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**Prepared For** Mike Inamine, Department of Water Resources, Division of Flood Management  
**Project** Non-Urban Levee Evaluations Project  
**Date** March 23, 2011  
**Subject** The Influence of Vegetation on Levee Past Performance – a Review of Historic Data Based on the Levee Evaluation Program Database  
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## **1.0 Purpose and Scope of this Memorandum**

At the request of the Department of Water Resources (DWR), URS Corporation and Kleinfelder (the project team) have reviewed, summarized, and prepared this summary of the information available in the Levee Evaluations Program (LEP) points of interest and documents databases (version 4.0.1) about the potential influence of vegetation on the past performance of levees.

## **2.0 Background**

### **2.1 DWR's FloodSAFE Program Overview**

The State of California has long recognized the need to upgrade aging and deteriorating levees in the Sacramento River Valley, San Joaquin River Valley and in the San Francisco Bay Delta. Through Assembly Bill 142 (AB 142), the State appropriated \$500 million in funding and charged the California Department of Water Resources (DWR) with the task of beginning a comprehensive levee evaluation and upgrade program. The levee evaluations program consists of Urban Levee Evaluations (ULE) and Non-Urban Levee Evaluations (NULE) projects. DWR is now engaged in an unprecedented effort to evaluate 470 miles of urban levees and 1,620 miles of non-urban levees. The ULE and NULE projects teams are evaluating State-Federal Project levees, including associated non-Project levees, to determine whether they meet defined geotechnical criteria and, where needed, identify remedial measures, including cost estimates, to meet those desired geotechnical criteria. In addition to the LEP, the recently completed DWR Delta Risk Management Strategy (DRMS) has also evaluated more than 600 additional miles of levees in the Delta.

### **2.2 Levee Evaluations Project Document Database**

As part of the LEP, the project team conducted a systematic and comprehensive effort to collect available documents that contain information about levees in the Central Valley. The

data collection effort identified and cataloged the information from a variety of sources and documents including:

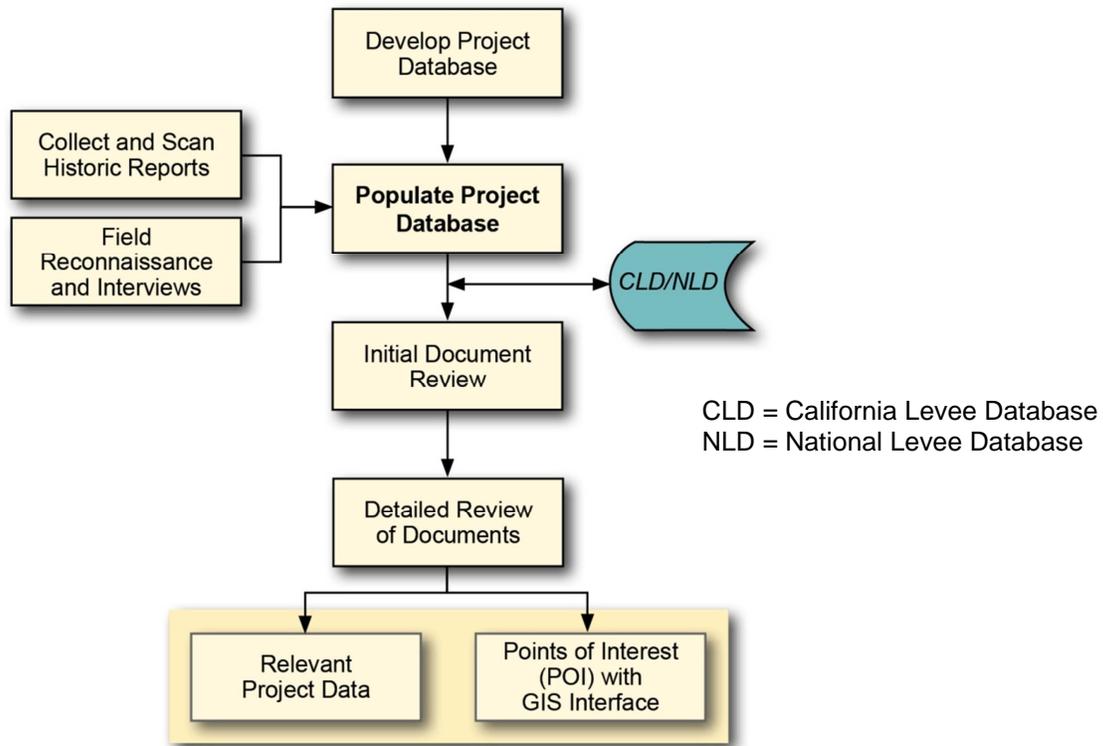
- Existing reports and documents
- Existing databases
- Interviews with local agencies and experts to obtain information on levee performance
- Historic data on levee performance and geotechnical characteristics
- Site reconnaissance and field observations

The project team cataloged the documents into a searchable database with links to electronic copies of the documents. Each document was reviewed to identify, locate and describe a variety of points of interest (POIs) related to levee performance including:

- Locations with reported instances of past levee performance issues such as erosion, underseepage (boils), throughseepage, breaches, slides and overtopping
- Locations with reported implemented mitigation measures, such as slurry cutoff walls or levee raises, completed
- Locations with levee engineering structures such as pipe penetrations, pump stations, or weirs

To facilitate a systematic and efficient review of the collected data, the data were initially screened to create a set of relevant documents. Each document was associated geographically with a levee segment (maintenance unit). The relevant documents typically included engineering design reports, construction records, maintenance records, and available exploration records including boring logs, letters, drawings, photographs, maps, and other media. As documents were reviewed, levee segment information was collected and stored in the GIS database to create a map of POIs. Significant events related to levee performance were grouped into categories consisting of seepage, stability, erosion, overtopping and levee breach. Some of these performance records contained additional data that discuss factors that may have caused the adverse performance.

Figure 1 below presents schematically the process of POI identification.



**Figure 1** – Development Process – Levee features and performance history locations

As of the date of this memorandum, the document database includes more than 10,000 records, which have been collected, scanned, and archived, requiring hundreds of gigabytes of storage space. The database is maintained through periodic updates. Each update undergoes quality control processes to maintain database integrity while allowing new entries as additional documents become available.

In addition, over 350 miles of urban levees are being evaluated in more detail using data obtained from field geotechnical investigations.

Based on the project team’s review of the performance data, geotechnical analyses and literature collected to date, the primary factors that play key role in levee performance are levee foundation characteristics, levee material, levee geometry, and hydraulic head. Secondary and external factors that impact levee performance to some degree are animal burrows and the presence of utility penetrations.

### **2.3 Use of Database for Assessment of Potential Vegetation Influence on Levees**

The large number of records and associated performance data collected to date presented an opportunity to make an assessment of the relationship between levee performance data and vegetation characteristics. In order to perform this assessment, the levees past performance records were screened for cause-effect relationship between vegetation and levee performance. For this review of historic data, these performance records were screened using search terms such as trees, roots, shrubs, and vegetation. Both the document database and the POI database (description) were searched. The performance records screened using these search terms were then reviewed and categorized into the following:

- Performance records that identified vegetation as a factor that adversely (or positively) influenced levee performance
- Performance records that identified vegetation as a factor influencing levee operations and maintenance (O&M)
- Performance records that had incidental description of vegetation and did not have an association with levee O&M nor performance
- Performance records that identified the occurrence of vegetation in association with performance data but with no clear cause-effect relationship between levee performance and vegetation

To further characterize these records, the levee breach records were reviewed separately from remaining performance records.

### **2.4 Results of Levee Vegetation Study**

Based on review of over 10,000 records to date, 6,970 performance records were identified in the categories above. Of these, there were 348 records of levee breaches resulting in floodwater flowing to landside of the levee. None of these records identified vegetation as an influence on the levee breach.

Of the remaining 6,622 performance records, 95 performance records indicated the presence of vegetation in the vicinity of an identified levee performance issue site. Of these 95 performance records:

- 11 performance records indicated that vegetation was a factor that influenced levee performance,
- 25 performance records indicated that vegetation had an influence on levee O&M
- 39 performance records referenced vegetation in a way that was not relevant to, or associated with the levee O&M or levee performance issue.

- The remaining 20 performance records discussed the presence of vegetation in the vicinity of the performance issue but with insufficient information about the role of vegetation on the levee performance.

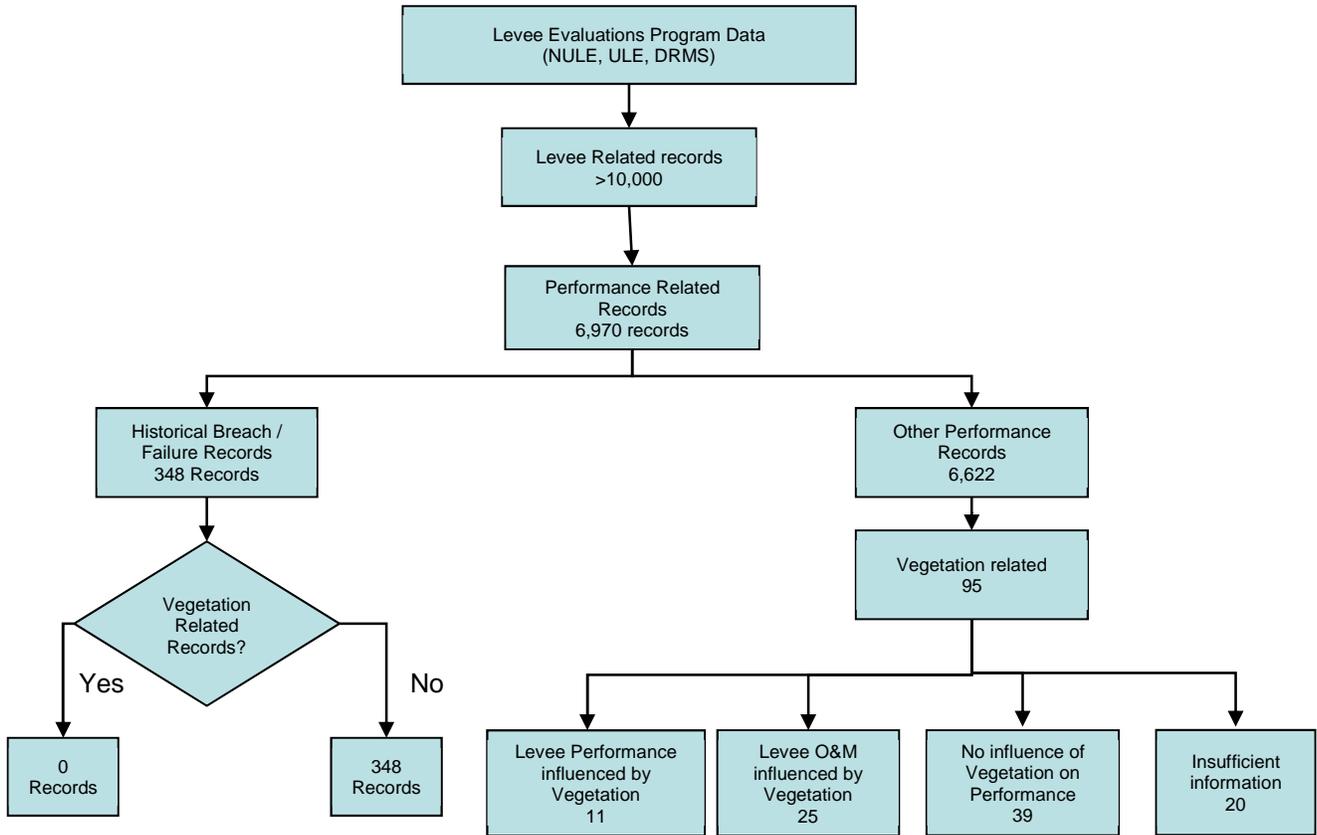
These results are summarized in the flowchart presented in Figure 2.

It should be noted that these results are based primarily on information presented in documents on performance records and individual records were not analyzed to assess validity of the findings. Also, most of these records are based on the interpretation of the author of the particular document and generally are not based on detailed cause-effect analyses. However, given the large magnitude of data reviewed, the results provide an assessment of the relative magnitude of recorded influence of vegetation in currently available performance records. The pie-chart in Figure 3 presents these results as a percent of the overall records reviewed in the study.

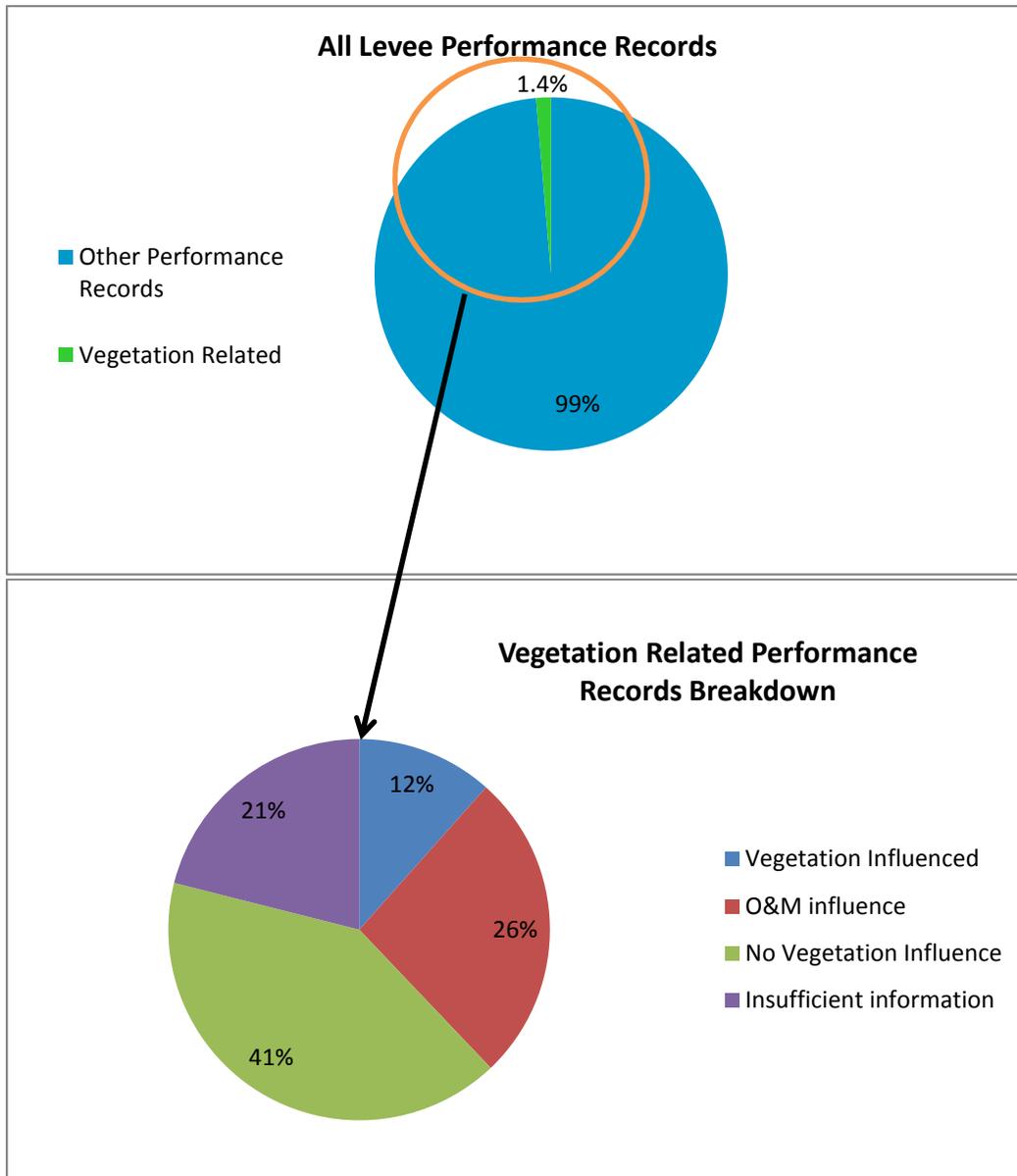
### **3.0 Conclusion**

The results of the study indicate that the number of performance records that discuss vegetation influence on levee performance is small (95 records or 1.4% of 6,970 records). Of these, a small number of records (11 records or 12% of the 95 records that indicate vegetation influence on levee performance) indicated that vegetation played a role in the levee performance. The majority of these performance records discussed the influence of vegetation on the levee O&M. Generally it described the inability to visually determine levee performance during high water events.

As this study is based on currently available data collected as part of the levee evaluations program, it is not a comprehensive assessment of all recorded performance data. However, it does provide an indication of the relative magnitude and nature of vegetation influence on levee performance. Next steps considered include analysis of interviews with local maintenance personnel about vegetation related factors influencing levee performance and O&M.



**Figure 2** – Levee Performance Records - Characterization Based on Vegetation Influence



**Figure 3** – Distribution of Performance Records