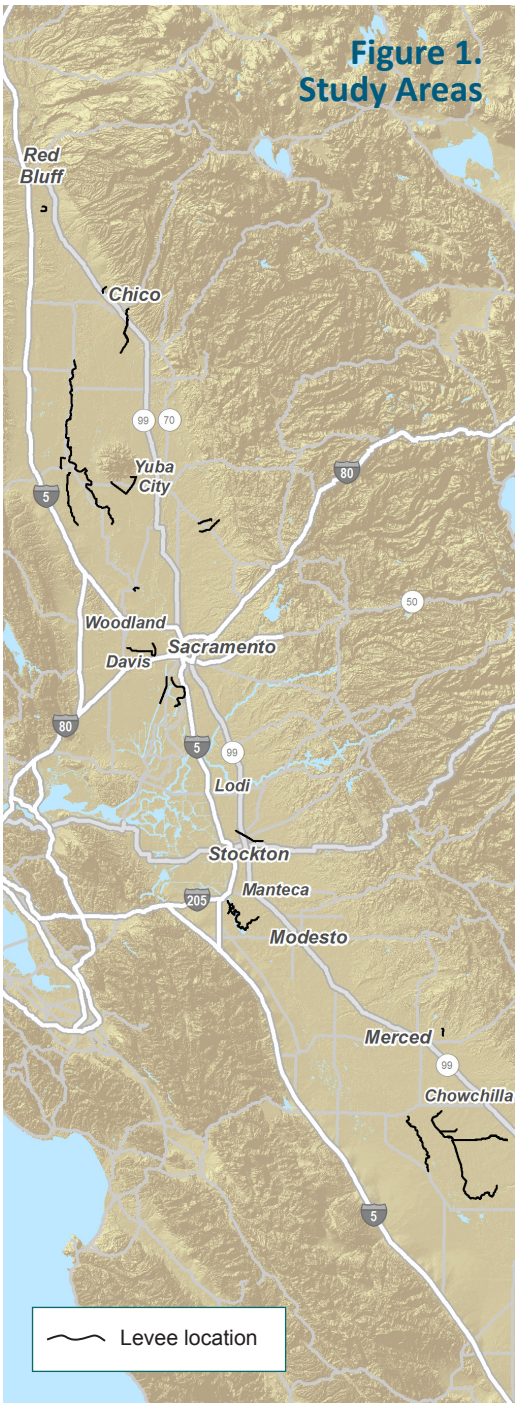
Non-Urban Levee Evaluation Project
Sacramento and San Joaquin River Basins
Study Area Summary



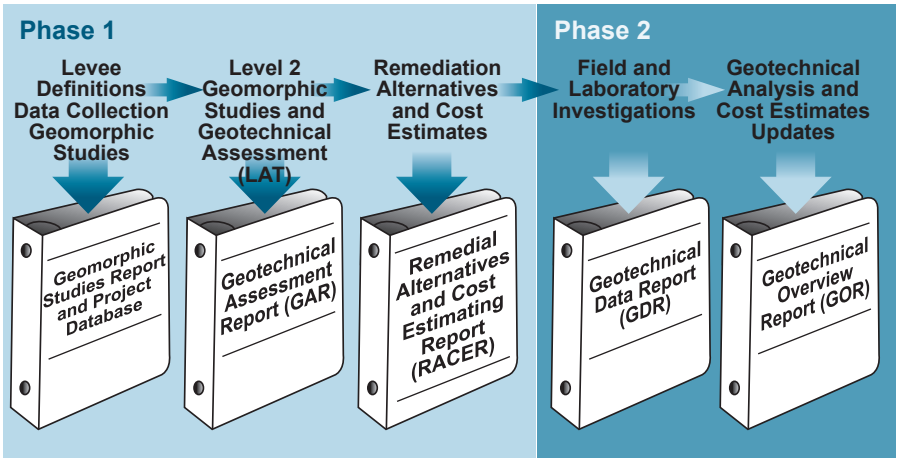
The California Department of Water Resources' (DWR) Division of Flood Management worked closely with USACE and local stakeholders to conduct the Non-Urban Levee Evaluation project (NULE) which assessed the existing conditions of over 1,200 miles of non-urban state/federal project levees and nearly 275 miles of appurtenant non-urban non-Project levees in California's Central Valley between 2008 and 2015 (see figure 1). The purpose of NULE was to support DWR's Central Valley Flood Protection Plan (CVFPP) and other flood management-related programs, to evaluate non-urban State/Federal project levees (including appurtenant non-project levees) to determine if they met defined geotechnical criteria and, if appropriate, to identify remedial measure(s) to improve levees to meet those criteria. Non-urban levees protect populations of fewer than 10,000 people.

Two-Phase Approach

As depicted in Figure 2, the NULE project was conducted in two phases. Phase 1 included all non-urban levees and consisted of review and assessment of available existing documents and original geomorphic mapping, field reconnaissance, and in-person interviews with local stakeholders. These data were used to conduct a screening level geotechnical assessment of expected levee performance with water at the 1955/57 design water surface elevation (WSE) where available or a water level a distance below the levee crest equal to the required design freeboard where design WSEs were not available.

Phase 2 included non-urban levees that protect more than 1,000 people. This included approximately 235 miles of Project levees and 34 miles of non-Project levees. This phase built on the results of Phase 1 and included field investigations and laboratory testing, geotechnical and other analyses, identification of potential remedial alternatives, and conceptual cost estimates for selected alternatives.

Figure 2. Two-Phase Approach



Phase 1 Assessment

Historical Data Collection

During Phase 1, historical data were collected from multiple sources including United States Army Corps of Engineers reports, DWR reports, local stakeholder reports, and historical newspapers. Interviews were conducted with local stakeholders to confirm and augment the paper records collected. Approximately 10,000 records and reports were collected, scanned, and indexed in a database. Documented locations of "points of interest" (POIs) were imported into a GIS-based map viewer. The document database now resides in DWR's California Data Exchange Center (CDEC) at dwr-lep.com. A web-based viewer was developed so that the collected information can be accessed by DWR personnel, local stakeholders, and the public. The documents collected under the NULE and ULE projects are included. Topographic and WSE data were obtained from other DWR programs such as the Central Valley Floodplain Evaluation and Delineation Project.

The information and data collected were used for Phase 1 assessments and to develop site-specific Phase 2 field investigations.

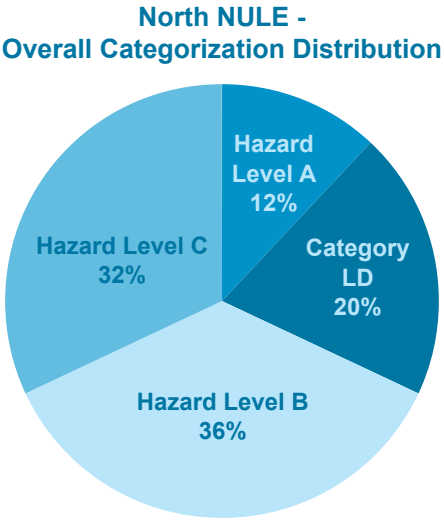
Geomorphic Mapping

Original mapping of geomorphology/surficial geology was performed at a scale of 1:24,000 for all NULE levees to assess the underlying foundation material. These maps were used to develop a preliminary characterization of levee foundation conditions and potential seepage and stability risk. The maps were also used to plan Phase 2 subsurface explorations and to assess the extent of encountered conditions by characterizing identified geologic units.

Geotechnical Assessment

Four potential failure modes were considered in the geotechnical assessment: through seepage, underseepage, landside slope stability, and erosion. Available data were reviewed for each potential failure mode to assess potential hazards. To achieve consistent and repeatable results, a NULE-specific levee assessment tool (LAT) was developed to compare documented past performance to the identified potential hazard. Using the LAT results, each levee segment was then assigned one of the following hazard rankings:

- **Hazard Level A:** low likelihood of either levee failure or flood fight when water is at the assessment water level
- **Hazard Level B:** moderate likelihood of either levee failure or flood fight when water is at the assessment water level



- **Hazard Level C:** high likelihood of either levee failure or flood fight when water is at the assessment water level
- **Lacking sufficient data (LD):** data about past performance or hazard indicators are not available, or there is poor correlation between past performance and other hazard indicators

The results of the geotechnical assessments were documented in two Geotechnical Assessment Reports (GARs): one for the Sacramento River basin and one for the San Joaquin River Basin.

Remedial Alternatives and Cost Estimates

The hazard rankings reported in the GARs were used to identify levee segments that could require remediation. For Phase 1, segments were generally entire USACE maintenance areas. Potential remedial alternatives were identified for levee segments that were ranked Hazard Level B, Hazard Level C, and LD. Conceptual cost estimates were developed for the potential remedial alternatives using a standardized parametric cost estimating template (PCET). The spreadsheet develops conceptual cost estimates for remedial alternatives for seepage, stability, freeboard, and erosion. Cost estimates were prepared as screening-level estimates conforming to Class 4 estimates as defined by the Association for the Advancement of Cost Engineering.

The results of the Phase 1 remedial alternative selection and cost estimates were documented in two Remedial Alternatives and Cost Estimate Reports (RACERs), one for the Sacramento River basin and one for the San Joaquin River Basin.

Phase 2

Selected levee areas were assessed during Phase 2 which generally included levees protecting more than 1,000 people (but fewer than 10,000). Levees assessed during Phase 2 were divided into 21 study areas, 10 in the Sacramento River Basin and 11 in the San Joaquin River Basin. Phase 2 included approximately 235 mile of project levees and 34 miles of non-project levees.

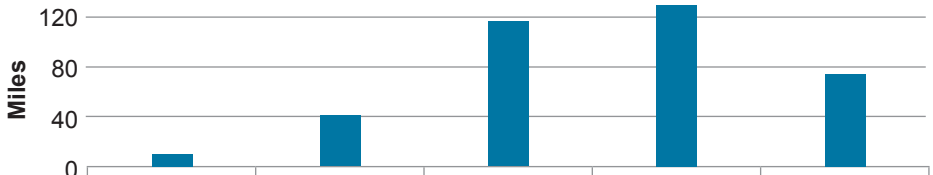
Field Investigations and Laboratory Testing

Site-specific geotechnical field investigations of the 21 non-urban levee study areas were implemented and included: approximately 1,357 cone penetration tests (CPTs) and approximately 502 sampled soil test borings. In general, there were up to five CPTs and one sampled boring per mile on levee crests, and approximately one CPT per mile and one soil boring every 5 miles along levee toes. Laboratory testing was performed on approximately 12,000 samples during the Phase 2 field investigation. These data were documented in 21 Geotechnical Data Reports (GDRs), one for each study area.

Analyses and Geotechnical Overview Reports (GORs)

The levees within each NULE Phase 2 study area were divided into reaches and sub-reaches with similar characteristics for analysis. Levees in each reach/sub-reach were analyzed for six static conditions at the 1955/57 WSE: erosion, through seepage, underseepage, landside slope stability, waterside slope stability, and freeboard.

Based upon the analyses, approximately 90 miles of 262 miles of levee met all static NULE criteria. The reaches/sub-reaches that did not meet static NULE criteria were further evaluated to identify conceptual remedial alternatives. The dimensions of these alternatives were verified by analyses, and then a screening-level Class 4 cost estimate was prepared for planning purposes. The chart on the following page summarizes the findings of the existing condition static assessments.

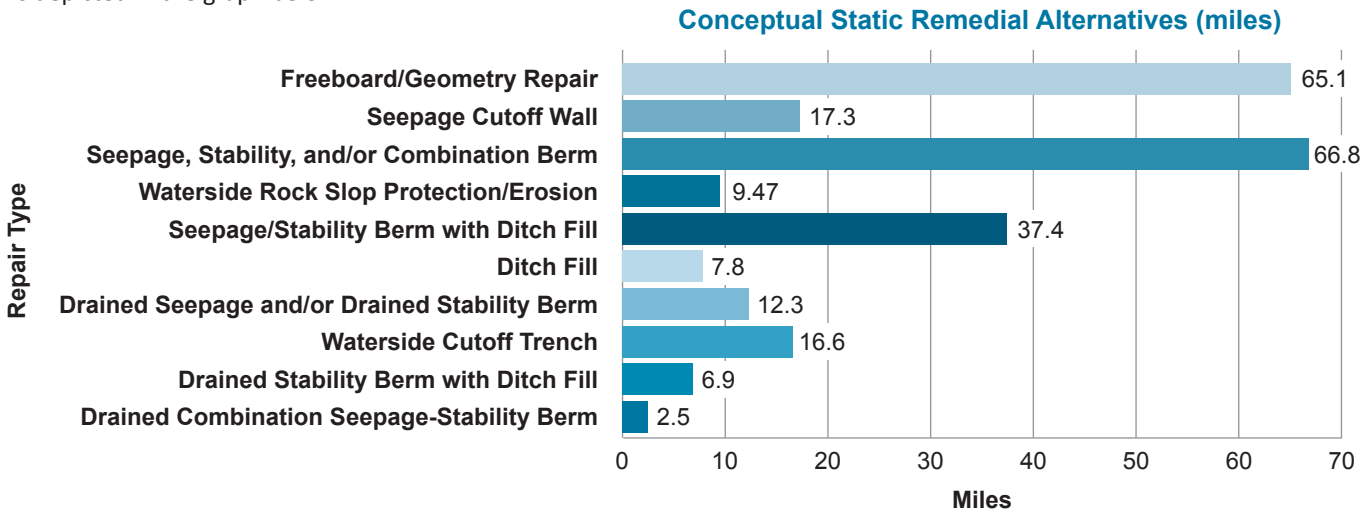


Total Miles of Levee That Do Not Meet Static NULE Criteria

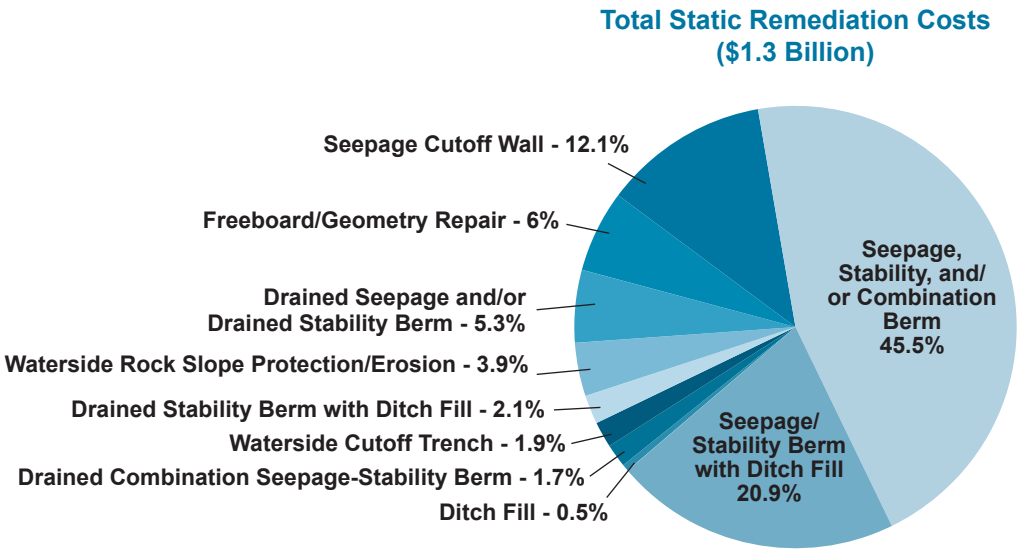
	Erosion Risk*	Freeboard*	Through Seepage	Under-Seepage	Landside Slope Stability
Assigned Water Surface Elevation	9.48	40.64	116.42	129.46	74.25

** Erosion and freeboard deficiencies were identified as portions of reaches where criteria were not met.*

Typical conceptual static remediation alternatives consist of installing cutoff walls along the centerline of the levees and constructing berms along the landside of the levees to address seepage and stability deficiencies, placing waterside rock slope protection for erosion and waterside slope stability deficiencies, and localizing freeboard repair. The total length of each type of repair in the study area is depicted in the graph below:



Screening-level Class 4 costs estimates were prepared on a 2013 basis. Class 4 estimates are not design-level cost estimates. However, they do include both construction costs and owners' "soft" costs, such as permitting, legal, environmental mitigation, and contingency. The total estimated costs of conceptual static remedial alternatives for all reaches in the study area that do not meet NULE criteria are shown in the pie chart:



Uses of Program Data

Flood System Repair Project

DWR developed the Flood System Repair Project (FSRP) to help Local Maintaining Agencies (LMAs) reduce flood risks in non-urban areas. Through FSRP, DWR provides LMAs with technical and financial support to repair documented critical problems with flood control facilities of the State Plan of Flood Control (SPFC) in non-urban areas. NULE supported FSRP by augmenting the NULE findings with additional field reconnaissance and site-specific interviews for all NULE levee segments. A field data collection tool was developed to identify critical sites (those with a high potential to fail in the next high water event) and serious sites (those with the potential to become critical). Detailed cost estimates were developed using PCET modified for FSRP purposes. Cost estimates were developed for all critical sites and most serious sites, and included remedial construction, permitting, and real estate costs. DWR is continuing to use the data obtained in FSRP to support funding decisions for critical sites.

San Joaquin River Restoration Program

The San Joaquin River Restoration Program (SJRRP) is a comprehensive long-term effort to restore flows to the San Joaquin River from Friant Dam to the confluence of Merced River and restore a self-sustaining Chinook salmon fishery in the river while reducing or avoiding adverse water supply impacts from restoration flows.

DWR, through NULE, provided geotechnical engineering support for 25 levee miles of the SJRRP. Using both NULE data with supplemental field investigation, laboratory, and geotechnical analyses project-specific data, a channel capacity technical memorandum was prepared to document WSEs in the San Joaquin River that will meet geotechnical criteria for the affected levees. In addition, NULE conducted a comprehensive field investigation of the Priority 1 levees that included 30.6 miles of geophysical surveys and 121 soil borings.

Levee Evaluation Program Web Interface

An intuitive and interactive Web interface was created and made available at http://www.dwr-lep.com to provide a one-stop shop for the majority of the Levee Evaluation Program products. The web interface offers direct access to finalized ULE and NULE reports, as well as a mapping application with multiple GIS layers of data that were collected and evaluated under ULE and NULE. These layers include past performance points of interest, subsurface exploration locations with hyperlinked PDFs of boring logs, and a seamless layer of mapped surficial geologic units and contacts.

References:
Non Urban Levee Evaluations Project, Geotechnical Overview Report Volume 1, Existing Conditions, and *Volume 2, Remedial Alternatives, for Chico North and South, Clarksburg, Colusa Drain, Colusa North, Colusa South, Gerber, Knights Landing, Sutter, Wheatland, Woodland South, Ash Slough, Berenda Slough, Black Rascal, Eastside Bypass, Fresno River, Gravelly Ford, RD 2064, RD 2075, RD 2095, SJRRP-CCID and Stockton Diversion Channel.* URS, April 2014 to April 2015.