



## Jacobs Avenue Levee: Preliminary Needs Assessment

March 1, 2021

### 1. Purpose

The levee system protecting the Jacobs Avenue area in Eureka was evaluated to assess potential failure risks and make recommendations for improvements to reduce these risks. Erosion, overtopping, seepage, and slope instability were identified as the primary potential modes of failure. The purpose of this assessment was to obtain a better understanding of the limitations of the levee for providing flood protection and to identify project concepts for improving the resilience of the levee. The analysis provided below utilizes existing data and information including the findings presented in the geotechnical report for the Jacobs Avenue Levee Evaluation Project (CGI, 2016).

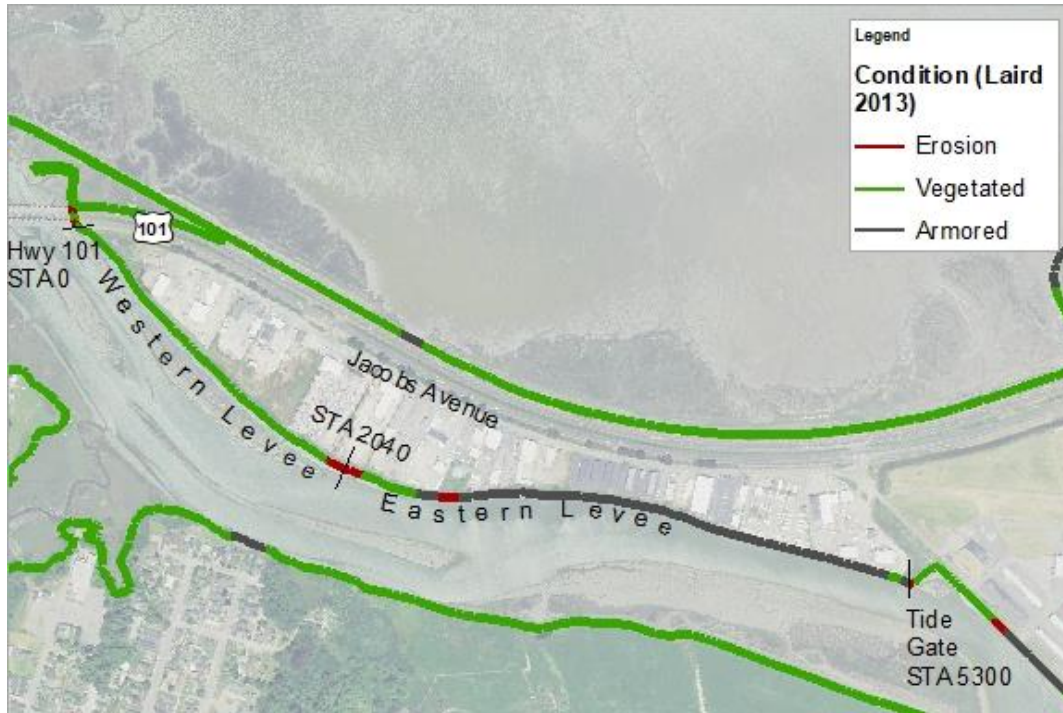
The existing condition assessment makes reference to current levee design criteria set forth by the Federal Emergency Management Agency (FEMA), the United States Army Corps of Engineers (USACE), or the State of California Department of Water Resources (DWR); however, it is recognized that improving the levee to fully achieve these criteria would likely be cost-prohibitive. Ownership of the levee is currently broken up into segments with individual property owners responsible for the levee segment that bisects their respective properties. Future planning efforts will need to consider costs and available funding relative to the levee owners' risk tolerance. These efforts will require further determination of appropriate design criteria that balances acceptable risk, improvement costs, and long-term operation and maintenance.

### 2. Existing Conditions

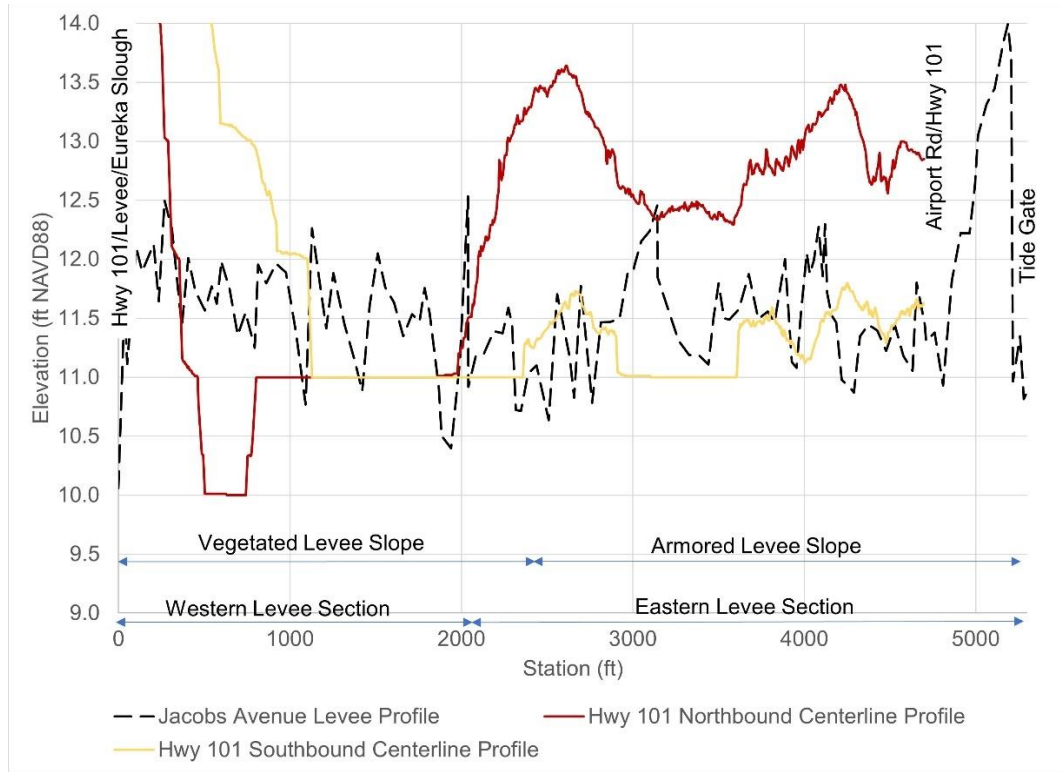
The Jacobs Avenue levee system is located along the northern shore of Eureka Slough and extends from the Highway 101 embankment at the west end to the Caltrans tide gate structure at the east end. The levee is an earthen embankment with two gated culverts and a Caltrans maintained tide gate structure. Construction of the levee is believed to have started around approximately 1930 by the landowner at the time. The U.S. Army Corps of Engineers or other flood protection agencies were not involved in the design or construction. A plan and profile of the levee are shown in Figure 1 and Figure 2, respectively. The stationing presented in Figure 2 begins at the Highway 101 embankment and western extent of the levee and extends to the Caltrans tide gate at approximate station 5,300 feet. This stationing differs from previous studies referenced in this report, including the geotechnical report by CGI and the hydraulic report by Northern Hydrology & Engineering (NHE, 2016). A previous review (Laird, 2013) of shoreline cover identified that the eastern half of the Eureka Slough-side levee bank is armored with rock slope protection and/or concrete rubble (Figure 1). The western half is heavily vegetated with limited, short sections showing erosion or an absence of vegetation. Levee crest elevations range from approximately 10 to 14 feet (NAVD88), with most of the levee between elevation 10.5 and 12.5 feet. For the purpose of this assessment, the Jacobs Avenue Levee has been segmented into two reaches based on a review of available geotechnical subsurface



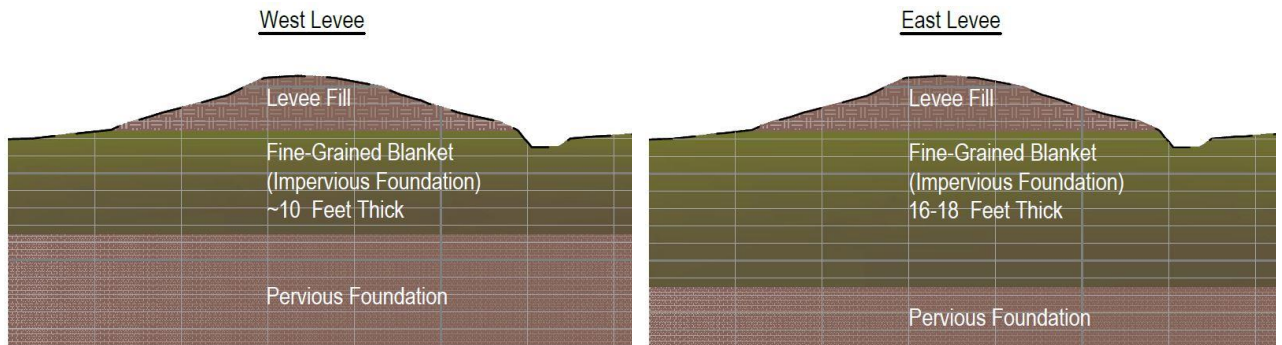
information. Initial analysis has determined that the eastern portion of the levee is generally in better condition relative to the western portion, largely due to a thinner fine-grained blanket layer underlying the western 2,000 feet of levee (Figure 3).



**Figure 1. Plan view of Jacobs Avenue Levee and surface conditions**



**Figure 2. Profile of Jacobs Avenue Levee Crest**



**Figure 3. Typical cross-sections of the west and east levee segments facing south with Eureka Slough on left of each cross-section. A thinner fine-grained blanket layer underlays the western 2,000 feet of levee (CGI 2016).**

## 2.1 Existing Condition Assessment

The following sections provide a brief description of the existing conditions relative to erosion, overtopping, slope instability, and seepage for the west and east levee sections.

### 2.1.1 Erosion

Nearly all of the western levee section is unarmored and vegetated with limited, localized areas of observable erosion (Figure 4). The western levee is located along an inside bend of Eureka Slough, where erosional forces are typically lower. Additionally, a tidal marsh bench at approximate elevation 6-7 feet (NAVD88) with variable width fronts much of the vegetative section of the slough-side levee. Without significant changes to the geomorphic characteristics of the slough channel, increased erosion is not expected in the near term. However, increased tidal prism at this location, due to sea level rise or levee breaches, could result in increased erosion.



**Figure 4. The western levee section is vegetated, fronted by a tidal marsh bench and does not show indications of surface erosion.**

The eastern levee section is armored with rock slope protection and/or concrete rubble to resist erosion (Figure 5). These preventative measures were implemented in the 1980s and appear to be providing sufficient erosion protection.



**Figure 5. The eastern levee is armored with rock slope protection and concrete rubble.**

Erosion was noted in isolated, short reaches of the levee corresponding to individual property shorelines (Figure 6). The erosion is typically at the base of the slope and the upper portion of the slope is vegetated. These erosional areas are located within gaps of armoring or vegetated toes and will require future observations to assess whether erosion is active and ongoing, or if the material is consolidated and resistant to further erosion.

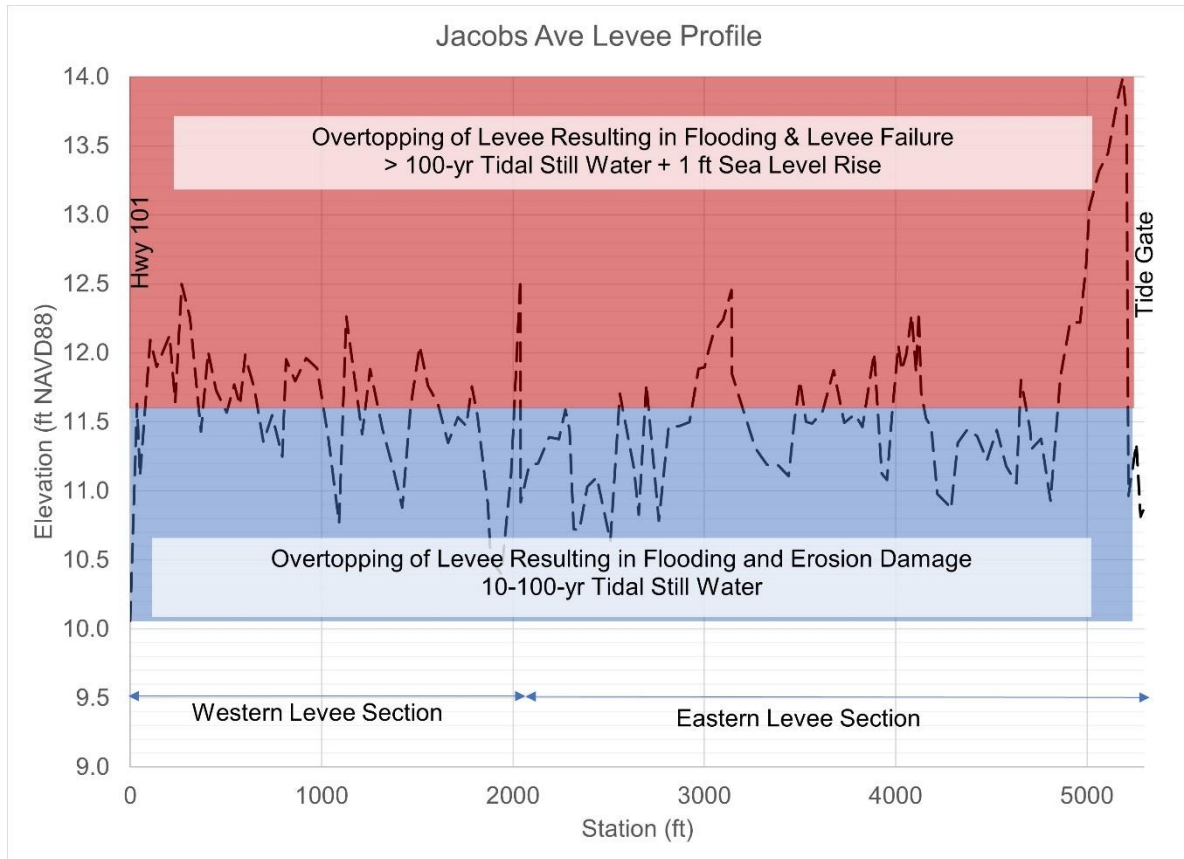


**Figure 6. Short Sections of Levee between Armored Sections show Indications of Erosion.**

### **2.1.2 Overtopping**

As previously shown in Figure 2, overtopping of the levee initiates at a tidal water level of approximately 10 feet, near the intersection of the levee with the Highway 101 road prism. Approximately 100 feet of levee is overtopped between tidal water levels 10 to 10.6 feet. Above water levels of 10.6 feet, the extent of overtopping rapidly increases, with more than half of the levee system overtopped at a water level of 11.6 feet. Failure of the levee due to significant erosion of the levee crest and landward slope is expected to occur when overtopping depth exceeds 1-foot for a duration exceeding 2 hours (USBR & USACE, 2019). These levee failure conditions are met at three locations on the levee when tidal water levels reach between 11.6 and 12.6 feet. While many factors can contribute to the rate of erosion as water crests over a levee, 1-foot depth criteria provides a planning-level threshold, as levees are typically designed to not be overtopped. Furthermore, FEMA/USACE criteria require the levee crest elevation be a minimum of 2-feet above the design water elevation, typically the 100-year event.

Temporary flooding of the Jacobs Avenue area from overtopping is initiated between tidal water levels between 10 to 10.6 feet, which corresponds to the 10- and 100-yr tidal still water event, resulting in flood depths up to approximately 1 foot. At a water level of 11.6 feet, flooding depth increases to 3-6 feet. Levee failure is likely to initiate when tidal water levels reach 11.6 to 12.6 feet, which corresponds to the 100-yr tidal still water event plus 1 to 2 feet of sea level rise (Figure 7). Levee failure could result in a breach allowing several feet of daily tidal flooding in the Jacobs Avenue area.



**Figure 7. Tidal Still Water Levels Above 11.6 feet result in approximately 1 foot of depth over the levee crest for > 2 hours and potential levee failure due to overtopping.**

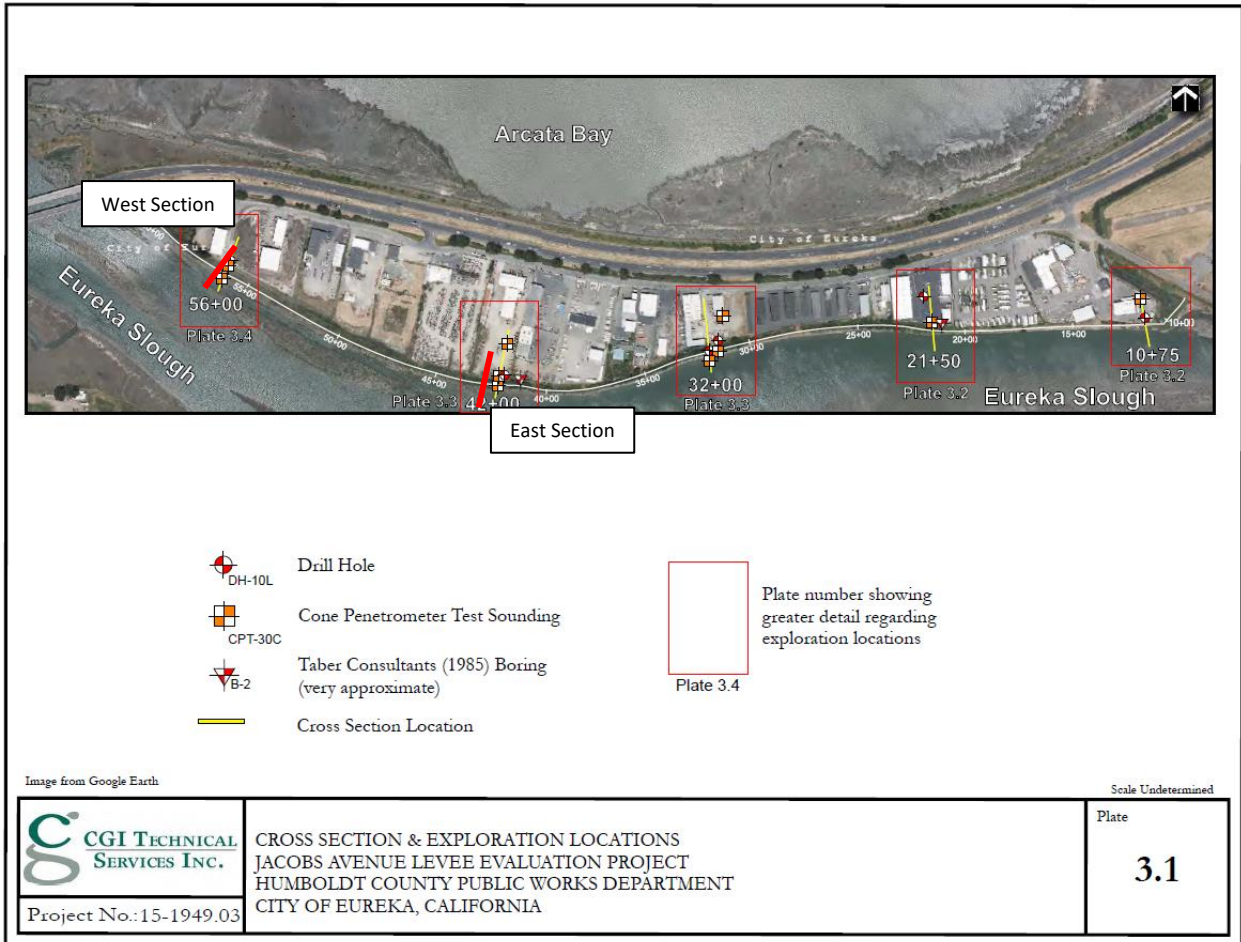
### 2.1.3 Slope Stability and Seepage

Slope stability and seepage were analyzed for levee cross sections near the CGI borings and are shown on Figure 8. These sections are representative of the west and east sections.

Slope stability is the risk of levee movement or failure. It is primarily a function of the fill material properties used for construction, geometry (height, crest width, embankment slopes), and water level. These parameters are evaluated with consideration of pore pressures in the levee that affect the shear strength, or internal resistance to movement, of the fill material.

Through seepage refers to when steady state saturation of underlying soils rises above the toe of the levee, also described as the phreatic water surface exiting the landside slope. The potential risk associated with through seepage is that as water travels through the embankment, it can carry soil particles with it and lead to piping which could lead to levee failure. The level of risk associated with through seepage is related to several factors, such as the level of compaction of the levee, the material used to construct the levee, and the geometry of the levee. Well compacted fine-grained levees are not as susceptible to piping as an embankment constructed with sand as an example. Levees with flatter side slopes aren't as susceptible to through seepage as levees with steeper slopes.

Underseepage is the risk of erosion and piping of levee foundation material resulting in failure. Underseepage is primarily a function of foundation soil properties, such as the fine-grained impermeable blanket layer and deeper permeable layer underlying the levee, as well as water level.



**Figure 8. Location of Analysis Sections**

Seepage and stability analyses were performed utilizing the Geostudios 2019 software package. Seepage analysis utilized the SEEP/W module with hydraulic loading conditions within the channel consistent with hazard scenarios already determined for the project. Seepage analysis results include hydrostatic pressure within the levee embankment and foundation for each loading condition assuming steady state conditions. Material properties were determined using laboratory test results from the CGI borings and engineering judgement.

Stability analysis utilized the SLOPE/W module coupled with results from the seepage analysis. Stability analyses were performed using Spencer's Methods of Slices, which satisfies both force and moment equilibrium. The exit/entry search routine was used to determine the critical failure surface for each hydraulic loading condition. Material properties for stability analyses were generally adopted from the CGI report.



Based on the available geotechnical information, stratigraphy at both sections included a fine-grained silt/clay surface blanket underlain by an aquifer consisting of sand and sand with silt. The levee is constructed with similar materials to the blanket layer, largely consisting of silt. Rock slope protection has been placed on the waterside slope of the levee along the eastern portion. The general differences between the two reaches are the thickness of the blanket layer, the depth of the existing landside ditch, and the presence of rock slope protection.

## 2.2 Typical Levee Criteria

The following regulatory guidelines were consulted to determine factor of safety (FS) criteria for stability, underseepage, and through seepage, consistent with 44 CFR 65.10 (FEMA standards) and standard of practice for levee analysis:

- Long Term Slope Stability Minimum FS = 1.4
  - EM 1110-2-1913, Design and Construction of Levees (USACE 2000)
  - EM 1110-2-1902, Slope Stability (USACE 2003)
- Underseepage Minimum FS = 1.6 based on an allowable exit gradient of 0.5
  - EM 1110-2-1913, Levees (USACE 2000)
- Through seepage analysis takes into consideration the location where the ground is completely saturated, also known as the breakout of the phreatic surface, on the landside slope and properties of the embankment soil.
  - EM 1110-2-1913, Design and Construction of Levees (USACE 2000)
  - EM 1110-2-1901, Seepage Analysis and Control for Dams (USACE 1993)

Slope stability and underseepage criteria were used as a benchmark for the analysis of the Jacobs Avenue Levee. The criteria for through seepage are reliant on engineering judgment. Slope stability is related to through seepage but has clear design criteria and is therefore used to assess risk. Therefore, through seepage was not directly assessed in this study. As previously described, it is likely not feasible to improve the levee to meet the above standard levee criteria completely; however, it is informative to include these criteria in this analysis for reference purposes.

## 2.3 Results of Seepage and Stability Analyses

To prioritize potential levee improvements as sea levels rise, multiple water surface elevations were analyzed for underseepage and stability. The water elevations analyzed extend from 6 to 13.6 feet and include several increments to represent a suite of saturated foundation conditions. Seepage and stability analyses were only performed for water levels contained by the analysis section as the levee would overtop at higher water levels. The seepage and stability analyses below assume a fully saturated embankment in accordance with FEMA/USACE standards.



### 2.3.1 Seepage – West Levee

The results of the seepage analysis for the water surfaces analyzed for the west levee are shown on Figure 9. In steady-state conditions, FEMA/USACE criteria are not achieved along the west levee at a water level greater than 6.6 feet. Failure for seepage would be expected to occur at an exit gradient of 0.8 (equivalent to an FS of 1.0), which would be anticipated at a water level greater than 9.7 feet.

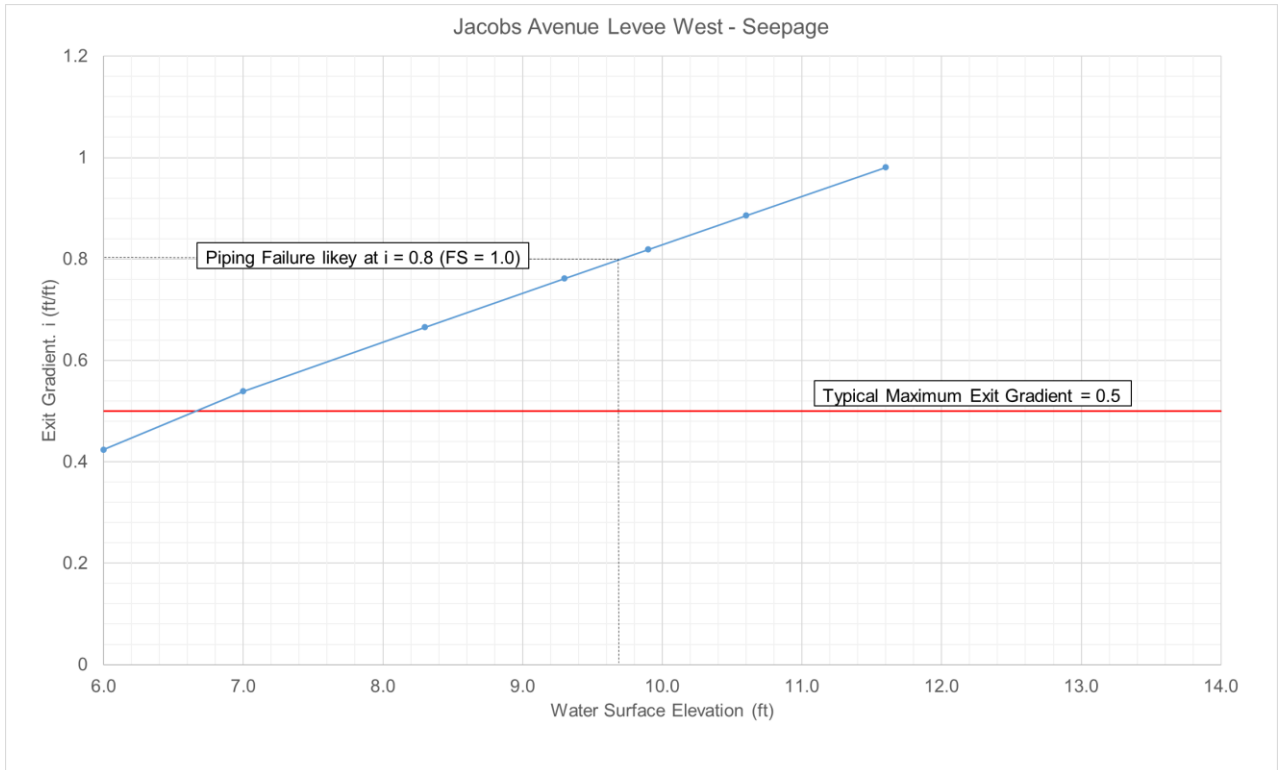
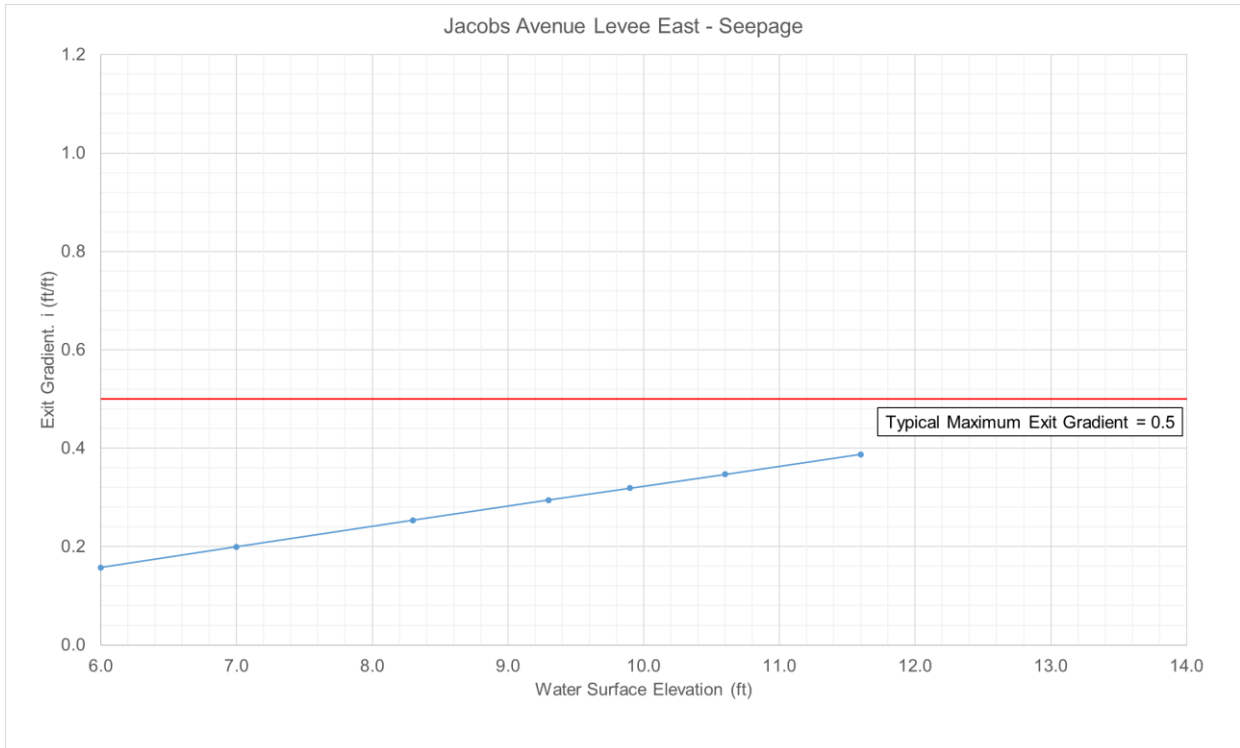


Figure 9. Seepage Analysis Results for West Levee

### 2.3.2 Seepage – East Levee

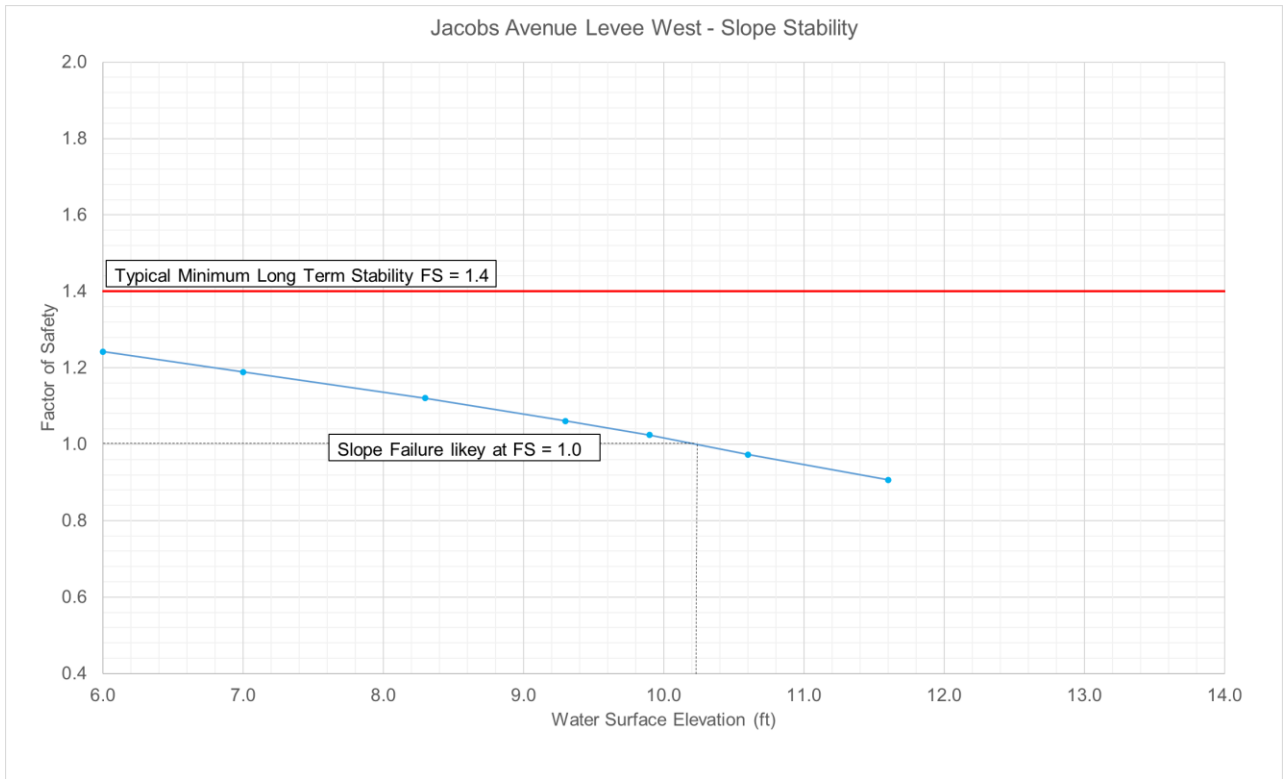
The results of the seepage analysis for the water surfaces analyzed for the east levee are shown on Figure 10. FEMA/USACE levee criteria are achieved along the east levee for all water levels analyzed. Failure due to seepage would not be anticipated along the east levee.



**Figure 10. Seepage Analysis Results for East Levee**

### 2.3.3 Stability – West Levee

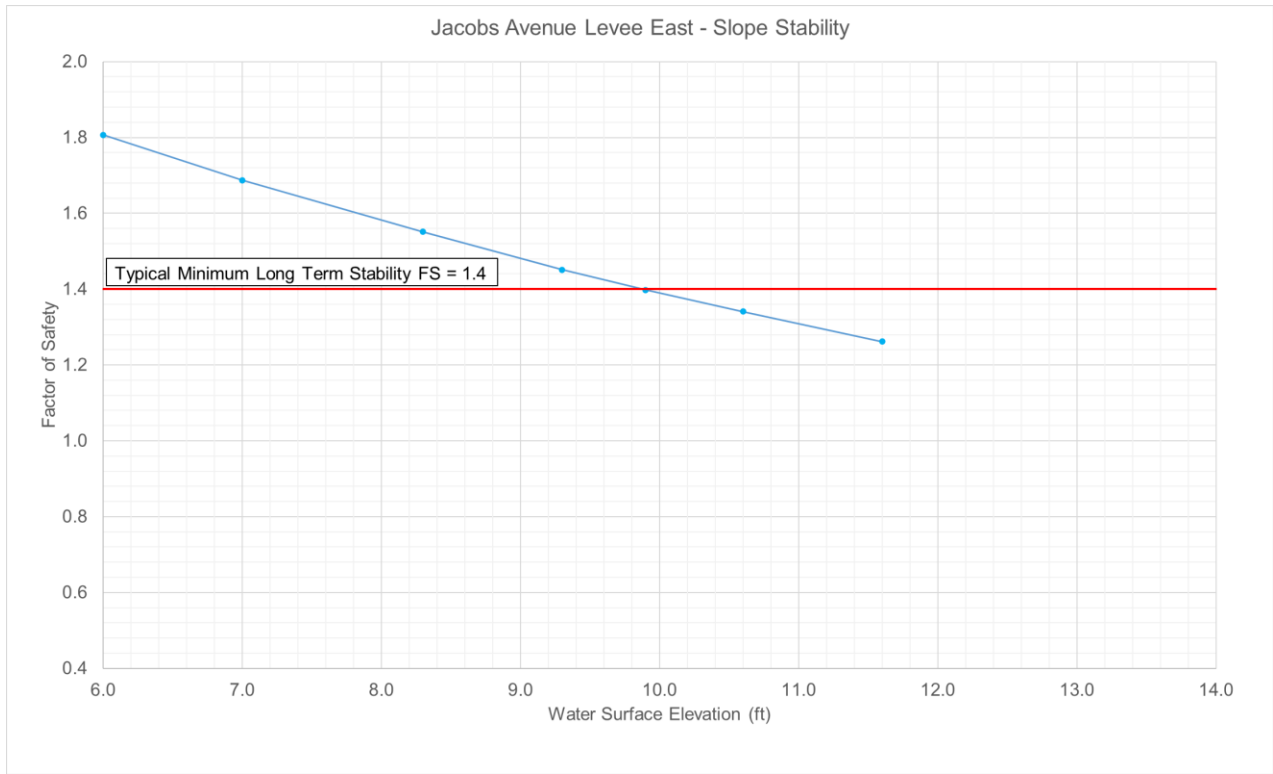
Stability results for the water levels analyzed are shown in Figure 11 for the west levee. The levee did not meet FEMA/USACE criteria for all water levels analyzed. Failure for stability would be expected to occur at an FS of 1.0, at an approximate saturated foundation elevation of approximately 10.2 feet.



**Figure 11. Slope Stability Analysis Results for West Levee**

### 2.3.4 Stability – East Levee

Stability results for the water levels analyzed are shown in Figure 12 for the east levee. The levee met FEMA/USACE criteria for water levels less than approximately 9.9 feet. Failure for stability was not determined to be a potential failure mode for the water surface elevations analyzed.



**Figure 12. Stability Analysis Results for East Levee**

### 2.3.5 Erosion Effects on Stability and Seepage

Based on a review of topographic data and field observations, surface erosion observed on the slough side of the levee is not currently deemed to be a significant issue on either levee reach. The levees were analyzed for the case where erosion reduces the levee embankment by half its neat thickness, which is more severe than what has been observed, and the results indicate only a slightly reduced slope stability FS and slightly increased susceptibility to through-seepage.

As water surface elevations increase with sea level rise, surface erosion is not likely to be a factor in levee stability in the near-term based on the presence of existing armoring on the east levee and the geomorphic characteristics of the west levee as previously discussed. If geomorphic or tidal flow characteristics change as water levels increase, erosion protection should be considered as should routine monitoring for observable changes in surface conditions.

### 2.4 Summary of Existing Conditions

Table 2.1 and Table 2.2 below provide a graphical representation of the existing condition assessment for the west and east levee reaches, respectfully. For seepage and slope stability, cells in green meet FEMA/USACE criteria, whereas yellow cells indicate the levee does not meet criteria but failure is not imminent (i.e.  $FS > 1.0$ ) and red cells reflect the water levels at which failure is anticipated. For overtopping, green cells indicate no overtopping, whereas yellow cells indicate overtopping resulting in likely damage and red cells indicate potential failure.



**Table 2.1 Summary of Existing Conditions – West Levee Reach**

| Water Elev. (ft) | Avg # of Hours Water Level Exceeded/Year* | Slope Stability   | Underseepage | Overtopping   | Erosion |
|------------------|---|---|--------------|---|---------|
| 6.0              | 1,524                                     |   |              |   |         |
| 7.0              | 520                                       |   |              |   |         |
| 8.3              | 41  |   |              |   |         |
| 9.3              | 1   |   |              |   |         |
| 9.9              | 0.1                                       |   |              |   |         |
| 10.6             | 0   |   |              |   |         |
| 11.6             | 0   |   |              |   |         |
| 12.6             | 0   | NA  | NA           |   |         |
| 13.6             | 0   | NA  | NA           |   |         |
| *See Table 2.3   |   | Green –FEMA/USACE Criteria Met<br>Yellow –FEMA/USACE Criteria not Met, FS > 1.0<br>Red –FEMA/USACE Criteria not Met, FS < 1.0<br>NA – Not Analyzed due to crest elevation below water elev. |              | Green –No Overtopping<br>Yellow –Overtopping <1ft or <2hr (Potential Damage, Temporary Flooding)<br>Red – Overtopping >1ft & >2hr (Potential Failure, Daily Flooding) |         |

**Table 2.2 Summary of Existing Conditions – East Levee Reach**

| Water Elev. (ft) | Avg # of Hours Water Level Exceeded/Year* | Slope Stability   | Underseepage | Overtopping   | Erosion |
|------------------|---|---|--------------|---|---------|
| 6.0              | 1,524                                     |   |              |   |         |
| 7.0              | 520                                       |   |              |   |         |
| 8.3              | 41  |   |              |   |         |
| 9.3              | 1   |   |              |   |         |
| 9.9              | 0.1                                       |   |              |   |         |
| 10.6             | 0   |   |              |   |         |
| 11.6             | 0   |   |              |   |         |
| 12.6             | 0   | NA  | NA           |   |         |
| 13.6             | 0   | NA  | NA           |   |         |
| *See Table 2.3   |   | Green –FEMA/USACE Criteria Met<br>Yellow –FEMA/USACE Criteria not Met, FS > 1.0<br>Red –FEMA/USACE Criteria not Met, FS < 1.0<br>NA – Not Analyzed due to crest elevation below water elev. |              | Green –No Overtopping<br>Yellow –Overtopping <1ft or <2hr (Potential Damage, Temporary Flooding)<br>Red – Overtopping >1ft & >2hr (Potential Failure, Daily Flooding) |         |

## 2.5 Discussion of Existing Condition Results

Overtopping of the levees is considered to be the most likely risk, followed by underseepage, slope stability and lastly, erosion. Overtopping resulting in temporary flooding is initiated at water levels between 9.9 and 10.6 feet. Conditions for overtopping failure occur at a peak water level between 11.6 and 12.6 feet. While underseepage failure is theoretically expected to occur at the lowest water levels, between 9.3 and 9.9 feet



due to the thin blanket layer of the west levee reach, and slope stability failure is expected to occur on the east levee reach at 10.6 feet due to geometric and soil conditions; sea level rise and inherent uncertainties that exist for the criteria described above must be considered when assessing relative risk of criteria.

As previously described, slope stability and seepage analyses rely on geometry, soil type, and water level parameters. Geometry parameters are generalized to describe the levee crown width, height, and water and landslide slopes that may vary along the length of the levee or are unobservable due to vegetation growth in some locations. Soil parameters are based on visual soil classifications logged during drill hole explorations at specific locations that show variations between locations. Assumptions must be made about the fill material used for the construction and improvements of the levee system, which span multiple decades. Additionally, there are no data available for the backfill surrounding penetrations such as culverts (CGI, 2016).

The seepage analysis used the best available information and standard analysis methods, assuming steady-state saturated conditions, which is assumed to be a conservative approach in a tidal system and does not represent the true dynamic nature of tidal water levels saturating the earthen embankment. The same is true for the slope stability analysis. However, steady-state condition may be representative of the condition when multiple feet of flooding on the landward side of the levee exists and under-sized drainage facilities and hydraulic conditions result in the persistence of flooded conditions for multiple days. A literature search was conducted for levee criteria in tidal dominated systems, however the search did not yield applied criteria. In tidal systems such as Eureka Slough at Jacobs Avenue, extreme water levels persist for short durations of time, typically measured in minutes or hours, and likely do not fully saturate the levee to the peak water surface elevation. During the December 31<sup>st</sup>, 2005 storm event detailed in Hazard Scenario 3, tidal still water of approximately 9.3 feet and wind effects adding 1 foot would have resulted in a water level of approximately 10.3 feet in Eureka Slough, but no failure or significant damage to the levee is known to have occurred. The Jacobs Avenue levee has persisted for nearly 90 years and been exposed to numerous extreme water levels, but there appears to be no record of seepage or slope stability failures. Recognizing the FEMA/USACE criteria is intended for systems with extended high water periods, additional field investigation, data, and transient modeling would be necessary to determine more appropriate criteria based on correlating slough water levels with inboard groundwater levels.

Sea level rise will increase all water levels throughout the tidal cycle, resulting in increasing water level datums, groundwater elevation, and the frequency of extreme events. The western levee segment begins to overtop at tidal water levels between 9.9 and 10.6 feet, which have a 10-yr and 100-yr recurrence or 10% and 1% chance of occurring in any given year, respectively. With one foot of sea level rise, the annual chance of occurrence is increased to 99% and 50% chance of occurring in any given year. Sea level rise will also increase the number of hours that a given water level is exceeded (Table 2.3 and Figure 13). Based on measured water levels at the North Spit from 1978 to 2020, tidal still water levels have not overtopped the levees. With two feet of sea level rise, an estimated 17 hours of overtopping would be expected per year. The duration of overtopping increases to 195 hours with three feet of sea level rise. Local wind effects may increase these peak water levels and duration of overtopping. Increases in water level datums will diminish the duration of favorable hydraulic conditions for drainage, resulting in an increased duration of flooding of the landward side of the levee during typical winter conditions and following overtopping events. Increasing

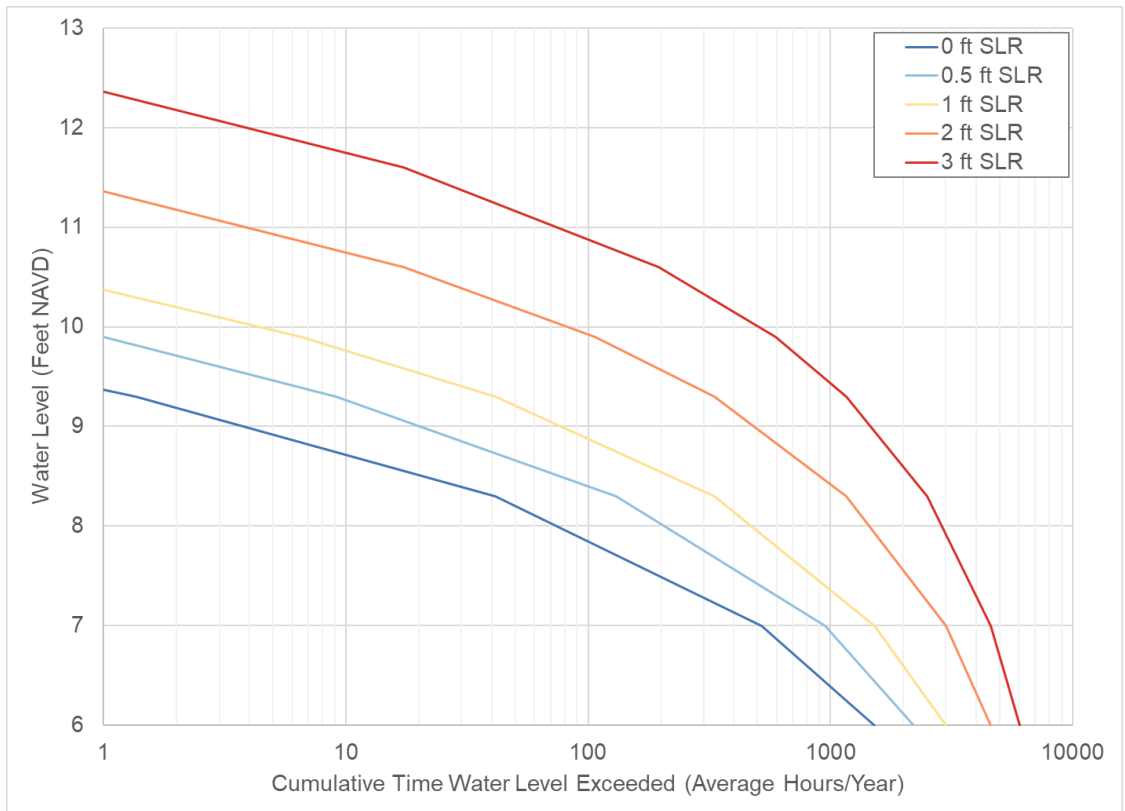


tidal datums would also increase the elevation of levee saturation and the phreatic surface, reducing the factor of safety currently provided for slope stability and under seepage failure.

**Table 2.3 Summary of Expected Average Number of Hours Water Levels Exceeded per Year**

| Water Elev. (ft) | Avg # of Hours Water Level Exceeded/Year* | Avg # of Hours Water Level Exceeded/Year* with Sea Level Rise |          |          |          |
|------------------|---|---|----------|----------|----------|
|                  |   | +0.5 ft   | + 1.0 ft | + 2.0 ft | + 3.0 ft |
| 6.0              | 1,524                                     | 2,209   | 2,991    | 4,594    | 6,046    |
| 7.0              | 520                                       | 954   | 1,524    | 2,991    | 4,594    |
| 8.3              | 41  | 130   | 331      | 1,167    | 2,515    |
| 9.3              | 1   | 9   | 41       | 331      | 1,167    |
| 9.9              | 0.1                                       | 1   | 7        | 107      | 596      |
| 10.6             | 0   | 0   | 0.4      | 17       | 195      |
| 11.6             | 0   | 0   | 0        | 0.4      | 17       |
| 12.6             | 0   | 0   | 0        | 0        | 0.4      |
| 13.6             | 0   | 0   | 0        | 0        | 0        |

\*Based on NOAA North Spit Tide Gage period of record January 1978 through December 2020 adjusted +0.49 feet based on MHHW difference between North Spit Tide Gage (NOAA) and Eureka Slough (NHE 2019). Does not include additional increased water levels due to wind.



**Figure 13. Cumulative amount of time water levels exceeded in a year at Jacobs Avenue levee**



## **2.6 Dependence on other Levee Systems**

The Jacobs Avenue area is also subject to flooding that originates from the overtopping of other hydraulically connected areas in Cell A. As described in Section 3.1 Existing Site Geomorphology and shown in Exhibit 3-14 of Appendix A, drainage originating in the northern extent of cell A, including areas along Highway 101 to the west and Fay Slough to the east, is conveyed to a drainage channel that outlets to Eureka Slough at the northeast end of Jacobs Avenue. As show in the Hazard Scenarios, overtopping of the rail prism along the bay and dikes along Fay Slough is initiated at water levels as low as 9.3 feet. At a water level of 10.3 feet, over 1,200 feet of levee along Fay Slough and Eureka slough will be overtopped. As flood levels within the interior of Cell A rise, flooding from the drainage network of Cell A are projected to flow over Airport Road and into the Jacobs Avenue area. This flooding from other areas of Cell A would likely occur prior to any significant overtopping in the immediate vicinity of Jacobs Avenue.

## **3. Next Steps and Considerations**

The assessment presented above reveals inherent uncertainties associated with estimating potential levee failure modes from elevated water levels. The need for improved observation, inspection, and reporting of failure indicators (seepage, slope stability, overtopping, and erosion), supplemented with additional subsurface exploration are needed to further advance the existing conditions assessment and inform conceptual levee improvements. Should planning advance beyond this current effort, developing a feasibility study is recommended to assess various design criteria relative to an acceptable level of risk to the levee owner(s) and protected critical resource managers. The design criteria should be developed congruent with Caltrans long-range planning for the Highway 101 corridor. For the purpose of this plan and to provide the basis for further assessment and fundraising, conceptual improvements were focused on extending the service life of the levee through cost-effective approaches. These conceptual improvements were preliminarily developed and described below.

### **3.1 Flood Protection and Drainage Improvements Within Cell A**

Residences and businesses along Jacobs Avenue are not only vulnerable to flooding from overtopping and levee failure in the immediate vicinity, but also from other areas of Cell A that experience overtopping and conditions for levee failure at lower, more frequent water levels. The levees along Eureka Slough, adjacent to Jacobs Avenue represent some of the highest levee crest elevations, most substantial armoring, and most recent construction compared to other levees and dikes protecting Cell A. However, overtopping of the levees along Fay Slough and the railroad prism or failure of these structures would result in flooding of the residences and businesses of Jacobs Avenue. Failure would likely result in daily flooding of Jacobs Avenue until isolation of the area or repair of the shoreline protection is implemented. As a means to prevent flooding originating from other areas of Cell A, where the level of protection is lower, a levee or higher ground may be implemented to separate the areas with higher ground in the vicinity of Airport Road. Additional drainage improvements, such as pump stations and increased storm system capacity could further reduce the potential for flooding.



### 3.2 West Levee - Conceptual Improvements

As described previously, levee overtopping is initiated at the existing 10- to 100-year tidal still water level and would begin to result in failure due to overtopping with more than one to two feet of sea level rise. Due to the potential for significant flooding and levee failure associated with overtopping under existing extreme events and increased likelihood of these water levels with sea level rise, failure due to overtopping is considered the highest priority. A determination of levee crest elevations would need to be made during a future feasibility study based on an acceptable level of risk and cost. For the purpose of this plan, a levee crest elevation of 14 feet was utilized, which raises the existing west reach between 1.5 and 3.5 feet above the existing crest elevation. Two design alternatives were considered: earthen fill and a sheetpile cut-off wall. Additionally, relocating the inboard ditch approximately 15 feet away from the levee toe would reduce stability and seepage risk. Geostudios 2019 was utilized to assess the reduction in seepage and slope stability failure and determined a sheetpile wall would provide functionally equivalent results. Table 3.1 presents the results of the analyses relative to existing conditions. The results indicate an improvement to slope stability and a modest improvement to seepage. As part of the recommended next steps, a feasibility study can further evaluate seepage and/or other project components added to reduce seepage such as drains with relief wells and sump pumps or seepage berms.

**Table 3.1. Existing and Proposed Conditions - West Levee Reach**

| Water Elev. (ft)   | Slope Stability |          | Underseepage |          | Overtopping  |          | Erosion  |          |
|--|-----------------|----------|--------------|----------|--|----------|----------|----------|
|  | Existing        | Proposed | Existing     | Proposed | Existing   | Proposed | Existing | Proposed |
| 6.0  | Yellow          | Green    | Green        | Green    | Green  | Green    | Green    | Green    |
| 7.0  | Yellow          | Green    | Yellow       | Green    | Green  | Green    | Green    | Green    |
| 8.3  | Yellow          | Green    | Yellow       | Yellow   | Green  | Green    | Green    | Green    |
| 9.3  | Yellow          | Green    | Yellow       | Yellow   | Green  | Green    | Green    | Green    |
| 9.9  | Yellow          | Green    | Red          | Yellow   | Green  | Green    | Green    | Green    |
| 10.6   | Red             | Green    | Red          | Red      | Yellow   | Green    | Green    | Green    |
| 11.6   | Red             | Green    | Red          | Red      | Yellow   | Green    | Green    | Green    |
| 12.6   | NA              | Green    | NA           | Red      | Red  | Green    | Green    | Green    |
| 13.6   | NA              | Green    | NA           | Red      | Red  | Green    | Green    | Green    |
| NA – Not Analyzed<br>Green –FEMA/USACE Criteria Met<br>Yellow –FEMA/USACE Criteria not Met, FS > 1.0<br>Red –FEMA/USACE Criteria not Met, FS < 1.0   |                 |          |              |          | Green –No Overtopping<br>Yellow –Overtopping <1ft & <2hr (Potential Damage, Temporary Flooding)<br>Red – Overtopping >1ft & >2hr (Potential Failure, Daily Flooding) |          |          |          |
| <b>Proposed Conditions:</b> <ol style="list-style-type: none"> <li>Elevate levee crest to elevation 14 feet with either an earthen inboard embankment at 2H:1V maintaining a minimum 12-foot top width or sheet pile wall through levee core.</li> <li>Relocate existing inboard ditch approximately 15 feet away from the levee toe.</li> </ol> |                 |          |              |          |  |          |          |          |



### 3.3 East Levee - Conceptual Improvements

The analysis of the eastern levee segment identified higher resiliency to under-seepage, slope stability, and overtopping relative to the west segment. Criteria for slope stability was not met at water levels exceeding 10.6 feet and overtopping was initiated between 10.6 and 11.6 feet. Improvements to elevate the levee crest to elevation 14 feet with a sheet pile wall through the levee core would address the overtopping due to flooding and improve slope stability. Table 3.2 presents the results of the analyses relative to existing conditions.

**Table 3.2. Existing and Proposed Conditions - East Levee Reach**

| Water Elev. (ft)   | Slope Stability |          | Underseepage |          | Overtopping  |          | Erosion  |          |
|--|-----------------|----------|--------------|----------|--|----------|----------|----------|
|  | Existing        | Proposed | Existing     | Proposed | Existing   | Proposed | Existing | Proposed |
| 6.0  | Green           | Green    | Green        | Green    | Green  | Green    | Green    | Green    |
| 7.0  | Green           | Green    | Green        | Green    | Green  | Green    | Green    | Green    |
| 8.3  | Green           | Green    | Green        | Green    | Green  | Green    | Green    | Green    |
| 9.3  | Green           | Green    | Green        | Green    | Green  | Green    | Green    | Green    |
| 9.9  | Green           | Green    | Green        | Green    | Green  | Green    | Green    | Green    |
| 10.6   | Yellow          | Green    | Green        | Green    | Green  | Green    | Green    | Green    |
| 11.6   | Yellow          | Green    | Green        | Green    | Yellow   | Green    | Green    | Green    |
| 12.6   | NA              | Green    | NA           | Green    | Yellow   | Green    | Green    | Green    |
| 13.6   | NA              | Yellow   | NA           | Green    | Red  | Green    | Green    | Green    |
| NA – Not Analyzed<br>Green –FEMA/USACE Criteria Met<br>Yellow –FEMA/USACE Criteria not Met, FS > 1.0<br>Red –FEMA/USACE Criteria not Met, FS < 1.0 |                 |          |              |          | Green –No Overtopping<br>Yellow –Overtopping <1ft & <2hr (Potential Damage, Temporary Flooding)<br>Red – Overtopping >1ft & >2hr (Potential Failure, Daily Flooding) |          |          |          |
| <u>Proposed Conditions:</u><br><br>1. Elevate levee crest to elevation 14 feet with sheet pile wall and maintain a minimum 10-foot top width       |                 |          |              |          |  |          |          |          |

### 3.4 Emergency Response and Preparedness Plan

This memo provided a summary assessment of levee vulnerability to sea level rise and conceptual improvements that could extend the service life of the levee. The timeframe to secure funding, conduct the additional engineering, environmental compliance, and construction related tasks would likely require a minimum of 10 to 15 years. Given the hazard exposure and potential consequences identified in the qualitative risk assessment, development of an emergency response and preparedness plan is recommended in the interim. The plan should also consider hazard exposures to tsunamis and earthquakes and post-event assessments. An example plan structured consistent with the Federal Emergency Management Agency (FEMA) Comprehensive Preparedness Guide (CPG) 101 is provided in Appendix A.

**Appendix A  
Example Emergency  
Operations Plan Outline**



# Emergency Operations Plan

Jacobs Avenue Community

Example Template

Draft for Review

This document is in draft form. A final version of this document may differ from this draft. As such, the contents of this draft document shall not be relied upon. GHD disclaims any responsibility or liability arising from decisions made based on this draft document.



11191743 | March 2021



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## **Annex Index**

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## **Plan Promulgation**

Letter stating that plan is official emergency action plan for the community, with approval and implementation by the agency.

# Record of Changes

| Revision # | Sections Revised | Date of Distribution | Name of Approving Authority |
|------------|------------------|----------------------|-----------------------------|
|            |                  |                      |                             |
|            |                  |                      |                             |
|            |                  |                      |                             |
|            |                  |                      |                             |
|            |                  |                      |                             |
|            |                  |                      |                             |

# Record of Initial Distribution

| Agency Name | Address | Date Provided |
|-------------|---------|---------------|
|             |         |               |
|             |         |               |
|             |         |               |
|             |         |               |
|             |         |               |
|             |         |               |

# **1. Introduction**

## **1.1 Purpose**

Brief description of the purpose of the plan, i.e. to be used in conjunction with other EOPs relevant to the State of California, County, other jurisdictions in the area.

## **1.2 Scope**

States the scope of emergency and disaster response and the entities (e.g., departments, agencies, private sector, citizens) and geographic areas to which the plan applies. Would include flood preparedness procedures, levee patrol procedures, flood fight procedures, recovery and after-action procedures, etc.

## **1.3 Plan Structure**

Statement that the plan is structured consistent with the Federal Emergency Management Agency (FEMA) Comprehensive Preparedness Guide (CPG) 101.

# **2. Hazards**

## **2.1 Situation Overview**

Overview of the basin, landmarks, land use, etc.

## **2.2 Overview of Flood Hazards**

Overview of hazards and pathways for flooding

# **3. Concept of Operations**

## **3.1 General Approach to Seasonal Operations**

General statement about routine preparedness for the basin.

## **3.2 Public Alert and Warning**

Discussion of how the public will be notified in the event of a threat to the basin.

## **3.3 Flood Fight Operations**

Discussion of flood fight operations and levee patrols.

## **3.4 Federal and State Disaster Assistance**

This may not be applicable – not a Federal levee?

## **4. Organization and Assignment of Responsibilities**

### **4.1 Organization**

Overview of the organization of the body overseeing the levee.

### **4.2 Assignment of Responsibilities**

Details regarding responsibilities of those shown on the org chart.

## **5. Direction, Control, and Coordination**

This section describes the framework for all direction, control, and coordination activities.

### **5.1 Management and Control and Basin Operations**

Description of how the basin will be managed to organize response activities.

### **5.2 Management and Coordination with Other Jurisdictions**

Discussion of how the basin will be managed in coordination with other public agencies and jurisdictions, i.e. county emergency operations centers, state or federal emergency operation centers.

## **6. Communications**

This section describes the communication protocols and coordination procedures used between response organizations during emergencies and disasters.

### **6.1 Communications Organization**

Describes communication systems for personnel within the basin, other public agencies, State Flood Operations Center (SFOC), etc.

### **6.2 District Communications Equipment and Processes**

Description of the communication equipment to be utilized.

### **6.3 Communications with Other Jurisdictions**

Description of communication protocol with other jurisdictions, i.e. SFOC.

## **7. Logistics, Finance, and Administration**

This section covers general support requirements and the availability of services and support for all types of emergencies, as well as general policies for managing resources.

### **7.1 Resources**

Available resources for floodfighting.

### **7.2 Procurement**

Methods that will be used to contract with contractors to perform emergency work and repair work.

### **7.3 Logistics Facilities**

Descriptions of where supplies are located.

### **7.4 Finance and Administration**

General policies on keeping financial records, reporting, tracking resource needs, tracking the source and use of resources, acquiring ownership of resources, and compensating the owners of private property used by the jurisdiction.

## **8. Plan Development and Maintenance**

This section discusses the overall approach to planning and the assignment of plan development and maintenance responsibilities.

### **8.1 Plan Development and Maintenance**

Description of how this plan will be developed and maintained.

### **8.2 Training and Exercises**

Description of training and exercises that operations and maintenance staff will attend.

### **8.3 Plan Evaluation**

Describe process for reviewing this plan and revising on a regular basis.

## **9. Authorities and References**

This section provides the legal basis for emergency operations and activities. List of specific federal, state and local authorities.

## **10. References**

FEMA, 2010. Comprehensive Preparedness Guide (CPG) 101, Developing and Maintaining Emergency Operations Plans, Version 2.0. November.

Reclamation District 2030 McDonald Island, 2015. Emergency Operations Plan. December.

Reclamation District 2062 Stewart Tract, 2015. Emergency Operations Plan Basic Plan. December.

## **11. Annexes**

These will be detailed attachments that provide additional information to the outlined information above. Will depend on the specific information that will be required or available.

# **Annex A**

## **Emergency Response and Training Policy**

# **Annex B**

## **Flood Supply Inventory**

# **Annex C**

## **Standard Contract Forms**