A part of BMT in Energy and Environment

Assessment of Marine Sediments Adjacent to Fisherman Islands

R.B17527.001.01.doc

March 2010

Assessment of Marine Sediments Adjacent to Fisherman Islands Final Report

Offices

Brisbane
Denver
Mackay
Melbourne
Newcastle
Perth
Sydney
Vancouver

Prepared For:	Port of Brisbane Corporation
Prepared By:	BMT WBM Pty Ltd (Member of the BMT group of companies)

DOCUMENT CONTROL SHEET

BMT WBM Pty Ltd BMT WBM Pty Ltd Level 11, 490 Upper Edward Street Brisbane 4000 Queensland Australia PO Box 203 Spring Hill 4004 Tel: +61 7 3831 6744 Fax: + 61 7 3832 3627 ABN 54 010 830 421 www.wbmpl.com.au	***Document :*** ***Project Manager :*** ***Client :*** ***Client Contact:*** ***Client Reference***	R.B17527.001.01 Chris Pietsch Port of Brisbane Corporation Scott McKinnon

Title :	Assessment of marine sediment adjacent Fishermans Island Final Report
Author :	Markus Billerbeck, Chris Pietsch, Darren Richardson
Synopsis :	This report details the findings of a survey undertaken to determine the particle grain size composition of marine sediment of intertidal and subtidal banks situated to the south of Fisherman Islands. Survey results were compared to previous datasets to determine any broad scale shifts that may have occurred in the composition of these bed materials.

REVISION/CHECKING HISTORY

REVISION NUMBER	DATE OF ISSUE	CHECKED BY		ISSUED BY	
0	18 September 2009	DLR		MMB	
1	6 March 2010	DLR		CP	

DISTRIBUTION

DESTINATION	REVISION			
	0	1	2	3
Port of Brisbane Corporation	1 + PDF			
BMT WBM File	PDF			
BMT WBM Library	PDF			

CONTENTS

LIST OF FIGURES

LIST OF TABLES

1 EXECUTIVE SUMMARY

This report on spatial and temporal patterns in sediment distribution in Waterloo Bay was prepared by BMT WBM on behalf of the Port of Brisbane Corporation. The main objectives of the study were to describe the broad scale spatial patterns in sediment particle size composition within the Fisherman Islands study area and to identify potential temporal changes in sediment patterns by comparing the results of the present study with previous investigations undertaken by BMT WBM in 1992 and 1998. Any evidence of changes in sediment composition in the area indicative of impacts resulting from Port of Brisbane activities was discussed.

The spatial patterns of sediment distribution observed in 2009 in the study area were generally consistent with previous investigations in the area, indicating that no major changes in broad scale sediment patterns have occurred during the period 1992-2009. During this 17 year period the port has undergone significant development including the port expansion ("Superbund") works in 1992 and Future Port Expansion (FPE) project in 2002. Overall, the results suggested that broad scale sediment patterns in the study area are predominantly determined by hydrodynamic forces due to currents and wave action. Accordingly, fine sediment fractions were predominantly found in areas characterised by low wave and current activity and in deeper channels. Medium sands were the dominant sediment type in the study area and mainly found in offshore intertidal areas between Fisherman and St Helena Islands. Higher bed shear stresses are common in these relatively exposed and shallow areas and wave action is expected to be higher compared to sheltered nearshore areas and deeper channels.

The investigation of temporal patterns in sediment distribution between 1992 and 2009 indicated some localised changes in sediment distribution patterns within the broader study area, which appeared to be consistent with predicted changes to current patterns associated with the various construction stages of the port development. An area characterised by a major decrease in the fine sand fraction between 1992 and 1998 was identified off the north-eastern edge of the Superbund structure. This result indicated erosion of fines in this area due to localised disturbance of bed sediments by the protruding Superbund structure, as predicted based on interpretation of earlier modelling undertaken by WBM (1993).

In contrast, no such erosion was observed for the period 1998-2009, probably as a result of the truncated north-eastern seawall structure designed to minimise local disturbance of the seabed. However, a notable 3 to 7-fold increase in silts was recorded within a localised area adjacent to Fisherman Island and south of the seawall. This increase in fines may have been caused by local changes in hydrodynamic conditions associated with the FPE seawall structure, as supported by previous modelling (WBM 2000), which suggested a reduction in flow velocities at the southeast edge of the seawall and potential increase in silty material in the area.

Although some localised changes in sediment patterns appear to have occurred within the broader study area between 1992 and 2009, small scale patchiness in sediment characteristics may have contributed to the observed patterns to some extent. This may include micro-topographical variations in the seabed due to ripple formation and localised changes in hydrodynamic processes, which may reflect seasonal and interannual *changes in waves and currents*.

2 INTRODUCTION

2.1 Background

The Port of Brisbane Corporation (PBC) has its main port infrastructure at Fisherman Islands, situated at the mouth of the Brisbane River. Since the late 1960's strategic reclamation works have been undertaken within the area as a response to the growing demand for port land. Most recently, major port expansions include:

- The "Superbund" development initiated in 1992 that involved extensive reclamation of intertidal and shallow subtidal land to the east and southeast of Fisherman Islands, resulting in the amalgamation of Bishop Island with Fisherman Islands; and
- The Future Port Expansion (FPE) project commencing in 2002 resulted in the creation of a 4.6 kilometre seawall and the associated reclamation of ~230 ha of subtidal seabed. The seawall was completed in August 2005, and the area within the reclamation is progressively being in-filled with dredged material.

An investigation on the hydrodynamics and sedimentary characteristics (WBM 1992) and Impact Assessment Studies (WBM 2000) had identified the potential for port expansion works to cause localised changes to intertidal and subtidal habitats in the vicinity of Fisherman Islands. Such changes included modification of bed sediment characteristics and sedimentation processes through altering tidal current dynamics and the direction of freshwater flow from the Brisbane River.

An investigation conducted by WBM (1998) generally found no substantial shifts in sediment composition post construction of the Superbund, except for an area off the northeast edge of the Superbund. Furthermore, sediment characteristics directly adjacent the FPE seawall were surveyed by BMT WBM (2009b) with results also indicating no major change in sediment particle grain size. However, since seawall completion, no studies to date have examined the nature of sediments on a broader spatial scale that consider areas utilised by commercial and recreational baitworm diggers.

The present study was commissioned by the PBC to determine possible changes in the characteristics of bed sediments adjacent to Fisherman Islands through surveys of particle size distribution (PSD) of sediment.

2.2 Study Aims & Objectives

The broad aim of this investigation was to determine any notable changes in marine sediment composition since completion of the FPE seawall of the intertidal and shallow subtidal banks situated south to south west of Fisherman Islands. The specific objectives of this study were to:

- Identify and describe broad scale spatial patterns in sediment grain size composition within the Fisherman Islands area;
- Describe temporal changes to sediment grain size composition within each site, based on data collected in the present study and previous studies in the Fisherman Islands area (WBM 1992, 1998); and

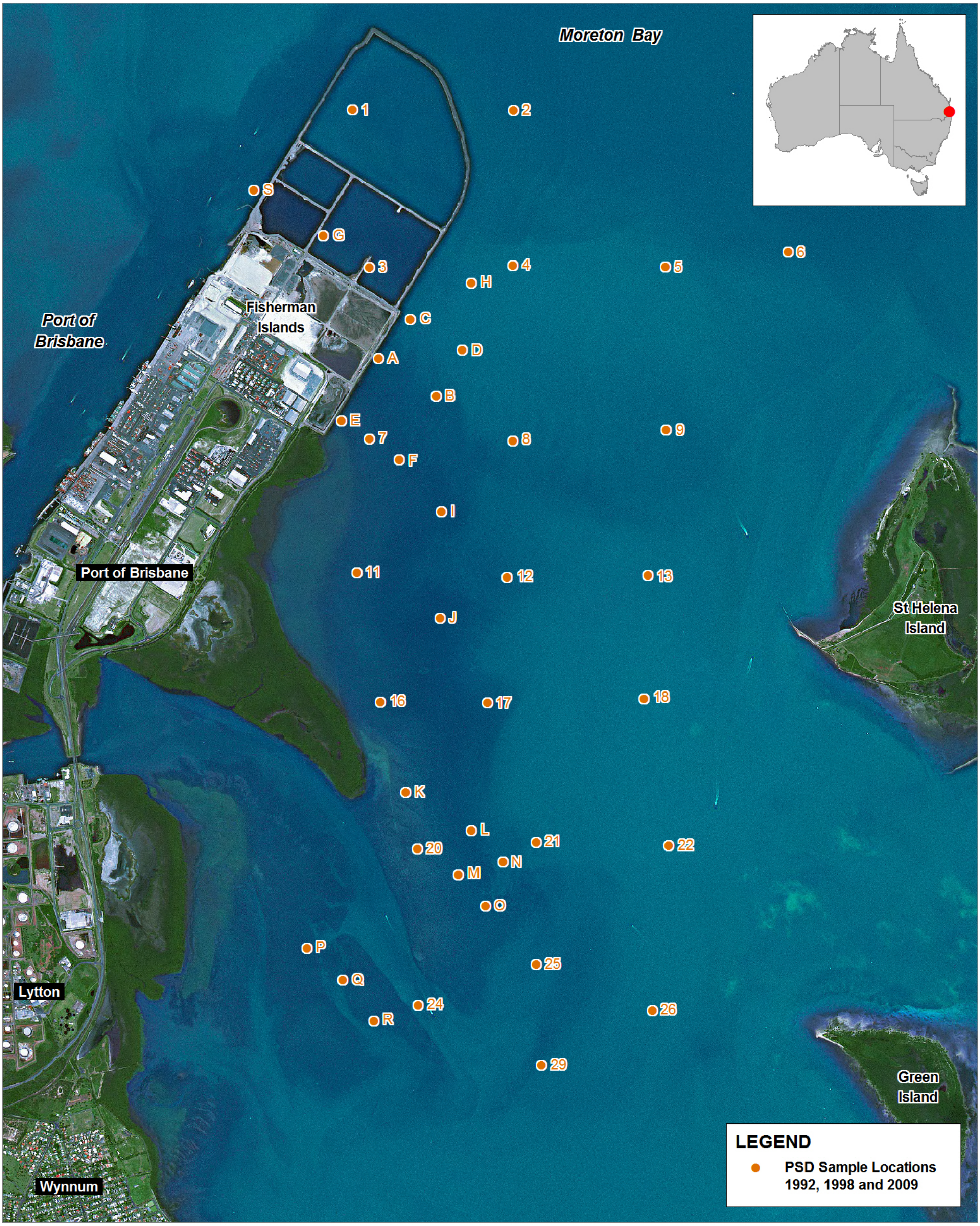
- Discuss any evidence of changes to sediment grain size that may be indicative of impacts resulting from Port of Brisbane activities.

2.3 Description of the Study Area

The Port of Brisbane is located at Fisherman Islands (the study area), which is situated at the mouth of the Brisbane River on the western foreshore of Moreton Bay, Queensland (Figure 2-1). The port facilities at the river mouth have been established on land reclaimed over a shallow sub-tidal river delta containing a series of low lying mangrove islands, collectively called the Fisherman Islands. The area was reserved for harbour purposes in the 1940's. Reclamation commenced in the late 1960's and the decision was taken to re-locate port facilities from the city reaches in 1974. The Port of Brisbane is now Queensland's largest container port facility (third largest capital city port in Australia) and exists as an area of approximately 975 hectares of reclamation either complete and in use, or under progressive filling within the existing perimeter bund (WBM Oceanics Australia 2000; 2005).

Construction of the present day port facilities over intertidal and sub tidal areas has resulted in extensive changes to the environmental attributes of the Fisherman Islands area. However, significant areas of mangrove, saltmarsh and seagrass have also been retained, and form part of the Fisherman Islands wetland complex on the southern side of the Port of Brisbane. Situated to the south and east of the FPE seawall lays Moreton Bay Marine Park, which is thought to contain one of the largest semi-contiguous seagrass beds in western Moreton Bay. A Ramsar listed wetland is situated only kilometres to the south of the Port facilities, comprising intertidal portions of the Fisherman Islands wetland complex. The seagrass and mudflats of this Ramsar area are recognised for their importance to dugong, marine turtles and migratory and resident shorebirds (BMT WBM 2009a).

On the northern side of the Port of Brisbane, dredging occurs within the shipping channel through the Bar Cutting, the Swing Basin and berth areas, which are presently maintained to a declared depth of 14m (relative to Port Datum – Lowest Astronomical Tide, hereafter referred to as LAT). The Port facilities are situated at the mouth of the Brisbane River, which comprises the largest river catchment in Moreton Bay, and experiences freshwater flows and ongoing inputs of sediments and contaminants derived from human activities in its catchment. Two major sewage treatment plants also have their sewage discharges within kilometres of the Port facilities (Luggage Point and Wynnum North wastewater treatment plant).



Title:

Sediment Sampling Sites used for Comparison of 1992, 1998 and 2009 Data. Sampling Sites from BMT WBM 2009b Not Shown.

Figure: **2-1**

Rev: **A**

N

0 1 2km

Approx. Scale

BMT WBM

www.wbmpl.com.au

Filepath : I:\B17527_I_cp_POB PSD\DRG\ECO_001_090625_Sample_Sites.wor

3 METHODOLOGY

3.1.1 Sampling Design

Sampling methodology and site locations within the current survey are consistent to methodologies used in previous studies undertaken by BMT WBM within the study area (WBM 1992, WBM 1998, BMT WBM 2009b). The BMT WBM (2009b) study assessed bed sediments adjacent to the FPE seawall along four transects. While the sampling locations were different to those sampled in 1992 and 1998 and cannot be used for temporal analysis, results from these sites were integrated in the analysis of spatial patterns (refer Section 4 for location of these sites).

A total of 37 sites were sampled within the present survey (refer to Figure 2-1 and APPENDIX D:). Some sites previously sampled were not included within this survey. These were sites 1, 3, and G that now lie within the reclamation area, also site S on the Brisbane River where dredging works were undertaken at the time of sampling.

Location and navigation to sites was undertaken using a real time differential Global Positioning System (dGPS) to provide position-fixing accuracy's of ±1m. A two-point anchoring system was employed to hold the vessel in position whilst sediment collection was undertaken.

Sediment samples were collected using a stainless steel Van Veen grab with a surface gape of $0.028m^2$. Only whole grab samples (i.e. those in which the sampler jaws remained closed following the sample capture) were retained to reduce the loss of finer material. Sediment and any collected overlying waters were placed into a plastic sample tray. One kilogram of sediment was extracted and transferred into pre-labelled plastic zip locked bags. The Van Veen grab, sample trays and utensils were rinsed with seawater between samples to avoid cross contamination of samples.

During collection, samples were photographed, and the following details recorded on a standardised pro-forma:

- sediment colour;
- field texture (i.e. fine sand, coarse sand, silts, shell fragments etc);
- estimation of dominant grain size and composition;
- sediment odour;
- presence of organic material or any foreign objects; and
- presence of any marine flora and fauna.

3.1.2 Particle Size Distribution Analysis

Sediment samples were sent to Australian Geomechanical Laboratories Pty Ltd (AGL) for Particle Size Distribution (PSD) analysis. Sediments were passed through a series of Australian standard sieves identifying particle size down to 0.075mm. A selection of samples (6 replicates) was chosen for further hydrometric analysis to determine particle size down to 1µm. This further analysis was undertaken to allow an estimation of the proportion of material within smaller size categories. Furthermore, sample moisture and particle density were also measured.

3.1.3 Data Analysis

PSD data from the present study and previous WBM studies were collated. Since PSD data from all three studies were determined using the same Australian standard sieves, direct data comparisons could be made between studies.

The particle size distribution results are described hereafter for the percentage composition of the particle size fractions shown in Table 3-1.

Table 3-1 Particle grain size fractions adopted in the present study

Size fraction	Sediment size
Silt	Grain size of less than 0.075 mm
Fine grain sand	Grain size of 0.075 mm to 0.15 mm
Medium grained sand	Grain size of 0.15 mm to 0.600 mm
Coarse grain sand	Grain size of 0.600 mm to 2.36 mm

Note that the shell grit/fine gravel size fraction (>2.36 mm) was only minor in the study area contributing only an average 2% of the sediments composition across all study sites. Therefore, the shell grit fraction is not further considered within the context of this study.

Data were collated into GIS to illustrate the following spatial and temporal trends:

- Distribution of silt, fine sands, medium sands and coarse sand; and
- % change in proportion of silt and fine sand, medium sand and coarse sand material between each sampling episode.

It is important to note that the previous WBM (1998) study used different criteria to describe the bounds/limits for the various particle size fractions described in Table 3.1. The results presented here, which conforms more to widely accepted methods to define sediment fractions/classes, supersede the results outlined in the WBM (1998) study.

4 RESULTS AND DISCUSSION

Spatial patterns of the particle size fractions are illustrated for the 2009 investigation and temporal patterns are described by comparing the 2009 data to previous investigations at the same sites in 1992 (WBM 1992) and 1998 (WBM 1998). Particle size analysis results and cumulative particle size distribution plots of the 2009, 1998 and 1992 data are given for all study sites in Appendix B and Appendix C, respectively.

4.1 Spatial Patterns 2009

Overall, the dominant sediment type recorded within the study area during 2009 was medium grained sands with a number of sites characterised by high proportions of fine sands and silts (Table 4-1).

Table 4-1 Dominant particle size and classification of sediment in 2009 based on Wentworth (1922)

Site	Dominant particle size	Classification	Site	Dominant particle size	Classification
2	medium sand	silty sand	**A**	medium sand	sand
4	fine sand	silty sand	**B**	medium sand	sand
5	medium sand	sand	**C**	medium sand	sand
6	silt	sandy silt	**D**	medium sand	sand
7	medium sand	sand	**E**	medium sand	silty sand
8	medium sand	sand	**F**	medium sand	silty sand
9	medium sand	sand	**H**	medium sand	sand
11	medium sand	silty sand	**I**	medium sand	silty sand
12	medium sand	sand	**J**	medium sand	silty sand
13	silt	sandy silt	**K**	medium sand	sand
16	medium sand	silty sand	**L**	medium sand	sand
17	medium sand	sand	**M**	medium sand	sand
18	silt	silty sand	**N**	medium sand	silty sand
20	medium sand	sand	**O**	medium sand	silty sand
21	medium sand	sand	**P**	medium sand	silty sand
22	fine sand	silty sand	**Q**	silt	silty sand
24	silt	silty sand	**R**	medium sand	sand
25	medium sand	sand	**A1-A5**	medium sand	sand
26	fine sand	silty sand	**B1-B5**	silt	sandy silt
29	medium sand	sand	**C1-C5**	medium sand	silty sand
			D1-D5	medium sand	silty sand

It should be noted that the particle size data presented from 2009 represents the average value of duplicate samples collected at each site. In considering small scale variability at the study sites, the range of values between 2009 duplicates for each size fraction was calculated. Based on these results, the composition of silts between duplicate samples varied by an average of 3.0% (standard deviation ±3.4%) across all study sites. The average variation within the fine sand fraction was 2.6% (±2.6%) and 4.2% (±3.3%) for medium grained sand fractions.

The spatial patterns of sediment distribution in 2009 are described for the different size fractions in the following sections.

4.1.1 Size Fractions

Silts

Across all study sites investigated in 2009, silt content ranged between 2% and 59%. Areas within the study area with silt contents > 25% were predominantly found in the deeper channel area west of St. Helena and Green Islands (Figure 4-1). Other areas with relatively high silt content included the mouth of Boat Passage to the south of Fisherman Islands as well as an area adjacent to Fisherman Islands and south of the seawall. A small, isolated area with high silt contents was noted directly east of the seawall (Figure 4-1).However, silt contents were markedly lower at the study sites south and north of this area, indicating that this area of silts was highly localised.

Hydrometer analysis conducted on samples from Site 6, 11, 16, B, O and P (refer Figure 2-1 and Appendix C) indicated an average clay content (<0.004 mm; Wentworth 1922) of about 32% within the silty fraction (<0.075 mm) in most samples. Clay content within the silt fraction was somewhat lower at Site O with 22%. Particle density ranged between 2.69 t m^{-3} and 2.74 t m^{-3} across these six sites indicating a dominance of quartz and clay minerals in the sediments.

Fine sand

The proportion of fine sand ranged between 3% and 67% across all study sites. Similar to the silt fraction, high proportions of fine sands were most notable in the deeper channel area west of St. Helena and Green Islands (

Figure 4-2). Another area characterised by a >20% proportion of fine sands was found adjacent of Fisherman Islands. Isolated sites with a relatively high proportion of fine sands included Site Q (mouth of Boat Passage), Site 4 (east of the seawall) and Site 16 (southern outcrop of Fisherman Islands).

Medium sand

Medium sand was the dominant sediment size fraction within the study area and ranged between 4% and 87% across all study sites. Medium sands with a proportion >50% were predominantly found across the shallow intertidal flats located between Fisherman Islands and the tidal channel west of St. Helena and Green Islands (Figure 4-3). Furthermore, relatively high proportions of medium sands were also found directly adjacent to Fisherman Islands and along the seawall.

Coarse sand

Coarse sands were relatively uncommon in the study area. On average across all study sites, coarse sands contributed only about 2% to the total sediment.

Figure 4-4 shows the distribution of coarse sands across the study area, highlighting the relatively low proportion of coarser sediment fractions in the area. An area with slightly higher proportion of coarse sands was noted at the northeast section of the seawall (

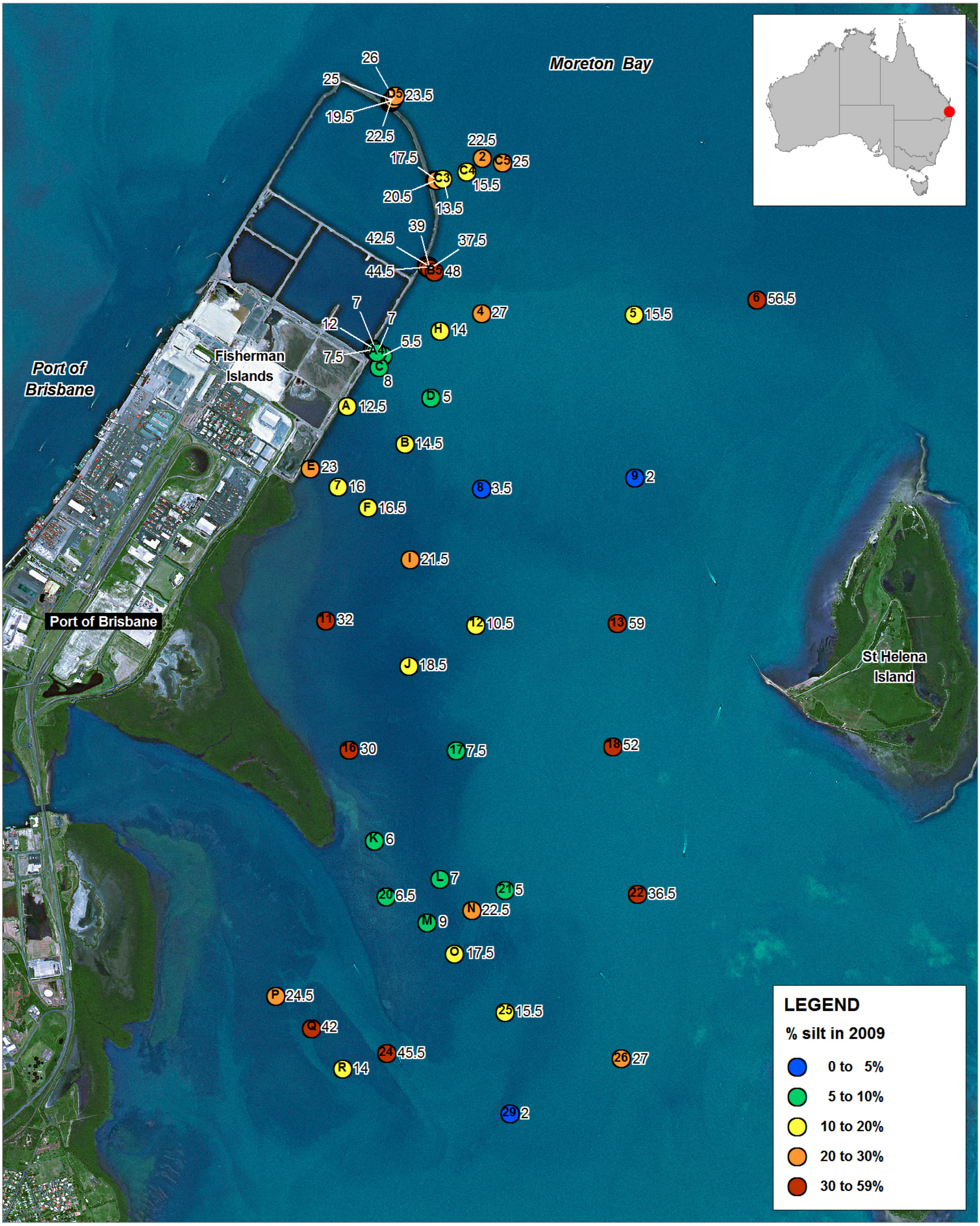
Figure 4-4).

4.1.2 Discussion of Spatial Patterns

The spatial patterns of sediment distribution are generally consistent with patterns observed in previous studies (WBM 1992, WBM 1998), indicating that no major broad scale changes in sediment patterns have occurred during the period 1992-2009 involving the Superbund construction 1992 and Future Port Expansion project 2002. Fine sediment fractions (silts and fine sands) were predominantly found in areas south-west of St. Helena Island and within the deeper channels adjacent to St. Helena and Green Islands. While the deeper channel areas were predicted to exhibit moderate to high bed shear stress levels, it was also noted that bed armouring may be important in these areas, which protect the fine sediment from erosion (WBM 1992). Fine sediments comprised also a relatively high proportion of the sediments at near-shore intertidal flats adjacent to southeast Fisherman Islands. Previous studies indicated low bed shear stress levels (WBM 1992) as well as very low current velocities and wave action in this area (WBM 2000). Furthermore, accretion of fine sediments in this area may be facilitated by dense seagrass cover in this area, which can lead to a reduction of near-bed current action (WBM 1998, Orth et al. 2006).

Medium sands were the dominant sediment type, reflecting the generally shallow nature and wide extent of intertidal flats within the study area. The sandy deposits in the study area are likely remnants of the original river mouth delta (WBM 1998). Sediments with a particularly high proportion of medium sands were mainly found within a broad offshore area between Fisherman and St. Helena Islands, mainly comprising intertidal flats. Relatively high bed shear stress is common in these shallow and exposed areas (WBM 1992) and wave action is expected to be stronger than in sheltered nearshore areas and deeper water. Therefore, a combination of tidal currents and wave action may prevent accumulation of fine sediments in these areas. The general lack of coarser sands across the study area reflects the mainly moderate to low bed shear stresses in the area and relatively sheltered nature of Waterloo Bay (WBM 1992, WBM 2000).

Overall, the investigations of particle size distributions in 1992, 1998 and 2009 support that broad scale sediment patterns in the study area are likely determined by hydrodynamic forcing due to currents and wave action in the area.



Title:

Distribution of Silt Material (<0.075mm) in 2009

Figure: **4-1**

Rev: **A**

BMT WBM endeavours to ensure that the information provided in this map is correct at the time of publication. BMT WBM does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

N

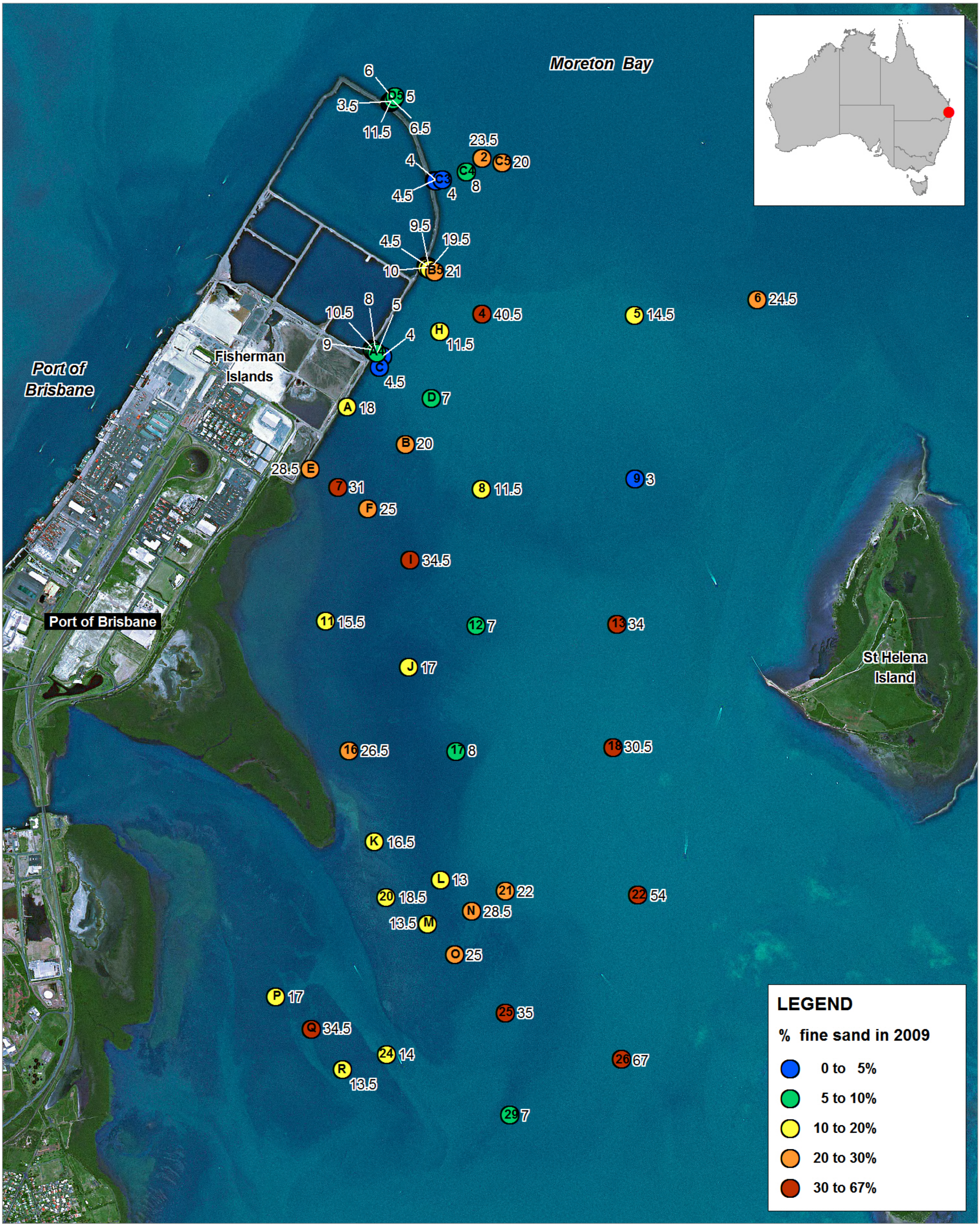
0 1 2km

Approx. Scale

BMT WBM

www.wbmpl.com.au

Filepath : I:\B17527_I_cp_POB PSD\DRG\ECO_009_090909_Silts2009.wor



Title:

Distribution of Fine Sand Material (0.075 to 0.15mm) in 2009

Figure: 4-2

Rev: A

N

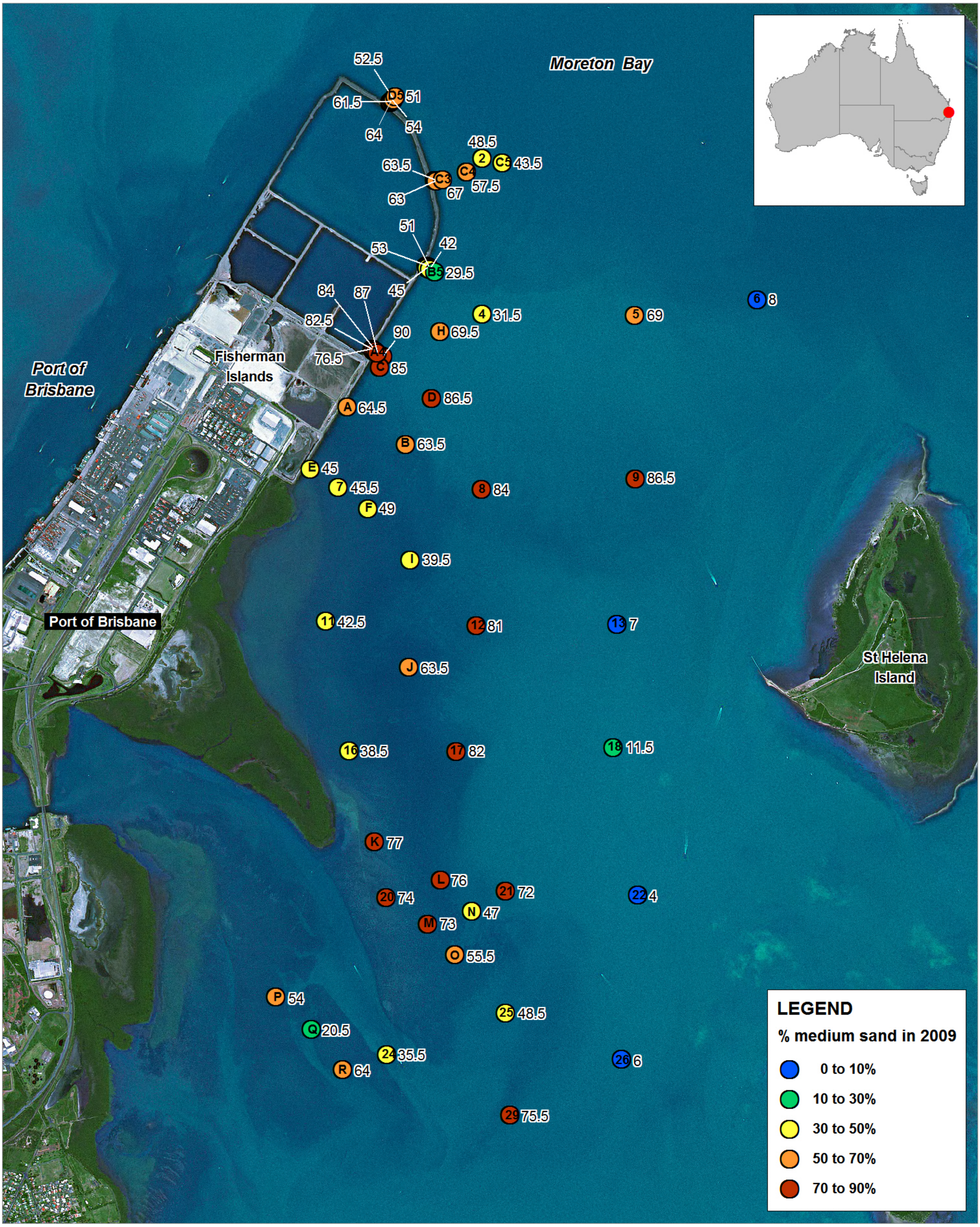
0 1 2km

Approx. Scale

BMT WBM

www.wbmpl.com.au

Filepath : I:\B17527_I_cp_POB PSD\DRG\ECO_010_090909_Finesand2009.wor



Title:

Distribution of Medium Sand Material (0.15 to 0.600mm) in 2009

Figure: **4-3**

Rev: **A**

BMT WBM endeavours to ensure that the information provided in this map is correct at the time of publication. BMT WBM does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

N

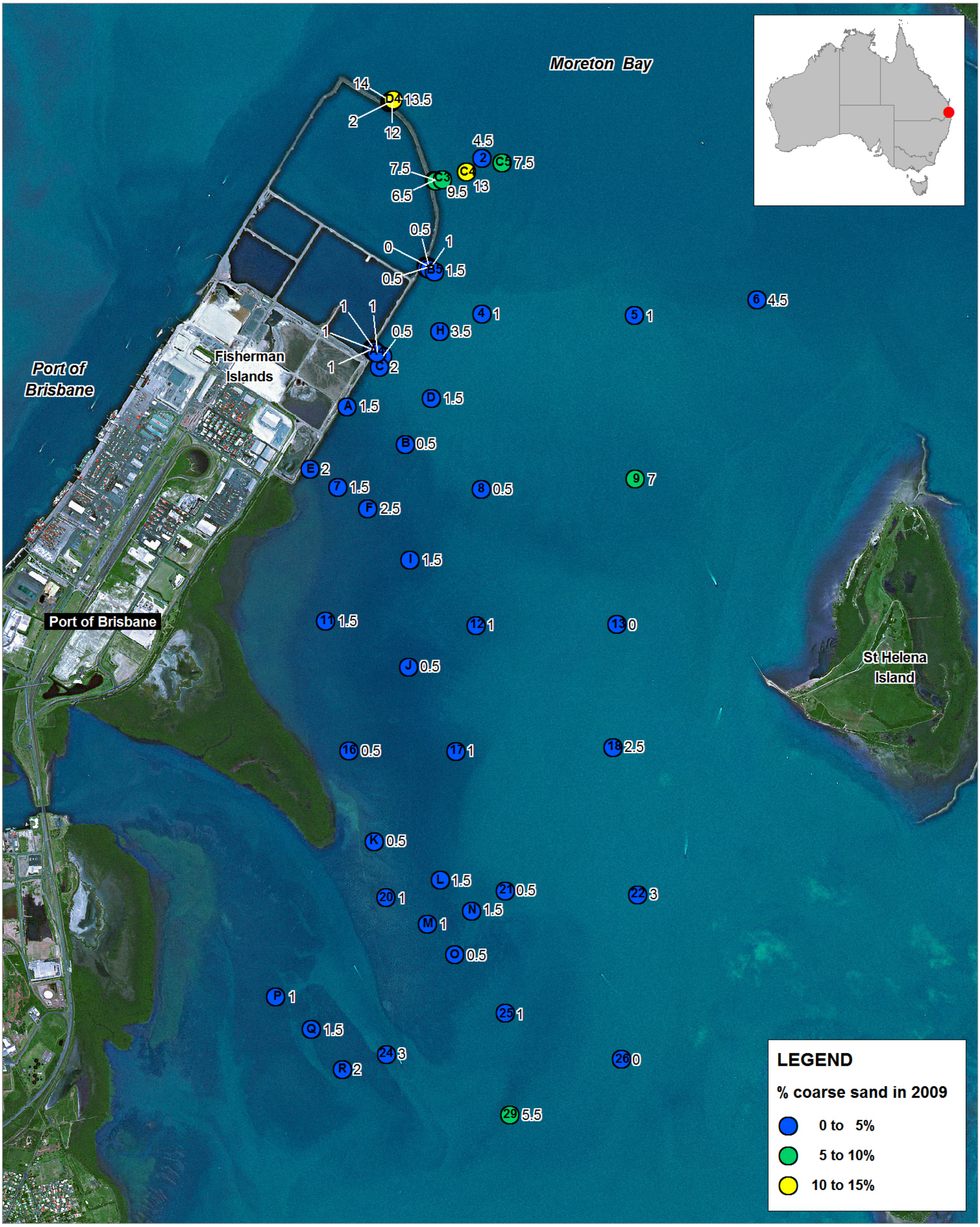
0 1 2km

Approx. Scale

BMT WBM

www.wbmpl.com.au

Filepath : I:\B17527_I_cp_POB PSD\DRG\ECO_011_090909_Medium_sand2009.wor



Title:

Distribution of Coarse Sand Material (0.600 to 2.36 mm) in 2009

Figure: 4-4

Rev: A

N

0 1 2km

Approx. Scale

BMT WBM

www.wbmpl.com.au

Filepath : I:\B17527_I_cp_POB PSD\DRG\ECO_012_090909_Coarse_sand2009.wor

4.2 Temporal Patterns

The percentage change between 1998 and 2009 as well as 1992 and 1998 is described in the following for the individual size fractions. The total changes for the period 1992 to 2009 are given in APPENDIX A: and a comparison of sediment grain size for all years in APPENDIX C: Given the small scale variability observed between duplicate samples in the study area (average 3-4% difference, see Section 4.1), only changes exceeding 10% were considered "significant" in the context of this study.

4.2.1 Trends in Size Fractions

Silt

The percentage change in the proportion of silts for the period 1992-1998 and 1998-2009 is presented for the study area in

Figure 4-5 and Figure 4-6, respectively. Table 4-2 shows the percentage of silt material measured across the study area for the years 2009, 1998 and 1992.

Between 1992 and 1998 increases in silt content >10% were noted in an area adjacent to the south-eastern Fisherman Islands mangrove area. This increase was notable considering the very low silt content observed at Sites A, B and F during 1992 and 1998, and equates to a 3 to 7-fold relative increase in silts at these sites (refer also to Appendix C). Locally restricted increases in silt content were measured at Site H northeast of Fisherman Islands and Site 18 in the channel area west of St Helena Island. Some local decreases in silt content >10% were measured at Site 2 at the north of the study area and Site 22 in the southern offshore area. For the period 1998 to 2009, the area of silt accumulation adjacent to Fisherman Islands appears to have shifted slightly towards a northern direction south of the existing seawall structure. No significant increases in silt content were noted for that area (Site A, B and F) for the period 1992-1998. Some local increases (Sites 18 and Q) and decreases (Site 24) were noted for the period 1998-2009.

Table 4-2 Percentage of silt material at each site for all years

Site	2009	1998	1992	Site	2009	1998	1992
2	22.5	16	27	**A**	12.5	2	1
4	27	28	23	**B**	14.5	2	1
5	15.5	11	17	**C**	8	2	0
6	56.5	-	73	**D**	5	2	-
7	16	12	15	**E**	23	18	22
8	3.5	2	5	**F**	16.5	5	4
9	2	2	4	**H**	14	14	2
11	32	22	12	**I**	21.5	13	-
12	10.5	6	12	**J**	18.5	11	-
13	59	48	47	**K**	6	5	-
16	30	31	18	**L**	7	6	-
17	7.5	4	12	**M**	9	6	-
18	52	61	33	**N**	22.5	20	-
20	6.5	4	8	**O**	17.5	10	-
21	5	12	15	**P**	24.5	24	-
22	36.5	44	60	**Q**	42	27	-
24	45.5	57	65	**R**	14	9	-
25	15.5	23	19				
26	27	26	35				
29	2	-	6				

Note: “-“ indicates no sample collected

Fine sand

Figure 4-7 and Figure 4-9 highlight the changes in fine sand composition across the study area for the periods 1992-1998 and 1998-2009, respectively. Most of the changes in fine sand composition occurred between 1992 and 1998 within a large area east of Fisherman Islands and adjacent to the past Superbund are exhibiting a decrease in the fine sand fraction (

Table 4-3 and figure 4-7). An increase in fine sands was noted between 1992 and 1998 at sites 22 and 26 west of St. Helena and Green Islands (

Table 4-3). In contrast, fine sand composition changes >10% were noted only locally for the period 1998-2009 at Sites B, 18 and 22 (Figure 4-8).

Table 4-3 Percentage of fine sand material at each site for all years

Site	2009	1998	1992	Site	2009	1998	1992
2	23.5	21	21	**A**	18	11	22
4	40.5	50	40	**B**	20	8	36
5	14.5	17	26	**C**	4.5	1	9
6	24.5	-	15	**D**	7	3	-
7	31	35	32	**E**	28.5	25	33
8	11.5	13	30	**F**	25	17	35
9	3	1	5	**H**	11.5	8	18
11	15.5	17	16	**I**	34.5	40	-
12	7	7	20	**J**	17	9	-
13	34	44	37	**K**	16.5	10	-
16	26.5	18	26	**L**	13	13	-
17	8	6	0	**M**	13.5	9	-
18	30.5	22	14	**N**	28.5	29	-
20	18.5	15	11	**O**	25	17	-
21	22	22	25	**P**	17	12	-
22	54	44	28	**Q**	34.5	32	-
24	14	11	12	**R**	13.5	9	-
25	35	28	26				
26	67	71	60				
29	7	-	19				

Note: “-“ indicates no sample collected

Medium sand

Between 1992 and 1998, percent composition of medium sands increased concurrent with the decrease in fine sands in the area east of Fisherman Islands and adjacent to the past Superbund structure (Figure 4-9 and Table 4-4). Some local increases (Site 2 and 24) and decreases (Site 4 and 18) were noted for 1992-1998. In contrast, substantial decreases in medium sands were observed for 1998-2009 roughly in the same area where increases in silty material were observed for the same time period (Figure 4-10 and Figure 4-6). Localised increases (Site 4) and decreases (Site O and Q) were noted in 1998-2009 at some study sites.

Table 4-4 Percentage of medium sand material at each site for all years

Site	2009	1998	1992	Site	2009	1998	1992
2	48.5	52	38	**A**	64.5	87	-
4	31.5	21	36	**B**	63.5	90	-
5	69	71	56	**C**	85	90	-
6	8	-	6	**D**	86.5	93	-
7	45.5	44	37	**E**	45	45	-
8	84	84	64	**F**	49	52	-
9	86.5	88	81	**H**	69.5	76	-
11	42.5	58	63	**I**	39.5	41	-
12	81	82	66	**J**	63.5	75	-
13	7	8	16	**K**	77	85	-
16	38.5	46	50	**L**	76	78	-
17	82	88	81	**M**	73	71	-
18	11.5	12	50	**N**	47	49	-
20	74	78	79	**O**	55.5	66	-
21	72	65	58	**P**	54	59	-
22	4	3	3	**Q**	20.5	35	-
24	35.5	28	17	**R**	64	74	-
25	48.5	47	48				
26	6	3	5				
29	75.5	-	67				

Note: “-“ indicates no sample collected

Coarse sand

Coarse sands made up only a small fraction of the sediments in the study area. Only minor changes in the coarse sand fraction were noted in the study area for the period 1992-1998 (Figure 4-11) and 1998-2009 (Figure 4-12). Maximum changes in the coarse sand fraction were 6% and 4% for 1992-1998 and 1998-2009, respectively (Table 4-5).

Table 4-5 Percentage of coarse sand material at each site for all years

Site	2009	1998	1992	Site	2009	1998	1992
2	4.5	8	9	**A**	1.5	0	-
4	1	1	1	**B**	0.5	0	-
5	1	1	1	**C**	2	6	-
6	4.5	-	2	**D**	1.5	2	-
7	1.5	1	2	**E**	2	1	-
8	0.5	1	1	**F**	2.5	1	-
9	7	9	3	**H**	3.5	2	-
11	1.5	1	1	**I**	1.5	2	-
12	1	1	2	**J**	0.5	1	-
13	0	0	0	**K**	0.5	0	-
16	0.5	1	1	**L**	1.5	1	-
17	1	1	1	**M**	1	1	-
18	2.5	2	1	**N**	1.5	1	-
20	1	1	2	**O**	0.5	2	-
21	0.5	0	1	**P**	1	2	-
22	3	2	2	**Q**	1.5	1	-
24	3	0	3	**R**	2	2	-
25	1	2	2				
26	0	0	0				
29	5.5	-	3				

Note: “-“ indicates no sample collected

4.2.2 Discussion of Temporal Patterns

The overall temporal patterns observed between 1998 and 2009 indicated an area of increase in silty material adjacent to Fisherman Islands and south of the south-eastern seawall. Compared to accumulation of silts noted between 1992 and 1998, this area of silt accretion appears to have shifted slightly northwards to an area adjacent to the southern end of the seawall. A notable 3 to 7-fold increase in silts was recorded at some of the sites in the area compared to 1998 data. The proportion of fine sands generally increased as well in the same area during 1998-2009, but changes were generally less than 10% fine sand composition during this period. The general increase in fine sediments in this area is also manifested in the concurrent reduction in the proportion of medium sands in the same general area.

The observed pattern of an increase in fines south of the seawall may reflect a possible influence of the FPE northward extension of the port reclamation area. Based on the interpretation of modelling results outlined in WBM (2000), it appears that this area of increased fines occurs in a small area on southeast edge of the seawall where a reduction in current velocities was predicted to occur. Based on interpretation of modelling results, reduced current velocities were predicted to occur during ebbing and flooding tides during northerly wind/wave conditions, and under such conditions, deposition of silty material could be expected to occur.

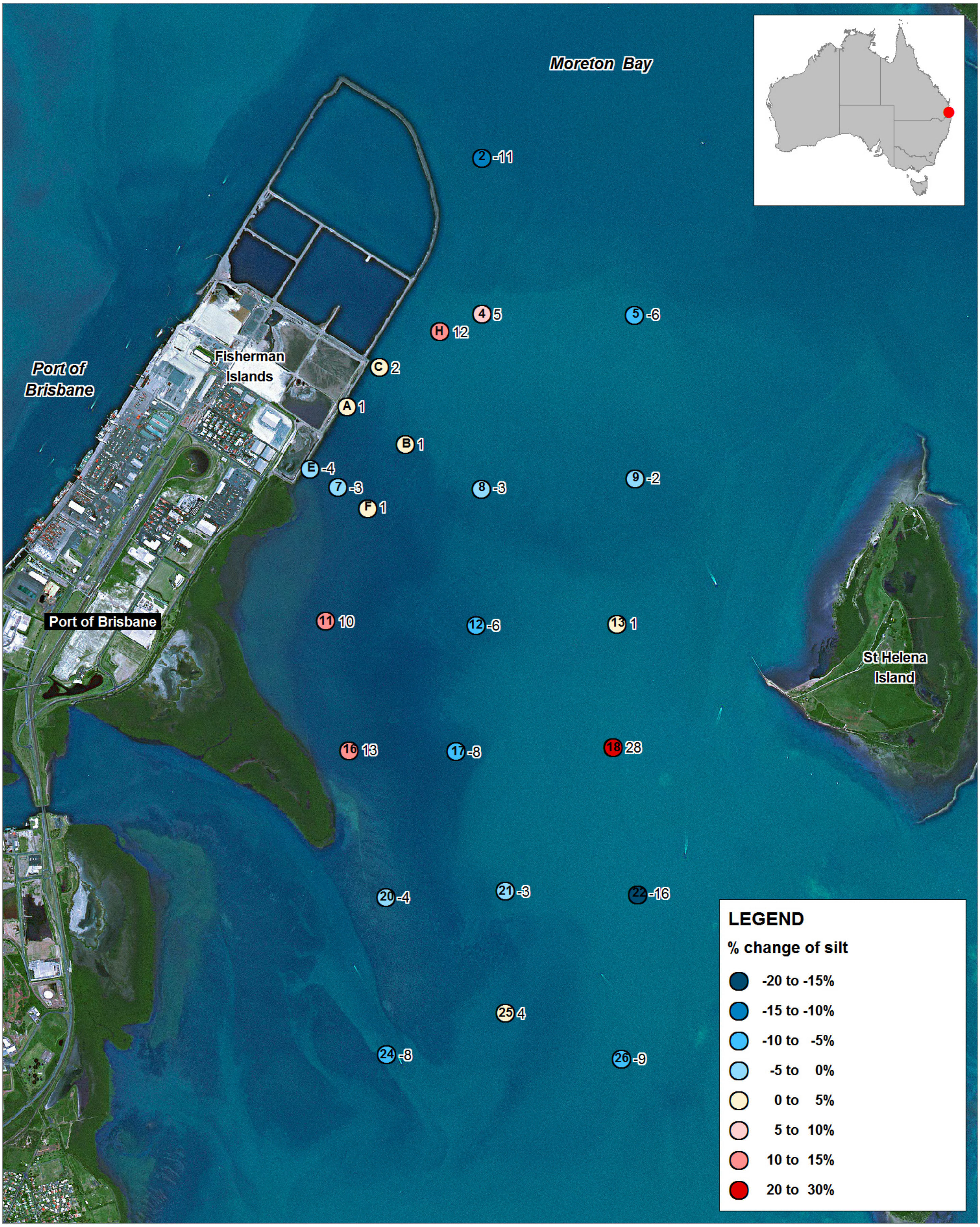
Fine sediments may be supplied to the system by river loads as well as resuspension of fines in other areas or through suspended sediment from dredging activities. Given that bait worm digging areas are located on the intertidal flats close to Fisherman Islands, a further source of fine sediments may be the bait worm fishery. The silty fraction of dug up sediments during ebb tide can be resuspended during the following flood tide and deposited in sheltered areas with low current and wave activity.

In contrast to the increase in fines observed between 1998 and 2009, a notable reduction of fine sand within the sediment composition was recorded in the same general area between 1992 and 1998 (WBM 1998), concurrent with an increase in the medium sand fraction.

WBM (1998) indicated that there was an increase of 'fine sands' at particular locations where the present study has noted a decrease. As discussed in Section 3.1.3, these discrepancies are a result of the criteria used to define size fractions (i.e. specific cut-off values used to define "fine sands" categories differs between studies). Given the different approaches adopted in the two studies, the results of the present study supersede and replace those outlined in the WBM (1998).

Silt contents were low at a number of these sites in 1992 and 1998, so the reduction in fines was not reflected in changes of silt content. While the previous results appear to contradict the changes in fines observed for the period 1998-2009, they can be explained by the prevailing hydrodynamic conditions in the area at the time. Hydrodynamic modelling undertaken by WBM (1993) suggested an area of potential erosion at the north-eastern edge of the Superbund caused by interaction of currents with the structure. This area of potential erosion is the same area where an actual decrease in fine sediments was noted by WBM (1998), supporting previous model findings. The FPE port expansion used a truncated and rounded shape for the seawall to prevent potential localised disturbance of the seabed and erosion. Accordingly, no similar erosion of fine sediments was evident between 1998 and 2009.

Even though some localised changes in sediment patterns appear to have occurred within the broader study area between 1992 and 2009, it should be noted that duplicate sample variability of percent composition in sediment fractions in 2009 was about 3-4% (±3%). This finding indicates that small scale patchiness in sediment characteristics may have contributed to the observed patterns to some extent. For example, such patchiness may be a result of variations in sediment topography due to ripple formation, with finer sediments accumulating in ripple troughs and slightly coarser sediments commonly found at the ripple crests. Localised changes in sediment composition observed at some study sites across the area may have been caused by local changes in hydrodynamic processes, which may reflect seasonal and interannual changes in waves and currents.



Title:

Percentage Change in Proportion of Silt (<0.075mm) Material Between 1992 and 1998

Figure: 4-5

Rev: A

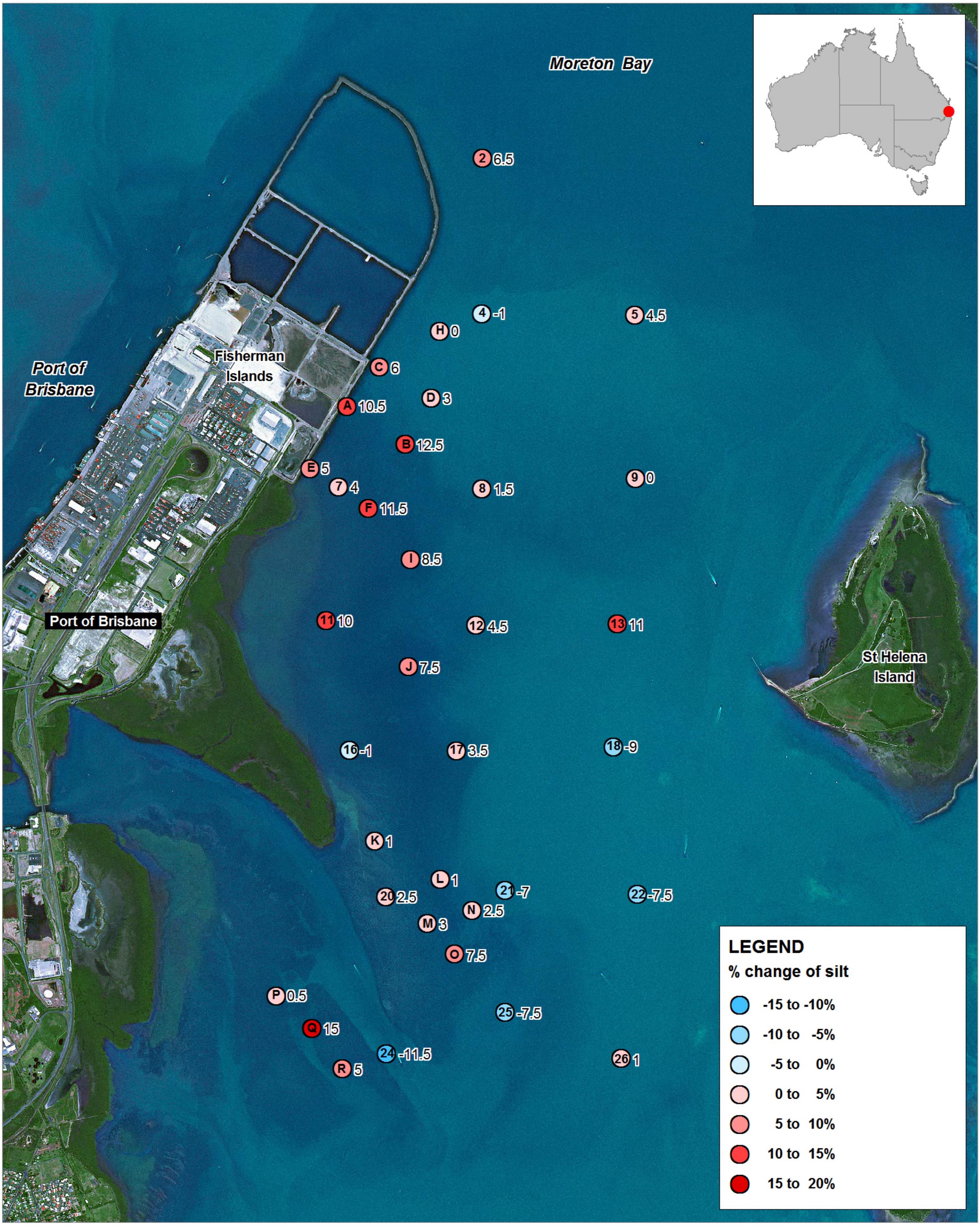
N

0 1 2km

Approx. Scale

BMT WBM
www.wbmpl.com.au

Filepath : I:\B17527_I_cp_POB PSD\DRG\ECO_018_090909_Percentage_Change _Silt 92to98.wor



Title:

Percentage Change in Proportion of Silt (<0.075mm) Material Between 1998 and 2009

Figure: 4-6

Rev: A

BMT WBM endeavours to ensure that the information provided in this map is correct at the time of publication. BMT WBM does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

N

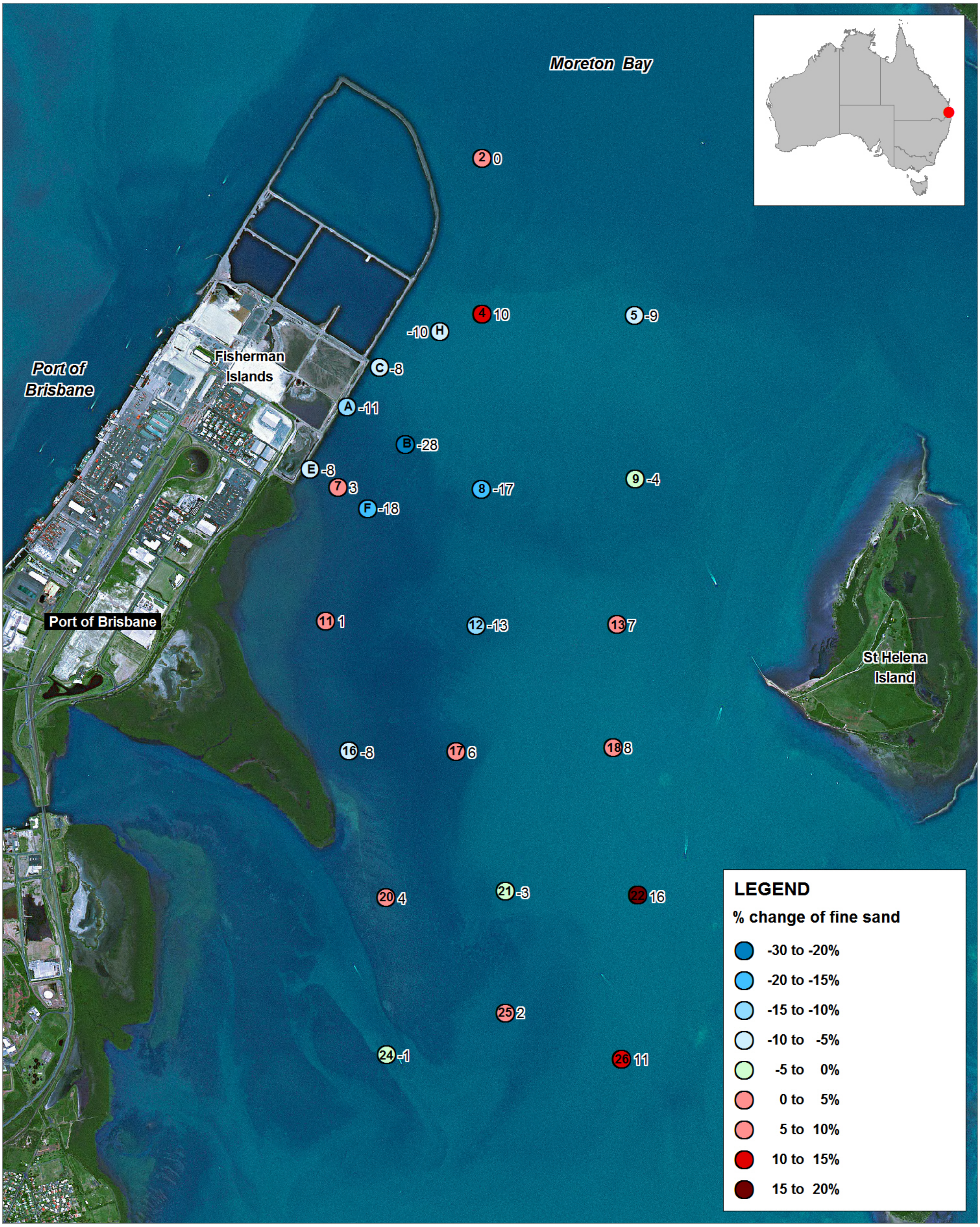
0 1 2km

Approx. Scale

BMT WBM

www.wbmpl.com.au

Filepath : I:\B17527_I_cp_POB PSD\DRG\ECO_002_090909_Percentage_Change _Silt98.wor



Title:

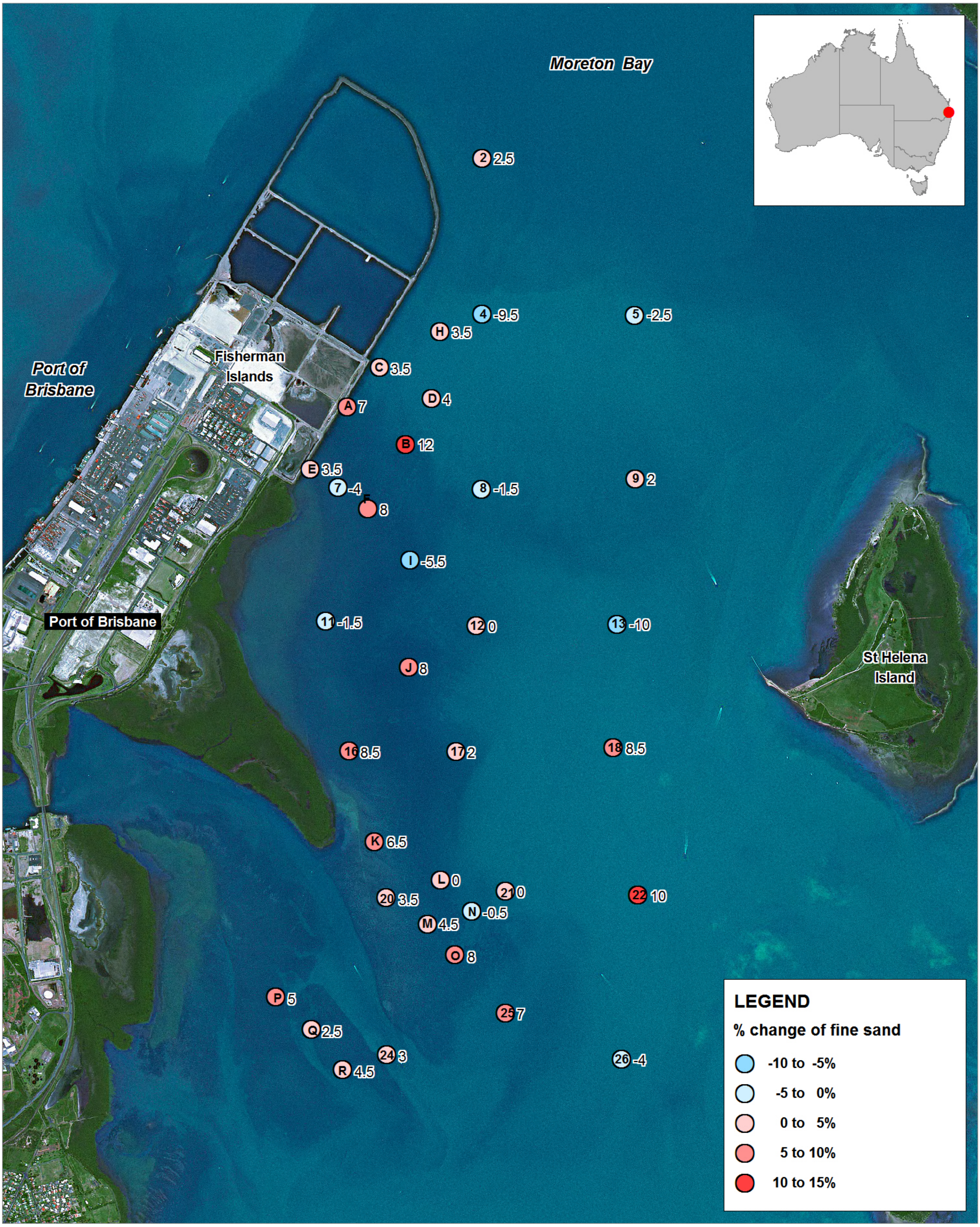
Percentage Change in Proportion of Fine Sand (0.075 to 0.15mm) Material Between 1992 and 1998

Figure: 4-7

Rev: A

BMT WBM
www.wbmpl.com.au

Filepath : I:\B17527_I_cp_POB PSD\DRG\ECO_019_090909_Percentage_Change _finesand92to98.wor



Title:

Percentage Change in Proportion of Fine Sand (0.075 to 0.15mm) Material Between 1998 and 2009

Figure: 4-8

Rev: A

N

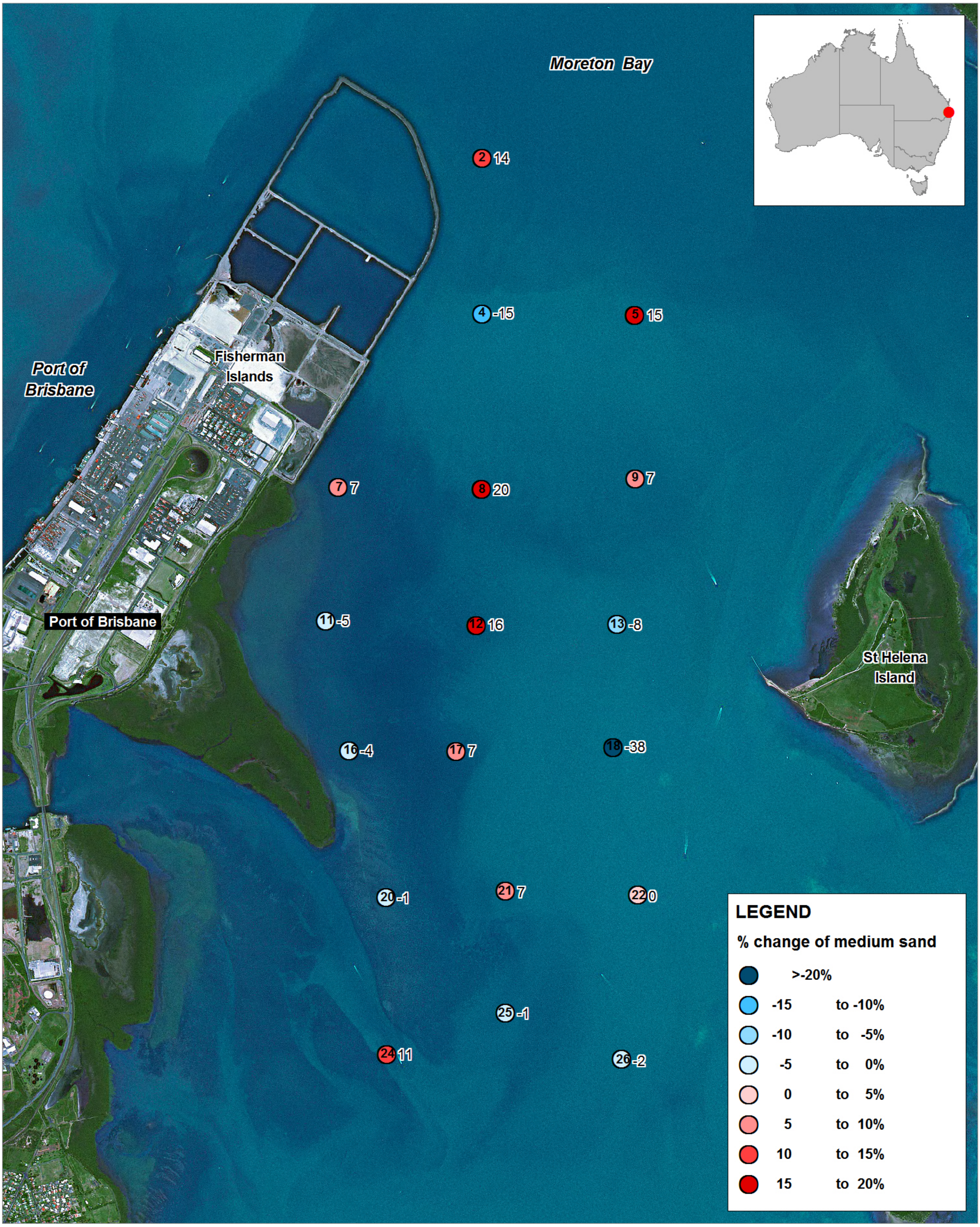
0 1 2km

Approx. Scale

BMT WBM

www.wbmpl.com.au

Filepath : I:\B17527_I_cp_POB PSD\DRG\ECO_003_090909_Percentage_Change _finesand98.wor



Title:

Percentage Change in Proportion of Medium Sand (0.15 to 0.600mm) Material Between 1992 and 1998

Figure: 4-9

Rev: A

N

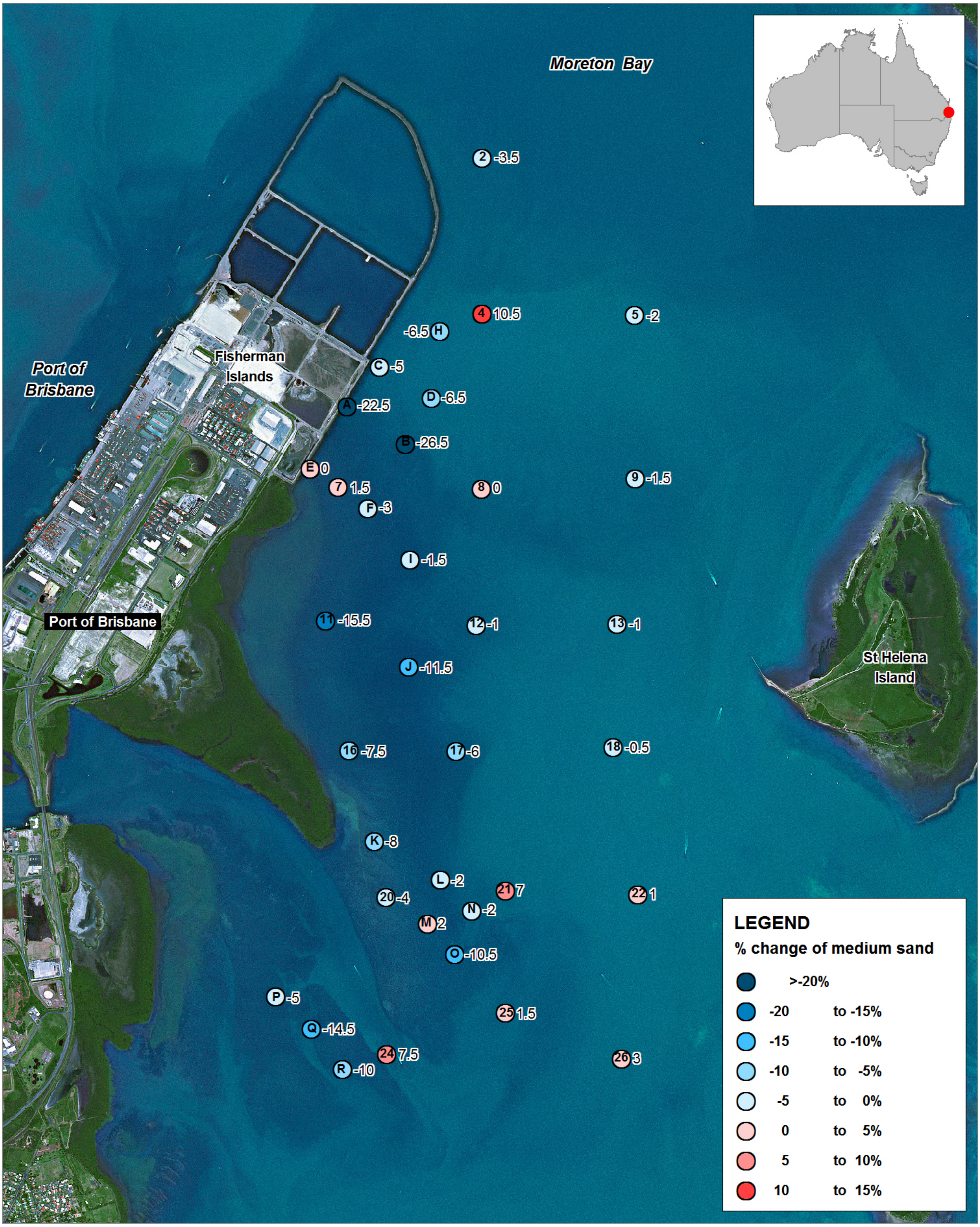
0 1 2km

Approx. Scale

BMT WBM

www.wbmpl.com.au

Filepath : I:\B17527_I_cp_POB PSD\DRG\ECO_020_090909_Percentage_Change _mediumsand92to98.wor



Title:

Percentage Change in Proportion of Medium Sand (0.15 to 0.600mm) Material Between 1998 and 2009

Figure: **4-10**

Rev: **A**

N

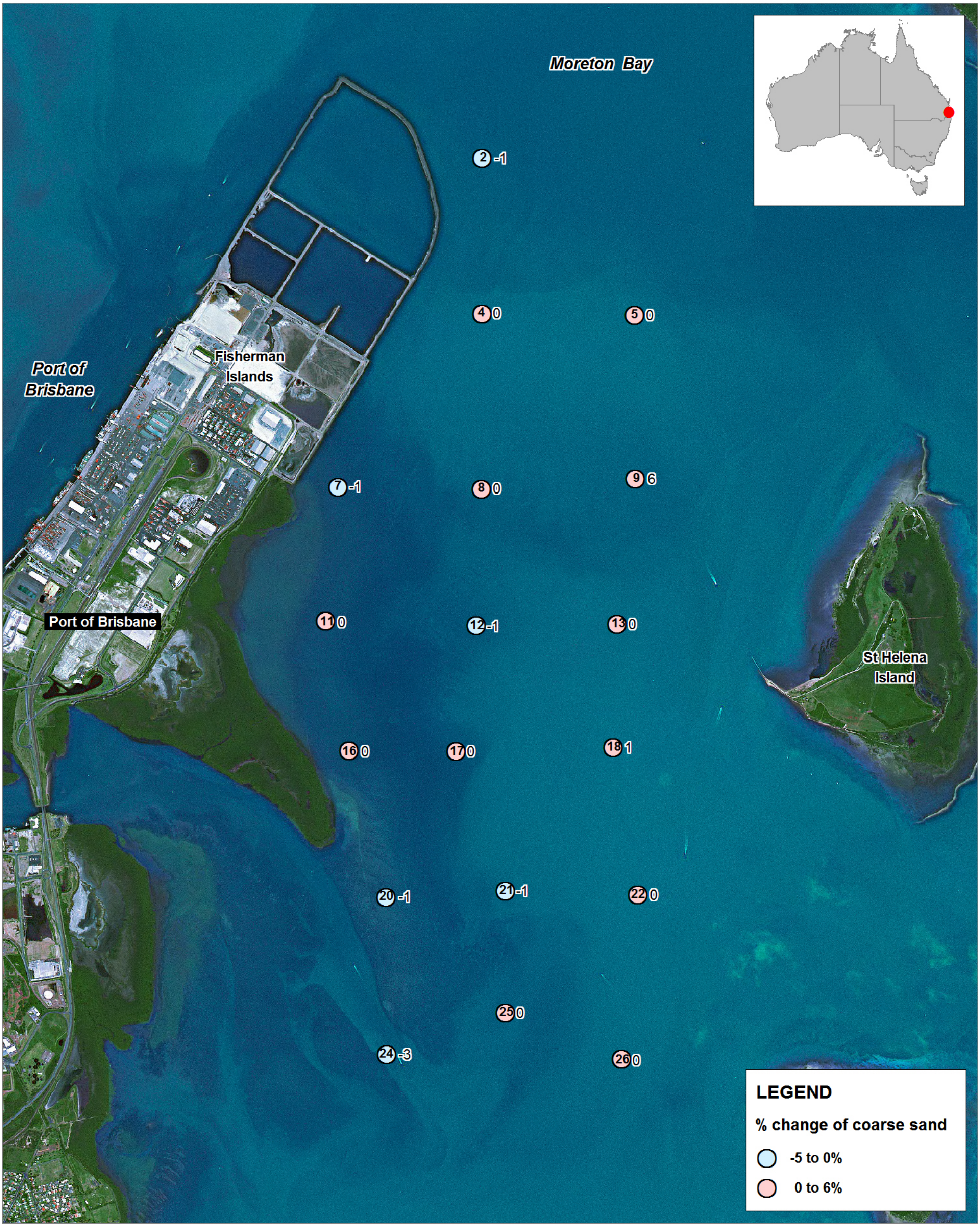
0 1 2km

Approx. Scale

BMT WBM

www.wbmpl.com.au

Filepath : I:\B17527_I_cp_POB PSD\DRG\ECO_005_090909_Percentage_Change _mediumsand98.wor



Title:

Percentage Change in Proportion of Coarse Sand (0.600 to 2.36mm) Material Between 1992 and 1998

Figure: 4-11

Rev: A

BMT WBM endeavours to ensure that the information provided in this map is correct at the time of publication. BMT WBM does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

N

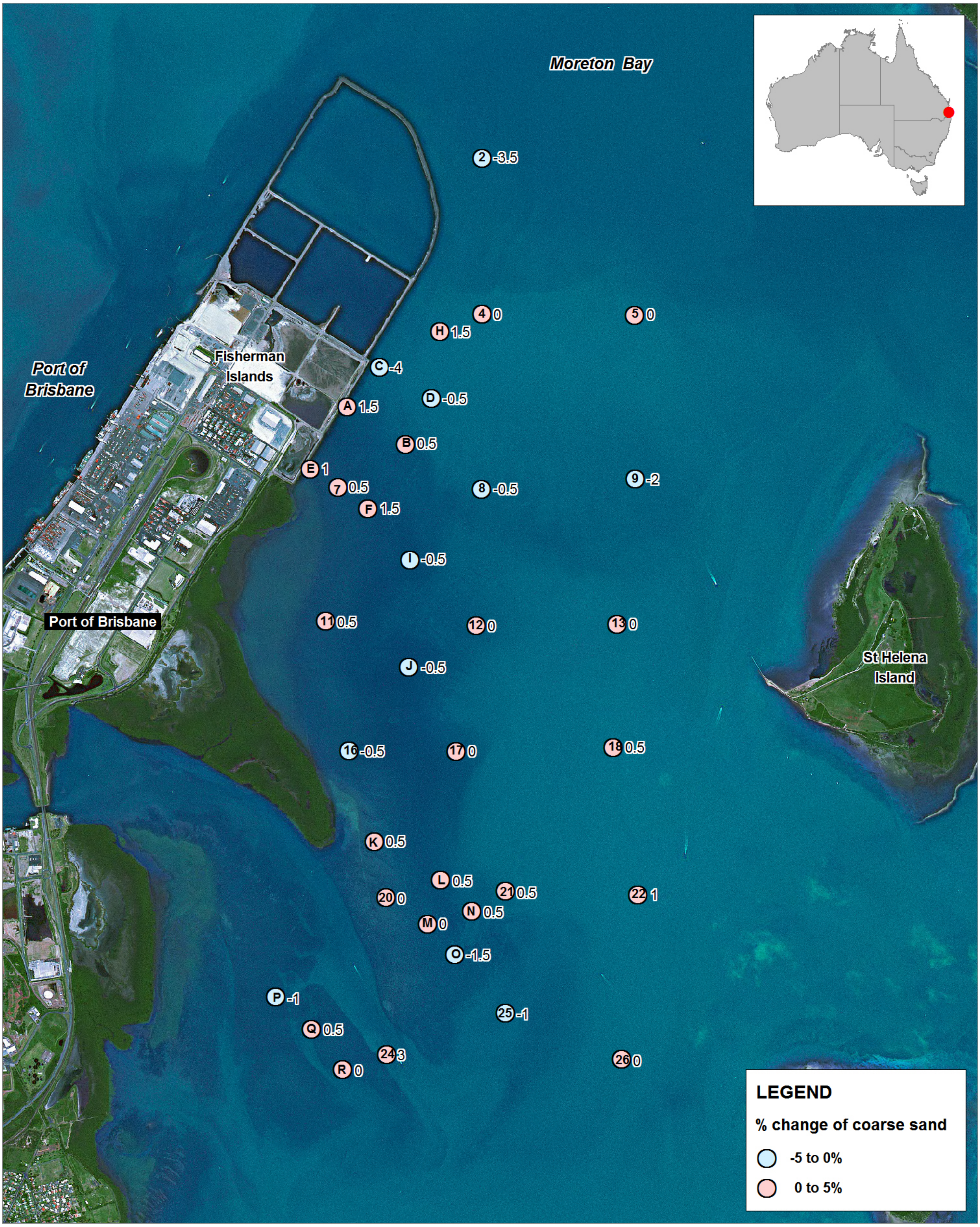
0 1 2km

Approx. Scale

BMT WBM

www.wbmpl.com.au

Filepath : I:\B17527_I_cp_POB PSD\DRG\ECO_021_090909_Percentage_Change _coarsesand92to98.wor



Title:

Percentage Change in Proportion of Coarse Sand (0.600 to 2.36mm) Material Between 1998 and 2009

Figure: **4-12**

Rev: **A**

N

0 1 2km

Approx. Scale

BMT WBM

www.wbmpl.com.au

Filepath : I:\B17527_I_cp_POB PSD\DRG\ECO_006_090909_Percentage_Change _coarsesand98.wor

5 CONCLUSIONS

The spatial patterns of sediment distribution observed in 2009 in the study area were generally consistent with previous investigations in the area, indicating that no major changes in broad scale sediment patterns have occurred during the period 1992-2009, which includes the Superbund construction (1992) and Future Port Expansion project (2002). Overall, the results suggested that broad scale sediment patterns in the study area are predominantly determined by hydrodynamic forcing due to currents and wave action. Accordingly, fine sediment fractions (silts and fine sands) were mainly found in deeper channels exhibiting bed armouring as well as in sheltered nearshore areas adjacent to Fisherman Islands, characterised by low bed shear stress and low current velocities. Medium sands were the dominant sediment type, and predominantly found in offshore intertidal areas between St Helena and Fisherman Islands. Higher bed shear stresses are common in these relatively exposed and shallow areas and wave action is expected to be higher compared to sheltered nearshore areas and deeper channels.

The investigation of temporal patterns in sediment distribution between 1992 and 2009 indicated some smaller scale changes in sediment distribution patterns, which appeared to be associated with the various construction stages of the port development. While no substantial broad scale changes in sediment distribution were observed for the period 1992-1998, an area characterised by a decrease in the fine sand fraction was identified off the protruding north-eastern edge of the Superbund structure, indicating erosion of fines in this area as predicted in a previous modelling study. In contrast, no such erosion was observed for the period 1998-2009 with data indicating an increase in silts and fine sands within the sediment composition at this location. The truncated north-eastern seawall structure, which was designed to minimise changes to current patterns, appears to have mitigated some of these effects to seabed habitats.

A notable 3 to 7-fold increase in silts was recorded within an area adjacent to Fisherman Islands and south of the seawall. This increase in fines may have been caused by local changes in hydrodynamic conditions associated with the FPE seawall structure, as supported by previous modelling suggesting a reduction in flow velocities at the southeast edge of the seawall and potential increase in silty material in the area. Potential sources of suspended fine material that can deposit in this low energy area may include river loads, bed sediment resuspension by wave and current action, dredging activities and potentially baitworm fishery activities.

Although some localised changes in sediment patterns appear to have occurred within the broader study area between 1992 and 2009, small scale patchiness in sediment characteristics may have contributed to the observed patterns to some extent. This may include micro-topographical variations in the seabed due to ripple formation and localised changes in hydrodynamic processes, which may reflect seasonal and interannual changes in waves and currents.

The environmental implications of the observed local changes in sediment characteristics are unknown at present. In particular, the potential effects of increased fine sediment on seagrass and benthic fauna should be considered, given the sensitivity of these species to sedimentation and potential increased sediment loading.

6 REFERENCES

BMT WBM (2009a) Ecological Character Description for the Moreton bay Ramsar Site. Report prepared on behalf of the Commonwealth Department of the Environment, Water, Heritage and the Arts and Queensland Environmental Protection Agency.

BMT WBM (2009b) FPE Seawall Ecological Assessment – Final Report. Report prepared for Port of Brisbane Corporation.

Orth, R.J., Carruthers, T.J.B., Dennison, W.C. et al. (2006) A Global Crisis for Seagrass Ecosystems. Bioscience 56, 987-996.

WBM (1992) Marine Currents and Sediments near Fisherman Islands. Report prepared for Port of Brisbane Authority.

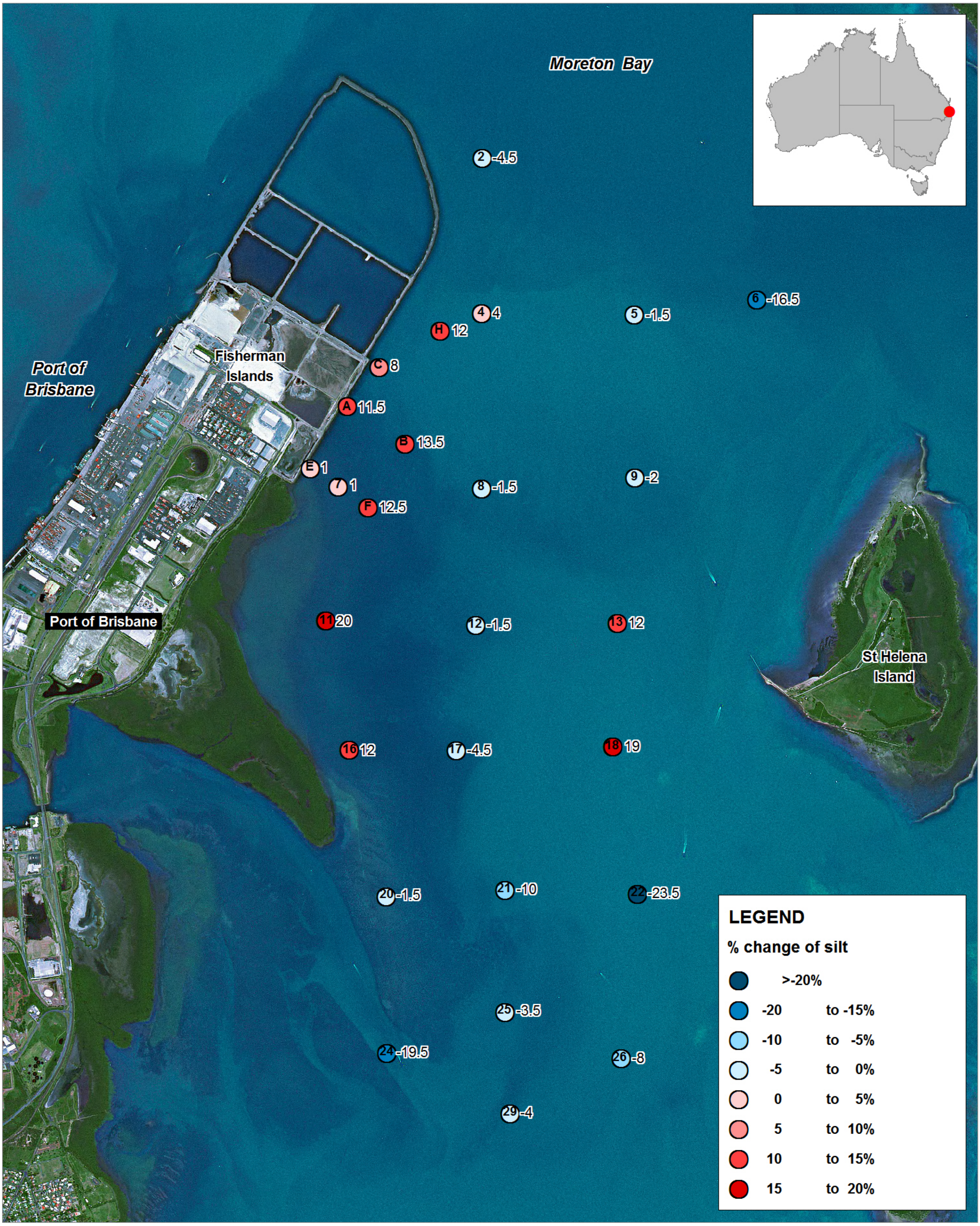
WBM (1993) Monitoring Programme – Effects of Port Extension on Sedimentation Patterns. Report prepared for Port of Brisbane Authority.

WBM (1998) Review of Potential Impacts Associated with Superbund Construction. Report prepared for Port of Brisbane Corporation.

WBM (2000) Port of Brisbane – Port Expansion Impact Assessment Study. Report prepared for Port of Brisbane Corporation.

Wentworth, C.K. (1922) A Scale of Grade and Class Terms for Clastic Sediments. Journal of Geology 30, 377-392.

APPENDIX A: TEMPORAL PATTERNS 1992-2009



Title:

Percentage Change in Proportion of Silt (<0.075mm) Material Between 1992 and 2009

Figure: **6-1**

Rev: **A**

N

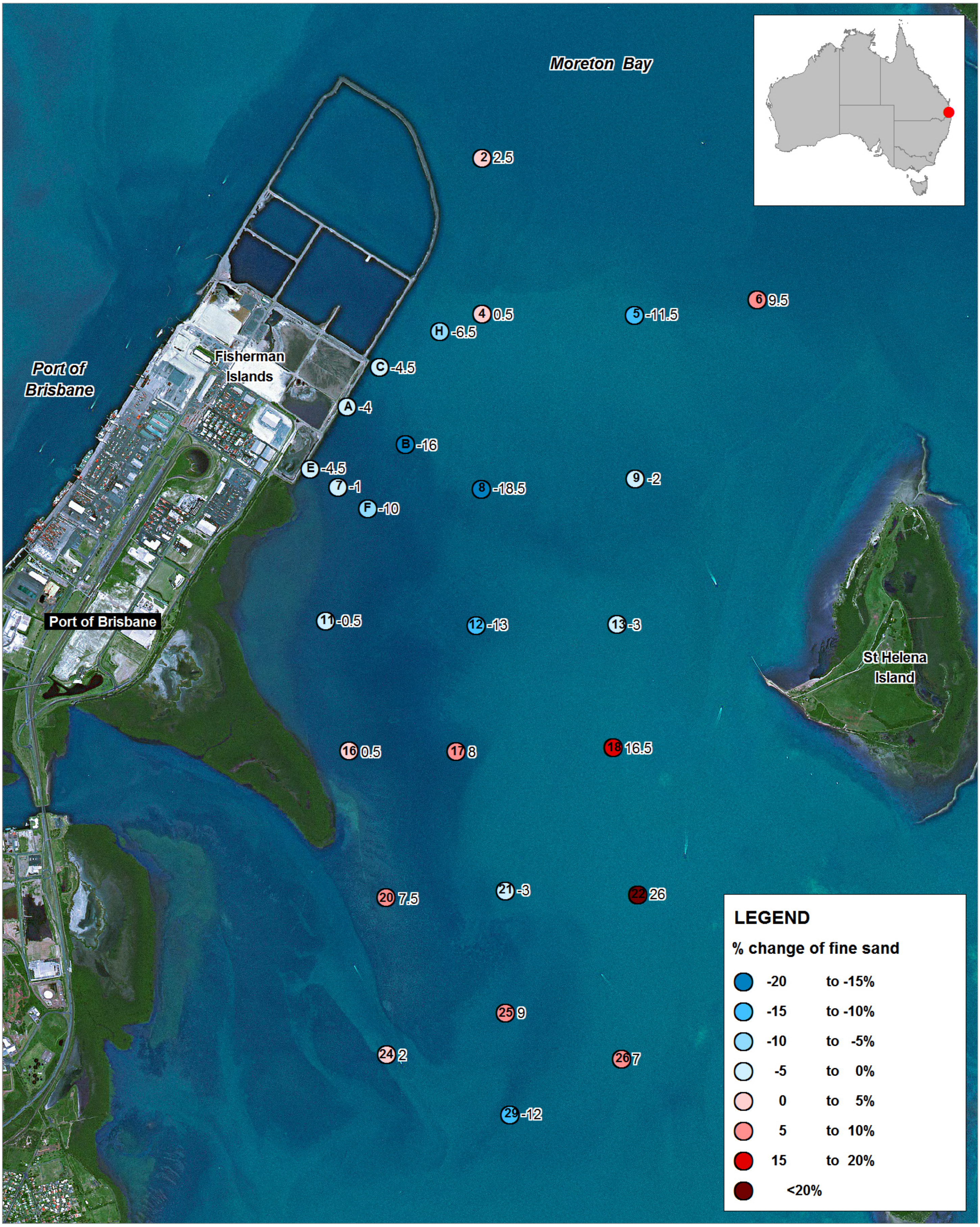
0 1 2km

Approx. Scale

BMT WBM

www.wbmpl.com.au

Filepath : I:\B17527_I_cp_POB PSD\DRG\ECO_013_090909_Percentage_Change _Silt 92.wor



Title:

Percentage Change in Proportion of Fine Sand (0.075 to 0.15mm) Material Between 1992 and 2009

Figure: **6-2**

Rev: **A**

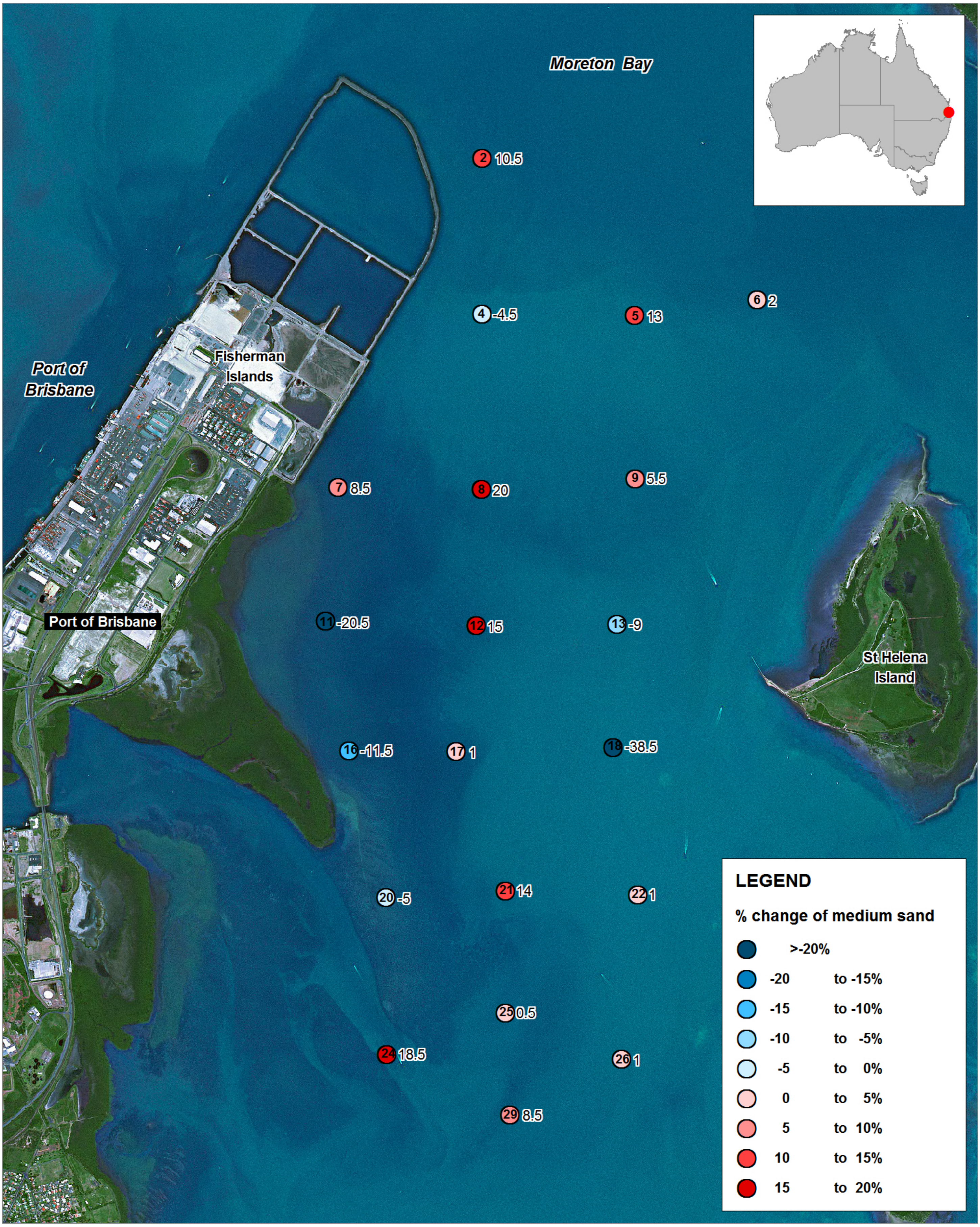
N

0 1 2km

Approx. Scale

BMT WBM
www.wbmpl.com.au

Filepath : I:\B17527_I_cp_POB PSD\DRG\ECO_014_090909_Percentage_Change finesand92.wor



Title:

Percentage Change in Proportion of Medium Sand (0.15 to 0.600mm) Material Between 1992 and 2009

Figure: 6-3

Rev: A

N

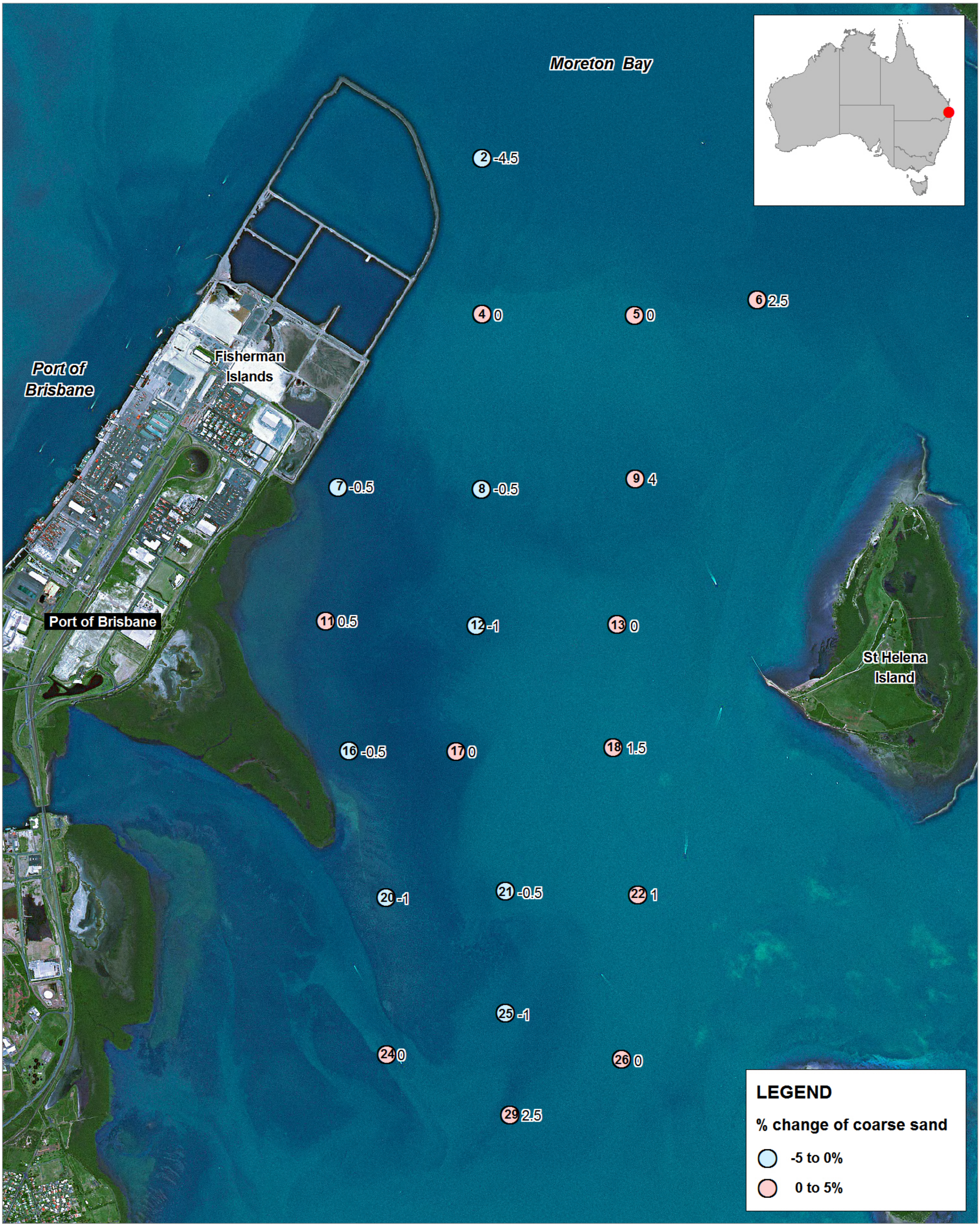
0 1 2km

Approx. Scale

BMT WBM

www.wbmpl.com.au

Filepath : I:\B17527_I_cp_POB PSD\DRG\ECO_015_090909_Percentage_Change medsand92.wor



Title:

Percentage Change in Proportion of Coarse Sand (0.600 to 2.36mm) Material Between 1992 and 2009

Figure: 6-4

Rev: A

N

0 1 2km

Approx. Scale

BMT WBM

www.wbmpl.com.au

Filepath : I:\B17527_I_cp_POB PSD\DRG\ECO_016_090909_Percentage_Change coarse sand92.wor

APPENDIX B: SEDIMENT PARTICLE SIZE DISTRIBUTION (PSD) DATA (2009)

A.G. LABS

Australian Geomechanical Laboratories P/L
ABN: 25 065 630 506

Soil & Rock Testing

Postal: PO Box 3317 Newmarket Qld 4051
Address: 10/104 Newmarket Rd Windsor Qld 4030
(Phone) 07 3357 5535
(Fax) 07 3357 5531
windsor@aglabs.com.au

PARTICLE SIZE DISTRIBUTION TEST REPORT

Test Method: AS1289 3.6.1, 2.1.1

Client: BMT WBM Pty Ltd

Project: 17527

Report No. 9080232-g

Test Date: 10/08/09
Report Date: 25/08/09

Sample No.	9080232	9080233	9080234	9080235	9080236	9080237
Client ID:	POB 17 REP1	POB 17 REP2	POB F REP1	POB F REP2	POB K REP1	POB K REP2
Depth (m):	-	-	-	-	-	-
Moisture (%)	63.2	39.9	66.7	61.1	29.0	38.4

AS SIEVE SIZE (mm)	**PERCENT PASSING**					
26.5						
19	100		100	100		
9.5	99	100	97	98		
4.75	98	99	95	98		
2.36	98	99	94	92		
1.18	98	99	93	90		100
0.600	97	98	93	88	100	99
0.425	94	93	91	87	96	98
0.300	74	62	87	83	79	89
0.150	16	15	41	42	14	31
0.075	8	7	16	17	3	9

Sample/s supplied by the client

Authorised Signatory

J. Russell

Manager

Form Number: GT005-5/6

A.G. LABS

Australian Geomechanical Laboratories P/L
ABN: 25 065 630 506

Soil & Rock Testing

Postal: PO Box 3317 Newmarket Qld 4051
Address: 10/104 Newmarket Rd Windsor Qld 4030
(Phone) 07 3357 5535
(Fax) 07 3357 5531
windsor@aglabs.com.au

PARTICLE SIZE DISTRIBUTION TEST REPORT

Test Method: AS1289 3.6.1, 2.1.1

Client:	BMT WBM Pty Ltd	Report No.	9080238-g
Project:	17527	Test Date:	10/08/09
		Report Date:	25/08/09

Sample No.	9080238	9080239	9080240	9080241	9080242	9080243
Client ID:	POB H REP1	POB H REP2	POB L REP1	POB L REP2	POB I REP1	POB I REP2
Depth (m):	-	-	-	-	-	-
Moisture (%)	38.2	36.7	52.3	37.5	47.4	46.1

AS SIEVE SIZE (mm)	**PERCENT PASSING**					
26.5						
19						100
9.5	100	100	100	100	100	99
4.75	99	99	98	98	98	98
2.36	98	99	97	98	97	97
1.18	97	98	96	97	96	96
0.600	94	96	95	97	96	95
0.425	82	87	90	92	92	92
0.300	60	64	72	75	80	82
0.150	25	26	19	21	53	59
0.075	14	14	7	7	20	23

Sample/s supplied by the client

Authorised Signatory

J. Russell

Manager

A.G. LABS

Australian Geomechanical Laboratories P/L
ABN: 25 065 630 506

Soil & Rock Testing

Postal: PO Box 3317 Newmarket Qld 4051
Address: 10/104 Newmarket Rd Windsor Qld 4030
(Phone) 07 3357 5535
(Fax) 07 3357 5531
windsor@aglabs.com.au

PARTICLE SIZE DISTRIBUTION TEST REPORT

Test Method: AS1289 3.6.1, 2.1.1

Client:	BMT WBM Pty Ltd	Report No.	9080244-g
Project:	17527	Test Date:	10/08/09
		Report Date:	25/08/09

Sample No.	9080244	9080245	9080246	9080247	9080248	9080249
Client ID:	POB M REP1	POB M REP2	POB J REP1	POB J REP2	POB N REP1	POB N REP2
Depth (m):	-	-	-	-	-	-
Moisture (%)	35.4	49.5	37.7	44.5	40.9	47.0

AS SIEVE SIZE (mm)	**PERCENT PASSING**					
26.5						
19	100					
9.5	99	100		100		100
4.75	97	98		99		99
2.36	96	97		99	100	99
1.18	96	97		98	99	98
0.600	95	96	100	98	99	97
0.425	90	91	98	95	96	94
0.300	75	73	87	82	89	85
0.150	21	24	39	32	54	48
0.075	9	9	21	16	24	21

Sample/s supplied by the client

Authorised Signatory

J. Russell

Manager

A.G. LABS

Australian Geomechanical Laboratories P/L
ABN: 25 065 630 506

Soil & Rock Testing

Postal: PO Box 3317 Newmarket Qld 4051
Address: 10/104 Newmarket Rd Windsor Qld 4030
(Phone) 07 3357 5535
(Fax) 07 3357 5531
windsor@aglabs.com.au

PARTICLE SIZE DISTRIBUTION

Test Method: AS 1289 3.6.3, 3.5.1

Client: BMT WBM Pty Ltd

Report No.: 9080250-g

Project: 17527

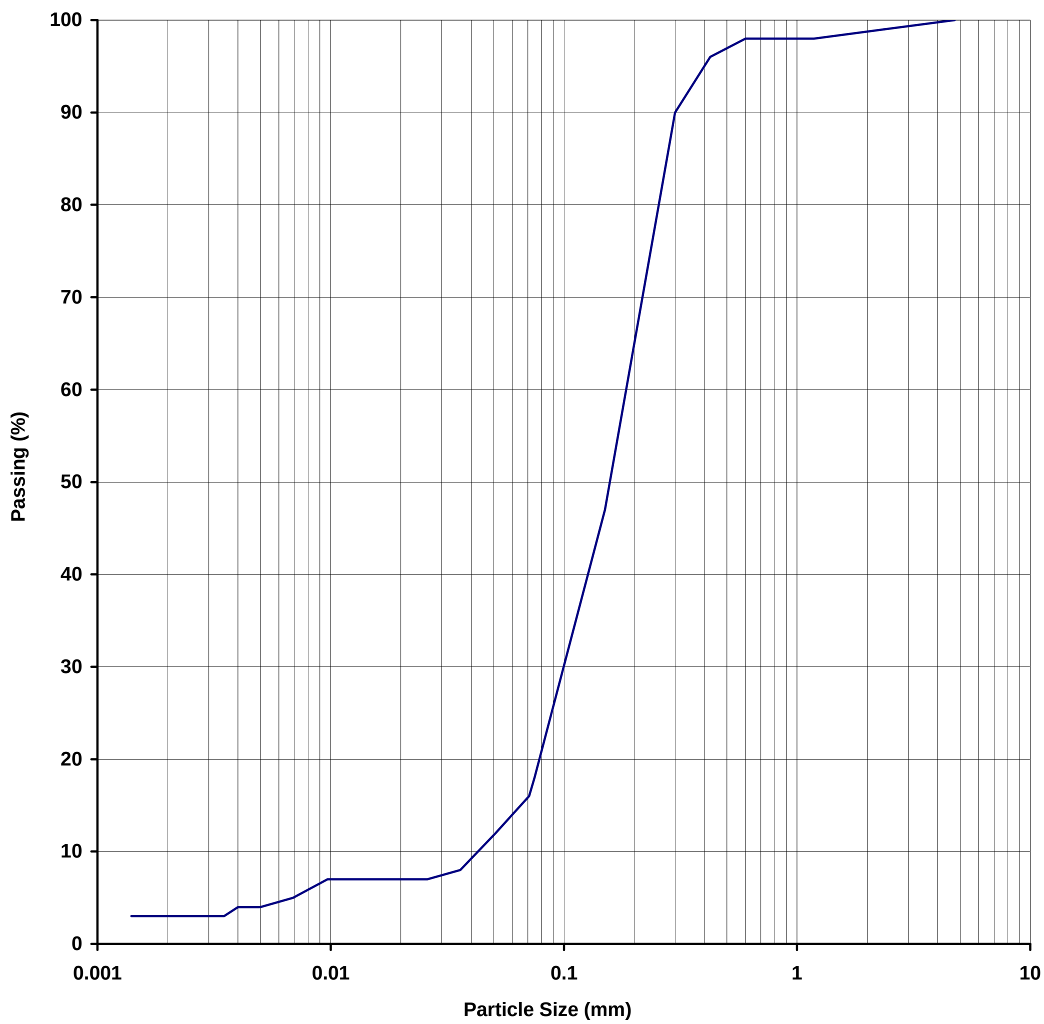
Test Date: 10,21/08/09

Report Date: 24/08/2009

Client Id.: POB O REP1

Depth (m): -

Sieve Size (mm)	Passing %
150.0	
75.0	
53.0	
37.5	
26.5	
19.0	
9.5	
4.75	100
2.36	99
1.18	98
0.600	98
0.425	96
0.300	90
0.150	47
0.075	18
0.071	16
0.051	12
0.036	8
0.026	7
0.019	7
0.014	7
0.0097	7
0.0069	5
0.005	4
0.004	4
0.0035	3
0.0029	3
0.0025	3
0.0014	3



Remarks:

Sample Moisture (%): 31.9

Soil Particle Density(t/m^3): 2.71

Sample/s supplied by the client

Authorised Signatory

J. Russell

A.G. LABS

Australian Geomechanical Laboratories P/L
ABN: 25 065 630 506

Soil & Rock Testing

Postal: PO Box 3317 Newmarket Qld 4051
Address: 10/104 Newmarket Rd Windsor Qld 4030
(Phone) 07 3357 5535
(Fax) 07 3357 5531
windsor@aglabs.com.au

PARTICLE SIZE DISTRIBUTION TEST REPORT

Test Method: AS1289 3.6.1, 2.1.1

Client:	BMT WBM Pty Ltd	Report No.	9080251-g
Project:	17527	Test Date:	10/08/09
		Report Date:	25/08/09

Sample No.	9080251	9080252	9080253	9080255	9080256	9080257
Client ID:	POB O REP2	POB R REP1	POB R REP2	POB P REP2	POB Q REP1	POB Q REP2
Depth (m):	-	-	-	-	-	-
Moisture (%)	32.5	33.9	35.9	54.5	55.5	61.9

AS SIEVE SIZE (mm)	**PERCENT PASSING**					
26.5						
19		100	100			
9.5	100	97	99	100		100
4.75	99	94	97	99		97
2.36	98	92	95	99	100	97
1.18	98	91	94	99	100	96
0.600	98	90	93	98	99	95
0.425	95	86	88	93	99	94
0.300	86	70	76	78	96	91
0.150	38	24	31	41	79	74
0.075	17	13	15	23	42	42

Sample/s supplied by the client

Form Number: GT005-5/6

Authorised Signatory

J. Russell

Manager

A.G. LABS

Australian Geomechanical Laboratories P/L
ABN: 25 065 630 506

Soil & Rock Testing

Postal: PO Box 3317 Newmarket Qld 4051
Address: 10/104 Newmarket Rd Windsor Qld 4030
(Phone) 07 3357 5535
(Fax) 07 3357 5531
windsor@aglabs.com.au

PARTICLE SIZE DISTRIBUTION

Test Method: AS 1289 3.6.3, 3.5.1

Client: BMT WBM Pty Ltd

Report No.: 9080254-g

Project: 17527

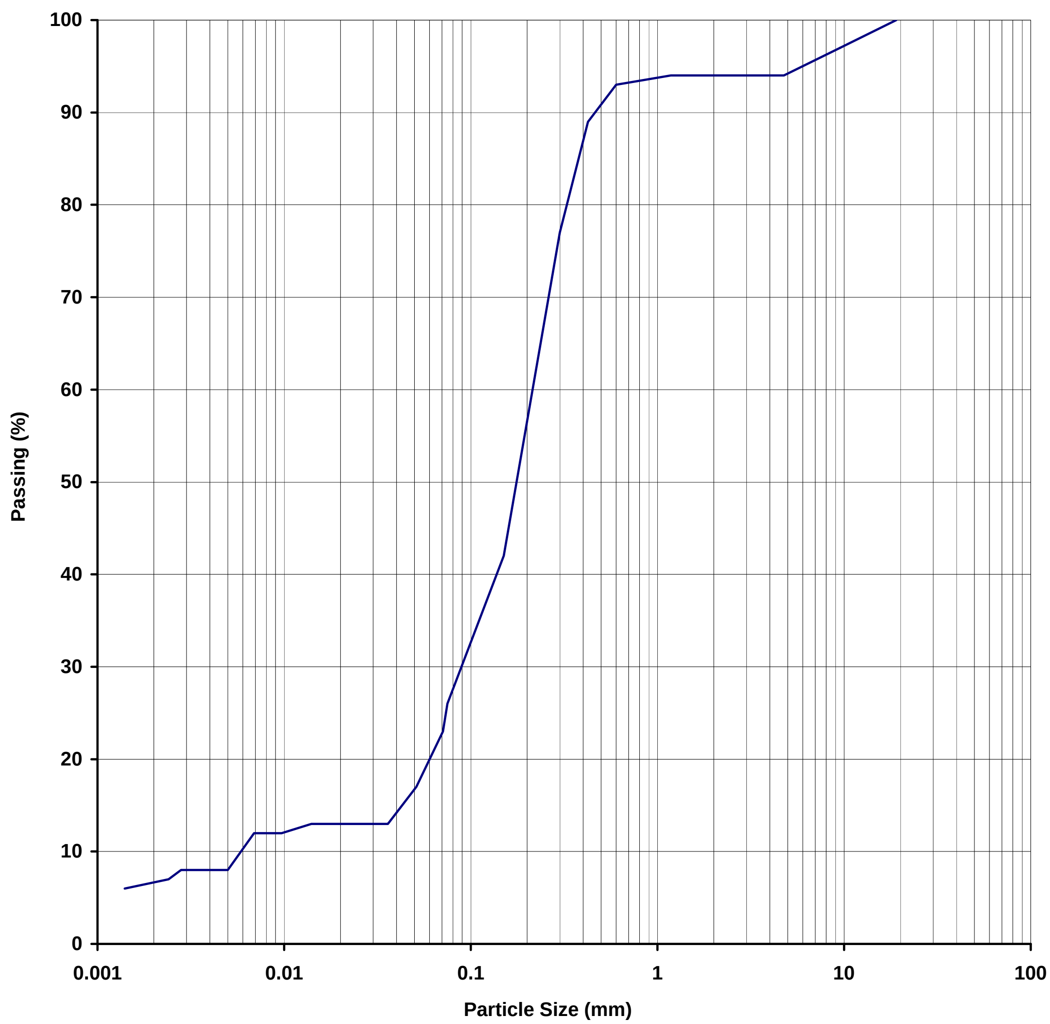
Test Date: 10,21/08/09

Report Date: 24/08/2009

Client Id.: POB P REP1

Depth (m): -

Sieve Size (mm)	Passing %
150.0	
75.0	
53.0	
37.5	
26.5	
19.0	100
9.5	97
4.75	94
2.36	94
1.18	94
0.600	93
0.425	89
0.300	77
0.150	42
0.075	26
0.071	23
0.051	17
0.036	13
0.026	13
0.019	13
0.014	13
0.0097	12
0.0069	12
0.005	8
0.004	8
0.0035	8
0.0028	8
0.0024	7
0.0014	6



Remarks:

Sample Moisture (%): 44.8

Soil Particle Density(t/m^3): 2.69

Sample/s supplied by the client

Authorised Signatory

J. Russell

A.G. LABS

Australian Geomechanical Laboratories P/L
ABN: 25 065 630 506

Soil & Rock Testing

Postal: PO Box 3317 Newmarket Qld 4051
Address: 10/104 Newmarket Rd Windsor Qld 4030
(Phone) 07 3357 5535
(Fax) 07 3357 5531
windsor@aglabs.com.au

PARTICLE SIZE DISTRIBUTION TEST REPORT

Test Method: AS1289 3.6.1, 2.1.1

Client:	BMT WBM Pty Ltd	Report No.	9080260-g
Project:	17527	Test Date:	10/08/09
		Report Date:	25/08/09

Sample No.	9080260	9080261	9080262	9080263	9080264	9080265
Client ID:	POB 18 REP1	POB 18 REP2	POB 2 REP1	POB 2 REP2	POB 20 REP1	POB 20 REP2
Depth (m):	-	-	-	-	-	-
Moisture (%)	52.3	56.9	46.8	44.8	28.7	30.9

AS SIEVE SIZE (mm)	**PERCENT PASSING**					
26.5						
19						
9.5	100	100				
4.75	97	99	100	100		
2.36	95	98	99	99		
1.18	93	97	99	99	100	100
0.600	92	96	95	94	99	99
0.425	91	96	80	79	95	96
0.300	90	94	66	64	81	79
0.150	80	85	46	46	27	23
0.075	51	53	23	22	5	8

Sample/s supplied by the client

Authorised Signatory

J. Russell

Manager

Form Number: GT005-5/6

A.G. LABS

Australian Geomechanical Laboratories P/L
ABN: 25 065 630 506

Soil & Rock Testing

Postal: PO Box 3317 Newmarket Qld 4051
Address: 10/104 Newmarket Rd Windsor Qld 4030
(Phone) 07 3357 5535
(Fax) 07 3357 5531
windsor@aglabs.com.au

PARTICLE SIZE DISTRIBUTION TEST REPORT

Test Method: AS1289 3.6.1, 2.1.1

Client:	BMT WBM Pty Ltd	Report No.	9080266-g
Project:	17527	Test Date:	10/08/09
		Report Date:	25/08/09

Sample No.	9080266	9080267	9080268	9080269	9080270	9080271
Client ID:	POB 21 REP1	POB 21 REP2	POB 4 REP1	POB 4 REP2	POB 22 REP1	POB 22 REP2
Depth (m):	-	-	-	-	-	-
Moisture (%)	32.2	33.8	43.3	38.7	47.8	48.0

AS SIEVE SIZE (mm)	**PERCENT PASSING**					
26.5						
19						
9.5					100	
4.75	100				97	100
2.36	99	100			96	99
1.18	99	99	100	100	94	98
0.600	99	99	99	99	93	96
0.425	94	95	97	96	93	95
0.300	80	79	90	88	92	94
0.150	26	28	70	65	90	91
0.075	5	5	30	24	38	35

Sample/s supplied by the client

Authorised Signatory

J. Russell

Manager

N ATA Accredited Laboratory Number 9926

Form Number: GT005-5/6

A.G. LABS

Australian Geomechanical Laboratories P/L
ABN: 25 065 630 506

Soil & Rock Testing

Postal: PO Box 3317 Newmarket Qld 4051
Address: 10/104 Newmarket Rd Windsor Qld 4030
(Phone) 07 3357 5535
(Fax) 07 3357 5531
windsor@aglabs.com.au

PARTICLE SIZE DISTRIBUTION TEST REPORT

Test Method: AS1289 3.6.1, 2.1.1

Client:	BMT WBM Pty Ltd	Report No.	9080272-g
Project:	17527	Test Date:	10/08/09
		Report Date:	25/08/09

Sample No.	9080272	9080273	9080274	9080275	9080277	9080278
Client ID:	POB 5 REP1	POB 5 REP2	POB 24 REP1	POB 24 REP2	POB 6 REP2	POB 25 REP1
Depth (m):	-	-	-	-	-	-
Moisture (%)	39.5	35.0	81.6	81.5	58.6	30.7

AS SIEVE SIZE (mm)	**PERCENT PASSING**					
26.5						
19						
9.5			100	100	100	
4.75			99	99	95	
2.36			98	98	90	100
1.18	100	100	96	96	87	99
0.600	99	99	95	95	85	99
0.425	98	98	93	94	84	94
0.300	87	88	85	85	83	84
0.150	28	32	60	59	74	53
0.075	14	17	46	45	49	14

Sample/s supplied by the client

Authorised Signatory

J. Russell

Manager

N ATA Accredited Laboratory Number 9926

Form Number: GT005-5/6

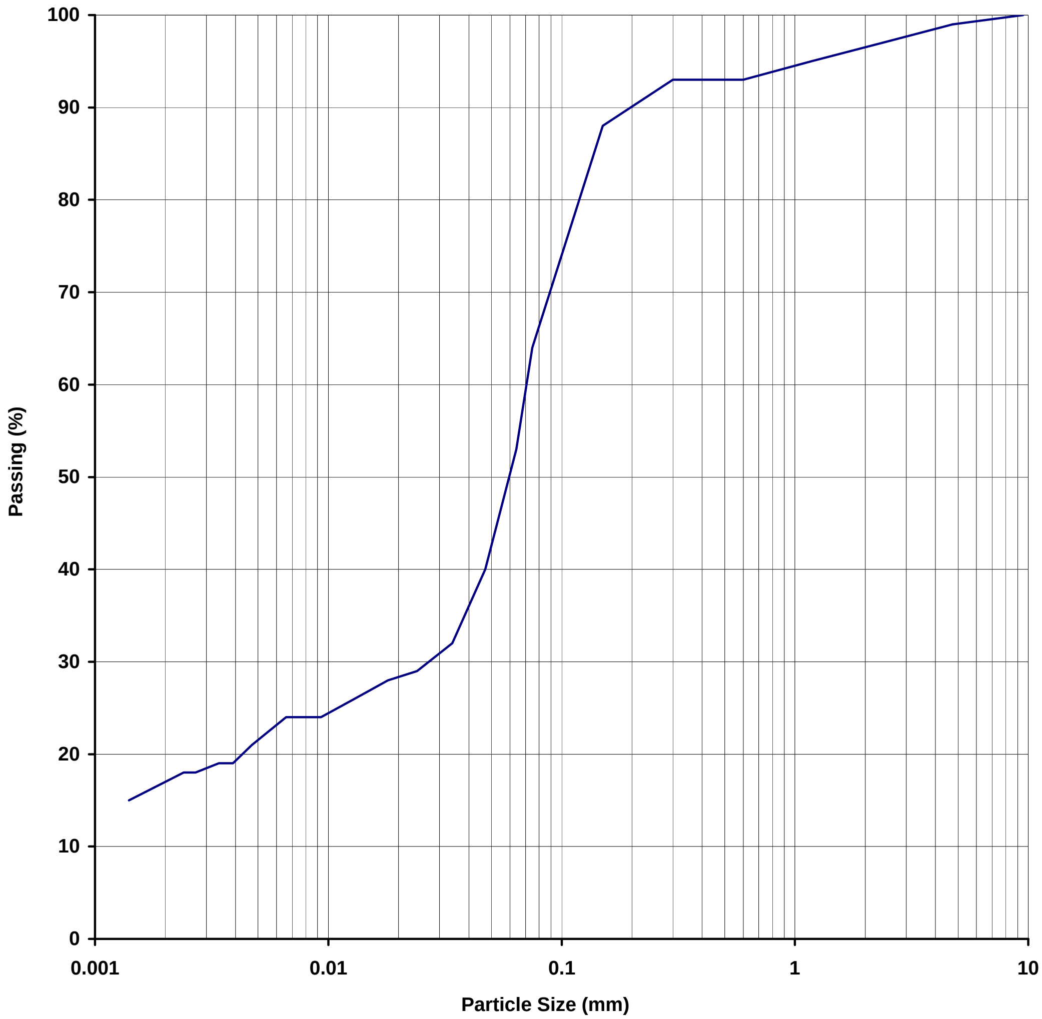
A.G. LABS
Australian Geomechanical Laboratories P/L
ABN: 25 065 630 506
Soil & Rock Testing
Postal: PO Box 3317 Newmarket Qld 4051
Address: 10/104 Newmarket Rd Windsor Qld 4030
(Phone) 07 3357 5535
(Fax) 07 3357 5531
windsor@aglabs.com.au

PARTICLE SIZE DISTRIBUTION

Test Method: AS 1289 3.6.3, 3.5.1

Client:	BMT WBM Pty Ltd	**Report No.:**	9080276-g
Project:	17527	**Test Date:**	10,21/08/09
		Report Date:	24/08/2009
Client Id.:	POB 6 REP1	**Depth (m):**	-

Sieve Size (mm)	Passing %
150.0	
75.0	
53.0	
37.5	
26.5	
19.0	
9.5	100
4.75	99
2.36	97
1.18	95
0.600	93
0.425	93
0.300	93
0.150	88
0.075	64
0.064	53
0.047	40
0.034	32
0.024	29
0.018	28
0.013	26
0.0093	24
0.0066	24
0.0047	21
0.0039	19
0.0034	19
0.0027	18
0.0024	18
0.0014	15



Remarks:

Sample Moisture (%): 72.7 Soil Particle Density(t/m^3): 2.74

Sample/s supplied by the client

NATA Accredited Laboratory Number 9926

This Document is issued in accordance with NATA's accreditation requirements. Accredited for compliance with ISO/IEC 17025. The results of the tests, calibrations, and/or measurements included in this document are traceable to Australian/National standards.

NATA ACCREDITED FOR TECHNICAL COMPETENCE

Authorised Signatory

J. Russell

A.G. LABS

Australian Geomechanical Laboratories P/L
ABN: 25 065 630 506

Soil & Rock Testing

Postal: PO Box 3317 Newmarket Qld 4051
Address: 10/104 Newmarket Rd Windsor Qld 4030
(Phone) 07 3357 5535
(Fax) 07 3357 5531
windsor@aglabs.com.au

PARTICLE SIZE DISTRIBUTION TEST REPORT

Test Method: AS1289 3.6.1, 2.1.1

Client:	BMT WBM Pty Ltd	Report No.	9080279-g
Project:	17527	Test Date:	10/08/09
		Report Date:	25/08/09

Sample No.	9080279	9080280	9080281	9080282	9080283	9080284
Client ID:	POB 25 REP2	POB 7 REP1	POB 7 REP2	POB 26 REP1	POB 26 REP2	POB 8 REP1
Depth (m):	-	-	-	-	-	-
Moisture (%)	33.6	51.0	51.0	47.8	45.0	32.3

AS SIEVE SIZE (mm)	**PERCENT PASSING**					
26.5						
19		100	100			
9.5		98	99			
4.75		95	95			
2.36		94	94			
1.18	100	94	93			
0.600	99	93	92	100		100
0.425	96	92	91	99		99
0.300	87	86	86	95	100	95
0.150	48	46	48	90	98	14
0.075	17	15	17	25	29	3

Sample/s supplied by the client

Authorised Signatory

J. Russell

Manager

N ATA Accredited Laboratory Number 9926

Form Number: GT005-5/6

A.G. LABS

Australian Geomechanical Laboratories P/L
ABN: 25 065 630 506

Soil & Rock Testing

Postal: PO Box 3317 Newmarket Qld 4051
Address: 10/104 Newmarket Rd Windsor Qld 4030
(Phone) 07 3357 5535
(Fax) 07 3357 5531
windsor@aglabs.com.au

PARTICLE SIZE DISTRIBUTION TEST REPORT

Test Method: AS1289 3.6.1, 2.1.1

Client: BMT WBM Pty Ltd

Project: 17527

Report No. 9080285-g

Test Date: 10/08/09
Report Date: 25/08/09

Sample No.	9080285	9080286	9080287	9080288	9080289	9080290
Client ID:	POB 8 REP2	POB 29 REP1	POB 29 REP2	POB 9 REP1	POB 9 REP2	POB A REP1
Depth (m):	-	-	-	-	-	-
Moisture (%)	34.2	36.5	43.5	32.0	31.5	65.3

AS SIEVE SIZE (mm)	**PERCENT PASSING**					
26.5						
19			100			100
9.5	100	100	97	100		97
4.75	99	96	93	99	100	95
2.36	99	93	87	98	99	95
1.18	99	91	83	97	98	94
0.600	98	88	81	91	92	93
0.425	98	83	74	70	70	92
0.300	94	60	52	49	48	88
0.150	16	10	8	5	5	30
0.075	4	2	2	2	2	13

Sample/s supplied by the client

Authorised Signatory

J. Russell

Manager

Form Number: GT005-5/6

A.G. LABS

Australian Geomechanical Laboratories P/L
ABN: 25 065 630 506

Soil & Rock Testing

Postal: PO Box 3317 Newmarket Qld 4051
Address: 10/104 Newmarket Rd Windsor Qld 4030
(Phone) 07 3357 5535
(Fax) 07 3357 5531
windsor@aglabs.com.au

PARTICLE SIZE DISTRIBUTION TEST REPORT

Test Method: AS1289 3.6.1, 2.1.1

Client:	BMT WBM Pty Ltd	Report No.	9080291-g
Project:	17527	Test Date:	10/08/09
		Report Date:	25/08/09

Sample No.	9080291	9080293	9080295	9080296	9080297	9080298
Client ID:	POB A REP2	POB 11 REP2	POB B REP2	POB 12 REP1	POB 12 REP2	POB C REP1
Depth (m):	-	-	-	-	-	-
Moisture (%)	53.6	73.0	52.2	34.2	39.3	39.7

AS SIEVE SIZE (mm)	**PERCENT PASSING**					
26.5						
19		100				100
9.5	100	93				99
4.75	99	92	100	100		99
2.36	98	91	99	99	100	99
1.18	98	90	99	99	99	99
0.600	97	90	99	98	99	97
0.425	96	86	98	93	95	91
0.300	91	77	93	73	77	72
0.150	31	48	34	15	20	15
0.075	12	33	13	9	12	10

Sample/s supplied by the client

Authorised Signatory

J. Russell

Manager

A.G. LABS

Australian Geomechanical Laboratories P/L
ABN: 25 065 630 506

Soil & Rock Testing

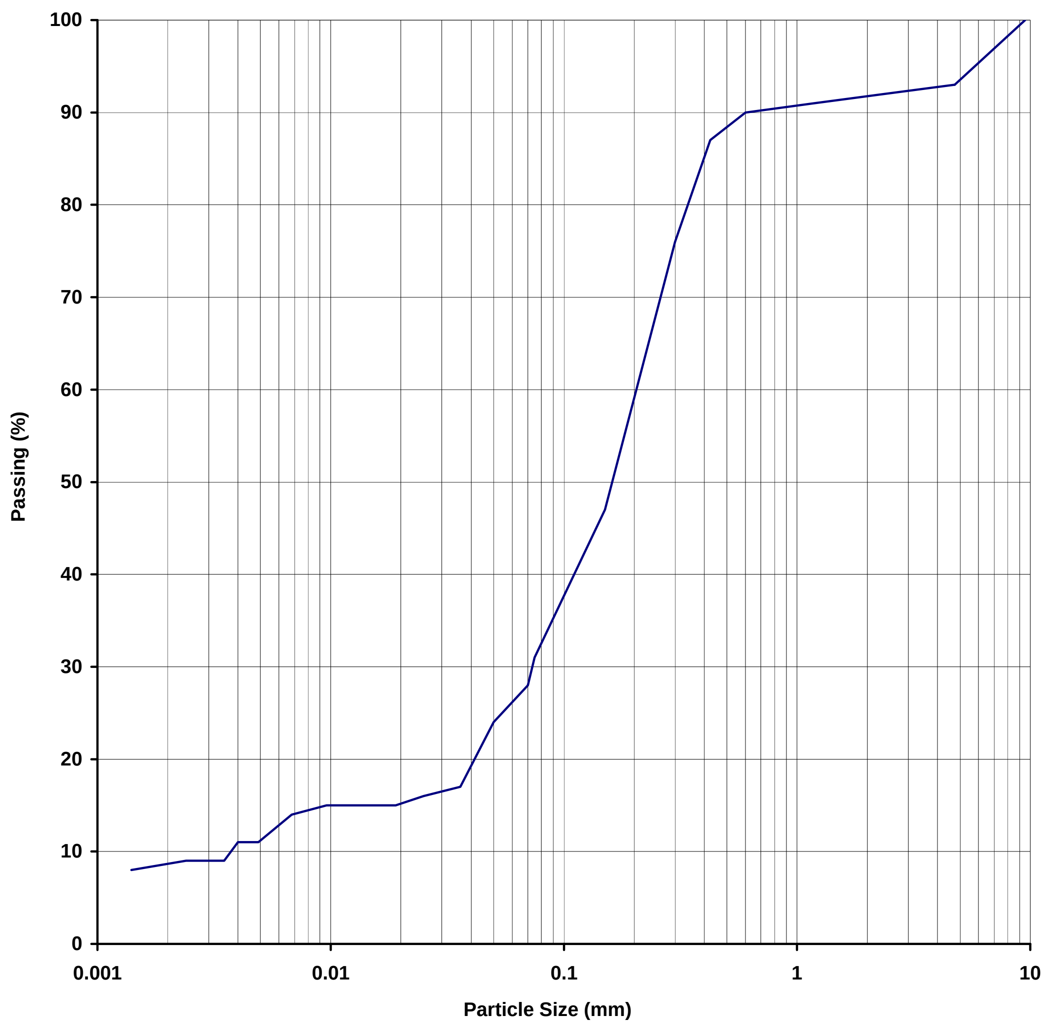
Postal: PO Box 3317 Newmarket Qld 4051
Address: 10/104 Newmarket Rd Windsor Qld 4030
(Phone) 07 3357 5535
(Fax) 07 3357 5531
windsor@aglabs.com.au

PARTICLE SIZE DISTRIBUTION

Test Method: AS 1289 3.6.3, 3.5.1

Client:	BMT WBM Pty Ltd	**Report No.:**	9080292-g
Project:	17527	**Test Date:**	10,21/08/09
		Report Date:	24/08/2009
Client Id.:	POB 11 REP1	**Depth (m):**	-

Sieve Size (mm)	Passing %
150.0	
75.0	
53.0	
37.5	
26.5	
19.0	
9.5	100
4.75	93
2.36	92
1.18	91
0.600	90
0.425	87
0.300	76
0.150	47
0.075	31
0.07	28
0.05	24
0.036	17
0.025	16
0.019	15
0.014	15
0.0096	15
0.0068	14
0.0049	11
0.004	11
0.0035	9
0.0028	9
0.0024	9
0.0014	8



Remarks:

Sample Moisture (%): 79.2 Soil Particle Density(t/m^3): 2.70

Sample/s supplied by the client

NATA Accredited Laboratory Number 9926

This Document is issued in accordance with NATA's accreditation requirements. Accredited for compliance with ISO/IEC 17025. The results of the tests, calibrations, and/or measurements included in this document are traceable to Australian/National standards.

NATA ACCREDITED FOR TECHNICAL COMPETENCE

Authorised Signatory

J. Russell

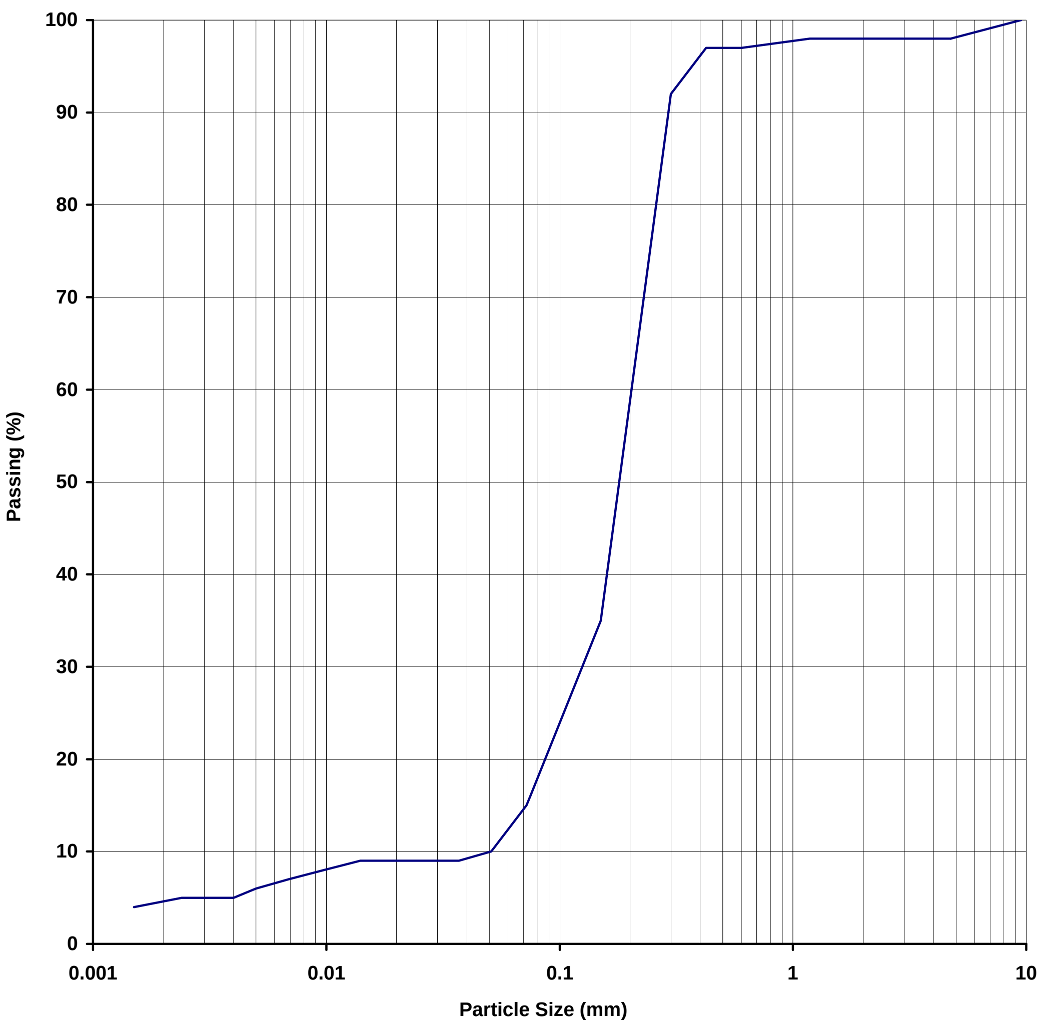
A.G. LABS
Australian Geomechanical Laboratories P/L
ABN: 25 065 630 506
Soil & Rock Testing
Postal: PO Box 3317 Newmarket Qld 4051
Address: 10/104 Newmarket Rd Windsor Qld 4030
(Phone) 07 3357 5535
(Fax) 07 3357 5531
windsor@aglabs.com.au

PARTICLE SIZE DISTRIBUTION

Test Method: AS 1289 3.6.3, 3.5.1

Client: BMT WBM Pty Ltd
Report No.: 9080294-g
Project: 17527
Test Date: 10,21/08/09
Report Date: 24/08/2009
Client Id.: POB B REP1
Depth (m): -

Sieve Size (mm)	Passing %
150.0	
75.0	
53.0	
37.5	
26.5	
19.0	
9.5	100
4.75	98
2.36	98
1.18	98
0.600	97
0.425	97
0.300	92
0.150	35
0.075	16
0.072	15
0.051	10
0.037	9
0.026	9
0.019	9
0.014	9
0.0098	8
0.0069	7
0.005	6
0.004	5
0.0035	5
0.0028	5
0.0024	5
0.0015	4



Remarks:

Sample Moisture (%): 36.6

Soil Particle Density(t/m^3): 2.69

Sample/s supplied by the client

NATA Accredited Laboratory Number 9926

This Document is issued in accordance with NATA's accreditation requirements. Accredited for compliance with ISO/IEC 17025. The results of the tests, calibrations, and/or measurements included in this document are traceable to Australian/National standards.

NATA ACCREDITED FOR TECHNICAL COMPETENCE

Authorised Signatory

J. Russell

A.G. LABS
Australian Geomechanical Laboratories P/L
ABN: 25 065 630 506
Soil & Rock Testing
Postal: PO Box 3317 Newmarket Qld 4051
Address: 10/104 Newmarket Rd Windsor Qld 4030
(Phone) 07 3357 5535
(Fax) 07 3357 5531
windsor@aglabs.com.au

PARTICLE SIZE DISTRIBUTION TEST REPORT

Test Method: AS1289 3.6.1, 2.1.1

Client:	BMT WBM Pty Ltd	Report No.	9080299-g
Project:	17527	Test Date:	10,17/08/09
		Report Date:	25/08/09

Sample No.	9080299	9080300	9080301	9080302	9080303	9080305
Client ID:	POB C REP2	POB 13 REP1	POB 13 REP2	POB D REP1	POB D REP2	POB 16 REP2
Depth (m):	-	-	-	-	-	-
Moisture (%)	37.7	50.9	54.8	32.9	23.4	57.0

AS SIEVE SIZE (mm)	**PERCENT PASSING**					
26.5						
19						100
9.5						97
4.75						95
2.36	100				100	94
1.18	99			100	99	93
0.600	98		100	99	98	93
0.425	91	100	99	94	93	91
0.300	70	100	99	79	77	83
0.150	10	95	91	11	13	51
0.075	6	64	54	5	5	25

Sample/s supplied by the client

Authorised Signatory

J. Russell

Manager

Form Number: GT005-5/6

A.G. LABS

Australian Geomechanical Laboratories P/L
ABN: 25 065 630 506

Soil & Rock Testing

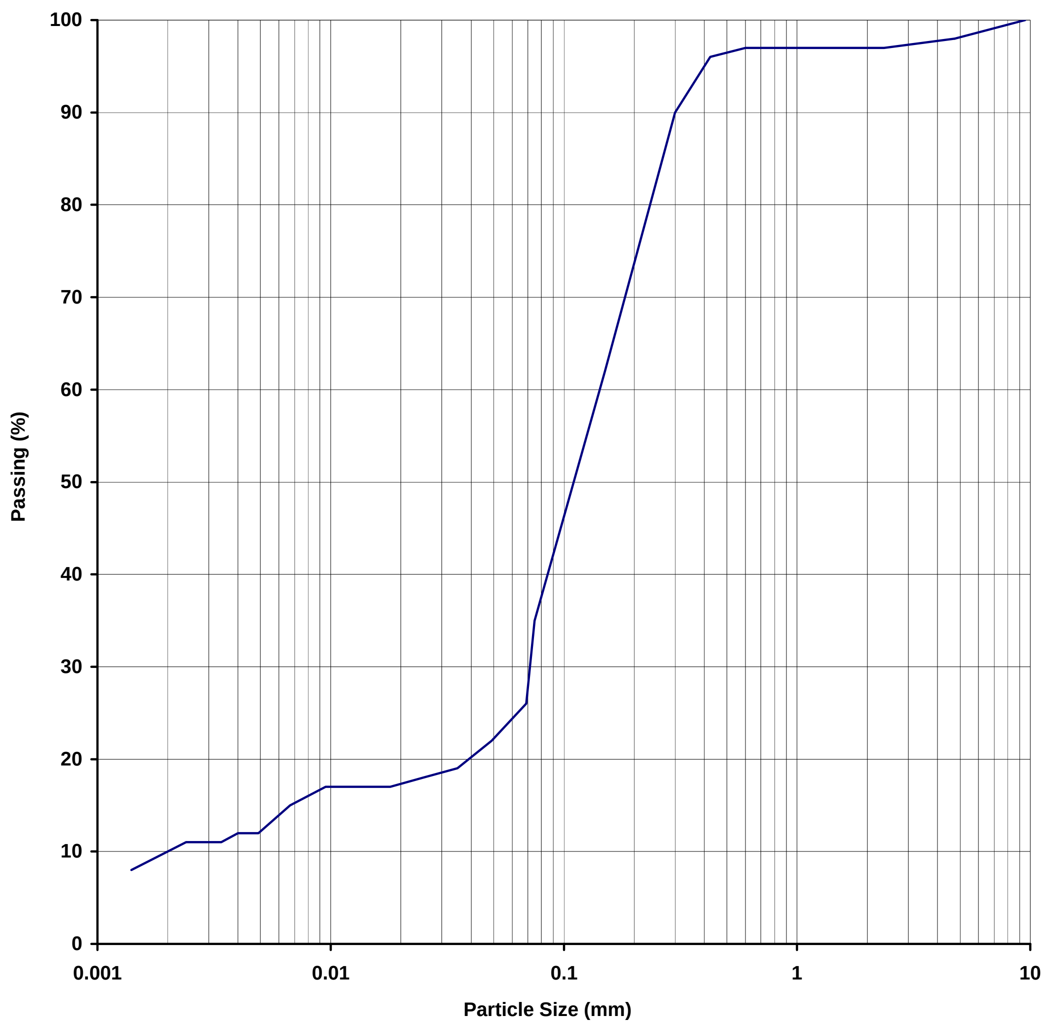
Postal: PO Box 3317 Newmarket Qld 4051
Address: 10/104 Newmarket Rd Windsor Qld 4030
(Phone) 07 3357 5535
(Fax) 07 3357 5531
windsor@aglabs.com.au

PARTICLE SIZE DISTRIBUTION

Test Method: AS 1289 3.6.3, 3.5.1

Client:	BMT WBM Pty Ltd	**Report No.:**	9080304-g
Project:	17527	**Test Date:**	10,21/08/09
		Report Date:	24/08/2009
Client Id.:	POB 16 REP1	**Depth (m):**	-

Sieve Size (mm)	Passing %
150.0	
75.0	
53.0	
37.5	
26.5	
19.0	
9.5	100
4.75	98
2.36	97
1.18	97
0.600	97
0.425	96
0.300	90
0.150	62
0.075	35
0.069	26
0.049	22
0.035	19
0.025	18
0.018	17
0.013	17
0.0095	17
0.0067	15
0.0049	12
0.004	12
0.0034	11
0.0028	11
0.0024	11
0.0014	8



Remarks:

Sample Moisture (%): 62.5 Soil Particle Density(t/m^3): 2.72

Sample/s supplied by the client

Authorised Signatory

J. Russell

A.G. LABS

Australian Geomechanical Laboratories P/L
ABN: 25 065 630 506

Soil & Rock Testing

Postal: PO Box 3317 Newmarket Qld 4051
Address: 10/104 Newmarket Rd Windsor Qld 4030
(Phone) 07 3357 5535
(Fax) 07 3357 5531
windsor@aglabs.com.au

PARTICLE SIZE DISTRIBUTION TEST REPORT

Test Method: AS1289 3.6.1, 2.1.1

Client:	BMT WBM Pty Ltd	Report No.	9080306-g
Project:	17527	Test Date:	10/08/09
		Report Date:	25/08/09

Sample No.	9080306	9080307
Client ID:	POB E REP1	POB E REP2
Depth (m):	-	-
Moisture (%)	52.0	44.3

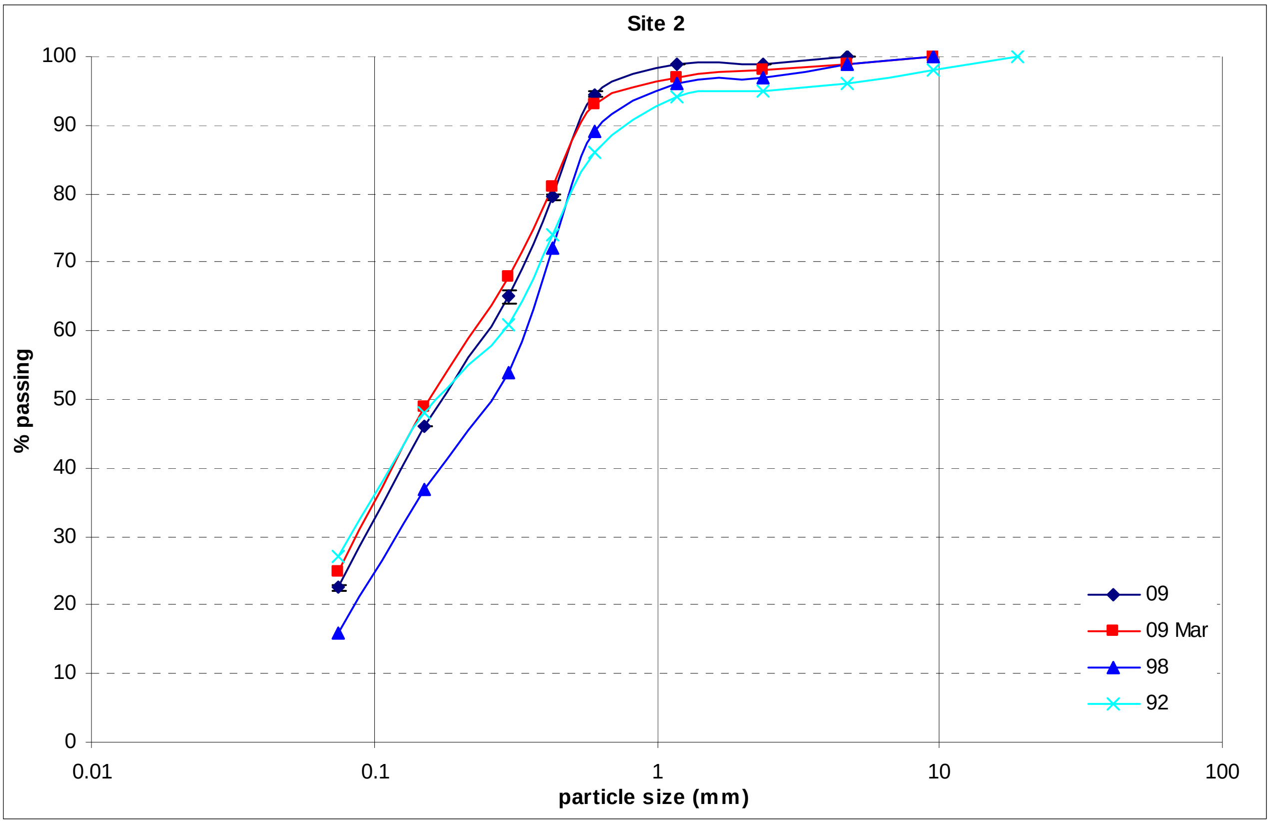
AS SIEVE SIZE (mm)	**PERCENT PASSING**	
19.0		
9.5	100	100
4.75	98	99
2.36	98	99
1.18	97	97
0.600	97	96
0.425	96	94
0.300	92	88
0.150	57	46
0.075	28	18

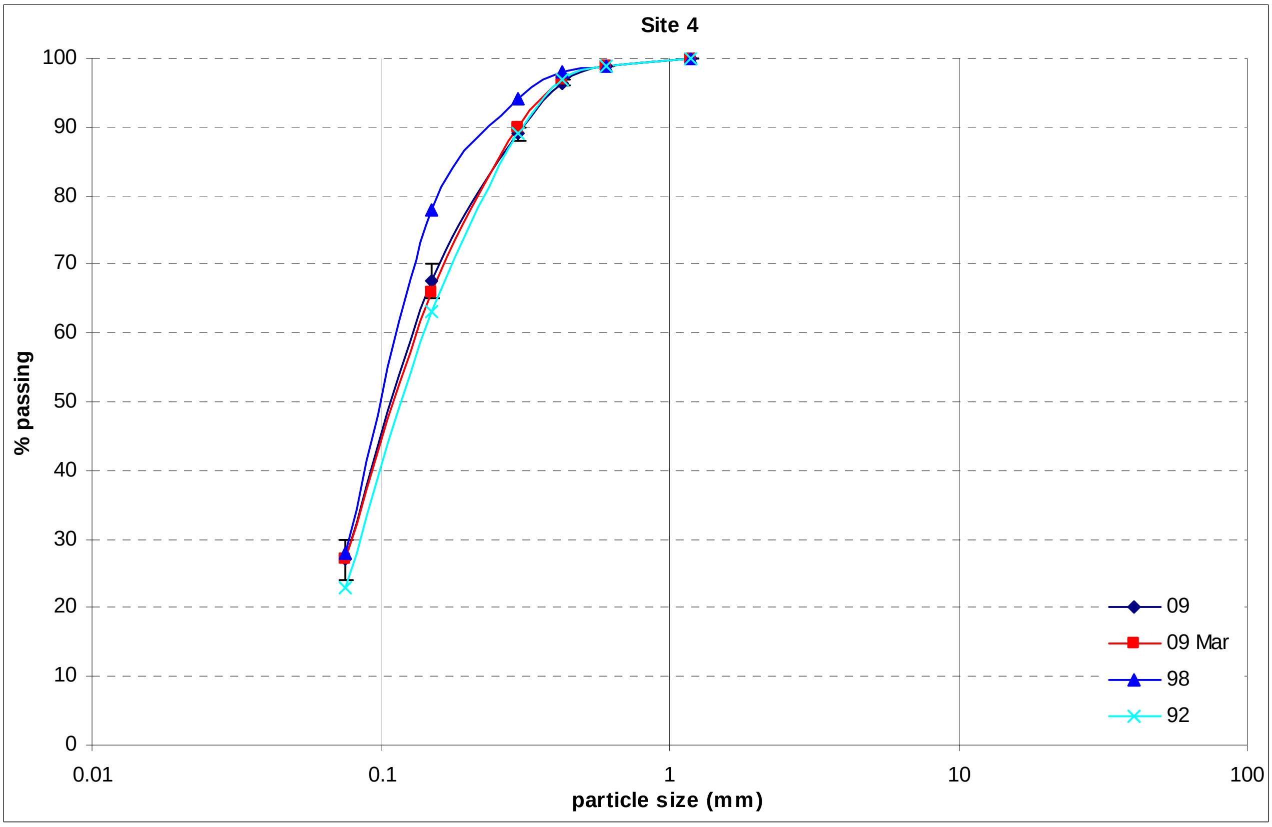
Sample/s supplied by the client

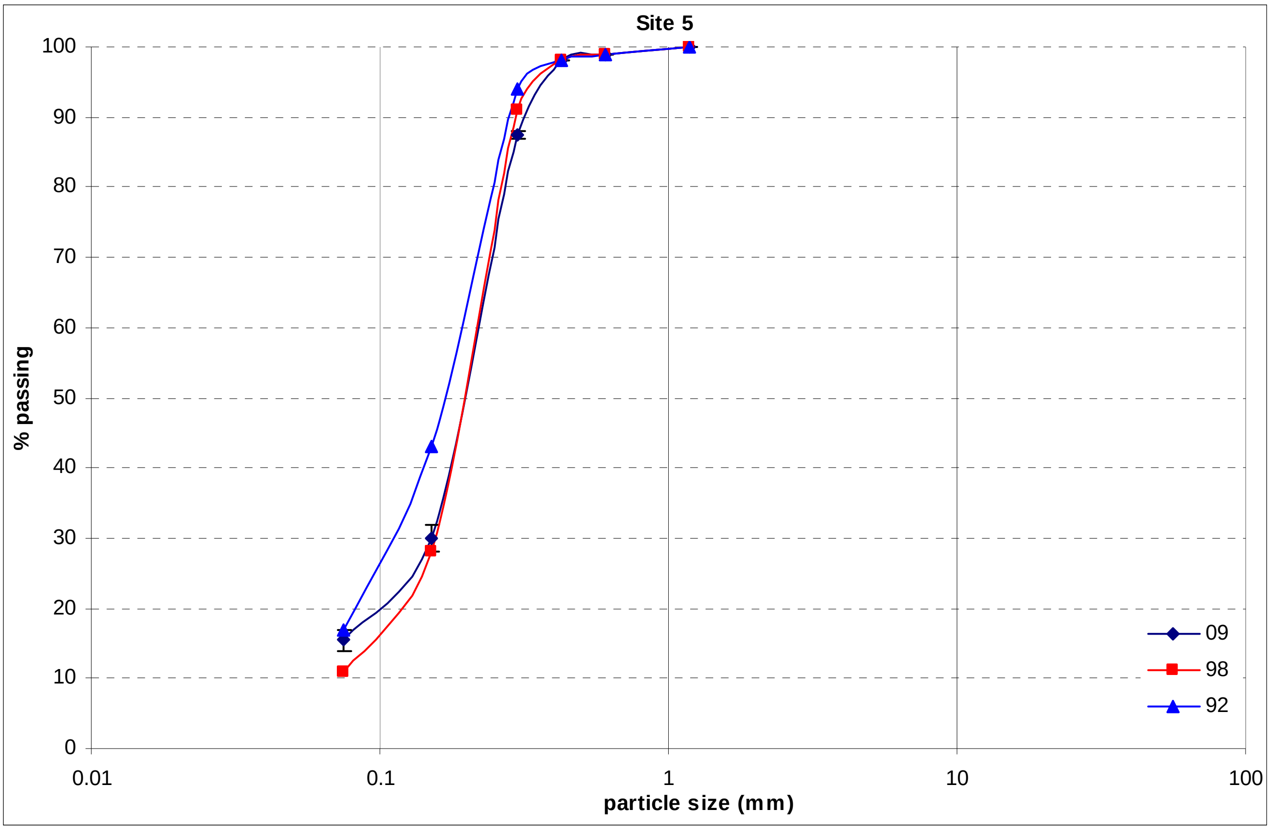
Authorised Signatory
J. Russell
Manager

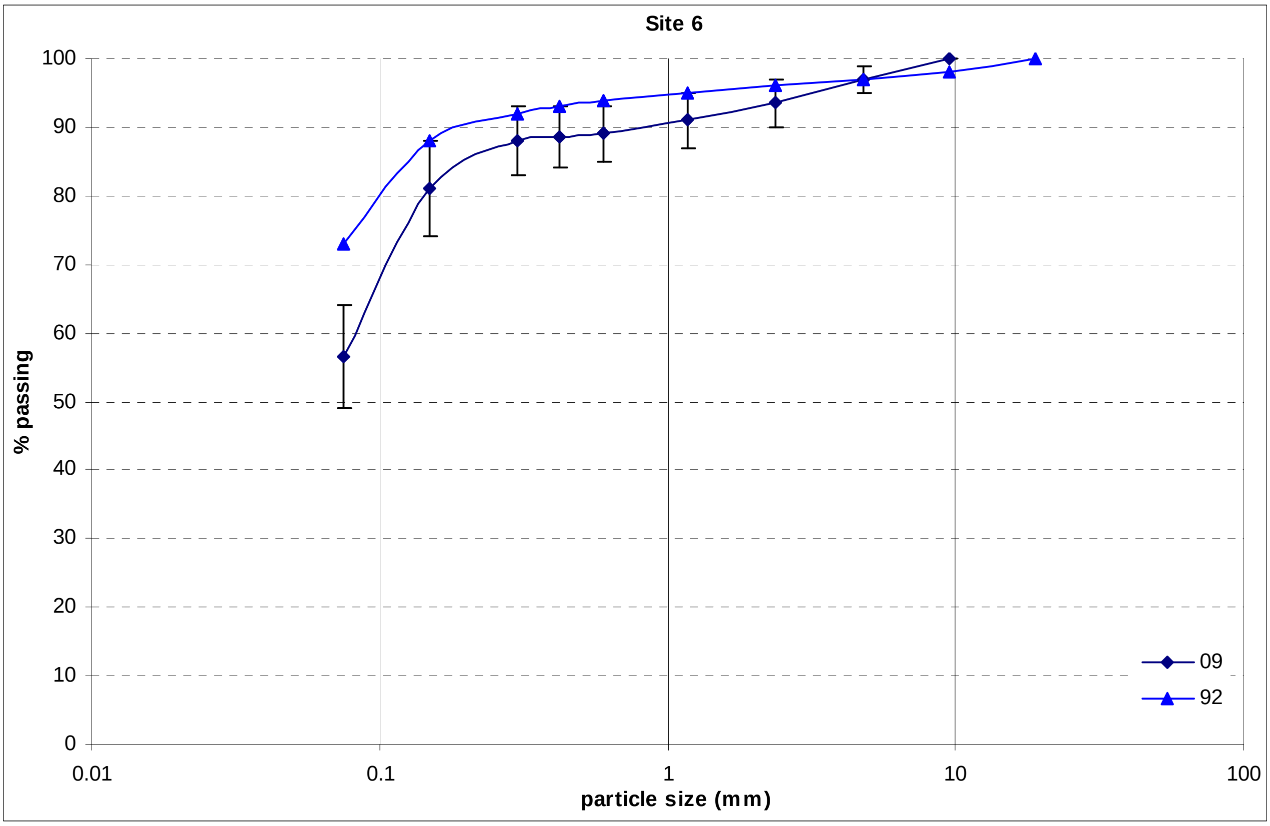
Form Number: GT005-/2

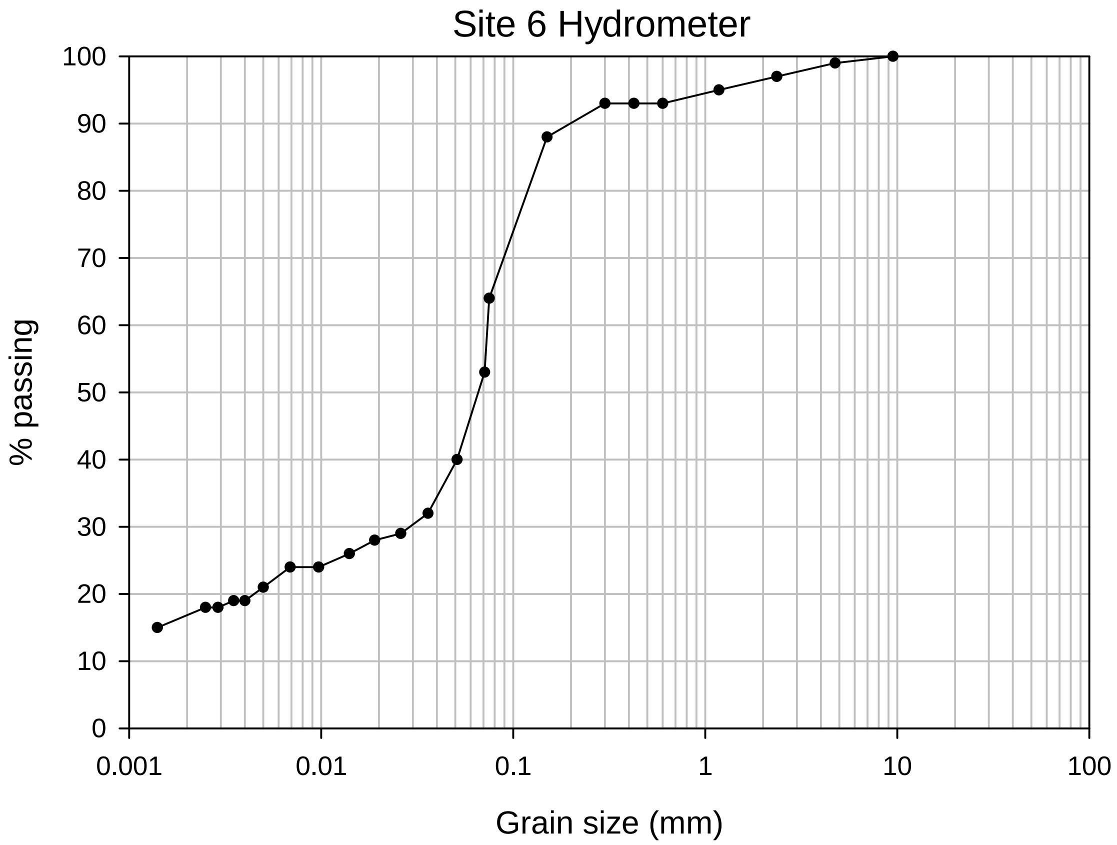
APPENDIX C: TEMPORAL PATTERNS IN PSD PROFILES

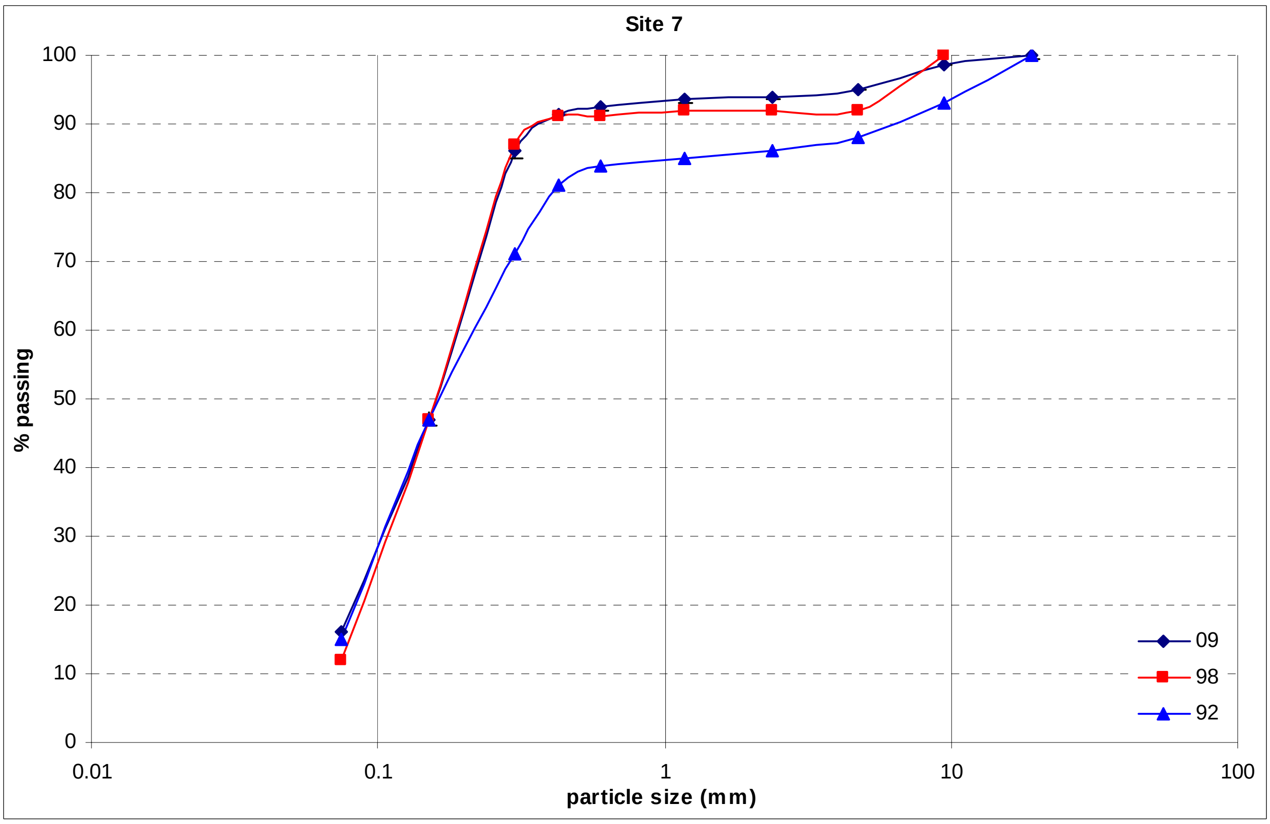


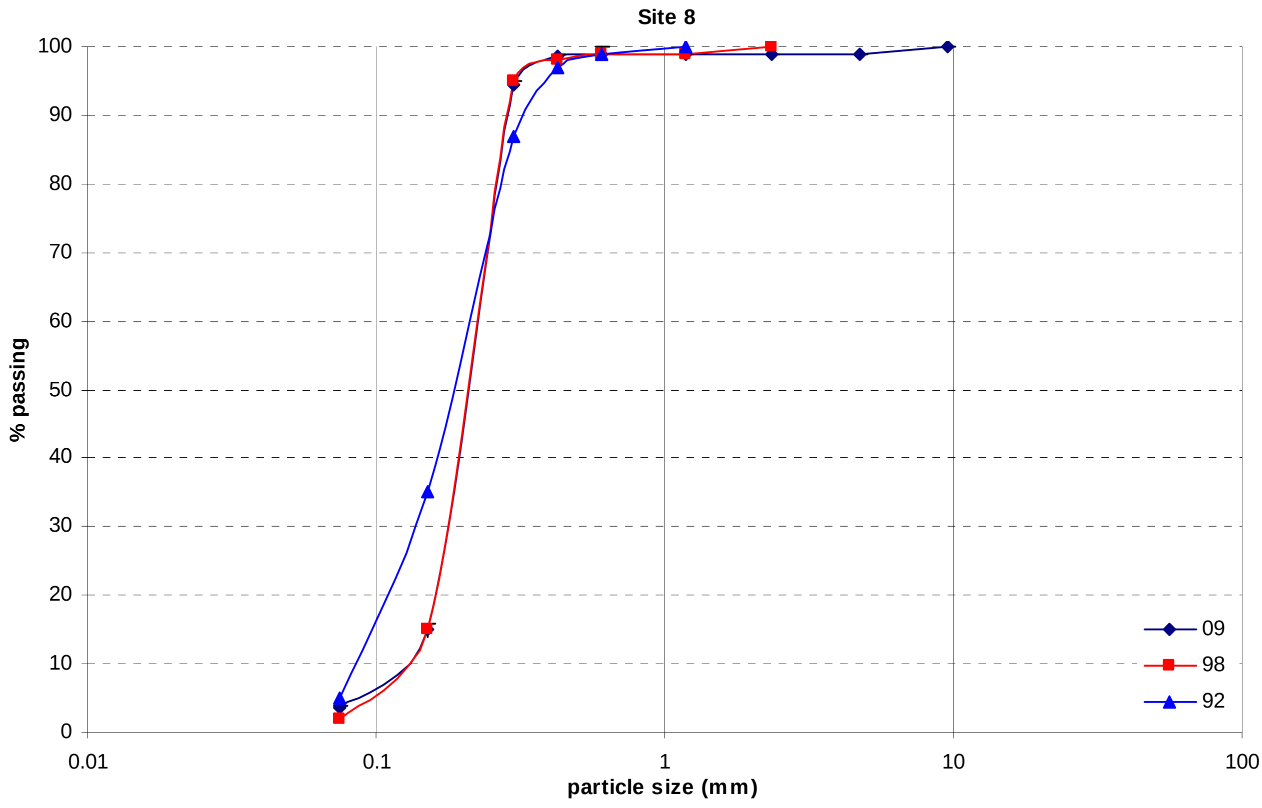


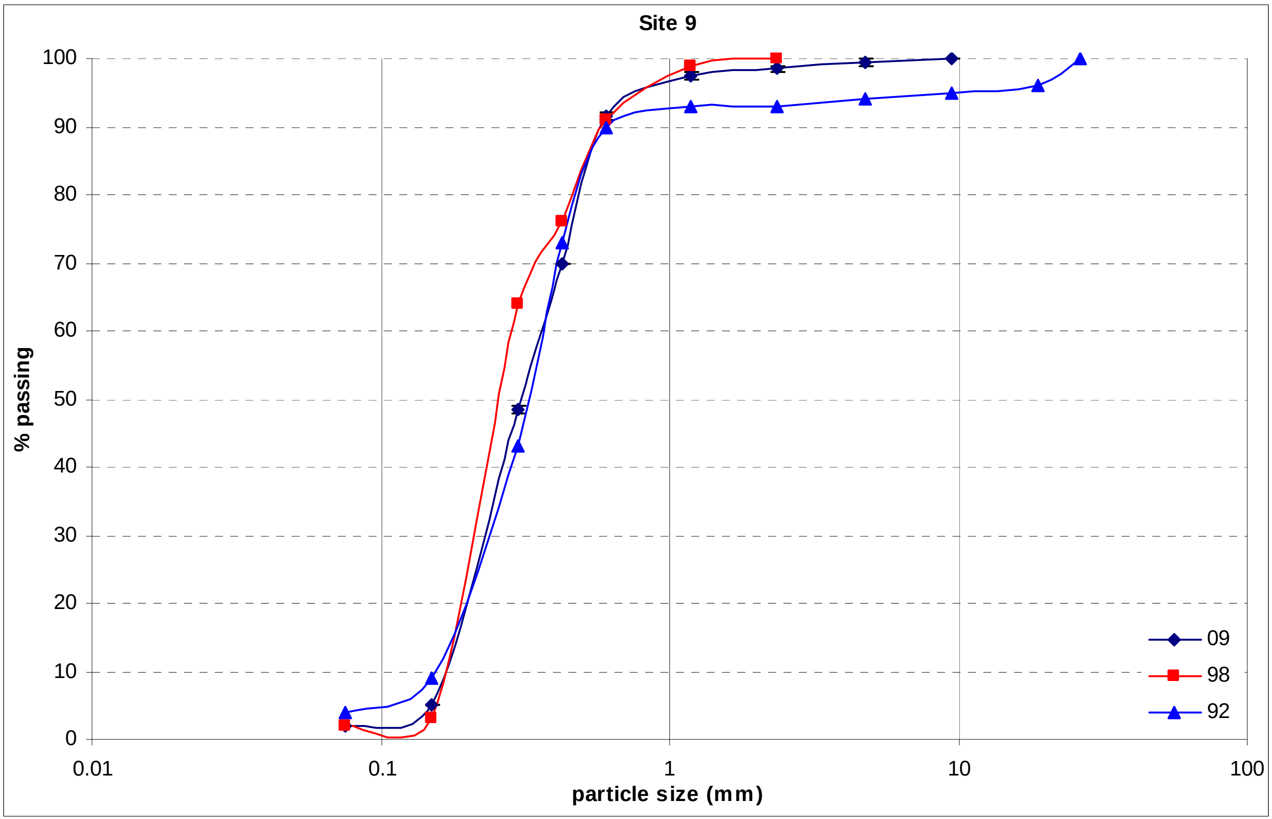

Site 5
100
90
80
70
60
50
40
30
20
10
0
% passing
0.01
0.1
1
10
100
particle size (mm)
09
98
92

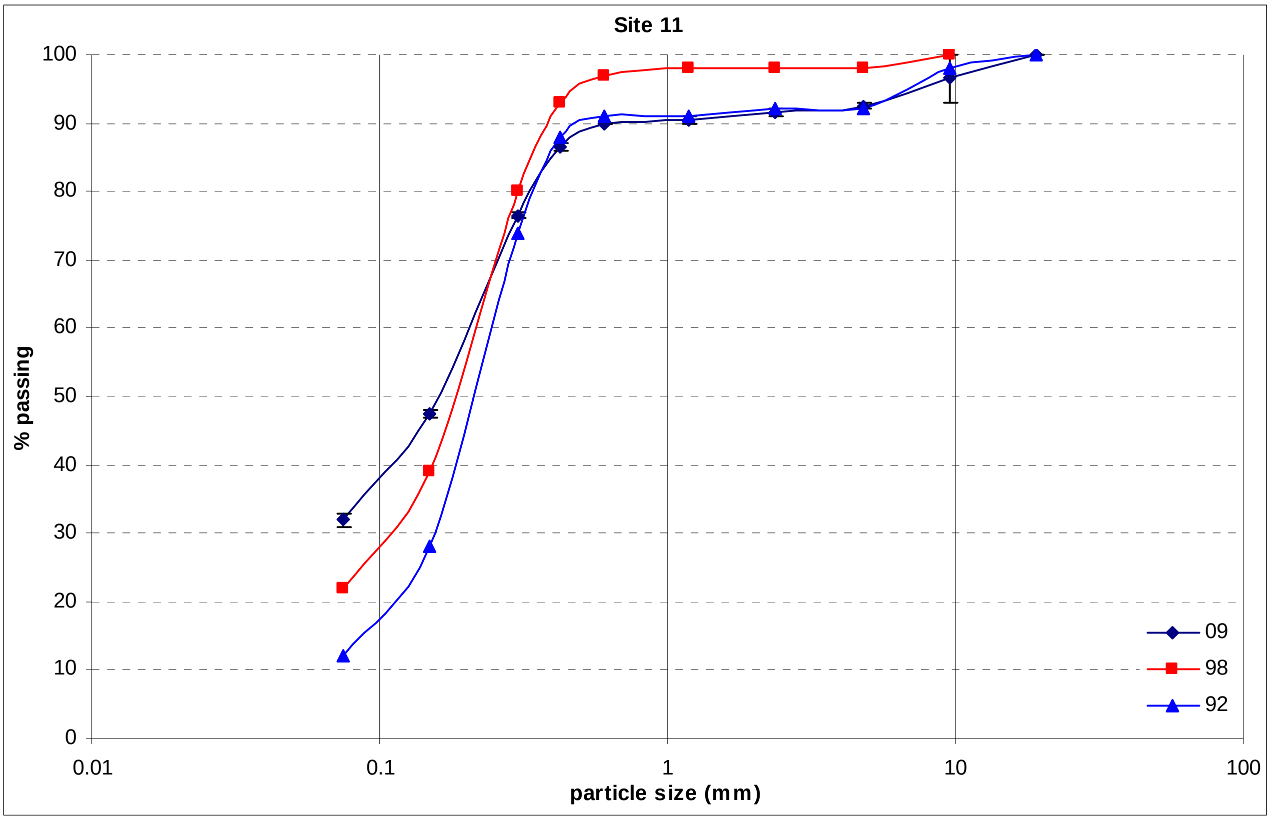

Site 6
100
90
80
70
60
50
40
30
20
10
0
% passing
0.01
0.1
1
10
100
particle size (mm)
09
92

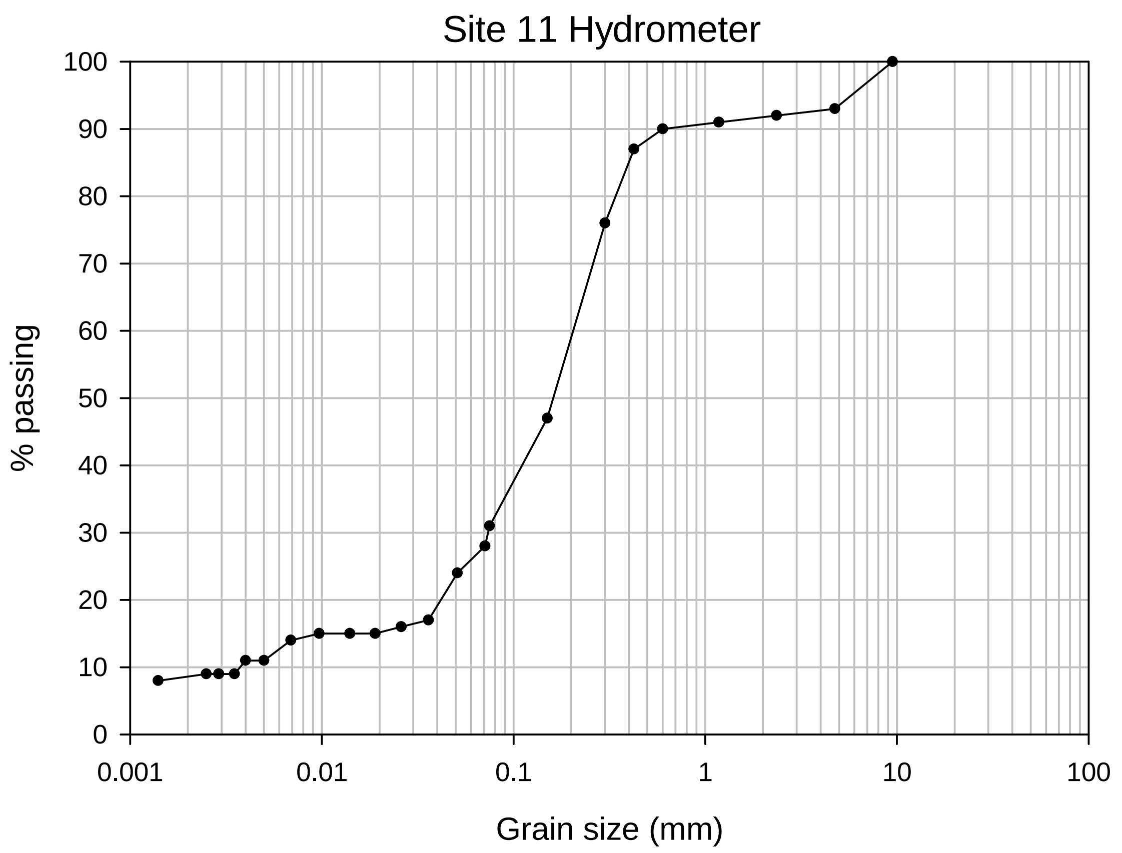

Site 6 Hydrometer
% passing
100
90
80
70
60
50
40
30
20
10
0
0.001
0.01
0.1
1
10
100
Grain size (mm)

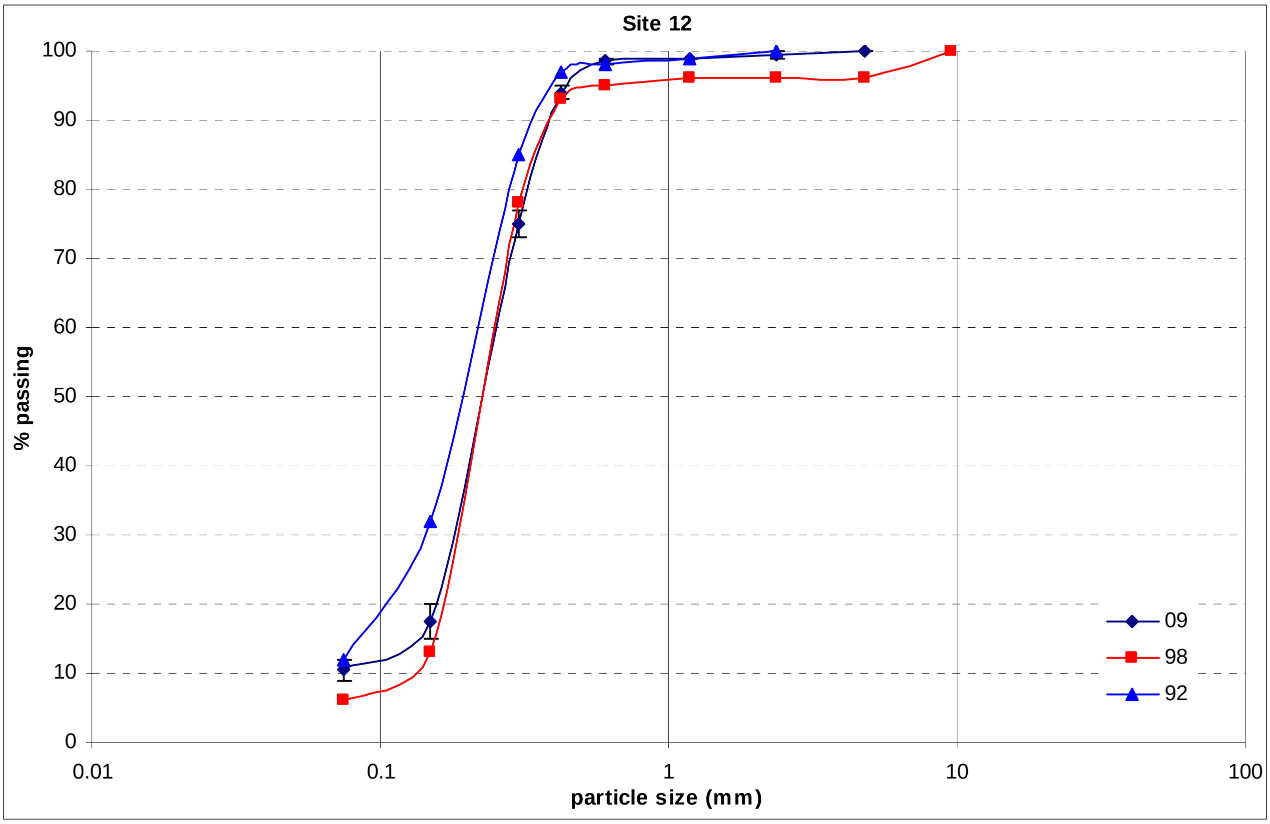

Site 7
% passing
100
90
80
70
60
50
40
30
20
10
0
0.01
0.1
1
10
100
particle size (mm)
09
98
92

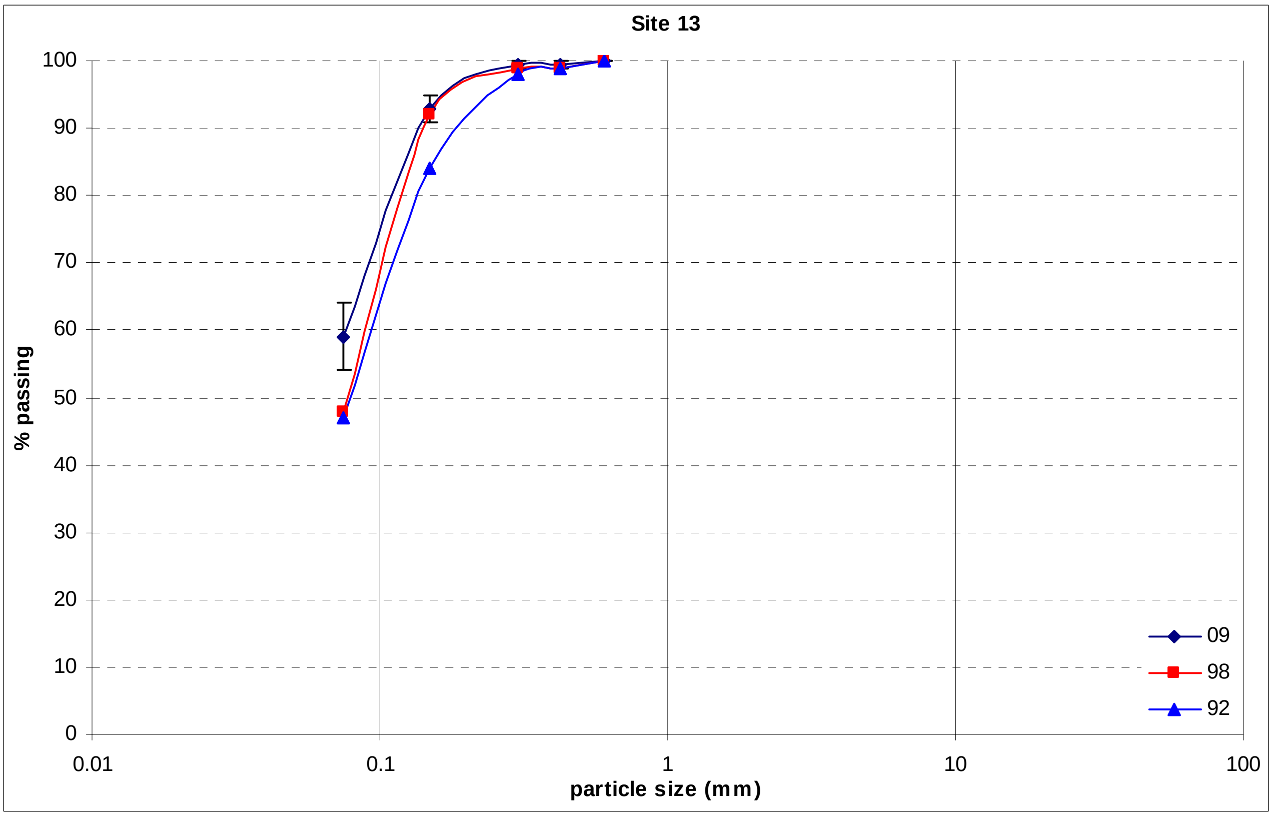

Site 8
% passing
100
90
80
70
60
50
40
30
20
10
0
0.01
0.1
1
10
100
particle size (mm)
09
98
92

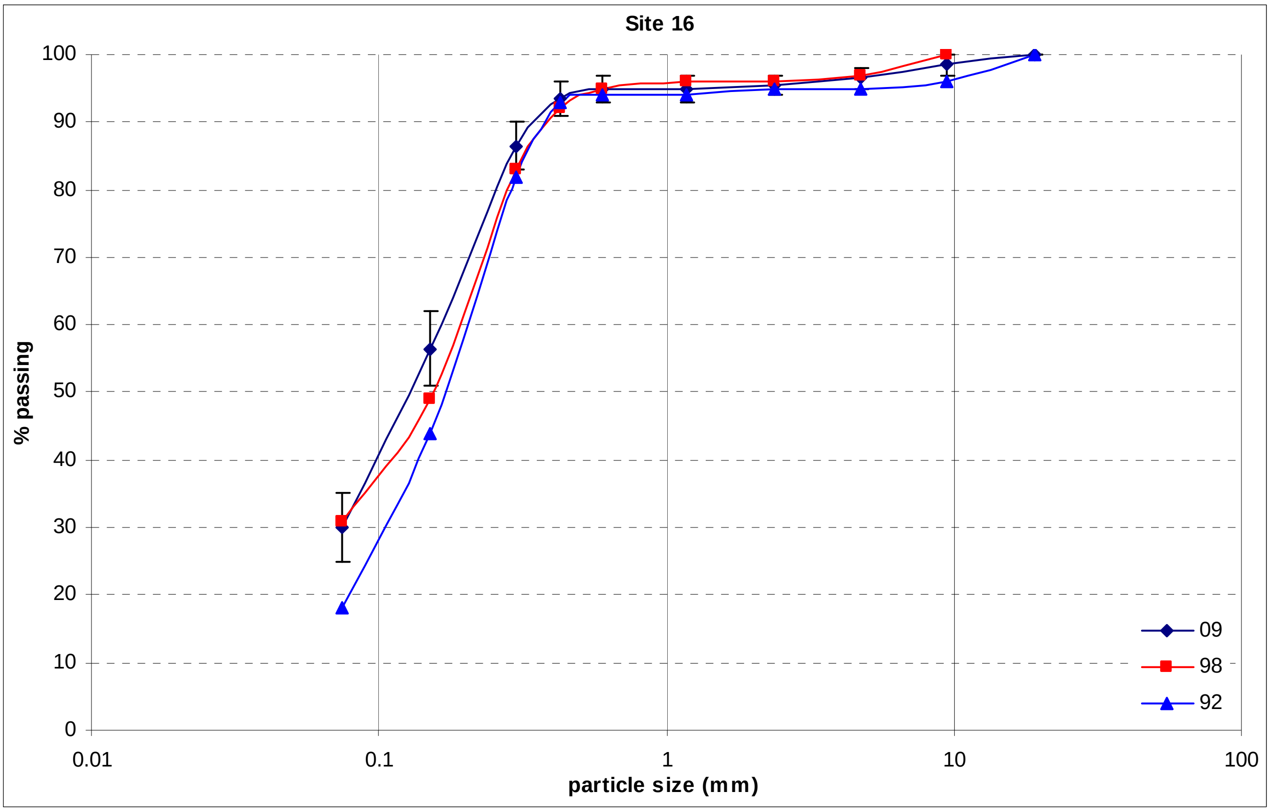

Site 9
% passing
100
90
80
70
60
50
40
30
20
10
0
0.01
0.1
1
10
100
particle size (mm)
09
98
92

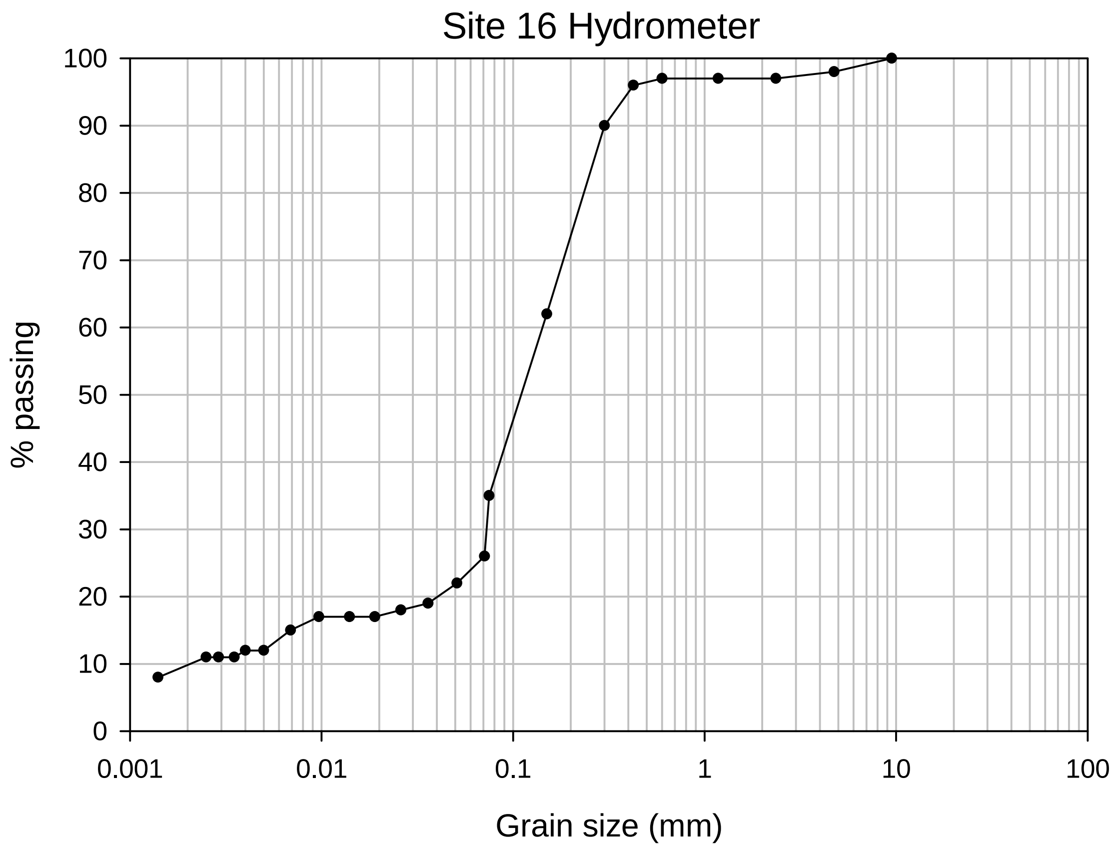

Site 11
100
90
80
70
60
50
40
30
20
10
0
% passing
0.01
0.1
1
10
100
particle size (mm)
09
98
92

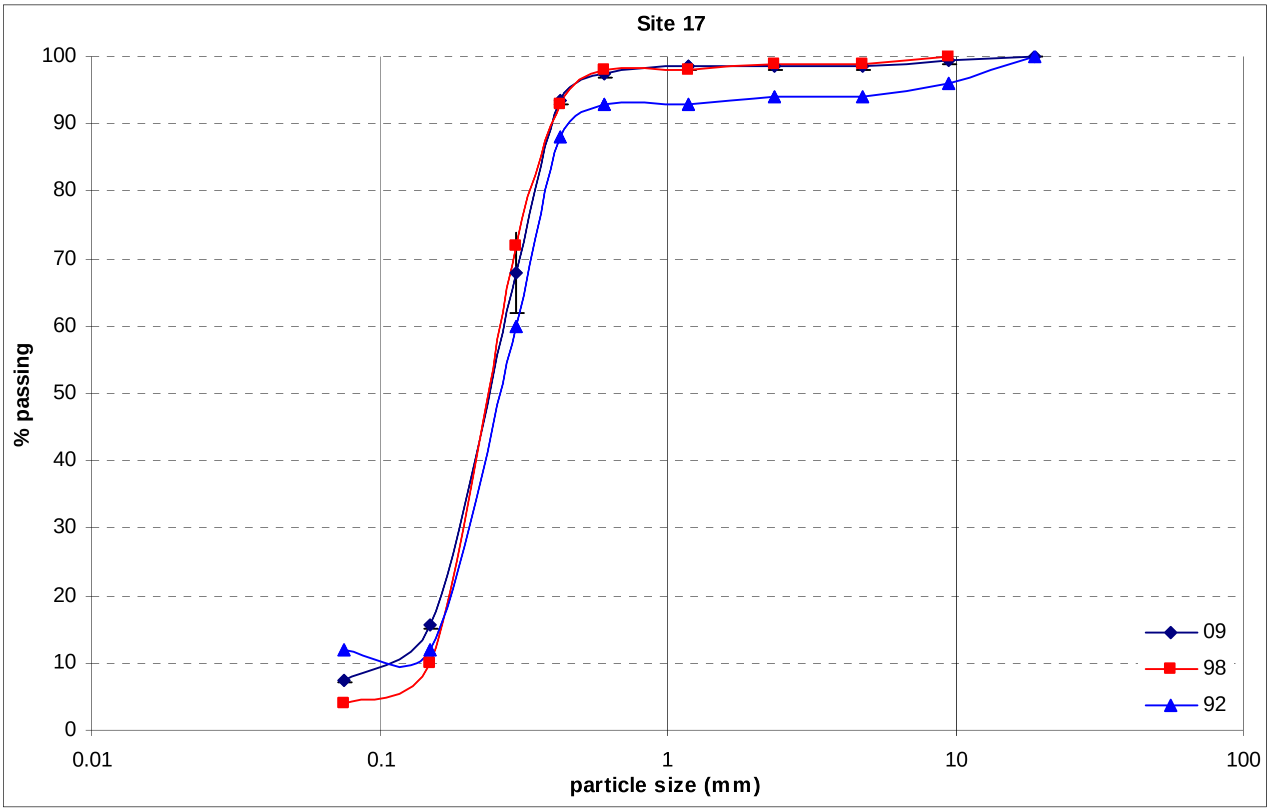

Site 11 Hydrometer
100
90
80
70
60
50
40
30
20
10
0
% passing
0.001
0.01
0.1
1
10
100
Grain size (mm)

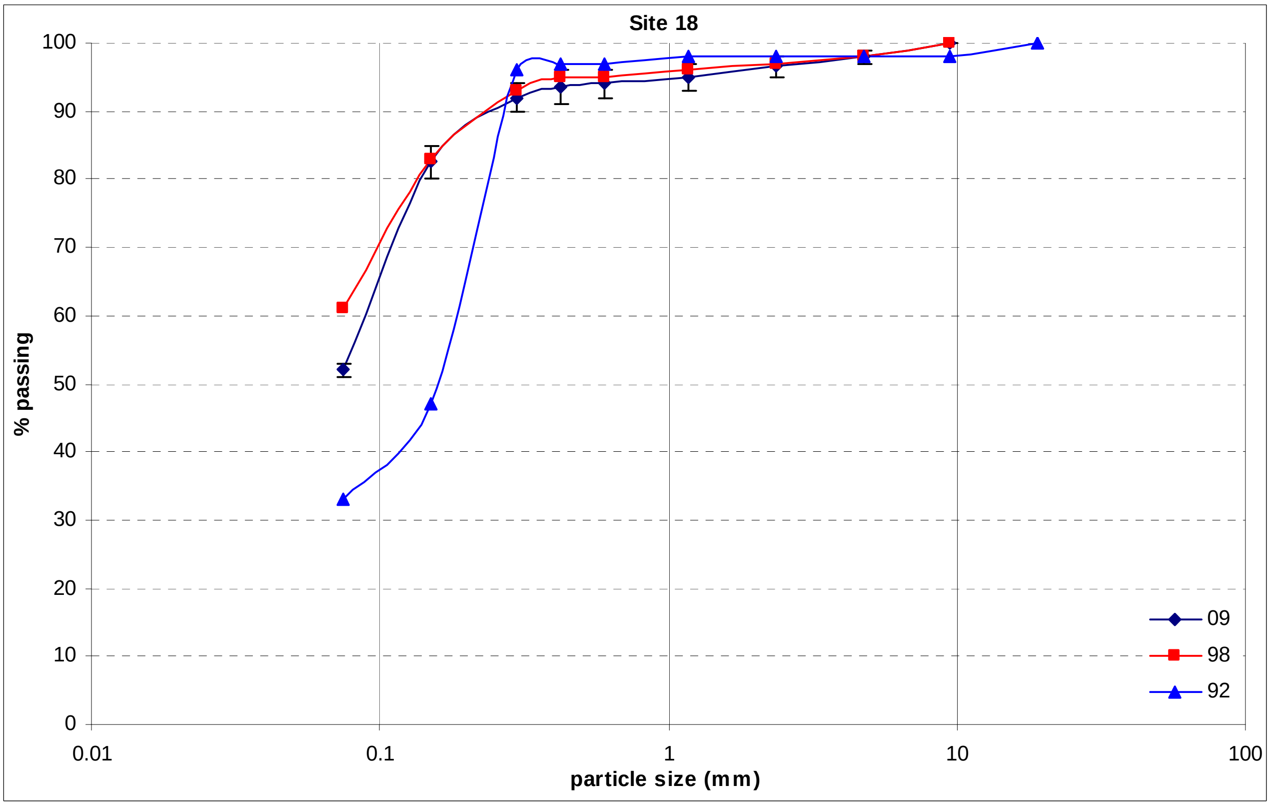

Site 12
100
90
80
70
60
50
40
30
20
10
0
% passing
0.01
0.1
1
10
100
particle size (mm)
09
98
92


Site 13
100
90
80
70
60
50
40
30
20
10
0
% passing
0.01
0.1
1
10
100
particle size (mm)
09
98
92

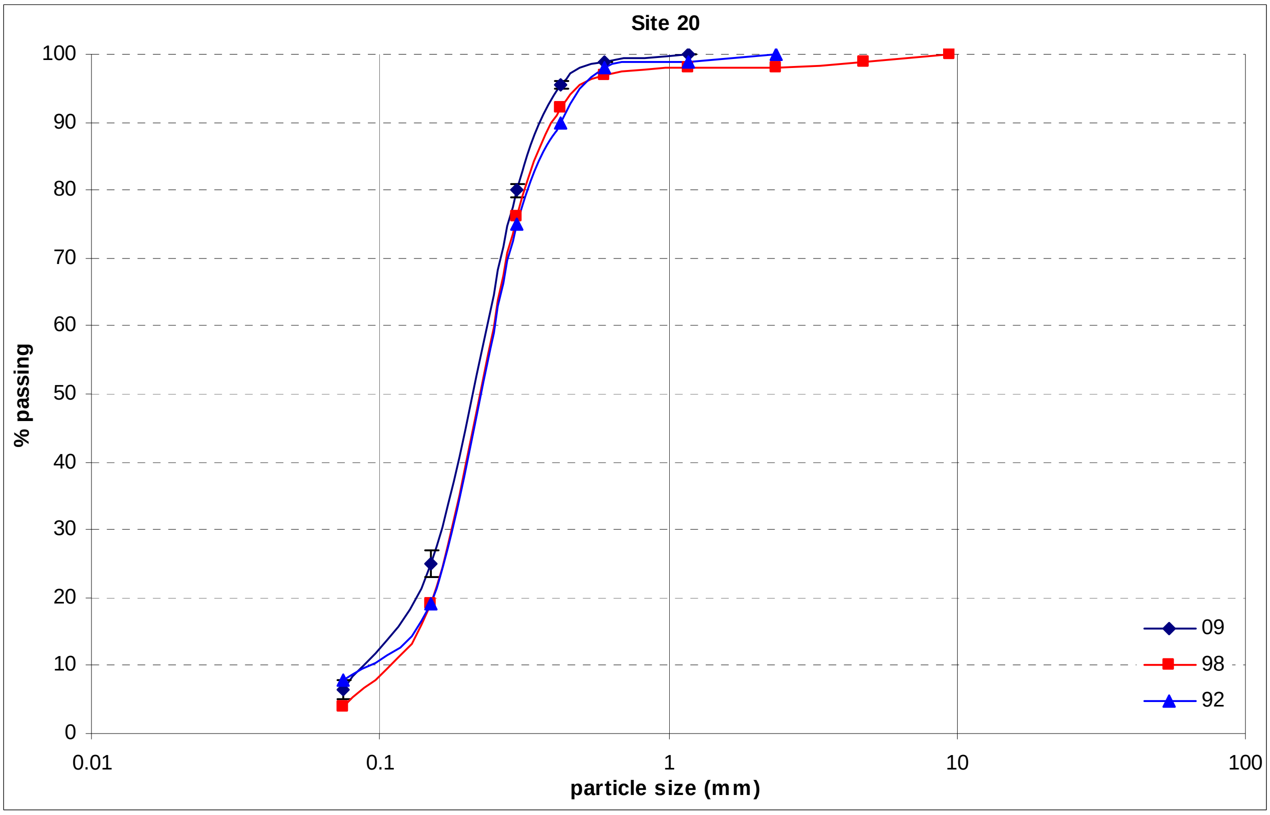

Site 16
% passing
100
90
80
70
60
50
40
30
20
10
0
0.01
0.1
1
10
100
particle size (mm)
09
98
92

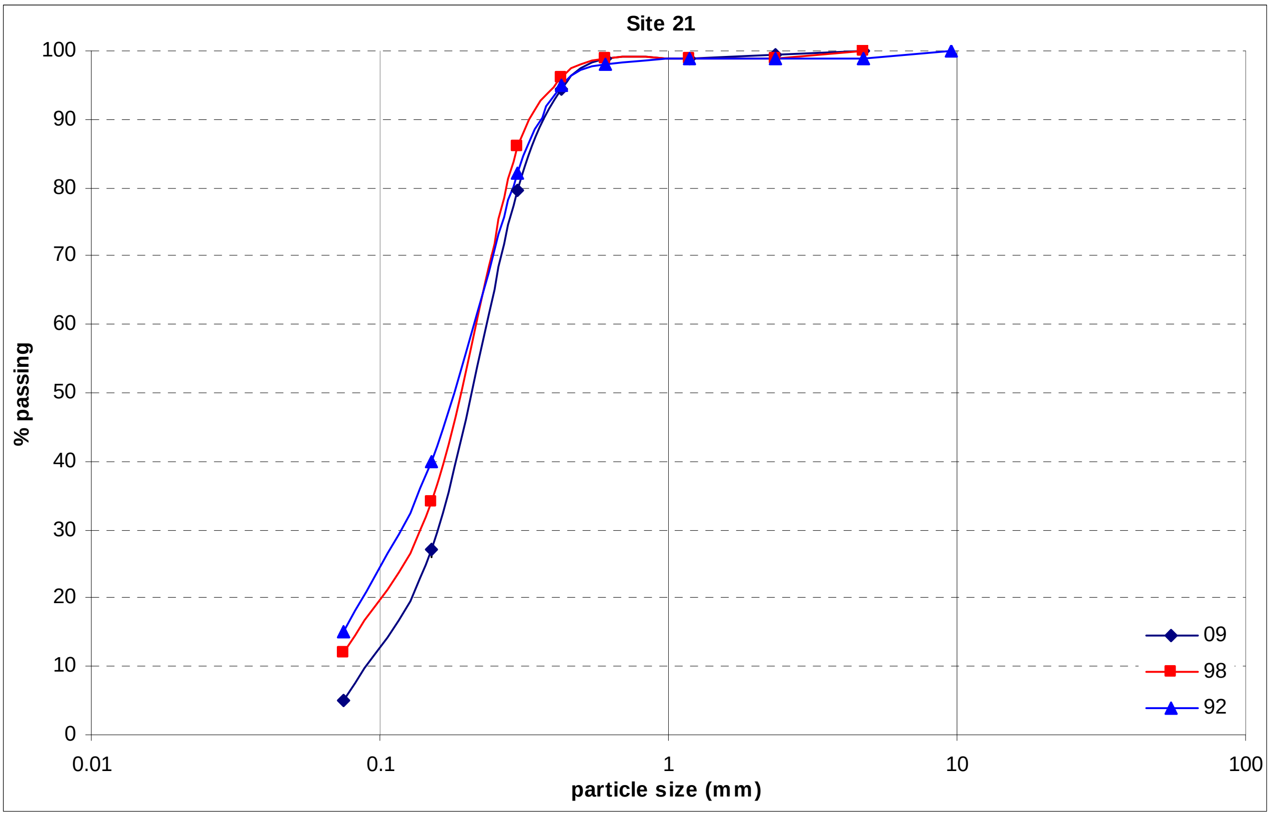

Site 16 Hydrometer
% passing
100
90
80
70
60
50
40
30
20
10
0
0.001
0.01
0.1
1
10
100
Grain size (mm)

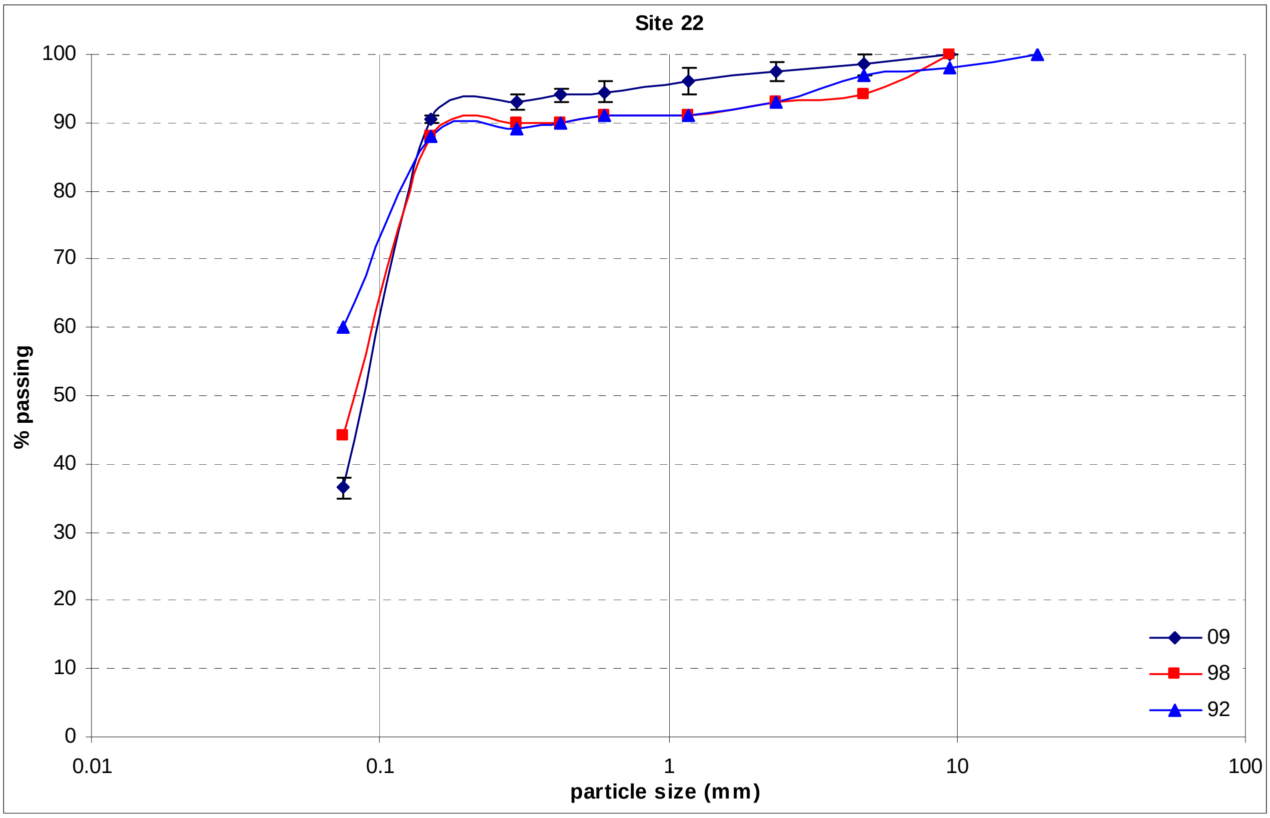

Site 17
% passing
100
90
80
70
60
50
40
30
20
10
0
0.01
0.1
1
10
100
particle size (mm)
09
98
92

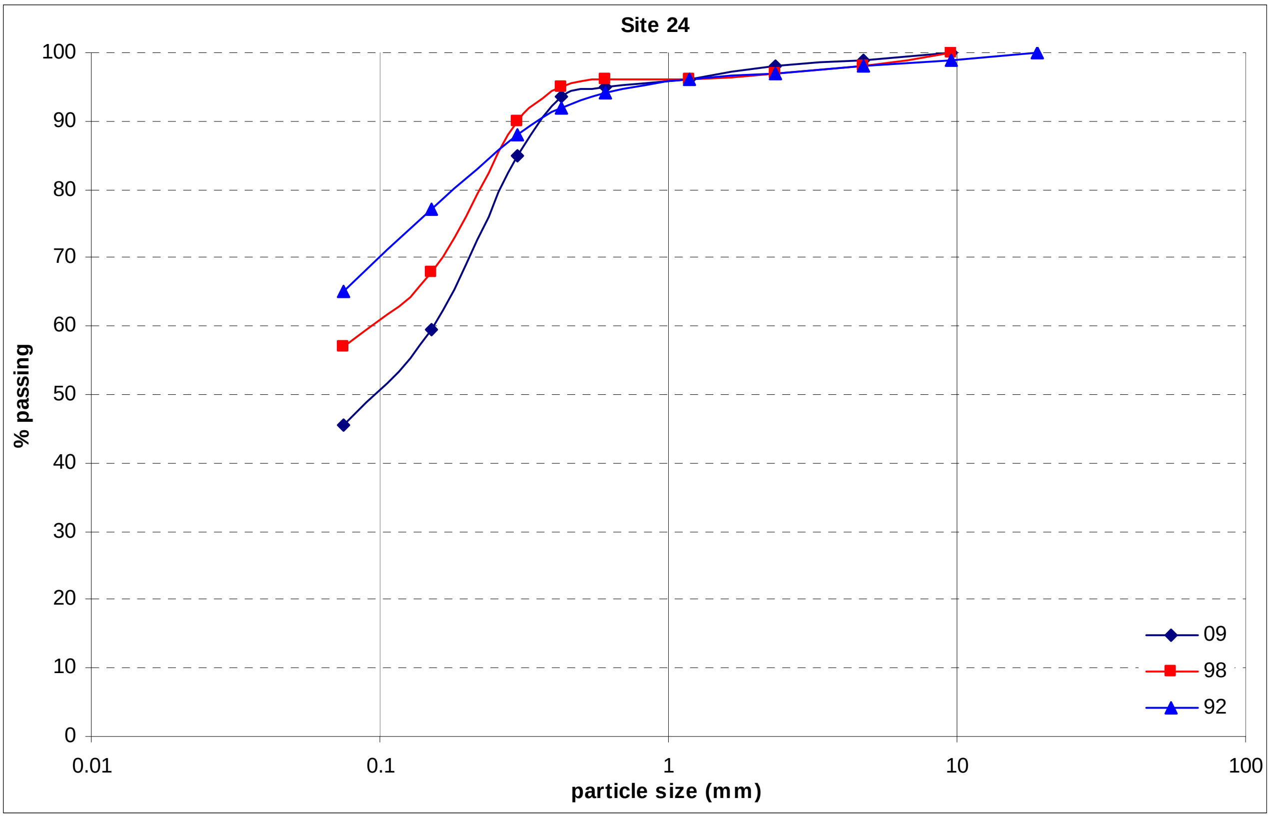

Site 18
% passing
100
90
80
70
60
50
40
30
20
10
0
0.01
0.1
1
10
100
particle size (mm)
09
98
92

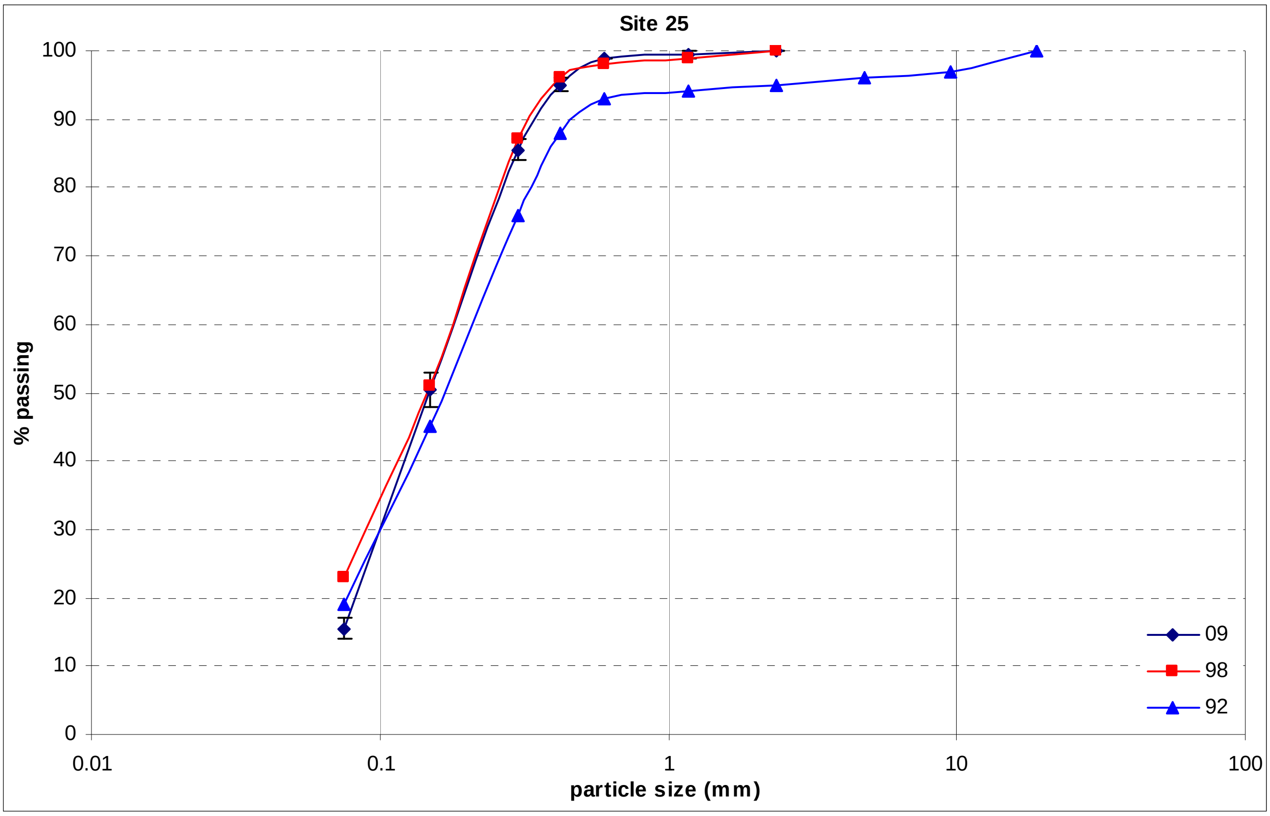
BMT WBM


Site 20
100
90
80
70
60
50
40
30
20
10
0
% passing
0.01
0.1
1
10
100
particle size (mm)
09
98
92

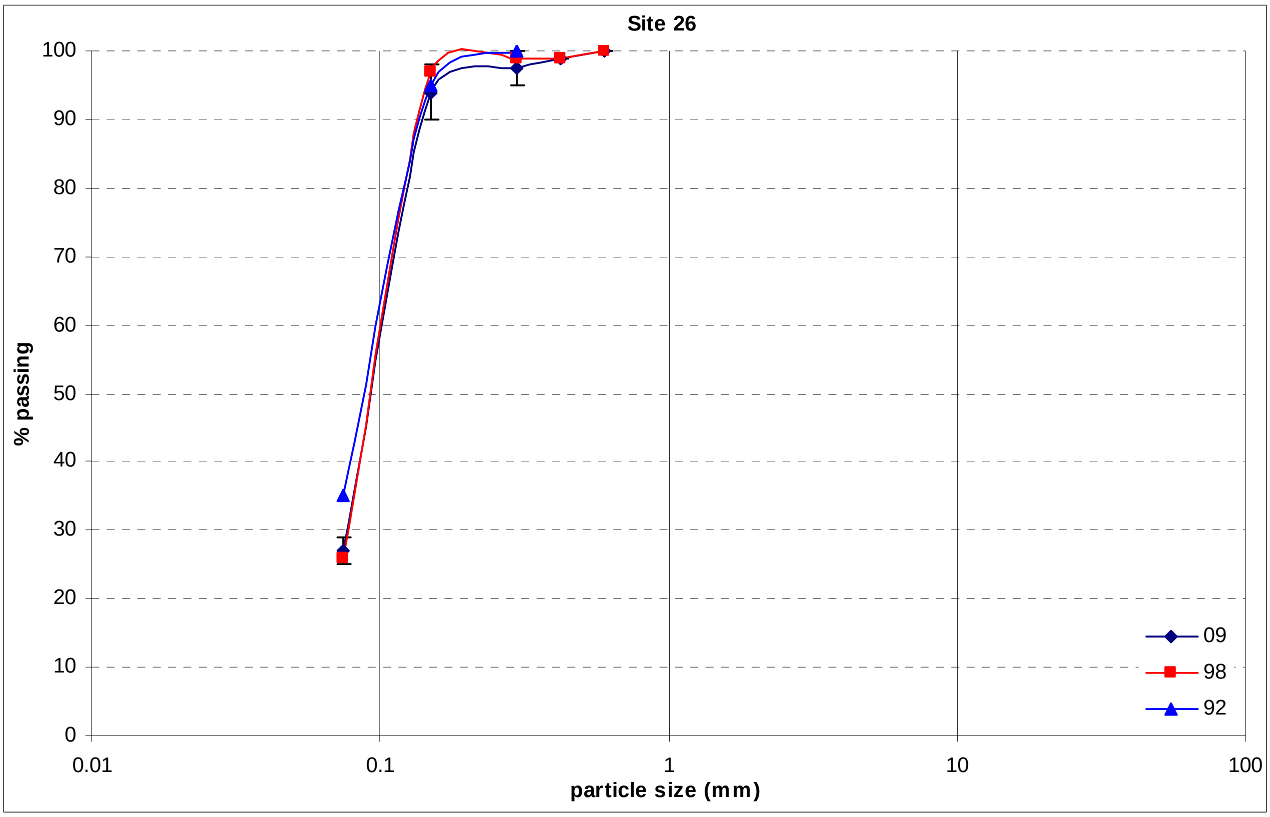

Site 21
100
90
80
70
60
50
40
30
20
10
0
% passing
0.01
0.1
1
10
100
particle size (mm)
09
98
92


Site 22
100
90
80
70
60
50
40
30
20
10
0
% passing
0.01
0.1
1
10
100
particle size (mm)
09
98
92

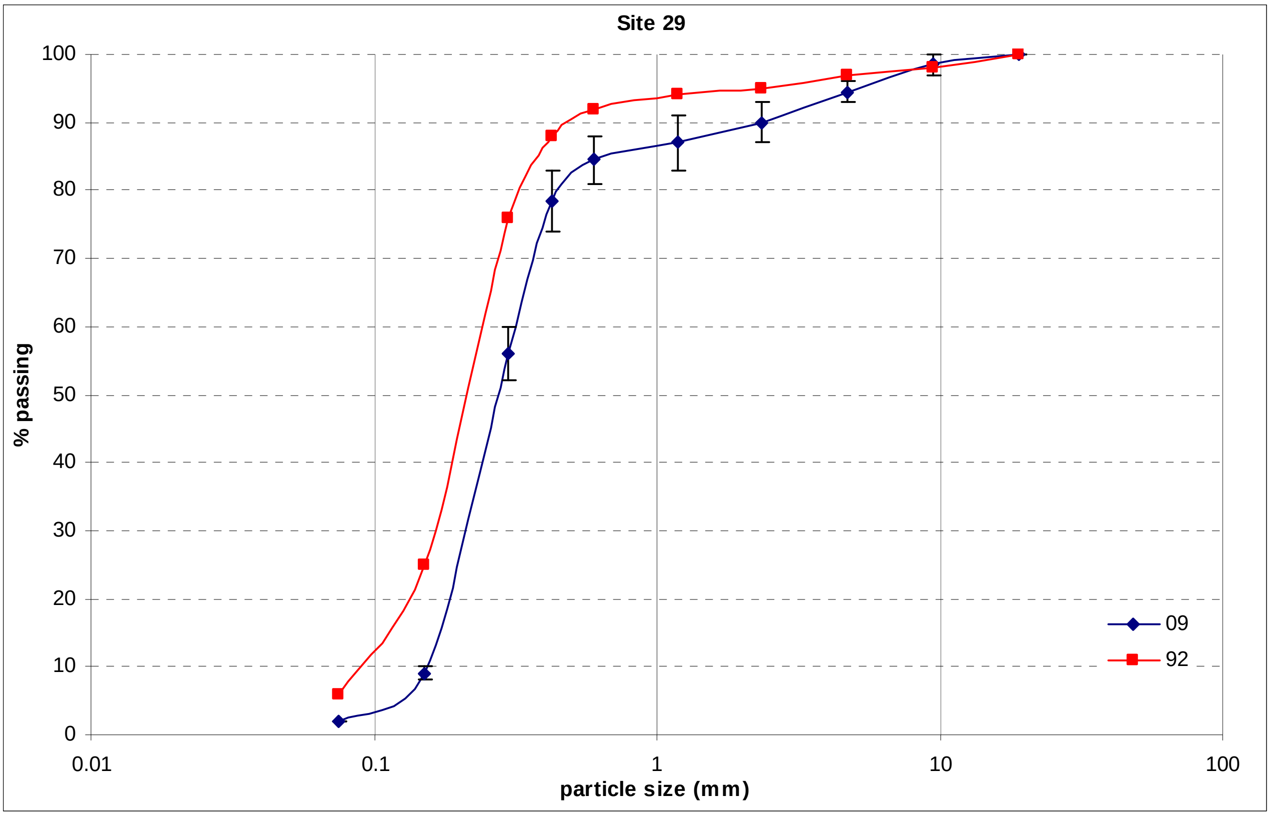

Site 24
100
90
80
70
60
50
40
30
20
10
0
% passing
0.01
0.1
1
10
100
particle size (mm)
09
98
92

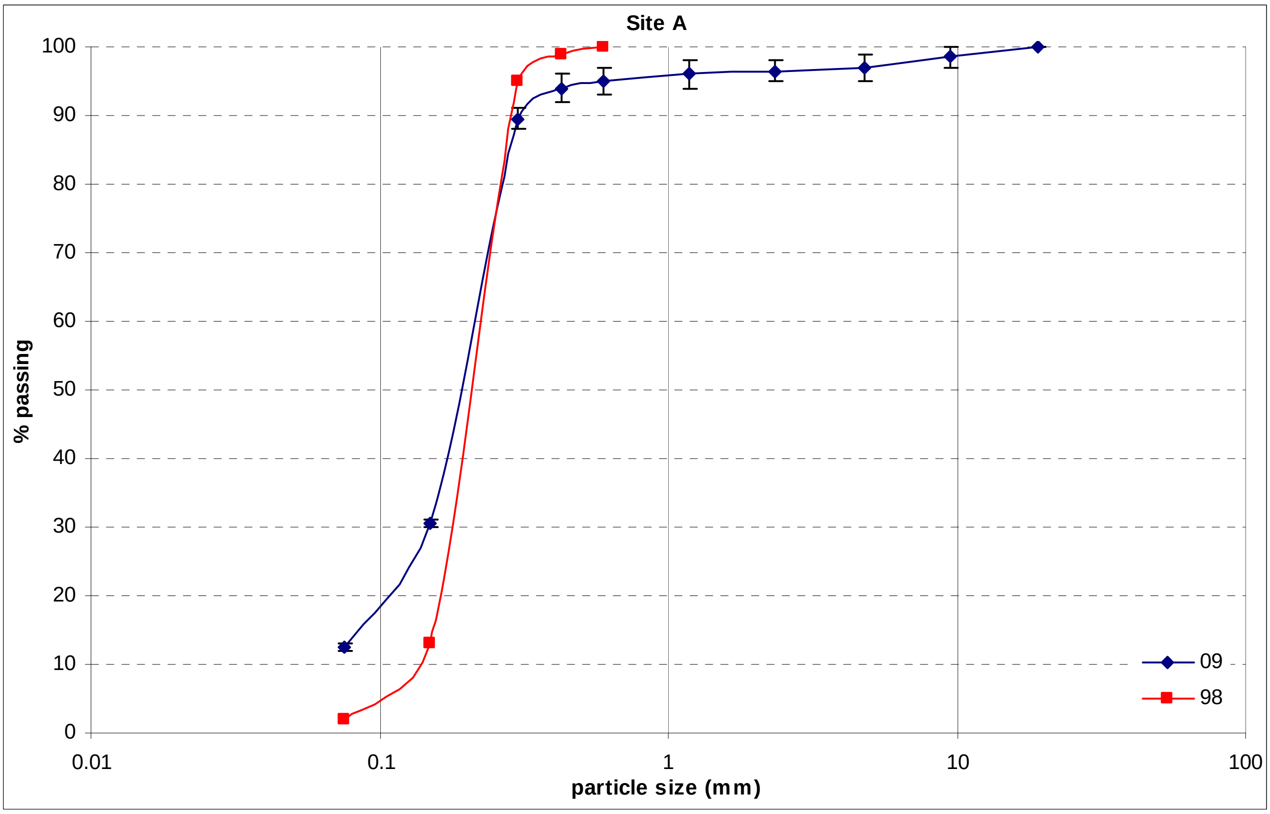


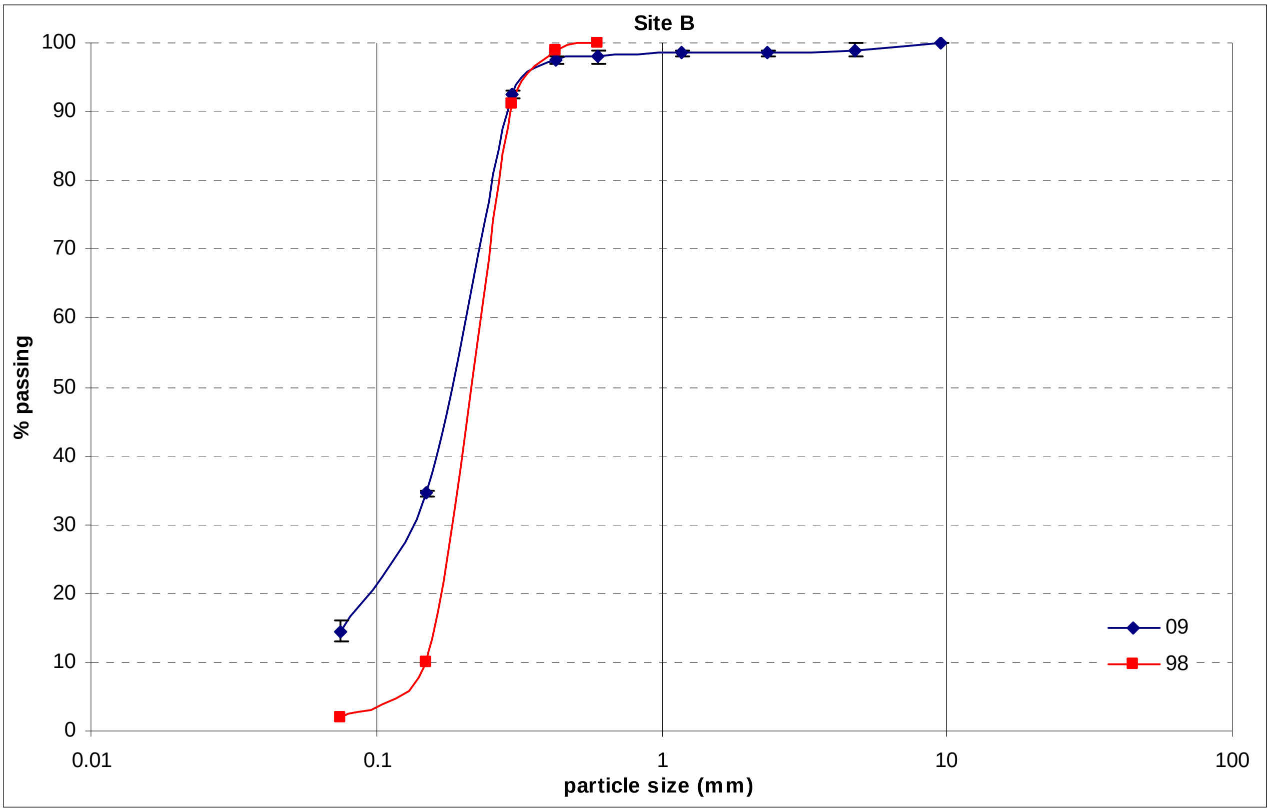
Site 25
% passing
100
90
80
70
60
50
40
30
20
10
0
0.01
0.1
1
10
100
particle size (mm)
09
98
92

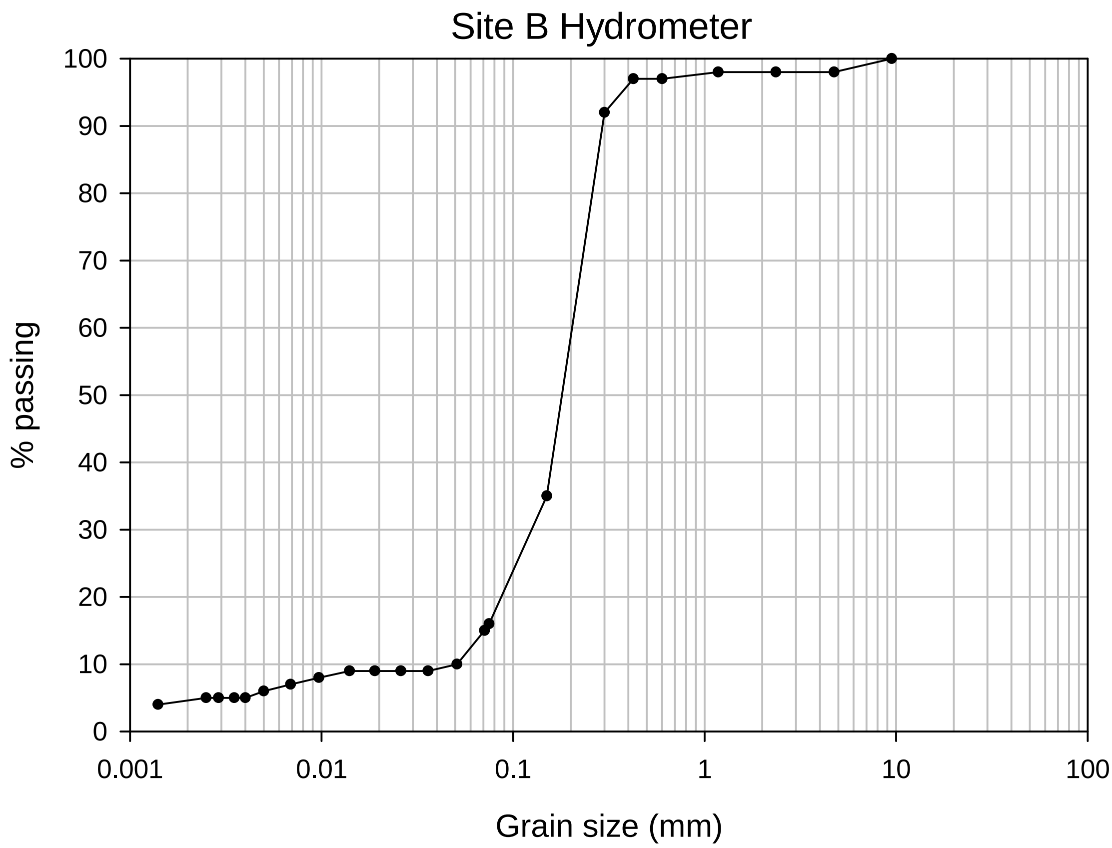


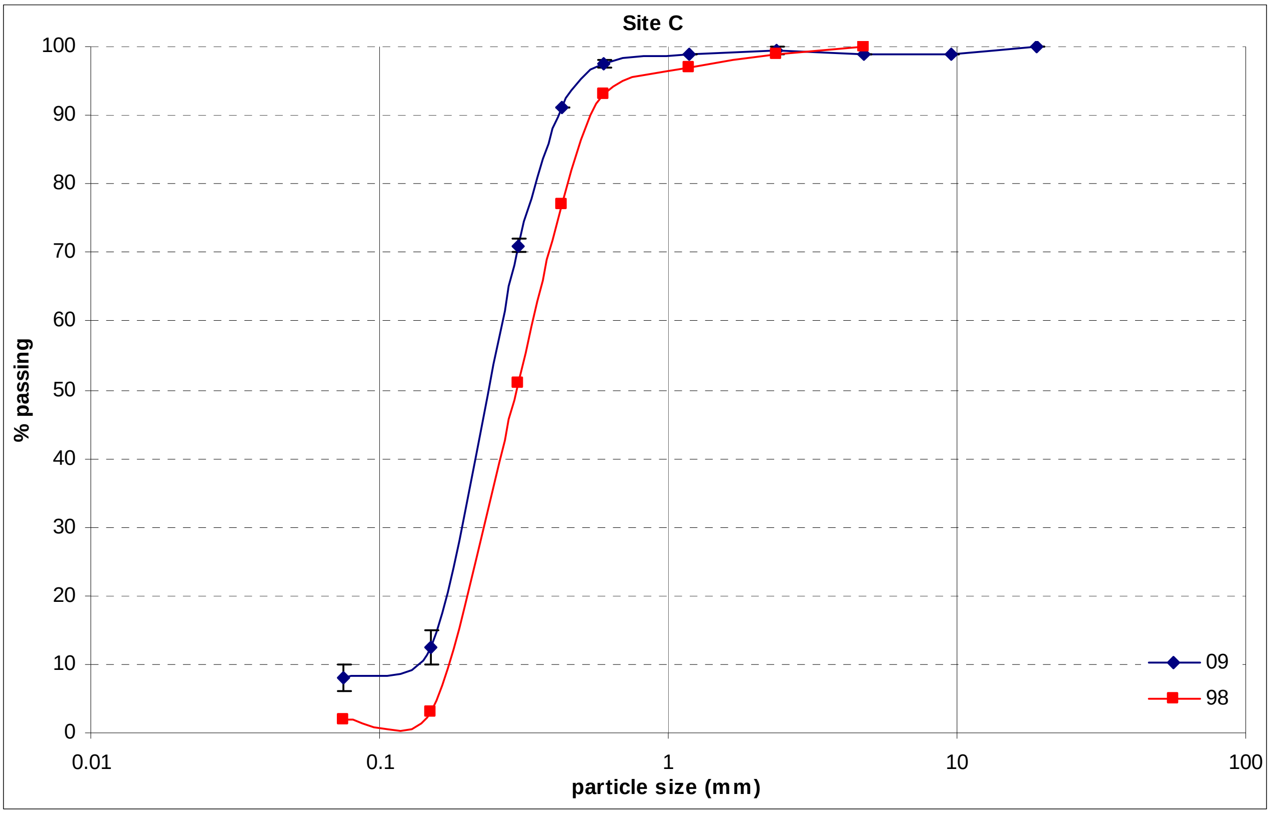
Site 26
% passing
100
90
80
70
60
50
40
30
20
10
0
0.01
0.1
1
10
100
particle size (mm)
09
98
92

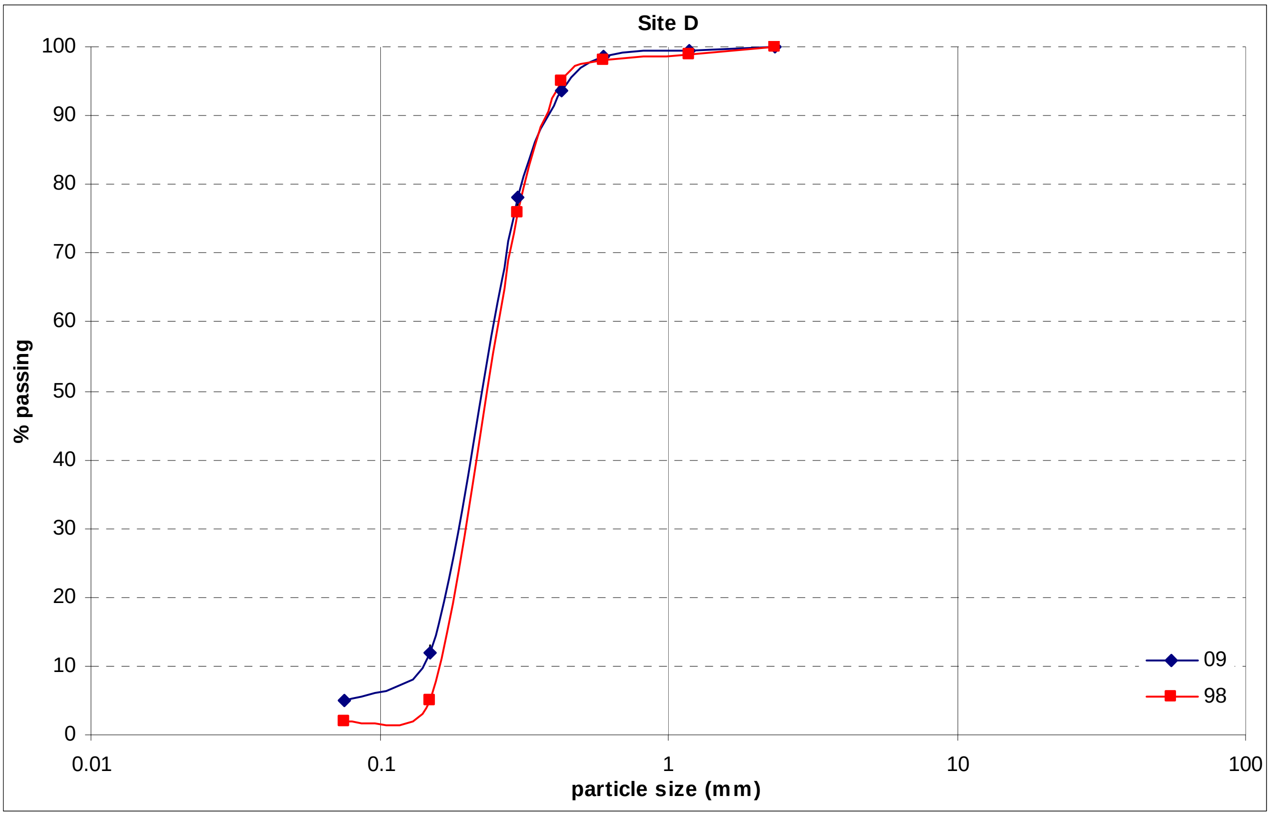

Site 29
100
90
80
70
60
50
40
30
20
10
0
% passing
0.01
0.1
1
10
100
particle size (mm)
09
92

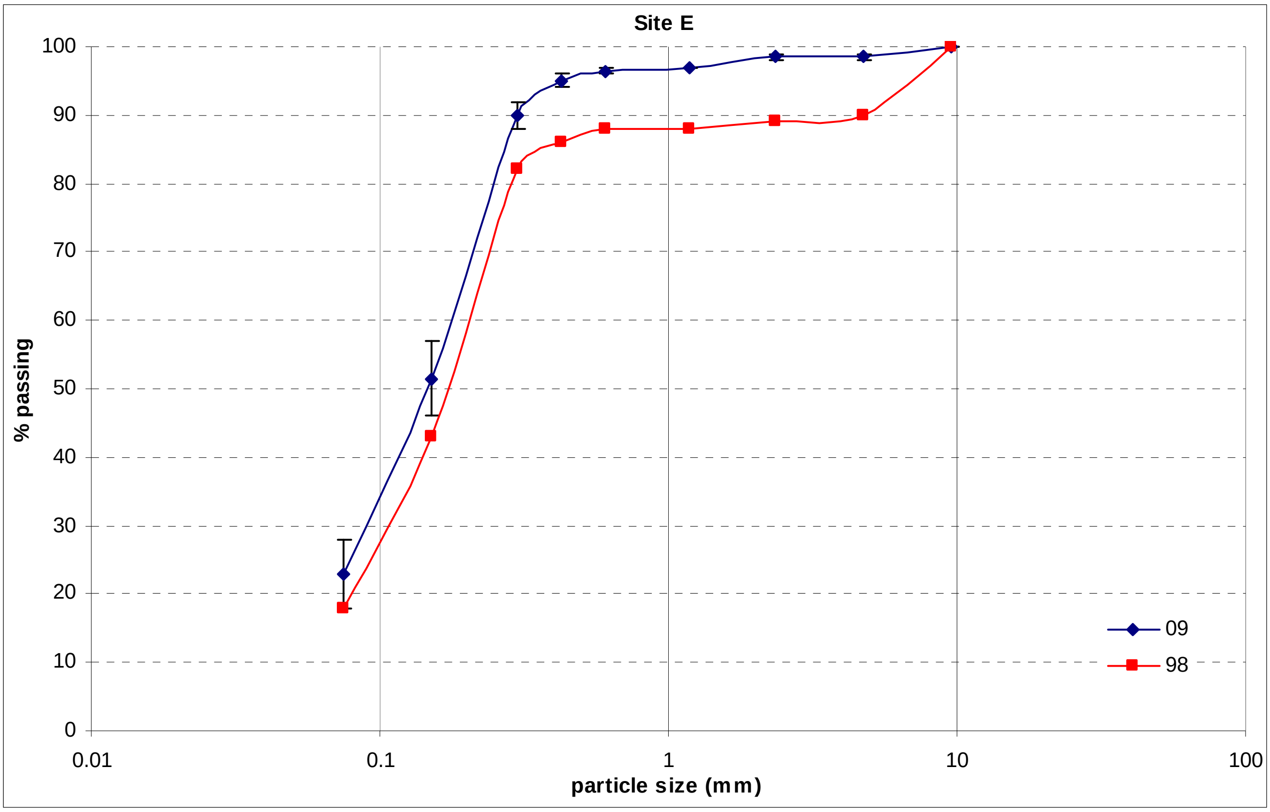

Site A
100
90
80
70
60
50
40
30
20
10
0
% passing
0.01
0.1
1
10
100
particle size (mm)
09
98

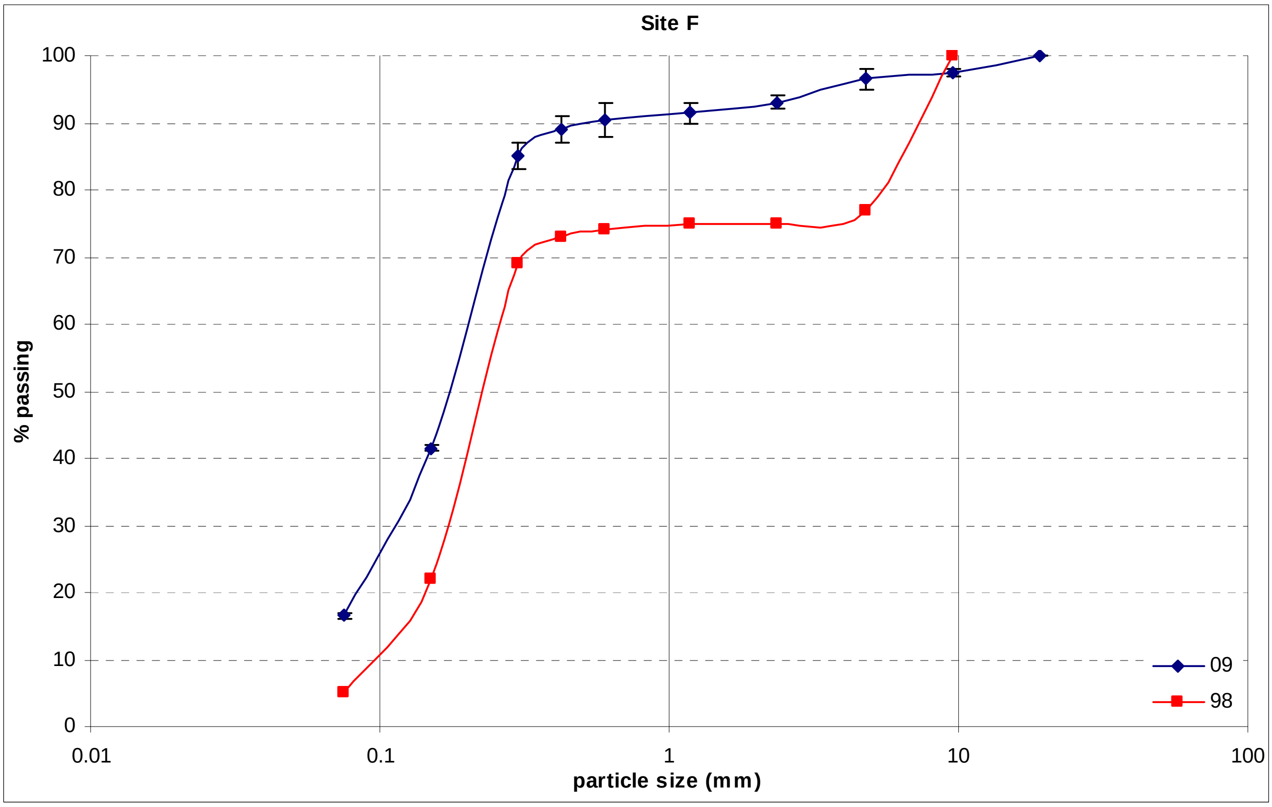

Site B
% passing
100
90
80
70
60
50
40
30
20
10
0
0.01
0.1
1
10
100
particle size (mm)
09
98

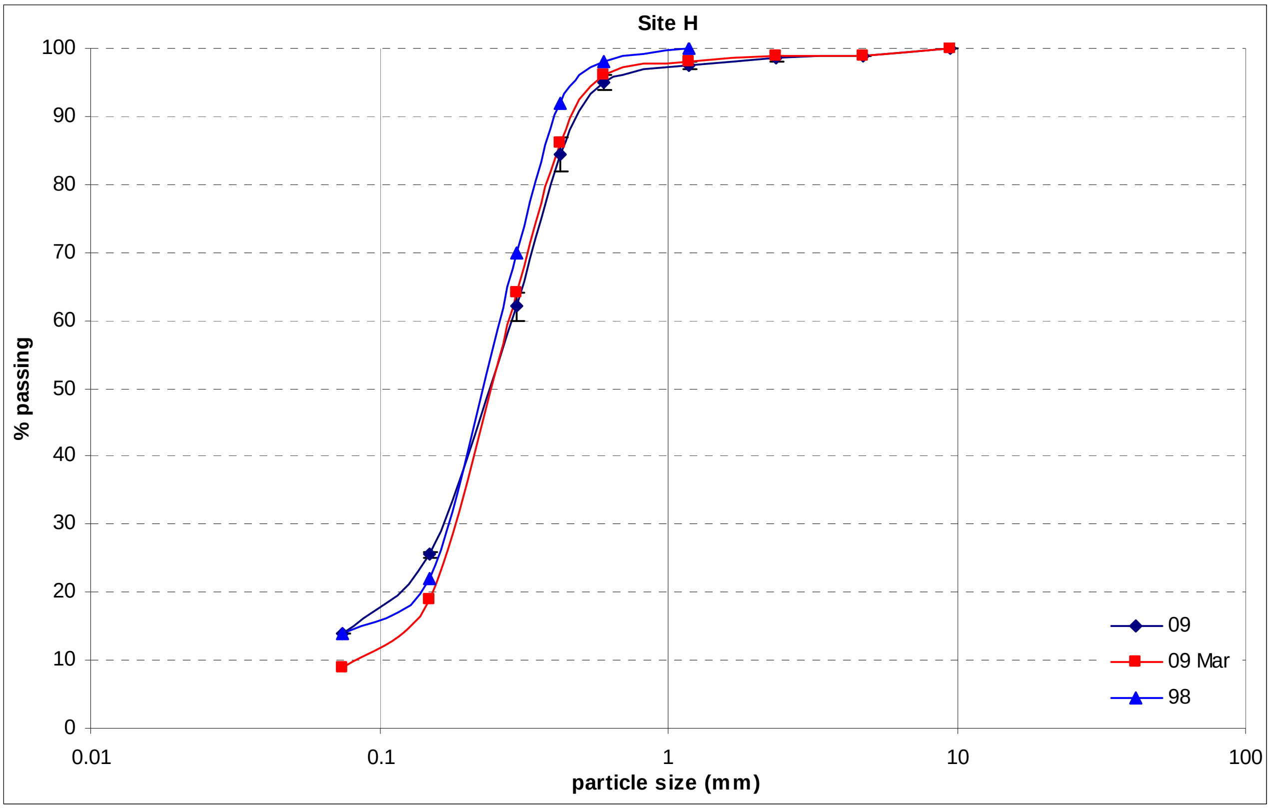

Site B Hydrometer
% passing
100
90
80
70
60
50
40
30
20
10
0
0.001
0.01
0.1
1
10
100
Grain size (mm)

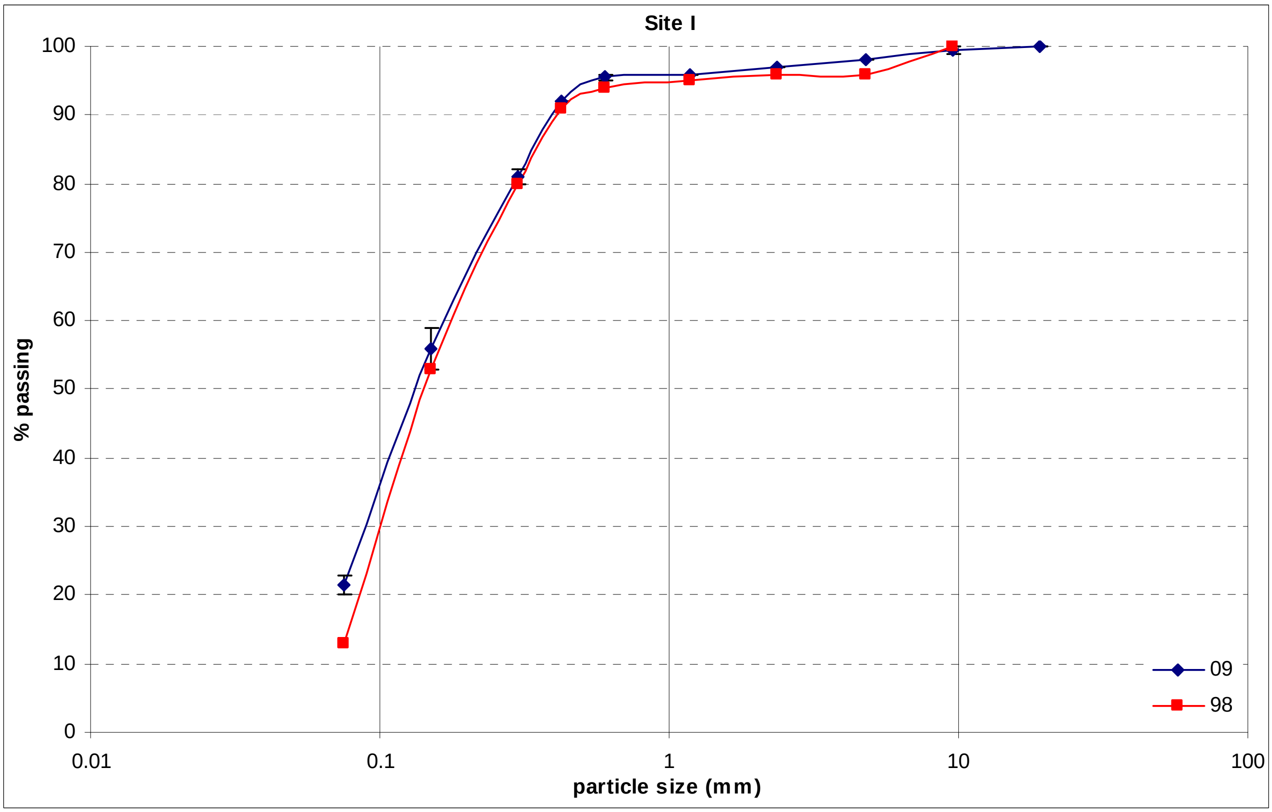

Site C
100
90
80
70
60
50
40
30
20
10
0
% passing
0.01
0.1
1
10
100
particle size (mm)
09
98

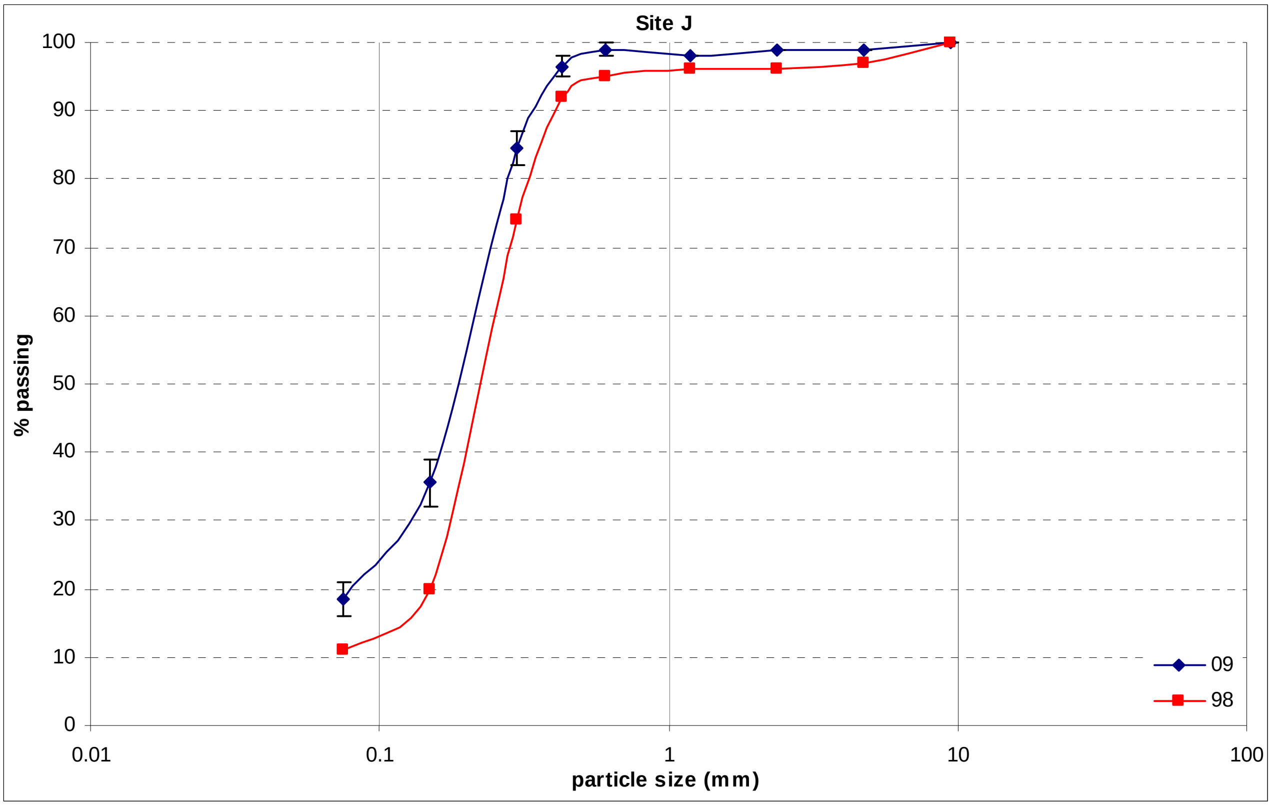

Site D
100
90
80
70
60
50
40
30
20
10
0
% passing
0.01
0.1
1
10
100
particle size (mm)
09
98

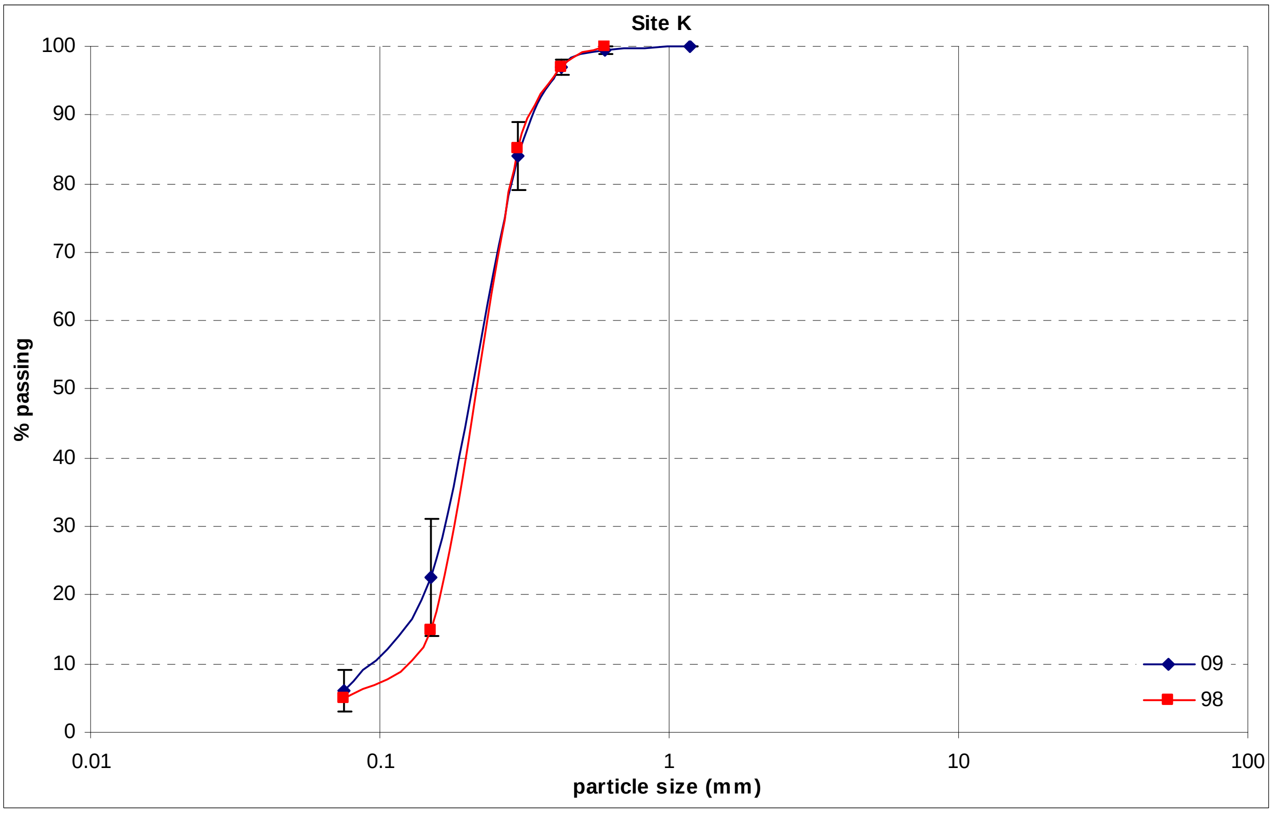

Site E
100
90
80
70
60
50
40
30
20
10
0
% passing
0.01
0.1
1
10
100
particle size (mm)
09
98

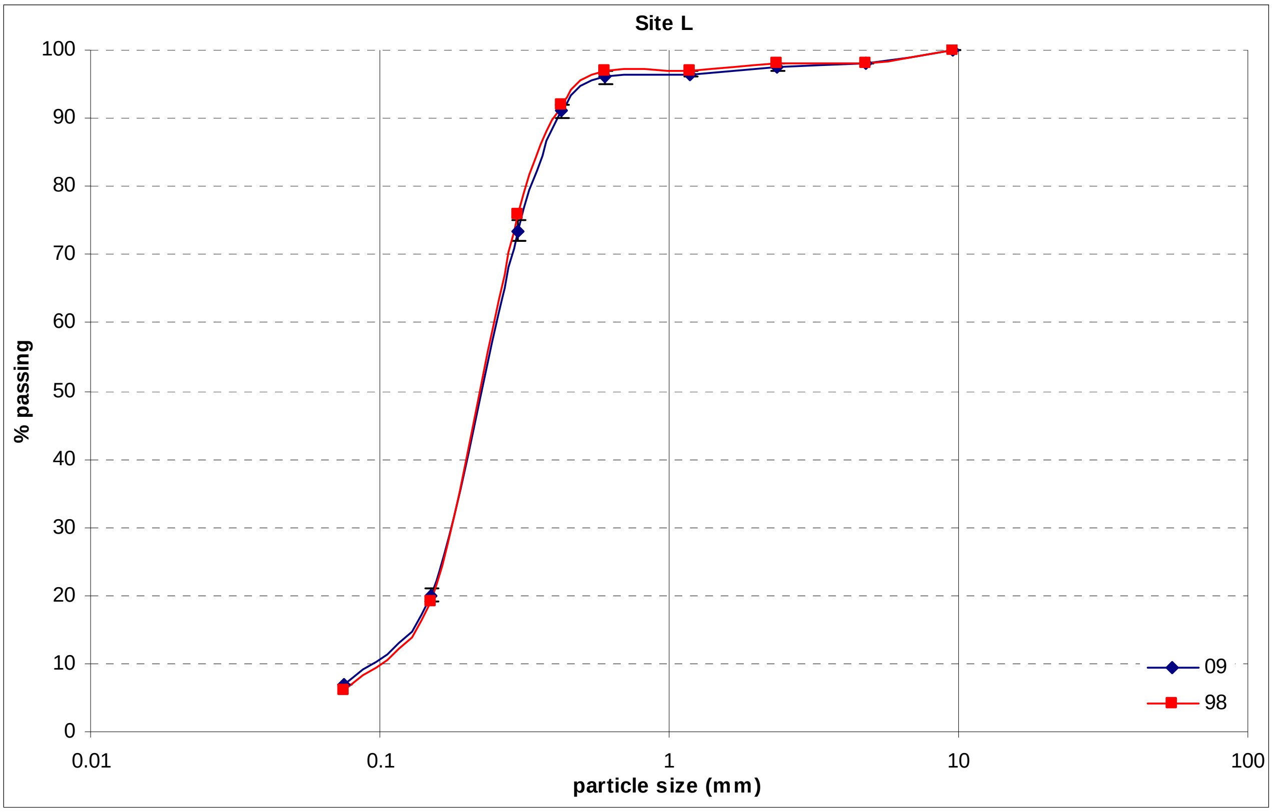

Site F
100
90
80
70
60
50
40
30
20
10
0
% passing
0.01
0.1
1
10
100
particle size (mm)
09
98

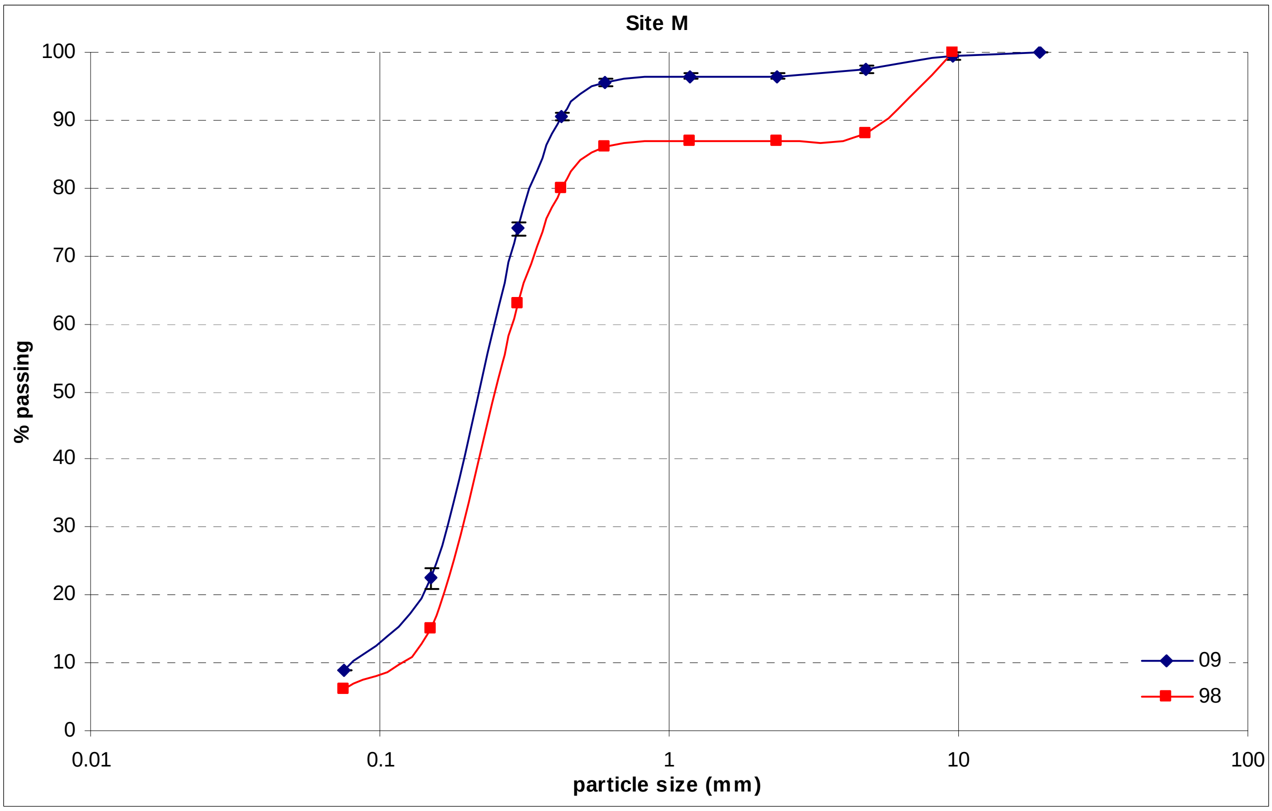

Site H
100
90
80
70
60
50
40
30
20
10
0
% passing
0.01
0.1
1
10
100
particle size (mm)
09
09 Mar
98

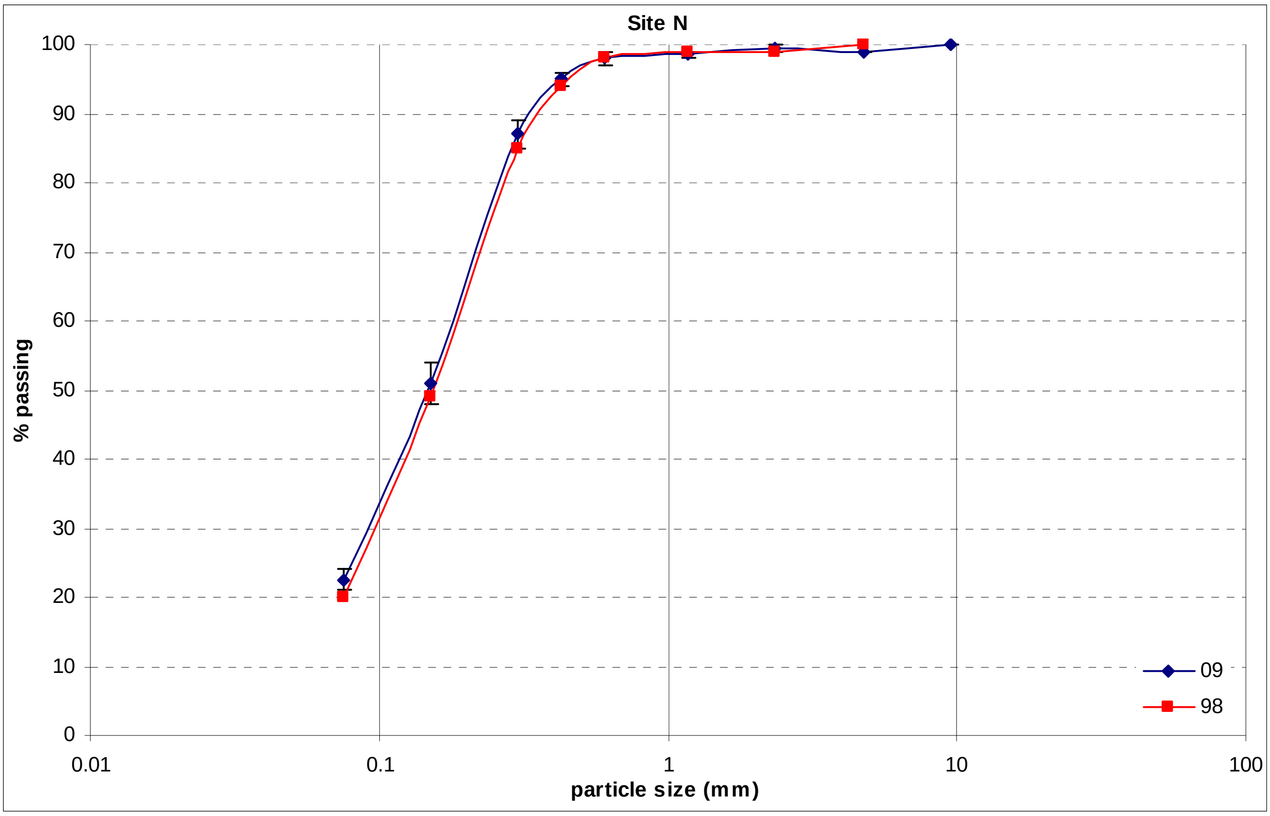

Site I
100
90
80
70
60
50
40
30
20
10
0
% passing
0.01
0.1
1
10
100
particle size (mm)
09
98

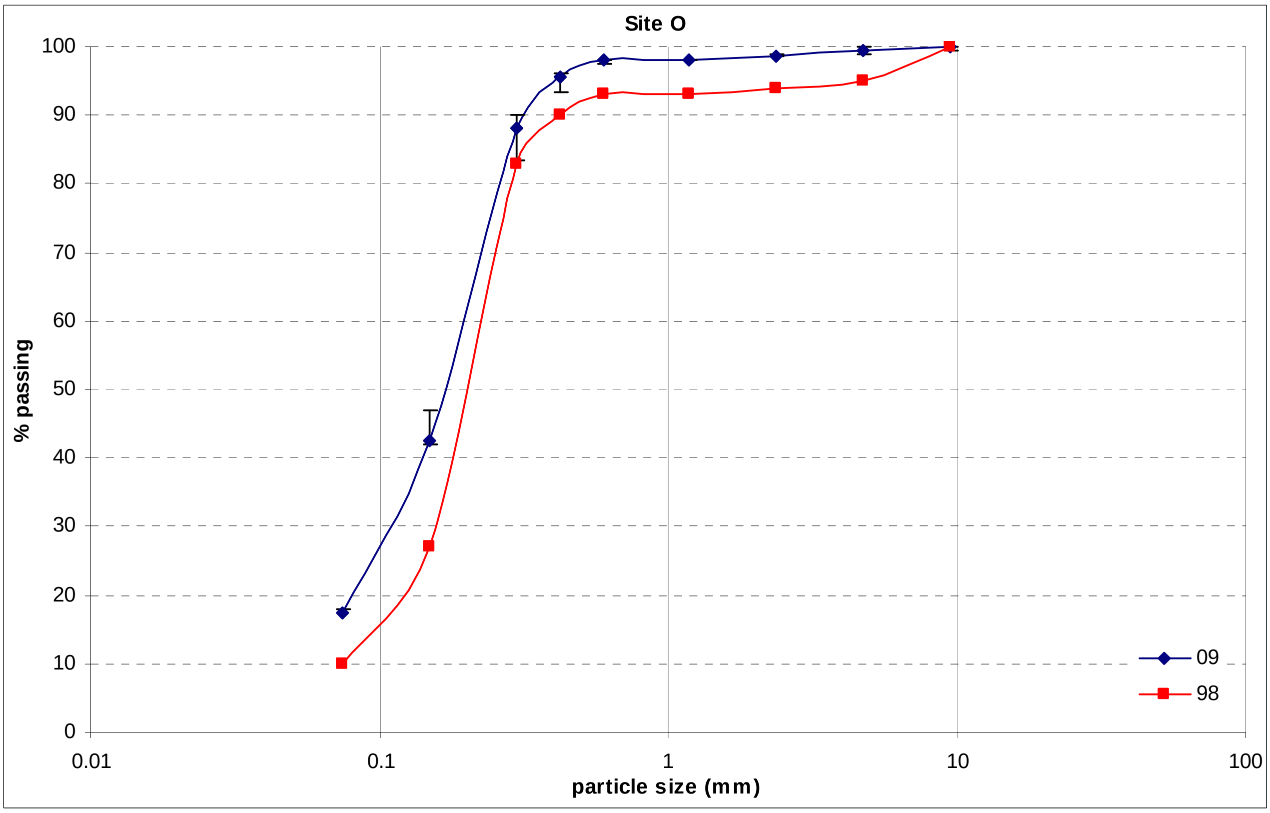

Site J
100
90
80
70
60
50
40
30
20
10
0
% passing
0.01
0.1
1
10
100
particle size (mm)
09
98

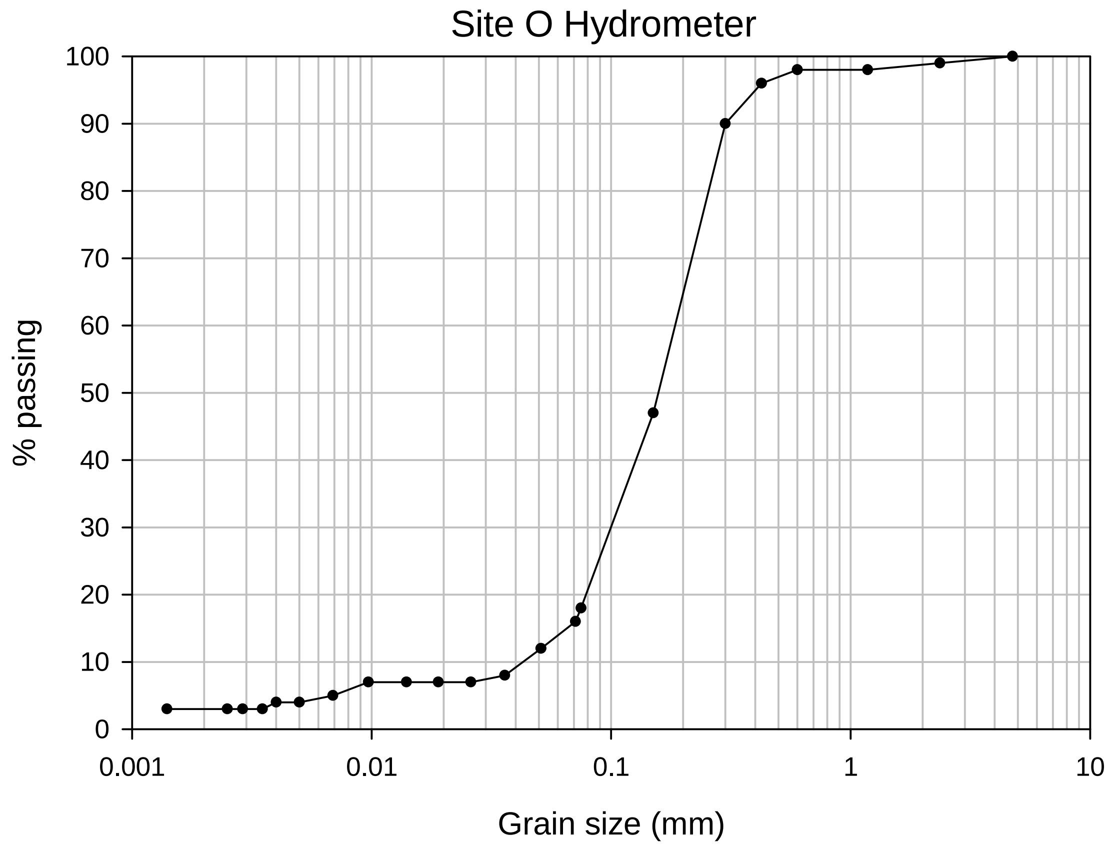

Site K
100
90
80
70
60
50
40
30
20
10
0
% passing
0.01
0.1
1
10
100
particle size (mm)
09
98

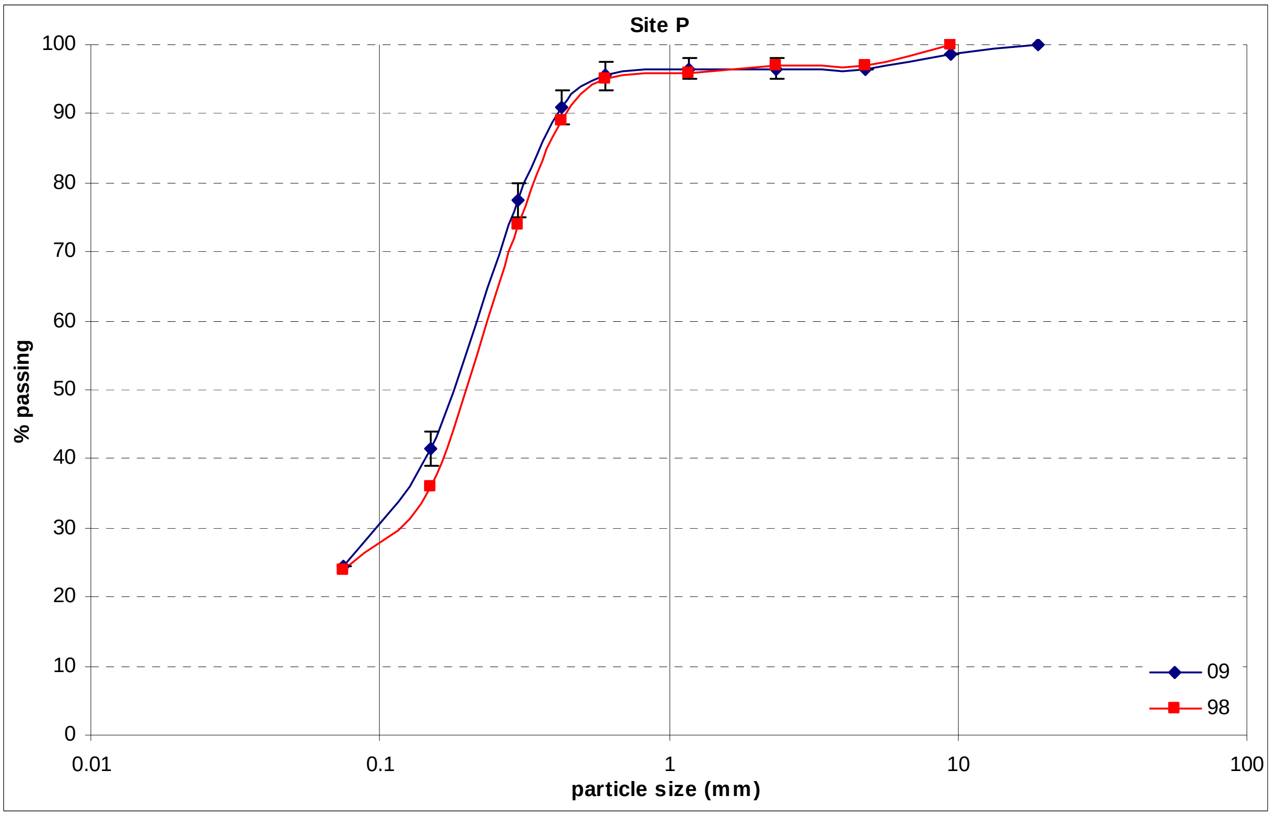

Site L
100
90
80
70
60
50
40
30
20
10
0
% passing
0.01
0.1
1
10
100
particle size (mm)
09
98

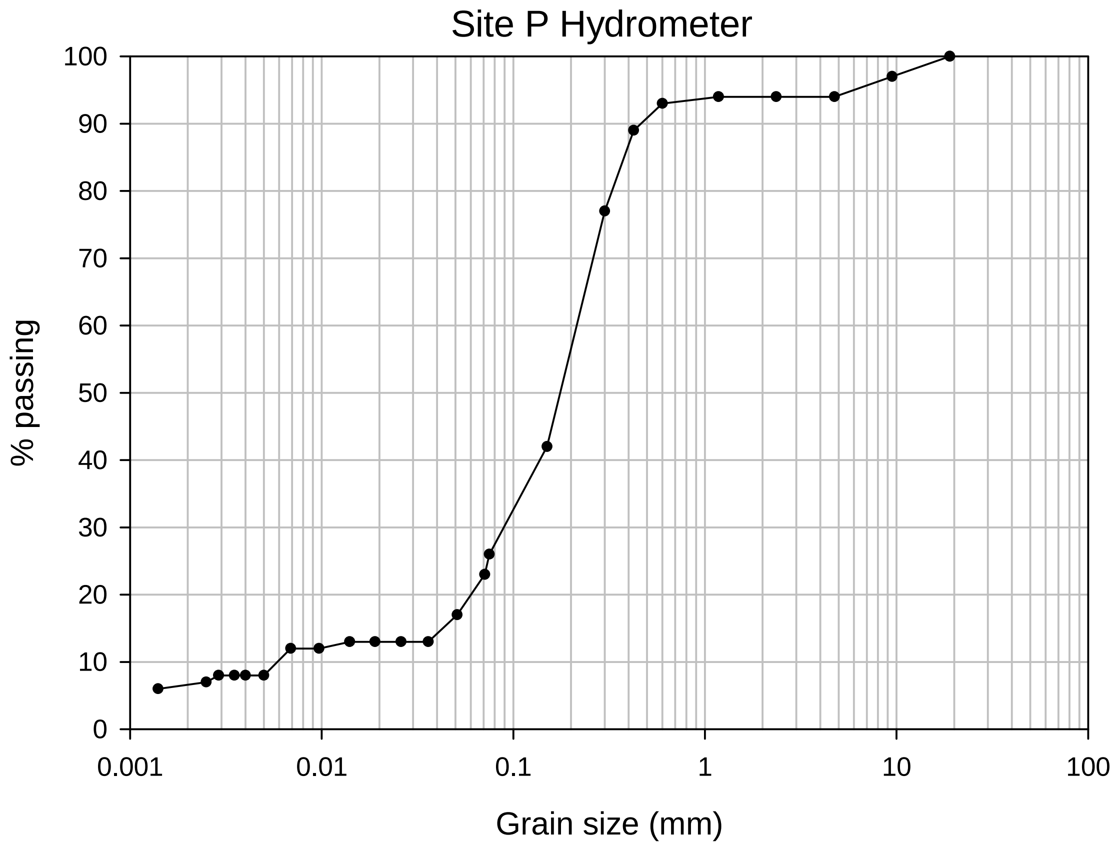

Site M
100
90
80
70
60
50
40
30
20
10
0
% passing
0.01
0.1
1
10
100
particle size (mm)
09
98

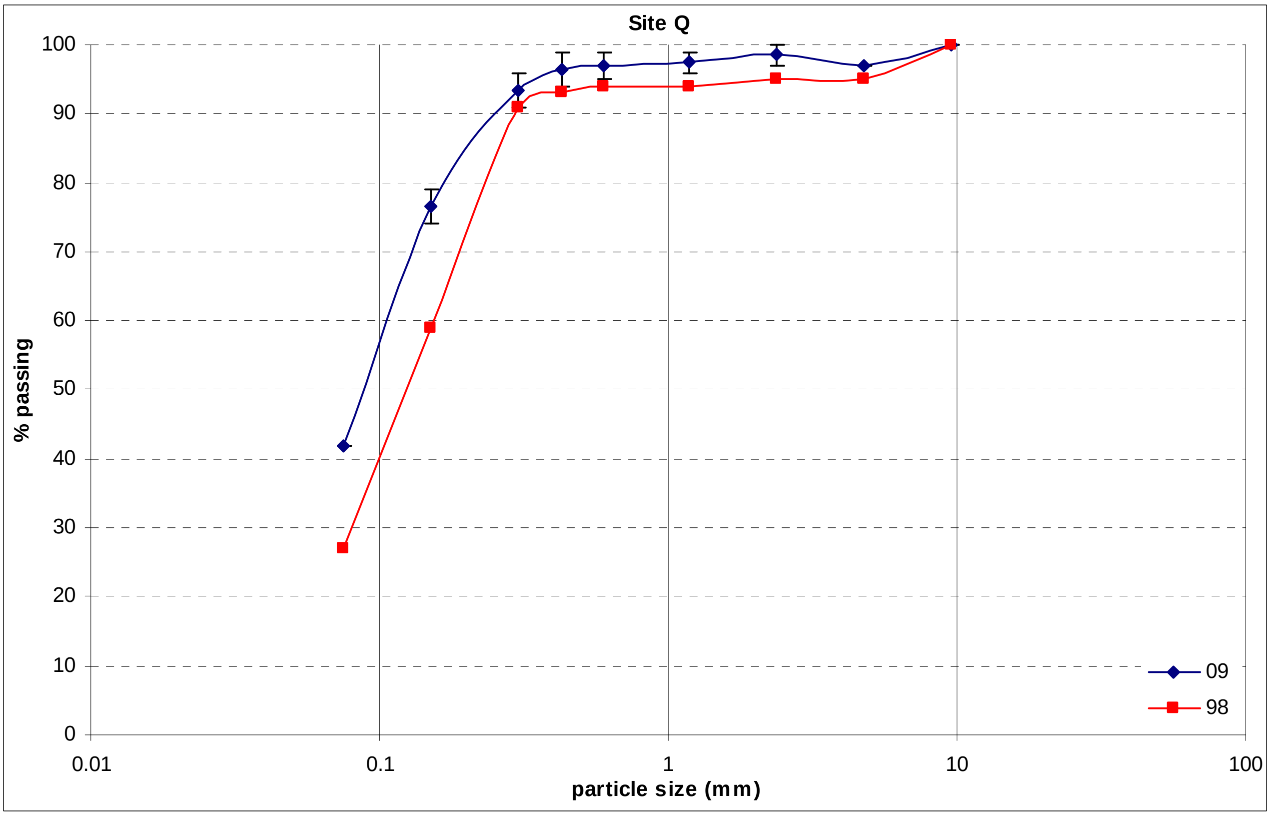

Site N
% passing
100
90
80
70
60
50
40
30
20
10
0
0.01
0.1
1
10
100
particle size (mm)
09
98

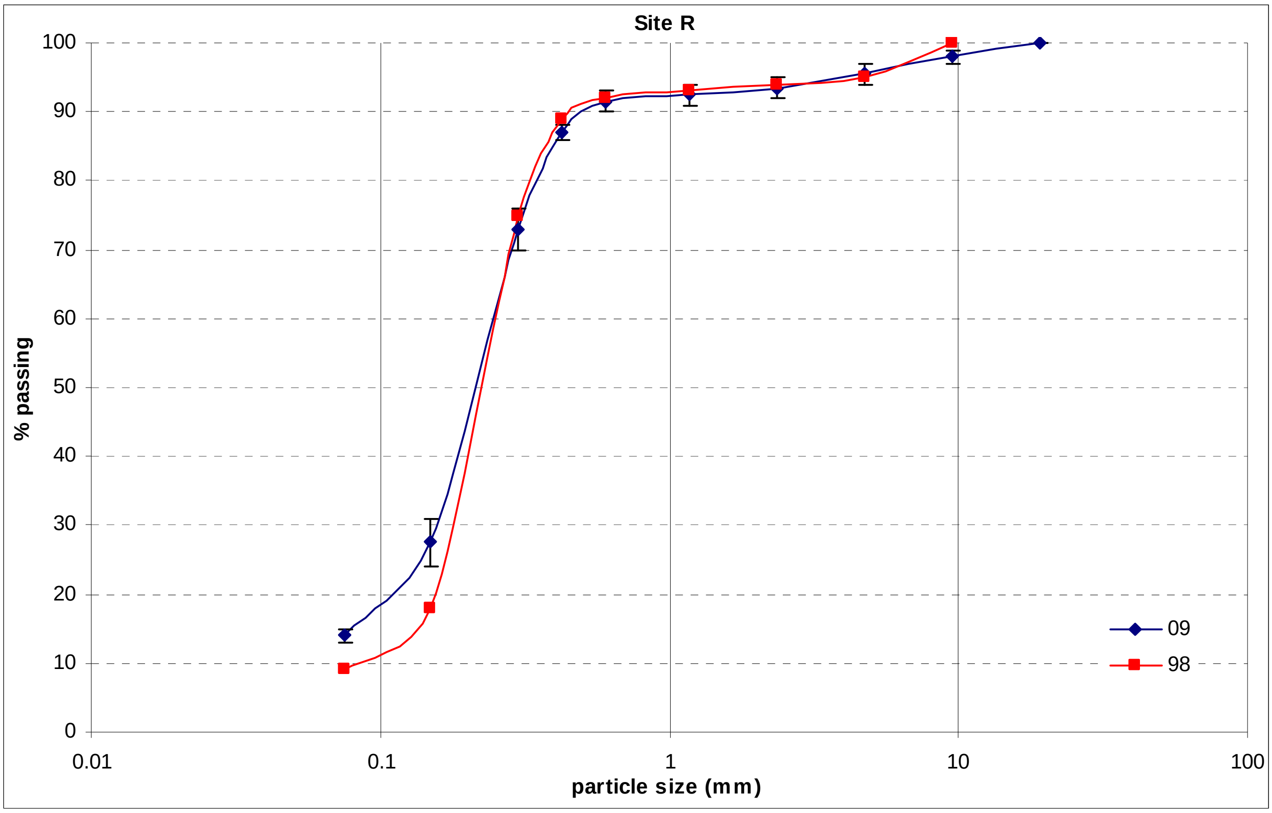

Site O
% passing
100
90
80
70
60
50
40
30
20
10
0
0.01
0.1
1
10
100
particle size (mm)
09
98


Site O Hydrometer
% passing
100
90
80
70
60
50
40
30
20
10
0
0.001
0.01
0.1
1
10
Grain size (mm)


Site P
% passing
100
90
80
70
60
50
40
30
20
10
0
0.01
0.1
1
10
100
particle size (mm)
09
98


Site P Hydrometer
% passing
100
90
80
70
60
50
40
30
20
10
0
0.001
0.01
0.1
1
10
100
Grain size (mm)


Site Q
% passing
100
90
80
70
60
50
40
30
20
10
0
0.01
0.1
1
10
100
particle size (mm)
09
98


Site R
100
90
80
70
60
50
40
30
20
10
0
% passing
0.01
0.1
1
10
100
particle size (mm)
09
98

APPENDIX D: SAMPLING LOCATIONS

Co-ordinates are supplied in UTM in WGS 84 Datum

Site	Easting	Northing
2	519876.5	6974480.4
4	519872.6	6973220.3
5	521109.1	6973210.0
6	522099.7	6973333.9
7	518711.8	6971819.3
8	519872.4	6971805.0
9	521114.4	6971890.4
11	518612.0	6970737.5
12	519825.8	6970699.9
13	520968.6	6970712.6
16	518801.0	6969687.7
17	519667.4	6969684.8
18	520936.1	6969717.8
20	519098.2	6968503.1
21	520063.8	6968554.6
22	521133.6	6968525.5
24	519103.2	6967234.0
25	520063.2	6967567.1
26	521000.9	6967194.3
29	520101.3	6966747.7
A	518783.4	6972468.1
B	519253.4	6972168.1
D	519463.4	6972538.1
E	518483.4	6971968.1
F	518953.4	6971648.1
G	518338.2	6973465.2
H	519533.4	6973078.1
I	519294.1	6971232.1
J	519282.1	6970367.0
K	519006.1	6968956.5
L	519537.3	6968645.9
M	519432.5	6968290.7
N	519791.4	6968393.8
O	519653.7	6968040.7
P	518206.4	6967698.2
Q	518495.7	6967437.0
R	518745.3	6967110.2

BMT WBM Brisbane	**Level 11, 490 Upper Edward Street Brisbane 4000** **PO Box 203 Spring Hill QLD 4004** **Tel +61 7 3831 6744 Fax +61 7 3832 3627** **Email wbm@wbmpl.com.au** **Web www.wbmpl.com.au**
BMT WBM Denver	**14 Inverness Drive East, #B132** **Englewood Denver Colorado 80112 USA** **Tel +1 303 792 9814 Fax +1 303 792 9742** **Email wbmdenver@wbmpl.com.au** **Web www.wbmpl.com.au**
BMT WBM Mackay	**Suite 1, 138 Wood Street Mackay 4740** **PO Box 4447 Mackay QLD 4740** **Tel +61 7 4953 5144 Fax +61 7 4953 5132** **Email wbmmackay@wbmpl.com.au** **Web www.wbmpl.com.au**
BMT WBM Melbourne	**Level 5, 99 King Street Melbourne 3000** **PO Box 604 Collins Street West VIC 8007** **Tel +61 3 8620 6100 Fax +61 3 8620 6105** **Email wbmmelbourne@wbmpl.com.au** **Web www.wbmpl.com.au**
BMT WBM Newcastle	**126 Belford Street Broadmeadow 2292** **PO Box 266 Broadmeadow NSW 2292** **Tel +61 2 4940 8882 Fax +61 2 4940 8887** **Email wbmnewcastle@wbmpl.com.au** **Web www.wbmpl.com.au**
BMT WBM Perth	**1 Brodie Hall Drive Technology Park Bentley 6102** **Tel +61 8 9328 2029 Fax +61 8 9486 7588** **Email wbmperth@wbmpl.com.au** **Web www.wbmpl.com.au**
BMT WBM Sydney	**Suite 206, 118 Great North Road Five Dock 2046** **PO Box 129 Five Dock NSW 2046** **Tel +61 2 9713 4836 Fax +61 2 9713 4890** **Email wbmsydney@wbmpl.com.au** **Web www.wbmpl.com.au**
BMT WBM Vancouver	**1190 Melville Street #700 Vancouver** **British Columbia V6E 3W1 Canada** **Tel +1 604 683 5777 Fax +1 604 608 3232** **Email wbmvancouver@wbmpl.com.au** **Web www.wbmpl.com.au**