CALIFORNIA DEPARTMENT OF WATER RESOURCES
Delta Habitat Conservation & Conveyance Program
DHCCP Washington Team

Technical Memorandum

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Project Name:	DWR DHCCP	**Project No.:**	29624
Subject:	Flood Elevations and Protection		
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1.0 INTRODUCTION

1.1 Purpose and Scope

The purpose of this technical memorandum is to establish the design flood WSEs and flood protection elevations for the conveyance facilities in the Delta Habitat Conservation and Conveyance Program (DHCCP). This Technical Memorandum (TM) describes the data, methods and results of analyses of flood water surface elevations (WSEs) along each of the conveyance alignment options. The flood protection criteria are also described. The current conveyance alignment options are illustrated in Figure 1.

1.2 Exclusion and Limitations

Data used in this TM were limited to readily available data. These data included information used in previous Department of Water Resources (DWR) and United States Army Corps of Engineers (USACE) projects. This TM does not address Federal Emergency Management Agency (FEMA) guidelines. The stage-frequency data reflect present conditions and engineering knowledge and do not reflect any expected probability adjustment. Nor do the data show the effects of any proposed dams, levee improvements, or possible Sacramento-San Joaquin Delta (Delta) operation changes. Considerations of interior drainages for the Delta islands were not included in the scope of this TM. Because the alignments are still being revised at the time of this TM, for the purpose of reference along the alignment, the alignment stationing was approximated from the DHCCP Option Description – Map Book (December 31, 2008). The alignment stationing shall be used with the names of rivers and islands to identify the location for each flood elevation. Except for those presented in the previous DWR or USACE studies, the WSE data and plots presented in this TM were not developed using a hydraulic model.

1.3 Usage

This TM is intended to provide initial tentative general flood protection information and guidelines. The data developed in this TM will be used for describing DHCCP option descriptions and performing preliminary design at the conceptual engineering level. Detailed study on a case-by-case basis is recommended for obtaining detailed flood protection elevations for design and construction.

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1.4 Study Area

The Delta, covering more than 1,000 square miles, is in Central California. In general, the Delta extends north to Sacramento, south to Stockton, west to Pittsburg and east to Interstate 5. The region, situated at the confluence of the Sacramento and San Joaquin Rivers at the head of Suisun Bay, is very flat and has been reclaimed from a natural tidal area by hundreds of miles of levees along natural and manmade waterways that divide it into approximately 100 tracts, locally known as "islands." Land elevations in the Delta range from just above mean sea level to 10 feet below mean sea level. Before islands were reclaimed, much of the Delta was covered by water from the daily tide cycle. During times of high runoff from the Sacramento and San Joaquin Basins, much of the Delta would be flooded.

The contributing drainage area to the Delta encompass approximately 40,000 square miles of the Sacramento, San Joaquin and Mokelumne River Basins. Flows and the annual maximum stages in these river systems are generated from areas that are geographically and physically different. These differences are caused by the geographical distribution of the contributing drainage basin and the fluctuations of storm tracks over Northern California.

The tidal influence of the Pacific Ocean also contributes a profound effect on water surface elevations in the lower and central parts of the Delta. If high tides combine with high runoff events, a very high flood stage will result. Flood tides from the Pacific Ocean will have a tendency to slow down and backup high inflows from the river basins. When this "stacking" occurs, especially with high wind periods, levee failures and flood flights are a common occurance.

2.0 DELTA FLOODING

2.1 Data

Delta river and slough flooding elevations and flood hazard data are available from the DWR *Delta Risk Management Strategy (DRMS) Report* (URS, 2008) and the annual maximum data sets from the USACE report *Office Report: Sacramento-San Joaquin Delta, California, Special Study, Hydrology* (Special Study) (USACE, 1992). The 100-year, 200-year, and projected 500-year WSEs that are presented in this TM were obtained and/or calculated using data from these two reports.

USACE's report presents stage-frequency curves for 24 water level gage locations, wave runup data for 12 locations and 50-, 100-, and 500-year maximum WSE plots throughout the Delta. The stage-frequency curves in this report, which include stage data recorded through water year 1988, do not consider possible levee failures.

Most of DHCCP conveyance intakes are located along the main stem of Sacramento River. River flooding elevations within Sacramento River are based on results of hydraulic modeling using the UNET hydraulic model that was developed by USACE for the *1997 Sacramento and San Joaquin River Basins, California, Comprehensive Study* (Comp Study) (USACE, 2002) and later modified by MBK Consultants. The UNET hydraulic model simulates unsteady flow through a full network of open channels, weirs, bypasses and storage areas.

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All flood elevations in this TM are referenced to the English unit, feet, with the North American Vertical Datum of 1988 (NAVD88). Data presented in previous studies that used the National Geodetic Vertical Datum of 1929 (NGVD29) were converted for use in these studies to NAVD88 using the latitude and longitude of each station and the Corpscon software from USACE (2004). In the Delta and DHCCP project area, the correction varies from 1.97 to 2.50 feet. The standardized conversion of the DHCCP involves adding 2.3 feet.

2.2 Potential Flooding Sources

The Isolated Conveyance Facility (ICF) East and West alignments (ICF-East and ICF-West) pass through several islands or tracts that are adjacent to Delta rivers and sloughs. A levee breach on one of the rivers or sloughs could discharge flood water into the adjacent island or tract and fill it to an elevation that may impact the isolated facility. The islands or tracts which, if flooded, could impact either the ICF-East or ICF-West are presented in the following tabulation along with the assumed source of the flood water.

Island or Tract	Flood Water Source
Eastern Alignment:	
Pierson	Sacramento River or Snodgrass Slough
Glanville	Snodgrass Slough
McCormack-Williamson	Mokelumne River
New Hope	Mokelumne River
Canal Ranch	South Fork Mokelumne River
Brack Tract	South Fork Mokelumne River
Terminous Tract	South Fork Mokelumne River
Shin Kee Tract	South Fork Mokelumne River
King Island	South Fork Mokelumne River
Rindge Tract	Disappointment Slough or San Joaquin River
Lower and Middle Roberts Island	San Joaquin River
Drexler Tract	Middle Fork San Joaquin River
Union Island	Middle Fork San Joaquin River
Western Alignment:	
Netherlands	Elk Slough, Sutter Slough
Ryer Tract	Steamboat Slough
Grand Island	Steamboat Springs, Sacramento River
Brannan-Andrus Island	Sacramento River, Seven Mile Slough, Georgiana Slough
Twitchell Island	Seven Mile Slough, Three Mile Slough, San Joaquin River
Bradford Island	San Joaquin River, False River
Bethel Island	False River, Taylor Slough, Dutch Slough
Hotchkiss Tract	Dutch Slough, Rock Slough
Bryon Tract	Old River (San Joaquin)

The elevation to which an adjacent island or tract will be filled by flood water depends upon several factors, including size of the flood event, location of the breach, size of the breach, size of the island or tract that is flooded, and when the breach occurs relative to the flood event. The flood events considered in these analyses are the 100-year, 200-year, and 500-year floods. The potential breaches were assumed to be at locations that would result in the maximum flooding of the island or tract. Breach sizes were assumed to be large but were not estimated as part of these initial

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evaluations. It was assumed that levee breaches would occur during the peak of flood events such that the maximum one-day or five-day flood volumes could enter the islands.

The size of an island or tract will determine how much flood water is needed to fill it to any given elevation. Stage-storage relationships for the islands and tracts listed above for the eastern and western alignments of the isolated facility were developed for use in these analyses. These relationships are presented in Table 1.

2.3 Potential Flooding Scenarios

Six potential flooding scenarios were considered in evaluation of flood protection needs along the DHCCP alignments. These potential flooding scenarios are:

- River flooding assuming no levee failures;
- Floodplain flooding assuming multiple river levee failures or overflows;
- Island flooding limited by levee heights;
- Island flooding limited by river stage;
- Island flooding limited by flood volume; and
- Tidal flooding, due to sea level rise and assuming a levee breach without a storm flood event.

For flooding scenarios 1 through 5, stage-frequency relationships were developed and 100-, 200-, and 500-year WSEs were tabulated. For scenario 6, an estimate of mean higher high water (MHHW) was estimated along each DHCCP alignment. The six potential flooding scenarios are described in the following paragraphs.

2.3.1 Flood Scenario #1: River Flooding – No Levee Failures

River flooding, or overtopping without levee failure, could cause damage to DHCCP facilities located on either the waterside of the river levee or adjacent to the landside of the river levee. After overtopping, flows on the landside of the levee would very quickly spread out, resulting in a relatively shallow sheet flow in the direction of the land slope. Thus, this flooding scenario would be the critical scenario only for facilities on the waterside of the levee or in the immediate vicinity of the levee on the landside.

Gauge stations used to derive flood elevations were chosen based on proximity to the alignments and availability of data. Table 2 lists the data used to derive flood elevations along the alignments and how the elevation at each alignment location was estimated from the data.

Flood elevations are based upon two reports (URS, 2008, and USACE, 1992). The URS data was derived by the Monte Carlo (MC) method as part of the DRMS study and is presented in the NAVD88 datum. USACE data consists of annual maximum stage data taken from USACE's Special Study (USACE, 1992). The period of record varied by station from 30 to 44 years. The elevation datum was NGVD29, which was converted to NAVD88 for this TM. Some flood elevation discrepancies exist in these two data sets. Where there is a discrepancy in these two data, the superiority elevation is selected for conservatism.

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2.3.2 Flood Scenario #2: Floodplain Flooding – Levee Failures or Overflows

Flood waters overtopping or failing a levee will flow in the down slope direction across the surface of the island. This flow will continue until it encounters a downstream obstacle, such as a downstream levee or a body of water that is impounded by a downstream levee. In many historical cases, levee failures have resulted in flood waters entering an island, flowing to the low point in the island (generally at a down slope levee), and ponding until the water level reaches the elevation of the lowest elevation of the levee crest that surrounds the island. Flood elevations associated with the floodplain flooding scenario apply to DHCCP facilities in river overbank areas where breach and overtopping flood waters are flowing as sheet flow over the surface of the overbank areas.

Floodplain flooding elevations due to river levee failures and overflows are based on the flood hazard data developed in the Comp Study, Appendix D. The Comp Study levee failure methodology was devised to determine when simulated flows would cause levees to fail and a floodplain would be formed. A likely failure point (LFP) profile was developed for levees in the Sacramento and San Joaquin River Basins on a reach-by-reach basis. The LFP represents the approximate elevation at which there is 50 percent probability of levee failure. The LFP approach represents a simplified analysis to yield generic conditional probability of failure versus WSE with respect to top of levee. After levee failure, the flood WSE remains relatively constant and the flows escape into the floodplain through the levee break. The floodplain flooding WSE is assumed to equal to the maximum flood WSE at and adjacent to the levee break. The flood WSE will decrease as the landside distance from the levee break increases due to the floodplain slope. The maximum flood WSE at the levee break represents the conservative assumption for the floodplain flooding elevation and was adopted for use in this TM.

2.3.3 Flood Scenario #3: Island Flooding Limited by Levee Heights

A levee breach will result in flood water entering the island or tract and then flowing to the low point within the island or tract, where it will pond until it overtops the low point in the levee that surrounds the island or tract. When the water overtops the low portion of levee it will breach that portion of the levee and any subsequent inflows will flow out of the new breach.

For this potential failure scenario, it was assumed that the maximum WSE of the ponded water is equal to the minimum elevation of the confining levee plus 1 foot. Minimum crest elevations of the levees surrounding each of the islands or tracts were obtained from available topography.

2.3.4 Flood Scenario #4: Island Flooding Limited by River Stage

It is possible that a maximum river or slough WSE is less than the minimum crest elevation of the surrounding levee, or that a levee failure occurs where the levee surrounding the island is at its lowest elevation. In this case, if the levee breaches and the island is small enough, the maximum WSE that would develop in the island or tract is the maximum WSE in the river or slough that is adjacent to the breach.

For this potential failure scenario, it was assumed that maximum WSEs are controlled by the maximum elevation of flood flows in the adjacent major rivers, that is, the levee failure occurs at the worst possible location for island flooding.

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2.3.5 Flood Scenario #5: Island Flooding Limited by Flood Volume

Some of the islands or tracts that the isolated facility alignments pass through are quite large and can possibly accommodate more water than the flood event can deliver during the duration of peak flows. In this case, water would start to accumulate on the island immediately after the breach and will continue to accumulate until the flood peak passes and then begin to drain. Thus, the maximum flood elevation on the island depends upon the discharge-duration characteristics of the flood, when the flood occurs relative to the peak flow, and how much of the flood waters enter the island, which is dependent upon how large the breach is and how rapidly it develops.

For this flood scenario it was assumed that flood water would accumulate to the maximum five-day average stage in the river segment that is adjacent to the island or tract, if this elevation is less than the minimum elevation of the surrounding levee. The five-day average river stages were estimated using the flow data and WSE equations developed for the *Technical Memorandum, Delta Risk Management Strategy (DRMS), Phase 1* (URS, 2008). Maximum annual five-day average WSEs were calculated and Log Pearson Type III analyses of the results were made to determine the 100-year, 200-year, and 500-year maximum annual five-day average elevation. If the Log Pearson Type III analyses presented higher elevations than the adjacent levee crests, the levee crest elevation was assumed. The volume of water that would be temporarily stored on the island or tract under this potential failure scenario relative to the total volume of water that can be stored can be estimated from the stage-storage relationships presented in Table 1.

2.3.6 Flood Scenario #6: Tidal Flooding – Sea Level Rise

Tidal flooding is based on MHHW elevation. MHHW is the average of the higher high water height of each tidal day observed over the National Tidal Datum Epoch (note that a tidal day is 24 hours and 50 minutes long). The Tidal Epoch is a specific 19-year period (the present Epoch is 1983 to 2001) over which WSE is measured. Relating all tidal data to a specific epoch ensures that sea level changes and other tidal features are consistent between stations. The elevation of MHHW is not available throughout the Delta. The National Oceanographic and Atmospheric Administration (NOAA) maintain several tide gauges in San Francisco Bay that are used to estimate the MHHW. They have also made several short term measurements at stations in the Delta. For stations with shorter series, comparison of simultaneous observations with a control tide station is made in order to derive the equivalent datum of the National Tidal Datum Epoch.

Where tidal datum data from NOAA were available and could be related to the NAVD88 datum, the data were obtained from the NOAA Web site:

> *http://tidesandcurrents.noaa.gov/station_retrieve.shtml?type=Bench%20Mark%20Data%20Sheets&state=California&id1=941*.

DWR maintains a database of water level recorders in the Delta (referred to as the California Data Exchange Center [CDEC]). The water level recorders are maintained by a variety of agencies. Data for stations near the proposed alignments were obtained from the CDEC database *(http://cdec.water.ca.gov/)*. Data for all stations were obtained for the period April 1, 2008 to October 31, 2008. This period was chosen to have a consistent time period for comparison between stations

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that did not contain any storm data. From these data the maximum WSE for each day was obtained. The average of all these data was used to represent the MHHW datum.

Over the next 100 years sea level is projected to increase, thereby increasing the tidal elevation in the Delta. Rahmstorf (2007) developed a semi-empirical relationship between the increase in atmospheric surface temperature above a base value and the rate of sea level rise (SLR). Using estimates of the increase in atmospheric temperature developed by the International Panel on Climate Change (IPCC), Rahmstorf predicted an increase in sea level from 1990 to 2100 of 22 to 49 inches (55 to 125 cm). If the statistical error in his model of one standard deviation is included in the estimate the range in sea level rise is 20 to 55 inches (50 to 140 cm) from 1990 to 2100. A value of 55 inches of sea level rise at the Golden Gate Bridge was used in this analysis.

The increases in sea level cannot simply be added to the estimated WSE. The SLR will change the hydraulic characteristics of flow through the Delta and its impact should decrease the farther inland a location is and the larger the storm event. A simple method to approximate changes in WSE in the Delta due to SLR was developed in the *Technical Memorandum, Delta Risk Management Strategy (DRMS), Phase 1* (URS, 2008). The 55-inch increase in sea level rise will occur in the ocean, or, at the Golden Gate Bridge. Estimates of the increases in tidal MHHW due sea level rises along the DHCCP alignments were made using the following assumptions:

- Flows in the rivers and sloughs can be represented by Manning's Equation.
- Flows in the channels are unaffected by sea level rise.
- Channels are wide so that the hydraulic radius in Manning's Equation can be represented by the depth of water.

With these assumptions a relationship between the rise in sea level downstream (e.g., Golden Gate Bridge) and upstream is:

$$d_B = d_A + \left[\left(\frac{h}{h + d_B}\right)^{10/3} - 1\right]\left[E_B - E_A\right] \quad (1)$$

Where:

d_B = increase in WSE at the location of interest

d_A = sea level rise downstream (e.g., it is approximately 55 inches, or 4.58 feet, at the Golden Gate Bridge)

h = existing depth of water

E_B = existing WSE at location of interest

E_A = existing WSE downstream (e.g., , which is approximately 5.9 feet at the Golden Gate Bridge)

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The term $\left[\left(\frac{h}{h+d_B}\right)^{10/3} - 1\right]$ may be assumed to be a factor of -0.2 for most of the area.

Equation (1) can be simplified as:

$$d_B = 4.58 - 0.2 \times (E_B - 5.9) \quad (2)$$

2.4 Wind-Wave Runup

Flooded areas in the Delta, including areas within the river channels and sloughs, will have waves generated by the Delta winds. Large bodies of water, such as flooded islands, may have long wind fetches and, therefore, have high waves generated by a strong Delta wind. Wind waves could cause overtopping and/or erosion of levees and lead to damage of the DHCCP facilities. Protection of thees DHCCP facilities against wind waves must be considered in design of the facilities.

The *Phase 1 Final Technical Memorandum for Wind-Wave Hazard* developed for the DRMS project for DWR (DWR, 2008) provides tables and figures for wind speed frequencies, wave heights and wave runup for various locations throughout the Delta. The wave height and runup values presented in the tables are based on calculations using procedures in the Coastal Engineering Manual developed by USACE. A median wind speed (50 percent chance of being exceeded in any given years) was used as a representative wind speed for estimating wave runup. This value varies from approximately 18 to 20 miles per hour (mph) along the east side of the Delta (near the eastern and through-Delta alignments) to approximately 30 mph near the western alignment. The runup slope is assumed as 1.5 horizontal to 1.0 vertical (H:V) slope. Table 3 presents wave runup for different fetch lengths.

The values in Table 3 are consistent the wind-wave calculations in the Special Study (USACE, 1992), which also indicated wave runup values of 3 to 5 feet. For portions of the alignment located along the edge of tracts, the wave runup values will be smaller. To achieve a wave runup value of 5 feet, the water depth near the alignments would need to be on the order of 15 feet. The wave height and runup values would be smaller as the water depth becomes smaller.

For example, for sloughs and rivers, where wind waves are bounded by banks and levees, fetch length is assumed to be less than 1,000 feet, with no wave runup. For most floodplain and island flooding scenarios, the fetch length was assumed to be pn the order of 20,000 to 30,000 feet The recommended wave runup for these flooding scenarios is 5.0 feet for conservatism.

3.0 WSES FOR FLOOD ELEVATION SCENARIOS

Estimated WSEs associated with each of the six flood elevation scenarios are presented in the following paragraphs followed by a summary of all estimated WSEs. In these tables, the alignment stationing was approximated from the alignment length. The alignment stationing is suggested to be used with the names of rivers and islands to identify the location for the flood elevation. Flooding elevations from sloughs, the Sacramento River, floodplains, islands and tidal data were listed.

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3.1 River Flooding

River flooding WSEs (Flooding Scenario #1) along the ICF-East and ICF-West and TDF are presented in Table 4 and Figure 2. Elevations are also shown with an estimated increase in WSE due to sea level rise of 55 inches at the Golden Gate Bridge.

Table 5 tabulates the 200-year river flooding elevations with and without SLR from Sacramento to Collinsville. These Sacramento River flooding WSEs are illustrated in Figure 3.

River Miles (RMs) in the hydrology and hydraulics (H&H) data table in Table 4 are derived from river alignments from the Comp Study. These UNET hydraulic model RM rerference marks are not necessarily the same as those shown on the United States Geological Survey (USGS) quadrangle maps or quoted in other reports. The RM reference marks shown on the USGS quadrangle maps may be antiquated, as the river lengths have variously increased or decreased over time due to meadering or cutoff impacts. The Comp Study developed new river alignments based on the aerial photos of the river system taken at the time of the study. The RM reference marks in the Comp Study alignments are the most current information available, and have been used for many other studies and hydraulic models to represent the current river systems; therefore, these values were used in the H&H data tables for referencing relative locations along the river reaches.

3.2 Floodplain Flooding

Floodplain flooding WSEs (Flooding Scenario #2) developed for this TM are based on the maximum flood WSE at the levee break from the Comp Study. The results are tabulated in Table 6 and illustrated in Figure 4.

3.3 Island Flooding

WSEs for the three island flooding scenarios (Scenarios #3, #4, and #5) are summarized in Tables 7 and 8. Also presented in these tables are the WSEs tentatively recommended for design. The island flooding WSEs are illustrated in Figure 5.

The recommended design elevations presented in Tables 7 and 8 were selected based on consideration of historic (water years 1956 to 2005) maximum one-day and five-day runoff volumes in the Sacramento, San Joaquin, and Mokelumne Rivers. These runoff volumes are presented in Table 9. The design flood events are larger than the historic flood events, but not all flood waters will enter an island or tract. Breach flood routings are necessary to refine these estimates.

Furthermore, the recommended design elevations assume levee breaches along the main rivers and sloughs and not along branch sloughs. For example, the South Fork Mokelumne River 200-year WSE at Brack Track is approximately 17 feet, and the low point on the Brack Tract surrounding levee is 12.1 feet. The recommended design elevation is 12.1 feet plus 1 foot. However, the WSE in Hog Slough where it crosses ICF-East is approximately equal to the river elevation (~17 feet), and a levee failure at the crossing could impact the immediately adjacent facilities.

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3.4 Tidal Flooding

Estimated tidal flooding elevations are presented in Tables 10 and 11. In general, the MHHW elevation can be considered constant throughout the Delta at approximately 6 feet NAVD88. The tidal WSE generally increases in the upstream direction in the Sacramento River. Due to Sacramento River flow, the WSE remains constant at approximately 6.7 feet at the I Street Bridge. Estimated tidal flooding with SLR is approximately 10 to 11 feet. Tidal flooding WSEs are illustrated in Figure 6.

4.0 FLOOD PROTECTION NEEDS

More than 90 percent of the DHCCP facilities are located within Delta flood-prone areas. It is essential that the DHCCP facilities be protected from flooding. Flood waters entering the facilities would be highly contaminated. In addition, they would contribute massive amounts of silt that would reduce hydraulic capacity, requiring lengthy service outages necessary for cleaning. Therefore, design of the ICF facilities and TDF levees should include protection designed for the required maximum expected flood event.

Both USACE and FEMA are currently in the process of revising their flood protection criteria. At this time neither agency is able to provide definitive criteria for design of levee systems that meet the needs for the State of California. In the absence of updated federal levee protection guideline, DWR published *Proposed Interim Levee Design for Urban and Urbanizing Area State-Federal Project Levees* in August 2008 (DWR, 2008). The interim criteria, currently calling for public comments, is intended to provide interim guidance and criteria for design WSEs and levee design, as well as planning and engineering studies, such as DHCCP.

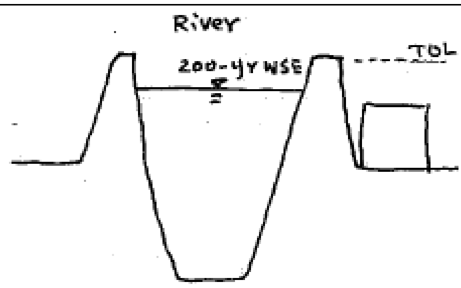
4.1 Protection criteria

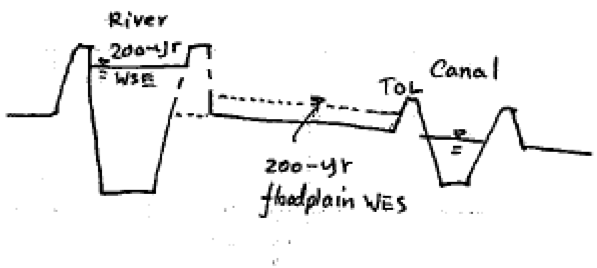
The flood protection criteria described below follows the DWR interim urban/urbanizing levee design approach No. 1, which is a modified version of the FEMA approach. The DHCCP facilities, as critical water infrastructure for the State of California, are designed to be protected against a 200-year flood event. The DWR interim criteria recommended that the 200-year expected WSE is calculated or obtained through conventional deterministic hydraulic analysis. Also, the DWR interim urban/urbanizing levee design criteria recommends: the physical top of levee would need to be at least three feet higher than the expected WSE, with an additional freeboard (FB) allowance for wind-wave runup.

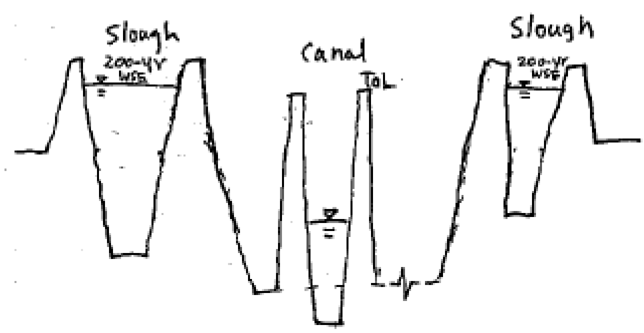
For DHCCP canal embankments, the recommended design flood protection elevation is the superiority of the flooding elevations of floodplain, island, and tidal flood scenarios, plus 5 feet for wind-wave runup and 3 feet of freeboard. For DHCCP infrastructure between the left bank and right bank levees and immediately adjacent to the levee, where wind-wave runup is not an immediate threat, the recommended design flood protection elevation is the superiority of the slough and Sacramento River flooding elevations, plus three feet of freeboard. Table 12 lists the recommended flood protection criteria.

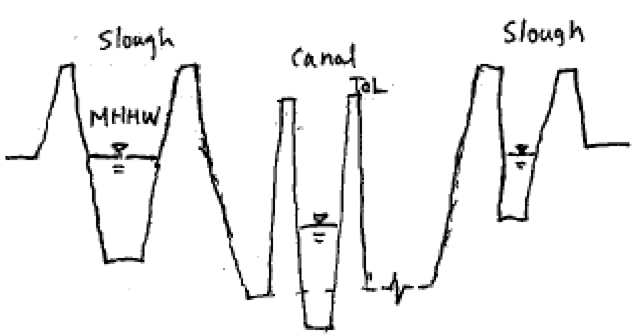
Table 12. Recommended Flood Protection Criteria

<table>
<tr><th>Flooding Scenarios</th><th>Concept Figure</th><th>Flooding Sources</th><th>Flood Protection</th></tr>
<tr><td>1.

River Flooding</td><td>
</td><td>200-year WSE in River and Streams</td><td>200-year WSE + 3-foot FB</td></tr>
<tr><td>2.

Floodplain Flooding</td><td>
</td><td>200-year River Floodplain due to Levee Break</td><td>200-year Floodplain WSE + 3-foot FB, plus Wind-Wave Runup</td></tr>
<tr><td>3, 4 and 5.

Island Flooding</td><td>
</td><td>Island Flooding (200-year flood or island maximum) WSE due to Levee Break</td><td>200-year Island Flooding WSE + 3-foot FB, plus Wind-Wave Runup</td></tr>
<tr><td>6.

Tidal Flooding</td><td>
</td><td>MHHW</td><td>MHHW + 3-foot FB, plus Wind-Wave Runup</td></tr>
</table>

In addition, the DWR interim urban/urbanizing levee design criteria encourages an upward adjustment of the expected WSE to account for sea level rise, based on judgment and consideration of the physical limits of upstream and nearby regional flood protection system.

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4.2 Recommended Flood Protection

4.2.1 Without Sea Level Rise

The 200-year flood expected WSE, not including sea level rise, are tabulated in Tables 13, 14, and 15 for the ICF-East, ICF-West and TDF Options. These tables also include recommended flood protection, accounting for wind wave runup, for embankment design and river crossing. Figures 7, 8, and 9 show the expected WSE without sea level rise and the recommended flood protection for the ICF-East, ICF-West and TDF Options, respectively.

The Dual Conveyance Facility Option (DCF) will follow the recommended flood protection for the applicable segments of the ICF and TDF options.

4.2.2 With Sea Level Rise

The 200-year flood expected WSE, including sea level rise, are tabulated in Tables 16, 17, and 18 for the ICF-East, ICF-West and TDF Options. These tables also include recommended flood protection, accounting for wind wave runup, for embankment design and river crossing. Figures 10, 11, and 12 show the expected WSE with sea level rise and the recommended flood protection for the ICF-East, ICF-West and TDF Options, respectively.

The DCF Option will follow the recommended flood protection for the applicable segments of the ICF and TDF options.

5.0 REFERENCES

Department of Water Resources (DWR), 2008. Proposed interim Levee Design for Urban and Urbanizing Area State-Federal Project Levees. August 22.

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USACE, 2004. Corpscon Software, Version 6.0.1.

URS Corporation (URS), 2008. Technical Memorandum, Delta Risk Management Strategy (DRMS), Phase 1, March 4.

Table 1. Stage-Storage Relationships For Islands or Tracts - Eastern and Western Alignment Isolated Facility

Elevation, feet (NAVD88)	Pierson, acre-feet	Glanville, acre-feet	McCormack-Williamson, acre-feet	New Hope, acre-feet	Canal Ranch, acre-feet	Brack Tract, acre-feet	Terminous Tract, acre-feet	Shin Kee, acre-feet	King Island, acre feet	Ringe Tract, acre-feet	Roberts Island, acre-feet	Drexler, acre-feet	Union, acre-feet	Netherlands, acre feet	Ryer, acre-feet	Byron, acre-feet
-26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-25	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
-24	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
-23	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
-22	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
-21	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0
-20	0	0	0	0	0	0	1	0	0	3	0	0	0	0	0	0
-19	0	0	0	0	0	0	1	0	0	9	1	0	0	0	0	0
-18	0	0	0	0	0	0	2	0	0	53	5	0	0	0	0	0
-17	0	0	0	0	0	0	3	0	1	268	29	0	1	0	0	0
-16	0	0	0	0	0	6	16	0	2	855	132	0	1	0	0	0
-15	0	0	0	0	0	46	141	1	12	1,977	447	0	1	0	0	0
-14	0	0	0	0	1	202	686	1	62	3,701	1,162	0	2	0	0	0
-13	1	0	0	0	1	585	1,999	1	220	6,104	2,402	0	3	0	0	1
-12	1	0	0	0	8	1,265	4,279	2	585	9,244	4,238	0	4	0	2	5
-11	3	0	0	1	58	2,288	7,623	3	1,316	13,058	6,790	0	6	0	18	21
-10	5	0	0	1	217	3,638	12,044	4	2,533	17,462	10,200	1	9	0	131	78
-9	22	0	0	2	505	5,211	17,287	6	4,170	22,371	14,563	1	16	0	595	317
-8	73	0	0	3	953	6,980	23,112	9	6,182	27,709	19,871	4	41	1	1,813	994
-7	196	0	0	14	1,648	8,976	29,435	18	8,509	33,403	26,034	29	158	4	4,045	2,212
-6	487	0	0	58	2,673	11,226	36,210	45	11,016	39,370	32,974	141	545	14	7,696	3,896
-5	1,271	0	0	181	3,994	13,717	43,366	115	13,672	45,595	40,667	455	1,573	43	12,904	5,946
-4	2,715	0	1	433	5,599	16,428	50,885	239	16,488	52,038	49,152	1,096	3,736	78	19,557	8,316
-3	4,758	0	2	846	7,485	19,343	58,659	403	19,464	58,602	58,639	2,158	7,374	127	27,578	10,948
-2	7,528	0	15	1,465	9,635	22,457	66,696	615	22,552	65,198	69,384	3,692	12,731	219	36,748	13,779
-1	11,117	1	59	2,381	12,025	25,775	75,034	925	25,688	71,808	81,606	5,608	19,909	523	46,682	16,797
0	16,049	3	180	4,089	14,968	29,592	84,090	1,548	28,847	78,441	96,797	8,279	30,528	3,354	57,272	20,175
1	21,474	6	366	6,400	18,173	33,654	93,515	2,328	32,012	85,083	113,364	11,213	42,627	8,833	68,037	23,749
2	27,335	11	807	9,519	21,605	37,897	103,247	3,235	35,182	91,737	131,325	14,351	56,152	17,205	78,943	27,531
3	33,571	19	1,606	13,463	25,277	42,296	113,159	4,244	38,359	98,402	150,664	17,663	71,102	29,371	89,976	31,520
4	40,112	37	2,730	18,030	29,181	46,870	123,193	5,359	41,541	105,080	171,334	21,107	87,586	45,988	101,122	35,718
5	46,940	91	4,058	23,257	33,297	51,644	133,354	6,686	44,741	111,790	193,756	24,621	105,706	66,437	112,357	40,156
6	54,044	328	5,507	29,124	37,645	56,600	143,631	8,184	47,965	118,568	217,054	28,171	125,406	89,646	123,664	44,823
7	61,409	716	7,024	35,475	42,204	61,693	153,957	9,867	51,198	125,371	240,874	31,739	146,381	114,816	135,032	49,655
8	69,024	1,273	8,577	42,255	46,943	66,890	164,303	11,715	54,438	132,195	264,981	35,321	168,233	141,547	146,455	54,621
9	76,869	2,009	10,145	49,434	51,876	72,170	174,660	13,683	57,682	139,033	289,240	38,911	190,628	169,555	157,927	59,692
10	84,926	2,957	11,719	56,915	56,993	77,499	185,025	15,720	60,929	145,877	313,589	42,510	213,413	198,617	169,446	64,838
11	93,165	4,158	13,298	64,584	62,209	82,845	195,395	17,789	64,177	152,726	338,003	46,115	236,499	228,511	181,006	70,032
12	101,562	5,620	14,881	72,360	67,455	88,196	205,769	19,876	67,426	159,576	362,466	49,726	259,786	259,029	192,604	75,262
13	110,089	7,309	16,468	80,211	72,709	93,549	216,147	21,975	70,675	166,426	386,970	53,344	283,181	290,022	204,233	80,516
14	118,727	9,212	18,058	88,115	77,968	98,902	226,527	24,083	73,925	173,277	411,509	56,967	306,641	321,338	215,869	85,787
15	127,466	11,321	19,651	96,053	83,230	104,256	236,908	26,196	77,176	180,128	436,076	60,595	330,146	352,865	227,566	91,070
16	136,289	13,620	21,247	104,015	88,493	109,610	247,291	28,314	80,426	186,980	460,664	64,227	353,694	384,529	239,260	96,361
17	145,187	16,063	22,846	111,999	93,758	114,964	257,675	30,434	83,677	193,832	485,273	67,861	377,280	416,275	250,966	101,660
18	154,144	18,613	24,447	120,002	99,024	120,318	268,060	32,557	86,928	200,684	509,898	71,497	400,898	448,086	262,684	106,965
19	163,145	21,231	26,050	128,020	104,291	125,672	278,446	34,682	90,180	207,536	534,536	75,135	424,542	479,955	274,411	112,274
20	172,176	23,886	27,656	136,052	109,558	131,027	288,832	36,809	93,431	214,388	559,184	78,773	448,209	511,878	286,147	117,586
21	181,229	26,561	29,263	144,094	114,826	136,382	299,219	38,938	96,682	221,240	583,842	82,412	471,895	543,852	297,890	122,901
22	190,303	29,249	30,871	152,146	120,094	141,737	309,606	41,069	99,934	228,093	608,507	86,053	495,597	575,872	309,640	128,219
23	199,396	31,949	32,480	160,206	125,363	147,092	319,994	43,200	103,186	234,946	633,180	89,693	519,312	607,935	321,395	133,538
24	208,507	34,657	34,090	168,276	130,632	152,447	330,382	45,332	106,437	241,798	657,858	93,334	543,037	640,036	333,155	138,859
25	217,635	37,374	35,701	176,353	135,901	157,802	340,771	47,465	109,689	248,651	682,542	96,975	566,772	672,173	344,918	144,180
26	226,776	40,096	37,312	184,437	141,170	163,157	351,159	49,599	112,941	255,504	707,231	100,617	590,515	704,343	356,685	149,502
27	235,931	42,824	38,924	192,526	146,439	168,512	361,548	51,734	116,193	262,357	731,926	104,259	614,263	736,542	368,453	154,825
28	245,096	45,556	40,536	200,621	151,709	173,867	371,936	53,870	119,445	269,210	756,626	107,901	638,017	768,768	380,222	160,148
29	254,272	48,291	42,149	208,721	156,978	179,222	382,325	56,006	122,697	276,063	781,329	111,543	661,775	801,019	391,993	165,472
30	263,458	51,029	43,762	216,824	162,248	184,577	392,714	58,144	125,949	282,916	806,037	115,186	685,536	833,292	403,764	170,796
31	272,651	53,770	45,375	224,932	167,518	189,932	403,103	60,281	129,201	289,769	830,747	118,829	709,300	865,585	415,537	176,120
32	281,851	56,513	46,988	233,042	172,788	195,288	413,493	62,419	132,453	296,622	855,461	122,472	733,067	897,897	427,310	181,445
33	291,057	59,258	48,602	241,156	178,058	200,643	423,882	64,557	135,705	303,475	880,177	126,115	756,837	930,226	439,083	186,770
34	300,268	62,004	50,216	249,270	183,328	205,998	434,271	66,695	138,957	310,328	904,895	129,758	780,607	962,569	450,858	192,095
35	309,484	64,751	51,830	257,388	188,598	211,353	444,660	68,834	142,209	317,181	929,614	133,401	804,379	994,925	462,633	197,420
36	318,704	67,499	53,444	265,508	193,868	216,708	455,050	70,972	145,461	324,034	954,334	137,044	828,152	1,027,292	474,408	202,745
37	327,927	70,248	55,058	273,629	199,139	222,064	465,439	73,111	148,713	330,887	979,056	140,688	851,926	1,059,668	486,183	208,071
38	337,154	72,997	56,672	281,751	204,409	227,419	475,828	75,249	151,966	337,740	1,003,779	144,331	875,701	1,092,053	497,959	213,397
39	346,383	75,746	58,286	289,875	209,679	232,774	486,218	77,388	155,218	344,593	1,028,503	147,975	899,477	1,124,445	509,736	218,723

Table 2. Flood Elevation Data Sets And Extrapolation Methods

Location along Alignment	Data Stations	Extrapolation Method
East Alignment at Clifton Court Forebay	USACE (Old River at Clifton Court Forebay)	Flood elevation at alignment equals flood elevation at data station.
East Alignment at Middle River	MC (MTM, MHR)	Flood elevation at alignment is based on a linear extrapolation of the flood elevation slope between stations MTM and MHR.
East Alignment at San Joaquin River	MC (VNI, SJR)	Flood elevation at alignment is based on a linear interpolation of the flood elevation slope between stations VNI and SJR.
East Alignment at Disappointment Slough	MC (VNI, SJR)	Flood elevation at alignment is based on the flood elevation slope between stations VNI and SJR and the distance from VNI.
East Alignment at White Slough	MC (VNI, SJR)	Flood elevation at alignment is based on the flood elevation slope between VNI and SJR and the distance from VNI.
East Alignment at Sycamore Slough	MC (VNI) & USACE (Mokelumne R at New Hope Bridge)	Flood elevation at alignment equals flood elevation at the confluence of Sycamore Slough and Mokelumne River, which is based on the flood elevation slope between VNI and Mokelumne River at New Hope Bridge.
East Alignment at Mokelumne River	MC (GSS, BEN) & USACE (Sacramento River at Walnut Grove, Mokelumne River at New Hope Bridge)	Flood elevation at alignment is equal to an average of flood elevations based on linear interpolation of the flood elevation slope between GSS and BEN, Sacramento River at Walnut Grove and BEN, and Mokelumne River at New Hope Bridge and BEN.
East Alignment at Snodgrass Slough	USACE (Sacramento River at Snodgrass Slough)	Flood elevation at alignment equals flood elevation at data station.
Through-Delta: Old River at Clifton Court Forebay	USACE (Old River at Clifton Court Forebay)	Flood elevation at alignment equals flood elevation at data station.
Through-Delta: Middle River at Borden Highway	USACE (Middle River at Borden Highway)	Flood elevation at alignment equals flood elevation at data station.
Through-Delta: Venice Island Station	MC (VNI)	Flood elevation at alignment equals flood elevation at data station.
Through-Delta: Mokelumne River at Sycamore Slough	MC (VNI) & USACE (Mokelumne River at New Hope Bridge)	Flood elevation at alignment is based on a linear interpolation of the flood elevation slope between VNI and Mokelumne River at New Hope Bridge.
Through-Delta: Mokelumne River at New Hope Bridge	USACE (Mokelumne River at New Hope Bridge)	Flood elevation at alignment equals flood elevation at data station.
West Alignment at Clifton Court Forebay	USACE (Old River at Clifton Court Forebay)	Flood elevation at alignment equals flood elevation at data station.
West Alignment at Victoria Island Road	MC (ORB)	Flood elevation at alignment equals flood elevation at data station.
West Alignment at Rock Slough	USACE (Old River at Rock Slough)	Flood elevation at alignment equals flood elevation at data station.
West Alignment at Miner Slough	MC (SSS)	Flood elevation at alignment equals flood elevation at data station.
West Alignment at Upstream End	MC (LIS)	Flood elevation at alignment equals flood elevation at data station.

Table 3. Recommended Wind-Generated Wave Runup Values		
Fetch Length (feet)	**Wave Height (feet)**	**Wave Runup (feet)**
3,000 – 7,000	0.5 to 0.7	1.5 – 2.5
7,000 – 10,000	0.7 – 1.0	2.5 – 3.0
10,000 – 20,000	1.0 – 1.5	3.0 – 4.0
20,000 – 30,000	1.5 – 2.0	4.0 – 5.0

Table 4. River Flooding Water Surface Elevations

Location Along ICF-East Alignment	Approx. Existing Stage without SLR At East Alignment			Lower Levee Height	Flood Elevation Data Set	WSE increase due to SLR of 55 inches at Golden Gate Bridge			Approx. Projected Stage with SLR At East Alignment		
	100-yr feet	200-yr feet	500-yr feet	feet		100-yr Inches	200-yr Inches	500-yr Inches	100-yr feet	200-yr feet	500-yr feet
East Align. at Clifton Court Forebay	10.5	11.0	11.7	18.6	USACE (Old River at Clifton Court Forebay)	43.9	42.7	41.1	14.2	14.6	15.1
East Align. at Middle River	11.1	11.8	12.6	13.9	MC (MTM, MHR)	42.5	40.9	38.8	14.7	15.2	15.9
East Align. at San Joanquin River	11.4	11.9	12.8	12.7	MC (VNI, SJR)	41.9	40.5	38.3	14.8	15.3	16.0
East Align. at Disappointment Slough	11.3	11.9	12.8	11.3	MC (VNI, SJR)	41.9	40.5	38.4	14.8	15.3	16.0
East Align. at White Slough	11.4	12.0	12.9	11.4	MC (VNI, SJR)	41.8	40.3	38.2	14.9	15.4	16.1
East Align. at Sycamore Slough	13.8	14.9	16.4	12.9	MC (VNI) & USACE (Mokelumne River at New Hope Bridge)	36.0	33.4	29.8	16.8	17.7	18.9
East Align. at Mokelumne River	18.9	20.3	22.0	20.7	MC (GSS, BEN) & USACE (Sacramento River at Walnut Grove, Mokelumne River at New Hope Bridge)	23.7	20.4	16.3	20.9	22.0	23.4
East Align. at Snodgrasss Slough	24.0	24.7	25.4	15.6	USACE (Sacramento River at Snodgrass Slough)	11.5	9.9	8.2	25.0	25.5	26.1

Location Along TDF Alignment	Approx. Existing Stage without SLR for Thourgh-Delta			Lower Levee Height	Flood Elevation Data Set	WSE increase due to SLR of 55 inches at Golden Gate Bridge			Approx. Projected Stage with SLR for Throguh-Delta		
	100-yr feet	200-yr feet	500-yr feet	feet		100-yr Inches	200-yr Inches	500-yr Inches	100-yr feet	200-yr feet	500-yr feet
Old River at Clifton Court Forebay	10.5	11.0	11.7	20.0	USACE (Old River at Clifton Court Forebay)	43.9	42.7	41.1	14.2	14.6	15.1
Middle River at Highway 4	9.8	10.2	10.8	12.4	USACE (Middle River at Borden Highway)	45.7	44.7	43.2	13.6	13.9	14.4
Venice Island Station	10.3	10.7	11.3	10.2	MC (VNI)	44.5	43.4	42.1	14.0	14.3	14.8
Mokelumne River at Sycamore Slough	13.8	14.9	16.4	11.4	MC (VNI) & USACE (Mokelumne River at New Hope Bridge)	36.0	33.4	29.8	16.8	17.7	18.9
Mokelumne River at New Hope Bridge	17.5	19.2	21.7	18.9	USACE (Mokelumne River at New Hope Bridge)	27.2	23.0	17.1	19.8	21.2	23.1

Location Along ICF-West Alignment	Approx. Existing Stage without SLR At West Alignment			Lower Levee Height	Flood Elevation Data Set	WSE increase due to SLR of 55 inches at Golden Gate Bridge			Approx. Projected Stage with SLR At West Alignment		
	100-yr feet	200-yr feet	500-yr feet	feet		100-yr Inches	200-yr Inches	500-yr Inches	100-yr feet	200-yr feet	500-yr feet
West Align. at Clifton Court Forebay	10.5	11.0	11.7	15.6	USACE (Old River at Clifton Court Forebay)	43.9	42.7	41.1	14.2	14.6	15.1
West Align. at Victoria Island Road	13.0	13.9	15.3	14.1	MC (ORB)	37.9	35.9	32.4	16.2	16.9	18.0
West Align. at Rock Slough	9.4	9.8	10.2	13.1	USACE (Old River at Rock Slough)	46.6	45.8	44.6	13.3	13.6	13.9
West Align. at Miner Slough	17.3	18.6	20.3	23.4	MC (SSS)	27.7	24.6	20.4	19.6	20.6	22.0
West Align. at Upstream End	33.5	36.9	42.1	33.1	MC (LIS)	0.0	0.0	0.0	33.5	36.9	42.1

Note:
- All Elevations in NAVD88

Table 5. Sacramento River Flooding Water Surface Elevations

USACE Comp Sudy UNET Model	100-year	200-year	Sea Level Rise (SLR)	200-year + SLR	USACE Comp Sudy UNET Model	100-year	200-year	Sea Level Rise (SLR)	200-year + SLR	USACE Comp Sudy UNET Model	100-year	200-year	Sea Level Rise (SLR)	200-year + SLR
Sacramento River	NAVD88	NAVD88	NAVD88	NAVD88	Sacramento River	NAVD88	NAVD88	NAVD88	NAVD88	Sacramento River	NAVD88	NAVD88	NAVD88	NAVD88
River Mile (RM)	feet	feet	feet	feet	RM	feet	feet	feet	feet	RM	feet	feet	feet	feet
52.0	31.1	32.2	0.0	32.2	34.0	21.6	22.7	1.2	23.9	18.8	14.0	14.9	2.8	17.7
51.8	31.1	32.2	0.0	32.2	33.8	21.4	22.6	1.2	23.8	18.5	13.9	14.8	2.8	17.6
51.5	30.9	32.1	0.0	32.1	33.6	21.4	22.6	1.2	23.8	18.3	13.7	14.6	2.8	17.4
51.3	30.7	31.8	0.0	31.8	33.6	21.4	22.5	1.3	23.8	18.0	13.7	14.5	2.9	17.4
51.0	30.6	31.7	0.0	31.7	33.6	21.4	22.5	1.3	23.8	17.8	13.5	14.4	2.9	17.3
50.8	30.6	31.7	0.0	31.7	33.6	21.4	22.6	1.2	23.8	17.5	13.5	14.3	2.9	17.2
50.5	30.5	31.7	0.0	31.7	33.5	21.4	22.5	1.3	23.8	17.3	13.4	14.3	2.9	17.2
50.3	30.4	31.6	0.0	31.6	33.3	21.2	22.3	1.3	23.6	17.0	13.2	14.1	2.9	17.1
50.0	30.3	31.5	0.0	31.5	33.0	20.9	22.1	1.3	23.4	16.8	13.2	14.1	2.9	17.0
49.8	30.1	31.3	0.0	31.3	32.8	20.9	22.0	1.4	23.4	16.5	13.1	14.0	3.0	17.0
49.5	29.9	31.1	0.0	31.1	32.7	20.8	22.0	1.4	23.3	16.3	13.0	14.0	3.0	16.9
49.3	29.8	30.9	0.0	30.9	32.6	20.8	22.0	1.4	23.3	16.0	12.9	13.9	3.0	16.9
49.0	29.6	30.7	0.0	30.7	32.5	20.7	21.9	1.4	23.3	15.8	12.8	13.7	3.0	16.8
48.8	29.5	30.6	0.0	30.6	32.3	20.6	21.7	1.4	23.1	15.5	12.7	13.7	3.0	16.7
48.5	29.4	30.5	0.0	30.5	32.0	20.5	21.6	1.4	23.0	15.3	12.7	13.6	3.0	16.7
48.3	29.3	30.5	0.0	30.5	31.8	20.4	21.5	1.5	23.0	15.0	12.5	13.5	3.1	16.6
48.0	29.2	30.4	0.0	30.4	31.5	20.2	21.4	1.5	22.9	14.8	12.5	13.4	3.1	16.5
47.8	29.1	30.2	0.0	30.2	31.3	20.1	21.2	1.5	22.7	14.6	12.5	13.5	3.1	16.5
47.5	28.9	30.1	0.0	30.1	31.0	20.0	21.2	1.5	22.7	14.3	12.5	13.5	3.1	16.5
47.3	28.6	29.8	0.0	29.8	30.8	19.8	21.0	1.6	22.5	14.0	12.2	13.0	3.2	16.2
47.0	28.5	20.6	0.0	20.6	30.5	19.7	20.0	1.0	22.4	13.8	12.1	13.0	3.2	16.1
46.8	28.5	29.6	0.0	29.6	30.3	19.6	20.7	1.6	22.3	13.5	12.1	12.9	3.2	16.1
46.5	28.4	29.6	0.0	29.6	30.0	19.4	20.5	1.7	22.2	13.3	12.0	12.8	3.2	16.0
46.4	28.4	29.6	0.0	29.6	29.8	19.3	20.4	1.7	22.1	13.0	11.8	12.6	3.2	15.8
46.4	28.4	29.5	0.0	29.5	29.5	19.2	20.3	1.7	22.0	12.9	11.7	12.5	3.3	15.8
46.4	28.4	29.5	0.0	29.5	29.3	19.1	20.2	1.7	21.9	12.9	11.6	12.3	3.3	15.6
46.4	28.4	29.5	0.0	29.5	29.0	19.0	20.0	1.8	21.8	12.9	11.6	12.3	3.3	15.6
46.3	28.3	29.4	0.0	29.4	28.8	18.8	19.9	1.8	21.7	12.9	11.7	12.5	3.3	15.8
46.0	28.1	29.3	0.0	29.3	28.5	18.7	19.8	1.8	21.6	12.8	11.7	12.5	3.3	15.7
45.8	28.0	29.2	0.0	29.2	28.3	18.5	19.6	1.8	21.4	12.5	11.5	12.2	3.3	15.5
45.5	27.9	29.0	0.0	29.0	28.0	18.4	19.5	1.9	21.3	12.3	11.3	12.0	3.4	15.3
45.3	27.6	28.8	0.0	28.8	27.8	18.3	19.3	1.9	21.2	12.0	11.1	11.8	3.4	15.2
45.0	27.4	28.6	2.3	30.9	27.5	18.2	19.2	1.9	21.1	11.8	10.9	11.6	3.4	15.0
44.8	27.3	28.4	0.1	28.5	27.3	18.1	19.1	1.9	21.0	11.5	10.8	11.4	3.5	14.9
44.5	27.1	28.2	0.1	28.3	27.3	17.9	18.9	2.0	20.9	11.3	10.7	11.4	3.5	14.9
44.3	27.0	28.1	0.1	28.2	27.0	17.8	18.7	2.0	20.7	11.0	10.6	11.2	3.5	14.7
44.0	26.9	28.1	0.1	28.2	26.9	17.8	18.8	2.0	20.8	10.8	10.4	10.9	3.6	14.5
43.8	26.9	28.1	0.2	28.2	26.9	17.8	18.7	2.0	20.7	10.5	10.2	10.8	3.6	14.4
43.5	26.6	27.7	0.2	27.9	26.9	17.8	18.7	2.0	20.7	10.3	10.1	10.6	3.6	14.2
43.3	26.5	27.6	0.2	27.8	26.9	17.8	18.8	2.0	20.8	10.0	9.9	10.4	3.7	14.1
43.0	26.3	27.4	0.3	27.7	26.8	17.8	18.8	2.0	20.8	9.8	9.7	10.2	3.7	14.0
42.8	26.3	27.4	0.3	27.7	26.7	17.8	18.8	2.0	20.8	9.5	9.6	10.1	3.7	13.8
42.5	26.3	27.4	0.3	27.7	26.5	17.7	18.7	2.0	20.7	9.0	9.6	10.1	3.7	13.8
42.3	26.2	27.3	0.3	27.6	26.3	17.7	18.6	2.0	20.7	8.8	9.5	10.0	3.8	13.7
42.0	26.0	27.2	0.3	27.5	26.0	17.5	18.4	2.1	20.5	8.5	9.4	9.8	3.8	13.6
41.8	25.9	27.0	0.4	27.3	25.8	17.3	18.3	2.1	20.4	8.3	9.3	9.8	3.8	13.6
41.5	25.8	26.9	0.4	27.3	25.5	17.2	18.2	2.1	20.3	8.0	9.3	9.7	3.8	13.5
41.3	25.6	26.8	0.4	27.2	25.3	17.1	18.1	2.1	20.2	7.8	9.2	9.6	3.8	13.4
41.0	25.5	26.6	0.4	27.1	25.0	17.0	17.9	2.2	20.1	7.5	9.1	9.5	3.9	13.4
40.8	25.3	26.5	0.5	26.9	24.8	16.9	17.8	2.2	20.0	7.3	9.0	9.4	3.9	13.3
40.5	25.2	26.3	0.5	26.8	24.5	16.7	17.6	2.2	19.9	7.0	9.0	9.4	3.9	13.3
40.3	25.0	26.2	0.5	26.7	24.3	16.5	17.3	2.3	19.6	6.8	9.0	9.4	3.9	13.3
40.0	24.8	25.9	0.6	26.5	24.0	16.4	17.2	2.3	19.5	6.5	8.9	9.3	3.9	13.2
39.8	24.7	25.8	0.6	26.4	23.8	16.3	17.2	2.3	19.5	6.3	8.9	9.2	3.9	13.1
39.5	24.6	25.7	0.6	26.3	23.5	16.2	17.0	2.4	19.4	6.0	8.8	9.1	3.9	13.1
39.3	24.3	25.5	0.7	26.1	23.3	16.1	17.0	2.4	19.3	5.8	8.7	9.0	4.0	13.0
39.0	24.2	25.4	0.7	26.1	23.0	16.0	16.8	2.4	19.2	5.5	8.6	8.9	4.0	12.9
38.8	24.2	25.3	0.7	26.0	22.8	15.8	16.6	2.4	19.0	5.3	8.5	8.8	4.0	12.8
38.5	24.1	25.2	0.7	25.9	22.5	15.7	16.5	2.5	19.0	5.0	8.4	8.7	4.0	12.7
38.3	24.0	25.1	0.7	25.9	22.3	15.6	16.4	2.5	18.9	4.8	8.4	8.6	4.0	12.7
38.0	23.7	24.8	0.8	25.6	22.0	15.5	16.3	2.5	18.8	4.5	8.2	8.5	4.1	12.6
37.8	23.6	24.7	0.8	25.5	21.8	15.3	16.1	2.5	18.7	4.3	8.2	8.4	4.1	12.5
37.5	23.6	24.7	0.8	25.6	21.5	15.2	16.0	2.6	18.6	4.0	8.1	8.2	4.1	12.3
37.3	23.5	24.6	0.8	25.5	21.3	15.1	15.9	2.6	18.5	3.8	8.1	8.2	4.1	12.3
37.0	23.4	24.5	0.9	25.3	21.0	14.9	15.7	2.6	18.4	3.5	8.0	8.1	4.1	12.3
36.8	23.2	24.3	0.9	25.2	20.8	14.9	15.7	2.6	18.3	3.3	8.0	8.1	4.1	12.2
36.5	22.8	24.0	1.0	24.9	20.5	14.8	15.6	2.6	18.3	3.0	8.0	8.1	4.2	12.2
36.3	22.9	24.0	1.0	25.0	20.3	14.7	15.5	2.7	18.2	2.8	8.0	8.0	4.2	12.2
36.0	22.8	23.9	1.0	24.9	20.0	14.5	15.4	2.7	18.1	2.5	8.0	8.0	4.2	12.2
35.8	22.6	23.7	1.0	24.7	19.8	14.4	15.2	2.7	17.9	2.3	7.9	8.0	4.2	12.1
35.5	22.3	23.4	1.1	24.5	19.5	14.3	15.1	2.7	17.9	2.0	7.9	7.9	4.2	12.1
35.3	22.3	23.4	1.1	24.5	19.3	14.2	15.0	2.8	17.8	1.8	7.9	7.9	4.2	12.1
35.0	22.2	23.4	1.1	24.5	19.0	14.1	14.9	2.8	17.7	1.5	7.8	7.9	4.2	12.1
34.8	22.1	23.2	1.1	24.3	18.9	14.0	14.9	2.8	17.7	1.3	7.8	7.8	4.2	12.0
34.5	21.9	23.0	1.2	24.2	18.9	14.0	14.9	2.8	17.7	1.0	7.8	7.8	4.2	12.0
34.3	21.8	22.9	1.2	24.1	18.8	14.0	14.9	2.8	17.7	0.8	7.8	7.8	4.2	12.0
34.2	21.7	22.9	1.2	24.1	18.8	14.0	14.9	2.8	17.7					

Table 6. River Floodplain Flooding Water Surface Elevations

	Impact Area No.	Impact Area Name	100-year Floodplain WSE	200-year Floodplain WSE	200-year Floodplain WSE	Sea Level Rise (SLR)	200-year Floodplain WSE + SLR
			NGVD29 (feet)	NGVD29 (feet)	NAVD88 (feet)	NAVD88 (feet)	NAVD88 (feet)
Sacramento River Basin	41	Lisbon District, RD 302	23.6	25.6	27.9	0.2	28.1
	42	Netherlands, RD 999	13.7	13.7	16.0	2.6	18.6
	43	Clarksberg	13.7	13.7	16.0	2.6	18.6
	44	Stonelake	19.1	20.1	22.4	1.3	23.7
	45	Hood	19.1	20.1	22.4	1.3	23.7
	46	Merritt Island	20.7	20.8	23.1	1.1	24.2
	47	Vorden, RD 551	18.0	18.8	21.1	1.5	22.6
	48	Courtland	18.0	18.8	21.1	1.5	22.6
	49	Sutter Island	13.8	13.8	16.1	2.5	18.6
	50	Grand Island	9.7	9.9	12.2	3.3	15.5
	51	Locke	13.2	13.3	15.6	2.6	18.2
	52	Walnut Grove	12.5	12.6	14.9	2.8	17.7
	53	Tyler Island	7.8	7.8	10.1	3.7	13.8
	54	Brannan-Andrus Island	7.5	7.6	9.9	3.8	13.7
	55	Ryer Island	12.2	12.2	14.5	2.9	17.4
	56	Prospect Island	15.0	15.2	17.5	2.3	19.8
	57	Twitchell Island	6.4	6.7	9.0	4.0	13.0
	58	Sherman Island	6.3	6.4	8.7	4.0	12.7
	62	Lindsey Slough, Egbert Tract	15.6	15.7	18.0	2.2	20.2
San Joaquin River Basin	30	Paradise Cut	12.2	13.4	15.7	2.6	18.3
	31	Stewart Tract	16.7	17.6	19.9	1.8	21.7
	33	Lathrop / Sharp	10.8	13.0	15.3	2.7	18.0
	34	French Camp	10.8	13.0	15.3	2.7	18.0
	35	Stockton	10.60	12.30	14.6	2.8	17.4
	36	Roberts Island	10.90	13.00	15.3	2.7	18.0
	37	Rough and Ready Island	9.60	10.30	12.6	3.2	15.8
	38	Drexler Tract	10.00	11.30	13.6	3.0	16.6
	39	Union Island	9.25	11.10	13.4	3.1	16.5
	40	SE Union Island	12.50	13.30	15.6	2.6	18.2
	41	Fabian Tract	10.40	11.20	13.5	3.1	16.6
	42	Pico Naglee Tract, RD 1007	10.60	11.60	13.9	3.0	16.9

Note: Impact Area was used in the USACE Comp Study, Appendix D and F (USACE, 2002) to delineate within the floodplain to facilitate the flood damage analysis. The Impact Area No. was used here for reference to the Comp Study.

Table 7. Island or Tract Water Surface Elevations - Eastern Alignment

Tract/Island	Location	Flood Event	Minimum Levee Crest Elevation, feet	Maximum River Water Surface Elevation, feet	5-Day Average River Water Surface Elevation, feet	Recommended Design Elevation, feet	Sea Level Rise, feet	Recommended Design Elevation + SLR, feet
Pierson District	Levee at Southwest Corner	100-year	27.7	22.5	21.5	22.5	1.3	23.8
		200-year	27.7	23.0	21.9	23	1.2	24.2
		500-year	27.7	23.5	22.3	23.5	1.1	24.5
Glanville Tract	Levee at South End (near Sacramento River)	100-year	21.2	21.1	21.1	21.1	1.5	22.6
		200-year	21.2	22.1	22.1	22.1	1.3	23.4
		500-year	21.2	23.1	23.1	23.1	1.1	24.2
McCormack-Williamson Tract	Levee at Dead Horse Slough	100-year	18.0	21.1	21.1	19.0	2.0	21.0
		200-year	18.0	22.1	22.1	19.0	2.0	21.0
		500-year	18.0	23.1	23.1	19.0	2.0	21.0
New Hope Tract	Levee at Beaver Slough	100-year	14.3	18.4	18.2	15.3	2.7	18.0
		200-year	14.3	19.3	19.1	15.3	2.7	18.0
		500-year	14.3	20.2	19.9	15.3	2.7	18.0
Canal Ranch	Levee at Hog Slough	100-year	13.0	16.7	16.4	14.0	3.0	16.9
		200-year	13.0	17.4	17.1	14.0	3.0	16.9
		500-year	13.0	18.2	17.8	14.0	3.0	16.9
Brack Tract	Levee at Sycamore Slough	100-year	12.1	15.3	14.8	13.1	3.1	16.2
		200-year	12.1	15.9	15.5	13.1	3.1	16.2
		500-year	12.1	16.7	16.2	13.1	3.1	16.2
Terminous Tract	Levee at White Slough	100-year	10.8	14.2	13.7	11.8	3.4	15.2
		200-year	10.8	14.8	14.2	11.8	3.4	15.2
		500-year	10.8	15.5	14.9	11.8	3.4	15.2
Shin Kee Tract	Levee at West End	100-year	8.5	10.4	9.6	9.5	3.9	13.3
		200-year	8.5	10.8	9.9	9.5	3.9	13.3
		500-year	8.5	11.3	10.3	9.5	3.9	13.3
King Island	Levee at Dissapointment Slough	100-year	11.4	10.4	9.6	10.4	3.7	14.0
		200-year	11.4	10.8	9.9	10.8	3.6	14.4
		500-year	11.4	11.3	10.3	11.3	3.5	14.8
Rindge Tract	Levee at Little Tinsel Island	100-year	10.9	10.4	9.6	9.6	3.8	13.5
		200-year	10.9	10.8	9.9	9.9	3.8	13.7
		500-year	10.9	11.3	10.3	10.3	3.7	14.0
Roberts Island (Upper)	Levee at Drexler Tract	100-year	10.1	13.2	12.4	11.1	3.5	14.6
		200-year	10.1	14.1	13.2	11.1	3.5	14.6
		500-year	10.1	15.3	14.2	11.1	3.5	14.6
Drexler Tract	Levee on Trapper Slough	100-year	5.7	11.8	11.1	6.7	4.4	11.1
		200-year	5.7	12.5	11.7	6.7	4.4	11.1
		500-year	5.7	13.4	12.4	6.7	4.4	11.1
Union Island	Levee at Clifton Court Forebay	100-year	17.6	10.9	10.2	10.9	3.6	14.5
		200-year	17.6	11.4	10.6	11.4	3.5	14.9
		500-year	17.6	12.1	11.2	12.1	3.3	15.4

Table 8. Island or Tract Water Surface Elevations - Western Alignment

Tract/Island	Location	Flood Event	Minimum Levee Crest Elevation, feet	Maximum River Water Surface Elevation, feet	5-Day Average River Water Surface Elevation, feet	Recommended Design Elevation, feet	Sea Level Rise, feet	Recommended Design Elevation + SLR, feet
Netherlands	Levee at Southwest Corner Peaks at FTP	100-year	23.3	29.2	27.7	24.3	0.9	25.2
		200-year	23.3	29.8	28.2	24.3	0.9	25.2
		500-year	23.3	30.4	28.6	24.3	0.9	25.2
Ryer Island	Levee at South End (near Sacramento River) Peaks at SSS	100-year	21.3	19.2	18.4	19.2	1.9	21.1
		200-year	21.3	19.6	18.8	19.6	1.8	21.5
		500-year	21.3	20.0	19.1	20.0	1.8	21.8
Byron Tract	Levee at South End (near Clifton Court Forebay) Peaks at ORB	100-year	15.0	12.9	11.7	12.9	3.2	16.1
		200-year	15.0	13.8	12.4	13.8	3.0	16.8
		500-year	15.0	15.0	13.4	15.0	2.8	17.8

Table 9. Runoff Volumes of Historic Floods of Record

River	Duration	Date	Volume, Acre-Feet
Sacramento River	1-Day	February 19, 1986	228,099
	5-Day	February 17-21, 1986	1,065,322
San Joaquin River	1-Day	January 5, 1997	107,702
	5-Day	February 27 - March 3, 1969	451,438
Mokelumne River	1-Day	December 24, 1955	28,165
	5-Day	December 24-28, 1955	81,064

Table 10. Mean Higher High Water in the Sacramento River

(feet, NAVD88)

	MHHW (feet, NAVD88)				
Location	NOAA	CDEC*	Used in Study	SLR Increase (feet)	MHHW with SLR
Golden Gate Bridge	5.9		5.9	4.6	10.5
Port Chicago	6.09		6.0	4.6	10.6
Antioch	5.95	5.98	6.0	4.6	10.6
Rio Vista	7.01	6.31	6.3	4.5	10.8
Freeport		6.64	6.6	4.5	11.1
I Street Bridge		6.73	6.7	4.5	11.2

Table 11. Mean Higher High Water in the San Joaquin and Mokelumne Rivers

(feet, NAVD88)

	MHHW (feet, NAVD88)				
Location	NOAA	CDEC*	Used in Study	SLR Increase (feet)	MHHW with SLR
Golden Gate Bridge	5.9	5.86	5.9	4.6	10.5
Port Chicago	6.09	6.03	6.0	4.6	10.6
Antioch	5.95	5.98	6.0	4.6	10.6
Three Mile Slough	5.89		6.0	4.6	10.6
Venice Island		6.21	6.0	4.6	10.6
Mokulumne River at Benson's Ferry		5.77	6.0	4.6	10.6

* CDEC - April 1, 2008-Oct 31, 2008 data

Table 13. ICF-EAST: Recommended Flood Protection for Design Embankment and River Crossings Without Sea Level Rise

Station	Location	From	To	200-year Streams Flooding WSE	200-year Sac River Flooding WSE	200-year Floodplain Flooding WSE	200-year Island Flooding WSE	Tidal Flooding WSE	Wind-Wave Runup	Recommended Design Embankment Flood Protection*	Recommended Design River Crossing Flood Protection**
				NAVD88 (ft)	NAVD88 (ft)	NAVD88 (ft)	NAVD88 (ft)	NAVD88 (ft)	(ft)	NAVD88 (ft)	NAVD88 (ft)
-395+15	Sacramento River at Freeport				29.6			6.6			32.6
-332+34	Sacramento River at Clarksburg				27.4						30.4
-135+25	Sacramento River at Stone Lake				26.6						29.6
100+00	Pierson Tract	Hood	Snodgrass Slough		25.2	22.4	23.0		5.0	31.0	
140+00	Snodgrass Slough			24.7							27.7
242+50	Glanville Tract	Snodgrass Slough	Lost Slough		22.1	21.1	22.1		5.0	30.1	
345+00	Lost Slough										
365+00	McComack Williamson Tract	Lost Slough	Mokelumne River		18.7	15.6	19.0		5.0	27.0	
385+00	Mokelumne River			20.3							23.3
487+50	New Hope Tract	Mokelumne River	Beaver Slough		17.2	14.9	15.3		5.0	23.3	
590+00	Beaver Slough			19.2							22.2
652+50	Canal Ranch	Beaver Slough	Hog Slough				14.0		5.0	22.0	
715+00	Hog Slough										
765+00	Brack Tract	Hog Slough	Sycamore Slough				13.1		5.0	21.1	
815+00	Sycamore Slough			14.9							17.9
897+50	Terminous Tract	Sycamore Slough	Upland Canal				11.8		5.0	19.8	
980+00	Upland Canal / North Guard Road										
1012+50	Shin Kee Tract	Upland Canal	White Slough				9.5		5.0	17.5	
1045+00	White Slough			12.0							15.0
1122+50	Kinkg Island	White Slough	Disappointment Slough				10.8		5.0	18.8	
1200+00	Disappointment Slough			11.9							14.9
1287+50	Rindge Tract	Disappointment Slough	San Joaquin River				9.9		5.0	17.9	
1375+00	San Joaquin River			11.9				6.0			14.9
1610+00	Roberts Island	San Joaquin River	Middle River			12.6	6.7		5.0	20.6	
1845+00	Middle River			11.8							14.8
2005+00	Union Island	Middle River	Old River			13.6	11.4		5.0	21.6	
2165+00	Old River			11.0							14.0
2230+00	Byron Tract 2	Old River	Jones PP			13.4			5.0	21.4	
2310+00			Banks PP			13.4			5.0	21.4	

Note: * Design Embankment Flood Protection is the highest elevation of floodplain, island and tidal flooding water surface elevation plus wind-wave runup and 3 feet of freeboard protection.

** Design River Crossing Flood Protection is the highest elevation of Sacramento River and stream flooding water surface elevation plus 3 feet of freeboard protection.

Table 14. ICF-WEST: Recommended Flood Protection for Design Embankment and River Crossings Without Sea Level Rise

Station	Location	From	To	200-year Streams Flooding WSE	200-year Sac River Flooding WSE	200-year Floodplain Flooding WSE	200-year Island Flooding WSE	Tidal Flooding WSE	Wind-Wave Runup	Recommended Design Embankment Flood Protection*	Recommended Design River Crossing Flood Protection**	
				NAVD88 (ft)	NAVD88 (ft)	NAVD88 (ft)	NAVD88 (ft)	NAVD88 (ft)	(ft)	NAVD88 (ft)	NAVD88 (ft)	
-34+43	Sacramento River near Babel Slough			36.9	31.7			6.6			39.9	
100+00	Lisbon District	Sacramento River	Winchester Lake			27.9	24.3		5.0	35.9		
195+00	Winchester Lake											
525+00	Netherlands	Winchester Lake	Miner Slough			16.0			5.0	24.0		
855+00	Miner Slough			18.6							21.6	
1077+50	Ryer Island	Miner Slough	Sacramento River			14.5	19.6		5.0	27.6		
1300+00	Sacramento River				13.5			6.3			16.5	Tunnel
1400+00	Brannan-Andrus Island	Sacramento River	Sevenmile Slough			9.9			5.0	17.9		Tunnel
1550+00	Twitchell Island	Sevenmile Slough	San Joaquin River			9.0			5.0	17.0		Tunnel
1600+00	San Joaquin River							6.0			9.0	Tunnel
1665+00	Bradford Island	San Joaquin River	False River						5.0			Tunnel
1730+00	False River											Tunnel
1807+50	Bethel Island	False River	Dutch Slough						5.0			Tunnel
1885+00	Dutch Slough											Tunnel
1942+50	Hotchkiss Tract 1	Dutch Slough	Contra Costa Canal						5.0			
2000+00	Contra Costa Canal			9.8							12.8	
2350+00	Bryon Tract 1	Highway 4	Bryon Tract Forebay			13.9			5.0	21.9		
2520+00		Bryon Tract Forebay	Jones and Banks PP	11.0			13.8		5.0	21.8		

Note: * Design Embankment Flood Protection is the highest elevation of floodplain, island and tidal flooding water surface elevation plus wind-wave runup and 3 feet of freeboard protection.

** Design River Crossing Flood Protection is the highest elevation of Sacramento River and stream flooding water surface elevation plus 3 feet of freeboard protection.

Table 15. TDF: Recommended Flood Protection for Design Embankment and River Crossings Without Sea Level Rise

Station	From	To	200-year Streams Flooding WSE	200-year Sac River Flooding WSE	200-year Floodplain Flooding WSE	200-year Island Flooding WSE	Tidal Flooding WSE	Wind-Wave Runup	Recommended Design Embankment Flood Protection*	Recommended Design River Crossing Flood Protection**
			NAVD88 (ft)	NAVD88 (ft)	NAVD88 (ft)	NAVD88 (ft)	NAVD88 (ft)	(ft)	NAVD88 (ft)	NAVD88 (ft)
-335+00	Sacramento River at Upstream of Hood			25.2			6.6			28.2
-245+00	Hood	Snodgrass Slough		25.2	22.4	23.0		5.0	31.0	
-155+00	Snodgrass Slough		24.7							27.7
-45+00	Snodgrass Slough	Lost Slough		22.1	21.1	22.1		5.0	30.1	
65+00	Lost Slough									
85+00	Lost Slough	Mokelumne River		18.7	15.6	19.0		5.0	27.0	
105+00	Mokelumne River		20.3							
222+50	Mokelumne River	Beaver Slough		17.2	14.9	15.3		5.0	23.3	
340+00	Beaver Slough		19.2							22.2
460+00	Beaver Slough	Sycamore Slough				14.0		5.0	22.0	
580+00	Sycamore Slough		14.9							17.9
820+00	Sycamore Slough	San Joaquin River						5.0		
1060+00	San Joaquin River		10.7				6.0			13.7
1470+00	San Joaquin River	Victoria Canal			13.6			5.0	21.6	
1880+00	Victoria Canal		11.8							14.8
2010+00	Victoria Canal	Old River			13.4	11.4		5.0	21.4	
2140+00	Old River		11.0							14.0
2190+00	Clifton Court Forebay	Old River			13.4			5.0	21.4	

Note: * Design Embankment Flood Protection is the highest elevation of floodplain, island and tidal flooding water surface elevation plus wind-wave runup and 3 feet of freeboard protection.

** Design River Crossing Flood Protection is the highest elevation of Sacramento River and stream flooding water surface elevation plus 3 feet

Table 16. ICF-EAST: Recommended Flood Protection for Design Embankment and River Crossings With Sea Level Rise

Station	Location	From	To	200-year Streams Flooding WSE	200-year Sac River Flooding WSE	200-year Floodplain Flooding WSE	200-year Island Flooding WSE	Tidal Flooding WSE	Wind-Wave Runup	Recommended Design Embankment Flood Protection*	Recommended Design River Crossing Flood Protection**
				NAVD88 (ft)	NAVD88 (ft)	NAVD88 (ft)	NAVD88 (ft)	NAVD88 (ft)	(ft)	NAVD88 (ft)	NAVD88 (ft)
-395+15	Sacramento River at Freeport				29.6			11.1			32.6
-332+34	Sacramento River at Clarksburg				27.7						30.7
-135+25	Sacramento River at Stone Lake				27.1						30.1
100+00	Pierson Tract	Hood	Snodgrass Slough		25.9	23.7	24.2		5.0	32.2	
140+00	Snodgrass Slough			25.5							28.5
242+50	Glanville Tract	Snodgrass Slough	Lost Slough		23.4	22.6	23.4		5.0	31.4	
345+00	Lost Slough										
365+00	McComack Williamson Tract	Lost Slough	Mokelumne River		20.7	18.2	21.0		5.0	29.0	
385+00	Mokelumne River			22.0							25.0
487+50	New Hope Tract	Mokelumne River	Beaver Slough		19.6	17.7	18.0		5.0	26.0	
590+00	Beaver Slough			21.2							24.2
652+50	Canal Ranch	Beaver Slough	Hog Slough				16.9		5.0	24.9	
715+00	Hog Slough										
765+00	Brack Tract	Hog Slough	Sycamore Slough				16.2		5.0	24.2	
815+00	Sycamore Slough			17.7							20.7
897+50	Terminous Tract	Sycamore Slough	Upland Canal				15.2		5.0	23.2	
980+00	Upland Canal / North Guard Road										
1012+50	Shin Kee Tract	Upland Canal	White Slough				13.3		5.0	21.3	
1045+00	White Slough			15.4							18.4
1122+50	Kinkg Island	White Slough	Disappointment Slough				14.4		5.0	22.4	
1200+00	Disappointment Slough			15.3							18.3
1287+50	Rindge Tract	Disappointment Slough	San Joaquin River				13.7		5.0	21.7	
1375+00	San Joaquin River			15.3				10.6			18.3
1610+00	Roberts Island	San Joaquin River	Middle River			15.8	11.1		5.0	23.8	
1845+00	Middle River			15.2							18.2
2005+00	Union Island	Middle River	Old River			16.6	14.9		5.0	24.6	
2165+00	Old River			14.6							17.6
2230+00	Byron Tract 2	Old River	Jones PP			16.5			5.0	24.5	
2310+00			Banks PP			16.5			5.0	24.5	

Note: * Design Embankment Flood Protection is the highest elevation of floodplain, island and tidal flooding water surface elevation plus wind-wave runup and 3 feet of freeboard protection.

** Design River Crossing Flood Protection is the highest elevation of Sacramento River and stream flooding water surface elevation plus 3 feet of freeboard protection.

Table 17. ICF-WEST: Recommended Flood Protection for Design Embankment and River Crossings With Sea Level Rise

Station	Location	From	To	200-year Streams Flooding WSE	200-year Sac River Flooding WSE	200-year Floodplain Flooding WSE	200-year Island Flooding WSE	Tidal Flooding WSE	Wind-Wave Runup	Recommended Design Embankment Flood Protection*	Recommended Design River Crossing Flood Protection**	
				NAVD88 (ft)	NAVD88 (ft)	NAVD88 (ft)	NAVD88 (ft)	NAVD88 (ft)	(ft)	NAVD88 (ft)	NAVD88 (ft)	
-34+43	Sacramento River near Babel Slough			36.9	31.7			11.1			39.9	
100+00	Lisbon District	Sacramento River	Winchester Lake			28.1	25.2		5.0	36.1		
195+00	Winchester Lake											
525+00	Netherlands	Winchester Lake	Miner Slough			18.6			5.0	26.6		
855+00	Miner Slough			20.6							23.6	
1077+50	Ryer Island	Miner Slough	Sacramento River			17.4	21.5		5.0	29.5		
1300+00	Sacramento River				16.6			10.8			19.6	Tunnel
1400+00	Brannan-Andrus Isla	Sacramento River	Sevenmile Slough			13.7			5.0	21.7		Tunnel
1550+00	Twitchell Island	Sevenmile Slough	San Joaquin River			13.0			5.0	21.0		Tunnel
1600+00	San Joaquin River							10.6			13.6	Tunnel
1665+00	Bradford Island	San Joaquin River	False River						5.0			Tunnel
1730+00	False River											Tunnel
1807+50	Bethel Island	False River	Dutch Slough						5.0			Tunnel
1885+00	Dutch Slough											
1942+50	Hotchkiss Tract 1	Dutch Slough	Contra Costa Canal						5.0			
2000+00	Contra Costa Canal			13.6							16.6	
2350+00	Bryon Tract 1	Highway 4	Bryon Tract Forebay			16.9			5.0	24.9		
2520+00		Bryon Tract Forebay	Jones and Banks PP	14.6			16.8		5.0	24.8		

Note: * Design Embankment Flood Protection is the highest elevation of floodplain, island and tidal flooding water surface elevation plus wind-wave runup and 3 feet of freeboard protection.

** Design River Crossing Flood Protection is the highest elevation of Sacramento River and stream flooding water surface elevation plus 3 feet of freeboard protection.

Table 18. TDF: Recommended Flood Protection for Design Embankment and River Crossings With Sea Level Rise

Station	From	To	200-year Streams Flooding WSE	200-year Sac River Flooding WSE	200-year Floodplain Flooding WSE	200-year Island Flooding WSE	Tidal Flooding WSE	Wind-Wave Runup	Recommended Design Embankment Flood Protection*	Recommended Design River Crossing Flood Protection**
			NAVD88 (ft)	NAVD88 (ft)	NAVD88 (ft)	NAVD88 (ft)	NAVD88 (ft)	(ft)	NAVD88 (ft)	NAVD88 (ft)
-335+00	Sacramento River at Upstream of Hood			25.9			11.1	2.5		28.9
-245+00	Hood	Snodgrass Slough		25.9	23.7	24.2		5.0	32.2	
-155+00	Snodgrass Slough		25.5							28.5
-45+00	Snodgrass Slough	Lost Slough		23.4	22.6	23.4		5.0	31.4	
65+00	Lost Slough									
85+00	Lost Slough	Mokelumne River		20.7	18.2	21.0		5.0	29.0	
105+00	Mokelumne River		22.0							
222+50	Mokelumne River	Beaver Slough		19.6	17.7	18.0		5.0	26.0	
340+00	Beaver Slough		21.2							24.2
460+00	Beaver Slough	Sycamore Slough				16.9		5.0	24.9	
580+00	Sycamore Slough		17.7							20.7
820+00	Sycamore Slough	San Joaquin River						5.0		
1060+00	San Joaquin River		14.3				10.6			17.3
1470+00	San Joaquin River	Victoria Canal			16.6			5.0	24.6	
1880+00	Victoria Canal		15.2							18.2
2010+00	Victoria Canal	Old River			16.5	14.9		5.0	24.5	
2140+00	Old River		14.6							17.6
2190+00	Clifton Court Forebay	Old River			16.5			5.0	24.5	

Note: * Design Embankment Flood Protection is the highest elevation of floodplain, island and tidal flooding water surface elevation plus wind-wave runup and 3 feet of freeboard protection.
** Design River Crossing Flood Protection is the highest elevation of Sacramento River and stream flooding water surface elevation plus 3 feet of freeboard protection.

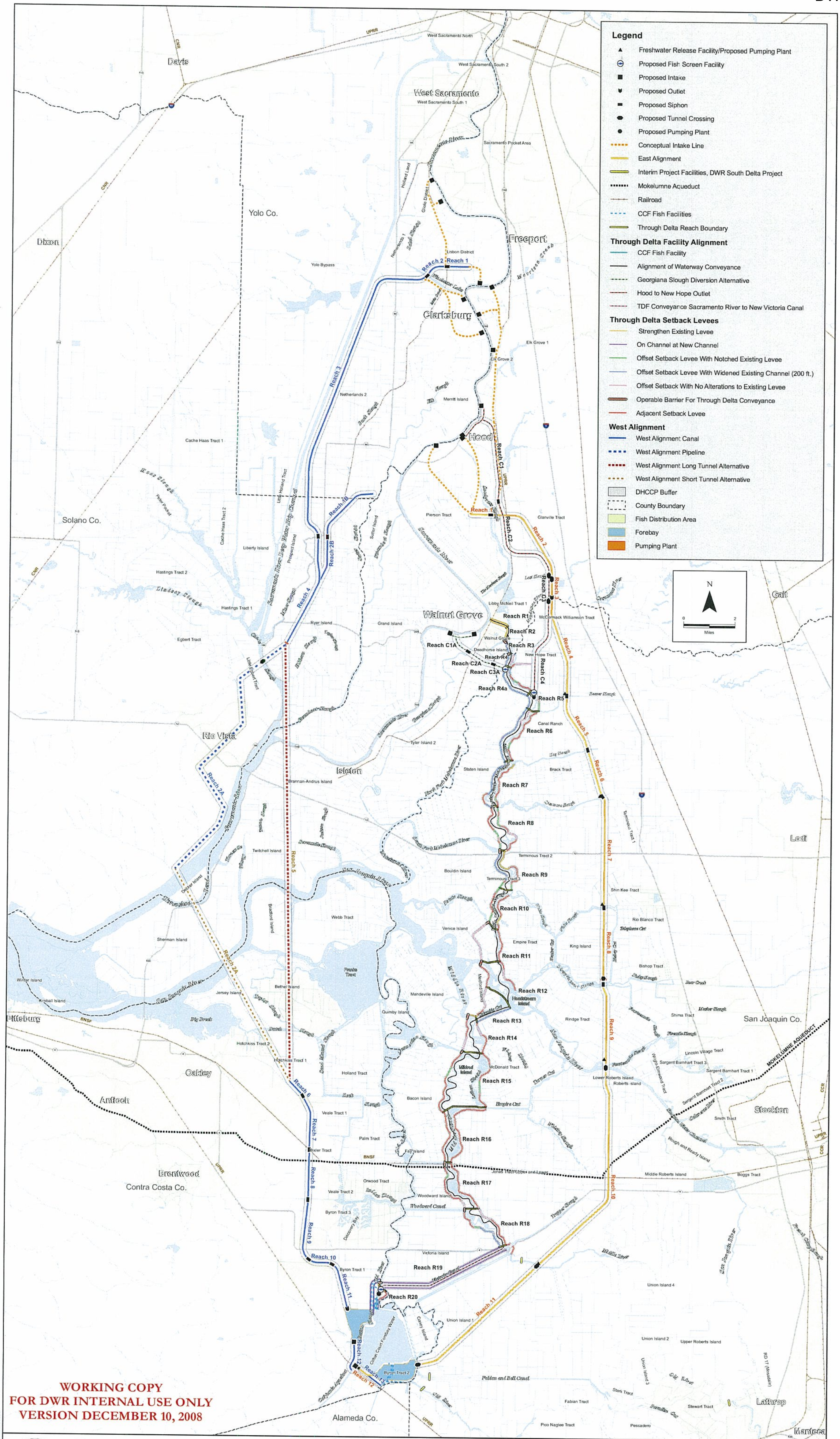

Figure 1: **Delta Habitat Conservation & Conveyance Program**
All Alignments Overview

DHCCP Washington Team

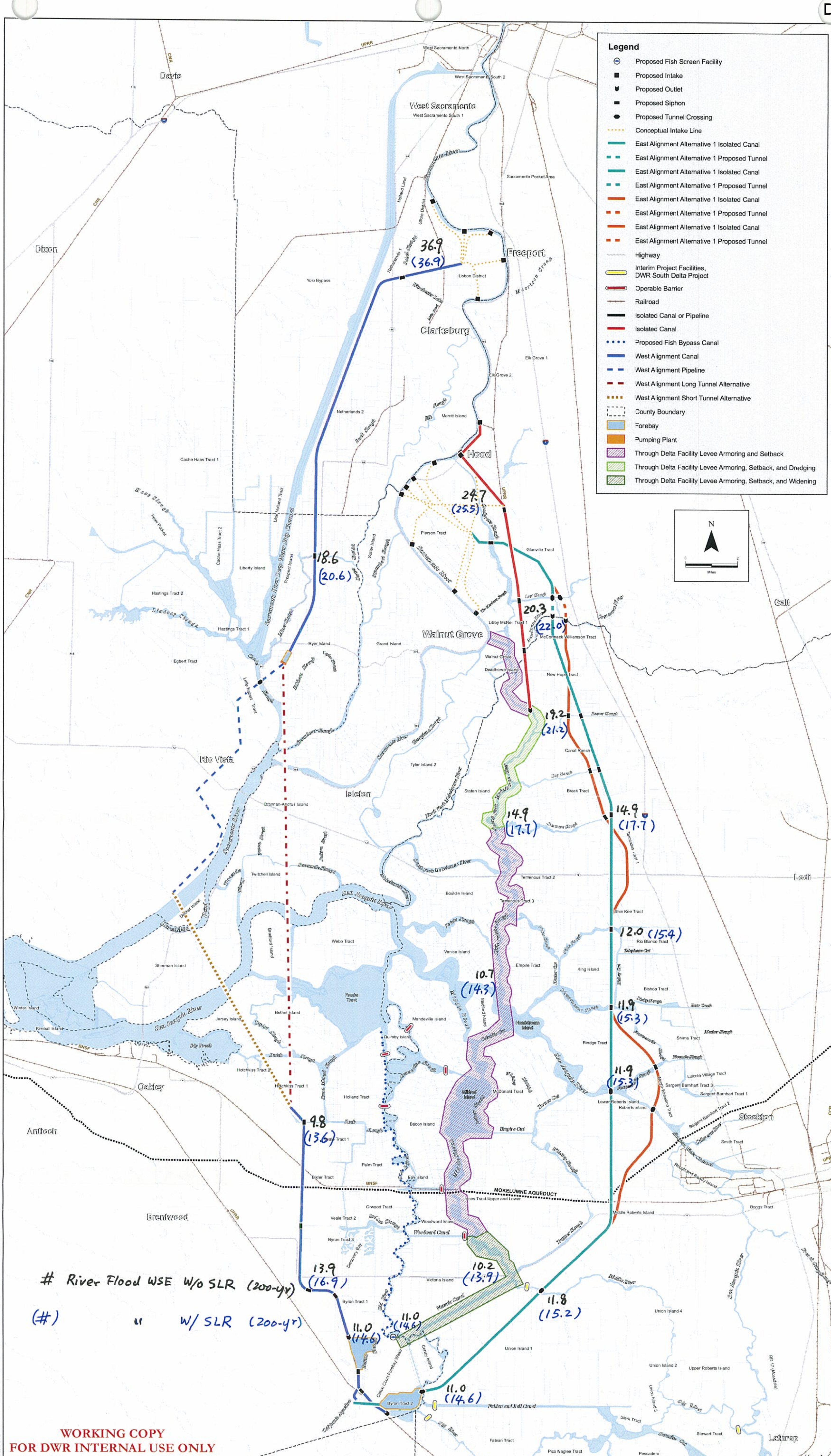

Figure 2: River Flooding Water Surface Elevations (Streams and Tribs)

DHCCP Washington Team

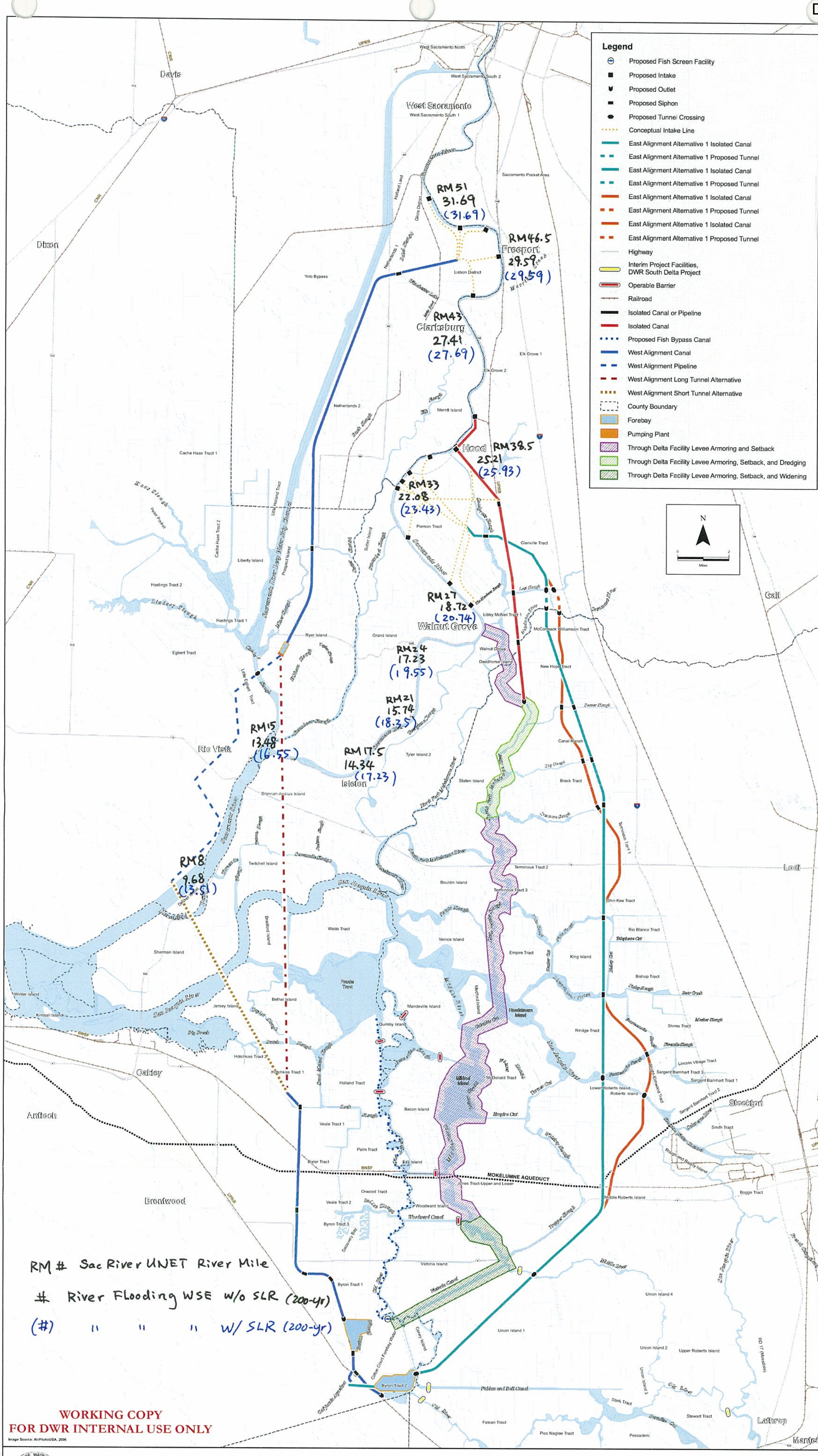

Figure 3 River Flooding Water Surface Elevations (Sacramento River)

DHCCP Washington Team

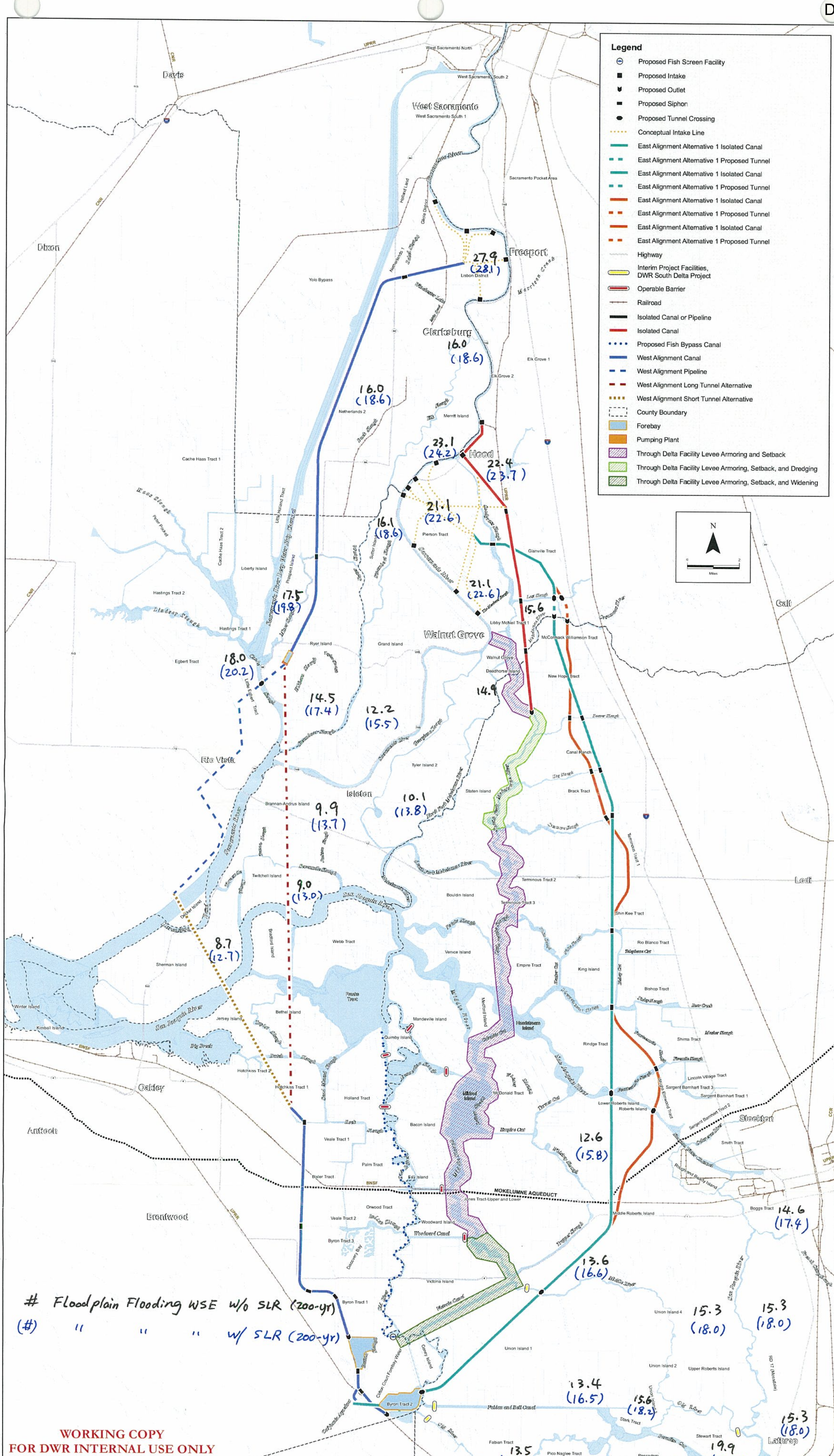

Figure 4: Floodplain Flooding Water Surface Elevations

DHCCP Washington Team

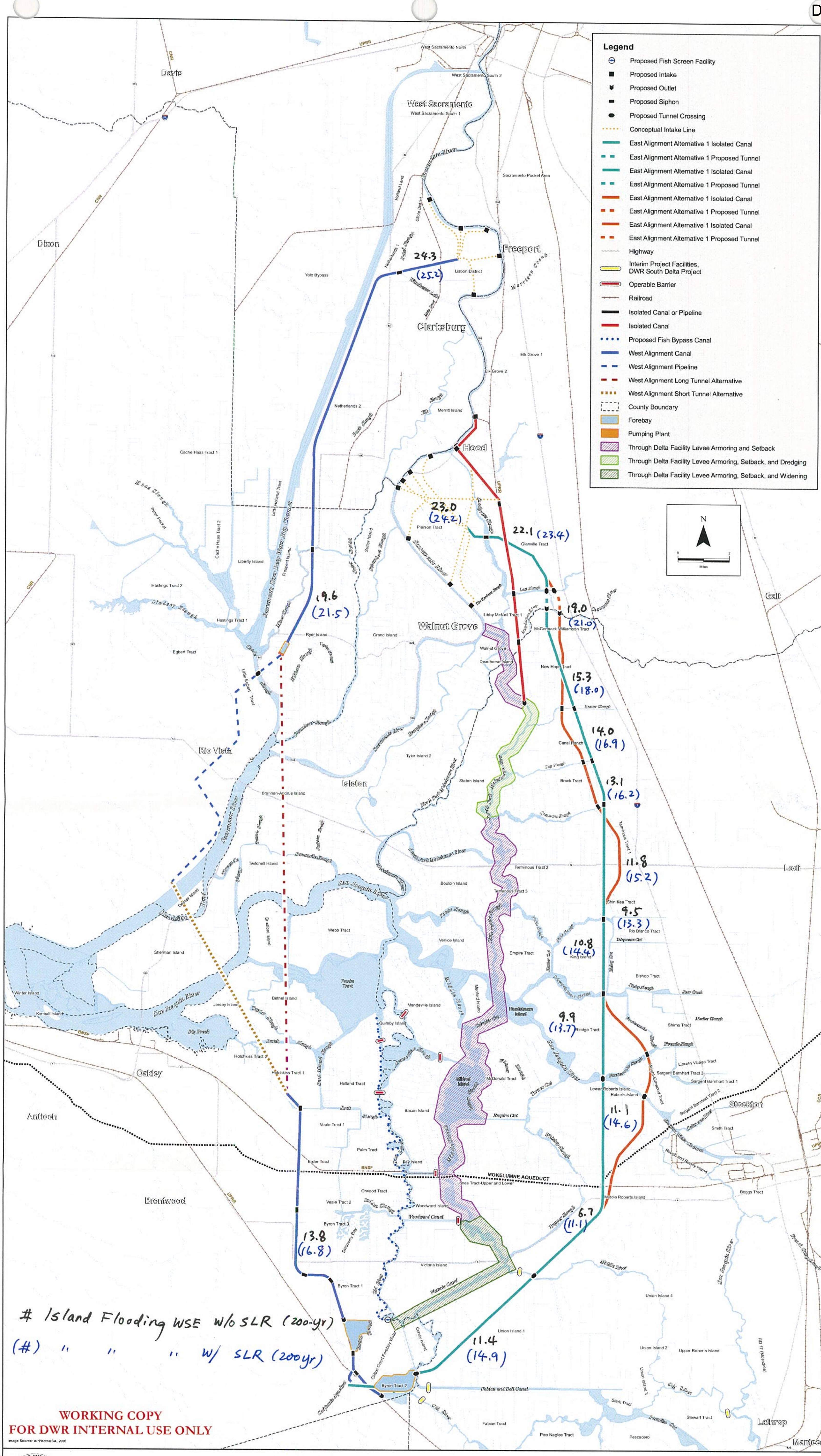

Figure 5: Island Flooding Water Surface Elevations

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DWR-661

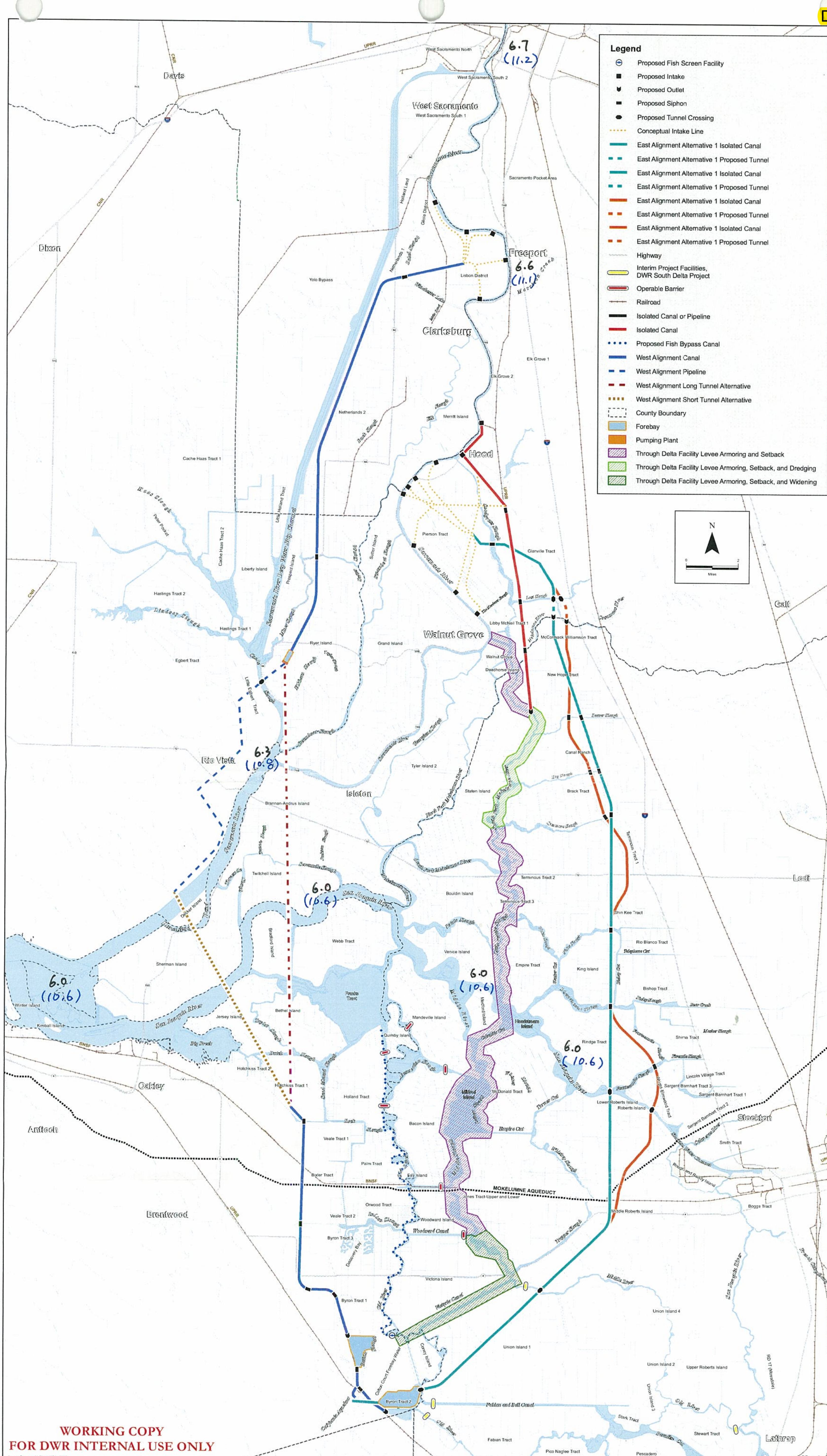

Figure 6: Tidal Flooding Water Surface Elevations

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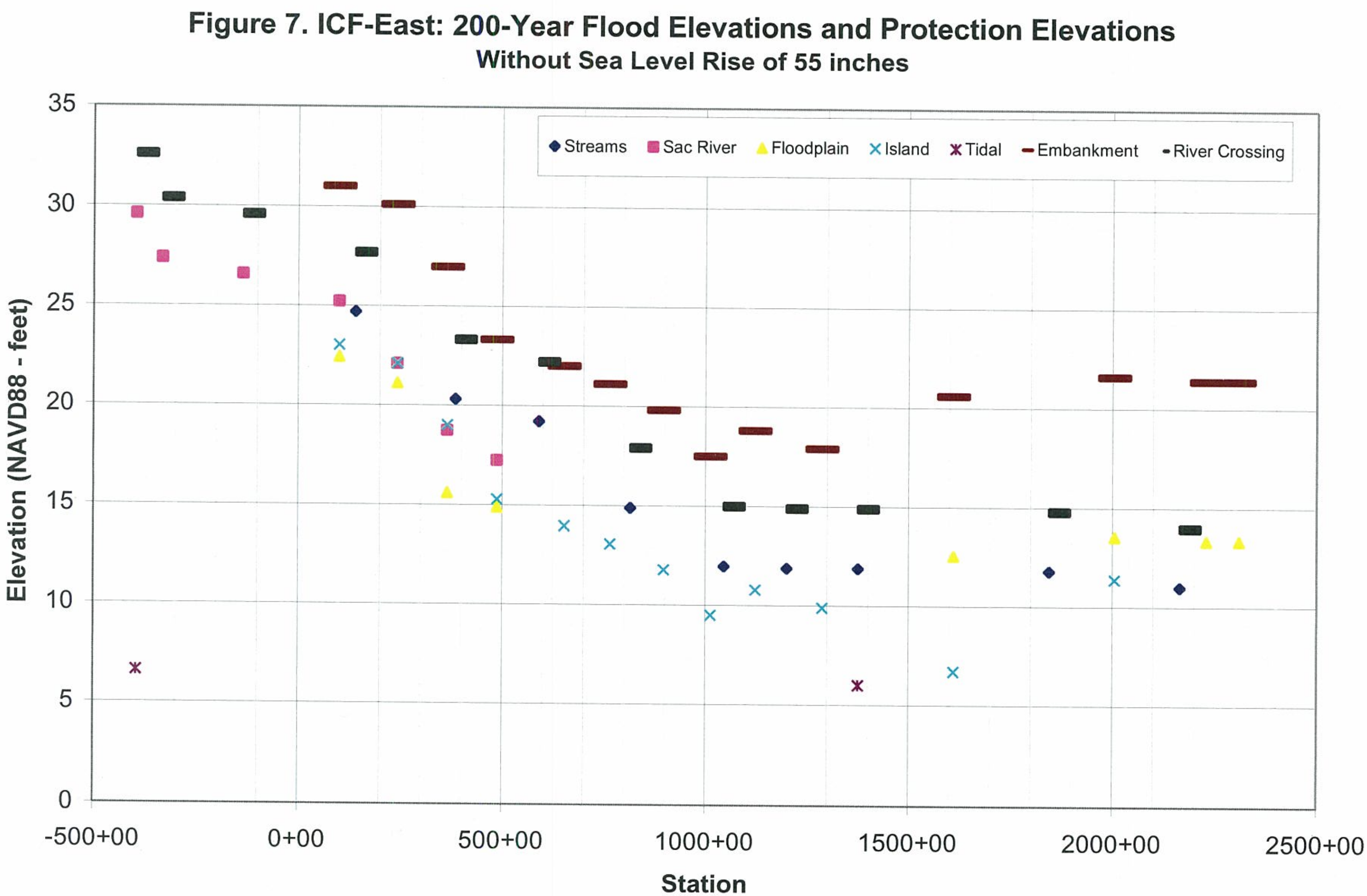


Figure 7. ICF-East: 200-Year Flood Elevations and Protection Elevations
Without Sea Level Rise of 55 inches
Streams
Sac River
Floodplain
Island
Tidal
Embankment
River Crossing
Elevation (NAVD88 - feet)
35
30
25
20
15
10
5
0
-500+00
0+00
500+00
1000+00
1500+00
2000+00
2500+00
Station

Figure 8. ICF-West: 200-Year Flood Elevations and Protection Elevations

Without Sea Level Rise of 55 inches

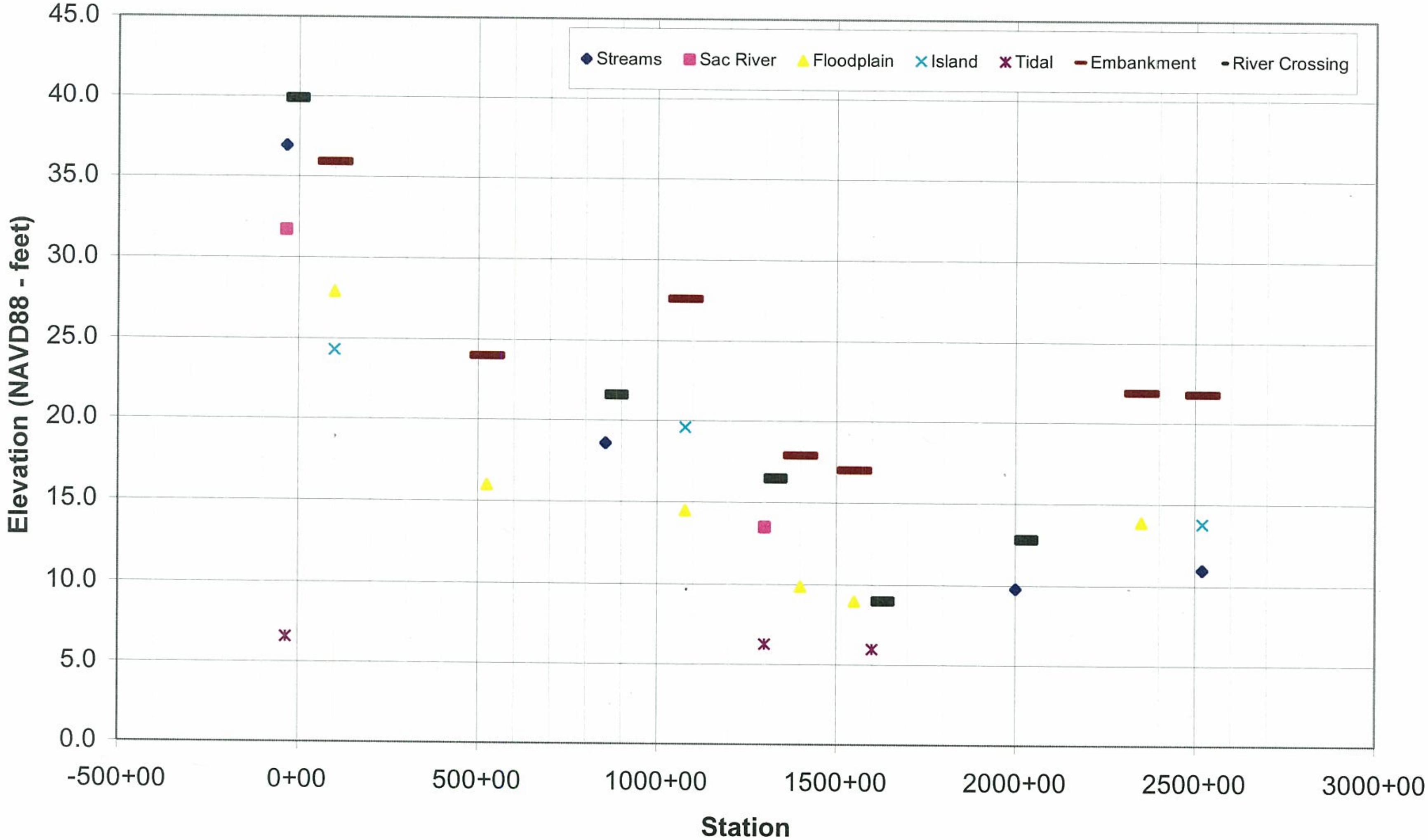


Figure 9. TDF: 200-Year Flood Elevations and Protection Elevations
Without Sea Level Rise of 55 inches

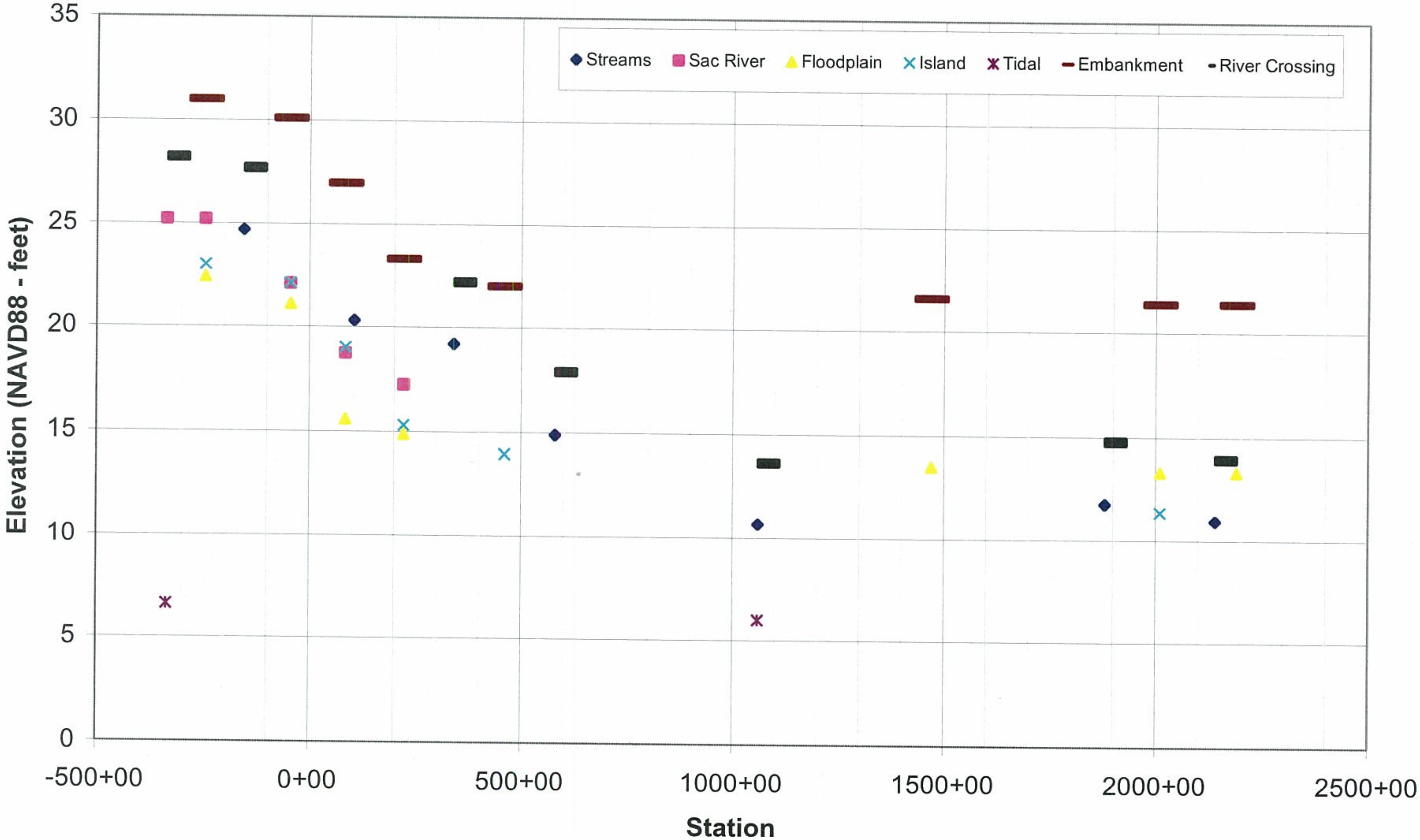
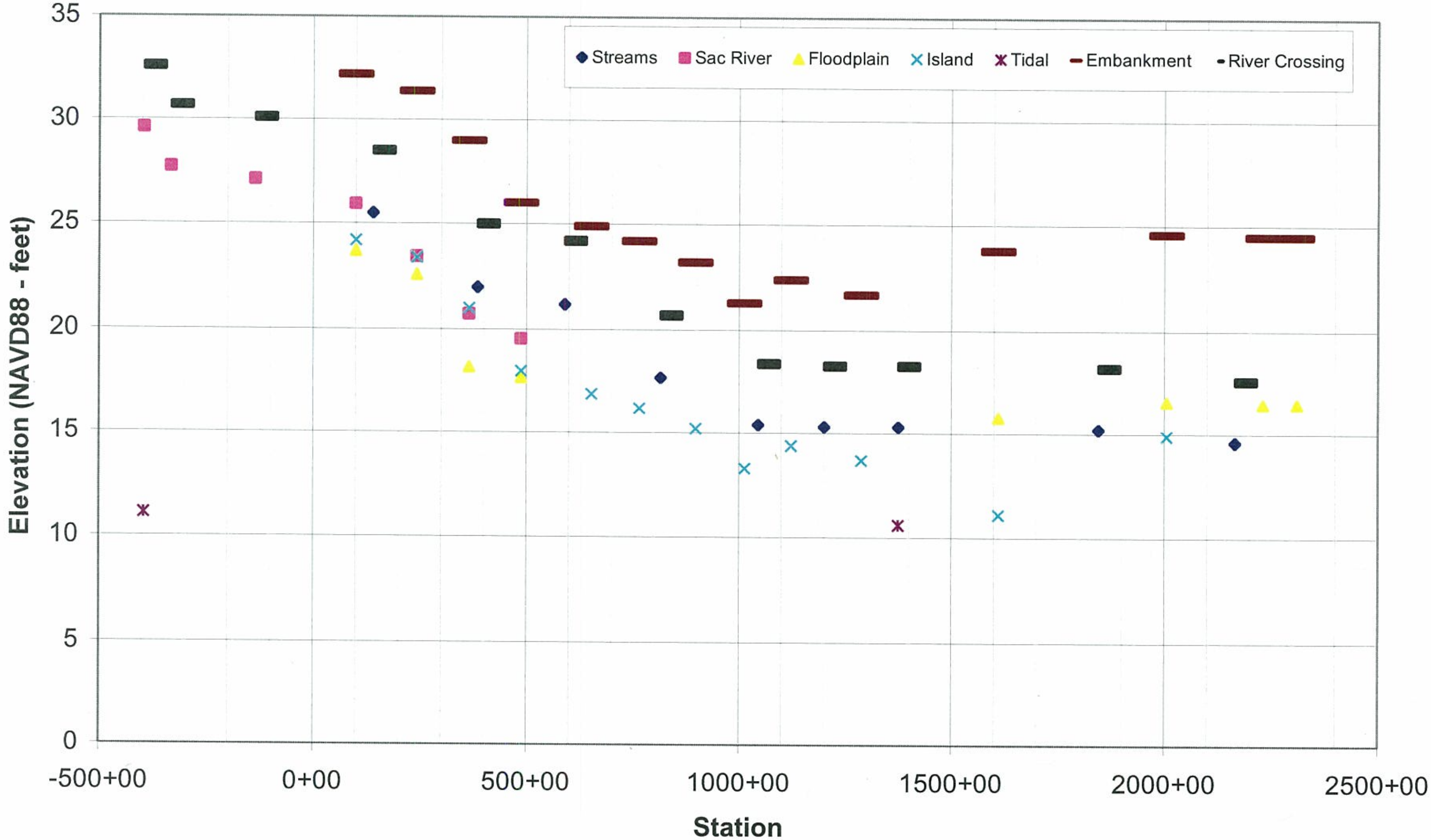


Figure 10. ICF-East: 200-Year Flood Elevations and Protection Elevations

With Sea Level Rise of 55 inches



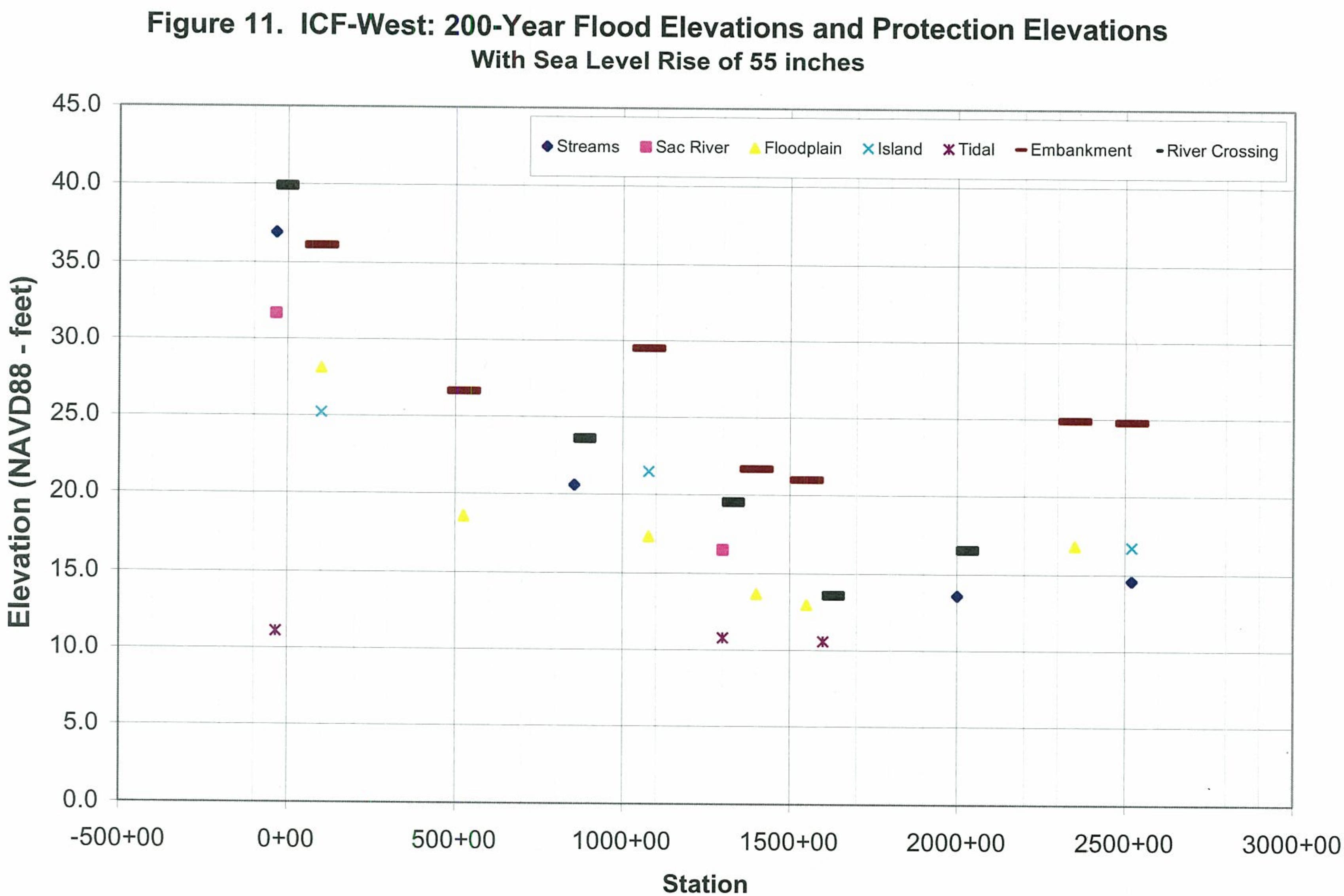


Figure 11. ICF-West: 200-Year Flood Elevations and Protection Elevations
With Sea Level Rise of 55 inches
Streams
Sac River
Floodplain
Island
Tidal
Embankment
River Crossing
Elevation (NAVD88 - feet)
45.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
-500+00
0+00
500+00
1000+00
1500+00
2000+00
2500+00
3000+00
Station

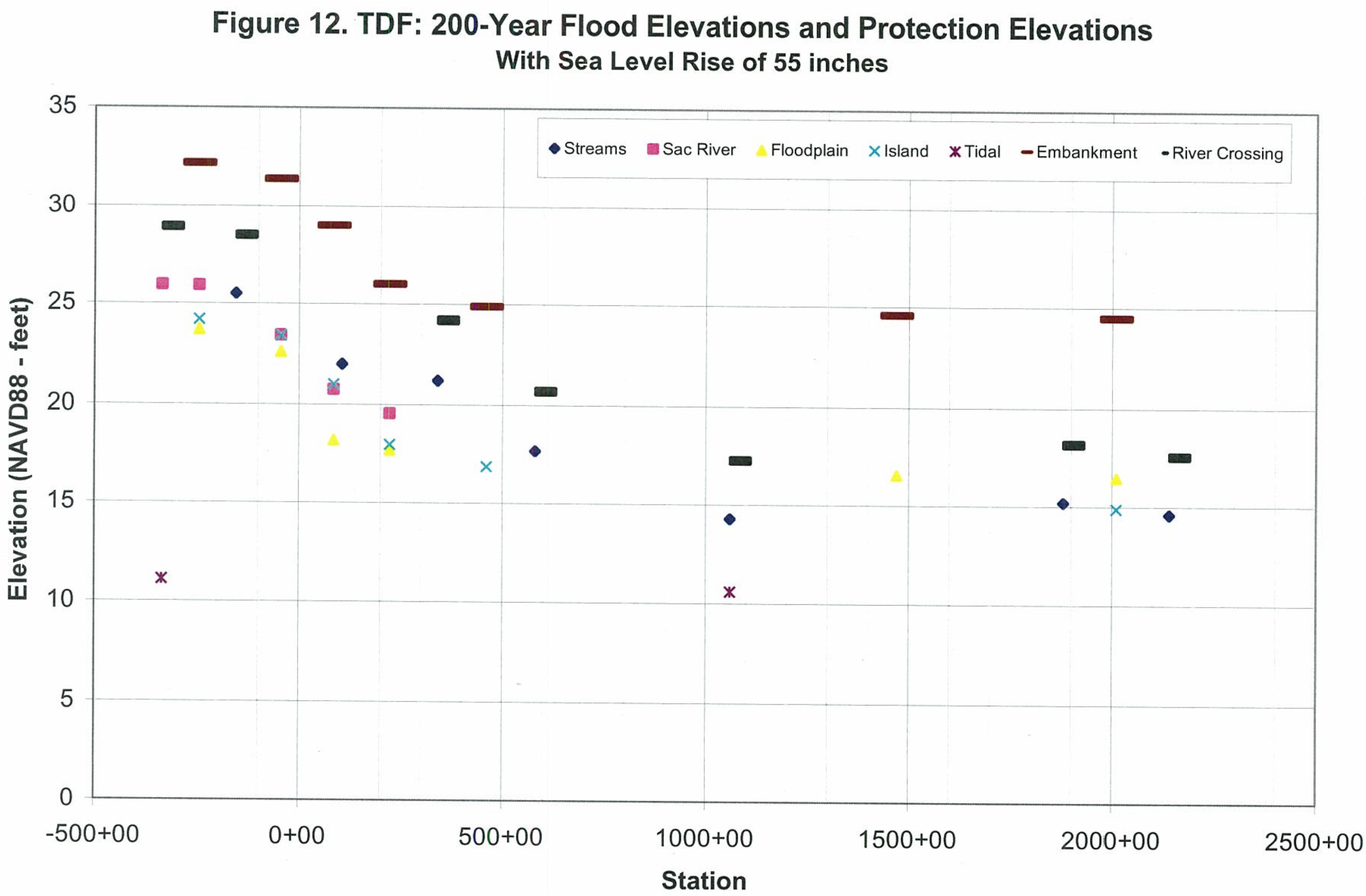


Figure 12. TDF: 200-Year Flood Elevations and Protection Elevations
With Sea Level Rise of 55 inches
Streams
Sac River
Floodplain
Island
Tidal
Embankment
River Crossing
Elevation (NAVD88 - feet)
35
30
25
20
15
10
5
0
-500+00
0+00
500+00
1000+00
1500+00
2000+00
2500+00
Station