Distribution of silty sediments in the shallow subsurface of the shipping channels of Tauranga Harbour

2014

ERI report number 43

Prepared for the Port of Tauranga Ltd

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Cite report as:

de Lange, W.P., Moon, V.G., and Fox, B.R.S., 2014. Distribution of silty sediments in the shallow subsurface of the shipping channels of Tauranga Harbour. *Environmental Research Institute Report No 28*. Client report prepared for Port of Tauranga. Environmental Research Institute, Faculty of Science and Engineering, The University of Waikato, Hamilton. 76 pp.

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Executive summary

Capital dredging in 1992 encountered some areas of siltier sediments that resulted in the formation of a highly visible plume. Subsequently multibeam and diver observations indicated that there are further areas of sediments within the shipping channel whose silt content exceeds the 5% threshold specified in the consent conditions of resource consents 65806 and 65807.

A trial seismic reflection survey was conducted through the entire shipping channels from Stella Passage to A Beacon using a Knudsen Pinger Sub-bottom Profiler. This survey indicated that the harbour sediments consist of Holocene sediments (<7200 years old) overlying a complex topography of Pleistocene deposits. The underlying sediments have been eroded into a ridge and valley morphology that appears to be orientated with the valleys running sub-parallel to the present day open coast shoreline. This older deposit probably occurs underneath the entire length of the shipping channels, but the thickness of overlying Holocene sediment varies: being thicker over the valleys and thinner over the ridges.

The proposed capital dredging will further reduce the Holocene sediment cover, and expose more of the older siltier sediments at the seabed. The existing exposures within the shipping channels do not appear to be susceptible to scour and form a resistant surface with a thin veneer of modern sand, and it is probable that any material exposed during the proposed capital dredging will also be stable.

The proposed capital dredging anticipated the extraction of ~2.1 Mm^3 of silty sediment from Stella Passage, the new Turning Basin, and Tanea Shelf. The seismic survey indicated that additional areas of potentially silty sediment occurred within the Maunganui Roads, Cutter Channel and the Entrance Channel. The Port of Tauranga undertook vibrocoring in the areas identified, and the resulting cores were described and sampled by the University of Waikato.

The core results were used to create a three-dimensional model of the subsurface stratigraphy of the shipping channels that was used to identify areas of silt content exceeding 5%. The likely silt content is indicated by a colour coding: green = less than 5% silt; red = more than 5% silt, which requires management to minimise turbidity during dredging and involves restrictions on disposal options.

Introduction

During the 1991-1992 capital dredging approximately 5 Mm^3 of sediment was removed from the shipping channels, particularly Stella Passage. During dredging in 1992, the trailing cutter-suction dredge encountered sediments within Stella Passage that generated a milky-white turbid plume. This plume was highly visible, and generated some public anxiety about the potential effects on harbour ecology.

Subsequent to the capital dredging, biannual maintenance dredging identified zones within Stella Passage where the drag head of the dredge tended to deviate from the intended path, resulting in incomplete dredging of accumulated sediment. In order to deal with dredgings containing silt, the Port of Tauranga established a new disposal site in deeper water (Site G) than the existing disposal sites, and consent conditions were established that defined 5% silt content as the threshold for disposal at the new site. Under the definitions for the consent, silt was taken to be all sediment finer than 63 μm, even though it is common in sedimentology and engineering geology to distinguish between silt and clay.

Protocols were established to manage and monitor the silt content within dredge hopper loads (*viz*. resource consent 60078 conditions s8.1 & s9), and alternative dredging methodologies adopted were adopted within Tauranga Harbour to minimise the formation of turbid plumes when the expected silt content exceeded 5%.

The Environmental Impact Assessment for the proposed capital-dredging programme identified areas of silty sediment occurring within Stella Passage, the Otumoetai Channel in the area of the proposed Turning Basin, and at depths greater than 2-3 m within the Maunganui Roads (Healy *et al*, 2009). Two main silty units were recognised: a pumiceous unit of varying colour that was interpreted as a distal ignimbrite; and a greenish stiff mud of unknown origin. Healy *et al* (2009) suggested that these units were predominantly Pleistocene sequences deposited during the Stage 5e interglacial around 120,000-125,000 BP, although the greenish mud was thought to be estuarine sediments deposited early in the Holocene (7,000-10,000 BP).

Healy *et al* (2009) reported on a single core taken from Tanea Shelf. The Shelf has been modified by previous capital dredging campaigns in 1968 and 1991-1992 and consists of a predominantly sand and silt sequence, with a weakly cemented outer crust 2-3 metres thick. This crust formed the underwater slope surface before capital dredging commence, and is covered with a variable density of boulders that are typically <1.5 m in diameter. Healy *et al* (2009) indicate that the below the boulders the Shelf is a mixture of shell and gravel, with silty layers starting 3 m below the surface. They also report iron staining, which they attributed to geothermal seepage. No other evidence for geothermal activity was observed.

The Environmental Impact Assessment did not include data from the Entrance Channel, because the coring barge could not operate outside the harbour. It was considered that the ebb tidal (Matakana Banks and Entrance Channel) consisted predominantly of Holocene sand (Hicks and Hume, 1996), although sidescan data suggested that there might be a zone of Pleistocene material along the northwestern margin of the Entrance Channel (Healy et al, 2009).

Subsequent to the Healy *et al* (2009) report, additional evidence indicated that there were more silty areas than detected by the coring and CPT work done for the assessment of environmental effects.

Data collected since the AEE

Fraccascia (in prep) undertook high-resolution side-scan and multibeam echosounder (MBES) surveys of Cutter Channel for her University of Bremen InterCoast PhD investigation into the behaviour of sand waves in tidal channels. This indicated the possible presence of isolated boulders or outcrops of harder materials along the southern margin of the Cutter Channel, and also an erosional planar surface on the southern side of the junction of the Cutter Channel and Maunganui Roads (Figure 1).

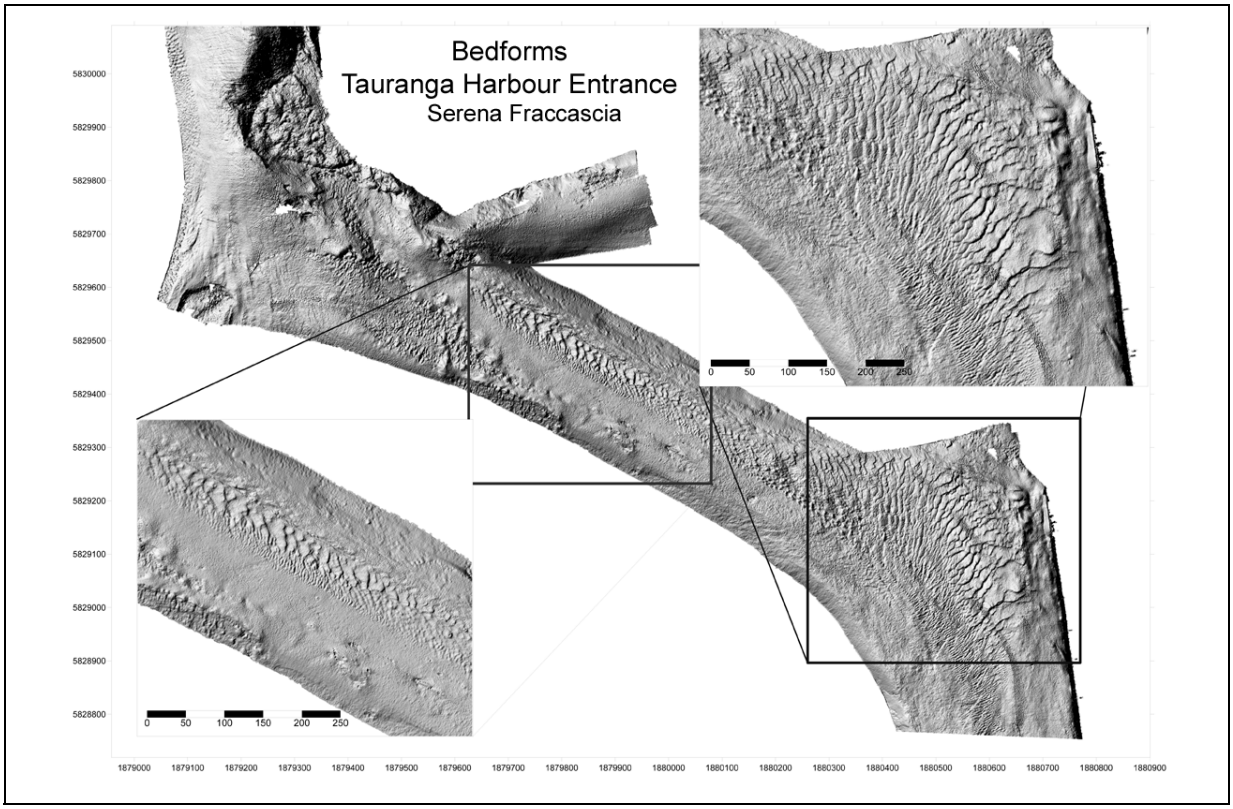

Figure 1. High-resolution 300kHz SIMRAD EM3002 MBES imagery collected in September 2010 by the Universities of Bremen and Waikato for Fraccascia (in prep) PhD research. The enlarged boxes are areas where the data indicated the presence of resistant strata or boulders.

These areas were subsequently examined by the Port of Tauranga using underwater video and divers, and found to have outcrops of silty (38% <63 µm), weakly cemented sediments.

The University of Waikato ran some trial seismic reflection profiles over the western Cutter Channel area with a Knudsen Pinger SBP to see if any strong reflectors indicating the presence of harder strata could be detected. This survey indicated the presence of isolated patches of moderate reflectors, but the data were of poor quality (subsequently it was determined that the manufacturer had installed a key control switch upside down so the instrument was operating in the wrong mode).

The seismic reflection trials focussed primarily on the Stella Passage. As part of an InterCoast PhD project undertaken by Jorat (2014), the University of Bremen brought an experimental submersible CPT (GOST) to Tauranga. This was deployed within Stella Passage in March 2012 (Moon *et al*, 2013), where previous studies had identified the presence of potentially sensitive silty sediments. To assist with the interpretation of the CPT data the seismic reflection trials were conducted in the areas sampled by the CPT probe, and the Port of Tauranga provided core samples collected at the northern end of the Sulphur Pt wharves. Moon *et al* (2013) present the results of a 3D stratigraphic model fitted to the observations and they identified a ridge-and-valley topography infilled with Holocene sands and shells. The trend of the ridges and valleys appeared to be sub-parallel

to the present day open coastline, and almost at right angles to the alignment of the present day ridges and valleys flanking the harbour. The silty outcrops that produced the turbidity problems during the 1991-1992 capital dredging coincided with the crests of the ridges. Moon *et al* (2013) also identified that the presence of halloysite within some units was an indicator of the potential generation of milky white turbid plumes, as well sensitive soil behaviour that could affect the stability of dredged batters.

During the GOST deployment in March 2012, the Port of Tauranga was aware of reports of isolated areas of resistant material within the Entrance Channel. During a period of relatively calm fine weather, GOST was also used to obtain CPT profiles at 4 sites within the Entrance Channel. All 4 sites were found to have a resistant layer at varying depths (0.4-4.0 m)below the seabed, under a veneer of loose sand.

The University of Waikato with assistance from Discovery Marine Limited (DML) then collected a series of seismic reflection profiles along the shipping channels in September 2013 that concentrated on Cutter Channel, the Entrance Channel and Matakana Banks (Figure 2). These were intended to identify the structures associated with the identified resistant areas, assess if any rhyolite flows or boulder deposits extended into the shipping channels, and determine if the ebb tidal delta was draped over a resistant structure that would provide locational stability for a PhD project being undertaken by Andi Ramli (with financial support from Port of Tauranga Ltd).

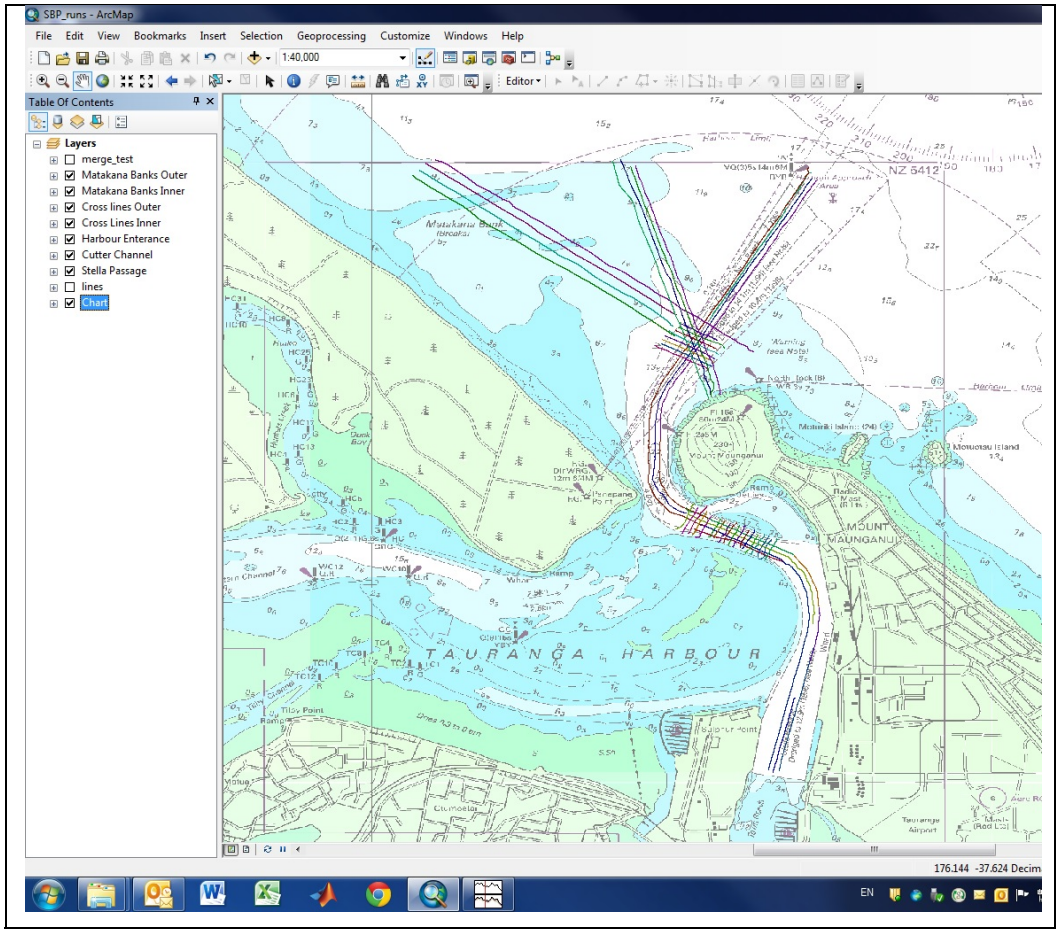

Figure 2. Summary of seismic survey lines collected in September 2013 by the University of Waikato and DML using a 3.5 kHz Knudsen Pinger SBP shallow chirp seismic reflection system.

The seismic survey identified a ridge and valley topography infilled by recent sediment, and indicated that the resistant zones in the Cutter and Entrance Channels represented the crests of ridges. Although this appeared similar to the stratigraphy reported by Moon *et al*

(2013) for Stella Passage, the variability of the onshore geology around Tauranga Harbour, it was considered inappropriate to assume the stratigraphy was constant throughout the shipping channels.

Therefore, the Port of Tauranga undertook vibrocoring at key locations that were identified as being ridge crests that would be exposed by the proposed capital dredging. The University of Waikato described the cores that contained any evidence of sediments older than Holocene deposits, and collected subsamples for textural analysis.

This report summarises the results of the seismic survey, core descriptions, and sediment textural analyses, and identifies areas likely to contain more than 5% of sediment finer than 63 μm.

Methods

Seismic data were collected using SounderSuite-USB software connected to a Knudsen Pinger SBP dual frequency CHIRP portable seismic reflection system operating at 3.5 kHz for seismic and 200 kHz for bottom location. Positional data were also logged by SounderSuite-USB from an OTF kinematic DGPS navigation system. The resulting data were exported to SEG-Y format and processed using Matlab. Some difficulties were experienced with the SounderSuite-USB software, which was not completely compatible with the firmware in the new system, resulting in some data loss when power settings were changed (usually in response to a major change in water depth, such as in the deepest part of the harbour entrance). Further, since the survey was intended as an initial inspection, the Pinger was configured for maximum penetration, which resulted in a loss of resolution, particularly close to the seabed.

The raw Pinger data were examined in PostSurvey, which allowed identification of areas where the underlying ridges came close to the surface. Most of these corresponded to areas already identified by the Port of Tauranga as having resistant surficial deposits. However, some new areas were identified in the Maunganui Roads. The areas identified by the seismic data, and other evidence, were subsequently targeted by a coring programme.

The Pinger SEG-Y data were processed in MATLAB using routines from the package SegyMAT.

The Port of Tauranga, under the supervision of the Port Engineer, Rowan Johnstone, undertook Vibrocoring. Aluminium core barrels were fitted with a core cutter and sediment catcher, and driven in until a maximum depth of 3 m was reached, or there was too much resistance to allow further penetration. The retrieved core barrel was cut to the length of the core obtained, and capped at both ends. The amount of compaction of the contents of the core barrel was not measured.

The core barrels had a small section (about 1/5 of the circumference) cut away to allow Rowan Johnstone to make a description of the core. This included the depth of top of the core and any obvious boundaries measured relative to chart datum (CD). The description included an estimate of the sediment texture (sand, silt, gravel), the colour, any obvious features (such as strong smell), and any evidence of sample loss.

The University of Waikato subsequently photographed and described the cores using standard sedimentological (Dr Bethany Fox) and geotechnical (Dr Vicki Moon) methods. For the purposes of delineating areas of “silty” sediments, the geotechnical core logs are included here (Appendix 2). The descriptions were done for all cores that contained material other than Holocene sands and shells. Cores that appeared to only consist of Holocene sediment were noted, but not described.

Subsamples of 10-20 g were collected from the cores, such that all the units present were sampled. Each sub-sample represented a portion of a 10 mm thick slice of the core. The depth of the sample was recorded as the top of the slice. Wherever possible, a sample was collected at a standard distance of 50 mm from the top of the core to represent the surficial sediment texture. In some cores, too much material had been lost from the top of the core to allow sampling to occur for the top of the core. Samples of nodules, concretions and organic matter were also taken separately from the sediment texture samples.

The sub-samples were further sub-sampled to provide <1 g of sample for the Malvern Lasersizer. The sub-sampled sediment was pre-sieved through a 2 mm sieve to prevent blockages in the Lasersizer, and then the size distribution between 0.05 and 2000 µm was measured. The distribution was analysed using the moment method to determine the sediment textural parameters, and the proportions of sand, silt, clay and fines (silt + clay or <63µm) were determined. The silt:clay boundary was taken to be 2 µm. The detailed textural analysis results are presented in Appendix 1.

The core photos, descriptions and summaries of the textural analysis were displayed on the core geotechnical log sheets (Appendix 2). These highlight the silt content in the grain size column using green for units with less than 5% fines, and red for units that exceed 5% silt. The actual proportions are given for the depths sampled as sand % fine % (eg. s 56 f 44 indicates 44% finer than 63 µm).

ArcGIS was used to map the extents of silty deposits using recent MBES survey data for the shipping channels provided by DML to represent the bathymetry. Leapfrog 3D geological modelling software was also used to analyse the distributions and produce a model that can be sliced at any depth. However, time constraints meant that only the ArcGIS results are reported here.

Sub-surface stratigraphy and silt distribution observations

The following sections consider specific regions of the shipping channels where silty sediment and/or resistant strata have been identified that may influence dredging procedures as specified in the resource consent conditions.

Entrance Channel

The Entrance Channel is presently maintained at a design depth of 14.1 m, with a shallower shelf at 10.4 m on the eastern side of channel (Figure 3A). The AEE considered deepening the main part of the channel to 17.4 m. However, dredging of the Entrance Channel is now planned to a depth of 16.0 m, with a 0.2 m allowance for over-dredging. Therefore, the focus for this report was the silt content of sediments shallower than 16 m CD, corresponding to a deepening of ~2 m.

A single seismic profile (0030-274-1112) was obtained through the four GOST CPT sites within the Entrance Channel as part of a survey down the axis of the channel (Figure 3B). Most of the other profiles collected were transverse to the Channel and were primarily looking at the Matakana Banks area of the ebb tidal delta. All the profiles indicated a sequence of ridges and valleys underlying the Channel and Matakana Banks (Figure 4 and Appendix 1). They also show that the Mt Maunganui rhyolite dome does not extend into the shallow subsurface under the Channel.

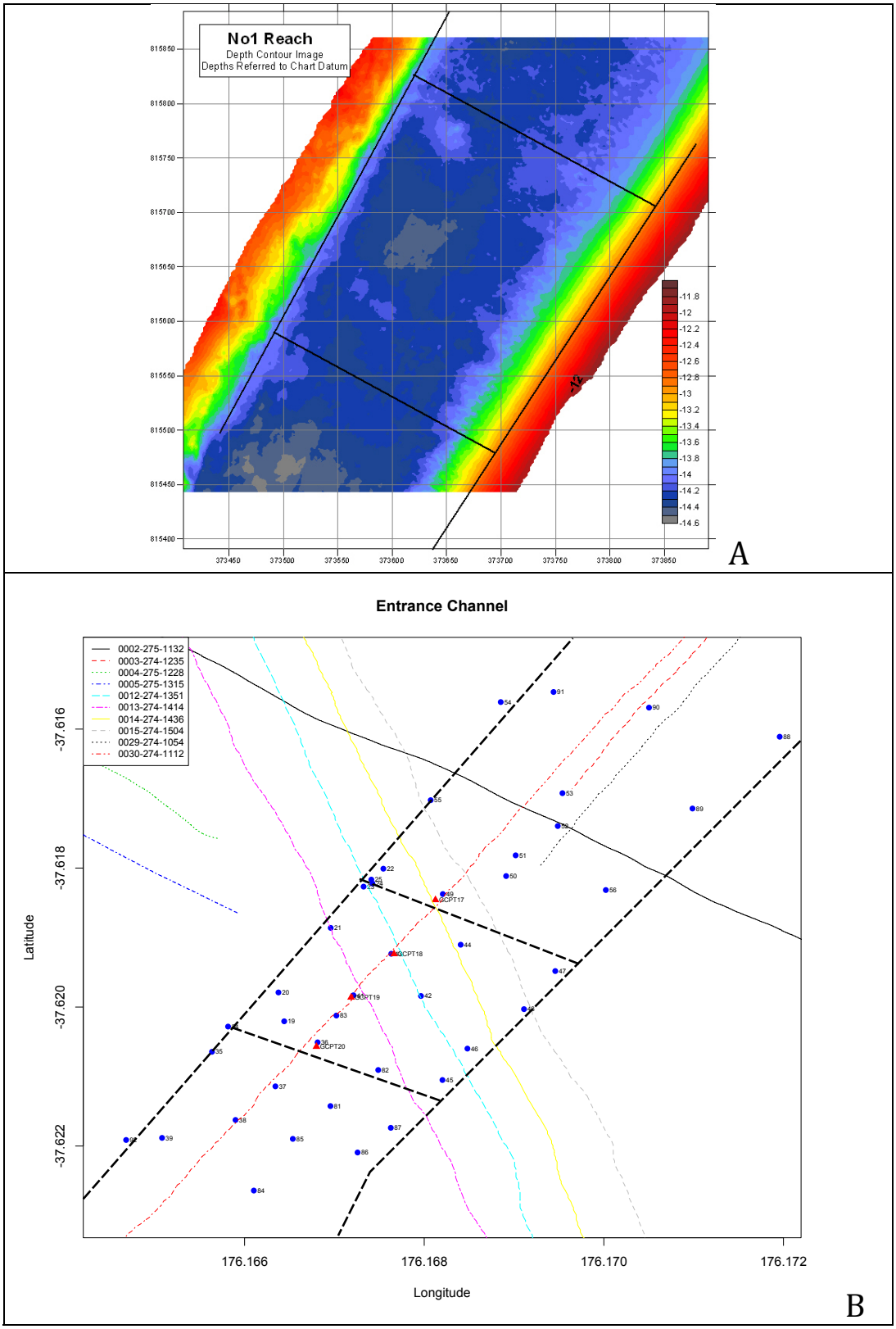

Figure 3. R2Sonic 2022 (400 kHz) MBES bathymetry provided by DML (A) and locations of seismic reflection profiles, CPT profiles, and vibrocorer samples within the Entrance Channel (No 1 Reach).

A total of 43 sites were cored within the Entrance Channel (Figure 3). Sampling focussed initially on the area where earlier studies suggested there may be an exposure of non-Holocene sediment or ignimbrite (Healy *et al*, 2009) and the seismic profiles indicated the presence of a ridge. Four cores corresponded to the locations CPT profiles obtained by

GOST in March 2012. The cores were highly variable in both stratigraphy and depth of penetration. Hence, the sampling programme expanded along the axis of the channel in order to locate the onset of sufficient thickness of Holocene sediment that would exceed the proposed depth of the capital dredging.

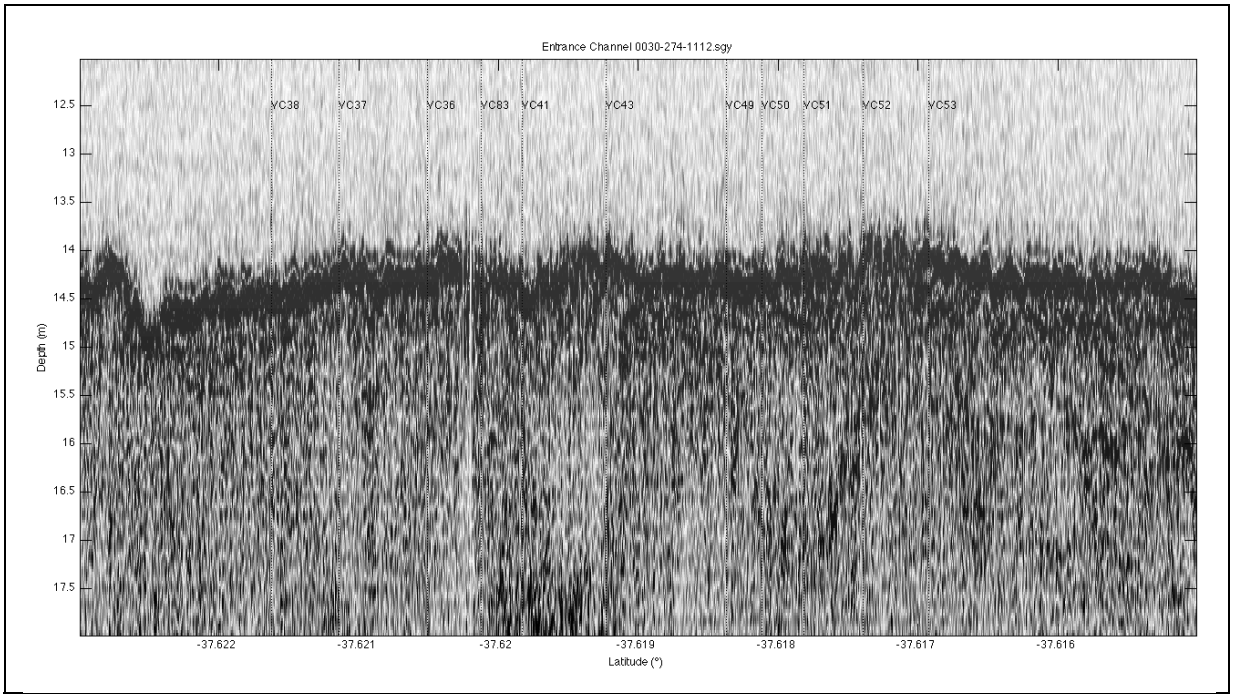

Figure 4. Section of seismic profile 0030-274-1112 for the region of the Entrance Channel vibrocored by the Port of Tauranga (Figure 3). This profile runs from SW to NE (left to right). Four core locations coincided with the GOST CPT profiles: VC36=CPT20; VC41=CPT19; VC43=CPT18; and VC49=CPT17.

Several of the cores were unable to penetrate a shallow subsurface resistant layer. However, there was no consistent relationship between the CPT data and the vibrocorer maximum penetration (Table 1). When GOST was deployed in the Entrance Channel, it was not equipped with an automatic system for stopping when the tip encountered resistance that could break the probe. Therefore, the operators were manually stopping the test when tip resistance began to increase sharply. It is possible that the test could have proceeded to greater depths at some sites, such as CPT17-VC49. Further, the vibrocorer was stopped when the core barrel was no longer making progress, which generally was associated with high silt content layers that were not necessarily "strong".

Table 1. Summary of penetration depth data for the GOST CPT and Port of Tauranga vibrocoring in the Entrance Channel (locations in Figure 3B).

GOST CPT				Vibrocorer			
Site	Collar depth CD (m)	Final depth CD (m)	Profile length (m)	Site	Collar depth CD (m)	Final depth CD (m)	Profile length (m)
CPT17	14.20	14.70	0.50	VC49	14.20	17.00	2.80
CPT18	14.20	19.20	5.00	VC43	14.20	15.55	1.35
CPT19	14.20	15.30	1.10	VC41	14.20	14.80	0.60
CPT20	14.00	19.30	5.30	VC36	14.00	14.65	0.65

The CPT, seismic and core data indicate that there is a sequence of ridges transverse to the axis of the channel. The valleys between the ridges are infilled with Holocene sand of sufficient thickness that the capital dredging will not encounter silty sediment. However, the ridges do reach the seafloor in some areas, and elsewhere are sufficiently close to the

surface that dredging will expose them. Site CPT19-VC41 is the only location where both the CPT and core data indicate the presence of resistant strata within the proposed dredging depth. Site CPT17-VC49 indicates a resistant layer within a metre below the 16 m design depth.

It is likely that all of the material that will be encountered will consist of deposits of volcaniclastic sediments of various ages. Some layers up to 30 cm thick have been weakly to moderately cemented by iron oxides, or calcite, due to weathering and the formation of soils during past glacial periods.

Cutter Channel

The Cutter Channel was initially dredged through the flood-tidal delta along the alignment of a blind flood channel, separating the bulk of the delta (Centre Bank) from the distal end of the ebb shield (Pilot Bay bank). The flood delta was assumed to be predominantly Holocene sand (Healy *et al*, 2009). However, there were reports of isolated "boulders" within parts of the channel. MBES and sidescan sonar surveys showed pockmarked areas along the southern margin of the Channel, that could be associated with scour around boulders or outcrops of resistant material (Figures 1 and 5A). The Port of Tauranga undertook video and diver inspections that found isolated outcrops of resistant hard white silty material. Around location T19 (Figure 5B), this appeared to form a pavement with a thin veneer of mobile sand and shell hash.

The Knudsen Pinger SBP trials examined Cutter Channel to look for isolated strong reflectors indicative of boulders, and are more systematic grid survey was undertaken later (Figure 2). The seismic data (Figure 6) indicate that a ridge of older sediment runs along the southern side of the Cutter Channel parallel to the main axis (generally in the deepest parts of the channel shown in Figure 5A). The ridge outcrops at the surface at several locations, and is flanked by deposits of Holocene sandy valley infill. The centreline and northern flank of the Cutter Channel appears to be entirely over a former valley. Drill core D08-10 was obtained within the valley area and consisted only of sand and shell fragments. Drill core D08-09 was located just to the east of the area plotted in Figure 5B, and this core did have a transition to silty sediment below 16 m CD (Healy *et al*, 2009). No seismic data are available for the immediate area around D08-09, but the closest seismic profiles (0005-274-859 and 0003-274-0851) suggest that another subsurface ridge occurs across the entrance to Pilot Bay at the eastern end of Cutter Channel.

The seismic data also indicate the presence of isolated strong reflectors (Figure 6B), which may be boulders or buried trees as encountered in Stella Passage during the 1991-1992 capital dredging (Healy *et al*, 2009). These all appear to occur below the proposed channel depths (16 m transitioning eastward to 14.5 m within Cutter Channel), and are unlikely to be encountered during dredging. There is also a shallow reflector evident in the northeastern area of the Cutter Channel (Figure 6B). This reflector is patchy and not continuous. Also it is not obvious in the vibrocore samples, and may represent a change in sediment consolidation at the depth of maintenance dredging that occurs in this area of the Channel.

Sediment cores and seismic profiles were also obtained at the northwestern end of Cutter Channel. No obvious structures were evident in the seismic data, although divers reported a hard layer at 0.4-0.6 m depth at DS-4 in July 2014. This appears to correspond to a shelly layer at the base of core VC15. Core VC18 was reported as black and smelly. When described, the smell was still present and was similar to the geothermal discharge in Pilot Bay. Low concentrations of silt (<3%) were also present in core VC18. Weak isolated

reflectors were observed at depth, but the proposed dredging will not expose them and their origin is unknown.

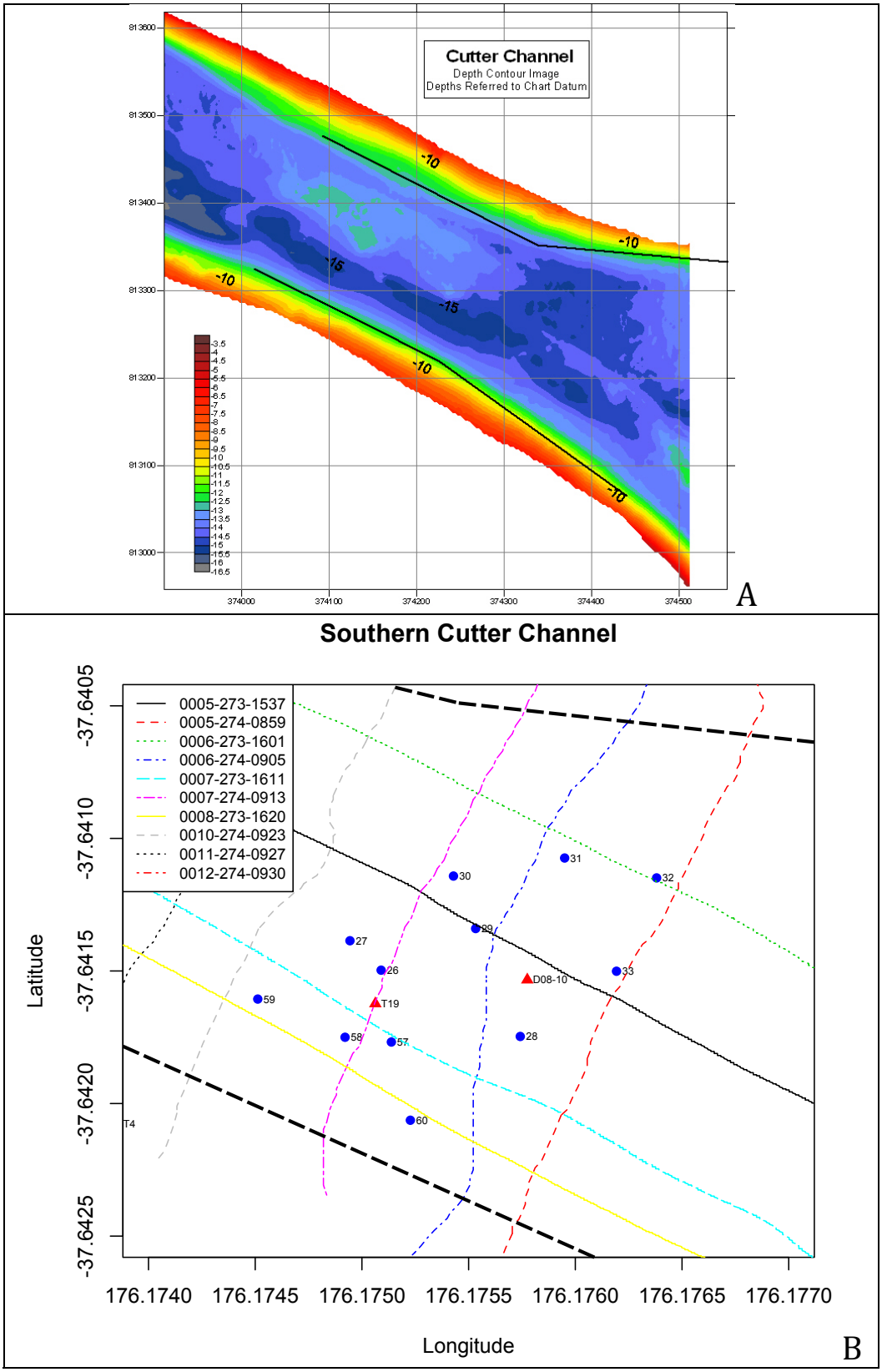

Figure 5. R2Sonic 2022 (400 kHz) MBES bathymetry provided by DML (A) and locations of seismic reflection profiles, drill core (D08-10), surficial sample (T19) and vibrocorer samples within the southeastern Cutter Channel.

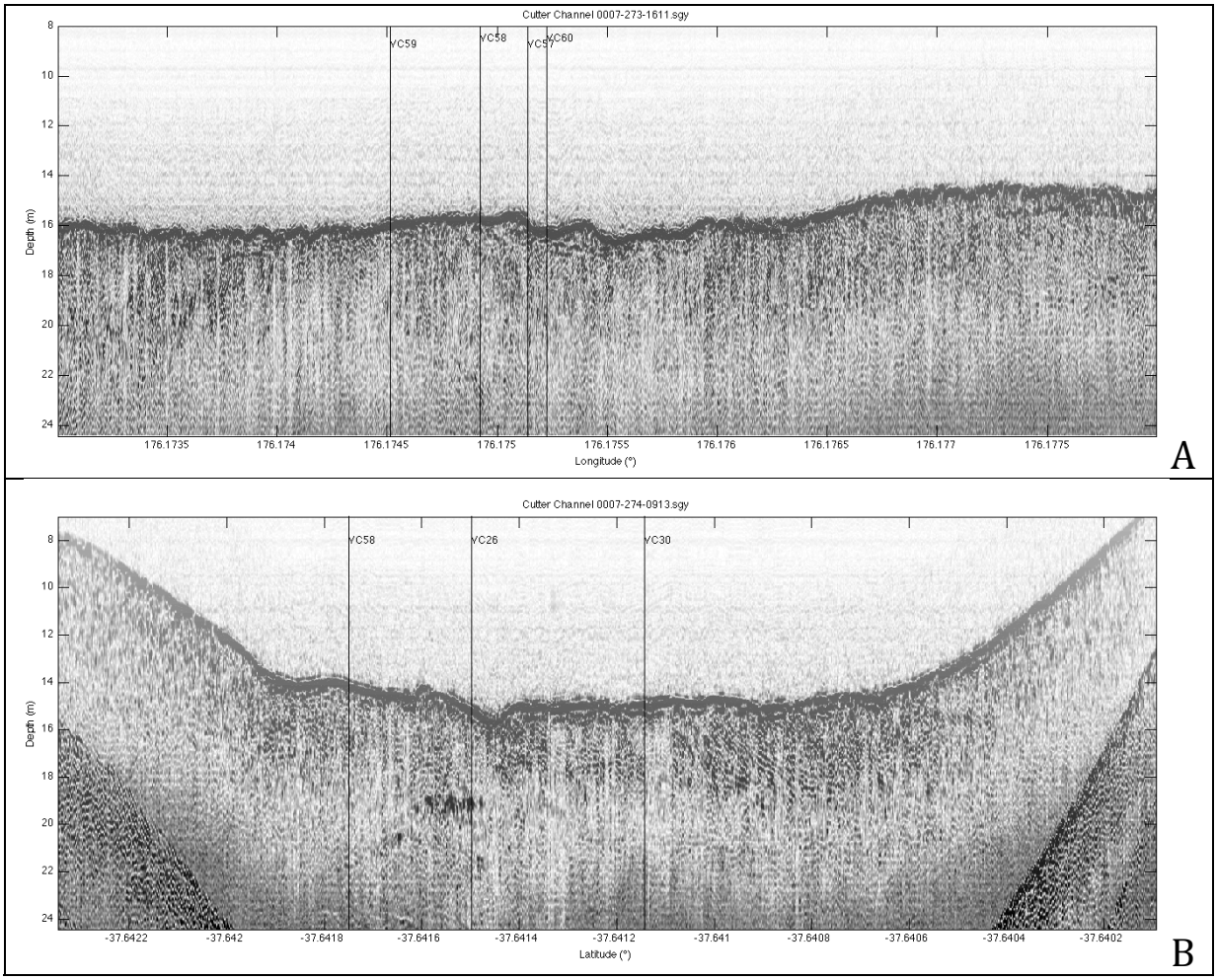

Figure 6. Section of seismic profiles (A) 0007-273-1611 from west to east, and (B) 0007-274-0913 from south to north, for the southeastern region of the Cutter Channel vibrocored by the Port of Tauranga (Figure 5B). These profiles intersect close to the surficial exposure of silty material observed by video and divers (T19). Note the blobby strong reflectors near core VC26 in profile B.

Maunganui Roads

Previous studies indicated that the Maunganui Roads occupied a relatively thick sequence of Holocene sand and shell (Healy *et al*, 2009), and MBES data suggests that mobile recent sands form a series of sand waves migrating northwards along the western side of the channel (Figure 7) A limited number of cores taken along the Maunganui Roads showed no near surface (<2 m) evidence of silty sediment. Cores D08-7 and D08-8 reported stiff or compacted mud at depths of ~2 m and ~ 3 m respectively. The mud layers had a minimum silt content of 40%. A single core (D08-05) was obtained from the east end of the Otumoetai Channel in the middle of the proposed turning basin at the southern end of Maunganui Roads, which identified a stiff mud with 42% fines at 12.5 m below Chart Datum.

Uniboom seismic reflection profiles obtained during the Tauranga Harbour Study in the early 1980s (Healy 1985) indicated the presence of a strong shallow reflector under the northern Maunganui Roads. Moon *et al* (2013) also reported shallow Pleistocene sediments in Stella Passage that probably extended northwards into the Maunganui Roads. Therefore, a few seismic profiles were obtained along the main axis of the Maunganui Roads (Figure 8).

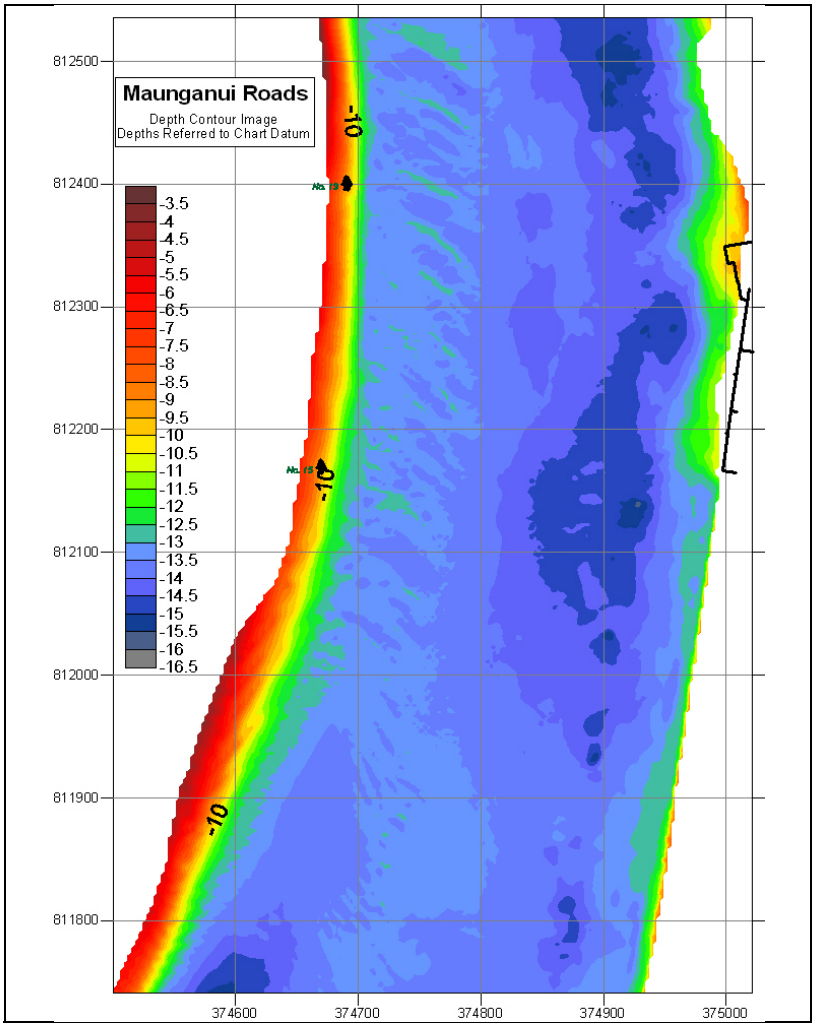

Figure 7. R2Sonic 2022 (400 kHz) MBES bathymetry provided by DML (A) for the Maunganui Roads. The location of the former Roll-on Roll-off (RoRo) berth is indicated on the eastern margin of the channel.

The seismic profiles confirmed the presence of strong subsurface reflector in the vicinity of the former Roll-on Roll-off facility (Berths 7-8), as is evident in Figure 9A. However, this feature does not appear to be sufficiently shallow to impact on the proposed dredging. It is likely that it may become an issue for further deepening in the future.

The seismic profiles also indicated the presence of shallower sequences that may reach the surface within the channel. Therefore, a concentric series of cores were obtained (Figure 8A) around the location where the subsurface layers were thought to be closest to the surface (VC7). The cores show the presence of very silty Pleistocene sediment (>80% fines), forming a SW-NE trending ridge across 2/3 of the channel opposite berth 7 (between channel markers 15 and 17). Healy *et al* (2009) note that the early seismic data (presumably the Uniboom measurements during the Tauranga Harbour Study) suggest the presence of "paleosols" with the Centre Bank flood tidal delta. These probably represent the same Pleistocene reflectors identified within the channels, and the subsurface ridge extends under the shallow ebb shield of the Centre Bank.

Seismic profiles for the southern end of the Maunganui Roads (Figure 9B) reveal a continuation of the Pleistocene ridge and valley topography reported by Moon *et al* (2013)

for Stella Passage. The topography has an apparent dip towards the north, so the crests of the ridges become progressively deeper, except for the ridge at Berth 7 discussed above.

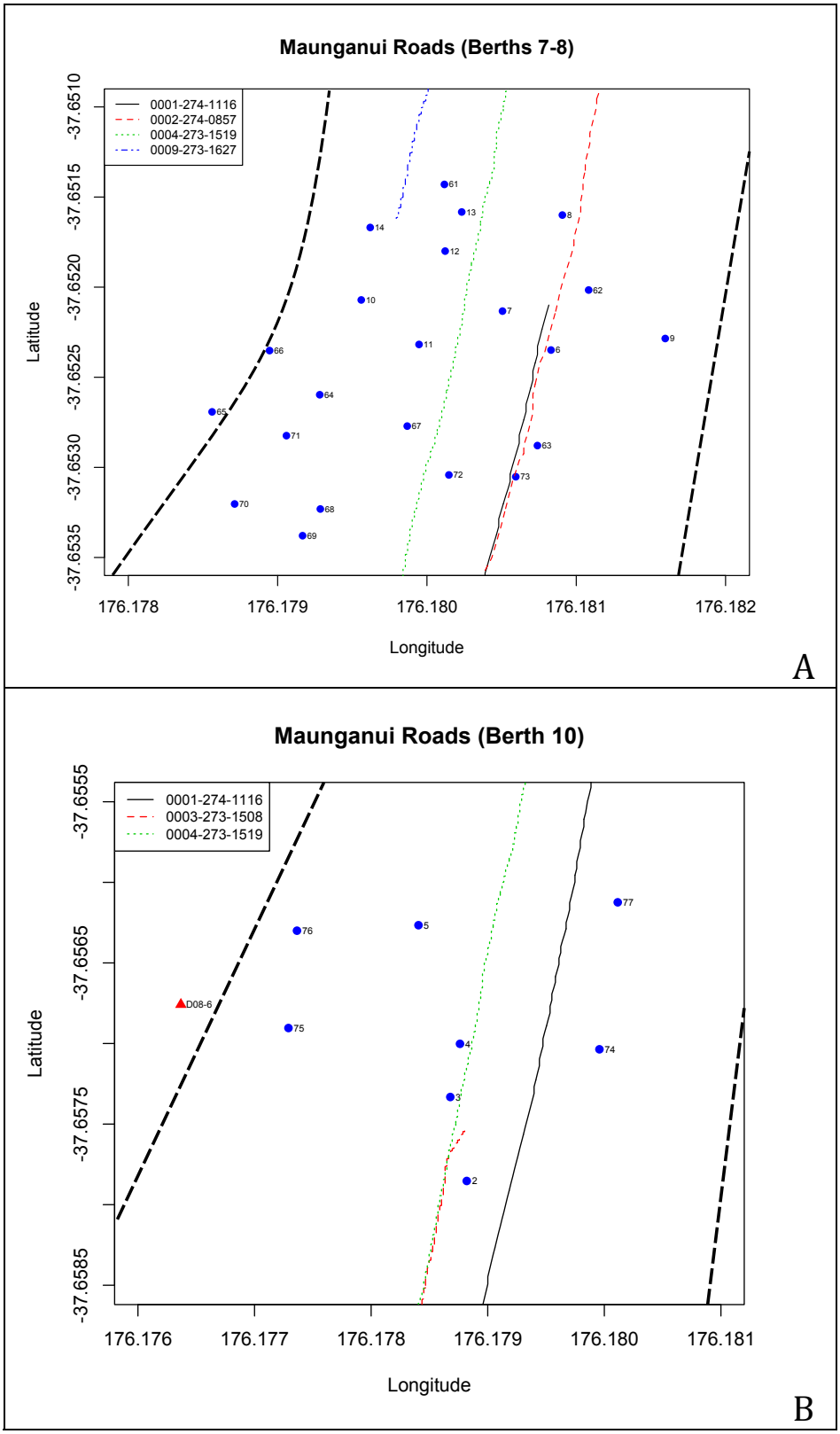

Figure 8. Locations of seismic reflection profiles, drill core (D08-6) and vibrocorer samples within the central (A) and southern (B) Maunganui Roads. These locations correspond to berths 7-8 (RoRo) and 10 respectively

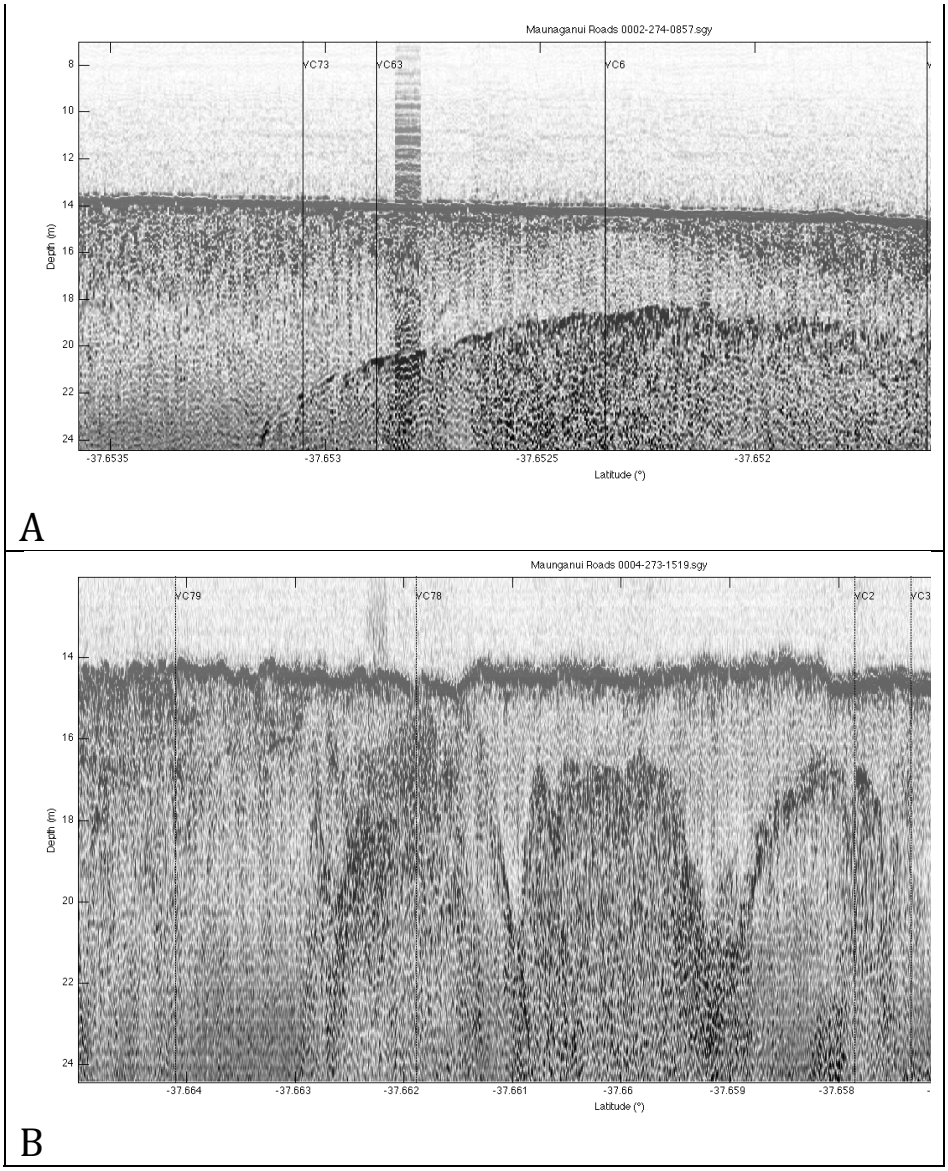

Figure 9. Seismic profiles (A) 0002-274-0857 from south to north in the vicinity of berths 7-8, and (B) 0004-273-1519 from south to north, for the southeastern region of the Cutter Channel vibrocored by the Port of Tauranga (Figure 5B). These profiles intersect close to the surficial exposure of silty material observed by video and divers (T19).

Shallow silty sediment occurs south of a line through cores (VC76 – VC5 – VC77), although due to the ridge and valley topography, the distribution is patchy with silty sediment in the ridges, and clean sand/shell in the valleys. Heading southwards, the proportion of channel floor overlying valleys decreases.

Stella Passage

The seismic profiles for Stella Passage were previously described by Moon *et al* (2013), who linked the profiles to a series of cores drilled off the northern end of the Sulphur Pt wharves as part of the site investigation for the northern wharf expansion. Healy *et al* (2009) identified Stella Passage as containing a high proportion of silty sediment based on cores D08-01, D08-2, D08-3 and D08-4. Divers investigating targets identified by a MBES survey in March 2014 have also recorded surficial exposures of "papa" rock, which represents silty Pleistocene volcaniclastic sediments (T7, T8 and T9 on Figure 10B).

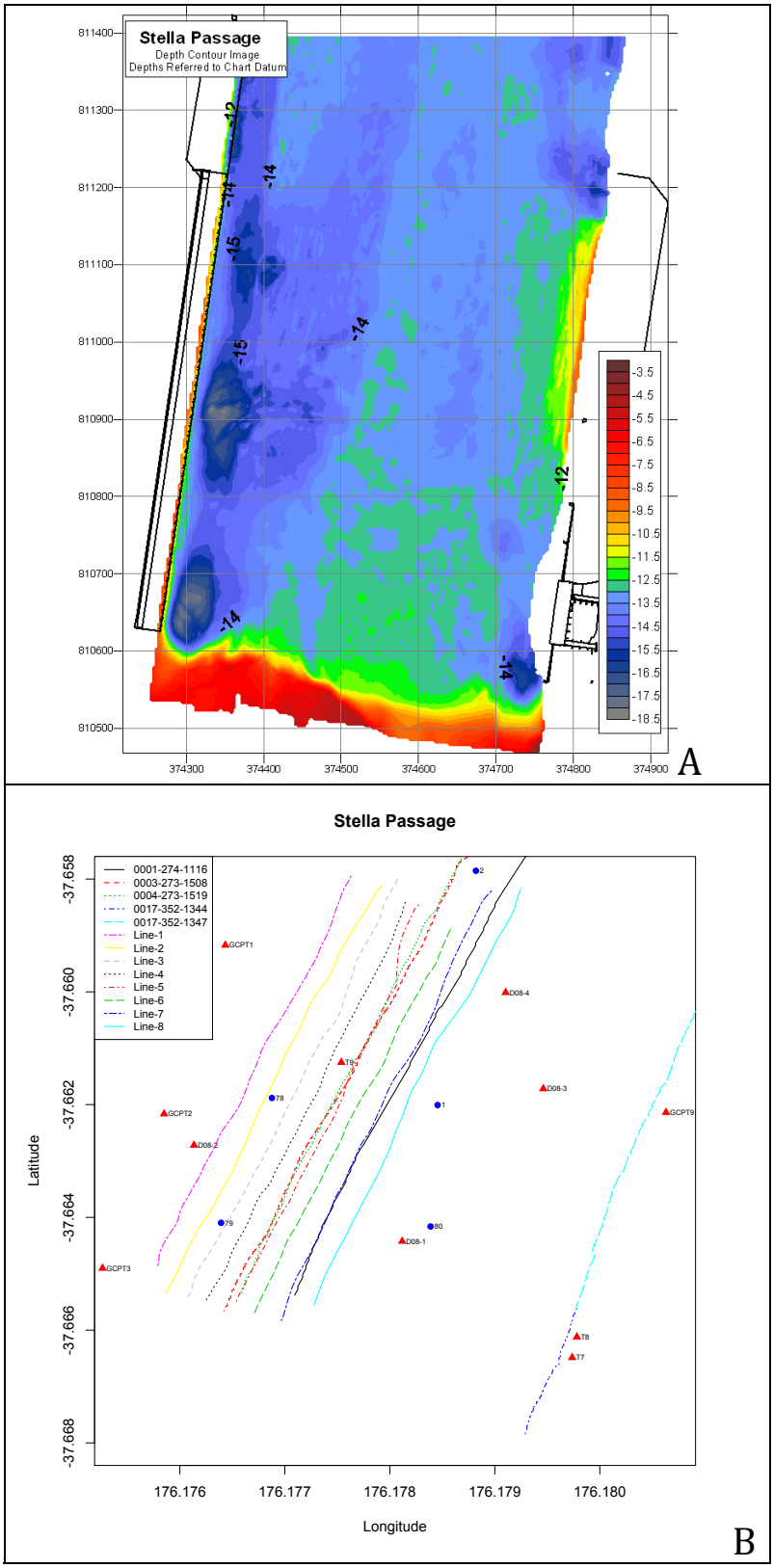

Figure 10. R2Sonic 2022 (400 kHz) MBES bathymetry provided by DML (A) and locations of seismic reflection profiles, drill cores (D08-1, D08-2, D08-3 and D08-4), GOST CPT sites (GCPT1, GCPT2, GCPT3 and GCPT9), surficial samples (T7, T8 and T19) and vibrocorer samples within the Stella Passage.

The interpretation by Moon *et al* (2013) was that ridges and valleys within Pleistocene volcaniclastic deposits underlie Stella Passage. This is similar to the assumed structure in the AEE (Healy et al, 2009), except that seismic indicates that the ridges are transverse to the axis of the channel, and not parallel to it. The AEE interpretation was based on sparse borehole data, and two Uniboom seismic lines undertaken during the Tauranga Harbour Study (Healy 1985). Moon *et al* (2013) utilised more data, but these were predominantly from the western side of the channel.

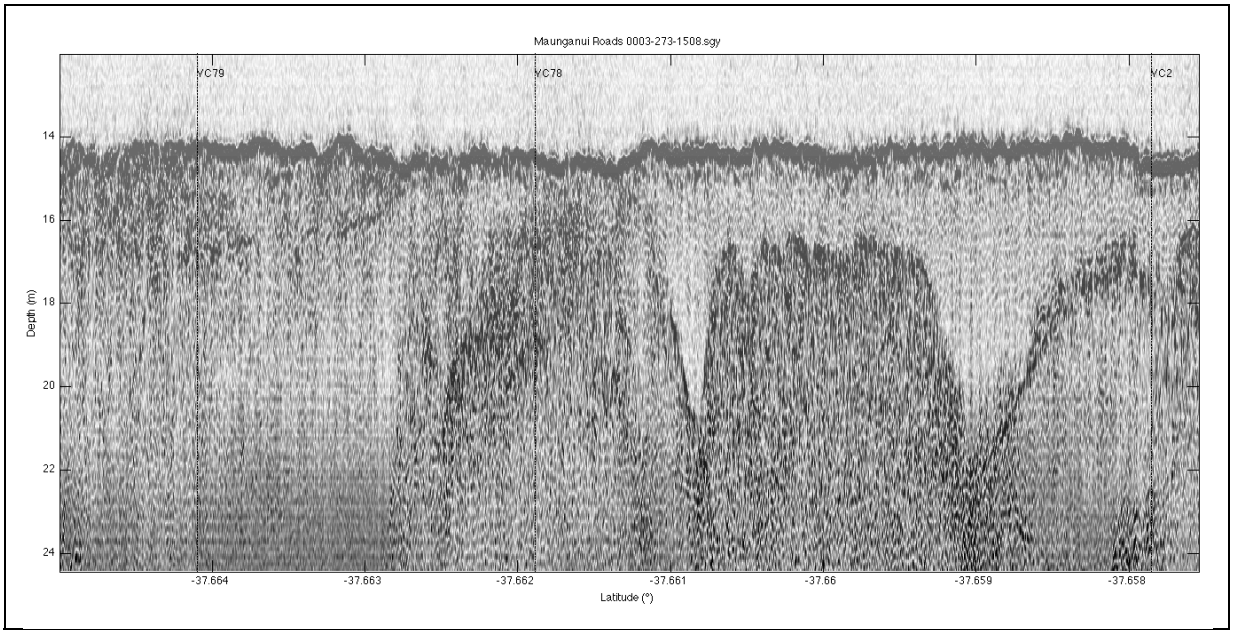

Figure 11. Section of seismic profile 0003-273-1508 along the centre of Stella Passage (Figure 10). This profile runs from S to N (left to right). The locations of recent vibrocorer samples are marked. Divers reported surficial outcrops of "papa rock" over the ridge north of core VC79 (Site T9 in Figure 10).

Some additional data were obtained since the seismic surveys reported by Moon *et al* (2013), and the extra seismic profiles all show the same pattern of ridges and valleys (Figure 11). Unfortunately, the single run line along the eastern margin of the channel is very poor quality and difficult to interpret. However, drill cores (D08-1, D08-3 and D08-4). GOST CPT data (GCPT9) diver observations of surficial "papa rock" (T7 and T8), and vibrocorer samples VC1 and VC80, all show that Pleistocene deposits are at or close to the surface in the eastern half of the channel. The observations are consistent with the eastward extension of the ridges identified by Moon *et al* (2013).

The available data indicate that the area of silty sediment to be dredged is a little larger than assumed by the AEE (Healy *et al*, 2009). The AEE also indicated that there might be buried logs within Stella Passage, due to some being encountered at shallower depths during the 1990 deepening of Stella Passage. No evidence of these was seen in the seismic traces, but their presence cannot be ruled out.

Predicted distribution of silty sediment

The sediment textural data obtained from the vibrocorer samples (Appendix 2), seismic profiles and any additional data indicating the depth of sediments containing at least 5% fines was uploaded to an ArcGIS database. In addition, the inferred boundary between the Holocene and Pleistocene deposits was recorded, since the silty sediments predominantly occur within the Pleistocene material. There are isolated deposits of fine sediment

associated with fluid mud in the southern Stella Passage that were ignored for this report. All the Holocene deposits analysed contained much less than 5% fines.

The seismic profile data for ArcGIS were extracted from the seismic profiles by identifying locations where additional data were needed to better define modelled surfaces. The corresponding section of the profile was then used to identify the location of the Holocene-Pleistocene boundary, given the constraints of nearby vibrocore data that identified the depth of the boundary. Although the seismic data were collected at instrument settings that maximised the depth of penetration, and, therefore, provided poor resolution for weaker near-surface reflectors, this approach is considered to be a reliable indication of the depth of the boundary.

The MBES data provided by DML was also incorporated into the ArcGIS database, and all the data were adjusted to Chart Datum and the Bay of Plenty Circuit 2000 projection. Much of the channel seabed consists of mobile sediment, which means that the bathymetry may have changed between the MBES survey and the vibrocoring. Table 2 summarises the average differences between the MBES survey depth and the measured depth during the vibrocoring. These data indicate that the average difference and absolute difference are comparable to the overdredging allowance of 0.2 m. However, the last two columns of Table 2 demonstrate that there are systematic errors associated with accretion and erosion. In terms of managing the generation of turbidity, there is a potential for areas currently scoured below the design channel depth to undergo further scour below the new dredged channel depth. Therefore, the following analysis considered both the excavation of a new flat floored channel by dredging, and a potential adjusted channel floor with the same shape as the present channels.

Table 2. Comparison of depths between the February 2014 MBES survey and the measured depth during the vibrocoring. A positive average difference indicates the sea bed has accreted, and a negative difference indicates erosion. The last 2 columns represent the averages for only those sites that showed accretion, or erosion, respectively.

Location	Average difference (m)	Average absolute difference (m)	Average accretion difference (m)	Average erosion difference (m)
Entrance Channel	0.02	0.17	0.15	0.21
Cutter Channel – western end	-0.13	0.22	0.18	0.23
Cutter Channel – eastern end	0.21	0.24	0.24	0.18
Stella Passage and Maunganui Roads	0.22	0.22	0.19	0.29

A raster and TIN were generated for the bathymetry, depth to the shallowest sediment containing at least 5% fines, and the Holocene-Pleistocene boundary. Additional bathymetric surfaces were generated to correspond to the proposed depth of dredging assuming a depth of 14.7 m (design depth of 14.5 m plus 0.2 m overdredging) inside the harbour, and an assumed depth of 16.0 m (design depth of 15.8 m plus 0.2 m overdredging) outside the harbour. Within Cutter Channel surfaces were generated for both 14.7 m and 16.0 m as the design depths are intended to transition from 15.8 m at the northwestern end to 14.5 m at the southeastern end of the channel.

In addition to considering a flat surface at the proposed dredging depths (14.7 m inside the harbour and 16 m outside the harbour), the existing bathymetry was shifted downwards by the difference between the present design depth and the proposed dredging depth (1.8

m inside the harbour and 1.9 m outside the harbour respectively). This was done to reflect the possible scouring of the bed by tidal currents, and also the accumulation of Holocene sediment that tends to form sand waves predominantly along the margins of the channels. It also means that the presentation is consistent with the measured core depths, which were relative to the seabed (assumed to be the February 2014 MBES survey bathymetry).

This approach may underpredict the exposed silty sediments in the areas shallower than the current design depth and overpredict the exposed silty sediments in areas deeper than the current design depth. Therefore, the surface for the Holocene-Pleistocene boundary was extended beyond the channel margins to identify areas where the extent of potentially silty sediments could be significantly affected by the approach used. The only area where the effect of shoaling was considered significant was the zone of sand waves in the Entrance Channel, particularly along the western channel margin. The effect of scour was significant in the Maunganui Roads.

The harbour channels were subdivided into 3 regions to facilitate the 3D analysis in ArcGIS, primarily on the basis of the main channel orientation. However, these areas also reflect possible differences in the subsurface structure, which may have implications for another round of capital dredging in the future, but do not affect the current proposed dredging. The three regions are: Entrance Channel; Cutter Channel; and Stella Passage and Maunganui Roads. These will be discussed separately below.

Entrance Channel

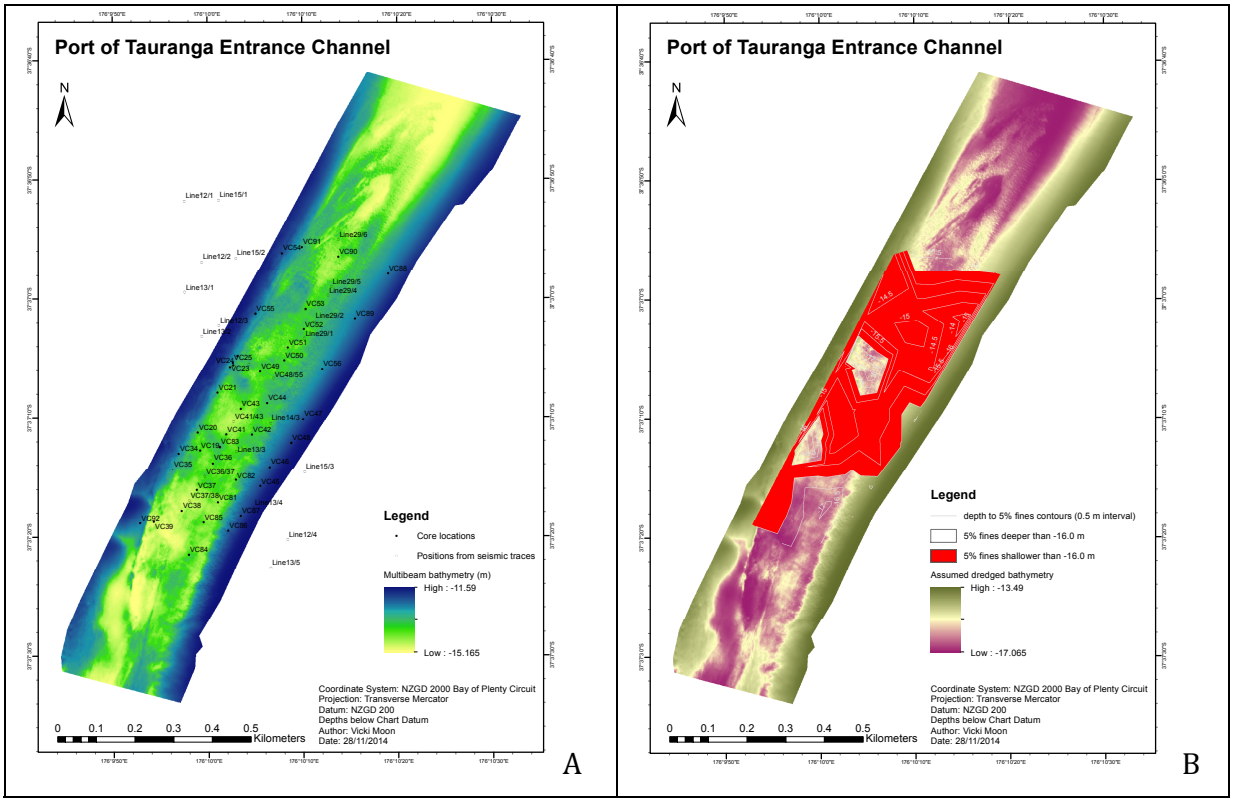

Figure 12. (A) Distribution of vibrocore, extracted seismic "cores", and other observations used to derive the surfaces for the Entrance Channel, superimposed on the MBES base data. (B) The extent and thickness of sediment with >5% fines above the 16.0 m dredging surface. Thickness contours are at 0.5 m intervals. Note that deeper silty sediments have been made transparent.

The Entrance Channel had the highest concentration of core samples (Figure 12), and a reasonable coverage of seismic profiles. However, the profiles were primarily collected to assess the suitability of the equipment for detecting the Holocene-Pleistocene boundary

under the Matakana Banks ebb-tidal delta, and there were gaps in the coverage (Figure 3B).

After an initial analysis, areas were identified that lacked adequate seismic data and no core samples. The Port of Tauranga Ltd collected additional cores to fill these gaps, and the descriptions provided by the Port Engineer were used to identify the Holocene-Pleistocene boundary. Further, the colour of the Pleistocene sediment was used as a proxy for the proportion of fines. Generally, any colour other than pale yellow, was found to exceed the 5% threshold, and darker colours, particularly green, indicated higher fines content.

Figure 12A shows the distribution of cores and extracted seismic profile data used to generate the surfaces in ArcGIS. Figure 12B displays the area of silty sediment that would be exposed in the channel floor assuming a flat surface at a dredging depth of 16 m. The contour lines indicate the thickness of silty sediment above that surface, which will be removed by dredging.

Figure 13 contains two 3D scene views looking along the axis of the Entrance Channel that show the shape of the silty sediment deposits in relation to a potential future bathymetry following dredging. The red area in Figure 13A is determined using the fines content determined from the cores (Appendix 1), while the green area in Figure 13B is the inferred Holocene-Pleistocene boundary determined from the core descriptions (Appendix 2) and seismic profiles. Comparison of Figures 13A and 13B indicate that dredging through the shoaling areas associated with sand waves will probably encounter more silty sediment than indicated in Figures 12B and 13A.

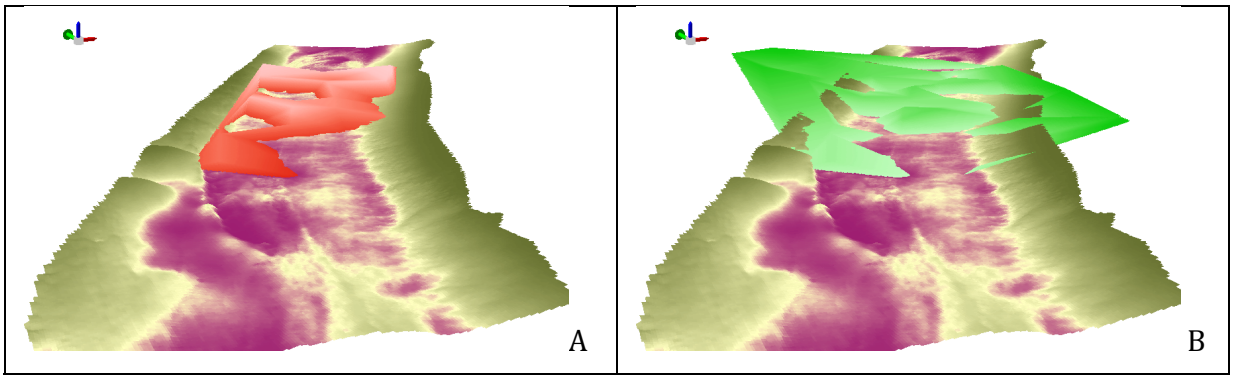

Figure 13. Scene view looking northwards along the axis of the Entrance Channel for the 16 m design depth potential bathymetry. (A) Shows the exposed surface of sediments containing at least 5% silt as determined by core samples. (B) Shows the surface corresponding to the Holocene-Pleistocene boundary determined from core samples and seismic profiles.

The core data also indicate that along the western side of the channel, silty Pleistocene sediments occur at a very shallow depth (<0.2 m) beneath a mobile modern sand layer. It is also evident from the seismic profiles that Pleistocene sediments to the west of the current channel occur at a higher elevation than found within the channel. Therefore, it is likely that overdredging during the previous capital-dredging programme excavated into the Pleistocene sediments. However, there is no record of a significant turbid plume being generated. Figure 14 shows a turbid plume within the Entrance Channel during the 1992 capital dredging. At this time a bucket excavator was working on the Tanea Shelf and the cutter suction dredge was operating in Stella Passage. The scale of any turbidity associated with the silty sediments in the Entrance Channel would have been considerably smaller.

Figure 14. Oblique aerial view of a turbid plume generated during the 1992 capital dredging by a cutter suction dredge operating in Stella Passage.

Cutter Channel

Figures 15 and 16 were generated for the Cutter Channel following the procedure discussed above.

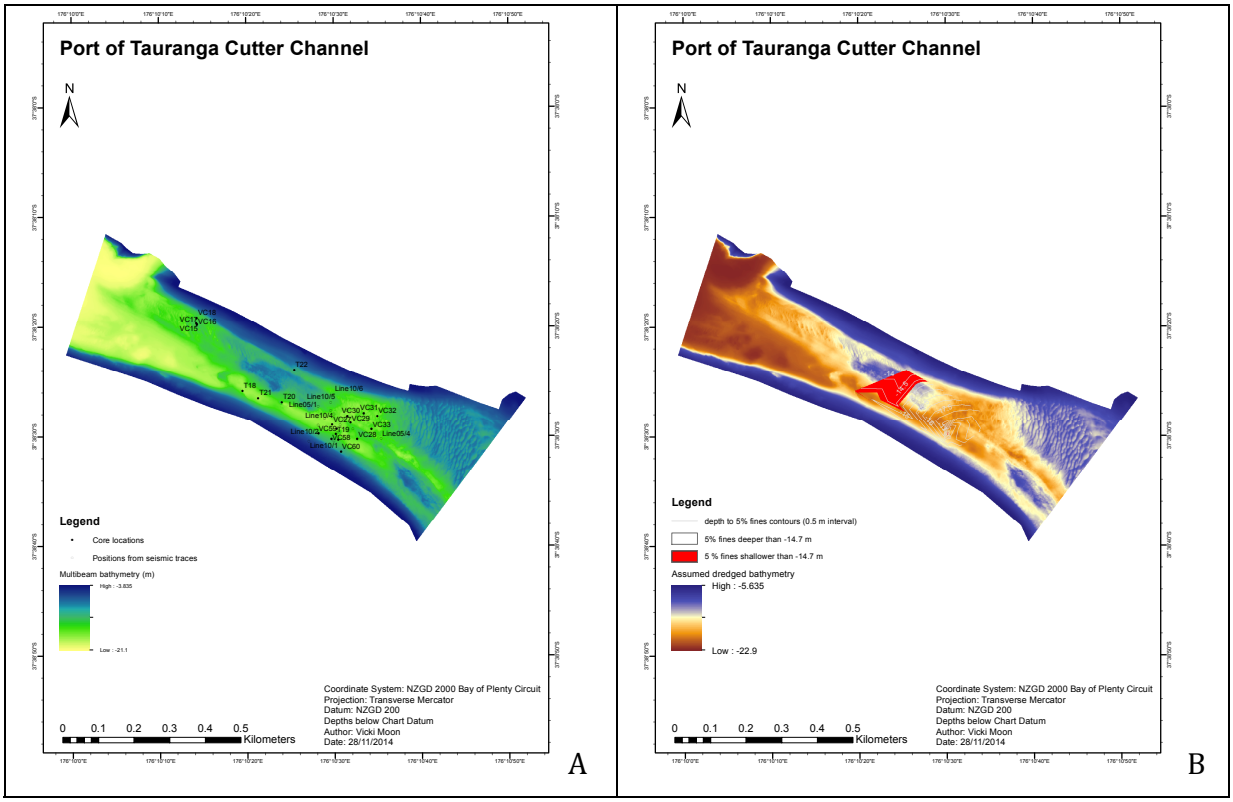

Figure 15. (A) Distribution of vibrocore, extracted seismic "cores", and other observations used to derive the surfaces for the Cutter Channel, superimposed on the MBES base data. (B) The extent and thickness of sediment with >5% fines above the 14.7 m dredging surface. Thickness contours are at 0.5 m intervals. Note that deeper silty sediments have been made transparent.

The Cutter channel had the best seismic coverage (Figures 2 and 5) with profiles along the channel and a series of cross channel profiles. The density of profiles arose due to know exposures of "rocks" in the floor of the channel. Examination of the samples obtained by

divers in 2014 indicated that these consisted of two main units: silty cohesive Pleistocene volcaniclastic sediments; and harder cemented marine shells and sands. The cemented silts and sands have a distinctive sulphurous smell and the shells may also be stained black. Cores taken at the northwest end of the Cutter Channel (VC15-VC18) reported similar material, and it is possible that there is a geothermal discharge occurring through this region (Similar to the nearby source for the Mount Maunganui Hot Salt Water Pools in Adams Ave)

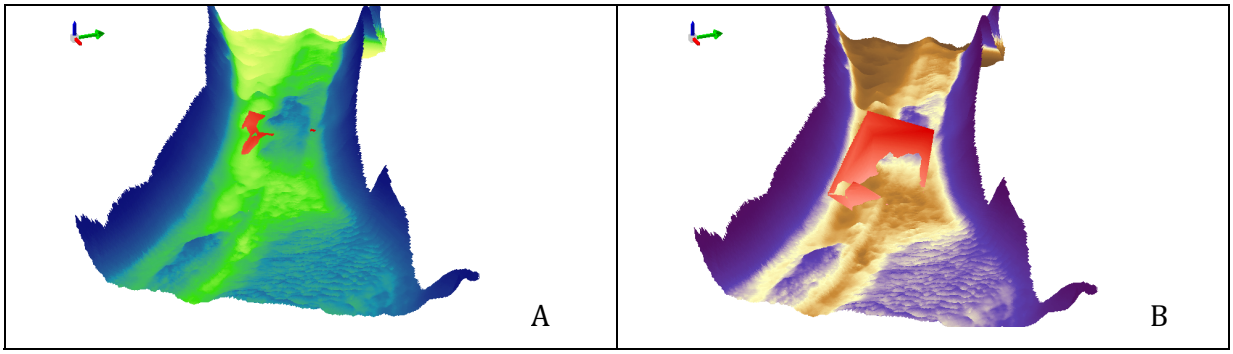

Figure 16. Scene view looking westwards along the axis of Cutter Channel for the (A) 2014 bathymetry and (B) the 14.7 m post-dredging bathymetry. The red shaded area indicates the exposed surface of sediments containing at least 5% silt as determined by surficial samples and core samples for each bathymetry, assuming scour and accretion after dredging.

The silty Pleistocene sediments have more than 5% fines, and appear as a small red patch in Figure 16A. The current exposure was the result of the dredging through the crest of a ridge of Pleistocene material, and it tends to be buried by accreting sand waves moving along the flanks of Centre Bank. The Pilot Bay side of the channel is scoured below the design depth. Therefore, there is a significant difference in the extent of silty sediment plotted in Figures 15B and 16B. The larger extent in Figure 16B assumes that the bed will scour below the dredge depth.

Stella Passage and Maunganui Roads

The Stella Passage and Maunganui Roads channels are treated as one continuous zone, because the Pleistocene sediments are forming a sequence of ridges and valleys that progressively dip deeper heading northwards. Hence, for all practical purposes it is one continuous unit.

The seismic data for this region is concentrated around the western margin of Stella Passage, with some long profiles along the main axis of the channels (Figures 2, 8 and 10). The vibrocoring was concentrated around berths 7-8 in the Maunganui Roads where a previously unknown area of near surface Pleistocene sediment was indicated by the seismic profiles. Hence there are gaps in the available data (Figure 17A), but the work of Moon *et al* (2013) in Stella Passage indicates that the calculated silty sediment distribution is reasonable.

Figure 18A shows the present surface exposures of silty sediment, and indicates an extensive area along the eastern side of the channel. There was only one poor quality seismic profile in this area. However, the data from cores, multibeam imagery and diver observations and surficial samples, suggest that there is a fairly continuous excavated surface in Pleistocene sediments, with a patchy thin cover of recent sediment. The plume in Figure 14 was generated while the cutter suction dredge was working in this area.

Figures 17B and 18B suggest that the area of silty sediment off berths 7-8 is associated with a shallow ridge that extends SW towards the proposed turning basin at the junction of the Otumoetai Channel and Maunganui Roads. This area was not investigated for this

report, but, as noted in the AEE (Healy *et al.*, 2009), there is likely to be silty sediment within the dredged volume.

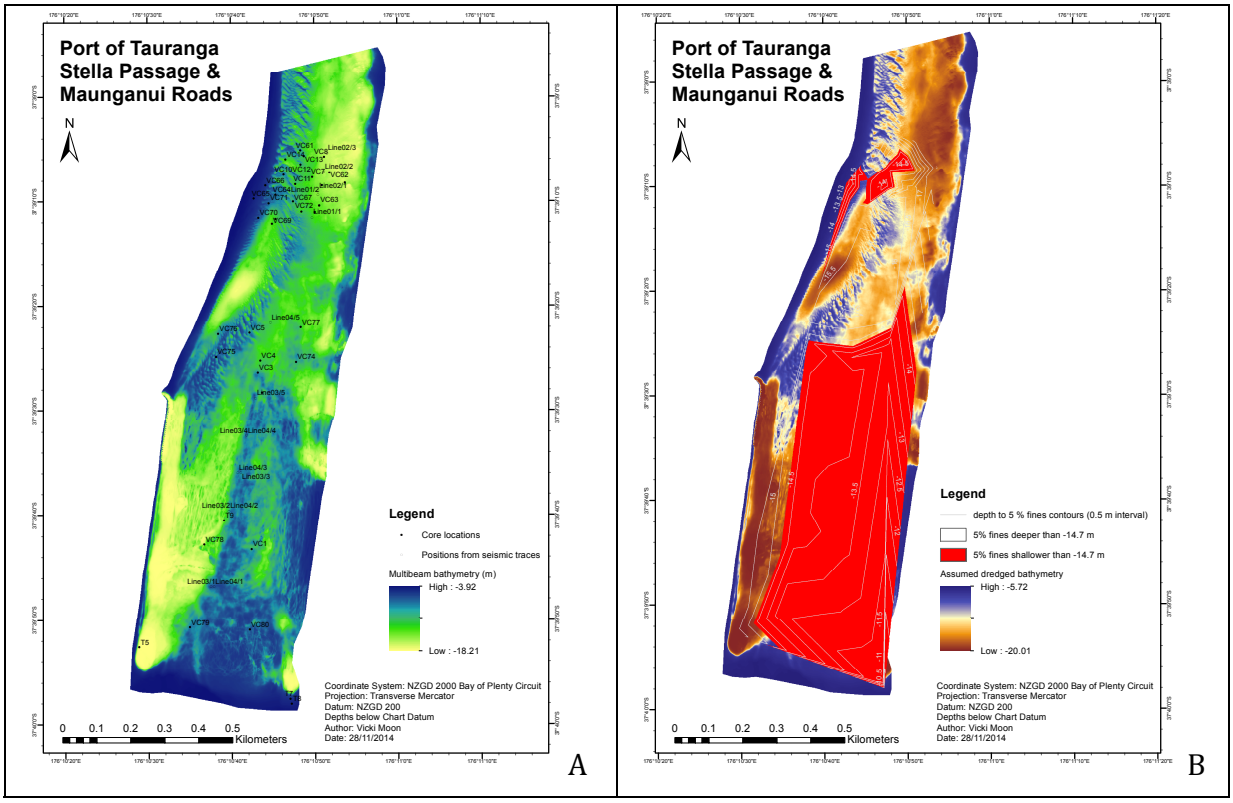

Figure 17. (A) Distribution of vibrocore, extracted seismic "cores", and other observations used to derive the surfaces for the Stella Passage and Maunganui Roads, superimposed on the MBES base data. (B) The extent and thickness of sediment with >5% fines above the 14.7 m post-dredging surface. Thickness contours are at 0.5 m intervals. Note that deeper silty sediments have been made transparent.

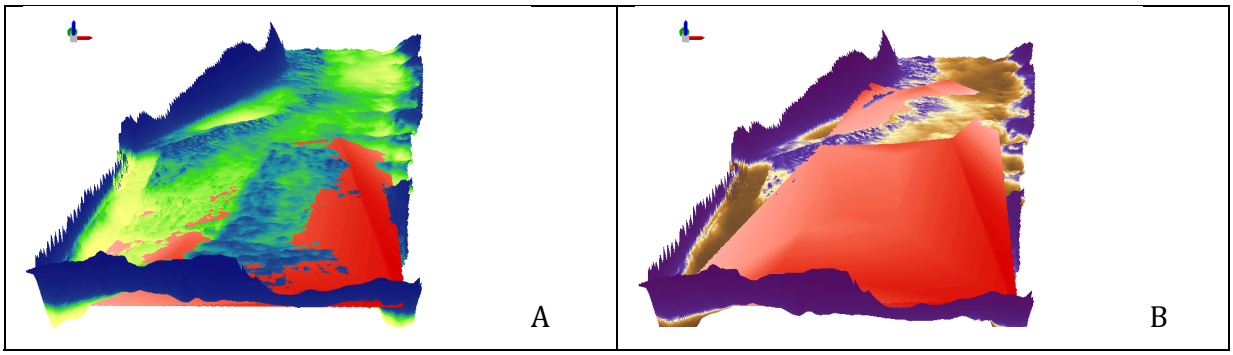

Figure 18. Scene view looking northwards along the axis of the Stella Passage (lower half) and Maunganui Roads (upper half) for the (A) 2014 bathymetry and (B) the 14.7 m post-dredging depth bathymetry. The red shading represents the exposed surface of sediments containing at least 5% silt as determined by core and surficial samples, assuming scour and accretion after dredging.

It is also evident from a comparison of Figure 17B and 18B, that scouring associated primarily with ebb flows from the Otumoetai Channel has a significant effect on the area of silty sediment exposed in the Maunganui Roads. However, the extent of silty sediment in Stella Passage is very similar for the two approaches used.

Estimated volumes

The volumes of sediment exceeding the 5% threshold were determined by using standard tools in ArcGIS to compare the MBES bathymetry with the proposed dredging surface and

post-dredging bathymetry. Table 3 summarises the estimate volumes for the three regions analysed. There are two sets of estimates for the Cutter Channel assuming either a 16 m or 14.7 m dredged depth through the entire channel. Since the area of silty sediments occurs predominantly at the eastern (wharf) end of the channel, the dredged depth is likely to be close to 14.7 m.

Table 3. Estimated volumes of sediment containing at least 5% fines determined from the difference between the existing bathmetry offset by 1.9 m and 1.8 m for the outside and inside of the harbour, and assuming a fixed planar dredged at depths of 16 m and 14.7 m outside and inside the harbour.

Location	Post-dredging bathymetry Volume (m^3)	Dredging surface Volume (m^3)
Entrance Channel	129,110	122,940
Cutter Channel – 16.0 m dredged depth	25,860	24,180
Cutter Channel – 14.7 m dredged depth	23,560	3,630
Stella Passage and Maunganui Roads	648,220	413,680

It is evident from Table 3 that there is a wide range in estimates for Cutter Channel, and Stella Passage and Maunganui Roads. As discussed before, this arises predominantly because of the potential effects of post-dredging scour (although scouring may start during the dredging process). Figures 19-21 compare the extents of silty sediment determined by the two approaches, and show the effects of scour and the increased exposure of the Pleistocene ridges associated with the assumed post-dredging bathymetry.

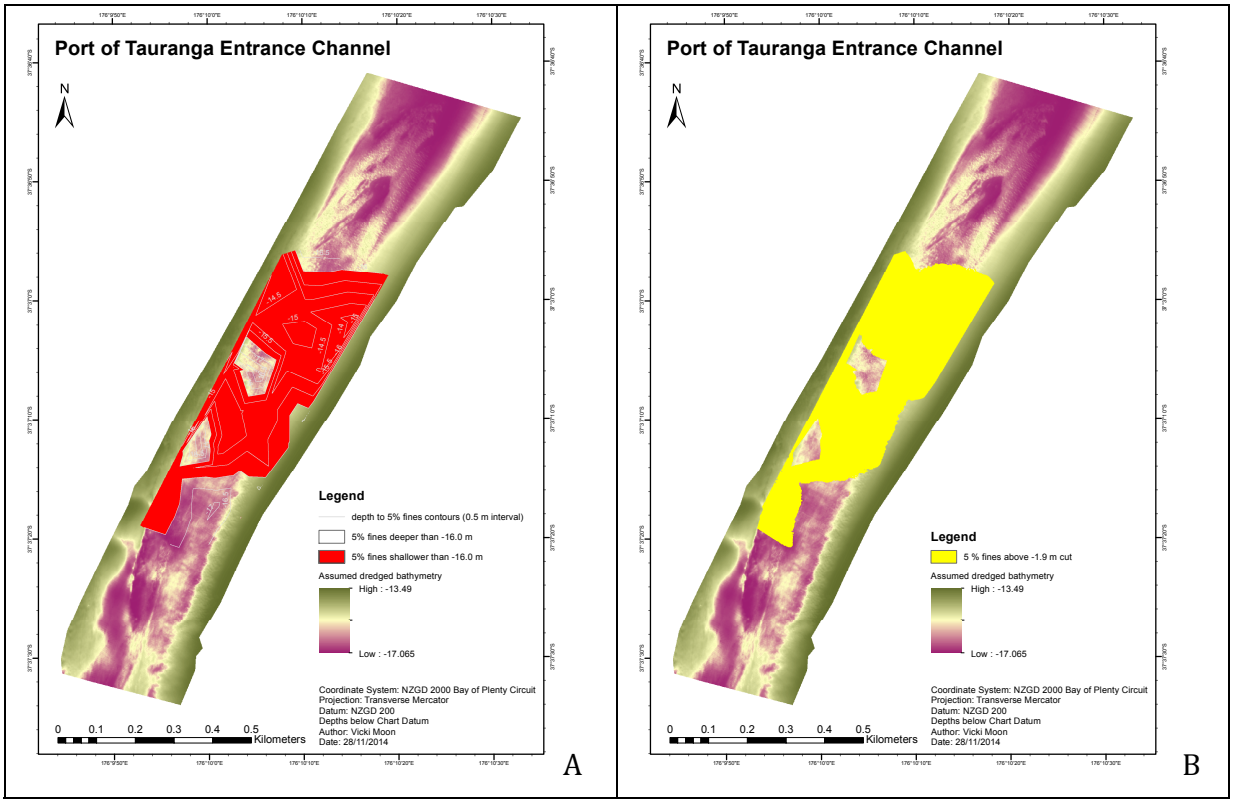

Figure 19. The extent of sediment with >5% fines in the Entrance Channel: (A) above the 16 m dredging surface (Figure 12B); and (B) above the 16 m post-dredging bathymetry.

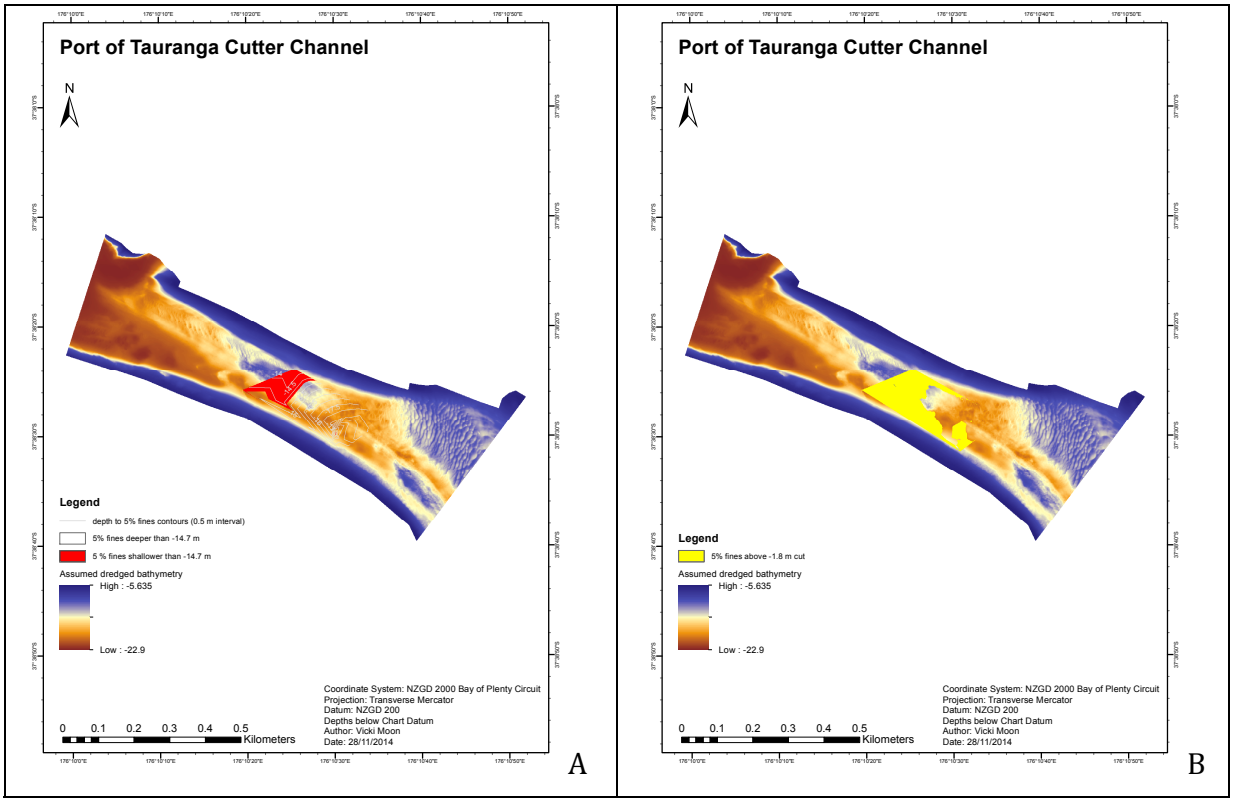

Figure 20. The extent of sediment with >5% fines in Cutter Channel: (A) above the 14.7 m dredging surface (Figure 15B); and (B) above the 14.7 m post-dredging bathymetry.

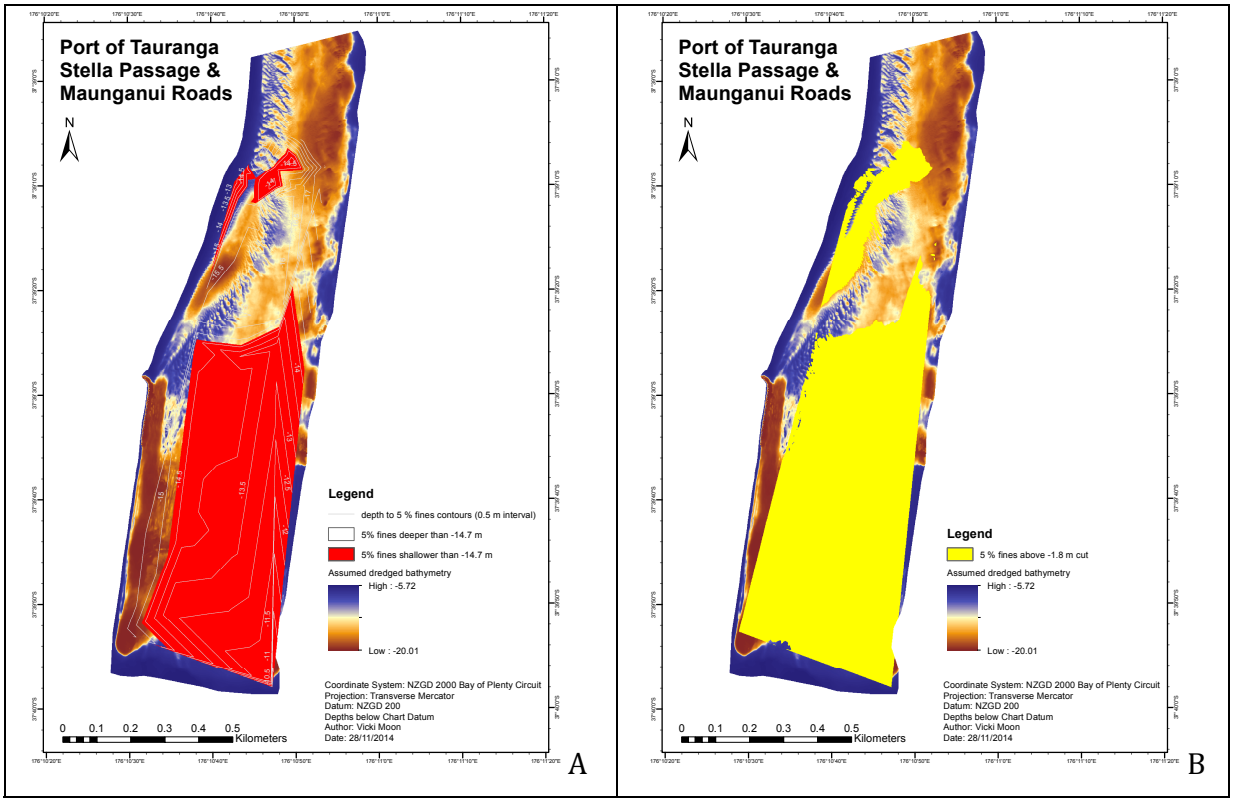

Figure 21. The extent of sediment with >5% fines: (A) above the 14.7 m dredging surface (Figure 17B); and (B) above the 14.7 m post-dredging bathymetry.

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Appendix 1 – Textural statistics for vibrocorer samples

The following tables summarise the Malvern Lasersizer textural analysis results for the samples obtained from the cores collected by the Port of Tauranga. The depth of the sample is given relative to datum (R.L.) and the seabed as measured during the vibrocoring. The proportion of fines represents the sum of silt and clay fractions. The reported mean grain sizes were determined using the graphical method of Folk and Ward (1957)[1].

Core	Depth R.L. (m)	Depth below seabed (m)	Sample	Sand (%)	Fines (%)	Silt (%)	Clay (%)	Mean (mm)	Mean (µm)
VC1	13.63	0.43	C1/0.43	54.5	45.5	40.3	5.2	0.039	39
	13.85	0.65	C1/0.65	87.4	12.6	11.6	1.0	0.240	240
	14.07	0.87	C1/0.87	85.3	14.7	13.3	1.4	0.221	221
	14.43	1.23	C1/1.23	75.2	24.8	20.9	3.9	0.233	233
	15.00	1.80	C1/1.80	79.8	20.2	18.5	1.7	0.188	188
	15.47	2.27	C1/2.27	82.4	17.6	16.0	1.6	0.232	232
	15.62	2.42	C1/2.42	55.2	44.8	41.2	3.6	0.050	50
	15.73	2.53	C1/2.53	29.6	70.4	64.6	5.8	0.024	24
VC3	15.00	0.30	C3/0.30	19.8	80.2	64.9	15.3	0.010	10
	15.50	0.80	C3/0.80	22.4	77.6	63.8	13.8	0.012	12
	16.00	1.30	C3/1.30	35.1	64.9	55.1	9.7	0.018	18
	16.50	1.80	C3/1.80	38.8	61.2	52.1	9.0	0.024	24
VC6	15.10	0.90	C6/0.90	45.3	54.7	45.8	8.9	0.028	28
	15.60	1.40	C6/1.40	19.5	80.5	67.7	12.8	0.011	11
	16.10	1.90	C6/1.90	19.8	80.2	66.9	13.2	0.011	11
VC7	13.65	0.05	C7/0.05	18.6	81.4	67.6	13.8	0.010	10
	14.10	0.50	C7/0.50	18.0	82.0	68.7	13.4	0.010	10
	14.60	1.00	C7/1.00	19.8	80.2	68.5	11.7	0.011	11
	14.96	1.36	C7/1.36	53.9	46.1	40.4	5.7	0.034	34
	15.22	1.62	C7/1.62	55.8	44.2	38.1	6.1	0.038	38
VC11	14.05	0.75	C11/0.75	49.5	50.5	42.7	7.8	0.059	59
	14.50	1.20	C11/1.20	36.0	64.0	54.8	9.2	0.019	19
	14.80	1.50	C11/1.50	39.9	60.1	51.9	8.2	0.025	25
VC12	15.47	1.97	C12/1.97	19.0	81.0	71.2	9.8	0.011	11
	15.90	2.40	C12/2.40	21.9	78.1	63.6	14.5	0.012	12
	16.40	2.90	C12/2.90	40.8	59.2	49.5	9.6	0.025	25
VC13	15.54	2.14	C13/2.14	25.3	74.7	63.2	11.5	0.014	14
	15.85	2.45	C13/2.45	26.3	73.7	61.4	12.3	0.013	13
	16.35	2.95	C13/2.95	47.9	52.1	43.4	8.6	0.029	29
VC18	14.70	0.50	C18/0.50	97.1	2.9	2.9	0.0	0.282	282
	15.70	1.50	C18/1.50	98.8	1.2	1.2	0.0	0.314	314
	16.70	2.50	C18/2.50	99.2	0.8	0.8	0.0	0.341	341
VC19	14.70	0.50	C19/0.50	96.7	3.3	3.3	0.0	0.455	455
	16.20	2.00	C19/2.00	97.6	2.4	2.4	0.0	0.509	509
	16.50	2.30	C19/2.30	97.3	2.7	2.7	0.0	0.460	460
VC20	14.90	0.80	C20/0.80	100.0	0.0	0.0	0.0	0.558	558
	15.70	1.60	C20/1.60	99.4	0.6	0.6	0.0	0.522	522
	16.05	1.95	C20/1.95	100.0	0.0	0.0	0.0	0.568	568
	16.22	2.12	C20/2.12	100.0	0.0	0.0	0.0	0.517	517
	16.40	2.30	C20/2.30	98.4	1.6	1.6	0.0	0.510	510
	16.58	2.48	C20/2.48	97.3	2.7	2.7	0.0	0.453	453

[1] Folk, R.L., and Ward, W.C., 1957. Brazos River Bar – a study in the significance of grain size parameters. *Journal of Sedimentary Petrology* 27: 3-26.

Core	Depth R.L. (m)	Depth below seabed (m)	Sample	Sand (%)	Fines (%)	Silt (%)	Clay (%)	Mean (mm)	Mean (µm)
VC21	14.25	0.05	C21/0.05	99.3	0.7	0.7	0.0	0.440	440
	14.58	0.38	C21/0.38	19.2	80.8	69.4	11.3	0.012	12
VC25	14.40	0.30	C25/0.30	96.1	3.9	3.9	0.0	0.238	238
	15.30	1.20	C25/1.20	98.8	1.2	1.2	0.0	0.680	680
	16.10	2.00	C25/2.00	92.0	8.0	7.6	0.4	0.468	468
	16.24	2.14	C25/2.14	76.3	23.7	22.7	1.0	0.123	123
VC26	14.89	0.29	C26/0.29	48.7	51.3	48.6	2.7	0.038	38
	14.92	0.32	C26/CC	46.4	53.6	50.8	2.7	0.040	40
VC29	14.75	0.05	C29/0.05	99.1	0.9	0.9	0.0	0.424	424
	16.65	1.95	C29/1.95	89.9	10.1	9.9	0.2	0.349	349
	16.70	2.00	C29/2.00	97.4	2.6	2.6	0.0	0.465	465
	16.72	2.02	C29/2.02	55.8	44.2	42.2	2.0	0.046	46
	17.10	2.40	C29/2.40	58.3	41.7	39.4	2.3	0.053	53
VC34	14.05	0.05	C34/0.05	97.8	2.2	2.2	0.0	0.414	414
	14.40	0.40	C34/0.40	100.0	0.0	0.0	0.0	0.698	698
	15.01	1.01	C34/1.01	100.0	0.0	0.0	0.0	0.516	516
	15.25	1.25	C34/1.25	62.3	37.7	32.1	5.7	0.054	54
	15.42	1.42	C34/1.42	96.7	3.3	3.3	0.0	0.364	364
	15.61	1.61	C34/1.61	96.0	4.0	4.0	0.0	0.355	355
	15.77	1.77	C34/1.77	86.7	13.3	11.6	1.7	0.388	388
VC35	15.60	1.60	C35/1.60	81.6	18.4	17.6	0.8	0.204	204
VC36	14.05	0.05	C36/0.05	98.2	1.8	1.8	0.0	0.613	613
	14.50	0.50	C36/0.50	96.2	3.8	3.7	0.1	0.501	501
VC38	16.12	1.72	C38/1.72	95.0	5.0	5.0	0.0	0.444	444
	16.20	1.80	C38/1.80	91.2	8.8	8.6	0.2	0.481	481
	16.32	1.92	C38/1.92	90.2	9.8	9.5	0.3	0.382	382
VC41	14.50	0.30	C41/0.30	37.7	62.3	54.4	7.9	0.026	26
	14.60	0.40	C41/0.40	56.2	43.8	40.9	2.9	0.061	61
	14.65	0.45	C41/0.45	36.6	63.4	57.2	6.2	0.025	25
	14.72	0.52	C41/0.52	56.4	43.6	37.0	6.6	0.047	47
	14.76	0.56	C41/0.56	42.6	57.4	46.5	10.9	0.027	27
	14.83	0.63	C41/0.63	89.6	10.4	7.9	2.5	0.545	545
VC42	15.03	0.93	C42/0.93	44.0	56.0	49.9	6.1	0.037	37
	15.20	1.10	C42/1.10	65.3	34.7	32.4	2.3	0.070	70
	15.35	1.25	C42/1.25	39.2	60.8	53.5	7.2	0.028	28
	15.60	1.50	C42/1.50	36.4	63.6	52.9	10.7	0.022	22
	15.86	1.76	C42/1.76	74.0	26.0	21.7	4.3	0.079	79
	16.20	2.10	C42/2.10	72.0	28.0	24.9	3.0	0.091	91
VC43	14.44	0.24	C43/0.24	98.1	1.9	1.9	0.0	0.370	370
	14.68	0.48	C43/0.48	99.9	0.1	0.1	0.0	0.709	709
	14.90	0.70	C43/0.70	24.9	75.1	65.3	9.9	0.015	15
	15.20	1.00	C43/1.00	20.5	79.5	70.5	9.1	0.013	13
	15.46	1.26	C43/1.26	24.2	75.8	66.7	9.2	0.015	15
VC45	13.70	0.30	C45/0.30	96.1	3.9	3.9	0.0	0.303	303
	14.40	1.00	C45/1.00	100.0	0.0	0.0	0.0	0.393	393
	14.90	1.50	C45/1.50	97.2	2.8	2.8	0.0	0.541	541
	15.50	2.10	C45/2.10	97.5	2.5	2.5	0.0	0.558	558
	16.10	2.70	C45/2.70	96.0	4.0	4.0	0.0	0.577	577
VC46	15.80	2.20	C46/2.20	80.7	19.3	16.7	2.6	0.133	133
	15.97	2.37	C46/2.37	91.7	8.3	8.3	0.0	0.386	386
	16.20	2.60	C46/2.60	95.6	4.4	4.4	0.0	0.573	573
	16.40	2.80	C46/2.80	96.9	3.1	3.1	0.0	0.617	617

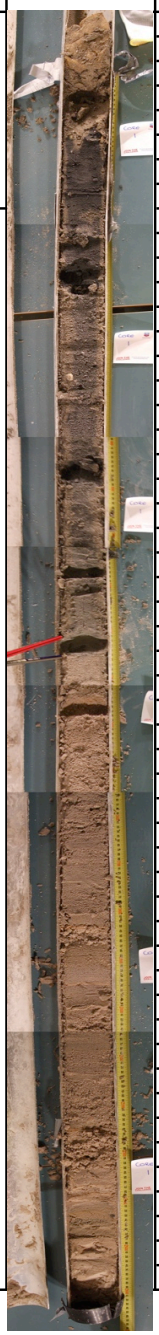
Core	Depth R.L. (m)	Depth below seabed (m)	Sample	Sand (%)	Fines (%)	Silt (%)	Clay (%)	Mean (mm)	Mean (μm)
VC49	14.25	0.05	C49/0.05	96.0	4.0	4.0	0.0	0.372	372
	14.70	0.50	C49/0.50	99.2	0.8	0.8	0.0	0.435	435
	15.70	1.50	C49/1.50	98.4	1.6	1.6	0.0	0.535	535
	16.80	2.60	C49/2.60	100.0	0.0	0.0	0.0	0.352	352
VC50	14.15	0.05	C50/0.05	100.0	0.0	0.0	0.0	0.316	316
	14.40	0.30	C50/0.30	99.7	0.3	0.3	0.0	0.601	601
	14.56	0.46	C50/0.46	98.3	1.7	1.7	0.0	0.551	551
	14.64	0.54	C50/0.54	85.2	14.8	14.6	0.2	0.176	176
	14.83	0.73	C50/0.73	82.9	17.1	16.8	0.3	0.154	154
VC51	14.25	0.05	C51/0.05	100.0	0.0	0.0	0.0	0.326	326
	14.50	0.30	C51/0.30	98.7	1.3	1.3	0.0	0.597	597
	14.71	0.51	C51/0.51	72.7	27.3	26.9	0.3	0.096	96
	14.79	0.59	C51/0.59	62.1	37.9	36.3	1.6	0.062	62
	14.86	0.66	C51/0.66	80.3	19.7	19.5	0.2	0.128	128
VC52	14.25	0.05	C52/0.05	92.6	7.4	7.4	0.0	0.287	287
	14.70	0.50	C52/0.50	100.0	0.0	0.0	0.0	0.381	381
	15.40	1.20	C52/1.20	85.4	14.6	14.4	0.2	0.309	309
	15.50	1.30	C52/1.30	84.7	15.3	15.1	0.2	0.295	295
	15.68	1.48	C52/1.48	81.1	18.9	18.6	0.2	0.168	168
VC53	14.05	0.05	C53/0.05	100.0	0.0	0.0	0.0	0.436	436
	14.35	0.35	C53/0.35	92.1	7.9	7.8	0.1	0.177	177
	14.53	0.53	C53/0.53	89.9	10.1	9.1	1.0	0.189	189
VC55	13.85	0.05	C55/0.05	100.0	0.0	0.0	0.0	0.327	327
	14.40	0.60	C55/0.60	100.0	0.0	0.0	0.0	0.683	683
	14.83	1.03	C55/1.03	93.3	6.7	6.7	0.0	0.191	191
	15.10	1.30	C55/1.30	75.7	24.3	22.9	1.4	0.094	94
VC56	14.56	0.56	C56/0.56	83.5	16.5	15.4	1.1	0.158	158
	14.82	0.82	C56/0.82	91.9	8.1	7.9	0.2	0.334	334
VC63	14.00	0.50	C63/0.50	100.0	0.0	0.0	0.0	0.582	582
	15.00	1.50	C63/1.50	99.6	0.4	0.4	0.0	0.527	527
VC64	13.17	0.17	C64/0.17	100.0	0.0	0.0	0.0	0.501	501
	13.50	0.50	C64/0.50	100.0	0.0	0.0	0.0	0.562	562
	14.61	1.61	C64/1.61	100.0	0.0	0.0	0.0	0.521	521
	14.69	1.69	C64/1.69	15.1	84.9	70.9	14.0	0.010	10
	14.90	1.90	C64/1.90	27.0	73.0	60.7	12.3	0.013	13
VC67	13.25	0.05	C67/0.05	99.7	0.3	0.3	0.0	0.581	581
	13.50	0.30	C67/0.30	46.2	53.8	45.4	8.4	0.029	29
	13.80	0.60	C67/0.60	32.7	67.3	57.0	10.2	0.015	15
	14.10	0.90	C67/0.90	26.0	74.0	62.7	11.3	0.014	14
	14.40	1.20	C67/1.20	18.8	81.2	68.6	12.6	0.011	11
VC68	14.50	1.00	C68/1.00	86.4	13.6	12.4	1.3	0.164	164
	14.75	1.25	C68/1.25	80.1	19.9	17.5	2.4	0.096	96
	15.10	1.60	C68/1.60	28.4	71.6	60.6	10.9	0.014	14
VC69	15.35	1.75	C69/1.75	77.3	22.7	20.0	2.7	0.078	78
VC71	14.91	2.01	C71/2.01	18.4	81.6	69.9	11.7	0.011	11
	15.13	2.23	C71/2.23	31.2	68.8	58.4	10.4	0.015	15

Core	Depth R.L. (m)	Depth below seabed (m)	Sample	Sand (%)	Fines (%)	Silt (%)	Clay (%)	Mean (mm)	Mean (μm)
VC74	13.15	0.05	C74/0.05	83.6	16.4	14.8	1.7	0.197	197
	13.48	0.38	C74/0.38	90.8	9.2	8.3	0.9	0.354	354
	13.48	0.38	C74/0.38	94.8	5.2	5.0	0.2	0.471	471
	13.62	0.52	C74/0.52	60.2	39.8	33.7	6.2	0.041	41
	14.00	0.90	C74/0.90	77.8	22.2	19.2	3.0	0.110	110
	14.12	1.02	C74/1.02	82.7	17.3	15.2	2.0	0.205	205
	14.37	1.27	C74/1.27	64.9	35.1	32.1	2.9	0.076	76
	14.63	1.53	C74/1.53	63.6	36.4	32.7	3.7	0.068	68
	14.78	1.68	C74/1.68	74.4	25.6	23.9	1.7	0.123	123
VC78	14.05	0.05	C78/0.05	61.4	38.6	35.3	3.3	0.048	48
	14.23	0.23	C78/0.23	74.5	25.5	24.0	1.5	0.086	86
	14.39	0.39	C78/0.39	56.2	43.8	40.4	3.4	0.042	42
	14.52	0.52	C78/0.52	79.6	20.4	20.0	0.4	0.129	129
	14.65	0.65	C78/0.65	51.7	48.3	44.6	3.7	0.038	38
	14.75	0.75	C78/0.75	54.5	45.5	42.0	3.5	0.040	40
	14.90	0.90	C78/0.90	53.8	46.2	42.8	3.3	0.050	50
	15.36	1.36	C78/1.36	53.8	46.2	43.1	3.1	0.051	51
	15.68	1.68	C78/1.68	55.9	44.1	40.9	3.2	0.055	55
	15.95	1.95	C78/1.95	76.2	23.8	22.1	1.7	0.105	105
	16.20	2.20	C78/2.20	50.4	49.6	46.9	2.7	0.041	41
	16.39	2.39	C78/2.39	72.3	27.7	24.9	2.9	0.082	82
VC79	13.05	0.05	C79/0.05	82.1	17.9	16.6	1.3	0.142	142
	13.30	0.30	C79/0.30	84.1	15.9	14.6	1.2	0.224	224
	14.10	1.10	C79/1.10	81.0	19.0	17.6	1.5	0.195	195
	14.60	1.60	C79/1.60	81.9	18.1	16.4	1.7	0.227	227
	13.65	0.65	C79/0.65	21.4	78.6	73.7	4.9	0.017	17
	13.79	0.79	C79/0.79	67.4	32.6	30.2	2.4	0.082	82
	14.50	1.50	C79/1.50	83.9	16.1	14.9	1.2	0.217	217
	14.60	1.60	C79/1.60	77.5	22.5	19.9	2.6	0.132	132
	14.64	1.64	C79/1.64	6.7	93.3	84.9	8.5	0.009	9
	14.73	1.73	C79/1.73	40.5	59.5	56.2	3.3	0.040	40
	14.82	1.82	C79/1.82	19.6	80.4	74.4	6.0	0.014	14
	14.90	1.90	C79/1.90	34.3	65.7	58.4	7.4	0.020	20
	14.92	1.92	C79/1.92	68.1	31.9	30.4	1.5	0.083	83
	14.94	1.94	C79/1.94	48.7	51.3	47.4	3.8	0.038	38
	15.14	2.14	C79/2.14	89.6	10.4	10.4	0.0	0.227	227
VC80	12.95	0.05	C80/0.05	76.8	23.2	21.8	1.4	0.152	152
	13.40	0.50	C80/0.50	77.0	23.0	21.7	1.4	0.151	151
	13.90	1.00	C80/1.00	75.7	24.3	22.5	1.7	0.120	120
	14.42	1.52	C80/1.52	76.1	23.9	21.9	1.9	0.133	133
	14.70	1.80	C80/1.80	68.0	32.0	28.8	3.2	0.078	78

Appendix 2 – Geotechnical log sheets for selected cores

The following geotechnical log sheets summarise the descriptions and core photos for the cores that were described. The cores were selected for detailed description based on an initial examination of the core, which assessed if any layers present would potentially contain silt and/or clay-sized sediment. The log sheets also include the interpretation of the age of the sediment (Holocene or Pleistocene), and are coloured to indicate the fines content: green represents units with <5% fines; and red represents units with at least 5% fines. The depths are reported relative to the sea floor at the time of vibrocoring, and these data are summarised in Appendix 1.

Port of Tauranga Cores - 27 August 2014 — **Core Number: 01**

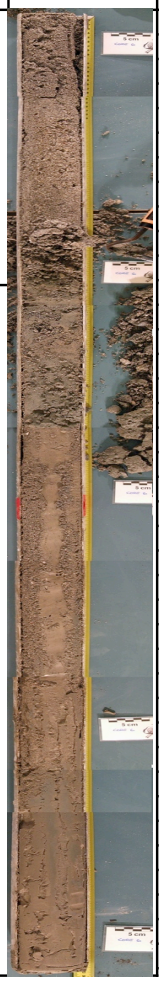


Fm.	depth (mm)	grain size	description
Holocene	0–350		dark grey, anerobic medium SAND with minor clay grading to coarse SAND with bivalve shells
Holocene	400	s 54 f 46	dark grey fine SAND with minor clay; non-sticky, low plasticity
Holocene	450–650	s 87 f 13	medium grey coarse SAND with minor pumice pieces upto 10 mm reduced clay content, paler grey compared with overlying layer
Holocene	700–850	s 85 f 15	@ ~ 900 mm: ~ 30 mm thick clay-rich layer
Holocene	900–1150		pale grey, medium SAND with small pumice pieces upto 2 mm 1 cm thick pebble horizon; dark pebbles (obsidian?)
Pleistocene	1200	s 75 f 25	pale grey, silty fine SAND
Pleistocene	1250		buff, fine SAND with pale grey anaerobic band - 10 mm thick at base
Pleistocene	1300		pale orange fine SAND with silt; stiff in place
Pleistocene	1350–1600		buff, pumiceous PEBBLES with coarse sand
Pleistocene	1650–1750		buff, well-sorted, medium SAND
Pleistocene	1800	s 80 f 20	orange SILT, overlying coarse pumiceous pebbles (buff)
Pleistocene	1850–1900		thin (5 mm) orange SILT buff, well-sorted, medium SAND
Pleistocene	1950–2100		buff, well-sorted, medium SAND
Pleistocene	2150–2200		buff, pumiceous, coarse SAND,with abundant pumice pebbles up to 5 mm
Pleistocene	2250	s 82 f 18	orange SILT, overlying pumiceous pebbley fine SAND
Pleistocene	2300		buff fine SAND
Pleistocene	2350		buff, fine SANDS intercalated with orange / buff SILTS upto 10 mm thick
Pleistocene	2400	s 55 f 45	very stiff in place - hard to scrape
Pleistocene	2450–2550	s 30 f 70	pale grey, SILTS and fine SANDS non-sticky, non-plastic, sensitive?
	2600		Core ends 2600 mm

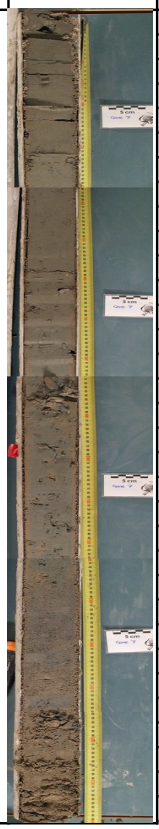
Port of Tauranga Cores - 27 August 2014 — **Core Number: 03**

Fm.	photo	depth (mm)	clay	silt	sand fi	sand md	sand cs	gran	pebb	grain size	description
Holocene		0									subangular to subrounded, medium to coarse SAND clean quartz crystals, rounded shell fragments and lithics cm-scale shell fragments + whole, disarticulated bivalves
		50									
		100									
		150									
		200									
		250									
Pleistocene		300								s 20 f 80	10 GY 5/1 greenish grey, silty CLAY non-sticky, moderately plastic stiff in place, soft when remoulded
		350									
		400									
		450									
		500									
		550									
		600									
		650									
		700									
		750									
		800								s 22 f 78	
		850									
		900									
		950									
		1000									
		1050									
		1100									
		1150									
		1200									
		1250									
		1300								s 35 f 65	
		1350									
		1400									
		1450									
		1500									@ 1500 mm: slightly sticky
		1550									
		1600									
		1650									
		1700									@ 1700 mm: minor fine sand, mildly sulphurous
		1750									
		1800								s 39 f 61	
		1850									
		1900									
		1950									towards base: silty CLAY, slightly sticky, fine sand disappears
		2000									Core ends 2000 mm

Port of Tauranga Cores - 3 September 2014 **Core Number: 06**

Fm.	photo	depth (mm)	clay	silt	sand fi	sand md	sand cs	gran	pebb	grain size	description
Holocene		0									grey, coarse SAND, with shell fragments (10 %)
		50									
		100									
		150									
		200									
		250									
		300									
		350									
		400									shell fragments increase in size and proportion at base (50 %)
		450									includes whole, disarticulated cockles
		500									
Pleistocene		550									@ 600 mm: 7.5 GY 6/1 greeenish grey, SILT with fine sand
		600									slightly sticky, slightly plastic
		650									firm in place, soft on remoulding
		700									
		750									
		800									
		850								s 45 f 55	
		900									
		950									
		1000									
		1050									decrease sand, increase clay downwards
		1100									
		1150									
		1200									
		1250									
		1300									
		1350									
		1400								s 20 f 80	
		1450									
		1500									
		1550									
		1600									
		1650									
		1700									
		1750									
		1800									
		1850									@ 1850 mm: 10GY 6/1 greenish grey, silty CLAY
		1900								s 20 f 80	non-sticky, moderately plastic
											firm in place, soft on remoulding
											Core ends 1965 mm

Port of Tauranga Cores - 28 August 2014 — **Core Number: 07**

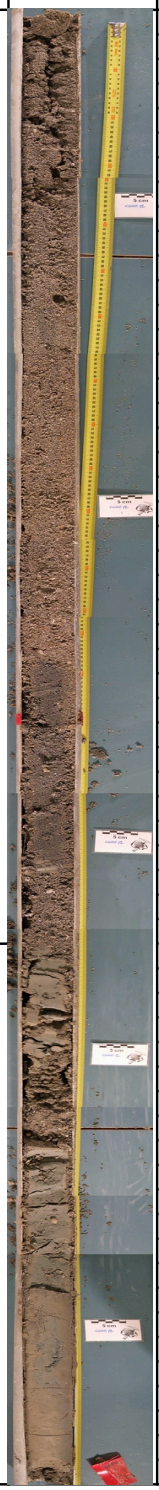
Fm.	photo	depth (mm)	clay	silt	sand fi	sand md	sand cs	gran	pebb	grain size	description
Pleistocene		0								s 19 f 81	10 GY 5/1 greenish grey, silty CLAY non-sticky, slightly plastic stiff in place, soft on remoulding
		50									
		100									
		150									
		200									
		250									
		300									
		350									
		400									
		450									
		500								s 18 f 82	
		550									
		600									@ 630 mm: small concretion - 15 mm long, very hard strong acid reaction on broken surface
		650									
		700									
		750									
		800									
		850									@ 870 mm: second larger concretion, 20 mm long
		900									
		950									
		1000								s 20 f 80	apparent gradation colour change towards base (not quantifiable)
		1050									@ 1100 mm: 10 GY 5/1 greenish grey, silty CLAY non-sticky, moderately plastic stiff in place, soft on remoulding
		1100									
		1150									
		1200									
		1250									7.5 GY 5/1 greenish grey, clayey SILT slightly sticky, slightly plastic very stiff in place, softish (less than above) when remoulded
		1300									
		1350								s 54 f 46	
		1400									
		1450									10Y 5/1 grey (browner), clayey SILT + minor fine sand; slightly sticky, non-plastic
		1500									7.5 GY 5/1 greenish grey, silty CLAY with trace fine sand; non-sticky, mod. plastic
		1550									7.5 GY 5/1 greenish grey, silty CLAY; slightly sticky, mod. plastic
		1600								s 56 f 44	7.5 Y 6/1 grey, SILT with fine sand, non-sticky, slightly plastic

Core ends ~ 1660 mm

Port of Tauranga Cores - 27 August 2014 **Core Number: 11**

Fm.	photo	depth (mm)	clay	silt	sand fi	sand md	sand cs	gran	pebb	grain size	description
Holocene		0									10 Y 6/1 grey, subangular, medium to coarse SAND clean quartz crystals, with rounded shell fragments and lithics
		350									coarse SAND at base with minor granule-sized shell fragments
		400									coarse SAND, with abundant large whole bivalves, one articulated
Pleistocene		700								s 50 f 50	10 GY 6/1 greenish grey, CLAY (possibly silty) slightly sticky, moderately plastic
		1150								s 36 f 64	
		1450								s 40 f 60	
		1650									from 1670 mm: CLAY with very minor fine sand mildly sulphurous smell in coarser parts
		1750									Core ends 1750 mm

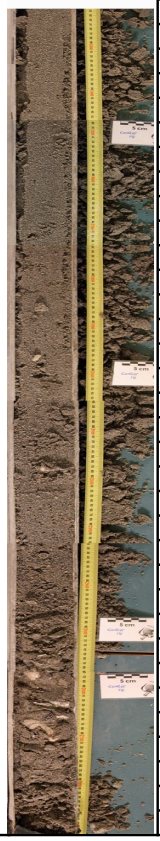
Port of Tauranga Cores - 3 September 2014 **Core Number: 12**

Fm.	photo	depth (mm)	clay	silt	sand fi	sand md	sand cs	gran	pebb	grain size	description
Holocene		0									brownish grey, coarse SAND, with shell fragments 10 - 20 %
		50									
		100									
		150									
		200									
		250									
		300									
		350									
		400									
		450									
		500									
		550									
		600									
		650									
		700									
		750									
		800									
		850									
		900									
		950									
		1000									
		1050									
		1100									
		1150									
		1200									
		1250									
		1300									dark grey, medium SAND, with sand-sized shell fragments ~ 5 %
		1350									
		1400									
		1450									
		1500									
		1550									@ 1700 mm: lump of greeenish grey SILT ~ 40 mm across derived from lower in profile
		1600									
		1650									
		1700									brownish grey, medium to coarse SAND shell fragments to 10 mm comprise ~ 10 %
		1750									
		1800									
		1850									
Pleistocene		1900								S 19 f 81	@ 1950 mm: 7.5 GY 6/1 greenish grey, silty CLAY non-sticky, mocderately plastic firm in place, soft when remoulded 1900 - 2300 mm, poor core washout filled with sand from above
		1950									
		2000									
		2050									
		2100									
		2150									
		2200									
		2250									
		2300									
		2350									
		2400								s 22 f 78	
		2450									
		2500									
		2550									
		2600									
		2650									
		2700									
		2750									
		2800									
		2850									@ 2850 mm: 7.5 GY 5/1 greenish grey, silty CLAY non-sticky, highly plastic stiff in place, soft on remoulding
		2900								s 41 f 59	
		2950									
		3000									Core ends 3000 mm

Port of Tauranga Cores - 3 September 2014 **Core Number: 13**

Fm.	photo	depth (mm)	clay	silt	sand fi	sand md	sand cs	gran	pebb	grain size	description
Holocene		0									0 - 1200 mm obscured as bent core barrel not cut
		1200									brownish grey medium SAND shell fragments to 10 mm comprise ~ 20 %
		1750									dark grey coarse SAND shell fragments to 50 mm increase in frequency with depth
		2000									shell fragments ~ 50 % at base
Pleistocene		2100								s 25 f 75	@ 2200 mm: 7.5 GY 5/1 greenish grey, silty CLAY slightly sticky, moderately plastic stiff in place, soft on remoulding
		2450								s 26 f 74	
		2800									@ 2900 mm: 10 GY 6/1 greenish grey, clayey SILT with trace fine sand slightly sticky, moderately plastic firm in place, very soft on remoulding
		3000									Core ends 3000 mm

Port of Tauranga Cores - 28 August 2014 — **Core Number: 18**

Fm.	photo	depth (mm)	clay	silt	sand fi	sand md	sand cs	gran	pebb	grain size	description
Holocene		0									@ 0 mm: 7.5 Y 6/2 greyish olive, well-sorted, sub-angular, medium SAND clean crystals, lithics, minor shell fragments
		50									
		100									
		150									
		200									
		250									
		300									
		350									
		400									
		450									
		500								s 97 f 3	
		550									
		600									
		650									
		700									
		750									
		800									
		850									
		900									
		950									
		1000									
		1050									
		1100									
		1150									
		1200									
		1250									
		1300									
		1350									
		1400									
		1450									
		1500								s 99 f 1	
		1550									
		1600									
		1650									
		1700									
		1750									
		1800									
		1850									@ 1800 mm: 7.5 Y 7/1 light grey, moderately-sorted, angular, medium SAND clean crystals, lithics, few shell fragments up to granules
		1900									@ 1900 mm: increase in larger shell fragments up to 20 mm (rare)
		1950									
		2000									
		2050									
		2100									
		2150									
		2200									
		2250									@ 2300 mm: 7.5 Y 7/1 light grey, moderately-sorted, angular, medium SAND shell fragments up to 20 %, occasional complete shell
		2300									
		2350									
		2400									
		2450									@ 2470 mm: shell fragments increase to 50 % includes large bivalve 70 mm long at base - lag?
		2500								s 99 f 1	
		2550									
		2600									
		2650									
		2700									
		2750									core catcher stuck in shelly base
		2800									core ends 2800 mm

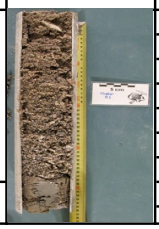
Port of Tauranga Cores - 27 August 2014 **Core Number: 19**

Fm.	photo	depth (mm)	clay	silt	sand fi	sand md	sand cs	gran	pebb	grain size	description
Holocene		0								s 97 f 3	angular, coarse SAND yellow stained quartz with lithics abundant shell fragments increasing in size with depth
		50									
		100									
		150									
		200									
		250									
		300									
		350									
		400									
		450									
		500									
		550									
		600									
		650									
		700									
		750									
		800									
		850									
		900									
		950									
		1000									
		1050									
		1100									
		1150									
		1200									
		1250									
		1300									
		1350									
		1400									
		1450									
		1500									
		1550									
		1600									
		1650									
		1700									
		1750									
		1800									
		1850								s 98 f 2	SAND same as above with occasional black lithic pebbles shells common (?very common) bivalve + gatropod shells, some whole, disarticulated
		1900									
		1950									
		2000									
		2050									
		2100									
		2150									
		2200									
		2250								s 97 f 3	moderately-sorted, angular, medium to coarse SAND very yellow-green grains (?glaucony), some shell fragments
		2300									
		2350									
		2400									sand as above contains one semi-consolidated sand lump plus other small lumps medium SAND with silt, rounded, ironstained on outside of nodule
		2450									
		2500									Core ends 2500 mm

Port of Tauranga Cores - 3 September 2014 **Core Number: 20**

Fm.	photo	depth (mm)	clay	silt	sand fi	sand md	sand cs	gran	pebb	grain size	description
Holocene		0									brownish grey, medium SAND, small pumice clasts
		50									
		100									
		150									
		200									gradational change
		250									brownish grey, well-sorted, medium SAND
		300									yellow satined crystals, black lithics, shell fragments up to 5 mm
		350									
		400									
		450									
		500									
		550									
		600									
		650									
		700									
		750									
		800								s 100 f 0	
		850									
		900									
		950									
		1000									
		1050									
		1100									
		1150									
		1200									
		1250									
		1300									
		1350									
		1400									
		1450									
		1500									
		1550								s 99 f 1	
		1600									
		1650									
		1700									
		1750									
		1800									shell fragments up to 5 mm increase down to ~ 15 %
		1850									
Pleistocene		1900									yellow, moderately-sorted, medium SAND
		1950								s 100 f 0	dark lithics, shell fragments up to 5 - 10 mm
		2000									WITH: large black nodules occupying full width of corer (80 mm)
		2050									with yellow surface staining
		2100								s 100 f 0	NODULES OCCUPY BULK OF SPACE (90 %)
		2150									
		2200									
		2250								s 98 f 2	
		2300									
		2350									
		2400									
		2450								s 97 f 3	

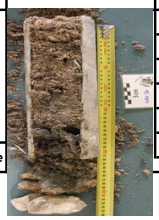
Core ends 2510 mm

Port of Tauranga Cores - 28 August 2014											**Core Number: 21**
Fm.	**photo**	**depth (mm)**	**clay**	**silt**	**sand**			**gran**	**pebb**	**grain size**	**description**
					fi	**md**	**cs**				
Holocene		0 50 100 150 200 250 300								**s 99 f 1**	@ 0 mm: 2.5 Y 6/3 dull yellow, moderately sorted coarse SAND sub-angular crystals, lithics, shell fragments; occasional pumice granules bivalve shell fragments and some whole shells, ~ 30 % shell generally 10 - 15 mm, up to 40 mm @ 300 mm: 7.5 Y 6/1 grey, poorly sorted medium - coarse SAND clear crystals, grey / black lithics; shell fragments up to 15 mm; loose
Pleistocene		350								**s 19 f 81**	7.5 GY 5/1 greenish grey, clayey SILT, non-sticky, slightly plastic soft in place, very soft when remoulded
											Core ends 435 mm

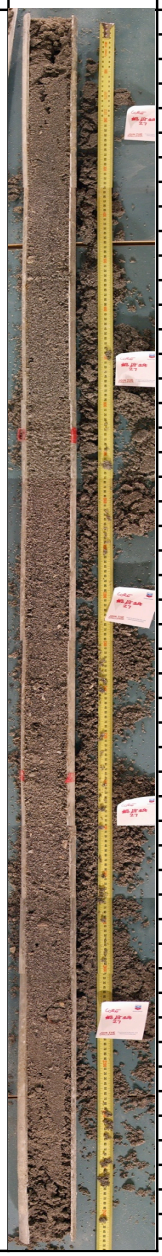
Port of Tauranga Cores - 18 September 2014 **Core Number: 25**

Fm.	photo	depth (mm)	clay	silt	sand fi	sand md	sand cs	gran	pebb	grain size	description
Holocene		0									0 - 250 mm washed out of corer
		250								s 96 f 4	2.5 Y 7/6 bright yellowish brown, moderately sorted, sub-angular, coarse SAND yellow stained crystals give colour, black lithics, sand-sized shell fragments small shell fragments comprise ~ 10 %
		1150									
		1200								s 99 f 1	SHELL HASH, same sand matrix with ~ 60 % shell fragments up to 40 mm maximum shell fragment proportion 1400 - 1600 mm including one pipi that was alive at time of sampling at 1400 mm
		1600									
Pleistocene		1650									10 Y 4/2 olive grey, very hard, silty SAND; impossible to dig
		1750									
		1800									2.5 Y 5/6 yellowish brown, moderately-sorted, medium to coarse SAND yellow crystals, black lithics; very stiff in place
		1950									
		2000								s 92 f 8	2.5 Y 6/8 bright yellowish brown, moderately to well-sorted, medium SAND yellow crystals, black lithics; slightly silty?
		2150								s 76 f 24	

Core ends 2180 mm

Port of Tauranga Cores - 3 September 2014											**Core Number: 26**
Fm.	**photo**	**depth (mm)**	**clay**	**silt**	**sand**			**gran**	**pebb**	**grain size**	**description**
					fi	**md**	**cs**				
Holocene		0 50 100 150 200 250 300									brownish grey, coarse SAND shell fragments to 15 mm comprise ~ 30 % size and abundance of shell fragments reduce downwards dark grey, medium SAND can't see shells, lots of dark lithics very dark grey, medium SAND, small shell fragments (< 5 %), up to 15 mm dark lithics
Pleistocene										**s 49 f 51** **s 46 f 54**	10 GY 6/1 greenish grey, fine sandy SILT (5 - 10 mm), orange ironstained margin ~ 2mm 2.5GY 8/1 light grey, SILT with minor clay, non-sticky, non-plastic, very firm in place Core ends 300 mm @ base below catcher, 2.5 GY 8/1 light grey, clayey SILT with trace fine sand slightly sticky, slightly plastic, hard and dry, soft on remoulding

Port of Tauranga Cores - 3 September 2014 **Core Number: 27**

Fm.	photo	depth (mm)	clay	silt	sand fi	sand md	sand cs	gran	pebb	grain size	description
Holocene		0									subangular to subrounded, medium to coarse SAND clean quartz crystals with rounded shell fragments and lithics medium to coarse sand at top, coarsening to very coarse at base shell fragments mm to cm increasing in size and abundance with depth
		50									
		100									
		150									
		200									
		250									
		300									
		350									
		400									
		450									
		500									
		550									
		600									
		650									
		700									
		750									
		800									
		850									
		900									
		950									
		1000									
		1050									
		1100									
		1150									
		1200									
		1250									
		1300									
		1350									
		1400									
		1450									from 1500 mm: 10 Y 6/1 grey
		1500									occasional whole disarticulated bivalves
		1550									
		1600									
		1650									
		1700									
		1750									
		1800									
		1850									
		1900									
		1950									
		2000									
		2050									
		2100									subangular to subrounded medium SAND clean quartz crystals, with rounded shell fragments and lithics sand sized shell fragments but no larger
		2150									
		2200									
		2250									
		2300									
		2350									
		2400									
		2450									

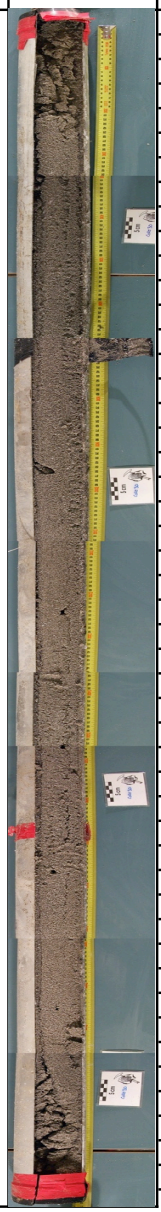
Core ends 2520 mm

Port of Tauranga Cores - 3 September 2014 — **Core Number: 29**

Fm.	photo	depth (mm)	clay	silt	sand fi	sand md	sand cs	gran	pebb	grain size	description
Holocene		0								s 99 f 1	medium to coarse SAND clean, angular quartz, lithics, rounded sand-sized shell fragments shell fragments increase in size with depth (remain < 10 mm)
		50									
		100									
		150									
		200									
		250									
		300									
		350									
		400									430 mm:clast of consolidated SILT with fine, black lithics (~ 3 %)
		450									similar to silt @ 1980 mm except consolidated and green-stained
		500									
		550									
		600									
		650									
		700									
		750									
		800									
		850									
		900									
		950									
		1000									
		1050									
		1100									
		1150									
		1200									
		1250									
		1300									
		1350									
		1400									
		1450									
		1500									
		1550									
		1600									
		1650									
		1700									
		1750									
		1800									
		1850									
		1900									whole disarticulated bivalve ~ 50 mm
		1950								s 90 f 10	
Pleistocene		2000								s 56 f 44	2.5 Y 7/1 light grey, clayey SILT with minor fine sand slightly plastic 2080-2090 mm:coarse SAND lens surrounded by consolidated silt
		2050									
		2100									
		2150									
		2200									
		2250									
		2300									
		2350									
		2400								s 58 f 42	
		2450									
		2500									@ 2500 mm: layer of consolidated green-stained silt
		2550									

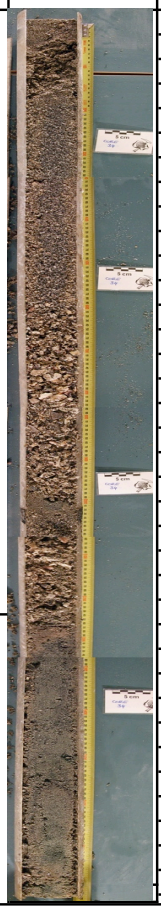
Core ends 2620 mm

Port of Tauranga Cores - 3 September 2014 **Core Number: 30**

Fm.	photo	depth (mm)	clay	silt	sand fi	sand md	sand cs	gran	pebb	grain size	description
Holocene		0 50 100 150 200 250 300 350 400 450 500 550 600 650 700 750 800 850 900 950 1000 1050 1100 1150 1200 1250 1300 1350 1400 1450 1500 1550 1600 1650 1700 1750 1800 1850 1900 1950 2000 2050 2100 2150 2200 2250 2300 2350									grey, well-sorted, medium SAND clear crystals, black lithics, few sand-sized shell fragments no large shell fragments

Core ends 2430 mm

Port of Tauranga Cores - 28 August 2014 — **Core Number: 34**



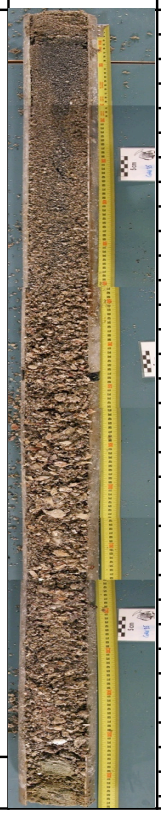
Fm.	depth (mm)	grain size	description
Holocene	0	f 98 s 2	5 Y 6/2 greyish olive, poorly sorted, medium - coarse SAND clear crystals, black lithics, abundant pumice to 3 mm very loose
	50		
	100		
	150		5 Y 5/1 grey, moderately sorted coarse angular SAND clear (no staining) crystals, black lithics, rare shell fragments loose
	200		
	250		
	300		matrix stays same increase in size and abundance of shell fragments
	350		
	400	s 100 f 0	
	450		
	500		
	550		
	600		SHELL HASH, 5 Y 5/1 grey, moderately sorted coarse angular SAND clear (no staining) crystals, black lithics, gastropod and bivalve shells, mostly broken, few intact, 80 % shell upto 40 mm, typically shell fragments < 5 mm from 600 mm shell size increases to max. ~ 800 mm, then decreases to 970 mm very "tight" and crunchy shell fragments ~ 40 mm shell fragments ~ 15 mm
	650		
	700		
	750		
	800		
	850		
	900		
	950	s 100 f 0	10 Y 4/1 grey, well sorted, medium (lower) SAND clean crystals, black lithics, occasional shell fragments
	1000		
	1050		mixed SHELL HASH, gastropod & bivalves in coarse, poorly sorted, angular sand ~ 80 % shell, shells up to 60 mm, shell size and proportion maximum ~ 1100 mm shells finer and reduced proportion downwards
	1100		
	1150		10 YR 4/2 greyish yellllllow brown, silty CLAY with moderate fine sand, non-sticky, moderately plastic
	1200		
	1250	s 62 f 38	at top (1230 mm) very thin stringers dark brown to black organic material (wood)
Pleistocene	1300		7.5 GY 5/1 greenish grey, well-sorted, angular, medium - coarse SAND green stained crystals, black flecks, grey lithics, no shells occasional black nodule, breaks up under light pressure very loose
	1350	s 97 f 3	
	1400		
	1450		
	1500		
	1550		
	1600	s 96 f 4	
	1650		
	1700		
	1750		material retained in catcher: 5Y 6/3 olive yellow well-sorted, medium SAND
		s 87 f 13	greenish stain on crystals, trace clay, slight plasticity, small pieces ~ 10 mm thick, break down under mild pressure

very bottom 3 - 5 mm higher clay content and more plastic, not sticky

suspect did not sample whatever stopped corer

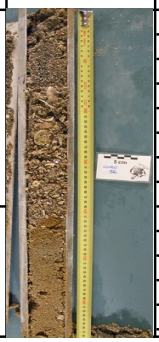
Core ends1790 mm + ~ 20 mm in core catcher

Port of Tauranga Cores - 3 September 2014 — **Core Number: 35**

Fm.	photo	depth (mm)	clay	silt	sand fi	sand md	sand cs	gran	pebb	grain size	description
Holocene		0									brownish yellow, medium - coarse SAND, includes pumice clasts (3 mm)
		50									grey, coarse SAND, abundant shell fragments to 5 mm
		100									< 5 % shell fragments at start
		150									
		200									
		250									
		300									shell fragments increase in proportion downwards
		350									
		400									
		450									
		500									
		550									~ 60 % shell fragments at base
		600									coarse SHELL HASH, bivalve and gastropod fragments to 40 mm, ~ 60 %
		650									bivalve and gastropod fragments to 40 mm
		700									shell proportion increases downwards
		750									
		800									
		850									
		900									
		950									
		1000									
		1050									
		1100									
		1150									
		1200									
		1250									
		1300									
		1350									
		1400									
		1450									
		1500									> 80 % shell fragments at base
Pleistocene		1550								s 82 f 18	10 GY 7/1 light greenish grey, silty fine SAND, non-sticky, slightly plastic, soft in place
											10 GY 7/1 dark greenish grey with brown streaks, silty fine to medium SAND
											10 GY 7/1 light greenish grey, silty fine to medium SAND

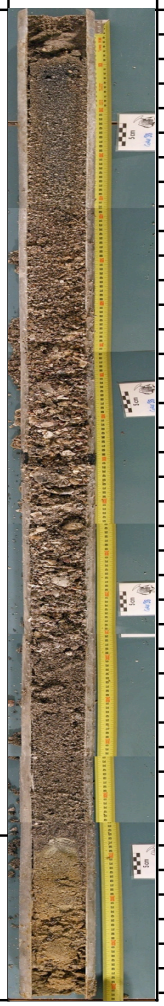
Core ends 1620 mm

Port of Tauranga Cores - 28 August 2014 **Core Number: 36**

Fm.	photo	depth (mm)	clay	silt	sand fi	sand md	sand cs	gran	pebb	grain size	description
Holocene		0								s 98 f 2	7.5 Y 7/2 light grey, poorly-sorted, coarse, angular SAND clean crystals, lithics, some shell fragments loose
		50									
		100									
		150									7.5Y 7/2 light grey, SHELL HASH, with coarse, angular sand matrix
		200									large shell fragments & complete bivalves, up to 60 mm shells, comprise ~ 80 %
		250									same sand matrix, shell fragments reduce to 15 mm, proportion reduces to 70 %
		300									tight and crunchy
		350									
Pleistocene		400									2.5 Y 6/6 bright yellowish brown, well-sorted, coarse SAND (lower); yellow crystals, lithics, no shell fragments, loose
		450								s 96 f 4	colour change only 10 Y 6/2 olive grey, yellowish staining greatest at top and bottom
		500									greenish grey deeper in core from 440 - 520
		550									
		600									

Core ends 660 mm

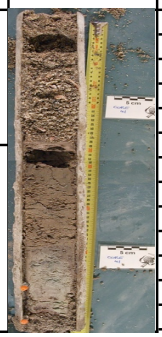
Port of Tauranga Cores - 3 September 2014 **Core Number: 38**



Fm.	depth (mm)	grain size	description
Holocene	0		yellowish brown, medium SAND with small pumice clasts (3 mm)
	50		
	100		grey, medium to coarse SAND clean angular crystals, black lithics, sand-sized shell fragments @ 100 mm: shell fragments < 10 %
	150		
	200		
	250		shell fragments increasing in size and abundance with depth
	300		
	350		
	400		
	450		
	500		
	550		@ 600 mm: shell fragments ~ 60 %
	600		coarse SHELL HASH with 80 - 90 % shell fragments and whole disarticulated bivalves to 50 mm
	650		
	700		
	750		
	800		
	850		
	900		
	950		
	1000		
	1050		
	1100		
	1150		
	1200		
	1250		
	1300		grey, very coarse SAND clean, angular crystals, black lithics, pumice clasts (3 mm) no shell fragments observed
	1350		
	1400		
	1450		
	1500		
	1550		
	1600		
	1650		
Pleistocene	1700	s 95 f 5	10 GY 5/1 greenish grey with pale grey oter rim, silty, medium SAND slightly plastic
	1750		
	1800	s 91 f 8	
	1850		
	1900	s 90 f 10	grading to: 5Y 8/4 pale yellow, silty SAND
	1950		

Core ends 2010 mm

Port of Tauranga Cores - 28 August 2014 — **Core Number: 41**



Fm.	depth (mm)	clay	silt	sand fi	sand md	sand cs	gran	pebb	grain size	description
Holocence	0–250									5Y 8/1 light grey, mixed SHELL HASH poorly sorted coarse sand matrix with rare lithic granules (10 mm) includes shell fragments up to 30 mm ~ 40 %, both bivalves and gastropods 100 - 175 mm: coarser shells comprise ~ 70 % shell fragments (10 - 15 mm) comprise ~ 50 %
Pleistocene	250–300								s 38 f 62	7.5Y 7/1 light grey, silty CLAY with trace fine sand; sticky, slightly plastic stiff in place, soft on remoulding, sensitive?
	300–350								s 56 f 44	7.5Y 6/1 grey, clayey SILT with trace fine sand; slightly sticky, slightly plastic stiff in place, soft on remoulding, small aggregates on sampling
	350–400								s 37 f 63	5Y 7/1 light grey, clayey SILT with trace fine sand; sticky, slighly plastic; stiff in place, small aggregates difficult to break down
	400–500								s 56 f 44	10GY 8/1 light greenish grey, SILT with minor fine sand and trace clay moderately plastic, NOT sticky less stiff in place, very soft when remoulded
	500–600								s 43 f 57 s 90 f 10	10Y 7/1 light grey, poorly sorted coarse SAND, abundant pumice pieces up to 3 mm, loose

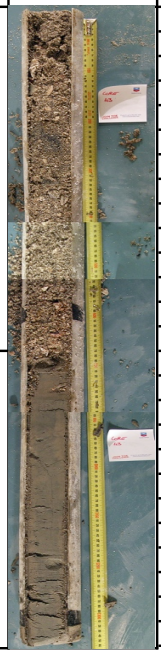
Core ends 650 mm

Port of Tauranga Cores - 3 September 2014 — **Core Number: 42**

Fm.	photo	depth (mm)	clay	silt	sand fi	sand md	sand cs	gran	pebb	grain size	description
Holocene		0									yellowish grey medium SAND shell fragments small (< 10 mm) and sparse (< 10 %) at top
		50									
		100									
		150									sand size increses and shell proportion increses with depth
		200									
		250									
		300									
		350									
		400									
		450									
		500									
		550									
		600									yellowish grey SHELL HASH with coarse sand matrix shells up to 50 mm comprising 60 - 70 %
		650									
		700									
		750									
		800									
		850									
Pleistocene		900								s 44 f 56	2.5 GY 5/1 olive grey sandy SILT with trace clay non-sticky, slightly plastic, fiirm in place black mottles (< 5 mm) increase downwards
		950									
		1000									
		1050									@ 1090 mm: piece of wood extracted
		1100								s 65 f 35	grades to fine SAND at base
		1150									2.5 Y 8/1 light grey clayey SILT with trace fine sand non-sticky, moderately plastic, very firm in place
		1200									
		1250								s 39 f 61	black streaks / nodules throughout top 150 mm present right through but less abundant with depth
		1300									
		1350									
		1400									
		1450									
		1500								s 36 f 64	
		1550									grades to more sandy with depth
		1600									
		1650									
		1700									
		1750								s 74 f 26	yellow/orange stained streaks ~ 2 mm thick at boundary 10 GY 7/1 light greenish grey sandy CLAY with minor silt
		1800									slightly sticky, moderately plastic, very firm in place
		1850									
		1900									
		1950									
		2000									
		2050									
		2100								s 72 f 30	

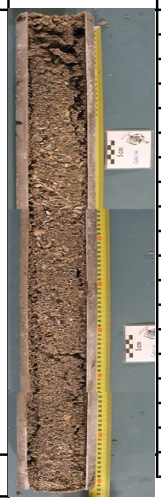
Core ends 2160 mm

Port of Tauranga Cores - 27 August 2014 **Core Number: 43**

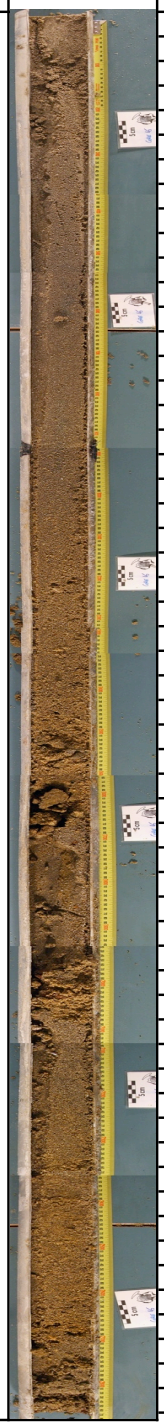
Fm.	photo	depth (mm)	clay	silt	sand fi	sand md	sand cs	gran	pebb	grain size	description
Holocene		0								s 98 f 2	angular, coarse SAND quartz + lithics + common shell fragments shells - fragments and whole disarticulated bivalves + gastropods, up to 20 mm
		50									
		100									
		150									
		200									slightly darker, medium SAND, fewer / smaller shell fragments
		250									
		300								s 100 f 0	angular, coarse SAND quartz + lithics + common shell fragments shells - fragments and whole disarticulated bivalves + gastropods, up to 20 mm
		350									
		400									
		450									
		500									
		550									
		600									
		650									
Pleistocene		700								s 25 f 75	2.5 Y 4/1 yellowish grey silty CLAY non-sticky, moderately plastic small roots at 820 mm
		750									
		800									
		850									
		900									
		950								s 20 f 80	
		1000									
		1050									
		1100									
		1150									
		1200									
		1250								s 24 f 76	

Core ends 1300 mm

Port of Tauranga Cores - 3 September 2014 — **Core Number: 44**

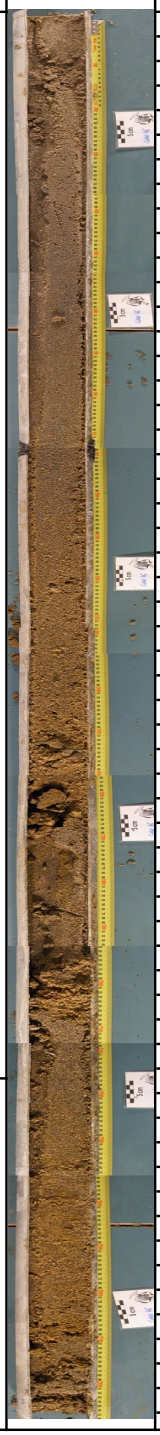
Fm.	photo	depth (mm)	clay	silt	sand fi	sand md	sand cs	gran	pebb	grain size	description
Holocene		0									yellowish grey medium to coarse SAND with shell fragments and pumice to 5 mm
		50									dark grey medium SAND with few small shell fragments
		100									
		150									
		200									grey coarse SAND with shell upto 30 mm comprising ~ 50 %
		250									broken bivalve and whole gastropod
		300									
		350									
		400									
		450									
		500									
		550									sand size and shell size reduce with depth
		600									
		650									
		700									
		750									
		800									
		850									medium SAND at base, shells up to 10 mm comprise ~ 20 %
Pleistocene		855									Core length 900 mm
		890									apparently 100 mm of "pug" adhered to base of core, fell off and not retreived
											similar to core 42 or 43

Port of Tauranga Cores - 3 September 2014 **Core Number: 45**

Fm.	photo	depth (mm)	clay	silt	sand fi	sand md	sand cs	gran	pebb	grain size	description
Holocene		0									@ 0 mm:pale yellowish grey moderately sorted medium SAND clear and green crystals, black lithics, rare shell fragments occasional pumice to 3 mm
		50									
		100									
		150									
		200									grades to grey sand otherwise the same
		250									
		300								s 96 f 4	
		350									
		400									
		450									
		500									
		550									
		600									
		650									
		700									
		750									
		800									
		850									
		900									
		950									
		1000								s 100 f 0	
		1050									
		1100									
		1150									
		1200									
		1250									
		1300									yellowish moderately sorted medium to coarse SAND much more yellow staining on crystals (no green), black lithics, no shell fragments DISTINCT COLOUR CHANGE, BUT NO OBVIOUS DIFFERENCE EXCEPT FEWER SAND-SIZED SHELL FRAGMENTS
		1350									
		1400									
		1450									
		1500								s 97 f 3	grades to: same sand with large brown / black nodules from 1520 - 1660 mm
		1550									
		1600									
		1650									lost core (? washed out) 1660 - 1970 mm
		1700									
		1750									
		1800									
		1850									
		1900									
		1950									@ 1970 mm: same yellowish sand with iron-encrusted nodules up to 50 mm
		2000									
		2050								s 97 f 3	grey coarse SAND grading to yellow coarse SAND
		2100									
		2150									
		2200									
		2250									
		2300									
		2350									
		2400									
		2450									
		2500									
		2550									
		2600									
		2650									@ 2670 mm shell fragment 15 mm
		2700								s 96 f 4	2700 mm to end: grey coarse SAND
		2750									
		2800									

Core ends 2860 mm

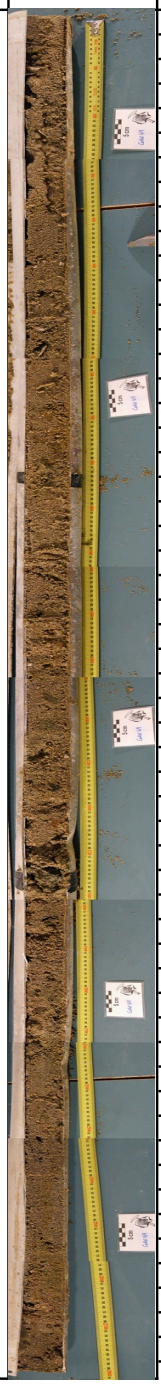
Port of Tauranga Cores - 3 September 2014 **Core Number: 46**



Fm.	depth (mm)	grain size	description
Holocene	0–2100		pale grey, well-sorted, medium SAND, clear crystals, lots of black lithics, sand-sized shell fragments rare visible shell fragments 1 whole gastropod and 2 weathered pumice clasts at base
Pleistocene	2150–2300	s 81 f 19	5Y 7/3 pale yelow, well-sorted, silty, fine SAND slightly coherant, firm in place; brown oxidising along core margins
	2350–2450	s 92 f 8	2.5 YR 6/8 bright yellowish brown, moderately sorted, medium to coarse SAND with dark orange stringers at top and black concretions up to 30 mm very tight in place
	2500–2650	s 96 f 4	2.5 YR 6/8 bright yellowish brown, moderately sorted, medium to coarse SAND yellow , subangular crystals, black lithics; loose in place
	2700–2800	s 97 f 3	slightly coarser towards base, but mostly grains yellower and more rounded

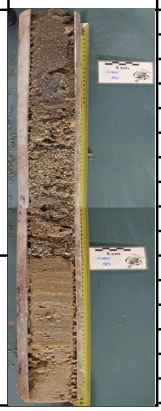
Core ends 2880 mm

Port of Tauranga Cores - 3 September 2014 **Core Number: 49**

Fm.	photo	depth (mm)	clay	silt	sand fi	sand md	sand cs	gran	pebb	grain size	description
Assumed Pleistocene		0								s 96 f 4	2.5 YR 7/8 yellow, moderately sorted, medium SAND yellow stained crystals, lots of black lithics, no sand-sized shell fragments coarse shell fragments to 20 mm comprise < 5 %, pipi, cockle
		50									
		100									
		150									
		200									
		250									
		300									
		350									
		400									
		450									
		500								s 99 f 1	
		550									
		600									
		650									
		700									
		750									
		800									
		850									
		900									
		950									
		1000									
		1050									
		1100									
		1150									
		1200									
		1250									@ 1250 mm: same sand, black concretions 60 mm long by 25 mm wide 1250 - 2100 mm9:10 pm darker yellow stained patches + black stained patches ? FLUCTUATING WATER TABLE
		1300									
		1350									
		1400									
		1450									
		1500								s 98 f 2	
		1550									
		1600									
		1650									
		1700									
		1750									
		1800									
		1850									
		1900									
		1950									
		2000									
		2050									
		2100									2100 mm to end of core: same sand
		2150									
		2200									
		2250									
		2300									
		2350									
		2400									
		2450									
		2500									
		2550									
		2600								s 100 f 0	
		2650									
		2700									

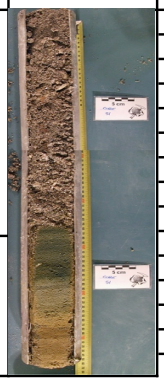
Core ends 2780 mm

Port of Tauranga Cores - 28 August 2014 **Core Number: 50**

Fm.	photo	depth (mm)	clay	silt	sand fi	sand md	sand cs	gran	pebb	grain size	description
Holocene		0								s 100 f 0	2.5 Y 5/1 yellowish grey, well-sorted medium SAND clear sub-rounded crystals, dark lithics, shell fragments < 10 %
		50									
		100									@ 200 mm: well-sorted medium to coarse SAND, greyer, few shell fragments
		150									grades over 20 mm
		200									shell hash within same sand, shell fragments up to 30 mm, ~ 60 % shell
		250									grades over 20 mm
		300								s 100 f 0	2.5 Y 6/2 greyish yellow, poorly sorted medium - coarse SAND clean crystals, ~ 20 % shell fragments
		350									
		400									@ 460 mm: pumice pebble ~ 10 mm long, streaky pumice - Loisels?
		450								s 98 f 2	increase in shell towards base (~ 30 %)
Pleistocene		500					cream, pumiceous SAND and GRANULES			s 85 f 15	grey, fine-medium SAND; followed by alternating sequence of yellow / orange and grey well-sorted SANDS
		550									
		600									
		650					grey sands yellowsands				
		700								s 83 f 17	2.5 Y 7/2 greyish yellowgrey with diffuse yellow patches well sorted fine - medium
		750									

Core ends 800 mm

Port of Tauranga Cores - 28 August 2014 — **Core Number: 51**



Fm.	depth (mm)	grain size	description
Holocene	0	s 100 f 0	5 Y 5/1 grey well-sorted medium SAND,abundant black lithics,sparse shell fraction
	50		
	100		mixed SHELL HASH, grey medium sand matrix, abundant shell fragments to 30 mm comprise ~ 60 %, very compacted
	150		
	200		
	250	s 99 f 1	sand matrix coarsens with depth
	300		very gradational
	350		coarse sand lower 100 mm
	400		
Pleistocene	450	s 73 f 27	alternations of 2.5 GY 7/10 dark green fine SAND and 10 Y 7/8 pale green medium SAND
	500		dark green fine SAND includes bright white patch 5 x 10 mm - collapsed pumice?
	550		pale green fine SAND
	600	s 62 f 38	dark green fine SAND
	650		pale green medium SAND
			olive fine SAND
			2.5 Y 6/6 bright yellowish brown fine SAND with minor silt
		s 80 f 20	2.5 Y 4/6 olive brown fine SAND with minor silt
			2.5 Y 6/6 bright yellowish brown fine to medium SAND
			all Pleistocene sand units well sorted and compact.

Core ends 740 mm

Port of Tauranga Cores - 3 September 2014 **Core Number: 52**

Fm.	depth (mm)	grain size	description
Holocene	0–50	s 93 f 7	greenish grey fine (to medium) SAND with trace silt, rare sand-sized shell fragments
	50–1100	s 100 f 0	300 mm: grey, clean, fine to medium, well-sorted, sub-rounded SAND with very rare sand-sized shell fragments @ 900 mm: grey, moderately sorted, angular, coarse SAND with frequent sand-sized shell fragments @ 1100 mm: fine SHELL HASH; shell fragments to 8 mm comprise ~ 70 %; angular coarse sand with lots of black lithics
Pleistocene	1100–1150	s 85 f 15	10 GY greeenish grey sandy SILT with trace clay non-sticky, slightly plastic, very stiff in place
	1150–1400	s 85 f 15	pales to: 2.5 GY 8/1 light grey
	1400–1500	s 81 f 19	2.5 Y 5/6 yellowish brown, well-sorted, fine SAND, no shell, hard dark nodules, very stiff in place
	1500–1550		2.5 Y 5/6 yellowish brown, well-sorted, rounded fine SAND with minor silt non-sticky, slightly plastic, soft in place
			Core ends 1610 mm

Port of Tauranga Cores - 18 September 2014 **Core Number: 53**

Fm.	photo	depth (mm)	clay	silt	sand fi	sand md	sand cs	gran	pebb	grain size	description
Holocene		0								s 100 f 0	pale brown, moderately-sorted, medium SAND clean crystals, lithics, and sand-sized shell fragments shell fragments upto 12 mm at start, increase in frequency downwards whole gastropod at boundary
		50									
		100									
		150									
		200									
		250									
		300									
Pleistocene		350								s 92 f 8	dark grey, well-sorted, fine SAND clear crystals, very abundant dark lithics, no sand-sized shell fragments becomes slightly finer and paler with depth
		400									
		450									
		500									
		550								s 90 f 10	

Core ends 580 mm

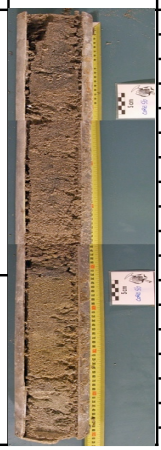
Port of Tauranga Cores - 18 September 2014 — **Core Number: 55**

Fm.	photo	depth (mm)	clay	silt	sand fi	sand md	sand cs	gran	pebb	grain size	description
Holocene		0								s 100 f 0	5 Y 5/1 greywell-sorted, medium SAND clean crystals, black lithics, some sand-sized shell fragments
		50									
		100									5 Y 8/1 light grey, poorly-sorted, angular, coarse SAND clean crystals, balck lithics, abundant sand-sized shell fragments up to 10 % shell fragments up to 15 mm
		150									
		200									
		250									
		300									
		350									
		400									
		450									
		500									
		550									
		600								s 100 f 0	
		650									
		700									
		750									
		800									
		850									
		900									
		950									SHELL HASH at base; ~ 70 % shell, mostly broken, few whole
Pleistocene		1000								s 93 f 7	10 GY 4/1 dark greenish grey, very well-sorted, fine SAND clean, sub-rounded crystals, abundant black lithics, no sand-sized shell fragments no large shell fragments possible slight horizontal bedding - faint colour changes
		1050									
		1100									
		1150									
		1200									
		1250								s 76 f 24	

5 Y 5/6 olive, mod.-sorted, silty fine S clumps, slightly plastic discoloured crystals, no shell

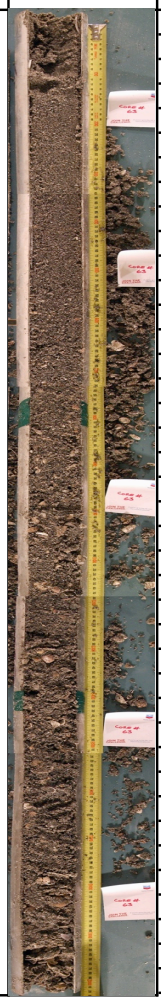
Core ends 1310 mm

Port of Tauranga Cores - 3 September 2014 **Core Number: 56**

Fm.	photo	depth (mm)	clay	silt	sand fi	sand md	sand cs	gran	pebb	grain size	description
Holocene		0									yellowish grey well-sorted medium SAND
		50									
		100									
		150									
		200									
		250									
		300									
		350									
		400									
		450									
		500									grey well-sorted medium SAND
Pleistocene		550								s 84 f 16	yellow medium SAND yellow colour intensifies downwards
		600									
		650									
		700									
		750									2.5 GY 7/1 light grey well-sorted, sub-angular medium SAND
		800								s 92 f 8	

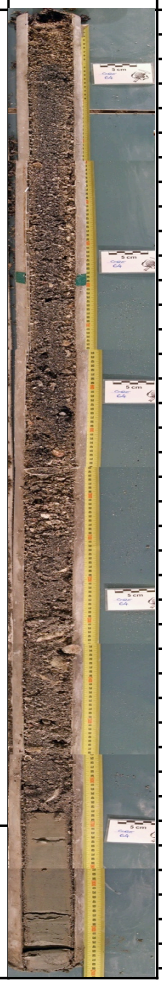
Core ends 880 mm

Port of Tauranga Cores - 27 August 2014 **Core Number: 63**

Fm.	photo	depth (mm)	clay	silt	sand fi	sand md	sand cs	gran	pebb	grain size	description
Holocene		0									subangular to subrounded, medium to coarse SAND with clean quartz crystals rounded shell fragments and lithics granule-sized shell fragments at top
		50									
		100									
		150									
		200									
		250									
		300									
		350									
		400									
		450								s 100 f 0	
		500									
		550									
		600									coarsening to coarse SAND at base
		650									
		700									
		750									
		800									
		850									@ 850 mm: shell fragments coarsen to cm-scale
		900									
		950									
		1000									from 1000 mm: whole, disarticulated bivalves and gastropods
		1050									
		1100									
		1150									
		1200									
		1250									
		1300									
		1350									
		1400									
		1450									
		1500								s 100 f 0	
		1550									
		1600									
		1650									
		1700									
		1750									
		1800									
		1850									
		1900									
		1950									

Core ends 2000 mm

Port of Tauranga Cores - 28 August 2014 **Core Number: 64**

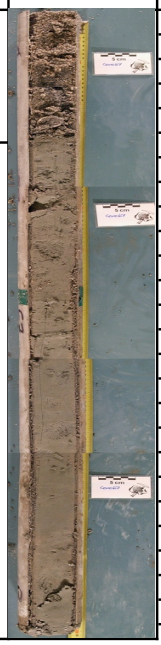


Fm.	depth (mm)	clay	silt	sand fi	sand md	sand cs	gran	pebb	grain size	description
Holocene	0									7.5 Y 5/1 grey (darker inside), poorly sorted, medium - coarse pumiceous SAND abundant pumice granules, no shell fragments
	50									
	100									7.5 Y 4/1 grey (darker than above), well-sorted, sub-rounded medium SAND no staining on crystals, dark lithics, shell fragments
	150								s 100 f 0	
	200									@ 200 mm: shell fragments up to 15 mm make up ~ 10 %
	250									
	300									
	350									
	400									
	450									
	500								s 100 f 0	
	550									proportion of shell fragments increases downwards
	600									
	650									
	700									
	750									
	800									
	850									
	900									910 - 1100: shell fragments ~ 60 %, up to 40 mm in size bivalves with one gastropod @ 920 mm
	950									
	1000									
	1050									
	1100									N 6/0 grey well-sorted medium to coarse SAND sub-rounded, clear crystals, abundant grey lithics, scarce shell in sand fraction ~ 10 % shell fragments up to 8 mm shell content increases downwards
	1150									
	1200									
	1250									1270 - 1400 mm: coarse SHELL HASH, all bivalves up to 50 mm long bored, encrusted with barnacles
	1300									
	1350									
	1400									
	1450									shell content decreases downwards
	1500									
	1550									
	1600								s 100 f 0	grey coarse SAND with 10 - 20 % shell fragments
Pleistocene	1650								s 15 f 85	10 GY 5/1 greenish grey clayey SILT (silty CLAY?) non-sticky, moderately plastic, slightly stiff in place, soft on reworking
	1700									@ 1700 mm: small (< 15 mm long) concretion extracted mild surface reaction with acid, cemented silt
	1750									
	1800									very uniform - slight increse in stickiness with depth
	1850									
	1900								s 27 f 73	slightly softer in place with depth

large brown/black twig fragments

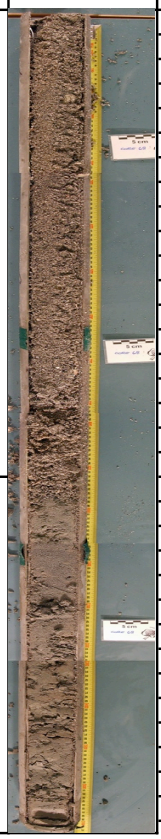
Core ends 1970 mm

Port of Tauranga Cores - 28 August 2014 — **Core Number: 67**

Fm.	photo	depth (mm)	clay	silt	sand fi	sand md	sand cs	gran	pebb	grain size	description
Holocene		0								s 100 f 0	moderately sorted coarse grey SAND, clean, sub-angular crystals, black lithics shell fragments up to 15 mm, typically 5 mm, comprise ~ 20 %
		50									
		100									dark grey, moderately sorted coarse SAND sub-angular crystals, dark lithics, colour change due to increase in lithics in sand few shells at start, shell content increases with depth
		150									
		200									~ 30 % shell fragments including one large cockle (30 mm)
		250									
Pleistocene		300								s 46 f 54	@ 320 mm: 7.5 GY 5/1 greenish grey, clayey SILT with trace fine sand slightly sticky, moderately plastic, stiff in place, very soft when remoulded
		350									
		400									
		450									
		500									
		550									
		600								s 33 f 67	shell fragments - very worn and bored
		650									
		700									@ 700 mm: 7.5GY 5/1 greenish grey silty CLAY slightly sticky, moderately plastic
		750									
		800									long, monotonous grey silt / clay, trace fine sand at start disappears with depth varies silty CLAY / clayey SILT but changes not readily identified
		850									
		900								s 26 f 74	- no colour or other obvious indications
		950									
		1000									@ 1000 mm: 7.5 GY 6/1 greenish grey clayey SILT (silty CLAY) slightly sticky, low plasticilty, stiff in place, very soft on remoulding
		1050									
		1100									
		1150									
		1200								s 19 f 81	@ 1240 mm: 10GY 5/1 greenish grey silty CLAY; slightly sticky, slightly plastic

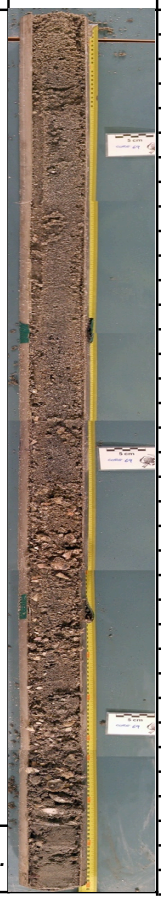
Core ends 1280 mm

Port of Tauranga Cores - 3 September 2014 — **Core Number: 68**

Fm.	photo	depth (mm)	clay	silt	sand fi	sand md	sand cs	gran	pebb	grain size	description
Holocene		0									brownish grey medium to coarse SAND shell fragments up to 20 mm comprise 30 - 40 % throughout
		50									
		100									
		150									
		200									
		250									
		300									
		350									
		400									
		450									
		500									
		550									
		600									
		650									
		700									
		750									
		800									
		850									
		900									
Pleistocene		950								s 86 f 14	@ 1040 mm: 7.5 GY 6/1 greenish grey (fine) sandy SILT with minor clay non-sticky, slightly plastic, soft in place, very soft on remoulding
		1000									
		1050									
		1100									
		1150									@ 1180 mm: small, creamy-white, ~ 10 mm sandy concretion @ 1190 mm: bigger complex version of same concretion - burrow infill?
		1200									
		1250								s 80 f 20	@ 1250 mm: whole, 40 mm disraticulated cockle shell, black, not pitted, no edge weathering
		1300									sand content reduces with depth
		1350									
		1400									
		1450									
		1500									
		1550									
		1600								s 28 f 72	7.5 GY 6/1 greenish grey clayey SILT (silty CLAY?) non-sticky, moderately plastic, stiff in place, soft when remoulded

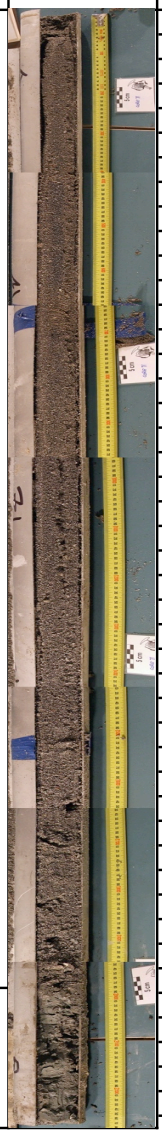
Core ends 1670 mm

Port of Tauranga Cores - 3 September 2014 — **Core Number: 69**

Fm.	photo	depth (mm)	clay	silt	sand fi	sand md	sand cs	gran	pebb	grain size	description
Holocene		0									brownish grey coarse SAND, with some pumice clasts and sadn-sized shell
		50									
		100									dark grey medium SAND with few small shell fragments
		150									
		200									
		250									
		300									
		350									
		400									
		450									
		500									
		550									
		600									
		650									
		700									
		750									
		800									
		850									
		900									shell fragments increase with depth to ~ 10 % at base
		950									grey SHELL HASH in a medium sand matrix
		1000									broken shell fragments up to 30 mm, bored, comprise ~ 30 %
		1050									
		1100									dark grey medium to coarse SAND with abundant shell fragments
		1150									whole, disarticulated bivalve shells to 50 mm comprise ~ 20 %
		1200									
		1250									
		1300									
		1350									
		1400									
		1450									
		1500									
		1550									
		1600									shell fragments grade to ~ 70 % at base (lag)
Pleisto.		1650								s 77 f 23	10 GY 5/1 greenish grey silty SAND (fine to medium sand); firm in place
		1700									
		1750									

Core ends 1790 mm

Port of Tauranga Cores - 3 September 2014 **Core Number: 71**

Fm.	photo	depth (mm)	clay	silt	sand fi	sand md	sand cs	gran	pebb	grain size	description
Holocene		0									brownish grey medium to coarse SAND, with small pumice clasts (< 2 mm)
		50									grey medium to coarse SAND, with shell fragments to 5 mm comprising < 5 %
		100									
		150									
		200									
		250									
		300									
		350									
		400									
		450									
		500									
		550									
		600									
		650									
		700									
		750									
		800									
		850									
		900									
		950									
		1000									
		1050									
		1100									
		1150									
		1200									
		1250									
		1300									
		1350									
		1400									
		1450									
		1500									grey coarse SAND
		1550									
		1600									
		1650									
		1700									
		1750									
		1800									
		1850									
		1900									
		1950									increase in shell fragments to a few of 20 mm length at base, comprise ~ 10 %
Pleistocene		2000								s 18 f 82	7.5 GY 5/1 greenish grey silty CLAY with trace fine sand slightly sticky, moderately plastic, firm in place, quite soft on remoulding
		2050									
		2100									
		2150									mucked up by coring
		2200								s 31 f 69	

Core ends 2270 mm

Port of Tauranga Cores - 27 August 2014 **Core Number: 74**

Fm.	depth (mm)	grain size	description
Holocene	0	s 84 f 16	2.5 Y 6/4 dull yellow sub-angular to angular, medium SAND yellow stained quartz, shell fragments, some coarse-sand to granule sized lithics
	100		@ 120 mm: small silt lumps up to cm size, consolidated grey silt 7.5 Y 4/1 grey subangular to subrounded, coarse SAND clean quartz crystals, fewer shell fragments, angular lithics are sand sized
	350	s 91 f 9	coarse SHELL HASH with cm-sized pebbles - consolidated greensand + rounded rhyolite
Pleistocene	450	s 60 f 40	10 Y 7/1 light grey fine SAND with clay; slightly plastic with mottles of 7.5 YR 5/8 light brown; ~ 20 % mottles
	800		medium SAND with minor clay
	900	s 78 f 22	
	1000	s 83 f 17	
	1100		mottles increasing with depth to cover whole core by 1140 mm
	1200	s 65 f 35	gradational colour change
	1250		10 R 5/3 reddish brown fine to medium SAND with minor clay; slightly plastic gradational colour change
	1300		2.5 Y 7/3 light yellow silty medium SAND rounded quartz grains and lithics, low plasticity
	1500	s 64 f 36	2.5 Y 7/4 light yellow sandy CLAY; moderately plastic; in hard, crumbly lumps
	1600		2.5 Y 7/4 light yellow, silty, fine to medium SAND low plasticity; possibly organic black fragments?
	1700	s 74 f 26	
	1750		Core ends 1800 mm

Port of Tauranga Cores - 27 August 2014 **Core Number: 78**

Fm.	depth (mm)	clay	silt	sand fi	sand md	sand cs	gran	pebb	grain size	description
Pleistocene	0								s 61 f 39	2.5 Y 7/1 light grey fine SAND with minor silt; non-sticky, non-plastic, slightly bouncy at top 0 - 100 mm 3 slightly anoxic layers below 400 mm, ~ 100 mm thick
	50									
	100									
	150								s 74 f 26	
	200									
	250									
	300									
	350								s 56 f 44	
	400									
	450									
	500								s 80 f 20	
	550									
	600									
	650								s 52 f 48	
	700									
	750								s 55 f 45	
	800									
	850									2.5 Y 7/3 light yellow medium SAND with silt cm to dm scale ver consolidated (semi-lithified?) chunks in sandy matrix with silt; may have been broken up by core?
	900								s 54 f 46	
	950									
	1000									
	1050									
	1100									
	1150									
	1200									
	1250									
	1300									
	1350								s 54 f 46	
	1400									
	1450									
	1500									
	1550									2.5 Y 6/4 dull yellow sandy SILT (varying silt/sand ratio); slightly plastic; organic smears; rare pumice pieces
	1600									
	1650								s 56 f 44	
	1700									
	1750									
	1800									
	1850									2.5 Y 7/3 light yellow medium SAND; dark quartz grains with lithics and glaucony includes consolidated pale sand / silt clasts (like above?), 50 mm scale @ 2040 mm: pebble sized dark sand concretion; galucony?
	1900								s 76 f 24	
	1950									
	2000									
	2050									
	2100									
	2150									
	2200								s 50 f 50	
	2250									
	2300									2.5 Y 7/3 light yellow medium SAND, pale colour matrix varies with: 2.5 Y 4.1 yellowish grey medium SAND; dark colour only change
	2350									
	2400								s 72 f 28	
	2450									

Core ends at 2500 mm

Port of Tauranga Cores - 27 August 2014 — **Core Number: 79**

Fm.	depth (mm)	grain size	description
Holocene	0–550	s 82 f 18	black fine to medium SAND, anoxic - very dark, smelly
			at base:blob of pale grey SAND with silt, ~ 50 mm
		s 84 f 16	2.5 Y 6/1 yellowish grey coarse SAND with pumice pebbles and minor shell fragments
Pleistocene	600–650	s 21 f 79	complex of orange SILTY bands, coherant
	700–1150	s 67 f 33	medium to coarse SAND with occasional pumice pebbles
		s 81 f 19	increased pumice pebble content with depth
	1200–1350		cream clast-supported CONGLOMERATE; pebbly with coarse sand matrix; pumice pebbles up to 20 mm ?ignimbrite?
	1400–1500	s 84 f 16	medium to coarse SAND
	1550	s 77 f 23	pumice pebble "lag", pebbles > 16 mm diameter
	1600–1650	s 7 f 93	2.5 Y 8/3 pale yellow SILT with some clay, non-sticky, slightly plastic
	1650–1750	s 40 f 60	decreasing clay with depth (more sand)
	1800	s 20 f 80	silty SAND
	1850		fine to medium SAND
	1900	s 34 f 66	2.5 Y 7/3 light yellow clayey SILT; plastic
		s 49 f 51	2.5 Y 8/2 light grey SILT
	1950–2250	s 90 f 10	medium to coarse SAND; normally graded
			some granules at base
			Core ends 2300 mm

sandy SILT

Port of Tauranga Cores - 27 August 2014 **Core Number: 80**

Fm.	photo	depth (mm)	clay	silt	sand fi	sand md	sand cs	gran	pebb	grain size	description
Pleistocene		0								s 77 f 23	2.5 Y 7/1 light grey well-sorted, medium to coarse angular SAND
		50									
		100									
		150									
		200									
		250									
		300									
		350									
		400									
		450									
		500								s 77 f 23	
		550									
		600									
		650									
		700									
		750									
		800									
		850									
		900									from 900 mm: occasional pumiceous pebbles 5 mm; smell of sulphide
		950									
		1000								s 76 f 24	
		1050									
		1100									
		1150									
		1200									
		1250									
		1300									
		1350									
		1400									
		1450									2.5 Y 7/1 light grey fine SAND
		1500								s 76 f 24	
		1550									2.5 Y 7/1 light grey medium SAND with black stringers
		1600									
		1650									
		1700									
		1750									
		1800								s 68 f 32	
		1850									
		1900									
		1950									
		2000									
		2050									

Core ends 2100 mm