SAN JOAQUIN RIVER
RESTORATION PROGRAM

Program EIS/R
Levee Criteria

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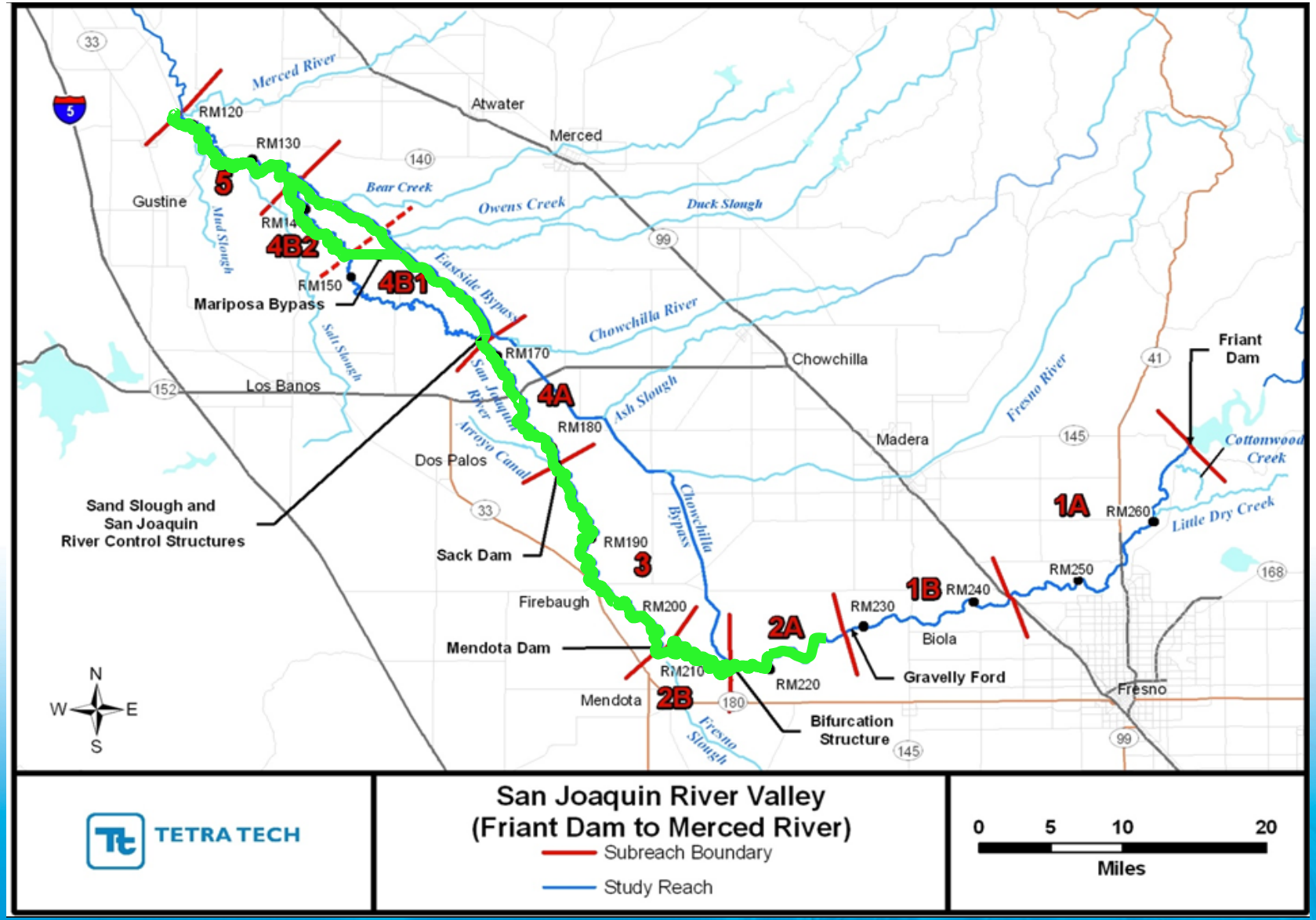
Study Area



Flow-related Issues for Flood Management

- Flows can increase flood risk as a result of several potential failure modes, including through-levee seepage, under-levee seepage, and erosion
- Emergency access could be affected
- Existing maintenance practices could be impeded
- Future efforts may be needed to address erosion, sediment deposition, and vegetation

Channel Capacity Defined

Then-existing channel capacity is defined in the Program EIS/R as…

"the flow that would not significantly increase flood risk from Interim and Restoration flows in the Restoration Area."

When we talk about flood risk it is further defined as…

"*the risk of levee failure due to seepage and levee stability*."

Application of Performance Standards to Interim and Restoration Flows

- Then-existing channel capacity limits flows to levels that would meet USACE Factors of Safety for Levee Slope Stability and Underseepage
- Until adequate data are available to determine levee stability Factors of Safety, limit flows to those which would remain “in-channel”
- Implementing these standards would allow the SJRRP to manage the risk of levee failure due to under-seepage, through-seepage, and associated levee stability issues to less-than-significant levels

Completed Studies to Inform Channel Capacity

Studies and Work Completed

- In-channel Capacity Study
- Geotechnical Study in Eastside Bypass
- Bypass Subsidence Study
- Reach 2A Sediment Transport Study
- Seepage Management Plan

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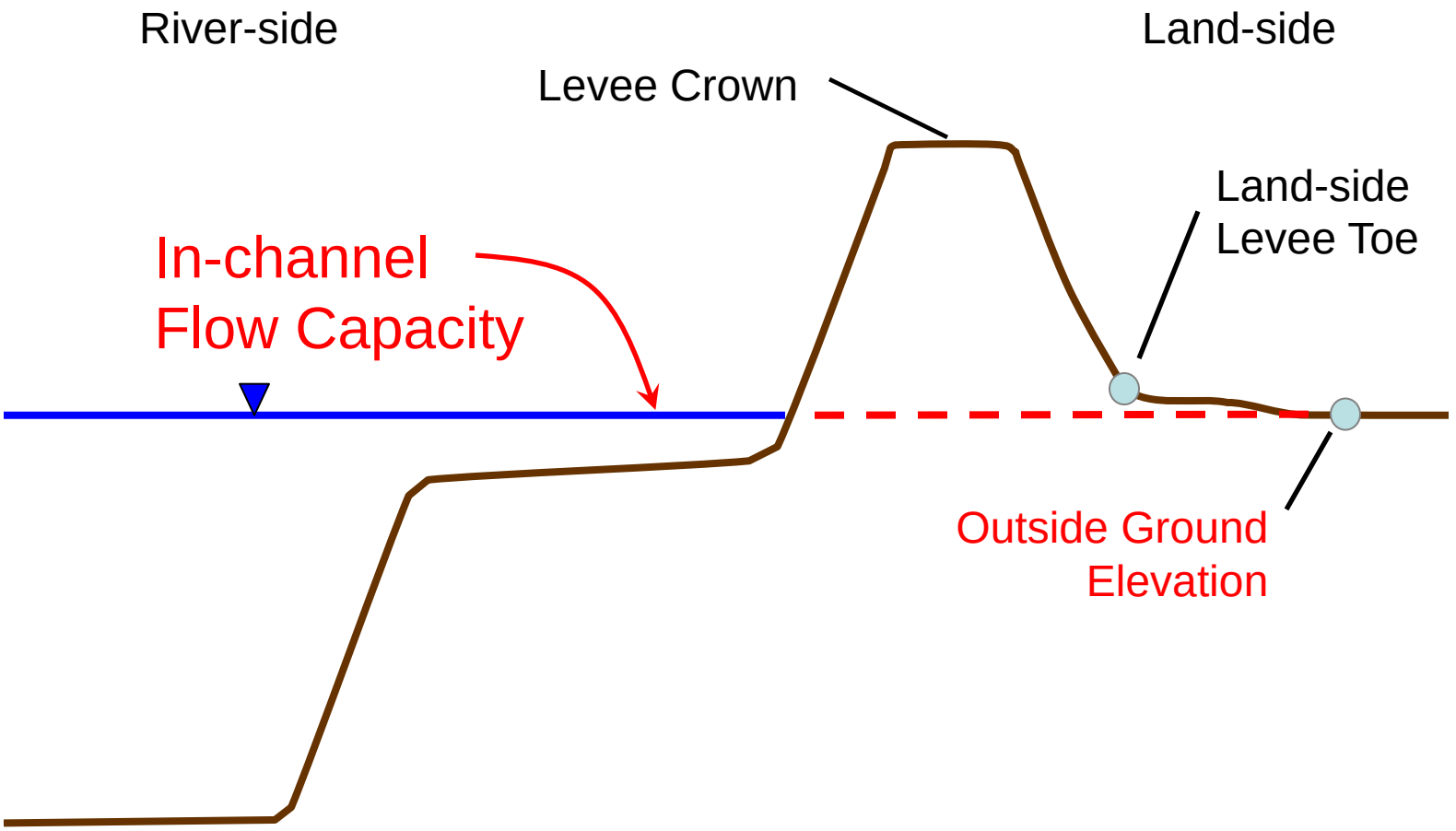
In-channel Flow Capacity Study

In-channel Flow Capacity

- Restoration flows would remain “in-channel” until adequate data are available on the levees
- In-channel flow is the maximum flow whose water surface elevation would not exceed the ground elevation on the landside of the levee
- Study has lead to identifying the highest priority levees for further geotechnical analyses

In-channel Flow Capacity



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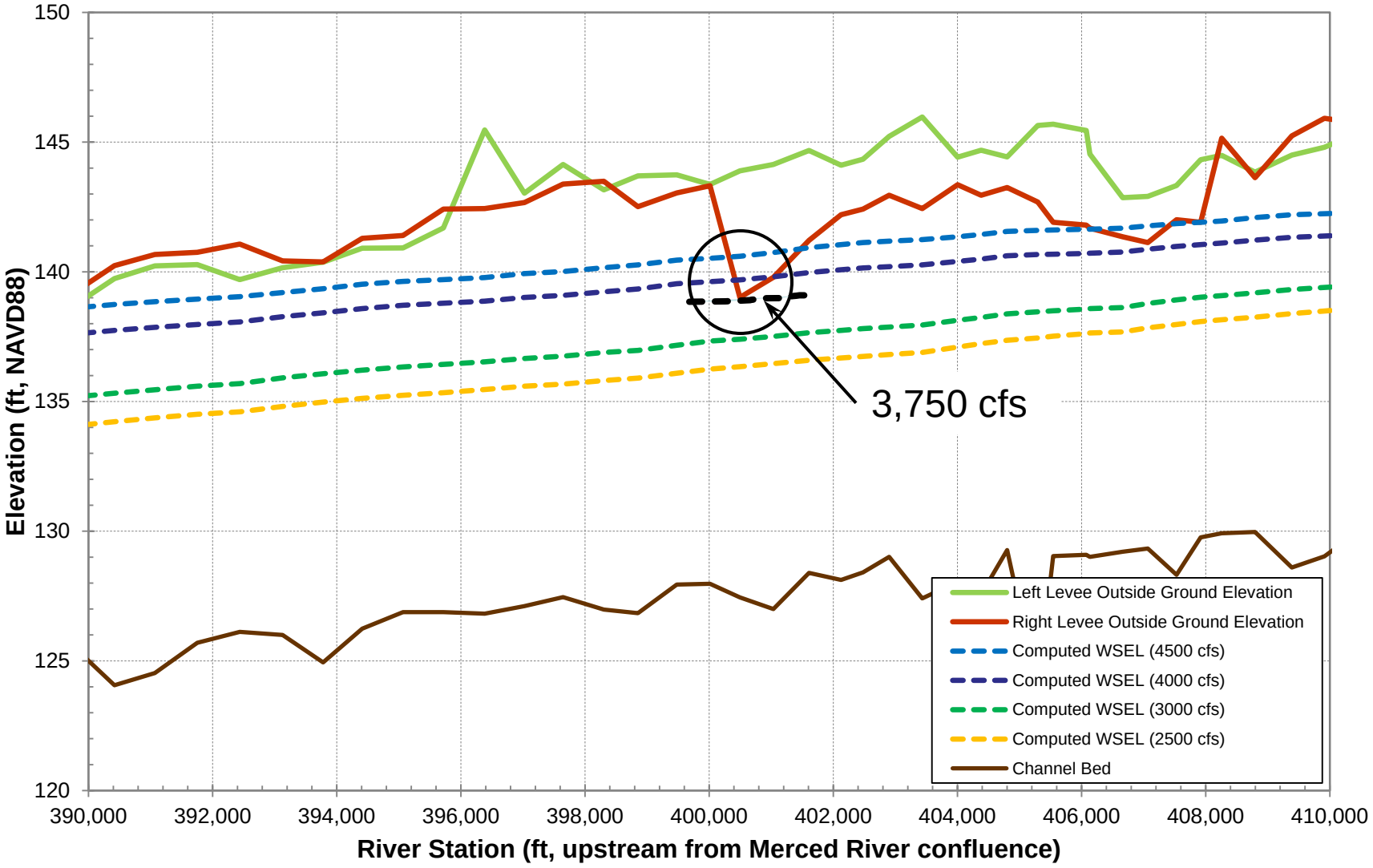
In-channel Flow Capacity



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In-channel Flow Capacity

Reach	Settlement Exhibit B Restoration Flows (cfs)	In-channel Capacity (cfs)
2A	3,850	1,630
2B	3,850	1,120
3	3,655	2,760
4A	3,655	970
4B2	3,655	930
5	4,055	1,940
Middle Eastside Bypass	3,655	10
Lower Eastside Bypass	3,655	2,890
Mariposa Bypass	3,655	350

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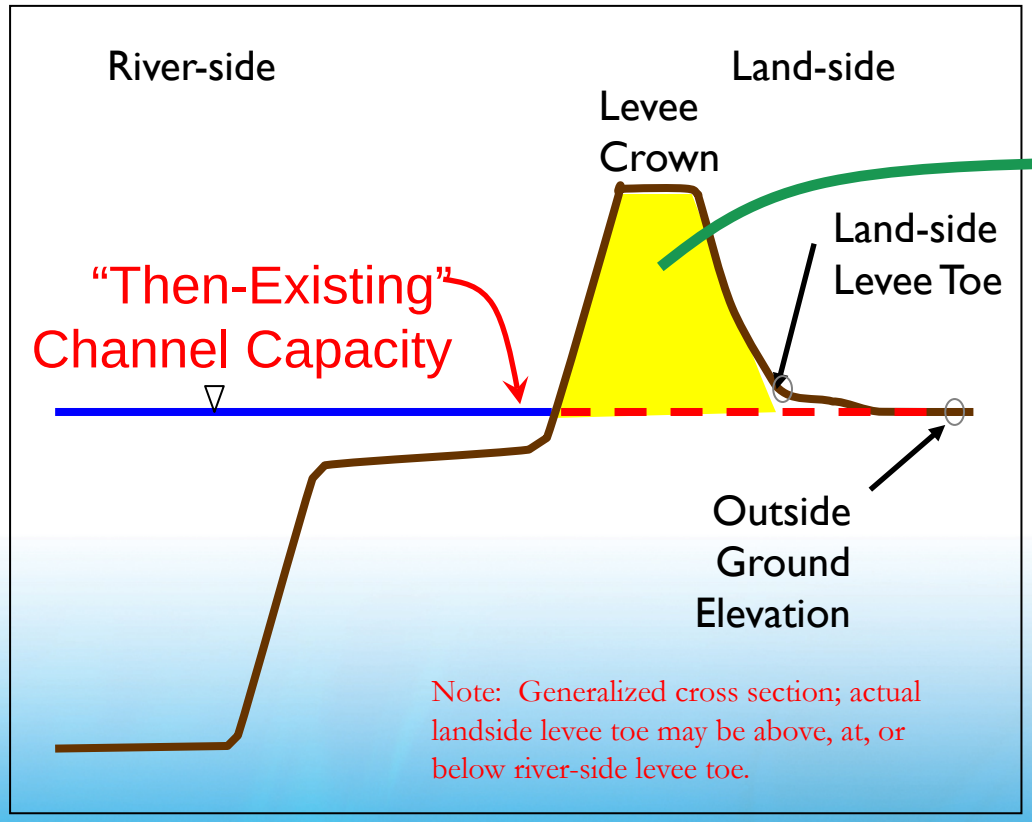
Geotechnical Studies

Geotechnical Role in Channel Capacity



Levee Evaluations

- *Non-Urban Levee Evaluation (NULE)*
- *San Joaquin Levee Evaluation (SJLE)*

Levee Improvements

- *CVFPP and related DWR projects*
- *Settlement-driven projects*

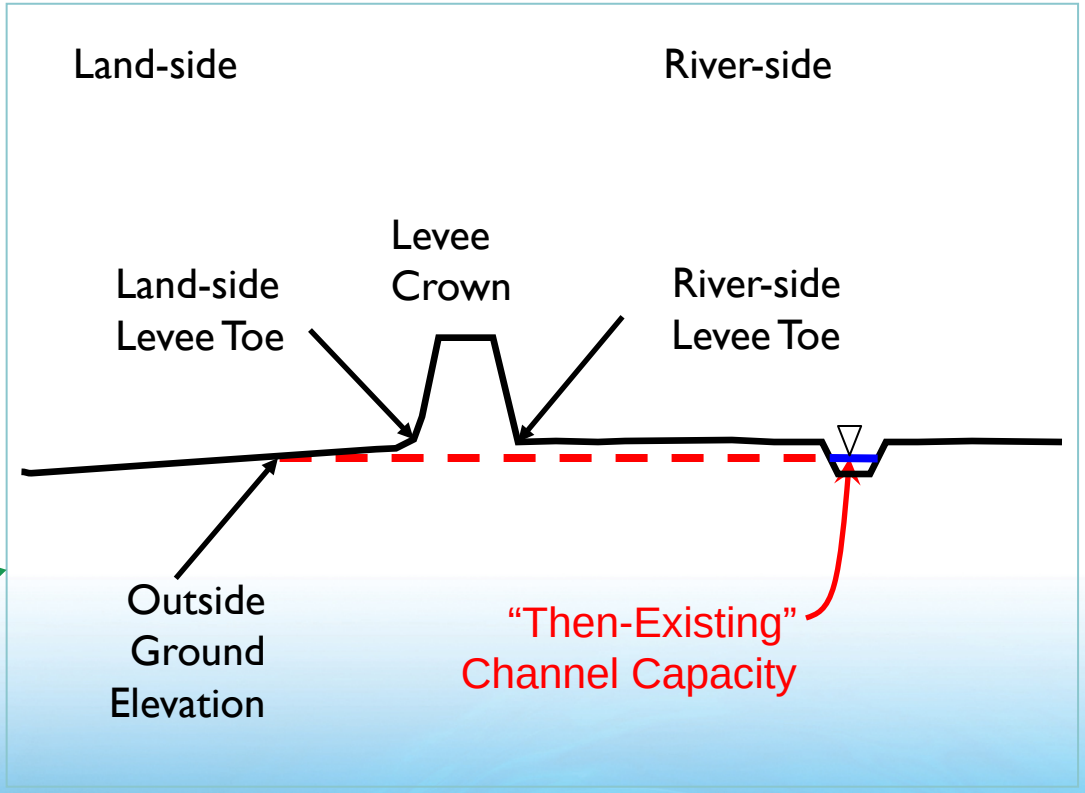
Identification of Low Channel Capacity Sites

Reach	In-channel Capacity[1] (cfs)
Reach 2A	1,630
Reach 2B (Entire Reach)[2]	0
Reach 2B (Excluding Mendota Pool)	1,120
Reach 3	2,760
Reach 4A	970
Reach 4B2	930 [3]
Reach 5	1,940
Middle Eastside Bypass	10
Lower Eastside Bypass	2,890
Mariposa Bypass	350

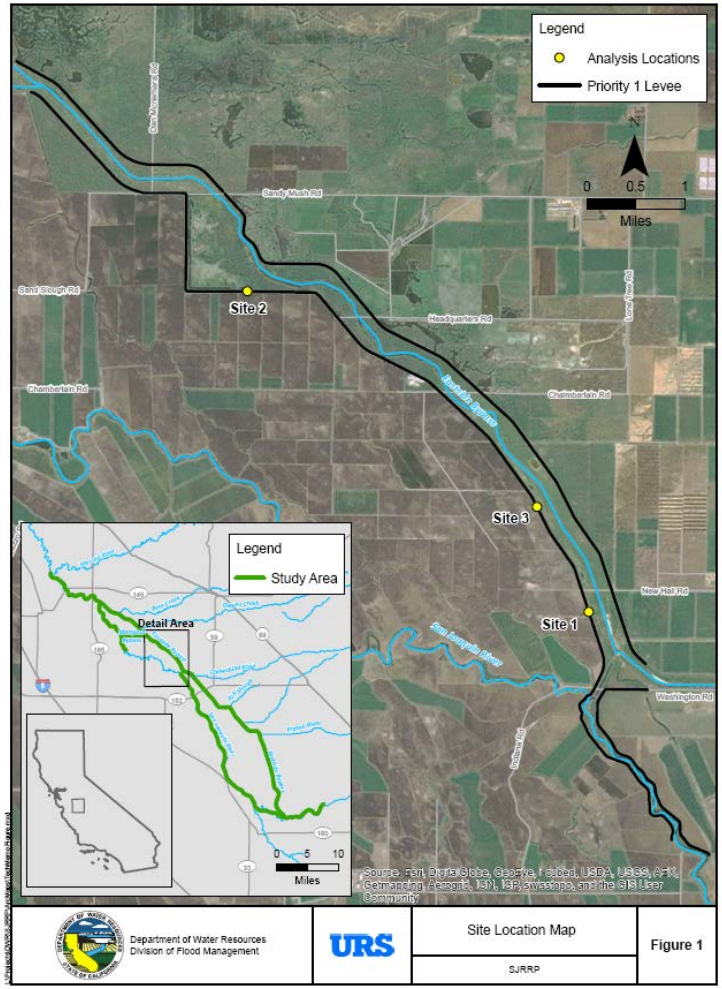
[1] Capacity based on outside ground elevations

[2] Portion of reach above influence of Mendota Pool

[3] Capacity excludes localized deep depressions



Immediate Efforts to Assess Low Channel Capacity Sites



- Three Sites Assessed
  - Site 1 (10 cfs)
  - Site 2 (120 cfs)
  - Site 3 (230 cfs)
- Geotechnical Data from Crest CPT/borings (SJLE)
- Seepage/Stability analyses
  - Applied ULE protocols
  - Followed USACE criteria

Site Analysis Findings

- Approximate Height of Water on Levee w/o Exceeding Geotechnical Criteria
  - Site 1 – 1.2 feet
  - Site 2 – 6.5 feet
  - Site 3 – 3.7 feet
- Data incorporated into revised hydraulic analyses
  - Of the three sites result for Site 1 is lowest (520 cfs)
  - Revised then-channel capacity controlled by right bank (370 cfs)

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Bypass Subsidence Study

Subsidence

- Subsidence is a known fact in the San Joaquin Valley and project area
- Historical rates ranged from about 0.1’ to 0.2’ per year
- Ground control surveys used to confirm 2008 LiDAR showed extreme subsidence rates near the flood bypass
- Subsidence potential effects:
  - Reduce levee freeboard
  - Change the performance of the control structures
  - Cause erosion and change sediment deposition patterns

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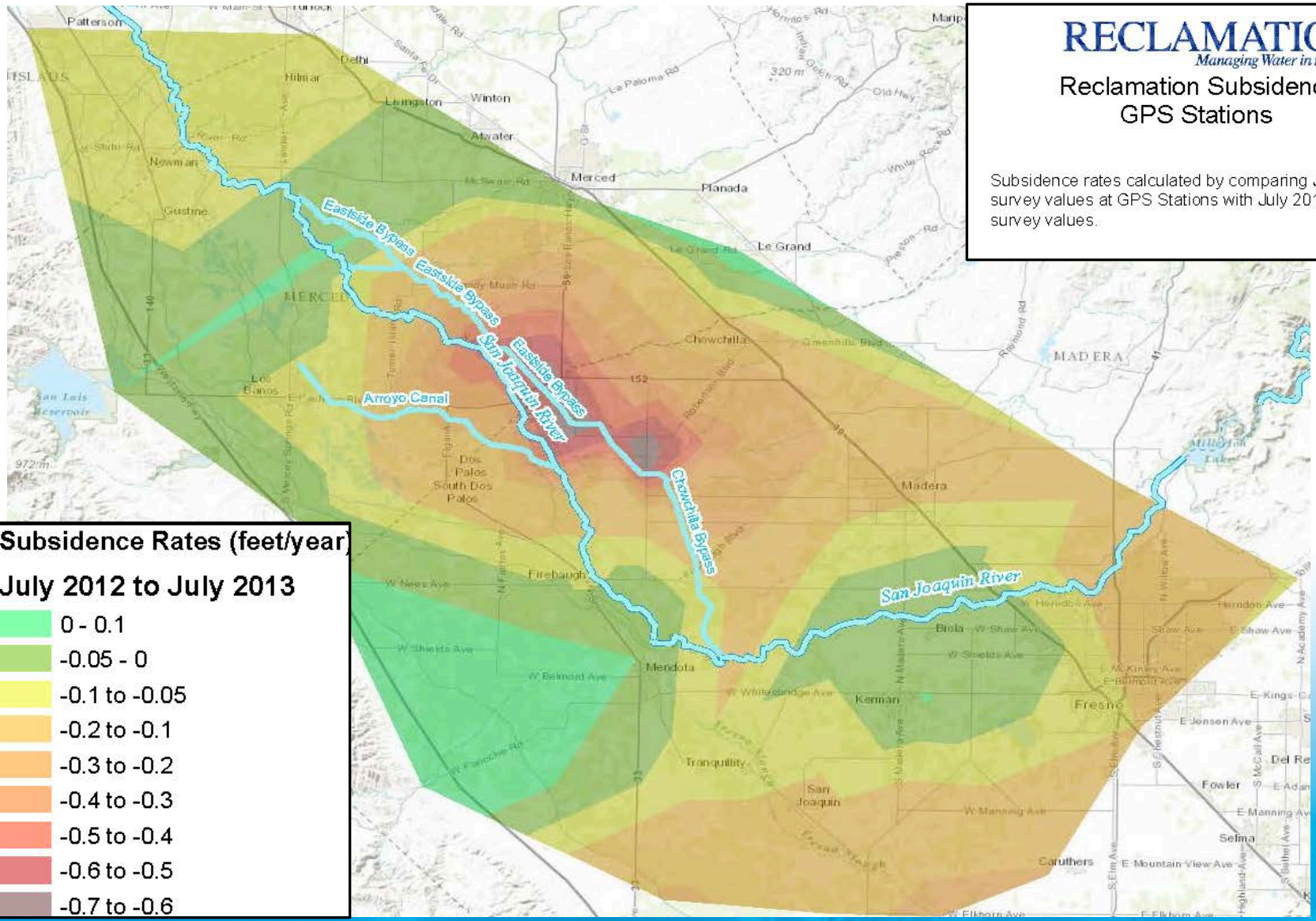
Subsidence Map



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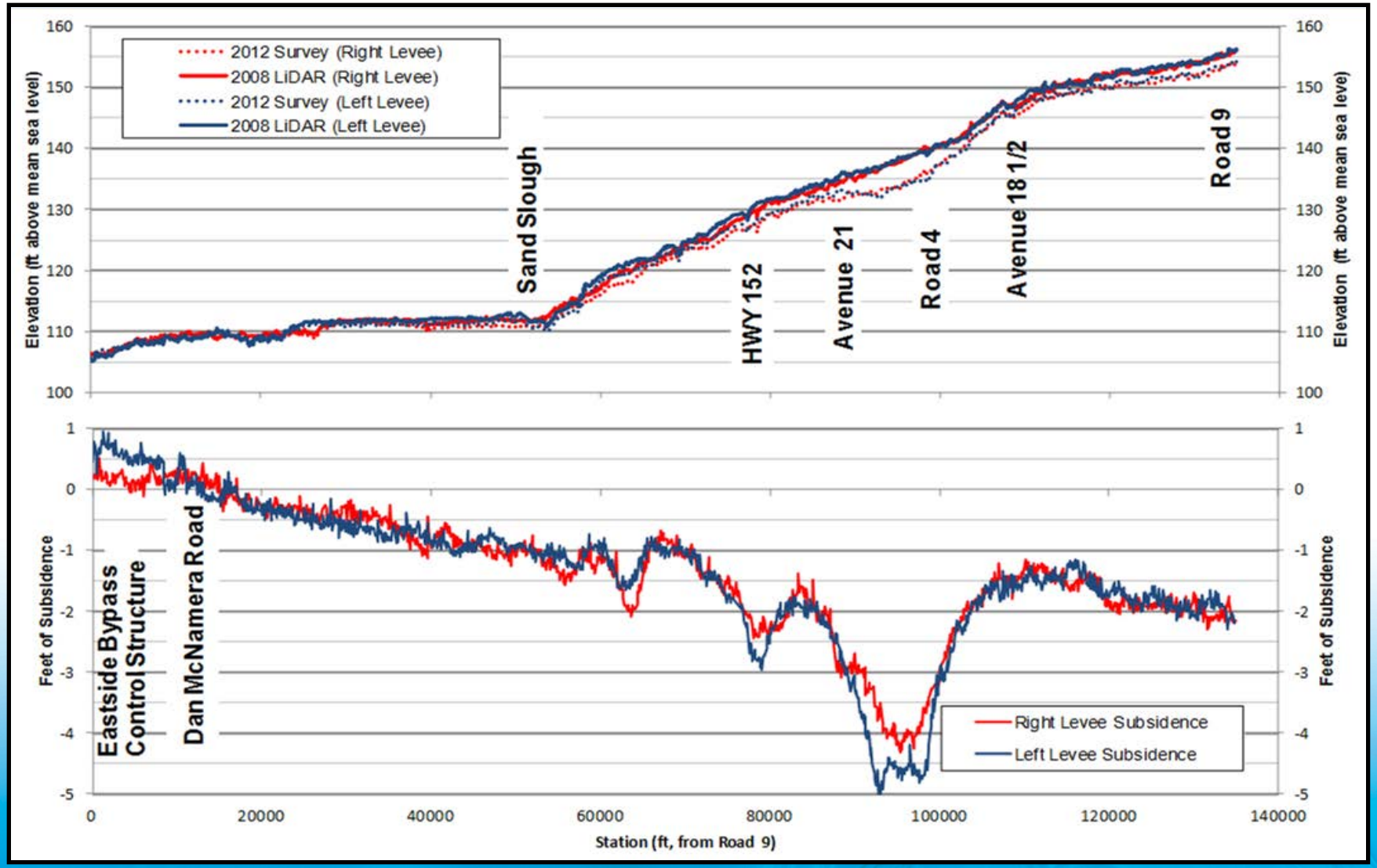
Eastside Bypass Levee Profiles



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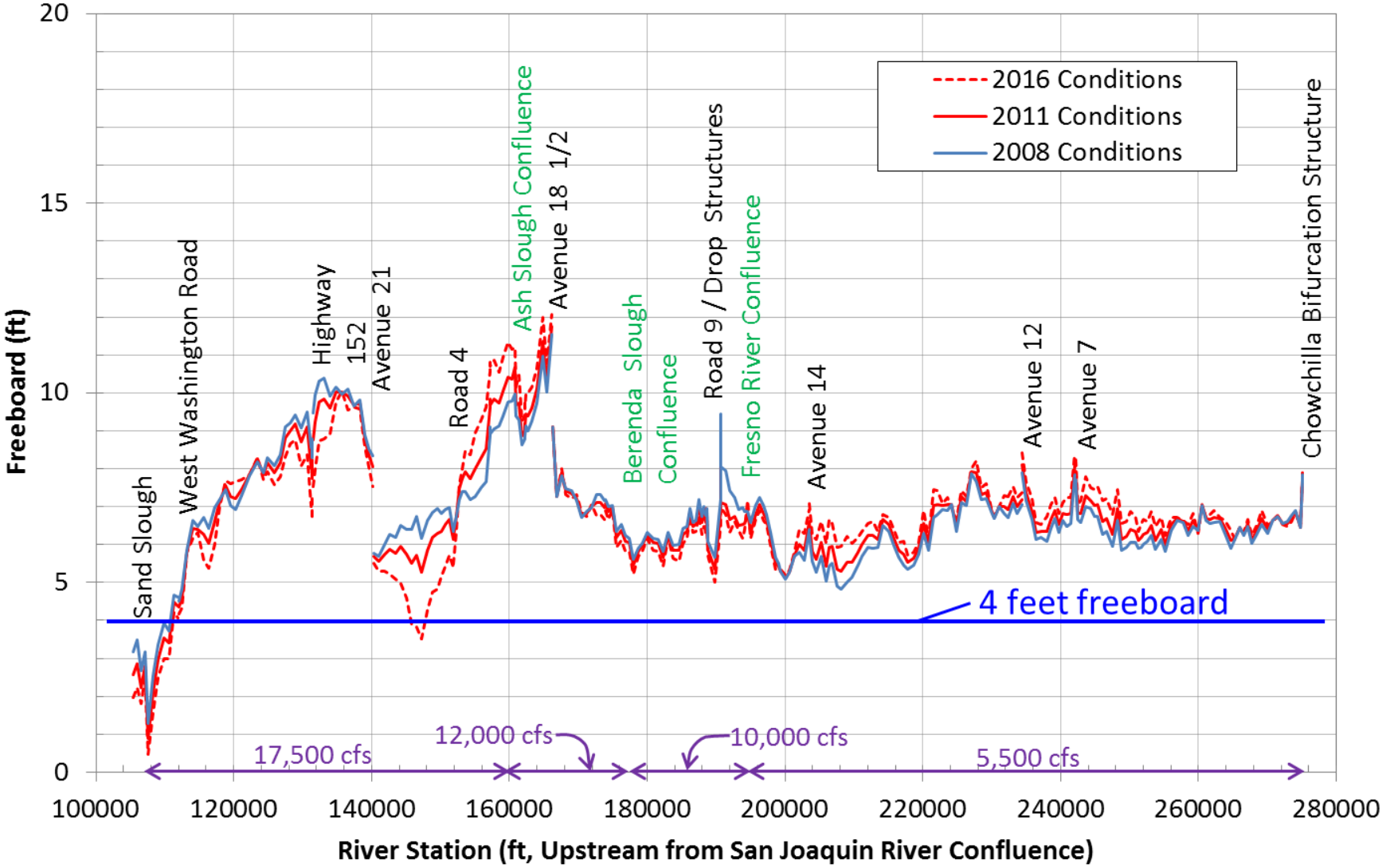
Freeboard Estimates



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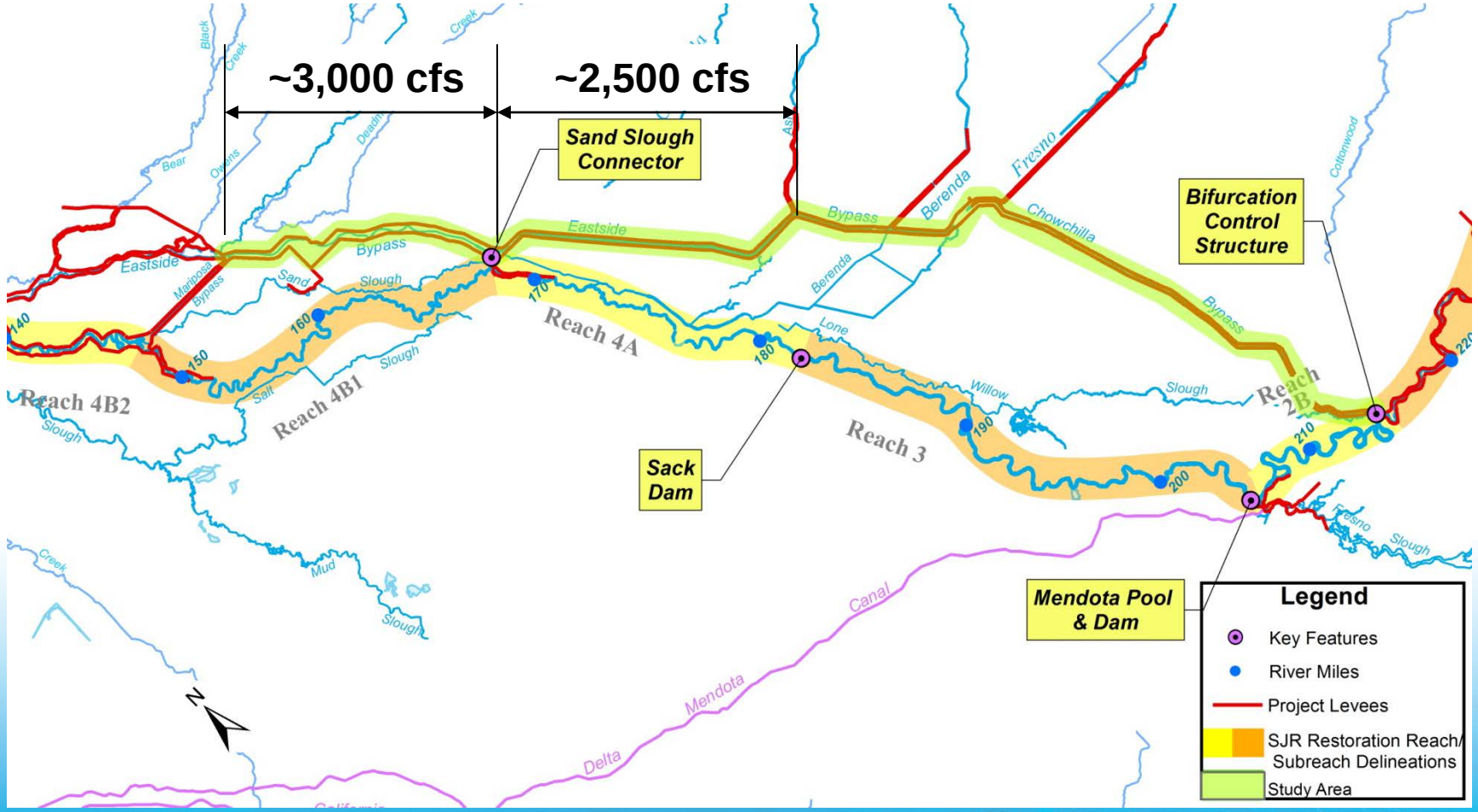
Capacity Change in Study Area



TIME FRAME FROM 2008 to 2016

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Recommended Then-existing Channel Capacities

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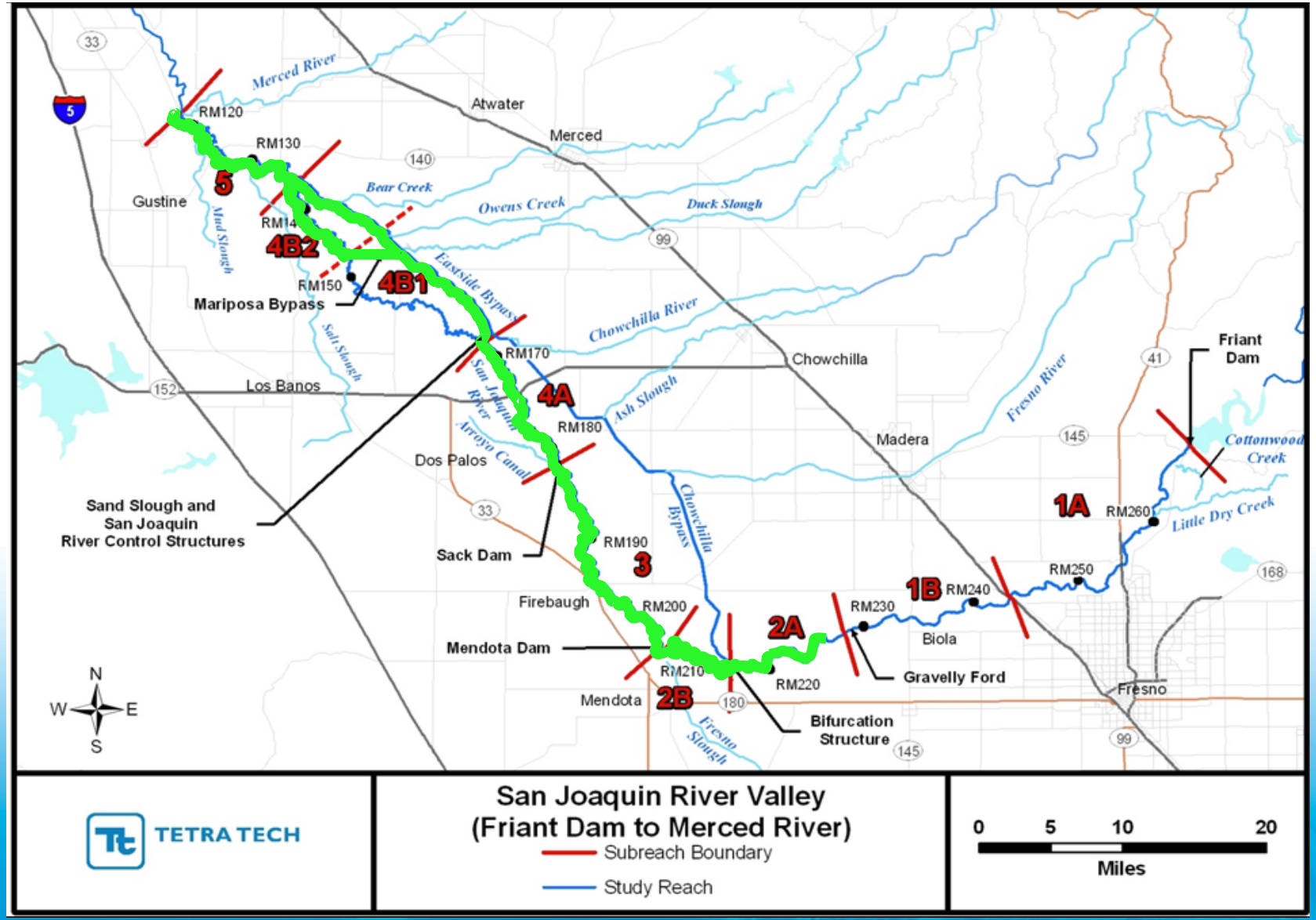
Study Area



Then-existing Channel Capacity

- Then-existing channel capacity limits flows to levels that would meet USACE Factors of Safety for Levee Slope Stability and Underseepage
- Until adequate data are available to determine levee stability Factors of Safety, limit flows to those which would remain “in-channel”

Studies and Work Completed

- **Reach 2A Sediment Transport Study**
  - Study showed only minor changes in channel capacity in Reach 2A
- **Bypass Subsidence Study**
  - Study evaluated flood design flows and considered impacts based on levee design freeboard
- **Seepage Management Plan**
  - Study focuses on agricultural seepage, not levee stability
- **In-channel Capacity Study**
  - Main study used to make recommendation on then-existing channel capacities in this report. Results in the Eastside Bypass were further refined.

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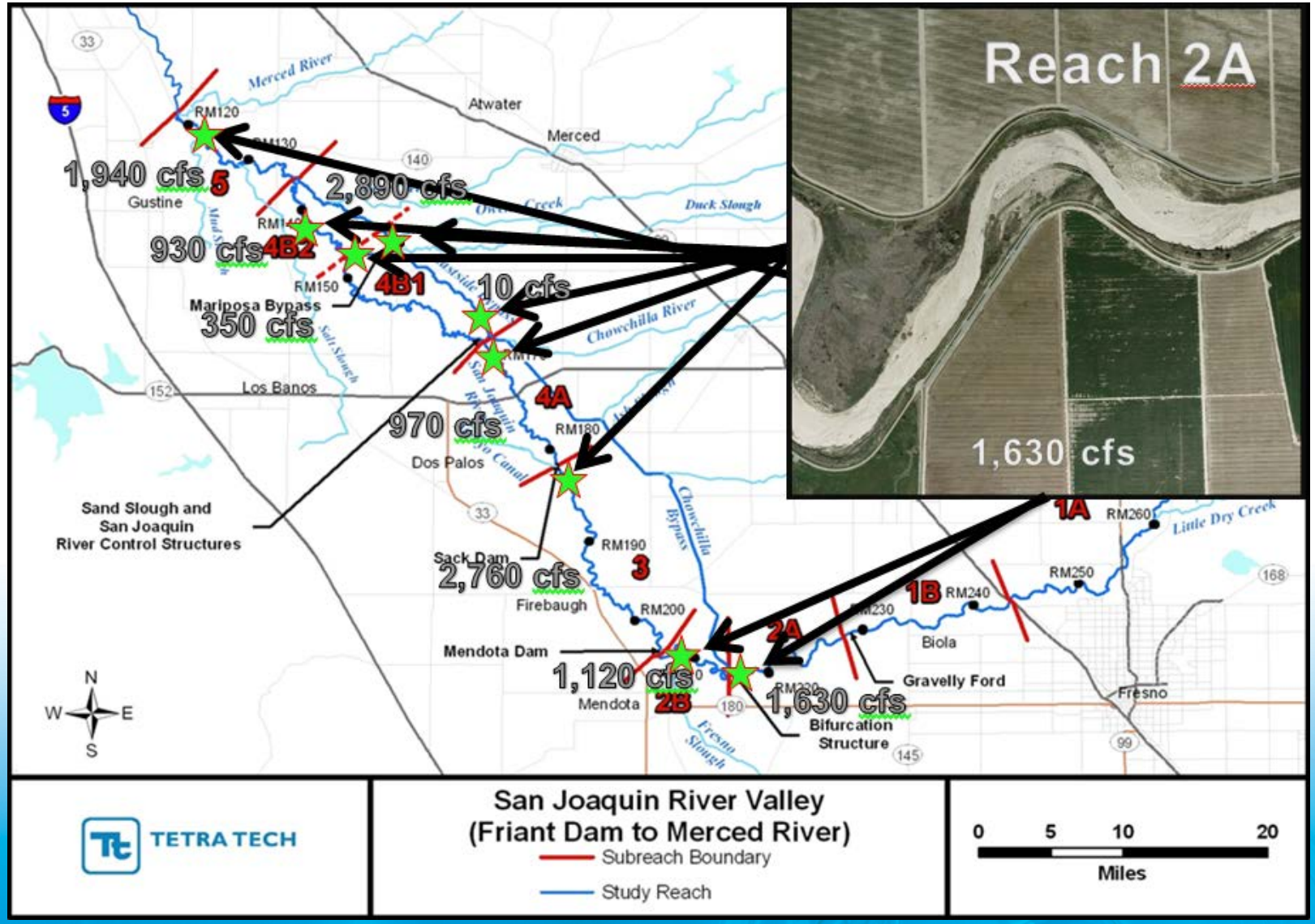
In-channel Capacity Results



Bypass Geotechnical Study

Levee seepage and stability analyses performed at locations with capacity less than 300 cfs

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Bypass Geotechnical Study

Site	Maximum Water Surface Elevation (feet, NAVD88)	Approximate Height of Water on the Levee (ft)	Flow (cfs)
1	100.7	1.2	520
2	104.0	6.5	>4,500
3	101.7	3.7	2,270

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Then-existing Channel Capacity

Reach	Current Capacity Considering Levee Stability (cfs)	2014 Recommended Then-Existing Channel Capacity (cfs)
2A	1,060	1,630
2B	810	1,120
3	2,140	2,760
4A	630	970
4B2	990	930
5	1,690	1,940
Middle Eastside Bypass	600	370
Lower Eastside Bypass		2,890
Mariposa Bypass	N/A	350

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Ongoing and Future Studies and Monitoring Work

Future Channel Capacity Studies

Ongoing/Future Studies include:

- San Joaquin Levee Evaluation Project
- In-channel Capacity Verification Study
- Reach 2A Sediment Transport Study
- Subsidence Monitoring Study
- Vegetation Study
- Other Monitoring Activities

Capacity Verification Study

Study Goals

- Verify that the estimated flow capacities reported for each reach are accurate and will avoid levee impacts
- Develop and implement a monitoring plan to detect changes in the system to avoid future levee impacts

Capacity Verification Study

Major study tasks include:

- Evaluating channel capacity studies completed thus far, including available data and assumptions
- Collecting additional topographic data and completing site-specific assessments
- Developing a monitoring plan to ensure future changes in the system are detected

Potential Monitoring Program

- Evaluate existing monitoring network
- Install added gages at critical sites
- Monitor changes in channel

Subsidence Studies

Study and Monitoring Goals

- Determine changes in then-existing channel capacities considering geomorphic, sediment and hydraulic changes as a result of subsidence
- Provide more refined and updated data on subsidence rates, as needed
- Determine if updates to the topographic data, modeling tools or design criteria for the site-specific projects are necessary

Subsidence Studies

Major study efforts could include:

- Bi-annual surveys of approx. 61 control points
- Annual surveys of select bypass levees
- “Pilot study” survey of Reach 4A to assess subsidence along the SJR
- Sediment transport study within the bypass
- Site-Specific project design

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On-going and Future Geotechnical Studies

DWR NULE Project

- Goals
  - Support CVFPP and federal/local flood projects
  - Provide geotechnical data, analysis and remedial alternatives to stakeholders
- Phase 1 – Preliminary Evaluations Using Existing Data
  - Compilation of prior data and past performance
  - Assessment of potential levee failure or flood fight need by hazard category
    - Hazard Level A – Low
    - Hazard Level B – Moderate
    - Hazard Level C – High
    - Category LD – Lacking sufficient data
  - Geotechnical Analysis Report (GAR) completed June 2011

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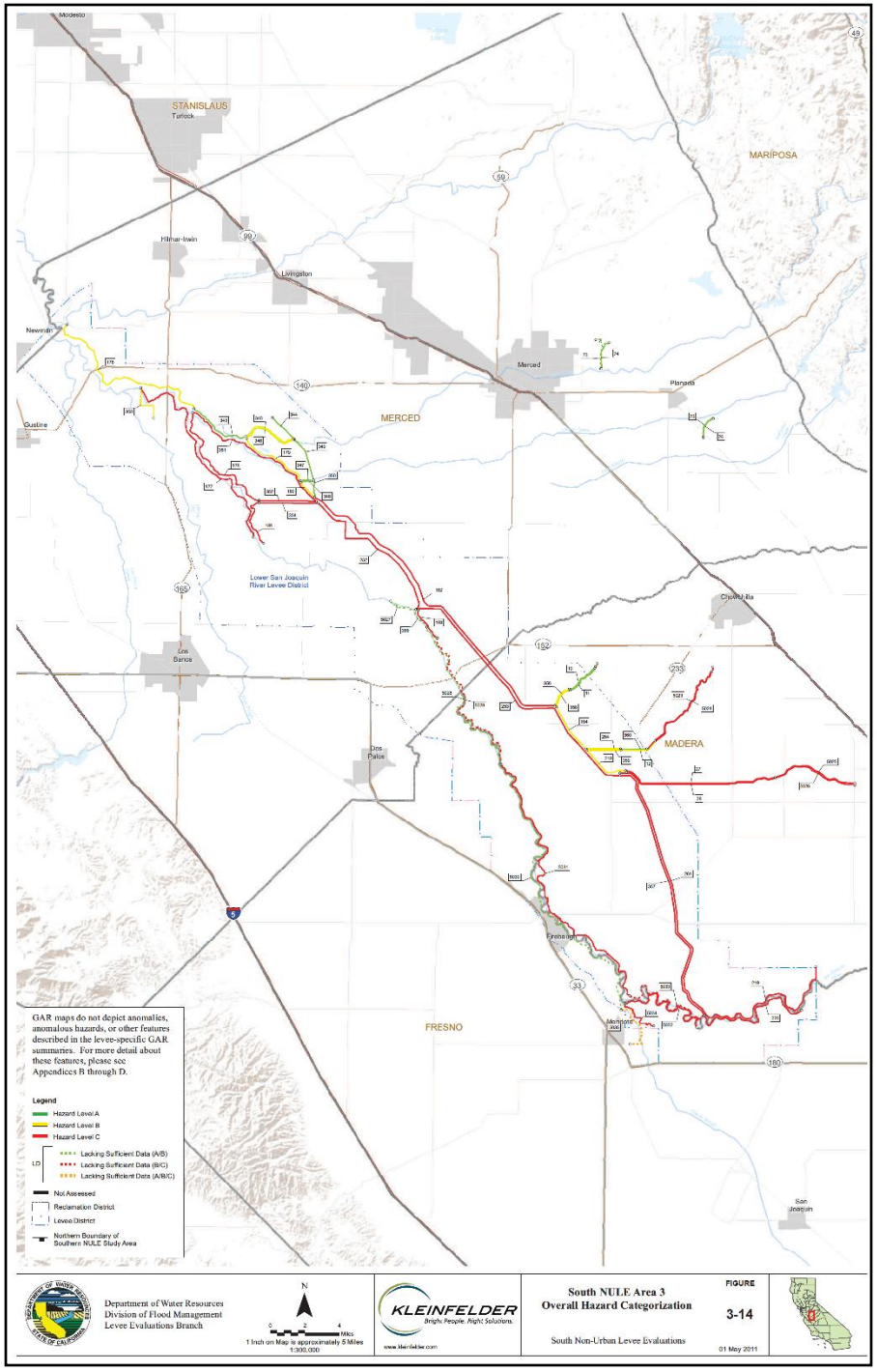
NULE Phase 1 - Findings

South NULE (Area 3 including Restoration Area)



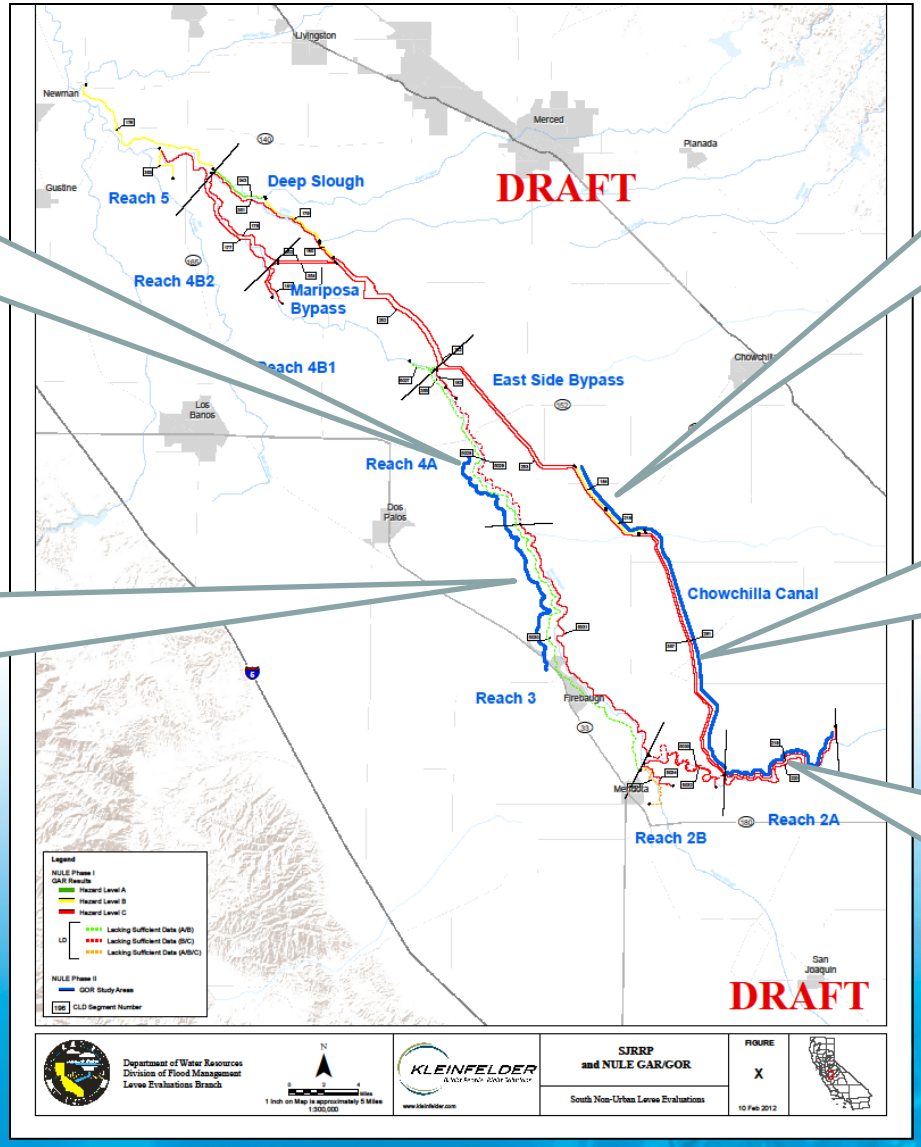
NULE Phase 2 - Summary

- Phase 2 – Targeted Geotechnical Analyses
  - Geomorphic Studies
  - Field Explorations of levees protecting > 1,000 people
    - CPT on crest every 1,000 feet
    - Rotary borings on crest every 5,000 feet
    - Select borings/CPTs at landside levee toe
  - Geotechnical Analyses
  - Documentation
    - Geomorphic Study Report – January 2011
    - GDR (Geotechnical Data Report) - December 2013
    - GOR (Geotechnical Overview Report) – mid/late 2014

NULE Phase 2 - Explorations

Reach 4A
45 CPTs
10 Borings

Reach 3A
69 CPTs
12 Borings



Eastside Bypass
35 CPTs
11 Borings

Chowchilla Canal
90 CPTs
35 Borings

Reach 2A
40 CPTs
18 Borings

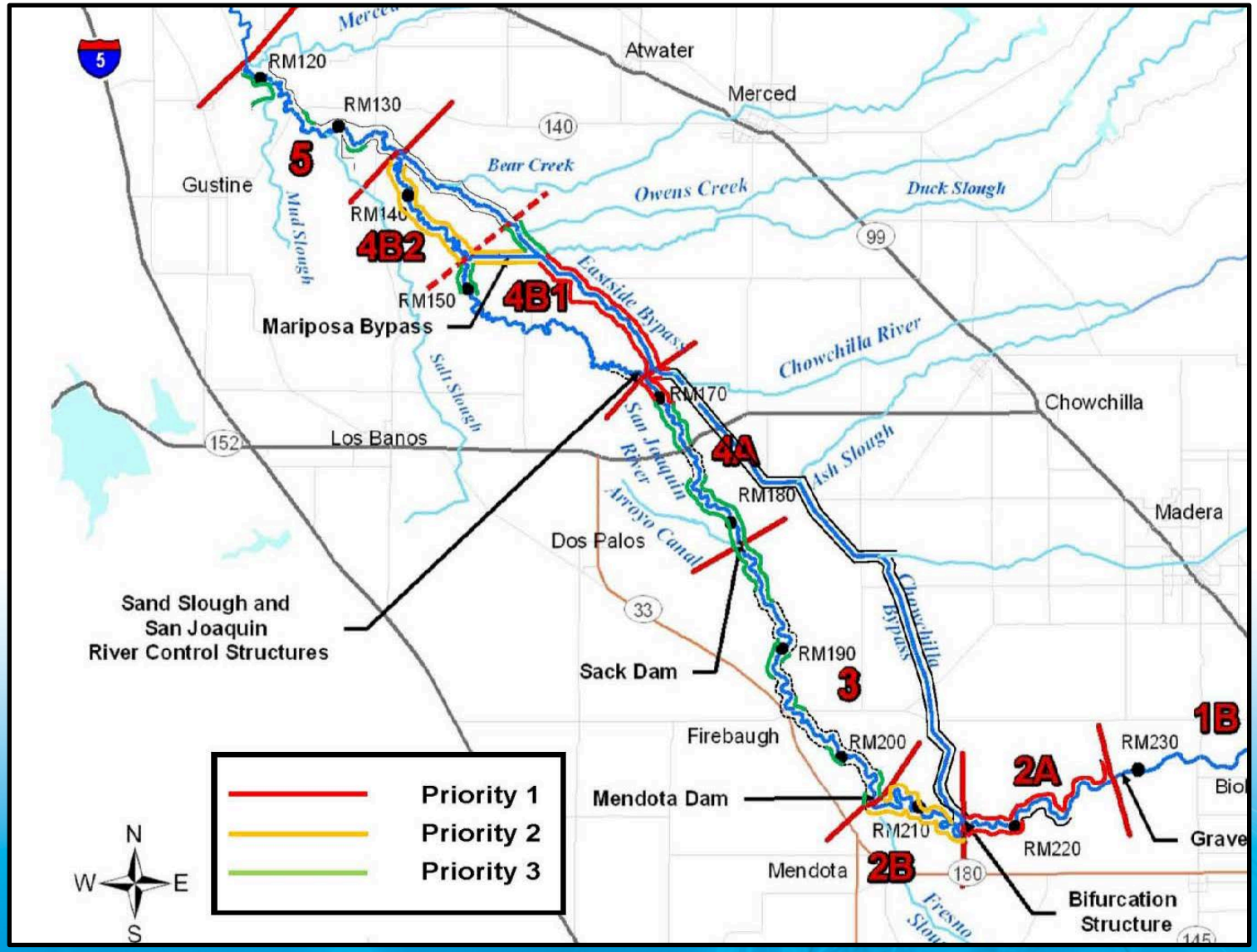
San Joaquin Levee Evaluation (SJLE) Project

- Goal: Assist SJRRP in assessing flood control system integrity associated with seepage and stability
- Scope
  - Task 1 - Preliminary assessment of levee integrity and Prioritization based on hydraulic capacity
  - Task 2 - Geotechnical explorations
  - Task 3 – Geotechnical analyses with respect to Corps criteria
- Limitations
  - Analyses limited to seepage and stability
  - Study area excludes Reaches 2B and 4B1

SJLE Task 1 - Assessment and Prioritization

- NULE data indicate high flood hazards
- Hydraulic analyses used to identify levees with highest hydraulic impacts
- Levees prioritized for geotechnical exploration based on:
  - Hydraulic impacts
  - Current channel capacity limitations
  - Relationship to NULE explorations
  - Anticipated Restoration Flow routing

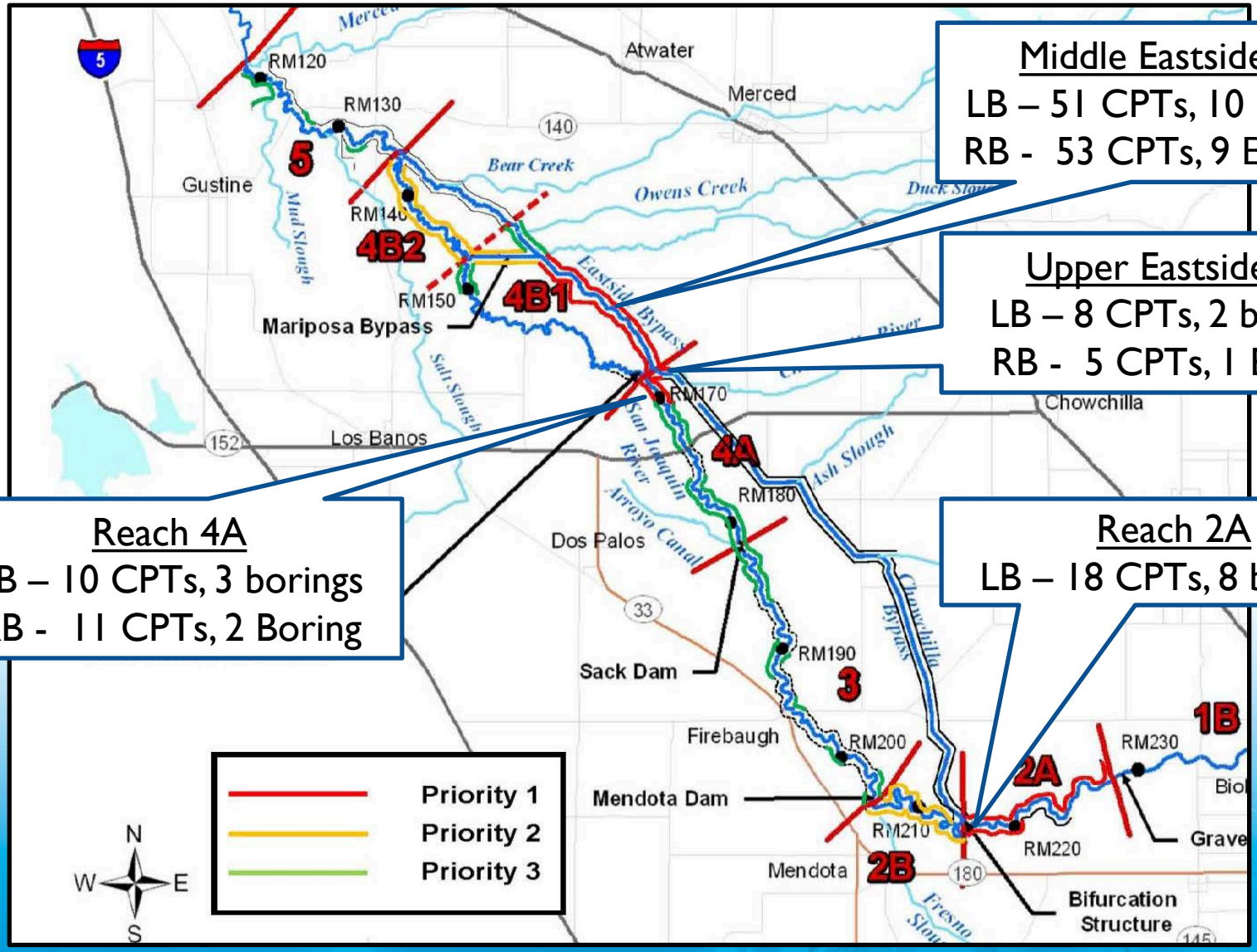
SJLE Task 1 - Levee Evaluation Priorities



SJLE Task 2 – Geotechnical Explorations

- Phased exploration of Priority 1 levee segments consistent with NULE protocol
- Initial Phase completed January 2013
  - Middle Eastside Bypass RB/LB, 124 locations
  - Reach 2A LB, 26 locations
- Supplemental Phase completed May 2013
  - Reach 4A RB/LB, 26 locations
  - Upper Eastside Bypass RB/LB, 16 locations

SJLE Task 2 – Geotechnical Explorations



SJLE Task 3 – Geotechnical Analysis

- Geotechnical analyses of Priority 1 levees
  - Limited to seepage and stability
  - USACE levee performance criteria
- Key subtasks
  - Analyses of low channel capacity sites in Eastside Bypass
  - Geotechnical data gap analysis
  - Supplemental Explorations
    - Geophysical testing
    - Supplemental explorations
    - Development of analytical methodology
  - Geotechnical analyses and reporting

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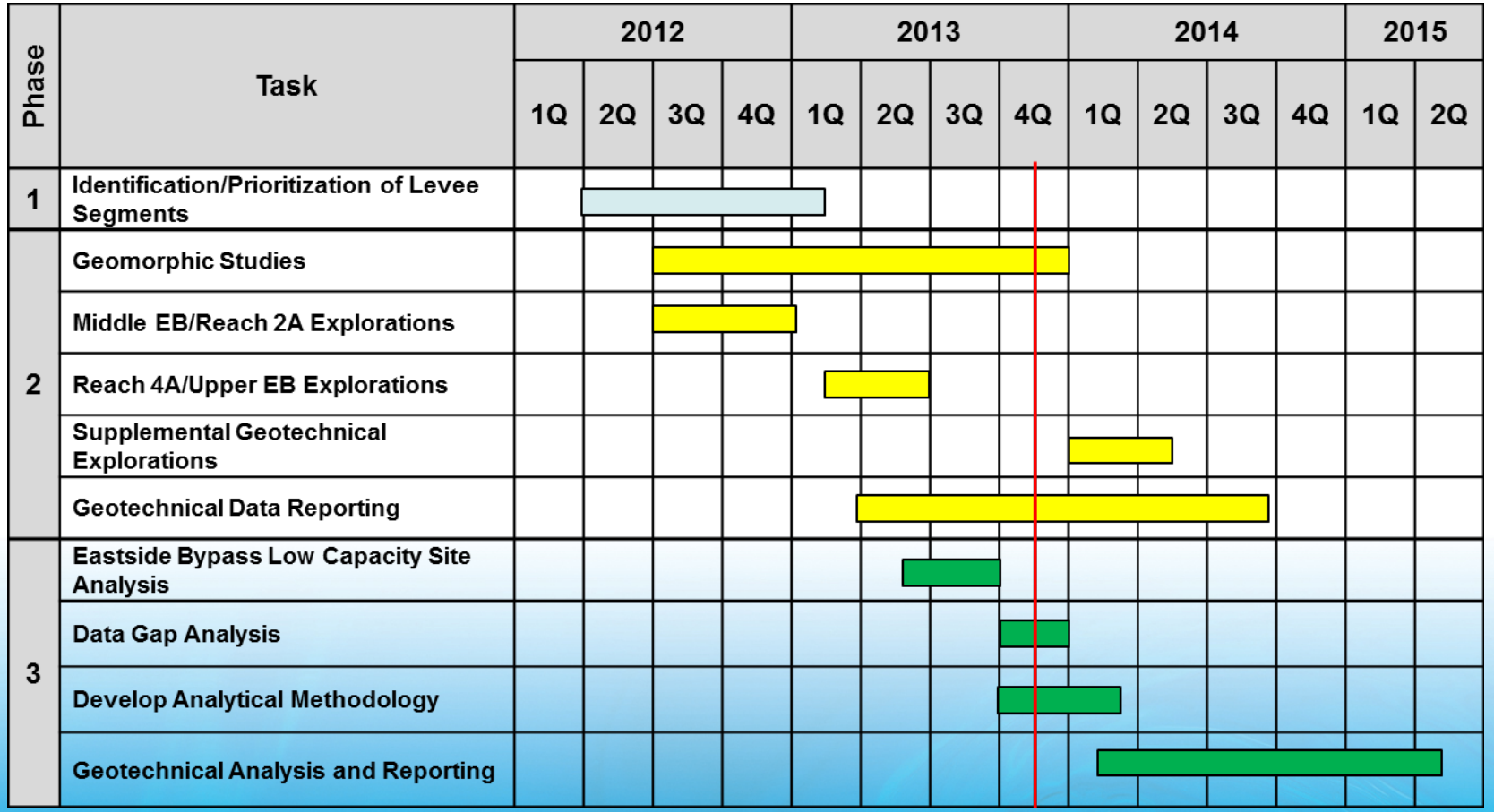
SJLE – Schedule



SJLE – Next Steps

- Complete Priority 1 levee evaluation
- Support SJRRP in:
  - Assessing channel capacity revisions
  - Identifying levee remediation needs
  - Identify monitoring needs for flood management under Restoration flows
- Continue coordination with SJRRP and Bureau on Priority 2 and 3 needs
- Identify future funding availability for additional evaluations