1.0 Introduction

The Salton Sea Study and Evaluation of Alternatives for Restoration of the Salton Sea is being undertaken by the U.S. Bureau of Reclamation (Reclamation). This report and the supporting technical appendices document the technical, risk and cost evaluations completed by Kleinfelder Inc. (Kleinfelder) as part of this study.

1.1 Study Location

The Salton Sea (Sea) is the largest inland body of water in California. It is in the southeastern corner of California and spans Riverside and Imperial Counties as shown on Figure 1.1. The closest cities include Palm Springs, Indio, Brawley, and El Centro and the general area is primarily an agricultural community with some opportunities for recreation. A few residential communities dot the shoreline.

The Sea is a terminal hypersaline lake that occupies a below-Sea-level desert basin known as the Salton Trough, a topographic low that extends from the Gulf of California northwest into southern California. The Salton Trough (also referred to as the Salton Sink) has experienced multiple episodes of flooding and drying due to changes in the course of the Colorado River since prehistoric times. The Sea occupies two local depressions of the main trough, called the northern basin and the southern basin.

Currently, the existing Sea is maintained by agricultural runoff/drainage, municipal effluent and storm water runoff that flow into the Sea through rivers and creeks in the Imperial, Coachella, and Mexicali Valleys. The current salinity of the Sea is around 48,000 mg/L. The estimated current annual inflow to the Sea is approximately 1.3 million-acre-feet. This amount of inflow is expected to decrease in the future due to conservation efforts and implementation of the Quantification Settlement Agreement (QSA).

The northern portion of the study area is drained by the Whitewater River and its tributaries within the Coachella Valley. Salt Creek drains the southern slope of the Orocopia Mountains and the northern end of the Chocolate Mountains. It enters the northeast portion of the Sea within the Salton Sea State Park boundaries. The most significant drainage from the west is San Felipe Creek. The New and Alamo Rivers drain the Imperial Valley and to a lesser extent, the Mexicali Valley to the south. These two rivers account for most of the flow into the Sea. The principal geographic and geologic features in the area surrounding the Sea are shown on Figures 1.2 and 1.3.

The Salton Trough is located in a highly active tectonic region with frequent earthquakes. Tectonically, the vicinity is dominated by the San Andreas, Imperial, San Jacinto and Elsinore fault systems. Many moderate to large earthquakes have occurred on faults in the Salton Trough vicinity.

1.2 Study Purpose and Objectives

Public Law 108-361, titled the Water Supply Reliability and Environmental Improvement Act, includes a requirement that:

> "Not later than December 31, 2006, the Secretary of the Interior, in coordination with the State of California and the Salton Sea Authority, shall complete a feasibility study on a preferred alternative for Salton Sea restoration."

The overall objectives for the Salton Sea Study generally follow the 1998 Salton Sea Reclamation Act (P.L. 105-372):

- ✓ Permit the continued use of the Salton Sea as a reservoir for irrigation drainage
- ✓ Reduce and stabilize the overall salinity of the Salton Sea
- ✓ Stabilize the surface elevation of the Salton Sea
- ✓ Reclaim, in the long term, healthy fish and wildlife resources and their habitats
- ✓ Enhance the potential for recreational uses and economic development of the Salton Sea
- ✓ Minimize exposed areas subject to potential air quality problems

The last objective listed above was not included in the Salton Sea Restoration Act. It was added by Reclamation because of its importance to restoration.

With the above purposes in mind, these studies have been undertaken to achieve the following objectives:

- ✓ Optimize and analyze the designs of the embankment(s) to provide adequate static (including seepage) and seismic stability based on technical reliability, constructability and comparative costs
- ✓ After Reclamation conducts a decision-making process to identify its preferred alternatives, further optimize the embankment structure designs and perform deformation analyses on those embankment structures
- ✓ Perform a risk analysis and prepare construction cost estimates for the preferred engineering solutions to these alternatives

- ✓ Provide general technical support to Reclamation in the development of technical presentations and reports associated with the Salton Sea Restoration Study

Each of the overall alternatives under consideration by Reclamation includes a variety of support infrastructure in addition to the embankments that are the subject of the evaluations summarized in this report. Information on the other infrastructure is provided in Volume I documentation being prepared by Reclamation.

1.3 Scope of Work

The work summarized in this report was performed under sixteen primary work tasks as outlined below.

Task 1 – Review of government furnished data and kick-off information sharing meeting

Task 2 - Evaluation of the current geotechnical investigation program

Task 3 - Evaluation of embankment construction material sources

Task 4 – Stability and seepage analyses of design options for a mid-Sea dam and perimeter dike

Task 5 - Stability and seepage analyses of design options for a mid-Sea barrier and habitat pond embankments

Task 6 - Presentation and draft report of results of tasks 2 through 5

Task 7 - Optimization of the design cross-sections of the mid-Sea dam and perimeter dikes

Task 8 - Two-dimensional FLAC (Fast Lagragian Analysis of Continua) deformation analyses of the optimized mid-Sea dam and perimeter dike cross-sections

Task 9 - Optimization of the design cross-sections of the mid-Sea barrier and habitat pond embankments

Task 10 - Optimization of the design cross-section of the concentric lakes dikes

Task 11 - Optimization of the design cross-section of the north-Sea dam

Task 12 - Presentation and draft report of the results of tasks 7 through 11

Task 13 - Risk Analysis

Task 14 - Cost Estimate

Task 15 - Prepare and present the final draft report for the project

Task 16 - Revise the final draft report

In addition, during the course of these studies, additional meetings, coordination, and design activities were performed at Reclamation's request.

It should be noted that this planning level study has developed embankment configurations and cost estimates beyond what was accomplished in the 2005 appraisal level studies. However, because of the limited amount of subsurface exploration work that has been completed to date, the concepts and cost estimates are not yet at a funding level of detail. Funding level concept and cost estimate updates should be prepared when sufficient supplemental explorations are completed for this purpose. The concepts and cost estimates could change dramatically if additional exploration information indicates significant differences from the baseline assumptions that have been made.

1.4 Authorization

The scope of work outlined above was performed based on authorization by Reclamation under Order No. 04B8810942 of Contract No. 04CA810942, dated April 21, 2006 between the Bureau of Reclamation and Samuel Engineering, Inc. of Englewood, Colorado. Kleinfelder has performed the work summarized in this report under subcontract agreement with Samuel Engineering.

1.5 Project Personnel

The following personnel from Kleinfelder performed the work described in this report:

Project Manager: Keith A. Ferguson, P.E.

Seepage and Stability Analysis and Report Preparation:
Scott Shewbridge, PhD, P.E.
Elena Sossenkina, E.I.T.
Jie Yu, P.E.
Mark Furman, P.E.
Jorge Meneses, PhD, P.E.

Deformation Analyses and Report Preparation:
Zia Zafir, PhD, P.E.
Scott Anderson
Endi Zhai, PhD, P.E.
Jorge Meneses, PhD, P.E.

Risk Analysis and Report Preparation:
Scott Shewbridge, PhD, P.E.
Elena Sossenkina, E.I.T.
Keith A. Ferguson, P.E.

Constructability and Cost Estimating and Report Preparation:
Chris Spandau, P.E.
Mike Pauletto
Phil Mortensen
Jie Yu, P.E.
Rebecca Allen, E.I.T.

Richard Wiltshire and Paul Weghorst of Reclamation directed, coordinated and reviewed the work for this project. Perry Hensley and Robert Dewey provided technical support and input and Karl Dise facilitated the risk analysis. The input from, and support of Reclamation is gratefully acknowledged.