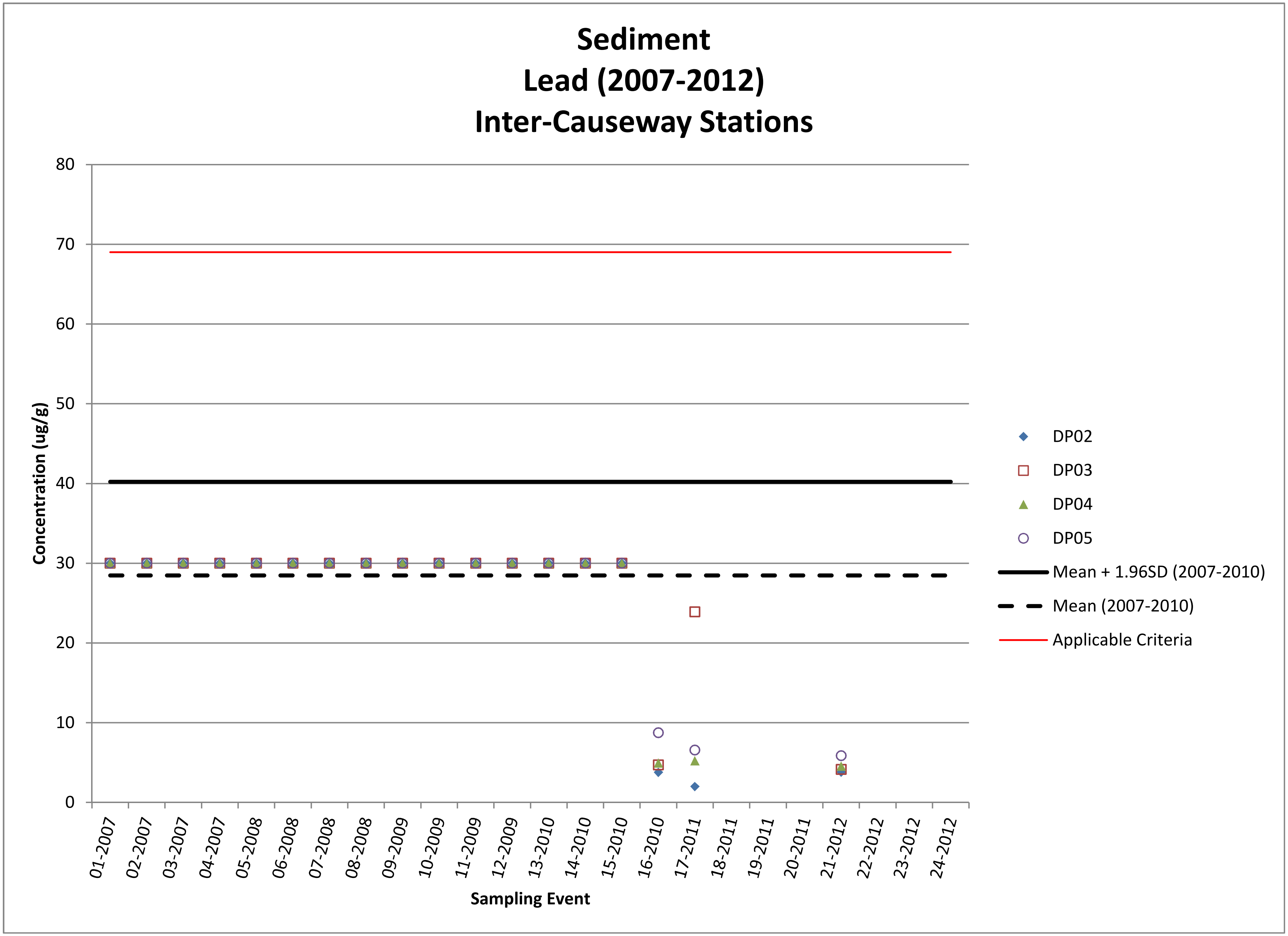
Sediment
Zinc (2007-2012)
Inter-Causeway Stations
Concentration (ug/g)
0
20
40
60
80
100
120
140
160
180
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
Sampling Event
DP02
DP03
DP04
DP05
Mean + 1.96SD (2007-2010)
Mean (2007-2010)
Applicable Criteria


Sediment
Zinc (2007-2012)
Reference Stations
Concentration (ug/g)
0
20
40
60
80
100
120
140
160
180
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
Sampling Event
DP06
DP07
Mean + 1.96SD (2007-2010)
Mean (2007-2010)
Applicable Criteria

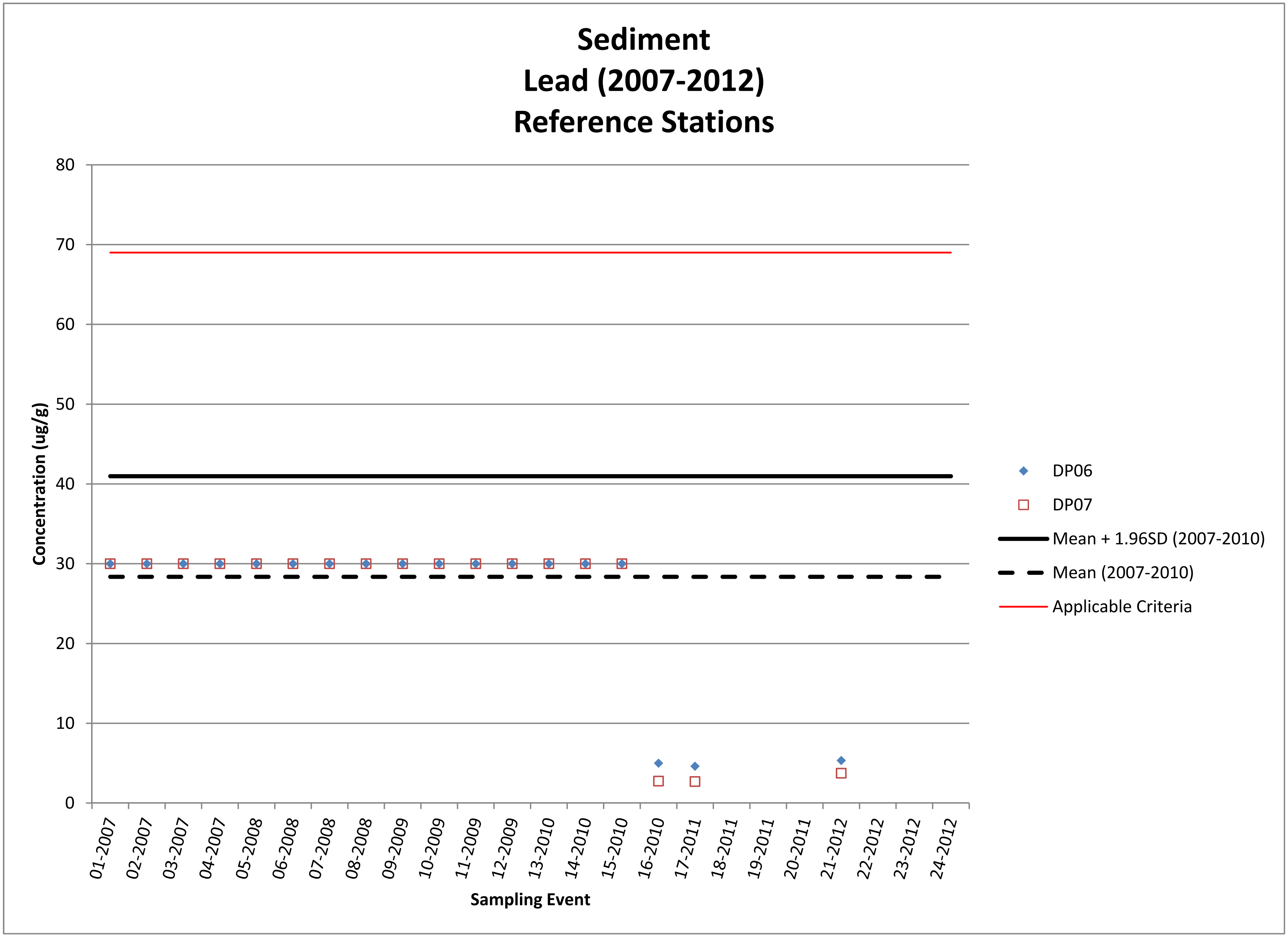


Sediment
Cadmium (2007-2012)
Inter-Causeway Stations
Concentration (ug/g)
3
2.5
2
1.5
1
0.5
0
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
Sampling Event
DP02
DP03
DP04
DP05
Mean + 1.96SD (2007-2010)
Mean (2007-2010)
Applicable Criteria


Sediment
Cadmium (2007-2012)
Reference Stations
Concentration (ug/g)
0
0.5
1
1.5
2
2.5
3
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
Sampling Event
DP06
DP07
Mean + 1.96SD (2007-2010)
Mean (2007-2010)
Applicable Criteria



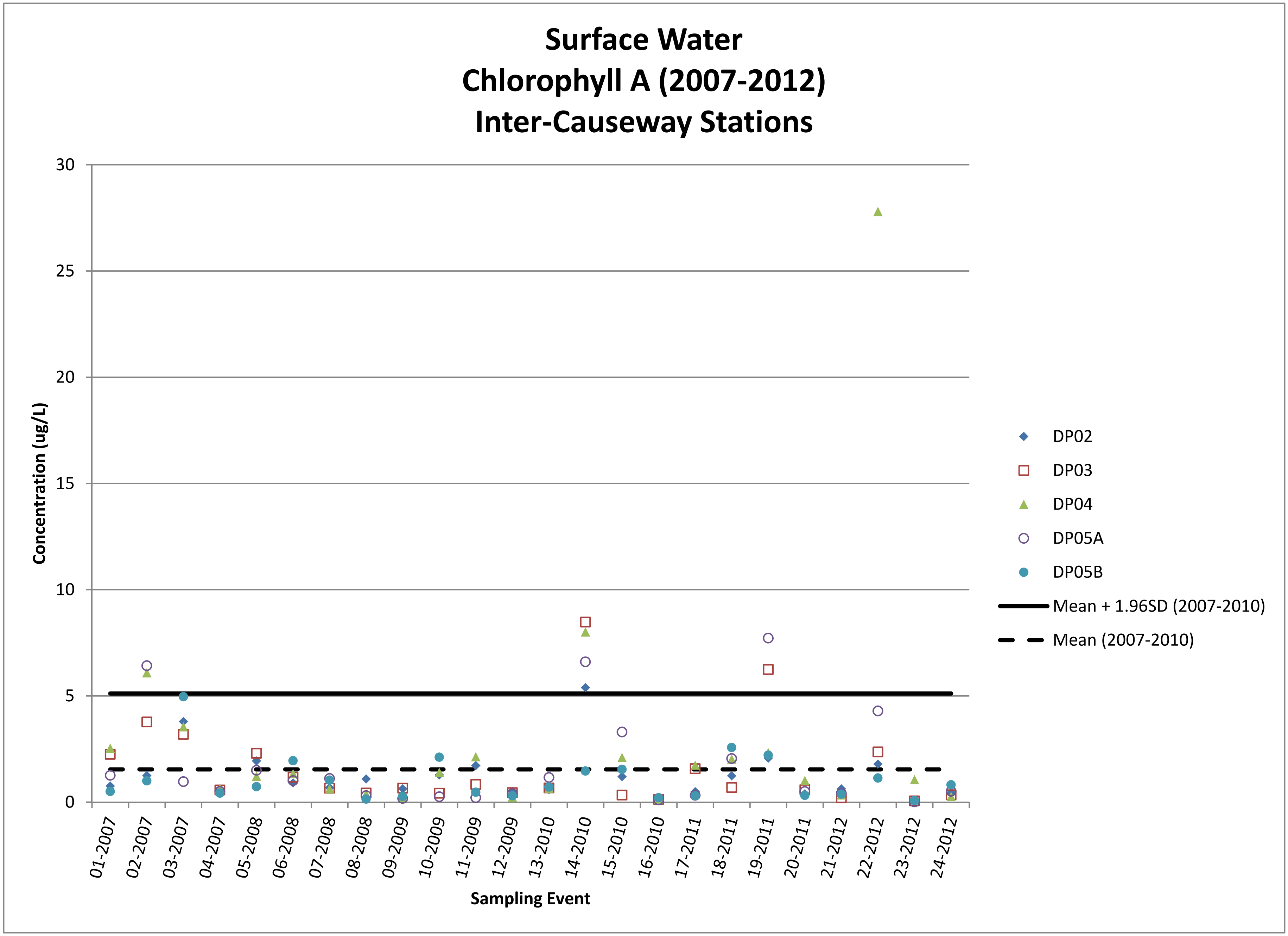
Sediment
Lead (2007-2012)
Inter-Causeway Stations
Concentration (ug/g)
80
70
60
50
40
30
20
10
0
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
Sampling Event
DP02
DP03
DP04
DP05
Mean + 1.96SD (2007-2010)
Mean (2007-2010)
Applicable Criteria



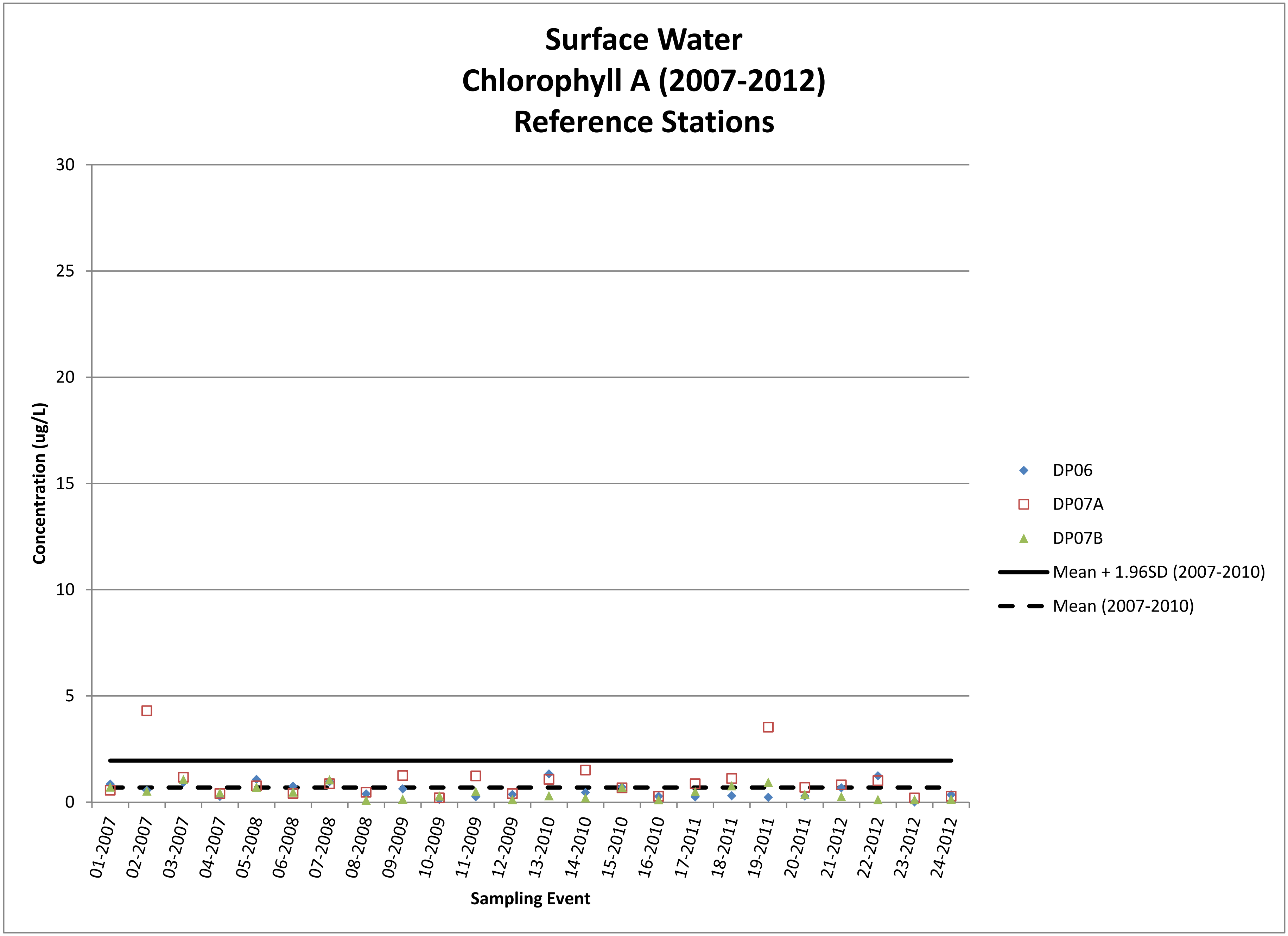
Sediment
Lead (2007-2012)
Reference Stations
Concentration (ug/g)
80
70
60
50
40
30
20
10
0
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
Sampling Event
DP06
DP07
Mean + 1.96SD (2007-2010)
Mean (2007-2010)
Applicable Criteria

APPENDIX F

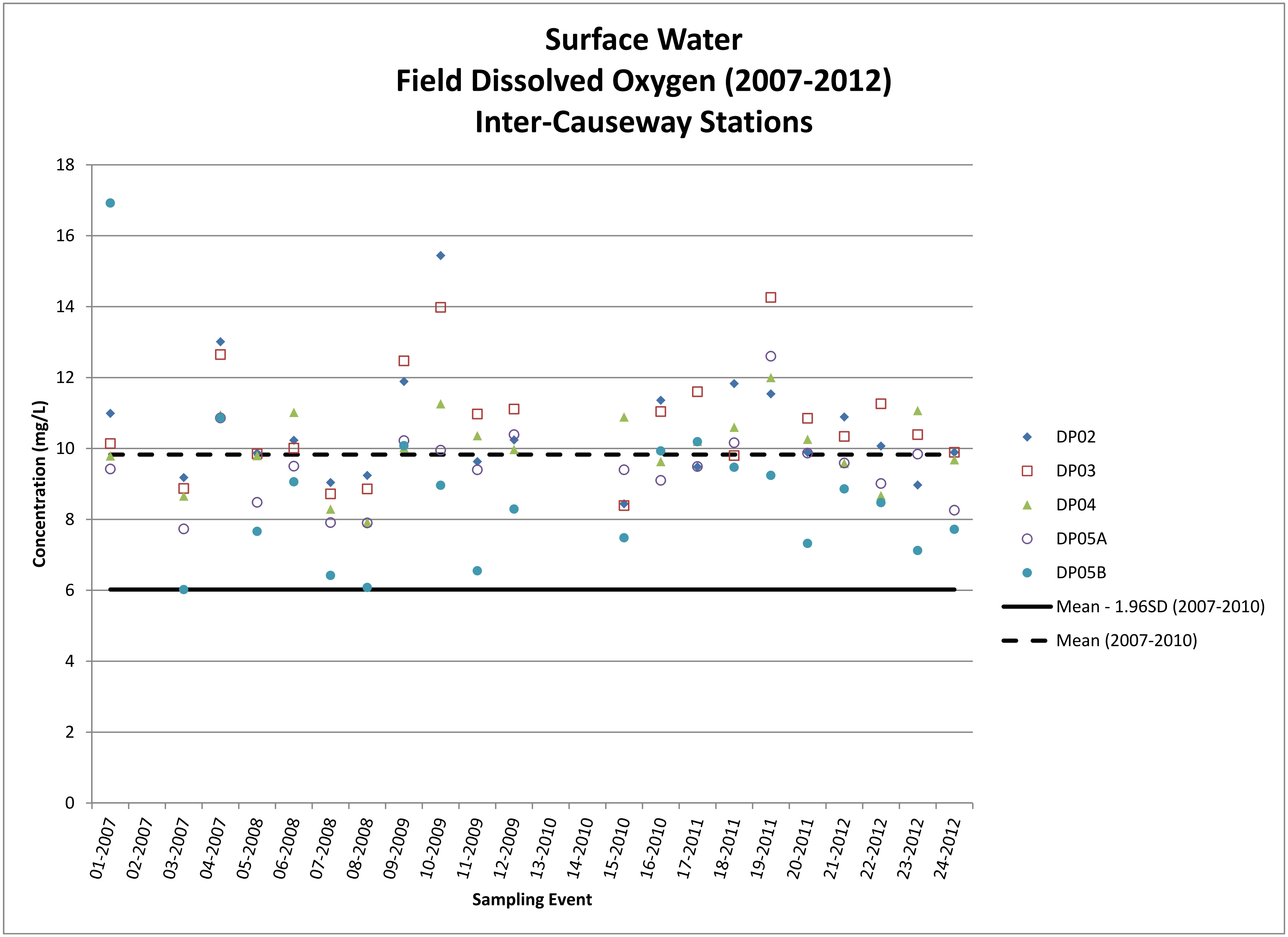
Trend Graphs for Surface Water and Sediment Chemistry – Eutrophication Parameters

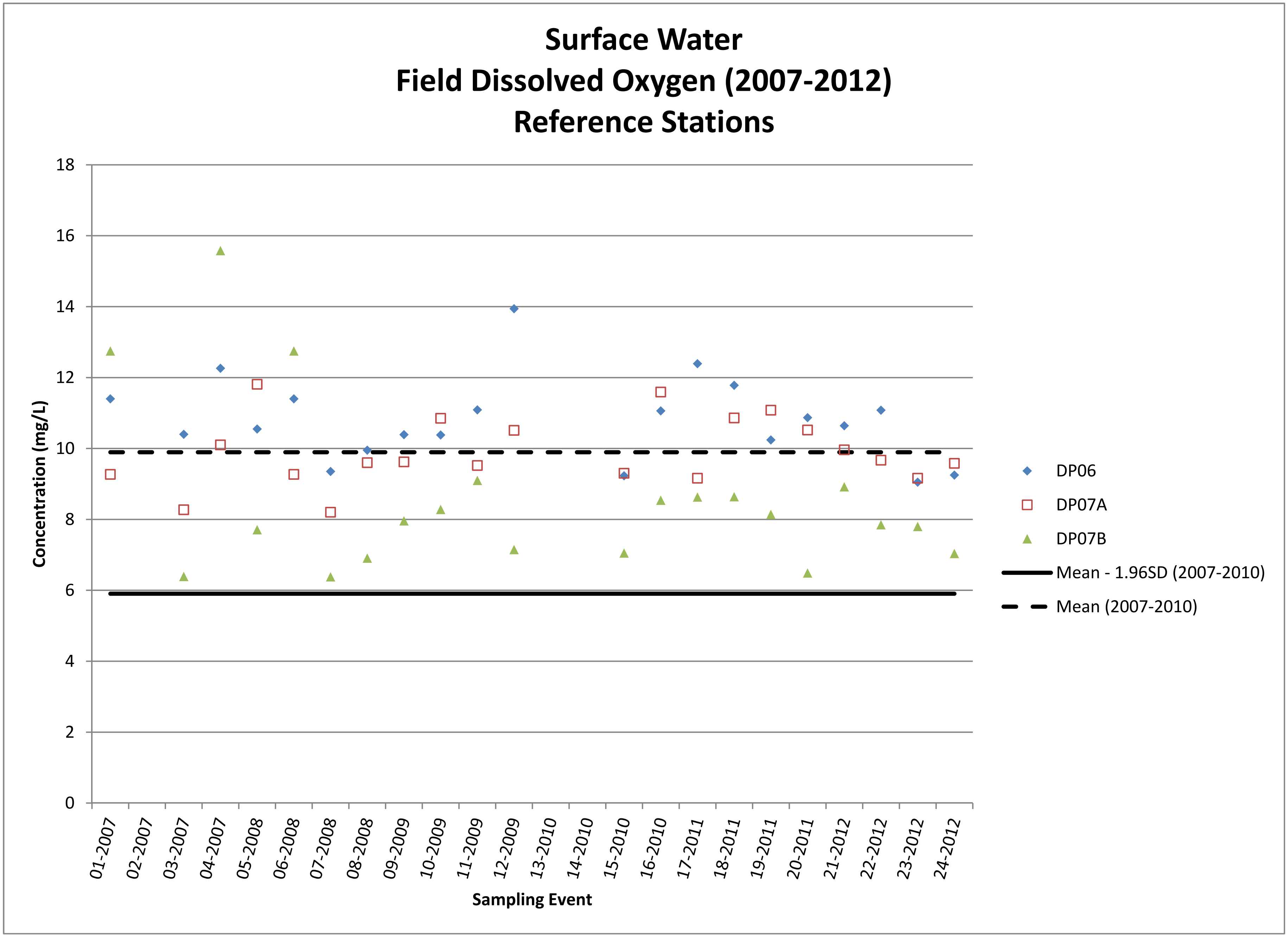


Surface Water
Chlorophyll A (2007-2012)
Inter-Causeway Stations
Concentration (ug/L)
30
25
20
15
10
5
0
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
Sampling Event
DP02
DP03
DP04
DP05A
DP05B
Mean + 1.96SD (2007-2010)
Mean (2007-2010)

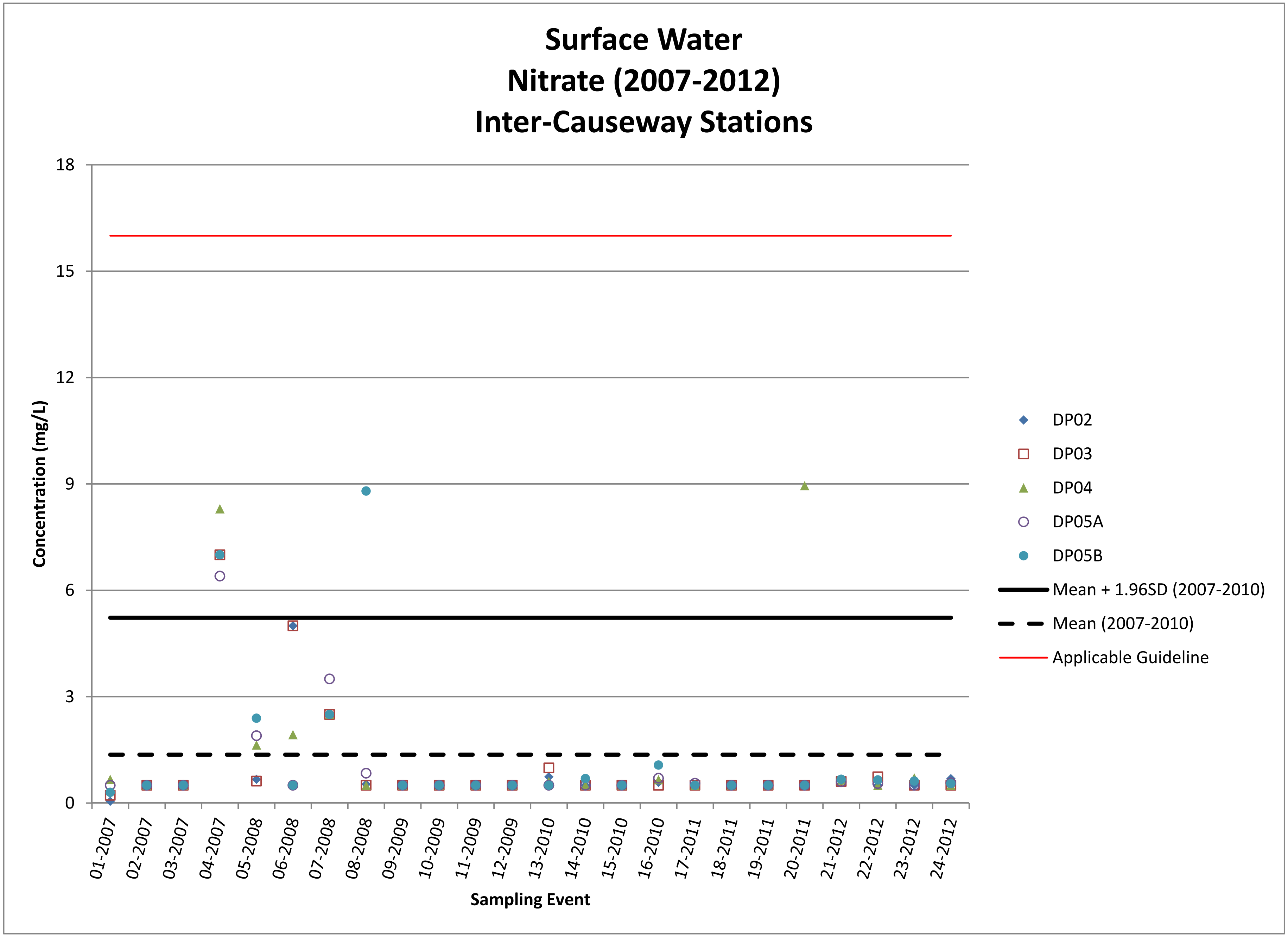


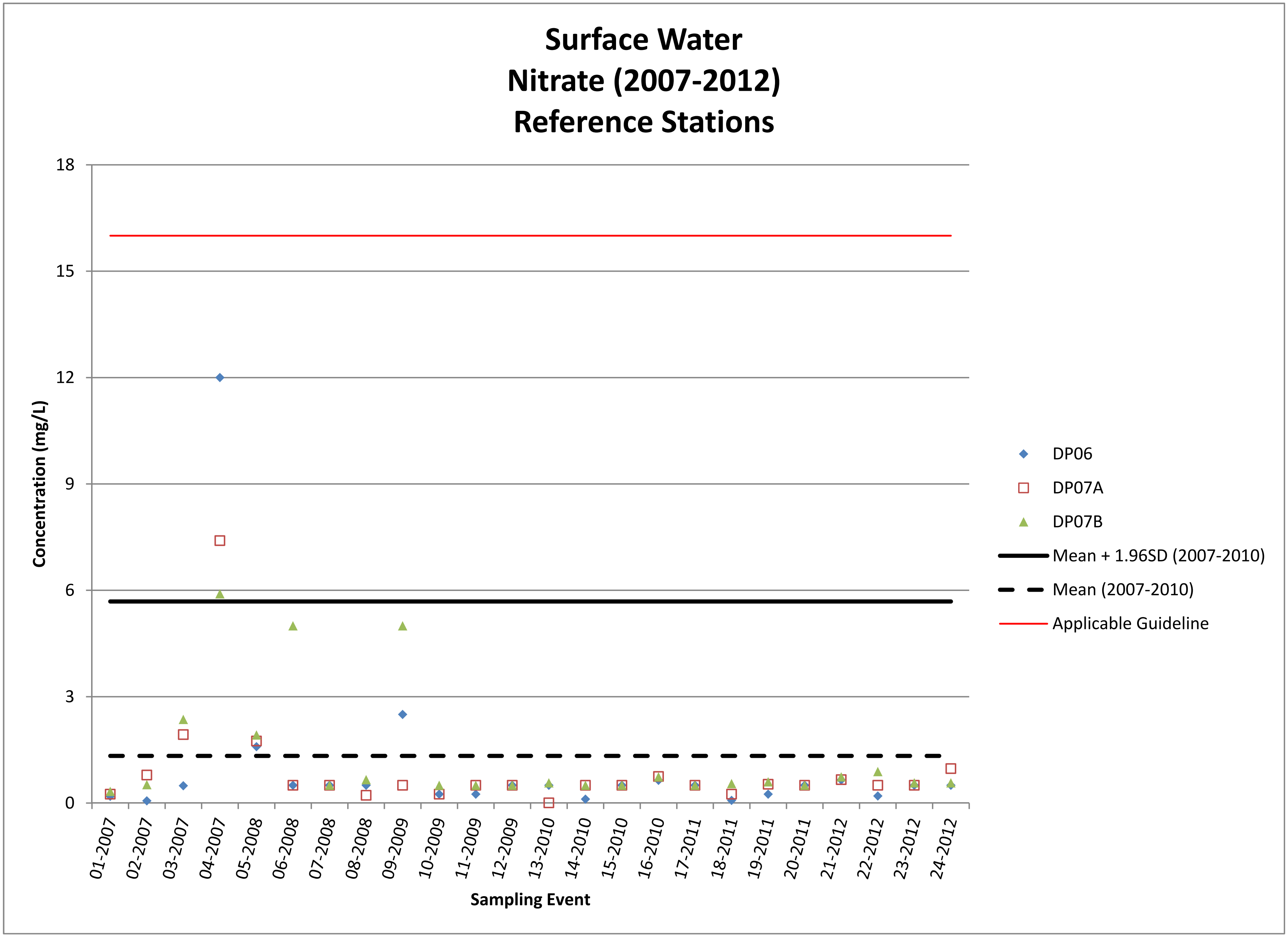
Surface Water
Chlorophyll A (2007-2012)
Reference Stations
Concentration (ug/L)
30
25
20
15
10
5
0
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
Sampling Event
DP06
DP07A
DP07B
Mean + 1.96SD (2007-2010)
Mean (2007-2010)


Surface Water
Field Dissolved Oxygen (2007-2012)
Inter-Causeway Stations
Concentration (mg/L)
Sampling Event
0
2
4
6
8
10
12
14
16
18
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
DP02
DP03
DP04
DP05A
DP05B
Mean - 1.96SD (2007-2010)
Mean (2007-2010)

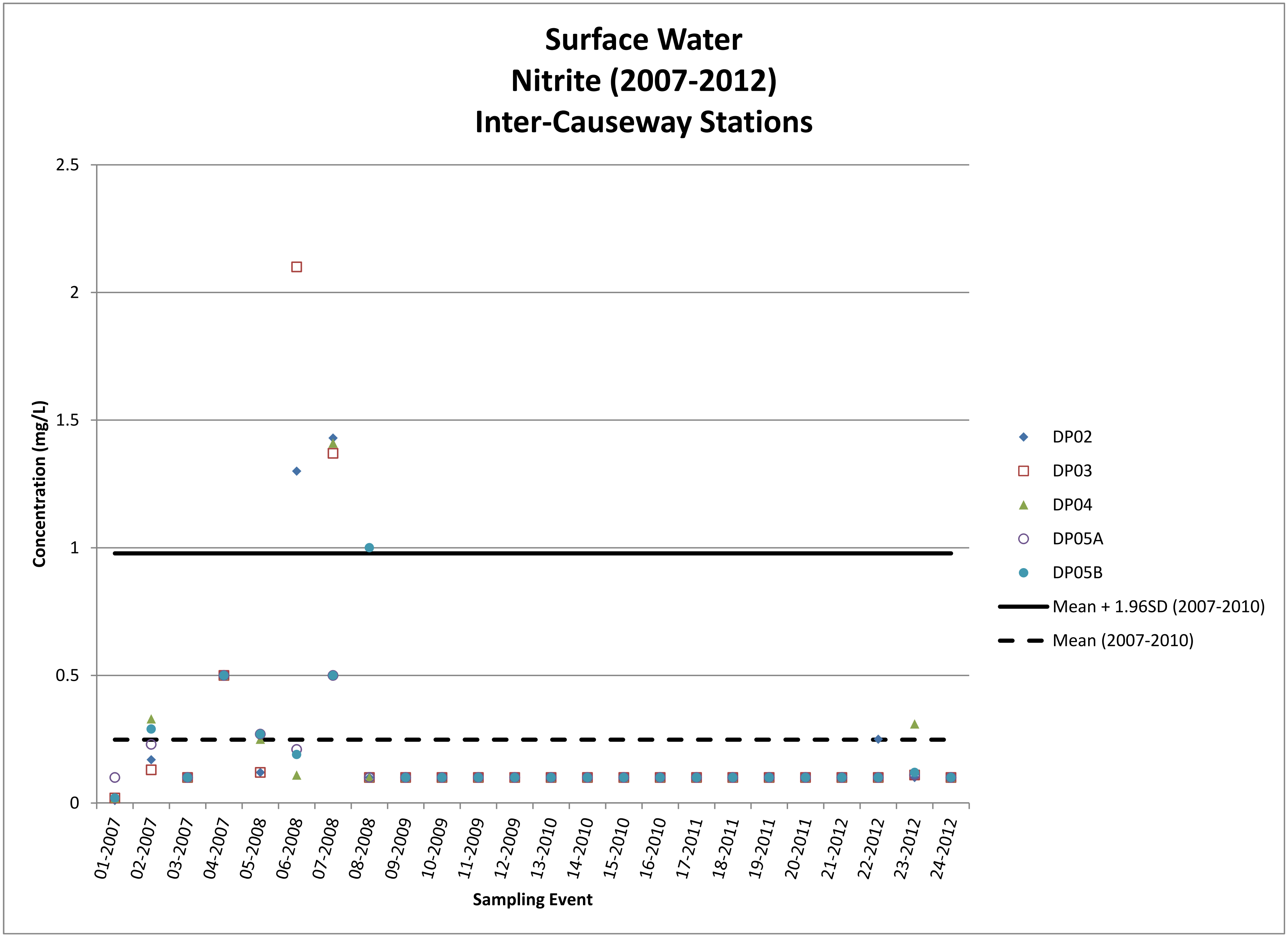


Surface Water
Field Dissolved Oxygen (2007-2012)
Reference Stations
Concentration (mg/L)
0
2
4
6
8
10
12
14
16
18
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
Sampling Event
DP06
DP07A
DP07B
Mean - 1.96SD (2007-2010)
Mean (2007-2010)

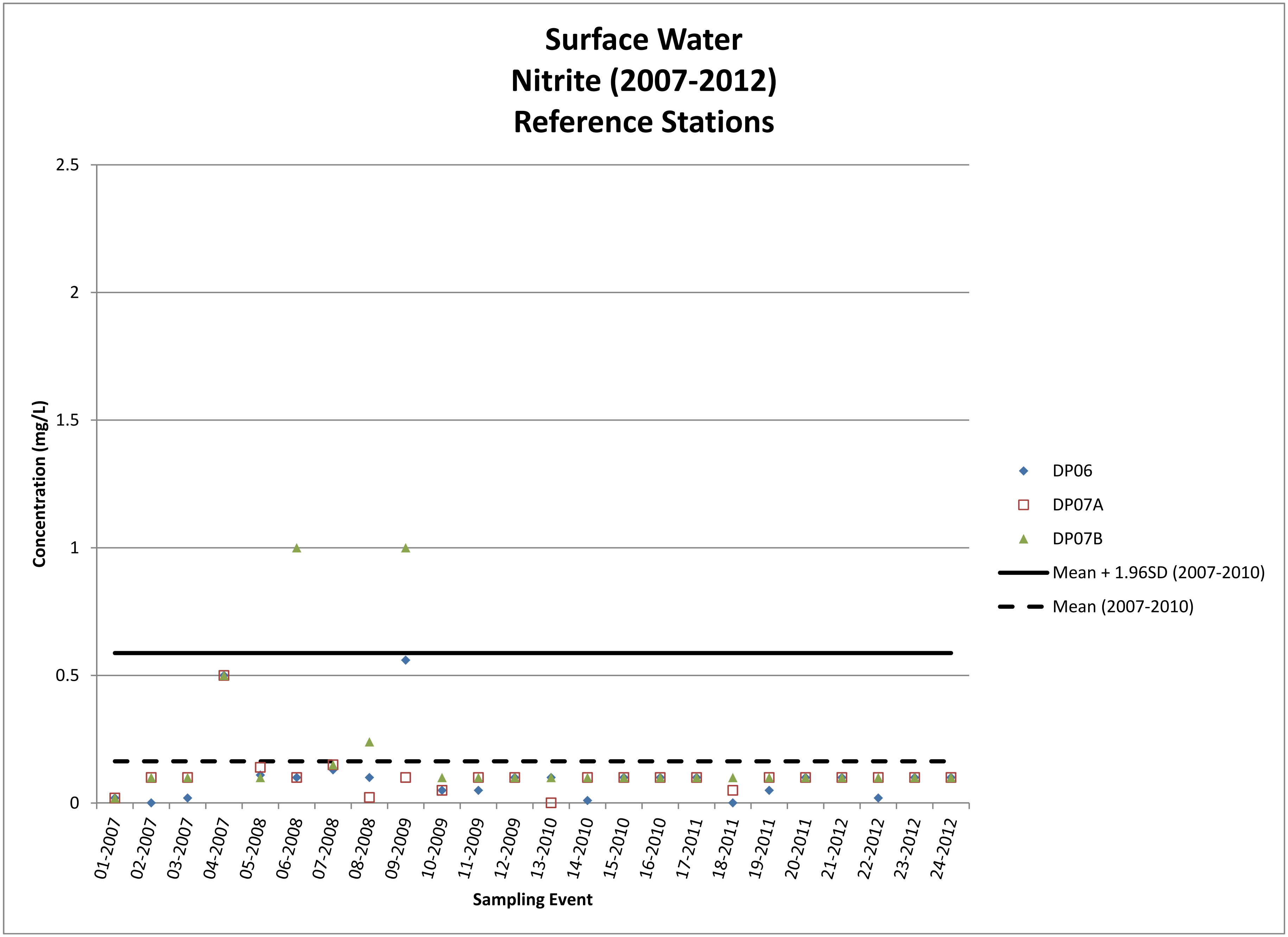

Surface Water
Nitrate (2007-2012)
Inter-Causeway Stations
Concentration (mg/L)
0
3
6
9
12
15
18
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
Sampling Event
DP02
DP03
DP04
DP05A
DP05B
Mean + 1.96SD (2007-2010)
Mean (2007-2010)
Applicable Guideline

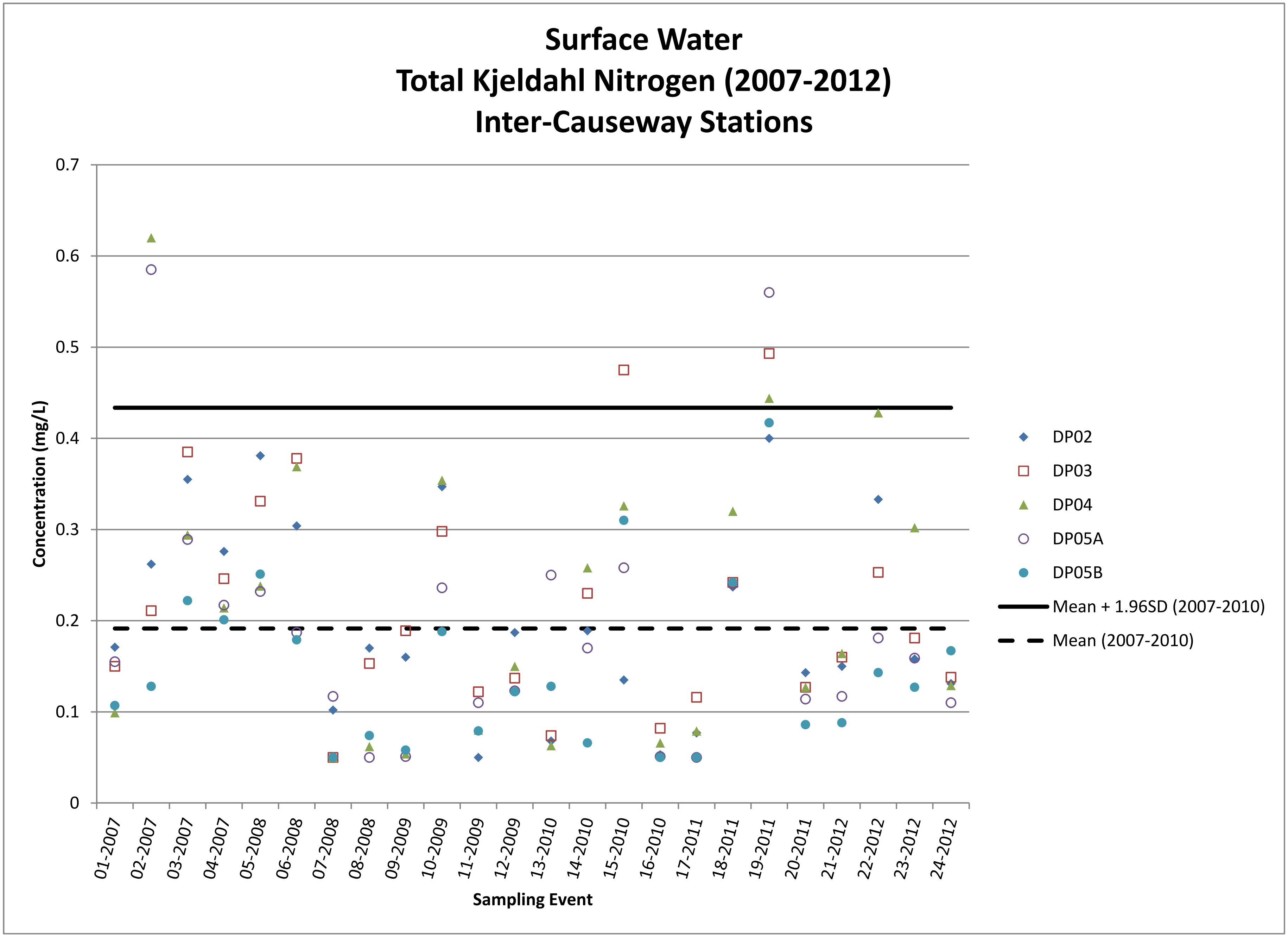


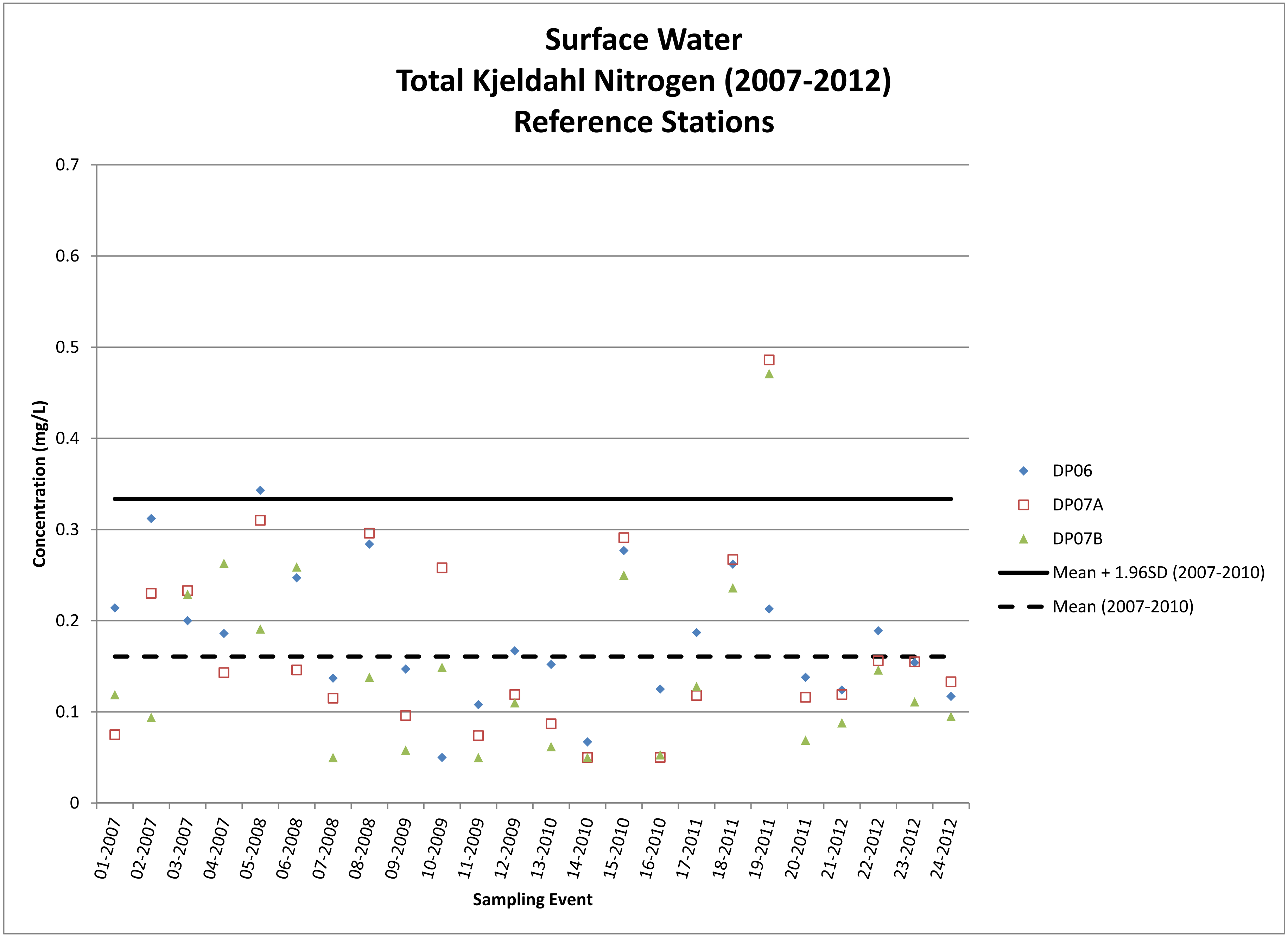
Surface Water
Nitrate (2007-2012)
Reference Stations
Concentration (mg/L)
18
15
12
9
6
3
0
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
Sampling Event
DP06
DP07A
DP07B
Mean + 1.96SD (2007-2010)
Mean (2007-2010)
Applicable Guideline



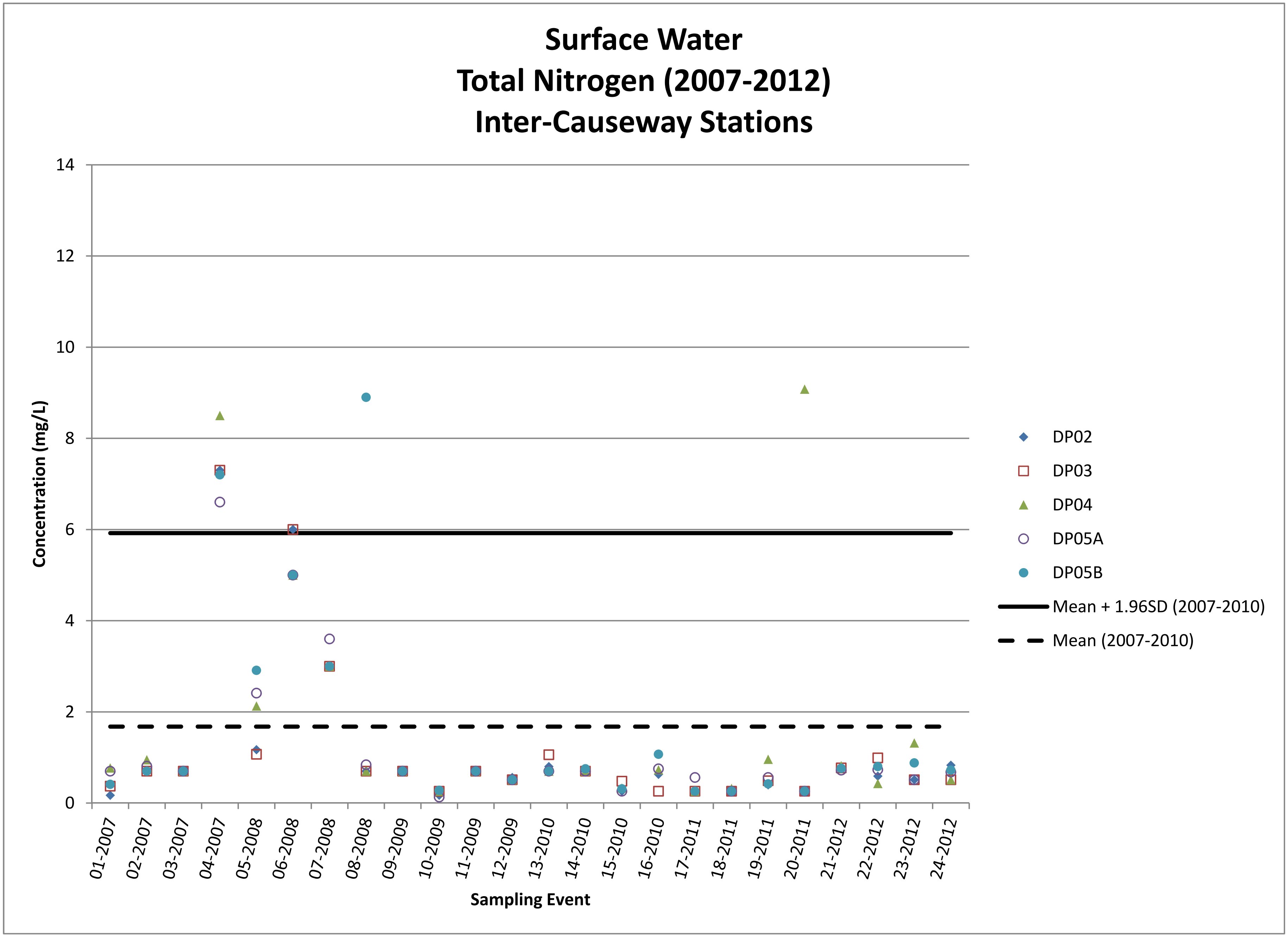
Surface Water
Nitrite (2007-2012)
Inter-Causeway Stations
Concentration (mg/L)
2.5
2
1.5
1
0.5
0
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
Sampling Event
DP02
DP03
DP04
DP05A
DP05B
Mean + 1.96SD (2007-2010)
Mean (2007-2010)

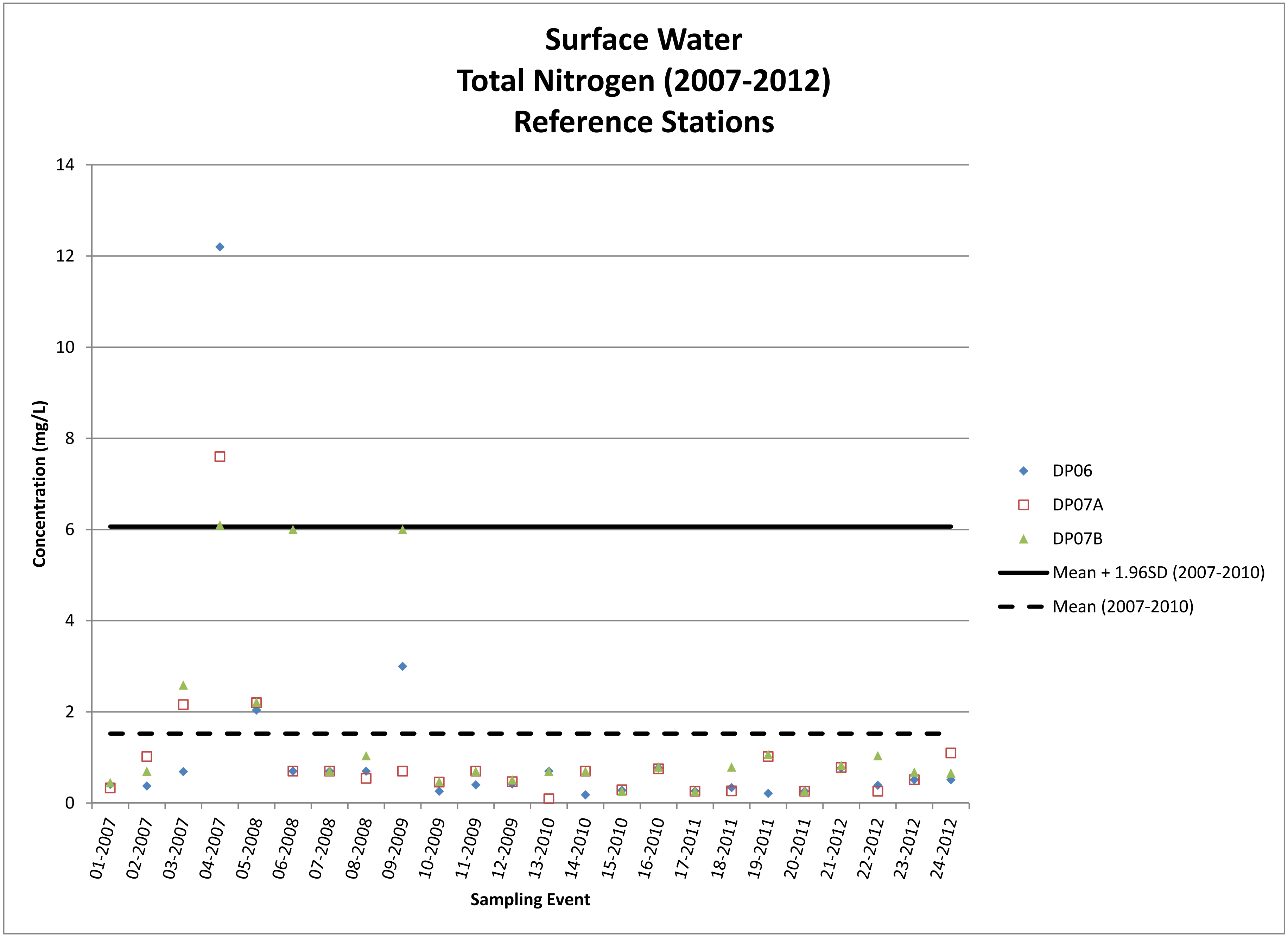

Surface Water
Nitrite (2007-2012)
Reference Stations
Concentration (mg/L)
2.5
2
1.5
1
0.5
0
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
Sampling Event
DP06
DP07A
DP07B
Mean + 1.96SD (2007-2010)
Mean (2007-2010)

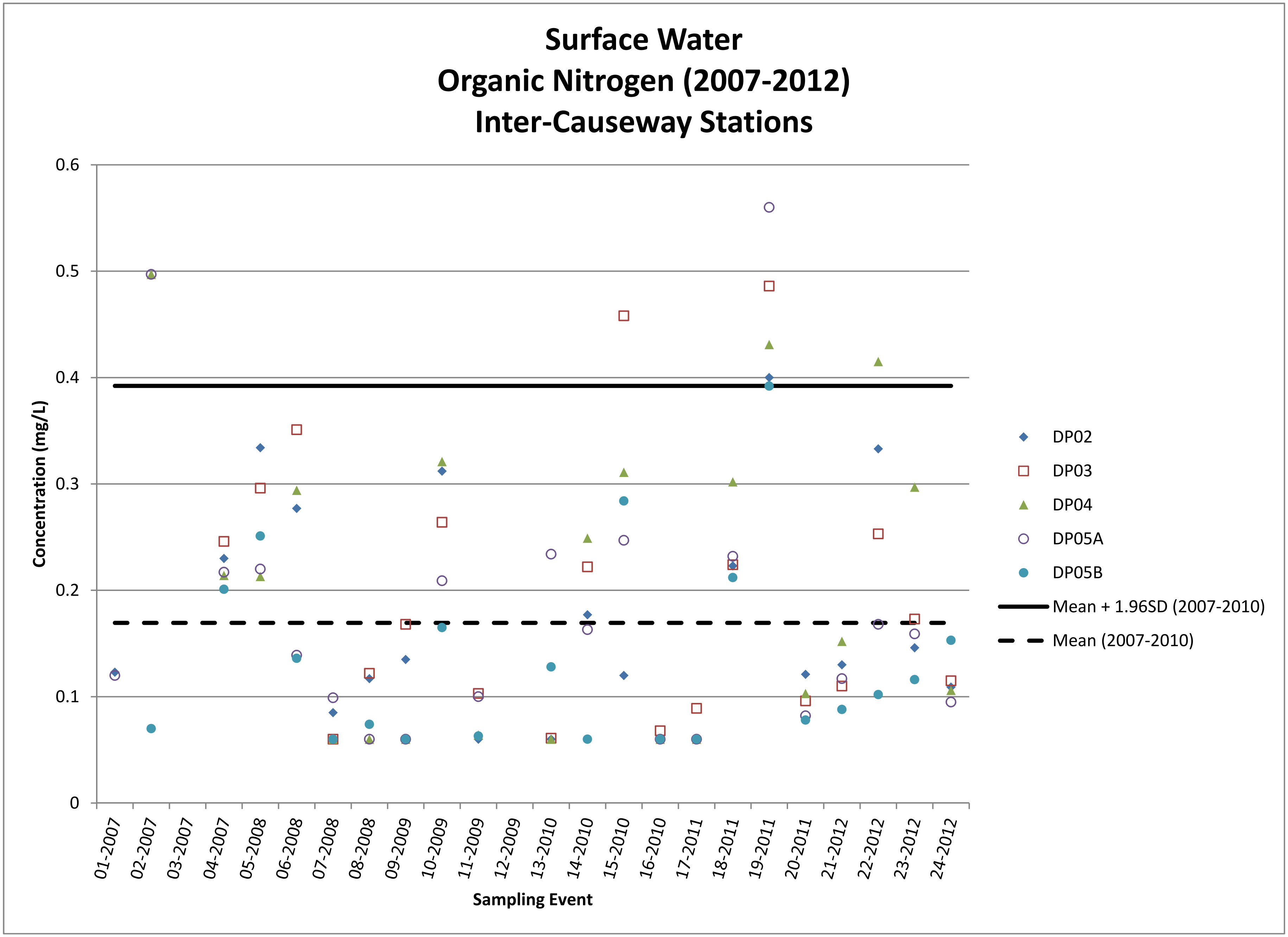

Surface Water
Total Kjeldahl Nitrogen (2007-2012)
Inter-Causeway Stations
Concentration (mg/L)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
Sampling Event
DP02
DP03
DP04
DP05A
DP05B
Mean + 1.96SD (2007-2010)
Mean (2007-2010)



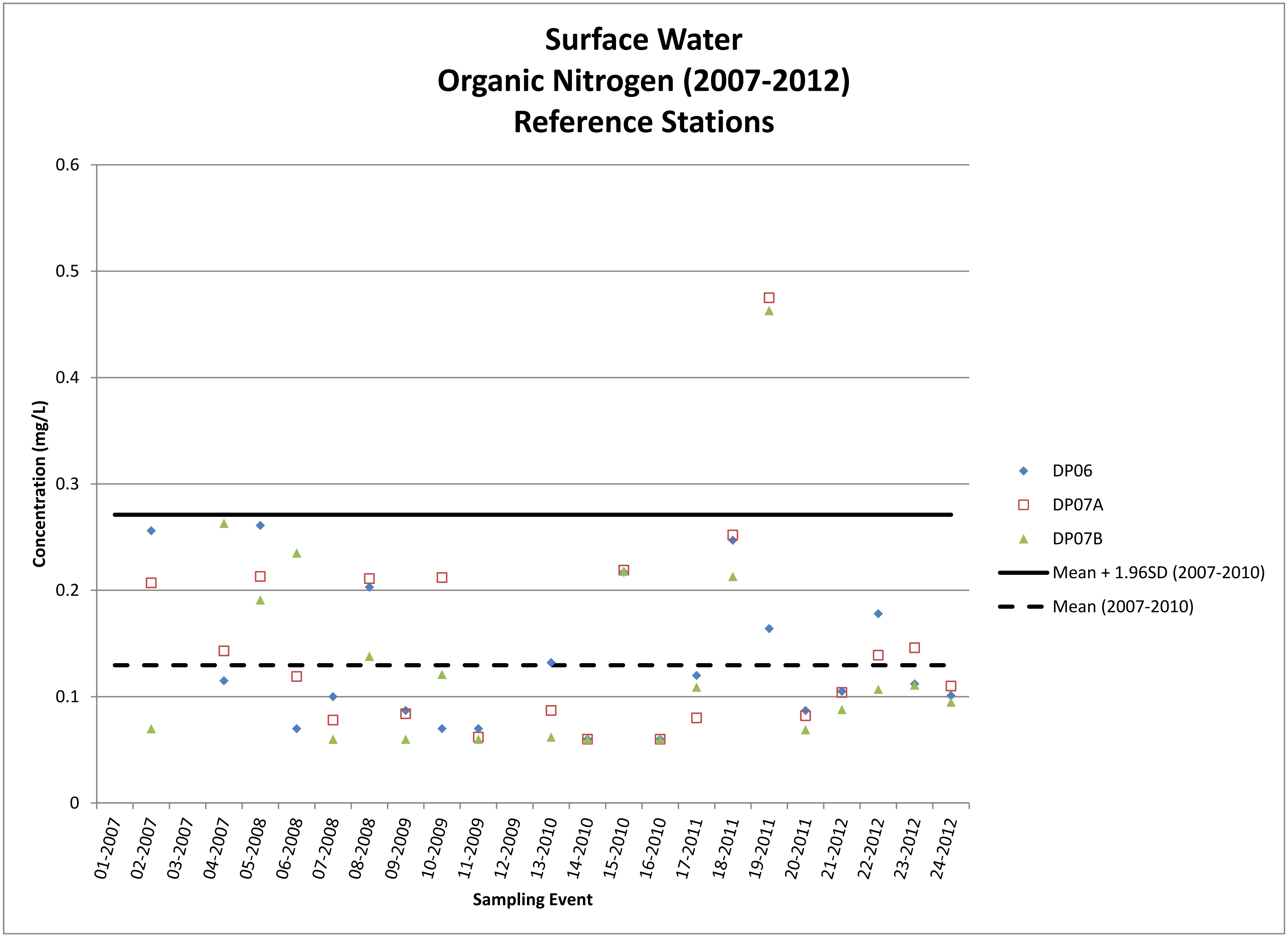
Surface Water
Total Kjeldahl Nitrogen (2007-2012)
Reference Stations
Concentration (mg/L)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
Sampling Event
DP06
DP07A
DP07B
Mean + 1.96SD (2007-2010)
Mean (2007-2010)


Surface Water
Total Nitrogen (2007-2012)
Inter-Causeway Stations
Concentration (mg/L)
0
2
4
6
8
10
12
14
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
Sampling Event
DP02
DP03
DP04
DP05A
DP05B
Mean + 1.96SD (2007-2010)
Mean (2007-2010)

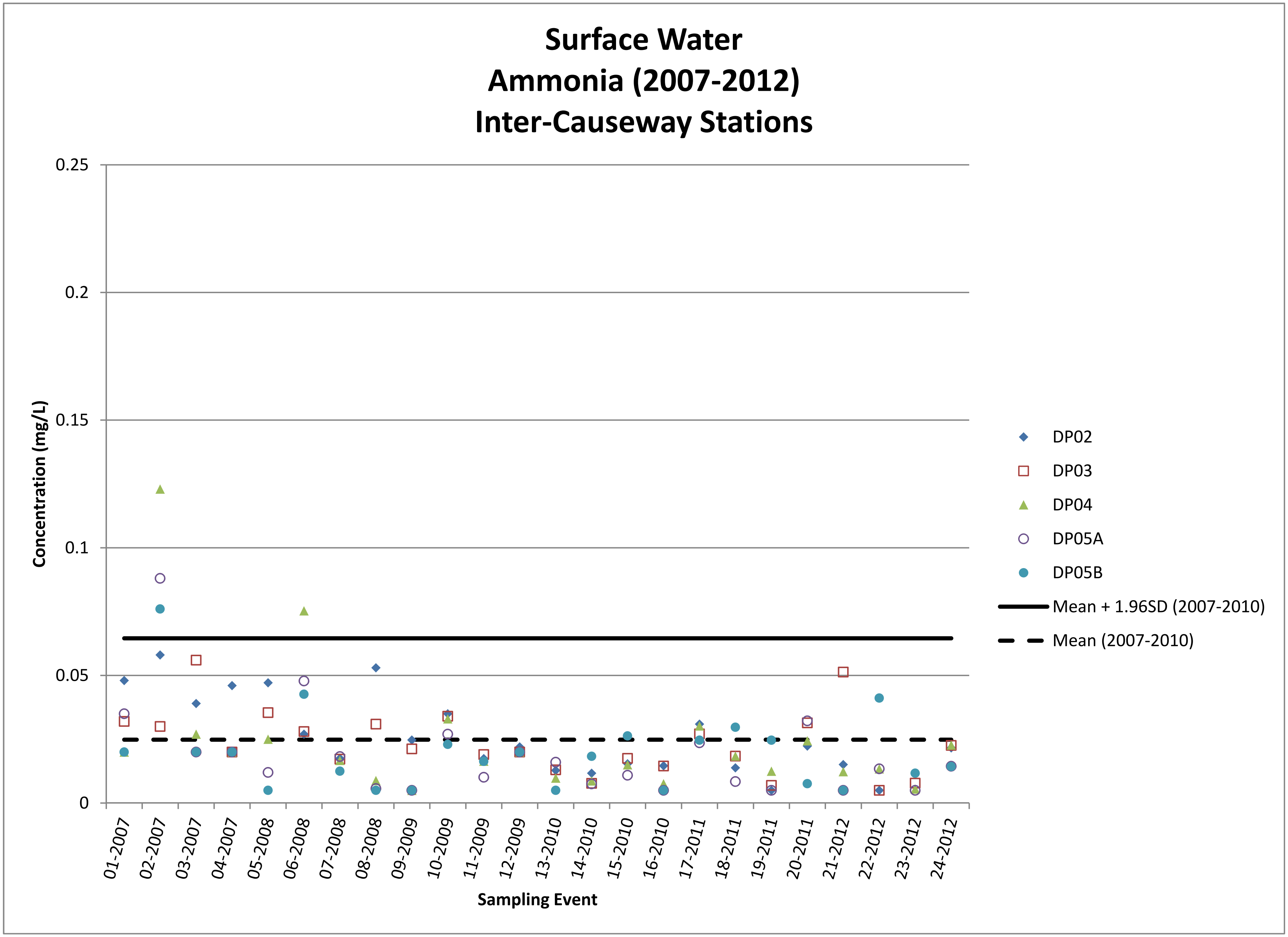

Surface Water
Total Nitrogen (2007-2012)
Reference Stations
Concentration (mg/L)
0
2
4
6
8
10
12
14
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
Sampling Event
DP06
DP07A
DP07B
Mean + 1.96SD (2007-2010)
Mean (2007-2010)

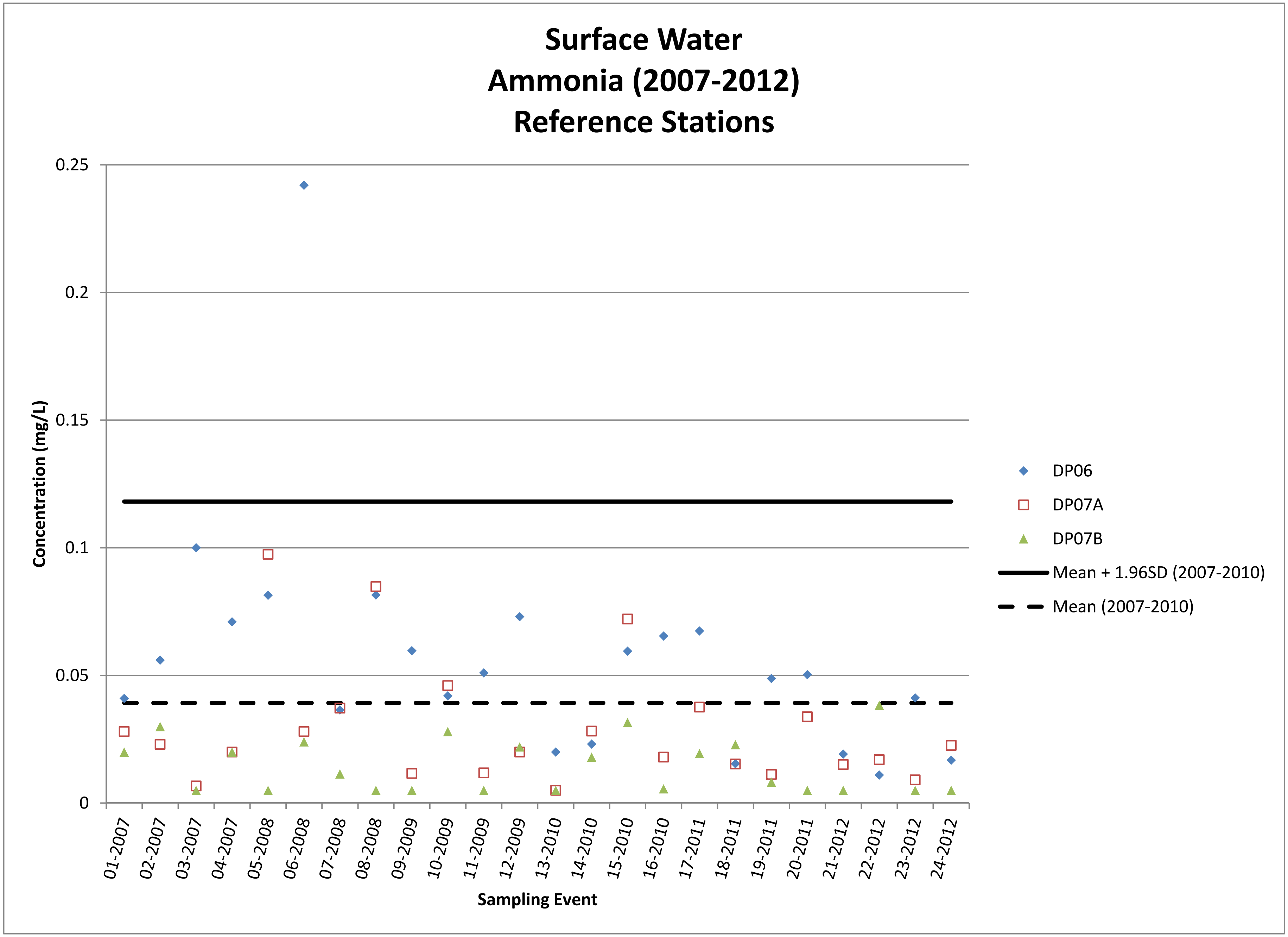


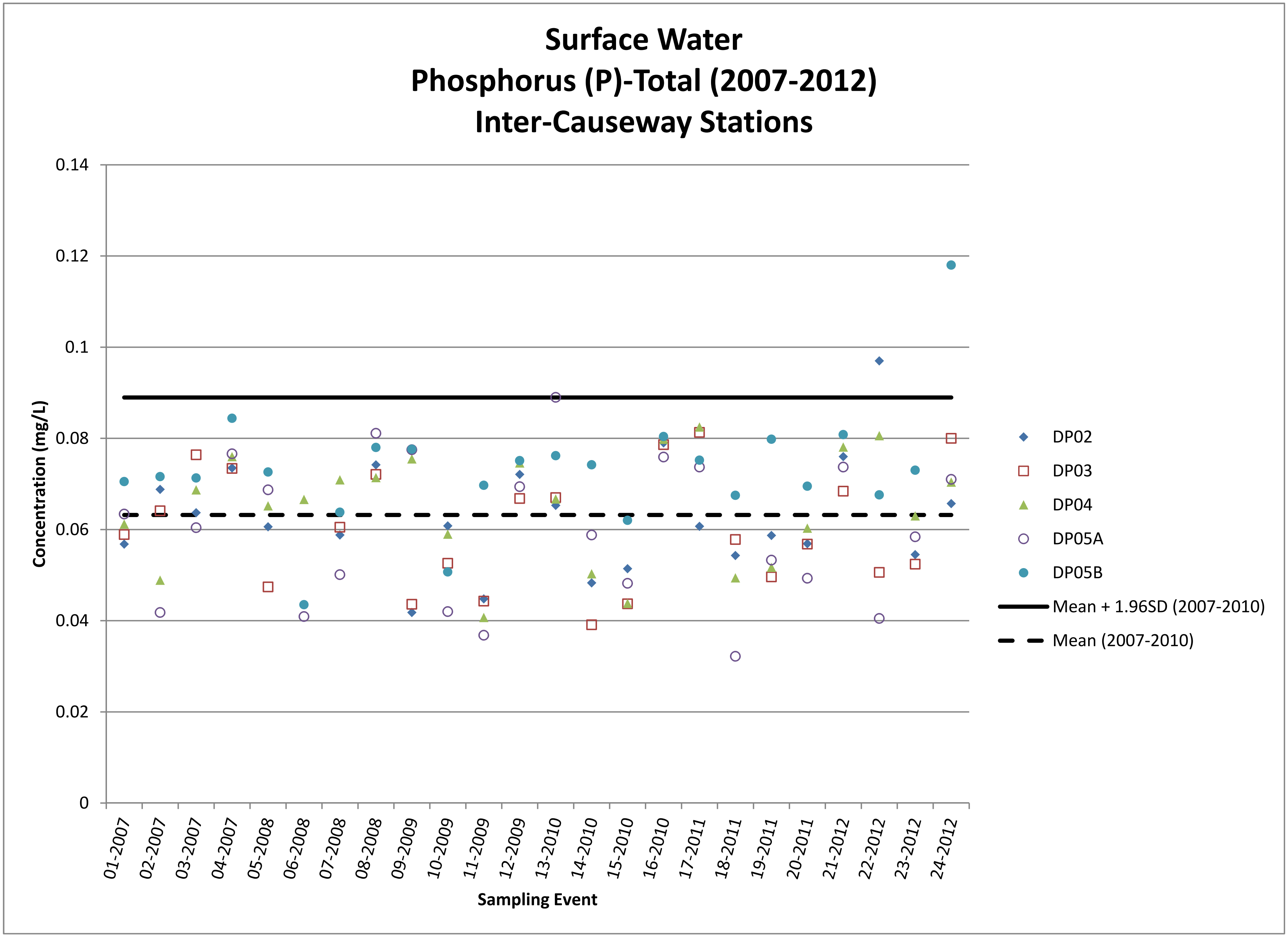
Surface Water
Organic Nitrogen (2007-2012)
Inter-Causeway Stations
Concentration (mg/L)
0.6
0.5
0.4
0.3
0.2
0.1
0
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
Sampling Event
DP02
DP03
DP04
DP05A
DP05B
Mean + 1.96SD (2007-2010)
Mean (2007-2010)



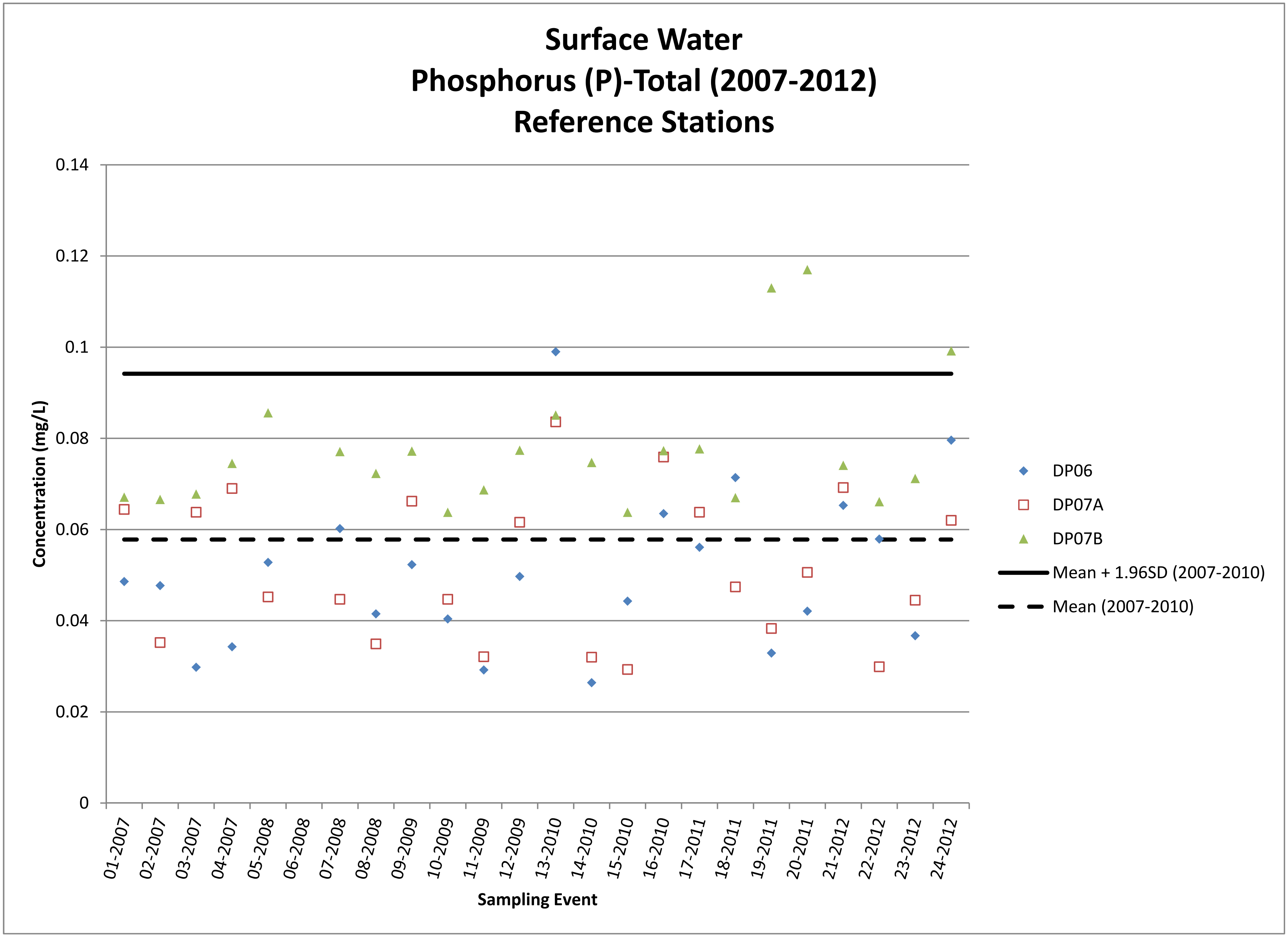
Surface Water
Organic Nitrogen (2007-2012)
Reference Stations
Concentration (mg/L)
0.6
0.5
0.4
0.3
0.2
0.1
0
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
Sampling Event
DP06
DP07A
DP07B
Mean + 1.96SD (2007-2010)
Mean (2007-2010)


Surface Water
Ammonia (2007-2012)
Inter-Causeway Stations
Concentration (mg/L)
0.25
0.2
0.15
0.1
0.05
0
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
Sampling Event
DP02
DP03
DP04
DP05A
DP05B
Mean + 1.96SD (2007-2010)
Mean (2007-2010)

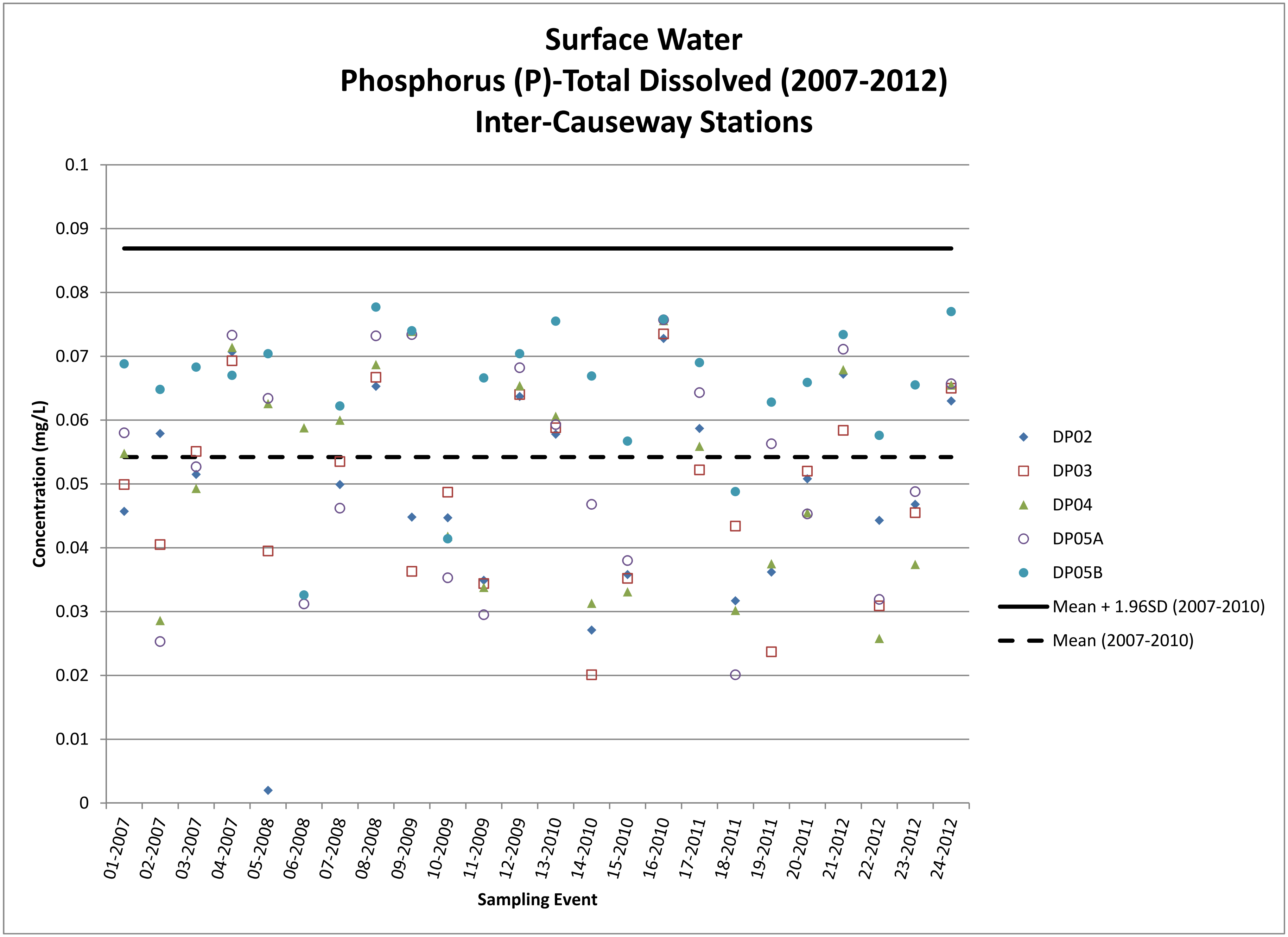

Surface Water
Ammonia (2007-2012)
Reference Stations
Concentration (mg/L)
0.25
0.2
0.15
0.1
0.05
0
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
Sampling Event
DP06
DP07A
DP07B
Mean + 1.96SD (2007-2010)
Mean (2007-2010)

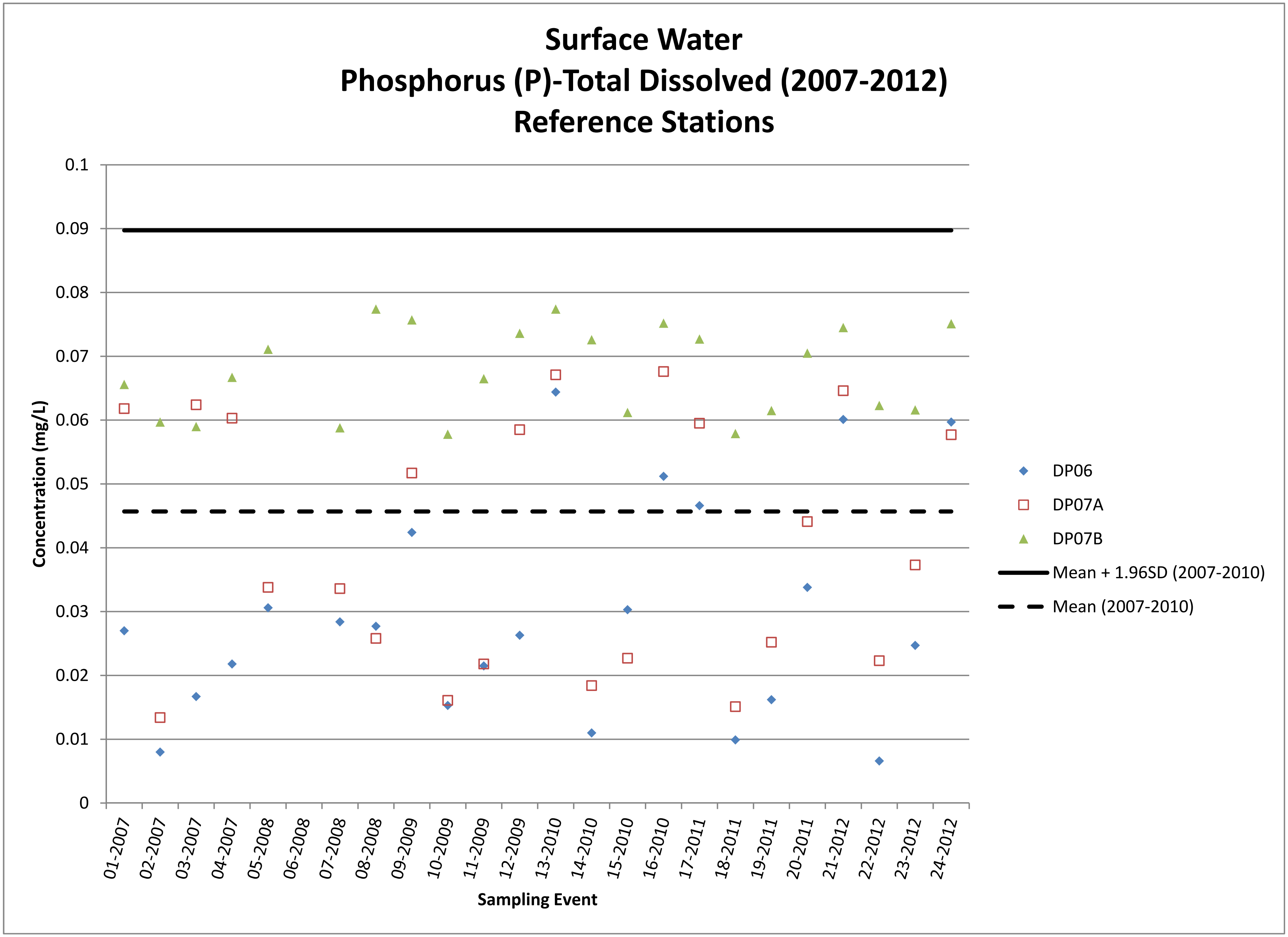


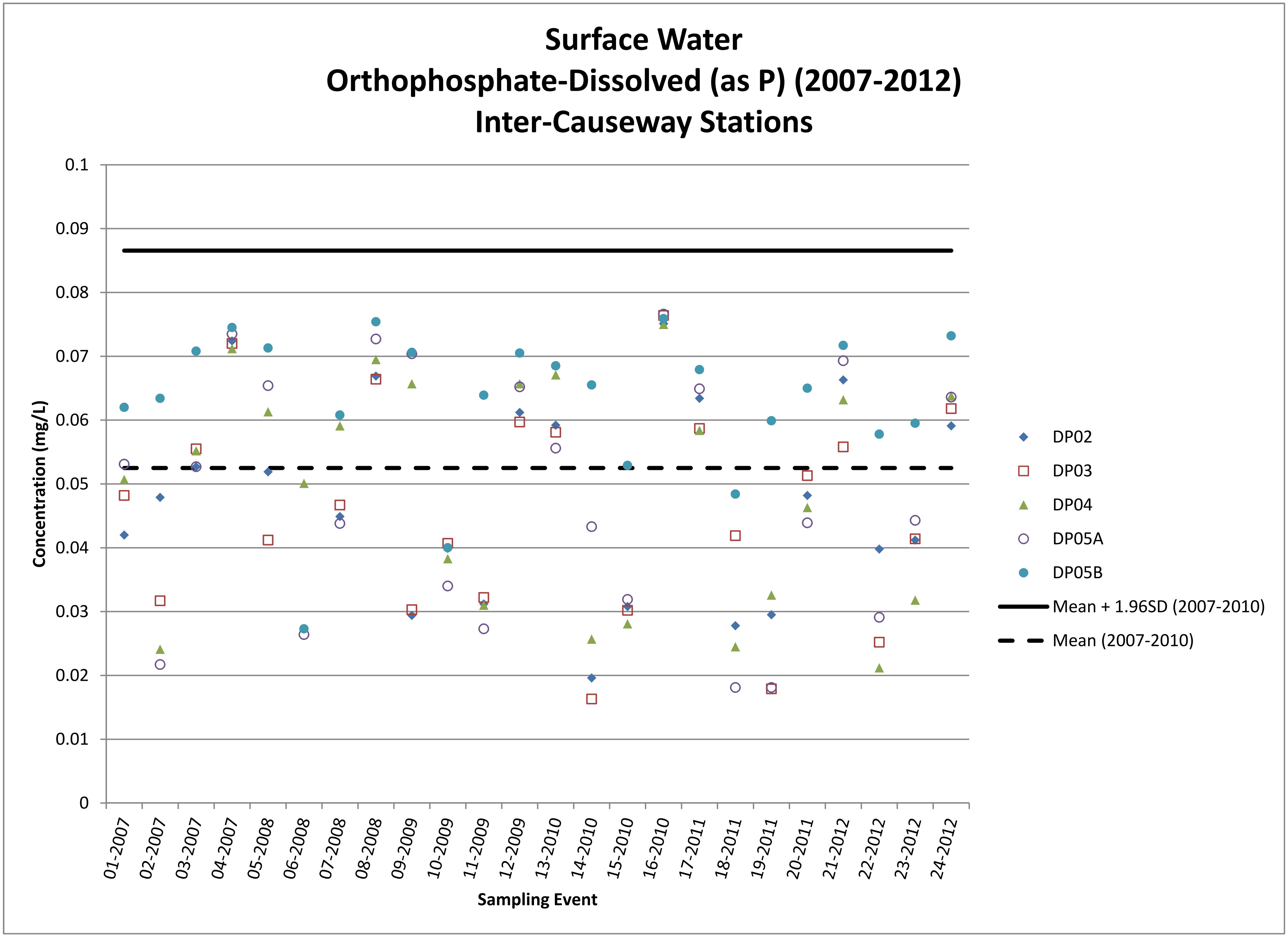
Surface Water
Phosphorus (P)-Total (2007-2012)
Inter-Causeway Stations
Concentration (mg/L)
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
Sampling Event
DP02
DP03
DP04
DP05A
DP05B
Mean + 1.96SD (2007-2010)
Mean (2007-2010)



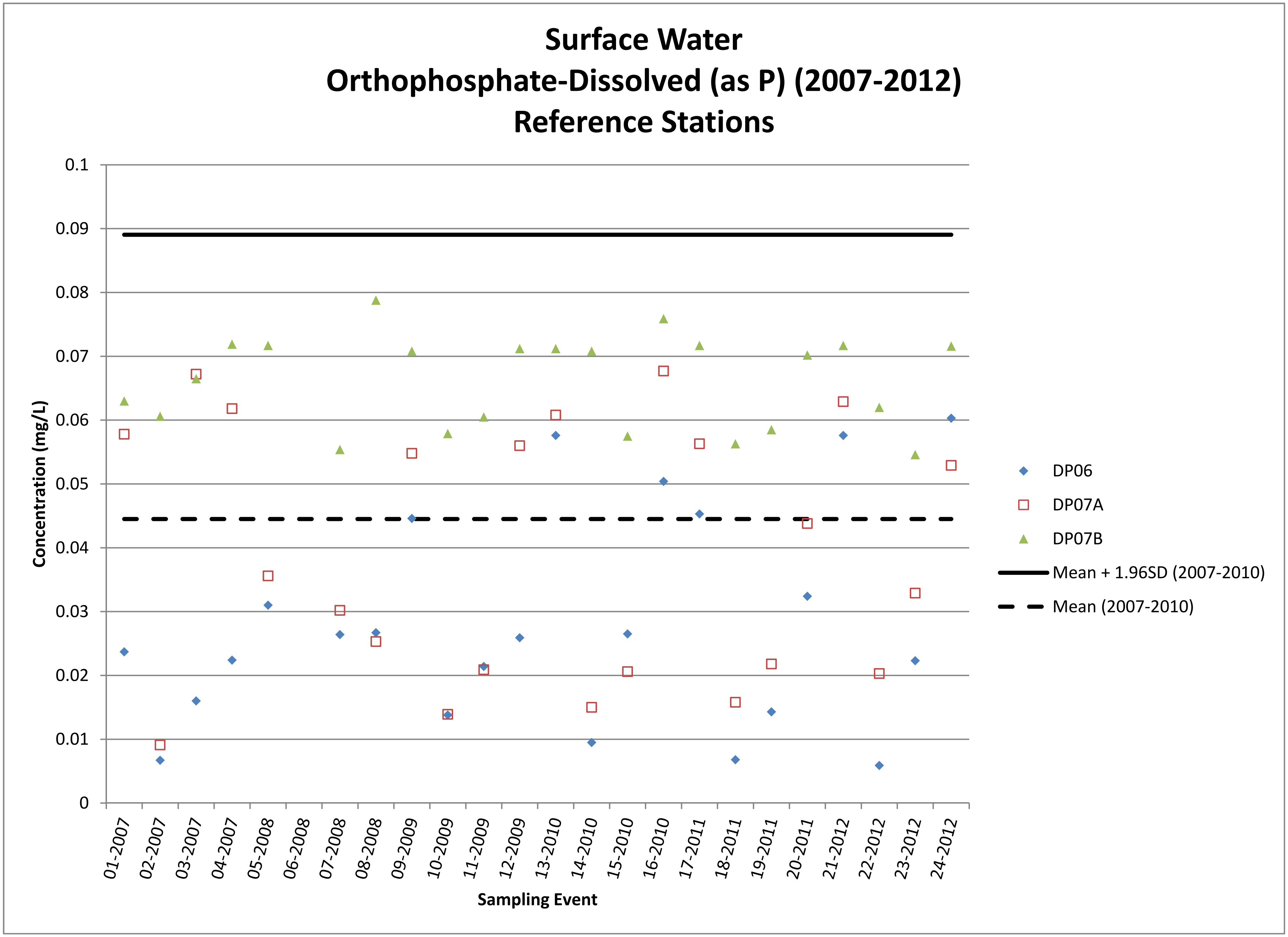
Surface Water
Phosphorus (P)-Total (2007-2012)
Reference Stations
Concentration (mg/L)
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
Sampling Event
DP06
DP07A
DP07B
Mean + 1.96SD (2007-2010)
Mean (2007-2010)

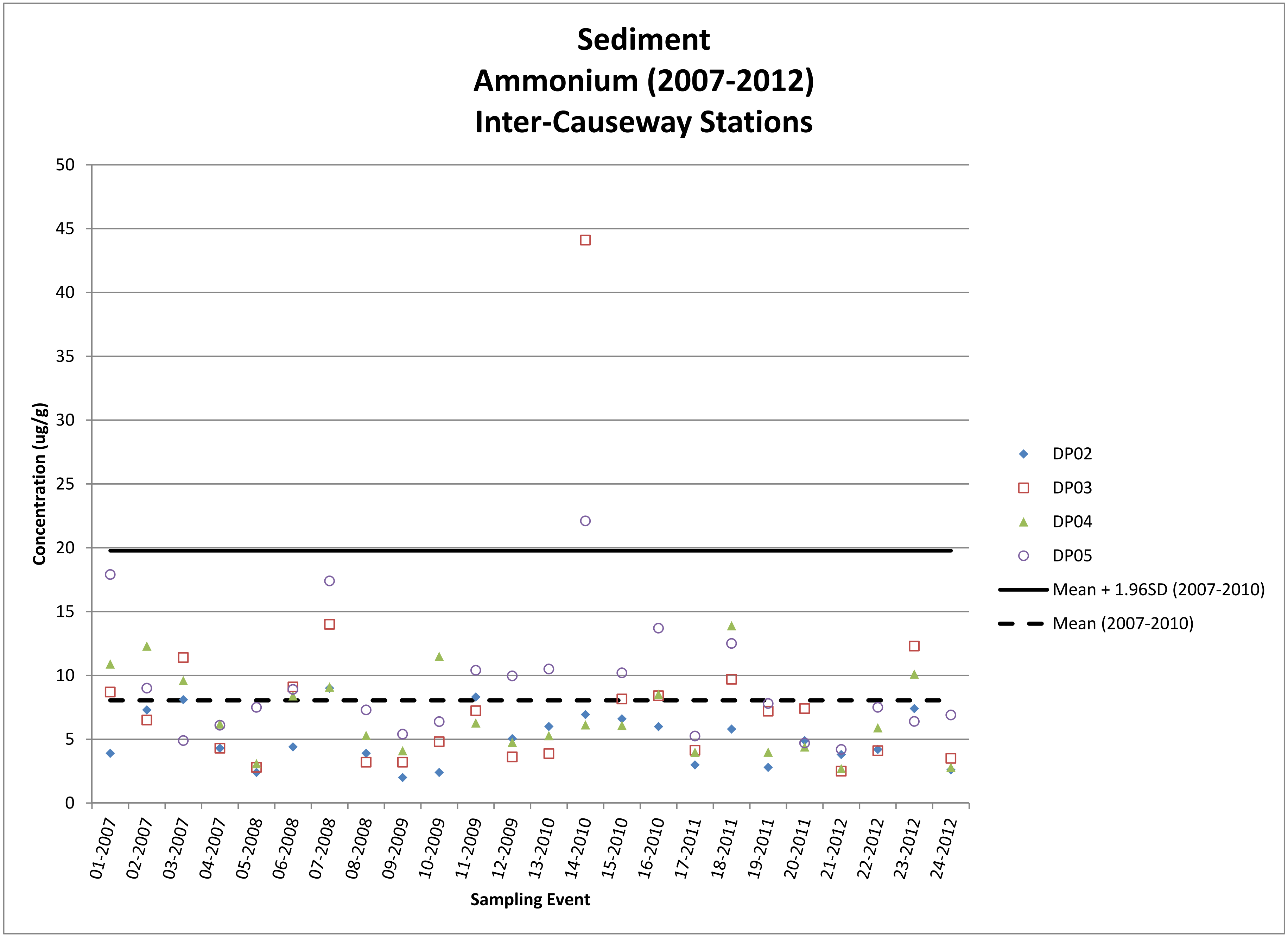

Surface Water
Phosphorus (P)-Total Dissolved (2007-2012)
Inter-Causeway Stations
Concentration (mg/L)
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
Sampling Event
DP02
DP03
DP04
DP05A
DP05B
Mean + 1.96SD (2007-2010)
Mean (2007-2010)

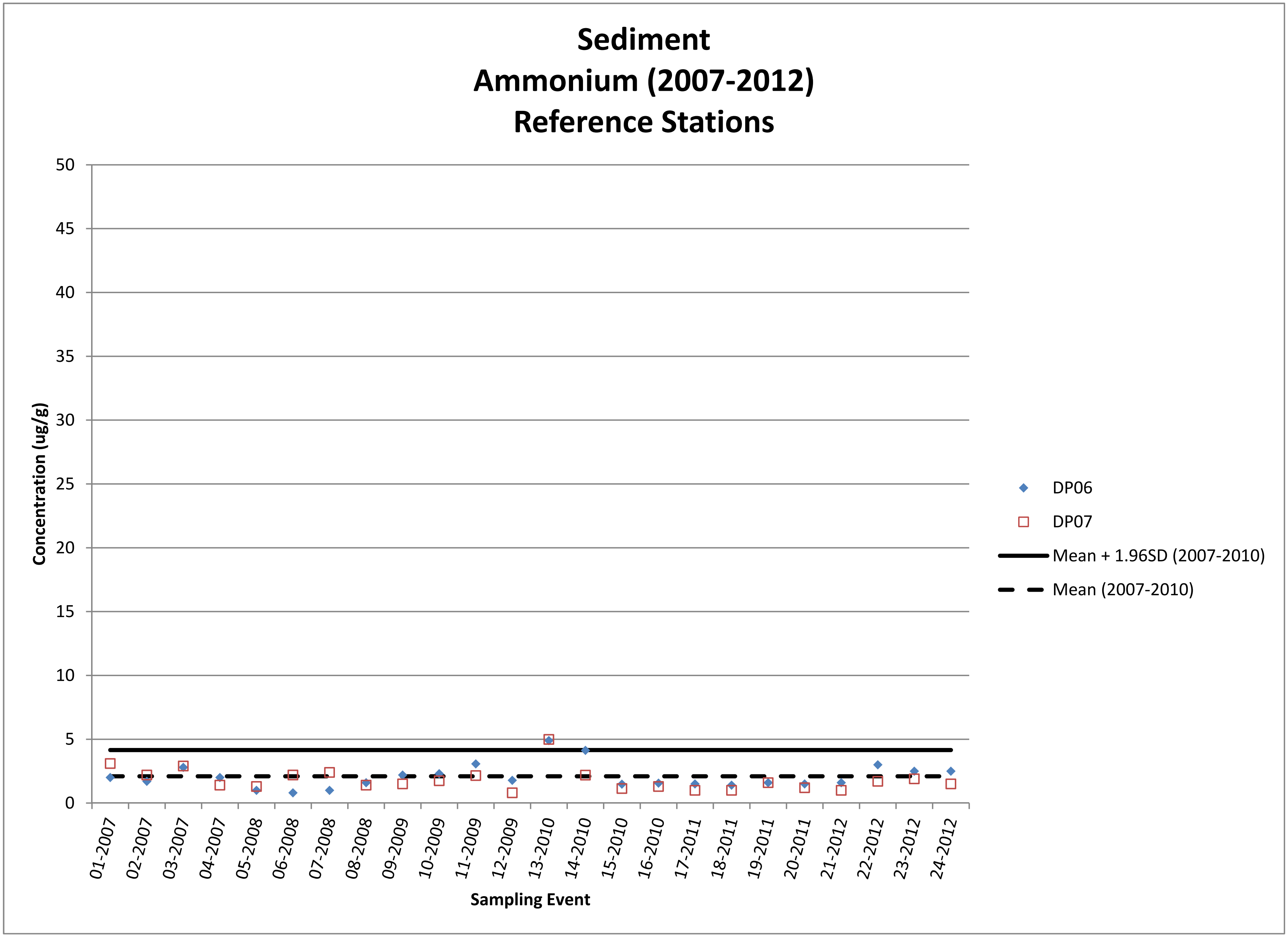

Surface Water
Phosphorus (P)-Total Dissolved (2007-2012)
Reference Stations
Concentration (mg/L)
0
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.08
0.09
0.1
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
Sampling Event
DP06
DP07A
DP07B
Mean + 1.96SD (2007-2010)
Mean (2007-2010)



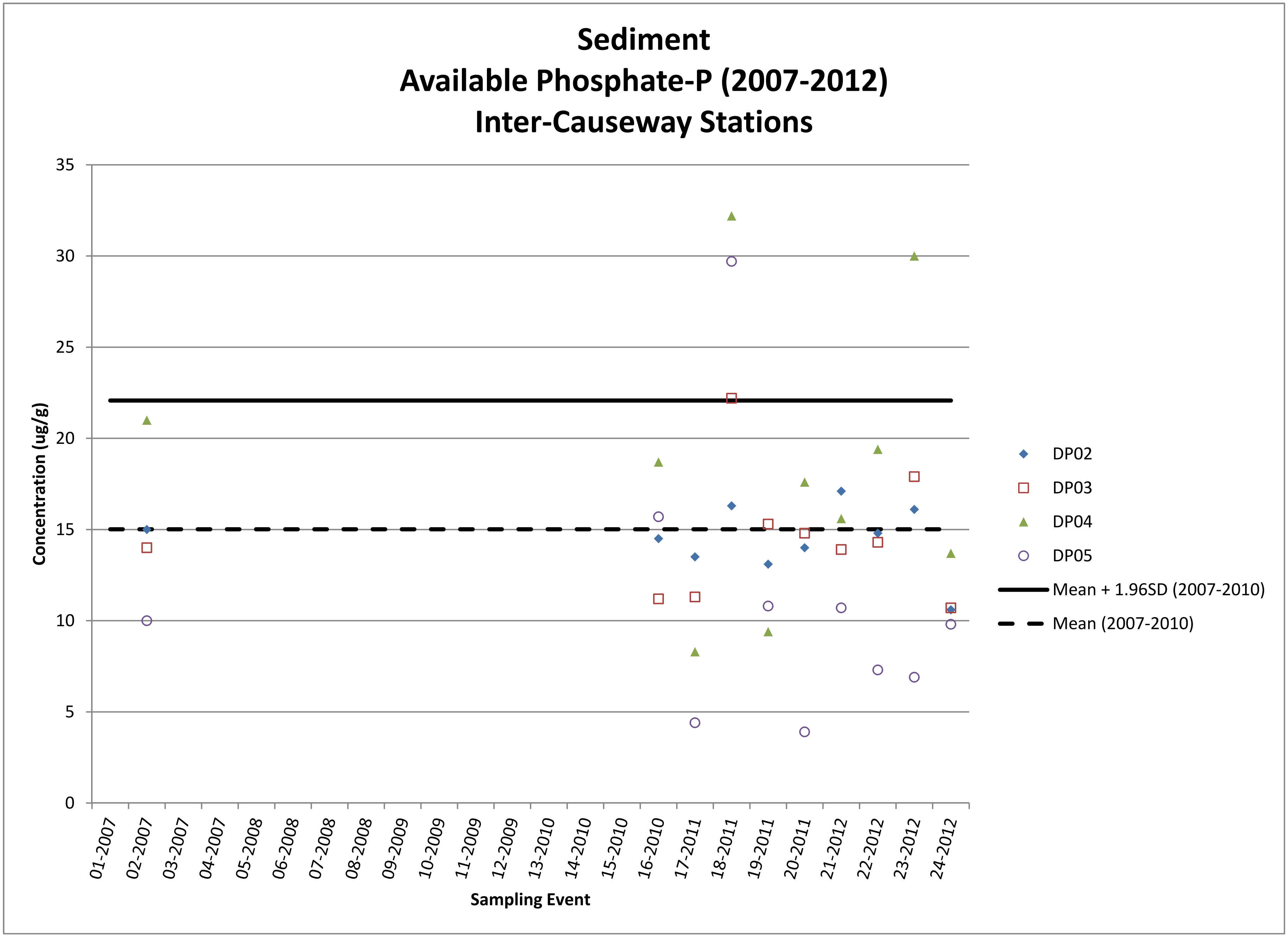
Surface Water
Orthophosphate-Dissolved (as P) (2007-2012)
Inter-Causeway Stations
Concentration (mg/L)
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
Sampling Event
DP02
DP03
DP04
DP05A
DP05B
Mean + 1.96SD (2007-2010)
Mean (2007-2010)

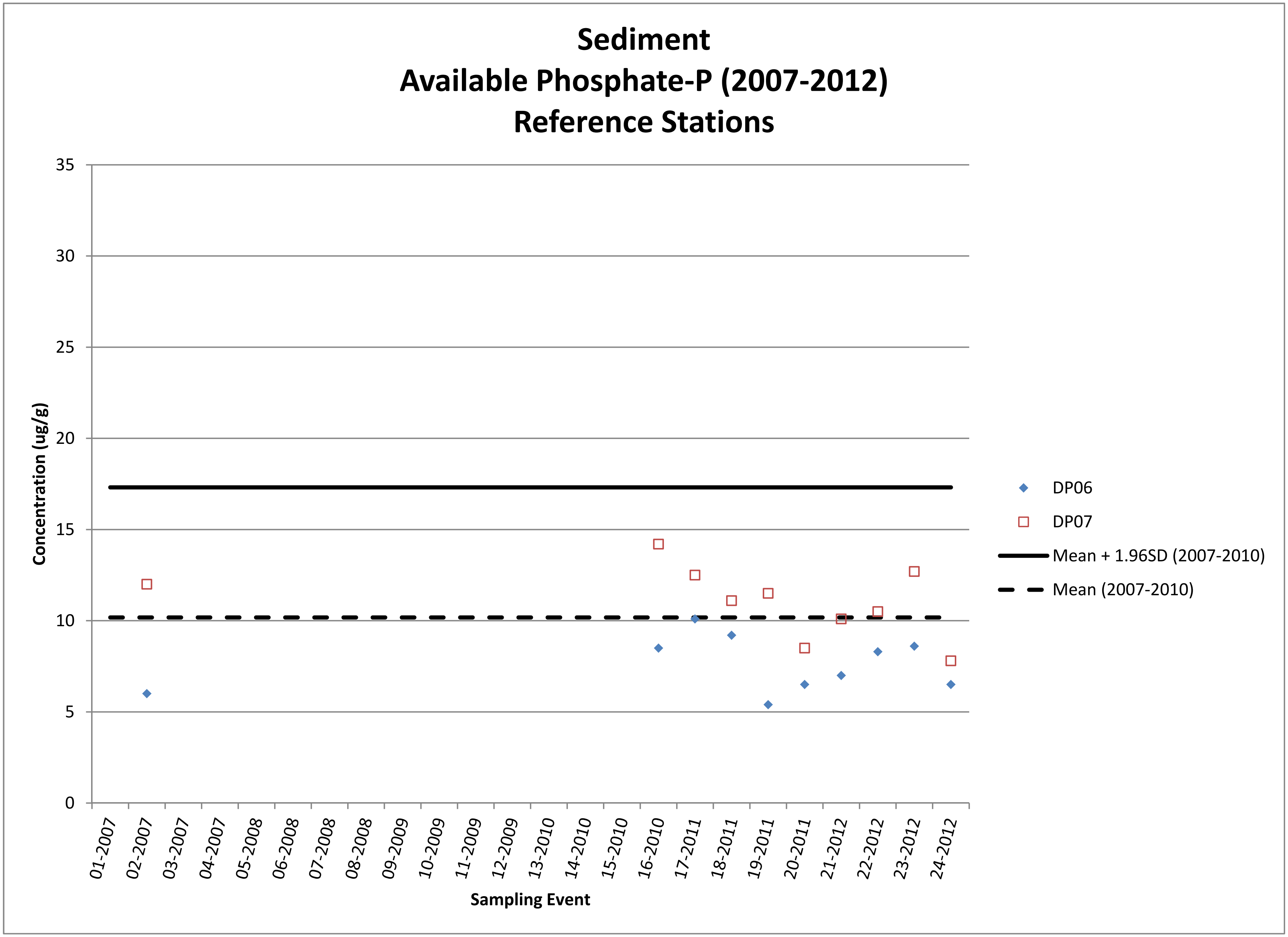

Surface Water
Orthophosphate-Dissolved (as P) (2007-2012)
Reference Stations
Concentration (mg/L)
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
Sampling Event
DP06
DP07A
DP07B
Mean + 1.96SD (2007-2010)
Mean (2007-2010)


Sediment
Ammonium (2007-2012)
Inter-Causeway Stations
Concentration (ug/g)
0
5
10
15
20
25
30
35
40
45
50
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
Sampling Event
DP02
DP03
DP04
DP05
Mean + 1.96SD (2007-2010)
Mean (2007-2010)

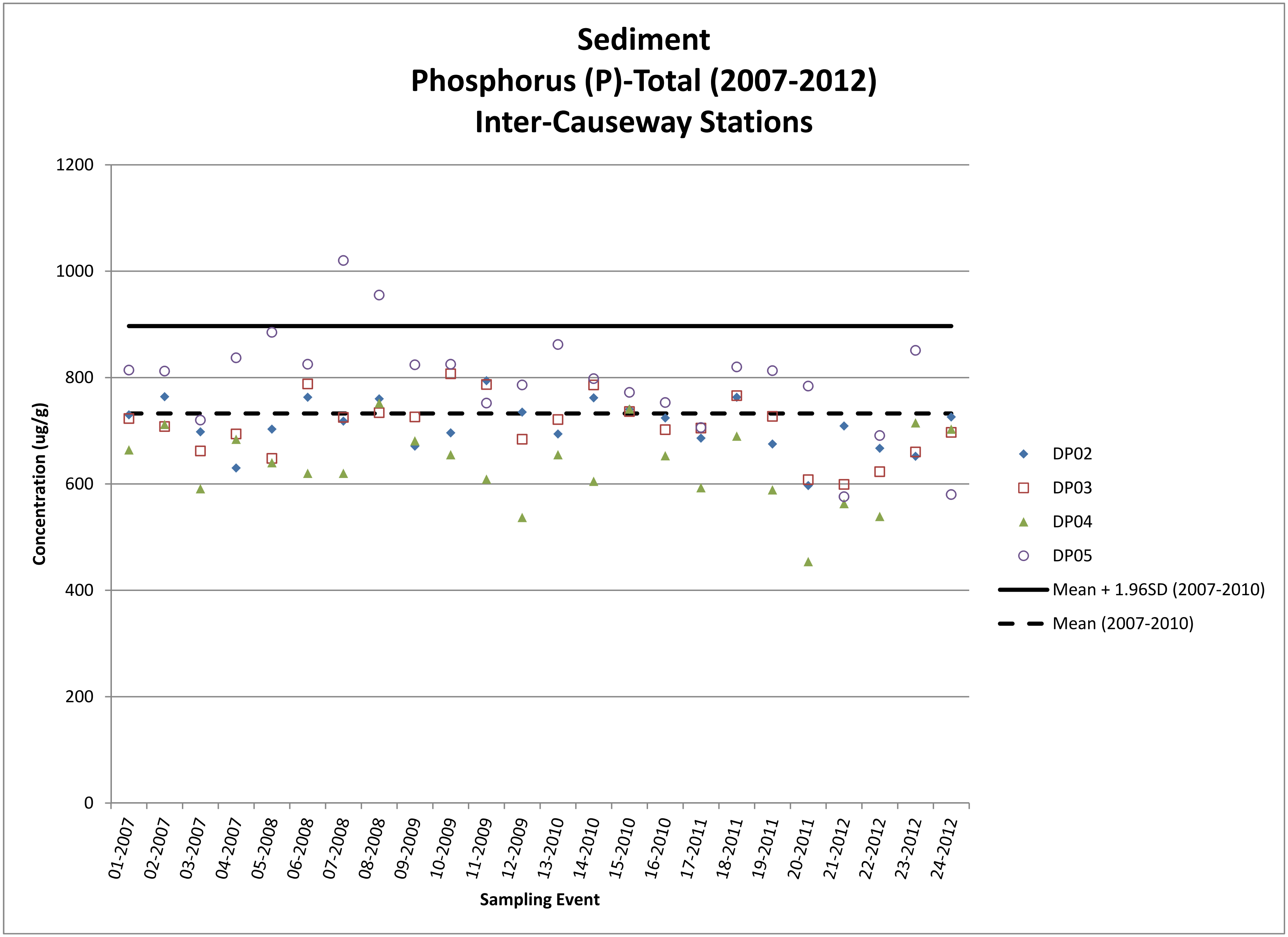


Sediment
Ammonium (2007-2012)
Reference Stations
Concentration (ug/g)
50
45
40
35
30
25
20
15
10
5
0
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
Sampling Event
DP06
DP07
Mean + 1.96SD (2007-2010)
Mean (2007-2010)

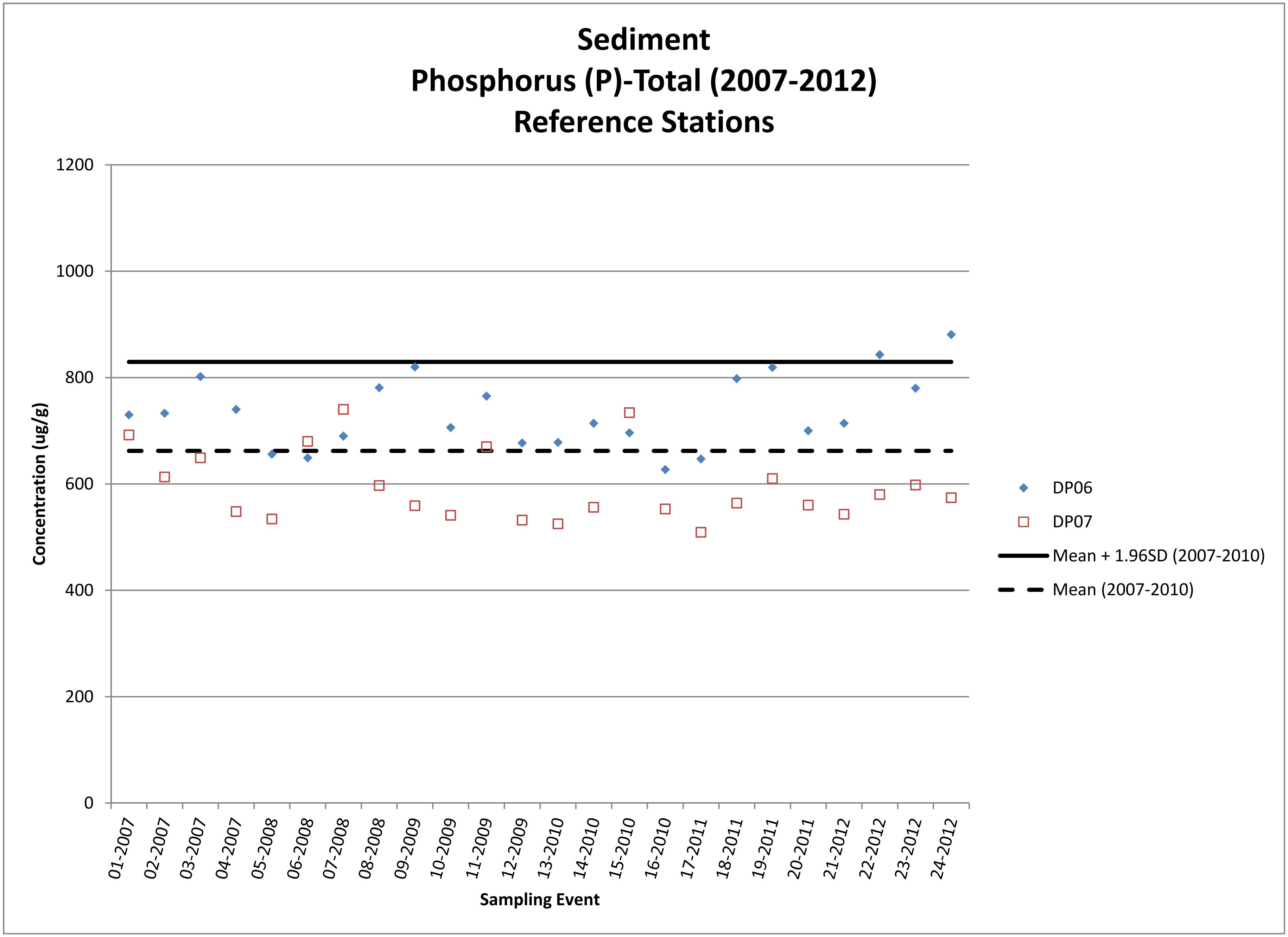

Sediment
Available Phosphate-P (2007-2012)
Inter-Causeway Stations
Concentration (ug/g)
35
30
25
20
15
10
5
0
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
Sampling Event
DP02
DP03
DP04
DP05
Mean + 1.96SD (2007-2010)
Mean (2007-2010)

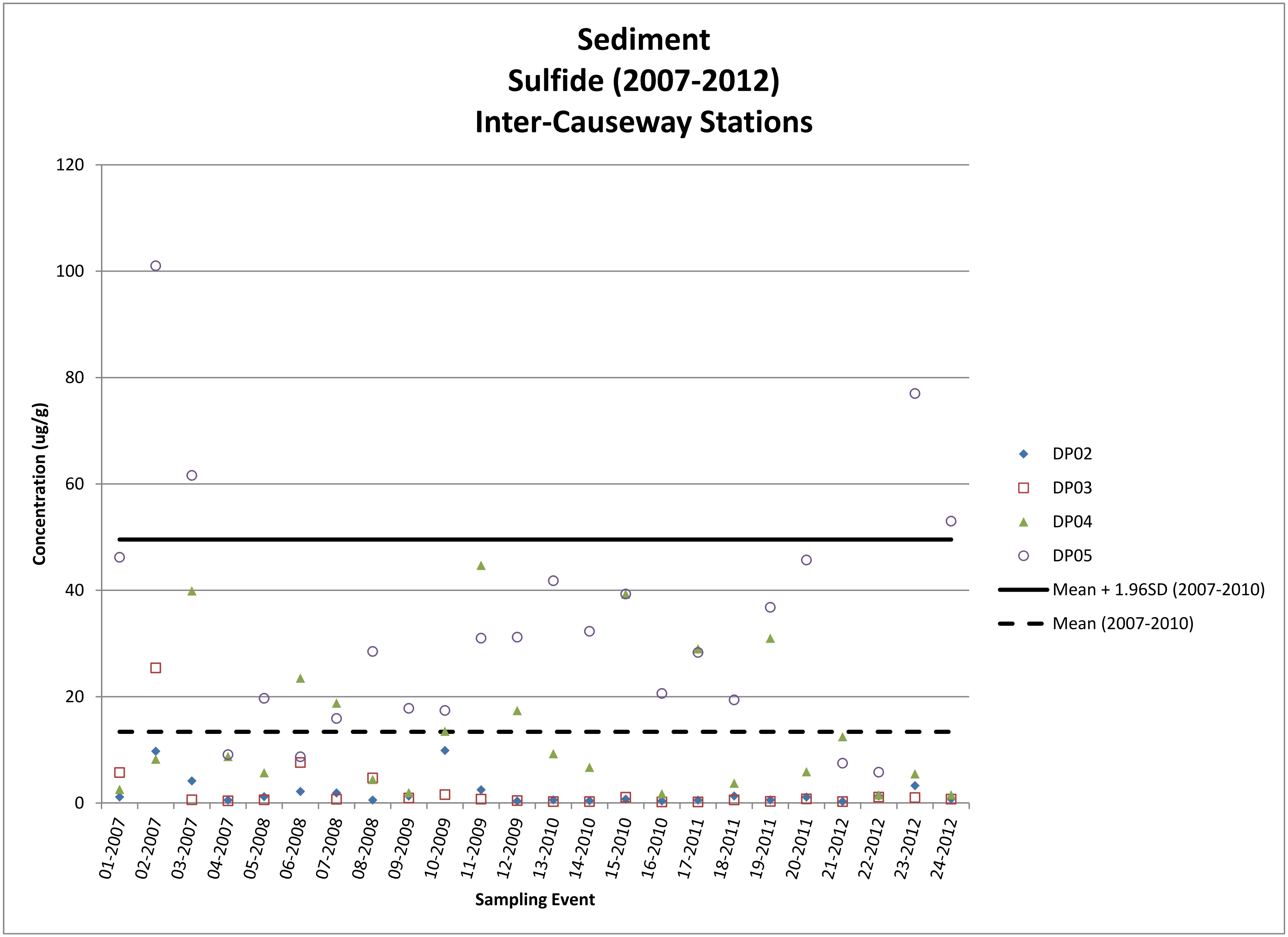


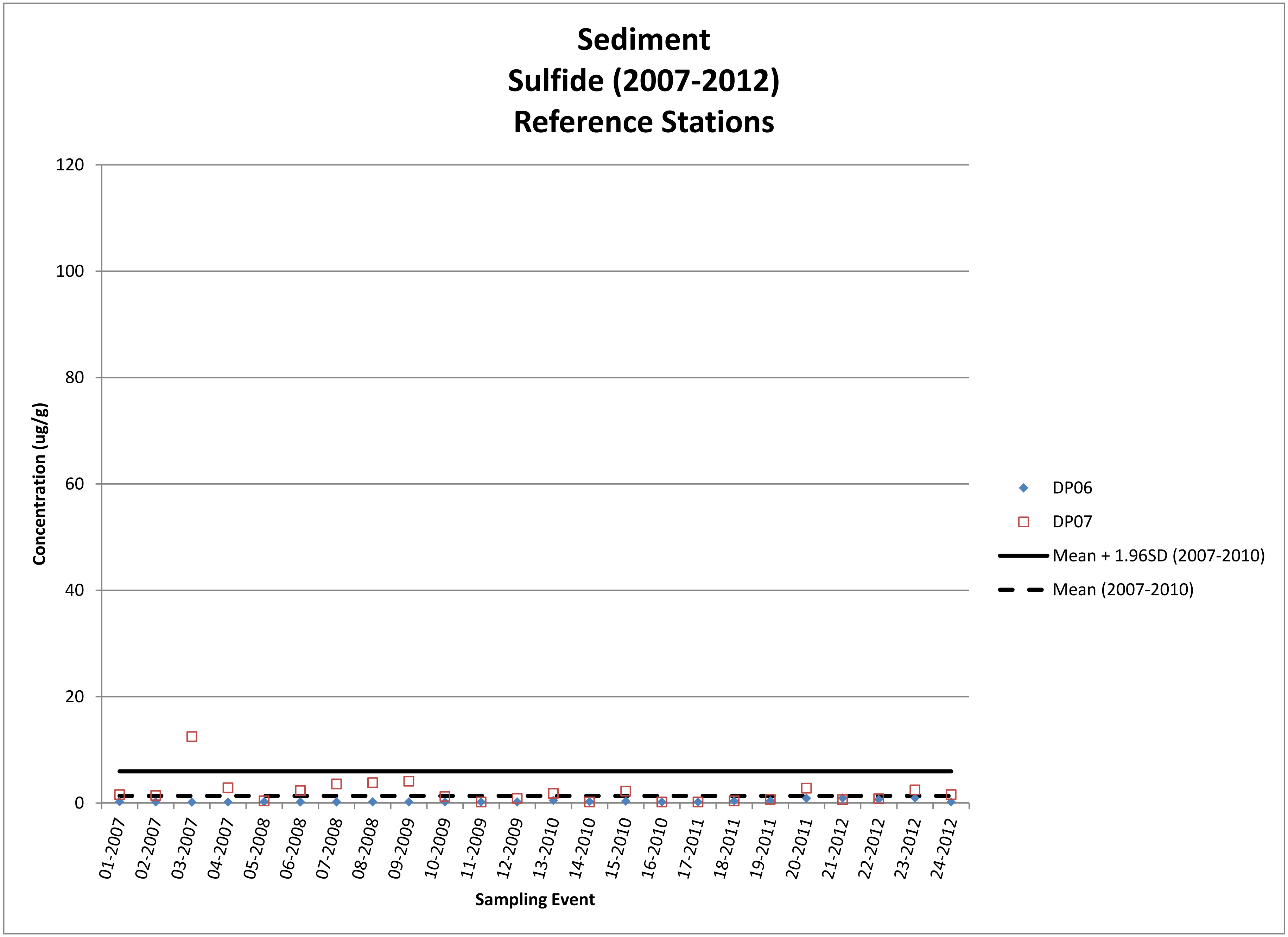
Sediment
Available Phosphate-P (2007-2012)
Reference Stations
Concentration (ug/g)
0
5
10
15
20
25
30
35
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
Sampling Event
DP06
DP07
Mean + 1.96SD (2007-2010)
Mean (2007-2010)



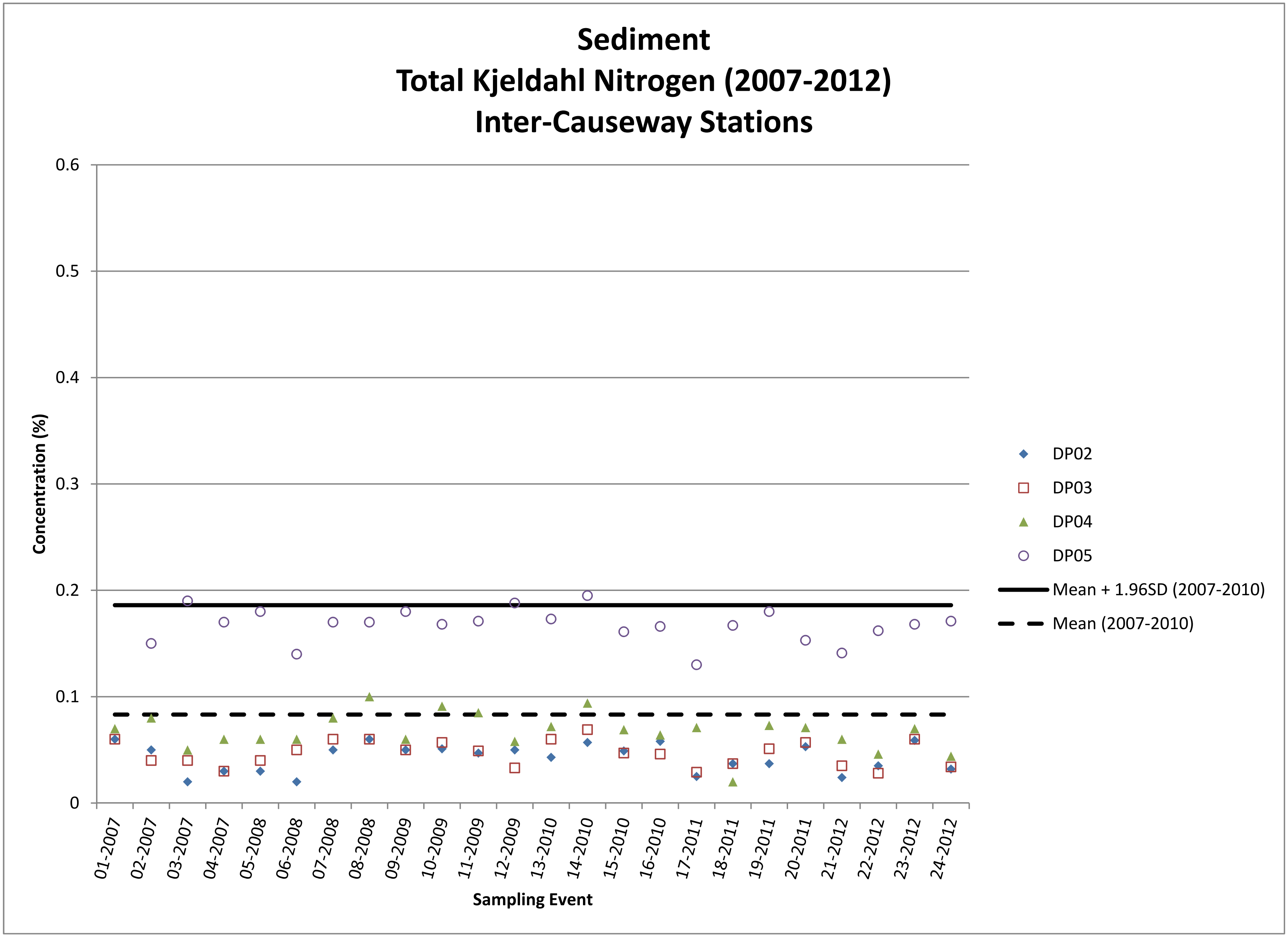
Sediment
Phosphorus (P)-Total (2007-2012)
Inter-Causeway Stations
Concentration (ug/g)
0
200
400
600
800
1000
1200
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
Sampling Event
DP02
DP03
DP04
DP05
Mean + 1.96SD (2007-2010)
Mean (2007-2010)

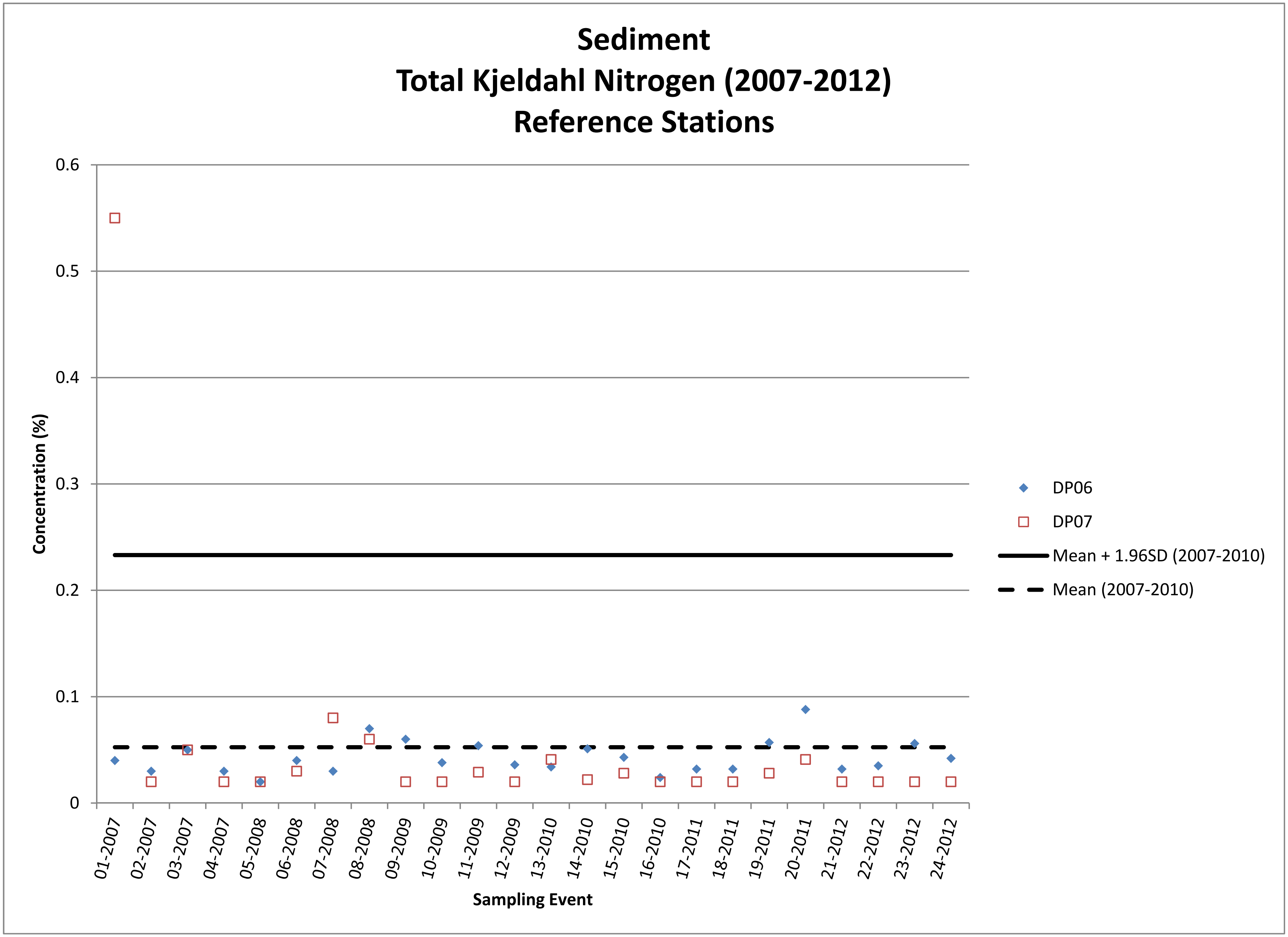

Sediment
Phosphorus (P)-Total (2007-2012)
Reference Stations
Concentration (ug/g)
1200
1000
800
600
400
200
0
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
Sampling Event
DP06
DP07
Mean + 1.96SD (2007-2010)
Mean (2007-2010)

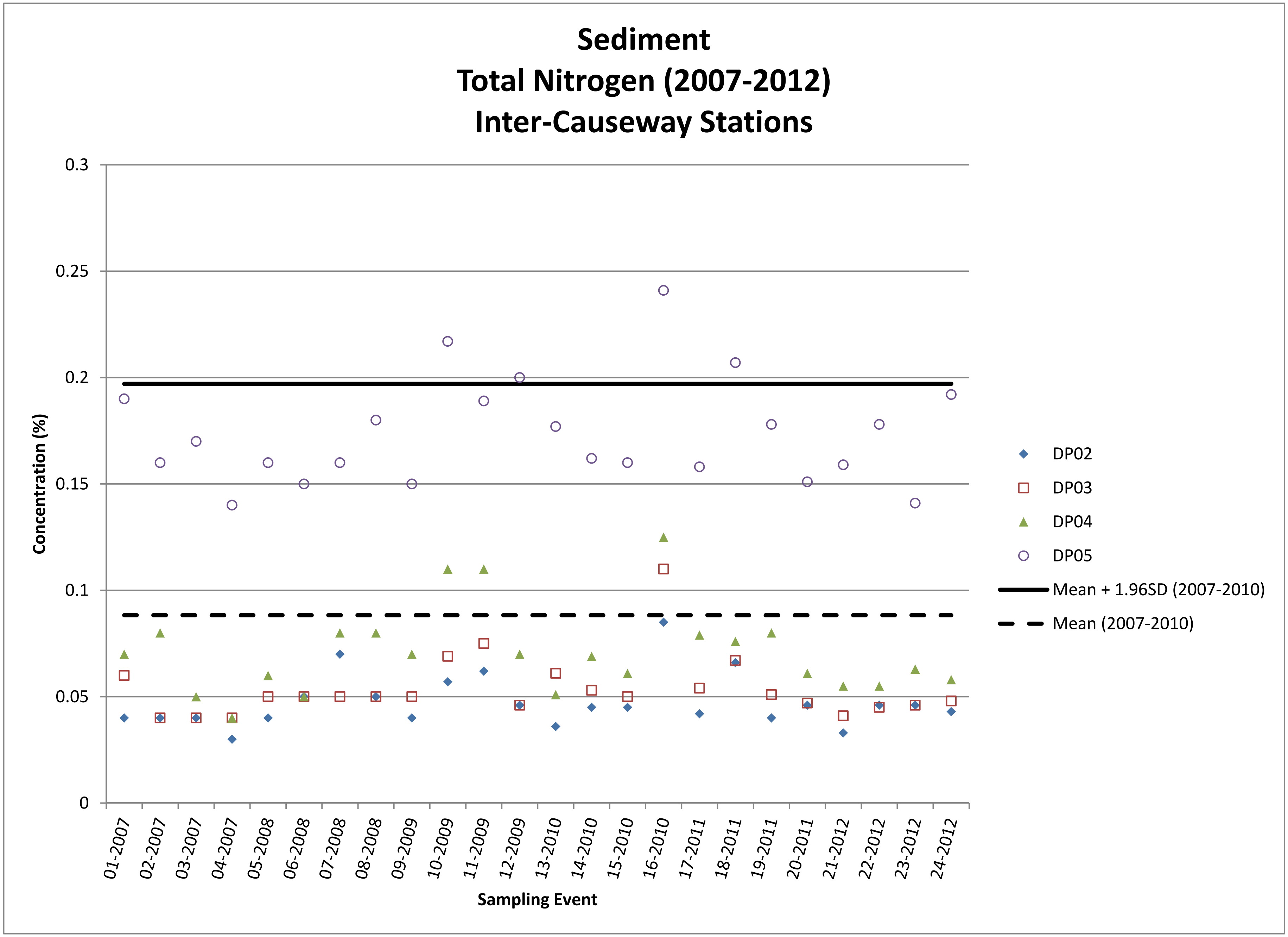

Sediment
Sulfide (2007-2012)
Inter-Causeway Stations
Concentration (ug/g)
0
20
40
60
80
100
120
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
Sampling Event
DP02
DP03
DP04
DP05
Mean + 1.96SD (2007-2010)
Mean (2007-2010)

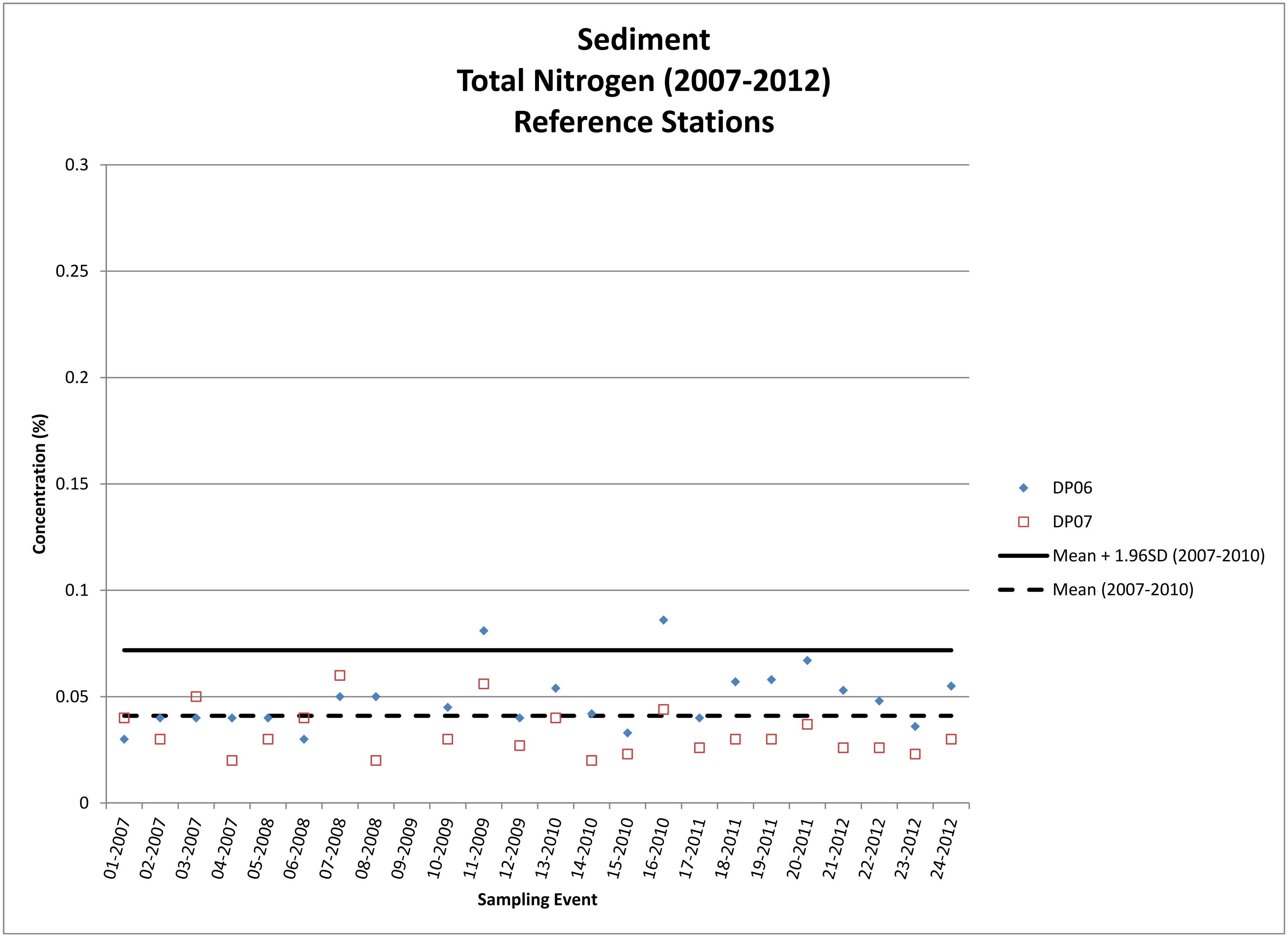


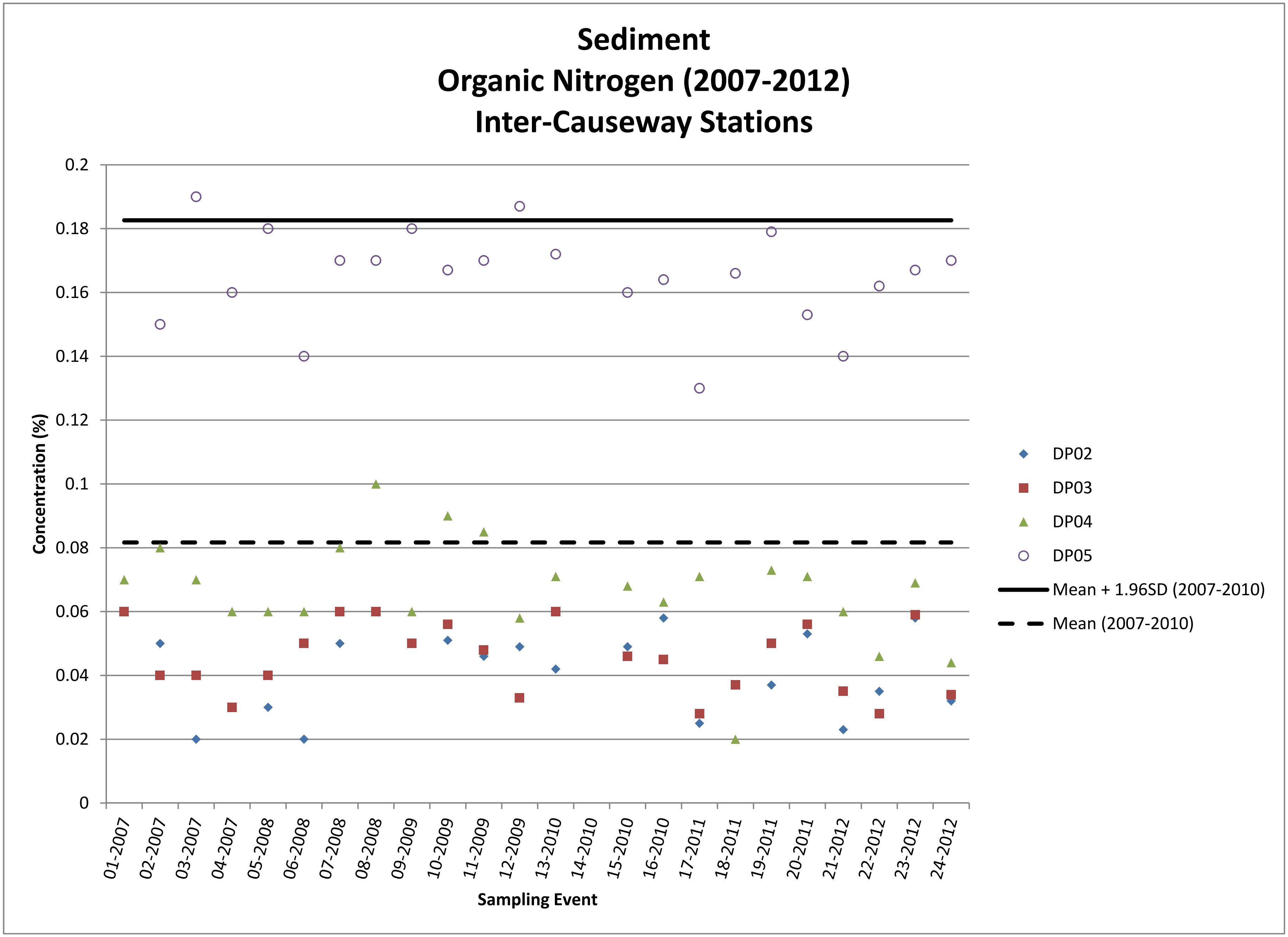
Sediment
Sulfide (2007-2012)
Reference Stations
Concentration (ug/g)
120
100
80
60
40
20
0
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
Sampling Event
DP06
DP07
Mean + 1.96SD (2007-2010)
Mean (2007-2010)

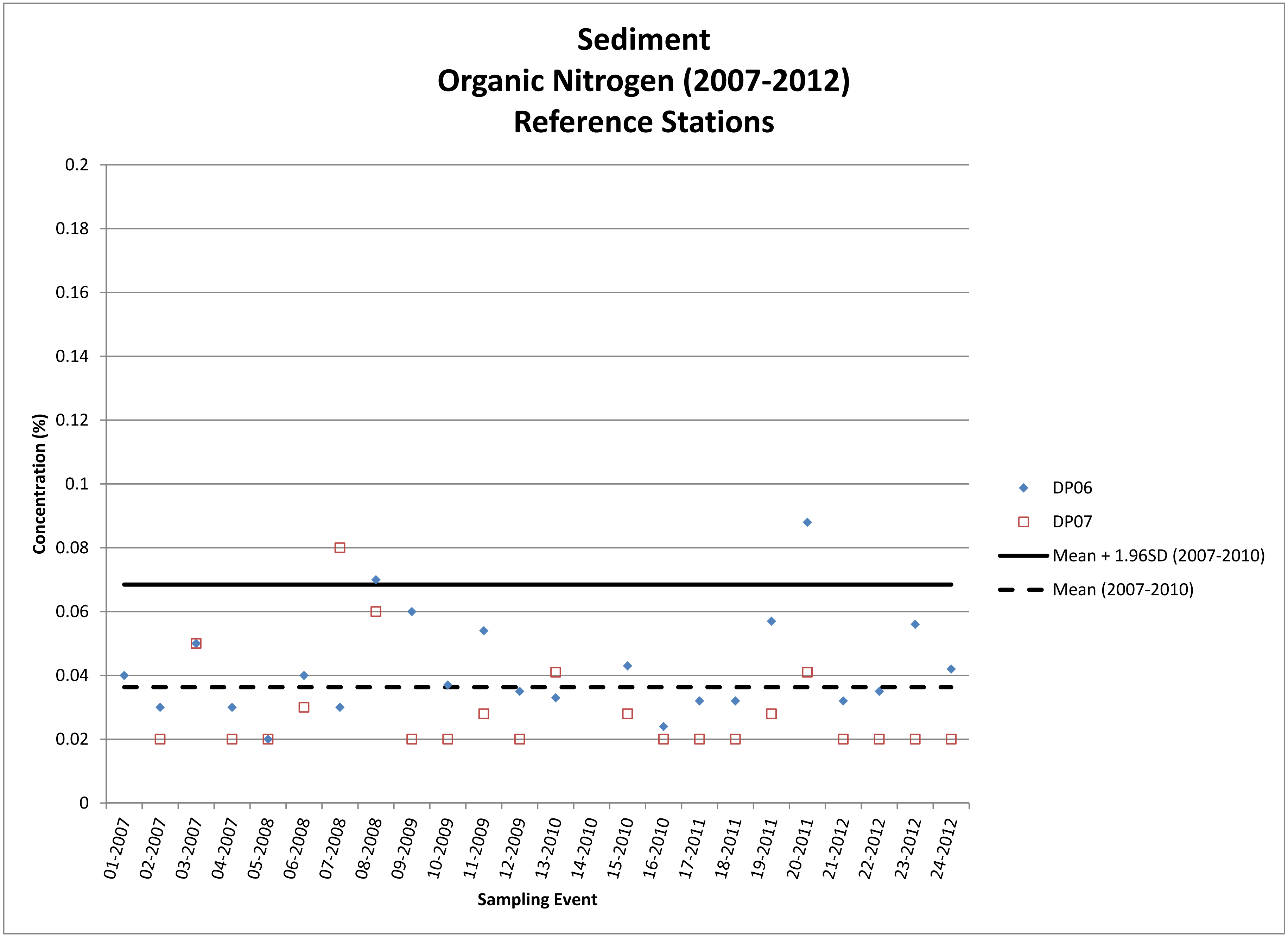

Sediment
Total Kjeldahl Nitrogen (2007-2012)
Inter-Causeway Stations
Concentration (%)
0.6
0.5
0.4
0.3
0.2
0.1
0
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
Sampling Event
DP02
DP03
DP04
DP05
Mean + 1.96SD (2007-2010)
Mean (2007-2010)


Sediment
Total Kjeldahl Nitrogen (2007-2012)
Reference Stations
Concentration (%)
0.6
0.5
0.4
0.3
0.2
0.1
0
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
Sampling Event
DP06
DP07
Mean + 1.96SD (2007-2010)
Mean (2007-2010)

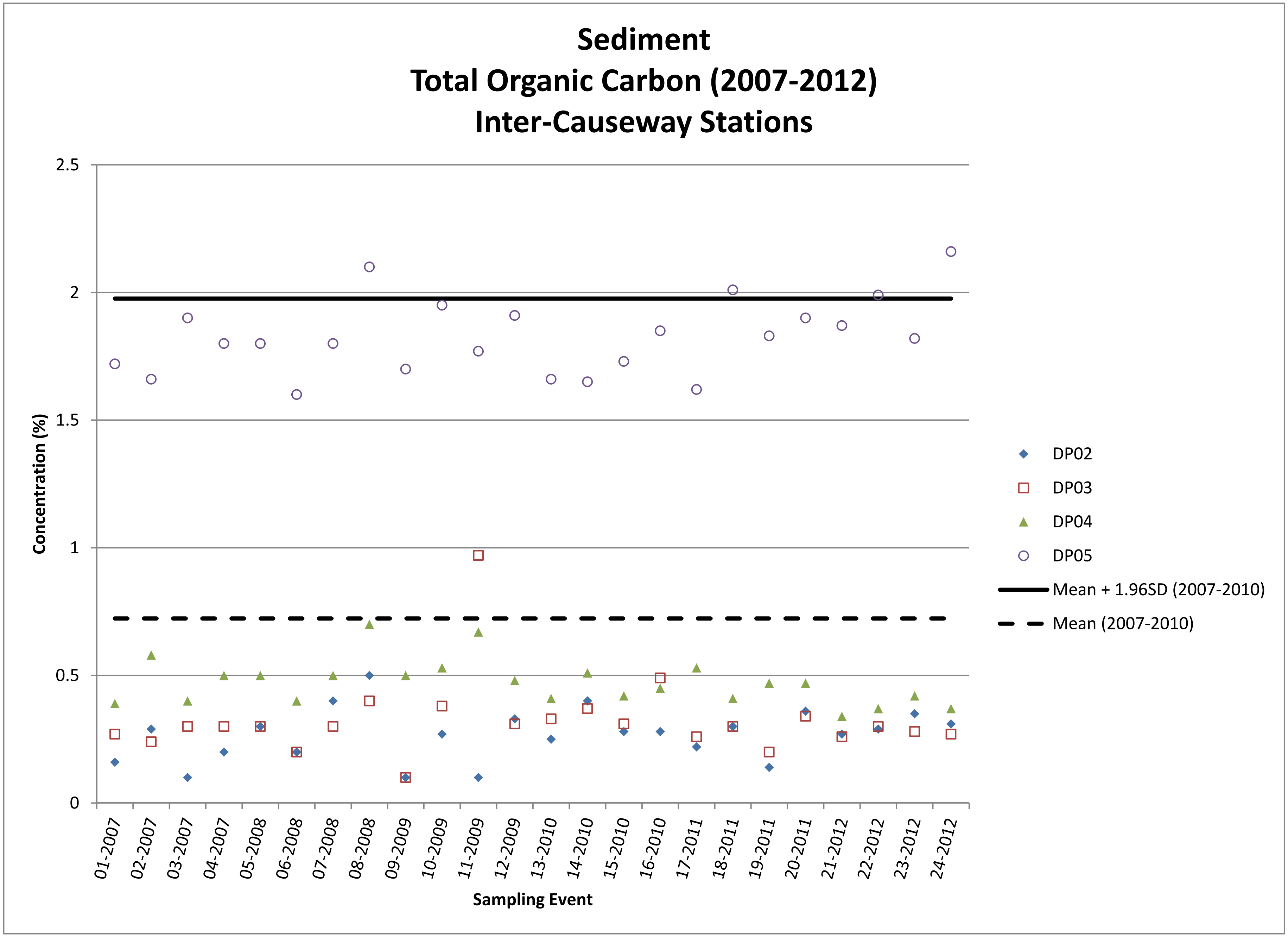

Sediment
Total Nitrogen (2007-2012)
Inter-Causeway Stations
Concentration (%)
0.3
0.25
0.2
0.15
0.1
0.05
0
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
Sampling Event
DP02
DP03
DP04
DP05
Mean + 1.96SD (2007-2010)
Mean (2007-2010)

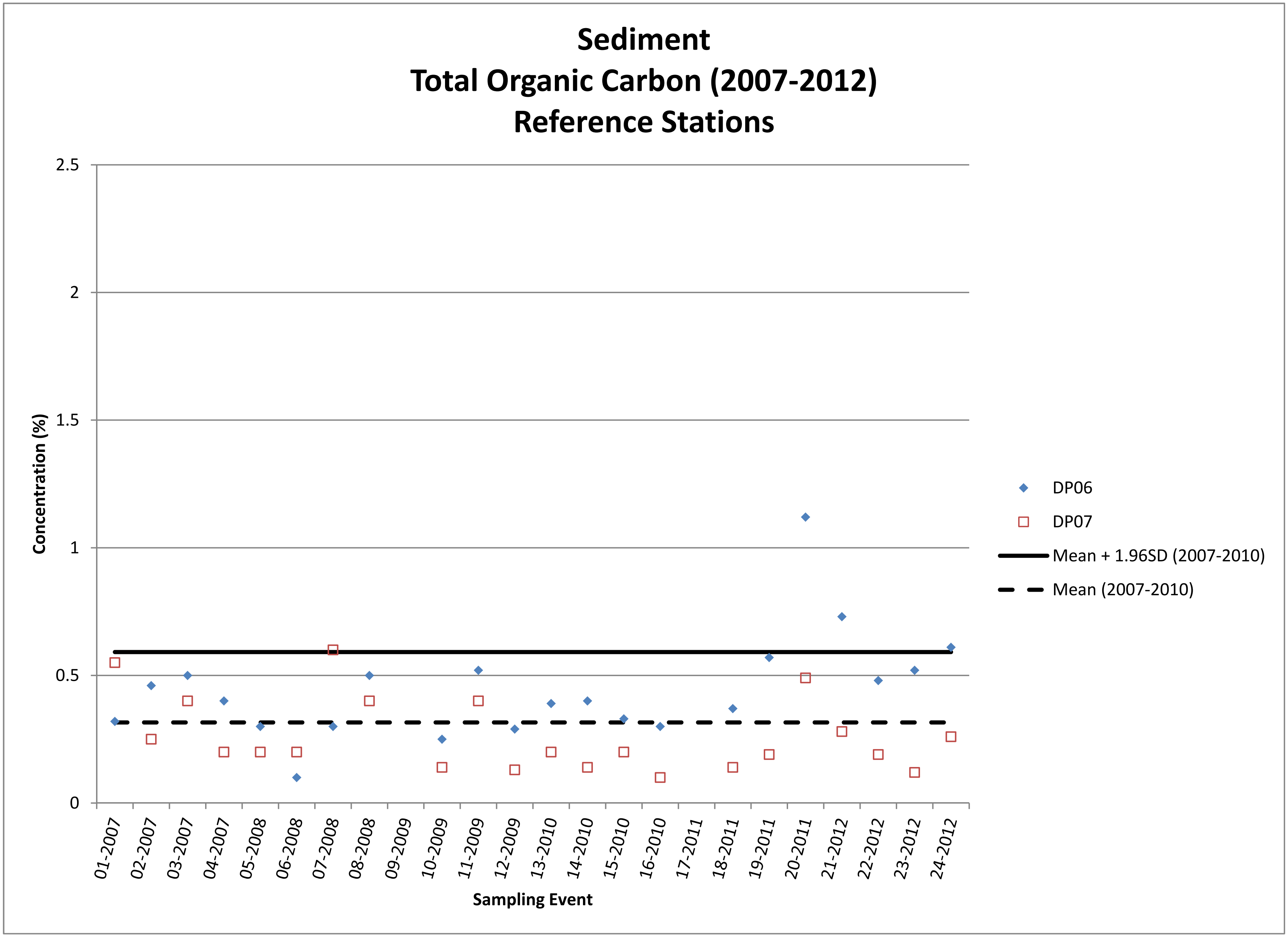

Sediment
Total Nitrogen (2007-2012)
Reference Stations
Concentration (%)
0.3
0.25
0.2
0.15
0.1
0.05
0
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
Sampling Event
DP06
DP07
Mean + 1.96SD (2007-2010)
Mean (2007-2010)


Sediment
Organic Nitrogen (2007-2012)
Inter-Causeway Stations
Concentration (%)
Sampling Event
DP02
DP03
DP04
DP05
Mean + 1.96SD (2007-2010)
Mean (2007-2010)
0
0.02
0.04
0.06
0.08
0.1
0.12
0.14
0.16
0.18
0.2
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012

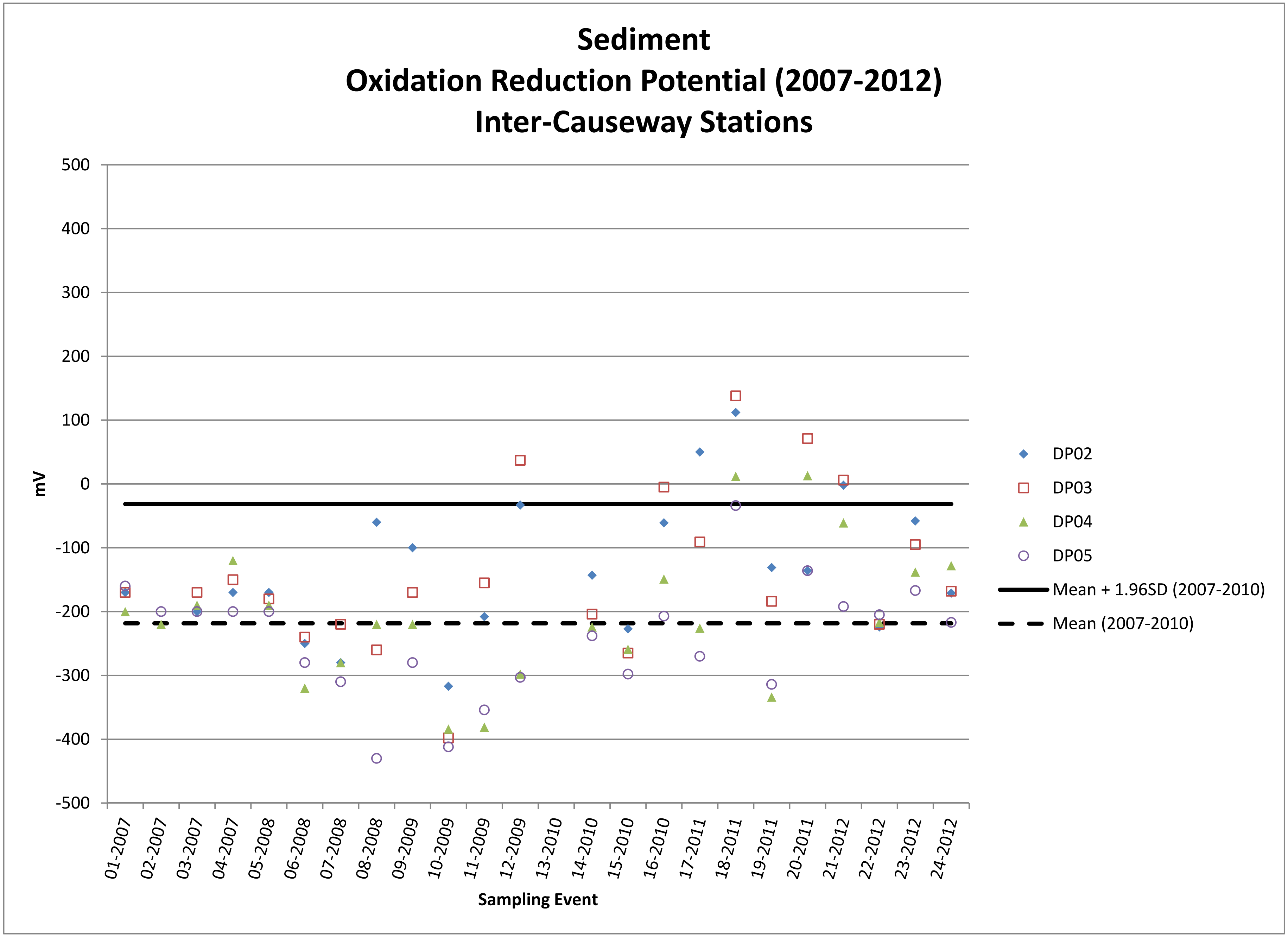


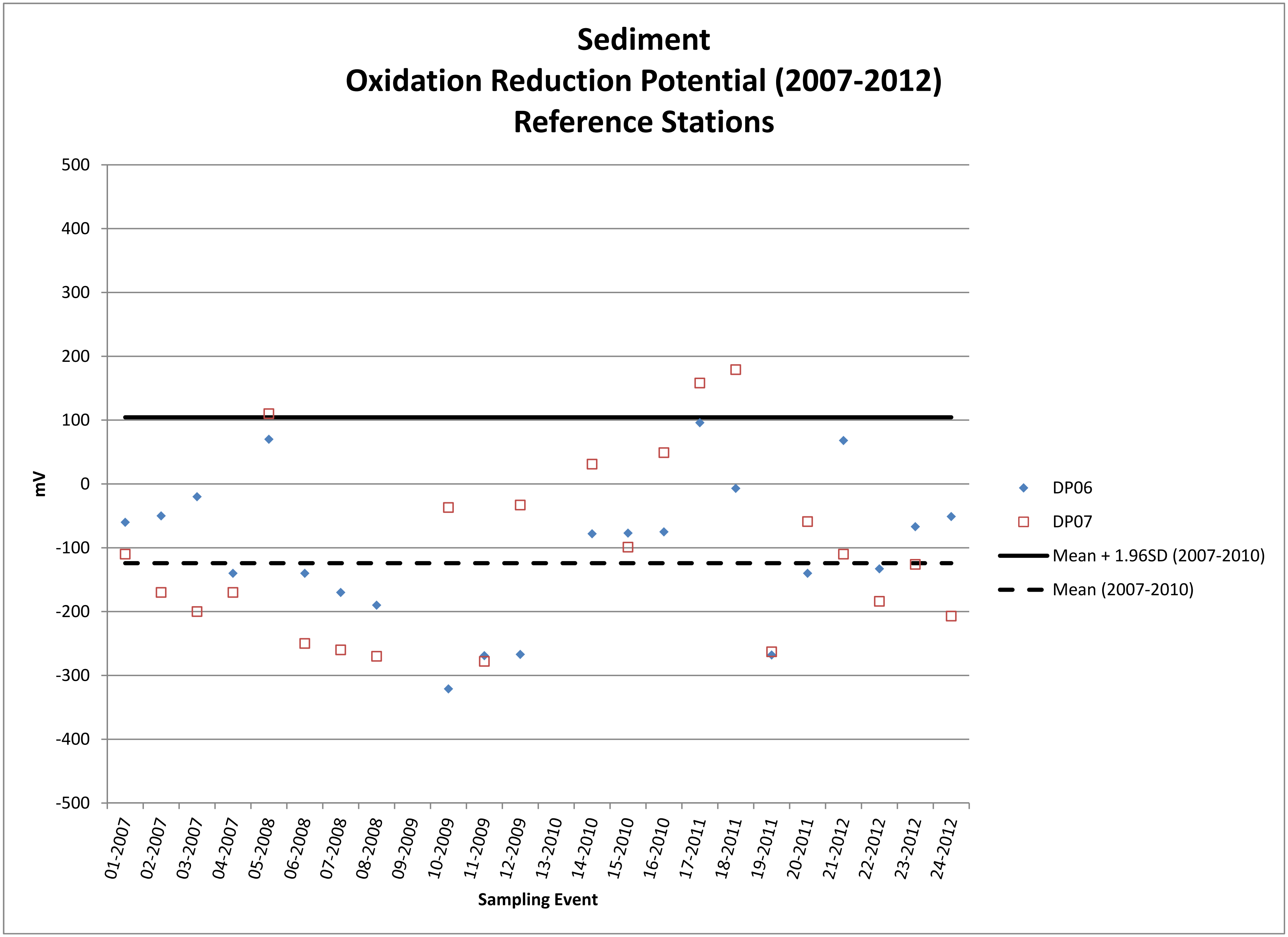
Sediment
Organic Nitrogen (2007-2012)
Reference Stations
Concentration (%)
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
Sampling Event
DP06
DP07
Mean + 1.96SD (2007-2010)
Mean (2007-2010)

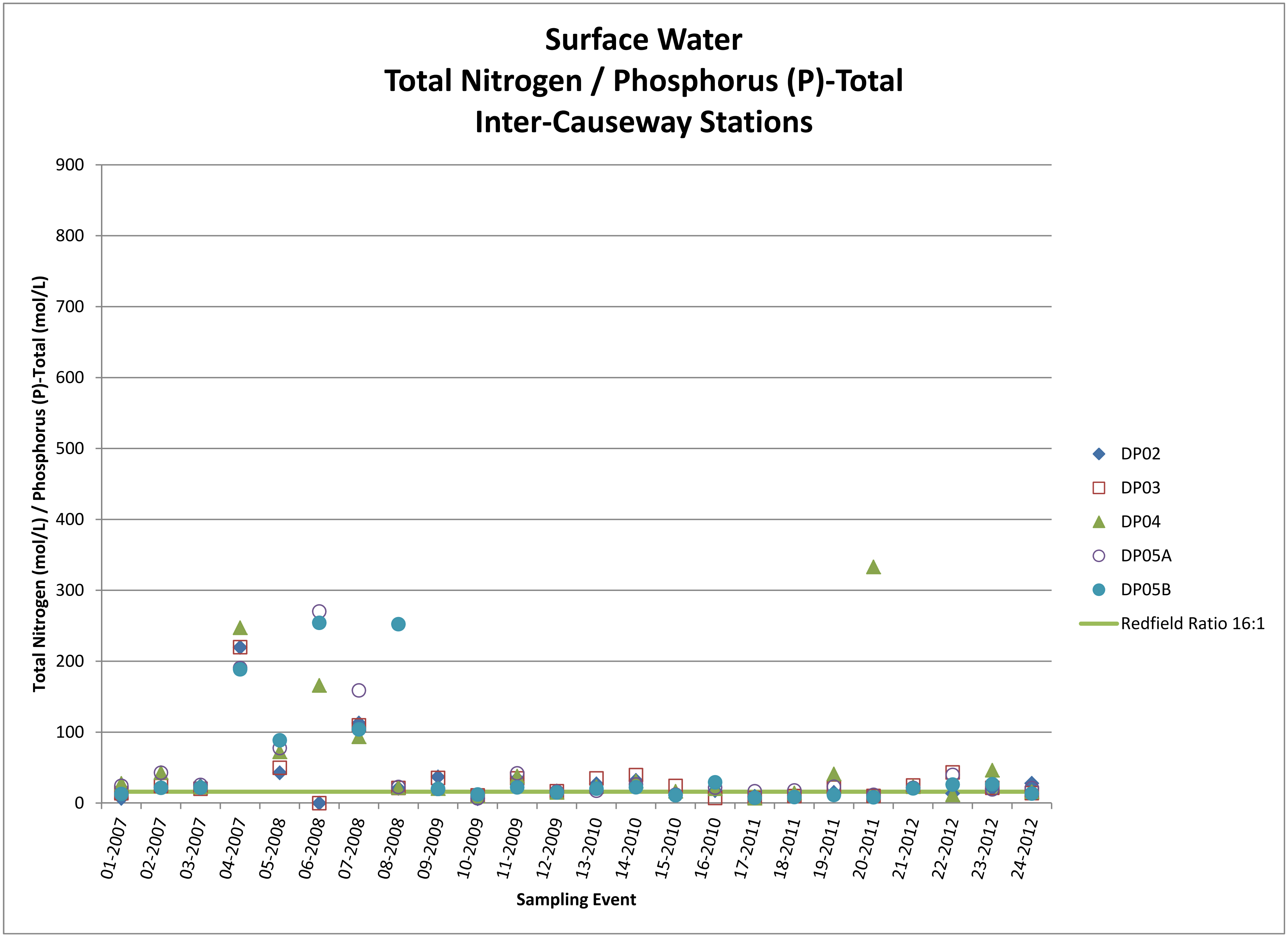

Sediment
Total Organic Carbon (2007-2012)
Inter-Causeway Stations
Concentration (%)
0
0.5
1
1.5
2
2.5
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
Sampling Event
DP02
DP03
DP04
DP05
Mean + 1.96SD (2007-2010)
Mean (2007-2010)



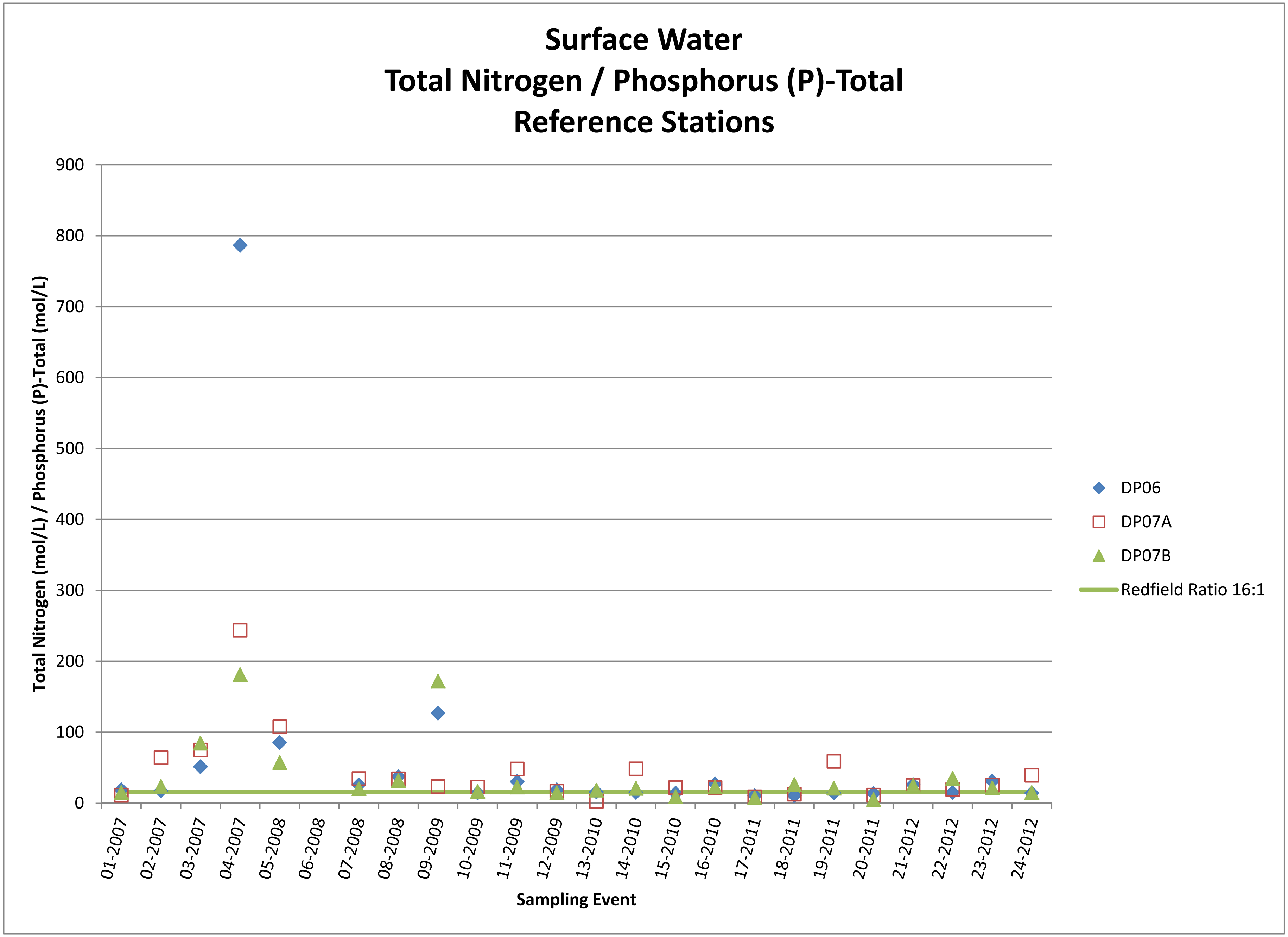
Sediment
Total Organic Carbon (2007-2012)
Reference Stations
Concentration (%)
2.5
2
1.5
1
0.5
0
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
Sampling Event
DP06
DP07
Mean + 1.96SD (2007-2010)
Mean (2007-2010)

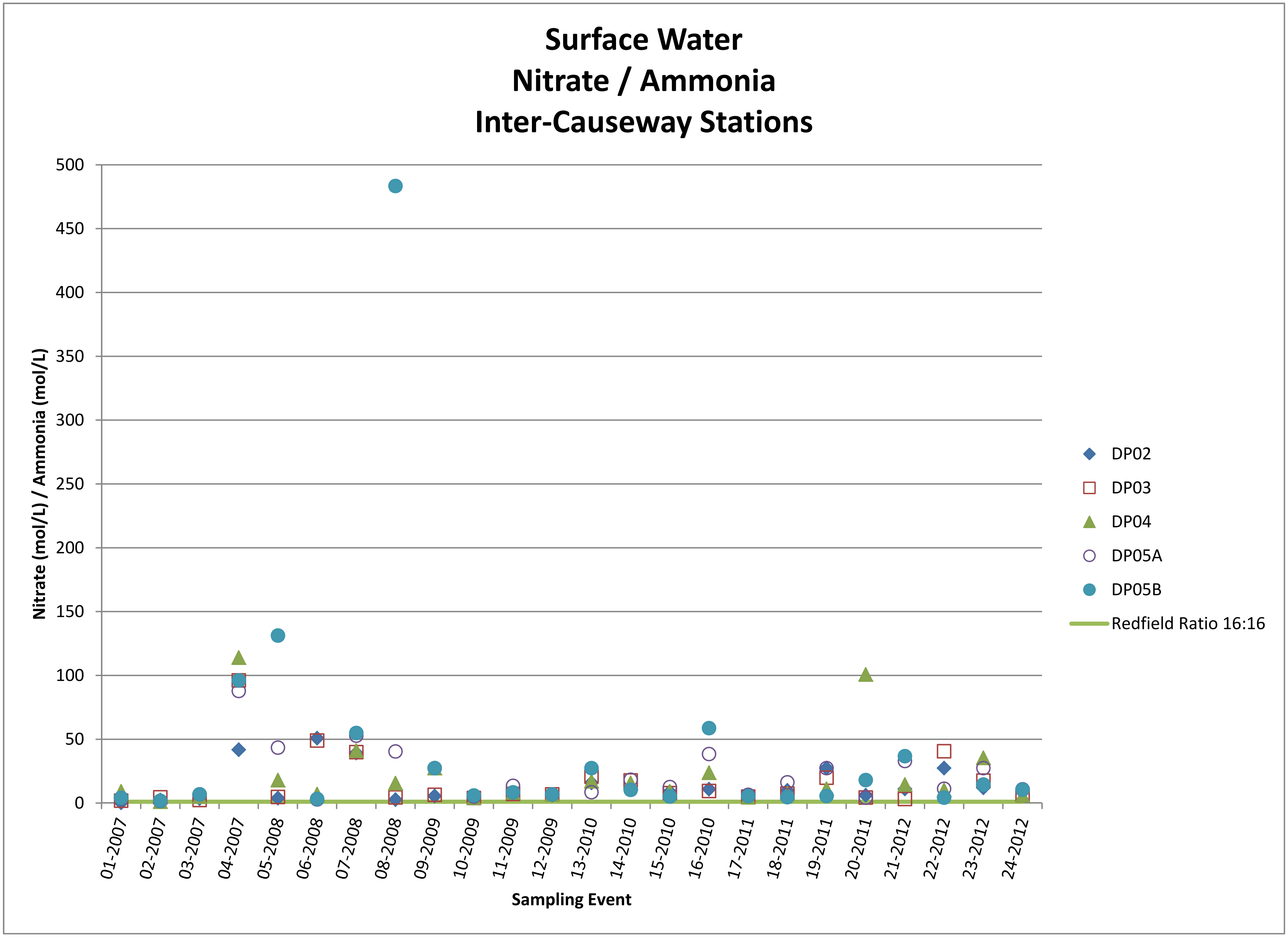

Sediment
Oxidation Reduction Potential (2007-2012)
Inter-Causeway Stations
mV
500
400
300
200
100
0
-100
-200
-300
-400
-500
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
Sampling Event
DP02
DP03
DP04
DP05
Mean + 1.96SD (2007-2010)
Mean (2007-2010)

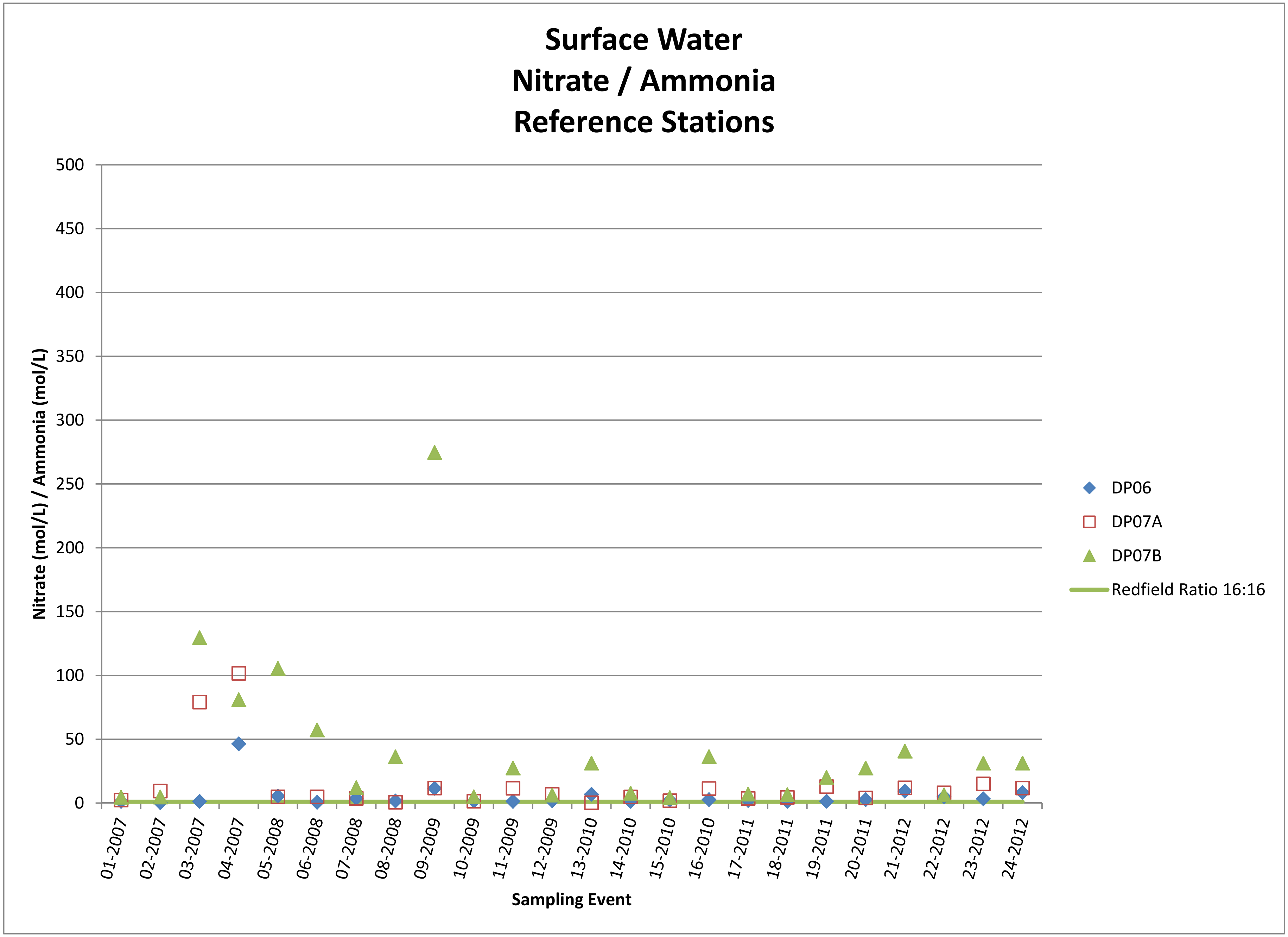

Sediment
Oxidation Reduction Potential (2007-2012)
Reference Stations
mV
500
400
300
200
100
0
-100
-200
-300
-400
-500
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
Sampling Event
DP06
DP07
Mean + 1.96SD (2007-2010)
Mean (2007-2010)



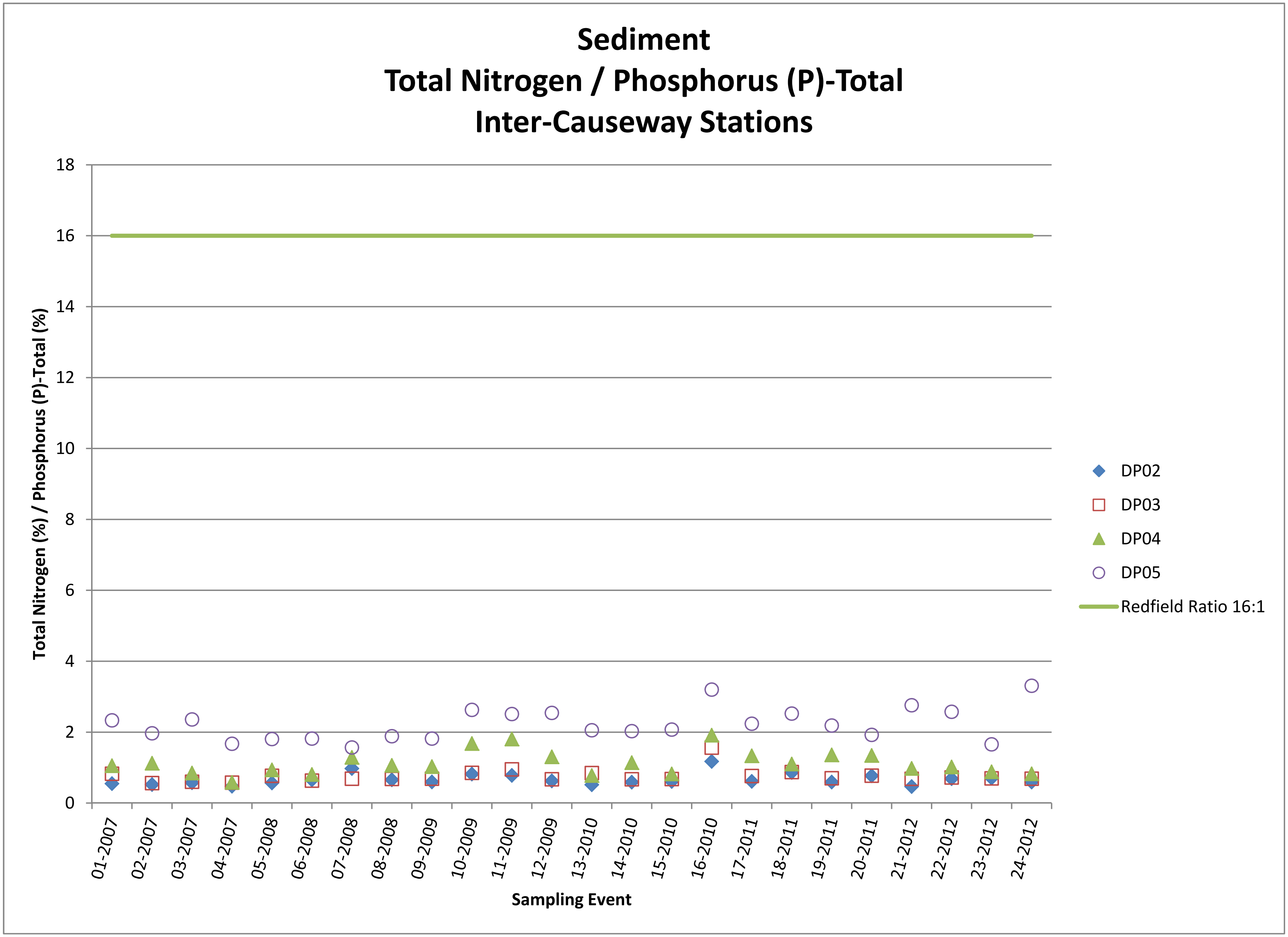
Surface Water
Total Nitrogen / Phosphorus (P)-Total
Inter-Causeway Stations
Total Nitrogen (mol/L) / Phosphorus (P)-Total (mol/L)
0
100
200
300
400
500
600
700
800
900
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
Sampling Event
DP02
DP03
DP04
DP05A
DP05B
Redfield Ratio 16:1


Surface Water
Total Nitrogen / Phosphorus (P)-Total
Reference Stations
Total Nitrogen (mol/L) / Phosphorus (P)-Total (mol/L)
900
800
700
600
500
400
300
200
100
0
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
Sampling Event
DP06
DP07A
DP07B
Redfield Ratio 16:1

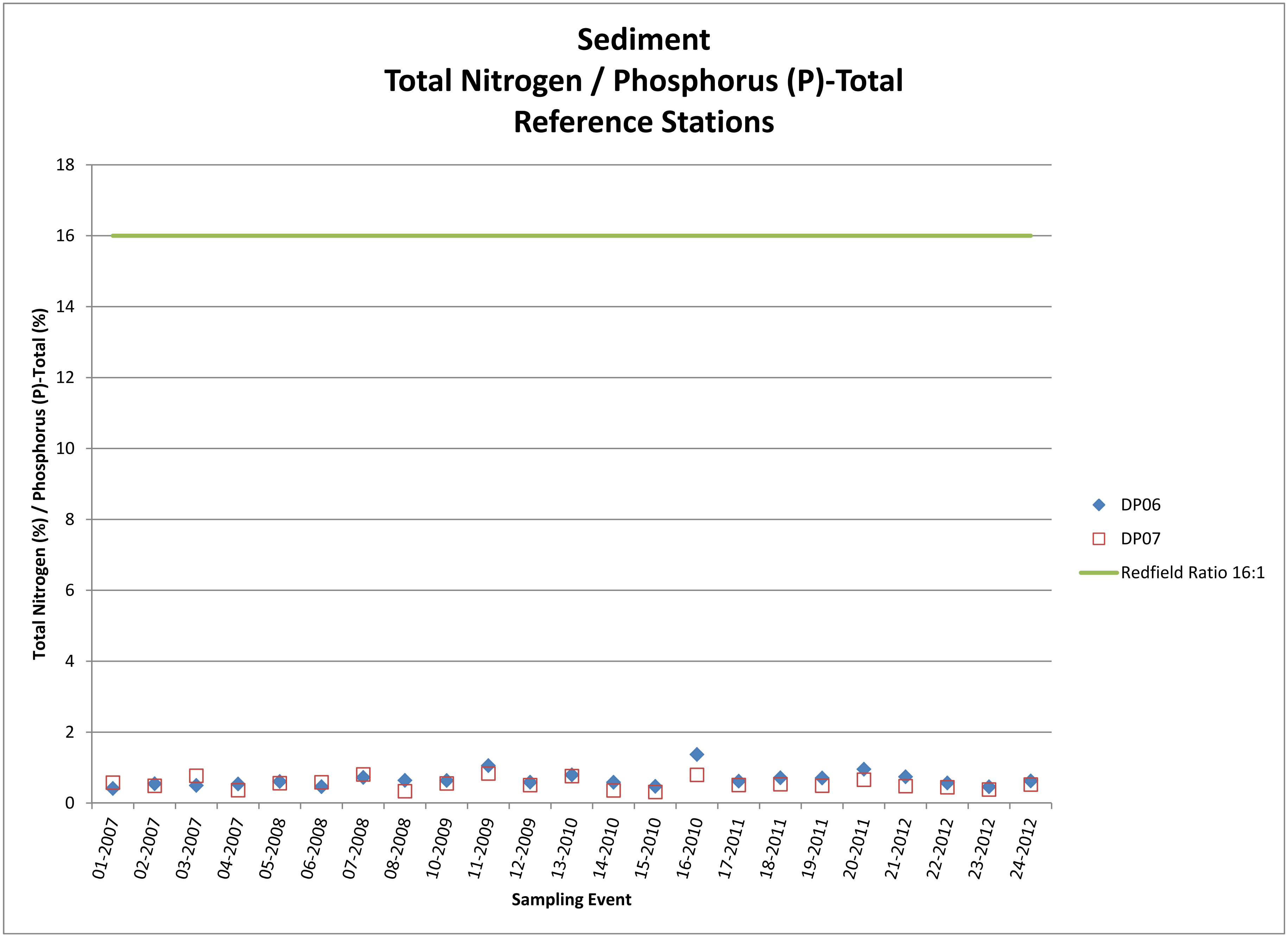

Surface Water
Nitrate / Ammonia
Inter-Causeway Stations
Nitrate (mol/L) / Ammonia (mol/L)
500
450
400
350
300
250
200
150
100
50
0
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
Sampling Event
DP02
DP03
DP04
DP05A
DP05B
Redfield Ratio 16:16



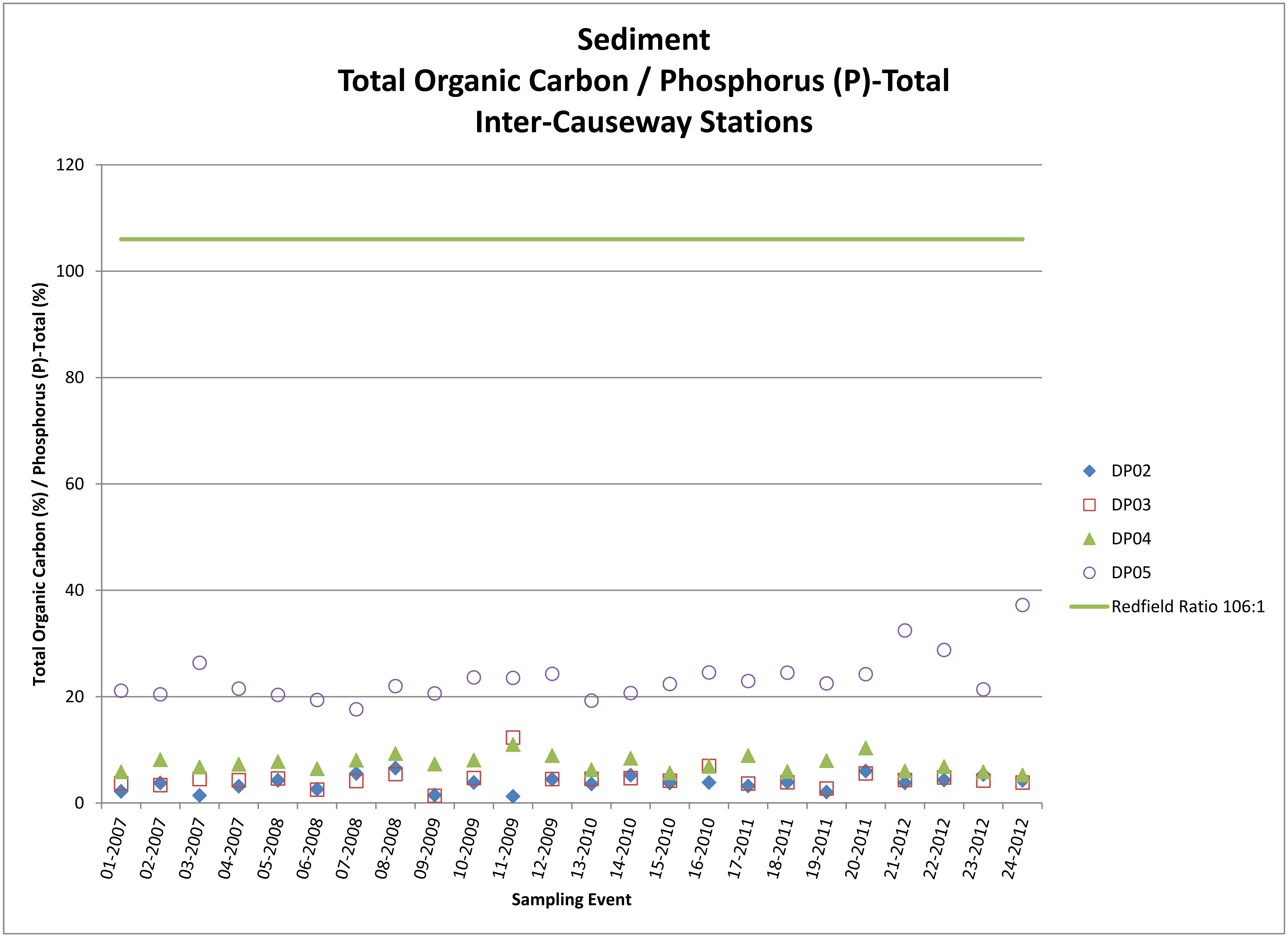
Surface Water
Nitrate / Ammonia
Reference Stations
Nitrate (mol/L) / Ammonia (mol/L)
500
450
400
350
300
250
200
150
100
50
0
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
Sampling Event
DP06
DP07A
DP07B
Redfield Ratio 16:16

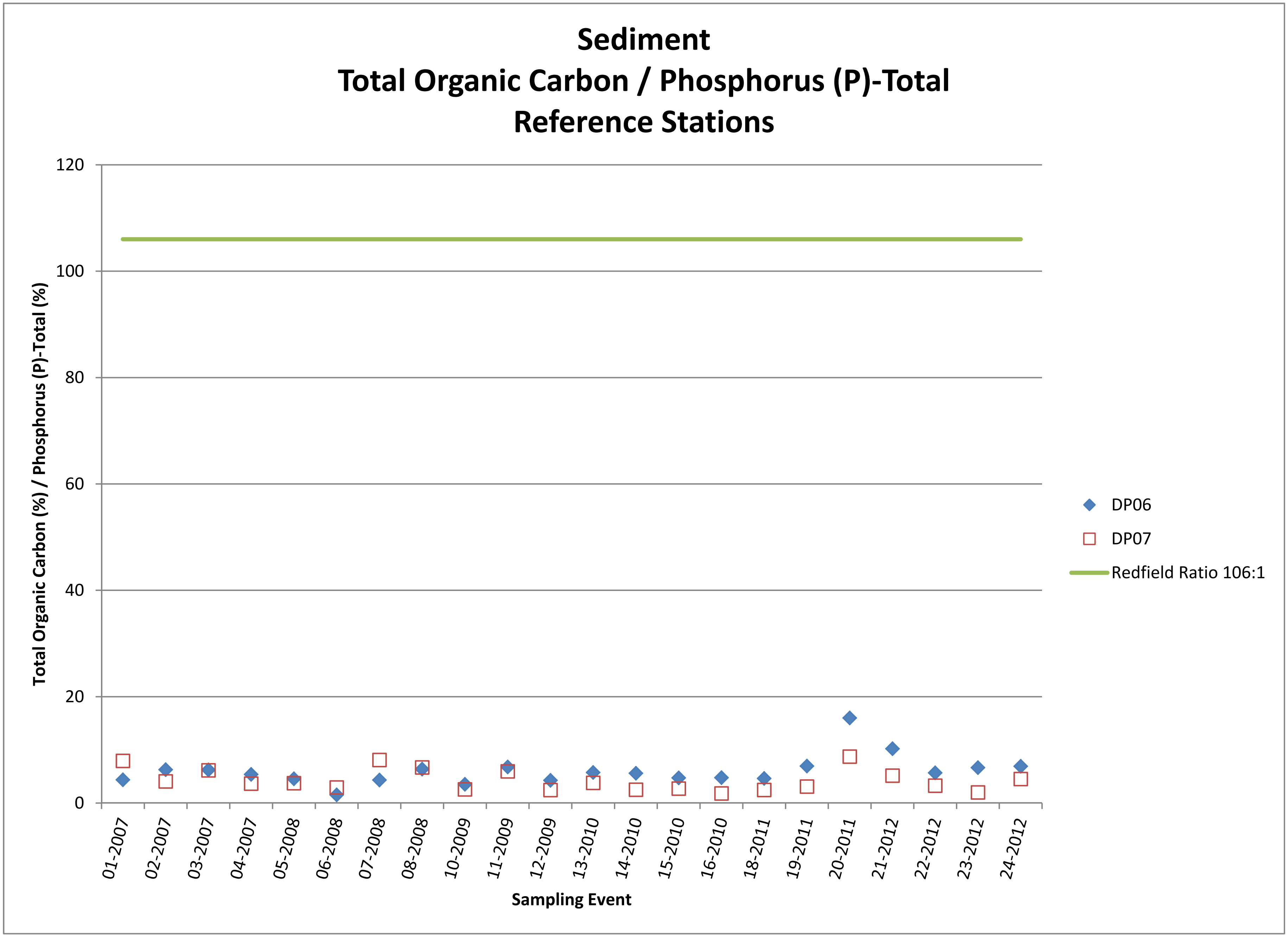


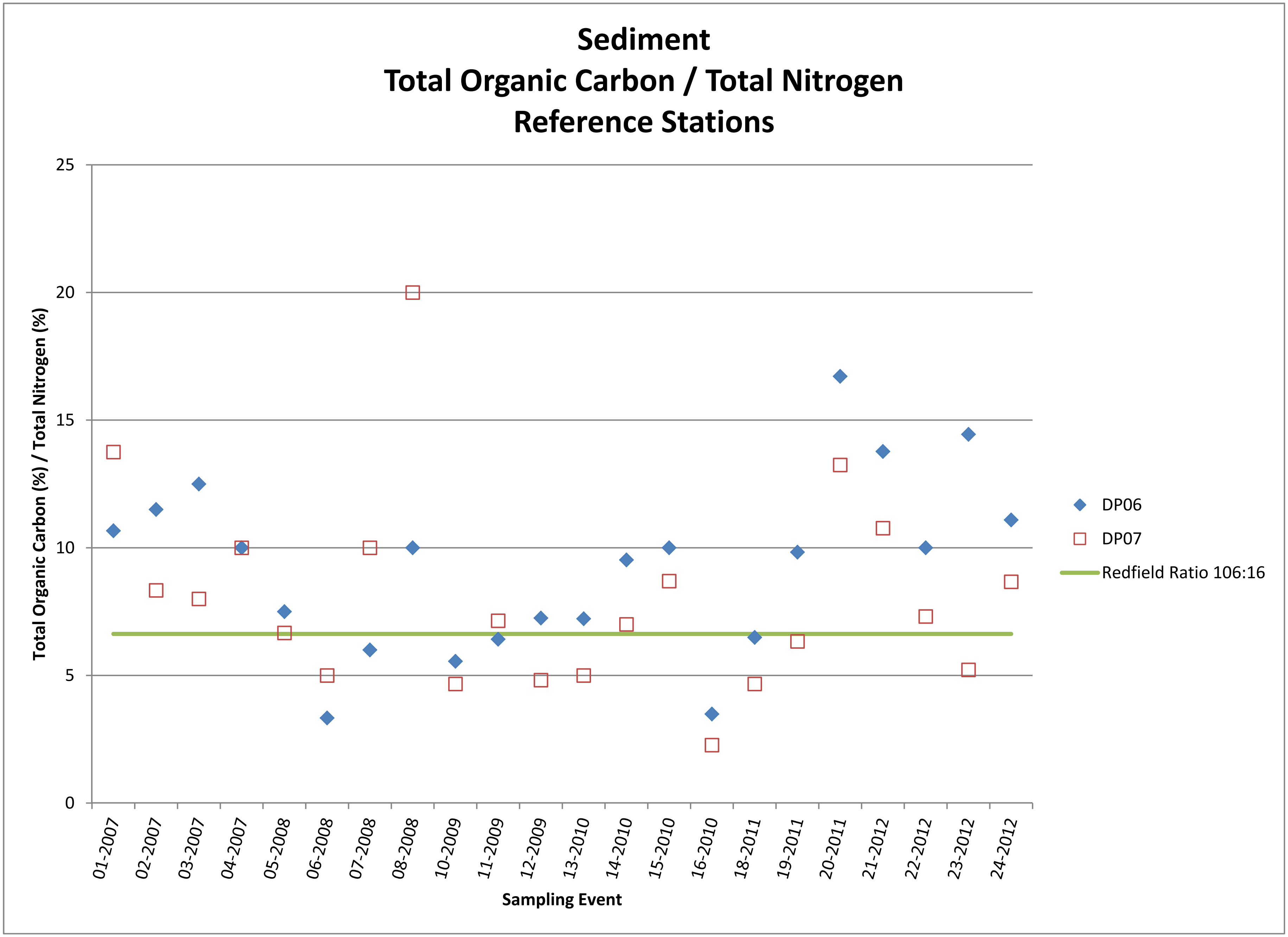
Sediment
Total Nitrogen / Phosphorus (P)-Total
Inter-Causeway Stations
Total Nitrogen (%) / Phosphorus (P)-Total (%)
0
2
4
6
8
10
12
14
16
18
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
Sampling Event
DP02
DP03
DP04
DP05
Redfield Ratio 16:1

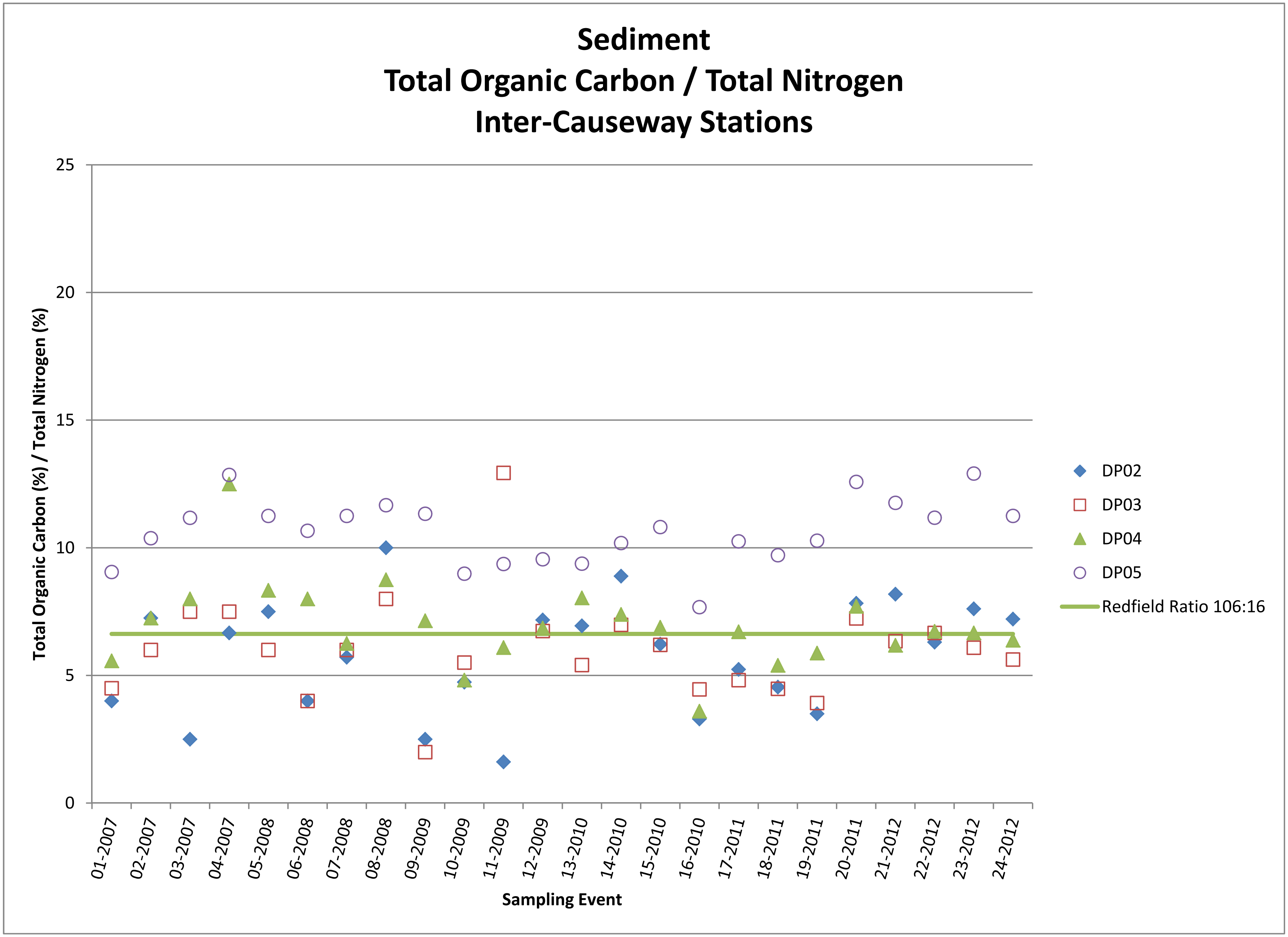


Sediment
Total Nitrogen / Phosphorus (P)-Total
Reference Stations
Total Nitrogen (%) / Phosphorus (P)-Total (%)
0
2
4
6
8
10
12
14
16
18
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
Sampling Event
DP06
DP07
Redfield Ratio 16:1


Sediment
Total Organic Carbon / Phosphorus (P)-Total
Inter-Causeway Stations
Total Organic Carbon (%) / Phosphorus (P)-Total (%)
0
20
40
60
80
100
120
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
Sampling Event
DP02
DP03
DP04
DP05
Redfield Ratio 106:1


Sediment
Total Organic Carbon / Phosphorus (P)-Total
Reference Stations
Total Organic Carbon (%) / Phosphorus (P)-Total (%)
120
100
80
60
40
20
0
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
Sampling Event
DP06
DP07
Redfield Ratio 106:1


Sediment
Total Organic Carbon / Total Nitrogen
Reference Stations
25
20
15
10
5
0
Total Organic Carbon (%) / Total Nitrogen (%)
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
Sampling Event
DP06
DP07
Redfield Ratio 106:16


Sediment
Total Organic Carbon / Total Nitrogen
Inter-Causeway Stations
Total Organic Carbon (%) / Total Nitrogen (%)
0
5
10
15
20
25
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
Sampling Event
DP02
DP03
DP04
DP05
Redfield Ratio 106:16