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Subject: Oceano Dunes SVRA - Sand Grain Size Analyses, Part I
Comparison of Sieved Sand Samples with NRCS Soils Data

Since 2007, the California Geological Survey (CGS) has assisted California State Parks (CSP) with the geologic review of various projects related to the Oceano Dunes State Vehicular Recreation Area (ODSVRA) and Pismo State Beach. At the request of CSP, CGS compared data from 60 sieved sand samples collected from ODSVRA, and adjacent lands managed by CSP, with soils data published by the USDA Natural Resource Conservation Service (NRCS, 2008). Details of the comparison are summarized below and included in the attached Appendices, Figures, and Plates.

GEOLOGIC SETTING

ODSVRA and adjacent lands managed by CSP are located at the northwestern end of the Santa Maria River valley in what is known as the Callender dune sheet (Cooper, 1967; Hunt, 1993; Orme and Tchakerian, 1986). Several phases of dune formation are present in the area, the oldest (25,000 to 80,000 years old) occurring inland on elevated terraces within the Nipomo Mesa. The majority of the ODSVRA lies within the youngest (2,000 years to present), most active sequence of beach and dune sands, which is directly inland from the present shoreline. In most places, aeolian transport of the sand is ongoing and the dunes are actively migrating inland. Sand supplied to the coastal dunes comes from the ocean flat and banks at low water and from dry inland margins of the beach. The dunes lie in the general northwest-southeast direction of the underlying geologic structure and the prevailing winds of the area, which are generally between 300 and 320 degrees NNW. Recent studies by Griggs and others (2005) estimate 115,000 cubic yards of sand are blown inland each year along the 55 mile stretch of coastline from Pismo Beach to Point Arguello.

PURPOSE OF STUDY

The purpose of this study is to compare results of site specific surface grain size analyses conducted by CGS with nearby existing soil grain size data published by the USDA Natural Resource Conservation Service (NRCS, 2008) and the Soil Conservation Service (SCS, 1984). This information can be used in future studies, both within and adjacent to ODSVRA, that require knowledge of similarities and differences in sand and soil grain sizes at different locations and how they relate to wind direction and velocity, sand transport, dune shape and topography, and vegetation. For example, the wind threshold velocity required to lift a sand grain into saltation, the height of saltation, and the distance a sand grain will travel are all dependent upon sand grain size and particle size distribution at a given location (Bagnold, 1941; Welland, 2009; and Zheng, 2009). Microprobe analyses of grain size and mineral composition for selected samples within the ODSVRA (CGS, Part 2, in progress) can also be used in understanding and mitigating various potential sources of particulate matter, both within and outside of the areas managed by CSP.

UNITS OF MEASURE

The standard unit of measure used in soil grain size analyses by NRCS and in the American Society for Testing and Materials (ASTM) sieve analyses methods used in this study, is the millimeter (mm). For this report, we have converted millimeters to microns (0.001 mm = 1 micron) throughout the text and have used microns only in the Summary of Findings and Conclusions. The following definitions for sand, silt, and clay grain size particles were used by NRCS and in the ASTM sieve analyses:

<table>
<tr><th colspan="2">ASTM</th><th colspan="2">NRCS</th></tr>
<tr><td>Coarse Sand</td><td>> 2 mm (> 2000 microns)</td><td rowspan="5">> 0.05 mm (> 50 microns)</td><td rowspan="5">Sand</td></tr>
<tr><td>Medium Sand</td><td>> 0.425 mm (> 425 microns)</td></tr>
<tr><td>Fine Sand</td><td>> 0.150 mm (> 150 microns)</td></tr>
<tr><td>Very Fine Sand</td><td>> 0.075 mm (> 75 microns)</td></tr>
<tr><td>Silt/Clay</td><td>> 0.045 mm (> 45 microns)</td></tr>
<tr><td rowspan="2">Silt/Clay</td><td rowspan="2">< 0.045 mm (< 45 microns)</td><td>> 0.002 mm (> 2 microns)</td><td>Silt</td></tr>
<tr><td>< 0.002 mm (< 2 microns)</td><td>Clay</td></tr>
</table>

The lower limit of very fine sand used in the ASTM sieve analyses is 0.075 mm (75 microns) while NRCS uses 0.05 mm (50 microns). As a result, percentages for silt/clay fractions in the sieve analyses study may contain some very fine sands as defined by NRCS. Because the samples collected for sieve analyses contained a relatively small percent of particles less than 0.075 mm (75 microns) (Table B-2), they were not sieved below the combined silt/clay fraction of 0.045 mm (45 microns). Percentages of silt/clay-sized particles less than 0.045 mm (45 microns) found in the sieved samples will be considered in the microprobe analyses of grain size and mineral composition in Part 2 of this study (CGS, in progress).

SUMMARY OF FINDINGS

NRCS Soils Data

- NRCS mapping (Plate 1) shows the majority of ODSVRA and other lands managed by CSP lies within two soil map units, the Beaches map unit (Unit 107) and the Dune land map unit (Unit 134). According to NRCS, both units are comprised of 97.9 to 98.9% windblown sand greater than 50 microns in size (Table A-1).

- NRCS shows the majority of soils within ODSVRA and other lands managed by CSP are representative of the lowest percentage (0.5%) of clay (less than 2 microns) and the lowest percentage (1.1%) of silt and clay combined (particles less than 50 microns in size) when compared with soils in surrounding areas (Tables 1, 2, and A-1; Plates 2 and 3).

- Soils in the southeast corner of the ODSVRA east of Oso Flaco Lake, and in areas adjacent to lands managed by CSP, have greater percentages of clay (less than 2 microns) and silt/clay (less than 50 microns), some of which are as high as 50 to 80% (Tables 1, 2, and A-1; Plates 2 and 3).

Sieved Sand Grain Size Analyses

- All 60 sieved sand samples are located within NRCS soil map units Beaches and Dune land (Plates 3 and 4). Sieve analyses indicate all samples are 95.3 to 100% sand greater than 75 microns in size (Table B-1).

- In 48 samples, 70% or more of the sand grains are between 150 and 425 microns in size, indicating the sand is well sorted. In the remaining 12 samples, 15% to 59% of the sand grains are more than 425 microns in size (Tables B-1; Figures B-1 and B-2).

- In general, samples taken in vegetated and/or flat areas on the northern and eastern sides of the vegetation islands have a higher (0.0 to 4.7%) silt/clay component (particles less than 75 microns) than samples taken from the western side of the islands, in the OHV ride area, in the Dune Preserve, or along the beach (0.0 to 1.0% silt/clay) (Table B-1; Plate 3).

Comparison of Sieved Sand Grain Size Analyses with NRCS Data

- NRCS grain sizes for sand, silt, and clay are generally consistent with the various mesh sizes used in the sieve analyses.

- All sieved sand samples within the NRCS Beaches soil map unit contain a silt/clay fraction (less than 75 microns) of 0.3% or less. This is well below the NRCS 2.1% silt/clay value (less than 50 microns) for Beaches.

- Twelve (12) samples (20%) have a silt/clay fraction (less than 75 microns) between 1.2 and 4.7%, which is above the NRCS 1.1% silt/clay fraction (less than 50 microns) for Dune land (Table B-1). The samples are located primarily on the eastern side of the vegetation islands within flat valley or topographically depressed areas (Plates 3 and 4).

EXISTING NRCS SOILS DATA

Abbreviated descriptions of the soil units mentioned below are presented in Appendix A and Table A-1, as excerpted from the NRCS (2008) and SCS (1984).

Soils within ODSVRA and Other Lands Managed by CSP (Plate 1)

The western edge of ODSVRA and most of Pismo State Beach are within the Beaches soil map unit (NRCS, 2008; Plate 1). The remainder of the two parks is primarily in the Dune land soil map unit, with two exceptions. Within the eastern boundary of lands managed by CSP, there are small areas of water, older stabilized sand dunes, and water-deposited sands and loamy sands that often contain layers of organic material located within poorly drained basins. In the southeast corner of the ODSVRA, near Oso Flaco Lake, small patches of loamy sand, loam, and sandy loam are exposed. These areas account for about 10% of the CSP managed lands.

The Beaches soil map unit (Unit 107) includes sands in the intertidal zone. The permeability of the sands within the Beaches unit is very rapid; available water capacity is low or very low; surface runoff is slow; and the erosion hazard is high or very high because of wind and wave action (SCS, 1984). According to NRCS (2008), Beaches soils are 97.9% sand, 1.6% silt, and 0.5% clay (Table 1 and Table A-1).

Table 1: Soils within CSP Managed Lands (excerpted from NRCS, 2008)

Soil Unit	% Sand	% Silt	% Clay
134- Dune land	98.9	0.6	0.5
107- Beaches	97.9	1.6	0.5
124 -Corralitas sand, 0-2% slopes	96.0	1.5	2.5
125 -Corralitas sand, 2-15% slopes	96.0	1.5	2.5
184 -Oceano sand, 0-9% slopes	95.0	1.5	3.5
126- Corralitos Variant loamy sand	80.5	17.0	2.5
193- Psamments and Fluvents, wet	78.5	16.5	5.0
111- Camarillo sandy loam	66.8	19.2	14.0
112- Camarillo loam, drained	43.0	38.5	18.5
174- Mocho loam	39.8	37.7	22.5
170 -Marimel silty clay loam, drained	18.1	50.9	31.0

Dune land (Unit 134) consists primarily of hilly areas along the coast that are composed of sand-sized particles that shift with the wind. The majority of the soils within the ODSVRA and adjacent CSP managed lands are classified by NRCS as Dune land. While a portion of these lands is used for vehicular recreation, a large percentage is considered Dune Preserve and/or is closed to vehicles. While most Dune land is devoid of vegetation, some areas, such as the vegetation islands within the ODSVRA, are partially vegetated. Some of the vegetation is native and/or natural; while some is non-native or has been introduced over time (CGS, 2007). According to SCS (1984), the permeability of soils in the Dune land map unit is very rapid; available water capacity is very low; surface runoff is slow; and the hazard of sand blowing is very high. According to NRCS (2008), Dune land is 98.9% sand, 0.6% silt, and 0.5% clay (Table 1 and Table A-1).

Within the eastern boundary of lands administered by CSP, small areas of Oceano sand, 0-9% (Unit 184) and Psamment and Fluvents, wet (Unit 193) are present. Both soil units have formed in areas of old stabilized sand dunes or windblown sand. According to NRCS (2008), these units range from 78.5 to 95.0% sand, 1.5 to16.5% silt, and 3.5 to 5.0% clay (Table 1 and Table A-1).

In the northern portion of the area, along the eastern boundary of Pismo State Beach northwest of Grover Beach, three additional smaller units are present. These include Corralitos sand (Units 124 and125) and Marimel silty clay loam. According to NRCS (2008), the Corralitos sand units are 96.0% sand, 1.5% silt, and 2.5% clay; Marimel silty clay loam is 18.1% sand, 50.9% silt, and 31.0% clay (Table 1 and Table A-1).

In the southeast corner of the ODSVRA near Oso Flaco Lake, small areas of Camarillo sandy loam (Unit 111), Camarillo loam, drained (Unit 112), Corralitos Variant loamy sand (Unit 126), Mocho loam (174), and Psamments and Fluvents, wet (Unit 193) are present (Plate 1). All of these units are associated with alluvial fan and flood plain deposits of sedimentary origin. Except for Unit 193, they are used primarily for cultivated crops and/or as rangeland. Units 111, 112, and 174 also meet NRCS requirements for prime farmland when irrigated. According to NRCS (2008), these five units range from 39.8 to 80.5% sand, 16.5 to 38.5% silt, and 2.5 to 22.5% clay (Table 1 and Table A-1).

<u>Soils Adjacent to ODSVRA and Lands Managed by CSP (Plate 1)</u>

As shown on Plate 1, much of the land immediately adjacent to ODSVRA and Pismo State Beach is formed of Dune land (Unit 134, described above) and Oceano sand (Units 184 and 185). The Oceano sand units are located east of CSP managed lands, primarily north of the town of Oceano and on the Nipomo Mesa. They consist of very deep, excessively drained, brown to stratified pale brown and pink sand formed on older stabilized sand dunes in deposits of windblown sand. Some of these soils have a sandy loam surface layer. Permeability of the soil is rapid; available water capacity is low; surface runoff is slow to rapid and the hazard of water erosion is slight to high, both depending upon slope. The hazard of soil blowing is high. In addition, the susceptibility to piping is high and gully erosion is a hazard during wet years due to the channeling of runoff. According to the NRCS (2008), both units of Oceano sand (Units 184 and 185) are 95.0% sand, 1.5% silt, and 3.5% clay (Table 2 and Table A-1).

Smaller areas of Oceano sand, 0-9% (Unit 184) and Psamments and Fluvents, wet (Unit 193) are also present throughout the area east of CSP managed lands. Both of the above soils units have formed in areas of old stabilized sand dunes or windblown sand. According to NRCS (2008), Psamments and Fluvents, wet (Unit 193) are 78.5% sand, 16.5% silt, and 5.0% clay (Table 2 and Table A-1).

Table 2: Soils adjacent to CSP Managed Lands (excerpted from NRCS, 2008)

Soil Unit	% Sand	% Silt	% Clay
134 -Dune land	98.9	0.6	0.5
124 -Corralitas sand, 0-2% slopes	96.0	1.5	2.5
125 -Corralitas sand, 2-15% slopes	96.0	1.5	2.5
184 -Oceano sand, 0-9% slopes	95.0	1.5	3.5
185 -Oceano sand, 9-30% slopes	95.0	1.5	3.5
126 -Corralitos Variant loamy sand	80.5	17.0	2.5
219 -Tujunga loamy sand, 0-2% slopes	80.5	17.0	2.5
193 -Psamments and Fluvents, wet	78.5	16.5	5.0
176 -Mocho Variant fine sandy loam	70.5	16.5	13.0
173 -Mocho fine sandy loam	68.8	16.2	15.0
111- Camarillo sandy loam	66.8	19.2	14.0
191 -Pismo-Tierra complex, 9-15% slopes	65.9	19.1	15.0
112 -Camarillo loam, drained	43.0	38.5	18.5
174 -Mocho loam	39.8	37.7	22.5
210 -Still gravelly sandy clay loam, 2-9% slopes	55.1	17.4	27.5
169 -Marimel sandy clay loam, occas. flooded	55.1	17.4	27.5
170 -Marimel silty clay loam, drained	18.1	50.9	31.0
197 -Salinas silty clay loam, 0-2% slopes	18.1	50.9	31.0
195- Rock outcrop-Lithic Haploxerolls complex, 30-75% slopes	NA	NA	NA
221–Xerts-Xerolls-Urban land complex, 0-15% 0-15% slopes	NA	NA	NA
223- Xerorthents, escarpment	NA	NA	NA

In the northern part of the area, in the vicinity of Pismo Beach, soil units east of CSP managed lands include: Corralitas sand (Units 124 and 125); Marimel sandy clay loam (Unit 169) and Marimel silty clay loam (Unit 170); Mocho fine sandy loam (Unit 173) and Mocho Variant fine sandy loam (Unit 176); Pismo-Tierra complex (Unit 191); Rock outcrop-Lithic Haploxerolls complex (Unit 195, rock outcrops or rock with soils less than 20 inches deep); Still gravelly clay loam (Unit 210); and Xererts-Xerolls-Urban land (Unit 221, soil materials modified by earth movement and urban development). According to NRCS (2008), both units of the Corralitas sand (Units 124 and 125) are 96.0% sand, 1.5% silt, and 2.5% clay. With the exception of Rock outcrop-Lithic Haploxerolls complex (Unit 195) and Xererts-Xerolls-Urban land (Unit 221), all of the other units (Units 169, 170, 173, 176, 191, 210) consist of sandy, silty or clay loams ranging from 18.1to 70.5% sand, 16.5 to 50.9% silt, and 13.0 to 31.0% clay (Table 2 and Table A-1). All of these loam units also meet NRCS requirements of prime farmland, except for Unit 191 (SCS, 1984).

Three of the above loam units are also present immediately east of the Dune Preserve. These include moderately large-sized areas of: Marimel sandy clay loam (Unit 169), Marimel silty clay loam (Unit 173), and Mocho Variant fine sandy loam (Unit 176). According to NRCS (2008), these units range from 55.1 to 70.5% sand, 16.2 to 17.4% silt, and 13.0 to 27.5% clay (Table 2 and Table A-1).

Numerous soil units present in the southern part of the area, east of Oso Flaco Lake, are also used primarily for cultivated crops and/or rangeland. These include: Camarillo sandy loam (Unit 111) and Camarillo loam, drained (Unit 112); Corralitos Variant loamy sand (Unit 126); Dune land (Unit 134); Marimel silty clay loam, drained

(Unit 170); Mocho fine sandy loam (Unit 173) and Mocho loam (Unit 174); Psamments and Fluvents, wet (Unit 193); Salinas silty clay loam (Unit 197); Tujunga loamy sand (Unit 219); and Xerorthents, escarpment (Unit 223). With the exception of Dune land (Unit 134) and Psamments and Fluvents, wet (Unit 193), all of these units meet NRCS requirements of prime farmland, either naturally or when irrigated. According to NRCS (2008), these units range from 39.8 to 80.5% sand, 16.5 to 38.5% silt, and 2.5 to 22.5% clay (Table 2 and Table A-1).

Comparison of Grain Size Distribution among Soil Types (Plates 2 and 3)

NRCS (2008) defines various grain sizes and soil types as follows:

Sand: Individual rock or mineral fragments from 0.05 mm to 2.0 mm (50 to 2000 microns) in diameter. Most sand grains consist of quartz. As a soil textural class, the soil is 85% or more sand and not more than 10% clay.

Silt: Individual mineral particles that range in diameter from the upper limit of clay (0.002 mm or 2 microns) to the lower limit of very fine sand (0.05 mm or 50 microns). As a textural class, the soil is 80% or more silt and less than 12% clay.

Clay: Mineral soil particles less than 0.002 mm (2 microns) in diameter. As a soil textural class, the soil material is 40% or more clay, less than 45% sand, and less than 40% silt.

The mineral particle sizes in these definitions are generally consistent with the various mesh sizes used the sieved sand analyses (Table 3).

Based on information in NRCS (2008) Geographic Information System (GIS) files and on Table A-1, CGS prepared soil data maps showing NRCS soils by percent clay (Plate 2) and by a combination of percent silt/clay (Plate 3). The maps are color coded with various shades of green, yellow, orange and pink to highlight different ranges of percent clay and percent silt/clay content by location and soil type. Where a combination of soil types is represented by just one NRCS map unit on Plate 1 and Table A-1, either the silt/clay percentages of the dominant unit, or the unit where percentages were greatest, were used where multiple soil types were of equal dominance. One exception was Pismo-Tierra complex, 9-15% slopes (Unit 191). Even though Pismo soils represent 40% of the unit and Tierra soils 30% of the unit, according to SCS (1984), the remaining 30% of the unit is comprised of multiple soils more similar in nature to the Tierra soils than to the Pismo soils. Therefore, the higher percentages of silt and clay reflected in the Tierra soil values were used. Plate 3 was used to provide a comparison of NRCS data with site specific sand data (Plate 4).

As shown on both Plate 2 and Plate 3, the majority of soils within ODSVRA, Pismo State Beach and other lands managed by CSP are representative of both the lowest percentages of clay (0.5%) and the lowest percentages of silt/clay combination (1.1%). NRCS shows the majority of the area is within Beaches and Dune land, 97.9 to 98.9% of which is comprised of windblown sand greater than 0.05 mm (50 microns) in size. The one exception is in the southeast corner of the ODSVRA, east of Oso Flaco Lake and outside of the ODSVRA ride area, where lands with higher percentages of silt and clay are used primarily for agricultural purposes. Soils adjacent to lands managed by CSP, in general, also have higher percentages of clay and silt/clay, some of which are between 50 and 80%.

NRCS characterizes Beaches (Unit 107) as having a high or very high erosion hazard because of wind and wave action; in Dune land (Unit 134) the hazard of soil blowing is very high. NRCS also describes the hazard of soil blowing as high in several of the soils within the southeast corner of ODSVRA and adjacent to lands managed by CSP. These include Corralitas sand (Units 124, 125, 126), Oceano sand (Units 184 and 185) and Tujunga loamy sand (Unit 219).

SIEVED SAND GRAIN SIZE ANALYSES

Sample Collection (Plates 3 and 4)

Sixty (60) sand samples were collected from ODSVRA, and surrounding lands managed by CSP, using hand-driven 6-inch long, 2.5-inch diameter, thin-walled brass tubes, typically used in a Modified California Split Barrel Sampler. The open-ended tube ends were sealed with removable plastic caps. Locations of the samples are shown on Plates 3 and 4. While some samples were taken randomly at different times of the year, others were taken at specific times and locations to reflect such conditions as prevailing winds, wet zones along the beach, ride areas, vegetation islands, and other protected areas within ODSVRA. In addition, three to four main zones of dune advancement are represented from west to east.

While the top 6 inches of sand were sampled at most locations, the sample sizes varied in weight due to moisture content and an organic and/or small shell component in some samples. In most sample areas, some degree of moisture was encountered 3 to 6 inches below the surface.

Sieved Sand Analyses (Table B-1)

Per the ASTM Standard D421-85 for dry preparation of soil samples for particle-size analysis, the collected samples were exposed in the laboratory to air at room temperature until dried thoroughly. Organic materials were removed from the samples, where present, prior to shaking. The loosely consolidated nature of the sand precluded the need for further break-up of aggregated materials. Each sample was then weighed using an OHAUS Triple Beam Balance, metric model, taking into consideration the tare. Next, each sample was placed into consecutively stacked ASTM E-11 Specification, wire mesh USA Standard Testing Sieves and a receiver, with the following dimensions:

Table 3: USA Standard Sieve Size and Equivalent Size Conversions

Sieve Size	mm opening	inches	microns
No. 10	2.000	0.0787	2000
No. 40	0.425	0.0165	425
No. 100	0.150	0.0059	150
No. 200	0.075	0.0029	75
No. 325	0.045	0.0017	45

After securing the test sieve lid, the sieves were clamped onto an electric shaker and shaken for 5 minutes. Sand remaining on each sieve and in the receiver at the base of the stack was weighed and the percent weight computed into five or six categories:

Coarse:	Sands remaining on the No. 10 sieve, greater than 2 mm (2000 microns) in diameter
Medium:	Sands remaining on the No. 40 sieve, greater than 0.425 mm but less than 2 mm in diameter (between 425 and 2000 microns)
Fine:	Sands remaining on the No. 100 sieve, greater than 0.150 mm but less than 0.425 mm in diameter (between 150 and 425 microns)
Very Fine:	Sands remaining on the No. 200 sieve, greater than 0.075 mm but less than 0.150 mm in diameter (between 75 and 150 microns)
Silt/Clay:	Material remaining on the No. 325 sieve, greater than 0.045 mm but less than 0.075 mm (between 45 and 75 microns); in undifferentiated samples, material remaining in the receiver, less than 0.075 mm (75 microns) in diameter
Silt/Clay:	Material remaining in the receiver, but less than 0.045 mm (45 microns)

Sieved Sand Analyses Findings (Table B-1, Figures B-1 and B-2)

Results of the sieve analyses are shown in Appendix B, both by percent (Table B-1) and graphically by location (Figures B-1 and B-2). Based on these findings, in 48 of the 60 samples (80%), more than 70% of the sand grains are between 0.150 mm and 0.425 mm (150 to 425 microns) in size, with a less than 10% very fine sand component between 0.075 mm and 0.150 mm (75 to 150 microns) in size, and less than 0.5% combined silt/clay component less than 0.075 mm (75 microns) in size. This indicates the sands are well-sorted.

In all but two samples, there is no coarse sand component (more than 2 mm or 2000 microns in size). Of the 60 samples, 12 samples (20%) contained a 25% to 59.3% medium sand component ranging between 0.425 mm and 2.0 mm (425 to 2000 microns) in size. Most of these samples were located near or within the NRCS Beaches soil map unit or near the vegetation islands. The sample from Pismo Beach (PB-1) showed the highest component (23.6%) of very fine sand between 0.075 mm and 150 mm (75 to 150 microns) in size.

In general, samples taken in vegetated and/or flat areas on the northern and eastern sides of the vegetation islands have a higher combined silt/clay component (0.0 to 4.7%) than samples taken from the western side of the islands (0.0 to 0.7%), within the ride area (0.2 to 1.0%), within the Plover area (0.0 to 0.2%), within the Dune Preserve (0.4%), or along the beach (0.0 to 0.2%).

COMPARISON OF SIEVED SAND ANALYSES WITH NRCS DATA

The mineral particle size definitions for sand, silt, and clay used by NRCS are generally consistent with the various mesh sizes used in the sieved sand analyses. However, in the sieved sand analyses, 0.075 mm (75 microns) is used as the lower limit of very fine sand, as defined in standard geological and engineering studies, rather than the 0.05 mm (50 microns) used by NRCS for soils. Therefore, percentages for silt/clay fractions in the sieved sand analyses may contain some very fine sands as defined by NRCS. Also, because the sieved sand samples contained a relatively small percent of particles less than 0.075 mm (75 microns; Table B-2), they were not sieved below the combined silt/clay fraction of 0.045 mm (45 microns). Therefore, percentages of clay-sized particles (less than 0.002 mm/ 2 microns) were not differentiated from the silt size particles less than 0.045 mm (45 microns). Further analysis of fine material less than 0.045 mm (45 microns) found in the sieved samples will be considered in Part 2 of this study (CGS, in progress).

In order to compare the sieved sand data with the NRCS grain size data, NRCS silt and clay percentages were combined on Plate 3. Sieved sand sample locations with combined silt/clay fractions that were not consistent with the NRCS values were then designated with the appropriate percentage color code to highlight the differences.

All 60 sieved sand samples are located within the NRCS Beaches and Dune land soil map units and fall within the NRCS definition for soil textural class sand, i.e., a soil that is 85% or more sand (individual fragments between 0.050 mm and 2.0 mm/50 and 2000 microns) and not more than 10% clay (particles less than 0.002 mm/2 microns in size). NRCS shows the Beaches and Dune land soil map units are comprised of 97.9 to 98.9% windblown sand greater than 0.050 mm (50 microns) in size, while all sieved samples were comprised of 95.3% to 100% sand grain-sized particles greater than 0.075 mm (75 microns).

While NRCS data show both Beaches and Dune land to soil map units to have a 0.5% clay fraction (less than 0.002 mm/2 microns in size), eleven (11) of the sieved samples have a combined silt/clay fraction (less than 0.075 mm/75 microns) of 0.1% or less.

Twelve (12) of the 60 sieved samples (20%) had a combined silt/clay fraction (less than 0.075 mm/75 microns) between 1.2 and 4.7% which is above the NRCS 1.1% combined silt/clay fraction (less than 0.050 mm/50 microns) for Dune land. All of these samples were taken within the vegetation islands (Table B-1; Plates 3 and 4). In addition, all but one (PH-1) are on the eastern side of the vegetation islands and all but one (C-2) are in flat valley or topographically depressed areas.

All areas sampled along the beach and within the NRCS Beaches soil map unit contain a silt/clay fraction (less than 0.075 mm/75 microns) that is below the NRCS 2.1% combined silt/clay value (less than 0.050 mm/50 microns) (Plate 3). In fact, all samples had a combined silt/clay value of 0.3% or less, which is also significantly below the NRCS 1.1% combined silt/clay fraction for Dune land.

NRCS data show the majority of soils within ODSVRA and other lands managed by CSP are representative of both the lowest percentages of clay (0.5%) and the lowest percentages of silt and clay combined (1.1%) when compared with soils in surrounding areas (Plate 2 and Plate 3). NRCS data also show the alluvial-derived soils in the southeast corner of the ODSVRA, outside the OHV ride area and east of Oso Flaco Lake, and in areas adjacent to lands managed by CSP, in general, have higher percentages of clay and silt/clay, some of which are as high as 50 to 80%.

DISCUSSION

The sieve analyses of samples collected within ODSVRA show that the sand is well sorted and has a predominant sand grain size between 0.150 mm and 0.425 mm (150 and 425 microns). The silt/clay component of the sand less than 0.075 mm (75 microns) in diameter is generally less than 0.5%. This data can be of use in assessing the nature of sand movement, threshold wind speeds, and dust generation in the ODSVRA. While there are many related studies that focus on arid desert sands commonly derived from soils exhibiting a high clay content, there are several factors that should be considered in comparative studies of the loosely consolidated coastal sands at ODSVRA. For example:

Sand Movement: Studies by Bagnold indicate there will be more mass movement if the sand is composed of different grain sizes (if it is poorly sorted) than if it is of a more uniform size (Bagnold, 1941; Welland, 2009). Grain size is also responsible for dune shapes, i.e., transverse dunes are generally comprised of well sorted fine sand while interdune and/or flat areas in the dunes tend to be more bimodal in size composition (White and Tsoar, 1998). In addition, studies of sand movement on inclined dune surfaces show there is a gradual decrease in surface grain size and an exponential increase in sand flux with the height of the dune; there is also an increase in wind speed going over the escarpment (White and Tsoar, 1998). Coarser grains not moved by the wind at the base of the slope cause a winnowing of the fines upslope near dune crest. Seasonal variations in grain size distribution may also occur as a result of heating and cooling, which alter turbulence and control sand transport at each location on the surface of the dune.

Threshold Wind Speed: Bagnold (1941) also determined that the wind speed needed to start grains moving depends upon the size of the sand grains. He found that a minimum wind speed of 10 mph is needed to move desert sands between 0.08 and 0.150 mm (80 and 150 microns) in size (Bagnold, 1941; Welland, 2009). This sand grain size range is significantly less than the predominant sand grain size range at ODSVRA, which is between 0.150 mm and 0.425 mm (150 to 425 microns). Additional field studies by Bagnold (1941) predicted a grain of sand 0.4 mm (400 microns) should require an initial wind speed of 31 miles per hour to be lifted from the ground. Owing to air drag, the grain would rise 1.6 meters (5.2 feet) within a 0.4 second time frame (Bagnold, 1941). Actual variations in threshold wind speed as related to grain size would need to be verified at ODSVRA.

Studies conducted in loose soils by Nickling (1988) also indicate that threshold velocity of a natural sediment cannot be represented by a single value. This is because natural environments are generally not characterized by a unique sand grain size diameter. However, erosion thresholds observed in both natural and wind tunnel experiments were found to be significantly higher on rough surfaces than on smooth surfaces (Musick and Gillette, 1990; Gillette and others, 1982).

Dust Generation: In their model for loose soils, Marticorena and Bergametti (1995) defined the following grain size parameters for various types of sand and finer soil particle movement:

Particles greater than 2000 microns are generally too heavy to be lifted and tend to roll or "creep" along the surface of the ground.

Grains 60 to 2000 microns are lifted by saltation to a vertical height of about 1 meter (3.27 feet).

Loose soil particles less than 60 microns are small enough to be transported upward by turbulent eddies, sometimes very far from the sources, in movement known as "suspension".

According to Greeley and Iversen (1985), the value of the particle diameter for the saltation-suspension boundary is about 50 microns or the silt/clay grain size boundary. Marticorena and Bergametti (1995) also indicate the soil fraction able to deliver fine particles is controlled by the clay fraction. Both studies show that both the mass and size distribution of the dust generated is dependent upon the size distribution of the initial particle bed (i.e., the size distribution of the source material). White and Tsoar (1997) also found that sand texture reflects changes in the transportation capacity of the wind, which ultimately has an effect on the amount of particles available for suspension. For example, they report that Tsoar (1976) showed that active desert sand dunes contain no more than 3% of particles less than 74 microns that enter into suspension through the impingement of saltating grains.

These factors need to be considered in assessing the nature of sand movement, threshold wind velocity, and dust generation at ODSVRA.

CONCLUSIONS

The grain size distributions within the 60 sieved sand samples are generally consistent with NRCS soils mapping and supporting data. This confirms the validity of using NRCS soil data as a reference in understanding the existing distribution of grain sizes of surficial materials within and adjacent to ODSVRA.

According to the NRCS soils data and results of the sieved sand analyses, sand on the beach and within the dunes of ODSVRA has a very small component of silt and/or clay size materials. Between 95 and 100% of the samples collected are composed of grain sizes greater than 75 microns. In contrast, according to NRCS, many of the soils adjacent to lands managed by CSP have a 20 to 80% silt/clay component less than 50 microns in size.

The sand in samples collected within ODSVRA is well-sorted and has a predominant sand grain size between 150 and 425 microns. This may be important in assessing the nature of sand movement, threshold wind speeds, and dust generation in the ODSVRA.

Variations between some sieved samples and the NRCS data are most logically explained based on the prevailing wind direction and land morphology in the vicinity of the samples. It appears from the sieved sand analyses that finer grained particles are present on the leeward side of the dunes, especially in the flat or topographically depressed areas of the vegetated islands.

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Appendix A: Description of NRCS Soil Map Units
Table A-1: RUSLE2 Related Attributes, showing major soils in each map unit
Table B-1: CGS Sieved Sand Sample Results
Figures B-1: Relative Percent Sieved Grain Size – Sieved Sand Samples
Figures B-2: Relative Percent Sieved Grain Size – Sieved Sand Samples
Plate 1: NRCS Soils, Distribution of Soils, Oceano Dunes SVRA and Surrounding Areas
Plate 2: NRCS Soils, Relative Distribution of Soils by Percent Clay
Plate 3: NRCS Soils, Relative Distribution of Soils by Percent Silt/Clay
Plate 4: CGS Sand Sample Locations, Oceano Dunes SVRA

Cc: Phil Jenkins, Chief, CSP, Off-highway Motor Vehicle Recreation Division
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APPENDIX A: DESCRIPTION OF NRCS SOIL MAP UNITS

Descriptions of the soil units within and adjacent to the Oceano Dunes SVRA are excerpted below from the Natural Resource Conservation Service (NRCS, 2008), formerly the Soil Conservation Service (SCS, 1984).

Beaches (Unit 107): Beaches are partly covered by waves during high tide and are exposed during low tide. Typically, this layer is stratified with layers of sand or gravel; some portions are covered by cobbles. Permeability is very rapid; available water capacity is low or very low; surface runoff is slow; and the erosion hazard is high or very high because of wind and wave action. This unit is used almost exclusively for recreation. According to the NRCS (2008), Beaches are 97.9% sand, 1.6% silt, and 0.5% clay (Table A-1).

Camarillo sandy loam (Unit 111): This unit is a very deep, somewhat poorly drained, stratified pale brown to light yellowish soil on alluvial plains near existing drainages. Areas are typically long and narrow and subject to brief periods of flooding. Although most of these soils are used for cultivated crops or as rangeland, in swales and drainages, the wetlands are important plant and wildlife areas. Permeability of the soil is moderate; available water capacity is high; surface runoff is slow; the hazard of water erosion is slight; and the hazard of soil blowing is moderate. However, soil deposition can be a problem during years of heavy rainfall and plant residue is needed to control erosion of the soil surface. According to the NRCS (2008), Camarillo sandy loam is 66.8% sand, 19.2% silt, and 14.0% clay (Table A-1).

Camarillo loam, drained (Unit 112): Similar to Camarillo sandy loam, this unit is a very deep, somewhat poorly drained, stratified pale brown to light yellowish soil. However, it is found on alluvial fans and plains and is typically artificially drained. The soils are used for cultivated crops and pasture. Permeability of the soil is moderate; available water capacity is high; surface runoff is slow; the hazard of water erosion is slight; and the hazard of soil blowing is moderate. Also, crop residue is needed on the soil surface to control soil blowing. According to the NRCS (2008), Camarillo loam is 43.08% sand, 38.5% silt, and 18.5% clay (Table A-1).

Corralitos sand, 0 to 2% slopes (Unit 124): This unit is a very deep, somewhat excessively drained, pale brown soil found on alluvial fans and plains formed in alluvium weathered from sedimentary rocks. The surface layer is typically light brownish gray sand about 24 inches thick. The underlying material is light gray sand with small areas containing thin strata of loamy sand. Permeability of the soil is rapid; available water capacity is low; surface runoff is slow; the hazard of water erosion is slight; and the hazard of soil blowing is high. According to the NRCS (2008), Corralitos sand is 96.0% sand, 1.5% silt, and 2.5% clay (Table A-1).

Corralitos sand, 2 to15% slopes (Unit 125): This unit is a very deep, somewhat excessively drained, moderately and strongly sloping soil found on alluvial fans and plains. The surface layer is typically light brownish gray sand about 24 inches thick; the underlying material is a light gray sand. Some small areas have thin strata of loamy sand. Permeability of the soil is rapid; available water capacity is low; surface runoff is slow; the hazard of water erosion is slight; and the hazard of soil blowing is high. According to the NRCS (2008), Corralitos sand is 96.0% sand, 1.5% silt, and 2.5% clay (Table A-1).

Corralitos Variant loamy sand (Unit 126): This unit is a very deep, somewhat poorly drained, pale brown soil found on alluvial fans and plains. Most areas are elongated or irregular in shape and are used for vegetable crops and pasture. Some small areas have thin strata of silty clay loam and very fine sandy loam. Permeability of the soil is rapid; available water capacity is low; surface runoff is slow; the hazard of water erosion is slight; and the hazard of soil blowing is high. This soil is also subject to occasional brief, flooding. According to the NRCS (2008), Carralitos Varient loamy sand is 80.5% sand, 17.0% silt, and 2.5% clay (Table A-1).

Dune land (Unit 134): Like Beaches, Dune land is used for recreation in most areas. This map unit consists of hilly areas along the coast that are composed of sand-sized particles that shift with the wind. While most Dune land is almost devoid of vegetation, some areas, such as the vegetation islands within the ODSVRA, are partially vegetated and somewhat temporarily stabilized. Permeability of this map unit is very rapid; available water capacity is very low; surface runoff is slow; and the hazard of sand blowing is very high. According to NRCS (2008), Dune land is 98.9% sand, 0.6% silt, and 0.5% clay (Table A-1).

Marimel sandy clay loam, occasionally flooded (Unit 169): This unit is a very deep, somewhat poorly drained soil on alluvial fans, flood plains, and in narrow valleys, formed in alluvium weathered from sedimentary rocks. The surface layer is typically a grayish brown sandy clay loam about 16 inches thick. Underlying material is stratified grayish brown clay loam and gray or pale olive silty clay loam with mottled areas of yellowish brown and strong brown. Permeability of the soil is moderately slow; available water capacity is high or very high; surface runoff is slow; the hazard of water erosion is slight. This soil is also subject to occasional brief, flooding from December to March. Most areas with this soil are used for cultivated crops. According to the NRCS (2008), Marimel sandy clay loam is 55.1% sand, 17.4% silt, and 27.5% clay (Table A-1).

Marimel silty clay loam, drained (Unit 170): This unit is a very deep, somewhat poorly drained soil on alluvial fans and in narrow valleys, formed in alluvium weathered from sedimentary rocks. It is naturally drained due to downcutting of nearby streams. The surface layer is typically a grayish brown silty clay loam about 16 inches thick. Underlying material is stratified grayish brown clay loam and gray or pale olive silty clay loam with mottled areas of yellowish brown and strong brown. Some areas have a loam, clay loam or sandy clay loam surface layer. Permeability of this soil is moderately slow; available water capacity is high or very high; surface runoff is slow; the hazard of water erosion is slight. According to the NRCS (2008), Marimel silty clay loam is 18.1% sand, 50.9% silt, and 31.0% clay (Table A-1).

Mocho fine sandy loam (Unit 173): This unit is a very deep, well drained, nearly level soil on alluvial fans and plains, formed in alluvium weathered from sedimentary rocks. The surface layer is typically brown fine sandy loam about 18 inches thick. Underlying material is pale brown silty clay loam; below this is stratified pale brown sand and gravelly sand. Permeability of the soil is moderately slow; available water capacity is moderate; surface runoff is slow; the hazard of soil blowing is moderate. Most areas with this soil are used for cultivated crops. The primary farming hazard is soil blowing of unprotected fields. According to the NRCS (2008), Mocho fine sandy loam is 68.81% sand, 16.2% silt, and 15.0% clay (Table A-1).

Mocho loam (174): Mocho loam is a very deep, well drained, brown to pale brown soil found on alluvial fans and plains. Most areas are irregular in shape and cultivated. Permeability of the soil is moderately slow; available water capacity is high or very high; surface runoff is slow; and the hazard of water erosion is slight. According to the NRCS (2008), Mocho loam is 39.8% sand, 37.7.0% silt, and 22.5% clay (Table A-1).

Oceano sand, 0 to 9% slopes (Unit 184): Oceano sand is a very deep, excessively drained, brown to stratified pale brown and pink sand formed on old stabilized sand dunes in deposits of windblown sand, primarily on the Nipomo Mesa. Some areas of this soil have a sandy loam surface layer. Permeability of the soil is rapid; available water capacity is low; surface runoff is slow to medium; and the hazard of water erosion is slight or moderate. The hazard of soil blowing is high. In addition, the susceptibility to piping is high and gully erosion is a hazard during wet years due to the channeling of runoff. According to the NRCS (2008), the Oceano sand, Unit 184, is 95.0% sand, 1.5% silt, and 3.5% clay (Table A-1).

Oceano sand, 9 to 30% slopes (Unit 185): This unit is a very deep, excessively drained, strongly sloping and moderately steep brown to stratified pale brown and pink sand formed on old stabilized sand dunes in deposits of windblown sand, primarily on the Nipomo Mesa. Some areas of this soil have a sandy loam surface layer. Permeability of the soil is rapid; available water capacity is low; surface runoff is medium or rapid; and the hazard of water erosion is moderate or high. The hazard of soil blowing is also high. In addition, gully erosion is a hazard during wet years due to the channeling of runoff. According to the NRCS (2008), the Oceano sand, Unit 185, is 95.0% sand, 1.5% silt, and 3.5% clay (Table A-1).

Pismo-Tierra complex, 9 to 15% slopes (Unit 191): This unit represents strongly sloping soils on foothills and mountainous areas. The complex is about 40% Pismo soil, 30% Tierra soil, and 30% a mixture of small areas with loamy sand, soils shallower than 40 inches that are similar to Tierra soils, and soils similar to Pismo soil that have darker surface colors and a sandy loam texture. Pismo soil is a shallow soil derived from somewhat excessively drained residual material weathered from sandstone. The surface layer is a light brownish gray loamy sand with soft fractured sandstone at a depth of 19 inches. Some surfaces have a sand layer. Permeability of the Pismo soil is rapid; available water capacity is very low; surface runoff is medium or rapid; the hazard of soil blowing is high; and the hazard of water erosion is moderate or high. In contrast, the Tierra soil is a very deep soil formed in alluvium weathered from sedimentary rocks and has a clay subsoil. The surface layer is typically gray sandy loam about 9 inches thick, with a subsurface light gray sandy loam about 2 inches thick. The subsoil is a gray, pale brown and brown sandy clay to about 42 inches and a pale brown sandy clay loam to about 60 inches. Tierra soil is moderately well drained; the permeability is very slow; available water capacity low or moderate; surface runoff is rapid; the hazard of soil blowing is moderate; and the hazard of water erosion is high. In addition, Tierra soil has a high shrink-swell potential in the subsoil. According to the NRCS (2008), the Pismo soil component of the complex is 80.5% sand, 17.0% silt, and 2.5% clay; the Tierra soil component is 65.9% sand, 19.1% silt, and 15.0% clay (Table A-1).

Psamments and Fluvents, wet (Unit 193): Psamments and Fluvents, wet consist of small, very poorly drained basins in areas of Dune land or in coarse textured valley alluvium near streams and river bottoms. The soils are wind- or water-deposited sands and loamy sand that commonly contain layers of organic material. Areas where these soils are present are generally very poorly drained, with free water within 10 to 20 inches of the surface for most of the year. Because areas underlain by these soils have little or no farming value, they have been used mainly as wildlife habitat. According to NRCS (2008), Psamments and Fluvents, wet are 78.5% sand, 16.5% silt, and 5.0% clay (Table A-1).

Rock outcrop – Lithic Haploxerolls complex, 30-75% slope (Unit 195): This complex is found on steep and very steep mountain slopes. It is about 55% rock outcrop and 25% Haploxerolls, or soils less than 20 inches deep to hard rock.

Salinas silty clay loam, 0 to 2% slopes (Unit 197): Salinas silty clay loam consists of very deep, well drained, nearly level soil on alluvial fans and plains formed in alluvium weathered from sedimentary rocks. The surface layer is typically a dark gray silty clay loam about 29 inches thick, underlain by stratified layers of very pale brown fine sandy loam and light yellowish brown silty caly loam to a depth of 60 inches or more. Some portions of the soil have a sandy loam or clay loam surface layer. Other areas within this soil unit have stratified layers of coarse sand or gravel in the substratum. Permeability of the soil is moderately slow; available water capacity is high or very high; surface runoff is slow; and the hazard of water erosion is slight. According to NRCS (2008), Salinas silty clay loam is 18.1% sand, 50.9% silt, and 31.0% clay (Table A-1).

Still gravelly sandy clay loam, 2 to 9% slopes (Unit 210): Still gravelly sandy loam consists of very deep, well drained, gently sloping and moderately sloping soil on alluvial plains and marine terraces. Surface layers are typically very dark grayish brown sandy clay loam to a depth of 60 inches or more. Some portions of the soil contain higher amounts of gravel. Permeability of the soil is moderately slow; available water capacity is moderate or high; surface runoff is slow or medium; and the hazard of water erosion is slight. In addition,the gravelly sandy clay loam surface layer is subject to sheet erosion. According to NRCS (2008), Still gravelly sandy clay loam is 55.1% sand, 17.4% silt, and 27.5% clay (Table A-1).

Tujunga loamy sand, 0 to 2% slopes (Unit 219): Tujanga loamy sand consists of very deep, somewhat excessively drained, nearly level soil on alluvial fans and flood plains formed from alluvium weathered from sedimentary rocks. Surface layers are typically pale brown loamy sand about 11 inches thick, underlain by layers of very pale brown sand and loamy sand to a depthe of 31 inches. Below this, is pale brown gravelly sand. Permeability of the soil is rapid; available water capacity is low; surface runoff is slow; and the hazard of water erosion is slight. The hazard of wind blowing is high. In addition, this soil is subject to occasional brief periods of flooding between

December and march. According to NRCS (2008), Tujunga loamy sand is 80.5% sand, 17.0% silt, and 2.5% clay (Table A-1).

Xererts-Xerolls-Urban land complex, 0 to 15% slopes (Unit 221): This map unit consists of nearly level to steeply sloping soils that have been modified by earth moving equipment or are largely covered by urban structures so that their original physical characteristics have been altered. The Xererts are clay soils that shrink and swell with changes in moisture content. Portions of the Xerolls include poorly drained alluvial soils, well drained silty clay loam, and soils with a slowly permeable clay subsoil that also shrinks and swells with changes in moisture.

Xerorthents, escarpment (Unit 223): This map unit consists of moderately steep and steep, relatively smooth, descending slopes at the ends of terraces. Characteristics of the soil vary considerably within short distances, but generally include light colored loam, sandy loam or loamy sand 24 to 48 inches deep. Available water holding capacity is low to moderate. When the soil surface is bare, runoff is rapid and the hazard of erosion and gullying is high.

Water (Unit 228)

CGS Appendix A: Table A-1

RUSLE2 Related Attributes

San Luis Obispo County, California, Coastal Part

[This report shows only the major soils in each map unit]

Map symbol and soil name	Pct. of map unit	Hydrologic group	Kf	T factor	Representative value % Sand	% Silt	% Clay
101:							
Aquolls	*85*	*D*	---	*5*	---	---	---
102:							
Arnold	85	B	.28	4	78.5	16.5	5.0
103:							
Arnold	85	B	.28	4	78.5	16.5	5.0
104:							
Baywood	85	A	.17	5	96.8	0.7	2.5
105:							
Baywood	85	A	.17	5	96.8	0.7	2.5
106:							
Baywood	85	A	.17	5	96.8	0.7	2.5
107:							
Beaches	90	D	.17	5	97.9	1.6	0.5
108:							
Briones	85	B	.24	3	80.5	17.0	2.5
109:							
Briones	40	B	.24	3	80.5	17.0	2.5
Pismo	30	D	.20	2	80.5	17.0	2.5
110:							
Briones	50	B	.24	3	80.5	17.0	2.5
Tierra	25	D	.37	3	65.9	19.1	15.0
111:							
Camarillo	85	C	.28	5	66.8	19.2	14.0
112:							
Camarillo	85	C	.28	5	43.0	38.5	18.5
113:							
Capistrano	85	B	.20	5	67.4	19.6	13.0
114:							
Capistrano	85	B	.20	5	67.4	19.6	13.0

CGS Appendix A: Table A-1

RUSLE2 Related Attributes

San Luis Obispo County, California, Coastal Part

Map symbol and soil name	Pct. of map unit	Hydrologic group	Kf	T factor	Representative value % Sand	% Silt	% Clay
115:							
Chamise	85	C	.28	3	39.8	37.7	22.5
116:							
Chamise	85	C	.28	3	39.8	37.7	22.5
117:							
Chamise	85	C	.20	3	59.6	17.9	22.5
118:							
Cieneba	40	C	.28	2	45.7	41.8	12.5
Kinkel variant	30	C	.32	4	45.7	41.8	12.5
119:							
Cieneba	50	C	.28	2	45.7	41.8	12.5
Millsap	30	C	.37	2	39.2	37.3	23.5
120:							
Concepcion	85	D	.32	3	43.0	38.5	18.5
121:							
Concepcion	85	D	.32	3	43.0	38.5	18.5
122:							
Concepcion	85	D	.32	3	43.0	38.5	18.5
123:							
Concepcion	85	D	.32	3	43.0	38.5	18.5
124:							
Corralitos	85	A	.15	5	96.0	1.5	2.5
125:							
Corralitos	85	A	.15	5	96.0	1.5	2.5
126:							
Corralitos variant	85	C	.28	5	80.5	17.0	2.5
127:							
Cropley	85	D	.15	5	22.1	27.9	50.0
128:							
Cropley	85	D	.15	5	22.1	27.9	50.0
129:							
Diablo	85	D	.15	4	23.3	29.2	47.5

CGS Appendix A: Table A-1

RUSLE2 Related Attributes

San Luis Obispo County, California, Coastal Part

Map symbol and soil name	Pct. of map unit	Hydrologic group	Kf	T factor	Representative value % Sand	% Silt	% Clay
130:							
Cibo	45	D	.28	2	26.1	28.9	45.0
Diablo	45	D	.15	4	23.3	29.2	47.5
131:							
Cibo	45	D	.28	2	26.1	28.9	45.0
Diablo	45	D	.15	4	23.3	29.2	47.5
132:							
Cibo	45	D	.28	2	26.1	28.9	45.0
Diablo	45	D	.15	4	23.3	29.2	47.5
133:							
Diablo	45	D	.15	4	23.3	29.2	47.5
Lodo	35	D	.17	1	35.2	38.3	26.5
134:							
Dune land	90	A	.15	5	98.9	0.6	0.5
135:							
Elder	85	B	.28	5	67.4	19.6	13.0
136:							
Elder	85	B	.28	5	67.4	19.6	13.0
137:							
Elder	85	B	.28	5	67.4	19.6	13.0
138:							
Elder	85	B	.28	5	67.4	19.6	13.0
139:							
Elder	85	B	.28	5	67.4	19.6	13.0
140:							
Garey	85	C	.32	5	68.8	23.7	7.5
141:							
Gaviota	85	D	.32	1	66.8	19.2	14.0
142:							
Gaviota	85	D	.32	1	69.6	16.4	14.0

CGS Appendix A: Table A-1

RUSLE2 Related Attributes

an Luis Obispo County, California, Coastal Part

Map symbol and soil name	Pct. of map unit	Hydrologic group	Kf	T factor	Representative value % Sand	% Silt	% Clay
143:							
Gazos	45	C	.20	2	34.2	37.3	28.5
Lodo	40	D	.17	1	35.2	38.3	26.5
144:							
Gazos	45	C	.20	2	34.2	37.3	28.5
Lodo	40	D	.17	1	35.2	38.3	26.5
145:							
Gazos	45	C	.20	2	34.2	37.3	28.5
Lodo	40	D	.17	1	35.2	38.3	26.5
146:							
Henneke	45	D	.17	1	32.7	31.3	36.0
Rock outcrop	35	D	---	---	---	---	---
147:							
Lodo	85	D	.17	1	35.2	38.3	26.5
148:							
Lodo	85	D	.17	1	35.2	38.3	26.5
149:							
Lodo	85	D	.17	1	35.2	38.3	26.5
150:							
Lodo	85	D	.17	1	35.2	38.3	26.5
151:							
Lodo	55	D	.17	1	35.2	38.3	26.5
Rock outcrop	40	D	---	---	---	---	---
152:							
Lodo	55	D	.17	1	35.2	38.3	26.5
Rock outcrop	35	D	---	---	---	---	---
153:							
Lompico	45	B	.24	3	43.0	39.5	17.5
McMullin	20	D	.24	1	42.1	37.9	20.0

CGS Appendix A: Table A-1

RUSLE2 Related Attributes

San Luis Obispo County, California, Coastal Part

Map symbol and soil name	Pct. of map unit	Hydrologic group	Kf	T factor	Representative value % Sand	% Silt	% Clay
154:							
Lompico	45	B	.24	3	43.0	39.5	17.5
McMullin	20	D	.24	1	42.1	37.9	20.0
155:							
Lopez	85	D	.15	1	34.7	37.8	27.5
156:							
Lopez	85	D	.15	1	34.7	37.8	27.5
157:							
Lopez	60	D	.15	1	34.7	37.8	27.5
Rock outcrop	35	D	---	---	---	---	---
158:							
Los Osos	85	C	.32	3	39.2	37.3	23.5
159:							
Los Osos	85	C	.32	3	39.2	37.3	23.5
160:							
Los Osos	85	C	.32	3	39.2	37.3	23.5
161:							
Los Osos	85	C	.32	3	39.2	37.3	23.5
162:							
Los Osos	35	C	.32	3	39.2	37.3	23.5
Diablo	30	D	.15	4	23.3	29.2	47.5
163:							
Los Osos	35	C	.32	3	39.2	37.3	23.5
Diablo	30	D	.15	4	23.3	29.2	47.5
164:							
Los Osos	35	C	.32	3	39.2	37.3	23.5
Diablo	30	D	.15	4	23.3	29.2	47.5
165:							
Los Osos	40	C	.32	3	39.2	37.3	23.5
Diablo	35	D	.15	4	23.3	29.2	47.5

CGS Appendix A: Table A-1

RUSLE2 Related Attributes

San Luis Obispo County, California, Coastal Part

Map symbol and soil name	Pct. of map unit	Hydrologic group	Kf	T factor	Representative value % Sand	% Silt	% Clay
166:							
Los Osos	50	C	.32	3	39.2	37.3	23.5
Lodo	30	D	.17	1	35.2	38.3	26.5
167:							
Los Osos	50	C	.32	3	39.2	37.3	23.5
Lodo	30	D	.17	1	35.2	38.3	26.5
168:							
Los Osos variant	85	C	.24	5	35.4	33.6	31.0
169:							
Marimel	85	D	.15	5	55.1	17.4	27.5
170:							
Marimel	85	C	.28	5	18.1	50.9	31.0
171:							
Millsap	85	C	.37	2	39.2	37.3	23.5
172:							
Millsap	60	C	.37	2	39.2	37.3	23.5
Rock outcrop	20	D	---	---	---	---	---
173:							
Mocho	85	B	.28	4	68.8	16.2	15.0
174:							
Mocho	85	B	.28	5	39.8	37.7	22.5
175:							
Mocho	85	B	.32	4	18.1	50.9	31.0
176:							
Mocho variant	85	A	.24	3	70.5	16.5	13.0
177:							
Nacimiento	85	C	.24	3	18.1	50.9	31.0
178:							
Nacimiento	85	C	.24	3	18.1	50.9	31.0
179:							
Nacimiento	85	C	.24	3	18.1	50.9	31.0

CGS Appendix A: Table A-1

RUSLE2 Related Attributes

San Luis Obispo County, California, Coastal Part

Map symbol and soil name	Pct. of map unit	Hydrologic group	Kf	T factor	Representative value % Sand	% Silt	% Clay
180:							
Nacimiento	45	C	.24	3	18.1	50.9	31.0
Calodo	35	C	.28	2	39.2	37.3	23.5
181:							
Nacimiento	45	C	.24	3	18.1	50.9	31.0
Calodo	35	C	.28	2	39.2	37.3	23.5
182:							
Calodo	45	C	.28	2	39.2	37.3	23.5
Nacimiento	25	C	.24	3	18.1	50.9	31.0
183:							
Obispo	50	D	.15	1	22.1	27.9	50.0
Rock outcrop	30	D	---	---	---	---	---
184:							
Oceano	85	A	.20	5	95.0	1.5	3.5
185:							
Oceano	85	A	.20	5	95.0	1.5	3.5
186:							
Perkins	85	C	.32	5	68.0	16.0	16.0
187:							
Perkins	85	C	.32	5	68.0	16.0	16.0
188:							
Perkins	85	C	.32	5	68.0	16.0	16.0
189:							
Pismo	85	D	.20	2	80.5	17.0	2.5
190:							
Pismo	40	D	.20	2	80.5	17.0	2.5
Rock outcrop	35	D	---	---	---	---	---
191:							
Pismo	40	D	.20	2	80.5	17.0	2.5
Tierra	30	D	.37	3	65.9	19.1	15.0

CGS Appendix A: Table A-1

RUSLE2 Related Attributes

San Luis Obispo County, California, Coastal Part

Map symbol and soil name	Pct. of map unit	Hydrologic group	Kf	T factor	Representative value % Sand	% Silt	% Clay
192:							
Fluvents	45	A	.24	5	80.5	17.0	2.5
Psamments	45	A	.15	5	96.0	1.5	2.5
193:							
Fluvents	45	B	.24	5	78.5	16.5	5.0
Psamments	45	B	.20	5	78.5	16.5	5.0
194:							
Riverwash	90	D	.15	---	97.9	1.6	0.5
195:							
Rock outcrop	55	D	---	---	---	---	---
Lithic Haploxerolls	25	D	---	1	---	---	---
196:							
Salinas	85	C	.28	5	41.6	37.4	21.0
197:							
Salinas	85	C	.28	5	18.1	50.9	31.0
198:							
Salinas	85	C	.28	5	18.1	50.9	31.0
199:							
San Simeon	85	D	.28	3	65.9	19.1	15.0
200:							
San Simeon	85	D	.28	3	65.9	19.1	15.0
201:							
San Simeon	85	D	.28	3	65.9	19.1	15.0
202:							
San Simeon	85	D	.28	3	65.9	19.1	15.0
203:							
Santa Lucia	85	C	.10	2	33.5	36.5	30.0
204:							
Santa Lucia	85	C	.10	2	33.5	36.5	30.0
205:							
Santa Lucia	85	C	.10	2	35.4	33.6	31.0

CGS Appendix A: Table A-1

RUSLE2 Related Attributes

San Luis Obispo County, California, Coastal Part

Map symbol and soil name	Pct. of map unit	Hydrologic group	Kf	T factor	Representative value % Sand	% Silt	% Clay
206:							
Santa Lucia	85	C	.10	2	35.4	33.6	31.0
207:							
Santa Lucia	85	C	.10	2	35.4	33.6	31.0
208:							
Still	85	B	.32	5	39.2	37.3	23.5
209:							
Still	85	B	.20	4	55.5	14.5	30.0
210:							
Still	85	B	.20	5	55.1	17.4	27.5
211:							
Still	85	B	.20	5	55.1	17.4	27.5
212:							
Suey	85	B	.37	5	11.3	67.7	21.0
213:							
Suey	85	B	.37	5	11.3	67.7	21.0
214:							
Suey	85	B	.37	5	11.3	67.7	21.0
215:							
Suey	85	B	.37	5	11.3	67.7	21.0
216:							
Tierra	85	D	.37	3	65.9	19.1	15.0
217:							
Tierra	85	D	.37	3	41.6	37.4	21.0
218:							
Tierra	85	D	.37	3	41.6	37.4	21.0
219:							
Tujunga	85	A	.20	5	80.5	17.0	2.5
220:							
Tujunga	85	A	.20	5	80.5	17.0	2.5
221:							
Xererts	30	---	---	5	---	---	---

CGS Appendix A: Table A-1

RUSLE2 Related Attributes

San Luis Obispo County, California, Coastal Part

Map symbol and soil name	Pct. of map unit	Hydrologic group	Kf	T factor	Representative value % Sand	% Silt	% Clay
221:							
Xerolls	30	---	---	5	---	---	---
Urban land	20	---	---	---	---	---	---
222:							
Xerorthents	85	---	---	5	---	---	---
223:							
Xerorthents	85	---	---	5	---	---	---
224:							
Zaca	85	D	.15	4	22.1	27.9	50.0
225:							
Zaca	85	D	.15	4	22.1	27.9	50.0
226:							
Zaca	85	D	.15	4	22.1	27.9	50.0
227:							
Zaca	85	D	.15	4	22.1	27.9	50.0
228:							
Water	100	---	---	---	---	---	---
229:							
Dams	100	---	---	---	---	---	---

TABLE B-1: CGS SIEVED SAND SAMPLE RESULTS
Percentage Sieve Grain Size

Sample #, Location, and Date Collected	+10 (Coarse)	10-40 (Medium)	40-100 (Fine)	100-200 (Very Fine)	-200 (Silt/Clay)	-325 (Silt/Clay)
Sample # (03/08/07)						
FA-1 (W side top)	0	0.2	93.6	6.0	0.2	NA
FA-2 (W side bottom)	0	7.0	87.7	5.1	0.2	NA
FA-3 (N side ridge, veg)	0	6.2	85.7	7.1	1.0	NA
FA-4 (N side transect)	0	1.7	95.0	3.2	0.1	NA
FA-5 (transect trough)	0	0.1	85.1	14.1	0.7	NA
FA-6 (W side depression)	0	3.3	89.7	7.0	0	NA
FA-7 (E side flute)	0	15.2	77.2	7.3	0.3	NA
FA-8 (S side ridge)	0	33.1	60.0	6.5	0.4	NA
Sample # (03/28/07)						
MM-1 (N side ridge)	0	0	91.7	7.8	0.5	NA
MM-2 (SE corner flat)	0	10.2	77.7	10.7	1.4	NA
WV-1 (W side top)	0	0.8	93.8	5.1	0.3	NA
PH-1 (N side valley)	0	15.3	70.0	12.3	2.4	NA
PH-2 (W side top)	0	1.1	91.0	7.8	0.1	NA
PH-3 (S side flat)	0	7.2	83.0	9.6	0.2	NA
BBQ-1 (SE corner bog)	0	30.0	62.0	6.4	1.6	NA
BBQ-2 (NE side flat)	0	4.5	89.5	6.0	0	NA
BBQS-1 (NE side ridge)	0	0.3	92.7	6.2	0.8	NA
Sample # (03/29/07)						
IM-1 (E side flat)	0	20.6	76.9	2.1	0.4	NA
IM-2 (SE corner ridge)	0	0.9	90.7	7.9	0.5	NA
IMS-1 (W side top)	0	1.1	90.0	8.3	0.6	NA
IMS-2 (SE side flat)	0	7.6	87.3	4.1	1.0	NA
Sample # (05/15/07)						
H-1 (SE corner flat)	0	8.3	80.5	10.0	1.2	NA
H-2 (NW corner top)	0	0.1	87.0	12.7	0.2	NA
A-1 (E side flat)	0	2.2	92.5	4.8	0.5	NA
A-2 (W side top)	0	4.7	83.4	11.5	0.4	NA
C-1 (W side top)	0	8.3	83.4	7.9	0.4	NA
C-2 (NE side ridge)	0	0.3	85.6	11.8	2.3	NA
C-3 (E side flat)	0	4.8	82.3	10.8	2.1	NA
EN-1 (W side top)	0	25.4	68.0	6.1	0.5	NA
EN-2 (E side flat)	0	14.9	78.8	4.5	1.8	NA
ET-1 (W side top)	0	2.7	84.8	12.3	0.2	NA
ET-2 (E side flat)	0	0.5	89.7	9.1	0.7	NA
ES-1 (E side flat)	0	22.0	72.5	4.3	1.2	NA
ES-2 (NW corner top)	0	45.0	47.2	7.1	0.7	NA
Sample # (05/16/07)						
BSN-1 (W side top)	0	24.7	71.1	4.1	0.1	NA
BSN-2 (SE corner flat)	0	26.8	69.0	2.8	1.4	NA
BSC-1 (E side flat)	0.3	28.7	65.9	3.9	1.2	NA
BSC-2 (NE side flat)	0	0.8	85.0	9.5	4.7	NA
BSC-3 (W side top)	0	12.2	82.2	5.3	0.3	NA

Sample #, Location, and Date Collected	+10 (Coarse)	10-40 (Medium)	40-100 (Fine)	100-200 (Very Fine)	-200 (Silt/Clay)	-325 (Silt/Clay)
Sample # (05/17/07)						
MP-4 (wet zone)	0.2	4.4	87.8	7.4	0.2	NA
MP-5 (below high tide)	0	28.8	67.4	3.7	0.1	NA
MP-6 (wet zone)	0	16.8	82.2	0.1	0	NA
MP-7 (Plover area)	0	59.3	40.5	0.2	0	NA
7.5 Reveg (E side swale)	0	38.1	60.2	1.6	0.1	NA
TT-1 N side corridor)	0	1.7	89.0	8.9	0.4	NA
Sample # (01/28/08)						
MP-6 (wet zone)	0	9.5	88.8	1.7	0	NA
C-2 (NE side ridge)	0	0	85.0	13.4	1.6	NA
SH-12 (ride area, E of PH/BBQ)	0	1.0	87.0	11.0	1.0	NA
SH-16 (E of Cottonwood)	0	2.4	89.5	7.7	0.4	NA
Sample # (3/23/10)						
DP-2 (S of Silver Spur)	0	0.2	84.4	15.0	0.3	0.1
Sample # (9/9/10)						
PB-1 (wet zone)	0	1.1	75.3	23.6	trace	trace
S1-3 (wet zone, W of S1)	0	7.9	89.9	2.2	0	0
S1-4 (Plover area, W of fence)	0	19.5	79.1	1.4	trace	trace
S1-5 (Plover area, W inside fence)	0	10.4	86.1	3.2	0.2	0.1
S1-6 (Plover area, M, inside fence)	0	28.0	64.7	7.1	0.2	trace
S1-7 (Plover area, E, inside fence)	0	41.4	56.1	2.4	0.1	trace
S1-8 (ride area, E of Plover fence)	0	21.9	76.1	1.8	0.1	0.1
S1-9 (ride area, W of S1)	0	3.7	92.1	3.9	0.2	0.1
S1-10 (ride area E of S1, top)	0	29.0	65.2	5.0	0.7	0.1
S1-11 (ride area E of S1, flat)	0	9.4	84.6	5.5	0.4	0.1

Figure B-1: Relative Percent Sieved Grain Size-CGS Sand Samples, ODSVRA

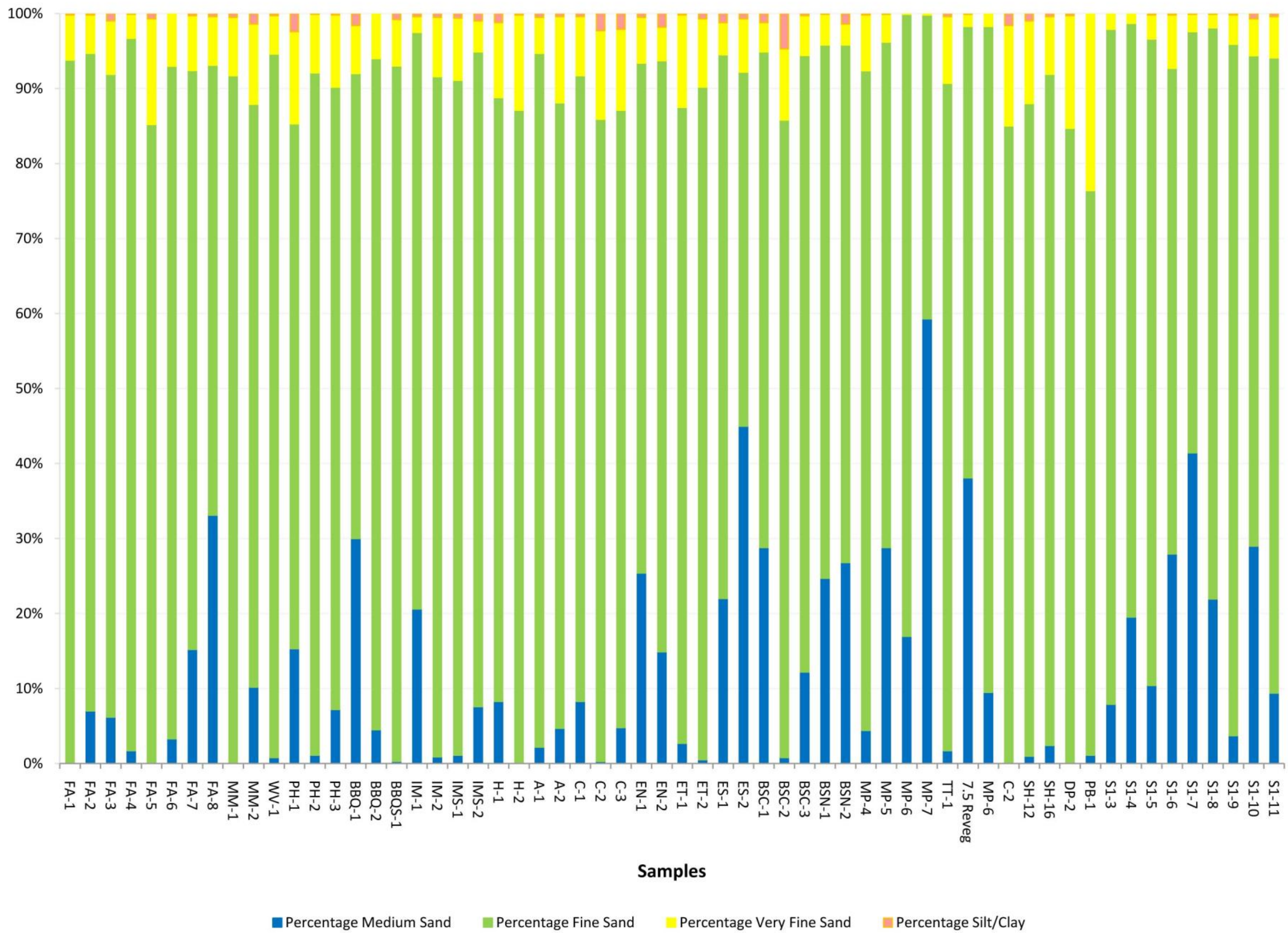
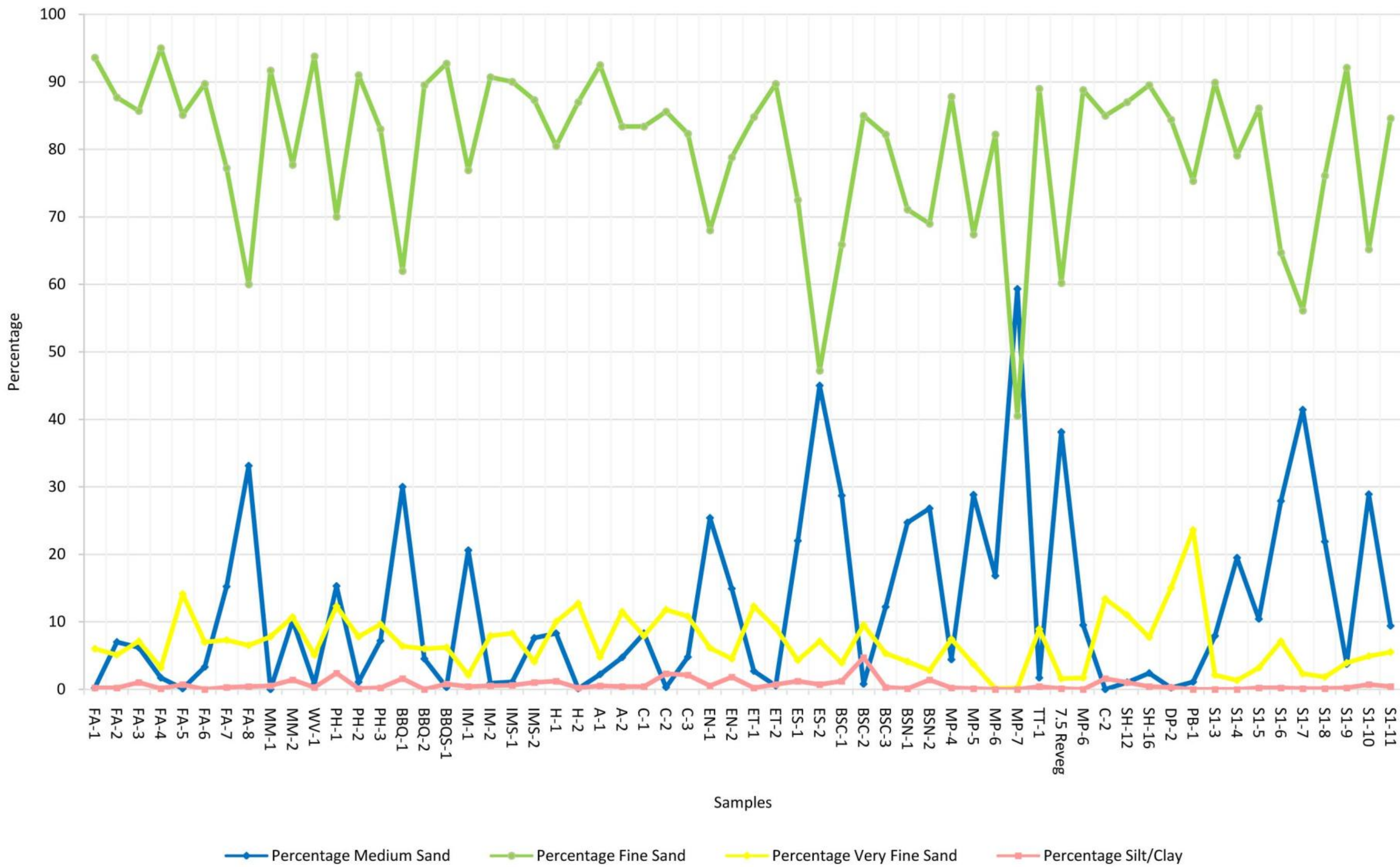


Figure B-2: Relative Percent Sieved Grain Size - CGS Sand Grain Size Analyses

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DEPARTMENT OF CONSERVATION - DEREK CHERNOW, ACTING DIRECTOR
CGS SAND GRAIN SIZE ANALYSES, ODSVRA, PLATE 1
NRCS SOILS DATA
Pismo Beach
Arroyo Grande
Grover Beach
Oceano
P1
P2
P3
P4
P5
P6
S1
P7
P8
CDF
Mesa 2
NRCS Soils
Distribution of Soils
Oceano Dunes State Park
and Surrounding Area
January 2011
Postmarker
S1 Windtower
State Park Boundary
Riding Area
Seasonal Exclosure
Dune Preserve
Pismo State Beach
CDF and Mesa 2 Air Monitoring Stations
0 0.5 1
Miles
Map Scale: 1:24,000
NRCS Soil Map Units
102 103 107 108 109 110 111 112 115 116 117 124
125 126 129 130 131 134 135 136 140 142 151 155
156 158 159 160 169 170 173 174 175 176 177 178
179 181 184 185 186 187 189 190 191 192 193 194
195 196 197 198 203 204 206 207 208 209 210 216
217 219 220 221 222 223 224 225 227 228
Soils data excerpted and modified from: Natural Resources Conservation Service, 2008, Soil Survey of San Luis Obispo County, California, Coastal Part

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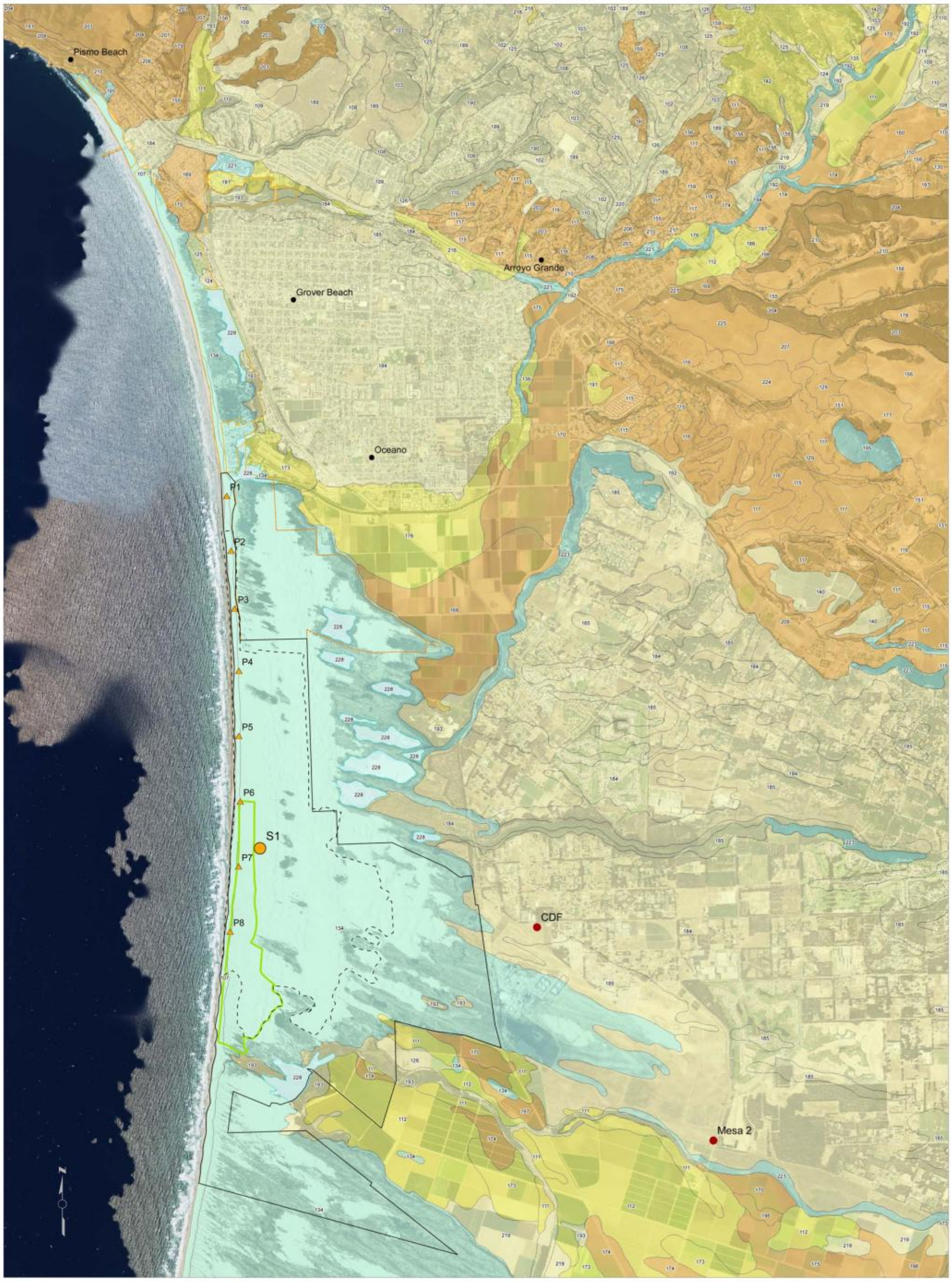
CGS SAND GRAIN SIZE ANALYSES, ODSVRA, PLATE 2
NRCS SOILS, CLAY



NRCS Soils Clay

Relative Distribution of Soils by Percent Clay
Oceano Dunes State Park and Surrounding Areas

January 2011

- Postmarker
- S1 Windtower
- State Park Boundary
- Riding Area
- Seasonal Exclosure
- Dune Preserve
- Pismo State Beach
- Water - Map Unit 228
- CDF and Mesa 2 Air Monitoring Stations

0 0.5 1
Miles

Map Scale: 1:24,000

Percent Clay

- 0% to 1% (actual = 0 to 0.5%)
- 1% to 10% (actual = 2.5% to 7.5%)
- 10% to 20% (actual = 13.0% to 18.5%)
- 20% to 50% (actual = 21.0% to 50%)

Map Unit: Percent Clay

102: 5%	129: 47.5%	169: 27.5%	189: 2.5%	208: 23.5%
103: 5%	130: 47.5%	170: 31%	190: 2.5%	209: 30%
107: 0.5%	131: 47.5%	173: 15%	191: 15%	210: 27.5%
108: 2.5%	134: 0.5%	174: 22.5%	192: 2.5%	216: 15%
109: 2.5%	135: 13%	175: 31%	193: 5%	217: 21%
110: 2.5%	136: 13%	176: 13%	194: 0.5%	219: 2.5%
111: 14%	140: 7.5%	177: 31%	195: 0%	220: 2.5%
112: 18.5%	142: 14%	178: 31%	196: 21%	221: 0%
115: 22.5%	151: 26.5%	179: 31%	197: 31%	222: 0%
116: 22.5%	155: 27.5%	181: 31%	198: 31%	223: 0%
117: 22.5%	156: 27.5%	184: 3.5%	203: 30%	224: 50%
124: 2.5%	158: 23.5%	185: 3.5%	204: 30%	225: 50%
125: 2.5%	159: 23.5%	186: 16%	206: 31%	227: 50%
126: 2.5%	160: 23.5%	187: 16%	207: 31%	228: 0%

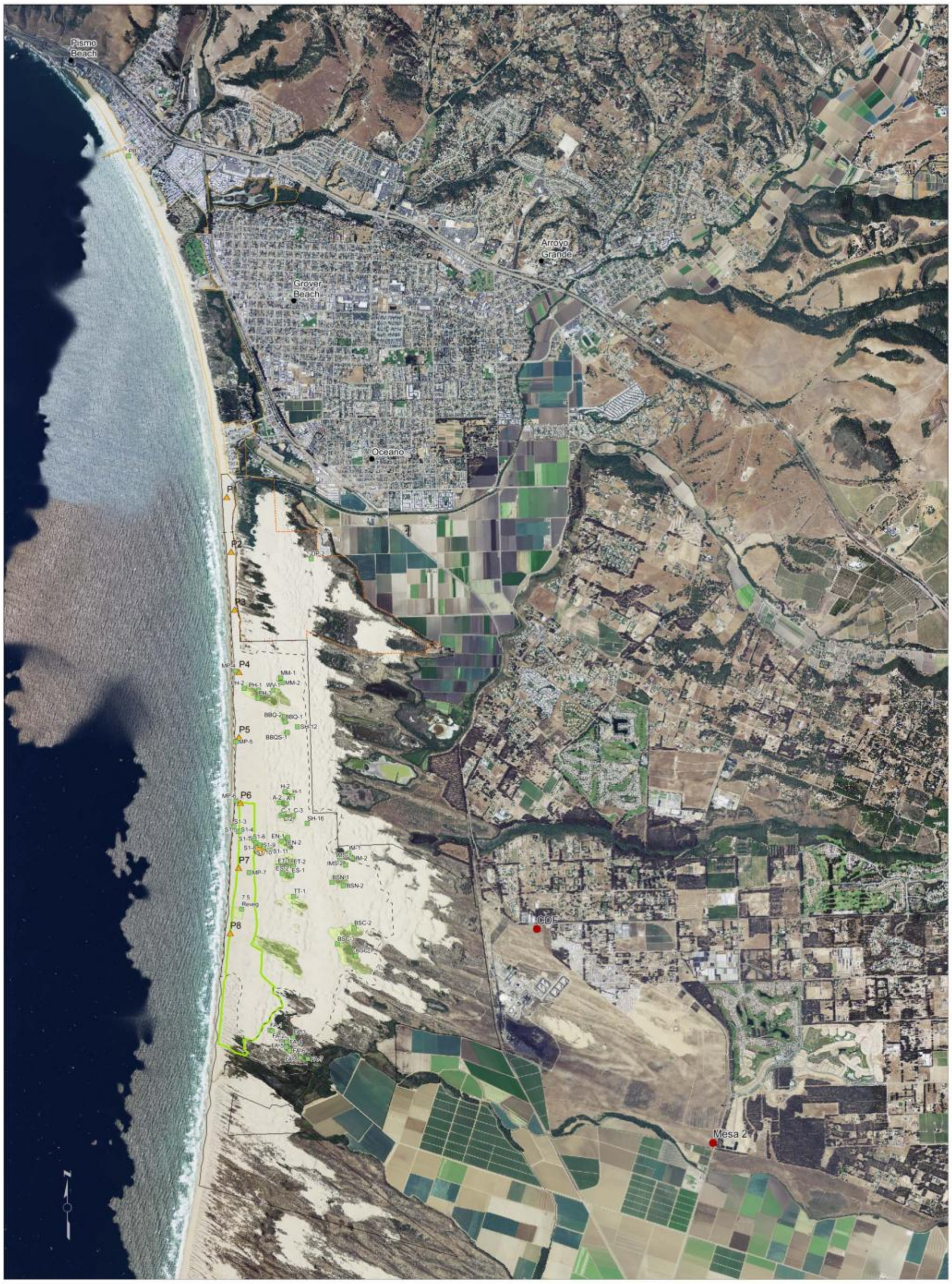
Soils data excerpted and modified from: Natural Resources Conservation Service, 2008, Soil Survey of San Luis Obispo County, California, Coastal Part

102: 21.5%	129: 76.7%	169: 44.9%	189: 19.5%	208: 60.8%
103: 21.5%	130: 76.7%	170: 81.9%	190: 19.5%	209: 44.5%
107: 2.1%	131: 76.7%	173: 31.2%	191: 34.1%	210: 44.9%
108: 19.5%	134: 1.1%	174: 60.2%	192: 19.5%	216: 34.1%
109: 19.5%	135: 32.6%	175: 81.9%	193: 21.5%	217: 58.4%
110: 19.5%	136: 32.6%	176: 29.5%	194: 2.1%	219: 19.5%
111: 33.2%	140: 31.2%	177: 81.9%	195: 0%	220: 19.5%
112: 57%	142: 30.4%	178: 81.9%	196: 58.4%	221: 0%
115: 60.2%	151: 64.8%	179: 81.9%	197: 81.9%	222: 0%
116: 60.2%	155: 65.3%	181: 81.9%	198: 81.9%	223: 0%
117: 40.4%	156: 65.3%	184: 5%	203: 66.5%	224: 77.9%
124: 4%	158: 60.8%	185: 5%	204: 66.5%	225: 77.9%
125: 4%	159: 60.8%	186: 32%	206: 64.6%	227: 77.9%
126: 19.5%	160: 60.8%	187: 32%	207: 64.6%	228: 0%

CALIFORNIA GEOLOGICAL SURVEY
JOHN G. PARRISH, Ph.D., STATE GEOLOGIST

STATE OF CALIFORNIA - EDMUND G. BROWN, JR., GOVERNOR
THE RESOURCES AGENCY - LESTER SNOW, SECRETARY
DEPARTMENT OF CONSERVATION - DEREK CHERNOW, ACTING DIRECTOR

CGS SAND GRAIN SIZE ANALYSES, ODSVRA, PLATE 4
CGS SAND SAMPLE LOCATIONS



CGS Sand Sample Locations

Oceano Dunes SVRA

January 2011

- CGS Sand Sample Site
- Postmarker
- S1 Windtower
- Vegetation Island
- State Park Boundary
- Riding Area
- Seasonal Exclosure
- Dune Preserve
- Pismo State Beach
- CDF and Mesa 2 Air Monitoring Stations

0 0.5 1
Miles
Map Scale: 1:24,000

Explanation

The California Geological Survey (CGS) collected sixty (60) sand samples from Oceano Dunes SVRA and surrounding lands managed by California State Parks (CSP). Samples were collected from the wet zone along the beach; unvegetated dunes, both within the off-highway vechicle riding area and in protected areas; and within various vegetation islands. Sample numbers are keyed to Table B-1, CGS Sand Sample Results, and the following locations:

Pismo Beach (PB)
Postmarkers (MP)
Pavilion Hill (PH)
S1 Windtower (S-1)
7.5 Reveg

Moymell (MM)
Worm Valley (WV)
Barbecue (BBQ) Flats
BBQ South (BBQS)
Heather (H)
Acacia (A)
Cottonwood (C)

Eucalyptus North (EN)
Eucalyptus Tree (ET)
Eucalyptus South (ES)
Tabletop (TT)
40-Acre Woods (FA)

Dune Preserve (DP)
Sand Highway (SH)
Indian Midden (IM)
Indian Midden South (IMS)
Boy Scout North (BSN)
Boy Scout Camp (BSC)