5.0 Summary of Results

Results of the Geomorphic Assessment, Sediment Transport Modeling, and Vegetation Analysis are summarized by reach in the following sections.

5.1 Reach 1a

5.1.1 Description

Reach 1a is bounded by Friant Dam at the upstream end and continues downstream to State Route 99. The present channel is incised into alluvial fans and terraces that were formed during the Holocene (less than 10 kiloannum (ka)) and Pleistocene (10ka to 1.6 megaannum (Ma)). These surfaces provide a lateral control on the river channel in this reach and reflect the complex history of valley erosion and filling during the glacial and interglacial periods of the Quaternary (McBain and Trush 2002). Bedrock that outcrops along the river also provides a base-level control in this reach and is particularly notable for several miles immediately downstream from Friant Dam. While a more complex channel network existed historically, multiple channels are still present in sections of this reach. Riparian vegetation exists along sections of the river, although much of the reach is currently or was historically heavily mined, which removed much of the vegetation that existed before large-scale gravel operations. Channel morphology spans a variety of types depending on location in the reach and includes straight, single-channel, island-braided, and low-amplitude, irregular meanders. In 1938, the reach contained numerous split-flow channels around vegetated islands, long side channels and relatively unvegetated flood channels formed during high-flow events. Sediment mobilization of smaller material than is present in the channel bed today is evidenced by visible sediment splays along the margins of the main channel and unvegetated mid-channel and point bars that had been recently modified by flows equal to or less than bankfull.

The average bed slope in this reach is 0.00067, as computed from the MEI HEC-RAS model (2002a). Sediment sampling in this reach has focused on the riffle sections, and the median bed material at riffles sections varies between about 85 millimeters (mm) in the upper part of Reach 1a to about 40 mm in the lower part of Reach 1a (see Table 5-1, Figure 5-1, and Attachment 1 for a description of bed material sampling). Considerable variability in the bed material is present in the reach. Pool sections are mostly dominated by sand, while riffle sections are composed primarily of gravels and some cobbles (Figure 5-2). In general, the amount of sand increases with distance from the dam. Large amounts of sand material are stored in the floodplain and banks of this reach (Figure 5-3). Although the riffles sections are composed primarily of gravel, significant amounts of sand are present in the majority of the riffles, especially below River Post (RP) 258 (Figures 5-4 and 5-5). Two possible factors contribute to this (1) there are large sand supplies in this reach, and (2) gravels in the riffles are not often mobilized to free the sand trapped in the interstitial spaces. Both of these factors are likely important.

Because no large tributaries are present in this reach, and Friant Dam traps all sand and gravel, the sand supply in the reach should be decreasing over time as clear water flows flush sand from the floodplain, pools, and banks of the reach. However, the magnitude and rates of the sand supply to the reach are uncertain. No substantial measurements of the suspended sediment load have been conducted in this reach, and a comprehensive inventory of the sand sources in the reach has not been performed. Therefore, the rate at which the sand supply and sand presence in the bed and storage areas has depleted over time is uncertain.

Table 5-1.
The Average Slope and D_{50} of the Bed Material

Subreach	Average Bed Slope	Average D_{50}
1a	0.00067	85 to 40
1b	0.00043	30 to 20
2a	0.00041	1.2 to 0.7
2b	0.00022	0.65*
3	0.00021	0.85*
4a	0.00021	0.55
4b1	0.00017	**
4b2	0.00019	0.56
5	0.00020	0.52
Eastside	0.00020	***
Mariposa	0.00019	***

Note:

In Reach 1, D_{50} indicates the median diameter of the riffle bed material or the alluvial sections controlling the water surface profiles at low flow. (*from MEI 2002a and 2002b, ** Not measured, *** Mostly native soil material).

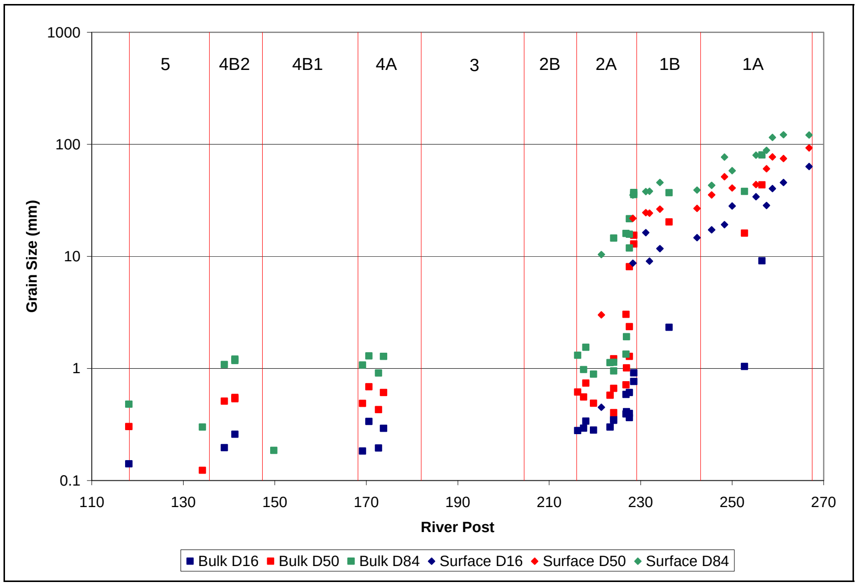


Figure 5-1.
Results of Reclamation Bed Material Sampling in Reach in 2008

Figure 5-2.
Gravel Bar Below Rank Island in Reach 1a (RP 259)

Figure 5-3.
Sand Bar in Reach 1a (RP 248)

Figure 5-4.
Riffle just Downstream from Highway 41 in Reach 1a (RP 255.1)

Note: Frame in photos is (0.5 m by 0.5 m).

Figure 5-5.
Riffle Approximately 0.5 Mile Upstream from Highway 99 in Reach 1a (RP 245.5)

McBain and Trush (2002) state that even under unimpaired conditions, sand storage in Reach 1 (partially due to the low gradient) was substantial. Presently, the transition between a gravel-dominated channel bed and sand-dominated channel bed occurs near Gravelly Ford at the downstream end of Reach 1. Based upon historical accounts and historical aerial photography, this reach was most likely a mixed sand-gravel bed before the closure of Friant Dam. This is corroborated by field observations of large amounts of sand stored in the pools, banks, and floodplains of the river. Even though there has been essentially no sand supplied to this reach for more than 60 years, remnants of the pre-dam sand supply to the reach still exist.

The reach downstream from Friant Dam was characterized by low sediment supply and low transport rates, even before the sediment supply was disconnected by the construction of Friant Dam (McBain and Trush 2002). Since the construction of Friant Dam, the reach downstream from Friant Dam has become significantly armored, meaning that the bed material at hydraulic controls (riffle sections) is rarely mobilized. Stillwater Sciences (2003) and MEI (2002a) both concluded that general bed mobilization and scour do not occur at flows below 10,000 cfs.

The banks of the reach are generally stabilized with vegetation. Post-dam flows do not appear to be able to scour out vegetation. McBain and Trush (2002) found that exposed gravel point bars are virtually nonexistent because infrequent bed mobility and scour has permitted riparian encroachment of formerly exposed gravel bars.

Gravel mining has significantly altered the morphology of the river in this reach. Cain (1997) estimated that between 1939 and 1989, 1.6 million cubic yards were removed from the active channel, and 3.1 million cubic yards were removed from the floodplain and terraces of the San Joaquin River. Long sections of the river now pass through abandoned gravel pits. The width and depth of the active channel in these sections are much greater than other parts of the river. Large pools and widened channel areas resulting from the gravel mines likely trap most of the incoming gravel bed material and reduce the sediment supply to downstream reaches. The lack of sediment supply to the reaches downstream from the gravel pits could contribute to further armoring of the bed material.

5.1.2 Summary of Findings

Under Project Conditions, the relatively small changes in the high flows will produce minimal channel change in Reach 1a. Evidence from the 1997 flood indicates that even larger, infrequent floods may not change channel width or position to a great extent. Depending on the magnitude of flows, greater connectivity of existing side channels and intermittent reconnection of currently abandoned side channels may occur depending on their height above the active channel. Slight increases in channel width may also be anticipated in association with the removal of vegetation along channel margins.

The geomorphic assessment found that the between 1938 and 2007, channel widths in Reach 1a narrowed by about 50 percent on average, while sinuosity remained similar. The active channel and side channels decreased in coverage by approximately 50 percent and 90 percent, respectively. The number and area of both unvegetated and vegetated bars also decreased in the study reach by about 55 percent and 30 percent, respectively. These data indicate that overall channel complexity has been dramatically reduced over the 70-year historical period. Reduced flows from dam construction, modifications to the channel by gravel mining operations, as well as reductions in sediment load are likely causes for these changes. The majority of channel narrowing is suspected to have equilibrated to modified flows, and the river width is relatively constant. Further narrowing could occur because the peak flows will be slightly reduced. The reduced peak flows under Project Conditions will scour even less vegetation than is currently scoured, and vegetation may encroach on the river channel. The rate of channel migration in Reach 1a has been relatively slow since 1937. Under Project Conditions, the rate should be even less than under Baseline Conditions because of the reduction in peak flows.

Mobilization can be categorized as either reach-averaged or local mobilization. Reach-averaged mobilization occurs when the entire reach is being mobilized, and hydraulic forces are sufficient to carry sediment through the entire reach. Local mobilization occurs when material comprising a single riffle or pool is mobilized. Under local mobilization, the sediment may be eroded but then quickly deposited in the downstream pool. No significant reach-averaged mobilization was predicted in Reach 1a for either Baseline or Project conditions. As found in the previous work of Stillwater Sciences (2003) and MEI (2002a), the bed slope and post-dam flows in the reach are not sufficient to mobilize the armored bed surface. However, locations exist where local mobilization may occur. Based upon the local sediment mobilization analysis, slightly less local “significant mobilization” was predicted under Project Conditions than Baseline Conditions (as defined in Table 4-1). This is due to the slight reduction in the frequency of flows over 2,300 cfs. However, “slight mobilization” was predicted to occur in more years under Project Conditions than under Baseline Conditions. Under Baseline Conditions, several years in a row passed in which essentially no mobilization occurred.

Sediment transport modeling using SRH-1D indicated that the bed in Reach 1a would remain stable under Baseline or Project conditions. There is evidence of bed erosion since the construction of Friant Dam in this reach, but the reach has likely stopped degrading. Significant amounts of bedrock are exposed in the reach, and the gravels in the riffle sections are relatively immobile. The SRH-1D model predicted that bed elevations do not significantly change under Baseline or Project conditions.

Plant productivity widths for native plants are shown in Figure 5-6 and for Baseline and Alternative A flow regimes. The plant productivity width was computed by dividing the plant productivity area by the reach length. Plant productivity area in this report is defined as the total vegetation area of all species within a given reach. In some cases, multiple species can be present in the same area and therefore, the productivity area can be greater than the actual area. Productivity width is similarly defined. Predictive results were intended to over-estimate, instead of under-estimate, vegetation establishment and survival in an effort to err conservatively on conveyance issues. Vegetation coverage under Alternative A increased by approximately 30 percent in Reach 1a relative to Baseline Conditions. The consistent and larger low-flows (base flows) under Alternative A conditions relative to Baseline Conditions, with consistently occurring small, peak flows increase the opportunity for recruitment and reduce plant desiccation.

Reach 1a, like all downstream sections of the river, has been impacted by the spread of red sespania and arundo. Red sespania established in recent years in the San Joaquin main channel and colonizes downstream when high flow transports large seed pods. Arundo can be spread through rhizoids or other parts of the plant that break off and wash downstream during high flows. The response of the invasive plants is similar to the response of the native plants: the amount of invasive vegetation was predicted to approximately increase by a factor of 17 percent under Alternative A as compared to Baseline Conditions (Figure 5-7). Native plants under Baseline and Alternative A conditions are primarily removed by shading/competition while invasive plants under Baseline and Alternative A conditions are primarily removed by desiccation.

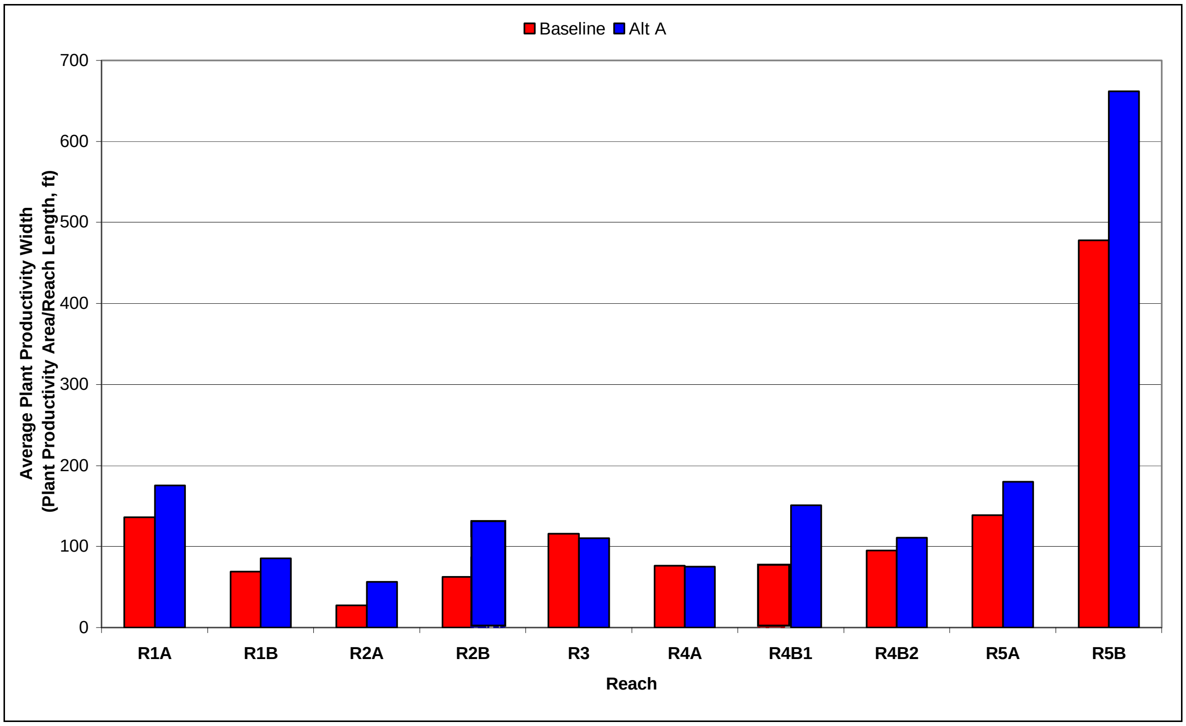


Figure 5-6.
Comparison of Native Plant Productivity Width by Reach for Baseline and Alternative A Flows

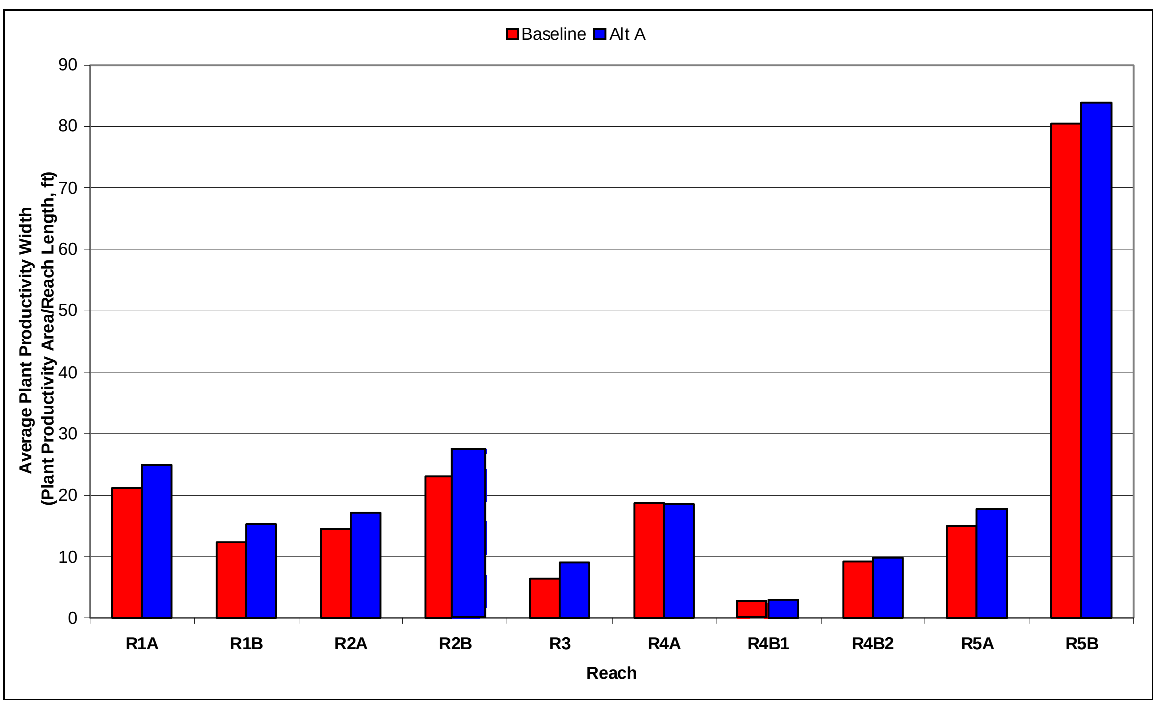


Figure 5-7.
Comparison of Invasive Plant Productivity Width by Reach for Baseline and Alternative A Flows

5.2 Reach 1b

5.2.1 Description

Reach 1b is similar in many respects to Reach 1a. This reach has recently (last few thousand years) incised within a large-scale alluvial fan exiting the San Joaquin River that was formed during periodic glacial periods with increased sediment yield (McBain and Trush 2002). Large deposits of sand are present throughout this reach. Many banks are composed of erodible sand and gravel, and several large sand bars exist (see Figures 5-8 and 5-9). These features likely supply sand to the lower reaches. However, many of the banks are heavily vegetated and may act to stabilize the bars and banks of the river. The post-Friant flows are not sufficient to scour the vegetated banks of the river (McBain and Trush 2002). A photograph of the heavily vegetated banks is presented in Figure 5-10.

Reach 1b has an average slope of approximately 0.0004, which is approximately 40 percent less than the average slope in Reach 1a. The riffles are composed of slightly smaller gravels than Reach 1a and contain significant amounts of sand. Photographs of the riffles material in the upper, middle, and lower parts of Reach 1b are found in Figures 5-11, 5-12, and 5-13, respectively. Material in the riffles gradually becomes finer, and the fraction of sand in the bed gradually increases in the downstream direction. The trend of fining bed material is also visible in the measured representative diameters of riffle material shown in Figure 5-1.

This reach has also been extensively mined for gravel, particularly for the 4 miles downstream from Highway 99, and then for about 1 mile downstream from Skaggs Bridge. The river passes through several abandoned gravel pits, which are expected to trap the majority of gravel entering them. Gravel supply to downstream reaches is likely limited because of the presence of these gravel pits. Gravels present in the lower portions of Reach 1b are probably from supplies stored in the bed and banks of the channel.

5.2.2 Summary of Findings

Reach 1b has slightly smaller gravels than in Reach 1a, with the median size of the riffle bed material ranging between 20 and 40 mm. This reach also has a larger fraction of sand in the bed and bars along the river. Because the material is smaller, the bed material in this reach is slightly more mobile than in Reach 1a. Therefore, “significant mobilization” was predicted more frequently in Reach 1b than in 1a. Under Project Conditions, the reach experienced more years in which slight mobilization occurred than under Baseline Conditions, but the reach experienced “significant mobilization” slightly less often under Project Conditions than Baseline Conditions.

Reach 1b is expected to be relatively stable in the future under Baseline or Project conditions. Sediment modeling showed no significant changes to the bed elevations. Because the peak flows are only slightly reduced under Project Conditions, and no changes are expected in bed elevation, the overall channel morphology will likely be similar to current conditions. However, slight reductions in channel widths may occur, similar to what is expected in Reach 1a. Local reworking of the river bed material may also occur, but the average elevations of the bed are anticipated to remain stable. Because the peak flows are slightly reduced under Project Conditions, slightly less channel migration and bank erosion may occur than under Baseline Conditions.

As mentioned in Reach 1a, the sand supply and the rate at which the sand supply is being depleted in this reach is uncertain. The sand is stored in the floodplain, banks, and pools of the river. Some of this sand is mobilized during larger flows, but it is difficult to determine the rate at which it is being mobilized. Because the peak flows are slightly reduced during Project Conditions, the rate of depletion may be slightly less under Project Conditions than Baseline Conditions.

The average plant productivity width for Reach 1b was predicted to respond similarly to Reach 1a (Figure 5-6), although the reach contributes less vegetated area due to a shorter length of river. Cross sections in Reach 1a and 1b are also similar in shape. The current channel is often incised in an over-sized channel, which is a remnant from pre-dam flows. Water surface fluctuations were predicted to remain primarily within the incised location, with occasional overtop to the higher bench of the former river bed, which can often support vegetative cover. At gravel pits and complex channels, the vegetated area is anticipated to increase under Baseline and Historical conditions, while at simple channels with smaller width-to-depth ratios, reductions in vegetative cover were simulated.

Simulations with Project Conditions indicated that the vegetated area will increase relative to Baseline Conditions by approximately 20 to 25 percent in response to increased base flows and consistent small peaks. Although invasive plants are still prevalent, they have a more limited presence in this reach compared to upstream Reach 1a (Figure 5-7). Approximately 20 to 25 percent more invasive vegetation was predicted under Alternative A than under Baseline Conditions.

Under Baseline and Project Conditions, the main causes of mortality in Reaches 1a and 1b is competition/shading (Figures 5-14 and 5-15). The second most common cause of mortality is desiccation. However, under Project Conditions, there is slightly more competition/shading and slightly less desiccation.

Figure 5-8.
Sandy Bank at RP 241

Figure 5-9.
Sand Bar Downstream from SH 145 (RP 233.9)

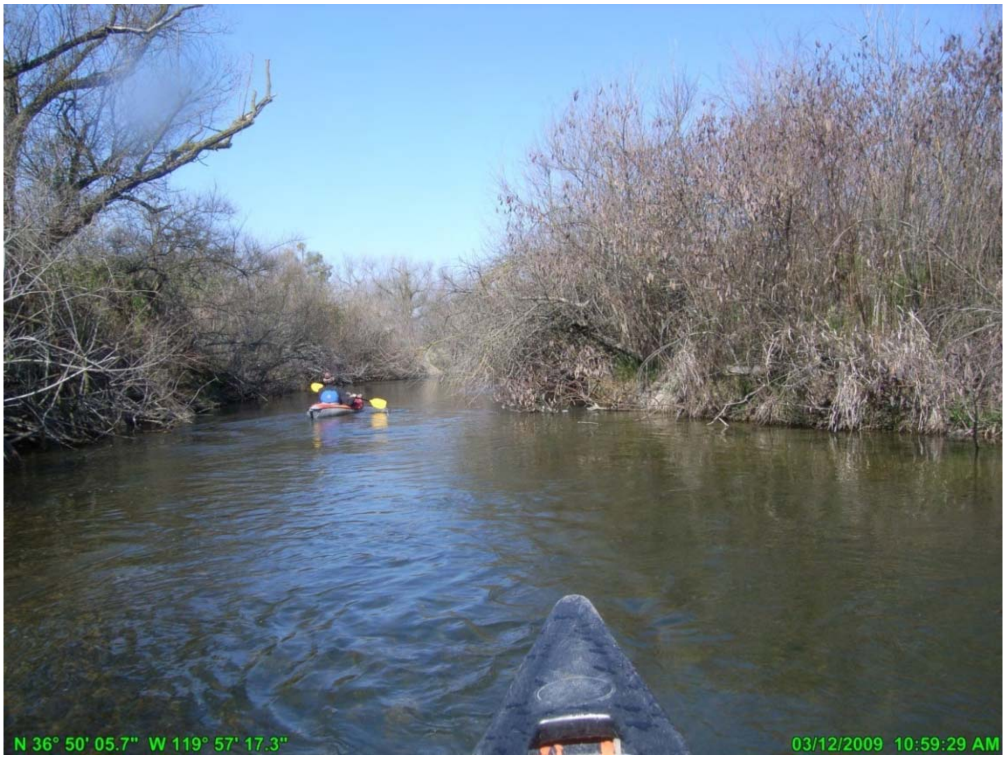
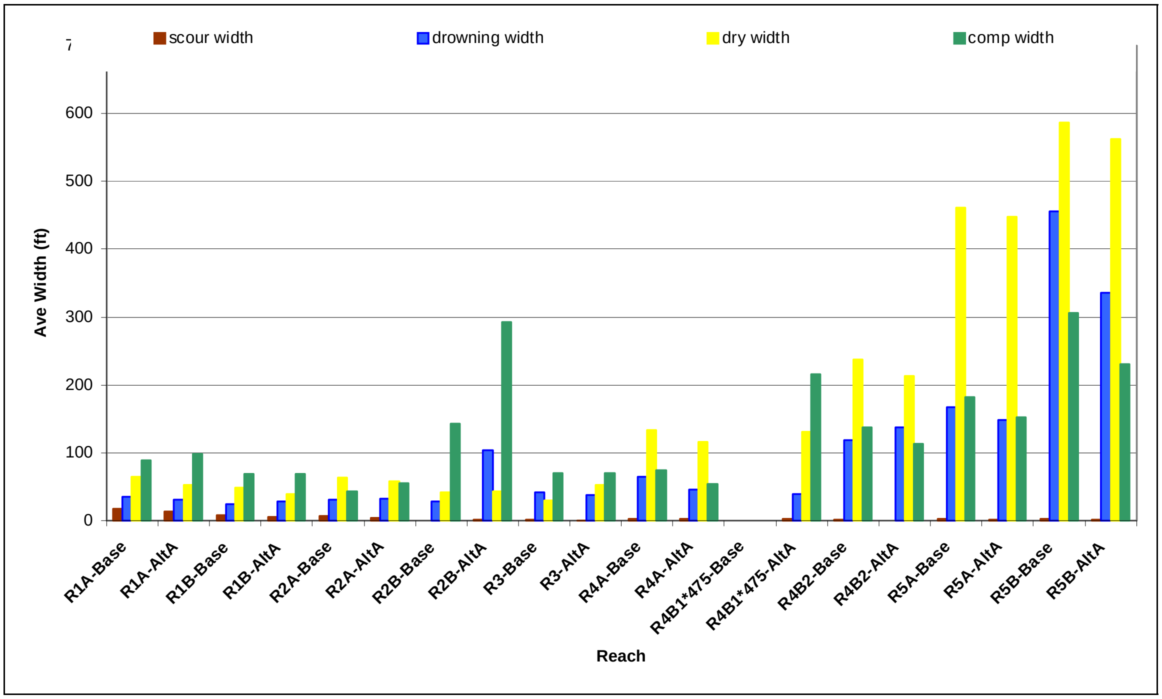


Figure 5-10.
Heavily Vegetated Banks in Reach 1b

Figure 5-11.
Riffle Bed Material Between Highway 99 and Skaggs Bridge in Reach 1b

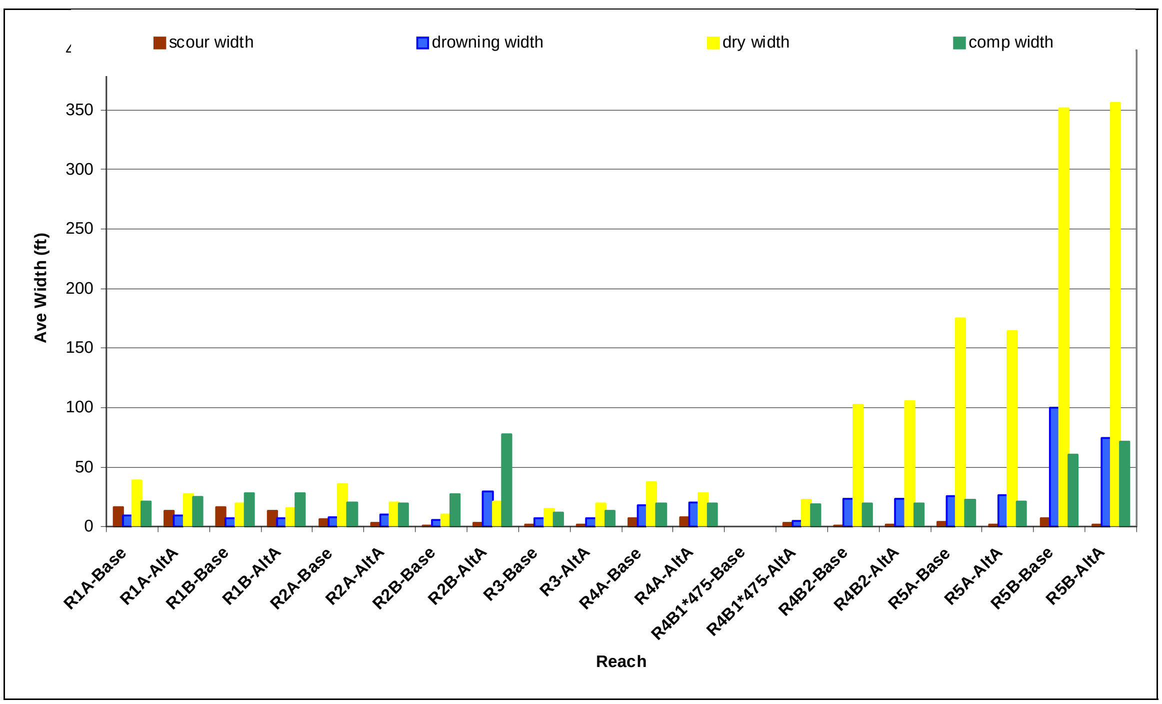
Figure 5-12.
Riffle Bed Material Upstream from SH 145 in Reach 1b

Figure 5-13.
Riffle Bed Material at Gravelly Ford



Key: Scour = mortality by scour; drowning = mortality by inundation; dry = mortality by desiccation, and comp = mortality by shading or competition

Figure 5-14.
Native Vegetation Mortality with Baseline and Alternative A Flows



Key: Scour = mortality by scour; drowning = mortality by inundation; dry = mortality by desiccation, and comp= mortality by shading or competition

Figure 5-15.
Invasive Vegetation Mortality with Baseline and Alternative A Flows

5.3 Reach 2a

5.3.1 Description

The upstream boundary of Reach 2a is near Gravelly Ford. This is the downstream boundary of the incision within a large-scale alluvial fan exiting the San Joaquin River that was formed during periodic glacial periods. The confinement of the valley is not present downstream from Gravelly Ford. The average slope of Reach 2a is 0.0004, which is the same as the slope of Reach 1b. At this location, a rapid transition occurs from a gravel bed with a D_{50} of approximately 20 mm to a sand-bed with a D_{50} of approximately 0.7 mm in less than a mile. Photographs of the transition in bed material at RP 227.1 and at RP 226.9 are presented in Figure 5-16 and Figure 5-17. Previously, McBain and Trush (2002) stated that the transition between sand to gravel in this reach was due to the reduction in stream slope and valley confinement. However, the transition seems more related to the reduced valley confinement as the bed slope is fairly consistent between Reach 1b and 2a. The transition is probably also due to limited base flows downstream from Gravelly Ford.

The river typically ceases to flow a few hundred feet downstream from Gravelly Ford unless flood releases occur. The current water rights agreement requires a minimum flow of 5 cfs at Gravelly Ford, which quickly infiltrates into the substrate. Therefore, Reach 2a is dry the majority of the year and can even be dry for several years in a row. The termination of the wet channel in Reach 2a is shown in Figure 5-18. The dry channel downstream from Gravelly Ford is shown in Figure 5-19.

Reach 2a is largely devoid of vegetation because of the lack of water. Because of the lack of vegetation, no defined channel exists for much of the reach. The location of the low-flow channel commonly changes after the high flows. However, releases from Friant Dam were near 300 cfs for most of 2008 until the construction of the grade break feature near Rank Island in August 2008. These higher flows over a short period of time formed a low-flow channel at the upper end of Reach 2a with initial vegetation growth. A photograph taken from the low-flow channel is shown in Figure 5-20, approximately 5 miles downstream from Gravelly Ford. Flow had just recently receded from this location, and the previous bank line was evident. A dense line of vegetation was present but was desiccating due to the lack of water. Figure 5-21 is a picture approximately 0.7 mile downstream from Gravelly Ford when the channel was flowing. Vegetation is visible along the margins of the channel for a short stretch downstream from Gravelly Ford where flows are more common than in the lower portion of Reach 2a.

Levees confine Reach 2a for the majority of its length. The distance between the levees ranges from approximately 2,500 feet to 500 feet. The banks in this reach are considered highly erodible, and bank erosion is evident along many of the outside meander bends (Figure 5-22). Many of the channel bends near the levee are covered in riprap.

5.3.2 Summary of Findings

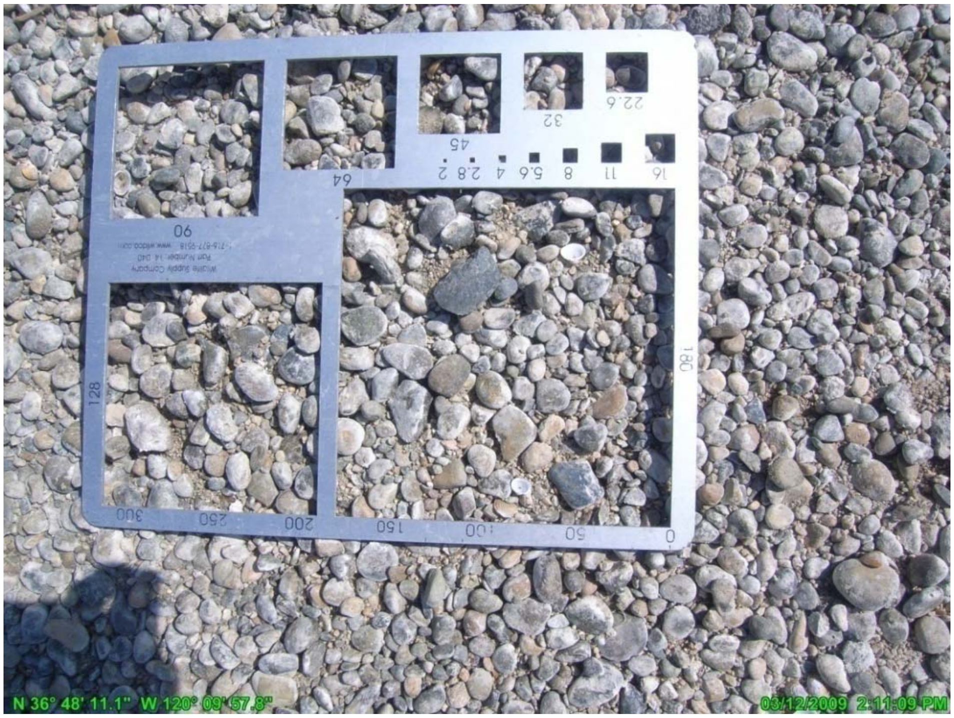
The main impact to this reach from the implementation of Project Conditions will be the introduction of a continuous base flow. This reach is currently dry for large periods of time, but under Project Conditions, the minimum flow will be 100 cfs. There will be a slight reduction in peak flows under Project Conditions, similar to Reach 1.

SRH-1D was used to simulate the erosion and deposition in the reach using the hydrologic period from January 2, 1980, to September 30, 2003. This reach is expected to degrade under Project and Baseline conditions. The magnitude of the degradation is somewhat uncertain because the supply of sand from Reach 1 is uncertain. The model is likely underestimating the supply of sand from Reach 1, and therefore overestimating the degradation. Sand sources in Reach 1 are primarily the pools, banks, and floodplain. A one-dimensional model such as SRH-1D cannot simulate the detailed flow and sediment exchange processes that are responsible for the mobilization of this fine sediment. Suspended sediment measurements in Reaches 1 and 2 will help define the sediment supply and monitor its changes. At the end of the 24-year simulation, the SRH-1D model predicted approximately 3 feet of erosion under Baseline Conditions and 2 feet of erosion under Project Conditions in Reach 2a. This is an average erosion rate of 0.13 to 0.09 foot per year. While the predicted rate using SRH-1D is slightly higher than the 0.04 foot per year estimated by MEI (2002a), the values are relatively close considering no measurements of sediment transport rates are available with which to calibrate a model. Predicted erosion under Project Conditions was less than that predicted under Baseline Conditions because the peak flows are smaller in magnitude under Project Conditions than under Baseline Conditions. The erosion estimates are considered upper (or conservative) estimates due to the lack of information on the sand supplied from Reach 1 to Reach 2.

The amount of bank erosion and channel migration is also anticipated to be less under Project Conditions than Baseline Conditions because of smaller peak flows under Project Conditions. In addition, the base flow under Project Conditions in this reach will substantially increase the amount of vegetation in the reach. The increase in bank vegetation will increase the resistance of the bank to erosion and further limit the expected bank erosion in this reach.

Plant productivity width decreases from Reach 1B to Reach 2A due to the dryer conditions of Reach 2A. More vegetation is present in the upstream quarter of the reach than in the downstream three-quarters. The downstream subreach of Reach 2A is constricted by levees on both sides of the channel, and limited space is available for vegetation to establish. However native plant productivity doubles from Baseline Conditions when Alternative A flow is introduced. Invasive plants also increase by 18 percent. Desiccation removed most native and invasive plants in Reach 2A, with both Baseline and Alternative A conditions.

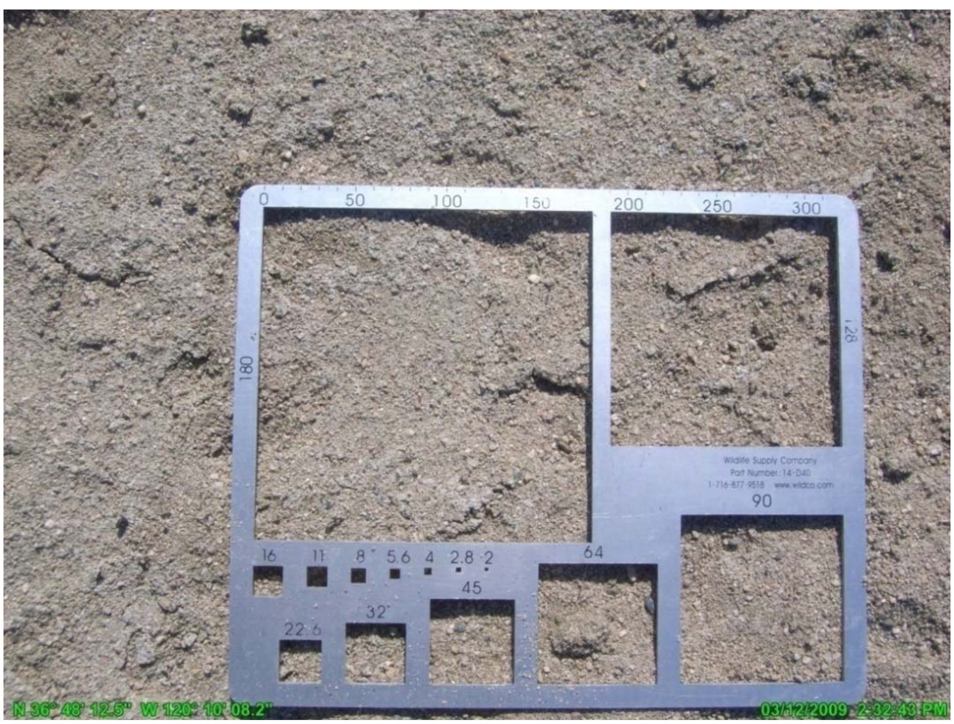
In the downstream subreach of Reach 2A, Alternative A flows increased base level of low flows and subsequently increased vegetation coverage along the banks. However, flows tended to stay in the channel, and the degree of in-channel complexity did not support large increases in vegetation in the downstream reach. There was also deposition predicted in the overbank areas, which could limit vegetation coverage on the raised overbank surface.



Note: Measurements shown in picture are in mm.

Figure 5-16.

Bed Material in Reach 2a at RP 227.1, Approximately 0.25 Mile Downstream from Gravelly Ford Stream Gage



Note: Measurements shown in picture are in mm.

Figure 5-17.

Bed Material in Reach 2a at RP 226.9, Approximately 0.5 Mile Downstream from Gravelly Ford Stream Gage

Figure 5-18.
Termination of the Wet Reach of the San Joaquin River in the Transition Between Reach 1b and 2a, Approximately 0.25 Mile Downstream from the Gravelly Ford Stream Gage (RP 227.1)

Figure 5-19.
Dry Channel in Reach 2a at RP 218

Figure 5-20.
Picture Taken from Low-Flow Channel in Reach 2a During Period of 300-cfs Releases in 2008 (RP 222)

Note: Picture taken in February 2008.

Figure 5-21.
Wet Channel in Reach 2a at RP 226.9, Approximately 0.7 Mile Downstream from Gravelly Ford

Figure 5-22.
Typical Bank Composed of Fines Along the Outside of a Bend in Reach 2a

5.4 Reach 2b

5.4.1 Description

Reach 2b extends from just downstream from the Chowchilla Bifurcation Structure downstream to Mendota Pool. The slope decreases to 0.00022 or about 1 foot per mile, which is almost a factor of 2 less than in Reach 2a. The median bed material diameter is approximately 0.65 mm (MEI 2002a). Currently, water operations only allow a maximum flow of approximately 1,300 cfs in this reach with all excess flow diverted into the Chowchilla Bypass. No tributaries are present in Reach 2b, and therefore this reach is also dry the majority of the time. Reach 2b is confined by levees its entire length, and the distance between the levees ranges from approximately 500 feet to 300 feet. Figure 5-23 shows a photograph of the reach looking downstream from the Chowchilla Bifurcation Structure.

The backwater of Mendota Pool extends upstream to approximately San Mateo Crossing at RP 211.9. Photographs looking upstream and downstream from San Mateo Crossing are shown in Figure 5-24 and Figure 5-25. The photograph looking upstream shows the extent of the backwater pool from Mendota Dam. The channel upstream from the pool is much less vegetated due to the lack of water. The photograph looking downstream illustrates the dense vegetation present in the channel due to the backwater from Mendota Pool.

There are large-amplitude meander bends in this reach (Figure 5-26). These bends have been relatively stable in the recent past but little flow has been conveyed in the channel to promote lateral channel migration.

5.4.2 Summary of Findings

With the implementation of Project Conditions, flows in Reach 2b may increase from the current maximum of approximately 1,300 cfs to a maximum of 4,500 cfs in the future. This significant increase will increase the sediment transport in this reach, and therefore increase the annual sediment load in Reach 2b. Sand transport was estimated to increase from 4,300 tons/year to more than 33,000 tons/year. This is a seven fold increase in the amount of sand transported in this reach.

This reach is expected to be depositional under Baseline and Project Conditions. Expected values of deposition in the main channel are found in Table 5-2. Two potential conditions for the project are shown: Average Levee Setback (ALS) and Maximum Levee Setback (MLS). These conceptual levee setbacks were extracted from the work of MEI (2008). Levee conditions refer to the distance at which the levees may be set back to convey the increase in flow. Less deposition was predicted in the main channel with the MLS because more sediment deposited in the floodplain, which subsequently resulted in less sediment available for deposition in the main channel. Under Project Conditions with ALS, approximately 0.1 foot more channel deposition occurred than under Baseline Conditions using the 24-year simulated hydrology. Although this amount was relatively minor, overall, this reach is considered to be depositional. Levee and flood control measures are recommended in this reach to account for future deposition. Annual collection of high-flow water surface elevations in this reach should be performed to monitor significant changes.

The increase in base flows in this reach under Project Conditions is anticipated to increase the amount of vegetation in the channel. Currently, the stretch of river between the Chowchilla Bifurcation and San Mateo Crossing is generally devoid of flow and supports little vegetation. Increases in base flow will support a riparian vegetation community.

Potential bank erosion and channel migration could be slightly increased under Project Conditions because of the increase in peak flows. However, due to the anticipated development of riparian vegetation under Project Conditions, potential channel migration rates are uncertain. Stillwater Sciences (2003) stated that flows of 4,500 cfs will not likely be sufficient to cause channel migration. McBain and Trush (2002) found that historical migration rates of the bankfull channel in this reach were low, even during pre-dam conditions. The stabilizing effect of vegetation may be greater than the erosive effect of increased flows. Because of the large-amplitude bends in the reach, another potential result of higher flows under Project Conditions is a meander bend cutoff. Currently, levees line the main channel of the reach as shown in Figure 5-27. If a levee setback is constructed and these interior levees are removed, the river will be free to cutoff the meander bends. A cutoff can have beneficial impacts, such as increasing habitat complexity, and flow and sediment transport capacities.

Table 5-2.
Summary of Expected Deposition in the Main Channel in Reach 2b over the 24-Year Simulation Period

Hydrology	Baseline	Project with ALS	Project with MLS
Deposition	0.25 foot	0.37 foot	0.22 foot

Key:
ALS = Average Levee Setback
MLS = Maximum Levee Setback

Currently, the river between the Chowchilla Bypass and San Mateo Crossing is generally devoid of flow and supports little vegetation. The vegetation response in Reach 2b can be divided into two subreaches depending on the location where the backwater effect from Mendota Pool ends (Figure 5-28). Project Conditions increase base flows, and increase the upstream extent of backwater areas. In the downstream subreach of Reach 2b under Project Conditions, survival of vegetation was predicted to increase due to increases in the ground water level. At irregularities in the overbank area, there were also increases in vegetation as less root depth is needed to access the groundwater surface.

Average plant productivity width in this reach is estimated to increase by a factor of 1.5 to 2, relative to Baseline Conditions. A change in vegetation cover resulting from setting back levees was also assessed in Reach 2b. ALS topography and MLS topography were compared to existing locations of levees with Project Conditions. If banks can be overtopped, vegetation coverage should increase with the levee setback area. Oddly, the MLS produced less vegetation than the ALS for both native and invasive vegetation. One explanation is associated with sediment transport results for Reach 2b. More deposition occurred in the channel with the ALS simulation, while more floodplain deposition occurred with MLS. With more overbank deposition and less channel deposition, overbank flooding occurs less frequently, and subsequently vegetation has less opportunity for establishment. Based on current results, native plant productivity with MLS is expected to increase by a maximum factor of 2 relative to the ALS.

Desiccation is expected to eliminate most of the vegetation under Baseline Conditions in the upper part of Reach 2B. However, under Project Conditions and in the lower part of Reach 2B for both Baseline and Project conditions, competition/shading is the dominate cause of mortality. Inundation also removed a large number of both native and invasive plants with Alternative A flows. Scour removed very little vegetation under Project Conditions in this reach.

Figure 5-23.
Looking Downstream from Chowchilla Bifurcation Structure at Upstream End of Reach 2b

Figure 5-24.
Looking Upstream from San Mateo Crossing (RP 211.9)

Figure 5-25.
Looking Downstream from San Mateo Crossing (RP 211.9)

Figure 5-26.
Overview of Reach 2b, Showing Large-Amplitude Meanders

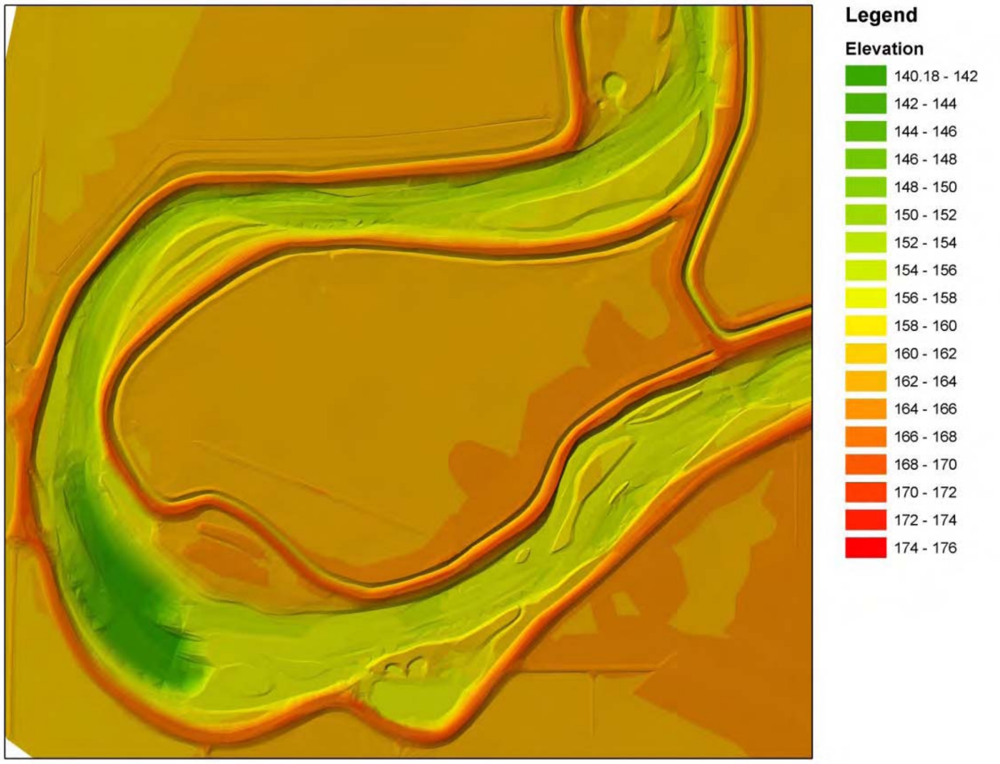
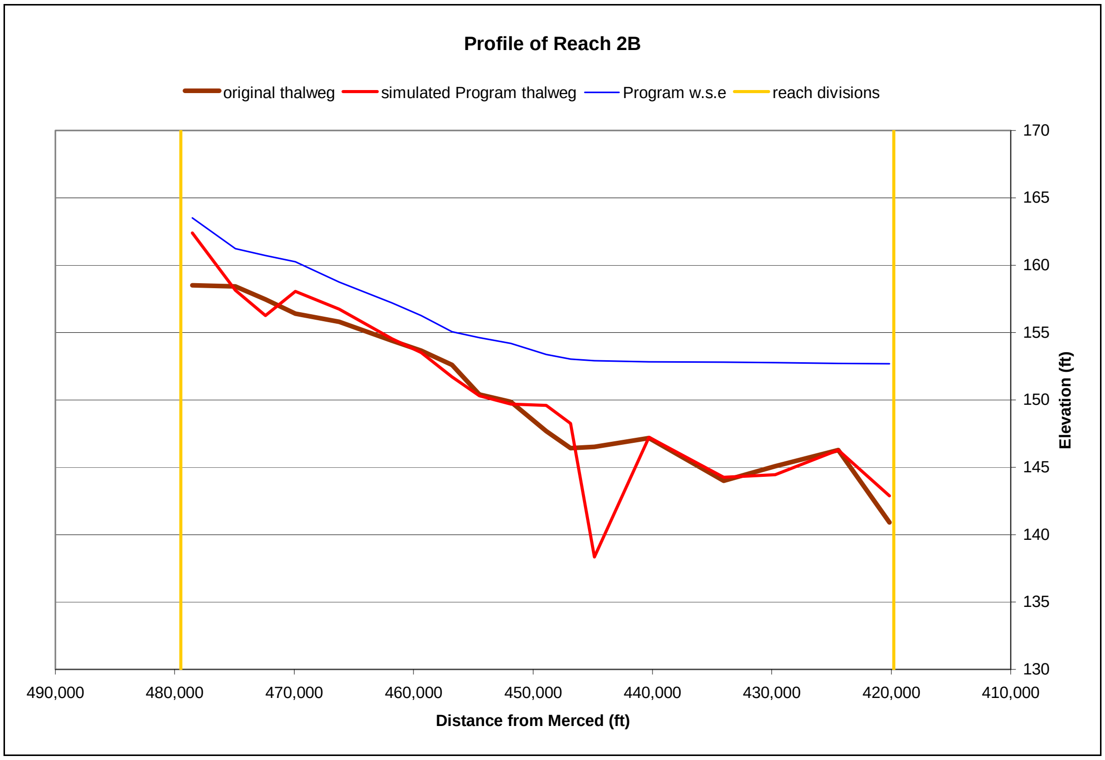


Figure 5-27.
Detailed Topographic Map of Bend in Reach 2b



Note: Backwater of Mendota Pool extends to approximately 420,000 to 445,000 feet.

Figure 5-28.
Thalweg Profiles of Existing Conditions (1998 Topography) and of Alternative A in Reach 2b After a Simulation of 24 Years of Alternative A Flow Regime

5.5 Reach 3

5.5.1 Description

Reach 3 extends from Mendota Dam to Sack Dam. The Delta-Mendota Canal supplies approximately 100 cfs to 600 cfs of water to this reach throughout most of the year. Flows from the Kings River enter the San Joaquin River at the Mendota Pool. Water from the Delta-Mendota Canal is then diverted back out of the San Joaquin River at Sack Dam into the Arroyo Canal. McBain and Trush (2002) state that the sediment supply to Reach 3 has been lower than to upstream reaches because floodplain deposition in Reaches 1 and 2 reduce the amount of sediment available for transport in Reach 3. Also, since the construction of Mendota Dam, sediment routing is temporarily disrupted to Reach 3 because sediment is trapped in Mendota Pool during normal operations, but pulsed downstream during periods of high flow when the boards on the dam are pulled.

Reach 3 is a single thread channel with dense riparian vegetation along its banks. Levees extend along most of Reach 3. These restrict the river width to less than 200 feet in locations and eliminate most of the active floodplain. Because the river has a relatively constant flow, and peak flows are diverted into the bypass system, insufficient energy is typically available to scour riparian vegetation or channel banks. A photograph looking downstream from Mendota Dam is shown in Figure 5-29. Dense riparian vegetation was evident along the banks, and the water in the river was from the Delta-Mendota Canal.

No flow was present in Reach 2b when this photograph was acquired. Figure 5-30 is a photograph taken from the levee at Firebaugh looking upstream. Figure 5-31 is a photograph looking downstream from Sack Dam. Some seepage was evident through Sack Dam at the time of the photograph, but little flow usually enters the river downstream from Sack Dam, except during flood flows.

Bed material in Reach 3 is primarily coarse sand that is slightly larger in diameter than sediment in Reach 2b or in Reach 4a. The slope of Reach 3 is 0.00021, which is similar to Reach 2b and Reach 4a. The current flow capacity in Reach 3 is significantly greater than Reach 2b. Flow capacity in this reach varies between approximately 6,300 cfs near Mendota Dam to approximately 7,200 cfs near Sack Dam (MEI 2002b). The rate of channel migration since construction of Friant Dam has been low (McBain and Trush 2002). This is likely the result of decreased peaks flow and a continued base flow that encourage dense riparian vegetation. McBain and Trush (2002) also cite a decrease in bed elevation in this reach because of land subsidence and channel erosion. Their analysis estimated that the bed elevation decreased by 10.5 feet from 1914 to 1998, with 5 to 6 feet of that resulting from land subsidence and the remaining from channel bed erosion.

5.5.2 Summary of Project Impacts

Because the flow in Reach 2b is substantially increased from Baseline to Project conditions, the flow in Reach 3 is also substantially increased (Figure 3-7). The frequency of flow above 250 cfs will be increased, and the maximum daily average flow will be increased from approximately 6,000 cfs to 8,000 cfs. Relatively sand-free water is also introduced at the confluence with the Delta-Mendota Canal. This water has the tendency to promote erosion by increasing the capacity to convey sediment in the reach. Because of these factors, this reach was predicted to erode under Baseline or Project conditions. The SRH-1D model predicted Reach 3 to erode approximately 1 foot on average under Baseline Conditions and approximately 2 feet on average under Project Conditions using the 24-year simulated hydrology.

A sensitivity analysis was performed to evaluate the impacts of various sediment loads from the Mendota Bypass on model results. Three different scenarios under Project Conditions were simulated:

1. No sediment from Reach 2b enters into Reach 3.
2. Sediment from Reach 2b enters Reach 3 via the Mendota Pool Bypass with Average Levee Setbacks in Reach 2b.
3. Sediment from Reach 2b enters Reach 3 via the Mendota Pool Bypass and with Maximum Levee Setbacks in Reach 2b.

The simulations indicate no significant differences in the average bed changes in Reach 3 between these conditions. Several factors contribute to the insensitivity of Reach 3 to the incoming sediment load from Reach 2b, including:

1. Reach 3 has a median bed material size of 0.85 mm, which is slightly coarser than the 0.65 mm in Reach 2b.

2. The flow capacity in Reach 3 is greater than in Reach 2b.
3. The introduction of relatively sediment starved flow from the Delta-Mendota Canal.

These factors, regardless of the incoming sediment loads from Reach 2b, contribute to predicted erosion downstream from Mendota Dam.

The increase in flow magnitude under Project Conditions may increase the channel migration and bank erosion rates, but the increase is expected to be minimal and may not be detectable. Because the banks in Reach 3 are densely vegetated (Figure 5-29 and Figure 5-30), the flows under Project Conditions are not anticipated to scour the vegetation from the banks and cause bank erosion. Pre-dam channel migration rates were small in this reach (McBain and Trush 2002). The peak flows under Project Conditions are still much less than the peak flows under pre-dam conditions, and therefore, the rate of channel migration should be small. McBain and Trush (2002) also determined that potential future flows under Project Conditions will likely not be sufficient to erode the well established vegetation and they estimated that channel migration does not occur until the flow exceeds 12,000 cfs.

Vegetation simulations with Project Conditions predicted similar amounts of vegetation in Reach 3 to Baseline Conditions. This is consistent with the hydrologic regime of Alternative A flows downstream from Mendota Pool. Unlike the discharge downstream from Friant Dam, there is little difference between Baseline and Alternative A base flows in Reach 3, while Alternative A peak flows are actually larger than Baseline peak flows (Figure 5-32).

Distinct from upstream reaches, Reach 3, which is operated like a delivery canal, never experienced large losses of plants from desiccation or scour. Under Project Conditions, this pattern continued, but an increase in desiccation losses was simulated, possibly due to the larger peak flows that could strand more germinating plants.

Mortality based on plant productivity is the lowest of any reach for invasive plants and has the third smallest plant removal, behind only Reach 1B and Reach 1A, for native plants. Shading and competition removes the most native plants while desiccation is the largest cause of invasive plant mortality (Figure 5-14).

Figure 5-29.
Looking Downstream at Reach 3 from Mendota Dam

Figure 5-30.
Looking Upstream at Reach 3 near Firebaugh

Figure 5-31.
Looking Downstream at Sack Dam

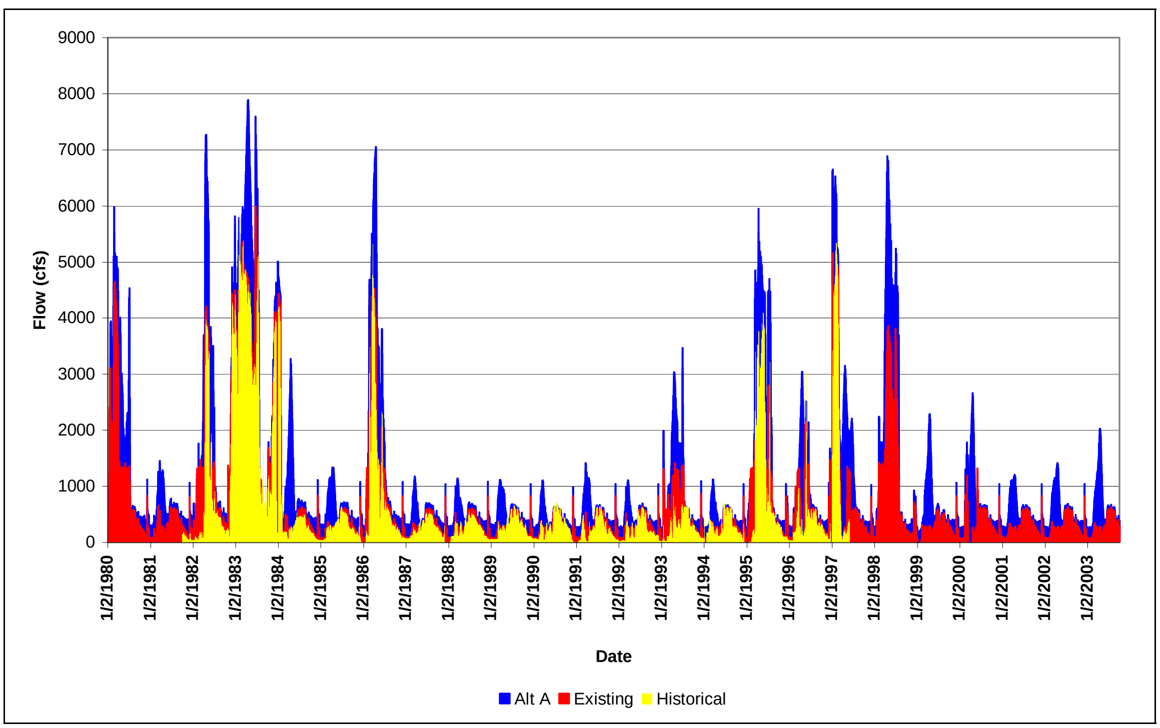


Figure 5-32.
Discharge at Mendota Pool: Historical, Baseline, and Alternative A

5.6 Reach 4a

5.6.1 Description

Reach 4a extends from Sack Dam to the Sand Slough Control Structure. The width between the levees varies between 200 and 700 feet. The average channel slope is 0.00021, and the median bed material size is 0.55 mm. Flow capacity was estimated to be 7,400 cfs by MEI (2002b). The current supply of sediment to Reaches 4 and 5 may be larger than the historical supply because of irrigation return flows carrying sediment eroded from agricultural fields (Stillwater Sciences 2003). However, the flow is much more confined now in Reach 4a than historically due to levee construction. The confinement of the flood flows would tend to increase the sediment transport capacity of the channel between the levees. Also, most of the increase in sediment loads to Reach 4a is composed of fine sediment that would not tend to deposit in the sand-bed. Therefore, even with slightly higher total sediment transport delivery to the channel, Reach 4a may not be aggradational. McBain and Trush (2002) compared cross-section surveys from 1914 to 1998 measurements and found that in all three cross sections in which comparisons were made, erosion between 1 to 4 feet had occurred.

The channel morphology undergoes a transition in the upstream portion of Reach 4a from being moderately confined in Reaches 2 and 3 into the extensive flood basin morphology of much of Reach 4 and all of Reach 5 (McBain and Trush 2002). Overbank flows become more frequent, and numerous large-scale anabranching sloughs originate in the reach. McBain and Trush (2002) state that historical river migration rates are probably less in Reaches 4 and 5 than in Reaches 2 and 3. The historically low migration rates are probably attributable to low sediment supply, low stream energy, and riparian berms that bordered the channel (Stillwater Sciences 2003). Much of the connection to these anabranching sloughs is removed now in Reach 4a because of the reclamation of agricultural land and the construction of levees.

This reach is now typically dry due to the diversion of flow at Sack Dam. However, seepage from Sack Dam and return flows from irrigation supply provide sufficient quantities of water to support some vegetation between the levees. Seepage from Sack Dam seems to maintain water in the channel for approximately 2 to 3 miles downstream from the dam where vegetation is correspondingly denser. A photograph taken from Sack Dam looking downstream is shown in Figure 5-33. Further downstream from Sack dam (more than 3 miles), the vegetation is not continuous, and sections of the reach are essentially devoid of woody vegetation. In this lower portion of Reach 4a, there are periodic locations where deep pools collect water and maintain vegetation. One such location, shown in Figure 5-34, is approximately 5 miles downstream from Sack Dam. Sections of river are also present in the reach that seem to be dry most of the year, such as at RP 172.7 (Figure 5-35). These dry stretches are dominated by grasses and brush with just a few trees present along the channel margins.

5.6.2 Summary of Findings

Substantial increases in the frequency of flow above 100 cfs were simulated under Project Conditions relative to Baseline Conditions. Based upon the simulations of Project Conditions, the flow in Reach 4a will be above 100 cfs 99 percent of the time. Under the

Baseline scenario, the flow is less than 100 cfs 50 percent of the time and less than 10 cfs 15 percent of the time (Figure 3-8). The maximum daily discharge in this reach under Baseline Conditions was 5,200 cfs and under Project flows was 7,616 cfs.

The sediment transport modeling predicted slight deposition for Reach 4a under Baseline Conditions, but slight erosion for Reach 4a under Project Conditions. Currently, a significant portion of the flow in Reach 3 is diverted at Sack Dam, and much of the sediment is deposited in the channel behind Sack Dam. With the increase in Baseline and peak flows under Project Conditions, degradation was predicted in the reach. However, the magnitude of the erosion was small at approximately 0.3 foot over the 24-year simulation.

The increase in the frequency of high flows could increase the potential for channel migration and bank erosion. However, the increase in base flows under Project Conditions is expected to increase the vegetation in the channel and have a stabilizing effect on the channel banks. Bank erosion could possibly decrease under Project Conditions in Reach 4a due to vegetation establishment, despite an increase in the frequency of large flows. Although the increase in large flows is anticipated to increase the erosive forces acting on the bank, the possibility for large scale channel migration and bank erosion in this reach is considered remote. McBain and Trush (2002) compared 1855 maps with 1917 maps and 1998 aerial photos to review changes in channel alignment for sample sites in Reaches 4 and 5. Results from their analysis suggest that the rate of channel migration in Reaches 4 and 5 were lower than that in Reaches 2 and 3. McBain and Trush (2002) estimated that the threshold for initiating channel migration is approximately 10,000 cfs, which is greater than the peak flows under Project Conditions.

The Baseline simulations in Reach 4a predicted almost continuous base flow in this reach. However, this is not considered realistic based upon field observations of the reach. A large portion of the reach is dry a majority of the time. Typically, water only exists in deep pools or downstream from Sack Dam. This small flow, sometimes just a few cubic feet per second, was sufficient to maintain the riparian vegetation within the model. It is expected that the base flows may be overestimated in the Baseline hydrology simulations and consistent with field observation, this reach is often dry. Additional monitoring of low flows and groundwater levels in Reach 4a would help to improve hydrologic models in this reach.

Because of the continuous base flow in Reach 4a under Baseline Conditions, the SRH-1Dv simulations of vegetation showed very little difference between Alternative A and Baseline conditions.

Plant mortality in Reach 4a was dominated by desiccation under Project and Baseline conditions. Competition/Shading and drowning were also significant factors in plant mortality. Almost no plant removal by scour was predicted.

Figure 5-33.
Taken from Sack Dam Looking Downstream

Figure 5-34.
Photograph Showing Pool Supplied by Seepage from Canal Flows or Irrigation Returns (RP 177.1)

Figure 5-35.
Dry Section of Reach 4a (RP 172.7)

5.7 Reach 4b1

5.7.1 Description

Reach 4b1 extends from the Sand Slough Control Structure to the return of the Mariposa Bypass. This reach has had very little flowing water since the construction of the Sand Slough Control Structure. Before the construction of the Sand Slough, the reach is thought to have functioned similarly to Reach 4a.

Currently, the capacity of the river is severely limited by vegetation in the channel and adjacent land use. Levees are not present in the reach to contain flood flows. A photograph taken from the bridge at RP 157.1 is shown in Figure 5-36. This section of the river receives agricultural return flows and therefore maintains a pool of water. Other sections of the reach are completely overgrown with vegetation, such as at RP 153.5 (Figure 5-37). MEI (2002b) estimated the flow capacity of Reach 4b1 to be 400 cfs.

The capacity of the lower portion of Reach 4b1 within the San Luis National Wildlife Refuge is expected to be much larger than 400 cfs. A photograph of the channel in the San Luis National Wildlife Refuge reach is given in Figure 5-38. The channel is wider here and has a well developed floodplain. The slope is 0.00017, which is the lowest slope of all project reaches.

5.7.2 Summary of Findings

For the Project Conditions, two scenarios were simulated with SRH-1D in Reach 4b1: one scenario allowed a maximum flow of 475 cfs to enter Reach 4b1 and the other allowed a maximum flow of 4,500 cfs. The Project Conditions provided in Appendix H, Modeling, assumed a maximum flow of 475 cfs in Reach 4b1, and the flow-duration curve for this scenario is shown in Figure 3-9. The alternate scenario with a maximum flow of 4,500 cfs in Reach 4b1 was developed to test the sensitivity of the reach to increased flows. To route a flow of 4,500 cfs through the reach, levees were assumed to be present at the cross-section endpoints. Future levee design to protect adjacent properties should be incorporated in future modeling runs to more accurately predict sediment transport and geomorphic channel change in this reach. Results presented herein are preliminary and do not represent the influence of possible levees.

Within Reach 4b1, the average depth of erosion reached 0.4 foot over a 17-year period for the scenario with a maximum flow of 475 cfs. Most of the erosion for a maximum flow of 475 cfs occurred in the lower end of the reach and was due to the base-level lowering in Reach 4b2 and 5 (explained in next section). Overall, Reach 4b1 is considered to be stable if the maximum release to the reach is 475 cfs.

No significant bank erosion and/or channel migration for the 475 cfs scenario 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 will not be sufficient to erode the vegetation along the bank. A simple channel will likely form in this reach with minimal in-channel complexity. With a maximum of 475 cfs, the reach may function much like a canal due to a limited flow range.

An average of 1.9 feet of erosion was predicted for the alternative scenario with 4,500 cfs in Reach 4b1 over a 17-year period. Most of the erosion was predicted near the upstream and downstream ends of the reach with greater stability present in the central portion of the reach. Erosion in the downstream portion of the reach was due to the base-level lowering in Reach 4b2 and 5. Erosion in the upstream portion of the reach was caused by the higher flows being discharged to the reach. Because Reach 4a was predicted to be degrading, Reach 4b1 is also expected to degrade in the future if flows are sufficiently high. One potential benefit of erosion in this reach is the anticipated increase in flow capacity over time.

With a maximum flow of 4,500 cfs, some initial channel adjustment is expected. Over the long term, however, the channel should function much like Reach 4a, with small channel migration rates. The reach is anticipated to be quickly vegetated, and the flows will not likely have sufficient energy to erode the banks and associated vegetation. The design of the initial channel in Reach 4b1 needs to ensure that initial channel adjustments do not damage levees or other infrastructure.

Average plant productivity width for Reach 4b1 is shown in Figure 5-6 under Alternative A flows where a maximum 475 cfs is allowed in the reach. Plant productivity under Project Conditions is expected to increase by approximately a factor of 2 relative to Baseline Conditions.

Currently, the channel of Reach 4B1 is filled with well-established vegetation. The productivity width for this reach is slightly higher for Alternative A flows than typical values for Alternative A flows in Reaches 1B, 2A, and 4B2. The slope of 0.00017, which is the lowest slope of all project reaches, would initially promote a wider floodplain until the channel equilibrates to steeper grade consistent with upstream and downstream slopes. It would take multiple years for mature woody vegetation to be eliminated and even longer for debris to be removed with natural processes, but over time the productivity width is predicted to decrease under Project Conditions. Decrease in vegetation coverage is anticipated to occur in the low-flow channel where there is continuous flow.

Figure 5-36.
Taken Looking Downstream at Reach 4b1 from Bridge on Erreca Road at RP 157.1

Figure 5-37.
Taken Looking at the San Joaquin River at RP 153.5 in Reach 4b1

Figure 5-38.
Photograph Taken in Reach 4b1 in the San Luis National Wildlife Refuge (RP 149.1)

5.8 Reach 4b2

5.8.1 Description

Reach 4b2 extends from Mariposa Bypass at the upstream end to the return of the Eastside Bypass into the San Joaquin River at the downstream end. This reach is bordered on the south side by the San Luis National Wildlife Refuge. Levees bound the river, but the width between the levees is generally more than 1,000 feet. MEI (2002b) estimated the channel capacity in this reach to be greater than 10,000 cfs. The river slope is approximately 0.00019, and the median bed material size is 0.56 mm.

The return flow from Mariposa Bypass during flood flows maintains a well-defined channel. The river has a much wider floodplain area and is generally well connected to it. Overbank flow occurs at relatively low discharges in the range of 3,000 to 4,000 cfs.

The channel is heavily vegetated and is generally lined by dense woody vegetation or brush (Figure 5-39 and Figure 5-40). Higher floodplain surfaces, however, are generally only covered by grasses (Figure 5-41). Meander rates are low, as described in Reach 4a. Figure 5-42 shows other vegetation types within Reach 4b2.

5.8.2 Summary of Findings

Because base flow in Reach 4b1 is increased significantly, the base flow in Reach 4b2 is also increased (Figure 3-10). Under Baseline Conditions, flow was predicted to be less than 10 cfs more than 87 percent of the time, based upon the hydrologic period 1-1-1980 to 5-31-1997. Under Project Conditions, the flow was predicted to be above 100 cfs more than 99 percent of the time. Peak flows between Baseline and Project conditions are considered to be approximately the same.

Based on the sediment transport modeling, the reach was predicted to erode under Baseline and Project conditions. Channel bed erosion of 0.2 foot was predicted under Baseline Conditions, and approximately 1 foot of channel bed erosion was predicted under Project Conditions over the 24-year simulation period. Because this reach is comprised of a sand-bed, the bed is mobile for flows below bank full discharge, and the model predicted that the increase in the frequency of base flows under Project Conditions is sufficient to increase the erosion of the bed.

The magnitude of the high flow in this reach is approximately the same under Baseline and Project conditions. Therefore, the amount of bank erosion and channel migration is expected to be similar under Project Conditions as compared with Baseline Conditions.

The Alternative A flows had approximately 15 to 20 percent more native plant productivity in this reach (Figure 5-6). This reach already supports more riparian vegetation than upstream reaches due to the wider floodplain that can be accessed at high flows. Much of the existing vegetation is old established woody vegetation (represented by cottonwood and black willow in the model) and highland grasses. Longer roots of the established woody species can access low groundwater. Shade from established trees discourages new growth, while grass cover can prevent new plants from establishing (competition/shading mortality). Base flows increased the groundwater level, but the simulated flow remained mostly well below the floodplain bench. This condition is exacerbated by the incision that is predicted under Baseline and Alternative A flows. Root depths of narrow-leaf willow roots cannot reach the water surface for long periods and eventually die from desiccation. One large and long high flow is simulated near the start of the hydrologic record that persisted long enough to remove grasses and establish new native and invasive plants. Root growth of the cottonwood and black willow could reach the new base flow levels and survive while other plants eventually die. Remaining peak flow events occasionally overtopped the floodplain bench, but with grass cover and shaded areas from woody vegetation, very little area was available for new growth.

Figure 5-39.
Main Channel in Reach 4b2 at RP 138.8 Looking Upstream

Figure 5-40.
Photograph of Reach 4b2 Looking Downstream near RP 141.2

Figure 5-41.
Floodplain Terrace in Reach 4b2 at RP 138.8

Figure 5-42.
Reach 4b2 Looking Upstream at an Old Ferry Dock

5.9 Reach 5

5.9.1 Description

Reach 5 extends from the confluence of Bear Creek (which is also the return of flow from the Eastside Bypass) to the Merced River. The reach is located within the Fremont Ford State Park and San Luis Wildlife Refuge, and the flows from the bypass system return at the upstream end of this reach, making this reach probably the least disturbed of the project reaches.

The historic channel morphology appears to be similar between Reaches 4 and 5 (McBain and Trush 2002) with few minor differences (i.e., flows may access the floodplain less in Reach 4b2). MEI (2002b) estimated the capacity of this reach to be over 20,000 cfs. The slope is 0.0002, and the median bed material size is 0.52 mm. The river is generally much wider as it receives larger flows with the return of the water from the Eastside Bypass. A photograph taken at RP 134.1 approximately 1.5 miles downstream from the return of the Eastside Bypass is shown in Figure 5-43. The confluence with the Merced River is shown in Figure 5-44.

Erosion in this reach is suspected to have taken place as evidenced by the exposure of the bridge piers at SH 165 at RP 132.8. Figure 5-45 illustrates the erosion and was taken in August 2007. By August 2008, the bridge piers were reinforced with steel piers (Figure 5-46). The erosion is most likely driven by the return of relatively sediment-free water from the bypass system. McBain and Trush (2002) determined no change between 1972 and 1997 based upon the survey data at the SR 165 bridge. However, the photographs taken in 2007 and 2008 seem to indicate that erosion is now occurring at the SR 165 Bridge. McBain and Trush (2002) also found that a cross section in the upper portion of Reach 5 had degraded 8.5 feet from 1914 to 1998. Based on these findings, erosion may be progressing downstream beginning at the return of the Eastside Bypass.

5.9.2 Summary of Findings

The frequency of flows above 200 cfs and below 2,000 cfs was predicted to increase significantly under Project Conditions, as compared to Baseline Conditions. The frequency of flows above 2,000 cfs is almost unchanged, compared to Baseline Conditions (Figure 3-11). The sand-bed in Reach 5 is mobile at flows under 2,000 cfs, and therefore, flows below 2,000 cfs can alter the sediment transport rates.

Because of the return of relatively sediment free water from the Eastside Bypass system, erosion is expected in Reach 5 under Baseline and Project conditions. The predicted erosion was slightly larger under Project Conditions. The overall average of the simulated channel erosion in Reach 5 was 2 feet for the Baseline Conditions and 2.1 feet for the Project Conditions. This difference is not considered significant. Reach 5 was divided into three subreaches to compute the differences at a smaller scale, and the differences in the simulated channel erosion for each subreach were larger. However, Reach 5 is influenced by several sloughs and tributaries, and the sediment contributions from these sources are uncertain, which results in uncertainty in the significance of the differences

between the subreaches. Some erosion is evidenced by photographs taken at Highway 165, however the extent of the erosion is unknown. Additional topographic surveys could be performed in this reach to document recent channel erosion.

The banks are largely vegetated, and a minimal increase in the amount of vegetation is expected under Project Conditions. The peak flows remain essentially unchanged and therefore, the rate of bank erosion and channel migration should be similar to Baseline Conditions.

Based on the SRH-1DV model simulations, Reach 5 supports more native plant productivity than any other project reaches under both Baseline Conditions and Alternative A flows. Reach 5 was divided into two subreaches for the vegetation analysis: 5a upstream from the Salt Slough and 5b downstream from the Salt Slough.

Reach 5 is one of the longest reaches in the study area and its large vegetated area is due to the wide, accessible floodplain. Despite incision, and less access by peak flows to the floodplain, this reach is thought to still function similar to pre-Settlement conditions (McBain and Trush 2002). Similar to Reach 2B there are compressed and cross-valley meander bends in Reach 5 that can contribute to an overestimate of vegetative cover when computed with simple one-dimensional area computations (productivity area= river length multiplied by cross-section width). Plant productivity width in the lower part of Reach 5 is probably overestimated, but this reach is still believed to support more vegetation than upstream reaches and still anticipated to have more increase with implementation of project flows. There is good access to the floodplain and roots of narrow-leaf willow extend to base flow/groundwater. New growth occasionally occurred even after the one long-duration peak flow.

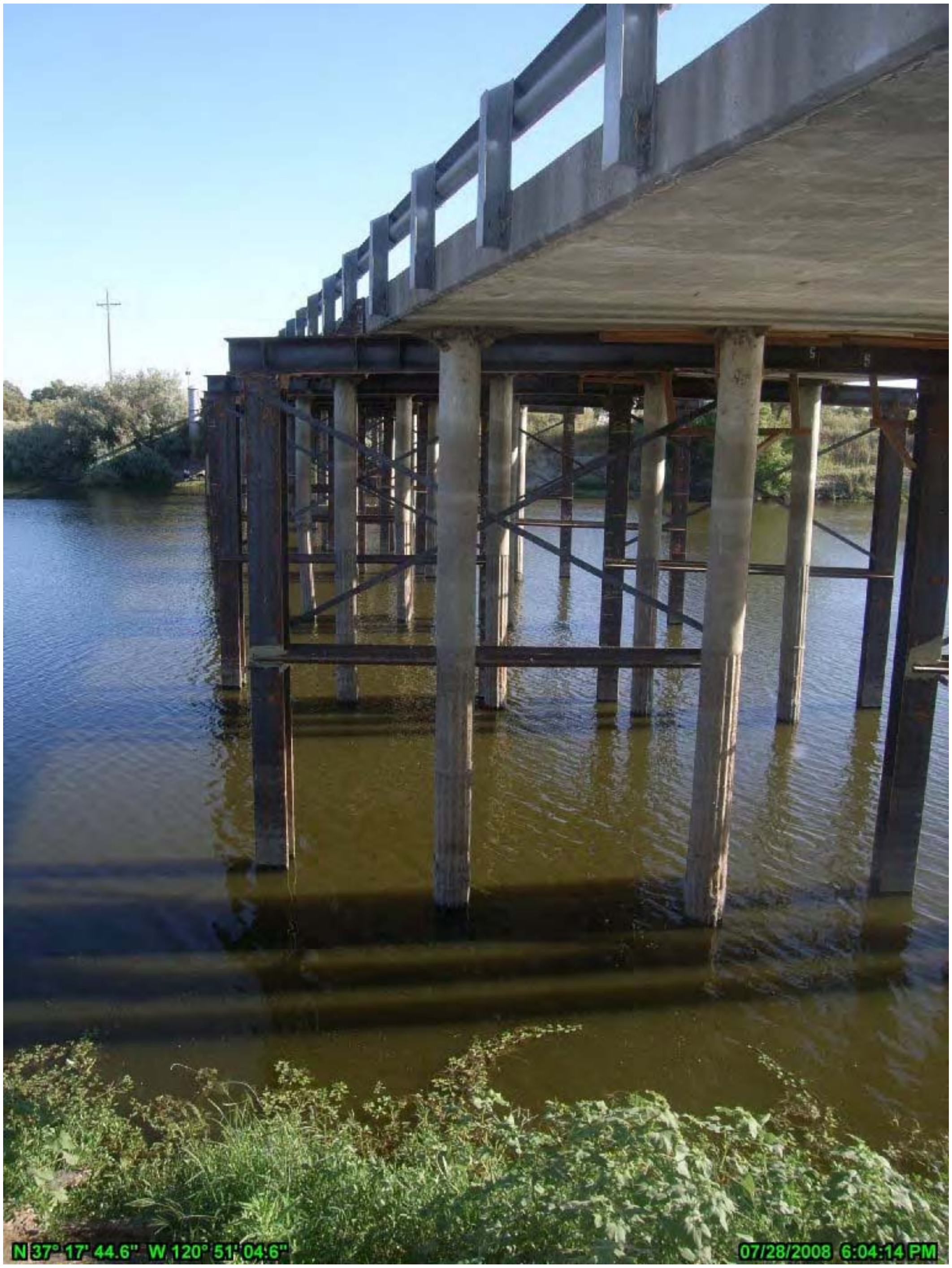
The simulated plant productivity under Alternative A flows was approximately 30 percent greater in Reach 5a and 38 percent greater in Reach 5b. Desiccation was the most prevalent factor in plant mortality. It is expected that the majority of the desiccation occurs in the floodplain where the roots cannot access the water table. Competition and drowning were also important in Reach 5.

Figure 5-43.
Looking Downstream at Reach 5 at RP 134.1

Figure 5-44.
Confluence of San Joaquin and Merced Rivers

Note:
Degradation is Evident from the Bridge Pier Exposure (Dated 8-23-2007).

Figure 5-45.
Photograph of SH 165 Bridge (RP 132.8)



Note:
Degradation is Evident from the Bridge Pier Exposure. Photograph is Taken in 2008 Showing the Structural Reinforcement of the Bridge Piers.

**Figure 5-46.
Photograph of SH 165 Bridge**

5.10 Eastside Bypass

5.10.1 Description

The Eastside Bypass, for the purposes of this report, begins at the confluence of the Chowchilla Bypass and the Sand Slough Bypass Channel and continues to the confluence with the San Joaquin River. The upper Eastside Bypass is considered to be the reach from the confluence of the Chowchilla Bypass and the Sand Slough Bypass Channel to the Mariposa Control Structure, while the lower Eastside Bypass is the reach from the Mariposa Control Structure to the Merced River. Practically all the water from Reach 4a currently enters the Eastside Bypass and is prevented from entering Reach 4b1 by the Sand Slough Control Structure.

The average width between the levees in the upper Eastside Bypass is approximately 1,500 feet, and the average slope is 0.0002, which is similar to the slope in Reaches 3, 4, and 5. Bed material in the Eastside Bypass is mostly composed of the soil into which the bypass was cut. However, a sand-bed is present for approximately the first mile within the bypass (Figure 5-47). The Mariposa Control Structure provides a base-level control that structure limits the amount of potential erosion upstream.

The bed elevation of the lower Eastside Bypass has lowered over time, particularly below the confluence with Bear Creek (Figures 5-48 and 5-49). The base-level control for the lower Eastside Bypass is the upstream portion of Reach 5, and Reach 5 appears to have also experienced degradation in the recent past (Section 5.9.1). Therefore, both the lack of sediment supply to the Eastside Bypass and the lowering of the base-level control in Reach 5 would contribute to additional bed degradation in the lower Eastside Bypass.

The bypass system is mostly covered by grasses and is devoid of woody vegetation (see Figures 5-50, 5-51, and 5-52). The combination of a lack of base flow and possibly the soil conditions prevent establishment of woody species. More vegetation is present within the incised lower Eastside Bypass (Figure 5-53). This may be due to more base flow in the lower Eastside Bypass resulting from flow contributions from Bear Creek and other smaller tributaries. The incised channel in the lower Eastside Bypass is developing a floodplain within the incised channel. The process in the lower Eastide Bypass below Bear Creek confluence is similar to the conceptual channel development model of Simon (1989), where a disturbance introduces channel incision, followed by channel widening, followed by a development of alluvial channel and floodplain.

5.10.2 Summary of Findings

Under Project Conditions, flows are restored to Reach 4b1, and less flow is diverted to the Eastside Bypass. Flow was projected to be less than 10 cfs at the upstream end of the Eastside Bypass 70 percent of the time. Under Baseline Conditions, flow was simulated to be below 10 cfs only 15 percent of the time. The Historical Gage record for the El Nido gage is not considered reliable for low flows, which results in a considerable discrepancy between the gage record and hydrology under Baseline Conditions. Peak flows under Project Conditions are also reduced in the Eastside Bypass, but the impacts of reduced peak flows are less significant than reduced low flows.

The primary impact of the implementation of Project Conditions will be a reduction in the erosion rates in the Eastside Bypass. Simulated channel erosion under Baseline Conditions was 1.6 feet, and under Project Conditions, with a maximum flow of 475 cfs entering 4b1, the predicted channel erosion was 1.1 feet. For the case of a maximum flow of 4,500 cfs entering 4b1, the predicted channel erosion was less.

Under Project Conditions, the bypasses are expected to continue to have limited woody vegetation. Reduced low flows under Project Conditions may continue to support vegetation with established deep roots but it may be difficult for new plants to survive. Bank erosion will likely also decrease under Project Conditions. Bank erosion in the Eastside Bypass seems to be primarily influenced by channel incision, after which channel widening and then floodplain formation occurs. Because channel incision was predicted to decrease under Project Conditions, the amount of bank erosion is also expected to decrease.

Figure 5-47.
Looking Upstream at Eastside Bypass Approximately 1 Mile Downstream from Sand Slough Control Structure

Figure 5-48.
Looking Upstream at Eastside Bypass, Approximately 4 miles Upstream from the Confluence with the San Joaquin River, Downstream from the Confluence with Bear Creek

Figure 5-49.
Picture looking Downstream on Bear Creek. After Confluence of Eastside Bypass and Bear Creek, Approximately 1 Mile Upstream from Confluence with San Joaquin River

Note: Dated 02/2008.

Figure 5-50.
Looking Downstream from El Nido Stream Gage. Approximately 2.5 Miles Downstream from Sand Slough Control Structure

Figure 5-51.
Looking Upstream at Eastside Bypass. Approximately 1 Mile Upstream from the Mariposa Control Structure

Figure 5-52.
Looking Upstream at Eastside Bypass. Approximately 8 Miles Upstream from the Confluence with the San Joaquin River, 1.5 Miles Downstream from Mariposa Bypass Channel

Note: Dated 02/06/2008.

Figure 5-53.
Looking Upstream at East Side Bypass Approximately 1.5 Miles Upstream from Confluence with Bear Creek, 4 Miles Downstream from Mariposa Control Structure

5.11 Mariposa Bypass

5.11.1 Description

The Mariposa Bypass is similar in bed material and vegetation to the upper Eastside Bypass (Figures 5-54, 5-55, 5-56, and 5-57). The width is constant at 700 feet, and the slope is 0.00019, which is similar to the slope of Reaches 3, 4, and 5. A gated control structure is located at the upstream end of the reach, and a concrete grade control is located at the downstream end before it enters the San Joaquin River. Scour pools are present downstream from structures that are about 14 to 16 feet deep, based upon the 1998 survey of the U.S. Army corps of Engineers. There is also an approximately 8-foot drop in average bed elevation across the downstream grade control. Overall degradation in Mariposa Bypass is limited due to the grade control at its downstream end.

5.11.2 Summary of Findings

Sediment transport modeling predicted erosion under Baseline and Project conditions, but the magnitude of erosion was less under Project Conditions. The frequency of flow above 2 cfs was reduced under Project Conditions in this reach, and therefore less energy was available for erosion. Approximately 1.4 feet of channel erosion was predicted under Baseline Conditions, and 1.2 feet of channel erosion was predicted under Project Conditions.

The Mariposa Bypass will likely continue to be devoid of woody vegetation with low survivability for new plants. Mariposa Bypass is estimated to have even less low flow than Eastside Bypass and will subsequently have even more mortality and less plant productivity than the upstream reach. New plants will be located even lower in the stream bed. Due to reduced flows in the reach under Project Conditions, it is unlikely woody vegetation will establish.

Because the vegetation type and density is expected to be similar between Project and Baseline conditions and because flows decrease in magnitude under Project Conditions, the overall bank erosion rates in the reach are expected to decrease.

Figure 5-54.
Looking Downstream from Mariposa Control Structure at Mariposa Bypass

Figure 5-55.
Looking Upstream in Mariposa Bypass

Figure 5-56.
Looking Upstream from Downstream Grade Control on Mariposa Bypass

Figure 5-57.
Looking Downstream from Downstream Grade Control on Mariposa Bypass

6.0 Summary

A summary of project effects is given in Table 6-1.

Table 6-1.
Summary of Effects Relative to Baseline Conditions

Project Reach	Primary Effects to Project Conditions Hydrology	Anticipated Response of Reach
Reach 1a	Substantial increase in flows between 350 and 2,300 cfs; Slight reduction in frequency of flows over 2,300 cfs	Slightly less mobilization of bed material; channel bed elevations remain stable; reduced channel migration potential; increase in vegetation
Reach 1b	Substantial increase in flows between 200 and 2,300 cfs; Slight reduction in frequency of flows over 2,300 cfs	More frequent slight mobilization but less frequent significant mobilization; stable bed; slightly reduced channel migration potential; increase in vegetation
Reach 2a	Substantial increase in frequency flows below 2,300 cfs; Slight reduction in frequency of flows over 2,300 cfs	Increased vegetation due to increased base flows; reduced bank erosion and channel migration rate
Reach 2b	Continuous base flows and substantially increased high flows	Increased sediment transport rates; slight increase in potential for channel deposition; slightly increased bank erosion and channel migration rate potential, increase in vegetation in upper portion of reach
Reach 3	Substantially increased high-flow frequency	Increased channel bed erosion; minimal changes in channel migration; slight increase in vegetation
Reach 4a	Substantial increases frequency of all flows	Slight increase in channel erosion; increased vegetation; undetermined effect on bank erosion and channel migration potential
Reach 4b1	Establishment of flows up to 475 cfs	Slight channel erosion; increased potential for bank erosion and channel migration; rapid vegetation establishment
Reach 4b2	Increased frequency of flows between 100 and 475 cfs	Increased channel bed erosion; minimal change in vegetation; reduced bank erosion and channel migration potential
Reach 5	Significant increase in flows between 200 and 2,000 cfs	No significant differences in channel erosion, bank erosion or vegetation
Eastside Bypass	Reduced frequency of flows above 2 cfs	Reduced erosion rates; minimal change in vegetation; reduced bank erosion
Mariposa Bypass	Reduced frequency of flows above 2 cfs	Slightly reduced erosion rates; minimal change in vegetation; reduced bank erosion potential

Key:
cfs = cubic feet per second

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7.0 References

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