7.0 Project Constructability

7.1 General

7.1.1 Introduction and Scope

This chapter addresses various constructability issues associated with the "optimized" sand dam with stone column embankment configurations presented in this report. In addition, this chapter outlines assumptions and considerations related to material properties, material sources, and construction methods. These factors are considered in both the context of constructability as well as the basis for the project cost estimates presented in Chapter 8.0 of this report. [Note that this chapter only deals with the sand dam with stone columns for Alternative 1; the other options for the mid-Sea dam other embankments, and other alternatives are not discussed.]

Given the preliminary nature of this evaluation, constructability is described in relatively broad terms. This is necessary since the final project alternative is not known and definitive factors such as project scope, master schedule, and a variety of associated known and unknown project risks have not been defined at this time. Our evaluation has looked at the means and methods that are currently available to build any of the project alternatives in the current marketplace. The Salton Sea restoration project would take many years to plan and permit before construction actually begins. Changes in the construction marketplace as well as new technologies may occur that could impact the constructability of concepts discussed in this chapter.

7.1.2 Project Alternatives

Five overall project alternatives are under consideration for restoration of the Sea as described in Chapter 3.0. The design aspects of each of the "optimized" embankment configurations required for these alternatives are described in Chapters 4.0 and 5.0.

7.2 Embankment Materials

7.2.1 Dredging

The dredged materials consist of a heterogeneous mixture of earth materials found on the floor of the Sea. These materials consist of semi-liquid seafloor deposits, soft fine-grained lacustrine soils and coarse-grained alluvial soils. The sea floor and soft lacustrine deposits would be removed from the foundation zones of the various embankments prior to placing the embankment materials. These materials are expected to be removed using barge-mounted, suction dredges.

These materials would be pumped as slurry to areas well outside of the embankment limits and discharged at the sea floor.

7.2.2 Type A Sand/Gravel

Type A sand/gravel would be used to build the interior zones within all of the project alternatives with the exception of the habitat pond embankments. Type A sand/gravel would be developed from alluvial borrow sources and screened to create a 3/4 –inch minus material. Fines contents would be limited to less than 10% passing the No. 200 screen. If required, these materials would be suitable for densification using stone column construction techniques.

7.2.3 Type B Sand/Gravel

Type B sand/gravel would be used in the outer shell zones of the various embankment dam elements. Type B soils would be developed concurrently with the screening operations for the Type A sand/gravel. This material would not be as tightly controlled as the Type A sand/gravel with gravels and cobbles allowed up to 1 foot in maximum dimension, or perhaps more. Fines content requirements would also be relaxed relative to the Type A sand/gravel. (Some Type B material would be used as blanket drain material, which would require a low fines content.)

7.2.4 Filter and Drain Materials

Filter and drain materials would be developed for drainage blankets and internal drainage features in the various alternatives. The gradations of these materials would be controlled to meet filter compatibility standards consistent with sound embankment design criteria. Both fine and coarse filter and drain gradations would likely be needed for the project. These materials would be produced concurrent with the Type A sand/gravel and Type B sand/gravel materials described above.

7.2.5 Riprap

Large riprap rock would be required to provide protection against of the high waves that occur on the Sea. The riprap material has been tentatively sized to consist of hard angular rock ranging from one to four feet in diameter. The riprap would be quarried from either a new source near the west shore (the Coolidge Mountain site) or salvaged from the waste rock stockpiles or a new quarry at the Eagle Mountain Mine site.

7.2.6 Stone Columns

The Type A sand/gravel material would be densified to improve its insitu strength characteristics using stone column or vibrodensification techniques. Stone columns would be placed within the Type A sand/gravel on a 10-foot triangular grid spacing and would average about 3 feet in diameter. The replacement stone within the columns would be produced concurrent with the Type A, Type B, and filter/drain material screening operations. The replacement gravel would range from ¾ to 1½ inch in diameter.

7.2.7 Soil-Cement-Bentonite Slurry Wall

The soil-cement-bentonite (SCB) slurry wall would be constructed to cut off seepage through the permeable Type A sand/gravel within the interior zones of the various embankments. The SCB slurry walls would extend fully through the embankment height, and penetrate through the underlying foundation upper alluvial and/or soft lacustrine deposits and into the underlying upper stiff lacustrine deposit. The upper stiff lacustrine deposit embedment would vary from 35 feet for the perimeter dikes, concentric lakes dikes, and south-Sea dam to 40 feet for the north-Sea and mid-Sea dam options. The total depths would vary but could conceivably extend up to 120 feet from crest to bottom. As added protection against seepage through imperfections in the SCB slurry wall, an HDPE membrane could be inserted into the SCB wall as well. However, at this time a specialty contractor who has inserted the membranes to the depths contemplated for the Salton Sea restoration project has not been located. New techniques or procedures would have to be developed to insert a membrane properly into the SCB slurry wall. Vinyl sheet piles may also be an alternative to the HDPE membrane. The slurry itself is contemplated to have a 7% bentonite and 2% cement content. The Type A sand/gravel would be used as the aggregate mass for the SCB wall. Construction of an SCB slurry wall in saline conditions would require special precautions to reduce flocculation of the bentonite and cement within the slurry and associated potential for adverse settlement of the flocculated materials and collapse of the upper portions of the slurry wall excavation.

7.2.8 Wick Drains

Wick Drains would be used to accelerate consolidation of the soft lacustrine deposits that would be left in place below select locations of the various embankment options. The wick drains would be installed from barges after dredging of the Seafloor Deposits and prior to dumping of the Type A or B sand/gravel. Wick drain depths would vary. Wick drains are expected to average 25 feet in depth and be placed on a 5-foot by 5-foot square grid pattern.

7.2.9 Habitat Pond Embankments

Shallow habitat ponds are planned for all of the restoration alternatives with the exception of the concentric lakes dikes. The size of these features varies from 12,000 to over 42,000 acres. As opposed to the various embankment options such as the mid-Sea dam, south-Sea dam, north-Sea dam, mid-Sea barrier, perimeter dikes, and concentric lakes dikes, the habitat pond embankments would be built entirely “in the dry” using earth materials salvaged from the dried seafloor as the Sea retreats. The embankment heights would range from 6 to 9 feet. Soft materials would be over excavated from beneath the embankments, aerated to reduce moisture contents to manageable levels in order to achieve compaction, and replaced as compacted earthfill. A geogrid or geotextile would be placed on the bottom of the over excavation area to reduce pumping and improve equipment mobility. The over excavation depth is estimated to be about 10 feet. The pond embankments would incorporate a horizontal drainage blanket to prevent uncontrolled seepage from exiting the downstream embankment face and improve the stability of the embankments.

7.3 Material Sources

The results of the Task 3 materials evaluation (see Appendix 2A) identified three possible sources for embankment materials. These sources include the Coolidge Mountain /Aggregate Products (API) site on the west shore, the Eagle Mountain mine site located well north of the project, and relatively small borrow sites located along the east shore near the Bombay Beach area. The Bombay Beach sites are relatively thin and after further evaluation, have been eliminated from consideration as a possible source for large scale aggregate and riprap production. The two remaining sources are described in detail below.

7.3.1 Coolidge Mountain / API Pits

The Coolidge Mountain / API site is located within the Torres Martinez Indian Reservation. API operates a sand and gravel pit and screening operation just west of Highway 86 near the northwest shore of the Sea. The API pit produces a variety of aggregate products including washed and natural sands, gravels for asphalt concrete and Portland cement concrete, and similar rock products. The source is a natural sand and gravel deposit within a broad alluvial fan. The existing pit is about 140 feet deep with indications that the alluvial materials continue to considerably greater depths. The surrounding topography infers that the alluvial deposits continue in all directions over a large area. This site seems promising for production of all of the embankment materials with the exception of riprap.

West and upslope of the existing API pit, Coolidge Mountain rises above the alluvial fan. Much of this area is also located within the Torres Martinez Indian Reservation. Geology within this area appears to be more complex than previously known when Task 3 evaluations were completed (see Appendix 2A). Outcrops of hard granites, siliceous limestones, and perhaps metasedimentary rocks exist in this area. These materials could be used to quarry the riprap for the project. Tight joint spacing could affect the “yield” for 4-foot minus riprap from the quarry. This constraint should be evaluated to assess whether the tight jointing will limit production of the larger riprap sizes.

7.3.2 Eagle Mountain / Kaiser Ventures

The Eagle Mountain mine site is located well northeast of the Sea beyond Interstate 10. The Eagle Mountain site is owned by Kaiser Ventures, which manages this former iron mine and mill site. The materials available at the Eagle Mountain site are vast and diverse. Processed materials such as sands and gravels are available within mill tailing waste dumps. In addition, large angular rock derived from granites, monzonites and iron ore have been deposited in huge waste rock stockpiles. The existing tailings and waste rock have been estimated by Kaiser Ventures to be up to 800 million tons.

The Eagle Mountain site was once served by a rail line that extends from the mine itself to a tie-in to the Union Pacific Railroad at the northeast margin of the Sea. The existing rail line has been destroyed by flash flooding and would need to be rebuilt prior to shipping materials out of the Eagle Mountain site. This single-track line is estimated to be about 52 miles long. Kaiser Ventures estimates that the line can be placed back into service for approximately $6 million. The restored line has considerable capacity constraints given its curvature, grade, and single-track nature. Kaiser Ventures believes the line can be restored to transport about 5,000,000 tons of rock per year. This production rate is very small in comparison to the volume of materials contemplated for the various project alternatives. More information on the Eagle Mountain mine site can be found in Appendix 2A.

7.4 Construction Materials and Methods

7.4.1 Quarry Stone

The most promising source for quarry stone appears to be the Coolidge Mountain area at the northwest margin of the Sea. This site appears to be sufficient to produce all of the riprap needs for the project without using the Eagle Mountain mine site as a secondary source. Riprap would be produced within a hard rock quarry operation. Extensive drilling and blasting would be required to produce the riprap. Because the riprap size is closely controlled in the 1-foot to 4-foot range, the yield from the quarry would be impacted by the presence of particles less than one foot in diameter. In simple terms, the undersized fragments would need to be separated from the riprap production stream. The undersized material would be generated by the same drilling and blasting that creates the riprap. However, there is no direct alternative use for this material within the project and it would have to be stockpiled or “wasted” from the riprap production line. Crushing the sub-one-foot particles to create Type B materials or stone for the stone columns may be economical and should be evaluated as part of future materials evaluations. For planning level cost estimating analyses, it was assumed that the Coolidge Mountain quarry site would operate at 50% yield. In other words, two cubic yards of material would need to be blasted and screened to create each cubic yard of suitable riprap.

7.4.2 Alluvial Soil Sources

As described above, the API site and its surrounding deposits appear to represent a promising source for all of the embankment materials (except for rockfill and riprap) for the various project alternatives. There appear to be abundant deposits for Type A, Type B, Stone, and filter rock materials. The source is near the northwest shore of the Sea and in close proximity to Highway 86. This would facilitate economical hauling by trucks and transport by barge for at least the closest portions of the work. The close proximity to Highway 86 also provides opportunity for extensive hauling by truck. Transportation for elements that are significant distances from this location would have significantly higher transportation costs. These higher transportation costs have been considered in these planning level cost estimates.

7.4.3 Screening and Crushing

It appears possible for all of the embankment materials to be mined, crushed, screened, and distributed from a single integrated plant at or near the existing API site. It may also be possible to create a portion of the processing operations at the API site and others at a location adjacent to or at a beach location. Multiple product lines can be used to create Type A, Type B, filter rock, and stone column infill materials. Quality control data provided by API indicates that the source would not require extensive washing to reduce fines content. Depending on the option selected, there appears to be sufficient area to support embankment material production.

7.4.4 Sorting

Embankment materials could be distributed from the API site using conveyors, trucks, or a combination of these methods. The material handling and processing site(s) would need to be developed to allow suitable stockpile of Type A, Type B, filter rock, and stone column infill material necessary to meet project schedule, maintenance, and contingency requirements. Multiple conveyors would likely be needed within the production plant area to move the processed materials from stockpiles to either trucks for land deployment or to barges for over-water conveyance. The sorting operations would have to be sequenced so the different materials could be delivered using the same mainline conveyor to the shore or trucks as needed.

7.4.5 Waste Materials

As discussed above, the rock quarry operations for riprap production may create a relatively large volume of material that cannot be economically used, and consequently would have to be wasted. It is likely that the API alluvial pit operations could be managed so that unsuitable materials could be kept to a minimum. A materials production evaluation should be performed to determine the most economical and effective systems for the large amounts of materials that would be required.

7.4.6 Transport and Placement

Using the Coolidge Mountain / API site for the embankment materials provides opportunities for transport using both over-water and over land methods. The Torres Martinez Indian Reservation extends eastward out into the Sea itself. This allows for creation of barge load-out facilities contiguous to the quarry and pit production facilities. Highway 86 bisects this area. A conveyor system could be used to load barges. The conveyor would be threaded through an elevated CMP casing over the highway so that any materials dislodged from the belts would not impact the traffic. The conveyor would be used to move all of the Type A, Type B, and filter rock that would be placed over-water. Riprap cannot be moved by conveyor but must be transported by truck. A temporary traffic bridge over Highway 86 would likely be required to minimize traffic conflicts between construction traffic and the traveling public.

Most of the embankments needed for the various project alternatives call for the creation of a broad crest width to allow for densification of the Type A sand/gravel using stone columns. The broad crest width provides the opportunity to use overland trucks to transport and place the embankment materials. It is possible that up to two-thirds of embankment materials could be placed by overland material handling methods and one-third could be placed over-water using barges. The over-water placement would be needed on the outer edges of the embankments, which cannot be reasonably reached from the edge of the broad crest areas. Temporary causeways would be required to provide access for trucks for construction of the mid-Sea dam, the south-Sea dam, the north-Sea dam, and perimeter dike features. Causeways would vary from 4,000 to 7,000 feet long and would be built out from shore using end dump techniques. Though relatively long, the shallow water depths inhibit the use of barges for constructing the temporary causeways.

As described above, all of the dam alternatives would rely heavily on overland hauling of embankment materials. However, it is possible that substantial portions if not the entire mid-Sea barrier would be built with over-water techniques allowing the barrier to emerge and become effective as the water level drops.

7.4.7 Dredging

Dredging would be performed for removal of the Seafloor deposits from the entire embankment footprint. Dredging would be done with barge-mounted suction dredges and the slurried waste material would be pumped by flexible pipeline several miles to a designated Sea-bottom discharge location within the Sea. It may be necessary for barges to place a berm of Type B sand/gravel at the outer toe of the dredged zone to prevent migration of the soft deposits back into the embankment footprint.

After removal of the seafloor deposits, a second pass of dredging would remove the soft lacustrine deposits from the central core area of the various alternative embankments. The slurried materials removed from the foundation area would be similarly discharged outside of the project area.

7.4.8 Foundation Treatment

Depending on the project alternatives, unsuitable foundation materials would be treated by either removal by dredging or by accelerated consolidation using wick drains. Wick drain installation would also be performed using a barge mounted mandrel system.

7.4.9 Foundation Excavation

All foundation treatment and dredging for the major embankment alternatives would be performed over-water. However, construction of the habitat pond embankments is expected to be performed “in the dry” as the current Sea shrinks in the future. The habitat pond embankment foundations would be overexcavated using track-mounted excavators. The materials removed would then be spread and aerated using low ground pressure equipment prior to replacement into the overexcavated foundation area.

7.4.10 Stone Columns

Stone columns would be used to densify the Type A sand/gravel used to construct the various embankments. The crest widths would be overbuilt to allow for overland access to equipment used for the densification process. Stone infill for the stone columns would also be delivered overland as well. Stone column densification would occur once the final embankment prism is in place including all of the Type A and Type B materials. Placement of the Type B material is needed to provide lateral containment of the Type A sand/gravel during the densification process.

7.4.11 Soil-Cement-Bentonite Slurry Walls

The soil-cement-bentonite (SCB) slurry walls would be constructed from the embankment crest following installation of the stone columns. The SCB slurry walls would extend up to 120 feet deep and would have a nominal width of 5 feet. The potential benefits of an HDPE membrane inserted into the SCB wall to serve as a redundant seepage protection against “windows” or other potential defects were evaluated during the risk analysis. The benefits appear to be significant but HDPE membranes have not been installed to this depth. Some technology innovations would be required to derive the potential benefits of the membrane.

7.5 Schedule and Project Duration

A master schedule has not been developed for any of the restoration alternatives under evaluation. Project schedules have been discussed only in very broad terms. Cost estimates have been developed using year 2006 cost data. Further, it has been assumed that each of the project alternatives would be bid and constructed as a single continuous project. Project costs are a function of time and market conditions. A master schedule should be developed for each of the project alternatives so that future cost values can be better estimated.

7.6 Contracting Methods and Packaging

Many opportunities exist for using alternative contracting methods and packages to optimize the constructability of the various embankment alternatives. The project definition currently available does not provide a basis to identify which options should be considered. The very large size of the project would severely limit the number of potential contractors given the large bonding requirements as well as physical resources necessary to complete the work. Developing a contract packaging strategy early would be a key to accessing as large a contracting pool as possible.

7.7 Project Risks

There are many risks to the completion of construction of the various alternatives. These risks are both physical and economic/contractual. Examples of physical risks included the need to protect workers from the hydrogen sulfide releases that can occur as the Sea turns in the spring and heavy sea conditions that develop during high wind events. Examples of contractual/economic risks include such items as escalation of fuel prices, labor disputes, and bonding capacity.