# SACRAMENTO RIVER ECOLOGICAL FLOWS STUDY: HEC-RAS CROSS SECTIONS AND MATCHING STAGE-DISCHARGE CURVES FOR USE IN THE SACEFT V.2 MODEL OF RIPARIAN INITIATION

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# Table of Contents

# Table of Figures

## Executive Summary

Bed topography data from three cross sections (RM 192, 183, and 172) on the Upper Sacramento River, and their respective stage-discharge rating curves were used in the Sacramento River Ecological Flows Tool (SacEFT) v.1 to model cottonwood seedling initiation. Similar topographic and stage-discharge data were desired from additional locations. Cross section bed topography and related stage-discharge rating curves were developed from an existing HEC-RAS hydraulic model for the same three sites (RM 192, 183, and 172) and the results were compared with the initial data from SacEFT v.1. There was relatively good agreement between the original data and the data generated from the HEC-RAS model. The HEC-RAS model was then used to generate bed topography and related stage-discharge relationships for an additional nine sites on the Upper Sacramento River between River Miles 210 and 160. This memorandum documents the work done and the data developed for the nine additional sites.

## Background and overview

One of the primary recommendations by an advisory group on riparian dynamics modeling in SacEFT v.1 was to increase the representativeness of cross section profiles, stage-discharge relationships, and default parameter values associated with SacEFT's riparian initiation indicator (FC1). Any modeling that allowed cross sections of sufficient resolution along the channel face and floodplain could be used, if paired stage-discharge relations were available. Studies reported in this memo explored possible HEC-RAS cross-section and stage-discharge inventories to include more representative index locations; that is, to include sites beyond the classic point bars at RM 192, 183, and 172. In support of this effort, preliminary analyses of a HEC-RAS cross section at RM 192 suggested that the HEC-RAS cross sections were of adequate resolution and were adequately comparable to the cross sections that were used in EFT v.1 (ESSA, TNC, Stella, et al. conference call; Figure 1). The two other cross sections from SacEFT v.1 (RM 183 and 172) were analyzed in a similar manner and showed similar agreement between the cross sections taken from HEC-RAS and the ones measured by TNC (Figure 2 and Figure 3).

## Comparison of EFT v.1/HEC-RAS XS data

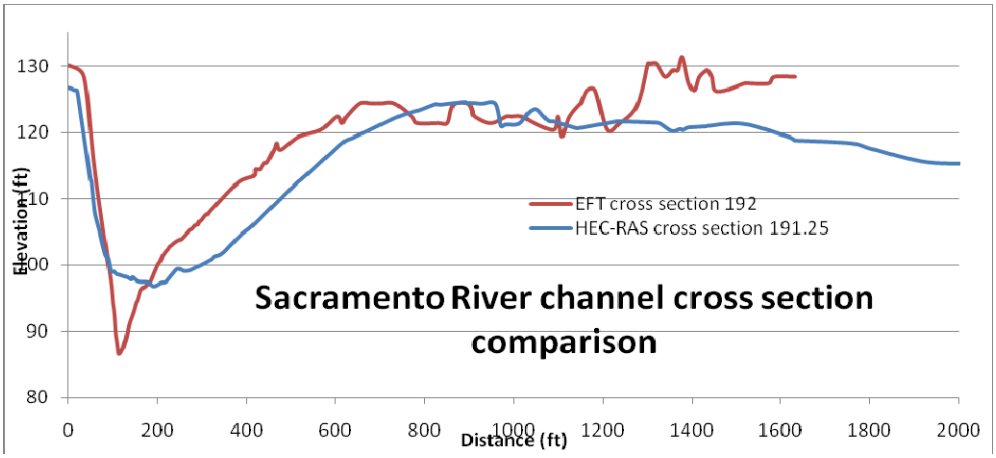



Figure 1 Cross section 192: EFT v.1 and HEC RAS XS data.

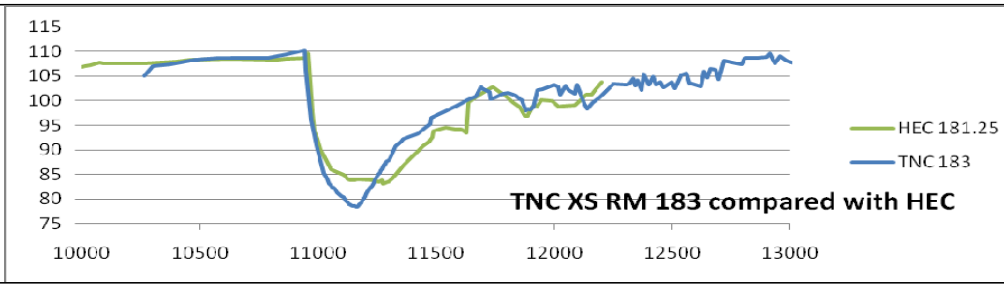



Figure 2 Cross section 183: EFT v.1 and HEC RAS XS data.

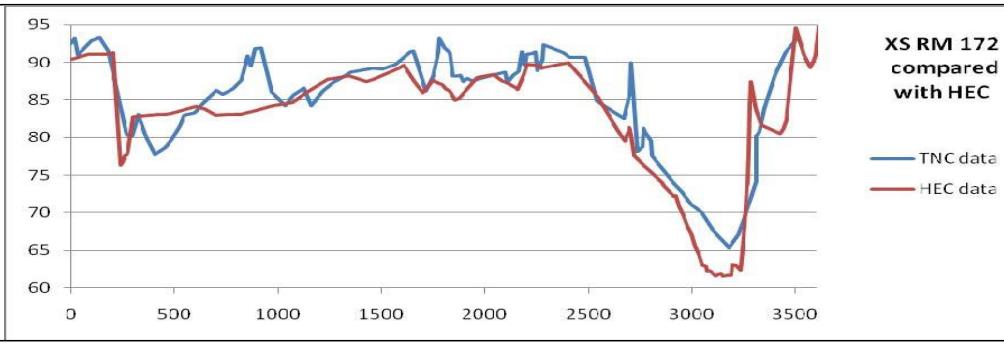



Figure 3 Cross section 172: EFT v.1 and HEC RAS XS data.

In order to match cross section locations as accurately as possible, GIS layers were visually inspected with DWR river mile designations for the locations of the TNC cross sections, and visually matched with the same locations on the HEC-RAS geometry-graphic (Appendix 1).

## Comparison of EFT v.1/HEC-RAS stage-discharge rating curves

The data that were available in the HEC-RAS model for each cross section included data that could produce a stage-discharge rating curve based on model runs performed for selected flows. In a phone discussion with an informal advisory group (Alexander, Larsen, Golet, Henderson), there was a question about the precision of the HEC-RAS modeled flows to produce useable rating curves. In order to investigate this issue, the rating curves for the three sites that were used in the EFT v.1 and the corresponding HEC-RAS modeled rating curves were plotted and compared on the same graph.

HEC-RAS flows were modeled from 5000 to 79,000 cfs (and up to 150,000, although this was not plotted in the following figures). The range of interest is roughly limited to the range between 8,500 and 80,000 cfs (Clint Alexander, pers. com.). Graphs of these data are shown in the following figures (Figure 4, Figure 5, and Figure 6).

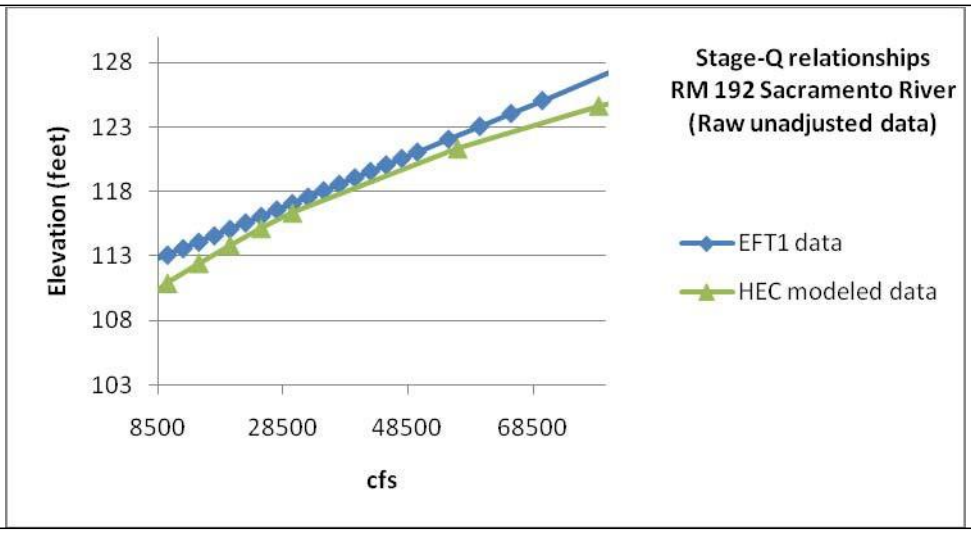



Figure 4 Cross section 192: EFT v.1 and HEC RAS stage-Q rating curve data.

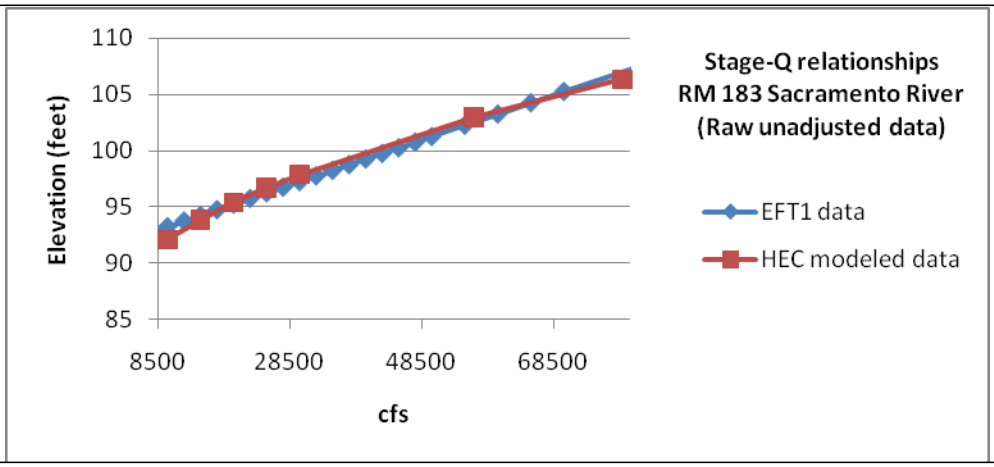



Figure 5 Cross section 183: EFT v.1 and HEC RAS stage-Q rating curve data.

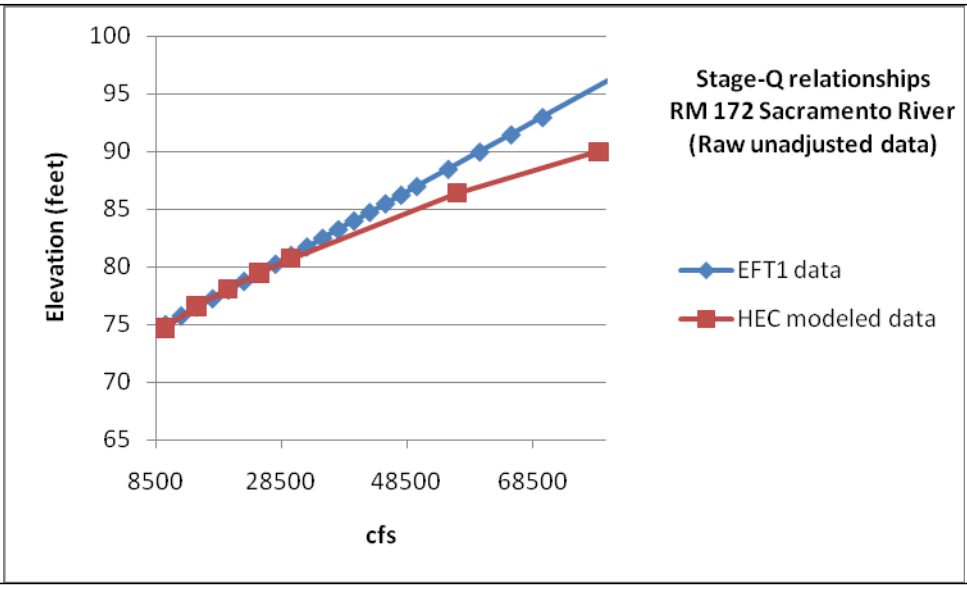



Figure 6 Cross section 172: EFT v.1 and HEC RAS stage-Q rating curve data.

The results of comparing the stage-discharge relationships (rating curves) as derived in these two different ways show that the EFT1 data were exact linear regressions, where the linear approximation was derived from observed data. For a brief discussion of these observed data, see Appendix 3. The HEC-RAS rating curves tend to be exponential, with the slope decreasing with increasing discharge, which is characteristic of observed stage-discharge rating curves.

## New cross sections and rating curves generated using HEC-RAS

Cross section locations were chosen based on discussions with an advisory group, and subsequent consideration of EFT v.2 needs. Most of the sites were chosen from a table provided by the advisory group (Appendix 2).

The sites that were depicted with the HEC-RAS data are not exact representations of sites that exist in the field today. The data from the HEC-RAS model consist of measured cross section bed topography from a former time period (still not identified[1]) and the **modeled rating curves that correspond to the observed bed topography**. It would be inappropriate to use the modeled rating curves with any other data than the ones for which they were derived – i.e. the cross section bed topography used in the HEC-RAS model, although some agreement is possible where the cross section bed topography matches (such as the test cases RM 192, 183, and 172).

The matched pairs of 1) cross-section bed topography data (from the model) and 2) modeled-rating-curves are good representations of the hydraulics at a complex point bar cross-section on this reach of the Sacramento River. The specific data (from the model) do not represent exact cross sections that may be on the river today; they do represent the flow-topography dynamics of representative cross sections from another time. Our comparisons showed that the cross sections that were originally measured by TNC (RM's 192,183, and 172) can be well approximated by cross sections from the HEC-RAS model that was used for developing the data at the nine additional locations. Furthermore, our comparisons with the TNC

[1] Note: to date, the exact metadata for the HEC-RAS data has not been identified (pers. Com. USACE, Sacramento District). It has been suggested that the data are post 1995 (Sacramento San Joachim Rivers Comprehensive Study) and pre-2007 (pers. Com. USACE, Sacramento District).

data also showed that the modeled rating curves linked with modeled cross sections appear to represent the flow-discharge relationship quite well.

In spite of the agreement at the three test sections, one conclusion of this reasoning is that it would not be effective to try to match the modeled data exactly to TNC or other contemporary field data. The modeled sections and *related* rating curves typify dynamics of point bars that are typical of this section of the river, but the modeled data may not exactly match currently existing cross section data.

A corollary to this conclusion is that it is not necessary, nor perhaps even most effective to use the exact locations that were chosen by the advisory work group for developing data from the model (Appendix 2). Although the majority of the nine sites were chosen from the advisory group data, in hindsight, this might not have been most effective. In many cases, the advisory group ignored sites with active point bars and good cottonwood activity because the sites were not on public land, and were therefore not easily accessible (Appendix 2); they also chose based on the fact that they were on public land although the sites were not the most representative of the cottonwood dynamics. With the current modeling effort, public access is not an issue. In the cross sections taken from the model, at least 2 (HR165 and HR164) were not first-choices taken from the advisory group list. The locations of the cross sections, both in the GIS format (and nomenclature) and in the HEC-RAS format and nomenclature are all shown in Appendix 4.

What is important for the purposes of modeling in the EFT v.2 are the cross sections and the associated rating curves, which are included in the following figures.

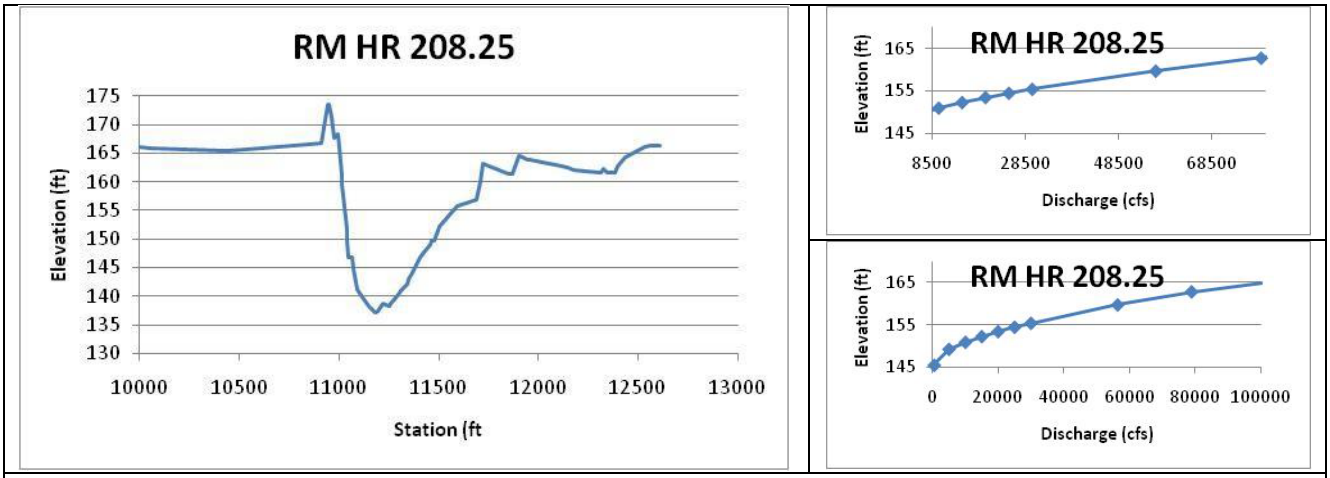
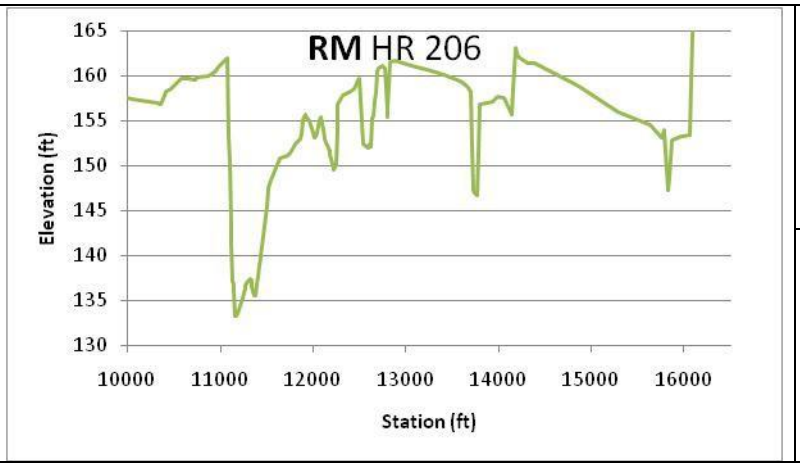
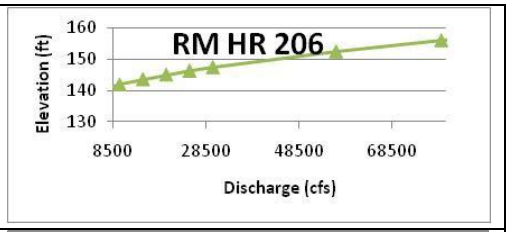



Figure 7 HR 208.25 cross section bed topography and rating curves



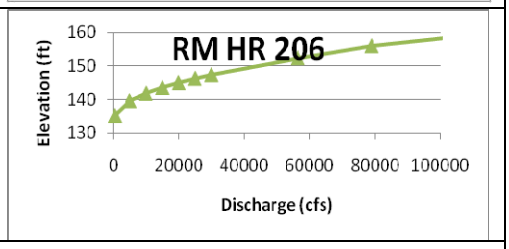
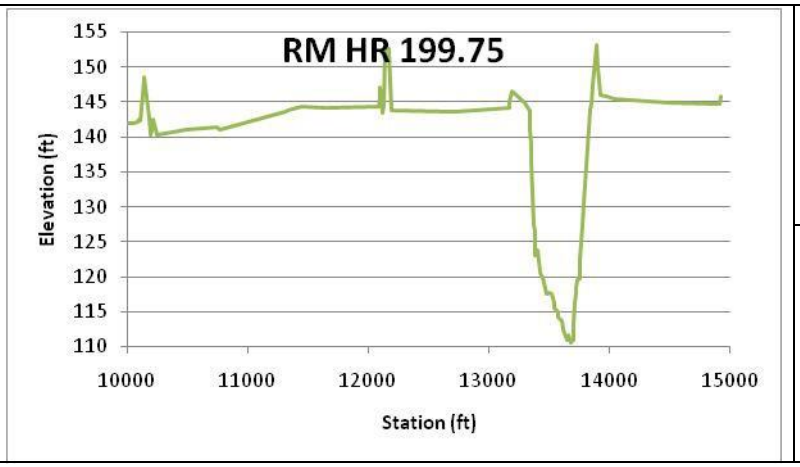
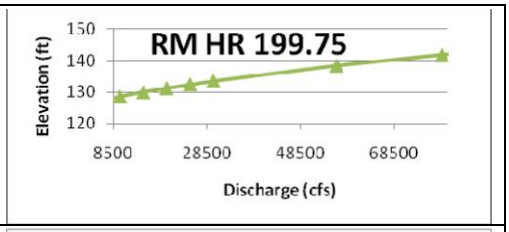




Figure 8 HR 206 cross section bed topography and rating curves



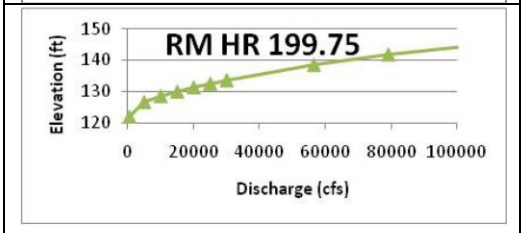




Figure 9 HR 199.75 cross section bed topography and rating curves

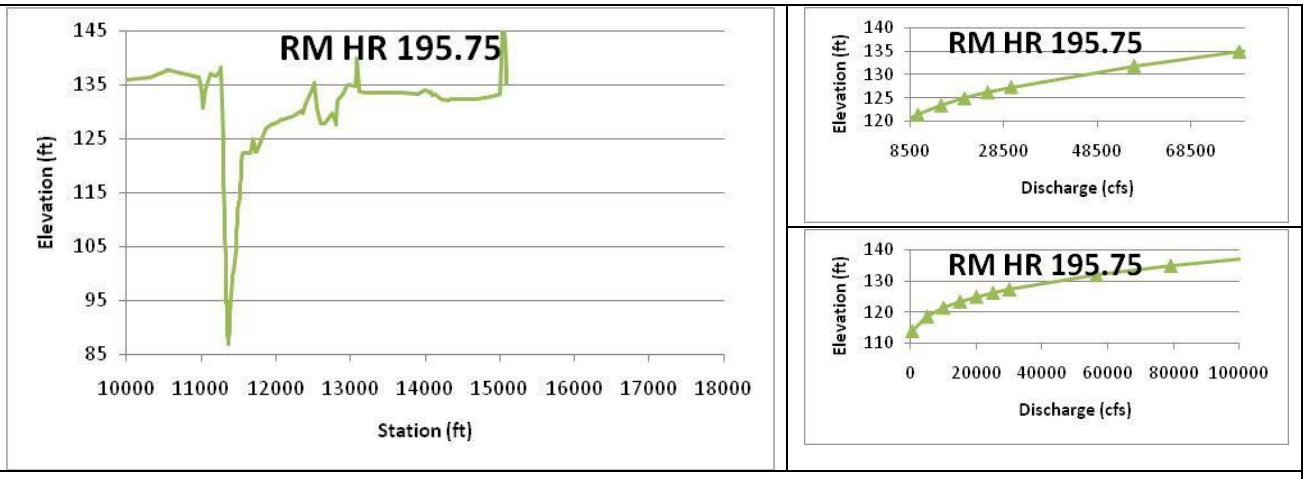



Figure 10 HR 195.75 cross section bed topography and rating curves

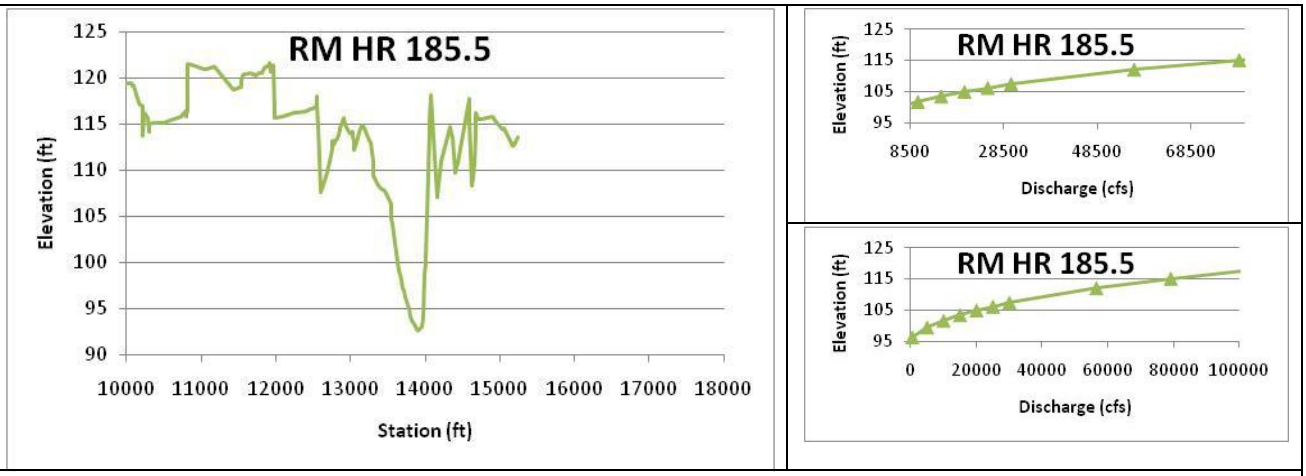
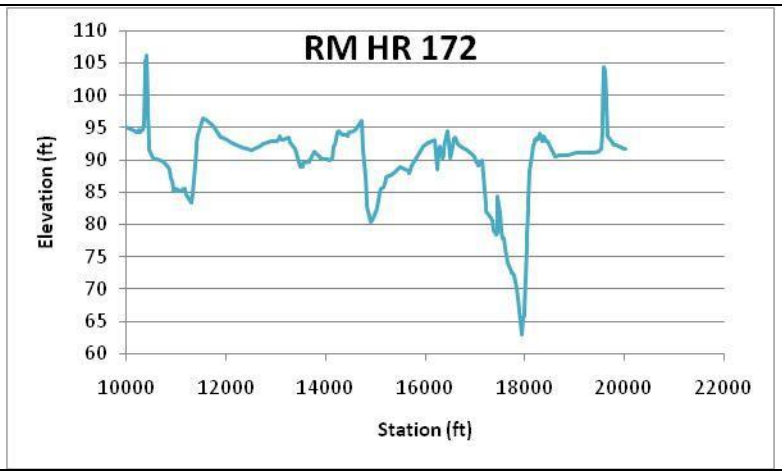
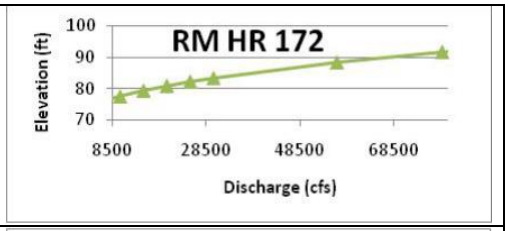



Figure 11 HR 185.5 cross section bed topography and rating curves



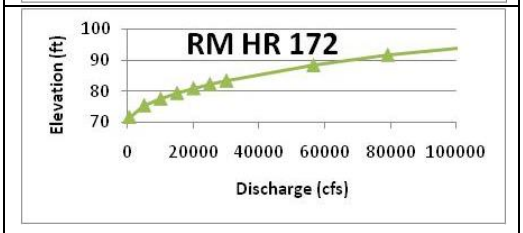
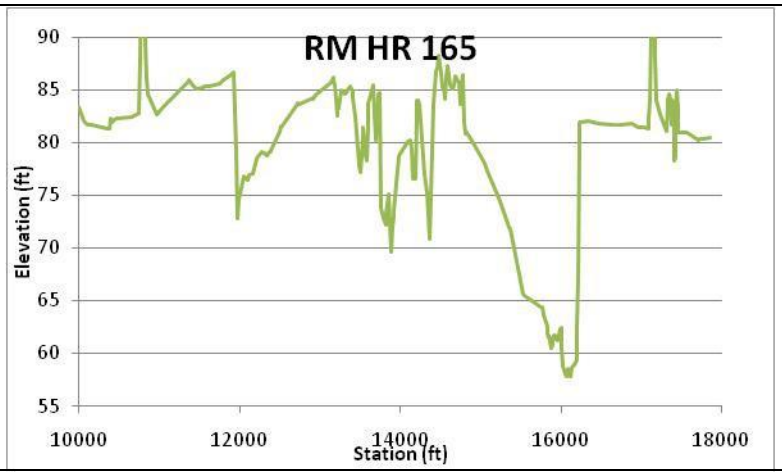
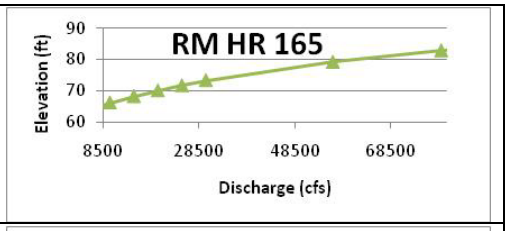




Figure 12 HR 172 cross section bed topography and rating curves



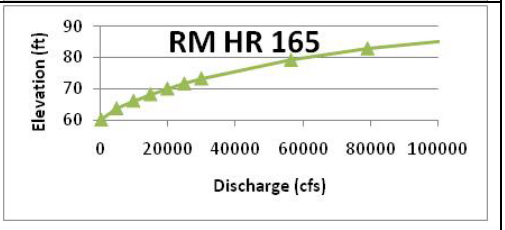




Figure 13 HR 165 cross section bed topography and rating curves

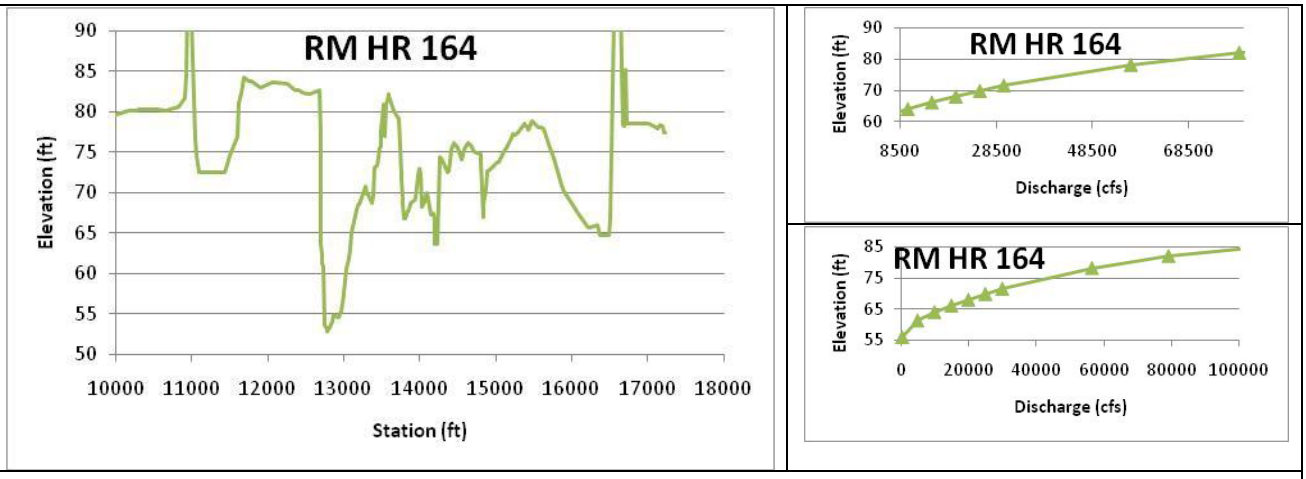



Figure 14 HR 164 cross section bed topography and rating curves

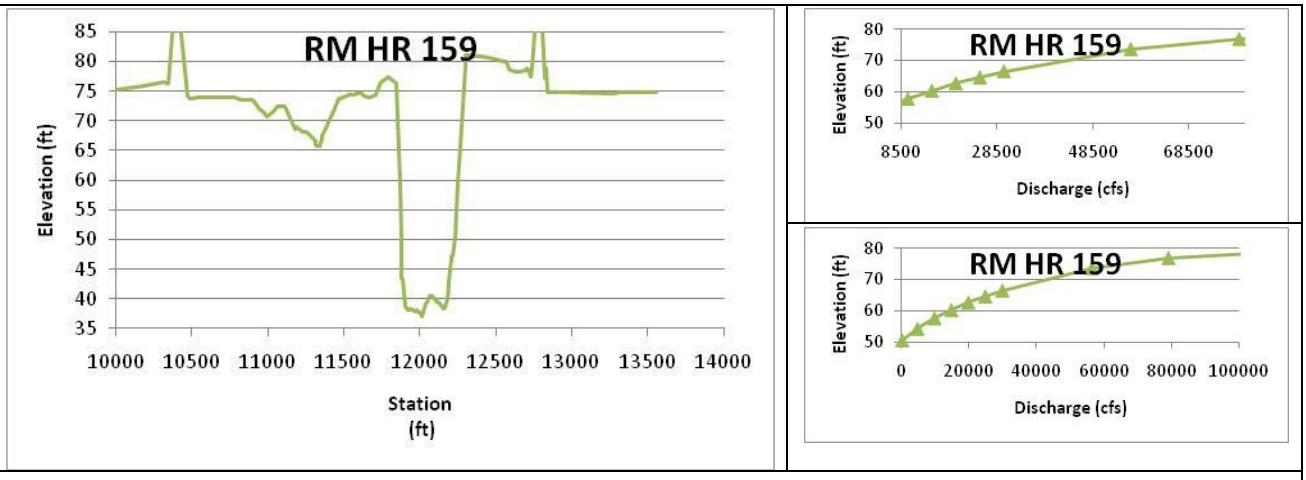



Figure 15 HR 159 cross section bed topography and rating curves

## Discussion and summary

Based on a comparison of the quantitative data from cross sections at RM 192, 183 and 172, taken from SacEFT v.1, our hypothesis is that the HEC-RAS stage-discharge relationships, linked with their corresponding cross section bed topography data, are an adequate representation of the actual relationships that exist in the field for the purposes of EFT modeling of cottonwood recruitment on the Sacramento River.

In order to test this hypothesis, the HEC-RAS *modeled* stage-discharge relationships for the cross- sections at RM 192, 183, and 172 could be used in EFT v.1 cottonwood recruitment modeling and the results compared with the results based on the existing (linear) stage-discharge relationships currently in EFT v.1. This is essentially a sensitivity analysis. If the results are the same, it suggests that both methods are equal in their impact on the EFT cottonwood modeled results. If the results differ, it is possible the HEC-RAS modeled stage-discharge relationships provide a better approximation of the real-world situation than the linearized rating curves originally used in EFT v.1. A third EFT v.1 run could be made using the observed (TNC) stage-discharge relationships. In this case, a shift, which was discovered between the observed data and the previously-used linear EFT v.1 relationship needs to be investigated before using the observed data in the model (pers.com. Clint Alexander).

In summary, cross section bed topography and related stage-discharge rating curves were developed from an existing HEC-RAS hydraulic model for nine sites on the Upper Sacramento River. These data are to be used in SacEFT v.2, along with data from the original cross sections from SacEFT v.1 (RM 192, 183, and 172) to model riparian vegetation seedling initiation.

# Appendices

## Appendix 1 Cross section locations RM 192, 183, 172

### River Mile 192

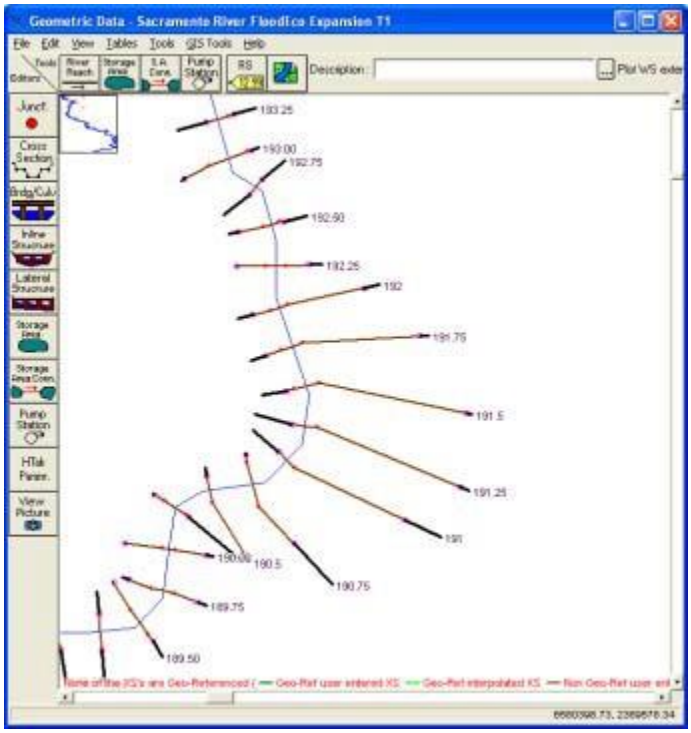



Figure 16 GIS 192 location on HEC-RAS map

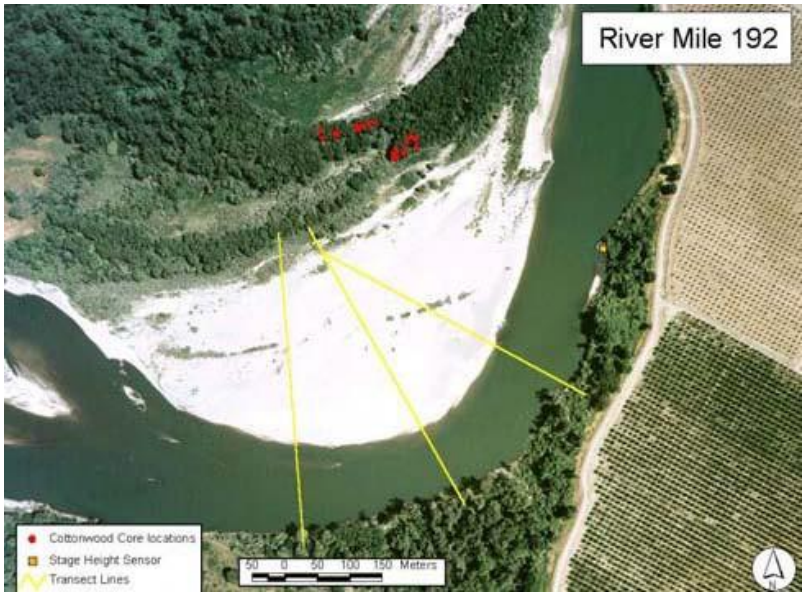



Figure 17 GIS 192 cottonwood sites

## River Mile 183

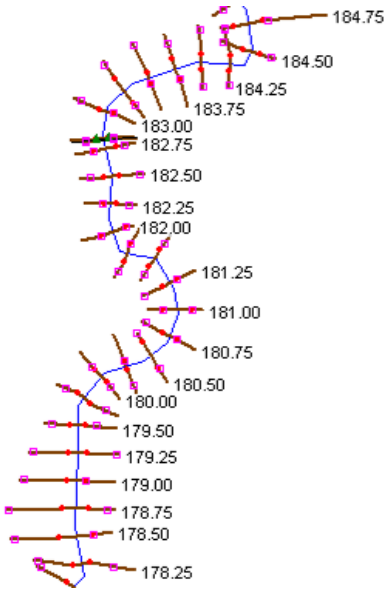



Figure 18 GIS 183 location on HEC-RAS map

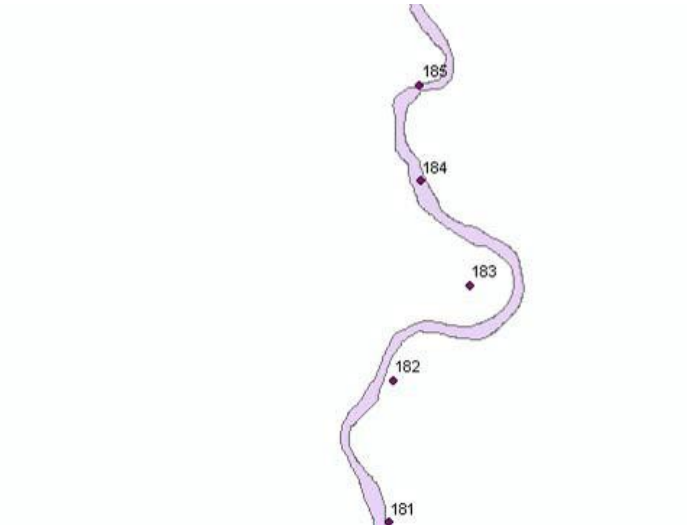



Figure 19 GIS 183 GIS location

## River Mile 172

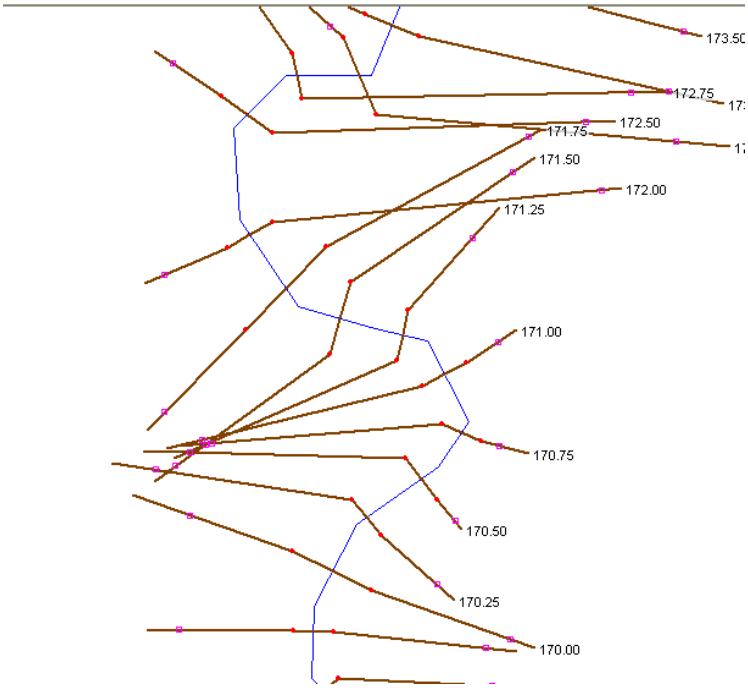



Figure 20 GIS 172 location on HEC-RAS map

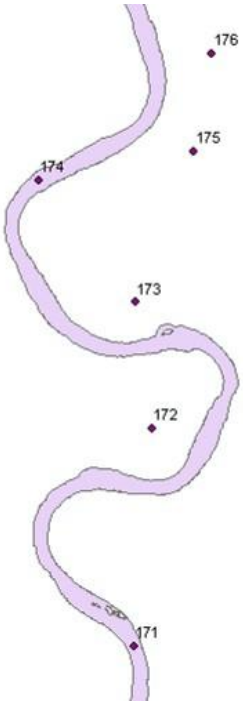



Figure 21 GIS 172 GIS location

## Appendix 2 Potential study site list from cottonwood advisory work group (Stella et al.)

Assesment of point bars and straight reaches that have Cottonwood Presen c

Sites highlighted in Blue are those that meet the search crieria in Stella's Protocol and are on public land

| River Mile | Bank | Channel Cut-off | Multiple Cottonwood Forest bands using height class | Floodplain Age variety | Geomorphic History | Public Land? | Land Access | Agency-Contact | Rip Rap (present, historic removed, never present) | NOTES | EWL NOTES | # | HEC RAS name |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 239 | R | No | Only 1 height class | | Straight channel, no bare substrate | Yes- Todd Isand Unit | River only | BLM: 530-224-2100 | | | | | |
| 237 | R | Yes | Yes-2 | Yes | Bare substrate, arc veg, abandoned channel | Yes- Todd Island Unit | Public access River only | Beareu of land management, Redding CA 530-224-2100 | | | | | |
| 236 | L | Maybe- there is an abandoned channel | Yes-2 (3rd small patch on DS end of point bar) | Yes | Bare substrate, meandering reach | No- Private land, no ownership record in GIS layer | No, would need to contact land owner | | | | | | |
| 235 | R | No | Yes-2 (younger patch is small) | Yes | meandering reach | Yes- Mooney Unit SRNWR | Public Access- River only | USFWS-530-934-2801 | | | NO HEC ANALYSIS AVAILABLE | | |
| 235 | L | Yes | Yes-2 (younger patch is small) | Yes | meandering reach | Yes- Sacramento Bar | | | | | | | |
| 234 | L | Yes | No | Yes | meandering reach | Yes- Sacramento Bar | | | | Looks like it is a restoration site? | | | |
| 233 | R | No | Yes | Yes | bare substrate, meandering reach, forest bands | Yes- Ohm Bar Unit | Public- No Access | USFWS-530-934-2801 | | | NO HEC ANALYSIS AVAILABLE | | |
| 232/233 | L | No | Yes- 2 smaller patches of younger | Yes | bare substrate, meandering reach, forest bands | No- Private land | Private- Would need to contact land owner | | | | | | |
| 231 | R | No | Yes- Just 1 height class- large patches | Yes | bare substrate, meandering reach, forest bands | Yes- Flynn Unit | Public- River Only Access | USFWS-530-934-2801 | | | NO HEC ANALYSIS AVAILABLE | | |
| 231 | L | No | Yes- 2 class heights | No | meandering reach | No- Private | Private- Would need to contact land owner | | | | | | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 230 | R | No | Looks like a restoration site | | | | | | | | | |
| 229 | L | No | No- 1 height class present- small | No | Straight channel, no bare substrate | Yes- North Mill Creek Boat Launch | Public | | | | | |
| 228 | L | Maybe- small backwater that coulde remnant abandoned channel | No- 1 height class present, large patches | Yes | meandering reach | Yes- Heron Island Unit | Public- River Only Access | USFWS- 530-934- 2801 | | | | |
| 227 | R | Yes | | | | | | | | | | |
| 227 | R | No | Yes- 3 height classes present | Yes | meandering reach | No- Private Land | Private- Would need to contact land owner | | | | | |
| 225 | L | No | No- 1 height class. Large patches | Yes | meandering reach, bare substrate | No- Private Land | Private- Would need to contact land owner | | | | | |
| 224/225 | R | No | No- 1 height class | Yes | straight reach | No- Private Land | Private- Would need to contact land owner | | | | | |
| 224 | L | No | No- 1 height class | Yes | straight reach | No- Private Land | Private- Would need to contact land owner | | | | | |
| 223 | L | Yes | No- 1 height class, large patches | | meandering, channel cut off | No- Private Land | Private- Would need to contact land owner | | | | | |
| 222 | R | No | No -1 height class | Yes | meandering reach, bare substrate | No- Private Land | 530-897- 6370 | | | | | |
| 221 | R | No | 1 height class, small aptches | Yes | meandering reach | Yes- Kopta Slough | Public- No Access | State Land Commission on Sacramento River: 530-897- 6370 | | | | |
| 220 | L | No- tributary | 3 height classes present | Yes | meandering reach | No- Private | Private- Would need to contact land owner | | | | | |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 219 | R | Yes-abadoned channel present | Yes | Yes | channel cut off | Yes-Kopta Slough | Public Access | | | | | | |
| 216/218 | L | No | Yes-restoration site | Yes | straight reach | Yes-Rio Vista Unit | Public Access | USFWS-530-934-2801 | | | | | |
| 216-217 | R | No | small scattered patches | Yes | straight reach | No-Private | Private-Would need to contact land owner | | | | | | |
| 215 | R | No | 1 height class | Yes | meandering reach | No-Private | Private-Would need to contact land owner | | | | | | |
| 213-214 | L | Yes | Yes-2 height classes present | Yes | channel cut off | Yes-Merrill's Landing Unit | Public Access | | | | | | |
| 212 | R | No | Yes-2 height classes present | Yes | meandering reach, bare substrate, arc shaped veg | No-Private | Private-Would need to contact land owner | | | | | | |
| 211 | L | Yes | Yes-3 height classes present | Yes | abadoned channel | No-Private | Private-Would need to contact land owner | | | | | | |
| 210 | R | No | No-1 height class present | Yes | meandering reach, bare substrate, arc shape veg | Public-Foster Island | Public-River Only Access | BLM:530-2 | 24-2100 | | POSSIBLE | 1 | 208.3 |
| 209 | R | No | Yes-3 height classes present | Yes | meandering reach, bare substrate | Dicus Slough | Public-River Only Access | DFG:916-3 | 58-2900 | | POSSIBLE | 2 | 206 |
| 206-208 | L | No | Yes-2 height classes present | Yes | meandering reach, bare substrate | Private | Private-Would need to contact land owner | | | | | | |
| 206 | L | No | Yes-2 height classes present | Yes | relatively straight | Private | Private-Would need to contact land owner | | | | | | |
| 203-205 | L | Yes | Yes-3 height classes present | Yes | abadoned channel | public-Wilson's Landing | Public | | | | | | |
| 202 | R | Split Channel | No-1 height class present | Yes | | | | | | | | | |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 201 | L | No | Large patch of Cottonwood | Yes | meandering reach, bare substrate, backwater (abandoned channel?) | Public-Mcintosh Landing South | Public-No Access | USFWS-530-934-2801 | | | POSSIBLE | 3 | 199.8 |
| 200 | R | No | 2 patches of CW, Could this be a restoration site-younger CW | No | relatively straight reach, some bare substrate | Public-McIntosh Landing South Unit | Public-No access | USFWS-530-934-2802 | | | | | |
| 196-198 | L | No-tributary confluence of Pine Creek | Very large CW stand, ~130 acres | Yes | meandering reach | Public-Pine Creek Unit | Public-Acces to Day Use area only other areas (point bar not open to Public) | USFWS: 530-934-2802 and DFG: 916-358-2900 | | | POSSIBLE | 4 | 195.8 |
| 194-195 | L | Yes | lots of CW stands | ? | potential channel cut off | Public-Pir | Public-No | USFWS: 530-934-2802 and DFG: 916-358-2901 | | | | | |
| 194-195 | R | Yes | lots of CW stands | ? | potential channel cut off | Public-Pir | Public-No | USFWS: 530-934-2802 and DFG: 916-358-2902 | | | | | |
| 193 | R | NO | CW stand at edge of river channel | Yes | relatively straight-some meandering, bare substrate | Public-Ca | Public-Riv | USFWS-530-934-2801 | | | not good | | |
| 193 | L | No- tribut | CW stand at edge of river channel | Yes | relatively straight, bare substrate on DS bend | Public-Bidwell Sacramento State parks | Public-Road Access | Department of Parks and Recreation (DPR) (530) 342-5185 | | | | | |
| 192 | R | No | Large CW stands, bands of veg | Yes | meandering, bare substrate, arc shaped veg | Public-Phelan Island Unit | Public-River Only Access | USFWS-530-934-2801 | | Shaw Bar (RM 192.5) TNC Pilot Study Site | DONE | | |
| 191 | L | Yes | Large CW stands, bands of veg | Yes | meandering, bare substrate, arc shaped veg | Public-Sacramento River Parcel | Public-River Only Access | Sacramento Valley Flood Control Board | | | | | |
| 191 | R | No | Restoration Site | | | | | | | | | | |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 190 | R | No | Multiple forest bands, large CW stands | Yes | abadoned channel | Private Point Bar-Phelan Isalnd surrounding | Private-Would need to contact land owner | | | | | | |
| 190 | L | Yes | Multiple forest bands, large CW stands | Yes | abadoned channel | Private | Private-Would need to contact land owner | | | | | | |
| 189 | L | No | small patch of CW | Yes | meanderi ng reach | Public-Murphy's Slough, Golden State Island | Public-River Only Access | Central Valley Flood Protection Control Board | | | | | |
| 189 | R | No | Multiple forest bands | Yes | meanderi ng reach | Public-? | Public Land not sure about access | ? | | | | | |
| 188 | L | No | Multiple forest bands, large CW stands | Yes | meanderi ng reach, bare substrate, arc shaped veg | Private | Private-Would need to contact land owner | | | | | | |
| 187 | R | No | Large CW stands | Yes | meaderin g reach, bare substrate, bands of veg | Public-Shannon Slough Unit | Public-River Only or levee road walk | DFG:916-358-2900 | | | POSSIBLE | 5 | 185.5 |
| 186 | R | No | Large CW stand on bar ~ 28 acres | Yes | meanerin g reach, bare subsrate, arc shaped veg | Public-Jacinto Unit | Public-River Only | USFWS-530-934-2801 | | | POSSIBLE | | hold |
| 185 | L | No | CW stand on bar ~11 acres | Yes | meanerin g reach, bare subsrate, arc shaped veg | Public-Dead Man's Reach | Public-River Only | USFWS-530-934-2802 | | | POSSIBLE | | hold |
| 185 | R | Maybe? | 2 CW stands-Large | Yes | meanerin g reach, bare subsrate, arc shaped veg | Private | Private-Would need to contact land owner | | | | | | |
| 183 | L | No | multiple bands | Yes | meanderi ng reach, bare substrate, arc shaped veg | Private | Private-Would need to contact land owner | | | | | | |
| 183 | R | No | multiple bands | Yes | meanderi ng reach, bare substrate, arc shaped veg | Public-Ord Bend Unit | Public-River Only | South Ord Bend USFWS: 530-934-2802 and Ord Bend DFG: 916-358-2902 | | TNC CW Pilot Study Site | DONE | | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 181 L | No | 1 large CW stand ~ 41 acres | | relatively straight | Private | Private-Would need to contact land owner | | | | | | |
| 180 R | Maybe-abadoned channel | 1 large CW stand-92 acres | | meandering reach | Public-Jacinto Unit | Pulic-River Only | DFG:916-358-2900 | | | | | |
| 179 L | Some CW further from river may be from channel cut off | 1 large stand on point bar-~42 acres | Yes | meandering reach, bare substrate | Private | Private-Would need to contact land owner | | | | | | |
| 178 R | No | 1 large CW stand on point bar- ~40 acres | | meandering reach, bare substrate | Public-Llano Seco Island Unit 2 | Public-River Only | USFWS: 530-934-2801 | | | POSSIBLE | | hold |
| 173 L | No | 1 Lrge CW stand-~ 80 acres on point bar | Yes | meandering reach, bare substrate, arc shaped veg | Public-The Nature Conservancy | Public-No access | TNC: would need to contact the Chico office | | | POSSIBLE | 6 | 172 |
| 172 R | No | Large CW stand ~70 acres on point bar | Yes | meandering reach, bare substrate, arc shaped veg | Public-Central Valley Flood Protection Control Board | Public-No Access | ? | | TNC CW Pilot Study Site | DONE | | |
| 171 L | No | Large CW stabd on Point Bar ~ 50 acres | Yes | meandering reach, bare substrate, arc shaped veg | Private | Private-Would need to contact land owner | | | | | | |
| 170 R | Yes | | | | Public-Beehive bend | | | | | | | |
| 169 R | No | Large CW stand ~50 acres | Yes | bare substrate, small point bar, relatively straight | Public-Site 79 F | Public-River Only | Central Valley Flood Protection Control Board | | | POSSIBLE | | hold |
| 169 R | No? (Maybe old cutoff) | Large CW stand ~60 acres | Yes | bare substrate at DS end of point bar-some backwater (maybe old abandoned channel?) | Public-Sul Norte Unit | Public-No Access | USFWS: 530-934-2801 | | | | | |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 167 | R | No | ~ 25 Acres of CW on point bar | Yes | meandering reach, bare substrate, bands of veg | Public-Packer Unit | Public-Road Access | USFWS: 530-934-2802 | | | POSSIBLE | | hold |
| 166 | L | No | ~ 50 acres of CW stand on point bar | Yes | meandering reach, bare substrate, arc shaped veg | Private | Private-Would need to contact land owner | | | | in similar vicinty | 7 | 165 |
| 165 | R | No- there is an abandoned channel farther back | ~ 100 acres of CW- some CW may be from an channel cutoff around the abandoned channel | Yes | bare subsrate, meandering reach, veg in bands | Public-Drumheller North Unit | Public-River Only | USFWS: 530-934-2801 | | | in similar vicinty | 8 | 164 |
| 162 | R | No | ~ 20 acres of CW stabd on point bar | Yes | meandering reach, bare substrate, veg bands | Public-Princeton South | Public-River Only | DFG:916-358-2900 | | | POSSIBLE | | hold |
| 161 | R | No | ~ 20 acres of CW on point bar | Yes | meandering reach, bare substrate, veg bands | Public-Princeton South-Boggs Bend | Public-River Only | DFG:916-358-2901 | | | POSSIBLE | | hold |
| 161 | L | Yes | Multiple CW bands | | channel cut-off, abadoned channel | Public-Princeton Southeast | Public-Road Access | DFG: 916-358-2901 | | | | | |
| 159 | R | No | Multiple pathces of CW on point bar | Yes | meandering reach, bare substrate, veg in bands near water edge | Public-Stegemen Unit | Public-River Only | DFG: 916-358-2901 | | | POSSIBLE | 9 | 156 |
| 158 | L | No | multiple patches of CW | | meandering reach, bare substrate, veg in bands near water edge | Private | Private-Would need to contact land owner | | | | | | |
| 156 | L | No | multiple patches of CW | Yes | meandering reach, bare substrate, veg in bands near water edge | Private | Private-Would need to contact land owner | | | | | | |

## Appendix 3 Stage-discharge rating curves

For the current comparisons, the observed data were obtained from TNC (Mike Roberts, pers. Com.) and the same graphs were plotted with the observed data (as provided) also included (Figure 25, Figure 26, and Figure 27).

What is not clear in the comparison of the EFT1 (linearized data) and the TNC raw data is the offset that is observed in all cases. For RM 172, the TNC notes say "RM 172 site is relative to an arbitrary datum."

Stage-Q relationships on the Sacramento River, and indeed on most rivers, tend to be non-linear, and the shape of the rating curve depends on the shape of the cross section. Such rating curves tend to increase at a greater rate at lower elevations, because there is a pool with steep sides, and tend to taper off at higher flows as the flow goes more onto the floodplain. This is the general shape of the stage-discharge relationships produced by the HEC-RAS modeling.

Note that the EFT rating curves were intended to be used in the 8500 to 80,000 cfs range, where the observed rating curve is relatively linear except for XS 172. The linear approximations of EFT1 are not effective for relatively low flows (0 to 5000), as shown in the rating curves that include these flows (see Appendix 3: Figure 22, Figure 23, and Figure 24). The "0" flow in the EFT stage-discharge (linear) relationship is consistently well above the observed deepest part of the pool.

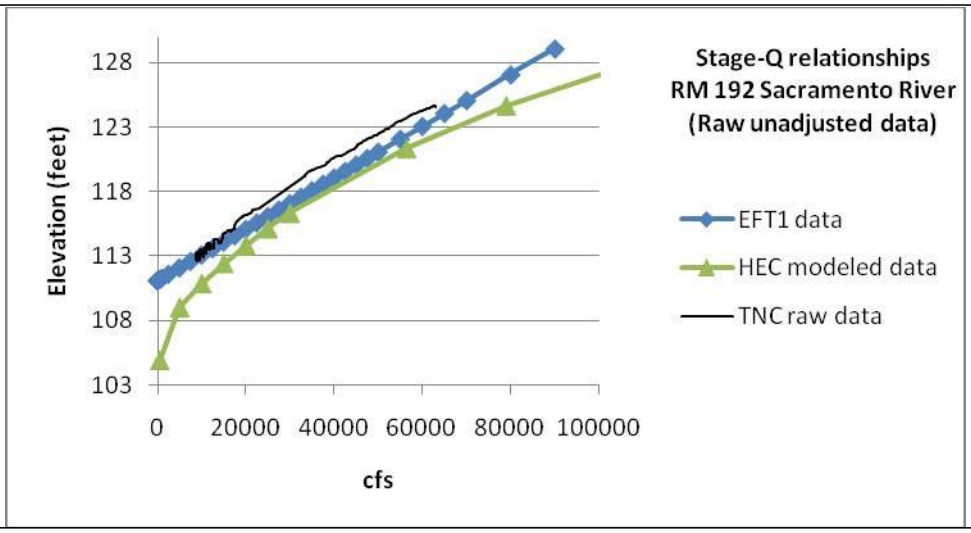



Figure 22 Cross section 192: EFT v.1 and HEC RAS stage-Q rating curve data. (100,000 cfs).

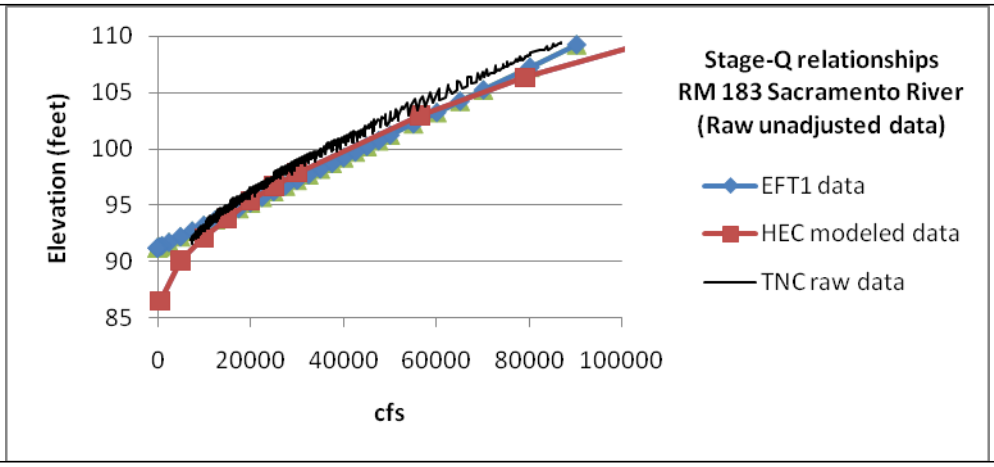



Figure 23 Cross section 183: EFT v.1 and HEC RAS stage-Q rating curve data. (100,000 cfs).

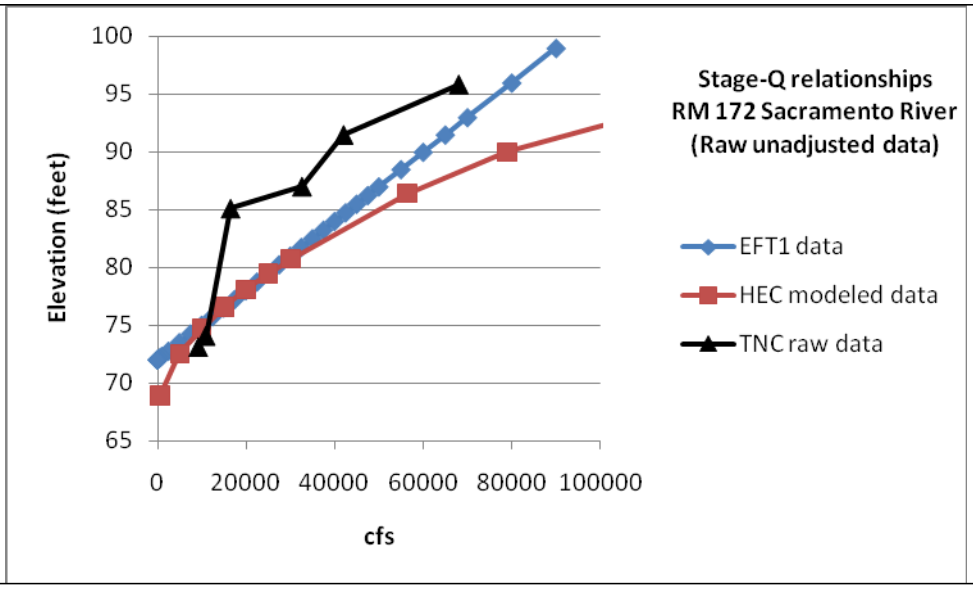



Figure 24 Cross section 172: EFT v.1 and HEC RAS stage-Q rating curve data. (100,000 cfs).

These data were also plotted showing only data for the range of discharge that was of interest.

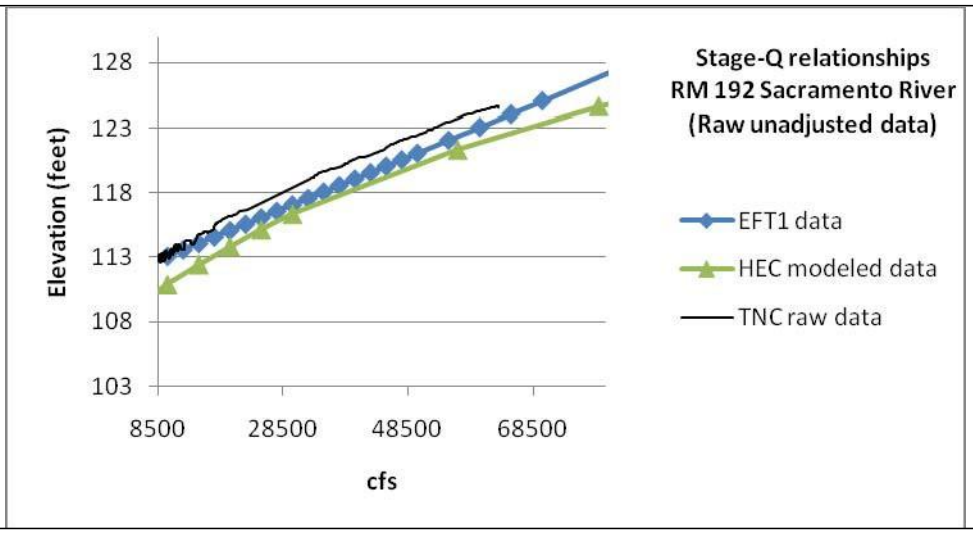



Figure 25 Cross section 192: EFT v.1, HEC RAS, TNC stage-Q rating curve data. (100,000 cfs).

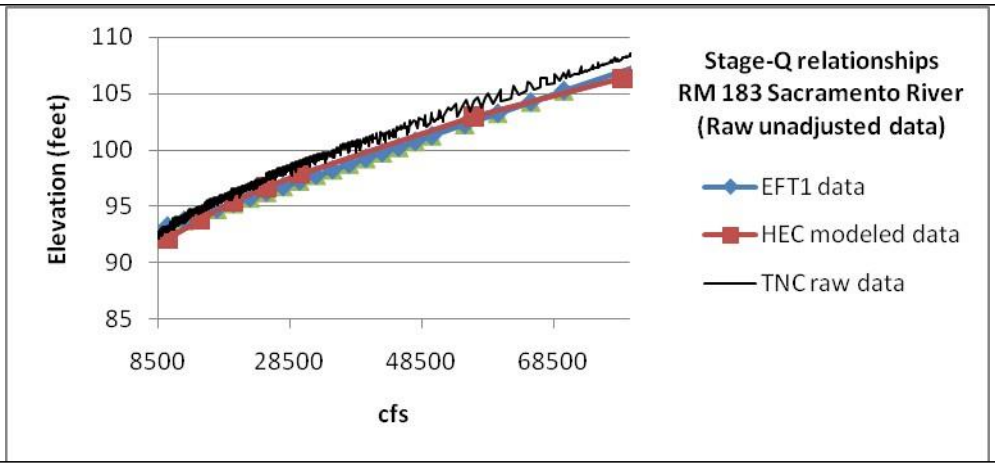



Figure 26 Cross section 183: EFT v.1, HEC RAS, TNC stage-Q rating curve data. (100,000 cfs).

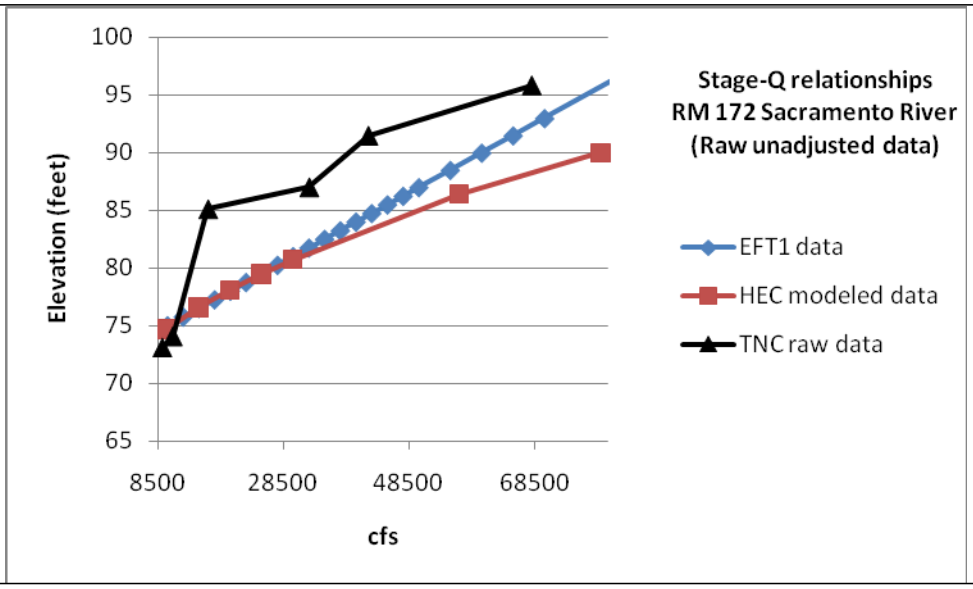



Figure 27 Cross section 172: EFT v.1, HEC RAS, TNC stage-Q rating curve data. (100,000 cfs).

## Appendix 4 Detailed data from each new site

The HEC-RAS model used slightly different river mile designations than the GIS data from which the original cross sections at RM 192, 183, and 172 were derived. The locations were matched by visual inspection of both sets of maps. The nomenclature gives both locations. "GIS" refers to the GIS mapping, and "HR" refers to the HEC-RAS mapping locations.

### HR 208.25 (GIS 210R)

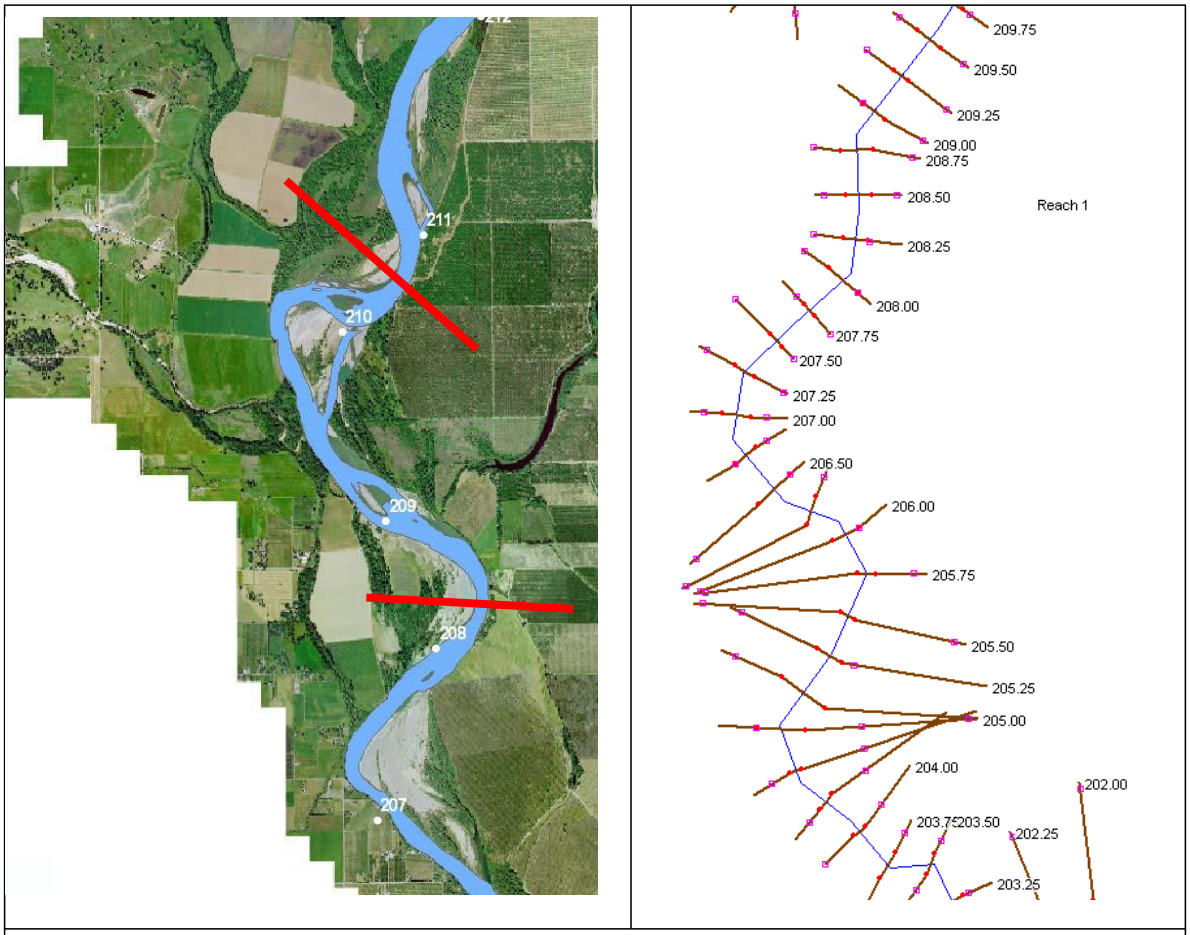



Figure 28 HR 208.25 (GIS 210R) location maps

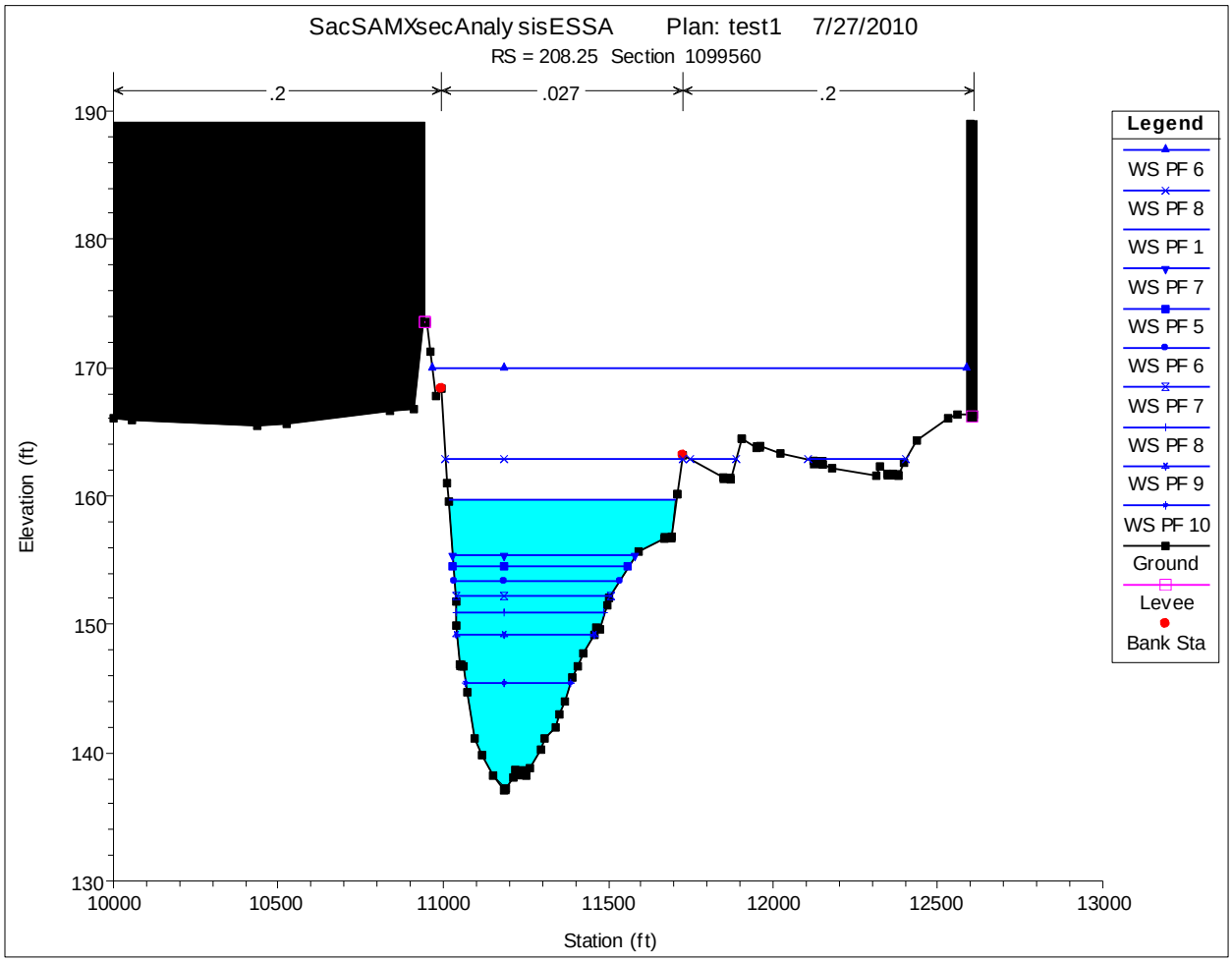



Figure 29 HR 208.25 HEC-RAS cross section plot

## HR 206.00 (GIS 209R)

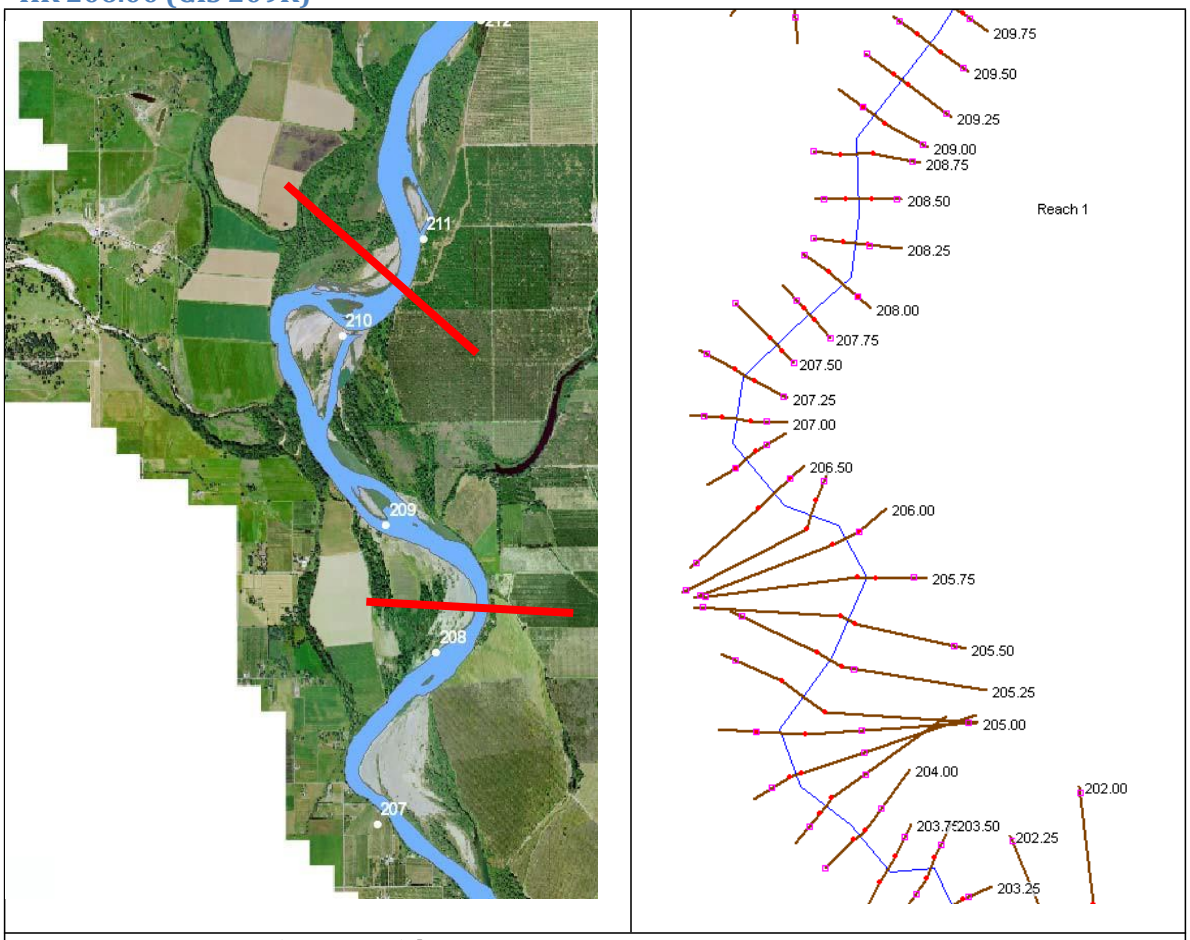



Figure 30 HR 206.00 (GIS 209R) location maps

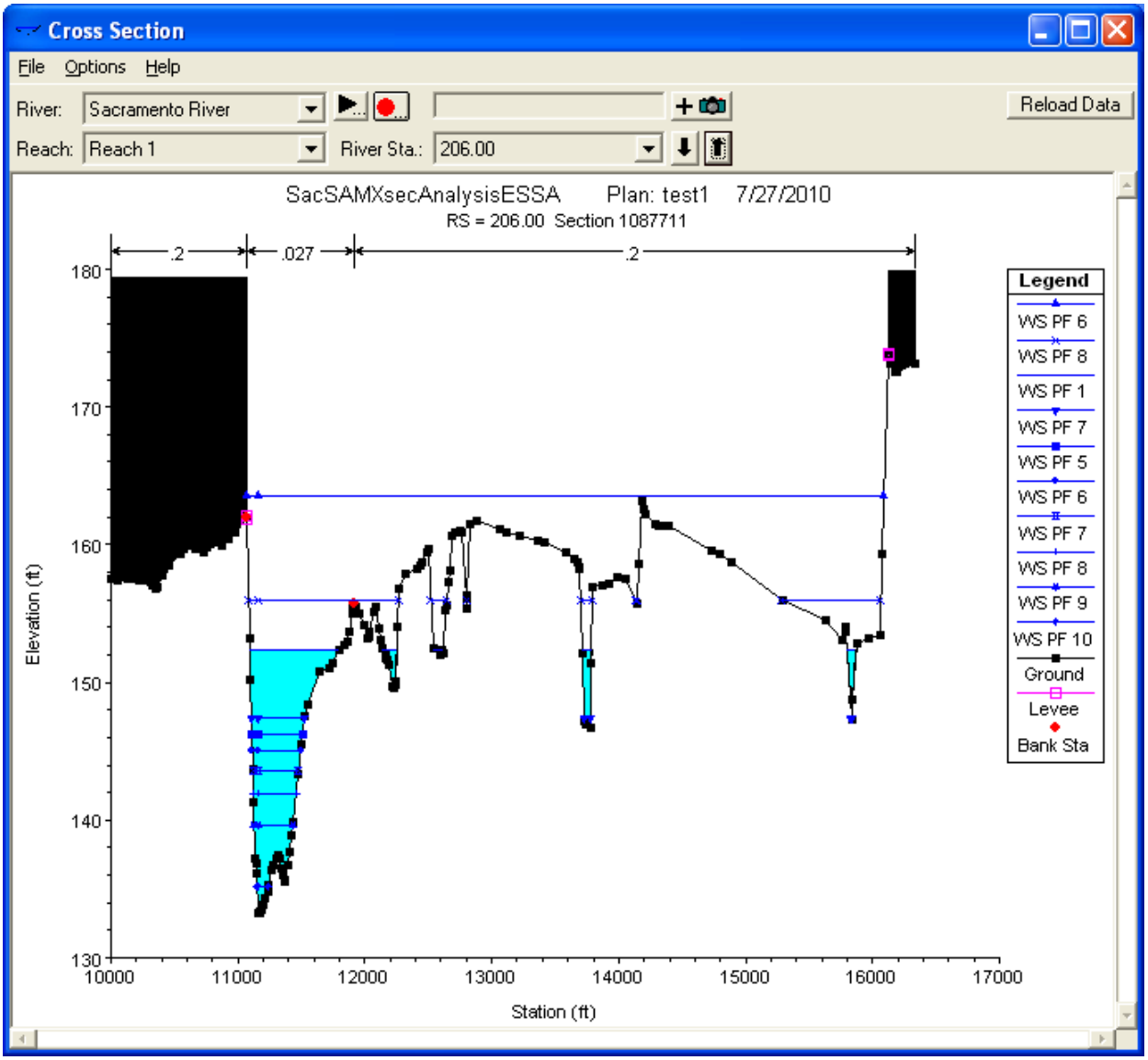



Figure 31 HR 206.00 HEC-RAS cross section plot

## HR 199.75 (GIS 201L)

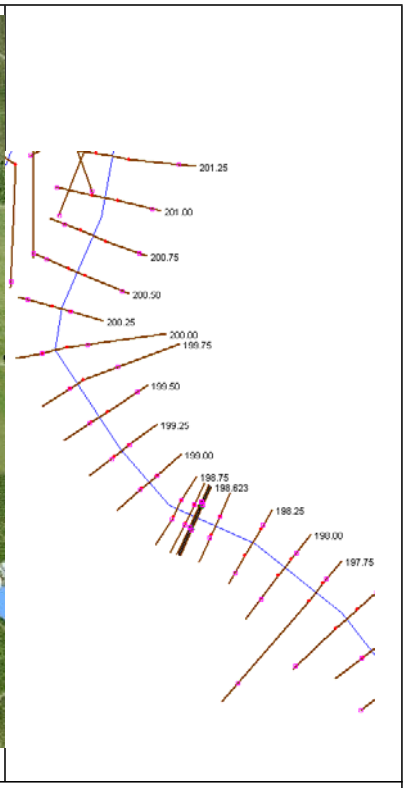




Figure 32 HR 199.75 (GIS 201L) location maps

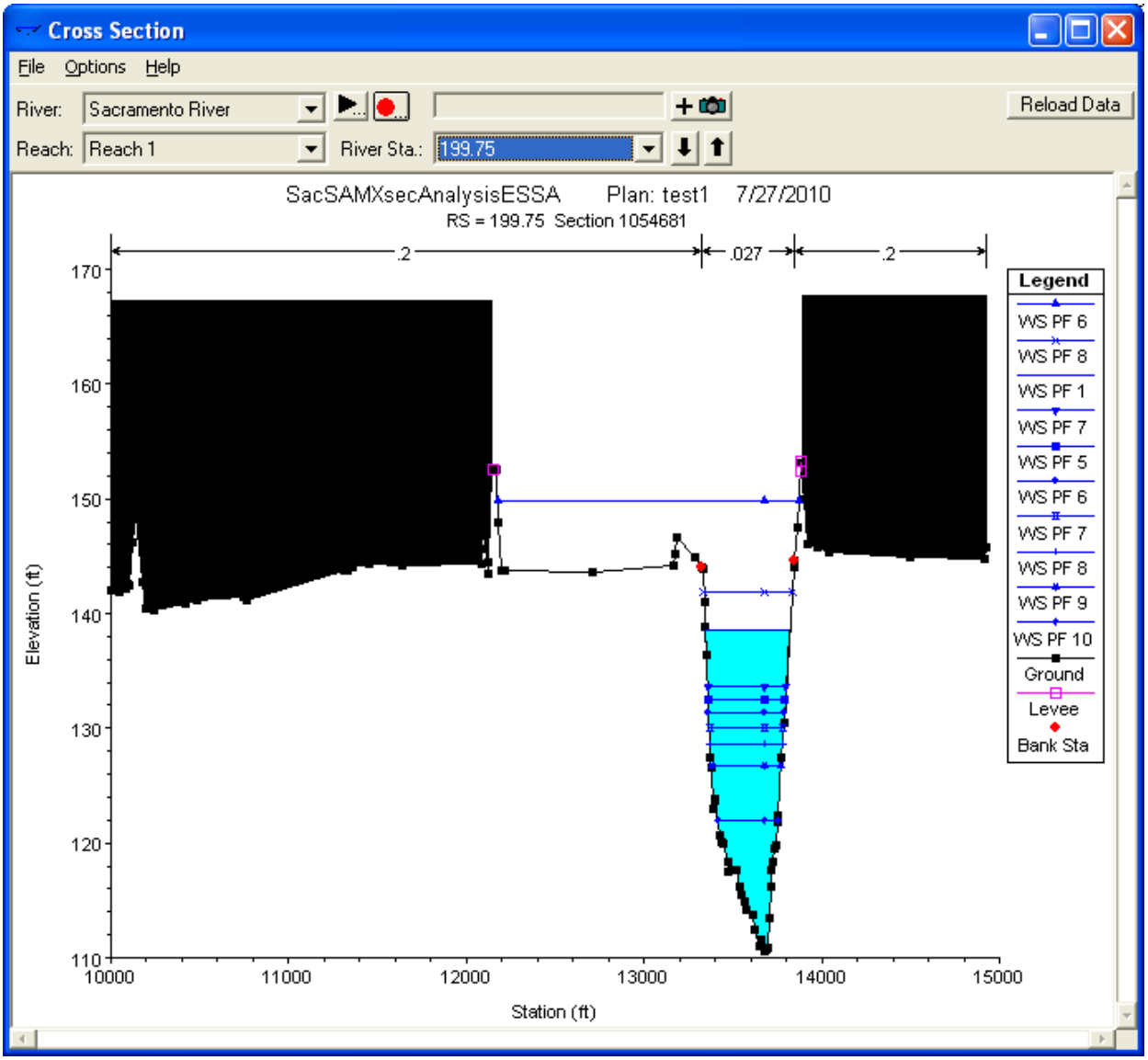



Figure 33 HR 199.75 HEC-RAS cross section plot

There is a “levee” on the edge of the floodplain.

## HR 195.75 (GIS 197.0)

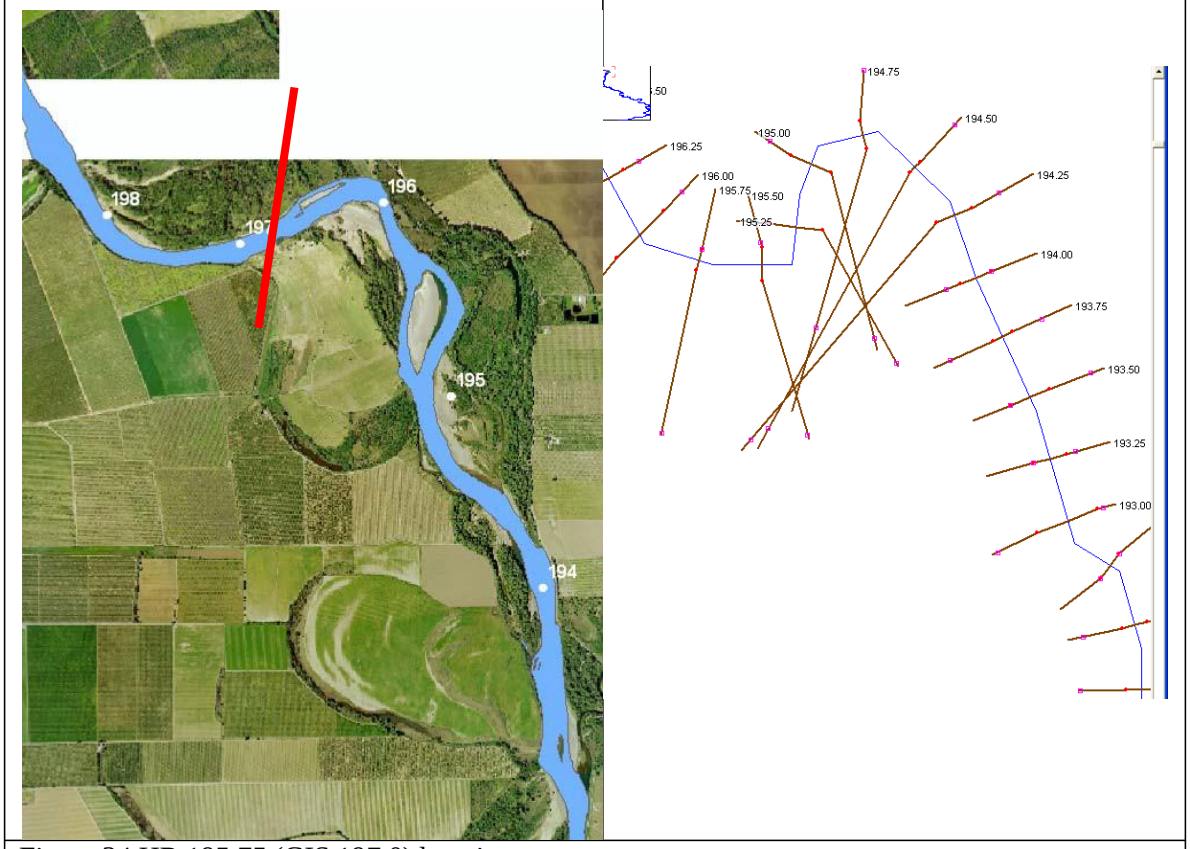



Figure 34 HR 195.75 (GIS 197.0) location maps

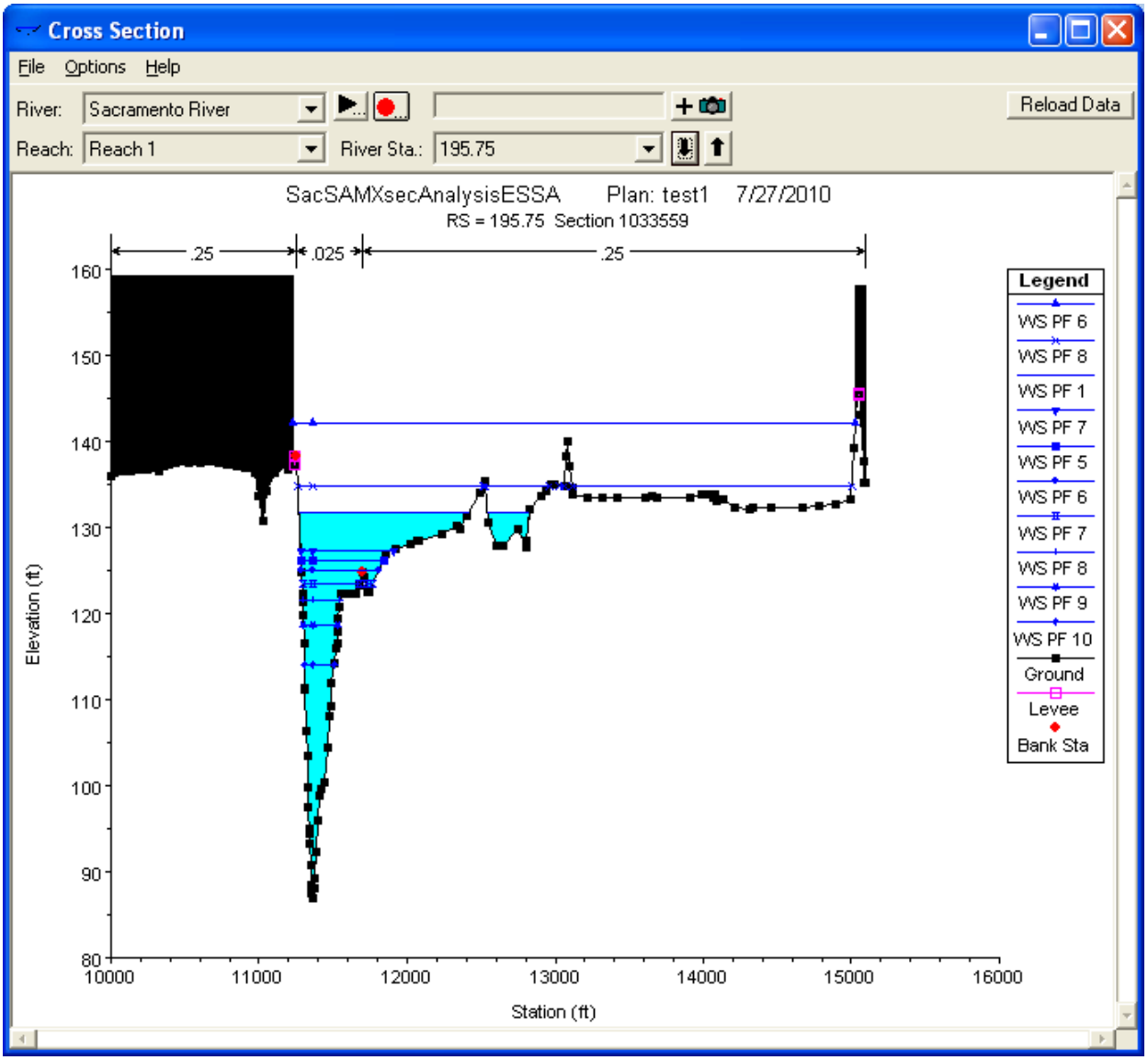



Figure 35 HR 195.75 HEC-RAS cross section plot

195.75 seems like a classic point bar.

## HR 185.50 (GIS 187R)

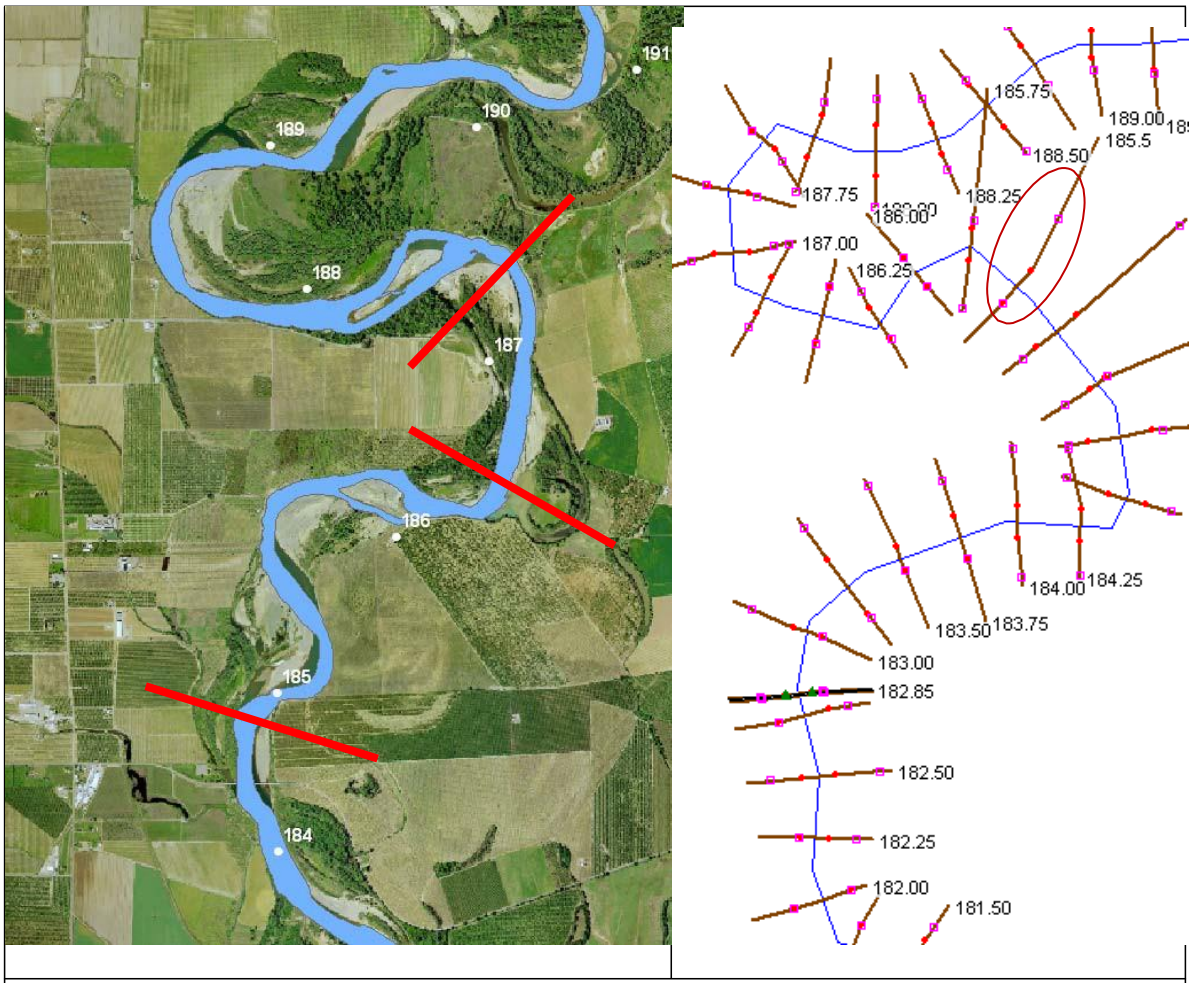



Figure 36 HR 185.50 (GIS 187R) location maps

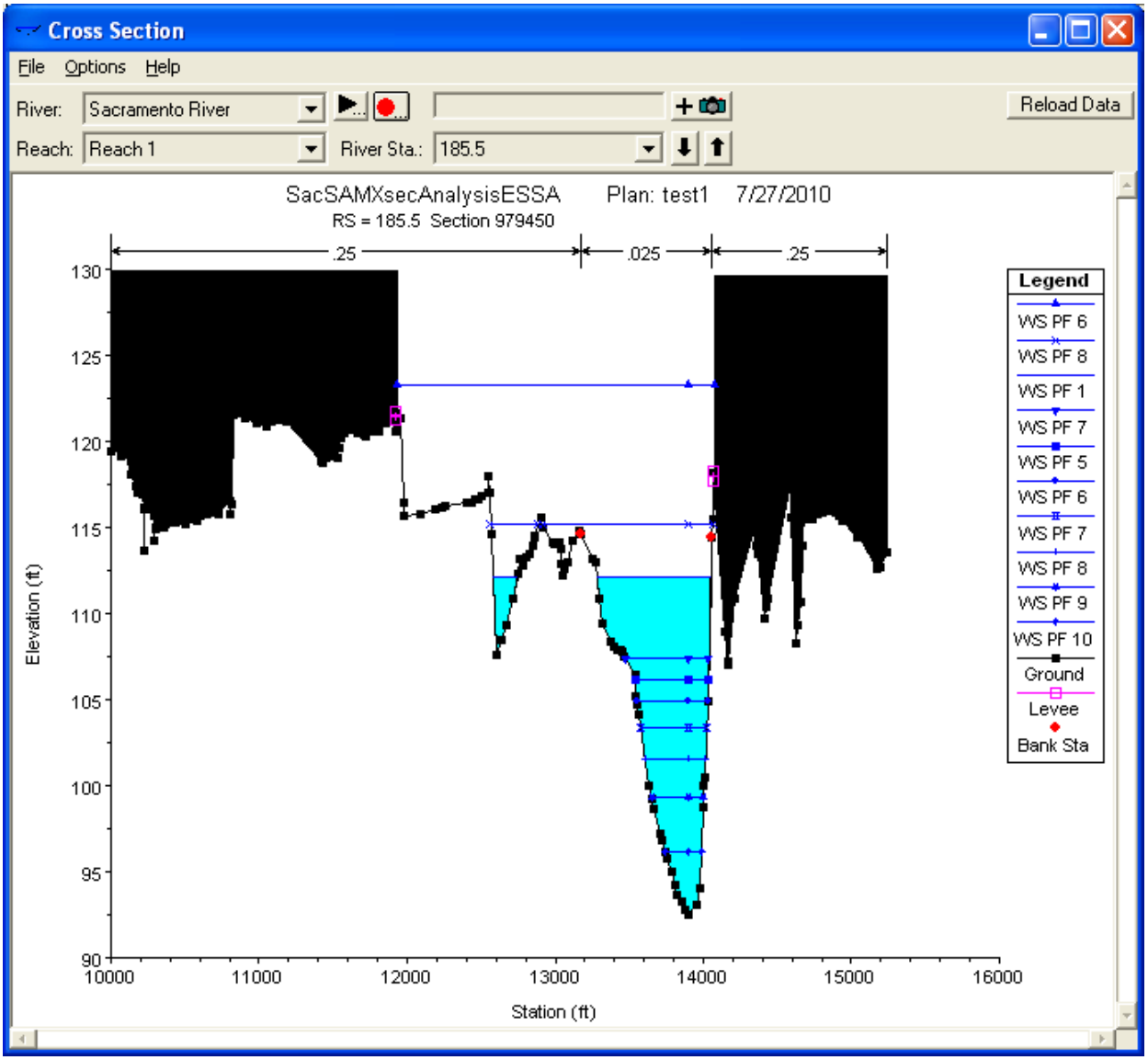



Figure 37 HR 185.50 HEC-RAS cross section plot

## HR 172.00 (GIS 173.5)

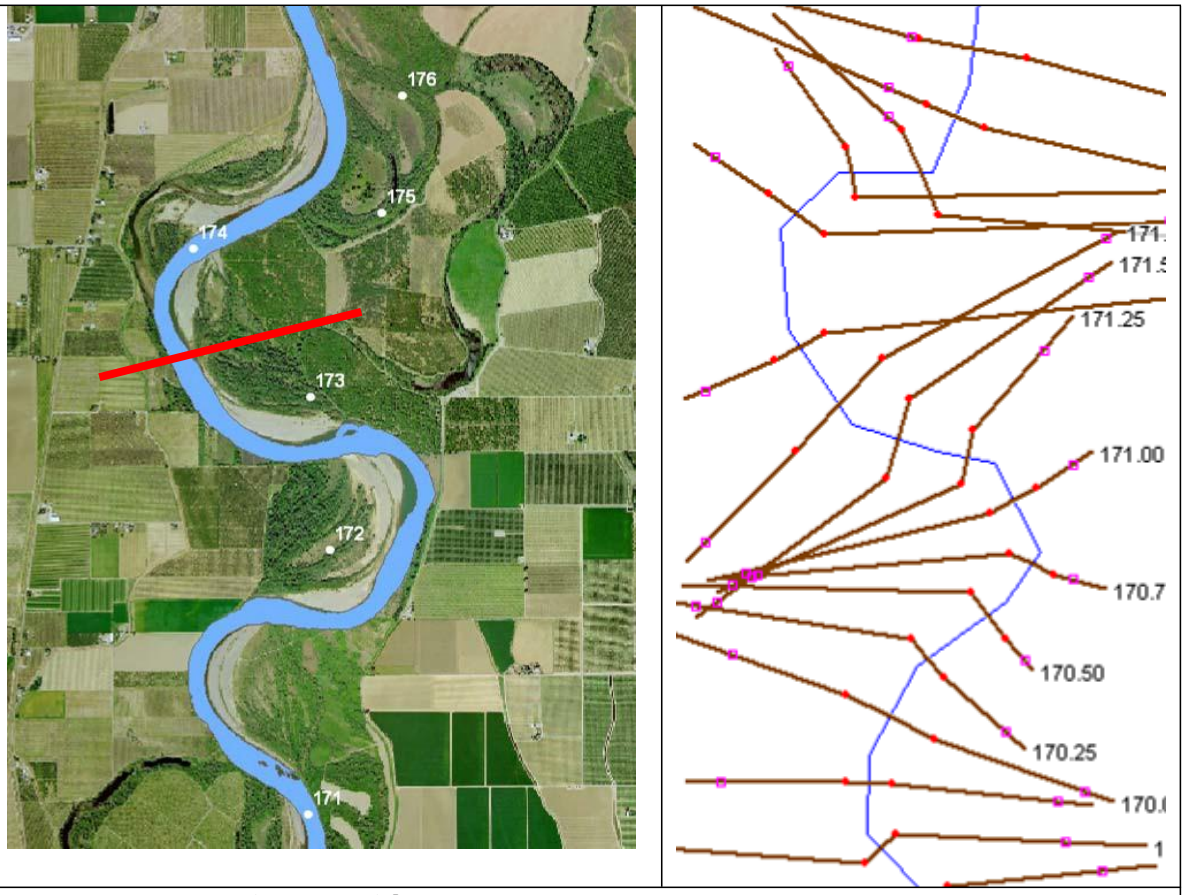



Figure 38 HR 172.00 (GIS 173.5) location maps

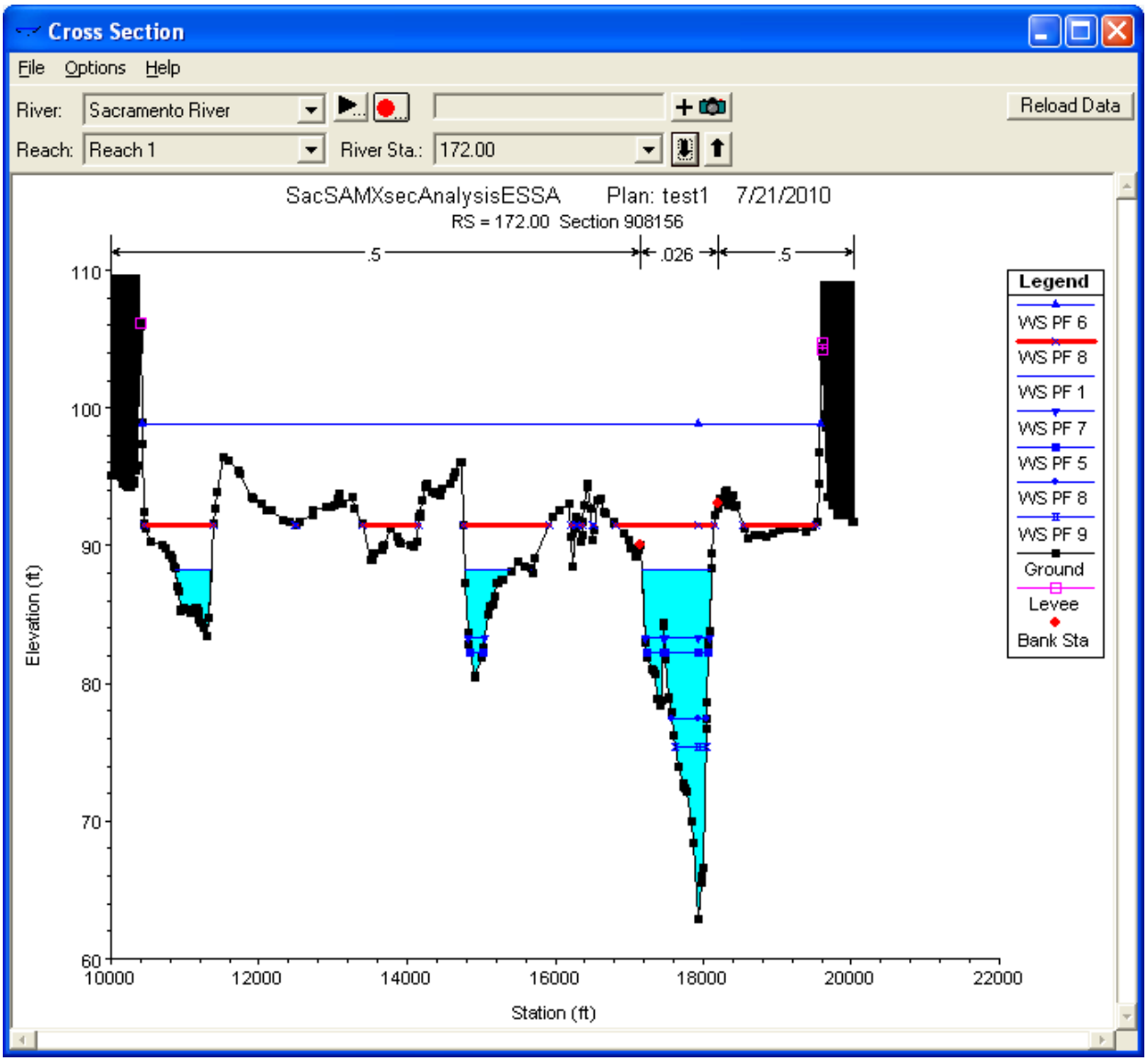



Figure 39 HR 172.00 HEC-RAS cross section plot

Lots of heterogeneity below bankfull.

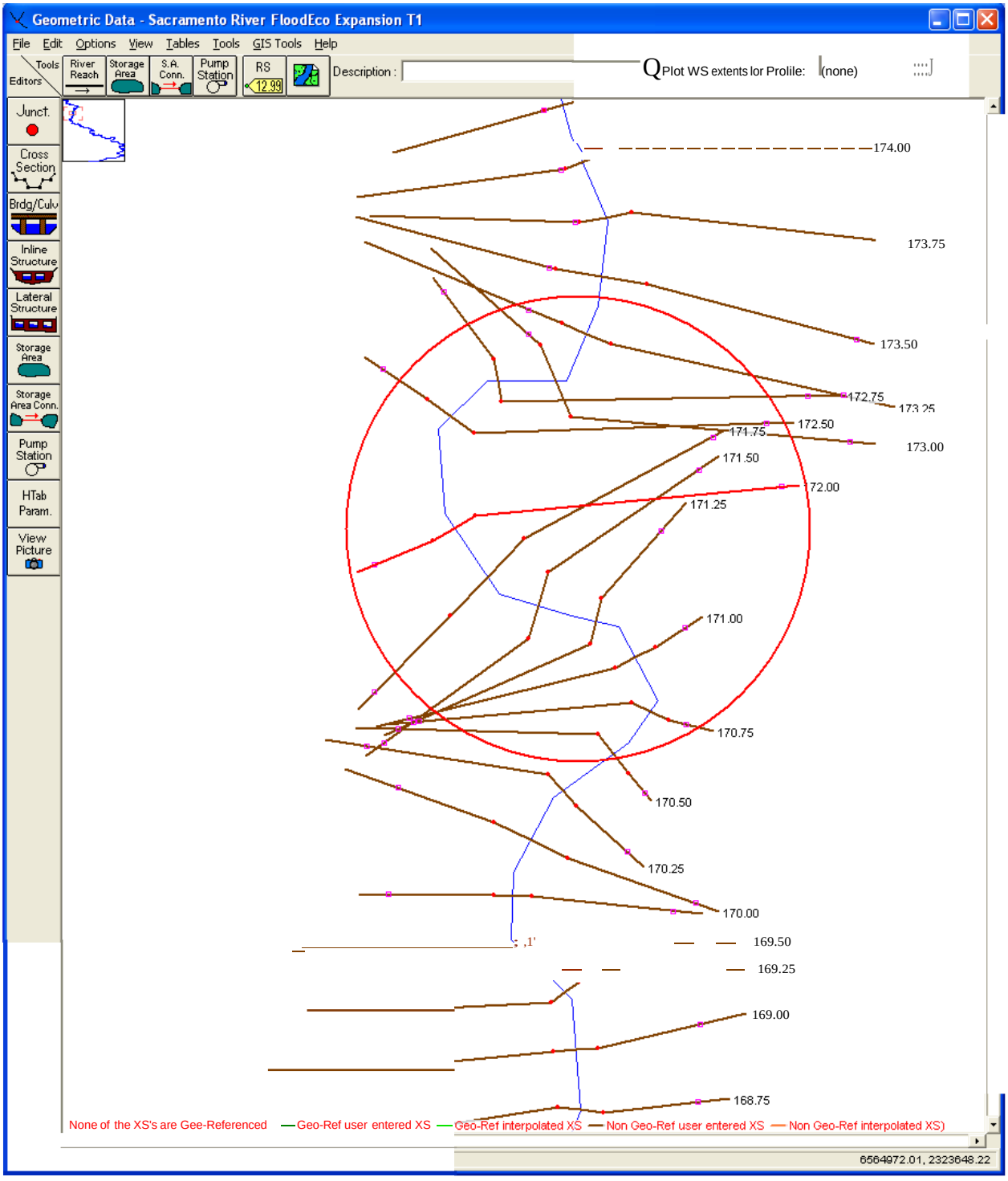



Figure 40 HR. 172.00 HEC-RAS cross section location map

## HR 165.00 (GIS 166.5)

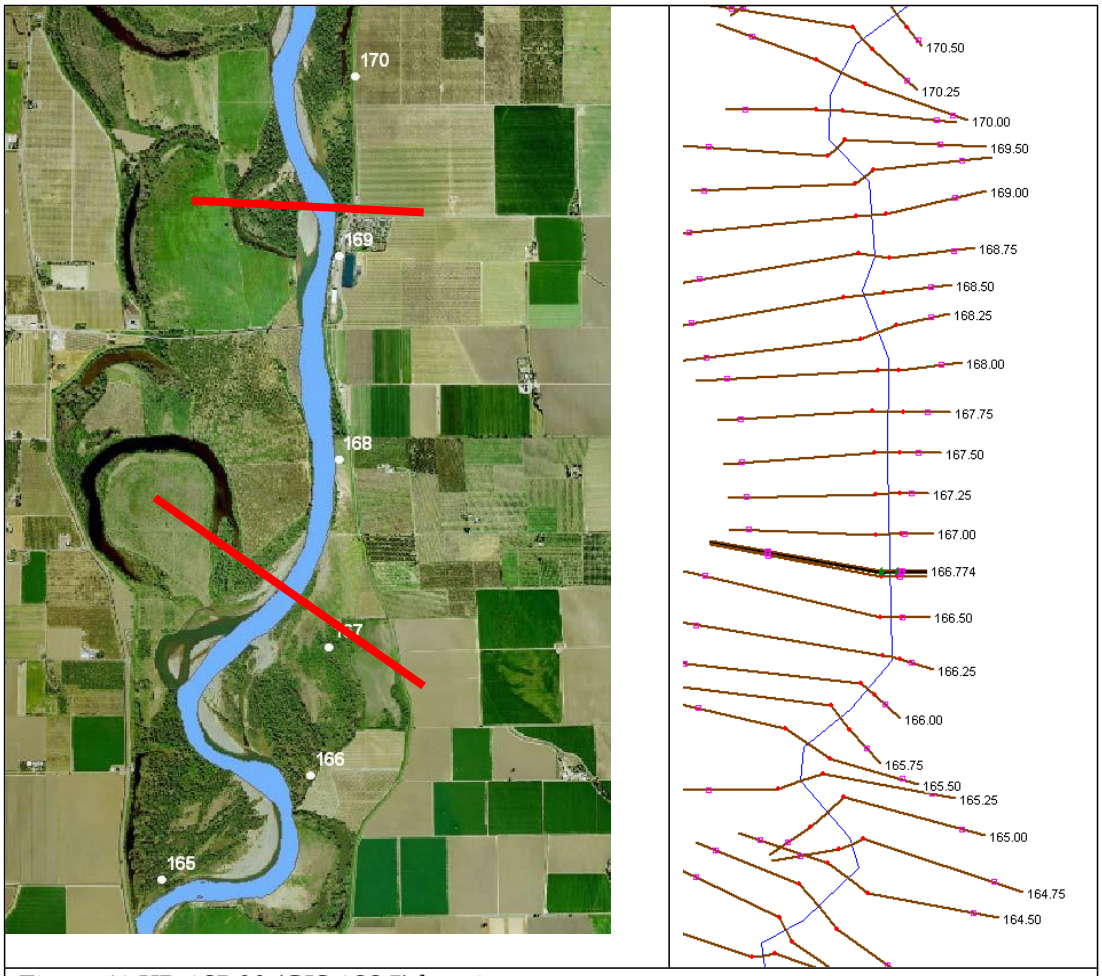



Figure 41 HR 165.00 (GIS 166.5) location maps

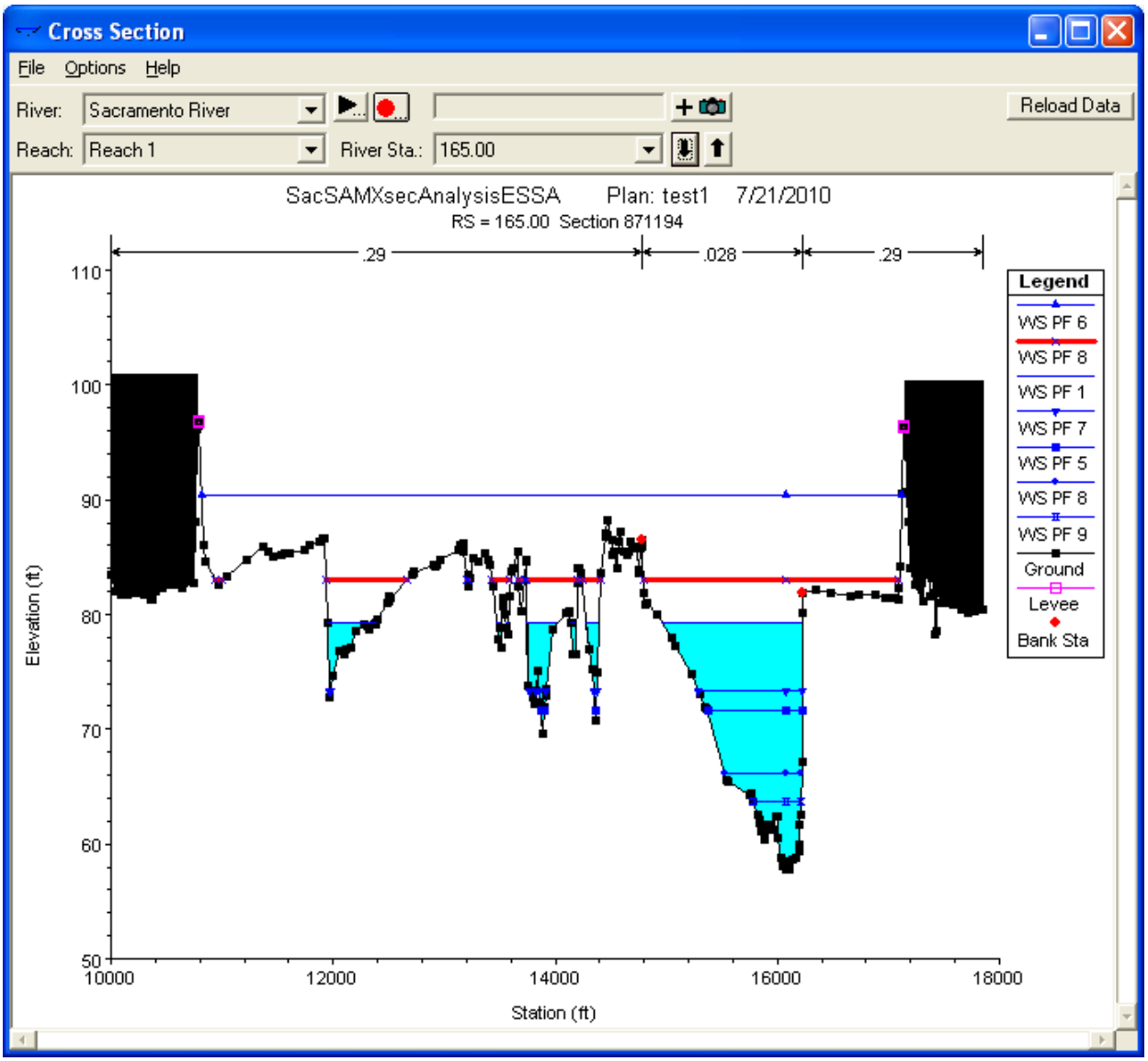



Figure 42 HR 165.00 HEC-RAS cross section plot

### HR 164.00 (GIS 165.5)

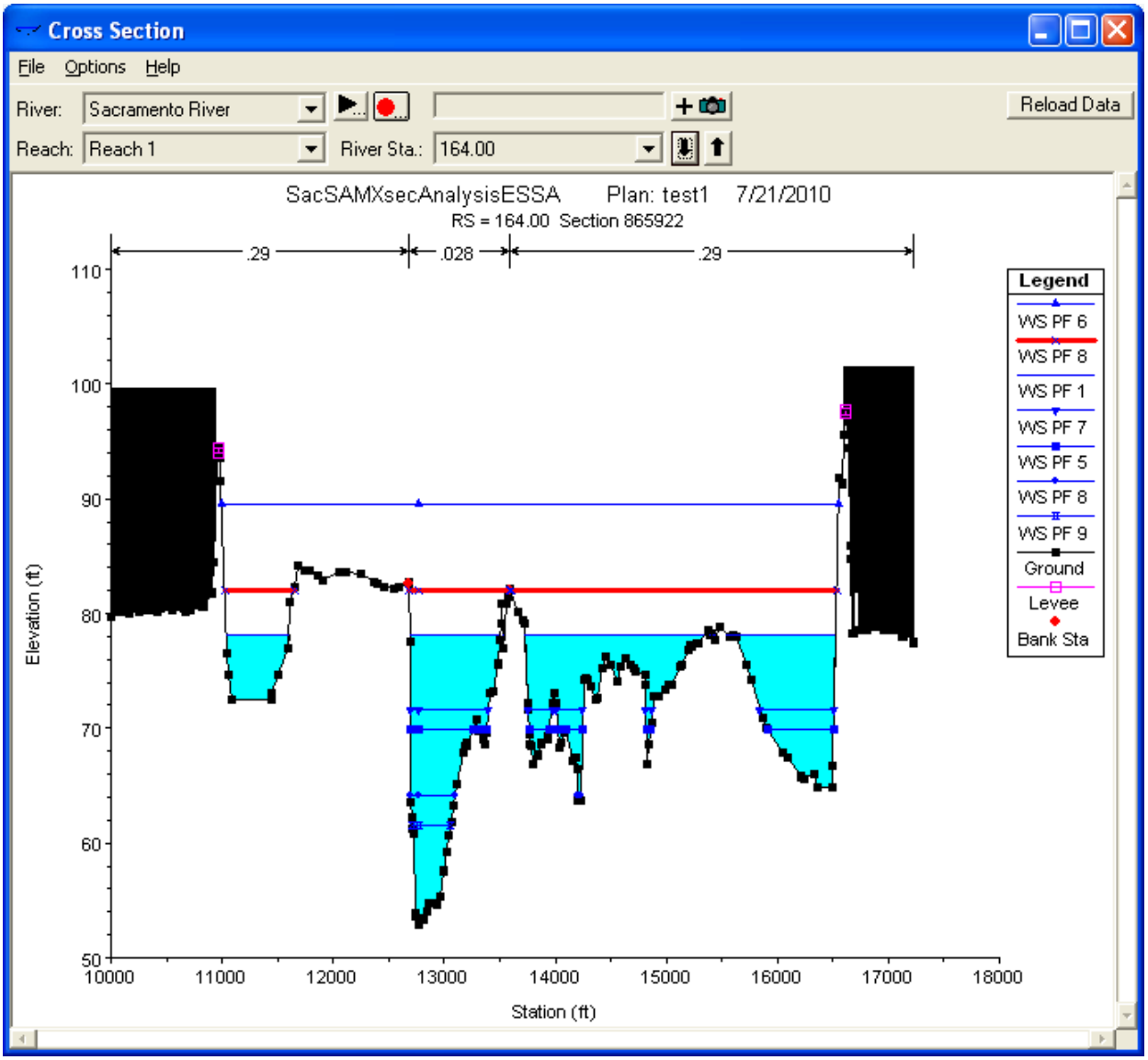



Figure 43 HR 164.00 HEC-RAS cross section plot

## HR 159.00 (GIS 160.0)

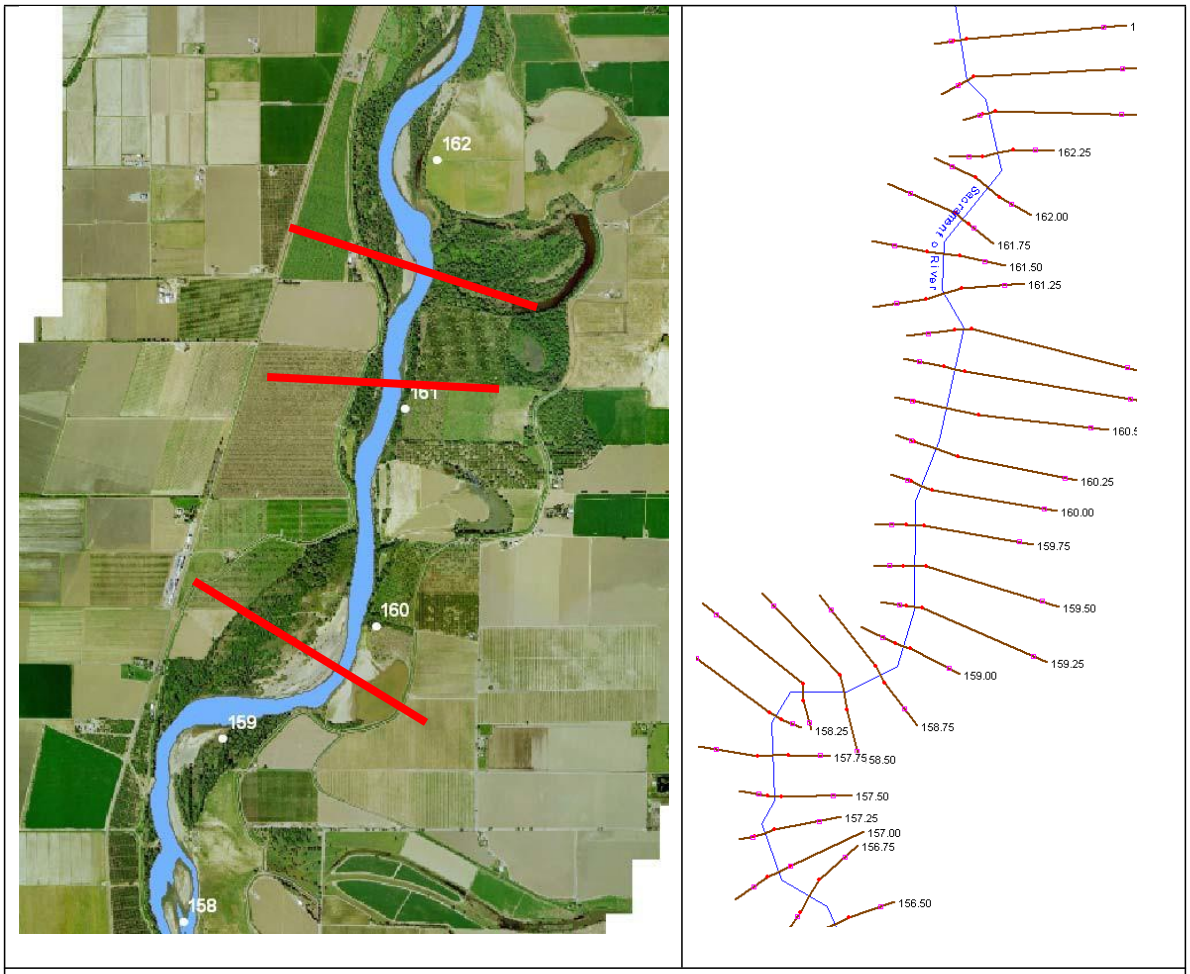



Figure 44 HR 159.00 (GIS 160.0) location maps

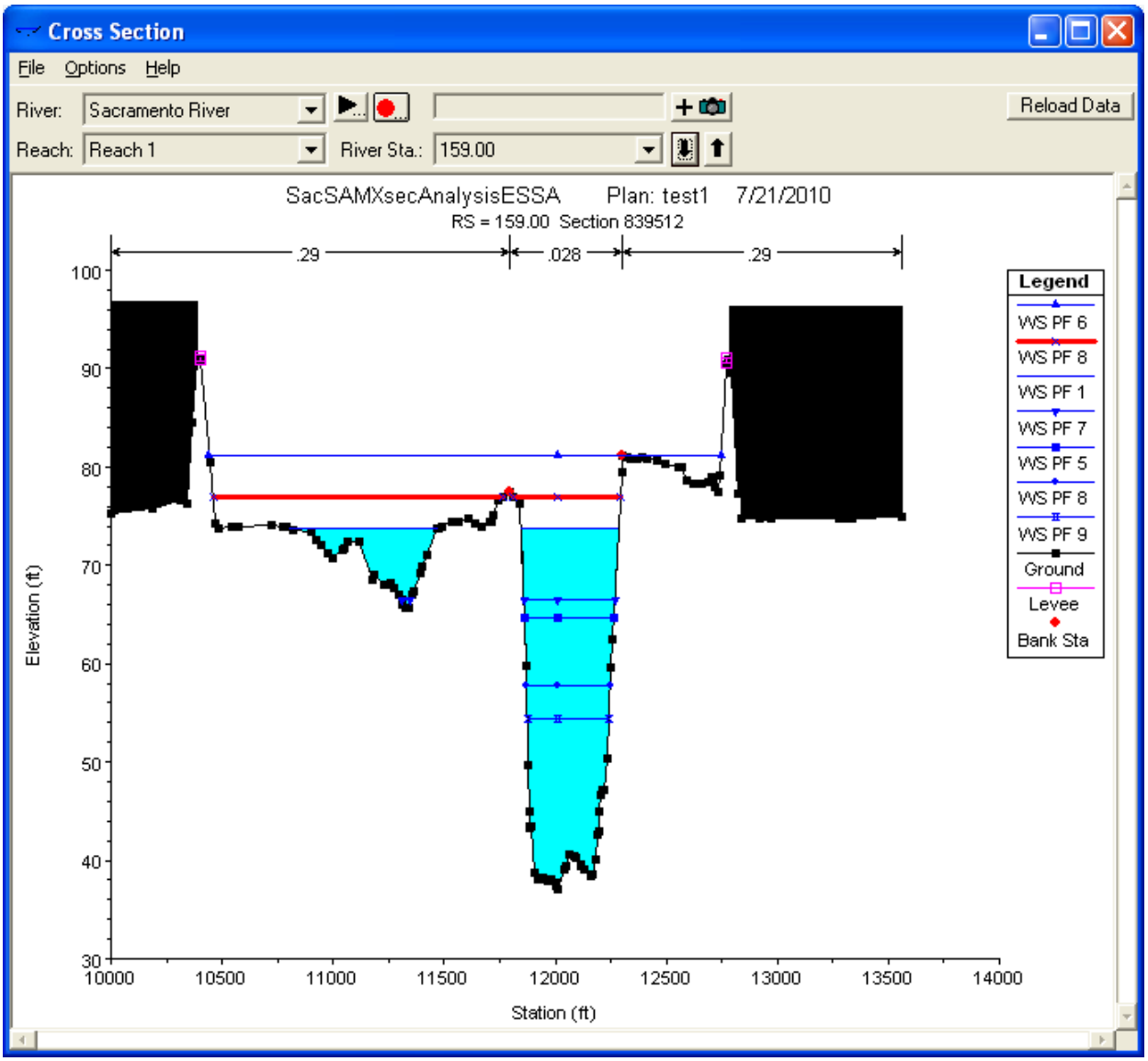



Figure 45 HR 159.00 HEC-RAS cross section plot