APPENDIX J

MINERAL STUDIES

BROAD BEACH RESTORATION PROJECT

REVISED SAMPLING AND ANALYSIS PLAN

AND TEST RESULTS REPORT

Prepared for:

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Contents

Figures

Tables

1.0 Introduction

In accordance with the request of the State Lands Commission, the Broad Beach Geologic Hazard Abatement District (BBGHAD) provides this Sampling and Analysis Plan and Test Results Report (SAP) for the Broad Beach Restoration Project. The SAP investigates available upland quarry sand sources for beach nourishment as a component of the Project, which is estimated to require 600,000 cubic yards (cy) of sand to restore Broad Beach. The BBGHAD has completed a number of prior offshore and onshore investigations in conjunction with the proposed Project. The BBGHAD's prior sampling efforts, the locations of same, and the associated documents are shown in Figure 1 and presented in Table 1 along with this effort solely for clarity and ease of reference.

Table 1. SAP Document Chronology

<table>
<tr><th>Document Name</th><th>Approval / Document Date</th><th>Investigation Areas</th></tr>
<tr><td>Final SAP Report (FSAP)</td><td>April 2011</td><td rowspan="2">Trancas
Zuma
Corral Canyon</td></tr>
<tr><td>Final SAP Results Report</td><td>June 2011</td></tr>
<tr><td>Draft SAP Addendum Report</td><td>July 2011</td><td rowspan="2">Venice – North
Venice – South
Dockweiler – North
Dockweiler – South</td></tr>
<tr><td>SAP Addendum Results Report</td><td>November 2011</td></tr>
<tr><td>Modification to the SAP Addendum</td><td>July 2012</td><td>Venice – North (Revised)</td></tr>
<tr><td>Addendum No. 2 to the FSAP</td><td>August 2012</td><td>North Manhattan Beach
Central Manhattan Beach
South Manhattan Beach</td></tr>
<tr><td>Addendum No. 3 to the FSAP</td><td>September 2012</td><td>Stockpile at Calleguas Creek</td></tr>
<tr><td>Proposed State Lands SAP (This Document)</td><td>June 2013</td><td>Stockpiles at Grimes Rock, CEMEX, and P.W. Gillibrand</td></tr>
</table>

The agency-led Dredged Material Management Team (DMMT) previously approved other sand sources for the 600,000 cy of sand required for the Project (the Central Trancas site for use as dune restoration and the Dockweiler – North site for use as beach nourishment). Since DMMT's approval of use of these two borrow areas, the BBGHAD has elected to focus on other sand sources for the Project.

In recent months, the BBGHAD has determined that it will not seek permitting of offshore sand borrow sources, and investigated the feasibility of using upland quarry sand as the sole source of the beach and dune restoration material. This SAP outlines an approach to investigate upland sources of sediment stockpiled at three commercial quarries in Ventura County, CA, and concurrently presents chemistry and grain size test results.

The stockpiled materials at two quarries (CEMEX and Grimes Rock) originate from a sandstone geologic formation called the Saugus Formation (Pleistocene age). This formation consists of both non-marine and marine deposits (Dibblee and Ehrenspeck 1992A), and this location is believed to be a former seabed (Bryan Forgey, CEMEX, Personal Communication on May 20, 2013). Grimes Rock and CEMEX possess the capacity to provide the quantity of sand required for the project (600,000 cy of material). A third quarry, P.W. Gillibrand, is located within the Pico Formation that is marine clastics and sandstone (Dibblee and Ehrenspeck 1992B). This quarry is presently limited to providing a capacity of approximately 100,000 cubic yards for this project, but it can either potentially supplement the project if the other quarries cannot meet the capacity needed to serve the project, or expand its operations to provide significantly more material. The Gillibrand quarry is therefore not yet a focus of this analysis, but is included in the case that their sand would be needed for a specific project objective or to supply a larger quantity of the material. Further investigation of sand from this quarry may occur if needed. Figure 2 shows the locations of the quarries within the region, and Figure 3 through Figure 5 show aerial photographs of the stockpiles at each quarry, respectively. The stockpiles at the quarries are relatively small, from a fraction of an acre at Grimes (0.22 acre), to 1.2 acres at CEMEX, to 2.6 acres at P.W. Gillibrand. The height of the stockpiles is similar among the sites, reaching approximately 15 to 20 feet maximum.

Figure 1. Broad Beach Restoration Project, Prior Offshore and Upland Investigation Areas

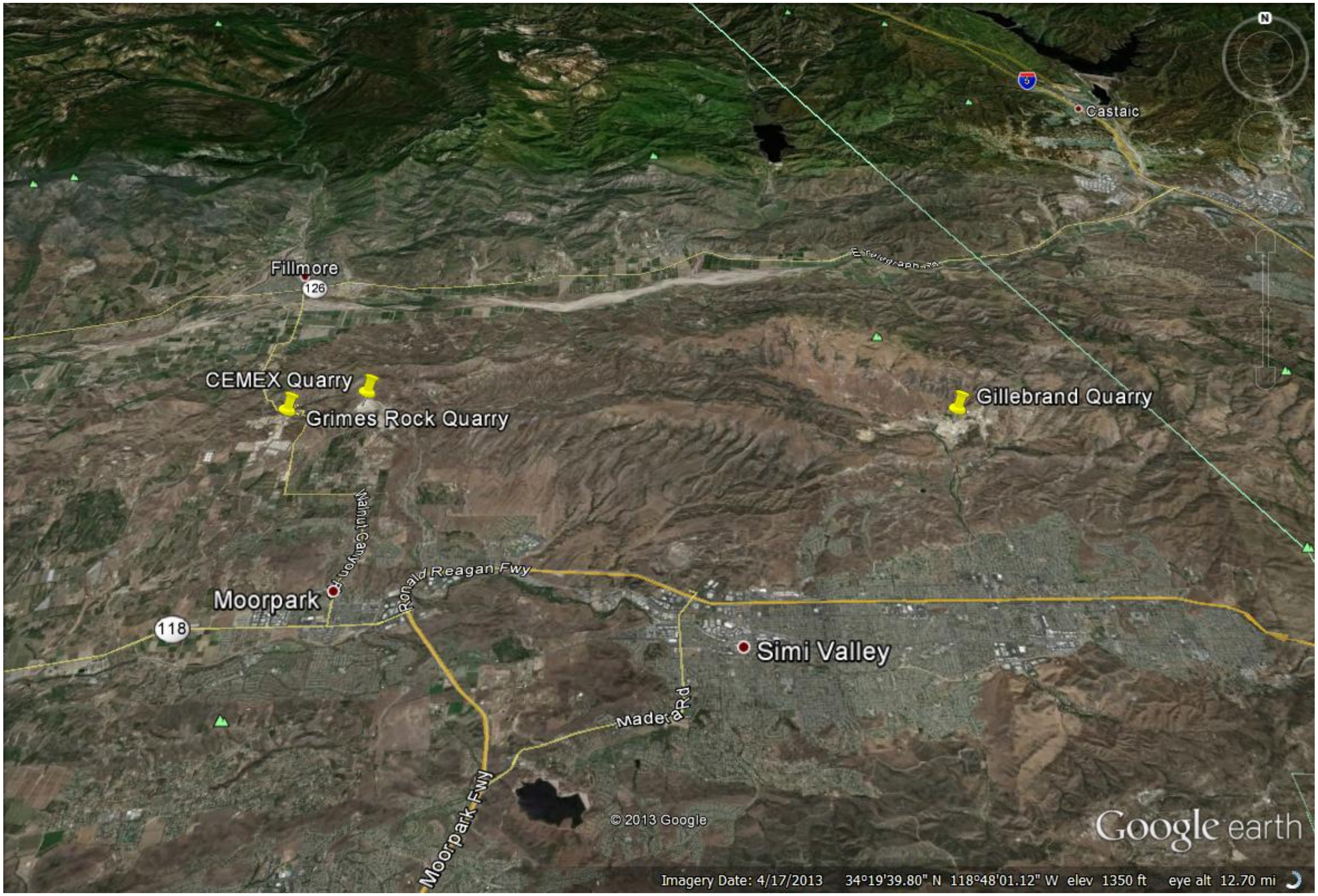

Figure 2. Vicinity Map - Proposed Upland Quarries Investigation Area in Moorpark/Simi

Figure 3. Proposed Grimes Rock Stockpile Investigation Area

Figure 4. Proposed CEMEX Stockpile Investigation Area

Figure 5. Proposed P.W. Gillibrand Stockpile Investigation Area

Photographs of the existing sand stockpiles at each quarry are provided below as Figure 6 through Figure 8. These stockpiles are continually reworked, turned over, removed, and replaced for commercial purposes, so the sand is very well mixed and homogeneous throughout the piles. Material in the stockpiles is completely renewed on a frequent basis.

Figure 6. Sand Stockpile at the Grimes Rock Quarry

Figure 7. Sand Stockpile at the CEMEX Quarry

Figure 8. Sand Stockpile at the P.W. Gillibrand Quarry

2.0 SITE HISTORY

The proposed borrow sites investigated as part of this SAP comprise of upland stockpiles of material in commercial quarries excavated from a sandstone geologic formation in marine sedimentary rock. The material is continually excavated, stockpiled, and removed as part of ongoing quarry and aggregate sales operations.

2.1 TIER I ASSESSMENT OF EXISTING DATA

In general, an initial evaluation (Tier I Assessment) of existing data may be used to determine if actual sampling and analysis of inland quarry material is needed to approve the material for a beneficial use - here, beach fill. In this instance, the BBGHAD believes that the inland quarry material satisfies Tier I Assessment requirements (see below). However, the BBGHAD has nonetheless chosen to sample and analyze the material, and not rely solely on a Tier I Assessment, so that it may share empirical data with the Project's various permitting authorities. The empirical sampling and testing approach is presented in Sections 3-2 below, with results presented in Section 5.0.

Chemical contamination of sediments is addressed in great detail in the Inland Testing Manual, or ITM (USEPA and USACE 1998). The ITM does not address terrestrial soils in as much detail as dredged materials. However, material compatibility criteria specified in the ITM also apply to terrestrial materials. The ITM outlines a tiered testing approach for analyses; it is necessary to proceed through the tiers only until sufficient information exists to determine whether the proposed material is suitable for beneficial uses of dredged sediment. Tier I of the ITM focuses on existing information regarding the proposed source material. Review of this information may result in the decision that further analyses are not needed, or that confirmatory chemical measurements may be adequate for determination of the material's suitability for beneficial uses of sediment.

Title 40 CFR, Part 230 - Section 404(b)(1) contains EPA-established guidelines that provide the substantive environmental criteria used in evaluating activities regulated under Section 404 of the Clean Water Act (NARA 2013). The guidelines specify that:

> "[d]redged or fill material is most likely to be free from chemical, biological, or other pollutants where it is composed primarily of sand, gravel, or other naturally occurring inert material. Dredged material so composed is generally found in areas of high current or wave energy such as streams with large bed loads or coastal areas with shifting bars and channels."

Isolation of the material from sources of contamination, based on previous testing and information about past and present land uses at the source location, may also be considered in a determination that there is no “reason to believe” contaminants are present.

Tier I Assessment considerations about testing may be based on the following criteria:

1. Criterion for Lack of Sources of Contamination - If the sediments are from locations far removed from sources of contaminants; the sediments are from deposits in preindustrial times and not exposed to modern sources of pollution. However, potential impacts from natural mineral deposits must also be considered; and

2. Criterion for Sand Grain Size - If an evaluation of the source site indicates that the material is not a “carrier of contaminants," testing may not be necessary. Such situations are most likely to arise if the material is composed primarily of sand, gravel and/or inert materials.

If these criteria are satisfied, factual determinations for the material can be made and further evaluation may not be required. If these criteria are not met, Tier II chemistry testing may be required and the material evaluated based on all existing information.

A brief presentation of data pertaining to the two applicable criteria is provided below.

2.1.1 Lack of Potential Historic Sources of Contamination

The inland quarries are located far removed from potential sources of contamination such as urbanization, manufacturing, and farming. The quarry operations are located in natural geologic formations deposited in pre-industrial times on upper elevations of foothills in the Santa Susana Mountains and upstream of any development. The deposits are unmodified by man and not exposed to modern sources of pollution. In addition, quarry operations do not add any chemicals to the materials during and after excavation. Figure 2 shows that the quarries are located outside areas of urbanization. Figure 9 shows the quarries are located in the topographic ridge of foothills, and upslope/upstream of drainage sources. Historically, farming did not occur at these sites because the terrain is rough and highly uneven owing to their location near the ridges of foothills. The sand is located far removed from sources of contamination and the material likely lacks contamination sources. Figure 10 shows the geologic setting of the quarries and indicates that sandstone is the sediment source. Large strata of sandstone are typically formed in pre-historic marine environments, suggesting that these materials are former seabed.

2.1.2 Grain Size

Previous testing of the stockpiled material consists of grain size analysis of surface grab samples from the stockpiles. Sand from both the CEMEX and Grimes Rock quarries was tested for grain size by certified soils laboratories to determine its sand content. Test results show that all materials contain more than 92.5 percent sand and less than 7.5 percent fine-grained particles (silts and clays). Results of grain size testing are provided in Table 2. Visual inspection of the sand stockpiles and deposits confirmed that the material is significantly composed of sand and is desirable for use as beach nourishment and dune-building.

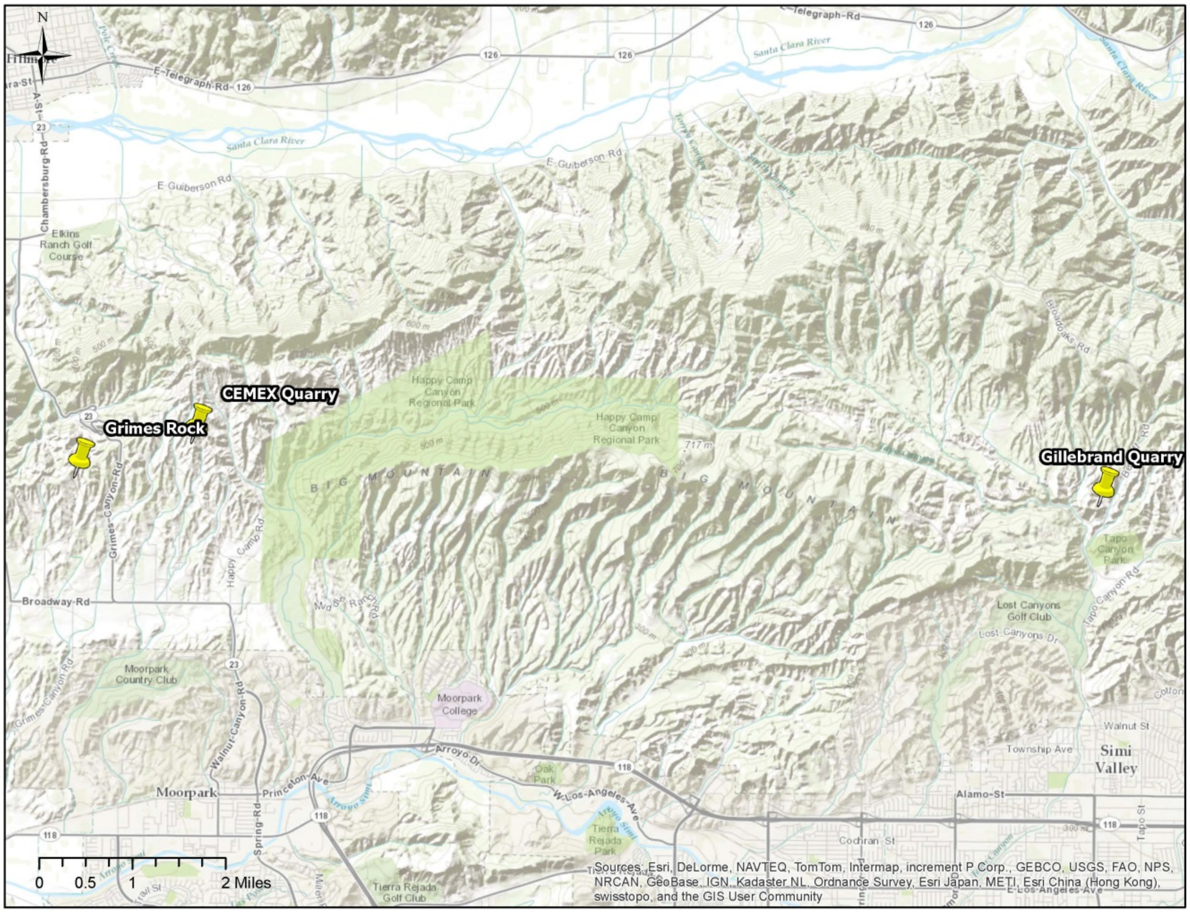

Figure 9. Topography of the Vicinity of the Quarries

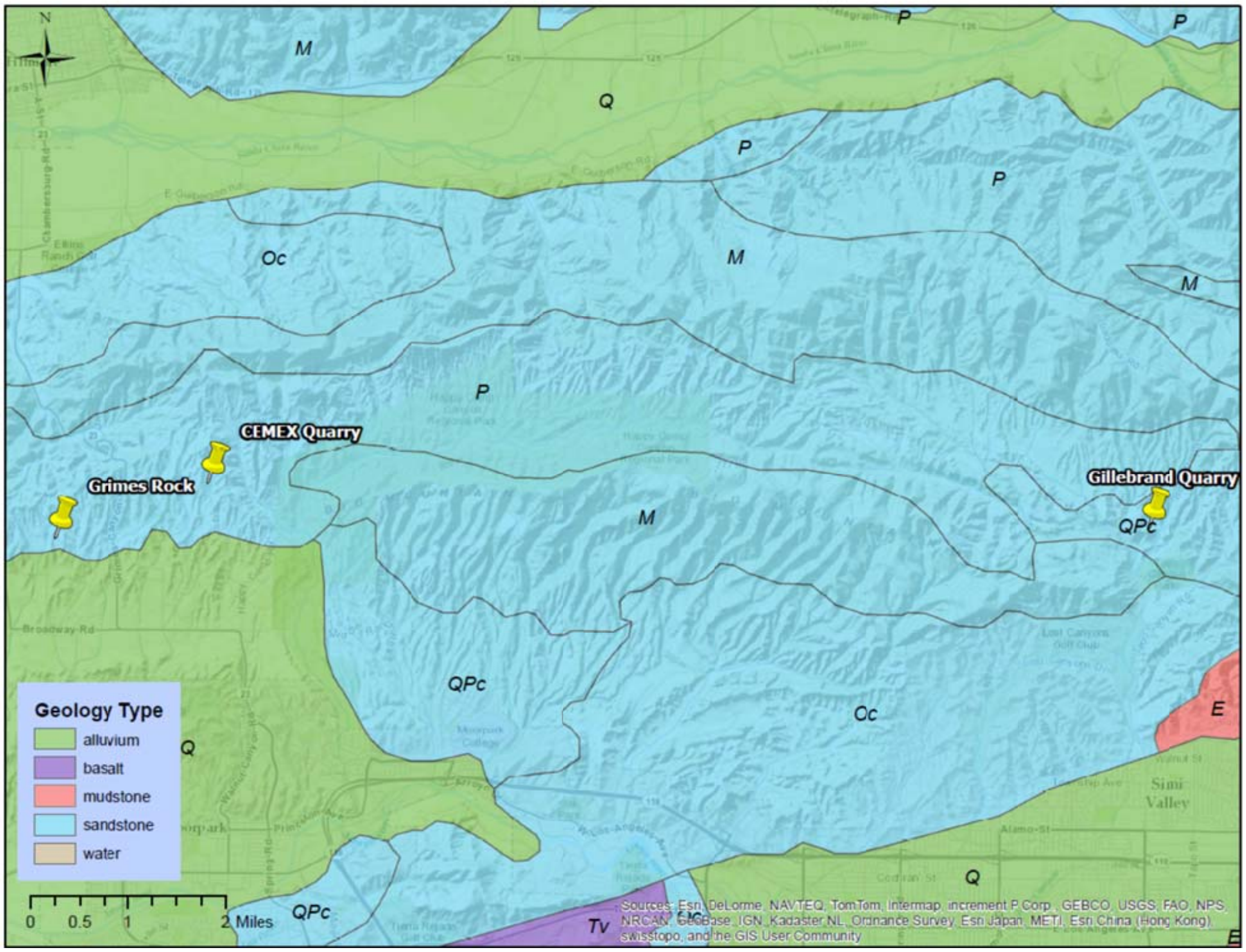

Figure 10. Geology Strata of the Quarries as Sandstone (Source: Cal. Geologic Survey 2013)

Table 2. Gradation Test Results for Sand at CEMEX, Grimes Rock, and P.W. Gillibrand Quarries

Sieve Size	Percent Passing – CEMEX Quarry	Percent Passing - Grimes Rock Quarry	Percent Passing - P.W. Gillibrand	Soil Type from the United Soils Classification
3/8" (9.5 mm)	100	100	100	Gravel
#4 (4.75 mm)	95	99	100	Coarse Sand
#8 (2.36 mm)	79	90	99	Coarse Sand
#16 (1.18 mm)	[illegible]8 (high end of the range of the median)	72	66	Medium Sand
#30 (0.60 mm)	38 (low end of the range of the median)	50 (the median)	[illegible]	Medium Sand
#50 (0.30 mm)	21	27	[illegible]	Medium Sand
#100 (0.15 mm)	12	12	[illegible]	Fine Sand
#200 (0.075 mm)	8	7	[illegible]	Silts and Clays

Tier I Assessment analyses are based on readily available existing information. In accordance with the ITM, for certain materials with information indicating a lack of potential for contamination, Tier I Assessment analysis may be sufficient for making factual determinations. In the current instance, the quarry materials should be free of contamination and determined as suitable for beach nourishment for the following reasons:

(1) The sediment sources at the quarry sites were formed in pre-industrial times and have not been exposed to modern sources of pollution. Further, they are far removed from potential contamination sources and are upslope/upstream and urbanization or drainage sources; and

(2) All quarry materials are comprised of over 92.5% sand and therefore should not hold onto any contaminants.

Therefore, Tier II analyses based on chemical testing may not be warranted to make a compatibility determination for use of these materials for beach nourishment at Broad Beach. However, the BBGHAD has performed voluntary supplemental analyses consisting of chemical testing of the quarry sand to inform its decision-making and provide all permitting agencies with empirical data regarding the proposed sand fill material. The BBGHAD's approach to this supplemental chemical testing is provided in subsequent sections of this document.

3.0 METHODS

This section outlines the proposed number and location of supplemental grain size and chemical testing samples taken at the quarries' stockpiles to provide additional information to the BBGHAD regarding material compatibility for nourishment at Broad Beach. The BBGHAD previously collected physical and chemistry data from the proposed Broad Beach receiver site during previous DMMT processes. All sampling planning and execution was done consistent with the guidelines provided in the Sand Compatibility and Opportunistic Use Program (SCOUP) prepared for the Coastal Sediment Management Workgroup and approved by resource and permit agencies (Moffatt & Nichol 2006).

3.1 SAMPLING DESIGN

The quarries actively excavate native material from on-site formations and move it on conveyor belts through various screens to sort the material by grain size. Sand is conveyed to a portion of the site and dumped off the conveyor belt into a large stockpile. The stockpile can vary in size and shape, depending on the quantity of sand in the pile. Sand is continually taken from the stockpile and loaded onto trucks for delivery to processing and/or construction sites, and replaced in the stockpile by continued excavation and screening. The sand in each stockpile is well-mixed. Each of the three quarries varies in its sand production rate and stockpile volume. However, the sand is remarkably similar among the quarries as a result of excavation from the same geologic formation.

Each of the three stockpiles is divided into quadrants for investigation, as shown in Figure 11. Representative samples were retrieved on May 22, 2013. One separate sample was taken from each quadrant and archived for future testing if needed. A second, smaller sample was taken from each quadrant and mixed with a smaller sample from all other quadrants to combine as a composite sample for chemistry testing. A third sample was taken from each stockpile for grain size testing. The proposed sampling approach for physical and chemical characterization is as follows:

- Grain Size Sampling - Collection of one sample from each individual stockpile and tested for grain size. The sample was then combined with a smaller sample taken at each quadrant to create a composite. Eventually, samples archived at the chemistry lab that were not needed for chemistry testing were also individually tested for grain size. Additional samples were taken for grain size testing only on October 2, 2013 to test material from different excavation areas at both Grimes Rock and CEMEX quarries.

- Chemical Sampling – Collection of two discrete chemical samples from each quadrant of the stockpile. One composite sample was then prepared for each stockpile by combining proportional aliquots from each sample.

Table 3 outlines the number of samples proposed for grain size and chemistry testing per subarea, as sampled on May 22, 2013.

Table 3. Proposed Sampling Plan Summary

Quarries	Composites for Chemistry	Archived for Chemistry	Composites for Grain Size	Individuals Tested for Grain Size
Grimes Rock	1	4	1	4
CEMEX	1	4	1	4
P.W. Gillibrand	1	4	1	4
Total	**3**	**12**	**3**	**12**

The BBGHAD completed sediment chemistry testing on a total of three composite samples, one for each quarry.

Archives of each of the discrete chemistry samples were retained for supplemental testing, but that was ultimately deemed unnecessary due to their lack of contaminants. All samples were collected and stored according to the USACE and the United States Environmental Protection Agency (USEPA) protocols.

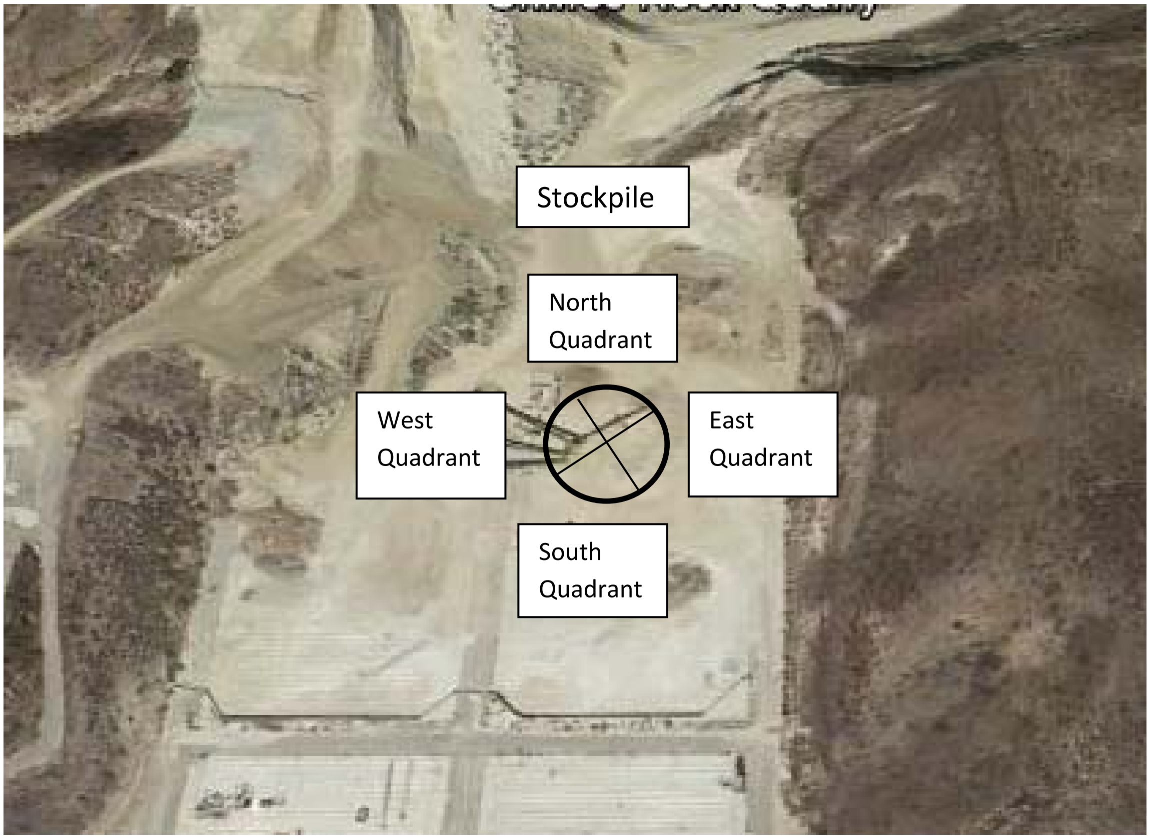

Figure 11. Grimes Rock Stockpile Sampling Locations

3.2 PHYSICAL AND CHEMICAL TESTING

Samples were collected and analyzed consistent with USACE and USEPA established protocols for the disposal of dredged material as outlined in the ITM (USEPA and USACE 1998). Samples were collected with sample containers (jars) and containers were labeled according to sample location within the stockpile. Quality assurance/quality control measures were identical to that described in the FSAP document for the DMMT (Moffatt & Nichol 2011).

3.2.1 Grain Size Testing

Grain size composite samples were collected from each of the stockpiles. Gradation curves were generated from each individual sample for comparison with the established Broad Beach grain size envelope to evaluate compatibility. Samples were sieved consistent with American Society for Testing and Materials (ASTM) D 422-63 (Standard Test Method of Particle-Size Analysis of Soils, ASTM 2007). Samples from both the May and October dates were tested.

3.2.2 Chemistry Testing

Composite samples for chemical analysis were prepared by combining proportional aliquots from each individual boring sample collected for the composite test areas, as described in Section 3.1. A discrete sample from each quadrant of each stockpile was archived for supplemental chemistry sampling, if necessary. Chemical samples have been analyzed in accordance with USACE ITM guidelines for a complete list of analytes and their associated detection limits issued by the USACE and USEPA (1998).

4.0 SEDIMENT COMPATIBILITY DETERMINATION

The USACE (1989) developed guidelines for determining grain size compatibility of source material to receiving beach material. For this Project, the BBGHAD used USACE (1989) and SCOUP (Moffatt & Nichol 2006) guidelines to evaluate the source material compatibility with the beach placement site(s). These guidelines instruct:

- Development of a source material composite gradation curve and comparison with the receiver site grain size distribution envelope(s). If the source material composite gradation curve falls within the limits of the grain size distribution envelope(s) of the receiving beach(s), then the material is deemed compatible with the native beach material.
- The fraction of fines in beach fill sediment may exceed the existing sediment at the receiving beach placement site by no more than 10% without more detailed review.
- If the source material has higher fines content, then the material could be placed at the waterline at low tide for immediate dispersion into the nearshore zone, rather than being placed on the subaerial beach.
- The median grain size is coarser than the existing beach, but according to the USACE (1989) this condition is typically not a concern if aesthetic reasons do not restrict the use of the material.

The BBGHAD completed bulk chemistry testing on composite samples of the borings as a screening mechanism for chemical compatibility. Sediment chemistry results were compared to NOAA Screening Quick Reference Table (SQUIRT) Guidelines (Buchman 2008). These guidelines are used to screen sediments for contaminant concentrations that might cause biological effects and to identify sediments for further toxicity testing. For any given contaminant, the Effects Range Low (ERL) guideline represents the 10^{th} percentile concentration value in the NOAA database that might be expected to cause adverse biological effects. If chemistry results reveal any constituent above SQUIRT or other approved USACE established screening level, further chemical testing may be required. Testing was completed per USACE Inland Testing Manual (ITM) guidelines.

5.0 RESULTS

This section summarizes the physical and chemical compatibility of sand stockpiles from three commercial quarries in the Ventura County, California vicinity with Broad Beach. The BBGHAD evaluated materials from Grimes Rock, CEMEX and P.W. Gillibrand. Stockpiled materials from each of these quarries were sampled on May 22nd, 2013 by M&N staff Chris Webb and Colin Averill. The sampling plan and collection methods strictly followed protocols established in the Inland Testing Manual (ITM), as administered by the U.S. Environmental Protection Agency (EPA) and the U.S. Army Corps of Engineers (USACE), and approved verbally by USACE staff prior to sampling. One composite grain size sample was collected from each of the stockpiles. A composite sample is a combination of several individual samples to represent a greater area of the stockpile. Chris Webb visited the Grimes Rock and CEMEX quarries again on October 2, 2013 and sampled the stockpiles to test them for grain size using the same approach. Quarry owners indicated that cuts had shifted into material that may be more compatible with the beach, and an effort was made to physically characterize that material.

5.1 PHYSICAL TESTING

Several approaches were taken to determine material grain size compatibility with the existing beach. These approaches include: 1) determining the content of sand and fines within the quarry sand; 2) comparing the median grain size of quarry sand with native sand; and 3) comparing the grain size envelopes between quarry and native sand. Results of each approach are presented below.

5.1.1 Content of Sand and Fines Within the Quarry Sand

Sand sieve test results show the quarry material from May 22, 2013 to be approximately 92.5% sand and 7.5% silts and clays, and material from October 2, 2013 to be approximately 97.5% sand and 2.5% silts and clays, which is compatible with the beach. The fraction of fines in the quarry sand from May 22 does exceed the existing sediment at the receiving beach placement site by 7%. However, this fines percentage is below the threshold of 10% cited in the USACE (1989) and SCOUP (2006) criteria, and the material should be considered compatible from that standpoint. The October quarry sand possesses approximately the same percentage of fines as exists at the beach.

5.1.2 Comparison of the Median Grain Size of Quarry and Native Sand

The results of all sieve testing of quarry sands and native sands were analyzed for the median grain sizes. Median grain size is defined as the 50 percentile of the gradation range, or approximately the mid-point of the gradation curve. It is intended to represent the average grain size of the material. Table 4 shows a comparison of the median grain sizes of the quarry sand, and native sand at Broad Beach and the dunes, and at Zuma Beach. The data show that the median grain size of the Grimes Rock Quarry sand (0.60 millimeters, or mm on May 22 and 0.47 mm on October 2) is more similar to that of the receiving beach (0.25 mm), dunes (0.32 mm), and immediate downdrift beach (0.40 mm) than other sources, but all quarries are determined to be compatible according to USACE criteria (1989).

Table 4. Sand Median Grain Sizes

Sand Identification	Median Grain Size (in Millimeters)
Broad Beach – Beach Sample Above 0' MLLW	0.25
Broad Beach Dunes	0.32
Zuma Beach (3 Locations Along its Reach)	0.40
Grimes Rock Quarry	0.60 (May 22); 0.47 (Oct. 2)
CEMEX Quarry	0.95 (May 22); 0.85 (Oct. 2)
P.W. Gillibrand Quarry	1.00

For context, this similar type of situation occurred in San Diego County in 2012 where sand was dredged off the seafloor one-half mile offshore at three borrow sites and pumped to eight different beaches for nourishment. That project was completed by the San Diego Association of Governments (SANDAG). The median grain size of the native beach sand there is also 0.25 mm, while the median grain size of the nourishment sand ranged from 0.54 mm to 0.66 mm. The coarser nourishment sand of between 0.55 and 0.66 mm median grain size was placed at the majority of the placement sites (six of eight), and was the majority of the material placed for the project (52% of the total). This coarser sand has performed well on the beach, with no detrimental effect on downcoast or adjacent beaches documented by SANDAG. The sand did form a temporary beach profile that was steeper than the ultimate equilibrium profile, but the beach profile is presently reverting back to the pre-construction profile at placement sites. Monitoring data of beach profiles after the 2001 SANDAG project (similar to the 2012 project, but with more sand placed) indicate that affected profiles reverted to pre-construction conditions within one year (Coastal Frontiers Corporation 2012). Data of nourishment sand compared to receiver beach gradation curves for SANDAG are provided in Appendix A for reference.

5.1.3 Comparison of Grain Size Envelopes Between Quarry and Native Sand

In accordance with ITM protocol, sample gradation results were compared to the composite grain size envelope for Broad Beach, which is created by plotting the coarsest and finest limits of native beach materials. Materials are considered compatible from a physical perspective if they are within the envelope or within 10% finer than the finest limit of the receiving beach. Sand coarser than the receiving beach is considered acceptable.

Grain size results from CEMEX and Grimes Rock quarries on May 22, 2013 were superimposed onto the composite grain size envelope and were found to be within 10% of the finer limit of the Broad Beach, as shown in Figure 12 through Figure 14, respectively. Figure 15 shows the Broad Beach gradation envelope with the gradation curves for the two most likely quarry sand sources, and the offshore SANDAG sand source of SO-5 for comparison. Figure 16 shows results of additional sampling and grain size testing for Grimes Rock and CEMEX quarries on October 2, 2013 compared to beach sand. The proposed nourishment sand from quarries falls outside of the Broad Beach gradation envelope (except on the coarse and fine ends of the curves) by intent to provide sand most suited to withstand erosive forces at the beach. SANDAG's sand from all offshore sources fell largely outside of the beach gradation curves at receiving beaches by intent, and up to 1.5 million cy of sand with these gradation properties was placed on San Diego County Beaches in 2012. Appendix A shows those gradation curves for SANDAG beaches and sand sources, and provides specific project information for each site. SANDAG source sand falls mostly outside of beach envelopes, while proposed Broad Beach sand falls within the beach envelope on the coarse and fine ends of the curves.

Therefore, the materials from these quarries are within acceptable limits in terms of grain size. The material outside of the coarsest grain curves is primarily medium to coarse <u>sand</u>. As stated in the SCOUP document (M&N 2006), coarse sands remain longer and provide steeper equilibrium slopes that dissipate wave energy more efficiently and, thus, protect finer-grain backshore areas more effectively. Although some of the borrow site sediments are <u>coarser</u> than the coarsest curve of the nourishment sites, this should be acceptable per USACE guidelines, coastal engineering principles, and as demonstrated on previously constructed projects. The coarser median diameter of the quarry material is an attribute for beach nourishment as the fill material will reside on the beach longer and prolong benefits. SANDAG used beach fill material that was coarser than the native material in both 2001 and 2012 to maximize the project's life, and to also maximize the width of the new beach berm. Coarser sand resides higher on the beach profile and typically results in a wider recreational beach berm area than finer sand.

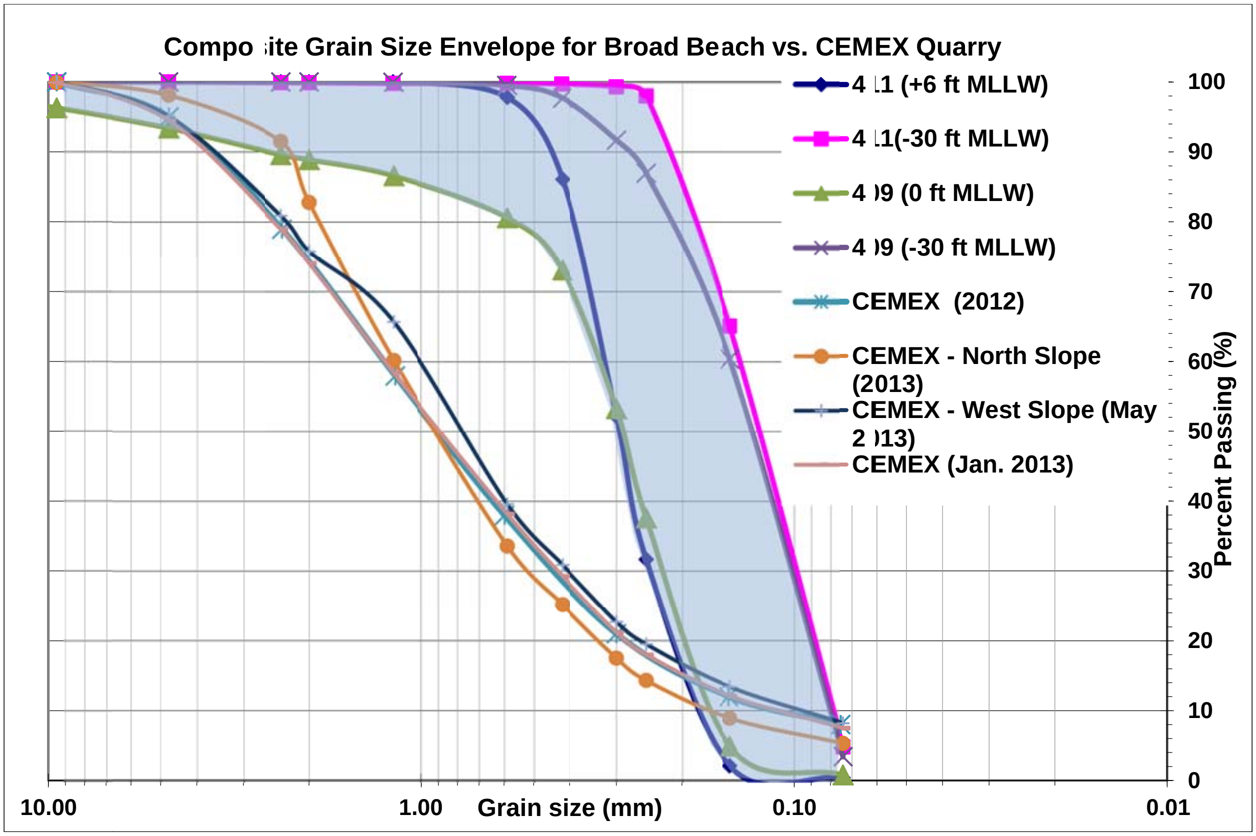

Figure 12. Broad Beach Composite Grain Size Envelope vs. CEMEX Quarry Material Gradation Results

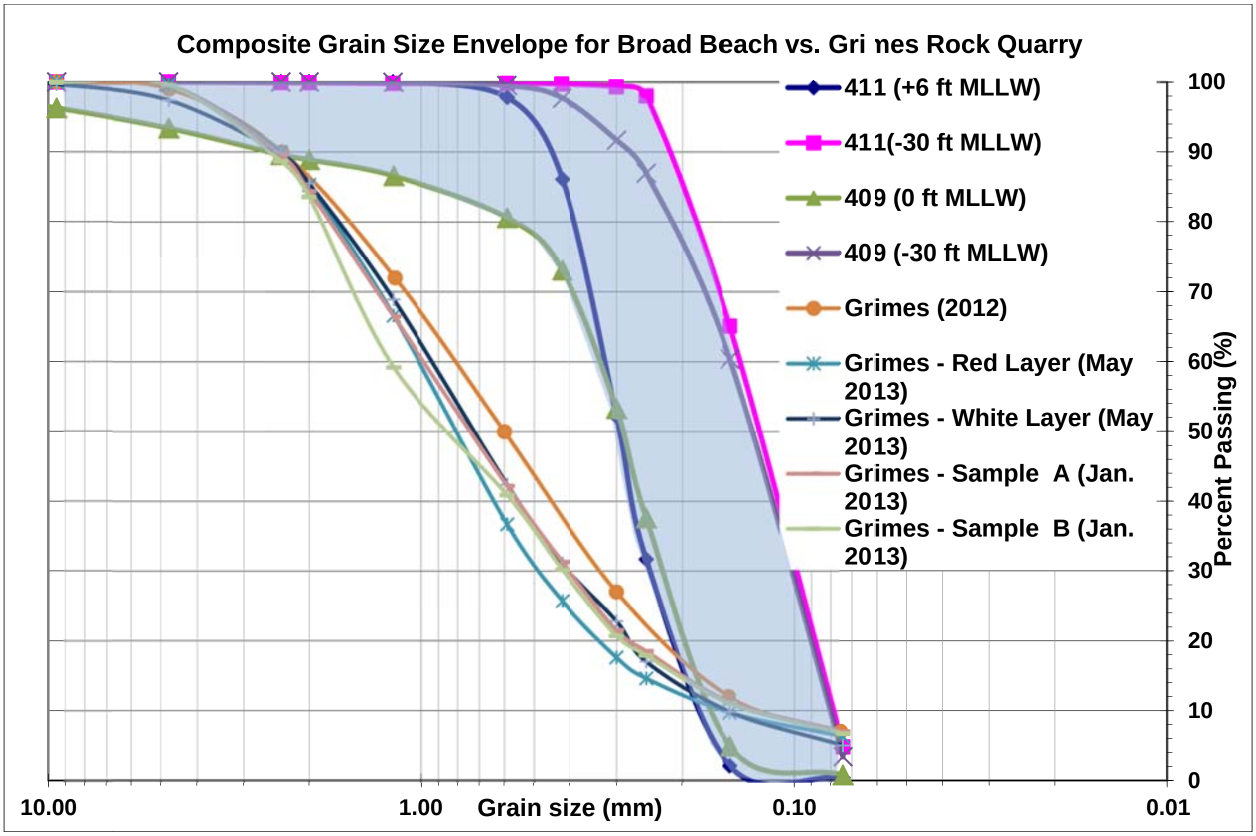

Figure 13. Broad Beach Composite Grain Size Envelope vs. Grimes Rock Quarry Material Gradation Results

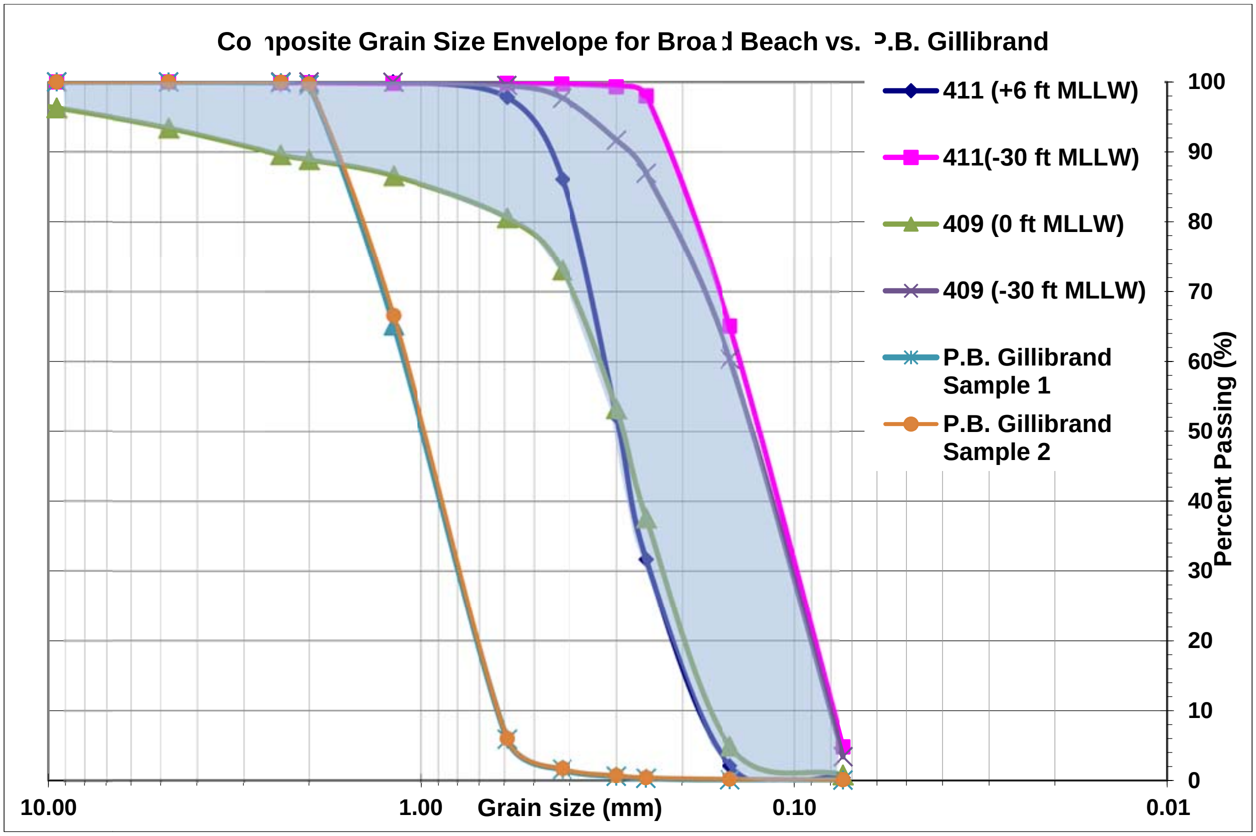

Figure 14. Broad Beach Composite Grain Size Envelope vs. P.W. Gillibrand Quarry Material Gradation Results

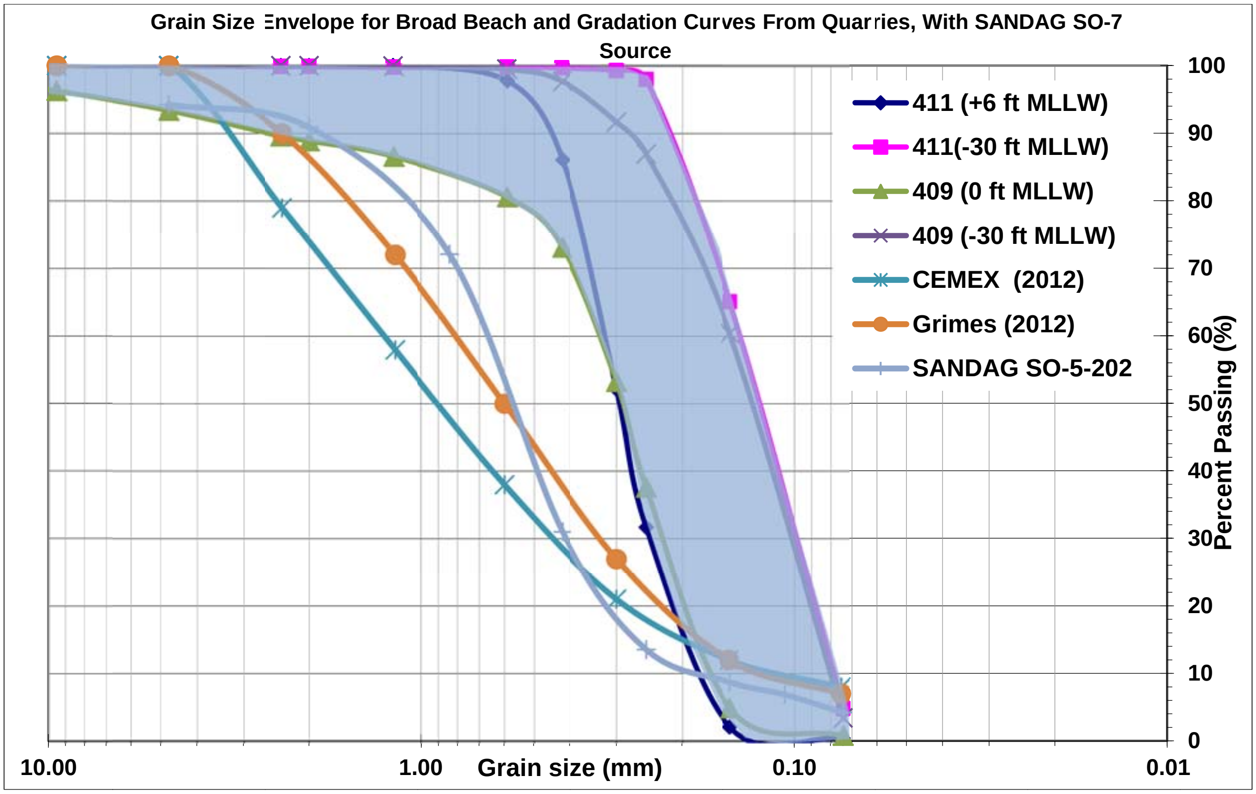

Figure 15. Grain Size Envelope for Broad Beach (In Blue Shading) Plotted Against Curves for Sand Proposed to be Used From Quarries, With Sand From SANDAG Offshore Site SO-5 for Reference.

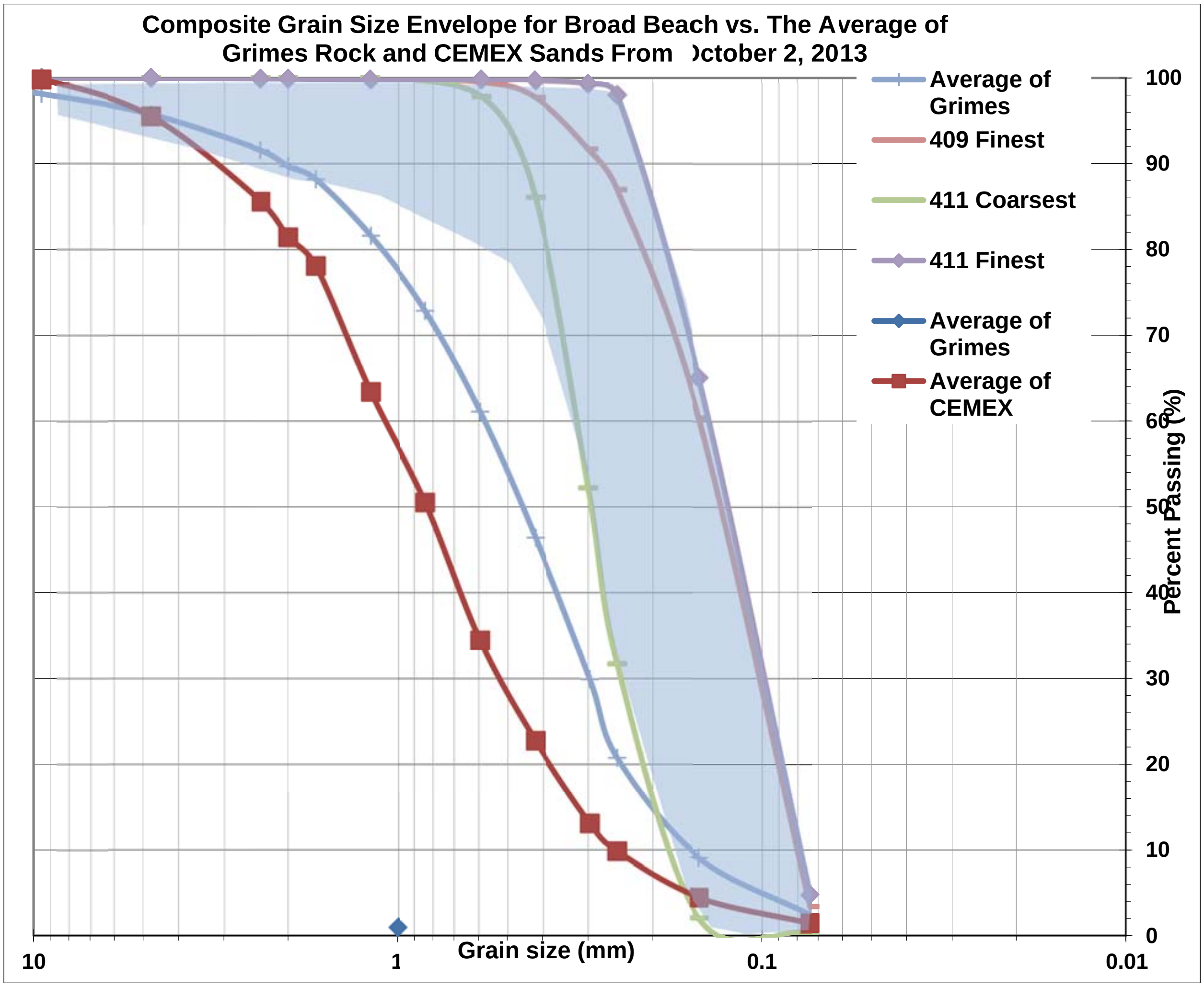

Figure .6. Broad Beach Grain Size Envelope vs The Average of CEMEX and Grimes Rock Sands on October 2, 2013

5.2 CHEMICAL TESTING

One chemistry sample from each of the three quarries was tested by a certified analytical laboratory (American Environmental Testing Laboratory in Burbank, CA) for a standard suite of bulk chemistry analytes, as specified in the ITM. The analysis included metals, polyaromatic hydrocarbons, phenols, chlorinated pesticides, and aroclors. Each chemistry sample was comprised of equal portions of four (4) discrete samples taken from stockpile "quadrants." This compositing technique is commonly used to address spatial variability in sediment composition. Chemistry results were compared to established numeric screening guidelines as used by the

EPA and the USACE for material compatibility determinations. Relevant screening levels and results are provided in Table 5.

The BBGHAD's engineer and lead consultant, M&N, found that no screening levels were exceeded in the results and, therefore, the material is free of contaminants.

Table 5. Chemistry Results Compared to Established Screening Levels

		RSL		CHHSL	NOAA Screening				
		Carcinogenic	**Noncancer**	**Residential Land Use**	**Salt ERL**	**Salt ERM**	Grimes Rock Quarry	P.W. Gillibrand Quarry	CEMEX Quarry
Valid Analyte Name	**Units**	**(mg/kg)**	**(mg/kg)**	**(mg/kg)**			**69605**	**69606**	**69607**
SEDIMENT CONVENTIONALS									
Percent Solids (total)	%						98.6	99.9	99.4
Total Organic Carbon	mg/kg dry						450	370	440
TPH (total)	mg/kg dry						ND	ND	ND
Solids, Volatile (%)	%						0.79	0.184	0.398
Total Sulfides	mg/kg dry						ND	ND	ND
Oil & Grease	mg/kg dry						ND	ND	ND
METALS									
Arsenic	mg/kg dry	0.39	22	0.07	8.2	70	1.74	ND	0.232
Cadmium	mg/kg dry	1800	70	1.7	1.2	9.6	ND	ND	ND
Chromium	mg/kg dry			100000	81	370	1.7	1.78	1.48
Copper	mg/kg dry		3100	3000	34	270	2.24	0.748	1.22
Lead	mg/kg dry		400	150	46.7	218	1.26	0.261	0.705
Mercury	mg/kg dry		5.6	18	0.15	0.71	ND	ND	ND
Nickel	mg/kg dry			1600	20.9	51.6	1.57	1.12	1.25
Selenium	mg/kg dry		390	380			ND	ND	ND
Silver	mg/kg dry		390	380	1	3.7	ND	ND	ND
Zinc	mg/kg dry		23000	23000	150	410	10.3	3.68	8
POLYAROMATIC HYDROCARBONS									
1-Methylnaphthalene	mg/kg dry								
1-Methylphenanthrene	mg/kg dry								
1,6,7-Trimethylnaphthalene	mg/kg dry								
2,6-Dimethylnaphthalene	mg/kg dry								
2-Methylnaphthalene	mg/kg dry				70	670			
Acenaphthene	mg/kg dry		3400000		16	500	ND	ND	ND
Acenaphthylene	mg/kg dry				44	640	ND	ND	ND
Anthracene	mg/kg dry		17000000		85.3	1100	ND	ND	ND
Benzo(a)anthracene	mg/kg dry	150			261	1600	ND	ND	ND
Benzo(a)pyrene	mg/kg dry	150		38	430	1600	ND	ND	ND
Benzo(b)fluoranthene	mg/kg dry	150					ND	ND	ND
Benzo(e)pyrene	mg/kg dry						ND	ND	ND
Benzo(g,h,i)perylene	mg/kg dry								
Benzo(k)fluoranthene	mg/kg dry	1500					ND	ND	ND
Biphenyl	mg/kg dry								
Chrysene	mg/kg dry	15000			384	2800	ND	ND	ND
Dibenzo(a,h)anthracene	mg/kg dry	150			63.4	260	ND	ND	ND
Dibenzothiophene	mg/kg dry								
Fluoranthene	mg/kg dry		2300000		600	5100	ND	ND	ND
Fluorene	mg/kg dry		2300000		19	540			
Indeno(1,2,3-cd)pyrene	mg/kg dry	150					ND	ND	ND

		RSL		CHHSL	NOAA Screening				
		Carcinogenic	Noncancer	Residential Land Use	Salt ERL	Salt ERM	Grimes Rock Quarry	P.W. Gillibrand Quarry	CEMEX Quarry
Valid Analyte Name	**Units**	**(mg/kg)**	**(mg/kg)**	**(mg/kg)**			**69605**	**69606**	**69607**
Naphthalene	mg/kg dry		140000		160	2100	ND	ND	ND
Perylene	mg/kg dry								
Phenanthrene	mg/kg dry				240	1500	ND	ND	ND
Pyrene	mg/kg dry		1700000		665	2600	ND	ND	ND
Total Low Weight PAHs	mg/kg dry				552	3160	ND	ND	ND
Total High Weight PAHs	mg/kg dry				1700	9600	ND	ND	ND
Total PAHs	mg/kg dry				4022	44792	ND	ND	ND
ORGANICS - PHENOLS									
2,4,6-Trichlorophenol	mg/kg dry						ND	ND	ND
2,4-Dichlorophenol	mg/kg dry						ND	ND	ND
2,4-Dimethylphenol	mg/kg dry		1200000				ND	ND	ND
2,4-Dinitrophenol	mg/kg dry						ND	ND	ND
2-Chlorophenol	mg/kg dry						ND	ND	ND
2-Methyl-4,6-dinitrophenol	mg/kg dry						ND	ND	ND
2-Nitrophenol	mg/kg dry						ND	ND	ND
4-Chloro-3-methylphenol	mg/kg dry						ND	ND	ND
4-Nitrophenol	mg/kg dry						ND	ND	ND
Pentachlorophenol	mg/kg dry	3000	1400000	4400			ND	ND	ND
Phenol	mg/kg dry		18000000				ND	ND	ND
CHLORINATED PESTICIDES									
2,4'-DDD	ug/kg dry	2000		2300					
2,4'-DDE	ug/kg dry	1400		1600					
2,4'-DDT	ug/kg dry	1700	36000	1600					
4,4'-DDD	ug/kg dry	2000		2300	2	20	ND	ND	ND
4,4'-DDE	ug/kg dry	1400		1600	2.2	27	ND	ND	ND
4,4'-DDT	ug/kg dry	1700	36000	1600	1	7	ND	ND	ND
Total DDT	ug/kg dry				1.58	46.1			
Aldrin	ug/kg dry	29	1800	33			ND	ND	ND
BHC-alpha	ug/kg dry						ND	ND	ND
BHC-beta	ug/kg dry						ND	ND	ND
BHC-delta	ug/kg dry						ND	ND	ND
BHC-gamma	ug/kg dry						ND	ND	ND
Chlordane-alpha	ug/kg dry						ND	ND	ND
Chlordane-gamma	ug/kg dry						ND	ND	ND
cis-Nonachlor	ug/kg dry								
DCPA (Dacthal)	ug/kg dry				0.02	8			
Dicofol	ug/kg dry								
Dieldrin	ug/kg dry	30	3100	35			ND	ND	ND
Endosulfan Sulfate	ug/kg dry		370000				ND	ND	ND
Endosulfan-I	ug/kg dry						ND	ND	ND
Endosulfan-II	ug/kg dry						ND	ND	ND
Endrin	ug/kg dry		18000	21000			ND	ND	ND

		RSL		CHHSL	NOAA Screening				
		Carcinogenic	Noncancer	Residential Land Use	Salt ERL	Salt ERM	Grimes Rock Quarry	P.W. Gillibrand Quarry	CEMEX Quarry
Valid Analyte Name	**Units**	**(mg/kg)**	**(mg/kg)**	**(mg/kg)**			**69605**	**69606**	**69607**
Endrin Aldehyde	ug/kg dry						ND	ND	ND
Endrin Ketone	ug/kg dry						ND	ND	ND
Heptachlor	ug/kg dry	110	31000	130			ND	ND	ND
Heptachlor Epoxide	ug/kg dry	53	790				ND	ND	ND
Methoxychlor	ug/kg dry			340000			ND	ND	ND
Mirex	ug/kg dry	27	12000	31					
Oxychlordane	ug/kg dry								
Perthane	ug/kg dry								
Toxaphene	ug/kg dry	440		460			ND	ND	ND
trans-Nonachlor	ug/kg dry								
Total Chlordane[2]	ug/kg dry	1600	35000	430	0.5	6	ND	ND	ND
ORGANICS - AROCLORS									
Aroclor 1016	ug/kg dry						ND	ND	ND
Aroclor 1221	ug/kg dry						ND	ND	ND
Aroclor 1232	ug/kg dry						ND	ND	ND
Aroclor 1242	ug/kg dry						ND	ND	ND
Aroclor 1248	ug/kg dry						ND	ND	ND
Aroclor 1254	ug/kg dry						ND	ND	ND
Aroclor 1260	ug/kg dry						ND	ND	ND
Total Aroclor PCBs	ug/kg dry			89	22.7	180	ND	ND	ND

ND: non-detect – means the constituent being tested for was below the detection limit of the testing lab.

5.3 CONCLUSIONS

Based on the results of this evaluation, stockpiled materials at Grimes Rock, CEMEX, and P.W. Gillibrand quarries are compatible for use as beach nourishment. Quarry sand grain size is generally coarser than the sand on the beach, but that presents advantages as beach fill material with minimal disadvantages. Advantages are that the material will reside on the beach longer, create a wider berm play area, and remain higher on the profile with less intrusion into the intertidal zone habitat area. Disadvantages are a steeper post-construction beach profile at the placement site, and potentially at downcoast beaches if material disperses from the placement site. This disadvantage is short-term and eventually becomes non-existent as the beach profiles at the placement site and downdrift beaches revert back to pre-construction conditions, generally within a year. Results of the second sampling effort performed in October of 2013 confirm that quarry sand is suitable as beach fill, complementing results from the May 2013 sampling effort.

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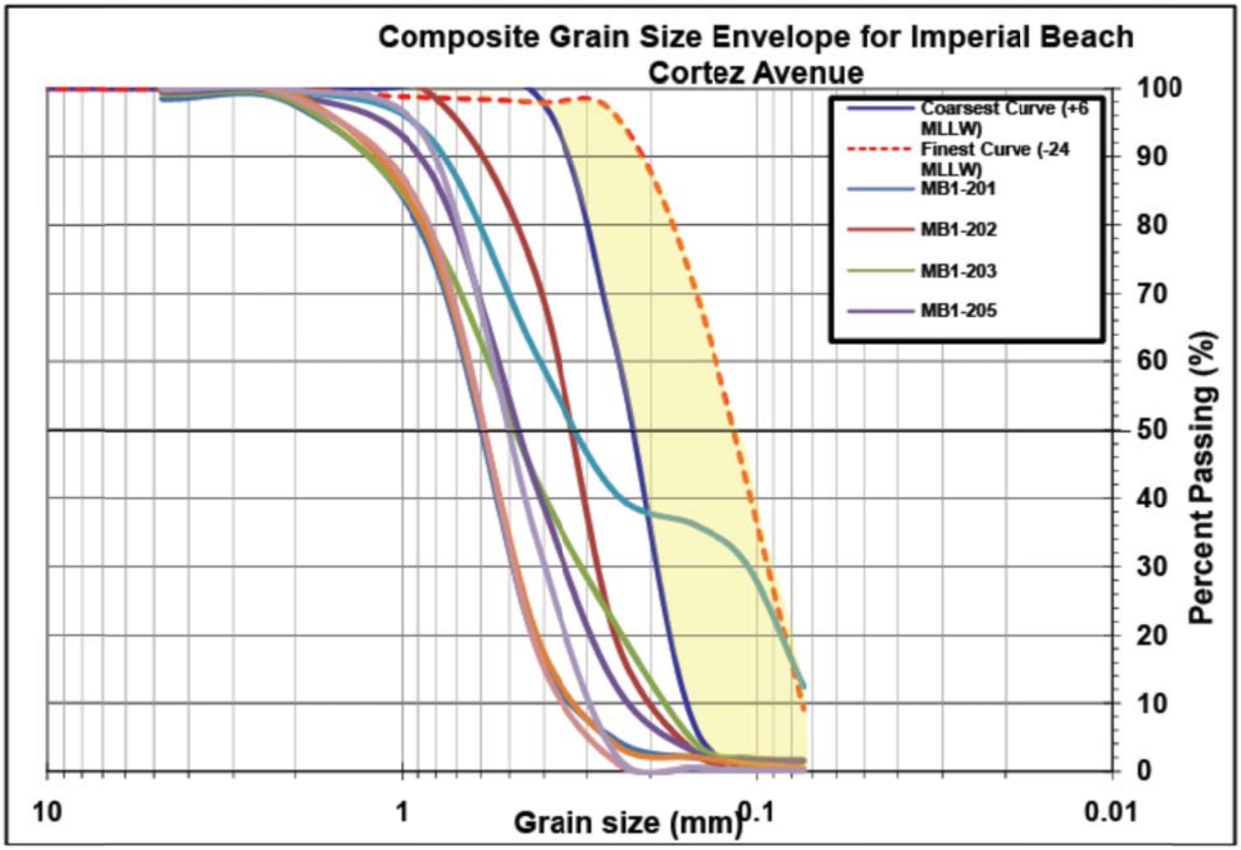
APPENDIX A

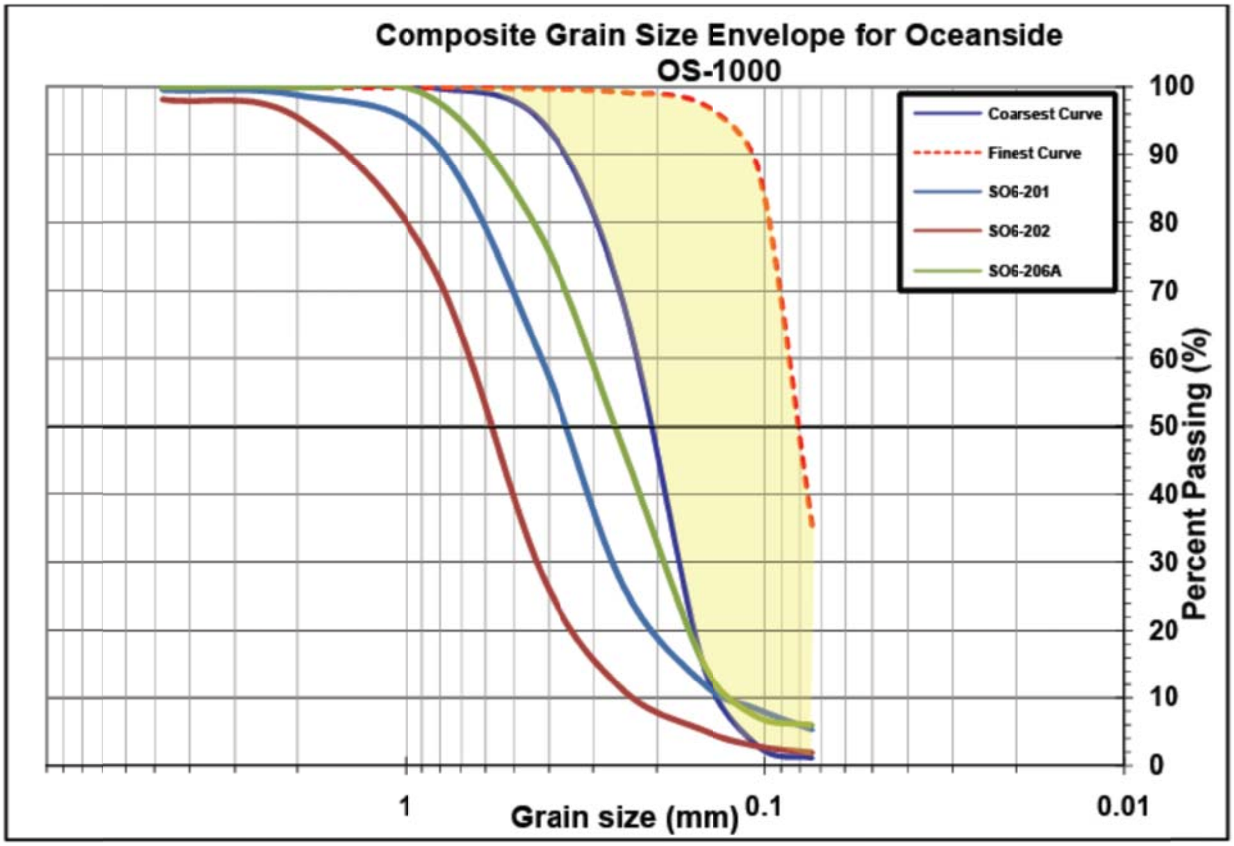
GRADATION CURVES FOR SAN DIEGO COUNTY BEACHES

AND OFFSHORE SAND USED FOR NOURISHMENT FOR SANDAG RBSP II



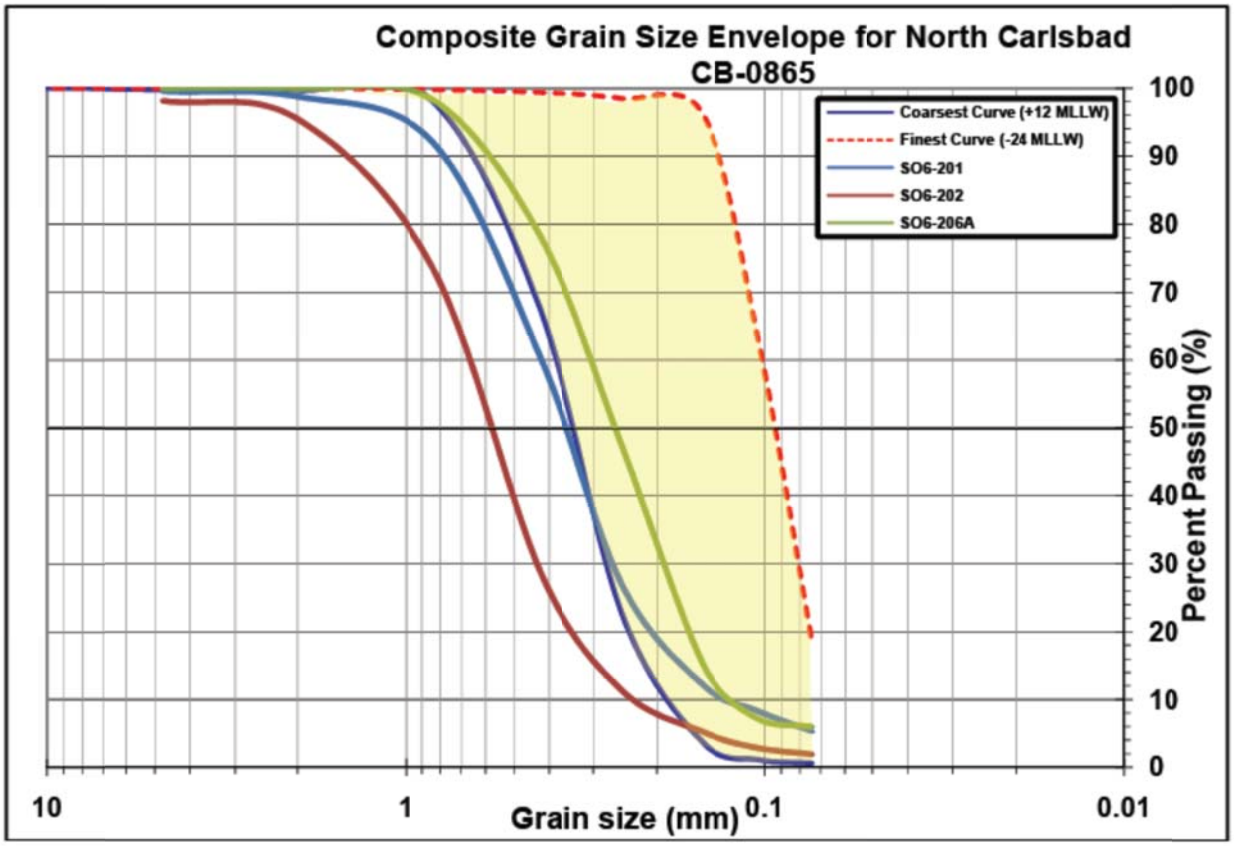
Grain Size Envelope for Imperial Beach (In Yellow Shading) Plotted Against Curves for Sand Dredged From Offshore Site MB01 Off Mission Beach in 2012. The Source Sand Falls Entirely Outside of Beach Envelope.

Imperial Beach Received 450,140 Cubic Yards of This Sand From September 7 to October 4, 2012. The Median Grain Size of The Sand Placed at This Site Was 0.53 Millimeters.



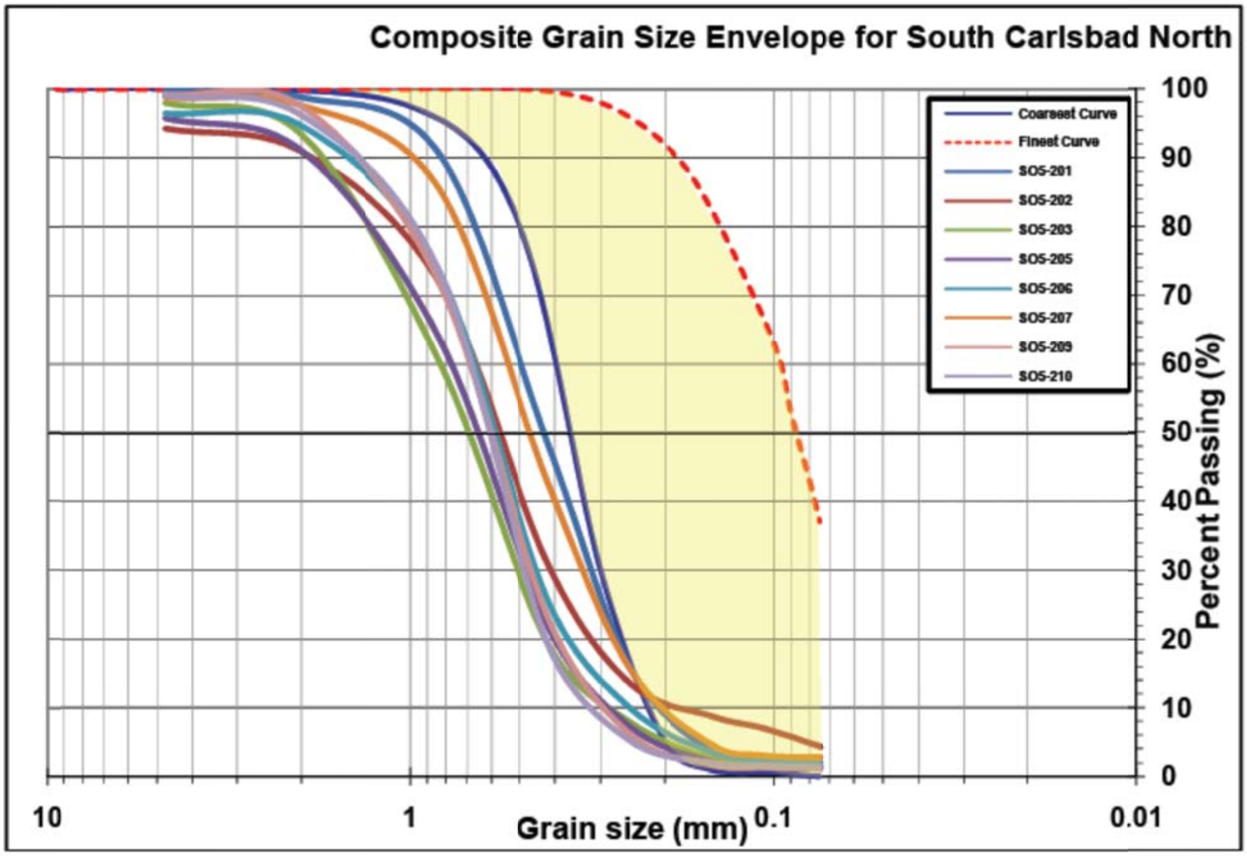
Grain Size Envelope (In Yellow Shading) for South Oceanside Beach Plotted Against Curves for Sand Dredged From Offshore Site SO-6 Off Cardiff in 2012. The Source Sand Falls Outside of Beach Envelope Except for the Low (Fine) End of the Curves.

South Oceanside Received 292,822 Cubic Yards of This Sand From October 5 - 20, 2012. The Median Grain Size of The Sand Placed at This Site Was 0.54 Millimeters.



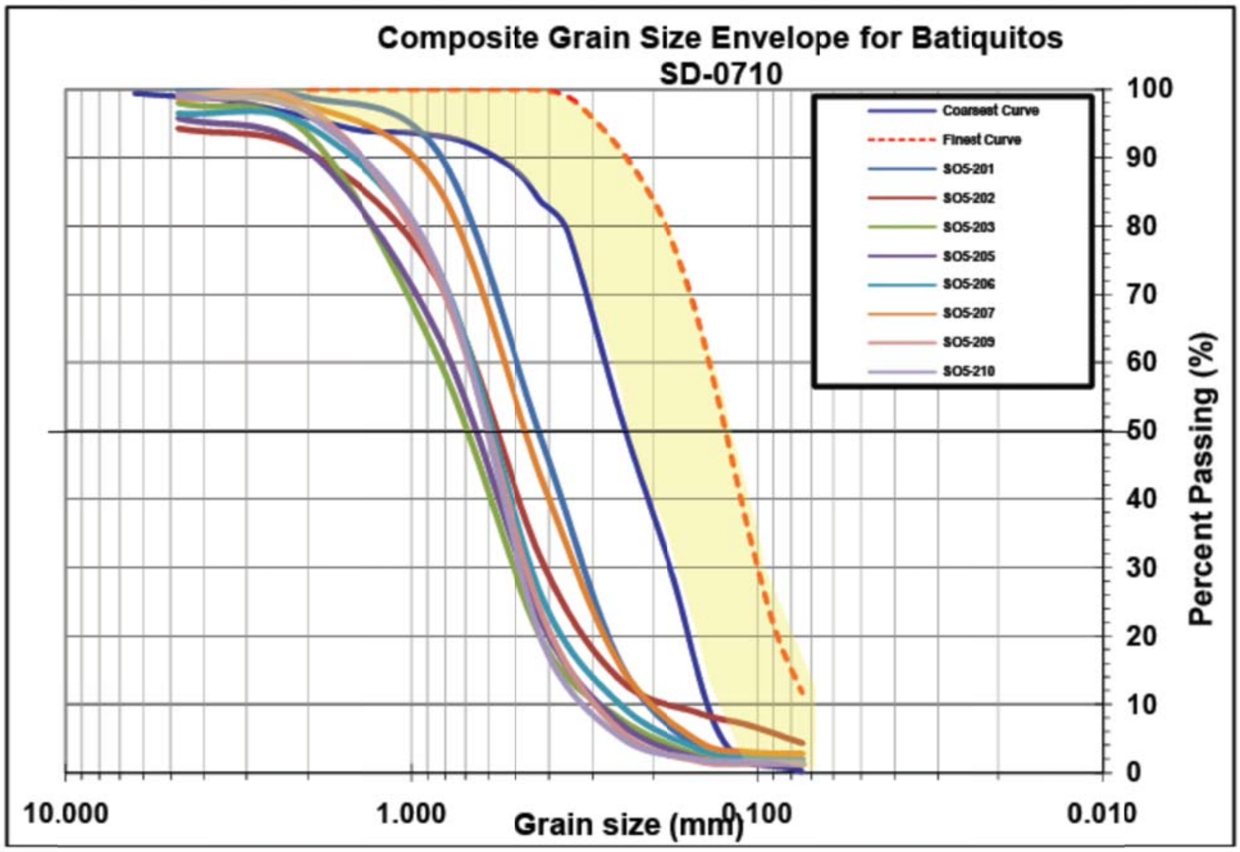
Grain Size Envelope (In Yellow Shading) for North Carlsbad B :ach Plotted Against Curves for and Dredg :d From Offshore Site SO-6 Off Cardiff in 2012. Note That This Sand Source Was Not Used for This Site, But Rather Coarser Sand From SO -5 Was Used to Nourish This B :ach. The SO-5 Sand Source Falls O utside of Beach Envelope.

North Carlsbad Received 218,728 Cubic Yards of This San d From November 24 to December 7, 2012. The Median Grain Size of T ie Sand Pla :ed at This Site Was 0.57 Millimeters.



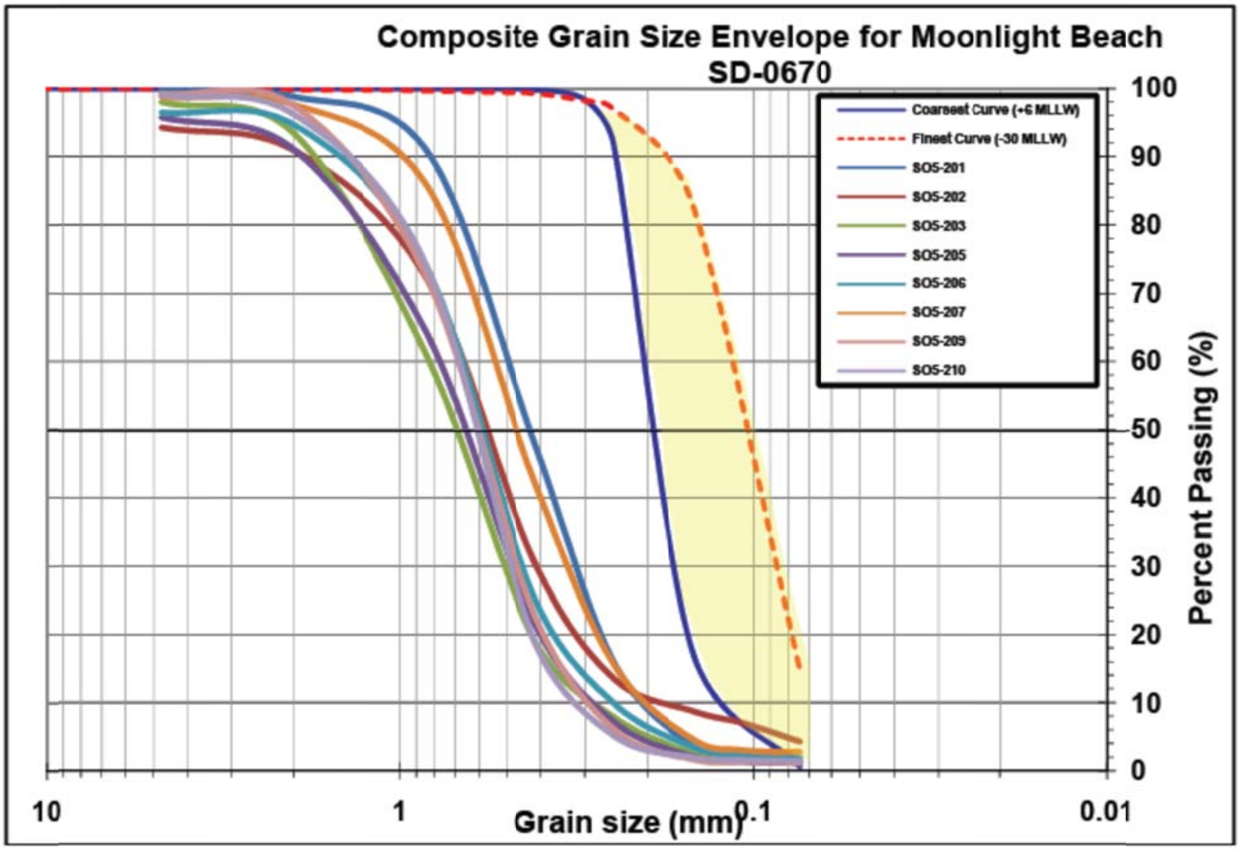
Grain Size Envelope (In Yellow Shading) for South Carlsbad Beach North Plotted Against Curves for Sand Dredged From Offshore Site SO-5 Off Del Mar in 2012. The Source Sand Falls Outside of Beach Envelope Except for the Low (Fine) End of the Curves.

South Carlsbad North Received 140,763 Cubic Yards of This Sand From November 15 - 23, 2012. The Median Grain Size of The Sand Placed at This Site Was 0.66 Millimeters.



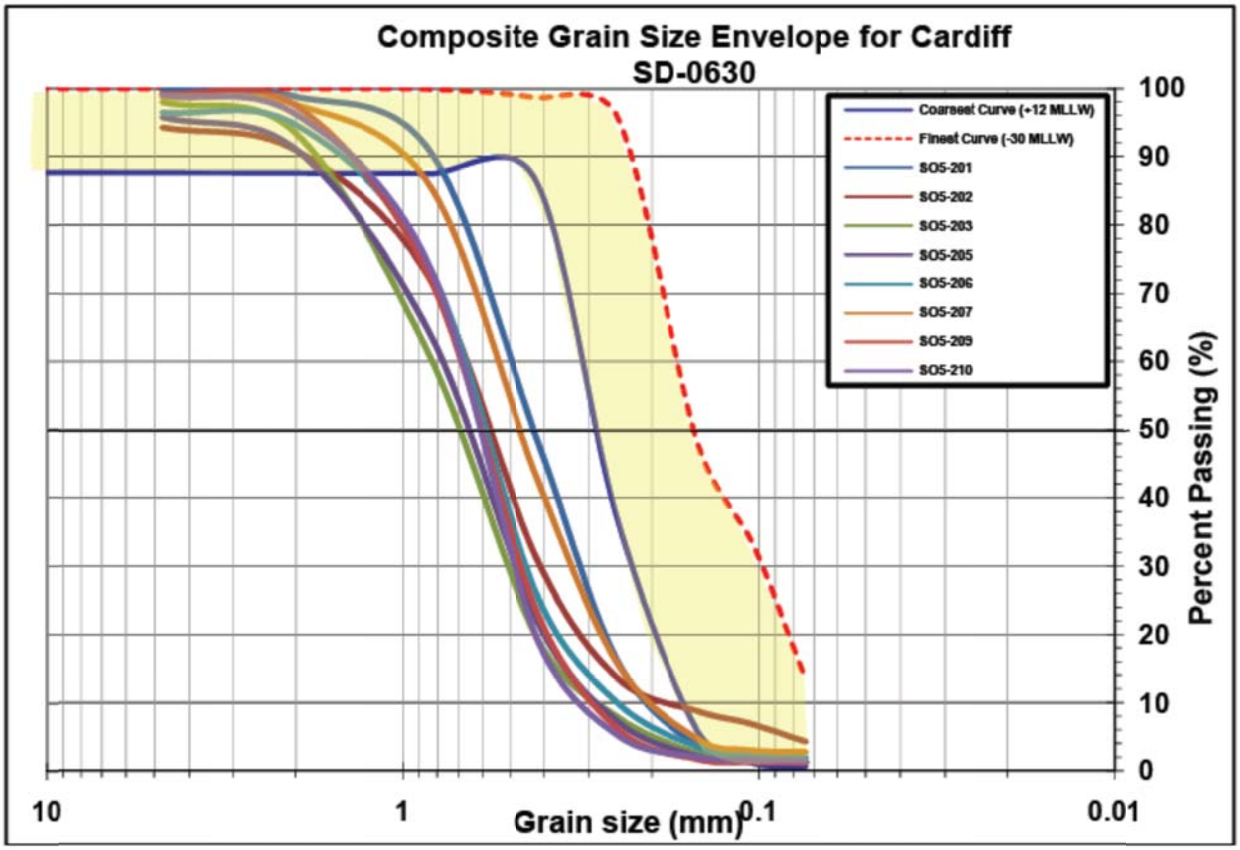
Grain Size Envelope (In Yellow Shading) for Batiquitos Beach North Plotted Against Curves for Sand Dredged From Offshore Site SO-5 Off Del Mar in 2012. The Source Sand Falls Outside of Beach Envelope Except for the Highest (Coarse) and Lowest (Fine) Ends of the Curves.

Batiquitos Beach Received 106,052 Cubic Yards of This Sand From October 28 to November 24, 2012. The Median Grain Size of The Sand Placed at This Site Was 0.59 Millimeters.



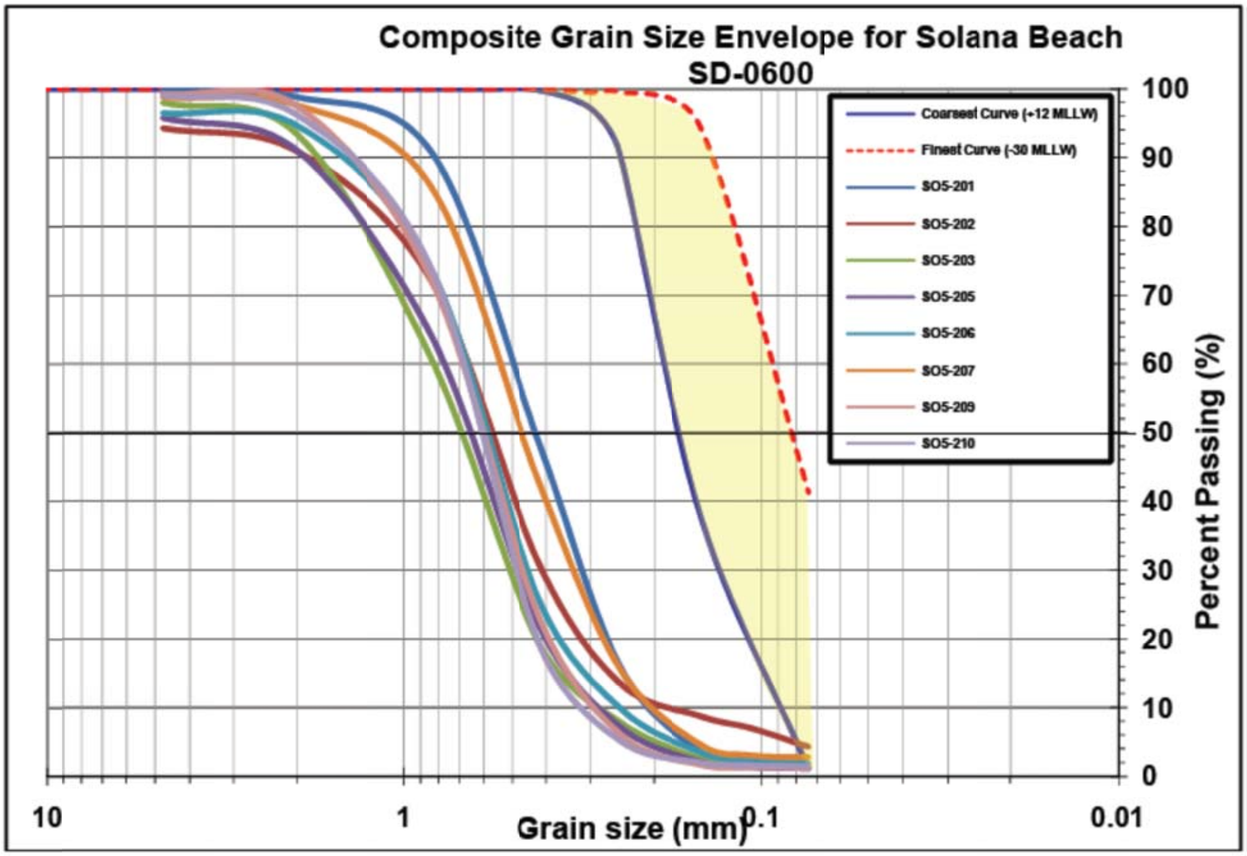
Grain Size Envelope (In Yellow Shading) for Moonlight Beach Plotted Against Curves for Sand Dredged From Offshore Site SO-5 Off Del Mar in 2012. The Source Sand Falls Outside of Beach Envelope Except for the Very Lowest (Fine) End of the Curves.

Moonlight Beach Received 92,287 Cubic Yards of This Sand From October 20 - 25, 2012. The Median Grain Size of The Sand Placed at This Site Was 0.48 Millimeters. The Median Grain Size was Lower at This Site Than at Other Sites Because It was the First to Receive Sand From SO-5 and Received Fines a Surface Layer Over the Dredge Site.



Grain Size Envelope (In Yellow Shading) for Cardiff Beach Plotted Against Curves for Sand Dredged From Offshore Site SO-5 Off Del Mar in 2012. The Source Sand Falls Outside of Beach Envelope Except for the Highest (Coarse) and Lowest (Fine) Ends of the Curves.

Cardiff Beach Received 88,751 Cubic Yards of This Sand From October 25 - 28, 2012. The Median Grain Size of The Sand Placed at This Site Was 0.57 Millimeters.



Grain Size Envelope (In Yellow Shading) for Solana Beach Plotted Against Curves for Sand Dredged From Offshore Site SO-5 Off Del Mar in 2012. The Source Sand Falls Entirely Outside of Beach Envelope.

Solana Beach Received 142,430 Cubic Yards of This Sand From November 4 - 27, 2012. The Median Grain Size of The Sand Placed at This Site Was 0.55 Millimeters.

BROAD BEACH RESTORATION PROJECT

UPLAND SAND SOURCE

COARSER-THAN-NATIVE GRAIN SIZE IMPACT ANALYSIS

Prepared for:

Broad Beach Geologic Hazard Abatement District

Prepared by:

moffatt & nichol

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November 2013

Contents

Figures

Tables

1.0 Introduction

The Broad Beach Geologic Hazard Abatement District (BBGHAD) proposes to nourish the Broad Beach coastal area and create dunes using sand from up to three inland quarries. The proposed project is presented in detail in the Project Description document and the Coastal Engineering Report submitted to both the California Coastal Commission (CCC) and the State Lands Commission (SLC) and used as the basis for environmental review. Sand from these quarries is coarser in grain size than native sand at Broad Beach. Table 1 below shows the median grain size of quarry sand compared to the native beach sand. Since the outset of this project, the BBGHAD's Engineer, Moffatt & Nichol (M&N), has encouraged the use of "coarser than native" grain size sand for beach nourishment, and hence recommends use of the identified sources of inland quarry sand. Coarser than native sand presents significant performance benefits to the littoral zone with little, if any, negative impact. Better physical performance implies a wider dry beach and greater longevity, thereby maximizing both benefits to the public and the BBGHAD's economic investment.

Table 1. Sand Median Grain Sizes

Sand Identification	Median Grain Size (in Millimeters)
Broad Beach – Beach Sample Above 0' MLLW	0.25
Broad Beach Dunes	0.32
Zuma Beach (3 Locations Along its Reach)	0.40
Grimes Rock Quarry	0.47
CEMEX Quarry	0.85
P.W. Gillibrand Quarry	1.00

The recommendation to nourish with sand coarser than native is neither novel nor unique. Previous beach nourishment projects in Southern California have used sand coarser than the native beach for nourishment, largely for the identical reasons as posed by the BBGHAD and M&N. Simply, the coarser sand performs better than finer grained sand by staying on the beach longer. Grain size can be characterized by its median grain size diameter (represents the average grain size of the material) and is expressed in millimeters (mm). Example Southern California projects that used sand coarser than native sand for nourishment are:

- 75,000 cubic yards (cy) at Seal Beach in 1997-98 (native beach sand = 0.35 mm; beach fill = 0.59 mm);

- 75,000 cubic yards (cy) at Seal Beach in 2009 (native beach sand = 0.35 mm; beach fill = 0.42 mm);
- 2 million cy at Surfside Colony/Sunset Beach in 2009/2010 (native sand = 0.25 mm; beach fill = 0.42 mm);
- 2.1 million cy by SANDAG in 2001 (native beaches = 0.25 mm; beach fill at 6 of 12 sites was 0.62 mm); and
- 1.5 million cy by SANDAG in 2012 (native beaches = 0.25 mm; beach fill was up to 0.61 mm).
- Native at Broad Beach = 0.25 mm; 600,000 cy proposed beach fill is between 0.60 and 1.00 mm, depending on the quarry or quarries used as the sand source(s).

The specific sand gradation statistics of mean grain size diameter, and the variations from the mean (D_{84} and D_{16}) are provided in Table 2 below for four recent nourishment projects. Each of these projects utilized sand coarser than the receiving beach for nourishment.

Table 2. Sand Gradation Statistics for Recent Nourishment Projects

Project	Sand Source	Quantity (Cubic Yards)	Sand Gradation Statistics			
			Existing Beach	Nourishment Sand		
			D_{50}	D_{84}	D_{50}	D_{16}
Seal Beach 1997-1998	Palmdale – Holliday Rock Quarry	75,000	0.33	2.00	0.59	0.21
SANDAG 2001	Multiple Offshore Sources – SO-7 Served Most of North County	828,000	0.25	Not Available	0.62	Not Available
Seal Beach 2009	Offshore Surfside/Sunset Beach	75,000	0.33	1.13	0.42	0.25
SANDAG 2012	Multiple Offshore Sources – SO-5 Served Most of North County	789,011	0.25	1.57	0.61	0.27

Gradation curves for the proposed quarry sand and existing Broad Beach sand are shown in Appendix A. The curves indicate that the proposed quarry material is coarser than the existing beach, as intended for optimum performance and effect. For context, the same types of curves for San Diego County beaches are provided in Appendix B. In San Diego County, 1,531,973 cy of sand coarser than that at any of the receiving beaches was used for nourishment in 2012. One of the San Diego sites, Imperial Beach, received 450,140 cy of sand, similar to the volume proposed for Broad Beach. Although the quarry sand proposed for Broad Beach lies outside of the gradation curve (except at the coarse and fine ends), the sand is high quality for nourishment to meet the competing needs of resisting erosion, providing backshore protection, enhancing recreation, and providing substrate for habitat. Permit agencies have requested more information on the sand's effect on beach use and ecology, as well as the suitability of the coarser sand for dune restoration. We also want to address potential concerns that might be posed by the public as part of the environmental review process. The BBGHAD has requested information to help respond to these issues. M&N provides this report for these purposes.

The Broad Beach Restoration Project is intended to help offset a sediment budget imbalance at an eroding area of coast and, to the extent possible and feasible, provide a coastal beach and dune environment reminiscent of earlier decades (before prevalent erosion). The BBGHAD cannot exactly re-create historical conditions at the site, and does not attempt to do so because, among other reasons, the relative coarseness of the native sand rendered the beach and dune areas prone to high rates of erosion. In fact, as noted in other reports submitted to the CCC and SLC, sand has eroded off of Broad Beach at the rate of 35,000 - 50,000 cubic yards per year for more than a decade. The condition of the future nourished beach will not be the same as the historic wide beach because the sand composing the proposed beach fill will be coarser. However, the future beach will be restored to a widened condition for a longer period of time than has occurred in recent decades. Moreover, the proposed material will allow for the re-establishment of a healthy beach and dune environment at Broad Beach.

2.0 Objective of These Analyses

Sand proposed for Broad Beach nourishment is coarser than other sand sources previously considered for this project, e.g., the Dockweiler offshore sand source, Ventura Harbor sand source, and coarser than the existing beach by intent. These analyses address the agencies' request for analysis of its performance both physically and ecologically.

- Physical performance - final beach berm width, beach slope, and the equilibrium beach profile (on-site effects), and the rate and pattern of sand dispersion (downcoast effects).
- Ecological performance - how it affects existing habitat and provides new habitat for intertidal species and dune species.

3.0 Physical Performance

Physical parameters that describe the characteristics and performance of sand used for beach fill include width of the berm, the beach profile, and rate of dispersion from the placement site. Each parameter is discussed below. Resulting maintenance considerations and ramifications on sand backpassing are also provided.

3.1 Beach Berm Width

The use of sand coarser than the receiving beach results in formation of a wider beach berm than would be formed by finer sand. The beach berm is the level, recreational area on a beach, often referred to as the dry beach or "towel area." Formation of a wide berm is due to the ability of coarser sand to withstand higher energy of wave attack than finer sand, and therefore remain in place longer over time. The wider berm provides for a greater beach recreational area, and a higher level of protection for infrastructure behind the beach than a narrower berm. Figure 1 through Figure 3, from the U.S. Army Corps of Engineers Coastal Engineering Manual (CEM 2012), shows the concept of a wider beach berm forming from using coarser sand for beach fill. Finer sand used for beach fill results in narrower beach berms.

The resulting berm width to form from coarser sand will be slightly different than historical conditions, but will not present an adverse effect. The most significant benefit of a wider berm is maximum beach width for the cost of the project.

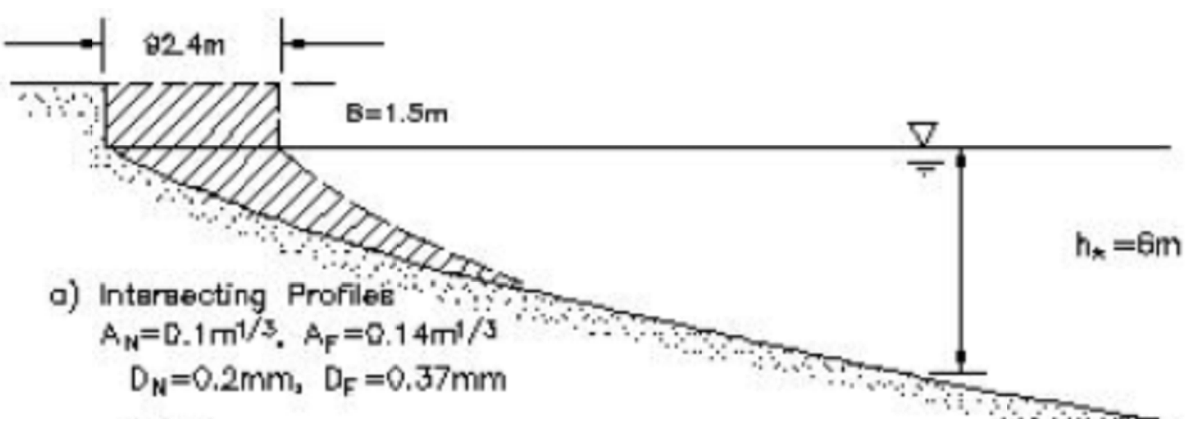


Figure 1. Beach Berm Width From Using Coarser Beachfill Sand Size Than Native Sand

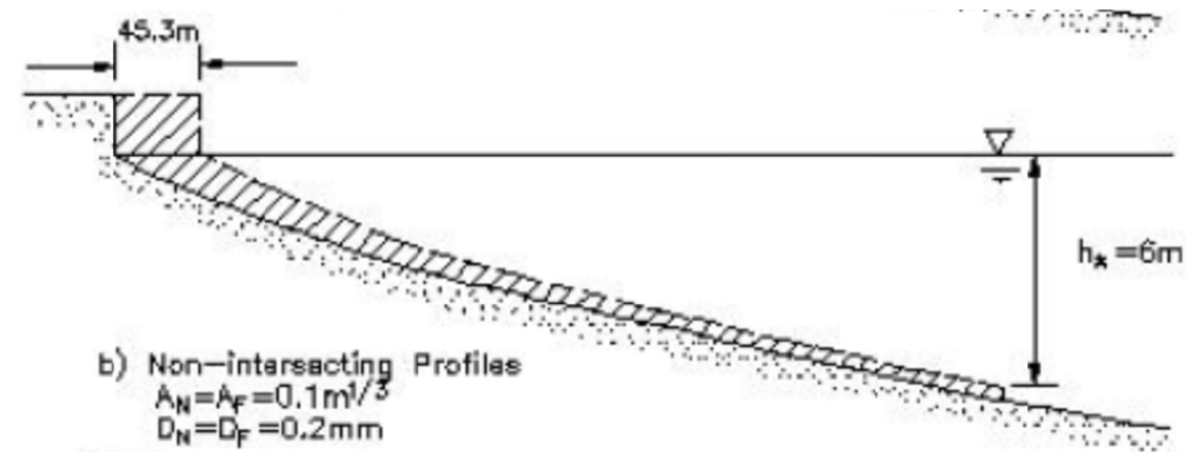


Figure 2. Beach Berm Width From Using The Same Beachfill Sand Size As Native Sand

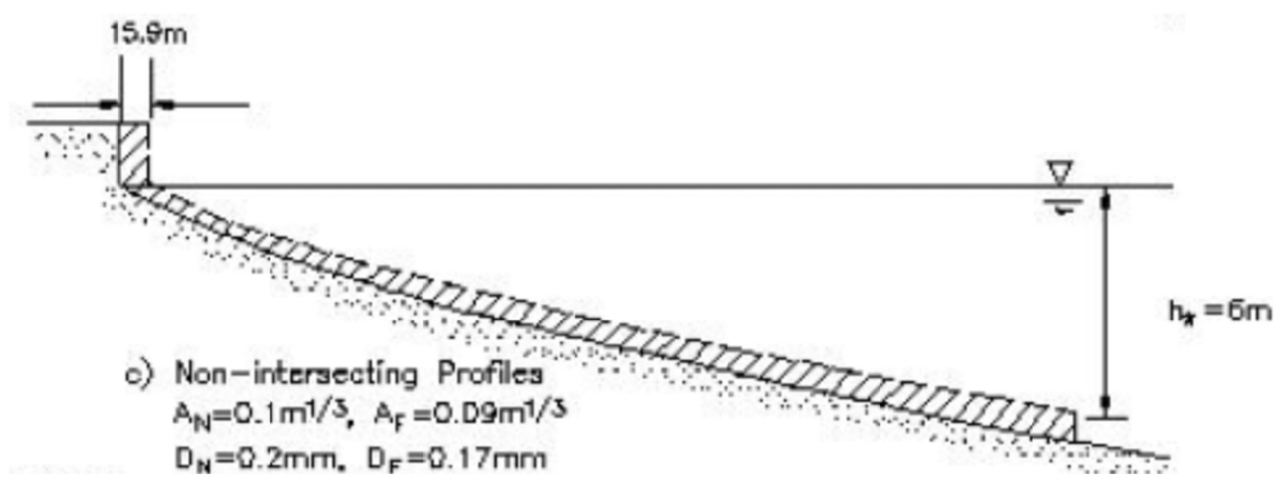


Figure 3. Beach Berm Width From Using Finer Beachfill Sand Size Than Native Sand

3.2 Equilibrium Beach Profile

In addition to the wider beach berm, coarser sand forms a steeper equilibrium beach profile from the berm to the water (the upper beach profile) than finer sand. This is due to the coarser sand remaining higher on the beach profile than finer sand. By remaining relatively higher on the beach profile, the coarser sand will not extend as far into the intertidal area as a fill using finer sand. The toe of the fill will not extend as far offshore into rocky intertidal habitat as would a fill composed of finer sand. Figure 4 shows equilibrium beach profiles for coarse sand (e.g., Grimes, CEMEX, and Gillibrand) and finer sand. The coarser sand sits higher on the profile and produces a wider beach berm than finer sand, and the toe of the fill does not reach as far into the subtidal habitat zone. Figure 5 is a cross-section of the beach for existing and future conditions, assuming coarser sand as beach fill. The existing beach profile is gently sloping and low, with very little variation over its length, while the proposed beach is somewhat steeper along the upper profile and flattens toward its toe.

3.3 Rate of Dispersion from the Placement Site

Beach fill sand disperses from placement sites by waves and currents. Given a particular sand grain size, higher waves and currents generally disperse beach fill material more rapidly than lower waves and currents. Assuming a given set of conditions of waves and currents, larger grain-sized sand disperses more slowly than finer-grain sized sand. Therefore, the relatively coarse-grained material proposed for nourishment at Broad Beach should disperse relatively slowly compared to finer sand, assuming average ocean wave and current conditions. This will extend the life of the beach nourishment, both on the initial receiver beach (Broad Beach) and the downdrift beaches that will be nourished by this fill via littoral transport (Zuma Beach and beyond into Santa Monica Bay).

Sand dispersion at Broad Beach is challenging to predict in an exact fashion, but tools exist to provide order of magnitude estimates. One useful tool is predicting sand dispersion using methods for sand diffusion developed by researchers and presented in detail in the Coastal Engineering Report. Another applicable tool is analyses of monitoring data from 2001 projects in San Diego County.

3.3.1 Diffusion Method

The analysis of sand dispersion using the diffusion method is presented in the Coastal Engineering Report to support the environmental document. Section 9.2.1 of that document presents the diffusion method, and an analysis of finer-grained and coarser-grained sand. The finer-grain sand is specified at 0.25 mm in grain size diameter, and the coarse-grained sand is specified at 0.85 mm in diameter. The analysis shows the coarser beach fill will disperse over time with gradually reducing fill remaining over 10 years. Figure 6 graphically shows the fill dispersing from the placement area (centered on longshore position 0) toward the southeast over time. The width of the beach berm is progressively reduced from approximately 150 feet initially, to approximately:

- 100 feet at the end of year 1,
- 75 feet at year 2,
- 60 feet at year 3,
- 50 feet at year 4,
- 40 feet at year 5,
- 30 feet at year 7, and
- 10 feet at year 10.

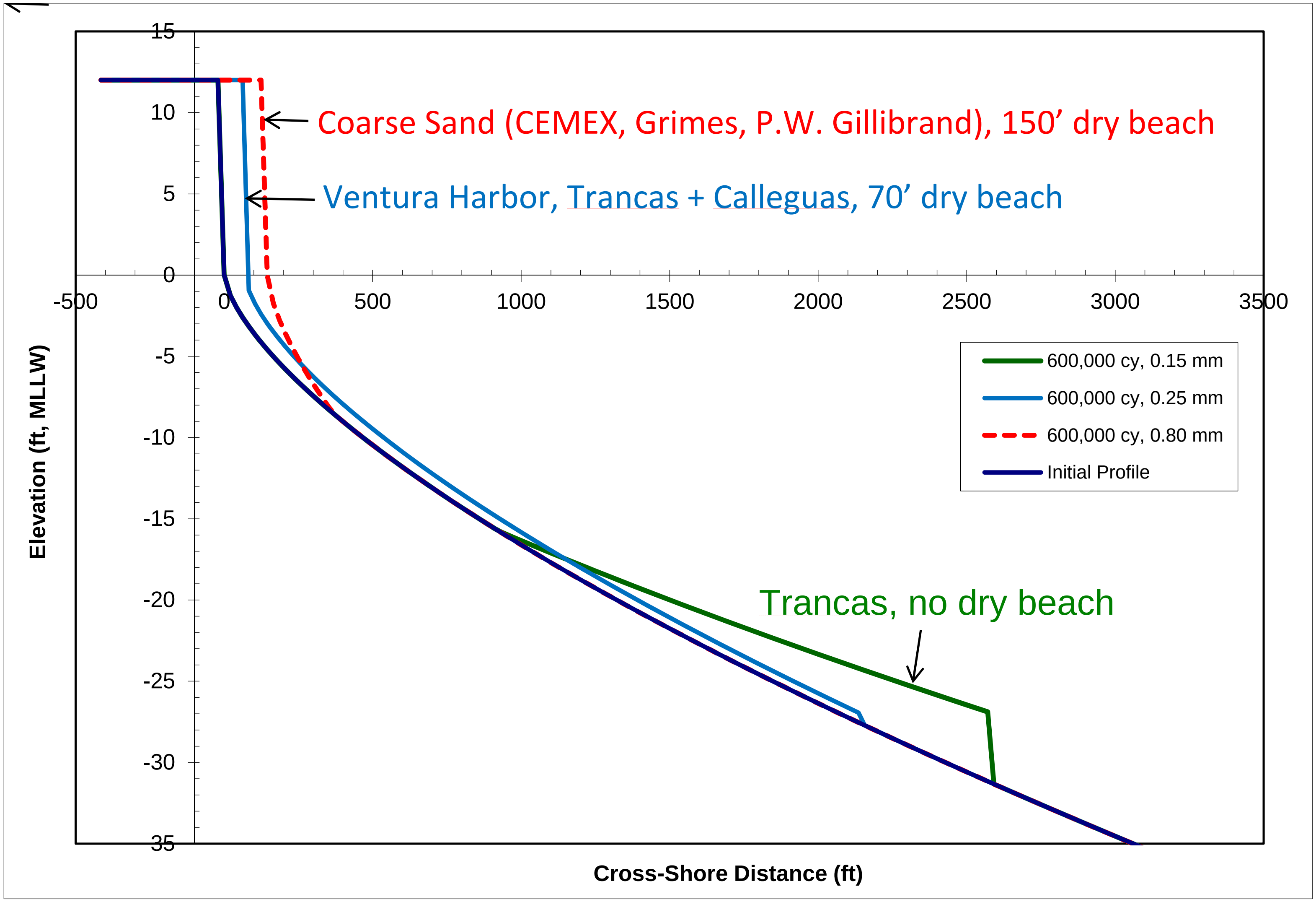


Figure 4. Equilibrium Beach Profiles for Coarse and Fine Sand Compared to the Initial Profile (M&N 2012)

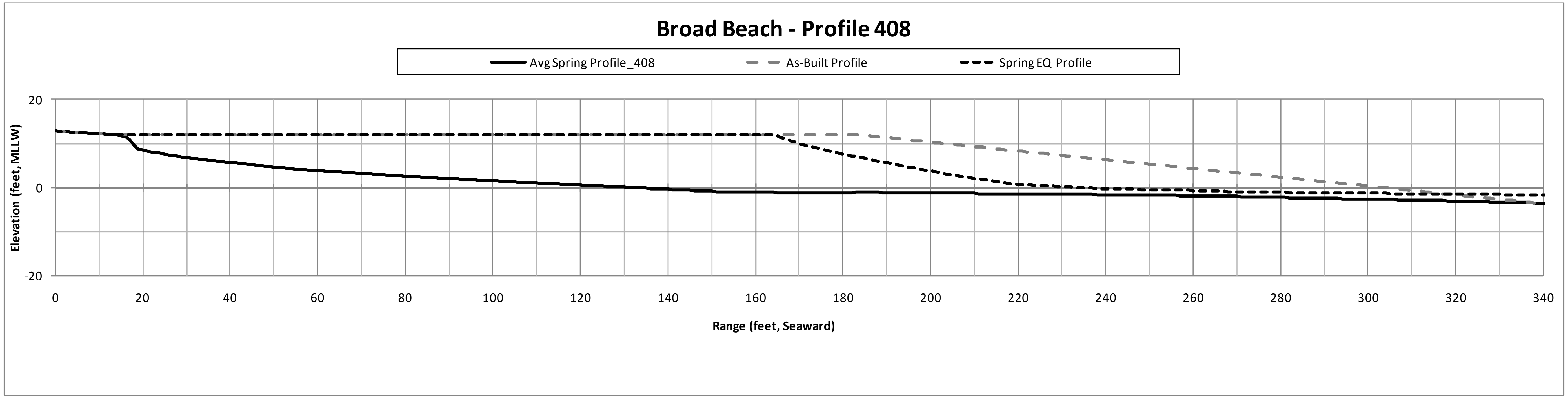


Figure 5. Beach Profile Slope for Existing Conditions (Solid Line) and Proposed Equilibrium Conditions (Bold Dashed Line)

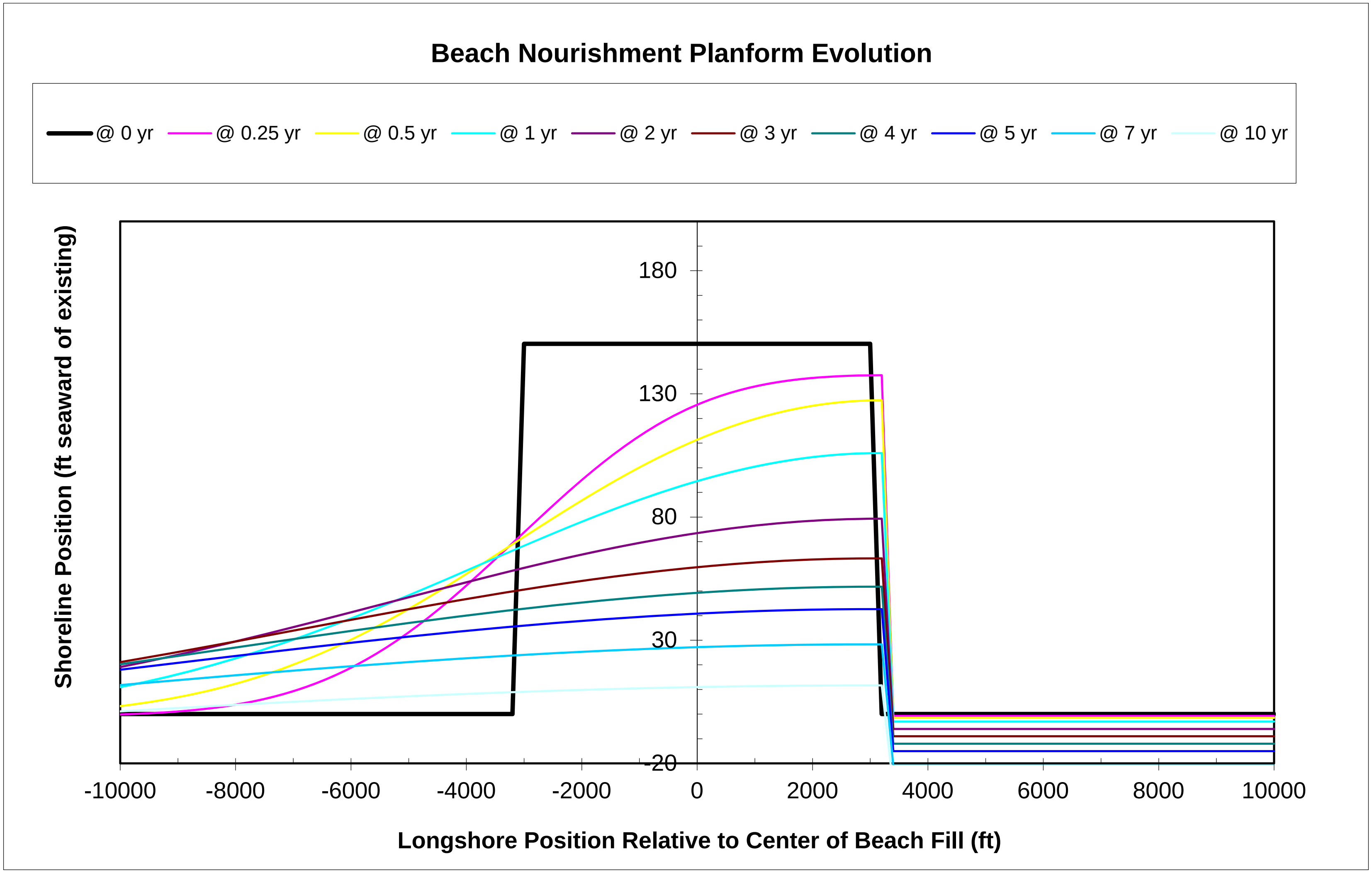


Figure 6. Beach Fill Planform Evolution Assuming One-Way Dispersion, Sand Median Diameter = 0.85 mm (M&N Coastal Engineering Report 2013)

Figure 7 shows the percent of beach fill remaining over time for 10 years. As the coarser sand clearly will remain on the beach for a longer time period than less coarse or native sand, the performance of actual "coarser than native" beach fills is of great value for this performance analysis.

3.3.2 Comparing Performance of Other Beach Fill Projects Using Coarser Than Native Sand

The San Diego Associations of Governments (SANDAG) conducted a pilot regional beach fill project in mid- to late-2001. That project's objective was to fill multiple beaches to "feed" the littoral cell and gradually increase beach widths as the sand dispersed over longer reaches of coast beyond the placement sites. Due to widespread environmental sensitivity within this region, SANDAG designed the fills to be relatively small and numerous. Therefore, twelve (12) placement sites were filled with a cumulative total of 2.1 million cy of sand. The largest fill was at South Oceanside, where 421,000 cy was placed, and the median sand grain size was 0.62 mm. The SANDAG project was monitored with beach profiles for 11 years after construction. These data are used to assess fill dispersion below. Another SANDAG project was constructed in 2012, and is also being monitored for 5 years, but the fate of those fills is still being measured. Data are not yet available for this specific analysis.

Monitoring of the 2001 SANDAG Regional Beach Sand Project (RBSP) yielded data useful to assessing fill dispersion, longevity, and other conditions. Coastal Frontiers Corporation (CFC) has measured beach profiles approximately every ½ mile along the coast since 1996, for 66 profiles total. Monitoring has showed widening of beaches and increased sand volume in the littoral zone immediately after the 2001 project, as compared to pre-project conditions. The increased sand volume within the littoral cell, compared to pre-project conditions, was discernible for 10 years. After 10 years, conditions of beaches and the littoral cell essentially reverted back to pre-2001 project conditions. Figure 8 and Figure 9 show the beach width and sand volume conditions at South Oceanside over time after the 2001 project. At this site, sand appears discernible for 7 years after construction. Other sites, such as North Carlsbad and Cardiff, show increased beach width and sand volume for the full 10 years after construction.

These monitoring data appear to show a similar sand dispersion rate and project lifespan compared to the predictions using sand diffusion discussed above. Proposed beach fill material that is coarser than the material placed at South Oceanside should remain in place longer and disperse more slowly. In addition, the wave exposure at South Oceanside is greater than at Broad Beach, so the forces dispersing sand at this SANDAG beach are greater. Therefore, the proposed sand with median diameter of between 0.60 and 1.00 mm (depending on the designated quarry) for Broad Beach should remain on the beach longer than the beach fill at South Oceanside, all other variables aside.

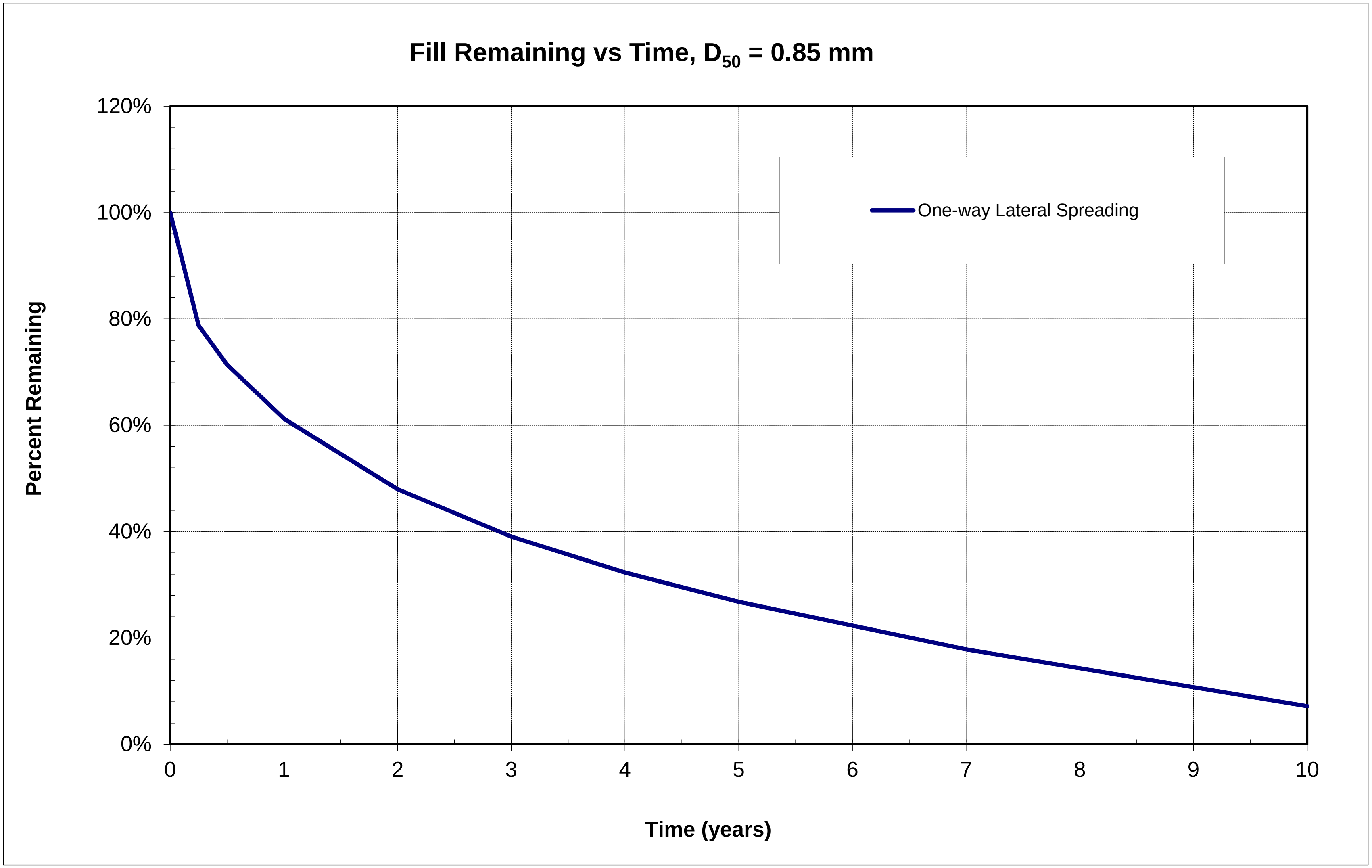


Figure 7. Beach Nourishment Project Longevity, Sand Median Diameter = 0.85 mm (M&N Coastal Engineering Report 2013)

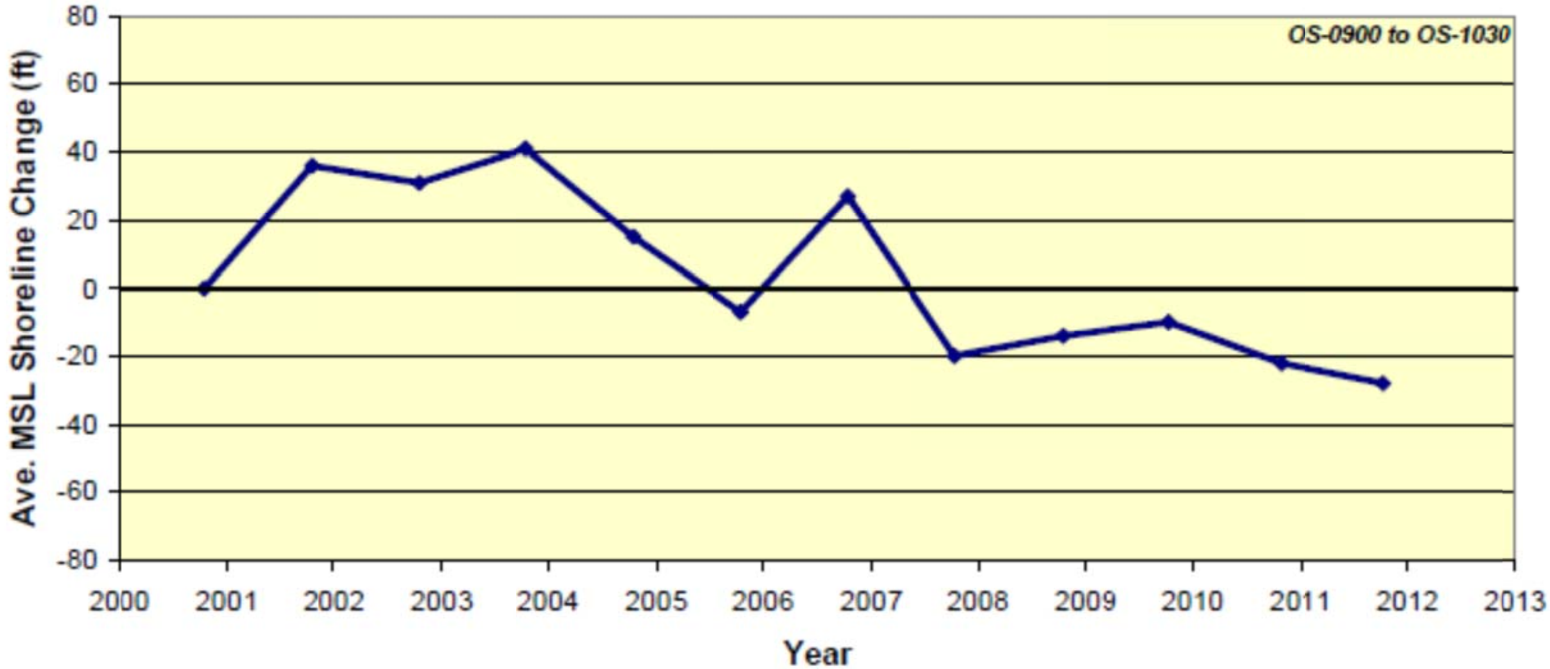


Figure 8. Beach Width Trend at South Oceanside After the 2001 SANDAG RBSP, Sand Median Diameter Was 0.62 mm (SANDAG 2011 Regional Beach Monitoring Program, Annual Report 2012)

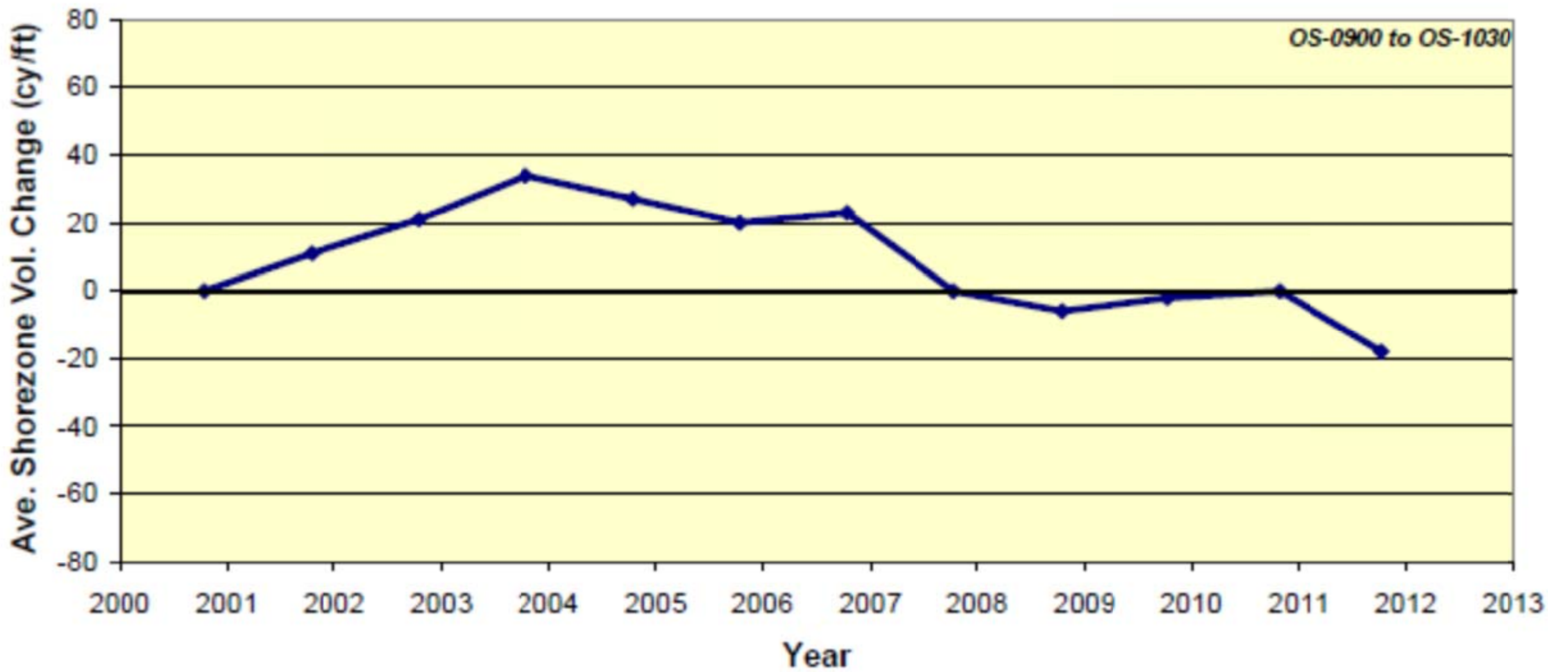


Figure 9. Sand Volume Trend at South Oceanside After the 2001 SANDAG RBSP, Sand Median Diameter Was 0.62 mm (SANDAG 2011 Regional Beach Monitoring Program, Annual Report 2012)

Finally, CFC measured beach profiles at South Oceanside to demonstrate any change in steepening of the beach profile and profiles at downdrift beaches from nourishment using coarse sand. Table 3 shows the values for beach slope along the upper beach (above mean sea level) existing before the project at the placement site and at the beach immediately downdrift. Both beaches had slopes of 1:20 (Vertical:Horizontal dimensions) before the project. The beach at the sand placement site steepened to 1:8 (V:H) for less than a year, and then reverted back to 1:20 again. The immediate downdrift beach remained unchanged until one year after the project, then steepened to 1:11 (V:H) for less than a year and reverted to the pre-project condition and remained that way.

Table 3. Beach Slope Measurements Before and After Nourishment with Coarser Than Native Sand At South Oceanside Beach for the RBSP I Project (CFC Unpublished Data 2012)

Time Relative to RBSP I Project	Beach Slope (Vertical:Horizontal)
South Oceanside Beach Sand Placement Site	
Before Project	1:20
After Project	1:8
One Year After Project	1:20
Beach Immediately Downdrift (South) of Sand Placement Site	
Before Project	1:20
One Year After Project	1:11
Two Years After Project	1:20

Figure 10 shows that the beach profile at the placement site at South Oceanside steepened temporarily from placement of the fill, and reverted back to pre-project conditions with a year. As sand moved south, the profile at the next downdrift beach showed a similar steepening of the beach for a year, and reversion to pre-project conditions shortly thereafter. Figure 11 shows the beach profile at the beach downdrift of the South Oceanside placement site. In both instances, the beaches responded with short-term shifts in beach profile in response to the fill, but gradually returned to pre-project profiles within a relatively short time.

The sand volume of the beach fill represents a relatively small proportion of the entire volume of sand within the littoral zone near Broad Beach and Zuma Beach, and will not control the beach profile slope for more than a short-term time period. Beach profile adjustment toward equilibrium for a short period of time after construction is a common occurrence, and a temporary condition.

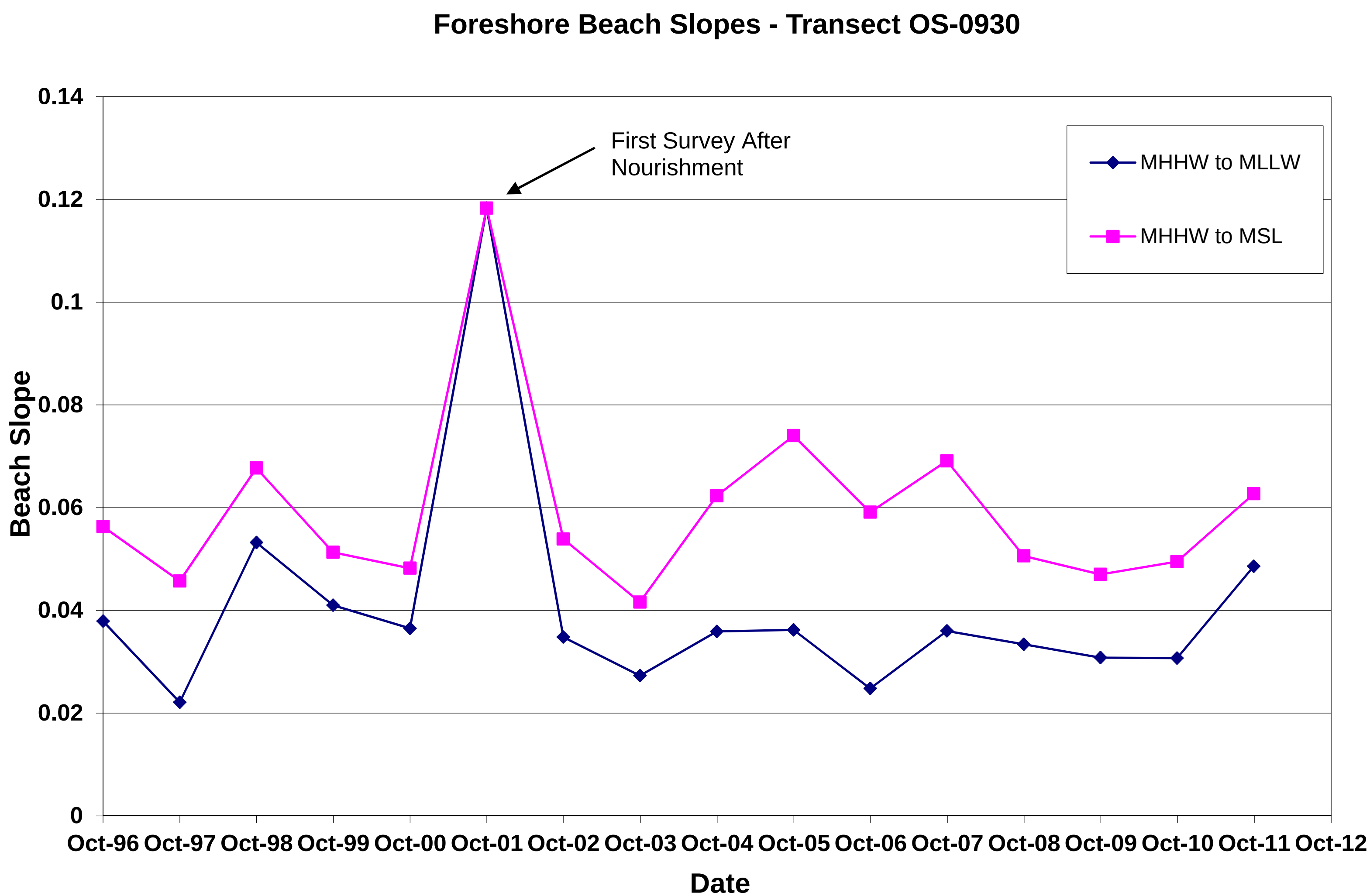


Figure 10. Beach Slope Changes at the South Oceanside Sand Placement Site Before and After the 2001 SANDAG RBSP; the Sand Median Diameter Was 0.62 mm (CFC Unpublished Data 2012)

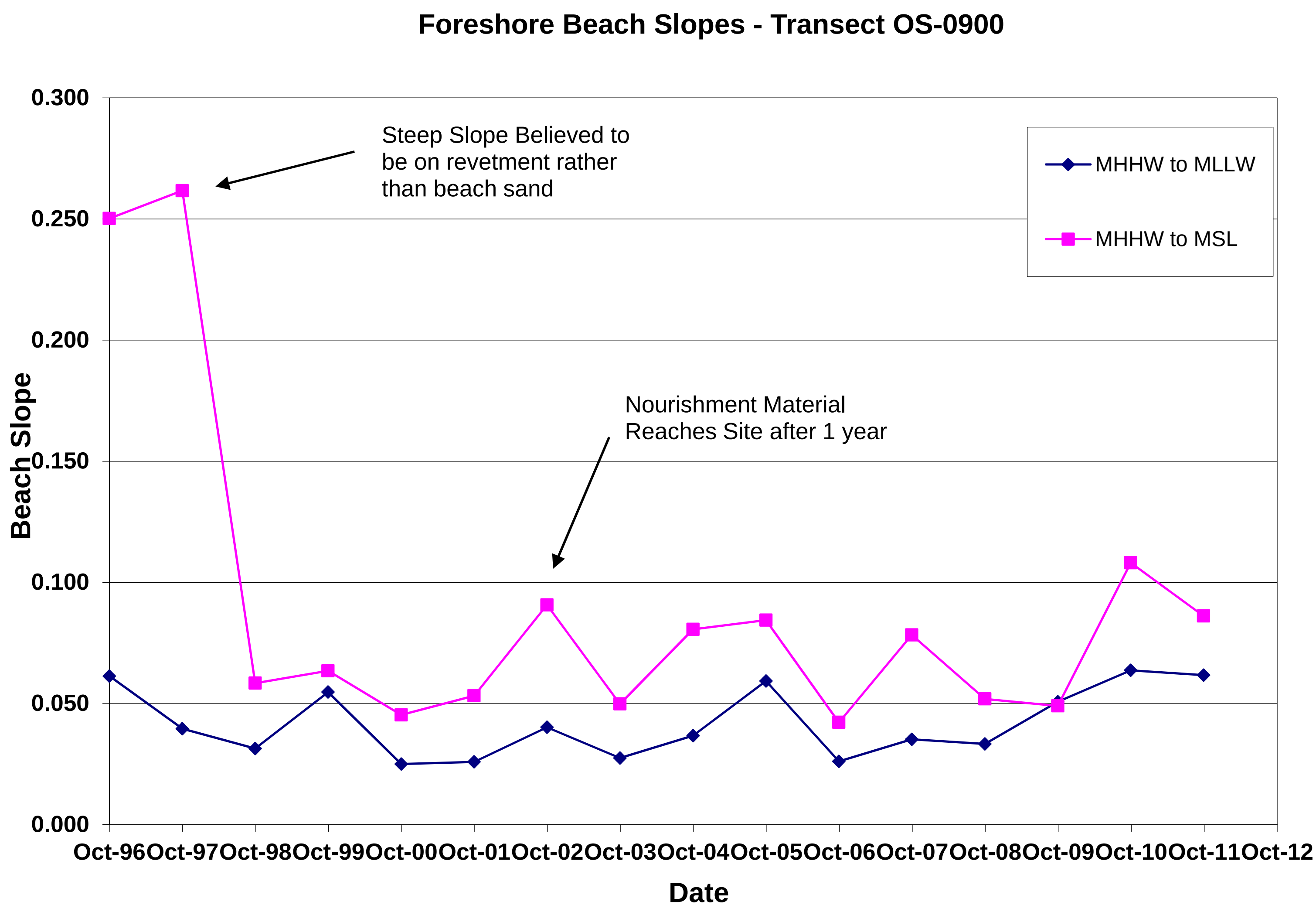


Figure 11. Beach Slope Changes at the Beach Downdrift to the South of the South Oceanside Sand Placement Site Before and After the 2001 SANDAG RBSP; the Sand Median Diameter Was 0.62 mm (CFC Unpublished Data 2012)

3.4 Maintenance Ramifications

Proposed maintenance actions for the proposed beach fill consist of annual sand backpassing at Broad Beach. Annual sand backpassing will move sand from the eastern portion of Broad Beach to the western area of the beach. Backpassing is proposed to retain as much of the beach fill along Broad Beach as possible to enhance the longevity of the fill, and to widen the western end of the beach where sand loss rates have historically been the highest. Sand backpassing is facilitated by having sand present to backpass, and having visually distinct material to target for excavation. Properties of the proposed coarse sand pertaining to its grain size and color will lead to enhanced maintenance practices.

As the coarser sand should reside on Broad Beach longer than finer sand, more of it will be present when backpassing operations occur. Having more sand available to backpass makes it easier for equipment operators to make cuts and increases the efficiency of the operation. More sand can be backpassed from a smaller cut footprint over a shorter period of time. The color of the imported sand may also facilitate backpassing. The new material may be a slightly lighter hue of beige than the existing sand, and may stand out, visually making it easy to see. This attribute has made it easier for other jurisdictions to move their nourishment sand as a maintenance action, and could facilitate backpassing at Broad Beach in the same way.

If beach maintenance is successful and efficient, the residence time of the nourishment material on the beach will be maximized. Maximizing the project's lifespan will lead to reduced renourishment needs, and reduction of the associated impacts and disturbance by nourishment activities.

4.0 Ecological Performance

Beach ecology consists of intertidal habitat and dune habitat. The project has the potential to affect both habitat types. Coarse sand may function differently than finer sand as an environment for non-human species living at the beach. Considerations of sand grain size for each habitat are discussed below.

4.1 Low Intertidal Habitat

Higher levels of energy are required to move coarse sand. Coarse sand will deposit mainly along the higher portion of the beach profile, with less dispersal along the lower portion of the profile. As such, the toe of the beach fill will not extend as far into the lower intertidal zone as finer sand. Less indirect burial of rocky intertidal habitat will result, with a significant reduction of potential environmental impacts. This effect is due to the smaller footprint occupied by coarser sand as compared to finer sand.

4.2 High Intertidal Habitat

High intertidal habitat provides area for wrack to collect, birds to forage, and grunion to spawn. Coarse sand that resides high on the beach profile creates a wide berm for higher intertidal sandy habitat. Very little high intertidal habitat exists at Broad Beach, with the only portion existing east of approximately the Malibu West Beach Club. Coarse sand would lead to a larger high intertidal habitat area. All zones of high intertidal habitat from low, mid to high will exist where they do not exist now.

The coarse sand grain size could be potentially less optimal for certain macroinvertebrates due to roughness, but is not prohibitive. Sand grain size may change conditions for existing invertebrate habitat on-site but not necessarily adversely. The total sand volume added and the area affected is a relatively small portion of the entire existing sandy intertidal habitat area in the region and the overall impact is negligible. In contrast, the benefits of creating lost high intertidal habitat are significant.

4.3 Dune Habitat

Quarry sand is also proposed for construction of dunes. Dunes are proposed by the BBGHAD as a means to restore historic dunes at Broad Beach, to provide additional habitat value to the site, to cover the revetment, and to increase the volume of sand available on-site for protection against severe coastal storms. Dunes previously existed on-site, and small areas of dune still exist at the eastern end of Broad Beach, but they are rapidly being lost to shoreline erosion. The sand grain size of the existing dunes at Broad Beach is larger than the sand grain size on the beach according to microscopic examination of sand samples from the dunes and the beach by URS Corporation as part of the Sand Angularity Analysis, provided as Exhibit G(d).

The BBGHAD's Engineer and WRA tested the proposed inland sand material to determine its suitability for dune habitat. Results show that the inland sand material will be highly suitable for dune foundation and habitat. In an effort to provide an optimal growing environment for native dune plant material and best control the infiltration rate, the BBHAD Engineer and WRA propose to augment the inland sand material in the area of the dunes with a minor amendment to increase nutrient and organic material content. As previously noted, irrigation will be required for a limited period of time to provide sufficient water (WRA, Personal Communication with M&N, September 12, 2013). The proposed soil amendment in the restored dune area would provide the optimal environment to colonize juvenile plants, and can be used to provide the appropriate soil texture for percolation and root systems. As a benefit, the more-coarse-than-native inland sand material discourages non-native weed growth, so maintenance of the dunes from non-native weed growth may be reduced.

The BBGHAD's proposed dune restoration constitutes a proposed project feature intended to provide additional habitat benefits to the region. As such, they may be considered a pilot dune re-establishment project that may experience relative degrees of success over time and space. The project provides an opportunity to add a sand foundation to the currently eroded dune system for possible dune re-colonization. Therefore, the BBGHAD proposes that the SLC and other agencies gauge the success of the dune restoration and native plant landscaping in this light, especially given the current level of dune erosion. Monitoring of general dune conditions over time after construction will provide valuable data for dune augmentation or modification as part of future renourishment efforts to improve habitat value and function.

5.0 Overall Experience for Beach Users

People use Broad Beach and Zuma Beach on a regular basis for recreation, and even for commercial purposes (i.e. Malibu Makos Surf Camp). The BBGHAD has undertaken significant study to understand how the sand might affect the experience of beach users on both beaches. This section provides an overview of the anticipated beach experience as a result of the proposed project and use of the inland sand material.

5.1 Overall Effect of the Inland Sand Material on Broad Beach and nearby sections of Zuma Beach

Broad Beach – The different sand on Broad Beach will create a beach that does not exist today, which should, in and of itself, constitute a significant benefit with certain considerations. Anecdotal and photographic evidence of historic conditions at Broad Beach indicate that it was relatively flat and wide (with a median sand grain size of 0.22 to 0.25 mm), depending on the tide. This general condition likely varied by season and year, but prevailed over the long-term. This historic condition may have been somewhat similar to what exists at the far east end of Broad Beach and at the far west end of Zuma Beach at low tide. New Broad Beach will also be wide, but will exhibit a steeper upper beach profile slope than east Broad Beach/west Zuma from the high water line up to the dry play area. Qualitatively, new Broad Beach may look more like Balboa Peninsula Beach in Newport (median sand grain size 0.45 mm; slope 1:8 V:H), shown in Figure 12 and Figure 13, than historic Broad Beach. This condition will be more pronounced immediately after construction and for approximately the first post-nourishment year as the new sand temporarily dominates the surface condition. The beach will then gradually revert toward a pre-construction condition as the new sand disperses and mixes with finer sand reaching the beach from updrift via littoral processes, and the beach profile equilibrates. As the sand disperses and mixes over time, the condition of the beach will continue to trend toward pre-project conditions and ultimately will revert to that state within approximately a decade prior to any renourishment. Backpassing may not significantly change this trend due to the relatively small quantity of material to be moved compared to the total volume of sand placed as nourishment.

The evolution of the post-nourishment beach has been recorded and observed at San Diego County beaches from the 2001 and 2012 nourishment projects. For example, at Imperial Beach, pre-project native sand grain size was 0.25 mm and nourishment sand grain size was 0.55 mm. Initially after nourishment, the beach form was very different from what local users previously experienced. After the first year, the beach at Imperial Beach had significantly reverted back toward the pre-project slope and condition as the sand dispersed. The resulting beach is similar to the pre-project beach, but with a wider berm (or level play area or towel area).

Zuma Beach – Effects on Zuma Beach from the project will be reduced in magnitude from effects on Broad Beach for the following reasons:

1. Zuma Beach is naturally steeper in slope than historic and existing Broad Beach due to its coarser existing sand grain size of 0.40 mm. The new sand will be more similar to sand at Zuma than at Broad Beach (although somewhat coarser) and changes will be less dramatic.
2. Effects at Zuma will be secondary effects from dispersion of new sand from Broad Beach. Zuma Beach is not located within the construction zone, so it will never develop the post-construction profile that will form at Broad Beach. Effects on the Zuma Beach profile will be from sand gradually reaching the site from upcoast. Therefore, any changes to Zuma will be slower and less pronounced than at Broad Beach.
3. Zuma Beach is composed of a large volume of sand in the littoral zone. The nourishment sand comprises a relatively small volume compared to what already exists. By receiving sand indirectly at Zuma Beach, a smaller proportion of new sand will exist over time at Zuma than at Broad Beach. Zuma will be less affected by nourishment sand, and more influenced by native sand-- which composes the majority of the sand volume in the littoral cell. Therefore, the resulting slope of the upper beach profile should not be as steep at Zuma Beach as that at Broad Beach.
4. Due to the fairly broad range of grain sizes in the new sand (more diverse gradation curve), it will disperse more widely over the downcoast beach profile once it leaves Broad Beach, thereby leaving a smaller fraction of the material along the upper beach profile to affect its slope (less concentration of new sand along the upper profiles leads to less influence on its slope).

Figure 12. Upper Beach Profile Slope Along Balboa Peninsula in Newport, Looking North From Balboa Pier on September 5, 2013, 3:30 PM

Figure 13. Upper Beach Profile Slope Along Balboa Peninsula in Newport, Looking South From Balboa Pier on September 5, 2013, 3:30 PM

Depending on the rate of sand dispersion to Zuma, that beach may experience a gradual transition to a slightly steeper beach along the west end that eventually reaches the rest of Zuma. Conditions at Zuma will then revert back toward the pre-fill condition over time. The broad range of sand grain sizes in nourishment material will result in a smaller proportion of it influencing the upper beach profile slope than would otherwise occur. The gradation of the nourishment sand is variable enough so that roughly one-half or less of the sand (between 0.25 mm and 1 mm in grain size diameter) would end up depositing on the upper beach profile. The remaining 50% or more of the sand will deposit in two areas: 1) the high energy shallow nearshore area of breaking waves (sand larger than 1 mm in diameter), and 2) in lower energy deeper areas of the nearshore zone and the offshore zone (sand smaller than 0.25 mm in diameter).

The nourishment sand placed at Broad Beach that reaches Zuma Beach will affect the beach slope, but its effects will be temporary. That nourishment sand will also disperse from Zuma Beach over time, thereby reducing the volume present at Zuma and its effect on the upper beach profile as compared to Broad Beach.

Measuring beach profiles at Broad Beach and Zuma Beach as part of post-project monitoring will clarify changes to the beaches and provide data needed for any adaptive management actions. Los Angeles County Department of Harbors and Beaches staff regularly groom and grade Zuma Beach. That action will serve to preserve conditions at Zuma Beach that are desirable for beachgoers.

5.2 Effect of Coarser-grained Sand On Walking on the Beach

Walking on the new dry sand will not be significantly different than walking on the current, native dry sand. Both soft sand scenarios present similar scenarios for walking. However, the new sand beach will obviously present a much wider beach for walking as compared to the existing beach that enables traversing at high tide. Any new beach fill sand is harder to walk on than a native beach because the new sand has not experienced any natural processes of wetting and drying, and resulting sand grain adjustment. Sand on a beach will experience natural compaction from being re-worked through wetting, drying, moving, and re-deposition. Natural re-working of sand on a beach results in a slightly more compact surface and easier locomotion. Dry soft sand is always more difficult to walk on than the wet hard sand.

There will be more opportunity to walk on the wet hard sand at Broad Beach in the future after nourishment as compared to existing conditions. Walking on the wet hard sand at Broad Beach is limited to very low tides at present due to the lack of a beach. With a wider beach, more moderate low tides will be passable along the beach for walkers. Thus, beach users will have the ability to walk on the wet hard sand more often than at present. Walking along the sloping beach may be more difficult than walking along a flatter slope, however.

As previously mentioned, the project will have limited effects on Zuma beach. Walking on Zuma Beach may correspondingly be affected, but to a lesser extent that walking at Broad Beach for the same reasons that reduce impacts to Zuma compared to Broad Beach. Zuma is composed of a large quantity of 0.40 mm sand. That condition will be temporarily modified as new sand moves through Zuma from dispersion, but the relatively small quantity of new sand compared to the large quantity of existing sand will significantly limit the magnitude of the influence of the new sand.

5.3 The Underfoot Feel of Sand Within the Medium Gran Size Classification – Broad Beach and Zuma Beach

As noted above, Zuma Beach sand has a current, native grain size of approximately 0.4 mm. The sand proposed for Broad Beach will likely range from 0.47 mm to 0.8 mm. Sand with a grain size of 0.59 to 0.9 mm is within the "medium" sand classification according to the United Soils Classification. As a result, the proposed sand for Broad Beach will feel soft underfoot and will be largely indiscernible to the touch and feel as compared to existing sand at Broad Beach and Zuma. A sand grain angularity analysis was completed, and revealed the angularity of the quarry sand was indiscernible from that of native sand at Broad Beach and the dunes. The nourishment sand and the native sand should feel the same on the feet of users.

5.4 Effect of Steeper Beach Slope on Surfing and Swimming

Surfing and swimming at Broad Beach should both be improved with the addition of the new sand. The sand will result in shallower water off the beach compared with existing conditions that are characterized by a relative low, flat profile and deeper water close to shore. Surfing is fully analyzed in a surfing analysis prepared to address Coastal Commission concerns. See, the Surfing Impact Analysis as Appendix 6 to the Coastal Engineering Report in Exhibit L. More pronounced sand bar development will occur with the nourishment project leading to better wave shape and improved surfing conditions.

At Zuma Beach, swimming and surfing should not be adversely affected. However, there may be periodic effects during high tides if wave uprush along the upper beach profile slope causes backwash. Most beach nourishment projects on open coasts result in a temporarily steeper upper beach profile slope that causes some form of backwash to exist. This condition is temporary and gradually diminishes once the beach profile slope equilibrates toward a flatter, more natural slope after reworking by waves and tides. Overall, adding sand to Zuma by dispersion should result in more pronounced sand bar development and improved surfing conditions all along the length of beach.

5.5 Effect of Inland Sand Material on Wave Shape

Waves at Broad Beach presently break close to shore and to the revetment due to the lack of a beach and a lack of sand. Adding sand will provide a larger area and buffer between breaking waves and the beach, thereby reducing the slope and the "shorebreak" type of wave. A shorebreak wave is a wave breaking relatively close to shore and is typically a relatively hard-breaking wave. As previously stated, beach nourishment projects tend to form a temporarily steeper constructed slope high on the upper beach profile that gradually equilibrates to a flatter, more natural profile. A temporary condition of waves breaking close to shore at high tides may exist at Broad Beach, but this condition should not remain for more than a season of the sand being reworked by waves and tides.

Zuma Beach and, especially Westward Beach to the east of Zuma, already has a clear reputation as a "shorebreak" wave. This project should not appreciably change the shape of breaking waves at Zuma because Zuma will receive sand indirectly from Broad Beach and therefore in much smaller quantities. Its condition will therefore be influenced more by existing native sand rather than new nourishment sand. Zuma Beach may experience a temporary condition of a steeper slope and waves breaking closer to shore at high tide as new sand arrives from upcoast, but that condition will be short-lived and the beach will revert to the typical condition as the sand is reworked by tides and waves.

Broad Beach and Zuma Beach should not permanently experience a condition that is unusual to these sites, nor should they change character into a shorebreak type of wave. This condition should not permanently form because both Broad Beach and Zuma possess a large volume of finer sand on the lower portion of the beach profile that affects the shape of the profile. The portion of the beach profile in the nearshore zone off the beach should rise and remain flatter, causing waves to break farther from the beach. Beach nourishment projects can result in a temporarily steeper slope high on the beach profile that gradually equilibrates to a flatter, more natural profile. A temporary condition of waves breaking close to shore at high tides may exist at Broad Beach, but this condition should not remain permanently after the sand is reworked by waves and tides.

5.6 Similarity of Post-Nourishment Broad Beach Condition and That Currently Experienced at Western Zuma Beach

The upper beach profile slope of western Zuma is relatively steep and that condition should not change as a result of the Broad Beach nourishment project. Also, that condition should not extend farther into Zuma and Broad Beach from this project for the long-term. Short-term conditions may vary and reflect a temporarily steeper upper beach profile, but the overall beach profile will revert to the natural shape over the long-term. This project will not contribute a sufficient volume of sand to permanently change the beach geometry along Zuma and Broad Beaches. Sand samples were retrieved from west Zuma Beach, as well as central Zuma and east Zuma and the gradation was the same at each site.

6.0 Conclusions

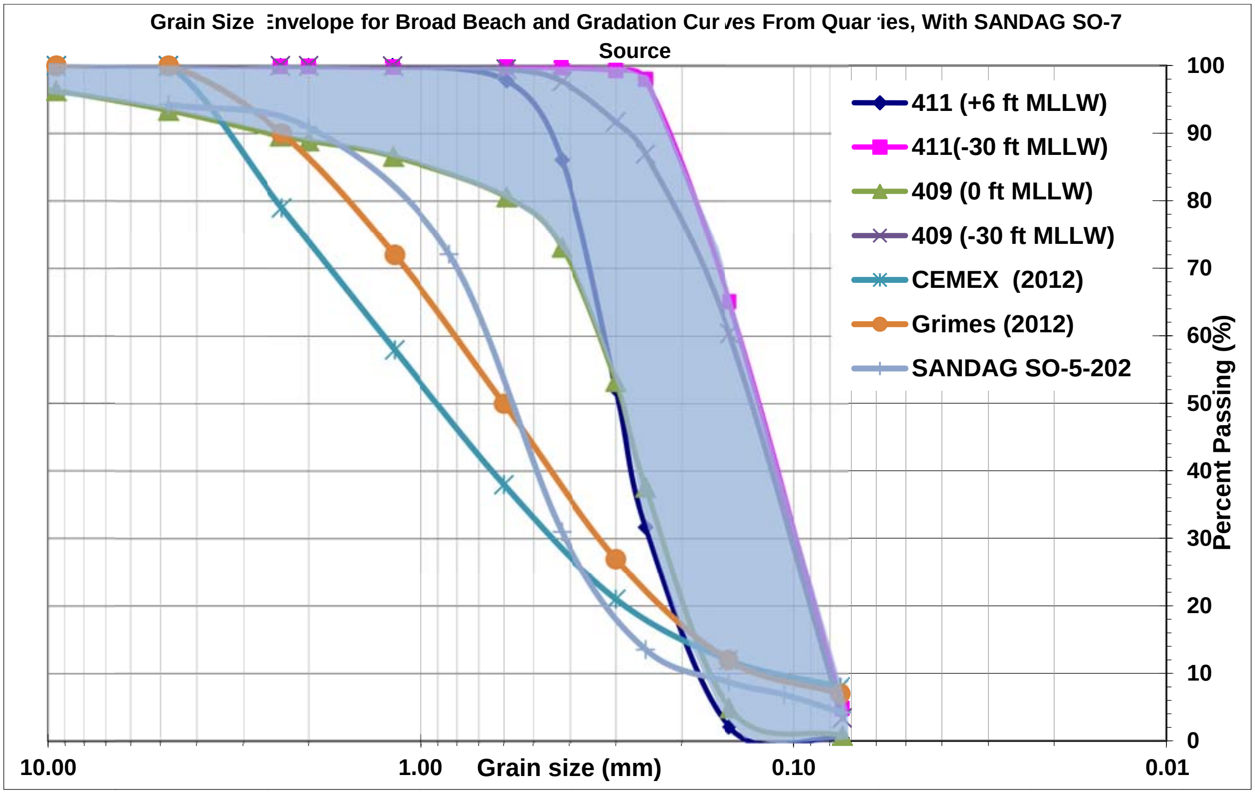
The primary purpose of the Broad Beach Restoration Project is to help offset a sediment budget imbalance in an eroding area. The project will benefit Broad Beach by adding sand to a denuded reach of beach. Specifically, the project:

1. Increases recreational opportunities and associated benefits.
2. Improves protection and water quality preservation (from septics).
3. May extend the longevity of the fill, therefore requiring less renourishment (and less impact from renourishment).
4. Sand may be more effectively backpassed due to its longer retention time, larger grain size, and visibly different condition than existing sand.
5. Provides habitat that no longer exists (mid and high-intertidal sandy habitat, and dune habitat) for use by invertebrates, birds, and grunion (to name a few species).
6. Will impact rocky intertidal habitat to a lesser extent as would occur with finer sand due to the limited footprint of the proposed coarser sand compared to the native finer sand.
7. Will cause short-term effects to beach conditions as the upper beach profile steepens from construction and effects of coarse sand, but the beach profile will revert to pre-project less steep conditions as sand disperses over time, thus preserving the long-term condition of Zuma and Broad Beaches.

APPENDIX A

GRADATION CURVES FOR BROAD BEACH AND PROPOSED QUARRY SAND,

WITH SANDAG OFFSHORE SOURCE SO-5 INCLUDED FOR REFERENCE



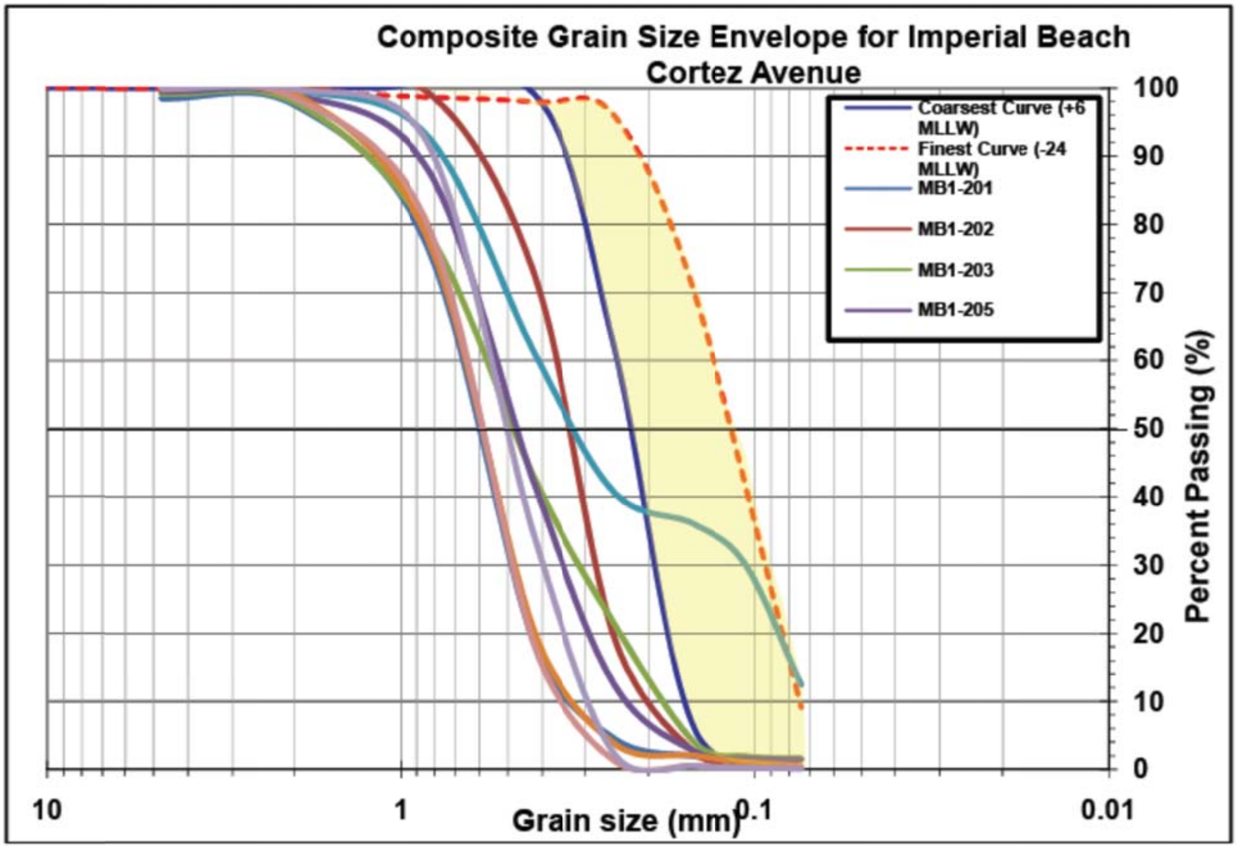
Grain Size Envelope for Broad Beach (In Blue Shading) Plotted Against Curves for Sand Proposed to be Used From Quarries, With Sand From SANDAG Offshore Site SO-5 for Reference.

The Proposed Nourishment Sand From Quarries Mostly Falls Outside of the Broad Beach Gradation Envelope by Intent to Provide Sand Most Suited to Withstand Erosive Forces at the Beach. SANDAG's Sand From All Offshore Sources Also Fell Outside of the Beach Gradation Curves at Receiving Beaches by Intent. Up to 1.5 Million CY of This Gradation of Sand Was Placed on San Diego County Beaches in 2012. The Following Appendix B Shows Those Gradation Curves for Beaches and Sand Sources, and Provides Specific Project Information for Each Site. SANDAG Source Sand Mostly Falls Outside of Beach Envelopes, While Proposed Broad Beach Sand Falls Within the Beach Envelope on the Coarse and Fine Ends of the Curves.

APPENDIX B

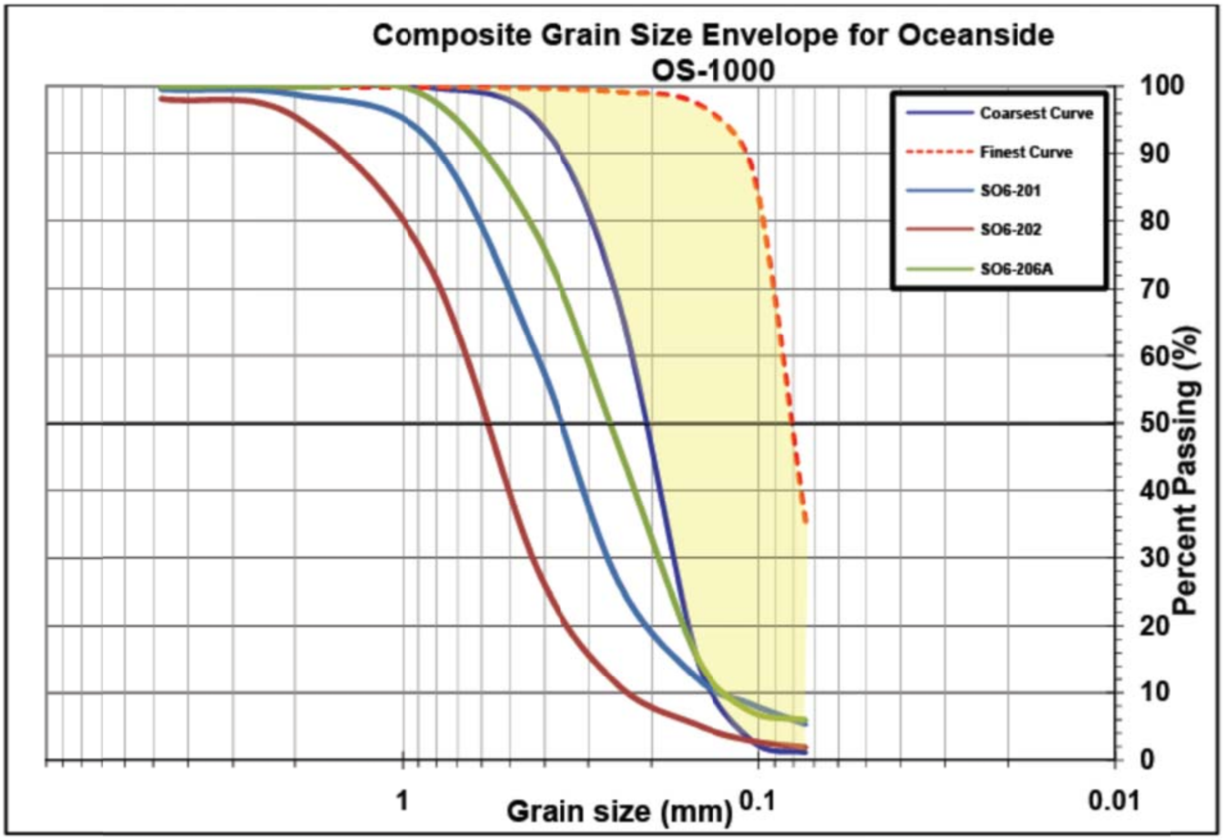
GRADATION CURVES FOR SAN DIEGO COUNTY BEACHES

AND OFFSHORE SAND USED FOR NOURISHMENT FOR SANDAG RBSP II



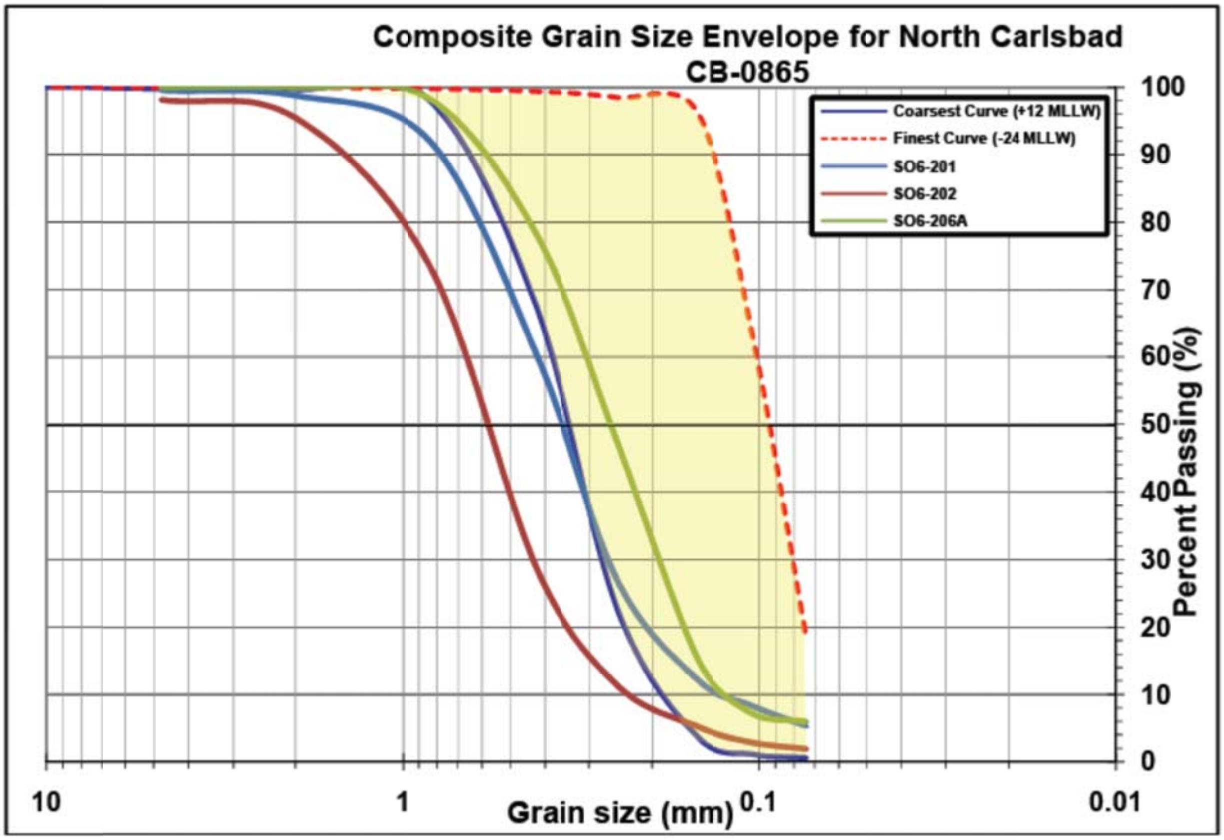
G ain Size En elope for Imperial Beach (In Yello v Shading) Plotted Against Curves for Sand Dredged From Offshore Site MB01 Off Missi n Beach in 2012. The Source Sand Falls Entirely Outside of Beach Envelop .

Imperial Beach Received 450,140 Cubic Yards of This Sand Fr m September 7 to October 4, 2012. The Median Grain Size of The Sand Placed at This Site Was 0.53 Millimeters.



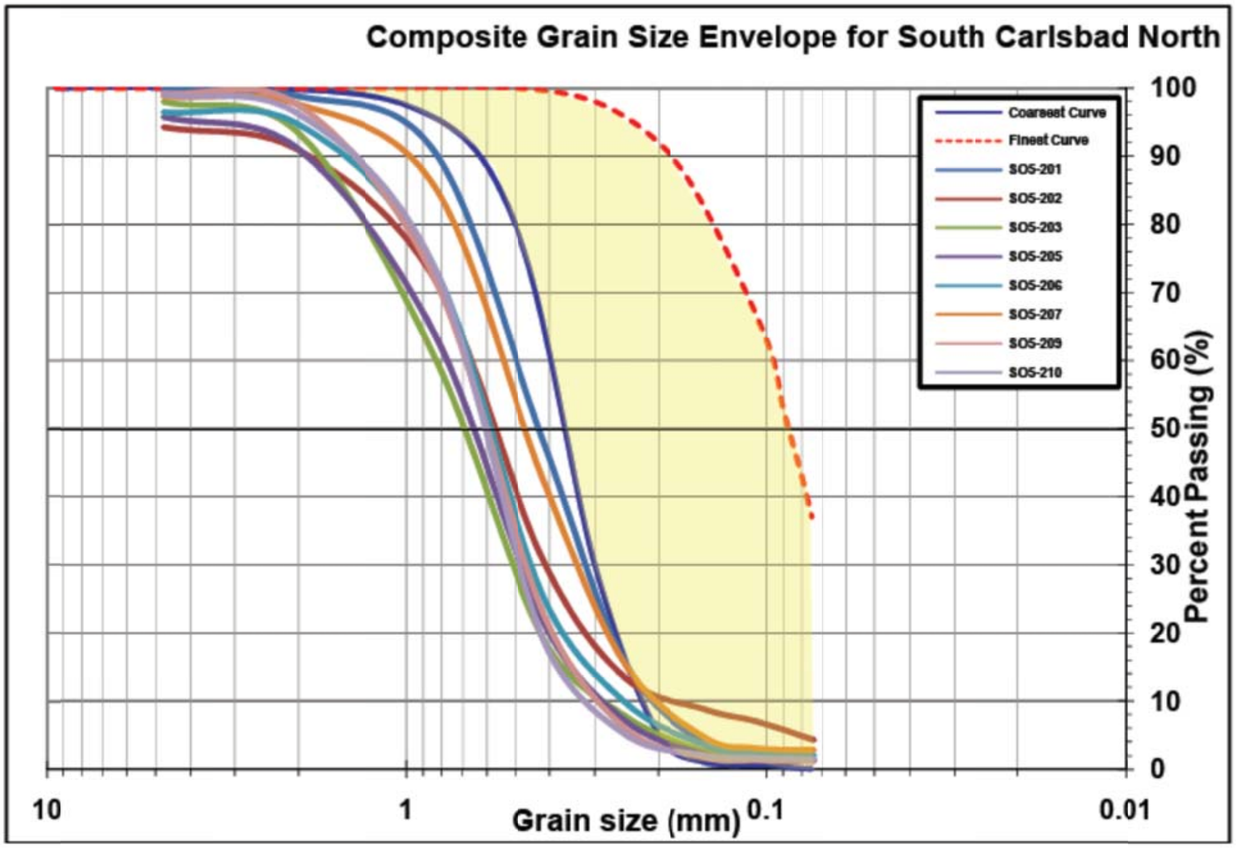
Grain Size Envelope (In Yellow Shading) for South Oceanside Beach Plotted Against Curves for Sand Dredged From Offshore Site SO-6 Off Cardiff in 2012. The Source Sand Falls Outside of Beach Envelope Except for the Low (Fine) End of the Curves.

South Oceanside Received 292,822 Cubic Yards of This Sand From October 5 - 20, 2012. The Median Grain Size of The Sand Placed at This Site Was 0.54 Millimeters.



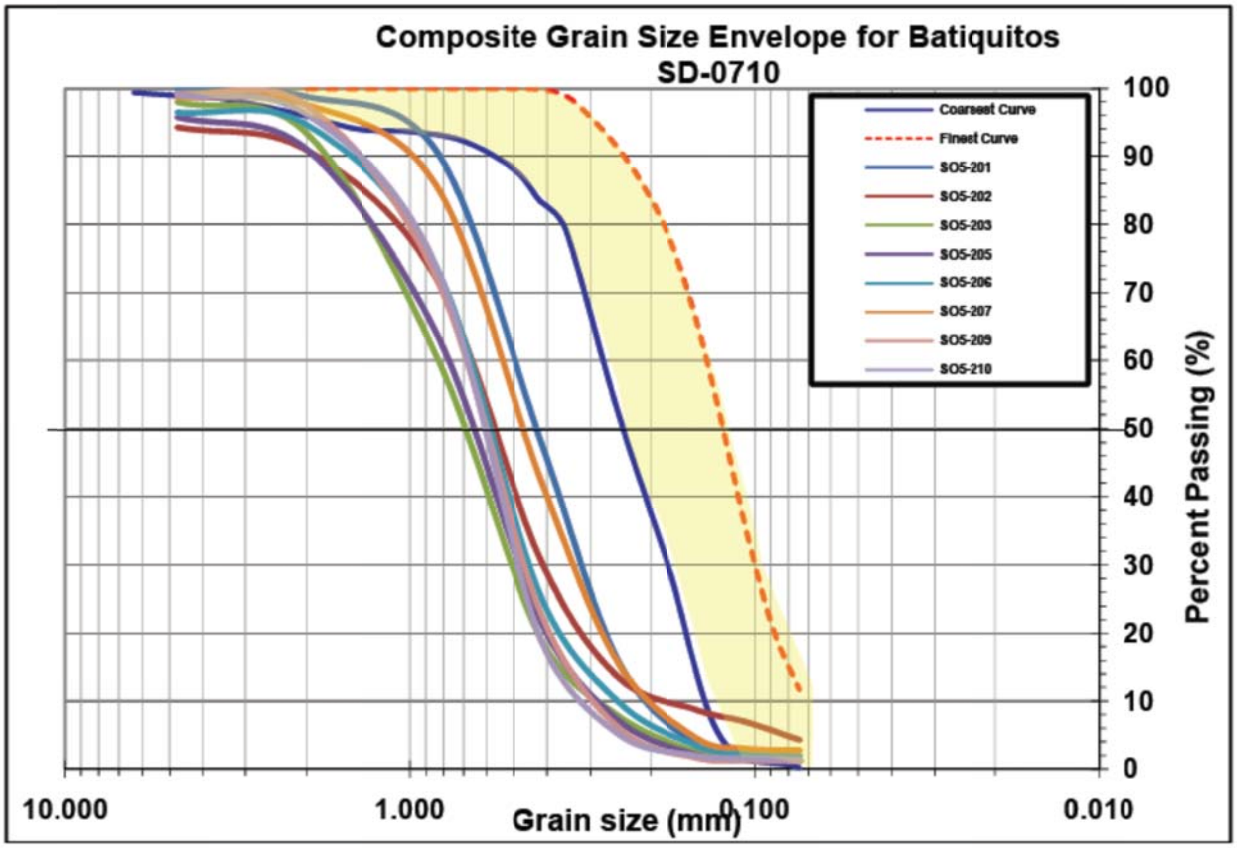
Grain Size Envelope (In Yellow Shading) for North Carlsbad Beach Plotted Against Curves for Sand Dredged From Offshore Site SO-6 Off Cardiff in 2012. Note That This Sand Source Was Not Used for This Site, But Rather Coarser Sand From SO-5 Was Used to Nourish This Beach. The SO-5 Sand Source Falls Outside of Beach Envelope.

North Carlsbad Received 218,728 Cubic Yards of This Sand From November 24 to December 7, 2012. The Median Grain Size of The Sand Placed at This Site Was 0.57 Millimeters.



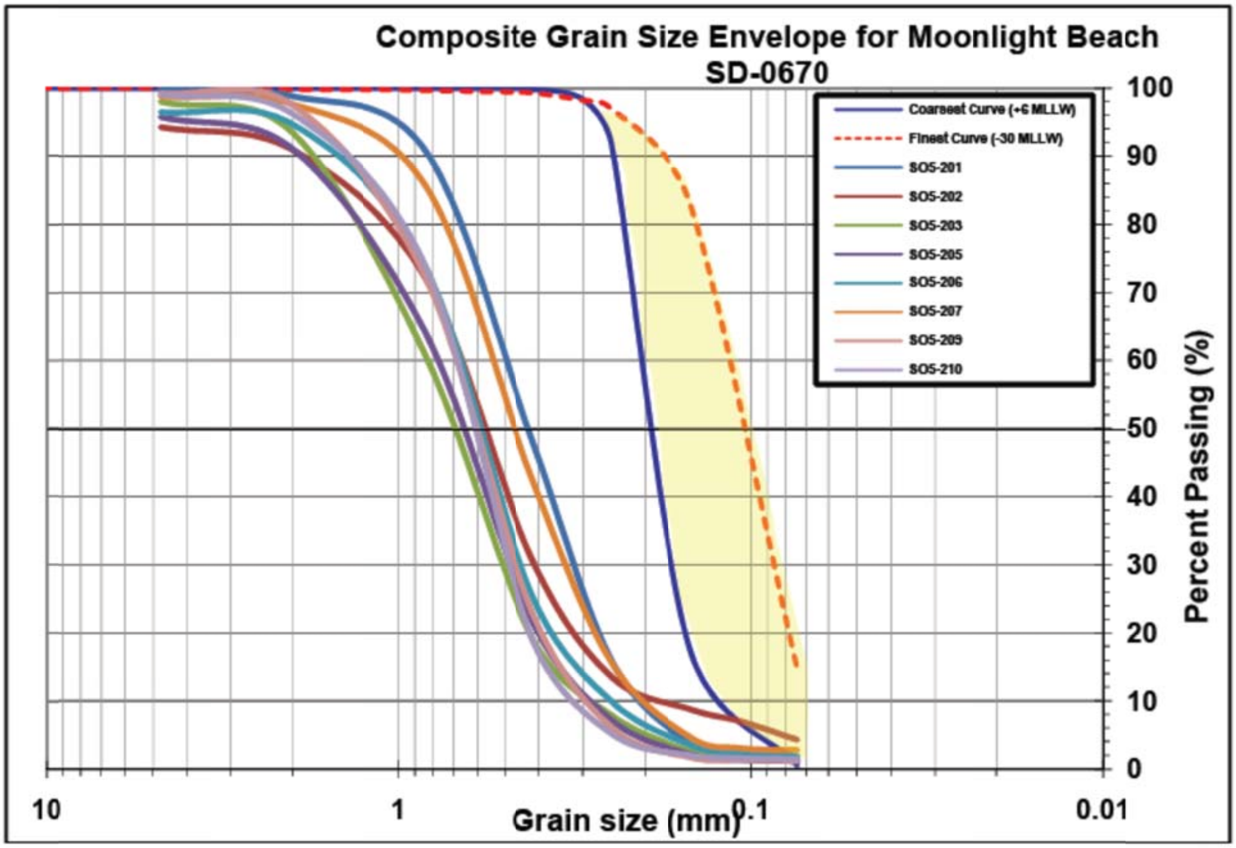
Grain Size Envelope (In Yellow Shading) for South Carlsbad Beach North Plotted Against Curves for Sand Dredged From Offshore Site SO-5 Off Del Mar in 2012. The Source Sand Falls Outside of Beach Envelope Except for the Low (Fine) End of the Curves.

South Carlsbad North Received 140,763 Cubic Yards of This Sand From November 15 - 23, 2012. The Median Grain Size of The Sand Placed at This Site Was 0.66 Millimeters.



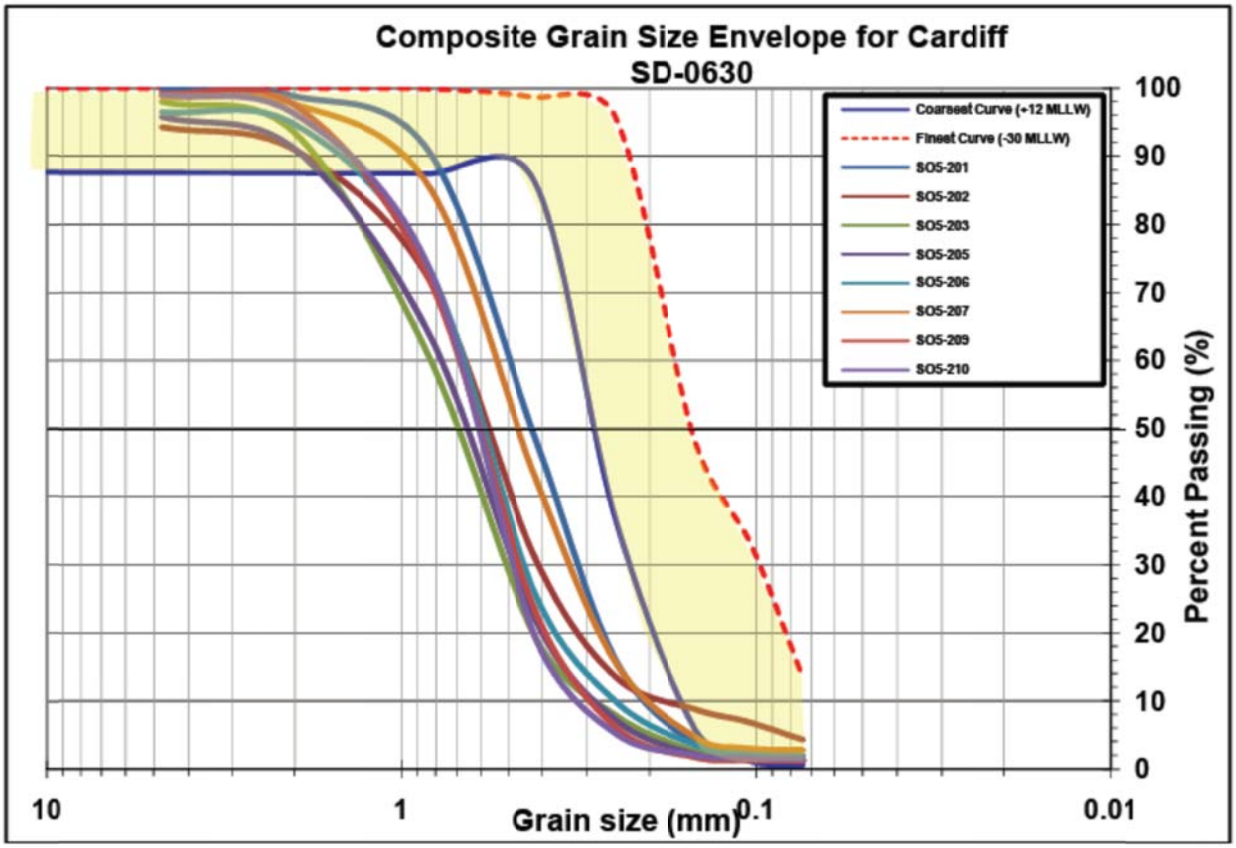
Grai ı Size Envelope (In Yellow Shading) for Batiquitos Beach Iorth Plotted Against Curves for Sand Dredged From Offshore Site SO-5 Off Del Mar in 2012. The Source Sand Falls Outside of Bea :h Envelope Except for the Highest (Coarse) and Lowest (Fine) Ends of the Curves.

Batiquitos Beach Received 106,052 Cubic Yar ls of This Sand From October 28 to November 2 I, 2012. The Median Grain Size of The Sand Placed at This Site Was 0.59 Millimeters.



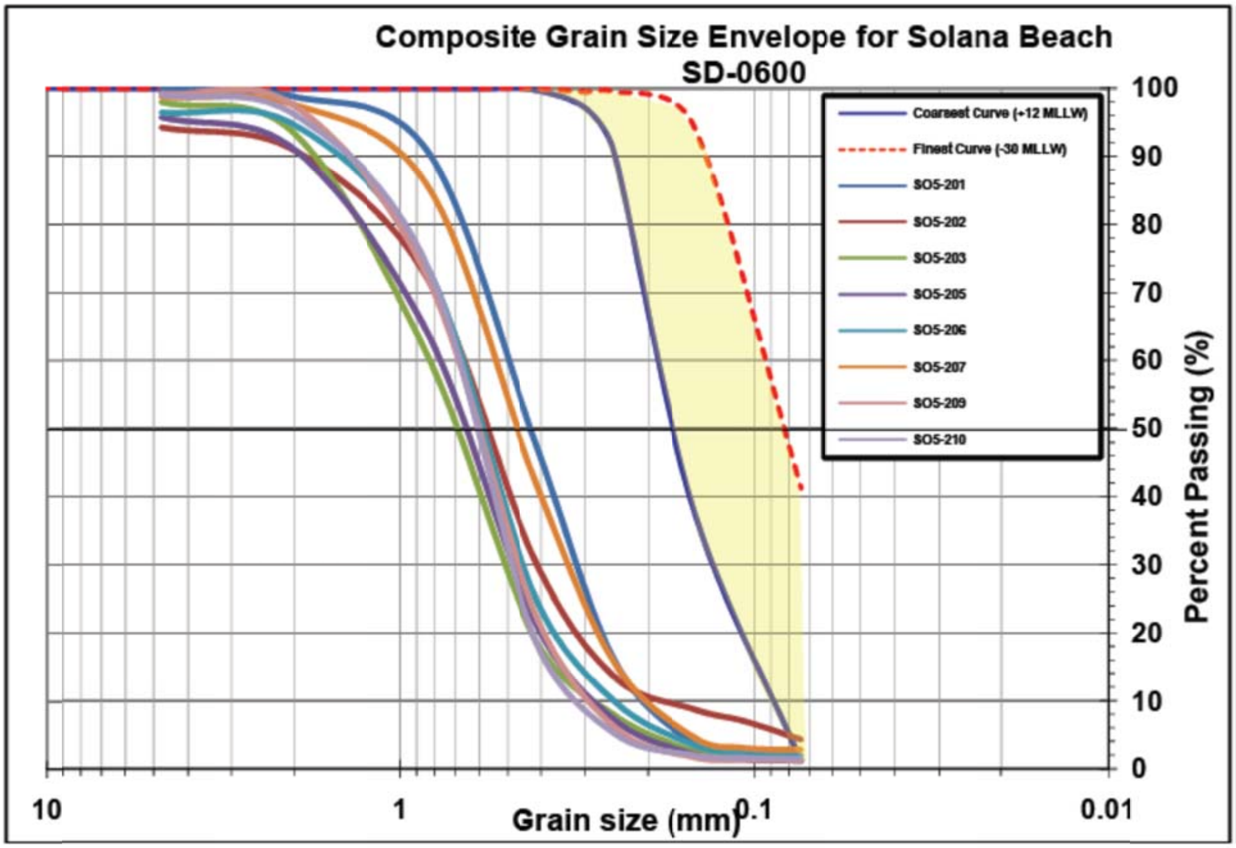
Grain Size Envelope (In Yellow Shading) for Moonlight Beach Plotted Against Curves for Sand Dredged From Offshore Site SO-5 Off Del Mar in 2012. The Source Sand Falls Outside of Beach Envelope Except for the Very Lowest (Fine) End of the Curves.

Moonlight Beach Received 92,287 Cubic Yards of This Sand From October 20 - 25, 2012. The Median Grain Size of The Sand Placed at This Site Was 0.48 Millimeters. The Median Grain Size was Lower at This Site Than at Other Sites Because It was the First to Receive Sand From SO-5 and Received Fines a Surface Layer Over the Dredge Site.



Grain Size Envelope (In Yellow Shading) for Cardiff Beach Plotted Against Curves for Sand Dredged From Offshore Site SO-5 Off Del Mar in 2012. The Source Sand Falls Outside of Beach Envelope Except for the Highest (Coarse) and Lowest (Fine) Ends of the Curves.

Cardiff Beach Received 88,751 Cubic Yards of This Sand From October 25 - 28, 2012. The Median Grain Size of The Sand Placed at This Site Was 0.57 Millimeters.



Grain Size Envelope (In Yellow Shading) for Solana Beach Plotted Against Curves for Sand Dredged From Offshore Site SO-5 Off Del Mar in 2012. The Source Sand Falls Entirely Outside of Beach Envelope.

Solana Beach Received 142,430 Cubic Yards of This Sand From November 4 - 27, 2012. The Median Grain Size of The Sand Placed at This Site Was 0.55 Millimeters.

URS

August 14, 2013

Chris Webb
Moffat & Nichol
3780 Kilroy Airport Way
Long Beach, CA 90806

Subject: Malibu Beach Sand Replenishment
Sand Grain Angularity Analysis
Malibu, California
URS Project No. 03003261

Dear Mr. Webb:

This report presents our assessment of sand angularity for the proposed use of inland sediment for beach replenishment.

Project Understanding

We (URS) understand that Moffat & Nichol is working on a proposed beach replenishment project for the beaches in the Malibu, California area. Potential source sand for placement on the beaches is being characterized for compatibility with the receiving beaches. The compatibility is in part determined by the grain size, shape, make up, and lack of chemical by-products. URS received five sand samples on August 8th, 2013 from Moffat & Nichol. Two of the samples were from the Broad Beach area, labeled *Broad Beach – Beach*, and *Broad Beach – Dunes*. Three samples were from potential source areas labeled, *Grimes Quarry*, *Cemex Quarry*, and *P.W. Gillebrand (PWG)*. The specific locations of the collected sand samples are unknown.

Scope

The general shape, in terms of roundness, of the sand grains from each sample was visually characterized. This is done with a hand lens magnifier examining the boundaries of the sand grains and noting the angularity and roundness of their edges. The relative roundness of the sand grains was qualitatively compared to diagrams based on the Krumbein sand grain analysis method (Krumbein, 1951). The Krumbein analysis breaks the shape of sand grains into six different types: 1) Very angular, 2) Angular, 3) Sub-angular, 4) Sub-rounded, 5) Rounded, and 6) Well rounded. Two example diagrams are shown below in Figure 1.

A more quantitative approach was used to characterize the five sand samples by performing point counts. This is done by viewing the samples with a 10 x10 grid overlain over the samples and characterizing the individual grain for roundness at each intersection of the grid for a total of 100 individual data points. The data is compiled in a table and histograms were created for each sample. The size of sand ranges from fine (0.05 mm) to coarse (2.00 mm) and can be seen with the naked eye. However, the ability to see the individual grain boundaries with clarity is difficult with out magnification. To perform the point count analysis, the samples were viewed under a stage

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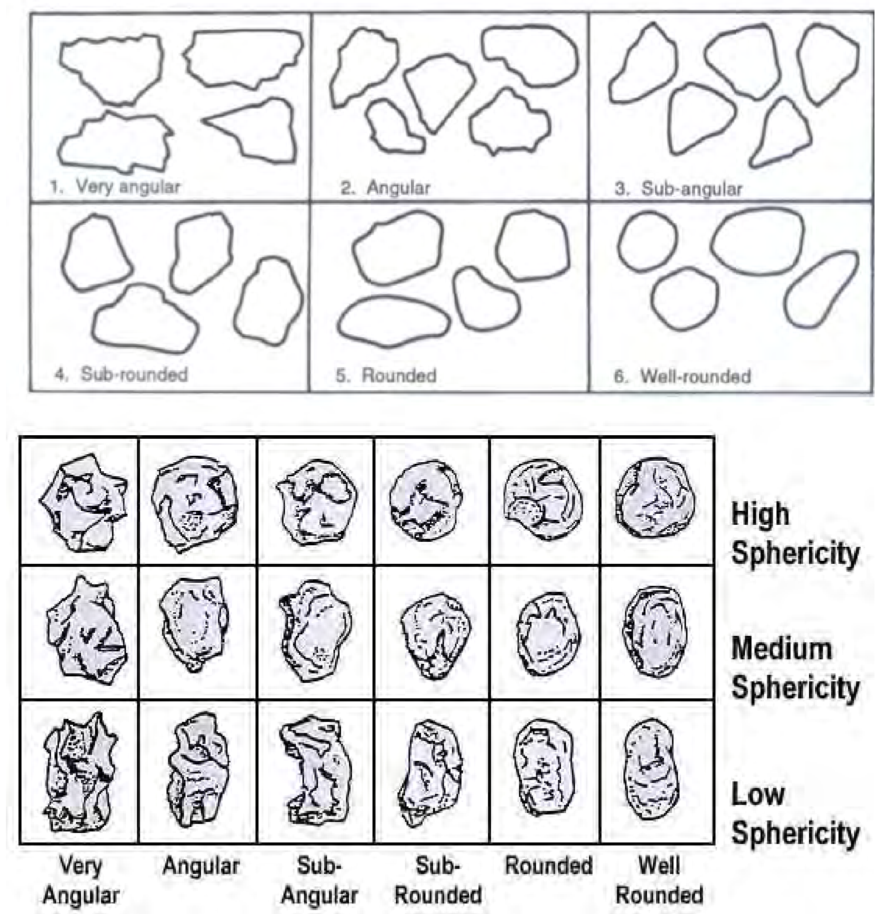
microscope at a magnification of 20x and 40x. Photographs of each sample at 20x are attached to this report.

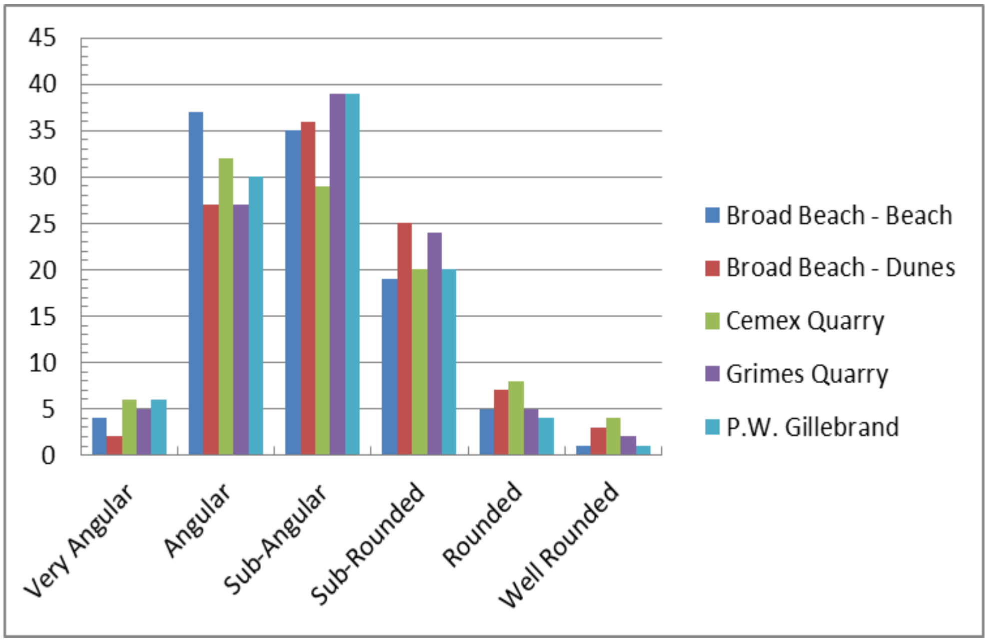
Figure 1. Relative Angularity Diagrams Based on Krumbein, 1951.



Results and Conclusions

Visual inspection, characterization, and point count data are provided for each of the samples provided by Moffat & Nichol below. Qualitative evaluations of grain size are provided below, but sieve analysis are warranted to obtain correct data regarding size relationships. In general the two receiving sand samples are fine grained and well sorted (i.e. the majority of the sand grains are of a similar size), and the potential source samples are generally poorly sorted and medium to coarse grained. The PWG sample has better sorting and less apparent mineral coating on the individual sand grains than the other two potential source samples. A summary graph showing the point count data based on roundness is shown in Figure 2. Graphs of each of the individual sample data are attached to this report.

Figure 2. Summary Graph of Point Count Data Based on Angularity.



Broad Beach – Beach

The *beach* sample from Broad Beach is a fine grained sand that is well sorted. It has a generalized color of light gray (Munsell 10YR, 7/1), but the individual grains range from very dark (black) to light (white). The individual grains of sand are relatively clean (without coatings) and are generally angular to sub-rounded in shape.

Broad Beach – Dunes

The *dunes* sample from Broad Beach is also a fine grained sand that is well sorted. It has a generalized color of light gray to very pale brown (Munsell 10YR, 7/2 to 7/3), and the individual grains range from very dark (black) to light (white). The individual grains of sand are relatively clean and are generally angular to sub-rounded in shape. There is a slightly higher percentage of rounding in this sample relative to the *beach* sample, but it is very nominal.

Cemex Quarry

The Cemex Quarry sample is a poorly sorted, fine to coarse grained sand. It has a generalized color of very pale brown to light gray (Munsell 10YR, 7/3 to 7/2), but the individual grains range from dark (gray) to light (white). The sample in general is angular to sub-rounded. There is a general relationship between the grain size and the roundness. The coarse size grains tend to be sub-rounded to rounded, and the fine to medium size grains tend to be angular to sub-angular. To be noted, there is minor mineral coating on the sand grains and minor amount of fines (silts/clays) exist in this sample.

Grimes Quarry

The sample from Grimes Quarry is also a poorly sorted, fine to coarse grained sand. It has a generalized color of very pale brown to yellow (Munsell 10YR, 7/4 to 7/6), but the individual grains range from dark (gray) to light (white). The sample in general is angular to sub-rounded. Unlike the Cemex Quarry sample there is not a general relationship between the grain size and the roundness, and the coarse size grains It should be noted that there is minor mineral coating on the sand grains and minor fines content exists in this sample.

PWG

The P.W. Gillebrand sample is also a well sorted, medium grained sand. It has a generalized color of light gray to white (Munsell 10YR, 7/1 to 8/1), but the individual grains range from dark (gray) to light (white). The sample in general is angular to sub-rounded. The individual grains of sand are relatively clean and no significant fines are present in this sample.

Summary

The overall angularity of the sand is not appreciably different between the proposed source samples and the receiving beach and dunes samples. Minor color and sorting differences were noted as described above.

Sincerely,

URS CORPORATION

David L. Schug, P.G., C.E.G., C.Hg.
Principal Geologist

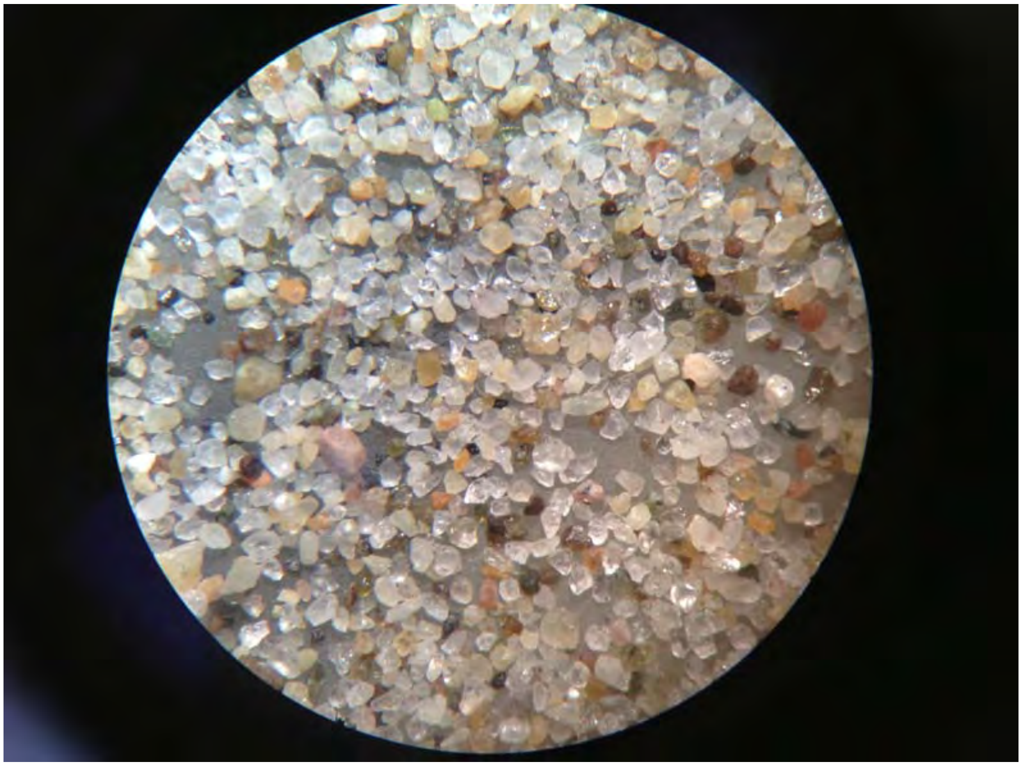
Derek Rector, P.G.
Project Geologist

DLS/DR:wp

Attachment: 1). Sand Grain Photographs. 2) Graphs of Point Count Data.

References-

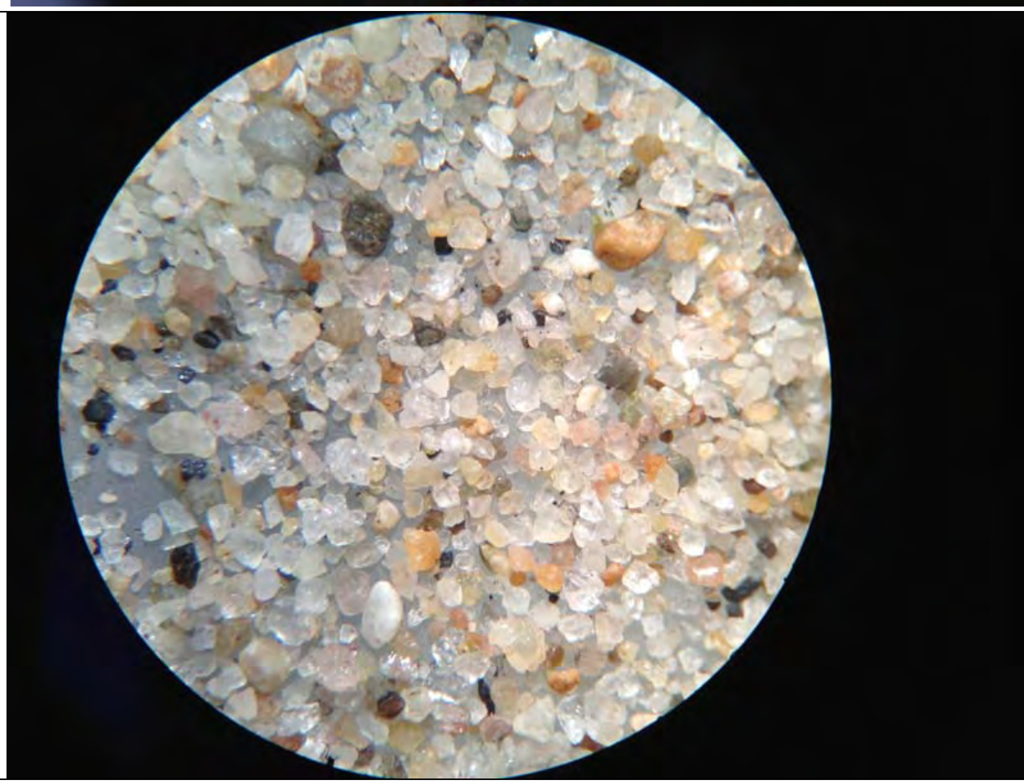
Krumbein, W. C. and L. L. Sloss (1951) Stratigraphy and Sedimentation. 2nd. Ed. W. H. Freeman and Company. London.



Photograph-
Broad Beach -
Beach
(Magnified 20x)

Date: 8/13/13

Comments:
The beach sand is slightly finer than the dune sand below. Note - this appears greater here due to the 20x magnification of the photo.

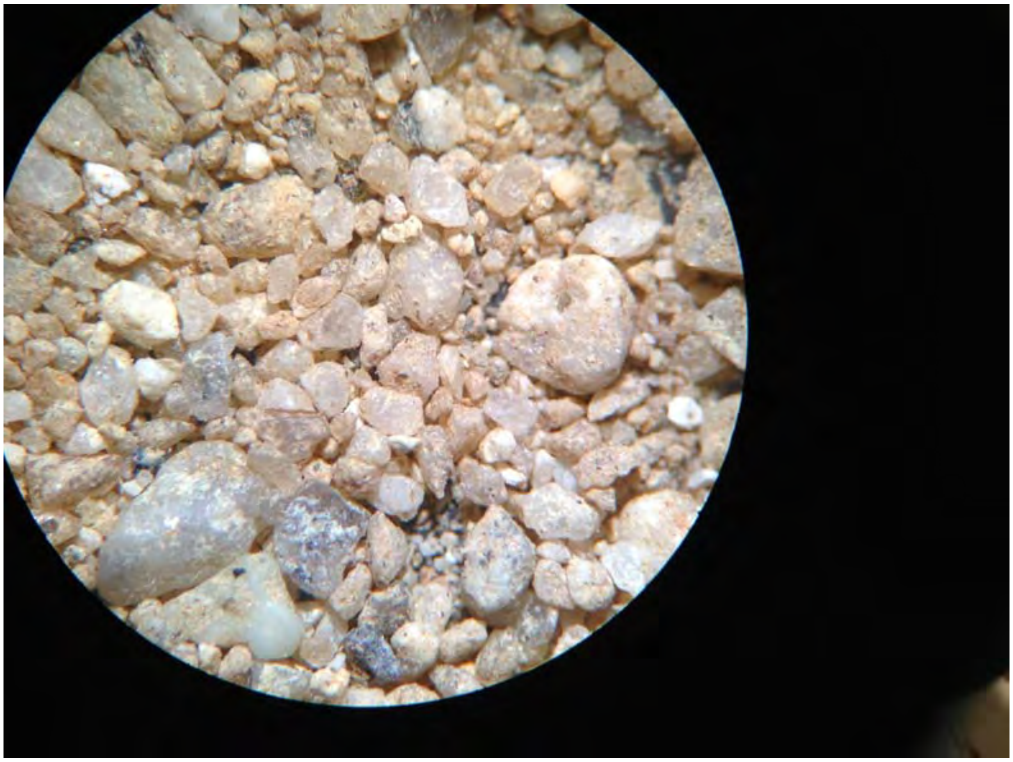


Photograph-
Broad Beach -
Dunes
(Magnified 20x)

Date: 8/13/13

Comments:
The dune sand is slightly coarser than the beach sand above. Also note this sample is lighter in color than above.

	Photograph-Cemex Quarry 01 (Magnified 20x) Date: 8/13/13 Comments: The two photos on this page are from different parts of the same sample.
	Photograph-Cemex Quarry 02 (Magnified 20x) Date: 8/13/13 Comments: The two photos on this page are from different parts of the same sample.

	Photograph-Grimes Quarry 01 (Magnified 20x) Date: 8/13/13 Comments: The two photos on this page are from different parts of the same sample.
	Photograph-Grimes Quarry 02 (Magnified 20x) Date: 8/13/13 Comments: The two photos on this page are from different parts of the same sample.

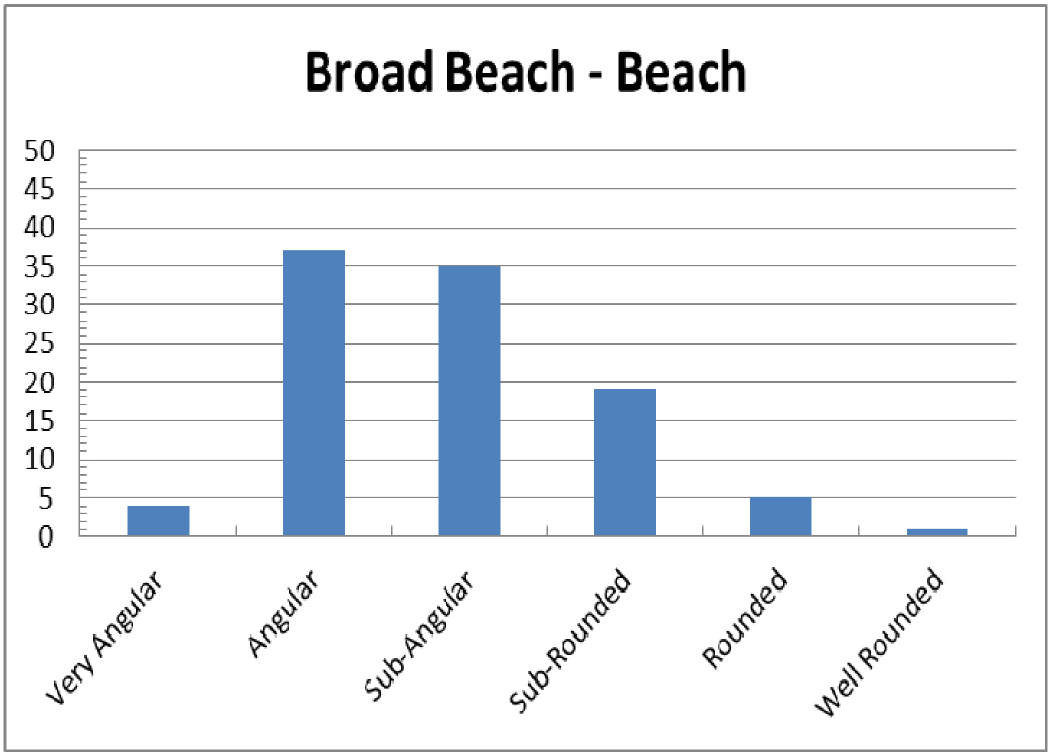
<table>
<tr><td></td><td>Photograph-
PWG 01
(Magnified 20x)

Date: 8/13/13

Comments:
The two photos on this page are from different parts of the same sample.</td></tr>
<tr><td></td><td>Photograph-
PWG 02
(Magnified 20x)

Date: 8/13/13

Comments:
The two photos on this page are from different parts of the same sample.</td></tr>
</table>



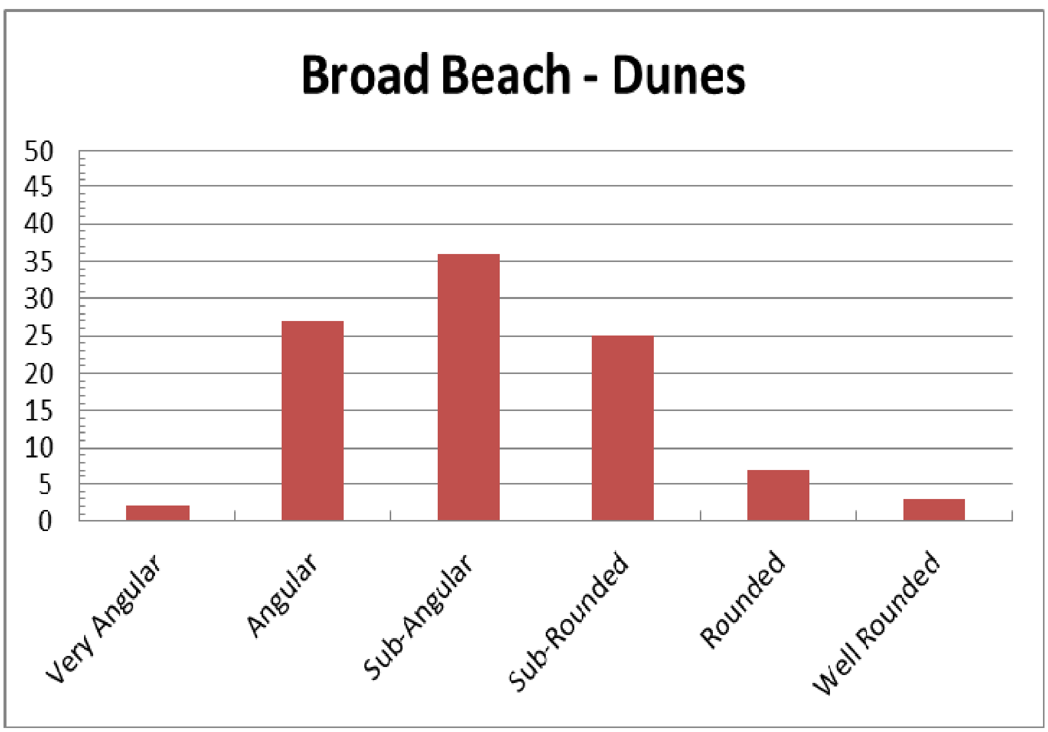
Point Count Data Based on Angularity -

(Total points = 100)

Date: 8/13/13

Comments:

Angular to Sub-Rounded.



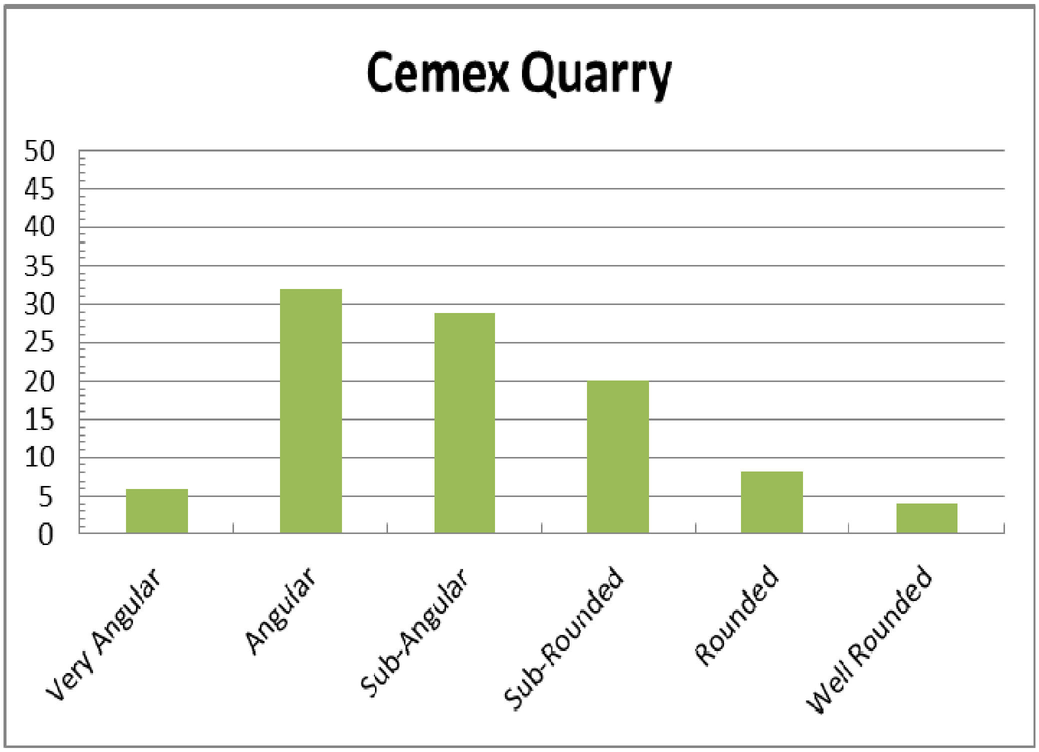
Point Count Data Based on Angularity -

(Total points = 100)

Date: 8/13/13

Comments:

Angular to Sub-Rounded.



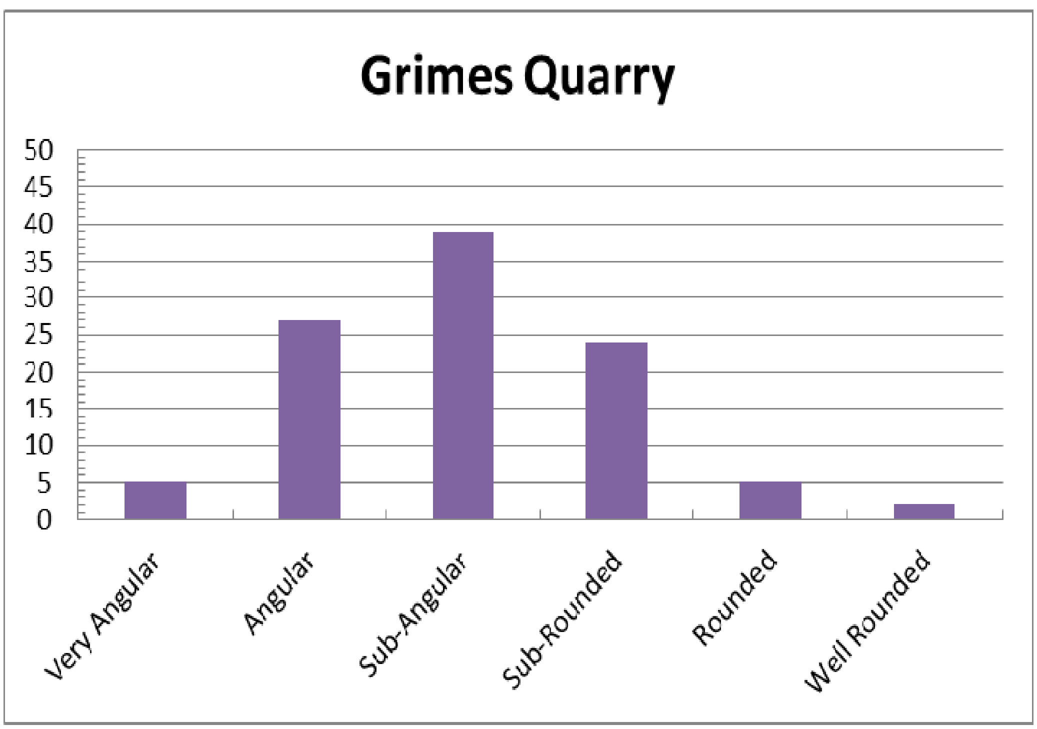
Point Count Data Based on Angularity -

(Total points = 100)

Date: 8/13/13

Comments:

Angular to Sub-Rounded.



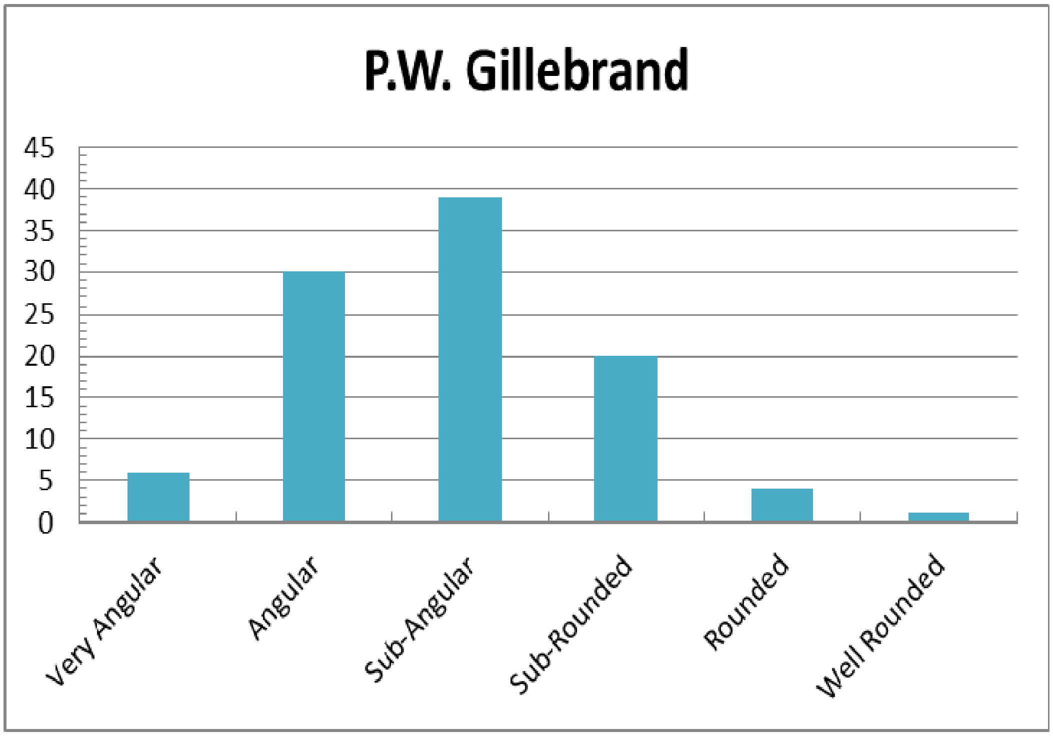
Point Count Data Based on Angularity -

(Total points = 100)

Date: 8/13/13

Comments:

Angular to Sub-Rounded.



Point Count Data Based on Angularity -

(Total points = 100)

Date: 8/13/13

Comments:

Angular to Sub-Rounded.