Restoration of the Salton Sea

Volume 2: Embankment Designs and Optimization Study

Figures

Prepared for:
U.S. Department of the Interior
Bureau of Reclamation
Lower Colorado Region
Boulder City, Nevada

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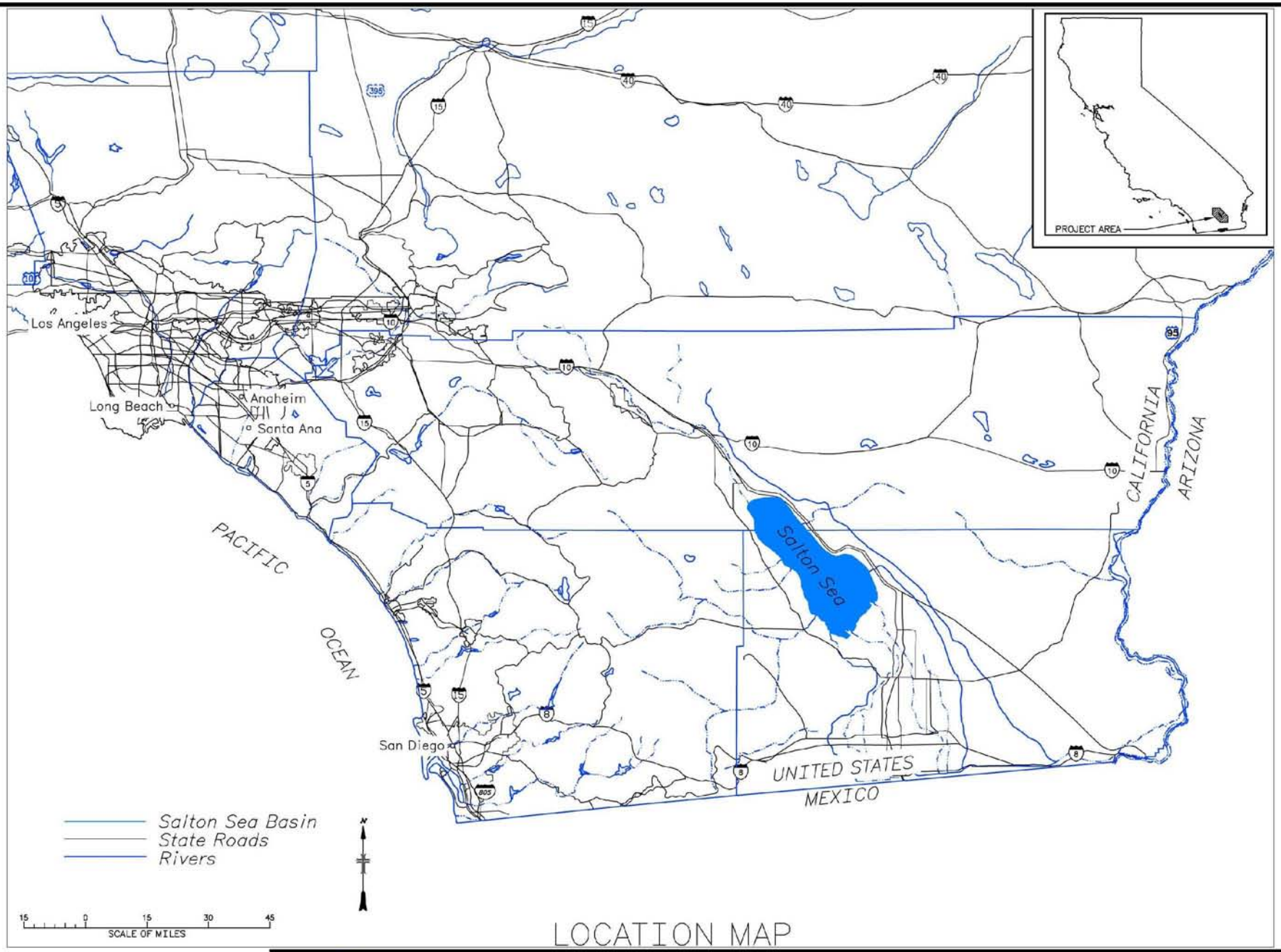
Project No. 71100

May 2007



LOCATION MAP

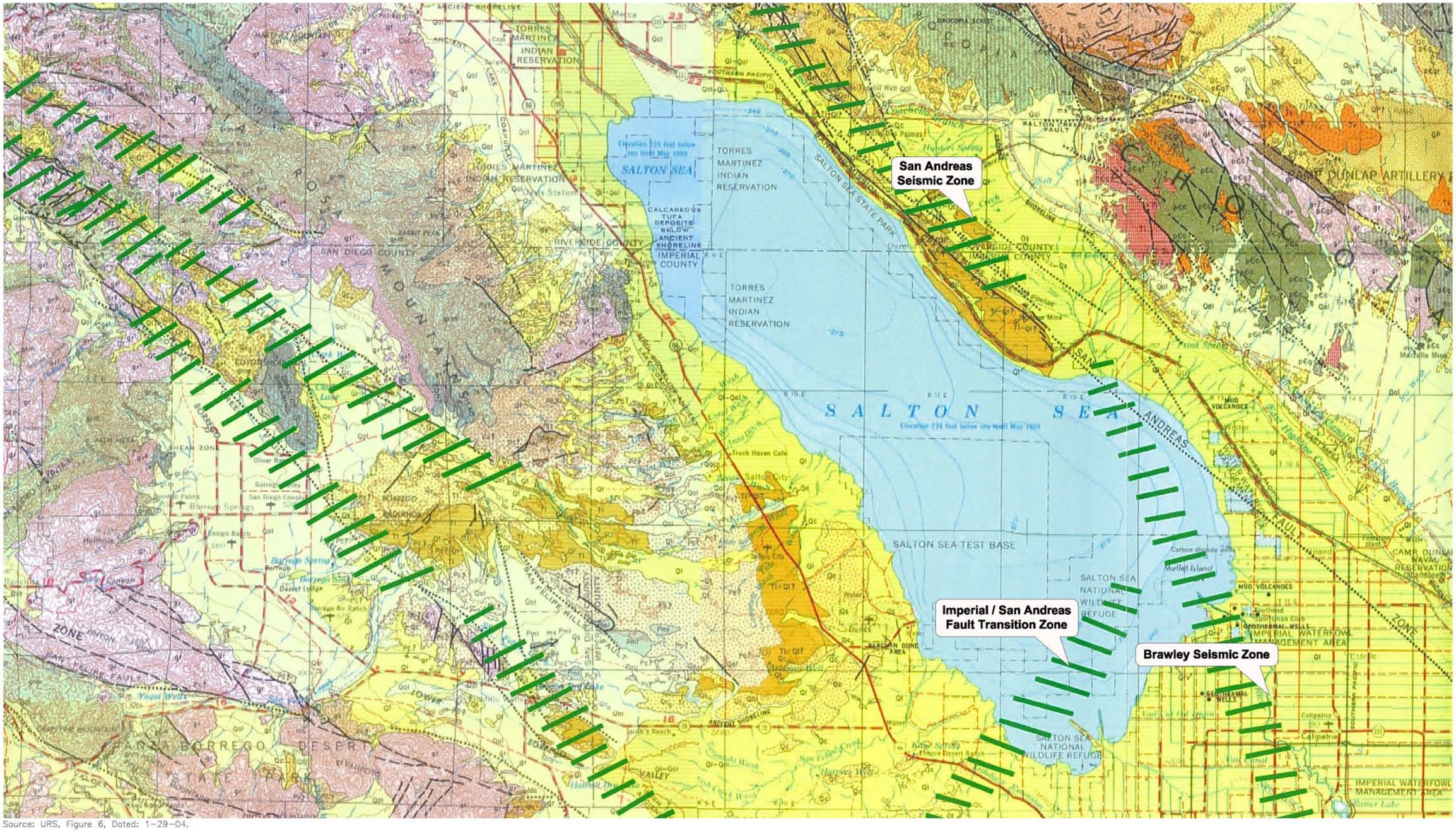
United States Department of the Interior
Bureau of Reclamation

KLEINFELDER

SALTON SEA RESTORATION PROJECT
Embankment Designs and Optimization Study

PROJECT LOCATION MAP

Project: 71100	By: KAF/CL	Date: August 2006	**FIGURE 1.1**



Source: URS, Figure 6, Dated: 1-29-04.

0 3 6 12 18

SCALE IN MILES

United States Department of the Interior
Bureau of Reclamation

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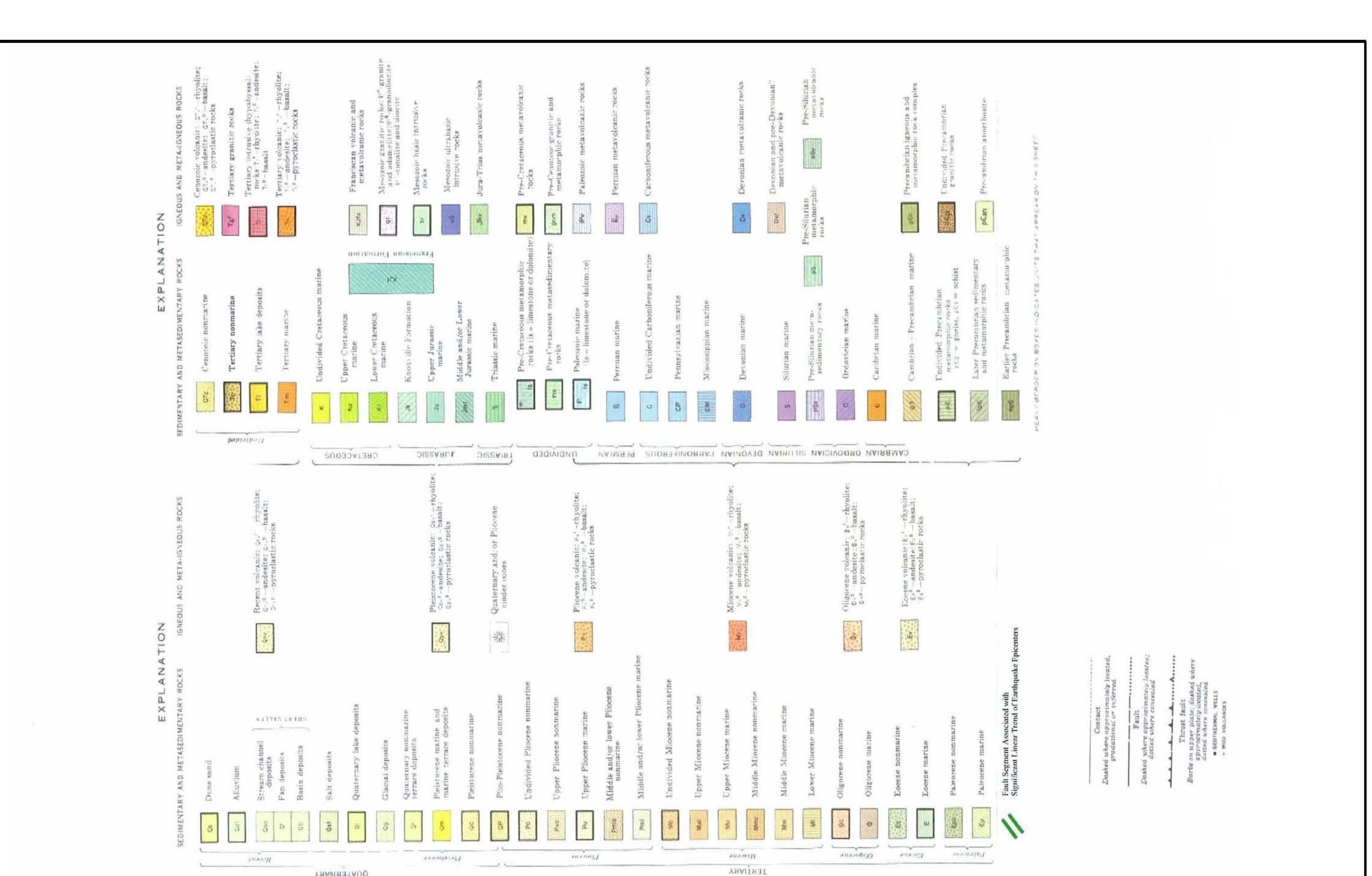
SALTON SEA RESTORATION PROJECT
Embankment Alternatives Optimization Study

Principal Geologic Features Surrounding the Salton Sea

Project: 71100	By: KAF/CL	Date: August 2006

FIGURE 1.2



Source: URS, Figure 7, Dated: 1-29-04.

United States Department of the Interior
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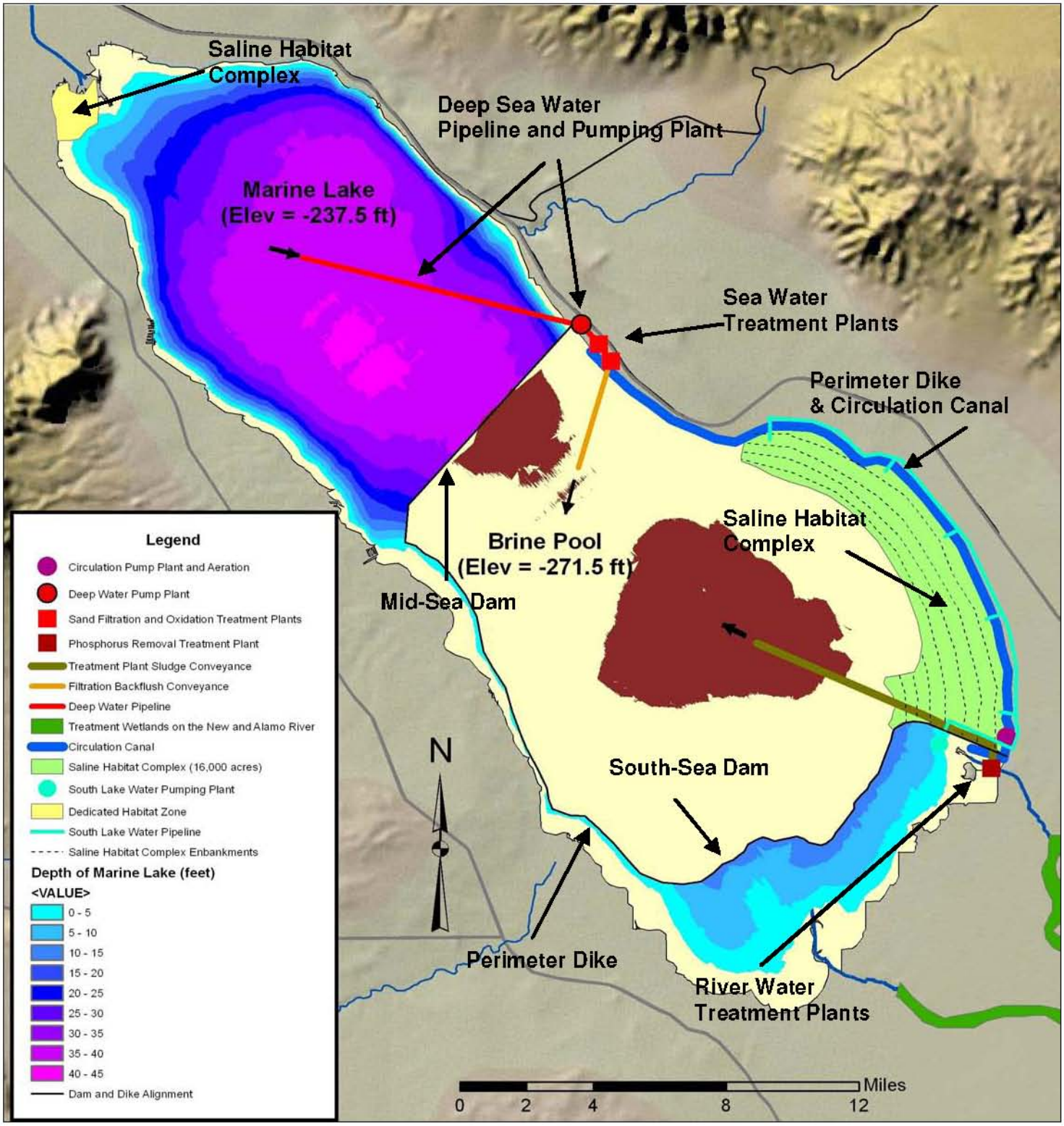
SALTON SEA RESTORATION PROJECT
Embankment Designs and Optimization Study

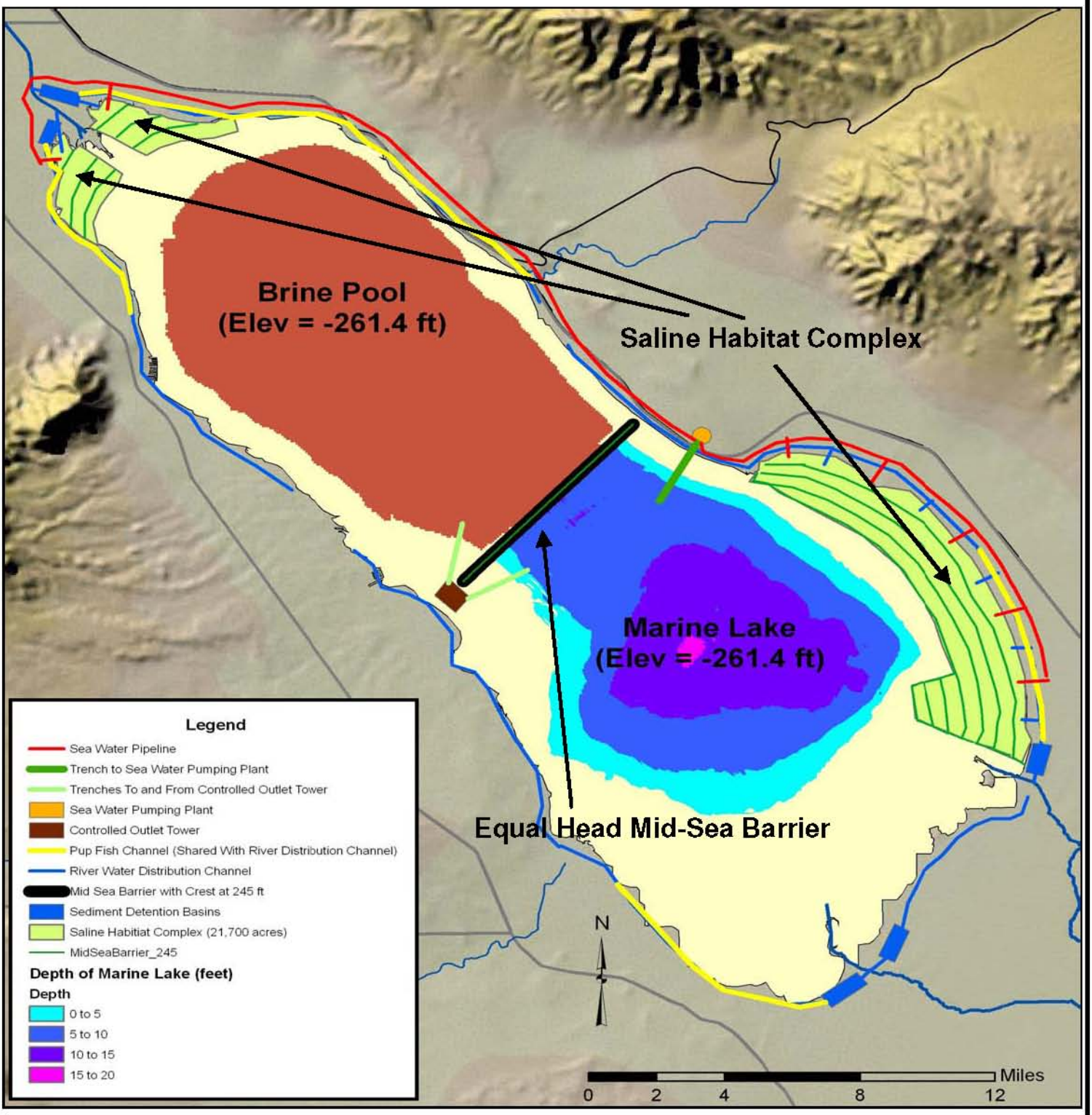
Geologic Features Legend

Project: 71100	By: KAF/CL	Date: August 2006

FIGURE 1.3



United States Department of the Interior Bureau of Reclamation	**SALTON SEA RESTORATION PROJECT** Embankment Designs and Optimization Study	**Alternative No. 1** Mid-Sea-Dam / North Marine Lake (Salton Sea Authority Alternative)
KLEINFELDER	Project: 71100 | By: KAF/CL | Date: April 2007	**FIGURE 3.1**



United States Department of the Interior
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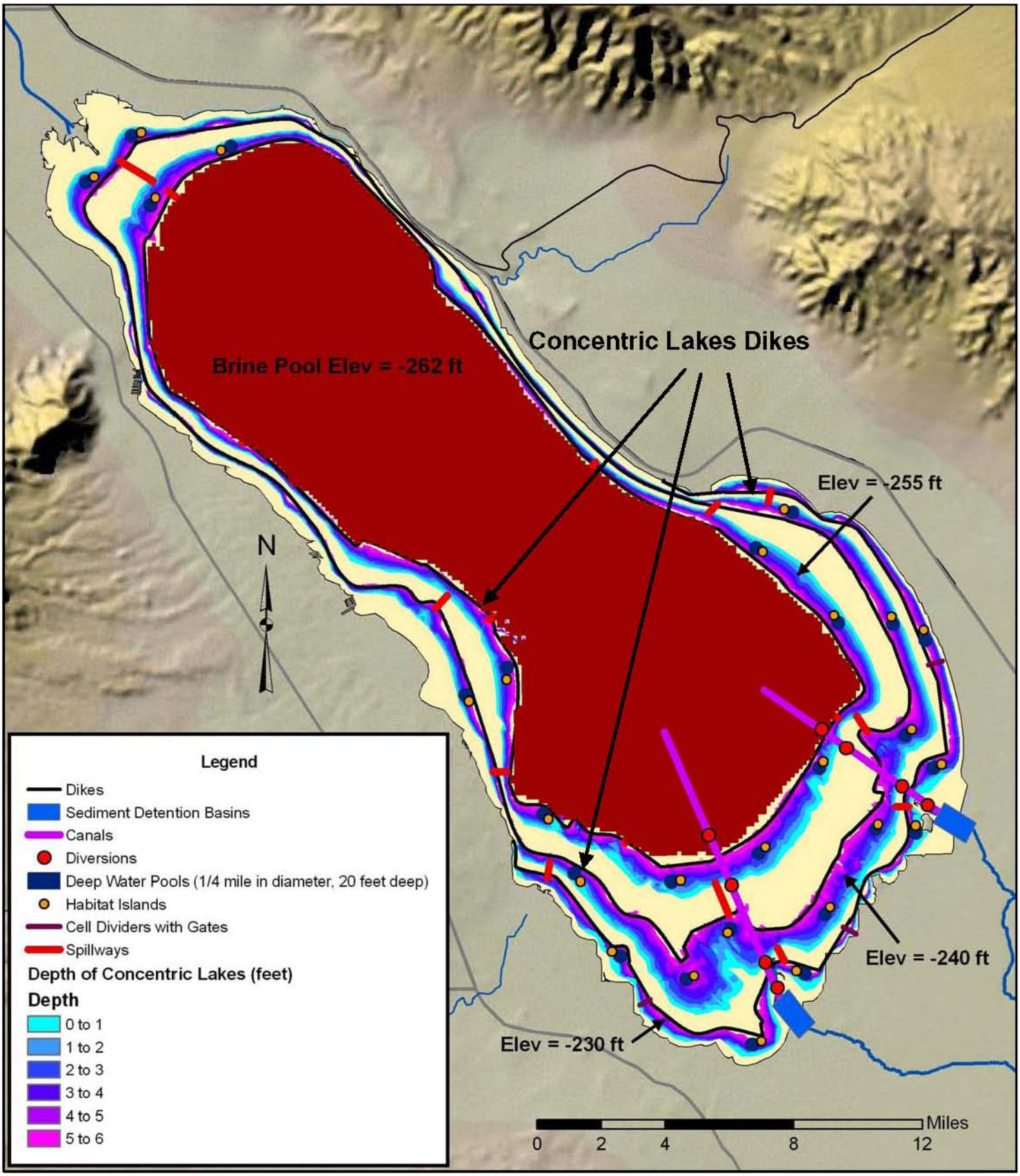
SALTON SEA RESTORATION PROJECT
Embankment Designs and Optimization Study

Alternative No. 2

Mid-Sea-Barrier / South Marine Lake

Project: 71100	By: KAF/CL	Date: April 2007	**FIGURE 3.2**



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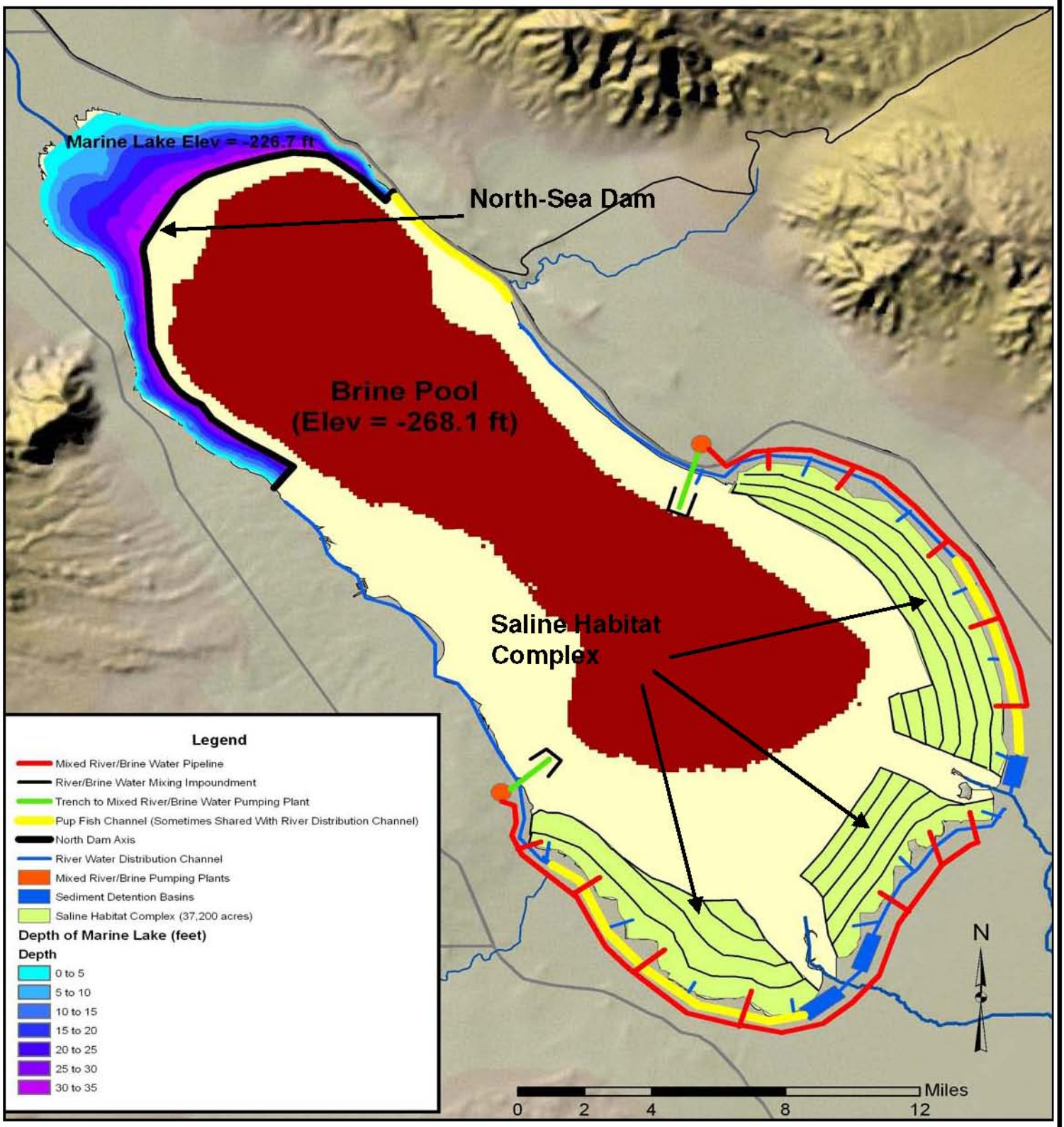
SALTON SEA RESTORATION PROJECT
Embankment Designs and Optimization Study

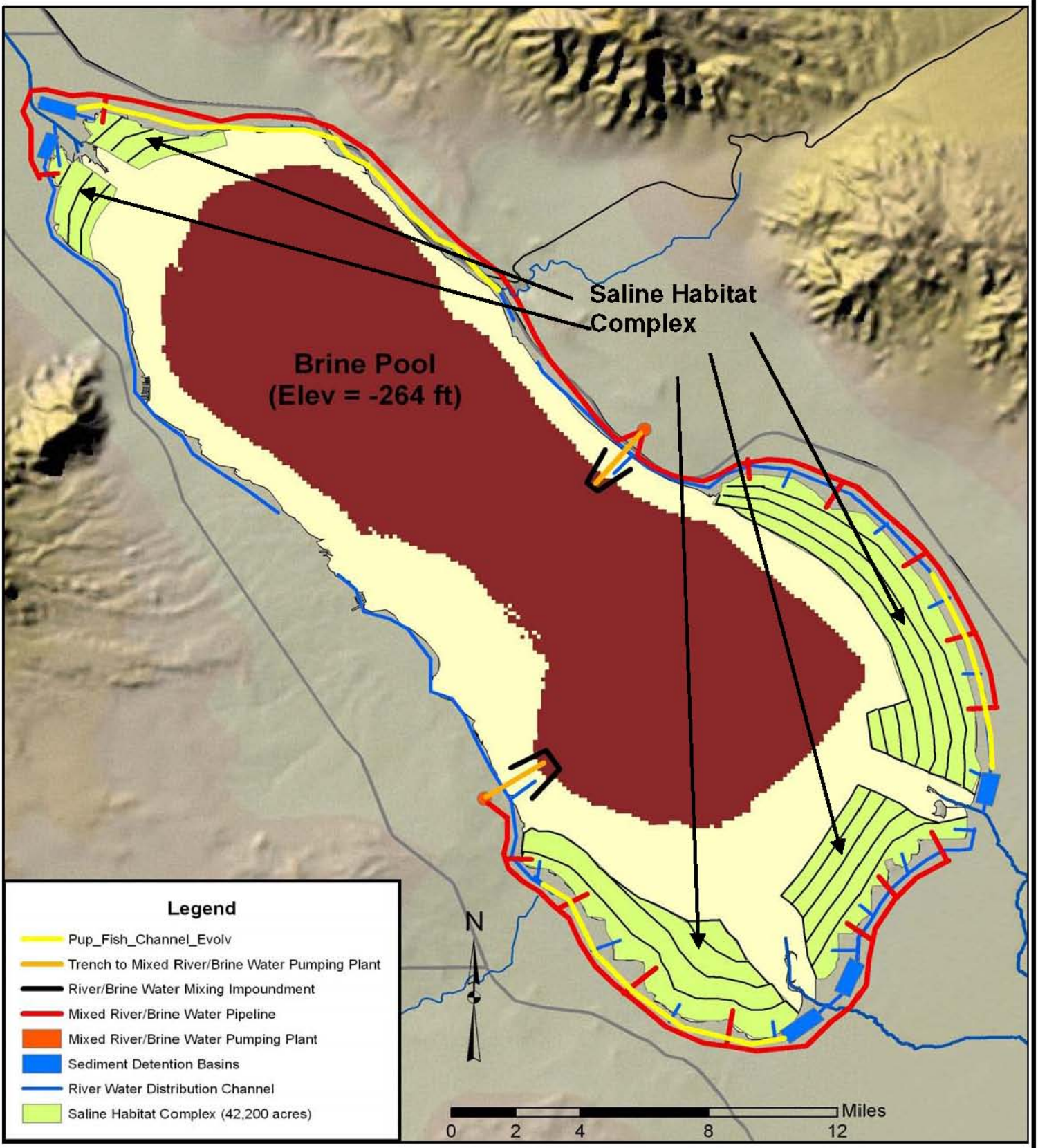
Alternative No. 3

Concentric Lakes Dikes

Project: 71100	By: KAF/CL	Date: April 2007	**FIGURE 3.3**



United States Department of the Interior Bureau of Reclamation	**SALTON SEA RESTORATION PROJECT** Embankment Designs and Optimization Study	**Alternative No. 4** North-Sea Dam / Marine Lake
KLEINFELDER	Project: 71100 | By: KAF/CL | Date: April 2007	**FIGURE 3.4**



United States Department of the Interior
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SALTON SEA RESTORATION PROJECT
Embankment Designs and Optimization Study

Alternative No. 5

Habitat Enhancement without Marine Lake

Project: 71100	By: KAF/CL	Date: April 2007	**FIGURE 3.5**

Note: Base drawing taken from Reclamation's Statement of Work, dated April 11, 2006.

"Baseline" Mid-Sea Dam Characteristics and Assumptions :

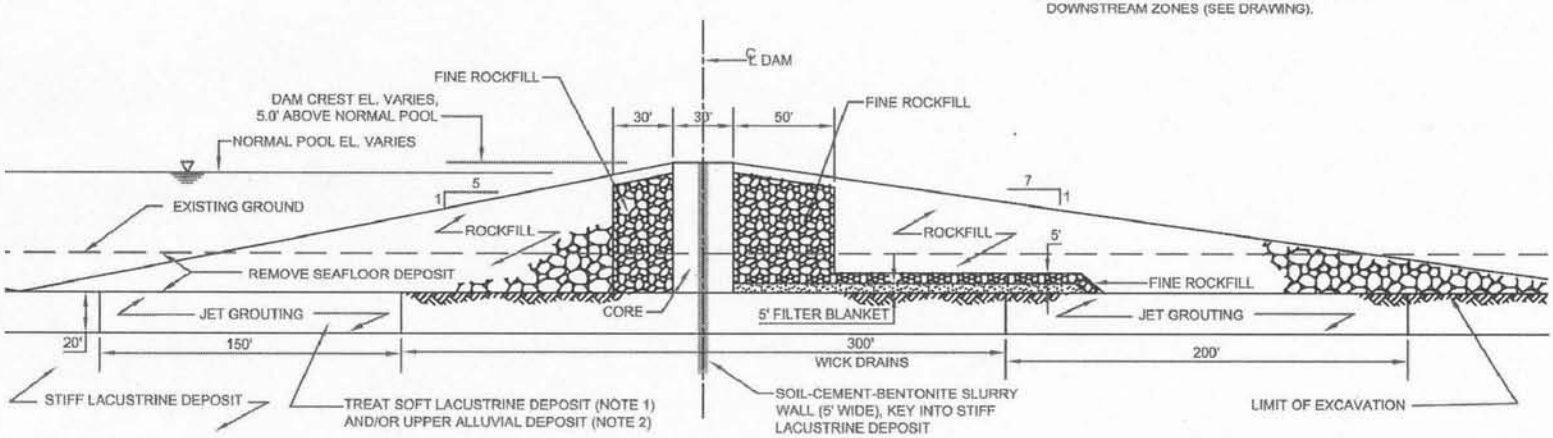
1. Dam crest at El -223 ft.
2. Pre-dredge mudline at El -268 ft.
3. Upstream pool at El -228 ft.
4. Downstream pool at El -268 ft.
5. Dredge exsiting Seafloor Deposits to El -280 ft.
6. Bottom of Soft Lacustrine Deposits at El -305 ft.

EMBANKMENT ZONES

ROCKFILL -	1' - 4' SOUND AND DURABLE QUARRY ROCK, DUMPED UNDERWATER.
FINE ROCKFILL -	3" - 12" SOUND AND DURABLE QUARRY ROCK, DUMPED UNDERWATER.
CORE -	CLEAN SAND AND GRAVEL, BUCKET PLACED IN LAYERS UNDERWATER.
FILTER BLANKET -	LAYER OF CLEAN SAND COVERED BY A LAYER OF GRAVEL, PLACED BY DUMPING IN WATER.

NOTES:

1) IN THE SOFT LACUSTRINE DEPOSIT, JET GROUT UPSTREAM AND DOWNSTREAM ZONES AND CONSOLIDATE MIDDLE ZONE WITH WICK DRAINS. (SEE DRAWING).
2) IN THE UPPER ALLUVIAL DEPOSIT, JET GROUT UPSTREAM AND DOWNSTREAM ZONES (SEE DRAWING).



ALTERNATIVE TYPICAL DAM CROSS SECTION

0 50 100
Approximate Scale in Feet

SALTON SEA RESTORATION PROJECT

FIGURE 1
ALTERNATE TYPICAL DAM CROSS SECTION

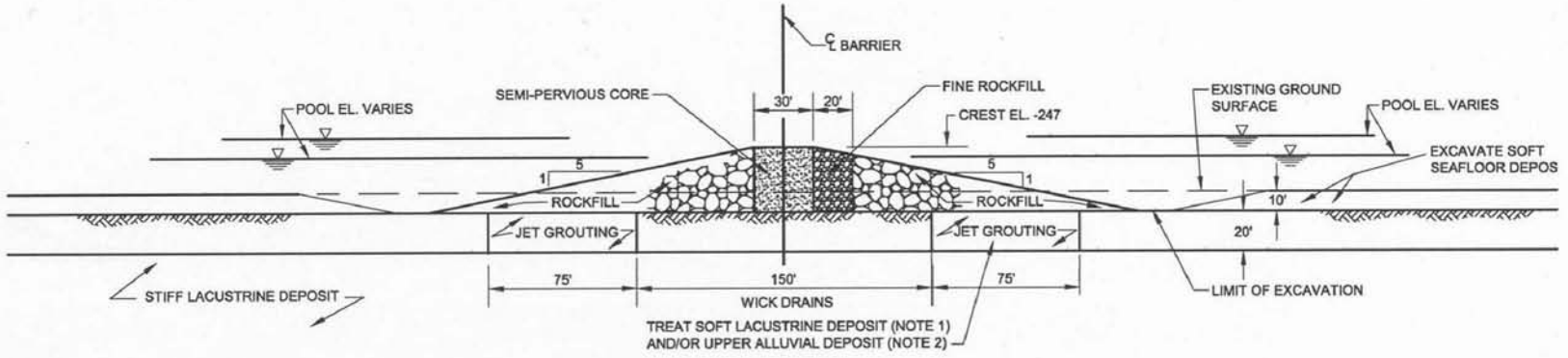
CONSTRUCTABILITY REVIEW
8/4/2005

United States Department of the Interior Bureau of Reclamation	**SALTON SEA RESTORATION PROJECT** Embankment Designs and Optimization Study			**Reclamation Preferred Mid-Sea-Dam Configuration - Appraisal Study**
KLEINFELDER	Project: 71100	By: KAF/CL	Date: August 2006	**FIGURE 4.1**

Note: Base drawing taken from Reclamation's Statement of Work, dated April 11, 2006.

"Baseline" Mid-Sea Barrier Characteristics and Assumptions :

1. Embankment crest at El -247 ft.
2. Pre-dredge mudline at El -268 ft.
3. Upstream pool at El -252 ft.
4. Downstream pool at El -257 ft.
5. Dredge exsiting Seafloor Deposits to El -280 ft.
6. Bottom of Soft Lacustrine Deposits at El -305 ft.
7. No post-dredging ground improvement (contrary to what is shown on this illustration).



ALTERNATE BARRIER
TYPICAL CROSS SECTION

0 50 100
Approximate Scale in Feet

LEGEND

ROCKFILL -	1' - 4' HARD DURABLE QUARRY ROCK, DUMPED UNDERWATER.
FINE ROCKFILL	3" - 12" HARD DURABLE QUARRY ROCK, DUMPED UNDERWATER.
SEMI-PERVIOUS CORE -	SAND AND GRAVEL, BUCKET PLACED IN LAYERS UNDERWATER.

NOTES:

1) IN THE SOFT LACUSTRINE DEPOSIT, JET GROUT UPSTREAM AND DOWNSTREAM ZONES AND CONSOLIDATE MIDDLE ZONE WITH WICK DRAINS. (SEE DRAWING).
2) IN THE UPPER ALLUVIAL DEPOSIT, JET GROUT UPSTREAM AND DOWNSTREAM ZONES (SEE DRAWING).

SALTON SEA RESTORATION PROJECT

FIGURE 2
ALTERNATE BARRIER
TYPICAL CROSS SECTION

CONSTRUCTABILITY REVIEW
8/4/2005

United States Department of the Interior Bureau of Reclamation

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SALTON SEA RESTORATION PROJECT
Embankment Designs and Optimization Study

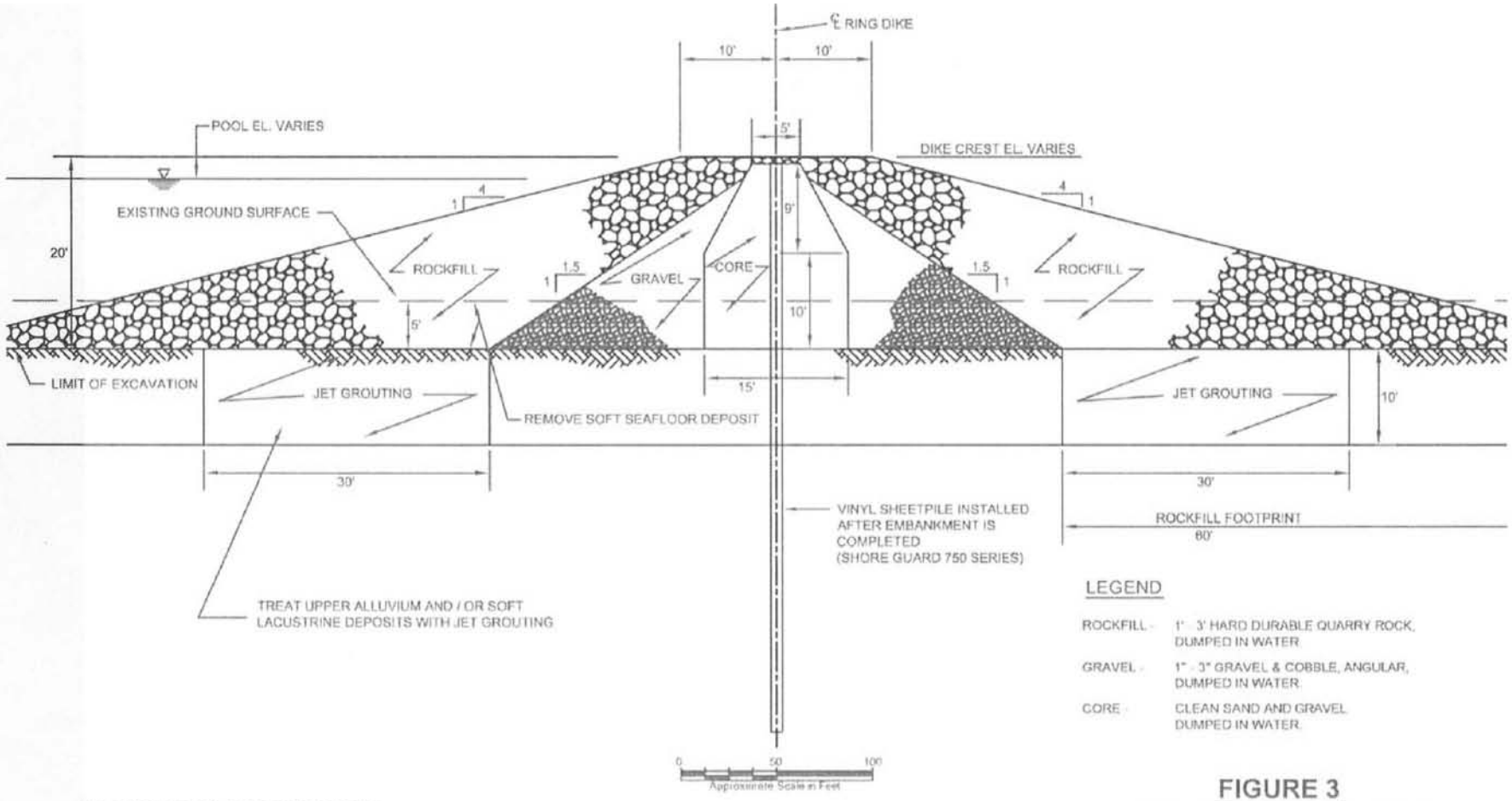
Reclamation Preferred Mid-Sea Barrier Configuration - Appraisal Study

Project: 71100	By: KAF/CL	Date: August 2006	**FIGURE 4.2**

Note: Base drawing taken from Reclamation's Statement of Work, dated April 11, 2006.

"Baseline" Ring / Perimeter Dike Characteristics and Assumptions :

1. Embankment crest at El -240 ft.
2. Pre-dredge mudline at El -260 ft.
3. Upstream pool at El -240.5 ft (0.5 ft freeboard).
4. Downstream pool at El -255 ft.
5. Dredge exsiting Seafloor Deposits to El -265 ft (west side) or to El -270 ft (east side).
6. Bottom of Soft Lacustrine Deposits at El -280 ft (east side).
7. Bottom of Upper Alluvium at El -275 ft (west side).



SALTON SEA RESTORATION PROJECT

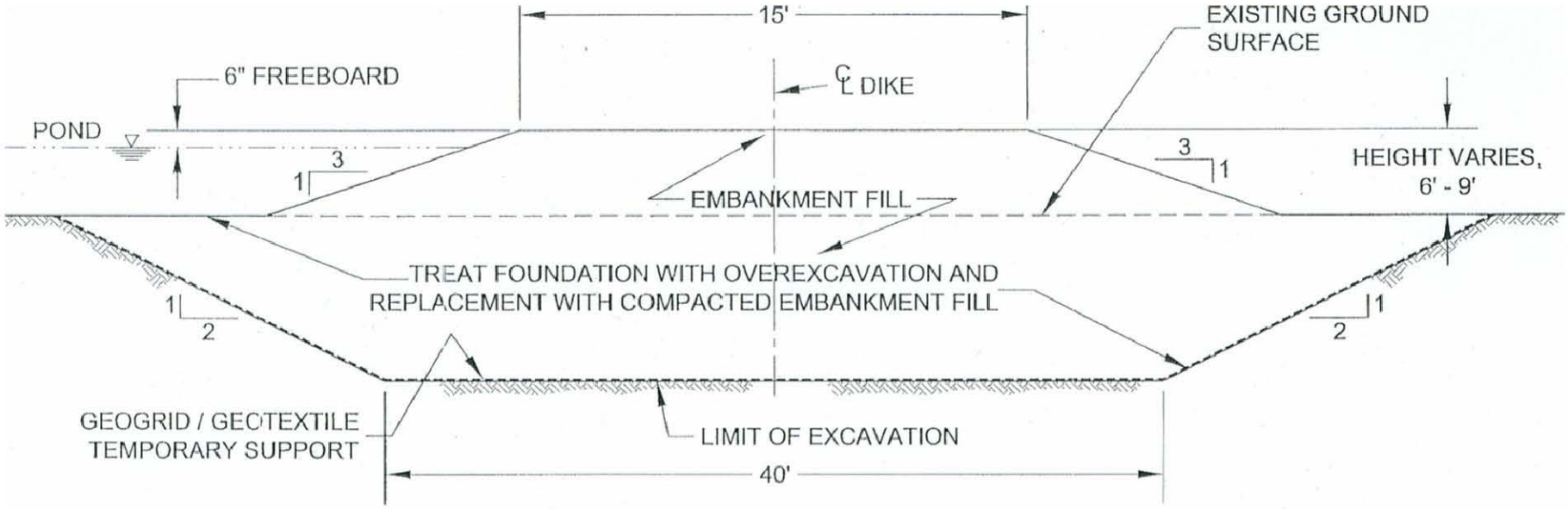
FIGURE 3
ALTERNATE TYPICAL RING DIKE CROSS SECTION

United States Department of the Interior Bureau of Reclamation	**SALTON SEA RESTORATION PROJECT** Embankment Alternatives Optimization Study			**Reclamation Preferred Ring Dike Configuration - Appraisal Study**
KLEINFELDER	Project: 71100	By: KAF/CL	Date: August 2006	**FIGURE 4.3**

Note: Base drawing taken from Reclamation's Statement of Work, dated April 11, 2006.

"Baseline" Habitat Pond Earthfill Embankment Characteristics and Assumptions :

1. Embankment crest at El -241 ft.
2. Pre-dredge mudline at El -250 ft.
3. Upstream pool at El -241.5 ft.
4. Downstream pool at El -250 ft.
5. Dredge exsiting Seafloor Deposits to El -260 ft.
6. Embankment founded on 5 ft of Upper Alluvium, underlain by 5 ft of Stiff Lacustrine, underlain by additional Upper Alluvium.



TYPICAL EARTHFILL EMBANKMENT FOR HABITAT PONDS

(NOT TO SCALE)

LEGEND

EMBANKMENT FILL - COMPACTED (IN THE DRY) EARTHFILL (CLAY, SILT)

United States Department of the Interior Bureau of Reclamation

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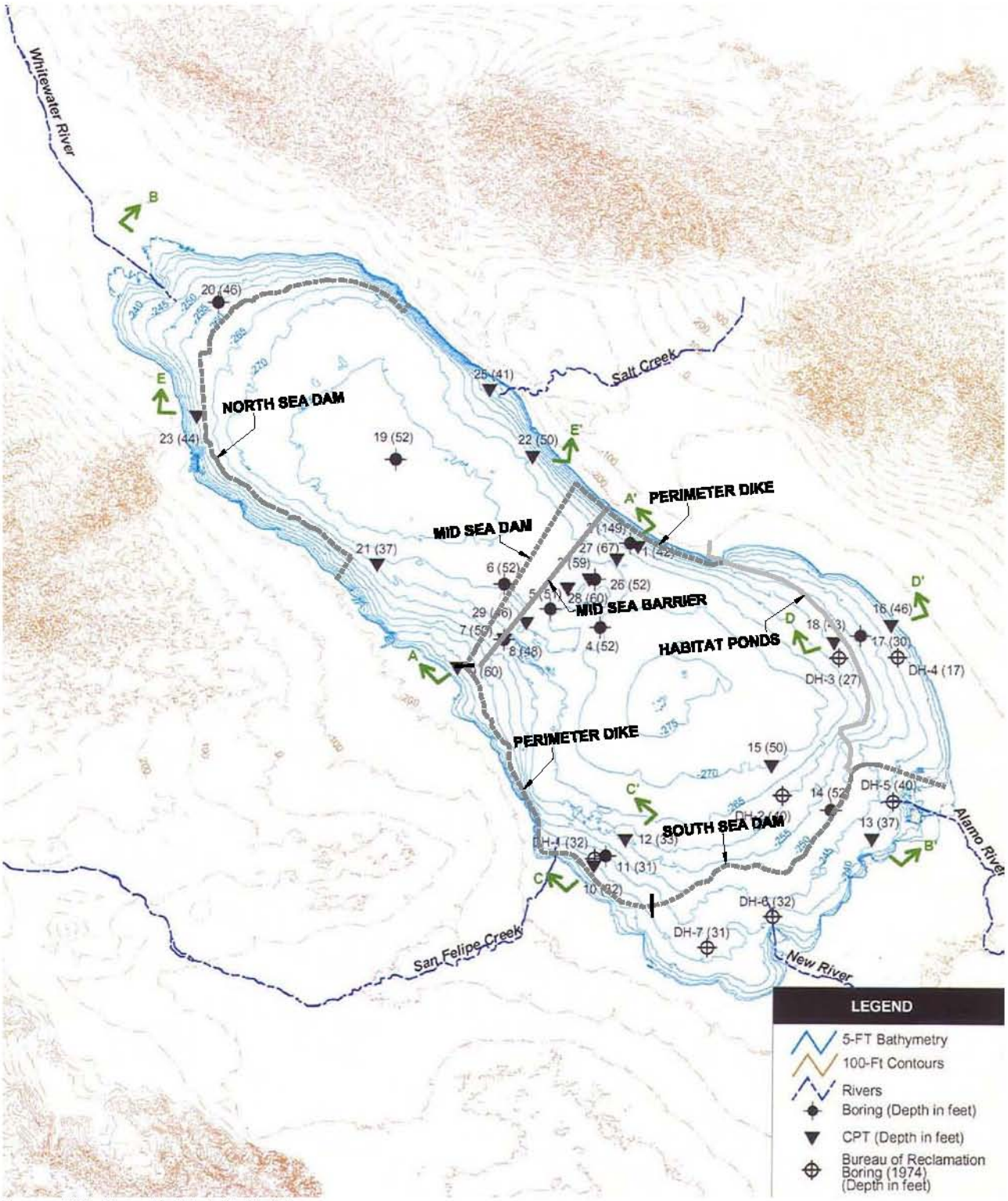
SALTON SEA RESTORATION PROJECT
Embankment Alternatives Optimization Study

Reclamation Preferred Habitat Pond Embankment Configuration - Appraisal Study

Project: 71100	By: KAF/CL	Date: August 2006	**FIGURE 4.4**



Source: URS, Figure 2, Dated: 2-24-04.

0 3 6 12 18

SCALE IN MILES

United States Department of the Interior Bureau of Reclamation

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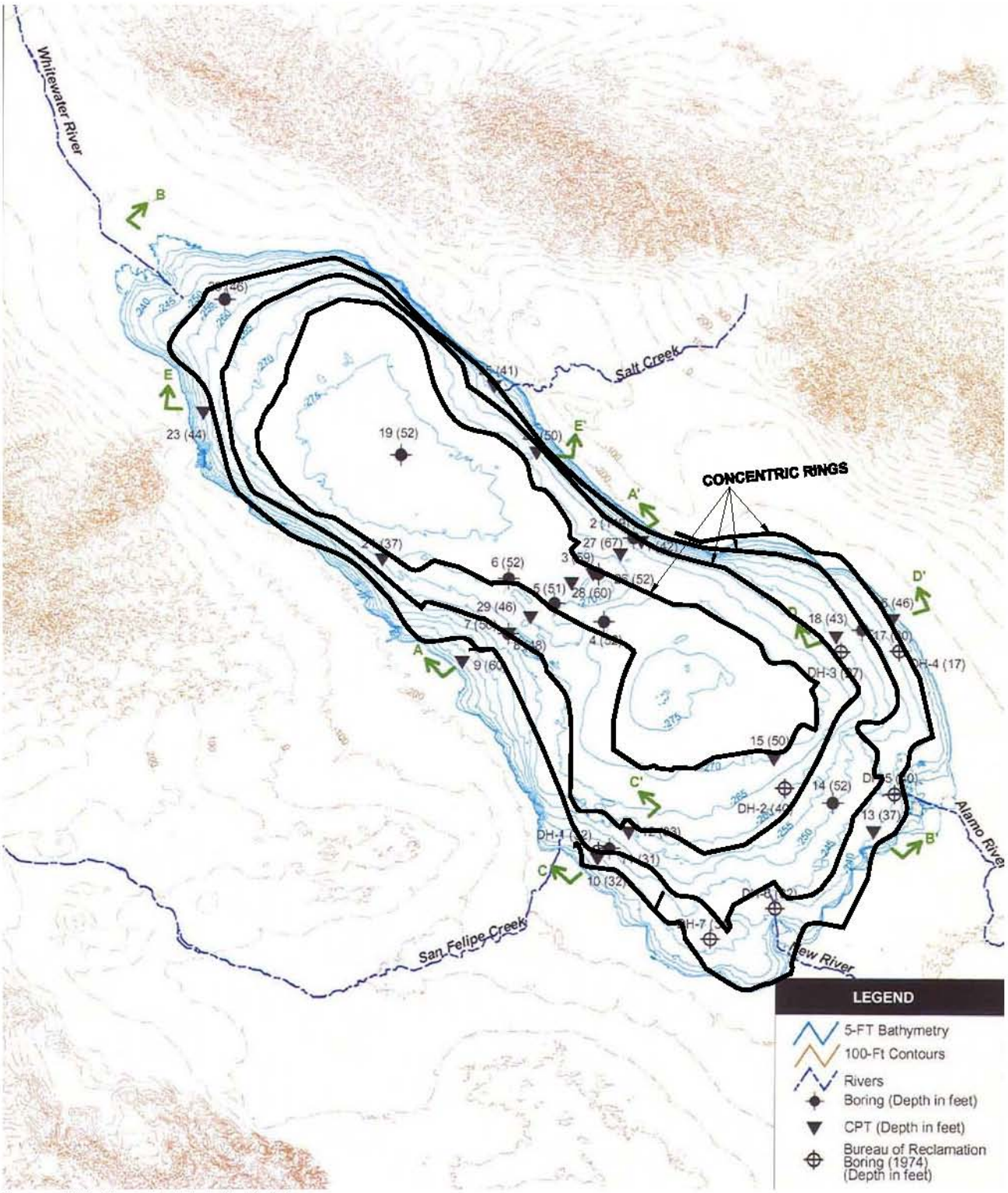
SALTON SEA RESTORATION PROJECT
Embankment Designs and Optimization Study

Location of 2004 Explorations Relative to Alternatives 1, 2 and 4 Embankments

Project: 71100	By: KAF/CL	Date: August 2006	**FIGURE 4.5**



Source: URS, Figure 2, Dated: 2-24-04.

0 3 6 12 18

SCALE IN MILES

United States Department of the Interior Bureau of Reclamation

KLEINFELDER

SALTON SEA RESTORATION PROJECT
Embankment Designs and Optimization Study

Location of 2004 Explorations Relative to Alternative 3 Embankments

Project: 71100	By: KAF/CL	Date: August 2006	**FIGURE 4.6**

A

WEST

A'

EAST

CPT-9

B-7

CPT-8

CPT-29

B-5

CPT-28

CPT-3

B-26

CPT-27

B-2

CPT-1

ELEVATION (Feet, MSL)

-200

-250

-300

-350

-400

Notes:

1. Refer to Figure 2 for section locations.
2. The subsurface conditions illustrated were obtained by interpolation between widely spaced explorations. Information on actual subsurface conditions exists only at locations of explorations; conditions between explorations may vary from those depicted.
3. The discussions in the text of this report should be reviewed to obtain a proper understanding of the nature of the subsurface conditions.
4. Complete boring logs and CPT data are presented in the appendices of this report.

Legend:

Stratigraphy:

- Seafloor Deposits
- Soft Lacustrine Deposits
- Upper Alluvial Deposits
- Upper Stiff Lacustrine Deposits
- Lower Alluvial Deposits
- Lower Stiff Lacustrine Deposits

Data Plotted Next to Exploration:

For CPTs:

Qtn (tsf)

0 50 100 150 200 250

For Borings:

W%

0 100

(VERTICAL SCALE = 100 X HORIZONTAL SCALE)

Source: URS, Figure 9, Dated: 1-29-04.

0 1500 3000 6000 9000

SCALE IN FEET

United States Department of the Interior Bureau of Reclamation

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SALTON SEA RESTORATION PROJECT

Embankment Designs and Optimization Study

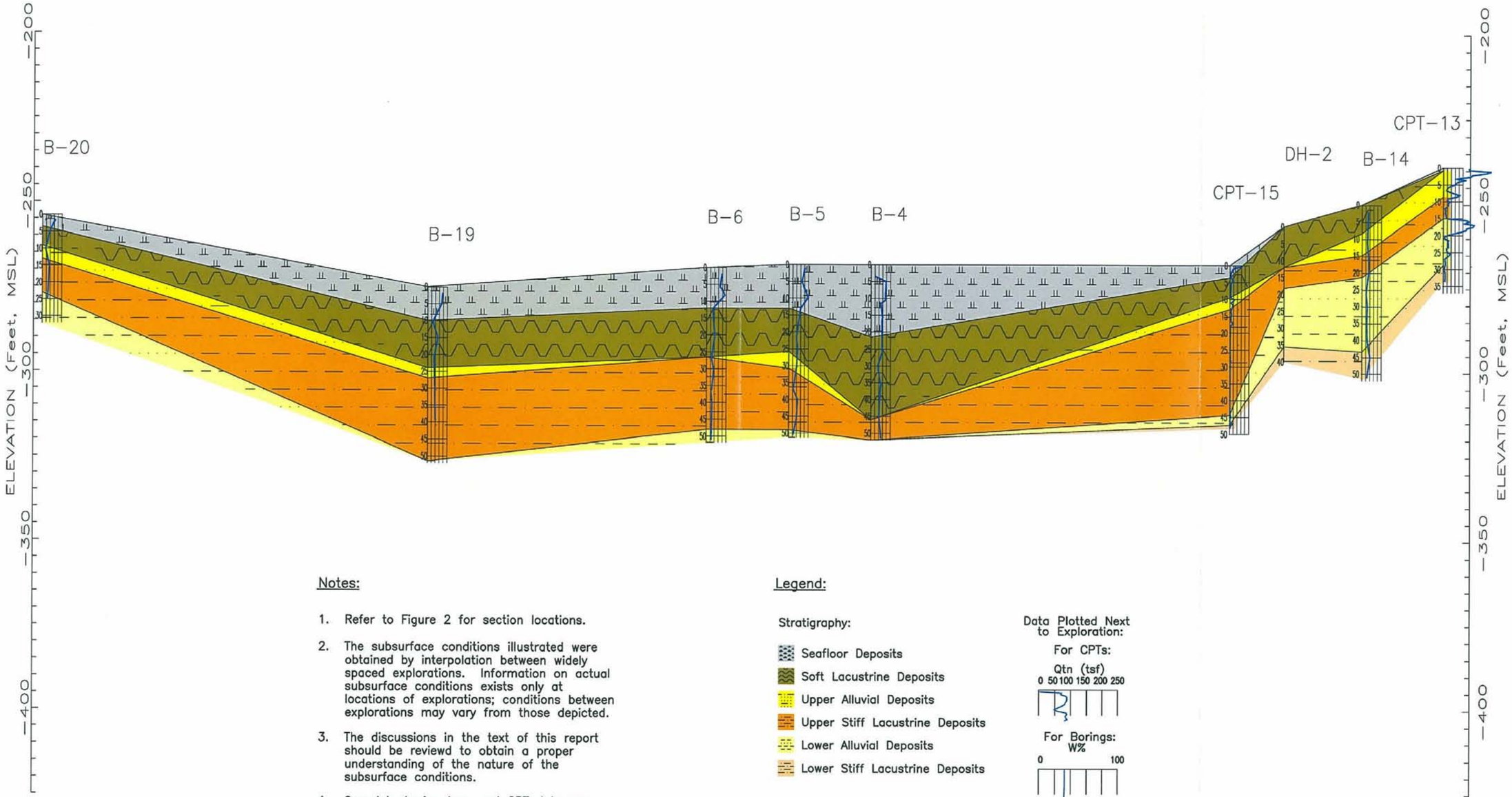
GEOLOGIC CROSS SECTION A-A'

Project: 71100 | By: KAF/CL/MB | Date: August 2006

FIGURE 4.7a

B
NORTHWEST

B'
SOUTHEAST



Notes:

1. Refer to Figure 2 for section locations.
2. The subsurface conditions illustrated were obtained by interpolation between widely spaced explorations. Information on actual subsurface conditions exists only at locations of explorations; conditions between explorations may vary from those depicted.
3. The discussions in the text of this report should be reviewd to obtain a proper understanding of the nature of the subsurface conditions.
4. Complete boring logs and CPT data are presented in the appendices of this report.

Legend:

Stratigraphy:

- Seafloor Deposits
- Soft Lacustrine Deposits
- Upper Alluvial Deposits
- Upper Stiff Lacustrine Deposits
- Lower Alluvial Deposits
- Lower Stiff Lacustrine Deposits

Data Plotted Next to Exploration:

For CPTs:

Qtn (tsf)

0 50 100 150 200 250

For Borings:

W%

0 100

(VERTICAL SCALE = 400 X HORIZONTAL SCALE)

Source: URS, Figure 10, Dated: 12-10-03.

0 6250 12500 25000 37500

SCALE IN FEET

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SALTON SEA RESTORATION PROJECT
Embankment Designs and Optimization Study

GEOLOGIC CROSS SECTION B-B'

Project: 71100 | By: KAF/CL/MB | Date: August 2006

FIGURE 4.7b

C
WEST

C'
EAST

CPT-10

DH-1

B-11

CPT-12

ELEVATION (Feet, MSL)

0
-250
-300

0
5
10
15
20
25
30

Notes:

1. Refer to Figure 2 for section locations.
2. The subsurface conditions illustrated were obtained by interpolation between widely spaced explorations. Information on actual subsurface conditions exists only at locations of explorations; conditions between explorations may vary from those depicted.
3. The discussions in the text of this report should be reviewd to obtain a proper understanding of the nature of the subsurface conditions.
4. Complete boring logs and CPT data are presented in the appendices of this report.

Legend:

Stratigraphy:

- Seafloor Deposits
- Soft Lacustrine Deposits
- Upper Alluvial Deposits
- Upper Stiff Lacustrine Deposits
- Lower Alluvial Deposits
- Lower Stiff Lacustrine Deposits

Data Plotted Next to Exploration:

For CPTs:

Qtn (tsf)

0 50 100 150 200 250

For Borings:

W%

0 100

(VERTICAL SCALE = 100 X HORIZONTAL SCALE)

Source: URS, Figure 11, Dated: 1-29-04.

0 500 1000 2000 3000

SCALE IN FEET

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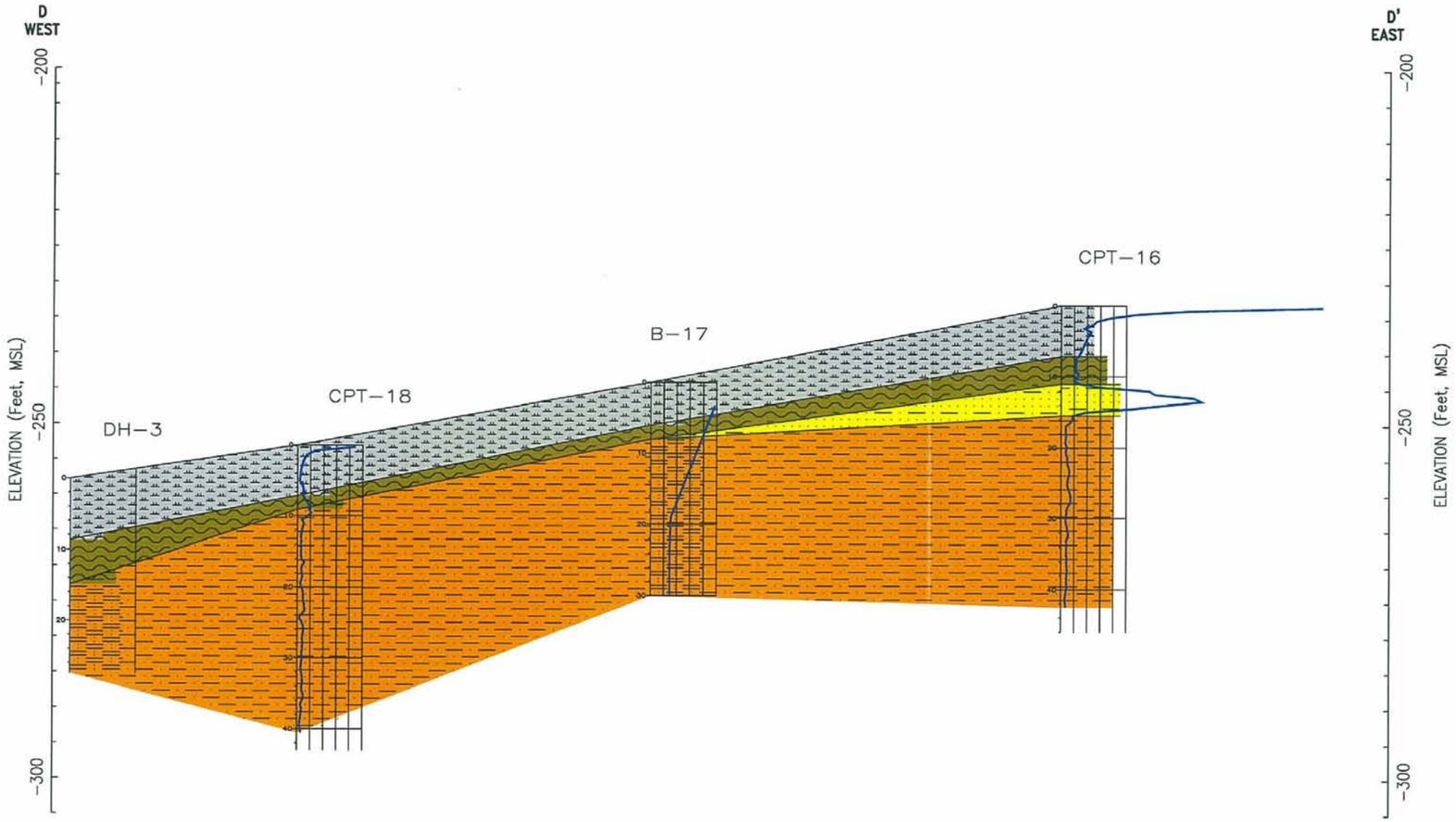
SALTON SEA RESTORATION PROJECT
Embankment Alternatives Optimization Study

GEOLOGIC CROSS SECTION C-C'

Project: 71100 | By: KAF/CL/MB | Date: August 2006

FIGURE 4.7c



Legend:

Stratigraphy:

- Seafloor Deposits
- Soft Lacustrine Deposits
- Upper Alluvial Deposits
- Upper Stiff Lacustrine Deposits
- Lower Alluvial Deposits
- Lower Stiff Lacustrine Deposits

Data Plotted Next to Exploration:

For CPTs:

Qtn (tsf)

0 50 100 150 200 250

For Borings:

W%

0 100

Notes:

1. Refer to Figure 2 for section locations.
2. The subsurface conditions illustrated were obtained by interpolation between widely spaced explorations. Information on actual subsurface conditions exists only at locations of explorations; conditions between explorations may vary from those depicted.
3. The discussions in the text of this report should be reviewd to obtain a proper understanding of the nature of the subsurface conditions.
4. Complete boring logs and CPT data are presented in the appendices of this report.

(VERTICAL SCALE = 100 X HORIZONTAL SCALE)

Source: URS, Figure 12, Dated: 1-29-04.

0 500 1000 2000 3000

SCALE IN FEET

United States Department of the Interior
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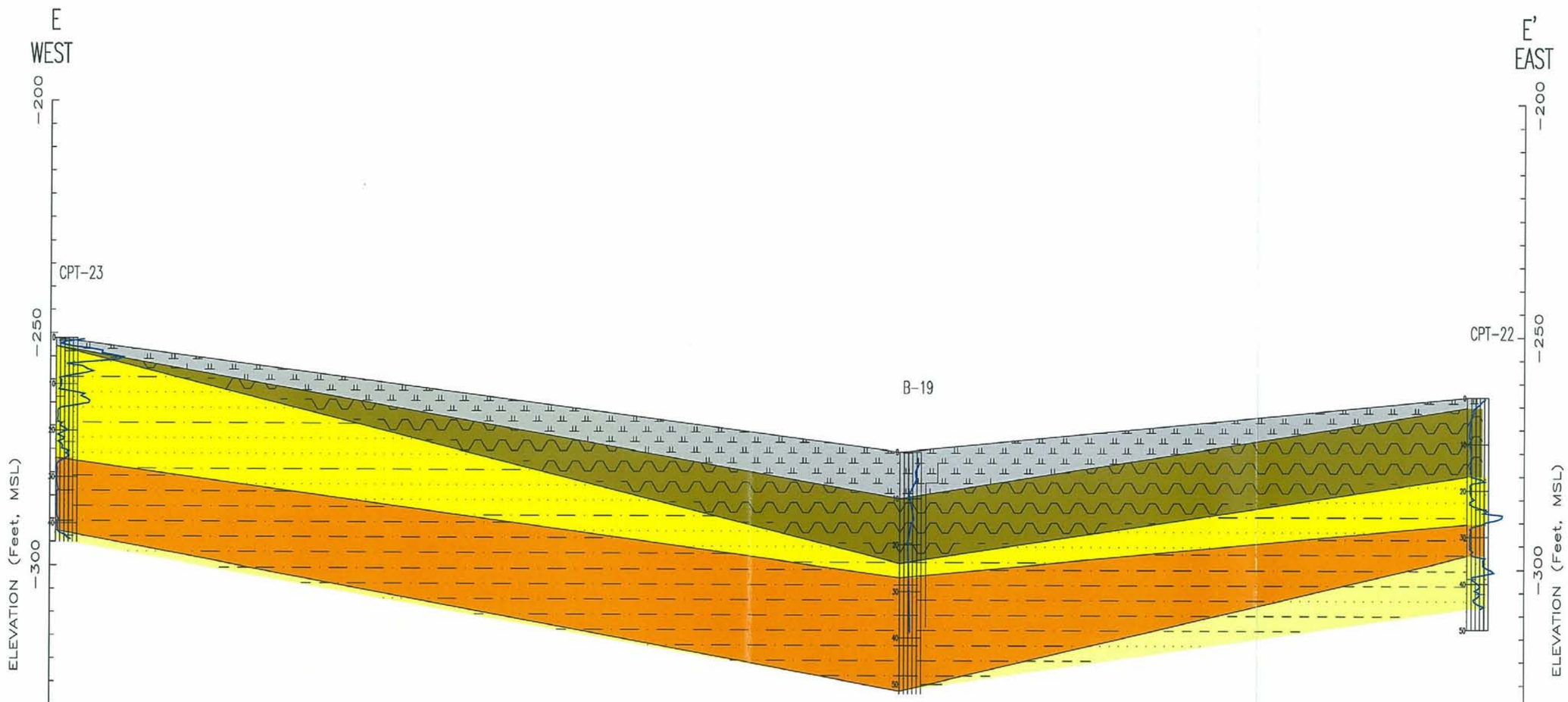
SALTON SEA RESTORATION PROJECT
Embankment Designs and Optimization Study

GEOLOGIC CROSS SECTION D-D'

Project: 71100	By: KAF/CL/MB	Date: August 2006

FIGURE 4.7d



Notes:

1. Refer to Figure 2 for section locations.
2. The subsurface conditions illustrated were obtained by interpolation between widely spaced explorations. Information on actual subsurface conditions exists only at locations of explorations; conditions between explorations may vary from those depicted.
3. The discussions in the text of this report should be reviewd to obtain a proper understanding of the nature of the subsurface conditions.
4. Complete boring logs and CPT data are presented in the appendices of this report.

Legend:

Stratigraphy:

- Seafloor Deposits
- Soft Lacustrine Deposits
- Upper Alluvial Deposits
- Upper Stiff Lacustrine Deposits
- Lower Alluvial Deposits
- Lower Stiff Lacustrine Deposits

Data Plotted Next to Exploration:

For CPTs:

Qtn (tsf)

0 50 100 150 200 250

For Borings:

W%

0 100

(VERTICAL SCALE = 200 X HORIZONTAL SCALE)

Source: URS, Figure 13, Dated: 1-29-04.

0 2500 5000 10000 15000

SCALE IN FEET

United States Department of the Interior
Bureau of Reclamation

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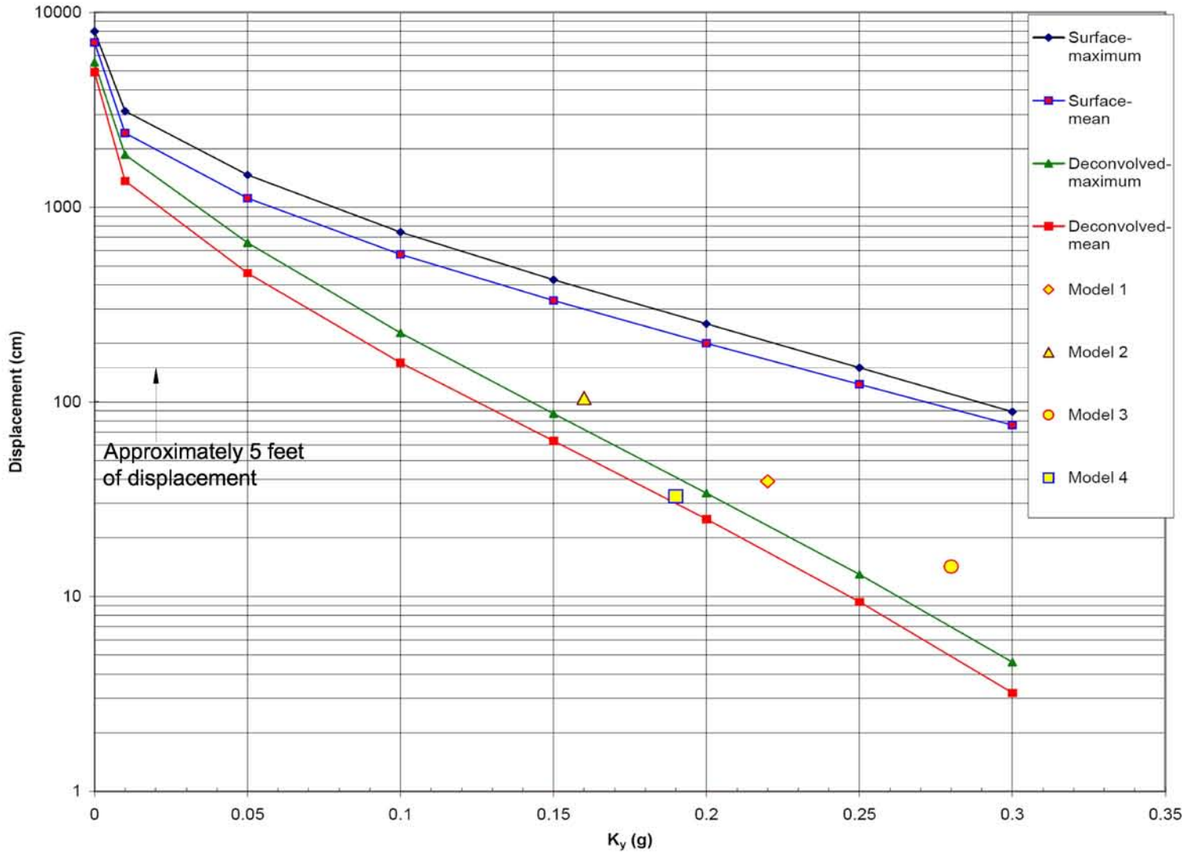
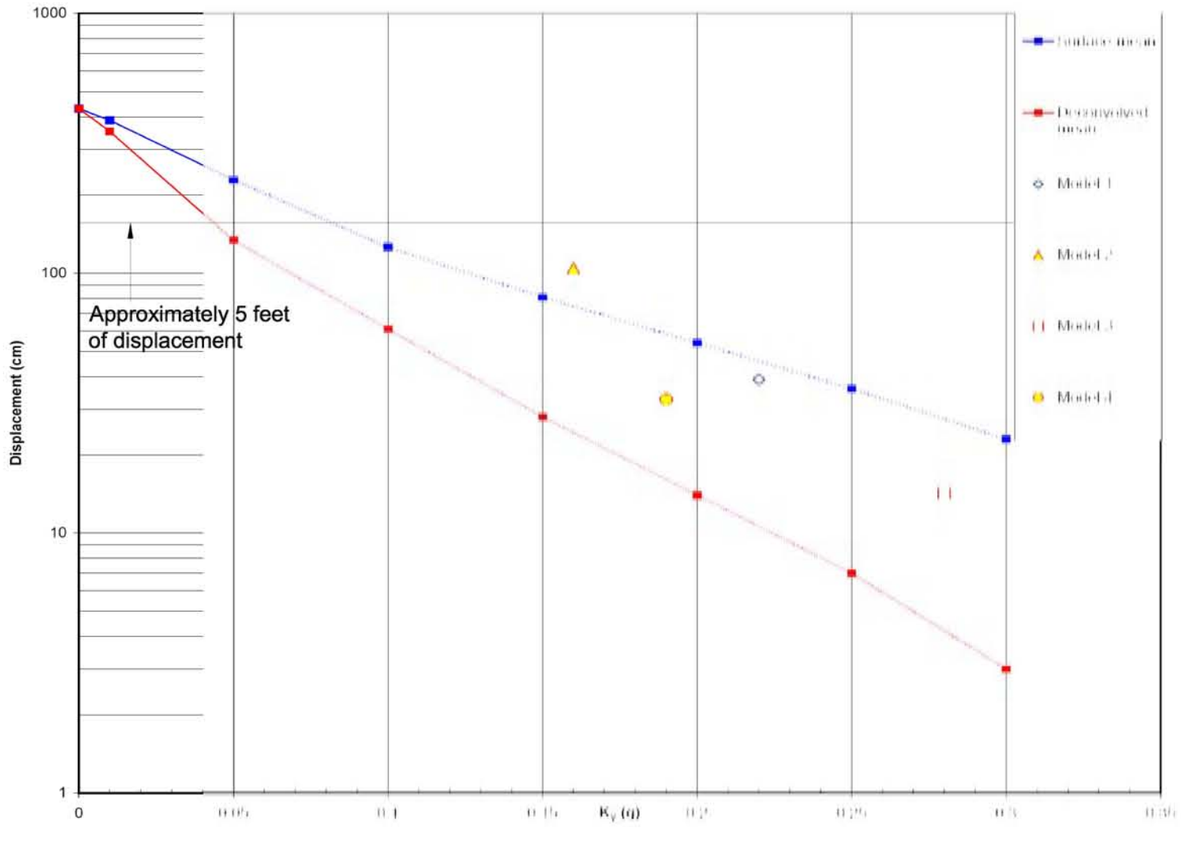
SALTON SEA RESTORATION PROJECT
Embankment Designs and Optimization Study

GEOLOGIC CROSS SECTION E-E'

Project: 71100	By: KAF/CL/MB	Date: August 2006

FIGURE 4.7e





United States Department of the Interior
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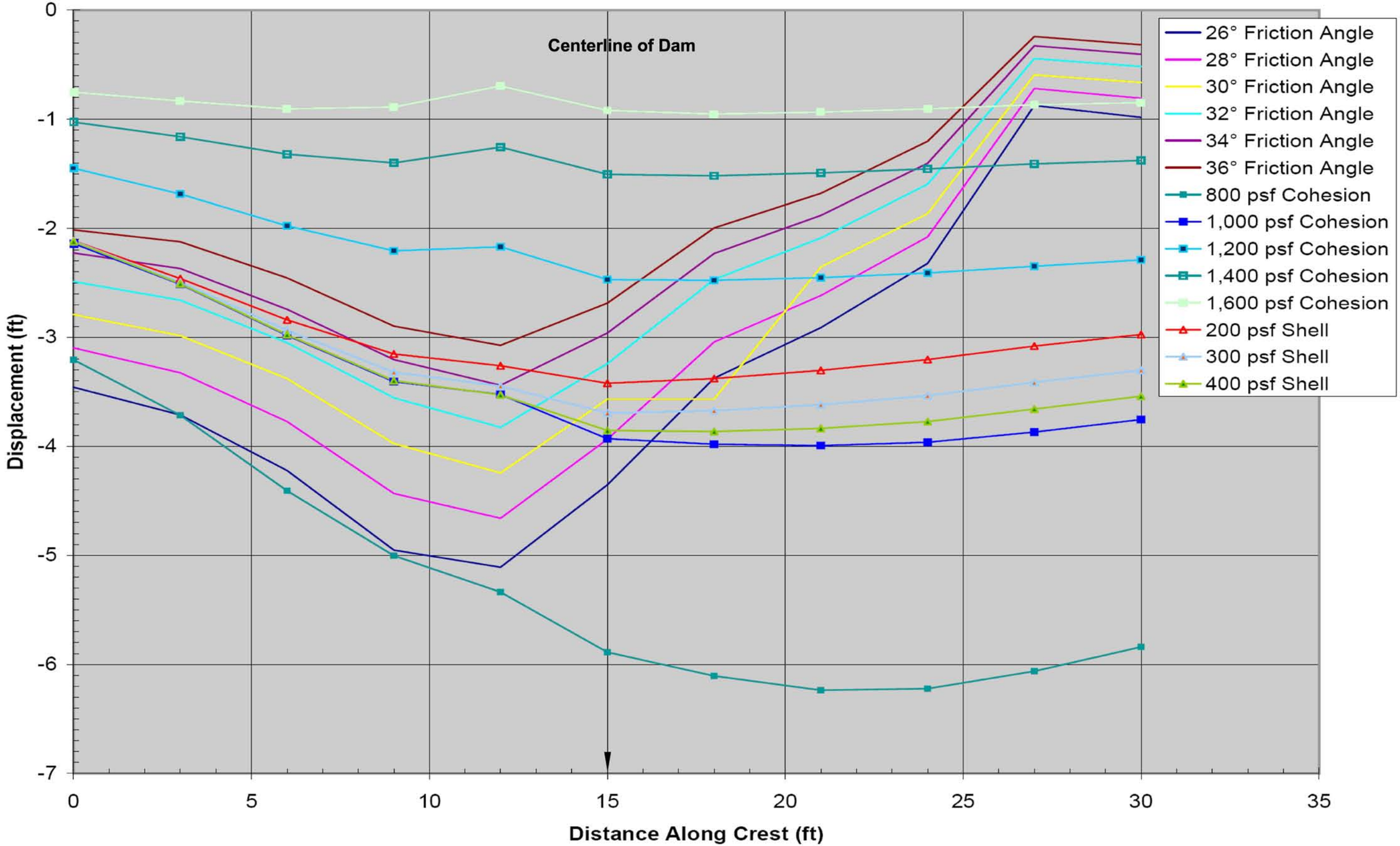
KLEINFELDER

SALTON SEA RESTORATION PROJECT
Embankment Designs and Optimization Study

Summary of Deformation Analysis Results

Project: 71100 | By: KAF/CL/SA | Date: August 2006

FIGURE 4.8



United States Department of the Interior
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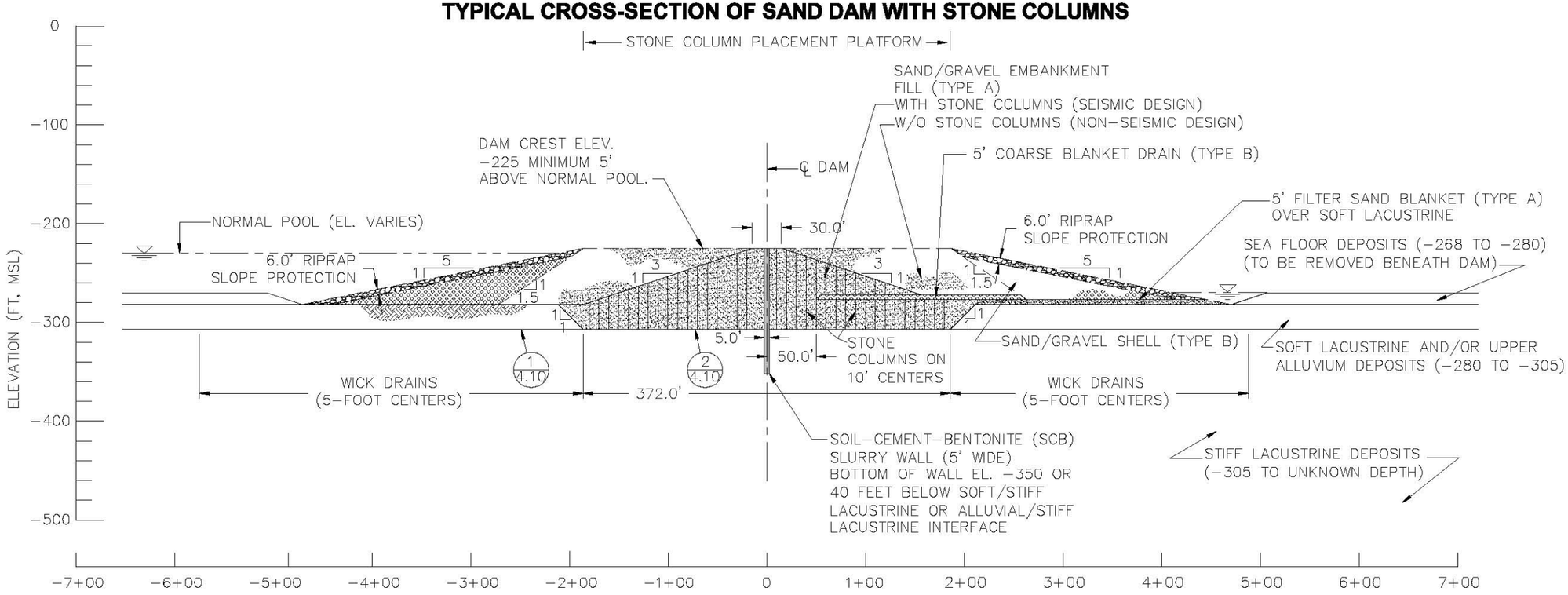
SALTON SEA RESTORATION PROJECT
Embankment Designs and Optimization Study

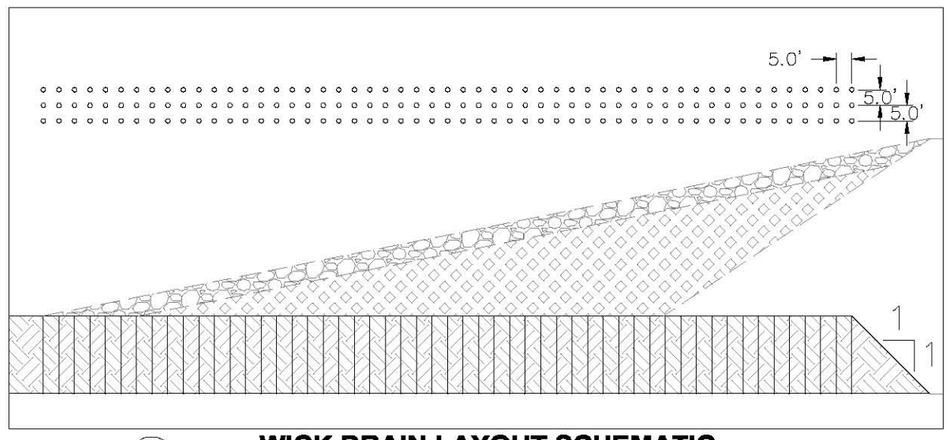
Predicted Crest Deformation of the Mid-Sea-Dam from Parametric Evaluation

Project: 71100 | By: KAF/CL/SA | Date: August 2006

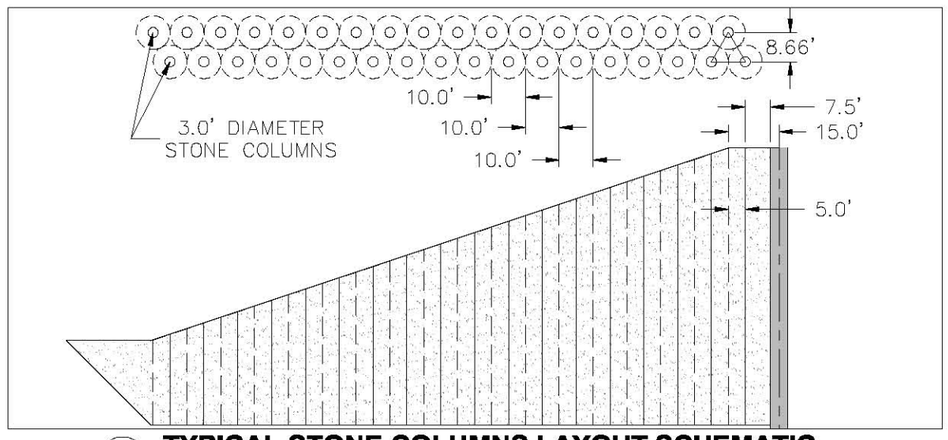
FIGURE 4.9

TYPICAL CROSS-SECTION OF SAND DAM WITH STONE COLUMNS





(1 / 4.10) **WICK DRAIN LAYOUT SCHEMATIC**



(2 / 4.10) **TYPICAL STONE COLUMNS LAYOUT SCHEMATIC**

LEGEND

SAND/GRAVEL EMBANKMENT FILL (TYPE A): FINE TO COARSE SAND AND GRAVEL, MIX WITH MAXIMUM 3/4-INCH GRAVEL SIZE AND MAXIMUM 10% FINES SUITABLE FOR COMPACTION WITH STONE COLUMNS

SAND/GRAVEL SHELL (TYPE B): FINE TO COARSE SAND AND GRAVEL WITH VARIABLE FINES NOT INTENDED FOR COMPACTION WITH STONE COLUMNS

TYPE A WITH STONE COLUMNS: 3' DIA. STONE COLUMNS, 10' ON CENTERS, INSTALLED IN TYPE A SAND/GRAVEL (TRIANGULAR PATTERN).

RIP RAP SLOPE PROTECTION: 1'-4' DIAMETER SOUND AND DURABLE QUARRY ROCK DUMPED UNDER WATER

0 50 120 240 360

SCALE IN FEET

United States Department of the Interior
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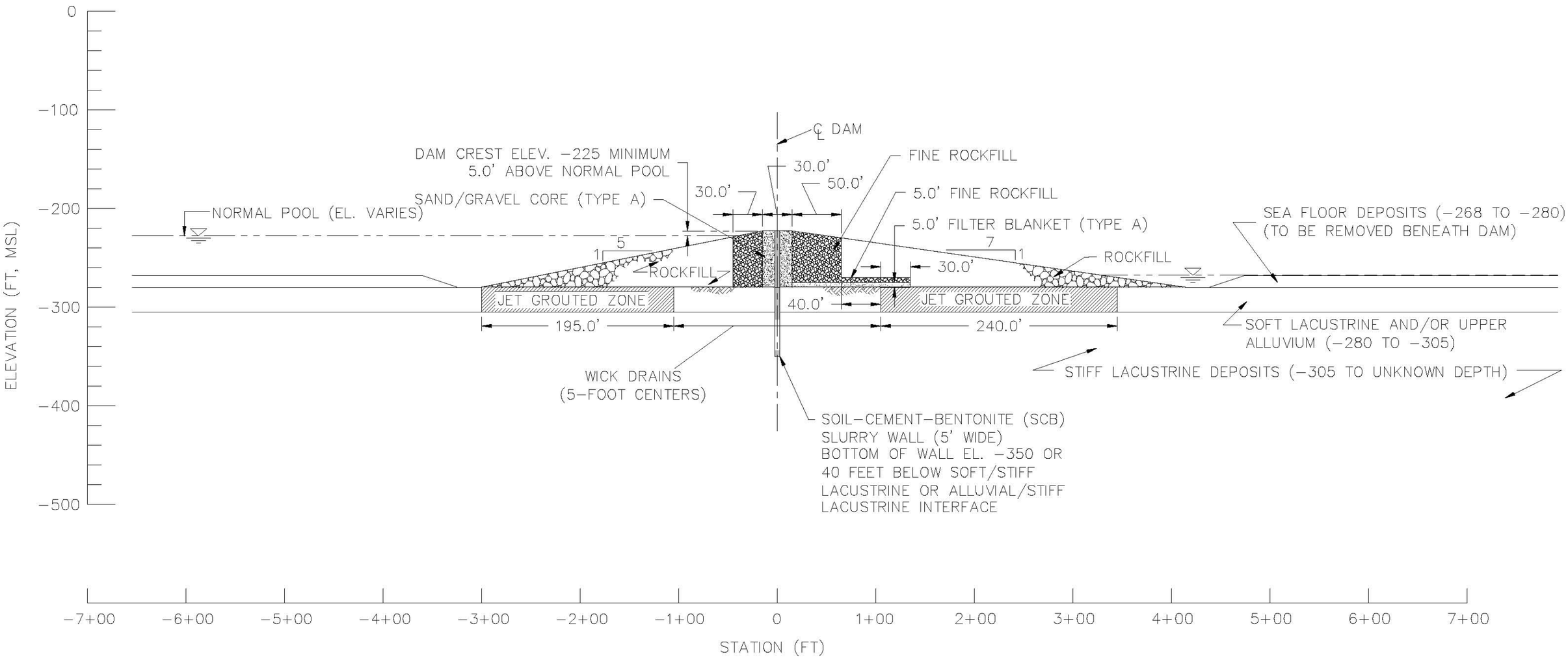
SALTON SEA RESTORATION PROJECT
Embankment Designs and Optimization Study

OPTION A
"OPTIMIZED" SAND DAM WITH STONE COLUMNS

Project: 71100 | By: KAF/CL/MB | Date: August 2006

FIGURE 4.10



TYPICAL CROSS-SECTION OF ROCKFILL DAM WITH JET GROUTED FOUNDATION

0 50 100 200 300

SCALE IN FEET

LEGEND

ROCKFILL: 1'−4' SOUND AND DURABLE QUARRY ROCK DUMPED UNDERWATER

FINE ROCKFILL: 3"−12" SOUND AND DURABLE QUARRY ROCK DUMPED UNDERWATER

TYPE A SAND/GRAVEL CORE: CLEAN SAND AND GRAVEL, BUCKET PLACED IN LAYERS UNDERWATER

FILTER BLANKET: LAYER OF TYPE A SAND/GRAVEL COVERED BY A LAYER OF FINE ROCKFILL, PLACED BY DUMPING UNDERWATER

United States Department of the Interior
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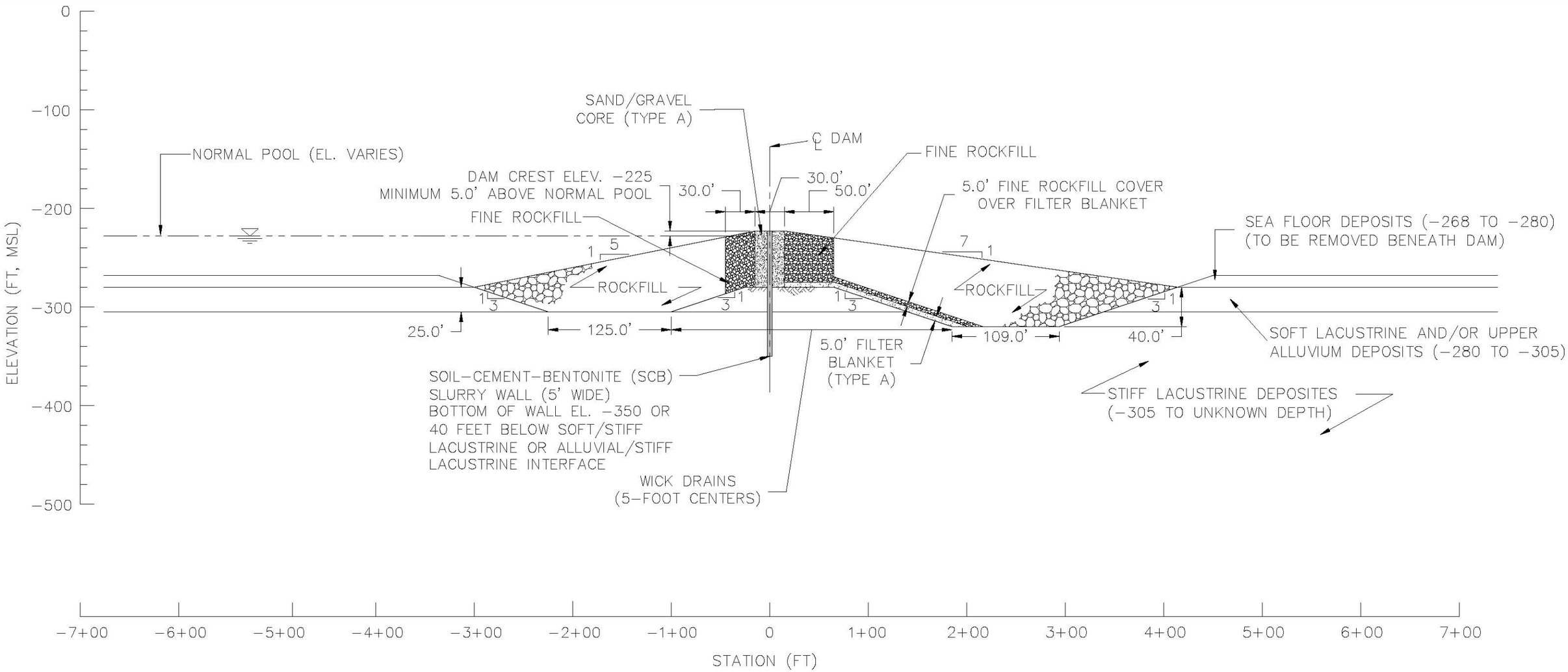
SALTON SEA RESTORATION PROJECT
Embankment Designs and Optimization Study

OPTION B
ROCKFILL DAM WITH JET GROUTED FOUNDATION

Project: 71100 | By: KAF/CL/MB | Date: August 2006

FIGURE 4.11



TYPICAL CROSS-SECTION OF MODIFIED ROCK NOTCHES WITH MINIMUM FILTERS

0 50 100 200 300

SCALE IN FEET

LEGEND

ROCKFILL: 1'−4' SOUND AND DURABLE QUARRY ROCK DUMPED UNDERWATER

FINE ROCKFILL: 3"−12" SOUND AND DURABLE QUARRY ROCK DUMPED UNDERWATER

TYPE A SAND/GRAVEL CORE: CLEAN SAND AND GRAVEL, BUCKET PLACED IN LAYERS UNDERWATER

FILTER BLANKET: LAYER OF TYPE A SAND/GRAVEL COVERED BY A LAYER OF FINE ROCKFILL, PLACED BY DUMPING UNDERWATER

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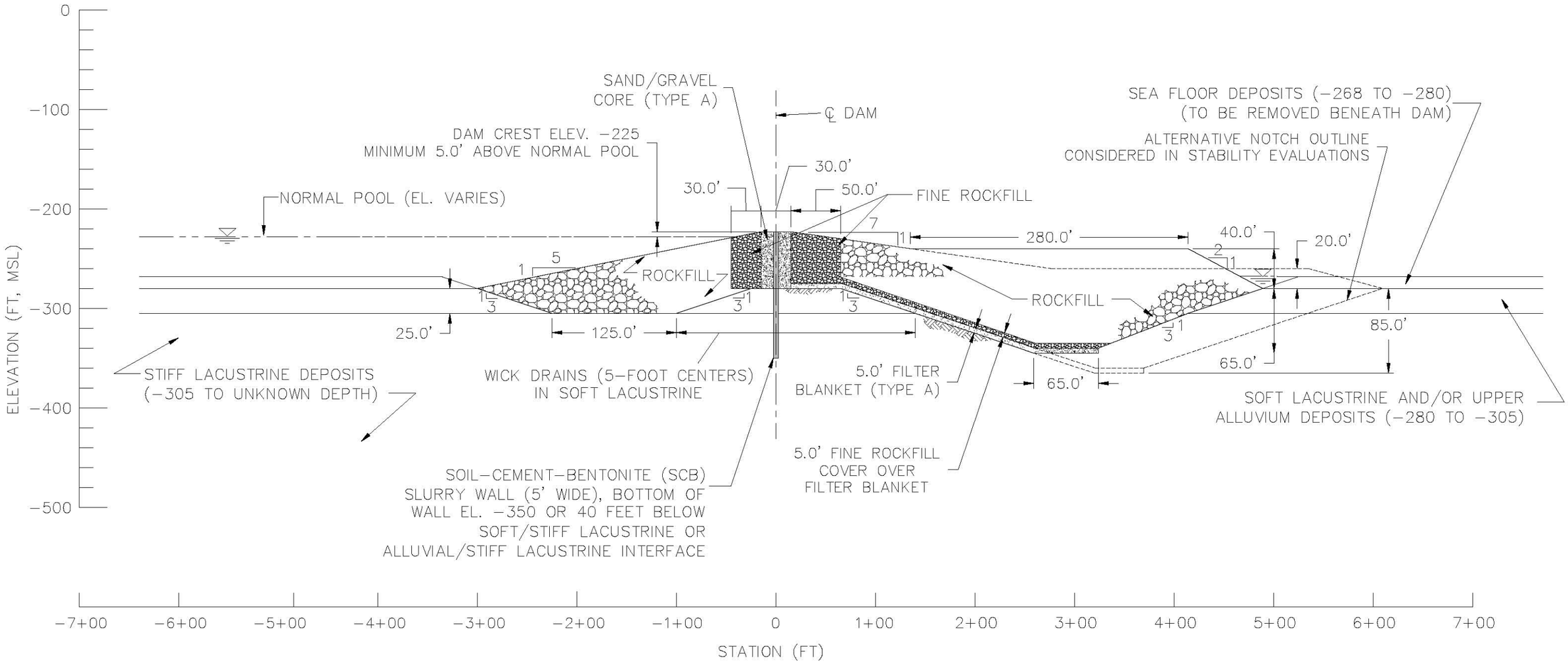
SALTON SEA RESTORATION PROJECT
Embankment Designs and Optimization Study

OPTION C

MODIFIED ROCK NOTCHES DAM WITH MINIMUM FILTERS

Project: 71100 | By: KAF/CL/MB | Date: August 2006

FIGURE 4.12



TYPICAL CROSS-SECTION OF MODIFIED ROCK NOTCHES WITH MAXIMUM SEISMIC FILTERS

0 50 100 200 300

SCALE IN FEET

LEGEND

ROCKFILL: 1'−4' SOUND AND DURABLE QUARRY ROCK DUMPED UNDERWATER

FINE ROCKFILL: 3"−12" SOUND AND DURABLE QUARRY ROCK DUMPED UNDERWATER

TYPE A SAND/GRAVEL CORE: CLEAN SAND AND GRAVEL, BUCKET PLACED IN LAYERS UNDERWATER

FILTER BLANKET: LAYER OF TYPE A SAND/GRAVEL COVERED BY A LAYER OF FINE ROCKFILL, PLACED BY DUMPING UNDERWATER

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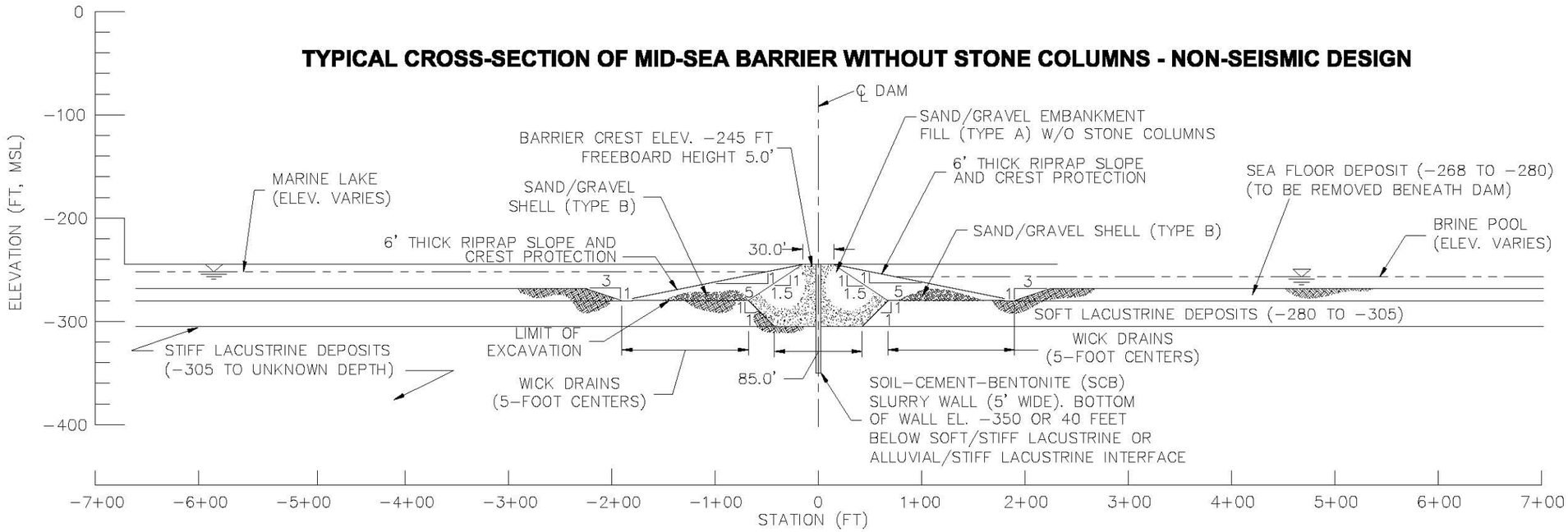
SALTON SEA RESTORATION PROJECT
Embankment Designs and Optimization Study

OPTION D
MODIFIED ROCK NOTCHES DAM WITH MAXIMUM SEISMIC FILTERS

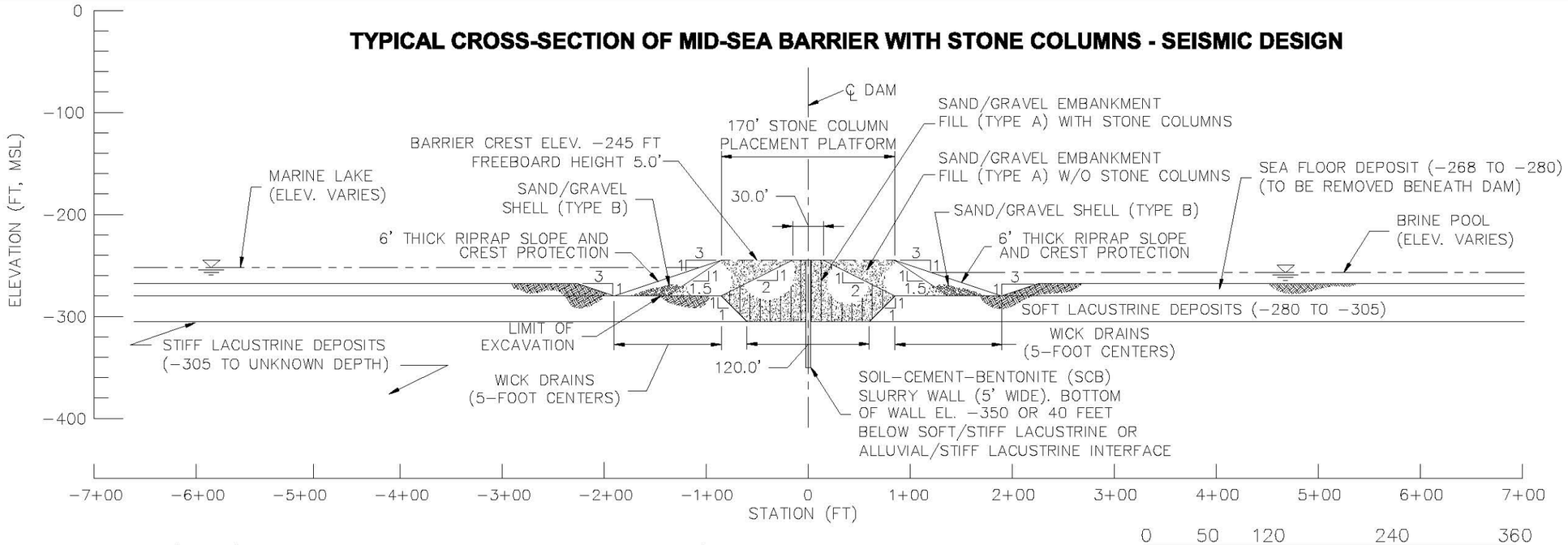
Project: 71100 | By: KAF/CL/MB | Date: August 2006

FIGURE 4.13

TYPICAL CROSS-SECTION OF MID-SEA BARRIER WITHOUT STONE COLUMNS - NON-SEISMIC DESIGN



TYPICAL CROSS-SECTION OF MID-SEA BARRIER WITH STONE COLUMNS - SEISMIC DESIGN



LEGEND

SAND/GRAVEL EMBANKMENT FILL (TYPE A): FINE TO COARSE SAND AND GRAVEL, MIX WITH MAXIMUM 3/4−INCH GRAVEL SIZE AND MAXIMUM 10% FINES SUITABLE FOR COMPACTION WITH STONE COLUMNS

SAND/GRAVEL SHELL (TYPE B): FINE TO COARSE SAND AND GRAVEL WITH VARIABLE FINES NOT INTENDED FOR COMPACTION WITH STONE COLUMNS

STONE COLUMNS: 3' DIA. STONE COLUMNS, 10' ON CENTERS, INSTALLED IN TYPE A SAND/GRAVEL (TRIANGULAR PATTERN).

RIPRAP SLOPE PROTECTION: 1'−4' DIAMETER SOUND AND DURABLE QUARRY ROCK DUMPED UNDERWATER

0 50 120 240 360

SCALE IN FEET

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SALTON SEA RESTORATION PROJECT
Embankment Designs and Optimization Study

"OPTIMIZED" MID-SEA BARRIER WITH AND WITHOUT STONE COLUMNS

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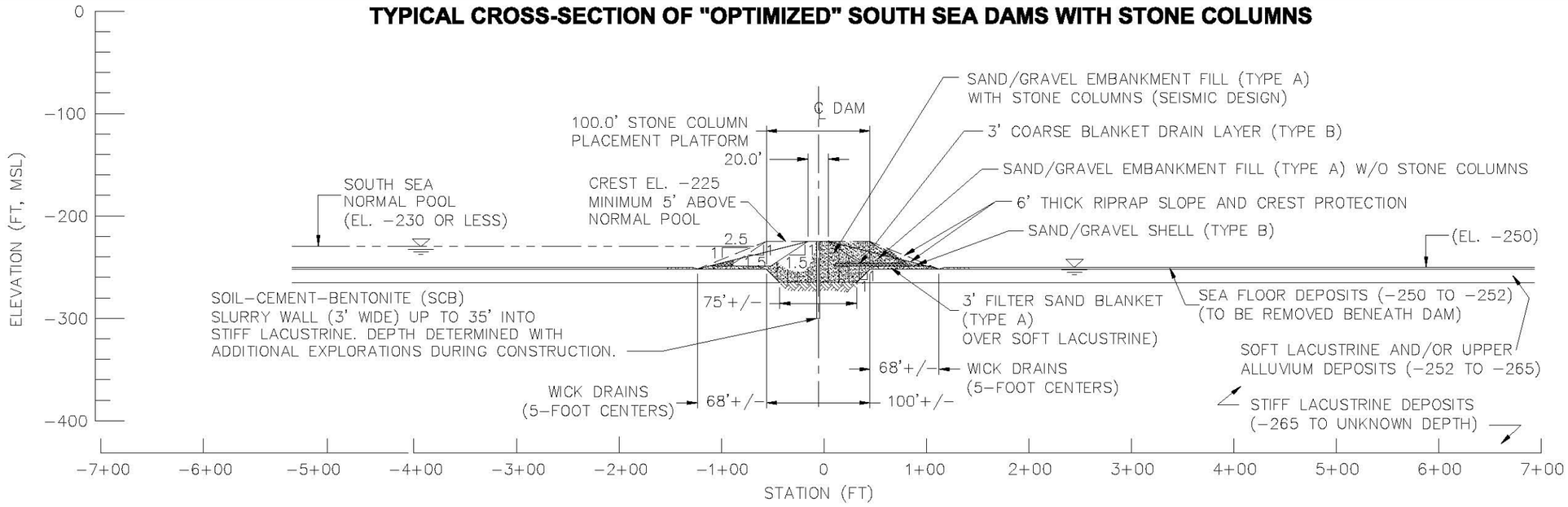
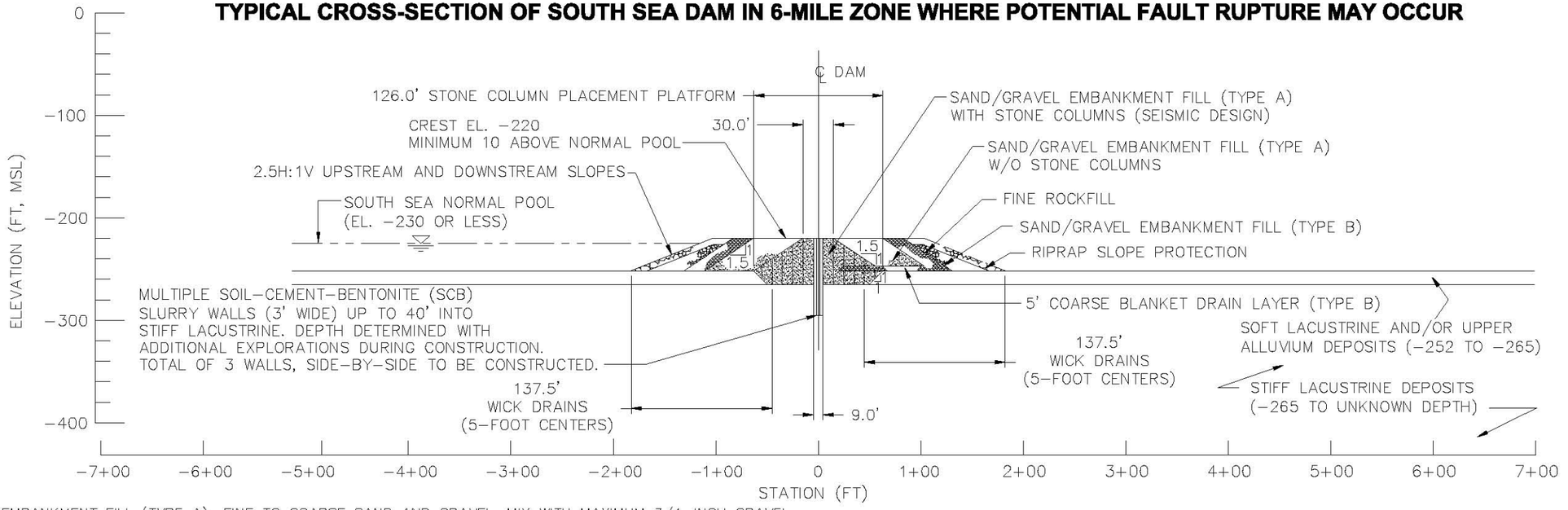
FIGURE 4.14

TYPICAL CROSS-SECTION OF "OPTIMIZED" SOUTH SEA DAMS WITH STONE COLUMNS



TYPICAL CROSS-SECTION OF SOUTH SEA DAM IN 6-MILE ZONE WHERE POTENTIAL FAULT RUPTURE MAY OCCUR



LEGEND

SAND/GRAVEL EMBANKMENT FILL (TYPE A): FINE TO COARSE SAND AND GRAVEL, MIX WITH MAXIMUM 3/4−INCH GRAVEL SIZE AND MAXIMUM 10% FINES SUITABLE FOR COMPACTION WITH STONE COLUMNS

SAND/GRAVEL SHELL (TYPE B): FINE TO COARSE SAND AND GRAVEL WITH VARIABLE FINES NOT INTENDED FOR COMPACTION WITH STONE COLUMNS

STONE COLUMNS: 3' DIA. STONE COLUMNS, 10' ON CENTERS, INSTALLED IN TYPE A SAND/GRAVEL (TRIANGULAR PATTERN).

RIPRAP SLOPE PROTECTION: 1'−4' DIAMETER SOUND AND DURABLE QUARRY ROCK DUMPED UNDERWATER

FINE ROCKFILL: 1"−6" SAND AND GRAVEL

0 50 120 240 360

SCALE IN FEET

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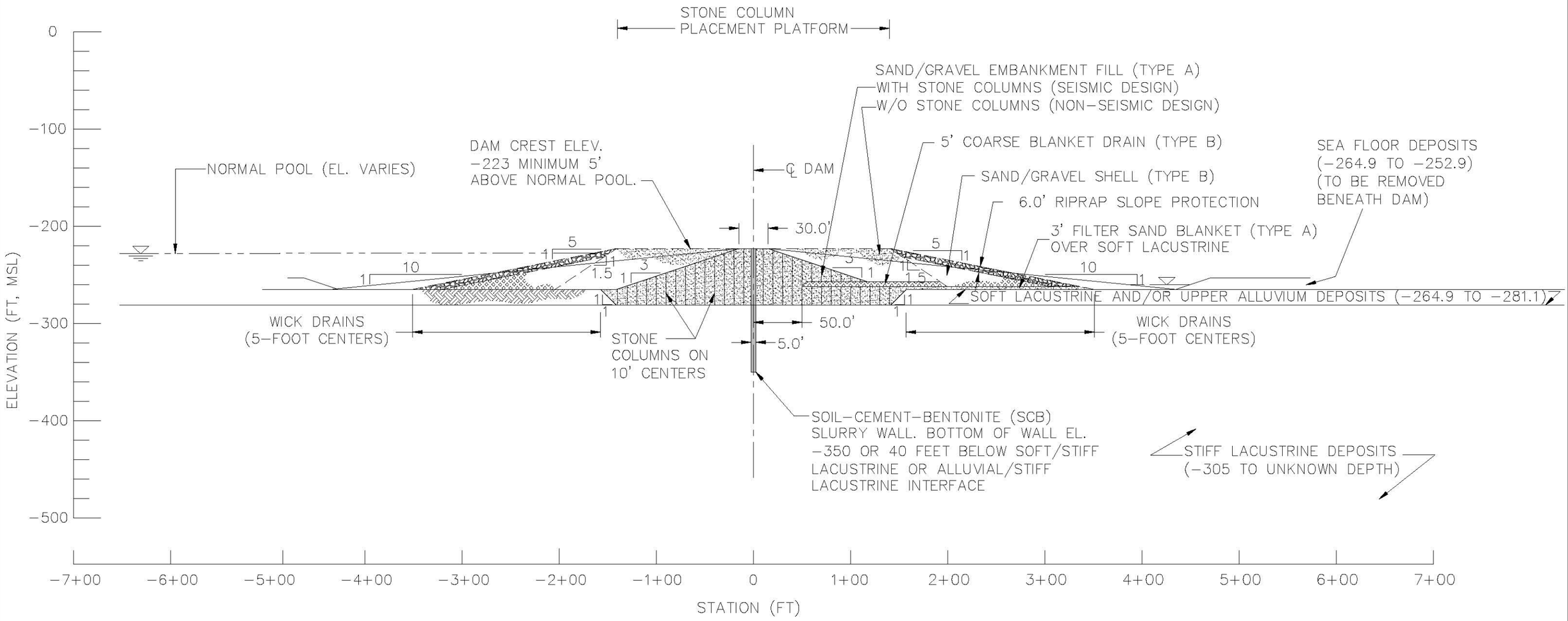
SALTON SEA RESTORATION PROJECT
Embankment Designs and Optimization Study

"OPTIMIZED" SOUTH-SEA SAND DAM WITH STONE COLUMNS

Project: 71100 | By: KAF/CL/MB | Date: August 2006

FIGURE 5.1



TYPICAL CROSS-SECTION OF NORTH SEA SAND DAM WITH STONE COLUMNS

NOTES

SOLID LINES SHOW THE IDEALIZED SECTION USED IN STABILITY AND SEEPAGE ANALYSES. DASHED LIINES SHOW THE SECTION FOR CONSTRUCTION USING CONVEYOR PLACEMENT METHODS.

0 50 100 200 300
SCALE IN FEET

LEGEND

SAND/GRAVEL EMBANKMENT FILL (TYPE A): FINE TO COARSE SAND AND GRAVEL, MIX WITH MAXIMUM 3/4-INCH GRAVEL SIZE AND MAXIMUM 10% FINES SUITABLE FOR COMPACTION WITH STONE COLUMNS

SAND/GRAVEL SHELL (TYPE B): FINE TO COARSE SAND AND GRAVEL WITH VARIABLE FINES NOT INTENDED FOR COMPACTION WITH STONE COLUMNS

TYPE A WITH STONE COLUMNS: 3' DIA. STONE COLUMNS, 10' ON CENTER, INSTALLED IN TYPE A SAND/GRAVEL (TRIANGULAR PATTERN).

RIP RAP SLOPE PROTECTION: 1'-4' DIAMETER SOUND AND DURABLE QUARRY ROCK DUMPED UNDERWATER

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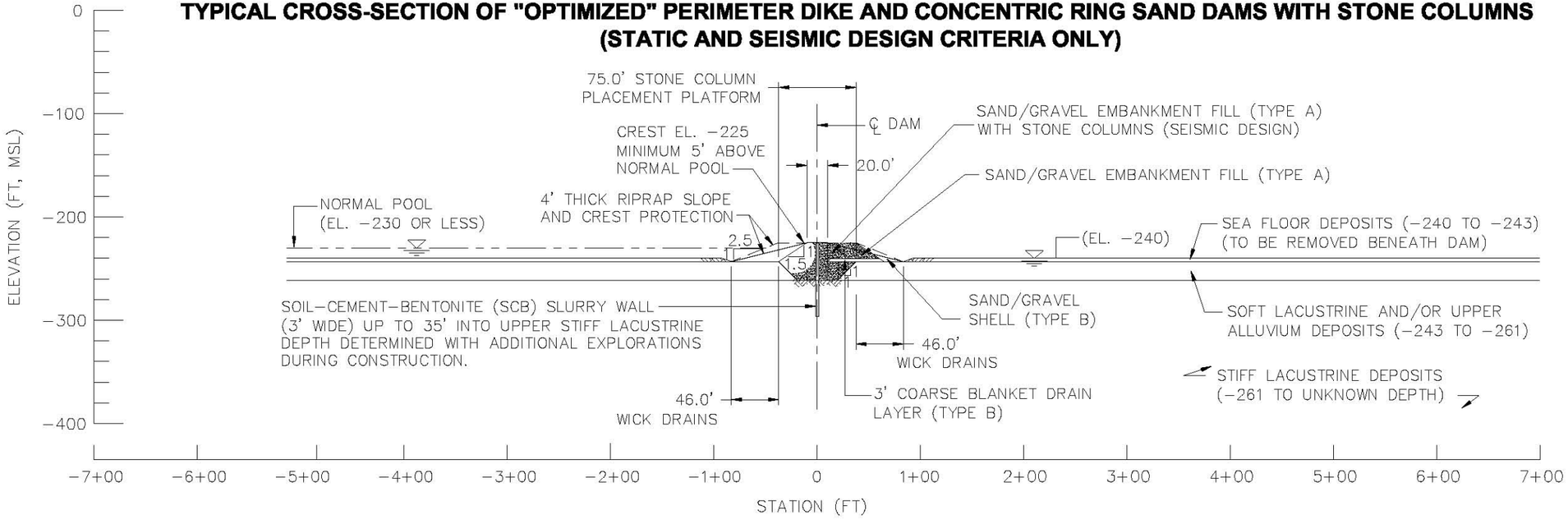
SALTON SEA RESTORATION PROJECT
Embankment Designs and Optimization Study

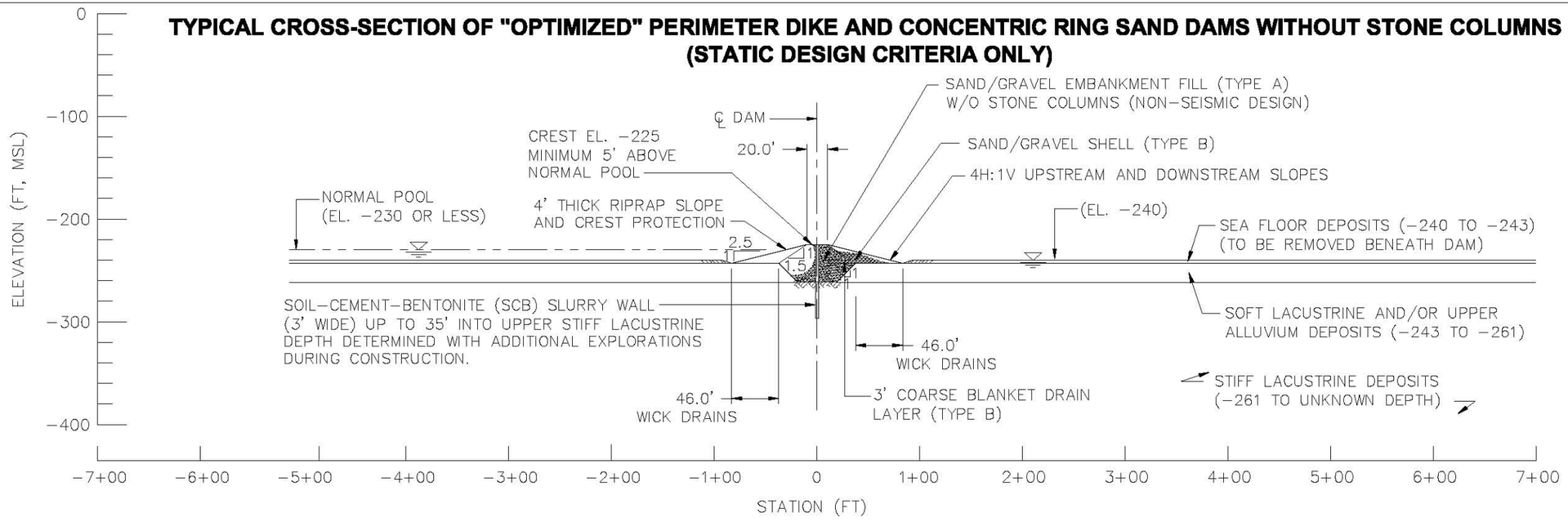
"OPTIMIZED" NORTH-SEA DAM WITH STONE COLUMNS

Project: 71100	By: KAF/CL/MB	Date: August 2006	**FIGURE 5.2**

TYPICAL CROSS-SECTION OF "OPTIMIZED" PERIMETER DIKE AND CONCENTRIC RING SAND DAMS WITH STONE COLUMNS (STATIC AND SEISMIC DESIGN CRITERIA ONLY)



TYPICAL CROSS-SECTION OF "OPTIMIZED" PERIMETER DIKE AND CONCENTRIC RING SAND DAMS WITHOUT STONE COLUMNS (STATIC DESIGN CRITERIA ONLY)



LEGEND

SAND/GRAVEL EMBANKMENT FILL (TYPE A): FINE TO COARSE SAND AND GRAVEL, MIX WITH MAXIMUM 3/4−INCH GRAVEL SIZE AND MAXIMUM 10% FINES SUITABLE FOR COMPACTION WITH STONE COLUMNS

SAND/GRAVEL SHELL (TYPE B): FINE TO COARSE SAND AND GRAVEL WITH VARIABLE FINES NOT INTENDED FOR COMPACTION WITH STONE COLUMNS

STONE COLUMNS: 3' DIA. STONE COLUMNS, 10' ON CENTERS, INSTALLED IN TYPE A SAND/GRAVEL (TRIANGULAR PATTERN).

RIPRAP SLOPE PROTECTION: 1'−4' DIAMETER SOUND AND DURABLE QUARRY ROCK DUMPED UNDERWATER

0 50 120 240 360

SCALE IN FEET

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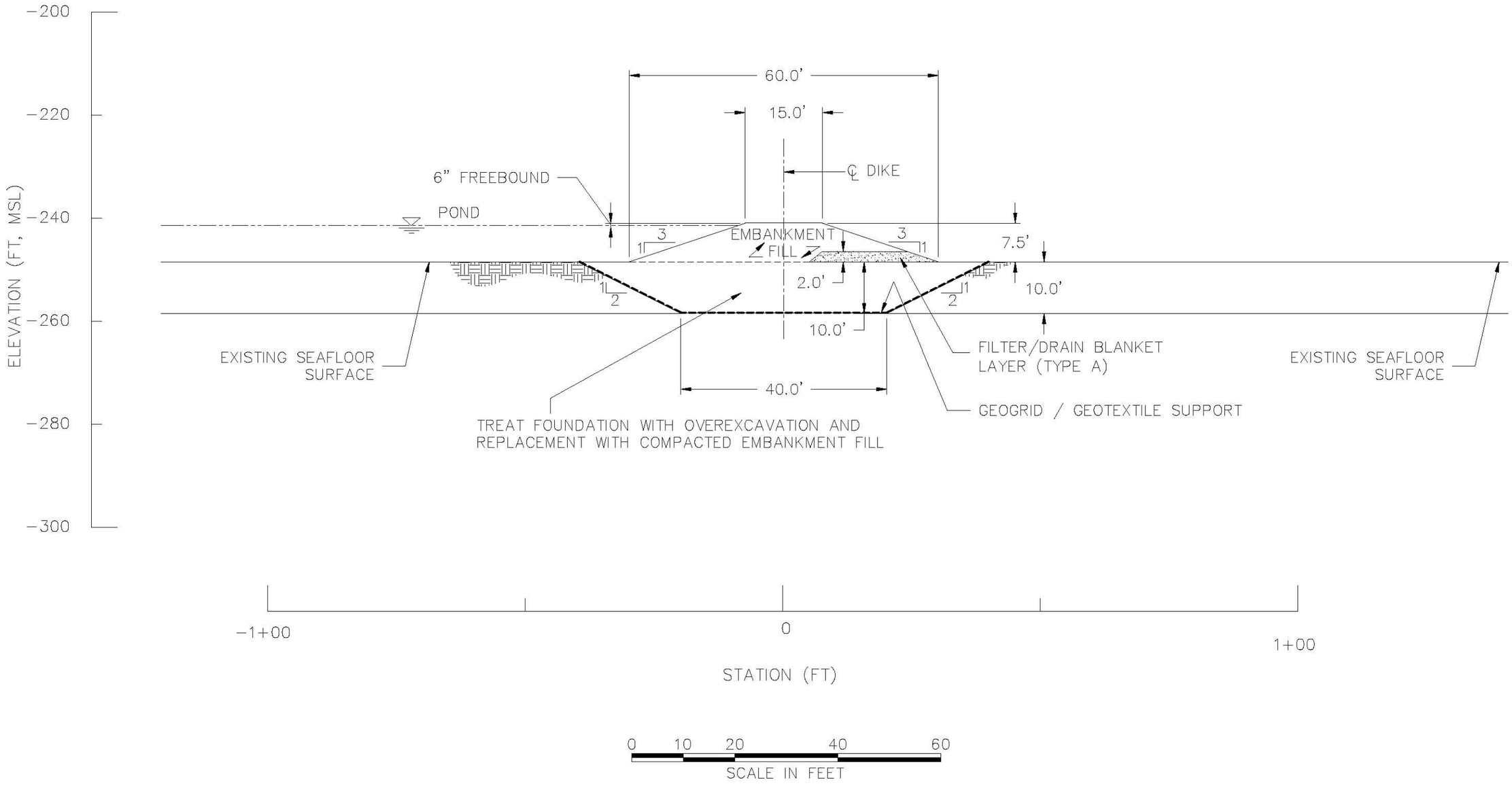
SALTON SEA RESTORATION PROJECT
Embankment Designs and Optimization Study

"OPTIMIZED" PERIMETER AND CONCENTRIC LAKES SAND DAMS (DIKES) WITH AND WITHOUT STONE COLUMNS

Project: 71100 | By: KAF/CL/MB | Date: August 2006

FIGURE 5.3



LEGEND

FILTER/DRAIN BLANKET (TYPE A): FINE TO COARSE SAND AND GRAVEL, MIX WITH MAXIMUM 3/4−INCH GRAVEL SIZE AND MAXIMUM 10% FINES.

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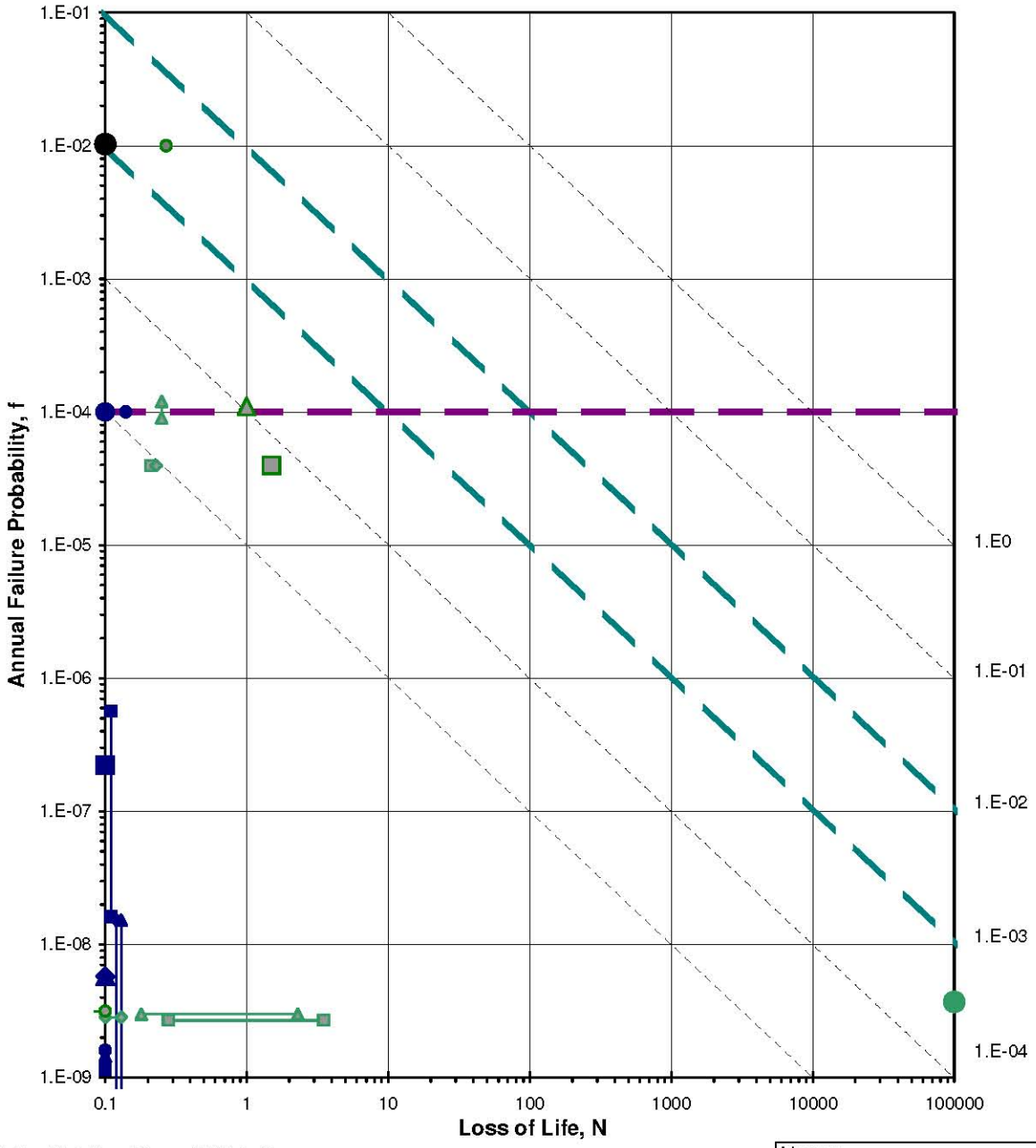
SALTON SEA RESTORATION PROJECT
Embankment Designs and Optimization Study

"OPTIMIZED" HABITAT POND EMBANKMENT CONFIGURATION

Project: 71100 | By: KAF/RJS/MB | Date: August 2006

FIGURE 5.4

Risk Estimates
Alternative No 1



- Static-Mid-Sea-Dam, FM No 8
- Static-Perimeter Dike, Based on FM No 2
- Static-South-Sea Dam, Based on FM No 2
- Static-Habitat Ponds, Under Seepage
- Seismic-Mid-Sea-Dam, FM No 6
- Seismic-Perimeter Dike, Based on FM No 6
- Seismic-South-Sea Dam, Based on FM No 12 with mitigation design features
- Seismic-Habitat Ponds, Overtopping

Notes:
These values are estimated based on maximum APF for static and seismic FMs for each structure in the alternative

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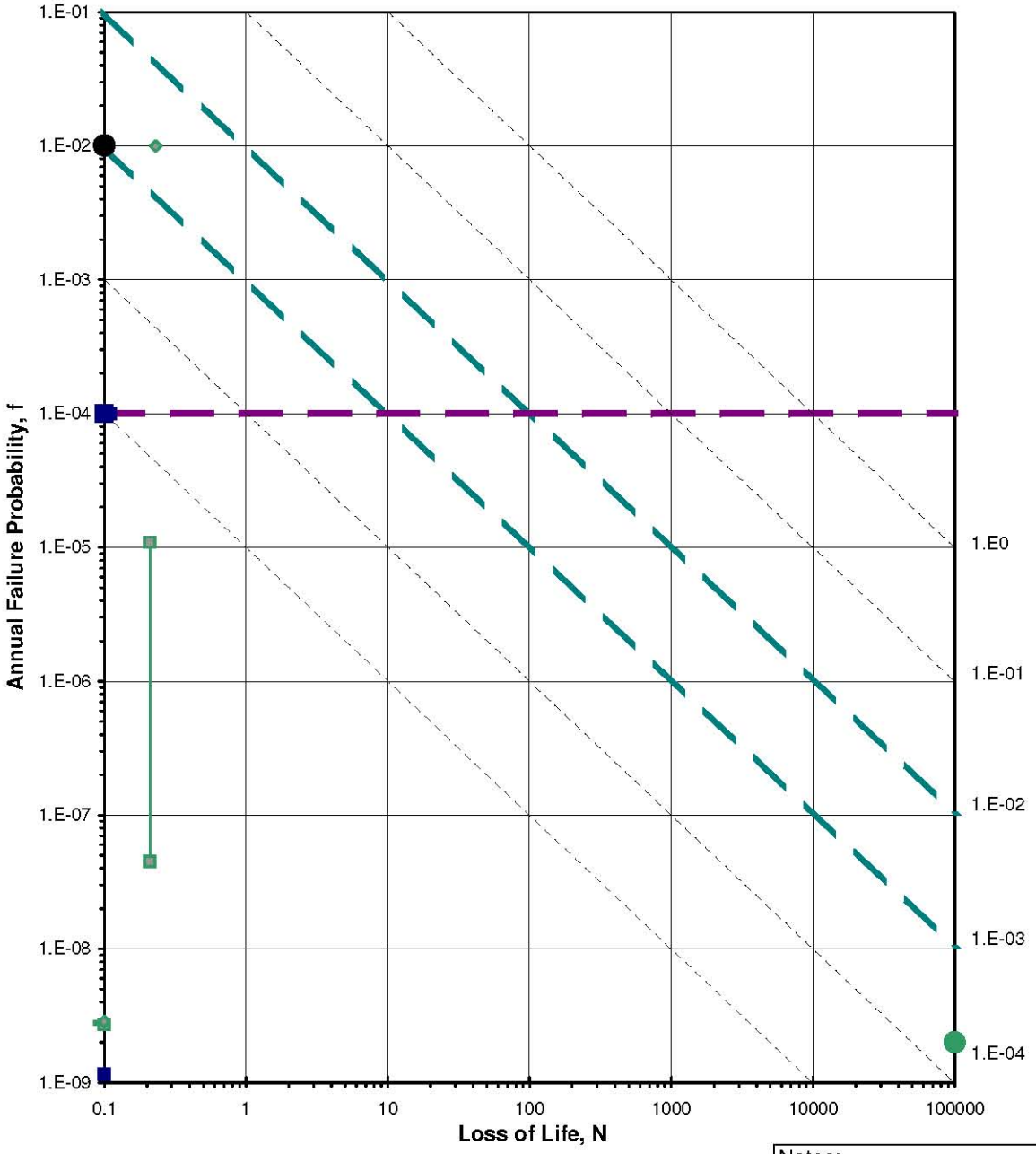
SALTON SEA RESTORATION PROJECT
Embankment Designs and Optimization Study

f-N Diagram Portraying Risks for Restoration Alternative No. 1 - Mid-Sea-Dam/North Marine Lake

Project: 71100	By: KAF/CL/ES	Date: August 2006	**FIGURE 6.1**

Risk Estimates
Alternative No 2



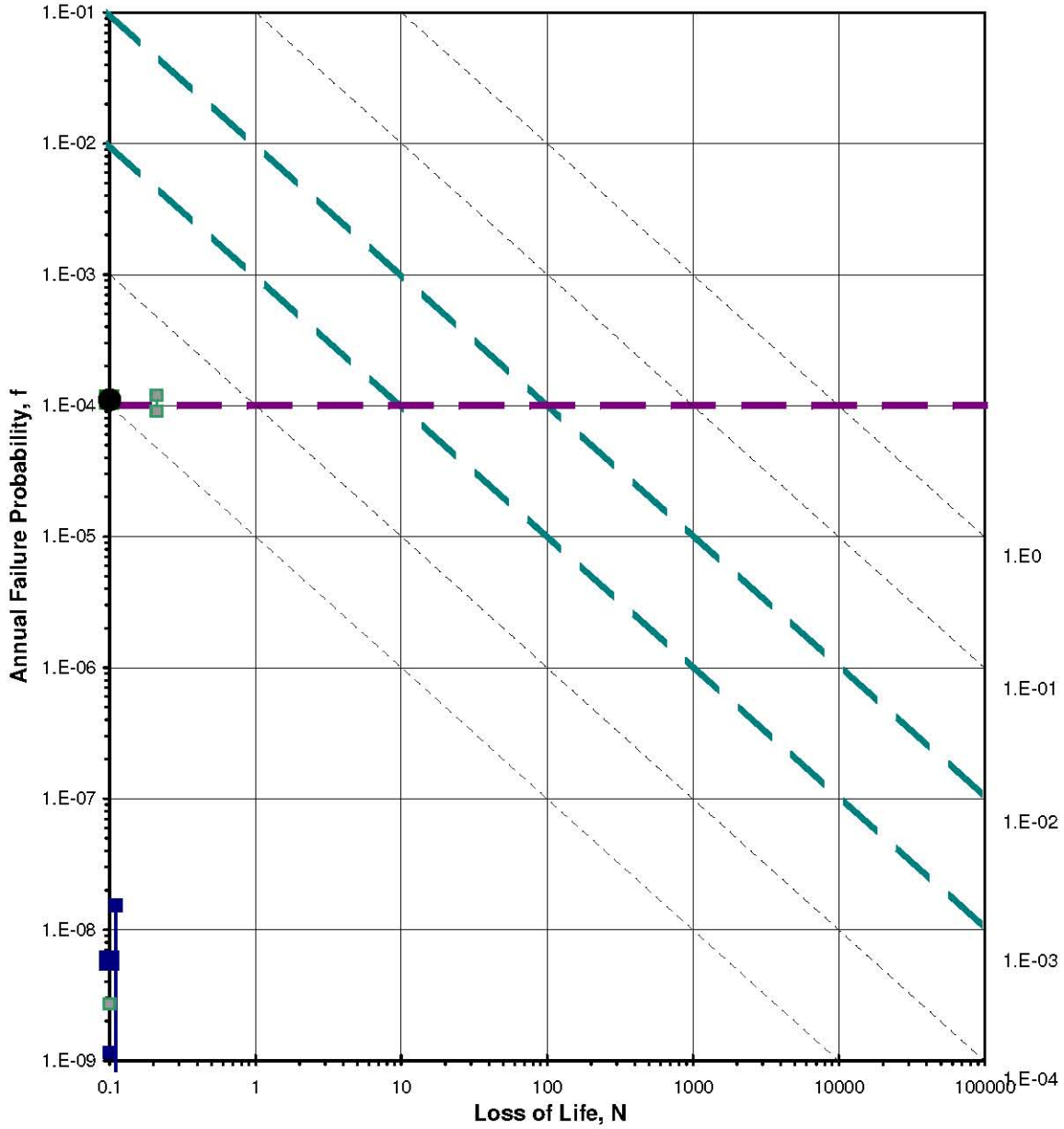
- Static-Habitat Ponds, Under Seepage
- Seismic-Mid-Sea Barrier, Based on FM No 3 with stone columns
- Seismic-Habitat Ponds, Overtopping
- Total Static Risk Estimate
- Total Seismic Risk Estimate
- Total Probability of Failure - All Loadings

Notes:
These values are estimated based on maximum APF for static and seismic FMs for each structure in the alternative

Mid-Sea Barrier without stone columns would have APF 1.0E-02 and ALL 0.0E-00

United States Department of the Interior Bureau of Reclamation	**SALTON SEA RESTORATION PROJECT** Embankment Designs and Optimization Study	**f-N Diagram Portraying Risks for Restoration Alternative No. 2 - Mid-Sea-Barrier/South Marine Lake**
KLEINFELDER	Project: 71100 | By: KAF/CL/ES | Date: August 2006	**FIGURE 6.2**

Risk Estimates
Alternative No 3



- Static-Concentric Ring Dikes (outter rings), Underseepage
- Seismic-Concentric Ring Dikes (outer rings) with mitigation design features, Translation
- Total Static Risk Estimate
- Total Seismic Risk Estimate
- Total Probability of Failure - All Loadings

Notes:
These values are estimated based on maximum APF for static and seismic FMs for each structure in the alternative

Outer Concentric Ring Embankment without design features mitigating translation failure, would have APF of 1.0E-02 (failure by translation) and ALL of 0.0E-00

inner Concentric Rings not meeting seismic or seepage design criteria, would have APF 1.0E-02 (Overtopping) and ALL of 0.0E-000

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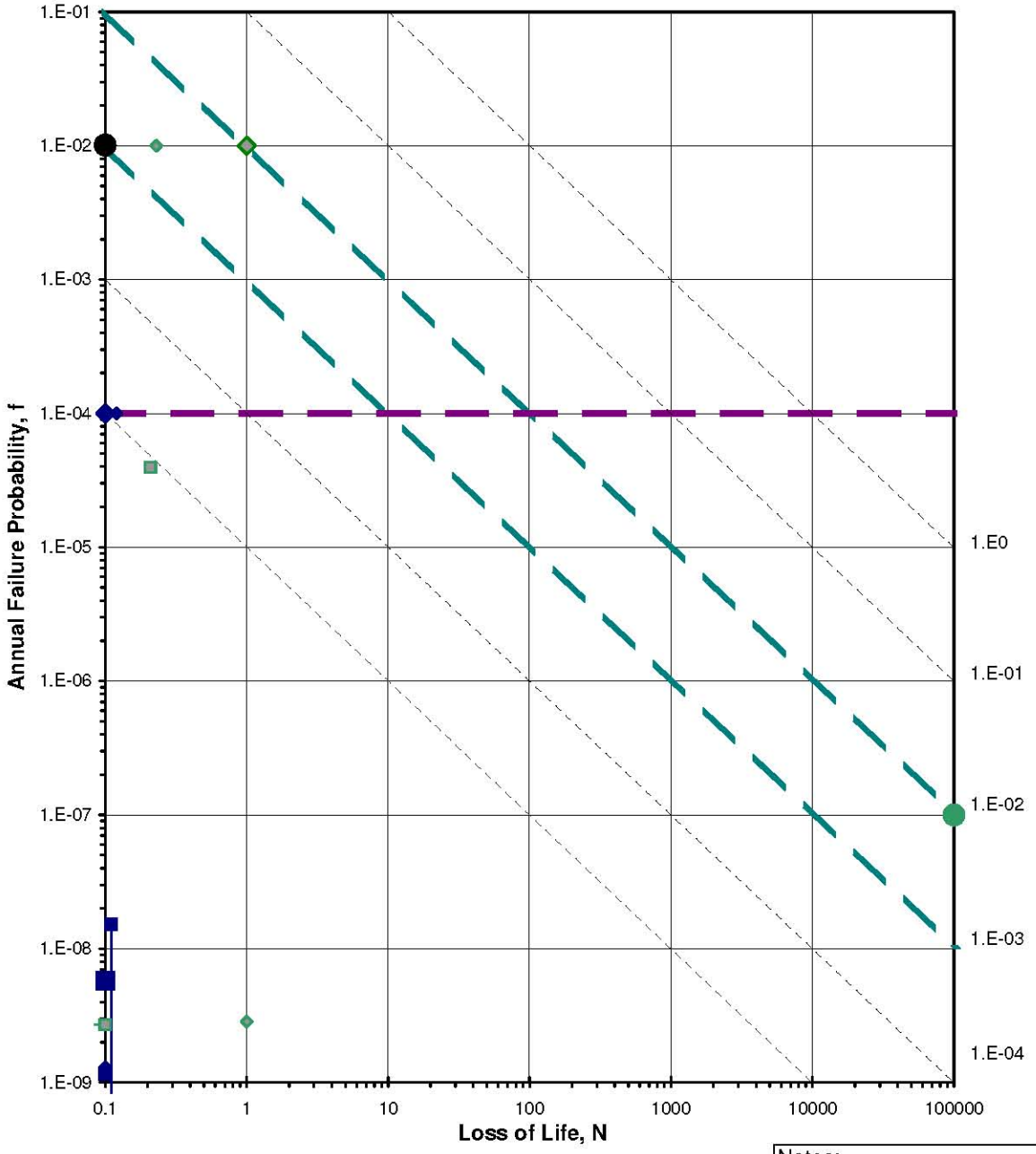
SALTON SEA RESTORATION PROJECT
Embankment Designs and Optimization Study

f-N Diagram Portraying Risks for Restoration Alternative No. 3 - Concentric Lakes Dikes

Project: 71100	By: KAF/CL/ES	Date: August 2006	**FIGURE 6.3**

Risk Estimates
Alternative No 4

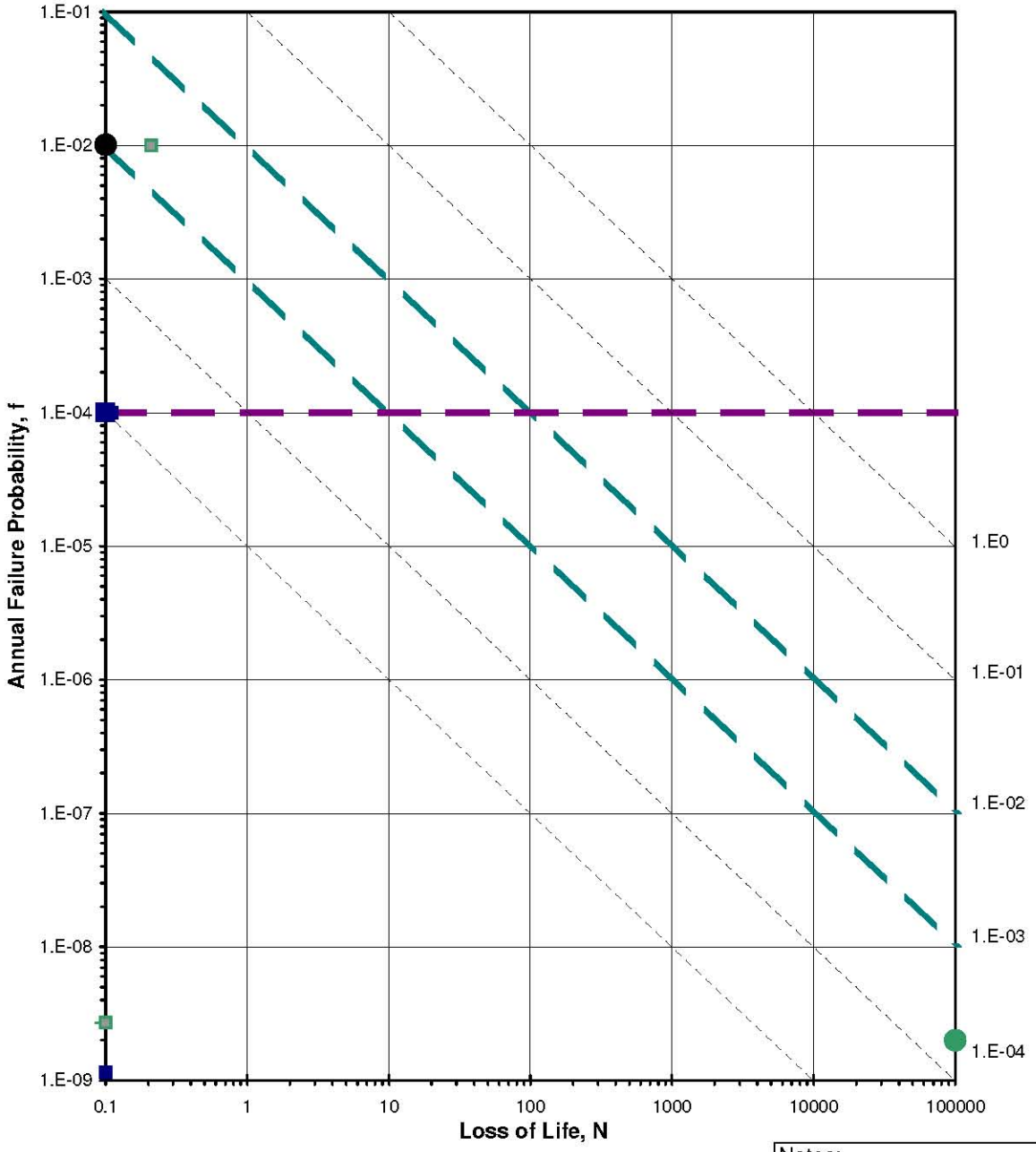


- Static-North-Sea Dam, Based on FM No 2
- Static-Habitat Ponds, Under Seepage
- Seismic-North-Sea Dam, Based on FM No 6
- Seismic-Habitat Ponds, Overtopping
- Total Static Risk Estimate
- Total Seismic Risk Estimate
- Total Probability of Failure - All Loadings

Notes:
These values are estimated based on maximum APF for static and seismic FMs for each structure in the alternative

United States Department of the Interior Bureau of Reclamation KLEINFELDER	**SALTON SEA RESTORATION PROJECT** Embankment Designs and Optimization Study	**f-N Diagram Portraying Risks for Restoration Alternative No. 4 - North-Sea Dam / Marine Lake**
Project: 71100 | By: KAF/CL/ES | Date: August 2006		**FIGURE 6.4**

Risk Estimates
Alternative No 5



- Static-Habitat Ponds, Under Seepage
- Seismic-Habitat Ponds, Overtopping
- Total Static Risk Estimate
- Total Seismic Risk Estimate
- Total Probability of Failure - All Loadings

Notes:
These values are estimated based on maximum APF for static and seismic FMs for each structure in the alternative

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SALTON SEA RESTORATION PROJECT
Embankment Designs and Optimization Study

f-N Diagram Portraying Risks for Restoration Alternative No. 5 - Habitat Enhancement without Marine Lake

Project: 71100	By: KAF/CL/ES	Date: August 2006	**FIGURE 6.5**