Delta Tidal Datum: Determination & Methodology

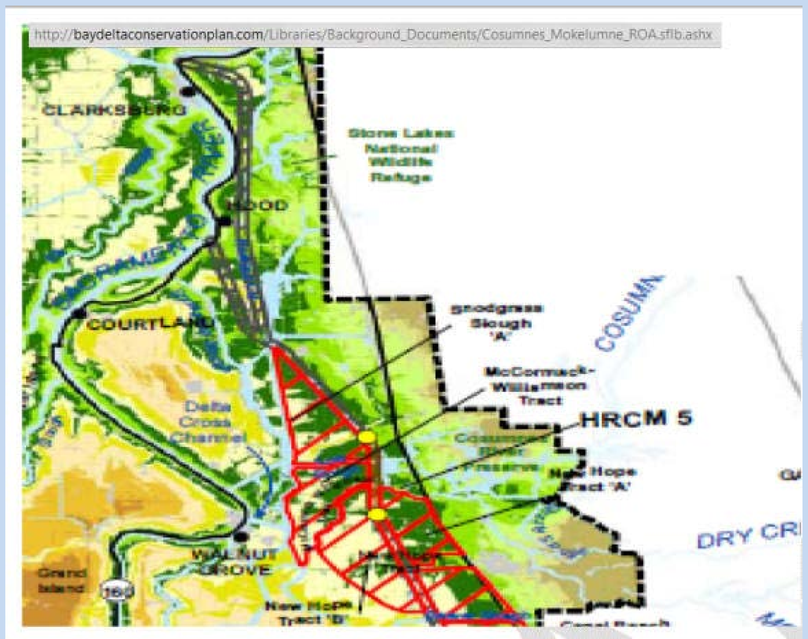
Joel Dudas (California Department of Water Resources), Stuart Siegel (San Francisco State University), Chris Enright (San Francisco State University), Bradley Tom (California Department of Water Resources), Jeff Galef (California Department of Water Resources)

Abstract: Tidal datums are of critical importance in estimating current typical Delta tide stages for use in water resource and ecosystem restoration planning and implementation projects.. We are developing a standardized data tidal datum product that is developed synthetically for all Delta channels for use as a baseline condition. Also, the methodology is non-trivial, and the methodology will need to be utilized again whenever studying effects from changes that occur in the Delta hydrodynamic channel network due to future sea level rise and levee breaching scenarios. The methodology therefore requires peer reviewed scrutiny so that future comparative analyses of scenario evaluations against the current baseline are considered to be reasonable and consistent.

Franks Tract

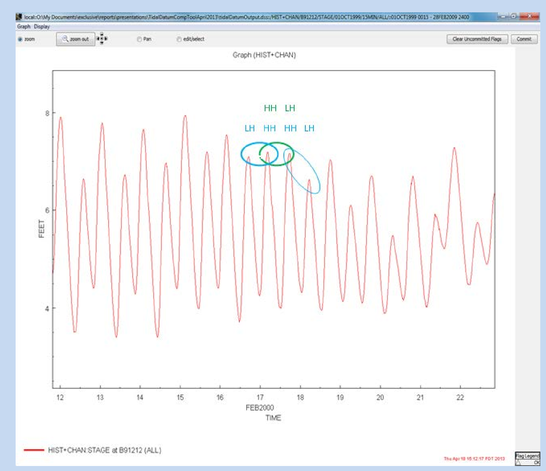
Lower Sherman Lake

Importance: The above graphic illustrates why accurate estimates of water levels are crucial to success of restoration. Both photos depict once-reclaimed lands that flooded in the first half of the twentieth century due to levee failure, and then were left submerged. At left, Franks Tract has remained an open-water body dominated by submerged aquatic plants. At right, Lower Sherman Lake is an ever-growing intertidal marsh with a large network of self-organizing dendritic channels. Lower Sherman Lake's elevations overlapped with water levels describable by the tidal datum, whereas Franks Tract was too deep. Environmental planners that seek to identify good areas with higher likely restoration success need to be able to intersect water level estimates with elevations that overlap (as occurred naturally at Lower Sherman Lake). One such effort that received attention during the BDCP process was the "bathtub ring", as shown below, that identified potential intertidal restoration sites. The values used for water levels can drastically influence such planning data by shifting areas identified by their intersection of current terrestrial elevations with future potential tidal datum components, illustrating the importance of estimating such water levels properly.



Method: A few years ago, DWR technical staff began producing a draft tidal datum product for the entire Delta and Suisun Marsh. RMA model output was used to generate simulated hydrology at over 33,000 node points. The historical time period of 2000-2004 was used for input conditions, and the effect of riverine inputs from storms was removed. The derived data were then subjected to an extraction technique to generate the point data products. The point data includes 11 components of the tidal datum, and were calculated for various water management operations conditions for the Delta (DCC open/closed, temporary barriers in/out, and all data combined). Those data were then used as input for breakline-controlled interpolations to generate GIS grids of water surfaces. The grids were generated for each of the tidal datum components and water management operation control sets, resulting in 55 separate data sets for each format type (5 conditions x 11 components).

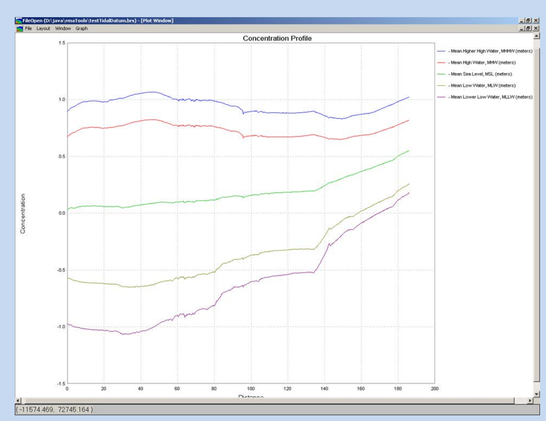
It is crucial to understand that future changes will occur to Delta hydrology as a result of islands left submerged after levee failures, as a result of restoration projects involving levee breaching, sedimentation/erosion dynamics, and sea level rise. In order to compare impacts from such scenarios, an "apples-to-apples" analysis is required. Peer review of the methodology used here is therefore a vital component of this effort.



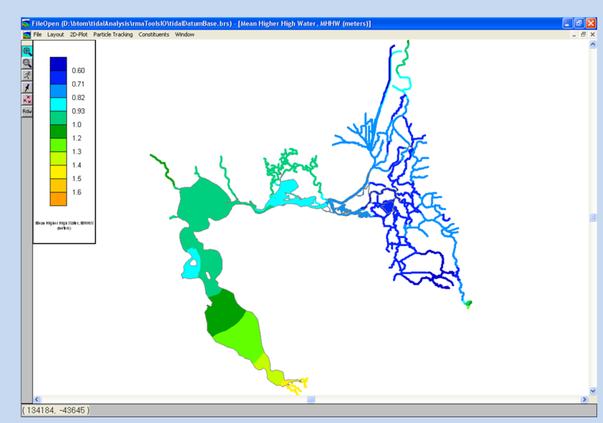
Hydrology data from 2000-2004 were selected, high riverine input periods were removed, and tidal datum components were extracted.

Constituent #	Tidal Datum	Abbreviation	Computation
1	Mean Higher High Water	MHHW	Average of all highs
2	Mean High Water	MHW	Average of all highs
3	Mean Sea Level	MSL	Average of all values
4	Mean Low Water	MLW	Average of all lows
5	Mean Lower Low Water	MLLW	Average of all low lows
6	Mean Tide Level	MTL	Average of MHW and MLW
7	Diurnal Tidal Level	DTL	Average of MHHW and MLLW
8	Mean Range	Mn	MHW – MLW
9	Diurnal High Water Inequality	DHQ	MHHW – MHW
10	Diurnal Low Water Inequality	DLQ	MLW – MLLW
11	Great Diurnal Range	Gt	MHHW – MLLW
12	Extreme High Water	EHW	Max stage

11 components of the tidal datum were estimated in order to provide more insight into the hydrological characterization of the channels.



The above is an extraction of tidal datum components along a line running from the Golden Gate up the Sacramento River to Freeport. This essentially shows the change in the tidal prism as one proceeds up-estuary.



GIS grids and point data files are available as final output. The data can be used to display the overall heights of the tidal datum components throughout the estuary, or supply queryable data at specific locations of interest.

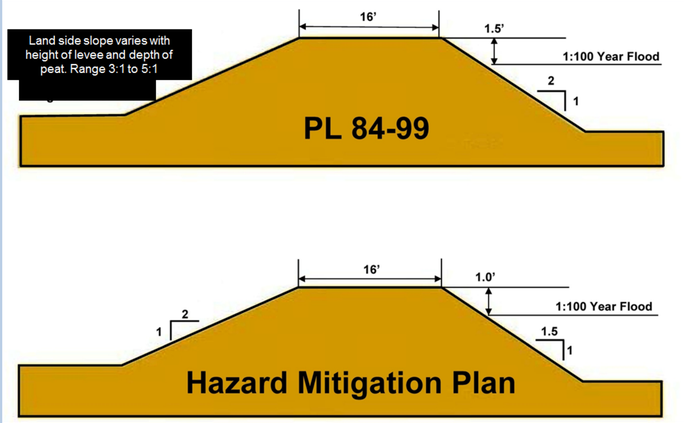
Delta 100-Year Hydrology Modernization

Joel Dudas (California Department of Water Resources), Melissa Hallas (US Army Corps of Engineers),
John High (US Army Corps of Engineers), Jeff Galef (California Department of Water Resources)

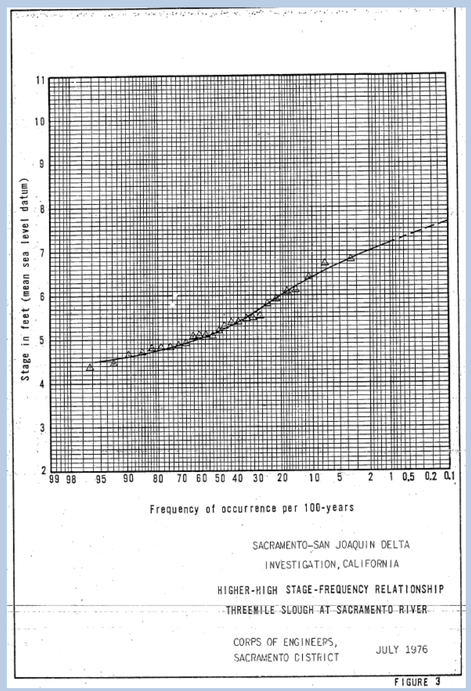
Abstract: 100-year stages are a critical data component for the design of all Delta levees, as levee standards include geometry requirements that are hinged to the 100-year stage. Compliance with geometry standards affects post-disaster assistance eligibility, as well as utility of future investments for proposed levee projects. The sustainability of the entire Delta levee system is also shaped by estimated levels of risk that correspond to 100-year stages. The current stages in use were determined using data collected at tide stations from the period between 1945-1974. With a longer data record, a larger number of better distributed stations, use of new hydrodynamic models, and a more modern geodetic datum, a better estimate of the stages is now possible. DWR and USACE will work together to develop a modernized stage analysis.

Problem: 100-year stages are a crucial dataset for the design of the entire Delta levee system and for specific Delta levees. Differences in estimates of 100-year stage can be the difference between whether project funding happens, whether levees fail or not, and whether flooded islands receive post-disaster assistance. The existing official stages are extremely out-of-date, referenced to obsolete vertical control, and are poorly distributed spatially. The official hydrology is stipulated in an agreement between FEMA and the State of California in 1987, and relies on an analysis from the Corps of Engineers published in 1976. The derived stage-frequency curves were therefore derived from records from less than 30 years of older data, which is a somewhat short period of time to statistically estimate 100-year stages, and is biased by the decadal-scale rainfall/storm frequency pattern from the period of record. Furthermore, while California Public Resources Code stipulates NAVD88 as the geodetic datum to be used on projects, the current stages are referenced to the NGVD29 vertical datum.

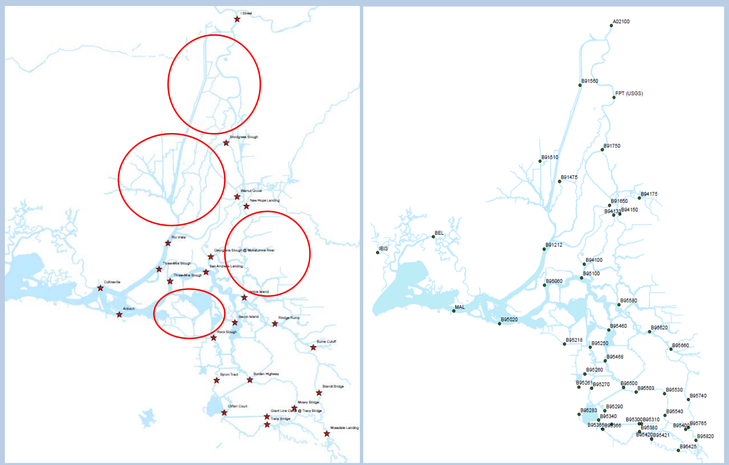
Solution: Many of these issues can be resolved if a new study is undertaken to re-estimate the stages. DWR and the Corps of Engineers have developed a Letter of Agreement, whereby DWR is committing approximately $760,000 in Proposition 1E funds under the Delta Knowledge Improvements Program, for the Corps of Engineers to undertake the technical work to perform the study. The work is expected to take 3 years, involve other agencies and Delta stakeholders, and provide an analysis that FEMA would utilize in any future post-disaster evaluations.



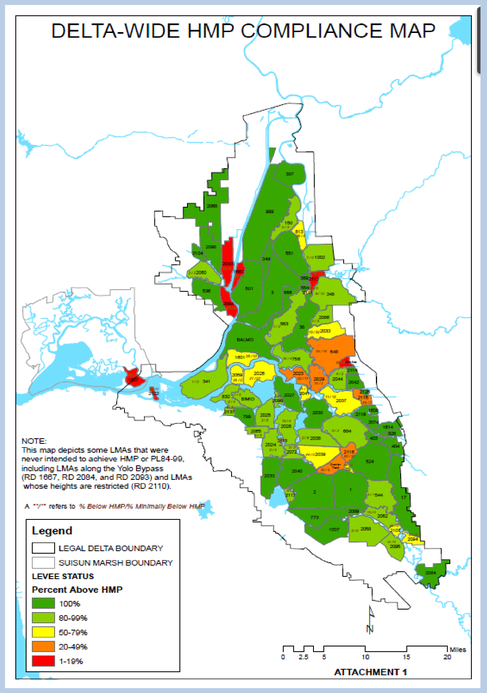
Due to the fact that historic eligibility for FEMA post-disaster assistance was directly tied to compliance with levee geometry standards, the 100-year stage drives the design of all Delta levees. Above, two such geometry standards are shown, and as can be seen, both are driven by the level of the 100-year stage.



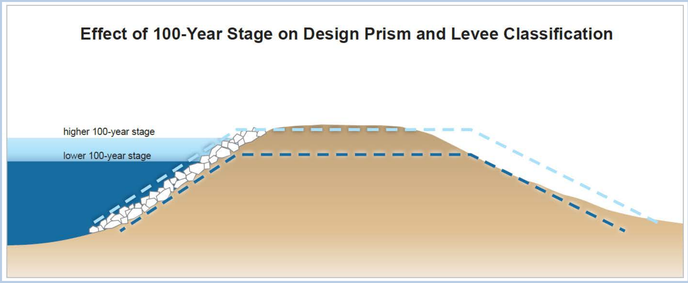
The current analysis plotted annual high water data from 1945-1974 and estimated a 100-year stage. This happens to correspond to the approximate period of black-and-white television broadcasting in the United States.



The original analysis relied upon using historical water level data from 24 tide gauges scattered around the Delta (shown above and at left). Data in areas between these 24 stations was interpolated. In many areas (shown in red circles in above left), significant gaps make any estimation problematic. The new analysis will use many more gauges (above right) and fill in many of these poorly-defined areas. Modeling will also be used to estimate stages in areas not covered by historic observed gauge data.



Regional analysis of levee geometry compliance has historically shaped perceptions about the sustainability of the Delta levees, as well as where future public investments may be prioritized. The 2012 map of HMP compliance performed by DWR and published by the Delta Stewardship Council is one such example.



The above is an extraction of tidal datum components along a line running from the Golden Gate up the Sacramento River to Freeport. This essentially shows the change in the tidal prism as one proceeds up-estuary.