Davidson Environmental Limited

Post-remediation monitoring of sediments and biota from estuarine sites located adjacent to the former Fruitgrowers Chemical Company (FCC) site, Mapua, Nelson

Research, survey and monitoring report number 616

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Summary

Marine areas adjacent to the former Fruitgrowers Chemical Company (FCC) site were sampled in Spring 2009. Sampling included:

- Pesticides in sediment (shallow 0-2 cm, deep 10-20 cm);
- Pesticides in molluscs (mudflat snail, topshell snail, cockle);
- Total organic carbon (TOC) in shallow and deep sediments;
- Particle analysis from selected shallow and deep sediments;
- Invertebrate community composition and abundance from surface and within sediment samples; and
- Macroalgal distribution and percentage cover.

The sampling regime was based on recommendations made in the site auditors report (Pattle Delamore 2009). Where possible, sites previously sampled were adopted for on-going monitoring.

Three of 26 deep marine sediment samples adjacent to the FCC met the DDX (DDT, DDE, DDD) Soil Acceptance Criteria (SAC), while approximately 70% or 18 of 26 samples for ADL (aldrin, dieldrin, lindane) achieved the SAC.

In sediments where the SAC was exceeded, DDX and ADL concentrations were dramatically lower than values recorded prior to remediation.

Small increases in ADL and DDX were recorded at some sites. Reasons for these relatively small increases are most likely related to re-contamination of remediated sediment from the FCC site during remediation and via natural movement of marine sediments from offshore and adjacent areas. Highest DDX and ADL values were recorded from the West Stream, West estuarine stream channel, a low-lying area in the central area of the West FCC shore, and southern parts of the East FCC shore.

Moderate levels of nutrient enrichment occurred in Eastern and Western FCC marine sediments. Enrichment of sediment is probably from water runoff via the numerous seepages flowing from the FCC site. Enrichment has not resulted in anaerobic conditions or a change in community composition; however, numbers of some species may be elevated due to nutrients and their effect on environmental variables such as food availability.

Present levels of pesticide in marine sediments have not resulted in a decrease in invertebrate community diversity or abundance.

ADL and DDX levels in cockles were comparable to other areas in New Zealand considered representative of contaminated sites. These sites have usually been located close to large cities or development. Contaminants in cockles were, however, relatively low when compared to many contaminated sites overseas and were below the US and Canadian limits for the protection of human health.

ADL and DDX levels in mudflat snails from the West FCC shore were unusually high relative to previous samples. This was in contrast to contaminant levels recorded from the sediment snails were living on (i.e. DDX and ADL values declining in sediment). The reason for this result remains a mystery.

The second sampling event is due in Spring 2010. These data will provide more information on contaminant levels and the reasons for those patterns.

1.0 Background

Historic environmental investigations carried out at Mapua have found elevated concentrations of contaminants in marine sediments adjacent to the FCC site. The major contaminants of concern were organochlorine pesticides (OCPs), which include DDT, DDD and DDE (collectively known as DDX), and aldrin, dieldrin and lindane (collectively known as ADL). A decision was made to remediate the site to prevent further effects on the marine environment. Following initial trials, remediation works commenced in October 2004 and were completed in early 2008. The remediation Validation Report was submitted to MfE in December 2008. The site has remained vacant since remediation was completed.

During the works, two areas of foreshore adjacent to the FCC site were included in the remediation:

- the tidal beach in Mapua Channel located to the east of FCC East; and
- the tidal mudflats in Waimea Inlet located to the south of FCC Landfill, including a tidal channel that crosses the mudflats (the "swale"). Also included was a section of the tidal creek running along the north-west edge of FCC Landfill. This Stream carries stormwater from adjacent housing developments.

The extent of contamination at these locations was broadly defined by previous investigation results and additional sampling during the remediation works. Based on the pre-remediation results, a surface layer of contaminated sediment was excavated down to the low tide contour in East FCC. In the west, the creek (for most of its length adjacent to the site), part of the foreshore, and part of the tidal swale were excavated and backfilled. The removal of contaminated sediments was completed in a series of cells, each backfilled with imported gravels after validation sampling from the base of the excavation. The resource consent required that excavated cells were sampled and backfilled within one tide. Consequently, the excavations were backfilled before the validation test results were received.

In June 2009, the audit report for the remediation of the former Fruitgrowers Chemical Company site, Mapua, was completed (Pattle Delamore Partners Ltd. 2009). The auditor provided a comprehensive document that included a variety of recommendations with respect to monitoring marine sediments and biota. The general recommendations are outlined below, while the full recommendations can be viewed in Chapter 6 of the audit report).

The auditor has stated with respect to the marine sediments that:

"*It is considered that remediation to the extent practicable has been broadly achieved in the marine foreshore areas. The benefits of further remediation are likely to be outweighed by the additional disruption and impacts to the environment. It is clear that the remediation in these areas has not been successful in meeting the SACs for DDX and ADL. However, re-*

deposition of non-complying sediment from the surrounding marine environment probably meant that compliance with the SACs could not be achieved within the foreshore surface sediments. In addition, re-contamination of the deeper backfill material has occurred during the remediation works. The mechanism(s) for this are not clear, but site runoff is probably a major contributor. While contamination remains within the backfilled material, there is evidence that the surface sediment quality has been improving since completion of the remediation. A key aspect of the foreshore remediation is the removal of the site as a source of ongoing sediment contamination. This will allow natural attenuation processes to slowly improve the foreshore sediment quality over the coming years. Apart from localised effects on the marine ecosystem, the effects of the residual sediment contamination on other receptors are not likely to be significant. In the case of risks to human health via seafood consumption, additional data is required to confirm this as the current dataset is limited."

The auditor stated with respect to monitoring that:

"Sediment and snail sampling should continue, following a review of the sampling design to ensure it is adequately quantifying the risk via seafood consumption and is properly representing the quality of the surface sediments. The health and diversity of the foreshore ecosystems should be benchmarked relative to suitable control sites elsewhere in the Waimea Inlet. The information will contribute to assessing the significance of the residual contamination in the foreshore sediments and the local effects of contaminated groundwater discharge. The current annual monitoring of sediment and biota by TDC should be continued and expanded.

The aim of the monitoring will be to:

1. *confirm OCP concentrations in snails (as appropriate bio-indicators) remain below levels that might present an unacceptable risk to human health;*

2. *confirm apparent improving trends in the chemical quality of shallow sediment using a larger sample set; and*

3. *provide additional information on localised effects of nutrients in groundwater discharges on the foreshores (see Section 7.10.2 of the audit report)."*

The present document presents data collected during the first sample event during Spring 2009 and provides a comparison, where possible, with data collected previously by various authors.

2.0 Site history

The following section on the history of operations at the site has been extracted from the auditors report.

FCC operated an agrichemical formulation plant on FCC East and West from 1932 until 1988, producing pesticides, herbicides and fungicides that were used throughout the country. The north-eastern portion of FCC East was operated by a subsidiary company, originally known as Lime and Marble Limited and later as Mintech Ltd. The Mintech site was generally used for processing non-toxic minerals but also included the FCC micronising plant and some biocide preparation. Facilities used for agrichemical formulation and storage were operated on both FCC East and West.

From the 1950s, a number of areas were either in-filled or reclaimed, including: low lying areas of FCC East; the area now known as FCC Landfill, reclaimed from the Waimea Inlet; and the eastern portions of FCC East, reclaimed from the Mapua Channel. The fill material used contained waste material from site operations.

FCC ceased operations in 1988 and by 1996 TDC had either inherited or acquired the FCC portions of the site, i.e. FCC Landfill, FCC West and FCC East. FCC Landfill was inherited first, in the early 1990s. In May 1992, TDC installed a clay cut-off wall along the southern edge of FCC Landfill to reduce leachate migration into the Waimea Inlet. From the early 1990s onwards, the site was the subject of a number of environmental investigations and assessments. It was clear from the investigation results that some form of remediation or management of residual contamination at the site was required. Elevated contaminant concentrations were detected in soil on and adjacent to the site, groundwater and in nearby marine sediments. The major contaminants of concern which drove the need for remediation were organochlorine pesticides. Other contaminants included heavy metals, organonitrogen pesticides, organophosphorous pesticides, petroleum hydrocarbons, acid herbicides and elemental sulphur.

The peak soil concentrations were typically found in the vicinity of historical process areas. Marine sediments appear to have been contaminated from site runoff and drainage, including from the landfill, to the nearby estuary and Mapua Channel – see next section.

A decision was made to remediate the site after initial plans for capping the site were set aside. Soil treatment trials to select an appropriate technology were carried out in 1999 – 2000. Resource consents for the remediation were granted in November 2003.

3.0 Previous estuarine contaminant studies

Woodward Clyde (1996) presented contaminant monitoring data for a variety of biota sampled from estuarine habitats adjacent to the FCC site (east, west and general area). The species sampled included mudflat snail (*Amphibola crenata*), cockle (*Austrovenus stutchburyi*), green-lipped mussel (*Perna canaliculus*), and Pacific oyster (*Crassostrea gigas).* Most sampling occurred from areas adjacent to the FCC site between 1993 and 1996.

Landcare Research scientists sampled contaminants from sediments at upper and lower catchment positions of the western mudflat channel, as well as a western mudflat site (Tahi Street) and eastern site located adjacent to the FCC site (O'Halloran and Cavanagh 2002; Cavanagh and O'Halloran 2003). These authors also sampled contaminants from mudflat snail (*Amphibola crenata*), crab (Grapsid family), short-finned eel (*Anguilla australis*), cockle (*Austrovenus stutchburyi*), and Pacific oyster (*Crassostrea gigas*). They also collected samples from a control channel and a control mudflat site.

The authors reported that crabs and cockles did not accumulate high levels of organochlorine contaminants compared to snails (*Amphibola*). The authors reported that, apart from eels, snails accumulated much higher concentrations of organochlorine contaminants compared to other organisms sampled. Cavanagh and O'Halloran (2003) recommended that snail (*Amphibola*) was the most appropriate bioindicator to assess the success of remediation of the FCC site and its associated contaminated areas. The authors also recommended that some "opportunistic sampling be conducted of higher animals such as eels inhabiting the drain".

TDC has sampled contaminants from sediments and snails on a number of occasions since 2005 (Easton 2005; 2007a; 2007b; 2008; 2009; 2009a, 2010). Two sets of sampling sites have been used in repeat monitoring programmes. Sample of sediment and snail contamination were collected along the western estuary parallel to Tahi Street (Easton 2007b, 2009). Another set of sample sites were repeat monitored for snail and sediment contamination as part of the consent condition 522/19 requiring testing of the sediments and macroinvertebrates 12, 24 and 36 months after the coastal marine area remediation (Easton 2007a, 2008, 2009a). It is the latter set of samples that the site auditor suggested should be repeat sampled on at least two more occasions prior to a review of monitoring.

TDC sampled snails (*Amphibola crenata*) from the West FCC site and from a control site located further westward in the Waimea Inlet. Following remediation of the east FCC tidal shore, mudflat snails failed to recolonise. The author instead sampled a topshell (*Diloma subrostrata*). This species was also sampled from a control area located further eastwards in Waimea Inlet. *D. subrostrata* lives on a combination of rock, shell and soft substrata. Bioaccumulation levels recorded for this species were consistently lower than levels recorded for *Amphibola* samples collected from the west FCC site.

Following the present studies sampling regime the TDC sampled sediment and mudflat snail contaminants from JMB 084 located at the West FCC shore in January 2010 (Easton 2010).

4.0 Review of biological sampling

The auditor recommended that:

Prior to undertaking the next sediment and snail monitoring round, an appropriately qualified person should review the monitoring programme to confirm that the current programme is sufficient and appropriate given the altered habitat and different species that have re-colonised East FCC. The review should assess the previous reports on the subject, including that by Landcare Research (2002), and take into account recent monitoring data and the likely site use. Consideration should be given to the need for confirmatory sampling of other biota and extending the programme to improve its statistical robustness. The review should also consider whether the sampling is properly representing the quality of the surface sediments.

Davidson (2009) provided a review report and concluded that:

1. West FCC site: no change to the existing sampling protocol.

2. East FCC site: (1) collect an additional one or up to two mudflat snail composite samples; (2) at present, one topshell sample is collected from the East FCC site. It is recommended that two topshell samples from the East FCC site be collected on the first sample occasion (i.e. one sample from hard substrata and one sample from soft substrata).

3. East FCC site: one cockle sample should be collected from the East FCC site on each sample event.

5.0 Methods (present study)

Three broad types of monitoring were conducted in the marine environment adjacent to the FCC site, Mapua: (1). organism and sediment contaminant sampling (OPC's), (2) environmental variable sampling (total organic carbon, particle size analysis, redox cores), and (3) biological community sampling (invertebrate density and size, macroalgae cover). A summary of the laboratory methods and tests are displayed in Appendix 6.

5.1 Mollusc and sediment contaminant sampling

On 20th October 2009, sediment and invertebrates were sampled from the estuary adjacent to the FCC site and controls and sent to Hill Laboratories for analysis. Sediment was collected from two strata, (1) surface (0-2 cm) and (2) deep (10-20 cm) (Table 1, Figures 1 and 2). Surface samples were collected using a stainless steel sampler from undisturbed substratum at each sample site. Deep sites were sampled by first extracting a core of sediment followed by the collection of the sample using a stainless steel sampler. All

samples were placed in containers supplied by Hills Laboratories. Samplers were thoroughly washed between each sample and site.

An additional three contaminant samples were collected from the stream flowing adjacent to the West FCC site on the 10th November 2009. All stream sediment samples were collected from the surface layer (Table 1, Figure 1).

A variety of invertebrates were collected for contaminant analysis from FCC impact and Waimea Inlet control sites on 20th October 2009 (Table 2, Figures 3 and 4). At one control site and two impact sites (West FCC and East FCC), the mudflat snail (*A. crenata*) was collected for analysis. The topshell (*Diloma subrostrata*) was sample from an East FCC site. Based on the review by Davidson (2009), topshell that lived on (a) mud or (b) rock substratum were collected and kept separate for analysis. In addition, a cockle sample was collected from the East FCC site and an appropriate control located adjacent to Hunter Brown Reserve, some 1.4 km south-east of Mapua (Table 2, Figures 3 and 4).

Invertebrates were collected by hand using a haphazard sampling technique from an area of approximately $10m^2$ at each site. The only exception was the composite mudflat snail sample collected at the East FCC site (see yellow area in Figure 3). At this site, mudflat snails were rare; therefore the whole shoreline was used to provide sufficient snail specimens for analysis.

All invertebrates were kept in seawater for a period of 24 hours prior to transportation to Hill Laboratories to enable sediment purging from their digestive tracts prior to analysis. Fresh seawater was replaced periodically during this period to ensure their survival during this process.

Table 1. Sediment contaminant and environmental variable monitoring sites located at East and West (FCC) impact and control sites.

Type	Site number	Coordinates	Strata	OCP surface	OCP deep	TOC (surface)	TOC (deep)	Particle (surface)
West control	JME 080	41° 15.482'S, 173° 5.540'E	0-2 cm & 10-20 cm	1	1	1	1	1
Impact (west)	JME 083	41° 15.463'S, 173° 5.819'E	0-2 cm & 10-20 cm	1	1	1	1	1
Impact (west)	JME 081	41° 15.484'S, 173° 5.821'E	0-2 cm & 10-20 cm	1	1	1	1	1
Impact (west)	JME 082	41° 15.501'S, 173° 5.825'E	0-2 cm & 10-20 cm	1	1	1	1	
Impact (west)	West FCC new 1 (west)	41° 15.471'S, 173° 5.849'E	0-2 cm & 10-20 cm	1	1	1	1	
Impact (west)	West FCC new 2 (middle)	41° 15.473'S, 173° 5.867'E	0-2 cm & 10-20 cm	1	1	1	1	1
Impact (west)	West FCC new 3 (east)	41° 15.480'S, 173° 5.879'E	0-2 cm & 10-20 cm	1	1	1	1	
Impact (west)	JME 084	41° 15.484'S, 173° 5.859'E	0-2 cm & 10-20 cm	1	1	1	1	
Impact (west)	West FCC Stream 1 (lower)	41° 15.446'S, 173° 5.839'E	0-2 cm	1		1		1
Impact (west)	West FCC Stream 2 (middle)	41° 15.433'S, 173° 5.863'E	0-2 cm	1		1		1
Impact (west)	West FCC Stream 1 (upper)	41° 15.425'S, 173° 5.877'E	0-2 cm	1		1		
Impact (east)	JME 088	41° 15.418'S, 173° 6.089'E	0-2 cm & 10-20 cm	1	1	1	1	1
Impact (east)	JME 087	41° 15.421'S, 173° 6.093'E	0-2 cm & 10-20 cm	1	1	1	1	
Impact (east)	JME 086	41° 15.423'S, 173° 6.097'E	0-2 cm & 10-20 cm	1	1	1	1	
Impact (east)	East FCC New 1 (north)	41° 15.408'S, 173° 6.098'E	0-2 cm & 10-20 cm	1	1	1	1	1
Impact (east)	East FCC New 2 (south)	41° 15.428'S, 173° 6.083'E	0-2 cm & 10-20 cm	1	1	1	1	
Impact (east)	JME 090	41° 15.436'S, 173° 6.079'E	0-2 cm & 10-20 cm	1	1	1	1	1
East control	Hunter-Brown	41° 16.187'S, 173° 6.497'E	0-2 cm & 10-20 cm	1	1	1	1	1
TOTAL SAMPLES				18	15	18	15	10

Figure 1. Location of sediment contaminant sites at West FCC location. Insert is West control site (1st bay to the west of West FCC).

Figure 2. Location of sediment contaminant sites at East FCC location. Insert is East control site at Hunter-Brown Reserve.

Figure 3. Location of invertebrate contaminant samples collected from West FCC site and West control site.

Figure 4. Location of invertebrate contaminant samples collected from East FCC site. Yellow area indicates the composite *Amphibola* collection area. Insert map is East control cockle sample site located at Hunter-Brown Reserve.

Table 2. Invertebrate contaminant sample sites located at impact (FCC) and control sites.

Type	Site number	Coordinates	Samples per site
West control	JME 080 (*Amphibola*)	41° 15.482'S, 173° 5.540'E	1
West FCC	JME 084 (*Amphibola*)	41° 15.484'S, 173° 5.859'E	1
East FCC (soft)	East FCC New 2 (south soft) (*Diloma*)	41° 15.438'S, 173° 6.076'E	1
East FCC (rocky)	East FCC New 2 (south rocky) (*Diloma*)	41° 15.438'S, 173° 6.076'E	1
East FCC (composite)	East FCC (*Amphibola*)	Whole area	1
East FCC (JME 090)	East FCC (cockle)	41° 15.436'S, 173° 6.079'E	1
East control	Hunter-Brown (cockle)	41° 16.190'S, 173° 6.497'E	1
TOTAL SAMPLES			7

5.2 Environmental variable sampling

Total organic carbon (TOC), particle size analysis and redox data were collected from impact and control sites on the 20th October and 10th November 2009 (Table 1, Figures 1 and 2). Apart from deep stream sites, total organic carbon samples were collected from shallow and deep strata at all sites sampled for sediment contamination, while sediment for particle analysis was collected from approximately 50% of all samples (Table 1). When collected, particle analyses were performed on a combination of both surface and deep samples. Sediment was collected using the sample methods used during the collection of sediment contaminant samples.

At each contaminant sample site (n = 18), a 15 cm deep by 13 wide core sample was collected to assess the redox layer. Each core was photographed and notes taken on colour and odour.

5.3 Biological community sampling

A variety of biological sampling was conducted at FCC and control sites in Spring 2009.

5.3.1 Macroalgae cover

On one occasion at two control sites (3 September) and on three occasions at impact sites (3 and 16 September, 10 November 2009), photographs of macroalgae cover were collected. At each site, a reference point that could be easily relocated was chosen. At the West FCC site, a total of three fixed point locations were selected, while two fixed points were chosen at the East FCC site (Table 3, Figure 5). On each occasion, a series of photographs were collected spanning the adjacent estuarine area. Photographs were rendered into a panoramic photograph using Autostitch. It is noted that this process may result in a small level of distortion and image-bending.

On 16th September 2009, the percentage cover of macroalgae over the substratum were estimated from a series of contiguous $1m^2$ quadrats deployed perpendicular to the shoreline from fixed points (Table 4, Figure 6). The start of each series of quadrats was positioned near or at mean high water or at the foot of the rock embankments. The series of quadrats extended 10 m to 14 m distance from the point of origin. A photograph of representative quadrats was collected from each series of quadrats at each site.

5.3.2 Epifauna and infauna invertebrate density and size

Macroinvertebrates were sampled from four impact and two control sites on 16th September 2009 (Table 5, Figure 7). At each site, surface counts of conspicuous macroinvertebrates were collected from 14 replicate, haphazardly deployed $1m^2$ quadrats. Only macroinvertebrates that were living on the surface or partially visible from the surface were counted.

Three replicate core samples (13 cm wide by 15 cm deep) were collected at each site (Table 5). Cores were processed on-site through a 1 mm mesh size sieve and the contents preserved in 70% isopropyl alcohol (IPA) for later sorting and identification. Macroinvertebrates were identified to the most practical taxonomic level by Rod Asher of the Cawthron Institute. All cockles obtained from core samples were measured for maximum length. To increase the sample size, additional cockles were collected and a representative sub-sample was also measured.

Table 3. Macroalgae photo-points at Mapua FCC impact and control sites.

Location	Site	Description	Coordinates
West control	North	Located at seaward edge of rushes	41° 15.487'S, 173° 5.544'E
West FCC	Western	At imbedded marble rocks at foot of bank	41° 15.458'S, 173° 5.825'E
West FCC	Middle	At imbedded marble rocks at foot of bank	41° 15.461'S, 173° 5.859'E
West FCC	Eastern	At imbedded marble rocks at foot of bank	41° 15.463'S, 173° 5.897'E
East FCC	Drain	On top of storm water pipe	41° 15.408'S, 173° 6.095'E
East FCC	South	At southern end of shoreline rock wall	41° 15.442'S, 173° 6.072'E
East control		12 m seaward of large tree lucerne	41° 16.187'S, 173° 6.492'E

Table 4. Macroalgae transects at Mapua FCC impact and control sites.

Location	Site	Description	Coordinates	Quadrats in series
West control	North	Transect located north side of rushes, start at rush edge	41° 15.487'S, 173° 5.544'E	10
West control	South	Transect located south side of rushes, start at rush edge	41° 15.494'S, 173° 5.545'E	10
West FCC	West	Start on imbedded marble rock	41° 15.461'S, 173° 5.859'E	13
West FCC	East	Start on imbedded marble rock	41° 15.461'S, 173° 5.884'E	14
East FCC	North	16 m south of storm water pipe	41° 15.414'S, 173° 6.093'E	13
East FCC	South	16 m north from end of shoreline rock wall	41° 15.430'S, 173° 6.081'E	13
East control	West	12 m seaward of large tree lucerne	41° 16.187'S, 173° 6.492'E	13
East control	East	12 m seaward of large tree lucerne	41° 16.189'S, 173° 6.496'E	13
TOTAL QUADRATS				99

Table 5. Invertebrate infaunal and epifaunal sites from FCC impact and control sites.

Location	Site	Core replicates	Surface m^2 replicates	Coordinates
West control	JME 080	3	14	41° 15.482'S, 173° 5.540'E
West FCC	West FCC (new2)	3	14	41° 15.473'S, 173° 5.867'E
West FCC	West FCC (new3)	3	14	41° 15.480'S, 173° 5.879'E
East FCC	East FCC (new1)	3	14	41° 15.408'S, 173° 6.098'E
East FCC	East FCC (new 2)	3	14	41° 15.428'S, 173° 6.083'E
Huunter-Brown	East Control	3	14	41° 16.187'S, 173° 6.497'E

Figure 5. Location of macroalgae photo points. Insert is East control (Hunter Brown Reserve).

Figure 6. Location of macroalgae transects at impact and control sites. Insert is East control.

Figure 7. Location of invertebrate infaunal and epifaunal sites at impact and control sites.

6.0 Results

6.1 Mollusc and sediment contaminant sampling

Contaminants in estuary and stream sediment varied with depth, both between and at the same sites, as well as at the same depth between sites (Figure 8, Table 6, Appendix 6). ADL (aldrin, dieldrin, lindane) exceeded the Soil Acceptance Criteria (SAC) at seven of 16 shallow impact sites and four of 13 deep impact sites. No elevated ADL values were recorded from control sites at either depth strata. The highest ADL value was recorded from JME 090 located close to the rock wall at the southern end of the East FCC site (Figures 2 and 8). The second highest ADL value was recorded from East FCC new2 (south), also located in the southern half of the East FCC shore close to the rock wall (Figures 2 and 8). All three shallow sediment sites sampled from the West FCC stream recorded values between 0.6 and 0.8 mg/kg dry weight. Deep stream sediments were not sampled during the present study. At seven impact sites, ADL was recorded below the SAC at both shallow and deep substrata. At another four sites, either the deep or the shallow sample was recorded below the SAC (Figure 8). DDX (2,4 DDT; 4,4 DDT; 2,4 DDD; 4,4 DDD; 2,4 DDE; 4,4 DDE) was recorded above the SAC from a deep sample collected from the West Control site (0.09 mg/kg; Table 6, Figure 8). DDX exceeded the SAC at all 16 shallow impact sites and 10 of the 13 impact deep sample sites (Table 6, Figure 8). The sites that were below the SAC were all located at the West FCC location (Figure 1). The highest DDX values were recorded from Stream (upper), JME 090 (East FCC), East FCC new2 (south) and Stream (lower) sites (Figure 8).

Comparison of DDX, dieldrin and aldrin levels sampled from the same sites on five occasions between 2005 and 2009 revealed high levels at particular sites in 2005 and 2008. Samples collected in 2008 and 2009 showed dramatically lower values (Figures 9 and 10, Table 7). Highest mean values for the sites sampled on all occasions between 2005 and 2009 showed peaks for DDX and dieldrin in 2005 and highest lindane levels in 2007 (Figure 10). In the three sample events between 2008 and 2009, values for DDX, dieldrin and lindane were dramatically lower than values recorded in 2005 and 2007. Despite this large decline, mean values for DDX (0.3984 mg/kg) and dieldrin (0.03986 mg/kg) remained above the SAC for the entire period including the two 2009 samples. The mean concentration of lindane, however, was below the SAC in 2008, 2009a and 2009b. Aldrin, the third component of ADL, has not been reported in figures as concentrations were typically below laboratory detection limits. A sample collected in January 2010 at one West FCC site (JMB 084) after the present study, produced slightly higher values for DDX (0.49 mg/kg) and dieldrin (0.014 mg/kg) (Easton 2010, Table 7).

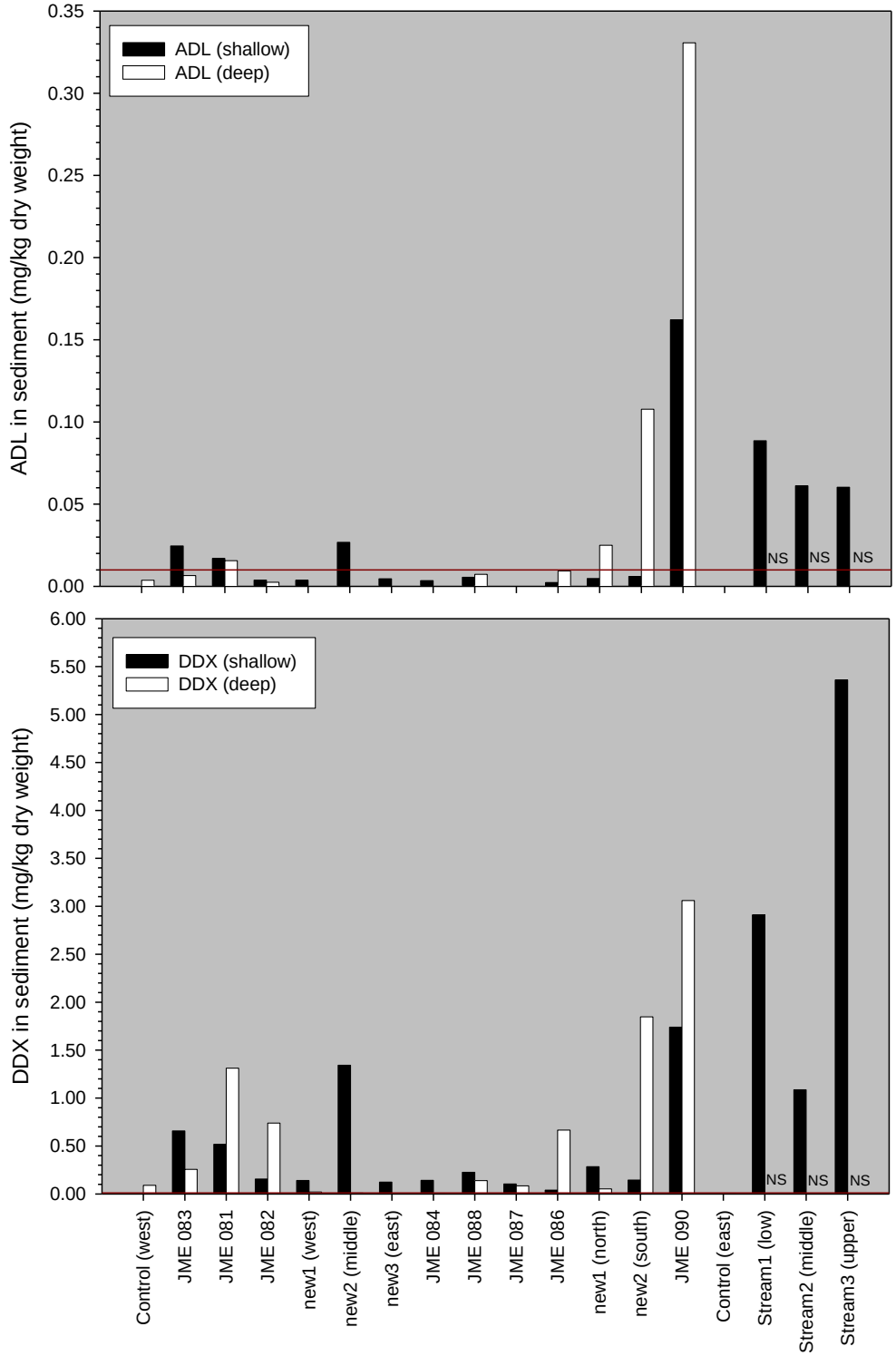

Figure 8. Levels of ADL (aldrin, dieldrin, lindane) and DDX (2,4DDT; 4,4DDT; 2,4DDD; 4,4DDD; 2,4DDE; 4,4DDE) (mg/kg dry weight) recorded from sediment samples collected at control and impact sites. NS = not sampled. Red line = SAC.

Table 6. Summary of ADL and DDX levels and their component analytes sampled in 2009 from impact (FCC sites) and control sites.

SURFACE (0 - 2 cm) Test	SAC	West Control	West FCC JME 083	West FCC JME 081	West FCC JME 082	West FCC new1 (west)	West FCC new2 (middle)	West FCC new3 (east)	West FCC JME 084	East FCC JME 088	East FCC JME 087	East FCC JME 086	East FCC new1 (north)	East FCC new2 (south)	East FCC JME 090	East Control	West FCC Stream1 (low)	West FCC Stream2 (middle)	West FCC Stream3 (upper)
Aldrin		< 0.0010	< 0.0011	0.001	< 0.0010	< 0.00099	< 0.0011	< 0.00099	< 0.00099	< 0.0011	< 0.00098	< 0.0010	< 0.0010	< 0.00099	0.0016	< 0.00099	0.0088	0.0047	0.0075
Dieldrin		< 0.0010	0.023	0.015	0.0028	0.0027	0.024	0.0036	0.0025	0.0044	< 0.00098	0.0013	0.0038	0.005	0.16	< 0.00099	0.076	0.054	0.05
gamma-BHC (Lindane)		< 0.0010	0.001	0.001	< 0.0010	< 0.00099	0.0022	< 0.00099	< 0.00099	< 0.0011	< 0.00098	< 0.0010	< 0.0010	< 0.00099	< 0.0010	< 0.00099	0.0038	0.0025	0.0028
2,4-DDD		< 0.0010	0.084	0.065	0.018	0.014	0.19	0.014	0.014	0.014	0.0038	0.0031	0.014	0.0073	0.39	< 0.00099	0.34	0.19	0.36
4,4 DDD		< 0.0010	0.2	0.16	0.046	0.033	0.53	0.031	0.051	0.033	0.015	0.014	0.038	0.025	1	< 0.00099	0.93	0.3	1.1
2,4 DDE		< 0.0010	0.038	0.027	0.0062	0.0039	0.041	0.006	0.0038	0.0021	< 0.00098	< 0.0010	< 0.0010	< 0.00099	< 0.0010	< 0.00099	0.2	0.11	0.18
4,4 DDE		< 0.0010	0.21	0.16	0.039	0.057	0.48	0.047	0.054	0.037	0.011	0.0068	0.038	0.018	0.11	< 0.00099	1.2	0.32	1.2
2,4 DDT		< 0.0010	0.025	0.091	0.0073	0.002	0.008	0.0032	0.0028	0.019	0.015	0.0018	0.034	0.01	0.029	< 0.00099	0.041	0.027	0.12
4,4 DDT		0.0014	0.1	0.015	0.04	0.031	0.094	0.023	0.016	0.12	0.059	0.014	0.16	0.084	0.21	< 0.00099	0.2	0.14	2.4
ADL (aldrin, dieldrin, lindane) [1]	0.01	ND	0.02455	0.017	0.0038	0.00369	0.02675	0.00459	0.00349	0.0055	ND	0.0023	0.0048	0.00599	0.1621	ND	0.0886	0.0612	0.0603
DDX [1]	0.01	0.0039	0.657	0.518	0.1565	0.1409	1.343	0.1242	0.1416	0.2251	0.10429	0.0402	0.2843	0.1448	1.7395	ND	2.911	1.087	5.36

DEEP (15 - 20 cm) Test	SAC	West Control	West FCC JME 083	West FCC JME 081	West FCC JME 082	West FCC new1 (west)	West FCC new2 (middle)	West FCC new3 (east)	West FCC JME 084	East FCC JME 088	East FCC JME 087	East FCC JME 086	East FCC new1 (north)	East FCC new2 (south)	East FCC JME 090	East Control
Aldrin		< 0.00098	< 0.0011	0.0025	< 0.00099	< 0.0011	< 0.0010	< 0.00099	< 0.00099	< 0.0010	< 0.0010	< 0.0010	< 0.0010	0.0072	0.028	< 0.0010
Dieldrin		0.0027	0.0055	0.011	0.0015	< 0.0011	< 0.0010	< 0.00099	< 0.00099	0.0063	< 0.0010	0.0083	0.024	0.1	0.3	< 0.0010
gamma-BHC (Lindane)		< 0.00098	< 0.0011	0.0021	< 0.00099	< 0.0011	< 0.0010	< 0.00099	< 0.00099	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	0.0026	< 0.0010
2,4-DDD		< 0.00098	0.022	0.081	0.044	< 0.0011	0.0012	< 0.00099	< 0.00099	0.0049	0.0028	0.016	0.0035	0.086	0.47	< 0.0010
4,4 DDD		0.0071	0.054	0.15	0.15	0.012	0.0025	< 0.00099	0.0021	0.0062	0.0036	0.035	0.0069	0.11	1.2	0.0026
2,4 DDE		0.024	0.0075	0.031	0.013	< 0.0011	< 0.0010	< 0.00099	< 0.00099	0.0044	0.0011	0.0046	< 0.0010	< 0.0010	< 0.0010	< 0.0010
4,4 DDE		0.001	0.046	0.18	0.11	0.0026	0.0029	0.0013	0.0036	0.031	0.013	0.2	0.014	0.31	0.37	0.0011
2,4 DDT		0.056	0.017	0.15	0.022	< 0.0011	< 0.0010	< 0.00099	< 0.00099	0.014	0.011	0.091	0.004	0.35	0.17	< 0.0010
4,4 DDT		0.0015	0.11	0.72	0.4	0.0035	0.0014	< 0.00099	0.001	0.078	0.053	0.32	0.024	0.99	0.85	0.002
ADL (aldrin, dieldrin, lindane) [1]	0.01	0.00368	0.0066	0.0156	0.00249	ND	ND	ND	ND	0.0073	ND	0.0093	0.025	0.1077	0.3306	ND
DDX [1]	0.01	0.09009	0.2565	1.312	0.739	0.01975	0.00855	0.003775	0.008185	0.1385	0.0845	0.6666	0.0529	1.8465	3.0605	0.0072

Notes:	
1	For multiple analyte totals, the concentration detected below the LOR is assumed to have a concentration of 0.5 the LOR
SAC	Soil acceptance criteria
LOR	Limit of laboratory reporting
ND	Not detected above LOR's
	Value exceeds Soil Acceptance Criteria (SAC)

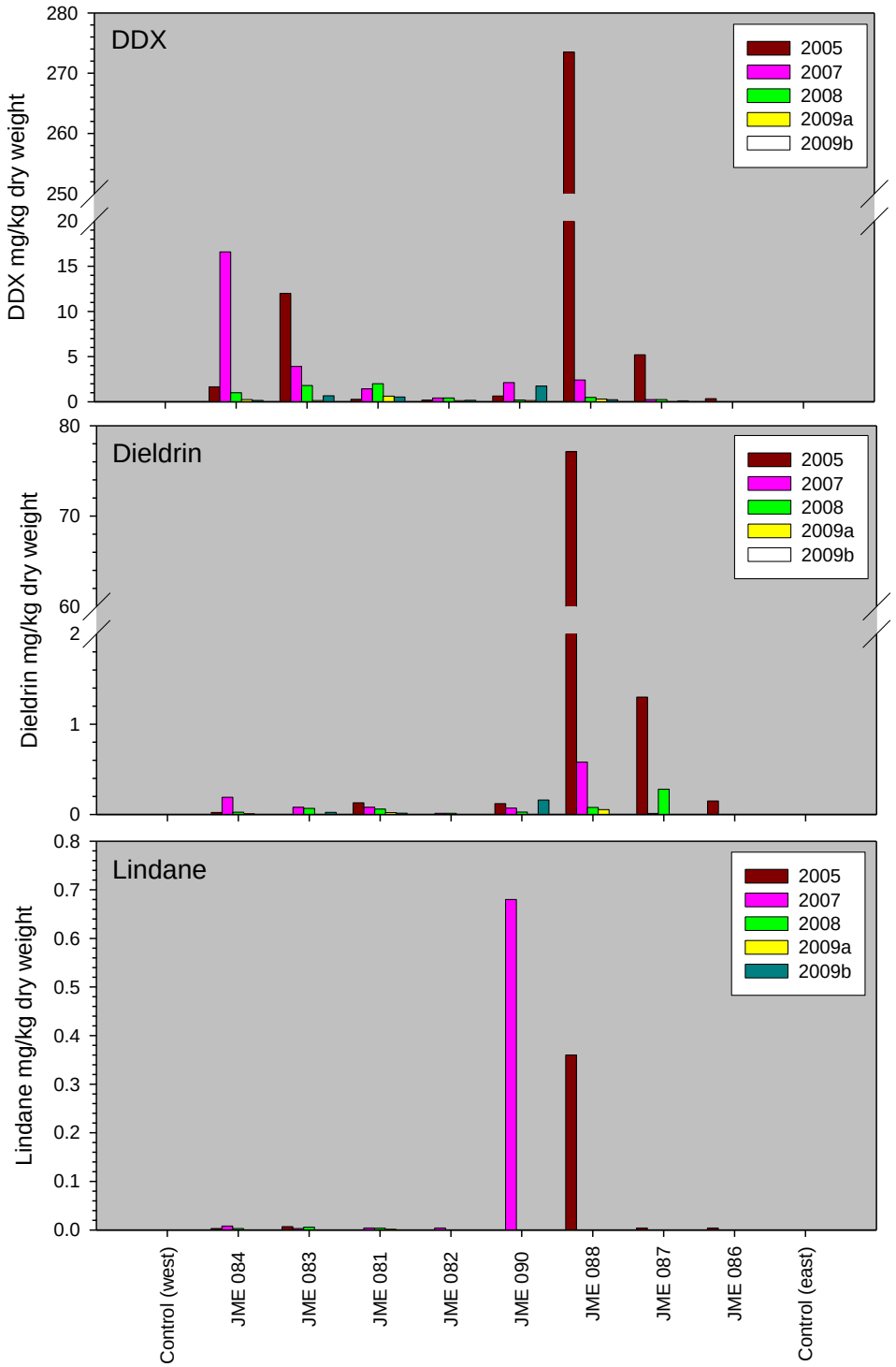

Figure 9. Levels of DDX (2,4DDT; 4,4DDT; 2,4DDD; 4,4DDD; 2,4DDE; 4,4DDE), dieldrin and lindane (mg/kg dry weight) recorded from the same control and impact sites in 2005, 2007, 2008, 2009a and 2009b (present study).

Table 7. Summary of DDX, dieldrin and lindane levels from surface samples collected between 2005 and October 2009 from impact (FCC) and control sites. Only sites common to all studies have been included.

Location	Area	DDX (mg/kg)						Dieldrin (mg/kg)						Lindane (mg/kg)			
		2005	2007	2008	2009a	2009b	2010	2005	2007	2008	2009a	2009b	2010	2005	2007	2008	2009a
Control	West (1 bay west of FCC)	0.0056	ND	ND	0.005	0.0039		-	ND	ND	ND	ND		-	ND	ND	ND
JME 084 (West FCC snail sample site) 10m (2005, 2007), 40 m (2008), 45m (2009) from MHWS	West FCC	1.64	16.6	0.987	0.23	0.1416	0.49	0.022	0.19	0.025	0.009	0.0025	0.014	0.003	0.008	0.003	ND
JME 083 (at concrete bridge)	West FCC	12	3.9	1.8	0.129	0.657		0.0018	0.08	0.067	0.005	0.023		0.007	0.003	0.0057	ND
JME 081 (40 m down ditch)	West FCC	0.26	1.43	2	0.62	0.518		0.129	0.08	0.06	0.02	0.015		-	0.004	0.0039	0.0016
JME 082 (80 m down ditch)	West FCC	0.17	0.42	0.41	0.12	0.1565		0.0035	0.013	0.013	0.004	0.0028		0.0005	0.004	ND	ND
JME 090	East FCC	0.63	2.12	0.187	0.13	1.7395		0.12	0.071	0.026	0.006	0.16		-	0.68	ND	ND
JME 088 (top of beach)	East FCC	273.5	2.4	0.477	0.3	0.2251		77.13	0.58	0.078	0.054	0.0044		0.36	ND	ND	ND
JME 087 (10 m down beach) [1]	East FCC	5.2	0.24	0.24	0.016	0.1043		1.3	0.0108	0.28	0.005	ND		0.004	ND	ND	ND
JME 086 (15 m down beach) [2]	East FCC	0.34	0.023	0.044	0.013	0.0402		0.15	0.0057	0.004	ND	0.0013		0.004	ND	ND	ND
Control	East (Hunter-Brown)	-	-	-	-	ND		-	-	-	-	ND		-	-	-	-

Notes:	
1	10m (2005, 2009b), 5m (2007), 4.8m (2008), 8m (2009a)
2	22m (2005), 15m (2007, 2009a, 2009b), 10.5m (2008)
Source for data before October 2009	Easton (2009)
Source after October 2010	Easton (2010)
2009b	Present report
	Values greater than Soil Acceptance Criteria (SAC)

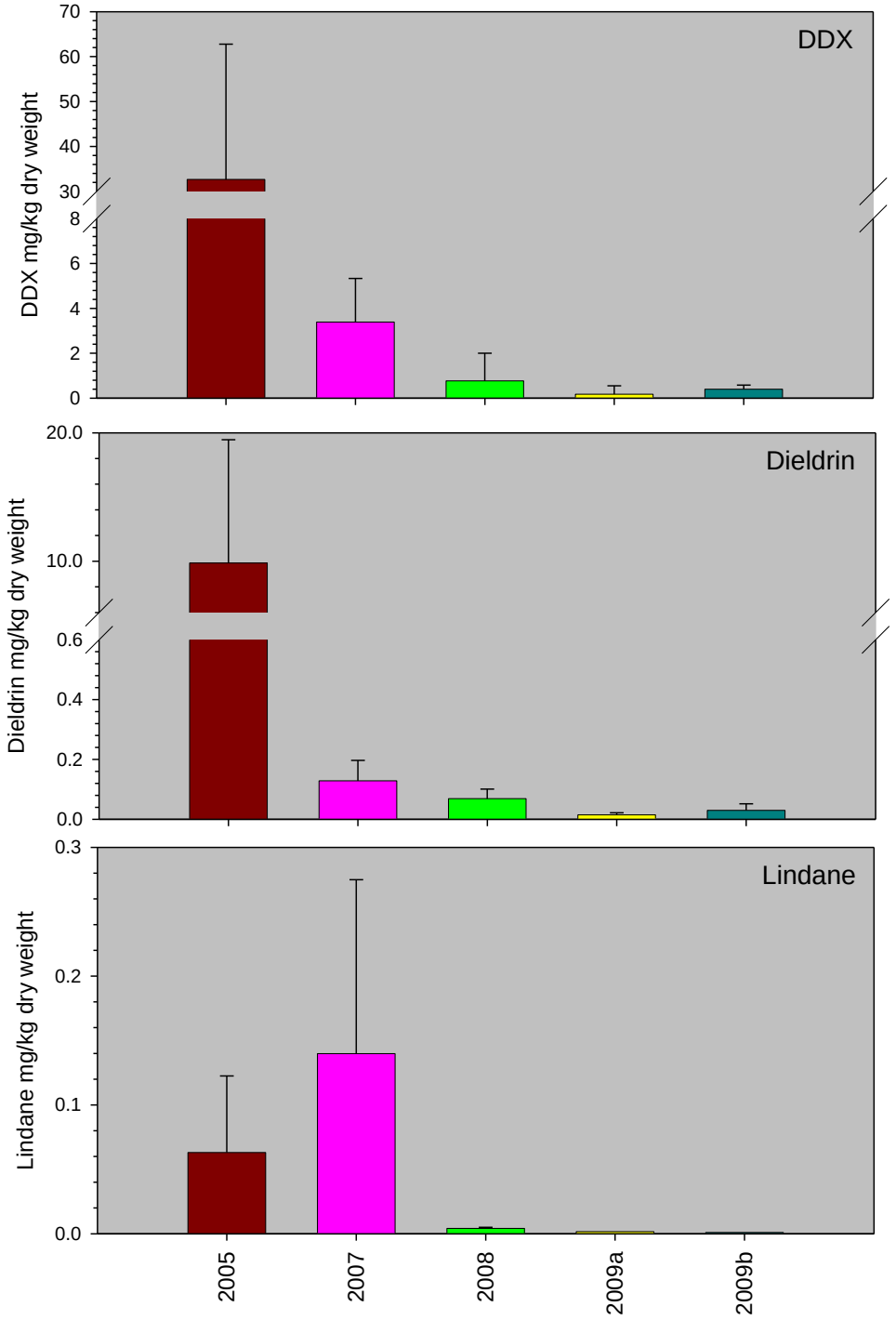

Figure 10. Mean DDX (2,4DDT; 4,4DDT; 2,4DDD; 4,4DDD; 2,4DDE; 4,4DDE), aldrin and lindane (mg/kg dry weight) recorded from the same control and impact sites sampled in 2005, 2007, 2008, 2009a and 2009b. Note: x axis values are variable between and within graphs. Error bars +/- 1 se.

A variety of molluscs were tested for pesticide contamination from five impact and two control samples (Table 8). Levels of ADL in cockles sampled at the East FCC impact site were relatively low (0.0033 mg/kg). DDX levels for this cockle sample was three times higher than the control site, but was dramatically lower than the value recorded for mudflat snail (Table 8). Mudflat snail ADL and DDX concentrations from the West FCC site (JME 084) were the highest values recorded in the present study with DDX values being the second highest since 2005 (i.e. 22.09 mg/kg compared to 51.14 mg/kg in 2007) (Table 9). This represented a six fold increase between the February 2009 sample and the October 2009 sample. Dieldrin also showed an increase over the same nine month period, however, lindane was not detectable. A sample collected by TDC in January 2010 confirmed higher values for snails at JMB 084 comapred to early 2009, however, values for both DDX and dieldrin were lower than the values recorded during the present study (Table 9).

Mudflat snails had not been sampled at the East FCC site since 2005 (Easton 2005). DDX and dieldrin levels both declined over this period, with DDX levels showing a 3.5 fold decline between sample occasions (Table 9).

Topshells (*Diloma*) were sampled from rock and soft substrata during the present study based on a recommendation by Davidson (2009). Slightly higher values of DDX were recorded from topshells living on soft substrata; however, higher levels of ADL were recorded from hard substrata topshells (Table 8). ADL and DDX levels for topshells were lower than levels recorded for mudflat snails at the East FCC beach. DDX levels in topshells at the East FCC beach exhibited a 5.8 fold increase between February 2009 (0.025 mg/kg) and October 2009 (0.1465 mg/kg), but concentrations were well below peaks recorded in 2007 (0.543 mg/kg) (Table 9).

Table 8. Pesticide concentrations in molluscs sampled from impact and control sites on 20 October 2009.

Location	West	West FCC	East FCC	East FCC	East FCC	East FCC	East
Site	Control	JME 084	Composite	new2 (north)	new2 (south)	JME 090	Control
Species	Amphibola	Amphibola	Amphibola	Diloma	Diloma	Cockle	Cockle
Substrata	Soft	Soft	Soft	Rocky	Soft	Soft	Soft
Pesticides (mg/kg)							
Aldrin	< 0.00050	< 0.0015	< 0.00050	< 0.00050	< 0.00050	< 0.00050	< 0.00050
Dieldrin	0.002	0.52	0.23	0.031	0.027	0.0028	< 0.00050
gamma-BHC (Lindane)	< 0.00050	< 0.0015	< 0.00050	< 0.00050	< 0.00050	< 0.00050	< 0.00050
2,4-DDD	< 0.00050	1.8	0.12	0.0095	0.013	0.0012	< 0.00050
4,4 DDD	0.015	5.9	0.46	0.067	0.082	0.0044	0.00069
2,4 DDE	< 0.00050	0.18	0.0069	0.0019	0.0036	< 0.00050	< 0.00050
4,4 DDE	0.068	11	0.013	0.058	0.08	0.0041	0.0011
2,4 DDT	< 0.00050	0.11	0.31	0.0011	0.0017	< 0.00050	< 0.00050
4,4 DDT	0.012	3.1	0.23	0.009	0.0088	0.00081	< 0.00050
ADL (aldrin, dieldrin, lindane) [1]	0.0025	0.5215	0.2305	0.0315	0.0275	0.0033	ND
DDX [1]	0.09575	22.09	1.1399	0.1465	0.1891	0.01101	0.00279

Notes:

1	For multiple analyte totals, if below the LOR it is assumed to have a concentration of 0.5 the LOR
ND	Not detected above LOR's
Scale	All values presented as mg/kg
LOR	Limit of laboratory reporting

Table 9. Historical pesticide concentrations in molluscs recorded from impact and control sites sampled between 2002 and 2010.

Site	Location	Species	Substrata	DDX (mg/kg)						Dieldrin (mg/kg)						Lindane (mg/kg)				
				2005	2007	2008	2009a	2009b	2010	2005	2007	2008	2009a	2009b	2010	2005	2007	2008	2009a	2009b
Control	West	Amphibola	Soft	0.11	-	-	-	0.09575		0.007	-	-	-	0.002		-	-	-	-	ND
JME 084	West FCC	Amphibola	Soft	6.2	51.14	10.34	3.5	22.09	13 [2]	0.364	2.18	0.48	0.22	0.52	0.39 [2]	-	-	-	-	ND
Composite	East FCC	Amphibola	Soft	3.96	-	-	-	1.1399		1	-	-	-	0.23		-	-	-	-	ND
New2 (north)	East FCC	Diloma	Rocky	-	0.543	0.078	0.025	0.1465		-	0.027	0.01	0.005	0.0031		-	0.001	ND	ND	ND
New2 (south)	East FCC	Diloma	Soft	-	-	-	-	0.1891		-	-	-	-	0.0027		-	-	-	-	ND
JME 090	East FCC	Cockle	Soft	-	-	-	-	0.01101		-	-	-	-	0.0028		-	-	-	-	ND
Control	East	Cockle	Soft	<0.01 [1]	-	-	-	0.00279		-	-	-	-	ND		-	-	-	-	ND

Note:

1 O'Halloran and Cavanagh (2002)

- No data supplied

2 Easton (2010)

6.2 Environmental variable sampling

6.2.1 Total organic carbon

For each impact and control site, total organic carbon (TOC) values were higher from surface sediments compared to sediments sampled from 15-20 cm depth (Figure 11, Appendix 6). Apart from the deep sample collected from JME 082, all TOC values in the West FCC estuary were below or very close to the control value (Figure 11). At East FCC sites, values from deep sediments were mostly higher than the control value, but dramatically lower than surface sediment values at the same sites.

TOC values for most impact surface sediments were elevated compared to control values (Figure 11). The exceptions were sites West FCC (new3), located at the east end of the shore, and East FCC (JME 086), being the most distant sites to the FCC site and were close to the low water mark. The highest value from an estuary site was recorded from West FCC (new2) located approximately 25 m from the FCC edge and situated centrally along the site. Samples collected from the stream showed the highest values of all being > 2 g/100g dry weight (Figure 11).

6.2.2 Particle size

Of the total samples collected (10 shallow, 7 deep), percent volume of particles >2000 µm ranged from 0 to 72.6% (see Appendix 7). In general, deep samples supported the highest percentage of very coarse material. Field observations suggested that the surface layer at all sites was characterised by relatively fine material with deeper sediment often, but not always, dominated by pebble substrata (4-64mm). Most deep samples collected from the East FCC site had a relatively high proportion of this coarse material as the substrata used to replace substrata during remediation was very coarse.

For the purpose of analysing the finer sediment particles, this coarse material was excluded from the following calculations. The size of particles < 2000 µm (i.e. gravel size and below) varied with depth and between sites (Figure 12). In general, particle size < 2000 µm was dominated by a greater proportion of coarse material (i.e. 1000-2000 µm) at the deep strata (10-20 cm) compared to shallow strata (0-2 cm) where silt substrata represented a dramatically greater proportion (Appendix 8). Five of the seven deep sites supported > 50% gravel substrata compared to all of the shallow samples being < 35% gravel (Figure 12). Fine particles between 1-63 µm (silt) represented < 30% composition at only six of the ten shallow sites, whereas at deep sites, all sites had composition < 30% silt. Sand (63-1000 µm)

was represented by similar proportions at both shallow and deep samples with the mean for all sites being 46% for shallow sites and 42% for deep sites.

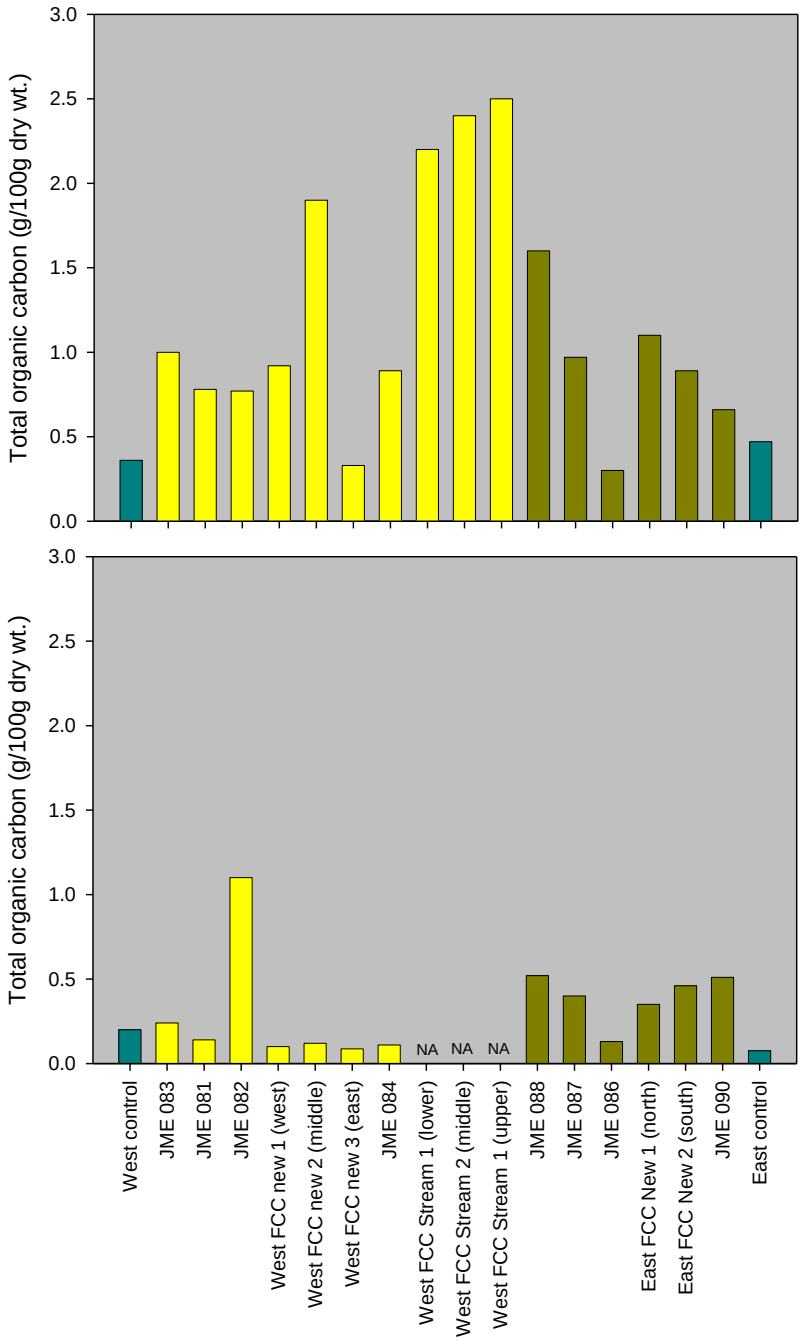

Figure 11. Total organic carbon (g/100g dry weight) recorded from control and impact sites. Top graph = shallow, bottom graph = deep. Green = controls, light yellow = West FCC, dark yellow = East FCC sites.

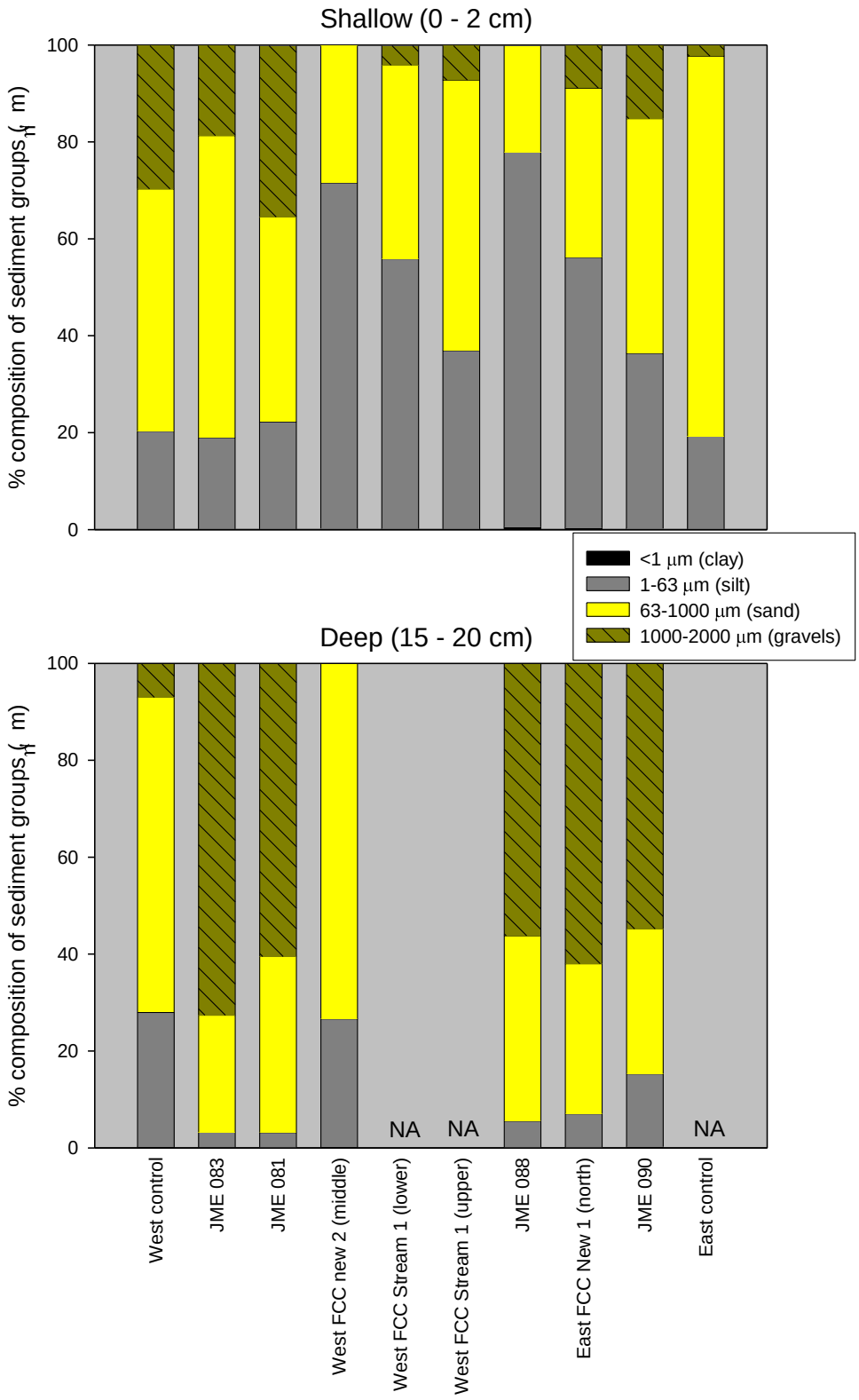

Figure 12. Particle size composition (µm) recorded from control and impact sites.

6.2.3 Redox

One redox core sample was collected from each of the sediment contaminant sampling sites (Table 1, Figures 1 and 2). Photographs of all cores have been included in Appendix 5. One core sample was collected from each of the two control sites (i.e. West and East controls). The West Control site showed no sign of any redox layer (i.e. distinct black colouration or layer), while the East Control site showed a mild discolouration, but no defined redox or anaerobic layer (Photo 1). No anaerobic smell was detected from either sample.

Photo 1. Core samples collected from West Control site (left) and East control site (Hunter-Brown)(right) on 20 October 2009.

A total of seven redox core samples were collected from the West FCC impact shore (one per site; Appendix 5). Site JME 081 sampled from mid-way down the estuarine stream channel showed little or no discolouration, while all other samples showed mild to moderate discolouration. Site JME 082 showed the strongest discolouration of any West FCC impact estuary sites (Photo 2). This site was the further-most site into the estuary on the edges of the stream channel (Figure 1). The core showed a relatively even discolouration from near the surface to the bottom of the core, however no strong smell was associated with the core indicating only a moderate level of enrichment.

Photo 2. Core samples collected from West FCC (JME 082) (left) and West FCC (new3) (right) on 20 October 2009.

A total of six redox core samples were collected from the East FCC impact shore (one per site; Appendix 5). All cores apart from JME 090 located at the southern end of the beach showed little or no discolouration (Photo 3). JME 090 was located in an area of the shore where sediments were finer than the rest of sample sites located along this shore. The anaerobic layer was apparent very close to the surface and was represented by a strong black colour and a characteristic enriched odour (Photo 3).

Photo 3. Core samples collected from East FCC (JME 090) (left) and East FCC (new1) (right) on 20 October 2009.

One core was collected from each of three sample sites located in the West FCC stream channel (Appendix 5). Cores showed streaky discolouration with odour present (photo 4). All samples showed mild effects of nutrient enrichment. Core samples were characterised by small coarse material from the remediation (i.e. small cobbles, pebbles, gravels with fine substrata between; photo 4).

Photo 4. Core samples collected from Stream middle (left) and Stream upper (right) on 10 November 2009.

6.3 Biological community sampling

6.3.1 Macroalgae cover

Photographs collected from comparable tidal heights at impact and control sites showed more macroalgae at sites adjacent to FCC sites (Photo 5).

Photo 5. Panoramic photos (September 2009). From top: West control, West FCC middle, East FCC south, and East control (Hunter Brown).

Macroalgal cover was particularly apparent at the West FCC new2 (middle) where a green cover of mostly *Enteromorpha* sp. was observed (Photo 6).

Photo 6. *Enteromorpha* sp. recorded from the West FCC (new2 middle) site close to the edge of the embankment.

Mean percentage cover values recorded from the four impact and four control series of quadrats also showed greater cover of macroalgae at impacts sites compared to control sites (Figure 13, Appendix 1). The West FCC sites (east and middle) had the highest mean values (Figure 13), ranging from 1-98% cover for individual quadrats (Appendix 1). The East FCC site had the second highest values, ranging from 1-30 % cover. Values at the two control sites were low, with the highest individual quadrat value of 10% cover.

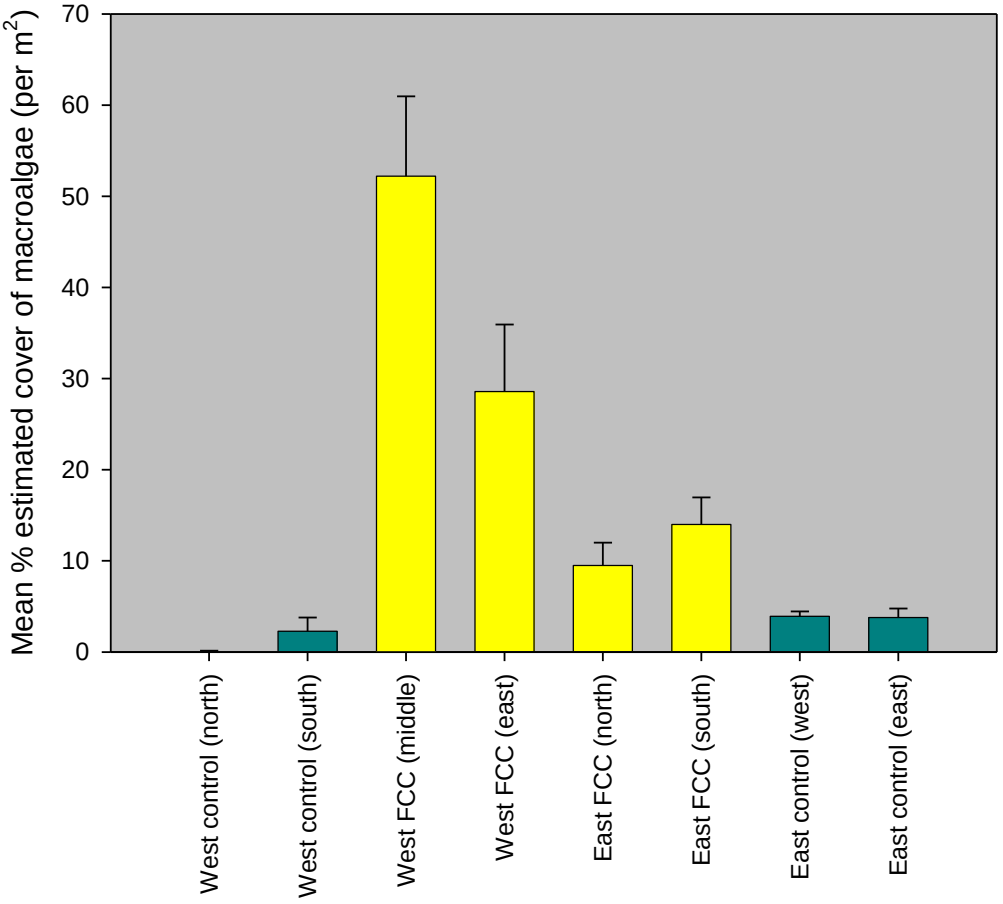

Figure 13. Mean percentage cover of macroalgae recorded from 14 contiguous 1m^2 quadrats deployed at each impact and control site. Error bars are +/- 1 standard error.

6.3.2 Epifauna and infauna invertebrate density and size

The mean number of macroinvertebrate species recorded from three replicate core samples collected at sites in September 2009 varied from 2 to 6 species (Figure 14, Appendix 2). Highest number of species from core samples occurred at one control site (East control) and one impact site (East FCC new1), while the lowest value was recorded from the second east impact site (East FCC new2). An intermediate but relatively consistent number of species were recorded from the western control and impact sites (3-3.3 species per site; Figure 14).

The mean number of individual macroinvertebrates recorded from impact and control sites also varied (Figure 14, Appendix 2). The highest values were recorded from one control site (East control) and one impact site (West FCC new2), while the lowest value was at the

second control site (West control). Intermediate and relatively consistent densities were recorded from the remaining impact sites (West FCC, East FCC (new1 and new2)).

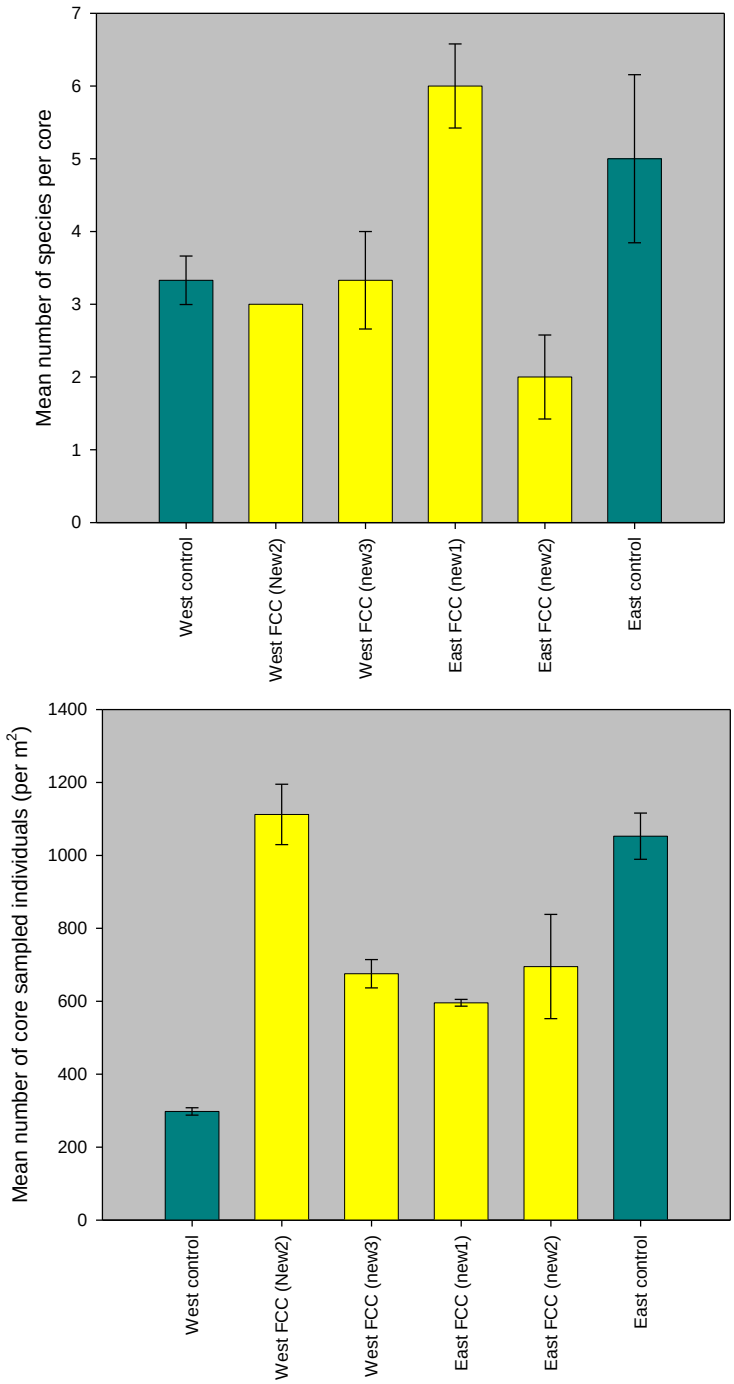

Figure 14. Mean number of invertebrate species (top) and mean number of individual invertebrates per m^2 averaged from three replicate core samples collected at impact (yellow) and control (green) sites sampled on 16 September 2009.

The mean density and composition of macroinvertebrates recorded from surface counts at East and West sites exhibited distinct differences (Figure 15, Appendix 3). Eastern sites were dominated by cockle (*C. stutchburyi*) and topshell (*D. subrostrata*), while western sites were dominated by mudflat snail (*A. crenata*) and spire shell (*Zeacumantus subcarinatus*). Some species were present at both West and East FCC sites. These species were, however, more abundant at either East or West sites, but not both.

Densities of topshell remained relatively consistent between East impact and control sites, whereas densities of mudflat snail were higher from the West impact sites compared to the West control site (Figure 15, Appendix 3). The spire shell was more abundant the West control site compared to the two West impact sites and cockles were more abundant at the East control site, especially compared to the East FCC (new1) site.

The mean size of cockles collected from one impact and one control site was virtually identical (Figure 16, Appendix 4). Overall, cockles at both sites were relatively small, ranging in size from 3-29 mm at the control site and 2.5-32 mm at the East FCC impact site. A small number of cockles were recorded from West FCC infaunal core samples, but cockles were small, ranging from 3.5-13 mm.

The mean size of mudflat snails was comparable between the West control and the East FCC impact site (Figure 16, Appendix 4). The mean size of mudflat snails at impact site West FCC JME 084 was nearly half that of the West control and East FCC impact site. This result was reflected in the size ranges, with the West impact site supporting a smaller range of individuals down to 6 mm compared to the smallest size at the other two sites being 14-15 mm (Appendix 4).

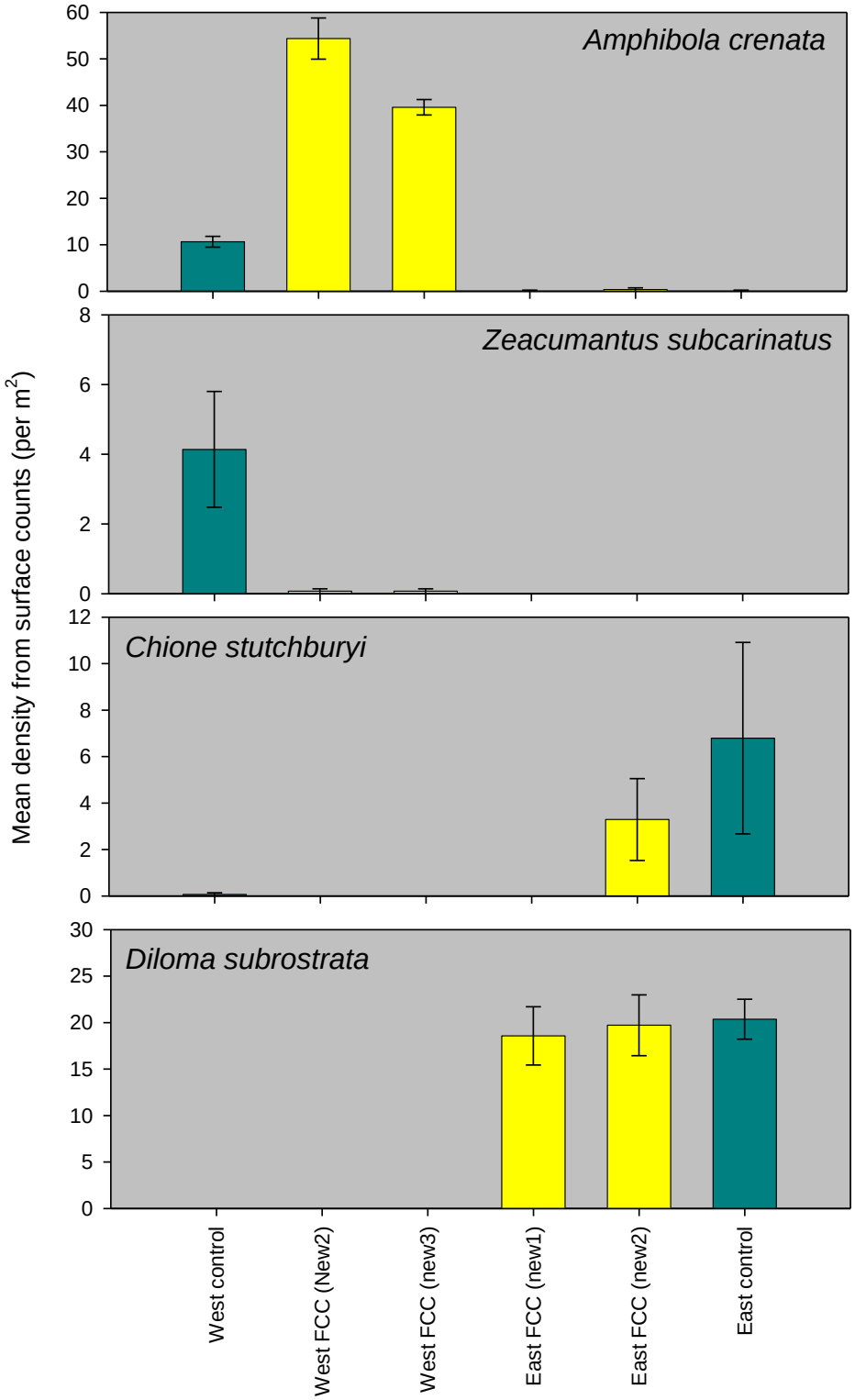

Figure 15. Mean number of conspicuous invertebrates recorded from surface 1m^2 counts at impact (yellow) and control (green) sites sampled in 16 September 2009.

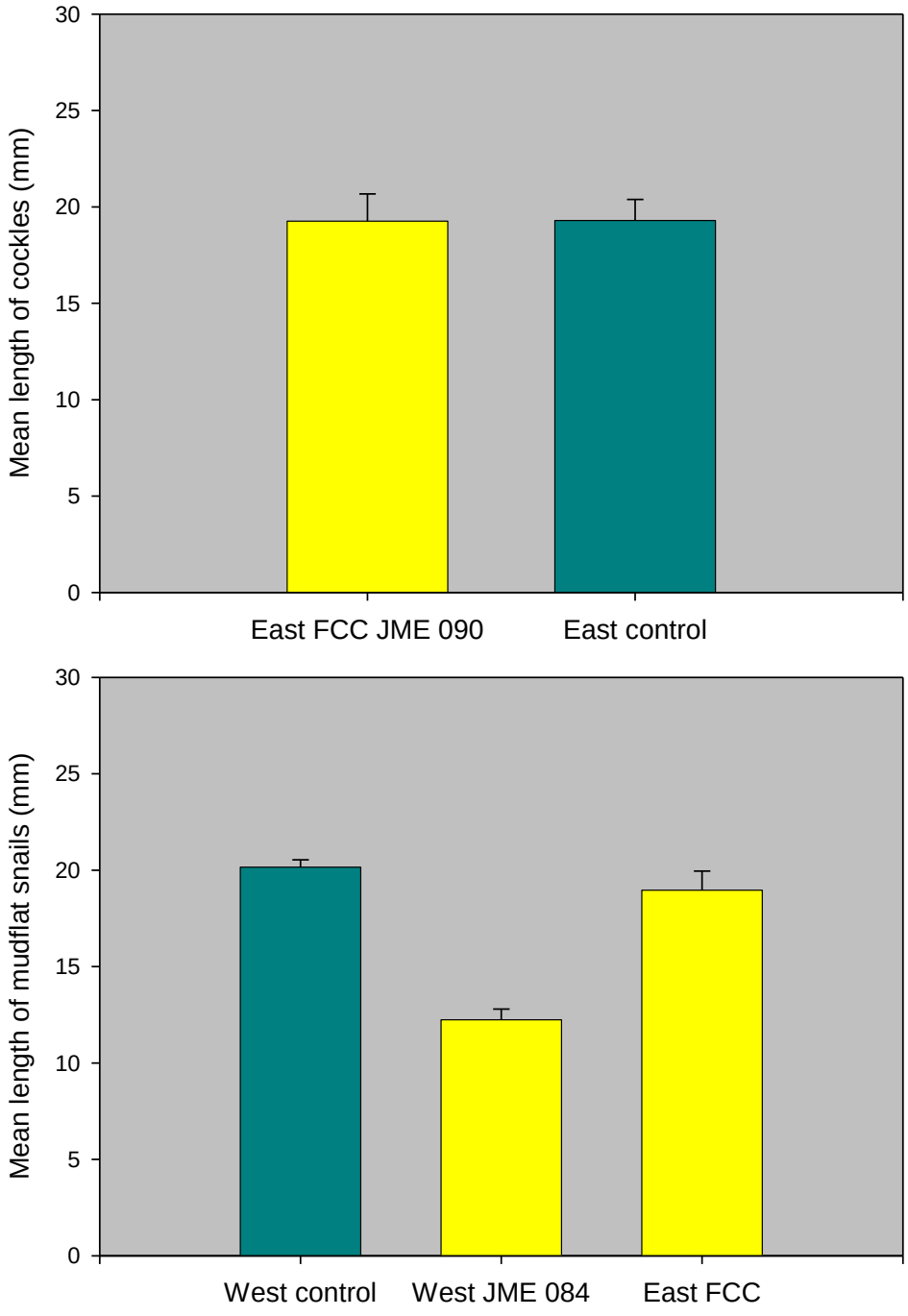

Figure 16. Mean size of cockles (top) and mudflat snails (bottom) from impact (yellow) and control (green) sites sampled on 16 September 2009.

7.0 Discussion

7.1 Organism and sediment contaminant sampling

DDX and ADL concentration in sediment varied depending on location. At West FCC sites, highest concentrations were recorded in or near the stream channel that crosses the estuary and within the stream proper. A site located centrally on the West FCC shore (FCC West new2 middle) also shower higher contaminant levels than sites located in areas away from channels or standing water. West FCC new1 (west), West FCC new3 (east) and West FCC JME 084 all had relatively low concentrations of ADL and DDX. At these sites, the Soil Acceptance Criteria (SAC) for ADL was achieved and DDX levels were at their lowest for any impact site in the present study.

CH2M Hill (2007) sampled sediment OCP's from three sites along the stream. Authors reported the SAC was exceeded at all sites and reported highest concentrations of DDX and ADL near the mouth of the stream where it entered the estuary (DDX 3.296 mg/kg, ADL 0.105 mg/kg). In the present study, stream samples also exceeded the SAC, however, highest OCP values were recorded from the upper stream site (DDX 5.36 mg/kg, ADL 0.0603 mg/kg), with the downstream site having comparable levels to the CH2M Hill (2007) study (DDX 2.9 mg/kg, ADL 0.0886 mg/kg). The reason for the higher DDX value recorded at the upstream site in the present study compared with the 2007 sample may be related to the presence of a contaminant "hotspot" buried close to the stream edge (see Audit section 6.7.3.2).

The elevated OCP levels in the West FCC stream were noted by the auditor and their presence have been confirmed during the present study. The auditor stated that these "hotspots" could be remediated, however, he stated that this was not warranted as they presented no particular risk as creek-bed gravel and vegetative cover prevents sediment mobilisation and hence the pathway to potential receptors. The auditor recommended that the Site Management Plan ensure measures be established to control excavation in the area and to prevent the creek from being eroded.

At the East FCC shore, highest sediment concentrations of ADL and the second highest values for DDX were recorded. Unlike West FCC sites where ADL levels were higher from the shallow strata, higher values at the East FCC sites were recorded from the deep strata. Higher ADL and DDX concentrations at East FCC were recorded from the southern half of the shore. The redox core at JME 090 also indicated the greatest effect from nutrient enrichment compared to northern East FCC cores and West FCC cores. This nutrient enrichment was presumably from nutrients introduced via water seepage from the FCC site.

Water seepage channels arising from the foot of the rock wall occur regularly along this shore and carry water from the FCC site across the mudflat towards the Mapua Channel.

Despite elevated ADL and DDX above the SAC recorded during the present study, levels were dramatically lower than values recorded historically from this area. For example, 2005 DDX levels at JME 088 (East FCC) were 273 mg/kg compared to October 2009 when values were 0.225 mg/kg. This represents a 1213 fold decrease following remediation of contaminated estuarine sediments. At JME 084, DDX in 2007 and 2008 was 16.6 and 10.34 mg/kg respectively compared to 0.1416 mg/kg in October 2009. Interestingly for JME 090, highest DDX values were recorded in the present study and in 2007 (2.12 and 1.73 mg/kg respectively).

In the 2009 Audit of the remediation, the auditor stated that the SAC for DDX and ADL in estuarine sediments was not met (Pattle Delamore 2009). The present study confirms that three of the 26 marine sediment samples adjacent to the FCC met the DDX SAC, while approximately 70% of ADL samples achieved the SAC. The auditor stated that re-deposition from adjacent non-complying sediment from the surrounding marine environment was one of the primary reasons for recontamination of remediated estuarine sediments. Sampling of West FCC site from offshore of the remediated beach (site JME 084) confirmed that the surface layer of this non-remediated substrata is contaminated with variable levels of OCP's (DDX 0.14-1.34 mg/kg, ADL 0.003-0.026 mg/kg). Sampling of these non-remediated sediments also confirmed that deeper material exhibited relatively low levels of contamination, often achieving the SAC.

The auditor also stated that there was evidence that re-contamination of deeper backfill material had occurred during remediation works and that this may have been due to runoff from the site during remediation works. CH2M Hill (2007) first raised the issue of runoff from the FCC land during remediation works and recommended a variety of measures to minimise recontamination of the estuary sediments. Based on DDX and ADL levels recorded from particular remediated sites sampled during the present study, it appears that some recontamination has occurred. For example, DDX and ADL increased in October 2009 compared to most previous results in the stream (3 sites), the East FCC site (JME 090) and for mudflat snails at West FCC (JME 084). An increase in OCP concentrations above estuary background concentrations recorded from offshore sediment samples suggests runoff of OCP's from FCC land has occurred. Possible mechanisms for this increase include (a) runoff during remediation works after the CH2M Hill (2007) data were collected, (b) variable OCP concentrations in sediment at sample sites resulting in variable results from sites, (c) groundwater seepage from the FCC site into the stream and low lying estuarine flats, and (d) recontamination from adjacent non-remediated marine sediments that have OPC's.

Comparison between the present sample and the next sample due in 2010 will help assess the source or sources of recontamination.

Of interest during the present study was a DDX result exceeding the SAC at the deep West Control site. This was unexpected and cannot be explained by cross contamination during sampling as this site was the first location sampled for OCP's. It is possible that the elevated DDX in deep sediments relates to the historical impact of the FCC site during its operation. It is possible that the FCC site resulted contamination over a large spatial scale in Waimea Inlet.

DDX and ADL concentrations in cockles at East FCC were elevated above the control values, but were comparable to higher values recorded from other studies located in estuaries close to large cities such as the Avon Heathcote (Thomson and Davies 1993) and Manukau Harbour (Hickey *et al.* 1995). At the East FCC shore, both cockles and topshells had lower levels of DDX and ADL compared to mudflat snails. This confirms the conclusion by O'Halloran and Cavanagh (2002) that mudflat snails represent the best candidate mollusc to monitor contaminants at Mapua. Of particular note in the present study was an increase in DDX and dieldrin in mudflat snails at the West FCC site between February 2009 and October 2009. DDX recorded on October 2009 (JME 084 at 22.09 mg/kg) represented the second highest value after 2007 (51.15 mg/kg) recorded during the five sample events, while the dieldrin value in the present study was the highest recorded (0.52 mg/kg). Snails at this site were very abundant, but were all small in size. As these are mostly juvenile snails, it is unlikely they have migrated into this area from elsewhere, therefore the OCP concentrations in the flesh will have been received from the surface layer of estuarine sediment. The reason for the increase in ADL and DDX between 2008, early 2009 and the present study is unknown as sediment levels were declining over the same period, achieving the SAC for both dieldrin and lindane.

7.2 Environmental variable sampling

7.2.1 Total organic carbon

Total organic carbon values (TOC) were highest from the surface layer of sediment compared to samples collected from 10-20 cm depth. TOC values from most impact sites were elevated well above control sites. These data suggest that enrichment of sediment is likely and the most probable source is soluble nutrients in the water seeping from the adjacent FCC site. The highest value for an estuarine site was recorded from a low lying area that received seepage from adjacent areas (West FCC new2 middle). TOC values from the surface sediments of the stream adjacent to the West FCC site were the highest recorded in the present study (> 2 g/100g dry weight). The catchment of the stream includes storm-

water including nutrients from urban properties. Presumably, seepage of nutrient-rich water from the West FCC site would also enter the stream. Flushing of the stream is limited and only occurs on large tides or during flood events.

7.2.2 Particle size

The East FCC sample sites were mostly located on remediated shores, whereas the West FCC sample sites were located in substrata offshore of remediated sediment. The sediment used to replace contaminated estuarine sediments during remediation was composed of gravels, pebbles and small cobbles. At East FCC, sample sites with coarse material were dominant below the immediate surface of the beach. It was not surprising therefore that sample sites in East FCC shore were dominated by substrata > 2 mm. For practical reasons, this coarse material was excluded from the analysis of fine substrata < 2 mm. As expected, and based on field observations, surface sediment contained a greater proportion of silt material than deeper substrata. Although present at shallow sites, coarse substrata in the sand and gravel size range represented a greater proportion at deeper sites.

No obvious pattern between particle size and contaminant levels was apparent. Some sites had higher levels of OCP's at the surface compared to deeper samples; however, some of the highest OCP values were recorded from deep compared to the surface samples.

7.3 Epifauna and infauna invertebrate density and size

Distinct differences between the environmental variables at western and eastern sites probably have considerable influence on species composition and abundance. It is probable that most of the biological differences between western and eastern sites were due to these environmental differences. Eastern impact and control sites are located on the edge of a channel swept by very strong and regular tidal currents, whereas western impact and control sites are located in sheltered embayments.

It is difficult to distinguish between the importance of environmental factors and the potential effect of pesticides on invertebrate density, presence/absence, and size (Liess and Carsten 2005). Each site has a unique set of environmental variables that largely determine species composition and abundance. In addition, estuarine environments are notoriously patchy, with relatively high variation being common place, even between sites situated in close proximity (Robertson *et al*. 2002). Further compounding this variability is the vulnerability of species to pesticides and a lack of information on the effects of pesticides on marine invertebrates.

Based on invertebrate data collected during the present study, sites exhibited both differences and similarities between impact and control locations. The number of species

recorded from one eastern impact site (East FCC new2) was well below the number recorded from the other eastern impact site (East FCC new1) and the eastern control site. The reason for this difference is difficult to establish, however, DDX values were higher at the East FCC (new2) compared to the other impact site located at the northern end of the shore. Whether this result is related to the heavily contaminated surge chamber that was removed from the southern end of the beach during remediation is unknown.

The number of species recorded at the west impact and control sites was comparable; however, the density of invertebrates was considerably higher at impact sites, especially West FCC (new2). This result was due to the high numbers of mudflat snail and estuarine snail (*Potamopyrgus estuarinus*) recorded from the impact sites compared to the control site. The high numbers of estuarine snails and small mudflat snails at western impact sites may be related to differences in habitat composition combined with relatively high total organic carbon values recorded from surface sediments. The enriched sediments at this impact site may support higher numbers of snails due to an enhanced food source compared to the control site where snail numbers were comparatively low.

Of interest was the topshell (*D. subrostrata*) at the two eastern impact sites and the associated control. At these sites, densities were almost identical. Similarly, the mean size of cockles recorded from eastern impact and control sites were almost identical. In contrast, sizes of mudflat snails varied between the West JME 084 site and the West control and East FCC sites. The West JME 084 site supported large numbers of small individuals compared to less common, larger animals found at the other two sites. JME 084 may represent an ideal habitat for juvenile settlement and growth, with individuals moving away as they reach a larger size. It is also possible that high densities may limit the size that individuals can grow due to overcrowding.

Overall, the composition, abundance and size of macroinvertebrates were distinctly different between east and west sites. Differences between impact and control sites were most likely due to enrichment of sediments and natural environmental variation between sites. Despite this environmental variability, some components of the invertebrate community were strikingly similar. The presence of contaminants and nutrient enrichment as indicated by TOC and redox results shows that sites adjacent to the FCC site are not natural when compared with the control sites, however, contaminant and enrichment was not at levels resulting in a mass reduction in the diversity, abundance and size of macroinvertebrates.

7.4 Macroalgae cover

Macroalgae blooms are traditionally indicative of nutrient enrichment. A localised macroalgae bloom was recorded from the West FCC site with relatively minor levels of macroalgae being recorded from the East FCC shore. The macroalgae present in the West FCC shore was dominated by *Enteromorpha* sp., a species usually associated with freshwater flows into a marine environment. This species therefore confirms the presence of freshwater seepage from the West FCC site into the estuary. The spatial scale and the quantity of macroalgae growth was best described as a localised bloom with a high percentage cover, but relatively low biomass of macroalgae when compared to some blooms in estuaries around New Zealand. In particular locations these blooms can become a nuisance as algae decomposes and smells. The relatively small spatial scale and low biomass suggest that nutrient enrichment is not excessive in this area. It is probable that the macroalgal bloom will be seasonal at the West FCC site, with biomass declining in the summer and winter months.

References

Cavanagh, J.E.; O'Halloran, K. 2003. Investigation of organochlorine contamination in mud snails (Amphibola sp.) and sediment collected from mudflats adjacent to the Fruit Chemical Company (FCC) site at Mapua – summary of results. Landcare Research Contract Report prepared for Tasman District Council.

CH2M HILL, 2007. Groundwater and sediment investigation report, former Fruitgrower Chemical Company site, Mapua. Report prepared for Ministry for the Environment.

Davidson, R.J. 2009. Review of snail sampling protocols for the east intertidal shore adjacent to the FCC remediation site, Mapua. Prepared by Davidson Environmental Ltd. for Tasman District Council and Ministry for the Environment. Survey and monitoring report no. 607.

Easton, J. 2005. Report on macroinvertebrate and sediment quality monitoring for FCC site remediation. Samples 22 February 2005. Prepared by Tasman District Council.

Easton, J. 2007a. Report on snails and sediment a year after East and West beach remediation. Samples 25 & 31 January, 23 April and 22 May 2007 Prepared by Tasman District Council.

Easton, J. 2007b. Report on assessment of mud snail and estuarine sediments: west side of Grossi Point Peninsula: 24 October 2007. Prepared by Tasman District Council.

Easton, J. 2008. Report on snails and sediment, second round after west and east beach remediation, April 2008. Prepared by Tasman District Council.

Easton, J. 2009. Report on snail and sediment quality on the west side of Grossi Point, Mapua. Sample June 2009. Prepared by Tasman District Council.

Easton, J. 2009a. Report on snail and sediment quality, third annual round after FCC west and east beach remediation. Sample 3 February 2009. Prepared by Tasman District Council.

Easton, J. 2010. Report on West FCC snails and sediment:repeat sampling on 18 January 2010. Prepared by Tasman District Council.

Hickey, C.W.; Roper, D.S.; Holland, P.T.; Trower, T.M. 1995. Accumulation of organic contaminants in two sediment-dwelling shellfish with contrasting feeding modes: Deposit- (*Macomona liliana*) and filter-feeding (*Austrovenus stutchburyi*). *Archives of Environmental Contamination and Toxicology*, 29, 221-231.

Liess, M.; Carsten, P. 2005. Analyzing effects of pesticides on invertebrate communities in streams. *Environmental Toxicology and Chemistry*, Vol. 24, 954-965.

O'Halloran, K.; Cavanagh, J.E. 2002. Investigation of organochlorine contamination in biota and sediment collected from mudflats adjacent to the Fruit Chemical Company (FCC) site at Mapua. Environmental Toxicology, Landcare Research, Lincoln, March 2002.

Pattle Delamore Partners Ltd. 2009. Audit of the remediation of the former Fruitgrowers Chemical Company site, Mapua. A report prepared by Mike Clyde and Graeme Proffitt for the Ministry of the Environment. File W01738100 R01.

Robertson, B.M.; Gillespie, P.A.; Asher, R.A.; Frisk, S.; Keeley, N.B.; Hopkins, G.A.; Thompson, S.J.; Tuckey, B.J. 2002. Estuarine Environmental Assessment and Monitoring: A National Protocol. Part A. Development, Part B. Appendices, and Part C. Application. Prepared for supporting Councils and the Ministry for the Environment, Sustainable Management Fund Contract No. 5096. Part A. 93p. Part B. 159p. Part C. 40p plus field sheets.

Scobie, S.; Buckland, S.; Ellis, H.; Salter, R. 1998. Organochlorines in New Zealand: Ambient concentrations of selected organochlorines in estuaries. Organochlorines Programme, Ministry for the Environment.

Thomson, B.; Davies, J. 1993. Interpretation of organochlorine and hydrocarbon contaminants in the Avon and Heathcote river and estuary system. Report to the Canterbury Regional Council, Christchurch, New Zealand.

Woodward-Clyde. 1996. Mapua site remediation, assessment of environmental effects. Report prepared for Tasman District Council.

Appendix 1. Estimated percentage cover of macroalgae present at impact and control sites in 16th September 2009.

Meters	West control		West FCC		East FCC		East control (Hunter-Brown)	
	North	South	Middle	East	North	South	West	East
0	1	20	60	75	30	20	3	0
1	0	8	80	65	15	10	3	1
2	0	4	75	65	10	10	2	0
3	0	0	75	50	25	20	6	1
4	0	0	98	60	5	8	6	1
5	0	0	65	20	8	1	2	1
6	0	0	65	15	20	20	2	1
7	0	0	50	15	5	35	2	2
8	0	0	75	5	1	30	8	8
9	0	0	65	8	2	25	6	8
10	0	0	20	10	3	10	4	8
11	0	0	3	5	2	5	4	8
12	0	0	0	1	3	2	2	10
13	0	0	0	6	4	0	5	4
Mean %	0.07	2.29	52.21	28.57	9.50	14.00	3.93	3.79
Range	0-1%	0-20%	0-98%	1-75%	1-30%	0-30%	2-8%	0-10%
N	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00
SD	0.27	5.59	32.69	27.52	9.38	11.09	1.98	3.72
Std. error	0.07	1.50	8.74	7.36	2.51	2.96	0.53	1.00

Photo points

Appendix 2. Density of macroinvertebrates recorded from core samples (16th September 2009). Densities converted to per m^2 values.

General Group	Taxa	Common Name	East control			East FCC			East FCC		
			Per m^2	Std. dev.	95%	Per m^2	Std. dev.	95%	Per m^2	Std. dev.	95%
Sipuncula	*Themiste* sp. (ex *Dendrostomium*)	Peanut worm	39.73	34.40	19.86	79.45	91.03	52.55			
Gastropoda	*Potamopyrgus estuarinus*	Estuarine snail									
Gastropoda	*Amphibola crenata*	Mud snail							19.86	34.40	19.86
Gastropoda	*Diloma subrostrata*	Top shell	39.73	68.81	39.73						
Gastropoda	*Diloma zealandica*	Top shell	19.86	34.40	19.86						
Gastropoda	*Cominella glandiformis*	Mud flat whelk	19.86	34.40	19.86						
Bivalvia	*Austrovenus stutchburyi*	Cockle	734.94	396.77	229.08	119.18	157.66	91.03	635.63	396.77	229.08
Polychaeta: Spionidae	*Scolecolepides benhami*	Worm							39.73	34.40	19.86
Polychaeta: Spionidae	*Boccardia acus*	Worm				99.32	34.40	19.86			
Polychaeta: Nereidae	Nereidae (juvenile)	Rag worms				39.73	34.40	19.86			
Polychaeta: Nereidae	Nereidae (unidentified)	Rag worms				19.86	34.40	19.86			
Polychaeta: Nereidae	*Nicon aestuariensis*	Rag worms									
Polychaeta: Nereidae	*Nereis cricognatha*	Rag worms									
Polychaeta: Maldanidae	Maldanidae	Bamboo worm									
Polychaeta: Pectinidae	*Pectinaria australis*	Worm				59.59	59.59	34.40			
Isopoda	*Eurylana cookii*	Isopod	19.86	34.40	19.86						
Amphipoda	Amphipoda A (Phoxocephalidae)	Hopper				39.73	34.40	19.86			
Decapoda	*Helice crassa*	Mud crab	99.32	68.81	39.73	119.18	0.00	0.00			
Cirripedia	*Austrominius modestus* (ex *Elminius*)	Barnacle	79.45	34.40	19.86						
Insecta	Dolichopodidae larvae	Fly larvae									
Acaria	Spider (terrestrial)	Spider				19.86	34.40	19.86			
	Number of species		8			9			3		
	Mean number of species		5.00			6.00			2.00		
	N		3			3			3		
	SD		2			1			1		
	Standard error		1.15			0.58			0.58		
	Mean number of individuals per m^2		1053			596			695		
	N		15			18			6		
	SD		245.57			39.73			349.92		
	Standard error		63.41			9.36			142.85		

Appendix 3. Surface 1m^2 quadrat counts of macroinvertbrates from impact and control sites (16th September 2009).

General Group	Taxa	Common Name	West control														Total	Mean density per m^2	Std. dev.	Std. error
			1	2	3	4	5	6	7	8	9	10	11	12	13	14				
Gastropoda	*Amphibola crenata*	Mud flat snail	15	4	6	6	5	17	8	13	10	10	11	16	15	13	149	10.64	4.34	1.16
Gastropoda	*Zeacumantus subcarinatus*	Spire shell	0	2	1	2	0	2	0	3	2	9	23	5	9	0	58	4.14	6.21	1.66
Bivalvia	*Austrovenus stutchburyi*	Cockle	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0.07	0.27	0.07

General Group	Taxa	Common Name	West FCC (new2)														Total	Mean density per m^2	Std. dev.	Std. error
			1	2	3	4	5	6	7	8	9	10	11	12	13	14				
Gastropoda	*Amphibola crenata*	Mud flat snail	52	44	40	29	37	39	72	47	54	66	81	59	58	83	761	54.36	16.56	4.43
Gastropoda	*Zeacumantus subcarinatus*	Spire shell	0	0	0	0	0	1	0	0	0	0	0	1	0	0	2	0.14	0.36	0.10

General Group	Taxa	Common Name	West FCC (new3)														Total	Mean density per m^2	Std. dev.	Std. error
			1	2	3	4	5	6	7	8	9	10	11	12	13	14				
Gastropoda	*Amphibola crenata*	Mud flat snail	45	37	47	43	36	43	37	45	25	36	35	49	38	38	554	39.57	6.22	1.66
Gastropoda	*Zeacumantus subcarinatus*	Spire shell	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0.07	0.27	0.07
Bivalvia	*Zenostrobus pulex*	Little black mussel	0	0	0	0	0	0	4	5	0	2	0	0	0	0	11	0.79	1.67	0.45

General Group	Taxa	Common Name	East control (Hunter-Brown)														Total	Mean density per m^2	Std. dev.	Std. error
			1	2	3	4	5	6	7	8	9	10	11	12	13	14				
Gastropoda	*Amphibola crenata*	Mud flat snail	0	0	1	0	0	0	0	0	0	1	0	0	0	0	2	0.14	0.36	0.10
Gastropoda	*Diloma subrostrata*	Top shell	6	24	26	21	31	27	10	24	12	21	32	14	13	24	285	20.36	8.05	2.15
Bivalvia	*Austrovenus stutchburyi*	Cockle	1	0	3	58	6	5	0	0	0	0	3	0	2	17	95	6.79	15.42	4.12

General Group	Taxa	Common Name	East FCC (new1)														Total	Mean density per m^2	Std. dev.	Std. error
			1	2	3	4	5	6	7	8	9	10	11	12	13	14				
Gastropoda	*Amphibola crenata*	Mud flat snail	0	0	0	0	0	1	0	1	0	0	0	0	0	0	2	0.14	0.36	0.10
Gastropoda	*Diloma subrostrata*	Top shell	8	14	19	10	26	4	44	8	36	25	5	17	23	21	260	18.57	11.73	3.14

General Group	Taxa	Common Name	East FCC (new2)														Total	Mean density per m^2	Std. dev.	Std. error
			1	2	3	4	5	6	7	8	9	10	11	12	13	14				
Gastropoda	*Amphibola crenata*	Mud flat snail	0	0	0	0	0	0	0	0	0	0	0	0	5	0	5	0.36	1.34	0.36
Gastropoda	*Diloma subrostrata*	Top shell	11	12	18	32	38	44	13	37	15	12	12	12	9	11	276	19.71	12.24	3.27
Bivalvia	*Austrovenus stutchburyi*	Cockle	0	0	0	0	0	0	0	0	0	0	13	16	0	17	46	3.29	6.58	1.76

Appendix 4. Cockle and mudflat snail measurement data (16th September 2009).

Site	Hunter-Brown	East FCC JME 090	East FCC	West FCC JME 085	West control
Species	Cockle	Cockle	*Amphibola*	*Amphibola*	*Amphibola*
	3	2.5	14	6	15
	3	4	14	7	15
	3.5	4	15	7	17
	4	4	16	7	18
	4	4	17	7	18
	6	5	17	8	18
	9	5	17	9	19
	11	5.5	18	9	19
	11	6	18	9	19
	12	6	18	9	19
	13	6	18	9	19
	14	6	19	10	19
	14	7	19	10	19
	14	7	19	10	19
	14	7	19	10	19
	14	8	20	11	20
	15	8	20	11	20
	15	9	20	11	20
	15	10	20	11	20
	15	10	21	12	20
	16	11	21	12	20
	16	11	21	12	20
	16	11	21	12	20
	16	12	22	12	20
	17	12	22	12	20
	17	12	22	12	20
	17	13	24	12	20
	17	13		12	20
	17	14		12	20
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	18	16		12	20
	18	16		12	20
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	18	17.5		13	21
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	18	18		13	21
	19	19		13	21
	19	20		13	21
	19	20		13	21
	19	20		13	21
	19	20		13	21
	19	20		13	21
	19	20		14	21
	19	20		14	21
	19	21		14	21
	20	21		14	21
	20	21		14	21
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		28			
		30			
		32			
Total	104	112	27	71	63
Mean size	19.29	19.26	18.96	12.24	20.16
SD	5.61	7.57	2.50	2.34	1.50
se	0.55	0.72	0.48	0.28	0.19
Size range	3-29 mm	2.5-32 mm	14-24 mm	6-16 mm	15-24 mm

Appendix 5. Photographs of core contaminant sediment samples (20 October 2009).

West control

West FCC JME 081

West FCC JME 082

West FCC JME 083

West FCC JME 084

West FCC (new1)

West FCC (new2)

West FCC (new3)

East FCC (JME 086)

East FCC (JME 087)

East FCC (JME 088)

East FCC (JME 090)

East FCC (new1)

East FCC (new2)

East control (Hunter-Brown)

Stream (low)

Stream (middle)

Stream (upper)

Appendix 6. Hill Laboratories results sheets.

Hill Laboratories
BETTER TESTING BETTER RESULTS
R J Hill Laboratories Limited
1 Clyde Street
Private Bag 3205
Hamilton 3240, New Zealand
Tel +64 7 858 2000
Fax +64 7 858 2001
Email mail@hill-labs.co.nz
Web www.hill-labs.co.nz

ANALYSIS REPORT

Client:	Davidson Environmental Ltd	**Lab No:**	737701 SPv1
Contact:	R Davidson	**Date Registered:**	22-Oct-2009
	C/- Davidson Environmental Ltd	**Date Reported:**	23-Nov-2009
	PO Box 958	**Quote No:**	37503
	Nelson 7040	**Order No:**	
		Client Reference:	
		Submitted By:	R Davidson

Sample Type: Sediment

Sample Name:		FCC West Control Surface 20-Oct-2009 3:00 pm	FCC West Control Deep 20-Oct-2009 3:05 pm	JME083 Surface 20-Oct-2009 3:35 pm	JME083 Deep 20-Oct-2009 3:52 pm	JME081 Surface 20-Oct-2009 3:32 pm
Lab Number:		737701.1	737701.2	737701.3	737701.4	737701.5
Individual Tests						
Total Organic Carbon	g/100g dry wt	0.36	0.20	1.0	0.24	0.78
Organochlorine Pesticides Trace in Soil						
Aldrin	mg/kg dry wt	< 0.0010	< 0.00098	< 0.0011	< 0.0010	0.0010
alpha-BHC	mg/kg dry wt	< 0.0010	< 0.00098	< 0.0011	< 0.0010	< 0.00098
beta-BHC	mg/kg dry wt	< 0.0010	< 0.00098	< 0.0011	< 0.0010	< 0.00098
delta-BHC	mg/kg dry wt	< 0.0010	< 0.00098	< 0.0011	< 0.0010	< 0.00098
gamma-BHC (Lindane)	mg/kg dry wt	< 0.0010	< 0.00098	0.0010	< 0.0010	0.0010
cis-chlordane	mg/kg dry wt	< 0.0010	< 0.00098	< 0.0011	< 0.0010	< 0.00098
trans-chlordane	mg/kg dry wt	< 0.0010	< 0.00098	< 0.0011	< 0.0010	< 0.00098
2,4'-DDD	mg/kg dry wt	< 0.0010	0.0071	0.084	0.022	0.065
4,4'-DDD	mg/kg dry wt	< 0.0010	0.024	0.20	0.054	0.16
2,4'-DDE	mg/kg dry wt	< 0.0010	0.0010	0.038	0.0075	0.027
4,4'-DDE	mg/kg dry wt	< 0.0010	0.056	0.21	0.046	0.16
2,4'-DDT	mg/kg dry wt	< 0.0010	0.0015	0.025	0.017	0.010
4,4'-DDT	mg/kg dry wt	0.0014	0.016	0.10	0.11	0.091
Dieldrin	mg/kg dry wt	< 0.0010	0.0027	0.023	0.0055	0.015
Endosulfan I	mg/kg dry wt	< 0.0010	< 0.00098	< 0.0011	< 0.0010	< 0.00098
Endosulfan II	mg/kg dry wt	< 0.0010	< 0.00098	< 0.0011	< 0.0010	< 0.00098
Endosulfan sulphate	mg/kg dry wt	< 0.0010	< 0.00098	< 0.0011	< 0.0010	< 0.00098
Endrin	mg/kg dry wt	< 0.0010	< 0.00098	< 0.0011	< 0.0010	< 0.00098
Endrin aldehyde	mg/kg dry wt	< 0.0010	< 0.00098	0.0021	< 0.0010	0.0029
Endrin Ketone	mg/kg dry wt	< 0.0010	< 0.00098	< 0.0011	< 0.0010	< 0.00098
Heptachlor	mg/kg dry wt	< 0.0010	< 0.00098	< 0.0011	< 0.0010	< 0.00098
Heptachlor epoxide	mg/kg dry wt	< 0.0010	< 0.00098	< 0.0011	< 0.0010	< 0.00098
Hexachlorobenzene	mg/kg dry wt	< 0.0010	< 0.00098	< 0.0011	< 0.0010	< 0.00098
Methoxychlor	mg/kg dry wt	< 0.0010	< 0.00098	< 0.0011	< 0.0010	< 0.00098
Total Chlordane [(cis+trans)* 100/42]	mg/kg dry wt	< 0.0020	< 0.0020	< 0.0020	< 0.0020	< 0.0020

Sample Name:		JME081 Deep 20-Oct-2009 3:53 pm	JME082 Surface 20-Oct-2009 3:32 pm	JME082 Deep 80m 20-Oct-2009 4:00 pm	West FCC 1 (West) Surface 20-Oct-2009 4:30 pm	West FCC 1 (West) Deep 20-Oct-2009 4:30 pm
Lab Number:		737701.6	737701.7	737701.8	737701.9	737701.10
Individual Tests						
Total Organic Carbon	g/100g dry wt	0.14	0.77	1.1	0.92	0.10
Organochlorine Pesticides Trace in Soil						

This Laboratory is accredited by International Accreditation New Zealand (IANZ), which represents New Zealand in the International Laboratory Accreditation Cooperation (ILAC). Through the ILAC Mutual Recognition Arrangement (ILAC-MRA) this accreditation is internationally recognised.
The tests reported herein have been performed in accordance with the terms of accreditation, with the exception of tests marked *, which are not accredited.

Sample Type: Sediment						
Sample Name:		JME081 Deep 20-Oct-2009 3:53 pm	JME082 Surface 20-Oct-2009 3:32 pm	JME082 Deep 80m 20-Oct-2009 4:00 pm	West FCC 1 (West) Surface 20-Oct-2009 4:30 pm	West FCC 1 (West) Deep 20-Oct-2009 4:30 pm
Lab Number:		737701.6	737701.7	737701.8	737701.9	737701.10
Organochlorine Pesticides Trace in Soil						
Aldrin	mg/kg dry wt	0.0025	< 0.0010	< 0.00099	< 0.00099	< 0.0011
alpha-BHC	mg/kg dry wt	< 0.00099	< 0.0010	< 0.00099	< 0.00099	< 0.0011
beta-BHC	mg/kg dry wt	< 0.00099	< 0.0010	< 0.00099	< 0.00099	< 0.0011
delta-BHC	mg/kg dry wt	< 0.00099	< 0.0010	< 0.00099	< 0.00099	< 0.0011
gamma-BHC (Lindane)	mg/kg dry wt	0.0021	< 0.0010	0.0011	< 0.00099	< 0.0011
cis-chlordane	mg/kg dry wt	< 0.00099	< 0.0010	< 0.00099	< 0.00099	< 0.0011
trans-chlordane	mg/kg dry wt	< 0.00099	< 0.0010	< 0.00099	< 0.00099	< 0.0011
2,4'-DDD	mg/kg dry wt	0.081	0.018	0.044	0.014	< 0.0011
4,4'-DDD	mg/kg dry wt	0.15	0.046	0.15	0.033	0.0012
2,4'-DDE	mg/kg dry wt	0.031	0.0062	0.013	0.0039	< 0.0011
4,4'-DDE	mg/kg dry wt	0.18	0.039	0.11	0.057	0.0026
2,4'-DDT	mg/kg dry wt	0.15	0.0073	0.022	0.0020	< 0.0011
4,4'-DDT	mg/kg dry wt	0.72	0.040	0.40	0.031	0.0035
Dieldrin	mg/kg dry wt	0.011	0.0028	0.0015	0.0027	< 0.0011
Endosulfan I	mg/kg dry wt	< 0.00099	< 0.0010	< 0.00099	< 0.00099	< 0.0011
Endosulfan II	mg/kg dry wt	< 0.00099	< 0.0010	< 0.00099	< 0.00099	< 0.0011
Endosulfan sulphate	mg/kg dry wt	< 0.00099	< 0.0010	< 0.00099	< 0.00099	< 0.0011
Endrin	mg/kg dry wt	< 0.00099	< 0.0010	< 0.00099	< 0.00099	< 0.0011
Endrin aldehyde	mg/kg dry wt	0.0080	< 0.0010	< 0.00099	< 0.00099	< 0.0011
Endrin Ketone	mg/kg dry wt	< 0.00099	< 0.0010	< 0.00099	< 0.00099	< 0.0011
Heptachlor	mg/kg dry wt	< 0.00099	< 0.0010	< 0.00099	< 0.00099	< 0.0011
Heptachlor epoxide	mg/kg dry wt	< 0.00099	< 0.0010	< 0.00099	< 0.00099	< 0.0011
Hexachlorobenzene	mg/kg dry wt	< 0.00099	< 0.0010	< 0.00099	< 0.00099	< 0.0011
Methoxychlor	mg/kg dry wt	< 0.00099	< 0.0010	< 0.00099	< 0.00099	< 0.0011
Total Chlordane [(cis+trans)* 100/42]	mg/kg dry wt	< 0.0020	< 0.0020	< 0.0020	< 0.0020	< 0.0020

Sample Name:		West FCC 2 (Middle) Surface 20-Oct-2009 4:30 pm	West FCC 2 (Middle) Deep 20-Oct-2009 4:30 pm	West FCC 3 (East) Surface 20-Oct-2009 4:30 pm	West FCC (East) Deep 20-Oct-2009 4:30 pm	JME0084 Surface 20-Oct-2009 3:33 pm
Lab Number:		737701.11	737701.12	737701.13	737701.14	737701.15
Individual Tests						
Total Organic Carbon	g/100g dry wt	1.9	0.12	0.33	0.087	0.89
Organochlorine Pesticides Trace in Soil						
Aldrin	mg/kg dry wt	< 0.0011	< 0.0010	< 0.00099	< 0.00099	< 0.00099
alpha-BHC	mg/kg dry wt	< 0.0011	< 0.0010	< 0.00099	< 0.00099	< 0.00099
beta-BHC	mg/kg dry wt	< 0.0011	< 0.0010	< 0.00099	< 0.00099	< 0.00099
delta-BHC	mg/kg dry wt	< 0.0011	< 0.0010	< 0.00099	< 0.00099	< 0.00099
gamma-BHC (Lindane)	mg/kg dry wt	0.0022	< 0.0010	< 0.00099	< 0.00099	< 0.00099
cis-chlordane	mg/kg dry wt	< 0.0011	< 0.0010	< 0.00099	< 0.00099	< 0.00099
trans-chlordane	mg/kg dry wt	< 0.0011	< 0.0010	< 0.00099	< 0.00099	< 0.00099
2,4'-DDD	mg/kg dry wt	0.19	0.0012	0.014	< 0.00099	0.014
4,4'-DDD	mg/kg dry wt	0.53	0.0025	0.031	< 0.00099	0.051
2,4'-DDE	mg/kg dry wt	0.041	< 0.0010	0.0060	< 0.00099	0.0038
4,4'-DDE	mg/kg dry wt	0.48	0.0029	0.047	0.0013	0.054
2,4'-DDT	mg/kg dry wt	0.0080	< 0.0010	0.0032	< 0.00099	0.0028
4,4'-DDT	mg/kg dry wt	0.094	0.0014	0.023	< 0.00099	0.016
Dieldrin	mg/kg dry wt	0.024	< 0.0010	0.0036	< 0.00099	0.0025
Endosulfan I	mg/kg dry wt	< 0.0011	< 0.0010	< 0.00099	< 0.00099	< 0.00099
Endosulfan II	mg/kg dry wt	< 0.0011	< 0.0010	< 0.00099	< 0.00099	< 0.00099
Endosulfan sulphate	mg/kg dry wt	< 0.0011	< 0.0010	< 0.00099	< 0.00099	< 0.00099
Endrin	mg/kg dry wt	< 0.0011	< 0.0010	< 0.00099	< 0.00099	< 0.00099
Endrin aldehyde	mg/kg dry wt	< 0.0011	< 0.0010	< 0.00099	< 0.00099	0.0087
Endrin Ketone	mg/kg dry wt	< 0.0011	< 0.0010	< 0.00099	< 0.00099	< 0.00099

Sample Type: Sediment						
Sample Name:		West FCC 2 (Middle) Surface 20-Oct-2009 4:30 pm	West FCC 2 (Middle) Deep 20-Oct-2009 4:30 pm	West FCC 3 (East) Surface 20-Oct-2009 4:30 pm	West FCC (East) Deep 20-Oct-2009 4:30 pm	JME0084 Surface 20-Oct-2009 3:33 pm
Lab Number:		737701.11	737701.12	737701.13	737701.14	737701.15
Organochlorine Pesticides Trace in Soil						
Heptachlor	mg/kg dry wt	< 0.0011	< 0.0010	< 0.00099	< 0.00099	< 0.00099
Heptachlor epoxide	mg/kg dry wt	< 0.0011	< 0.0010	< 0.00099	< 0.00099	< 0.00099
Hexachlorobenzene	mg/kg dry wt	< 0.0011	< 0.0010	< 0.00099	< 0.00099	< 0.00099
Methoxychlor	mg/kg dry wt	< 0.0011	< 0.0010	< 0.00099	< 0.00099	< 0.00099
Total Chlordane [(cis+trans)* 100/42]	mg/kg dry wt	< 0.0020	< 0.0020	< 0.0020	< 0.0020	< 0.0020

Sample Name:		JME0084 Deep 20-Oct-2009 3:55 pm	JME088 High Surface 20-Oct-2009 5:50 pm	JME088 High Deep 20-Oct-2009 5:50 pm	JME087 Mid Surface 20-Oct-2009 6:00 pm	JME087 Mid Deep 20-Oct-2009 6:00 pm
Lab Number:		737701.16	737701.17	737701.18	737701.19	737701.20
Individual Tests						
Total Organic Carbon	g/100g dry wt	0.11	1.6	0.52	0.97	0.40
Organochlorine Pesticides Trace in Soil						
Aldrin	mg/kg dry wt	< 0.00099	< 0.0011	< 0.0010	< 0.00098	< 0.0010
alpha-BHC	mg/kg dry wt	< 0.00099	< 0.0011	< 0.0010	< 0.00098	< 0.0010
beta-BHC	mg/kg dry wt	< 0.00099	< 0.0011	< 0.0010	< 0.00098	< 0.0010
delta-BHC	mg/kg dry wt	< 0.00099	< 0.0011	< 0.0010	< 0.00098	< 0.0010
gamma-BHC (Lindane)	mg/kg dry wt	< 0.00099	< 0.0011	< 0.0010	< 0.00098	< 0.0010
cis-chlordane	mg/kg dry wt	< 0.00099	< 0.0011	< 0.0010	< 0.00098	< 0.0010
trans-chlordane	mg/kg dry wt	< 0.00099	< 0.0011	< 0.0010	< 0.00098	< 0.0010
2,4'-DDD	mg/kg dry wt	< 0.00099	0.014	0.0049	0.0038	0.0028
4,4'-DDD	mg/kg dry wt	0.0021	0.033	0.0062	0.015	0.0036
2,4'-DDE	mg/kg dry wt	< 0.00099	0.0021	0.0044	< 0.00098	0.0011
4,4'-DDE	mg/kg dry wt	0.0036	0.037	0.031	0.011	0.013
2,4'-DDT	mg/kg dry wt	< 0.00099	0.019	0.014	0.015	0.011
4,4'-DDT	mg/kg dry wt	0.0010	0.12	0.078	0.059	0.053
Dieldrin	mg/kg dry wt	< 0.00099	0.0044	0.0063	< 0.00098	< 0.0010
Endosulfan I	mg/kg dry wt	< 0.00099	< 0.0011	< 0.0010	< 0.00098	< 0.0010
Endosulfan II	mg/kg dry wt	< 0.00099	< 0.0011	< 0.0010	< 0.00098	< 0.0010
Endosulfan sulphate	mg/kg dry wt	< 0.00099	< 0.0011	< 0.0010	< 0.00098	< 0.0010
Endrin	mg/kg dry wt	< 0.00099	< 0.0011	< 0.0010	< 0.00098	< 0.0010
Endrin aldehyde	mg/kg dry wt	< 0.00099	< 0.0011	< 0.0010	0.0015	< 0.0010
Endrin Ketone	mg/kg dry wt	< 0.00099	< 0.0011	< 0.0010	< 0.00098	< 0.0010
Heptachlor	mg/kg dry wt	< 0.00099	< 0.0011	< 0.0010	< 0.00098	< 0.0010
Heptachlor epoxide	mg/kg dry wt	< 0.00099	< 0.0011	< 0.0010	< 0.00098	< 0.0010
Hexachlorobenzene	mg/kg dry wt	< 0.00099	< 0.0011	< 0.0010	< 0.00098	< 0.0010
Methoxychlor	mg/kg dry wt	< 0.00099	< 0.0011	< 0.0010	< 0.00098	< 0.0010
Total Chlordane [(cis+trans)* 100/42]	mg/kg dry wt	< 0.0020	< 0.0020	< 0.0020	< 0.0020	< 0.0020

Sample Name:		JME086 Low Surface 20-Oct-2009 6:00 pm	JME086 Deep Low Deep 20-Oct-2009 5:51 pm	East FCC New 1 Surface 20-Oct-2009 6:14 pm	East FCC New 1 Deep 20-Oct-2009 6:14 pm	East FCC New 2 Surface 20-Oct-2009 6:15 pm
Lab Number:		737701.21	737701.22	737701.23	737701.25	737701.27
Individual Tests						
Total Organic Carbon	g/100g dry wt	0.30	0.13	1.1	0.35	0.89
Organochlorine Pesticides Trace in Soil						
Aldrin	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.00099
alpha-BHC	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.00099
beta-BHC	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.00099
delta-BHC	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.00099
gamma-BHC (Lindane)	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.00099
cis-chlordane	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.00099
trans-chlordane	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.00099

Sample Type: Sediment						
Sample Name:		JME086 Low Surface 20-Oct-2009 6:00 pm	JME086 Deep Low Deep 20-Oct-2009 5:51 pm	East FCC New 1 Surface 20-Oct-2009 6:14 pm	East FCC New 1 Deep 20-Oct-2009 6:14 pm	East FCC New 2 Surface 20-Oct-2009 6:15 pm
Lab Number:		737701.21	737701.22	737701.23	737701.25	737701.27
Organochlorine Pesticides Trace in Soil						
2,4'-DDD	mg/kg dry wt	0.0031	0.016	0.014	0.0035	0.0073
4,4'-DDD	mg/kg dry wt	0.014	0.035	0.038	0.0069	0.025
2,4'-DDE	mg/kg dry wt	< 0.0010	0.0046	< 0.0010	< 0.0010	< 0.00099
4,4'-DDE	mg/kg dry wt	0.0068	0.20	0.038	0.014	0.018
2,4'-DDT	mg/kg dry wt	0.0018	0.091	0.034	0.0040	0.010
4,4'-DDT	mg/kg dry wt	0.014	0.32	0.16	0.024	0.084
Dieldrin	mg/kg dry wt	0.0013	0.0083	0.0038	0.0017	0.0050
Endosulfan I	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.00099
Endosulfan II	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.00099
Endosulfan sulphate	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.00099
Endrin	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.00099
Endrin aldehyde	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	0.0056
Endrin Ketone	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.00099
Heptachlor	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.00099
Heptachlor epoxide	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.00099
Hexachlorobenzene	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.00099
Methoxychlor	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.00099
Total Chlordane [(cis+trans)* 100/42]	mg/kg dry wt	< 0.0020	< 0.0020	< 0.0020	< 0.0020	< 0.0020

Sample Name:		East FCC New 2 Deep 20-Oct-2009 6:15 pm	JME090 Surface 20-Oct-2009 6:15 pm	JME090 Deep 20-Oct-2009 6:17 pm	East Control Hunter Brown Surface 20-Oct-2009 7:00 pm	East Control Hunter-Brown Deep 20-Oct-2009 7:07 pm
Lab Number:		737701.28	737701.29	737701.30	737701.31	737701.32
Individual Tests						
Total Organic Carbon	g/100g dry wt	0.46	0.66	0.51	0.47	0.076
Organochlorine Pesticides Trace in Soil						
Aldrin	mg/kg dry wt	0.0072	0.0016	0.028	< 0.00099	< 0.0010
alpha-BHC	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.00099	< 0.0010
beta-BHC	mg/kg dry wt	< 0.0010	< 0.0010	0.0012	< 0.00099	< 0.0010
delta-BHC	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.00099	< 0.0010
gamma-BHC (Lindane)	mg/kg dry wt	< 0.0010	< 0.0010	0.0026	< 0.00099	< 0.0010
cis-chlordane	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.00099	< 0.0010
trans-chlordane	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.00099	< 0.0010
2,4'-DDD	mg/kg dry wt	0.086	0.39	0.47	< 0.00099	< 0.0010
4,4'-DDD	mg/kg dry wt	0.11	1.0	1.2	< 0.00099	0.0026
2,4'-DDE	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.00099	< 0.0010
4,4'-DDE	mg/kg dry wt	0.31	0.11	0.37	< 0.00099	0.0011
2,4'-DDT	mg/kg dry wt	0.35	0.029	0.17	< 0.00099	< 0.0010
4,4'-DDT	mg/kg dry wt	0.99	0.21	0.85	< 0.00099	0.0020
Dieldrin	mg/kg dry wt	0.10	0.16	0.30	< 0.00099	< 0.0010
Endosulfan I	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.00099	< 0.0010
Endosulfan II	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.00099	< 0.0010
Endosulfan sulphate	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.00099	< 0.0010
Endrin	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.00099	< 0.0010
Endrin aldehyde	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.00099	< 0.0010
Endrin Ketone	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.00099	< 0.0010
Heptachlor	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.00099	< 0.0010
Heptachlor epoxide	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.00099	< 0.0010
Hexachlorobenzene	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.00099	< 0.0010
Methoxychlor	mg/kg dry wt	< 0.0010	< 0.0010	< 0.0010	< 0.00099	< 0.0010
Total Chlordane [(cis+trans)* 100/42]	mg/kg dry wt	< 0.0020	< 0.0020	< 0.0020	< 0.0020	< 0.0020

Sample Type: Shellfish						
Sample Name:		East FCC Cockle JME090	East Control Hunter Brown Cockles			
Lab Number:		737701.38	737701.39			
Individual Tests						
Dry Matter	g/100g as rcvd	16	14	-	-	-
Organochlorine Pesticides in Biomatter						
Aldrin	mg/kg	< 0.00050	< 0.00050	-	-	-
alpha-BHC	mg/kg	< 0.00050	< 0.00050	-	-	-
beta-BHC	mg/kg	< 0.00050	< 0.00050	-	-	-
delta-BHC	mg/kg	< 0.00050	< 0.00050	-	-	-
gamma-BHC (Lindane)	mg/kg	< 0.00050	< 0.00050	-	-	-
cis-chlordane	mg/kg	< 0.00050	< 0.00050	-	-	-
trans-chlordane	mg/kg	< 0.00050	< 0.00050	-	-	-
2,4'-DDD	mg/kg	0.0012	< 0.00050	-	-	-
4,4'-DDD	mg/kg	0.0044	0.00069	-	-	-
2,4'-DDE	mg/kg	< 0.00050	< 0.00050	-	-	-
4,4'-DDE	mg/kg	0.0041	0.0011	-	-	-
2,4'-DDT	mg/kg	< 0.00050	< 0.00050	-	-	-
4,4'-DDT	mg/kg	0.00081	< 0.00050	-	-	-
Dieldrin	mg/kg	0.0028	< 0.00050	-	-	-
Endosulfan I	mg/kg	< 0.00050	< 0.00050	-	-	-
Endosulfan II	mg/kg	< 0.00050	< 0.00050	-	-	-
Endosulfan sulfate	mg/kg	< 0.00050	< 0.00050	-	-	-
Endrin	mg/kg	< 0.00050	< 0.00050	-	-	-
Endrin aldehyde	mg/kg	< 0.00050	< 0.00050	-	-	-
Endrin Ketone	mg/kg	< 0.00050	< 0.00050	-	-	-
Heptachlor	mg/kg	< 0.00050	< 0.00050	-	-	-
Heptachlor epoxide	mg/kg	< 0.00050	< 0.00050	-	-	-
Hexachlorobenzene	mg/kg	< 0.00050	< 0.00050	-	-	-
Methoxychlor	mg/kg	< 0.00050	< 0.00050	-	-	-
Total Chlordane [(cis+trans)*100/42]	mg/kg	< 0.0020	< 0.0020	-	-	-

Sample Type: Snails						
Sample Name:		West FCC Control Amphibola 20-Oct-2009	West FCC JME084 Amphibola 20-Oct-2009	East FCC New 2 Soft Dilloma 20-Oct-2009	East FCC New 2 Rocky Dilloma	East FCC Amphibola
Lab Number:		737701.33	737701.34	737701.35	737701.36	737701.37
Individual Tests						
Dry Matter	g/100g as rcvd	17	16	24	25	18
Organochlorine Pesticides in Biomatter						
Aldrin	mg/kg	< 0.00050	< 0.0015	< 0.00050	< 0.00050	< 0.00050
alpha-BHC	mg/kg	< 0.00050	< 0.0015	< 0.00050	< 0.00050	< 0.00050
beta-BHC	mg/kg	< 0.00050	< 0.0015	< 0.00050	< 0.00050	< 0.00050
delta-BHC	mg/kg	< 0.00050	< 0.0015	< 0.00050	< 0.00050	< 0.00050
gamma-BHC (Lindane)	mg/kg	< 0.00050	< 0.0015	< 0.00050	< 0.00050	< 0.00050
cis-chlordane	mg/kg	< 0.00050	< 0.0015	< 0.00050	< 0.00050	< 0.00050
trans-chlordane	mg/kg	< 0.00050	< 0.0015	< 0.00050	< 0.00050	< 0.00050
2,4'-DDD	mg/kg	< 0.00050	1.8	0.013	0.0095	0.12
4,4'-DDD	mg/kg	0.015	5.9	0.062	0.067	0.46
2,4'-DDE	mg/kg	< 0.00050	0.18	0.0036	0.0019	0.0069
4,4'-DDE	mg/kg	0.068	11	0.080	0.058	0.44
2,4'-DDT	mg/kg	< 0.00050	0.11	0.0017	0.0011	0.013
4,4'-DDT	mg/kg	0.012	3.1	0.0088	0.0090	0.31
Dieldrin	mg/kg	0.0020	0.52	0.027	0.031	0.23
Endosulfan I	mg/kg	< 0.00050	< 0.0015	< 0.00050	< 0.00050	< 0.00050
Endosulfan II	mg/kg	< 0.00050	< 0.0015	< 0.00050	< 0.00050	< 0.00050
Endosulfan sulfate	mg/kg	< 0.00050	< 0.0015	< 0.00050	< 0.00050	< 0.00050
Endrin	mg/kg	< 0.00050	< 0.0015	< 0.00050	< 0.00050	< 0.00050

Sample Type: Snails						
Sample Name:		West FCC Control Amphibola 20-Oct-2009	West FCC JME084 Amphibola 20-Oct-2009	East FCC New 2 Soft Diloma 20-Oct-2009	East FCC New 2 Rocky Diloma	East FCC Amphibola
Lab Number:		737701.33	737701.34	737701.35	737701.36	737701.37
Organochlorine Pesticides in Biomatter						
Endrin aldehyde	mg/kg	< 0.00050	< 0.0015	< 0.00050	< 0.00050	< 0.00050
Endrin Ketone	mg/kg	< 0.00050	< 0.0015	< 0.00050	< 0.00050	< 0.00050
Heptachlor	mg/kg	< 0.00050	< 0.0015	< 0.00050	< 0.00050	< 0.00050
Heptachlor epoxide	mg/kg	< 0.00050	< 0.0015	< 0.00050	< 0.00050	< 0.00050
Hexachlorobenzene	mg/kg	< 0.00050	< 0.0015	< 0.00050	< 0.00050	< 0.00050
Methoxychlor	mg/kg	< 0.00050	< 0.0015	< 0.00050	< 0.00050	< 0.00050
Total Chlordane [(cis+trans)*100/42]	mg/kg	< 0.0020	< 0.0021	< 0.0020	< 0.0020	< 0.0020

Analyst's Comments

Attached are the particle size results The samples have particles greater than 2mm and therefore the results are made up of a combination of lasersizer results and sieving results. The excel spreadsheet has the final results. Also included are the lasersizer results which only show the results of part of the sample which was less that 2mm.

Appendix No.1 - Particle Size Results

Appendix No.2 - Particle Size Results

Appendix No.3 - Particle Size Results

Appendix No.4 - Particle Size Results

Appendix No.5 - Particle Size Results

Appendix No.6 - Particle Size Results

Appendix No.7 - Particle Size Results

Appendix No.8 - Particle Size Results

Appendix No.9 - Particle Size Results

Appendix No.10 - Particle Size Results

Appendix No.11 - Particle Size Results

Appendix No.12 - Particle Size Results

Appendix No.13 - Particle Size Results

Appendix No.14 - Particle Size Results

Appendix No.15 - Particle Size Results

Appendix No.16 - Final Results

SUMMARY OF METHODS

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively clean matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis.

Sample Type: Sediment			
Test	**Method Description**	**Default Detection Limit**	**Samples**
Environmental Solids Sample Preparation	Air dried at 35°C and sieved, <2mm fraction.	-	1-23, 25, 27-32
Organochlorine Pesticides Trace in Soil	Sonication extraction, SPE cleanup, GPC cleanup (if required), dual column GC-ECD analysis	-	1-23, 25, 27-32
Particle size analysis*	Malvern Laser Sizer particle size analysis. Subcontracted to Earth Sciences Department, Waikato University, Hamilton.	-	1-6, 11-12, 17-18, 23, 25, 29-31
Total Organic Carbon	Acid pretreatment to remove carbonates if present, Elementar Combustion Analyser.	0.050 g/100g dry wt	1-23, 25, 27-32

Sample Type: Snails			
Test	**Method Description**	**Default Detection Limit**	**Samples**

Sample Type: Snails			
Test	Method Description	Default Detection Limit	Samples
Homogenisation of Biological samples for Organics Tests*	Mincing, chopping, or blending of sample to form homogenous sample fraction.	-	33-39
Shucking of Shellfish*	Removal of tissue from shell. Analysis performed at Hill Laboratories - Food & Bioanalytical Division, Waikato Innovation Park, Ruakura Lane, Hamilton.	-	33-39
Organochlorine Pesticides in Biomatter	Sonication extraction, SPE cleanup, GPC cleanup, dual column GC-ECD analysis	-	33-39
Dry Matter (Env)	Dried at 103°C (removes 3-5% more water than air dry) for 18hr, gravimetry. US EPA 3550.	0.10 g/100g as rcvd	33-39

These samples were collected by yourselves (or your agent) and analysed as received at the laboratory.

Samples are held at the laboratory after reporting for a length of time depending on the preservation used and the stability of the analytes being tested. Once the storage period is completed the samples are discarded unless otherwise advised by the client.

This report must not be reproduced, except in full, without the written consent of the signatory.

Ara Heron BSc (Tech)
Client Services Manager - Environmental Division

MALVERN INSTRUMENTS

MASTERSIZER 2000

Result Analysis Report

Sample Name:
737701.1 FCC West Control Surface

SOP Name:
Marine Sediment

Measured:
Tuesday, 17 November 2009 11:32:11 a.m.

Sample Source & type:

Measured by:
rodgers

Analysed:
Tuesday, 17 November 2009 11:32:12 a.m.

Sample bulk lot ref:
2009118/1

Result Source:
Measurement

Particle Name:
Marine Sediment

Accessory Name:
Hydro 2000G (A)

Analysis model:
General purpose

Sensitivity:
Enhanced

Particle RI:
1.500

Absorption:
0

Size range:
0.020 to 2000.000 um

Obscuration:
23.39 %

Dispersant Name:
Water

Dispersant RI:
1.330

Weighted Residual:
0.816 %

Result Emulation:
Off

Concentration:
0.0999 %Vol

Span :
3.285

Uniformity:
1.06

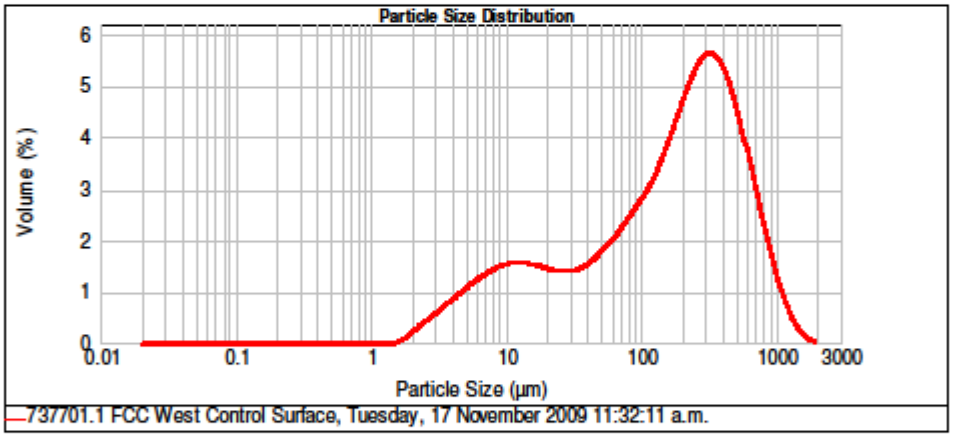
Result units:
Volume

Specific Surface Area:
0.195 m²/g

Surface Weighted Mean D[3,2]:
30.726 um

Vol Weighted Mean D[4,3]:
255.370 um

d(0.1): 9.918 um **d(0.5):** 182.015 um **d(0.9):** 607.769 um



Size (µm)	Volume In %
0.050	0.00
0.060	0.00
0.120	0.00
0.240	0.00
0.490	0.00
0.700	0.00
0.980	0.00

Size (µm)	Volume In %
0.980	0.15
2.000	2.29
3.900	5.22
7.800	6.97
15.600	6.50
31.000	1.68
37.000	

Size (µm)	Volume In %
37.000	1.76
44.000	2.11
53.000	2.20
63.000	2.30
74.000	2.76
88.000	3.16
105.000	

Size (µm)	Volume In %
105.000	3.52
125.000	4.04
149.000	4.54
177.000	5.13
210.000	5.83
250.000	6.57
300.000	

Size (µm)	Volume In %
300.000	5.69
350.000	6.54
420.000	5.69
500.000	4.62
590.000	4.10
710.000	2.72
840.000	

Size (µm)	Volume In %
840.000	1.91
1000.000	2.01
2000.000	

Operator notes:

Malvern Instruments Ltd.
Malvern, UK

Mastersizer 2000 Ver. 5.22
Serial Number : MAL102144

File name: Hill
Record Number: 218

MALVERN INSTRUMENTS

MASTERSIZER 2000

Result Analysis Report

Sample Name:
737701.2 FCC West Control Control

Sample Source & type:

Sample bulk lot ref:
2009118/2

SOP Name:
Marine Sediment

Measured by:
rodgers

Result Source:
Measurement

Measured:
Tuesday, 17 November 2009 11:40:33 a.m.

Analysed:
Tuesday, 17 November 2009 11:40:34 a.m.

Particle Name:
Marine Sediment

Particle RI:
1.500

Dispersant Name:
Water

Accessory Name:
Hydro 2000G (A)

Absorption:
0

Dispersant RI:
1.330

Analysis model:
General purpose

Size range:
0.020 to 2000.000 um

Weighted Residual:
0.759 %

Sensitivity:
Enhanced

Obscuration:
22.66 %

Result Emulation:
Off

Concentration:
0.0858 %Vol

Specific Surface Area:
0.216 m²/g

Span :
3.028

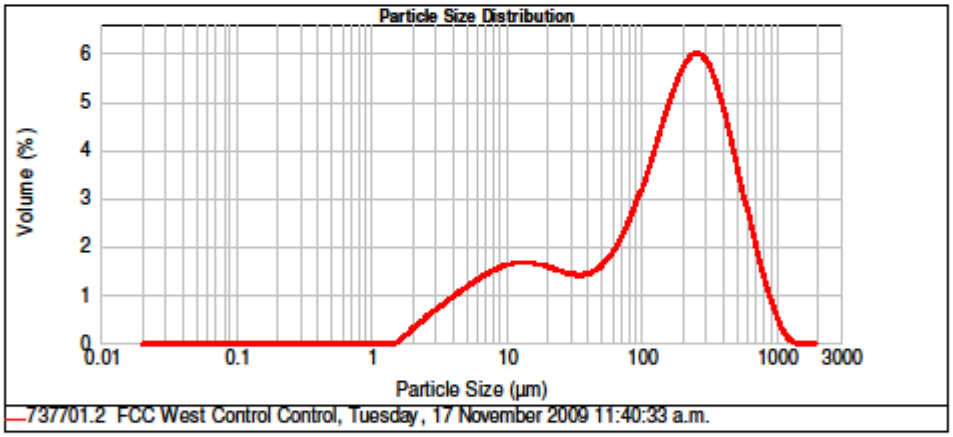
Surface Weighted Mean D[3,2]:
27.752 um

Uniformity:
0.965

Vol Weighted Mean D[4,3]:
209.959 um

Result units:
Volume

d(0.1): 9.003 um **d(0.5):** 159.046 um **d(0.9):** 490.645 um



Size (µm)	Volume In %
0.050	0.00
0.060	0.00
0.120	0.00
0.240	0.00
0.490	0.00
0.700	0.00
0.980	0.00

Size (µm)	Volume In %
0.980	0.24
2.000	2.72
3.900	5.59
7.800	7.37
15.600	6.94
31.000	1.54
37.000	

Size (µm)	Volume In %
37.000	1.63
44.000	1.90
53.000	2.01
63.000	2.21
74.000	2.85
88.000	3.54
105.000	

Size (µm)	Volume In %
105.000	4.23
125.000	5.04
149.000	5.69
177.000	6.25
210.000	6.76
250.000	7.12
300.000	

Size (µm)	Volume In %
300.000	5.75
350.000	6.11
420.000	4.87
500.000	3.62
590.000	2.89
710.000	1.66
840.000	

Size (µm)	Volume In %
840.000	0.96
1000.000	0.39
2000.000	

Operator notes:

Malvern Instruments Ltd.
Malvern, UK

Mastersizer 2000 Ver. 5.22
Serial Number : MAL102144

File name: Hill
Record Number: 219

MALVERN INSTRUMENTS

MASTERSIZER 2000

Result Analysis Report

Sample Name:
737701.3 JME083 Surface

Sample Source & type:

Sample bulk lot ref:
2009118/3

SOP Name:
Marine Sediment

Measured by:
rodgers

Result Source:
Measurement

Measured:
Tuesday, 17 November 2009 11:48:16 a.m.

Analysed:
Tuesday, 17 November 2009 11:48:18 a.m.

Particle Name:
Marine Sediment

Particle RI:
1.500

Dispersant Name:
Water

Accessory Name:
Hydro 2000G (A)

Absorption:
0

Dispersant RI:
1.330

Analysis model:
General purpose

Size range:
0.020 to 2000.000 um

Weighted Residual:
1.532 %

Sensitivity:
Enhanced

Obscuration:
17.50 %

Result Emulation:
Off

Concentration:
0.0954 %Vol

Specific Surface Area:
0.15 m²/g

Span :
2.923

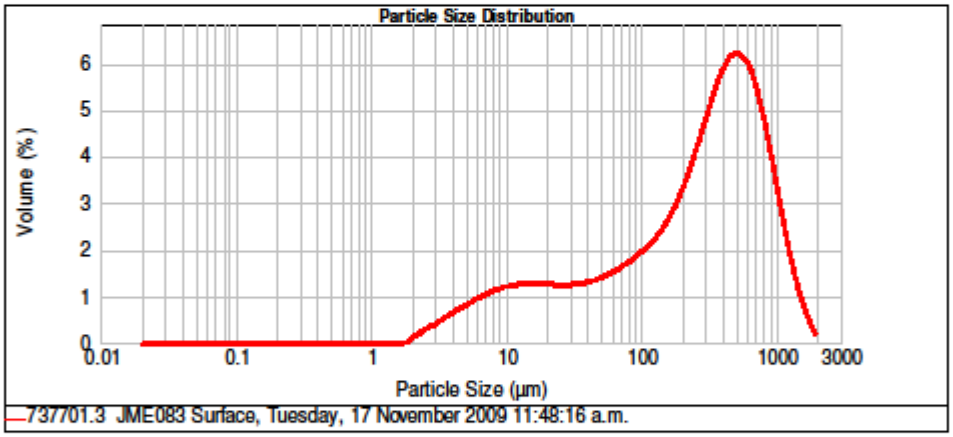
Surface Weighted Mean D[3,2]:
39.985 um

Uniformity:
0.937

Vol Weighted Mean D[4,3]:
376.009 um

Result units:
Volume

d(0.1): 13.367 um **d(0.5):** 292.852 um **d(0.9):** 869.428 um



Size (µm)	Volume In %
0.050	0.00
0.060	0.00
0.120	0.00
0.240	0.00
0.490	0.00
0.700	0.00
0.980	0.00

Size (µm)	Volume In %
0.980	0.04
2.000	1.65
3.900	4.04
7.800	5.57
15.600	5.70
31.000	1.48
37.000	

Size (µm)	Volume In %
37.000	1.50
44.000	1.70
53.000	1.69
63.000	1.69
74.000	1.98
88.000	2.22
105.000	

Size (µm)	Volume In %
105.000	2.43
125.000	2.76
149.000	3.10
177.000	3.59
210.000	4.31
250.000	5.33
300.000	

Size (µm)	Volume In %
300.000	5.19
350.000	6.85
420.000	7.01
500.000	6.70
590.000	7.02
710.000	5.48
840.000	

Size (µm)	Volume In %
840.000	4.48
1000.000	6.51
2000.000	

Operator notes:

Malvern Instruments Ltd.
Malvern, UK

Mastersizer 2000 Ver. 5.22
Serial Number : MAL102144

File name: Hill
Record Number: 220

MASTERSIZER 2000

Result Analysis Report

Sample Name:
737701.4 JME083 Deep

SOP Name:
Marine Sediment

Measured:
Tuesday, 17 November 2009 11:56:10 a.m.

Sample Source & type:

Measured by:
rodgers

Analysed:
Tuesday, 17 November 2009 11:56:11 a.m.

Sample bulk lot ref:
2009118/4

Result Source:
Measurement

Particle Name:
Marine Sediment

Accessory Name:
Hydro 2000G (A)

Analysis model:
General purpose

Sensitivity:
Enhanced

Particle RI:
1.500

Absorption:
0

Size range:
0.020 to 2000.000 um

Obscuration:
18.48 %

Dispersant Name:
Water

Dispersant RI:
1.330

Weighted Residual:
2.010 %

Result Emulation:
Off

Concentration:
0.1666 %Vol

Span :
2.213

Uniformity:
0.652

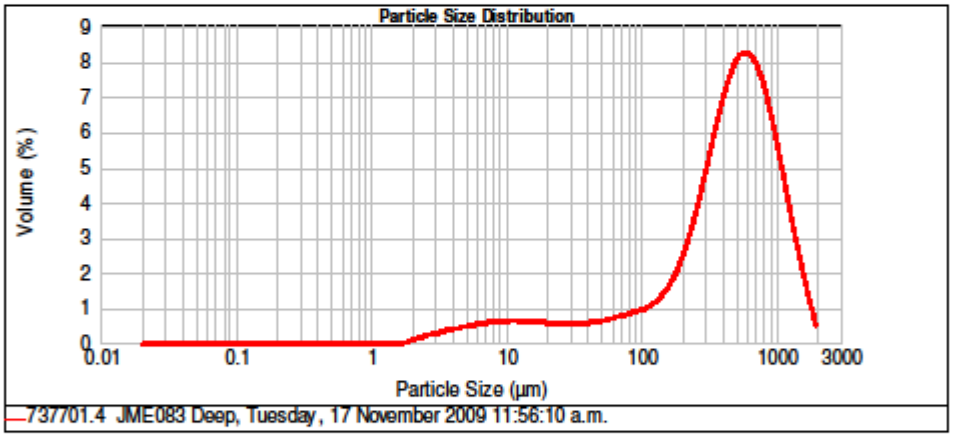
Result units:
Volume

Specific Surface Area:
0.09 m²/g

Surface Weighted Mean D[3,2]:
66.646 um

Vol Weighted Mean D[4,3]:
538.335 um

d(0.1): 41.614 um **d(0.5):** 474.407 um **d(0.9):** 1091.551 um



Size (µm)	Volume In %
0.050	0.00
0.060	0.00
0.120	0.00
0.240	0.00
0.490	0.00
0.700	0.00
0.980	0.00

Size (µm)	Volume In %
0.980	0.00
2.000	1.12
3.900	2.34
7.800	2.85
15.600	2.58
31.000	0.54
37.000	

Size (µm)	Volume In %
37.000	0.66
44.000	0.76
53.000	0.78
63.000	0.80
74.000	0.95
88.000	1.08
105.000	

Size (µm)	Volume In %
105.000	1.23
125.000	1.51
149.000	1.92
177.000	2.58
210.000	3.60
250.000	5.11
300.000	

Size (µm)	Volume In %
300.000	5.52
350.000	7.95
420.000	8.73
500.000	8.86
590.000	9.86
710.000	8.24
840.000	

Size (µm)	Volume In %
840.000	7.27
1000.000	13.05
2000.000	

Operator notes:

Malvern Instruments Ltd.
Malvern, UK

Mastersizer 2000 Ver. 5.22
Serial Number : MAL102144

File name: Hill
Record Number: 221

MASTERSIZER 2000

Result Analysis Report

Sample Name:
737701.5 JME081 Surface

Sample Source & type:

Sample bulk lot ref:
2009118/5

SOP Name:
Marine Sediment

Measured by:
rodgers

Result Source:
Measurement

Measured:
Tuesday, 17 November 2009 2:08:22 p.m.

Analysed:
Tuesday, 17 November 2009 2:08:23 p.m.

Particle Name:
Marine Sediment

Particle RI:
1.500

Dispersant Name:
Water

Accessory Name:
Hydro 2000G (A)

Absorption:
0

Dispersant RI:
1.330

Analysis model:
General purpose

Size range:
0.020 to 2000.000 um

Weighted Residual:
1.276 %

Sensitivity:
Enhanced

Obscuration:
20.93 %

Result Emulation:
Off

Concentration:
0.0753 %Vol

Specific Surface Area:
0.228 m²/g

Span :
3.333

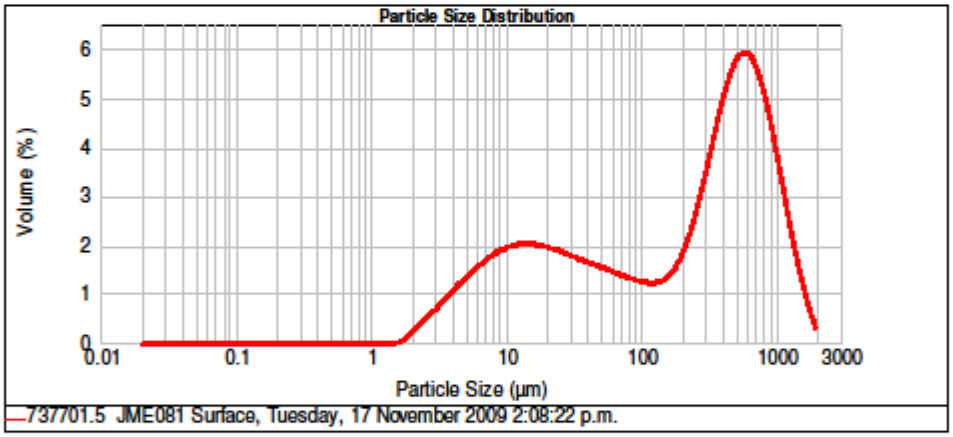
Surface Weighted Mean D[3,2]:
26.348 um

Uniformity:
1.13

Vol Weighted Mean D[4,3]:
376.576 um

Result units:
Volume

d(0.1): 8.169 um **d(0.5):** 278.376 um **d(0.9):** 935.980 um



Size (µm)	Volume In %
0.050	0.00
0.060	0.00
0.120	0.00
0.240	0.00
0.490	0.00
0.700	0.00
0.980	0.00

Size (µm)	Volume In %
0.980	0.14
2.000	2.78
3.900	6.54
7.800	8.90
15.600	8.63
31.000	2.01
37.000	

Size (µm)	Volume In %
37.000	1.87
44.000	1.92
53.000	1.69
63.000	1.49
74.000	1.53
88.000	1.47
105.000	

Size (µm)	Volume In %
105.000	1.41
125.000	1.46
149.000	1.60
177.000	1.95
210.000	2.60
250.000	3.64
300.000	

Size (µm)	Volume In %
300.000	3.94
350.000	5.69
420.000	6.29
500.000	6.38
590.000	7.05
710.000	5.80
840.000	

Size (µm)	Volume In %
840.000	4.98
1000.000	8.25
2000.000	

Operator notes:

Malvern Instruments Ltd.
Malvern, UK

Mastersizer 2000 Ver. 5.22
Serial Number : MAL102144

File name: Hill
Record Number: 222

MALVERN INSTRUMENTS

MASTERSIZER 2000

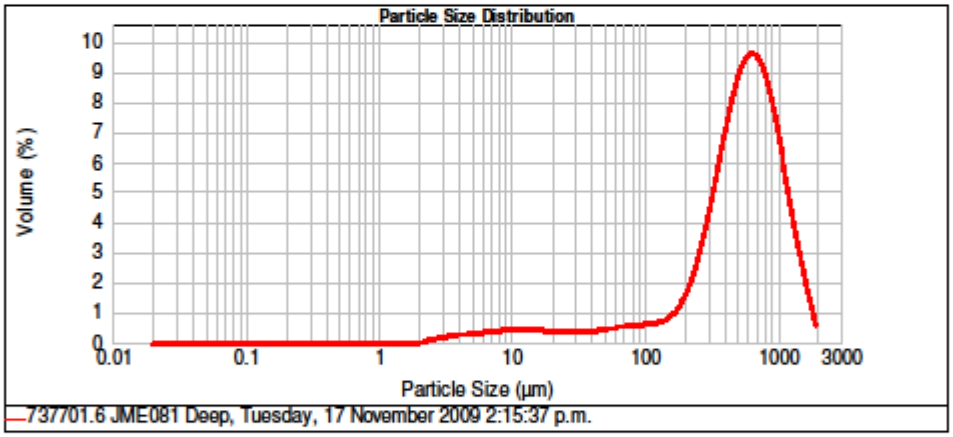
Result Analysis Report

Sample Name: 737701.6 JME081 Deep
SOP Name: Marine Sediment
Measured: Tuesday, 17 November 2009 2:15:37 p.m.
Sample Source & type:
Measured by: rodgers
Analysed: Tuesday, 17 November 2009 2:15:39 p.m.
Sample bulk lot ref: 2009118/6
Result Source: Measurement

Particle Name: Marine Sediment
Accessory Name: Hydro 2000G (A)
Analysis model: General purpose
Sensitivity: Enhanced
Particle RI: 1.500
Absorption: 0
Size range: 0.020 to 2000.000 um
Obscuration: 20.36 %
Dispersant Name: Water
Dispersant RI: 1.330
Weighted Residual: 2.708 %
Result Emulation: Off

Concentration: 0.2793 %Vol
Span : 1.891
Uniformity: 0.552
Result units: Volume
Specific Surface Area: 0.0614 m²/g
Surface Weighted Mean D[3,2]: 97.709 um
Vol. Weighted Mean D[4,3]: 611.566 um

d(0.1): 104.544 um **d(0.5):** 555.860 um **d(0.9):** 1155.855 um



Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %
0.050	0.00	0.980	0.00	37.000	0.45	105.000	0.75	300.000	5.09	840.000	8.88
0.060	0.00	2.000	0.67	44.000	0.55	125.000	0.85	350.000	7.95	1000.000	15.89
0.120	0.00	3.900	1.57	53.000	0.58	149.000	1.10	420.000	9.40	2000.000	
0.240	0.00	7.800	1.98	63.000	0.60	177.000	1.63	500.000	10.04		
0.490	0.00	15.600	1.78	74.000	0.69	210.000	2.61	590.000	11.60		
0.700	0.00	31.000	0.43	88.000	0.73	250.000	4.24	710.000	9.94		
0.980	0.00	37.000		105.000		300.000		840.000			

Operator notes:

Malvern Instruments Ltd.
Malvern, UK

Mastersizer 2000 Ver. 5.22
Serial Number : MAL102144

File name: Hill
Record Number: 223

MALVERN INSTRUMENTS

MASTERSIZER 2000

Result Analysis Report

Sample Name:
737701.11 FCC 2 West (2) Mid surface

SOP Name:
Marine Sediment

Measured:
Tuesday, 17 November 2009 2:24:10 p.m.

Sample Source & type:

Measured by:
rodgers

Analysed:
Tuesday, 17 November 2009 2:24:11 p.m.

Sample bulk lot ref:
2009118/7

Result Source:
Measurement

Particle Name:
Marine Sediment

Accessory Name:
Hydro 2000G (A)

Analysis model:
General purpose

Sensitivity:
Enhanced

Particle RI:
1.500

Absorption:
0

Size range:
0.020 to 2000.000 um

Obscuration:
22.15 %

Dispersant Name:
Water

Dispersant RI:
1.330

Weighted Residual:
0.639 %

Result Emulation:
Off

Concentration:
0.0382 %Vol

Span :
11.448

Uniformity:
3.74

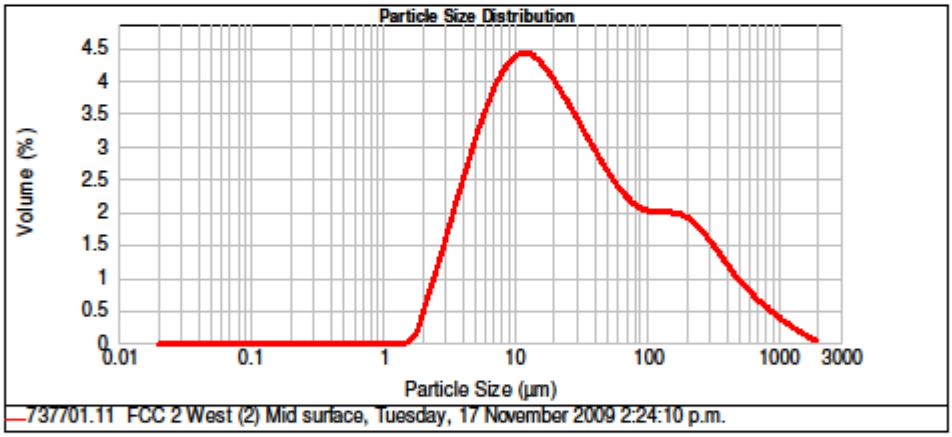
Result units:
Volume

Specific Surface Area:
0.479 m²/g

Surface Weighted Mean D[3,2]:
12.533 um

Vol Weighted Mean D[4,3]:
91.535 um

d(0.1): 4.826 um **d(0.5):** 21.805 um **d(0.9):** 254.451 um



Size (µm)	Volume In %
0.050	0.00
0.060	0.00
0.120	0.00
0.240	0.00
0.490	0.00
0.700	0.00
0.980	0.00

Size (µm)	Volume In %
0.980	0.25
2.000	6.02
3.900	15.03
7.800	19.69
15.600	17.42
31.000	3.74
37.000	

Size (µm)	Volume In %
37.000	3.36
44.000	3.28
53.000	2.77
63.000	2.38
74.000	2.41
88.000	2.35
105.000	

Size (µm)	Volume In %
105.000	2.28
125.000	2.30
149.000	2.24
177.000	2.18
210.000	2.10
250.000	2.01
300.000	

Size (µm)	Volume In %
300.000	1.50
350.000	1.53
420.000	1.25
500.000	0.97
590.000	0.89
710.000	0.65
840.000	

Size (µm)	Volume In %
840.000	0.53
1000.000	0.90
2000.000	

Operator notes:

Malvern Instruments Ltd.
Malvern, UK

Mastersizer 2000 Ver. 5.22
Serial Number : MAL102144

File name: Hill
Record Number: 224

MASTERSIZER 2000

Result Analysis Report

Sample Name:
737701.12 FCC 2 (Mid) Deep

Sample Source & type:

Sample bulk lot ref:
2009118/8

SOP Name:
Marine Sediment

Measured by:
rodgers

Result Source:
Measurement

Measured:
Tuesday, 17 November 2009 2:32:04 p.m.

Analysed:
Tuesday, 17 November 2009 2:32:06 p.m.

Particle Name:
Marine Sediment

Particle RI:
1.500

Dispersant Name:
Water

Accessory Name:
Hydro 2000G (A)

Absorption:
0

Dispersant RI:
1.330

Analysis model:
General purpose

Size range:
0.020 to 2000.000 um

Weighted Residual:
0.720 %

Sensitivity:
Enhanced

Obscuration:
22.94 %

Result Emulation:
Off

Concentration:
0.0976 %Vol

Span :
2.325

Uniformity:
0.755

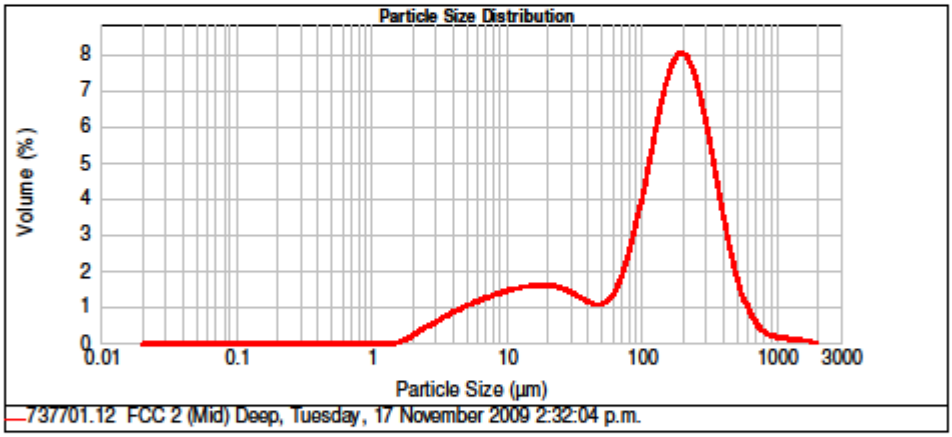
Result units:
Volume

Specific Surface Area:
0.195 m²/g

Surface Weighted Mean D[3,2]:
30.702 um

Vol Weighted Mean D[4,3]:
178.432 um

d(0.1): 10.327 um **d(0.5):** 152.866 um **d(0.9):** 365.727 um



Size (µm)	Volume In %
0.050	0.00
0.060	0.00
0.120	0.00
0.240	0.00
0.490	0.00
0.700	0.00
0.980	0.00

Size (µm)	Volume In %
0.980	0.15
2.000	2.31
3.900	4.97
7.800	6.71
15.600	6.99
31.000	1.51
37.000	

Size (µm)	Volume In %
37.000	1.30
44.000	1.31
53.000	1.38
63.000	1.75
74.000	2.80
88.000	4.26
105.000	

Size (µm)	Volume In %
105.000	5.85
125.000	7.50
149.000	8.52
177.000	8.95
210.000	8.82
250.000	8.09
300.000	

Size (µm)	Volume In %
300.000	5.51
350.000	4.77
420.000	2.93
500.000	1.62
590.000	0.93
710.000	0.40
840.000	

Size (µm)	Volume In %
840.000	0.23
1000.000	0.44
2000.000	

Operator notes:

Malvern Instruments Ltd.
Malvern, UK

Mastersizer 2000 Ver. 5.22
Serial Number : MAL102144

File name: Hill
Record Number: 225

MASTERSIZER 2000

Result Analysis Report

Sample Name:
737701.17 JME088 High Surface

Sample Source & type:

Sample bulk lot ref:
2009118/9

SOP Name:
Marine Sediment

Measured by:
rodgers

Result Source:
Measurement

Measured:
Tuesday, 17 November 2009 2:42:05 p.m.

Analysed:
Tuesday, 17 November 2009 2:42:07 p.m.

Particle Name:
Marine Sediment

Particle RI:
1.500

Dispersant Name:
Water

Accessory Name:
Hydro 2000G (A)

Absorption:
0

Dispersant RI:
1.330

Analysis model:
General purpose

Size range:
0.020 to 2000.000 um

Weighted Residual:
0.496 %

Sensitivity:
Enhanced

Obscuration:
22.62 %

Result Emulation:
Off

Concentration:
0.0360 %Vol

Span :
5.506

Uniformity:
2.27

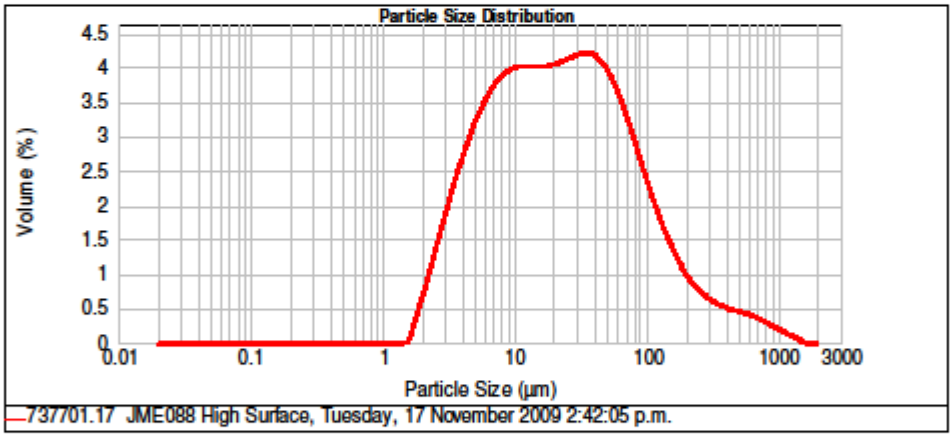
Result units:
Volume

Specific Surface Area:
0.516 m²/g

Surface Weighted Mean D[3,2]:
11.634 um

Vol Weighted Mean D[4,3]:
59.706 um

d(0.1): 4.431 um **d(0.5):** 22.051 um **d(0.9):** 125.843 um



Size (µm)	Volume In %
0.050	0.00
0.060	0.00
0.120	0.00
0.240	0.00
0.490	0.00
0.700	0.00
0.980	0.00

Size (µm)	Volume In %
0.980	0.50
2.000	7.19
3.900	15.13
7.800	18.08
15.600	18.30
31.000	4.86
37.000	

Size (µm)	Volume In %
37.000	4.72
44.000	4.89
53.000	4.22
63.000	3.55
74.000	3.33
88.000	2.85
105.000	

Size (µm)	Volume In %
105.000	2.31
125.000	1.87
149.000	1.47
177.000	1.18
210.000	0.98
250.000	0.84
300.000	

Size (µm)	Volume In %
300.000	0.61
350.000	0.64
420.000	0.55
500.000	0.46
590.000	0.48
710.000	0.36
840.000	

Size (µm)	Volume In %
840.000	0.29
1000.000	0.32
2000.000	

Operator notes:

Malvern Instruments Ltd.
Malvern, UK

Mastersizer 2000 Ver. 5.22
Serial Number : MAL102144

File name: Hill
Record Number: 226

MASTERSIZER 2000

Result Analysis Report

Sample Name:
737701.18 JME 088 High Deep

SOP Name:
Marine Sediment

Measured:
Tuesday, 17 November 2009 2:49:16 p.m.

Sample Source & type:

Measured by:
rodgers

Analysed:
Tuesday, 17 November 2009 2:49:17 p.m.

Sample bulk lot ref:
2009118/10

Result Source:
Measurement

Particle Name:
Marine Sediment

Accessory Name:
Hydro 2000G (A)

Analysis model:
General purpose

Sensitivity:
Enhanced

Particle RI:
1.500

Absorption:
0

Size range:
0.020 to 2000.000 um

Obscuration:
23.37 %

Dispersant Name:
Water

Dispersant RI:
1.330

Weighted Residual:
3.394 %

Result Emulation:
Off

Concentration:
0.1687 %Vol

Span :
1.974

Uniformity:
0.558

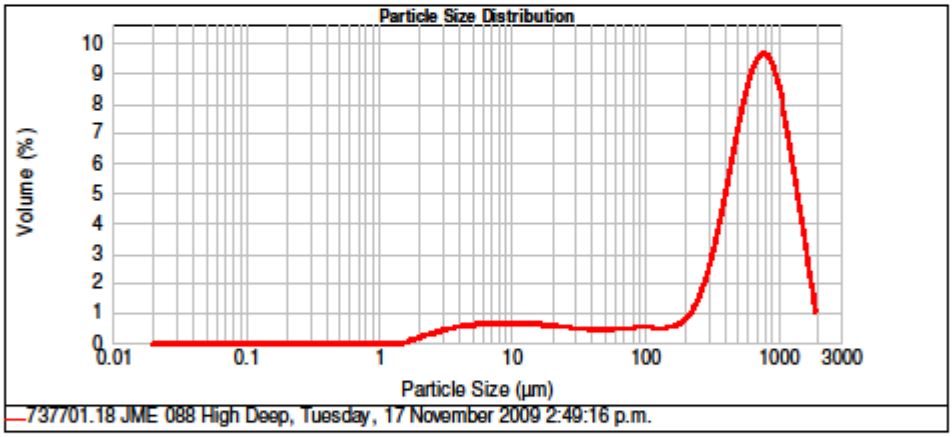
Result units:
Volume

Specific Surface Area:
0.11 m²/g

Surface Weighted Mean D[3,2]:
54.325 um

Vol Weighted Mean D[4,3]:
674.847 um

d(0.1): 27.275 um **d(0.5):** 640.207 um **d(0.9):** 1291.196 um



Size (µm)	Volume In %
0.050	0.00
0.060	0.00
0.120	0.00
0.240	0.00
0.490	0.00
0.700	0.00
0.980	0.00

Size (µm)	Volume In %
0.980	0.17
2.000	1.71
3.900	2.88
7.800	3.07
15.600	2.61
31.000	0.57
37.000	

Size (µm)	Volume In %
37.000	0.53
44.000	0.57
53.000	0.54
63.000	0.53
74.000	0.60
88.000	0.62
105.000	

Size (µm)	Volume In %
105.000	0.61
125.000	0.60
149.000	0.64
177.000	0.83
210.000	1.32
250.000	2.33
300.000	

Size (µm)	Volume In %
300.000	3.12
350.000	5.48
420.000	7.37
500.000	8.65
590.000	11.13
710.000	10.62
840.000	

Size (µm)	Volume In %
840.000	10.49
1000.000	22.52
2000.000	

Operator notes:

Malvern Instruments Ltd.
Malvern, UK

Mastersizer 2000 Ver. 5.22
Serial Number : MAL102144

File name: Hill
Record Number: 227

MALVERN INSTRUMENTS

MASTERSIZER 2000

Result Analysis Report

Sample Name:
737701.23 East FCC New 1 Surface

SOP Name:
Marine Sediment

Measured:
Wednesday, 18 November 2009 9:23:28 a.m.

Sample Source & type:

Measured by:
rodgers

Analysed:
Wednesday, 18 November 2009 9:23:29 a.m.

Sample bulk lot ref:
2009118/11

Result Source:
Measurement

Particle Name:
Marine Sediment

Accessory Name:
Hydro 2000G (A)

Analysis model:
General purpose

Sensitivity:
Enhanced

Particle RI:
1.500

Absorption:
0

Size range:
0.020 to 2000.000 um

Obscuration:
19.65 %

Dispersant Name:
Water

Dispersant RI:
1.330

Weighted Residual:
0.446 %

Result Emulation:
Off

Concentration:
0.0409 %Vol

Span :
5.906

Uniformity:
1.92

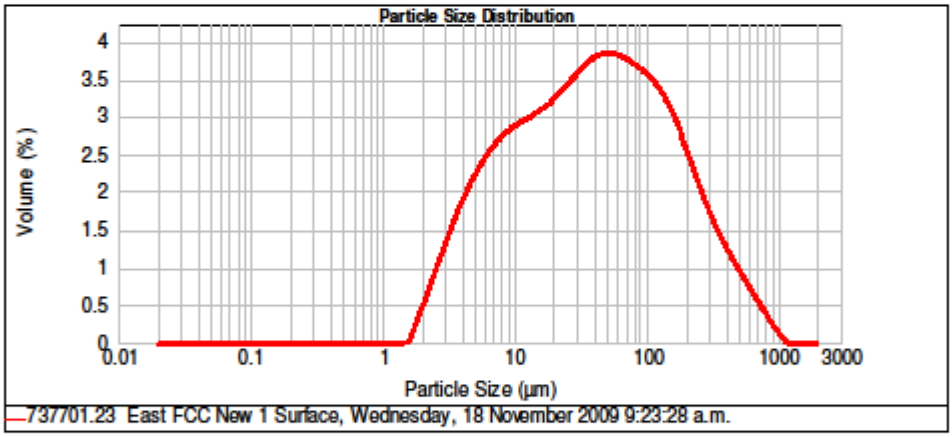
Result units:
Volume

Specific Surface Area:
0.386 m²/g

Surface Weighted Mean D[3,2]:
15.542 um

Vol Weighted Mean D[4,3]:
91.098 um

d(0.1): 5.436 um **d(0.5):** 39.519 um **d(0.9):** 238.834 um



Size (µm)	Volume In %
0.050	0.00
0.060	0.00
0.120	0.00
0.240	0.00
0.490	0.00
0.700	0.00
0.980	0.00

Size (µm)	Volume In %
0.980	0.36
2.000	5.08
3.900	10.58
7.800	13.22
15.600	14.88
31.000	4.25
37.000	

Size (µm)	Volume In %
37.000	4.29
44.000	4.67
53.000	4.33
63.000	3.97
74.000	4.19
88.000	4.15
105.000	

Size (µm)	Volume In %
105.000	3.94
125.000	3.74
149.000	3.37
177.000	2.99
210.000	2.63
250.000	2.31
300.000	

Size (µm)	Volume In %
300.000	1.63
350.000	1.60
420.000	1.25
500.000	0.95
590.000	0.80
710.000	0.48
840.000	

Size (µm)	Volume In %
840.000	0.26
1000.000	0.07
2000.000	

Operator notes:

Malvern Instruments Ltd.
Malvern, UK

Mastersizer 2000 Ver. 5.22
Serial Number : MAL102144

File name: Hill
Record Number: 228

MALVERN INSTRUMENTS

MASTERSIZER 2000

Result Analysis Report

Sample Name:
737701.25 East FCC New 1 Deep

Sample Source & type:

Sample bulk lot ref:
2009118/12

SOP Name:
Marine Sediment

Measured by:
rodgers

Result Source:
Measurement

Measured:
Wednesday, 18 November 2009 9:31:24 a.m.

Analysed:
Wednesday, 18 November 2009 9:31:25 a.m.

Particle Name:
Marine Sediment

Particle RI:
1.500

Dispersant Name:
Water

Accessory Name:
Hydro 2000G (A)

Absorption:
0

Dispersant RI:
1.330

Analysis model:
General purpose

Size range:
0.020 to 2000.000 um

Weighted Residual:
2.612 %

Sensitivity:
Enhanced

Obscuration:
24.17 %

Result Emulation:
Off

Concentration:
0.1203 %Vol

Specific Surface Area:
0.16 m²/g

Span :
2.221

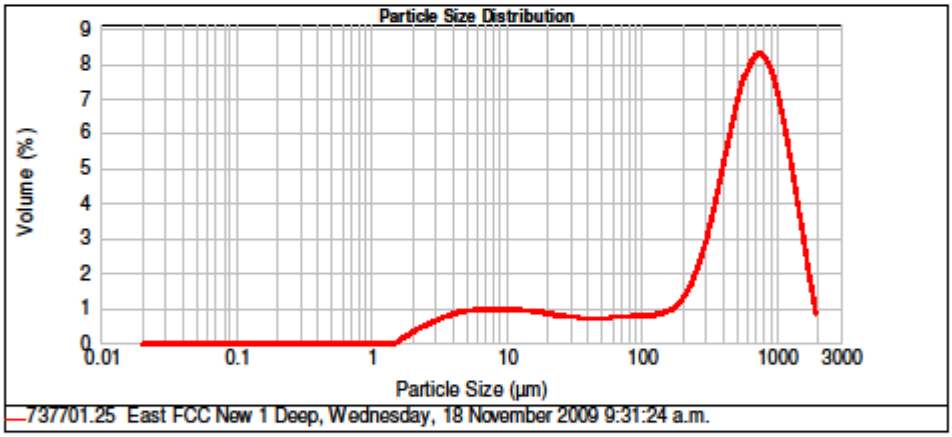
Surface Weighted Mean D[3,2]:
37.600 um

Uniformity:
0.675

Vol Weighted Mean D[4,3]:
587.167 um

Result units:
Volume

d(0.1): 12.280 um **d(0.5):** 545.038 um **d(0.9):** 1222.731 um



Size (µm)	Volume In %
0.050	0.00
0.060	0.00
0.120	0.00
0.240	0.00
0.490	0.00
0.700	0.00
0.980	0.00

Size (µm)	Volume In %
0.980	0.28
2.000	2.56
3.900	4.23
7.800	4.41
15.600	3.71
31.000	0.84
37.000	

Size (µm)	Volume In %
37.000	0.81
44.000	0.87
53.000	0.82
63.000	0.79
74.000	0.87
88.000	0.91
105.000	

Size (µm)	Volume In %
105.000	0.91
125.000	0.96
149.000	1.07
177.000	1.33
210.000	1.89
250.000	2.89
300.000	

Size (µm)	Volume In %
300.000	3.45
350.000	5.55
420.000	6.90
500.000	7.85
590.000	9.76
710.000	9.08
840.000	

Size (µm)	Volume In %
840.000	8.81
1000.000	18.46
2000.000	

Operator notes:

Malvern Instruments Ltd.
Malvern, UK

Mastersizer 2000 Ver. 5.22
Serial Number : MAL102144

File name: Hill
Record Number: 229

MASTERSIZER 2000

Result Analysis Report

Sample Name:
737701.29 JME090 Surface

Sample Source & type:

Sample bulk lot ref:
2009118/13

SOP Name:
Marine Sediment

Measured by:
rodgers

Result Source:
Measurement

Measured:
Wednesday, 18 November 2009 9:40:06 a.m.

Analysed:
Wednesday, 18 November 2009 9:40:07 a.m.

Particle Name:
Marine Sediment

Particle RI:
1.500

Dispersant Name:
Water

Accessory Name:
Hydro 2000G (A)

Absorption:
0

Dispersant RI:
1.330

Analysis model:
General purpose

Size range:
0.020 to 2000.000 um

Weighted Residual:
0.522 %

Sensitivity:
Enhanced

Obscuration:
20.25 %

Result Emulation:
Off

Concentration:
0.0578 %Vol

Specific Surface Area:
0.282 m²/g

Span :
3.952

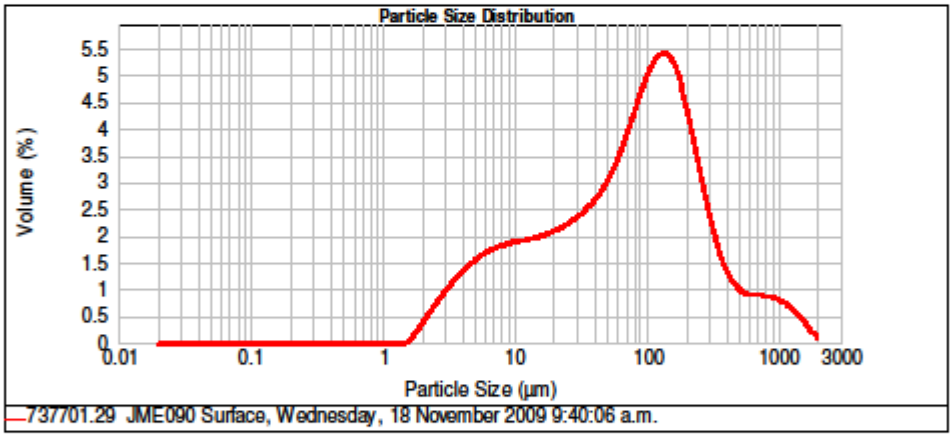
Surface Weighted Mean D[3,2]:
21.300 um

Uniformity:
1.51

VoL Weighted Mean D[4,3]:
154.974 um

Result units:
Volume

d(0.1): 6.973 um **d(0.5):** 82.911 um **d(0.9):** 334.677 um



Size (µm)	Volume In %
0.050	0.00
0.060	0.00
0.120	0.00
0.240	0.00
0.490	0.00
0.700	0.00
0.980	0.00

Size (µm)	Volume In %
0.980	0.28
2.000	3.75
3.900	7.29
7.800	8.67
15.600	9.68
31.000	2.85
37.000	

Size (µm)	Volume In %
37.000	3.02
44.000	3.58
53.000	3.76
63.000	3.99
74.000	4.90
88.000	5.62
105.000	

Size (µm)	Volume In %
105.000	5.62
125.000	6.21
149.000	5.84
177.000	5.16
210.000	4.35
250.000	3.46
300.000	

Size (µm)	Volume In %
300.000	2.14
350.000	1.82
420.000	1.29
500.000	1.05
590.000	1.09
710.000	0.98
840.000	

Size (µm)	Volume In %
840.000	0.98
1000.000	2.26
2000.000	

Operator notes:

Malvern Instruments Ltd.
Malvern, UK

Mastersizer 2000 Ver. 5.22
Serial Number : MAL102144

File name: Hill
Record Number: 230

MALVERN INSTRUMENTS

MASTERSIZER 2000

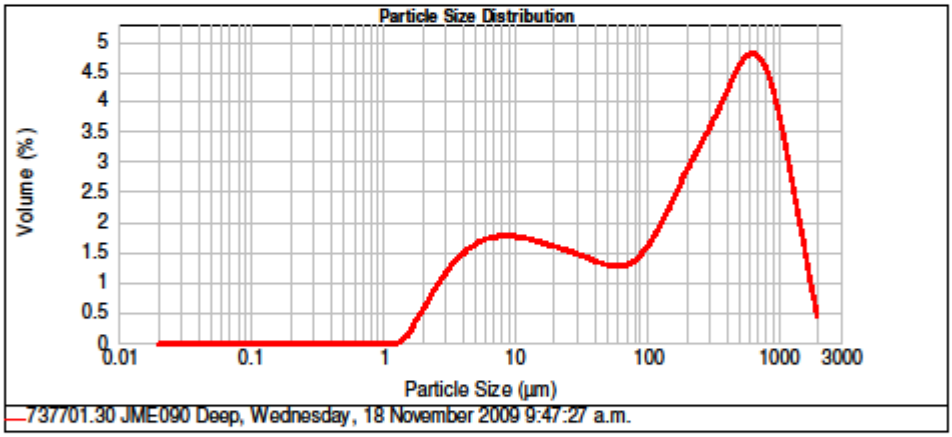
Result Analysis Report

Sample Name: 737701.30 JME090 Deep
SOP Name: Marine Sediment
Measured: Wednesday, 18 November 2009 9:47:27 a.m.
Sample Source & type:
Measured by: rodgers
Analysed: Wednesday, 18 November 2009 9:47:28 a.m.
Sample bulk lot ref: 2009118/14
Result Source: Measurement

Particle Name: Marine Sediment
Accessory Name: Hydro 2000G (A)
Analysis model: General purpose
Sensitivity: Enhanced
Particle RI: 1.500
Absorption: 0
Size range: 0.020 to 2000.000 um
Obscuration: 23.95 %
Dispersant Name: Water
Dispersant RI: 1.330
Weighted Residual: 1.097 %
Result Emulation: Off

Concentration: 0.0670 %Vol
Span : 4.353
Uniformity: 1.4
Result units: Volume
Specific Surface Area: 0.283 m²/g
Surface Weighted Mean D[3,2]: 21.201 um
Vol Weighted Mean D[4,3]: 370.443 um

d(0.1): 6.206 um **d(0.5):** 223.958 um **d(0.9):** 961.044 um



Size (µm)	Volume In %
0.050	0.00
0.060	0.00
0.120	0.00
0.240	0.00
0.490	0.00
0.700	0.00
0.980	0.00

Size (µm)	Volume In %
0.980	0.61
2.000	4.50
3.900	7.52
7.800	7.90
15.600	7.07
31.000	1.66
37.000	

Size (µm)	Volume In %
37.000	1.55
44.000	1.59
53.000	1.43
63.000	1.35
74.000	1.54
88.000	1.77
105.000	

Size (µm)	Volume In %
105.000	2.04
125.000	2.41
149.000	2.74
177.000	3.08
210.000	3.40
250.000	4.02
300.000	

Size (µm)	Volume In %
300.000	3.72
350.000	4.80
420.000	5.01
500.000	5.07
590.000	5.80
710.000	5.08
840.000	

Size (µm)	Volume In %
840.000	4.74
1000.000	9.52
2000.000	

Operator notes:

Malvern Instruments Ltd.
Malvern, UK

Mastersizer 2000 Ver. 5.22
Serial Number : MAL102144

File name: Hill
Record Number: 231

MASTERSIZER 2000

Result Analysis Report

Sample Name:
737701.31 East Control Hunter Brown

Sample Source & type:

Sample bulk lot ref:
2009118/15

SOP Name:
Marine Sediment

Measured by:
rodgers

Result Source:
Measurement

Measured:
Wednesday, 18 November 2009 9:54:45 a.m.

Analysed:
Wednesday, 18 November 2009 9:54:46 a.m.

Particle Name:
Marine Sediment

Particle RI:
1.500

Dispersant Name:
Water

Accessory Name:
Hydro 2000G (A)

Absorption:
0

Dispersant RI:
1.330

Analysis model:
General purpose

Size range:
0.020 to 2000.000 um

Weighted Residual:
0.898 %

Sensitivity:
Enhanced

Obscuration:
23.94 %

Result Emulation:
Off

Concentration:
0.1190 %Vol

Span :
1.578

Uniformity:
0.438

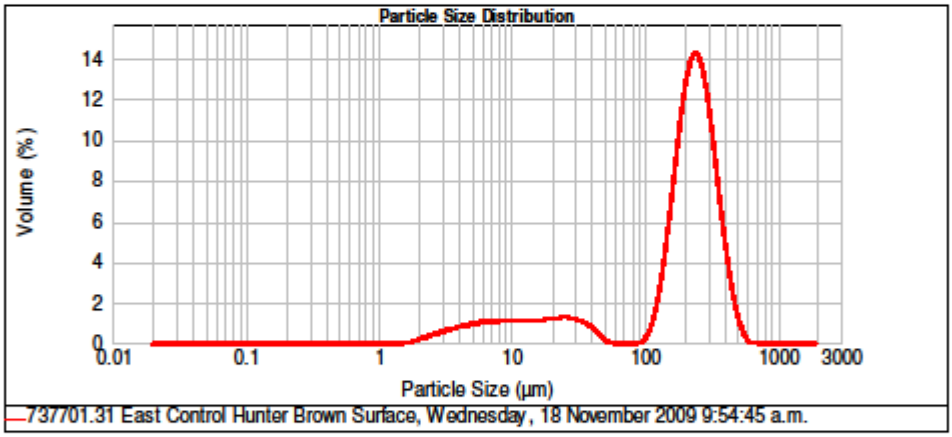
Result units:
Volume

Specific Surface Area:
0.167 m²/g

Surface Weighted Mean D[3,2]:
36.010 um

Vol Weighted Mean D[4,3]:
205.241 um

d(0.1): 12.095 um **d(0.5):** 214.581 um **d(0.9):** 350.773 um



Size (µm)	Volume In %
0.050	0.00
0.060	0.00
0.120	0.00
0.240	0.00
0.490	0.00
0.700	0.00
0.980	0.00

Size (µm)	Volume In %
0.980	0.13
2.000	2.22
3.900	4.49
7.800	5.03
15.600	5.48
31.000	1.23
37.000	

Size (µm)	Volume In %
37.000	0.83
44.000	0.30
53.000	0.00
63.000	0.00
74.000	0.00
88.000	0.14
105.000	

Size (µm)	Volume In %
105.000	1.37
125.000	4.46
149.000	8.96
177.000	13.43
210.000	16.15
250.000	15.73
300.000	

Size (µm)	Volume In %
300.000	9.98
350.000	6.85
420.000	2.64
500.000	0.61
590.000	0.02
710.000	0.00
840.000	

Size (µm)	Volume In %
840.000	0.00
1000.000	0.00
2000.000	

Operator notes:

Malvern Instruments Ltd.
Malvern, UK

Mastersizer 2000 Ver. 5.22
Serial Number : MAL102144

File name: Hill
Record Number: 232

Hill Laboratories
BETTER TESTING BETTER RESULTS
R J Hill Laboratories Limited
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Private Bag 3205
Hamilton 3240, New Zealand
Tel +64 7 858 2000
Fax +64 7 858 2001
Email mail@hill-labs.co.nz
Web www.hill-labs.co.nz

ANALYSIS REPORT

Client:	Davidson Environmental Ltd	**Lab No:**	742780	SPv1
Contact:	R Davidson	**Date Registered:**	11-Nov-2009	
	C/- Davidson Environmental Ltd	**Date Reported:**	24-Nov-2009	
	PO Box 958	**Quote No:**	38556	
	Nelson 7040	**Order No:**		
		Client Reference:	Mapua Stream	
		Submitted By:	R Davidson	

Sample Type: Sediment

Sample Name:		Stream Low 17m Surface 10-Nov-2009 2:43 pm	Stream Middle 56m Surface 10-Nov-2009 2:52 pm	Stream Upper 84m Surface 10-Nov-2009 3:02 pm		
Lab Number:		742780.1	742780.2	742780.3		
Individual Tests						
Total Organic Carbon	g/100g dry wt	2.2	2.4	2.5	-	-
Organochlorine Pesticides Trace in Soil						
Aldrin	mg/kg dry wt	0.0068	0.0047	0.0075	-	-
alpha-BHC	mg/kg dry wt	< 0.00099	< 0.00099	< 0.00098	-	-
beta-BHC	mg/kg dry wt	< 0.00099	< 0.00099	< 0.00098	-	-
delta-BHC	mg/kg dry wt	< 0.00099	< 0.00099	< 0.00098	-	-
gamma-BHC (Lindane)	mg/kg dry wt	0.0038	0.0025	0.0028	-	-
cis-chlordane	mg/kg dry wt	< 0.00099	< 0.00099	< 0.00098	-	-
trans-chlordane	mg/kg dry wt	< 0.00099	< 0.00099	< 0.00098	-	-
2,4'-DDD	mg/kg dry wt	0.34	0.19	0.36	-	-
4,4'-DDD	mg/kg dry wt	0.93	0.30	1.1	-	-
2,4'-DDE	mg/kg dry wt	0.20	0.11	0.18	-	-
4,4'-DDE	mg/kg dry wt	1.2	0.32	1.2	-	-
2,4'-DDT	mg/kg dry wt	0.041	0.027	0.12	-	-
4,4'-DDT	mg/kg dry wt	0.20	0.14	2.4	-	-
Dieldrin	mg/kg dry wt	0.076	0.054	0.050	-	-
Endosulfan I	mg/kg dry wt	< 0.00099	< 0.00099	< 0.00098	-	-
Endosulfan II	mg/kg dry wt	< 0.00099	< 0.00099	< 0.00098	-	-
Endosulfan sulphate	mg/kg dry wt	< 0.00099	< 0.00099	< 0.00098	-	-
Endrin	mg/kg dry wt	< 0.00099	< 0.00099	< 0.00098	-	-
Endrin aldehyde	mg/kg dry wt	< 0.00099	< 0.00099	< 0.00098	-	-
Endrin Ketone	mg/kg dry wt	< 0.00099	< 0.00099	< 0.00098	-	-
Heptachlor	mg/kg dry wt	< 0.00099	< 0.00099	< 0.00098	-	-
Heptachlor epoxide	mg/kg dry wt	< 0.00099	< 0.00099	< 0.00098	-	-
Hexachlorobenzene	mg/kg dry wt	< 0.00099	< 0.00099	< 0.00098	-	-
Methoxychlor	mg/kg dry wt	< 0.00099	< 0.00099	< 0.00098	-	-
Total Chlordane [(cis+trans)* 100/42]	mg/kg dry wt	< 0.0020	< 0.0020	< 0.0020	-	-

Analyst's Comments

Appendix No.1 - Particle Size Analysis Report

Appendix No.2 - Particle Size Analysis Report

SUMMARY OF METHODS

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively clean matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis.

Sample Type: Sediment			
Test	**Method Description**	**Default Detection Limit**	**Samples**
Environmental Solids Sample Preparation	Air dried at 35°C and sieved, <2mm fraction.	-	1-3
Organochlorine Pesticides Trace in Soil	Sonication extraction, SPE cleanup, GPC cleanup (if required), dual column GC-ECD analysis	-	1-3
Particle size analysis*	Malvern Laser Sizer particle size analysis. Subcontracted to Earth Sciences Department, Waikato University, Hamilton.	-	1, 3
Total Organic Carbon	Acid pretreatment to remove carbonates if present, Elementar Combustion Analyser.	0.050 g/100g dry wt	1-3

These samples were collected by yourselves (or your agent) and analysed as received at the laboratory.

Samples are held at the laboratory after reporting for a length of time depending on the preservation used and the stability of the analytes being tested. Once the storage period is completed the samples are discarded unless otherwise advised by the client.

Ara Heron BSc (Tech)
Client Services Manager - Environmental Division

MASTERSIZER 2000

Result Analysis Report

Sample Name:
742780.1 Stream Low 17m Surface

Sample Source & type:

Sample bulk lot ref:
2009126/1

SOP Name:
Marine Sediment

Measured by:
rodgers

Result Source:
Measurement

Measured:
Wednesday, 18 November 2009 11:22:21 a.m.

Analysed:
Wednesday, 18 November 2009 11:22:22 a.m.

Particle Name:
Marine Sediment

Particle RI:
1.500

Dispersant Name:
Water

Accessory Name:
Hydro 2000G (A)

Absorption:
0

Dispersant RI:
1.330

Analysis model:
General purpose

Size range:
0.020 to 2000.000 um

Weighted Residual:
0.612 %

Sensitivity:
Enhanced

Obscuration:
18.23 %

Result Emulation:
Off

Concentration:
0.0415 %Vol

Span :
12.478

Uniformity:
3.38

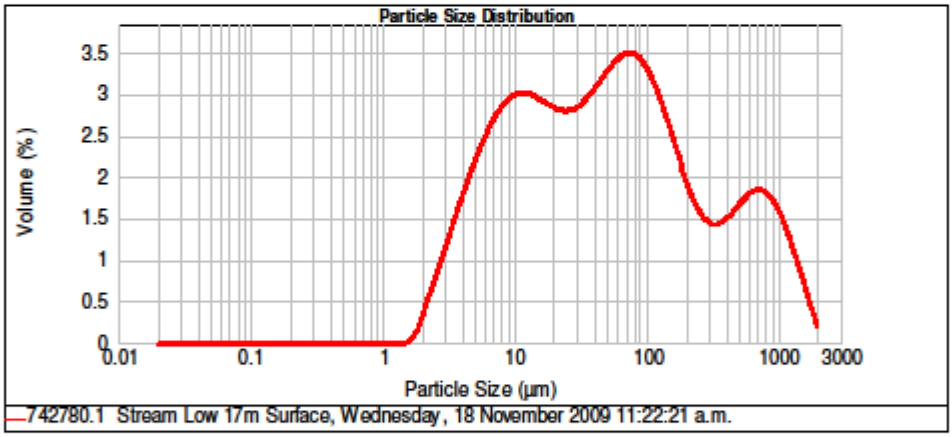
Result units:
Volume

Specific Surface Area:
0.355 m²/g

Surface Weighted Mean D[3,2]:
16.906 um

Vol Weighted Mean D[4,3]:
179.899 um

d(0.1): 5.801 um **d(0.5):** 48.149 um **d(0.9):** 606.576 um



Size (µm)	Volume In %
0.050	0.00
0.060	0.00
0.120	0.00
0.240	0.00
0.490	0.00
0.700	0.00
0.980	0.00

Size (µm)	Volume In %
0.980	0.18
2.000	4.39
3.900	10.56
7.800	13.44
15.600	12.74
31.000	3.36
37.000	

Size (µm)	Volume In %
37.000	3.46
44.000	3.93
53.000	3.82
63.000	3.65
74.000	3.93
88.000	3.87
105.000	

Size (µm)	Volume In %
105.000	3.55
125.000	3.19
149.000	2.70
177.000	2.37
210.000	1.97
250.000	1.80
300.000	

Size (µm)	Volume In %
300.000	1.44
350.000	1.75
420.000	1.81
500.000	1.87
590.000	2.21
710.000	2.01
840.000	

Size (µm)	Volume In %
840.000	1.94
1000.000	4.16
2000.000	

Operator notes:

Malvern Instruments Ltd.
Malvern, UK

Mastersizer 2000 Ver. 5.22
Serial Number : MAL102144

File name: Hill
Record Number: 233

MALVERN INSTRUMENTS

MASTERSIZER 2000

Result Analysis Report

Sample Name:
742780.3 Stream Upper 84m Surface

Sample Source & type:

Sample bulk lot ref:
2009126/2

SOP Name:
Marine Sediment

Measured by:
rodgers

Result Source:
Measurement

Measured:
Wednesday, 18 November 2009 11:30:51 a.m.

Analysed:
Wednesday, 18 November 2009 11:30:52 a.m.

Particle Name:
Marine Sediment

Particle RI:
1.500

Dispersant Name:
Water

Accessory Name:
Hydro 2000G (A)

Absorption:
0

Dispersant RI:
1.330

Analysis model:
General purpose

Size range:
0.020 to 2000.000 um

Weighted Residual:
0.944 %

Sensitivity:
Enhanced

Obscuration:
21.58 %

Result Emulation:
Off

Concentration:
0.0862 %Vol

Specific Surface Area:
0.212 m²/g

Span :
6.465

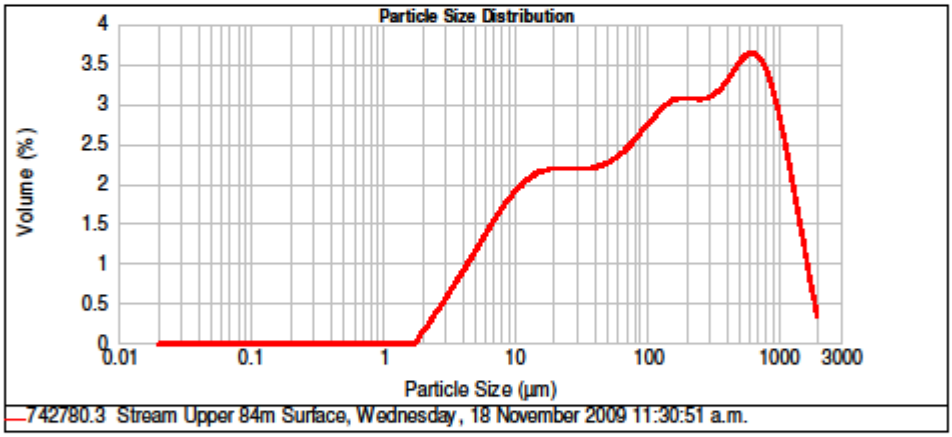
Surface Weighted Mean D[3,2]:
28.325 um

Uniformity:
1.96

Vol Weighted Mean D[4,3]:
303.619 um

Result units:
Volume

d(0.1): 9.383 um **d(0.5):** 133.521 um **d(0.9):** 872.629 um



Size (µm)	Volume In %
0.050	0.00
0.060	0.00
0.120	0.00
0.240	0.00
0.490	0.00
0.700	0.00
0.980	0.00

Size (µm)	Volume In %
0.980	0.04
2.000	2.10
3.900	5.73
7.800	8.86
15.600	9.81
31.000	2.53
37.000	

Size (µm)	Volume In %
37.000	2.50
44.000	2.73
53.000	2.62
63.000	2.55
74.000	2.89
88.000	3.12
105.000	

Size (µm)	Volume In %
105.000	3.25
125.000	3.42
149.000	3.44
177.000	3.44
210.000	3.50
250.000	3.65
300.000	

Size (µm)	Volume In %
300.000	3.14
350.000	3.85
420.000	3.89
500.000	3.87
590.000	4.40
710.000	3.85
840.000	

Size (µm)	Volume In %
840.000	3.59
1000.000	7.24
2000.000	

Operator notes:

Malvern Instruments Ltd.
Malvern, UK

Mastersizer 2000 Ver. 5.22
Serial Number : MAL102144

File name: Hill
Record Number: 234

Appendix 7. Percentage of total sample > 2000 µm.

Sample Name	>2000
737701.1 FCC West Control Surface	29.73
737701.2 FCC West Control Control	6.96
737701.3 JME083 Surface	18.72
737701.4 JME083 Deep	72.56
737701.5 JME081 Surface	35.53
737701.6 JME081 Deep	60.47
737701.11 FCC 2 West (2) Mid surface	0.00
737701.12 FCC 2 (Mid) Deep	0.00
737701.17 JME088 High Surface	0.00
737701.18 JME 088 High Deep	56.22
737701.23 East FCC New 1 Surface	8.85
737701.25 East FCC New 1 Deep	62.04
737701.29 JME090 Surface	15.25
737701.30 JME090 Deep	54.80
737701.31 East Control Hunter Brown Surface	2.28

Appendix 8. Summary of % composition of particle < 2000 µm

	% Clay	% Silt	% Sand	% Gravel
Sample Name				
737701.1 FCC West Control Surface	0.11	20.20	50.00	29.73
737701.2 FCC West Control Control	0.22	27.72	65.05	6.96
737701.3 JME083 Surface	0.03	18.96	62.31	18.72
737701.4 JME083 Deep	0.01	3.21	24.18	72.56
737701.5 JME081 Surface	0.09	22.14	42.27	35.53
737701.6 JME081 Deep	0.00	3.16	36.34	60.47
737701.11 FCC 2 West (2) Mid surface	0.23	71.32	28.45	0.00
737701.12 FCC 2 (Mid) Deep	0.15	26.49	73.36	0.00
737701.17 JME088 High Surface	0.50	77.39	22.12	0.00
737701.18 JME 088 High Deep	0.08	5.46	38.26	56.22
737701.23 East FCC New 1 Surface	0.32	55.85	34.92	8.85
737701.25 East FCC New 1 Deep	0.11	6.93	30.96	62.04
737701.29 JME090 Surface	0.24	36.12	48.44	15.25
737701.30 JME090 Deep	0.27	15.01	29.91	54.80
737701.31 East Control Hunter Brown Surface	0.12	19.13	78.44	2.28