# Restoration of the Salton Sea

## Volume 2: Embankment Designs and Optimization Study

## Appendix 2B: Seepage and Stability Analysis

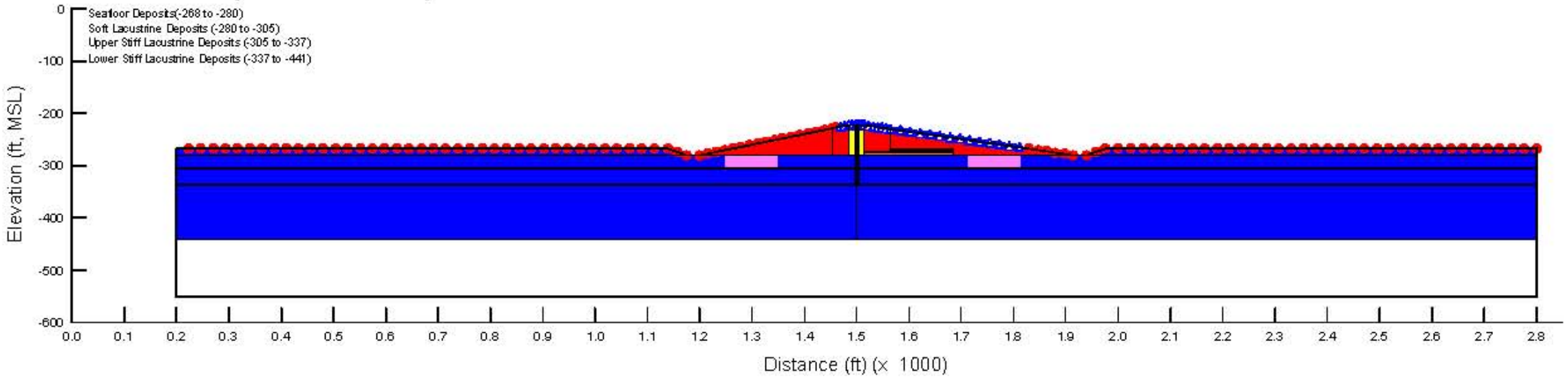
## Attachment B Seepage and Stability Analysis Results

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

**Prepared by:**
**Kleinfelder, Inc.**
**Golden, CO 80401**
**Project No. 71100**

**May 2007**

## Section Geometry and Boundary Conditions



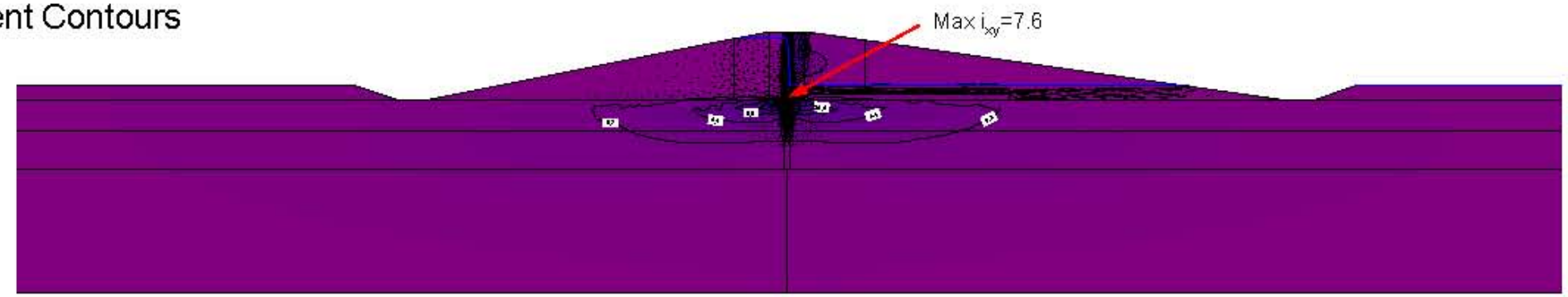

### Boundary Conditions Legend

- Constant Total Head
- Seepage Exit Boundary

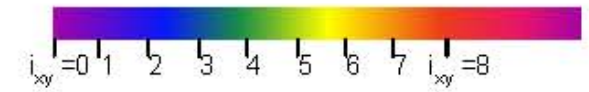
### Material Properties Legend

| Material | Kh ft/sec | Kv/Kh | Color |
|---|---|---|---|
| Rockfill | $3.28*10^{-2}$ | 0.25 | |
| Fine Rockfill | $3.28*10^{-2}$ | 0.25 | |
| Filter Blanket | $1.77*10^{-4}$ | 1 | |
| Sand Gravel Core | $3.28*10^{-4}$ | 0.25 | |
| Slurry Wall | $3.28*10^{-8}$ | 1 | |
| Seafloor Deposits | $3.28*10^{-7}$ | 0.1 | |
| Soft Lacustrine | $3.28*10^{-7}$ | 0.1 | |
| Stiff Lacustrine | $3.28*10^{-7}$ | 0.1 | |
| Jet-grouted Lacustrine | $4.92*10^{-8}$ | 1 | |

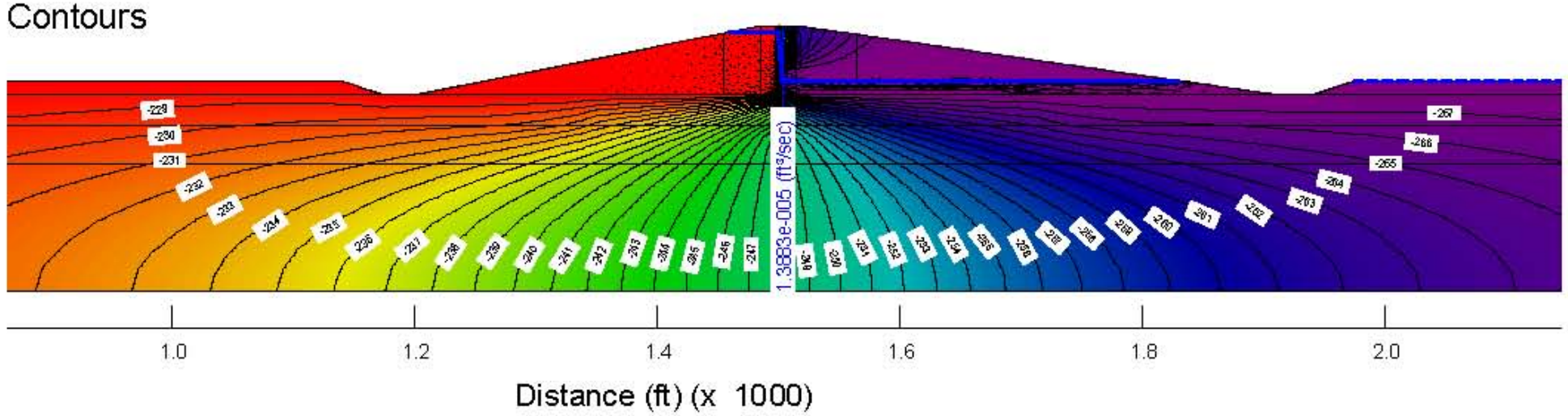
## XY Gradient Contours




### XY Gradient $i_{xy}$ Contours Legend




## Total Head Contours




### Total Head Contours Legend


Seafloor Deposits (-268 to -280)
Soft Lacustrine Deposits (-280 to -305)
Upper Stiff Lacustrine Deposits (-305 to -337)
Lower Stiff Lacustrine Deposits (-337 to -441)

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**SALTON SEA RESTORATION PROJECT**
EMBANKMENT DESIGNS AND OPTIMIZATION STUDY
Appendix 2B – Seepage and Stability Analyses

Seepage Analysis
Case 4,1 Mid-Sea Dam
Jetgrouting Under Shells

| Project 71100 | By E. Sossenkina | August 2006 | **FIGURE B.B-1** |
|---|---|---|---|

71100/DEN6R101

Description: Rockfill
Wt: 115
Cohesion: 0
Phi: 45
Piezometric Line: 1

Description: Core - Clean Sand & Gravel
Wt: 120
Cohesion: 0
Phi: 30
Piezometric Line: 1

Description: Fine Rockfill
Wt: 118
Cohesion: 0
Phi: 42
Piezometric Line: 1

Description: SCB Slurry Wall
Wt: 120
Cohesion: 100
Phi: 30
Piezometric Line: 1

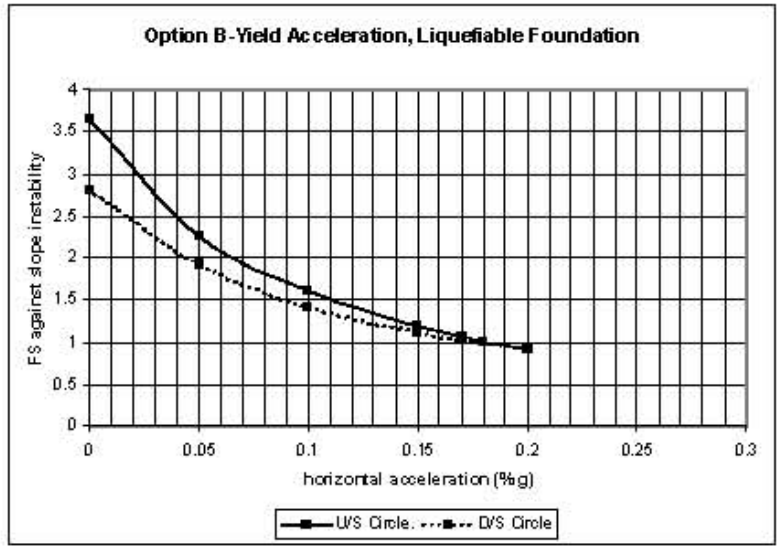
Description: Filter Blanket-Liquefied
Wt: 125
Cohesion: 150
Phi: 0
Piezometric Line: 1

Description: Untreated Lacustrine - Liquefied
Wt: 115
Cohesion: 250
Phi: 0
Piezometric Line: 1

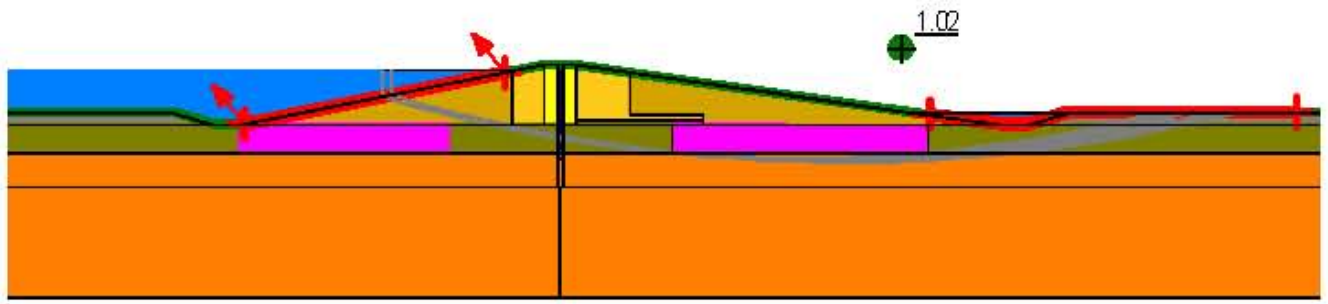
Description: Upper Stiff Lacustrine, Seismic
Wt: 118
Cohesion: 200
Phi: 33
Unit Wt. Above WT: 118
Phi-B: 0
Anisotropic Fn: 1
Piezometric Line: 1

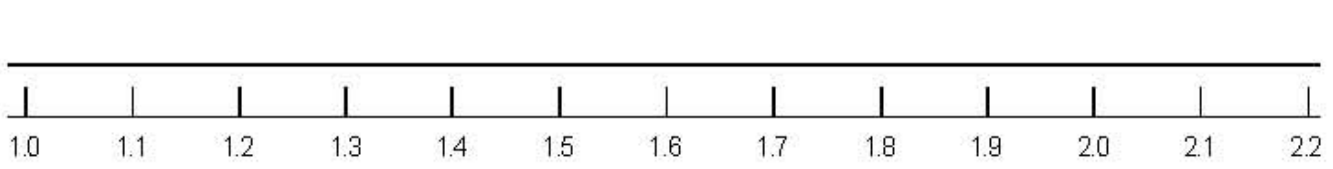
Description: Seafloor Deposit - Seismic
Wt: 98
C-Datum: 13
C-Rate of Increase: 15.4
Limiting C: 600
Elevation: -268
Piezometric Line: 1

Description: Jet Grouted Lacustrine
Wt: 120
Cohesion: 7200
Phi: 0
Piezometric Line: 1

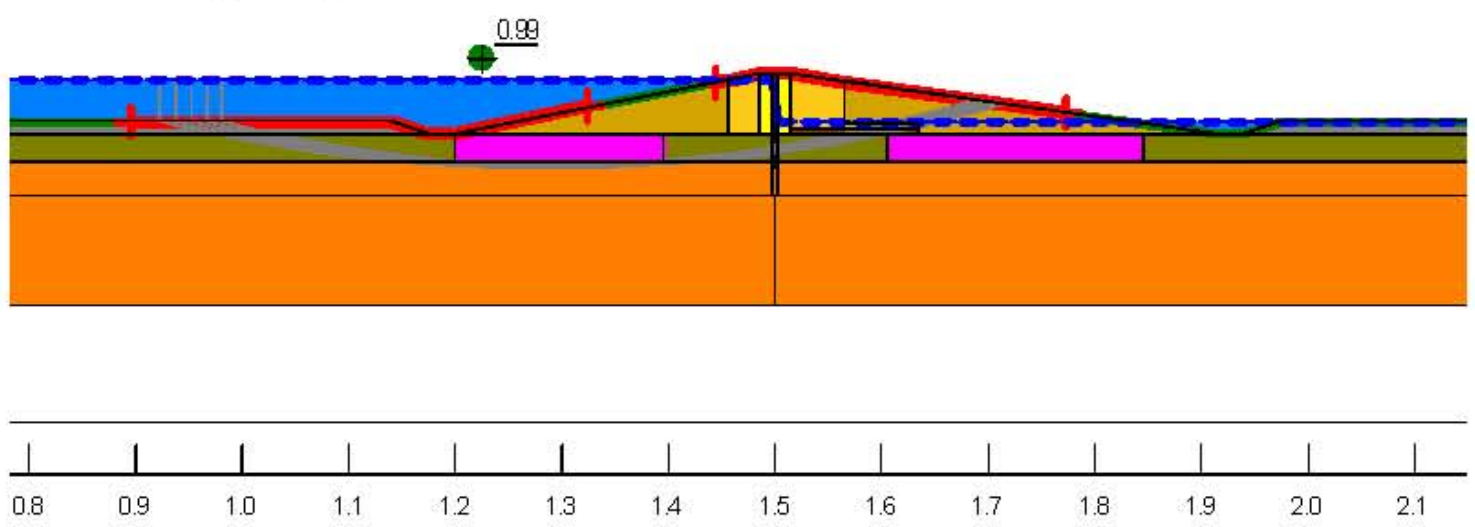



D/S Circles Ky =0.18g

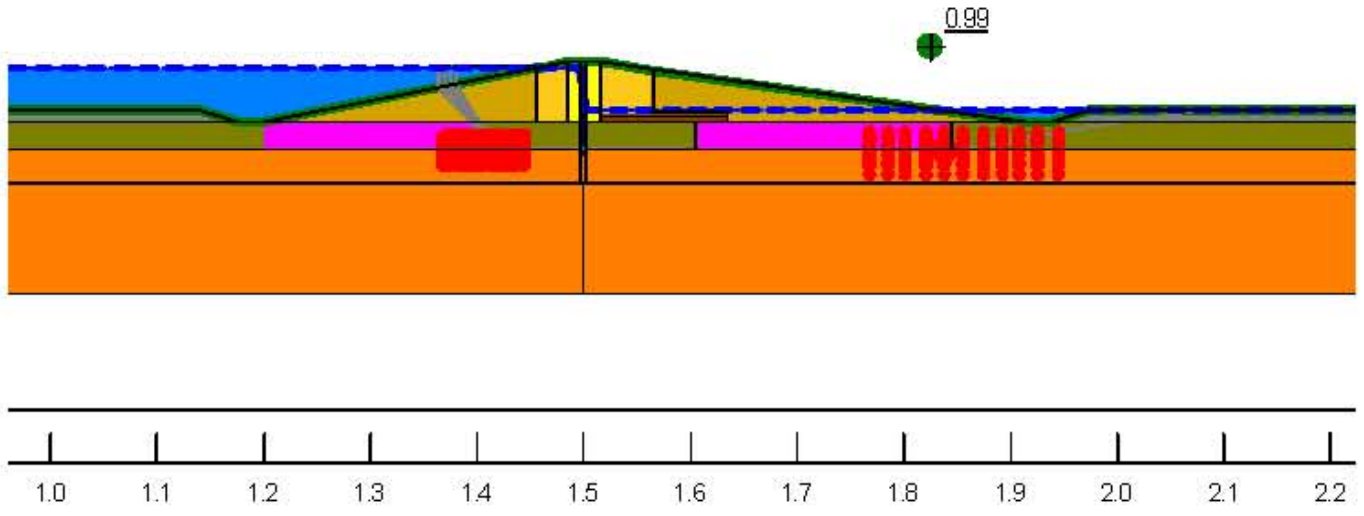



U/S Circles Ky=0.18g




D/S Wedge Ky=0.17g







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**SALTON SEA RESTORATION PROJECT**
EMBANKMENT DESIGNS AND
OPTIMIZATION STUDY
Appendix 2B – Seepage and Stability Analyses

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Seismic Slope Stability Analysis
Case 4,1 Mid-Sea Dam
Jetgrouting Under Shells

**FIGURE B.B-2**

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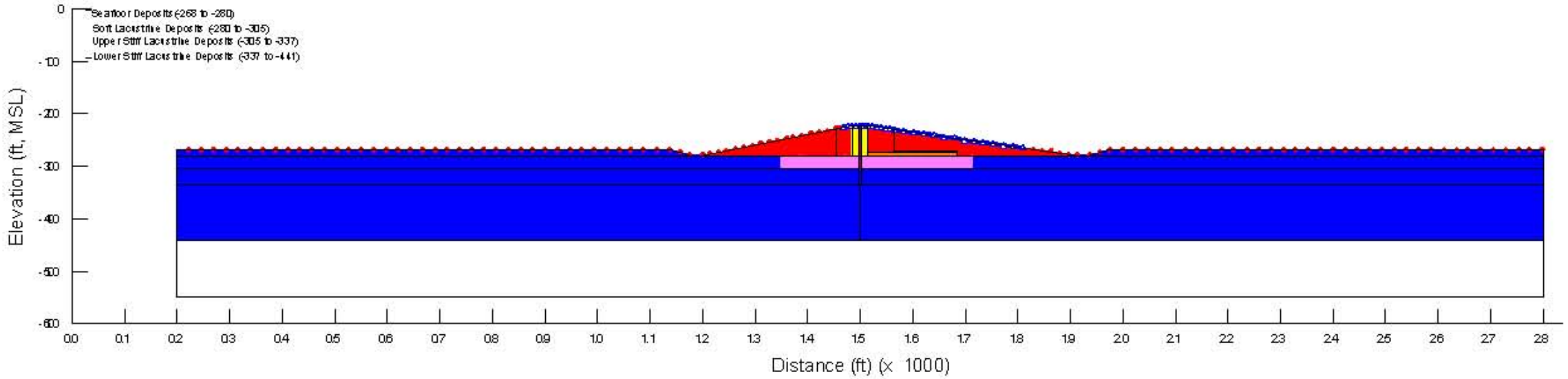
## Section Geometry and Boundary Conditions



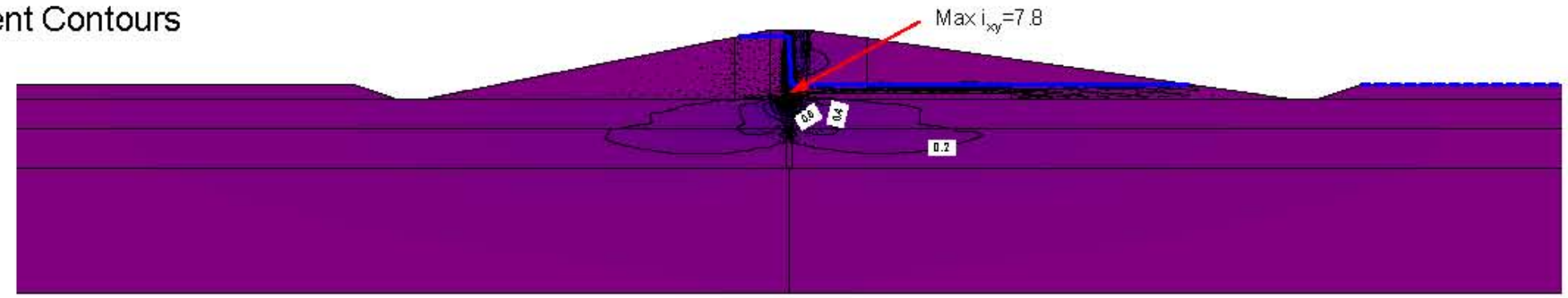

### Boundary Conditions Legend

Constant Total Head
Seepage Exit Boundary

### Material Properties Legend

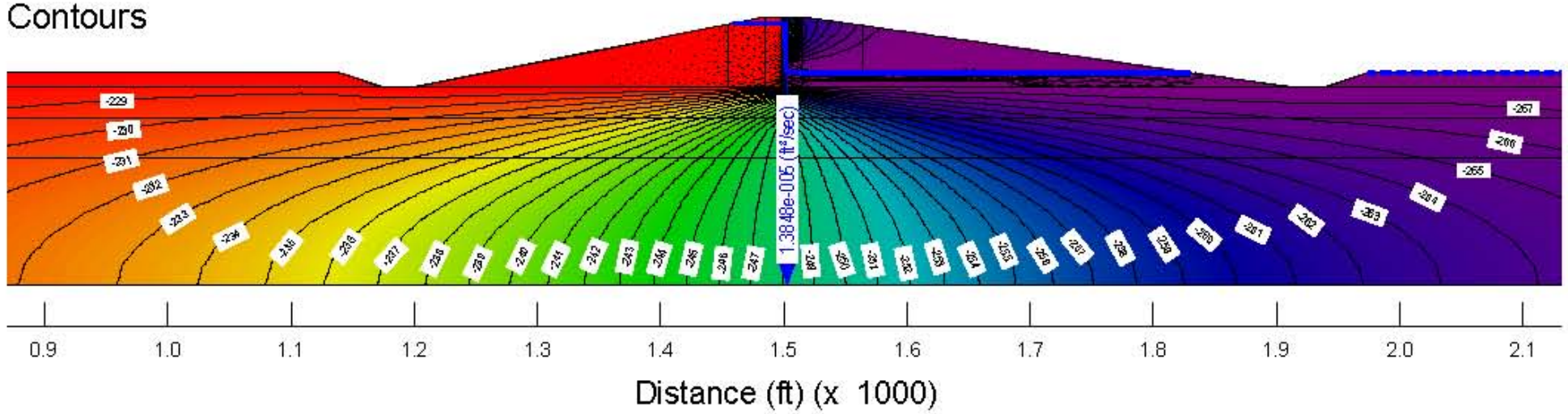
| Material | Kh ft/sec | Kv/Kh | Color |
|---|---|---|---|
| Rockfill | $3.28*10^{-2}$ | 0.25 | |
| Fine Rockfill | $3.28*10^{-2}$ | 0.25 | |
| Filter Blanket | $1.77*10^{-4}$ | 1 | |
| Sand Gravel Core | $3.28*10^{-4}$ | 0.25 | |
| Slurry Wall | $3.28*10^{-8}$ | 1 | |
| Seafloor Deposits | $3.28*10^{-7}$ | 0.1 | |
| Soft Lacustrine | $3.28*10^{-7}$ | 0.1 | |
| Stiff Lacustrine | $3.28*10^{-7}$ | 0.1 | |
| Jet-grouted Lacustrine | $4.92*10^{-8}$ | 1 | |

## XY Gradient Contours




### XY Gradient $i_{xy}$ Contours Legend


## Total Head Contours




### Total Head Contours Legend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**SALTON SEA RESTORATION PROJECT**
EMBANKMENT DESIGNS AND OPTIMIZATION STUDY
Appendix 2B – Seepage and Stability Analyses

Project 71100 | By E. Sossenkina | August 2006

Seepage Analysis
Case 4,2 Mid-Sea Dam
Jetgrouting Under Central Portion

**FIGURE B.B-3**

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Description: SCB Slurry Wall
Wt: 120
Cohesion: 100
Phi: 30
Piezometric Line: 1

Description: Core - Clean Sand & Gravel
Wt: 120
Cohesion: 0
Phi: 30
Piezometric Line: 1

Description: Fine Rockfill
Wt: 118
Cohesion: 0
Phi: 42
Piezometric Line: 1

Description: Rockfill
Wt: 115
Cohesion: 0
Phi: 45
Piezometric Line: 1

Description: Filter Blanket-Liquefied
Wt: 125
Cohesion: 150
Phi: 0
Piezometric Line: 1

Function Description: Sh/Sv = 0.9

Description: Seafloor Deposit - EOC Seismic
Wt: 98
C-Datum: 13
C-Rate of Increase: 15.4
Limiting C: 600
Elevation: -268
Piezometric Line: 1

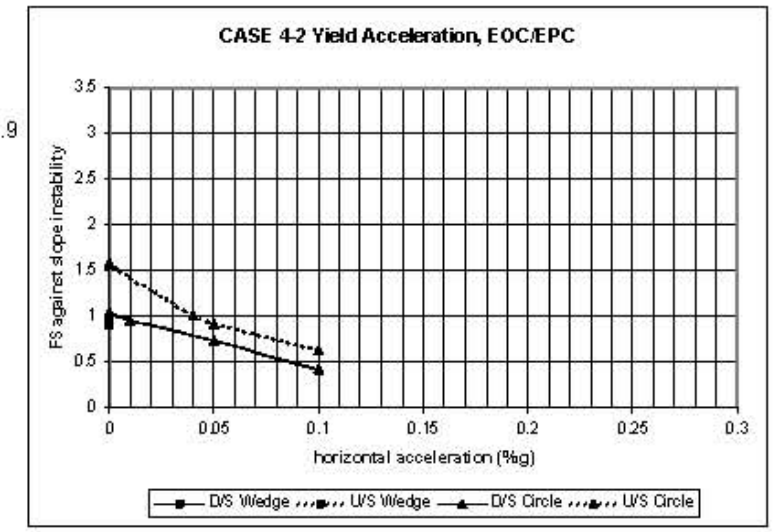
Seismic

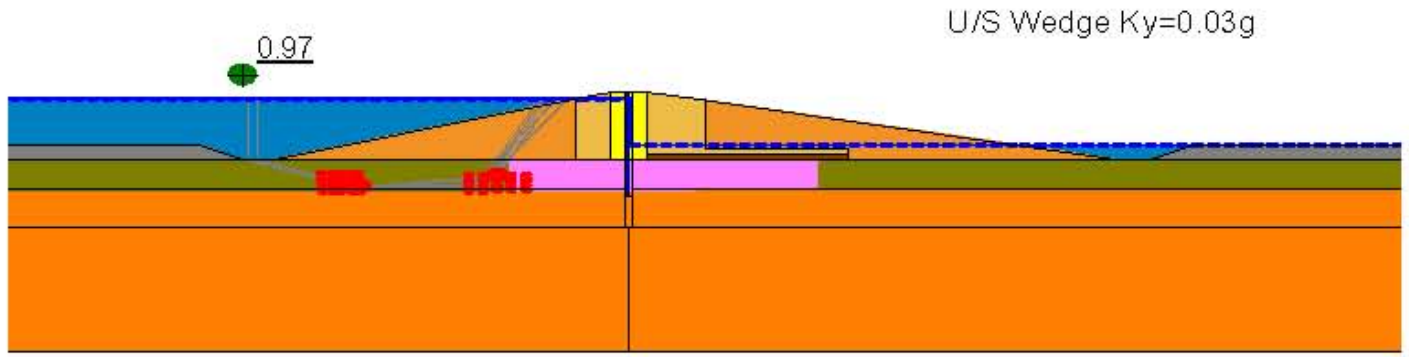
Description: Upper Stiff Lacustrine
Wt: 118
Cohesion: 200
Phi: 33
Piezometric Line: 1

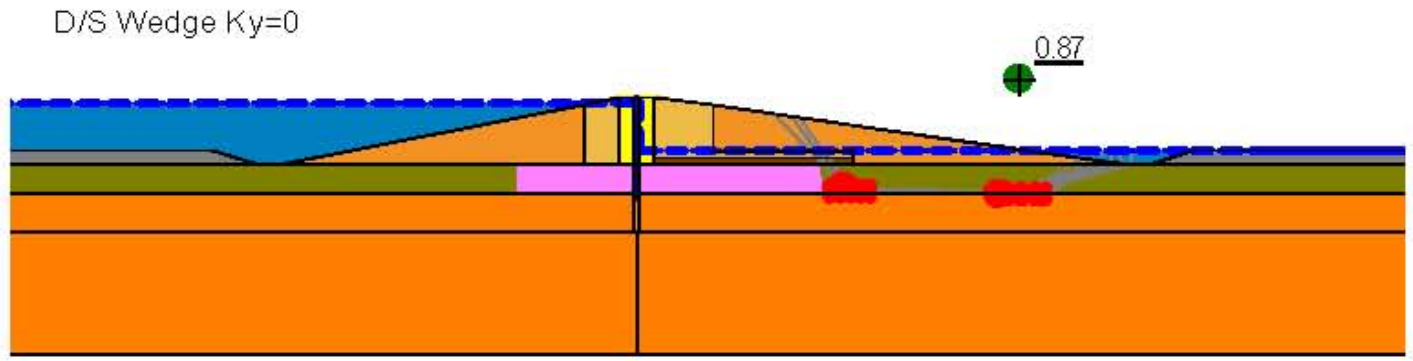
Description: Jet Grouted Lacustrine
Wt: 120
Cohesion: 7200
Phi: 0
Piezometric Line: 1

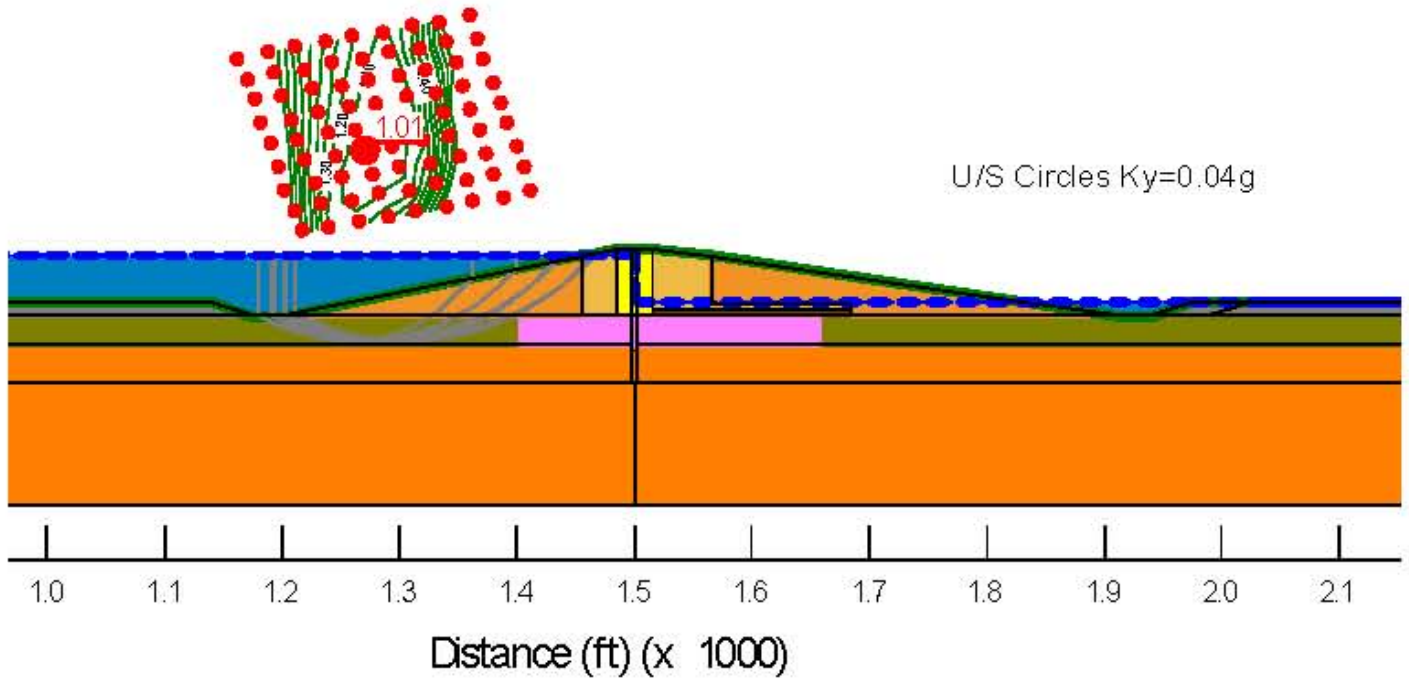
Soft Lacustrine - Liquefied

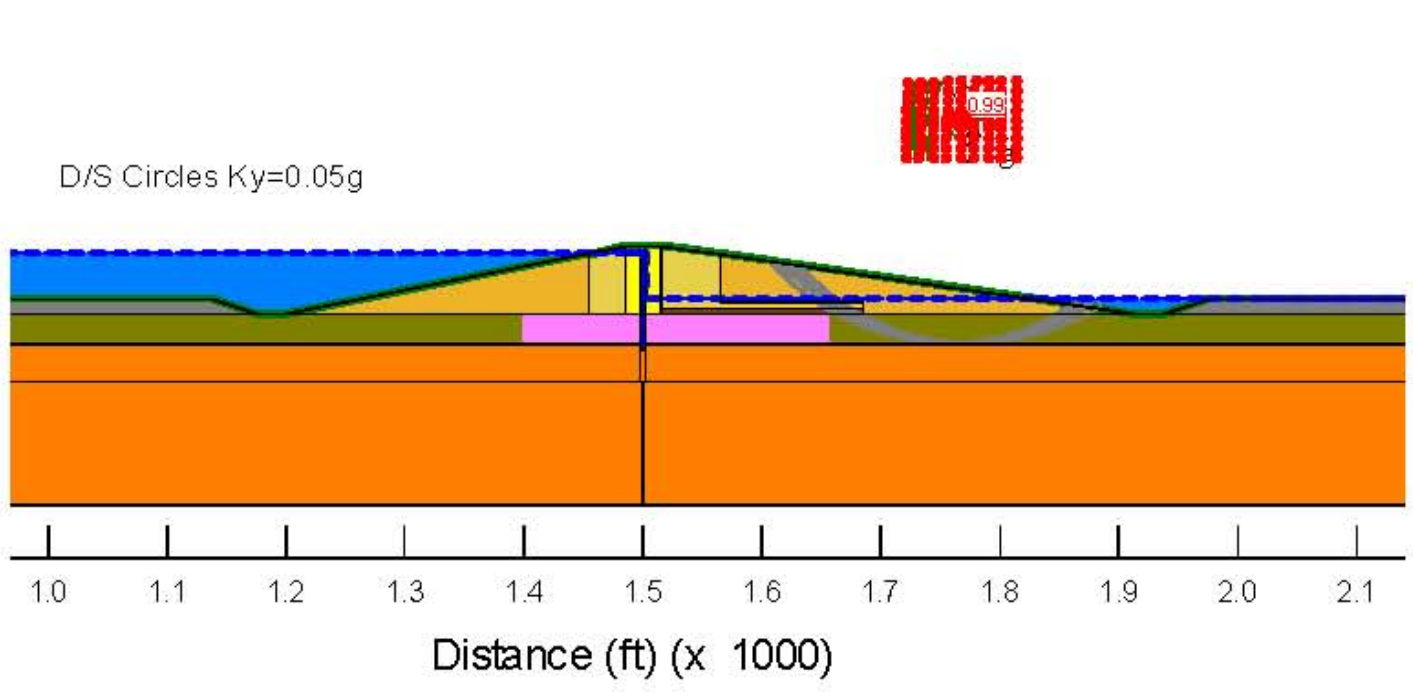
Description: Untreated Lacustrine - Liquefied
Wt: 115
Cohesion: 250
Phi: 0
Piezometric Line: 1

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**SALTON SEA RESTORATION PROJECT**
EMBANKMENT DESIGNS AND
OPTIMIZATION STUDY
Appendix 2B – Seepage and Stability Analyses

Seepage Analysis
Case 4,2 Mid-Sea Dam
Jetgrouting Under Central Portion

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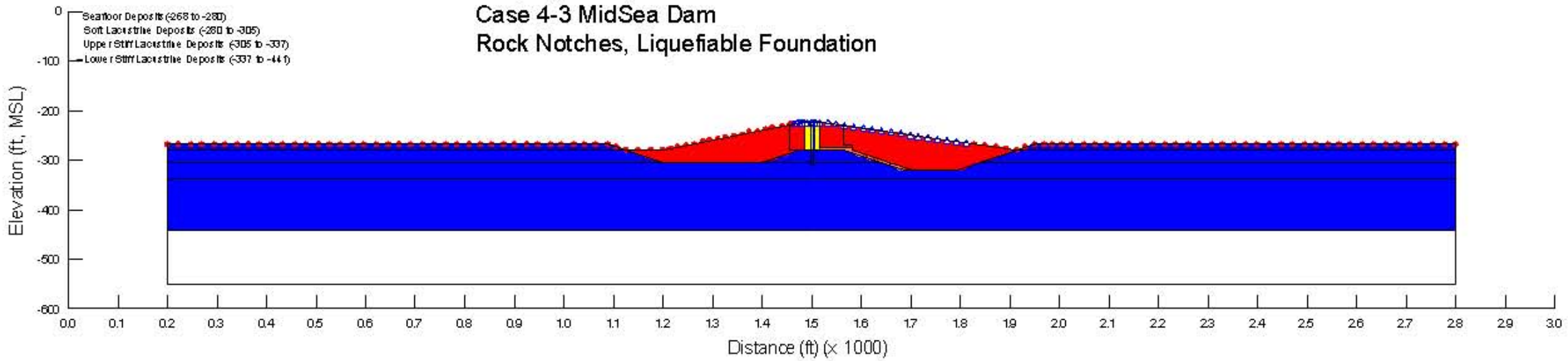
**FIGURE B.B-4**

## Section Geometry and Boundary Conditions



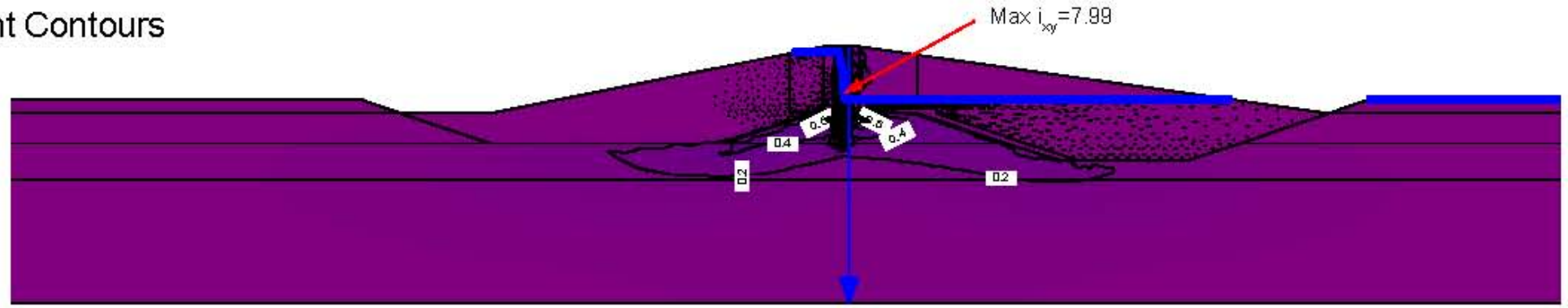

### Boundary Conditions Legend

- Constant Total Head
- Seepage Exit Boundary

### Material Properties Legend

| Material | Kh ft/sec | Kv/Kh | Color |
|---|---|---|---|
| Rockfill | $3.28*10^{-2}$ | 0.25 | |
| Fine Rockfill | $3.28*10^{-2}$ | 0.25 | |
| Filter Blanket | $1.77*10^{-4}$ | 1 | |
| Sand Gravel Core | $3.28*10^{-4}$ | 0.25 | |
| Slurry Wall | $3.28*10^{-8}$ | 1 | |
| Seafloor Deposits | $3.28*10^{-7}$ | 0.1 | |
| Soft Lacustrine | $3.28*10^{-7}$ | 0.1 | |
| Stiff Lacustrine | $3.28*10^{-7}$ | 0.1 | |

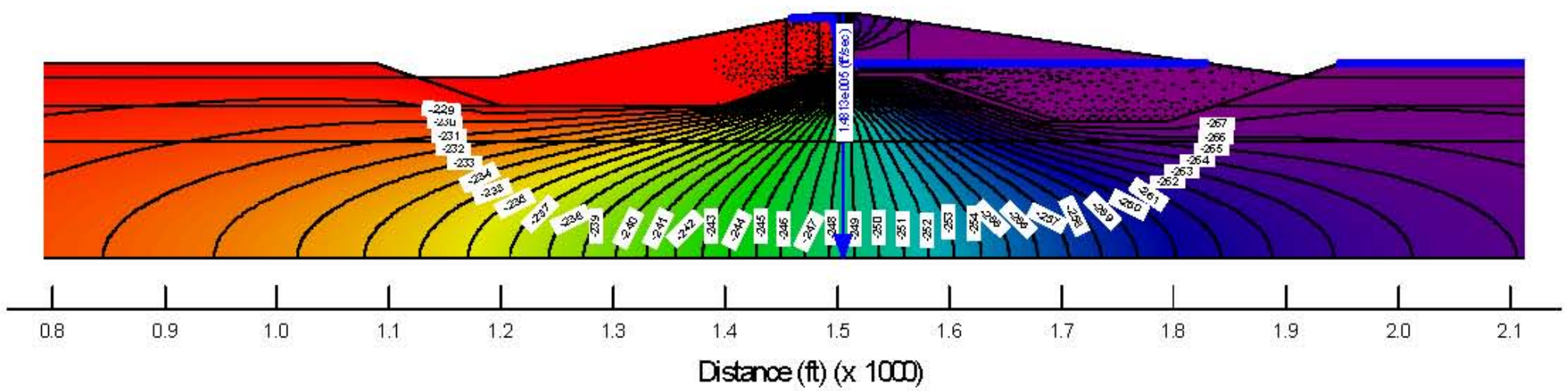
## XY Gradient Contours




### XY Gradient $i_{xy}$ Contours Legend

$i_{xy}$=0 — $i_{xy}$=8

## Total Head Contours

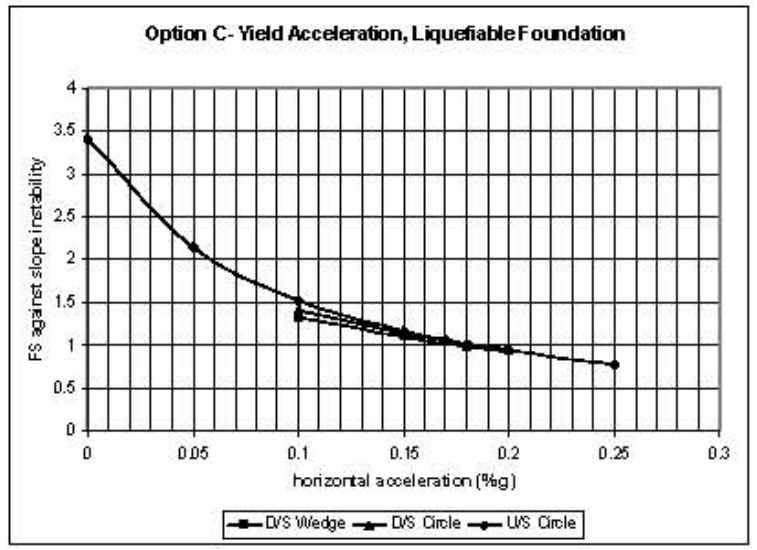



### Total Head Contours Legend

-268 ft — -228 ft

| | | | |
|---|---|---|---|
| United States Department of the Interior Bureau of Reclamation | SALTON SEA RESTORATION PROJECT<br>EMBANKMENT DESIGNS AND OPTIMIZATION STUDY<br>Appendix 2B – Seepage and Stability Analyses | | Seepage Analysis<br>Case 4,3 Mid-Sea Dam<br>Rock Notches, Liquefiable Foundation |
| KLEINFELDER | Project 71100 / By E. Sossenkina / August 2006 | | **FIGURE B.B-5** |

71100/DEN6R101




Material #: 1
Description: Slurry Cut- Off Wall
Model: Mohr Coulomb
Wt: 120
Cohesion: 100
Phi: 30
Piezometric Line: 1

Material #: 2
Description: Core
Model: Mohr Coulomb
Wt: 120
Cohesion: 0
Phi: 30
Piezometric Line: 1

Material #: 3
Description: Fine Rock Fill
Model: Mohr Coulomb
Wt: 118
Cohesion: 0
Phi: 42
Piezometric Line: 1

Material #: 4
Description: Rock Fill
Model: Mohr Coulomb
Wt: 115
Cohesion: 0
Phi: 45
Piezometric Line: 1

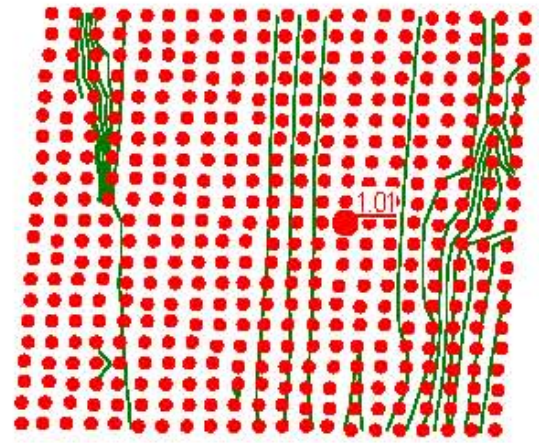
Material #: 5
Description: Filter Blanket
Model: Mohr Coulomb
Wt: 125
Cohesion: 150
Phi: 0
Piezometric Line: 1

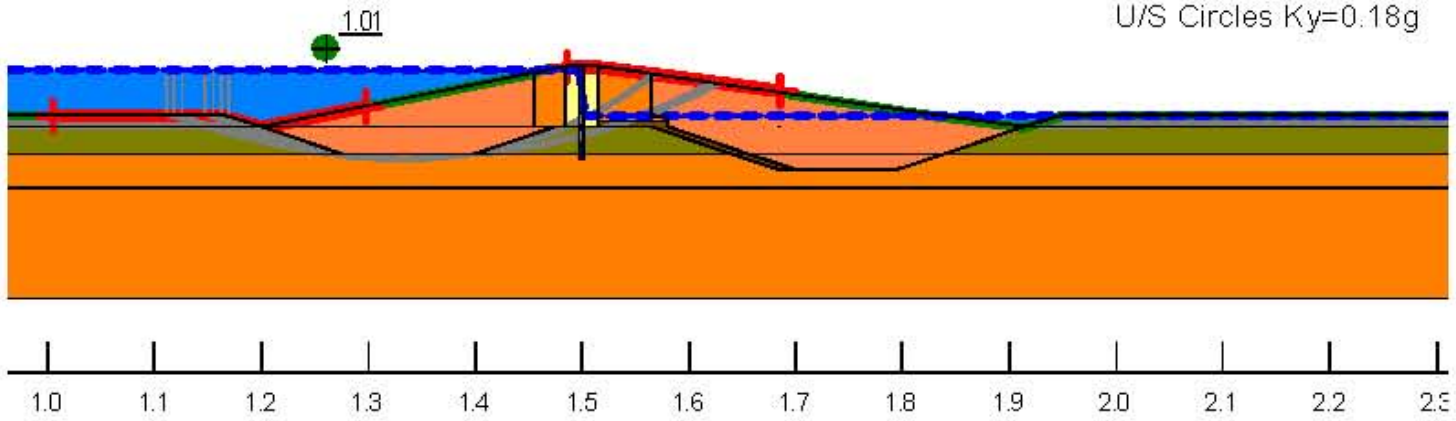
Material #: 6
Description: Untreated Lacustrine Deposites
Model: UndrainedPhiZero
Wt: 115
Cohesion: 250
Piezometric Line: 1

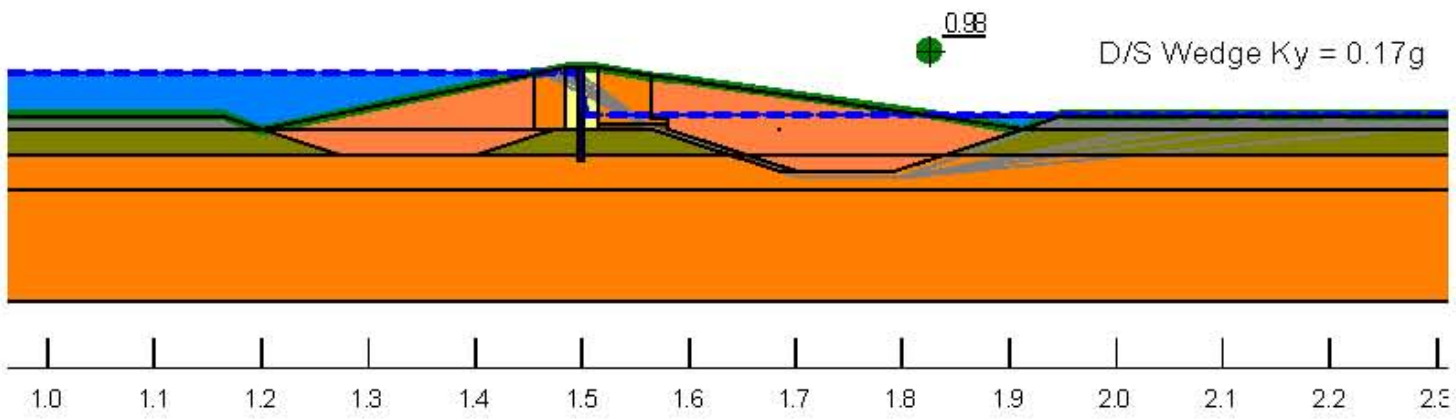
Material #: 7
Description: Seafloor Deposites
Model: SFn Datum
Wt: 98
C- Datum: 13
C- Rate of Increase: 15.4
Limiting C: 600
Elevation: -268
Piezometric Line: 1

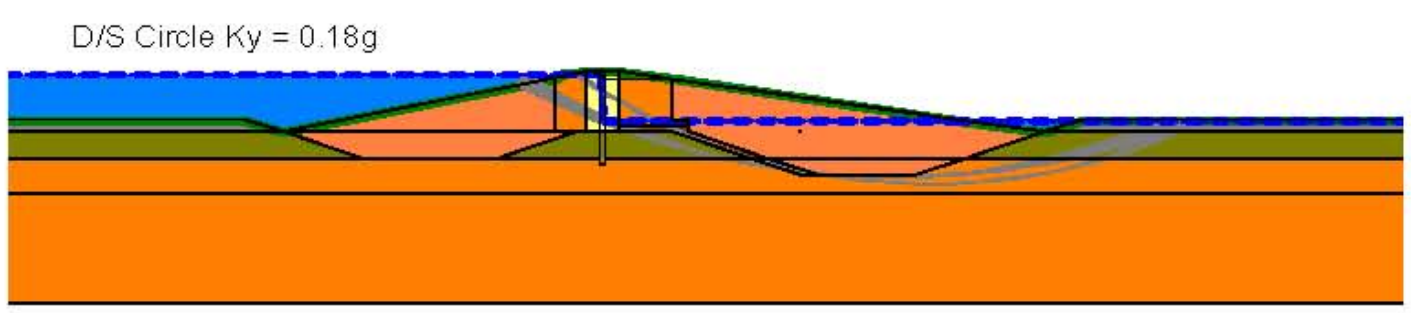
Material #: 8
Description: Stiff Lacustrine Deposites
Model: Mohr Coulomb
Wt: 118
Cohesion: 200
Phi: 33
Unit Wt. Above WT: 118
Phi- B: 0
Anisotropic Fn: 1
Piezometric Line: 1

Note:
Anisotropic Fn1= Sh/Sv=0.9

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**SALTON SEA RESTORATION PROJECT**
EMBANKMENT DESIGNS AND
OPTIMIZATION STUDY
Appendix 2B – Seepage and Stability Analyses

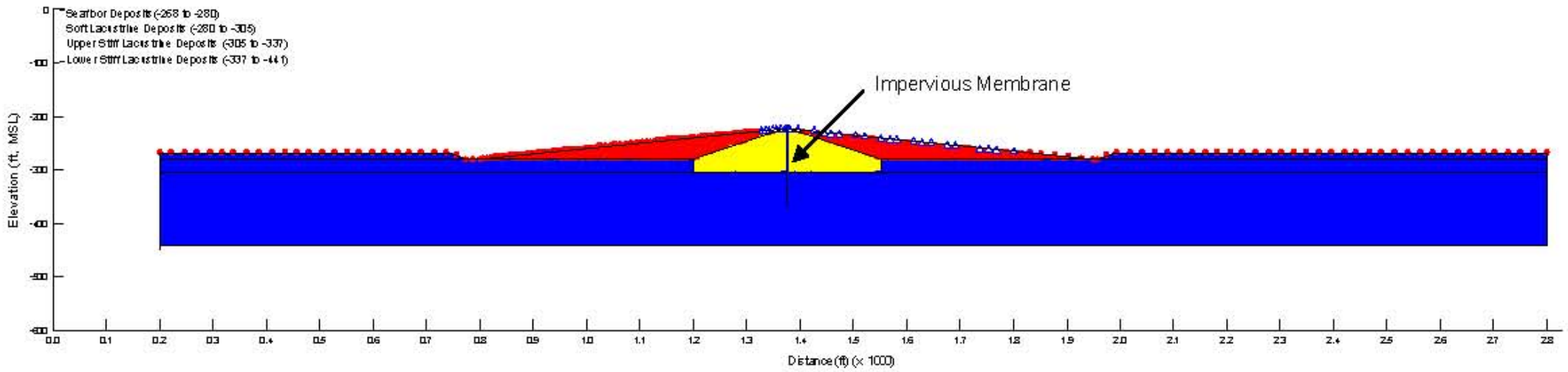
Seismic Slope Stability Analysis
Case 4,3 Mid-Sea Dam
Rock Notches, Liquefiable Foundation

Project 71100 | By E. Sossenkina | August 2006

**FIGURE B.B-6**

71100/DEN6R101

## Section Geometry and Boundary Conditions



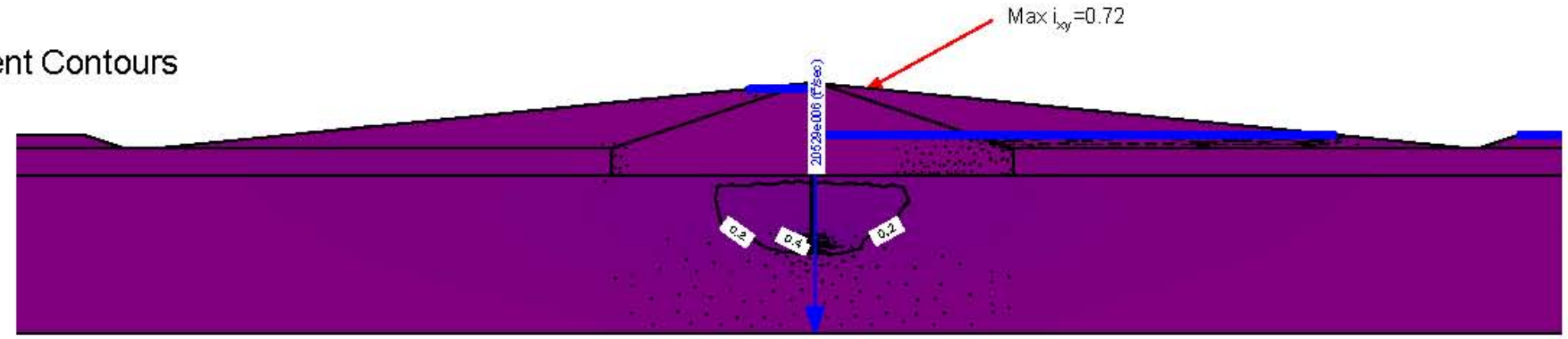

### Boundary Conditions Legend

Constant Total Head
Seepage Exit Boundary

### Material Properties Legend

| Material | Kh ft/sec | Kv/Kh | Color |
|---|---|---|---|
| Rock Fill | $3.28*10^{-2}$ | 0.25 | |
| Seafloor Deposits | $3.28*10^{-7}$ | 0.1 | |
| Soft Lacustrine | $3.28*10^{-7}$ | 0.1 | |
| Stiff Lacustrine | $3.28*10^{-7}$ | 0.1 | |
| Stone Column | $3.28*10^{-2}$ | 0.25 | |
| Membrane | Impervious | | |

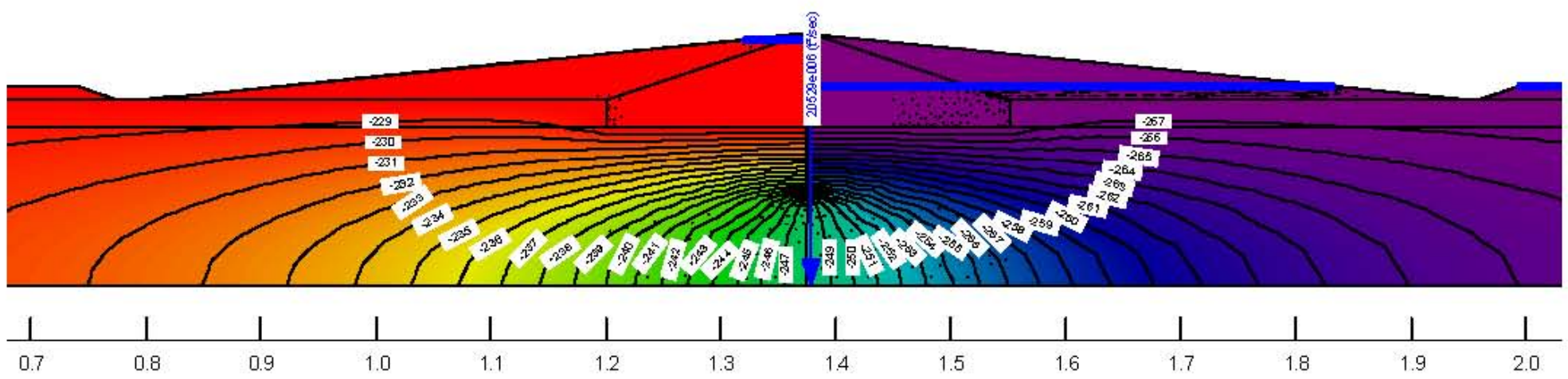
## XY Gradient Contours




### XY Gradient $i_{xy}$ Contours Legend

$i_{xy}$=0 $i_{xy}$=8

## Total Head Contours




### Total Head Contours Legend

-268 ft -228 ft

| | | | |
|---|---|---|---|
| United States Department of the Interior Bureau of Reclamation | **SALTON SEA RESTORATION PROJECT** EMBANKMENT DESIGNS AND OPTIMIZATION STUDY Appendix 2B – Seepage and Stability Analyses | | Seepage Analysis Case 4,4 Mid-Sea Dam Stone Columns, Liquefiable Foundation |
| KLEINFELDER | Project 71100 | By E. Sossenkina | August 2006 | **FIGURE B.B-7** |

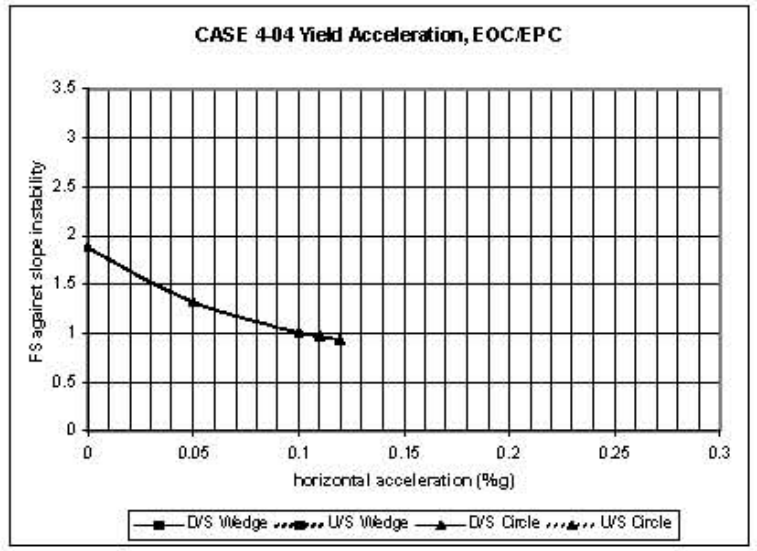
71100/DEN6R101

Description: Sand Embankment with Stone Columns - Liquefied
Wt: 120
Cohesion: 1000
Phi: 0
Piezometric Line: 1

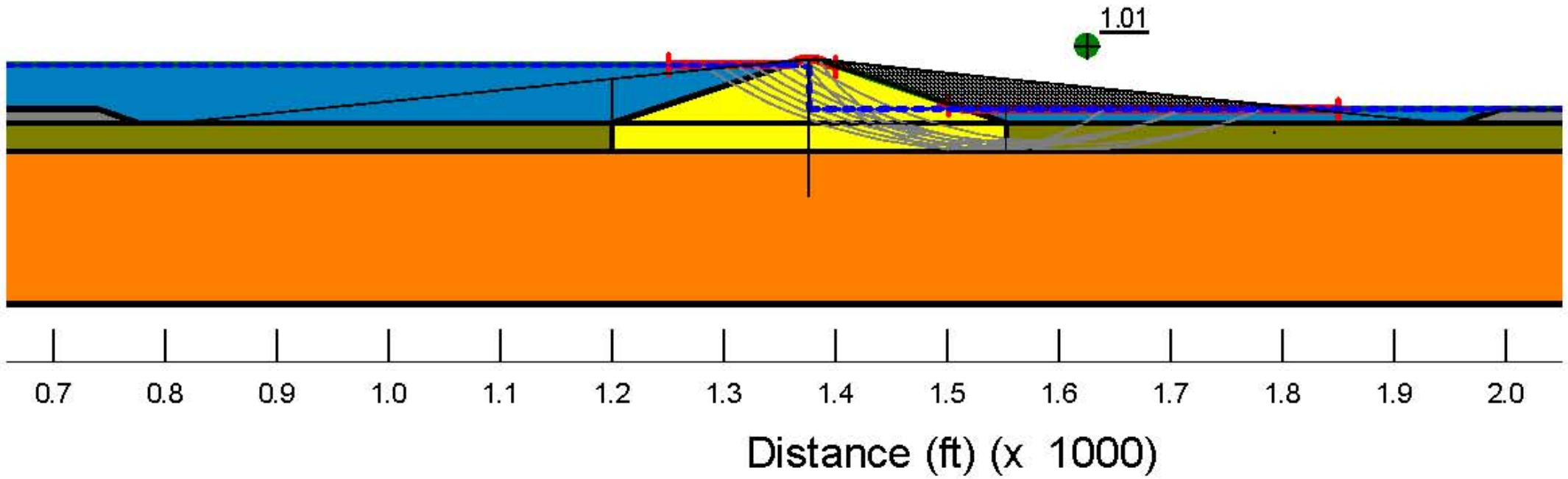
Description: Seafloor Deposit - EOC Seismic
Wt: 98
C-Datum: 13
C-Rate of Increase: 15.4
Limiting C: 600
Elevation: -268
Piezometric Line: 1

Description: Upper Stiff Lacustrine - Seismic
Wt: 118
Cohesion: 200
Phi: 33
Unit Wt. Above WT: 118
Phi-B: 0
Anisotropic Fn: 1
Piezometric Line: 1

Description: Soft Lacustrine - Liquefied
Wt: 115
Cohesion: 250
Phi: 0
Piezometric Line: 1

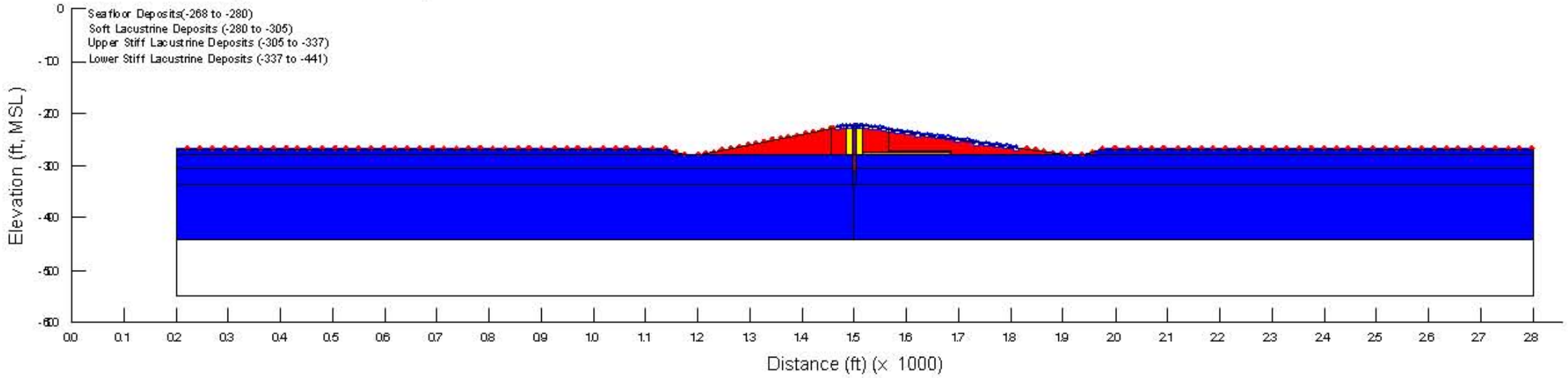



D/S Circle Ky = 0.11g




| | | | | |
|---|---|---|---|---|
| United States Department of the Interior Bureau of Reclamation<br>KLEINFELDER | SALTON SEA RESTORATION PROJECT<br>EMBANKMENT DESIGNS AND OPTIMIZATION STUDY<br>Appendix 2B – Seepage and Stability Analyses | | | Seismic Stability Analysis<br>Case 4,4 Mid-Sea Dam<br>Stone Columns, Liquefiable Foundation |
| | Project 71100 | By E. Sossenkina | August 2006 | **FIGURE B.B-8** |

## Section Geometry and Boundary Conditions



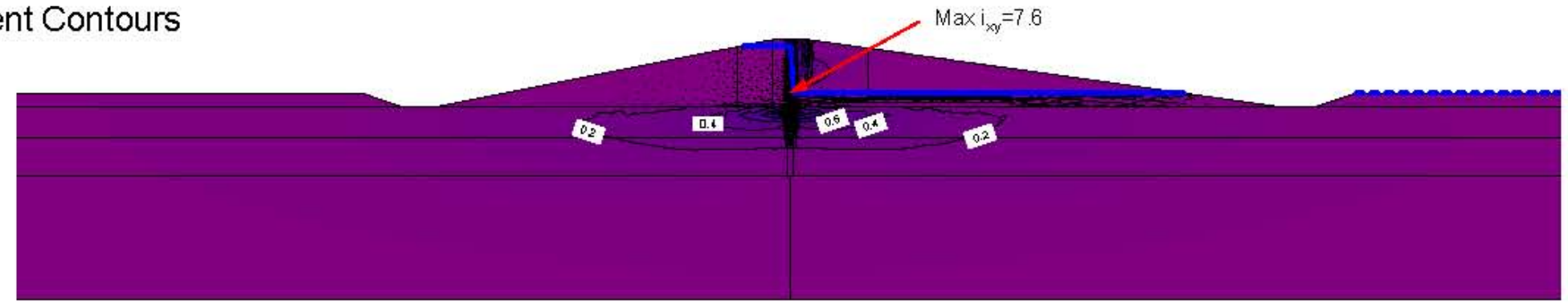

### Boundary Conditions Legend

Constant Total Head
Seepage Exit Boundary

### Material Properties Legend

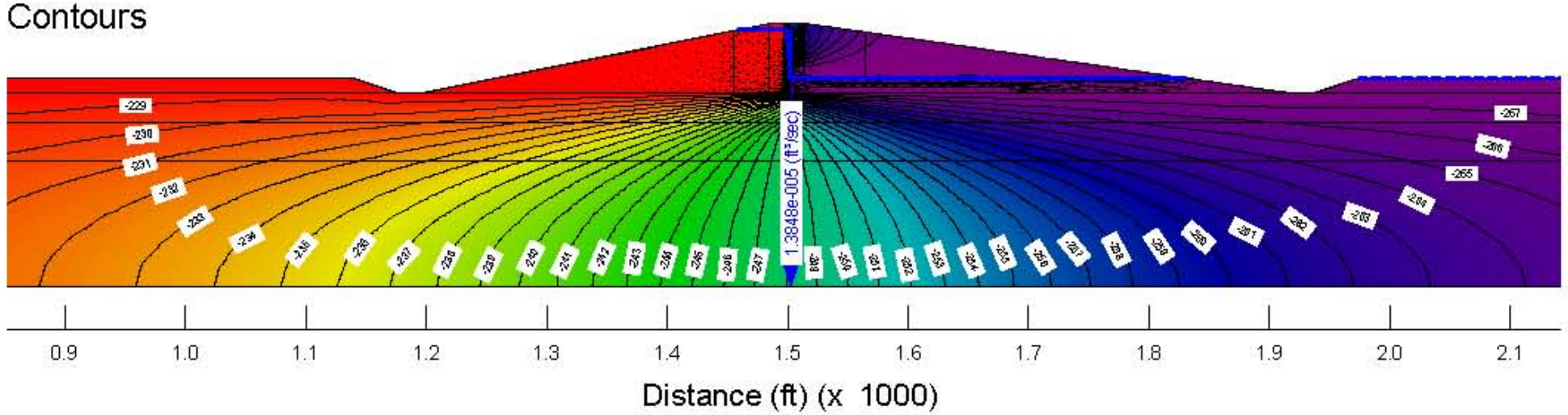
| Material | Kh ft/sec | Kv/Kh | Color |
|---|---|---|---|
| Rockfill | $3.28*10^{-2}$ | 0.25 | |
| Fine Rockfill | $3.28*10^{-2}$ | 0.25 | |
| Filter Blanket | $1.77*10^{-4}$ | 1 | |
| Sand Gravel Core | $3.28*10^{-4}$ | 0.25 | |
| Slurry Wall | $3.28*10^{-8}$ | 1 | |
| Seafloor Deposits | $3.28*10^{-7}$ | 0.1 | |
| Soft Lacustrine | $3.28*10^{-7}$ | 0.1 | |
| Stiff Lacustrine | $3.28*10^{-7}$ | 0.1 | |

## XY Gradient Contours




### XY Gradient $i_{xy}$ Contours Legend


## Total Head Contours




### Total Head Contours Legend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**SALTON SEA RESTORATION PROJECT**
EMBANKMENT DESIGNS AND
OPTIMIZATION STUDY
Appendix 2B – Seepage and Stability Analyses

Seepage Analysis
Case 4,5 Mid-Sea Dam
No Ground Improvements,
Liquefied Foundation

Project 71100 | By E. Sossenkina | August 2006

**FIGURE B.B-9**

71100/DEN6R101

Description : Rockfill
Wt: 115
Cohesion: 0
Phi : 45
Piezometric Line: 1

Description: Core - Clean Sand & Gravel
Wt: 120
Cohesion: 0
Phi : 30
Piezometric Line: 1

Description: Fine Rockfill
Wt: 118
Cohesion: 0
Phi: 42
Piezometric Line: 1

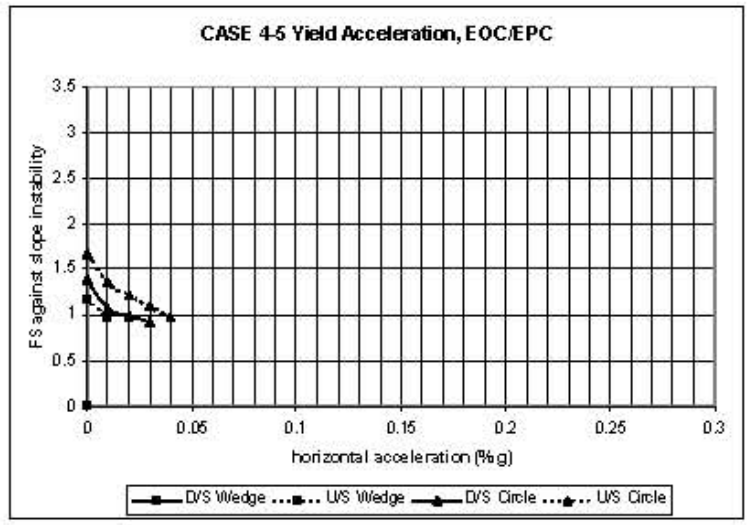
Description: S CB Slurry Wall
Wt: 120
Cohesion: 100
Phi: 30
Piezometric Line: 1

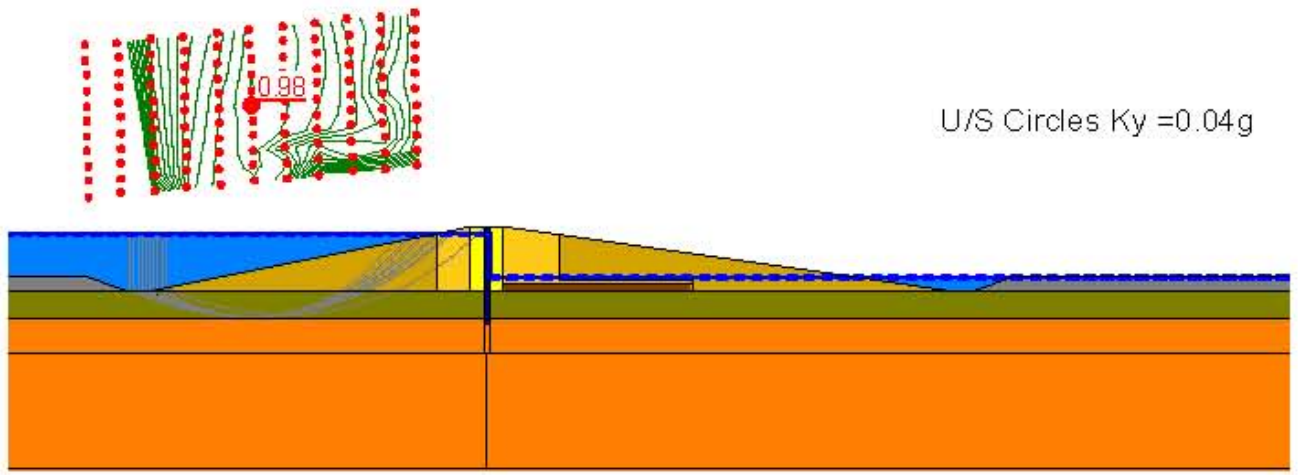
Description : Filter Blanket-Liquefied
Wt: 125
Cohesion: 150
Phi: 0
Piezometric Line: 1

Description: Seafloor Deposit - Seismic
Wt: 98
C-Datum: 13
C-Rate of Increase: 15.4
Limiting C: 600
Elevation: -268
Piezometric Line: 1

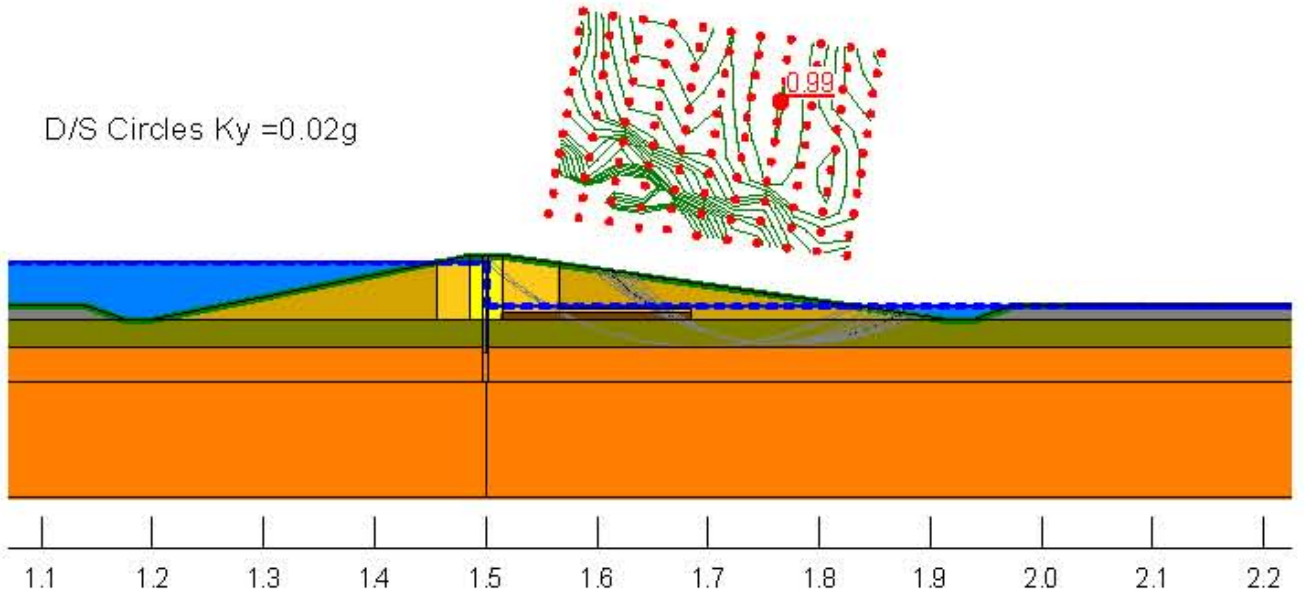
Description : Soft Lacustrine - Liquefied
Wt: 115
Cohesion: 250
Phi: 0
Piezometric Line: 1

Description : Upper Stiff Lacustrine, Seismic
Wt: 118
Cohesion: 200
Phi: 33
Unit Wt. Above WT: 118
Phi-B: 0
Anisotropic Fn: 1
Piezometric Line: 1

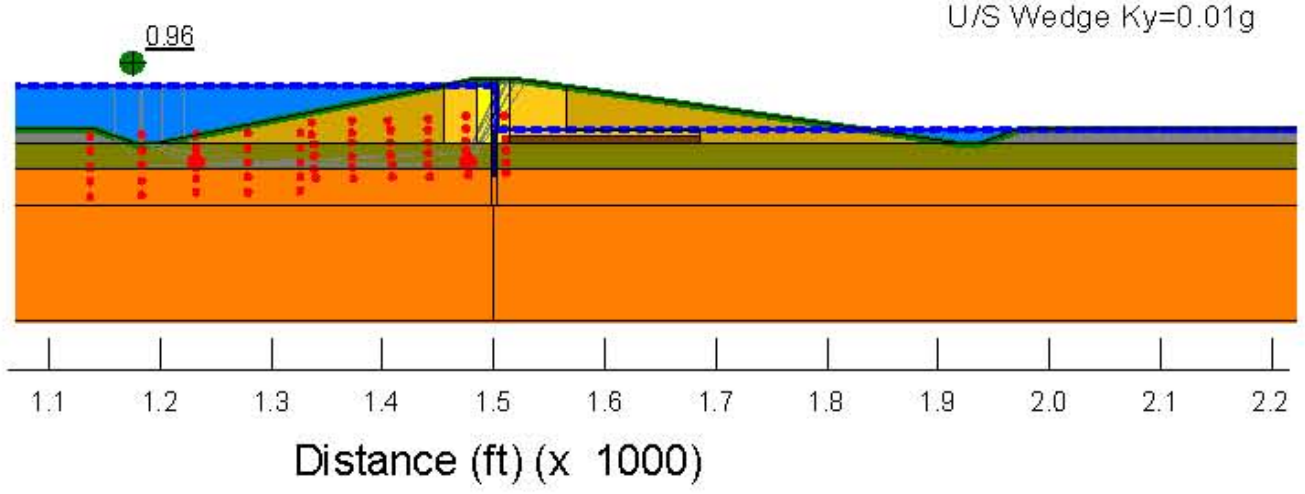



U/S Circles Ky =0.04g




D/S Circles Ky =0.02g




U/S Wedge Ky=0.01g

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**SALTON SEA RESTORATION PROJECT**
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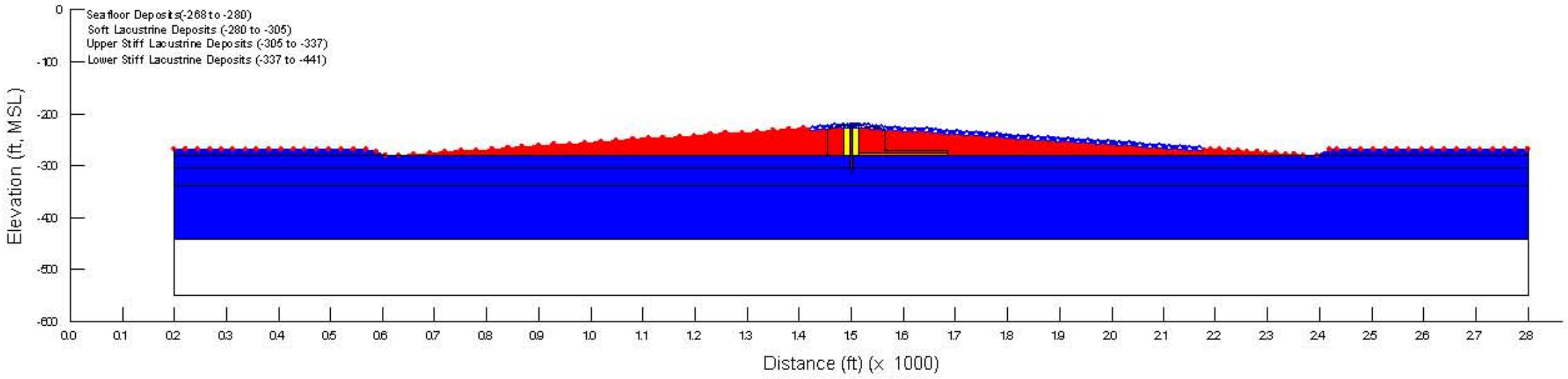
Seismic Slope Stability Analysis
Case 4,5 Mid-Sea Dam
No Ground Improvements, Liquefied Foundation

| Project 71100 | By E. Sossenkina | August 2006 |
|---|---|---|

**FIGURE B.B-10**

## Section Geometry and Boundary Conditions



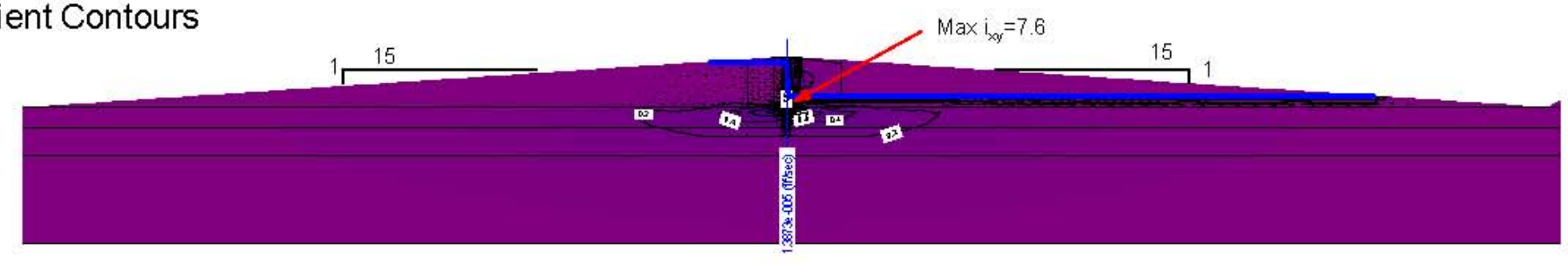

### Boundary Conditions Legend

Constant Total Head
Seepage Exit Boundary

### Material Properties Legend

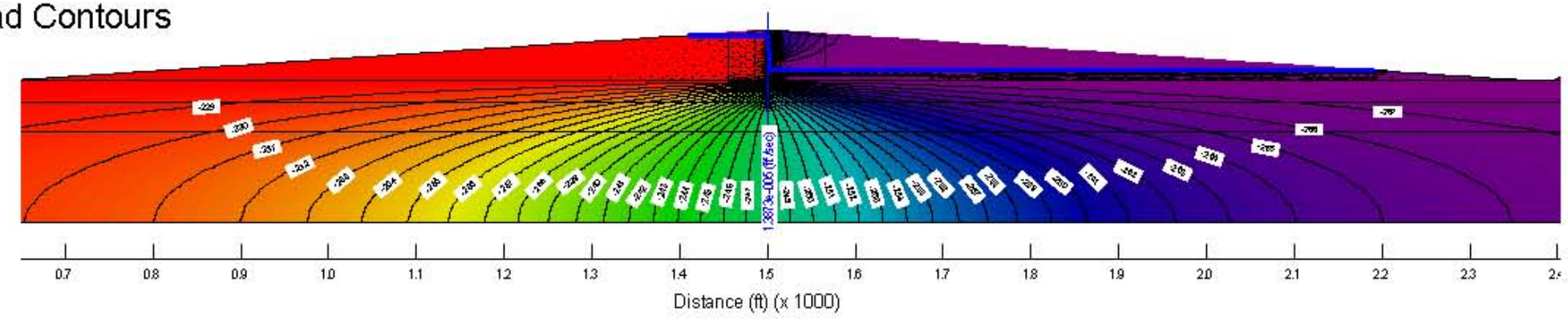
| Material | Kh ft/sec | Kv/Kh | Color |
|---|---|---|---|
| Rockfill | $3.28*10^{-2}$ | 0.25 | |
| Fine Rockfill | $3.28*10^{-2}$ | 0.25 | |
| Filter Blanket | $1.77*10^{-4}$ | 1 | |
| Sand Gravel Core | $3.28*10^{-4}$ | 0.25 | |
| Slurry Wall | $3.28*10^{-8}$ | 1 | |
| Seafloor Deposits | $3.28*10^{-7}$ | 0.1 | |
| Soft Lacustrine | $3.28*10^{-7}$ | 0.1 | |
| Stiff Lacustrine | $3.28*10^{-7}$ | 0.1 | |

## XY Gradient Contours




### XY Gradient $i_{xy}$ Contours Legend


## Total Head Contours




### Total Head Contours Legend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**SALTON SEA RESTORATION PROJECT**
EMBANKMENT DESIGNS AND OPTIMIZATION STUDY
Appendix 2B – Seepage and Stability Analyses

Seepage Analysis
Case 4,6 Mid-Sea Dam
15H:1V Slopes

Project 71100 | By E. Sossenkina | August 2006

**FIGURE B.B-11**

Description: Rockfill
Wt: 115
Cohesion: 0
Phi: 45
Piezometric Line: 1

Description: Core - Clean Sand & Gravel
Wt: 120
Cohesion: 0
Phi: 30
Piezometric Line: 1

Description: Fine Rockfill
Wt: 118
Cohesion: 0
Phi: 42
Piezometric Line: 1

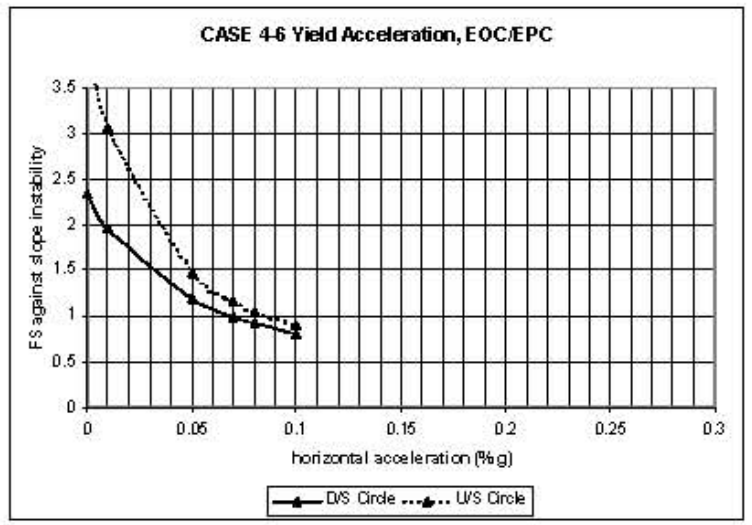
Description: SCB Slurry Wall
Wt: 120
Cohesion: 100
Phi: 30
Piezometric Line: 1

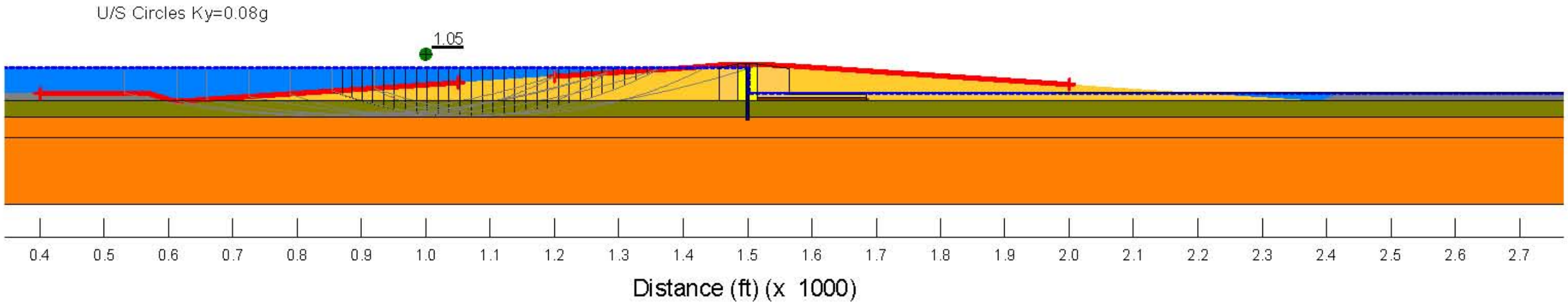
Description: Filter Blanket-Liquefied
Wt: 125
Cohesion: 150
Phi: 0
Piezometric Line: 1

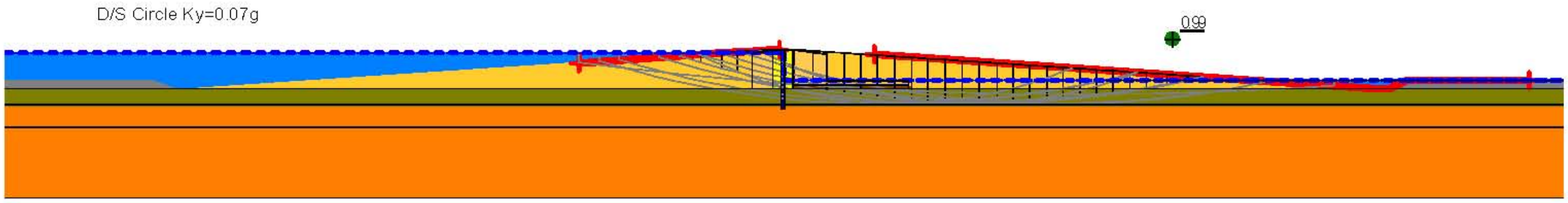
Description: Soft Lacustrine - Liquefied
Wt: 115
Cohesion: 250
Phi: 0
Piezometric Line: 1

Description: Upper Stiff Lacustrine, Seismic
Wt: 118
Cohesion: 200
Phi: 33
Unit Wt. Above WT: 118
Phi-B: 0
Anisotropic Fn: 1
Piezometric Line: 1

Description: Seafloor Deposit - Seismic
Wt: 98
C-Datum: 13
C-Rate of Increase: 15.4
Limiting C: 600
Elevation: -268
Piezometric Line: 1

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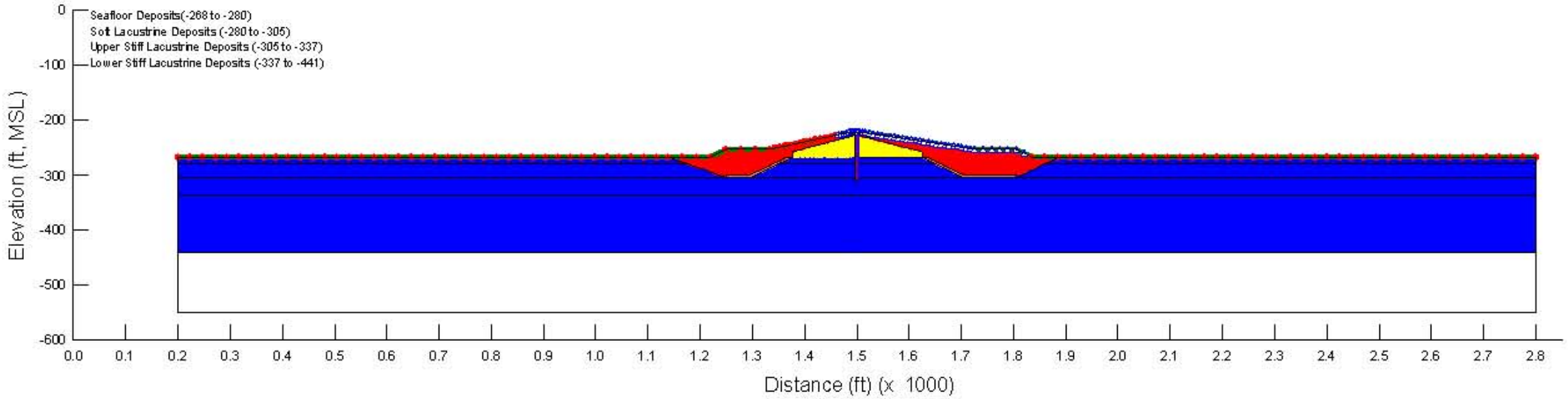
Appendix 2B – Seepage and Stability Analyses

Seismic Slope Stability Analysis
Case 4,6 Mid-Sea Dam
15H:1V Slopes

Project 71100 | By E. Sossenkina | August 2006

**FIGURE B.B-12**

## Section Geometry and Boundary Conditions



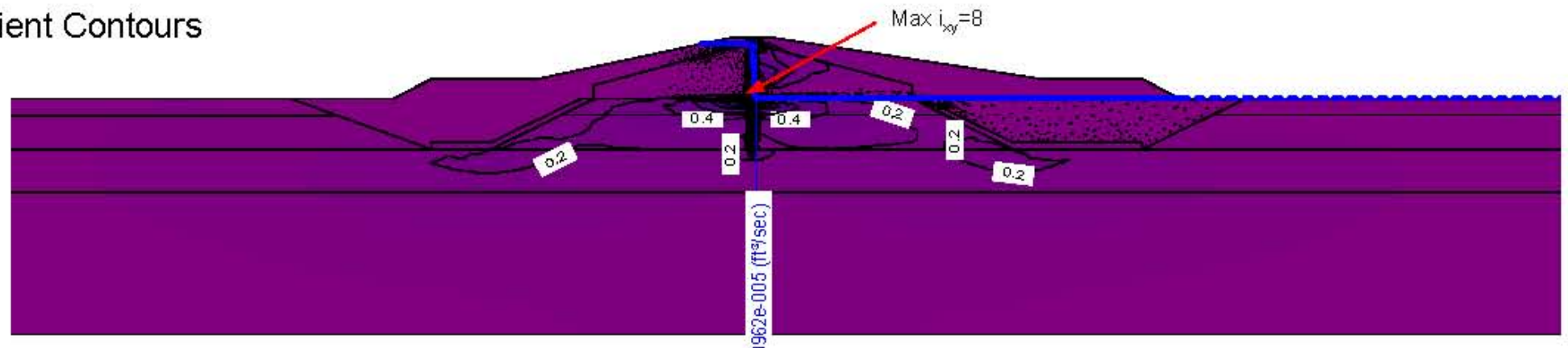

### Boundary Conditions Legend

- Constant Total Head
- Seepage Exit Boundary

### Material Properties Legend

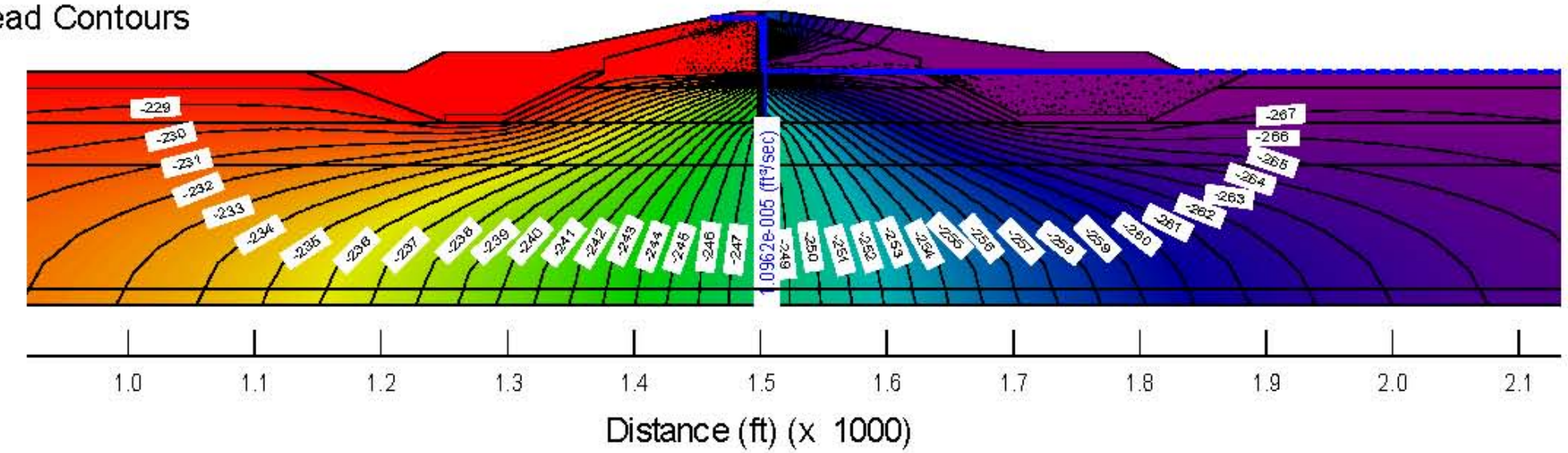
| Material | Kh ft/sec | Kv/Kh | Color |
|---|---|---|---|
| Rockfill | $3.28*10^{-2}$ | 0.25 | |
| Filter Blanket | $1.77*10^{-4}$ | 1 | |
| Sand Gravel Core | $3.28*10^{-4}$ | 0.25 | |
| Slurry Wall | $3.28*10^{-8}$ | 1 | |
| Seafloor Deposits | $3.28*10^{-7}$ | 0.1 | |
| Soft Lacustrine | $3.28*10^{-7}$ | 0.1 | |
| Stiff Lacustrine | $3.28*10^{-7}$ | 0.1 | |

## XY Gradient Contours




### XY Gradient $i_{xy}$ Contours Legend


## Total Head Contours




### Total Head Contours Legend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**SALTON SEA RESTORATION PROJECT**
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Appendix 2B – Seepage and Stability Analyses

Project 71100 | By E. Sossenkina | August 2006

Seepage Analysis
Case 4,7 Mid-Sea Dam
Modified Rock Notches, Liquefiable Foundation

**FIGURE B.B-13**

71100/DEN6R101

Description: Rockfill
Wt: 115
Cohesion: 0
Phi: 46
Piezometric Line: 1

Description: Core - Clean Sand & Gravel liquefied
Wt: 120
Cohesion: 300
Phi: 0
Piezometric Line: 1

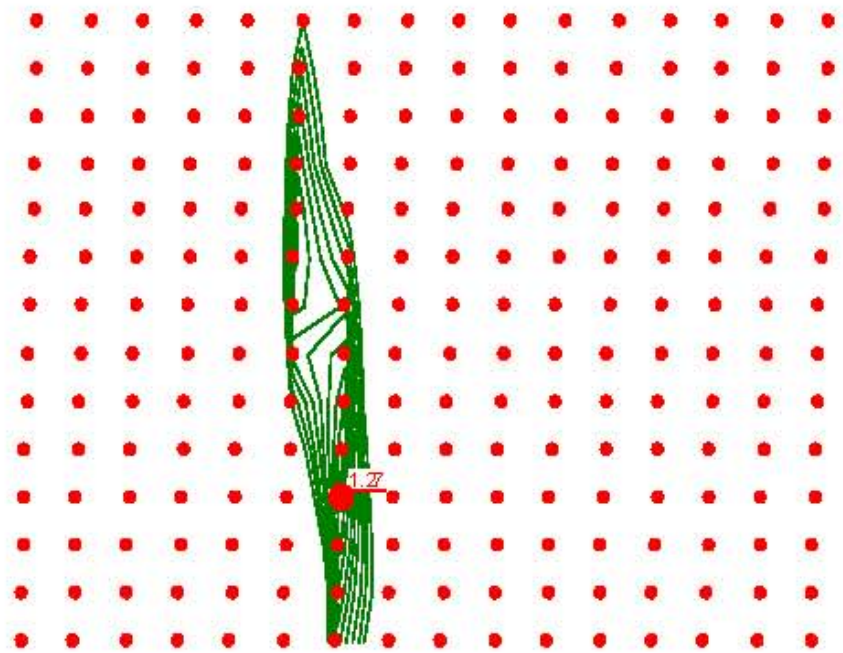
Description: Soft Lacustrine - Liquefied
Wt: 115
Cohesion: 250
Phi: 0
Piezometric Line: 1

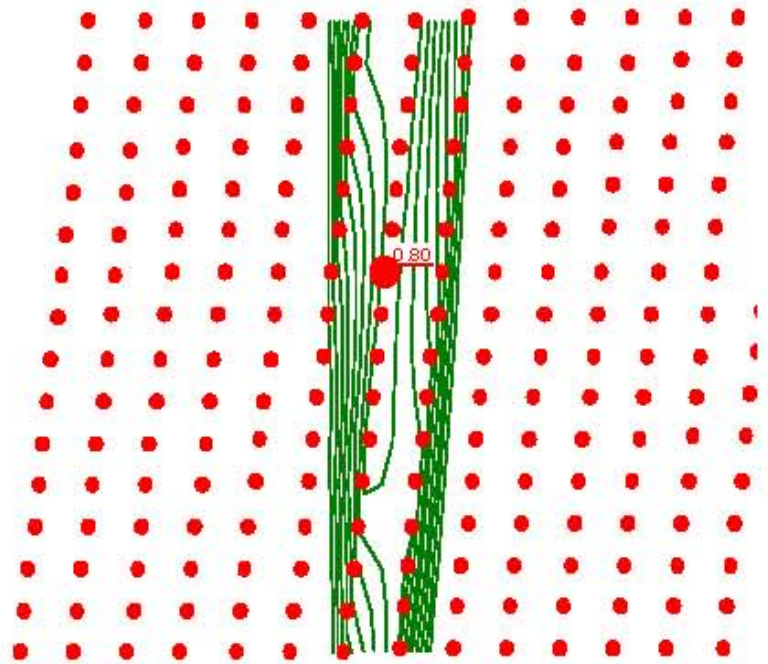
Description: Filter Blanket-Liquefied
Wt: 125
Cohesion: 150
Phi: 0
Piezometric Line: 1

Description: SCB Slurry Wall
Wt: 120
Cohesion: 100
Phi: 30
Piezometric Line: 1

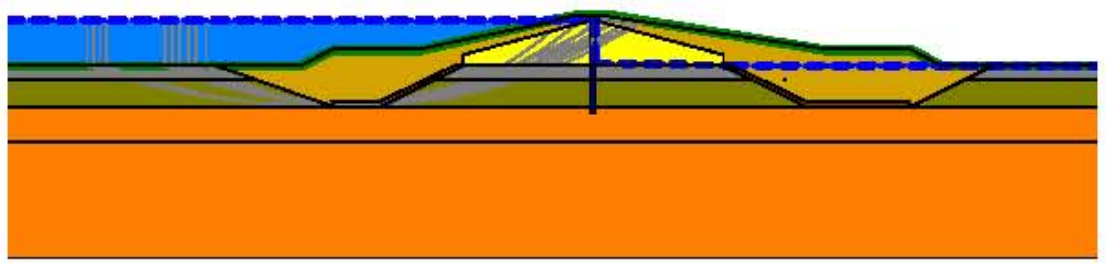
Description: Seafloor Deposit - Seismic
Wt: 98
C-Datum: 13
C-Rate of Increase: 15.4
Limiting C: 600
Elevation: -268
Piezometric Line: 1

Description: Upper Stiff Lacustrine, Seismic
Wt: 118
Cohesion: 200
Phi: 33
Unit Wt. Above WT: 118
Phi-B: 0
Anisotropic Fn: 1
Piezometric Line: 1

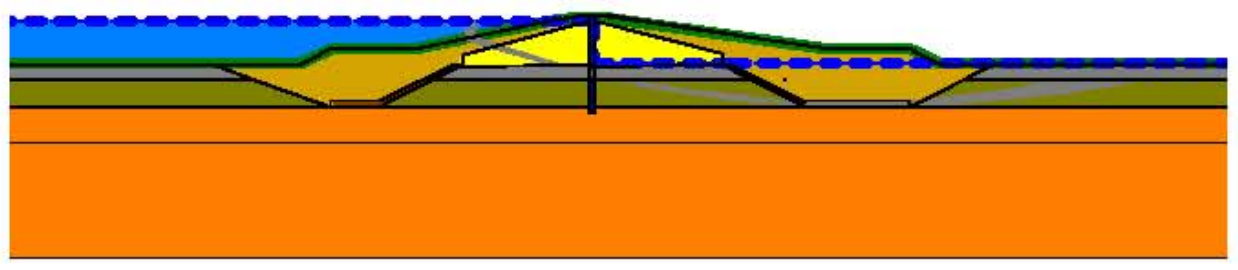


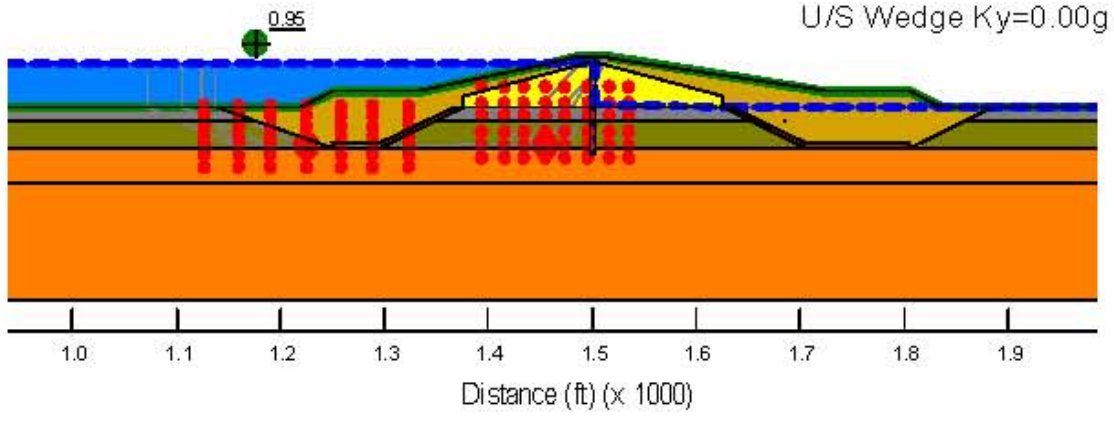

U/S Circles Ky=0.00g



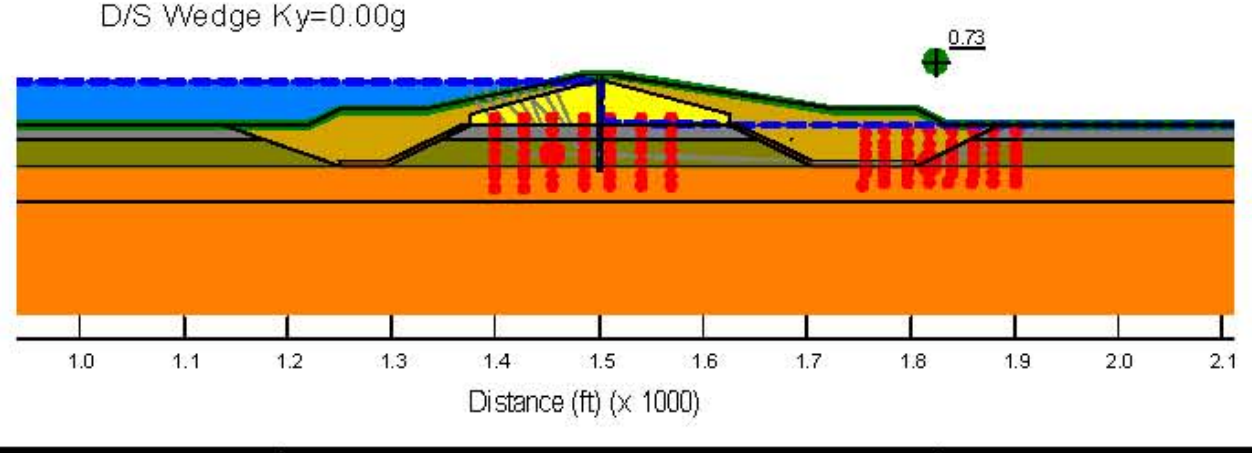
D/S Circles Ky=0.00g



U/S Wedge Ky=0.00g




D/S Wedge Ky=0.00g

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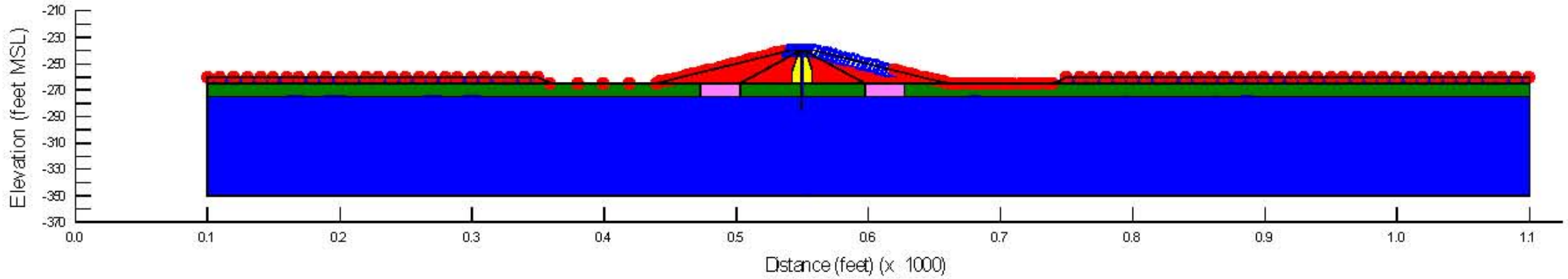
Appendix 2B – Seepage and Stability Analyses

Seismic Slope Stability Analysis
Case 4,7 Mid-Sea Dam
Modified Rock Notches, Liquefiable Foundation

Project 71100 | By E. Sossenkina | August 2006

**FIGURE B.B-14**

## Section Geometry and Boundary Conditions



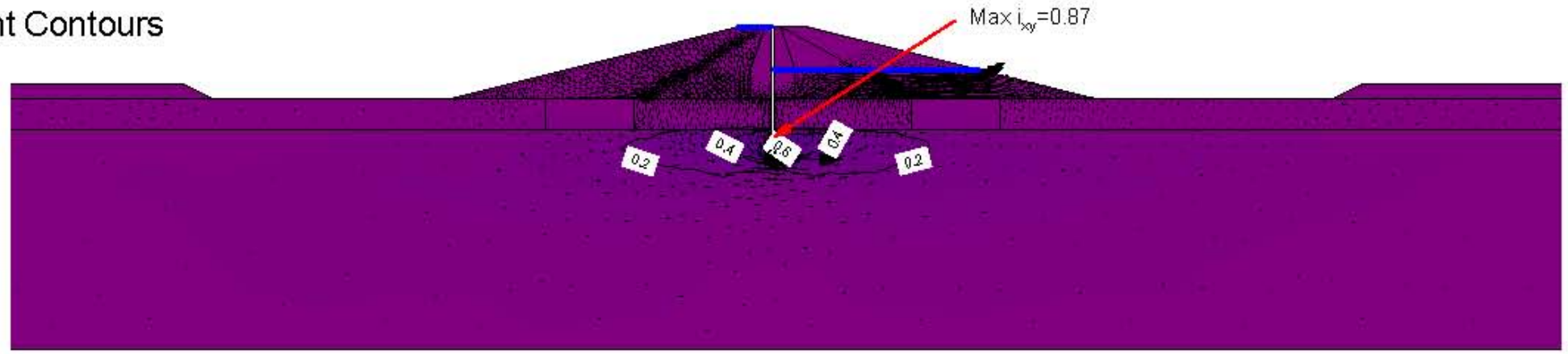

### Boundary Conditions Legend

Constant Total Head
Seepage Exit Boundary

### Material Properties Legend

| Material | Kh ft/sec | Kv/Kh | Color |
|---|---|---|---|
| Rockfill | $3.28*10^{-2}$ | 0.25 | |
| Fine Rockfill | $3.28*10^{-2}$ | 0.25 | |
| Sand Gravel Core | $3.28*10^{-4}$ | 0.25 | |
| Seafloor Deposits | $3.28*10^{-7}$ | 0.1 | |
| Stiff Lacustrine | $3.28*10^{-7}$ | 0.1 | |
| Alluvium | $1.32*10^{-5}$ | 0.25 | |
| jet-grouted alluvium | $3.28*10^{-8}$ | 1 | |
| Sheet Pile Wall | Impervious | | |

## XY Gradient Contours

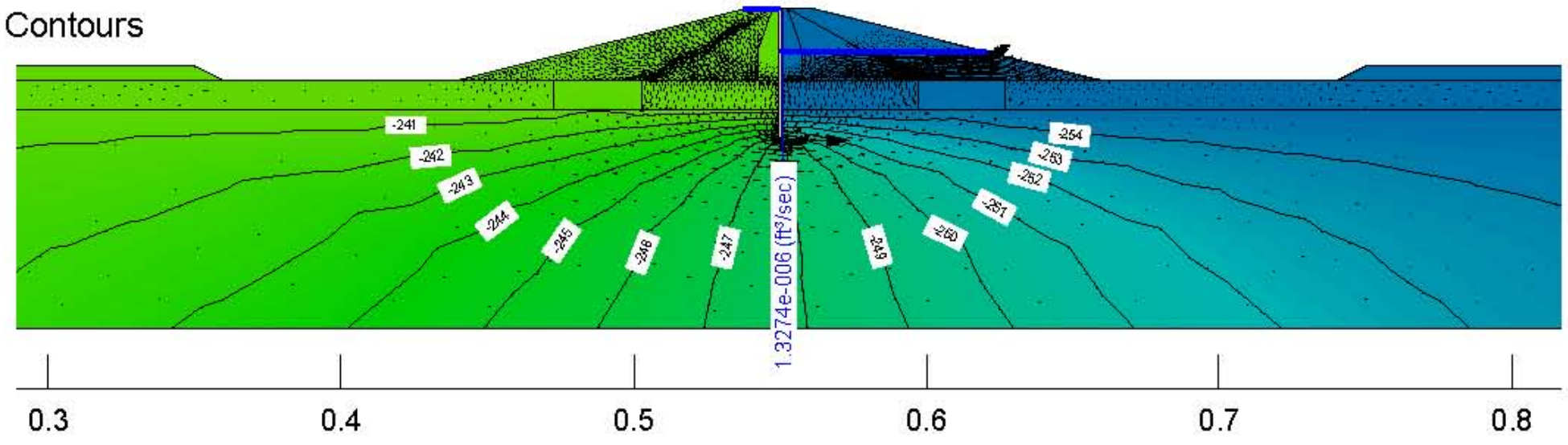



### XY Gradient $i_{xy}$ Contours Legend

$i_{xy}$ =8

$i_{xy}$ =0

## Total Head Contours




### Total Head Contours Legend

-268 ft
-228 ft

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EMBANKMENT DESIGNS AND OPTIMIZATION STUDY
Appendix 2B – Seepage and Stability Analyses

Seepage Analysis
Case 4,8 Perimeter Dike (West)
Jetgrouting Under Shells, Liquefiable Foundation

Project 71100 | By E. Sossenkina | August 2006

**FIGURE B.B-15**

71100/DEN6R101

Description: Vinyl Sheetpile Wall
Wt: 120
Cohesion: 100
Phi: 30
Piezometric Line: 1

Description: Core - Clean Sand & Gravel
Wt: 120
Cohesion: 0
Phi: 30
Piezometric Line: 1

Description: Fine Rockfill
Wt: 118
Cohesion: 0
Phi: 42
Piezometric Line: 1

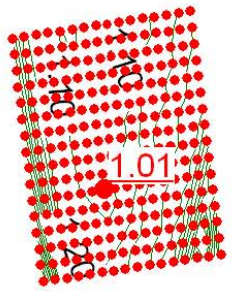
Description: Rockfill
Wt: 115
Cohesion: 0
Phi: 45
Piezometric Line: 1

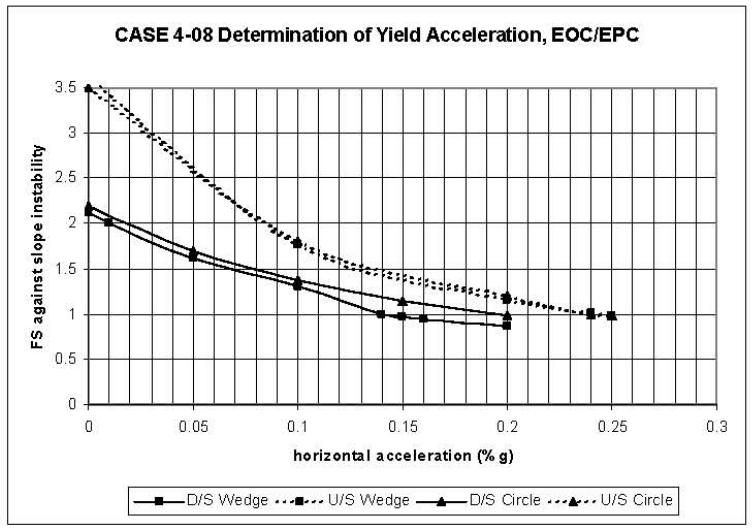
Description: Jet Grouted Alluvium
Wt: 130
Cohesion: 9360
Phi: 0
Piezometric Line: 1

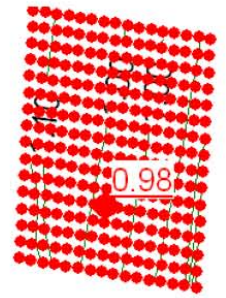
Description: Untreated Alluvium - Liquefied
Wt: 128
Cohesion: 400
Phi: 0
Piezometric Line: 1

Description: Seafloor Deposits - Seismic
Wt: 98
C-Datum: 13
C-Rate of Increase: 15.4
Limiting C: 600
Elevation: -260
Piezometric Line: 1

Description: Upper Stiff Lacustrine
Model: MohrCoulomb
Wt: 118
Cohesion: 200
Phi: 33
Anisotropic Fn: 1
Piezometric Line: 1

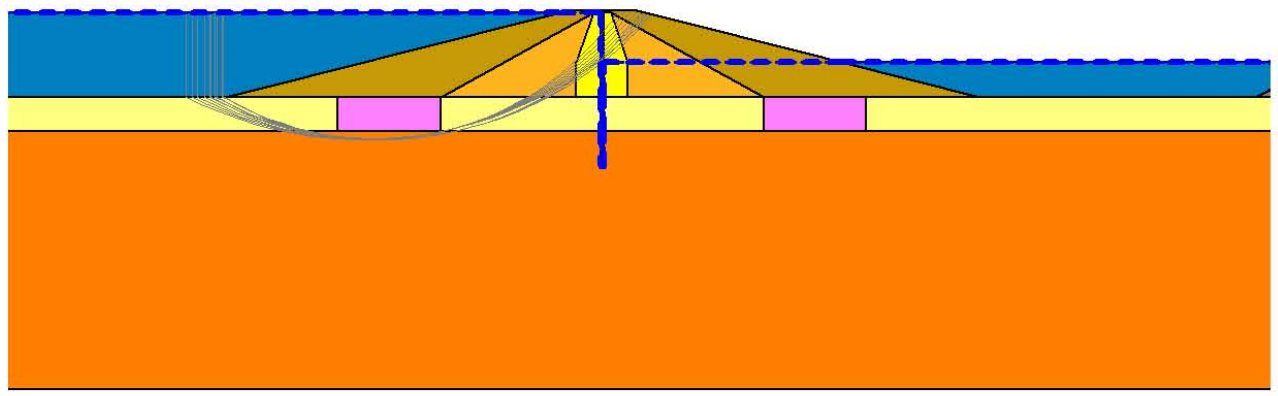


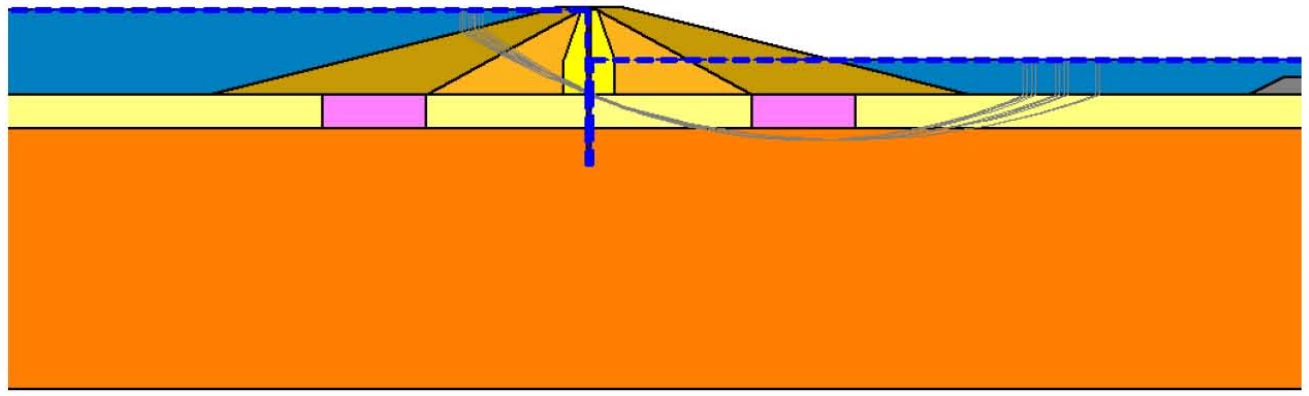




10 most critical failure surfaces
FS ranges from 1.01 to 1.05

U/S Circles Ky=0. 24g

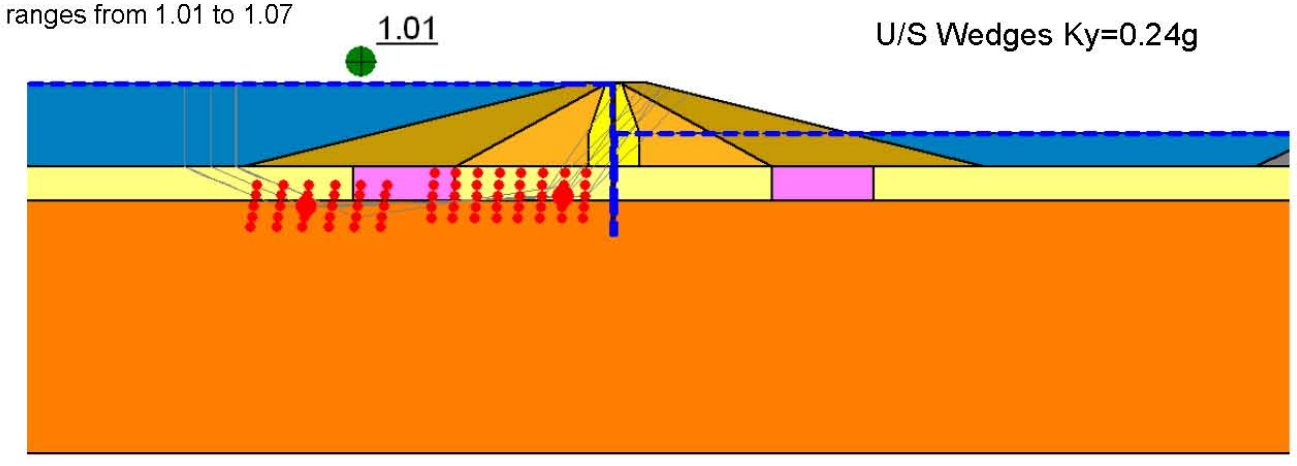


D/S Circles Ky=0.2g



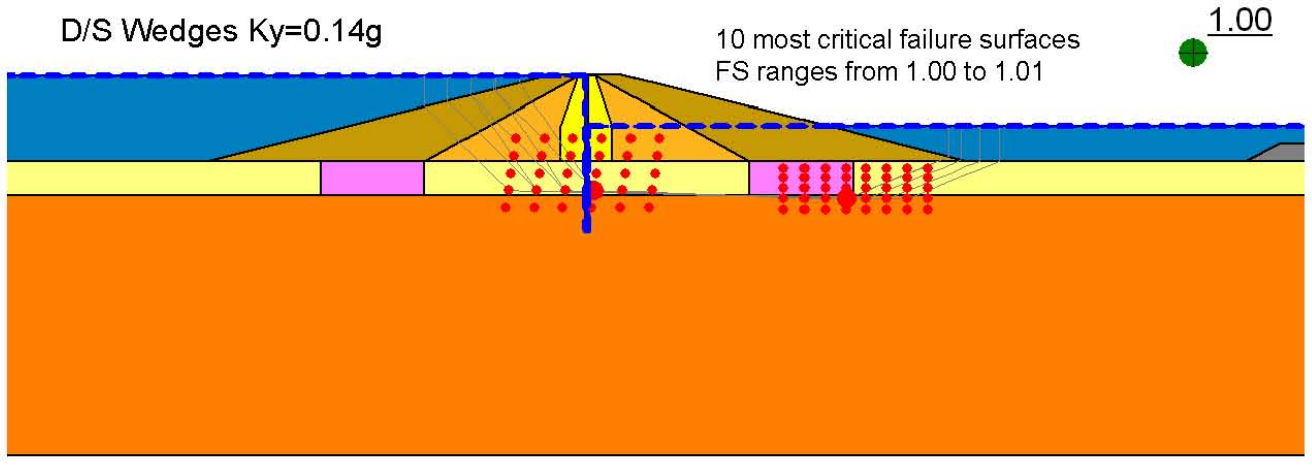
10 most critical failure surfaces
FS ranges from 0.98 to 0.99

10 most critical failure surfaces
FS ranges from 1.01 to 1.07




U/S Wedges Ky=0.24g

D/S Wedges Ky=0.14g




10 most critical failure surfaces
FS ranges from 1.00 to 1.01

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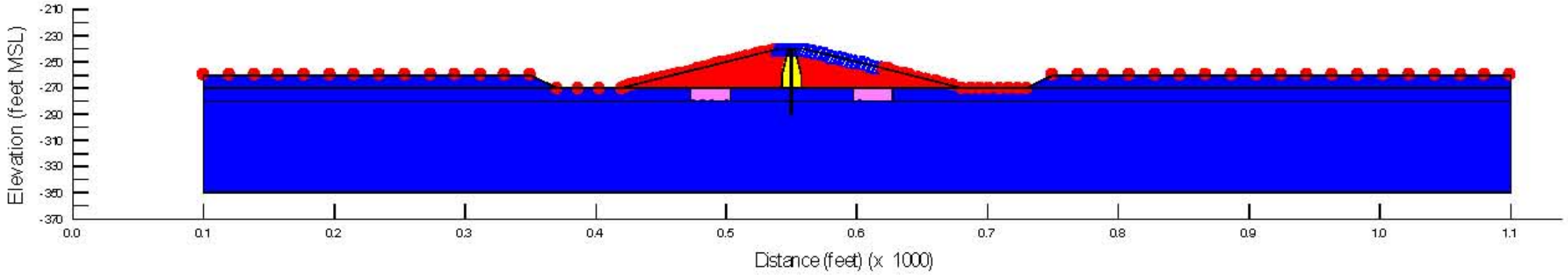
Seismic Stability Analysis
Case 4,8 Perimeter Dike (West)
Jetgrouting Under Shells, Liquefiable Foundation

| Project 71100 | By E. Sossenkina | August 2006 |
|---|---|---|

**FIGURE B.B-16**

## Section Geometry and Boundary Conditions



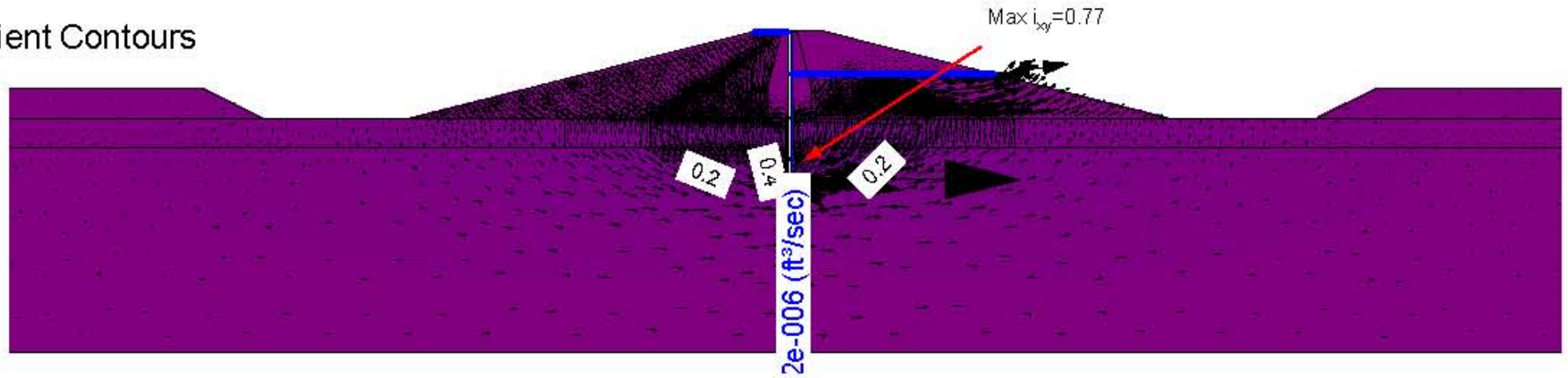

### Boundary Conditions Legend

Constant Total Head
Seepage Exit Boundary

### Material Properties Legend

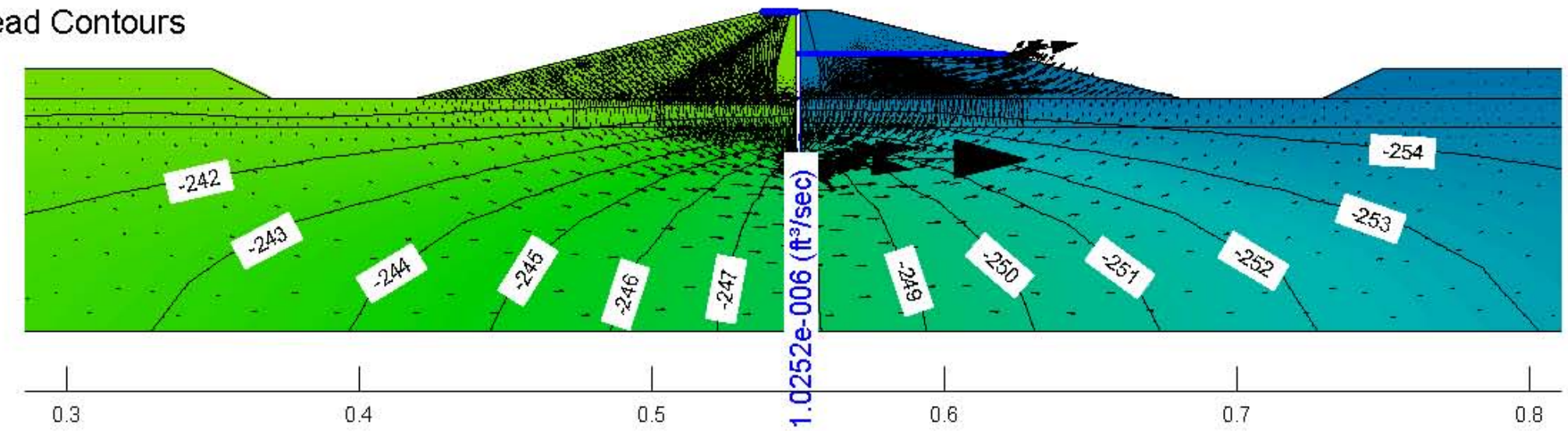
| Material | Kh ft/sec | Kv/Kh | Color |
|---|---|---|---|
| Rockfill | $3.28*10^{-2}$ | 0.25 | |
| Fine Rockfill | $3.28*10^{-2}$ | 0.25 | |
| Sand Gravel Core | $3.28*10^{-4}$ | 0.25 | |
| Seafloor Deposits | $3.28*10^{-7}$ | 0.1 | |
| Soft Lacustrine | $3.28*10^{-7}$ | 0.1 | |
| Stiff Lacustrine | $3.28*10^{-7}$ | 0.1 | |
| Jet-grouted Lacustrine | $3.28*10^{-8}$ | 1 | |
| Sheetpile Wall | Impervious | | |

## XY Gradient Contours




### XY Gradient $i_{xy}$ Contours Legend


## Total Head Contours




### Total Head Contours Legend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**SALTON SEA RESTORATION PROJECT**
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Appendix 2B – Seepage and Stability Analyses

Project 71100 | By E. Sossenkina | August 2006

Seepage Analysis
Case 4,9 Perimeter Dike (East)
Jetgrouting Under Shells, Liquefiable Foundation

**FIGURE B.B-17**

Description: Vinyl Sheetpile Wall
Wt: 120
Cohesion: 100
Phi: 30
Piezometric Line: 1

Description: Rockfill
Wt: 115
Cohesion: 0
Phi: 45
Piezometric Line: 1

Description: Fine Rockfill
Wt: 118
Cohesion: 0
Phi: 42
Piezometric Line: 1

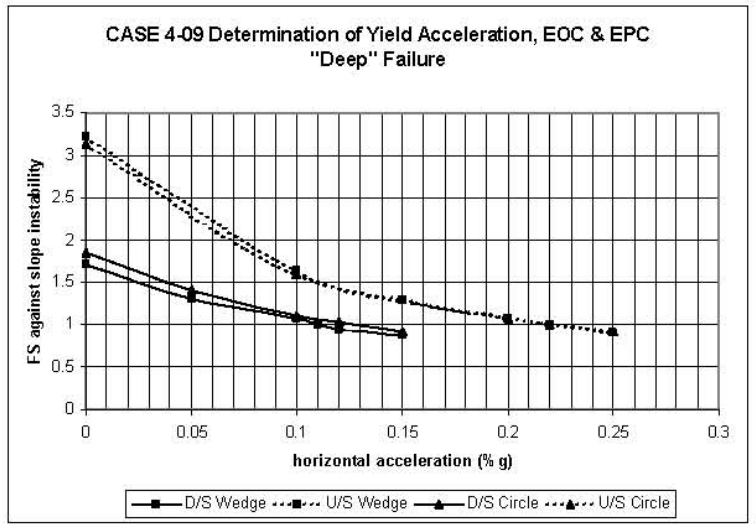
Description: Core - Clean Sand & Gravel
Wt: 120
Cohesion: 0
Phi: 30
Piezometric Line: 1

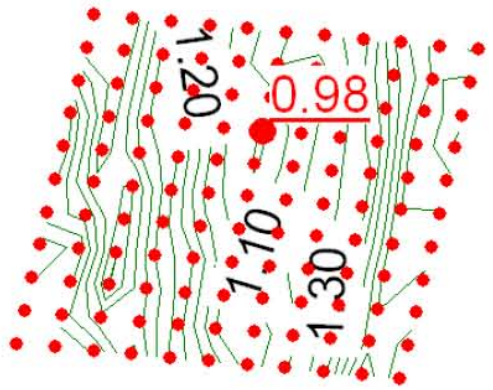
Description: Jet Grouted Lacustrine
Wt: 120
Cohesion: 7200
Phi: 0
Piezometric Line: 1

Description: Soft Lacustrine - Liquefied
Wt: 115
Cohesion: 250
Phi: 0
Piezometric Line: 1

Description: Upper Stiff Lacustrine
Wt: 118
Cohesion: 200
Phi: 33
Anisotropic Fn: 1
Piezometric Line: 1

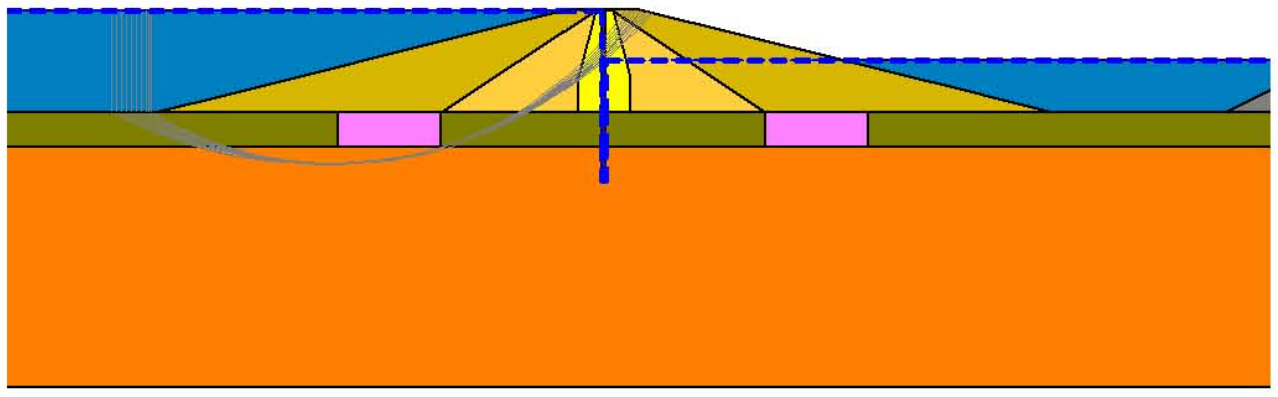
Description: Seafloor Deposit - Seismic
Wt: 98
C-Datum: 13
C-Rate of Increase: 15.4
Limiting C: 600
Elevation: -260
Piezometric Line: 1

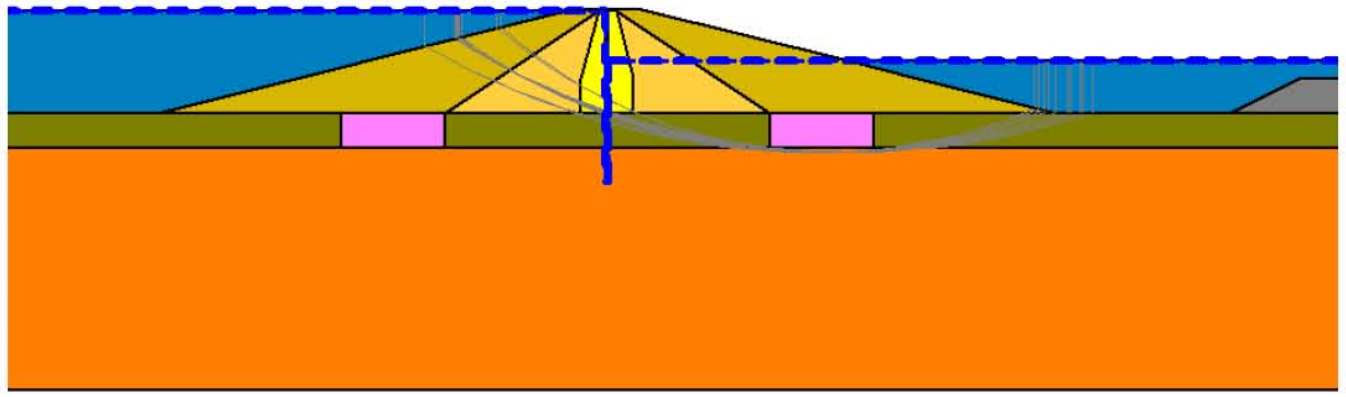




10 most critical failure surfaces
FS ranges from 1.01 to 1.02

U/S Circles Ky=0. 22g



D/S Circles Ky=0.11g

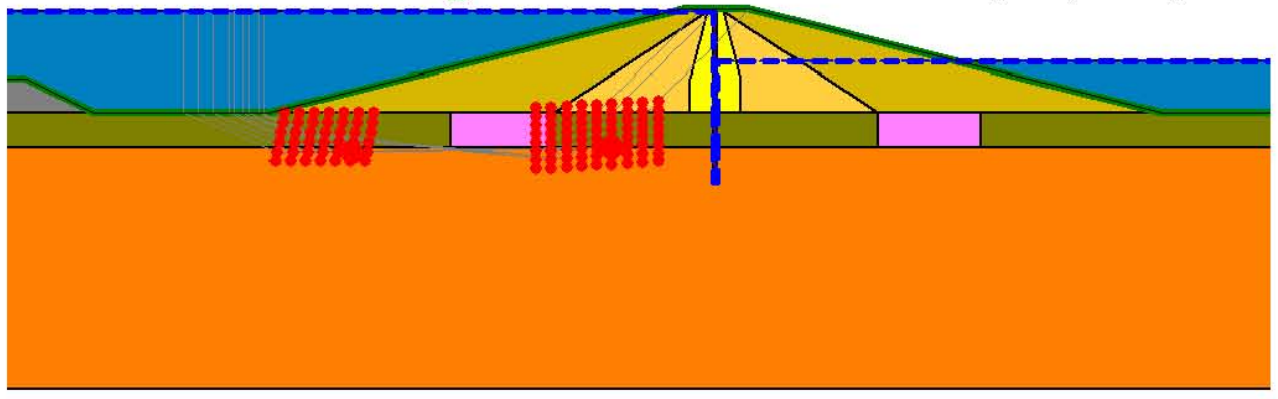


10 most critical failure surfaces
FS ranges from 0.98 to 1.06

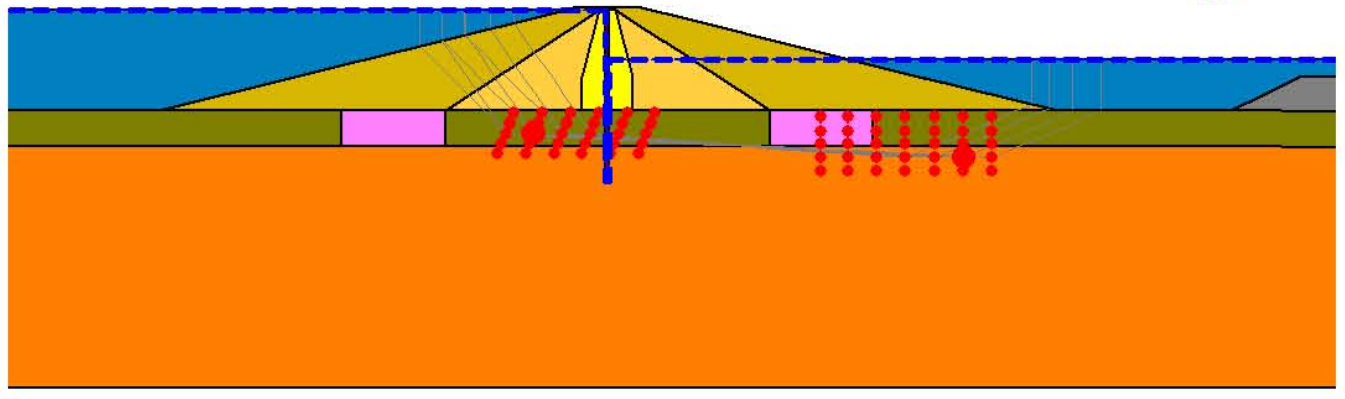
10 most critical failure surfaces
FS ranges from 1.01 to 1.02

1.00

U/S Wedges Ky=0.22g



D/S Wedges Ky=0.11g



10 most critical failure surfaces
FS ranges from 1.00 to 1.06

1.01

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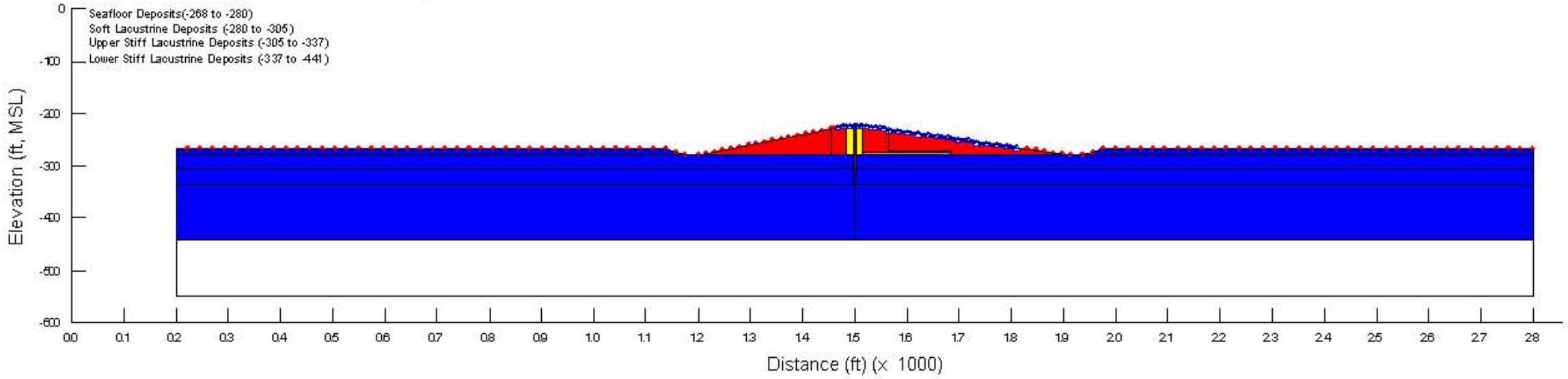
Seismic Stability Analysis
Case 4,9 Perimeter Dike (East)
Jetgrouting Under Shells, Liquefiable Foundation

| Project 71100 | By E. Sossenkina | August 2006 | **FIGURE B.B-18** |
|---|---|---|---|

## Section Geometry and Boundary Conditions



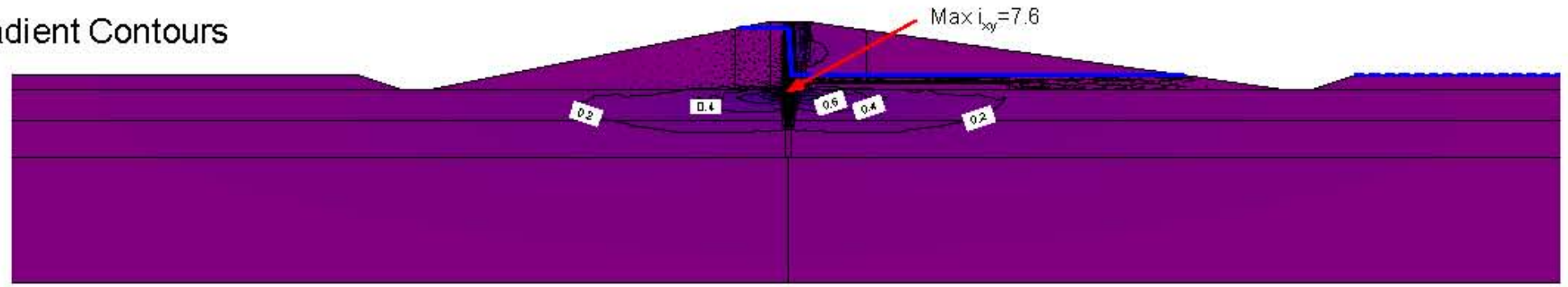

### Boundary Conditions Legend

Constant Total Head
Seepage Exit Boundary

### Material Properties Legend

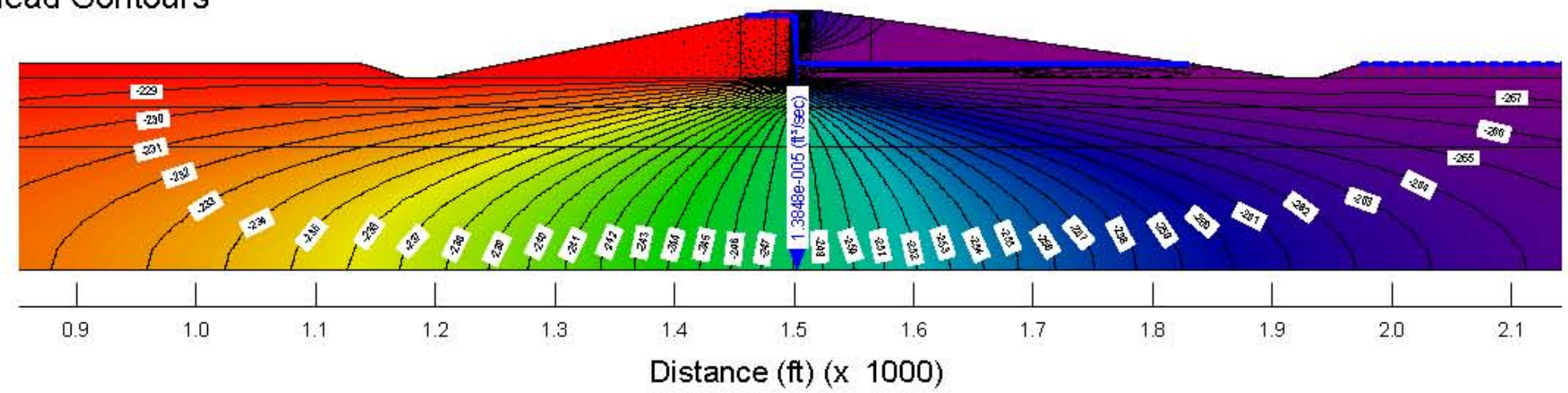
| Material | Kh ft/sec | Kv/Kh | Color |
|---|---|---|---|
| Rockfill | $3.28*10^{-2}$ | 0.25 | |
| Fine Rockfill | $3.28*10^{-2}$ | 0.25 | |
| Filter Blanket | $1.77*10^{-4}$ | 1 | |
| Sand Gravel Core | $3.28*10^{-4}$ | 0.25 | |
| Slurry Wall | $3.28*10^{-8}$ | 1 | |
| Seafloor Deposits | $3.28*10^{-7}$ | 0.1 | |
| Soft Lacustrine | $3.28*10^{-7}$ | 0.1 | |
| Stiff Lacustrine | $3.28*10^{-7}$ | 0.1 | |

## XY Gradient Contours




### XY Gradient $i_{xy}$ Contours Legend


## Total Head Contours




### Total Head Contours Legend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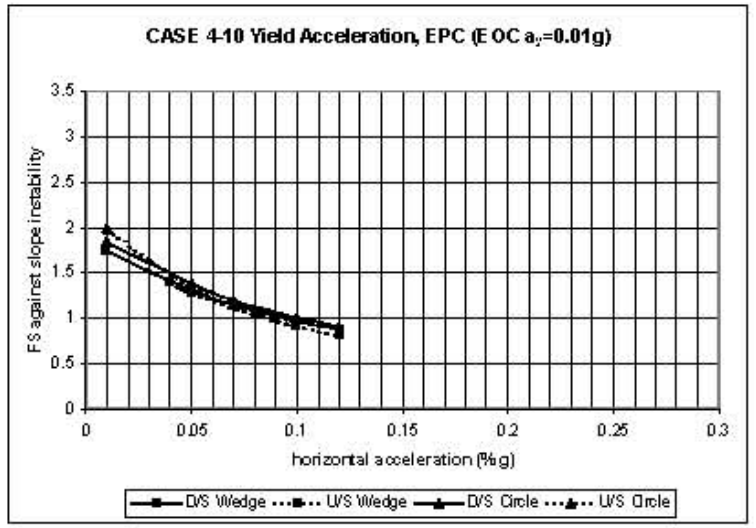
Seepage Analysis
Case 4,10 Mid-Sea Dam
Non-Liquefiable Foundation

Project 71100 | By E. Sossenkina | August 2006

**FIGURE B.B-19**




Description: Rockfill
Wt: 115
Cohesion: 0
Phi: 45
Piezometric Line: 1

Description: Core - Clean Sand & Gravel
Wt: 120
Cohesion: 0
Phi: 30
Piezometric Line: 1

Description: Fine Rockfill
Wt: 118
Cohesion: 0
Phi: 42
Piezometric Line: 1

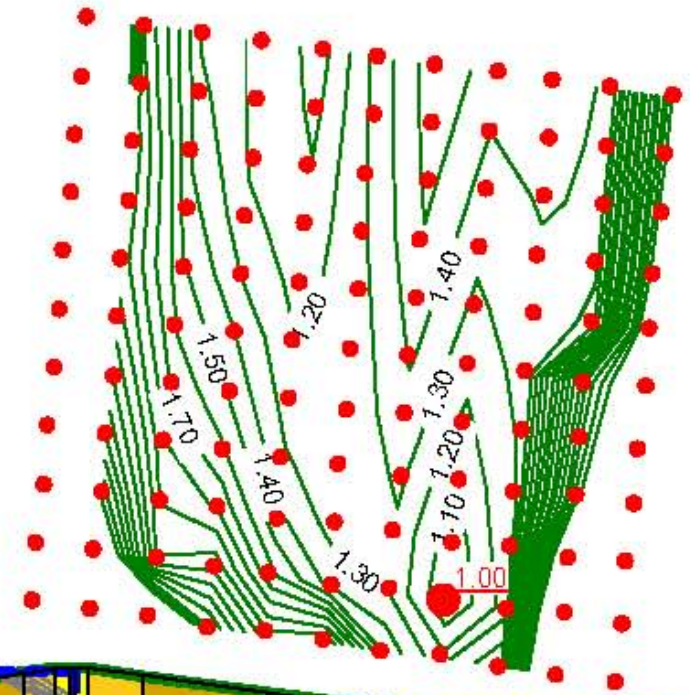
Description: Soft Lacustrine – EPC Seismic
Wt: 115
Cohesion: 0
Phi: 17
Unit Wt. Above WT: 115
Phi-B: 0
Anisotropic Fn: 1
Piezometric Line: 1

Description: SCB Slurry Wall
Wt: 120
Cohesion: 100
Phi: 30
Piezometric Line: 1

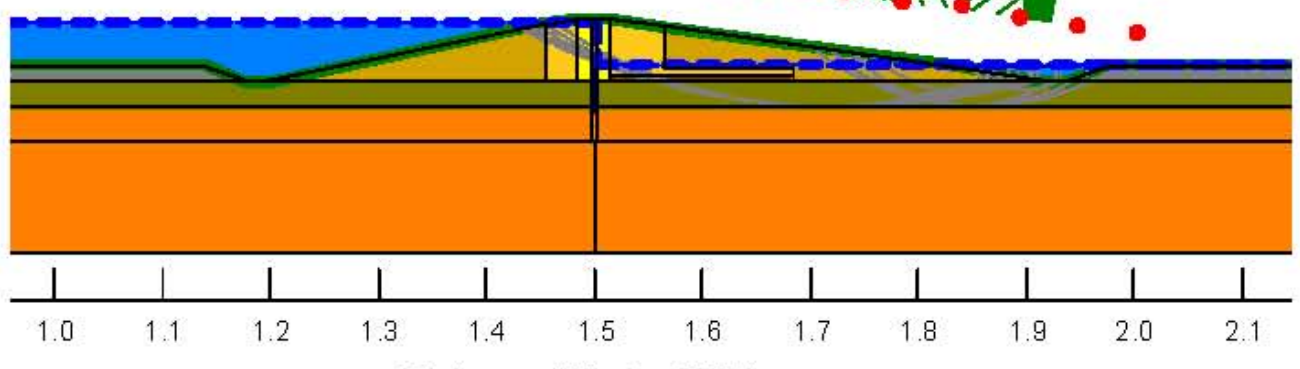
Description: Filter Blanket-Liquefied
Wt: 125
Cohesion: 150
Phi: 0
Piezometric Line: 1

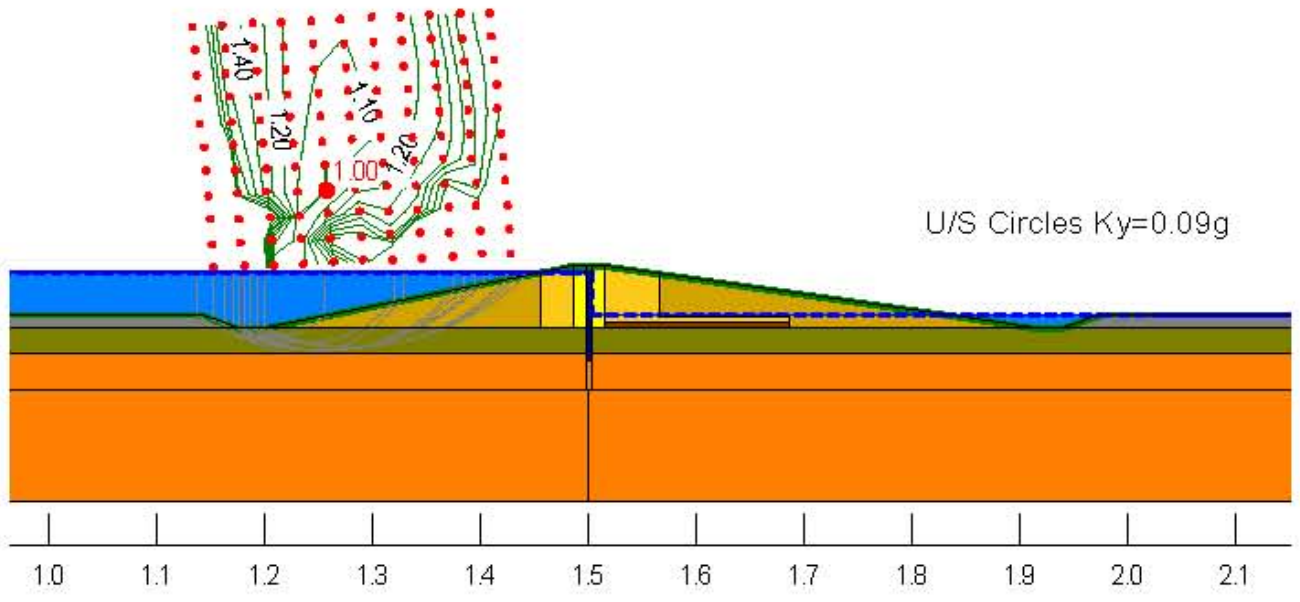
Description: Seafloor Deposit - Seismic
Wt: 98
C-Datum: 13
C-Rate of Increase: 15.4
Limiting C: 600
Elevation: -268
Piezometric Line: 1

Description: Upper Stiff Lacustrine, Seismic
Wt: 118
Cohesion: 200
Phi: 33
Unit Wt. Above WT: 118
Phi-B: 0
Anisotropic Fn: 1
Piezometric Line: 1



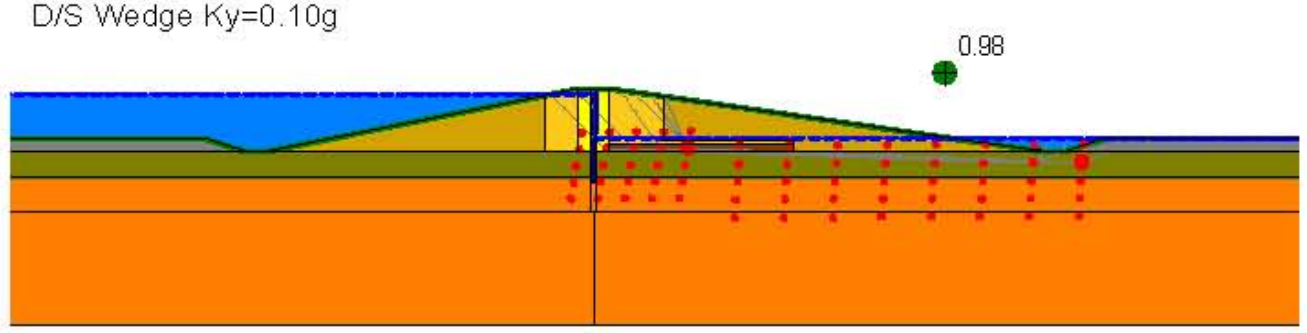

D/S Circles Ky=0.10g

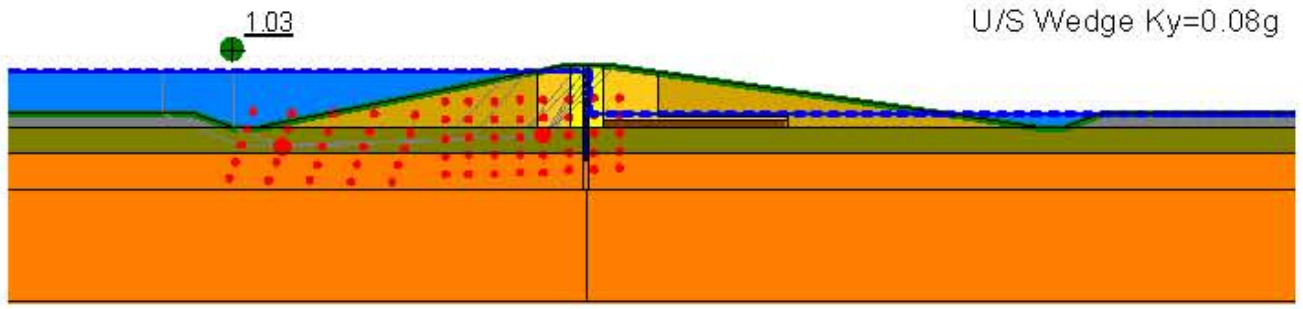



U/S Circles Ky=0.09g

D/S Wedge Ky=0.10g




U/S Wedge Ky=0.08g

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**SALTON SEA RESTORATION PROJECT**
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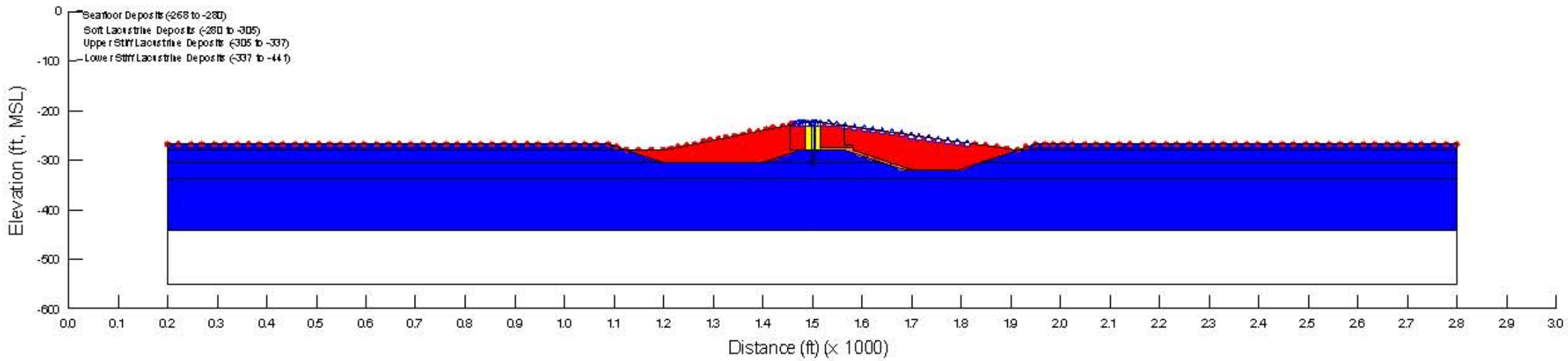
Seismic Slope Stability Analysis
Case 4,10 Mid-Sea Dam
Non-Liquefiable Foundation

Project 71100 | By E. Sossenkina | August 2006

**FIGURE B.B-20**

71100/DEN6R101

## Section Geometry and Boundary Conditions



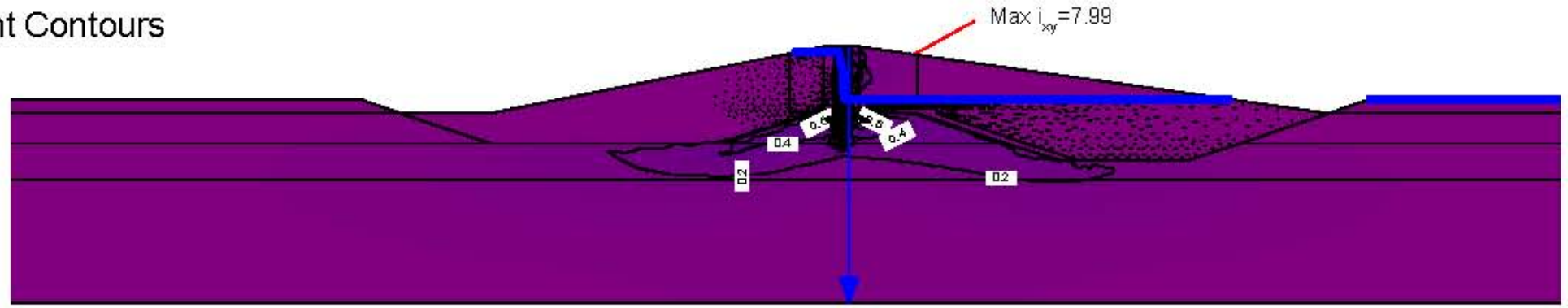

### Boundary Conditions Legend

Constant Total Head
Seepage Exit Boundary

### Material Properties Legend

| Material | Kh ft/sec | Kv/Kh | Color |
|---|---|---|---|
| Rockfill | $3.28*10^{-2}$ | 0.25 | |
| Fine Rockfill | $3.28*10^{-2}$ | 0.25 | |
| Filter Blanket | $1.77*10^{-4}$ | 1 | |
| Sand Gravel Core | $3.28*10^{-4}$ | 0.25 | |
| Slurry Wall | $3.28*10^{-8}$ | 1 | |
| Seafloor Deposits | $3.28*10^{-7}$ | 0.1 | |
| Soft Lacustrine | $3.28*10^{-7}$ | 0.1 | |
| Stiff Lacustrine | $3.28*10^{-7}$ | 0.1 | |

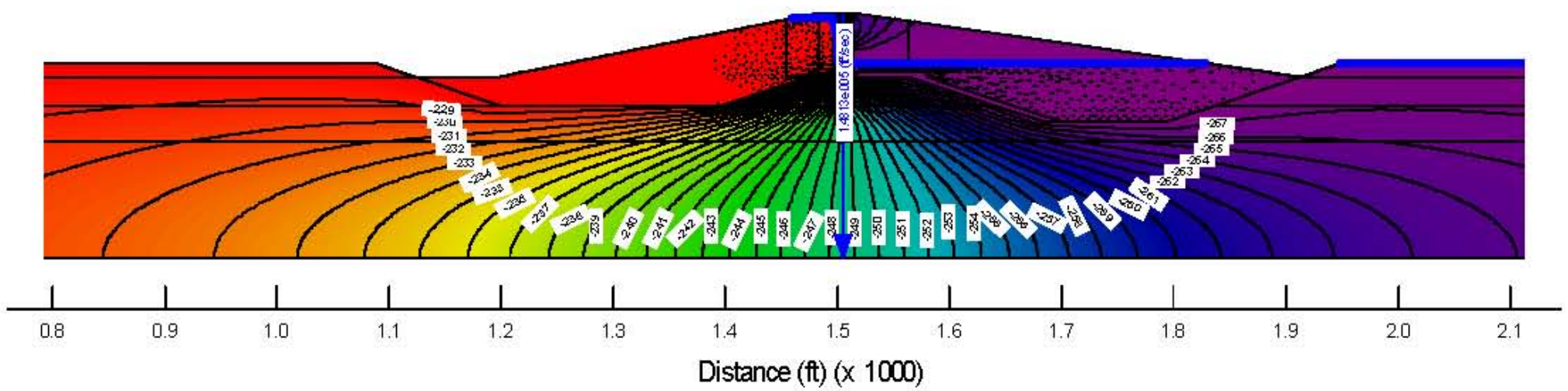
## XY Gradient Contours




### XY Gradient $i_{xy}$ Contours Legend

$i_{xy}$=0 $i_{xy}$=8

## Total Head Contours




### Total Head Contours Legend

-268 ft -228 ft

| | | | |
|---|---|---|---|
| United States Department of the Interior Bureau of Reclamation | **SALTON SEA RESTORATION PROJECT** EMBANKMENT DESIGNS AND OPTIMIZATION STUDY Appendix 2B – Seepage and Stability Analyses | | Seepage Analysis Case 4,11 Mid-Sea Dam Rock Notches, Non-Liquefiable Foundation |
| KLEINFELDER | Project 71100 | By E. Sossenkina | August 2006 |
| | | | **FIGURE B.B-21** |

71100/DEN6R101

Note:
Anisotropic Fn1=Sh/Sv=0.9

Material #: 1
Description: SCB Slurry Wall
Model: MohrCoulomb
Wt: 120
Cohesion: 100
Phi: 30
Piezometric Line: 1

Material #: 2
Description: Core - Clean Sand and Gravel
Model: MohrCoulomb
Wt: 120
Cohesion: 0
Phi: 30
Piezometric Line: 1

Material #: 3
Description: Fine Rock Fill
Model: MohrCoulomb
Wt: 118
Cohesion: 0
Phi: 42
Piezometric Line: 1

Material #: 4
Description: Rock Fill
Model: MohrCoulomb
Wt: 115
Cohesion: 0
Phi: 45
Piezometric Line: 1

Material #: 5
Description: Filter Blanket - Liquefiable
Model: MohrCoulomb
Wt: 125
Cohesion: 150
Phi: 0
Piezometric Line: 1

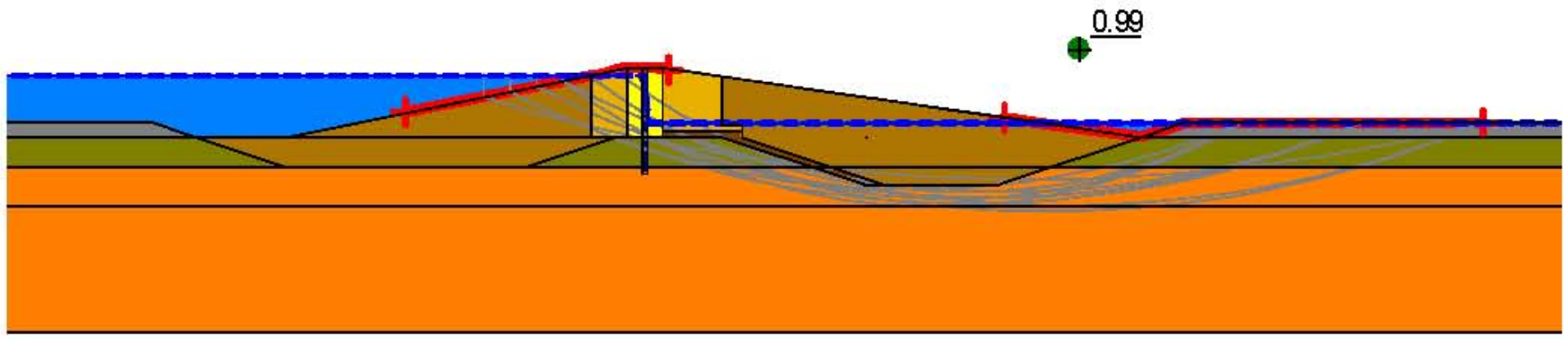
Material #: 7
Description: Seafloor Deposits - Seismic
Model: SFnDatum
Wt: 98
C-Datum: 13
C-Rate of Increase: 15.4
Limiting C: 600
Elevation: -288
Piezometric Line: 1

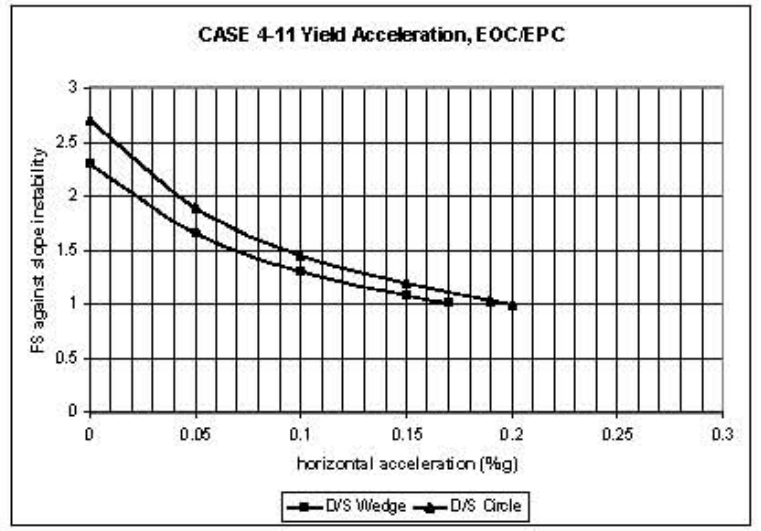
Material #: 8
Description: Upper Lacustrine, Seismic
Model: MohrCoulomb
Wt: 118
Cohesion: 200
Phi: 33
Unit Wt. Above WT: 118
Phi-B: 0
Anisotropic Fn: 1
Piezometric Line: 1

Material #: 10
Description: Soft Lacustrine, EOC seismic
Model: SFnDatum
Wt: 115
C-Datum: 13
C-Rate of Increase: 15.4
Limiting C: 600
Elevation: -288
Anisotropic Fn: 1
Piezometric Line: 1

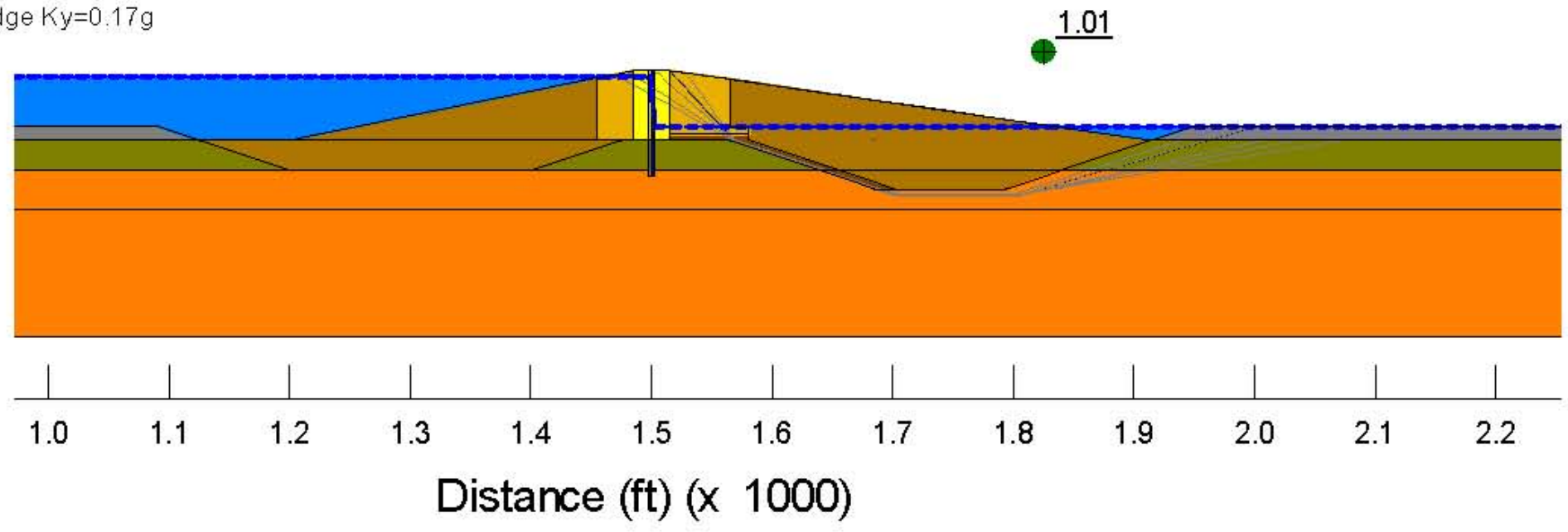
Material #: 11
Description: Soft Lacustrine, EPC seismic
Model: MohrCoulomb
Wt: 115
Cohesion: 0
Phi: 17
Anisotropic Fn: 1
Piezometric Line: 1

D/S Circles Ky=0.20g




D/S Wedge Ky=0.17g

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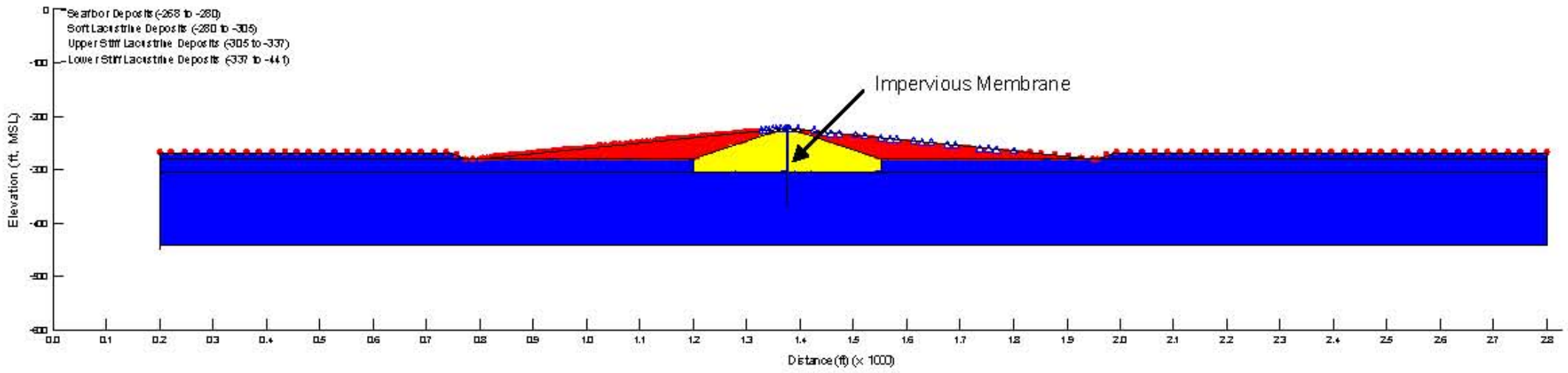
Seismic Slope Stability Analysis
Case 4,11 Mid-Sea Dam
Rock Notches, Non-Liquefiable Foundation

Project 71100 | By E. Sossenkina | August 2006

**FIGURE B.B-22**

71100/DEN6R101

## Section Geometry and Boundary Conditions



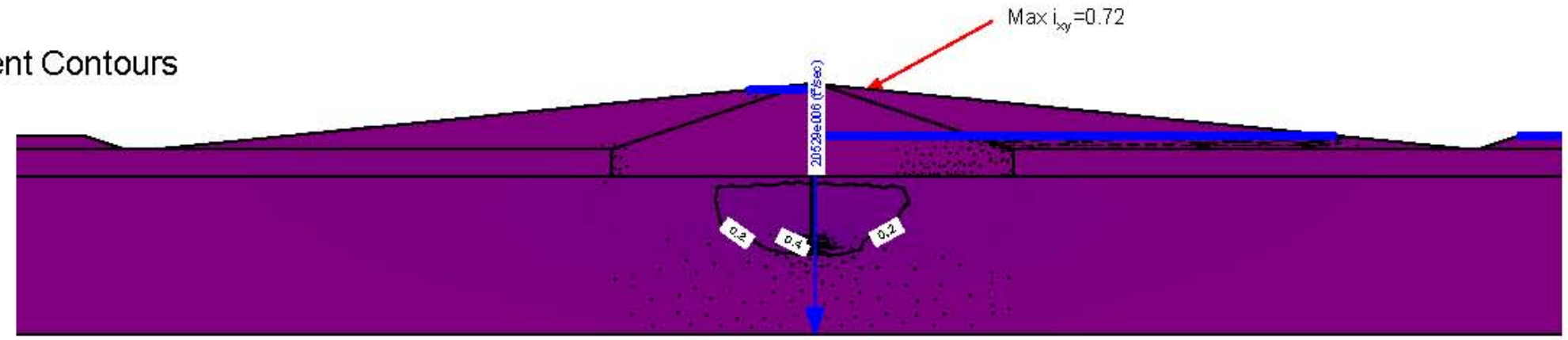

### Boundary Conditions Legend

Constant Total Head
Seepage Exit Boundary

### Material Properties Legend

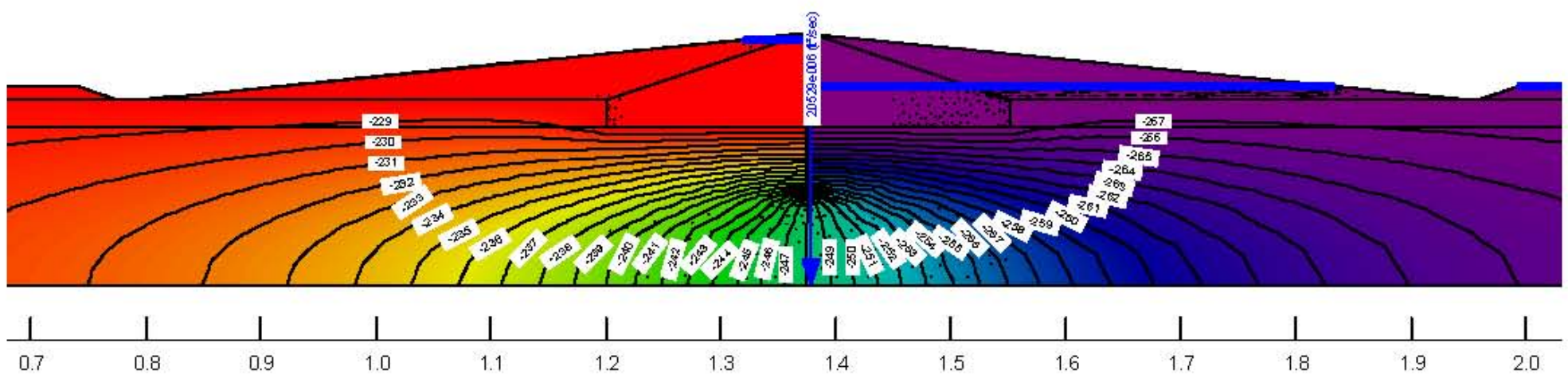
| Material | Kh ft/sec | Kv/Kh | Color |
|---|---|---|---|
| Rock Fill | $3.28*10^{-2}$ | 0.25 | |
| Seafloor Deposits | $3.28*10^{-7}$ | 0.1 | |
| Soft Lacustrine | $3.28*10^{-7}$ | 0.1 | |
| Stiff Lacustrine | $3.28*10^{-7}$ | 0.1 | |
| Stone Column | $3.28*10^{-2}$ | 0.25 | |
| Membrane | Impervious | | |

## XY Gradient Contours




### XY Gradient $i_{xy}$ Contours Legend


## Total Head Contours




### Total Head Contours Legend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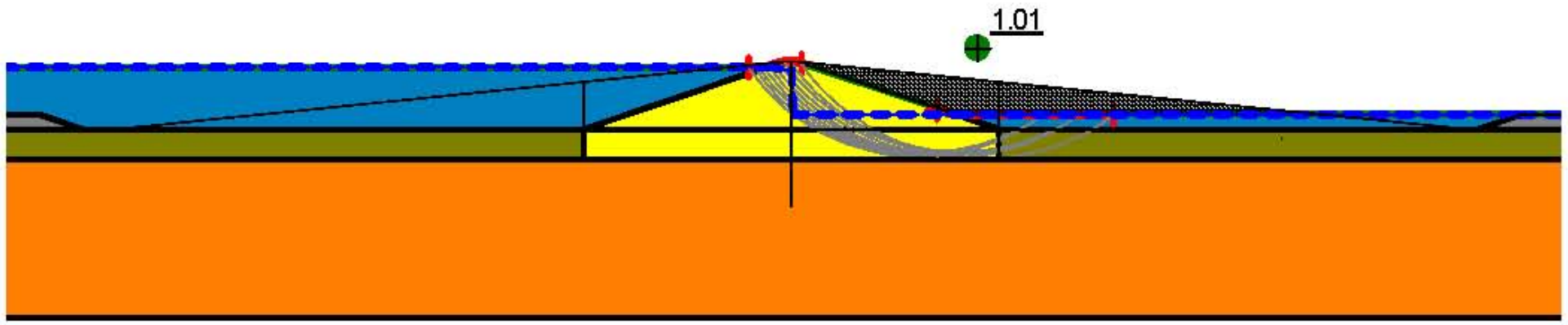
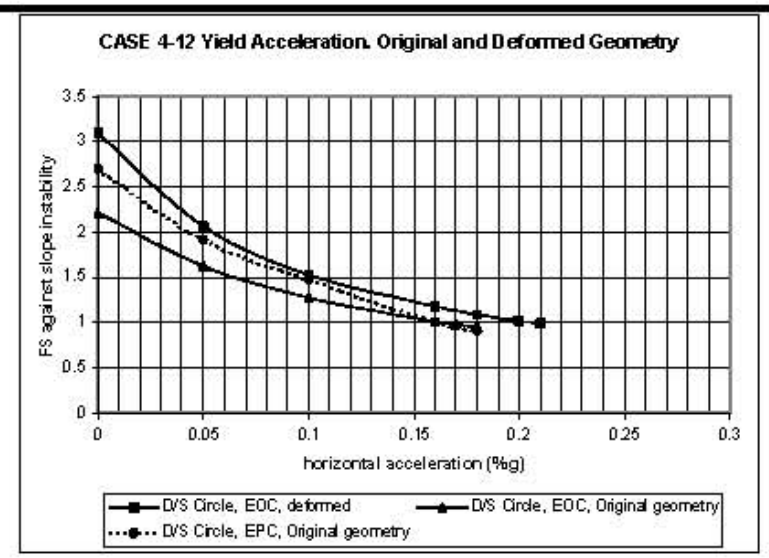
Seepage Analysis
Case 4,12 Mid-Sea Dam
Stone Columns, Non-Liquefiable Foundation

**FIGURE B.B-23**

71100/DEN6R101

D/S Circles, EOC, Original Geometry Ky=0.16g




End of Construction (EOC)

EOC Material Properties

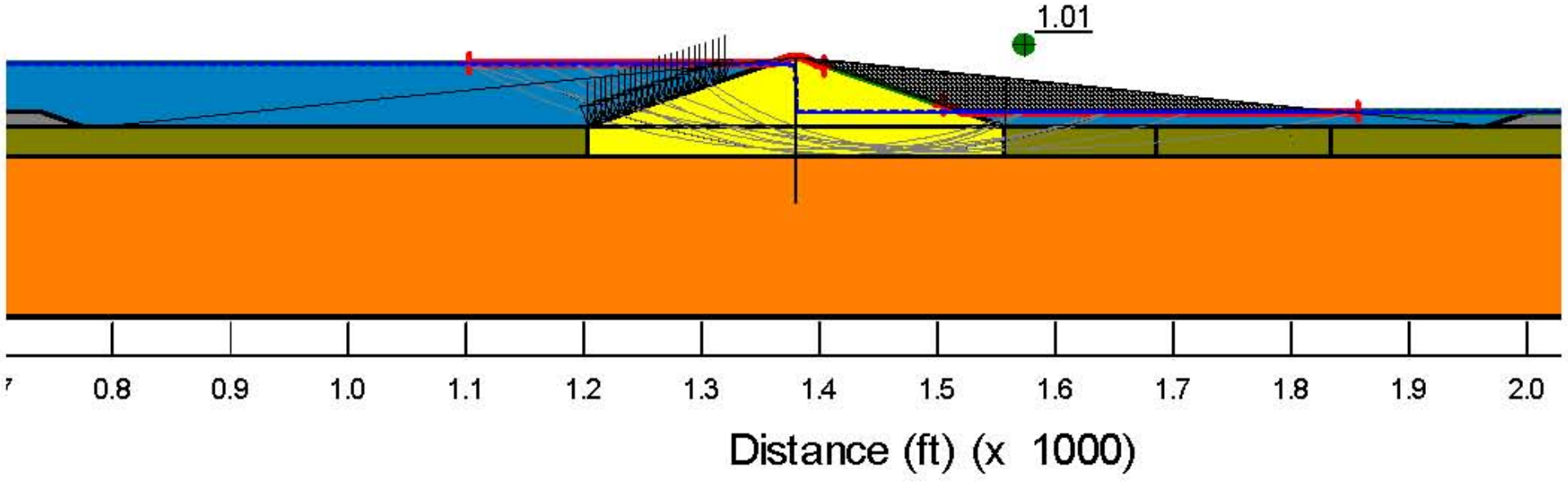
Material#: 14
Description: Searboor Deposit - EOC Seismic
Model: SFs Datum
Wt: 98
C-Datum: 13
C-Rate of Increase: 15.4
Limiting C: 600
Elevation: -268
Piezometric Line: 1

Material#: 8
Description: Upper Stiff Lacustrine
Model: Mohr/Coulomb
Wt: 118
Cohesion: 200
Phi: 33
Unit Wt. Above WT: 118
Phi-B: 0
Anisotropic Fn: 1
Piezometric Line: 1

Description: Soft Lacustrine - EOC Seismic
Wt: 115
C-Datum: 13
C-Rate of Increase: 15.4
Limiting C: 600
Elevation: -268
Unit Wt. Above WT: 115
Anisotropic Fn: 1
Piezometric Line: 1

Material#: 1
Description: Sand Embankment with Stone Columns - Liquefied
Model: Mohr/Coulomb
Wt: 120
Cohesion: 1000
Phi: 0
Piezometric Line: 1

D/S Circles, EPC, Original geometry, Ky=0.16g




End of Primary Consolidation (EPC)

EPC Material Properties

Material #: 1
Description: Sand Embankment with Stone Columns - Liquefied
Model: Mohr Coulomb
Wt: 120
Cohesion: 1000
Phi: 0
Piezometric Line: 1

Material #: 15
Description: Seafloor Deposit - EPC Seismic
Model: Mohr Coulomb
Wt: 98
Cohesion: 0
Phi: 12.5
Piezometric Line: 1

Description: Soft Lacustrine - EPC Seismic
Wt: 115
Cohesion: 0
Phi: 17
Unit Wt. Above WT: 115
Anisotropic Fn: 1
Piezometric Line: 1

Description: Soft Lacustrine - EPC Seismic 1
Wt: 115
C-Datum: 740
C-Rate of Increase: 15.4
Limiting C: 1600
Elevation: -268
Piezometric Line: 1

Material #: 8
Description: Upper Stiff Lacustrine
Model: Mohr Coulomb
Wt: 118
Cohesion: 200
Phi: 33
Unit Wt. Above WT: 118
Phi-B: 0
Anisotropic Fn: 1
Piezometric Line: 1

Description: Soft Lacustrine - EPC Seismic 2
Wt: 115
C-Datum: 530
C-Rate of Increase: 15.4
Limiting C: 1600
Elevation: -268
Piezometric Line: 1

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Seismic Stability Analysis
Case 4,12 Mid-Sea Dam
Stone Columns Non-liquefiable Foundation

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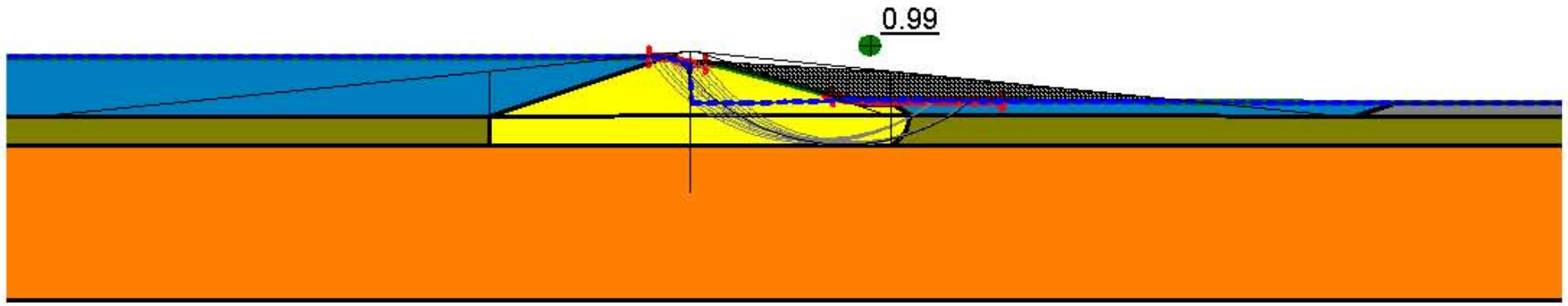
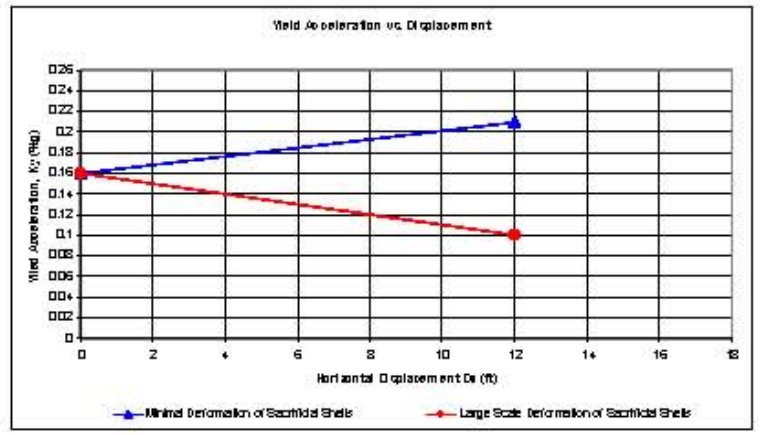
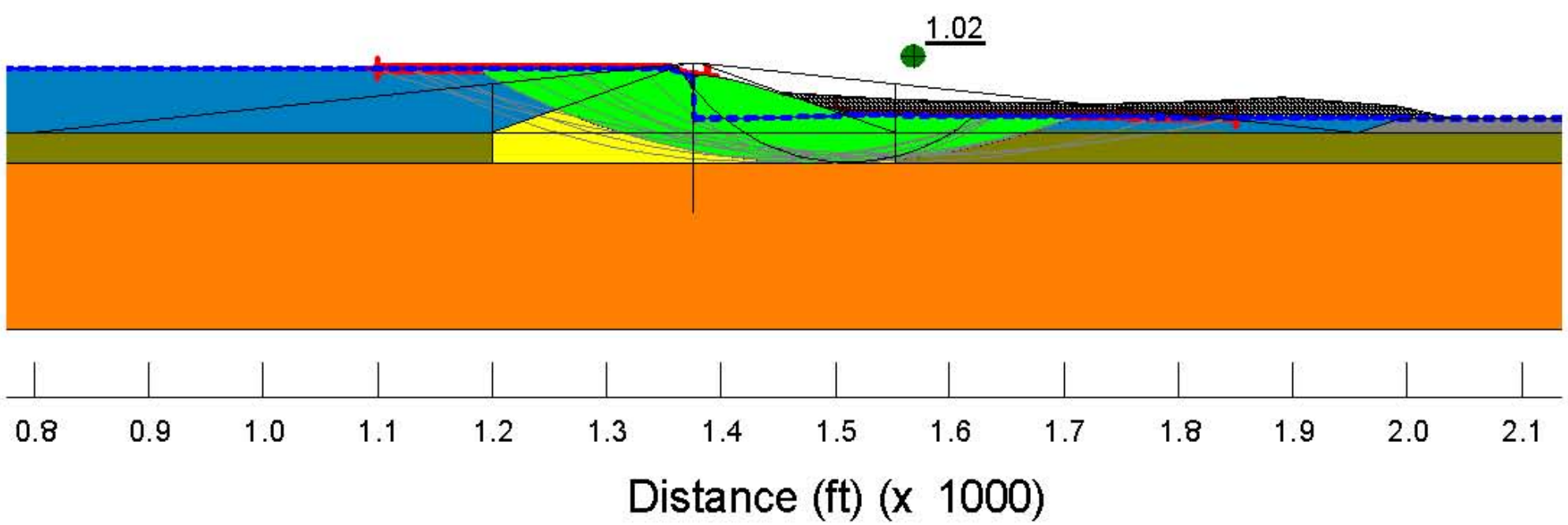
**FIGURE B.B-24a**

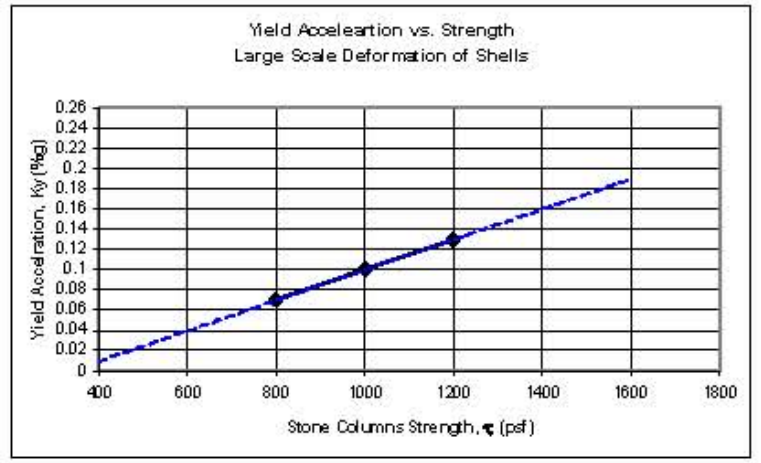
Deformed Central Section, 10 ft vertical displacement, 12 ft horizontal displacement
Minimal Deformation of sacrificial shells Ky=0. 21g




Deformed Central Section, 10 ft vertical displacement, 12 ft horizontal displacement
Large Scale Deformation of sacrificial shells Ky=0. 10g




| | | | | |
|---|---|---|---|---|
| United States Department of the Interior Bureau of Reclamation | **SALTON SEA RESTORATION PROJECT** EMBANKMENT DESIGNS AND OPTIMIZATION STUDY Appendix 2B – Seepage and Stability Analyses | | | Seismic Stability Analysis Case 4,12 Mid-Sea Dam Deformed Geometry |
| KLEINFELDER | Project 71100 | By E. Sossenkina | August 2006 | **FIGURE B.B-24b** |

71100/DEN6R101

Material # 1
Description: Slurry Cut-Off Wall
Model: MohrCoulomb
Wt: 120
Cohesion: 100
Phi: 30
Piezometric Line: 1

Material #: 2
Description: Core
Model: MohrCoulomb
Wt: 120
Cohesion: 0
Phi: 30
Piezometric Line: 1

Material #: 3
Description: Fine Rock Fill
Model: MohrCoulomb
Wt: 118
Cohesion: 0
Phi: 42
Piezometric Line: 1

Material # 4
Description: Rock Fill
Model: MohrCoulomb
Wt: 115
Cohesion: 0
Phi: 45
Piezometric Line: 1

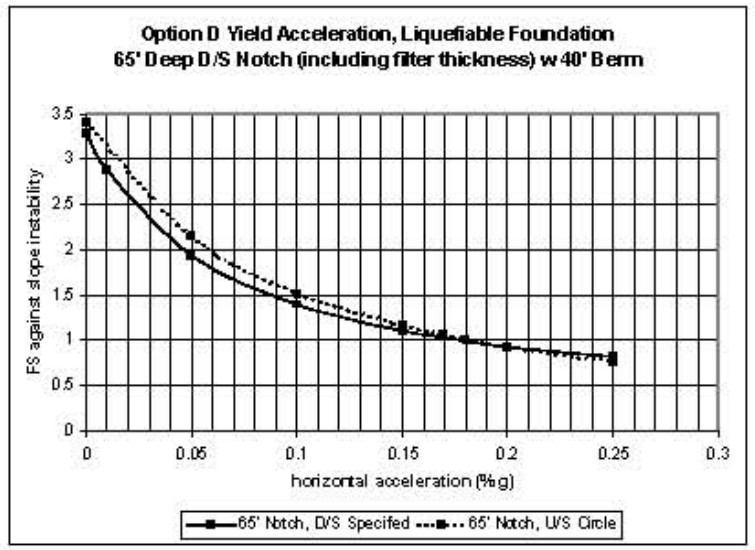
Material # 5
Description: Filter Blanket
Model: MohrCoulomb
Wt: 125
Cohesion: 150
Phi: 0
Piezometric Line: 1

Material # 6
Description: Untreated Lacustrine Deposites
Model: UndrainedPhiZero
Wt: 115
Cohesion: 250
Piezometric Line: 1

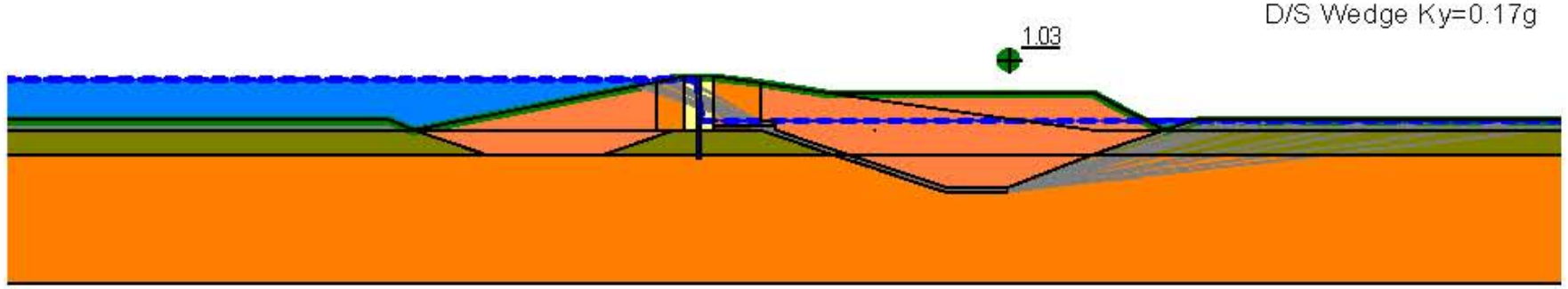
Material #: 7
Description: Seafloor Deposites
Model: SFnDatum
Wt: 98
C-Datum: 13
C-Rate of Increase: 15.4
Limiting C: 600
Elevation: -268
Piezometric Line: 1

Material # 8
Description: Stiff Lacustrine Deposites
Model: MohrCoulomb
Wt: 118
Cohesion: 200
Phi: 33
Unit Wt. Above WT: 118
Phi-B: 0
Anisotropic Fn: 1
Piezometric Line: 1

Note:
Anisotropic Fn1=Sh/Sv=0.9



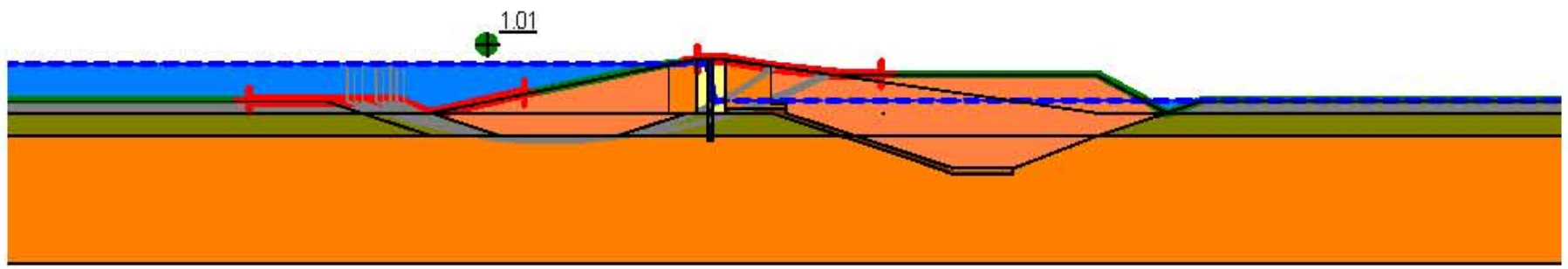

D/S Wedge Ky=0.17g

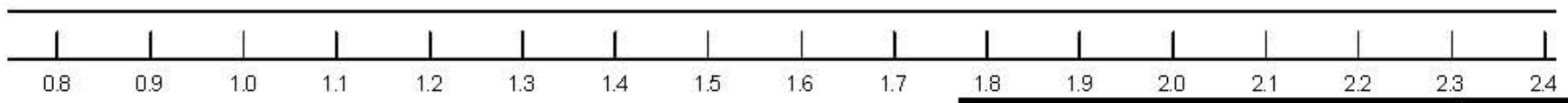




Distance (ft) (x 1000)

U/S Wedge Ky=0.18g




Distance (ft) (x 1000)

United States
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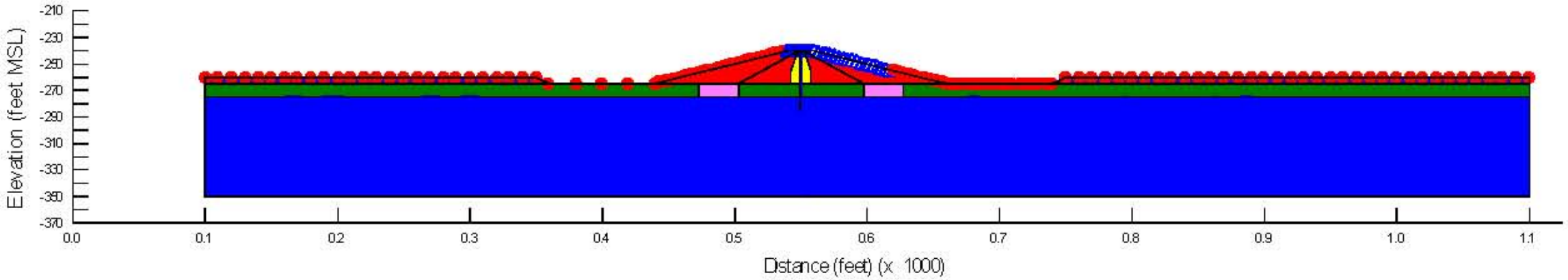
**SALTON SEA RESTORATION PROJECT**
EMBANKMENT DESIGNS AND
OPTIMIZATION STUDY
Appendix 2B – Seepage and Stability Analyses

Seismic Stability Analysis
Case 4,13 Mid-Sea Dam
Deep Rock Notches

Project 71100 | By E. Sossenkina | August 2006

**FIGURE B.B-25**

## Section Geometry and Boundary Conditions



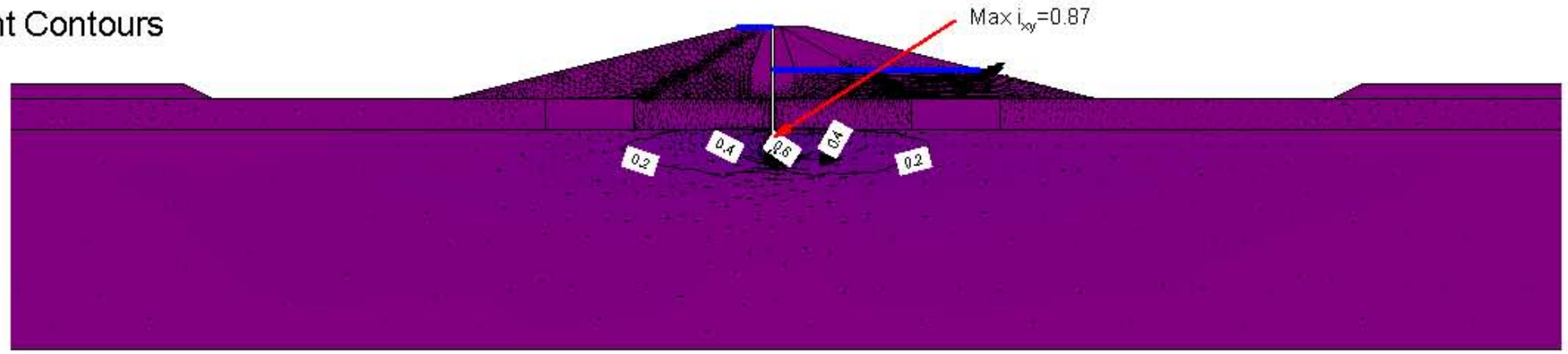

### Boundary Conditions Legend

Constant Total Head
Seepage Exit Boundary

### Material Properties Legend

| Material | Kh ft/sec | Kv/Kh | Color |
|---|---|---|---|
| Rockfill | $3.28*10^{-2}$ | 0.25 | |
| Fine Rockfill | $3.28*10^{-2}$ | 0.25 | |
| Sand Gravel Core | $3.28*10^{-4}$ | 0.25 | |
| Seafloor Deposits | $3.28*10^{-7}$ | 0.1 | |
| Stiff Lacustrine | $3.28*10^{-7}$ | 0.1 | |
| Alluvium | $1.32*10^{-5}$ | 0.25 | |
| jet-grouted alluvium | $3.28*10^{-8}$ | 1 | |
| Sheet Pile Wall | Impervious | | |

## XY Gradient Contours

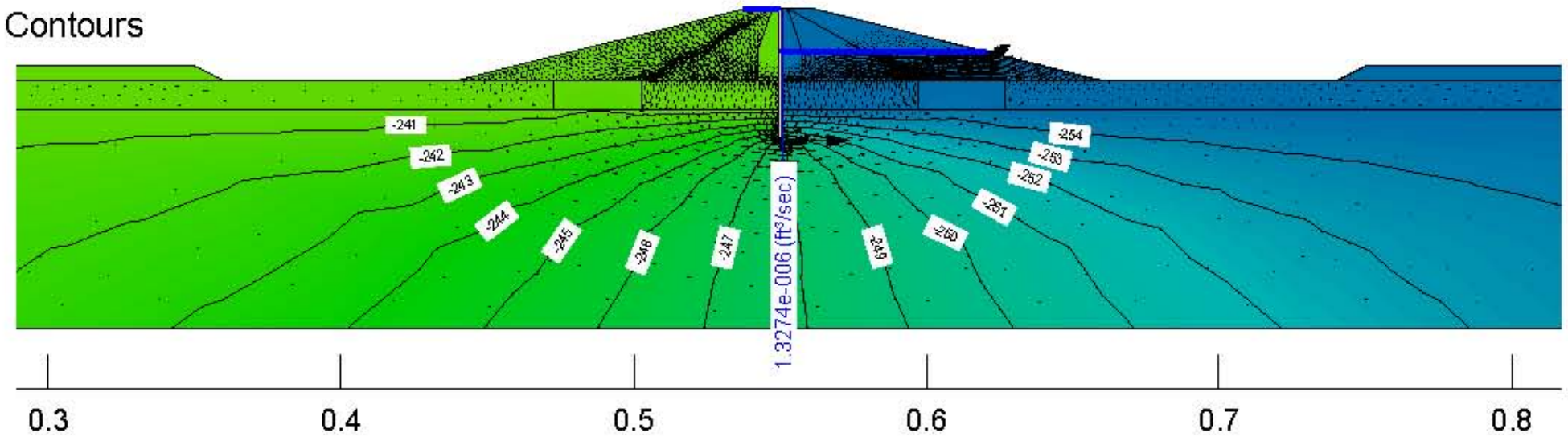



### XY Gradient $i_{xy}$ Contours Legend

$i_{xy}$ =8

$i_{xy}$ =0

## Total Head Contours




### Total Head Contours Legend

-268 ft -228 ft

| | | | |
|---|---|---|---|
| United States Department of the Interior Bureau of Reclamation | **SALTON SEA RESTORATION PROJECT** EMBANKMENT DESIGNS AND OPTIMIZATION STUDY Appendix 2B – Seepage and Stability Analyses | | Seepage Analysis Case 4,14 Perimeter Dike (West) Jetgrouting, Non-Liquefiable Foundation |
| KLEINFELDER | Project 71100 | By E. Sossenkina / August 2006 | **FIGURE B.B-26** |

71100/DEN6R101

Description: Vinyl Sheetpile Wal
Wt: 120
Cohesion: 100
Phi: 30
Piezometric Line: 1

Description: Core - Clean Sand & Gravel
Wt: 120
Cohesion: 0
Phi: 30
Piezometric Line: 1

Description: Rockfill
Wt: 115
Cohesion: 0
Phi: 45
Piezometric Line: 1

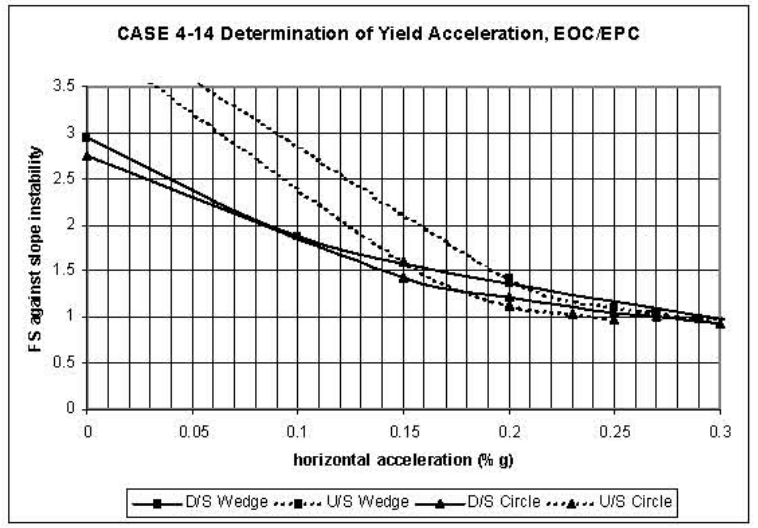
Description: Fine Rockfill
Wt: 118
Cohesion: 0
Phi: 42
Piezometric Line: 1

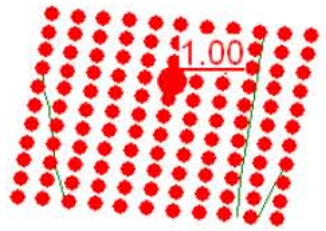
Description: Upper Stiff Lacustrine
Wt: 118
Cohesion: 200
Phi: 33
Anisotropic Fn: 1
Piezometric Line: 1

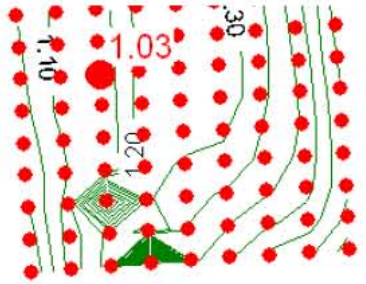
Description: Seafloor Deposits - Seismic EOC
Wt: 98
C-Datum: 13
C-Rate of Increase: 15.4
Limiting C: 600
Elevation: -260
Piezometric Line: 1

Description: Jet Grouted Alluvium
Wt: 130
Cohesion: 9360
Phi: 0
Piezometric Line: 1

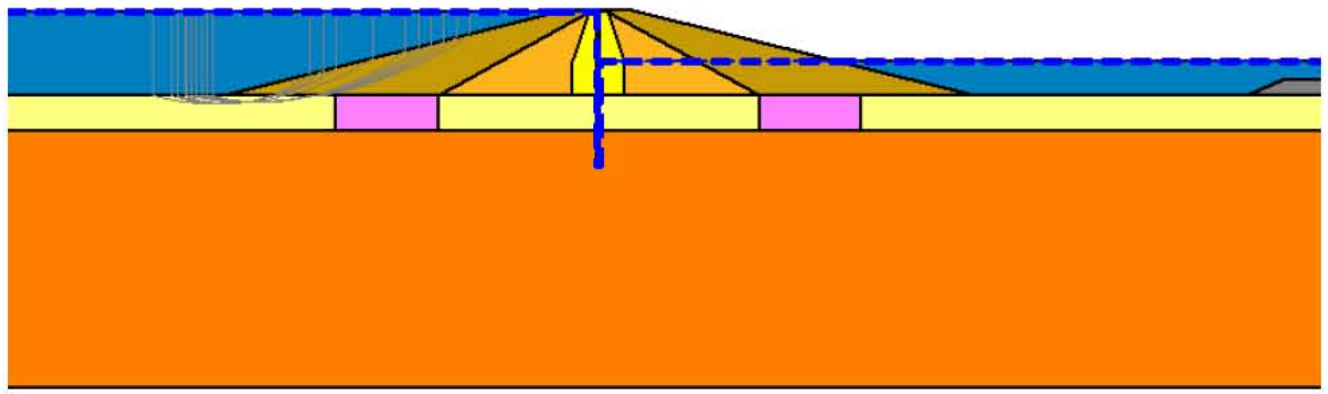
Description: Untreated Alluvium
Wt: 128
Cohesion: 0
Phi: 32
Piezometric Line: 1



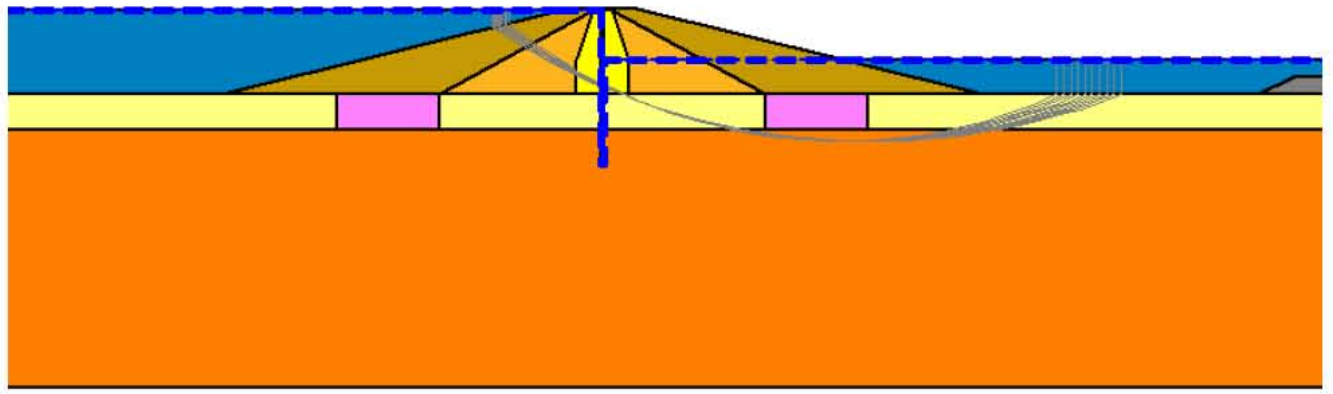



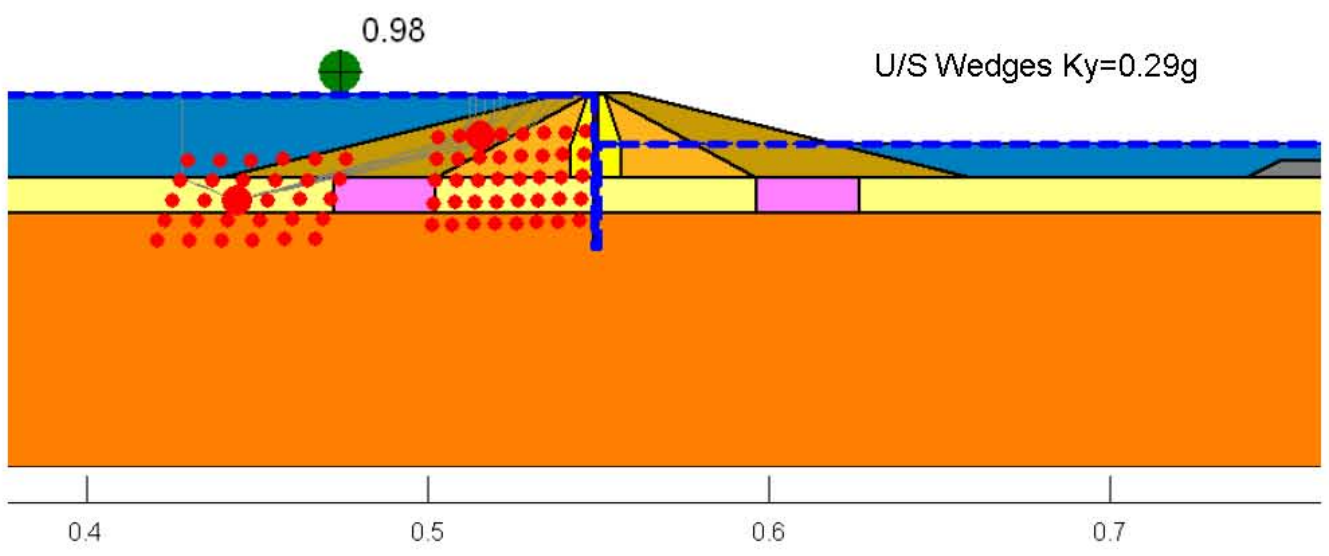



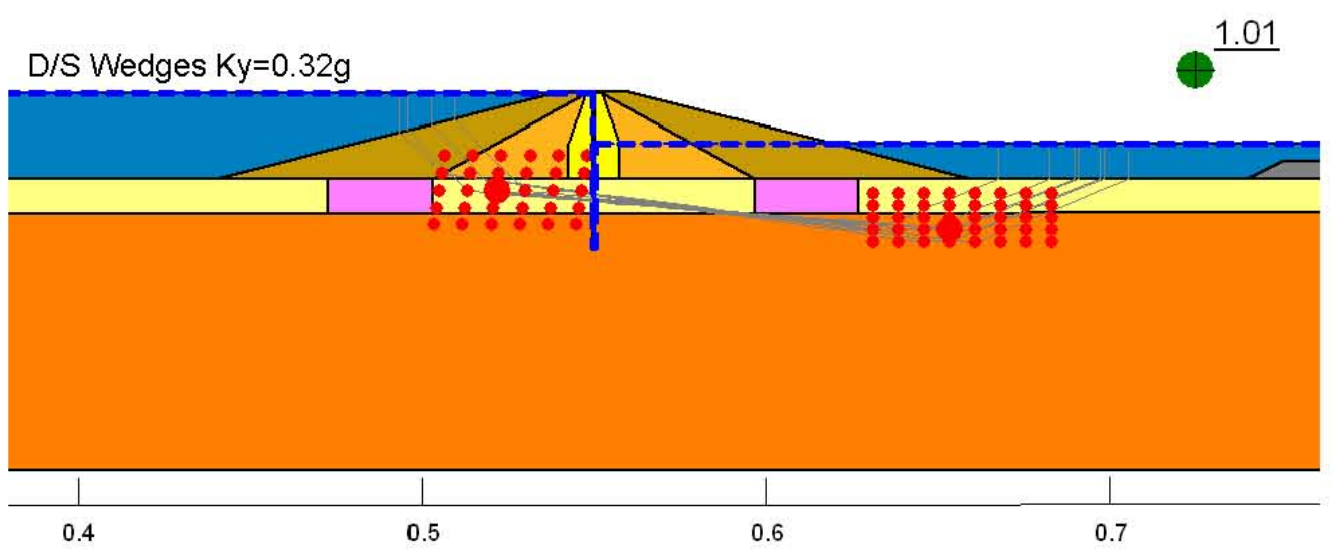

U/S Circles Ky=0. 24g



D/S Circles Ky=0.27g



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**SALTON SEA RESTORATION PROJECT**
EMBANKMENT DESIGNS AND
OPTIMIZATION STUDY
Appendix 2B – Seepage and Stability Analyses

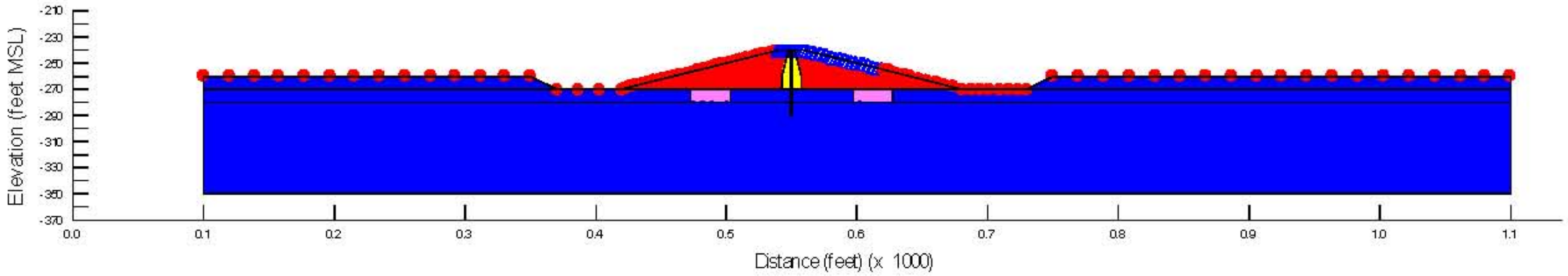
Seepage Analysis
Case 4,14 Perimeter Dike (West)
Jetgrouting, Non-Liquefiable Foundation

| Project 71100 | By E. Sossenkina | August 2006 |
|---|---|---|

**FIGURE B.B-27**

71100/DEN6R101

## Section Geometry and Boundary Conditions



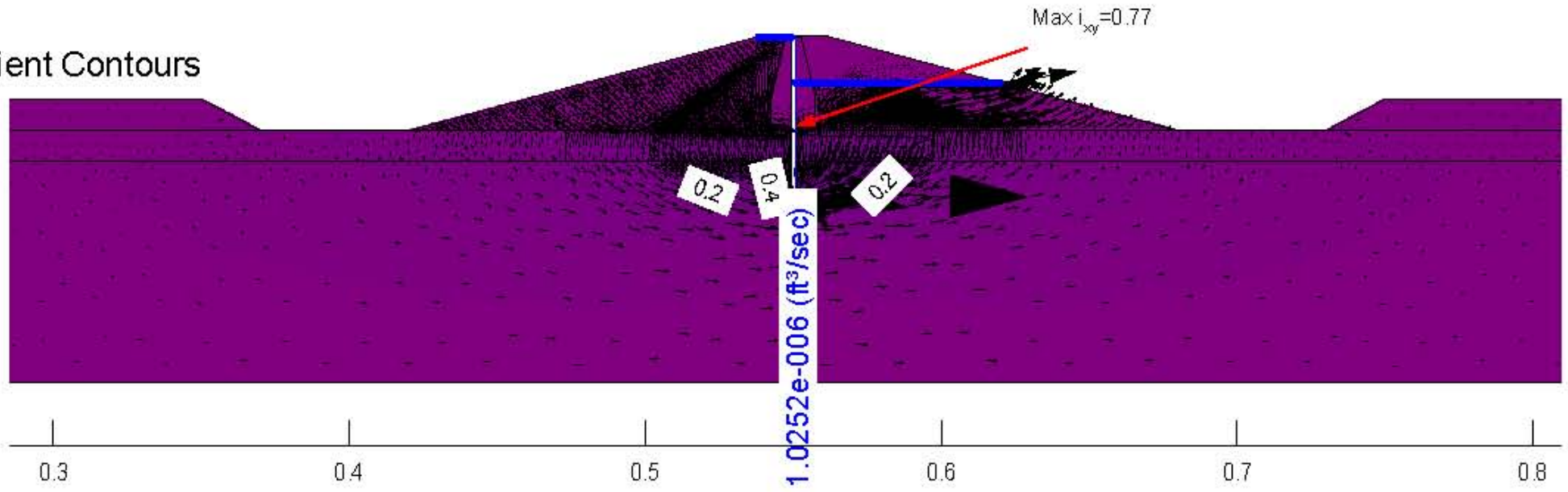

### Boundary Conditions Legend

Constant Total Head
Seepage Exit Boundary

### Material Properties Legend

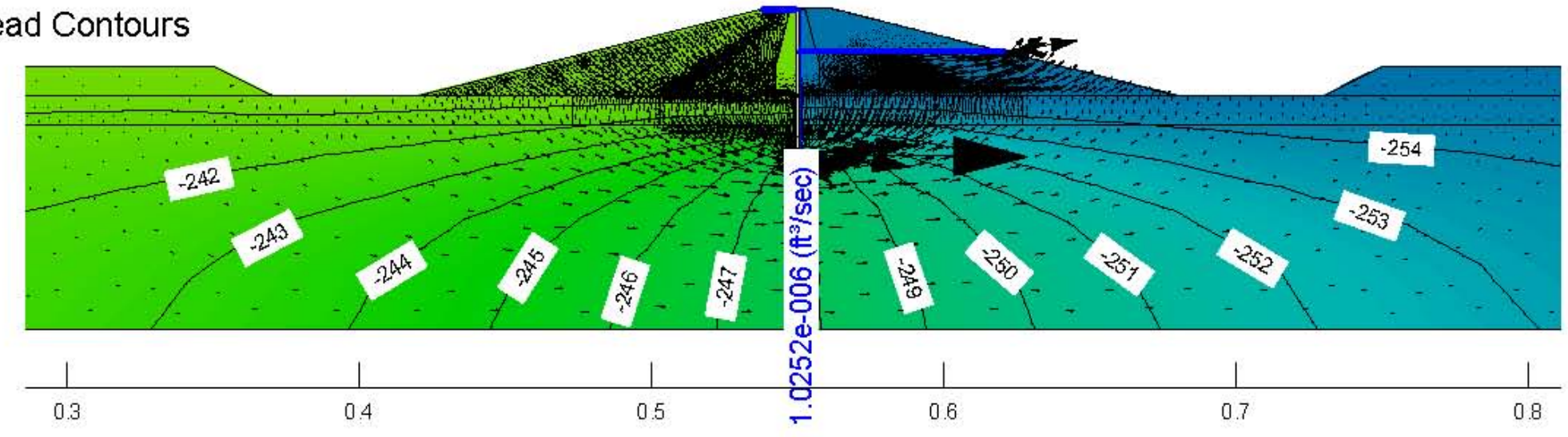
| Material | Kh ft/sec | Kv/Kh | Color |
|---|---|---|---|
| Rockfill | $3.28*10^{-2}$ | 0.25 | |
| Fine Rockfill | $3.28*10^{-2}$ | 0.25 | |
| Sand Gravel Core | $3.28*10^{-4}$ | 0.25 | |
| Seafloor Deposits | $3.28*10^{-7}$ | 0.1 | |
| Soft Lacustrine | $3.28*10^{-7}$ | 0.1 | |
| Stiff Lacustrine | $3.28*10^{-7}$ | 0.1 | |
| Jet-grouted Lacustrine | $3.28*10^{-8}$ | 1 | |
| Sheetpile Wall | Impervious | | |

## XY Gradient Contours




### XY Gradient $i_{xy}$ Contours Legend


## Total Head Contours




### Total Head Contours Legend


Distance (feet) (x 1000)

United States Department of the Interior
Bureau of Reclamation

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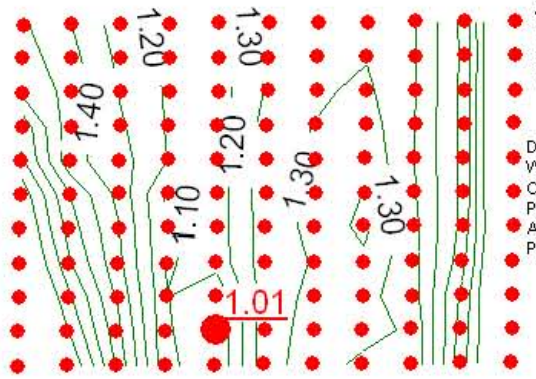
**SALTON SEA RESTORATION PROJECT**
EMBANKMENT DESIGNS AND OPTIMIZATION STUDY
Appendix 2B – Seepage and Stability Analyses

Seepage Analysis
Case 4,15 Perimeter Dike (East)
Jetgrouting, Non-Liquefiable Foundation

Project 71100 | By E. Sossenkina | August 2006

**FIGURE B.B-28**

71100/DEN6R101




Description: Vinyl Sheetpile Wall
Wt: 120
Cohesion: 100
Phi: 30
Piezometric Line: 1

Description: Rockfill
Wt: 115
Cohesion: 0
Phi: 45
Piezometric Line: 1

Description: Core - Clean Sand & Gravel
Wt: 120
Cohesion: 0
Phi: 30
Piezometric Line: 1

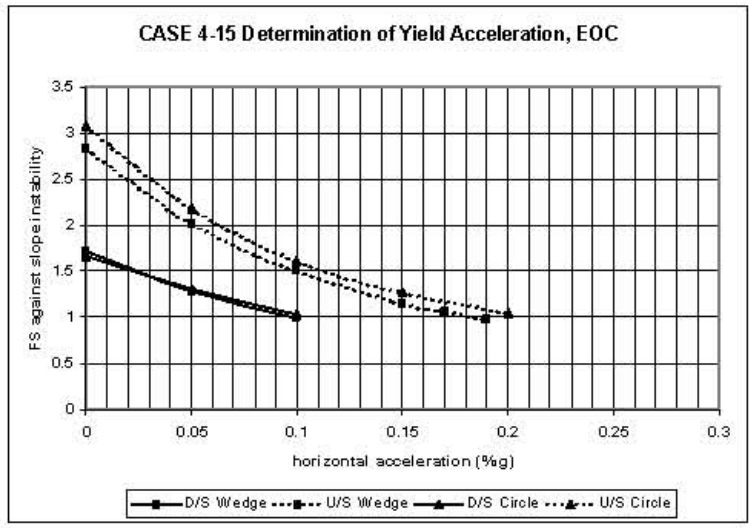
Description: Upper Stiff Lacustrine
Wt: 118
Cohesion: 200
Phi: 33
Anisotropic Fn: 1
Piezometric Line: 1

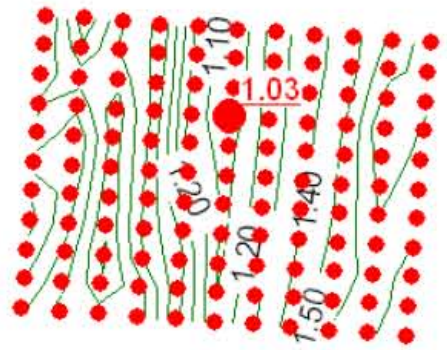
Description: Seafloor Deposit - Seismic
Wt: 98
C-Datum: 13
C-Rate of Increase: 15.4
Limiting C: 600
Elevation: -260
Piezometric Line: 1

Description: Jet Grouted Lacustrine
Wt: 120
Cohesion: 7200
Phi: 0
Piezometric Line: 1

Description: Fine Rockfill
Wt: 118
Cohesion: 0
Phi: 42
Piezometric Line: 1

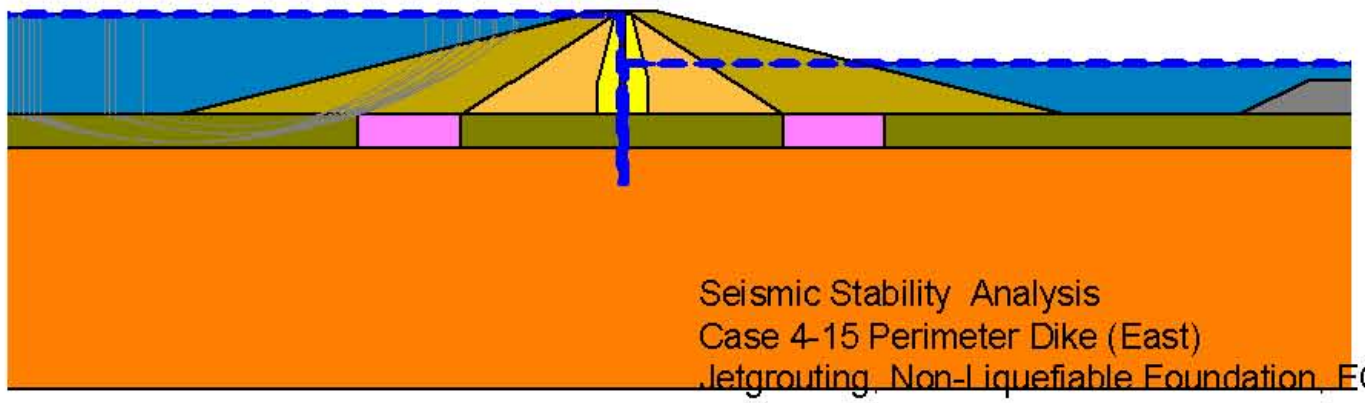
Description: Untreated Lacustrine - Seismic EOC
Wt: 115
C-Datum: 13
C-Rate of Increase: 15.4
Limiting C: 600
Elevation: -260
Anisotropic Fn: 1
Piezometric Line: 1



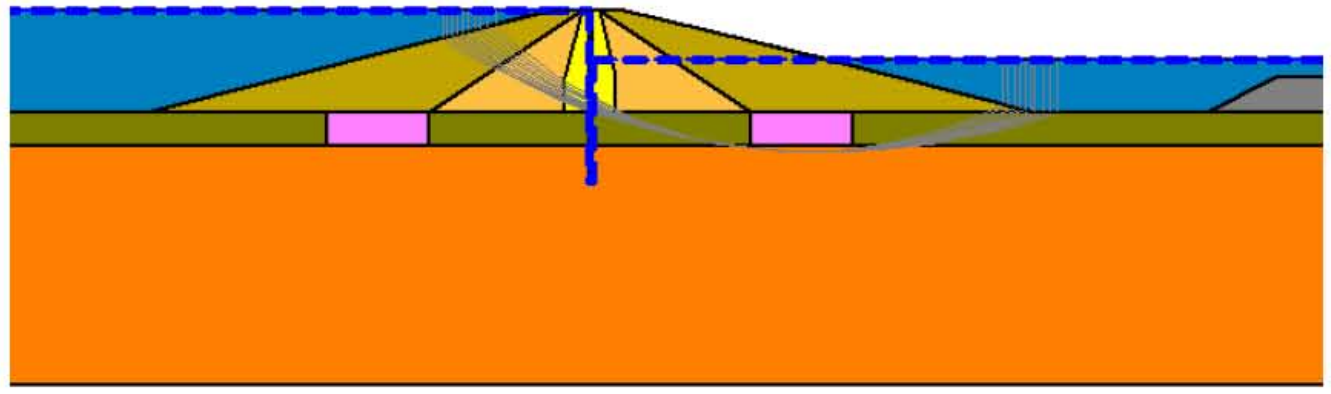

10 most critical failure surfaces
FS ranges from 1.01 to 1.02

U/S Circles Ky=0. 17g



10 most critical failure surfaces
FS ranges from 1.03 to 1.06

D/S Circles Ky=0.1g

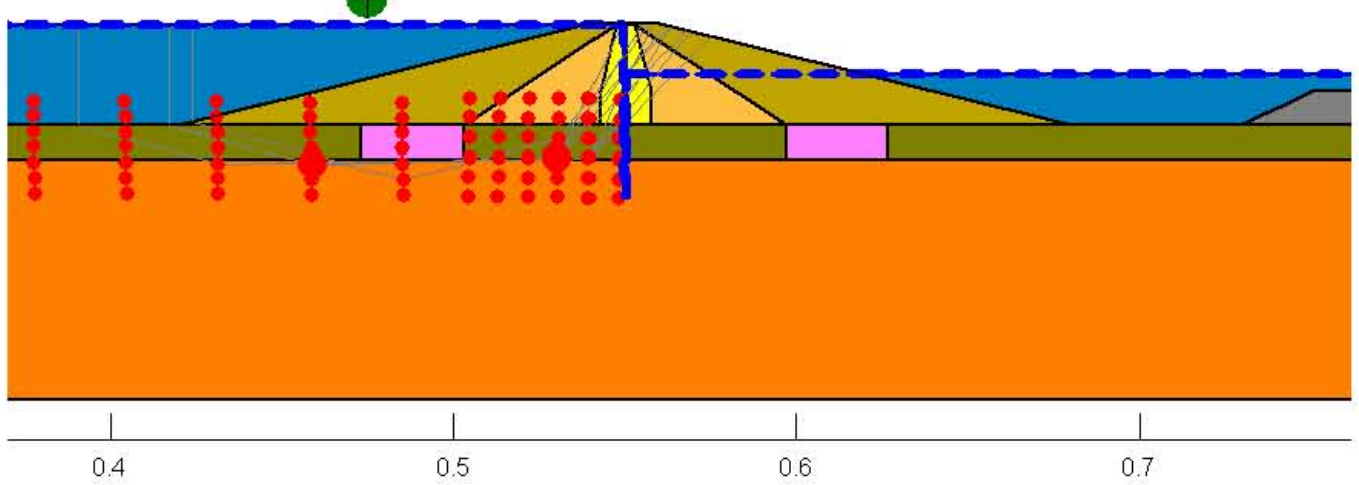


Seismic Stability Analysis
Case 4-15 Perimeter Dike (East)
Jetgrouting, Non-Liquefiable Foundation, EOC

10 most critical failure surfaces
FS ranges from 1.01 to 1.12

1.02

U/S Wedges Ky=0.18g

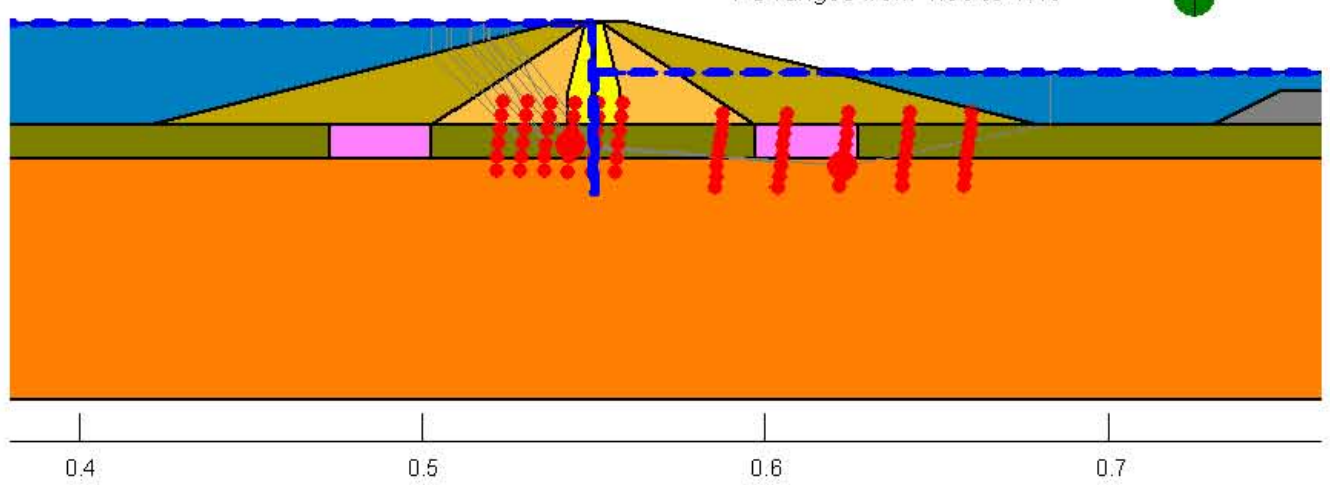



Distance (feet) (x 1000)

D/S Wedges Ky=0.08g

10 most critical failure surfaces
FS ranges from 1.00 to 1.10

0.99




Distance (feet) (x 1000)

United States
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**SALTON SEA RESTORATION PROJECT**
EMBANKMENT DESIGNS AND
OPTIMIZATION STUDY
Appendix 2B – Seepage and Stability Analyses

Seismic Stability Analysis
Case 4,15 Perimeter Dike (East)
Jetgrouting, Non-Liquefiable Foundation, EOC

| Project 71100 | By E. Sossenkina | August 2006 |
|---|---|---|

**FIGURE B.B-29a**

71100/DEN6R101

Description: Core - Clean Sand & Gravel
Wt: 120
Cohesion: 0
Phi: 30
Piezometric Line: 1

Description: Vinyl Sheetpile Wall
Wt: 120
Cohesion: 100
Phi: 30
Piezometric Line: 1

Description: Rockfill
Wt: 115
Cohesion: 0
Phi: 45
Piezometric Line: 1

Description: Fine Rockfill
Wt: 118
Cohesion: 0
Phi: 42
Piezometric Line: 1

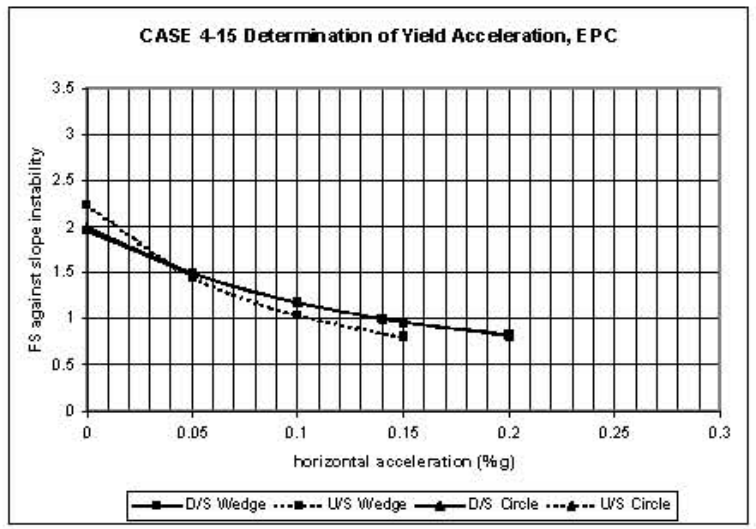
Description: Seafloor Deposit - EPC
Wt: 98
Cohesion: 0
Phi: 12.5

Description: Jet Grouted Lacustrine
Wt: 120
Cohesion: 7200
Phi: 0
Piezometric Line: 1

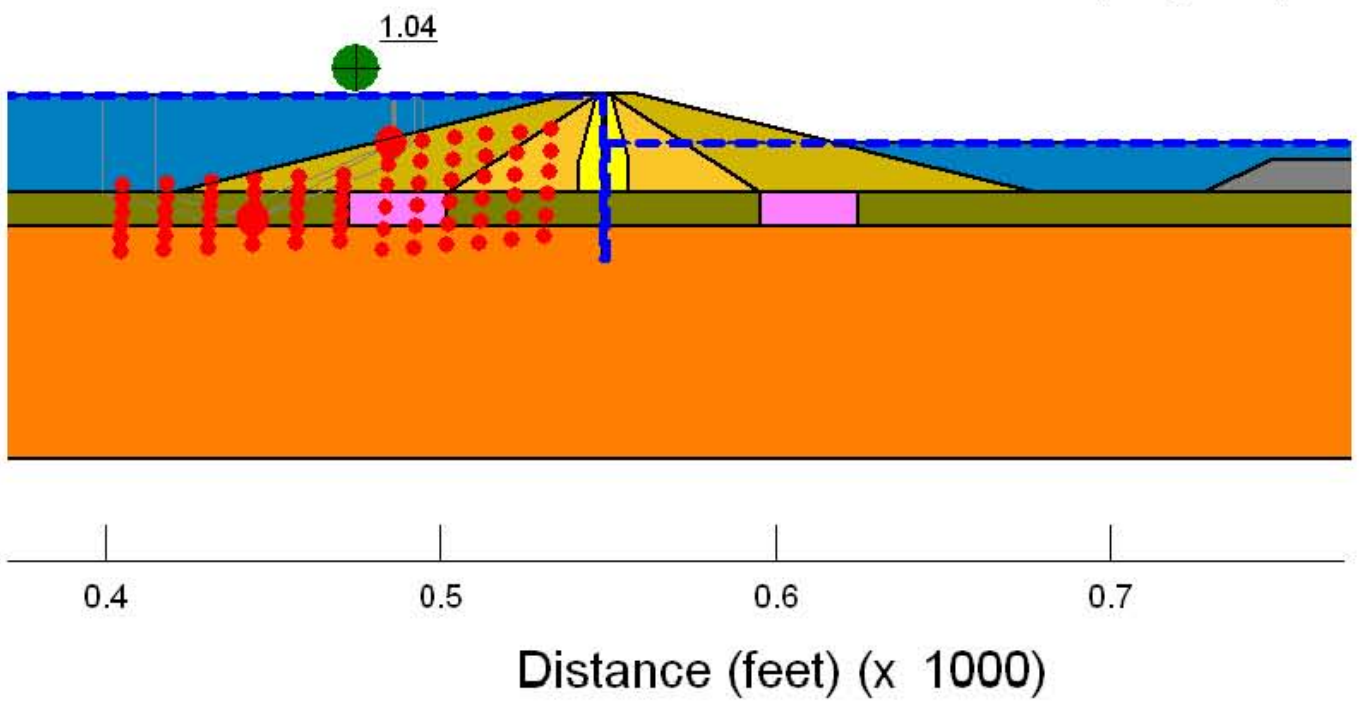
Description: Soft Lacustrine - EPC
Wt: 115
Cohesion: 0
Phi: 17
Anisotropic Fn: 1

Description: Upper Stiff Lacustrine - Seismic
Wt: 118
Cohesion: 200
Phi: 33
Anisotropic Fn: 1
Piezometric Line: 1

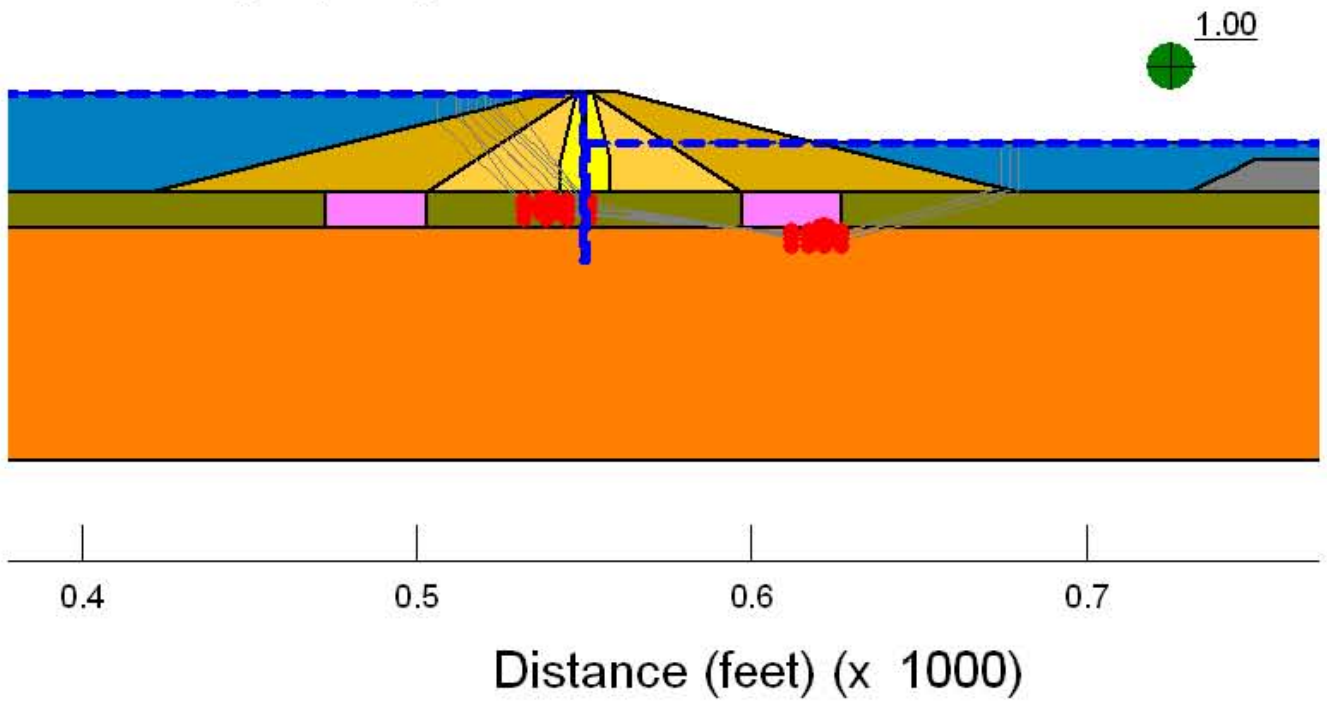
Function Description: Sh/Sv= 0.9




U/S Wedges Ky=0.10g

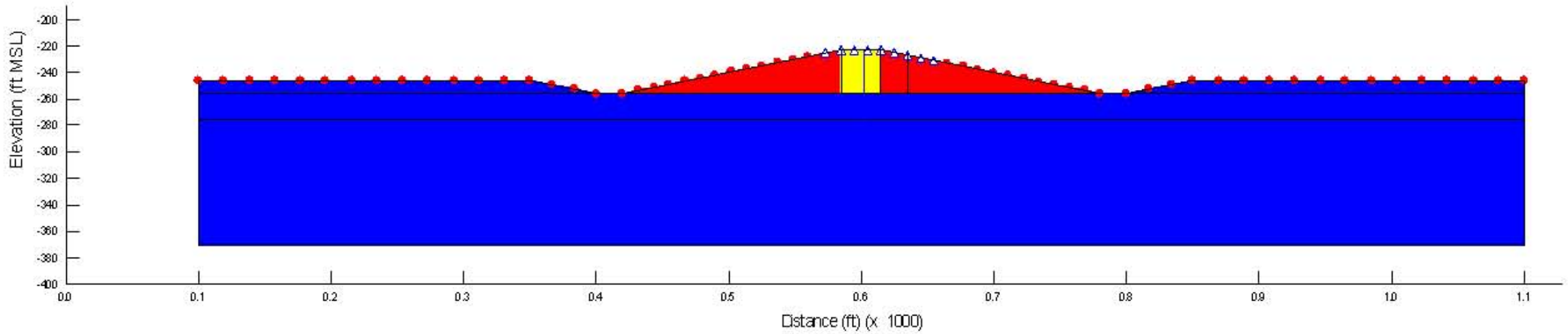



D/S Wedges Ky=0.14g




| | | | |
|---|---|---|---|
| *United States Department of the Interior Bureau of Reclamation* | **SALTON SEA RESTORATION PROJECT** EMBANKMENT DESIGNS AND OPTIMIZATION STUDY Appendix 2B – Seepage and Stability Analyses | | Seismic Stability Analysis Case 4,15 Perimeter Dike (East) Jetgrouting, Non-Liquefiable Foundation, EPC |
| KLEINFELDER | Project 71100 | By E. Sossenkina August 2006 | **FIGURE B.B-29b** |

## Section Geometry and Boundary Conditions



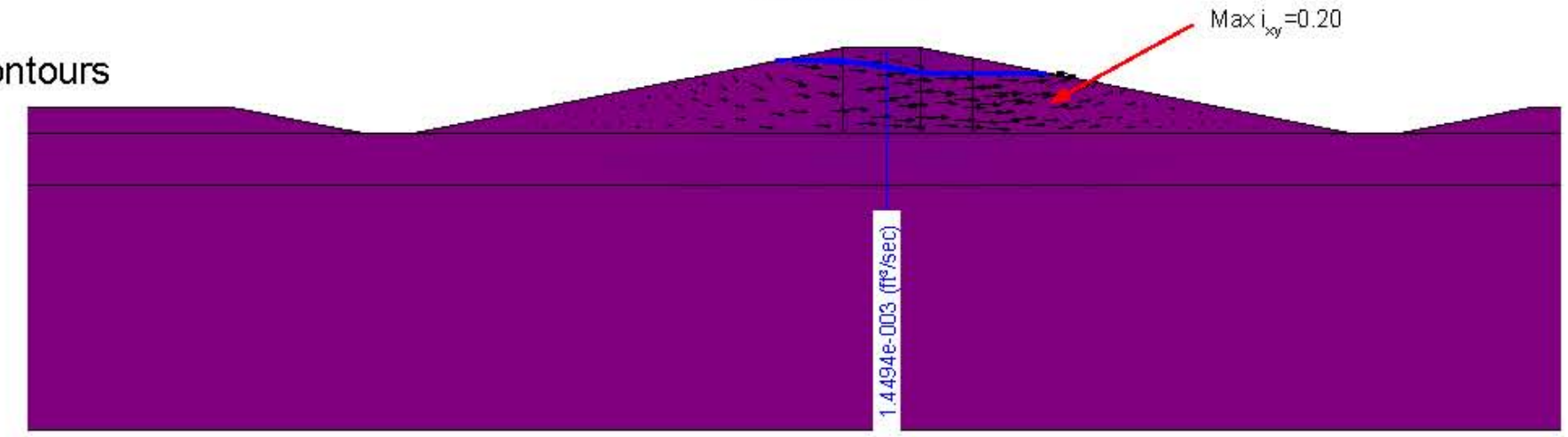

### Boundary Conditions Legend

Constant Total Head
Seepage Exit Boundary

### Material Properties Legend

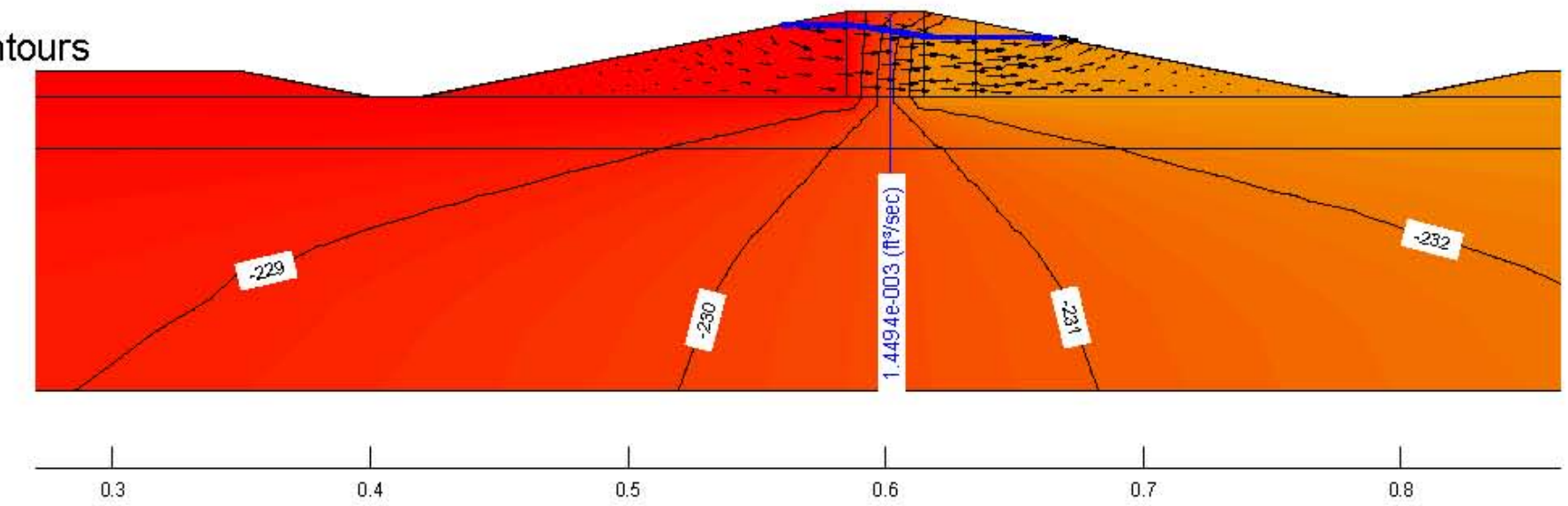
| Material | Kh ft/sec | Kv/Kh | Color |
|---|---|---|---|
| Rockfill | $3.28*10^{-2}$ | 0.25 | |
| Fine Rockfill | $3.28*10^{-2}$ | 0.25 | |
| Sand Gravel Core | $3.28*10^{-4}$ | 0.25 | |
| Seafloor Deposits | $3.28*10^{-7}$ | 0.1 | |
| Soft Lacustrine | $3.28*10^{-7}$ | 0.1 | |
| Stiff Lacustrine | $3.28*10^{-7}$ | 0.1 | |

## XY Gradient Contours




### XY Gradient $i_{xy}$ Contours Legend


## Total Head Contours




### Total Head Contours Legend


United States
Department of the Interior
Bureau of Reclamation

KLEINFELDER

**SALTON SEA RESTORATION PROJECT**
EMBANKMENT DESIGNS AND
OPTIMIZATION STUDY
Appendix 2B – Seepage and Stability Analyses

Seepage Analysis
Case 5,1 Mid-Sea Barrier

Project 71100 | By E. Sossenkina | August 2006

**FIGURE B.B-30**

Material #: 2
Description: Core -Clean Sand & Gravel
Model: MohrCoulomb
Wt: 120
Cohesion: 0
Phi: 30

Material #: 3
Description: Fine Rockfill
Model: MohrCoulomb
Wt: 118
Cohesion: 0
Phi: 42

Material #: 4
Description: Rockfill
Model: MohrCoulomb
Wt: 115
Cohesion: 0
Phi: 45

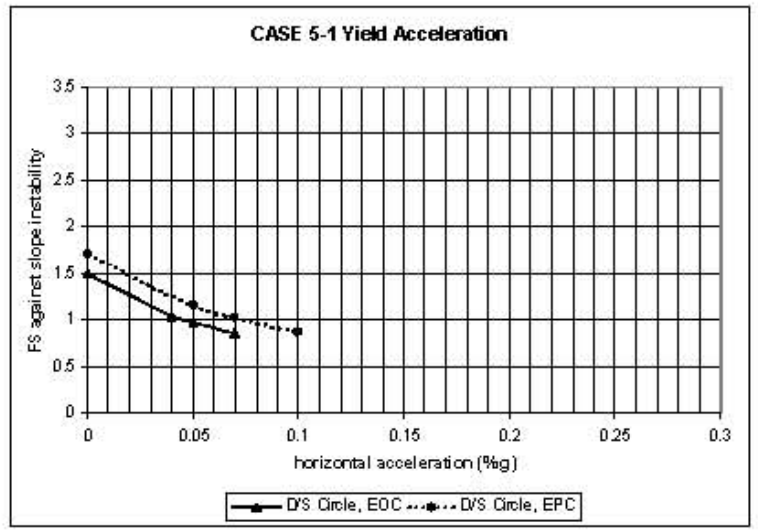
Function Description: Anisotropy Sh/Sv=0.9

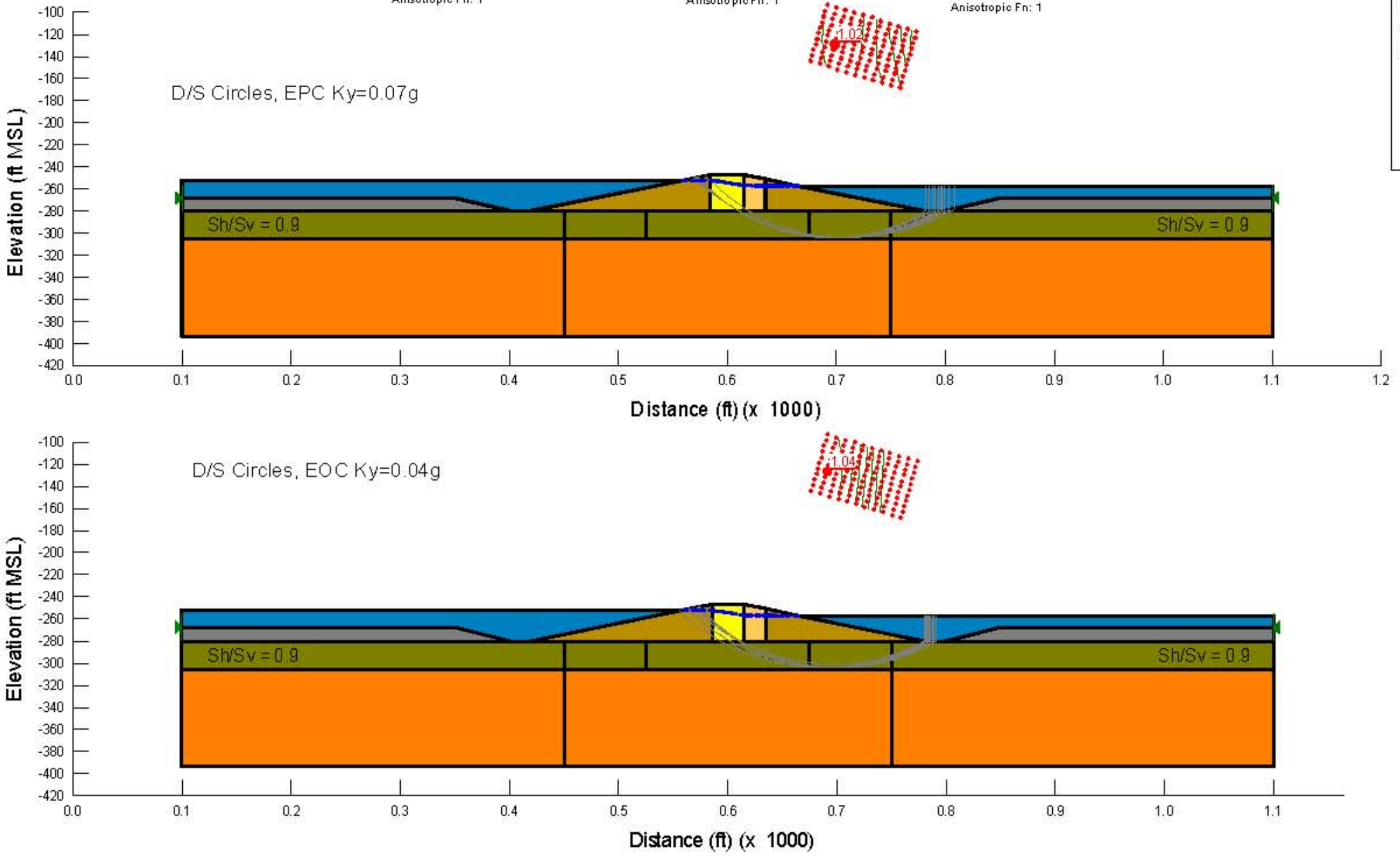
Material #: 11
Description: Upper Stiff Lacustrine Seismic
Model: MohrCoulomb
Wt: 118
Cohesion: 200
Phi: 33

Material #: 19
Description: Seafloor Deposit - EPC
Model: MohrCoulomb
Wt: 98
Cohesion: 0
Phi: 17
Anisotropic Fn: 1

Material #: 20
Description: Soft Lacustrine - EPC
Model: MohrCoulomb
Wt: 115
Cohesion: 0
Phi: 17
Anisotropic Fn: 1

Material #: 18
Description: Soft Lacustrine - EOC
Model: SFnDatum
Wt: 115
C-Datum: 13
C-Rate of Increase: 15.4
Limiting C: 600
Elevation: -268
Anisotropic Fn: 1

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**SALTON SEA RESTORATION PROJECT**
EMBANKMENT DESIGNS AND OPTIMIZATION STUDY
Appendix 2B – Seepage and Stability Analyses

Seismic Stability Analysis
Case 5,1 Mid-sea Barrier

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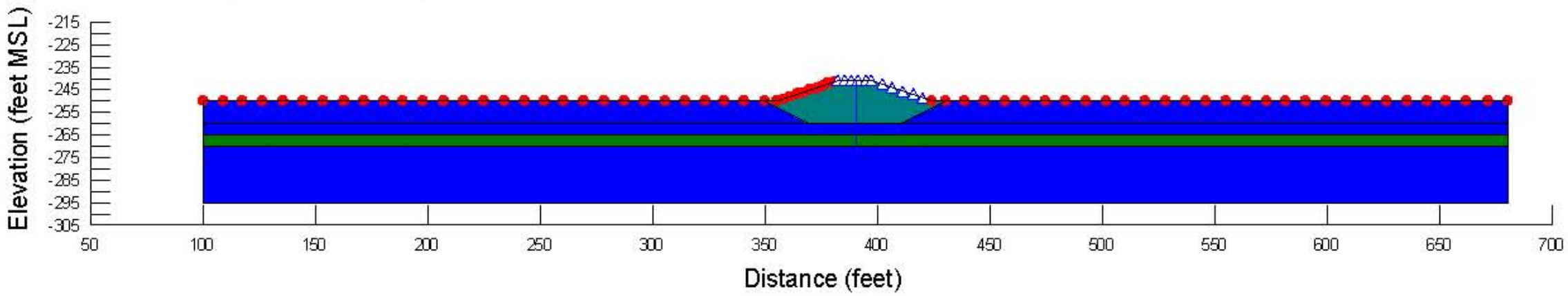
**FIGURE B.B-31**

71100/DEN6R101

## Section Geometry and Boundary Conditions



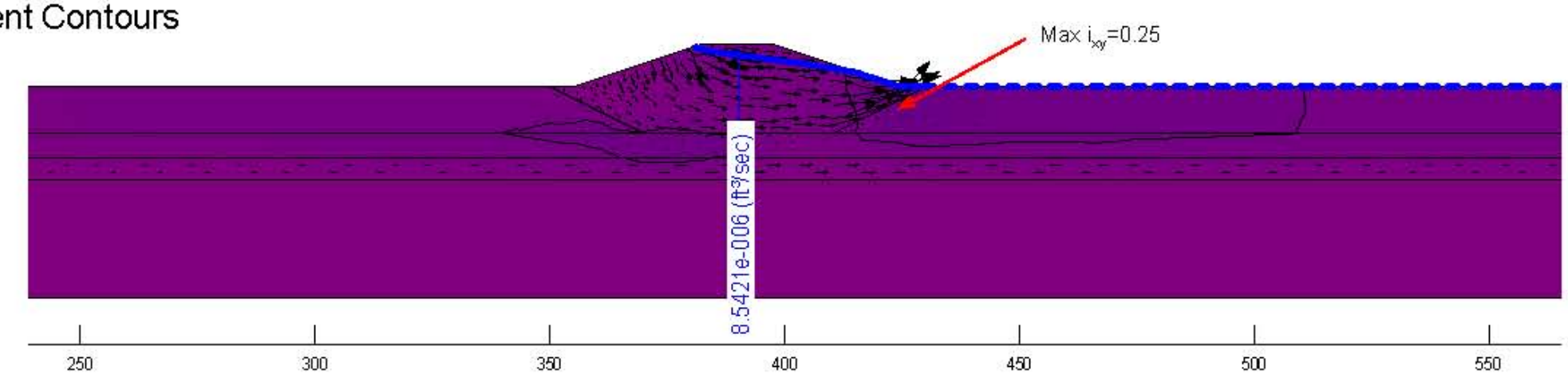

**Boundary Conditions Legend**

- Constant Total Head
- Seepage Exit Boundary

**Material Properties Legend**

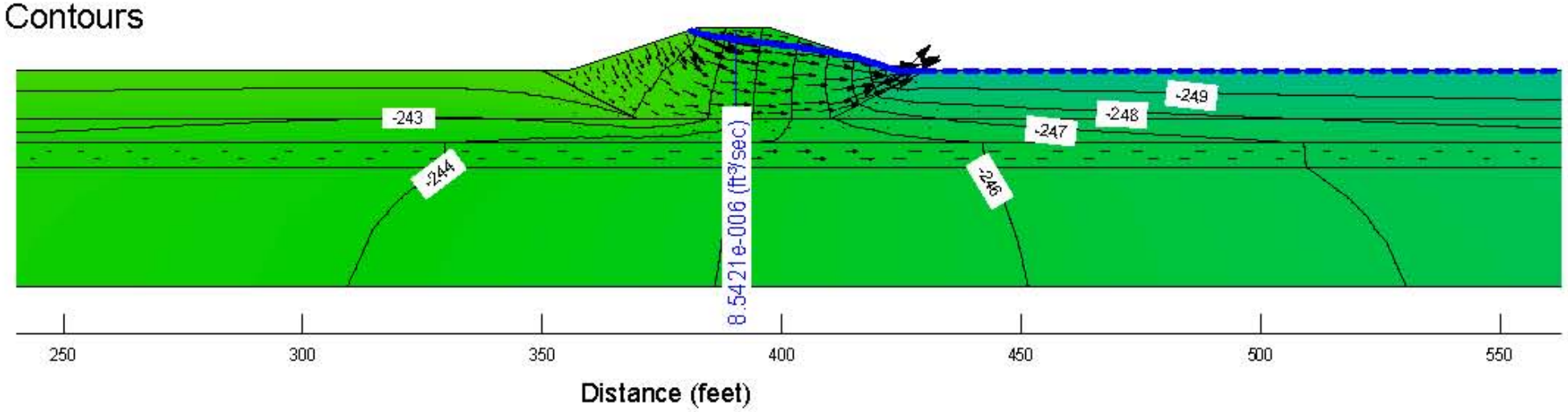
| Material | Kh ft/sec | Kv/Kh | Color |
|---|---|---|---|
| Soft Lacustrine | $3.28*10^{-7}$ | 0.1 | |
| Stiff Lacustrine | $3.28*10^{-7}$ | 0.1 | |
| Alluvium | $1.32*10^{-5}$ | 0.25 | |
| Embankment Fill | $3.28*10^{-6}$ | 1 | |

## XY Gradient Contours




**XY Gradient $i_{xy}$ Contours Legend**


## Total Head Contours




**Total Head Contours Legend**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**SALTON SEA RESTORATION PROJECT**
EMBANKMENT DESIGNS AND OPTIMIZATION STUDY
Appendix 2B – Seepage and Stability Analyses

Seepage Analysis
Case 5,3 Habitat Pond

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|---|---|---|

**FIGURE B.B-32**

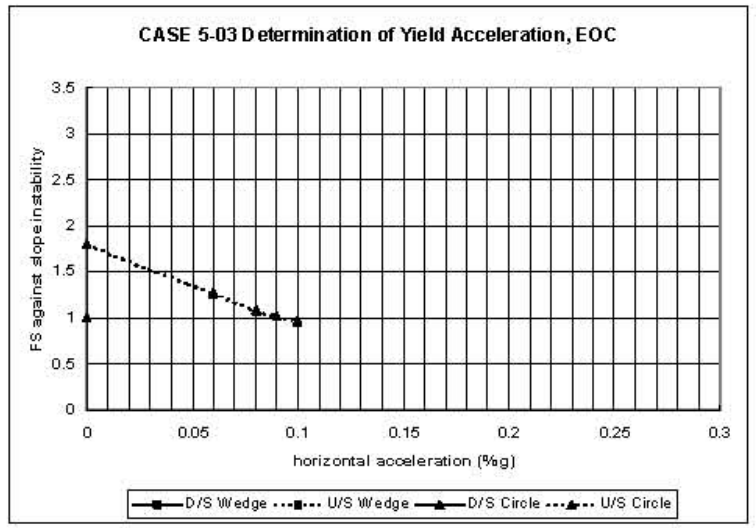
71100/DEN6R101

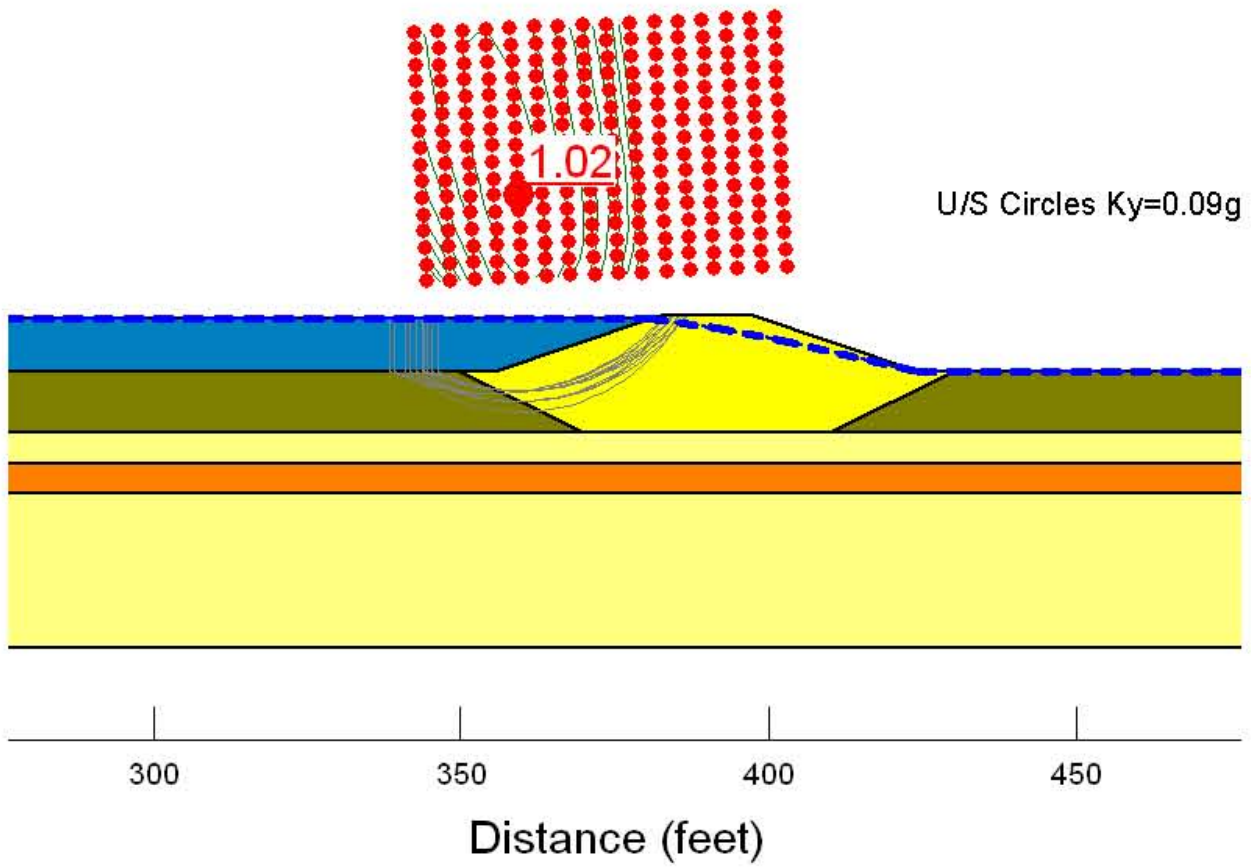
Description: Embankment Fill
Wt: 120
Cohesion: 0
Phi: 25
Piezometric Line: 1

Description: Untreated Alluvium - Non Liq.
Wt: 128
Cohesion: 0
Phi: 32
Piezometric Line: 1

Description: Upper Stiff Lacustrine Seismic
Wt: 118
Cohesion: 200
Phi: 33
Anisotropic Fn: 1
Piezometric Line: 1

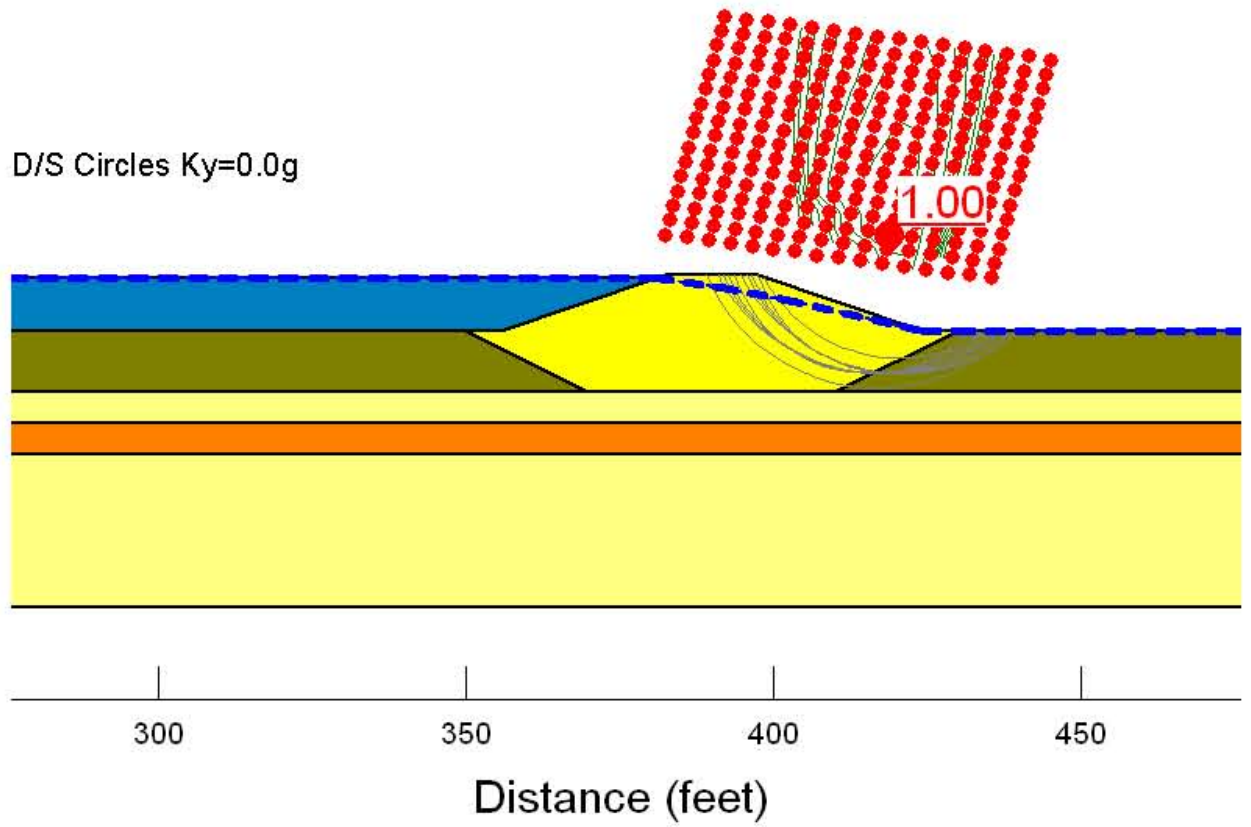
Description: Untreated Lacustrine - EOC Seismic
Wt: 115
C-Datum: 13
C-Rate of Increase: 15.4
Limiting C: 600
Elevation: -250
Piezometric Line: 1




U/S Circles Ky=0.09g

D/S Circles Ky=0.0g

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**SALTON SEA RESTORATION PROJECT**
EMBANKMENT DESIGNS AND
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Appendix 2B – Seepage and Stability Analyses

Seismic Stability Analysis
Case 5,3 Habitat Pond

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|---|---|---|

**FIGURE B.B-33**

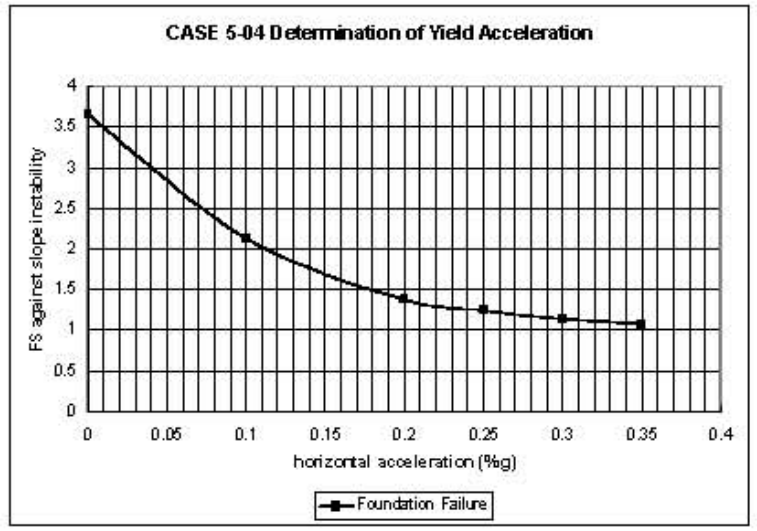
71100/DEN6R101

Material #: 1
Description:Soft Lacustrine - EOC Seismic
Model: SFnDatum
Wt: 115
C-Datum: 13
C-Rate of Increase: 15.4
Limiting C: 600
Elevation: -250
Piezometric Line: 1

Material #: 2
Description: Upper Stiff Lacustrine
Model: MohrCoulomb
Wt: 118
Cohesion: 200
Phi: 33
Unit Wt. Above WT: 118
Phi-B: 0
Anisotropic Fn: 1
Piezometric Line: 1

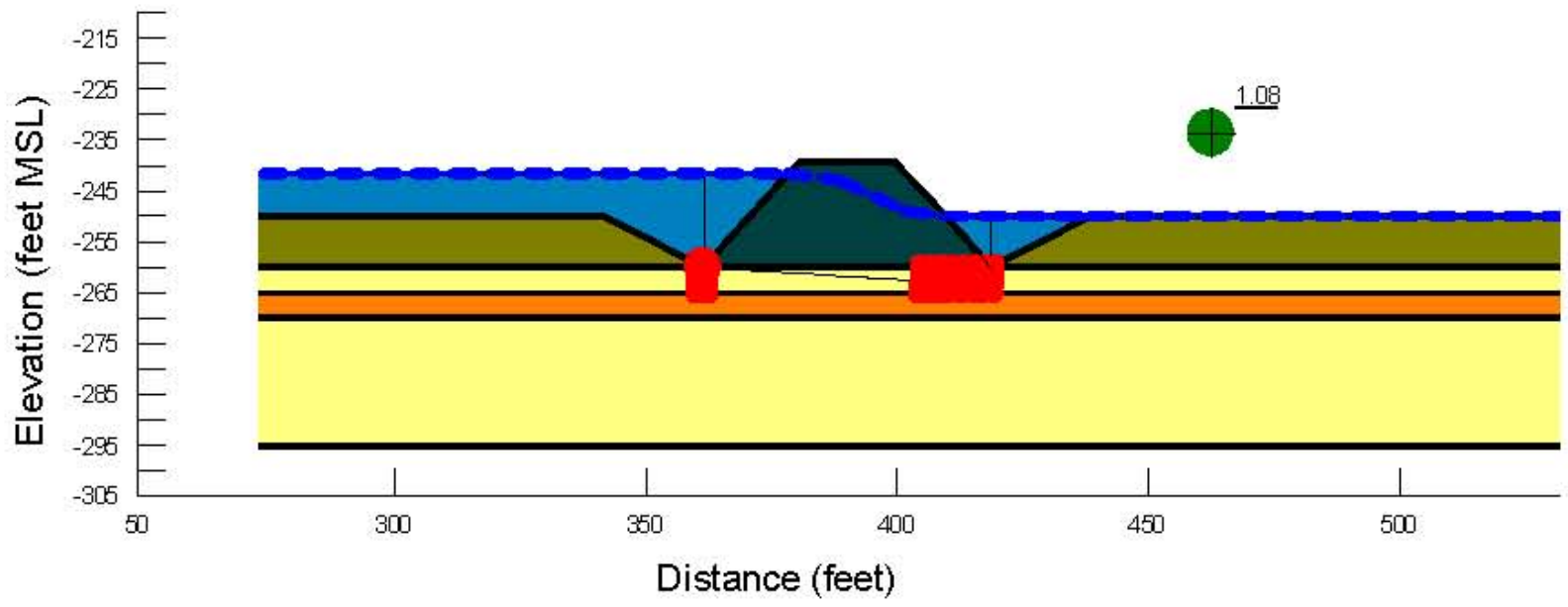
Material #: 5
Description: Geotubes
Model: MohrCoulomb
Wt: 125
Cohesion: 0
Phi: 45
Piezometric Line: 1

Material #: 6
Description: Untreated Alluvium - Non Liq.
Model: MohrCoulomb
Wt: 128
Cohesion: 0
Phi: 32
Piezometric Line: 1




Note: No failures through Geotubes considered

Foundation Failure Ky > 0.35g




Note: Internal Stability of Geotubes Not Analyzed

| | | | | |
|---|---|---|---|---|
| United States Department of the Interior Bureau of Reclamation | **SALTON SEA RESTORATION PROJECT** EMBANKMENT DESIGNS AND OPTIMIZATION STUDY Appendix 2B – Seepage and Stability Analyses | | | Seismic Stability Analysis Case 5,4 Habitat Pond Geotubes |
| KLEINFELDER | Project 71100 | By E. Sossenkina | August 2006 | **FIGURE B.B-34** |