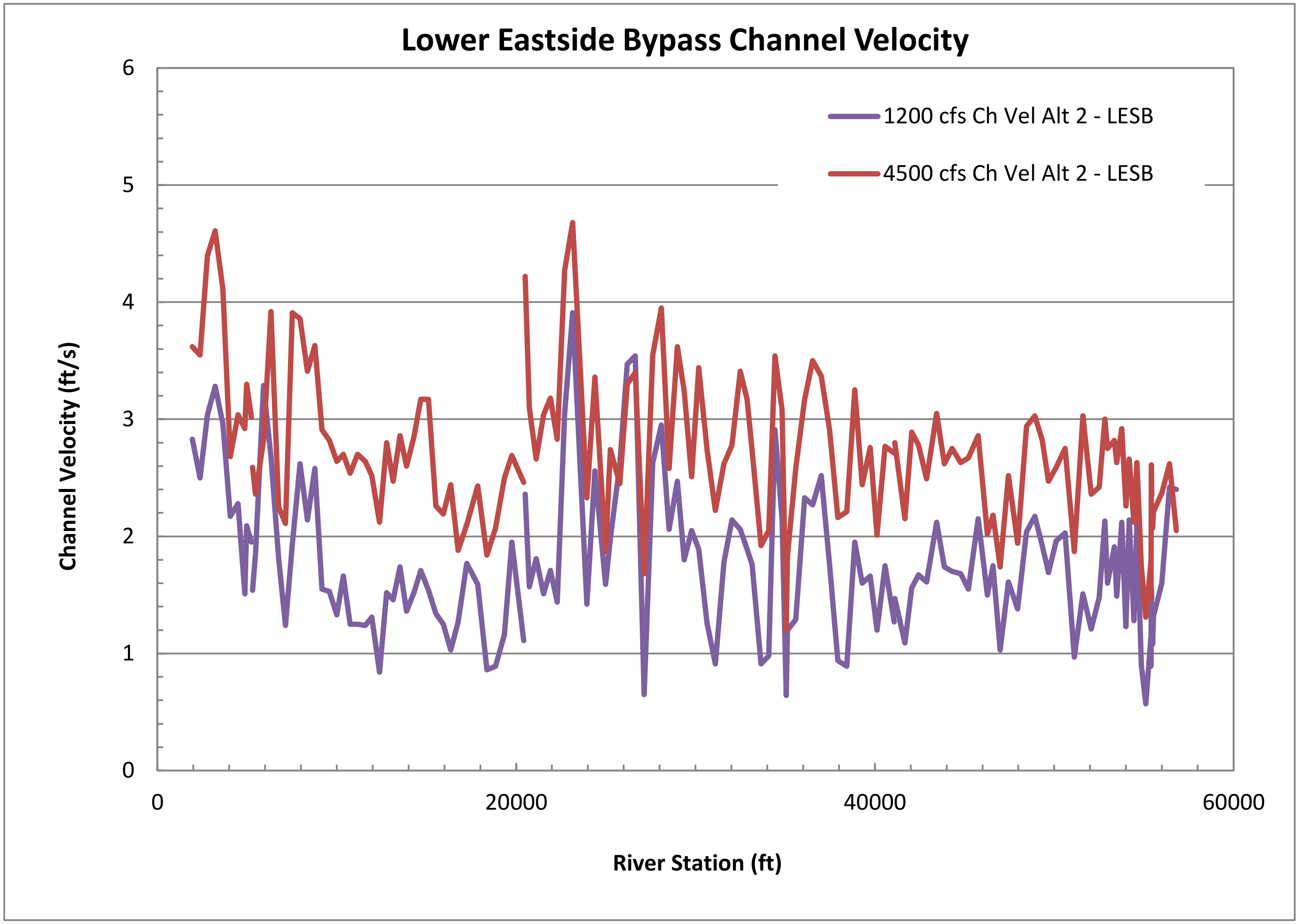


Figure 7-18. Channel velocity in Lower Eastside Bypass under Alternative 2 – LESB for a flow of 4500 and 1200 cfs.

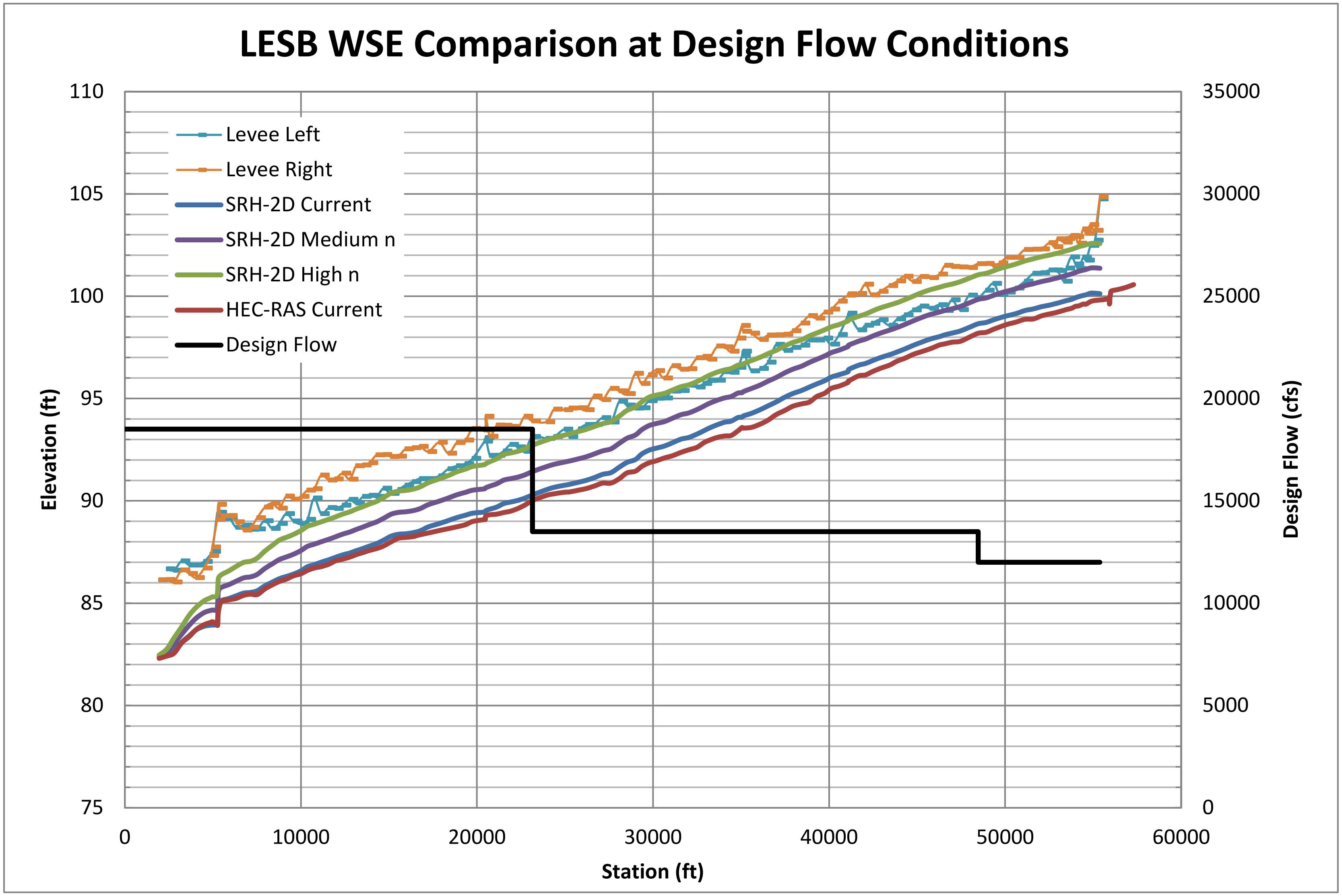


Figure 7-19. Lower Eastside Bypass WSE estimated by SRH-2D for the design flow under Current Conditions and Alternative 2-LESB Conditions. The results from HEC-RAS under current conditions are also shown for comparison.

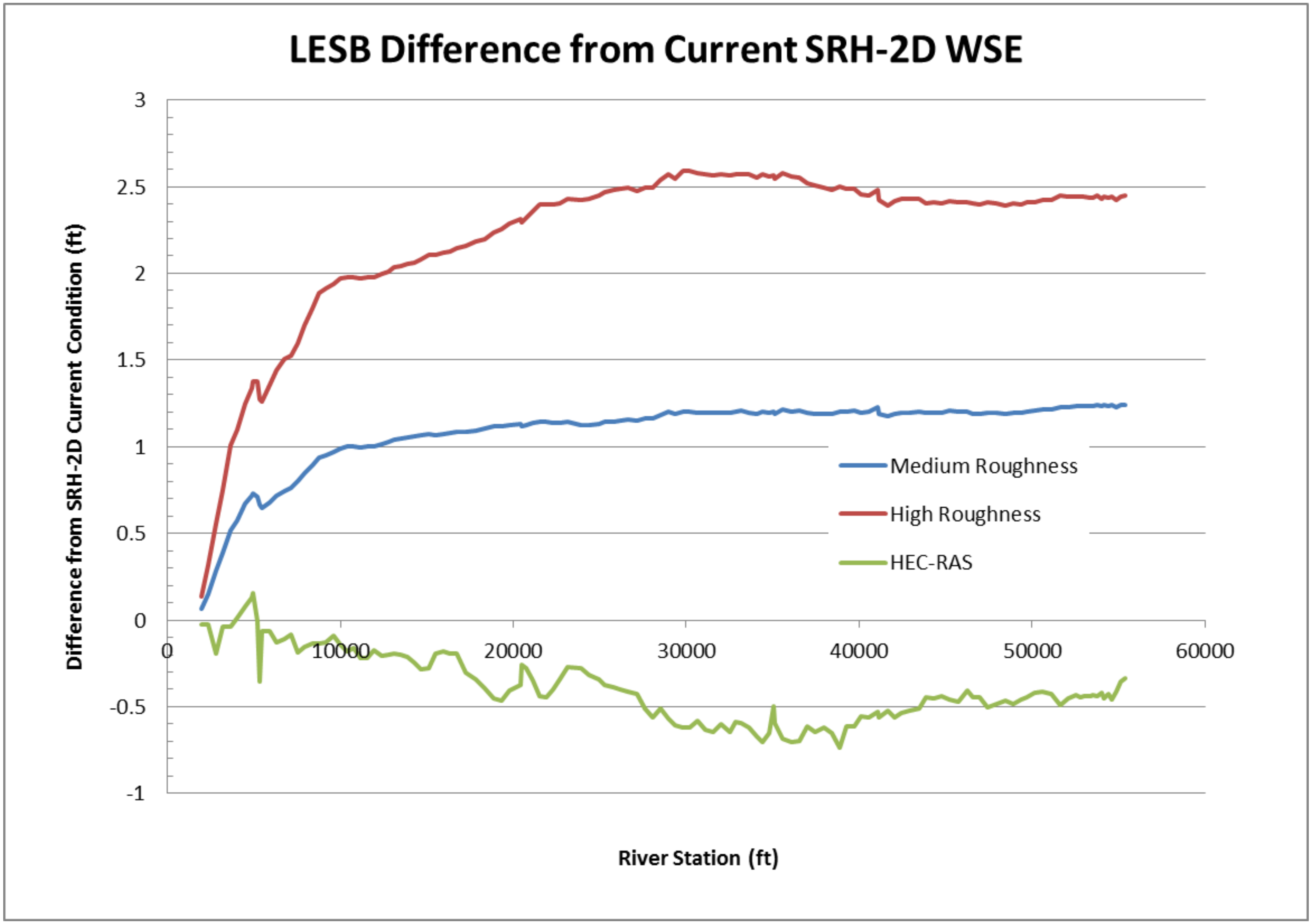


Figure 7-20. Difference in WSE from SRH-2D current condition for the Design Flows in the Lower Eastside Bypass.

7.5 Alternative 3

For Alternative 3, a base flow up to 475 cfs is restored to Reach 4B1 and there is no continuous base flow to the Eastside Bypass. Therefore, there would be little additional vegetation growth expected in the bypasses and no significant reduction in the capacity of the Eastside Bypass relative to the No Action Alternative.

There would have to be some improvement of road crossings and levees to contain the 475 cfs in 4B1. The hydraulic calculations are used in the design of these levees.

7.6 Alternative 4

For Alternative 4, a base flow up to 1500 cfs is restored to Reach 4B1 there is no continuous base flow to the Eastside Bypass. Therefore, there would be little additional vegetation growth expected in the bypasses and no significant reduction in the capacity of the Eastside Bypass relative to the No Action Alternative.

There would have to be some improvement of road crossings and levees to contain the 1500 cfs in Reach 4B1. The HEC-RAS hydraulic calculations are used in the design of these levees.

7.7 Subsidence

The USACE (2002) reported the future subsidence could be over 9 feet in the upper end of the project reach from 2000 until 2060 (Figure 7-21). Recent survey information has confirmed local subsidence rates of up to 0.85 ft/yr in the San Joaquin Valley near the project area (Sneed and Phillips, 2012). The potential subsidence would have significant effects on the hydraulics within the reach. The relationship between a decrease in slope and an increase in flow depth can be developed using the Manning's Roughness Equation:

$$Q = \frac{C}{n} A R^{2/3} S^{1/2}$$

where Q is the flow rate, C is Manning's constant, n is Manning's roughness, A is the flow area, R is the hydraulic radius, and S is the friction slope, which is equal to the bed slope under uniform flow conditions. It is possible to rearrange the equation to compute the relative change in the flow depth given a relative change in river slope if the channel is wide and width and roughness are assumed constant:

$$\frac{h_2}{h_1} = \left(\frac{S_1}{S_2}\right)^{0.3}$$

where the subscript 2 signifies the subsided condition and 1 signifies the current condition. The equation indicates that the relative change in the flow depth would be less than the relative change in river slope. In addition, the change in the flow depth due to subsidence would be proportional to the current flow depth. Therefore, because the Bypass has significantly larger design discharge of 16,500 cfs and significantly larger flow depths than the design discharge in Reach 4B1, the increase in the flow depth would be significantly larger in the Bypass than in 4B1.

Based upon the average subsidence rates at specific control points reported from December 2011 until December 2015 by Reclamation at: http://www.restoresjr.net/monitoring-data/subsidence-monitoring/ the following table of subsidence rates versus HEC-RAS river station was developed (Table 7-3, Figure 7-22).

Subsidence will also affect the sediment transport and channel morphology and therefore the quantitative effect of subsidence on water surface elevations and flood capacity are discussed in Section “Future Geomorphology and Sediment Transport.”

Table 7-3. Rates of subsidence used in 1D model simulations as a function of HEC-RAS river station.

Location	HEC-RAS Station	Subsidence Rate (ft/yr)
Sack Dam	336642	-0.4
Sand Slough Control	264898	-0.4
End of Reach 4B1	154077	-0.05

Information Paper
Subsidence in the Central Valley

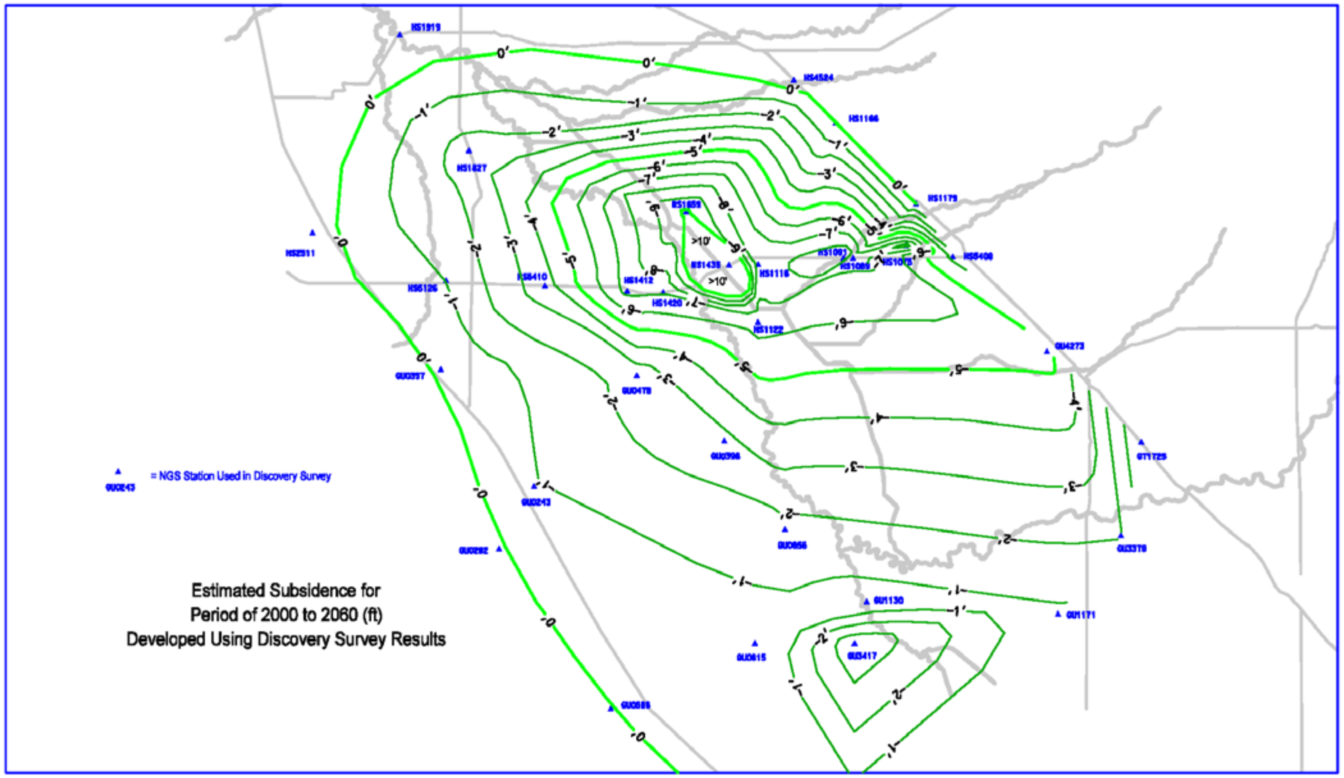
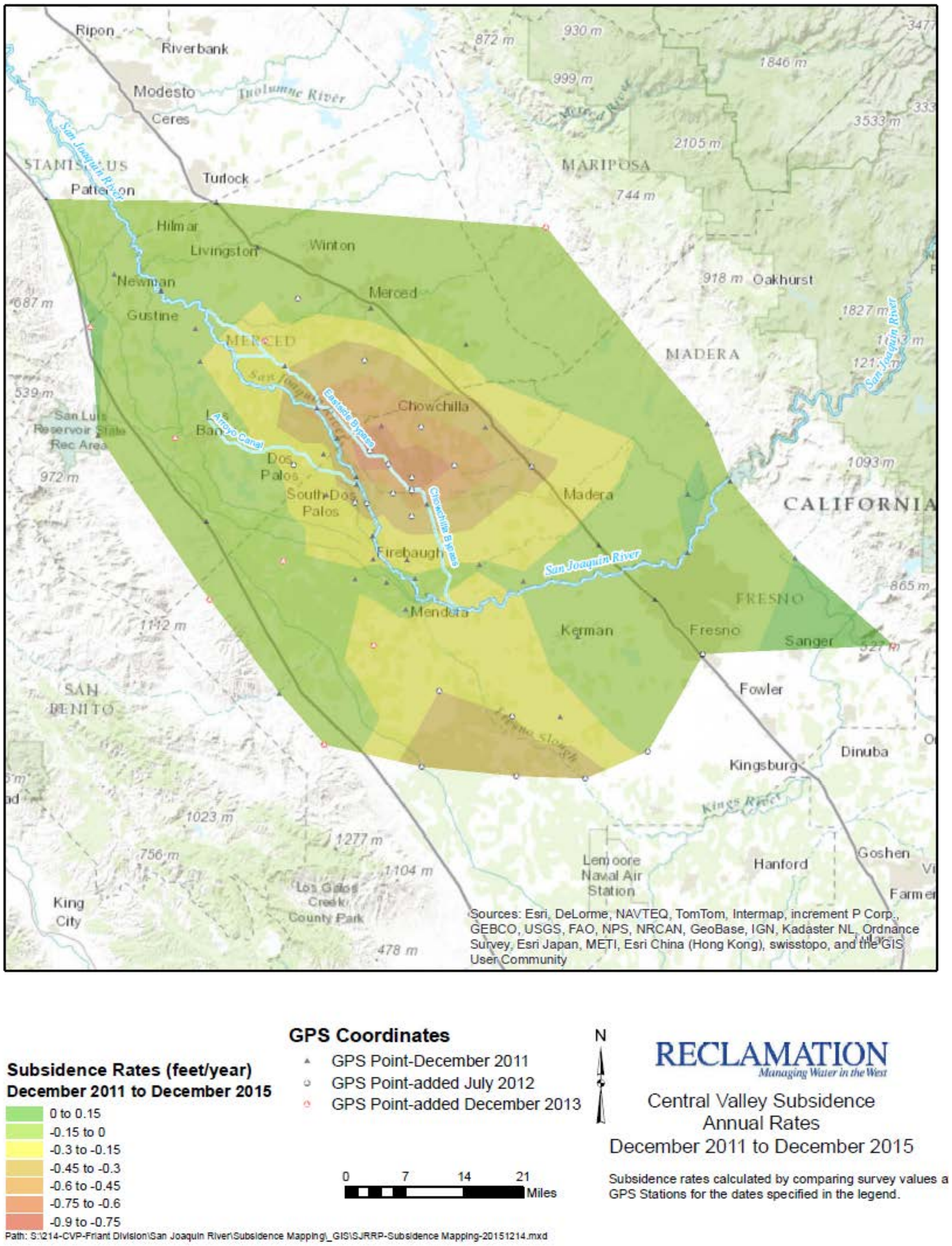


FIGURE 3 – ESTIMATED SUBSIDENCE FOR PERIOD OF 2000 TO 2060 USING DISCOVERY SURVEY

Technical Studies
December 2002
8
Sacramento and San Joaquin River Basins
Comprehensive Study, California

Figure 7-21. Estimated Subsidence from 2000 to 2060 from the USACE (2002) study.



Sources: Esri, DeLorme, NAVTEQ, TomTom, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, and the GIS User Community

Subsidence rates calculated by comparing survey values a GPS Stations for the dates specified in the legend.

Path: S:\214-CVP-Friant Division\San Joaquin River\Subsidence Mapping_GIS\SJRRP-Subsidence Mapping-20151214.mxd

Figure 7-22. Measured subsidence rates by Reclamation based upon data from December 2011 until December 2015, downloaded from: http://www.restoresjr.net/monitoring-data/subsidence-monitoring/.

8 Hydraulically Suitable Fish Habitat

The amount of hydraulically suitable fish habitat is assessed using the results of the SRH-2D hydraulic calculations. The hydraulic model described in Section 6 was used to compute the 2D flow within Reach 4B1 and the Eastside and Mariposa Bypasses. The impact of temperature is not included in this analysis. In addition, it is assumed that cover is not a limiting factor in the value of the habitat.

8.1 Fish Habitat Suitability Index for Depth and Velocity

Aceituno (1990) developed a relationship between the habitat suitability and water depth and velocity for Chinook salmon on the Stanislaus River. The habitat suitability is measured by a Habitat Suitability Index (HSI) that ranges from 0 to 1 with 0 indicating non-suitable habitat and 1 indicating optimum habitat conditions. The HSI curves used for juvenile Salmon are given in Figure 8-1. Hydraulic suitability relationships exist from other river systems such as the Trinity River (Hampton 1997); however, the Stanislaus River data had several benefits over the other data sets: Stanislaus River habitat suitability curves are from within the San Joaquin Basin, are based on data collected from actual fish observations over multiple years, and generally fit in the mean area of the range of curves from multiple river systems considered. It should be noted that Stanislaus River fish observations are based on habitat preferences within the channel, as there was no available data on fry or juvenile habitat preferences on floodplains within the San Joaquin Basin.

A total HSI of the hydraulic conditions (H_H) is computed by taking the minimum of the depth HSI and the velocity HSI (Equation 7-1). A grid (10 ft grid size) of HSI values is generated for a range of flows for each different alternative and levee option. Example maps of the total hydraulic HSI are given in Figure 8-2 and Figure 8-3.

$$H_H = \min\left(H_d, H_v\right) \qquad \text{Equation 8-1}$$

where H_d = depth HSI, H_v = velocity HSI, and H_H = total hydraulic HSI.

The weighted usable hydraulically suitable habitat (A_H) was calculated as the sum over all the grid cells of the inundated cell area multiplied by H_H for that grid cell:

$$A_H = \sum_{i=1}^{N} A_i H_H \qquad \text{Equation 8-2}$$

where A = area of hydraulically suitable habitat
A_i = inundated area within the grid cell *i*
$H_{H,i}$ = hydraulic suitability of the grid cell *i*
N = number of grid cells within simulation domain

The computational procedure is conceptually similar to that used in PHABSIM (Milhous 2012) and RIVER2D (Steffler and Blackburn 2002) computer programs.

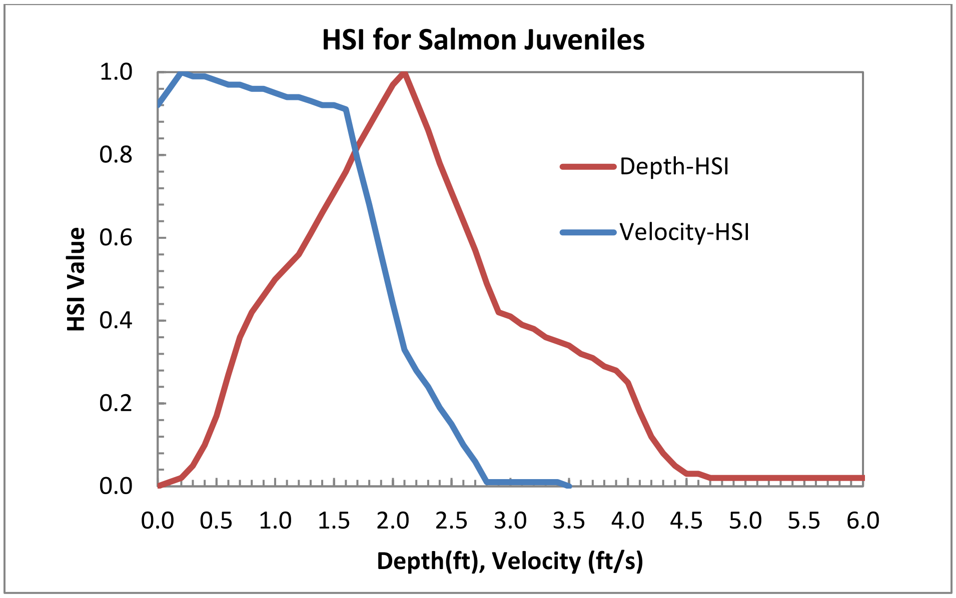


Figure 8-1. HSI as a function of water velocity for salmon juveniles.

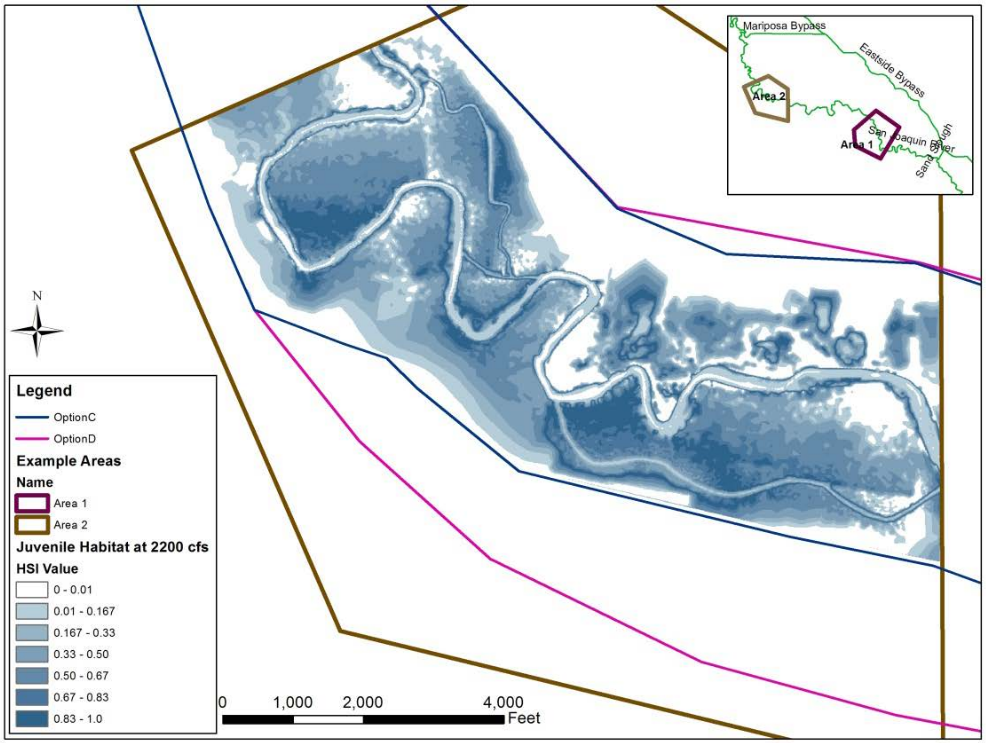


Figure 8-2. Total Hydraulic HSI for Juvenile Salmon at a flow of 2200 cfs for Alternative 1 Option C in Example Area 2 of Reach 4B1.

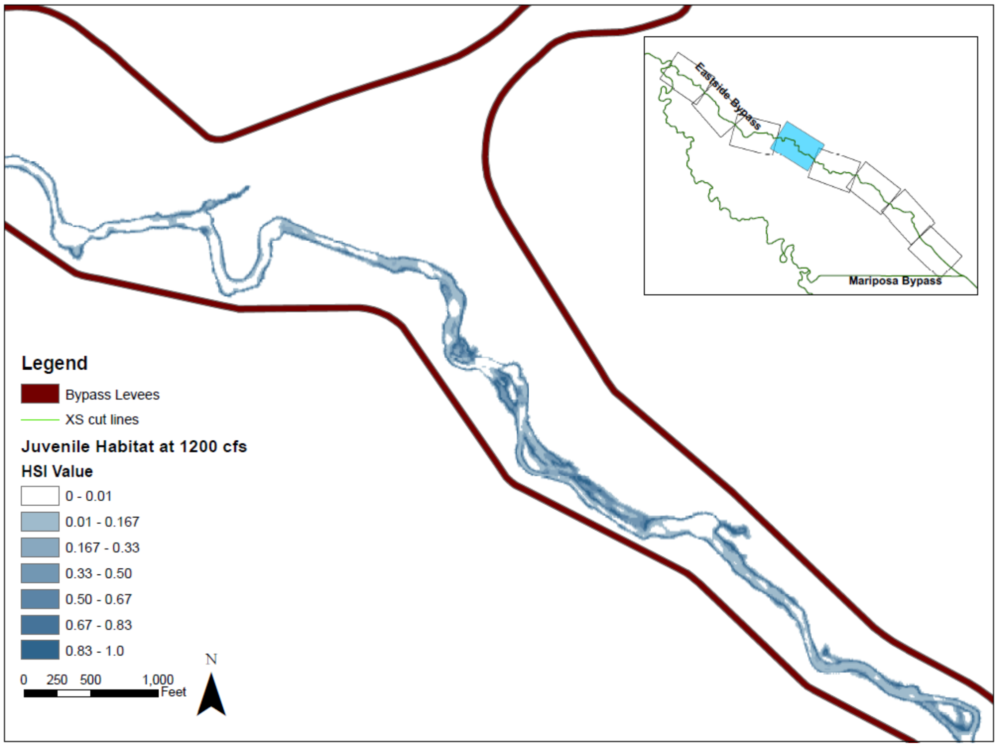


Figure 8-3. Total Hydraulic HSI for Juvenile Salmon at a flow of 1200 cfs in the Lower Eastside Bypass.

8.2 Final Habitat Value

The total area of inundation and the area of inundation with depth greater than various criteria are given in Table 8-1 and shown in graphical form in Figure 8-4.

The total area within the project reach is computed for each Alternative. For Alternative 1, the areas are a sum of the results in reaches 4B1 and 4B2. For Alternative 2, the areas are the sum of Middle Eastside Bypass, Mariposa Bypass and Reach 4B2. For Alternative 2-LESB, the areas are the sum of Middle Eastside Bypass and Lower Eastside Bypass. For Alternative 3 and 4, only the results from Reaches 4B1 and 4B2 are included. The maximum flow in Reach 4B1 in Alternative 3 is assumed to be 475 cfs and the maximum flow in Reach 4B1 under Alternative 4 is assumed to be 1500 cfs.

The weighted habitat area, in acres, as computed using Equation 7-2 is given in Table 8-2. The area within the low, medium and high HSI bins is also given in this table. The graphical representation of the habitat areas is given in Figure 8-5.

Alternative 1 has the largest area of available habitat of all alternatives for most all flows that occur under restoration releases. Alternative 2, where restoration flows are routed into the Middle Eastside and Mariposa Bypass then into Reach 4B2, has significantly more available habitat than Alternative 2 – LESB, where restoration flows are routed into the Middle Eastside and Lower Eastside Bypass. This is because there is significantly more inundated habitat in Reach 4B2 than the Lower Eastside Bypass. For example, the total weighted habitat area available in the LESB at a flow of 2200 cfs is only 54 acres, whereas it is 286 acres in Reach 4B2.

The setback of the Middle Eastside Bypass and Mariposa increases the available habitat at high flows. For Alternative 2 – LESB, the setback is only in the Middle Eastside and no setbacks are considered for the Lower Eastside.

The hydraulically suitable fish habitat for the No Action alternative will be qualitative similar to Alternative 2-LESB with No Levee Setback because Restoration flows are routed down the same path. Similar to Alternative 2-LESB, the No Action alternative includes removal of the fish weir in the Merced National Wildlife Refuge. However, the No Action alternative will have slightly higher suitable habitat values because it does not include channel grading to increase the slope of the MESB and, therefore, has more inundation overall in the MESB.

Table 8-1. Area (acres) of inundation for various depth criteria under each alternative.

Area (acres) of total inundation at various flow rates (cfs)								
Alternative/Flow (cfs)	**50**	**150**	**475**	**700**	**1,200**	**2,200**	**3,655**	**4,500**
Alt 1 – Option B	403	587	1,322	1,832	2,885	3,735	4,153	4,214
Alt 1 – Option C	430	624	2,076	2,846	4,181	6,327	7,234	7,370
Alt 1 – Option D	445	681	2,752	4,240	6,156	8,415	10,163	10,755
Alt 2 – Existing	267	451	625	814	1,262	1,927	2,786	3,164
Alt 2 – Setback	266	451	660	842	1,304	2,322	3,690	3,978
Alt 2 LESB – Existing	241	323	411	500	757	1,154	1,661	2,139
Alt 2 LESB – Setback	241	323	445	527	795	1,510	2,347	2,732
Alt 3 – Option A	412	577	783	886	1,066	1,373	1,706	1,760
Alt 4 – Option A	412	577	783	1,052	1,701	2,153	2,485	2,540
No Action	241	323	617	780	1,010	1,579	2,064	2,339
Area (acres) with Depth > 0.4 ft at various flow rates (cfs)								
	50	**150**	**475**	**700**	**1,200**	**2,200**	**3,655**	**4,500**
Alt 1 – Option B	293	443	982	1,385	2,251	3,399	3,989	4,124
Alt 1 – Option C	312	469	1,388	2,078	3,212	5,022	6,622	6,988
Alt 1 – Option D	323	491	1,666	2,759	4,427	6,705	8,652	9,469
Alt 2 – Existing	203	368	518	670	1,033	1,691	2,532	2,959
Alt 2 – Setback	203	368	538	680	1,047	1,969	3,358	3,718
Alt 2 LESB – Existing	181	264	336	415	601	1,029	1,475	1,926
Alt 2 LESB – Setback	181	264	356	425	613	1,277	2,099	2,466
Alt 3 – Option A	303	451	643	720	885	1,161	1,501	1,601
Alt 4 – Option A	303	451	643	837	1,469	2,010	2,349	2,449
No Action	181	264	489	630	859	1,400	1,849	2,125
Area (acres) with Depth > 1.2 ft at various flow rates (cfs)								
	50	**150**	**475**	**700**	**1,200**	**2,200**	**3,655**	**4,500**
Alt 1 – Option B	198	333	628	872	1,443	2,403	3,456	3,824
Alt 1 – Option C	209	352	726	1,089	1,893	3,219	4,615	5,233
Alt 1 – Option D	221	355	749	1,230	2,237	4,014	5,800	6,892
Alt 2 – Existing	144	286	420	538	780	1,374	2,092	2,552
Alt 2 – Setback	144	286	435	542	790	1,458	2,607	3,250
Alt 2 LESB – Existing	125	207	273	338	434	854	1,246	1,584
Alt 2 LESB – Setback	125	207	288	342	443	919	1,652	2,100
Alt 3 – Option A	205	345	532	590	722	950	1,239	1,371
Alt 4 – Option A	205	345	532	652	1,070	1,769	2,059	2,191
No Action	125	207	385	468	633	1,124	1,506	1,717
Area (acres) with Depth > 3.5 ft at various flow rates (cfs)								
	50	**150**	**475**	**700**	**1,200**	**2,200**	**3,655**	**4,500**
Alt 1 – Option B	40	99	274	345	472	728	1,182	1,493
Alt 1 – Option C	40	101	285	357	482	706	1,066	1,304
Alt 1 – Option D	41	104	277	346	465	680	996	1,203
Alt 2 – Existing	52	116	234	294	429	662	1,087	1,370
Alt 2 – Setback	52	116	238	298	434	654	995	1,355
Alt 2 LESB – Existing	42	76	159	193	244	398	690	909
Alt 2 LESB – Setback	42	76	163	197	248	389	588	873
Alt 3 – Option A	40	104	297	331	406	526	695	773
Alt 4 – Option A	40	104	297	377	536	834	1,003	1,081
No Action	42	76	185	233	291	478	727	857

Table 8-2. Weighted hydraulically habitat area (acres) and the area (acres) within specific bins of H_H for Juvenile Salmon for project alternatives.

Weighted hydraulically suitable Juvenile Salmon habitat area (acres) at various flows (cfs)								
Alternative/Flow (cfs)	**50**	**150**	**475**	**700**	**1,200**	**2,200**	**3,655**	**4,500**
Alt 1 – Option B	158	209	419	617	1,060	1,630	1,906	1,832
Alt 1 – Option C	169	223	606	959	1,615	2,613	3,355	3,557
Alt 1 – Option D	172	232	727	1,298	2,227	3,599	4,692	5,165
Alt 2 – Existing	143	304	188	245	377	677	941	1,092
Alt 2 – Setback	143	316	198	248	386	838	1,490	1,601
Alt 2 LESB – Existing	135	264	116	144	214	419	508	680
Alt 2 LESB – Setback	135	276	126	147	222	560	947	1,044
Alt 3 – Option A	165	212	232	258	318	419	533	561
Alt 4 – Option A	165	212	232	293	576	676	790	818
No Action	165	212	232	293	576	676	790	818
High Value (0.67< H_H ≤ 1.0) Juvenile Salmon habitat area (acres) at various flow (cfs)								
Alternative/Flow (cfs)	**50**	**150**	**475**	**700**	**1,200**	**2,200**	**3,655**	**4,500**
Alt 1 – Option B	93	101	175	275	522	826	1,182	1,162
Alt 1 – Option C	98	107	198	370	794	1,398	1,783	1,929
Alt 1 – Option D	95	108	199	439	943	1,904	2,636	3,054
Alt 2 – Existing	51	93	86	112	161	362	444	562
Alt 2 – Setback	51	93	91	111	165	423	771	863
Alt 2 LESB – Existing	44	77	50	66	82	241	223	306
Alt 2 LESB – Setback	44	77	55	65	86	290	509	504
Alt 3 – Option A	98	102	108	116	148	196	252	282
Alt 4 – Option A	98	102	108	125	263	311	367	397
No Action	0	17	18	19	18	19	24	31
Medium Value (0.33< H_H ≤ 0.67) Juvenile Salmon habitat area (acres) at various flow (cfs)								
Alternative/Flow (cfs)	**50**	**150**	**475**	**700**	**1,200**	**2,200**	**3,655**	**4,500**
Alt 1 – Option B	137	219	439	633	1,055	1,649	1,597	1,486
Alt 1 – Option C	148	233	709	1,070	1,590	2,479	3,350	3,566
Alt 1 – Option D	162	242	891	1,515	2,414	3,448	4,386	4,653
Alt 2 – Existing	127	294	198	260	416	660	1,064	1,137
Alt 2 – Setback	127	293	207	265	423	842	1,589	1,686
Alt 2 LESB – Existing	123	246	123	148	245	376	608	757
Alt 2 LESB – Setback	123	245	133	153	250	543	993	1,201
Alt 3 – Option A	141	223	219	254	310	424	546	563
Alt 4 – Option A	141	223	219	296	595	709	831	847
No Action	0	42	44	45	45	45	54	87
Low Value (0.01<H_H≤ 0.33) Juvenile Salmon habitat area (acres) at various flow rates (cfs)								
Alternative/Flow (cfs)	**50**	**150**	**475**	**700**	**1,200**	**2,200**	**3,655**	**4,500**
Alt 1 – Option B	100	170	486	629	876	966	1,030	1,177
Alt 1 – Option C	105	180	723	932	1,207	1,603	1,580	1,405
Alt 1 – Option D	107	203	954	1,375	1,754	2,000	2,065	2,072
Alt 2 – Existing	566	964	283	363	528	647	884	996
Alt 2 – Setback	565	1,061	300	385	565	807	964	996
Alt 2 LESB – Existing	554	913	208	240	348	361	558	748
Alt 2 LESB – Setback	553	1,010	225	262	382	508	602	734
Alt 3 – Option A	102	168	344	391	456	557	645	623
Alt 4 – Option A	102	168	344	460	587	689	776	755
No Action	0	56	63	79	83	83	104	157

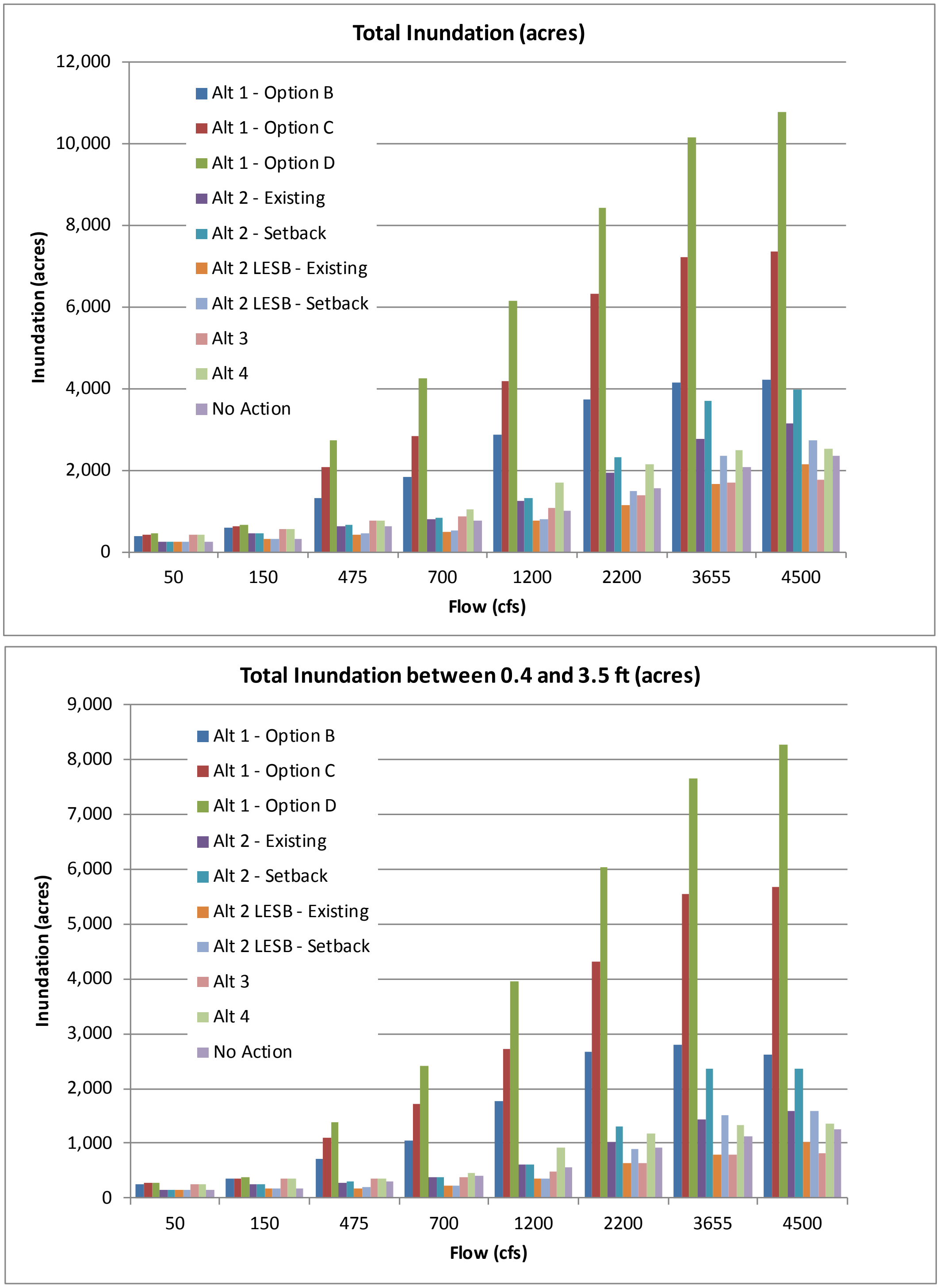


Figure 8-4. Area inundated at various flow rates and depths.

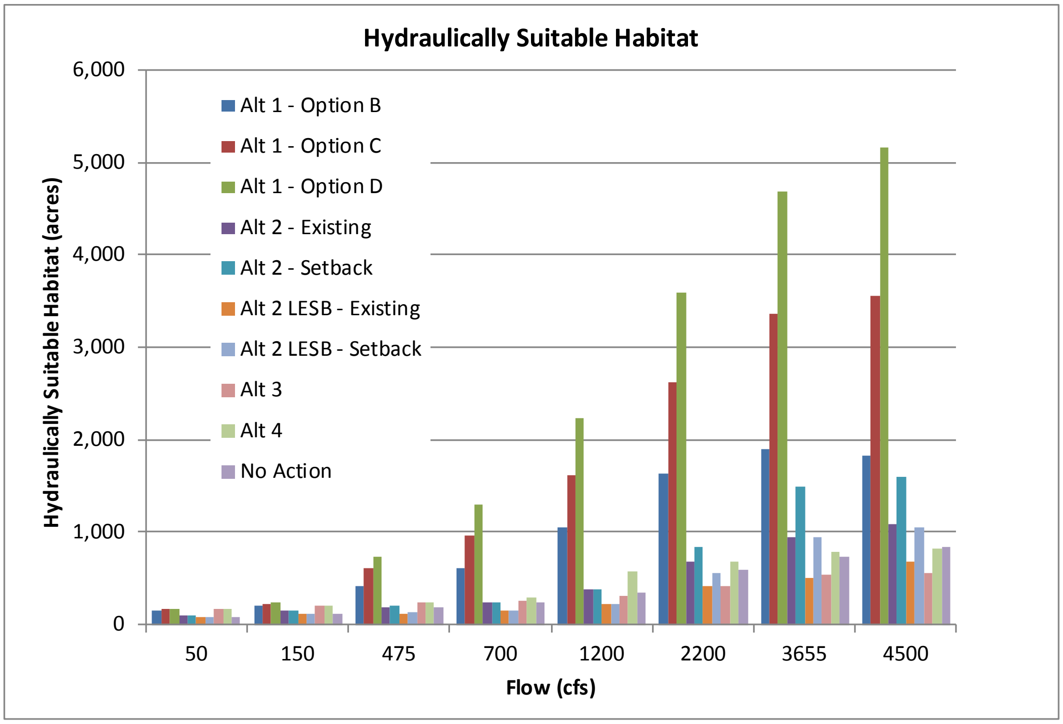


Figure 8-5. Hydraulically Suitable Area for Juvenile Salmon obtained with Equation 7-2.

9 Future Geomorphology and Sediment Transport

SRH-1D V4.0 was used to simulate the erosion and deposition under the alternative conditions. It is a one-dimensional cross section based model that simulates the hydraulics, sediment transport, and bed geometry of natural rivers. The input daily average flows were taken from the daily flow model described in Section Future Hydrology. A 50-yr simulation was performed in this analysis in which the period from WY 1954 through 2003 was used.

The reaches simulated for each alternative are given in Table 9-1. A reach was simulated only if it is intended to convey restoration flows. The Mariposa Reach was not simulated under existing conditions because of uncertainties about how the flows are split during current operations and because the reach is controlled on the upstream and downstream ends by concrete structures. Levee Options B and C were simulated for Alternative 1. Levee Option D was not simulated because the 1D model could not accurately model the extensive side channel network that exists under that option. No levee setback alternatives were simulated for Alternative 2 and 2-LESB and it is assumed that the major sediment conclusions for the Alternative 2 are also valid for the levee setback options.

Reach 4B1 and the Eastside Bypass were divided into sub-reaches based upon hydraulic controls within the reach and changes in the bed slope. The reach averaged hydraulic properties for a flow of 1200 cfs for the San Joaquin River for Alternative 1 Options B and C are given in Figure 9-1 and Figure 9-2. The reach averaged properties for the Existing Conditions in the MESB are given in Figure 9-3 and the reach average properties for Alternative 2 in the MESB are given in Figure 9-4. The reach averaged properties for Alternative 4 are given in Figure 9-5.

The overall simulation reach and the location of each subreach is given in Figure 9-6 and listed in Table 9-2.

Table 9-1. Reaches simulated for each alternative.

	Reach					
Alternative	**4A**	**4B1**	**Sand Slough Bypass**	**Middle Eastside Bypass**	**Mariposa**	**Lower Eastside Bypass**
No Action	×		×	×		
1	×	× (Opt B, C)				
2	×		×	×	×	
2 - LESB	×		×	×		×
3	×	×				
4	×	×				

Table 9-2. Sub-reaches defined in Reach 4B1 and Bypass.

Sub-reach	Downstream XC	Length (mi)
Reach4a	265295	13.41
Reach4b1-1	259249	1.15
Reach4b1-2	246231	2.47
Reach4b1-3	225537	3.92
Reach4b1-4	205407	3.81
Reach4b1-5	174419	5.87
Reach4b1-6	154244	3.82
Eastside Connect	104521	0.65
Middle Eastside – 1	87540	3.39
Middle Eastside – 2	57316	5.72
Mariposa	38789	3.51
Lower Eastside – 1	20497	6.83
Lower Eastside – 2	1947	3.50

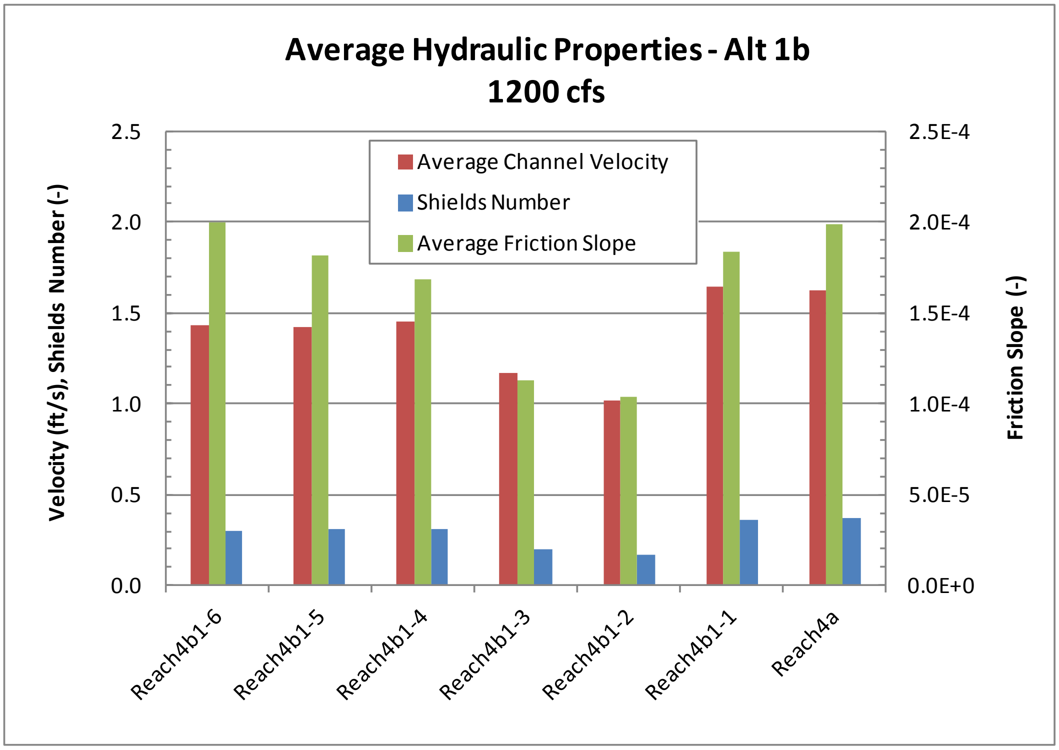


Figure 9-1. Reach averaged hydraulic properties for Alternative 1b.

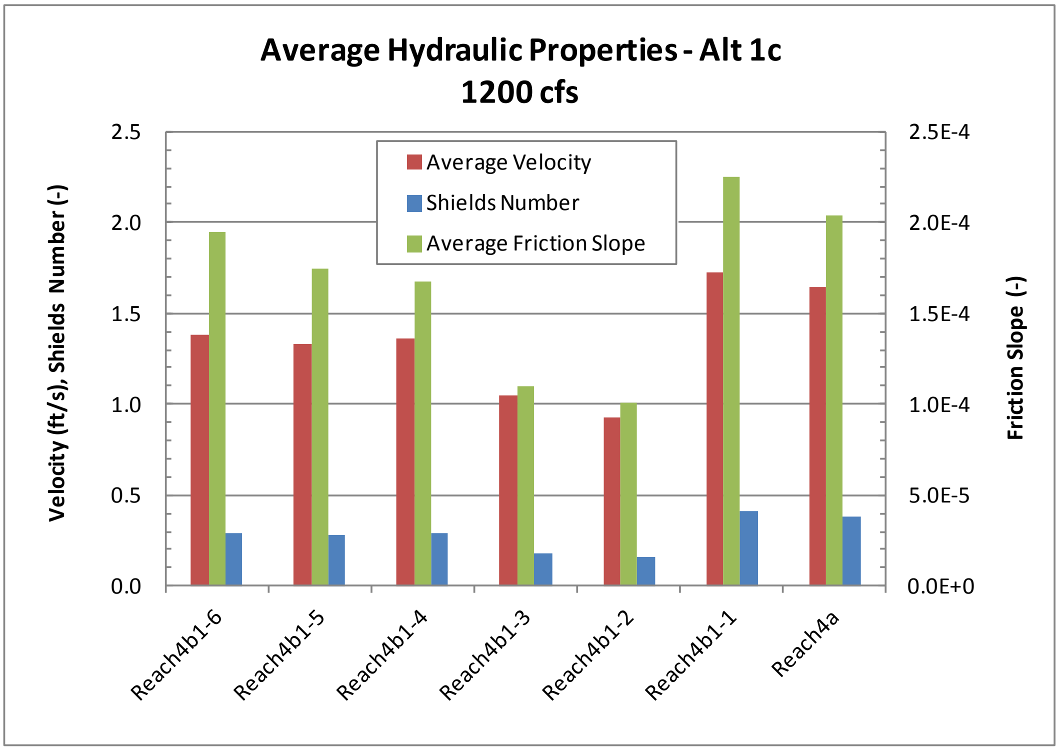


Figure 9-2. Reach averaged hydraulic properties for Alternative 1c.

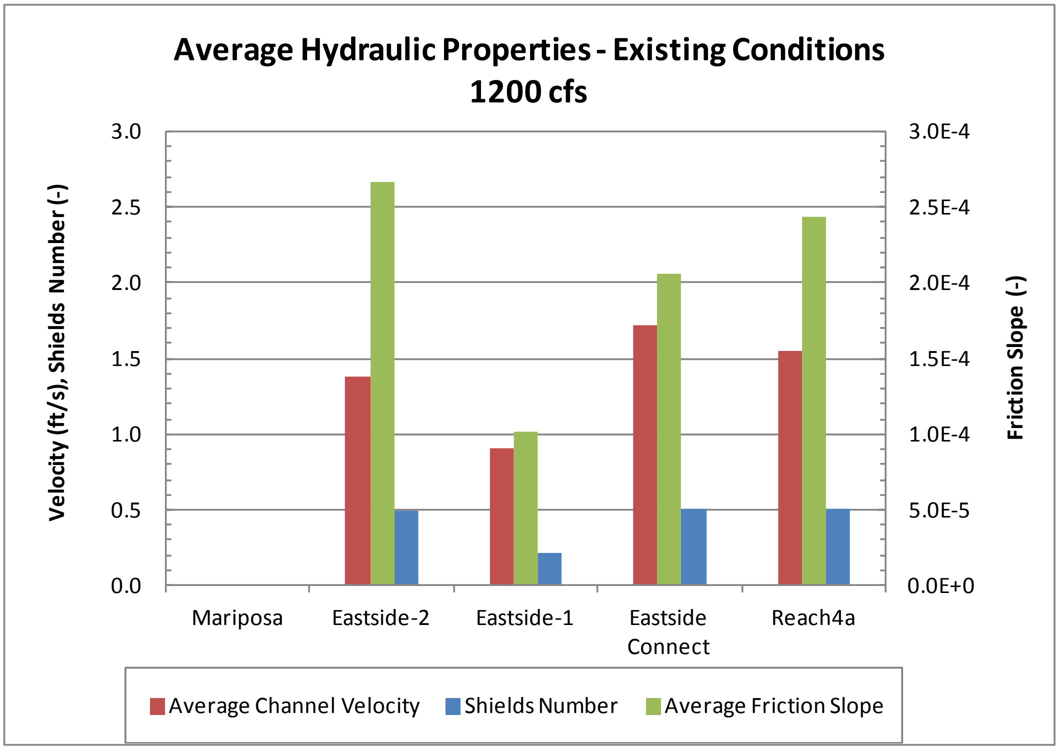


Figure 9-3. Reach averaged hydraulic properties for Existing Conditions in Bypass.

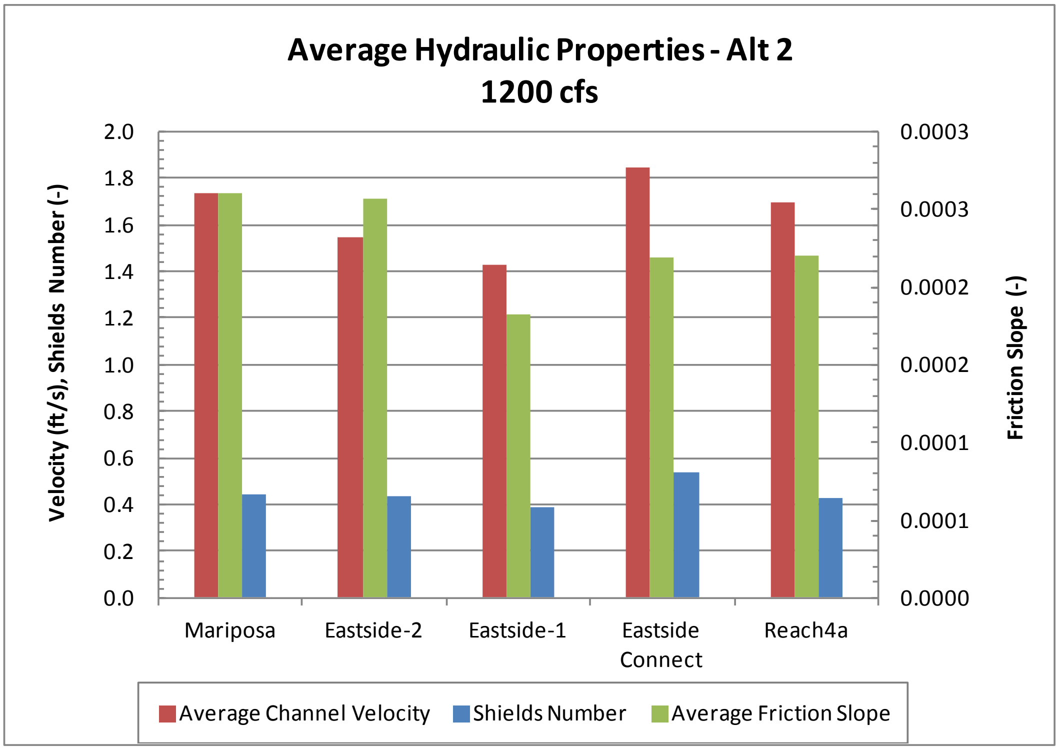


Figure 9-4. Reach averaged hydraulic properties for Alternative 2 in Bypass.

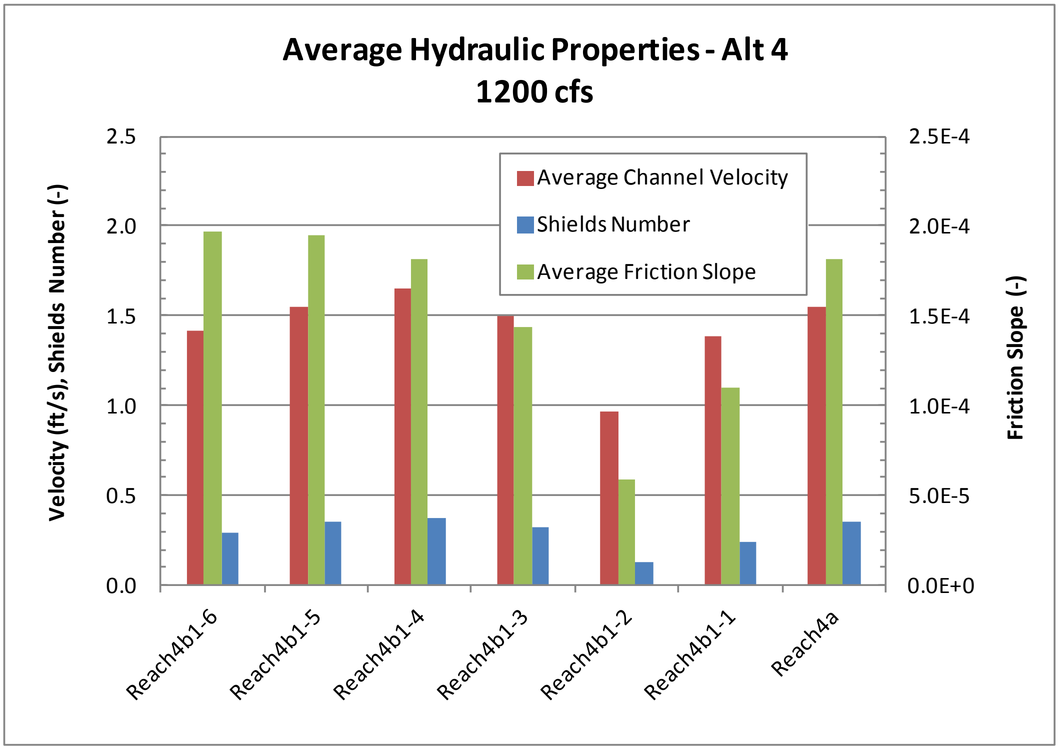


Figure 9-5. Reach averaged hydraulic properties for Alternative 4 in San Joaquin River.

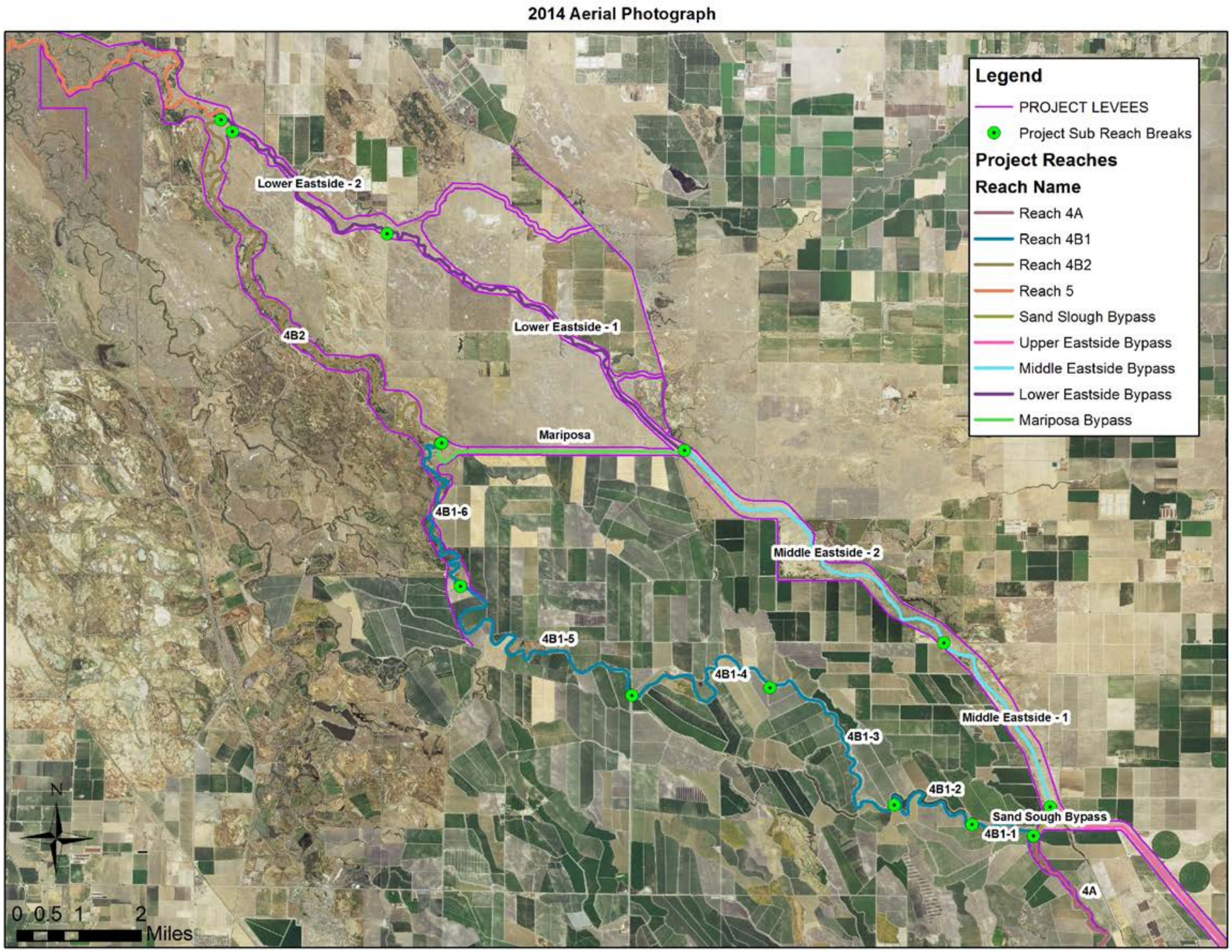


Figure 9-6. Subreaches used in sediment analyses for Reach 4B1 and Bypasses.

9.1 Model Description

9.1.1 Hydrology

The flows used in the sediment model were taken from the RiverWare model results described in Section 6. The sediment model uses a 50-yr hydrologic period from WY 1954 through 2003. The modeling includes inflows from Chowchilla Bypass during flood operations. For Alternative 2-LESB, the flows in the LESB were assumed to be the same as the flows in the Mariposa under Alternative 2.

9.1.2 Upstream Boundary Conditions

The upstream extent of the model was the cross section immediately downstream of Sack Dam (XC 336642). The sediment load was computed assuming the river was carrying sediment at capacity at the most upstream cross section. The sediment transport formula used to compute the sediment transport capacity is discussed in Section Sediment Transport Formula. Only bed material sediment load is simulated in this analysis and wash load is not considered. Practically, that means that only sand-sized sediment is considered and the silt and clay size sediment is ignored.

9.1.3 Lateral Sediment Sources

Under current conditions, flows from the Upper Eastside Bypass upstream of the Sand Slough Bypass merge with flows from the Sand Slough Bypass just upstream of the Eastside Bypass near El Nido gage (ELN). The RiverWare model included the flows from the Upper Eastside Bypass.

The lateral sediment source from the Eastside Bypass was estimated based on the transport capacity of the bypass as no sediment load measurement data were available for calibration. The transport capacity was calculated using the average hydraulic properties of the bypass and sediment samples collected in the bypass as described below. There is considerable uncertainty in estimating sediment loads in this manner; however, the results will be evaluated for existing conditions to determine if the assumption in computing the sediment loads are reasonable.

A separate HEC-RAS model was developed for this study for the Chowchilla Bypass and upstream reach of Eastside Bypass. A HEC-RAS geometry file was provided to Reclamation by MEI (MEI, 2002). MEI first developed a HEC-2 hydraulic model (an earlier version of HEC-RAS), which was later transferred into a HEC-RAS model. Multiple flow profiles were modeled over a wide range of possible hydrologic conditions from 10 cfs to 70,000 cfs. The downstream boundary condition was determined by assuming normal depth at an energy grade slope of 0.000395. HEC-RAS hydraulic results, including main channel discharge, main channel velocity, main channel top width, hydraulic radius, and friction slope are shown in Table 9-3. Reach-averaged channel slopes were calculated from the difference in thalweg elevation between the upstream cross section and downstream cross section divided by the channel length.

Table 9-3. Averaged hydraulic data in the Eastside Bypass upstream from the confluence of the Sand Slough Bypass.

Q Total	**Q Channel**	**Velocity Channel**	**Top Width**	**Hydraulic Radius**	**Friction Slope**	**Bed Slope**
(cfs)	**(cfs)**	**(ft/s)**	**(ft)**	**(ft)**	**(ft/ft)**	**(ft/ft)**
10	10	0.41	95	1.1	0.00020	0.000383
50	50	0.67	115	1.5	0.00023	0.000383
100	100	0.77	131	1.8	0.00024	0.000383
200	200	0.91	145	2.2	0.00024	0.000383
300	300	1.05	155	2.5	0.00026	0.000383
400	400	1.16	163	2.8	0.00028	0.000383
500	500	1.27	168	3.0	0.00029	0.000383
600	600	1.34	173	3.2	0.00030	0.000383
700	700	1.42	176	3.3	0.00031	0.000383
800	800	1.50	178	3.5	0.00032	0.000383
900	900	1.57	181	3.7	0.00032	0.000383
1000	1000	1.62	183	3.8	0.00033	0.000383
1100	1099	1.68	185	4.0	0.00033	0.000383
1200	1198	1.72	189	4.1	0.00033	0.000383
1300	1297	1.78	190	4.2	0.00033	0.000383
1400	1395	1.83	192	4.3	0.00034	0.000383
1500	1494	1.88	194	4.4	0.00034	0.000383
1600	1592	1.92	195	4.6	0.00034	0.000383
1700	1689	1.97	196	4.7	0.00034	0.000383
1800	1787	2.02	198	4.8	0.00034	0.000383
1900	1884	2.06	199	4.9	0.00035	0.000383
2000	1982	2.10	201	5.0	0.00035	0.000383
2500	2462	2.29	208	5.4	0.00036	0.000383
3000	2934	2.46	213	5.8	0.00037	0.000383
4000	3861	2.75	221	6.6	0.00038	0.000383
5000	4767	3.00	227	7.2	0.00039	0.000383
6000	5649	3.21	235	7.7	0.00040	0.000383
7000	6492	3.40	238	8.2	0.00041	0.000383
8000	7298	3.57	241	8.7	0.00042	0.000383
9000	8071	3.72	244	9.1	0.00043	0.000383
10000	8818	3.86	246	9.5	0.00044	0.000383
15000	12040	4.39	248	11.3	0.00045	0.000383
20000	14802	4.78	248	12.7	0.00045	0.000383
25000	17310	5.06	248	14.0	0.00046	0.000383
30000	19824	5.35	248	15.2	0.00046	0.000383
40000	24515	5.84	248	17.1	0.00047	0.000383
50000	29033	6.26	248	18.8	0.00047	0.000383

Surface bed material data were used to estimate the sediment load in the Eastside Bypass. Sediment samples collected in February 2008 (Reclamation, 2008) provided 5 sample sites, 1-10, 1-7, 1-8, 1-9, and 2-20, located in the Eastside Bypass upstream of the Sand Slough Bypass confluence. The sediment size fractions at the 5 sample sites were averaged to get a representative sediment size fraction in the reach as shown in Table 9-4.

Table 9-4. Sampled cumulative bed sediment fraction (% finer) used in the upstream reach of the Eastside Bypass.

Site ID	**1-10**	**1-7**	**1-8**	**1-9**	**2-20**	**average**
Diameter (mm)	**Percent Finer**					
0.0625	3%	2%	1%	3%	2%	2%
0.125	4%	3%	2%	4%	2%	3%
0.25	9%	7%	5%	9%	12%	7%
0.5	35%	23%	30%	53%	58%	35%
1	58%	65%	64%	93%	87%	70%
2	81%	91%	92%	99%	98%	91%
4	98%	98%	100%	100%	100%	99%
8	100%	100%	100%	100%	100%	100%
16	100%	100%	100%	100%	100%	100%

Averaged channel hydraulic data and averaged bed material data were used to estimate the sediment rating curve and sediment size fractions in the Eastside Bypass upstream from the Sand Slough Bypass confluence. Given the bed material size and averaged channel hydraulic data, SRH-Capacity, a program developed by Reclamation, was used to calculate the sediment transport capacity. Engelund and Hansen’s (1972) formula was applied and results are shown in Figure 9-7.

The bed material of the Eastside Bypass upstream from the Sand Slough Bypass was composed mainly of medium sand; thus, the sediment gradation of the sediment load showed almost no change with increasing flow. A constant gradation of the incoming load was used (Table 9-5). This sediment transport capacity rating curve was used as a sediment point source at the confluence with the Eastside Bypass and Sand Slough Bypass.

Table 9-5. Fraction of sediment load within each sediment size class used as input at the upstream end of the Middle Eastside Bypass.

Class	**Silt**	**vfsnd**	**fsnd**	**msnd**	**csnd**	**vcsnd**	**vfgrv**	**fgrv**	**mgrv**
Fraction	0.0	0.0528	0.1550	0.4649	0.2458	0.0682	0.0125	0.0007	0.0

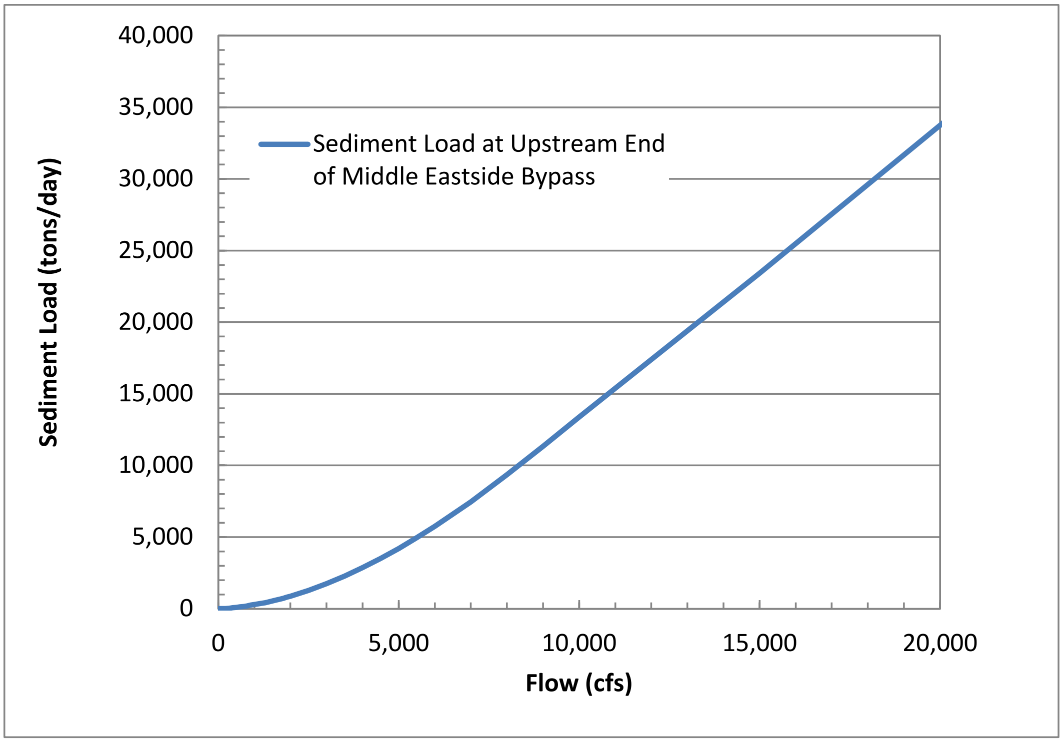


Figure 9-7. Sediment load rating curve used as lateral input at the upstream end of the Middle Eastside Bypass.

9.1.4 Cross Section Geometry

The channel geometry used in the SRH-1D model is identical to that described in the hydraulic calibration section (Section One-Dimensional Model). The downstream boundary conditions for the model were also taken from the HEC-RAS model at the corresponding cross sections.

9.1.5 In-Channel Structures

The cross sections for each control structure were directly entered into the SRH-1D model and not allowed to erode.

9.1.6 Downstream Boundary Conditions

The downstream boundary conditions used in the simulations were taken from HEC-RAS model at the downstream most cross section in the simulations. The values used in the model for each alternative are given in Table 9-6.

Table 9-6. River elevation versus flow table for the downstream boundary of the SRH-1D model.

Alternative	No Action	1, 2, 3, 4	2-LESB
Downstream Reach	Mariposa	Reach 4B2	Lower Eastside
Downstream Boundary	57316.3	152682	1947

XC ID			
Flow (cfs)	Water Surface Elevation(ft)		
0	90.4	71.9	63.5
50	90.6	79.7	64.4
100	90.7	80.4	64.8
300	91.1	82.1	66.6
500	91.5	83.1	67.8
1,000	92.2	84.9	69.7
2,000	93.3	86.8	72.0
3,000	94.2	88.1	73.6
4,000	95.0	89.0	74.9
5,000	95.8	89.6	76.0
6,000	96.5	90.0	76.9
7,000	97.2	90.5	77.6
8,000	97.9	90.9	78.3
9,000	97.9	91.3	78.9
10,000	97.9	91.7	79.4
12,500	98.0	92.5	80.5
15,000	98.0	93.3	81.3
20,000	98.0	94.8	81.3

9.1.7 River Bed Material

Surface bed material data used in the sediment transport analysis were derived from 10 surface samples collected in Reach 4A, Middle Eastside Bypass, and Mariposa Bypass. Example pictures of the reaches are given in Figure 9-9 through Figure 9-12.

No samples were available in Reach 4B1 and the samples in the Lower Eastside were not collected below water and may not have adequately represented the true bed material. The bed material samples were collected in February 2008 (Reclamation, 2008). The samples used are given in Table 9-7 and Table 9-8.

The samples were averaged within the reach and the gradations used within the model are given in Table 9-9. For cross sections between the sample locations, SRH-1D automatically interpolates the bed material. The bed material does not change appreciably between reaches 4A and 4B2 and therefore interpolating the bed material in 4B1 does not likely introduce significant error (Figure 9-8, Table 9-9).

Table 9-7. Bed material samples collected in bypass system

Site ID:	2-19	2-20	1-10	1-9	1-8	1-7
River Mile:	19.10	21.00	21.10	21.70	22.40	24.70
Reach:	Middle Eastside	Sand Slough	Sand Slough	Upper Eastside	Upper Eastside	Upper Eastside
Easting	6098635	6105659	6106169	6108062	6110387	6118459
Northing	2297734	2292459	2292021	2289883	2286679	2277358
Date	2/6/2008	2/6/2008	2/6/2008	2/6/2008	2/6/2008	2/6/2008
Site Description	1.2 miles DS of CS	DS of Washington Road	US of Washington Rd	3.1 miles DS of SH 152	2.3 miles DS of SH 152	DS of SH 152
Diameter (mm)	Bulk Bed Material Percent Finer					
0.063	3.5%	1.6%	2.5%	3.0%	1.4%	2.2%
0.125	9.1%	2.5%	3.6%	3.8%	2.2%	3.2%
0.25	75.8%	12.3%	9.5%	8.6%	4.7%	6.6%
0.5	97.7%	58.4%	35.0%	52.9%	30.5%	23.5%
1	99.5%	87.5%	58.2%	93.2%	64.2%	64.9%
2	99.9%	97.6%	81.3%	99.3%	92.2%	90.6%
4	100.0%	99.8%	97.7%	99.9%	99.6%	98.4%
8	100.0%	100.0%	100.0%	100.0%	100.0%	99.6%
16	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Table 9-8. Bed material samples collected in San Joaquin River

Site ID:	3-23	3-24 & 3-25	1-13	1-12	1-11
River Mile:	139	141.3	170.6	172.7	173.8
Reach:	4B2	4B2	4A	4A	4A
Easting	6030601	6034555	6103407	6108133	6109304
Northing	2345186	2338088	2283696	2276321	2271423
Date	2/6/2008	2/6/2008	2/6/2008	2/6/2008	2/6/2008
Site Description	San Luis Refuge	San Luis Refuge	3.5 miles DS of SH 152.	1.3 miles DS of SH 152.	DS of SH 152.
Diameter (mm)	Bulk Material Percent Finer				
0.063	2.9%	2.6%	3.9%	6.9%	2.4%
0.125	6.2%	4.1%	5.2%	8.4%	3.6%
0.25	21.2%	14.5%	7.1%	20.2%	9.2%
0.5	49.0%	46.5%	28.0%	58.5%	39.1%
1	82.3%	80.4%	76.2%	87.9%	76.9%
2	96.6%	93.4%	97.1%	96.0%	96.7%
4	100.0%	97.4%	99.8%	98.9%	100.0%
8	100.0%	100.0%	100.0%	100.0%	100.0%
16	100.0%	100.0%	100.0%	100.0%	100.0%

Table 9-9. Sampled bed sediment fraction and representative bed material size gradations used in the sediment transport study.

Diameter (mm)	0.0625	0.125	0.25	0.5	1	2	4	8
Reach	Percent Finer							
US end of Reach 4a	4.4%	5.7%	12.2%	41.9%	80.4%	96.6%	99.6%	100.0%
US end of Reach 4B1 and Sand Slough	2.0%	3.0%	10.9%	46.7%	72.8%	89.5%	98.7%	100.0%
US end of Reach 4B2	2.7%	5.1%	17.8%	47.8%	81.4%	95.0%	98.7%	100.0%

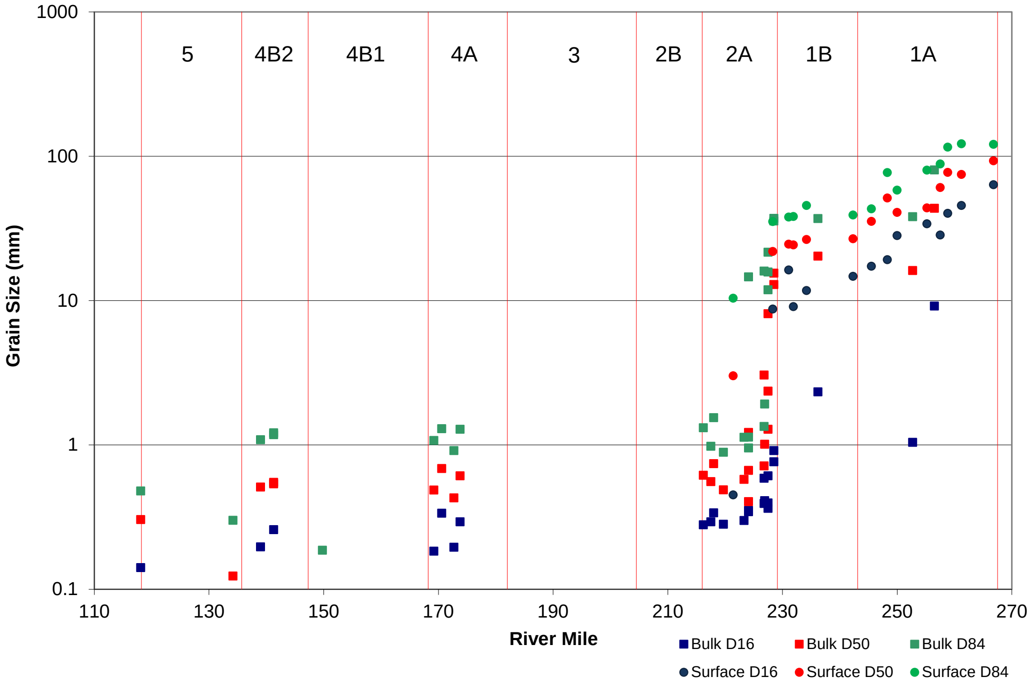


Figure 9-8. Bed material representative diameters for entire SJRRP project area, not including Bypasses.

Figure 9-9. Reach 4a looking downstream from Highway 152.

Figure 9-10. Sand Slough Bypass Channel looking downstream of Washington Road.

Figure 9-11. Middle Eastside Bypass Channel 1.2 miles DS of Sand Slough Control Structure.

Figure 9-12. Lower Eastside Bypass, upstream of Bear Creek Confluence.

9.1.8 Sediment Transport Formula

In SRH-1D, multiple sediment transport formulas are available for selection. Reclamation (2015) performed a comparison between the measured sand load and simulated sand load within SRH-1D using the transport formulas of Engelund and Hansen's (Engelund and Hansen, 1972) formula, Laursen's (Laursen, 1958) formula, Madden's modification of Laursen's method (Madden, 1993), Wu et al.'s (Wu et al., 2000) non-uniform sediment transport method, and the Parker (Parker, 1990) bed load formula. Results are shown in Figure 9-13 for the SJB stream gage in Reach 2B and for the MEN stream gage in Reach 3 Figure 9-14. There are no known measurements of total sand transport in Reach 4A and downstream.

Overall, Engelund-Hansen's formula was considered to have the best performance, but given the limited data set, no definitive conclusion could be made. The Engelund-Hansen formula was used in the comparison between alternatives.

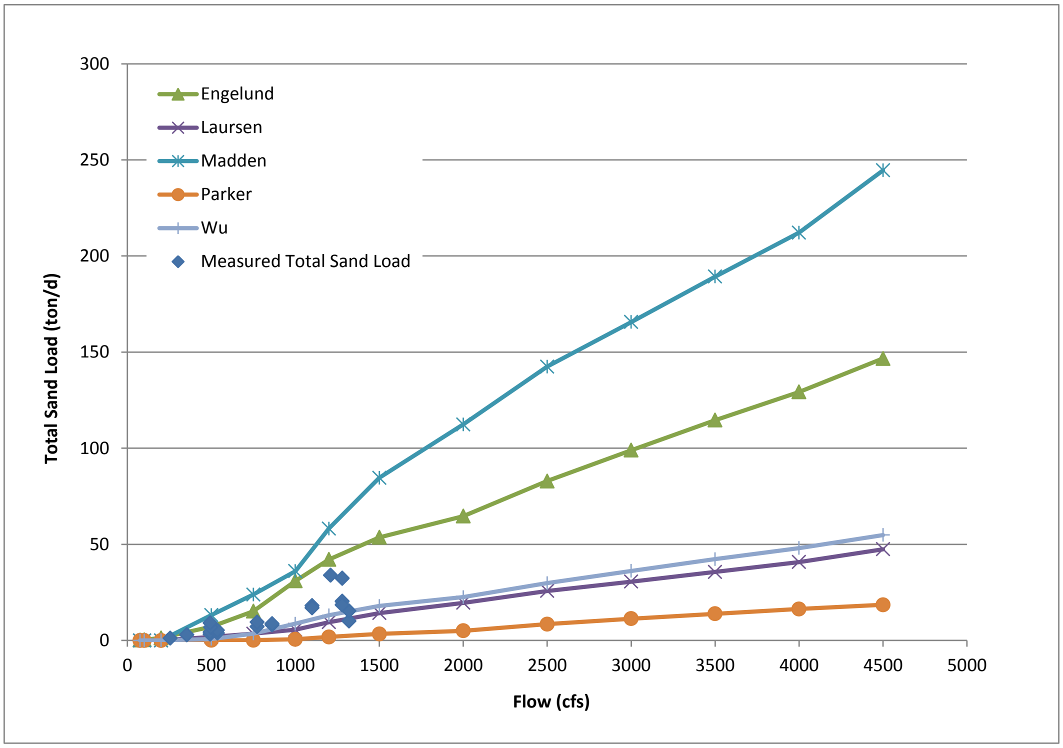


Figure 9-13. Comparison of transport formulas to measured sand load data at SJB in Reach 2B.

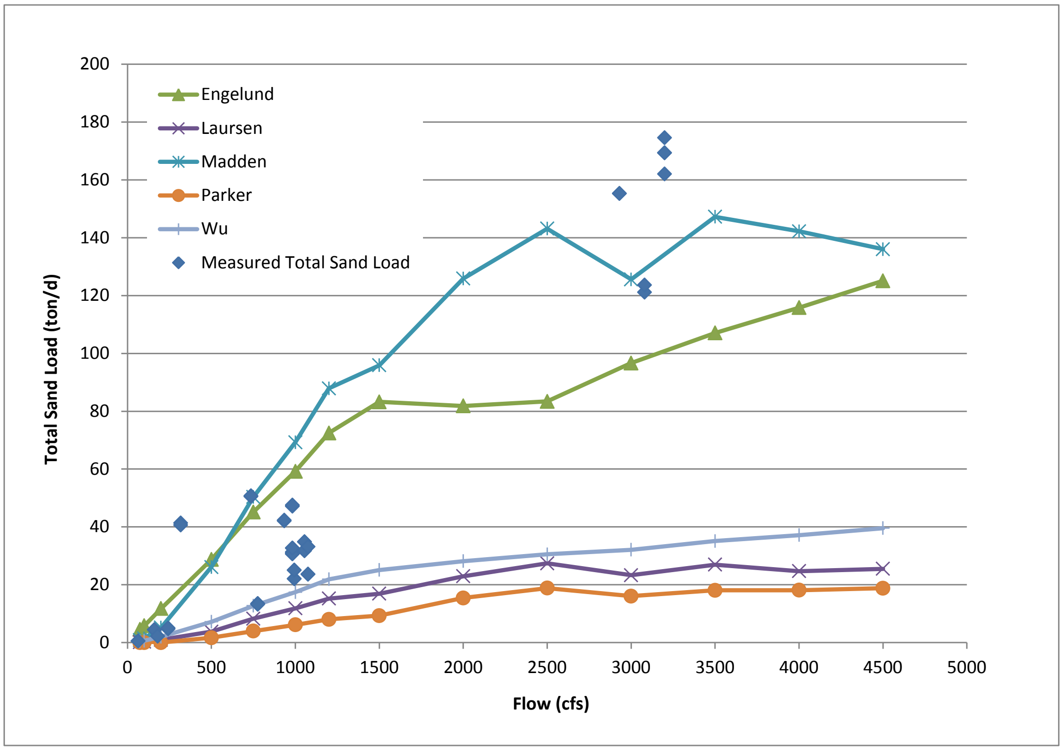


Figure 9-14. Comparison of transport formulas to measured sand load data at MEN in Reach 3.

9.1.9 Other Sediment Parameters

A final required input parameter is the active layer thickness. The active layer concept is used to simulate channel armoring and bed sorting. The active layer thickness was chosen as 1 ft and is constant for all simulations. The results are not sensitivity to the thickness of the active layer because the bed is dominated by a single sand size class.

9.1.10 Subsidence

Two sets of simulations were performed. The first set assumed no additional subsidence occurred in reach. The second set assumed subsidence rates as stated in Table 6-3. Future subsidence would have important effects on sedimentation. As discussed, futures subsidence is likely to increase the slope of reaches upstream of the Project Reach and decrease the slope within the Project Reach. The change in slopes will induce erosion in the upstream reaches and deposition in the project reach. Essentially, the river will try to recover the slopes that it previously had. Over a long time period, and if the downstream elevation control remains the same, the deposition in the project reach will raise riverbed elevations and increase water surface elevations to what they once were. Even though the levees and surrounding ground have subsided, the sedimentation will increase the bed elevations and the water surface elevations to current levels. To design adequate flood control levees that account for future subsidence and the potential sedimentation resulting from that subsidence, the levee height would be increased by the expected future subsidence in that area. A conceptual diagram of the effects of subsidence is shown in Figure 9-15.

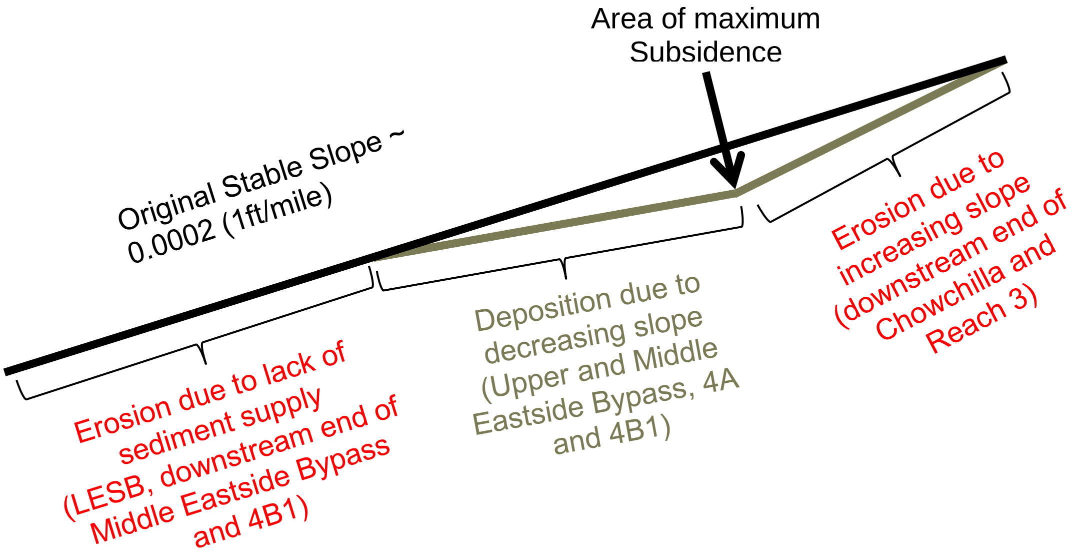


Figure 9-15. Conceptual diagram showing effects of subsidence on sedimentation in the San Joaquin and Bypasses.

9.1.11 Limitations

The 1D model is limited by the inherent assumptions of a 1D model that include using a cross sectional averaged velocity and shear stress to compute sediment transport. The 1D model does not route floodplain sediment separate from main channel sediment. Therefore, there are large uncertainties in partitioning the erosion and deposition values between the main channel and floodplain. In this report, we recommend using the floodplain values to compare alternatives, but one should be cautious in over-interpreting the differences between the main channel and floodplain values.

9.2 Future No Action

Under Future No-Action conditions, the expected erosion and deposition patterns occurring in the Middle and Lower Eastside Bypass are expected to be similar to those currently occurring. There has been active sediment removal over the last few decades in MESB-1 to maintain the capacity of the low flow channel and that will have to continue if the current capacity of the low flow channel is to be maintained.

The simulated sediment load passing each cross section is given in Figure 9-16 for both the cases of with and without future subsidence. The results are qualitatively similar for the with- and without-future subsidence cases, but subsidence exacerbates the deposition within the reaches with the highest subsidence rates. The lower 7 miles of Reach 4A is depositional and most of the sediment entering Reach 4A from Reach 3 is deposited within Reach 4A, particularly during the first 25 years. Most of the sand sized sediment entering Reach MESB-1 in the first 25-years enters from Upper Eastside Bypass and then deposits within MESB-1. There is large uncertainty regarding the sediment loads exiting the Upper Eastside Bypass and separate models of the Chowchilla Bypass and Upper Eastside Bypass may help in analyzing them. Regardless of this uncertainty, the model result is consistent with the recently observed deposition in this reach.

The simulated river bed elevations are given in Figure 9-17 and are consistent with the simulated sediment load. The lower portion of Reach 4A and the MESB-1 deposit sediment while the reaches downstream of these are expected to erode because of the lack of sediment supplied to them. The erosion in MESB-2 is consistent with the lack of sand-sized sediment in reaches below MESB-1.

The increase in bed elevation in the MESB-1 with or without future subsidence is substantial. The bed elevation in MESB-1 is over 5 ft higher than the bed in lower Reach 4A. It is likely that the low flow channel elevation will become higher than the land outside of the levees. This will greatly increase the seepage onto agriculture land. The deposition and decrease in slope due to subsidence will also decrease the levee freeboard (Figure 9-18). Assuming 25 years of future subsidence, the freeboard will reduce approximately 1 ft in the MESB downstream of Chamberlain Road. Upstream of Chamberlain Rd, the freeboard will decrease up to 3 ft upstream of El Nido Rd.

Figure 9-19 shows an example cross section under the No Action Alternative showing the predicted changes after 25-years of land subsidence and sediment deposition. The subsidence and sedimentation causes a decrease in levee freeboard and an increase in potential for seepage onto adjacent agricultural lands.

It should be noted that with 25-years of future subsidence, there is zero river bed slope from the lower portion of Reach 4A until just upstream of the East Bypass Control Structure, a distance of over 10 miles.

9.3 Alternative 1

Floodplain options B and C were simulated in this alternative. Option D was not simulated because the wide floodplain and the multiple side channels could not be accurately simulated in the one-dimensional (1D) model. A two-dimensional sediment transport model would be necessary to detail the interactions between the main channel, floodplains, and side channels. Such a simulation is recommended for this alternative if it is selected as the preferred alternative.

The simulated sediment loads are given in Figure 9-20. Similar to existing conditions the lower portion of Reach 4A is deposition and the first two sub-reaches of Reach 4B-1 (4B1-1 and 4B1-2) are also depositional. Very little sediment is transported out of the first two sub-reaches. Because of the lack of sediment supply to the downstream reaches, sub-reaches 4B1-3 through 4B1-6 are erosional or stable. The behavior of Option B and C are similar, but Option C traps even more sediment in sub-reaches 1 and 2. Option C is a wider setback than Option B and will have lower velocities at high flow and potentially less sediment transport capacity.

The simulated channel bed elevations are given in Figure 9-21. Sub-reaches 4B1-1 and 4B1-2 are aggradational due to the reduced channel slope in the area. The channel aggradation for Option C is smaller because more deposition occurs in the floodplain (Figure 9-22), however, the differences are relatively minor. As mentioned previously, it is difficult for the 1D model to simulate the differences between the channel and floodplain so there is some uncertainty regarding the exact split between channel and floodplain transport.

After 25 years of subsidence, the slope in the lower portion of Reach 4A and the upper seven miles of Reach 4B1 is practically zero. There will be almost no sediment transported out of the first two sub-reaches of Reach 4B1. The water surface elevations at 4500 cfs under initial conditions of Alternative 1 Option B and after 25-yr of subsidence are given in Figure 9-23. Subsidence has little effect on the levee freeboard in Reach 4B1 under Alternative 1. There are two main reasons for this: 1) the increase in flow depth for a given amount of subsidence is proportional to the original flow depth (Section Subsidence). The flow depth in Reach 4B1 at the design flow of 4,500 cfs is significantly less than the flow depth in the MESB at a flow of 16,500 cfs. 2) There is overall channel erosion in Subreaches 4B1-3 through 6 which increases the conveyance area of Reach 4B1.

There is some uncertainty regarding the permanency of side channels because side channels can fill with sediment and vegetation if high flows do not flush them on occasion. However, the side channels in the river are generally stable and persist for long periods of time, as evident in comparison of aerial photographs in Reach 5 (Figure 9-24). These side channels in Reach 5 have been self-sustaining for over 70 years.

9.3.1 Sand Slough Bypass Channel

A sediment model of the Sand Slough Bypass Channel was not developed for Alternative 1 analysis. However, there are significant issues related to the sedimentation in this channel for Alternative 1. In most all flow conditions, the Sand Slough Bypass Channel would not convey water between the Bypass and the river channel. The flow in the Chowchilla Bypass would be routed into the Eastside Bypass and flow from Reach 4A would be routed into Reach 4B1. The only condition when there would be flowing water through the Sand Slough Bypass Channel would be when flow is routed from Reach 4A into the Bypass. Because the capacity of Reach 4A and Reach 4B1 is 4500 cfs, there is little need to route flow from Reach 4A into the Bypass.

Because of the limited opportunities to move sediment through the Sand Slough Bypass Channel, sediment and debris would collect in this channel and this material would become vegetated and the vegetation would collect additional sediment. A natural levee would form within the connector channel without removal of sediment in the Sand Slough Bypass Channel. This natural levee would eventually separate the San Joaquin from the Bypass if there is no mechanical excavation of the material.

The Sand Slough Bypass may not be necessary to maintain current flood conveyance capacity of the system under Alternative 1 and it would be possible to remove the Sand Slough Bypass Channel from the flood control system under Alternative 1. Eliminating the Sand Slough Bypass Channel would also eliminate the need for control structures in the Eastside Connector Channel and upstream end of Reach 4B1. Eliminating the Sand Slough Bypass Channel would significantly reduce the long term maintenance costs of Alternative 1.

9.4 Alternative 2

Reaches 4A and MESB-1 are still depositional under Alternative 2, but there is less deposition under Alternative 2 than the No Action Alternative (Figure 9-25). There is less deposition under Alternative 2 because the slope in the MESB was increased due to the channel grading and removal of the MNWR weir and lowering of the sill of the Mariposa Control structure.

The channel bed profile in the Eastside Bypass is relatively stable for Alternative 2 (Figure 9-26). However, there is still overall deposition in the upper portion of the Eastside Bypass because of the sediment inputs from the Chowchilla. The deposition would most likely occur on the floodplain surfaces and perhaps some narrowing of the 150-ft wide inset channel. The elevation of the low flow channel is expected to remain relatively stable.

The low flow channel planform is also expected to be maintained under Alternative 2. The banks of the Eastside Bypass channel will also be stabilized with riparian vegetation, and bank erosion is expected to be relatively minor.

When subsidence is included in the simulation, the MESB-1 reach traps a greater portion of the sediment entering the reach. However, less sediment enters into the MESB because Reach 4A also traps additional sediment under subsided conditions.

The water surface profile after a 25-yr simulation that includes future subsidence and future sediment erosion and deposition is shown in Figure 9-27. No levee setback is included in the results presented in this figure. The decrease in levee freeboard is also shown in Figure 9-27. At the end of the 25-yr simulation there is approximately 9 ft of subsidence at the upper end of the MESB and approximately 2 ft of subsidence at the downstream end of the Mariposa Bypass. It is assumed that the water surface elevation at the end of the Mariposa Bypass remains stable. Because of subsidence reducing the slope of the bypass and deposition in the upper portion of the MESB, there is a substantial reduction in the levee freeboard. The most severe reductions in levee freeboard occur upstream of Chamberlain Road and the reduction in freeboard exceeds 2.5 ft upstream of El Nido Road. It should be noted that this reduction in freeboard is in addition to the reduction in freeboard that occurs due to increases in vegetation roughness.

The changes due to subsidence and sedimentation at a particular cross section (97705, just downstream of El Nido Rd) are shown in Figure 9-28. There was 8.8 ft of subsidence at this cross section and 1.3 ft of floodplain deposition. The design water surface elevation at a flow of 16500 cfs decreased 6.6 ft, which results in a net decrease in the levee freeboard of 2.2 ft.

9.5 Alternative 2 - LESB

The LESB is significantly shorter than the Mariposa – Reach 4B2 path, and therefore, the LESB has a significantly greater slope. The increase in slope causes erosion to occur within the LESB that then also causes erosion to occur in the MESB-2 reach. MESB-1 reach remains depositional under this alternative, but the deposition is less than under Alternative 2 (Figure 9-29).

Significant erosion is expected to continue to occur in the LESB, which will cause further channel incision and further separate the channel from the floodplain of the LESB (Figure 9-30). The majority of the incision will occur in the upper portion of the LESB because incision has already occurred in the lower portion of the LESB. Up to 4 ft of incision will occur in the next 25 years in the upper portion of the LESB.

The large amounts of channel incision will likely also increase the bank erosion that is occurring in the LESB and the bank erosion that is occurring at select locations in the LESB will begin to occur throughout the entire LESB. Significant bank protection will likely be necessary to maintain the integrity of the levee in LESB.

When subsidence is included in the simulation, the MESB-1 reach traps a greater portion of the sediment entering the reach. However, less sediment enters into the

MESB because the Reach 4A also traps additional sediment under subsided conditions. The erosion in LESB continues because even though the slope is decreased in the LESB, less sediment is delivered to the reach and significant erosion continues to occur in the LESB.

9.6 Alternative 3

Significant deposition in the main channel of 4B1 is expected in the upper 4 miles due to the low bed slopes in this reach and because the relatively low flows are not sufficient to mobilize sediment through the reach (Figure 9-31, Figure 9-32). It is likely that the deposition in the upper portion of the channel would continue and the channel may not be able to convey the high sediment concentrations that occur during high flows in Reach 4A.

No significant bank erosion and/or channel migration in Reach 4B1 is expected. Vegetation should quickly establish along the bank where it is not already present to aid in bank stabilization. A flow of 475 cfs would not be sufficient to erode the vegetation along the bank. A simple channel would likely form in this reach with minimal in-channel complexity. With a maximum of 475 cfs, the reach may function much like an earthen canal due to the limited flow range.

9.7 Alternative 4

The maximum flow in Reach 4B1 is 1500 cfs under Alternative 4. Only Levee Option A is considered in this alternative. Sub-reaches 4B1-1 and 4B1-2 are still depositional, but a significant amount of sediment makes it through these reaches to lower reaches (Figure 9-33).

Significant channel erosion is expected downstream of sub-reach 4B1-1 and 2 because the 1500 cfs flow would be sufficient to mobilize sediment and the narrow levees increase the velocity of the flow relative to the velocities under Alternative 1 (Figure 9-34).

Because the maximum flow is 1500 cfs, the peak flow in most years will be 1500 cfs. The lack of flow diversity and narrow levee alignment will likely cause a simplified floodplain to form to contain this flow. The more variable flows under Alternative 1, with a maximum flow of 4500 cfs and wider levee alignments would create and maintain a more diverse set of side and overflow channels.

9.8 Summary of Sedimentation Results

A summary of the sediment transport, deposition, and channel bed elevation changes predicted by SRH-1D at the end of a 25-yr simulation are given in Table 9-10 assuming no future subsidence and Table 9-11 assuming future subsidence.

Bar charts of the same information are given: Figure 9-35 contains a chart of the sediment loads entering each reach without subsidence. Figure 9-36 contains deposition within each reach without subsidence. Figure 9-37 contains change in average channel bed elevation without subsidence. Figure 9-38 contains deposition within each reach with subsidence.

The upper portion of both the Middle Eastside Bypass and Reach 4B1 are depositional reaches because of the subsidence that has already occurred in these reaches. The sedimentation in these reaches will continue and accelerate if subsidence continues. As a result, the levee design for the project will need to include additional freeboard to contain the flood flows. However, the degree to which subsidence affects the levee design is significantly different between alternatives.

No Action

Deposition is expected to continue in the upper portion of the MESB under the No Action alternative. The majority of the sand-sized sediment that enters the MESB from upstream deposits in the first subreach of the MESB. Because of the deposition in the subreach MESB-1, there is reduction in sediment supply resulting in erosion in the reaches downstream of this.

Assuming 25 years of future subsidence, the freeboard will reduce approximately 1 ft in the MESB downstream of Chamberlain Road. The decrease in freeboard will be up to 3 ft upstream of El Nido Rd. Because of the subsidence and deposition in MESB-1, the potential for seepage onto agriculture lands increases at low flows.

Alternative 1

Deposition will occur in the first two sub-reaches MESB-1 and 2. Erosion is likely downstream of these reaches because of the reduction of sediment supply to the lower reaches. The same qualitative sediment behavior is expected for levee options B and C, with slightly more deposition occurring within the first two sub-reaches under Option C than B.

The erosion in the lower reaches of Reach 4B1 and the relatively small depths in 4B1, create a condition where the future subsidence causes relatively small decreases in the levee freeboard after 25 years.

Alternative 2

Deposition of sediment in the Middle Eastside Bypass under Alternative 2 may be less than under No Action for two reasons:

1. The flood releases from Friant are less frequent under Project conditions
2. The regrading of the Bypass, elimination of the MNWR weir and lowering of the Mariposa Bypass increases the channel velocities for restorations flows and increases the overall transport capacity of the reach.

However, deposition in the MESB-1 will still occur, especially if subsidence continues and levees will need to include extra freeboard to accommodate this accumulation of sediment. It is estimated that the freeboard will reduce approximately 1 ft in the MESB downstream of Chamberlain Road. The freeboard will decrease up to 2.5 ft upstream of El Nido Rd.

Alternative 2-LESB

In the MESB, the results for Alternative 2-LESB are similar to those for Alternative 2. However, slightly less deposition occurs in MESB-1 under Alternative 2-LESB than under Alternative 2.

The LESB shows evidence of historical and active incision and this is expected to continue under Alternative 2-LESB. The incision will occur throughout the entire LESB and further decrease the connection between the low flow channel and the floodplain. The incision may also cause increases in bank erosion and there is the potential that significant bank armoring is necessary to protect existing levees.

Alternative 3

The maximum flow entering Reach 4B1 under Alternative 3 is 475 cfs. Because of the limited flow range supplied to the reach, the reach is expected to function like an earthen canal and a simple channel would likely form in this reach with minimal in-channel complexity.

The first two sub-reaches of Reach 4B1 will be depositional and it is possible that it is difficult to maintain a low flow channel because of the lack of high flows that would scour the channel and prevent the channel from becoming overgrown with vegetation

Alternative 4

The first two subreaches of 4B1 are still depositional under Alternative 4, however, significantly more sediment makes it through these upper reaches. In addition, significantly more erosion occurs in the lower subreaches of 4B1 because of the narrow levee alignment that constrains the flow and increases the channel velocities.

Because the maximum flow is 1500 cfs, the peak flow in most years will be 1500 cfs. The lack of flow diversity and narrow levee alignment will likely cause a simplified floodplain to form to contain this flow. The more variable flows under Alternative 1, with a maximum flow of 4500 cfs and wider levee alignments would create and maintain a more diverse set of side and overflow channels.

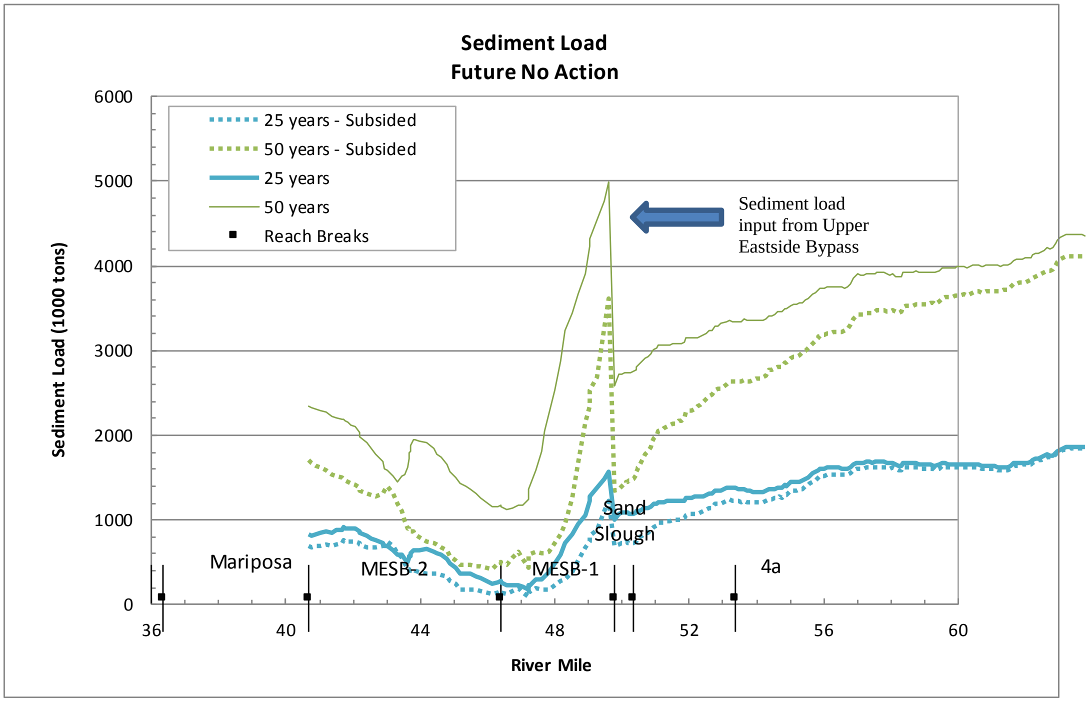


Figure 9-16. Cumulative sediment load passing each cross section for Future No-Action Alternative.

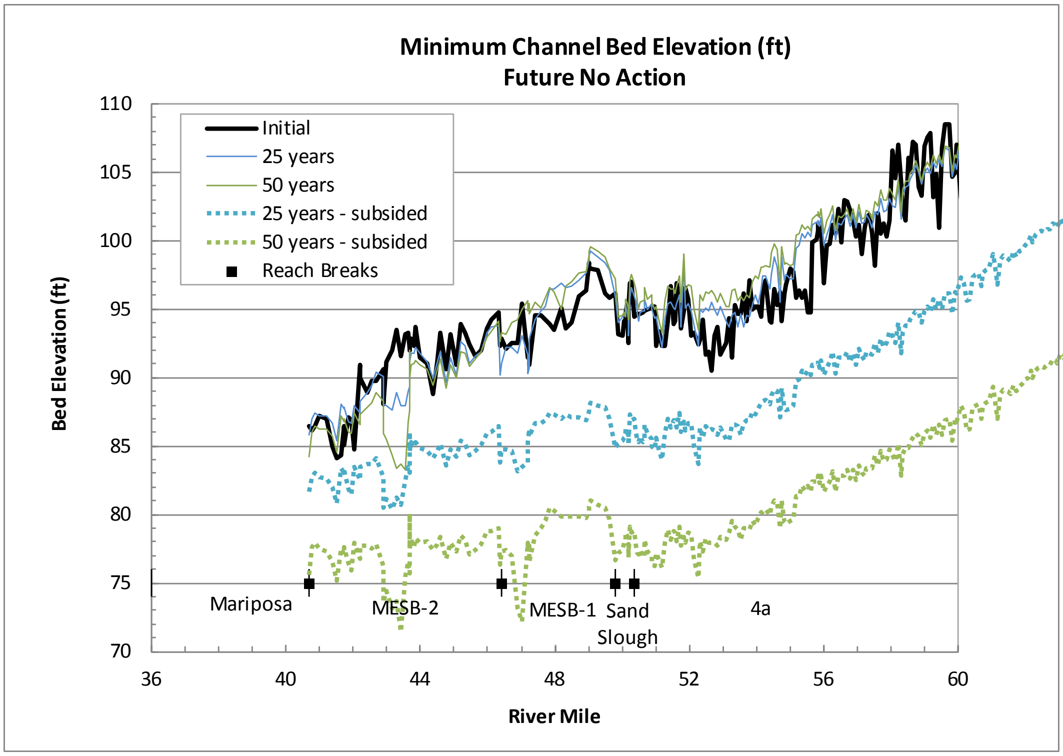


Figure 9-17. Minimum bed elevations for Future No Action Alternative. The 25 and 50 year subsided profiles include the effects of subsidence as well as erosion and deposition.

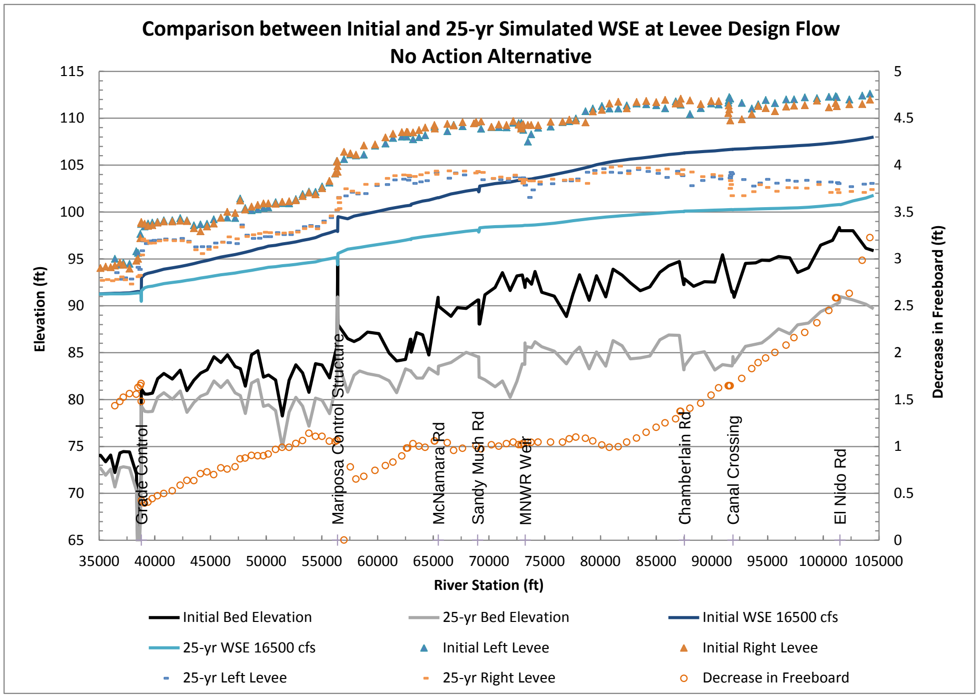


Figure 9-18. Initial and 25-yr simulated water surface and bed profiles for No Action with future subsidence.

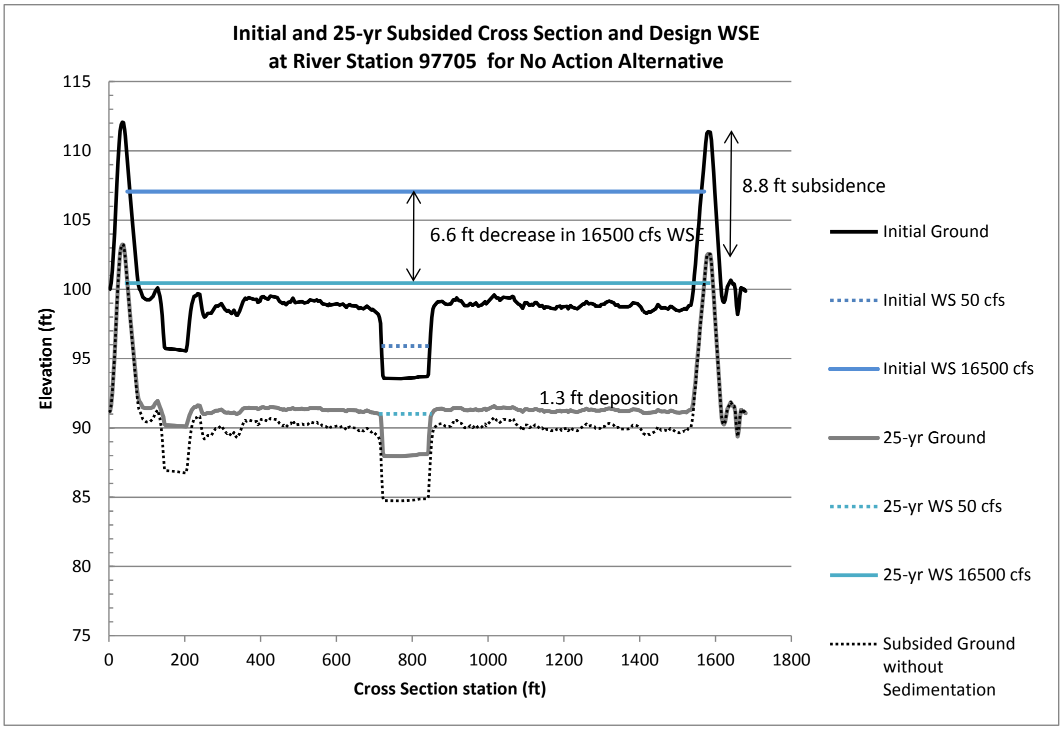


Figure 9-19. Initial and 25-yr simulated water surfaces and example cross section for No Action Alternative with future subsidence.

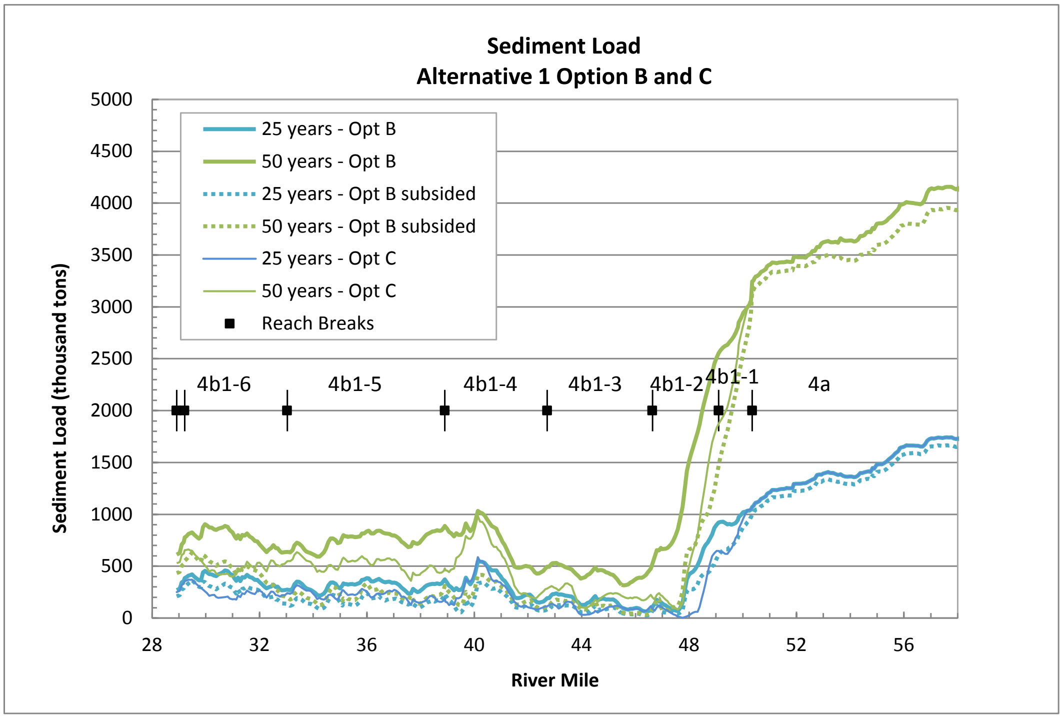


Figure 9-20. Simulated cumulative sediment load from Alternative 1 Levee Option B and C with and without subsidence.

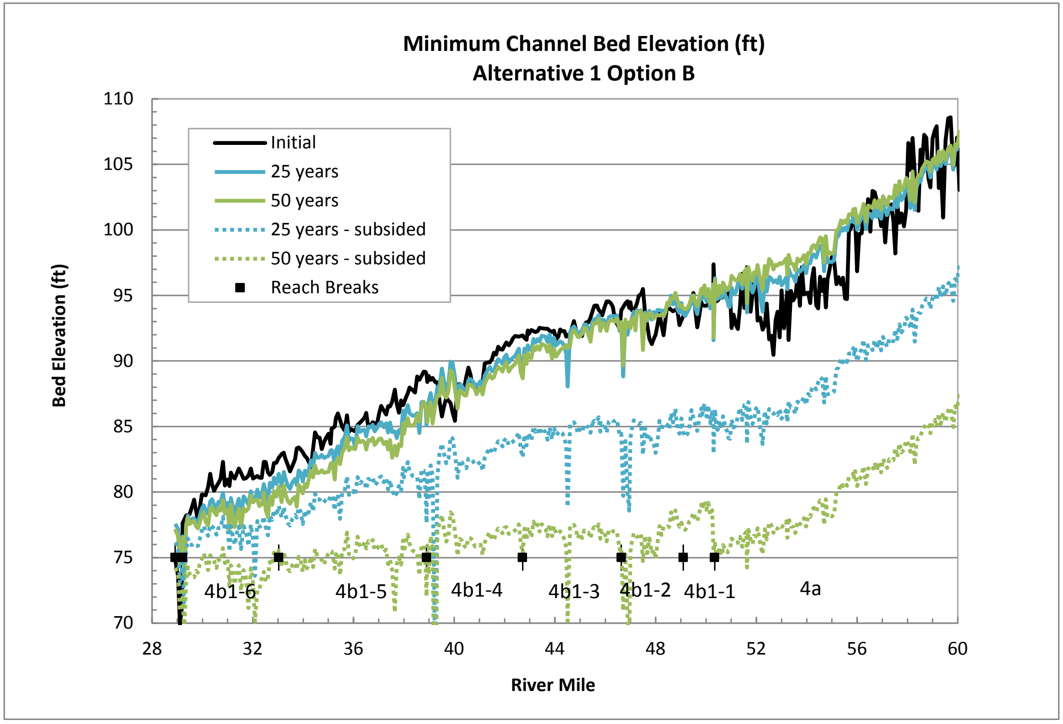


Figure 9-21. Minimum bed elevations for Alternative 1 Levee Option B. 25 and 50 year subsided profiles include the effects of subsidence as well as erosion and deposition.

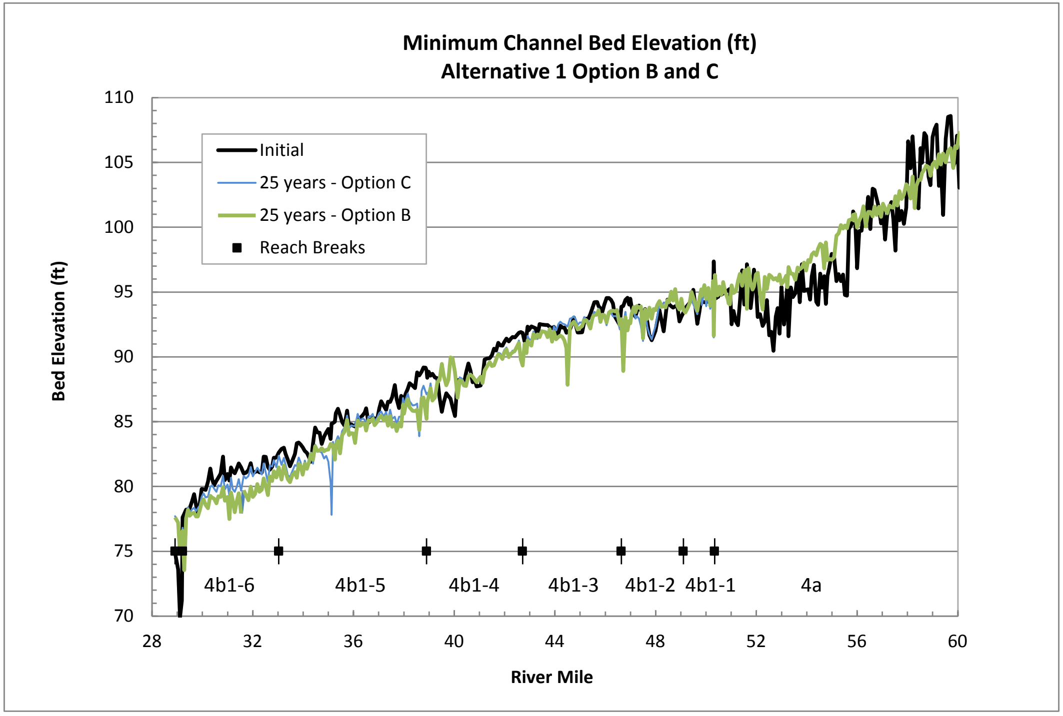


Figure 9-22. Minimum bed elevations comparison for Alternative 1 Levee Options B and C.

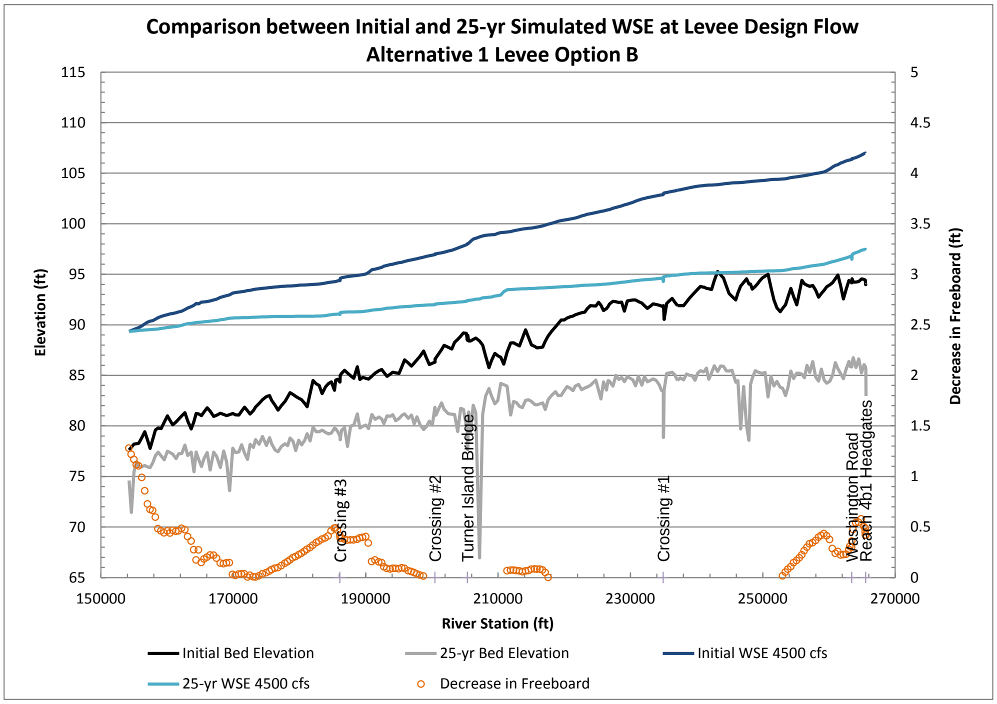


Figure 9-23. Initial and 25-yr simulated water surface and bed profiles for Alternative 1 Option B with future subsidence in Reach 4B1. The 25 year subsided profiles include the effects of subsidence as well as erosion and deposition.

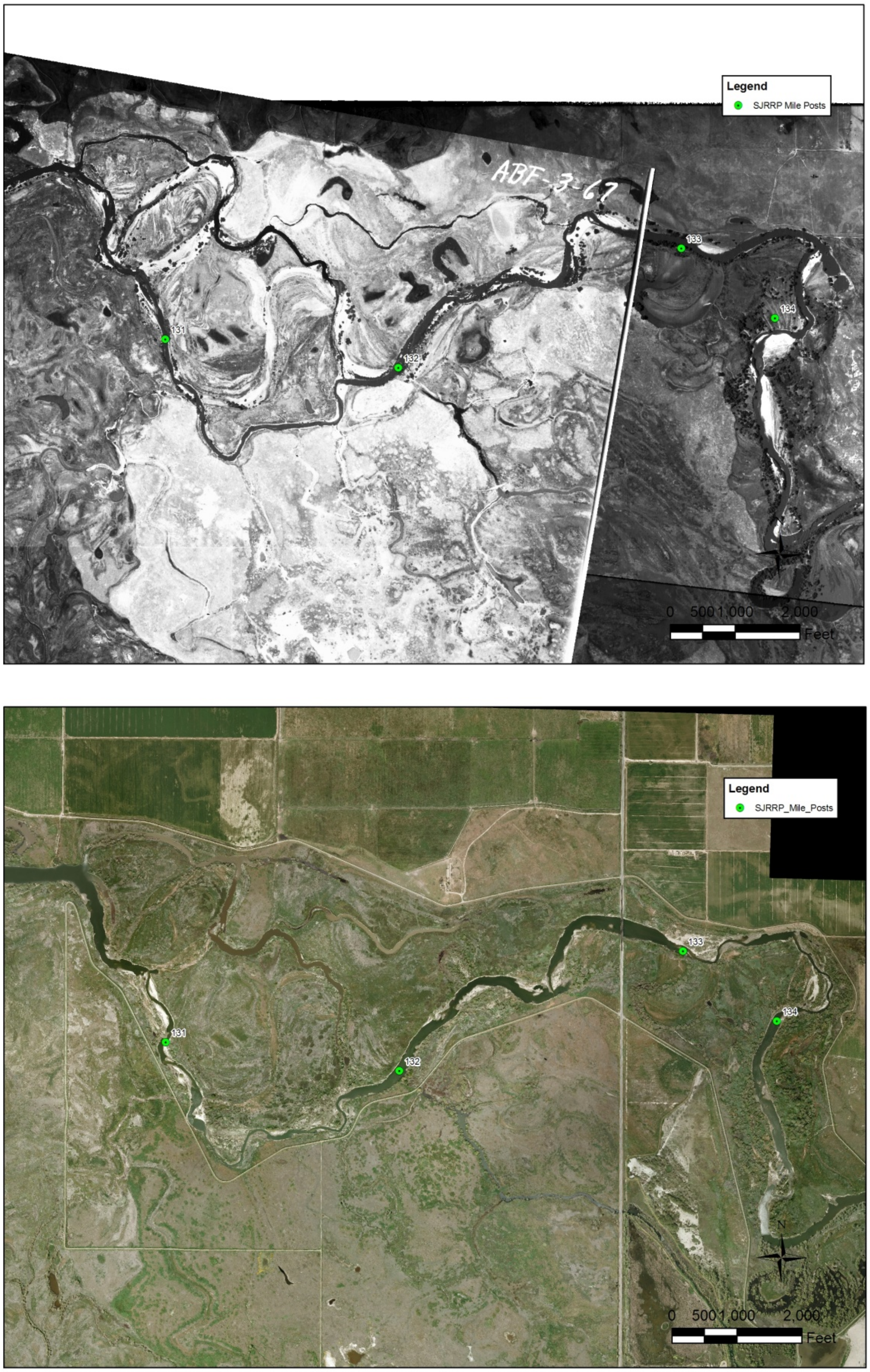


Figure 9-24. Aerial Photographs in 1937 and 2007 of Reach 5 at RP 132 showing permanency of side channels on the river.

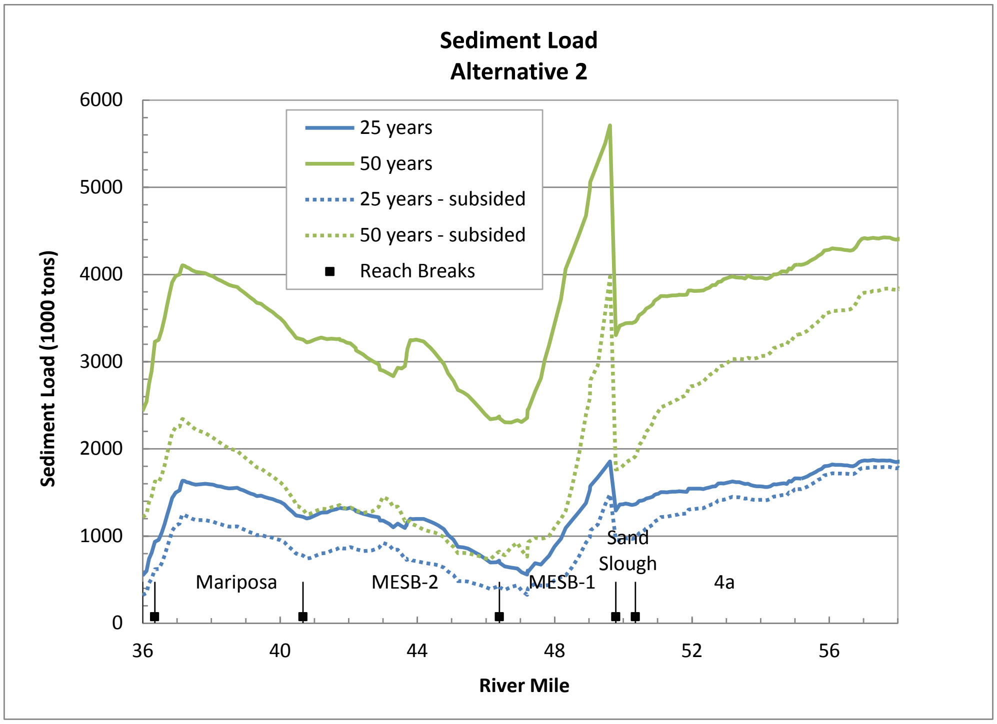


Figure 9-25. Simulated cumulative sediment load from Alternative 2 with and without future subsidence.

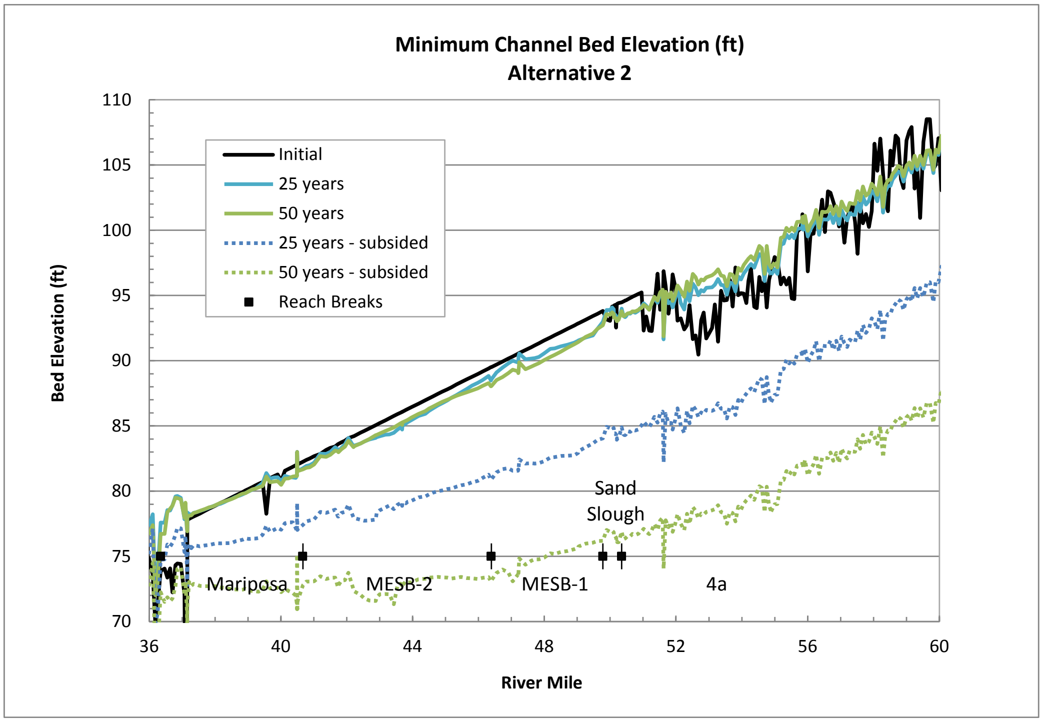


Figure 9-26. Minimum bed elevations for Alternative 2 with and without future subsidence. The 25 and 50 year subsided profiles include the effects of subsidence as well as erosion and deposition

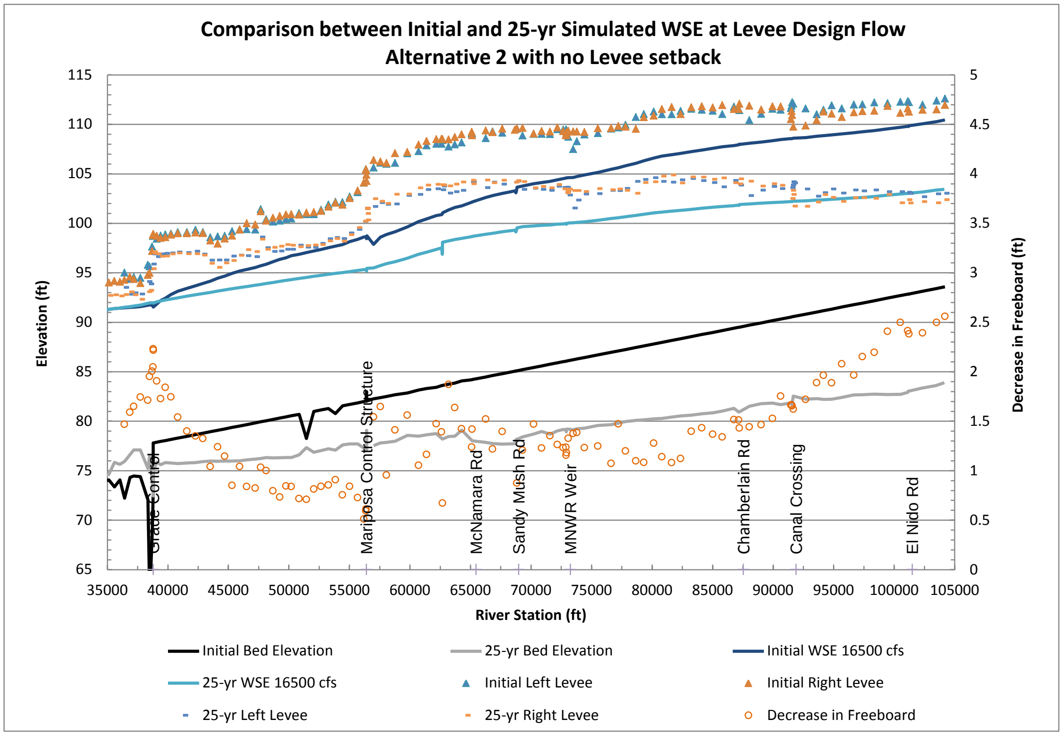


Figure 9-27. Initial and 25-yr simulated water surface and bed profiles for Alternative 2 with future subsidence.

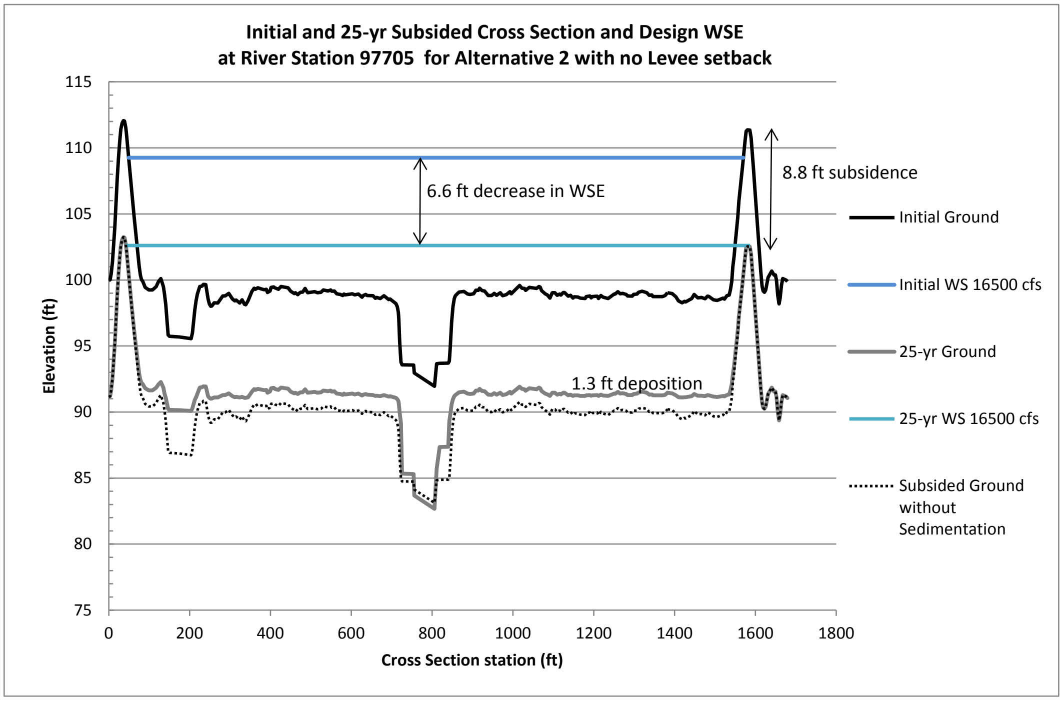


Figure 9-28. Initial and 25-yr simulated water surface and example cross section for Alternative 2 with future subsidence.

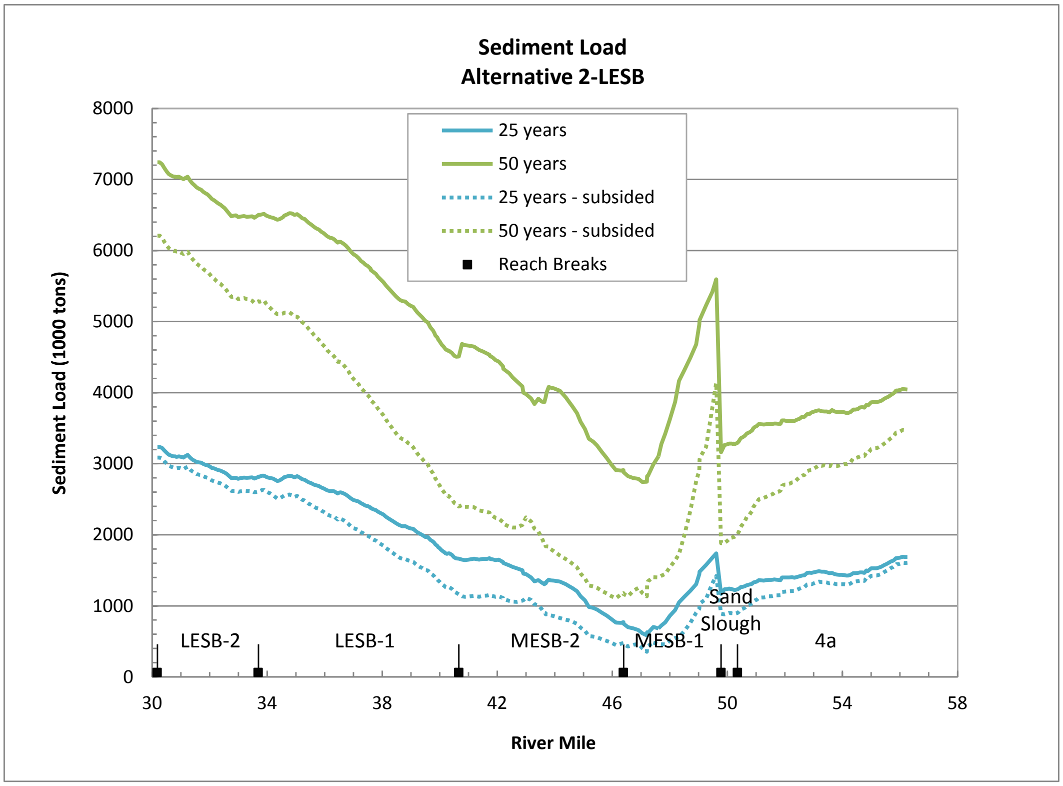


Figure 9-29. Simulated cumulative sediment load from Alternative 2 – LESB with and without future subsidence.

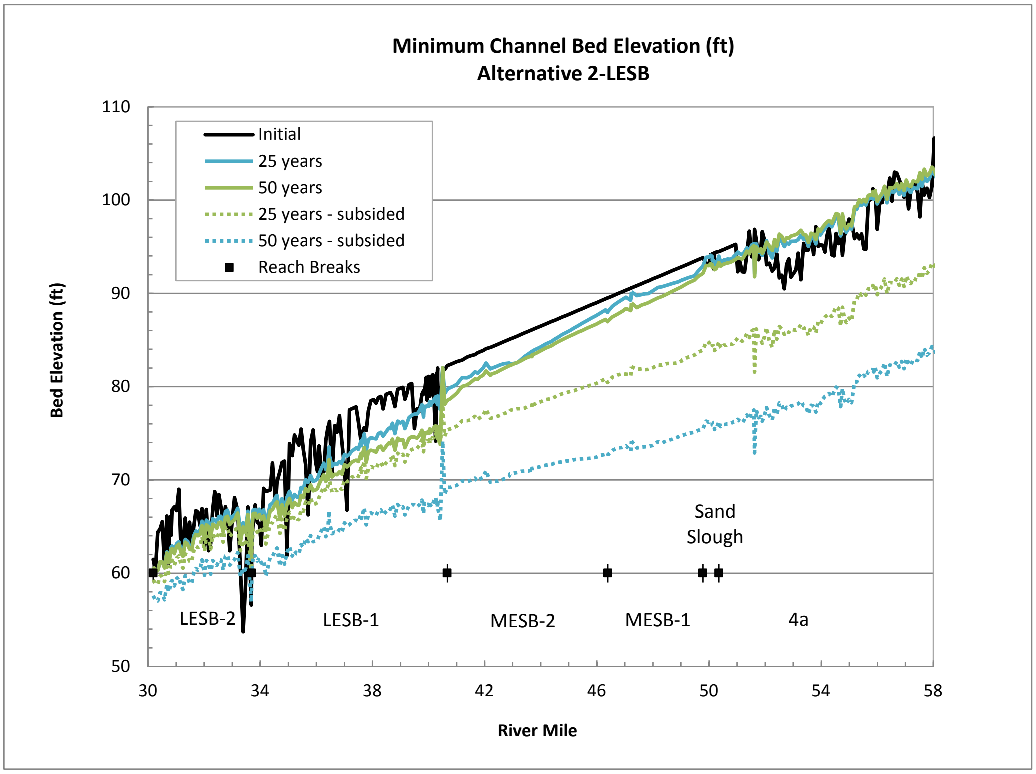


Figure 9-30. Minimum bed elevations for Alternative 2 with and without future subsidence.

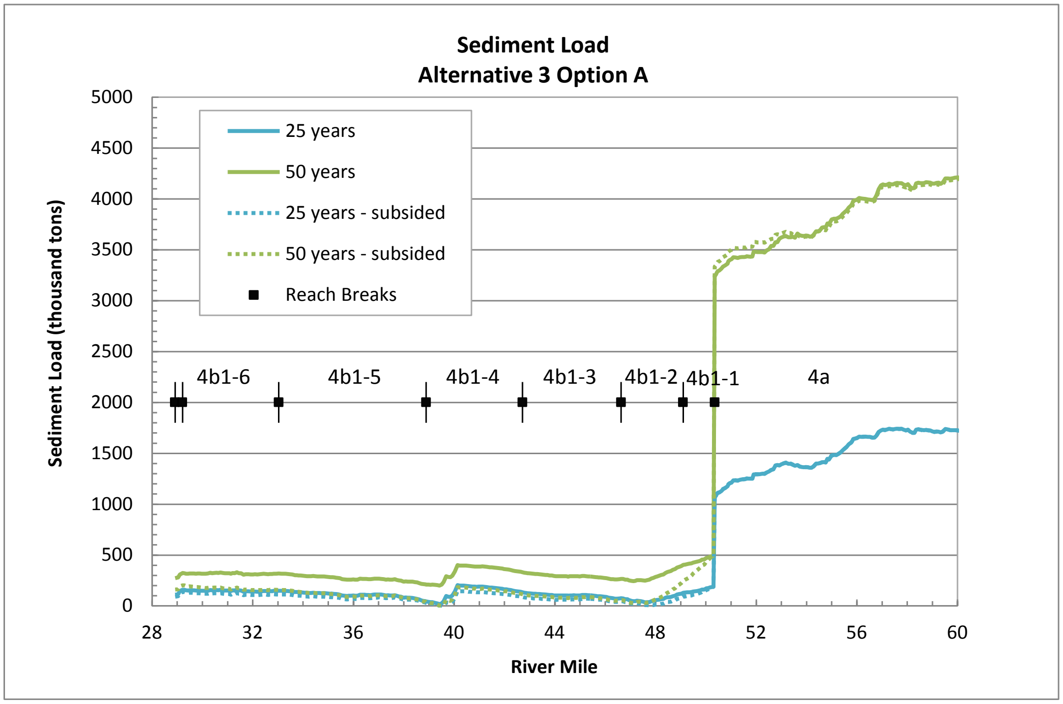


Figure 9-31. Simulated cumulative sediment load from Alternative 3.

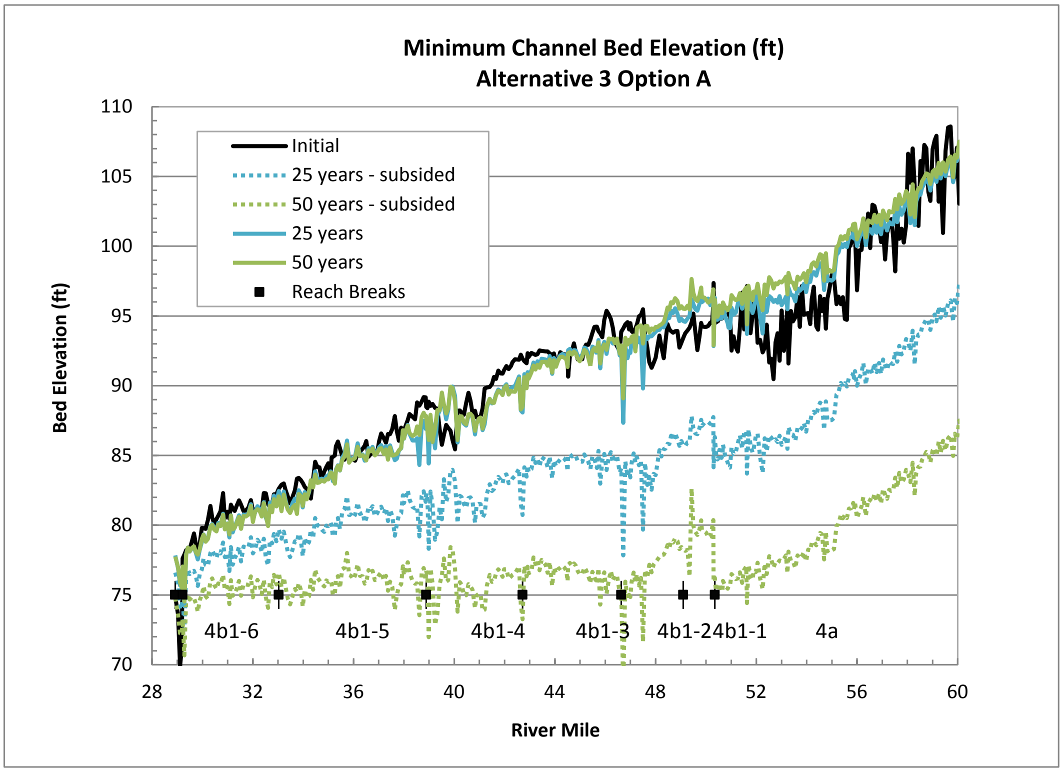


Figure 9-32. Minimum bed elevations for Alternative 3 with and without future subsidence.

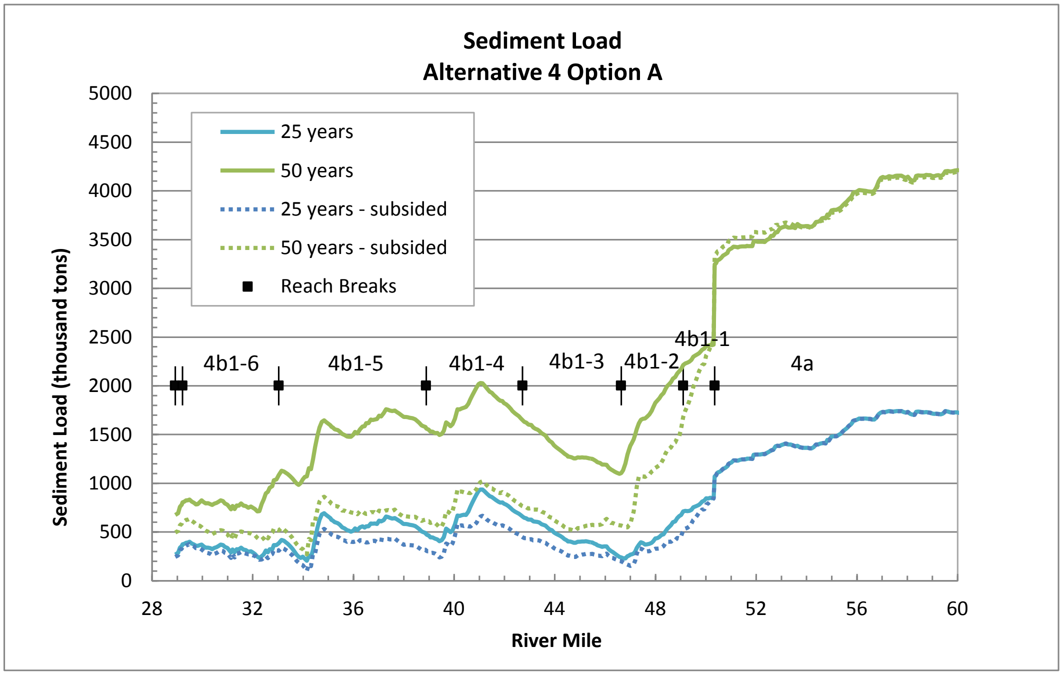


Figure 9-33. Simulated cumulative sediment load from Alternative 4 with and without future subsidence.

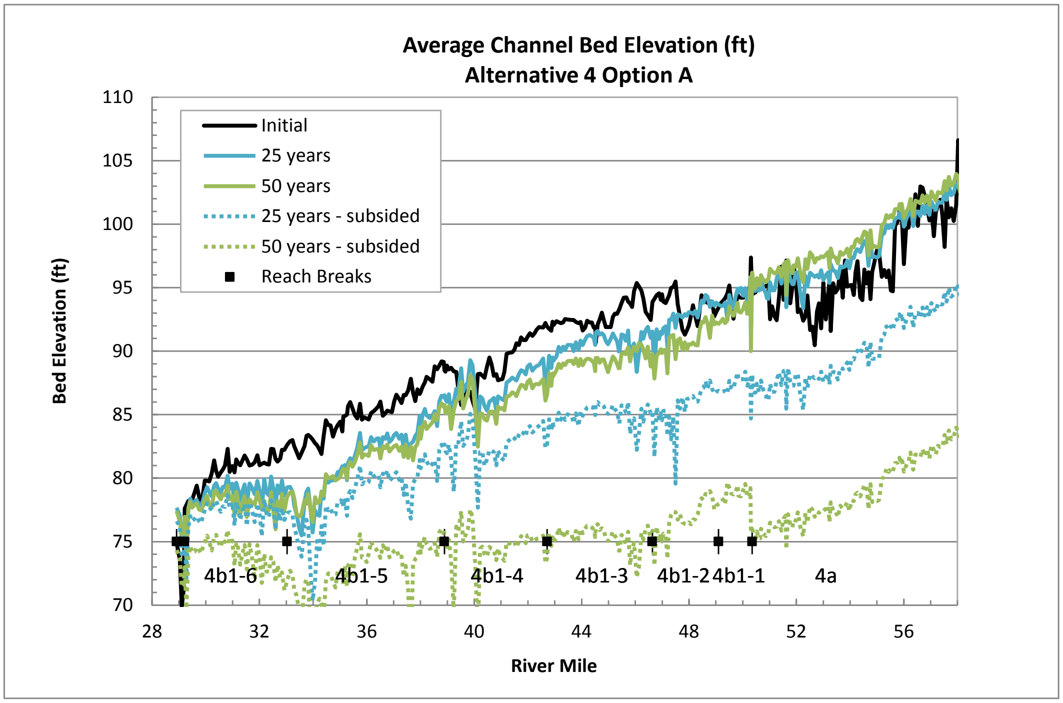


Figure 9-34. Minimum bed elevations for Alternative 4 with and without future subsidence.