Erosion Screening Process (ESP)

The Society of American Military Engineers (SAME)
Sacramento Post – California Water Conference

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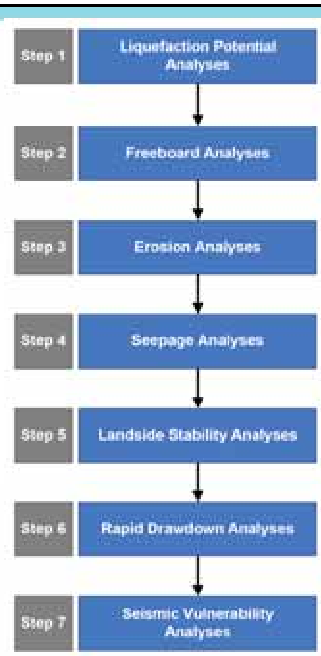
GER Technical Directive Analyses Process Overview



Erosion assessments are one of seven geotechnical evaluations completed under the Urban Levee Evaluations (ULE) Program and one component of the resulting Geotechnical Engineering Report (GER)

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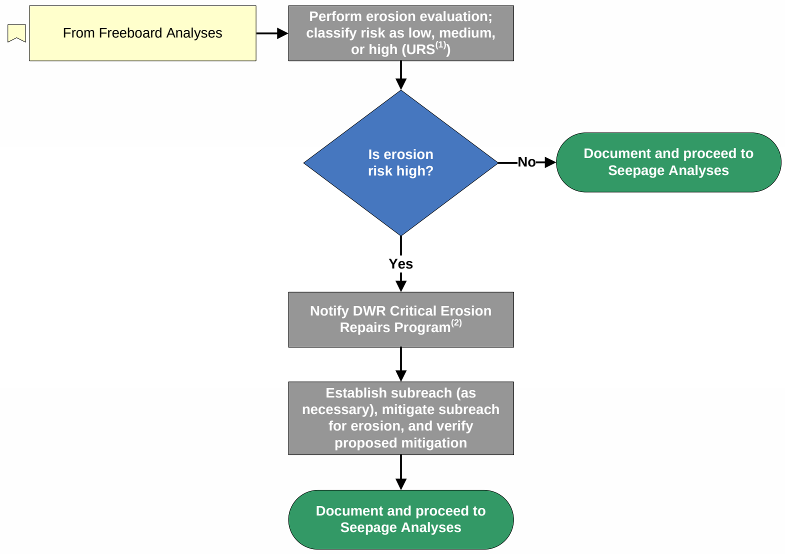
Erosion Component Process Overview



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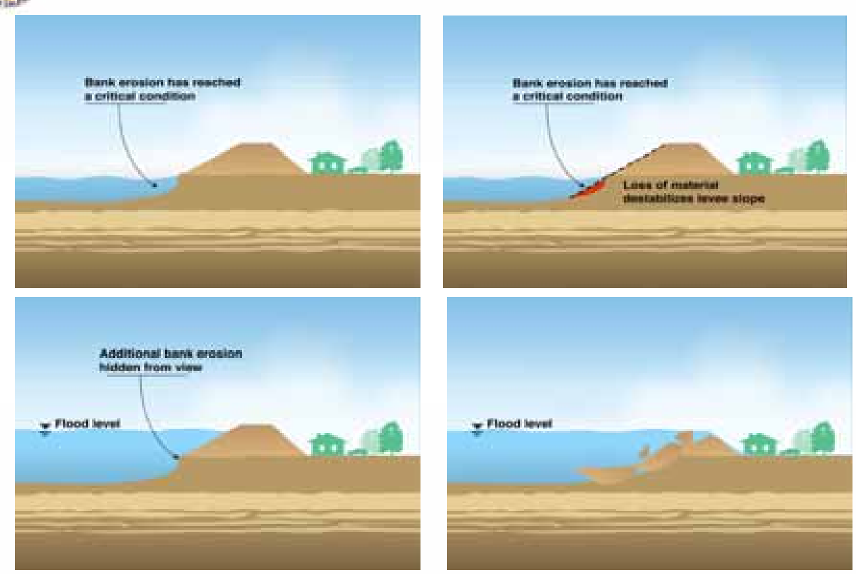
Levee Erosion Process



(Courtesy of DWR)

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Erosion Advisory Panel

- Panel Members:
  - Prof. Jean-Louis Briaud, PhD, PE
  - Ron Copeland, PhD, PE
  - Tom Smith, PE, GE
- Collected over 50 hand-augered soil samples on the waterside slope or on overbank in 15 ULE study areas
- Lab tests of Atterberg Limits, hydrometer and grain size
- Completed 12 Erosion Function Apparatus (EFA) Tests
- Completed a field review
- Revised the ESP spreadsheet and provided better documentation.

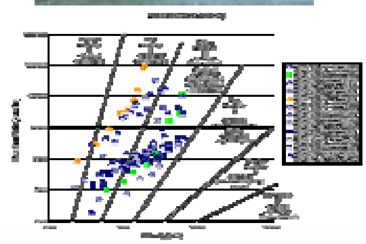


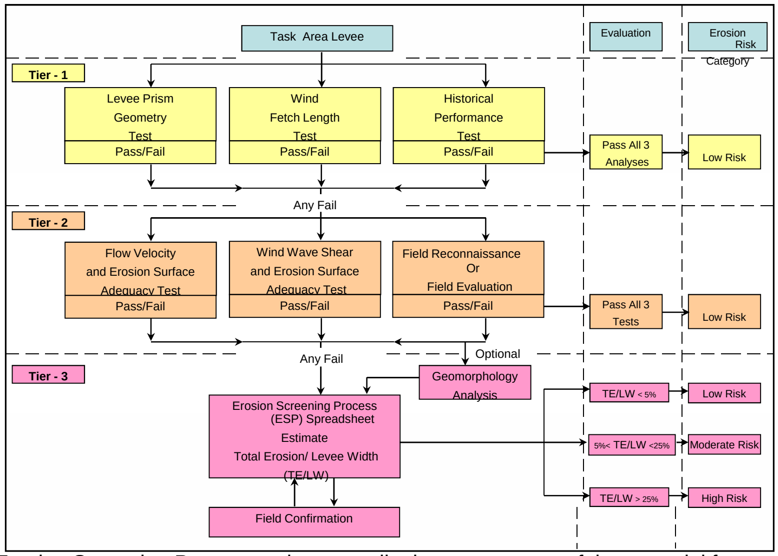
Photo 1: Soil sample at the beginning of the EFA test

Objectives

The final Erosion Screening Process:

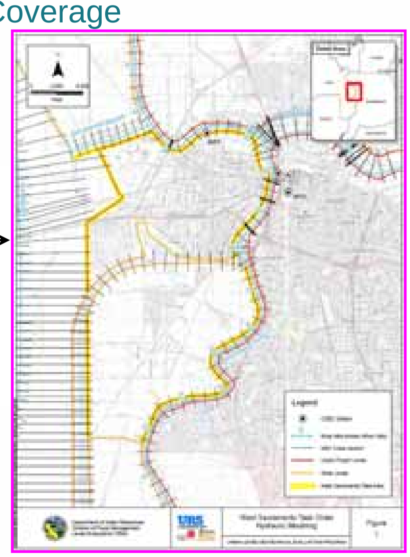
- Uses defendable models consistent with the current body of scientific and engineering knowledge;
- Can be implemented based on the limited level of investigation and testing currently underway; and
- Adequately identifies current erosion risks to urban levees.

Erosion Screening Process (ESP)



The Erosion Screening Process makes a qualitative assessment of the potential for erosion failure of levees within the various task areas of the ULGEP

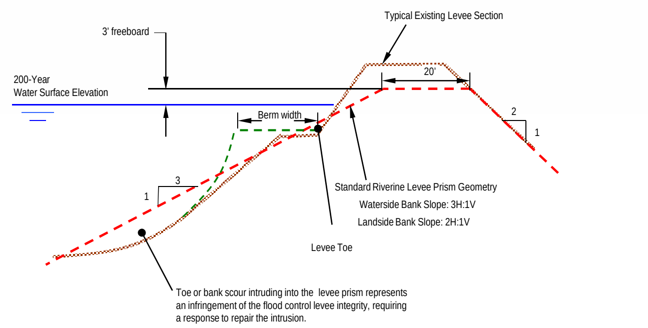
Study Area
Hydraulic Model Coverage



Sacramento River
Sacramento Bypass
Yolo Bypass
Sacramento Deepwater Ship Channel

Tier One – Geometry Test

- Merge LIDAR and Bathymetry Data (GIS)
- Design Profile, 100-yr and 200-yr WSE
- Locate levee prism top elevation
  - Add 3' freeboard
  - Top of levee
- Compare levee ground surface with the levee prism
- Identify levee geometry deficiencies (potential erosion)



Present – authorized prior 1944 / Proposed – authorized FCA of 1944	Crown Width	Waterside Slope	Landside Slope	Freeboard
Present authorized River Levees (Old Project)	20 Feet	1 : 3	1 : 2	3 Feet
Proposed River Levees (Major & Minor Tributaries Project)	20 Feet	1 :3	1 : 2	3 Feet
Present authorized By-pass Levees (Old Project)	20 Feet	1 : 4 to 1 : 2 1/2	1 : 2 1/2	5 or 6 Feet
Proposed By-pass Levees (Major & Minor Tributaries Project)	20 Feet	1 : 4	1 : 3	5 or 6 Feet

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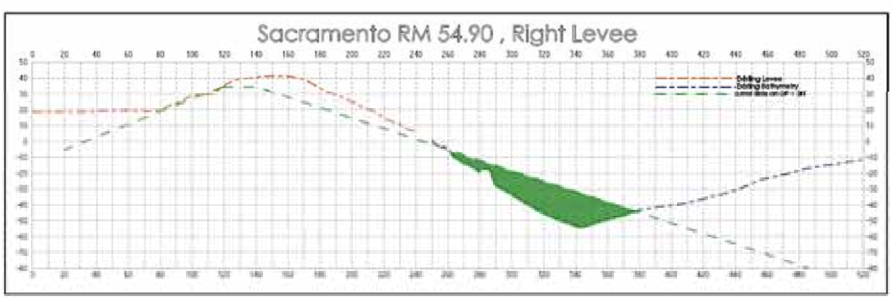
Tier One – Geometry Test



- Identify levee geometrically deficient areas (potential erosion sites)
- Level of deficiency varies with WSE profile applied and placement of the standard prism

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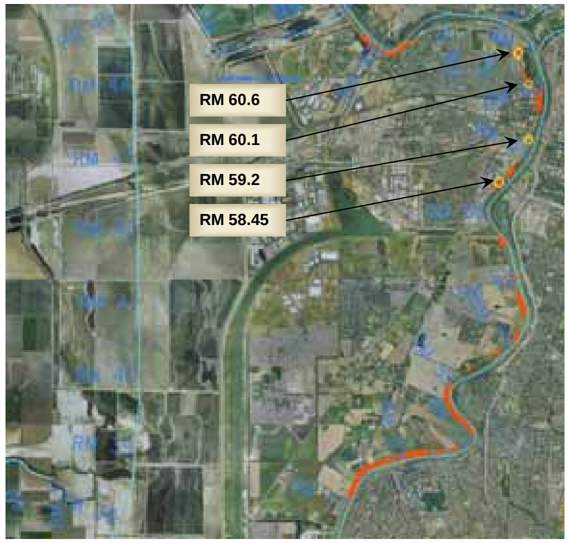
Sample Task Area Results – Tier 1 Geometry



Overtopping

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Sample Task Area Results – Tier 1 Wind Fetch

Calculating fetch length:

- Maximum open water distance at a 45 degree angle to the levee's waterside slope
- Fetch lengths greater than 1,000 feet with channel widths greater than 750 feet considered for analysis

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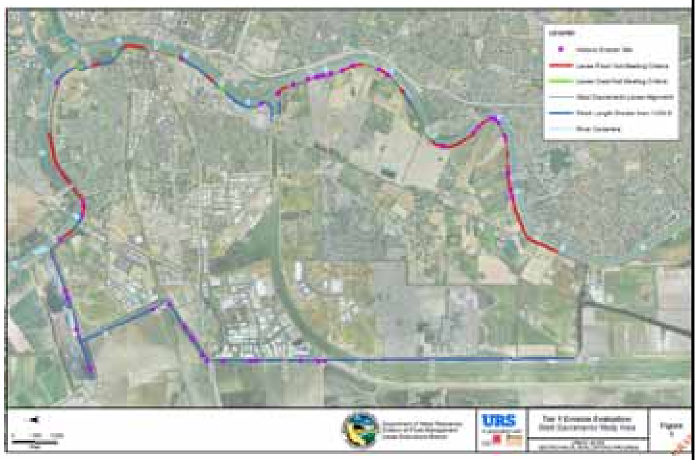
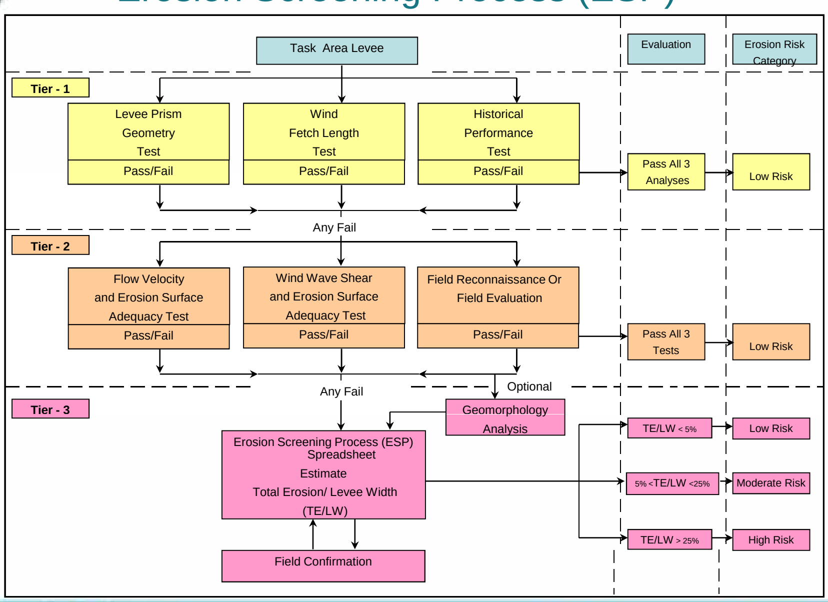
Sample Task Area Results – Tier 1 Historical

Collect existing and project erosion data inventories:

- Ayres Erosion Inventory for USACE Sac Bank Project
- Special Erosion Inventory, e.g. SAFCA (NHC) for Natomas



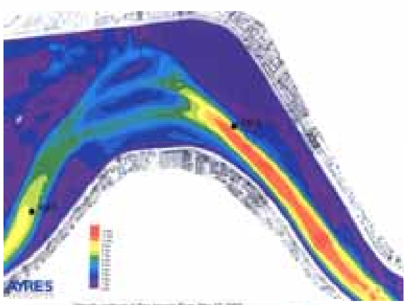
Erosion Screening Process (ESP)

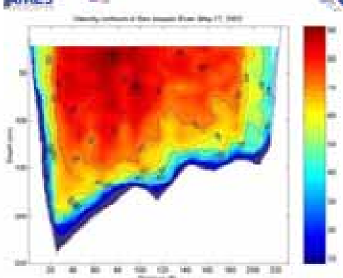


Tier Two – Velocity/Surface Adequacy Test

Levee Material	Maximum Design Velocity (feet per second)	
	Mean Channel Velocity at Straight Channel	Depth-Averaged Velocity at Channel Bend
Fine Sand, Sandy Silt	2.0	
Silt Clay, Soft Shale	3.5	
Coarse Sand, Fine Gravel, Clay	6.0	
Vegetation-lined Earth	8.0	
Poor Rock (Soft Sandstone, Non-uniform Revetment)	10.0	
Good Rock (Riprap, Uniform Revetment)	15.0	

A Note About Velocities



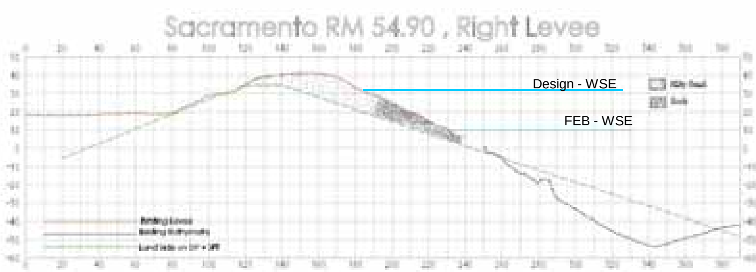


- The ESP uses channel mean velocity.
- A bend correction factor is applied (1.2).
- 2-D models more accurately predict local velocities in a river, but this information is not available in many areas of the ULE.
- Bank velocity may be over predicted. Toe velocities should be close.

Tier Two – Wind Wave Shear/ Surface Adequacy Test

Levee Material	Critical Shear Stress (psf – pounds per square foot)
Silt (ML)	0.003
Sand (SP, SM and mixtures)	0.014
Clay (CL, CH, SC, GC)	0.094
Gravel (GP-GW)	1.058
Boulder and Cobbles	4.869

Sample Task Area – Tier 2 Field Evaluation



- **<u>Confirm in the field:</u>**
- Geometrically deficient areas (obvious signs of existing or new erosion)
- Waterside levee slope
- Landside levee slope
- Presence, absence, or loss of vegetation
- Types and adequacy of armor
- Soil type category
- Levee material will be compared to maximum estimated velocity and to wind wave shear stress

Sample Task Area Results – Tier 2

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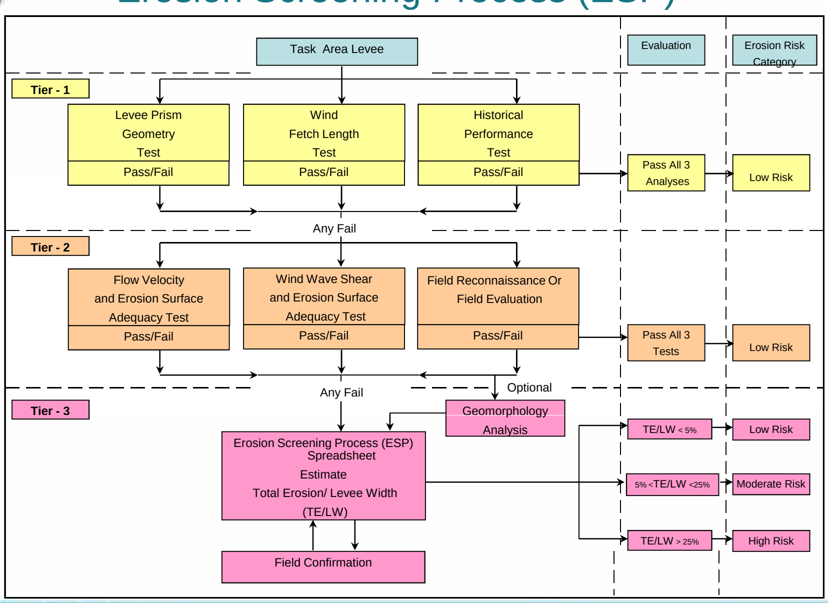
Erosion Screening Process (ESP)



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Tier Three – Erosion Screening Process Spreadsheet

Levee ID	Levee ABC
Reach	Location ABC
Station	Station 10+00
Notes	Trial 1

Water/Stream/River Current

	1st	2nd
Water Surface Elevation, NAVD 88 (ft) =	15	10
Velocity, V (ft/sec) =	6	3.5
Duration for Velocity, d (hours) =	200	2000

Wind/Wave

	1st	2nd
Is the levee location vulnerable to wind/wave erosion?	Yes	Yes
Wind Speed, U' (miles/hr) =	80	50
Duration of Wind (hrs) =	2	2
Maximum fetch length (ft), F =	60000	60000
Efficiency of wave breaking to erode sediments =	7.50%	7.50%

Geometry

Channel bottom elevation, NAVD 88 (ft) =	0
Landside toe elevation, NAVD 88 (ft), LTE =	8
Levee slope (X Horizontal to 1 Vertical; Specify X) =	4
Effective levee width against erosion (ft)	40

Soil Type

Levee Soil Type	LS04 - Erodible
Critical Shear Stress (psf), τ_c =	0.014
Erodibility Coefficient (ft^3/lb-hr), k =	0.409
Levee slope roughness (ft), K_s =	0.01970
Water Channel Bed Soil Type	LS03 - Moderate Roughness
Water Channel Bed Roughness (ft), K_s =	0.01970

Armor

Levee has armor? (Yes or No)	Yes
Velocity at which armor fails (ft/s) =	7
Wave height at which armor fails (ft) =	11

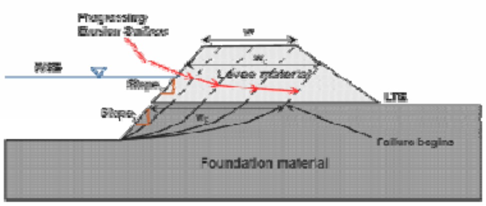
Vegetation

Levee has vegetation? (Yes or No)	Yes
Velocity at which vegetation protection is lost (ft/s) =	3
Wave height at which vegetation protection is lost (ft) =	5

		Wave Calculation				Orbital Stress				Breaking Stress			
Condition Analyzed	Water Surface Elevation above Channel Bottom, h (ft)	Wind-stress Factor, U_A (ft/sec)	Average Period of Wave, T (sec)	Wave Height, H (ft)	Wave Length, L (ft)	Horizontal Mean Wave Orbital Motion, a (ft)	Wave Friction Factor, f_w (unitless)	Horizontal Mean Orbital Wave Velocity, U_b (ft/sec)	Orbital Sheer Stress on Levee due to Wind Waves, τ_{LW} (lb/ft^2)	Wave Height at Breaking, h_b (ft)	Adjusted Water Depth for Wave Model, h' (ft)	Wave Breaking - Slope? (Y/N)	Sheer Stress on Levee due to Wave Breaking, τ_{LB} (lb/ft^2)
1st	15.0	189.7	6.4	9.0	130.9	3.804	0.017	3.762	0.228	11.3	14.5	Yes	1.418
2nd	10.0	106.4	5.2	6.0	88.3	2.661	0.019	3.071	0.176	7.6	9.7	Yes	0.937

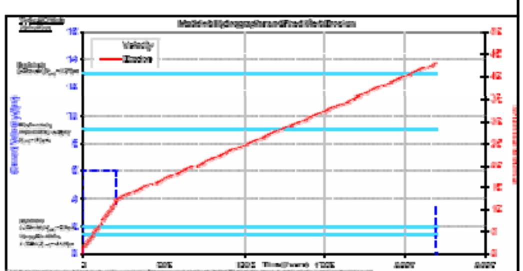
Current Velocity Stress		Erosion Rate w/o Armor or Veg		Armor or Vegetation Impact				Estimated Erosion	
Current Friction Factor - Levee, f_{CL} (unitless)	Sheer Stress on Levee due to Velocity, τ_{LV} (lb/ft^2)	Erosion due to Wave Bottom Current & Wave Breaking, without armor or vegetation (ft)	Erosion due to Velocity, without armor or vegetation, ε_{LV} (ft)	Would the armor or vegetation provide protection against analyzed wave height?	Would the armor or vegetation provide protection against analyzed current velocity?	Erosion due to Wave Bottom Current & Wave Breaking, including armor or vegetation protection, ε_{LWB} (ft) *	Erosion due to Velocity, including armor or vegetation protection, ε_{LV} (ft) *	Total Erosion, ε_{LT} (ft)	Erosion Potential
0.004	0.137	1.3	10.1	No	Yes	1.3	10.1	11.4	High
0.004	0.051	0.9	30.6	Yes	Yes	0.9	30.6	31.5	High
Total Estimated Erosion (ft), and Erosion Potential for the Analyzed Simplified Hydrograph:								42.9	High

Tier Three – Erosion Screening Process Spreadsheet

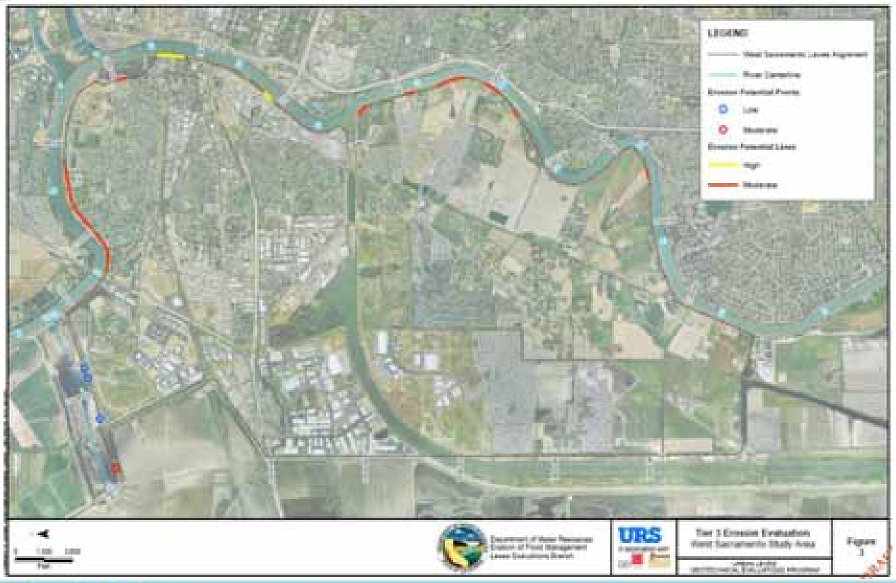


Notes:

1) LTE: Landside toe elevation
2) WSE: Water surface elevation
3) w: Levee crest width
4) w_E: Effective levee width
5) w_T: Width of levee at the LTE that must be eroded for failure to occur
6) For failure to occur, WSE must be greater than LTE



Sample Task Area Results – Tier 3

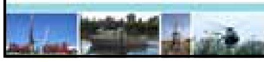


Moving Forward ….

- Implementation - 12 ULE Task Areas (300+ Miles)
- Schedule – Next 18 months
- Results and Findings (Including feasibility level remediation and costs) – Presented in GER

Questions?

Thank You!



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