

APPENDIX C
DUNE RESTORATION

Conceptual Foredune Creation and Enhancement Plan

BROAD BEACH RESTORATION PROJECT MALIBU, LOS ANGELES COUNTY, CALIFORNIA

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1.0 INTRODUCTION

Creation and enhancement of foredune habitat has been proposed as part of the Broad Beach Restoration Project (“Project”), located in the City of Malibu, Los Angeles County, California (Figure 1). The primary goal of the Project is to stabilize the shoreline along Broad Beach to protect existing residences, on-site sewage treatment systems, and other structures. To accomplish this objective, the project proponents propose a combination of beach nourishment and foredune creation and enhancement, integrating characteristics of southern foredune habitat (*sensu* Holland 1986) into existing and proposed shoreline stabilization efforts. Within the context of the larger project, foredune creation and enhancement is primarily intended to provide a reservoir of sand for natural beach nourishment as well as an additional buffer of relatively stabilized sand between the ocean and the residences. A secondary goal of foredune creation and enhancement is to increase the area of high-value foredune habitat at Broad Beach. Accomplishing these goals requires the enhancement of existing degraded foredune habitat at Broad Beach and the creation of new foredune habitat in areas where it has been removed by wave action. To accomplish the shoreline stabilization goals of the project, the foredune system must be relatively stable and self-sustaining. The foredune system must also be compatible with the needs of the Broad Beach residents and provide appropriate levels of both public and private access.

This Conceptual Foredune Creation and Enhancement Plan details the proposed approach for the enhancement of existing degraded foredune habitat and creation of new foredune habitat and includes plans for subsequent monitoring and adaptive management. The details of the Foredune Creation and Enhancement Plan draw from previous dune restoration projects in southern California and elsewhere, but have been tailored to fit the constraints at Broad Beach. The approach outlined here proposes the creation and enhancement of foredunes incorporating elements of naturally occurring coastal foredune systems in Los Angeles County. Creation and enhancement of the foredune system will be guided by conditions at a nearby reference site, reports on the geomorphology and vegetation of dune habitats in the region, and historical conditions at Broad Beach as determined from historic aerial imagery. Incorporating the natural geomorphology and vegetation of foredunes from the region will help to create a more sustainable dune system that blends with the natural environment of the Broad Beach area and provides valuable habitat for native plant and wildlife species while achieving the shoreline stabilization goals of the larger project.

Beach nourishment has been proposed as a separate, but complimentary, shoreline stabilization measure for Broad Beach. Although the proposed beach nourishment and foredune creation and enhancement are complementary parts of the larger Broad Beach Restoration Project and will be implemented concurrently, the proposed beach nourishment is beyond the scope of this plan. References to the proposed beach nourishment are included here for contextual purposes only.



Project Area

Broad Beach Restoration Project

Malibu, California

Figure 1.

Project Area
Location Map



0 250 500 1,000
Feet

2.0 EXISTING CONDITIONS AT BROAD BEACH

Historically, Broad Beach contained a broad sandy beach backed by an active foredune system which would have provided a buffer from extreme wave action and a reservoir of sand for beach nourishment following major storms (Figure 2). Over the years, development at Broad Beach, combined with a reduction in sand supply and a change in wave energy, has resulted in the loss of beach and foredune habitat (Moffatt and Nichol 2012). Between 1974 and 2009, Broad Beach suffered a loss of approximately 600,000 cubic yards of sand, causing the shoreline to move inland 65 feet or more (Moffatt and Nichol 2012). The negative sand budget at Broad Beach has resulted in a narrow sandy beach which is almost entirely inundated at high tide and is backed by a severely eroded remnant foredune system. By 2009, the loss of sand at Broad Beach had created critical conditions which threatened private property and eliminated public access to the beach during high tides (Moffatt and Nichol 2011). An emergency revetment was installed during the winter of 2009-2010 to halt further erosion and to preserve existing structures and on-site sewage treatment systems. The revetment consists of an approximately 20-foot wide band of ½- to 2-ton rock installed in a trench running the length of the beach, approximately 4,000 feet (Figure 3). The loss of sand at Broad Beach has been most extensive at the northwestern end of the beach—there, the rock revetment is more robust, approximately 40 feet wide and with rocks approaching 4 tons. The residences along the northwestern-most 1,500 feet of the beach are protected by a variety of seawalls and other structures, and as such, no revetment was constructed along this portion of the beach.

Below the revetment, Broad Beach consists of a flat, sandy beach which is nearly entirely inundated at high tide. Above the revetment, remnant foredune habitat intergrades with private residences in a mix of iceplant (*Carpobrotus* spp.), landscaping, patios, and open sand. The remnant foredune habitat has been highly degraded over the years and bears little resemblance to the less disturbed foredune habitat at Ormond Beach and other locations in southern California. In general, the foredunes at Broad Beach have lost their natural geomorphology and native vegetation, having been either eroded by wave action and/or altered to accommodate development. Remnant natural foredune geomorphology is apparent in limited areas along Broad Beach, primarily in association with undeveloped parcels at the eastern end of the beach. In this area, limited patches of native dune mat vegetation occur in association with the foredune mounds. The vast majority of native foredune vegetation at Broad Beach has either been displaced by iceplant or replaced with a mix of native and non-native landscaping. Where iceplant occurs, it generally forms a dense monotypic stand.



Figure 2. Image of the middle section of Broad Beach from 1979 showing an active beach backed by a band of foredune habitat (photograph courtesy of California Coastal Records Project).



Figure 3. Typical sections of the emergency rock revetment installed in 2010 (photos by Moffatt and Nichol).

3.0 DUNE ECOLOGY

Active coastal dunes are inherently dynamic systems changing in response to wind and waves (Nordstrom 2008). Sand is deposited on the beach through wave action and is blown inland by wind (i.e., aeolian transport). Reduced wind speeds behind objects on the beach such as plants, beach debris, sand fencing, etc., allows sand to collect behind such objects, eventually forming incipient dunes. If the incipient dunes are not removed by high tides or storm surges, sand will continue to collect, eventually forming larger foredunes. Given sufficient sand supply and space to move, foredunes will develop into a larger, more complex system of dune ridges, dune hollows or swales, deflation plains, and stabilized backdunes (Pickart and Sawyer 1998; Pickart and Barbour 2007). Active dunes along the immediate coastline are generally sparsely vegetated and not stabilized. As dunes move inland, they generally develop a more substantial plant community which stabilizes the dunes.

A wide variety of beach and dune zones, as well as an array of dune forms, have been described over the years. In general, however, dune systems in southern California consist of a relatively simple set of foredunes (Engstrom 2004). Historically, the coastal bluff running along the length of Broad Beach would have limited the development of the more complex dune system in this area. Historic photographs of Broad Beach (e.g., Figure 2) show low dune mounds occurring along the length of the beach, consistent with a relatively simple foredune system.

As foredunes grow, they are generally colonized by a limited suite of plant species adapted to the harsh beach environment. Plants adapted to life on the beach must cope with high salinity levels, low levels of essential plant nutrients, limited water availability, desiccating winds, high solar radiation (insolation) levels, and shifting sands (Pickart and Barbour 2007; Sawyer et al. 2009). This high level of environmental stress has resulted in a relatively limited beach and dune flora, particularly in southern California. Holland (1986) described a southern foredune plant community dominated by native perennial herbs and subshrubs such as sand verbena (*Abronia maritima*, *A. umbellata*), beach bur (*Ambrosia chamissonis*), beach saltbush (*Atriplex leucophylla*), beach morning glory (*Calystegia soldanella*), beach evening-primrose (*Camissoniopsis cheiranthifolia*, as *Camissonia cheiranthifolia*), salt grass (*Distichlis spicata*), and Menzies' goldenbush (*Isocoma menziesii*, as *Haplopappus venetus*). Non-native species common to this community include sea rocket (*Cakile maritima*) and iceplant (*Carpobrotus chilensis*, *C. edulis*). Holland's southern foredune community generally corresponds to the dune mat (*Abronia latifolia*–*Ambrosia chamissonis*) alliance described by Sawyer et al. (2009). Historically, dune mat stands were the sole plant community to colonize foredunes south of Morro Bay; foredune grassland and dune swale vegetation were largely absent south of Point Conception (Pickart and Barbour 2007). Holland describes the southern foredune community as grading into a southern dune scrub community dominated by subshrubs such as California croton (*Croton californicus*), California goldenbrush (*Ericameria ericoides*), Menzies' goldenbush, and dune bush lupine (*Lupinus chamissonis*), among other species. Holland's southern dune scrub community generally corresponds to the silver dune lupine-mock heather (*Lupinus chamissonis*-*Ericameria ericoides*) alliance described by Sawyer et al. (2009). It is likely that some area of southern dune scrub vegetation occurred at Broad Beach in more

stabilized portions of the dune system, near the coastal bluff. This community would have intergraded with the southern foredune community, and it is likely that some elements of the southern dune scrub community would have been present in the southern foredune community.

Foredune communities in southern California are generally more sparsely vegetated than foredune communities in northern California which can often be dominated by dense stands of native and non-native grasses (Pickart and Sawyer 1998). Detailed reports of plant density in southern foredune communities are generally lacking; however, in their review of beach and dune vegetation in California, Pickart and Barbour (2007) reported average cover of beach vegetation between 10 and 25 percent and reaching as high as 50 percent or more on the seaward face of foredunes. Pickart and Barbour do not provide estimates of plant cover for foredune communities; however, estimates of plant density made by WRA at the reference foredune system at Ormond Beach ranged from approximately 15 to 30 percent.

To the extent feasible and practicable, the proposed foredunes at Broad Beach have been designed to incorporate characteristic elements of foredune systems from the region. However, it should be recognized that the ecological factors that promote the formation and maintenance of dune systems are generally disrupted at Broad Beach. For instance, dune formation requires a substantial source of sand which usually occurs in the form of sandy beach habitat. Such a supply of sand is currently lacking at Broad Beach. The sandy beach habitat to be created by the proposed beach nourishment will provide a source of sand that can temporarily support natural dune formation following the initial foredune construction and enhancement. The natural processes of dune formation will be limited by the availability of sand from the beach, as well as by the development on the leeward side of the beach which limits the area available for dune movement. This limited area available for the inland movement of dunes necessitates increased levels of dune stability relative to natural dune formations which are inherently less stable.

A number of elements have been incorporated into the design of the proposed foredune system to compensate for the lack of natural dune formation processes at Broad Beach. The most significant of these design elements is the proposed beach nourishment which will provide a source of sand for foredune formation and maintenance beyond the initial construction. The second major design element is the use of a modified planting palette and a denser spacing than might otherwise occur in natural foredune formations. The planting palette has been modified to include a number of native sub-shrubs and shrubs that would normally occur further from the beach in more stabilized dune and coastal scrub habitats. The intent of the modified planting palette and the denser spacing is to provide increased stability to the foredunes. As noted previously, increased stability is needed to keep the dunes from encroaching on private residences along the landward side of the dunes and to protect residences and on-site sewage treatment systems from extreme storm events or wave run-up if beach nourishment does not provide the necessary level of protection. Increased stability will also help to counteract the reduced sand supply at Broad Beach by increasing sand retention. These design elements will allow for the creation of habitat with elements of southern foredune communities while maintaining the shoreline stabilization aspects of the project.

4.0 CONCEPTUAL FOREDUNE DESIGN

The foredune design for Broad Beach is primarily based on conditions at naturally occurring foredune systems in southern California and on historical imagery of Broad Beach, with modifications to achieve the shoreline stabilization goals of the larger project. The foredune formations at Ormond Beach, located near Oxnard, approximately 16 miles northwest of Broad Beach, served as the primary reference site for determining appropriate dune specifications and vegetation composition. WRA also reviewed the photographs from the California Coastal Records Project (Adelman and Adelman 2013) to determine the historical dune and beach landscape present at Broad Beach. Historic photographs from 1979 (e.g., Figure 2) indicate that foredune habitat similar to the reference foredunes at Ormond Beach was present along nearly the entire length of Broad Beach. The foredune system appears to have been relatively narrow and less well developed at the western end of the beach, expanding into a wider, more well developed foredune system at the eastern end of the beach.

Based on the review of historical photographs and observations at the reference site and of similar foredune systems in southern California, WRA has developed a foredune creation and enhancement plan that incorporates elements of the natural geomorphology and vegetation of foredunes in the area, but which provides more stability than would otherwise be found in naturally occurring dune systems. The foredune design presented here is at the 60 percent design stage and is intended to support the environmental review and regulatory permitting process. Final foredune design and construction will be determined by conditions present at Broad Beach at the time of construction as well as by the environmental review process and input from the regulatory agencies.

Foredune enhancement will occur in the existing, highly degraded foredunes landward of the emergency revetment where remnant, degraded dune hillocks persist. Foredune enhancement will consist of non-native plant removal, restoration of foredune geomorphology, and establishment of appropriate native foredune vegetation. Foredune creation will occur on top of and landward of the emergency rock revetment where foredune habitat has been lost to wave action. Foredune creation will include construction of foredunes and establishment of appropriate native foredune vegetation. Overall dune design will consist of a simple foredune system with two rows of dunes similar in size, shape, and orientation to the reference dunes at Ormond Beach. Footpaths will be created between dunes to maintain existing levels of lateral beach access for private residences. Existing levels of lateral access for the public will be maintained through the incorporation of footpaths at existing public access points. The created and enhanced foredunes will be vulnerable to damage from foot traffic, and any access to the foredunes themselves will be discouraged through the use of sensitive habitat signage and post and rope-type fencing.

The constructed and enhanced foredune habitat will be planted with native species typical of southern foredune and southern coastal scrub plant communities. In general, the seaward row of foredunes will be planted with low-growing perennial forbs typical of southern foredune habitat such as red sand verbena, pink sand verbena, beach bur, and beach morning glory. The landward row of foredunes will be planted with a mix of these species and additional low-

growing sub-shrubs and shrubs typical of more stabilized dunes and coastal scrub communities in southern California. The intent of including species typical of more stabilized dunes and coastal scrub communities is to provide increased sand stabilization along the landward side of the dunes.

5.0 FOREDUNE CREATION AND ENHANCEMENT

Preliminary designs for the proposed foredune creation and enhancement at Broad Beach are provided as Appendix A. As noted previously, the foredunes have been designed to mimic natural foredune systems in southern California, with specific reference to the foredune system at Ormond Beach near Oxnard. The information presented in this foredune creation and enhancement plan, and specifically in this section of the plan, is at the 60 percent design stage and is intended for planning and environmental review purposes only. However, any changes to the foredune design presented here are likely to be minimal in nature and should not substantially alter the information presented here.

5.1 Staging and Access

Staging for the proposed foredune creation and enhancement will occur at the western end of the parking lot for Zuma Beach. No equipment will be stored on Broad Beach or Zuma Beach. Best management practices will be implemented at the staging area to prevent potential impacts to the surrounding natural habitats. Access between the staging area and Broad Beach will be achieved through a defined travel route between the parking lot and Broad Beach. The access route will occur seaward of any inundated portion of Trancas Creek Lagoon, thereby minimizing potential impacts to this sensitive habitat.

5.2 Site Preparation

Site preparation will involve preservation or salvage of existing stands of native dune mat vegetation where feasible and practicable, removal of non-native and invasive plants, and sand sculpting to accommodate placement of sand for foredune construction. These components of site preparation are discussed in more detail below.

5.2.1 Preservation of Existing Native Vegetation

Limited patches of native dune mat vegetation occur in isolated patches interspersed with iceplant and other non-native species. More intact areas supporting approximately 0.10 acre dune mat vegetation occur at the eastern end of the beach (WRA 2013). Stands of dune mat vegetation will be preserved to the extent feasible and practicable. Prior to construction, areas of native dune mat vegetation to be preserved will be identified by a qualified biologist and will be delineated with orange construction or similar type of fencing. In some areas, dune mat vegetation has been so invaded by iceplant that preservation is not practical. Where it is not feasible or practicable to incorporate existing dune mat vegetation into the dune creation and enhancement, the dune mat vegetation may be salvaged as outlined in Section 5.5.3. Salvage

of existing dune mat vegetation will include some combination of transplanting or seed collection and subsequent establishment in the created and enhanced foredune habitats.

In addition to native dune mat vegetation, many other native plant species have been planted on the beach as landscape specimens. In general, these species are not typical of southern foredune plant communities (i.e., dune mat vegetation) and are not appropriate for incorporation into the restored foredunes. Native plants which are not appropriate for incorporation into the restored foredunes will not be preserved or salvaged. These species will be removed from the site and disposed of at an appropriately licensed facility.

5.2.2 Non-Native and Invasive Species Removal

All non-native plants will be removed from the area of foredune restoration prior to the initiation of foredune construction. Non-native plants will be removed through a combination of herbicide treatment (for invasive species only), hand pulling, and the use of a small excavator or similar machinery. Where stands of dune mat vegetation are to be preserved, non-native species within those stands will be removed by a combination of herbicide treatment (for invasive species only) and hand pulling to avoid damage to desired native species. Although all non-native vegetation will be removed during the site preparation phase, special attention will be given to the removal of non-native species listed as “moderate” or “high” by the California Invasive Plant Council (Cal-IPC). The primary species of concern at Broad Beach include iceplant and pampas grass. These species and appropriate removal techniques are discussed below. As part of the proposed foredune creation and enhancement, Broad Beach homeowners will be encouraged to remove invasive species, particularly iceplant and pampas grass, from as much of their property as possible and to use appropriate native species in their landscapes. A list of native species appropriate to foredune and dune scrub communities in the region, as well as literature on the value of native landscaping, will be provided to the homeowners for this purpose.

Iceplant

Iceplant (*Carpobrotus chilensis*, *C. edulis*) is a mat-forming subshrub initially introduced to California to reduce erosion in coastal dune systems. Since its introduction, iceplant has escaped cultivation and is now listed by the Cal-IPC as a serious threat to native California ecosystems (Cal-IPC 2013). Iceplant spreads rhizomously or by seed and is capable of creating monotypic stands across entire dune systems. Once established, iceplant reduces the natural shifting of the dunes and produces allelopathic compounds which reduce the viability of competing plants (Cosner and Conner 2009). Due to the aggressive and invasive nature of iceplant, its control is a crucial element of any coastal habitat restoration project.

Most large-scale iceplant removal projects utilize a combination of mechanical and chemical control methods. A two percent solution of glyphosate mixed with a surfactant has been shown to be an effective control method for areas of high iceplant density where incidental exposure to native plants is not a concern, as is the case for most areas at Broad Beach. Multiple glyphosate applications may be required to ensure all plants are killed; herbicide applications should be made three days to a week apart and at least one week prior to removal of the dead

plants (Cal-IPC 2013). This delay allows time for the herbicide to be translocated throughout the entire plant and increases the effectiveness of the application. Iceplant is capable of forming extensive seed banks, and it is important to note that glyphosate may not affect the fecundity of the seed bank. Iceplant will likely continue regenerate from this seed bank for years to come, and continued monitoring and removal will be necessary to prevent reestablishment. Mechanical or hand removal is the preferred method for controlling these resprouts (Cal-IPC 2013). Burying the seed bank under a deep layer of weed-free sand will help limit reestablishment from the seed bank.

Iceplant at Broad Beach will be treated with glyphosate followed by removal by hand or small machinery. Herbicides will be applied by an appropriately licensed applicator under the supervision of a qualified biologist or restoration specialist. In addition to removing iceplant from the area of foredune creation and enhancement, iceplant will be removed from as much of the adjacent properties as is feasible. Homeowners will be encouraged to remove iceplant from their landscapes and to replace it with appropriate native species.

Pampas Grass

Pampas grass (*Cortaderia jubata*, *C. selloana*) is a large, densely tufted perennial grass that was introduced to California from South America for erosion control (Cal-IPC 2013). Since its introduction, pampas grass has escaped cultivation and is currently listed by the Cal-IPC as a high threat to California plant communities (Cal-IPC 2013). Invasive features of pampas grass include rapid growth, large biomass accumulation, heavy seed production, and long-distance seed dispersal.

A single pampas grass inflorescence can produce up to 100,000 seeds which are widely dispersed by wind (DiTomaso 2007). Management of pampas grass is possible through physical control measures, or when physical control is not feasible, through chemical control measures. For smaller areas of pampas grass, physically removing the entire crown and top section of roots has proven effective (Cal-IPC 2013). Similar to iceplant, pampas grass can re-root if plants which have been pulled from the ground are not removed from the site. Chemical control with a solution of two percent glyphosate with added surfactant has proven effective for pampas grass eradication (Cal-IPC 2013). For large clumps, removal of top foliage via cutting or burning and treating the regrowth with herbicide may reduce the total amount of herbicide required for control compared to herbicide treatment alone (Cal-IPC 2013). Further spot application may be needed to prevent rapid reestablishment from the seedbank or from living crowns.

Given the limited extent of pampas grass at Broad Beach, it can be feasibly removed by hand. Following hand removal, occurrences will be treated with glyphosate as necessary to prevent reestablishment. Any herbicide application will be conducted by an appropriately licensed applicator under the supervision of a qualified biologist or restoration specialist. In addition to removing pampas grass from the area of foredune creation, pampas grass will be removed from as much of the adjacent properties as is feasible. Homeowners will be encouraged to remove pampas grass from their landscapes and to replace it with appropriate native species.

5.2.3 Grading

After removal of non-native vegetation, the site will be graded as necessary for foredune construction. Grading will be achieved through the use of small earth moving equipment and other heavy machinery. Except in areas where existing foredune habitat is to be preserved, existing sand will be capped with clean, weed free sand. This will allow for a cap of clean, weed-free sand to be placed on top of the existing sand which undoubtedly contains a significant non-native, invasive seed bank. This will also help reduce the effects of any allelopathic compounds that may remain in the sand following iceplant removal.

5.2.4 Beach Debris

Any drift wood or other natural beach debris present during the site preparation phase will be removed from the area of foredune construction and stockpiled on-site for later use. After foredune construction and enhancement, this material will be returned to the foredunes and placed in appropriate locations to provide habitat elements for wildlife.

5.3 Sand Sourcing and Composition

5.3.1 Sand Sourcing

Sand for other beach nourishment and dune creation projects has been sourced from both offshore deposits and inland sources such as from quarries, sand bars, or behind dams (Nordstrom 2008). Sand sourced from offshore borrow areas is generally dredged and pumped onshore via a floating or submerged pipeline. Given that offshore sources of sand typically originate from beaches or other coastal habitats, the sand in these borrow areas is generally compatible with beach nourishment and dune creation. Offshore-sourced sand has the potential to be excessively saline which could limit plant establishment in the created foredunes. Offshore sand also has the potential to contain anthropogenic contaminants such as metals or polycyclic aromatic hydrocarbons (PAHs). Sand sourced from inland borrow areas is either dredged (if sourced from an inland aquatic feature such as behind dams) or quarried. For both collection methods, inland-sourced sand would be trucked to the site. Inland sources of sand are less likely to have issues related to salinity; however, particle size compatibility is less certain. In addition, inland sources of sand can contain anthropogenic contaminants and may also harbor a large weed seed bank. The presence of a weed seed bank depends on whether the sand is freshly dredged or quarried or whether it has been stockpiled uncovered for long periods of time. Freshly quarried or dredged sand is more likely to lack a significant weed seed bank. If sand has been stockpiled uncovered for an extensive period, it is likely to contain a significant weed seed bank; if the pile has been properly covered, the potential for a significant weed seed bank is lessened.

Sand to be used in the foredune creation and enhancement will be sourced from inland quarry sites. Sand from these potential sources will be analyzed for physical and chemical suitability for foredune creation and enhancement. These analyses will focus on particle size, salinity, fertility, organic matter content, weed seed content, and levels of anthropogenic contaminants. The ultimate source of sand used in the restoration will be of compatible particle size, will be

with a range of salinity and fertility levels suitable for establishment of dune vegetation with the reasonable addition of soil amendments or other soil treatments, and will conform to criteria for anthropogenic contaminants established by the United States Environmental Protection Agency and the United States Army Corps of Engineers.

5.3.2 Particle Size

Sand particle size is an important factor in dune restoration and creation projects as particle size affects permeability and aeolian transport dynamics and the dissipation of wave energy, thereby affecting the natural processes of beach and dune formation (Nordstrom 2008). Smaller particle size may result in decreased permeability and increased water retention which can make the beach or dunes more susceptible to invasion by non-native plant species. Larger particle size may decrease the ability of the sand to be transported by wind and wave action, thereby increasing the longevity of the beach or dunes—this effect is more readily seen when using particle sizes approaching that of gravel (Nordstrom 2008). Because sand on the seaward side of the dunes will be quickly reworked by wind and wave action, particle size is of greater importance on the landward side of the dunes (Nordstrom 2008).

A particle size assessment using samples from four tidal elevations indicates that particle size at Broad Beach ranges from coarse gravel to very fine sand (10 to 0.65 millimeters), with the largest fraction of sand ranging from medium to fine sand (0.5 to 0.1 millimeters; Moffatt and Nichol 2013; Soil Survey Division Staff 1993). Sand sourced for beach nourishment and foredune construction at Broad Beach will have a grain size envelope comparable to that of Broad Beach, and care will be taken to ensure that the selected material does not contain significant amounts of very fine material which could cause cementation.

5.3.3 Soil Salinity, Fertility, and Amendments

The ultimate source of sand used in the proposed foredune creation and enhancement will be within the range of fertility levels suitable for the establishment of dune vegetation with the reasonable addition of soil amendments or other soil treatments. In addition to screening for anthropogenic contaminants, potential sources of sand will be analyzed for fertility levels as well as other chemical properties that affect plant establishment. It is unlikely that sand from any potential source will be suitable for plant establishment without some level of amending or other treatments. Only sand that can be made suitable for plant establishment with reasonable levels of amending or other treatments will be used in the foredune creation and enhancement.

Inland-sourced sand may be low in essential plant nutrients and may require fertilizers or other amendments at the time of planting. The use of fertilizers and soil amendments will be minimized to the fullest extent feasible. If it is determined that imported sand used for foredune creation is deficient in essential plant nutrients, appropriate fertilizers will be used to bring fertility levels to an acceptable range for plant establishment (i.e., up to the range of fertility levels found in existing foredune habitat at Broad Beach). Excessive fertilization can encourage establishment and spread of non-native species, reduce mycorrhizal colonization, and cause water quality issues. To minimize these potential effects, only slow-release fertilizers will be used, and application rates will be the minimum necessary for acceptable plant establishment.

5.4 Foredune Specifications

A variety of dune shapes and sizes have been employed in coastal restoration projects in southern California and elsewhere in the state (e.g., U.S. Army Corps of Engineers 1987; Guinon and Allen 1990; Sapphos Environmental 2004; LFR, Inc. 2006; Lortie and Engel 2008). Although the shape and size of foredunes to be created at Broad Beach will be limited by the area available for foredune creation, as well as the public and private access requirements of the project, several basic principles of dune formation apply. The foredune system at Broad Beach will be designed to mimic the reference foredunes at Ormond Beach to the extent feasible within the aforementioned confines. Although the constructed foredunes will mimic the size and orientation of the naturally formed foredunes at Ormond Beach, the constructed foredunes will be planted more densely to promote increased stabilization. Increased stabilization is required to retain the sand, prevent the foredunes from encroaching on the adjacent residences, and maintain existing levels of public and private access to the beach. Preliminary specifications, including overviews and cross-sections of typical reaches of created and enhanced foredune habitat, are provided as Appendix A. As noted above, the plans presented in Appendix A are subject to refinement or revision as the planning and permitting aspects of the project proceed. It is expected that any changes in the foredune design will be minimal in nature and that the ultimate design of the dunes will not be substantially changed.

5.4.1 Foredune Size and Layout

The foredune system will be constructed over the existing emergency rock revetment. The revetment will be covered by a trapezoidal sand berm running along the length of the beach, with a minimum of two feet of sand over the rock revetment and extending approximately 30 to 50 feet inland and 0 to 30 feet seaward of the revetment. The foredunes will be constructed on top of this berm. The dunes will slope downward on the landward side and tie into the existing grade where the dunes integrate with the backyards of the residences. On the seaward side of the revetment, the constructed foredunes will grade into the toe of the trapezoidal berm.

Using foredune profiles observed at the Ormond Beach reference site and on reports of dune profiles from other beaches in southern California (e.g., Longcore 2005; Lortie and Engel 2008) as a guide, the foredunes at Broad Beach will be constructed with side slopes ranging from 20 to 40 degrees (approximately 35 to 85 percent slope) and will range in height from 3 to 6 feet. Foredunes will be oriented in-line with the prevailing winds¹ and will be formed into rough teardrop shapes approximately 10 to 30 feet long, with the tail end oriented away from the prevailing winds.

5.4.2 Foredune Construction Methods

Depending on the ultimate source of sand to be used in the foredune creation and enhancement, sand will either be deposited on the beach via dump truck (for inland-sourced

¹ Prevailing winds at Broad Beach are from the southwest as determined by wind direction records from 2001 to 2012 at the California Irrigation Management Information System (CIMIS) weather station at Long Beach (CIMIS #174) and from 1993 to 2012 at the CIMIS weather station at Santa Monica (CIMIS #99).

sand) or will be pumped onto the beach via a pipeline (for offshore-sourced sand). In either scenario, the sand will be deposited in the approximate location where each foredune hillock will be created. Initial foredune formation will be achieved through the use of small earth moving equipment and other large machinery. Final grading will be conducted by hand using sand rakes and other hand tools.

5.4.3 Sand Stabilization Techniques

A wide range of sand stabilization techniques have been employed in previous dune restoration efforts including the use of sand fencing, hydromulch, soil-binding emulsions, nurse crops, crimped straw, jute netting, and vegetation (Pickart and Sawyer 1998; Nordstrom 2008). Although each method has value in encouraging dune formation and stabilization, long-term results indicate that none of the sand stabilization techniques provides results superior to those achieved by the use of vegetation alone (Pickart and Sawyer 1998; Rogers and Nash 2003). Sand fencing has been proven as a useful means of creating dunes where none exist, filling gaps in the crestline of existing dunes, and increasing the size of existing dunes (Nordstrom 2008). However, sand fencing can limit the development of natural dune formations if not designed properly and can have negative effects on pioneer plants at the leading edge of the dunes which require regular inundation by sand to maintain vigorous growth (Nordstrom 2008). In addition, the installation, maintenance, and eventual removal of sand fencing may be cost prohibitive for large-scale applications such as the one at Broad Beach. Given these drawbacks, the use of sand fencing is recommended only for emergency repairs following dune blowouts. Sand fencing may also be appropriate along the landward edge of the dunes to limit sand encroachment into adjacent properties and to define the extent of allowable landscaping on private property. The use of hydromulch, soil-binding emulsions, nurse crops, crimped straw, or jute netting should be used only as a last resort for stabilizing sand.

The use of appropriately spaced pioneer species such as sand verbena (*Abronia* spp.) or beach bur (*Ambrosia chamissonis*) is the preferred method for stabilizing the seaward edge of the foredunes at Broad Beach. Larger shrubby species such as California sagebrush (*Artemisia californica*) or California goldenbrush (*Ericameria ericoides*) will be used to stabilize the landward side of the dunes. Use of alternative methods of sand stabilization will be employed as an adaptive management strategy if it becomes clear within the first 1 to 2 years that the use of vegetation alone is insufficient for providing the required level of sand stabilization. To provide the necessary levels of sand stabilization, target plant cover will be between 30 and 60 percent. This level of plant cover is within what was observed at the reference foredunes at Broad Beach and is also within the range reported by Pickart and Barbour (2007). Although this level of plant cover is at the high end of what was observed at Ormond Beach and the range reported in the literature, a high level of plant cover is necessary to provide the required level of sand stabilization.

5.4.4 Preservation of Existing Foredune Habitat

Existing foredunes with significant stands of native dune mat vegetation will be preserved to the extent feasible and practicable. Such stands are primarily limited to the eastern portion of Broad Beach. To the extent feasible and practicable, these existing foredunes will be

incorporated into the design of the constructed foredunes, with constructed foredunes graded to gradually taper into preserved foredunes. Details of the proposed plant salvage are provided in Section 5.5. Any impacted dune mat vegetation will be reestablished in the created and enhanced foredunes. The proposed foredune creation and enhancement will result in a significant increase in the extent and quality of both foredune habitat and dune mat vegetation. The proposed increase in the extent and quality of foredune habitat and dune mat vegetation represents a significant improvement over existing conditions at Broad Beach.

5.4.5 Public and Private Access Routes

Regular pedestrian foot traffic can be highly damaging to dune vegetation and must be limited to designated areas if restoration efforts are to be successful (Rogers and Nash 2003; Nordstrom 2008). Access to the beach will be provided by designated public and private access paths to be created in dune troughs and at existing public access points. Public access paths may be demarcated by post and rope-type fencing or other fencing options and will be accompanied by signage indicating that the foredunes are environmentally sensitive areas which are easily damaged by foot traffic. The fencing and signage will help prevent impacts to foredune vegetation and will also help prevent impacts to special-status species which are expected to use the created and enhanced foredune system.

5.5 Plant Palette, Propagation, and Installation

5.5.1 Planting Palette and Sourcing

Plant species used in the project will be native to the region identified by Baldwin et al. (2012) as the “South Coast”, the area extending along the immediate coastline from Point Conception in Santa Barbara County south into Baja California in Mexico. Historically, dune mat stands were the sole plant community to colonize foredunes south of Morro Bay; foredune grassland and dune swale vegetation were largely absent south of Point Conception (Pickart and Barbour 2007). Dune mat stands, as defined by Sawyer et al. (2009), corresponds to Holland’s (1986) southern foredune vegetation and consist largely of short-statured herbaceous perennials such as sand verbena (*Abronia maritima*, *A. umbellata*) and beach bur (*Ambrosia chamissonis*), with annual herbs constituting a smaller portion of the species composition. Dune scrub is the vegetation type that would have been present on the stabilized backdunes in southern California (Pickart and Barbour 2007). This plant community would have been dominated by larger sub-shrub and shrub species such as California goldenbush (*Ericameria ericoides*) and bush lupine (*Lupinus chamissonis*). Although this vegetation type would have historically occurred further from the beach, the species that make up this plant community will be used to stabilize the landward side of the created foredunes at Broad Beach.

The plant palette presented in Tables 1 and 2, below, was compiled from a number of historic and contemporary references including Couch (1914); Pierce and Pool (1938); Munz (1959, 1974), Holland (1986), Pickart and Barbour (2007), and Sawyer et al. (2009). Although a number of other species have been employed in restoration projects in the Los Angeles region (e.g., Longcore 2005; Sapphos Environmental 2004), many of these species have not been

documented from historic reports of the composition of dune vegetation in the region and are more appropriate for restoration projects north of Point Conception.

Plants used in the dune creation will be sourced from local plant stock, ideally from the Malibu vicinity. However, plant stock may be sourced from anywhere within Santa Monica Bay watershed, as far north as Point Mugu and as far south as Point Fermin. Sourcing plant stock from as close as possible to Malibu will ensure that plants used in the restoration are adapted to the local climate and will help maintain the genetic integrity of the regional flora. Plant stock will be collected by a qualified biologist or restoration specialist holding all necessary permits. Collected seed will be cleaned and either stored for sowing directly onto the restored foredunes or will be grown out at a nursery for planting as plugs or containerized specimens.

Table 1. Potential Planting Palette for the Seaward Side of the Dune System

SCIENTIFIC NAME	COMMON NAME	LIFE FORM
<i>Abronia maritima</i>	Red sand verbena	Perennial herb
<i>Abronia umbellata</i>	Pink sand verbena	Perennial herb
<i>Ambrosia chamissonis</i>	Beach bur	Perennial herb
<i>Atriplex leucophylla</i>	Beach saltbush	Perennial herb
<i>Calystegia soldanella</i>	Beach morning glory	Perennial herb
<i>Camissoniopsis cheiranthifolia</i>	Beach evening primrose	Perennial herb
<i>Dithyrea californica</i>	California spectaclepod	Annual herb
<i>Heliotropium curassavicum</i>	Seaside heliotrope	Perennial herb

Table 2. Potential Planting Palette for the Landward Side of the Dune System

SCIENTIFIC NAME	COMMON NAME	LIFE FORM
<i>Abronia maritima</i>	Red sand verbena	Perennial herb
<i>Ambrosia chamissonis</i>	Beach bur	Perennial herb
<i>Artemisia californica</i>	California sagebrush	Sub-shrub
<i>Atriplex leucophylla</i>	Beach saltbush	Perennial herb
<i>Atriplex parishii</i>	Parish's saltbush	Annual herb
<i>Calystegia soldanella</i>	Beach morning glory	Perennial herb
<i>Camissoniopsis cheiranthifolia</i>	Beach evening primrose	Perennial herb
<i>Croton californicus</i>	California croton	Perennial herb
<i>Dithyrea californica</i>	California spectaclepod	Annual herb
<i>Ericameria ericoides</i>	California goldenbush	Sub-shrub
<i>Eriogonum parvifolium</i>	Coast buckwheat	Perennial herb
<i>Heliotropium curassavicum</i>	Seaside heliotrope	Perennial herb
<i>Lupinus chamissonis</i>	Chamisso bush lupine	Sub-shrub
<i>Peritoma arborea</i>	Bladderpod	Shrub
<i>Rhus integrifolia</i>	Lemonade berry	Shrub

5.5.2 Plant Propagation

All plant propagation will be conducted by a reputable firm specializing in habitat restoration or native plant propagation. The decision to seed directly or plant from plugs or containerized specimens will be determined based on available funding, the biology of the species, the desired planting size, and the professional judgment of the project's Landscape Architect or that of the restoration specialist or horticulturalist hired for the plant propagation. Seed to be sown directly onto the dunes will be appropriately stratified, if needed, and will be sown in the fall, after the onset of the winter rains. If dictated by the biology of the species, a later planting date may be appropriate. A number of studies have examined seed stratification and planting methods for dune restoration projects in California and elsewhere (e.g., van der Valk 1974; Maun and Lapierre 1986; Pickart 1988; Pickart and Oliphant 1990; Coastal Restoration Consultants 2007). These reports will be used to inform seed collection, stratification, and sowing methods for the proposed foredune creation and enhancement at Broad Beach.

Plants to be installed as plugs or containerized plantings will be grown out at least one year in advance of the expected planting date, or as needed to reach the desired planting size. Whether seeded directly onto the foredunes or grown out in containers, all plant material will be inoculated with arbuscular mycorrhizal (AM) fungi to increase establishment success and increase the ability of plants to take up water and nutrients (Taiz and Zeiger 2006). Ideally, a native strain of AM fungi will be used. Although native AM fungi are generally not commercially available, it may be possible to obtain inoculum material from existing, healthy dune mat

vegetation at Broad Beach or other sites such as Ormond Beach. Sand from reference foredune habitat will contain naturally occurring forms of AM fungi and can be incorporated, unsterilized, into seed mixes or growing media. The use of unsterilized sand for introducing AM fungi into seed mixes and planting media has been shown to produce superior results compared to the use of a commercially available inoculum (Pickart and Sawyer 1998). Any necessary permits or permissions will be obtained prior to the collection of sand from dune mat vegetation at Broad Beach or a reference site such as Ormond Beach. A commercially available strain of AM fungi such as *Glomus intraradices* will be substituted if native AM fungi cannot be feasibly or practicably obtained and incorporated into the planting mix.

Although using containerized plants may provide better establishment rates, containerized plants may be cost prohibitive given the large number of plants needed. Seeding and the use of plugs are more cost-effective methods of planting and have been successfully employed in other dune restoration efforts in southern California and elsewhere (e.g., Lortie and Engel 2008). All plant material will be inspected by the project's Landscape Architect prior to installation, and only healthy, vigorous, disease-free plants will be installed.

5.5.4 Soil Amendments

Potential sources of sand to be used for foredune enhancement or creation will be analyzed for fertility, toxicity, and other physical or chemical properties that may affect plant establishment. Only sand that can be made suitable for plant establishment with the reasonable and practicable addition of soil amendments will be used. Based on the results of the analyses, a plan for amending the sand to make it more favorable for plant establishment will be developed. Soil amendments such as slow release fertilizer or greenwaste compost may be added to provide a minimal amount of nutrition and organic matter for healthy plant establishment.

5.5.5 Plant Installation

Given that vegetation will be the primary source of sand stabilization in the restored dunes, it is important that the plants be installed and maintained properly to promote rapid establishment and spread. Plant installation will be conducted by a reputable firm specializing in native landscape restoration and with experience in planting coastal dunes. Plants will be installed in the fall, at the onset of the rainy season. Only healthy, disease-free nursery stock will be used.

Excessive fertilization and the use of organic amendments is likely to promote the establishment of undesired native and non-native vegetation (Rogers and Nash 2003). However, the use of a limited amount of a time-released fertilizer during planting can help promote rapid establishment of containerized plants and plugs. Because foredune species are adapted to low nutrient levels, they are easily damaged by regular fertilizer; only time-released fertilizers such as those offered by Osmocote® will be used. If needed, a small amount of time-release Osmocote® or similar type fertilizer will be added to the bottom of the planting hole for plugs and containerized plantings. Plants will not be fertilized in subsequent years. Because foredunes are a harsh environment for plant growth, high rates of plant mortality should be expected during the establishment period. To compensate for potentially high mortality rates, the site will initially be

over-planted, and additional planting will occur in years two and three if determined necessary to achieve the targeted level of plant cover. As noted previously, target plant cover for the created and enhanced foredune habitat is between 30 and 60 percent. It is expected that it will take between 3 and 5 years for the restoration plantings to reach this level of cover.

5.5.6 Irrigation

Although dune species are adapted to desiccating condition, temporary irrigation can help in the establishment of dune vegetation (Longcore 2005). However, long-term irrigation can promote shallow, poorly developed root systems and can lead to the establishment of undesired, weedy vegetation. To increase the speed and success of plant establishment and subsequent sand stabilization, the foredune plantings at Broad Beach will be irrigated. Temporary overhead irrigation will be installed along the length of the created and enhanced foredune habitat, and plantings will be irrigated for one to three years following initial or subsequent plantings. Overhead irrigation from an irrigation system installed under the sand or immediately on top of the sand will be used to supplement natural rainfall levels, and will only be used during the dry season or during prolonged dry periods during the rainy season. The temporary irrigation system will be removed from the beach once it is no longer being used.

5.5.7 Plant Maintenance

During establishment, plants may require supplemental irrigation and may also require protection from sun and wind. If it is determined that plant establishment is being hindered by excessive wind and sun exposure, as determined from visible signs of plant stress, plantings may be protected by straw bundles, sand fencing, or other suitable materials. Some level of plant mortality is expected during the initial years of the restoration. However, if significant mortality occurs during the first three years, plants will be replaced. The need for additional plantings beyond the first three years of the restoration will be made on a case by case basis. During both the establishment period and in subsequent years, the restored dunes will require regular weed control to prevent the re-establishment of invasive species such as ice plant or pampas grass.

6.0 MONITORING, PERFORMANCE GOALS, AND REPORTING

6.1 Monitoring and Performance Goals

Monitoring and performance goals for the proposed foredune creation and enhancement will be based primarily on vegetation composition and cover, with the goal of creating a relatively stabilized foredune system with relatively high cover of native species and low cover of non-native species. The created and enhanced foredunes will be monitored for a period of ten years, with monitoring conducted in years 1, 2, 5, 7, and 10. Monitoring conducted during the first two years will help identify the need for any design modifications early in the process, and monitoring during years seven and ten will help ensure the long-term survival of plantings and stability of the foredune system.

6.1.1 Monitoring

Monitoring will be conducted by a qualified biologist and will be conducted at least once per year on an annual basis following initial planting of the created foredune habitat. Monitoring will be both quantitative and qualitative. Quantitative monitoring will occur within a representational subset of the foredune system and will document the establishment and spread of foredune plantings, including the percent cover of native foredune species, red sand verbena, and invasive species listed as “high” or “moderate” by the Cal-IPC. Quantitative monitoring will be conducted in ten permanent plots to be established following initial foredune planting. The plots will be evenly spaced along the length of the created foredune habitat and will be square or rectangular, with sides between 25 and 50 feet long, depending on their location and the configuration of foredunes in that area. Within each plot, vegetation will be monitored using a modified relevé field sampling protocol (e.g., Mueller-Dombois and Ellenberg 1974). This method identifies the extent of vegetation communities and collects vegetation composition data from each distinct vegetation community that occurs within the sample area. In the case of Broad Beach, each patch of vegetation will be considered a vegetation “community”. Vegetation data collected for each patch or community includes canopy cover by species and overall canopy cover. Performance goals related to percent cover of native dune species, red sand verbena, and invasive species will be assessed using the data from the relevé plots. Within each relevé plot, two permanent photographic documentation points (photo points) will be established, one facing east and one facing west. Photographs will be taken at the photo points during each monitoring event and will be included in the annual monitoring reports to provide a visual representation of habitat development.

In addition to the quantitative monitoring in the relevé plots, qualitative monitoring will be conducted across the entirety of the created foredune habitat. Qualitative monitoring will document the location and approximate extent or severity of any invasive species listed as “high” or “moderate” by the Cal-IPC. Qualitative monitoring will also document the location and extent or severity of any substantial erosion, exposure of the rock revetment, or other noteworthy disturbance. The data collected from the qualitative monitoring will be used to inform management needs.

6.1.2 Performance Goals

Performance goals for the proposed foredune creation and enhancement will focus on the establishment of foredune plantings and the presence of invasive species listed by the Cal-IPC as “high” or “moderate”. It is assumed that native plantings will vary in the percent cover from year to year, given the nature of the dunes and the movement of sand. However, in an effort to achieve the goals outlined in this plan specific performance goals were developed and are as follows:

- Native foredune plantings should reach a cover of approximately 10-20 percent by the end of Year 1, 20-30 percent by Year 2, 30-40 percent in Year 5. Cover of approximately 50-60 percent will be maintained in subsequent years.

- Annual species will should signs of establishment and spread (i.e., seed production and germination in successive years) by Year 2 and will continue to be present in Year 3 and beyond.
- Perennial species should show signs of establishment and spread by Year 5 and will continue to expand in subsequent years.
- Cover of non-native species should remain low (below approximately 15 percent absolute cover) throughout the 10-year monitoring period.
- Cover of invasive species listed as “high” or “moderate” by the Cal-IPC should remain low (below approximately 10 percent absolute cover) throughout the 10-year monitoring period.

If performance goals are not achieved in any given year, an assessment will be conducted to determine the cause for the poor performance and appropriate adaptive management actions will be implemented. Adaptive management of the site is discussed in Section 7.

6.2 Reporting

Reporting will include both an initial as-built report and annual monitoring reports. Following the construction and initial planting of foredune habitat, an as-built report documenting foredune construction and planting will be prepared and submitted to the Trancas Property Owners Association and the appropriate regulatory agencies. The as-built report will document any deviances from the original construction documents, including the rationale for such changes, as well as the final layout of the irrigation system and plantings.

Results of the annual monitoring—including the quantitative estimates of plant cover; the qualitative assessment of invasive weeds, erosion, and other disturbance; and the photographic documentation—will be compiled into a single report to be submitted to the Trancas Property Owner’s Association and the appropriate regulatory agencies at the end of each monitoring year. The report will provide an assessment of the progress toward meeting performance goals and will include a discussion of all management activities conducted during the year.

7.0 ADAPTIVE MANAGEMENT

Post-construction management of the created and enhanced foredune habitat will be based on principles of adaptive management. Adaptive management is an iterative process whereby restoration practices are guided by best available technologies and hypothesis testing followed by implementation and monitoring to evaluate results. This approach allows for restoration and management under changing conditions and with uncertainties in the course of habitat development. Adaptive management involves six primary steps: (1) research and planning, (2) design, (3) implementation, (4) monitoring, (5) evaluation, and (6) modification or adaptation. Most importantly, adaptive management is a reflective process in which management actions

are continuously monitored and evaluated and necessary changes in management are planned and implemented, followed by continued monitoring and evaluation. For a more detailed discussion of adaptive management see Atkinson et al. (2004) or Fischenich and Vogt (2011).

Although a number of dune creation and restoration projects have been successfully accomplished along the California coastline and elsewhere, dune creation and restoration is not as well understood as is the creation or restoration of other more stable habitat types. The dynamic nature of dune systems combined with unique site conditions results in a range of uncertainties which could affect all aspects dune formation and maintenance. Although it is not possible to predict all of the potential problems that could arise during the course of the proposed dune creation and enhancement, the most obvious of these potential problems include excessive loss of sand through erosion or aeolian transport, poor establishment of foredune vegetation due to chemical or physical properties of the sand, and damage caused by pedestrian activity or pets.

Dune Stability and Sand Retention

If it is determined that rates of sand loss in the created and enhanced foredunes is excessive, adaptive management measures to stabilize the sand will be investigated and implemented. If it is determined that sand loss is due to poor plant establishment, temporary measures to stabilize sand will be implemented while the potential causes of poor plant establishment are investigated and resolved as discussed below. If it is determined that plant establishment is proceeding as expected and that sand loss is due to erosion, aeolian transport, or other causes, potential solutions will be investigated and implemented. Assuming plant establishment is proceeding as expected, potential solutions will be temporary in nature and will be designed to stabilize sand until plants have established well enough to stabilize the sand without additional stabilization measures. Potential temporary sand stabilization measures include the use of hydromulching, jute netting, straw bundles or bales, or sand fencing. If it is determined that plant cover alone does not provide sufficient levels of sand stability for long-term maintenance of the foredune system, sand fencing may be installed as a permanent solution for retaining sand.

Plant Establishment

If it is determined that plant establishment is not proceeding as expected, adaptive management measures to improve plant establishment will be investigated and implemented. If plant establishment is simply slower than expected and that poor establishment is not due to high mortality rates, no action may be necessary. However, if it is determined that poor plant establishment is due to high rates of mortality, potential adaptive management actions include additional plantings, the use of fertilizers or other soil amendments or treatments, or modification of the planting palette. Additional plantings may make use of alternative planting methods (e.g., the use of larger containerized specimens instead of plugs or seeds) or a modified planting palette (e.g., modifications to the planting ratios or substitution of other appropriate native species). If it is determined that plant establishment is being hindered by high salinity levels or nutrient deficiencies, appropriate soil amendments or treatments will be

implemented. Such measures may include a prolonged period of irrigation to reduce salinity levels in the upper part of the sand or the addition of slow-release fertilizer to temporarily boost plant establishment.

Foredune Disturbance

If it is determined that loss of sand, poor plant establishment, or other problems are the result of humans or pets walking on the foredunes, appropriate adaptive management measures will be implemented. Such measures may include the use of interpretive signage at public access points to highlight the sensitive nature of the foredune habitat or the use of pole and rope-type fencing or sand fencing to keep people and pets off of the foredunes.

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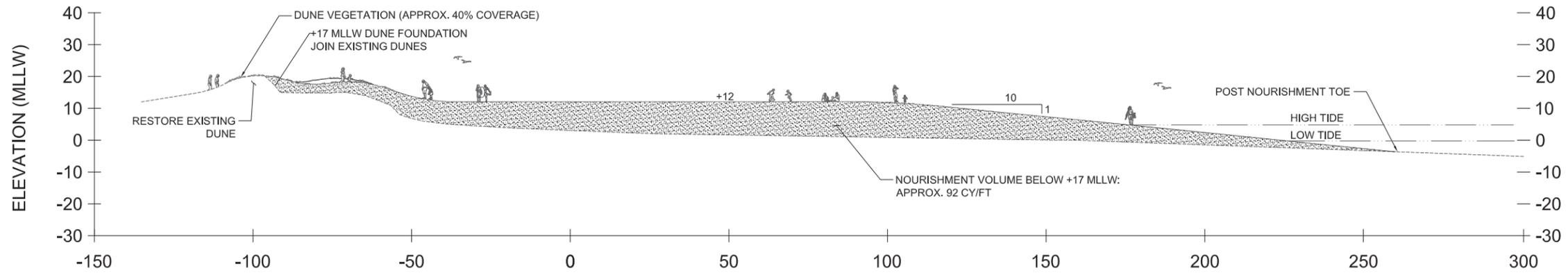
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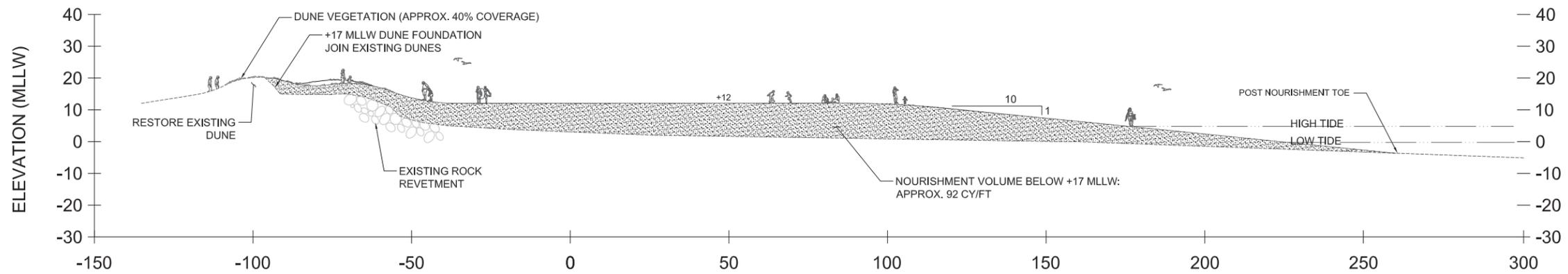
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APPENDIX A
PRELIMINARY DUNE RESTORATION SPECIFICATIONS

GROUP 1 - LOT 30708 TO LOT 30756 (DOUBLE ROW, WITHOUT REVETMENT)
RESTORE EXISTING DUNE HUMMOCKS, CREATE SECOND SEAWARD ROW



GROUP 2 - LOT 30760 TO LOT 31016 (DOUBLE ROW, WITH REVETMENT)
RESTORE EXISTING DUNE HUMMOCKS, CREATE SECOND SEAWARD ROW



NOTE: SEE SHEET L-4 FOR DUNE RESTORATION KEY MAP AND NOTES, DUNE HUMMOCK PROTOTYPES, AND PLANT LEGENDS. SEE SHEETS L-5 TO L-7 FOR TYPICAL DUNE HUMMOCK GRADING AND PLANTING PLANS.



LEGEND

- EXISTING GRADE
- PROPOSED GRADE (FOREGROUND)
- PROPOSED GRADE (BACKGROUND)

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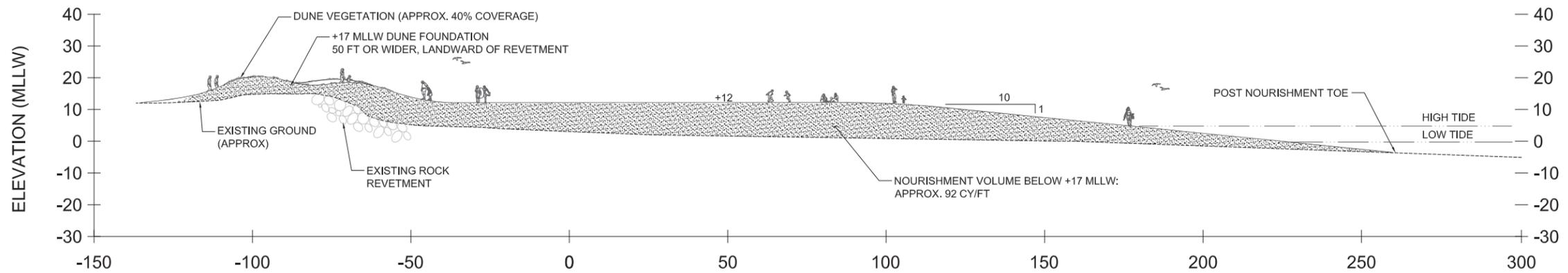
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DUNE RESTORATION:
TYPICAL SECTIONS

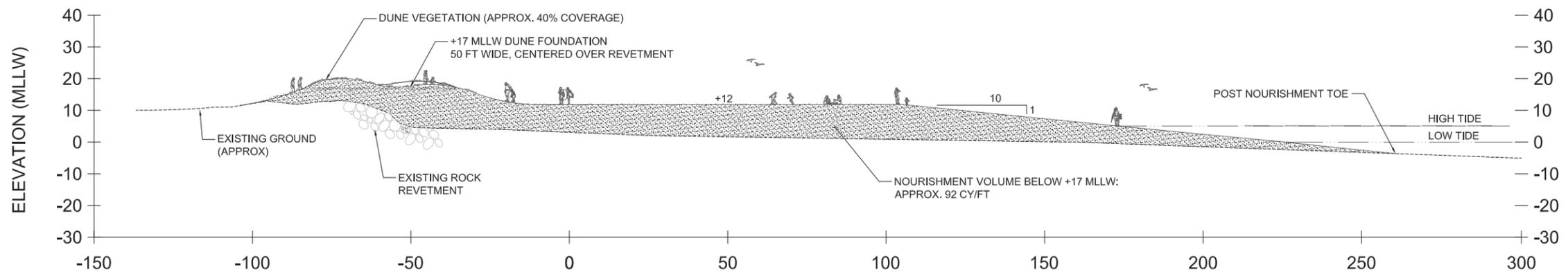
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L-1	

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GROUP 3 - LOT 31020 TO LOT 31220 (DOUBLE ROW)
CREATE TWO ROWS OF DUNE HUMMOCKS (NO REMNANT DUNE EXISTS)



GROUP 4 - LOT 31224 TO LOT 31346 (DOUBLE ROW)
CREATE ONE ROW OF DUNE HUMMOCKS LANDWARD OF REVETMENT AND ONE ROW SEAWARD OF THE REVETMENT.



NOTE: SEE SHEET L-4 FOR DUNE RESTORATION KEY MAP AND NOTES, DUNE HUMMOCK PROTOTYPES, AND PLANT LEGENDS. SEE SHEETS L-5 TO L-7 FOR TYPICAL DUNE HUMMOCK GRADING AND PLANTING PLANS.

SCALE: 1" = 20'

LEGEND

- EXISTING GRADE
- PROPOSED GRADE (FOREGROUND)
- PROPOSED GRADE (BACKGROUND)

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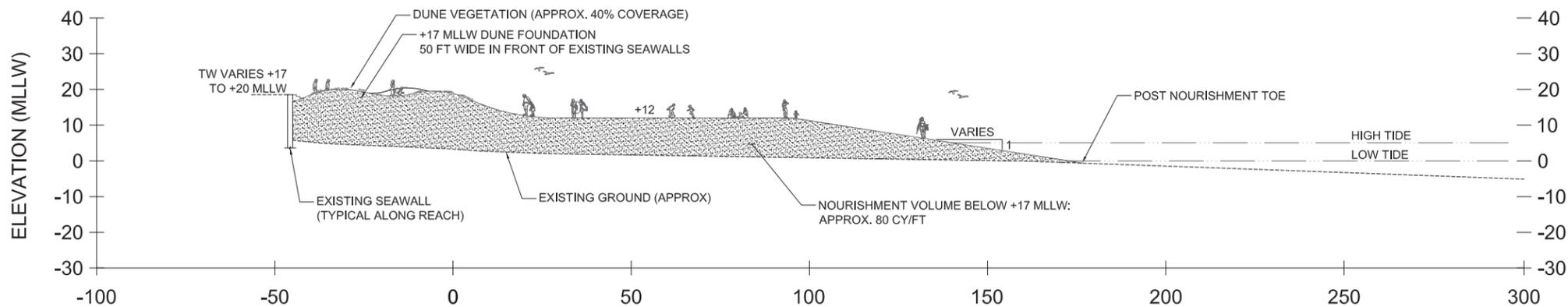
DUNE RESTORATION:
TYPICAL SECTIONS

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SHEET 25 of 30	
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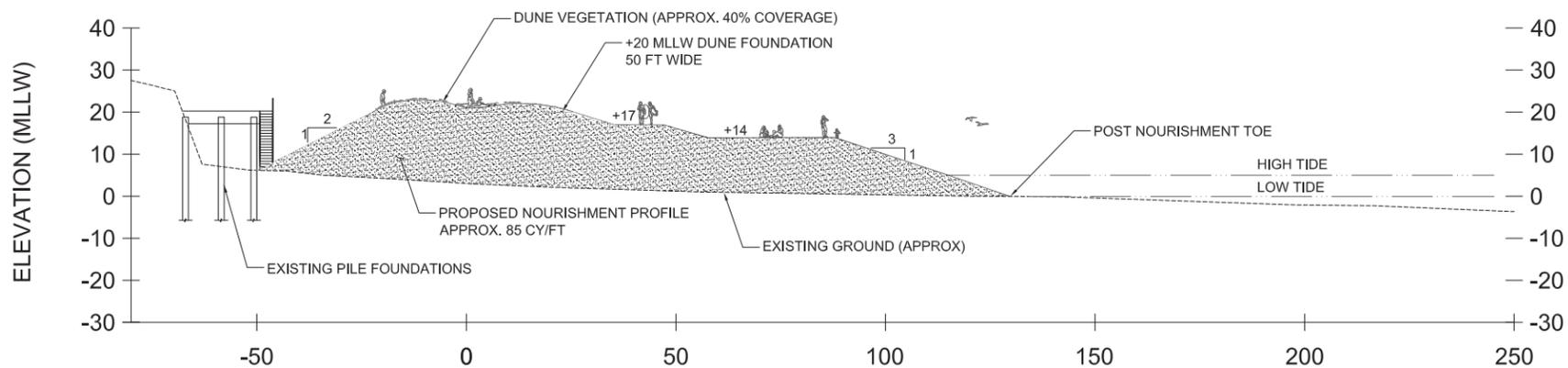
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GROUP 5 - LOT 31350 TO 31412 (UNPROTECTED DUNES)
 CREATE TWO ROWS OF DUNE HUMMOCKS ADJACENT TO EXISTING SEAWALL AND/OR FACE OF BLUFF.



GROUP 6 - LOT 31418 TO POINT LECHUZA (UNPROTECTED DUNES)
 CREATE TWO OR THREE ROWS OF DUNE HUMMOCKS ADJACENT TO EXISTING PILE FOUNDATIONS.



NOTE: SEE SHEET L-4 FOR DUNE RESTORATION KEY MAP AND NOTES, DUNE HUMMOCK PROTOTYPES, AND PLANT LEGENDS. SEE SHEETS L-5 TO L-7 FOR TYPICAL DUNE HUMMOCK GRADING AND PLANTING PLANS.



LEGEND

- EXISTING GRADE
- PROPOSED GRADE (FOREGROUND)
- PROPOSED GRADE (BACKGROUND)

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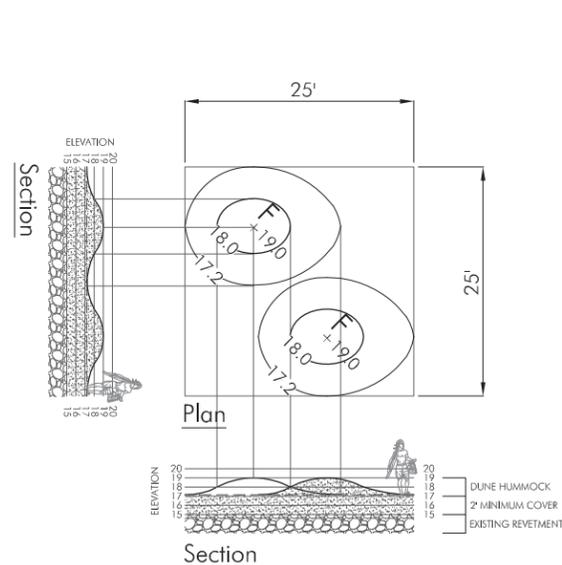
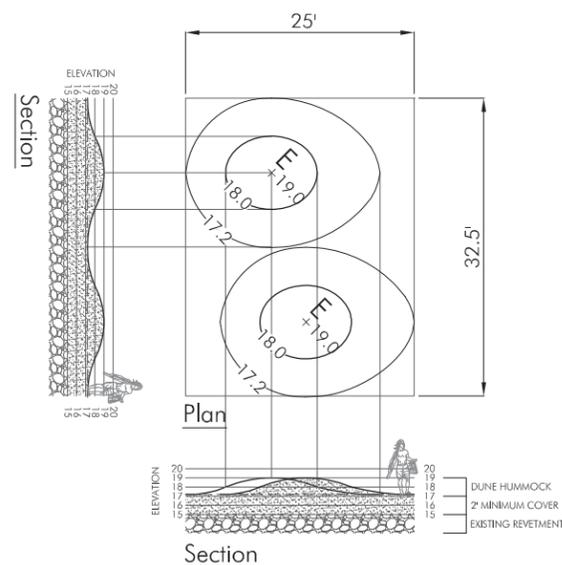
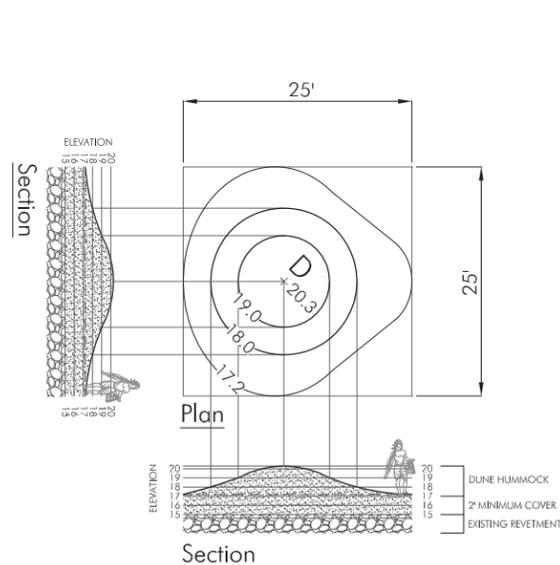
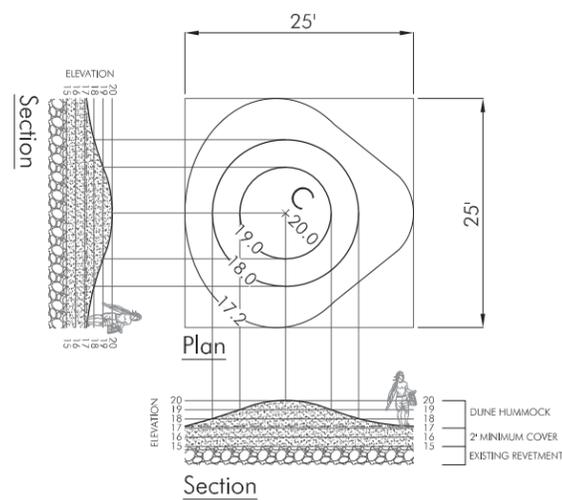
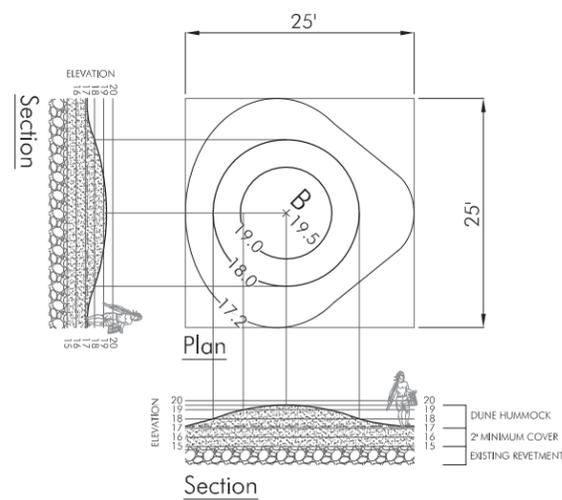
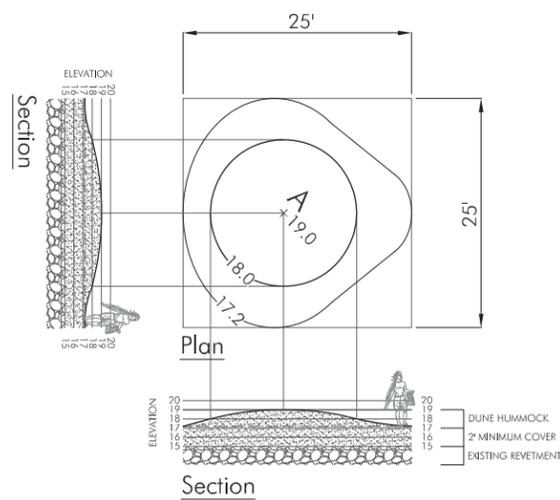
DUNE RESTORATION:
 TYPICAL SECTIONS

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JOB NO. 6935-02	
SHEET 26 of 30	
L-3	

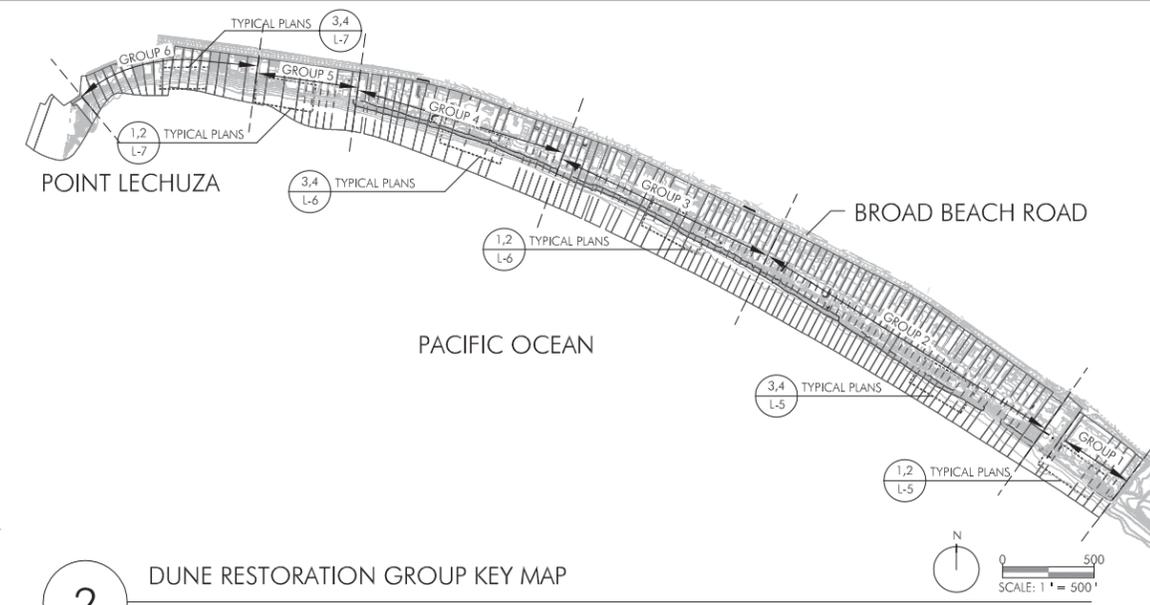
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1 DUNE HUMMOCK PROTOTYPES
SCALE: 1" = 10'-0"



2 DUNE RESTORATION GROUP KEY MAP
SCALE: 1" = 500'

PLANT LEGEND - ZONE A

SYMBOL	BOTANICAL NAME	COMMON NAME	LIFE FORM	SIZE	ON CENTER SPACING (FEET)	QUANTITY
[Symbol]	ABRONIA MARITIMA	RED SAND VERBENA	PERENNIAL FORB	TBD	TBD	TBD
	ABRONIA UMBELLATA	PINK SAND VERBENA	PERENNIAL FORB	TBD	TBD	TBD
	AMBROSIA CHAMISSONIS	BEACH BUR	PERENNIAL FORB	TBD	TBD	TBD
	ATRIPLEX LEUCOPHYLLA	BEACH SALTBRUSH	PERENNIAL FORB	TBD	TBD	TBD
	CALYSTEGIA SOLDANELLA	BEACH MORNING GLORY	PERENNIAL FORB	TBD	TBD	TBD
	CAMISSONIA CHEIRANTHIFOLIA	BEACH EVENING PRIMROSE	PERENNIAL FORB	TBD	TBD	TBD
	DISTICHUS SPICATA	SALT GRASS	PERENNIAL HERB	TBD	TBD	TBD
	FRAGARIA CHILOENSIS	BEACH STRAWBERRY	PERENNIAL HERB	TBD	TBD	TBD

NOTE: PLANT LEGEND IS PRELIMINARY, AND IS SUBJECT TO CHANGE DEPENDING UPON AVAILABILITY OF PLANT MATERIAL.

PLANT LEGEND - ZONE B

SYMBOL	BOTANICAL NAME	COMMON NAME	LIFE FORM	SIZE	ON CENTER SPACING (FEET)	QUANTITY
[Symbol]	ARTEMISIA CALIFORNICA	CALIFORNIA SAGEBRUSH	SUB-SHRUB	TBD	TBD	TBD
	CROTON CALIFORNICUS	CALIFORNIA CROTON	PERENNIAL FORB	TBD	TBD	TBD
	DISTICHUS SPICATA	SALT GRASS	PERENNIAL HERB	TBD	TBD	TBD
	DITHYREA CALIFORNICA	CALIFORNIA SPECTACLEPOD	ANNUAL HERB	TBD	TBD	TBD
	DITHYREA MARITIMA	BEACH SPECTACLEPOD	PERENNIAL FORB	TBD	TBD	TBD
	ERICAMERIA ERICOIDES	CALIFORNIA GOLDENBRUSH	SUB-SHRUB	TBD	TBD	TBD
	ERIOGONUM PARVIFLORUM	COAST BUCKWHEAT	PERENNIAL FORB	TBD	TBD	TBD
	LUPINUS CHAMISSONIS	CHAMISSO BUSH LUPINE	SUB-SHRUB	TBD	TBD	TBD

NOTE: PLANT LEGEND IS PRELIMINARY, AND IS SUBJECT TO CHANGE DEPENDING UPON AVAILABILITY OF PLANT MATERIAL.

3 PLANT LEGEND

DUNE RESTORATION NOTES:

- SEE SHEETS L-1 TO L-3 FOR TYPICAL DUNE RESTORATION SECTIONS AND SHEETS L-5 TO L-7 FOR TYPICAL DUNE HUMMOCK GRADING AND PLANTING PLANS. GRADING AND PLANTING PLANS FOR THE ENTIRE BEACH, INCLUDING ESTIMATED PLANT QUANTITIES, WILL BE DEVELOPED BASED UPON THESE TYPICAL PLANS AS A PART OF THE 100% SUBMITTAL FOR THE PROJECT.
- ALL PROPOSED PLANTING WILL BE IRRIGATED WITH A TEMPORARY IRRIGATION SYSTEM. THE IRRIGATION SYSTEM WILL PROVIDE THE MINIMUM AMOUNT OF WATER REQUIRED TO SUSTAIN GOOD PLANT HEALTH DURING THE PLANT ESTABLISHMENT PERIOD, AND IS EXPECTED TO BE DISCONTINUED APPROXIMATELY 2-3 YEARS AFTER INSTALLATION.
- THE EXISTING ROCK REVETMENT DEPICTED ON THE DUNE PROTOTYPE SECTIONS ON SHEET L-4 IS NOT PRESENT IN ALL LOCATIONS ALONG THE BEACH. SEE ENGINEERING PLANS FOR THE LIMITS OF THE EXISTING ROCK REVETMENT.
- THE DUNE PROTOTYPE SECTIONS ON SHEET L-4 ARE INTENDED TO DEPICT THE APPROXIMATE RELATIONSHIPS BETWEEN THE PROPOSED DUNE HUMMOCKS AND THE EXISTING ROCK REVETMENT, AND THE ACTUAL ELEVATIONS AND EXTENT OF ROCK MAY VARY. AS SHOWN, A 2' MINIMUM BASE LAYER OF SAND WILL BE PLACED OVER THE REVETMENT WHERE IT EXISTS, AND 2-3.3' HIGH DUNE HUMMOCKS WILL BE CREATED OVER THIS BASE LAYER OF SAND.

60% SUBMITTAL

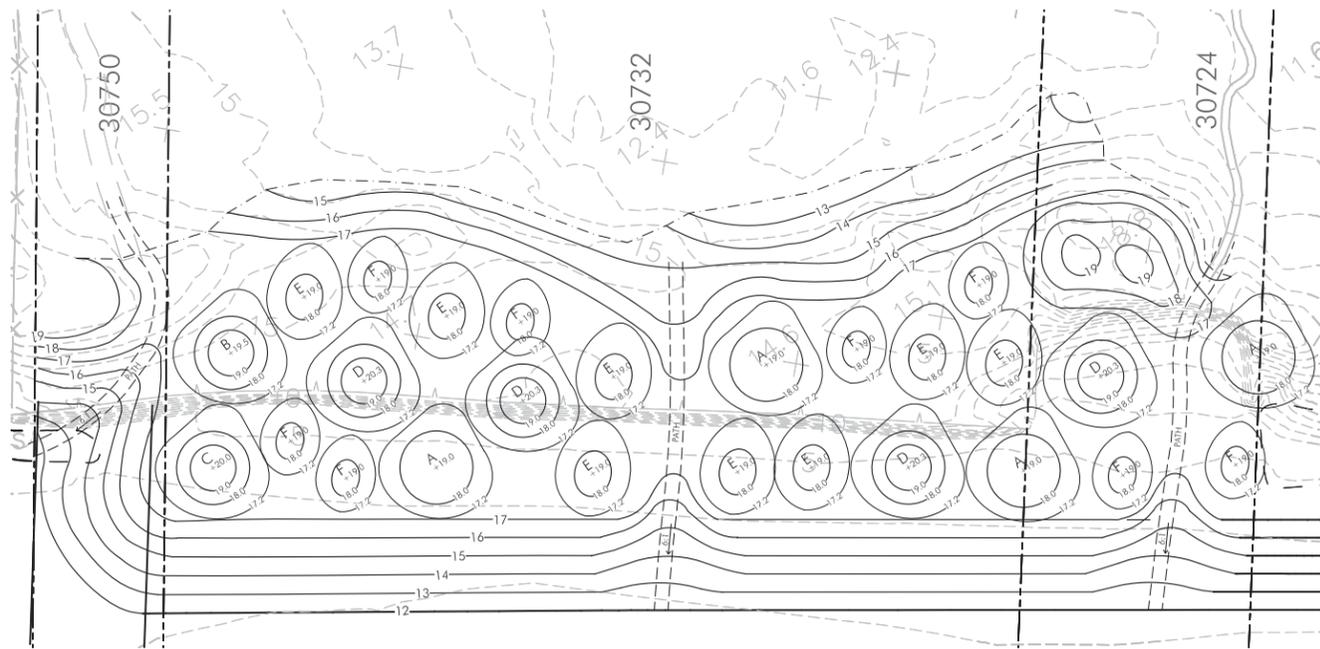
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BROAD BEACH RESTORATION PROJECT California State Lands Commission		SCALE AS SHOWN	DATE 11/7/12
DUNE RESTORATION PLANT LEGEND & DUNE PROTOTYPES		JOB NO. 6935-02	SHEET 27 of 30
		L-4	

FINAL
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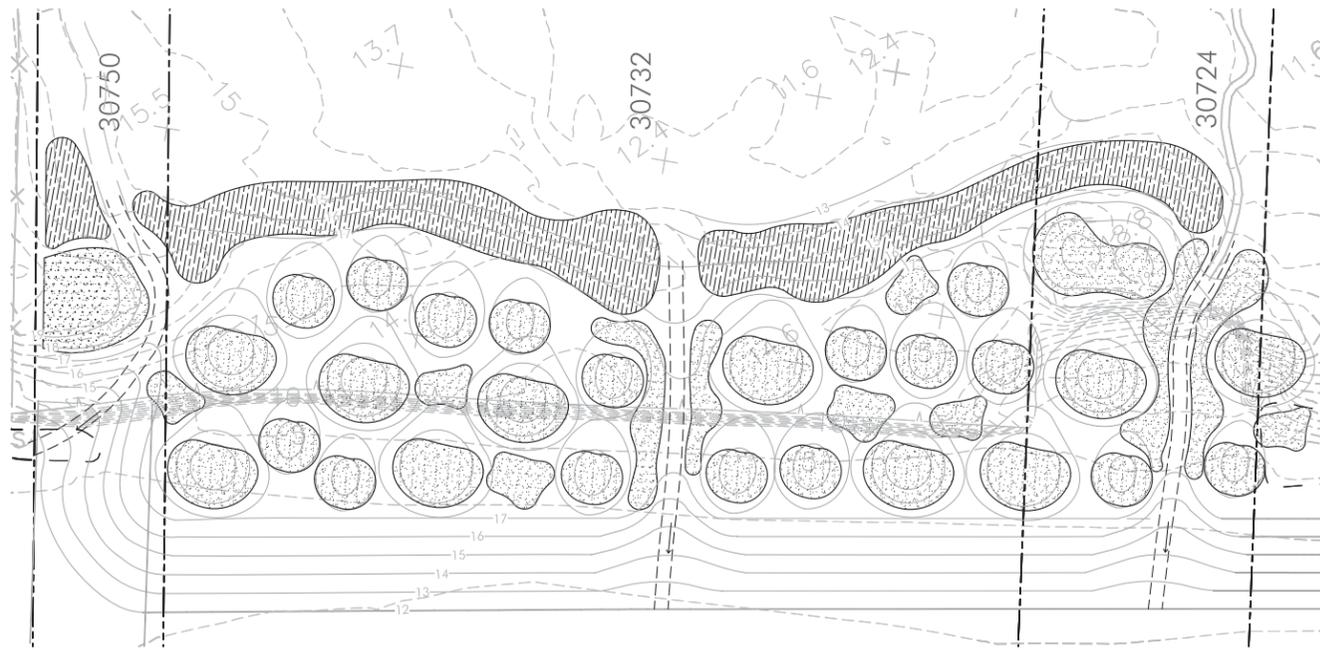
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1 TYPICAL DUNE HUMMOCK GRADING PLAN - GROUP 1



3 TYPICAL DUNE HUMMOCK GRADING PLAN - GROUP 2



2 TYPICAL DUNE HUMMOCK PLANTING PLAN - GROUP 1



4 TYPICAL DUNE HUMMOCK PLANTING PLAN - GROUP 2

GRADING LEGEND

- 17--- EXISTING CONTOUR
- 17.0 X EXISTING SPOT ELEVATION
- 17--- EXISTING REVETMENT
- 17--- PROPOSED CONTOUR
- + 17.0 PROPOSED SPOT ELEVATION
- PROPOSED HOUSE PATH
- PROPERTY LINE
- LIMIT OF GRADING

60% SUBMITTAL

NO.	REVISION	BY	DATE

NOTE: SEE SHEET L-1 TO L-3 FOR TYPICAL DUNE RESTORATION SECTIONS AND SHEET L-4 FOR DUNE RESTORATION KEY MAP AND NOTES, DUNE HUMMOCK PROTOTYPES, AND PLANT LEGENDS.

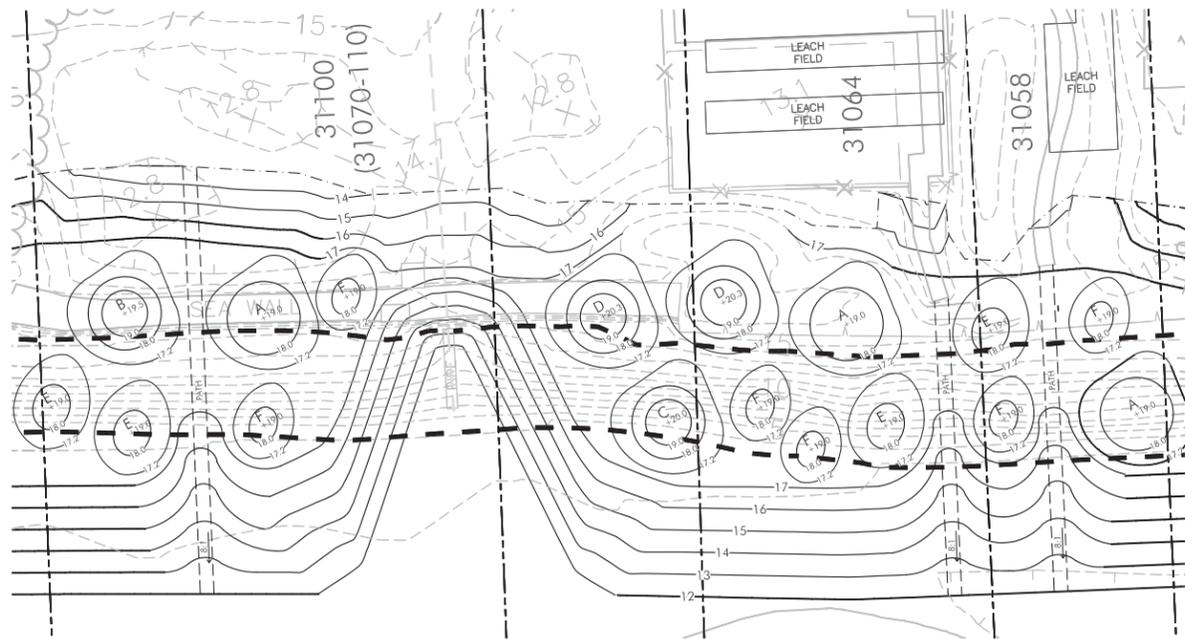
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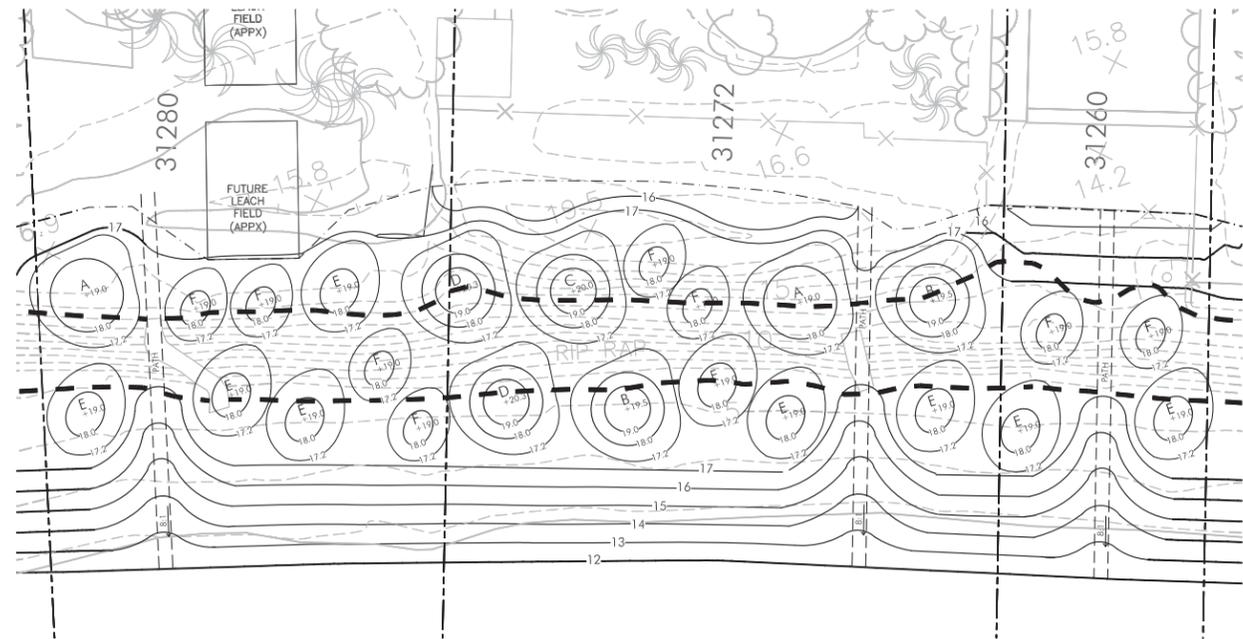
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 DUNE RESTORATION:
 TYPICAL DUNE HUMMOCK GRADING
 & PLANTING PLAN

SCALE 1" = 20'
 DATE 11/7/12
 JOB NO. 6935-02
 SHEET 28 of 30
L-5



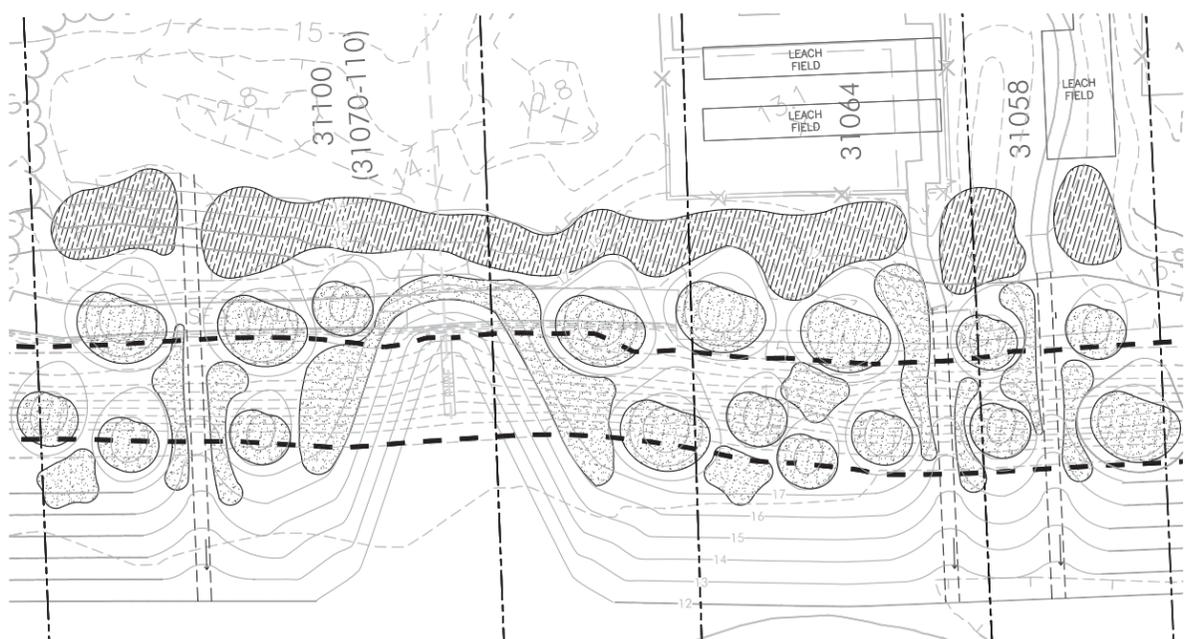
1 TYPICAL DUNE HUMMOCK GRADING PLAN - GROUP 3

SCALE: 1" = 20'



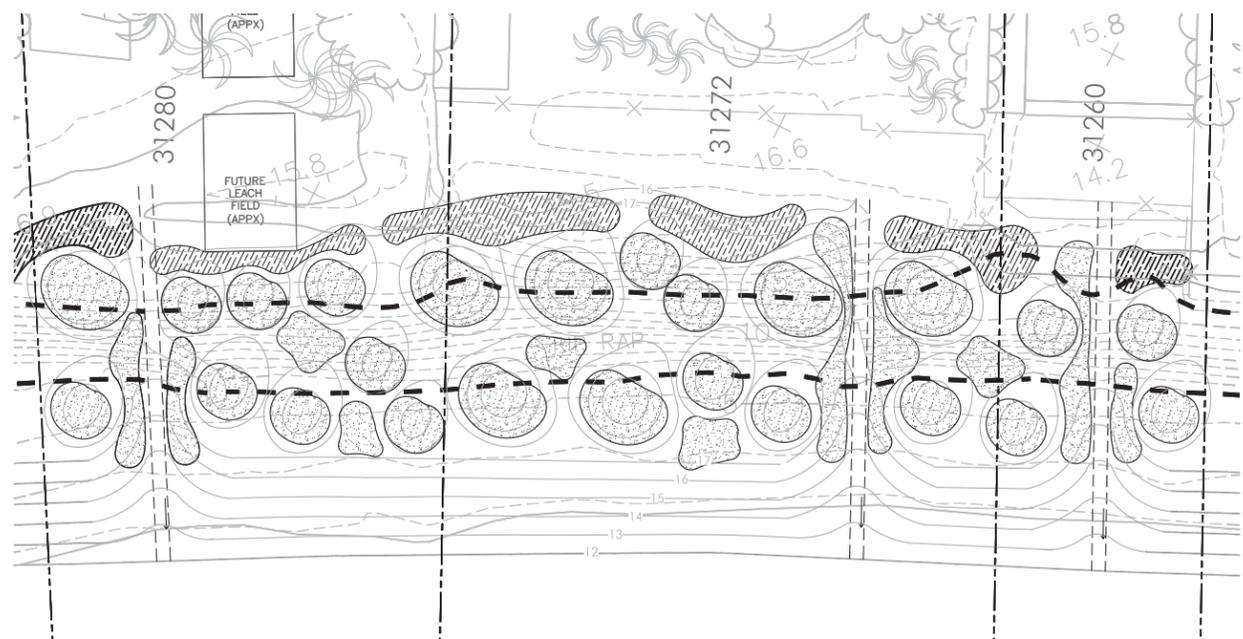
3 TYPICAL DUNE HUMMOCK GRADING PLAN - GROUP 4

SCALE: 1" = 20'



2 TYPICAL DUNE HUMMOCK PLANTING PLAN - GROUP 3

SCALE: 1" = 20'



4 TYPICAL DUNE HUMMOCK PLANTING PLAN - GROUP 4

SCALE: 1" = 20'

GRADING LEGEND

- 17---
- 17.0 X
-
- 17---
- + 17.0
-
-
-

- EXISTING CONTOUR
- EXISTING SPOT ELEVATION
- EXISTING REVETMENT
- PROPOSED CONTOUR
- PROPOSED SPOT ELEVATION
- PROPOSED HOUSE PATH
- PROPERTY LINE
- LIMIT OF GRADING

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NOTE: SEE SHEET L-1 TO L-3 FOR TYPICAL DUNE RESTORATION SECTIONS AND SHEET L-4 FOR DUNE RESTORATION KEY MAP AND NOTES, DUNE HUMMOCK PROTOTYPES, AND PLANT LEGENDS.

BROAD BEACH RESTORATION PROJECT
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**DUNE RESTORATION:
TYPICAL DUNE HUMMOCK GRADING
& PLANTING PLAN**

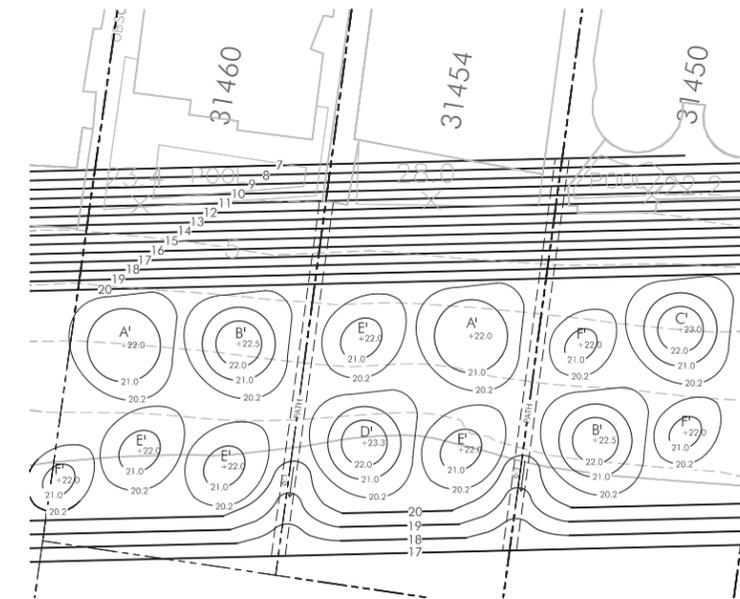
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SHEET	29 of 30
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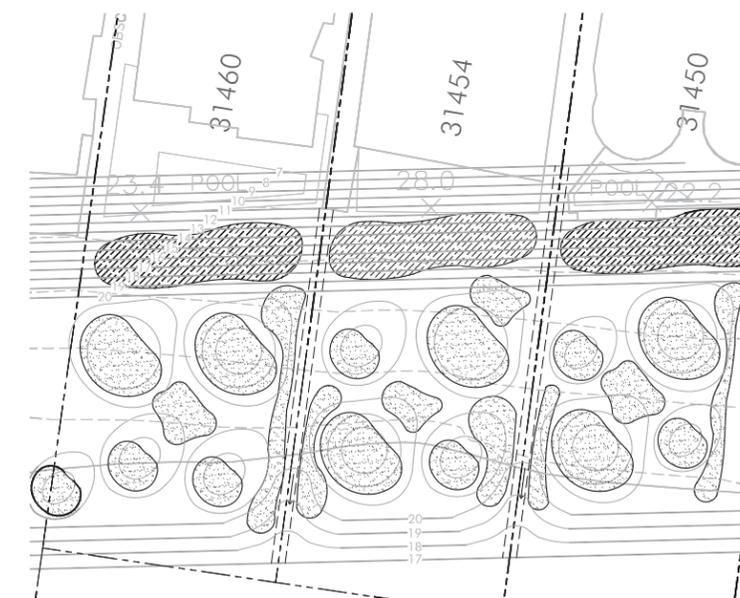
1 TYPICAL DUNE HUMMOCK GRADING PLAN - GROUP 5



3 TYPICAL DUNE HUMMOCK GRADING PLAN - GROUP 6



2 TYPICAL DUNE HUMMOCK PLANTING PLAN - GROUP 5



4 TYPICAL DUNE HUMMOCK PLANTING PLAN - GROUP 6

GRADING LEGEND

- 17--- EXISTING CONTOUR
- 17.0 X EXISTING SPOT ELEVATION
- EXISTING REVETMENT
- 17— PROPOSED CONTOUR
- + 17.0 PROPOSED SPOT ELEVATION
- PROPOSED HOUSE PATH
- PROPERTY LINE
- LIMIT OF GRADING

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**DUNE RESTORATION:
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JOB NO.	6935-02
SHEET	30 of 30
L-7	

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