Outer Harbour Development

PROPOSED DEWATERING AND DISCHARGE TO SALMON CREEK: IMPACT ASSESSMENT

- Rev 0
- 07 October 2011

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The sole purpose of this report and the associated services performed by Sinclair Knight Merz (SKM) is to provide a Salmon Creek Impact Assessment in accordance with the scope of services set out in the contract between SKM and FAST JV ('the Client'). That scope of services was defined by the request of the Client.

SKM derived the data in this report primarily from the data collected at Port Hedland from the RGP5 dredging and port development operations monitoring and the Boodarie Iron Plant groundwater monitoring. The passage of time, manifestation of latent conditions or impacts of future events may require further exploration at the site and subsequent data analyses, and re-evaluation of the findings, observations and conclusions expressed in this report.

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Executive Summary

Overview

The proposed Outer Harbour Development will involve the construction and operation of landside and marine infrastructure for the handling and export of iron ore from BHP Billiton's Iron Ore operations. The landside infrastructure includes stockyards, rail loops and associated infrastructure (e.g. car dumpers, stackers, reclaimers and a lump screening plant) at Boodarie. In order to excavate and construct infrastructure and facilities for car dumpers, BHP Billiton Iron Ore propose the construction dewatering of groundwater at Boodarie. It is proposed that the dewatering discharge will be used on site to support construction activities. Should the discharge be unsuitable or in excess of construction requirements, it is proposed to discharge the groundwater into Salmon Creek, north of Dredge Material Management Area A (DMMA A) constructed for the Finucane Island (Harriet Point) dredging project. Dewatering could occur continuously for a period of approximately 9 to 12 months for each car dumper with up to a 12 month break between each dumper excavation. During the first 12 months, up to 7 ML/day of abstracted groundwater would be piped overland to Salmon Creek and discharged continuously at one point.

Methods

The potential for physical and chemical impacts on the receiving environment of Salmon Creek arising from the discharge of abstracted groundwater were assessed as follows:

1. Determine the baseline spatial and temporal variability of water quality conditions within Salmon Creek.

2. Determine the sensitivity of the benthic habitat in Salmon Creek.

3. Assess the water quality of the groundwater to be abstracted with respect to ANZECC/ARMCANZ (2000) marine water quality guidelines for 99% species protection.

4. Where exceedances are identified, undertake ecotoxicity testing in accordance with the guidelines and determine the dilution levels required to meet the guidelines.

5. Undertake near-field mixing zone modelling to determine the size of the mixing zones required to achieve the necessary dilution levels.

6. Assess the physical impacts (particularly to mangroves) that may result from the proposed discharge.

Groundwater Quality

Initial testing of the groundwater under the HBI Plant License Conditions showed that some parameters measured, such as Cobalt and Zinc, in the groundwater were above the ANZECC/ARMCANZ (2000) marine water quality guidelines for 99% species protection and therefore considered unsuitable for discharge into Salmon Creek. In accordance with these guidelines, ecotoxicity testing was subsequently undertaken to determine if the groundwater was harmful to select species of flora and fauna.

Ecotoxicity Testing

Ecotoxicity testing was conducted on five of the groundwater samples. The results of the ecotoxicity testing have shown that the groundwater samples are not toxic to sea urchin fertilization, amphipods or fish but are moderately toxic to microalgae, sea urchin and rock oyster larval development and would need a 1:20 dilution to achieve 99% species protection.

However, even with a 1:20 dilution before the groundwater reached the Salmon Creek receiving environment, the elevated concentrations of nutrients would contribute significant amounts of nitrogen and phosphorus to Salmon Creek (in the vicinity of 5 kg of available phosphorus and 519 kg of available nitrogen per year). This would make the Boodarie groundwater discharge a significant point source of nutrients to the macrotidal system of Port Hedland.

Mixing Zone Modelling

Near-field hydrodynamic modelling indicates that an initial mixing zone of 3 to 4 metres is sufficient to dilute the heavy metal concentrations to levels below the ANZECC trigger levels (99% of species) when the water depths were greater than 0.5 m. This is very small compared with the size of Salmon Creek (average width of 90 m). However, the tides in Salmon Creek have a strong influence on the depth of water in the creek. Under low tide conditions, the tide completely drains out of the Salmon Creek exposing the mudflats. It is under these conditions that the discharge may constitute the majority of the flow and therefore impact on the aquatic ecosystems through acute heavy metal toxicity. This would only affect the ecosystem present at the bottom of the channel, and would not impact on the mangroves or rocky reef areas that are higher up in the channel. Overall, the heavy metal Boodarie groundwater discharge is not anticipated to have a highly significant impact on the Salmon Creek receiving environment as no sensitive habitats are present.

Mangroves

The results of the Finucane Island Dredging Project Mangrove Monitoring program were reviewed. Based on this review there is not expected to be any significant impact to mangroves from the proposed groundwater dewatering discharge.

1. Introduction

1.1. Project Overview

The proposed Outer Harbour Development involves the construction and operation of landside and marine infrastructure for the handling and export of iron ore from BHP Billiton's Iron Ore operations. The landside infrastructure includes stockyards, rail loops and associated infrastructure (e.g. car dumpers, stackers, reclaimers and a lump screening plant) at Boodarie. In order to excavate and construct infrastructure and facilities for car dumpers, BHP Billiton Iron Ore propose the construction dewatering of groundwater at Boodarie. It is proposed that the dewatering discharge will be used on site to support construction activities. Should the discharge be unsuitable or in excess of construction requirements, it is proposed to discharge the groundwater into Salmon Creek, north of Dredge Material Management Area A (DMMA A) constructed for the Finucane Island (Harriet Point) dredging project. Dewatering could occur continuously for a period of approximately 9 to 12 months for each car dumper with up to a 12 month break between each dumper excavation. During the first 12 months, up to 7 ML/day of abstracted groundwater will be piped overland to Salmon Creek and discharged continuously at one point (**Figure 1.1**).

1.2. Objectives

The primary objective of this study was to assess the potential impact(s) of discharging groundwater into Salmon Creek. This report presents the findings of this assessment and includes:

- collation and interpretation of water quality data in Salmon Creek and discharge volumes from Finucane Island (Harriet Point) Dredging Project discharge at Dredge Material Management Area A (DMMA A);
- review and assessment of mangrove monitoring data undertaken during the operation of DMMA A;
- collation and interpretation of water quality and falling head test data collected under the BHP Boodarie Iron Plant License Conditions.
- results of the ecotoxicity testing undertaken on the ground water; and
- results of the near-field hydrodynamic modelling to determine the required mixing zones.

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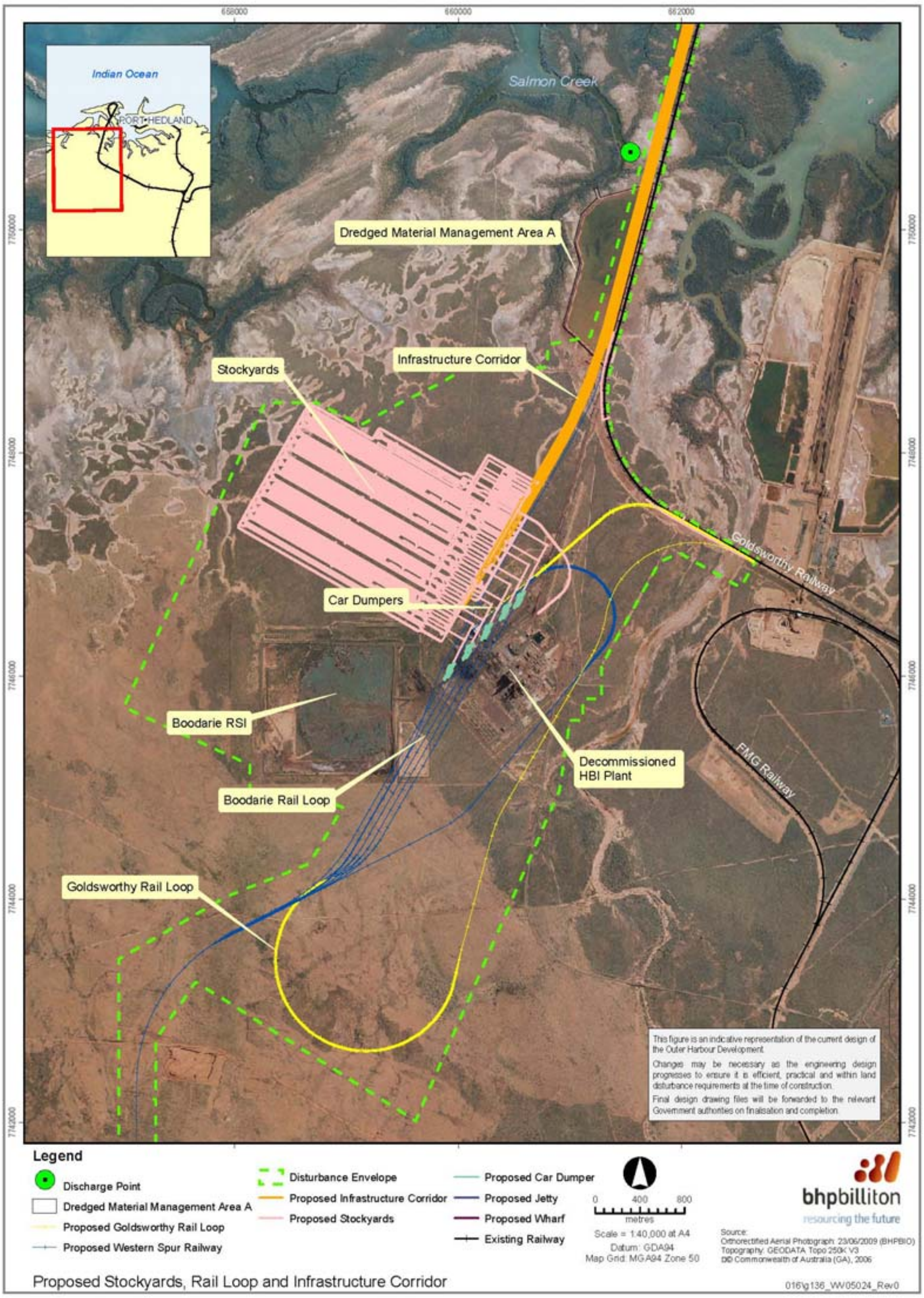


- **Figure 1.1 Location of Infrastructure at Boodarie and Dewatering Discharge Point at Salmon Creek**

1.3. Potential Impacts

The large semi-diurnal tides characteristic of the Pilbara region and of the study area in particular, have considerable influence on the hydrodynamics of creeks and the associated benthos and water quality. Since Salmon Creek reduces to only a small flow during low tide, the discharge of abstracted groundwater into Salmon Creek has the potential to have physical and chemical impacts on the receiving environment.

Physical impacts include scouring of the benthic habitat in the receiving environment, possible loss of marine habitats and erosion of the banks of Salmon Creek with potential loss of mangrove habitat.

Chemical impacts include possible contaminants present within the dewatering discharge affecting water quality, resident fish and invertebrate communities.

2. Methods and Data Inputs

2.1. Methods Overview

The potential for physical and chemical impacts on the receiving environment of Salmon Creek arising from the discharge of abastracted groundwater were assessed as follows:

1. Determine the baseline spatial and temporal variability of water quality conditions within Salmon Creek.
2. Determine the sensitivity of the benthic habitat in Salmon Creek.
3. Assess the water quality of the groundwater to be abstracted with respect to ANZECC/ARMCANZ (2000) marine water quality guidelines for 99% species protection.
4. Where exceedances are identified, undertake ecotoxicity testing in accordance with the guidelines and determine the dilution levels required to meet the guidelines.
5. Undertake near-field mixing zone modelling to determine the size of the mixing zones required to achieve the necessary dilution levels.
6. Assess the physical impacts (particularly to mangroves) that may result from the proposed discharge.

2.2. Salmon Creek Water Quality

The physical and chemical constituents of the groundwater were examined to assess the effect, if any, of the proposed groundwater dewatering discharge on the receiving environment of Salmon Creek. Data on a number of the physical and chemical constituents of the receiving water was available from the monitoring program undertaken as part of Finucane Island Dredging Project.

Water quality monitoring was under taken prior to and during the dredging activities and included:

- Continuous *in situ* monitoring of turbidity, dissolved oxygen, temperature, pH and conductivity at eight sites (**Figure 2.1**);
- Fortnightly sampling of common trace metals, total suspended solids and ammonium concentrations at eight sites; and
- Manual water quality sampling of turbidity, dissolved oxygen, temperature, pH and conductivity at the DMMA A discharge point twice daily during discharge in accordance with Ministerial Statement 781, Condition 6:3.

The physical parameters monitored include:

- temperature (ºC);
- dissolved oxygen (% saturation);
- pH;
- conductivity (mS/cm) and salinity (ppt);
- turbidity (NTU); and
- total suspended solids (mg/L).

The chemical parameters included:

- ammonium; and
- dissolved trace metals (arsenic, cadmium, chromium, cobalt, copper, mercury, nickel, lead, silver, vanadium and zinc).

A detailed description of sampling methods and equipment used are provided in the RGP5 Port Facilities Summary Water Quality and Coral Health Report (SKM 2010b).

While eight sites were monitored, only those sites located within Salmon Creek were considered in this assessment and in the preparation of this report (AOU, AOL and the DMMA discharge point).

2.3. Benthic Habitat within Salmon Creek

Benthic habitat mapping undertaken for the Nelson Point Dredging Project was used to identify the presence of sensitive benthic habitats within Salmon Creek. Details of the methods utilised to undertake this habitat mapping can be found in the RGP6 Port Facilities Benthic Primary Producer: Reference Area sub-tidal Mapping Report (SKM 2009).

2.4. Groundwater Quality

Groundwater monitoring has been undertaken on a quarterly basis in accordance with the BHP Boodarie Iron Plant (HBI Plant) License Conditions. Further testing of this groundwater was conducted to obtain data on water quality parameters that were not required to be tested under the license conditions.

This further testing incorporated sampling for the parameters already monitored in groundwater for the Finucane Island Dredging project in Salmon Creek and included ammonium, dissolved trace metals and physical parameters (dissolved oxygen, conductivity, temperature, pH and turbidity). In addition, hydrocarbons (total petroleum hydrocarbon, polyaromatic hydrocarbons and BTEX) and other nutrients (nitrate-nitrite (NOx), total nitrogen, filterable reactive phosphorus and total phosphorus) were also included. The additional parameters were included due to the fact that groundwater typically carries higher nutrient concentrations than marine water (particularly nitrogen) and that historic activities associated with the former HBI plant had the potential to introduce hydrocarbons into the groundwater and may still be present.

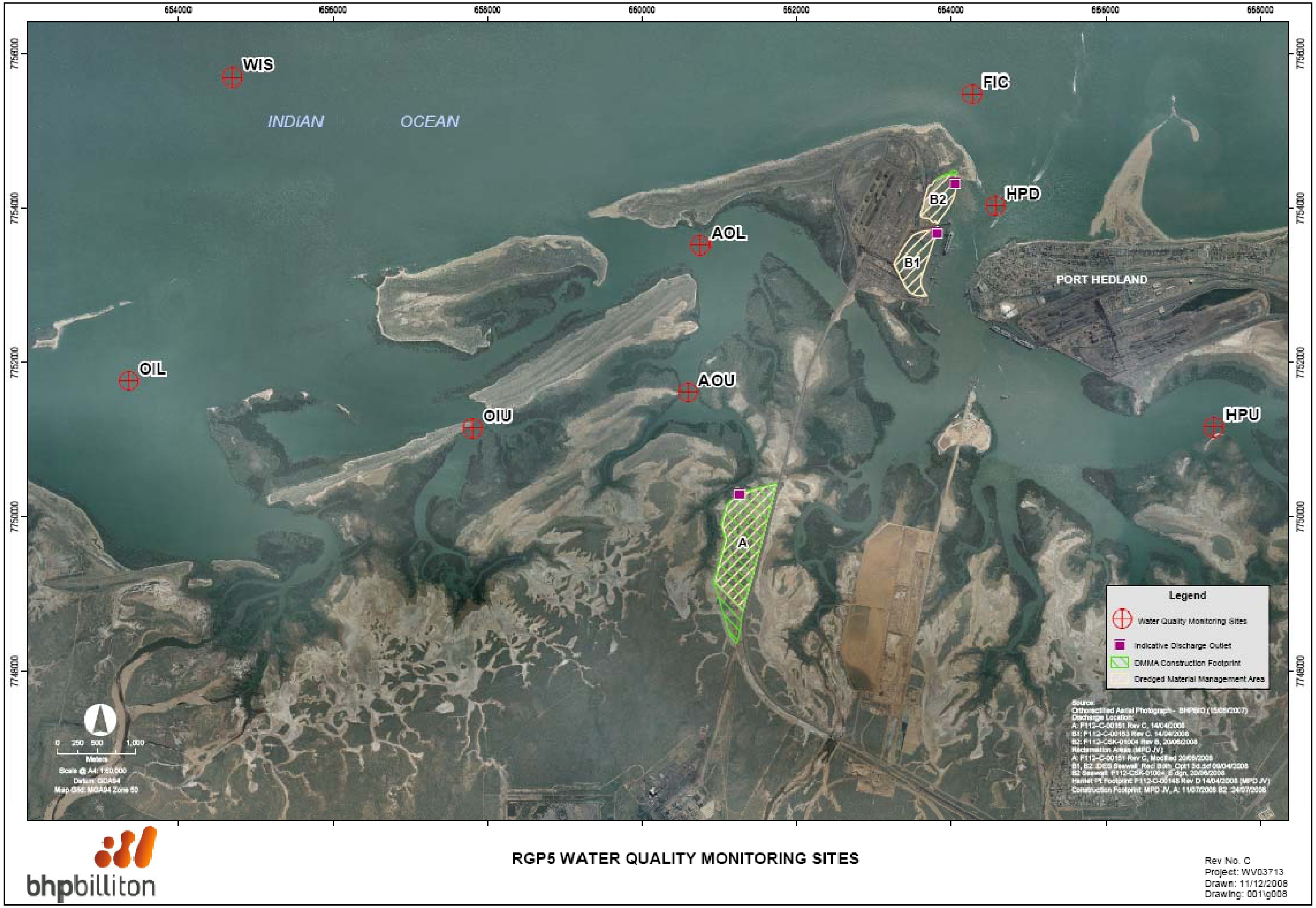
Hydrosolutions have been contracted by BHP Billiton Iron Ore to undertake groundwater sampling for the Boodarie Iron Plant License Conditions. For this study, Hydrosolutions were retained to undertake the additional sampling of 11 groundwater bores (**Figure 2.2**) for the expanded parameter list which included:

Physical water quality:

- Turbidity (NTU), temperature (ºC), dissolved oxygen (% saturation), conductivity (mS/cm) and pH.

Chemical water quality (metals and metalloids, nutrients and hydrocarbons):

- Nutrients (total nitrogen, total phosphorus, ammonium, nitrate-nitrite and filterable reactive phosphorus);
- Filtered metals: silver, arsenic, cadmium, chromium, cobalt, copper, mercury, nickel, lead, selenium, vanadium and zinc; and
- Hydrocarbons: total petroleum hydrocarbons (TPH), polycyclic aromatic hydrocarbons (PAH) and benzene, toluene, ethylbenzene and xylene (BTEX).



■ **Figure 2.1 Location of Finucane Island Dredging Project Water Quality Monitoring Sites**

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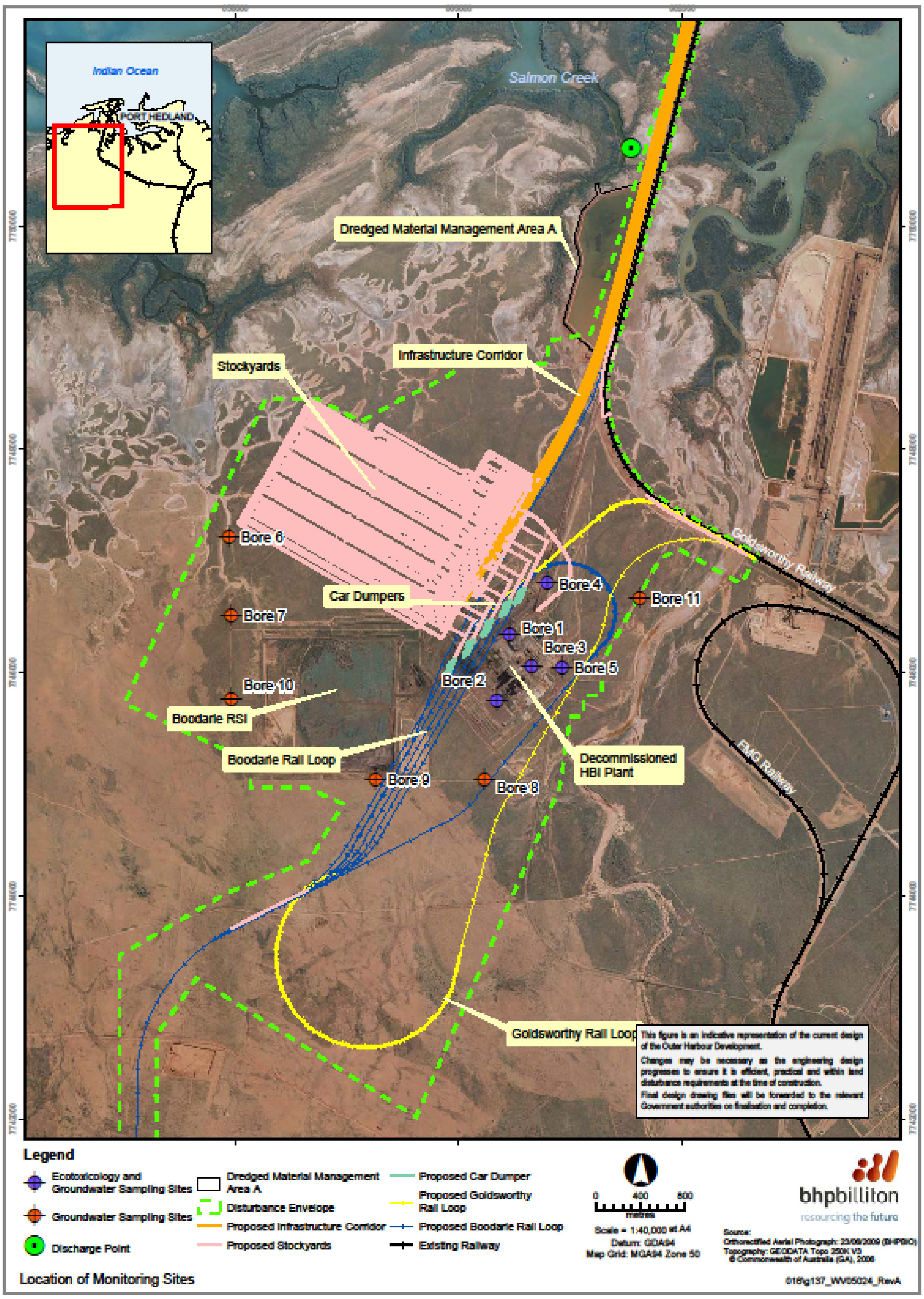

▪ **Figure 2.2 Location of groundwater and ecotoxicological monitoring sites**

2.5. Ecotoxicity Testing

Examination of the groundwater monitoring data (Hydrosolutions 2010) identified that some parameters in the groundwater were above the ANZECC/ARMCANZ (2000) marine water quality guidelines for 99% species protection.

In accordance with these guidelines, ecotoxicity testing was subsequently undertaken to determine if the groundwater was harmful to select species of flora and fauna. Further sampling of bores therefore included a subset of five specific bores samples sent to Ecotox Services Australasia for ecotoxicological assessment.

Six toxicity tests were undertaken on each of the five samples (**Table 2.1**). The test endpoint, type of test and the protocol used are also provided.

- **Table 2.1 Analytical methods and test end-points for ecotoxicology**

Toxicity Test	Test End-point	Type	Protocol
Microalga (*Nitzschia closterium*)	72-hour Growth inhibition	Sub-chronic	USEPA Method 1003.0 and Stauber *et al*. 1994
Sea Urchin fertilisation (*Heliocidaris tuberculata*)	1-hour Larval development	Acute	ESA SOP 104 (ESA 2009a), based on USEPA (2002) and Simon and Laginestra (1997)
Sea Urchin larval development (*Heliocidaris tuberculata*)	72-hour Larval development	Sub-chronic	ESA SOP 105 (ESA 2010), based on APHA (1998), Simon and Laginestra (1997)
Rock oyster larval development (*Saccostrea commercialis*)	48-hour Larval development	Sub-chronic	ESA SOP 106 (ESA 2009b), based on APHA (1998)
Amphipod (*Melita plumulosa*)	96-hour Survival	Acute	ESA SOP 108 (ESA 2009c) based on USEPA (2002)
Fish (barramundi) (*Lates calcarifer*)	96-hour Imbalance	Acute	ESA SOP 117 (ESA 2009d), based on USEPA (2002)

The toxicity test data are presented in several ways. Firstly the concentration at which no observed effects (NOEC) is experienced is generally used as the most conservative measure of toxicity, in that it is the lowest concentration and no test organisms are affected. The lowest observed effects concentration (LOEC) is the concentration where the first statistically discernable toxicity is observed. The concentration that kills 50% of the test organisms in the prescribed test duration (EC_{50}) or which inhibits growth or reproduction of 50% of the test organisms in the prescribed test duration (IC_{50}), are statistically calculated and are used to determine the species protection trigger values with the BurrliOz program (refer to **Appendix B**).

BurrliOZ is a statistical software package for use in environmental management of species with regard to understanding the effects of levels of toxins in an environment. BurrliOZ uses a flexible family of distributions, the Burr Type III, to estimate the greatest concentration of a toxin at which no observed effect to a species will be detected. The BurrliOz program was used to analyse the toxicity results and produce species protection values.

Note that the outputs shown in **Appendix C** indicate units of µg/L but should read % solution. This is a limitation of the graphical output of the program.

The generation of species protection trigger values can be used to predict the area of potential impact by numerically modelling the concentrations in the area being affected. For this purpose, the dilution of the test water (in this case the groundwater samples) needed to meet the calculated trigger value has been estimated.

All parameters were filtered on site, preserved and handled according to Australian and New Zealand Standard 5667.1:1998. Stringent QA/QC procedures were followed to determine any areas of contamination that occurred during the sampling procedures. Specific sampling methods were undertaken as follows:

- All bores were dipped prior to purging to obtain the water table elevation and plumbed to determine the height of the static water column. Bores were purged using a 12-volt submersible pump to remove between four to six times the standing water volumes, or until wellhead parameters had stabilised consistent with AS5667, 1998;
- Samples were taken after purging, with samples for specific parameters placed in appropriate bottles with/ without preservatives as specified by the laboratories;
- Samples for metals analysis were field filtered through 0.45 micron filters and acidified; this was consistent with AS5667 and with previous monitoring periods. This was necessary due to the delay between sampling from the remote site and submission to the laboratory, to prevent the loss of dissolved species;
- Quality assurance/ quality control (QA/QC) samples were taken consistent with AS5667, including field and transport blanks;
- All samples were labelled and stored in eskies with frozen ice bricks (while in the field) and placed in a dedicated sample fridge onsite to maintain the samples at 4^{o}C. Samples were accompanied by Chain of Custody documentation;
- The samples were despatched for analysis to three NATA accredited laboratories (ALS, MAFRL and Ecotox Services Australasia); and
- The samples were despatched from site using TNT couriers. To ensure samples were maintained at 4^{o}C, the eskies were sent via overnight air freight to the laboratories. Due to their intended testing, the Ecotox samples were sent on the same day as sampling.

2.6. Near Field Mixing Zone Modelling

Near-field hydrodynamic modelling was used to define and demonstrate the initial dilution and extent of the mixing zone for chemicals of concern (chemicals that occurred within the groundwater at concentrations above the ANZECC/ARMCANZ 2000 guidelines for 99% species protection). These chemicals included chromium, silver, mercury and zinc. Although not a toxicant, nitrogen levels were also considered because of the potential for eutrophication of the receiving environment from elevated levels in the discharge water.

The simulation included neap and spring tidal scenarios in both the dry and wet season. Dilution conditions were assessed at various tidal water levels (0.5 m, 1 m, 2 m for both neap and spring tides and 3 m and 4 m in spring tide) and were compared between the dry and wet season when salinity and temperature conditions were different.

Full details of the near-field modelling undertaken are included in the Salmon Creek Mixing Zone Report (**Appendix D**).

2.7. Physical Impacts to Mangroves

To access the potential impacts to mangroves from the discharge into Salmon Creek a review of the mangrove monitoring undertaken during the Finucane Island (Harriet Point) Dredging Project was undertaken. During the dredging, excess water was discharged from DMMA A into Salmon Creek over a period of approximately 40 weeks. The discharge point for the DMMA A discharge is in close proximity to the proposed discharge location for the dewatering activities. It is considered that the results of the monitoring undertaken during the DMMA A discharge provide a good indication of potential impacts to mangroves during the discharge of ground water to Salmon Creek.

A detailed description of sampling methods and equipment used in mangrove monitoring is provided in the Finucane Island Dredging Program Mangrove Health Monitoring Report (SKM 2010a).

The mangrove monitoring surveys were undertaken to assess the potential short and medium-term effects on the mangrove areas in the vicinity of the construction activities as well as act as a basis for monitoring longer term trends.

Mangrove health monitoring was undertaken prior to dredging, six months after dredging commenced and after the completion of dredging. Three potential impact sites (**Figure 2.3**) were selected in the vicinity of the DMMA A and two reference sites (**Figure 2.4**) on either side of the peninsular on the western end of the tidal creek system with similar attributes to the potential impact sites. A number of 50 m random transects were set up within each of the impact and reference sites and quadrats were randomly established along each transect. A number of attributes were measured along the transects and within the quadrats including:

- Species composition;
- Foliage density;
- Number of seedlings;
- Number of dead limbs;
- Number of stems;
- Stem diameter range;
- Health status; and
- Height range.

Sediment deposition monitoring was undertaken on a fortnightly basis and involved driving wooden stakes into the sediment along the mangrove health transects and recording the height of the secured stakes (distance from sediment surface to tip end of stake). The aim was not to measure changes of a few millimetres in the depth of sediment, but to detect changes in the order of decimetres (tens of centimetres), that may be associated with a large sedimentation event as it is only events of this magnitude that are likely to stress mangroves (Ellison 1998; Thampanya 2006).

Soil salinity readings were taken along transects at DMMA A, both within the closed canopy mangroves and at the outer edge of the mangrove stand nearest to the boundary of DMMA A for the baseline survey. Soil salinity readings were repeated in the mid-term survey and the final survey at slightly different locations near the DMMA A transects and at intervals approaching the bund wall.

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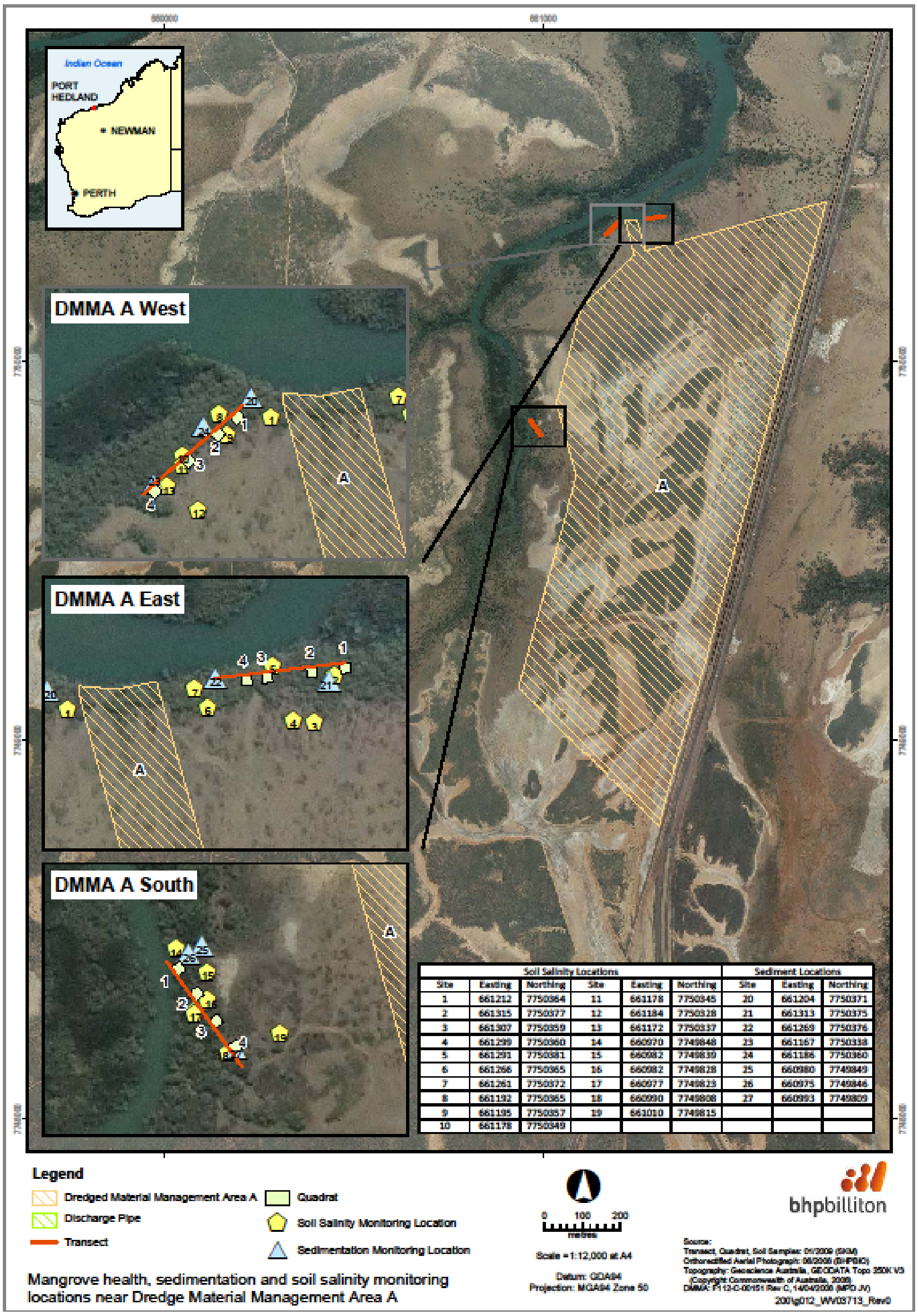
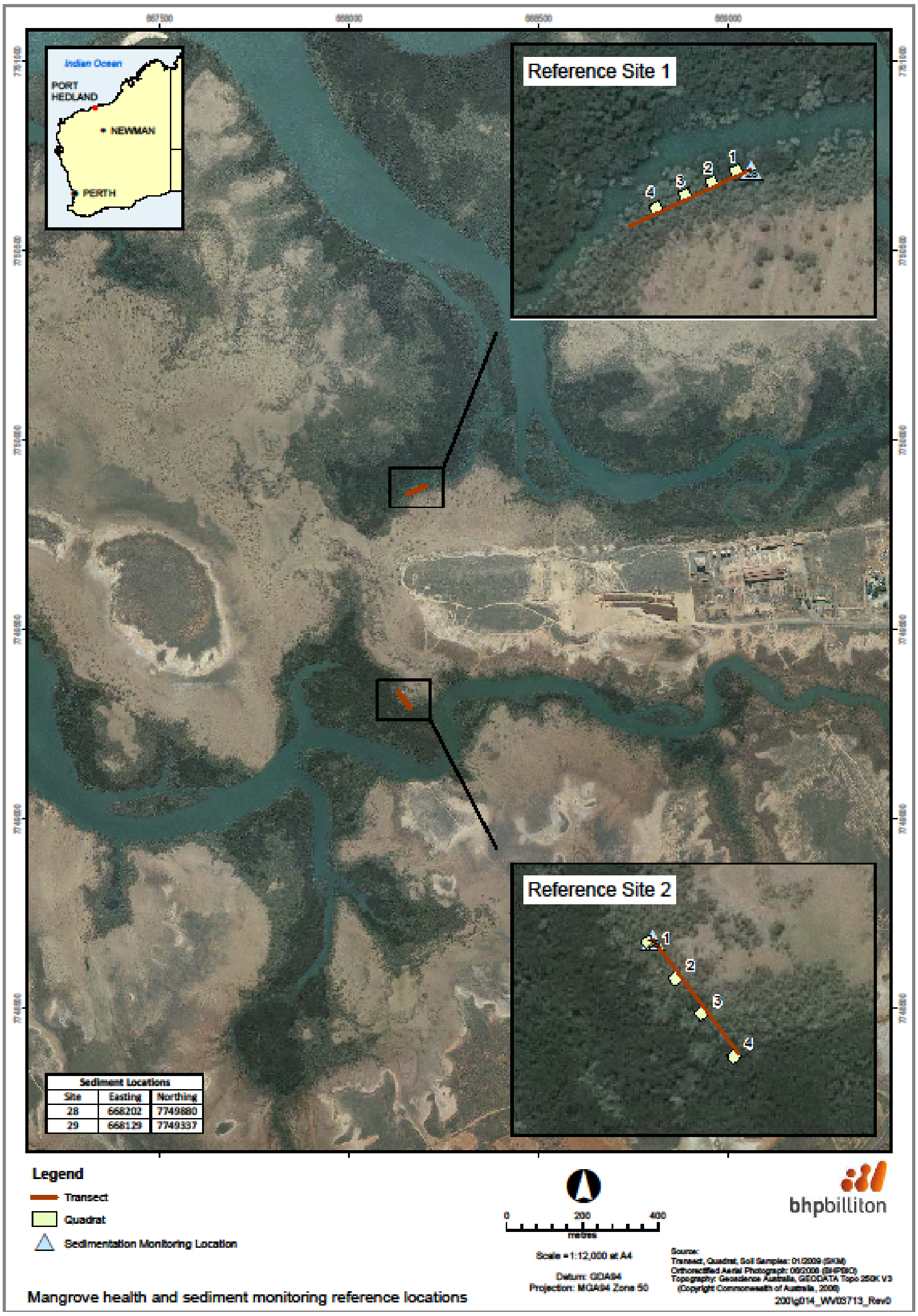


Soil Salinity Locations						Sediment Locations		
Site	Easting	Northing	Site	Easting	Northing	Site	Easting	Northing
1	661212	7750364	11	661178	7750345	20	661204	7750371
2	661315	7750377	12	661184	7750328	21	661313	7750375
3	661307	7750359	13	661172	7750337	22	661269	7750376
4	661299	7750360	14	660970	7749848	23	661167	7750338
5	661291	7750381	15	660982	7749839	24	661186	7750360
6	661266	7750365	16	660982	7749828	25	660980	7749849
7	661261	7750372	17	660977	7749823	26	660975	7749846
8	661192	7750365	18	660990	7749808	27	660993	7749809
9	661195	7750357	19	661010	7749815			
10	661178	7750349						

- **Figure 2.3 Location of mangrove monitoring sites near DMMA A for Finucane Island (Harriet Point) Dredging**



- **Figure 2.4 Location of reference sites for mangrove monitoring**

3. Results

3.1. Salmon Creek Water Quality

The major trends with respect to water quality within Salmon Creek observed during the Finucane Island (Harriet Point) Dredging Project baseline and dredging surveys are outlined below. For further detail on these trends refer the Spatial Baseline Water quality Report (SKM 2009b) and the Summary Water Quality and Coral Health Report (SKM 2010b).

- Over the entire Finucane Island Dredging Project monitoring period (baseline and dredging) the turbidity at site AOU (downstream from the discharge point at DMMA A) ranged from 6.80 NTU to 77.95 NTU. Turbidity levels from the discharge waters of DMMA A fluctuated widely, ranging from 1.7 NTU to 2,506 NTU, and the overall median was 13.6 NTU. During periods of elevated turbidity, the weir box at the DMMA A discharge point was closed to minimise the release of turbid water into Salmon Creek. This management response was successful, as there were no exceedances of the neap or spring tide turbidity trigger values at site AOU.

- During baseline surveys the majority of sites were hypersaline during the dry season, with the sites further upstream in Salmon Creek having the highest conductivities (ranging from 56 to 69 mS/cm). During the wet season conductivities were lower (ranging from 54 to 56 mS/cm). During dredging the conductivity levels at the DMMA A discharge point ranged from 29.91 mS/cm to 76.75 mS/cm and were found to exceed the 20^{th} and 80^{th} percentile trigger levels at site AOU across the neap and spring tides in the wet and dry seasons.

- During baseline surveys, dissolved oxygen levels in the upper reaches of Salmon Creek were generally supersaturated; however, levels did occasionally fall below 60% saturation but usually only for a maximum of two hours. Dissolved oxygen levels from the discharge waters of DMMA A fluctuated widely, ranging from 10 to 154%, with an overall median of 102%. During periods of low dissolved oxygen, the weir box at the DMMA A discharge point was closed to minimise the release of low dissolved oxygen water into Salmon Creek. This management response was successful, as there were no instances where dissolved oxygen was below the 60% saturation trigger level at site AOU.

- Over the entire monitoring period (baseline and dredging) the temperature at the downstream site AOU ranged from 17.3°C to 33.4°C, while the temperature of the discharge waters at DMMA A similarly ranged from 16.1°C to 32.6°C with an overall median of 25.8°C.

- Over the entire monitoring period (baseline and dredging) the pH at the site AOU ranged from 7.65 to 8.38 pH units. The pH of the discharge waters from DMMA A ranged from 7.38 to 8.38 pH units with an overall median of 8.05.
- Occasionally during baseline surveys the sites in the upper reaches of Salmon Creek had ammonium concentrations that exceeded the ANZECC/ARMCANZ (2000) trigger value of 10 µg/L (the highest being 15 µg/L). The majority of the other sites had ammonium concentrations lower than the laboratory detection limit of <3 µg/L. At the DMMA A discharge point the ammonium concentrations ranged from <3 to 140 µg/L, however the corresponding ammonium concentrations at the downstream site AOU were below the trigger value.
- Of the metals sampled at the DMMA A discharge, nickel marginally exceeded the ANZECC/ARMCANZ (2000) trigger value for 99% species protection of 7 µg/L and cobalt equalled the trigger value for 95% species protection of 3 µg/L on a number of occasions. These metals were not detected at the downstream site of AOU.

Table 3.1 presents the heavy metal concentrations within Salmon Creek based on monitoring associated with the Finucane Island Dredging Project.

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Table 3.1 Heavy metal concentrations in Salmon Creek at discharge point (SC5).

Heavy Metals (µg/L)	ANZECC Guidelines (99%)	Neap Tide		High Spring Tide	
		Dry season	Wet season	Dry season	Wet season
Silver	0.8	<1	1.2	<1	<5
Arsenic	4.5	2	<2	2.2	1.5
Cadmium	0.7	<0.1	<0.1	<0.1	<0.1
Chromium	7.7	<1	<1	<1	<1
Cobalt	0.005	<1	1.5	<1	<1
Copper	0.3	<1	<1	<1	<1
Mercury	0.1	<0.1	<0.1	<0.1	<0.1
Nickel	7	<1	<1	<1	<1
Lead	2.2	<1	<1	<1	<1
Vanadium	50	<10	7	<10	<10
Zinc	7	2	9	18	1
Other variables					
Ammonia (µg/L)	1-10	<3	<3	<3	
Turbidity (NTU)	1-20	13	nd	13	9
Electrical conductivity (mS/cm)	-	65	nd	55	56
Dissolved oxygen (%sat)	90-	150	Nd	140	85
Temperature (°C)	-	26	30	26	30
pH	8.0-8.4	7.9	nd	8.1	nd

Note: Data sourced from BHPBIO (2009). Highlighted cells shows elevated results compared to ANZECC trigger levels.
nd = no data.

3.2. Benthic Habitat within Salmon Creek

Figure 3.1 shows the benthic habitat within Salmon Creek based on the habitat mapping undertaken and reported by SKM in 2009 (SKM 2009). As can be seen by **Figure 3.1**, no sensitive habitat occurs within Salmon Creek.

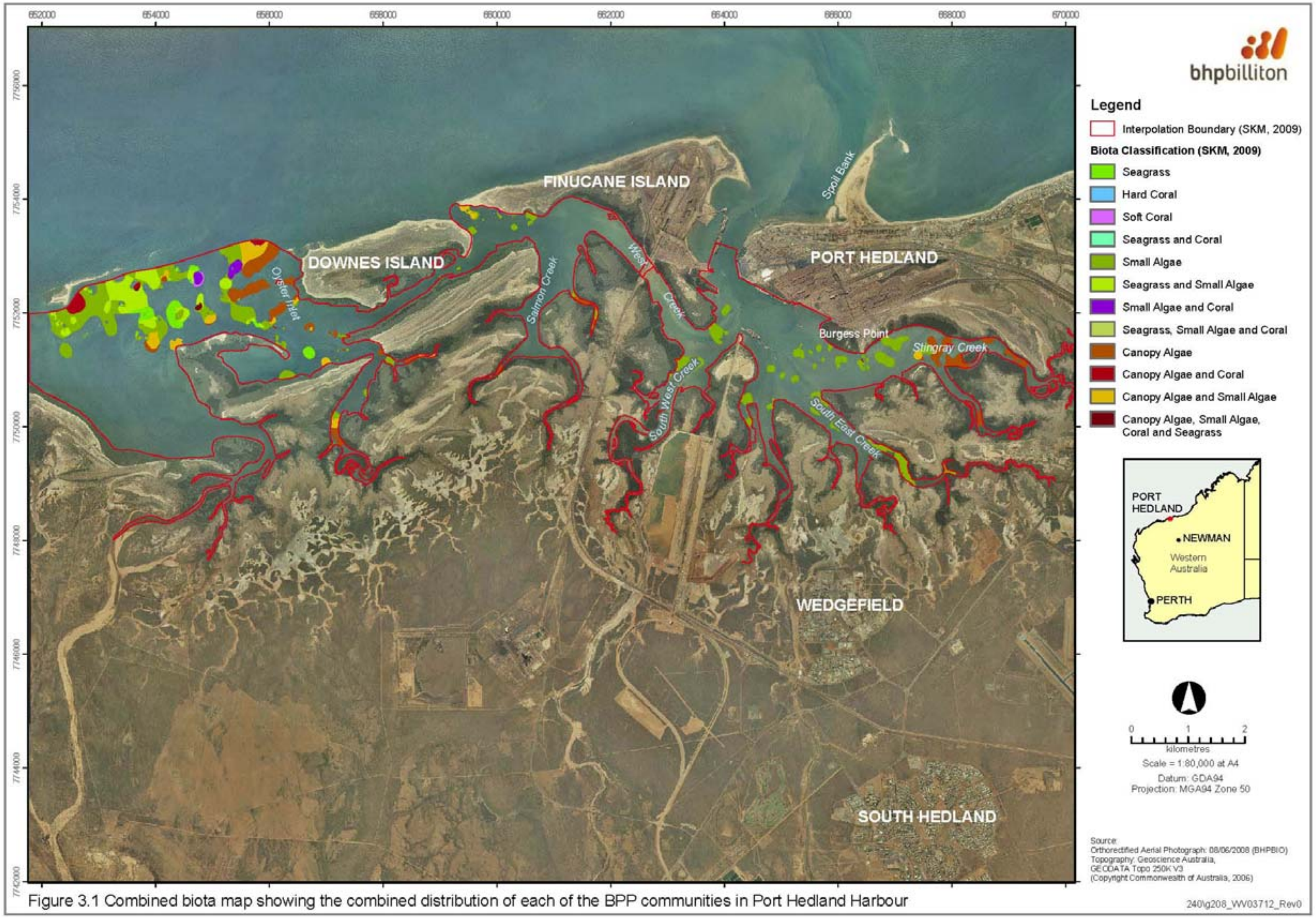

Figure 3.1 Combined biota map showing the combined distribution of each of the BPP communities in Port Hedland Harbour

- **Figure 3.1 Port Hedland Inner Harbour Benthic Primary Producer Map**

3.3. Groundwater Quality

Of the physical parameters measured from the 11 bores at Boodarie (conductivity, pH, dissolved oxygen, temperature and turbidity) only conductivity and dissolved oxygen had extreme ranges in readings (**Table 3.2**). Conductivity ranged from fresh (1.1 mS/cm in Bore 2) to hypersaline (76.4 mS/cm in Bore 6) while dissolved oxygen ranged from nearly deoxygenated (4% at Bore 9) to 82% at Bore 1. The turbidity ranged from 0.7 NTU (Bore 4) to 16 NTU (Bore 11). The temperature of each bore was in the low thirties (with the exception of Bore 9, 25ºC and Bore 3 27.3ºC) and pH was slightly acidic to neutral (pH 6.1 to 7.4).

There were no detectable total petroleum hydrocarbons (TPH), polycyclic aromatic hydrocarbons (PAHs) or benzene, toluene, ethylbenzene and xylene (BTEX) in any of the 11 groundwater bores sampled at Boodarie (**Table 3.** and **Appendix A**), except for Bore 10, which had detectable naphthalene (0.1 µg/L); this was, however, much lower than the ANZECC/ARMCANZ (2000) 99% species protection trigger value of 50 µg/L.

As one of the sampling bottles from Bore 10 was broken during transit to the laboratory there was not enough sample for the lowest detection limits to be used for analysis of PAH therefore the analytical detection limits were raised to accommodate sample volumes.

There were only a small number of parameters that had concentrations of TPH and PAH approaching ANZECC/ARMCANZ (2000) recommended 99% species protection trigger values; however the laboratory limit of reporting (LOR) were all below those that were available. The exception to this statement is anthracene for which the LOR was 0.02 µg/L and the 99% trigger value was 0.01 µg/L. Note, the ANZECC/ARMCANZ (2000) 95% species protection trigger value for anthracene was 0.4 µg/L.

Elevated concentrations of nitrate–nitrite (NOx) were recorded in the groundwater samples collected from bores at Boodarie, and contributed the majority fraction of total nitrogen in each bore. Concentrations ranged from 700 µg/L (sites Bore 7 and Bore 11) to 18,000 µg/L (Bore 2, **Table 3.1**); the exception to this was the NOx concentration measured in a sample collected from Bore 5 which only made up 47% of total nitrogen. There was no detectable ammonium (NH_4) in any of the bore samples, except Bore 2 in which it was high (210 µg/L). Therefore the majority of total nitrogen consisted of NOx and in the case of Bore 5 also organic nitrogen. The levels of ammonium in the groundwater of Bore 2 were greater than the ANZECC/ARMCANZ (2000) trigger value for inshore marine ecosystems in tropical Australia of 10 µg/L. Similarly, levels of NOx from the 11 bores were greater (up to 2,250 times) in nitrate-nitrite than the ANZECC/ARMCANZ (2000) trigger value for inshore marine ecosystems in tropical Australia of 8 µg/L and similarly total nitrogen concentrations were all higher than the ANZECC/ARMCANZ (2000) trigger value of 100 µg/L.

Filterable reactive phosphorus (FRP) concentrations in the 11 groundwater samples from the Boodarie area were quite similar ranging from 31 µg/L (Bore 7) to 44 µg/L (Bore 4, **Table 3.2**). All samples had higher FRP concentrations than the ANZECC/ARMCANZ (2000) trigger value for inshore marine ecosystems in tropical Australia of 5 µg/L.

Total phosphorus concentrations in the 11 groundwater samples collected from Boodarie bores ranged from 49 µg/L (Bores 6 and 7) to 130 µg/L (Bore 2, **Table 3.2**). All samples had greater total phosphorus concentrations than the ANZECC/ARMCANZ (2000) trigger value recommended for inshore marine ecosystems in tropical Australia of 15 µg/L.

- **Table 3.2 Physical Parameters Measured in the Groundwater Samples from Boodarie**

Parameter	ANZECC Guideline	Bore 1	Bore 2	Bore 3	Bore 4	Bore 5	Bore 6	Bore 7	Bore 8	Bore 9	Bore 10	Bore 11
Electrical Conductivity (mS/cm)	–	24.0	1.0	23.0	36.0	24.0	76.0	45.0	36.0	31.0	40.0	58.0
pH	8.0 – 8.4	6.4	6.6	6.4	6.4	6.1	7.2	7.3	7.2	6.4	7.4	7.3
Dissolved Oxygen (% sat)	90	82.0	33.0	74.0	34.0	14.0	13.0	6.0	38.0	4.0	7.0	31.0
Temperature (°C)	–	31.4	31.7	27.3	30.7	34.9	30.0	30.8	31.2	31.5	31.8	31.2
Turbidity (NTU)	1-20	1.8	14.0	5.4	0.7	1.7	1.5	1.4	2.4	1.0	5.4	16.0
Total Phosphorus (µg/L)	15	73	130	68	72	51	49	49	69	63	50	59
FRP (µg/L)	5	37	43	43	44	34	32	31	40	32	33	33
Total Nitrogen (mg/L)	0.1	8.20	24.0	3.60	1.70	4.00	1.00	0.85	1.40	1.90	0.94	0.78
NOx (mg/L)	0.008	7.60	18.0	3.30	1.70	2.00	0.90	0.70	1.40	1.90	0.89	0.70
NH_4 (µg/L)	1-10	<3	210	<3	<3	<3	<3	<3	<3	<3	<3	<3

Note: Samples taken Feb 2010. Values exceeded guidelines are highlighted.

- **Table 3.3 Concentrations of Polycyclic Aromatic Hydrocarbons, Total Petroleum Hydrocarbons and Benzene, Toluene, Ethylbenzene and Xylene (BTEX) in the Groundwater Samples from Boodarie**

Parameter	Units	LOR	ANZECC/ ARMCANZ 99% Species Protection Limit	Bore 1	Bore 2	Bore 3	Bore 4	Bore 5	Bore 6	Bore 7	Bore 8	Bore 9	Bore 10	Bore 11
Polycyclic Aromatic Hydrocarbons														
Naphthalene	µg/L	0.02	50	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.1	<0.02
Acenaphthylene	µg/L	0.02		<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.1	<0.02
Acenaphthene	µg/L	0.02		<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.1	<0.02
Fluorene	µg/L	0.02		<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.1	<0.02
Phenanthrene	µg/L	0.02		<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.1	<0.02
Anthracene[a]	µg/L	0.02	0.01	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.1	<0.02
Fluoranthene[a]	µg/L	0.02	1	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.1	<0.02
Pyrene	µg/L	0.02		<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.1	<0.02
Benz(a)anthracene	µg/L	0.02		<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.1	<0.02
Chrysene	µg/L	0.02		<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.1	<0.02
Benzo(b)fluoranthene	µg/L	0.02		<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.1	<0.02
Benzo(k)fluoranthene	µg/L	0.02		<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.1	<0.02
Benzo(a)pyrene	µg/L	0.005	0.1	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.05	<0.005
Indeno(1.2.3.cd)pyrene[a]	µg/L	0.02		<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.1	<0.02
Dibenz(a.h)anthracene	µg/L	0.02		<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.1	<0.02
Benzo(g.h.i)perylene	µg/L	0.02		<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.1	<0.02
Total Petroleum Hydrocarbons														
C6 – C9	µg/L	20		<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
C10 – C14	µg/L	50		<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
C15 – C28	µg/L	100		<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100
C29 – C36	µg/L	50		<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
BTEX														
Benzene	µg/L	1	500	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Toluene[a]	µg/L	2	110	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Ethylbenzene[a]	µg/L	2	50	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
meta-& para-Xylene[a]	µg/L	2	50	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
ortho-Xylene[a]	µg/L	2	350	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2

a Low reliability trigger value.

Of the metals measured in groundwater samples collected from Boodarie bores, cadmium, copper , lead and nickel in all 11 bores sampled were below the ANZECC/ARMCANZ (2000) 99% species trigger level, or 95% species protection trigger level in the case of copper (**Table 3.3** and **Appendix A**). The vanadium in Bore 2 equalled the ANZECC/ARMCANZ (2000) 99% species trigger level of 50 µg/L, while in all other bores the vanadium was lower. The cobalt in Bore 4 equalled the ANZECC/ARMCANZ (2000) 95% species trigger level of 1 µg/L, while in all other bores the cobalt was lower.

All other metals, arsenic, chromium, mercury, selenium, silver, vanadium and zinc were above the ANZECC/ARMCANZ (2000) recommended 99% species protection trigger levels, by up to 17 times in the case of mercury in Bore 9 and 20 times in the case of silver in Bore 6. The field blanks were below reporting limits for all metals, therefore it was assumed that the filtering process did not contribute to the exceedances (**Appendix A**).

- **Table 3.3 Concentrations of Metals in Groundwater Samples Collected from Boreholes at the Boodarie Site**

Parameter	Units	LOR	ANZECC guideline	No	Min	Max	Median	95th %ile
Arsenic[a]	µg/L	0.4	4.5	11	<0.4	6.6	1.0	5.3
Cadmium	µg/L	0.6	0.7	11	<0.6	-	-	-
Chromium[b]	µg/L	1.0	7.7	43	2	72	19	62.8
Cobalt[c]	µg/L	0.2	1.0	11	<0.2	1.0	1.0	1.0
Copper[c]	µg/L	1.0	1.3	11	<1.0	-	-	-
Lead	µg/L	0.2	2.2	11	<0.2	0.6	0.4	0.58
Mercury	µg/L	0.1	0.1	33	<0.1	1.4	0.4	1.24
Nickel	µg/L	7.0	7.0	36	<1.0	37	13	24.8
Selenium[a]	µg/L	0.5	3.0	31	2	26	12	22
Silver	µg/L	0.1	0.8	11	<0.1	16.2	4.5	13.5
Vanadium	µg/L	2.0	50	38	4	63	9.5	52
Zinc	µg/L	2.0	7.0	47	9	400	43	167

Note: a – Low reliability trigger value; b – Value for chromium III; c – 95% species protection limit
Values exceeding guidelines are highlighted.

3.4. Ecotoxicity Testing

The results of the ecotoxicity tests are summarised in **Table 3.4**. Detailed laboratory reports are provided in **Appendix A**. The results provided by the analysis undertaken by Ecotox Services Australasia (ESA) indicate that the groundwater samples were:

- Not toxic to sea urchin fertilisation (*Heliocidaris tuberculata*), amphipods (*Melita plumulosa*), or fish (barramundi); and
- Moderately toxic to microalga (*Nitzschia closterium*), sea urchin larval development (*Heliocidaris tuberculata*) and rock oyster larval development (*Saccostrea commercialis*).

Table 3.4 Average Toxicity Results Expressed as a Percentage of the Borewater Sample Concentration

Ecotox Test	Ecotox Results		
	EC_{50}/IC_{50}	LOEC	NOEC
Microalga (*Nitzschia closterium*)	45%	45%	45%
Sea Urchin fertilisation (*Heliocidaris tuberculata)*	>100%	100%	80%
Sea Urchin larval development (*Heliocidaris tuberculata)*	99.8%	100%	80%
Rock oyster larval development (*Saccostrea commercialis)*	>100%	100%	80%
Amphipod (*Melita plumulosa)*	100%	90%	85%
Fish (barramundi) (*Lates calcarifer*)	>100%	>100%	100%

The analysis of the toxicity data using the BurrliOz program produced species protection trigger values and the dilutions required to meet the trigger values are shown in **Table 3.5**. The percentile plots from the BurrliOz program are provided in **Appendix C**. Note that the outputs shown in **Appendix C** indicate units of µg/L but should read % solution. This is a limitation of the graphical output of the program.

The averaged results for the five groundwater samples indicate that:

- A 1:20 dilution would be required to produce a 5.0% solution that would achieve protection of 99% of species;
- A 1:15 dilution would be required to produce a 6.9% solution that would achieve protection of 95% of species; and
- A 1:12 dilution would be required to produce an 8.4% solution that would achieve protection of 90% of species.

▪ **Table 3.5 Species Protection Trigger Values**

Species Protection Level	Trigger Values	
	% of Borewater	Dilution
99%	5.0	1:20
95%	6.9	1:15
90%	8.4	1:12

Derived from toxicity results and the BurrliOz program.

Salmon Creek experiences considerable flushing associated with large semi-diurnal tides and this flushing action will provide a substantial dilution of contaminants within discharged dewatering water within the initial zone of mixing in the receiving environment. The level of dilution required to lower the 95th percentile of discharge heavy metal concentrations to below the ANZECC/ARMCANZ (2000) (99% species) trigger levels is 1:24 (**Table 3.6**).

▪ **Table 3.6 Dilution required of heavy metals and nutrients in dewatering discharge to achieve ANZECC/ARMCANZ (2000) 99% Species Protection**

Parameter	Units	ANZECC/ ARMCANZ 99% species	No.	Min.	Max.	Median	95th %ile	Dilution required
As[a]	µg/L	4.5		<0.4	6.6	1.0	5.3	1
Cd	µg/L	0.7	11	<0.6	-	-	-	<1
Cr[a]	µg/L	7.7	43	2	72	19	62.8	8
Co	µg/L	1.0	11	<0.2	1.0	1.0	1.0	<1
Cu	µg/L	1.3	11	<1.0	-	-	-	<1
Pb	µg/L	2.2	11	<0.2	0.6	0.4	0.58	<1
Hg	µg/L	0.1	33	<0.1	1.4	0.4	1.24	12
Ni	µg/L	7.0	36	<1.0	37	13	24.8	4
Se[b]	µg/L	3.0	31	2	26	12	22	7
V	µg/L	50	38	4	63	9.5	52	1
Zn	µg/L	7.0	47	9	400	43	167	24
Ag	µg/L	0.8	11	<0.1	16.2	4.5	13.5	17
TP	µg/L	15	11	49	130	63	101.5	7
FRP	µg/L	5	11	31	44	34	43.5	9
TN	mg/L	0.100	11	0.780	24.0	1.70	16.1	161
NOx	mg/L	0.008	11	0.700	18.0	1.70	12.8	1600

** Practical Quantitation Limit a Value for chromium III.b Low reliability trigger value.*

The expected nutrient levels in the dewatering discharge are extremely high compared to the ANZECC/ARMCANZ (2000) guidelines for tropical Australia (**Table 3.6**). No background nutrient data is available. Nutrients are not regarded as toxicants (except ammonia). However, elevated nutrient levels lead to eutrophication, where nuisance macroalgae and microalgae grow in abundance in place of the natural flora (SKM 2011). The elevated concentrations of nutrients in the discharge would contribute significant amounts of nitrogen and phosphorus to Salmon Creek in the vicinity of 5 kg of available phosphorus and 519 kg of available nitrogen per year (SKM 2011).

The ANZECC/ARMCANZ (2000) toxicant guidelines are not intended to be used as 'pollute to' levels in waterways. The dilutions required should also consider the background concentrations in Salmon Creek, therefore, a dilution of up to 1:125 is required to achieve background concentrations for heavy metals (**Table 3-7**). This is based on chromium levels, which are below detection in Salmon Creek (<1µg/L) compared to a discharge quality of 62.8 µg/L. Mercury levels also require a 1:30 dilution to achieve background levels, which were also below the detection limit of 0.1 µg/L.

- **Table 3-7 Dilution required of 95th percentile heavy metal concentrations in dewatering discharge (see Table 3.6; SKM 2011) to comply with background concentrations in Salmon Creek at discharge point**

Parameter (µg/L)	ANZECC	Neap tide (dry)	Neap tide (wet)	High spring tide (dry)	High spring tide (wet)	Average	Discharge quality	Dilution required
As	4.5	2	<2	2.2	1.5	1.93	5.3	2.8
Cd	0.7	<0.1	<0.1	<0.1	0.3	0.11	0.3	2.7
Cr	7.7	<1	<1	<1	<1	0.50	62.8	125
Co	0.005	<1	1.5	<1	0.5	0.75	1	1.3
Cu	0.3	<1	<1	<1	<1	0.50	0.5	1.0
Pb	2.2	<1	<1	<1	5	1.63	0.58	0.4
Hg	0.1	<0.1	<0.1	<0.1	<0.1	0.05	1.24	25
Ni	7	<1	1.5	<1	2	1.13	3.5	3.1
Se	3.0	No data						
Ag	0.8	<1	1.2	<1	5	1.80	13.5	7.5
V	50	5	7	4	0.5	4.13	36.5	8.8
Zn	7	2	9	18	1	7.50	12.5	1.7

In summary, the ecotoxicology analysis indicated that a 1:20 dilution is the minimum requirement to achieve 99% species protection of species found in Salmon Creek. However, the dilutions required to achieve both background and ANZECC/ARMCANZ (2000) guidelines are provided in **Table 3-8**. The main chemicals of concern are chromium, silver, mercury and zinc. These were selected as the levels in the discharge significantly exceeded both the ANZECC/ARMCANZ

(2000) guidelines and background concentrations. The extent of the mixing zone in Salmon Creek required to dilute these heavy metals to suitable levels is assessed in the next section. Although not a toxicant, nitrogen levels are also considered because of the potential for eutrophication of the receiving environment from high levels in the discharge water.

- **Table 3-8 Summary of dilutions required by dewatering discharge to achieve background and ANZECC levels at the 95th percentile.**

Parameter	Dilution required for background	Dilution required for ANZECC	Parameter	Dilution required for background	Dilution required for ANZECC
As	2.8	1.2	Se	Nd	7
Cd	2.7	<1	Ag	**7.5**	**17**
Cr	**125**	**8**	V	**8.8**	1
Co	1.3	<1	Zn	1.7	**24**
Cu	1.0	<1	TP	Nd	7
Pb	<1	<1	FRP	Nd	9
Hg	**25**	**12**	TN	Nd	**161**
Ni	3.1	4	NOx	Nd	**1600**

Red and maroon highlights indicate significant dilutions required for chemicals of concern for the receiving environment to meet ANZECC guidelines and background levels respectively.

3.5. Mixing Zone Modelling

The near-field hydrodynamic modelling (**Appendix D**) indicated that an initial mixing zone of 3 to 4 metres would be sufficient to dilute the heavy metal concentrations to levels below the ANZECC/ARMCANZ (2000) trigger levels (99% of species) when the water depths were greater than 0.5 m. This is very small compared with the size of Salmon Creek (average width of 90 m).

However, the tides in Salmon Creek have a strong influence on the depth of water in the creek. Under low tide conditions, the tide completely drains out of the Salmon Creek exposing the mudflats. It is under these conditions that the discharge may constitute the majority of the flow and therefore impact on the aquatic ecosystems through acute heavy metal toxicity. This would only affect the ecosystem present at the bottom of the channel, and would not impact on the mangroves or rocky reef areas that are higher up in the channel.

The modelling also showed that the NOx levels in the discharge waters are not adequately diluted to meet the ANZECC/ARMCANZ (2000) trigger levels for inshore ecosystems in the near-field mixing zone.

3.6. Assessment of Potential Physical Impacts to Mangroves

During the Fincucane Island Dredging Project, the potential short to mid-term indicators of stress (foliage cover, number of dead limbs and the general health of leaves) showed significant variability between baseline, mid-term and final surveys at all sites. The average number of dead limbs, however, did show that there had been an increase in the number of dead limbs per quadrat in the final survey at most sites when compared to previous surveys. The increase in the number of dead limbs recorded at DMMA A East and DMMA A West may be significant in the context of potential impacts from the dredging activities.

Although the results indicate a significant increase in the number of dead limbs observed in the final survey, the other potential short to medium-term indicators of health do not show a similar trend. There was no conclusive evidence that the increase in the number of dead limbs observed in the final survey was due to dredging or DMMA A discharge activities, although this is one of the short and medium term attributes that are most likely to show an early response to impacts near the construction footprints.

With respect to sedimentation, fluctuations in stake height measurements between successive surveys is a strong indicator that small scale changes in sediment height are occurring over short time scales in response to local sedimentation and erosion events. The amount of change recorded thus far was not considered to be an issue of concern for mangroves because the small increases in sedimentation were not sufficient to smother the pneumatophores of the trees in the area. The results indicate that the discharge activities did not lead to sedimentation events that would impact nearby mangroves.

There was no change to soil salinity ranges measured compared to baseline levels. The soil salinities measured under mangroves in both mid-term and final surveys did not exceed levels that can be tolerated by these mangrove species. There is therefore no evidence that an increase in the number of dead limbs at the two DMMA A transect sites might be explained by an increase in soil salinity.

4. Impact Conclusions

The groundwater that is proposed to be extracted and discharged into Salmon Creek differs from the receiving environment for a number of parameters that could influence the water quality and ultimately impact the flora and fauna of the receiving environment. These included physical parameters (dissolved oxygen, pH and conductivity), metals (arsenic, chromium, mercury, selenium, silver, vanadium and zinc) and nutrients (nitrate-nitrite and filterable reactive phosphorus).

Impacts to the marine environment of Salmon Creek may arise due to the presence of heavy metals and nutrients within the dewatering discharge. Groundwater chemistry analyses have indicated that some heavy metal and nutrient levels in the groundwater are above the recommended 99% species protection trigger values for marine waters (ANZECC/ARMCANZ 2000). However, Salmon Creek experiences considerable flushing associated with large semi-diurnal tides and would likely result in a substantial dilution of contaminants within discharged groundwater within the initial zone of mixing in the receiving environment.

The results of the ecotoxicity testing have shown that the groundwater samples are not toxic to sea urchin fertilization, amphipods or fish but are moderately toxic to microalgae, sea urchin and rock oyster larval development and would need a 1:20 dilution to achieve 99% species protection. If this was achieved there would be no predicted downstream toxic impacts to the receiving environment of Salmon Creek.

Near-field hydrodynamic modelling indicates that an initial mixing zone of 3 to 4 metres is sufficient to dilute the heavy metal concentrations to levels below the ANZECC/ARMCANZ (2000) trigger levels (99% of species) when the water depths were greater than 0.5 m. This is very small compared with the size of Salmon Creek (average width of 90 m). However, the tides in Salmon Creek have a strong influence on the depth of water in the creek. Under low tide conditions, the tide completely drains out of the Salmon Creek exposing the mudflats. It is under these conditions that the discharge may constitute the majority of the flow and therefore impact on the aquatic ecosystems through acute heavy metal toxicity. This would only affect the ecosystem present at the bottom of the channel, and will not impact on the mangroves or rocky reef areas that are higher up in the channel. Overall, the heavy metal Boodarie groundwater dewatering discharge is not anticipated to have any significant effects on the Salmon Creek receiving environment as no sensitive habitats are present.

It should be noted that even with a 1:20 dilution before the groundwater reached the Salmon Creek receiving environment, the elevated concentrations of nutrients would contribute significant amounts of nitrogen and phosphorus to Salmon Creek in the vicinity of 5 kg of available phosphorus and 519 kg of available nitrogen per year. This would make the Boodarie groundwater discharge a significant point source of nutrients to the macrotidal system of Port Hedland. This could cause long term impacts downstream in terms of eutrophication, where nuisance macroalgae and microalgae grow in abundance in place of the natural flora.

Scouring

The discharge location would experience periods of low tide when sediments on the creek floor would be directly exposed to the discharge waters. However, this would last only a few hours during a tidal cycle. The area receiving direct discharge would be scoured by the force of the discharge water, but the area of disturbance is predicted to be small (less than 10 m^2) and sediment will be brought in with the next tidal cycle.

The sea bed of the wide channels of tidal creeks in the Port Hedland area are typically comprised of coarse sand and gravel due to the shear stress caused by strong tides removing finer sedimentary material. As a result, any additional scouring attributable to the discharge is unlikely to be extensive.

Although there may be scouring of the benthic environment near the discharge point the area affected will be localised (an area less than 10 m^2) and will likely be restricted to short periods when the tide is turning.

Physical Impacts to Mangroves

Based on the findings of the Finucane Island Dredging Project Mangrove Monitoring (**Section 3.6**) there is not expected to be any significant impact to mangroves from the proposed ground water discharge.

5. References

ANZECC/ARMCANZ (2000). *Australian and New Zealand guidelines for fresh and marine water quality. National Water Quality Management Strategy No 4*, Australian and New Zealand Environment and Conservation Council and Agricultural and Resource Management Council of Australia and New Zealand, Canberra, ACT.

APHA. (1998) *Standard Methods for the Examination of Water and Wastewater*. 20th Ed. American Public Health Association, American Water Works Association and the Water Environment Federation, Washington, DC.

AS/NZS 5667.1:1998. *Water Quality – Sampling. Part 1: Guidance on the design of sampling programs, sampling techniques and the preservation and handling of samples*.

Ellison, J C (1998) Impacts of sediment burial on mangroves. *Marine Pollution Bulletin* 37: 420-426.

ESA. (2009a). *ESA SOP 104 – Sea Urchin Fertilisation Success Test. Issue No. 10*. Ecotox Services Australasia, Sydney, NSW.

ESA. (2009b). *SOP 106 – Bivalve Larval Development Test. Issue No. 10*. Ecotox Services Australasia, Sydney, NSW.

ESA. (2009c). *SOP 108 – Amphipod Acute Toxicity Test. Issue No 7*. Ecotox Services Australasia, Sydney, NSW.

ESA. (2009d). *SOP 117 –Freshwater and Marine Fish Imbalance Test. Issue No 6*. Ecotox Services Australasia, Sydney, NSW.

ESA. (2010). *ESA SOP 105 - Sea Urchin Larval Development Test. Issue No. 9*. Ecotox Services Australasia, Sydney, NSW.

Hydrosolutions (2010). *BHP Boodarie Iron Plant Site (Licence L6564/1995/13) Annual Surface Water and Groundwater Monitoring Report – July 2009 to June 2010*.

Krassoi, F.R., Everett, D., and Anderson, I. (1996) *Protocol for using Doughboy scallop Chlamys asperrima (Mollusca:Pectinidae) L. to test the sublethal toxicity of single compounds and effluents*. National Pulp Mills Research Program, Technical Report No. 17, CSIRO, Canberra. 56pp.

Port Hedland Port Authority. (PHPA 2008). [Online] Accessed at: http://www.phpa.com.au/

Simon, J. and Laginestra, E. (1997) *Bioassay for testing sublethal toxicity in effluents, using gametes of the sea urchin* Heliocidaris tuberculata. National Pulp Mills Research Program, Technical Report No. 20, CSIRO, Canberra. 42pp.

Sinclair Knight Merz (2009). *RGP6 Port Facilities Benthic Primary Producer: Reference Area sub-tidal Mapping Report*. Report Prepared for BHP Billiton Iron Ore

Sinclair Knight and Merz (2010a). *RGP5 Port Facilities Execution Phase Study Mangrove heath Monitoring Report – Final*, Sinclair Knight Merz. Perth.

Sinclair Knight and Merz (2010b). *RGP5 Port Facilities Summary Water Quality and Coral Health Report*, Sinclair Knight Merz. Perth.

Stauber JL, Tsai J, Vaughan GT, Peterson SM and BrockbankCI. (1994). *Algae as Indicators of Toxicity of the Effluent From Bleached Eucalypt Kraft Paper Mills.* Technical Report No 3, National Pulp Mills Research Program, CSIRO, Canberra, ACT, Australia.

Thampanya, U (2006) *Mangroves and Sediment Dynamics Along the Coasts of Southern Thailand*. Chapter 3.

USEPA. (2002). *Methods for measuring the acute toxicity of effluents and receiving waters to freshwater and marine organisms*. 5TH Edition. United States Environmental Protection Agency, Office of Research and Development, Washington DC, EPA/600/4-90/027F.

Appendix A Laboratory Results from the Groundwater Samples at Boodarie

CERTIFICATE OF ANALYSIS

Work Order	: **EP1100847**	Page	: 1 of 9
Amendment	: **1**		
Client	: **SINCLAIR KNIGHT MERZ**	Laboratory	: Environmental Division Perth
Contact	: CELESTE WILSON	Contact	: Scott James
Address	: P O BOX H615 PERTH WA, AUSTRALIA 6001	Address	: 10 Hod Way Malaga WA Australia 6090
E-mail	: cxxwilson@skm.com.au	E-mail	: perth.enviro.services@alsglobal.com
Telephone	: +61 08 9469 4400	Telephone	: +61-8-9209 7655
Facsimile	: +61 08 9469 4488	Facsimile	: +61-8-9209 7600
Project	: WV05024- BHPB345 - Salmon Creek Discharge WV05024	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Order number	: ----		
C-O-C number	: ----	Date Samples Received	: 14-FEB-2011
Sampler	: S.K	Issue Date	: 01-MAR-2011
Site	: ----		
		No. of samples received	: 13
Quote number	: EN/003/10	No. of samples analysed	: 13

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results
- Surrogate Control Limits

NATA Accredited Laboratory 825

This document is issued in accordance with NATA accreditation requirements.

Accredited for compliance with ISO/IEC 17025.

WORLD RECOGNISED ACCREDITATION

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Alex Rossi	Organic Chemist	Organics
Kerry Rodrigues	Senior Organic Chemist	Perth Organics
Luke Witham	Senior Inorganic Chemist	Inorganics
Rassem Ayoubi	Senior Organic Chemist	Perth Organics

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insuffient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting

- **24/02/2011: This report has been amended and re-released to allow the reporting of additional analytical data.**

Analytical Results

Sub-Matrix: WATER			Client sample ID	Bore 1	Bore 2	Bore 3	Bore 4	Bore 5
			Client sampling date / time	09-FEB-2011 11:45	09-FEB-2011 13:15	09-FEB-2011 14:30	09-FEB-2011 15:30	09-FEB-2011 16:30
Compound	CAS Number	LOR	Unit	EP1100847-001	EP1100847-002	EP1100847-003	EP1100847-004	EP1100847-005
EG093F: Dissolved Metals in Saline Water by ORC-ICPMS								
Cobalt	7440-48-4	0.2	µg/L	<0.2	<0.2	<0.2	**1.0**	<0.2
Copper	7440-50-8	1	µg/L	<1	<1	<1	<1	<1
Lead	7439-92-1	0.2	µg/L	<0.2	<0.2	<0.2	**0.2**	<0.2
Silver	7440-22-4	0.1	µg/L	<0.1	<0.1	<0.1	**0.8**	<0.1
Strontium	7440-24-6	10	µg/L	**8730**	**90**	**450**	**12400**	**5450**
EP071 SG: Total Petroleum Hydrocarbons - Silica gel cleanup								
C10 - C14 Fraction	----	50	µg/L	<50	<50	<50	<50	<50
C15 - C28 Fraction	----	100	µg/L	<100	<100	<100	<100	<100
C29 - C36 Fraction	----	50	µg/L	<50	<50	<50	<50	<50
^ C10 - C36 Fraction (sum)	----	50	µg/L	<50	<50	<50	<50	<50
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons								
Naphthalene	91-20-3	0.02	µg/L	<0.02	<0.02	<0.02	<0.02	<0.02
Acenaphthylene	208-96-8	0.02	µg/L	<0.02	<0.02	<0.02	<0.02	<0.02
Acenaphthene	83-32-9	0.02	µg/L	<0.02	<0.02	<0.02	<0.02	<0.02
Fluorene	86-73-7	0.02	µg/L	<0.02	<0.02	<0.02	<0.02	<0.02
Phenanthrene	85-01-8	0.02	µg/L	<0.02	<0.02	<0.02	<0.02	<0.02
Anthracene	120-12-7	0.02	µg/L	<0.02	<0.02	<0.02	<0.02	<0.02
Fluoranthene	206-44-0	0.02	µg/L	<0.02	<0.02	<0.02	<0.02	<0.02
Pyrene	129-00-0	0.02	µg/L	<0.02	<0.02	<0.02	<0.02	<0.02
Benz(a)anthracene	56-55-3	0.02	µg/L	<0.02	<0.02	<0.02	<0.02	<0.02
Chrysene	218-01-9	0.02	µg/L	<0.02	<0.02	<0.02	<0.02	<0.02
Benzo(b)fluoranthene	205-99-2	0.02	µg/L	<0.02	<0.02	<0.02	<0.02	<0.02
Benzo(k)fluoranthene	207-08-9	0.02	µg/L	<0.02	<0.02	<0.02	<0.02	<0.02
Benzo(a)pyrene	50-32-8	0.005	µg/L	<0.005	<0.005	<0.005	<0.005	<0.005
Indeno(1.2.3.cd)pyrene	193-39-5	0.02	µg/L	<0.02	<0.02	<0.02	<0.02	<0.02
Dibenz(a.h)anthracene	53-70-3	0.02	µg/L	<0.02	<0.02	<0.02	<0.02	<0.02
Benzo(g.h.i)perylene	191-24-2	0.02	µg/L	<0.02	<0.02	<0.02	<0.02	<0.02
^ Total PAH	----	0.005	µg/L	<0.005	<0.005	<0.005	<0.005	<0.005
EP080/071: Total Petroleum Hydrocarbons								
C6 - C9 Fraction	----	20	µg/L	<20	<20	<20	<20	<20
C10 - C14 Fraction	----	50	µg/L	<50	<50	<50	<50	<50
C15 - C28 Fraction	----	100	µg/L	<100	<100	<100	<100	<100
C29 - C36 Fraction	----	50	µg/L	<50	<50	<50	<50	<50
^ C10 - C36 Fraction (sum)	----	50	µg/L	<50	<50	<50	<50	<50
EP080: BTEX								
Benzene	71-43-2	1	µg/L	<1	<1	<1	<1	<1
Toluene	108-88-3	2	µg/L	<2	<2	<2	<2	<2
Ethylbenzene	100-41-4	2	µg/L	<2	<2	<2	<2	<2

Analytical Results

Sub-Matrix: WATER			Client sample ID	Bore 1	Bore 2	Bore 3	Bore 4	Bore 5
			Client sampling date / time	09-FEB-2011 11:45	09-FEB-2011 13:15	09-FEB-2011 14:30	09-FEB-2011 15:30	09-FEB-2011 16:30
Compound	CAS Number	LOR	Unit	EP1100847-001	EP1100847-002	EP1100847-003	EP1100847-004	EP1100847-005
EP080: BTEX - Continued								
meta- & para-Xylene	108-38-3 106-42-3	2	µg/L	<2	<2	<2	<2	<2
ortho-Xylene	95-47-6	2	µg/L	<2	<2	<2	<2	<2
EP080S: TPH(V)/BTEX Surrogates								
1.2-Dichloroethane-D4	17060-07-0	0.1	%	110	103	97.0	101	101
Toluene-D8	2037-26-5	0.1	%	97.2	102	98.7	100	98.8
4-Bromofluorobenzene	460-00-4	0.1	%	95.7	98.5	97.7	94.3	96.3
EP132T: Base/Neutral Extractable Surrogates								
2-Fluorobiphenyl	321-60-8	0.1	%	72.5	73.2	108	74.5	76.3
Anthracene-d10	1719-06-8	0.1	%	109	107	117	111	119
4-Terphenyl-d14	1718-51-0	0.1	%	80.9	90.5	89.8	86.7	88.2

Analytical Results

Sub-Matrix: **WATER**

Compound	CAS Number	LOR	Unit	Bore 6	Bore 7	Bore 8	Bore 9	Bore 10
Client sampling date / time				10-FEB-2011 09:30	10-FEB-2011 10:45	10-FEB-2011 13:45	10-FEB-2011 14:30	10-FEB-2011 16:00
				EP1100847-006	**EP1100847-007**	**EP1100847-008**	**EP1100847-009**	**EP1100847-010**
EG093F: Dissolved Metals in Saline Water by ORC-ICPMS								
Cobalt	7440-48-4	0.2	µg/L	<0.2	<0.2	<0.2	<0.2	<0.2
Copper	7440-50-8	1	µg/L	<1	<1	<1	<1	<1
Lead	7439-92-1	0.2	µg/L	**0.5**	<0.2	<0.2	<0.2	<0.2
Silver	7440-22-4	0.1	µg/L	**15.2**	**3.6**	**4.8**	**3.0**	**4.5**
Strontium	7440-24-6	10	µg/L	**33000**	**26400**	**27500**	**26300**	**32100**
EP071 SG: Total Petroleum Hydrocarbons - Silica gel cleanup								
C10 - C14 Fraction	----	50	µg/L	<50	<50	<50	<50	<50
C15 - C28 Fraction	----	100	µg/L	<100	<100	<100	<100	<100
C29 - C36 Fraction	----	50	µg/L	<50	<50	<50	<50	<50
^ C10 - C36 Fraction (sum)	----	50	µg/L	<50	<50	<50	<50	<50
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons								
Naphthalene	91-20-3	0.02	µg/L	<0.02	<0.02	<0.02	<0.02	----
Acenaphthylene	208-96-8	0.02	µg/L	<0.02	<0.02	<0.02	<0.02	----
Acenaphthene	83-32-9	0.02	µg/L	<0.02	<0.02	<0.02	<0.02	----
Fluorene	86-73-7	0.02	µg/L	<0.02	<0.02	<0.02	<0.02	----
Phenanthrene	85-01-8	0.02	µg/L	<0.02	<0.02	<0.02	<0.02	----
Anthracene	120-12-7	0.02	µg/L	<0.02	<0.02	<0.02	<0.02	----
Fluoranthene	206-44-0	0.02	µg/L	<0.02	<0.02	<0.02	<0.02	----
Pyrene	129-00-0	0.02	µg/L	<0.02	<0.02	<0.02	<0.02	----
Benz(a)anthracene	56-55-3	0.02	µg/L	<0.02	<0.02	<0.02	<0.02	----
Chrysene	218-01-9	0.02	µg/L	<0.02	<0.02	<0.02	<0.02	----
Benzo(b)fluoranthene	205-99-2	0.02	µg/L	<0.02	<0.02	<0.02	<0.02	----
Benzo(k)fluoranthene	207-08-9	0.02	µg/L	<0.02	<0.02	<0.02	<0.02	----
Benzo(a)pyrene	50-32-8	0.005	µg/L	<0.005	<0.005	<0.005	<0.005	----
Indeno(1.2.3.cd)pyrene	193-39-5	0.02	µg/L	<0.02	<0.02	<0.02	<0.02	----
Dibenz(a.h)anthracene	53-70-3	0.02	µg/L	<0.02	<0.02	<0.02	<0.02	----
Benzo(g.h.i)perylene	191-24-2	0.02	µg/L	<0.02	<0.02	<0.02	<0.02	----
^ Total PAH	----	0.005	µg/L	<0.005	<0.005	<0.005	<0.005	----
EP080/071: Total Petroleum Hydrocarbons								
C6 - C9 Fraction	----	20	µg/L	<20	<20	<20	<20	<20
C10 - C14 Fraction	----	50	µg/L	<50	<50	<50	<50	<50
C15 - C28 Fraction	----	100	µg/L	<100	<100	<100	<100	<100
C29 - C36 Fraction	----	50	µg/L	<50	<50	<50	<50	<50
^ C10 - C36 Fraction (sum)	----	50	µg/L	<50	<50	<50	<50	<50
EP080: BTEX								
Benzene	71-43-2	1	µg/L	<1	<1	<1	<1	<1
Toluene	108-88-3	2	µg/L	<2	<2	<2	<2	<2
Ethylbenzene	100-41-4	2	µg/L	<2	<2	<2	<2	<2

Analytical Results

Sub-Matrix: WATER			Client sample ID	Bore 6	Bore 7	Bore 8	Bore 9	Bore 10
			Client sampling date / time	10-FEB-2011 09:30	10-FEB-2011 10:45	10-FEB-2011 13:45	10-FEB-2011 14:30	10-FEB-2011 16:00
Compound	CAS Number	LOR	Unit	EP1100847-006	EP1100847-007	EP1100847-008	EP1100847-009	EP1100847-010
EP080: BTEX - Continued								
meta- & para-Xylene	108-38-3 106-42-3	2	µg/L	<2	<2	<2	<2	<2
ortho-Xylene	95-47-6	2	µg/L	<2	<2	<2	<2	<2
EP132B: Polynuclear Aromatic Hydrocarbons								
3-Methylcholanthrene	56-49-5	0.1	µg/L	----	----	----	----	<0.1
2-Methylnaphthalene	91-57-6	0.1	µg/L	----	----	----	----	<0.1
7.12-Dimethylbenz(a)anthracene	57-97-6	0.1	µg/L	----	----	----	----	<0.1
Acenaphthene	83-32-9	0.1	µg/L	----	----	----	----	<0.1
Acenaphthylene	208-96-8	0.1	µg/L	----	----	----	----	<0.1
Anthracene	120-12-7	0.1	µg/L	----	----	----	----	<0.1
Benz(a)anthracene	56-55-3	0.1	µg/L	----	----	----	----	<0.1
Benzo(a)pyrene	50-32-8	0.05	µg/L	----	----	----	----	<0.05
Benzo(b)fluoranthene	205-99-2	0.1	µg/L	----	----	----	----	<0.1
Benzo(e)pyrene	192-97-2	0.1	µg/L	----	----	----	----	<0.1
Benzo(g.h.i)perylene	191-24-2	0.1	µg/L	----	----	----	----	<0.1
Benzo(k)fluoranthene	207-08-9	0.1	µg/L	----	----	----	----	<0.1
Chrysene	218-01-9	0.1	µg/L	----	----	----	----	<0.1
Coronene	191-07-1	0.1	µg/L	----	----	----	----	<0.1
Dibenz(a.h)anthracene	53-70-3	0.1	µg/L	----	----	----	----	<0.1
Fluoranthene	206-44-0	0.1	µg/L	----	----	----	----	<0.1
Fluorene	86-73-7	0.1	µg/L	----	----	----	----	<0.1
Indeno(1.2.3.cd)pyrene	193-39-5	0.1	µg/L	----	----	----	----	<0.1
N-2-Fluorenyl Acetamide	53-96-3	0.1	µg/L	----	----	----	----	<0.1
Naphthalene	91-20-3	0.1	µg/L	----	----	----	----	**0.1**
Perylene	198-55-0	0.1	µg/L	----	----	----	----	<0.1
Phenanthrene	85-01-8	0.1	µg/L	----	----	----	----	<0.1
Pyrene	129-00-0	0.1	µg/L	----	----	----	----	<0.1
EP080S: TPH(V)/BTEX Surrogates								
1.2-Dichloroethane-D4	17060-07-0	0.1	%	**106**	**116**	**109**	**109**	**120**
Toluene-D8	2037-26-5	0.1	%	**101**	**95.7**	**96.4**	**98.2**	**116**
4-Bromofluorobenzene	460-00-4	0.1	%	**95.0**	**97.6**	**96.2**	**94.3**	**117**
EP132T: Base/Neutral Extractable Surrogates								
2-Fluorobiphenyl	321-60-8	0.1	%	**80.0**	**87.6**	**80.9**	**89.8**	----
2-Fluorobiphenyl	321-60-8	0.1	%	----	----	----	----	**87.1**
Anthracene-d10	1719-06-8	0.1	%	**115**	**100**	**110**	**116**	----
Anthracene-d10	1719-06-8	0.1	%	----	----	----	----	**102**
4-Terphenyl-d14	1718-51-0	0.1	%	**99.3**	**86.4**	**94.3**	**93.2**	----
4-Terphenyl-d14	1718-51-0	0.1	%	----	----	----	----	**104**

Analytical Results

Sub-Matrix: WATER			Client sample ID	Bore 11	Field Blank	Transport Blank	----	----
			Client sampling date / time	11-FEB-2011 09:00	11-FEB-2011 09:00	11-FEB-2011 10:00	----	----
Compound	CAS Number	LOR	Unit	EP1100847-011	EP1100847-012	EP1100847-013	----	----
EG093F: Dissolved Metals in Saline Water by ORC-ICPMS								
Cobalt	7440-48-4	0.2	µg/L	<0.2	<0.2	<0.2	----	----
Copper	7440-50-8	1	µg/L	<1	<1	<1	----	----
Lead	7439-92-1	0.2	µg/L	<0.2	<0.2	<0.2	----	----
Silver	7440-22-4	0.1	µg/L	**7.3**	<0.1	<0.1	----	----
Strontium	7440-24-6	10	µg/L	**28600**	<10	<10	----	----
EP071 SG: Total Petroleum Hydrocarbons - Silica gel cleanup								
C10 - C14 Fraction	----	50	µg/L	<50	----	----	----	----
C15 - C28 Fraction	----	100	µg/L	<100	----	----	----	----
C29 - C36 Fraction	----	50	µg/L	<50	----	----	----	----
^ C10 - C36 Fraction (sum)	----	50	µg/L	<50	----	----	----	----
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons								
Naphthalene	91-20-3	0.02	µg/L	<0.02	----	----	----	----
Acenaphthylene	208-96-8	0.02	µg/L	<0.02	----	----	----	----
Acenaphthene	83-32-9	0.02	µg/L	<0.02	----	----	----	----
Fluorene	86-73-7	0.02	µg/L	<0.02	----	----	----	----
Phenanthrene	85-01-8	0.02	µg/L	<0.02	----	----	----	----
Anthracene	120-12-7	0.02	µg/L	<0.02	----	----	----	----
Fluoranthene	206-44-0	0.02	µg/L	<0.02	----	----	----	----
Pyrene	129-00-0	0.02	µg/L	<0.02	----	----	----	----
Benz(a)anthracene	56-55-3	0.02	µg/L	<0.02	----	----	----	----
Chrysene	218-01-9	0.02	µg/L	<0.02	----	----	----	----
Benzo(b)fluoranthene	205-99-2	0.02	µg/L	<0.02	----	----	----	----
Benzo(k)fluoranthene	207-08-9	0.02	µg/L	<0.02	----	----	----	----
Benzo(a)pyrene	50-32-8	0.005	µg/L	<0.005	----	----	----	----
Indeno(1.2.3.cd)pyrene	193-39-5	0.02	µg/L	<0.02	----	----	----	----
Dibenz(a.h)anthracene	53-70-3	0.02	µg/L	<0.02	----	----	----	----
Benzo(g.h.i)perylene	191-24-2	0.02	µg/L	<0.02	----	----	----	----
^ Total PAH	----	0.005	µg/L	<0.005	----	----	----	----
EP080/071: Total Petroleum Hydrocarbons								
C6 - C9 Fraction	----	20	µg/L	<20	----	----	----	----
C10 - C14 Fraction	----	50	µg/L	<50	----	----	----	----
C15 - C28 Fraction	----	100	µg/L	<100	----	----	----	----
C29 - C36 Fraction	----	50	µg/L	<50	----	----	----	----
^ C10 - C36 Fraction (sum)	----	50	µg/L	<50	----	----	----	----
EP080: BTEX								
Benzene	71-43-2	1	µg/L	<1	----	----	----	----
Toluene	108-88-3	2	µg/L	<2	----	----	----	----
Ethylbenzene	100-41-4	2	µg/L	<2	----	----	----	----

Analytical Results

Sub-Matrix: WATER			Client sample ID	Bore 11	Field Blank	Transport Blank	----	----
			Client sampling date / time	11-FEB-2011 09:00	11-FEB-2011 09:00	11-FEB-2011 10:00	----	----
Compound	CAS Number	LOR	Unit	EP1100847-011	EP1100847-012	EP1100847-013	----	----
EP080: BTEX - Continued								
meta- & para-Xylene	108-38-3 106-42-3	2	µg/L	<2	----	----	----	----
ortho-Xylene	95-47-6	2	µg/L	<2	----	----	----	----
EP080S: TPH(V)/BTEX Surrogates								
1.2-Dichloroethane-D4	17060-07-0	0.1	%	117	----	----	----	----
Toluene-D8	2037-26-5	0.1	%	92.0	----	----	----	----
4-Bromofluorobenzene	460-00-4	0.1	%	111	----	----	----	----
EP132T: Base/Neutral Extractable Surrogates								
2-Fluorobiphenyl	321-60-8	0.1	%	72.6	----	----	----	----
Anthracene-d10	1719-06-8	0.1	%	107	----	----	----	----
4-Terphenyl-d14	1718-51-0	0.1	%	78.2	----	----	----	----

Surrogate Control Limits

Sub-Matrix: **WATER**

Compound	*CAS Number*	*Recovery Limits (%)* Low	*Recovery Limits (%)* High
EP080S: TPH(V)/BTEX Surrogates			
1.2-Dichloroethane-D4	17060-07-0	60.5	141.2
Toluene-D8	2037-26-5	73.4	126
4-Bromofluorobenzene	460-00-4	59.6	125.3
EP132T: Base/Neutral Extractable Surrogates			
2-Fluorobiphenyl	321-60-8	57.6	113
Anthracene-d10	1719-06-8	60.4	125
4-Terphenyl-d14	1718-51-0	58.2	128

Marine and Freshwater Research Laboratory
Environmental Science
Telephone: +61 8 93602907 Facsimile: +61 8 93606613

WORLD RECOGNISED ACCREDITATION
Accreditation Number: 10603
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Murdoch UNIVERSITY

WATER QUALITY DATA

Contact: Celeste Wilson
Customer: Sinclair Knight Merz
Address: Level 2, 47 Colin St, West Perth 6005

Date of Issue: 4/03/2011
Date Received: 14/02/2011
Our Reference: SKM11-1
Your Reference: BHPB345

METHOD SAMPLE CODE	Sampling Date	9200 EC 25ºC ms/cm	5060 Turbidity NTU	2000 AMMONIA µg.N/L	4100 ORTHO-P µg.P/L	2100 NO3+NO2 µg.N/L	4700 TOTAL-P µg.P/L	2700 TOTAL-N µg.N/L
Reporting Limit			<0.1	<3	<2	<2	<5	<50
File		**110215**	**110215**		**11022301-11030201**			**11021702**
B1	9/02/2011	24	1.8	<3	37	7600	73	8200
B2	9/02/2011	1.0	14	210	43	18000	130	24000
B3	9/02/2011	4.9	5.4	<3	43	3300	68	3600
B4	9/02/2011	35	0.7	<3	44	1700	72	1700
B5	9/02/2011	24	1.7	<3	34	2000	51	4200
B6	10/02/2011	76	1.5	<3	32	900	49	1000
B7	10/02/2011	45	1.4	<3	31	700	49	850
B8	10/02/2011	36	2.4	<3	40	1400	69	1400
B9	10/02/2011	31	1.0	<3	32	1900	63	1900
B10	10/02/2011	40	5.4	<3	33	890	50	940
B11	11/02/2011	58	16	<3	33	700	59	780
FIELD BLANK	10/02/2011			<3	2	<2	<5	<50
TRANSPORT BLANK				<3	2	<2	<5	<50

Signatory:

Date: 4/03/2011

All test items tested as received. Spare test items will be held for two months unless otherwise requested.

Marine and Freshwater Research Laboratory
Environmental Science
Telephone: +61 8 93602907 Facsimile: +61 8 93606613

NATA
WORLD RECOGNISED ACCREDITATION

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Murdoch UNIVERSITY

WATER QUALITY DATA

Contact: Celeste Wilson
Customer: Sinclair Knight Merz
Address: Level 2, 47 Colin St, West Perth 6005

Date of Issue: 4/03/2011
Date Received: 14/02/2011
Our Reference: SKM11-1
Your Reference: BHPB345

METHOD SAMPLE CODE	Sampling Date	9200 EC 25ºC ms/cm	5060 Turbidity NTU	2000 AMMONIA µg.N/L	4100 ORTHO-P µg.P/L	2100 NO3+NO2 µg.N/L	4700 TOTAL-P µg.P/L	2700 TOTAL-N µg.N/L
Reporting Limit			<0.1	<3	<2	<2	<5	<50
File		110215	110215		11022301-11030201		11021702	
QA/QC Data								
Duplicate % Difference		-	4%	15%	10%	13%	2%	2%
Spike Recovery		-	-	96%	96%	95%	98%	101%
Seawater control		-	-	98%	91%	106%	81%	101%
Freshwater control		-	-	116%	98%	98%	99%	94%

Signatory: [signature]

Date: 4/03/2011

All test items tested as received. Spare test items will be held for two months unless otherwise requested.

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Murdoch UNIVERSITY

WATER QUALITY DATA

Contact: Celeste Wilson
Customer: Sinclair Knight Merz
Address: Level 2, 47 Colin St, West Perth 6005

Date of Issue: 4/03/2011
Date Received: 14/02/2011
Our Reference: SKM11-1
Your Reference: BHPB345

METHOD	ICP001	ICP001	ICP001	ICP001	ICP001	ICP004	ICP004	ICP006
SAMPLE CODE	Cr	Cu	Ni	V	Zn	As	Se	Hg
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Reporting Limit	<0.001	<0.001	<0.007	<0.002	<0.002	<0.0004	<0.0005	<0.0001
File	11021601	11021601	11021601	11021601	11021601	11022401a	11022501b	11022202a
B1	0.060	<0.001	<0.007	0.012	0.007	0.0006	0.018	<0.0001
B2	0.003	<0.001	<0.007	0.050	0.005	0.0066	0.0074	<0.0001
B3	0.014	<0.001	<0.007	0.020	0.003	0.0014	0.0025	<0.0001
B4	0.018	<0.001	<0.007	0.008	0.017	0.0013	0.015	<0.0001
B5	0.019	<0.001	<0.007	0.007	0.005	<0.0004	0.012	<0.0001
B6	0.025	<0.002	<0.014	<0.004	<0.004	<0.0008	0.015	0.0006
B7	0.047	<0.001	<0.007	0.005	0.006	<0.0004	0.012	0.0006
B8	0.007	<0.001	<0.007	0.006	0.005	0.0006	0.0090	0.0012
B9	0.033	<0.001	<0.007	0.006	0.007	<0.0004	0.011	0.0017
B10	0.013	<0.001	<0.007	0.005	0.007	<0.0004	0.0089	0.0002
B11	0.008	<0.001	<0.007	0.007	0.007	0.0007	0.019	0.0002
FIELD BLANK	<0.001	<0.001	<0.007	<0.002	<0.002	<0.0004	<0.0005	<0.0001
TRANSPORT BLANK	<0.001	<0.001	<0.007	<0.002	<0.002	<0.0004	<0.0005	<0.0001

Note: Reporting Limits for B6 raised due to high salinity

Signatory:
Date: 4/03/2011

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Murdoch University

WATER QUALITY DATA

Contact: Celeste Wilson
Customer: Sinclair Knight Merz
Address: Level 2, 47 Colin St, West Perth 6005

Date of Issue: 4/03/2011
Date Received: 14/02/2011
Our Reference: SKM11-1
Your Reference: BHPB345

METHOD SAMPLE CODE	ICP001 Cr mg/L	ICP001 Cu mg/L	ICP001 Ni mg/L	ICP001 V mg/L	ICP001 Zn mg/L	ICP004 As mg/L	ICP004 Se mg/L	ICP006 Hg mg/L
Reporting Limit	**<0.001**	**<0.001**	**<0.007**	**<0.002**	**<0.002**	**<0.0004**	**<0.0005**	**<0.0001**
File	**11021601**	**11021601**	**11021601**	**11021601**	**11021601**	**11022401a**	**11022501b**	**11022202a**
QA/QC Data								
Inhouse standard	102%	117%	100%	101%	99%	102%	109%	
Certified organic standard						102%		98%
Certified standard 1						100%	119%	
Certified standard 2						102%	98%	
B6 duplicate	0.6%	<LOR	<LOR	<LOR	<LOR	4.2%	5.6%	
B8 duplicate								0.2%
B6 standard addition	102%	97%	96%	98%	104%			
B7 standard addition						97%	112%	
B10 standard addition								91%
Certified organic standard								99%
B10 duplicate	0.3%	0.9%	<LOR	3.5%	0.5%			
Inhouse standard	98%	100%	107%	101%	91%	100%	107%	
Field blank duplicate	<LOR	<LOR	<LOR	<LOR	<LOR			<LOR
Trans blank standard addition	99%	100%	103%	102%	101%			96%
Certified organic standard						104%		97%

Signatory:

Date: 4/03/2011

All test items tested as received. Spare test items will be held for two months unless otherwise requested.

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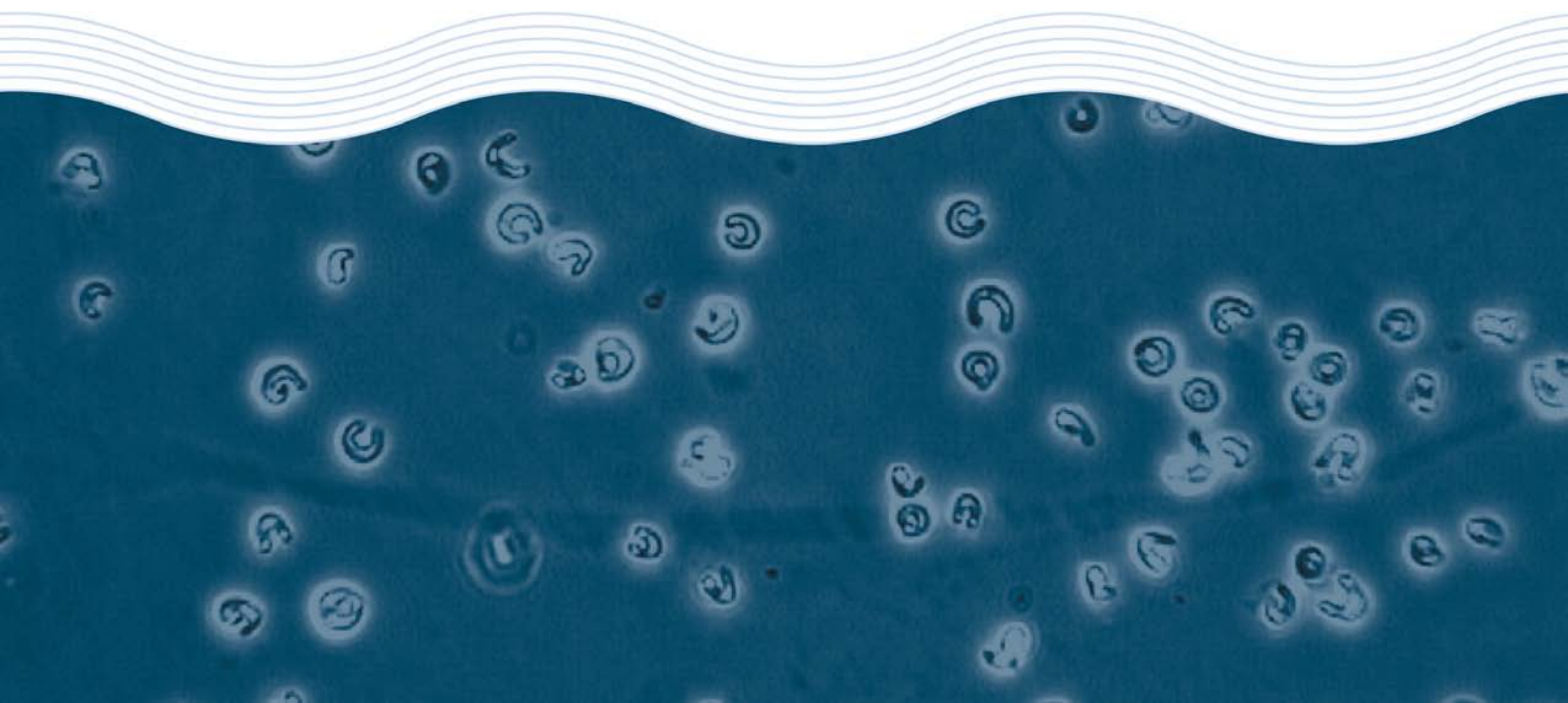
SERVICES AUSTRALASIA

Toxicity Assessment of Five Groundwater Discharge Samples

Sinclair Knight Merz Pty Ltd

Test Report

January 2011



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SERVICES AUSTRALASIA

Toxicity Assessment of Five Groundwater Discharge Samples

Sinclair Knight Merz Pty Ltd

Test Report

January 2011

ECOTOX Services Australasia Pty Ltd ABN>45 094 714 904
unit 27/2 chaplin drive lane cove nsw 2066 T>61 2 9420 9481 F>61 2 9420 9484 W>www.ecotox.com.au

Toxicity Test Report: TR0700/1

This document is issued in accordance with NATA's accreditation requirements

Client:	Sinclair Knight Merz Pty Ltd PO Box H615 Perth WA 6001	**ESA Job #:** **Date Sampled:** **Date Received:**	PR0700 9 February 2011 11 February 2011
Attention:	Celeste Wilson	**Sampled By:**	Client
Client Ref:	Not supplied	**ESA Quote #:**	PL0700_q01

Lab ID No.:	**Sample Name:**	**Sample Description:**
4581	Bore 1	Aqueous sample, pH 8.1, salinity 13.6‰, total ammonia <2.0mg/L*. Sample received at 23ºC in apparent good condition
4582	Bore 2	Aqueous sample, pH 8.5, salinity 0.3‰, total ammonia <2.0mg/L*. Sample received at 23ºC in apparent good condition
4583	Bore 3	Aqueous sample, pH 8.2, salinity 2.6‰, total ammonia <2.0mg/L*. Sample received at 23ºC in apparent good condition
4584	Bore 4	Aqueous sample, pH 7.4, salinity 22.0‰, total ammonia <2.0mg/L*. Sample received at 23ºC in apparent good condition
4585	Bore 5	Aqueous sample, pH 7.7, salinity 14.1‰, total ammonia <2.0mg/L*. Sample received at 23ºC in apparent good condition

*Ammonia analysis is not covered by Ecotox Services Australasia's scope of accreditation

Test Performed:	1-hr sea urchin fertilisation success test using *Heliocidaris tuberculata*
Test Protocol:	ESA SOP 104 (ESA 2010), based on USEPA (2002) and Simon and Laginestra (1996)
Test Temperature:	The test was performed at 20±1°C.
Deviations from Protocol:	Nil
Comments on Solution Preparation:	The samples were adjusted to a salinity of 35±1‰ with modified GP2 artificial sea salts prior to testing. The samples were serially diluted with filtered seawater (FSW) to achieve the test concentrations. A FSW control and an artificial seawater (ASW) control were tested concurrently with the samples.
Source of Test Organisms:	Field collected from South Maroubra, NSW.
Test Initiated:	15 February 2011 at 1230h

Sample 4581: *Bore 1*		Sample 4582: *Bore 2*		Sample 4583: *Bore 3*	
Concentration (%)	**% Fertilised Eggs (Mean ± SD)**	**Concentration (%)**	**% Fertilised Eggs (Mean ± SD)**	**Concentration (%)**	**% Fertilised Eggs (Mean ± SD)**
FSW Control	94.3 ± 3.0	FSW Control	94.3 ± 3.0	FSW Control	94.3 ± 3.0
ASW Control	92.8 ± 2.2	ASW Control	92.8 ± 2.2	ASW Control	92.8 ± 2.2
6.3	94.8 ± 2.8	6.3	94.0 ± 3.6	6.3	92.8 ± 1.7
12.5	94.0 ± 2.2	12.5	92.8 ± 1.7	12.5	94.3 ± 3.3
25	94.0 ± 3.2	25	93.3 ± 2.2	25	93.8 ± 2.2
50	93.0 ± 2.2	50	93.0 ± 1.6	50	95.0 ± 2.5
100	53.5 ± 9.6 *	100	92.8 ± 2.8	100	82.0 ± 5.0 *
IC10 = 64.4 (57.4-69.2)% **EC50 = >100%** **NOEC = 50%** **LOEC = 100%**		**EC10 = >100%** **EC50 = >100%** **NOEC = 100%** **LOEC = >100%**		**IC10 = 90.7%**** **EC50 = >100%** **NOEC = 50%** **LOEC = 100%**	

*Significantly lower percentage of fertilised eggs compared with the ASW Control (Dunnett's Test, 1-tailed, P=0.05)
** 95% Confidence limits not available

Toxicity Test Report: TR0700/1

Sample 4584: *Bore 4*		Sample 4585: *Bore 5*		*Vacant*
Concentration (%)	**% Fertilised Eggs (Mean ± SD)**	**Concentration (%)**	**% Fertilised Eggs (Mean ± SD)**	
FSW Control	94.3 ± 3.0	FSW Control	94.3 ± 3.0	
ASW Control	92.8 ± 2.2	ASW Control	92.8 ± 2.2	
6.3	93.3 ± 1.7	6.3	93.5 ± 2.1	
12.5	94.8 ± 2.6	12.5	93.3 ± 3.3	
25	93.5 ± 3.1	25	92.5 ± 2.1	
50	92.8 ± 1.7	50	94.5 ± 3.1	
100	94.3 ± 3.5	100	92.0 ± 2.2	
EC10 = >100% EC50 = >100% NOEC = 100% LOEC = >100%		**EC10 = >100% EC50 = >100% NOEC = 100% LOEC = >100%**		

QA/QC Parameter	Criterion	This Test	Criterion met?
Control mean % fertilised eggs	>70.0%	94.3%	Yes
Reference Toxicant within cusum chart limits	20.5-115.1µg Cu/L	43.9µg Cu/L	Yes

Test Report Authorised by: Dr Rick Krassoi, Director on 18 March 2011

Results are based on the samples in the condition as received by ESA.

NATA Accredited Laboratory Number: 14709

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Citations:

ESA (2010) ESA SOP 104 - *Sea Urchin Fertilisation Success Test*. Issue No. 10. Ecotox Services Australasia, Sydney NSW.

Simon, J. and Laginestra, E.(1997) Bioassay for testing sublethal toxicity in effluents, using gametes of sea urchin *Heliocidaris tuberculata*. National Pulp Mills Research Program Technical Report No. 20. CSIRO, Canberra ACT

USEPA (2002) Short-term methods for measuring the chronic toxicity of effluents and receiving waters to marine and estuarine organisms. Third Edition. United States Environmental Protection Agency, Office of Water, Washington DC, EPA-821-R-02-014.

Toxicity Test Report: TR0700/2

This document is issued in accordance with NATA's accreditation requirements

Client:	Sinclair Knight Merz Pty Ltd PO Box H615 Perth WA 6001	**ESA Job #:** **Date Sampled:** **Date Received:**	PR0700 9 February 2011 11 February 2011
Attention:	Celeste Wilson	**Sampled By:**	Client
Client Ref:	Not supplied	**ESA Quote #:**	PL0700_q01

Lab ID No.:	Sample Name:	Sample Description:
4581	Bore 1	Aqueous sample, pH 8.1, salinity 13.6‰, total ammonia <2.0mg/L*. Sample received at 23ºC in apparent good condition
4582	Bore 2	Aqueous sample, pH 8.5, salinity 0.3‰, total ammonia <2.0mg/L*. Sample received at 23ºC in apparent good condition
4583	Bore 3	Aqueous sample, pH 8.2, salinity 2.6‰, total ammonia <2.0mg/L*. Sample received at 23ºC in apparent good condition
4584	Bore 4	Aqueous sample, pH 7.4, salinity 22.0‰, total ammonia <2.0mg/L*. Sample received at 23ºC in apparent good condition
4585	Bore 5	Aqueous sample, pH 7.7, salinity 14.1‰, total ammonia <2.0mg/L*. Sample received at 23ºC in apparent good condition

*Ammonia analysis is not covered by Ecotox Services Australasia's scope of accreditation

Test Performed:	72-hr sea urchin larval development test using *Heliocidaris tuberculata*
Test Protocol:	ESA SOP 105 (ESA 2010), based on APHA (1998), Simon and Laginestra (1996) and Doyle *et al*. (2003)
Test Temperature:	The test was performed at 20±1°C.
Deviations from Protocol:	Nil
Comments on Solution Preparation:	The samples were adjusted to a salinity of 35±1‰ with modified GP2 artificial sea salts prior to testing. The samples were serially diluted with filtered seawater (FSW) to achieve the test concentrations. A FSW control and an artificial seawater (ASW) control were tested concurrently with the samples.
Source of Test Organisms:	Field collected from South Maroubra, NSW.
Test Initiated:	15 February 2011 at 1215h

Sample 4581: *Bore 1*		Sample 4582: *Bore 2*		Sample 4583: *Bore 3*	
Concentration (%)	**% Normal larvae (Mean ± SD)**	**Concentration (%)**	**% Normal larvae (Mean ± SD)**	**Concentration (%)**	**% Normal larvae (Mean ± SD)**
FSW Control	93.8 ± 2.8	FSW Control	93.8 ± 2.8	FSW Control	93.8 ± 2.8
ASW Control	93.5 ± 2.4	ASW Control	93.5 ± 2.4	ASW Control	93.5 ± 2.4
6.3	94.5 ± 3.5	6.3	94.3 ± 1.7	6.3	93.8 ± 2.2
12.5	93.5 ± 1.9	12.5	94.5 ± 2.7	12.5	94.3 ± 3.0
25	94.3 ± 1.7	25	94.3 ± 2.8	25	94.3 ± 3.3
50	94.0 ± 1.8	50	93.5 ± 1.3	50	93.3 ± 2.2
100	46.3 ± 6.0 *	100	93.5 ± 2.4	100	70.5 ± 6.4 *
72-hr IC10 = 64.1 (58.3-65.6)% **72-hr EC50 = 98.9 (92.5-100)%** **NOEC = 50%** **LOEC = 100%**		**72-hr EC10 = >100%** **72-hr EC50 = >100%** **NOEC = 100%** **LOEC = >100%**		**72-hr IC10 = 72.2 (62.4-81.4)%** **72-hr EC50 = >100%** **NOEC = 50%** **LOEC = 100%**	

*Significantly lower percentage of normally developed larvae compared with the ASW Control (Dunnett's Test, 1-tailed, P=0.05)

Toxicity Test Report: TR0700/2

Sample 4584: *Bore 4*		Sample 4585: *Bore 5*		*Vacant*
Concentration (%)	**% Normal larvae (Mean ± SD)**	**Concentration (%)**	**% Normal larvae (Mean ± SD)**	
FSW Control	93.8 ± 2.8	FSW Control	93.8 ± 2.8	
ASW Control	93.5 ± 2.4	ASW Control	93.5 ± 2.4	
6.3	93.5 ± 2.4	6.3	93.8 ± 2.8	
12.5	94.3 ± 3.0	12.5	93.8 ± 3.5	
25	93.8 ± 2.2	25	95.5 ± 2.4	
50	93.5 ± 3.1	50	92.5 ± 2.1	
100	92.5 ± 2.7	100	93.8 ± 2.2	
72-hr EC10 = >100% **72-hr EC50 = >100%** **NOEC = 100%** **LOEC = >100%**		**72-hr EC10 = >100%** **72-hr EC50 = >100%** **NOEC = 100%** **LOEC = >100%**		

QA/QC Parameter	**Criterion**	**This Test**	**Criterion met?**
Control mean % normal larvae	>70.0%	93.8%	Yes
Reference Toxicant within cusum chart limits	5.5-25.1µg Cu/L	8.9µg Cu/L	Yes

Test Report Authorised by: [signature] Dr Rick Krassoi, Director on 18 March 2011

Results are based on the samples in the condition as received by ESA.

NATA Accredited Laboratory Number: 14709

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Citations:

APHA (1998) Method 8810 D. Echinoderm Embryo Development Test. In Standard Methods for the Examination of Water and Wastewater, 20th Ed. American Public Health Association, American Water Works Association and the Water Environment Federation, USA.

Doyle, C.J., Pablo, F., Lim, R.P. and Hyne, R.V. (2003) Assessment of metal toxicity in sediment pore water from Lake Macquarie, Australia. *Arch. Environ. Contam. Toxicology*, 44(3): 343-350.

ESA (2010) *ESA SOP 105 - Sea Urchin Larval Development Test*. Issue No. 9. Ecotox Services Australasia, Sydney NSW.

Simon, J. and Laginestra, E.(1997) Bioassay for testing sublethal toxicity in effluents, using gametes of sea urchin *Heliocidaris tuberculata*. National Pulp Mills Research Program Technical Report No. 20. CSIRO, Canberra, ACT.

Toxicity Test Report: TR0700/3

This document is issued in accordance with NATA's accreditation requirements

Client:	Sinclair Knight Merz Pty Ltd PO Box H615 Perth WA 6001	**ESA Job #:** **Date Sampled:** **Date Received:**	PR0700 9 February 2011 11 February 2011
Attention:	Celeste Wilson	**Sampled By:**	Client
Client Ref:	Not supplied	**ESA Quote #:**	PL0700_q01

Lab ID No.:	Sample Name:	Sample Description:
4581	Bore 1	Aqueous sample, pH 8.1, salinity 13.6‰, total ammonia <2.0mg/L*. Sample received at 23ºC in apparent good condition
4582	Bore 2	Aqueous sample, pH 8.5, salinity 0.3‰, total ammonia <2.0mg/L*. Sample received at 23ºC in apparent good condition
4583	Bore 3	Aqueous sample, pH 8.2, salinity 2.6‰, total ammonia <2.0mg/L*. Sample received at 23ºC in apparent good condition
4584	Bore 4	Aqueous sample, pH 7.4, salinity 22.0‰, total ammonia <2.0mg/L*. Sample received at 23ºC in apparent good condition
4585	Bore 5	Aqueous sample, pH 7.7, salinity 14.1‰, total ammonia <2.0mg/L*. Sample received at 23ºC in apparent good condition

*Ammonia analysis is not covered by Ecotox Services Australasia's scope of accreditation

Test Performed:	48-hr larval development test using the rock oyster *Saccostrea commercialis*
Test Protocol:	ESA SOP 106 (ESA 2010), based on APHA (1998) and Krassoi (1995)
Test Temperature:	The test was performed at 25±1°C.
Deviations from Protocol:	Nil
Comments on Solution Preparation:	The samples were adjusted to a salinity of 35±1‰ with modified GP2 artificial sea salts prior to testing. The samples were serially diluted with filtered seawater (FSW) to achieve the test concentrations. A FSW control and an artificial seawater (ASW) control were tested concurrently with the samples.
Source of Test Organisms:	Farm-reared, Wallis Lakes, NSW.
Test Initiated:	15 February 2011 at 1700h

Sample 4581: *Bore 1* Concentration (%)	% Alive/Normal larvae (Mean ± SD)	Sample 4582: *Bore 2* Concentration (%)	% Alive/Normal larvae (Mean ± SD))	Sample 4583: *Bore 3* Concentration (%)	% Alive/Normal larvae (Mean ± SD)
FSW Control	75.0 ± 5.9	FSW Control	75.0 ± 5.9	FSW Control	75.0 ± 5.9
ASW Control	77.6 ± 2.9	ASW Control	77.6 ± 2.9	ASW Control	77.6 ± 2.9
6.3	76.0 ± 9.9	6.3	71.9 ± 7.7	6.3	76.0 ± 4.5
12.5	79.6 ± 6.0	12.5	70.9 ± 5.6	12.5	74.0 ± 7.0
25	76.0 ± 8.7	25	74.5 ± 7.9	25	70.9 ± 7.3
50	76.5 ± 3.9	50	74.5 ± 9.5	50	71.9 ± 5.4
100	63.3 ± 10.4 *	100	76.0 ± 4.2	100	74.0 ± 7.0
48-hr EC10 = 83.1** **48-hr EC50 = >100%** **NOEC = 50%** **LOEC = 100%**		**48-hr EC10 = >100%** **48-hr EC50 = >100%** **NOEC = 100%** **LOEC = >100%**		**48-hr EC10 = >100%** **48-hr EC50 = >100%** **NOEC = 100%** **LOEC = >100%**	

*Significantly lower percentage of normal surviving larvae when compared with the ASW Control (Dunnett's Test, 1-tailed, P=0.05)
** 95% Confidence limits not available

Toxicity Test Report: TR0700/3

Sample 4584: *Bore 4*		Sample 4585: *Bore 5*		*Vacant*
Concentration (%)	**% Alive/Normal larvae (Mean ± SD)**	**Concentration (%)**	**% Alive/Normal larvae (Mean ± SD)**	
FSW Control	75.0 ± 5.9	FSW Control	75.0 ± 5.9	
ASW Control	77.6 ± 2.9	ASW Control	77.6 ± 2.9	
6.3	75.0 ± 6.1	6.3	75.5 ± 6.9	
12.5	70.9 ± 2.6	12.5	74.0 ± 9.8	
25	77.0 ± 6.3	25	70.9 ± 5.1	
50	64.8 ± 5.9	50	66.8 ± 4.8	
100	64.8 ± 4.5 *	100	70.9 ± 6.1	
48-hr EC10 = 39.4% **48-hr EC50 = >100%** **NOEC = 50%** **LOEC = 100%**		**48-hr EC10 = 55.1%**** **48-hr EC50 = >100%** **NOEC = 100%** **LOEC = >100%**		

*Significantly lower percentage of normal surviving larvae when compared with the ASW Control (Steel's Many-One Rank Test, 1-tailed, P=0.05)
** 95% Confidence limits not available

QA/QC Parameter	Criterion	This Test	Criterion met?
FSW Control mean % survival	>70%	86.7%	Yes
FSW Control mean % normal	>70%	86.5%	Yes
Reference Toxicant within cusum chart limits	17.7-25.9µg Cu/L	24.3µg Cu/L	Yes

Test Report Authorised by: Dr Rick Krassoi, Director on 18 March 2011

Results are based on the samples in the condition as received by ESA.

NATA Accredited Laboratory Number: 14709

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Citations:

APHA (1998) Standard Methods for the Examination of Water and Wastewater. 20th Ed. American Public Health Association, American Water Works Association and the Water Environment Federation, Washington, DC.

ESA (2010) SOP 106 – *Bivalve Larval Development Test*. Issue No. 10. Ecotox Services Australasia, Sydney, NSW.

Krassoi, R (1995) Salinity adjustment of effluents for use with marine bioassays: effects on the larvae of the doughboy scallop Chlamys asperrimus and the Sydney rock oyster *Saccostrea commercialis*. *Australasian Journal of Ecotoxicology*, 1: 143-148.

Toxicity Test Report: TR0700/4

This document is issued in accordance with NATA's accreditation requirements

Client:	Sinclair Knight Merz Pty Ltd PO Box H615 Perth WA 6001	**ESA Job #:** **Date Sampled:** **Date Received:**	PR0700 9 February 2011 11 February 2011
Attention:	Celeste Wilson	**Sampled By:**	Client
Client Ref:	Not supplied	**ESA Quote #:**	PL0700_q01

Lab ID No.:	Sample Name:	Sample Description:
4581	Bore 1	Aqueous sample, pH 8.1, salinity 13.6‰, total ammonia <2.0mg/L*. Sample received at 23ºC in apparent good condition
4582	Bore 2	Aqueous sample, pH 8.5, salinity 0.3‰, total ammonia <2.0mg/L*. Sample received at 23ºC in apparent good condition
4583	Bore 3	Aqueous sample, pH 8.2, salinity 2.6‰, total ammonia <2.0mg/L*. Sample received at 23ºC in apparent good condition
4584	Bore 4	Aqueous sample, pH 7.4, salinity 22.0‰, total ammonia <2.0mg/L*. Sample received at 23ºC in apparent good condition
4585	Bore 5	Aqueous sample, pH 7.7, salinity 14.1‰, total ammonia <2.0mg/L*. Sample received at 23ºC in apparent good condition

*Ammonia analysis is not covered by Ecotox Services Australasia's scope of accreditation

Test Performed:	72-hr marine algal growth test using *Isochrysis aff. galbana*
Test Protocol:	ESA SOP 110 (ESA 2010), based on Stauber *et al*. (1994)
Test Temperature:	The test was performed at 29±1°C.
Deviations from Protocol:	Statistical analyses were only run to 50% (25% for Bore 3) due to a precipitate forming in the samples, which prevented accurate cell density calculations.
Comments on Solution Preparation:	The sample was adjusted to a salinity of 35±1‰ with modified GP2 artificial sea salts prior to testing. The sample was serially diluted with filtered seawater (FSW) to achieve the test concentrations. A FSW control and an artificial seawater (ASW) control were tested concurrently with the sample.
Source of Test Organisms:	In-house culture, originally sourced from CSIRO Microalgae Supply Service, TAS
Test Initiated:	25 February 2011 at 1300h

Sample 4581: *Bore 1*

Concentration (%)	Cell Yield (Mean number of cells/mL x10^4 ± SD)
FSW Control	46.0 ± 7.4
ASW Control	38.4 ± 3.4
6.3	49.1 ± 4.2
12.5	36.8 ± 16.4
25	48.2 ± 7.5
50	62.7 ± 6.2

72-hr IC10 = >50%
72-hr IC50 = >50%
NOEC = 50%
LOEC = >50%

Sample 4582: *Bore 2*

Concentration (%)	Cell Yield (Mean number of cells/mL x10^4 ± SD)
FSW Control	46.0 ± 7.4
ASW Control	38.4 ± 3.4
6.3	48.7 ± 16.9
12.5	49.6 ± 17.6
25	47.7 ± 16.2
50	68.3 ± 10.8

72-hr IC10 = >50%
72-hr IC50 = >50%
NOEC = 50%
LOEC = >50%

Sample 4583: *Bore 3*

Concentration (%)	Cell Yield (Mean number of cells/mL x10^4 ± SD)
FSW Control	46.0 ± 7.4
ASW Control	38.4 ± 3.4
6.3	38.6 ± 14.9
12.5	43.3 ± 10.6
25	48.0 ± 5.2

72-hr IC10 = >25%
72-hr IC50 = >25%
NOEC = 25%
LOEC = >25%

NATA WORLD RECOGNISED ACCREDITATION

ecotox SERVICES AUSTRALASIA

Toxicity Test Report: TR0700/4

Sample 4584: *Bore 4*		Sample 4585: *Bore 5*		*Vacant*
Concentration (%)	**Cell Yield (Mean number of cells/mL $x10^4 \pm$ SD)**	**Concentration (%)**	**Cell Yield (Mean number of cells/mL $x10^4 \pm$ SD)**	
FSW Control	46.0 ± 7.4	FSW Control	46.0 ± 7.4	
ASW Control	38.4 ± 3.4	ASW Control	38.4 ± 3.4	
6.3	39.8 ± 3.5	6.3	49.1 ± 1.7	
12.5	46.6 ± 7.6	12.5	35.2 ± 12.0	
25	48.9 ± 7.2	25	45.0 ± 8.7	
50	46.5 ± 15.3	50	44.2 ± 11.6	
72-hr IC10 = >50%		**72-hr IC10 = >50%**		
72-hr IC50 = >50%		**72-hr IC50 = >50%**		
NOEC = 50%		**NOEC = 50%**		
LOEC = >50%		**LOEC = >50%**		

QA/QC Parameter	Criterion	This Test	Criterion met?
Control mean cell density	>16.0x10^4 cells/mL	47.0x10^4 cells/mL	Yes
Control coefficient of variation	<20%	16.1%	Yes
Reference Toxicant within cusum chart limits	1.2-106.9µg Cu/L	12.6µg Cu/L	Yes

Test Report Authorised by: Dr Rick Krassoi, Director on 18 March 2011

Results are based on the samples in the condition as received by ESA.

NATA Accredited Laboratory Number: 14709

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Citations:

ESA (2009) SOP 110 – *Marine Algal Growth Test*. Issue No. 7. Ecotox Services Australasia, Sydney NSW

Stauber, J.L., Tsai, J., Vaughan, G.T., Peterson, S.M. and Brockbank, C.I. (1994) Algae as indicators of toxicity of the effluent from bleached eucalypt kraft pulp mills. National Pulp Mills Research Program, Technical Report No. 3. CSIRO, Canberra, ACT

Toxicity Test Report: TR0700/5

Client:	Sinclair Knight Merz Pty Ltd PO Box H615 Perth WA 6001	**ESA Job #:** **Date Sampled:** **Date Received:**	PR0700 9 February 2011 11 February 2011
Attention:	Celeste Wilson	**Sampled By:**	Client
Client Ref:	Not supplied	**ESA Quote #:**	PL0700_q01

Lab ID No.:	**Sample Name:**	**Sample Description:**
4581	Bore 1	Aqueous sample, pH 8.1, salinity 13.6‰, total ammonia <2.0mg/L. Sample received at 23ºC in apparent good condition
4582	Bore 2	Aqueous sample, pH 8.5, salinity 0.3‰, total ammonia <2.0mg/L. Sample received at 23ºC in apparent good condition
4583	Bore 3	Aqueous sample, pH 8.2, salinity 2.6‰, total ammonia <2.0mg/L. Sample received at 23ºC in apparent good condition
4584	Bore 4	Aqueous sample, pH 7.4, salinity 22.0‰, total ammonia <2.0mg/L. Sample received at 23ºC in apparent good condition
4585	Bore 5	Aqueous sample, pH 7.7, salinity 14.1‰, total ammonia <2.0mg/L. Sample received at 23ºC in apparent good condition

Test Performed:	96-hr fish imbalance toxicity test using barramundi *Lates calcarifer*
Test Protocol:	ESA SOP 117 (ESA 2009), based on USEPA (2002)
Test Temperature:	The test was performed at 25±2°C.
Deviations from Protocol:	Nil
Comments on Solution Preparation:	The samples were adjusted to a salinity of 35±1‰ with modified GP2 artificial sea salts prior to testing. The samples were serially diluted with filtered seawater (FSW) to achieve the test concentrations. A FSW control and an artificial seawater (ASW) control were tested concurrently with the samples.
Source of Test Organisms:	Hatchery reared, QLD
Test Initiated:	24 February 2011 at 1400h

Sample 4581: *Bore 1*		Sample 4582: *Bore 2*		Sample 4583: *Bore 3*	
Concentration (%)	**% Un-affected (Mean ± SD)**	**Concentration (%)**	**% Un-affected (Mean ± SD)**	**Concentration (%)**	**% Un-affected (Mean ± SD)**
FSW Control	100 ± 0.0	FSW Control	100 ± 0.0	FSW Control	100 ± 0.0
ASW Control	100 ± 0.0	ASW Control	100 ± 0.0	ASW Control	100 ± 0.0
6.3	100 ± 0.0	6.3	100 ± 0.0	6.3	100 ± 0.0
12.5	100 ± 0.0	12.5	100 ± 0.0	12.5	100 ± 0.0
25	100 ± 0.0	25	100 ± 0.0	25	100 ± 0.0
50	100 ± 0.0	50	100 ± 0.0	50	100 ± 0.0
100	100 ± 0.0	100	100 ± 0.0	100	100 ± 0.0
96-hr EC10 = >100% **96-hr EC50 = >100%** **NOEC = 100%** **LOEC = >100%**		**96-hr EC10 = >100%** **96-hr EC50 = >100%** **NOEC = 100%** **LOEC = >100%**		**96-hr EC10 = >100%** **96-hr EC50 = >100%** **NOEC = 100%** **LOEC = >100%**	

Toxicity Test Report: TR0700/5

Sample 4584: *Bore 4*		Sample 4585: *Bore 5*		*Vacant*
Concentration (%)	**% Un-affected (Mean ± SD)**	**Concentration (%)**	**% Un-affected (Mean ± SD)**	
FSW Control	100 ± 0.0	FSW Control	100 ± 0.0	
ASW Control	100 ± 0.0	ASW Control	100 ± 0.0	
6.3	100 ± 0.0	6.3	100 ± 0.0	
12.5	100 ± 0.0	12.5	100 ± 0.0	
25	100 ± 0.0	25	100 ± 0.0	
50	100 ± 0.0	50	100 ± 0.0	
100	100 ± 0.0	100	95.0 ± 10.0	
96-hr EC10 = >100% **96-hr EC50 = >100%** **NOEC = 100%** **LOEC = >100%**		**96-hr EC10 = >100%** **96-hr EC50 = >100%** **NOEC = 100%** **LOEC = >100%**		

QA/QC Parameter	**Criterion**	**This Test**	**Criterion met?**
Control mean % un-affected	>80.0%	100%	Yes
Reference Toxicant within cusum chart limits	Not applicable*	74.1µg Cu/L	n/a

* Cusum chart limits are not available due to limited testing of reference toxicant in freshwater with *L. calcarifer*

Test Report Authorised by: [signature] Dr Rick Krassoi, Director on 18 March 2011

Results are based on the samples in the condition as received by ESA. This document shall not be reproduced except in full.

Citations:

ESA (2009) SOP 117 –*Freshwater and Marine Fish Imbalance Test*. Issue No 6. Ecotox Services Australasia, Sydney, NSW

USEPA (2002) Methods for measuring the acute toxicity of effluents and receiving waters to freshwater and marine organisms. Fifth edition EPA-821-R-02-012. United States Environmental Protection Agency, Office of Research and Development, Washington FC, USA

Toxicity Test Report: TR0700/6 (page 1 of 2)

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Client:	Sinclair Knight Merz Pty Ltd PO Box H615 Perth WA 6001	**ESA Job #:** **Date Sampled:** **Date Received:**	PR0700 9 February 2011 11 February 2011
Attention:	Celeste Wilson	**Sampled By:**	Client
Client Ref:	Not supplied	**ESA Quote #:**	PL0700_q01

Lab ID No.:	**Sample Name:**	**Sample Description:**
4582	Bore 2	Aqueous sample, pH 8.5, salinity 0.3‰, total ammonia <2.0mg/L*. Sample received at 23ºC in apparent good condition

*Ammonia analysis is not covered by Ecotox Services Australasia's scope of accreditation

Test Performed:	96-hr acute toxicity test using the amphipod *Melita plumulosa*
Test Protocol:	ESA SOP 108 (ESA 2011), based on USEPA (2002) and Department of Transport and Communications (1990)
Test Temperature:	The test was performed at 20±1°C.
Deviations from Protocol:	Three replicates were used and not four due to a shortage of organisms.
Comments on Solution Preparation:	The sample was adjusted to a salinity of 35±1‰ with modified GP2 artificial sea salts prior to testing. The sample was serially diluted with filtered seawater (FSW) to achieve the test concentrations. A FSW control and an artificial seawater (ASW) control were tested concurrently with the sample.
Source of Test Organisms:	In-house culture, originally sourced from Hawkesbury River, NSW
Test Initiated:	24 February 2011 at 1500h

Sample 4582: *Bore 2*

Concentration (%)	**% Un-affected (Mean ± SD)**
FSW Control	100 ± 0.0
ASW Control	86.7 ± 11.6
6.3	100 ± 0.0
12.5	100 ± 0.0
25	100 ± 0.0
50	100 ± 0.0
100	100 ± 0.0

96-hr EC10 = >100%
96-hr EC50 = >100%
NOEC = 100%
LOEC = >100%

Vacant

Vacant

Toxicity Test Report: TR0700/6

QA/QC Parameter	Criterion	This Test	Criterion met?
Control mean % un-affected	≥90.0%	100%	Yes
Reference Toxicant within cusum chart limits	58.3-531.3µg Cu/L	168.2µg Cu/L	Yes

Test Report Authorised by: Dr Rick Krassoi, Director on 18 March 2011

Results are based on the samples in the condition as received by ESA.

NATA Accredited Laboratory Number: 14709

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Citations:

Department of Transport and Communications (1990) Guidelines for Acceptance of Oil Spill Dispersants in Australian Waters. Pollution Prevention Section, Department of Transport and Communications, Canberra ACT.

ESA (2011) SOP 108 – *Amphipod Acute Toxicity Test*. Issue No 7. Ecotox Services Australasia, Sydney, NSW.

USEPA (2002) Methods for measuring the acute toxicity of effluents and receiving waters to freshwater and marine organisms. Fifth Edition. United States Environmental Protection Agency, Office of Research and Development, Washington DC, EPA/600/4-90/027F.

Toxicity Test Report: TR0700/7

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Client:	Sinclair Knight Merz Pty Ltd PO Box H615 Perth WA 6001	**ESA Job #:** **Date Sampled:** **Date Received:**	PR0700 9 February 2011 11 February 2011
Attention:	Celeste Wilson	**Sampled By:**	Client
Client Ref:	Not supplied	**ESA Quote #:**	PL0700_q01

Lab ID No.:	Sample Name:	Sample Description:
4583	Bore 3	Aqueous sample, pH 8.2, salinity 2.6‰, total ammonia <2.0mg/L*. Sample received at 23ºC in apparent good condition

*Ammonia analysis is not covered by Ecotox Services Australasia's scope of accreditation

Test Performed:	96-hr acute toxicity test using the amphipod *Melita plumulosa*
Test Protocol:	ESA SOP 108 (ESA 2011), based on USEPA (2002) and Department of Transport and Communications (1990)
Test Temperature:	The test was performed at 20±1°C.
Deviations from Protocol:	Three replicates were used and not four due to a shortage of organisms.
Comments on Solution Preparation:	The sample was adjusted to a salinity of 35±1‰ with modified GP2 artificial sea salts prior to testing. The sample was serially diluted with filtered seawater (FSW) to achieve the test concentrations. A FSW control and an artificial seawater (ASW) control were tested concurrently with the sample.
Source of Test Organisms:	In-house culture, originally sourced from Hawkesbury River, NSW
Test Initiated:	3 March 2011 at 1100h

Sample 4583: *Bore 3*		*Vacant*	*Vacant*
Concentration (%)	**% Un-affected (Mean ± SD)**		
FSW Control	93.3 ± 11.6		
ASW Control	100 ± 0.0		
6.3	100 ± 0.0		
12.5	100 ± 0.0		
25	100 ± 0.0		
50	80 ± 20.0 *		
100	66.7 ± 11.6 *		
96-hr EC10 = 44.7 (13.7-65.9)% **96-hr EC50 = >100%** **NOEC = 25%** **LOEC = 50%**			

*Significantly lower percent survival compared with the ASW Control (Dunnett's Test, 1-tailed, P=0.05)

Toxicity Test Report: TR0700/7

QA/QC Parameter	Criterion	This Test	Criterion met?
Control mean % un-affected	≥90.0%	93.3%	Yes
Reference Toxicant within cusum chart limits	59.6-530.0µg Cu/L	146.2µg Cu/L	Yes

Test Report Authorised by: Dr Rick Krassoi, Director on 18 March 2011

Results are based on the samples in the condition as received by ESA.

NATA Accredited Laboratory Number: 14709

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Citations:

Department of Transport and Communications (1990) Guidelines for Acceptance of Oil Spill Dispersants in Australian Waters. Pollution Prevention Section, Department of Transport and Communications, Canberra ACT.

ESA (2011) SOP 108 – *Amphipod Acute Toxicity Test*. Issue No 7. Ecotox Services Australasia, Sydney, NSW.

USEPA (2002) Methods for measuring the acute toxicity of effluents and receiving waters to freshwater and marine organisms. Fifth Edition. United States Environmental Protection Agency, Office of Research and Development, Washington DC, EPA/600/4-90/027F.

Toxicity Test Report: TR0700/8

This document is issued in accordance with NATA's accreditation requirements

Client:	Sinclair Knight Merz Pty Ltd PO Box H615 Perth WA 6001	**ESA Job #:** **Date Sampled:** **Date Received:**	PR0700 9 February 2011 11 February 2011
Attention:	Celeste Wilson	**Sampled By:**	Client
Client Ref:	Not supplied	**ESA Quote #:**	PL0700_q01

Lab ID No.:	Sample Name:	Sample Description:
4581	Bore 1	Aqueous sample, pH 8.1, salinity 13.6‰, total ammonia <2.0mg/L*. Sample received at 23ºC in apparent good condition
4584	Bore 4	Aqueous sample, pH 7.4, salinity 22.0‰, total ammonia <2.0mg/L*. Sample received at 23ºC in apparent good condition
4585	Bore 5	Aqueous sample, pH 7.7, salinity 14.1‰, total ammonia <2.0mg/L*. Sample received at 23ºC in apparent good condition

*Ammonia analysis is not covered by Ecotox Services Australasia's scope of accreditation

Test Performed:	96-hr acute toxicity test using the amphipod *Melita plumulosa*
Test Protocol:	ESA SOP 108 (ESA 2011), based on USEPA (2002) and Department of Transport and Communications (1990)
Test Temperature:	The test was performed at 20±1°C.
Deviations from Protocol:	Two concentrations were prepared for each sample, and three replicates were used and not four due to a shortage of organisms.
Comments on Solution Preparation:	The samples were adjusted to a salinity of 35±1‰ with modified GP2 artificial sea salts prior to testing. The samples were serially diluted with filtered seawater (FSW) to achieve the test concentrations. A FSW control and an artificial seawater (ASW) control were tested concurrently with the samples.
Source of Test Organisms:	In-house culture, originally sourced from Hawkesbury River, NSW
Test Initiated:	11 March 2011 at 1400h

Sample 4581: *Bore 1*		Sample 4584: *Bore 4*		*Sample 4585: Bore 5*	
Concentration (%)	**% Un-affected (Mean ± SD)**	**Concentration (%)**	**% Un-affected (Mean ± SD)**	**Concentration (%)**	**% Un-affected (Mean ± SD)**
FSW Control	86.7 ± 11.6	FSW Control	86.7 ± 11.6	FSW Control	86.7 ± 11.6
ASW Control	80.0 ± 0.0	ASW Control	80.0 ± 0.0	ASW Control	80.0 ± 0.0
50	80.0 ± 0.0	50	100 ± 0.0	50	100 ± 0.0
100	80.0 ± 0.0	100	93.3 ± 11.6	100	66.7 ± 41.6
NOEC = 100%		**NOEC = 100%**		**NOEC = 100%**	
LOEC = >100%		**LOEC = >100%**		**LOEC = >100%**	

Toxicity Test Report: TR0700/8

QA/QC Parameter	Criterion	This Test	Criterion met?
Control mean % un-affected	≥90.0%	86.7%	Yes
Reference Toxicant within cusum chart limits	58.4-524.4µg Cu/L	126.1µg Cu/L	Yes

Test Report Authorised by: Dr Rick Krassoi, Director on 18 March 2011

Results are based on the samples in the condition as received by ESA.

NATA Accredited Laboratory Number: 14709

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Citations:

Department of Transport and Communications (1990) Guidelines for Acceptance of Oil Spill Dispersants in Australian Waters. Pollution Prevention Section, Department of Transport and Communications, Canberra ACT.

ESA (2011) SOP 108 – *Amphipod Acute Toxicity Test*. Issue No 7. Ecotox Services Australasia, Sydney, NSW.

USEPA (2002) Methods for measuring the acute toxicity of effluents and receiving waters to freshwater and marine organisms. Fifth Edition. United States Environmental Protection Agency, Office of Research and Development, Washington DC, EPA/600/4-90/027F.

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SERVICES AUSTRALASIA

Chain-of-Custody Documentation

Datasheet ID: 601.1
Last Revised: 23 March 2010

Chain-of-Custody / Service Request Form

ecotox
SERVICES AUSTRALASIA

Customer: Hydrosolutions
Contact Name: Steven Kinsey
Phone: (08) 9457 5448 Email: [crossed out] ← steven.kinsey@hydrosolutions.com.au (please provide an email address for sample receipt notification)
Sampled by: S. Kinsey

Ship To: ......
Attention: ......

Sample Date (day/month /year)	Sample Time	Sample Name (exactly as written on the sample vessel)	Sample Method (eg. Grab, composite etc.)	Number and Volume of Containers (eg 2 x 1L)	Tests Requested (See reverse for guidance)	Comments / Instructions
9/2/11	1130	Bore 1	Groundwater	4 x 2.5L	/	Refer to analysis
"	1320	Bore 2	"	"	/	request from Celeste
"	1445	Bore 3	"	"	/	Wilson - SKM
"	1530	Bore 4	"	"	/	(08) 9469 4438
"	1630	Bore 5	"	"	/	cxxwilson@skm.com.au

Note that testing will be delayed if an incomplete chain of custody is received

- Additional treatment of samples (i.e. spiking)
- Sub-contracted services (i.e. chemical analyses)
- Dilutions required (if different than 100% down to 6.25%)
- Sample holding time restriction (if applicable)
- Sample used for litigation (if applicable)

Note: An MSDS must be attached if Available

ESA Project Number: PR______

1) Released By: SK	Date: 10/2/11	2) Received By: Tina	Date: 11/2/11	3) Released By:	Date:	4) Received By:	Date:
Of: Hydrosolutions	Time: 0730	Of: ESA	Time: 11:00	Of:	Time:	Of:	Time:

Note that the chain-of-custody documentation will provide definitive information on the tests to be performed.

Ecotox Services Australasia . Unit 27, 2 Chaplin Drive, Lane Cove NSW 2066 AUSTRALIA
Phone: 61 2 9420-9481 Fax 61 2 9420-9484 info@ecotox.com.au

Statistical Printouts for the Sea Urchin Fertilisation Test

Sea Urchin Fertilisation Test-Proportion Fertilized

Start Date:	15/02/2011 12:30	Test ID:	PR0700/02	Sample ID:	Bore 1
End Date:	15/02/2011 13:50	Lab ID:	4581	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 104	Test Species:	HT-Heliocidaris tuberculata
Comments:					

Conc-%	1	2	3	4
FSW Control	0.9500	0.9300	0.9800	0.9100
ASW Control	0.9200	0.9600	0.9200	0.9100
6.3	0.9800	0.9600	0.9200	0.9300
12.5	0.9500	0.9100	0.9400	0.9600
25	0.9800	0.9200	0.9500	0.9100
50	0.9600	0.9300	0.9100	0.9200
100	0.4300	0.5700	0.6500	0.4900

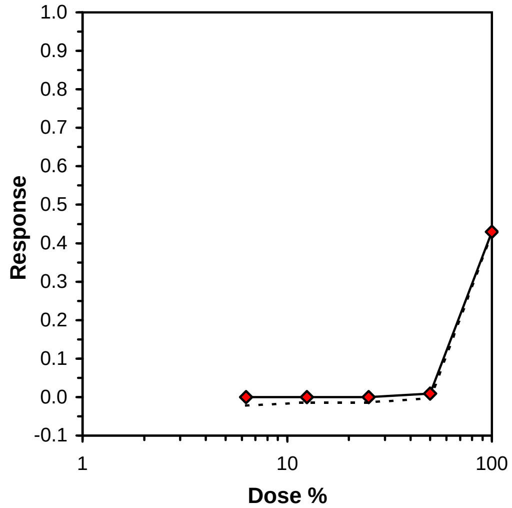
			Transform: Arcsin Square Root						1-Tailed		Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD	Mean	N-Mean
FSW Control	0.9425	1.0162	1.3358	1.2661	1.4289	5.238	4					
ASW Control	0.9275	1.0000	1.3009	1.2661	1.3694	3.572	4	*			0.9388	1.0000
6.3	0.9475	1.0216	1.3464	1.2840	1.4289	4.909	4	-0.990	2.410	0.1106	0.9388	1.0000
12.5	0.9400	1.0135	1.3260	1.2661	1.3694	3.331	4	-0.548	2.410	0.1106	0.9388	1.0000
25	0.9400	1.0135	1.3311	1.2661	1.4289	5.522	4	-0.657	2.410	0.1106	0.9388	1.0000
50	0.9300	1.0027	1.3057	1.2661	1.3694	3.456	4	-0.103	2.410	0.1106	0.9300	0.9907
*100	0.5350	0.5768	0.8210	0.7152	0.9377	11.790	4	10.455	2.410	0.1106	0.5350	0.5699

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.05)	0.96881	0.916	0.37484	-0.54829
Bartlett's Test indicates equal variances (p = 0.72)	2.877214	15.08627		
The control means are not significantly different (p = 0.44)	0.831581	2.446912		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU	MSDu	MSDp	MSB	MSE	F-Prob	df
Dunnett's Test	50	100	70.71068	2	0.06685	0.071966	0.168472	0.004214	3.9E-09	5, 18
Treatments vs ASW Control										

Log-Logit Interpolation (200 Resamples)

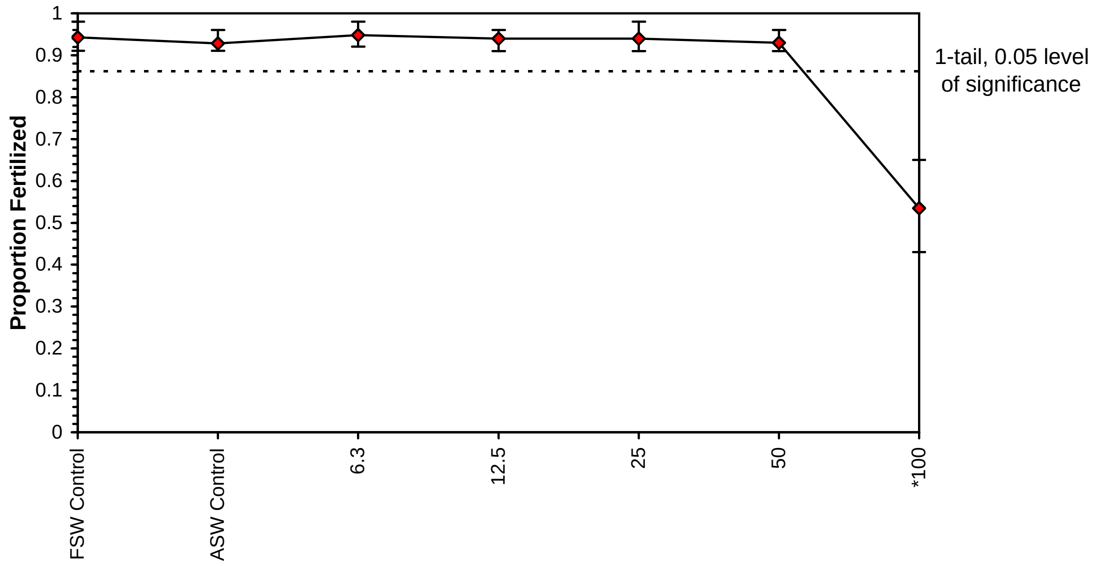
Point	%	SD	95% CL(Exp)		Skew
IC05	57.273	1.949	49.065	60.882	-0.2714
IC10	64.424	1.936	57.415	69.211	-0.0407
IC15	70.570	2.119	63.657	76.372	0.1011
IC20	76.166	2.422	67.767	84.070	0.1927
IC25	81.452	2.805	72.145	90.712	0.2615
IC40	96.831				
IC50	>100				



Sea Urchin Fertilisation Test-Proportion Fertilized

Start Date:	15/02/2011 12:30	Test ID:	PR0700/02	Sample ID:	Bore 1
End Date:	15/02/2011 13:50	Lab ID:	4581	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 104	Test Species:	HT-Heliocidaris tuberculata
Comments:					

Dose-Response Plot



 ToxCalc v5.0.23 Reviewed by:_____

Sea Urchin Fertilisation Test-Proportion Fertilized

Start Date:	15/02/2011 12:30	Test ID:	PR0700/02	Sample ID:	Bore 1
End Date:	15/02/2011 13:50	Lab ID:	4581	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 104	Test Species:	HT-Heliocidaris tuberculata
Comments:					

		Auxiliary Data Summary					
Conc-%	**Parameter**	**Mean**	**Min**	**Max**	**SD**	**CV%**	**N**
FSW Control	% Fertilised	94.25	91.00	98.00	2.99	1.83	4
ASW Control		92.75	91.00	96.00	2.22	1.61	4
6.3		94.75	92.00	98.00	2.75	1.75	4
12.5		94.00	91.00	96.00	2.16	1.56	4
25		94.00	91.00	98.00	3.16	1.89	4
50		93.00	91.00	96.00	2.16	1.58	4
100		53.50	43.00	65.00	9.57	5.78	4
FSW Control	pH	8.20	8.20	8.20	0.00	0.00	1
ASW Control		8.10	8.10	8.10	0.00	0.00	1
6.3		8.10	8.10	8.10	0.00	0.00	1
12.5		8.00	8.00	8.00	0.00	0.00	1
25		8.00	8.00	8.00	0.00	0.00	1
50		7.90	7.90	7.90	0.00	0.00	1
100		7.70	7.70	7.70	0.00	0.00	1
FSW Control	Salinity ppt	35.10	35.10	35.10	0.00	0.00	1
ASW Control		35.00	35.00	35.00	0.00	0.00	1
6.3		35.10	35.10	35.10	0.00	0.00	1
12.5		35.00	35.00	35.00	0.00	0.00	1
25		35.00	35.00	35.00	0.00	0.00	1
50		34.90	34.90	34.90	0.00	0.00	1
100		34.70	34.70	34.70	0.00	0.00	1
FSW Control	DO %	99.40	99.40	99.40	0.00	0.00	1
ASW Control		97.00	97.00	97.00	0.00	0.00	1
6.3		99.60	99.60	99.60	0.00	0.00	1
12.5		99.30	99.30	99.30	0.00	0.00	1
25		99.70	99.70	99.70	0.00	0.00	1
50		99.90	99.90	99.90	0.00	0.00	1
100		100.60	100.60	100.60	0.00	0.00	1

Sea Urchin Fertilisation Test-Proportion Fertilized

Start Date:	15/02/2011 12:30	Test ID:	PR0700/03	Sample ID:	Bore 2
End Date:	15/02/2011 13:50	Lab ID:	4582	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 104	Test Species:	HT-Heliocidaris tuberculata
Comments:					

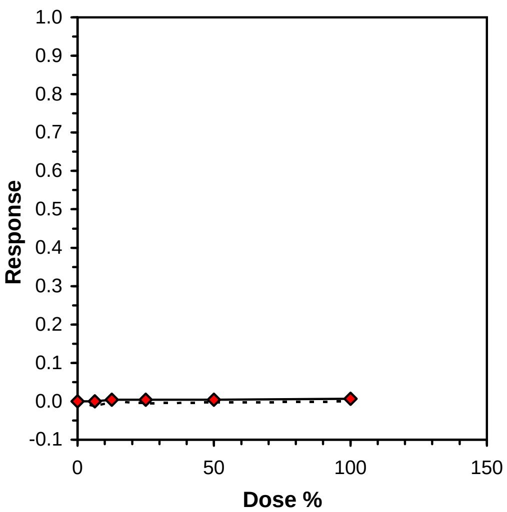
Conc-%	1	2	3	4
FSW Control	0.9500	0.9300	0.9800	0.9100
ASW Control	0.9200	0.9600	0.9200	0.9100
6.3	0.9100	0.9600	0.9800	0.9100
12.5	0.9200	0.9500	0.9100	0.9300
25	0.9400	0.9100	0.9600	0.9200
50	0.9500	0.9100	0.9300	0.9300
100	0.9400	0.9100	0.9600	0.9000

			Transform: Arcsin Square Root						1-Tailed		Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD	Mean	N-Mean
FSW Control	0.9425	1.0162	1.3358	1.2661	1.4289	5.238	4					
ASW Control	0.9275	1.0000	1.3009	1.2661	1.3694	3.572	4	*			0.9338	1.0000
6.3	0.9400	1.0135	1.3326	1.2661	1.4289	6.046	4	-0.869	2.410	0.0880	0.9338	1.0000
12.5	0.9275	1.0000	1.2996	1.2661	1.3453	2.614	4	0.035	2.410	0.0880	0.9300	0.9960
25	0.9325	1.0054	1.3107	1.2661	1.3694	3.499	4	-0.269	2.410	0.0880	0.9300	0.9960
50	0.9300	1.0027	1.3044	1.2661	1.3453	2.481	4	-0.095	2.410	0.0880	0.9300	0.9960
100	0.9275	1.0000	1.3020	1.2490	1.3694	4.229	4	-0.029	2.410	0.0880	0.9275	0.9933

Auxiliary Tests					Statistic		Critical		Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.05)					0.953163		0.916		0.452337	-0.73399
Bartlett's Test indicates equal variances (p = 0.67)					3.180778		15.08627			
The control means are not significantly different (p = 0.44)					0.831581		2.446912			
Hypothesis Test (1-tail, 0.05)	**NOEC**	**LOEC**	**ChV**	**TU**	**MSDu**	**MSDp**	**MSB**	**MSE**	**F-Prob**	**df**
Dunnett's Test	100	>100		1	0.051597	0.055546	0.000627	0.002664	0.941843	5, 18
Treatments vs ASW Control										

Linear Interpolation (200 Resamples)

Point	%	SD	95% CL(Exp)	Skew
IC05	>100			
IC10	>100			
IC15	>100			
IC20	>100			
IC25	>100			
IC40	>100			
IC50	>100			

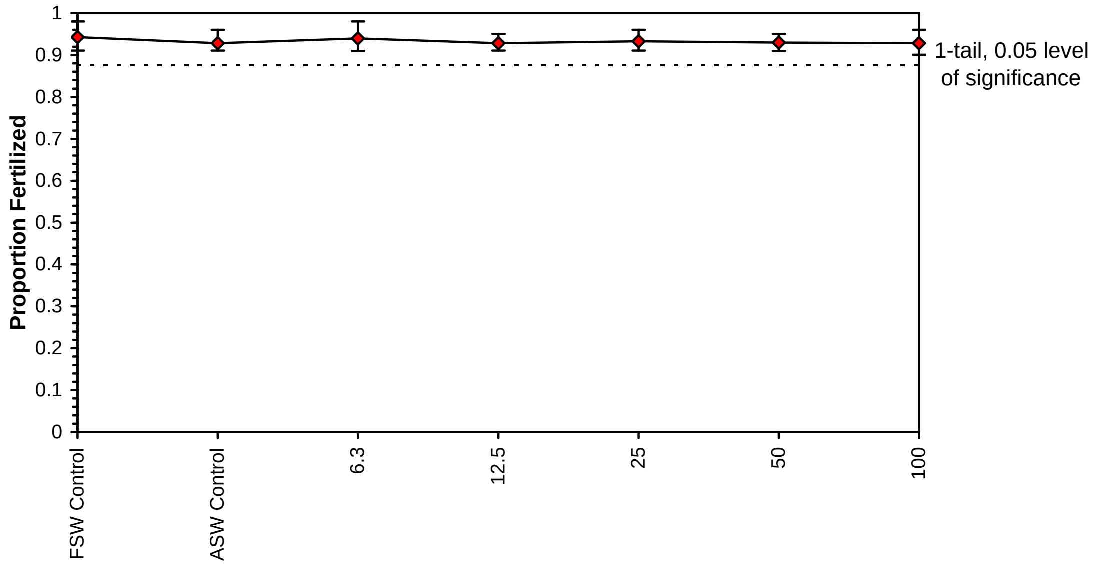


 ToxCalc v5.0.23 Reviewed by:_____

Sea Urchin Fertilisation Test-Proportion Fertilized

Start Date:	15/02/2011 12:30	Test ID:	PR0700/03	Sample ID:	Bore 2
End Date:	15/02/2011 13:50	Lab ID:	4582	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 104	Test Species:	HT-Heliocidaris tuberculata
Comments:					

Dose-Response Plot



Sea Urchin Fertilisation Test-Proportion Fertilized

Start Date:	15/02/2011 12:30	Test ID:	PR0700/03	Sample ID:	Bore 2
End Date:	15/02/2011 13:50	Lab ID:	4582	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 104	Test Species:	HT-Heliocidaris tuberculata
Comments:					

		Auxiliary Data Summary					
Conc-%	Parameter	Mean	Min	Max	SD	CV%	N
FSW Control	% Fertilised	94.25	91.00	98.00	2.99	1.83	4
ASW Control		92.75	91.00	96.00	2.22	1.61	4
6.3		94.00	91.00	98.00	3.56	2.01	4
12.5		92.75	91.00	95.00	1.71	1.41	4
25		93.25	91.00	96.00	2.22	1.60	4
50		93.00	91.00	95.00	1.63	1.37	4
100		92.75	90.00	96.00	2.75	1.79	4
FSW Control	pH	8.20	8.20	8.20	0.00	0.00	1
ASW Control		8.10	8.10	8.10	0.00	0.00	1
6.3		8.10	8.10	8.10	0.00	0.00	1
12.5		8.10	8.10	8.10	0.00	0.00	1
25		8.10	8.10	8.10	0.00	0.00	1
50		8.10	8.10	8.10	0.00	0.00	1
100		8.00	8.00	8.00	0.00	0.00	1
FSW Control	Salinity ppt	35.10	35.10	35.10	0.00	0.00	1
ASW Control		35.00	35.00	35.00	0.00	0.00	1
6.3		35.00	35.00	35.00	0.00	0.00	1
12.5		35.00	35.00	35.00	0.00	0.00	1
25		34.90	34.90	34.90	0.00	0.00	1
50		34.60	34.60	34.60	0.00	0.00	1
100		34.60	34.60	34.60	0.00	0.00	1
FSW Control	DO %	99.40	99.40	99.40	0.00	0.00	1
ASW Control		97.00	97.00	97.00	0.00	0.00	1
6.3		99.90	99.90	99.90	0.00	0.00	1
12.5		98.80	98.80	98.80	0.00	0.00	1
25		98.90	98.90	98.90	0.00	0.00	1
50		99.40	99.40	99.40	0.00	0.00	1
100		99.80	99.80	99.80	0.00	0.00	1

Sea Urchin Fertilisation Test-Proportion Fertilized

Start Date:	15/02/2011 12:30	Test ID:	PR0700/04	Sample ID:	Bore 3
End Date:	15/02/2011 13:50	Lab ID:	4583	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 104	Test Species:	HT-Heliocidaris tuberculata
Comments:					

Conc-%	1	2	3	4
FSW Control	0.9500	0.9300	0.9800	0.9100
ASW Control	0.9200	0.9600	0.9200	0.9100
6.3	0.9200	0.9100	0.9300	0.9500
12.5	0.9600	0.9100	0.9800	0.9200
25	0.9500	0.9100	0.9600	0.9300
50	0.9500	0.9800	0.9200	0.9500
100	0.7600	0.8100	0.8300	0.8800

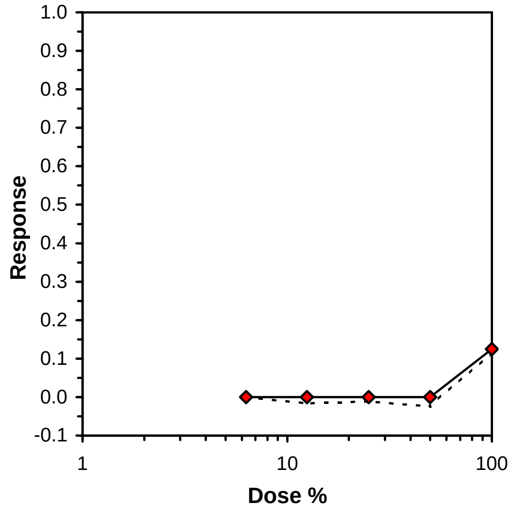
			Transform: Arcsin Square Root						1-Tailed		Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD	Mean	N-Mean
FSW Control	0.9425	1.0162	1.3358	1.2661	1.4289	5.238	4					
ASW Control	0.9275	1.0000	1.3009	1.2661	1.3694	3.572	4	*			0.9370	1.0000
6.3	0.9275	1.0000	1.2996	1.2661	1.3453	2.614	4	0.032	2.410	0.0959	0.9370	1.0000
12.5	0.9425	1.0162	1.3371	1.2661	1.4289	5.684	4	-0.910	2.410	0.0959	0.9370	1.0000
25	0.9375	1.0108	1.3210	1.2661	1.3694	3.461	4	-0.504	2.410	0.0959	0.9370	1.0000
50	0.9500	1.0243	1.3509	1.2840	1.4289	4.404	4	-1.255	2.410	0.0959	0.9370	1.0000
*100	0.8200	0.8841	1.1354	1.0588	1.2171	5.772	4	4.159	2.410	0.0959	0.8200	0.8751

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.05)	0.95119	0.916	0.326688	-0.81185
Bartlett's Test indicates equal variances (p = 0.83)	2.110964	15.08627		
The control means are not significantly different (p = 0.44)	0.831581	2.446912		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU	MSDu	MSDp	MSB	MSE	F-Prob	df
Dunnett's Test	50	100	70.71068	2	0.056873	0.061225	0.024804	0.003169	4.6E-04	5, 18
Treatments vs ASW Control										

Log-Logit Interpolation (200 Resamples)

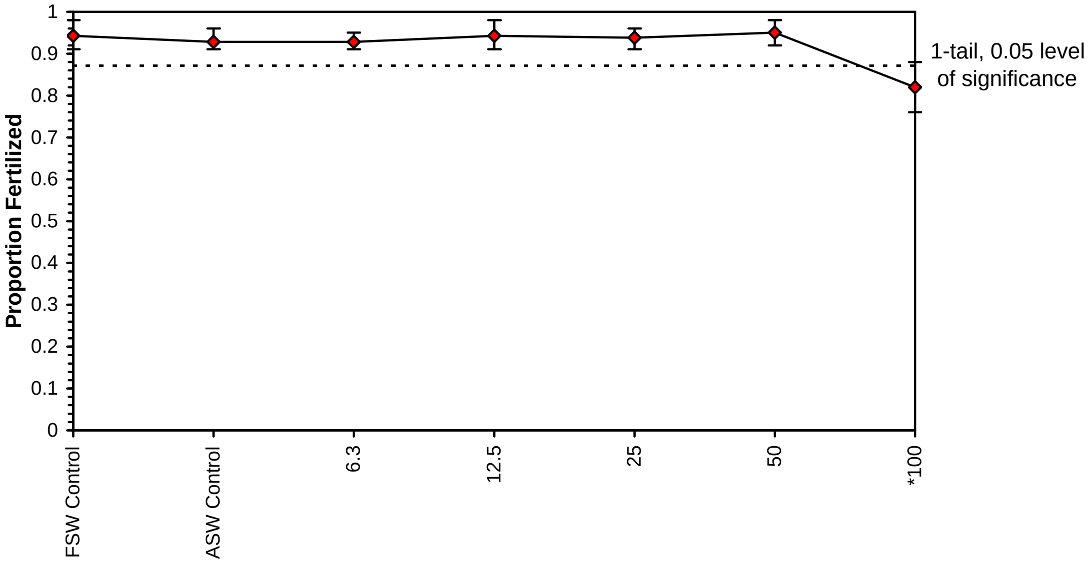
Point	%	SD	95% CL(Exp)		Skew
IC05	71.423	4.256	62.176	87.197	0.8311
IC10	90.733				
IC15	>100				
IC20	>100				
IC25	>100				
IC40	>100				
IC50	>100				



Sea Urchin Fertilisation Test-Proportion Fertilized

Start Date:	15/02/2011 12:30	Test ID:	PR0700/04	Sample ID:	Bore 3
End Date:	15/02/2011 13:50	Lab ID:	4583	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 104	Test Species:	HT-Heliocidaris tuberculata
Comments:					

Dose-Response Plot



ToxCalc v5.0.23
Reviewed by:_____

Sea Urchin Fertilisation Test-Proportion Fertilized

Start Date:	15/02/2011 12:30	Test ID:	PR0700/04	Sample ID:	Bore 3
End Date:	15/02/2011 13:50	Lab ID:	4583	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 104	Test Species:	HT-Heliocidaris tuberculata
Comments:					

		Auxiliary Data Summary					
Conc-%	**Parameter**	**Mean**	**Min**	**Max**	**SD**	**CV%**	**N**
FSW Control	% Fertilised	94.25	91.00	98.00	2.99	1.83	4
ASW Control		92.75	91.00	96.00	2.22	1.61	4
6.3		92.75	91.00	95.00	1.71	1.41	4
12.5		94.25	91.00	98.00	3.30	1.93	4
25		93.75	91.00	96.00	2.22	1.59	4
50		95.00	92.00	98.00	2.45	1.65	4
100		82.00	76.00	88.00	4.97	2.72	4
FSW Control	pH	8.20	8.20	8.20	0.00	0.00	1
ASW Control		8.10	8.10	8.10	0.00	0.00	1
6.3		8.10	8.10	8.10	0.00	0.00	1
12.5		8.10	8.10	8.10	0.00	0.00	1
25		8.00	8.00	8.00	0.00	0.00	1
50		8.00	8.00	8.00	0.00	0.00	1
100		7.80	7.80	7.80	0.00	0.00	1
FSW Control	Salinity ppt	35.10	35.10	35.10	0.00	0.00	1
ASW Control		35.00	35.00	35.00	0.00	0.00	1
6.3		35.00	35.00	35.00	0.00	0.00	1
12.5		35.00	35.00	35.00	0.00	0.00	1
25		35.00	35.00	35.00	0.00	0.00	1
50		34.80	34.80	34.80	0.00	0.00	1
100		34.70	34.70	34.70	0.00	0.00	1
FSW Control	DO %	99.40	99.40	99.40	0.00	0.00	1
ASW Control		97.00	97.00	97.00	0.00	0.00	1
6.3		99.10	99.10	99.10	0.00	0.00	1
12.5		99.10	99.10	99.10	0.00	0.00	1
25		99.50	99.50	99.50	0.00	0.00	1
50		98.50	98.50	98.50	0.00	0.00	1
100		97.10	97.10	97.10	0.00	0.00	1

Sea Urchin Fertilisation Test-Proportion Fertilized

Start Date:	15/02/2011 12:30	Test ID:	PR0700/05	Sample ID:	Bore 4
End Date:	15/02/2011 13:50	Lab ID:	4584	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 104	Test Species:	HT-Heliocidaris tuberculata
Comments:					

Conc-%	1	2	3	4
FSW Control	0.9500	0.9300	0.9800	0.9100
ASW Control	0.9200	0.9600	0.9200	0.9100
6.3	0.9500	0.9100	0.9400	0.9300
12.5	0.9600	0.9500	0.9100	0.9700
25	0.9200	0.9300	0.9800	0.9100
50	0.9200	0.9500	0.9300	0.9100
100	0.9600	0.9300	0.9800	0.9000

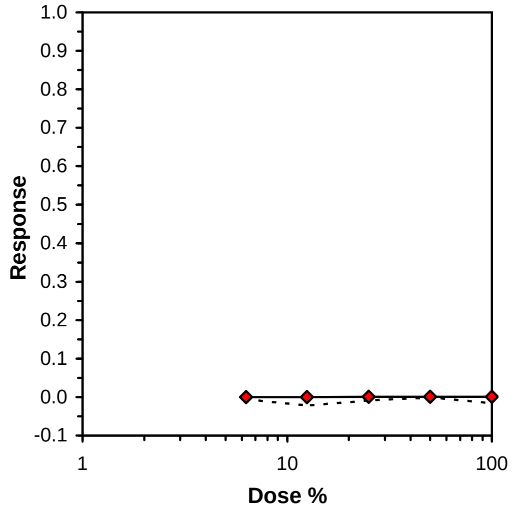
			Transform: Arcsin Square Root						1-Tailed		Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD	Mean	N-Mean
FSW Control	0.9425	1.0162	1.3358	1.2661	1.4289	5.238	4					
ASW Control	0.9275	1.0000	1.3009	1.2661	1.3694	3.572	4	*			0.9358	1.0000
6.3	0.9325	1.0054	1.3094	1.2661	1.3453	2.570	4	-0.213	2.410	0.0964	0.9358	1.0000
12.5	0.9475	1.0216	1.3444	1.2661	1.3967	4.185	4	-1.087	2.410	0.0964	0.9358	1.0000
25	0.9350	1.0081	1.3205	1.2661	1.4289	5.589	4	-0.491	2.410	0.0964	0.9350	0.9991
50	0.9275	1.0000	1.2996	1.2661	1.3453	2.614	4	0.032	2.410	0.0964	0.9350	0.9991
100	0.9425	1.0162	1.3376	1.2490	1.4289	5.853	4	-0.918	2.410	0.0964	0.9350	0.9991

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.05)	0.973605	0.916	0.411363	-0.17101
Bartlett's Test indicates equal variances (p = 0.64)	3.391911	15.08627		
The control means are not significantly different (p = 0.44)	0.831581	2.446912		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU	MSDu	MSDp	MSB	MSE	F-Prob	df
Dunnett's Test	100	>100		1	0.057163	0.061538	0.00143	0.003198	0.809834	5, 18
Treatments vs ASW Control										

Log-Logit Interpolation (200 Resamples)

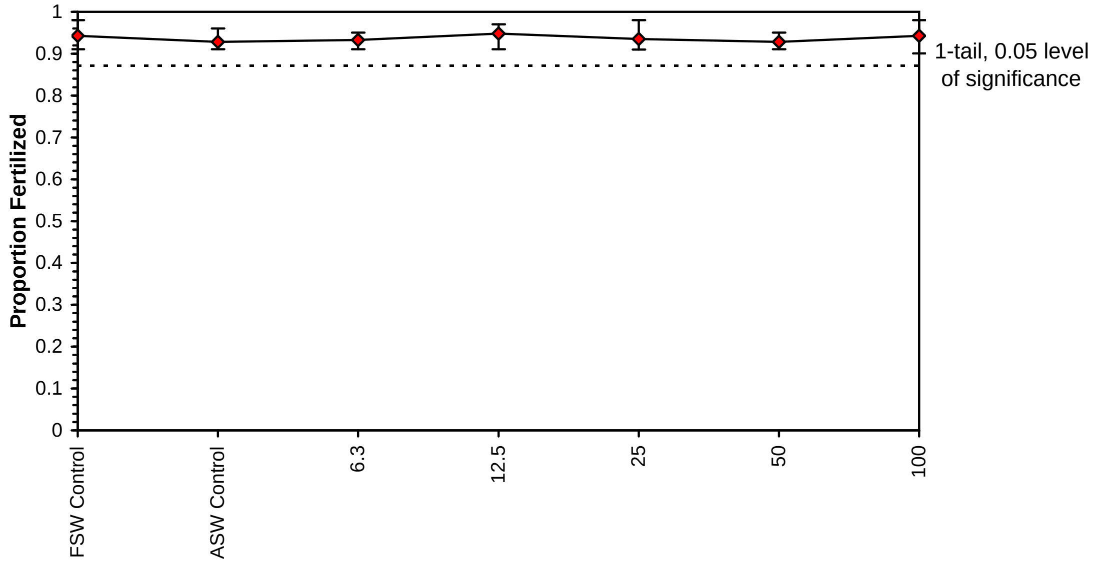
Point	%	SD	95% CL(Exp)	Skew
IC05	>100			
IC10	>100			
IC15	>100			
IC20	>100			
IC25	>100			
IC40	>100			
IC50	>100			



Sea Urchin Fertilisation Test-Proportion Fertilized

Start Date:	15/02/2011 12:30	Test ID:	PR0700/05	Sample ID:	Bore 4
End Date:	15/02/2011 13:50	Lab ID:	4584	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 104	Test Species:	HT-Heliocidaris tuberculata
Comments:					

Dose-Response Plot



Sea Urchin Fertilisation Test-Proportion Fertilized

Start Date:	15/02/2011 12:30	Test ID:	PR0700/05	Sample ID:	Bore 4
End Date:	15/02/2011 13:50	Lab ID:	4584	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 104	Test Species:	HT-Heliocidaris tuberculata
Comments:					

Auxiliary Data Summary

Conc-%	Parameter	Mean	Min	Max	SD	CV%	N
FSW Control	% Fertilised	94.25	91.00	98.00	2.99	1.83	4
ASW Control		92.75	91.00	96.00	2.22	1.61	4
6.3		93.25	91.00	95.00	1.71	1.40	4
12.5		94.75	91.00	97.00	2.63	1.71	4
25		93.50	91.00	98.00	3.11	1.89	4
50		92.75	91.00	95.00	1.71	1.41	4
100		94.25	90.00	98.00	3.50	1.98	4
FSW Control	pH	8.20	8.20	8.20	0.00	0.00	1
ASW Control		8.10	8.10	8.10	0.00	0.00	1
6.3		8.10	8.10	8.10	0.00	0.00	1
12.5		8.00	8.00	8.00	0.00	0.00	1
25		8.00	8.00	8.00	0.00	0.00	1
50		7.90	7.90	7.90	0.00	0.00	1
100		7.60	7.60	7.60	0.00	0.00	1
FSW Control	Salinity ppt	35.10	35.10	35.10	0.00	0.00	1
ASW Control		35.00	35.00	35.00	0.00	0.00	1
6.3		34.90	34.90	34.90	0.00	0.00	1
12.5		34.90	34.90	34.90	0.00	0.00	1
25		35.00	35.00	35.00	0.00	0.00	1
50		34.90	34.90	34.90	0.00	0.00	1
100		34.60	34.60	34.60	0.00	0.00	1
FSW Control	DO %	99.40	99.40	99.40	0.00	0.00	1
ASW Control		97.00	97.00	97.00	0.00	0.00	1
6.3		98.90	98.90	98.90	0.00	0.00	1
12.5		98.60	98.60	98.60	0.00	0.00	1
25		98.80	98.80	98.80	0.00	0.00	1
50		98.90	98.90	98.90	0.00	0.00	1
100		100.20	100.20	100.20	0.00	0.00	1

Sea Urchin Fertilisation Test-Proportion Fertilized

Start Date:	15/02/2011 12:30	Test ID:	PR0700/06	Sample ID:	Bore 5
End Date:	15/02/2011 13:50	Lab ID:	4585	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 104	Test Species:	HT-Heliocidaris tuberculata
Comments:					

Conc-%	1	2	3	4
FSW Control	0.9500	0.9300	0.9800	0.9100
ASW Control	0.9200	0.9600	0.9200	0.9100
6.3	0.9100	0.9600	0.9300	0.9400
12.5	0.9100	0.9800	0.9300	0.9100
25	0.9200	0.9300	0.9500	0.9000
50	0.9100	0.9600	0.9300	0.9800
100	0.9200	0.9100	0.9500	0.9000

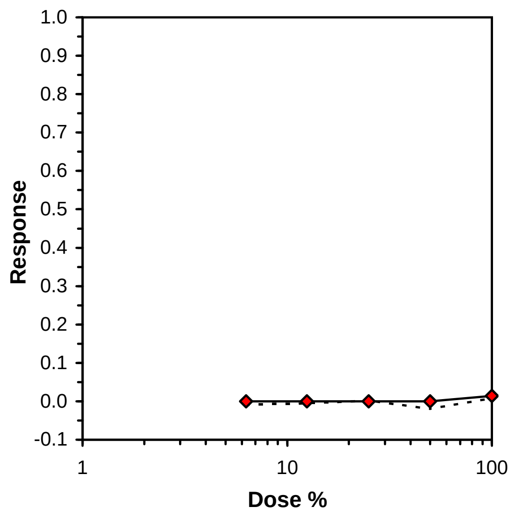
			Transform: Arcsin Square Root						1-Tailed		Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD	Mean	N-Mean
FSW Control	0.9425	1.0162	1.3358	1.2661	1.4289	5.238	4					
ASW Control	0.9275	1.0000	1.3009	1.2661	1.3694	3.572	4	*			0.9330	1.0000
6.3	0.9350	1.0081	1.3155	1.2661	1.3694	3.274	4	-0.371	2.410	0.0947	0.9330	1.0000
12.5	0.9325	1.0054	1.3160	1.2661	1.4289	5.868	4	-0.385	2.410	0.0947	0.9330	1.0000
25	0.9250	0.9973	1.2954	1.2490	1.3453	3.096	4	0.141	2.410	0.0947	0.9330	1.0000
50	0.9450	1.0189	1.3419	1.2661	1.4289	5.371	4	-1.042	2.410	0.0947	0.9330	1.0000
100	0.9200	0.9919	1.2861	1.2490	1.3453	3.262	4	0.376	2.410	0.0947	0.9200	0.9861

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.05)	0.931757	0.916	0.738208	-0.23782
Bartlett's Test indicates equal variances (p = 0.79)	2.411398	15.08627		
The control means are not significantly different (p = 0.44)	0.831581	2.446912		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU	MSDu	MSDp	MSB	MSE	F-Prob	df
Dunnett's Test	100	>100		1	0.056072	0.060363	0.001557	0.00309	0.769425	5, 18
Treatments vs ASW Control										

Log-Logit Interpolation (200 Resamples)

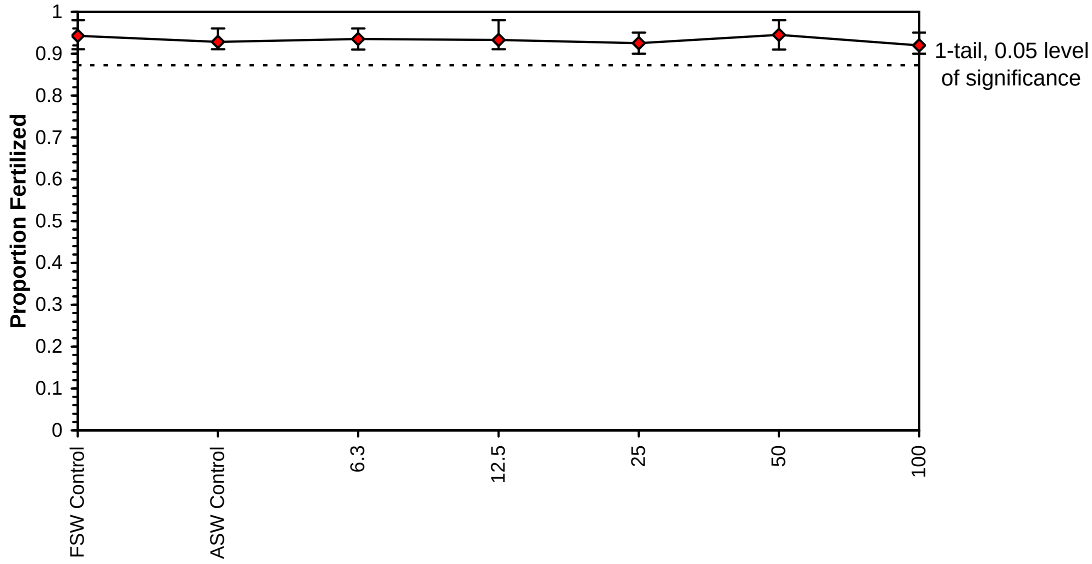
Point	%	SD	95% CL(Exp)	Skew
IC05	>100			
IC10	>100			
IC15	>100			
IC20	>100			
IC25	>100			
IC40	>100			
IC50	>100			



Sea Urchin Fertilisation Test-Proportion Fertilized

Start Date:	15/02/2011 12:30	Test ID:	PR0700/06	Sample ID:	Bore 5
End Date:	15/02/2011 13:50	Lab ID:	4585	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 104	Test Species:	HT-Heliocidaris tuberculata
Comments:					

Dose-Response Plot



Sea Urchin Fertilisation Test-Proportion Fertilized

Start Date:	15/02/2011 12:30	Test ID:	PR0700/06	Sample ID:	Bore 5
End Date:	15/02/2011 13:50	Lab ID:	4585	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 104	Test Species:	HT-Heliocidaris tuberculata
Comments:					

		Auxiliary Data Summary					
Conc-%	**Parameter**	**Mean**	**Min**	**Max**	**SD**	**CV%**	**N**
FSW Control	% Fertilised	94.25	91.00	98.00	2.99	1.83	4
ASW Control		92.75	91.00	96.00	2.22	1.61	4
6.3		93.50	91.00	96.00	2.08	1.54	4
12.5		93.25	91.00	98.00	3.30	1.95	4
25		92.50	90.00	95.00	2.08	1.56	4
50		94.50	91.00	98.00	3.11	1.87	4
100		92.00	90.00	95.00	2.16	1.60	4
FSW Control	pH	8.20	8.20	8.20	0.00	0.00	1
ASW Control		8.10	8.10	8.10	0.00	0.00	1
6.3		8.00	8.00	8.00	0.00	0.00	1
12.5		8.00	8.00	8.00	0.00	0.00	1
25		8.00	8.00	8.00	0.00	0.00	1
50		7.90	7.90	7.90	0.00	0.00	1
100		7.60	7.60	7.60	0.00	0.00	1
FSW Control	Salinity ppt	35.10	35.10	35.10	0.00	0.00	1
ASW Control		35.00	35.00	35.00	0.00	0.00	1
6.3		35.00	35.00	35.00	0.00	0.00	1
12.5		35.10	35.10	35.10	0.00	0.00	1
25		35.00	35.00	35.00	0.00	0.00	1
50		34.90	34.90	34.90	0.00	0.00	1
100		34.60	34.60	34.60	0.00	0.00	1
FSW Control	DO %	99.40	99.40	99.40	0.00	0.00	1
ASW Control		97.00	97.00	97.00	0.00	0.00	1
6.3		98.70	98.70	98.70	0.00	0.00	1
12.5		93.50	93.50	93.50	0.00	0.00	1
25		94.00	94.00	94.00	0.00	0.00	1
50		96.10	96.10	96.10	0.00	0.00	1
100		90.50	90.50	90.50	0.00	0.00	1

Statistical Printouts for the Sea Urchin Larval Development Test

Sea Urchin Larval Development Test-Proportion Normal

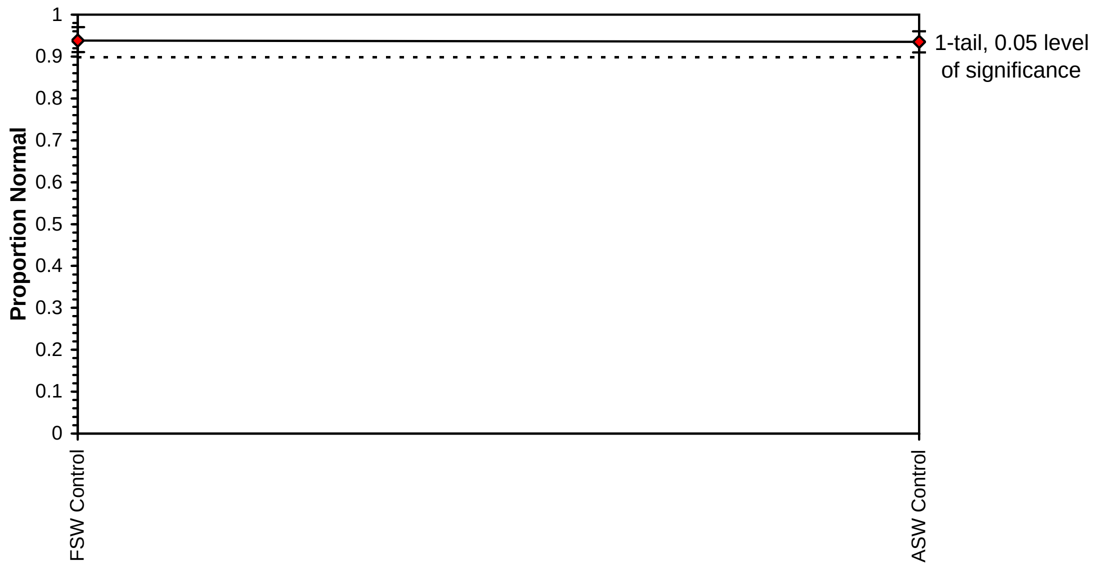
Start Date:	15/02/2011 12:15	Test ID:	PR0700/02	Sample ID:	Controls
End Date:	18/02/2011 12:15	Lab ID:		Sample Type:	Controls
Sample Date:		Protocol:	ESA 105	Test Species:	HT-Heliocidaris tuberculata
Comments:					

Conc-	1	2	3	4
FSW Control	0.9200	0.9500	0.9700	0.9100
ASW Control	0.9600	0.9200	0.9100	0.9500

			Transform: Arcsin Square Root						1-Tailed	
Conc-	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD
FSW Control	0.9375	1.0000	1.3230	1.2661	1.3967	4.511	4			
ASW Control	0.9350	0.9973	1.3162	1.2661	1.3694	3.728	4	0.177	1.943	0.0751

Auxiliary Tests	Statistic		Critical		Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.05)	0.895726		0.818		0.26981	-1.82818
F-Test indicates equal variances (p = 0.76)	1.479121		47.46723			
Hypothesis Test (1-tail, 0.05)	**MSDu**	**MSDp**	**MSB**	**MSE**	**F-Prob**	**df**
Homoscedastic t Test indicates no significant differences	0.040509	0.043101	9.3E-05	0.002985	0.865705	1, 6
Treatments vs FSW Control						

Dose-Response Plot



Sea Urchin Larval Development Test-Proportion Normal

Start Date:	15/02/2011 12:15	Test ID:	PR0700/02	Sample ID:	Controls
End Date:	18/02/2011 12:15	Lab ID:		Sample Type:	Controls
Sample Date:		Protocol:	ESA 105	Test Species:	HT-Heliocidaris tuberculata
Comments:					

Auxiliary Data Summary

Conc-	Parameter	Mean	Min	Max	SD	CV%	N
FSW Control	% Normal	93.75	91.00	97.00	2.75	1.77	4
ASW Control		93.50	91.00	96.00	2.38	1.65	4
FSW Control	pH	8.20	8.20	8.20	0.00	0.00	1
ASW Control		8.10	8.10	8.10	0.00	0.00	1
FSW Control	Salinity ppt	35.10	35.10	35.10	0.00	0.00	1
ASW Control		35.00	35.00	35.00	0.00	0.00	1
FSW Control	DO %	99.40	99.40	99.40	0.00	0.00	1
ASW Control		97.00	97.00	97.00	0.00	0.00	1

Sea Urchin Larval Development Test-Proportion Normal					
Start Date:	15/02/2011 12:15	Test ID:	PR0700/03	Sample ID:	Bore 1
End Date:	18/02/2011 12:15	Lab ID:	4581	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 105	Test Species:	HT-Heliocidaris tuberculata
Comments:					

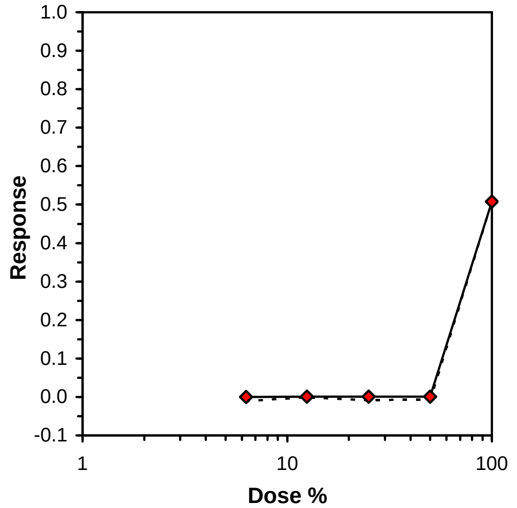
Conc-%	1	2	3	4
ASW Control	0.9600	0.9200	0.9100	0.9500
6.3	0.9100	0.9800	0.9200	0.9700
12.5	0.9500	0.9300	0.9500	0.9100
25	0.9400	0.9600	0.9200	0.9500
50	0.9200	0.9500	0.9300	0.9600
100	0.4600	0.5200	0.4900	0.3800

			Transform: Arcsin Square Root						1-Tailed		Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD	Mean	N-Mean
ASW Control	0.9350	1.0000	1.3162	1.2661	1.3694	3.728	4				0.9400	1.0000
6.3	0.9450	1.0107	1.3439	1.2661	1.4289	6.022	4	-0.738	2.410	0.0905	0.9400	1.0000
12.5	0.9350	1.0000	1.3149	1.2661	1.3453	2.902	4	0.034	2.410	0.0905	0.9392	0.9991
25	0.9425	1.0080	1.3305	1.2840	1.3694	2.725	4	-0.381	2.410	0.0905	0.9392	0.9991
50	0.9400	1.0053	1.3254	1.2840	1.3694	2.937	4	-0.246	2.410	0.0905	0.9392	0.9991
*100	0.4625	0.4947	0.7476	0.6642	0.8054	8.126	4	15.137	2.410	0.0905	0.4625	0.4920

Auxiliary Tests					Statistic		Critical		Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.05)					0.95782		0.916		-0.1668	-1.03774
Bartlett's Test indicates equal variances (p = 0.71)					2.912115		15.08627			
Hypothesis Test (1-tail, 0.05)	**NOEC**	**LOEC**	**ChV**	**TU**	**MSDu**	**MSDp**	**MSB**	**MSE**	**F-Prob**	**df**
Dunnett's Test	50	100	70.71068	2	0.051027	0.054483	0.223647	0.002822	1.3E-11	5, 18
Treatments vs ASW Control										

Log-Logit Interpolation (200 Resamples)

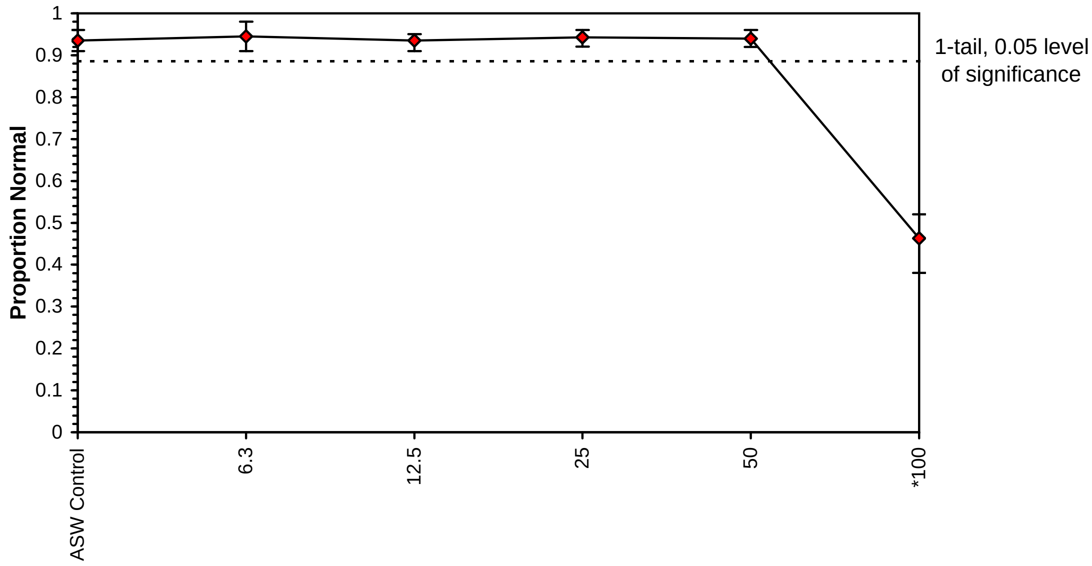
Point	%	SD	95% CL(Exp)		Skew
IC05	57.992	1.288	51.074	58.973	-0.8115
IC10	64.129	1.150	58.279	65.607	-0.5923
IC15	69.312	1.141	64.278	71.281	-0.3754
IC20	73.965	1.205	69.007	76.444	-0.2244
IC25	78.310	1.317	73.090	81.291	-0.1379
IC40	90.710	1.828	84.645	95.524	-0.0455
IC50	99.282				



Sea Urchin Larval Development Test-Proportion Normal

Start Date:	15/02/2011 12:15	Test ID:	PR0700/03	Sample ID:	Bore 1
End Date:	18/02/2011 12:15	Lab ID:	4581	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 105	Test Species:	HT-Heliocidaris tuberculata
Comments:					

Dose-Response Plot



Sea Urchin Larval Development Test-Proportion Normal

Start Date:	15/02/2011 12:15	Test ID:	PR0700/03	Sample ID:	Bore 1
End Date:	18/02/2011 12:15	Lab ID:	4581	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 105	Test Species:	HT-Heliocidaris tuberculata
Comments:					

		Auxiliary Data Summary					
Conc-%	**Parameter**	**Mean**	**Min**	**Max**	**SD**	**CV%**	**N**
ASW Control	% Normal	93.50	91.00	96.00	2.38	1.65	4
6.3		94.50	91.00	98.00	3.51	1.98	4
12.5		93.50	91.00	95.00	1.91	1.48	4
25		94.25	92.00	96.00	1.71	1.39	4
50		94.00	92.00	96.00	1.83	1.44	4
100		46.25	38.00	52.00	6.02	5.31	4
ASW Control	pH	8.10	8.10	8.10	0.00	0.00	1
6.3		8.10	8.10	8.10	0.00	0.00	1
12.5		8.00	8.00	8.00	0.00	0.00	1
25		8.00	8.00	8.00	0.00	0.00	1
50		7.90	7.90	7.90	0.00	0.00	1
100		7.70	7.70	7.70	0.00	0.00	1
ASW Control	Salinity ppt	35.00	35.00	35.00	0.00	0.00	1
6.3		35.10	35.10	35.10	0.00	0.00	1
12.5		35.00	35.00	35.00	0.00	0.00	1
25		35.00	35.00	35.00	0.00	0.00	1
50		34.90	34.90	34.90	0.00	0.00	1
100		34.70	34.70	34.70	0.00	0.00	1
ASW Control	DO %	97.00	97.00	97.00	0.00	0.00	1
6.3		99.60	99.60	99.60	0.00	0.00	1
12.5		99.30	99.30	99.30	0.00	0.00	1
25		99.70	99.70	99.70	0.00	0.00	1
50		99.90	99.90	99.90	0.00	0.00	1
100		100.60	100.60	100.60	0.00	0.00	1

Sea Urchin Larval Development Test-Proportion Normal

Start Date:	15/02/2011 12:15	Test ID:	PR0700/03	Sample ID:	Bore 1
End Date:	18/02/2011 12:15	Lab ID:	4581	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 105	Test Species:	HT-Heliocidaris tuberculata
Comments:					

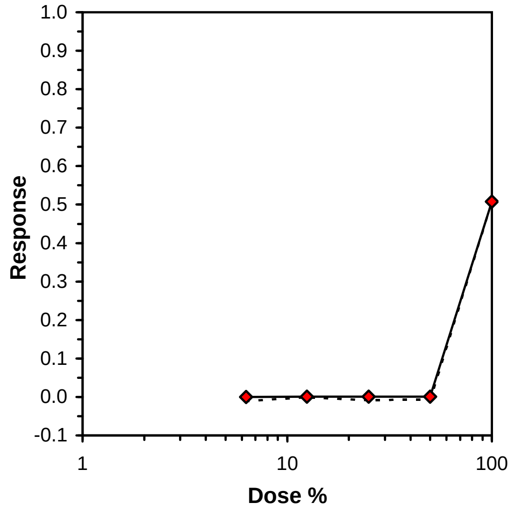
Conc-%	1	2	3	4
ASW Control	0.9600	0.9200	0.9100	0.9500
6.3	0.9100	0.9800	0.9200	0.9700
12.5	0.9500	0.9300	0.9500	0.9100
25	0.9400	0.9600	0.9200	0.9500
50	0.9200	0.9500	0.9300	0.9600
100	0.4600	0.5200	0.4900	0.3800

			Transform: Arcsin Square Root						1-Tailed		Number	Total
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD	Resp	Number
ASW Control	0.9350	1.0000	1.3162	1.2661	1.3694	3.728	4				26	400
6.3	0.9450	1.0107	1.3439	1.2661	1.4289	6.022	4	-0.738	2.410	0.0905	22	400
12.5	0.9350	1.0000	1.3149	1.2661	1.3453	2.902	4	0.034	2.410	0.0905	26	400
25	0.9425	1.0080	1.3305	1.2840	1.3694	2.725	4	-0.381	2.410	0.0905	23	400
50	0.9400	1.0053	1.3254	1.2840	1.3694	2.937	4	-0.246	2.410	0.0905	24	400
*100	0.4625	0.4947	0.7476	0.6642	0.8054	8.126	4	15.137	2.410	0.0905	215	400

Auxiliary Tests					Statistic		Critical		Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.05)					0.95782		0.916		-0.1668	-1.03774
Bartlett's Test indicates equal variances (p = 0.71)					2.912115		15.08627			
Hypothesis Test (1-tail, 0.05)	**NOEC**	**LOEC**	**ChV**	**TU**	**MSDu**	**MSDp**	**MSB**	**MSE**	**F-Prob**	**df**
Dunnett's Test	50	100	70.71068	2	0.051027	0.054483	0.223647	0.002822	1.3E-11	5, 18
Treatments vs ASW Control										

Trimmed Spearman-Karber

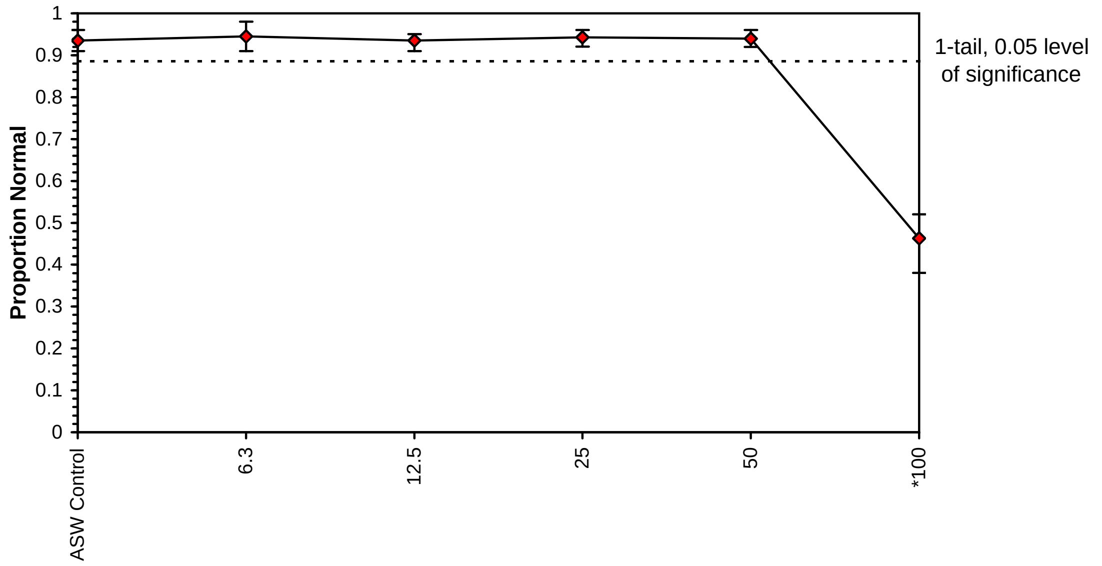
Trim Level	EC50	95% CL	
0.0%			
5.0%			
10.0%			
20.0%			
Auto-49.2%	98.915	92.481	105.797



Sea Urchin Larval Development Test-Proportion Normal

Start Date:	15/02/2011 12:15	Test ID:	PR0700/03	Sample ID:	Bore 1
End Date:	18/02/2011 12:15	Lab ID:	4581	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 105	Test Species:	HT-Heliocidaris tuberculata
Comments:					

Dose-Response Plot



Sea Urchin Larval Development Test-Proportion Normal

Start Date:	15/02/2011 12:15	Test ID:	PR0700/03	Sample ID:	Bore 1
End Date:	18/02/2011 12:15	Lab ID:	4581	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 105	Test Species:	HT-Heliocidaris tuberculata
Comments:					

		Auxiliary Data Summary					
Conc-%	**Parameter**	**Mean**	**Min**	**Max**	**SD**	**CV%**	**N**
ASW Control	% Normal	93.50	91.00	96.00	2.38	1.65	4
6.3		94.50	91.00	98.00	3.51	1.98	4
12.5		93.50	91.00	95.00	1.91	1.48	4
25		94.25	92.00	96.00	1.71	1.39	4
50		94.00	92.00	96.00	1.83	1.44	4
100		46.25	38.00	52.00	6.02	5.31	4
ASW Control	pH	8.10	8.10	8.10	0.00	0.00	1
6.3		8.10	8.10	8.10	0.00	0.00	1
12.5		8.00	8.00	8.00	0.00	0.00	1
25		8.00	8.00	8.00	0.00	0.00	1
50		7.90	7.90	7.90	0.00	0.00	1
100		7.70	7.70	7.70	0.00	0.00	1
ASW Control	Salinity ppt	35.00	35.00	35.00	0.00	0.00	1
6.3		35.10	35.10	35.10	0.00	0.00	1
12.5		35.00	35.00	35.00	0.00	0.00	1
25		35.00	35.00	35.00	0.00	0.00	1
50		34.90	34.90	34.90	0.00	0.00	1
100		34.70	34.70	34.70	0.00	0.00	1
ASW Control	DO %	97.00	97.00	97.00	0.00	0.00	1
6.3		99.60	99.60	99.60	0.00	0.00	1
12.5		99.30	99.30	99.30	0.00	0.00	1
25		99.70	99.70	99.70	0.00	0.00	1
50		99.90	99.90	99.90	0.00	0.00	1
100		100.60	100.60	100.60	0.00	0.00	1

Sea Urchin Larval Development Test-Proportion Normal

Start Date:	15/02/2011 12:15	Test ID:	PR0700/04	Sample ID:	Bore 2
End Date:	18/02/2011 12:15	Lab ID:	4582	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 105	Test Species:	HT-Heliocidaris tuberculata
Comments:					

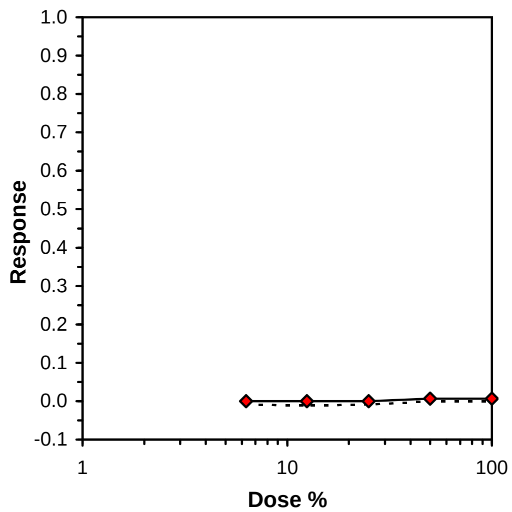
Conc-%	1	2	3	4
ASW Control	0.9600	0.9200	0.9100	0.9500
6.3	0.9400	0.9600	0.9200	0.9500
12.5	0.9200	0.9500	0.9800	0.9300
25	0.9700	0.9300	0.9100	0.9600
50	0.9300	0.9200	0.9500	0.9400
100	0.9100	0.9600	0.9200	0.9500

			Transform: Arcsin Square Root						1-Tailed		Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD	Mean	N-Mean
ASW Control	0.9350	1.0000	1.3162	1.2661	1.3694	3.728	4				0.9413	1.0000
6.3	0.9425	1.0080	1.3305	1.2840	1.3694	2.725	4	-0.411	2.410	0.0839	0.9413	1.0000
12.5	0.9450	1.0107	1.3403	1.2840	1.4289	4.802	4	-0.692	2.410	0.0839	0.9413	1.0000
25	0.9425	1.0080	1.3338	1.2661	1.3967	4.490	4	-0.506	2.410	0.0839	0.9413	1.0000
50	0.9350	1.0000	1.3139	1.2840	1.3453	2.006	4	0.066	2.410	0.0839	0.9350	0.9934
100	0.9350	1.0000	1.3162	1.2661	1.3694	3.728	4	0.000	2.410	0.0839	0.9350	0.9934

Auxiliary Tests					Statistic		Critical		Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.05)					0.952496		0.916		0.239031	-1.02602
Bartlett's Test indicates equal variances (p = 0.77)					2.526965		15.08627			
Hypothesis Test (1-tail, 0.05)	**NOEC**	**LOEC**	**ChV**	**TU**	**MSDu**	**MSDp**	**MSB**	**MSE**	**F-Prob**	**df**
Dunnett's Test	100	>100		1	0.046856	0.050029	0.000496	0.002426	0.956385	5, 18
Treatments vs ASW Control										

Log-Logit Interpolation (200 Resamples)

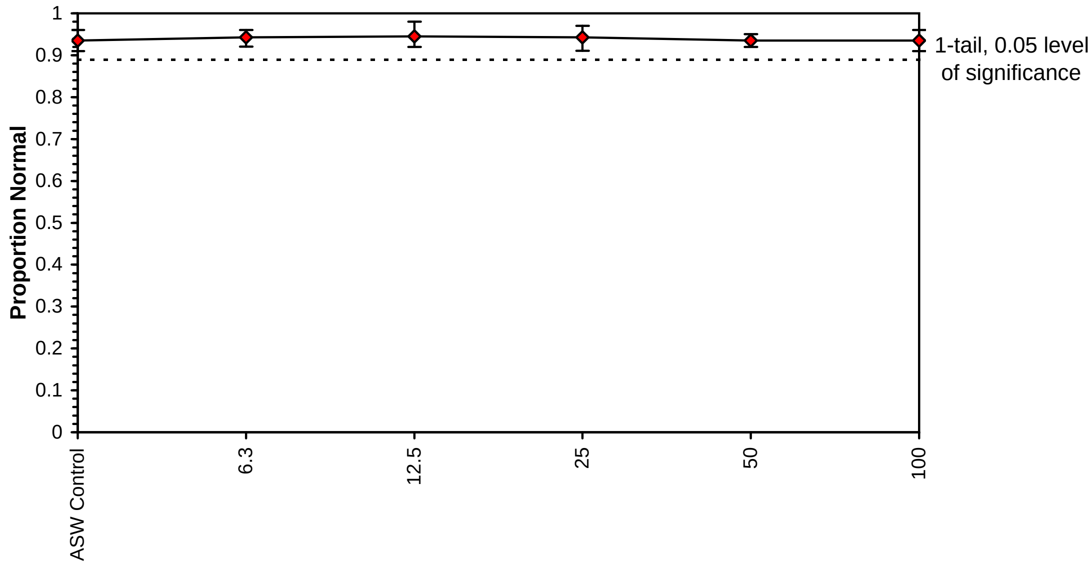
Point	%	SD	95% CL(Exp)	Skew
IC05	>100			
IC10	>100			
IC15	>100			
IC20	>100			
IC25	>100			
IC40	>100			
IC50	>100			



Sea Urchin Larval Development Test-Proportion Normal

Start Date:	15/02/2011 12:15	Test ID:	PR0700/04	Sample ID:	Bore 2
End Date:	18/02/2011 12:15	Lab ID:	4582	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 105	Test Species:	HT-Heliocidaris tuberculata
Comments:					

Dose-Response Plot



Sea Urchin Larval Development Test-Proportion Normal

Start Date:	15/02/2011 12:15	Test ID:	PR0700/04	Sample ID:	Bore 2
End Date:	18/02/2011 12:15	Lab ID:	4582	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 105	Test Species:	HT-Heliocidaris tuberculata
Comments:					

Auxiliary Data Summary

Conc-%	Parameter	Mean	Min	Max	SD	CV%	N
ASW Control	% Normal	93.50	91.00	96.00	2.38	1.65	4
6.3		94.25	92.00	96.00	1.71	1.39	4
12.5		94.50	92.00	98.00	2.65	1.72	4
25		94.25	91.00	97.00	2.75	1.76	4
50		93.50	92.00	95.00	1.29	1.22	4
100		93.50	91.00	96.00	2.38	1.65	4
ASW Control	pH	8.10	8.10	8.10	0.00	0.00	1
6.3		8.10	8.10	8.10	0.00	0.00	1
12.5		8.10	8.10	8.10	0.00	0.00	1
25		8.10	8.10	8.10	0.00	0.00	1
50		8.10	8.10	8.10	0.00	0.00	1
100		8.00	8.00	8.00	0.00	0.00	1
ASW Control	Salinity ppt	35.00	35.00	35.00	0.00	0.00	1
6.3		35.00	35.00	35.00	0.00	0.00	1
12.5		35.00	35.00	35.00	0.00	0.00	1
25		34.90	34.90	34.90	0.00	0.00	1
50		34.60	34.60	34.60	0.00	0.00	1
100		34.60	34.60	34.60	0.00	0.00	1
ASW Control	DO %	97.00	97.00	97.00	0.00	0.00	1
6.3		99.90	99.90	99.90	0.00	0.00	1
12.5		98.80	98.80	98.80	0.00	0.00	1
25		98.90	98.90	98.90	0.00	0.00	1
50		99.40	99.40	99.40	0.00	0.00	1
100		99.80	99.80	99.80	0.00	0.00	1

Sea Urchin Larval Development Test-Proportion Normal

Start Date:	15/02/2011 12:15	Test ID:	PR0700/05	Sample ID:	Bore 3
End Date:	18/02/2011 12:15	Lab ID:	4583	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 105	Test Species:	HT-Heliocidaris tuberculata
Comments:					

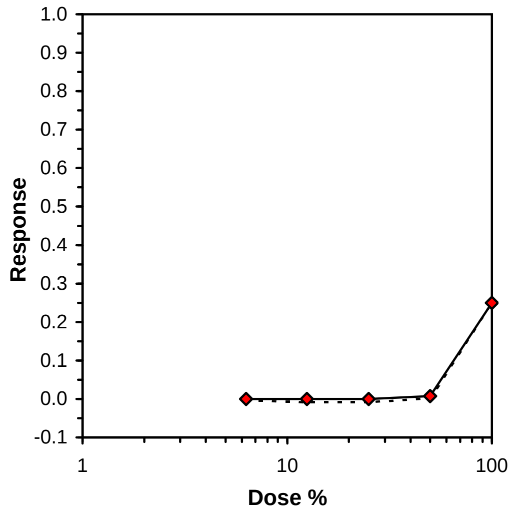
Conc-%	1	2	3	4
ASW Control	0.9600	0.9200	0.9100	0.9500
6.3	0.9600	0.9300	0.9100	0.9500
12.5	0.9800	0.9100	0.9300	0.9500
25	0.9800	0.9200	0.9100	0.9600
50	0.9400	0.9200	0.9600	0.9100
100	0.6400	0.7100	0.6800	0.7900

			Transform: Arcsin Square Root						1-Tailed		Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD	Mean	N-Mean
ASW Control	0.9350	1.0000	1.3162	1.2661	1.3694	3.728	4				0.9394	1.0000
6.3	0.9375	1.0027	1.3210	1.2661	1.3694	3.461	4	-0.110	2.410	0.1040	0.9394	1.0000
12.5	0.9425	1.0080	1.3358	1.2661	1.4289	5.238	4	-0.455	2.410	0.1040	0.9394	1.0000
25	0.9425	1.0080	1.3371	1.2661	1.4289	5.684	4	-0.485	2.410	0.1040	0.9394	1.0000
50	0.9325	0.9973	1.3107	1.2661	1.3694	3.499	4	0.127	2.410	0.1040	0.9325	0.9927
*100	0.7050	0.7540	0.9984	0.9273	1.0948	7.127	4	7.366	2.410	0.1040	0.7050	0.7505

Auxiliary Tests					Statistic		Critical		Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.05)					0.928891		0.916		0.395681	-1.00585
Bartlett's Test indicates equal variances (p = 0.91)					1.495372		15.08627			
Hypothesis Test (1-tail, 0.05)	**NOEC**	**LOEC**	**ChV**	**TU**	**MSDu**	**MSDp**	**MSB**	**MSE**	**F-Prob**	**df**
Dunnett's Test	50	100	70.71068	2	0.059725	0.06377	0.071186	0.003723	1.2E-06	5, 18
Treatments vs ASW Control										

Log-Logit Interpolation (200 Resamples)

Point	%	SD	95% CL(Exp)		Skew
IC05	61.210	2.584	51.473	66.144	-0.3783
IC10	72.160	2.879	62.416	81.421	0.1432
IC15	81.950	3.745	70.990	96.364	0.6246
IC20	91.152				
IC25	>100				
IC40	>100				
IC50	>100				

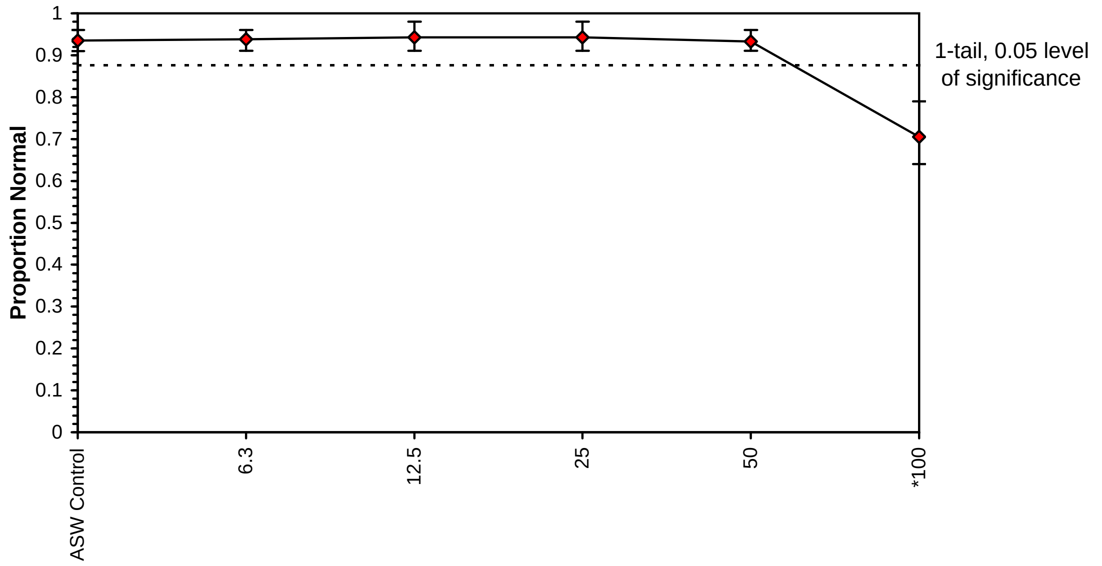


 ToxCalc v5.0.23 Reviewed by:_____

Sea Urchin Larval Development Test-Proportion Normal

Start Date:	15/02/2011 12:15	Test ID:	PR0700/05	Sample ID:	Bore 3
End Date:	18/02/2011 12:15	Lab ID:	4583	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 105	Test Species:	HT-Heliocidaris tuberculata
Comments:					

Dose-Response Plot



Sea Urchin Larval Development Test-Proportion Normal

Start Date:	15/02/2011 12:15	Test ID:	PR0700/05	Sample ID:	Bore 3
End Date:	18/02/2011 12:15	Lab ID:	4583	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 105	Test Species:	HT-Heliocidaris tuberculata
Comments:					

		Auxiliary Data Summary					
Conc-%	**Parameter**	**Mean**	**Min**	**Max**	**SD**	**CV%**	**N**
ASW Control	% Normal	93.50	91.00	96.00	2.38	1.65	4
6.3		93.75	91.00	96.00	2.22	1.59	4
12.5		94.25	91.00	98.00	2.99	1.83	4
25		94.25	91.00	98.00	3.30	1.93	4
50		93.25	91.00	96.00	2.22	1.60	4
100		70.50	64.00	79.00	6.35	3.57	4
ASW Control	pH	8.10	8.10	8.10	0.00	0.00	1
6.3		8.10	8.10	8.10	0.00	0.00	1
12.5		8.10	8.10	8.10	0.00	0.00	1
25		8.00	8.00	8.00	0.00	0.00	1
50		8.00	8.00	8.00	0.00	0.00	1
100		7.80	7.80	7.80	0.00	0.00	1
ASW Control	Salinity ppt	35.00	35.00	35.00	0.00	0.00	1
6.3		35.00	35.00	35.00	0.00	0.00	1
12.5		35.00	35.00	35.00	0.00	0.00	1
25		35.00	35.00	35.00	0.00	0.00	1
50		34.80	34.80	34.80	0.00	0.00	1
100		34.70	34.70	34.70	0.00	0.00	1
ASW Control	DO %	97.00	97.00	97.00	0.00	0.00	1
6.3		99.10	99.10	99.10	0.00	0.00	1
12.5		99.10	99.10	99.10	0.00	0.00	1
25		99.50	99.50	99.50	0.00	0.00	1
50		98.50	98.50	98.50	0.00	0.00	1
100		97.10	97.10	97.10	0.00	0.00	1

 Reviewed by:_____

Sea Urchin Larval Development Test-Proportion Normal

Start Date:	15/02/2011 12:15	Test ID:	PR0700/06	Sample ID:	Bore 4
End Date:	18/02/2011 12:15	Lab ID:	4584	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 105	Test Species:	HT-Heliocidaris tuberculata
Comments:					

Conc-%	1	2	3	4
ASW Control	0.9600	0.9200	0.9100	0.9500
6.3	0.9100	0.9500	0.9600	0.9200
12.5	0.9100	0.9800	0.9300	0.9500
25	0.9100	0.9500	0.9600	0.9300
50	0.9100	0.9300	0.9800	0.9200
100	0.9300	0.9100	0.9600	0.9000

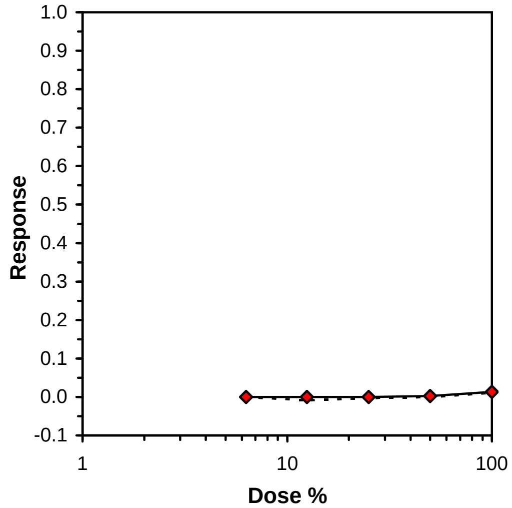
			Transform: Arcsin Square Root						1-Tailed		Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD	Mean	N-Mean
ASW Control	0.9350	1.0000	1.3162	1.2661	1.3694	3.728	4				0.9375	1.0000
6.3	0.9350	1.0000	1.3162	1.2661	1.3694	3.728	4	0.000	2.410	0.0986	0.9375	1.0000
12.5	0.9425	1.0080	1.3358	1.2661	1.4289	5.238	4	-0.479	2.410	0.0986	0.9375	1.0000
25	0.9375	1.0027	1.3210	1.2661	1.3694	3.461	4	-0.116	2.410	0.0986	0.9375	1.0000
50	0.9350	1.0000	1.3205	1.2661	1.4289	5.589	4	-0.105	2.410	0.0986	0.9350	0.9973
100	0.9250	0.9893	1.2969	1.2490	1.3694	4.113	4	0.472	2.410	0.0986	0.9250	0.9867

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.05)	0.921885	0.916	0.609096	-0.72719
Bartlett's Test indicates equal variances (p = 0.95)	1.136917	15.08627		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU	MSDu	MSDp	MSB	MSE	F-Prob	df
Dunnett's Test	100	>100		1	0.056229	0.060037	0.000627	0.003349	0.963664	5, 18
Treatments vs ASW Control										

Log-Logit Interpolation (200 Resamples)

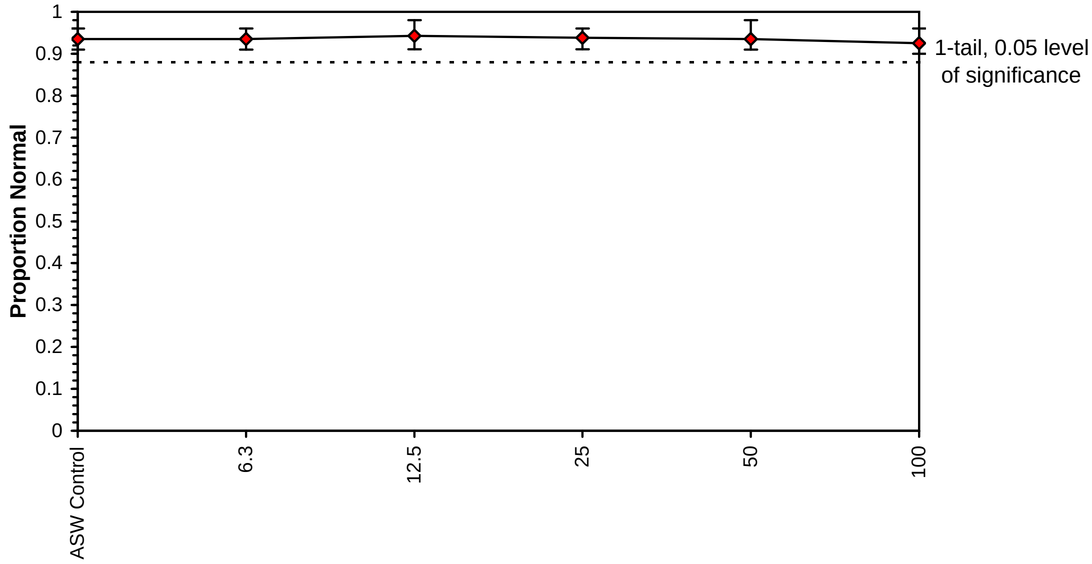
Point	%	SD	95% CL(Exp)	Skew
IC05	>100			
IC10	>100			
IC15	>100			
IC20	>100			
IC25	>100			
IC40	>100			
IC50	>100			



Sea Urchin Larval Development Test-Proportion Normal

Start Date:	15/02/2011 12:15	Test ID:	PR0700/06	Sample ID:	Bore 4
End Date:	18/02/2011 12:15	Lab ID:	4584	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 105	Test Species:	HT-Heliocidaris tuberculata
Comments:					

Dose-Response Plot



Sea Urchin Larval Development Test-Proportion Normal

Start Date:	15/02/2011 12:15	Test ID:	PR0700/06	Sample ID:	Bore 4
End Date:	18/02/2011 12:15	Lab ID:	4584	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 105	Test Species:	HT-Heliocidaris tuberculata
Comments:					

Auxiliary Data Summary

Conc-%	Parameter	Mean	Min	Max	SD	CV%	N
ASW Control	% Normal	93.50	91.00	96.00	2.38	1.65	4
6.3		93.50	91.00	96.00	2.38	1.65	4
12.5		94.25	91.00	98.00	2.99	1.83	4
25		93.75	91.00	96.00	2.22	1.59	4
50		93.50	91.00	98.00	3.11	1.89	4
100		92.50	90.00	96.00	2.65	1.76	4
ASW Control	pH	8.10	8.10	8.10	0.00	0.00	1
6.3		8.10	8.10	8.10	0.00	0.00	1
12.5		8.00	8.00	8.00	0.00	0.00	1
25		8.00	8.00	8.00	0.00	0.00	1
50		7.90	7.90	7.90	0.00	0.00	1
100		7.60	7.60	7.60	0.00	0.00	1
ASW Control	Salinity ppt	35.00	35.00	35.00	0.00	0.00	1
6.3		34.90	34.90	34.90	0.00	0.00	1
12.5		34.90	34.90	34.90	0.00	0.00	1
25		35.00	35.00	35.00	0.00	0.00	1
50		34.90	34.90	34.90	0.00	0.00	1
100		34.60	34.60	34.60	0.00	0.00	1
ASW Control	DO %	97.00	97.00	97.00	0.00	0.00	1
6.3		98.90	98.90	98.90	0.00	0.00	1
12.5		98.60	98.60	98.60	0.00	0.00	1
25		98.80	98.80	98.80	0.00	0.00	1
50		98.90	98.90	98.90	0.00	0.00	1
100		100.20	100.20	100.20	0.00	0.00	1

Sea Urchin Larval Development Test-Proportion Normal

Start Date:	15/02/2011 12:15	Test ID:	PR0700/07	Sample ID:	Bore 5
End Date:	18/02/2011 12:15	Lab ID:	4585	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 105	Test Species:	HT-Heliocidaris tuberculata
Comments:					

Conc-%	1	2	3	4
ASW Control	0.9600	0.9200	0.9100	0.9500
6.3	0.9200	0.9700	0.9500	0.9100
12.5	0.9800	0.9200	0.9500	0.9000
25	0.9700	0.9300	0.9400	0.9800
50	0.9200	0.9500	0.9000	0.9300
100	0.9100	0.9600	0.9300	0.9500

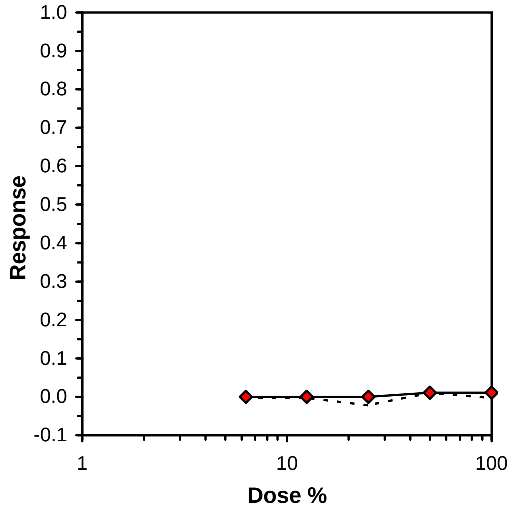
			Transform: Arcsin Square Root					1-Tailed			Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD	Mean	N-Mean
ASW Control	0.9350	1.0000	1.3162	1.2661	1.3694	3.728	4				0.9413	1.0000
6.3	0.9375	1.0027	1.3230	1.2661	1.3967	4.511	4	-0.169	2.410	0.0970	0.9413	1.0000
12.5	0.9375	1.0027	1.3268	1.2490	1.4289	5.941	4	-0.263	2.410	0.0970	0.9413	1.0000
25	0.9550	1.0214	1.3630	1.3030	1.4289	4.371	4	-1.162	2.410	0.0970	0.9413	1.0000
50	0.9250	0.9893	1.2954	1.2490	1.3453	3.096	4	0.519	2.410	0.0970	0.9313	0.9894
100	0.9375	1.0027	1.3210	1.2661	1.3694	3.461	4	-0.118	2.410	0.0970	0.9313	0.9894

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.05)	0.944862	0.916	0.272451	-1.07316
Bartlett's Test indicates equal variances (p = 0.90)	1.581924	15.08627		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU	MSDu	MSDp	MSB	MSE	F-Prob	df
Dunnett's Test	100	>100		1	0.055163	0.058898	0.001936	0.003239	0.702234	5, 18
Treatments vs ASW Control										

Log-Logit Interpolation (200 Resamples)

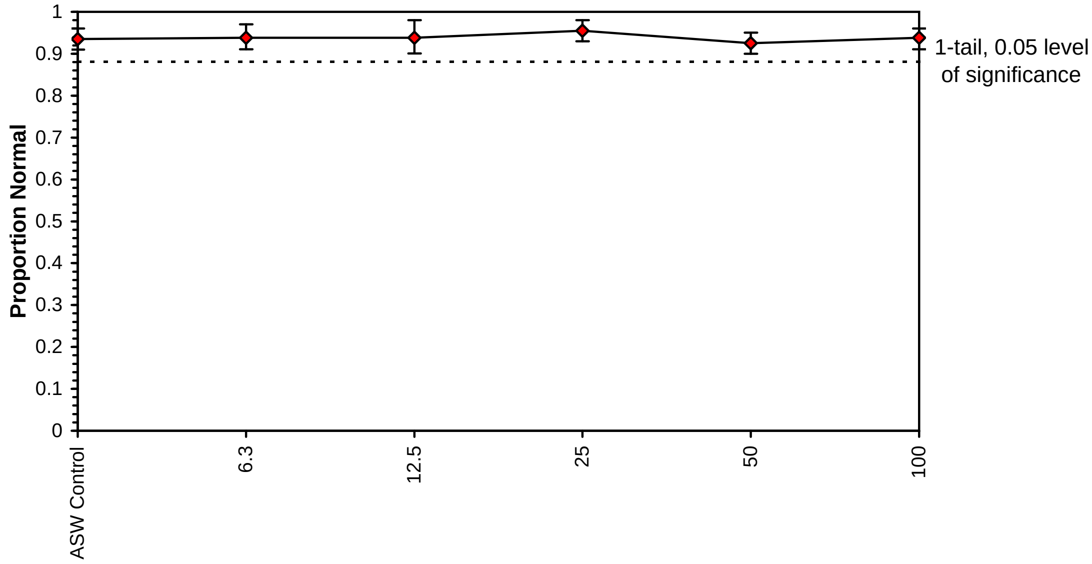
Point	%	SD	95% CL(Exp)	Skew
IC05	>100			
IC10	>100			
IC15	>100			
IC20	>100			
IC25	>100			
IC40	>100			
IC50	>100			



Sea Urchin Larval Development Test-Proportion Normal

Start Date:	15/02/2011 12:15	Test ID:	PR0700/07	Sample ID:	Bore 5
End Date:	18/02/2011 12:15	Lab ID:	4585	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 105	Test Species:	HT-Heliocidaris tuberculata
Comments:					

Dose-Response Plot



 ToxCalc v5.0.23 Reviewed by:_____

Sea Urchin Larval Development Test-Proportion Normal

Start Date:	15/02/2011 12:15	Test ID:	PR0700/07	Sample ID:	Bore 5
End Date:	18/02/2011 12:15	Lab ID:	4585	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 105	Test Species:	HT-Heliocidaris tuberculata
Comments:					

Auxiliary Data Summary

Conc-%	Parameter	Mean	Min	Max	SD	CV%	N
ASW Control	% Normal	93.50	91.00	96.00	2.38	1.65	4
6.3		93.75	91.00	97.00	2.75	1.77	4
12.5		93.75	90.00	98.00	3.50	2.00	4
25		95.50	93.00	98.00	2.38	1.62	4
50		92.50	90.00	95.00	2.08	1.56	4
100		93.75	91.00	96.00	2.22	1.59	4
ASW Control	pH	8.10	8.10	8.10	0.00	0.00	1
6.3		8.00	8.00	8.00	0.00	0.00	1
12.5		8.00	8.00	8.00	0.00	0.00	1
25		8.00	8.00	8.00	0.00	0.00	1
50		7.90	7.90	7.90	0.00	0.00	1
100		7.60	7.60	7.60	0.00	0.00	1
ASW Control	Salinity ppt	35.00	35.00	35.00	0.00	0.00	1
6.3		35.00	35.00	35.00	0.00	0.00	1
12.5		35.10	35.10	35.10	0.00	0.00	1
25		35.00	35.00	35.00	0.00	0.00	1
50		34.90	34.90	34.90	0.00	0.00	1
100		34.60	34.60	34.60	0.00	0.00	1
ASW Control	DO %	97.00	97.00	97.00	0.00	0.00	1
6.3		98.70	98.70	98.70	0.00	0.00	1
12.5		93.50	93.50	93.50	0.00	0.00	1
25		94.00	94.00	94.00	0.00	0.00	1
50		96.10	96.10	96.10	0.00	0.00	1
100		90.50	90.50	90.50	0.00	0.00	1

Statistical Printouts for the Rock Oyster Larval Development Tests

Bivalve Larval development Test-Proportion Alive/Normal

Start Date:	15/02/2011 17:00	Test ID:	PR0700/2	Sample ID:	Bore 1
End Date:	17/02/2011 17:00	Lab ID:	4581	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 106	Test Species:	SR-Saccostrea commercialis
Comments:					

Conc-%	1	2	3	4
ASW	0.7959	0.7347	0.7755	0.7959
6.3	0.6327	0.8163	0.8571	0.7347
12.5	0.7755	0.8776	0.7347	0.7959
25	0.6939	0.7755	0.8776	0.6939
50	0.7959	0.7551	0.7959	0.7143
100	0.7347	0.6735	0.6327	0.4898

			Transform: Arcsin Square Root						1-Tailed		Number	Total
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD	Resp	Number
ASW	0.7755	1.0000	1.0778	1.0297	1.1021	3.166	4				44	196
6.3	0.7602	0.9803	1.0651	0.9197	1.1832	10.881	4	0.204	2.410	0.1493	47	196
12.5	0.7959	1.0263	1.1056	1.0297	1.2133	7.041	4	-0.449	2.410	0.1493	40	196
25	0.7602	0.9803	1.0649	0.9845	1.2133	10.158	4	0.208	2.410	0.1493	47	196
50	0.7653	0.9868	1.0660	1.0069	1.1021	4.287	4	0.189	2.410	0.1493	46	196
*100	0.6327	0.8158	0.9218	0.7752	1.0297	11.684	4	2.518	2.410	0.1493	72	196

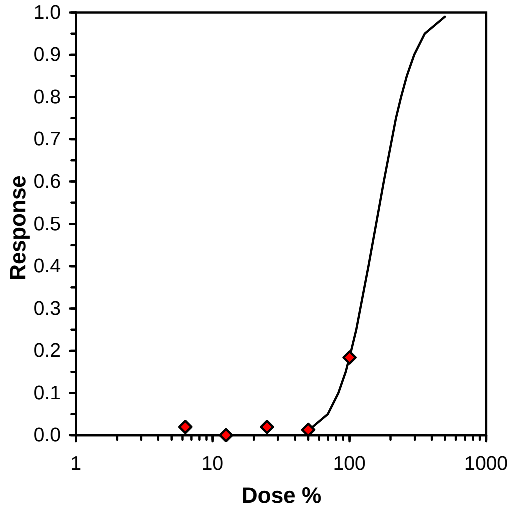
Auxiliary Tests					Statistic		Critical		Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.05)					0.974763		0.916		-0.02297	-0.27574
Bartlett's Test indicates equal variances (p = 0.37)					5.388119		15.08627			
Hypothesis Test (1-tail, 0.05)	**NOEC**	**LOEC**	**ChV**	**TU**	**MSDu**	**MSDp**	**MSB**	**MSE**	**F-Prob**	**df**
Dunnett's Test	50	100	70.71068	2	0.134856	0.173788	0.016804	0.007674	0.100761	5, 18
Treatments vs ASW										

Maximum Likelihood-Probit

Parameter	Value	SE	95% Fiducial Limits	
Slope	4.640233	5.16547	-5.48409	14.76455
Intercept	-5.18974	10.31033	-25.398	15.0185
TSCR	0.226929	0.015068	0.197396	0.256461

Control	Chi-Sq	Critical	P-value	Mu	Sigma	Iter
0.22449	0.950916	7.814728	0.81	2.195955	0.215506	8

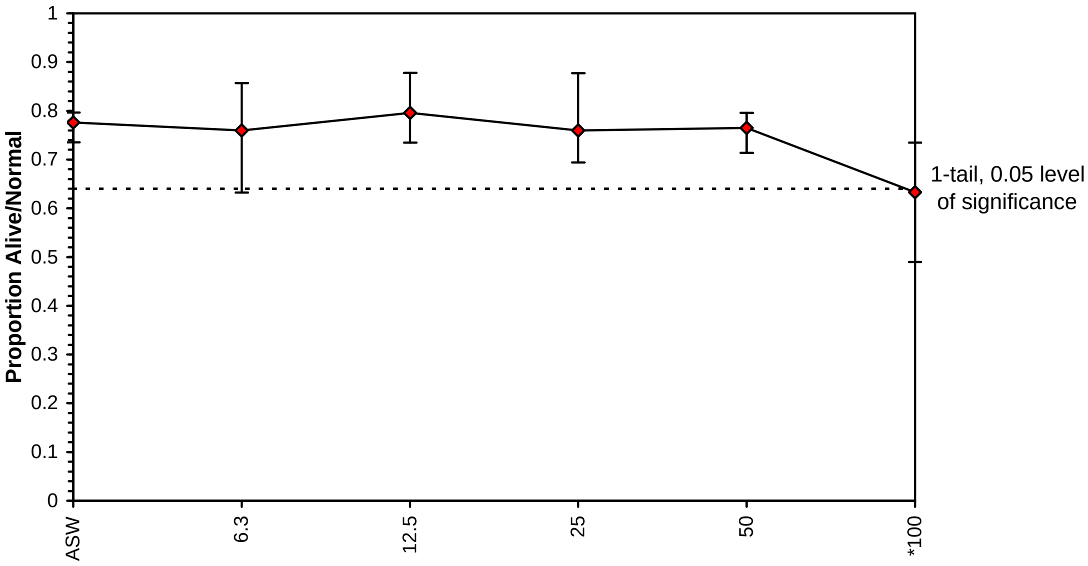
Point	Probits	%	95% Fiducial Limits
EC01	2.674	49.50075	
EC05	3.355	69.41897	
EC10	3.718	83.13274	
EC15	3.964	93.88509	
EC20	4.158	103.4141	
EC25	4.326	112.3564	
EC40	4.747	138.4703	
EC50	5.000	157.0199	
EC60	5.253	178.0544	
EC75	5.674	219.4378	
EC80	5.842	238.4127	
EC85	6.036	262.6109	
EC90	6.282	296.5768	
EC95	6.645	355.1658	
EC99	7.326	498.0783	



 ToxCalc v5.0.23 Reviewed by:_____

Bivalve Larval development Test-Proportion Alive/Normal					
Start Date:	15/02/2011 17:00	Test ID:	PR0700/2	Sample ID:	Bore 1
End Date:	17/02/2011 17:00	Lab ID:	4581	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 106	Test Species:	SR-Saccostrea commercialis
Comments:					

Dose-Response Plot



Bivalve Larval development Test-Proportion Alive/Normal

Start Date:	15/02/2011 17:00	Test ID:	PR0700/2	Sample ID:	Bore 1
End Date:	17/02/2011 17:00	Lab ID:	4581	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 106	Test Species:	SR-Saccostrea commercialis
Comments:					

		Auxiliary Data Summary					
Conc-%	**Parameter**	**Mean**	**Min**	**Max**	**SD**	**CV%**	**N**
ASW	% Alive/Normal	77.55	73.47	79.59	2.89	2.19	4
6.3		76.02	63.27	85.71	9.91	4.14	4
12.5		79.59	73.47	87.76	6.01	3.08	4
25		76.02	69.39	87.76	8.72	3.88	4
50		76.53	71.43	79.59	3.91	2.58	4
100		63.27	48.98	73.47	10.41	5.10	4
ASW	pH	8.10	8.10	8.10	0.00	0.00	1
6.3		8.10	8.10	8.10	0.00	0.00	1
12.5		8.00	8.00	8.00	0.00	0.00	1
25		8.00	8.00	8.00	0.00	0.00	1
50		7.90	7.90	7.90	0.00	0.00	1
100		7.70	7.70	7.70	0.00	0.00	1
ASW	Salinity ppt	35.00	35.00	35.00	0.00	0.00	1
6.3		35.10	35.10	35.10	0.00	0.00	1
12.5		35.00	35.00	35.00	0.00	0.00	1
25		35.00	35.00	35.00	0.00	0.00	1
50		34.90	34.90	34.90	0.00	0.00	1
100		34.70	34.70	34.70	0.00	0.00	1
ASW	DO %	97.00	97.00	97.00	0.00	0.00	1
6.3		99.60	99.60	99.60	0.00	0.00	1
12.5		99.30	99.30	99.30	0.00	0.00	1
25		99.70	99.70	99.70	0.00	0.00	1
50		99.90	99.90	99.90	0.00	0.00	1
100		100.60	100.60	100.60	0.00	0.00	1

Bivalve Larval Development Test-Proportion Alive/Normal						
Start Date:	15/02/2011 17:00	Test ID:	PR0700/3		Sample ID:	BORE 2
End Date:	17/02/2011 17:00	Lab ID:	4582		Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 106		Test Species:	SR-Saccostrea commercialis
Comments:						

Conc-%	1	2	3	4
ASW	0.7959	0.7347	0.7755	0.7959
6.3	0.8163	0.6327	0.7347	0.6939
12.5	0.6531	0.7755	0.6735	0.7347
25	0.8367	0.7143	0.6531	0.7755
50	0.7347	0.8776	0.7143	0.6531
100	0.7143	0.7347	0.7959	0.7959

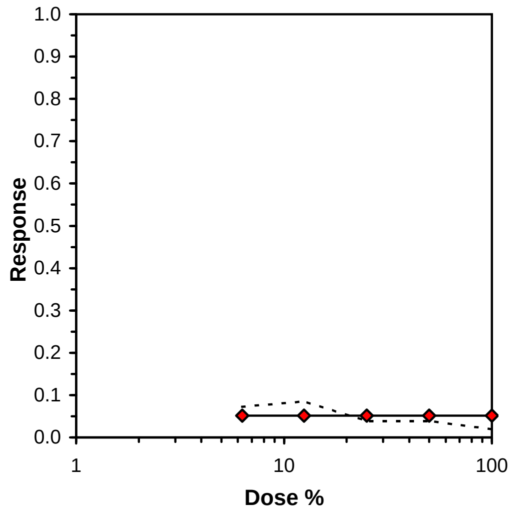
			Transform: Arcsin Square Root						1-Tailed		Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD	Mean	N-Mean
ASW	0.7755	1.0000	1.0778	1.0297	1.1021	3.166	4				0.7755	1.0000
6.3	0.7194	0.9276	1.0154	0.9197	1.1279	8.619	4	1.119	2.410	0.1342	0.7357	0.9487
12.5	0.7092	0.9145	1.0026	0.9410	1.0772	6.229	4	1.350	2.410	0.1342	0.7357	0.9487
25	0.7449	0.9605	1.0450	0.9410	1.1548	8.802	4	0.589	2.410	0.1342	0.7357	0.9487
50	0.7449	0.9605	1.0477	0.9410	1.2133	11.132	4	0.540	2.410	0.1342	0.7357	0.9487
100	0.7602	0.9803	1.0602	1.0069	1.1021	4.647	4	0.316	2.410	0.1342	0.7357	0.9487

Auxiliary Tests					Statistic		Critical		Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.05)					0.958548		0.916		0.556625	0.076463
Bartlett's Test indicates equal variances (p = 0.45)					4.696321		15.08627			
Hypothesis Test (1-tail, 0.05)	**NOEC**	**LOEC**	**ChV**	**TU**	**MSDu**	**MSDp**	**MSB**	**MSE**	**F-Prob**	**df**
Dunnett's Test	100	>100		1	0.120459	0.155234	0.003125	0.006203	0.769536	5, 18
Treatments vs ASW										

Log-Logit Interpolation (200 Resamples)

Point	%	SD	95% CL(Exp)	Skew
IC05*	5.9552			
IC10	>100			
IC15	>100			
IC20	>100			
IC25	>100			
IC40	>100			
IC50	>100			

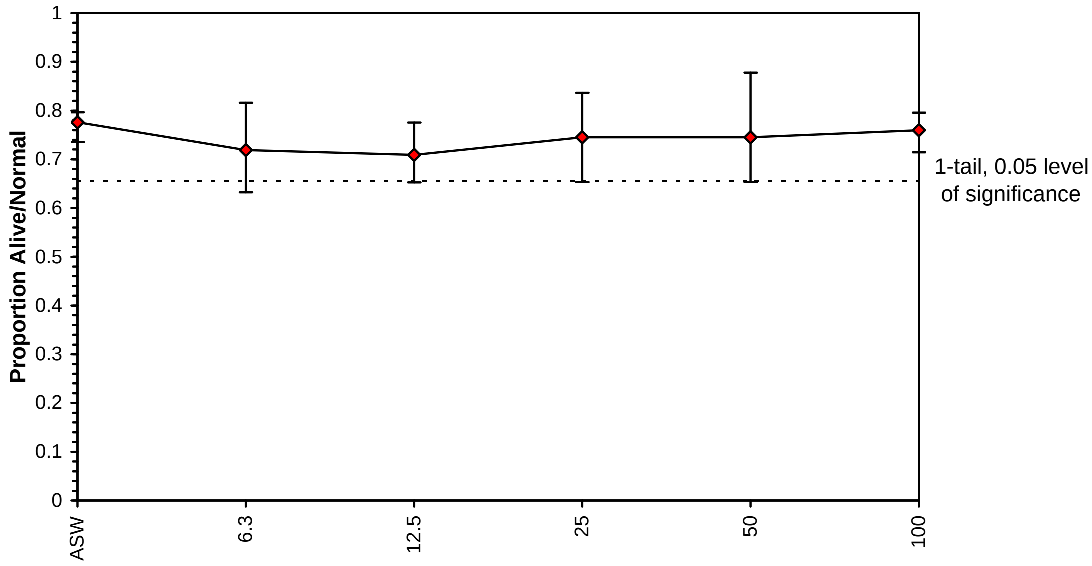
* indicates IC estimate less than the lowest concentration



Bivalve Larval Development Test-Proportion Alive/Normal

Start Date:	15/02/2011 17:00	Test ID:	PR0700/3	Sample ID:	BORE 2
End Date:	17/02/2011 17:00	Lab ID:	4582	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 106	Test Species:	SR-Saccostrea commercialis
Comments:					

Dose-Response Plot



 ToxCalc v5.0.23 Reviewed by:_____

Bivalve Larval Development Test-Proportion Alive/Normal

Start Date:	15/02/2011 17:00	Test ID:	PR0700/3	Sample ID:	BORE 2
End Date:	17/02/2011 17:00	Lab ID:	4582	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 106	Test Species:	SR-Saccostrea commercialis
Comments:					

		Auxiliary Data Summary					
Conc-%	**Parameter**	**Mean**	**Min**	**Max**	**SD**	**CV%**	**N**
ASW	% Alive/Normal	77.55	73.47	79.59	2.89	2.19	4
6.3		71.94	63.27	81.63	7.70	3.86	4
12.5		70.92	65.31	77.55	5.62	3.34	4
25		74.49	65.31	83.67	7.90	3.77	4
50		74.49	65.31	87.76	9.50	4.14	4
100		76.02	71.43	79.59	4.21	2.70	4
ASW	pH	8.10	8.10	8.10	0.00	0.00	1
6.3		8.10	8.10	8.10	0.00	0.00	1
12.5		8.10	8.10	8.10	0.00	0.00	1
25		8.10	8.10	8.10	0.00	0.00	1
50		8.10	8.10	8.10	0.00	0.00	1
100		8.00	8.00	8.00	0.00	0.00	1
ASW	Salinity ppt	35.00	35.00	35.00	0.00	0.00	1
6.3		35.00	35.00	35.00	0.00	0.00	1
12.5		35.00	35.00	35.00	0.00	0.00	1
25		34.90	34.90	34.90	0.00	0.00	1
50		34.60	34.60	34.60	0.00	0.00	1
100		34.60	34.60	34.60	0.00	0.00	1
ASW	DO %	97.00	97.00	97.00	0.00	0.00	1
6.3		99.90	99.90	99.90	0.00	0.00	1
12.5		98.80	98.80	98.80	0.00	0.00	1
25		98.90	98.90	98.90	0.00	0.00	1
50		99.40	99.40	99.40	0.00	0.00	1
100		99.80	99.80	99.80	0.00	0.00	1

Bivalve Larval Development Test-Proportion Alive/Normal						
Start Date:	15/02/2011 17:00	Test ID:	PR0700/4		Sample ID:	Bore 3
End Date:	17/02/2011 17:00	Lab ID:	4583		Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 106		Test Species:	SR-Saccostrea commercialis
Comments:						

Conc-%	1	2	3	4
ASW	0.7959	0.7347	0.7755	0.7959
6.3	0.7755	0.7143	0.7347	0.8163
12.5	0.6735	0.7143	0.8367	0.7347
25	0.6735	0.6939	0.6531	0.8163
50	0.7143	0.7959	0.6735	0.6939
100	0.7959	0.7143	0.7959	0.6531

			Transform: Arcsin Square Root						1-Tailed		Number	Total
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD	Resp	Number
ASW	0.7755	1.0000	1.0778	1.0297	1.1021	3.166	4				44	196
6.3	0.7602	0.9803	1.0604	1.0069	1.1279	5.063	4	0.359	2.410	0.1163	47	196
12.5	0.7398	0.9539	1.0385	0.9626	1.1548	7.937	4	0.814	2.410	0.1163	51	196
25	0.7092	0.9145	1.0040	0.9410	1.1279	8.417	4	1.529	2.410	0.1163	57	196
50	0.7194	0.9276	1.0140	0.9626	1.1021	6.059	4	1.321	2.410	0.1163	55	196
100	0.7398	0.9539	1.0380	0.9410	1.1021	7.585	4	0.824	2.410	0.1163	51	196

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.05)	0.942227	0.916	0.609654	-0.46469
Bartlett's Test indicates equal variances (p = 0.76)	2.623773	15.08627		

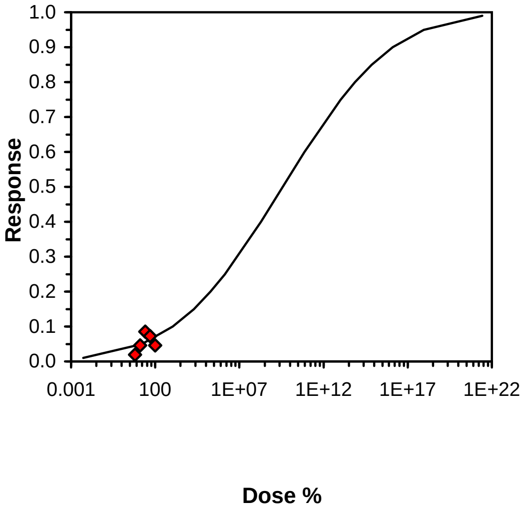
Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU	MSDu	MSDp	MSB	MSE	F-Prob	df
Dunnett's Test	100	>100		1	0.103557	0.133453	0.003051	0.004659	0.661838	5, 18
Treatments vs ASW										

Maximum Likelihood-Probit

Parameter	Value	SE	95% Fiducial Limits	
Slope	0.196181	0.408104	-0.6037	0.996064
Intercept	3.121715	0.711776	1.726634	4.516796
TSCR	0.22379	0.029765	0.16545	0.282129

Control	Chi-Sq	Critical	P-value	Mu	Sigma	Iter
0.22449	1.283578	7.814728	0.73	9.57426	5.097342	5

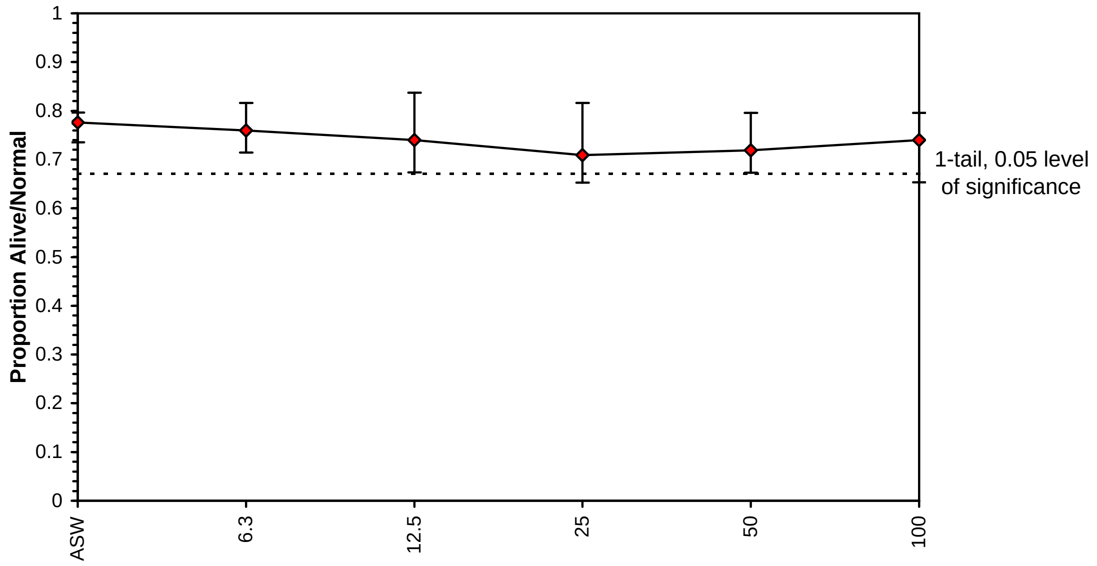
Point	Probits	%	95% Fiducial Limits
EC01	2.674	0.005201	
EC05	3.355	15.48386	
EC10	3.718	1100.915	
EC15	3.964	19552.63	
EC20	4.158	192410.7	
EC25	4.326	1368218	
EC40	4.747	1.92E+08	
EC50	5.000	3.75E+09	
EC60	5.253	7.34E+10	
EC75	5.674	1.03E+13	
EC80	5.842	7.32E+13	
EC85	6.036	7.2E+14	
EC90	6.282	1.28E+16	
EC95	6.645	9.09E+17	
EC99	7.326	2.71E+21	



Bivalve Larval Development Test-Proportion Alive/Normal

Start Date:	15/02/2011 17:00	Test ID:	PR0700/4	Sample ID:	Bore 3
End Date:	17/02/2011 17:00	Lab ID:	4583	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 106	Test Species:	SR-Saccostrea commercialis
Comments:					

Dose-Response Plot



Bivalve Larval Development Test-Proportion Alive/Normal

Start Date:	15/02/2011 17:00	Test ID:	PR0700/4	Sample ID:	Bore 3
End Date:	17/02/2011 17:00	Lab ID:	4583	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 106	Test Species:	SR-Saccostrea commercialis
Comments:					

Auxiliary Data Summary

Conc-%	Parameter	Mean	Min	Max	SD	CV%	N
ASW	% Alive/Normal	77.55	73.47	79.59	2.89	2.19	4
6.3		76.02	71.43	81.63	4.53	2.80	4
12.5		73.98	67.35	83.67	6.95	3.56	4
25		70.92	65.31	81.63	7.33	3.82	4
50		71.94	67.35	79.59	5.37	3.22	4
100		73.98	65.31	79.59	6.95	3.56	4
ASW	pH	8.10	8.10	8.10	0.00	0.00	1
6.3		8.10	8.10	8.10	0.00	0.00	1
12.5		8.10	8.10	8.10	0.00	0.00	1
25		8.00	8.00	8.00	0.00	0.00	1
50		8.00	8.00	8.00	0.00	0.00	1
100		7.80	7.80	7.80	0.00	0.00	1
ASW	Salinity ppt	35.00	35.00	35.00	0.00	0.00	1
6.3		35.00	35.00	35.00	0.00	0.00	1
12.5		35.00	35.00	35.00	0.00	0.00	1
25		35.00	35.00	35.00	0.00	0.00	1
50		34.80	34.80	34.80	0.00	0.00	1
100		34.70	34.70	34.70	0.00	0.00	1
ASW	DO %	97.00	97.00	97.00	0.00	0.00	1
6.3		99.10	99.10	99.10	0.00	0.00	1
12.5		99.10	99.10	99.10	0.00	0.00	1
25		99.50	99.50	99.50	0.00	0.00	1
50		98.50	98.50	98.50	0.00	0.00	1
100		97.10	97.10	97.10	0.00	0.00	1

Bivalve Larval Development Test-Proportion Alive/Normal

Start Date:	15/02/2011 17:00	Test ID:	PR0700/5	Sample ID:	Bore 4
End Date:	17/02/2011 17:00	Lab ID:	4584	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 106	Test Species:	SR-Saccostrea commercialis
Comments:					

Conc-%	1	2	3	4
ASW	0.7959	0.7347	0.7755	0.7959
6.3	0.7347	0.8367	0.6939	0.7347
12.5	0.6735	0.7143	0.7347	0.7143
25	0.7755	0.8571	0.7347	0.7143
50	0.6122	0.6327	0.7347	0.6122
100	0.6327	0.7143	0.6122	0.6327

			Transform: Arcsin Square Root					Rank	1-Tailed	Number	Total
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	Sum	Critical	Resp	Number
ASW	0.7755	1.0000	1.0778	1.0297	1.1021	3.166	4			44	196
6.3	0.7500	0.9671	1.0497	0.9845	1.1548	6.981	4	15.00	10.00	49	196
12.5	0.7092	0.9145	1.0015	0.9626	1.0297	2.806	4	10.50	10.00	57	196
25	0.7704	0.9934	1.0742	1.0069	1.1832	7.292	4	16.00	10.00	45	196
50	0.6480	0.8355	0.9366	0.8986	1.0297	6.707	4	10.50	10.00	69	196
*100	0.6480	0.8355	0.9362	0.8986	1.0069	5.142	4	10.00	10.00	69	196

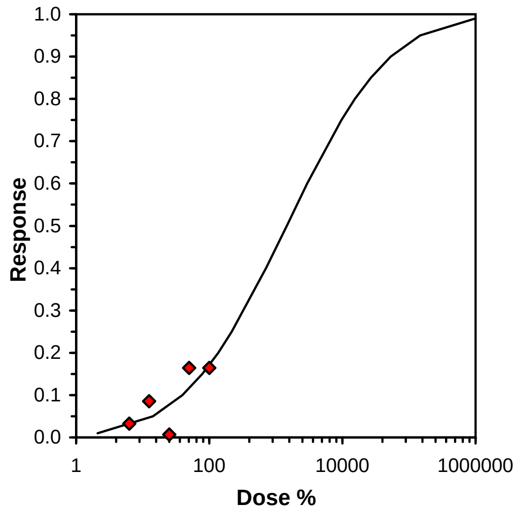
Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates non-normal distribution (p <= 0.05)	0.894545	0.916	0.956916	0.161177
Bartlett's Test indicates equal variances (p = 0.55)	4.026136	15.08627		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU
Steel's Many-One Rank Test	50	100	70.71068	2
Treatments vs ASW				

Maximum Likelihood-Probit

Parameter	Value	SE	95% Fiducial Limits		Control	Chi-Sq	Critical	P-value	Mu	Sigma	Iter
Slope	0.818924	0.460303	-0.08327	1.721117	0.22449	4.931739	7.814728	0.18	3.160301	1.221115	4
Intercept	2.411954	0.818852	0.807005	4.016904							
TSCR	0.227362	0.02875	0.171011	0.283713							

Point	Probits	%	95% Fiducial Limits
EC01	2.674	2.087194	
EC05	3.355	14.18227	
EC10	3.718	39.38941	
EC15	3.964	78.46879	
EC20	4.158	135.7016	
EC25	4.326	217.106	
EC40	4.747	709.4722	
EC50	5.000	1446.443	
EC60	5.253	2948.95	
EC75	5.674	9636.758	
EC80	5.842	15417.64	
EC85	6.036	26662.81	
EC90	6.282	53115.73	
EC95	6.645	147522	
EC99	7.326	1002398	

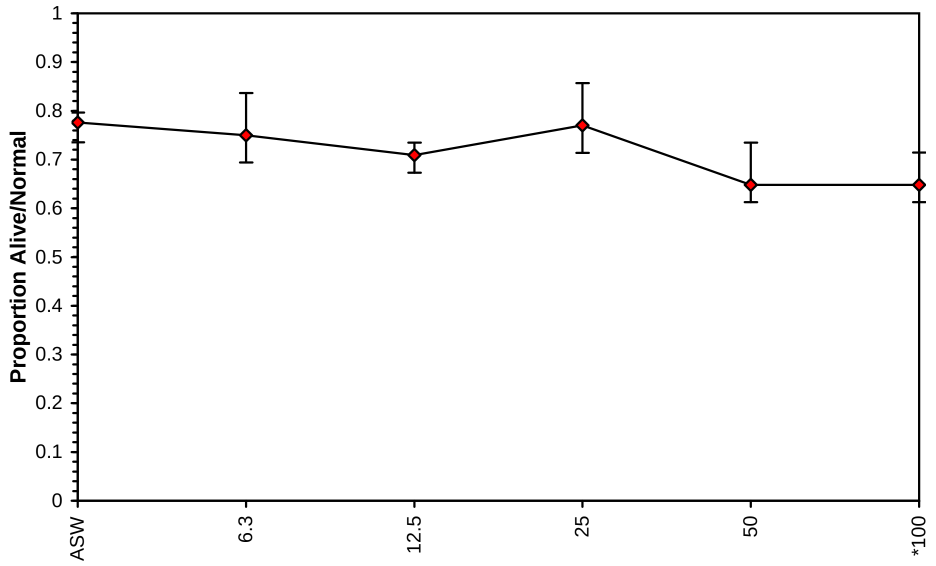


 ToxCalc v5.0.23 Reviewed by:_____

Bivalve Larval Development Test-Proportion Alive/Normal

Start Date:	15/02/2011 17:00	Test ID:	PR0700/5	Sample ID:	Bore 4
End Date:	17/02/2011 17:00	Lab ID:	4584	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 106	Test Species:	SR-Saccostrea commercialis
Comments:					

Dose-Response Plot



Bivalve Larval Development Test-Proportion Alive/Normal

Start Date:	15/02/2011 17:00	Test ID:	PR0700/5	Sample ID:	Bore 4
End Date:	17/02/2011 17:00	Lab ID:	4584	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 106	Test Species:	SR-Saccostrea commercialis
Comments:					

		Auxiliary Data Summary					
Conc-%	**Parameter**	**Mean**	**Min**	**Max**	**SD**	**CV%**	**N**
ASW	% Alive/Normal	77.55	73.47	79.59	2.89	2.19	4
6.3		75.00	69.39	83.67	6.09	3.29	4
12.5		70.92	67.35	73.47	2.57	2.26	4
25		77.04	71.43	85.71	6.32	3.26	4
50		64.80	61.22	73.47	5.86	3.74	4
100		64.80	61.22	71.43	4.53	3.28	4
ASW	pH	8.10	8.10	8.10	0.00	0.00	1
6.3		8.10	8.10	8.10	0.00	0.00	1
12.5		8.00	8.00	8.00	0.00	0.00	1
25		8.00	8.00	8.00	0.00	0.00	1
50		7.90	7.90	7.90	0.00	0.00	1
100		7.60	7.60	7.60	0.00	0.00	1
ASW	Salinity ppt	35.00	35.00	35.00	0.00	0.00	1
6.3		34.90	34.90	34.90	0.00	0.00	1
12.5		34.90	34.90	34.90	0.00	0.00	1
25		35.00	35.00	35.00	0.00	0.00	1
50		34.90	34.90	34.90	0.00	0.00	1
100		34.60	34.60	34.60	0.00	0.00	1
ASW	DO %	97.00	97.00	97.00	0.00	0.00	1
6.3		98.90	98.90	98.90	0.00	0.00	1
12.5		98.60	98.60	98.60	0.00	0.00	1
25		98.80	98.80	98.80	0.00	0.00	1
50		98.90	98.90	98.90	0.00	0.00	1
100		100.20	100.20	100.20	0.00	0.00	1

Bivalve Larval Development Test-Proportion Alive/Normal					
Start Date:	15/02/2011 17:00	Test ID:	PR0700/5	Sample ID:	BORE 5
End Date:	17/02/2011 17:00	Lab ID:	4585	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 106	Test Species:	SR-Saccostrea commercialis
Comments:					

Conc-%	1	2	3	4
ASW	0.7959	0.7347	0.7755	0.7959
6.3	0.8367	0.7347	0.7755	0.6735
12.5	0.7347	0.8776	0.6531	0.6939
25	0.7143	0.7755	0.6531	0.6939
50	0.6327	0.6735	0.7347	0.6327
100	0.7755	0.6939	0.7347	0.6327

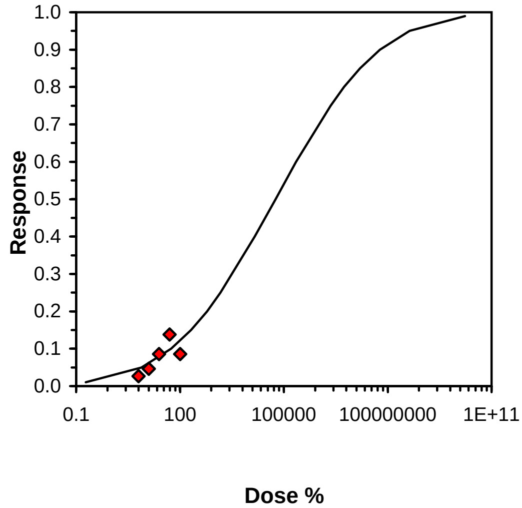
			Transform: Arcsin Square Root						1-Tailed		Number	Total
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD	Resp	Number
ASW	0.7755	1.0000	1.0778	1.0297	1.1021	3.166	4				44	196
6.3	0.7551	0.9737	1.0561	0.9626	1.1548	7.662	4	0.417	2.410	0.1254	48	196
12.5	0.7398	0.9539	1.0421	0.9410	1.2133	11.490	4	0.685	2.410	0.1254	51	196
25	0.7092	0.9145	1.0024	0.9410	1.0772	5.676	4	1.449	2.410	0.1254	57	196
50	0.6684	0.8618	0.9579	0.9197	1.0297	5.425	4	2.304	2.410	0.1254	65	196
100	0.7092	0.9145	1.0028	0.9197	1.0772	6.691	4	1.441	2.410	0.1254	57	196

Auxiliary Tests					Statistic		Critical		Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.05)					0.959886		0.916		0.711007	0.679574
Bartlett's Test indicates equal variances (p = 0.45)					4.69655		15.08627			
Hypothesis Test (1-tail, 0.05)	**NOEC**	**LOEC**	**ChV**	**TU**	**MSDu**	**MSDp**	**MSB**	**MSE**	**F-Prob**	**df**
Dunnett's Test	100	>100		1	0.112106	0.14447	0.007625	0.005415	0.2684	5, 18
Treatments vs ASW										

Maximum Likelihood-Probit

Parameter	Value	SE	95% Fiducial Limits		Control	Chi-Sq	Critical	P-value	Mu	Sigma	Iter
Slope	0.424828	0.353224	-0.26749	1.117147	0.22449	1.998693	7.814728	0.57	4.757992	2.353892	6
Intercept	2.97867	0.61629	1.770742	4.186598							
TSCR	0.221867	0.029577	0.163896	0.279839							

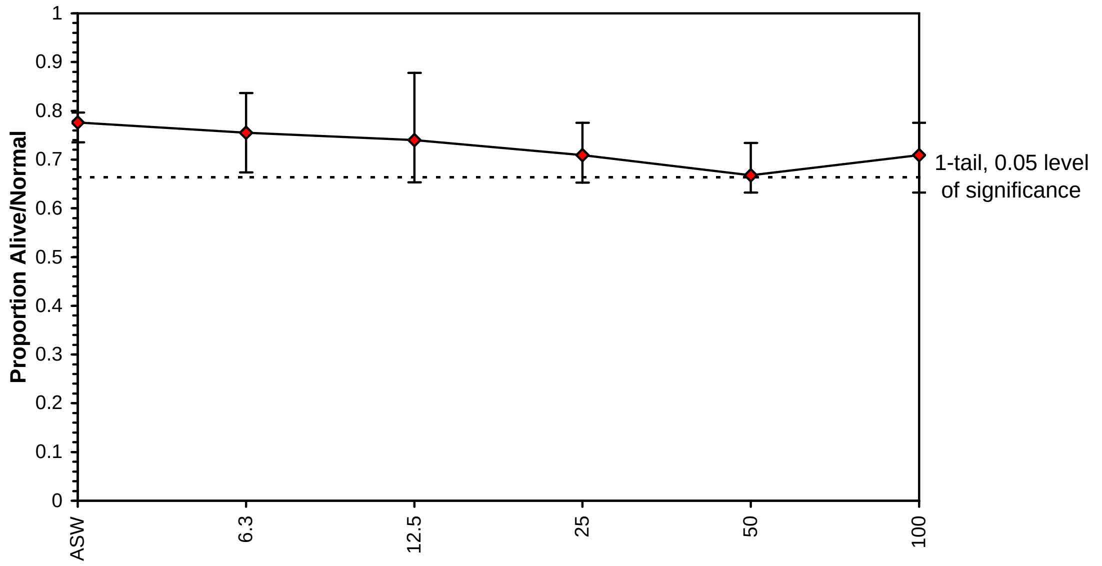
Point	Probits	%	95% Fiducial Limits
EC01	2.674	0.191435	
EC05	3.355	7.694572	
EC10	3.718	55.12622	
EC15	3.964	208.1325	
EC20	4.158	598.2829	
EC25	4.326	1480.185	
EC40	4.747	14509.09	
EC50	5.000	57278.53	
EC60	5.253	226122.4	
EC75	5.674	2216500	
EC80	5.842	5483744	
EC85	6.036	15763186	
EC90	6.282	59514818	
EC95	6.645	4.26E+08	
EC99	7.326	1.71E+10	



Bivalve Larval Development Test-Proportion Alive/Normal

Start Date:	15/02/2011 17:00	Test ID:	PR0700/5	Sample ID:	BORE 5
End Date:	17/02/2011 17:00	Lab ID:	4585	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 106	Test Species:	SR-Saccostrea commercialis
Comments:					

Dose-Response Plot



Bivalve Larval Development Test-Proportion Alive/Normal

Start Date:	15/02/2011 17:00	Test ID:	PR0700/5	Sample ID:	BORE 5
End Date:	17/02/2011 17:00	Lab ID:	4585	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 106	Test Species:	SR-Saccostrea commercialis
Comments:					

		Auxiliary Data Summary					
Conc-%	**Parameter**	**Mean**	**Min**	**Max**	**SD**	**CV%**	**N**
ASW	% Alive/Normal	77.55	73.47	79.59	2.89	2.19	4
6.3		75.51	67.35	83.67	6.87	3.47	4
12.5		73.98	65.31	87.76	9.77	4.23	4
25		70.92	65.31	77.55	5.10	3.19	4
50		66.84	63.27	73.47	4.82	3.29	4
100		70.92	63.27	77.55	6.09	3.48	4
ASW	pH	8.10	8.10	8.10	0.00	0.00	1
6.3		8.00	8.00	8.00	0.00	0.00	1
12.5		8.00	8.00	8.00	0.00	0.00	1
25		8.00	8.00	8.00	0.00	0.00	1
50		7.90	7.90	7.90	0.00	0.00	1
100		7.60	7.60	7.60	0.00	0.00	1
ASW	Salinity ppt	35.00	35.00	35.00	0.00	0.00	1
6.3		35.00	35.00	35.00	0.00	0.00	1
12.5		35.10	35.10	35.10	0.00	0.00	1
25		35.00	35.00	35.00	0.00	0.00	1
50		34.90	34.90	34.90	0.00	0.00	1
100		34.60	34.60	34.60	0.00	0.00	1
ASW	DO %	97.00	97.00	97.00	0.00	0.00	1
6.3		98.70	98.70	98.70	0.00	0.00	1
12.5		93.50	93.50	93.50	0.00	0.00	1
25		94.00	94.00	94.00	0.00	0.00	1
50		96.10	96.10	96.10	0.00	0.00	1
100		90.50	90.50	90.50	0.00	0.00	1

Statistical Printouts for the *Isochrysis* Growth Inhibition Tests

Marine Algal Growth Test-Cell Yield

Start Date:	25/02/2011 13:00	Test ID:	PR0700/02	Sample ID:	Bore 1
End Date:	28/02/2011 13:00	Lab ID:	4581	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 110	Test Species:	IG-isochrysis cf galbana
Comments:					

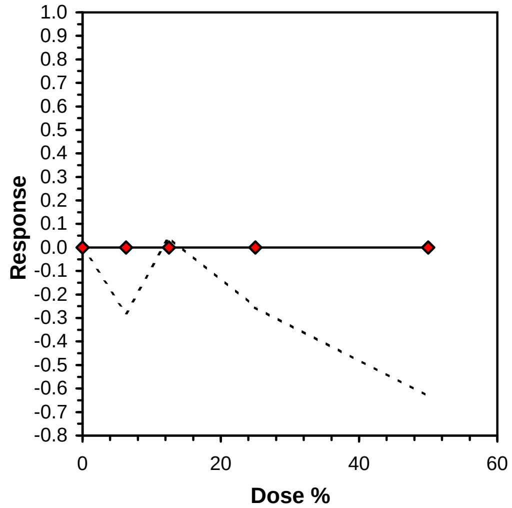
Conc-%	1	2	3	4
FSW Control	41.412	43.412	57.012	42.012
ASW Control	38.212	35.812	43.212	36.212
6.3	51.012	53.212	48.612	43.412
12.5	24.612	45.212	21.612	55.612
25	49.812	46.412	57.212	39.212
50	64.012	53.612	65.612	67.412
100	8.412	1.012	0.012	7.412

			Transform: Untransformed						1-Tailed		Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD	Mean	N-Mean
FSW Control	45.962	1.1981	45.962	41.412	57.012	16.131	4					
ASW Control	38.362	1.0000	38.362	35.812	43.212	8.862	4	*			47.002	1.0000
6.3	49.062	1.2789	49.062	43.412	53.212	8.579	4	-1.710	2.360	14.766	47.002	1.0000
12.5	36.762	0.9583	36.762	21.612	55.612	44.528	4	0.256	2.360	14.766	47.002	1.0000
25	48.162	1.2555	48.162	39.212	57.212	15.528	4	-1.566	2.360	14.766	47.002	1.0000
50	62.662	1.6334	62.662	53.612	67.412	9.880	4	-3.884	2.360	14.766	47.002	1.0000
100	4.212	0.1098	4.212	0.012	8.412	102.351	4					

Auxiliary Tests					Statistic		Critical		Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.05)					0.973045		0.905		0.17253	0.7753
Bartlett's Test indicates equal variances (p = 0.07)					8.52269		13.2767			
The control means are not significantly different (p = 0.11)					1.86357		2.446912			
Hypothesis Test (1-tail, 0.05)	**NOEC**	**LOEC**	**ChV**	**TU**	**MSDu**	**MSDp**	**MSB**	**MSE**	**F-Prob**	**df**
Dunnett's Test	50	>50		2	14.76632	0.384919	430.332	78.298	0.006275	4, 15
Treatments vs ASW Control										

Linear Interpolation (200 Resamples)

Point	%	SD	95% CL(Exp)	Skew
IC05	>50			
IC10	>50			
IC15	>50			
IC20	>50			
IC25	>50			
IC40	>50			
IC50	>50			

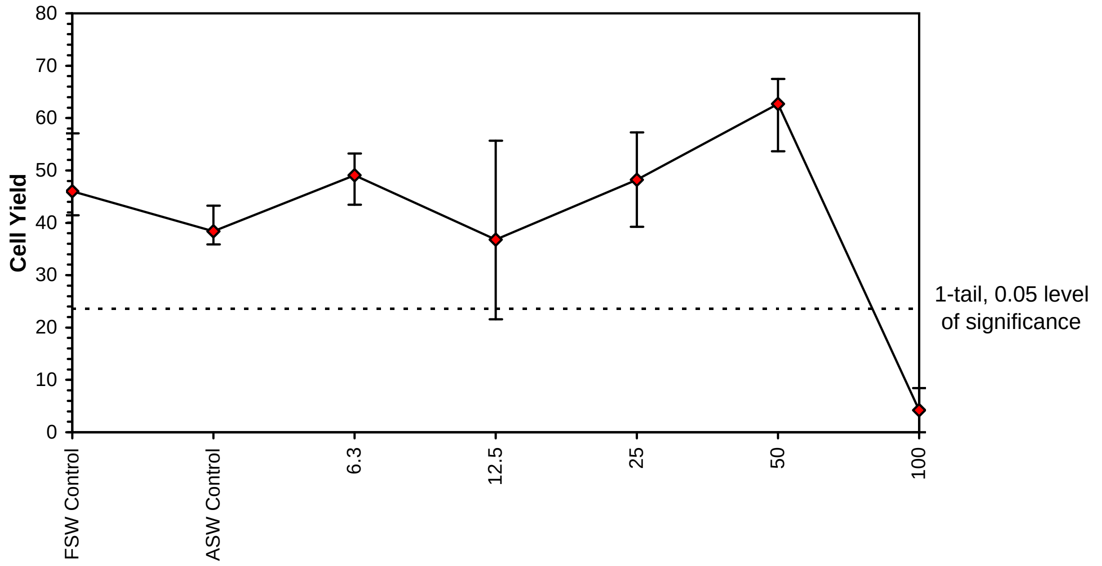


 ToxCalc v5.0.23 Reviewed by:_____

Marine Algal Growth Test-Cell Yield

Start Date:	25/02/2011 13:00	Test ID:	PR0700/02	Sample ID:	Bore 1
End Date:	28/02/2011 13:00	Lab ID:	4581	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 110	Test Species:	IG-isochrysis cf galbana
Comments:					

Dose-Response Plot



Marine Algal Growth Test-Cell Yield

Start Date:	25/02/2011 13:00	Test ID:	PR0700/02	Sample ID:	Bore 1
End Date:	28/02/2011 13:00	Lab ID:	4581	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 110	Test Species:	IG-isochrysis cf galbana
Comments:					

		Auxiliary Data Summary					
Conc-%	**Parameter**	**Mean**	**Min**	**Max**	**SD**	**CV%**	**N**
FSW Control	Cell Yield	45.96	41.41	57.01	7.41	5.92	4
ASW Control		38.36	35.81	43.21	3.40	4.81	4
6.3		49.06	43.41	53.21	4.21	4.18	4
12.5		36.76	21.61	55.61	16.37	11.01	4
25		48.16	39.21	57.21	7.48	5.68	4
50		62.66	53.61	67.41	6.19	3.97	4
100		4.21	0.01	8.41	4.31	49.29	4
FSW Control	pH	8.20	8.20	8.20	0.00	0.00	1
ASW Control		8.10	8.10	8.10	0.00	0.00	1
6.3		8.10	8.10	8.10	0.00	0.00	1
12.5		8.10	8.10	8.10	0.00	0.00	1
25		8.00	8.00	8.00	0.00	0.00	1
50		8.00	8.00	8.00	0.00	0.00	1
100		7.70	7.70	7.70	0.00	0.00	1
FSW Control	Salinity ppt	35.10	35.10	35.10	0.00	0.00	1
ASW Control		35.00	35.00	35.00	0.00	0.00	1
6.3		35.60	35.60	35.60	0.00	0.00	1
12.5		35.70	35.70	35.70	0.00	0.00	1
25		35.60	35.60	35.60	0.00	0.00	1
50		35.40	35.40	35.40	0.00	0.00	1
100		34.90	34.90	34.90	0.00	0.00	1

Marine Algal Growth Test-Cell Yield

Start Date:	25/02/2011 13:00	Test ID:	PR0700/03	Sample ID:	Bore 2
End Date:	28/02/2011 13:00	Lab ID:	4582	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 110	Test Species:	IG-isochrysis cf galbana
Comments:					

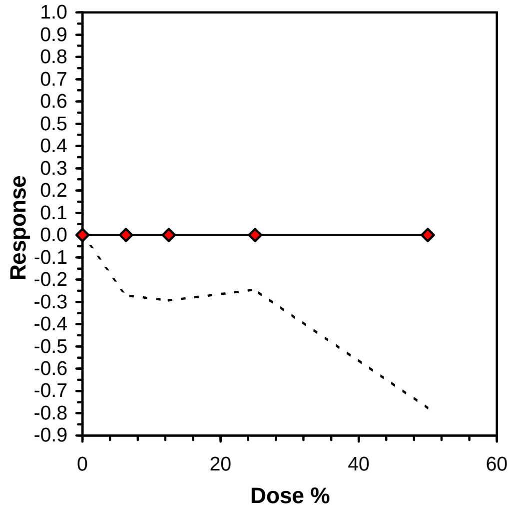
Conc-%	1	2	3	4
FSW Control	41.412	43.412	57.012	42.012
ASW Control	38.212	35.812	43.212	36.212
6.3	64.812	44.212	27.012	58.812
12.5	58.012	68.012	45.212	27.212
25	36.612	71.012	46.412	36.812
50	66.412	57.812	83.412	65.412
100	0.000	66.812	0.000	106.212

			Transform: Untransformed						1-Tailed		Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD	Mean	N-Mean
FSW Control	45.962	1.1981	45.962	41.412	57.012	16.131	4					
ASW Control	38.362	1.0000	38.362	35.812	43.212	8.862	4	*			50.532	1.0000
6.3	48.712	1.2698	48.712	27.012	64.812	34.603	4	-1.043	2.360	23.419	50.532	1.0000
12.5	49.612	1.2933	49.612	27.212	68.012	35.493	4	-1.134	2.360	23.419	50.532	1.0000
25	47.712	1.2437	47.712	36.612	71.012	33.938	4	-0.942	2.360	23.419	50.532	1.0000
50	68.262	1.7794	68.262	57.812	83.412	15.829	4	-3.013	2.360	23.419	50.532	1.0000
100	43.256	1.1276	43.256	0.000	106.212	121.310	4					

Auxiliary Tests					Statistic		Critical		Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.05)					0.961312		0.905		0.083566	-0.36923
Bartlett's Test indicates equal variances (p = 0.20)					5.960844		13.2767			
The control means are not significantly different (p = 0.11)					1.86357		2.446912			
Hypothesis Test (1-tail, 0.05)	**NOEC**	**LOEC**	**ChV**	**TU**	**MSDu**	**MSDp**	**MSB**	**MSE**	**F-Prob**	**df**
Dunnett's Test	50	>50		2	23.41892	0.610469	474.573	196.9427	0.095143	4, 15
Treatments vs ASW Control										

Linear Interpolation (200 Resamples)

Point	%	SD	95% CL(Exp)	Skew
IC05	>50			
IC10	>50			
IC15	>50			
IC20	>50			
IC25	>50			
IC40	>50			
IC50	>50			

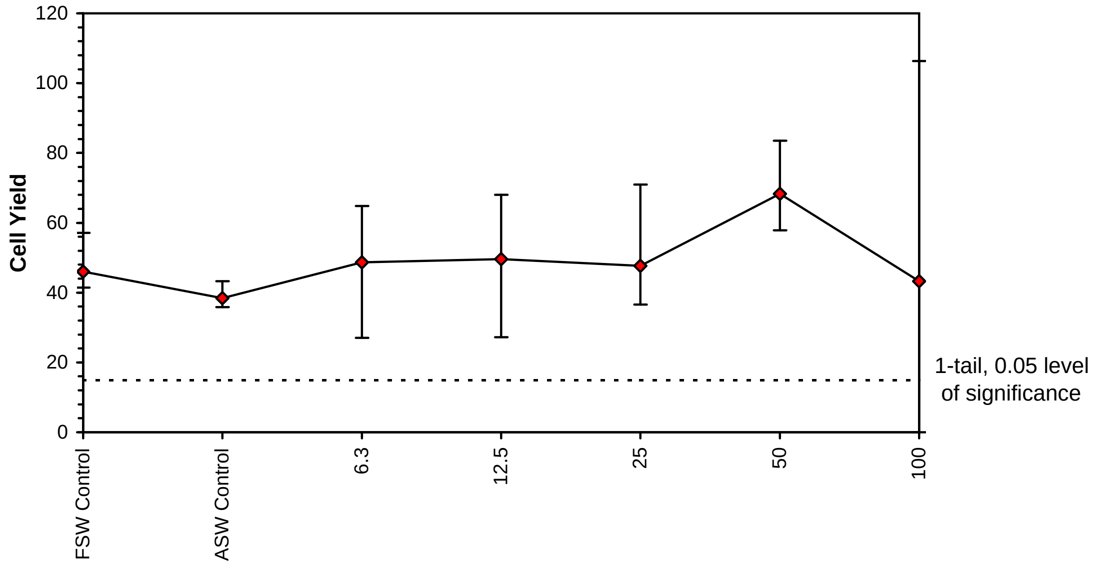


 ToxCalc v5.0.23 Reviewed by:_____

Marine Algal Growth Test-Cell Yield

Start Date:	25/02/2011 13:00	Test ID:	PR0700/03	Sample ID:	Bore 2
End Date:	28/02/2011 13:00	Lab ID:	4582	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 110	Test Species:	IG-isochrysis cf galbana
Comments:					

Dose-Response Plot



 ToxCalc v5.0.23 Reviewed by:_____

Marine Algal Growth Test-Cell Yield

Start Date:	25/02/2011 13:00	Test ID:	PR0700/03	Sample ID:	Bore 2
End Date:	28/02/2011 13:00	Lab ID:	4582	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 110	Test Species:	IG-isochrysis cf galbana
Comments:					

Auxiliary Data Summary

Conc-%	Parameter	Mean	Min	Max	SD	CV%	N
FSW Control	Cell Yield	45.96	41.41	57.01	7.41	5.92	4
ASW Control		38.36	35.81	43.21	3.40	4.81	4
6.3		48.71	27.01	64.81	16.86	8.43	4
12.5		49.61	27.21	68.01	17.61	8.46	4
25		47.71	36.61	71.01	16.19	8.43	4
50		68.26	57.81	83.41	10.81	4.82	4
100		43.26	0.00	106.21	52.47	16.75	4
FSW Control	pH	8.20	8.20	8.20	0.00	0.00	1
ASW Control		8.10	8.10	8.10	0.00	0.00	1
6.3		8.20	8.20	8.20	0.00	0.00	1
12.5		8.10	8.10	8.10	0.00	0.00	1
25		8.10	8.10	8.10	0.00	0.00	1
50		8.10	8.10	8.10	0.00	0.00	1
100		8.10	8.10	8.10	0.00	0.00	1
FSW Control	Salinity ppt	35.10	35.10	35.10	0.00	0.00	1
ASW Control		35.00	35.00	35.00	0.00	0.00	1
6.3		35.60	35.60	35.60	0.00	0.00	1
12.5		35.60	35.60	35.60	0.00	0.00	1
25		35.60	35.60	35.60	0.00	0.00	1
50		35.40	35.40	35.40	0.00	0.00	1
100		34.90	34.90	34.90	0.00	0.00	1

Marine Algal Growth Test-Cell Yield

Start Date:	25/02/2011 13:00	Test ID:	PR0700/04	Sample ID:	Bore 3
End Date:	28/02/2011 13:00	Lab ID:	4583	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 110	Test Species:	IG-isochrysis cf galbana
Comments:					

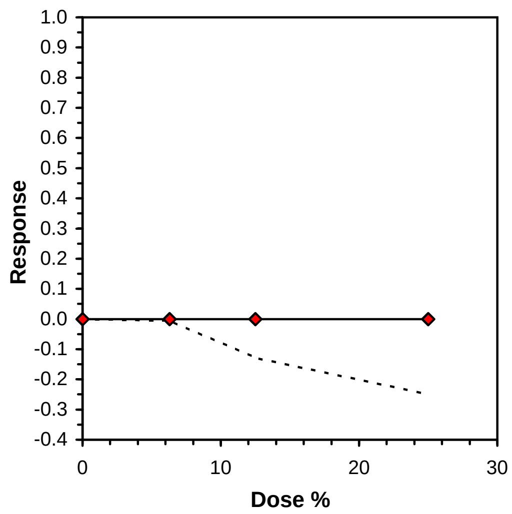
Conc-%	1	2	3	4
FSW Control	41.412	43.412	57.012	42.012
ASW Control	38.212	35.812	43.212	36.212
6.3	57.412	42.612	23.412	30.812
12.5	34.212	43.412	37.412	58.012
25	50.612	45.012	53.812	42.412
50	44.812	19.012	14.212	4.612
100	0.000	0.000	0.212	0.000

			Transform: Untransformed						1-Tailed		Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD	Mean	N-Mean
FSW Control	45.962	1.1981	45.962	41.412	57.012	16.131	4					
ASW Control	38.362	1.0000	38.362	35.812	43.212	8.862	4	*			42.037	1.0000
6.3	38.562	1.0052	38.562	23.412	57.412	38.502	4	-0.029	2.290	15.577	42.037	1.0000
12.5	43.262	1.1277	43.262	34.212	58.012	24.379	4	-0.720	2.290	15.577	42.037	1.0000
25	47.962	1.2502	47.962	42.412	53.812	10.817	4	-1.411	2.290	15.577	42.037	1.0000
50	20.662	0.5386	20.662	4.612	44.812	83.133	4	2.170	2.360	19.248		
100	0.053	0.0014	0.053	0.000	0.212	200.000	4	10.000	10.000			

Auxiliary Tests					Statistic		Critical		Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.05)					0.961478		0.887		0.621878	0.67056
Bartlett's Test indicates equal variances (p = 0.11)					5.961445		11.34487			
The control means are not significantly different (p = 0.11)					1.86357		2.446912			
Hypothesis Test (1-tail, 0.05)	**NOEC**	**LOEC**	**ChV**	**TU**	**MSDu**	**MSDp**	**MSB**	**MSE**	**F-Prob**	**df**
Dunnett's Test	25	>25		4	15.57677	0.406045	82.91667	92.53667	0.471401	3, 12
Treatments vs ASW Control										

Linear Interpolation (200 Resamples)

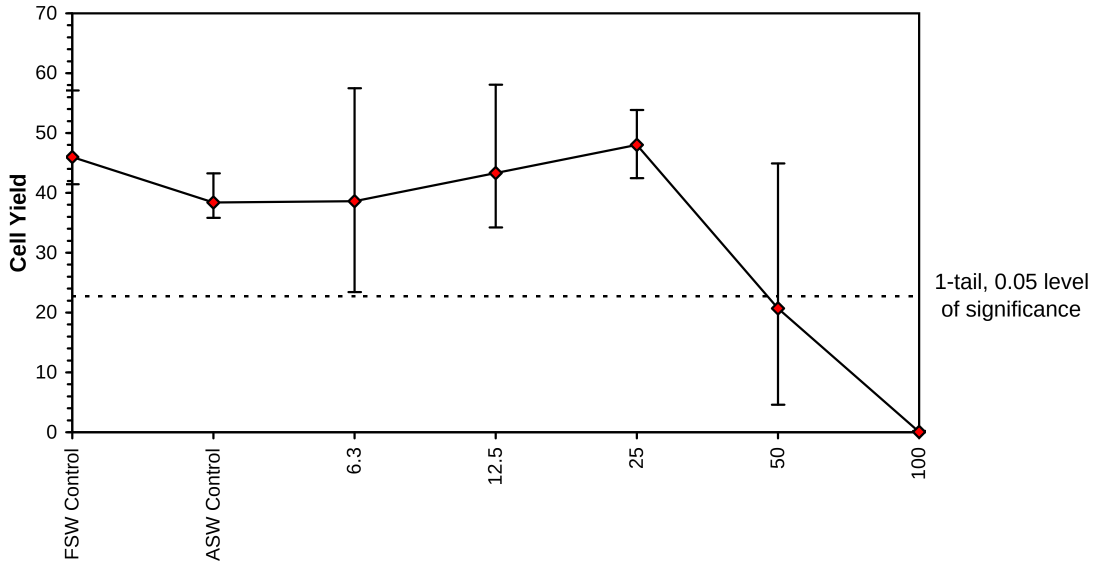
Point	%	SD	95% CL(Exp)	Skew
IC05	>25			
IC10	>25			
IC15	>25			
IC20	>25			
IC25	>25			
IC40	>25			
IC50	>25			



Marine Algal Growth Test-Cell Yield

Start Date:	25/02/2011 13:00	Test ID:	PR0700/04	Sample ID:	Bore 3
End Date:	28/02/2011 13:00	Lab ID:	4583	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 110	Test Species:	IG-isochrysis cf galbana
Comments:					

Dose-Response Plot



Marine Algal Growth Test-Cell Yield

Start Date:	25/02/2011 13:00	Test ID:	PR0700/04	Sample ID:	Bore 3
End Date:	28/02/2011 13:00	Lab ID:	4583	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 110	Test Species:	IG-isochrysis cf galbana
Comments:					

		Auxiliary Data Summary					
Conc-%	**Parameter**	**Mean**	**Min**	**Max**	**SD**	**CV%**	**N**
FSW Control	Cell Yield	45.96	41.41	57.01	7.41	5.92	4
ASW Control		38.36	35.81	43.21	3.40	4.81	4
6.3		38.56	23.41	57.41	14.85	9.99	4
12.5		43.26	34.21	58.01	10.55	7.51	4
25		47.96	42.41	53.81	5.19	4.75	4
50		20.66	4.61	44.81	17.18	20.06	4
100		0.05	0.00	0.21	0.11	614.01	4
FSW Control	pH	8.20	8.20	8.20	0.00	0.00	1
ASW Control		8.10	8.10	8.10	0.00	0.00	1
6.3		8.10	8.10	8.10	0.00	0.00	1
12.5		8.10	8.10	8.10	0.00	0.00	1
25		8.10	8.10	8.10	0.00	0.00	1
50		8.10	8.10	8.10	0.00	0.00	1
100		8.00	8.00	8.00	0.00	0.00	1
FSW Control	Salinity ppt	35.10	35.10	35.10	0.00	0.00	1
ASW Control		35.00	35.00	35.00	0.00	0.00	1
6.3		35.60	35.60	35.60	0.00	0.00	1
12.5		35.70	35.70	35.70	0.00	0.00	1
25		35.70	35.70	35.70	0.00	0.00	1
50		35.60	35.60	35.60	0.00	0.00	1
100		35.40	35.40	35.40	0.00	0.00	1

Marine Algal Growth Test-Cell Yield

Start Date:	25/02/2011 13:00	Test ID:	PR0700/05	Sample ID:	Bore 4
End Date:	28/02/2011 13:00	Lab ID:	4584	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 110	Test Species:	IG-isochrysis cf galbana
Comments:					

Conc-%	1	2	3	4
FSW Control	41.412	43.412	57.012	42.012
ASW Control	38.212	35.812	43.212	36.212
6.3	38.412	36.612	44.812	39.412
12.5	39.612	40.612	51.812	54.412
25	55.812	54.012	40.812	44.812
50	45.212	67.012	43.612	30.012
100	29.612	26.212	45.412	25.612

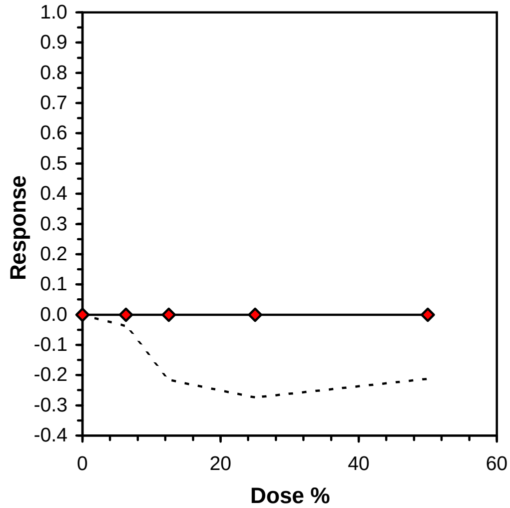
			Transform: Untransformed						1-Tailed		Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD	Mean	N-Mean
FSW Control	45.962	1.1981	45.962	41.412	57.012	16.131	4					
ASW Control	38.362	1.0000	38.362	35.812	43.212	8.862	4	*			44.022	1.0000
6.3	39.812	1.0378	39.812	36.612	44.812	8.864	4	-0.239	2.360	14.313	44.022	1.0000
12.5	46.612	1.2151	46.612	39.612	54.412	16.286	4	-1.360	2.360	14.313	44.022	1.0000
25	48.862	1.2737	48.862	40.812	55.812	14.759	4	-1.731	2.360	14.313	44.022	1.0000
50	46.462	1.2111	46.462	30.012	67.012	32.937	4	-1.336	2.360	14.313	44.022	1.0000
100	31.712	0.8267	31.712	25.612	45.412	29.331	4					

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.05)	0.938995	0.905	0.570632	2.213192
Bartlett's Test indicates equal variances (p = 0.09)	8.100696	13.2767		
The control means are not significantly different (p = 0.11)	1.86357	2.446912		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU	MSDu	MSDp	MSB	MSE	F-Prob	df
Dunnett's Test	50	>50		2	14.31342	0.373113	85.847	73.56867	0.364406	4, 15
Treatments vs ASW Control										

Linear Interpolation (200 Resamples)

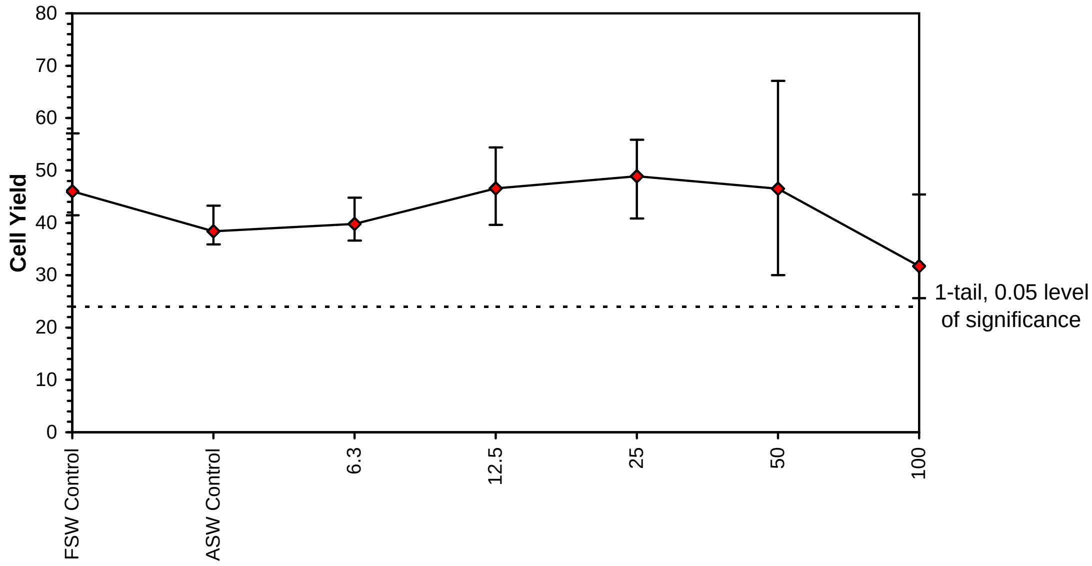
Point	%	SD	95% CL(Exp)	Skew
IC05	>50			
IC10	>50			
IC15	>50			
IC20	>50			
IC25	>50			
IC40	>50			
IC50	>50			



Marine Algal Growth Test-Cell Yield

Start Date:	25/02/2011 13:00	Test ID:	PR0700/05	Sample ID:	Bore 4
End Date:	28/02/2011 13:00	Lab ID:	4584	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 110	Test Species:	IG-isochrysis cf galbana
Comments:					

Dose-Response Plot



Marine Algal Growth Test-Cell Yield

Start Date:	25/02/2011 13:00	Test ID:	PR0700/05	Sample ID:	Bore 4
End Date:	28/02/2011 13:00	Lab ID:	4584	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 110	Test Species:	IG-isochrysis cf galbana
Comments:					

Auxiliary Data Summary

Conc-%	Parameter	Mean	Min	Max	SD	CV%	N
FSW Control	Cell Yield	45.96	41.41	57.01	7.41	5.92	4
ASW Control		38.36	35.81	43.21	3.40	4.81	4
6.3		39.81	36.61	44.81	3.53	4.72	4
12.5		46.61	39.61	54.41	7.59	5.91	4
25		48.86	40.81	55.81	7.21	5.50	4
50		46.46	30.01	67.01	15.30	8.42	4
100		31.71	25.61	45.41	9.30	9.62	4
FSW Control	pH	8.20	8.20	8.20	0.00	0.00	1
ASW Control		8.10	8.10	8.10	0.00	0.00	1
6.3		8.10	8.10	8.10	0.00	0.00	1
12.5		8.10	8.10	8.10	0.00	0.00	1
25		8.00	8.00	8.00	0.00	0.00	1
50		7.90	7.90	7.90	0.00	0.00	1
100		7.60	7.60	7.60	0.00	0.00	1
FSW Control	Salinity ppt	35.10	35.10	35.10	0.00	0.00	1
ASW Control		35.00	35.00	35.00	0.00	0.00	1
6.3		35.50	35.50	35.50	0.00	0.00	1
12.5		35.50	35.50	35.50	0.00	0.00	1
25		35.50	35.50	35.50	0.00	0.00	1
50		35.40	35.40	35.40	0.00	0.00	1
100		35.00	35.00	35.00	0.00	0.00	1

Marine Algal Growth Test-Cell Yield

Start Date:	25/02/2011 13:00	Test ID:	PR0700/06	Sample ID:	Bore 5
End Date:	28/02/2011 13:00	Lab ID:	4585	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 110	Test Species:	IG-isochrysis cf galbana
Comments:					

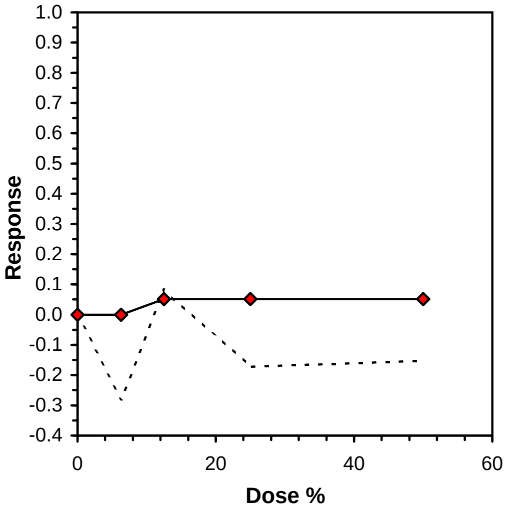
Conc-%	1	2	3	4
FSW Control	41.412	43.412	57.012	42.012
ASW Control	38.212	35.812	43.212	36.212
6.3	50.012	48.212	47.212	51.012
12.5	52.212	24.212	32.012	32.412
25	50.212	36.212	54.412	39.012
50	39.412	31.012	48.612	57.812
100	42.812	27.012	24.612	8.212

			Transform: Untransformed						1-Tailed		Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD	Mean	N-Mean
FSW Control	45.962	1.1981	45.962	41.412	57.012	16.131	4					
ASW Control	38.362	1.0000	38.362	35.812	43.212	8.862	4	*			43.737	1.0000
6.3	49.112	1.2802	49.112	47.212	51.012	3.495	4	-1.774	2.360	14.304	43.737	1.0000
12.5	35.212	0.9179	35.212	24.212	52.212	33.924	4	0.520	2.360	14.304	41.462	0.9480
25	44.962	1.1720	44.962	36.212	54.412	19.424	4	-1.089	2.360	14.304	41.462	0.9480
50	44.212	1.1525	44.212	31.012	57.812	26.169	4	-0.965	2.360	14.304	41.462	0.9480
100	25.662	0.6689	25.662	8.212	42.812	55.180	4					

Auxiliary Tests					Statistic		Critical		Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.05)					0.96792		0.905		0.518031	0.332408
Bartlett's Test indicates equal variances (p = 0.04)					9.964598		13.2767			
The control means are not significantly different (p = 0.11)					1.86357		2.446912			
Hypothesis Test (1-tail, 0.05)	**NOEC**	**LOEC**	**ChV**	**TU**	**MSDu**	**MSDp**	**MSB**	**MSE**	**F-Prob**	**df**
Dunnett's Test	50	>50		2	14.30362	0.372857	122.867	73.468	0.208473	4, 15
Treatments vs ASW Control										

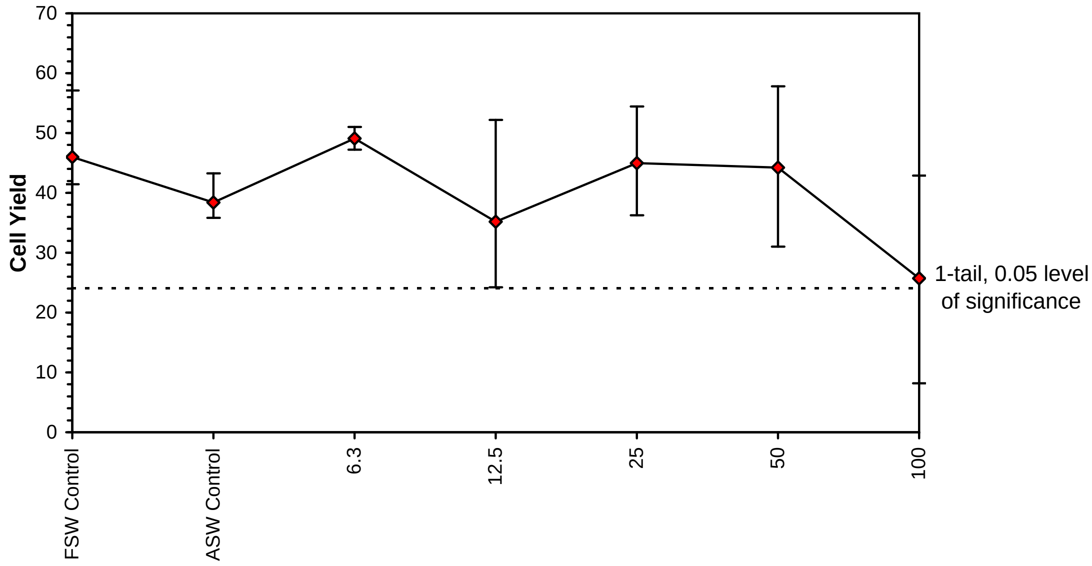
Linear Interpolation (200 Resamples)

Point	%	SD	95% CL(Exp)	Skew
IC05	12.260			
IC10	>50			
IC15	>50			
IC20	>50			
IC25	>50			
IC40	>50			
IC50	>50			



Marine Algal Growth Test-Cell Yield					
Start Date:	25/02/2011 13:00	Test ID:	PR0700/06	Sample ID:	Bore 5
End Date:	28/02/2011 13:00	Lab ID:	4585	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 110	Test Species:	IG-isochrysis cf galbana
Comments:					

Dose-Response Plot



 ToxCalc v5.0.23 Reviewed by:_____

Marine Algal Growth Test-Cell Yield

Start Date:	25/02/2011 13:00	Test ID:	PR0700/06	Sample ID:	Bore 5
End Date:	28/02/2011 13:00	Lab ID:	4585	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 110	Test Species:	IG-isochrysis cf galbana
Comments:					

		Auxiliary Data Summary					
Conc-%	**Parameter**	**Mean**	**Min**	**Max**	**SD**	**CV%**	**N**
FSW Control	Cell Yield	45.96	41.41	57.01	7.41	5.92	4
ASW Control		38.36	35.81	43.21	3.40	4.81	4
6.3		49.11	47.21	51.01	1.72	2.67	4
12.5		35.21	24.21	52.21	11.95	9.82	4
25		44.96	36.21	54.41	8.73	6.57	4
50		44.21	31.01	57.81	11.57	7.69	4
100		25.66	8.21	42.81	14.16	14.66	4
FSW Control	pH	8.20	8.20	8.20	0.00	0.00	1
ASW Control		8.10	8.10	8.10	0.00	0.00	1
6.3		8.10	8.10	8.10	0.00	0.00	1
12.5		8.10	8.10	8.10	0.00	0.00	1
25		8.10	8.10	8.10	0.00	0.00	1
50		8.00	8.00	8.00	0.00	0.00	1
100		7.90	7.90	7.90	0.00	0.00	1
FSW Control	Salinity ppt	35.10	35.10	35.10	0.00	0.00	1
ASW Control		35.00	35.00	35.00	0.00	0.00	1
6.3		35.30	35.30	35.30	0.00	0.00	1
12.5		35.60	35.60	35.60	0.00	0.00	1
25		35.70	35.70	35.70	0.00	0.00	1
50		35.60	35.60	35.60	0.00	0.00	1
100		35.30	35.30	35.30	0.00	0.00	1

Statistical Printouts for the Larval Fish Imbalance Tests

Fish Imbalance Test-96 hr Imbalance

Start Date:	24/02/2011 14:00	Test ID:	PR0700/2	Sample ID:	BORE 1
End Date:	28/02/2011 14:00	Lab ID:	4581	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 117	Test Species:	LT-Lates calcarifer
Comments:					

Conc-%	1	2	3	4
FSW Control	1.0000	1.0000	1.0000	1.0000
ASW Control	1.0000	1.0000	1.0000	1.0000
6.3	1.0000	1.0000	1.0000	1.0000
12.5	1.0000	1.0000	1.0000	1.0000
25	1.0000	1.0000	1.0000	1.0000
50	1.0000	1.0000	1.0000	1.0000
100	1.0000	1.0000	1.0000	1.0000

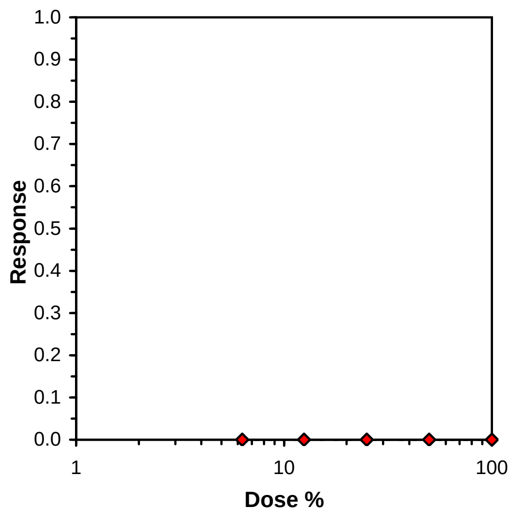
			Transform: Arcsin Square Root					Rank	1-Tailed	Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	Sum	Critical	Mean	N-Mean
FSW Control	1.0000	1.0000	1.3453	1.3453	1.3453	0.000	4				
ASW Control	1.0000	1.0000	1.3453	1.3453	1.3453	0.000	4	*		1.0000	1.0000
6.3	1.0000	1.0000	1.3453	1.3453	1.3453	0.000	4	18.00	10.00	1.0000	1.0000
12.5	1.0000	1.0000	1.3453	1.3453	1.3453	0.000	4	18.00	10.00	1.0000	1.0000
25	1.0000	1.0000	1.3453	1.3453	1.3453	0.000	4	18.00	10.00	1.0000	1.0000
50	1.0000	1.0000	1.3453	1.3453	1.3453	0.000	4	18.00	10.00	1.0000	1.0000
100	1.0000	1.0000	1.3453	1.3453	1.3453	0.000	4	18.00	10.00	1.0000	1.0000

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.05)	1	0.916		
Equality of variance cannot be confirmed				
The control means are not significantly different (p = 1.00)	0	2.446912		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU
Steel's Many-One Rank Test	100	>100		1
Treatments vs ASW Control				

Log-Logit Interpolation (200 Resamples)

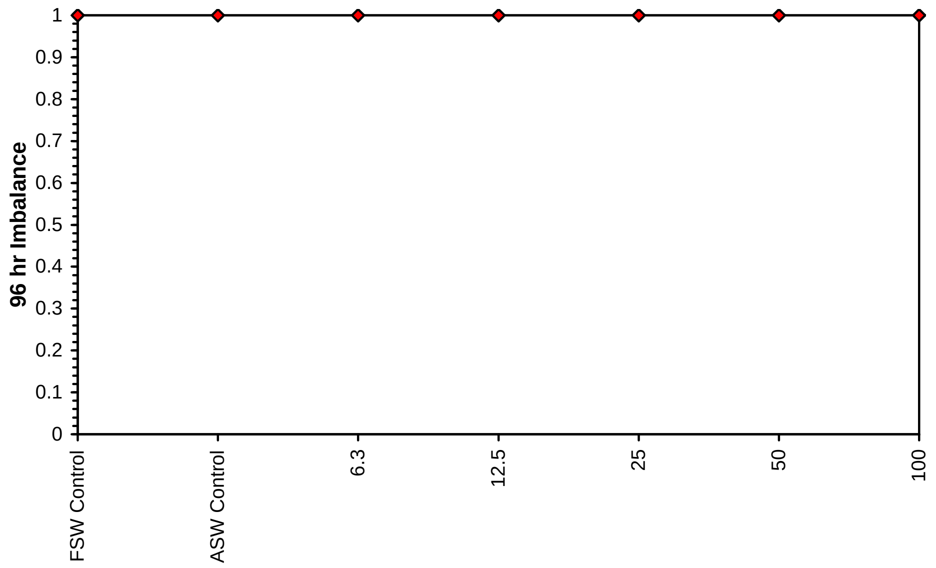
Point	%	SD	95% CL(Exp)	Skew
IC05	>100			
IC10	>100			
IC15	>100			
IC20	>100			
IC25	>100			
IC40	>100			
IC50	>100			



Fish Imbalance Test-96 hr Imbalance

Start Date:	24/02/2011 14:00	Test ID:	PR0700/2	Sample ID:	BORE 1
End Date:	28/02/2011 14:00	Lab ID:	4581	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 117	Test Species:	LT-Lates calcarifer
Comments:					

Dose-Response Plot



ToxCalc v5.0.23

Reviewed by:_____

Fish Imbalance Test-96 hr Imbalance

Start Date:	24/02/2011 14:00	Test ID:	PR0700/2	Sample ID:	BORE 1
End Date:	28/02/2011 14:00	Lab ID:	4581	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 117	Test Species:	LT-Lates calcarifer
Comments:					

		Auxiliary Data Summary					
Conc-%	**Parameter**	**Mean**	**Min**	**Max**	**SD**	**CV%**	**N**
FSW Control	% Unaffected	100.00	100.00	100.00	0.00	0.00	4
ASW Control		100.00	100.00	100.00	0.00	0.00	4
6.3		100.00	100.00	100.00	0.00	0.00	4
12.5		100.00	100.00	100.00	0.00	0.00	4
25		100.00	100.00	100.00	0.00	0.00	4
50		100.00	100.00	100.00	0.00	0.00	4
100		100.00	100.00	100.00	0.00	0.00	4
FSW Control	pH	8.10	8.10	8.10	0.00	0.00	1
ASW Control		8.10	8.10	8.10	0.00	0.00	1
6.3		7.90	7.90	7.90	0.00	0.00	1
12.5		7.90	7.90	7.90	0.00	0.00	1
25		7.70	7.70	7.70	0.00	0.00	1
50		7.60	7.60	7.60	0.00	0.00	1
100		7.40	7.40	7.40	0.00	0.00	1
FSW Control	Salinity ppt	35.40	35.40	35.40	0.00	0.00	1
ASW Control		35.10	35.10	35.10	0.00	0.00	1
6.3		35.30	35.30	35.30	0.00	0.00	1
12.5		35.30	35.30	35.30	0.00	0.00	1
25		35.20	35.20	35.20	0.00	0.00	1
50		35.00	35.00	35.00	0.00	0.00	1
100		34.80	34.80	34.80	0.00	0.00	1
FSW Control	DO %	96.80	96.80	96.80	0.00	0.00	1
ASW Control		87.90	87.90	87.90	0.00	0.00	1
6.3		98.00	98.00	98.00	0.00	0.00	1
12.5		97.70	97.70	97.70	0.00	0.00	1
25		98.50	98.50	98.50	0.00	0.00	1
50		98.50	98.50	98.50	0.00	0.00	1
100		96.50	96.50	96.50	0.00	0.00	1

Fish Imbalance Test-96 hr Imbalance

Start Date:	24/02/2011 14:00	Test ID:	PR0700/3	Sample ID:	BORE 2
End Date:	28/02/2011 14:00	Lab ID:	4582	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 117	Test Species:	LT-Lates calcarifer
Comments:					

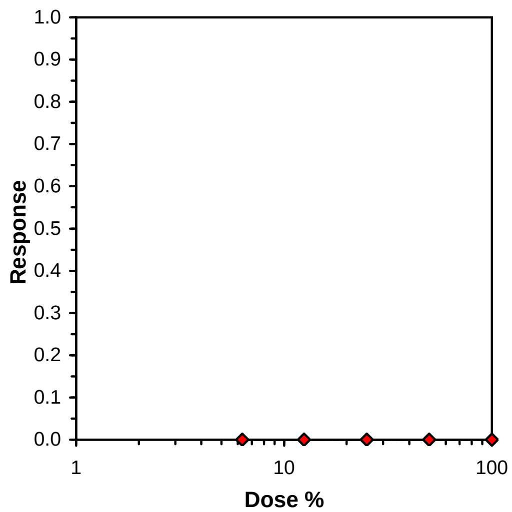
Conc-%	1	2	3	4
FSW Control	1.0000	1.0000	1.0000	1.0000
ASW Control	1.0000	1.0000	1.0000	1.0000
6.3	1.0000	1.0000	1.0000	1.0000
12.5	1.0000	1.0000	1.0000	1.0000
25	1.0000	1.0000	1.0000	1.0000
50	1.0000	1.0000	1.0000	1.0000
100	1.0000	1.0000	1.0000	1.0000

			Transform: Arcsin Square Root					Rank	1-Tailed	Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	Sum	Critical	Mean	N-Mean
FSW Control	1.0000	1.0000	1.3453	1.3453	1.3453	0.000	4				
ASW Control	1.0000	1.0000	1.3453	1.3453	1.3453	0.000	4	*		1.0000	1.0000
6.3	1.0000	1.0000	1.3453	1.3453	1.3453	0.000	4	18.00	10.00	1.0000	1.0000
12.5	1.0000	1.0000	1.3453	1.3453	1.3453	0.000	4	18.00	10.00	1.0000	1.0000
25	1.0000	1.0000	1.3453	1.3453	1.3453	0.000	4	18.00	10.00	1.0000	1.0000
50	1.0000	1.0000	1.3453	1.3453	1.3453	0.000	4	18.00	10.00	1.0000	1.0000
100	1.0000	1.0000	1.3453	1.3453	1.3453	0.000	4	18.00	10.00	1.0000	1.0000

Auxiliary Tests					Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.05)					1	0.916		
Equality of variance cannot be confirmed								
The control means are not significantly different (p = 1.00)					0	2.446912		
Hypothesis Test (1-tail, 0.05)	**NOEC**	**LOEC**	**ChV**	**TU**				
Steel's Many-One Rank Test	100	>100		1				
Treatments vs ASW Control								

Log-Logit Interpolation (200 Resamples)

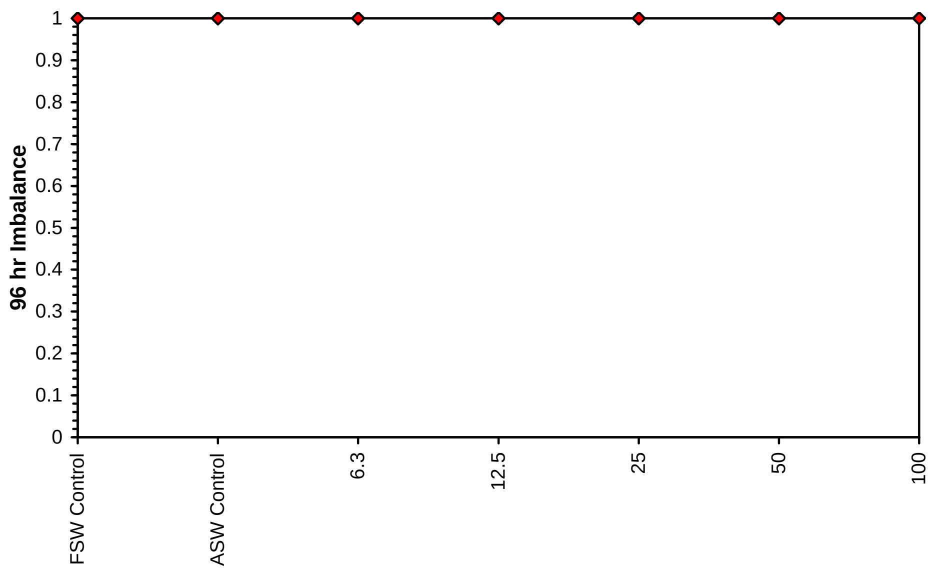
Point	%	SD	95% CL(Exp)	Skew
IC05	>100			
IC10	>100			
IC15	>100			
IC20	>100			
IC25	>100			
IC40	>100			
IC50	>100			



Fish Imbalance Test-96 hr Imbalance

Start Date:	24/02/2011 14:00	Test ID:	PR0700/3	Sample ID:	BORE 2
End Date:	28/02/2011 14:00	Lab ID:	4582	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 117	Test Species:	LT-Lates calcarifer
Comments:					

Dose-Response Plot



Fish Imbalance Test-96 hr Imbalance

Start Date:	24/02/2011 14:00	Test ID:	PR0700/3	Sample ID:	BORE 2
End Date:	28/02/2011 14:00	Lab ID:	4582	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 117	Test Species:	LT-Lates calcarifer
Comments:					

		Auxiliary Data Summary					
Conc-%	**Parameter**	**Mean**	**Min**	**Max**	**SD**	**CV%**	**N**
FSW Control	% Unaffected	100.00	100.00	100.00	0.00	0.00	4
ASW Control		100.00	100.00	100.00	0.00	0.00	4
6.3		100.00	100.00	100.00	0.00	0.00	4
12.5		100.00	100.00	100.00	0.00	0.00	4
25		100.00	100.00	100.00	0.00	0.00	4
50		100.00	100.00	100.00	0.00	0.00	4
100		100.00	100.00	100.00	0.00	0.00	4
FSW Control	pH	8.10	8.10	8.10	0.00	0.00	1
ASW Control		8.10	8.10	8.10	0.00	0.00	1
6.3		8.00	8.00	8.00	0.00	0.00	1
12.5		8.00	8.00	8.00	0.00	0.00	1
25		8.00	8.00	8.00	0.00	0.00	1
50		7.90	7.90	7.90	0.00	0.00	1
100		7.80	7.80	7.80	0.00	0.00	1
FSW Control	Salinity ppt	35.40	35.40	35.40	0.00	0.00	1
ASW Control		35.10	35.10	35.10	0.00	0.00	1
6.3		35.30	35.30	35.30	0.00	0.00	1
12.5		35.30	35.30	35.30	0.00	0.00	1
25		35.20	35.20	35.20	0.00	0.00	1
50		35.10	35.10	35.10	0.00	0.00	1
100		34.90	34.90	34.90	0.00	0.00	1
FSW Control	DO %	96.80	96.80	96.80	0.00	0.00	1
ASW Control		87.90	87.90	87.90	0.00	0.00	1
6.3		99.10	99.10	99.10	0.00	0.00	1
12.5		98.90	98.90	98.90	0.00	0.00	1
25		99.70	99.70	99.70	0.00	0.00	1
50		101.00	101.00	101.00	0.00	0.00	1
100		105.00	105.00	105.00	0.00	0.00	1

Fish Imbalance Test-96 hr Imbalance

Start Date:	24/02/2011 14:00	Test ID:	PR0700/4	Sample ID:	BORE 3
End Date:	28/02/2011 14:00	Lab ID:	4583	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 117	Test Species:	LT-Lates calcarifer
Comments:					

Conc-%	1	2	3	4
FSW Control	1.0000	1.0000	1.0000	1.0000
ASW Control	1.0000	1.0000	1.0000	1.0000
6.3	1.0000	1.0000	1.0000	1.0000
12.5	1.0000	1.0000	1.0000	1.0000
25	1.0000	1.0000	1.0000	1.0000
50	1.0000	1.0000	1.0000	1.0000
100	1.0000	1.0000	1.0000	1.0000

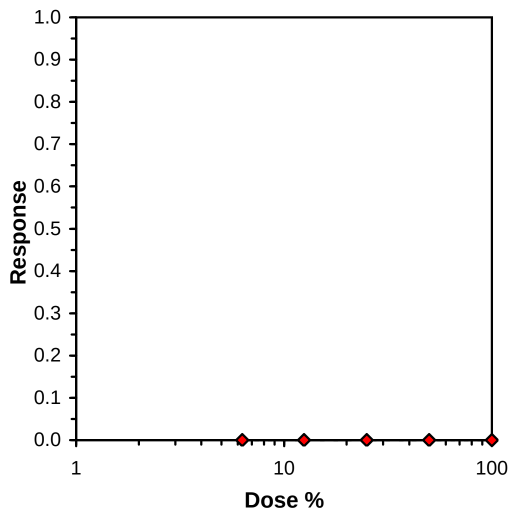
			Transform: Arcsin Square Root					Rank	1-Tailed	Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	Sum	Critical	Mean	N-Mean
FSW Control	1.0000	1.0000	1.3453	1.3453	1.3453	0.000	4				
ASW Control	1.0000	1.0000	1.3453	1.3453	1.3453	0.000	4	*		1.0000	1.0000
6.3	1.0000	1.0000	1.3453	1.3453	1.3453	0.000	4	18.00	10.00	1.0000	1.0000
12.5	1.0000	1.0000	1.3453	1.3453	1.3453	0.000	4	18.00	10.00	1.0000	1.0000
25	1.0000	1.0000	1.3453	1.3453	1.3453	0.000	4	18.00	10.00	1.0000	1.0000
50	1.0000	1.0000	1.3453	1.3453	1.3453	0.000	4	18.00	10.00	1.0000	1.0000
100	1.0000	1.0000	1.3453	1.3453	1.3453	0.000	4	18.00	10.00	1.0000	1.0000

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.05)	1	0.916		
Equality of variance cannot be confirmed				
The control means are not significantly different (p = 1.00)	0	2.446912		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU
Steel's Many-One Rank Test	100	>100		1
Treatments vs ASW Control				

Log-Logit Interpolation (200 Resamples)

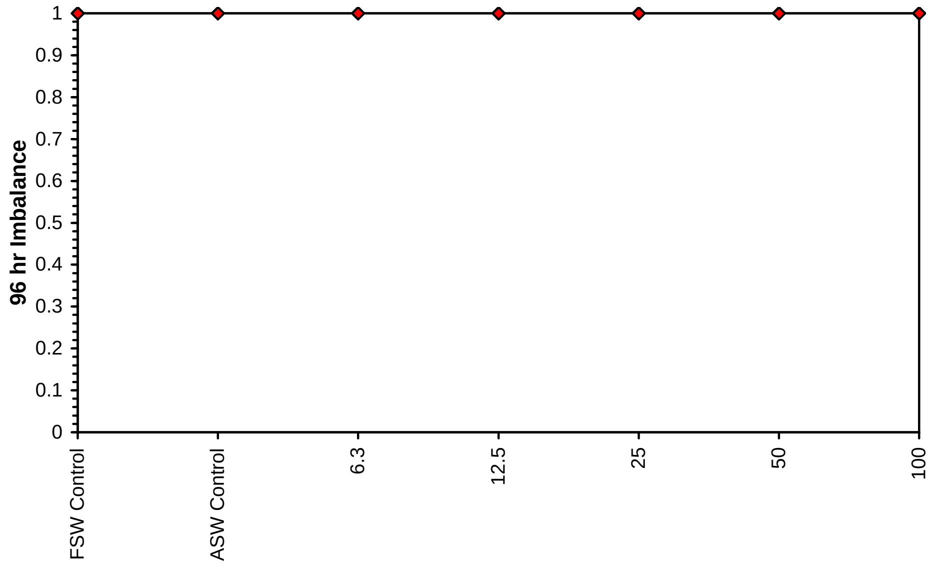
Point	%	SD	95% CL(Exp)	Skew
IC05	>100			
IC10	>100			
IC15	>100			
IC20	>100			
IC25	>100			
IC40	>100			
IC50	>100			



Fish Imbalance Test-96 hr Imbalance

Start Date:	24/02/2011 14:00	Test ID:	PR0700/4	Sample ID:	BORE 3
End Date:	28/02/2011 14:00	Lab ID:	4583	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 117	Test Species:	LT-Lates calcarifer
Comments:					

Dose-Response Plot



Fish Imbalance Test-96 hr Imbalance

Start Date:	24/02/2011 14:00	Test ID:	PR0700/4	Sample ID:	BORE 3
End Date:	28/02/2011 14:00	Lab ID:	4583	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 117	Test Species:	LT-Lates calcarifer
Comments:					

		Auxiliary Data Summary					
Conc-%	**Parameter**	**Mean**	**Min**	**Max**	**SD**	**CV%**	**N**
FSW Control	% Unaffected	100.00	100.00	100.00	0.00	0.00	4
ASW Control		100.00	100.00	100.00	0.00	0.00	4
6.3		100.00	100.00	100.00	0.00	0.00	4
12.5		100.00	100.00	100.00	0.00	0.00	4
25		100.00	100.00	100.00	0.00	0.00	4
50		100.00	100.00	100.00	0.00	0.00	4
100		100.00	100.00	100.00	0.00	0.00	4
FSW Control	pH	8.10	8.10	8.10	0.00	0.00	1
ASW Control		8.10	8.10	8.10	0.00	0.00	1
6.3		8.00	8.00	8.00	0.00	0.00	1
12.5		7.90	7.90	7.90	0.00	0.00	1
25		7.80	7.80	7.80	0.00	0.00	1
50		7.70	7.70	7.70	0.00	0.00	1
100		7.70	7.70	7.70	0.00	0.00	1
FSW Control	Salinity ppt	35.40	35.40	35.40	0.00	0.00	1
ASW Control		35.10	35.10	35.10	0.00	0.00	1
6.3		35.50	35.50	35.50	0.00	0.00	1
12.5		35.40	35.40	35.40	0.00	0.00	1
25		35.30	35.30	35.30	0.00	0.00	1
50		35.00	35.00	35.00	0.00	0.00	1
100		34.60	34.60	34.60	0.00	0.00	1
FSW Control	DO %	96.80	96.80	96.80	0.00	0.00	1
ASW Control		87.90	87.90	87.90	0.00	0.00	1
6.3		97.80	97.80	97.80	0.00	0.00	1
12.5		98.40	98.40	98.40	0.00	0.00	1
25		98.20	98.20	98.20	0.00	0.00	1
50		99.20	99.20	99.20	0.00	0.00	1
100		99.50	99.50	99.50	0.00	0.00	1

Fish Imbalance Test-96 hr Imbalance

Start Date:	24/02/2011 14:00	Test ID:	PR0700/5	Sample ID:	BORE 4
End Date:	28/02/2011 14:00	Lab ID:	4584	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 117	Test Species:	LT-Lates calcarifer
Comments:					

Conc-%	1	2	3	4
FSW Control	1.0000	1.0000	1.0000	1.0000
ASW Control	1.0000	1.0000	1.0000	1.0000
6.3	1.0000	1.0000	1.0000	1.0000
12.5	1.0000	1.0000	1.0000	1.0000
25	1.0000	1.0000	1.0000	1.0000
50	1.0000	1.0000	1.0000	1.0000
100	1.0000	1.0000	1.0000	1.0000

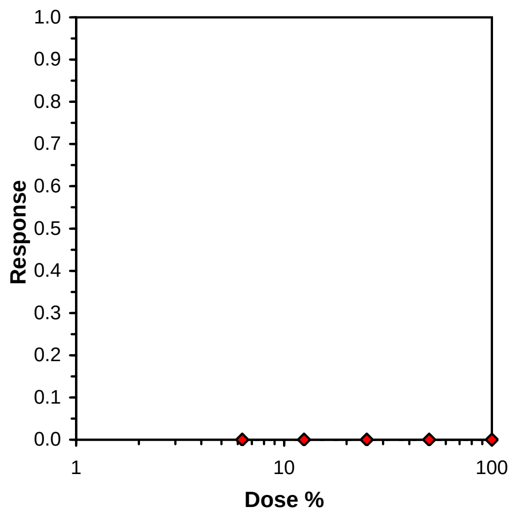
			Transform: Arcsin Square Root					Rank	1-Tailed	Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	Sum	Critical	Mean	N-Mean
FSW Control	1.0000	1.0000	1.3453	1.3453	1.3453	0.000	4				
ASW Control	1.0000	1.0000	1.3453	1.3453	1.3453	0.000	4	*		1.0000	1.0000
6.3	1.0000	1.0000	1.3453	1.3453	1.3453	0.000	4	18.00	10.00	1.0000	1.0000
12.5	1.0000	1.0000	1.3453	1.3453	1.3453	0.000	4	18.00	10.00	1.0000	1.0000
25	1.0000	1.0000	1.3453	1.3453	1.3453	0.000	4	18.00	10.00	1.0000	1.0000
50	1.0000	1.0000	1.3453	1.3453	1.3453	0.000	4	18.00	10.00	1.0000	1.0000
100	1.0000	1.0000	1.3453	1.3453	1.3453	0.000	4	18.00	10.00	1.0000	1.0000

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.05)	1	0.916		
Equality of variance cannot be confirmed				
The control means are not significantly different (p = 1.00)	0	2.446912		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU
Steel's Many-One Rank Test	100	>100		1
Treatments vs ASW Control				

Log-Logit Interpolation (200 Resamples)

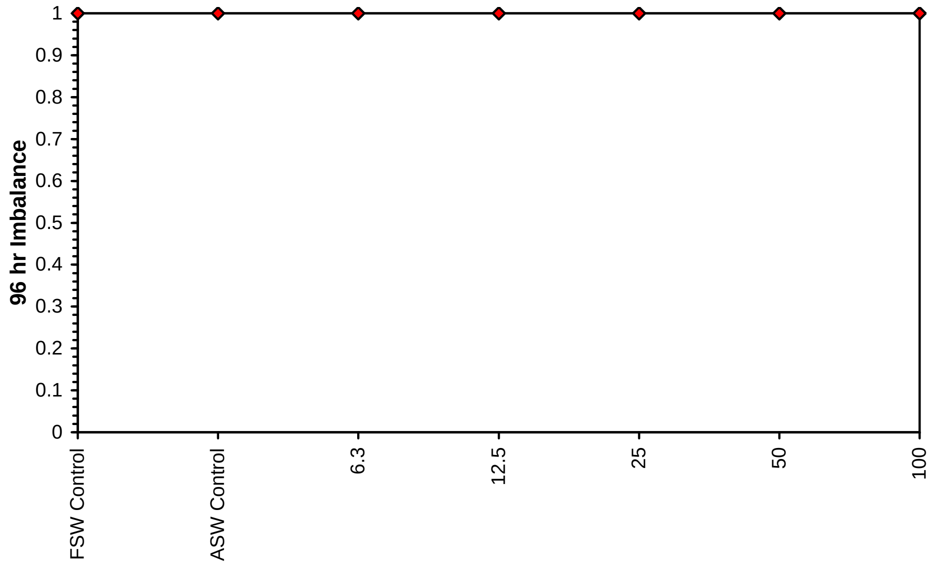
Point	%	SD	95% CL(Exp)	Skew
IC05	>100			
IC10	>100			
IC15	>100			
IC20	>100			
IC25	>100			
IC40	>100			
IC50	>100			



Fish Imbalance Test-96 hr Imbalance

Start Date:	24/02/2011 14:00	Test ID:	PR0700/5	Sample ID:	BORE 4
End Date:	28/02/2011 14:00	Lab ID:	4584	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 117	Test Species:	LT-Lates calcarifer
Comments:					

Dose-Response Plot



Fish Imbalance Test-96 hr Imbalance

Start Date:	24/02/2011 14:00	Test ID:	PR0700/5	Sample ID:	BORE 4
End Date:	28/02/2011 14:00	Lab ID:	4584	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 117	Test Species:	LT-Lates calcarifer
Comments:					

Auxiliary Data Summary

Conc-%	Parameter	Mean	Min	Max	SD	CV%	N
FSW Control	% Unaffected	100.00	100.00	100.00	0.00	0.00	4
ASW Control		100.00	100.00	100.00	0.00	0.00	4
6.3		100.00	100.00	100.00	0.00	0.00	4
12.5		100.00	100.00	100.00	0.00	0.00	4
25		100.00	100.00	100.00	0.00	0.00	4
50		100.00	100.00	100.00	0.00	0.00	4
100		100.00	100.00	100.00	0.00	0.00	4
FSW Control	pH	8.10	8.10	8.10	0.00	0.00	1
ASW Control		8.10	8.10	8.10	0.00	0.00	1
6.3		8.00	8.00	8.00	0.00	0.00	1
12.5		7.90	7.90	7.90	0.00	0.00	1
25		7.80	7.80	7.80	0.00	0.00	1
50		7.50	7.50	7.50	0.00	0.00	1
100		7.30	7.30	7.30	0.00	0.00	1
FSW Control	Salinity ppt	35.40	35.40	35.40	0.00	0.00	1
ASW Control		35.10	35.10	35.10	0.00	0.00	1
6.3		35.40	35.40	35.40	0.00	0.00	1
12.5		35.30	35.30	35.30	0.00	0.00	1
25		35.20	35.20	35.20	0.00	0.00	1
50		34.90	34.90	34.90	0.00	0.00	1
100		34.50	34.50	34.50	0.00	0.00	1
FSW Control	DO %	96.80	96.80	96.80	0.00	0.00	1
ASW Control		87.90	87.90	87.90	0.00	0.00	1
6.3		98.70	98.70	98.70	0.00	0.00	1
12.5		98.20	98.20	98.20	0.00	0.00	1
25		98.20	98.20	98.20	0.00	0.00	1
50		98.30	98.30	98.30	0.00	0.00	1
100		94.30	94.30	94.30	0.00	0.00	1

Fish Imbalance Test-96 hr Imbalance

Start Date:	24/02/2011 14:00	Test ID:	PR0700/6	Sample ID:	BORE 5
End Date:	28/02/2011 14:00	Lab ID:	4585	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 117	Test Species:	LT-Lates calcarifer
Comments:					

Conc-%	1	2	3	4
FSW Control	1.0000	1.0000	1.0000	1.0000
ASW Control	1.0000	1.0000	1.0000	1.0000
6.3	1.0000	1.0000	1.0000	1.0000
12.5	1.0000	1.0000	1.0000	1.0000
25	1.0000	1.0000	1.0000	1.0000
50	1.0000	1.0000	1.0000	1.0000
100	1.0000	1.0000	1.0000	0.8000

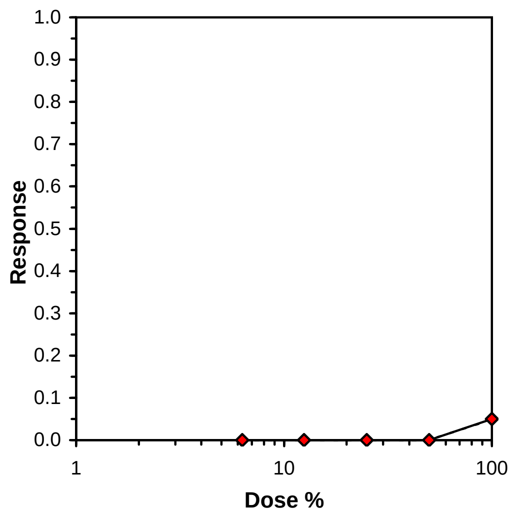
			Transform: Arcsin Square Root					Rank	1-Tailed	Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	Sum	Critical	Mean	N-Mean
FSW Control	1.0000	1.0000	1.3453	1.3453	1.3453	0.000	4				
ASW Control	1.0000	1.0000	1.3453	1.3453	1.3453	0.000	4	*		1.0000	1.0000
6.3	1.0000	1.0000	1.3453	1.3453	1.3453	0.000	4	18.00	10.00	1.0000	1.0000
12.5	1.0000	1.0000	1.3453	1.3453	1.3453	0.000	4	18.00	10.00	1.0000	1.0000
25	1.0000	1.0000	1.3453	1.3453	1.3453	0.000	4	18.00	10.00	1.0000	1.0000
50	1.0000	1.0000	1.3453	1.3453	1.3453	0.000	4	18.00	10.00	1.0000	1.0000
100	0.9500	0.9500	1.2857	1.1071	1.3453	9.261	4	16.00	10.00	0.9500	0.9500

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates non-normal distribution (p <= 0.05)	0.465078	0.916	-3.02059	13.98918
Equality of variance cannot be confirmed				
The control means are not significantly different (p = 1.00)	0	2.446912		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU
Steel's Many-One Rank Test	100	>100		1
Treatments vs ASW Control				

Log-Logit Interpolation (200 Resamples)

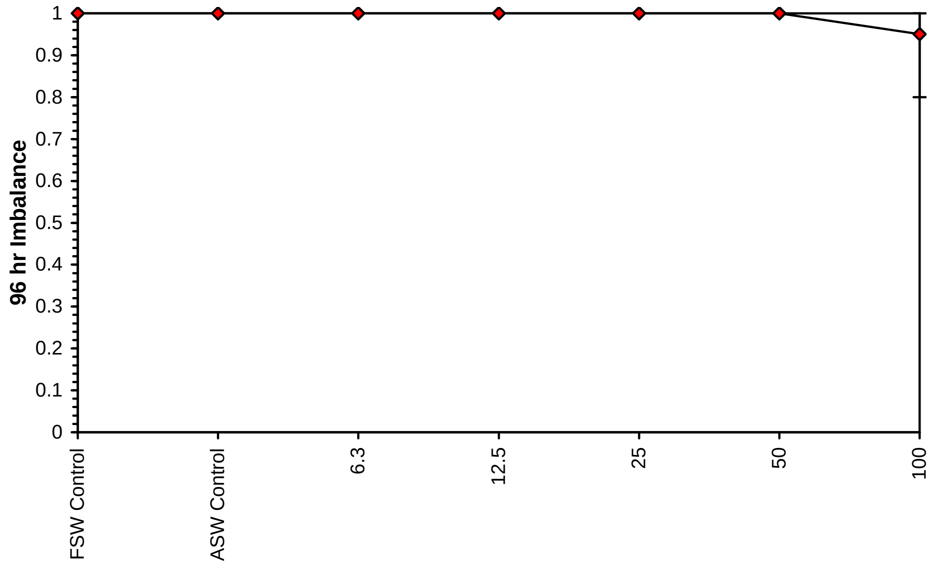
Point	%	SD	95% CL(Exp)	Skew
IC05	>100			
IC10	>100			
IC15	>100			
IC20	>100			
IC25	>100			
IC40	>100			
IC50	>100			



Fish Imbalance Test-96 hr Imbalance

Start Date:	24/02/2011 14:00	Test ID:	PR0700/6	Sample ID:	BORE 5
End Date:	28/02/2011 14:00	Lab ID:	4585	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 117	Test Species:	LT-Lates calcarifer
Comments:					

Dose-Response Plot



Fish Imbalance Test-96 hr Imbalance

Start Date:	24/02/2011 14:00	Test ID:	PR0700/6	Sample ID:	BORE 5
End Date:	28/02/2011 14:00	Lab ID:	4585	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 117	Test Species:	LT-Lates calcarifer
Comments:					

		Auxiliary Data Summary					
Conc-%	**Parameter**	**Mean**	**Min**	**Max**	**SD**	**CV%**	**N**
FSW Control	% Unaffected	100.00	100.00	100.00	0.00	0.00	4
ASW Control		100.00	100.00	100.00	0.00	0.00	4
6.3		100.00	100.00	100.00	0.00	0.00	4
12.5		100.00	100.00	100.00	0.00	0.00	4
25		100.00	100.00	100.00	0.00	0.00	4
50		100.00	100.00	100.00	0.00	0.00	4
100		95.00	80.00	100.00	10.00	3.33	4
FSW Control	pH	8.10	8.10	8.10	0.00	0.00	1
ASW Control		8.10	8.10	8.10	0.00	0.00	1
6.3		8.00	8.00	8.00	0.00	0.00	1
12.5		7.90	7.90	7.90	0.00	0.00	1
25		7.80	7.80	7.80	0.00	0.00	1
50		7.60	7.60	7.60	0.00	0.00	1
100		7.50	7.50	7.50	0.00	0.00	1
FSW Control	Salinity ppt	35.40	35.40	35.40	0.00	0.00	1
ASW Control		35.10	35.10	35.10	0.00	0.00	1
6.3		35.50	35.50	35.50	0.00	0.00	1
12.5		35.40	35.40	35.40	0.00	0.00	1
25		35.30	35.30	35.30	0.00	0.00	1
50		35.00	35.00	35.00	0.00	0.00	1
100		34.70	34.70	34.70	0.00	0.00	1
FSW Control	DO %	96.80	96.80	96.80	0.00	0.00	1
ASW Control		87.90	87.90	87.90	0.00	0.00	1
6.3		98.20	98.20	98.20	0.00	0.00	1
12.5		98.50	98.50	98.50	0.00	0.00	1
25		98.70	98.70	98.70	0.00	0.00	1
50		100.10	100.10	100.10	0.00	0.00	1
100		102.70	102.70	102.70	0.00	0.00	1

Statistical Printouts for the Juvenile *Melita plumulosa* Tests

Amphipod Acute Toxicity Test-96 hr survival

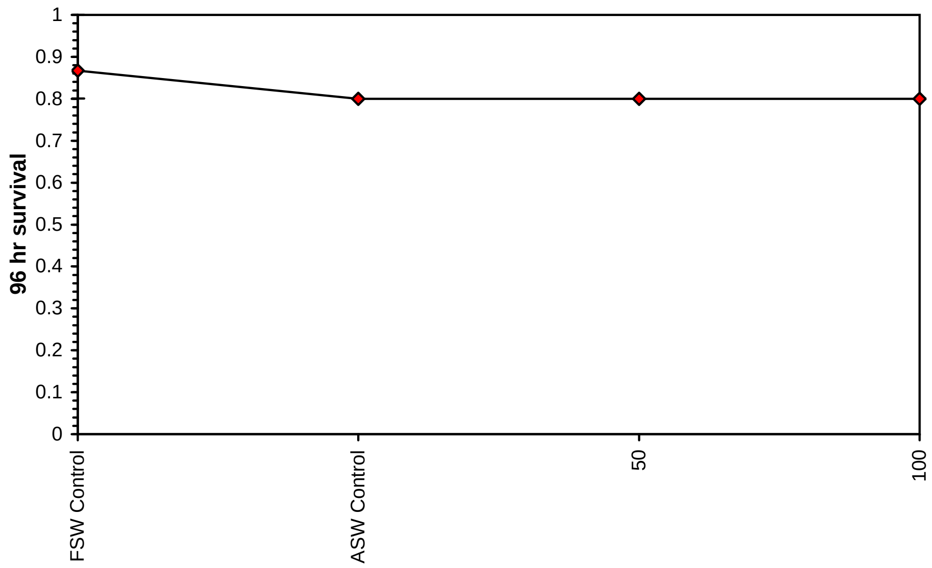
Start Date:	11/03/2011 14:00	Test ID:	PR0700/35	Sample ID:	Bore 1
End Date:	15/03/2011 14:00	Lab ID:	4581	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 108	Test Species:	ML-Melita Plumulosa
Comments:					

Conc-%	1	2	3
FSW Control	1.0000	0.8000	0.8000
ASW Control	0.8000	0.8000	0.8000
50	0.8000	0.8000	0.8000
100	0.8000	0.8000	0.8000

			Transform: Arcsin Square Root				
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N
FSW Control	0.8667	1.0833	1.1865	1.1071	1.3453	11.587	3
ASW Control	0.8000	1.0000	1.1071	1.1071	1.1071	0.000	3
50	0.8000	1.0000	1.1071	1.1071	1.1071	0.000	3
100	0.8000	1.0000	1.1071	1.1071	1.1071	0.000	3

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.05)	1	0.829		
Equality of variance cannot be confirmed				
The control means are not significantly different (p = 0.37)	1	2.776445		

Dose-Response Plot



Amphipod Acute Toxicity Test-96 hr survival

Start Date:	11/03/2011 14:00	Test ID:	PR0700/35	Sample ID:	Bore 1
End Date:	15/03/2011 14:00	Lab ID:	4581	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 108	Test Species:	ML-Melita Plumulosa
Comments:					

		Auxiliary Data Summary					
Conc-%	**Parameter**	**Mean**	**Min**	**Max**	**SD**	**CV%**	**N**
FSW Control	% Non-immobilised	86.67	80.00	100.00	11.55	3.92	3
ASW Control		80.00	80.00	80.00	0.00	0.00	3
50		80.00	80.00	80.00	0.00	0.00	3
100		80.00	80.00	80.00	0.00	0.00	3
FSW Control	pH	8.20	8.20	8.20	0.00	0.00	1
ASW Control		8.00	8.00	8.00	0.00	0.00	1
50		7.80	7.80	7.80	0.00	0.00	1
100		7.80	7.80	7.80	0.00	0.00	1
FSW Control	Salinity ppt	35.40	35.40	35.40	0.00	0.00	1
ASW Control		34.60	34.60	34.60	0.00	0.00	1
50		35.10	35.10	35.10	0.00	0.00	1
100		34.70	34.70	34.70	0.00	0.00	1
FSW Control	DO %	102.50	102.50	102.50	0.00	0.00	1
ASW Control		94.80	94.80	94.80	0.00	0.00	1
50		102.80	102.80	102.80	0.00	0.00	1
100		104.40	104.40	104.40	0.00	0.00	1

Amphipod Acute Toxicity Test-96 hr survival

Start Date:	24/02/2011 15:00	Test ID:	PR0700/30	Sample ID:	Bore 2
End Date:	28/02/2011 15:00	Lab ID:	4582	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 108	Test Species:	ML-Melita Plumulosa
Comments:					

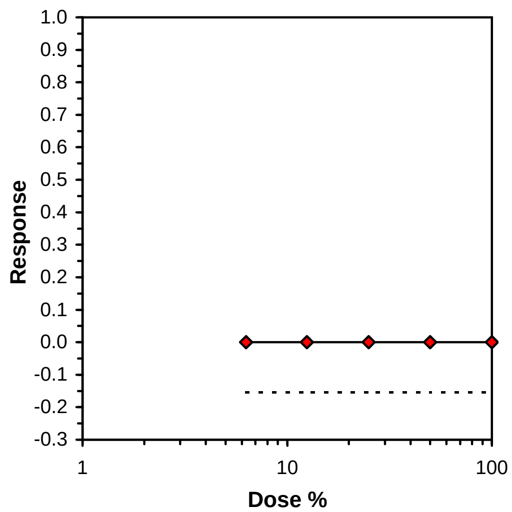
Conc-%	1	2	3
FSW Control	1.0000	1.0000	1.0000
ASW Control	1.0000	0.8000	0.8000
6.3	1.0000	1.0000	1.0000
12.5	1.0000	1.0000	1.0000
25	1.0000	1.0000	1.0000
50	1.0000	1.0000	1.0000
100	1.0000	1.0000	1.0000

			Transform: Arcsin Square Root						1-Tailed		Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD	Mean	N-Mean
FSW Control	1.0000	1.1538	1.3453	1.3453	1.3453	0.000	3					
ASW Control	0.8667	1.0000	1.1865	1.1071	1.3453	11.587	3	*			0.9778	1.0000
6.3	1.0000	1.1538	1.3453	1.3453	1.3453	0.000	3	-3.464	2.500	0.1146	0.9778	1.0000
12.5	1.0000	1.1538	1.3453	1.3453	1.3453	0.000	3	-3.464	2.500	0.1146	0.9778	1.0000
25	1.0000	1.1538	1.3453	1.3453	1.3453	0.000	3	-3.464	2.500	0.1146	0.9778	1.0000
50	1.0000	1.1538	1.3453	1.3453	1.3453	0.000	3	-3.464	2.500	0.1146	0.9778	1.0000
100	1.0000	1.1538	1.3453	1.3453	1.3453	0.000	3	-3.464	2.500	0.1146	0.9778	1.0000

Auxiliary Tests					Statistic		Critical		Skew	Kurt
Shapiro-Wilk's Test indicates non-normal distribution (p <= 0.05)					0.534673		0.897		1.893657	8.5
Equality of variance cannot be confirmed										
The control means are not significantly different (p = 0.12)					2		2.776445			
Hypothesis Test (1-tail, 0.05)	**NOEC**	**LOEC**	**ChV**	**TU**	**MSDu**	**MSDp**	**MSB**	**MSE**	**F-Prob**	**df**
Dunnett's Test	100	>100		1	0.088339	0.102783	0.012602	0.00315	0.022833	5, 12
Treatments vs ASW Control										

Log-Logit Interpolation (200 Resamples)

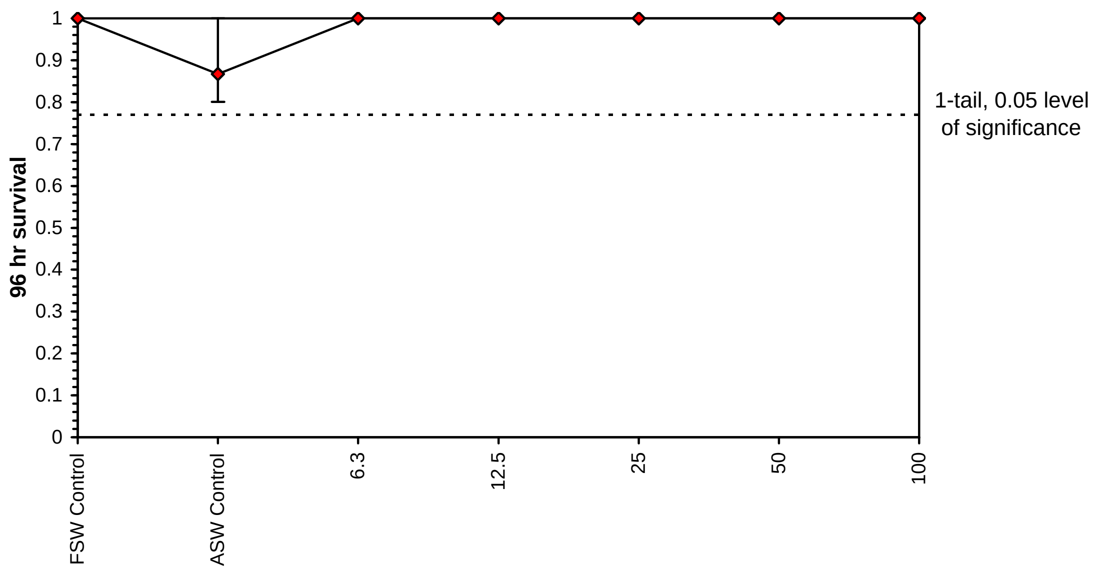
Point	%	SD	95% CL(Exp)	Skew
IC05	>100			
IC10	>100			
IC15	>100			
IC20	>100			
IC25	>100			
IC40	>100			
IC50	>100			



Amphipod Acute Toxicity Test-96 hr survival

Start Date:	24/02/2011 15:00	Test ID:	PR0700/30	Sample ID:	Bore 2
End Date:	28/02/2011 15:00	Lab ID:	4582	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 108	Test Species:	ML-Melita Plumulosa
Comments:					

Dose-Response Plot



Amphipod Acute Toxicity Test-96 hr survival

Start Date:	24/02/2011 15:00	Test ID:	PR0700/30	Sample ID:	Bore 2
End Date:	28/02/2011 15:00	Lab ID:	4582	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 108	Test Species:	ML-Melita Plumulosa
Comments:					

		Auxiliary Data Summary					
Conc-%	**Parameter**	**Mean**	**Min**	**Max**	**SD**	**CV%**	**N**
FSW Control	% Non-immobilised	100.00	100.00	100.00	0.00	0.00	3
ASW Control		86.67	80.00	100.00	11.55	3.92	3
6.3		100.00	100.00	100.00	0.00	0.00	3
12.5		100.00	100.00	100.00	0.00	0.00	3
25		100.00	100.00	100.00	0.00	0.00	3
50		100.00	100.00	100.00	0.00	0.00	3
100		100.00	100.00	100.00	0.00	0.00	3
FSW Control	pH	8.10	8.10	8.10	0.00	0.00	1
ASW Control		8.10	8.10	8.10	0.00	0.00	1
6.3		8.00	8.00	8.00	0.00	0.00	1
12.5		8.00	8.00	8.00	0.00	0.00	1
25		8.00	8.00	8.00	0.00	0.00	1
50		7.90	7.90	7.90	0.00	0.00	1
100		7.80	7.80	7.80	0.00	0.00	1
FSW Control	Salinity ppt	35.40	35.40	35.40	0.00	0.00	1
ASW Control		35.10	35.10	35.10	0.00	0.00	1
6.3		35.30	35.30	35.30	0.00	0.00	1
12.5		35.30	35.30	35.30	0.00	0.00	1
25		35.20	35.20	35.20	0.00	0.00	1
50		35.10	35.10	35.10	0.00	0.00	1
100		34.90	34.90	34.90	0.00	0.00	1
FSW Control	DO %	96.80	96.80	96.80	0.00	0.00	1
ASW Control		87.90	87.90	87.90	0.00	0.00	1
6.3		99.10	99.10	99.10	0.00	0.00	1
12.5		98.90	98.90	98.90	0.00	0.00	1
25		99.70	99.70	99.70	0.00	0.00	1
50		101.00	101.00	101.00	0.00	0.00	1
100		105.00	105.00	105.00	0.00	0.00	1

Amphipod Acute Toxicity Test-96 hr survival

Start Date:	3/03/2011 11:00	Test ID:	PR0700/33	Sample ID:	Bore 3
End Date:	7/03/2011 11:00	Lab ID:	4583	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 108	Test Species:	ML-Melita Plumulosa
Comments:					

Conc-%	1	2	3
FSW Control	1.0000	1.0000	0.8000
ASW Control	1.0000	1.0000	1.0000
6.3	1.0000	1.0000	1.0000
12.5	1.0000	1.0000	1.0000
25	1.0000	1.0000	1.0000
50	0.6000	0.8000	1.0000
100	0.6000	0.6000	0.8000

			Transform: Arcsin Square Root						1-Tailed		Number	Total
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD	Resp	Number
FSW Control	0.9333	0.9333	1.2659	1.1071	1.3453	10.861	3					
ASW Control	1.0000	1.0000	1.3453	1.3453	1.3453	0.000	3	*			0	15
6.3	1.0000	1.0000	1.3453	1.3453	1.3453	0.000	3	0.000	2.500	0.2190	0	15
12.5	1.0000	1.0000	1.3453	1.3453	1.3453	0.000	3	0.000	2.500	0.2190	0	15
25	1.0000	1.0000	1.3453	1.3453	1.3453	0.000	3	0.000	2.500	0.2190	0	15
*50	0.8000	0.8000	1.1128	0.8861	1.3453	20.637	3	2.654	2.500	0.2190	3	15
*100	0.6667	0.6667	0.9598	0.8861	1.1071	13.299	3	4.402	2.500	0.2190	5	15

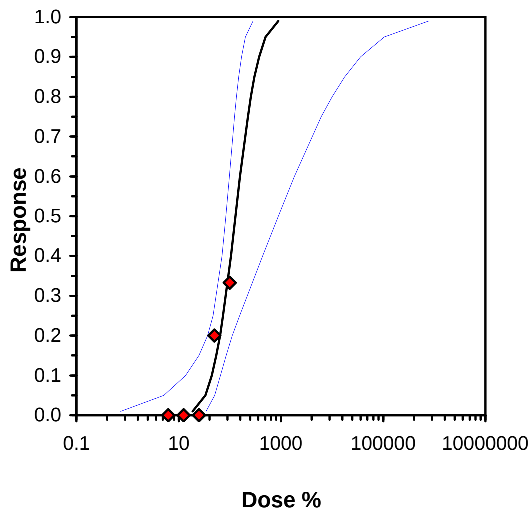
Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates non-normal distribution (p <= 0.05)	0.724391	0.897	0.298406	4.132287
Equality of variance cannot be confirmed				
The control means are not significantly different (p = 0.37)	1	2.776445		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU	MSDu	MSDp	MSB	MSE	F-Prob	df
Dunnett's Test	25	50	35.35534	4	0.134878	0.141976	0.083404	0.011505	0.002424	5, 12
Treatments vs ASW Control										

Maximum Likelihood-Probit

Parameter	Value	SE	95% Fiducial Limits		Control	Chi-Sq	Critical	P-value	Mu	Sigma	Iter
Slope	2.781279	1.021792	0.778567	4.783991	0	1.280418	7.814728	0.73	2.110796	0.359547	7
Intercept	-0.87071	1.864263	-4.52467	2.783245							
TSCR											

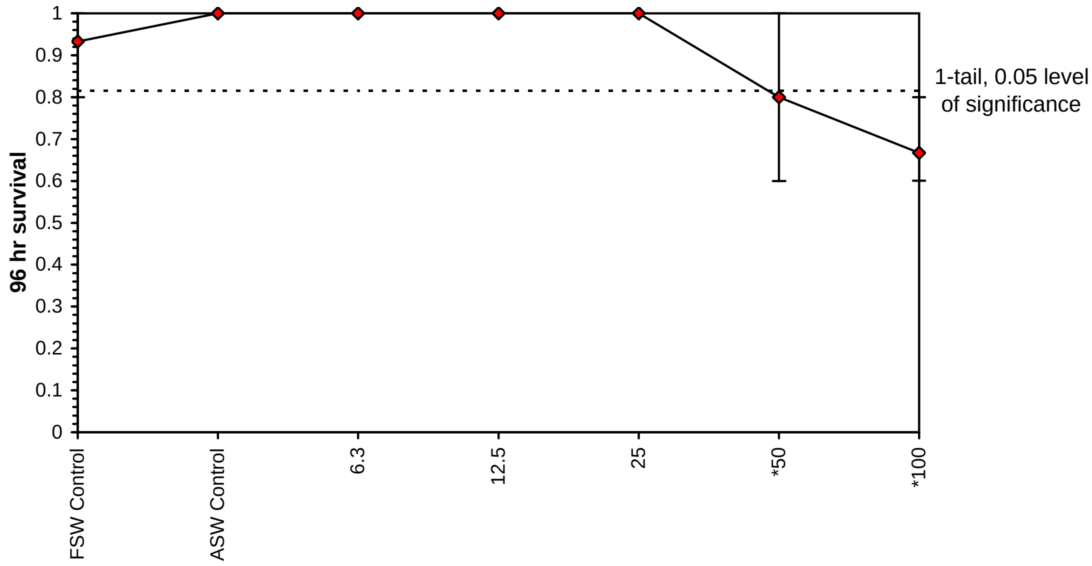
Point	Probits	%	95% Fiducial Limits	
EC01	2.674	18.80896	0.727728	34.23228
EC05	3.355	33.06692	5.127888	50.61014
EC10	3.718	44.6702	13.73971	65.88227
EC15	3.964	54.72041	24.89241	84.47898
EC20	4.158	64.2974	36.63315	112.1713
EC25	4.326	73.83886	47.12214	154.9287
EC40	4.747	104.6419	70.58775	440.1281
EC50	5.000	129.0612	83.81016	885.8714
EC60	5.253	159.179	97.56023	1818.668
EC75	5.674	225.5829	123.054	6135.95
EC80	5.842	259.0585	134.412	9980.23
EC85	6.036	304.3981	148.7302	17624.63
EC90	6.282	372.8836	168.6155	36115.26
EC95	6.645	503.7295	202.5447	104866.7
EC99	7.326	885.5777	284.2128	778550.3



Amphipod Acute Toxicity Test-96 hr survival

Start Date:	3/03/2011 11:00	Test ID:	PR0700/33	Sample ID:	Bore 3
End Date:	7/03/2011 11:00	Lab ID:	4583	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 108	Test Species:	ML-Melita Plumulosa
Comments:					

Dose-Response Plot



Amphipod Acute Toxicity Test-96 hr survival

Start Date:	3/03/2011 11:00	Test ID:	PR0700/33	Sample ID:	Bore 3
End Date:	7/03/2011 11:00	Lab ID:	4583	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 108	Test Species:	ML-Melita Plumulosa
Comments:					

		Auxiliary Data Summary					
Conc-%	**Parameter**	**Mean**	**Min**	**Max**	**SD**	**CV%**	**N**
FSW Control	% Non-immobilised	93.33	80.00	100.00	11.55	3.64	3
ASW Control		100.00	100.00	100.00	0.00	0.00	3
6.3		100.00	100.00	100.00	0.00	0.00	3
12.5		100.00	100.00	100.00	0.00	0.00	3
25		100.00	100.00	100.00	0.00	0.00	3
50		80.00	60.00	100.00	20.00	5.59	3
100		66.67	60.00	80.00	11.55	5.10	3
FSW Control	pH	8.10	8.10	8.10	0.00	0.00	1
ASW Control		8.10	8.10	8.10	0.00	0.00	1
6.3		8.10	8.10	8.10	0.00	0.00	1
12.5		8.10	8.10	8.10	0.00	0.00	1
25		8.00	8.00	8.00	0.00	0.00	1
50		7.90	7.90	7.90	0.00	0.00	1
100		7.70	7.70	7.70	0.00	0.00	1
FSW Control	Salinity ppt	35.50	35.50	35.50	0.00	0.00	1
ASW Control		34.50	34.50	34.50	0.00	0.00	1
6.3		35.60	35.60	35.60	0.00	0.00	1
12.5		35.40	35.40	35.40	0.00	0.00	1
25		35.30	35.30	35.30	0.00	0.00	1
50		35.00	35.00	35.00	0.00	0.00	1
100		34.50	34.50	34.50	0.00	0.00	1
FSW Control	DO %	97.80	97.80	97.80	0.00	0.00	1
ASW Control		96.00	96.00	96.00	0.00	0.00	1
6.3		100.20	100.20	100.20	0.00	0.00	1
12.5		99.60	99.60	99.60	0.00	0.00	1
25		100.50	100.50	100.50	0.00	0.00	1
50		99.90	99.90	99.90	0.00	0.00	1
100		76.30	76.30	76.30	0.00	0.00	1

Amphipod Acute Toxicity Test-96 hr survival

Start Date:	11/03/2011 14:00	Test ID:	PR0700/36	Sample ID:	Bore 4
End Date:	15/03/2011 14:00	Lab ID:	4584	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 108	Test Species:	ML-Melita Plumulosa
Comments:					

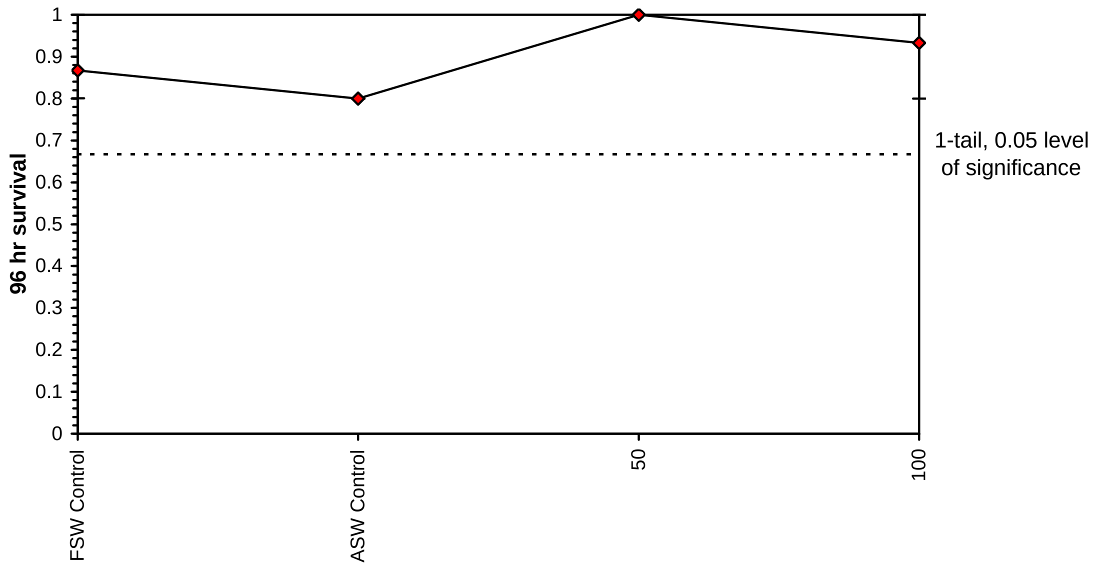
Conc-%	1	2	3
FSW Control	1.0000	0.8000	0.8000
ASW Control	0.8000	0.8000	0.8000
50	1.0000	1.0000	1.0000
100	1.0000	1.0000	0.8000

			Transform: Arcsin Square Root					1-Tailed		
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD
FSW Control	0.8667	1.0833	1.1865	1.1071	1.3453	11.587	3			
ASW Control	0.8000	1.0000	1.1071	1.1071	1.1071	0.000	3	*		
50	1.0000	1.2500	1.3453	1.3453	1.3453	0.000	3	-3.674	2.340	0.1517
100	0.9333	1.1667	1.2659	1.1071	1.3453	10.861	3	-2.449	2.340	0.1517

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates non-normal distribution (p <= 0.05)	0.728574	0.829	-1.48461	4
Equality of variance cannot be confirmed				
The control means are not significantly different (p = 0.37)	1	2.776445		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU	MSDu	MSDp	MSB	MSE	F-Prob	df
Dunnett's Test	100	>100		1	0.133171	0.166464	0.044106	0.006301	0.027	2, 6
Treatments vs ASW Control										

Dose-Response Plot



Amphipod Acute Toxicity Test-96 hr survival

Start Date:	11/03/2011 14:00	Test ID:	PR0700/36	Sample ID:	Bore 4
End Date:	15/03/2011 14:00	Lab ID:	4584	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 108	Test Species:	ML-Melita Plumulosa
Comments:					

		Auxiliary Data Summary					
Conc-%	**Parameter**	**Mean**	**Min**	**Max**	**SD**	**CV%**	**N**
FSW Control	% Non-immobilised	86.67	80.00	100.00	11.55	3.92	3
ASW Control		80.00	80.00	80.00	0.00	0.00	3
50		100.00	100.00	100.00	0.00	0.00	3
100		93.33	80.00	100.00	11.55	3.64	3
FSW Control	pH	8.20	8.20	8.20	0.00	0.00	1
ASW Control		8.00	8.00	8.00	0.00	0.00	1
50		7.80	7.80	7.80	0.00	0.00	1
100		7.80	7.80	7.80	0.00	0.00	1
FSW Control	Salinity ppt	35.40	35.40	35.40	0.00	0.00	1
ASW Control		34.60	34.60	34.60	0.00	0.00	1
50		34.60	34.60	34.60	0.00	0.00	1
100		34.70	34.70	34.70	0.00	0.00	1
FSW Control	DO %	102.50	102.50	102.50	0.00	0.00	1
ASW Control		94.80	94.80	94.80	0.00	0.00	1
50		103.70	103.70	103.70	0.00	0.00	1
100		103.10	103.10	103.10	0.00	0.00	1

Amphipod Acute Toxicity Test-96 hr survival

Start Date:	11/03/2011 14:00	Test ID:	PR0700/36	Sample ID:	Bore 5
End Date:	15/03/2011 14:00	Lab ID:	4585	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 108	Test Species:	ML-Melita Plumulosa
Comments:					

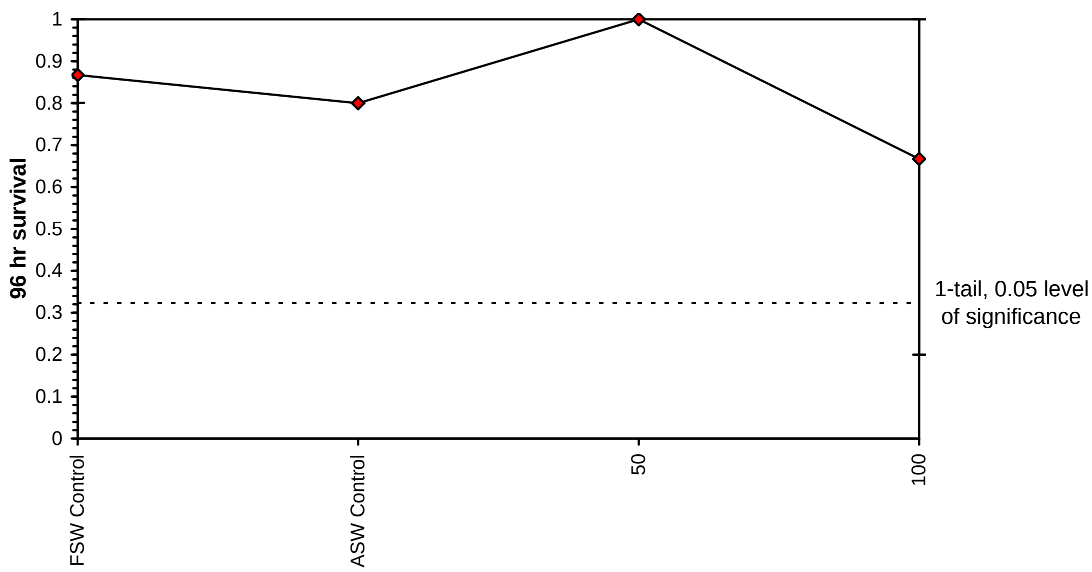
Conc-%	1	2	3
FSW Control	1.0000	0.8000	0.8000
ASW Control	0.8000	0.8000	0.8000
50	1.0000	1.0000	1.0000
100	0.2000	0.8000	1.0000

			Transform: Arcsin Square Root					1-Tailed		
Conc-%	**Mean**	**N-Mean**	**Mean**	**Min**	**Max**	**CV%**	**N**	**t-Stat**	**Critical**	**MSD**
FSW Control	0.8667	1.0833	1.1865	1.1071	1.3453	11.587	3			
ASW Control	0.8000	1.0000	1.1071	1.1071	1.1071	0.000	3	*		
50	1.0000	1.2500	1.3453	1.3453	1.3453	0.000	3	-1.108	2.340	0.5031
100	0.6667	0.8333	0.9720	0.4636	1.3453	46.921	3	0.628	2.340	0.5031

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates non-normal distribution (p <= 0.05)	0.761733	0.829	-1.04244	4
Equality of variance cannot be confirmed				
The control means are not significantly different (p = 0.37)	1	2.776445		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU	MSDu	MSDp	MSB	MSE	F-Prob	df
Dunnett's Test	100	>100		1	0.477401	0.596751	0.107143	0.069338	0.287538	2, 6
Treatments vs ASW Control										

Dose-Response Plot



Amphipod Acute Toxicity Test-96 hr survival

Start Date:	11/03/2011 14:00	Test ID:	PR0700/36	Sample ID:	Bore 5
End Date:	15/03/2011 14:00	Lab ID:	4585	Sample Type:	AQ-Aqueous
Sample Date:		Protocol:	ESA 108	Test Species:	ML-Melita Plumulosa
Comments:					

		Auxiliary Data Summary					
Conc-%	**Parameter**	**Mean**	**Min**	**Max**	**SD**	**CV%**	**N**
FSW Control	% Non-immobilised	86.67	80.00	100.00	11.55	3.92	3
ASW Control		80.00	80.00	80.00	0.00	0.00	3
50		100.00	100.00	100.00	0.00	0.00	3
100		66.67	20.00	100.00	41.63	9.68	3
FSW Control	pH	8.20	8.20	8.20	0.00	0.00	1
ASW Control		8.00	8.00	8.00	0.00	0.00	1
50		7.80	7.80	7.80	0.00	0.00	1
100		7.90	7.90	7.90	0.00	0.00	1
FSW Control	Salinity ppt	35.40	35.40	35.40	0.00	0.00	1
ASW Control		34.60	34.60	34.60	0.00	0.00	1
50		34.90	34.90	34.90	0.00	0.00	1
100		34.70	34.70	34.70	0.00	0.00	1
FSW Control	DO %	102.50	102.50	102.50	0.00	0.00	1
ASW Control		94.80	94.80	94.80	0.00	0.00	1
50		102.00	102.00	102.00	0.00	0.00	1
100		97.70	97.70	97.70	0.00	0.00	1

Appendix B BurrliOz Programme

SINCLAIR KNIGHT MERZ SKM

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BurrliOZ: a flexible approach to species protection

CSIRO Mathematical and Information Sciences

CSIRO

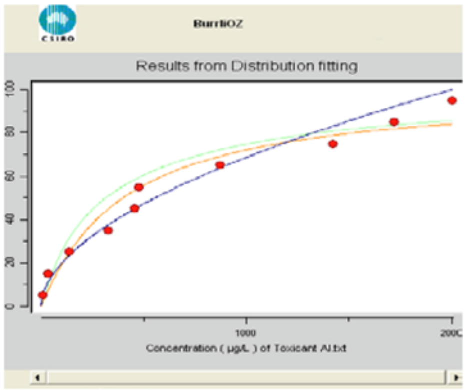
BurrliOZ is a statistical software package which enables environmental managers to generate trigger values for local conditions within Australia.

BurrliOZ is a statistical software package which enables environmental managers to generate trigger values for local conditions within Australia.

BurrliOZ uses a flexible family of distributions, the Burr Type III, to estimate the concentrations of chemicals such that a given percentage of species will survive.

Another software package that calculates trigger values using the Aldenberg and Slob (1993) approach exists, however this has been shown to be a special case of the approach implemented in BurrliOZ (Shao, 2000).

BurrliOZ was developed by CSIRO for Environment Australia.



> BurrliOZ screen capture.

Method

The protecting concentrations are estimated by fitting the Burr Type III distribution to the No Observed Effect Concentration (NOEC) data, collected for a range of species.

Other distributions are fitted to the data, including the log-normal and log-logistic as these are familiar to environmental managers.

However, they are provided only as a reference and are not used for the estimation of protecting concentrations.

The Burr III distribution is a very flexible three-parameter distribution, which can provide good approximations to many commonly used distributions such as the log-normal, log-triangular and Weibull.

The cumulative distribution function for the Burr III distribution is:

$$F(x) = \frac{1}{\left[1 + \left(\frac{b}{x}\right)^{c}\right]^{k}}$$

The three-parameters of the Burr III distribution, b, c, and k are estimated by maximum likelihood using the Nelder-Mead simplex algorithm, a derivative free optimisation technique.

A feature of the Burr Type III distribution is that as some of the parameters tend to limiting values the Burr Type III distribution tends to one of a set of limiting distribution (Shao, 2000). For example, as $k \rightarrow \infty$ the Burr III distribution tends to the reciprocal Weibull distribution. As $c \rightarrow \infty$ the Burr III distribution tends to the reciprocal Pareto distribution.

In practice, if k is estimated to be greater than 100 in a fit of the Burr distribution, then the parameter estimation is repeated, a reciprocal Weibull is fitted.

Similarly if c is estimated to be greater than 80 then the reciprocal Pareto distribution is fitted.

Estimating the protecting concentration

The protecting concentration, PC(q), is calculated from the Burr Type III distribution, or an associated limiting distribution.

The user requires the concentration corresponding to the statement that:

``q% of the species should be protected if the concentration of the chemical is less than the estimated protecting concentration''.

Thus, for a given value for q, the protecting concentration is estimated from the Burr III distribution fit as

$$PC(q) = \frac{b}{\left[\left(\frac{1}{1-q}\right)^{\frac{1}{k}} - 1\right]^{\frac{1}{c}}}$$

Typical values for q are 80, 85, 90 or 95.

Estimating a confidence interval for the protecting concentration

Unlike the estimation of the protecting concentration, there is no theoretically derived equation for estimating the lower bound of a confidence interval (CI) about the protecting concentration etimate, though Shao (1998) has shown that a delta method approximation works sometimes, particularly for large samples.

Instead, a technique known as bootstrapping is used to estimate the lower bound of the CI. Bootstrapping is a standard statistical approach in situations where theoretical results are difficult to obtain, or require unrealistic assumptions (Efron and Tibshirani, 1993).

To perform the bootstrapping, a new dataset of the same size as the original dataset is created by selecting values from the original set at random, but with replacement.

The PC(q) is estimated from this new dataset as above.

This process is repeated many times. This gives a large set of estimates for the PC(q) which, in essence, is a representation of the distribution of the PC(q).

The lower bound of a 90% confidence interval (for example) for the PC(q) can then be estimated by ordering all the PC(q) values and selecting the value that is ranked at 5%.

It should be noted that the estimated lower bound to the CI is based on a random sampling method and will not be exactly the same if the bootstrap procedure is repeated.

References

Aldenberg, T. and Slob, W. (1993). Confidence limits for hazardous concentrations based on logistically distributed NOEC toxicity data. Ecotoxicology and Environmental Safety, 25, 48-63

Efron, B. and Tibshirani, R.J. (1993). An introduction to the Bootstrap. New York: Chapman & Hall.

Shao, Q. (1998). Statistical Review and Assessment of Water Quality Guidelines, CSIRO Mathematical and Information Sciences Report No CMIS98/21

Shao, Q. (2000). Estimation for hazardous concentrations based on NOEC toxicity data: an alternative approach, Environmetrics. 11, 583-595.

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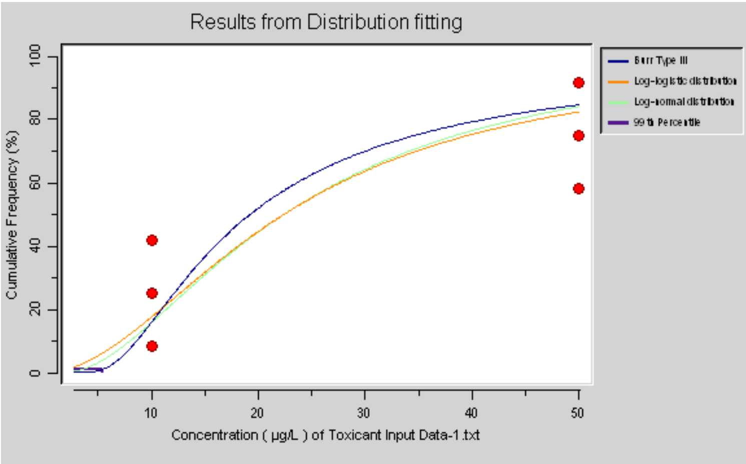
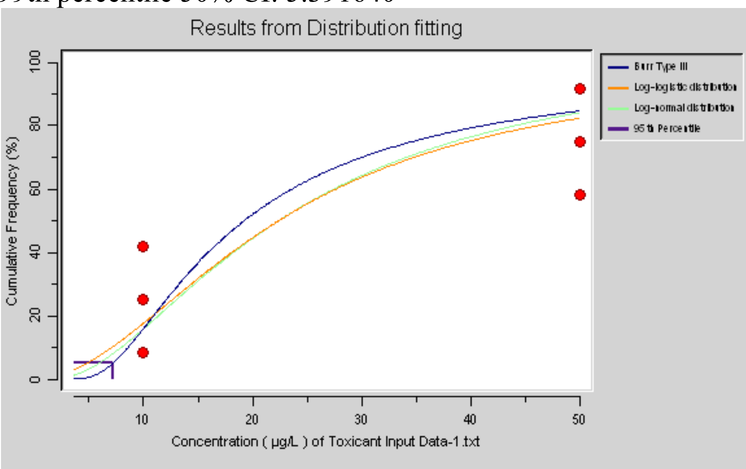
Download BurrliOZ from www.csiro.au/products/BurrliOZ

Appendix C BurrliOz Output Results

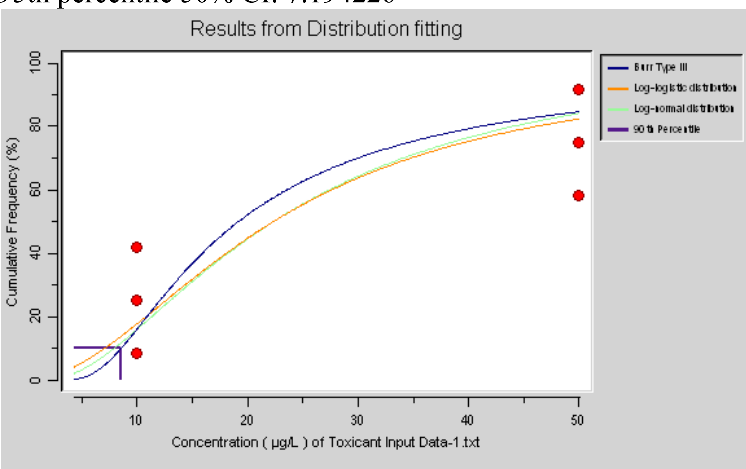
C.1 Borewater Sample 1



99th percentile 50% CI: 5.391640

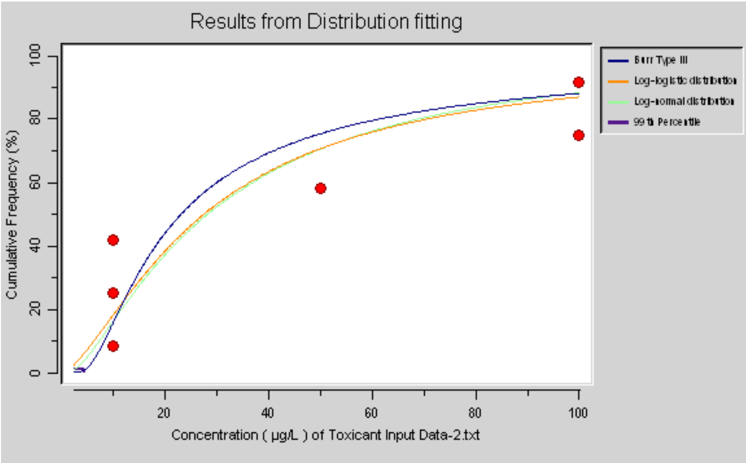


95th percentile 50% CI: 7.194226

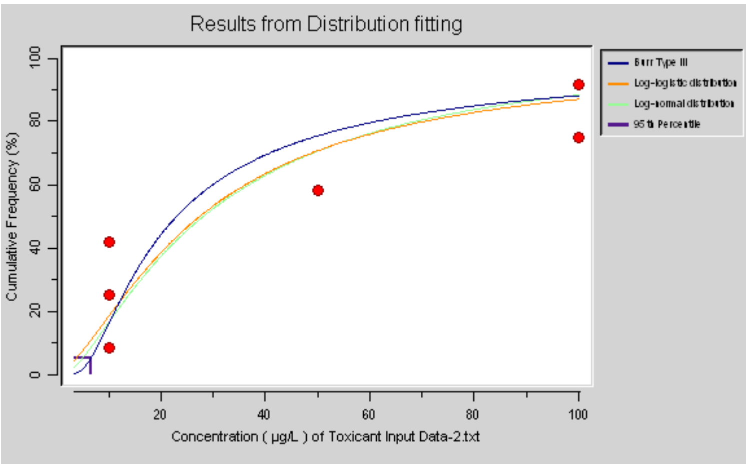


90th percentile 50% CI: 8.583129

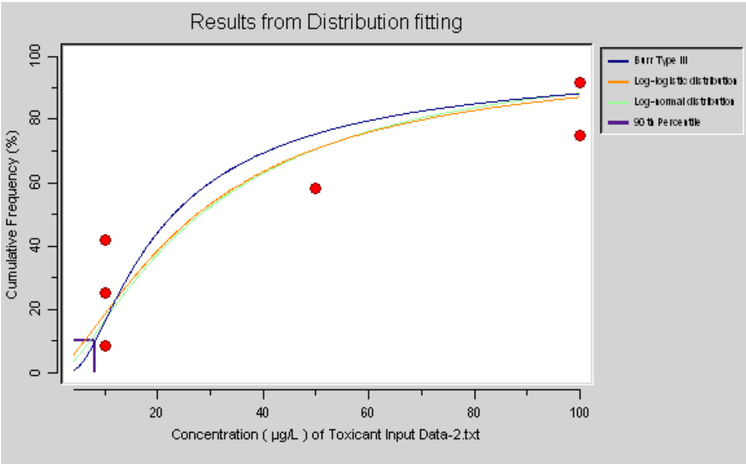
C.2 Borewater Sample 2



99th percentile 50% CI: 4.491416

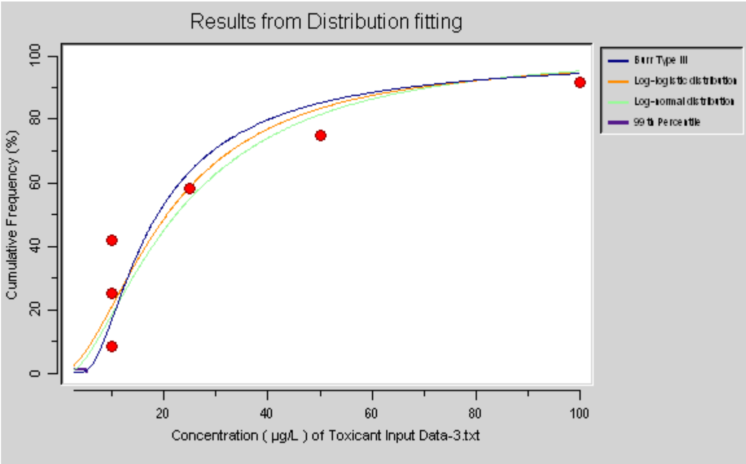


95th percentile 50% CI: 6.509545

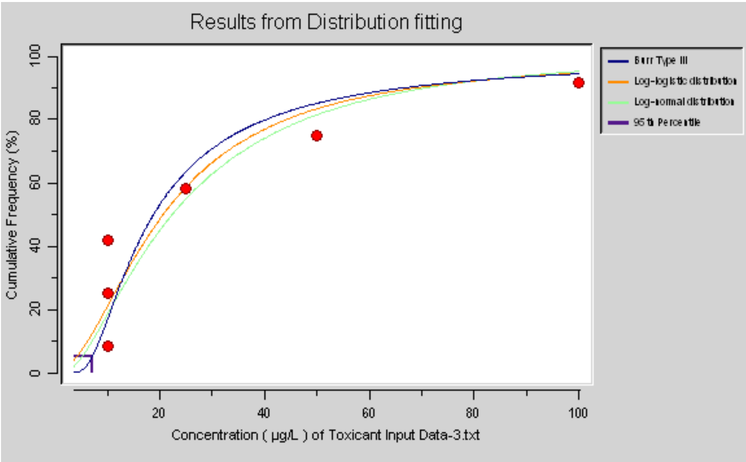


90th percentile 50% CI: 8.169316

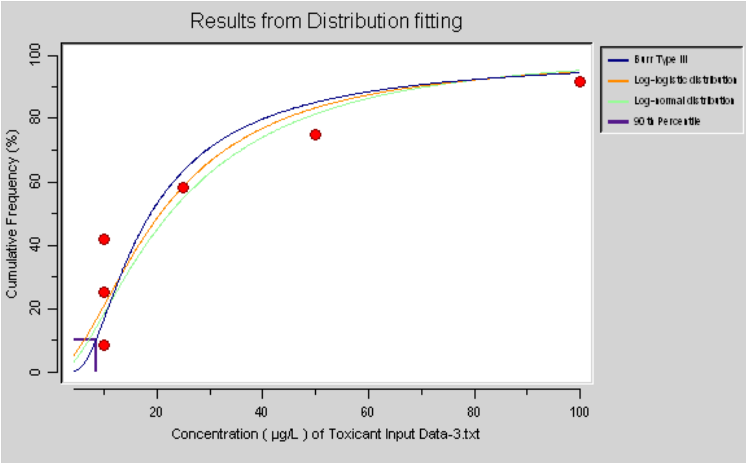
C.3 Borewater Sample 3



99th percentile 50% CI: 5.280032

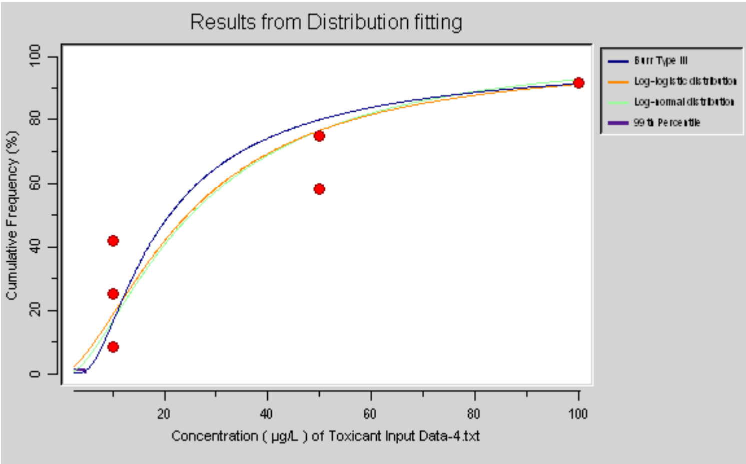


95th percentile 50% CI: 7.044146

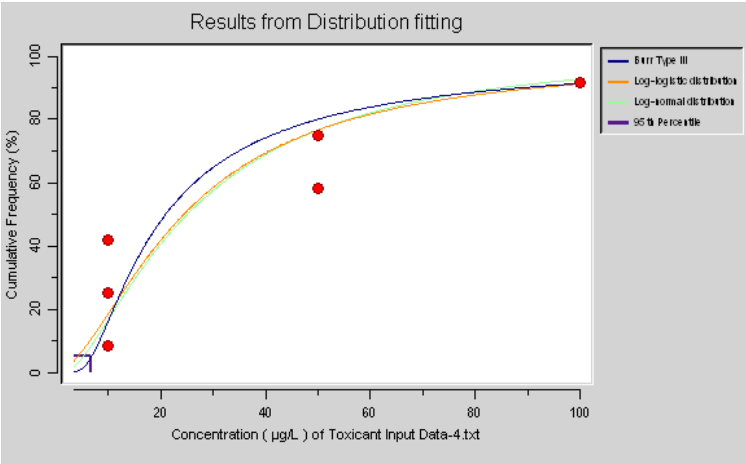


90th percentile 50% CI: 8.403231

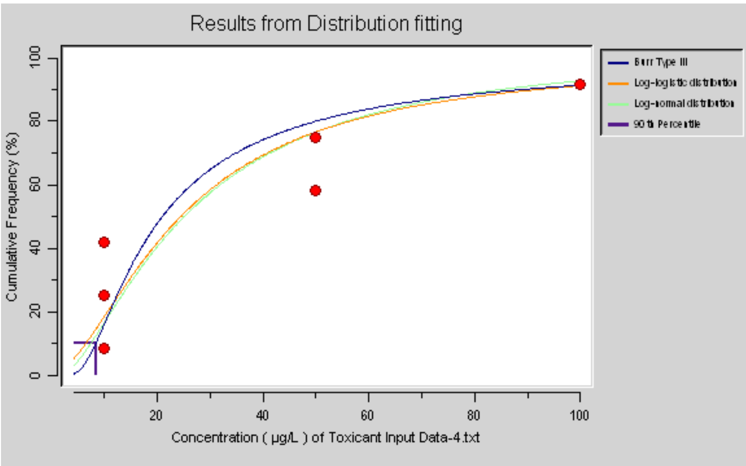
C.4 Borewater Sample 4



99th percentile 50% CI: 4.913440

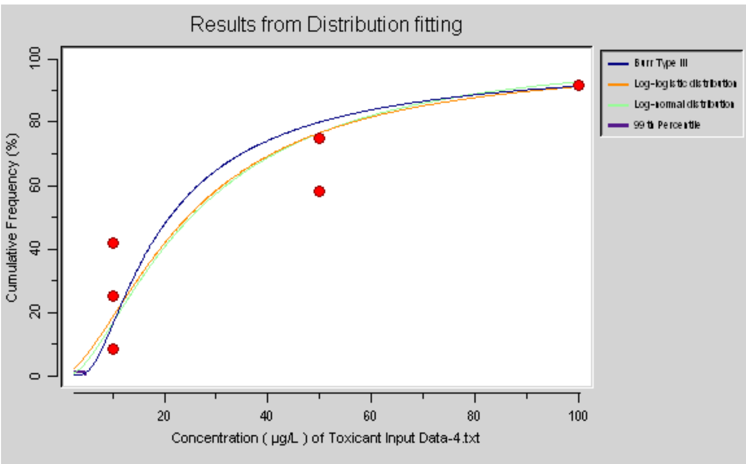


95th percentile 50% CI: 6.830409

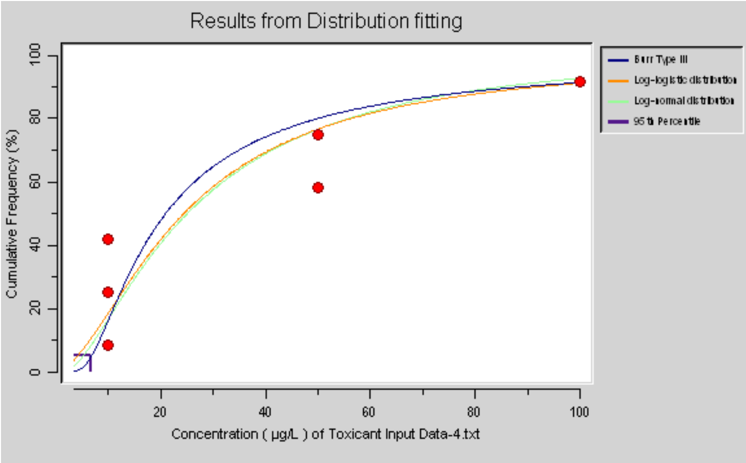


90th percentile 50% CI: 8.356043

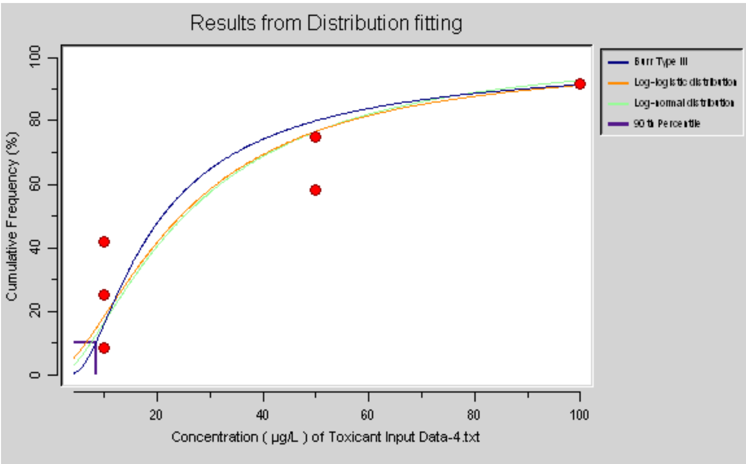
C.5 Borewater Sample 5



99th percentile 50% CI: 4.913440



95th percentile 50% CI: 6.830409



90th percentile 50% CI: 8.356043

Appendix D Salmon Creek Mixing Zone Modelling Report

SINCLAIR KNIGHT MERZ
SKM

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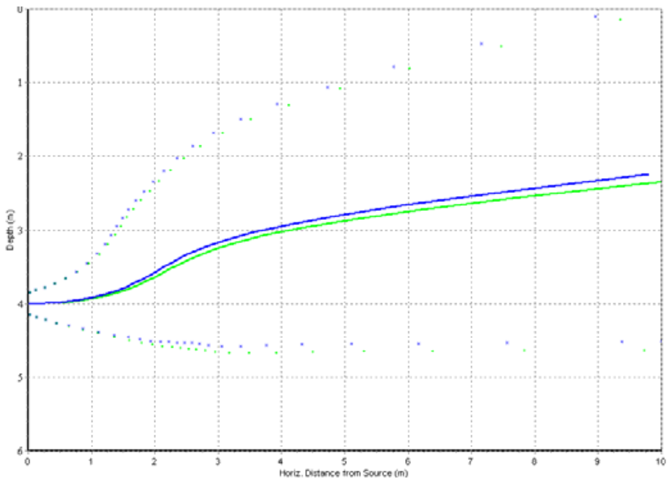

SALMON CREEK MIXING ZONE MODELLING

- Rev 0
- 7 October 2011

Outer Harbour Development

SALMON CREEK MIXING ZONE MODELLING

- Rev 0
- 7 October 2011

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Executive Summary

In order to excavate and construct infrastructure and facilities for the proposed car dumpers at Boodarie, BHP Billiton Iron Ore proposes to dewater groundwater and where practicable re-use the water for construction. Should the volume of water exceed construction demand, it is proposed to discharge the water into Salmon Creek. Dewatering may occur continuously for a period of approximately 9 to 12 months for each car dumper with up to a 12 month break between each dumper excavation. Up to 7 ML/day of groundwater could be abstracted during the first 12 months, and if not required for construction, would be piped overland to Salmon Creek and discharged.

Impacts to the marine environment of Salmon Creek may arise due to the presence of heavy metals and nutrients within the dewatering discharge. Groundwater chemistry analyses undertaken in 2010 have indicated that some heavy metal and nutrient levels in the groundwater are above the recommended 99% species protection trigger values for marine waters (ANZECC/ARMCANZ 2000). However, Salmon Creek experiences considerable flushing associated with large semi-diurnal tides and this flushing action and may likely result in a substantial dilution of contaminants within discharged groundwater within the initial zone of mixing in the receiving environment.

The objective of this study was to use near-field hydrodynamic modelling to define and demonstrate the initial dilution and extent of the mixing zone for chemicals of concern into the tidal flow in Salmon Creek. The chemicals of concern selected had concentrations above the ANZECC trigger levels. Those selected were chromium, silver, mercury and zinc. Although not a toxicant, nitrogen levels were also considered because of the potential for eutrophication of the receiving environment from high levels in the discharge water.

The simulation included neap and spring tidal scenarios in both the dry and wet season. For the purpose of this modelling, a worst case scenario of 7 ML/day of groundwater discharge has been assumed. Dilution conditions were assessed at various tidal water levels (0.5 m, 1 m, 2 m for both neap and spring tides and 3 m and 4 m in spring tide) and were compared between the dry and wet season when salinity and temperature conditions were slightly different.

An initial mixing zone of 3 to 4 metres was found to be sufficient to dilute the heavy metal concentrations to levels below the ANZECC trigger levels (99% of species) when the water depths were greater than 0.5 m. This is very small compared with the size of Salmon Creek (average width of 90 m). However, the tides in Salmon Creek have a strong influence on the depth of water in the creek. Under low tide conditions, the tide completely drains out of the Salmon Creek exposing the mudflats. It is under these conditions that the discharge may constitute the majority of the flow and therefore impact on the aquatic ecosystems through acute heavy metal toxicity. This would only affect the ecosystem present at the bottom of the channel, and should not impact on the mangroves or rocky reef areas that are higher up in the channel.

Nitrate-nitrite levels in the discharge are extremely high and are not adequately diluted to meet the ANZECC trigger levels for inshore ecosystems in the near-field mixing zone. This presents a risk of nutrient enrichment in the harbour environment.

Overall, the heavy metal Boodarie groundwater discharge is not anticipated to have a highly significant impact on the Salmon Creek receiving environment if no sensitive habitats are found to be present. Further modelling would be required to determine if continual high concentrations of nutrients entering the system over a long period of time would cause any negative impacts to the system.

Contents

Figures

Tables

Document history and status

Revision	Date issued	Reviewed by	Approved by	Date approved	Revision type
A	13/09/2011	D Dettrick	B Bonneville	13/09/2011	Technical Review
B	13/09/2011	C Wilson	S Harrison	19/09/2011	Technical Review
C	23/09/2011	C Wilson	S Harrison	23/09/2011	Draft for client review
D	06/10/2011	A de Vos	A de Vos	06/10/2011	Draft for client review
0	07/10/2011	A de Vos	A de Vos	07/10/2011	Final

Distribution of copies

Revision	Copy no	Quantity	Issued to
A	1	1 electronic	S Harrison
D	1	1 electronic	BHP Billiton Iron Ore (S Mavrick)
0	1	1 electronic	FAST and BHP Billiton Iron Ore (ADP)

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Author:	Dr Bonnie Bonneville; David Dettrick
Project manager:	Arne De Vos
Name of organisation:	SKM
Name of project:	Port Hedland Outer Harbour Development
Name of document:	Salmon Creek Mixing Zone Modelling
Document version:	Rev 0
Project number:	WV05024.140

1. Introduction

1.1. Overview

In order to excavate and construct infrastructure and facilities for the proposed car dumpers at Boodarie, BHP Billiton Iron Ore proposes to dewater groundwater and where practicable re-use the water for construction, should the volume of water exceed construction demand, it is proposed to discharge the water into Salmon Creek (SKM 2011). BHP Billiton Iron Ore are currently investigating the dewatering requirements. For the purpose of this modelling and impact assessment, a worst case scenario has been assumed. Dewatering may occur continuously for a period of approximately 9 to 12 months for each car dumper with up to a 12 month break between each dumper excavation. During the first 12 months up to 7 ML/day of abstracted groundwater could be abstracted, and if not required for construction, would be piped overland to Salmon Creek and discharged (SKM 2011), at the northern end of DMMA A, where discharge of supernatant water from dredge reclamation activities has taken place previously during the Harriet Point dredging programme (2009).

Impacts to the marine environment of Salmon Creek may arise due to the presence of heavy metals and/or nutrients within the dewatering discharge. Groundwater chemistry analyses undertaken in 2010 have indicated that some heavy metal and nutrient levels in the groundwater are above the recommended 99% species protection trigger values for marine waters (ANZECC/ARMCANZ 2000). Salmon Creek and other estuarine creeks of the Pilbara experiences considerable flushing associated with large semi-diurnal tides and this flushing action will result in a substantial dilution of contaminants within discharged dewatering water within the initial zone of mixing in the receiving environment.

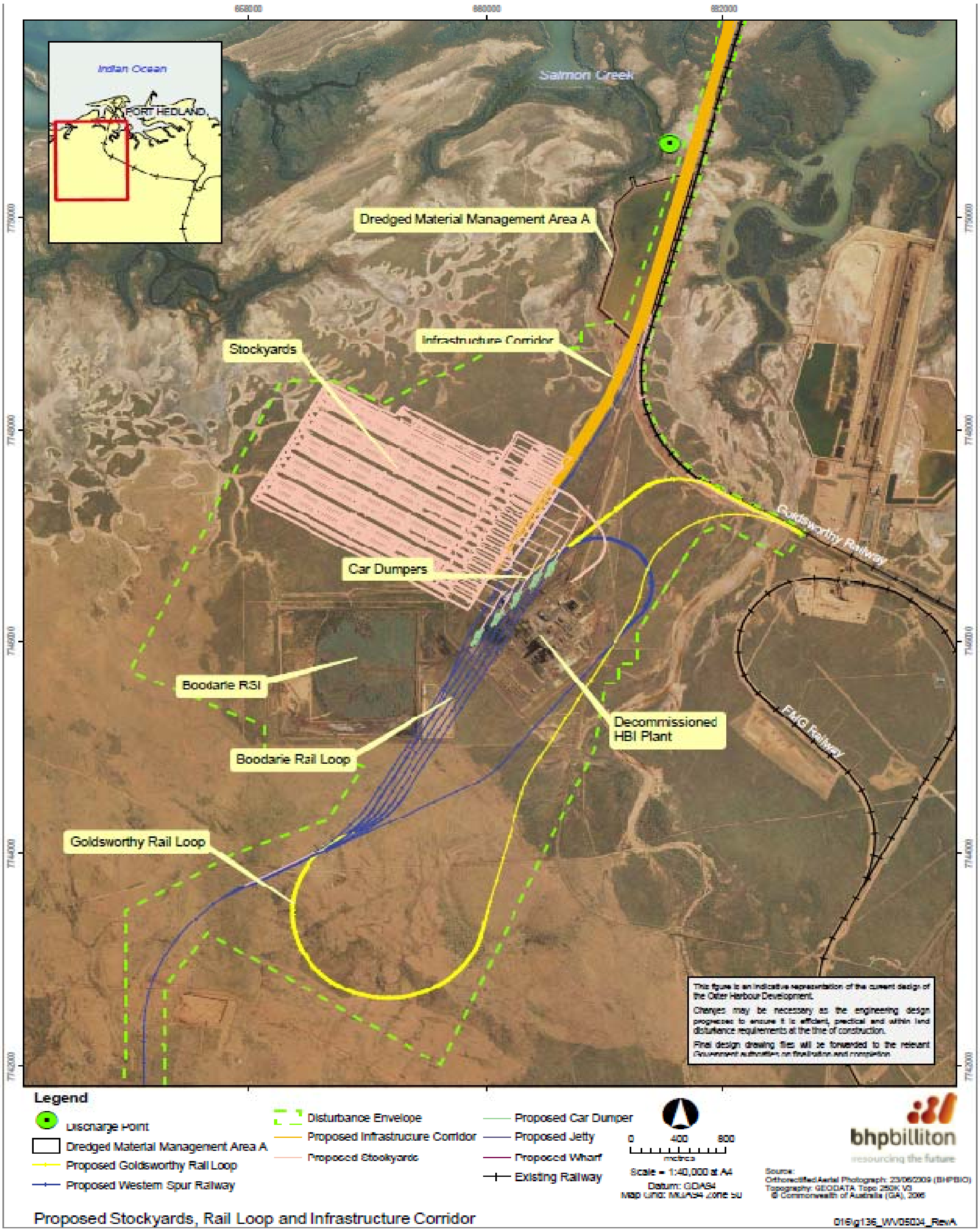
1.2. Project objective

The objective of this study is to use near-field hydrodynamic modelling to define and demonstrate the initial dilution and extent of the mixing zone for chemicals of concern in the mixing of the discharge into the tidal flow in Salmon Creek. The simulation includes a range of tidal scenarios.

2. Salmon Creek

2.1. Discharge location

The proposed discharge point is a located in the mid- reaches of Salmon Creek, which is a tributary of West Creek (**Figure 2-1**). This environment is separate from the Port Hedland inner harbour, due to the historic construction of a causeway from the mainland to Finucane Island. The freshwater inflows to Salmon Creek have not been quantified, but it is assumed that they would be small (increasing during the wet season) based on the small catchment size.



- **Figure 2-1 Map of the Boodarie Site and the proposed discharge location of dewatering discharges into Salmon Creek. (SKM 2011)**

The exact specifications of the discharge pipe, volume and locations will be confirmed following the hydrogeological site investigation being undertaken in November 2011. **Table 2-1** summarises the assumptions used for the purposes of this study. We are assuming that the discharge point will be located within the main flow path in Salmon Creek.

▪ **Table 2-1 Discharge pipe specifications**

Specification	Attribute
Discharge volume	7 ML/d
Discharge pipe diameter	0.3 m (assumed)
Discharge pipe elevation	0.3 m (assumed)
Discharge pipe angle	20 ° (vertical), 0° (horizontal) (assumed)
Discharge location	50 K 661515E; 7750696 S

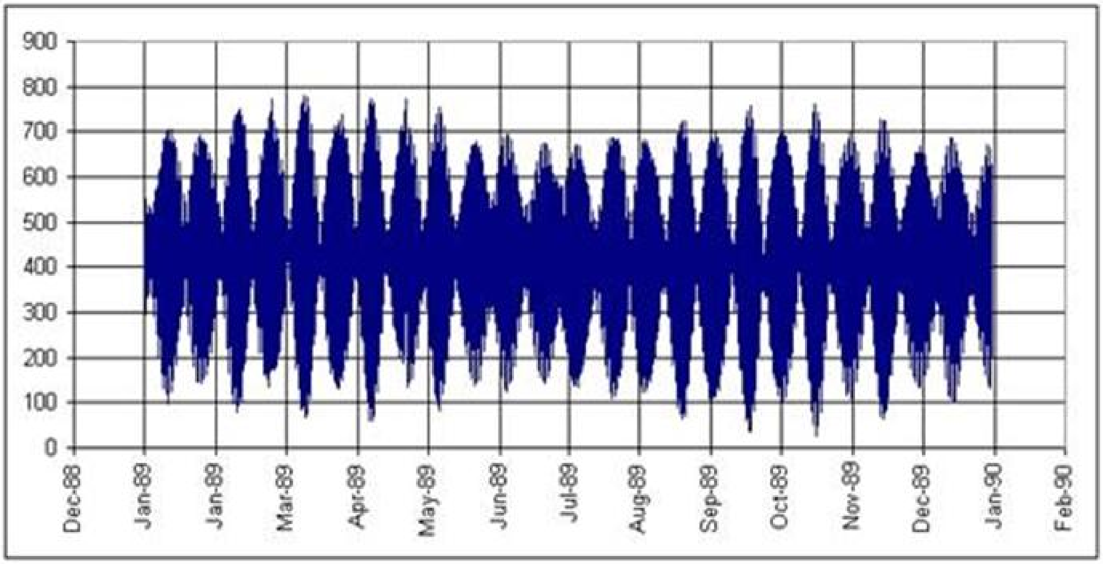
2.2. Tides, currents and bathymetry

The groundwater discharge point at Salmon Creek is situated in a macrotidal environment where extreme water level fluctuations occur twice daily during spring flooding tides and subsiding neap tides (**Table 2-2**). The tidal range can exceed five metres, with the potential to reach a maximum of eight metres during cyclonic events (PHPA 2008).

▪ **Table 2-2 Port Hedland Tide Station Tidal Planes (GEMS 2009)**

Tidal Plane	Level (to Lowest Astronomic Tide)	Level (to Mean Sea Level)
Highest Astronomic Tide	7.6m	+3.7m
Mean High Water Springs	6.7m	+2.8m
Mean High Water Neaps	4.6m	+0.7m
Mean Sea Level	3.9m	0.0m
Mean Low Water Neaps	3.2m	-0.7m
Mean Low Water Springs	0.9m	-3.0m
Lowest Astronomic Tide (LAT)	0.0m	-3.9m

The 28-day lunar spring-neap cycle is pronounced, with an average neap tide range of 1.4 m and average spring tide range of 5.8 m (**Figure 2-2**). This cycle is mildly influenced by the position of the solar equator, with the largest daily tide range experienced in March and September, near the vernal and autumnal equinoxes.



- **Figure 2-2 Recorded Water Levels 1989 (After GEMS 2009)**

No detailed bathymetry data were available for Salmon Creek at the discharge point. Instead, bathymetry data prepared by APASA (2009) on the tidal flushing of West Creek entrance was used to understand the channel bathymetry at the discharge point (**Figure 2-3**). The APASA (2009) bathymetry data was obtained from multiple sources to optimise coverage and resolution. For certain near-shore areas within West Creek, bathymetric data was acquired by BHP Billiton Iron Ore from an air-borne LiDAR survey. But, the LiDAR data did not cover the full domain and was augmented by field measurements carried out using a depth sounder. However, because of the incomplete coverage used to generate the data, the accuracy of the data was low over the mangrove areas, sand banks and mudflats; hence interpretation from aerial imagery was required in some areas beyond the extent of the LiDAR data (APASA 2009).

Using this information, it was determined that during a tidal height of 0 to 3 m the mudflats on Salmon Creek would be completely exposed and the small freshwater inflows would be the only water present to dilute the dewatering discharge. Above a tidal height of 3 m, the tidal water depth and inundated channel width was estimated for the tidal range in 1 m intervals (**Table 2-3**). The inundated area ranged from a width of 90 m at a depth of 2 m (typical of neap tide) to a width of 630 m at a depth of 4 m (highest astronomical tide).

Table 2-3 Tide height and the associated water depth and width (approximate) at the discharge point

Tide height (to LAT)	Water depth (m)	Water width (m)
0-3	0	0
4	1	45
5	2	90
6	3	270
7	4	630

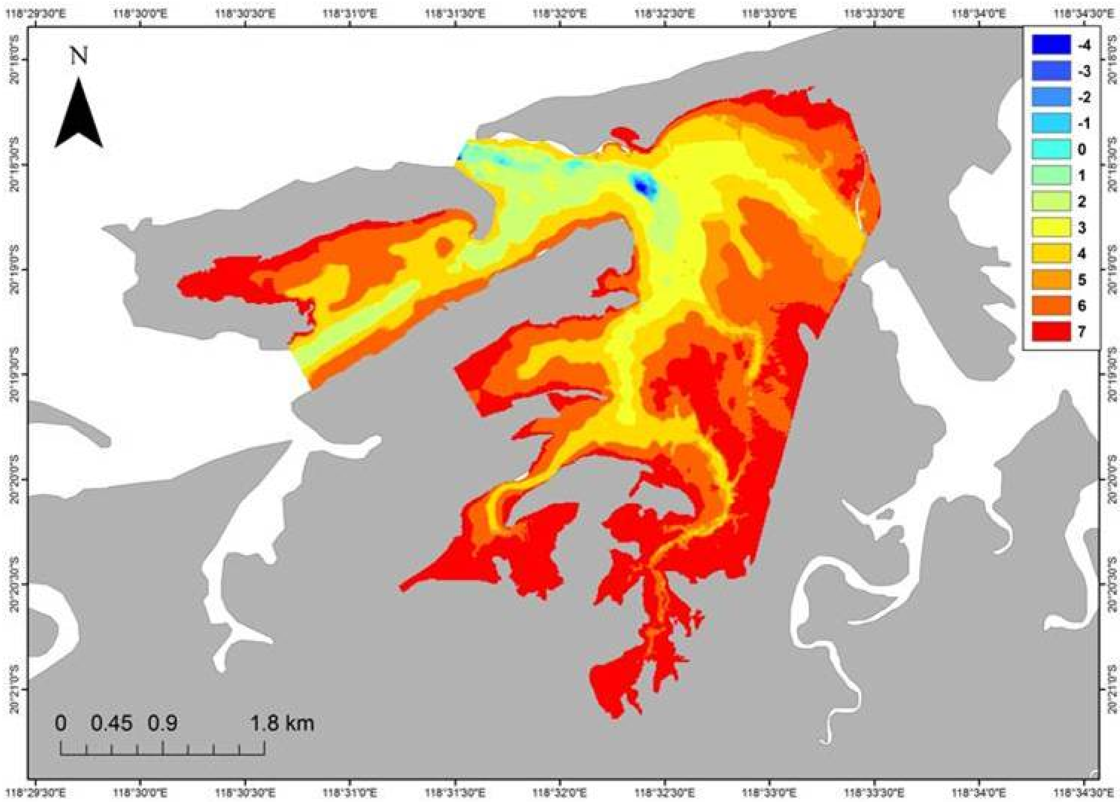


Figure 2-3 Bathymetry data (After APASA 2009)

The current speed at various stages in the tidal cycle was conservatively estimated based on the bathymetry and the tidal range due to the absence of current data at the discharge point (**Table 2-4**). The highest current speeds were estimated at 1 m/s during the start of the incoming tide and end of the outgoing tide. The slowest speeds were assumed to be 0.1 m/s at high tide.

- **Table 2-4 Tidal depth and current speed assumptions for each scenarios for input to Visual Plumes**

Scenarios	Current speed (m/s)			
	Dry Season (June - November)		Wet Season (December - May)	
Depth (m)	Neap	Spring	Neap	Spring
0	1	1	1	1
1	1	1	1	1
2	0.1	0.5	0.1	0.5
3	-	0.5	-	0.5
4	-	0.1	-	0.1
Max Channel width (m)	90	630	90	630

As Salmon Creek experiences strong flows due to the macrotidal regime, it is assumed that strong mixing occurs through the water column that minimises the potential for vertical density gradients to occur in the ambient system. Although rainfall in the region may be high, particularly associated with wet season (December - May) events including tropical cyclones, the catchment area is relatively small and the contribution of freshwater runoff to the density gradient is considered to be minor relative to the effect of tidal mixing (GEMS 2008). The effects of freshwater runoff on stratification patterns have therefore been omitted from the hydrodynamic modelling.

The near-field modelling takes into account potential density stratification due to differences between assumed ambient and discharged water density in the prediction of the final plume and mixing zone geometry.

2.3. Water quality in Salmon Creek

Only small amounts of point source water quality monitoring data were available for Salmon Creek. The available data shows that the water quality of the receiving environment at the discharge point varies with the tides and seasons. Upstream of the proposed discharge point, the estuarine water can back up into the freshwater reaches and concentrate in salinity during low freshwater inflow conditions from the Salmon Creek catchment. Salmon Creek can become hypersaline (ranging from 56 to 69 mS/cm) during the dry season (June - November). During the wet season, conductivities were lower (ranging from 54 to 56 mS/cm) (**Table 2-5**). The proposed discharge point is located in an area of the system that is well flushed and the water quality is not dissimilar from the downstream marine environment.

The background levels of ammonia and heavy metals were generally below the detection limit and complied with the ANZECC/ARMCANZ (2000) trigger values for 99% species (note: some of the laboratory detection limits were above the ANZECC/ARMCANZ (2000) guidelines). The exception was zinc levels, which marginally exceeded the ANZECC/ARMCANZ (2000) trigger value for 99% species protection in both the wet and dry season (**Table 2-5**).

Dissolved oxygen levels exceeded the upper trigger level of the ANZECC/ARMCANZ (2000) guidelines during the dry season. This indicates that the system is highly productive and it is possible that algal blooms/excessive biomass production occurs in backwaters and still water areas within the bay.

- **Table 2-5 Heavy metal concentrations in Salmon Creek at discharge point (SC5).**

Note: some of the laboratory detection limits were above the ANZECC/ARMCANZ (2000) guidelines

Heavy Metals (µg/L)	ANZECC Guidelines (99%)	Neap Tide		High Spring Tide	
		Dry season	Wet season	Dry season	Wet season
Silver	0.8	<1	1.2	<1	<5
Arsenic	4.5	2	<2	2.2	1.5
Cadmium	0.7	<0.1	<0.1	<0.1	<0.1
Chromium	7.7	<1	<1	<1	<1
Cobalt	0.005	<1	1.5	<1	<1
Copper	0.3	<1	<1	<1	<1
Mercury	0.1	<0.1	<0.1	<0.1	<0.1
Nickel	7	<1	<1	<1	<1
Lead	2.2	<1	<1	<1	<1
Vanadium	50	<10	7	<10	<10
Zinc	7	2	9	18	1
Other variables					
Ammonia (µg/L)	1-10	<3	<3	<3	
Turbidity (NTU)	1-20	13	nd	13	9
Electrical conductivity (mS/cm)	-	65	nd	55	56
Dissolved oxygen (%sat)	90-	150		140	85
Temperature (C)	-	26	30	26	30
pH	8.0-8.4	7.9		8.1	

Note: Data sourced from BHPBIO (2009). Highlighted cells shows elevated results compared to ANZECC trigger levels.
nd = no data.

3. Boodarie Dewatering Discharge

3.1. Discharge arrangement

For the purposes of this impact assessment a worse case scenario has been assumed. It is proposed that dewatering may occur continuously for a period of approximately 9 to 12 months for each car dumper with up to a 12 month break between each dumper excavation, and that the water is not used on site for construction purposes, which is the intent. During the first 12 months up to 7 ML/day (based on data available from previous car dumper dewatering undertaken on Finucane Island) of abstracted groundwater would be piped overland to Salmon Creek and discharged (SKM 2011).

The discharge will be delivered at the bottom of the water column of Salmon Creek at high tide, and onto tidal flats at low tide. The discharge location will experience periods of low tide in which sediments on the creek floor will be directly exposed to the discharge waters. However this should last only a few hours during a tidal cycle. The area receiving direct discharge will be scoured by the force of the discharge water, but the area of disturbance is predicted to be small (less than 10 m^2) (SKM 2011).

Potentially both physical and chemical impacts to the marine environment of Salmon Creek may occur as a result of the proposed dewatering activity.

Physical impacts include:

- a small area of scouring near the outfall in the receiving environment, and
- possible erosion of the banks of Salmon Creek with potential loss of mangrove habitat due to outfall pipeline construction.

Chemical impacts include:

- possible contaminants present within the dewatering discharge affecting resident fish and invertebrate communities.

The physical impacts are detailed in Chapter 10 of the Outer Harbour Development Public Environmental Review/Environmental Impact Statement (PER/EIS).

3.1.1. Boodarie groundwater quality

This study considers the chemical impacts of the discharge. The water quality of Salmon Creek was monitored during the Harriet Point dredging and port development project (2009) for baseline and during dredging operations (SKM 2009). The water quality of the groundwater at Boodarie was also monitored by BHP Boodarie Iron Plant, to meet their operating license conditions, which require surface and groundwater monitoring on a quarterly basis. Further testing of the groundwater was also conducted by SKM (2011).

The Boodarie groundwater differs from the receiving environment of Salmon Creek for a number of water quality parameters that could influence the water quality and ultimately impact the biota of the receiving environment. These included physical parameters (dissolved oxygen, pH and conductivity), metals (arsenic, chromium, mercury, selenium, silver, vanadium and zinc) and nutrients (nitrate-nitrite and filterable reactive phosphorus) (**Table 3-1**; **Table 3-2**) (SKM 2011). All Bores are brackish-saline with similar physicochemistry and nutrient concentrations. The exception is Bore 2, which is the only freshwater bore. Bore 2 has significantly higher nutrient levels, including ammonia, compared to the other bores.

- **Table 3-1 Physicochemistry and nutrients measured in the groundwater samples from Boodarie (from SKM 2011)**

Parameter	ANZECC Guideline	Bore 1	Bore 2	Bore 3	Bore 4	Bore 5	Bore 6	Bore 7	Bore 8	Bore 9	Bore 10	Bore 11
Electrical Conductivity (mS/cm)	–	24.0	1.0	23.0	36.0	24.0	76.0	45.0	36.0	31.0	40.0	58.0
pH	8.0 – 8.4	6.4	6.6	6.4	6.4	6.1	7.2	7.3	7.2	6.4	7.4	7.3
Dissolved Oxygen (% sat)	90	82.0	33.0	74.0	34.0	14.0	13.0	6.0	38.0	4.0	7.0	31.0
Temperature (ºC)	–	31.4	31.7	27.3	30.7	34.9	30.0	30.8	31.2	31.5	31.8	31.2
Turbidity (NTU)	1-20	1.8	14.0	5.4	0.7	1.7	1.5	1.4	2.4	1.0	5.4	16.0
Total Phosphorus (µg/L)	15	73	130	68	72	51	49	49	69	63	50	59
FRP (µg/L)	5	37	43	43	44	34	32	31	40	32	33	33
Total Nitrogen (mg/L)	0.1	8.20	24.0	3.60	1.70	4.00	1.00	0.85	1.40	1.90	0.94	0.78
NOx (mg/L)	0.008	7.60	18.0	3.30	1.70	2.00	0.90	0.70	1.40	1.90	0.89	0.70
NH_4 (µg/L)	1-10	<3	210	<3	<3	<3	<3	<3	<3	<3	<3	<3

Note: Samples taken Feb 2010. Values exceeded guidelines are highlighted.

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- **Table 3-2 Concentrations of Metals in Groundwater Samples Collected from Boreholes at the Boodarie Site (from SKM 2011)**

Parameter	Units	LOR	ANZECC guideline	No	Min	Max	Median	95th %ile
Arsenic[a]	µg/L	0.4	4.5	11	<0.4	6.6	1.0	5.3
Cadmium	µg/L	0.6	0.7	11	<0.6	-	-	-
Chromium[b]	µg/L	1.0	7.7	43	2	72	19	62.8
Cobalt[c]	µg/L	0.2	1.0	11	<0.2	1.0	1.0	1.0
Copper[c]	µg/L	1.0	1.3	11	<1.0	-	-	-
Lead	µg/L	0.2	2.2	11	<0.2	0.6	0.4	0.58
Mercury	µg/L	0.1	0.1	33	<0.1	1.4	0.4	1.24
Nickel	µg/L	7.0	7.0	36	<1.0	37	13	24.8
Selenium[a]	µg/L	0.5	3.0	31	2	26	12	22
Silver	µg/L	0.1	0.8	11	<0.1	16.2	4.5	13.5
Vanadium	µg/L	2.0	50	38	4	63	9.5	52
Zinc	µg/L	2.0	7.0	47	9	400	43	167

Note: a – Low reliability trigger value; b – Value for chromium III; c – 95% species protection limit
Values exceeding guidelines are highlighted.

3.1.2. Ecotoxicity

Ecotoxicity testing undertaken for SKM (2011) determined that the groundwater samples (proxy for discharge water) were not toxic to sea urchin fertilization, amphipods or fish, but were moderately toxic to microalgae, sea urchin and rock oyster larval development (SKM 2011). A 1:20 dilution would be required to achieve 99% species protection (**Table 3-3**).

- **Table 3-3 Species Protection Trigger Values (After SKM 2011)**

Species Protection Level	Trigger Values	
	% of Borewater	Dilution
99%	5.0	1:20
95%	6.9	1:15
90%	8.4	1:12

- Derived from toxicity results and the BurrliOz program.

3.1.3. Required dilutions

Salmon Creek experiences considerable flushing associated with large semi-diurnal tides and this flushing action should provide a substantial dilution of contaminants within discharged dewatering water within the initial zone of mixing in the receiving environment (SKM 2011). The level of dilution required to lower the 95th percentile of discharge heavy metal concentrations to below the ANZECC (99% species) trigger levels is 1:24 (**Table 3-4**).

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- **Table 3-4 Dilution required of heavy metals and nutrients in dewatering discharge to achieve ANZECC/ARMCANZ (2000) 99% Species Protection**

Parameter	Units	ANZECC/ ARMCANZ 99% species	No.	Min.	Max.	Median	95th %ile	Dilution required
As[a]	µg/L	4.5		<0.4	6.6	1.0	5.3	1
Cd	µg/L	0.7	11	<0.6	-	-	-	<1
Cr[a]	µg/L	7.7	43	2	72	19	62.8	8
Co	µg/L	1.0	11	<0.2	1.0	1.0	1.0	<1
Cu	µg/L	1.3	11	<1.0	-	-	-	<1
Pb	µg/L	2.2	11	<0.2	0.6	0.4	0.58	<1
Hg	µg/L	0.1	33	<0.1	1.4	0.4	1.24	12
Ni	µg/L	7.0	36	<1.0	37	13	24.8	4
Se[b]	µg/L	3.0	31	2	26	12	22	7
V	µg/L	50	38	4	63	9.5	52	1
Zn	µg/L	7.0	47	9	400	43	167	24
Ag	µg/L	0.8	11	<0.1	16.2	4.5	13.5	17
TP	µg/L	15	11	49	130	63	101.5	7
FRP	µg/L	5	11	31	44	34	43.5	9
TN	mg/L	0.100	11	0.780	24.0	1.70	16.1	161
NOx	mg/L	0.008	11	0.700	18.0	1.70	12.8	1600

** Practical Quantitation Limit a Value for chromium III.b Low reliability trigger value.*

The expected nutrient levels in the dewatering discharge are extremely high compared to the ANZECC guidelines for tropical Australia (**Table 3-4**). No background nutrient data is available. Nutrients are not regarded as toxicants (except ammonia). However, high nutrient levels lead to eutrophication, where nuisance macroalgae and microalgae grow in abundance in place of the natural flora (SKM 2011). The high concentrations of nutrients in the discharge would contribute significant amounts of nitrogen and phosphorus to Salmon Creek in the vicinity of 5 kg of available phosphorus and 519 kg of available nitrogen per year (SKM 2011).

The ANZECC (2000) toxicant guidelines are not intended to be used as 'pollute to' levels in waterways. The dilutions required should also consider the background concentrations in Salmon Creek, therefore, a dilution of up to 1:125 is required to achieve background concentrations for heavy metals (**Table 3-5**). This is based on chromium levels which are below detection in Salmon Creek (<1µg/L) compared to a discharge quality of 62.8 µg/L. Mercury levels also require a 1:30 dilution to achieve background levels, which were also below the detection limit of 0.1 µg/L.

- **Table 3-5 Dilution required of 95th percentile heavy metal concentrations in dewatering discharge (see Table 3-4; SKM 2011) to comply with background concentrations in Salmon Creek (see Table 2-5; BHPBIO 2009) at discharge point**

Parameter (µg/L)	ANZECC	Neap tide (dry)	Neap tide (wet)	High spring tide (dry)	High spring tide (wet)	Average	Discharge quality	Dilution required
As	4.5	2	<2	2.2	1.5	1.93	5.3	2.8
Cd	0.7	<0.1	<0.1	<0.1	0.3	0.11	0.3	2.7
Cr	7.7	<1	<1	<1	<1	0.50	62.8	125
Co	0.005	<1	1.5	<1	0.5	0.75	1	1.3
Cu	0.3	<1	<1	<1	<1	0.50	0.5	1.0
Pb	2.2	<1	<1	<1	5	1.63	0.58	0.4
Hg	0.1	<0.1	<0.1	<0.1	<0.1	0.05	1.24	25
Ni	7	<1	1.5	<1	2	1.13	3.5	3.1
Se	3.0	No data						
Ag	0.8	<1	1.2	<1	5	1.80	13.5	7.5
V	50	5	7	4	0.5	4.13	36.5	8.8
Zn	7	2	9	18	1	7.50	12.5	1.7

In summary, the ecotoxicology analysis indicated that a 1:20 dilution is the minimum requirement to achieve 99% species protection of species found in Salmon Creek. However, the dilutions required to achieve both background and ANZECC guidelines are provided in **Table 3-6**. The main chemicals of concern are chromium, silver, mercury and zinc. These were selected as the levels in the discharge significantly exceeded both the ANZECC guidelines and background concentrations. The extent of the mixing zone in Salmon Creek required to dilute these heavy metals to suitable levels is assessed in the next section. Although not a toxicant, nitrogen levels are also considered because of the potential for eutrophication of the receiving environment from high levels in the discharge water.

- **Table 3-6 Summary of dilutions required by dewatering discharge to achieve background and ANZECC levels at the 95th percentile.**

Red and maroon highlights indicate significant dilutions required for chemicals of concern for the receiving environment to meet ANZECC guidelines and background levels respectively.

Parameter	Dilution required for background	Dilution required for ANZECC	Parameter	Dilution required for background	Dilution required for ANZECC
As	2.8	1.2	Se	Nd	7
Cd	2.7	<1	Ag	**7.5**	**17**
Cr	**125**	**8**	V	**8.8**	1
Co	1.3	<1	Zn	1.7	**24**
Cu	1.0	<1	TP	Nd	7
Pb	<1	<1	FRP	Nd	9
Hg	**25**	**12**	TN	Nd	**161**
Ni	3.1	4	NOx	Nd	**1600**

4. Method

4.1. Visual plumes

Visual Plumes (VP) was the near-field hydrodynamic modelling package selected for the analysis. Visual Plumes is a windows-based computer application that simulates single and merging aquatic plumes in the near-field in arbitrarily stratified ambient flow (Frick *et al.* 2003), which is supported by the US EPA. Model predictions include dilution, rise, diameter and other plume variables. Among its features are graphics, time-series input files, user specified units, a conservative tidal background-pollutant build-up capability and a sensitivity analysis capability.

The model was set up based on the following assumptions:

1) The outfall is a simple end of pipe outfall at depth in the main flow path of channel. There is no diffuser.
2) At high tide there will be a mixing zone. At low tide there will be insufficient flow for dilution and the discharged water may form a surface flow down the thalweg of the creek channel.

The model was run for two tidal scenarios:

- Spring tide (4 m max. depth); and
- Neap tide (2 m max. depth).

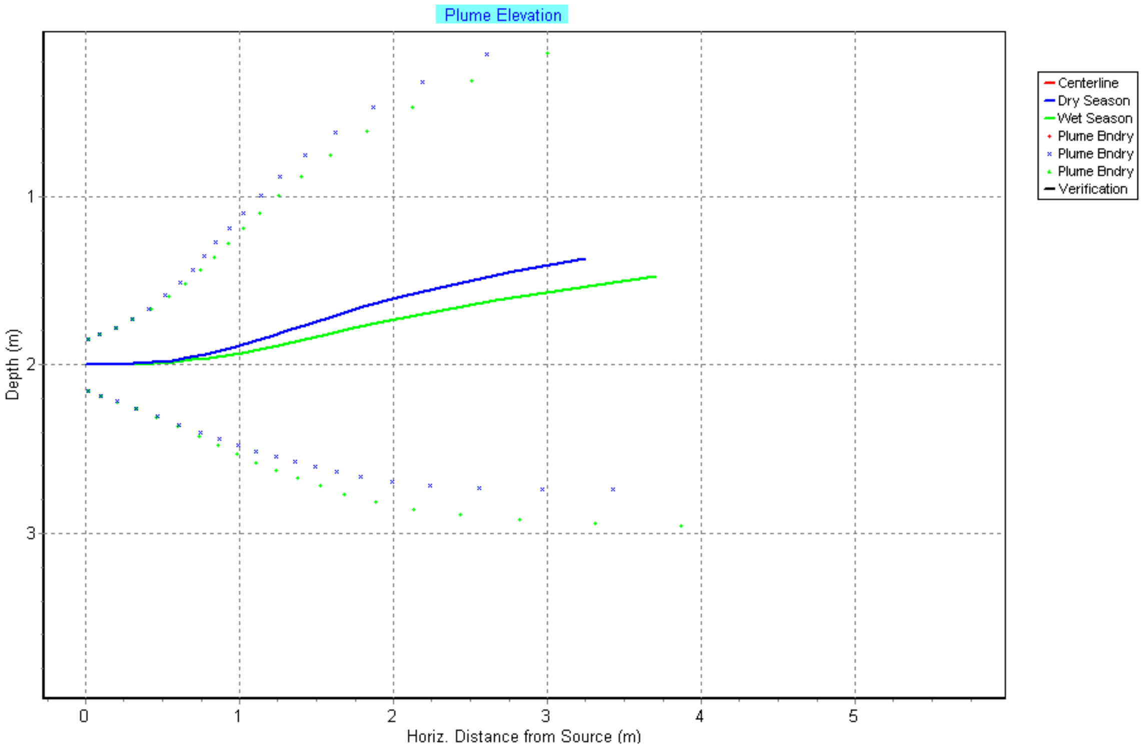
Dilution conditions were assessed at various depths (0.5 m, 1 m, 2 m for both tidal scenarios and 3 m and 4 m in spring tide) and were compared between the dry and wet season when salinity and temperature conditions were slightly different (**Table 4-1**).

- **Table 4-1 Salinity and temperature conditions for the model in the wet and dry season**

	Dewatering discharge quality	Dry season		Wet season	
		Spring tide	Neap tide	Spring tide	Neap tide
Temperature (°C)	31	26	26	30	30
Salinity (psu)	22.6	37	44	36	37

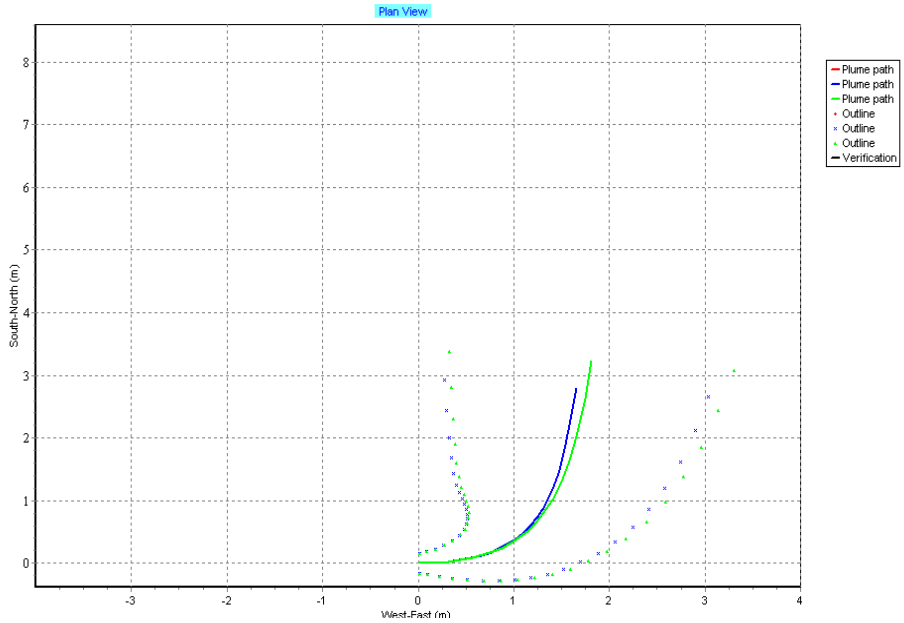
Only the downstream (positive) tidal direction was modelled on the assumption that the incoming tide (negative direction) would be symmetrical to the downstream direction at the same absolute velocities. The near-field model does not take into account possible far-field accumulation upstream or in the bay/backwaters downstream. This should be further investigated.

The visual plumes output provides four plots that shows (1) the plume elevation in terms of horizontal distance away from the outfall (**Figure 4-1**), (2) the plan view of the dispersal path of the plume (**Figure 4-2**), (3) the dilution curve as a function of distance from the outfall (**Figure 4-3**) and (4) the density gradient indicating the mixing of the plume through the water column (**Figure 4-4**). 'Average' represents the average of the plume. 'Centre line' represents the middle (most concentrated) section of the plume.



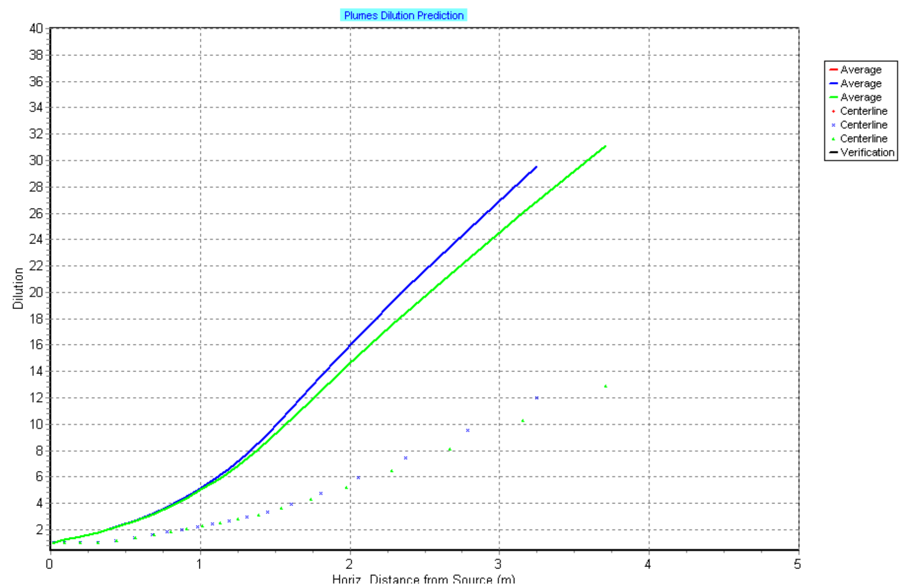
- **Figure 4-1 Horizontal distance of the plume from the outfall assuming a tidal depth of 2m.**

Note : This shows that complete mixing of the plume is achieved within 3.5 m of the outfall. The blue line represents the dry season and the green line the wet season.



- **Figure 4-2 Plan view of the plume from the outfall showing the path of the plume away from the outfall assuming a tidal depth of 2m.**

Note : The blue line represents the dry season and the green line the wet season.



- **Figure 4-3 Dilution prediction of the plume as a factor of the distance away from the outfall assuming a tidal depth of 2m.**

Note : The blue line represents the dry season and the green line the wet season. Maximum dilution is achieved about 3.5 m from the outfall.

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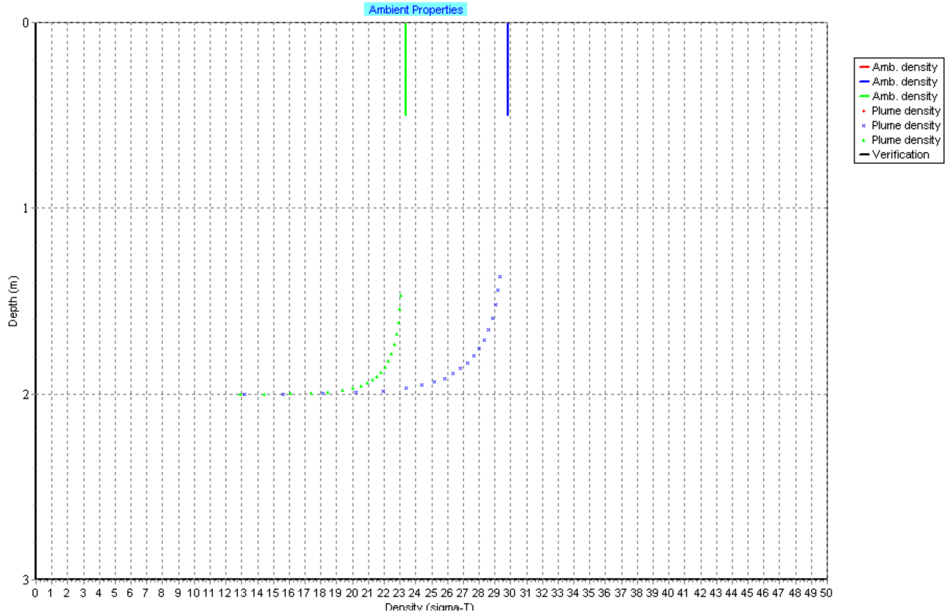


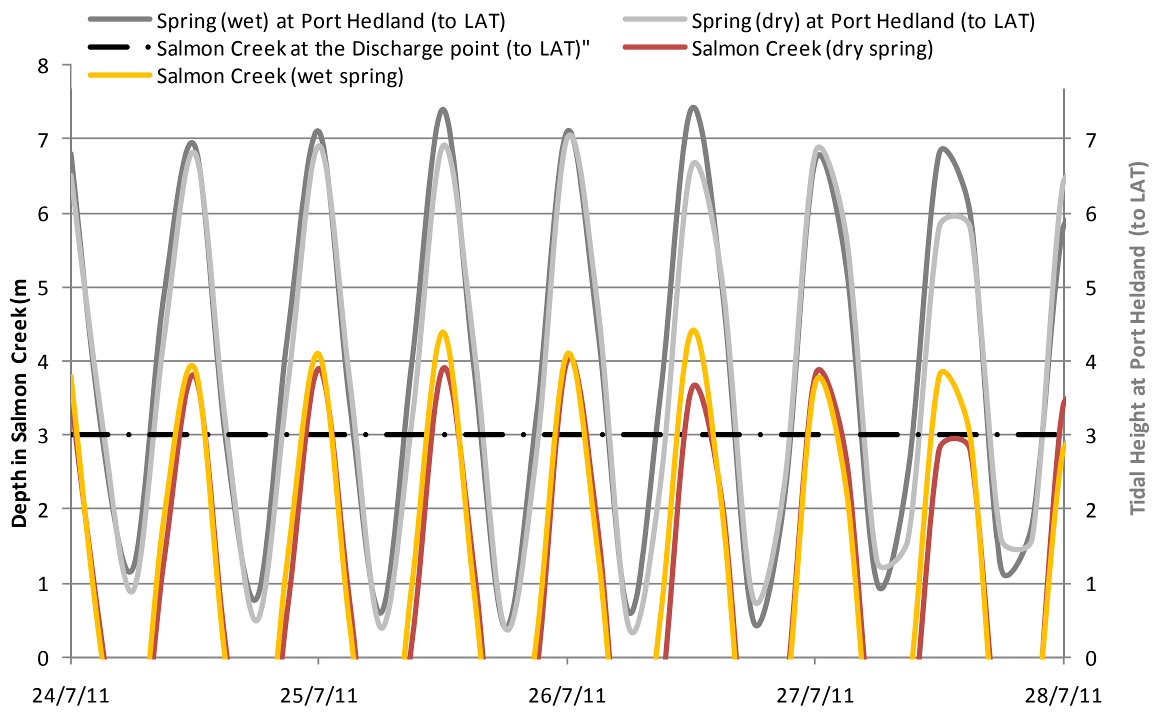
- **Figure 4-4 The density gradient of the plume as it changes with depth water depth to demonstrate the mixing of the plume through the water column of the receiving environment assuming a tidal depth of 2m.**

Note: The blue line represents the dry season and the green line the wet season. The density of the water in Salmon Creek is higher during the dry season because the water is more saline and colder than during the wet season.

5. Results

5.1. Tidal depths

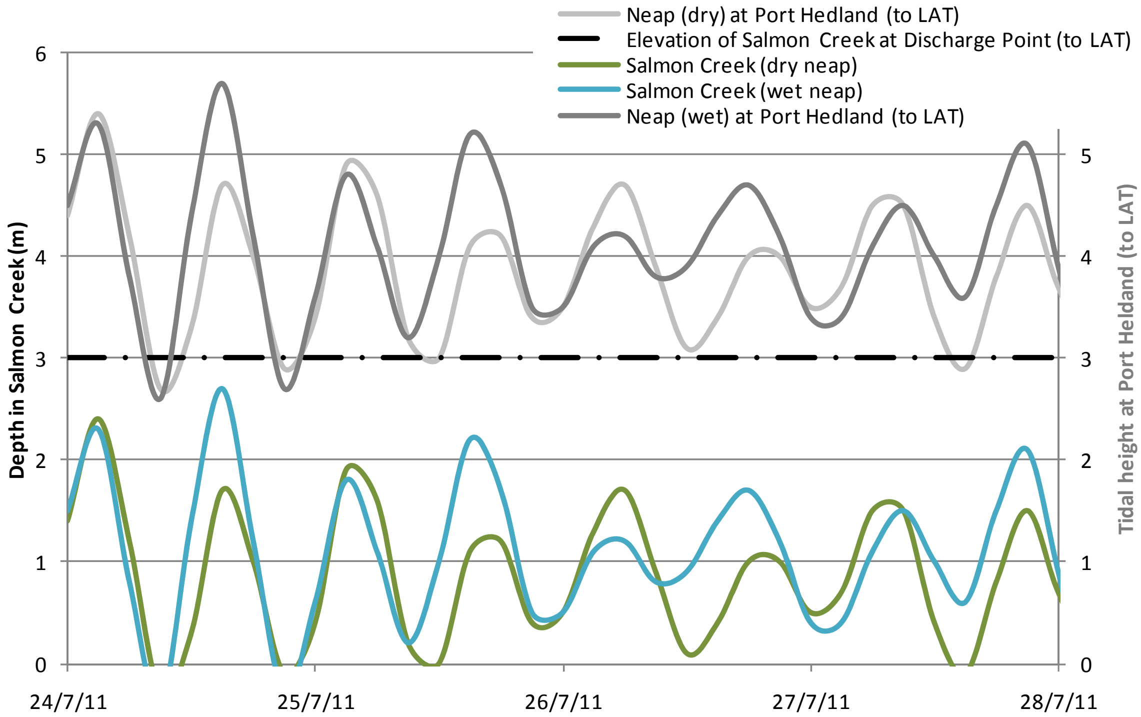
The tidal depths in Salmon Creek have been estimated using the bathymetry and tidal height record at Port Hedland for representative tides in the dry season (30/8/11- 4/9/11) and wet season (20/3/11-25/3/11) (see **Section 2.2**). The tide is assumed to flood into to Salmon Creek when the Port Hedland tidal height is greater than 3 m (**Figure 5-1**). The resultant spring tidal range is from 0 to 4 m in Salmon Creek.



■ **Figure 5-1 Water depths in Salmon Creek under a spring tide**

Note : simulated based on tidal data from http://tides.willyweather.com.au/wa/pilbara/port-hedland.html for five days in the wet season and five days in the dry season.

For neap tides, the tidal depths in Salmon Creek were estimated from representative neap tides in the dry season (24/7/11- 29/7/11) and wet season (13/3/11-18/3/11). The neap tidal depth at Salmon Creek ranges from 0 m to just above 2 m (**Figure 5-2**). Water is present in Salmon Creek for a higher proportion of the time in the neap tide scenario compared with the spring tide.



■ **Figure 5-2 Water depths in Salmon Creek under a neap tide**

Note : simulated based on tidal data from http://tides.willyweather.com.au/wa/pilbara/port-hedland.html for five days in the wet season and five days in the dry season.

5.2. Mixing Zone dilution

This section presents the results of the near-field hydrodynamic modelling used to define and demonstrate the initial dilution and extent of the mixing zone for the chemicals of concern from the discharge into the tidal flow in Salmon Creek. The main chemicals of concern are chromium, silver, mercury, zinc, total nitrogen and nitrate-nitrite as the levels in the discharge significantly exceed both the ANZECC guidelines and background levels.

5.2.1. Chromium

The concentration of chromium in the discharge is 63 µg/L (95th percentile), which exceeds the ANZECC (2000) trigger value of 7.7 µg/L for the protection of 99% species in marine waters. For the 95th percentile concentration of chromium, the dilution required in the receiving environment to comply with the ANZECC trigger level is 1:8 (**Table 5-1**).

Table 5-1 Model inputs

Chromium	ANZECC 99% trigger (ppb)	Discharge quality (ppb)	Ambient levels (ppb)				Dilution Required (95% ile)	
			Neap (dry)	Spring (dry)	Neap (wet)	Spring (wet)	ANZECC	Backgnd
95th percentile	7.7	63	0.5	0.5	0.5	0.5	1:8	1:125
Median		19					1:2.5	1:38
Maximum		72					1:9	1:144

Modelling of the 95th percentile chromium dilution levels under spring and neap tides in both the dry and wet seasons shows that the desired level of dilution is achievable under all conditions (**Table 5-2**). The one exception where the required dilution may not be met is when the depth of water is less than 0.5 m, which will occur under low tide conditions.

Table 5-2 Modelling results for 95th percentile Chromium levels

Depth (m)	Dry Season				Wet Season			
	Neap tide		Spring tide		Neap tide		Spring tide	
	Mixing zone (m)	Max dilution (distance)	Mixing zone (m)	Max dilution (distance)	Mixing zone (m)	Max dilution (distance)	Mixing zone (m)	Max dilution (distance)
<0.5	Not Achv		Not Achv		Not Achv		Not Achv	
0.5	1	1:7.5 (1)	1.1	1:8 (1.1)	1.2	1:8 (1.2)	1.1	1:8 (1.1)
1.0	1	1:20 (3.3)	1	1:27 (6)	1	1:22 (4)	1	1:27 (6)
2.0	1.3	1:30 (3.2)	1	1:53 (8.8)	1.3	1:31 (3.7)	1	1:53 (8.8)
3.0	-	-	1	1:75 (14)	-	-	1	1:75 (14)
4.0	-	-	1.8	1.88 (10)	-	-	1.75	1.88 (10)

The extent of the mixing zone is less than 2 m around the discharge outfall. The mixing zone is greater at a depth of 4 m compared to other depths due to the low velocity of the current during high tide and the slower mixing of the discharge through the water column. The mixing zone is less during the dry season because the Salmon Creek water is denser (more saline) and colder than during the wet season, which causes the discharge to rise more rapidly through the water column due to lighter relative density of the dewater discharge to the heavier marine water.

The median concentration of chromium in the discharge is 19 µg/L, which also exceeds the ANZECC (2000) trigger value of 7.7 µg/L for the protection of 99% species in marine waters. For chromium, the dilution required in the receiving environment to comply with the ANZECC trigger level is 1:2.5. This level of dilution is achieved under all conditions, except under low tide (<0.5m depth) when the estuary exists only as a small channel of any freshwater flows from the catchment

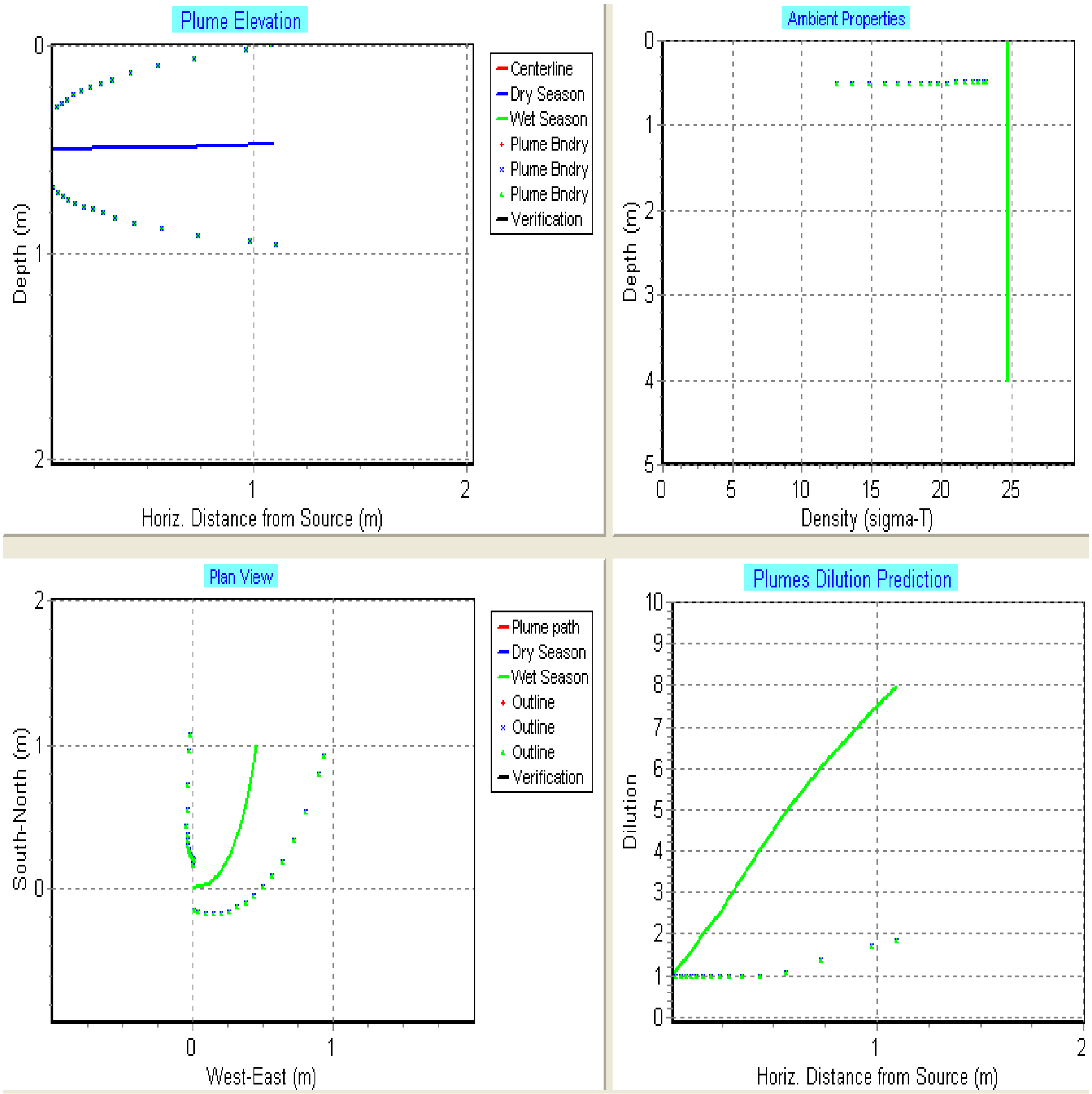
(**Table 5-3**). The catchment inflows may be very small, or non-existent, during the dry season, therefore there may be no dilution of the discharge under these conditions.

▪ **Table 5-3 Modelling results for median Chromium levels**

Depth (m)	Dry Season				Wet Season			
	Neap tide		Spring tide		Neap tide		Spring tide	
	Mixing zone (m)	Max dilution (distance)	Mixing zone (m)	Max dilution (distance)	Mixing zone (m)	Max dilution (distance)	Mixing zone (m)	Max dilution (distance)
<0.5	Not Achv		Not Achv		Not Achv		Not Achv	
0.5	0.25	1:7.5 (1)	0.25	1:8 (1.1)	0.25	1:8 (1)	0.25	1:8 (1.1)
1.0	0.2	1:20 (3.2)	0.25	1:26 (6)	0.2	1:22 (4)	0.25	1:26 (6)
2.0	0.5	1:30 (3.2)	0.3	1:54(8.5)	0.5	1:31 (3.6)	0.3	1:54(8.5)
3.0	-	-	0.3	1:75 (14)	-	-	0.3	1:75 (14)
4.0	-	-	0.75	1:90 (10)	-	-	0.25	1:200 (37)

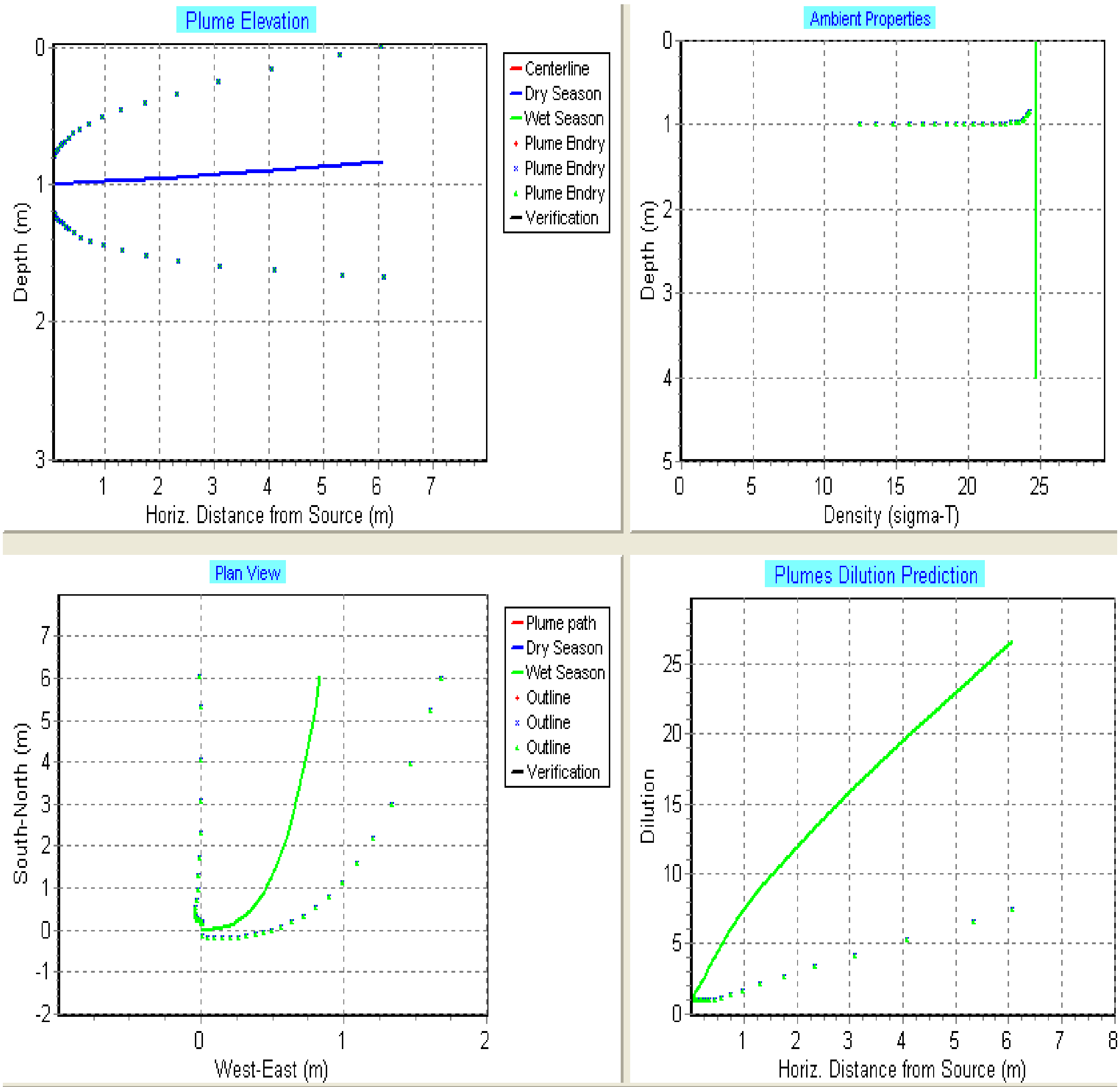
5.2.1.1. Spring tide (95th percentile)

The model outputs for the spring tide at various depths are presented in **Figure 5-3** to **Figure 5-7.** For the purposes of mixing zone analysis it is assumed that the incoming and outgoing tide have similar shaped plumes, upstream and downstream of the outfall point. Initial dilution reaches a maximum of 8 times at a depth of 0.5 m during a spring tide, the initial mixing zone being around 1m in radius.



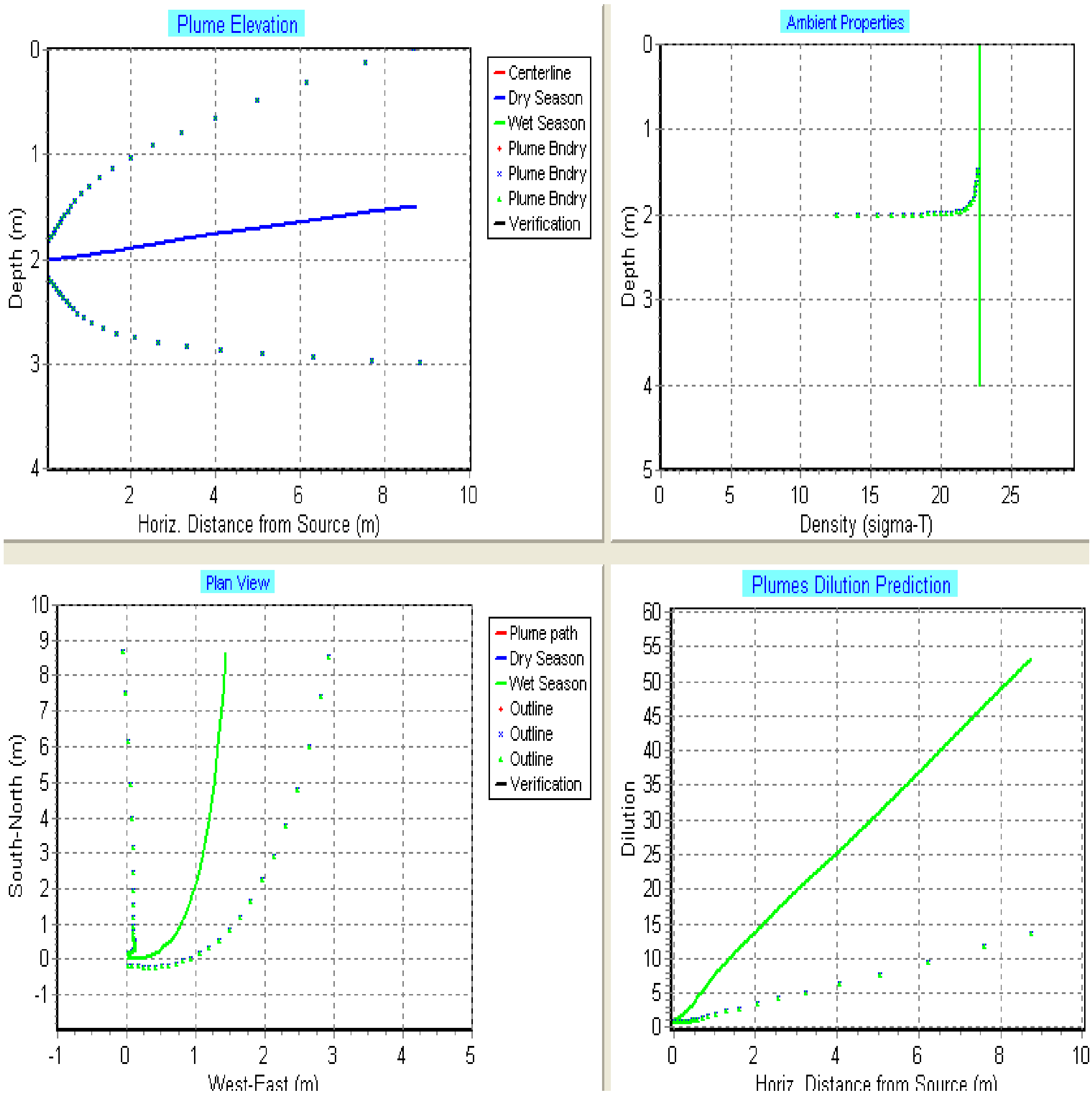
■ **Figure 5-3 Spring tide, discharge port depth = 0.5m.**

Note : At a depth of 0.5 m during a spring tide, the maximum dilution achievable is 1:8. The mixing zone is very similar in both the dry and wet seasons.



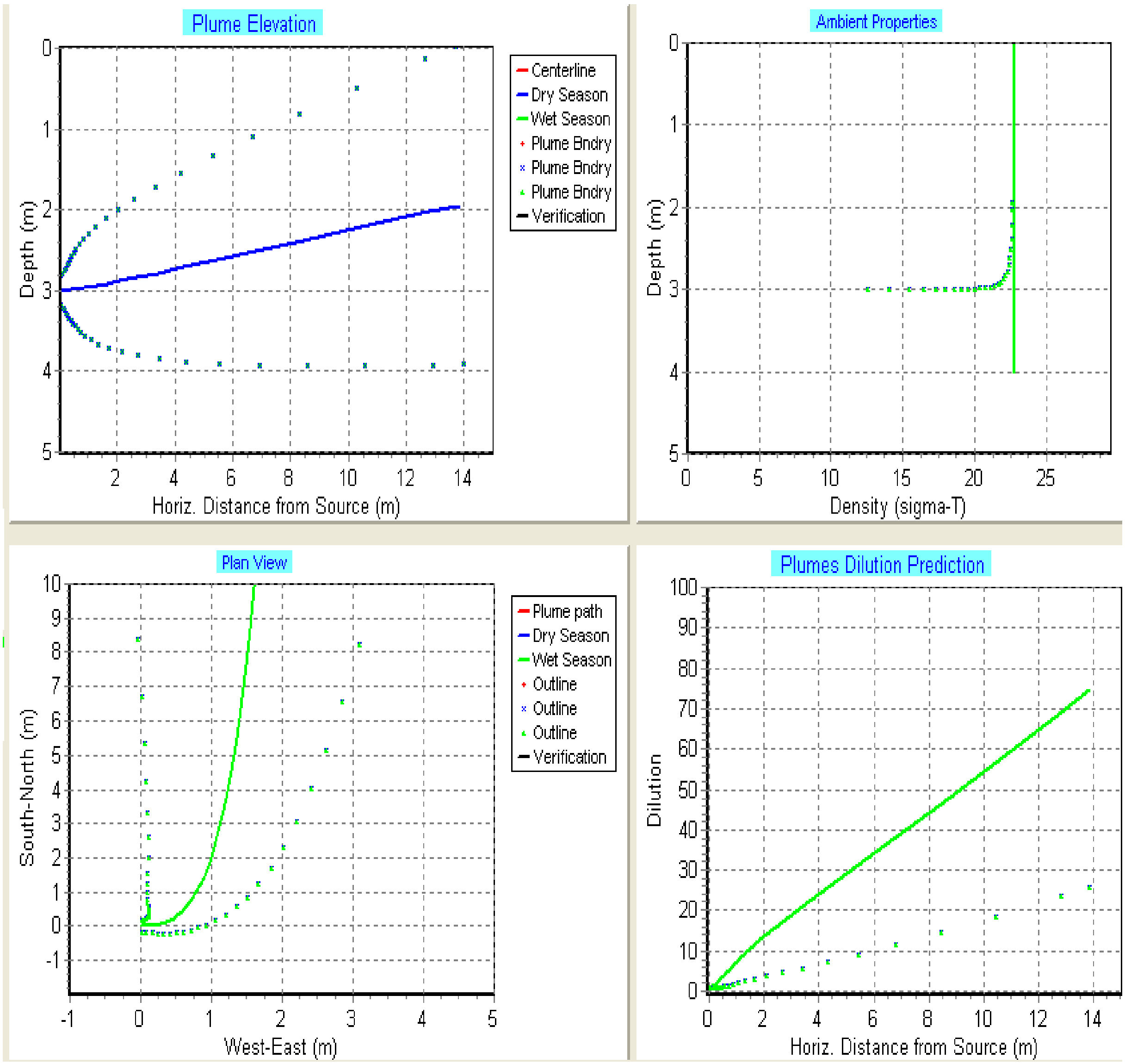
■ **Figure 5-4 Spring tide, discharge port depth = 1m.**

Note : At a depth of 1 m during a spring tide, the 1:8 dilution is achieved 1m downstream of the discharge port during both the dry and wet seasons.



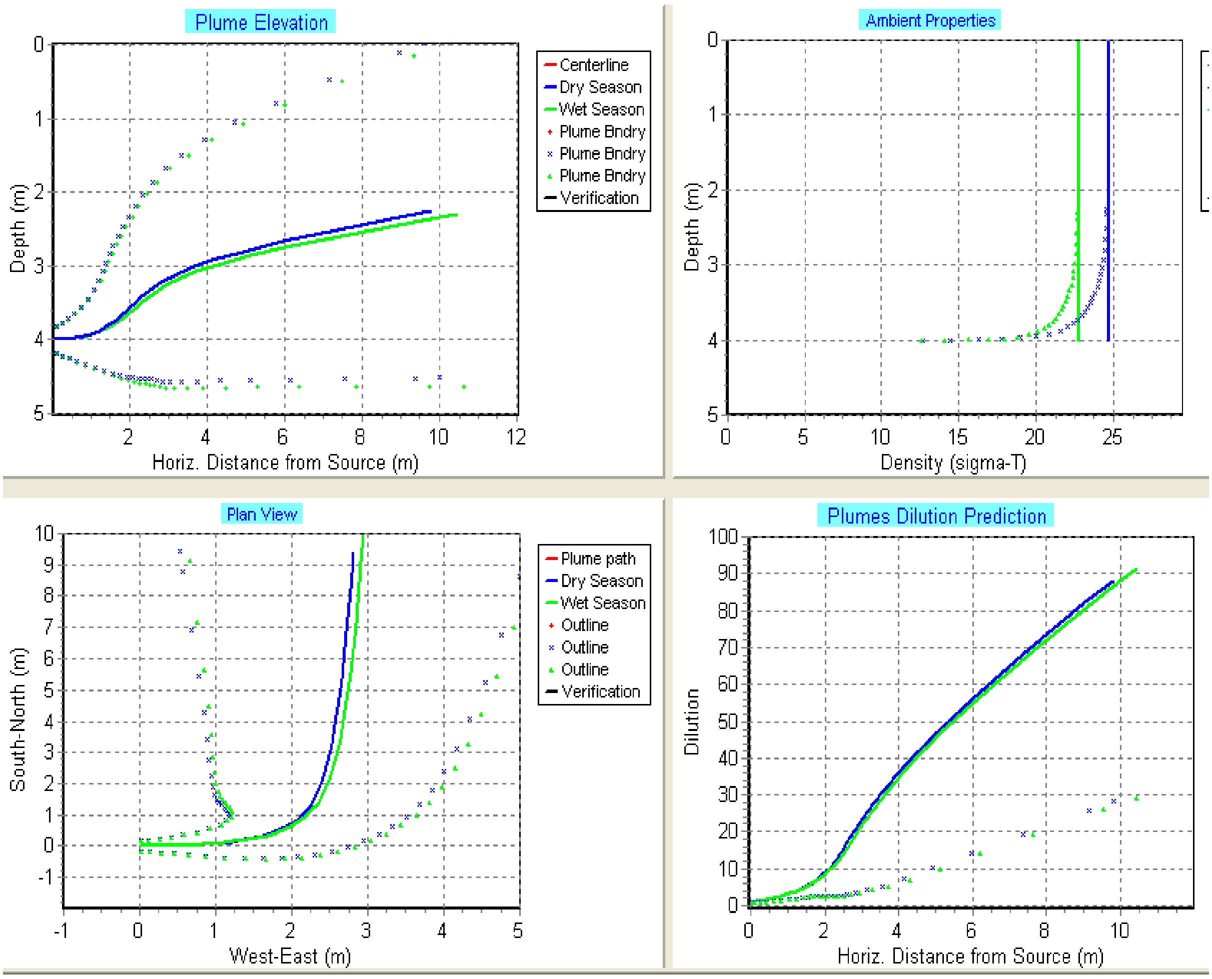
- **Figure 5-5 Spring tide, discharge port depth = 2m.**

Note : At a depth of 2 m during a spring tide, the 1:8 dilution is achieved 1 m downstream of the discharge port during both the dry and wet seasons.



- **Figure 5-6 Spring tide, discharge port depth = 3m.**

Note : At a depth of 3 m during a spring tide, the 1:8 dilution is achieved 1 metre downstream of the discharge port during both the dry and wet seasons.

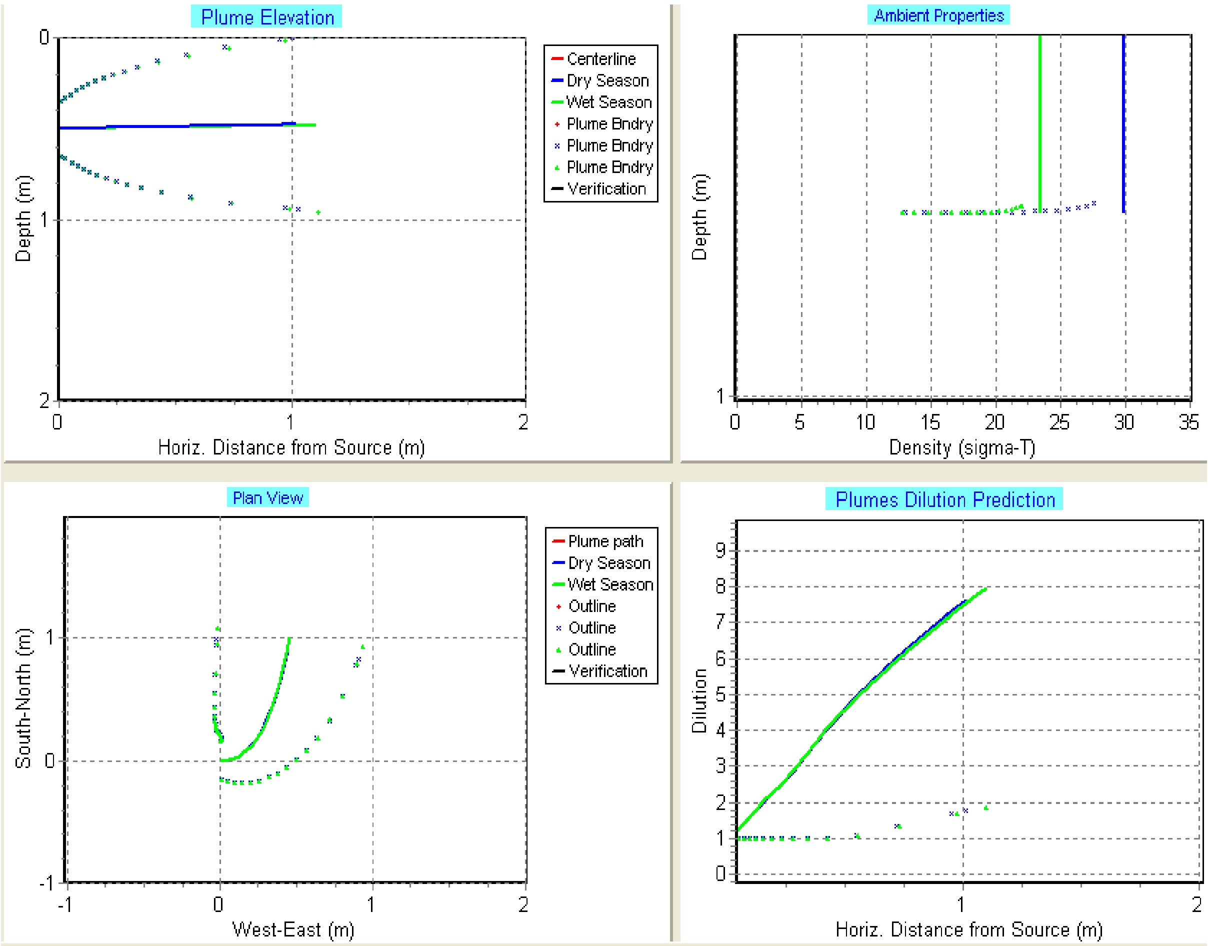


- **Figure 5-7 Spring tide, discharge port depth = 4m.**

Note : At the maximum depth of 4 m during a spring tide, the 1:8 initial dilution is achieved 1.75 m downstream of the discharge port during the dry and wet seasons. A maximum initial dilution (1:100) is achieved 10 m downstream. The mixing zone is very marginally less during the dry season because the Salmon Creek water is denser (more saline) and colder than during the wet season, which causes the discharge to rise more rapidly through the water column.

5.2.1.2. Neap tide (95th percentile)

The model outputs for the neap tide at various depths are presented in **Figure 5-8** to **Figure 5-10.** For the purposes of mixing zone analysis it is assumed that the incoming and outgoing tide have similar shaped plumes, upstream and downstream of the outfall point. Initial dilution reaches a maximum of 8 times at a depth of 0.5 m during a neap tide, the initial mixing zone being around 1m in radius.



- **Figure 5-8 Neap tide, discharge port depth = 0.5m.**

Note : At a depth of 0.5 m during a neap tide, the maximum initial dilution achievable is 1:8, which is the desired level. The mixing zone is very similar in both the dry and wet seasons.

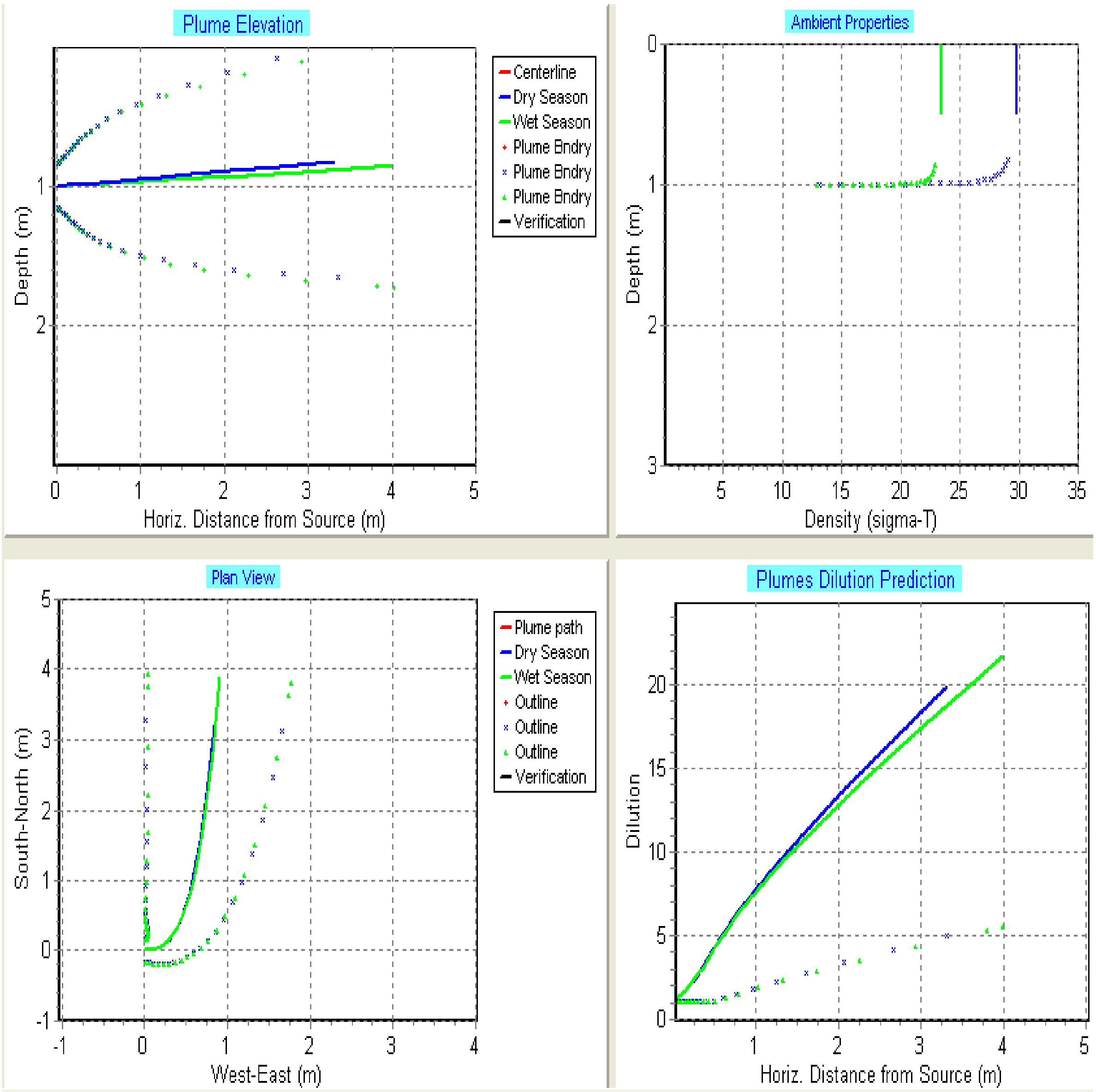


Figure 5-9 Neap tide, discharge port depth = 1m.

Note : At a depth of 1 m during a neap tide, the 1:8 initial dilution is achieved within 1 m downstream of the discharge port during the dry and wet seasons..

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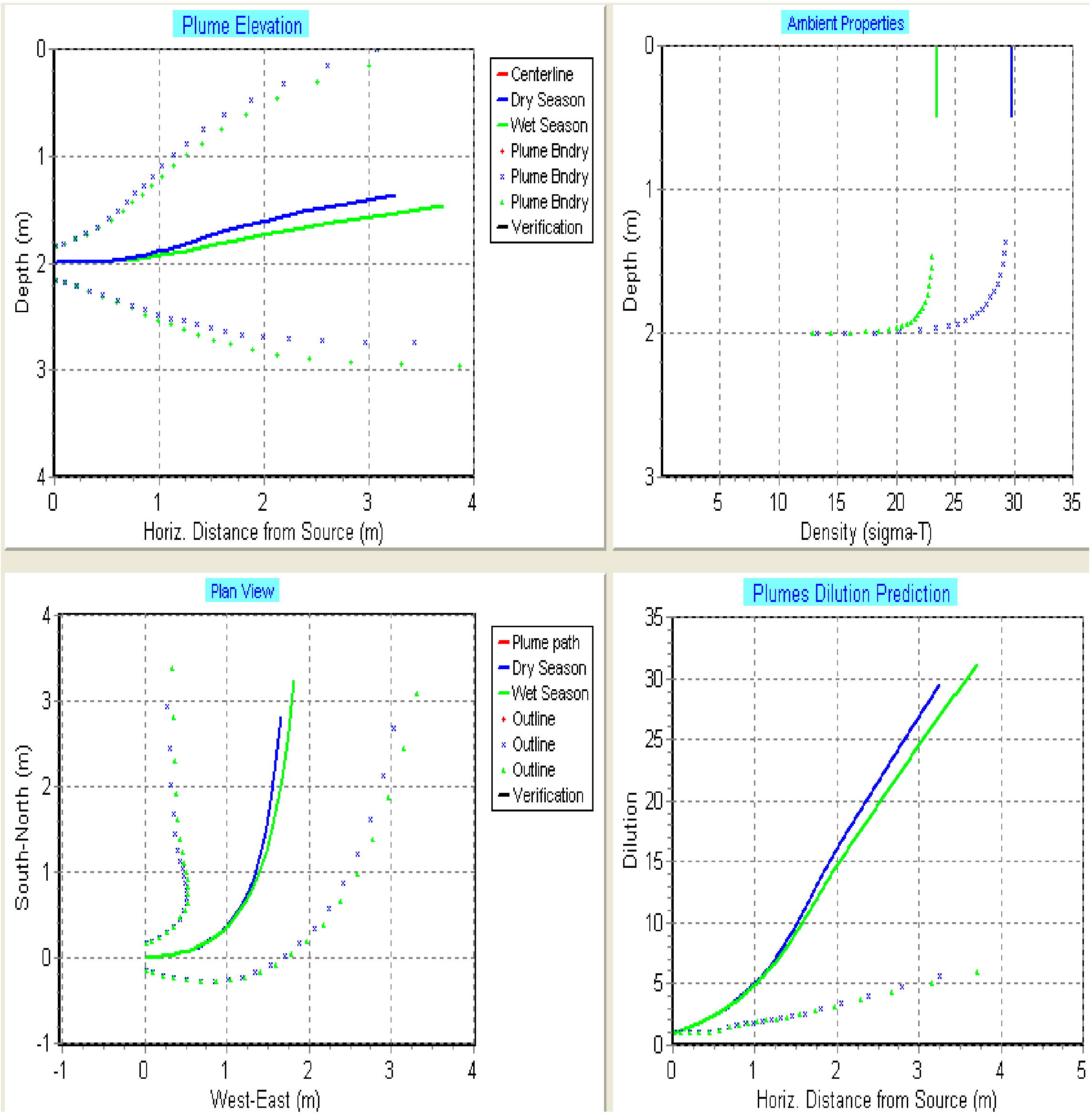

- **Figure 5-10 Neap tide, discharge port depth = 2m.**

Note : At a depth of 2 m during a neap tide, the 1:8 initial dilution is achieved within 1.3 m and 1.4 m downstream of the discharge port during the dry and wet seasons respectively. The mixing zone is less during the dry season because the Salmon Creek water is denser (more saline) and colder than during the wet season, which causes the discharge to rise more rapidly through the water column.

5.2.2. Silver

The concentration of silver the discharge is 13.5 µg/L (95^{th} percentile), which exceeds the ANZECC (2000) trigger value of 0.8 µg/L for the protection of 99% species in marine waters. For silver, the dilution in the receiving environment required to comply with the ANZECC trigger level is 1:17 (**Table 5-4**). The model outputs are provided in **Appendix A**.

- **Table 5-4 Model inputs**

Silver	ANZECC 99% trigger (ppb)	Discharge quality (ppb)	Ambient levels (ppb)				Dilution Required (95% ile)	
			Neap (dry)	Spring (dry)	Neap (wet)	Spring (wet)	ANZECC	Backgnd
95^{th} percentile		13.5					1:17	1:7
Median	0.8	4.5	<1	<1	1.2	5.0	1:5	1:2
Maximum		16.2					1:20	1:8

The modelling results indicate that a 1:17 level of dilution (95^{th} percentile) is unachievable at tidal depths less than 1 m (**Table 5-5**).

- **Table 5-5 Modelling results for 95^{th} percentile Silver levels**

Depth (m)	Dry Season				Wet Season			
	Neap tide		Spring tide		Neap tide		Spring tide	
	Mixing zone (m)	Max dilution (distance)	Mixing zone (m)	Max dilution (distance)	Mixing zone (m)	Max dilution (distance	Mixing zone (m)	Max dilution (distance)
<0.5	Not achv		Not achv		Not achv		Not achv	
0.5	Not achv	1:7 (1)	Not achv	1:8 (1.1)	Not achv	1:8	Not achv	1:8 (1.1)
1.0	2.5	1:20 (3.2)	2.6	1:27(6)	3.0 (4)	1:22	2.6	1:27(6)
2.0	2	1:29 (3.1)	2.5	1:52 (8.5)	2.2 (3.5)	1:31	2.5	1:52 (8.5)
3.0	-	-	2.5	1:75 (14)	-	-	2.5	1:75 (14)
4.0	-	-	2.5	1:89 (9.5)	-	-	2.6	1:91 (10)

For the median silver concentrations, the dilution required in the receiving environment to comply with the ANZECC trigger level is 1:5 (**Table 5-4**). This level of dilution is achieved under all conditions, except under low tide (<0.5 depth) when the creek exists only as a small channel of freshwater flows (**Table 5-6**).

■ **Table 5-6 Modelling results for median Silver levels**

Depth (m)	Dry Season				Wet Season			
	Neap tide		Spring tide		Neap tide		Spring tide	
	Mixing zone (m)	Max dilution (distance)	Mixing zone (m)	Max dilution (distance)	Mixing zone (m)	Max dilution (distance	Mixing zone (m)	Max dilution (distance)
<0.5	Not achv		Not achv		Not achv		Not achv	
0.5	0.6	1:7.5 (1)	0.6	1:8 (1)	0.6	1:8 (1.1)	0.6	1:8 (1)
1.0	0.5	1:20 (3.2)	0.6	1:27 (6)	0.5	1:22 (4)	0.6	1:27 (6)
2.0	1	1:30 (3.2)	0.75	1:53 (8.5)	1	1:31 (3.6)	0.75	1:53 (8.5)
3.0	-	-	0.75	1.75 (14)	-	-	0.75	1.75 (14)
4.0	-	-	1.5	1:89 (9.5)	-	-	1.5	1:91 (10.5)

5.2.3. Mercury

The concentration of mercury in the discharge is 1.24 µg/L (95th percentile), which exceeds the ANZECC (2000) trigger value of 0.1 µg/L for the protection of 99% species in marine waters. For mercury, the dilution in the receiving environment required to comply with the ANZECC trigger level is 1:12 (**Table 5-7**). The model outputs for mercury are provided in **Appendix A**. The required dilution is achieved in all tidal scenarios except below 1 m (**Table 5-8**).

■ **Table 5-7 Model inputs**

Mercury	ANZECC 99% trigger (ppb)	Discharge quality (ppb)	Ambient levels (ppb)				Dilution Required (95% ile)	
			Neap (dry)	Spring (dry)	Neap (wet)	Spring (wet)	ANZECC	Backgnd
95th percentile	0.1	1.24	0.05	0.05	0.05	0.05	1:12	1:25
Median		0.4					1:4	1:8
Maximum		1.4					1:14	1:28

■ **Table 5-8 Modelling results for 95th percentile Mercury levels**

Depth (m)	Dry Season				Wet Season			
	Neap tide		Spring tide		Neap tide		Spring tide	
	Mixing zone (m)	Max dilution (distance)	Mixing zone (m)	Max dilution (distance)	Mixing zone (m)	Max dilution (distance	Mixing zone (m)	Max dilution (distance)
<0.5	Not achv		Not achv		Not achv		Not achv	
0.5	Not achv	1:7.5 (1)	Not achv	1:8 (1)	Not achv	1:8(1.1)	Not achv	1:8 (1.1)
1.0	2.0	1:20 (3.3)	2.0	1:26 (6)	2.0	1:22 (4)	2.0	1:26 (6)
2.0	1.5	1:29 (3.2)	2.0	1:55 (8.5)	1.7	1:31 (3.6)	2.0	1:53 (8.5)
3.0	-	-	2.0	1:72 (13)	-	-	2.0	1:72 (13)
4.0	-	-	2.2	1:88 (9.5)	-	-	2.3	1:91 (10)

For the median concentration, the required dilution is 1:4. This is achieved at all tidal conditions, except under low tide when the estuary exists only as a small channel of when the estuary exists only as a small channel of any freshwater flows from the catchment (**Table 5-9**). The catchment inflows may be very small, or non-existent, during the dry season, therefore there may be no dilution of the discharge under these conditions.

■ **Table 5-9 Modelling results for median Mercury levels**

Depth (m)	Dry Season				Wet Season			
	Neap tide		Spring tide		Neap tide		Spring tide	
	Mixing zone (m)	Max dilution (distance)	Mixing zone (m)	Max dilution (distance)	Mixing zone (m)	Max dilution (distance	Mixing zone (m)	Max dilution (distance)
<0.5	Not achv		Not achv		Not achv		Not achv	
0.5	0.5	1:7.5 (1)	0.5	1:8 (1)	0.5	1:8 (1.1)	0.5	1:8 (1.1)
1.0	0.6	1:22 (3.2)	0.6	1:26 (6)	0.6	1:22 (4)	0.6	1:26 (6)
2.0	0.75	1:29 (3.2)	0.6	1:53 (8.5)	0.75	1:31 (4)	0.6	1:53 (8.5)
3.0	-	-	0.6	1:72 (13)	-	-	0.6	1:72 (13)
4.0	-	-	1.2	1:88 (9.5)	-	-	1.2	1:91 (10)

5.2.4. Zinc

The concentration of zinc in the discharge is 1.24 µg/L (95th percentile), which exceeds the ANZECC (2000) trigger value of 7.0 µg/L for the protection of 99% species in marine waters. For zinc, the dilution in the receiving environment required to comply with the ANZECC trigger level is 1:24 (**Table 5-10**). The model outputs for zinc are provided in **Appendix A**. The required dilution is achieved in when the water depth is above 1 m (**Table 5-11**).

- **Table 5-10 Model inputs**

Zinc	ANZECC 99% trigger (ppb)	Discharge quality (ppb)	Ambient levels (ppb)				Dilution Required (95% ile)	
			Neap (dry)	Spring (dry)	Neap (wet)	Spring (wet)	ANZECC	Backgnd
95th percentile	7.0	167	2	18	9	1	1:24	1:22
Median		43					1:6	1:6
Maximum		400					1:57	1:53

- **Table 5-11 Modelling results for 95th percentile zinc levels**

Depth (m)	Dry Season				Wet Season			
	Neap tide		Spring tide		Neap tide		Spring tide	
	Mixing zone (m)	Max dilution (distance)	Mixing zone (m)	Max dilution (distance)	Mixing zone (m)	Max dilution (distance	Mixing zone (m)	Max dilution (distance)
<0.5	Not achv		Not achv		Not achv		Not achv	
0.5	Not achv	1:7.5 (1)	Not achv	1:8 (1)	Not achv	1:8(1.1)	Not achv	1:8 (1.1)
1.0	Not achv	1:20 (3.3)	4.6	1:26 (6)	Not achv	1:22 (4)	4.6	1:26 (6)
2.0	2.7	1:29 (3.2)	2.8	1:55 (8.5)	3.0	1:31 (3.6)	2.8	1:53 (8.5)
3.0	-	-	3.8	1:72 (13)	-	-	3.8	1:72 (13)
4.0	-	-	2.5	1:88 (9.5)	-	-	2.5	1:91 (10)

The median zinc levels in the discharge require a 1:6 dilution. This is achieved at all tidal conditions, except under low tide when the creek exists only as a small channel of freshwater flows from the catchment (**Table 5-9**).

- **Table 5-12 Modelling results for median zinc levels**

Depth (m)	Dry Season				Wet Season			
	Neap tide		Spring tide		Neap tide		Spring tide	
	Mixing zone (m)	Max dilution (distance)	Mixing zone (m)	Max dilution (distance)	Mixing zone (m)	Max dilution (distance	Mixing zone (m)	Max dilution (distance)
<0.5	Not achv		Not achv		Not achv		Not achv	
0.5	0.75	1:7.5 (1)	0.5	1:8 (1)	0.75	1:8 (1.1)	0.5	1:8 (1.1)
1.0	0.5	1:22 (3.2)	0.6	1:26 (6)	0.5	1:22 (4)	0.6	1:26 (6)
2.0	1.2	1:29 (3.2)	0.6	1:53 (8.5)	1.2	1:31 (4)	0.6	1:53 (8.5)
3.0	-	-	0.6	1:72 (13)	-	-	0.6	1:72 (13)
4.0	-	-	1.2	1:88 (9.5)	-	-	1.2	1:91 (10)

5.2.5. Total Nitrogen

The concentration of nitrogen in the discharge is 16.1 mg/L (95th percentile), which exceeds the ANZECC (2000) trigger value of 0.10 mg/L trigger level for inshore marine in tropical Australia. For nitrogen, the dilution in the receiving environment required to comply with the ANZECC trigger level is 1:64 (**Table 5-13**). There is no ambient baseline data for nutrients in Salmon Creek. For the purposes of the modelling, the ambient nitrogen levels have been assumed as the value of the ANZECC default trigger value guidelines for Tropical Australia.

- **Table 5-13 Model inputs**

Total Nitrogen	ANZECC 99% trigger (ppb)	Discharge quality (ppb)	Ambient levels (ppb)* assumed to be ANZECC (no data)				Dilution Required (95% ile)	
			Neap (dry)	Spring (dry)	Neap (wet)	Spring (wet)	ANZECC	Backgnd
95th percentile		16.1					1:161	Nd
Median	0.100	1.70	0.10	0.10	0.10	0.10	1:17	Nd
Maximum		24.0					1:240	Nd

The required dilution of the 95th percentile concentrations is not achieved under any tidal scenario (**Table 5-14**). Under the median concentration of nitrogen the mixing zone is achieved in all tidal scenarios within a distance of 3.3 m, except when the water depth is less than 1m (**Table 5-15**).

- **Table 5-14 Modelling results for 95th percentile for total nitrogen levels**

Depth (m)	Dry Season				Wet Season			
	Neap tide		Spring tide		Neap tide		Spring tide	
	Mixing zone (m)	Max dilution (distance)	Mixing zone (m)	Max dilution (distance)	Mixing zone (m)	Max dilution (distance	Mixing zone (m)	Max dilution (distance)
<0.5	Not achv		Not achv		Not achv		Not achv	
0.5	Not Achv	1:7.5 (1)	Not Achv	1:8 (1)	Not Achv	1:8(1.1)	Not Achv	1:8 (1.1)
1.0	Not Achv	1:20 (3.3)	Not Achv	1:26 (6)	Not Achv	1:22 (4)	Not Achv	1:26 (6)
2.0	Not Achv	1:29 (3.2)	Not Achv	1:55 (8.5)	Not Achv	1:31 (3.6)	Not Achv	1:53 (8.5)
3.0	-	-	Not Achv	1:72 (13)	-	-	Not Achv	1:72 (13)
4.0	-	-	Not Achv	1:88 (9.5)	-	-	Not Achv	1:91 (10)

- **Table 5-15 Modelling results for median for total nitrogen levels**

	Dry Season				Wet Season			
	Neap tide		Spring tide		Neap tide		Spring tide	
Depth (m)	Mixing zone (m)	Max dilution (distance)	Mixing zone (m)	Max dilution (distance)	Mixing zone (m)	Max dilution (distance	Mixing zone (m)	Max dilution (distance)
<0.5	Not achv		Not achv		Not achv		Not achv	
0.5	Not Achv	1:7.5 (1)	Not Achv	1:8 (1)	Not Achv	1:8 (1.1)	Not Achv	1:8 (1.1)
1.0	0.5	1:22 (3.2)	0.6	1:26 (6)	0.5	1:22 (4)	0.6	1:26 (6)
2.0	1.2	1:29 (3.2)	0.6	1:53 (8.5)	1.2	1:31 (4)	0.6	1:53 (8.5)
3.0	-	-	0.6	1:72 (13)	-	-	0.6	1:72 (13)
4.0	-	-	1.2	1:88 (9.5)	-	-	1.2	1:91 (10)

5.2.6. Nitrate - Nitrite

The concentration of nitrate- nitrite (NOx) in the discharge is 12.8 mg/L (95th percentile), which significantly exceeds the ANZECC (2000) trigger value of 0.008 mg/L trigger level for inshore marine in tropical Australia. For NOx, the dilution in the receiving environment required to comply with the ANZECC trigger level is 1:1600 (**Table 5-13**). There is no ambient baseline data for NOx in Salmon Creek. For the purposes of the modelling, the ambient NOx levels have been assumed as the value of the ANZECC default trigger value guidelines for Tropical Australia.

- **Table 5-16 Model inputs**

Nitrate	ANZECC 99% trigger (ppb)	Discharge quality (ppb)	Ambient levels (ppb)* assumed to be ANZECC (no data)				Dilution Required (95% ile)	
			Neap (dry)	Spring (dry)	Neap (wet)	Spring (wet)	ANZECC	Backgnd
95th percentile	0.008	12.8	0.008	0.008	0.008	0.008	1:1600	Nd
Median		1.70					1:212	Nd
Maximum		18.0					1:2250	Nd

The required dilution of the 95th percentile and median concentrations is not achieved under any tidal scenario (**Table 5-14**; **Table 5-15**).

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Table 5-17 Modelling results for 95th percentile for nitrate-nitrite levels

Depth (m)	Dry Season				Wet Season			
	Neap tide		Spring tide		Neap tide		Spring tide	
	Mixing zone (m)	Max dilution (distance)	Mixing zone (m)	Max dilution (distance)	Mixing zone (m)	Max dilution (distance	Mixing zone (m)	Max dilution (distance)
<0.5	Not achv		Not achv		Not achv		Not achv	
0.5	Not Achv	1:7.5 (1)	Not Achv	1:8 (1)	Not Achv	1:8(1.1)	Not Achv	1:8 (1.1)
1.0	Not Achv	1:20 (3.3)	Not Achv	1:26 (6)	Not Achv	1:22 (4)	Not Achv	1:26 (6)
2.0	Not Achv	1:29 (3.2)	Not Achv	1:55 (8.5)	Not Achv	1:31 (3.6)	Not Achv	1:53 (8.5)
3.0	-	-	Not Achv	1:72 (13)	-	-	Not Achv	1:72 (13)
4.0	-	-	Not Achv	1:88 (9.5)	-	-	Not Achv	1:91 (10)

Table 5-18 Modelling results for median for nitrate-nitrite levels

Depth (m)	Dry Season				Wet Season			
	Neap tide		Spring tide		Neap tide		Spring tide	
	Mixing zone (m)	Max dilution (distance)	Mixing zone (m)	Max dilution (distance)	Mixing zone (m)	Max dilution (distance	Mixing zone (m)	Max dilution (distance)
<0.5	Not achv		Not achv		Not achv		Not achv	
0.5	Not Achv	1:7.5 (1)	Not Achv	1:8 (1)	Not Achv	1:8 (1.1)	Not Achv	1:8 (1.1)
1.0	Not Achv	1:22 (3.2)	Not Achv	1:26 (6)	Not Achv	1:22 (4)	Not Achv	1:26 (6)
2.0	Not Achv	1:29 (3.2)	Not Achv	1:53 (8.5)	Not Achv	1:31 (4)	Not Achv	1:53 (8.5)
3.0	-	-	Not Achv	1:72 (13)	-	-	Not Achv	1:72 (13)
4.0	-	-	Not Achv	1:88 (9.5)	-	-	Not Achv	1:91 (10)

5.3. Mixing zone extent

5.3.1. Spring tide

Table 5-19 summarises the mixing zone requirements to achieve the dilutions required to meet ANZECC trigger levels (99% and 95% of species) and background concentrations during different tidal depths (0.5 m to 4 m). This is pictorially represented in Section 5.3.3.

- **Table 5-19 Dilutions achieved at horizontal distances away from discharge outlet during spring tides using the 95th percentile discharge concentrations.**

4m	Zn	ug/L	Cr	ug/L	Ag	ug/L	Hg	ug/L	TN	mg/L	NOx	mg/L
(m)	DRY	WET	DRY	WET	DRY	WET	DRY	WET	DRY	WET	DRY	WET
0	167.0	167.0	63.0	63.0	13.50	13.50	1.24	1.24	16.10	16.10	12.80	12.80
1	53.9	53.9	20.3	20.3	4.35	4.35	0.40	0.40	5.19	5.19	4.13	4.13
2	16.7	16.7	6.3	6.3	1.35	1.35	0.12	0.12	1.61	1.61	1.28	1.28
3	8.4	8.4	3.2	3.2	0.68	0.68	0.06	0.06	0.81	0.81	0.64	0.64
4	4.8	4.8	1.8	1.8	0.39	0.39	0.04	0.04	0.46	0.46	0.37	0.37
5	3.7	3.7	1.4	1.4	0.30	0.30	0.03	0.03	0.36	0.36	0.28	0.28
6	3.0	3.0	1.1	1.1	0.25	0.25	0.02	0.02	0.29	0.29	0.23	0.23
7	2.6	2.6	1.0	1.0	0.21	0.21	0.02	0.02	0.25	0.25	0.20	0.20
8	2.3	2.3	0.9	0.9	0.18	0.18	0.02	0.02	0.22	0.22	0.17	0.17
9	2.1	2.1	0.8	0.8	0.17	0.17	0.02	0.02	0.20	0.20	0.16	0.16
10	1.9	1.9	0.7	0.7	0.15	0.15	0.01	0.01	0.18	0.18	0.14	0.14
3m	Zn	ug/L	Cr	ug/L	Ag	ug/L	Hg	ug/L	TN	mg/L	NOx	mg/L
(m)	DRY	WET	DRY	WET	DRY	WET	DRY	WET	DRY	WET	DRY	WET
0	167.0	167.0	63.0	63.0	13.50	13.50	1.24	1.24	16.10	16.10	12.80	12.80
1	22.3	22.3	8.4	8.4	1.80	1.80	0.17	0.17	2.15	2.15	1.71	1.71
2	11.9	11.9	4.5	4.5	0.96	0.96	0.09	0.09	1.15	1.15	0.91	0.91
3	8.4	8.4	3.2	3.2	0.68	0.68	0.06	0.06	0.81	0.81	0.64	0.64
4	6.7	6.7	2.5	2.5	0.54	0.54	0.05	0.05	0.64	0.64	0.51	0.51
5	5.6	5.6	2.1	2.1	0.45	0.45	0.04	0.04	0.54	0.54	0.43	0.43
6	4.8	4.8	1.8	1.8	0.39	0.39	0.04	0.04	0.46	0.46	0.37	0.37
7	4.2	4.2	1.6	1.6	0.34	0.34	0.03	0.03	0.40	0.40	0.32	0.32
8	3.7	3.7	1.4	1.4	0.30	0.30	0.03	0.03	0.36	0.36	0.28	0.28
9	3.3	3.3	1.3	1.3	0.27	0.27	0.02	0.02	0.32	0.32	0.26	0.26
10	3.0	3.0	1.1	1.1	0.25	0.25	0.02	0.02	0.29	0.29	0.23	0.23
11	2.8	2.8	1.1	1.1	0.23	0.23	0.02	0.02	0.27	0.27	0.21	0.21
12	2.6	2.6	1.0	1.0	0.21	0.21	0.02	0.02	0.25	0.25	0.20	0.20
13	2.4	2.4	0.9	0.9	0.19	0.19	0.02	0.02	0.23	0.23	0.18	0.18
14	2.2	2.2	0.8	0.8	0.18	0.18	0.02	0.02	0.21	0.21	0.17	0.17

2m	Zn	ug/L	Cr	ug/L	Ag	ug/L	Hg	ug/L	TN	mg/L	NOx	mg/L
(m)	DRY	WET	DRY	WET	DRY	WET	DRY	WET	DRY	WET	DRY	WET
0	167.0	167.0	63.0	63.0	13.50	13.50	1.24	1.24	16.10	16.10	12.80	12.80
1	23.9	23.9	9.0	9.0	1.93	1.93	0.18	0.18	2.30	2.30	1.83	1.83
2	11.1	11.1	4.2	4.2	0.90	0.90	0.08	0.08	1.07	1.07	0.85	0.85
3	8.4	8.4	3.2	3.2	0.68	0.68	0.06	0.06	0.81	0.81	0.64	0.64
4	6.4	6.4	2.4	2.4	0.52	0.52	0.05	0.05	0.62	0.62	0.49	0.49
5	5.4	5.4	2.0	2.0	0.44	0.44	0.04	0.04	0.52	0.52	0.41	0.41
6	4.4	4.4	1.7	1.7	0.36	0.36	0.03	0.03	0.42	0.42	0.34	0.34
7	3.9	3.9	1.5	1.5	0.31	0.31	0.03	0.03	0.37	0.37	0.30	0.30
8	3.2	3.2	1.2	1.2	0.26	0.26	0.02	0.02	0.31	0.31	0.25	0.25
1m	Zn	ug/L	Cr	ug/L	Ag	ug/L	Hg	ug/L	TN	mg/L	NOx	mg/L
(m)	DRY	WET	DRY	WET	DRY	WET	DRY	WET	DRY	WET	DRY	WET
0	167.0	167.0	63.0	63.0	13.50	13.50	1.24	1.24	16.10	16.10	12.80	12.80
1	23.9	23.9	9.0	9.0	1.93	1.93	0.18	0.18	2.30	2.30	1.83	1.83
2	13.9	13.9	5.3	5.3	1.13	1.13	0.10	0.10	1.34	1.34	1.07	1.07
3	10.4	10.4	3.9	3.9	0.84	0.84	0.08	0.08	1.01	1.01	0.80	0.80
4	8.4	8.4	3.2	3.2	0.68	0.68	0.06	0.06	0.81	0.81	0.64	0.64
5	7.3	7.3	2.7	2.7	0.59	0.59	0.05	0.05	0.70	0.70	0.56	0.56
6	6.2	6.2	2.3	2.3	0.50	0.50	0.05	0.05	0.60	0.60	0.47	0.47
0.5m	Zn	ug/L	Cr	ug/L	Ag	ug/L	Hg	ug/L	TN	mg/L	NOx	mg/L
(m)	DRY	WET	DRY	WET	DRY	WET	DRY	WET	DRY	WET	DRY	WET
0	167.0	167.0	63.0	63.0	13.50	13.50	1.24	1.24	16.10	16.10	12.80	12.80
0.5	33.4	33.4	12.6	12.6	2.70	2.70	0.25	0.25	3.22	3.22	2.56	2.56
1	22.3	22.3	8.4	8.4	1.80	1.80	0.17	0.17	2.15	2.15	1.71	1.71
1.1	20.9	20.9	7.9	7.9	1.69	1.69	0.16	0.16	2.01	2.01	1.60	1.60

Note: Highlighted cells indicate non-compliance; Red = above ANZECC (99%), Orange = above ANZECC (95%), Green = below ANZECC, but above background and Blue = background.

5.3.2. Neap tide

Table 5-20 summarises the mixing zone requirements to achieve the dilutions required to meet ANZECC trigger levels (99% and 95% of species) and background concentrations during different tidal depths (0.5 m to 2 m).

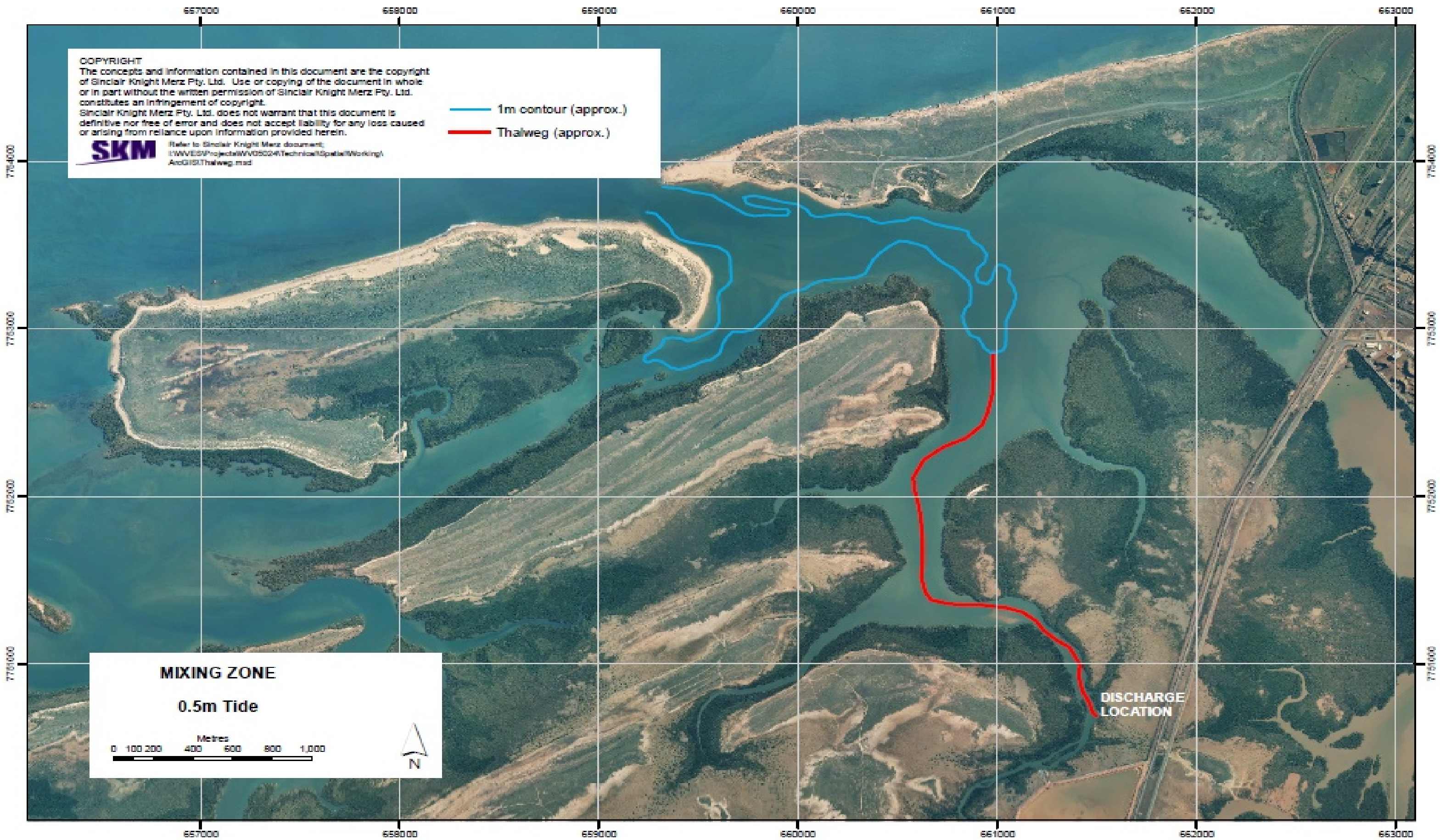
- **Table 5-20 Dilutions achieved at horizontal distances away from discharge outlet during neap tides using the 95th percentile discharge concentrations.**

2m (m)	Zn DRY	ug/L WET	Cr DRY	ug/L WET	Ag DRY	ug/L WET	Hg DRY	ug/L WET	TN DRY	mg/L WET	NOx DRY	mg/L WET
0	167.0	167.0	63.0	63.0	13.50	13.50	1.24	1.24	16.10	16.10	12.80	12.80
1	33.4	33.4	12.6	12.6	2.70	2.70	0.25	0.25	3.22	3.22	2.56	2.56
2	10.4	11.1	3.9	4.2	0.84	0.90	0.08	0.08	1.01	1.07	0.80	0.85
3	6.2	6.7	2.3	2.5	0.50	0.54	0.05	0.05	0.60	0.64	0.47	0.51
4	5.8	5.2	2.2	2.0	0.47	0.42	0.04	0.04	0.56	0.50	0.44	0.40
1m (m)	Zn DRY	ug/L WET	Cr DRY	ug/L WET	Ag DRY	ug/L WET	Hg DRY	ug/L WET	TN DRY	mg/L WET	NOx DRY	mg/L WET
0	167.0	167.0	63.0	63.0	1.24	1.24	1.24	1.24	16.10	16.10	12.80	12.80
1	23.9	23.9	9.0	9.0	0.18	0.18	0.18	0.18	2.30	2.30	1.83	1.83
2	12.8	13.9	4.8	5.3	0.10	0.10	0.10	0.10	1.24	1.34	0.98	1.07
3	9.3	10.4	3.5	3.9	0.07	0.08	0.07	0.08	0.89	1.01	0.71	0.80
4	8.4	7.6	3.2	2.9	0.06	0.06	0.06	0.06	0.81	0.73	0.64	0.58
0.5m (m)	Zn DRY	ug/L WET	Cr DRY	ug/L WET	Ag DRY	ug/L WET	Hg DRY	ug/L WET	TN DRY	mg/L WET	NOx DRY	mg/L WET
0	167.0	167.0	63.0	63.0	13.50	13.50	1.24	1.24	16.10	16.10	12.80	12.80
0.5	37.1	37.1	14.0	14.0	3.00	3.00	0.28	0.28	3.58	3.58	2.84	2.84
1	22.3	22.3	8.4	8.4	1.80	1.80	0.17	0.17	2.15	2.15	1.71	1.71
1.1	22.3	20.9	8.4	7.9	1.80	1.69	0.17	0.16	2.15	2.01	1.71	1.51

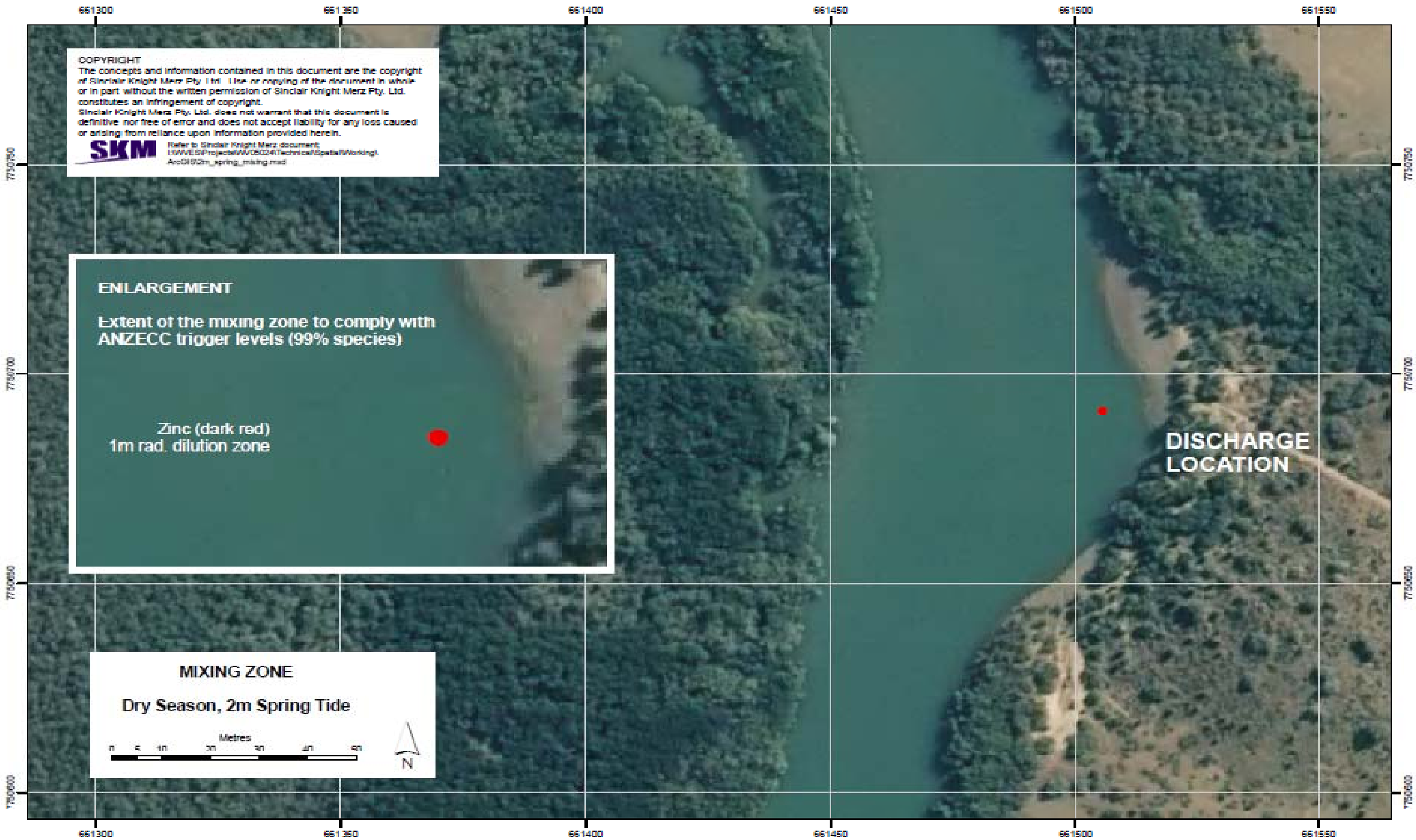
Note: Highlighted cells indicate non-compliance; Red = above ANZECC (99%), Orange = above ANZECC (95%), Green = below ANZECC, but above background and Blue = background.

5.3.3. Mixing zone maps

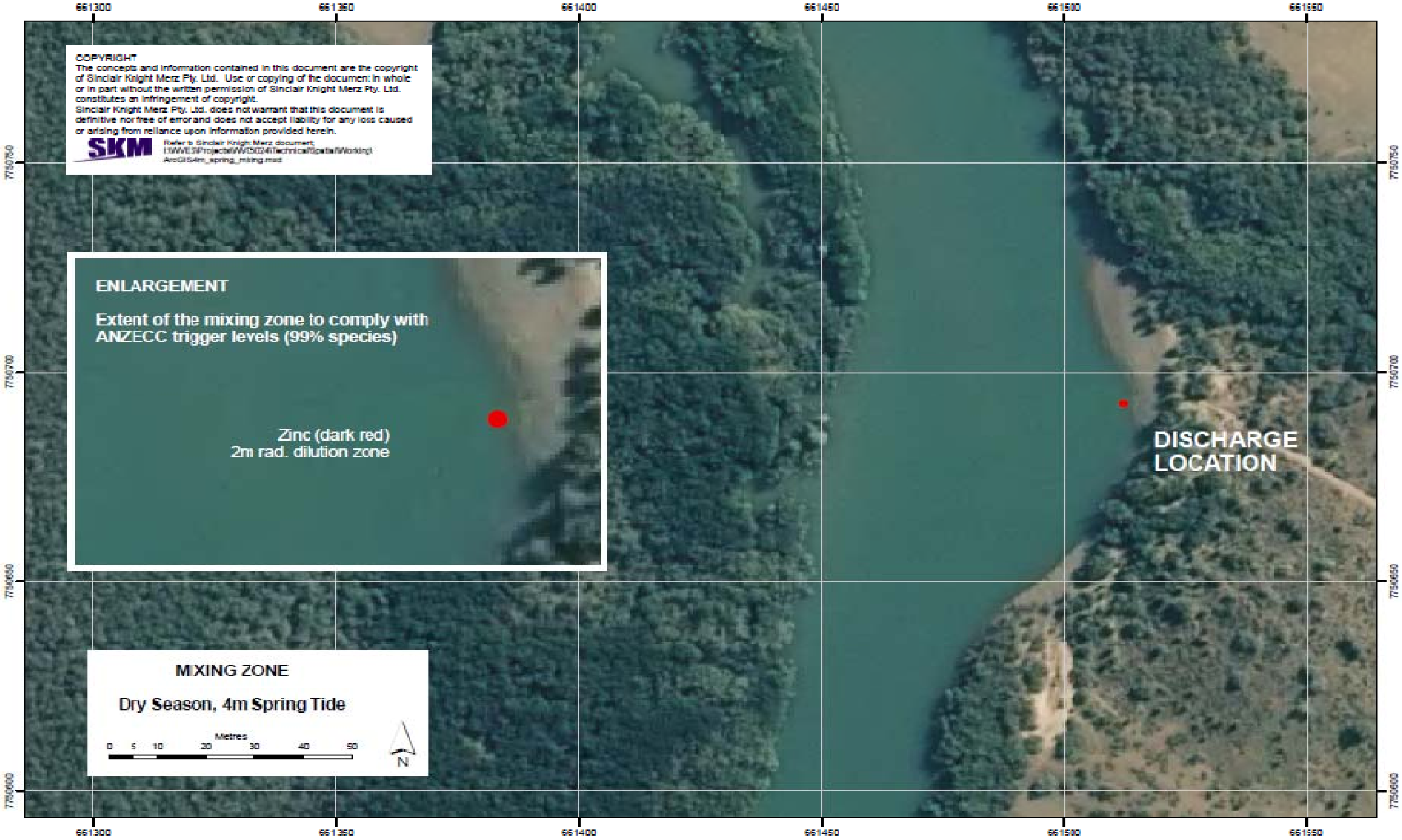
The discharge is likely to constitute a high proportion of the flow in Salmon Creek when the tidal depth is less than 0.5 m. This is demonstrated in **Figure 5-11**, which shows the main flow path of the creek leading out into deeper parts of the harbour. The red colour indicates non-compliance with the ANZECC trigger levels for heavy metals of concern (99% of species). When the tidal depth in the channel is greater than 0.5m the mixing zone for the dewatering discharge to dilute heavy metal concentrations to below the ANZECC guidelines is very small in the context of the size of Salmon Creek. The extent of the mixing zone at tidal depths of 2 m and 4 m is overlaid on aerial imagery of Salmon Creek in **Figure 5-12** and **Figure 5-13**.



- **Figure 5-11 The relative size of the mixing zone when the water depth is less than 0.5 m. This shows that the required dilution is not achieved until the flow path reaches the deeper part of the harbour**



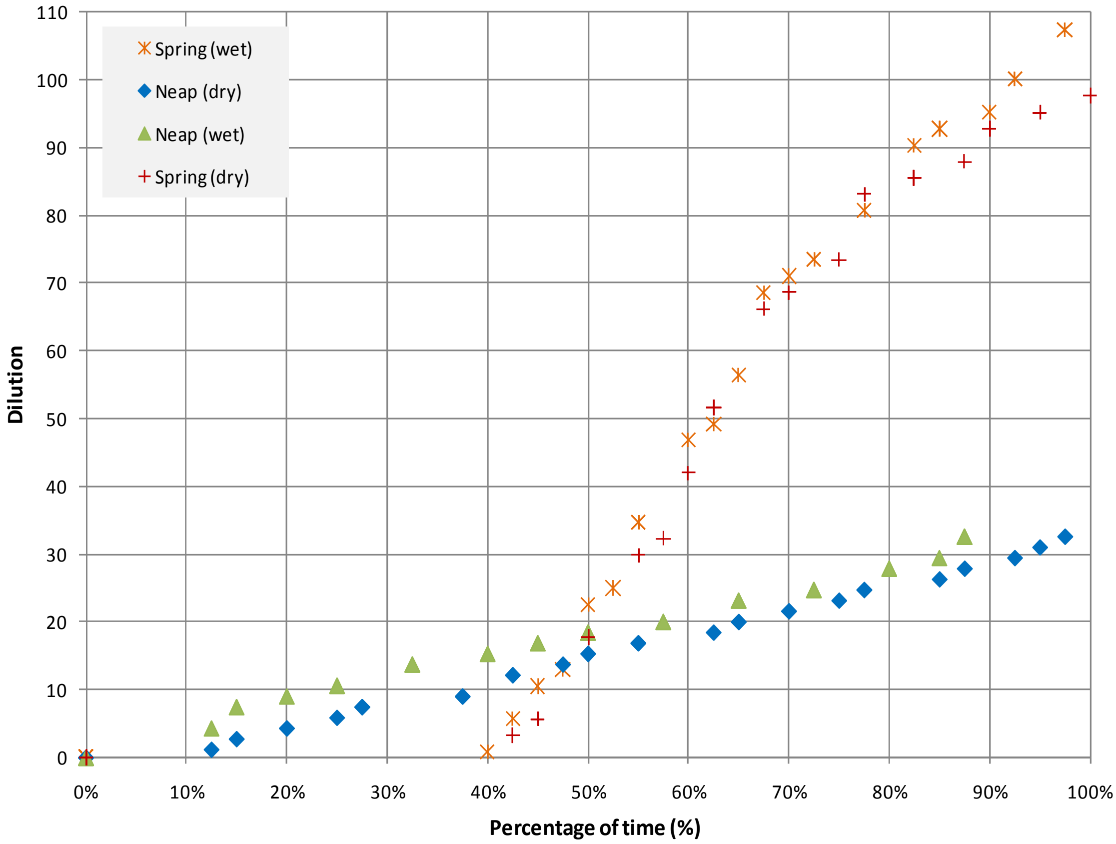
- **Figure 5-12 The relative size of the mixing zone required for zinc when the water depth is 2 m. In the context of the size of the channel, the mixing zone (2m) is very small when water is present.**



- **Figure 5-13 The relative size of the mixing zone when the water depth is 4 m. In the context of the size of the channel, the mixing zone (2m) is very small when water is present.**

5.4. Dilutions

The percentage of time various maximum dilution levels are possible in Salmon Creek was estimated using the tidal cycles for the neap and spring tides and the modelling results (**Figure 5-14**). The maximum dilution level relates to a reach length of 1 km and an assumed maximum channel width of 90 m for the neap tidal scenarios and 630 m maximum channel for a spring tide. The greatest levels of dilution (1:100) are achieved under a spring tide scenario in the dry and wet season. However, at low tide the mudflats are exposed and there is no diluting tidal water in Salmon Creek 40% of the time under the spring tide due to the large tidal range. These low tide conditions would persist for a maximum of 4 hours at a time, occurring twice per day (see **Figure 5-1**). Although the neap tide scenario does not achieve the high levels of dilution compared with the spring tide scenario, tidal water is present in the Salmon Creek 90% of the time to provide some dilution for the dewatering discharge. Low tide conditions would persist for a period of 1 to 3 hours at a time, occurring twice per day (see **Figure 5-2**).



▪ **Figure 5-14 Duration of dilutions under different tidal conditions in Salmon Creek**

5.4.1. Chromium

The percentage of time that Chromium levels may exceed the ANZECC guidelines was determined using the various dilutions afforded under the tidal cycles (ref **Figure 5-14**). Using the 95th percentile chromium levels in the discharge, the ANZECC trigger level (99%) will be exceeded 20% and 40% of the time under the wet and dry neap scenarios respectively (**Figure 5-15a**). Under the spring tide scenario, the chromium levels will exceed the ANZECC trigger level (99%) about 50% and 45% of the time under dry and wet conditions respectively (Figure 5-15a).

Using the median chromium levels in the discharge, the ANZECC trigger level (99%) will be exceeded 10% and 15% of the time under the wet and dry neap scenario. Under the spring tide scenario, the chromium levels will exceed the ANZECC trigger level (99%) about 40% of the time in both the wet and dry conditions (**Figure 5-15b**).

5.4.2. Silver

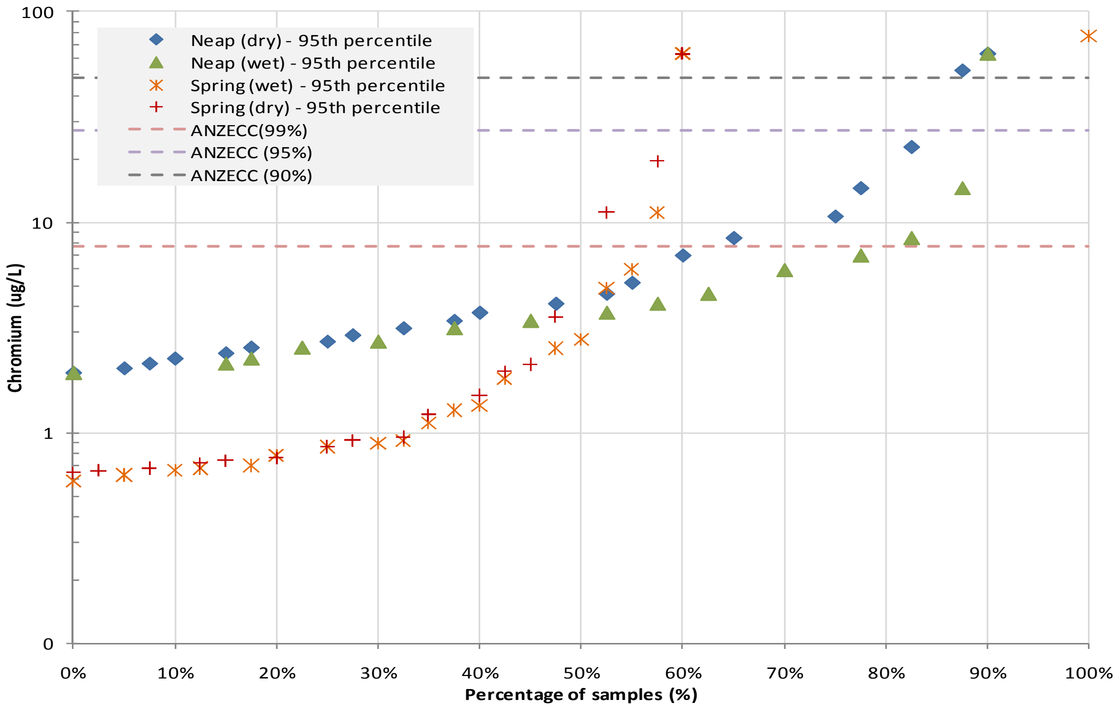
Using the 95th percentile silver levels in the discharge, the ANZECC trigger level (99%) will be exceeded 60% and 47% of the time under the dry and wet neap scenarios, respectively. Under the spring tide scenario, the silver levels will exceed the ANZECC trigger level (99%) about 55% and 47% of the time under dry and wet conditions, respectively (**Figure 5-16a**).

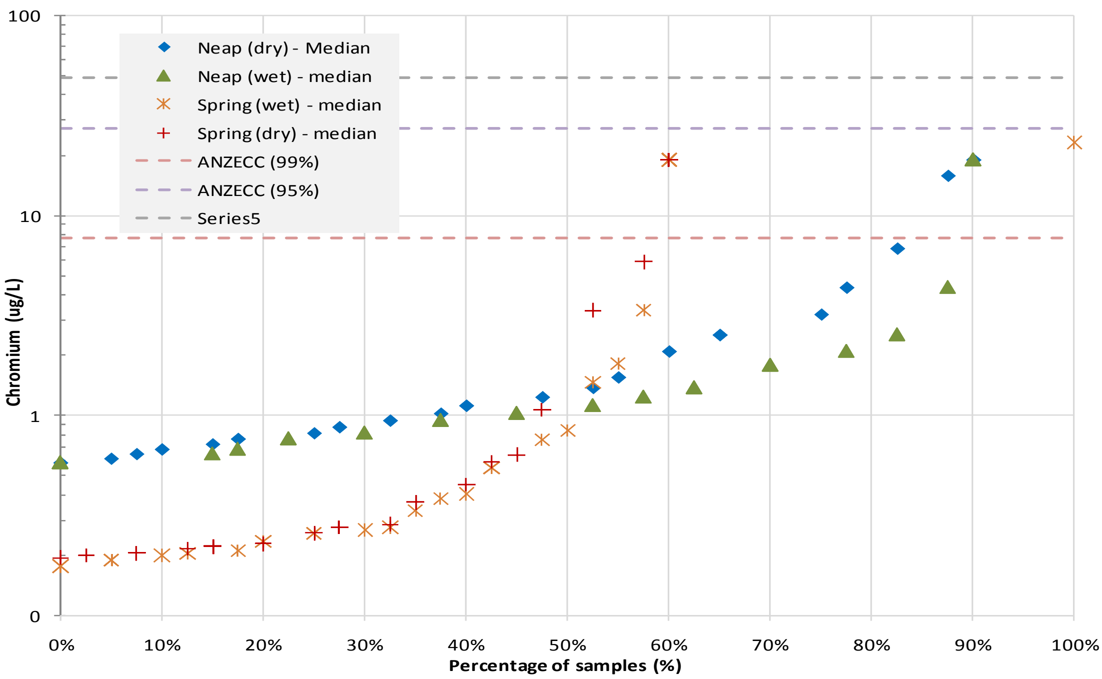
Using the median silver levels in the discharge, the ANZECC trigger level (99%) will be exceeded 15% and 25% of the time under the wet and dry neap scenarios. Under the spring tide scenario, the silver levels will exceed the ANZECC trigger level (99%) about 43% and 47% of the time in the wet and dry conditions, respectively (**Figure 5-16b**).

5.4.3. Mercury

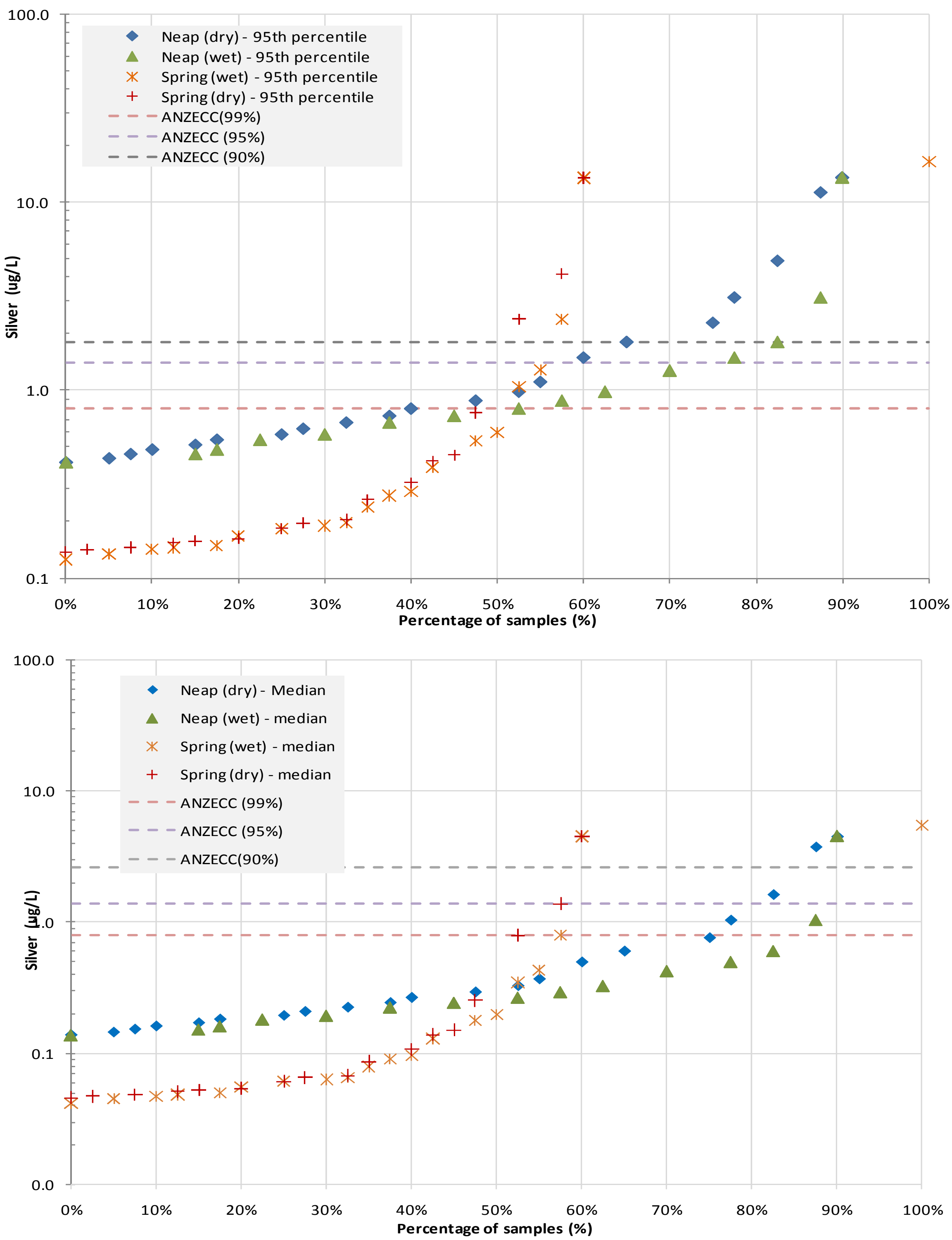
The ANZECC trigger level (99% of species) will be exceeded 45% and 35% of the time under the dry and wet neap scenario respectively using the 95th percentile mercury levels in the discharge. Under the spring tide scenario, the mercury levels will exceed the ANZECC trigger level (99%) about 50% and 45% of the time under dry and wet conditions, respectively (**Figure 5-17a**).

Using the median mercury levels in the discharge, the ANZECC trigger level (99%) will be exceeded 20% and 10% of the time under the dry and wet neap scenarios. Under the spring tide scenario, the mercury levels will exceed the ANZECC trigger level (99%) about 45% and 42% of the time in the dry and wet conditions, respectively (**Figure 5-17b**).

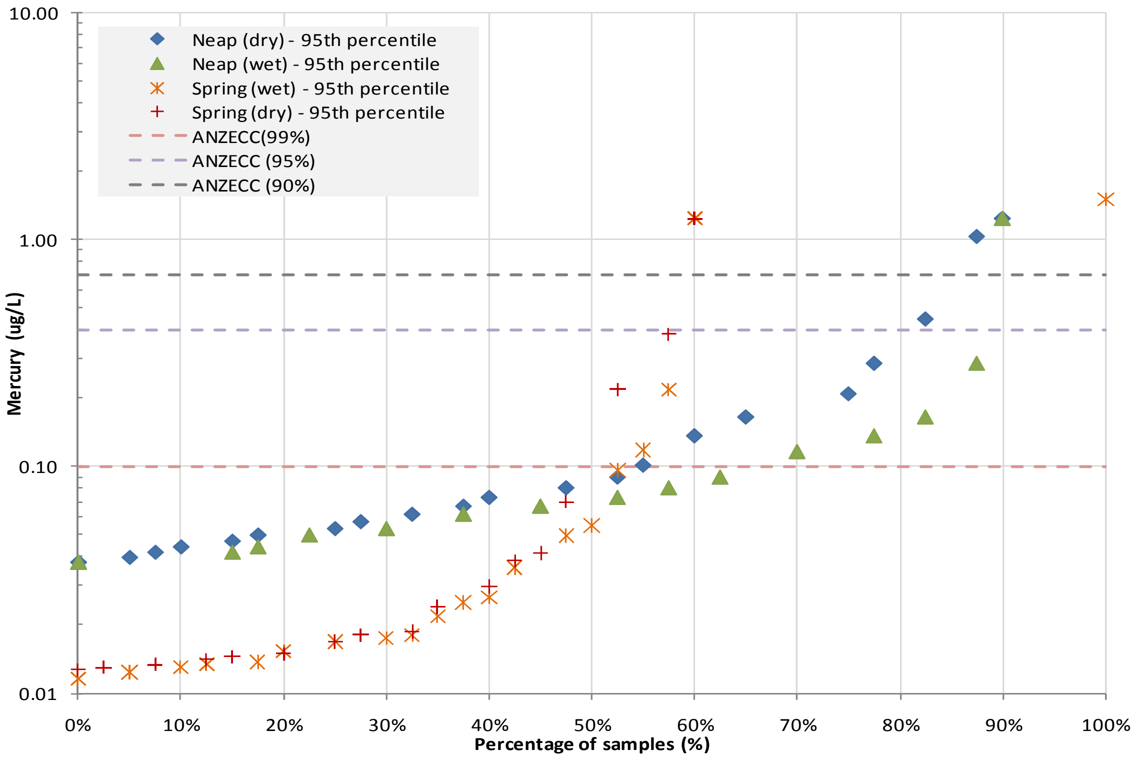


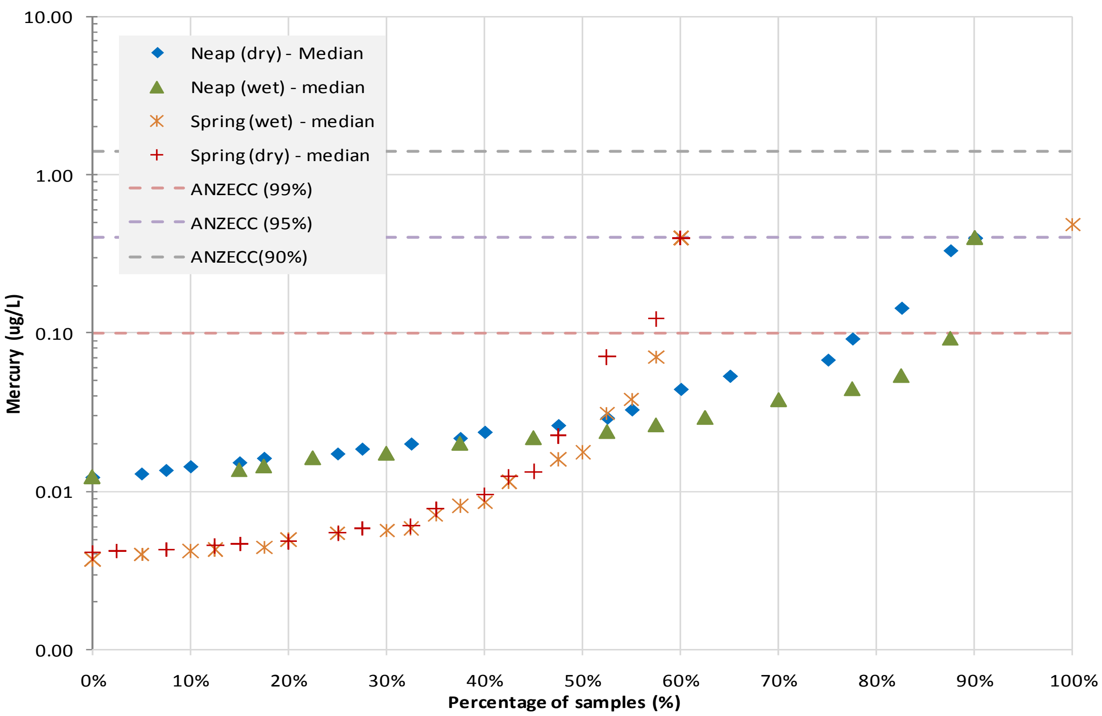


- **Figure 5-15 Dilution of discharge chromium levels under various tidal scenarios for a. 95th percentile concentrations and b. median concentrations.**



- **Figure 5-16 Dilution of discharge silver levels under various tidal scenarios for a. 95th percentile concentrations and b. median concentrations.**





- **Figure 5-17 Dilution of discharge mercury levels under various tidal scenarios for a. 95th percentile concentrations and b. median concentrations.**

5.4.4. Zinc

Using the 95th percentile zinc levels in the discharge, the ANZECC trigger level (99%) will be exceeded 75% and 30% of the time under the dry and wet neap scenario. Under the spring tide scenario, the zinc levels will exceed the ANZECC trigger level (99%) about 55% and 52% of the time under dry and wet conditions, respectively (**Figure 5-18a**).

Using the median zinc levels in the discharge, the ANZECC trigger level (99%) will be exceeded 25% and 15% of the time under the dry and wet neap scenario. Under the spring tide scenario, the zinc levels will exceed the ANZECC trigger level (99%) 50% and 42% of the time in the dry and wet conditions, respectively (**Figure 5-18b**).

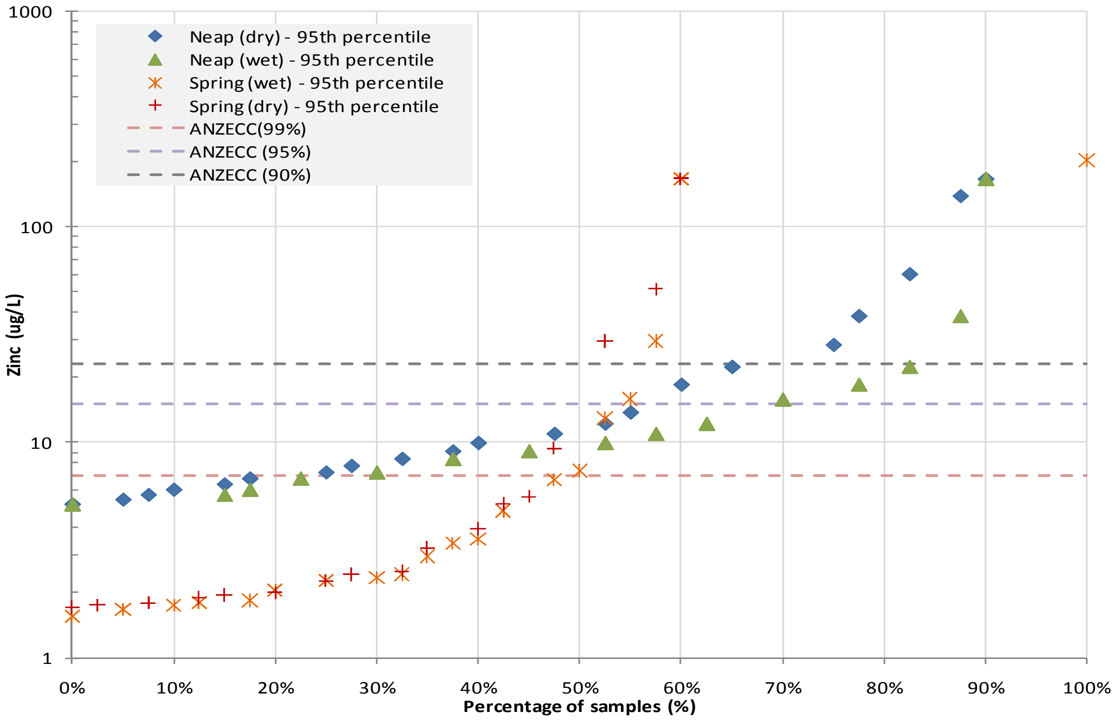
5.4.5. Total Nitrogen

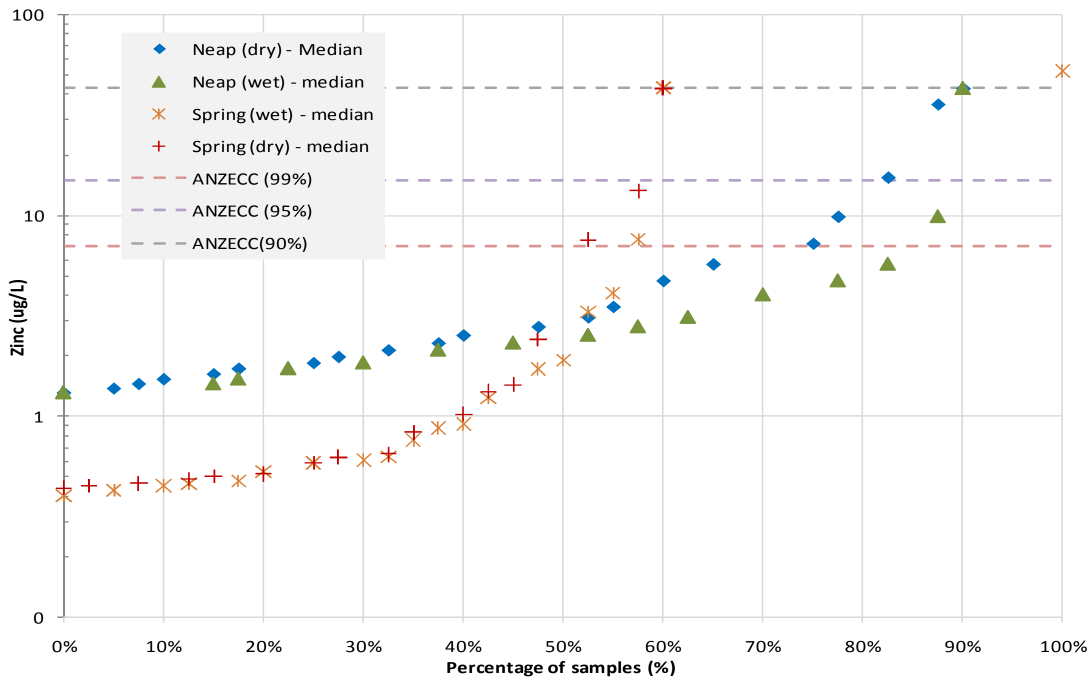
Using the 95th percentile total nitrogen levels in the discharge, the ANZECC trigger levels will be exceeded 100 % of the time under the dry and wet neap and spring tide scenarios (**Figure 5-19a**).

Using the median total nitrogen levels in the discharge, the ANZECC trigger levels will be exceeded 60% and 48% of the time under the dry and wet neap scenario. Under the spring tide scenario, the zinc levels will exceed the ANZECC trigger level 55% and 50% of the time in the dry and wet conditions, respectively (**Figure 5-19b**).

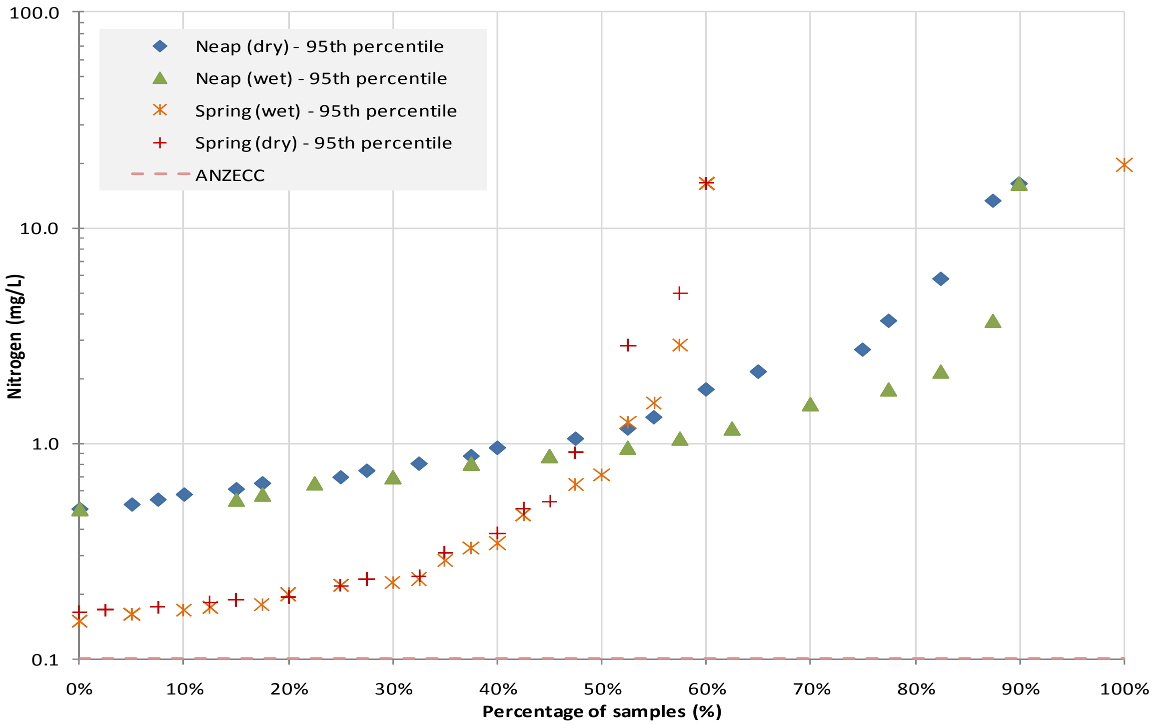
5.4.6. Nitrate-Nitrite

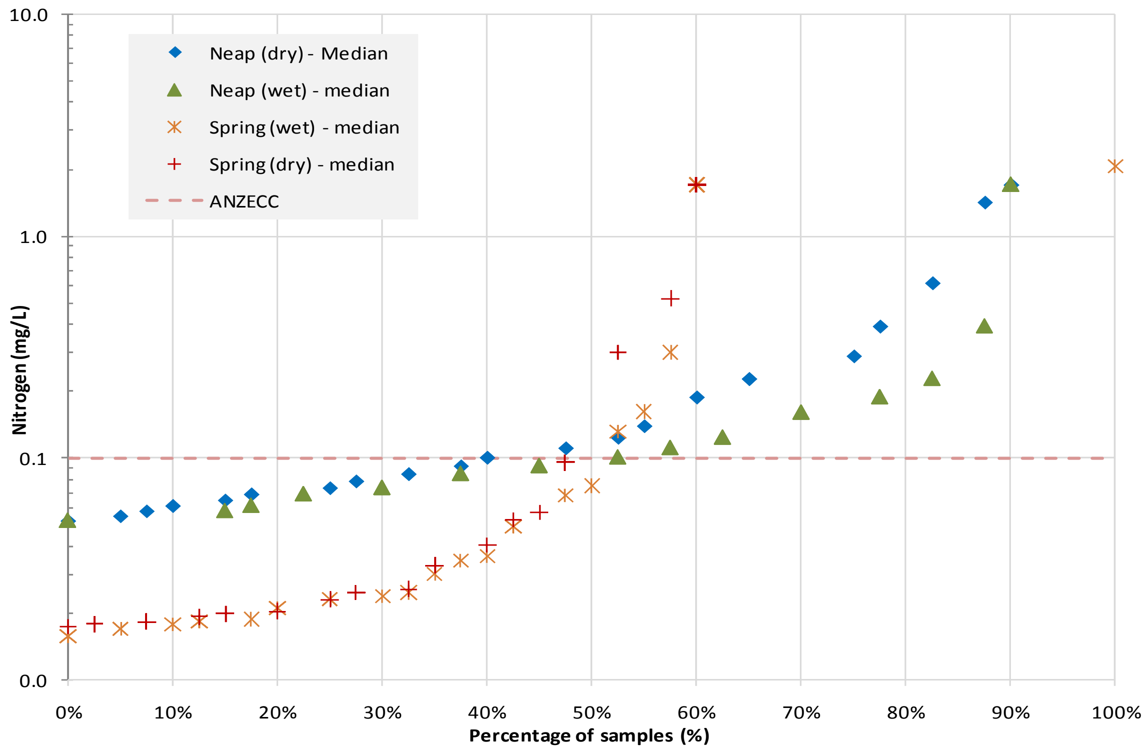
The ANZECC trigger levels will be exceeded 100 % of the time under the dry and wet neap and spring tide scenarios for both the 95th percentile and median nitrate levels in the discharge (**Figure 5-20**).



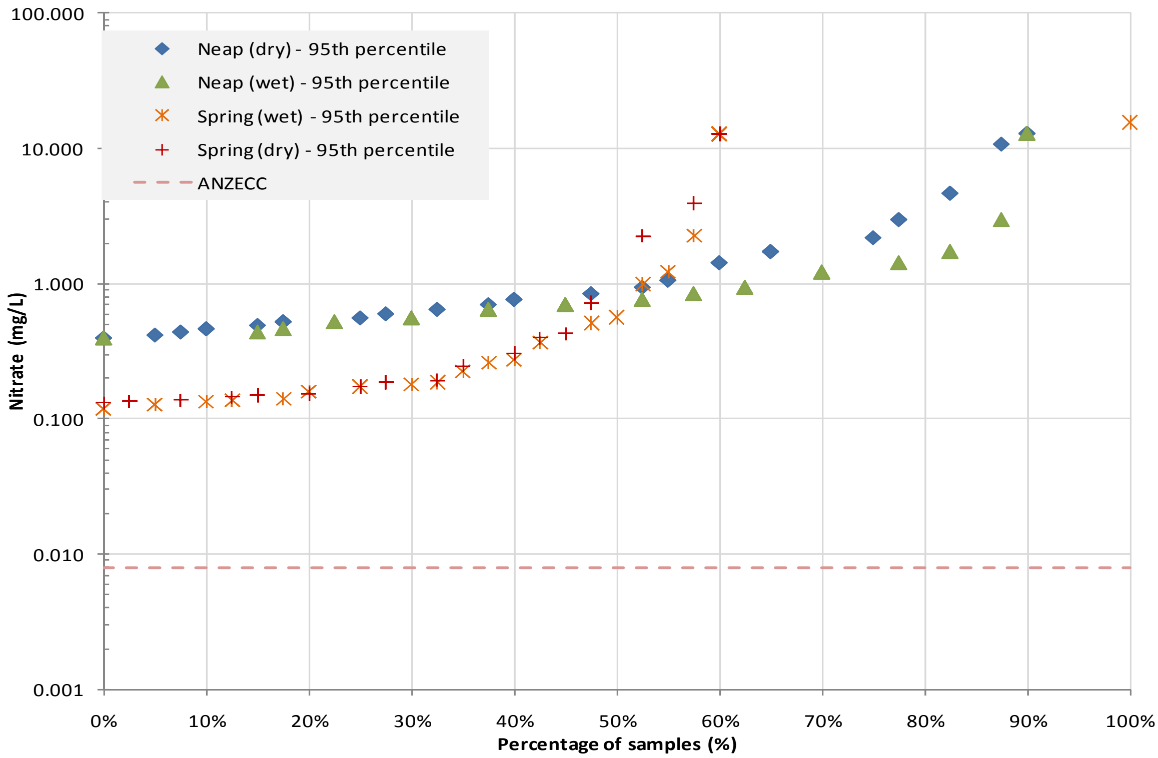


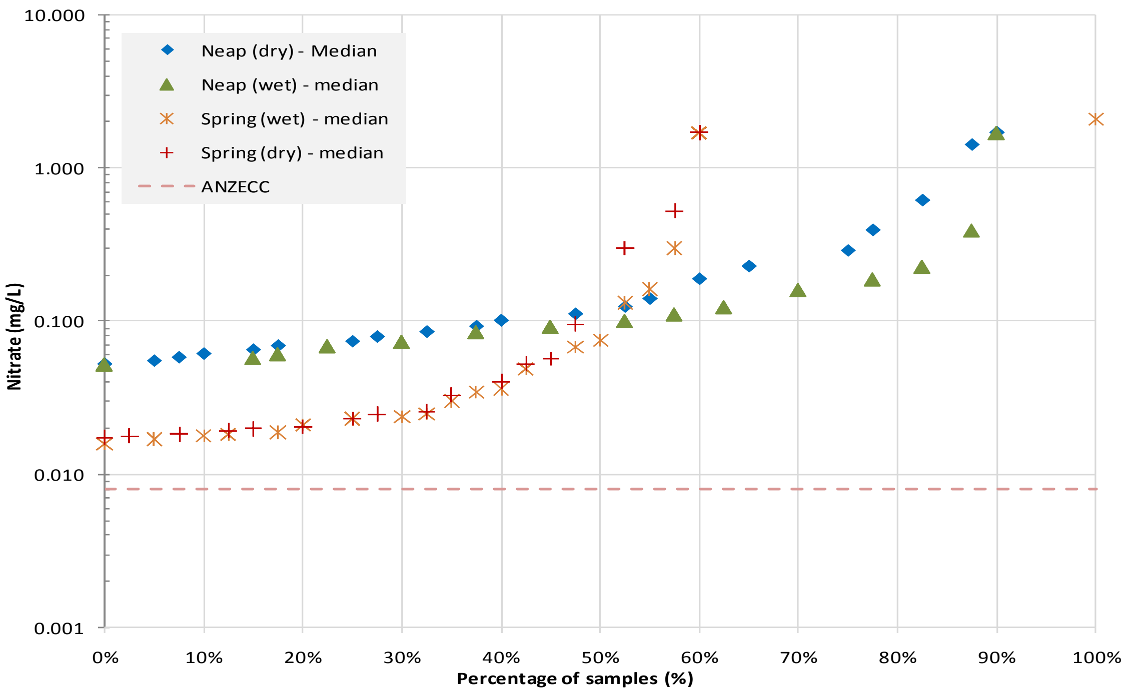
- **Figure 5-18 Dilution of discharge zinc levels under various tidal scenarios for a. 95th percentile concentrations and b. median concentrations.**





- **Figure 5-19 Dilution of discharge total nitrogen levels under various tidal scenarios for a. 95th percentile concentrations and b. median concentrations.**





- **Figure 5-20 Dilution of discharge nitrate-nitrite levels under various tidal scenarios for a. 95th percentile concentrations and b. median concentrations.**

6. Discussion

The dewatering discharge from car dumper construction at Boodarie may contain concentrations of nutrients and heavy metals that exceed the ANZECC water quality guidelines for the protection of aquatic ecosystems. The proposed discharge of up to 7 ML/day into Salmon Creek (if no water is used for construction purposes – worst case scenario) therefore has the potential to impact on the ecology of the receiving environment in Salmon Creek. The size and the extent of the mixing zone required to dilute the contaminant levels to below the ANZECC trigger levels (99 % protection of species) was modelled using the near-field hydrodynamic modelling package *Visual Plumes*.

Previous ecotoxicity studies on the discharge showed that the water quality was not toxic to sea urchin fertilisation, amphipods or fish, but was moderately toxic to microalgae, sea urchin and rock oyster larval development (SKM 2011). A 1:20 dilution was recommended to achieve 99% species protection (SKM 2011). Through this modelling, a 1:20 dilution was found to be possible within 3 to 4 m of the discharge point under most tidal depths (>0.5 m). The nature of the neap and spring tides means that water depths are less than 0.5 m for a significant proportion of the time. This assessment has estimated that water depths are less than 0.5 m in Salmon Creek up to 50 % of the time under spring tide conditions and up to 35 % of the time under neap tide conditions. It is under these conditions that the discharge into Salmon Creek has the potential to influence the local water quality and impact on ecological communities (SKM 2011).

In addition, the tidal range during a spring tide can be over 7 m at Port Hedland, which translates to a tidal range of 0 to 4 m in Salmon Creek. This means that under low tide conditions, the tidal water drains completely from the channel, exposing the mudflats and leaving only the small freshwater inflows including flows from the discharge point. This effect is particularly apparent during a spring tide, when the mudflats will be completely exposed in Salmon Creek 40 % of the time. The neap tide scenario does not have the same tidal range as the spring tide. Under neap tide conditions, the tidal influence will be present in Salmon Creek 90 % of the time to provide some dilution for the dewatering discharge.

The magnitude of the freshwater inflows to Salmon Creek are unknown, but based on the small catchment area, are expected to be highly seasonal and overall very small in the context of the size of Salmon Creek. These freshwater flows are not expected to provide any significant dilution for the discharged dewatering water. Therefore, the highest risk to the aquatic ecology in the receiving environment will occur when the tide is out and the mudflats are exposed. It is possible that the discharged water could constitute > 90% of the flow during these conditions and the concentrations of heavy metals could be toxic to certain flora and fauna in its path downstream. These low tide conditions would occur twice per day, but only persist for a maximum of 4 hours at a time during spring tide conditions and a maximum of 3 hours at a time during neap tide conditions

The aquatic ecosystem existing on the mudflats of the Salmon Creek receiving environment is likely to be highly adapted for changing conditions and high tidal velocities. Any areas containing sensitive flora and fauna within the low tide stream flow path may be impacted through nutrient enrichment and acute toxicity from heavy metals during low tide conditions due to lack of dilution from marine waters. The mangroves on the fringing edges of the estuary will not be affected by the discharge as the interaction of the tides with the mangroves will only occur under high tide conditions that will afford a high level of dilution of the discharge.

When tidal marine water is present, the modelling shows that the extent of the mixing zone required to dilute contaminants below the ANZECC trigger levels (99% species) is very small under most tidal conditions in the context of the size of Salmon Creek. The extent of the mixing zone is less than 4 m for heavy metals from the discharge point downstream during outgoing tide and upstream during an incoming tide. This is very small considering the width of the channel varies from 45 m at a tidal depth of 1 m to 630 m at a depth of 4 m. As the mixing zone only encapsulates a small portion of the channel, it is not expected to impact on fish passage or local habitat.

The extremely high nitrate-nitrite levels in the discharge require a larger mixing zone under all conditions (which is outside of the near-field model boundaries) to achieve compliance with ANZECC trigger levels for the slightly disturbed near shore ecosystems in tropical Australia. Nutrients are not considered toxicants (except ammonia - which is below trigger levels in the discharge water). Therefore, the concentrations in the mixing zone are not of concern for acute or chronic toxicity in the mixing zone. Rather nutrients, particularly nitrate-nitrite as it is highly bioavailable, are of concern for their potential to enrich the environment and increase the risk of algal blooms and nuisance plant growth. Background nutrient levels are not known. The nutrient load to the environment will increase with the discharge. However, the large tidal flushing cycle should ensure that there will be very limited build up of nutrients in the environment and limit the potential for algal blooms due to the short time between tide events.

7. Conclusion and recommendations

The objective of this study was to use near-field hydrodynamic modelling to define and demonstrate the initial zone of mixing and potential zones of effect from a range of chemicals of concern in the Boodarie groundwater discharge to the Salmon Creek receiving environment. The chemicals of concern had concentrations above the ANZECC trigger levels for toxicants. Those selected were chromium, silver, mercury and zinc. Although not a toxicant, nitrogen levels were also considered because of the potential for eutrophication of the receiving environment from high levels in the discharge water.

An initial mixing zone of 3 to 4 metres was found to be sufficient to dilute the heavy metal concentrations to levels below the ANZECC trigger levels (99% of species) when the water depths were greater than 0.5 m. This is very small compared with the size of Salmon Creek (average width of 90 m). However, the tides in Salmon Creek have a strong influence on the depth of water in the creek. Under low tide conditions, the tide completely drains out of the Salmon Creek exposing the mudflats. It is under these conditions that the discharge may constitute the majority of the flow and therefore impact on the aquatic ecosystems through acute heavy metal toxicity. These low tide conditions occur twice per day, but only persist for a maximum of 4 hours at a time during spring tide conditions and a maximum of 3 hours at a time during neap tide conditions. This will only affect the ecosystem present at the bottom of the channel, and will not impact on the mangroves or rocky reef areas that are higher up in the channel.

Nitrate-nitrate levels in the discharge are extremely high and are not adequately diluted to meet the ANZECC trigger levels for inshore ecosystems in the near-field mixing zone. This presents a risk of nutrient enrichment in the harbour environment.

Overall, the heavy metal Boodarie groundwater discharge is not anticipated to have a highly significant impact on the Salmon Creek receiving environment if no sensitive habitats are found to be present. Further modelling would be required to determine if the long term scenario of continual high concentrations of nutrients entering the system over a long period of time would cause any deleterious effects to the system.

8. References

ANZECC/ARMCANZ (2000). *Australian and New Zealand guidelines for fresh and marine water quality. National Water Quality Management Strategy No 4*, Australian and New Zealand Environment and Conservation Council and Agricultural and Resource Management Council of Australia and New Zealand, Canberra, ACT.

APASA (2009) *RGP5 and RGP6 Dredging Programme: Prediction of Sediment Fate*, Revision 4. A report prepared for SKM & BHPBilliton by Asia-Pacific ASA.

Frick W., Roberts P., Davis L., Keyes J., Baumgartner D. & George K. (2003) Dilution models for effluent discharges, 4th Edition (Visual Plumes) pp. March 2003. United States Environmental Protection Agency

GEMS (2008) *RGP5 Port Facilities: Dredging program simulation studies at Harriet Point*. A report prepared for BHP Billiton Iron Ore by Global Environmental Modelling Systems.

GEMS (2009) *RGP6 Port Development: Sediment Plume and Hydrodynamic Modelling*. A report prepared by BHP Billiton Iron Ore by Global Environmental Modelling Systems.

SKM (2009) *RGP5 Port Facilities Execution Phase Study: Baseline Water Quality Report – DMMA 'A' Spatial Assessment: - Dry and Wet Seasons.* A report prepared by Sinclair Knight Merz for BHP Billiton Iron Ore.

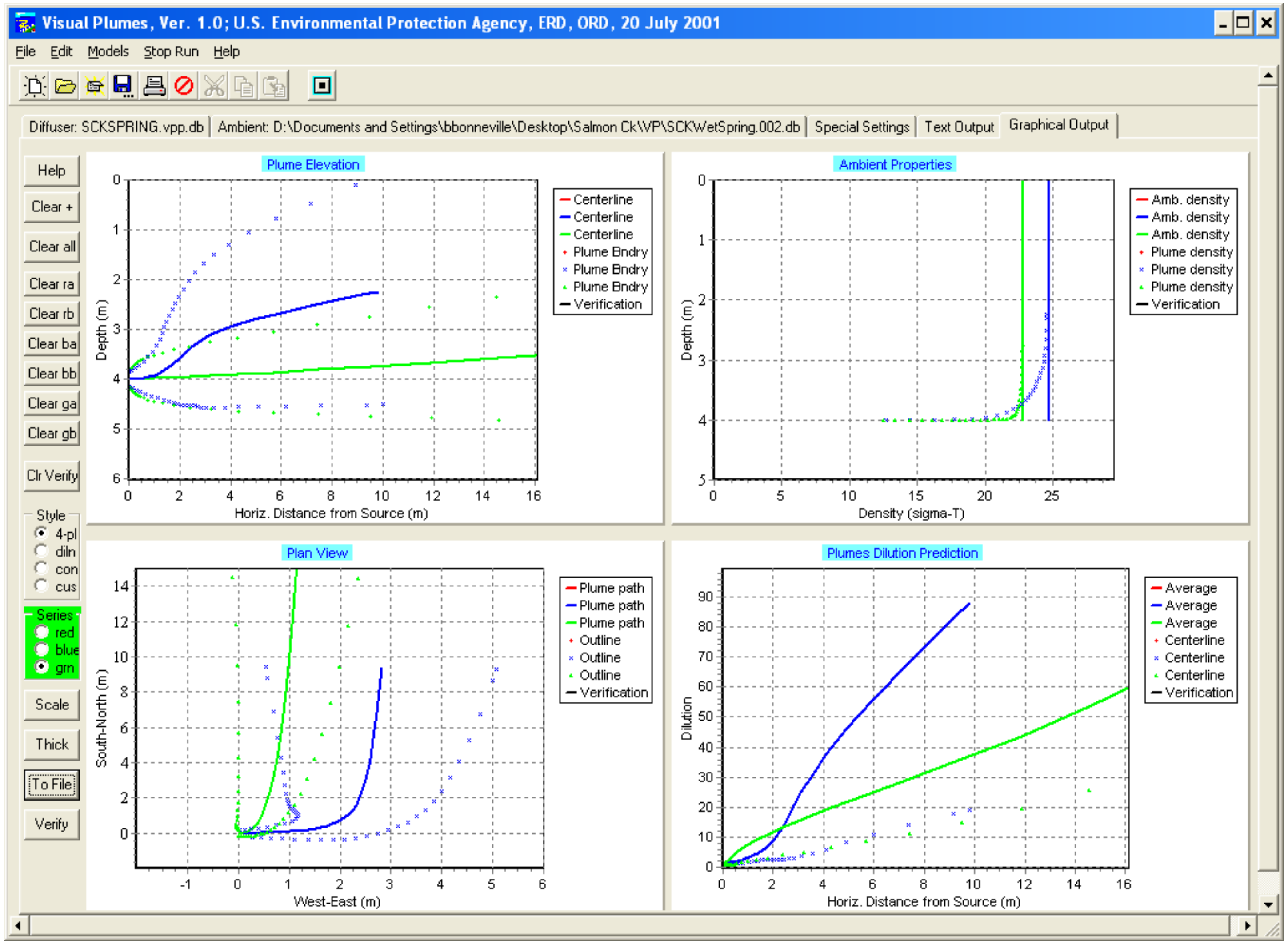
SKM (2010). *RGP5 Port Facilities Summary Water Quality and Coral Health Report*, Sinclair Knight Merz. Perth.

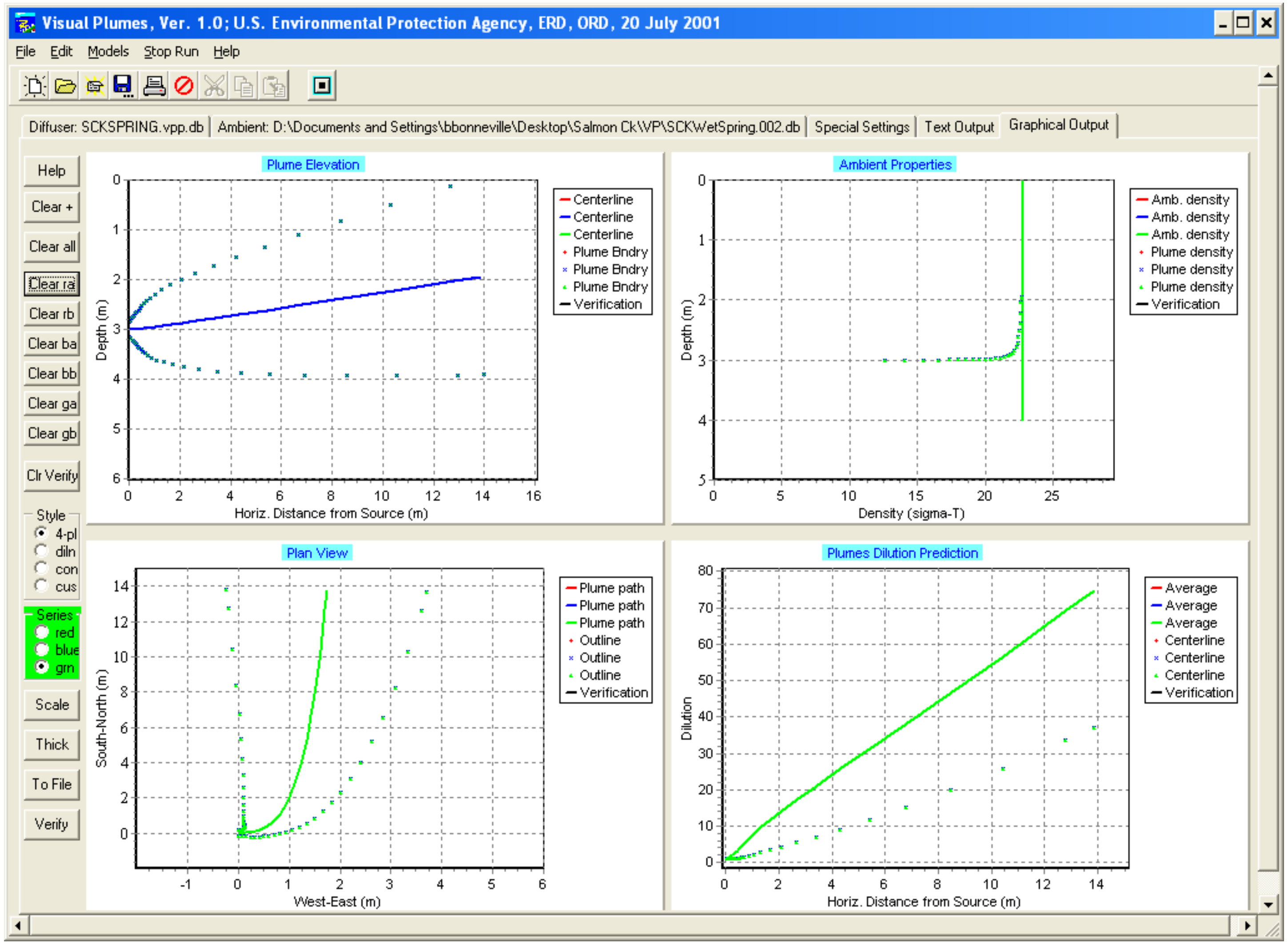
SKM (2011) *Proposed Outer Harbour Development Environmental Approvals: Proposed Dewatering and Discharge to Salmon Creek: Impact Assessment*, A report prepared by Sinclair Knight Merz for BHP Billiton.

Appendix A – Model Outputs

8.1. Chromium

8.1.1. MEDIAN - Spring


Visual Plumes, Ver. 1.0; U.S. Environmental Protection Agency, ERD, ORD, 20 July 2001
File Edit Models Stop Run Help
Diffuser: SCKSPRING.vpp.db
Ambient: D:\Documents and Settings\bbonneville\Desktop\Salmon Ck\VP\SCKWetSpring.002.db
Special Settings
Text Output
Graphical Output
Help
Clear +
Clear all
Clear ra
Clear rb
Clear ba
Clear bb
Clear ga
Clear gb
Clr Verify
Style
4-pl
diln
con
cus
Series
red
blue
grn
Scale
Thick
To File
Verify
Plume Elevation
Depth (m)
Horiz. Distance from Source (m)
Centerline
Centerline
Centerline
Plume Bndry
Plume Bndry
Plume Bndry
Verification
Ambient Properties
Depth (m)
Density (sigma-T)
Amb. density
Amb. density
Amb. density
Plume density
Plume density
Plume density
Verification
Plan View
South-North (m)
West-East (m)
Plume path
Plume path
Plume path
Outline
Outline
Outline
Verification
Plumes Dilution Prediction
Dilution
Horiz. Distance from Source (m)
Average
Average
Average
Centerline
Centerline
Centerline
Verification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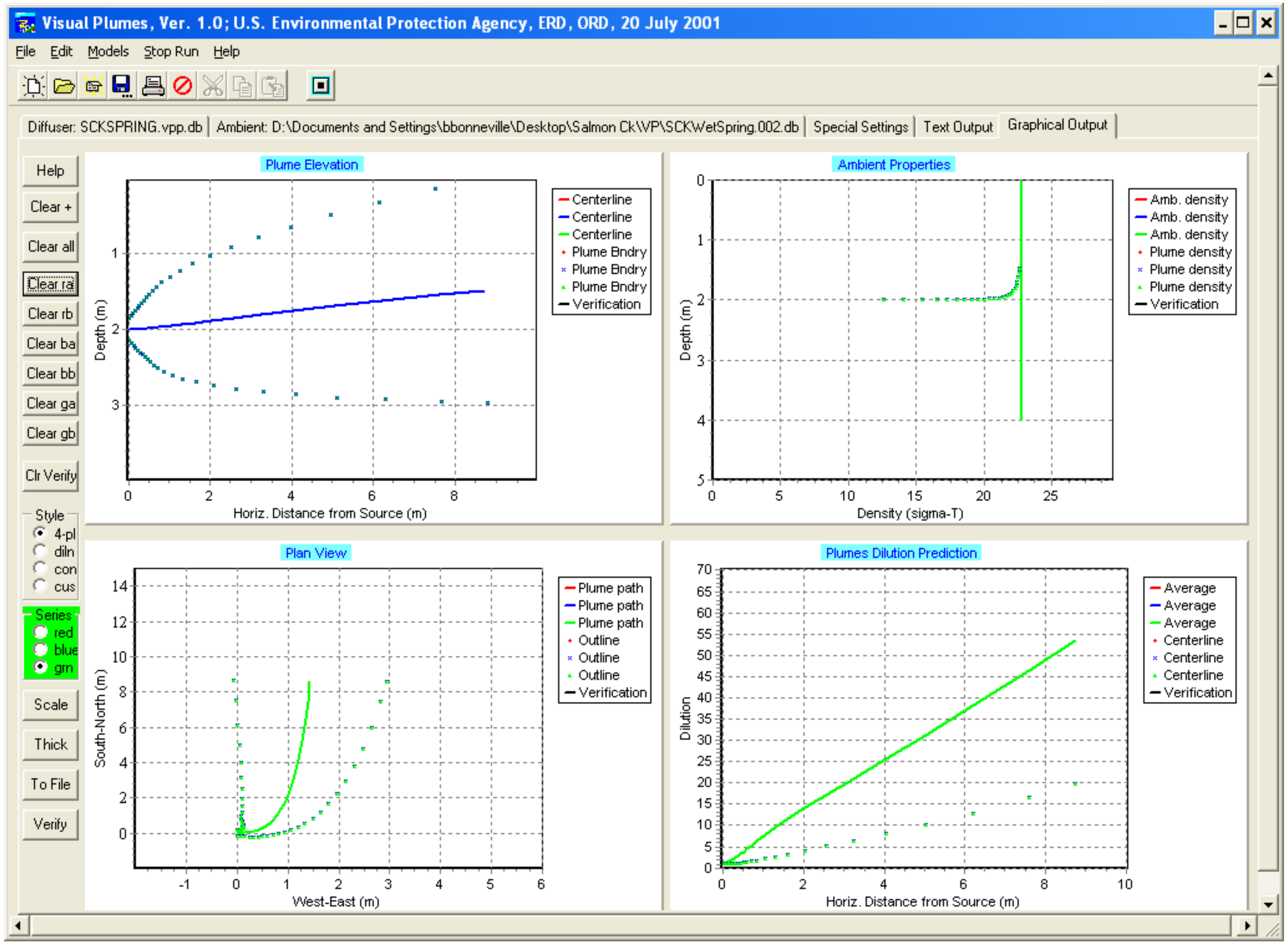
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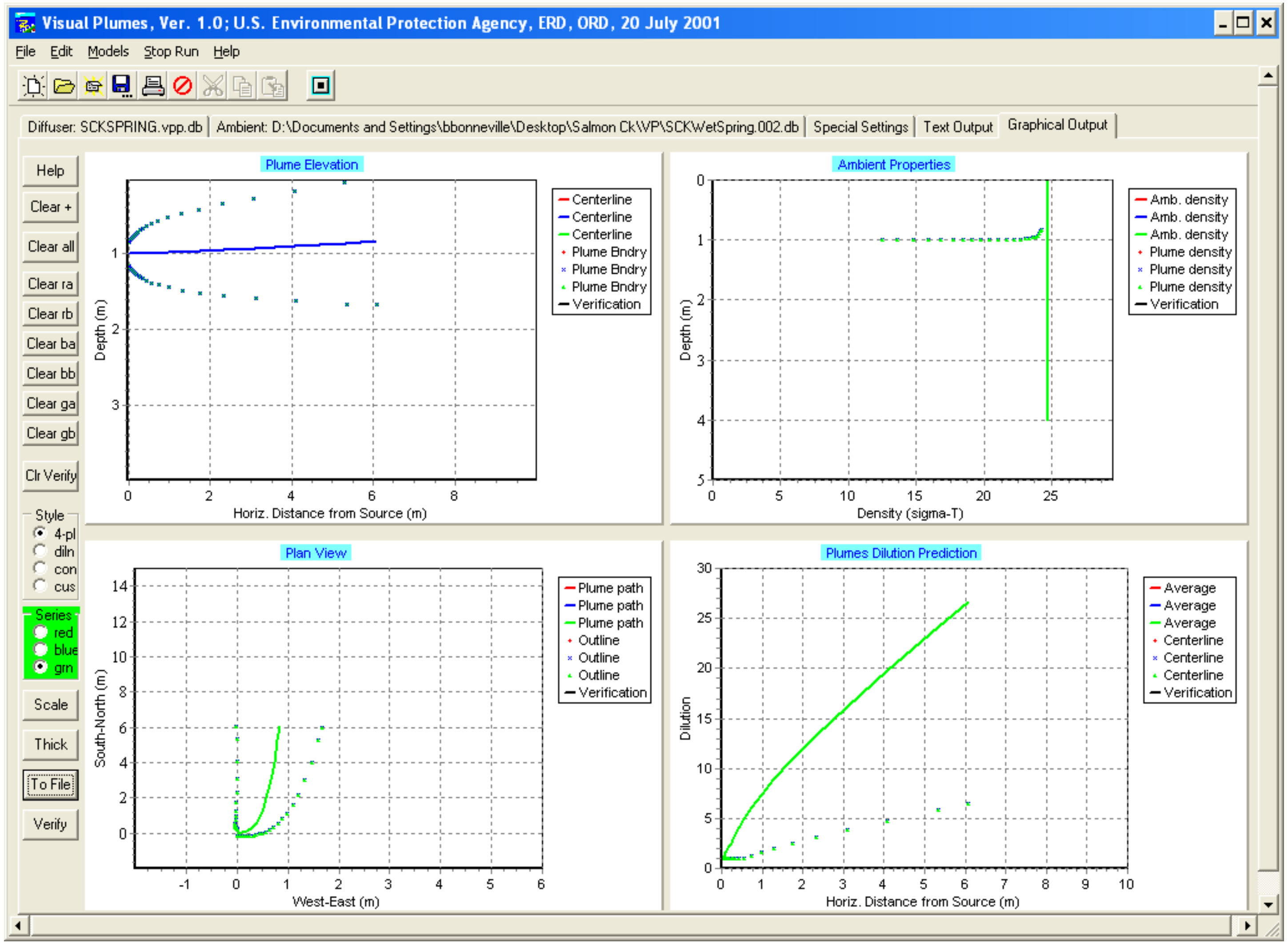
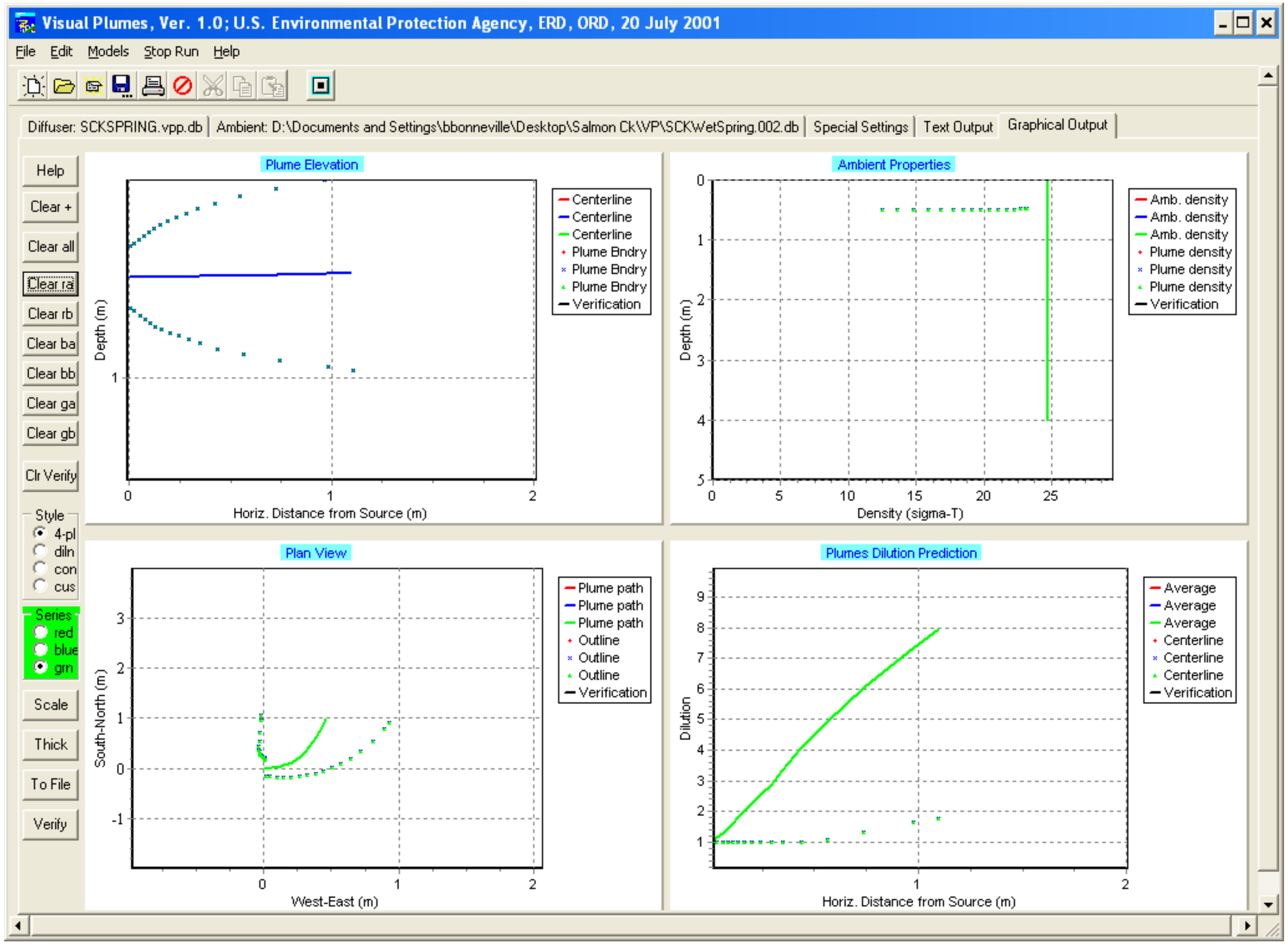


SINCLAIR KNIGHT MERZ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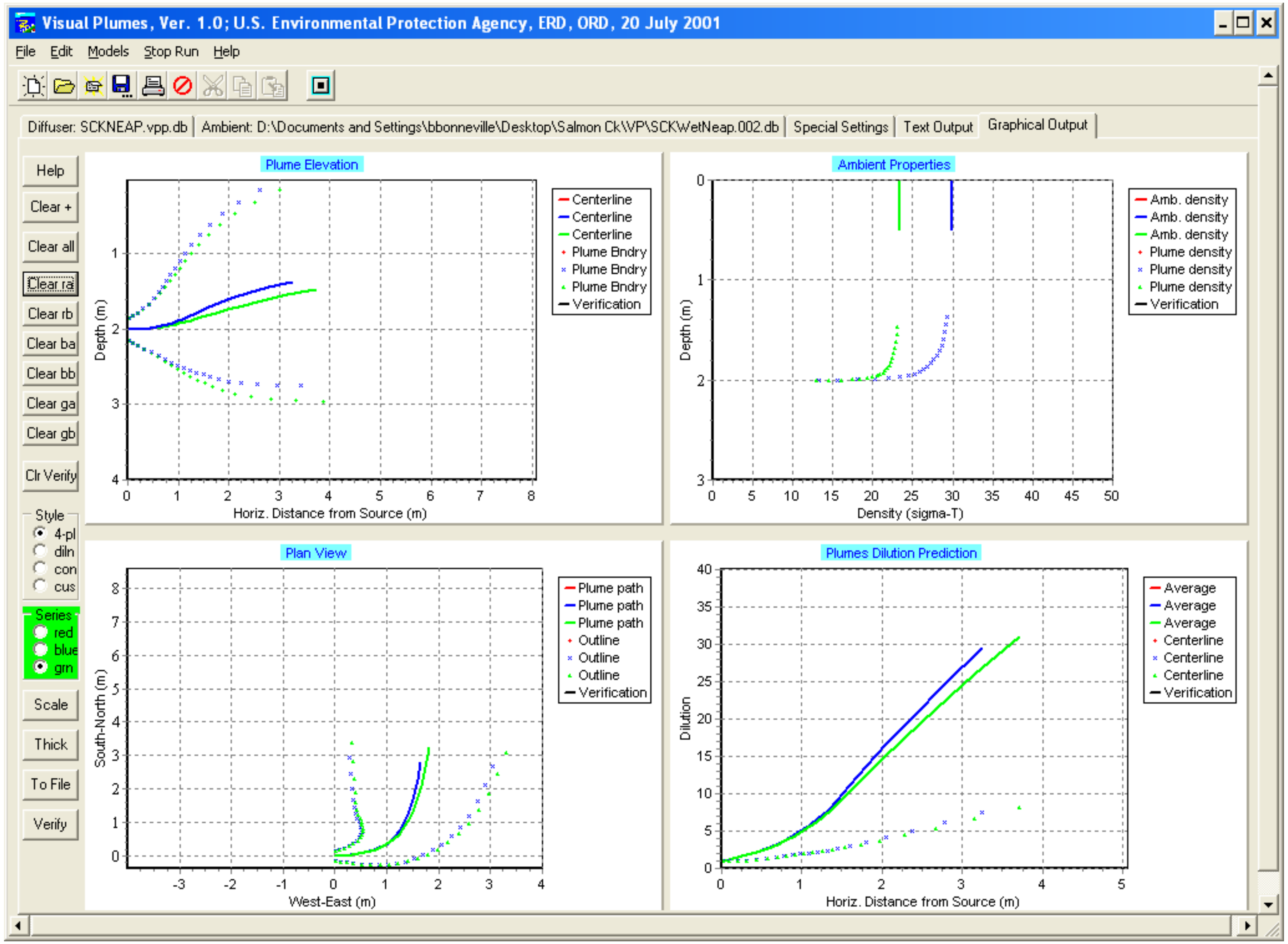
8.1.2. MEDIAN - Neap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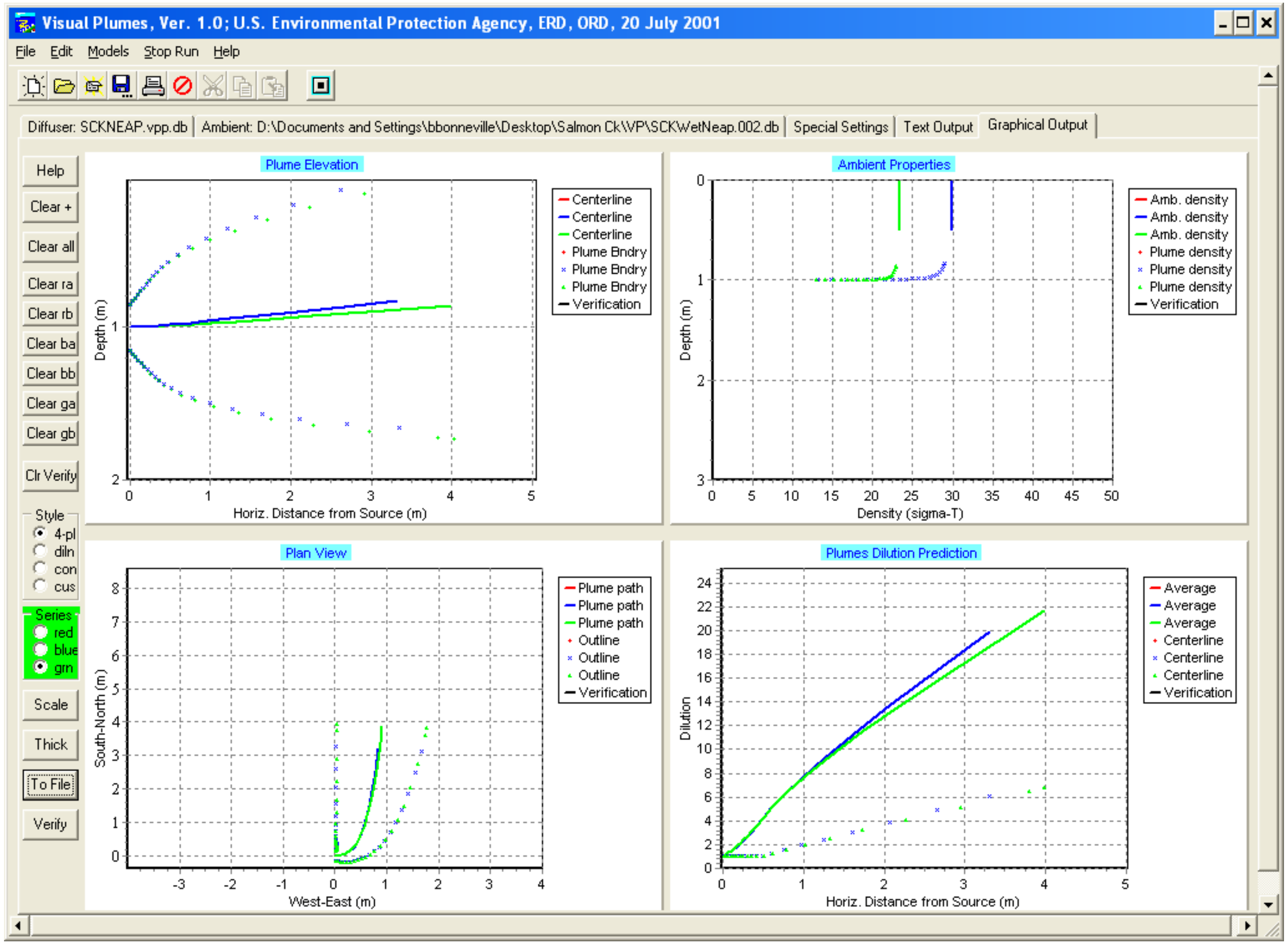
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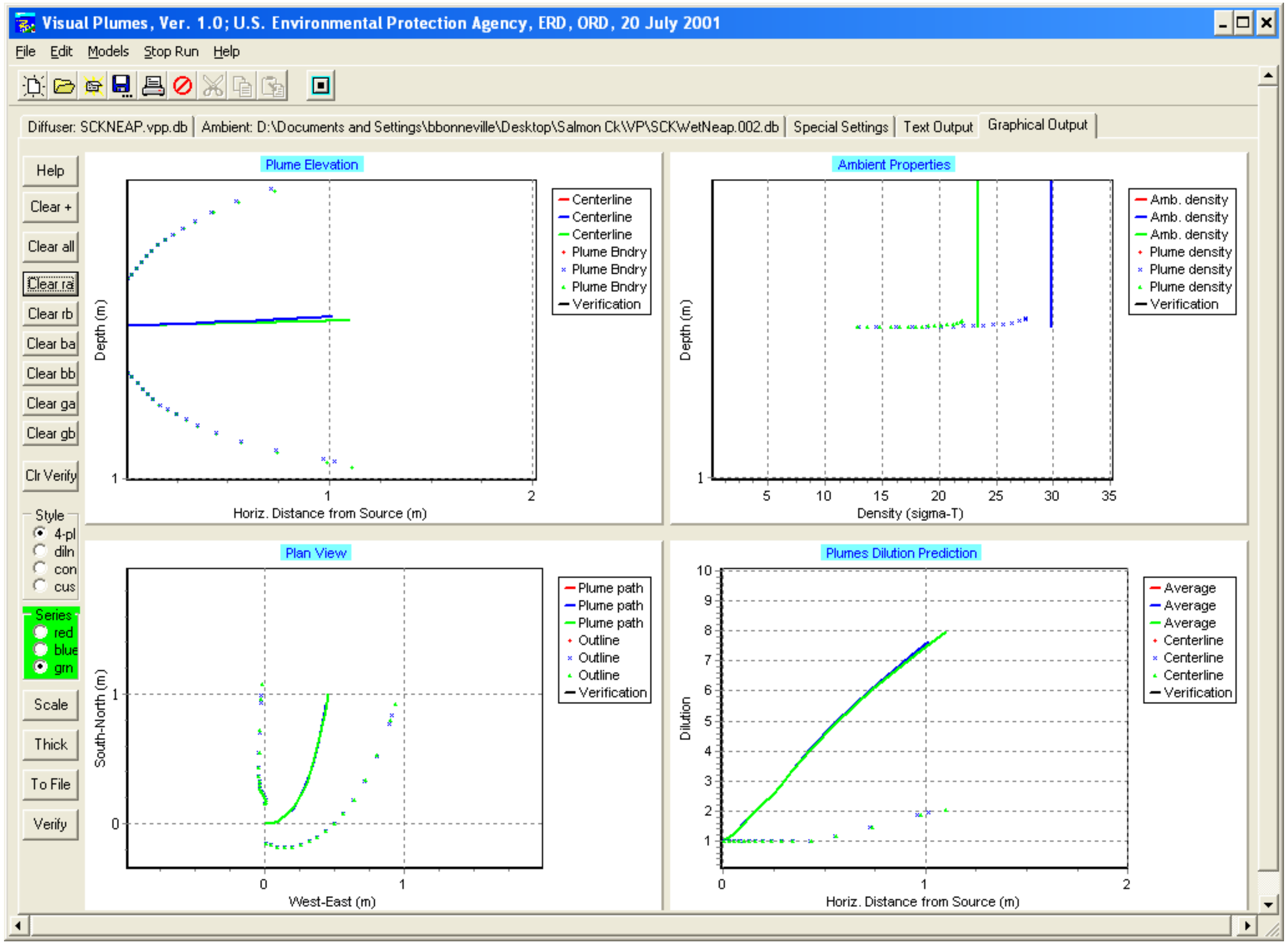
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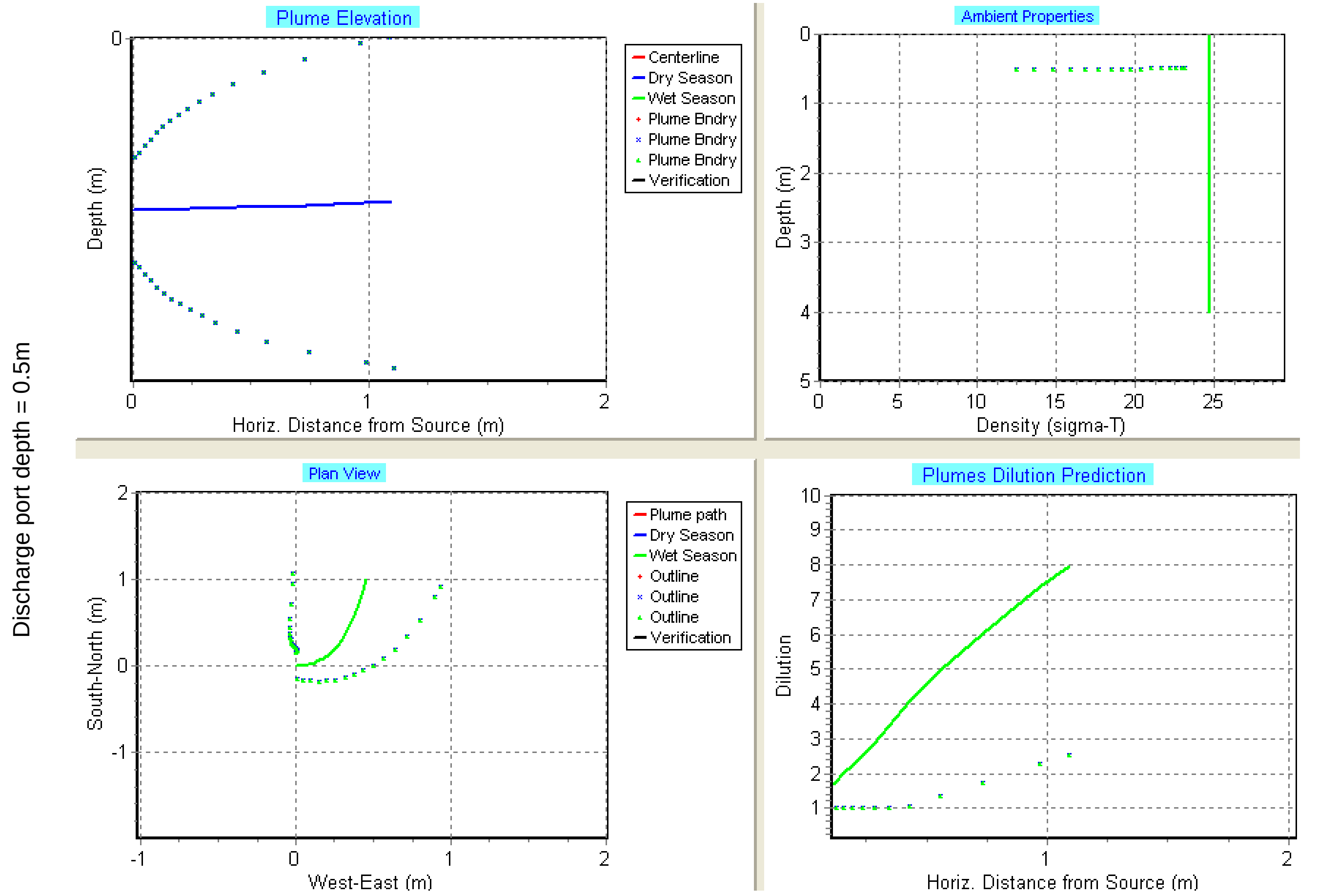
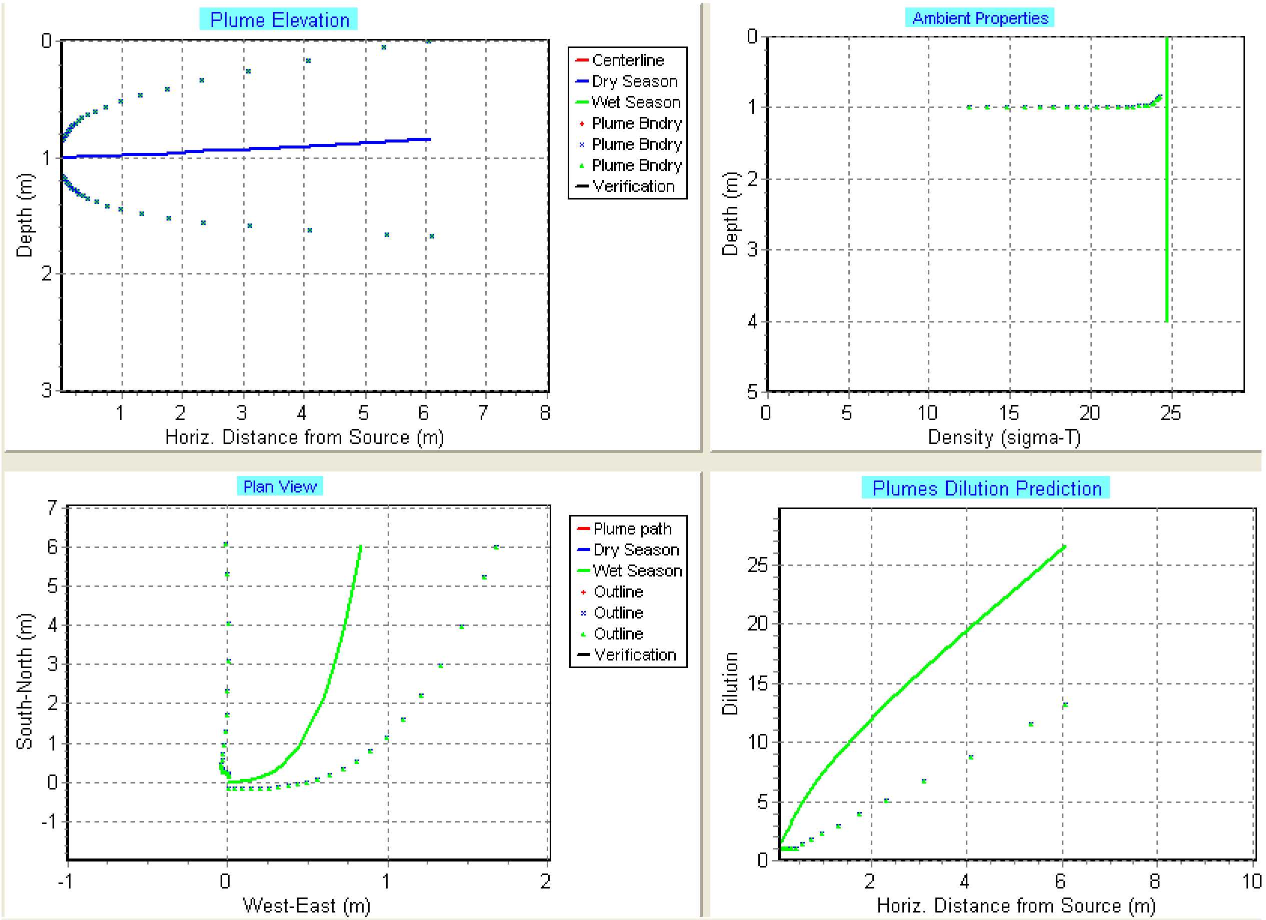
8.2. Silver

8.2.1. 95th Percentile – Spring



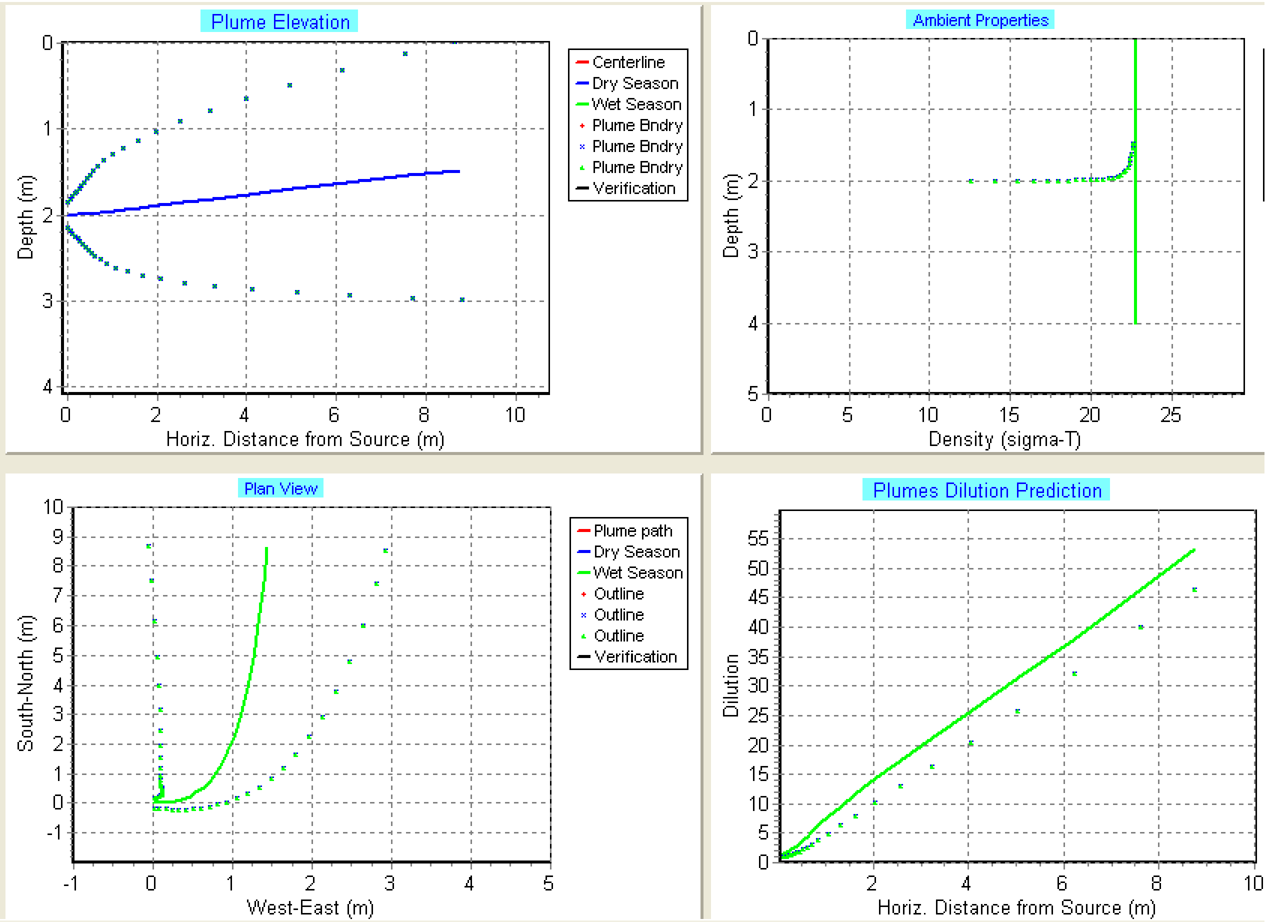
At a depth of 0.5 m during a spring tide, the maximum initial dilution achievable is 1:8, which is below the desired level of 1:17 for initial dilution. The maximum initial dilution is achieved 1m downstream of the discharge port. The mixing zone is very similar in both the dry and wet seasons.

Discharge port depth = 1m



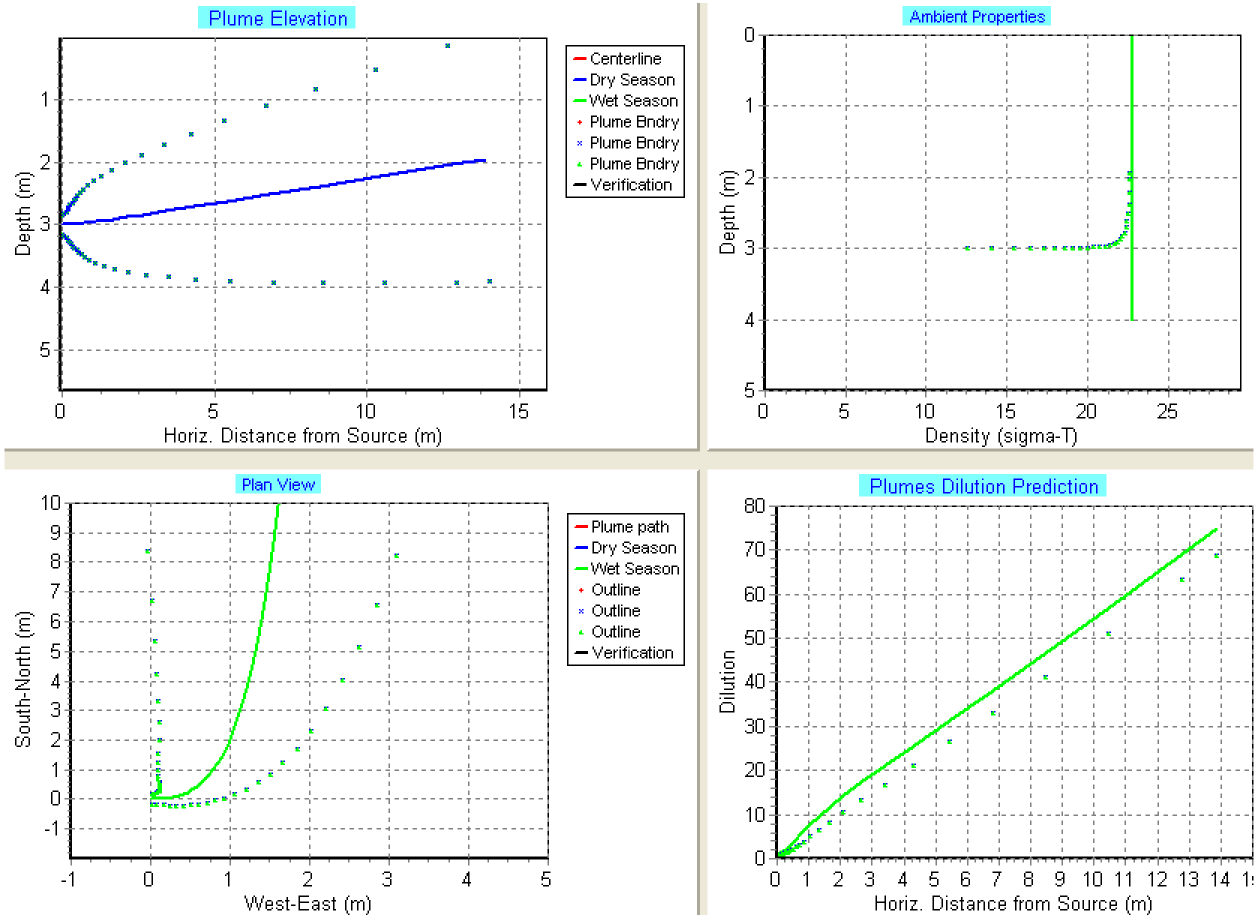
At a depth of 1m during a spring tide, the 1:17 initial dilution is achieved 2.6 m downstream of the discharge port during both the dry and wet seasons.

Discharge port depth = 2m



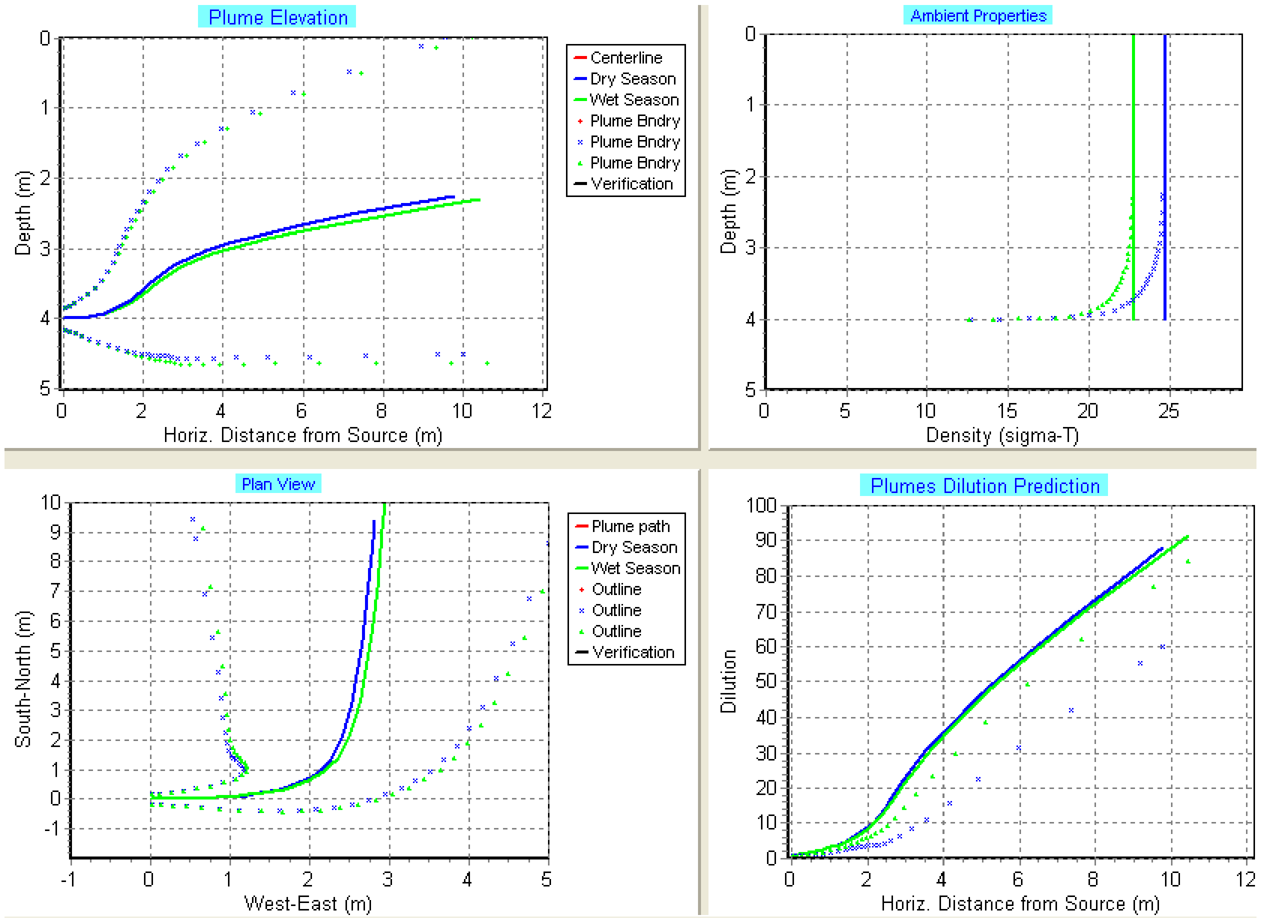
At a depth of 2m during a spring tide, the 1:17 initial dilution is achieved 2.5 metres downstream of the discharge port during both the dry and wet seasons.

Discharge port depth = 3m



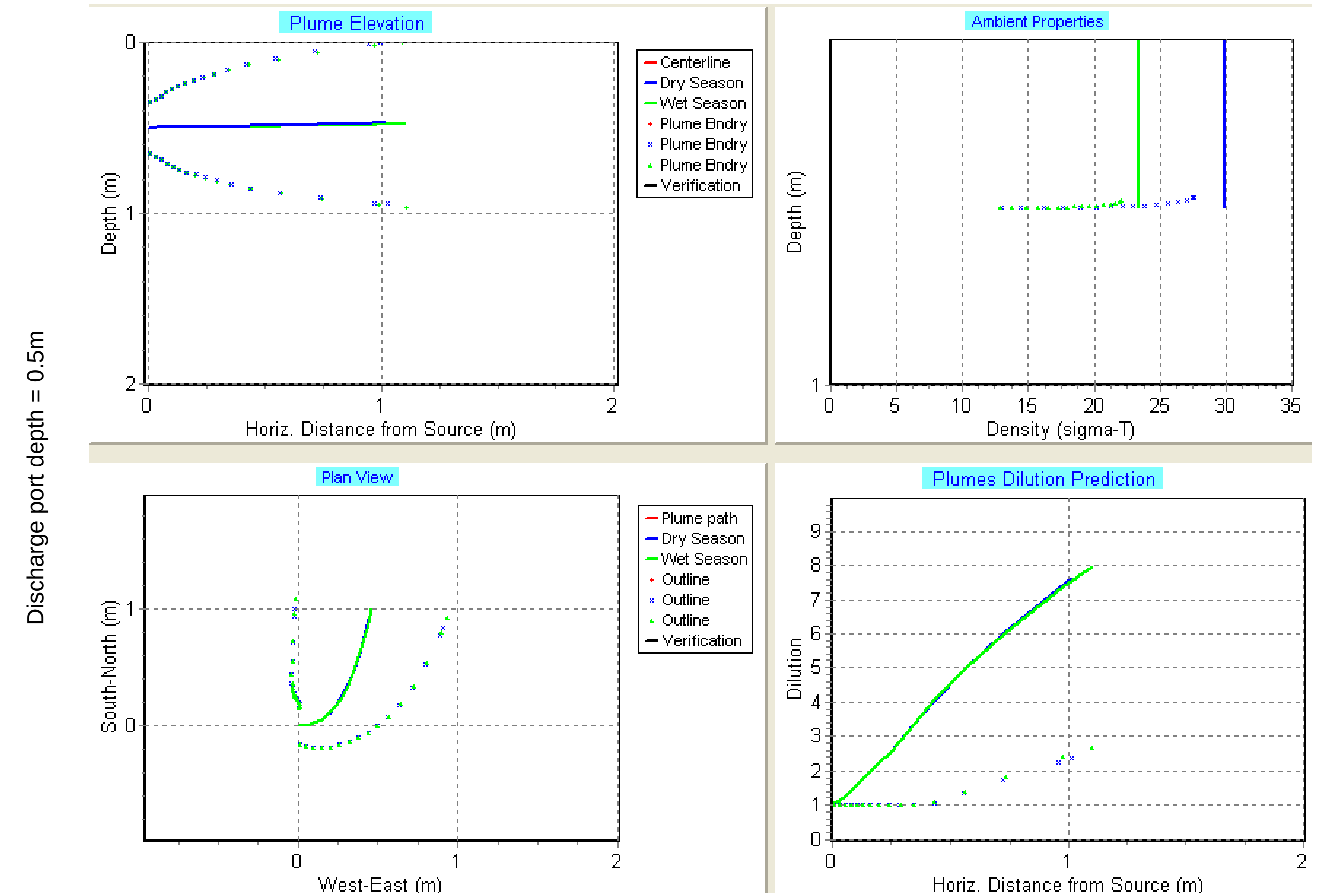
At a depth of 3m during a spring tide, the 1:17 initial dilution is achieved 2.5 metres downstream of the discharge port during both the dry and wet seasons.

Discharge port depth = 4m



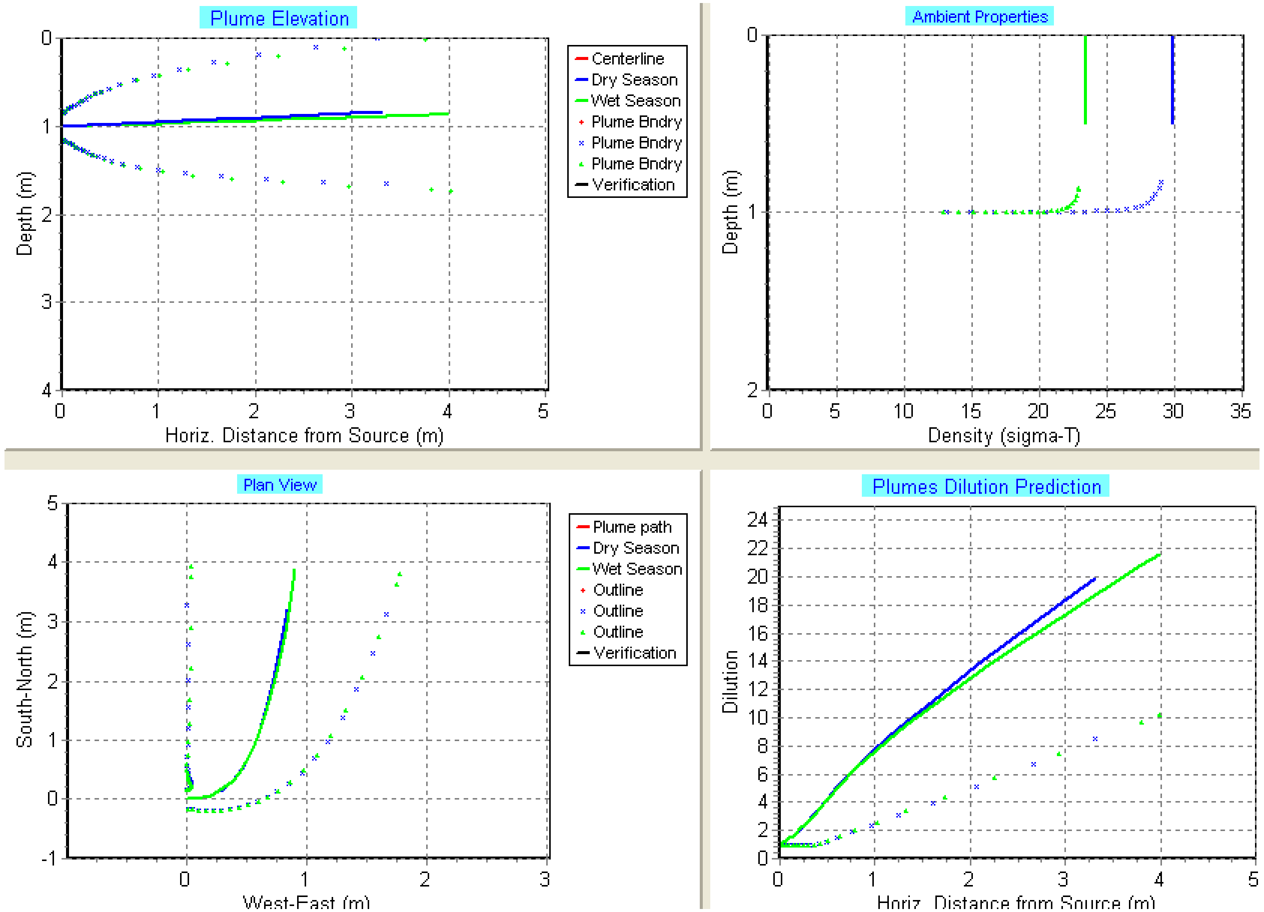
At the maximum depth of 4m during a spring tide, the 1:17 initial dilution is achieved 2.6 metres downstream of the discharge port during the dry and wet seasons.

8.2.2. 95th Percentile - Neap



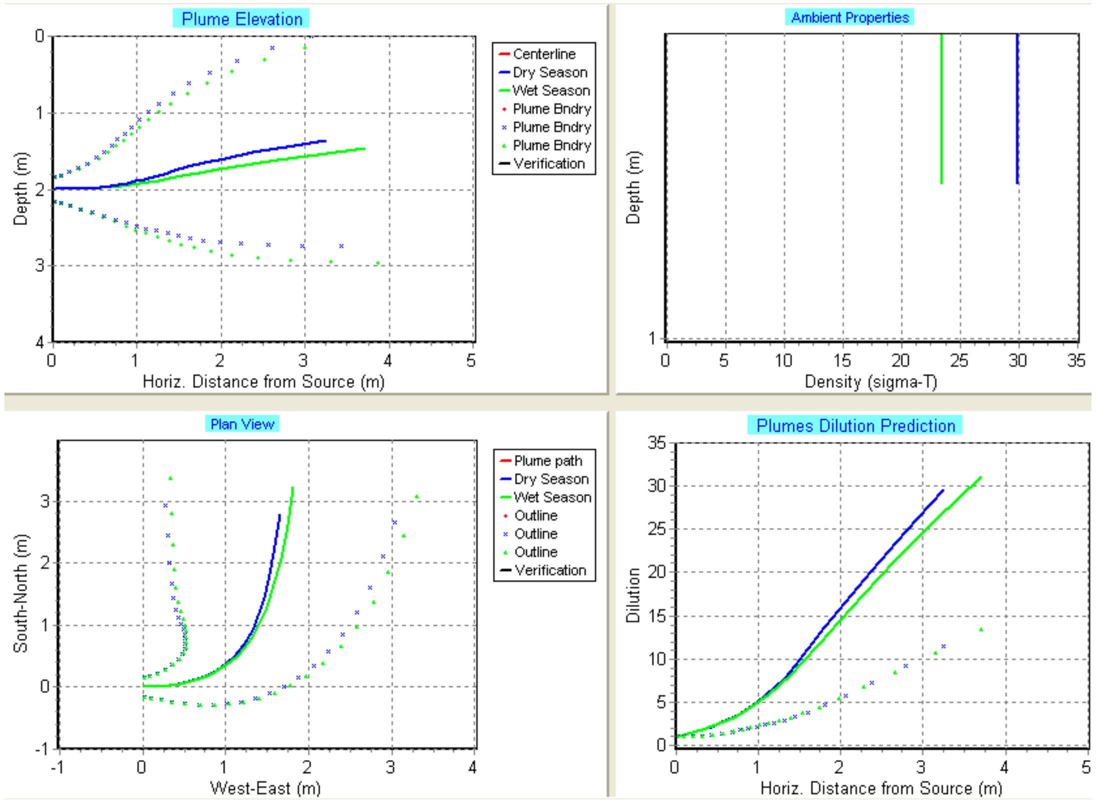
At a depth of 1m during a neap tide, the maximum initial dilution achievable is 1:8, which is below the desired level of 1:17 for initial dilution. The mixing zone is very similar in both the dry and wet seasons.

Discharge port depth = 1m



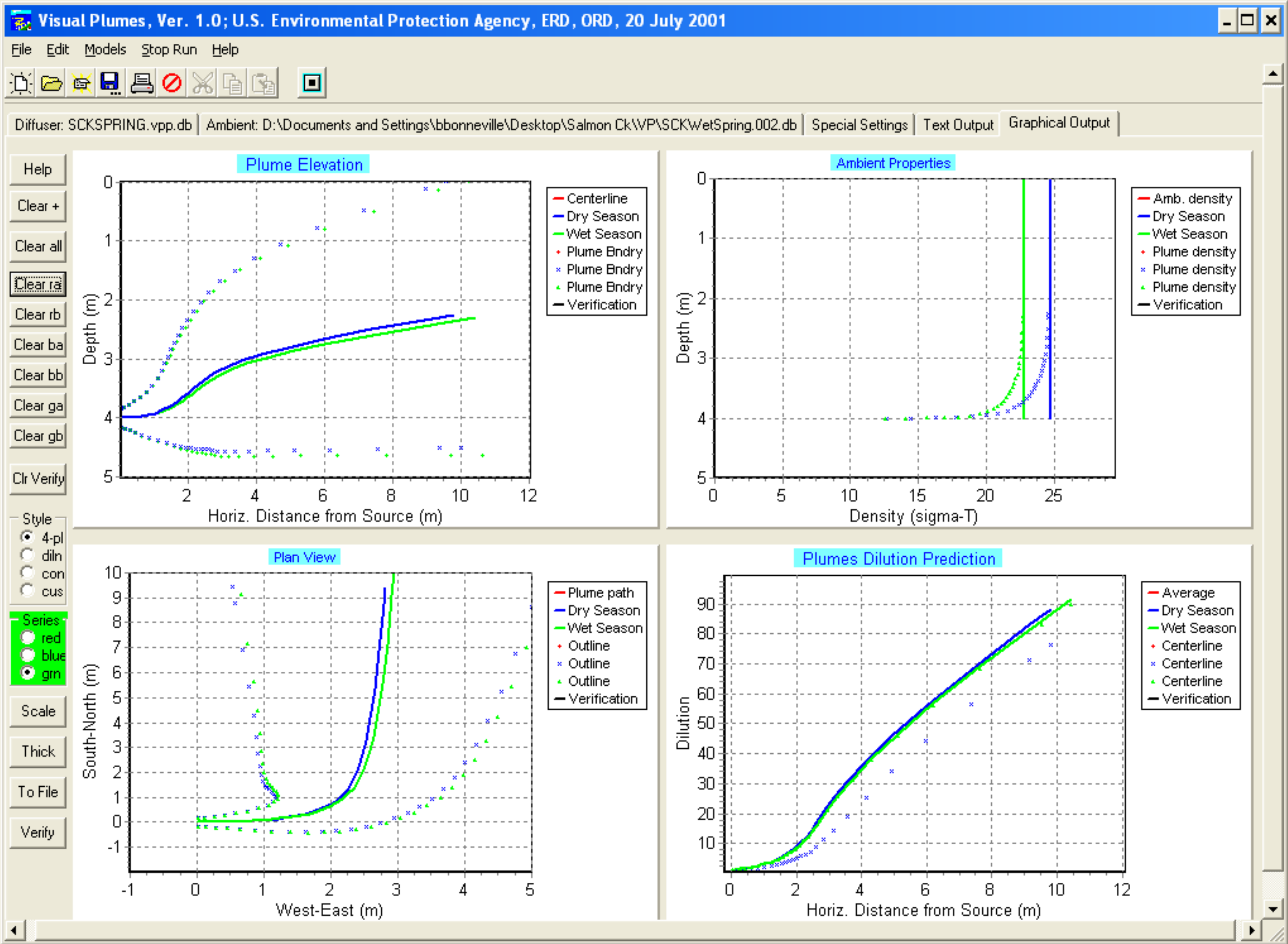
At a depth of 1m during a neap tide, the 1:17 initial dilution is achieved within 2.5 metres and 3m downstream of the discharge port during the dry and wet seasons respectively. The mixing zone is less during the dry season because the water is denser (more saline) and colder than during the wet season, which causes the discharge to rise more rapidly through the water column.

Discharge port depth = 2m

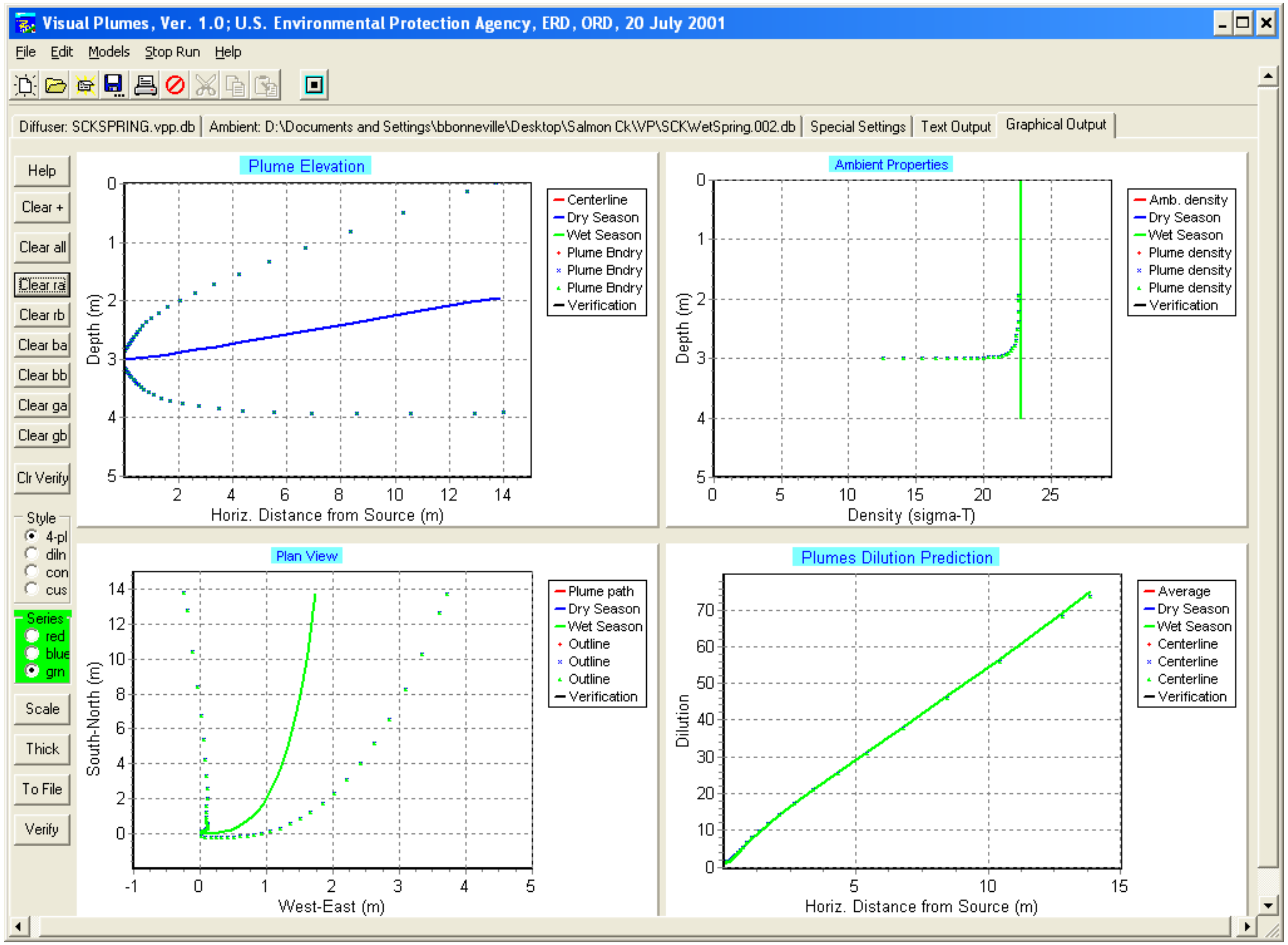


At a depth of 2m during a neap tide, the 1:17 initial dilution is achieved within 2.0 metres and 2.2 m downstream of the discharge port during the dry and wet seasons respectively. The mixing zone is less during the dry season because the water is denser (more saline) and colder than during the wet season, which causes the discharge to rise more rapidly through the water column.

8.2.3. MEDIAN -Spring



SINCLAIR KNIGHT MERZ



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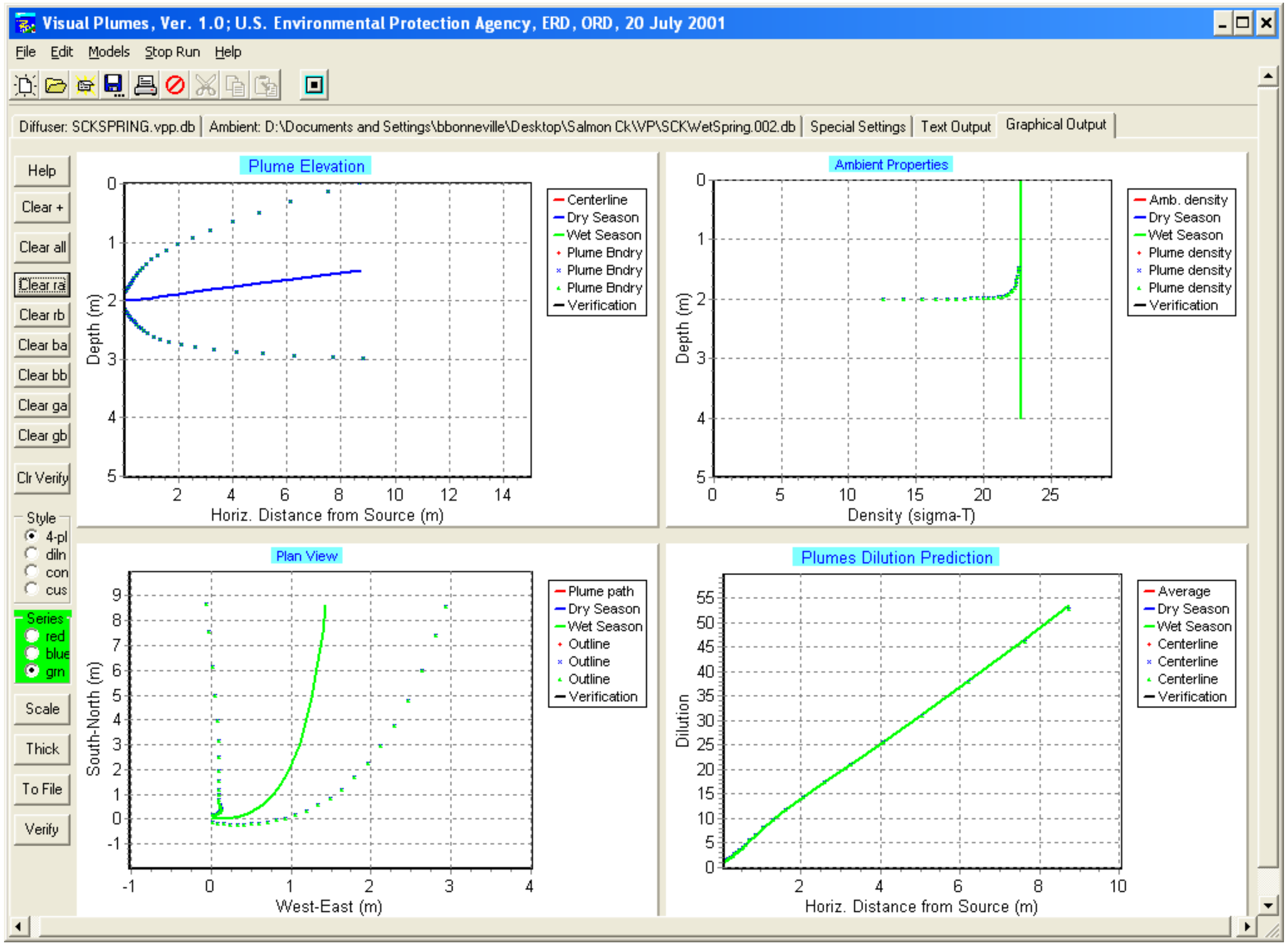
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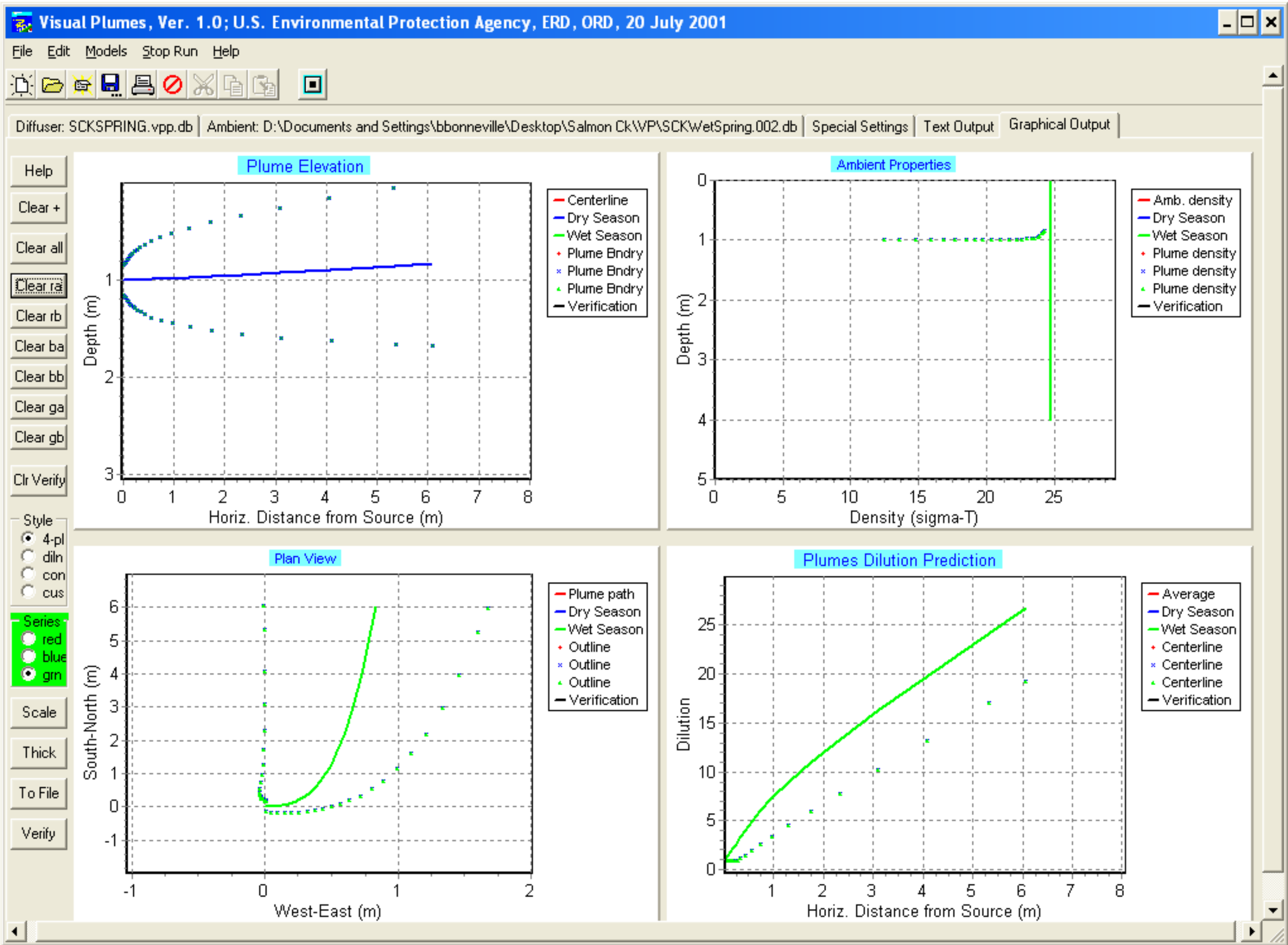
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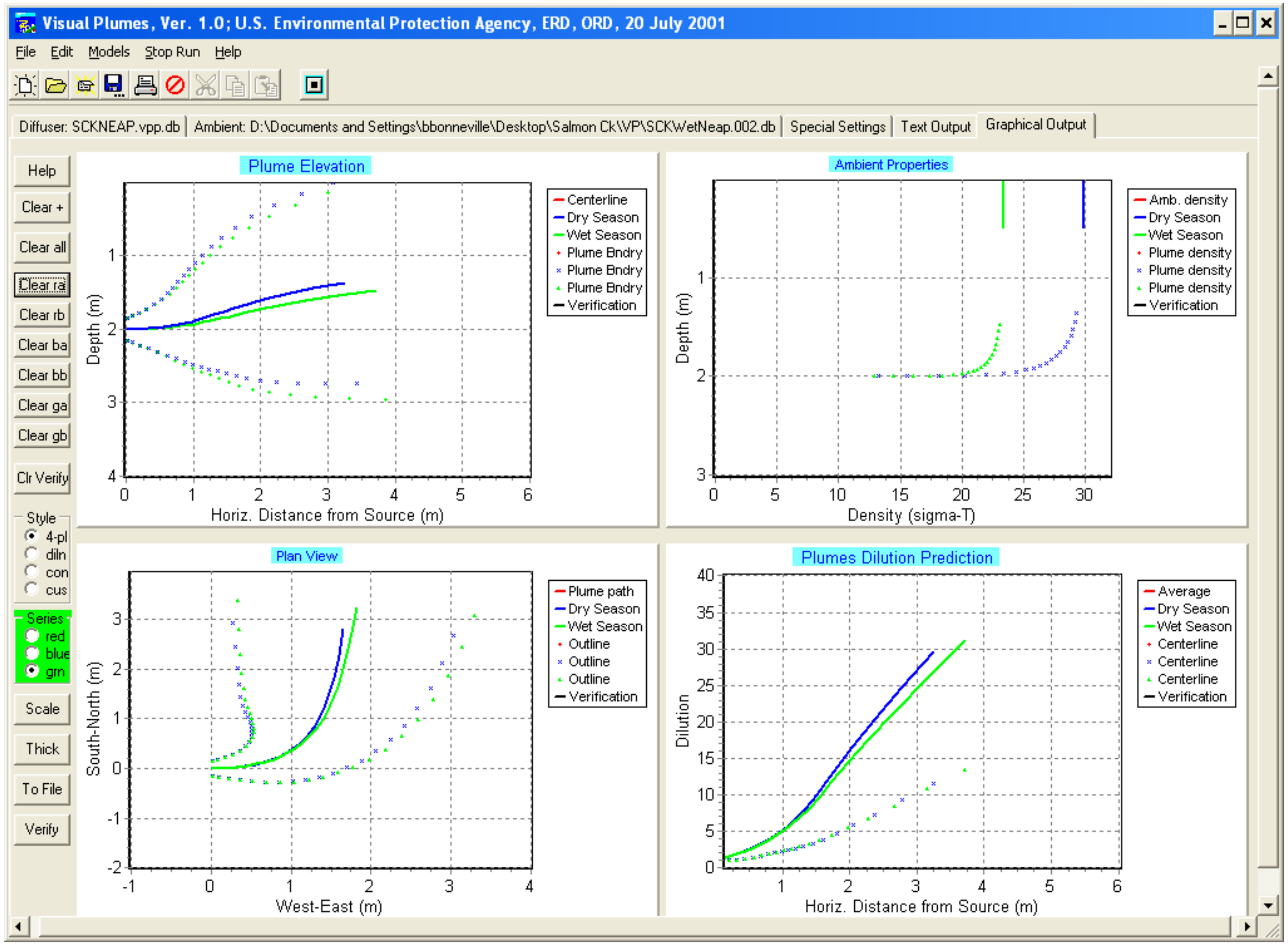
8.2.4. MEDIAN – neap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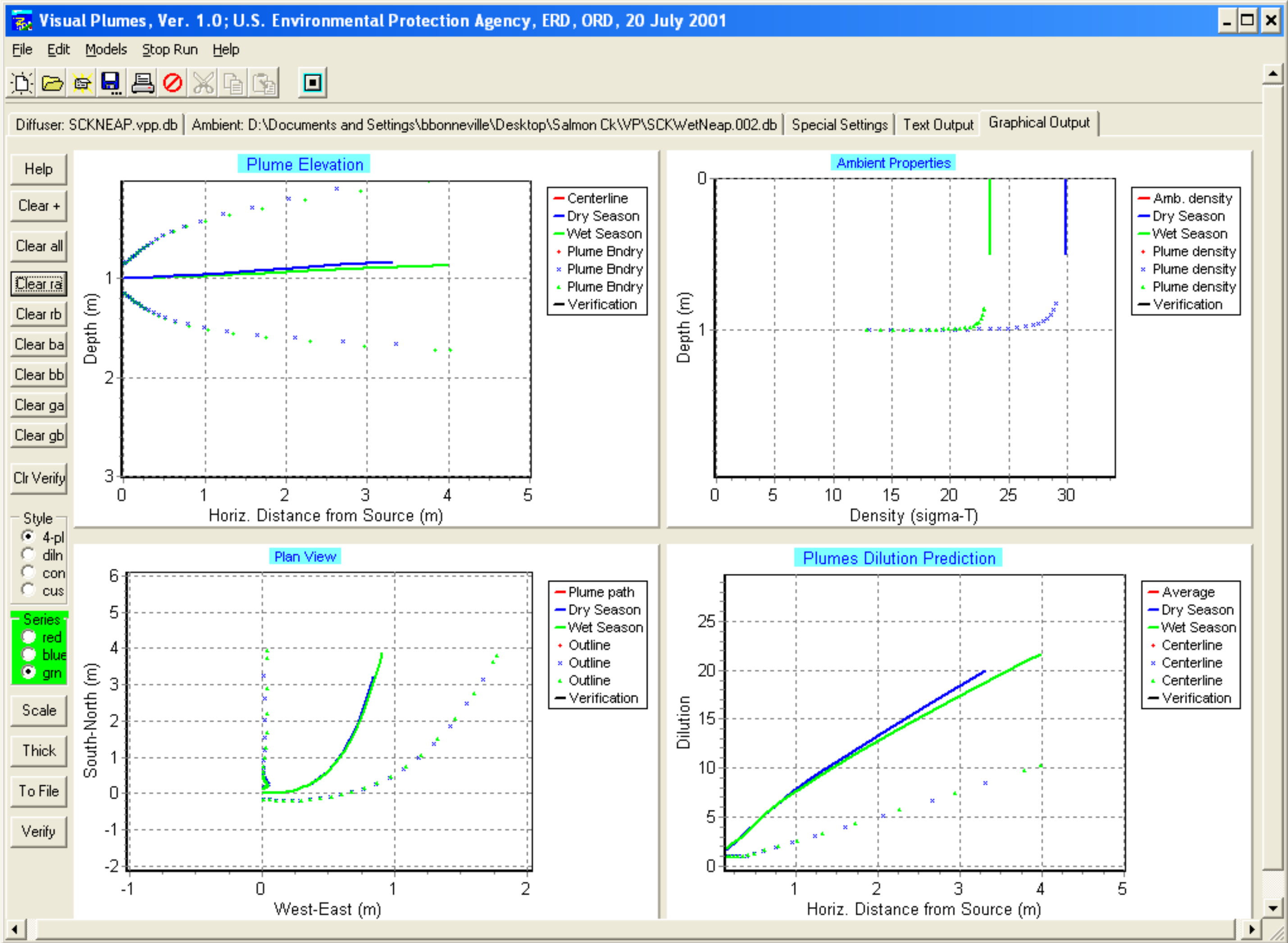
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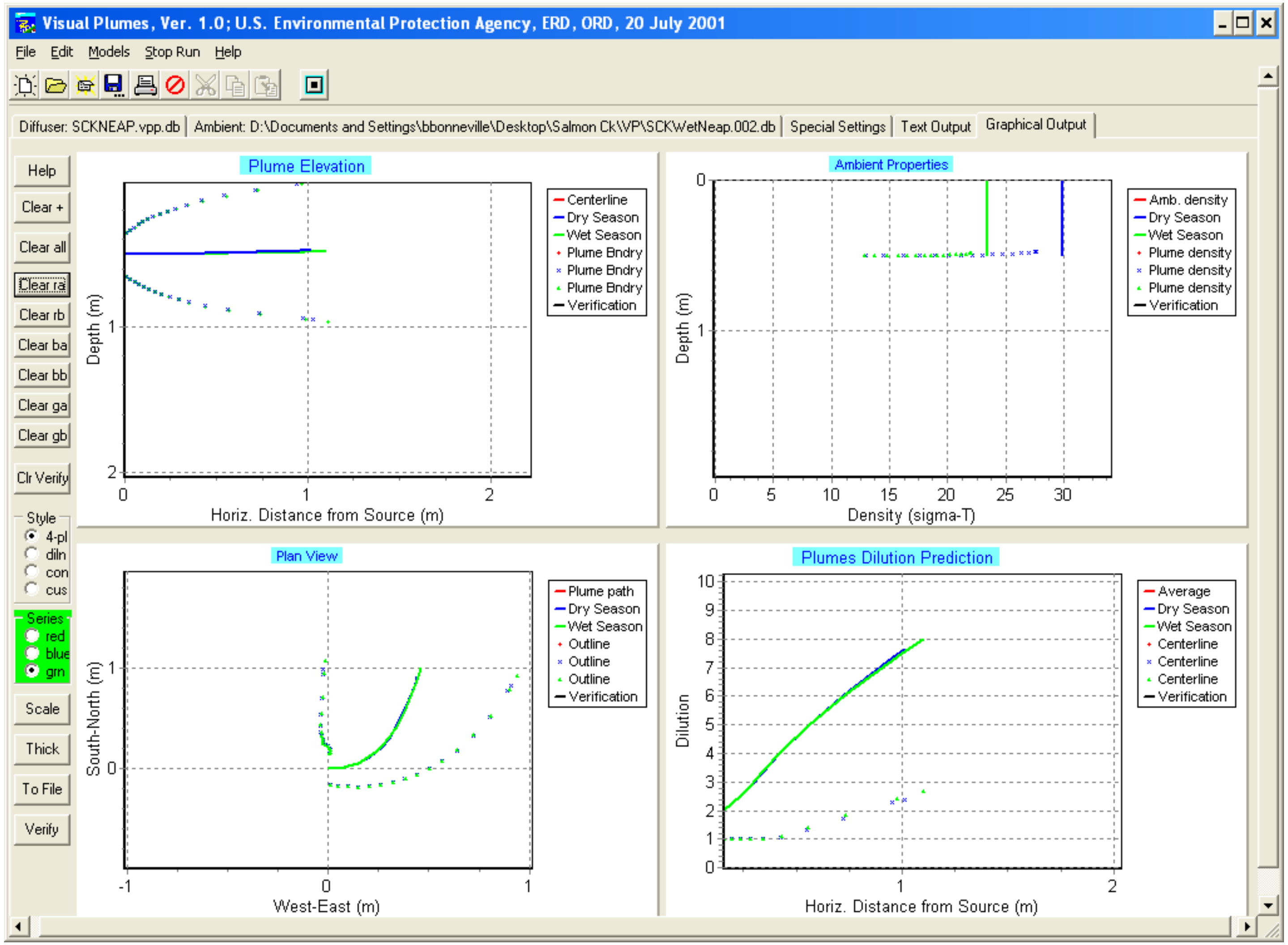
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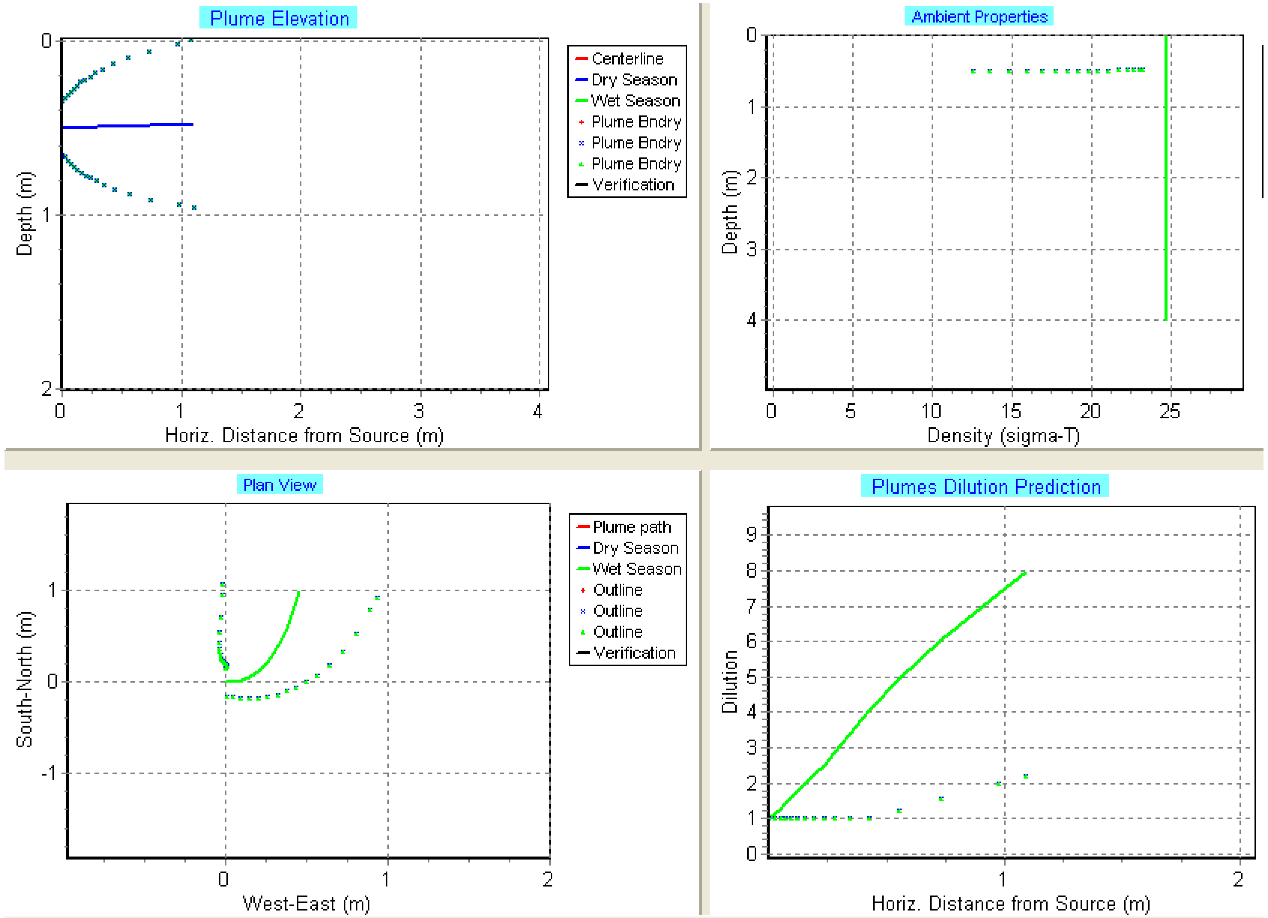
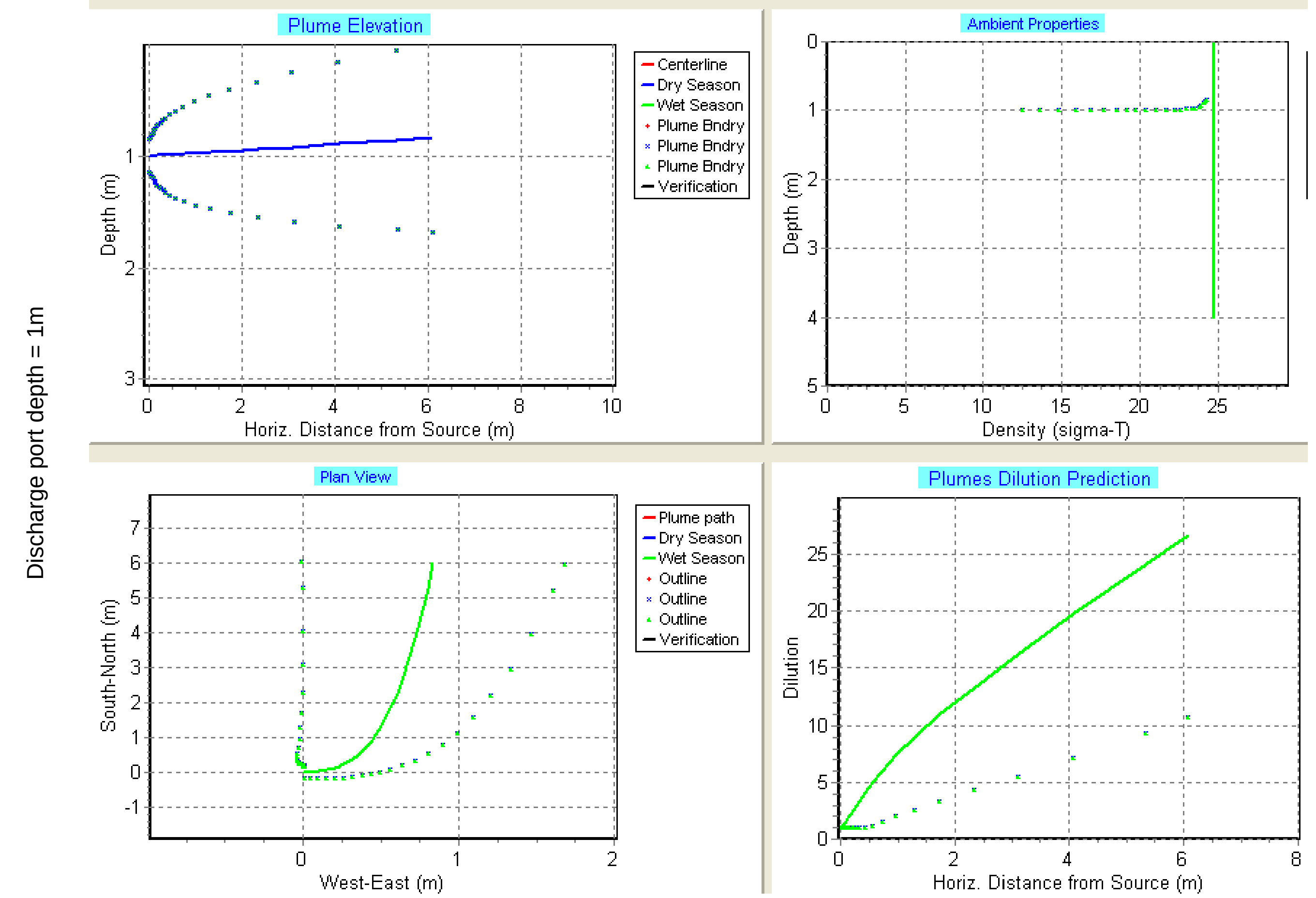
8.3. Mercury

8.3.1. 95th Percentile - Spring

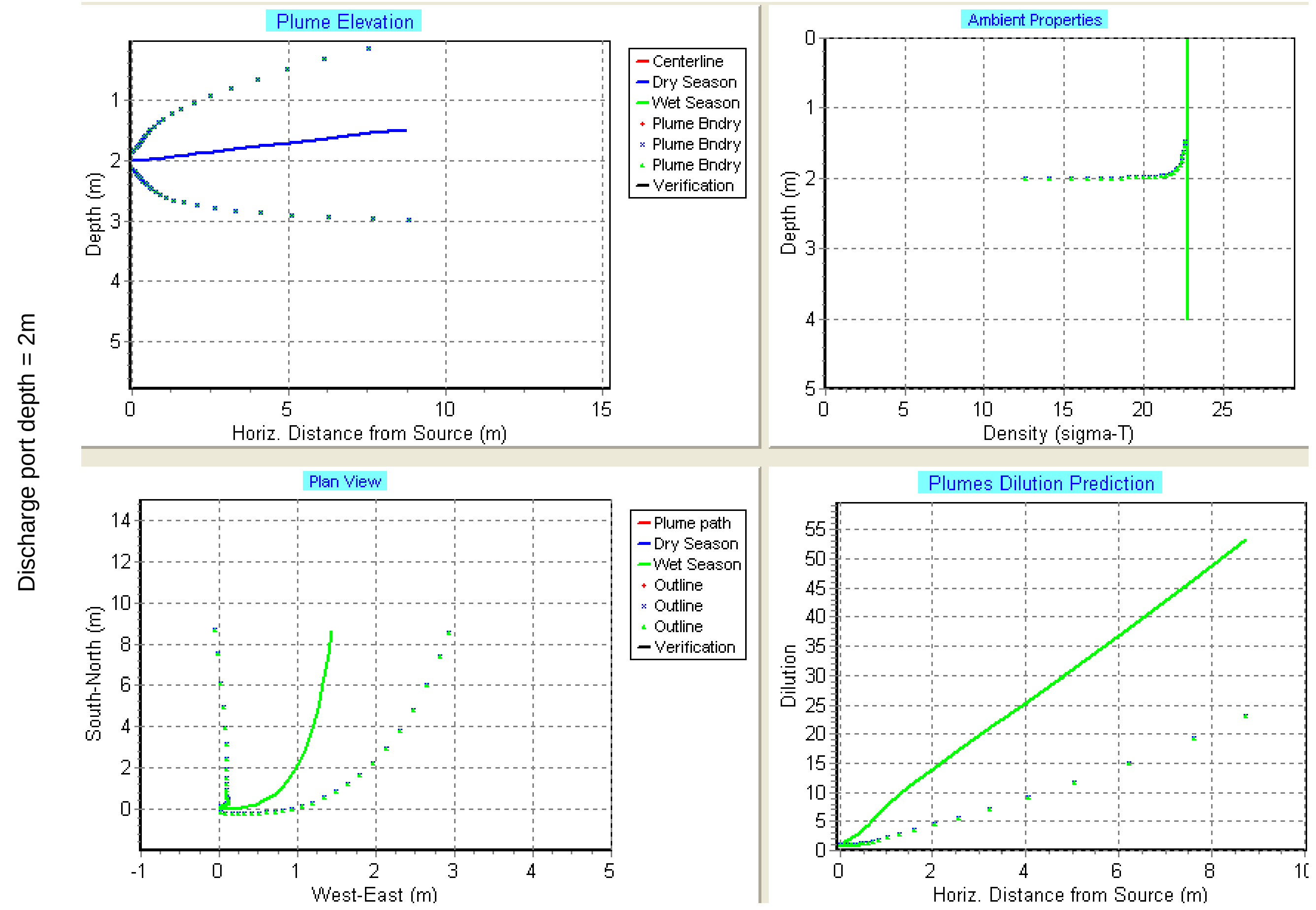
Discharge port depth = 0.5m



At a depth of 0.5m during a spring tide, the maximum initial dilution achievable is 1:8, which is below the desired level of 1:12 for initial dilution. The mixing zone is very similar in both the dry and wet seasons.

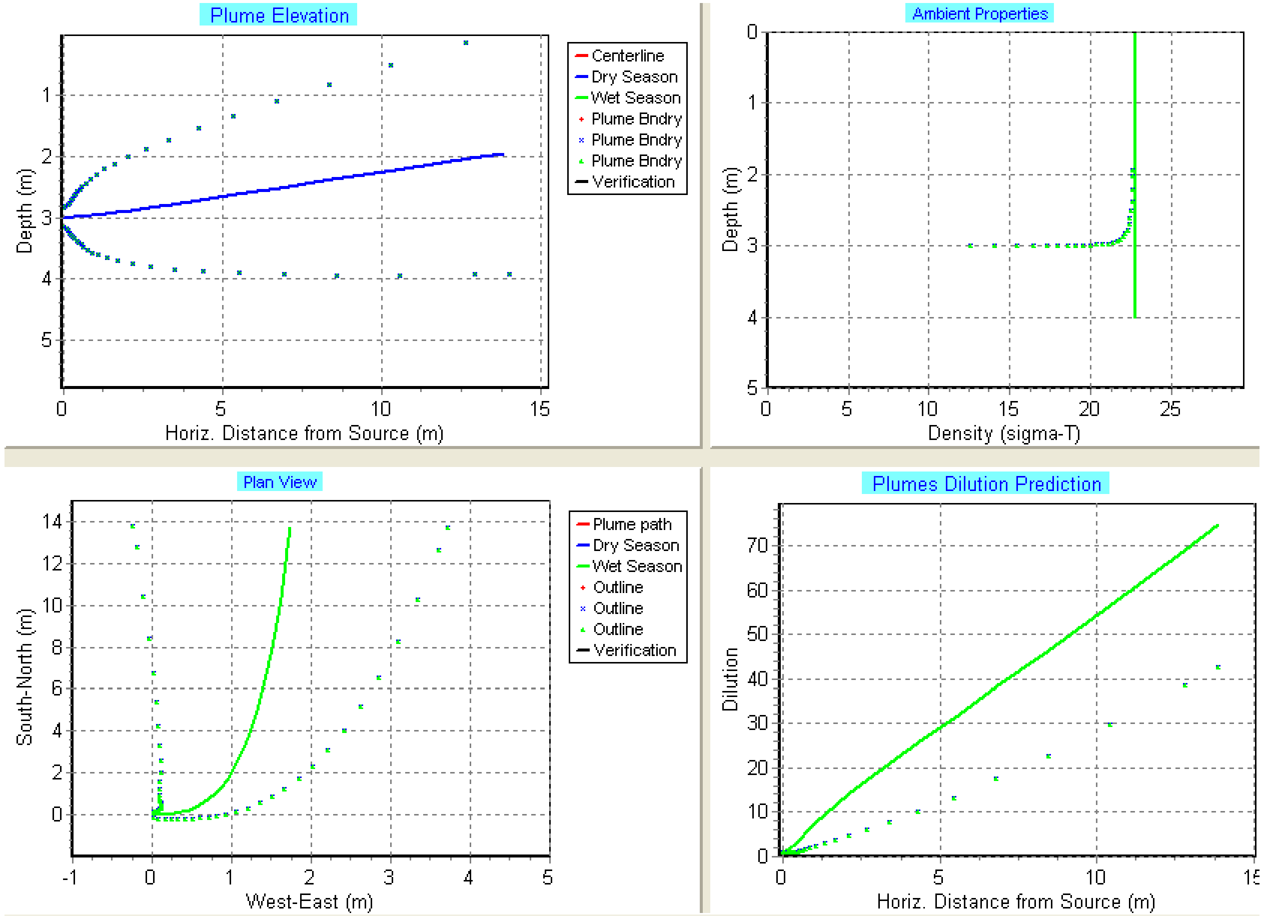


At a depth of 1m during a spring tide, the 1:12 initial dilution is achieved 2m downstream of the discharge port during both the dry and wet seasons.

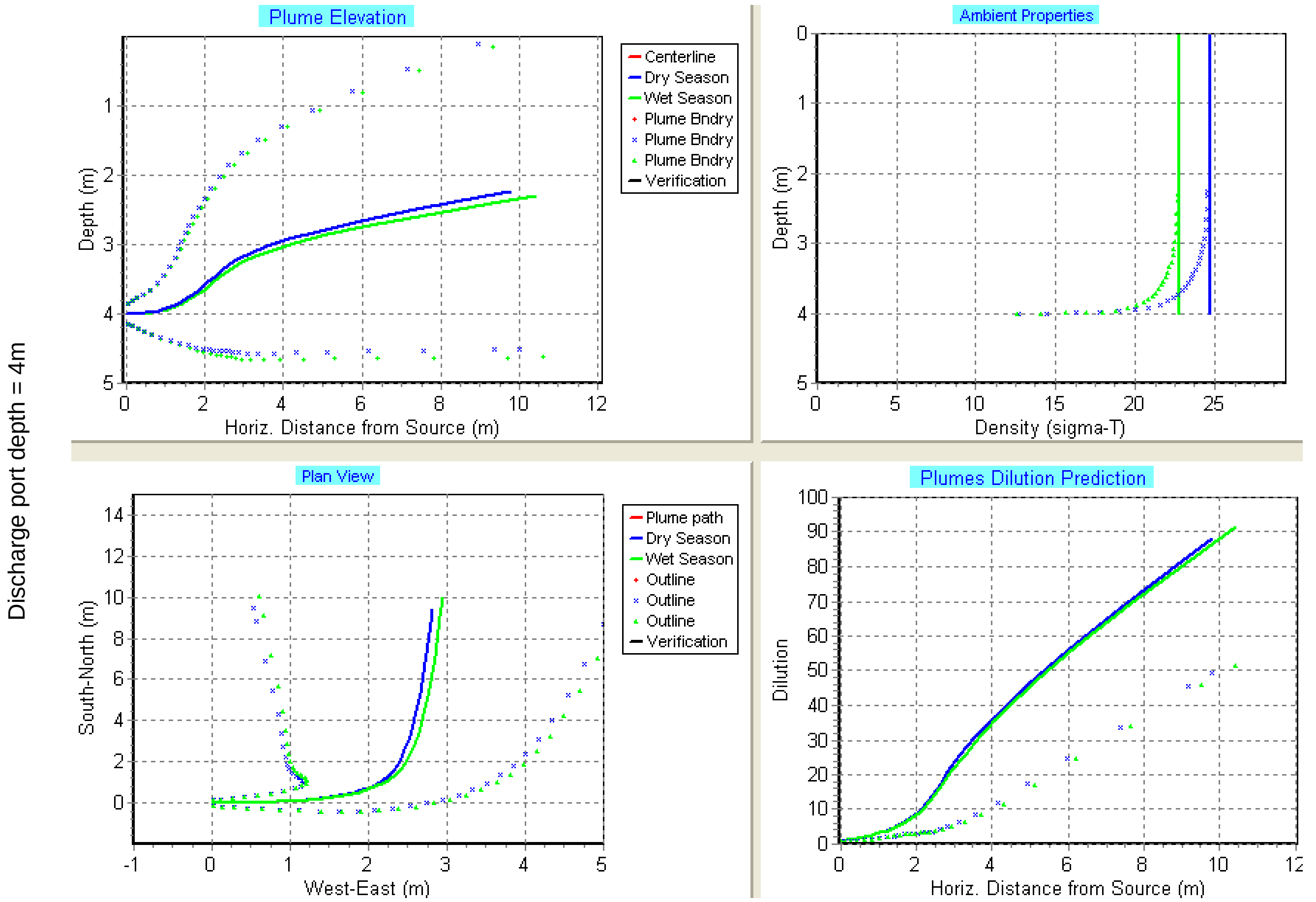


At a depth of 2m during a spring tide, the 1:12 initial dilution is achieved 1.5 metres downstream of the discharge port during both the dry and wet seasons.

Discharge port depth = 3m

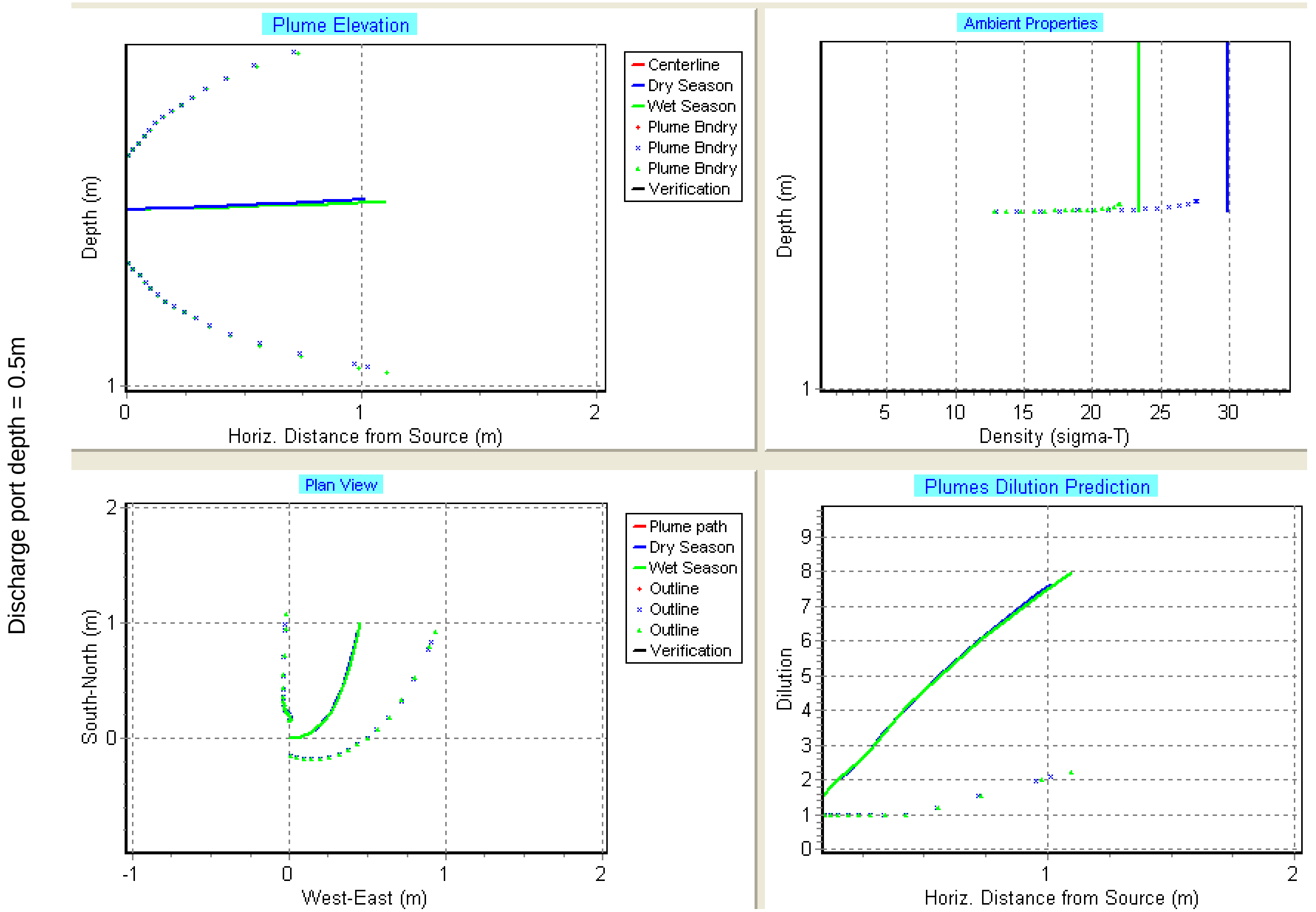


At a depth of 3m during a spring tide, the 1:12 initial dilution is achieved 1.5 metres downstream of the discharge port during both the dry and wet seasons.

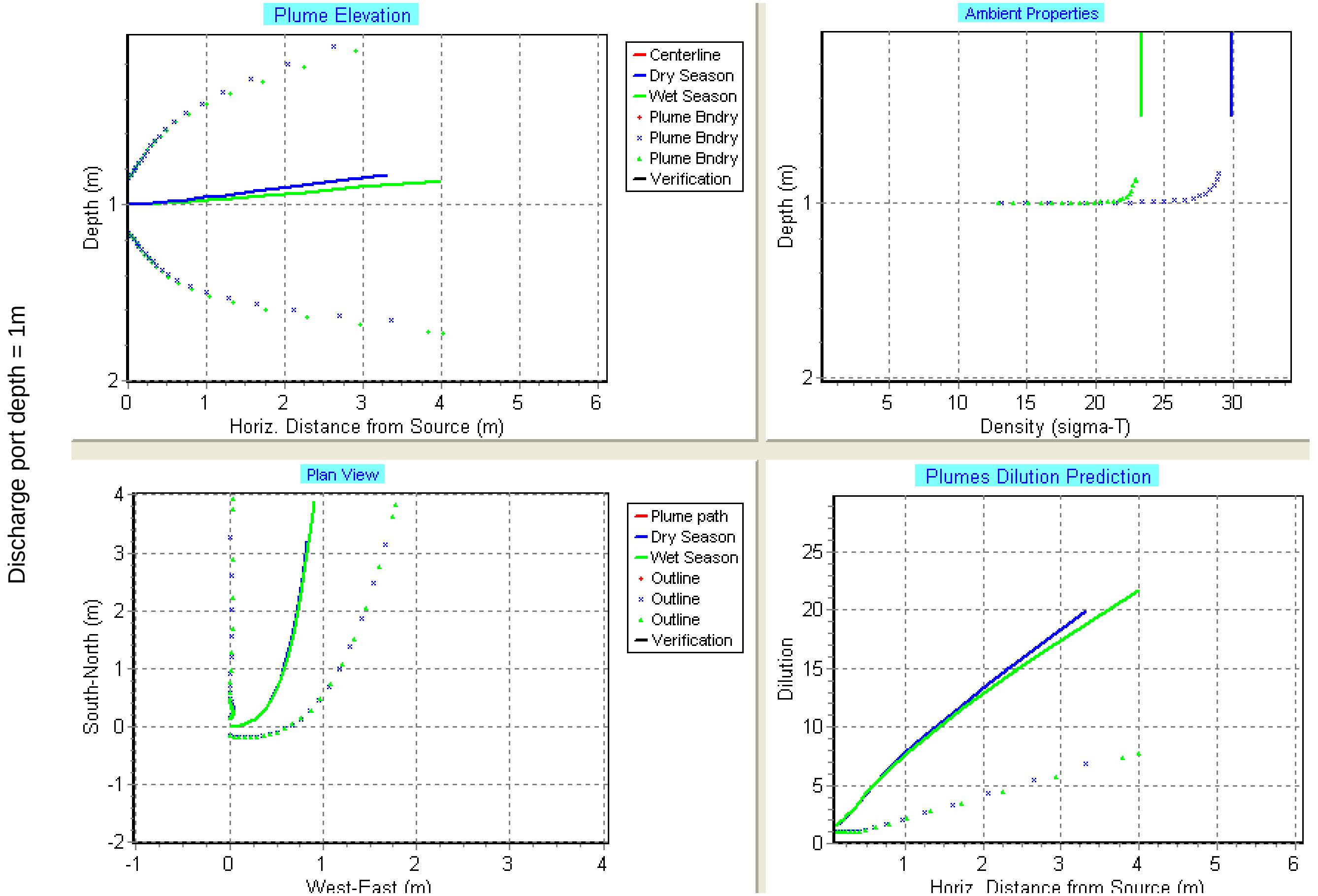


At the maximum depth of 4m during a spring tide, the 1:12 initial dilution is achieved 2.2 metres downstream of the discharge port during the dry and wet seasons.

8.3.2. 95th Percentile - Neap

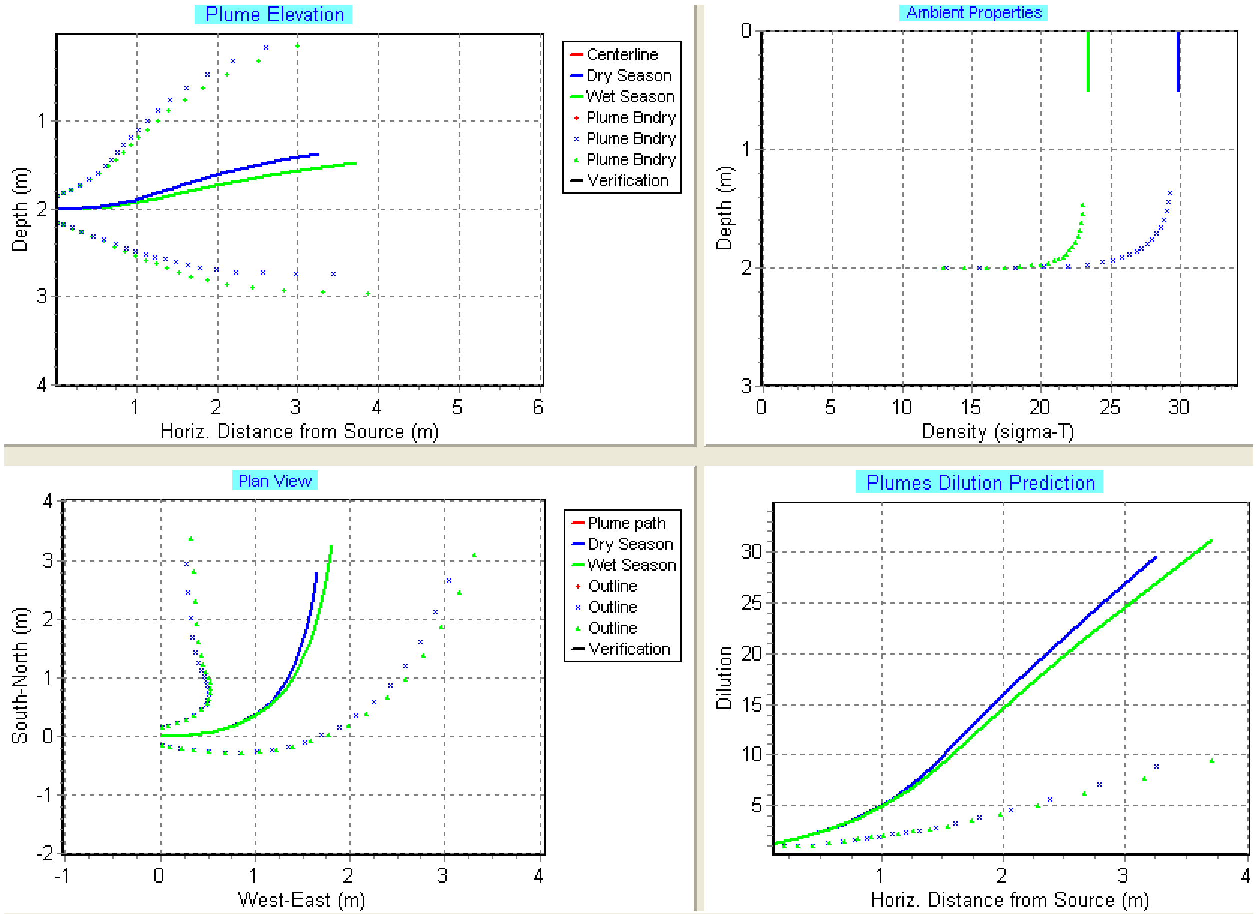


At a depth of 0.5m during a neap tide, the maximum initial dilution achievable is 1:8, which is below the desired level of 1:12 for initial dilution. The mixing zone is very similar in both the dry and wet seasons.



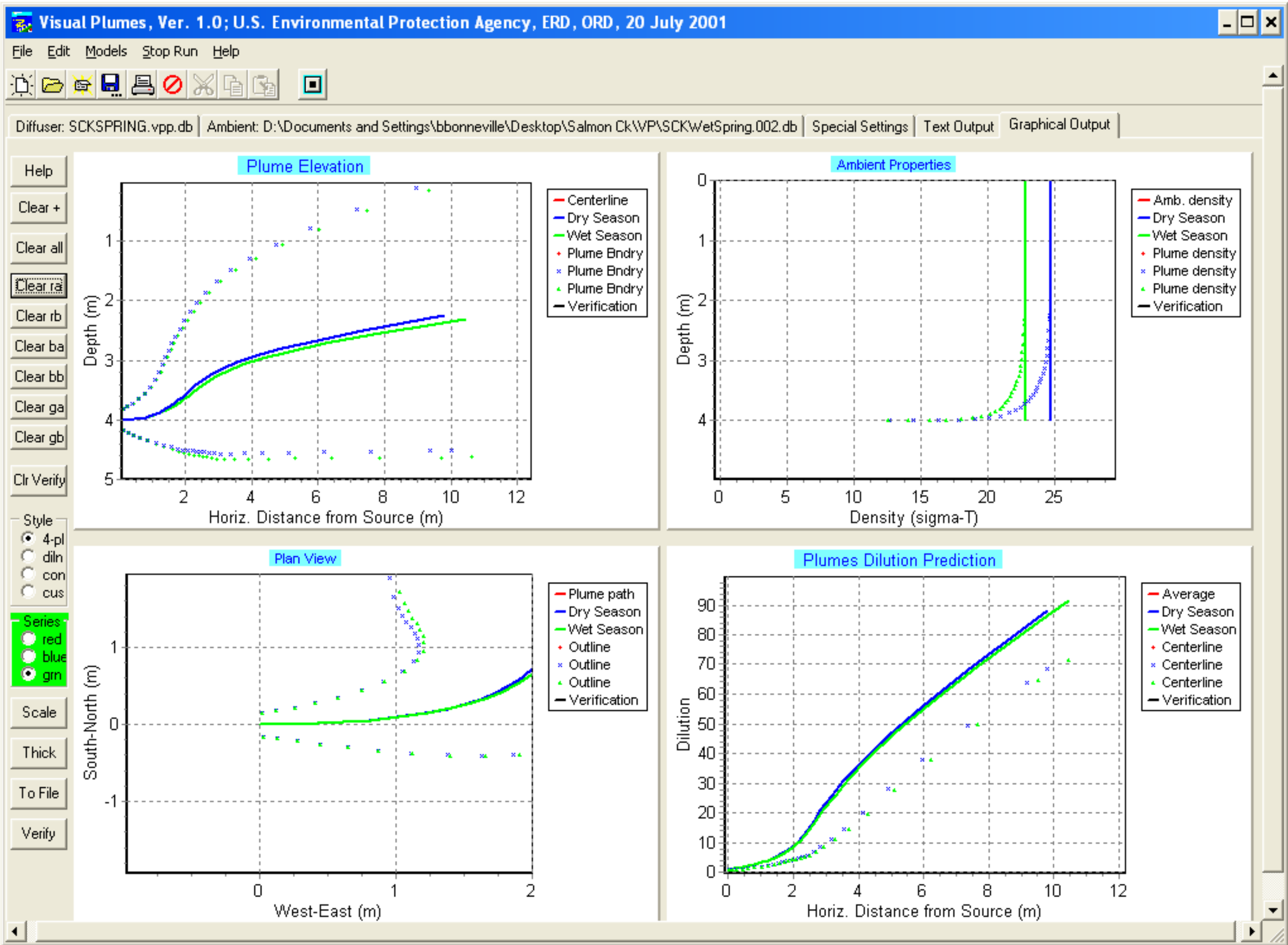
At a depth of 1m during a neap tide, the 1:12 initial dilution is achieved within 1.7 metres and 1.8m downstream of the discharge port during the dry and wet seasons respectively. The mixing zone is less during the dry season because the water is denser (more saline) and colder than during the wet season, which causes the discharge to rise more rapidly through the water column.

Discharge port depth = 2m



At a depth of 2m during a neap tide, the 1:12 initial dilution is achieved within 1.5 metres and 1.6 m downstream of the discharge port during the dry and wet seasons respectively. The mixing zone is less during the dry season because the water is denser (more saline) and colder than during the wet season, which causes the discharge to rise more rapidly through the water column.

8.3.3. MEDIAN - Spring


Visual Plumes, Ver. 1.0; U.S. Environmental Protection Agency, ERD, ORD, 20 July 2001
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Diffuser: SCKSPRING.vpp.db
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Special Settings
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Scale
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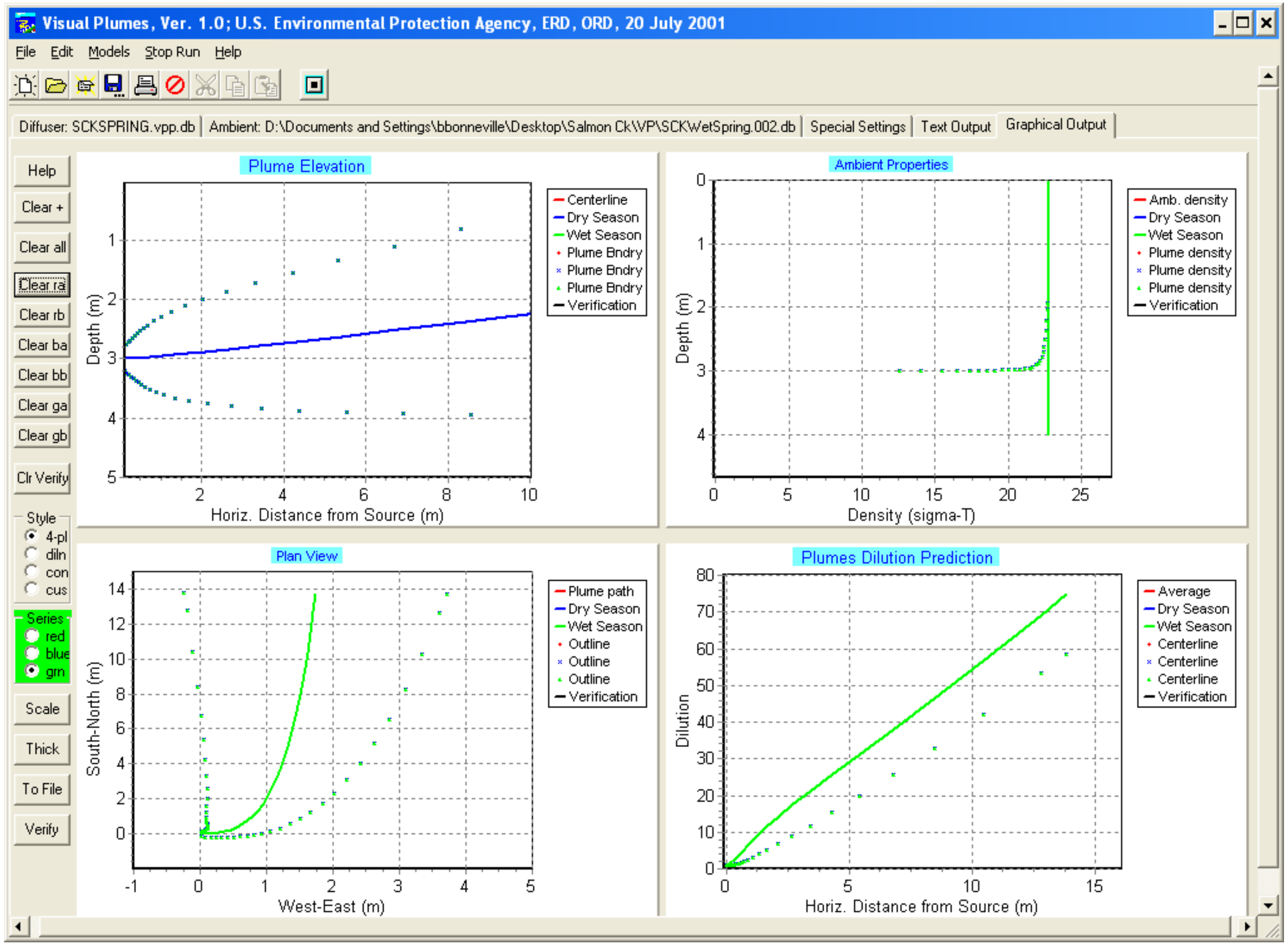
To File
Verify
Plume Elevation
Depth (m)
Horiz. Distance from Source (m)
Centerline
Dry Season
Wet Season
Plume Bndry
Plume Bndry
Plume Bndry
Verification
Ambient Properties
Density (sigma-T)
Amb. density
Dry Season
Wet Season
Plume density
Plume density
Plume density
Verification
Plan View
South-North (m)
West-East (m)
Plume path
Dry Season
Wet Season
Outline
Outline
Outline
Verification
Plumes Dilution Prediction
Dilution
Horiz. Distance from Source (m)
Average
Dry Season
Wet Season
Centerline
Centerline
Centerline
Verification


Visual Plumes, Ver. 1.0; U.S. Environmental Protection Agency, ERD, ORD, 20 July 2001
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Ambient Properties
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Plan View
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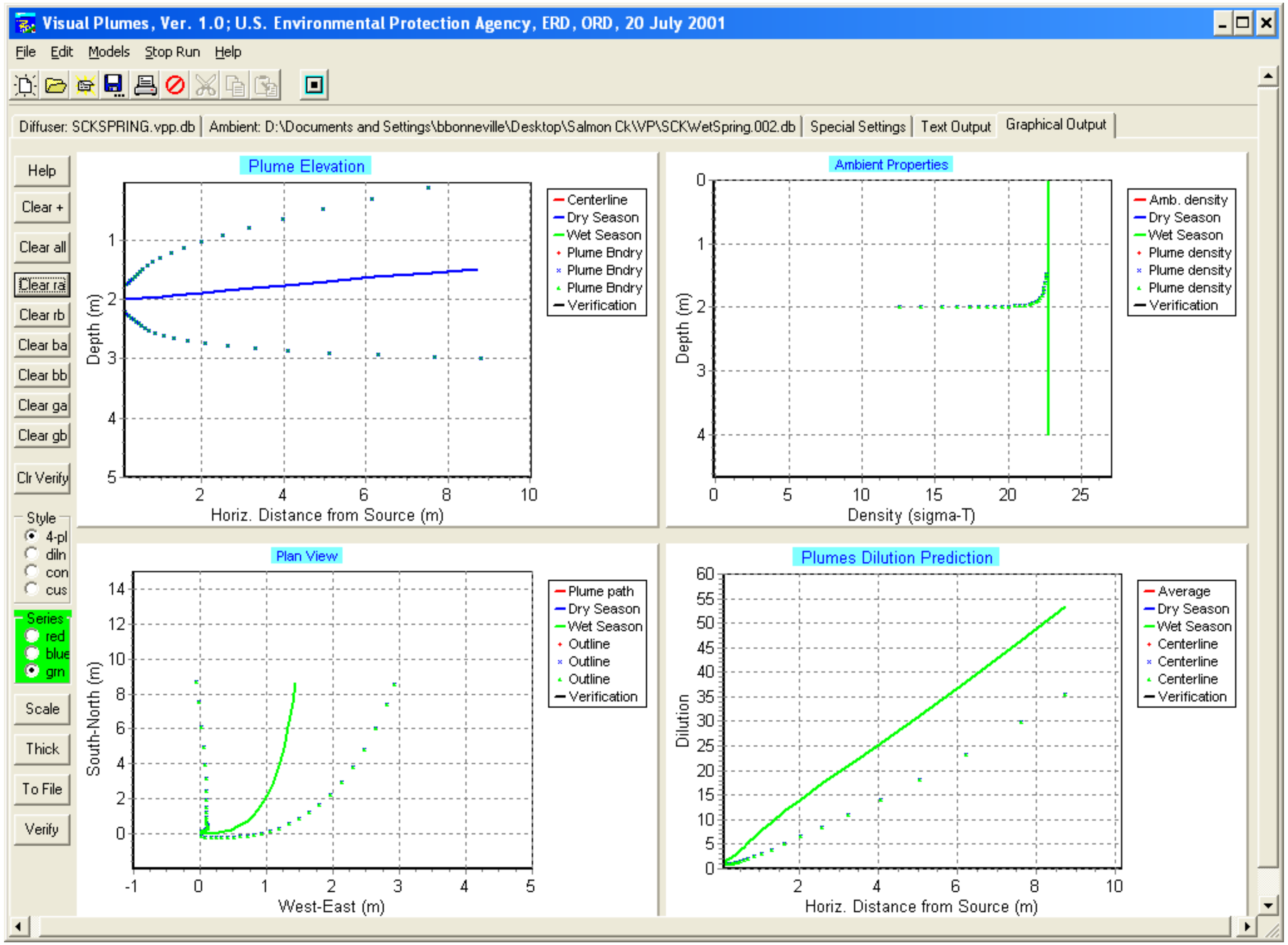
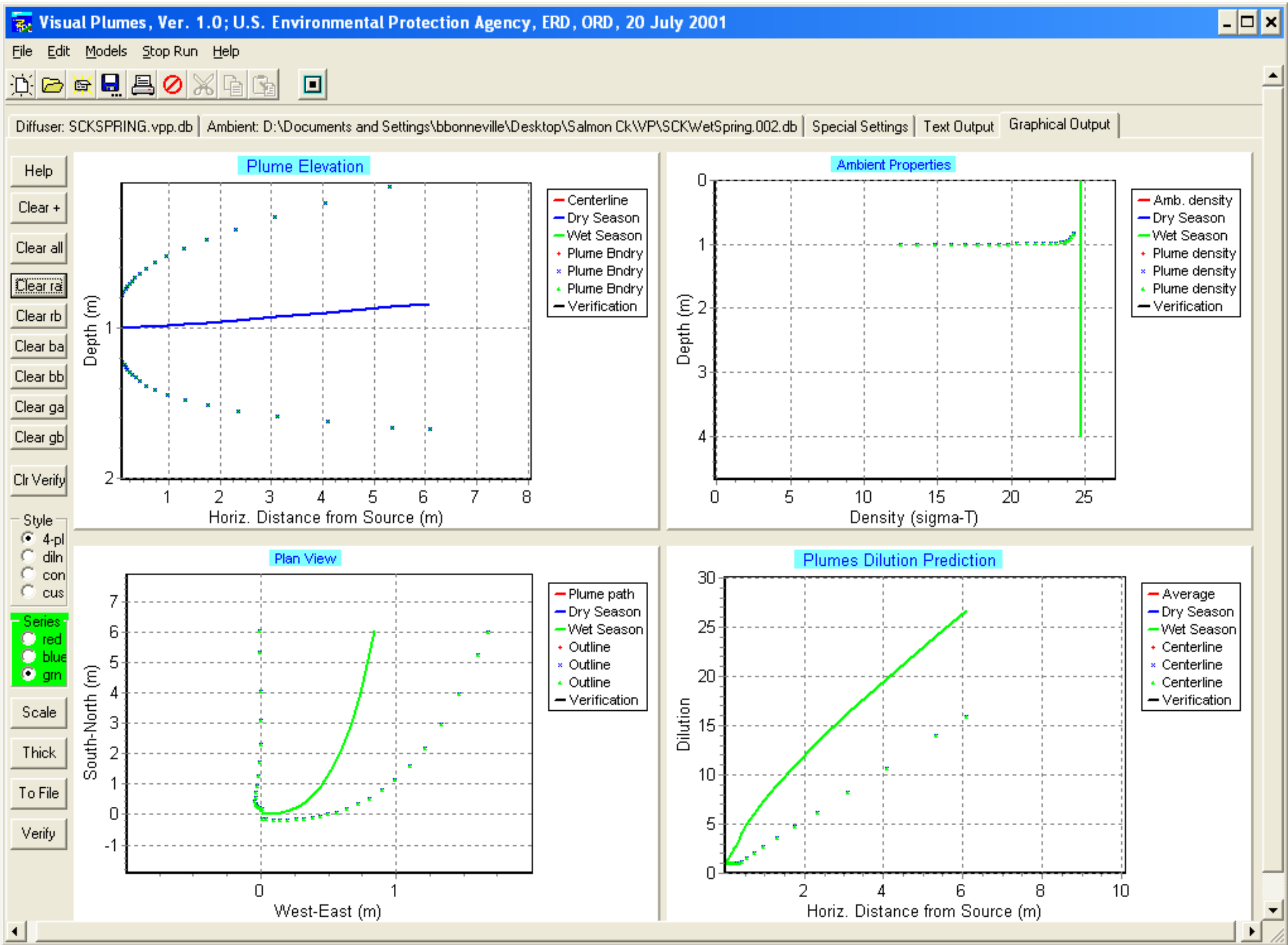
Plume path
Outline
Plumes Dilution Prediction
Dilution
Average
Centerline



SINCLAIR KNIGHT MERZ


Visual Plumes, Ver. 1.0; U.S. Environmental Protection Agency, ERD, ORD, 20 July 2001
File Edit Models Stop Run Help
Diffuser: SCKSPRING.vpp.db
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Plume Elevation
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Horiz. Distance from Source (m)
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Dry Season
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Plume Bndry
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Plume Bndry
Verification
Ambient Properties
Density (sigma-T)
Amb. density
Dry Season
Wet Season
Plume density
Plume density
Plume density
Verification
Plan View
South-North (m)
West-East (m)
Plume path
Dry Season
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Outline
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Verification
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Dilution
Horiz. Distance from Source (m)
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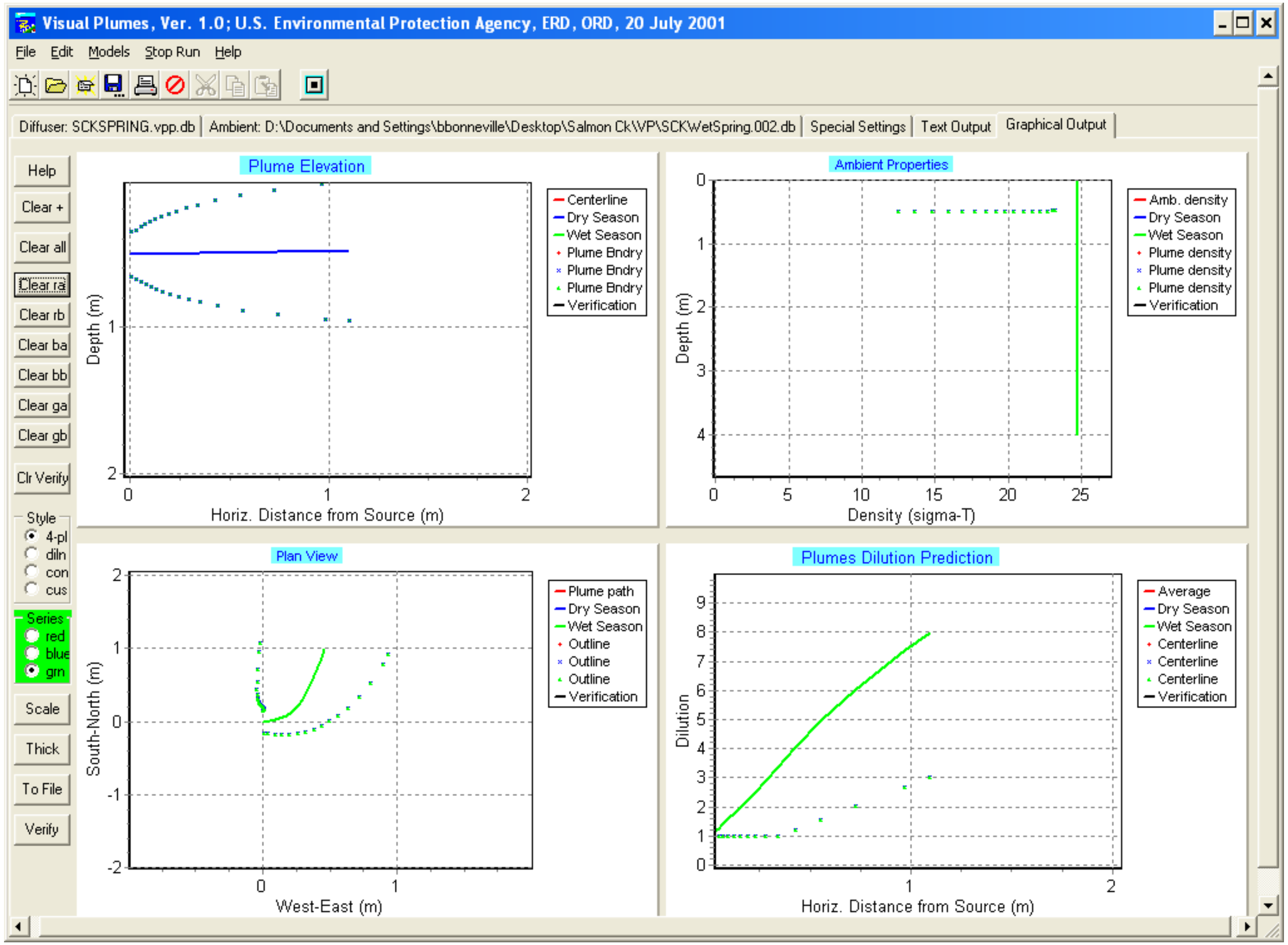
Dry Season
Wet Season
Centerline
Centerline
Centerline
Verification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Plume Bndry
Verification
Ambient Properties
Density (sigma-T)
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Plume path
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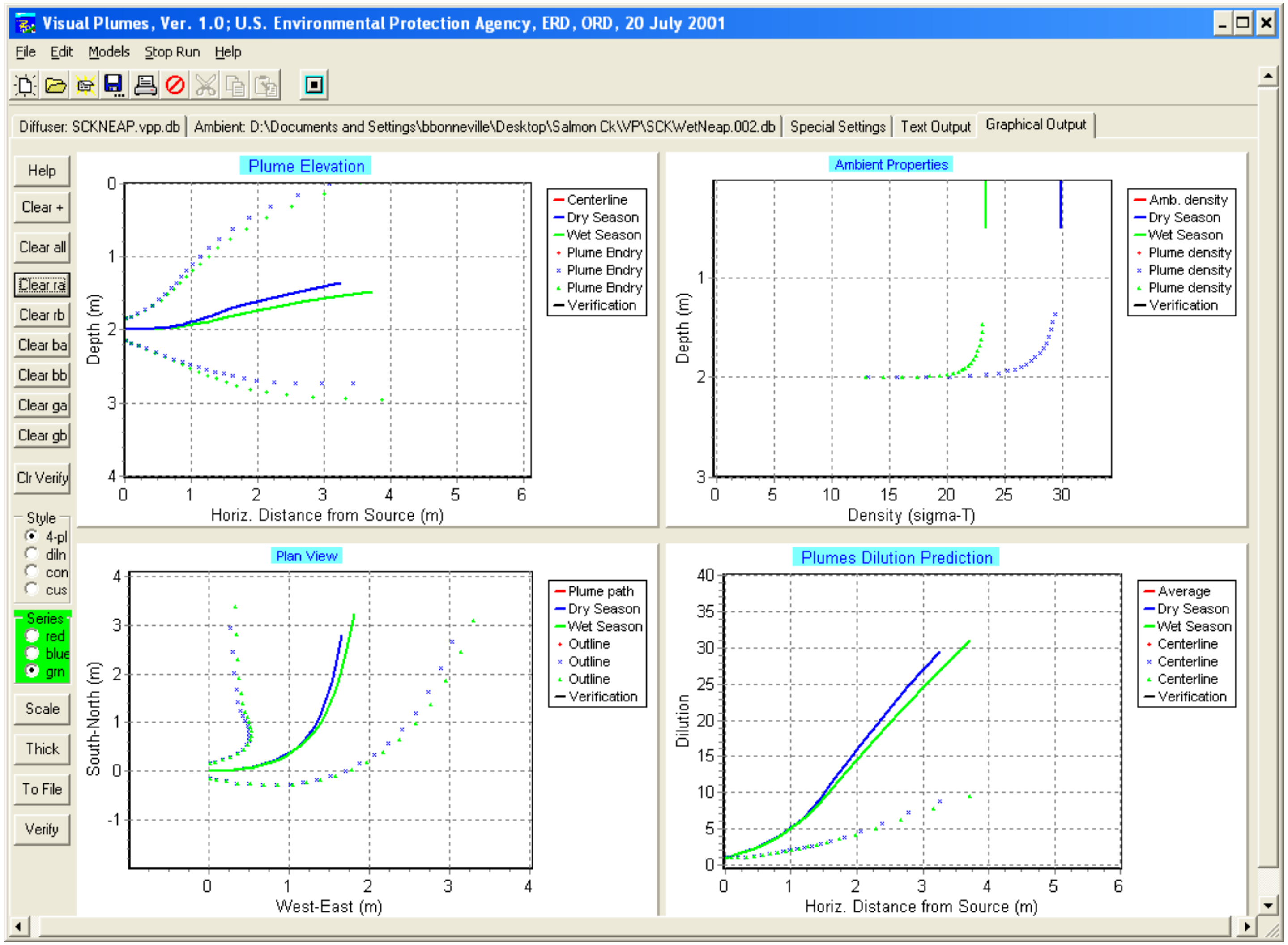
8.3.4. MEDIAN – Neap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Graphical Output
Plume Elevation
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Horiz. Distance from Source (m)
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Dry Season
Wet Season
Plume Bndry
Verification
Ambient Properties
Density (sigma-T)
Amb. density
Plume density
Plan View
South-North (m)
West-East (m)
Plume path
Outline
Plumes Dilution Prediction
Dilution
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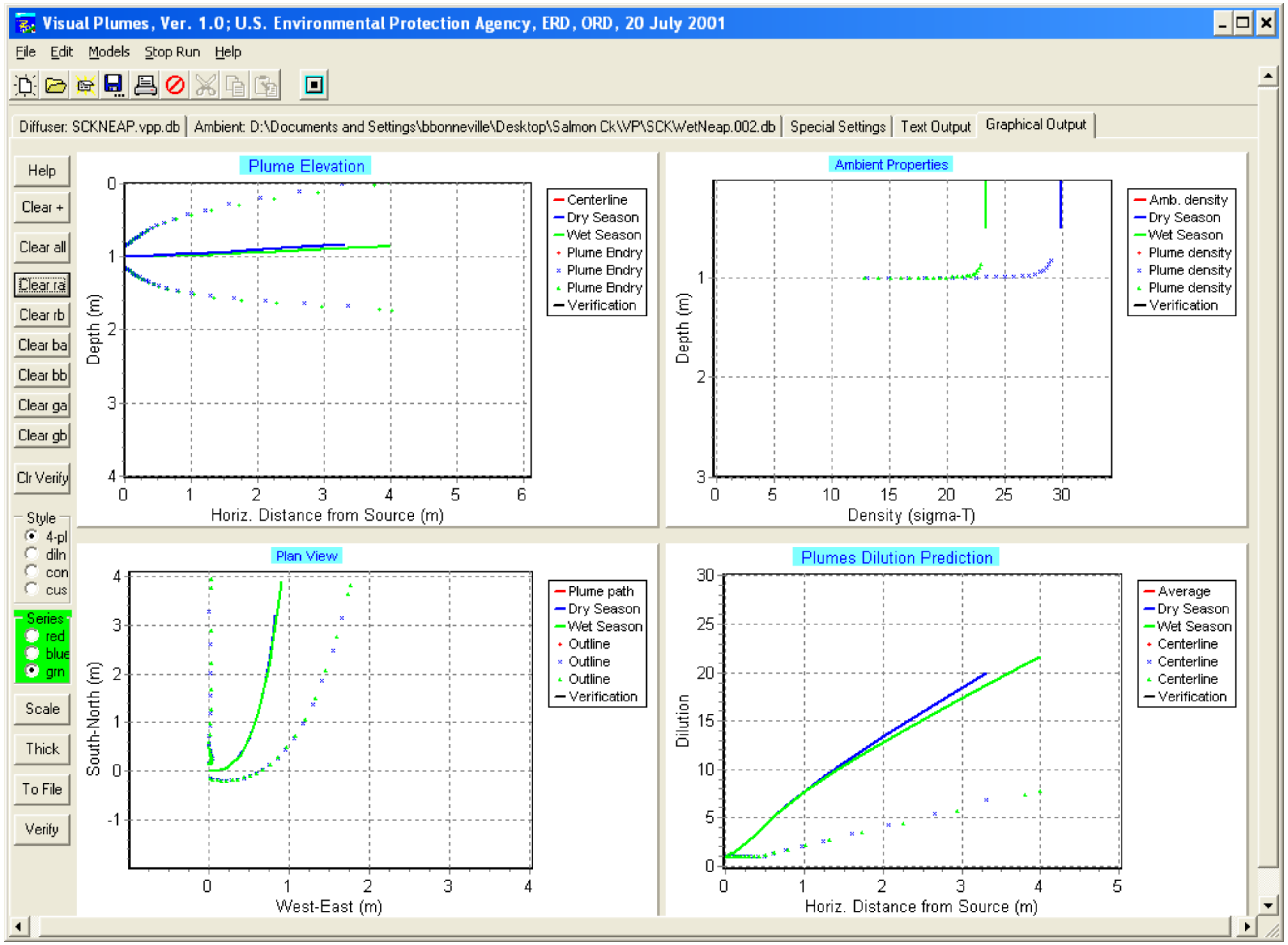
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Plume Elevation
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Plume Bndry
Plume Bndry
Plume Bndry
Verification
Ambient Properties
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Density (sigma-T)
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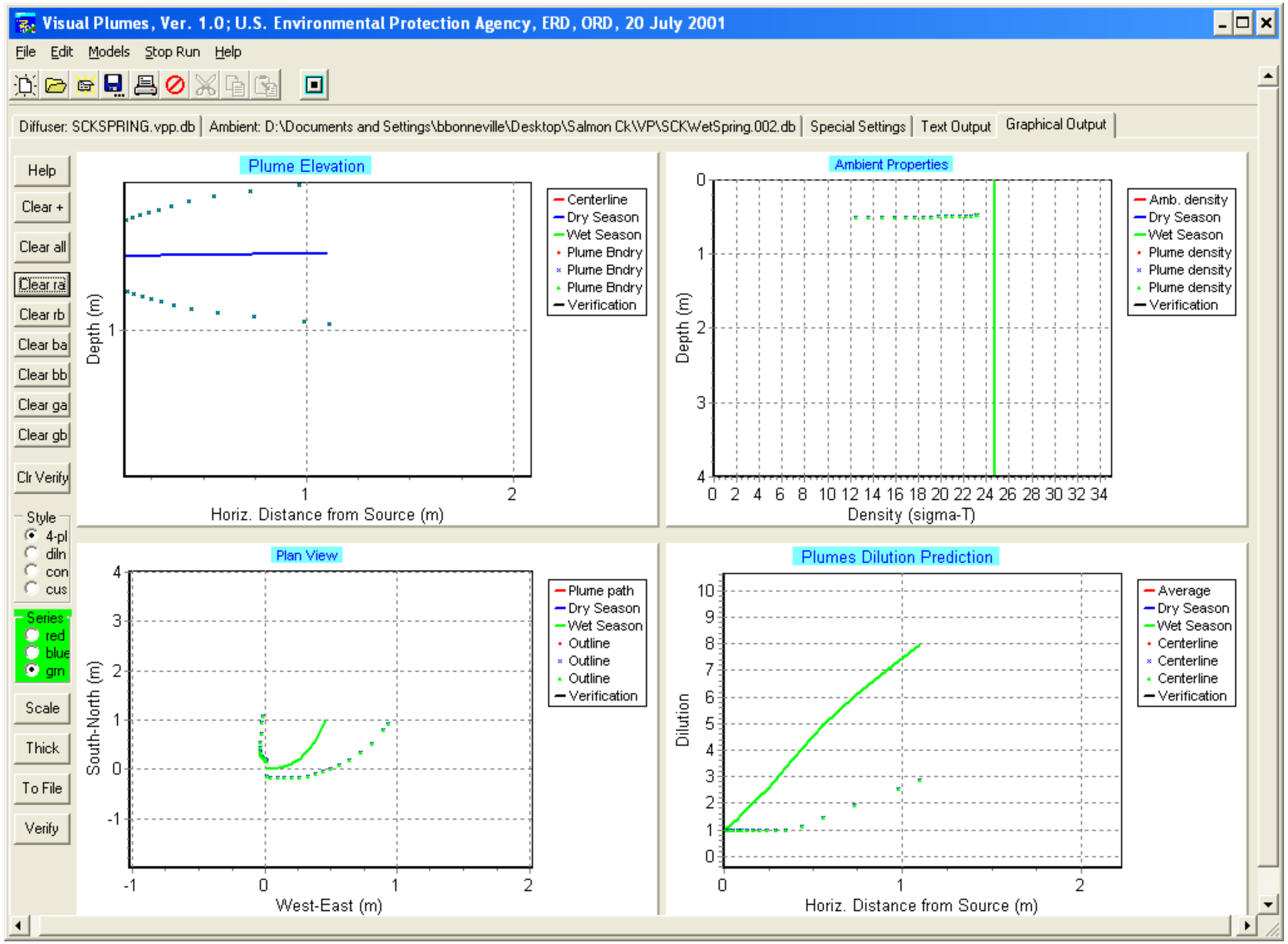
Wet Season
Plume density
Plume density
Plume density
Verification
Plan View
South-North (m)
West-East (m)
Plume path
Dry Season
Wet Season
Outline
Outline
Outline
Verification
Plumes Dilution Prediction
Dilution
Horiz. Distance from Source (m)
Average
Dry Season
Wet Season
Centerline
Centerline
Centerline
Verification

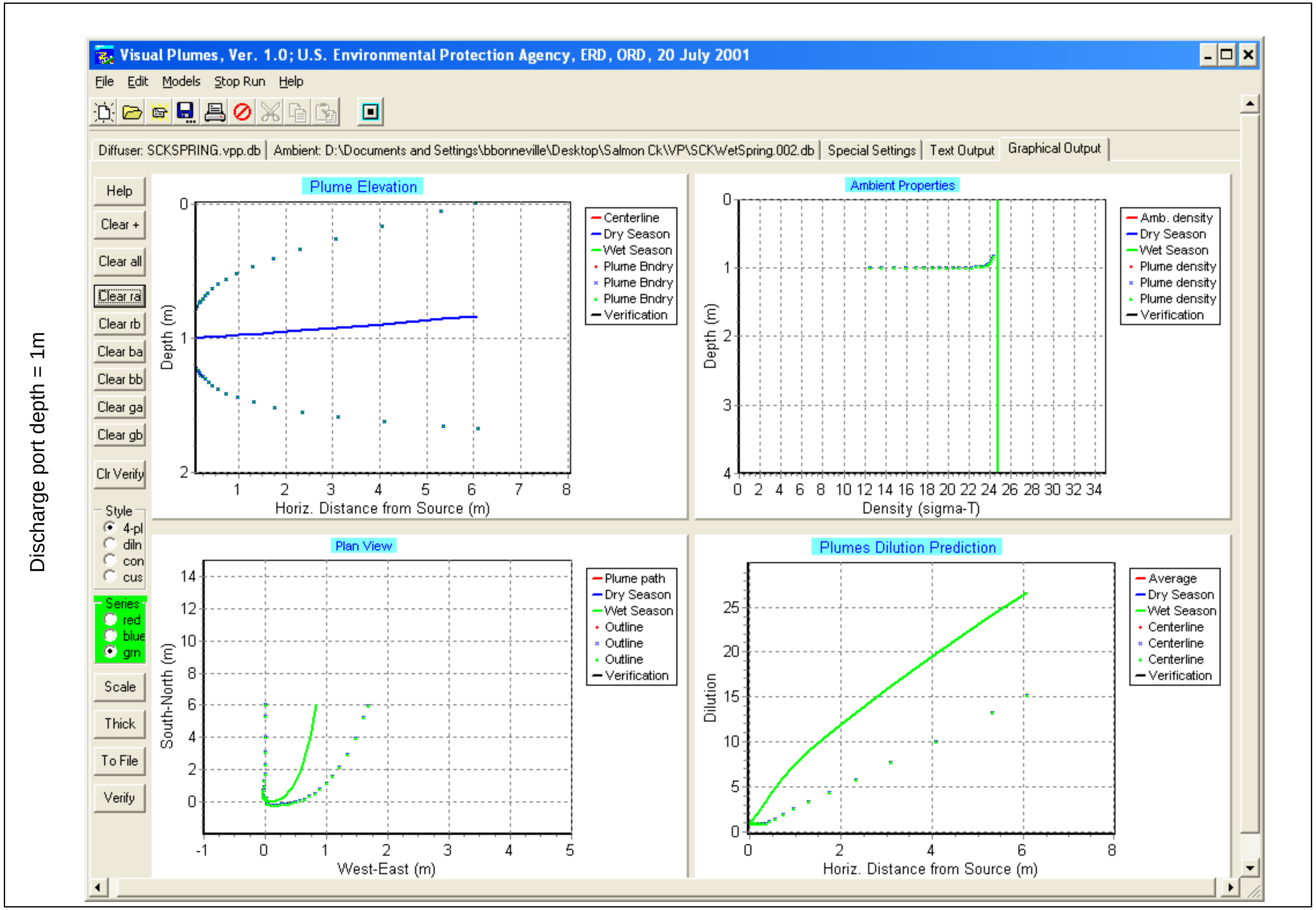
8.4. Zinc

8.4.1. 95th Percentile - Spring

Discharge port depth = 0.5m



At a depth of 1m during a spring tide, the maximum initial dilution achievable is 1:8, which is below the desired level of 1:16 for initial dilution. The mixing zone is very similar in both the dry and wet seasons.


Discharge port depth = 1m
Visual Plumes, Ver. 1.0; U.S. Environmental Protection Agency, ERD, ORD, 20 July 2001
File Edit Models Stop Run Help
Diffuser: SCKSPRING.vpp.db
Ambient: D:\Documents and Settings\bbonneville\Desktop\Salmon Ck\VP\SCKWetSpring.002.db
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Plume Elevation
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Wet Season
Plume Bndry
Plume Bndry
Plume Bndry
Verification
Ambient Properties
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Density (sigma-T)
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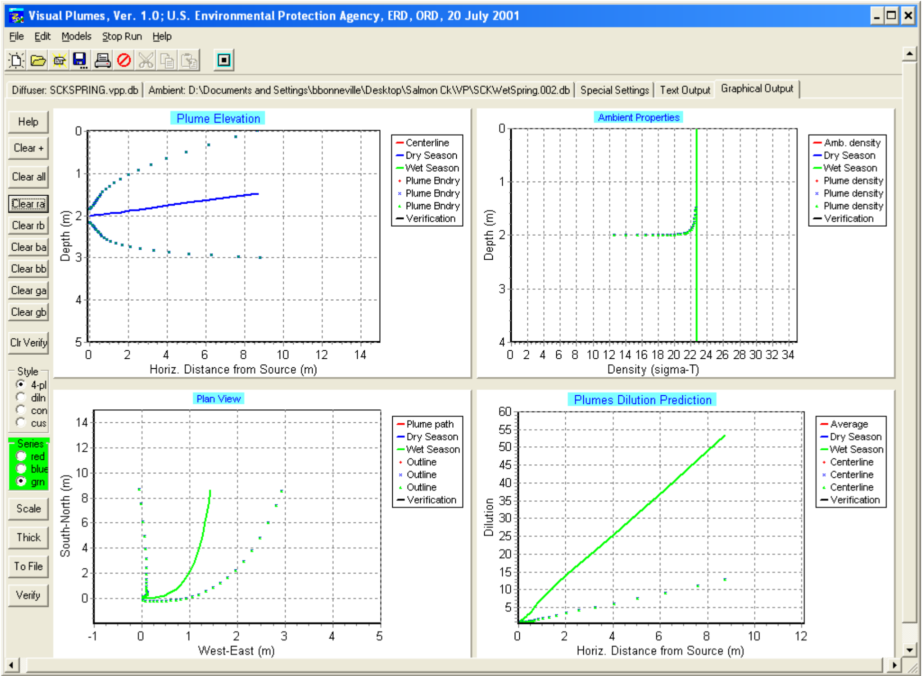
Dry Season
Wet Season
Plume density
Plume density
Plume density
Verification
Plan View
South-North (m)
West-East (m)
Plume path
Dry Season
Wet Season
Outline
Outline
Outline
Verification
Plumes Dilution Prediction
Dilution
Horiz. Distance from Source (m)
Average
Dry Season
Wet Season
Centerline
Centerline
Centerline
Verification

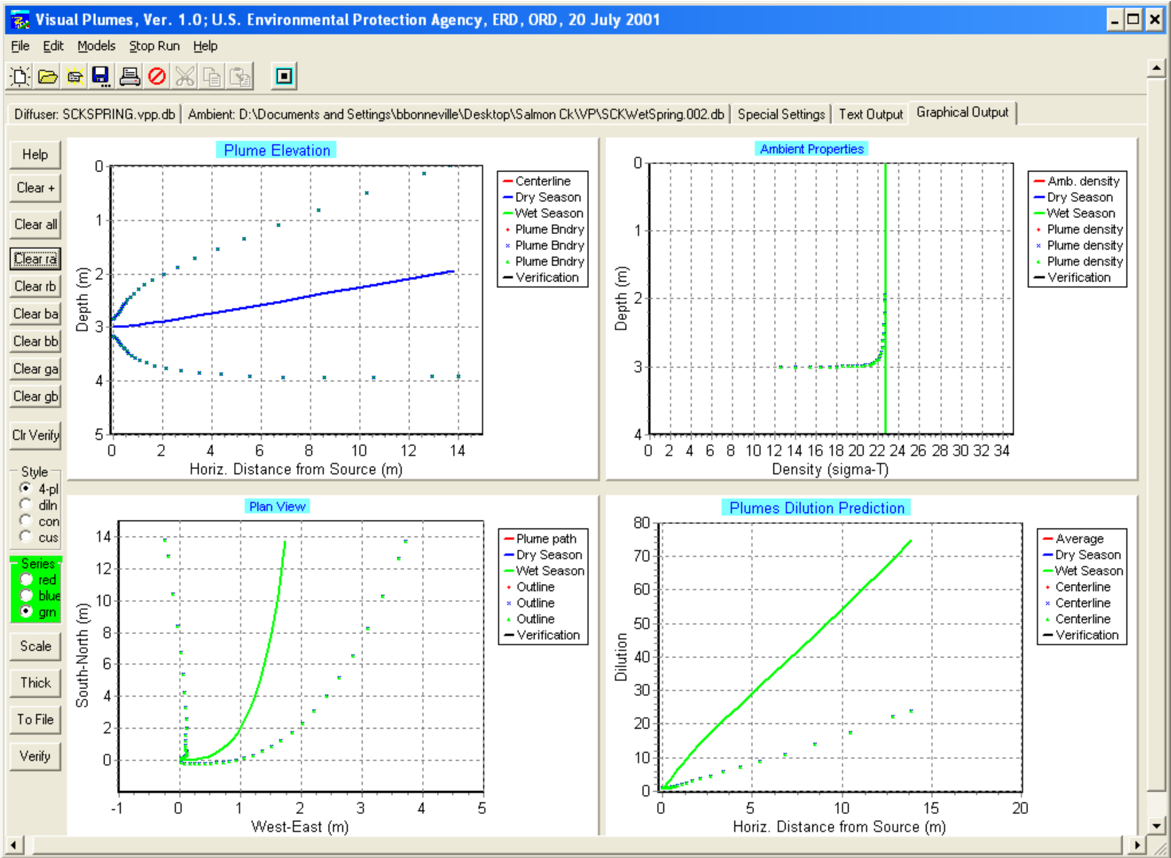
At a depth of 1m during a spring tide, the 1:16 initial dilution is achieved 3m downstream of the discharge port during both the dry and wet seasons.

Discharge port depth = 2m



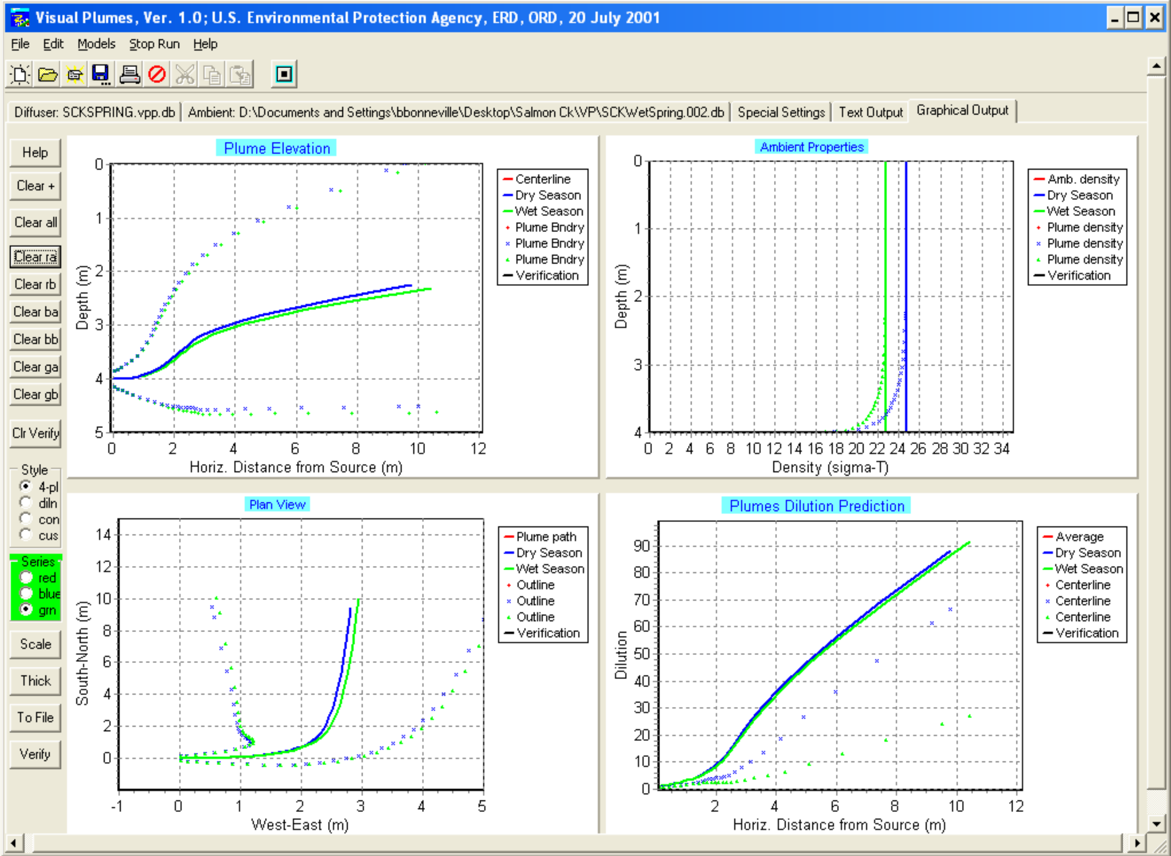
At a depth of 2m during a spring tide, the 1:16 initial dilution is achieved 2.2 metres downstream of the discharge port during both the dry and wet seasons.

Discharge port depth = 3m



At a depth of 3m during a spring tide, the 1:16 initial dilution is achieved 2.2 metres downstream of the discharge port during both the dry and wet seasons.

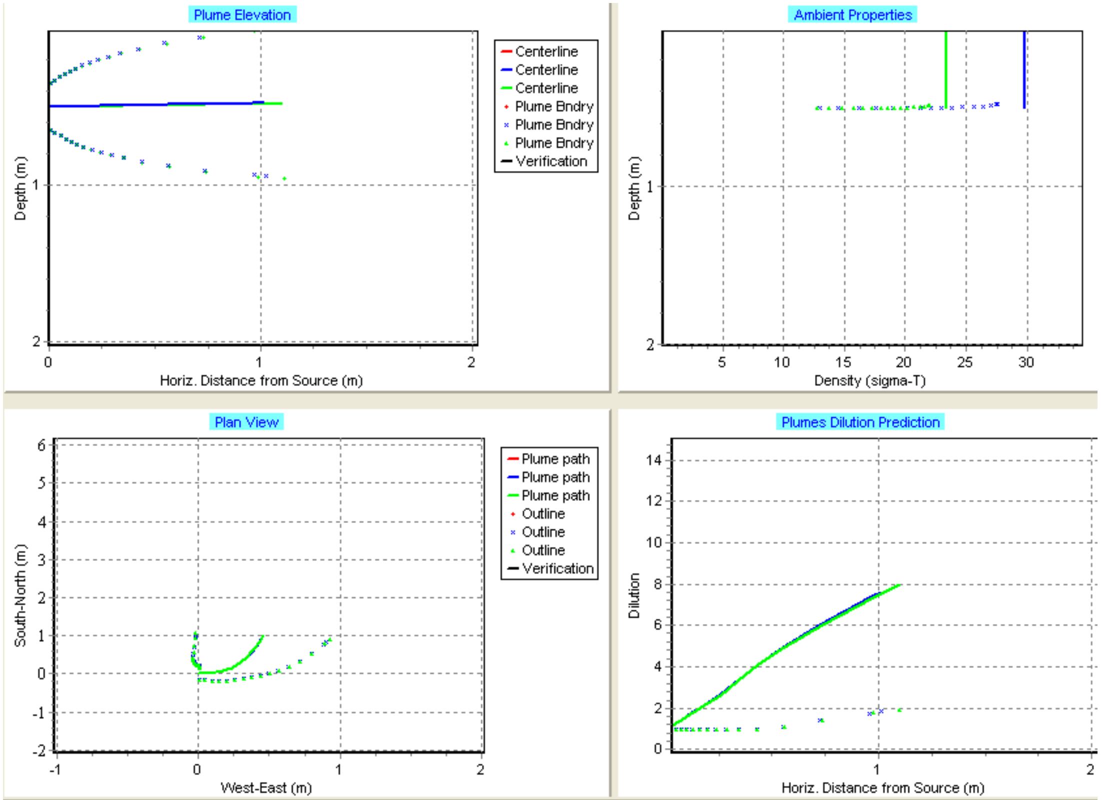
Discharge port depth = 4m



At the maximum depth of 4m during a spring tide, the 1:16 initial dilution is achieved 2.2 metres downstream of the discharge port during the dry and wet seasons. The mixing zone is very marginally less during the dry season because the water is denser (more saline) and colder than during the wet season, which causes the discharge to rise more rapidly through the water column. A maximum initial dilution (1:100) is achieved 10 m downstream

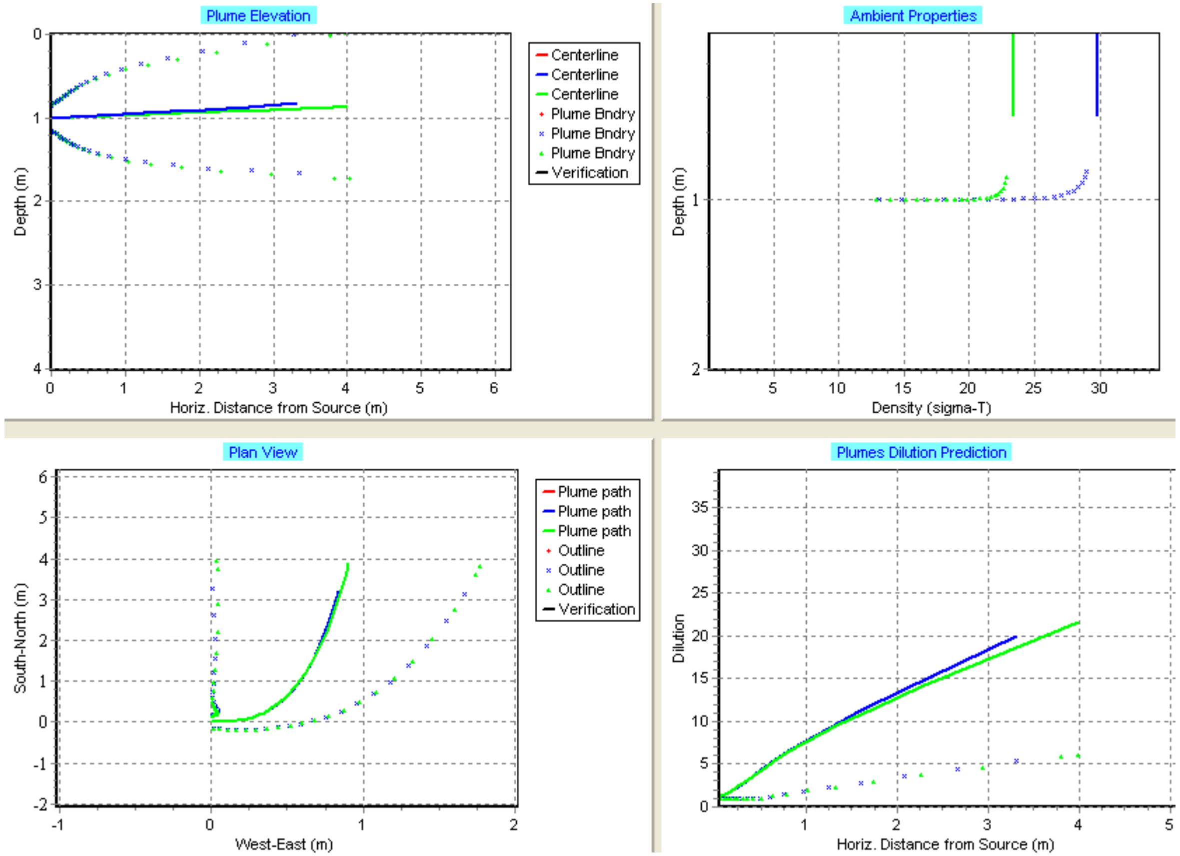
8.4.2. 95th Percentile - Neap

Discharge port depth = 0.5m



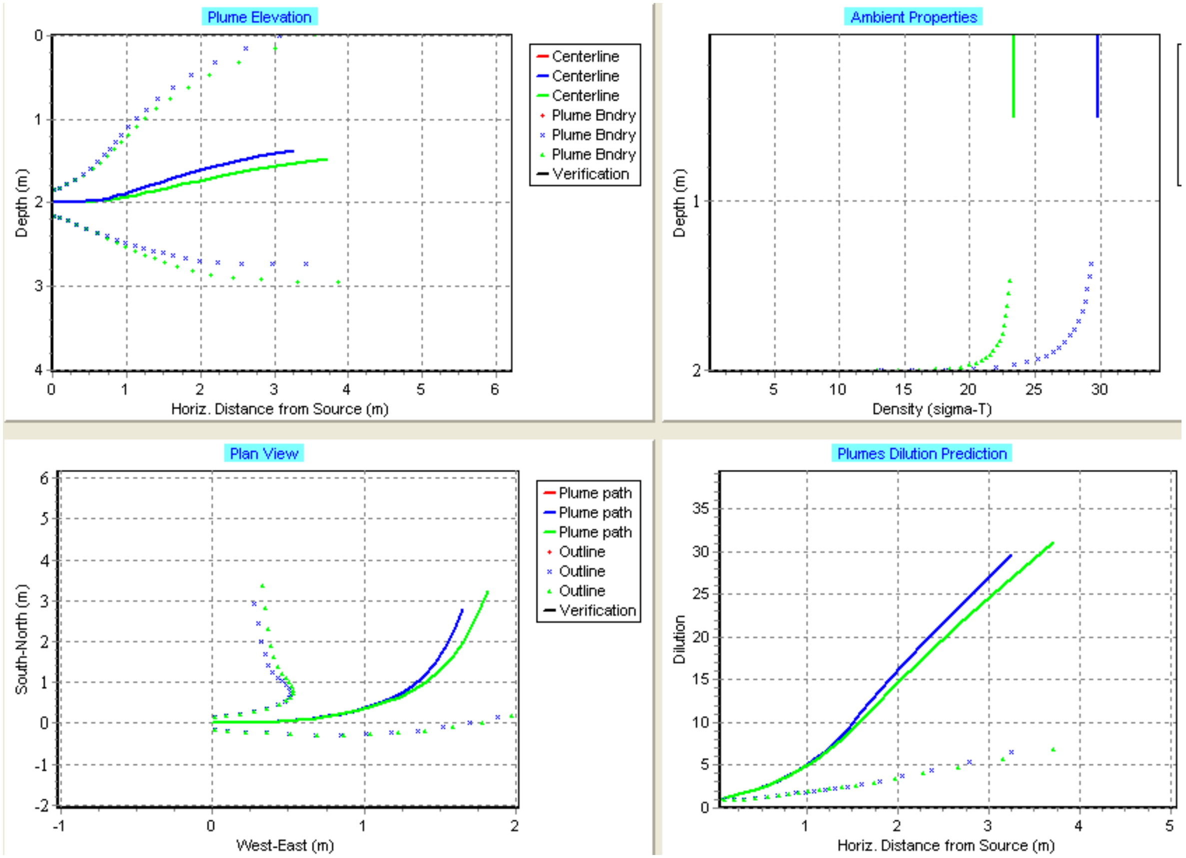
At a depth of 1m during a neap tide, the maximum initial dilution achievable is 1:8, which is below the desired level of 1:16 for initial dilution. The mixing zone is very similar in both the dry and wet seasons.

Discharge port depth = 1m



At a depth of 1m during a neap tide,

Discharge port depth = 2m

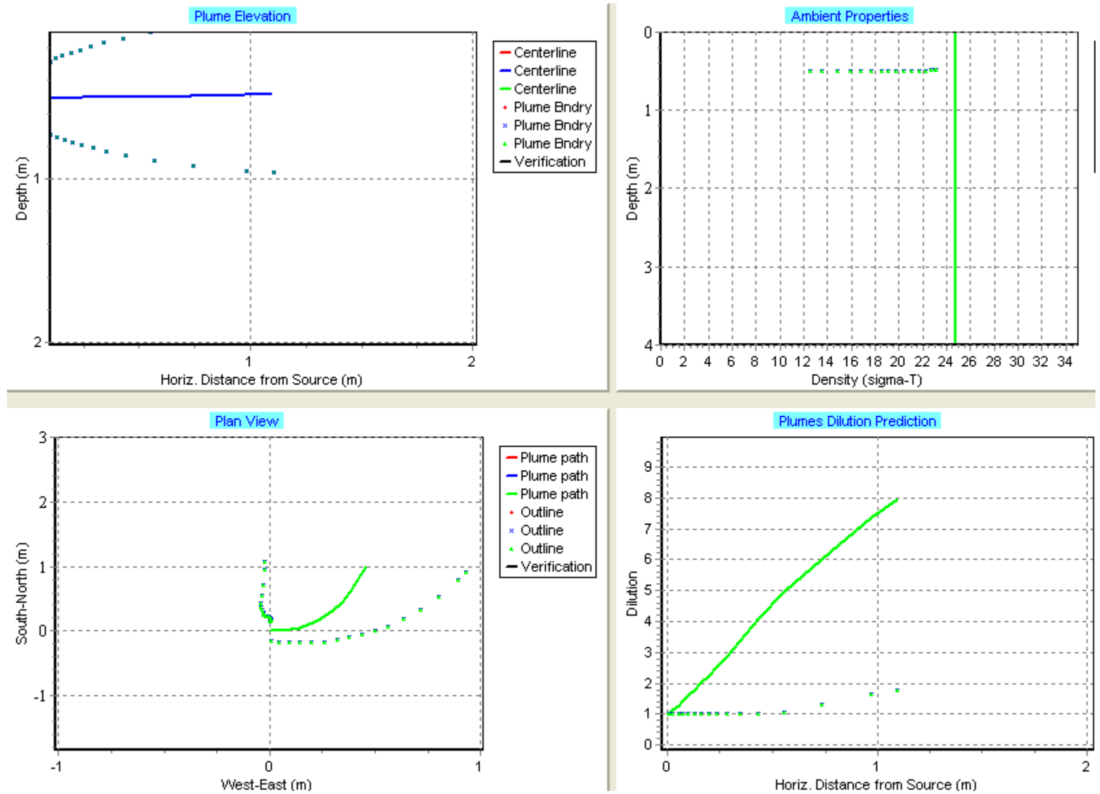


At a depth of 2m during a neap tide, the 1:16 initial dilution is achieved 2.2 metres downstream of the discharge port during both the dry and wet seasons.

8.5. Nitrate

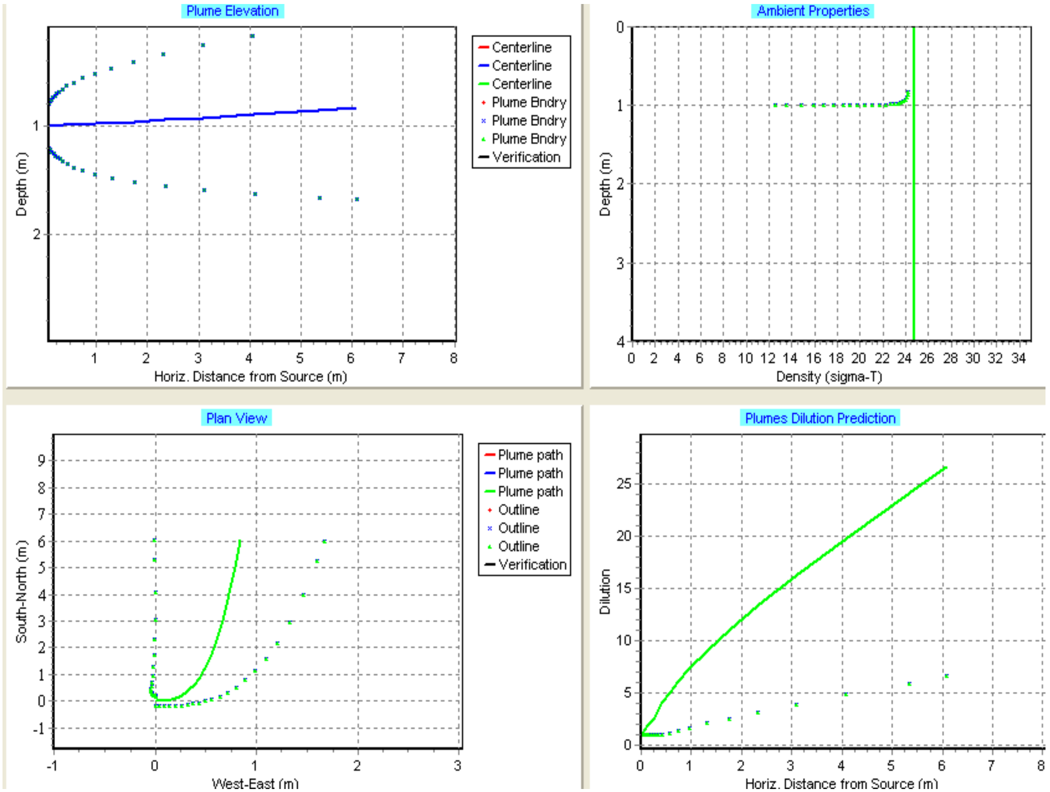
8.5.1. 95th percentile – Spring

Discharge port depth = 0.5m



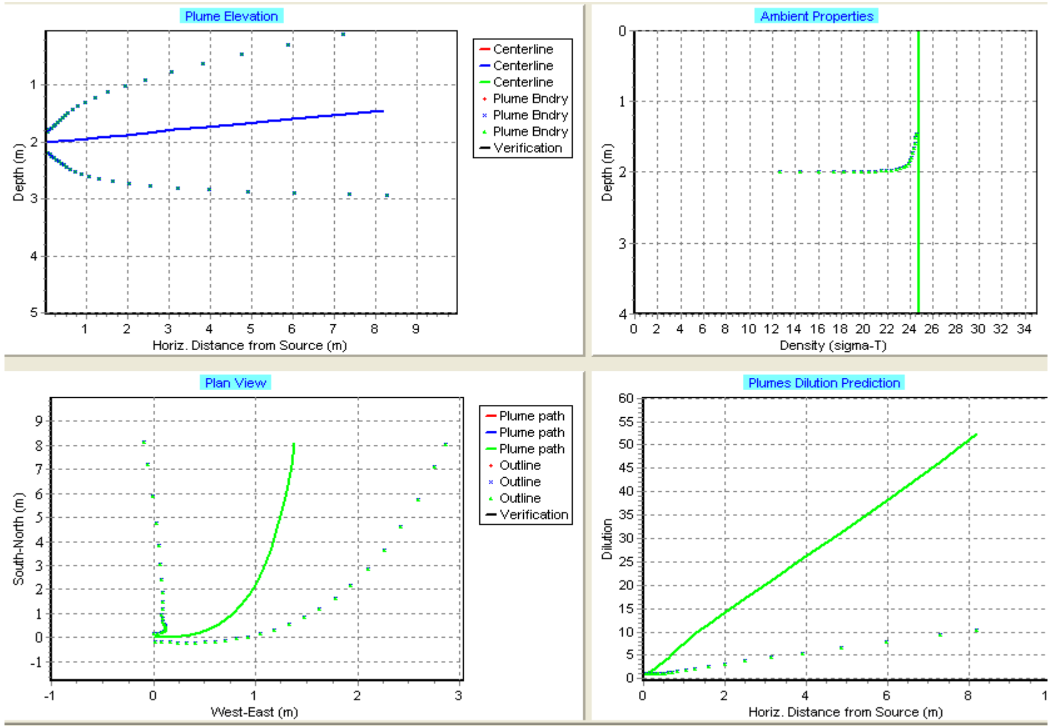
At a depth of 0.5m during a spring tide, the 1:1600 initial dilution is not achieved

Discharge port depth = 1m



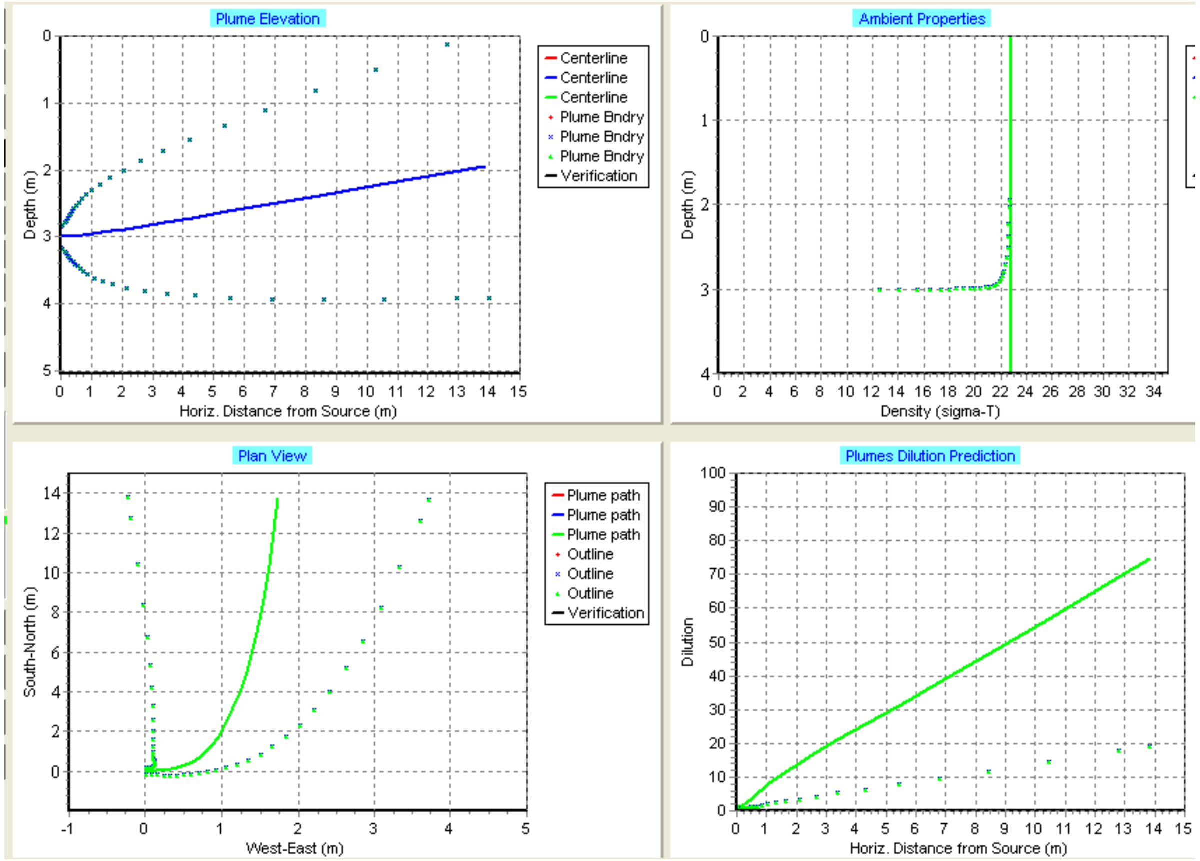
At a depth of 1m during a spring tide, the 1:1600 initial dilution is not achieved

Discharge port depth = 2m



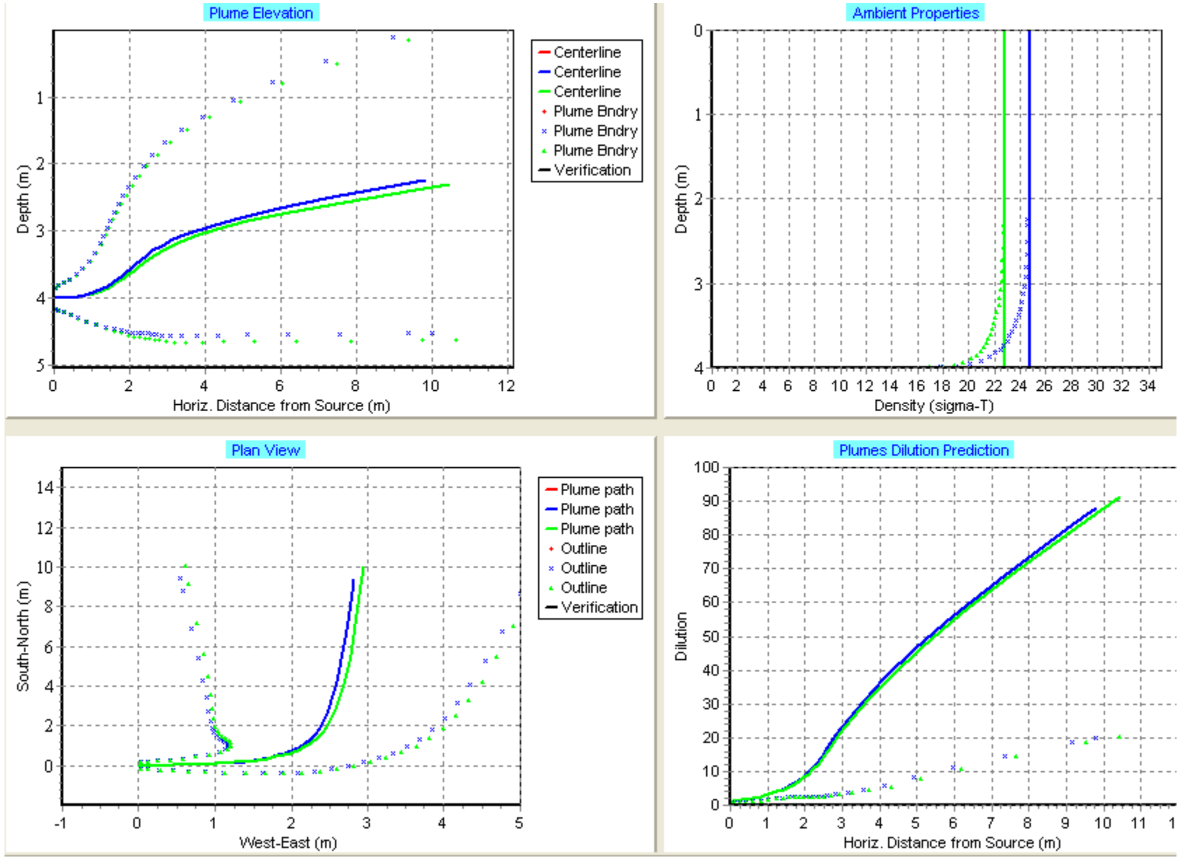
At a depth of 2m during a spring tide, the 1:1600 initial dilution is not achieved.

Discharge port depth = 3m



At a depth of 3m during a spring tide, the 1:1600 initial dilution is not achieved.

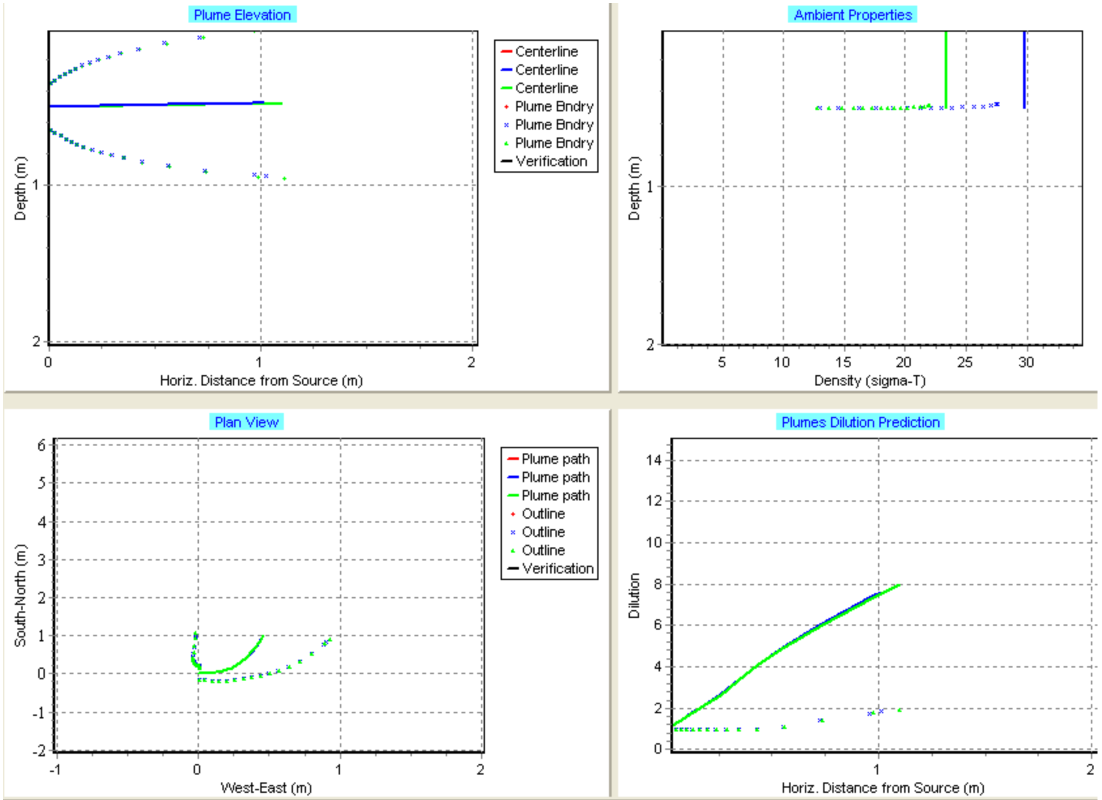
Discharge port depth = 4m



At the maximum depth of 4m during a spring tide, the 1:1600 initial dilution is not achieved.

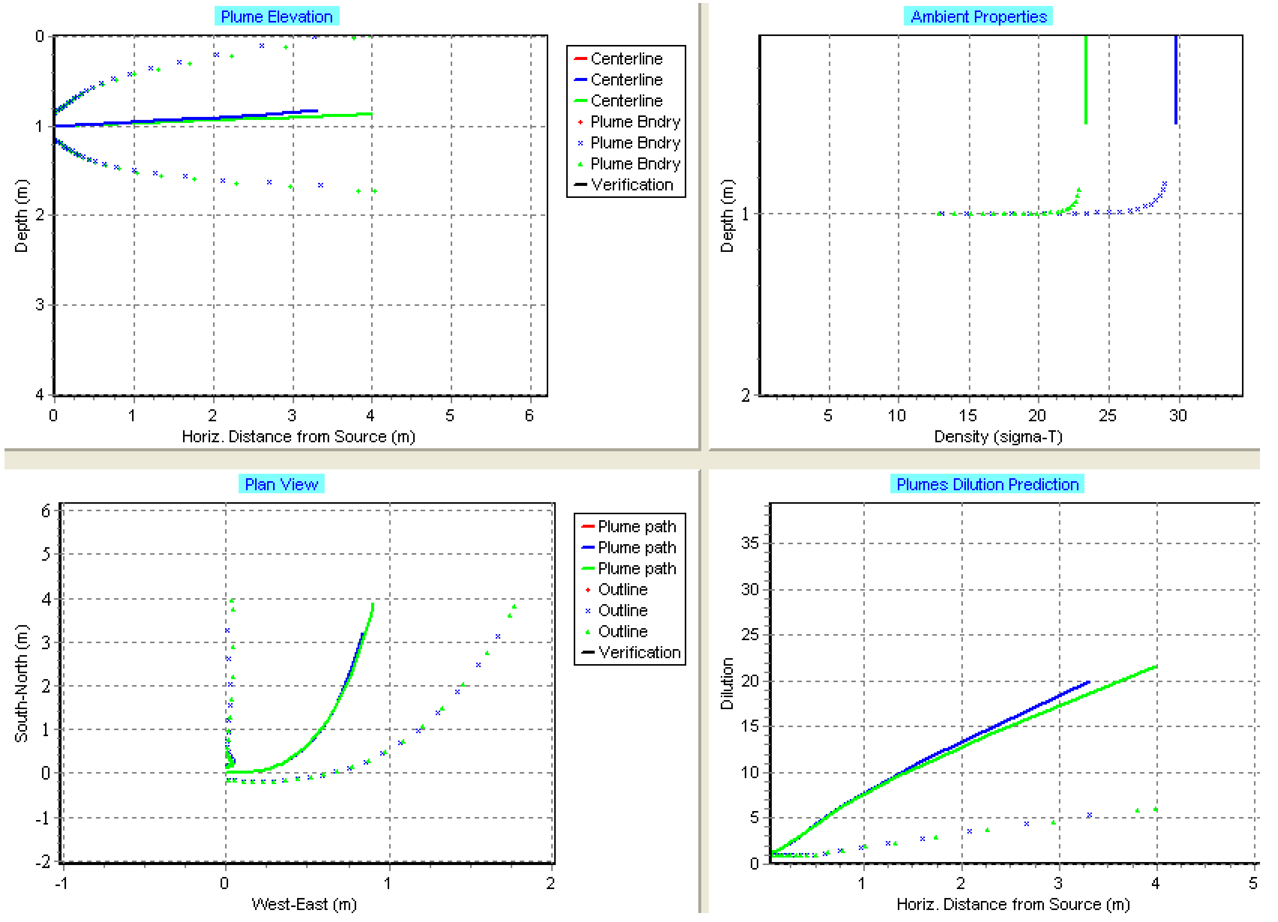
8.5.2. 95th Percentile – Neap

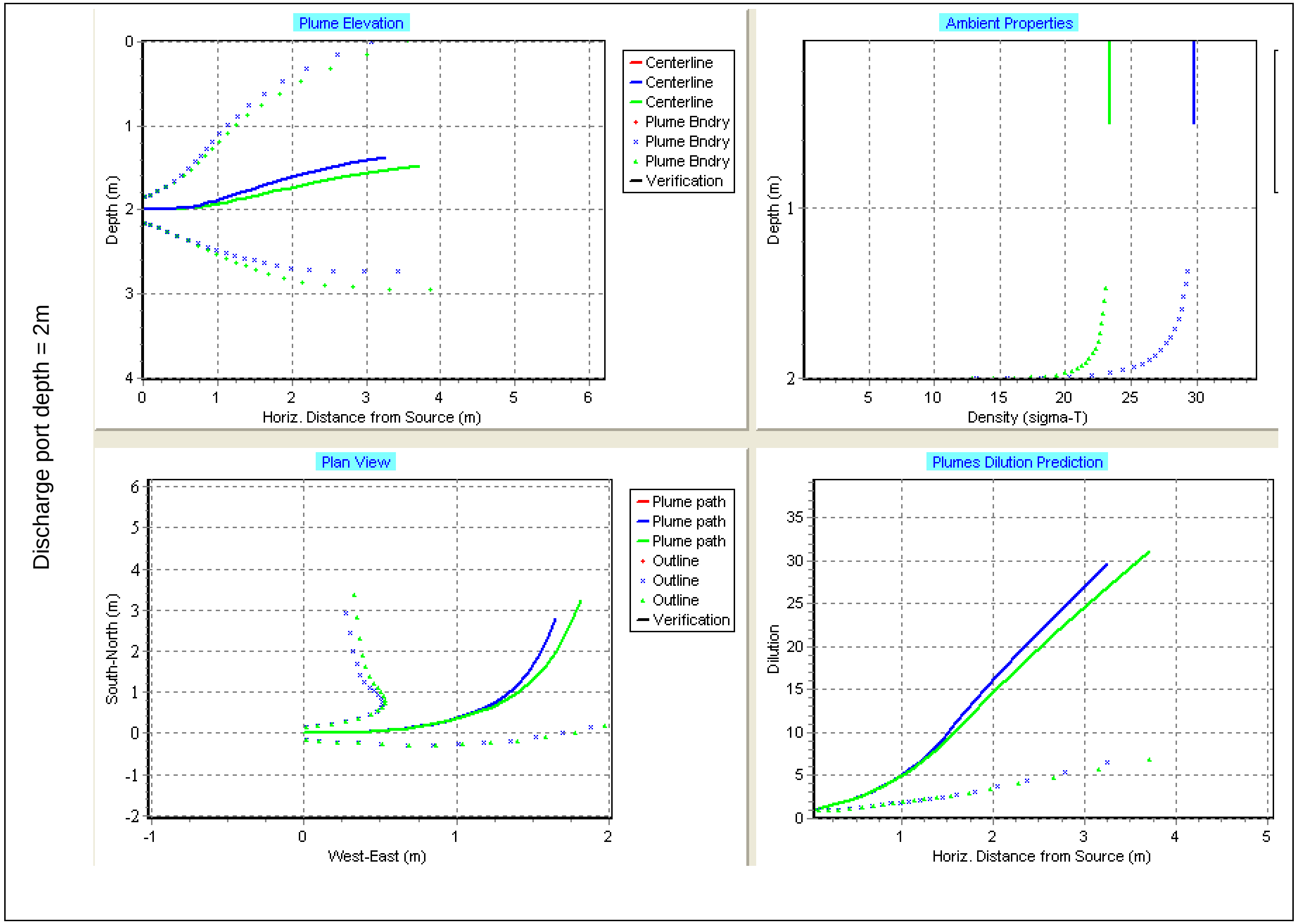
Discharge port depth = 0.5m



At a depth of 1m during a neap tide, the maximum initial dilution achievable is 1:8, which is below the desired level of 1:16 for initial dilution. The mixing zone is very similar in both the dry and wet seasons.

Discharge port depth = 1m




Discharge port depth = 2m
Plume Elevation
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Plume Bndry
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Density (sigma-T)
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Plumes Dilution Prediction
Dilution
Horiz. Distance from Source (m)