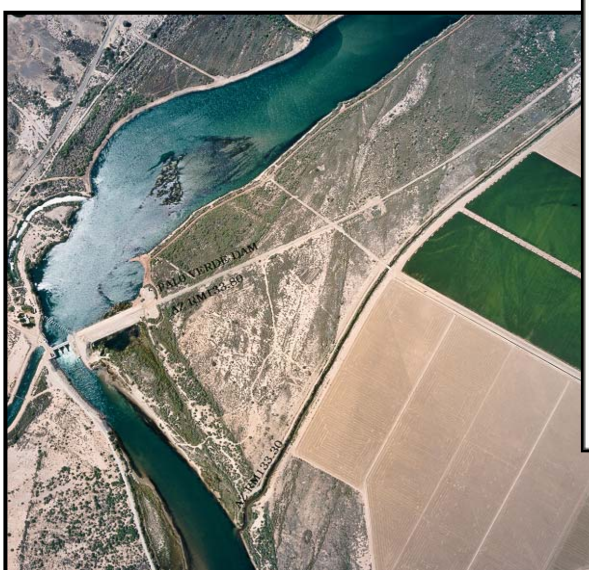
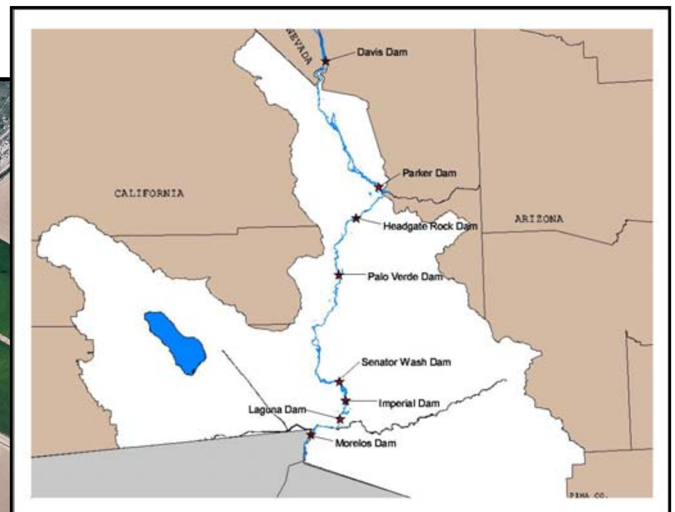
RECLAMATION

Managing Water in the West

Draft Environmental Assessment

Bankline Stabilization and River Control above Palo Verde Dam





U.S. Department of the Interior
Bureau of Reclamation

June 2005

Mission Statements

The mission of the Department of the Interior is to protect and provide access to our Nation's natural and cultural heritage and honor our trust responsibilities to Indian Tribes and our commitments to island communities.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

Draft Environmental Assessment

Bankline Stabilization and River Control above Palo Verde Dam

Yuma Area Office
Environmental Group
Yuma, Arizona

U.S. Department of the Interior
Bureau of Reclamation
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ACRONYMS AND ABBREVIATIONS

ACOE	Army Corp of Engineers
AGFD	Arizona Game and Fish Department
ASU	Arizona State University
CDFG	California Department of Fish and Game
cfs	cubic feet per second
CRFWLS	Colorado River Front Work and Levee System
CRIT	Colorado River Indian Tribes
CWA	Clean Water Act
DOI	United States Department of the Interior
EA	Environmental Assessment
ESA	Endangered Species Act
ft	feet
HCP	Habitat Conservation Plan
LCR	Lower Colorado River
MSCP	Multi species Conservation Plan
NEPA	National Environmental Policy Act
PVID	Palo Verde Irrigation District
Reclamation	Bureau of Reclamation
RPM	Reasonable and Prudent Measure
USFWS	United States Fish and Wildlife Service

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1.0 Purpose of and Need for Action

The Bureau of Reclamation (Reclamation) has prepared this Environmental Assessment (EA) pursuant to the National Environmental Policy Act of 1969 (NEPA) and in accordance with the guidelines established in Department of the Interior (DOI) regulations and the Reclamation NEPA Handbook (Reclamation 1997). The EA was prepared to evaluate potential environmental impacts associated with control of bankline erosion on the Lower Colorado River (LCR). The Project[1] is located approximately 9 miles northeast of the City of Blythe in Riverside County, CA and in La Paz County, AZ upstream of the Palo Verde Diversion Dam (the Dam) between river mile (RM) 133.8 and RM 135.0 (Figure 1).

1.1 Introduction

The Palo Verde Diversion Project, which includes the Dam along with the spillway and canal head-works, was constructed in 1957 to improve irrigation of the Palo Verde Irrigation District (PVID). Diversion structures at the Dam divert water through a series of lateral canals to irrigate approximately 121,000 acres of agricultural lands within the District.

The Dam is a semi-pervious barrier of sand, gravel, and rock fill, with a crest width of 20 feet (ft), a length of 1,850 ft (which includes the spillway), and a maximum height of 46 ft above the riverbed. The right abutment of the Dam is in Riverside County, CA and the left abutment is in La Paz County, AZ. The embankment consists of two zones, upstream and downstream, and contains 157,000 cubic yards of material. Both the upstream and downstream slopes of the embankment are sloped 4:1 from crest elevation to riverbed.

1.2 Project Background

A large sandbar (approximately 450,0000 cubic yards) has formed above the Dam and is deflecting the river flow against the California bankline causing extensive erosion and creating a large scallop approximately 3,500 ft long and 300 ft into the bankline (see photo inset).

[1] The project is authorized under the authority of the Colorado River Front Work and Levee System (CRFWLS) Act of March 3, 1925 (Public Law 85) and its amendments (January 21, 1927, July 1, 1940, June 28, 1946, May 1, 1958).

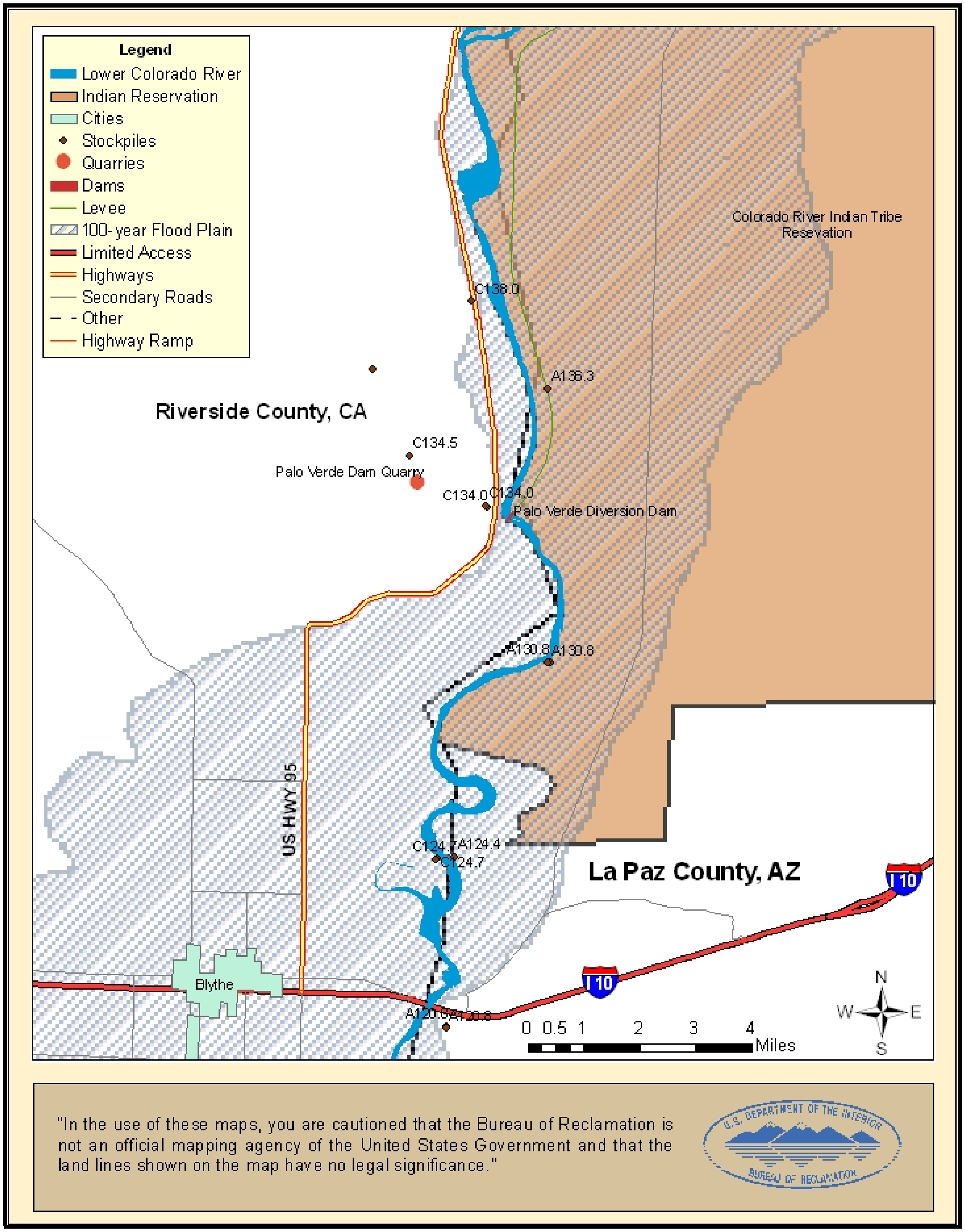

Figure 1. Location of the Palo Verde Dam Project Area

A hard point (rock-covered/armored area) at the downstream end of the scallop redirects the flow back toward the Arizona side of the channel, which creates a meandering flow pattern. The meander on the Arizona side poses a serious threat to the integrity of the earthen embankment of the Dam.

In 1999, during high flows, Reclamation placed armor, as a temporary emergency measure, along the Arizona embankment of the Dam and along the scallop to control additional erosion of the California bankline. This work was issued a 404 permit by the U.S. Army Corp of Engineers (ACOE) under Nationwide Permit No. 13, Bankline Stabilization, File Number: 199915057 (ACOE 1999). Additional bankline repair was conducted in 2004 and 2005 under 404 Nationwide Permit No. 3, Maintenance (ACOE 2004b and 2005c), that authorized a maximum discharge of 1,000 cubic yards of riprap on 150 linear ft of previously armored bankline.

1.3 Purpose and Need

1.3.1 Purpose of Proposed Action

The purpose of the proposed project is to redirect the current flow upstream of the Dam and improve the hydraulics of the river to minimize erosion processes, which are causing increased maintenance activities and will eventually threaten diversion of irrigation water to PVID. The long-term objectives are to: (1) train flows to the center of the present channel; (2) remove or diminish the sandbar and reduce the deposition of sediment in the area; (3) stabilize the banklines to prevent further erosion; and, (4) protect the earthen embankment of the Dam.

1.3.2 Need for Proposed Action

This project is needed to protect reduce annual maintenance activities, maintain operation of the diversion to PVID, and prevent the continued loss of tribal land on the Colorado River Indian Reservation. Hydraulic modeling of the river at this site indicates that meandering processes and deflected flows will continue require increased maintenance activities to prevent erosion and deposition near the Dam. Continued erosion and deposition in the area will aggravate the migration characteristics of the river channel. If corrective action is not taken the need for placing rip rap will continue and dredging may be required on an annual basis to slow channel migration. Further, continued migration will eventually threaten the diversion structure and the Dam abutment on the California side. The resulting failure of the Dam would cause loss of irrigation benefits to the PVID and the Colorado River Indian Tribe (CRIT) and further loss of tribal land. Approximately 12-acres of CRIT tribal land have already been lost because of erosion.

1.4 Scope of Analysis

Reclamation analyzed a range of alternatives and the potential impacts associated with the Proposed Action. Chapter 2.0 presents Reclamation's Proposed Action and the range of Alternatives considered. An alternatives analysis in accordance with Section 404 (b)(1) of the Clean Water Act (CWA) to determine the *least environmental damaging practicable alternative* (LEDPA) was also completed and is included as Appendix C. In determining the potential for impact to the natural and human environment, Reclamation evaluated a broad range of resources and issues. Chapter 3.0 presents detailed analysis of those resources and issues, and potential consequences of the Proposed Action. During planning activities and analysis for this EA, Reclamation coordinated and consulted with a variety of agencies and other entities. Chapter 4.0 summarizes this process, including applicable laws and regulations. Chapter 5.0 provides a listing of bibliographic references. Appendix A provides the Biological Evaluation Reclamation prepared under Section 7 of the Endangered Species Act (ESA) and Appendix B is a compilation of Reclamation's Environmental Commitments related to the Proposed Action. A list of individuals that participated in the preparation of the EA is included on the inside back cover.

2.0 Proposed Action and Alternatives Considered

Reclamation considered a range of alternatives to meet the purpose of and need for the project and a No-action Alternative. To facilitate development of a proposed action (preferred alternative) and eliminate those alternatives that would not adequately meet the need for the project, Reclamation performed engineering analysis and modeling (Reclamation 2004a). The modeling evaluated a range of control structures and measures under a variety of flow regimes scenarios ranging from high flows of 19,000cfs to high flood flows of 40,000cfs. The modeling report was provided to the Army Corp of Engineers (ACOE) for review and comment as part of the Section 404 Permitting effort.

2.1 Proposed Action (Preferred Alternative)

Based on the results of modeling, Reclamation proposes a multi -phase project to begin in April 2006. Once each phase is complete, Reclamation will monitor the site to evaluate the need for implementation of subsequent phases.

2.1.1 Training Structure and Repair Existing Jetty (Phase One)

During this phase, Reclamation will construct a training structure on the California side of the river and repair the existing spur jetty on the Arizona bankline (see figure 2 for a typical cross section of this feature). The training structure will function to narrow the channel and serve to control the meandering pattern of the river, which is contributing to the bankline erosion and increased maintenance to slow channel migration. The training structure will also increase the velocity of flow helping to scour the existing sandbar and minimize the deposition of future sediment in the same location.

The existing spur jetty on the Arizona side of the river at RM 134.0 deteriorated during the January 1999 high flows that created the California bankline scallop. This jetty was initially rebuilt as an emergency repair action after the 1999 event and will be reinforced during phase one of the proposed action. The jetty is essential to protecting the integrity of the earthen portion of the Dam on the Arizona side of the River.

2.1.1.1 Preconstruction Activities

The preconstruction phase of the project includes quarrying, hauling, and stockpiling of rock and preparing access roads to the construction area.

The core material for the training structure (approximately 78,000 cubic yards) will be obtained from a pit run at the Palo Verde Dam quarry. The core material will not be stockpiled at the quarry or project site; instead the core material will be quarried, loaded, weighed, hauled, and placed to build the training structure. Reclamation will use material previously quarried from the Agnes Wilson quarry, currently stockpiled at the Palo Verde Dam quarry location, for the gravel base on access roads and to riprap the finished slope of the training structure. All material (stockpiled and new pit run) will be hauled from the Palo Verde Dam quarry using dump trucks to end dump the material. Existing access roads will be used to transport material. Existing dirt roads will be improved by placing a gravel base. Graders will be used to spread and level material for road surfaces. Reclamation has coordinated with CRIT for use of an area adjacent to the river as an equipment staging area. All dirt and gravel road surfaces will be watered to provide dust suppression. Figure 2 shows the location and layout of these features.

Roadwork that is required to support the project includes grading and graveling existing dirt access roads that provide access to the scalloped bankline. The existing roads are on CRIT property immediately adjacent to the scalloped bankline.

About 40 acres of CRIT property along the river in California, and adjacent to the scalloped bankline, will serve as an equipment staging and materials lay down area. The site will be cleared of upland vegetation and graveled to accommodate vehicles and equipment and to minimize dust emissions. In addition, all fuels and other petroleum products used for the project will be stored at the staging area. Reclamation will ensure that the construction contractor acquires the applicable storm water construction permits prior to the start of construction.

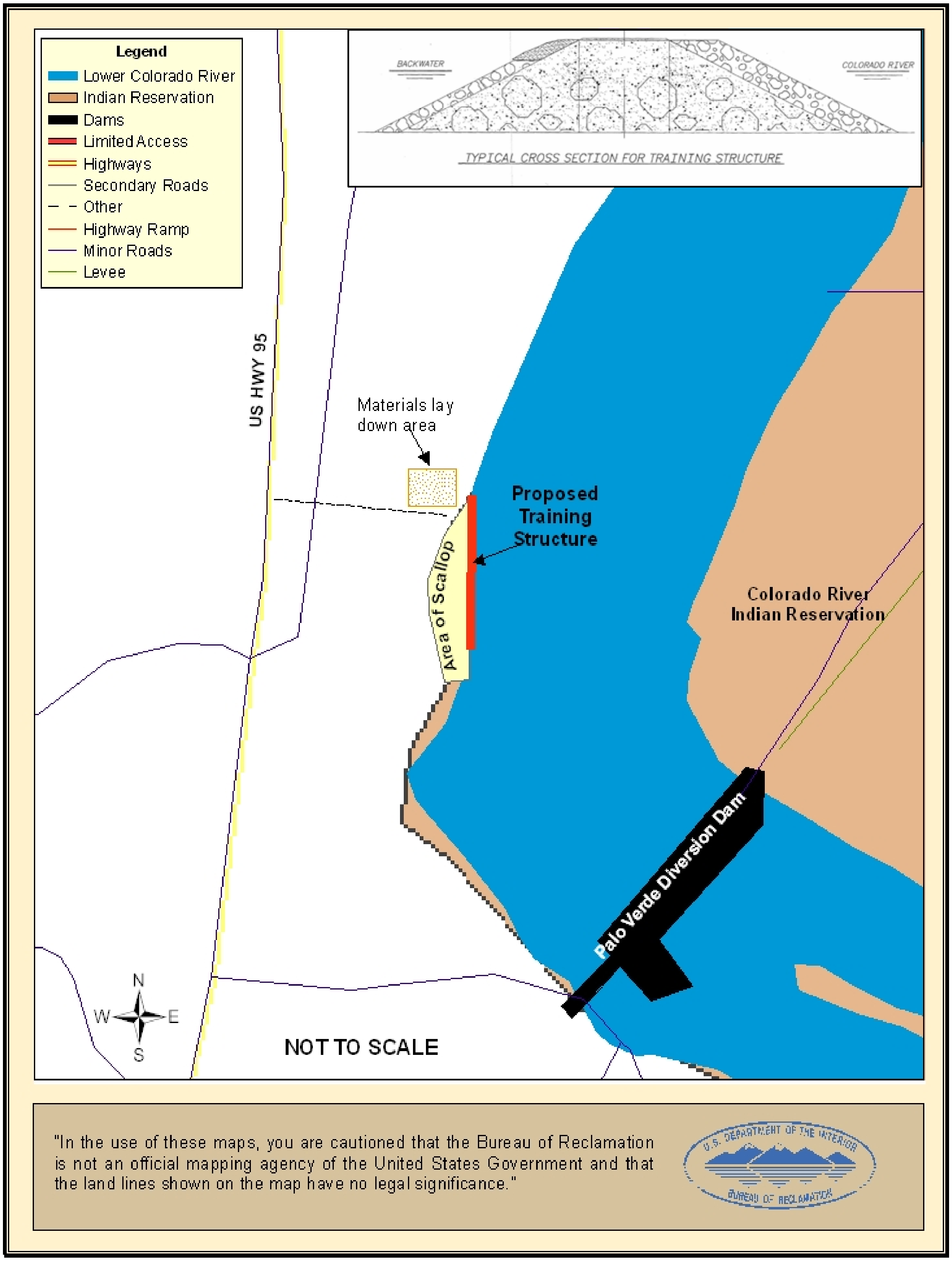

Figure 2. Phase One Project Elements

2.1.1.2 Construction Activities

Reclamation will haul riprap from existing stockpiles in Arizona (A130.8 or A136.3) to repair the spur jetty. Equipment required during construction includes dump trucks for hauling rock, a water truck, and a grader to maintain all roads for the duration of the project.

The spur jetty will be repaired by placing an estimated 7,000 cubic yards of riprap to reestablish and reinforce a jetty that is 100 ft long, 20 ft high from the river bed (approximately 290 ft elevation), and with a top width of 50 ft.

The training structure, a rock dike, will be constructed parallel to the scalloped bankline. The training structure is designed to be 1500 ft long and 20 ft high from the river bed with a top width of 20 ft and require approximately 100,000 cubic yards of rock material to construct. The training structure will be built up from the river bottom by end dumping rock in successive layers from the shoreline and structure, respectively. The majority of the structure will be beneath the water surface, with the approximately 5 to 8 ft of the structure visible above the water surface. The amount of structure visible will fluctuate depending on upstream water releases and releases from the Dam. Construction is planned to begin in April 2006 and will take approximately nine months. A general layout of the area and a typical cross section for the proposed training structure is shown in figure 2.

In order to provide for water flow (circulation) behind the training structure, the structure will be designed and built to include oversized rock along specified sections of the training structure. This will provide an estimated 5-10 cubic feet per second (cfs) of flow through the training structure to circulate water behind the structure.

Dump trucks would exit the stockpile area immediately across Highway 95 from the project site, travel across CRIT land, entering at the south end of the parcel, and head north to the river and bankline. Beginning at the upstream point of the proposed structure, dump trucks would incrementally deposit approximately 100,000 cubic yards of rock and other coarse fill to complete the structure. Hauling operations would occur from 5 a.m. through 5 p.m. daily (with occasional weekend operation, if necessary) with an estimated of 40 to 60 trips per day from the stockpile to the river.

2.1.2   Monitoring & Bankline Armor (Phase Two)

The training structure will function to increase the flow velocity in the river channel. Reclamation estimates that approximately 2500 ft of the Arizona bankline (across from the training structure) may be susceptible to short-term erosion due to increased flow velocity, until the sandbar erodes (Reclamation 2004a). In addition, approximately 1500 ft of previously armored CA bankline immediately downstream from the scallop is showing signs of deterioration and repairs will be performed as part of Phase Two, as needed.

Reclamation will monitor the project area between RM 133.8 and 134.6 for increased erosion to determine where spot repairs and additional armoring are required. Typical signs of increased erosion include slipping or sloughing of earth or armoring along the bankline and exposed roots. To facilitate the monitoring, Reclamation proposes to place wood stakes along the AZ bankline to be used as reference points to evaluate the extent of any erosion. In the event that excessive erosion is occurring, Reclamation will initiate the armoring phase of the proposed action (see Figure 3).

2.1.2.1 Preconstruction Activities
Access and bankline roads are already established in this area; therefore, no new road construction will occur. The existing roads will be graded prior to initiating this phase of the project. Riprap material will be obtained from existing stockpiles and no new quarrying is anticipated.

2.1.2.2 Construction Activities
Based on monitoring results, Reclamation may place riprap along 2500 ft of the Arizona bankline and spot repair up to 1500 ft of CA bankline. The riprap would consist of 18 to 24 inch and smaller rock and will be placed using dump trucks and dozers to push the material down the bankline slope. Rock used for armoring will be obtained from an exiting stockpile site (A136.3) located near the project site.

2.1.3 Monitoring & Dredging (Phase Three)
Reclamation anticipates that approximately 450,000 cubic yards of sediment has accumulated and may require dredging. While Reclamation anticipates that the training structure will cause erosion of the sandbar, the site will be monitored the area after construction of the training structure determine if the rate of scour is sufficient to diminish the sandbar and prevent future build up. If the flows and resulting velocities are not sufficient to remove the sandbar, Reclamation will dredge the sandbar. Reclamation will use a floating dredge and pump the dredged material to an upland area on the Arizona side of the river (Figure 3)

2.1.3.1 Preconstruction Activities
In the event that dredging is required, Reclamation will use existing roads to access the river and disposal area. Earthen berms and other appropriate measures will be erected to prevent return flows to the river. No clearing of vegetation is anticipated in the spoil area.

2.1.3.2 Construction Activities
No dredging will occur until Reclamation has evaluated the effectiveness of scouring caused by the training structure. If it is determined that the dredging is required, Reclamation will reevaluate the area and amount of sediment to be removed. The proposed disposal site for dredged material is approximately 75 acres of CRIT land adjacent to the project site.

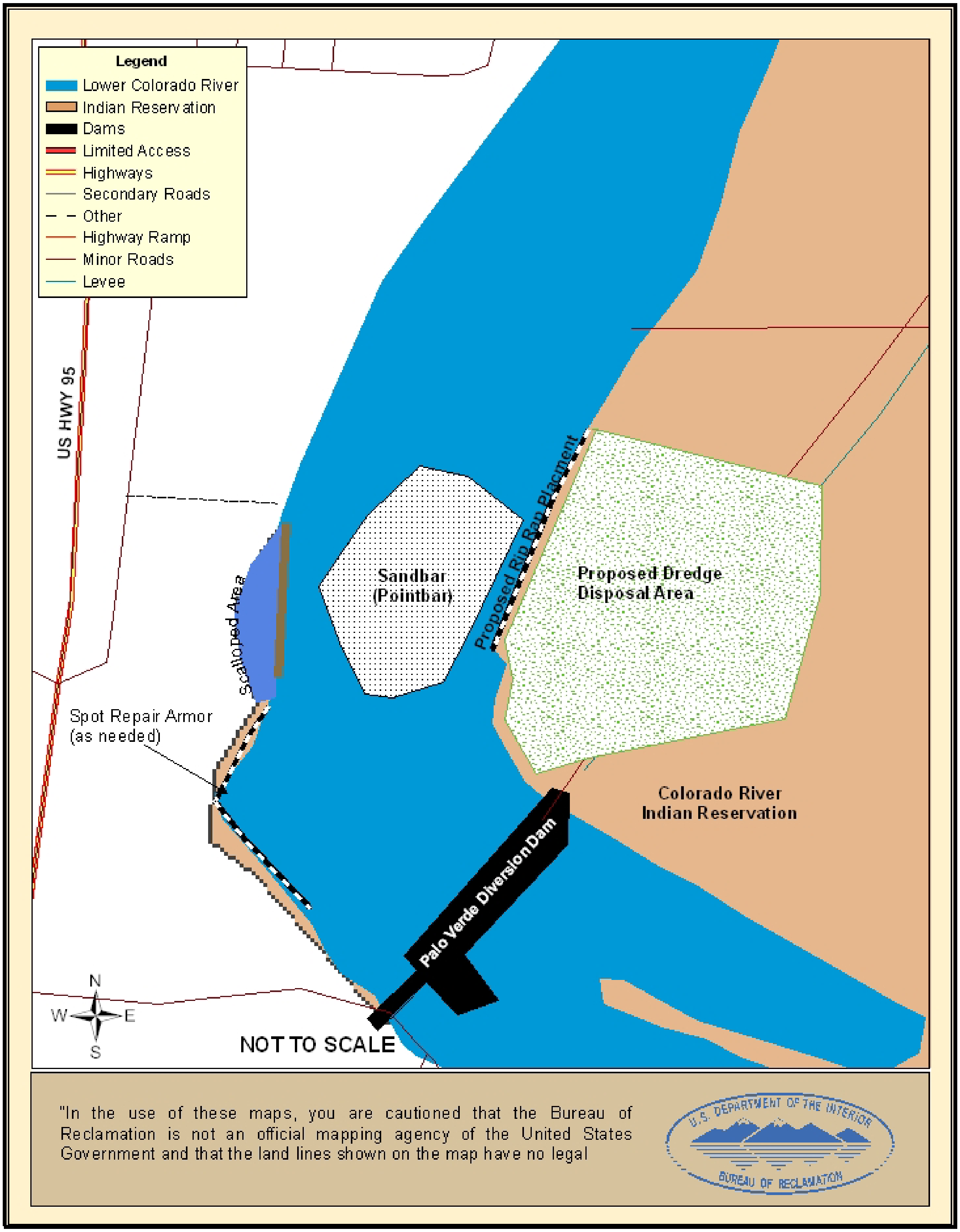

Figure 3. Phase Two & Three of the Proposed Action

2.2 No Action Alternative

If no action were taken, the river migration characteristics in this area continue to cause erosion on the west bankline and the spur jetty near the earthen portion of the Dam. In conjunction with the erosion, there would be an increase in sediment carried by the river downstream of the impact area. The sandbar on the east side of the river would continue to increase in size, which may further exacerbate the erosion of the west bankline.

2.3 Alternatives Considered but Eliminated From Further Analysis

Reclamation considered ten alternatives, including the proposed action, to address the problems above the Dam. Based on the complexity of factors influencing the erosion, modeling, engineering analysis, and cost constraints, Reclamation eliminated six of these alternatives from further consideration because they did not meet the purpose and need for the project. The three alternatives described below were considered in more detail and found not to be reasonable or practicable in terms of cost, constructability and project objectives. A brief discussion of these three alternatives is included below and the complete Alternatives Analysis, performed in compliance with Section 404 (b) (1) of the Clean Water Act (CWA), is provided in Appendix C.

2.3.1 Multiple L-Jetties, Armor Spur Jetty, and Hard Point

Reclamation initially considered constructing a series of six “L” jetties along the scalloped area, armoring the existing spur jetty on the AZ bankline, and armoring the hard point on the CA bankline. The alignment of the jetties would approximate the former location of the river bankline, which would recreate pre-1999 hydraulic conditions. This alternative would meet the purpose and need of the project; however, construction and maintenance costs were considered impractical, it would not perform as well as the proposed action, and the jetties would result in overall larger footprint than the training structure.

2.3.2 Sheetpile and Riprap CA Shoreline

Reclamation considered the use of a temporary sheetpile wall along the scallop to de-water the shoreline and placement of riprap with a filter layer to prevent the loss of fine material and prevent slumping of the riprap layer. This alternative was eliminated based on higher cost, additional loss of CRIT land, and constructability issues.

2.3.3 Sheetpile CA Shoreline and Cap with Riprap

Consideration was given to placing a permanent sheetpile wall along the scallop area and capping the wall with riprap. This alternatives was eliminated based on the difficulty of driving the sheetpile into previously placed riprap, high costs, and the resulting sheer bankline would not support the establishment of vegetation along the shoreline.

3.0 Affected Environment and Environmental Consequences

Reclamation performed an analysis to identify all potentially affected resources. Only those resources identified as potentially affected by the Proposed Action or the No Action are listed below and included in the analysis presented in this chapter.

- Air Quality
- Water Resources
- Land Use
- Cultural Resources
- Environmental Justice
- Biological Resources
- Special Status Species (ESA)
- Geologic Resources
- Socioeconomics
- Indian Trust Assets

Included under each resource area subsection is a brief description of the affected resources and an analysis of potential impacts associated with the proposed action and the no action alternative. Additionally, Reclamation has developed mitigation measures, as an integral part of project planning, to minimize unavoidable adverse impacts that may result from the proposed action and these measures are presented, as applicable.

3.1 Air Quality

The California Air Resources Board (Board) and the U.S. Environmental Protection Agency have promulgated ambient air quality standards to protect human health and/or welfare. Air quality of concern in the project area is focused on particulate matter under 10 microns (PM10) and Ozone.

3.1.1 Affected Environment

Quarries, stockpiles, and staging areas are all located within the Riverside County portion of the Mojave Desert Air Basin under the jurisdiction of the Mojave Desert Air Quality Management District (MDAQMD). The project area is currently classified as Attainment/Unclassifiable for all National Ambient Air Quality Standards (NAAQS) criteria pollutants and Non-Attainment for the State of California PM10 and Ozone standards (MDAQMD 2003).

3.1.2 Potential Consequences of the Proposed Action

Sources of impacts on ambient air quality would include (1) mobile source emissions released from heavy equipment and vehicle exhaust during quarrying, road construction and maintenance, and truck traffic to and from the river, and (2) emissions from quarrying activities and transport of material to the project and during the construction and upgrading of access roads to the river.

Emissions from heavy equipment operation would be intermittent and concentrated near operations for short periods of time during pre-construction and construction activities. Both truck traffic and equipment operation at the quarry would release exhaust emissions intermittently during the same period. Concentrations of exhaust pollutants would be expected to quickly disperse in the atmosphere and would likely be immeasurable and imperceptible beyond the immediate work area. Thus, incremental contributions of exhaust pollutants emitted by mobile sources will not adversely affect the areas attainment status.

Similarly, fugitive dust emissions from grading operations would be intermittent and temporary, during the pre-construction and construction activities. Fugitive dust emissions that would result from the proposed action are limited to those associated with quarry operations, material transport, and road preparation and maintenance. These emissions will be short-term and temporary, limited to the preconstruction and construction phases of the project. No permanent long-term fugitive dust emissions are anticipated.

Fugitive dust and equipment exhaust emissions would be concentrated in the general area of quarrying and processing operations. With dispersion and dilution in the atmosphere, effects on offsite ambient air quality concentrations would be immeasurable and imperceptible. Dust suppression will be minimized by the application of water on unpaved access roads used during pre-construction and construction activities. Further, the nearest receptor/resident to the construction and quarrying sites is several miles away. Thus, incremental contributions of pollutants emitted from quarry operations are not be expected to affect attainment status relative to Federal or state standards in eastern Riverside County.

No new permanent sources of air emissions will result from the proposed action. Thus, localized air emissions resulting from project operations are not likely to have an adverse effect on human health and well-being.

3.1.3 Potential Consequences of the No Action

Since quarry activities in the region would continue to occur at the existing level of operations, there would be no change to the air quality in the project area.

3.1.4 Mitigation measures

During earth-disturbing activities, the quarry, hauling, and construction contractor(s) will regularly spray water or a palliative on disturbed areas to minimize fugitive dust emissions. All heavy equipment and construction vehicles would meet California’s emissions control requirements. During periods of very high winds, earth-moving operations may be temporarily halted for both worker and environmental protection.

3.2 Geology and Soils

3.2.1 Affected Environment

The project location lies within the Mohave geologic province, which has a moderate to low rate of seismicity and very few mapped faults (Terra Nova 2003).

Soils at the proposed staging site are Holtville silty loam and Gilman silty clay loam. Without irrigation in place, the proposed site does not qualify for classification as prime or unique farmland (NRCS 2003).

3.2.2 Potential Consequences of the Proposed Action

In the unlikely event of a seismic occurrence, the project area could experience ground shaking, which may adversely affect the integrity of the river control structures. Nonetheless, workers at the site would be exposed to a similar risk of injury as non-workers in the local and regional area. At the staging area, a spill could introduce petroleum products or fuels into soils.

3.2.3 Potential Consequences of the No Action

If no action is taken to prevent continued erosion of the bankline, soil from this site will continue to contribute to the sediment load in the river and accumulate adjacent to the bankline and in downstream areas. The continued deposition of sediment in the center of the channel at this location will exacerbate the bankline erosion and could eventually threaten the Dam abutment on the California side and the earthen embankment on the AZ side of the river.

3.2.4 Mitigation Measures

Prior to the start of work, a Spill Prevention Control and Countermeasures (SPCC) Plan will be prepared. The Plan will include best management practices to prevent or minimize the likely hood of a leak or spill of petroleum products or fuels at the project site. In the event of a spill, implementation of containment and clean-up methods will minimize any contamination of soils.

3.3 Water Resources

3.3.1 Affected Environment

3.3.1.1 Surface Water

River flows are highly variable from year to year and from season to season. In September 1988 high flows of 42,300 cfs were recorded above the Dam [USGS 2004 (http://waterdata.usgs.gov/nwis)]. Recent records were not found for flows above the Dam; however, flows of 14,300 cfs were recorded below the Dam in June 2003 (USGS 2004).

3.3.1.2 Groundwater
Groundwater on the property adjacent to the river is continuous with river water or confined by rock to very deep (>200 ft) aquifers. At the quarry site, the depth to groundwater is about 50 ft. Because of the availability of river water for irrigation, there are no known users of groundwater in the vicinity (Brown 2003).

3.3.2 Potential Consequences of the Proposed Action

3.3.2.1 Surface Water
Impacts to the river may include effects on water availability/supply and water quality. The addition of a training structure would not affect normal river operations for flood control and diversions, including diversion of water by the PVID. Flows would continue to reflect downstream demand and the need for flood releases to increase storage capacity upstream.

About 6 acres of open (surface) water below the ordinary high-water mark would be disturbed during construction of the training structure (Phase I) and 25 additional acres if dredging (Phase III) is required. Reclamation has submitted an application for a CWA, Section 404 dredge and fill permit to the U.S. Army Corps of Engineers (December 8, 2004). In addition, an application for Clean Water Act, Section 401 water quality certification was sent to the U.S. Environmental Protection Agency (December 9, 2004).

With regard to water quality, sources of potential impact may include construction in the river itself, scouring of the existing sandbar, and accidental spills. Deposition of rocks into the river to build the control structures would temporarily disturb the gravel substrate, which would, in turn, cause sediment from the river bed to become suspended in the water. Turbidity due to sediment suspension would be greatest in the vicinity of construction. Suspended sediment would disperse and ultimately redeposit in the river bed below Palo Verde Dam. Typically deposition occurs where the river channel widens and flow velocities decrease. Affects of increased turbidity on water quality behind the Dam would be negligible.

In addition, water quality could be incrementally affected by suspension of sediment during scouring (or dredging) of the nearby sandbar. The quantity of suspended sediment would vary with the rate of flow, which is ultimately dependent on flood control and downstream demand. It is expected that increases in sediment load downstream of the Dam caused by such scouring would be gradual and that the deposition of the sediment would depend on naturally occurring processes.

3.3.2.2 Groundwater
Sources of impact to groundwater would include quarrying operations and accidental spills of petroleum products and fuels. Because the depth to groundwater at the quarry site is well below the range of mining operation (10 ft

deep or less), adverse effects would not be expected. At the staging area, a spill could introduce petroleum products or fuels into shallow groundwater.

3.3.3 Potential Consequences of the No Action

Without implementation of the proposed action, erosion would continue to occur, thus increasing the scallop. This erosion will continue to contribute sediment to the river channel increasing overall turbidity in the area.

3.3.4 Mitigation Measures

Prior to the start of work, a Spill Prevention Control and Countermeasures (SPCC) Plan will be prepared. The Plan will include best management practices to prevent or minimize the potential for a leak or spill of petroleum products or fuels at the project site. In the event of a spill, implementation of containment and clean-up methods will minimize any contamination of surface water and groundwater.

Earthen berms and other best management practices will be used at the dredge disposal site to prevent return flows from entering the river.

3.4 Biological Resources

3.4.1 Affected Environment

The staging area lies within the floodplain of the Colorado River; however, this area is sparsely vegetated with upland shrubs and no jurisdictional wetlands are present at the staging site.

3.4.1.1 Terrestrial

Vegetation found at the staging area and at the quarry/stockpile site across Highway 95 is typical of southwestern desert ecosystems. Vegetation within and outside of the levee system are typical of riparian uplands in the area and are comprised of mostly Salt cedar (*Tamarix chinensis*) , Salt Cedar-Mesquite (*Tamarix chinensis – Prosopis Sp*) , Arrowweed (*Tessaria sericea*), and agricultural lands (Reclamation GIS data 1997, field verified on October 25, 2004). Riparian is dominated by scrub vegetation, with a canopy of 6 to 10 ft and relatively dense stands dominated by exotic salt cedar and native arrow weed.

Typical species found in this desert scrub habitat are those adapted to sparse vegetation cover and xeric conditions, especially reptiles. Bird species known to occur in the area include great-tailed grackle (*Quiscalus mexicanus*), white-winged and mourning dove (*Zenaida asiatica, Z. macroura*), rock wren (*Salpinctes obsoletus*), house finch (*Carpodacus mexicanus*), and turkey vulture (*Cathartes aura*). Mammals that may use the area include coyote (*Canis latrans*), gray fox (*Urocyon cinereoargenteus*), mule deer (*Odocoileus hemionus*), bats, and various species of rodents and rabbits (CH2MHill 1996).

3.4.1.2 Aquatic

The aquatic ecosystem that exists in the LCR today is highly modified and is physically, chemically, and biologically different than that which existed historically (USFWS 2005).

Wetland habitat is limited in the project area. The point bar contains less than one acre (0.22) of marsh habitat and there are limited areas (narrow linear stretches) of emergent wetland vegetation along of AZ and CA bankline.

Native fishes are mostly extirpated or endangered of becoming so. Physical modifications by dam construction and reservoir formation have homogenized the river system, effectively removing the "extremes" to which only native fish species were adapted. Without such extremes native fish have no advantage over non-native fish species. Nonnative fish (game and rough fish) predation on early life stages of native fish prevents recruitment of native fish to the adult population. The primary limiting factor for recruitment of native fish in the LCR basin today is nonnative fish predation on young life stages.
Species found in this reach of river include, common carp (*Cyprinus carpio*), channel catfish (*Ictalurus punctatus*), flathead catfish (*Pylodictis olivaris*), tilapia (*Tilapia aureau*), largemouth bass (*Micropterus salmoides*), striped bass (*Morone saxatilis*), bluegill and redear sunfish (*Lepomis macrochirus*, L. *microlophus*), green sunfish (*Lepomis cyanellus*), and black crappie (*Pomoxis nigromaculatus*) (USBR 1996). Tramel-net and electrofishing surveys conducted in the project area in 2000 failed to capture any razorback sucker (*Xyrauchen texanus*) or other native fishes (ASU 2004).

3.4.2 Potential Consequences of the Proposed Action

3.4.2.1 Terrestrial

Construction activities and quarry operations may cause direct loss of individuals of native wildlife species, if they are unable to escape or avoid operating equipment and vehicles. Losses would be infrequent and occur less often as time passes than at the inception of disturbance, as individual species respond to human presence by relocating to adjacent undisturbed habitat for the duration of construction, traffic, and quarry operation.

Upland riparian habitat in the dredge disposal area will temporarily be lost, but is expected to reseed and reestablish rapidly. Overall, effects on native wildlife are expected to be minimal due to the low quantity of acreage to be disturbed, the relative abundance of similar habitat in the immediate vicinity, and the temporary duration of project activities.

3.4.2.2 Aquatic

As a result of the proposed action, there will be a net loss of less than half an acre (0.22 acres) of marsh habitat. The lost habitat is low quality and quantity and will not have a measurably adverse impact on the overall functions and values of wetland habitat in the area.

Both native and non-native aquatic species near the construction site would be temporarily displaced during construction of the training structure, jetty repair, and bankline armoring; however, the new rock substrate and slower flows behind the training structure may improve fish habitat in the area.

3.4.3 Potential Consequences of the No Action

If the proposed action is not implemented, high flow velocities along the California bankline will continue to scour the scallop and impede emergent vegetation from establishing. In the event that the uncontrolled meander results in a breach of the Dam then significant sediment built up behind the Dam would be flushed downstream; thereby, degrading to fish habitat.

3.4.4 Mitigation Measures

To compensate for loss of the 0.22 acres of wetland vegetation, Reclamation will establish approximately 0.66 acres of new marsh habitat from uplands in the project area. The new marsh area will be an in-kind mitigation for loss of special aquatic sites at a 3:1 area ratio and located in the immediate project area (Reclamation 2005b). The mitigation site is an old irrigation diversion located immediately south of the proposed training structure. The abandoned canal is flooded at normal river flows to a depth of about 3-5 ft, thus the site has hydrology supportive of wetland habitats

If dredging is required and the disposal area does not re-vegetate under natural conditions within two growing seasons, Reclamation will plant native vegetation to prevent erosion and promote development of upland habitat.

3.5 Special Status Species

The list of endangered and threatened species for the La Paz Co., Arizona and Riverside Co, California, maintained by the United States Fish and Wildlife Service (USFWS) website was reviewed for species that may be present in the project area. The potential for a species to be present in the project area was determined based on known distribution of the species, species' habitat needs, and a review of habitats in the project area. Species-specific survey or observation information was also used in the evaluation, where available.

3.5.1 Affected Environment

Species with potential, or known, to occur in the project area are listed below in Table 3-1 and are briefly discussed in the following sections. Further details on these species and a full analysis of potential impacts can be found in the Biological Evaluation (Appendix A). A number of species were eliminated from further consideration because the project area does not provide suitable habitat or the species is not likely occur in the project area. Species eliminated from further consideration are also listed in Table 3-1.

Table 3-1 Special Status Species

Species	Status	Potential Effect
Mohave Desert Tortoise (*Gopherus Xerobates*) *agassizii*)	Federal: Threatened, with critical habitat (Mohave desert Population west and north of Colorado River) State: CA – Threatened, AZ - Wildlife of Special Concern (as the Sonoran Desert Tortoise)	May affect, not likely to adversely affect.
Razorback sucker (*Xyrauchen texanus*)	Federal: Endangered, with critical habitat State: CA – Endangered, AZ - Wildlife of Special Concern	May affect, not likely to adversely affect.
Yuma clapper rail (*Rallus longirostris yumanensis*)	Federal: Endangered State: CA – Threatened, AZ - Wildlife of Special Concern	May affect, not likely to adversely affect.
Brown pelican (*Pelecanus occidentalis*)	Federal: Endangered State: CA – Endangered, AZ - None	May affect, not likely to adversely effect.
Eliminated from further evaluation		
Bald Eagle (*Haliaeetus leucocephlus*)	Federal: Threatened State: CA – Endangered; Fully Protected, AZ - Wildlife of Special Concern	No effect. Uncommon migrant in project area, discountable effects.
Bonytail chub (*Gila elegans*)	Federal: Endangered, no critical habitat in project area State: CA – Endangered, AZ - Wildlife of Special Concern	No effect. No suitable habitat in the project area. Fish surveys have found no Bonytail.
Desert pupfish (*Cyprinodon macularius*)	Federal: Endangered, no critical habitat in project area State: CA – Endangered, AZ - Wildlife of Special Concern	No effect. No suitable habitat in project area.
Gila topminnow (*Poeciliopsis occidentalis*)	Federal: Endangered State: CA – None, AZ - Wildlife of Special Concern	No effect. No suitable habitat in project area.
Southwestern willow flycatcher (*Empidonax traillii extimus*)	Federal: Endangered (project area is not within proposed critical habitat) State: CA - Endangered, AZ - Wildlife of Special Concern	No effect. No suitable breeding or migration habitat occurs at, or near the project area.
Western Yellow-Billed Cuckoo (*Coccyzus americanus occidentalis)*	Federal: Candidate species State: CA – Endangered, AZ - Wildlife of Special Concern	No effect. No suitable breeding or migration habitat occurs at, or near the project area.

Sources: Online information services (1) California Department of Fish and Game, Habitat Conservation Division (http://www.dfg.ca.gov/hcpb/species/t_e_spp/tespp.shtml) (2) Arizona Game and Fish Department (http://www.gf.state.az.us/w_c/edits/species_concern.shtml) (3) U.S. Fish and Wildlife Service (http://endangered.fws.gov/wildlife.html#Species)

3.5.1.1 Razorback Sucker

The razorback sucker was listed as endangered effective November 22, 1991. The species was formerly abundant and widespread throughout the Colorado River system. Extant populations of Razorback sucker are now limited to four small areas on the upper Colorado River, upstream of Lake Mead and small populations in the LCR, including Lake Mohave, the river below Davis Dam, Lake Mead and Senator Wash Reservoir (Bradford and Vlach 1995). Studies of sonic-tagged adult razorback sucker, reared in a hatchery, have demonstrated that they prefer deeper, interconnected river backwater habitats over main channel habitats (Gurtin, et al. 2003).

Critical habitat for the razorback sucker was designated on March 21, 1994 (Federal Register; Vol. 59, No. 54). Designated critical habitat for the razorback sucker includes the LCR from Parker Dam south to Imperial Dam, including the associated 100-year floodplain. Primary constituent elements of critical habitat include water, physical habitat such as spawning, nursery, feeding and rearing habitat, and a biological environment supporting the species.

3.5.1.2 Mohave Desert Tortoise

The entire Mohave population of the desert tortoise west of the LCR in California and Nevada, and north of the LCR in Arizona and Utah, including the Beaver Dam slope, was listed as a threatened species on April 2, 1990. Critical habitat was designated in February 1994; however, there is no designated critical habitat for this species in the project area.

The California Natural Diversity Database shows the closest known tortoise population being 5 miles west of the quarry and 6.5 miles west of the project construction site on the opposite side of the Big Maria Mountains. In May and July of 2003, Reclamation performed surveys at the Palo Verde Dam Quarry site. No tortoises or evidence were found during the surveys. However, the quarry site is an area of potential habitat for the desert tortoise, and is subject to section 7 consultation under the ESA. Reclamation is currently in the process of evaluating all quarry locations under a separate NEPA analysis. A programmatic EA and associated biological evaluation is being prepared and consultation under the ESA is pending for this project.

3.5.1.3 Brown Pelican

The Brown Pelican (*Pelicanus occidentalis*) was listed as endangered in December 1970 (35 Fed. Reg. 8495), including the Mexican and pacific populations of the Western United States. No critical habitat for this species has been designated. The primary threat was egg-shell thinning and reproductive failure due to pesticides. Brown Pelican are generally considered to be recovering from population decline as a result of pesticide regulation and other conservation efforts.

Nesting or breeding sites for Brown pelican do not occur in the project area (Appendix A). Brown Pelican are infrequent in the project area, but may occasionally use the river surface during summer, fall or winter for resting or feeding. Brown Pelican may occasionally forage in the project area. Any Brown Pelican present can easily avoid the project area during construction, by flying to other suitable areas nearby. The proposed project will not alter fish populations in the project vicinity that may provide prey for the pelican.

3.5.1.4 Yuma Clapper Rail

The Yuma clapper rail was listed as an endangered species on March 11, 1967, under endangered species legislation enacted in 1966 (Public Law 89-669). Only populations in the United States were listed, those in Mexico were not. There is no critical habitat for the species. The Yuma clapper rail is protected under the Migratory Bird Treaty Act. The Yuma clapper rail is a marsh bird found in dense cattail or cattail-bulrush marshes along the LCR from the Southerly International Boundary to the lower Muddy River and Virgin River in Utah above those rivers' confluence with Lake Mead.

The most productive clapper rail areas consist of a mosaic of uneven-aged marsh vegetation interspersed with open water of variable depths. Annual fluctuation in water depth and residual marsh vegetation are important in determining habitat use by the Yuma Clapper Rails. Crayfish (*Procambarus clarki*) are the preferred prey of Yuma Clapper Rails. Annual population surveys conducted by interagency biologists working with the Yuma Clapper Rail Recovery Team in the lower Imperial Division on the lower Colorado River show a fairly stable population in the Imperial Reservoir area (Appendix A).

3.5.2 Potential Consequences of the Proposed Action

3.5.2.1 Razorback Sucker

Designated critical habitat for the Razorback sucker includes habitat elements in the 100-year floodplain of the Colorado River. These include constituents related to water, physical habitat, and the biological environment. Palo Verde Diversion Dam and the proposed project area are within the 100-year floodplain of the Colorado River (1990 Floodplain map 423-300-3144); however, few if any of the critical habitat elements to support recruitment and or spawning preferred by the species are present in this area.

In 2004, during surveys performed by Arizona State University no occurrence of the razorback suckers was found at or near the project area (ASU 2004). Further, there have been no reported observations of the species in the project area and there have been only limited observations of adult razorback suckers on the LCR between Parker Dam and Imperial Dam. Therefore, there is likely top be non adverse effect on Razorback suckers as a result of the proposed action.

3.5.2.2 Mohave Desert Tortoise

Potential effects to desert tortoise could include mortality from vehicles and equipment, falling rock, blasting and collection. Indirect effects may include burial of burrows through blasting, decreased activity along roadways where traffic will temporarily increase due to hauling, and refuge generated on-site that may attract predators. However, as no tortoises were located and no evidence of habitation was found during surveys conducted at the Palo Verde Dam quarry in May and July of 2003, no impacts are anticipated. In addition, mitigation measures summarized below and detailed in Appendix B will further minimize the potential for adverse impacts to this species.

3.5.2.3 Brown Pelican

Given the infrequent occurrence of pelican in the project area, the ability of individual birds to avoid the project area during construction and the lack of any adverse effect on fish forage, no adverse effect are anticipated as a result of the proposed action.

3.5.2.4 Yuma Clapper Rail

There is no suitable rail nesting habitat in the project vicinity. The steep armored shorelines have scattered clumps of cattails. Actively eroding areas are devoid of vegetation. An isolated stand of cattail approximately 0.24 acres (0.097 ha) is found on the sandbar. This cattail stand is smaller than the smallest reported territory size for Colorado River YCR, and much smaller than the reported marsh patches or sloughs used by YCR. Marsh vegetation in the project area occurs in small, scattered patches and linear strips and do not provide the area, diversity or depth of cover that rails need for nesting. Individual adult or juvenile rails may use the linear shoreline vegetation in the project area for foraging or in traveling from suitable habitat up or downstream. Individual rails may occasionally forage on the shoreline. These uses are transitory in nature and are likely rare occurrences given the lack of suitable cover or forage habitat.

Project effects on transient rails may include temporary disturbance as passing rails avoid the noise of the project area. Therefore, no long-term adverse effects to YCR are likely to occur as a result from implementation of the proposed action (Reclamation 2005a).

3.5.3 Potential Consequences of the No Action

Under the No Action alternative no adverse impacts are anticipated. However, new backwater area would not be created for use by aquatic species.

3.5.4 Mitigation Measures

In 1997, a Biological Opinion (BO) for Reclamation operation and maintenance activities on the LCR System was issued by the (USFWS 1997). The 1997 BO is set to expire at the end of 2005 and will be replaced by the Biological and Conference Opinion issued in March 2005 (USFWS 2005). This new BO was issued for a region-wide habitat conservation plan, known as the Multi-species Conservation Plan (MSCP). Reclamation and its partners recently completed the MSCP to address a wide range of management activities on the LCR. These activities include flow related functions such as water releases and deliveries, and non-flow related functions such as operations and maintenance of existing facilities and construction of new structures. The MSCP Habitat Conservation Plan (HCP) (LCR MSCP 2004b) includes mitigation, minimization, avoidance, survey, monitoring, and reporting measures for the species discussed above (see Chapter 5 of the MSCP HCP) and the USFWS concluded that these reasonable and prudent measures fully mitigated affects of the actions covered by the LCR MSCP Biological Assessment (LCR MSCP 2004c). As part of the proposed action, Reclamation will implement the reasonable and prudent measures included in the MSCP HCP and hereby incorporates them by reference. Management and mitigation measures intended to avoid or minimize adverse effects to listed species are summarized in Appendix B.

Operation of Palo Verde Dam is discussed in the 1997 BO and includes RPMs specific to quarry and stockpile operations. In accordance with these RPMs and standard best management practices, Reclamation will require that a USFWS qualified Desert Tortoise monitor be onsite during operations at quarries, stockpiles sites, and other locations with suitable tortoise habitat. Further, a contract clause will include this requirement for any contractor operations in the quarry or stockpile locations. In addition, Reclamation and contract staff will adhere to the environmental commitments set forth in Appendix B.

3.6 Cultural Resources

3.6.1 Affected Environment

Field surveys, literature reviews, and Native American consultation with CRIT cultural resource staff in June, July, and August 2003 revealed no evidence of archaeological, historic, or cultural properties and resources at sites to be disturbed during implementation of the proposed action (RECON 2003). A Phase III cultural survey was performed at the existing quarry site and the survey report is being revised to include additional survey information for the proposed dredge spoil site. Reclamation will initiate consultation with the California and Arizona State Historic Preservation Offices (SHPO) in 2005 to coordinate any issues and avoidance measures that may be required.

3.6.2 Potential Consequences of the Proposed Action

Phase one is not likely to have any adverse effects on cultural resources, as none were identified in the project area adjacent to the CA bankline and appropriate/approved measures will be implemented to prevent adverse effects from occurring to cultural resources identified at the quarry location. In the event of a discovery of cultural resources at the proposed dredge disposal site, Reclamation in conjunction with the AZ SHPO, will establish appropriate measures to avoid or mitigate potential impacts.

3.6.3 Potential Consequences of the No Action

Under the No Action alternative no impacts are anticipated, as no direct land disturbing activities will take place. However, continued erosion of the bankline and eventual outflanking of the Dam could disturb or destroy previously undiscovered cultural sites in the area.

3.6.4 Mitigation Measures

Quarry operations will be restricted to previously disturbed areas and will avoid any areas known to contain cultural artifacts and resources. If artifacts or other evidence of potential cultural or historic resources are discovered during project implementation, all work shall immediately cease. The site supervisor shall contact Reclamation’s environmental staff and the CRIT Tribal Museum at Parker for guidance on how to proceed.

3.7 Indian Trust Assets

There are no Indian Trust Assets located in the project area and none will be affected by the proposed action or no action.

3.8 Land Use

3.8.1 Affected Environment

The California bankline (scalloped) project area is located on CRIT land and the surrounding land was previously used for agriculture, but is no longer in production. The land is dominated by desert scrub habitat and is typical of other land in the area. Across Highway 95, the area to be quarried is undeveloped desert. A portion of the area to be quarried is Reclamation property presently being used as a rock and gravel stockpile. The Arizona bankline and the proposed dredge spoil area are not developed, except for existing access road and levee road.

3.8.2 Potential Consequences of the Proposed Action

Implementation of the preferred alternative would temporarily preclude the use of the CRIT property for other purposes. However, CRIT has provided Reclamation with written permission to use this area for equipment staging, materials lay down, and vehicle access to the river.

Implementation of the proposed action will halt the loss of CRIT land and may support regaining the land through sediment deposition behind the training structure.

Quarry operations would change the character of the remainder of the site; however, Reclamation has discretion regarding the use of its property, given that such use is compatible with other surrounding uses and does not violate environmental or civil law.

If dredging is required, the proposed disposal area will be temporarily blocked from public access. At the conclusion of any dredging the area will be graded and access returned.

3.8.3 Potential Consequences of the No Action

Unless corrected, the present flow pattern would cause continued erosion of the California bankline at the scallop and at a spur jetty above the Dam resulting the continued loss of tribal land. The meandering pattern of flow below the scallop would persist, and result in adverse impact to the diversion structure and eventually the dam abutments. In conjunction with continued erosion, there would be an increase in sediment carried by the river downstream of the impact area. The sand bar on the east side of the river would continue to increase in size, which may further exacerbate the erosion of the west bankline.

3.8.4 Mitigation Measures

Reclamation has determined that mitigation measures are not required, as no significant impacts to land use are anticipated.

3.9 Socioeconomics

3.9.1 Affected Environment

The project is located in the extreme eastern portion of Riverside County, California. Most of the region is rural, with less than 250 persons per square mile. The nearest metropolitan area to the project site is Blythe, 9 miles south, which has a population of 8,428 (BOC 2000). The primary economic base in the Blythe area is agricultural production and support services.

3.9.2 Potential Consequences of the Proposed Action

The proposed action is unlikely to result in negative effects on the local economy and infrastructure. The construction contractor to Reclamation may be either a local or out-of-town entity. If local, the project would benefit the economy by providing about 9 months of employment opportunities. If an out-of-town contractor is used, the local economy would benefit from increased housing and services demanded by the temporary labor force.

3.9.3 Potential Consequences of the No Action

If corrective action is not taken, the PVID diversion intake would eventually be adversely impacted causing increased maintenance costs. Further, continued erosion of the California bankline could eventually result in adverse impacts to Highway 95.

3.9.4 Mitigation Measures

No adverse impacts are anticipated with implementation of the Proposed Action; therefore, no mitigation measures are required.

3.10 Environmental Justice

Executive Order 12898 (February 11, 1994) requires that, to the greatest extent practicable and permitted by law, and consistent with the principles set forth in the report on the National Performance Review, each Federal agency shall make achieving environmental justice part of its mission by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations.

3.10.1 Affected Environment

Hispanics and Native Americans are the predominant ethnic groups in the region. The CRIT occupy the Colorado River Indian Reservation, most of which is in La Paz County in western Arizona along the Colorado River. Part of the Reservation is also located in California extending to the north from the area adjacent to the scalloped bankline. Members of the Mohave, Chemehuevi, Hopi, and Navajo Nations are members of CRIT, and current enrollment is approximately 3,500 (http://members.tripod.com/~CRIT/).

3.10.2 Potential Consequences of the Proposed Action

The proposed action would not result in a greater affect to the Hispanic or Native American populations in the area than non-minority and or low-income populations. In fact, rather than create disproportionate adverse effects on the Native American population in the project area, the proposed action would benefit CRIT by reducing the continued erosion of CRIT land along the Colorado River, with consequent loss of this land for productive uses.

3.10.3 Potential Consequences of the No Action

Under the No Action Alternative CRIT land will continue to be lost to erosion.

3.10.4 Mitigation Measures

No adverse impacts are anticipated with implementation of the Proposed Action; therefore, no mitigation measures are required.

3.11 Cumulative Impacts

The assessment of cumulative impacts in NEPA analysis is required by Council of Environmental Quality regulations. Cumulative impacts may result when the effects of an action are added to or interact with other effects in a particular place and within a particular time. The cumulative impacts of an action can be viewed as the total effects on a resource, ecosystem, or human community of that action and all other activities affecting that resource no matter what entity (Federal, non-Federal, or private) is taking the actions.

Cumulative effects issues identified as being related to the proposed action are:

- Change in land use or property loss caused by erosion
- Change or degradation of habitat
- Change in aesthetic and visual values

For the purposes of analysis the geographic scope defined for potential cumulative effects associated with the proposed action are activities or other projects within a 10-mile radius of the proposed project site (Figure 4). Projects included for cumulative effects analysis are those past, present, and reasonably foreseeable actions within a 5-year period of the proposed action and are detailed in Table 3-2.

Table 3-2. Projects Potentially Contributing to Cumulative Effects

Project	Location	Status	Potential contribution to cumulative effects
Armored existing hard point above Palo Verde Dam	133.8	P	Short-term disturbance to aquatic species and habitat.
Stabilize approximately 1 mile of AZ bankline	RM 137 (.5 mi) & RM 143.5 (.5 mi)	RF	Short term disturbance to aquatic resources and loss of vegetated bankline.
Repair stabilized bankline abutments below PV Dam release gates.	RM 133.7 (CA)	RF	This area is already armored and the project is considered repair/maintenance of an existing facility. Minimal and short-term displacement of fish may occur during placement of the new riprap.
Inspect Palo Verde Dam subsurface structures and embankments	RM 133.8	RF	May require dramatically lowering water level and a temporary short-term shutdown of water releases at Palo Verde Dam.
Stabilize AZ bankline below PV Dam	RM 133.7 to RM 132.6 (AZ)	RF	The engineering scope of this project is not yet defined and potential impacts are unknown.
6th Avenue River Control and Bankline Stabilization Project	RM 133.8 to RM 123	RF	The engineering scope of this project is not yet defined and potential impacts are unknown.
Sporadic housing development along bankline (AZ & CA)	~ RM 120 to 136 and (upstream)	P, PR, RF	As a result of continued development along the banklines, Reclamation will lose access to perform bankline maintenance, thereby hampering their ability to meet responsibilities under the CRFWLS Act. In addition, loss of riparian habitat will increase as native vegetation may be replaced with nonnative species used in landscaping.

1-LCR-YAO Resource Management Plan (date)
2-Derived from the LCR MSP Final EIS (Vol 1)
3- P=Past, PR=Present, and RF=Reasonably Foreseeable

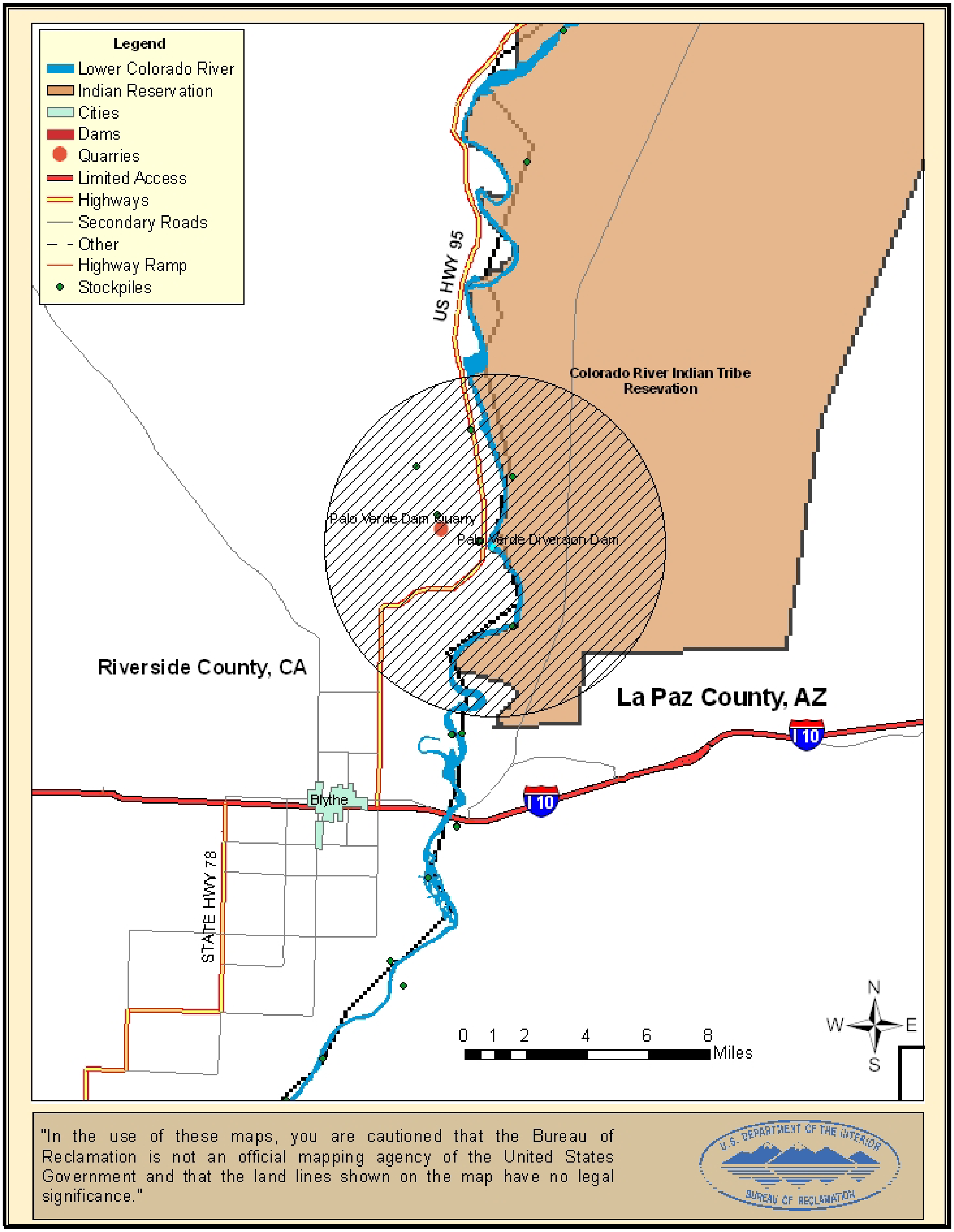

Figure 4. Area Included in Analysis of Potential Cumulative Affects

4.0 Coordination and Consultation

4.1 Agency

Reclamation project staff met on April 10, 2003, with staff from the Regulatory Branch of the U.S. Army Corps of Engineers, Los Angeles District to discuss the proposed action and to obtain input from the Corps regarding Clean Water Act permitting requirements for the project under Section 404. The Corp staff advised Reclamation that a Section 404 individual use permit would be needed prior to project implementation. A Section 404 permit application was originally submitted July 31, 2003 and then withdrawn (ACOE 2003). A revised permit was submitted December 8, 2004 and withdrawn (ACOE 2005b). Reclamation is continuing to coordinate with the Corp of Engineers to finalize the 404 permit process by compiling additional information requested (ACOE 2004a) and to respond to a memorandum report prepared by the ACOE, Hydrology and Hydraulics Branch responding to a request from the ACOE Tucson Project Office for technical assistance (ACOE 2005a).

On May 15, 2003, Reclamation staff met with state and Federal wildlife resource agencies at Blythe, California, to present a briefing on the project and to conduct a field visit to the project site. Other Federal participants include staff of the U.S. Fish and Wildlife Service (FWS), Arizona Ecological Field Services Office. FWS requested that Reclamation examine additional alternatives in its EA.

State agencies that participated in the meeting were the CDFG and the Arizona Game and Fish Department (AGFD). Both CDFG and AGFD expressed no concerns or issues related to the proposed action. In addition, CDFG indicated that a Streambed Alteration Permit would not be required under California statute.

4.2 Tribal

On December 12, 2002, YAO engineering staff met with CRIT staff to examine several design options that Reclamation proposed to meet the need for the project.

Subsequently, on January 28, 2003, Reclamation and CRIT staff conducted a field visit to the project area to review the suitability of CRIT land adjacent to the scallop area as a potential site for stockpiling rock prior to construction of the training structure. CRIT suggested that Reclamation proceed with plans to use the site for this purpose.

Reclamation staff again met with CRIT on March 8, 2003, to discuss environmental aspects of the proposed project. The project site was visited, and field notes were taken regarding the terrestrial resources adjacent to the scallop, which are proposed to serve equipment staging, materials lay down, and vehicle access purposes. Subsequent to this meeting, Reclamation submitted a written request to use the site for these purposes, and CRIT approved the request and a letter agreement (03-07-34-L01316) was implemented on March 26, 2003 (Reclamation-CRIT 2003). In addition the CRIT Tribal Council issued a Resolution (72-03) approving the issuance of an Army Corp of Engineers permit (404) to Reclamation for river construction projects on CRIT land (CRIT 2003).

On June 12, 2003 and April 28, 2005, CRIT led a field walk-over of the land adjacent to the proposed training structure with Reclamation and staff from Reclamation's cultural resources contractor.

4.3 Other

YAO staff met with PVID management at the District's office on February 7, 2003, to discuss proposed options to meet the need for remediation of the scallop.

5.0 References

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ACOE 2003 — *Letter from Marjorie Blaine to Cynthia Hoeft*. File No: 2003-00810-MB. Department of Army, Los Angeles District, Corp of Engineers, Tucson Project Office. Tucson, Arizona. September 20, 2003.

ACOE 2004a — *Letter from Marjorie Blaine to Cynthia Hoeft*. File No: 2003-00810-MB. Department of Army, Los Angeles District, Corp of Engineers, Tucson Project Office. Tucson, Arizona. December 22, 2004.

ACOE 2004b & 2005c — *Issuance of a Clean Water Act Section 404 under Nationwide Permit No. 3., Maintenance* (File Number: 2004-01203-MB). Department of Army, Los Angeles District, Corp of Engineers, Tucson Project Office. Tucson, Arizona. May 17, 2004 and January 5, 2005.

ACOE 2005a — *Memorandum from Hydrology and Hydraulics Branch to for CESPL-CO-RA to Marjorie Blaine, SUBJECT: Request for Technical Assistance – Proposed Training Structure Upstream of Palo Verde Diversion Dam on the Lower Colorado River*.

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CRIT 2003 — *Resolution 72-03: Approve the Granting of a Construction Permit by the Army Corp of Engineers for General Maintenance Along the Colorado River, Colorado River Indian Tribe*. Colorado River Tribal Council. April 14, 2003.

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LCR MSCP 2004b — *Lower Colorado River Multi-Species Conservation Program, Volume II: Habitat Conservation Plan*. Final. Lower Colorado River Multi-Species Conservation Program (J&S 00450.00.). Sacramento, CA. December 17. 2004

LCR MSCP 2004c	*Lower Colorado River Multi-Species Conservation Program, Volume III: Biological Assessment*. Final. Lower Colorado River Multi-Species Conservation Program (J&S 00450.00.). Sacramento, CA. December 17. 2004
LCR MSCP 2004d	*Lower Colorado River Multi-Species Conservation Program, Volume IV: Appendices to Volumes I-III and V*. Final. Lower Colorado River Multi-Species Conservation Program (J&S 00450.00.). Sacramento, CA. December 17. 2004
MDAQMD 2003	Personal communication, Mr. Alan DeSalvio, Mohave Desert Air Quality Management District, Air Quality Engineer, with Mr. Dave Gottfredson, RECON, Inc., and Ms. Andrea Campbell, Reclamation, Natural Resources Specialist, Yuma Area Office. June 24, 2003.
NRCS 2003	Personal communication, Mr. Steven Perkins, District Conservationist, Natural Resources Conservation District, Blythe, California, with Ms. Andrea Campbell, Natural Resource Specialist, Reclamation, Yuma Area Office. July 30, 2003.
Reclamation 2003	*Desert Tortoise Survey Report Forms for the Palo Verde Dam Quarry*. Bureau of Reclamation, Yuma Area Office. May 8, 2003 and July 25, 2003.
Reclamation 2004	*Hydraulic Modeling and Analysis of the Proposed Palo Verde Dam Training Structure*. U.S Department of Interior, Bureau of Reclamation, Technical Service Center. Denver, Colorado. September 2004.
Reclamation 2005	*Mitigation Concept Plan, Palo Verde Training Structure*. U.S. Department of Interior, Bureau of Reclamation Yuma Area Office. Yuma Arizona. May 2005.
Reclamation-CRIT	*Letter Agreement No. 03-07-34-L01316*. U.S. Department of Interior, Bureau of Reclamation Yuma Area Office and Colorado River Indian Tribe. Subject: Remediation of Bankline Scallop Above Palo Verde Diversion Dam. March 26, 2003.
RECON 2003	*Cultural Resource Survey Report for Palo Verde Bank Stabilization Project on the Colorado River proposed Extraction Area and Access Road*. RECON, J. K. Pete Finney, Associate Archaeologist. December 5, 2003.
Terra Nova 2003	*Environmental Assessment for the Queshan Recreation Park Improvement Project,* prepared for City of Blythe, California,

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USFWS 2005 *Biological and Conference Opinion on the Lower Colorado River Multi-Species Conservation Program, Arizona, California, and Nevada* (02-21-04-F-0161). U. S. Fish and Wildlife Service. Phoenix, AZ. March 4, 2005.

Appendix A – Biological Evaluation

Biological Assessment Palo Verde Dam Training Structure, Bankline Armoring, and Dredging

Introduction

Reclamation proposes to construct a rock training structure in the Colorado River channel upstream of Palo Verde Dam to maintain flows in the center of the present channel and to protect the shoreline from high water velocities. There may be dredging of an accreting pointbar in the channel if erosion does not remove it after the training structure is built. A hydrological modeling study of flow characteristics under several regimes supports the need for the proposed project (Reclamation 2004). The purpose of the proposed project is to prevent erosion of either dam footing by entraining the channel flow to prevent meander of the channel immediately upstream of the dam. Erosion of the outside (California (CA)) bend of the river has sculpted a large scallop on the Colorado River Indian Tribes (CRIT) shoreline removing about 12 acres of land. An accreting pointbar is building on the Arizona side near mid-channel as the river meanders to the west. Continued erosion and river meander may ultimately lead to dam failure without these actions.

This biological assessment addresses the impacts of the proposed action; construction of a rock training structure, bank armoring and possible dredging, on select biological resources in the project area. Potential impacts on endangered and threatened species and designated critical habitat are especially examined. This review is in compliance with Section 7, Endangered Species Act (ESA), regarding federal agency actions.

Project Setting and Description

The Palo Verde Diversion Project, which includes the Dam, spillway and canal head-works, was constructed in 1956-1957 to meet the irrigation needs of the Palo Verde Irrigation District (PVID). Diversion structures at the dam divert water through a series of lateral canals to irrigate approximately 121,000 acres of agricultural lands within the District. As a diversion dam, there is little upstream impoundment, the structure just maintains water level in the flowing river to allow diversion of irrigation water into canals. The un-diverted flow continues downstream through the dam headgates.

The earth-fill dam is a semi-pervious barrier of sand, gravel, and rock fill, with a crest width of 20 feet (ft), a length of 1,850 ft (which includes the spillway), and a maximum height of 46 ft above the riverbed. The right abutment of the dam is in Riverside County, CA and the left abutment is in LaPaz County, AZ. Both the upstream and downstream slopes of the embankment are sloped 4:1 from crest elevation to riverbed. The upstream zone consists of sand, gravel, and cobble fill, which is protected with 24 inches of riprap (rock boulders) to an elevation of 20.0 ft and the downstream zone is un-sized rock fill.

Proposed Construction

The proposed project includes three phases, with the second and third phases contingent on conditions observed after phase one.

- Phase 1: the construction of a 1500 ft. long rock training structure and armoring of the AZ spur (**Figure 1**).
- Phase 2: bankline armoring as needed in eroding areas with dumped rock rip-rap, and
- Phase 3: dredging of the accreting pointbar in the main channel, if necessary.

The training structure will be constructed from the California shore by dumping rock and working outward into the river channel. The structure will be trapezoidal in cross section with a 40 to 50 ft. top width. The bottom width will vary depending on depth to the river bed. The structure side-slope will be 2: 1. The structure bottom width will vary with depth and the top elevation will be 290 ft. mean sea level (MSL), or about 5-6 ft. above the normal high water line. Several sections of the training structure will contain only course rock fill, to function as flow-through sections providing some flows on the shoreward side. Training structure construction will begin in 2006, depending on permits and funding, and will take approximately nine months.

Rock for the project will be obtained from nearby Palo Verde Dam Quarry and other quarries and trucked to the construction site from stockpiles at the quarry or river-side stockpiles. At least 125,000 cubic yards of rock will be used in construction of the training structure and on bankline armoring. Hauling will be along established roads on Colorado River Indian Tribes lands.

Bankline in eroding areas will be protected with dumped rock along and below the high water mark (e.g. rip-rap). After the training structure is built, observations on the fate of the channel pointbar will be made. The pointbar may be dredged if it does not erode under new stream conditions (e.g. post-training structure). A 0.22 acre patch of emergent marsh is found on the pointbar (see photographs, **Exhibit A**) and will be replaced by a 0.75 acre cattail marsh planted in a prepared area in the abandoned canal. If dredging occurs, dredge material will be deposited on the Arizona shore in an upland dredge spoil area (**Figure 1**). The upland disposal area is vegetated with a xeroriparian stand of saltcedar (*Tamarix* sp.) and arrow weed (*Pluchea sericea*) of mixed stature and canopy cover.

Physical Description of River

The Colorado River bed substrate in this reach is predominantly sand. Underlying the river bed is igneous intrusive rock near the surface on the

California side, and alluvial fill on the Arizona side. Igneous rock in the area is fragmented and erodes easily. An old rock weir exists upstream of the dam, just below the project area, and forms a localized rocky channel bottom. A period of low flows in January 2005 provided an opportunity to photograph much of the bottom substrate that is normally covered by water (see photographs, **Exhibit A**). See **Exhibit A** for views and discussion of river bottom substrates in the project area.

The Colorado River channel in this reach is generally a straight, single channel with relatively high flows. The channel is contained by levees restricting the floodplain and flows moderated by upstream dams. There is minimal channel diversity. There are no eddy pools, side-channels or similar natural channel features within two miles upstream of the dam. There is an abandoned diversion canal on the California side and the existing distribution canal for PVID (**Figure 1**). The abandoned canal forms a small backwater.

Normal surface elevation of the Colorado River behind Palo Verde Dam is 283.5 ft MSL.

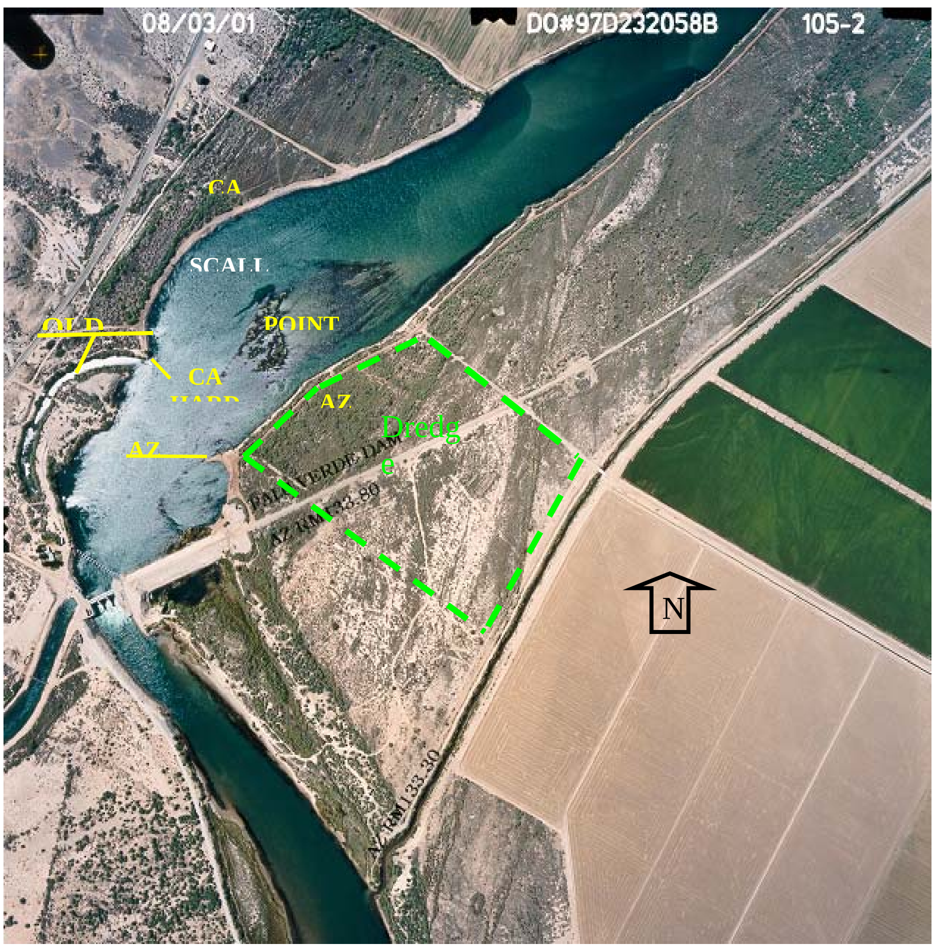

Figure 1. Palo Verde Diversion Dam on the Colorado River. Channel and shoreline features discussed in the text are identified. Aerial photograph dated August 3, 2001.

Immediately upstream of the dam are steep-sided depths to about 260 ft. MSL (Reclamation 2004). There is an eroded 'hole' that drops to below 250 ft. MSL (**Figure 1**) very near the dam. Thus, water depths are about 23.5 to over 35 ft. immediately upstream of the dam. The river thalweg (deepest part of channel) hugs the California shore, along the outside of the river bend. Depths in the area of the proposed training structure, about ¼ to ½ mile upstream from the dam, range from 15 to 18 ft (Reclamation 2004). The inside curve of the bend, along the AZ shore, is accreting and depths of <1 to 3 ft are found over a large sandbar. Hard against the AZ shore is a narrow channel with depths of about 13 ft (**Exhibit A**). Shorelines on both sides of the river are steep and have been armored with rock rip-rap (**Exhibit A**).

Flows in this reach vary throughout the day and season based on water deliveries, power demand and rainfall. River flows vary, but under normal operating conditions remain between approximately 4,500 to 15,000 cubic feet/second (cfs) through the dam (USGS flow data). Flows upstream of the dam are slightly higher because the PVID diversion can accommodate up to 1,800 cfs. High normal flows can reach 19,000 cfs and a 100-year flood event may exceed 42,500 cfs. The levee is designed to contain the 100-year flood event.

At 19,000 cfs flows, water surface velocities exceed five feet per second (> 5.0 ft/s) along the main channel near the CA shoreline (Reclamation 2004). Velocities along the AZ shoreline are similar; 3.0 to 4.0 ft/s. Water velocities near the pointbar are less than one ft/s (< 1.0 ft/s). Channel substrate reflects these water velocities, with sand in the high flow areas and silt deposition on the point bar (see photographs **Exhibit A**).

Shear stresses, a major factor in bottom substrate type and movement, during flows of 19,000 cfs were modeled by Reclamation (2004). In the main channel along the California bank, shear stress is about 0.03 lb/ft^2. Along the CA shore and near the point bar shear stress is < 0.005 lb/ft^2.

Physical Description Post-project.

The proposed project will alter local river conditions in several ways; bottom substrates, flow velocities, and water depths. During construction there will be local increases in suspended sediment in the water, however these will be temporary effects. Substrate, flows, and depths are important aquatic habitat variables and are discussed here to provide a setting for the analysis.

The rock training structure will create a rocky substrate on a portion of the river bottom over what is now sand. Over time, sediment will accumulate behind the training structure, likely forming a silt or mud substrate bottom. These changes will increase the local bottom substrate diversity by adding rock and silt or mud components to the existing sand in a patchy relationship. The submerged portion of the training structure will provide a vertical habitat component to the water column; comparable to the two armored shorelines (photographs **Exhibit A**).

The pointbar will be removed or greatly diminished, including the small emergent marsh in the mid-channel. Deeper waters will prevail in the pointbar area. Smooth, moderate velocity flows through this area will prevent future bar accretion if the river behaves as modeled.

Water velocities in the vicinity of the training structure will be altered. Immediately after construction of the training structure, main-channel flows will increase to about 6.0 or 7.0 feet/second (ft/s) until the point bar erodes or is dredged. Behind the training structure along the CA shoreline flows will diminish to < 1.0 ft/s. Several eddies will form downstream of the training structure. Once the point bar erodes or is dredged, flows in the main channel will decrease to < 3.0 ft/s (Reclamation 2004). Post-project water velocity effects will include a calm-water area behind the training structure, and high to medium velocity flows in the main channel.

Species Evaluation

The list of endangered and threatened species for the La Paz Co., AZ, maintained by the USFWS (website) was reviewed for species that may be present in the project area. The potential for the species to be present in the project area was determined based on known distribution of the species, species' habitat needs, and a review of habitats in the project area. Species-specific survey or observation information was also used in the evaluation, where available.

A number of species are eliminated from consideration because no suitable habitats, or populations, are known from the project area (e.g. Gila Topminnow [*Poeciliopsis occidentalis*] and Desert Pupfish [*Cyprinodon macularius*]). Species eliminated from further consideration include:

> **Bonytail Chub** (*Gila elegans*): Once found in the Colorado River, the bonytail is now considered extirpated from all but a few locations (reservoirs) on the Colorado River. No suitable habitat is present at the project site. There is no critical habitat for this species in the project area.
>
> **Bald Eagle (*Haliaeetus leucocephalus*):** Bald eagle are uncommon on the lower Colorado River and may be found there occasionally in the winter. No nesting occurs in the project area. The eagle has been proposed for delisting. The potential for a bald eagle to occur in the project area is discountable.
>
> **Yellow-billed Cuckoo** (*Coccyzus americanus*) is a candidate for listing as threatened or endangered. USFWS conclude that listing action is warranted, but precluded by other actions. The cuckoo depends on large stands of mature riparian cottonwood and willow, a habitat type not found in the project vicinity. There will be no affect on this candidate species.

Southwest Willow Flycatcher (*Empidonax trailii extimus*): No breeding habitat (moist or flooded soils beneath cottonwood/willow or tamarisk stands) for the flycatcher occurs at, or near, the project area. No breeding or migration habitat will be affected by this project. No proposed critical habitat for the flycatcher occurs in the project vicinity.

Razorback Sucker

The razorback sucker (*Xyrauchen texanus*) was listed as endangered effective November 22, 1991. Critical habitat for the razorback sucker was designated March 21, 1994. Historically known from the Colorado River and its larger tributaries, the species was known from a variety of riverine habitats typical of the main-channel river. The species was formerly abundant and widespread throughout the Colorado River system.

The species was listed due to population and range declines throughout its distribution, caused primarily by impoundment of the larger rivers. Impoundments altered habitats and changed cyclic river flow and temperature regimes. Non-native sportfish introductions brought increased predation to the razorback sucker. There is a recovery plan for the species and recovery efforts are underway in the Upper Colorado River Basin. Attempts to augment natural populations through release of young razorback suckers have met with limited success. The species appears to be unable to recruit new, younger members to an increasingly aged population, due primarily to predation by non-native, introduced fish.

Extant populations of Razorback sucker are now limited to four small areas on the upper Colorado River, upstream of Lake Mead and small populations in the Lower Colorado river, including Lake Mohave, the Colorado River below Davis Dam, Lake Mead and Senator Wash Reservoir (Bradford and Vlach 1995). Studies of sonic-tagged adult razorback sucker, reared in a hatchery, have demonstrated that they prefer deeper, interconnected river backwater habitats over main channel habitats (Gurtin, et al. 2003).

Spawning sites for razorback sucker are characterized by flowing water and gravel or similar suitable substrate. Flow rates reported for upper Colorado River spawning sites are consistently below 5.0 ft/s (1.5 meters/second [m/s]) [Bradford and Vlach 1995]. Flows on spawning sites averaged 0.37 m/s (>1.0 ft/s) on the Yampa and Green Rivers (Miller et al 1982). Other studies report flow ranges of 0.1 to 1.4 m/s (<<1.0 to <5.0 ft/s), 0.89 to 0.95 m/s (2.9 to 3.1 ft/s), and an average of 0.64 m/s (2.0 ft/s) [Tyus and Karp 1990, McAda and Wydoski 1980, and Tyus and Karp 1989]. On the lower Colorado River, all known spawning sites are in reservoirs, and flow data are not available (Bradford and Vlach 1995). High velocity water flows in spawning areas maintain interstitial spaces of gravel beds, preventing silt deposition and compaction of spawning substrate.

There is little information about larval and juvenile sucker habitat preferences. Larval sucker are found in the interstices of gravel beds immediately after hatching. Larval suckers can also be found in quiet shoreline areas near gravel beds. Juvenile suckers have been collected in shallow, warm backwaters over mud and silt substrates. In reservoirs, juvenile suckers are found in the littoral zone for a few weeks after hatching, but quickly move into deeper water.

Designated critical habitat for the razorback sucker includes the Colorado River to Imperial dam including the 100-year floodplain. Primary constituent elements of critical habitat include water, physical habitat such as spawning, nursery, feeding and rearing habitat, and a biological environment supporting the species (59 Fed. Reg. 13374).

Project Effects on Razorback Sucker and Critical Habitat

Operation of Palo Verde Dam is discussed in a Biological Opinion (BO) concerning the operation and maintenance of the Lower Colorado River System (USFWS 1997). The 1997 BO addresses measures Reclamation must pursue to recover the razorback sucker and other federally listed threatened and endangered species. Among the recommendations was participation in developing a region-wide habitat conservation plan, known as the Multi-species Conservation Plan (MSCP). Reclamation and others have developed the MSCP, expected to begin implementation in 2005. Razorback sucker recovery actions are covered by the MSCP. The 1997 BO was extended in 1999 and expires in 2005. Because dam operation and river system operation are covered in an existing BO and the recently completed MSCP, they will not be discussed here. Only training structure construction, maintenance, potential dredging and construction-related effects will be discussed.

Designated critical habitat for the Razorback sucker includes habitat elements in the 100-year floodplain of the Colorado River. Palo Verde Dam and the proposed project area are within the 100-year floodplain of the Colorado River (1990 Floodplain map 423-300-3144). Physical habitat features such as spawning, nursery, feeding and rearing habitat are absent from the project area. No suitable spawning habitat is present due to the absence of gravel substrate and the high flow velocities in this reach of the river (see photographs**, Exhibit A**). There is no feeding and rearing habitat, as vegetated, calm-water shallows are absent in the project area. Razorback sucker feed largely on detritus and there is limited opportunity for detritus accumulation given the high velocity flows and absence of backwaters or side channels. There may be suitable habitat conditions for adult razorback suckers, as they are known to use main channel river habitat, however these habitats are used in much lower frequency than other habitats (e.g. backwaters and side channels).

The project area lacks a biological environment supporting the species due to the presence of introduced sport and rough fishes. Introduced species of sportfish are known to limit recruitment of razorback sucker. In the main river, there are species capable of consuming even adult suckers (e.g. flathead catfish). The species of sportfish locally present in the project area are discussed in Marsh 2004 (**Exhibit B**).

The loss of <0.25 acres of emergent marsh can't be considered loss of nursery habitat, as it isn't adjacent to cobble (spawning) substrates and lacks the backwater characteristics (e.g. flow) contributing to sucker habitat. The marsh vegetation affected is surrounded by deep, fast flows and is on silt substrate. Compensating mitigation for the loss of this marsh will include replacement with ca. 0.75 acres of marsh in a nearby abandoned canal.

Water quality in the project area and downstream shouldn't be affected in any measurable way. Potential grease and oil contamination from construction equipment will be prevented by best management practices for stormwater, including upland, contained fueling and service areas for equipment; runoff retention and similar precautions. Fill material will be clean and free from contaminants as required by Section 404 of the Clean Water Act. There will be an increase in turbidity during construction, but those effects will be well within the range of the historic turbidity of the Colorado River, to which the sucker is adapted. The erosion, or dredging, of the sandbar will also create increased turbidity at the project site and for some distance downstream, though not exceeding the historic range of turbidity. Because there are no spawning or larval habitats for sucker in this reach, there should be no adverse effects to constituent elements from dredging or erosion of the pointbar.

Few, if any, constituent elements of razorback sucker critical habitat are present in the project area. Reclamation concludes that the project may affect, but will not likely adversely affect, critical habitat for the razorback sucker.

Fish sampling in the project area was conducted by Arizona State University biologists on June 7 through 9 and 28 through 30, 2004 (Marsh 2004, **Exhibit B**). Electrofishing and trammel nets were used to sample a range of aquatic habitats in the project area. A total of 140 minutes of electrofishing was conducted. A total of 20 overnight sets of 45.7 m trammel nets and four overnight sets of 91.5 m trammel nets were run during the sample period (15.36 net-km-hr sample effort). Net sampling and electrofishing were conducted in the abandoned canal and in the main river channel. A total of 302 fish were observed from the electrofishing effort and 215 fish were captured in nets. All fishes captured or observed were non-native sport and rough fishes, in a species assemblage typical of the Colorado River (Minckley 1997, Marsh 2004). No razorback sucker were captured or observed in the sample effort.

Given the absence of suitable spawning, rearing, or foraging habitat for razorback sucker; the presence of non-native predacious fishes; and the negative survey data for razorback sucker, Reclamation concludes that individuals of the species are unlikely to use the project area. Because the Colorado River is historic range for the species and a few adult individuals are known to use the mainstem river, Reclamation concludes that the project may affect, but will not adversely affect the razorback sucker.

Mojave Desert Tortoise

The Mojave population of the Desert Tortoise (*Gopherus* (*Xerobates*) *agassizii*) was listed as threatened, effective April 2, 1990. Critical habitat was designated for the Mojave population on February 24, 1994. The desert tortoise occurs on both sides of the Colorado River inhabiting desert areas below 4,000 ft. Only the population west and north of the Colorado River is protected under the ESA. The Arizona Population, referred to as the Sonoran Desert Tortoise, is a state species of special concern. Mojave Desert tortoise are found in relatively flat desert areas as well as rocky outcrops often dominated with creosotebush in association with other desert scrub.

Desert tortoise burrow into the soil to hibernate, escape temperature extremes and conserve moisture. Tortoise hibernate in their burrows in the winter, generally from October through February. They may spend up to 95% of their lives underground. Tortoise feed on desert plants and activity is generally controlled by ambient temperature and rainfall. The tortoise is extremely long-lived and is well adapted to the arid desert. Tortoise are most active after spring rains and the late summer monsoon season that fosters growth and flowering of native annuals, an essential component of their diet.

The tortoise is threatened by habitat loss and destruction, unauthorized collection, invasive plants, disease, grazing, development, energy and mineral development, fire, drought and mortality associated with authorized and unauthorized vehicle and off-highway vehicle (OHV) activity. Habitat loss and fragmentation through human activities are the largest threats.

The Desert Tortoise has 12 Critical Habitat Units (CHUs) in four states (Arizona, California, Nevada and Utah). In addition to the CHUs, land management agencies have also been developing large Desert Wildlife Management Areas (DWMA) to conserve this and other threatened, endangered and sensitive species.

Tortoise become less abundant near highways, roads and other active areas due to high mortality losses and lack of habitat. Tortoise may persist in low densities in suitable habitat areas altered by man.

Project Effects on Mojave Desert Tortoise

Rock for this project will be quarried from Palo Verde Dam Quarry, located about 1.5 miles west of the dam. Rock from Agnes Wilson Quarry will also be used, stockpiled at the Palo Verde Dam Quarry. Project construction will take place along the bank of the Colorado River in California just north of the Palo Verde Diversion Dam. The California Natural Diversity Database (CNDDB) shows the closest known tortoise population being 5 miles west of the quarry and 6.5 miles west of the project construction site on the opposite side of the Big Maria Mountains.

Two surveys conducted in 2003 by Reclamation Regional Office employees turned up no tortoise or sign at the Palo Verde Dam Quarry or along the access road. The surveyors conducted transect surveys within and immediately adjacent to the quarry and access road.

There are no CHUs in or adjacent to the project area. This area is not in or adjacent to a DWMA. Chuckwalla Mountains is the nearest DWMA, South of Blythe, California. The quarry and access road is marginal habitat for desert tortoise given the available habitat and high level of human disturbance present in the vicinity.

Potential direct effects to desert tortoise include direct mortality from vehicles and equipment, falling rock, blasting and collection. Indirect effects may include burial of burrows through blasting; decreased activity along roadways where traffic will temporarily increase due to hauling and refuse generated on-site that may attract predators. Interrelated and Interdependent Effects are addressed in the Biological and Conference Opinion on Lower Colorado River Operations and Maintenance (USFWS 1997) and incorporated into the MSCP (USFWS 2005).

Reclamation will implement the following practices in all tortoise habitat areas used during the project construction to minimize and mitigate for effects to desert tortoise:

- A biological monitor will be assigned to the project. The biological monitor will be responsible for ensuring mitigation compliance and surveying prior to the start of activities in the quarry, quarry-stockpiles and along the access road.
- Everyone working on-site will be required to attend a project specific desert tortoise presentation.
- A 25 mph speed limit will be enforced.
- Construction within the desert tortoise active period (March 1 through November 1) will require an on-site biological monitor.
- Unauthorized vehicle use and cross-country travel will be restricted.
- All construction will take place in previously disturbed areas.
- No new roads will be constructed.

Given the above mitigation measures, the project is unlikely to affect desert tortoise individuals or habitat. Reclamation determines that this project may affect, but will not adversely affect Mohave Desert Tortoise. There is no designated critical habitat for the tortoise in the project area.

Brown Pelican

The Brown Pelican (*Pelicanus occidentalis*) was listed as endangered in December 1970 (35 Fed. Reg. 8495), including the Mexican and pacific populations of the Western United States. No critical habitat for this species has been designated. The primary threat was egg-shell thinning and reproductive failure due to pesticides. Brown Pelican are generally considered to be recovering from population decline as a result of pesticide regulation and other conservation efforts.

Adult Brown Pelican are found from summer through the winter in Arizona, primarily along the Colorado River (Monson and Phillips 1981). Post-fledging dispersal of young from nesting areas in Mexico is also observed in mid-summer. Brown Pelican feed on fish, primarily marine, but will use fresh water species. Pelican nest on islands in marine areas near concentrations of preferred food fishes.

There are no nesting or breeding sites for Brown pelican in the project area. Brown Pelican are infrequent in the project area, but may occasionally use the river surface during summer, fall or winter for resting or feeding. Brown Pelican may occasionally forage in the project area. Any Brown Pelican present can easily avoid the project area during construction, by flying to other suitable areas nearby. The proposed project will not alter fish populations in the project vicinity that may provide prey for the pelican.

Given the infrequent occurrence of pelican in the project area, the ability of individual birds to avoid the project area during construction and the lack of any adverse effect on fish forage, Reclamation concludes that the project may affect, but will not adversely affect the Brown Pelican.

Yuma Clapper Rail

On March 11, 1967, the Yuma Clapper Rail (*Rallus longirostris yumanensis*) [YCR] was listed as endangered by the Secretary of the Interior pursuant to the Endangered Species Act of 1966. No critical habitat for the rail has been proposed or designated.

This subspecies of clapper rail is found along the lower Colorado River from Needles, California, to the Gulf of California, at the Salton Sea and other localities in the Imperial Valley, California: along the Gila River east from Yuma to at least Tacna, Arizona: and several areas in central Arizona, including Picacho Reservoir (Todd 1986: Rosenberg et al 1991). Anderson and Ohmart (1985) estimated a population size of 750 birds along the Colorado River north of the International Boundary. The USFWS (1983) estimated a total of 1,700 to 2,000 individuals throughout the range of the subspecies. This estimate was based on call count surveys which detect from 22 to 100 percent of the birds present (Eddleman 1989; Todd, 1986), so this is likely a minimum estimate. Some authorities (Ohmart and Smith 1973; Monson and Phillips 1981; Rosenberg et al 1991) consider the population to be expanding. Annual population surveys conducted by interagency biologists working with the Yuma Clapper Rail

Recovery Team in the lower Imperial Division on the lower Colorado River show a fairly stable population in the Imperial Reservoir area.

Yuma Clapper Rails begin exhibiting courtship and pairing behavior as early as February. Nest building and incubation can begin by mid March, with the majority of nests being initiated between late April and late May. The rails build their nests on dry hummocks, on or under dead emergent vegetation, and at the bases of cattail or bulrush. Sometimes they weave nests in the forks of small shrubs that lie just above moist soil or above water that is up to 60 centimeters (cm) (2 ft) deep. The incubation period is approximately 28 days so the majority of clapper rail chicks should be fledged by August. Yuma Clapper Rails nest in a variety of different micro-habitats within the emergent wetland vegetation type, with the only common denominator being a stable substrate. Nests can be found in shallow water near the shoreline or in the interior of marshes over deep water, and they usually do not have a canopy overhead as surrounding marsh vegetation provides protective cover (Eddleman, 1989).

Yuma Clapper Rails are found in emergent wetland vegetation such as dense or moderately dense stands of cattails (*Typha latifolia* and *T. domingensis*) and bulrush (*Scirpus californicus*) (Eddleman 1989: Todd 1986). They also use sparse cattail-bulrush stands or dense reed (*Phragmites australis*) stands (Rosenberg et al, 1991). The most productive clapper rail areas consist of a mosaic of uneven-aged marsh vegetation interspersed with open water of variable depths (Conway et al, 1993). Annual fluctuation in water depth and residual marsh vegetation are important in determining habitat use by the Yuma Clapper Rails (Eddlemen 1989). Crayfish (*Procambarus clarki*) are the preferred prey of Yuma Clapper Rails. Crayfish comprise as much as 9.5% of the diet of some Yuma clapper rail populations (Ohmart and Tomlinson 1977).

Rail breeding densities and home range sizes have been studied in several areas of the Lower Colorado River, including Topoc marsh (e.g. cattail), Mittry Lake (e.g. cattail dominated), and the lower Gila River (Todd 1986). Smith (1974) found an average density of one pair YCR per 13.5 ha. Mated pairs had territories ranging in sized from 0.13 to 1.62 ha (avg. 0.83 ha). Todd found densities of 2.06 rail pair/ha at Mittry Lake. Isolated sloughs on the Gila River occupied by YCR ranged in size from 0.12 to 3.63 ha. Todd (1986) concludes that most YCR-occupied riverine sloughs on the Colorado River are less than 1.41 ha each.

Project Effects on Yuma Clapper Rail

There is no suitable rail nesting habitat in the project vicinity. The steep armored shorelines have scattered clumps of cattails. Actively eroding areas are devoid of vegetation. An isolated stand of cattail approximately 0.22 acres (0.097 ha) is found on the pointbar. The pointbar cattail stand is smaller than the smallest reported territory size for Colorado River YCR, and much smaller than the reported marsh patches or sloughs used by YCR. Steep shorelines, high water velocities and lack of backwaters in the project area provide few opportunities for emergent vegetation (e.g. marsh) that is typical of rail habitat. Marsh vegetation in the project area occurs in small, scattered patches and linear strips and do not provide the area, diversity or depth of cover that rails need for nesting. Given the observed density of breeding YCR and territory sizes of nesting pairs on the Colorado River (discussed above), Reclamation concludes that there is likely no nesting YCR in the project area.

Individual adult or juvenile rails may use shoreline vegetation in the project area for foraging or in traveling from suitable habitat up or downstream. Individual rails may occasionally forage on the shoreline. These uses are transitory in nature and are likely rare occurrences given the lack of suitable cover or forage habitat. Project effects on these rails may include temporary disturbance as passing rails avoid the noise of the project area.

Temporary effects of increased sediment downstream are unlikely to adversely affect any YCR habitat. Sediment will be deposited in calmer waters downstream, contributing to marsh habitats.

Reclamation concludes that the project may affect, but will not adversely affect Yuma Clapper Rail. No critical habitat is designated for this species, thus none will be affected.

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EXHIBIT A - PHOTOGRAPHS

Biological Assessment
Palo Verde Training Structure

Photographs dated January 4, 2005 unless otherwise noted.

1. View west from AZ shore of Colorado River channel during annual low water. Rock (center) is old weir diversion that was replaced by present Palo Verde Diversion dam, located downstream (off photo-left). Channel bottom is predominantly sand. Foreground pool is eddy-carved from "AZ Spur". Yellow arrow is abandoned irrigation diversion canal intake (e.g. "Backwater" of Marsh 2004 study).

2. Pointbar in channel viewing toward AZ shore. Dark silt layer indicates low velocity flows near wetlands and ability of vegetation to trap sediment. Underlying unstratified sand layer indicates high velocity flow event that deposited sandbar. Exposed bank on bar is about 6 ft. high above water surface. Normally this area is flooded to obvious high water line.

3. View of pointbar (same as 2. above) during normal highwater flows. Only the emergent vegetation is above water. Photograph date 25 Oct. 2005.

4. View upstream of channel and sandbar during low water, CA shore in distance. Dark silt layer overlays thick sand forming bar. Silt layer (ca. 1 ft. thick) indicates modest flows in shallows over sandbar and current attenuation by wetland plants. Note deeper main channel to left, about 6 ft. below sandbar elevation (annual low-water).

5. Viewing upstream along AZ shoreline (riprap), sandbar is center left. High velocity channel along shore is over bottom of scoured, course sand. Note lack of channel diversity and smooth river bed, indicative of high velocity flows. Steep rip-rapped banks are typical.

6. AZ shoreline view of channel bottom looking downstream toward Palo Verde Dam. This area normally under 8 to 10 ft. of water. Note flat, sandy bottom and steep rip-rapped shoreline.

7. Slumped rip-rap on CA shoreline observed 1/4/2005, indicating steep banks and rapid erosion. Dam is visible in distance (upper right).

EXHIBIT B - RAZORBACK SUCKER SURVEYS

Biological Assessment
Palo Verde Training Structure

Razorback sucker surveys above Palo Verde Dam

CRIT Trip Report : 1 mile reach upstream of Palo Verde Diversion Dam,

Parker Division
7-9 June, 2004
28-30 June, 2004

Prepared by

Darren J. Thornbrugh and Jason D. Schooley

Submitted by

Paul C. Marsh

Arizona State University

Tempe, Arizona 85287-4501

Permit Number: 2004004

Arizona State University,

Colorado River Indian Tribes

Department of Fish & Game

and

U.S. Bureau of Reclamation

Yuma, Arizona 85366

July 19, 2004

Summary

A fish survey was conducted on portions of the 1.6 km reach upstream of Palo Verde Diversion Dam, Parker Division on June 7-9 and June 28-29 2004 for the presence of razorback suckers *Xyrauchen texanus.* The study area included the 1 river mile reach directly upstream of Palo Verde Diversion Dam, located at approximately river mile (RM)[1] 134 on the Colorado River and any accessible backwaters and interconnected channels. Methods were boat electrofishing and trammel netting, resulting in contact with a total of 517 fish representing at least 10 species. No native species were contacted during this survey.

Introduction

Razorback suckers have been repatriated to the lower Colorado River for more than 20 years, but stocking has recently been accelerated to meet requirements of a U.S. Fish and Wildlife Service Biological Opinion of lower river operations (USFWS 1997). Moreover, monitoring of these fish has been largely sporadic and incidental to sport-fish related activities. The purpose of this work was to conduct a fish survey targeting the contact of razorback suckers in the approximate 1.6 km reach directly upstream of Palo Verde Diversion Dam. The intention was to sample the main channel and all watercraft-accessible backwaters and side channels at least twice during the permitted period to assess presence or absence of the target species. The sample area consists of mostly the main channel with one large backwater (Fig. 1). The backwater is located on the California side about 0.4 km up river from the buoy line that protects the upstream entrance to the diversion dam spillway. It is approximately 25 meters wide, 400 meters long and 1 to 2 meters deep. The main Colorado River channel is approximately 200 to 260 meters wide and can be as deep as 15 meters in the 1.6 km sample reach. Main channel habitat sampled was primarily near shore in eddies and around a sand bar island that had a shallow area directly to the east. Most of the areas sampled were not deeper than 5 meters.

Methods

Sampling methods were boat electrofishing and trammel netting. Electrofishing (Smith-Root VVP-15 and CADFG Smith-Root) was conducted during evening and nighttime. Visual observations of habitat quality[2] were recorded for the main channel and backwater.

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[1] River miles are measured upstream from the Southerly International Boundary near San Luis, Arizona.
[2] Habitat observations include factors such as water depth, temperature, flow, turbidity, cover, and both aquatic and riparian vegetative communities.

Trammel nets (46 x 1.8 m x 3.8 cm mesh) were set in the evening, fished overnight, and retrieved the following day. Net set locations were chosen based on water depth (>1.5 m) and habitat (proximal to cover but free of submerged obstacles or debris). Net sites generally were in backwaters and eddies off main channel. Sets were in remote, slightly inaccessible locations. Nominal time for setting nets was 1930 hrs and removal was over a range of times depending on catch.

All fish were identified to species when possible and counted by life stage (age-0 [young-of-year plus small bodied species such as red shiner, mosquitofish, and mollies] and age-1+ [adult]) and method of capture. When applicable, native fish were individually measured (total length [TL], in cm), scanned for coded wire tag (CWT) or passive integrated transponder (PIT) tag, sexed (male, female, juvenile, and unknown [for adults for which gender could not be reliably determined]), and examined for general health and condition. A PIT tag was implanted into the abdominal cavity of natives if none was present, and all fish were released near the site of capture

Results and Discussion

Electrofishing and trammel netting combined yielded a total of 517 fish representing at least 10 species (Table 1). Bluegill sunfish accounted for about 27% of the total catch and was the most abundant variety overall, followed by common carp (22%), redear sunfish (16%), largemouth bass (13%), smallmouth bass (11%), and channel catfish and *Lepomis* sp. (juvenile sunfishes that could not reliably be assigned to species) (each 4%). Other species each contributed to < 2% of the total catch.

<u>Electrofishing:</u> A total of 8389 sec. real time (140 min.) of boat electrofishing resulted in contact with 302 fish representing at least 9 species (Table 1). Average catch rate was 36 fish per 1000 sec. Bluegill sunfish were most abundant (38%), followed by redear sunfish, smallmouth bass, largemouth bass, and *Lepomis sp.* Other species each comprised < 3% of the electrofishing catch.

The electrical field was observed as effective to a maximum depth of about 1.5 m. Field strength was not electronically measured. Before each electrofishing effort, we measured electrical conductivity and total dissolved solids (TDS) for later analysis (Table 2). Shocking began nightly at about 2000 hrs and concluded at various times thereafter.

Trammel Netting: A total of twenty 45.7 m and four 91.5 m overnight trammel net sets resulted in contact with 215 fish representing at least 7 species (Table 1). Catch averaged 9 fish per net and ranged from 1 to 32 for the 45.7 m trammel net sets. The average catch for the 91.5-m trammel net sets was 11 fish per net with a range from 1 to 33. Common carp was the most abundant species (47%), followed by redear sunfish, bluegill sunfish, largemouth bass, smallmouth bass and channel catfish. Other species each comprised < 3% of the total trammel net catch.

Average trammel netting depth was 1.5 meters in the backwater and 5 meters in the main channel. Nets were retrieved between 06:15 and 08:51 hrs and the average total net removal time was 01.5 hrs. Each trammel net fished on average for 11.8 hrs.

The single backwater navigable with a 5.5-m, flat bottom boat within the study area was sampled by our selected methods. Sampling provided contact with enough fish to reliably describe species composition in the area. A thorough effort was made to sample and explore the available study area in the allotted time.

Acknowledgements

Thanks to Charley Land, Colorado River Indian Tribe Department of Fish & Game Parker, for his coordination and assistance on these survey trips. Thanks to Jeff Lantow, USBR Boulder City, for his assistance on this survey. Due to the malfunction of our electrofishing boat, special thanks go to Joe Millosovich, Dave Baker, and Brad Crone, CADFG, for letting us borrow their electrofishing boat, and for technical assistance to help us complete the electrofishing portion of this survey.

Literature Cited

USFWS. 1997. Final Biological and Conference Opinion on lower Colorado River operations and maintenance – Lake Mead to Southerly International boundary. U.S. Fish and Wildlife Service, Albuquerque NM. 196 pages.

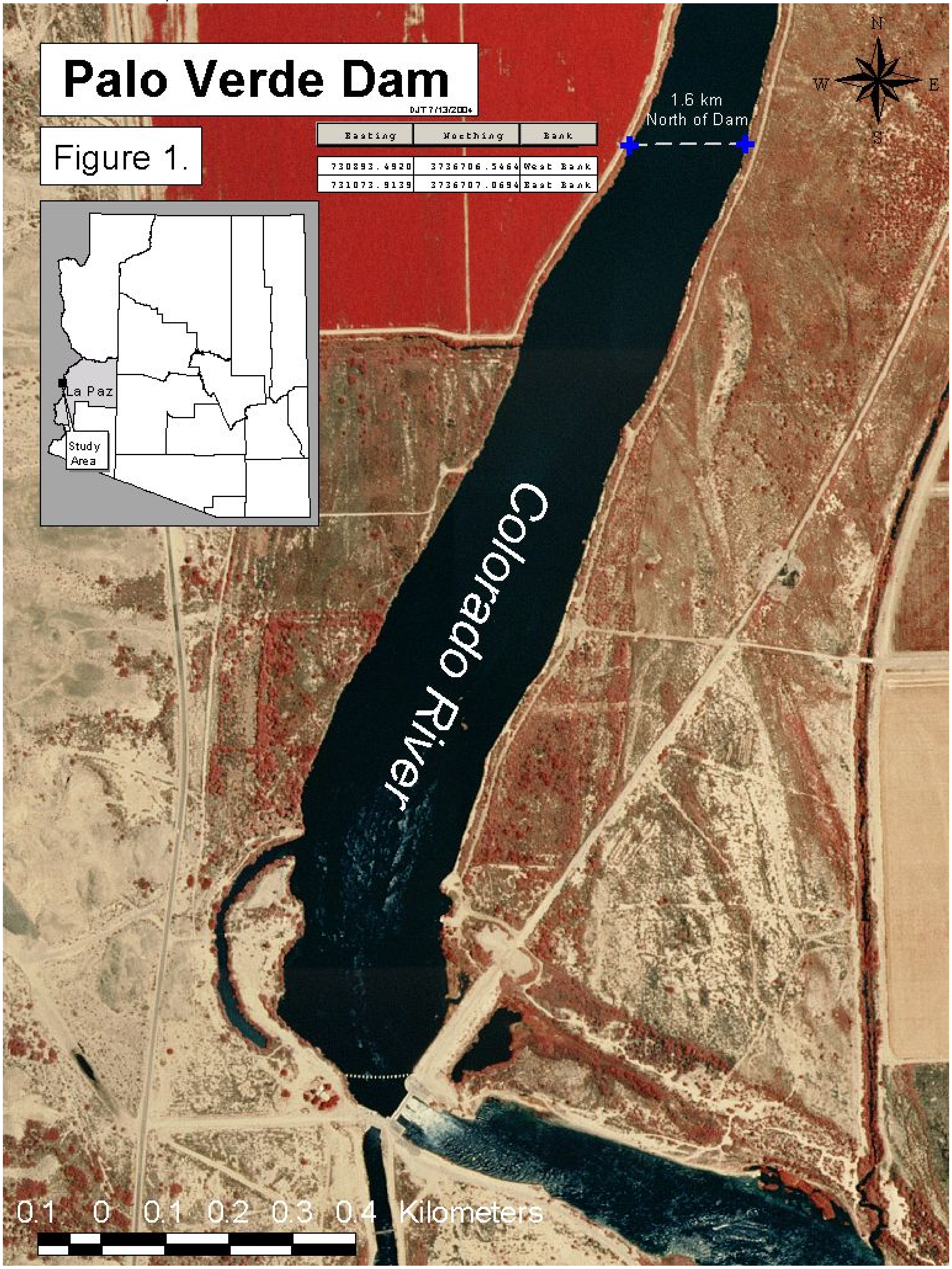
Table 1. Numbers of fish captured by electrofishing and trammel netting, total number caught, and proportion of total catch. Palo Verde Dam, lower Colorado River. June 7-9 and June 28-29 2004.

Species	Age	# Netted	# Shocked	Total	% of Catch
Cyprinus carpio	1	102	12	114	22%
Dorosoma petenense	0	0	1	1	<1%
Ictalurus punctatus	1	18	5	23	4%
Lepomis cyanellus	1	0	7	7	1%
Lepomis macrochirus	1	25	116	141	27%
Lepomis microlophus	1	29	54	83	16%
Lepomis sp.	0	0	20	20	4%
Micropterus dolomieu	0	0	19	19	4%
Micropterus dolomieu	1	17	17	34	7%
Micropterus salmoides	0	0	28	28	5%
Micropterus salmoides	1	20	22	42	8%
Pomoxis nigromaculatis	1	0	1	1	<1%
Pylodictis olivaris	1	4	0	4	1%
Totals		**215**	**302**	**517**	

Table 2. Locality, date, time, temperature, electrical conductivity and total dissolved solids (TDS), lower Colorado River. June 7-9 and June 28-29 2004.

Locality	Date	Time	Surface Temp. (°C)	Conductivity (µS/cm)	TDS (ppm)
Palo Verde Dam CA backwater	6/7/2004	19:50	22	2184	907
Palo Verde Dam main channel	6/8/2004	20:10	22	2205	1102
Palo Verde Dam CA backwater	6/28/2004	20:00	23	2355	1183

Figure 1. Palo Verde Diversion Dam study area. June 7-9 and June 28-29 2004. Lower Colorado River, Parker Division.



Appendix B - Environmental Commitments

ENVIRONMENTAL COMMITMENTS
for
Bankline Stabilization above Palo Verde Dam

Reclamation is committed to avoiding and/or minimizing environmental impacts from implementation of the proposed action through adherence to and applications of the following commitments.

1. During earthwork, vehicle traffic, and quarrying, water trucks would periodically spray disturbed areas to minimize fugitive dust emissions.

2. All equipment and vehicles shall be equipped with the best available pollution controls, including exhaust systems and noise abatement devices.

3. The following methods will be implemented in order to minimize and mitigate potential effects to desert tortoise and their habitat:
    - A biological monitor will be assigned to the project. The biological monitor will be responsible for ensuring mitigation compliance and surveying prior to the start of activities in the quarry and along the access road.
    - Everyone working on-site will be required to attend a project specific desert tortoise presentation.
    - A 25 mph speed limit will be enforced within the desert tortoise habitat.
    - Construction within the desert tortoise active period (March 1 through November 1) will require an on-site biological monitor.
    - Unauthorized vehicle use and cross-country travel will be restricted.
    - All construction will take place in previously disturbed areas.
    - No new roads will be constructed.
    - Refuge will be stored in predator proof receptacles.

4. If artifacts or other evidence of potential cultural or historic resources are discovered during ground disturbance, all work shall immediately halt. The site supervisor shall contact Reclamation's regional archaeological staff at (702) 293- 8705 and the CRIT Tribal Museum at Parker (928) 669-9211 for guidance on how to proceed.

5. A Spill Prevention, Control, and Countermeasures Plan shall be required of contractors for Reclamation approval prior to implementation of the proposed action.

6. Reclamation has prepared a conceptual mitigation plan (Reclamation 2005b), in accordance with 404 permit requirements, that details the

Appendix C - Alternatives Analysis, CWA 404 (b) (1)

Alternatives Analysis for Palo Verde Training Structure, Lower Colorado River Clean Water Act Section 404 (b.) (1.) U.S. Army Corps of Engineers Permit No. 2003-00810-MB

1.0 Introduction

There is significant erosion and migration of the Colorado River Channel upstream of Palo Verde Dam, continued westward migration of the river channel will eventually impact the safety of the dam. Hydraulic modeling of the river in the present condition indicates that erosion will continue and that several powerful eddies will remain upstream of the dam (Reclamation 2004). Water velocities in the channel upstream of the dam are very high at normal to high flows (19,000 and 42,000 cfs, Reclamation 2004). The present channel configuration directs flows against the California (CA) shore, creating erosion of the shoreline as the river meanders. A pointbar forming on the inside of the river bend exacerbates the deflection of current against the CA shore and forces a high velocity current onto the AZ shore as well.

1.1 Purpose and Need

The purpose of the proposed project is to entrain Colorado River flows in the existing channel immediately upstream of the Palo Verde Dam to limit erosion threatening the dam. The project objectives are to provide a long-term, viable solution that: (1) entrains flows in the center of the present river channel; (2) removes or diminishes the pointbar and reduces sediment deposition there; (3) prevents additional erosion of the river bankline; and (4) protects the earthen embankment of the dam.

To be practicable[1], the project selected must provide:

- Modification of water flow effects (e.g. hydraulics) on the river channel that are detrimental to the dam and its supporting structures. Thus, the proposed action is water dependent (40 CFR 230.10 (a.) (3.)).

- Long-term and sustained effects on the river's flows, minimizing maintenance or repeated short-term solutions.

[1] U.S. Army Corps of Engineers defines the term **practicable** to mean "available and capable of being done after taking into consideration cost, existing technology, and logistics in light of overall project purposes." (40 CFR Part 230.3).

- Ease and economy of construction using existing, locally obtainable materials and construction methods available to Reclamation.

- Economic maintenance within the capability of Reclamation.

- Limited consumption of land resources and space.

This project is needed to prevent the eventual erosion of the dam through river meander processes:

> *"The predicted velocity magnitude at the water surface is plotted in Figure 9 for the Baseline Case and Case I with the flow discharge of 19,000 cfs. The same results are also displayed in 3D perspective views in Figure 10. It is clearly shown that the flow under existing conditions undergoes the typical pattern of the bend flow near the Diversion Dam (designated as the bend region or point bar region). Presence of the point bar on the left bank 'forces' the water to flow mainly on the right bank which forms a bend. This flow pattern is the main cause for accelerated California side bank erosion observed in aerial photos of Figure 2."* [Reclamation 2004]

Protection of the dam will maintain an irrigation diversion structure and prevent loss of tribal land by erosion. If the dam is breached or the river outflanks the dam, there would be severe impacts to downstream users. The Colorado River Indian Tribes (CRIT) have already lost approximately 12 acres of tribal land in CA ("Scallop" **Figure 1**) because of erosion and more land will be lost as the pointbar has continued to enlarge. A second incipient "scallop" is forming on the CA bankline upstream of the first.

2. 0 Alternatives Evaluation

A variety of design alternatives were considered and examined against the project purpose and need including the practicable criteria (above). Reclamation civil engineers and hydraulic engineers reviewed each alternative against the project criteria to select a preferred alternative (Exhibit A). A few of the alternatives were extensively evaluated through 3-dimensional hydraulic modeling by Reclamation's Technical Services Center (Exhibit B: Reclamation 2004). Engineers from U.S. Army Corps of Engineers evaluated the hydraulic model used to evaluate some of the project alternatives.

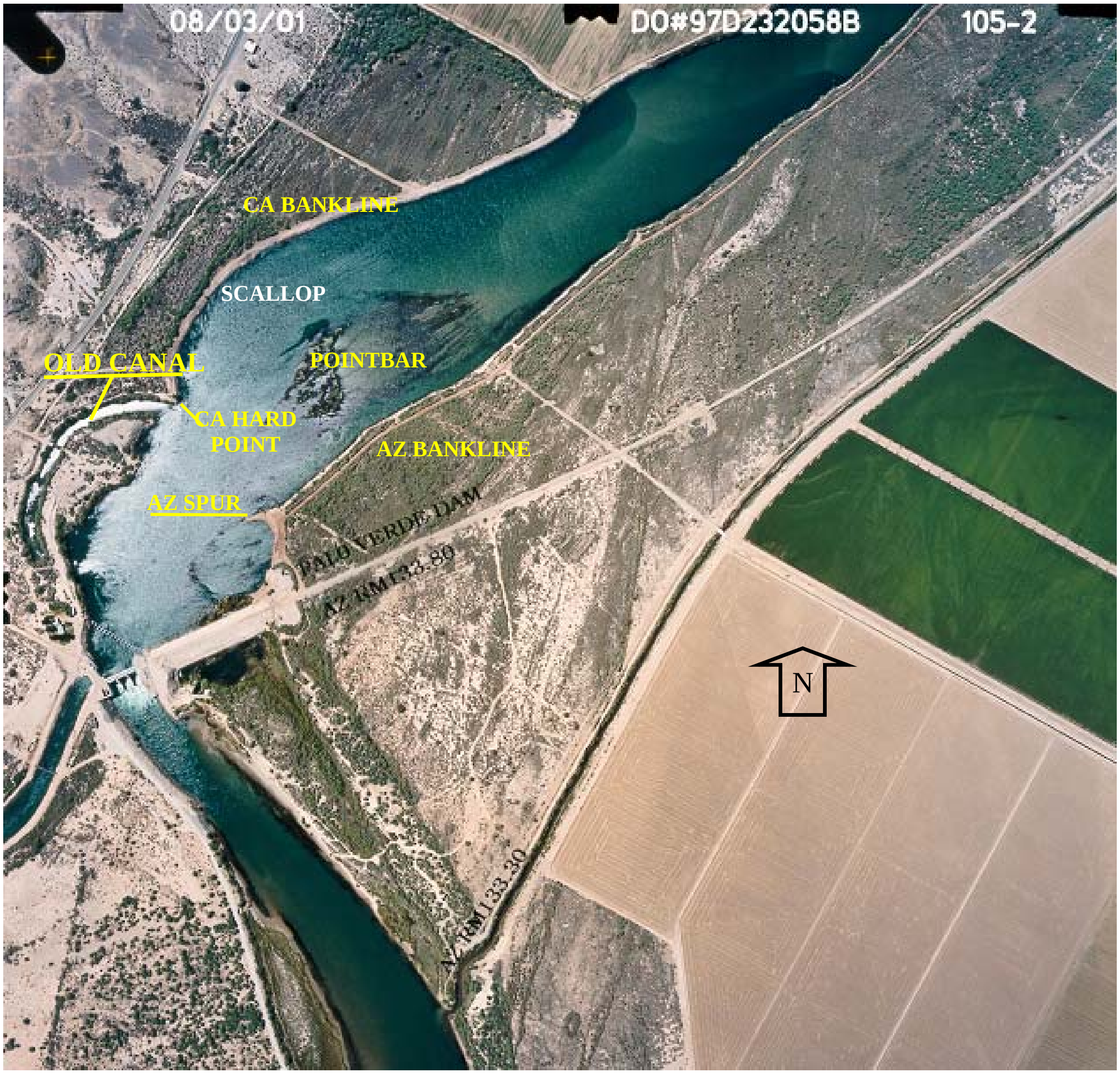


Figure 1. Palo Verde Diversion Dam on the Colorado River. Channel and shoreline features discussed in the text are identified. Aerial photograph dated August 3, 2001.

A number of alternatives evaluated were found to not meet one or more of the project requirements, stated above. Rejected alternatives are discussed below in two categories; those that didn't meet the purpose and need and those meeting purpose and need but were rejected due to practicable concerns. Refer to **Figure 1** for river and shoreline features discussed herein.

2.1 Alternatives Not Meeting Purpose and Need

No-Action: This alternative avoids placement of fill in jurisdictional waters of the U.S. The no-action alternative does not meet the project purpose and need, in that it fails to prevent further erosion and will not protect the dam footings. This alternative does not eliminate or reduce further erosion of land resources. The frequency of stop-gap rip-rap placement (Exhibit A) indicates the futility of this option.

Two CA jetties, armor CA hard point and AZ spur**:** This alternative includes construction of two "bumper' jetties upstream of the scallop on the CA bank and riprap armoring of the CA hard point and AZ spur. This alternative fails to alter the hydraulic conditions creating bank erosion, and may create another eddy in the river channel upstream of the pointbar, increasing erosion (Reclamation 2004).

> *"The proposed two jetties upstream of the training structure are predicted to cause high flow along the left bank, potentially leading to local bank erosion. In addition, the jetties lead to sinuous (meandering) motion downstream of the river once the point bar near the proposed training structure is eroded. Such motion could result in further erosion and deposition in the river reach having a negative impact on the training structure and river banks."* [from Reclamation 2004]

Bankline armor, AZ spur and CA hard point armoring. This alternative consists of reinforcing the CA bank with riprap, armoring the AZ spur and CA hard point (**Figure 1**). This alternative does not meet the project objectives as it fails to alter the hydraulic conditions creating bank erosion and does not provide a long-term solution to erosion and dam failure (Exhibits A and B):

> *"Presence of the point bar on the left bank 'forces' the water to flow mainly on the right bank which forms a bend. This flow pattern is the main cause for accelerated California side bank erosion observed in aerial photos of Figure 2. The bulk flow velocity (i.e., the cross-sectional area weighted velocity) in the bend region is in the neighborhood of 5.0 ft/s, while flow at the point bar is almost stagnant. This estimated 5.0 ft/s velocity at the discharge of 19,000 cfs should be taken into consideration if riprap is to be used instead of the proposed training structure;"* [from Reclamation 2004]

With the high velocity flows (see model, Exhibit B), bank armor will be undercut and constantly erode, requiring frequent maintenance. The alternative fails to adequately protect the dam footing by allowing continued erosion on each shoreline. Frequent maintenance of eroding bank armor is not economical in materials or labor.

Bankline armor, AZ spur and CA hardpoint armoring; dredging of pointbar. This alternative consists of reinforcing the CA bank with riprap, armoring the AZ spur and CA hardpoint and dredging of the pointbar (**Figure 1**). This alternative did not meet the project objectives as it fails to alter the hydraulic conditions creating bank erosion and does not provide a long-term solution to erosion and dam failure. Despite bank armor, high flow velocities directed at the CA shore (Reclamation 2004) will erode the bank and build a pointbar. The pointbar will require periodic dredging to maintain the channel. The alternative fails to adequately protect the dam footing by allowing continued erosion on each shoreline. Frequent maintenance of eroding bank armor and frequent dredging is not economical in materials or labor.

Pointbar dredging, armor of CA hard point and AZ spur: This alternative includes dredging of the pointbar, riprap armoring of the CA hard point and AZ spur. This alternative did not meet the project objectives as it fails to alter the hydraulic conditions creating bank erosion and does not provide a long-term solution to erosion and dam failure. This alternative does not alter the high velocity flows directed at the CA shore or attenuate velocities in a long-term manner. It fails to adequately protect the dam footing by allowing continued erosion on each shoreline. Periodic dredging will be required, not meeting the long-term and economic maintenance criteria.

Training structure, CA bank jetties, bank armor, point and spur armor, and dredging of the pointbar. This alternative included construction of a training structure, 2 jetties on the CA bank upstream of the training structure, bankline armoring on CA bank, armoring of the AZ spur, armoring the CA hardpoint downstream of the training structure and dredging of the pointbar. This alternative was not economical in construction effort or materials. Hydraulic modeling revealed that this alternative had the potential to create an increase in river meander processes upstream of the training structure due to current deflection (e.g. eddy) by the upstream jetties (Reclamation 2004, Figures 16 and 17 (b.)).

2.2 Alternatives Meeting the Purpose and Need but Not Practicable

Six L-jetties, armor CA bank, armor AZ spur, armor CA point. This alternative included construction of six L-shaped jetties on the CA side along the scallop, armoring of CA bank, the CA hard point and AZ spur. Dredging of the pointbar was not included. This alternative meets the project objectives. This alternative was not economical to construct or maintain and requires considerable land and material resources for construction. This alternative is about 1.5 times the cost to construct of the preferred alternative (Exhibit A). The alternative also occupies more area of the CA shore consuming more land resource. Thus, the alternative is not considered practicable.

Sheetpile and riprap CA shoreline “in dry”. This alternative includes construction of a temporary sheetpile wall to de-water the shoreline and construction of riprap with a filter layer along the CA shore. The filter layer prevents loss of fines from beneath the riprap that result in slumping of the riprap. A temporary sheetpile wall with site de-watering is the only way to construct a lasting riprap protection for a steep bank subject to high flow velocities. This alternative meets the purpose and need, however is not practicable compared to others. This alternative is more expensive to construct, about 3 times the cost of the preferred alternative (Exhibit A). It also consumes more land on the CA side. Thus this alternative does not meet the practicable criteria of construction economy and land and resource consumption.

Sheetpile CA shoreline with riprap. This alternative includes construction of permanent sheetpile along the CA shoreline with a riprap cap (Exhibit A). This alternative meets the purpose and need. However, the alternative is not considered practicable. This alternative would be difficult to construct due to the problem of driving sheetpile into the previously placed riprap. Costs of this alternative are very high and similar to the temporary sheetpile alternative, above. Construction of this alternative behind existing riprap would consume more land area. The high construction costs, land consumption and resulting sheer bank that limit any shoreline vegetation establishment are the reasons this alternative was rejected.

2.3 Preferred Alternative

Phased construction of a rock training structure, AZ spur and CA hard point armor, and dredging, if needed, of the pointbar. This alternative includes three phases: construction of a rock training structure from the CA shoreline extending into mid-channel to move flows away from the CA shore and toward mid-channel, armoring of the two points if indicated by observed erosion, and dredging of the pointbar if it is not removed within two years as a result of river flow shifts. This alternative modifies river hydraulics, moving the flow vector away from the CA shoreline and into mid-channel (Reclamation 2004).

The change in current flow is expected to erode the pointbar over time; however the bar will be dredged if it remains after two years following construction of the training structure. This alternative does not occupy as much shoreline as the alternatives above, thus is conservative of land resources. This alternative does not limit shoreline vegetation development or use as does the sheetpile or six L-jetty alternatives above. This alternative costs the least to construct of the alternatives that meet the purpose and need (Exhibit A).

2.3.1 Wetland Impacts

Impacts of the preferred alternative on jurisdictional waters of the U.S., including special aquatic sites, are addressed in the Mitigation and Monitoring Plan (Reclamation 2004b). Approximately 0.22 acres of cattail colonizing the pointbar will be lost as the pointbar erodes or is dredged. This impact will be mitigated by construction of about 0.66 acres of new cattail marsh in the old diversion channel just downstream of the CA point (**Figure 1**, old channel). The old channel provides suitable hydrology for wetlands and the created wetland will be protected from the main channel of the river. The mitigation site is in the project area, providing local replacement of wetland functions and values. There are no other special aquatic sites that will be affected by the proposed project, either directly or indirectly.

The project will not alter river flow volume or frequency, controlled by upstream dams and water orders. The project increases channel diversity, including the creation of calm water (e.g. low flow) habitats that are presently absent from the project area.

3.0 Discussion and Conclusions

A number of alternatives were considered to remedy the problem of erosion threatening the Palo Verde Diversion Dam and evaluated in light of the project purpose and need and practicable criteria. The alternative that emerges from the analysis; a rock training structure, point armoring and potential dredging, meets the purpose and need and satisfies all of the practicable criteria. The selected alternative is water dependent due to the nature of the problem.

The preferred alternative accomplishes the project objectives:

- Alters channel hydraulics by diverting the flow vector away from the CA shoreline where it is eroding the shore,
- Provides long-term protection to the dam and footings by reducing and redirecting flows,
- Achieves the desired result in the most economic way,
- Conserves land resources (e.g. land occupied by the project) and does not limit shoreline use.

Of the alternatives that meet the project purpose and need, impacts of the proposed project are least with the preferred alternative, including land and fiscal resources and alteration of current land uses. The preferred alternative is the least damaging practicable solution to the problem identified.

4.0 References

Reclamation 2004. DRAFT Hydraulic Modeling and Analysis of the Proposed Palo Verde Dam Training Structure. Technical Report, Bureau of Reclamation Technical Service Center, Denver, Co.

EXHIBIT A

Reclamation Hydraulic Engineer
Alternatives Evaluation

23 February 2005

MEMORANDUM

To: Environmental and Hazardous Materials Group (Attn: Rex Wahl)

From: Scott Tincher P.E.
Hydraulic Engineer, Water Systems Engineering Group

Subject: Palo Verde Scallop Protection, Screening of Alternatives

This memorandum is intended to overview possible bank protection alternatives that could be utilized at the scallop upstream of the Palo Verde Dam site. It compares alternatives that provide the most beneficial and reasonable solution.

Support data were prepared by Mike Igoe, P.E., Jeff Sanderson from the Facilities Engineering Group, and Carl Karr from the Trucking and Hauling Group.

BANKLINE STABILIZATION OBJECTIVES

1. <u>Stop Bankline Erosion at the Scallop Upstream of Palo Verde Diversion Dam.</u>

One of the primary objectives is to prevent further bankline erosion at this location. Currently the bankline on the California side of the river is eroding relatively rapidly. The Colorado River Indian Tribes (CRIT) are losing land due to this erosion. If erosion in this area is not stopped, Highway 95, the Palo Verde Irrigation District (PVID) canal intake, and right abutment of the Palo Verde Dam will also be threatened. The current rate of erosion is estimated to be about 15 feet per year.[2]

2. <u>Improve Sediment Transport Capacity.</u>

Sediment deposition is one major factor contributing to bankline erosion. The small reservoir behind the reservoir acts as a sediment trap. Sediment has been depositing in this area since construction of the dam. A percentage of the sediment near the dam is flushed when the area is drained once a year for maintenance. However, some sediment has remained over time. Once widening starts, the area upstream of the dam looses additional sediment transport capacity and as a result becomes more depositional. This trend has caused the channel to migrate towards the west. It is believed that this trend has increased radically in the last couple years. Therefore, another significant objective of this project will be to reestablish transport capacity.

3. <u>Avoid Frequent Dredging/Sluice Sand Bar.</u>

A related objective is to avoid frequent dredging. It is believed that, even if the bankline is stabilized, without redirecting the flow toward the dam, the current

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[2] The rate of bank erosion is based on a loss of 11.8 acres along the 3000 ft length of the scallop during an 11 year period between 1994 and 2005.

channel geometry that has evolved just upstream of the dam will not maintain itself with yearly flushing. As a result, it is anticipated that dredging of the area will be required frequently.

4. <u>Align Flow Path.</u>
The Palo Verde Dam is situated on a historic bend. Therefore, it is not possible to align the predominant flow path with the channel downstream of the dam. However, directing the flow path toward the dam gates will help to prevent high velocity water from reaching the channel banks and focus that water energy in the center of the channel where scour is desired.

5. <u>Local Support.</u>
The selected alternative must be supported by the CRIT, since they own the land and desire an alternative which helps to reestablish the land that has been lost due to erosion. Without a design supported by the CRIT, implementation will not be possible.

6. <u>Environmental.</u>
The selected alternative needs to be the least environmentally damaging, practicable alternative given all considerations.

7. <u>Cost.</u>
The desire will be to select an alternative that satisfies, to the degree possible, all objectives for the least cost. However, an alternative with a higher cost may be selected if the added cost is justified by a significant improvement in satisfying objectives.

Each alternative considered here is rated on a -1 to 1 scale at 0.5 increments. Local support is considered a yes or no. To overcome a “no” in the local support column will require a substantial benefit in order for the alternative to survive screening. The final score for each alternative will be the sum of the ratings on each of the objectives.

ALTERNATIVES CONSIDERED

1. <u>Flow Deflection.</u>
Flow deflection is a means of redirecting high velocity flow away from erodible areas. There are different configurations that can be considered, but for this analysis straight spur jetties and L-shaped jetties were chosen. Two possible straight jetty alternatives are discussed here. The first is a set of two bumper jetties just upstream of the scallop area and the other is a set of three larger straight spurs within the scallop. The final jetty configuration discussed is an L-jetty configuration.

A. Bumper Jetties Upstream of Dam.

Two bumper jetties were considered on the right bank about 4,400 ft upstream of the Palo Verde Dam (Figure 1). The bumper jetties were intended to reduce flow velocity along the right bank of the river and, therefore, reduce erosion along the right bank.

Three dimensional modeling was performed on this alternative using Unsteady Unstructured Reynolds Averaged Navier-Stokes (U^2RANS). The results of this modeling indicate that, although flow is diverted from the right bank, it could cause additional erosion on the left or east bank of the river.

In addition, this alternative would not improve sediment transport capacity near the dam and has no local support. As a result, no further analysis was done on this alternative.

Objectives Assessment Summary – Bumper Jetties

1. Prevent Erosion	2. Increase Sed. Trans.	3. Decrease Dredge	4. Align Flow	5. Local Support	6. Non-Damaging	7. Cost	Total	Survive Screening?
0.5	0.0	0.0	-1.0	No	1.0	1.0	1.5 No	No

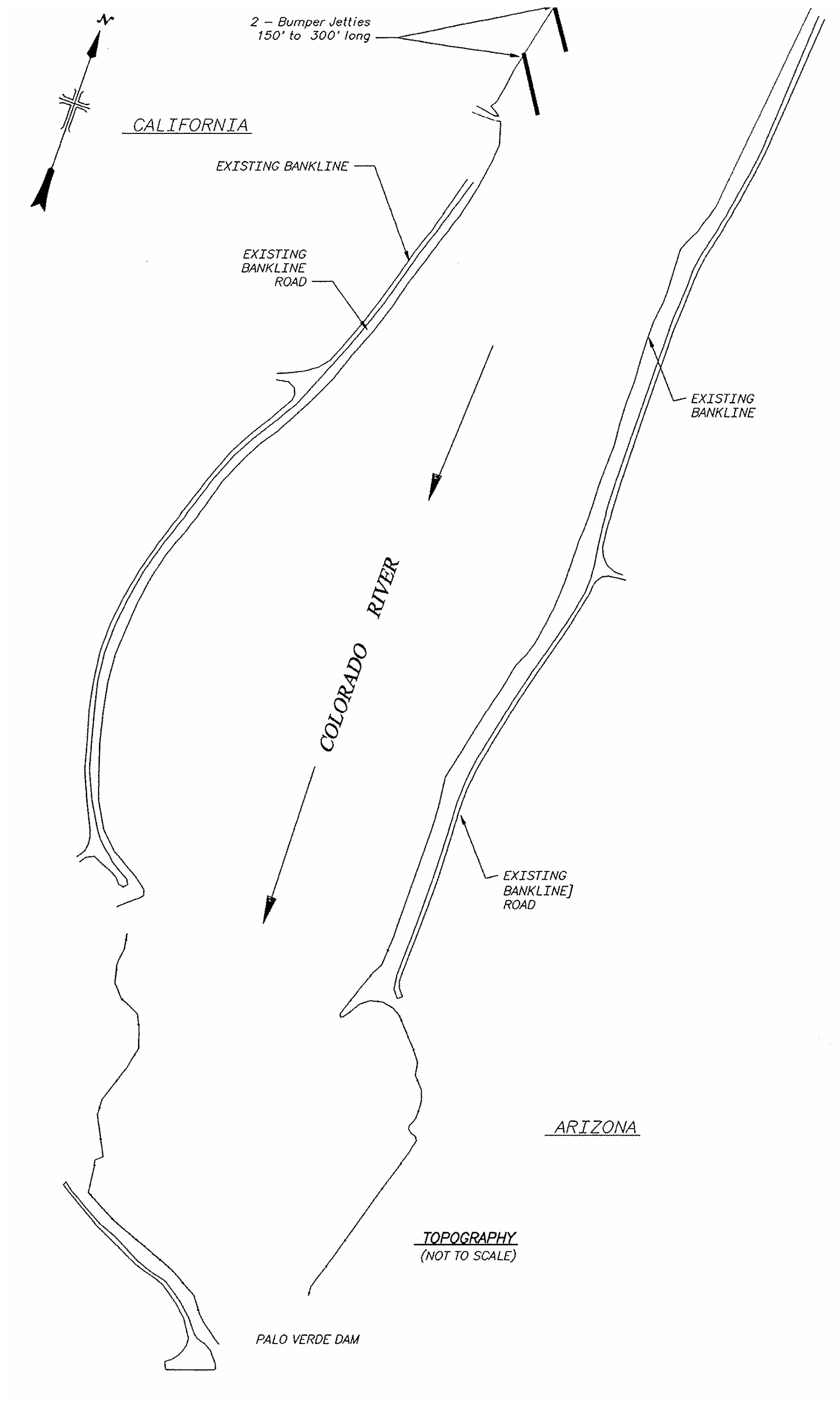


Figure 1. Bumper Jetties (Drwng # LB873OPT.DWG)

B. Three Spur Jetties

To address the current erosion of the west bankline, three spur jetties (Figure 2) were considered. The alignment of the jetty end points would approximate the former location of the river bankline, which would recreate pre-1994 hydraulic conditions. The jetties would be constructed of riprap (20 ft top width) and vary in length from 150 to 450 ft, depending upon the location in the scallop. The jetties would be designed to provide protection against future bankline erosion and improve river hydraulic conditions enough to discourage sediment deposition in the channel.

This alternative adequately achieves the objectives, but jetties tend to cause flow disturbances and turbulence near the upstream and downstream sides of each jetty. This could cause additional maintenance, but the magnitude of this potential problem is uncertain. This option was not modeled with U^2RANS, but it is anticipated that it would provide results approaching that of the training levee alternative. The transport capacity during normal summer flow conditions would not be as good as the training levee and, therefore, there would be a greater possibility dredging would be required.

There is a high probability that sediment would accumulate in the backwater areas of each spur jetty. Some of this accumulation could be near the Districts intake. Since the intake is elevated, there is little likelihood that sediment accumulating near the intake would appreciably effect the sediment concentration entering the PVID intake.

The cost was developed from quantities based on the cross section shown in Figure 3 and topography collected for the project. Total cost for this alternative is estimated to be about $610,000 as the breakdown summary shows in Attachment 1.

Objectives Assessment Summary – Three Spur Jetties

1. Prevent Erosion	2. Increase Sed. Trans.	3. Decrease Dredge	4. Align Flow	5. Local Support	6. Non-Damaging	7. Cost	Total	Survive Screening?
1.0	0.5	0.5	0.0	No	1.0	0.0	3.0 No	No

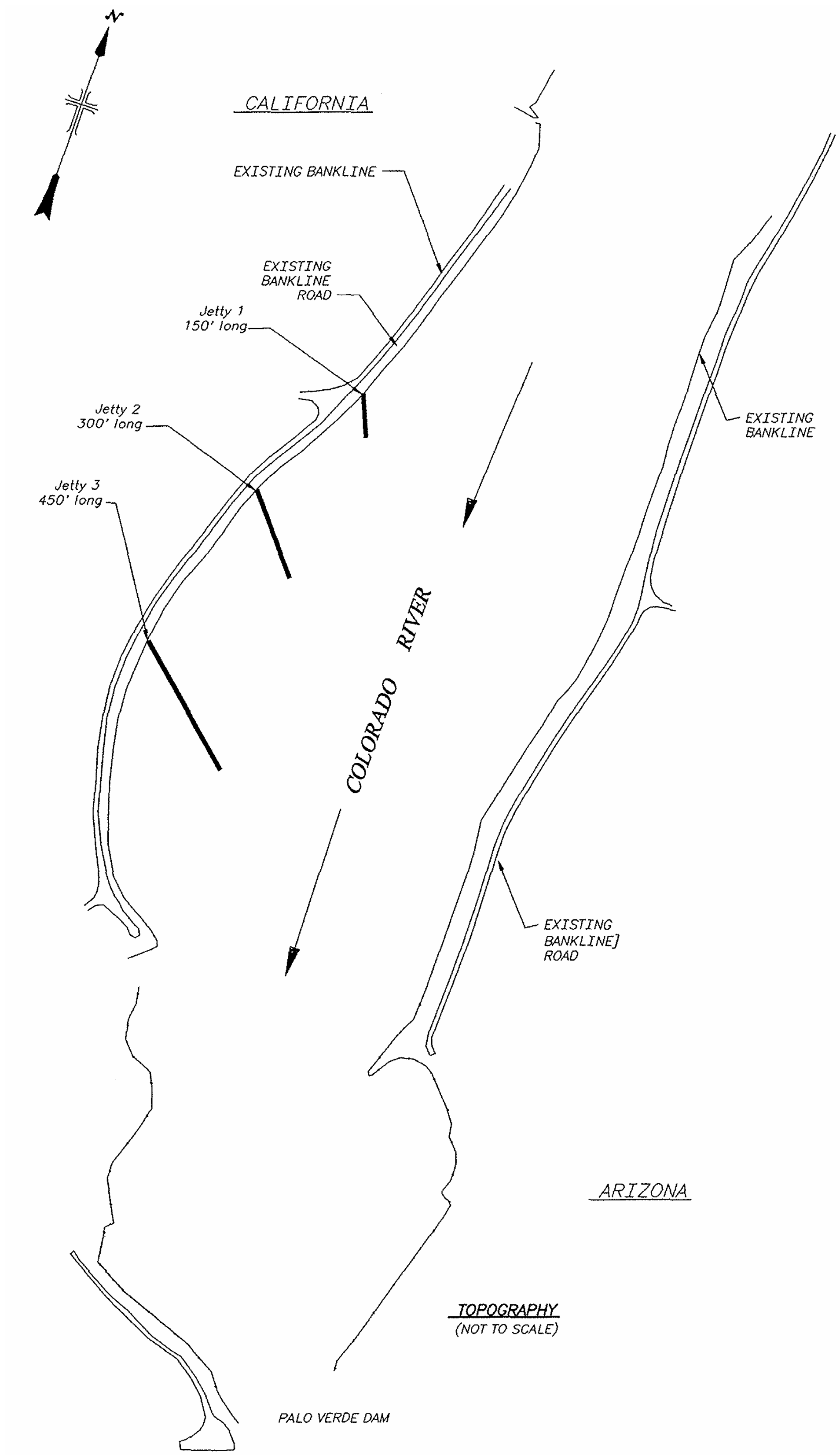


Figure 2. Three Spur Jetties (Drwng # LB873OPT.DWG)

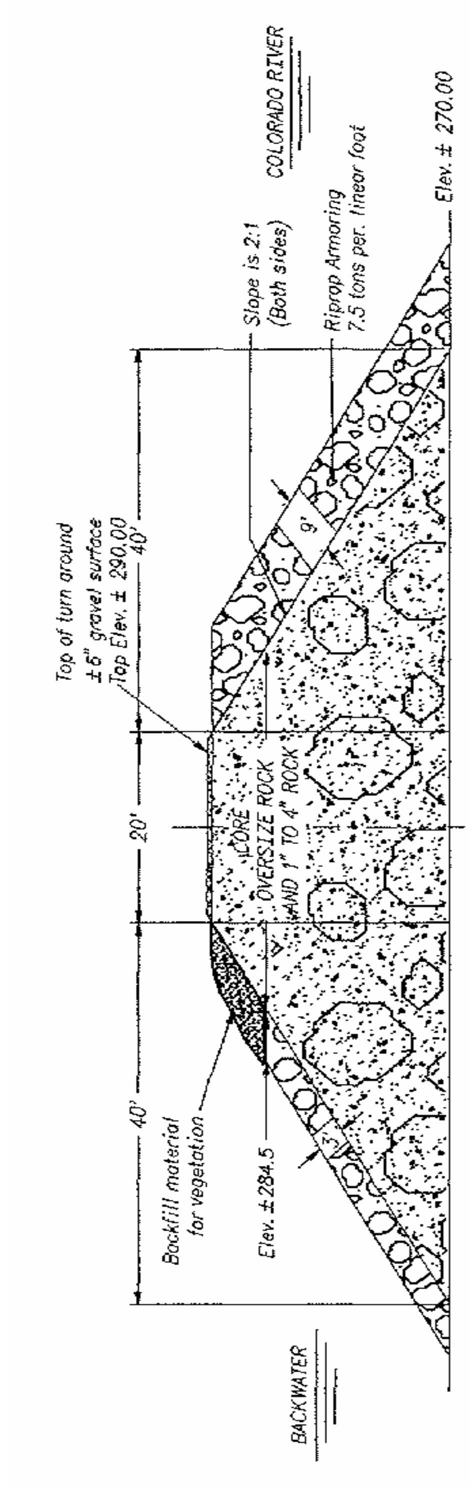


Figure 3. Typical Cross Section for Jetties and Training Levees
(Drwng # LB873OPT.DWG)

B. Six L-Jetties

This alternative expands on the straight jetty or spur dike solution. To improve sediment transport and flow alignment, three more jetties are added and each is extended along the original bankline alignment to form an L (Figure 4). The cross section of the L-jetties would be the same as that described for the straight jetties.

This alternative would improve transport capacity and improve the flow alignment, but is more expensive than other alternatives considered. This version of a spur dike solution provides nearly the same hydraulic benefits of a continuous training levee, but is about 1.3 times the cost.

The cost was developed from quantities based on the cross section shown in Figure 3 and topography collected for the project. Total cost for this alternative is estimated to be about $980,000 as the breakdown summary shows in Attachment 2.

Objectives Assessment Summary – L-Jetties

1. Prevent Erosion	2. Increase Sed. Trans.	3. Decrease Dredge	4. Align Flow	5. Local Support	6. Non-Damaging	7. Cost	Total	Survive Screening?
1.0	1.0	1.0	1.0	No	0.5	-0.5	4.0 No	No

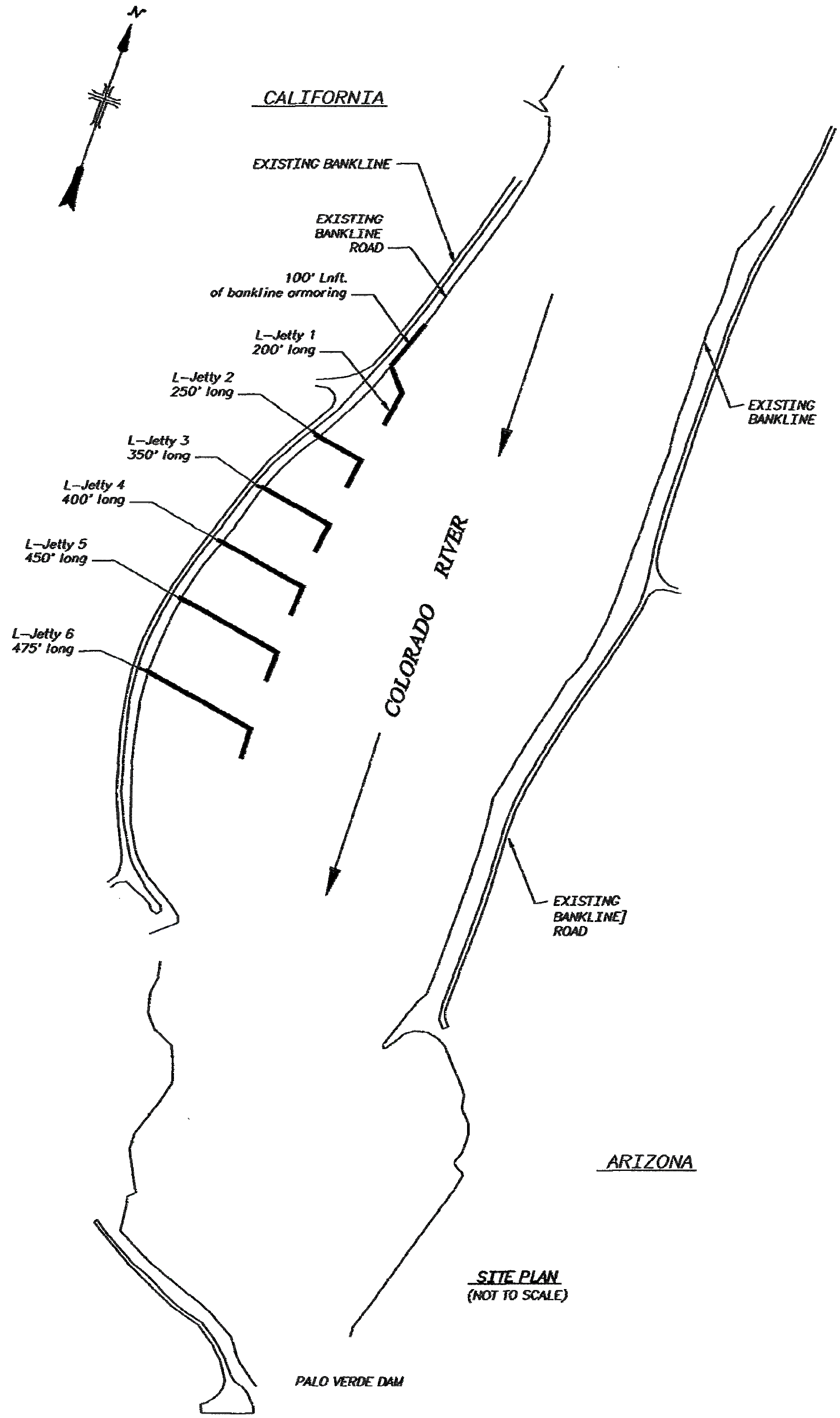


Figure 4. L-Jetties (Drwng # LB873OPT.DWG)

2. Bank Cover Protection.

The typical protection used for bank cover on the Colorado River is riprap. Riprap has been installed on the scallop for several years without success. The primary problem with the site is that the entire bank cannot be easily accessed. During 95% of year the pool elevation in the reservoir is at 283 feet elevation using the National Geodetic Vertical Datum (NGVD). The toe of the slope is near elevation 270 feet.

A potential alternative that was discussed was geotechnical soil stabilization. The process used would be similar to that used for constructing slurry barriers in levees. A trench could be dug behind the existing bank and concrete would be mixed with the native soil to create a soil slurry. The slurry would then be used to backfill the trench. This is not a typical means of providing bank stabilization and has some of the same drawbacks as driving sheetpiles behind the existing bankline and was therefore screened from consideration.

A. End Dump Riprap

To date all riprap installed on the bank has been dumped on the bank. The edge-of-bank elevation is at approximately 290 feet and the bank slope is between 0.75 and 1.75-horizontal foot to 1-vertical foot (0.75 and 1.75 to 1). The natural stability of a sand bank is near 1.5 to 1 and the steepest slope recommended for riprap is the 1.5 to 1.

To prevent the soil behind the rock from being pulled into the stream flow, a filter is required. The filter can be a Geotextile or finer grain rock such as gravel. With riprap dumped into 13 feet of moving water, applying a filter layer is not possible. To provide some filter effect, the Bureau of Reclamation leaves some fines and gravel size material in the riprap and covers the bank with a layer thicker than would normally be necessary. This type of installation has been implemented for decades and has performed well in most locations. However, when there is erosion at the toe or aggressive bank erosion, this technique can fail. In this particular instance this method of bank stabilization has and will continue to fail.

The following chart (Figure 5) shows the labor and equipment cost to maintain the scallop area since 1997. The effort to maintain the bank is generally increasing over time. Since 1997, $113,000 has been spent on labor and equipment.

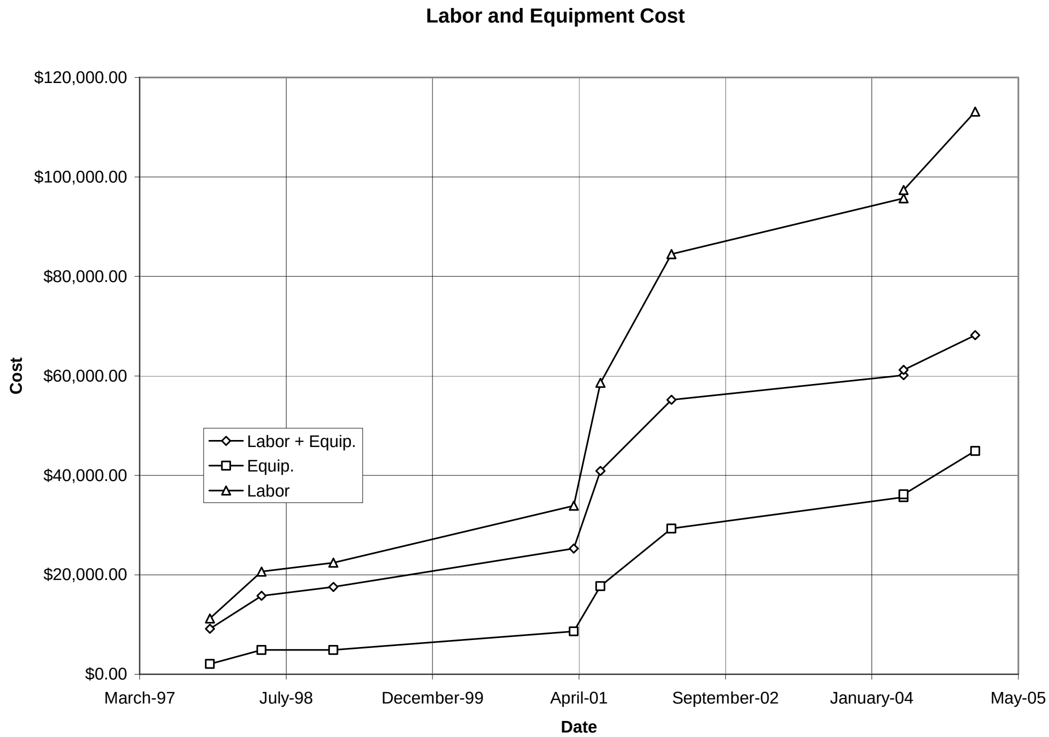


Figure 5. Labor and Equipment Cost for Scallop Bank Maintenance (1997-2005)

The riprap quantity was not tracked until last year. 3,370 cu yds and 2,830 cu yds of riprap were dumped on the scallop in 2004 and 2005 respectively. For these years, the riprap to labor and equipment cost was about .25 cu yds of riprap per dollar of labor and equipment. If that relationship is assumed since 1997, then 27,000 cu yds of riprap have been used at the site. Assuming $10/cu yd provides an estimated cost for riprap of $270,000.

The total approximate cost for maintaining the scallop is $383,000 for an 8 year period. With all this effort, however, the bank is still eroding at a rate of approximately 15 feet per year over the entire scallop.

Objectives Assessment Summary – End Dump Riprap

1. Prevent Erosion	2. Increase Sed. Trans.	3. Decrease Dredge	4. Align Flow	5. Local Support	6. Non-Damaging	7. Cost	Total	Survive Screening?
0.0	0.0	0.0	0.0	No	0.5	1.0	1.5 No	No

B. Place Riprap in Dry

This alternative is the most complex to implement logistically. The primary problem is with dewatering the site. As described earlier, the toe of the slope is under about 13 feet of water 95% of the time and the other 5% of the time it is under 5 feet of water in the middle of winter.

The general configuration of this alternative is shown in Figures 6 and 7. A sheetpile wall is constructed as a coffer dam to separate the bank from the river. As shown, the sheetpile wall would be about 3,000 feet long and at a distance of about 40 feet from the edge-of-bank. To construct the sheetpile wall, the driver would need to extend about 50 feet from the crane. It was estimated the sheetpiles would need to be driven about 1.5 times the water depth or 20 feet. With four feet of freeboard, the total length of sheetpile was estimated to be 37 feet.

Even with the sheetpile driven 20 feet into the ground, groundwater seepage will be a significant problem. As shown in Figure 7, the toe of the rock extends about 10 feet below ground. When the excavation is performed to place the toe rock, there will be 23 feet of head within 25 feet of the toe trench. It is likely that several large pumps would be required to keep the area dewatered.

A minimum slope of 2 horizontal to 1 vertical will be required. Slope protection near dams, subject to large variations in water levels, is often placed at 3 to 1. Because the amount of land used for the effort needs to be minimized, a 2 to 1 slope was assumed for this exercise.

Even at a 2 to 1 slope, more CRIT land could become unusable. The existing slope is close to 1 to 1. The elevation difference between the top of bank and toe is about 20 feet. If the toe is not located farther out into the river, the CRIT will lose about 20 more feet of usable land. If the toe is moved another 20 feet into the river, placing the sheepile coffer dam becomes even more difficult.

The cost for this alternative is nearly 3 times that of other alternatives that provide the same degree of bank protection. The cost was developed from quantities based on the cross section shown in Figure 7 and topography collected for the project. Total cost for this alternative is estimated to be about $2,840,000 as the breakdown summary shows in Attachment 3.

Objectives Assessment Summary – Riprap in Dry

1. Prevent Erosion	2. Increase Sed. Transport	3. Decrease Dredge	4. Align Flow	5. Local Support	6. Non-Damaging	7. Cost	Total	Survive Screening?
1.0	0.0	0.0	0.0	No	0.5	-1.0	0.5 No	No

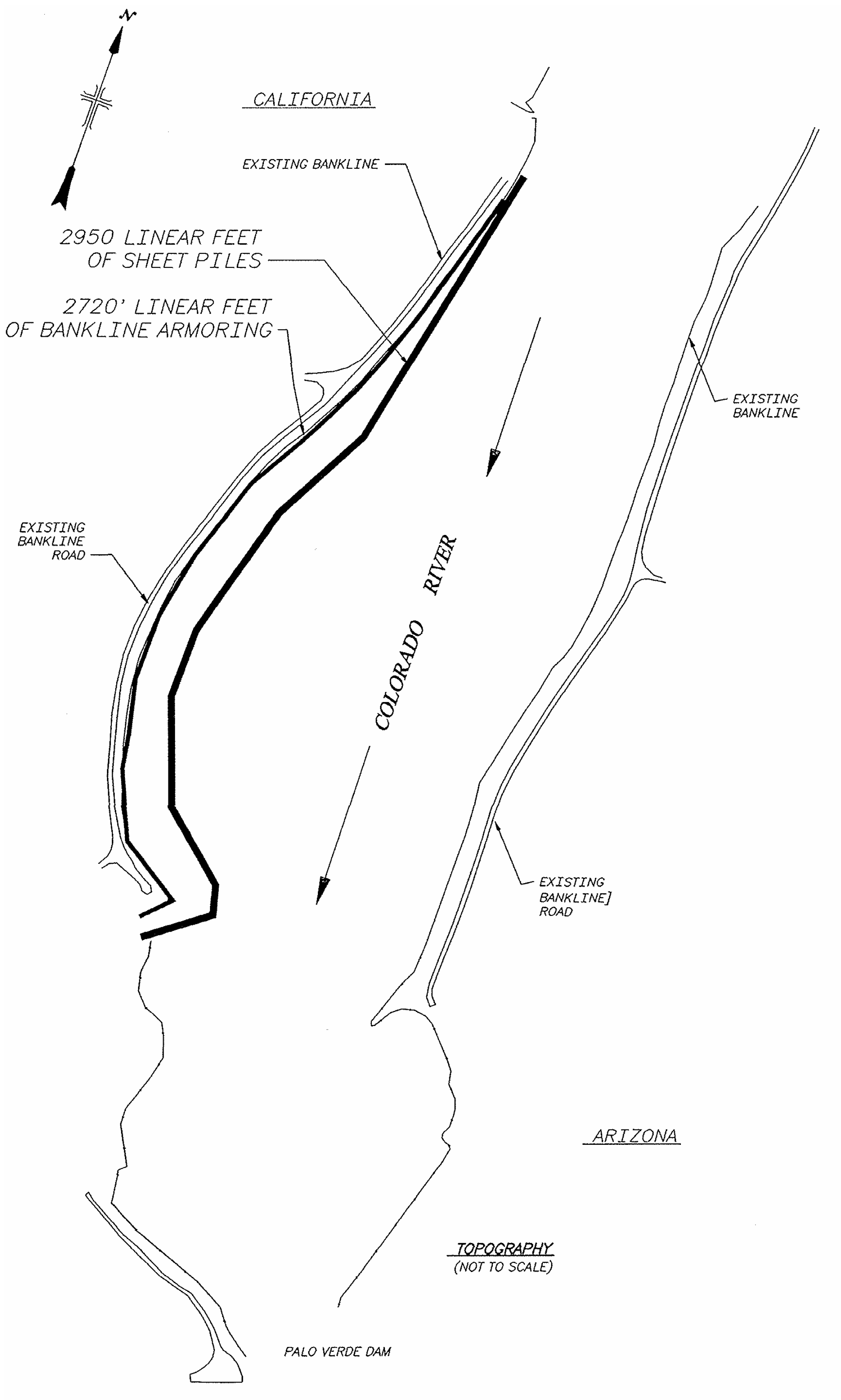


Figure 6. Riprap Bank Protection Placed in Dry (Drwng # LB873OPT.DWG)

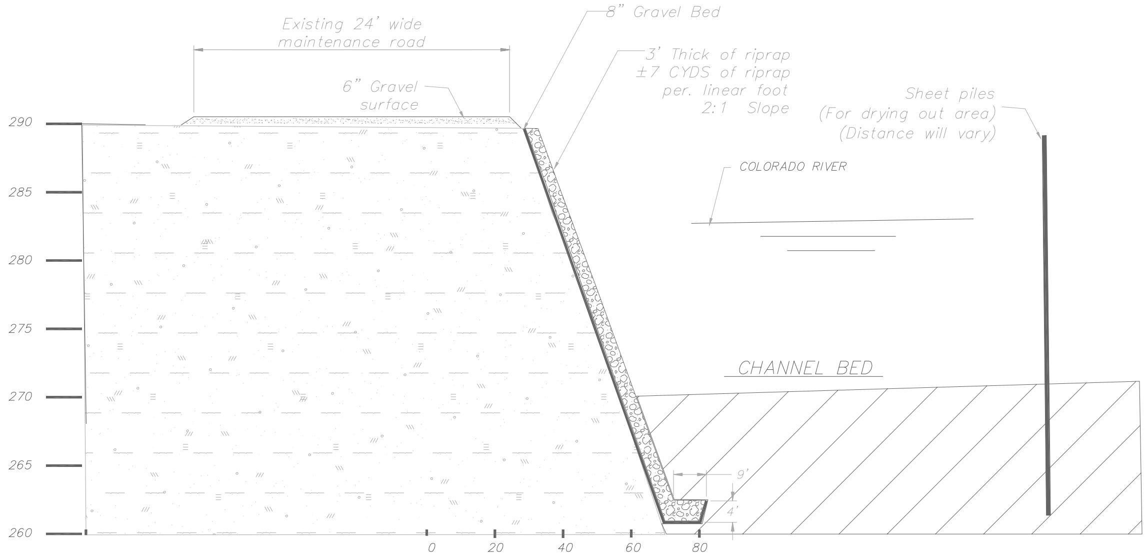


Figure 7. Typical Cross Section for Riprap Placement in Dry (Drwng # LB873OPT.DWG)

C. Riprap over Sheetpile

A combination sheetpile/riprap alternative was considered as shown in Figures 8 and 9. The sheetpile would be driven through the existing bank with the top extending up to the normal pool elevation of 283 feet. Once above elevation 283 feet, riprap could then be placed at a 2 to 1 slope.

This alternative was not considered constructible. There has been a large amount of riprap dumped over the channel bank. It is likely that the sheetpile would need to be driven through several feet of riprap. From past experience, this would not be a possible scenario considering the length of the structure. The sheetpile could be driven in behind the bank, but this would have taken more useable land from the CRIT.

Like the previous alternative, this type of treatment encroaches onto CRIT land. The amount of land affected is less than the rock alternative, but would still make an additional 6 feet of land behind the existing bank treatment unusable to the CRIT.

The cost turned out to be greater than placing riprap in the dry. The cost was developed from quantities based on the cross section shown in Figure 9 and topography collected for the project. Total cost for this alternative is estimated to be about $2,960,000 as the breakdown summary shows in Attachment 4. Because the sheetpile remains as part of the project, the sheetpile cost is much more expensive than that used in the cost estimate for Placing Riprap in the Dry and explains the higher cost for this alternative.

Objectives Assessment Summary – Riprap over Sheetpile

1. Prevent Erosion	2. Increase Sed. Transport	3. Decrease Dredge	4. Align Flow	5. Local Support	6. Non-Damaging	7. Cost	Total	Survive Screening?
1.0	0.0	0.0	0.0	No	0.5	-1.0	0.5 No	No

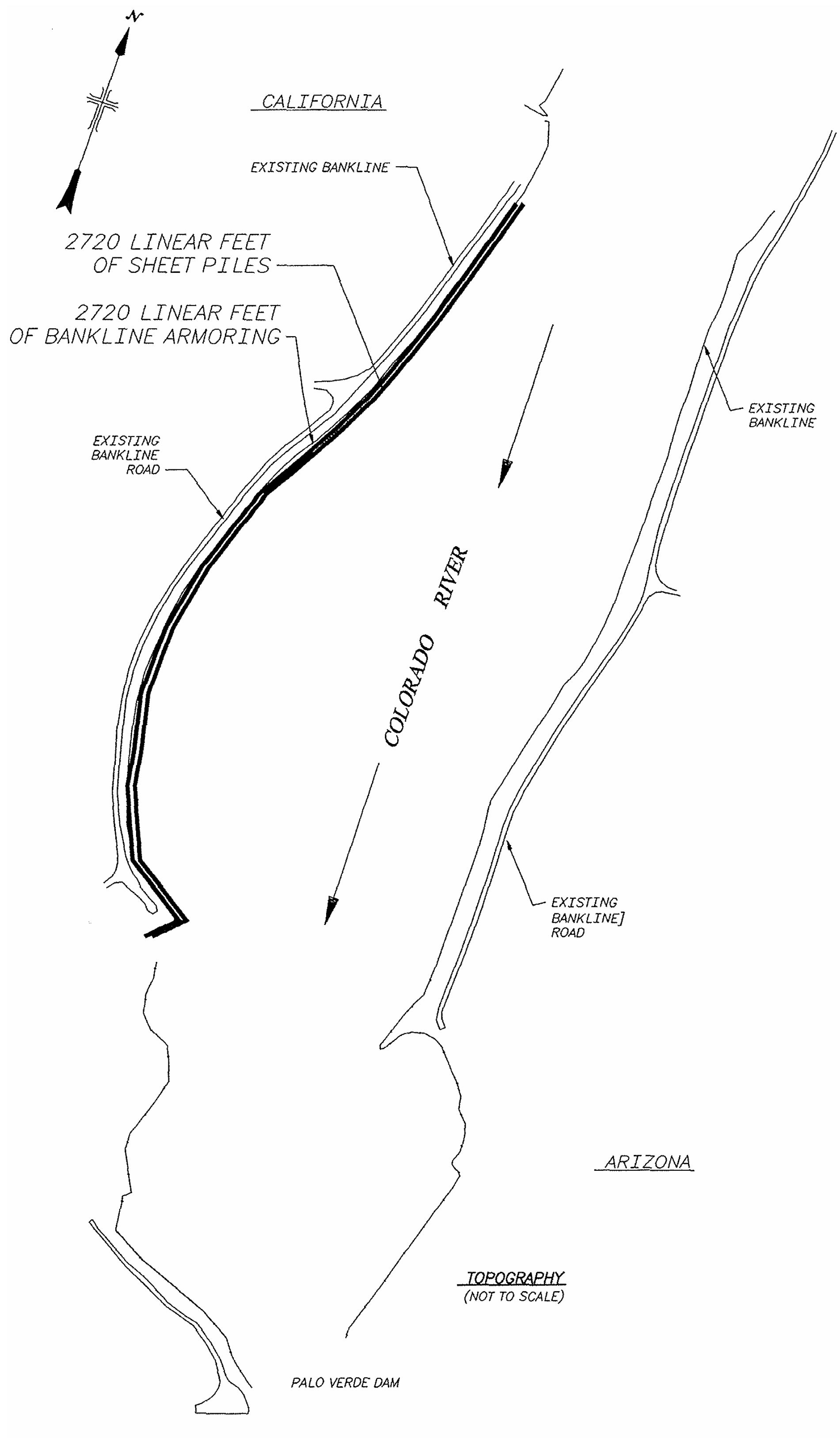


Figure 8. Riprap Over Sheetpile (Drwng # LB873OPT.DWG)

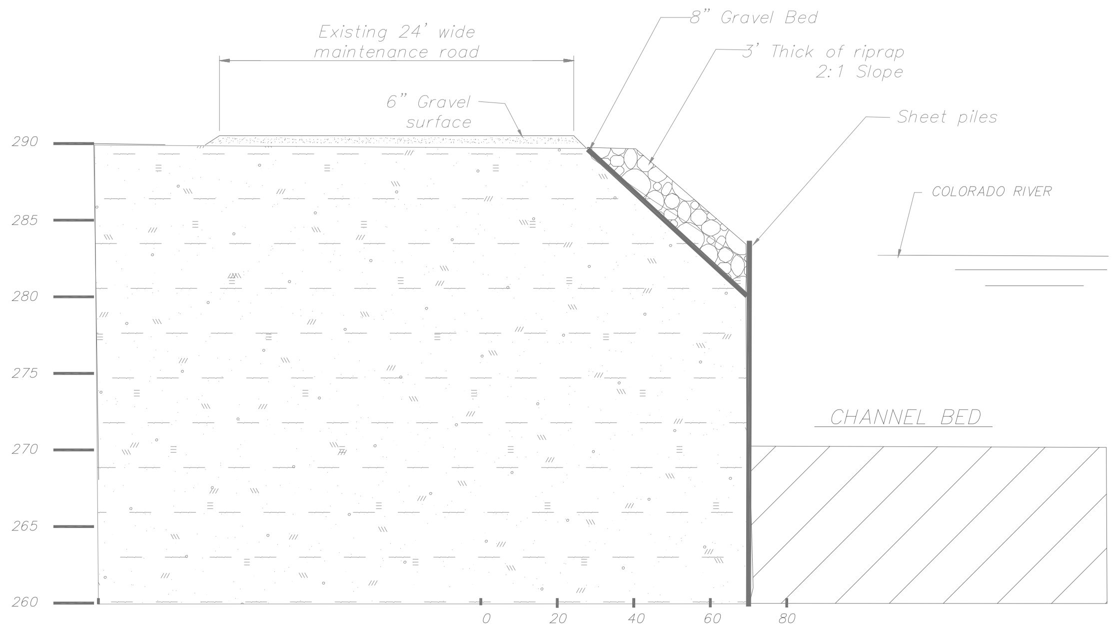


Figure 9. Typical Cross Section for Riprap Over Sheetpile (Drwng # LB873OPT.DWG)

3. Training Levee.

The intent of the training levee would be to reestablish the 1994 bankline. Training levees are very similar to spurs or jetties. The primary difference is that the flow is intended to be parallel along the length of the training levee. Jetties or spurs are typically used to deflect flow and, as a result, are at an angle to the direction of flow. The advantage of the training structure is that it would help to direct the flow toward the dam gates where jetty spurs tend to stir the water into eddies in the near vicinity of the dam.

The three dimensional model U^2RANS was used to evaluate this alternative. Results from the modeling indicate the desired objectives will be achieved. The predominant flow path is kept from the scallop area and directed to the dam without causing appreciable flow disturbances. For a more thorough description of the modeling, refer to the "Hydraulic Modeling and Analysis of the Proposed Palo Verde Dam Training Structure" dated September 2004.

The two primary materials considered were rock/fill and sheetpile. From previous analysis, sheetpile was shown to have a higher unit cost than the rock structures. In addition, the aesthetics of a steel wall rising from the water, safety concerns, and constructability issues make using sheetpile for this purpose a poor choice.

Therefore, the structure was designed with a fill core protected with riprap as shown previously in Figure 3. The structure extends in front of the scallop along the 1994 bankline alignment to a point downstream beyond the sand bar as shown in Figure 10. This configuration will restore the sediment transport capacity to that when the dam was built. By doing so, the point bar will likely erode over time. Once a new flow path has been carved near the training levee, new sediments will be more likely to pass through the dam. Therefore, the area within about a mile of the dam will require less dredging than would otherwise be required.

This alternative achieves the objectives best from a channel stability standpoint. It improves sediment transport, directs flow toward the dam, and protects the scallop area from high velocity water. In addition, it has local support from the CRIT and is of moderate cost.

The cost was developed from quantities based on the cross section shown in Figure 3 and topography collected for the project. Total cost for this alternative is estimated to be about $760,000 as the breakdown summary shows in Attachment 5.

Objectives Assessment Summary – Training Levee

1. Prevent Erosion	2. Increase Sed. Transprt	3. Decrease Dredge	4. Align Flow	5. Local Support	6. Non-Damaging	7. Cost	Total	Survive Screening?
1.0	1.0	1.0	1.0	Yes	0.5	0.0	4.5Yes	Yes

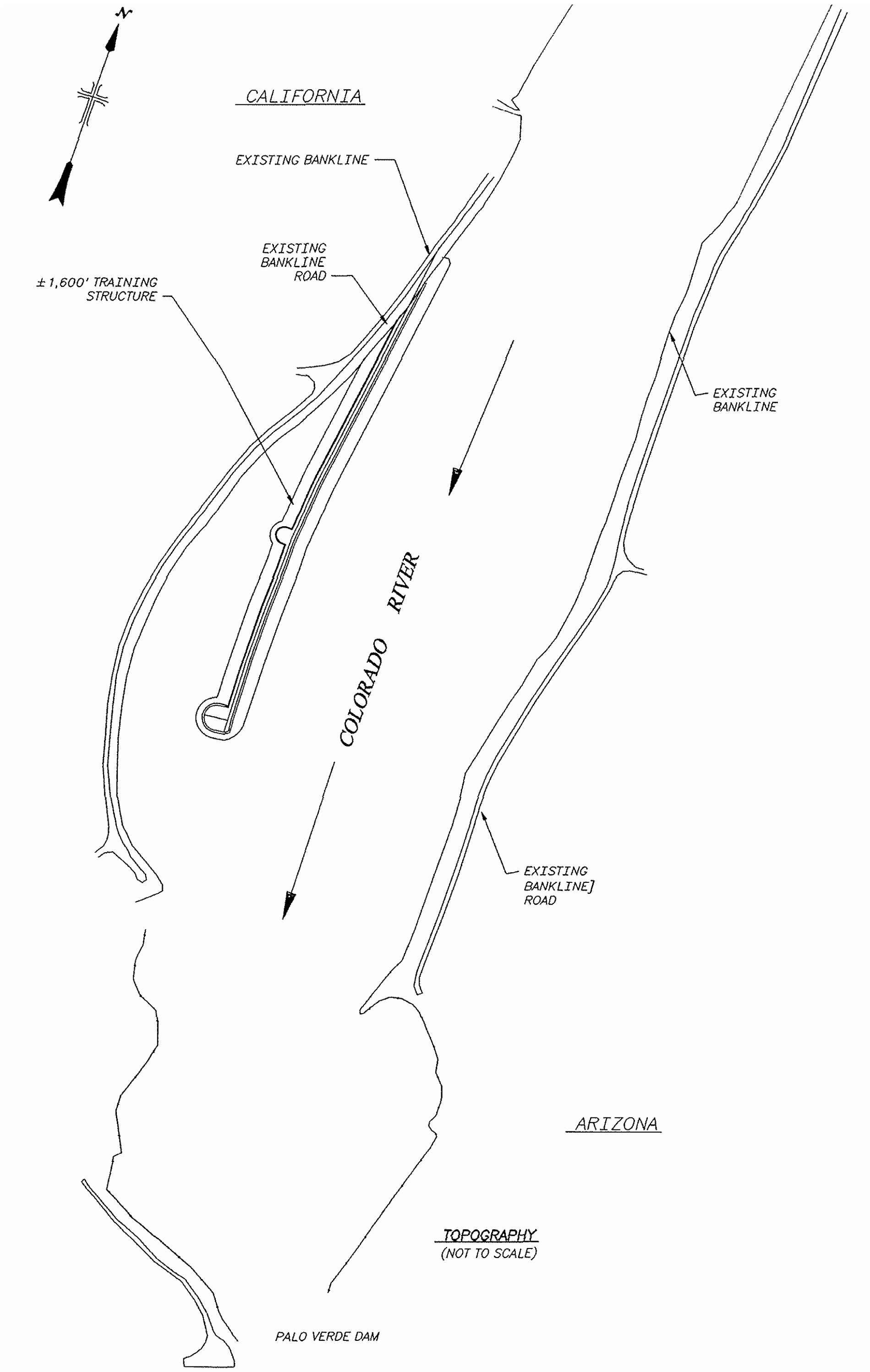


Figure 10. Training Levee (Drwng # LB873OPT.DWG)

COMPARISON OF ALTERNATIVES

Table 1 summarizes the alternatives considered. As shown, only one alternative is considered favorable to the CRIT. In addition, the training levee satisfies the primary objectives from a bank stabilization standpoint best and is of moderate cost. As a result, the training levee is considered the most appropriate alternative.

Table 1. Comparison Of Alternatives

Alternative	Objectives								
	1. Prevent Erosion	2. Increase Sed. Trans.	3. Decrease Dredge	4. Align Flow	5. Local Support	6. Non-Damaging	7. Cost	Total	Survive Screening?
Bumper Jetties	0.5	0.0	0.0	-1.0	No	1.0	1.0	1.5 No	No
Three Spur Jetties	1.0	0.5	0.5	0.0	No	1.0	0.0	3.0 Yes	No
L-Jetties	1.0	1.0	1.0	1.0	No	0.5	-0.5	4.0 Yes	No
End Dumped Riprap	0.0	0.0	0.0	0.0	No	0.5	1.0	1.5 No	No
Place Riprap in Dry	1.0	0.0	0.0	0.0	No	0.5	-1.0	0.5 No	No
Riprap Over Sheetpile	1.0	0.0	0.0	0.0	No	0.5	-1.0	0.5 Yes	No
Training Wall	1.0	1.0	1.0	1.0	Yes	0.5	0.0	4.5 Yes	Yes

Attachments
Atch 1. Cost Estimate Summary for Three Spur Jetty Alternative
Atch 2. Cost Estimate Summary for L-Jetty Alternative
Atch 3. Cost Estimate Summary for Place Riprap in Dry Alternative
Atch 4. Cost Estimate Summary for Riprap over Sheetpile Alternative
Atch 5. Cost Estimate Summary for Training Levee Alternative

Form 2417		COST ESTIMATE		Finish Date	02/02/05	File Name	3 Spur Jetty Estimate.xls
						Sheet 1 of 6	
Project Title -		Estimated by:		M. Igoe		ID #	PVBIS
Palo Verde Scallop - 3 Spur Jetty Estimate		STATUS OF DESIGN		Budgetary	30% Budgetary		

Item	Description	Quantity		Material		Labor		Equipment		Item Cost	
		Quantity	Unit of Mea.	Unit Cost	Total	Unit Cost	Total	Unit Cost	Total	Unit Cost	Total
1	Project Mobilization				$0.00		$35,167.95		$17,435.50		$52,603.44
2	Blast and Quarry Pit Run Material				$7,340.16		$53,035.07		$51,943.03		$112,318.26
3	Load, haul, weigh and place pit run				$0.00		$163,159.50		$229,257.56		$392,417.05
4	Load, haul, weigh and place riprap				$0.00		$23,755.69		$14,847.31		$38,602.99
5	Load, haul, weigh and place gravel base				$0.00		$8,172.00		$5,107.50		$13,279.50
6					$0.00		$0.00		$0.00		$0.00
7					$0.00		$0.00		$0.00		$0.00
8					$0.00		$0.00		$0.00		$0.00
	TOTAL				$7,340.16		$283,290.21		$318,590.88		$609,221.25

Prepared by:
Date:

Form 2417	**COST ESTIMATE**	Finish Date	02/03/05
		File Name	6 L Jetty Estimate.xls
		Sheet 1 of 6	
Project Title -	Estimated by:	M. Igoe	
		ID #	PVBLS
Palo Verde Scallop - 6 L Jetties Estimate	STATUS OF DESIGN	Budgetary	30% Budgetary

Item	Description	Quantity		Material		Labor		Equipment		Item Cost	
		Quantity	Unit of Mea.	Unit Cost	Total	Unit Cost	Total	Unit Cost	Total	Unit Cost	Total
1	Project Mobilization				$0.00		$40,471.66		$25,059.65		$65,531.31
2	Blast and Quarry Pit Run Material				$7,340.16		$101,857.80		$132,292.69		$241,490.65
3	Load, haul, weigh and place pit run				$0.00		$237,556.88		$330,865.30		$568,422.18
4	Load, haul, weigh and place riprap				$0.00		$49,253.53		$30,783.46		$80,036.99
5	Load, haul, weigh and place gravel base				$0.00		$13,755.14		$8,596.97		$22,352.11
6					$0.00		$0.00		$0.00		$0.00
7					$0.00		$0.00		$0.00		$0.00
8					$0.00		$0.00		$0.00		$0.00
	TOTAL				$7,340.16		$442,895.02		$527,598.07		$977,833.25

Prepared by:
Date:

Form 2417 | **COST ESTIMATE** | Finish Date 02/02/05 | File Name Bank Line Estimate.xls

Sheet 1 of 6

Project Title -
Palo Verde Scallop - Bankline Protection (Rip Rap in Dry)

Estimated by: M. Igoe | ID # PVBIS

STATUS OF DESIGN: Budgetary 30% Budgetary

		Quantity		Material		Labor		Equipment		Item Cost	
Item	Description	Quantity	Unit of Mea.	Unit Cost	Total	Unit Cost	Total	Unit Cost	Total	Unit Cost	Total
1	Project Mobilization				$0.00		$35,308.28		$17,435.50		$52,743.77
2	Furnish, install, remove and salvage sheet piling				$1,765,492.59		$661,514.65		$336,464.70		$2,763,471.93
3	Load, haul, weigh and place riprap				$0.00		$8,172.00		$5,107.50		$13,279.50
4	Load, haul, weigh, place and compact gravel basep				$0.00		$8,172.00		$5,107.50		$13,279.50
5					$0.00		$0.00		$0.00		$0.00
6					$0.00		$0.00		$0.00		$0.00
7					$0.00		$0.00		$0.00		$0.00
8					$0.00		$0.00		$0.00		$0.00
	TOTAL				$1,765,492.59		$713,166.93		$364,115.20		$2,842,774.71

Prepared by:
Date:

Form 2417	COST ESTIMATE	Finish Date	02/02/05	File Name	Sheet Pile and Bank Line Estimate.xls
				Sheet 1 of 5	
Project Title -	Estimated by:	M. Igoe		ID #	PVBlS
Palo Verde Scallop - Sheet Pile and Bankline Protection	STATUS OF DESIGN	Budgetary	30%		
			Budgetary		

Item	Description	Quantity		Material		Labor		Equipment		Item Cost	
		Quantity	Unit of Mea.	Unit Cost	Total	Unit Cost	Total	Unit Cost	Total	Unit Cost	Total
1	Project Mobilization				$0.00		$35,308.28		$17,435.50		$52,743.77
2	Furnish and install sheet piling				$2,512,537.62		$66,881.06		$280,387.25		$2,859,805.93
3	Load, haul, weigh and place riprap				$0.00		$15,106.57		$9,441.61		$24,548.18
4	Load, haul, weigh, place and compact gravel basep				$0.00		$15,106.57		$9,441.61		$24,548.18
5					$0.00		$0.00		$0.00		$0.00
6					$0.00		$0.00		$0.00		$0.00
7					$0.00		$0.00		$0.00		$0.00
8					$0.00		$0.00		$0.00		$0.00
	TOTAL				$2,512,537.62		$132,402.47		$316,705.96		$2,961,646.05

Prepared by:
Date:

Form 2417	COST ESTIMATE	Finish Date	02/03/05	File Name	Training Structure Preferred Alt.xls
				Sheet 1 of 6	
Project Title -	Estimated by:	M. Igoe		ID #	PVBLS
Palo Verde Scallop - Training Structure (Preferred Alternative)	STATUS OF DESIGN	Budgetary	30%		
			Budgetary		

Item	Description	Quantity		Material		Labor		Equipment		Item Cost	
		Quantity	Unit of Mea.	Unit Cost	Total	Unit Cost	Total	Unit Cost	Total	Unit Cost	Total
1	Project Mobilization				$0.00		$40,112.77		$25,059.65		$65,172.42
2	Blast and Quarry Pit Run Material				$7,340.16		$81,959.35		$99,219.52		$188,519.03
3	Load, haul, weigh and place pit run				$0.00		$178,167.66		$248,148.98		$426,316.64
4	Load, haul, weigh and place riprap				$0.00		$37,109.08		$23,193.17		$60,302.25
5	Load, haul, weigh and place gravel base				$0.00		$13,755.14		$8,596.97		$22,352.11
6					$0.00		$0.00		$0.00		$0.00
7					$0.00		$0.00		$0.00		$0.00
8					$0.00		$0.00		$0.00		$0.00
	TOTAL				$7,340.16		$351,104.00		$404,218.28		$762,662.44

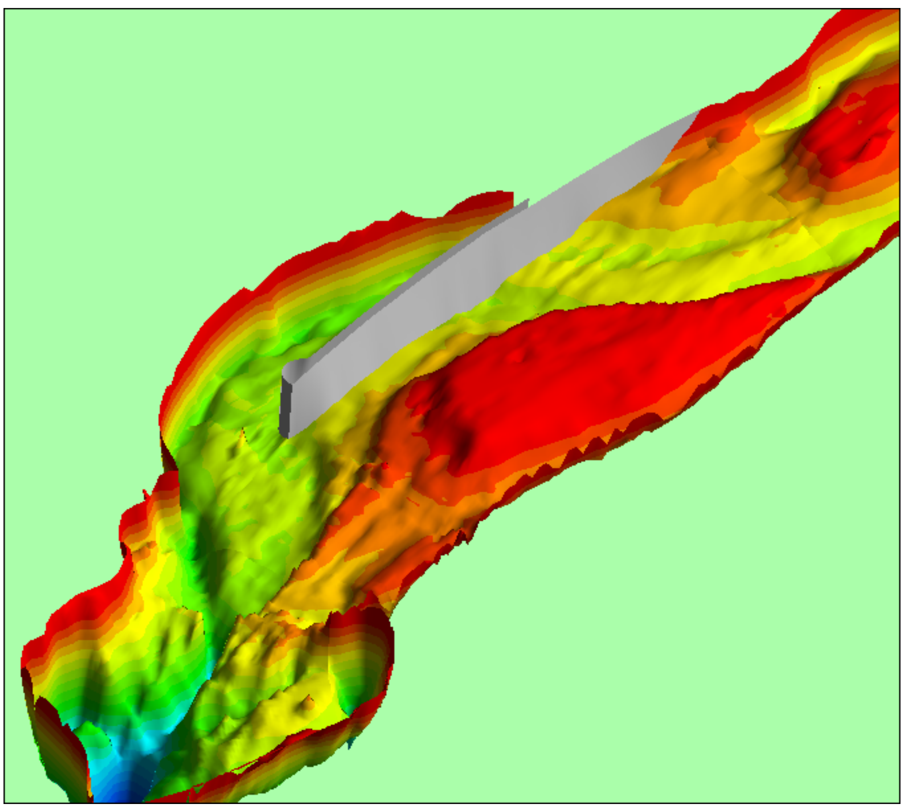
Prepared by:
Date:

EXHIBIT B

Hydraulic Modeling and Analysis of the Proposed Palo Verde Dam Training Structure

RECLAMATION
Managing Water in the West

Hydraulic Modeling and Analysis of the Proposed Palo Verde Dam Training Structure



U.S. Department of the Interior
Bureau of Reclamation

September 2004

HYDRAULIC MODELING AND ANALYSIS OF THE PROPOSED PALO VERDE DAM TRAINING STRUCTURE

Report Prepared by:

Yong G. Lai, Ph.D., Hydraulic Engineer
Sedimentation and River Hydraulics Group

Tim Randle, P.E., Hydraulic Engineer
Sedimentation and River Hydraulics Group

Report Peer Reviewed by:

Jennifer Bountry, P.E., Hydraulic Engineer
Sedimentation and River Hydraulics Group

U.S. Department of the Interior
Bureau of Reclamation
Technical Service Center
P.O. Box 25007
Denver, Colorado 80225

September 2004

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EXECUTIVE SUMMARY

A hydraulic flow analysis is carried out to evaluate the impact of the proposed training structure and jetties upstream of the Palo Verde Diversion Dam on the Lower Colorado River near Blythe, California. The three-dimensional hydraulic model, U^2RANS, is used for this study as it is an accurate, robust, and proven model. U^2RANS has been applied to many river projects in the past, with great success, with similar geometric characteristics.

A total of six cases are simulated representing scenarios under existing and installed-structure flow conditions, different river discharges, and assumed point bar and jetty configurations. Based on the simulation results, major findings of the study can be summarized below (right and left river bank designations are looking in the downstream direction):

(1) The model confirms that the flow regime near the Diversion Dam under existing conditions has a pattern typically observed at many river meanders. This meander bend is mainly responsible for the accelerated bank erosion observed on the California side (right side) of the river and the point bar on the opposite left bank. If left untreated, the bank erosion at the meander bend is expected to continue, potentially threatening the safety of the Palo Verde Diversion Dam.

(2) The upstream section of the river reach, near the proposed location of the two jetties, has high velocities along the right bank under the existing conditions. More riprap reinforcement may be needed or installation of jetties, as proposed, should be considered.

(3) The proposed two jetties upstream of the training structure are predicted to cause high flow velocity along the left bank, potentially leading to local bank erosion. In addition, the jetties impart a sinuous (meandering) motion to the river which continues downstream. Such motion could result in further erosion and deposition in the river reach having a negative impact on the training structure and river banks. Either of two options is recommended: the two jetties are not installed but the riprap along the right bank at the location is reinforced; or jetties shorter than what is currently proposed are used. The second option of shorter jetties would need further modeling to determine if an optimum length exists.

(4) The proposed training structure at the California side (right bank) of the river near the bend region just upstream of the Palo Verde Diversion Dam will be successful in preventing further bank erosion from happening. However, additional issues need to be considered as discussed in the next two conclusions.

(5) After the construction of the proposed training structure, the point bar along the left bank is expected to be eroded and will eventually disappear. However, high velocities might be developed along the training structure and on the left

bank of the point bar. This situation is dependent upon the magnitude of the river flow and how much erosion of the point bar has occurred. The worst scenario would result if high river flows combined with little erosion of the point bar occurred immediately following the construction of the proposed training structure. The high velocities in this case would potentially cause stability problems to the training structure and the left river bank.

(6) It is found that an eddy will develop behind the proposed training structure. The magnitude, extent, and impacts of the eddy are likely dependent upon the magnitude of the river flows. The eddy may cause sediment deposition at the mouth between the downstream end of the training structure and the right bank, limiting flow in and out of the backwater created by the training structure. A sill might be installed at the mouth as a possible solution to limit deposition due to the bed load sediment; but the success of it depends on the local flow hydraulics and the suspended sediment concentration. Additional analyses of the local flow conditions would be required to provide design details for this option.

(7) An existing eddy, located on the right bank immediately upstream of the canal headwork intake, becomes slightly stronger if the training structure is installed. During the site trip, it was noticed that the existing riprap at this location is not in good shape and might need to be strengthened.

(8) The hydraulic modeling also predicts, once the training structure is in place, a stronger eddy in front of the dam embankment to the left side of the spillway gates. The magnitude and impacts of this eddy are again likely dependent upon the magnitude of flow occurring in the river. Since armoring of this area was done to prevent further erosion, in the future only monitoring should be required to insure that there are no potential impacts to dam embankment stability or integrity.

1. Introduction

Palo Verde Diversion Dam (Diversion Dam) is located on the Colorado River approximately 12 miles northeast of Blythe, California. The dam is owned by the Bureau of Reclamation and is operated and maintained by the Palo Verde Irrigation District. A site map is shown in Figure 1. The Diversion Dam has a semi-pervious zoned earth and rockfill embankment section, a radial gated concrete gravity spillway and canal headworks section, and an auxiliary spillway section. The dam serves to raise the level of the river to elevation 283.5 ft for diversion into a canal for irrigation to nearby farmlands in California.

The spillway consists of a concrete ogee gated weir structure and has a design capacity of 75,000 cubic feet per second (cfs) at water elevation of 290 feet (ft). Spillway flows are controlled by three 50-foot by 24.91-foot radial gates, with a spillway ogee crest at elevation 259 ft. Spillway gates are automated to maintain the reservoir at a constant elevation of 283.5 ft under normal operations. Diversion is accomplished by the canal headworks structure located at the right side of the spillway. The concrete structure consists of four 12-foot by 8-foot top-seal radial gates and is designed to deliver 1,800 cfs to the Palo Verde canal, with the forebay at elevation 283.5 ft.

One of the current issues at the project site is the bank erosion at the California side (right bank) just upstream of the Palo Verde Diversion Dam. Shown in Figure 2 are aerial photos taken in 1994 and 2001, indicating the California bankline erosion and the developing point bar. The outward river migration will eventually impact the safety of the Palo Verde Diversion Dam. As a result, Yuma Area Office (YAO) is charged to provide a solution to protect the project site. One proposed solution is shown in Figure 3; it includes construction of a training structure and two jetties as a river control strategy. The objective of the proposed structures is to (1) protect the California (right) bankline from further erosion, (2) sluice the point bar and restore channel capacity to the river, and (3) protect the Diversion Dam from the potential negative impacts of the outward river migration.

The proposed training structures have undergone rigorous engineering design and assessment processes, but river hydraulics has yet to be evaluated using available modeling tools. For this purpose, the Sedimentation and River Hydraulics Group (SRHG) at the Technical Service Center (TSC) has been requested to conduct the current numerical flow modeling study for the project. The bank erosion that is occurring along the outside of the river bend (California side) is a very common feature of natural river channels. This bank erosion and deposition along the inside of the bend is caused by strong secondary currents. Strong secondary currents in the river flow are created by the curvature of the river channel. The secondary currents follow a spiral-type motion down the river channel so that there is a transverse velocity along the water surface toward the outside of the river bend. The currents then plunge down along the outside river bank and then flow back across the channel along the river bed toward the inside bank. The downward currents cause erosion along the river bank and the eroded material is transported along the riverbed and deposited to form a point bar. Deposition occurs as a function of flow velocities and bathymetric geometry. These secondary currents can only be numerically simulated by a three-dimensional (3D) hydraulic model. Therefore, it was determined that the 3D flow model, U^2RANS, developed by Dr. Lai, will be used for this study and is briefly presented in the next section.

The objective and scope of the proposed numerical modeling and analysis of flow hydraulics for the Palo Verde Diversion Dam Training Structure can be stated as follows:

> *Provide a quantitative assessment of the effect of the proposed training structures on the flow hydraulics at the project site. With 3D numerical modeling, detailed flow hydraulic behaviors, with and without the training structures, can be obtained. Such detailed data may be used by Reclamation engineers, both at D-8540 and YAO, to address issues such as: (a) velocity pattern and magnitude behind the training structure; (b) the kind of armor needed to prevent further erosion without the training wall given the velocity and flow shear stress information near the bank; (c) the possibility of point bar removal with known flow velocities and stresses at the site; and (d) the potential detrimental impacts to the Dam and bankline near the Dam.*

The priority of the study, established by YAO, is to evaluate the ability of the proposed structures to provide dam safety first, followed by bankline erosion, with sediment transport the last. With this understanding, this phase of the study focuses on the flow modeling and analysis of the river reach upstream of the Dam so that the impact of the proposed training structure can be assessed. The sediment modeling is not part of this work scope and can be carried out when it is determined necessary.

It needs to be pointed out that the current hydraulic study provides detailed information such as the flow velocity magnitude and direction, shear stress and flow eddies and patterns at any location of the modeled river reach. The above information provides key data to identify potential erosion (e.g., at the point bar and bank) and deposition within the modeled river reach. Sediment modeling may provide more details on these issues in terms of the rate and scope of the erosion and deposition but such analysis may not be necessary depending on the scope of the project.

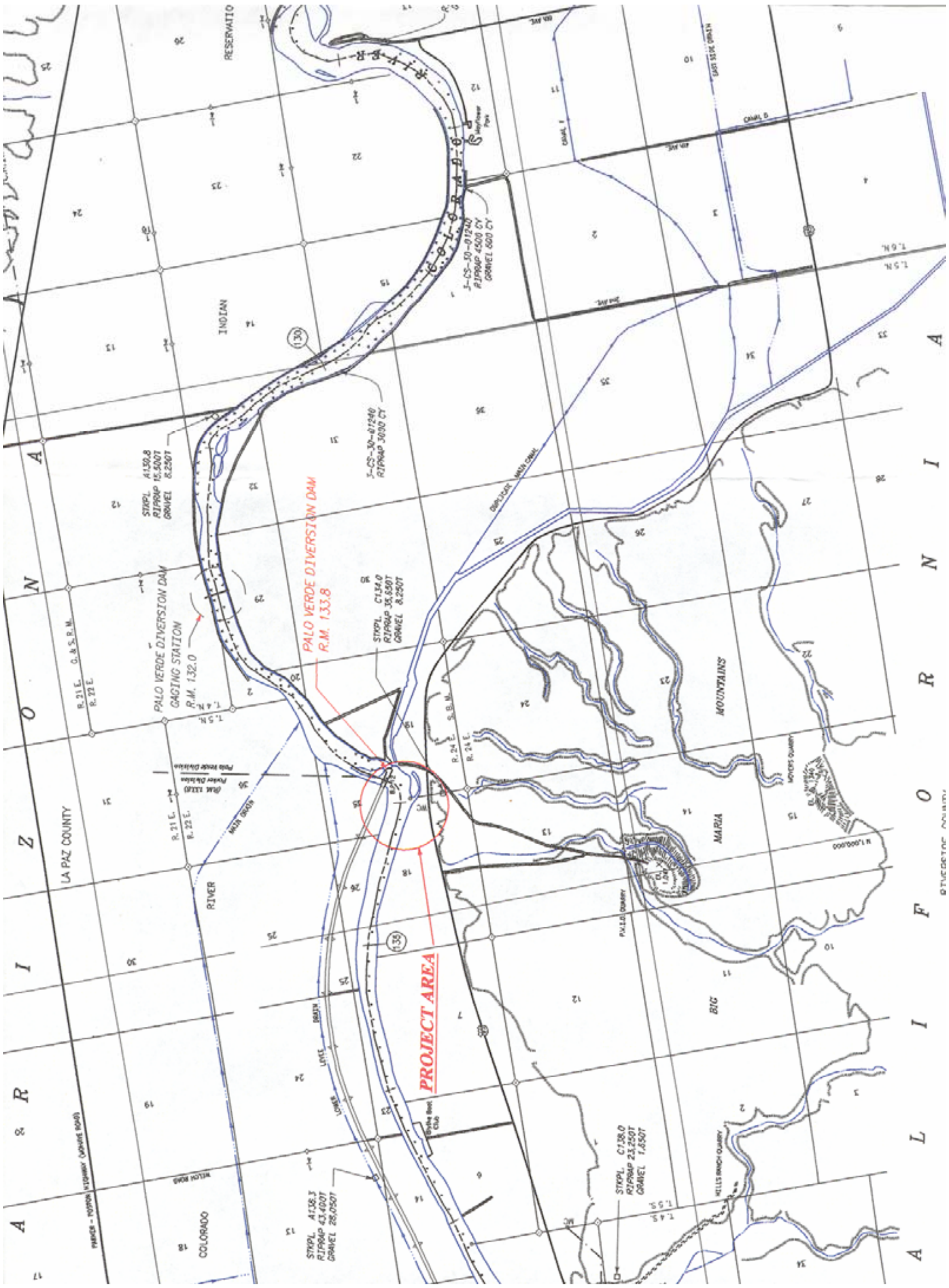
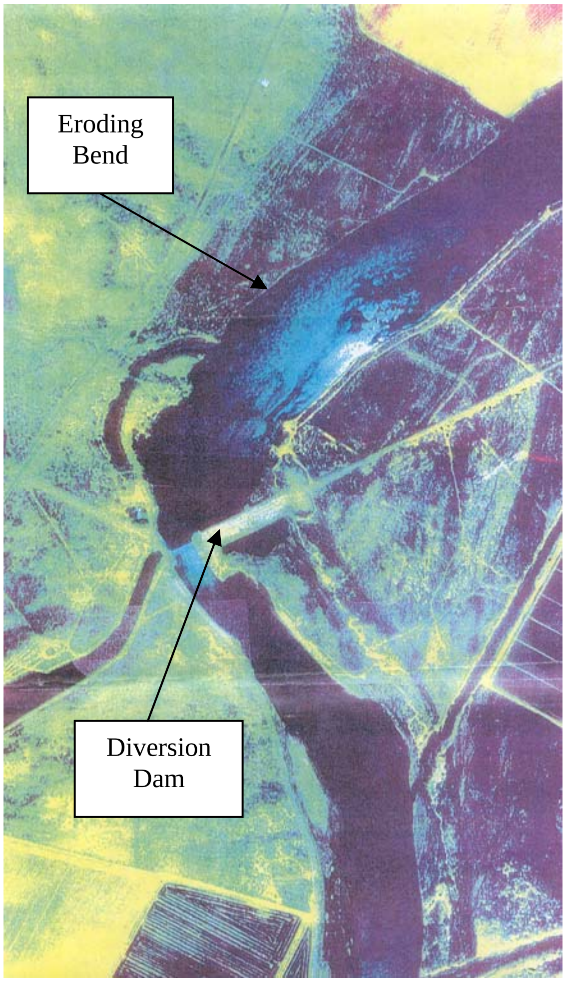
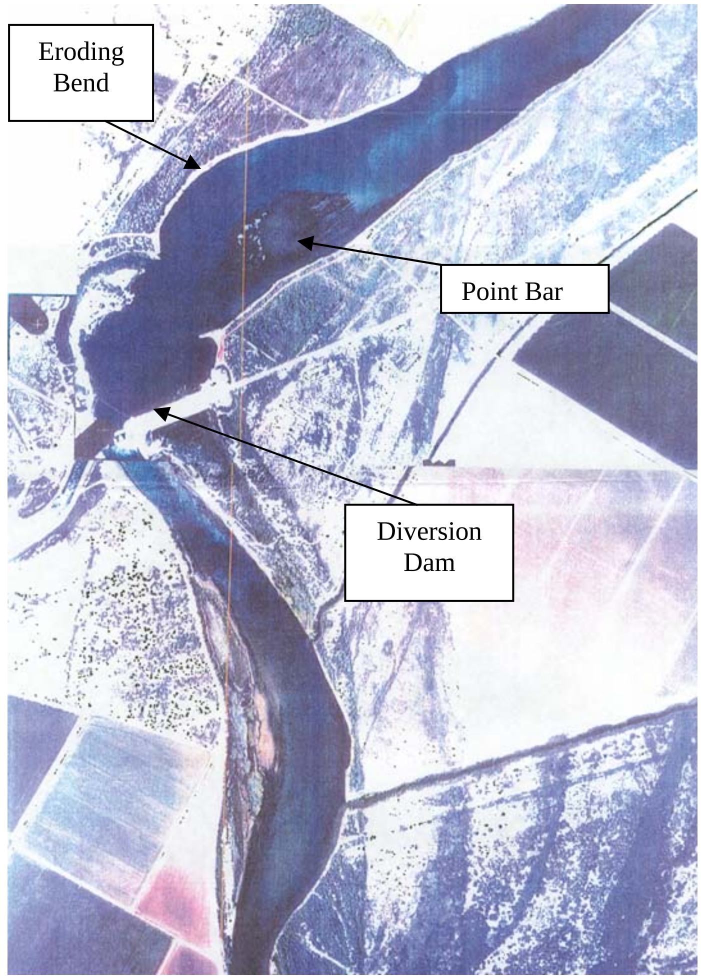


Figure 1. Location of the Proposed Project



(a) Aerial Photo Taken in 1994



(b) Aerial Photo Taken in 2001

Figure 2. Aerial Photos Taken in 1994 and 2001

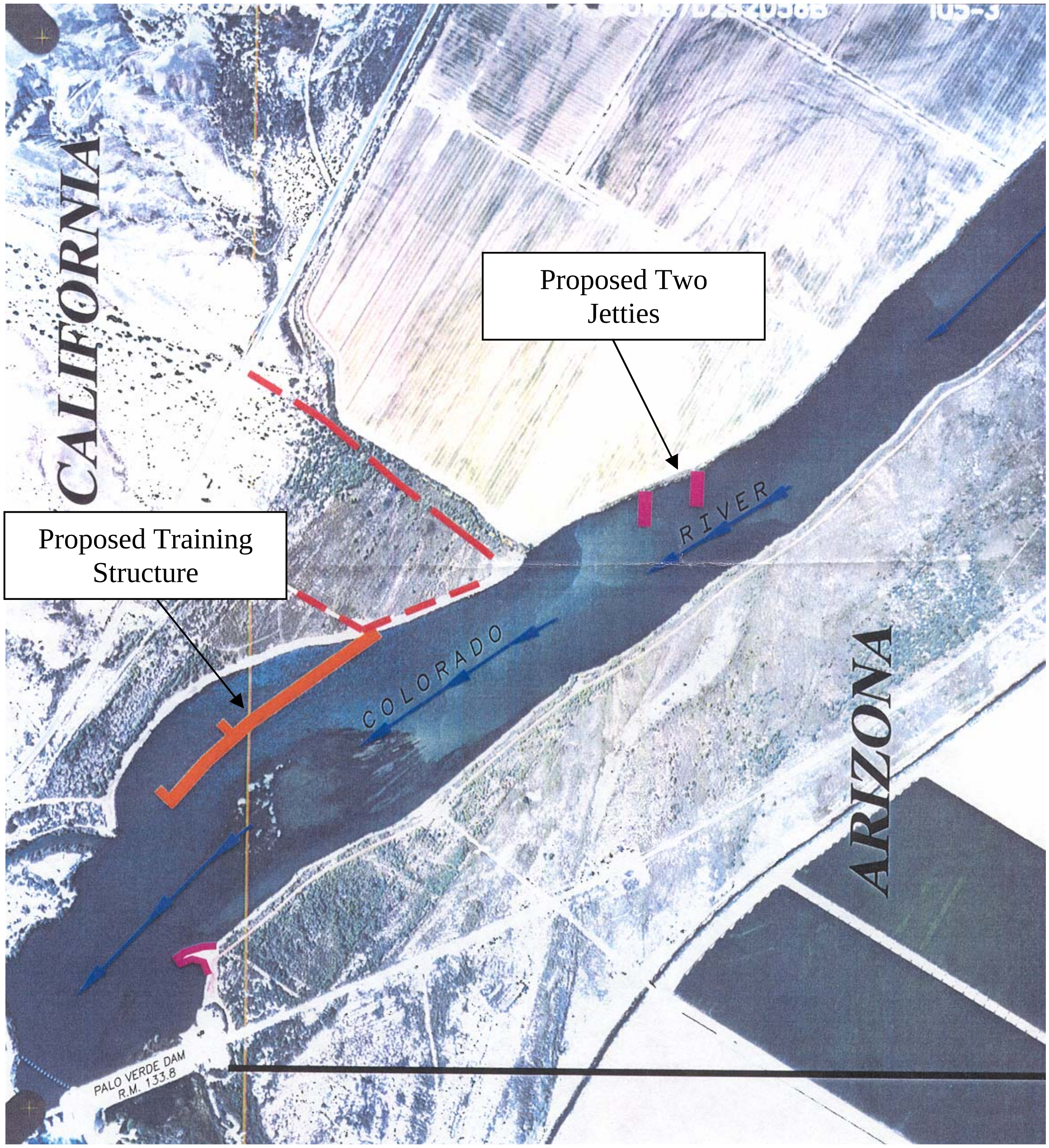


Figure 3. Proposed River Control Structures

2. Description of the Numerical Model

In this project, the three-dimensional (3D) numerical model, U^2RANS, is used; it is an **U**nsteady and **U**nstructured **R**eynolds **A**veraged **N**avier-**S**tokes solver. The code was developed by Dr. Yong Lai while he was employed as the senior research staff and adjunct associate professor at the Iowa Institute of Hydraulic Research (IIHR), the University of Iowa. U^2RANS is a well verified and validated numerical model and has been successfully applied to many research and engineering projects since its development. It has been used by research engineers and graduate students at the University of Iowa to solve many hydraulic flow problems, and it has also been used outside organizations. In the Reference section of this report, a list of selected publications and reports is provided relating to the theory and past applications of the U^2RANS model to practical problems.

Briefly, U^2RANS is a general-purpose code for modeling flow hydraulics, heat transfer and scalar transport. It has been specifically developed to solve fluid and thermal problems in hydraulic engineering such as flows in rivers, at hydropower dams, around hydraulic structures, with thermal discharge, etc. U^2RANS uses current state-of-the-art unstructured Computational Fluid Dynamics (CFD) technology and unifies multi-block structured mesh (quadrilateral or hexhedron) and unstructured mesh (quadrilateral, triangle, tetrahedron, hexhedron, wedge, pyramid, or hybrid elements) into a single framework.

Many commercial computer codes are user-friendly but require tremendous amounts of training and experience before a user can produce reliable quality results. A previous workshop, Turbine 99 (Gebart et al, 2000), on application of computer modeling to a draft tube simulation attracted sixteen research groups with four commercial codes (FLUENT, CFX, STAR-CD, FIDAP) and a number of university codes (U^2RANS is one of them). The results were compared to the measurements performed by the organizer after the computational results were submitted. It was found that the results varied widely among all submitted results. This is true not only between different codes but also within the same code but used by different groups. It was generally found that: (1) The code developer usually got the best results if applied by themselves; (2) Results from U^2RANS by IIHR and FLUENT produced by FLUENT engineers gave the best results in comparison with the measured data. The finding implies that both a good understanding of the code and experiences using the code are imperative in obtaining useful results and there is no guaranteed success by merely owning a commercial code. Another typical problem with commercial codes is that they are developed for a wide range of applications and are rarely developed specifically for hydraulic problems. Unique to hydraulic engineering are the free-surface, horizontal and vertical scale difference, gravity influence, large-scale motion, varying degree of roughness, and buoyant flow modeling, in addition to many other issues. These and many other issues are minimally addressed in commercial codes, and users do not have much freedom to change or modify such codes. It was this reason that U^2RANS was developed so that IIHR maintains the modeling expertise and have the flexibility to use the most up-to-date physical models and solution capabilities.

U^2RANS was also developed to avoid the problems associated with typical university type research codes. University research codes are typically up-to-date in terms of technology and are usually quite accurate for applications. However, many of these codes are developed by graduate students and post-doctoral associates. There are two problems: (1) There is usually a lack of continuity and loss of expertise as code developers leave the university once the projects are completed; (2) Most codes are hard-wired to solve a specific problem and therefore are very difficult to use for other problems as hard-wired changes are necessary for a new application. This leads to prolonged project length and increased chance of modeling errors. U^2RANS intends to avoid these pitfalls with the development of a user-friendly preprocessor which is interactive, provides on-the-fly input guidance, and is capable of prescreening potential setup errors.

A detailed description of the code is omitted here as technical details can be found in the following four publications:

- Lai, Y.G., Weber, L.J., Patel, V.C., "A Non-Hydrostatic Three-Dimensional Method for Hydraulic Flow Simulation - Part I: Formulation and Verification," ASCE J. Hydraulic Engineering, 129(3), pp.196-205, 2003.
- Lai, Y.G., Weber, L.J., Patel, V.C., "A Non-Hydrostatic Three-Dimensional Method for Hydraulic Flow Simulation - Part II: Application," ASCE J. Hydraulic Engineering, 129(3), pp.206-214, 2003.
- Lai, Y.G., "Unstructured Grid Arbitrarily Shaped Element Method for Fluid Flow Simulation," *AIAA Journal*, Vol.38, No.12, pp.2246-2252, 2000.
- Lai, Y.G., "An Unstructured Grid Method for a Pressure-Based Flow and Heat Transfer Solver," *Numerical Heat Transfer*, Part B, Vol.32, pp.267-281, 1997.

Three-dimensional hydraulic flow models such as U^2RANS are accurate and mature tools which have been routinely used to address many hydraulic engineering problems such as flow hydrodynamics upstream of hydropower dams and a section of river reaches, detailed flow characteristics around hydraulic structures, hydraulic impact of different project alternatives, fish passage facility design and evaluation, thermal mixing zone determination and design optimization, reservoir/lake stratification, selective cold water withdrawal, etc. The main limitation is that they are usually applied to a river reach less than five miles due to the required computer power.

3. Model Development for the Project

Simulation Case Selection

A select number of scenarios were chosen in order to assess the hydraulic impact of the proposed training structure and jetties. The number of scenarios depends on the problem under consideration, as well as the schedule and budget limits of the project. In the original work plan, four scenarios were proposed for the simulation; they represent the existing condition and conditions with the proposed structures in place under two different river discharges. Later, two more cases were added to address issues encountered during the project. The original four scenarios are described first next.

The first case is designated as the **Baseline Case**; the baseline case models the river reach under the existing conditions without the proposed training structure and two jetties in place. The river discharge chosen for the baseline case is 19,000 cfs, which corresponds to a high normal operational flow. The water surface elevation at the Diversion Dam face is maintained at 283.5ft due to the operation of the automated spillway gates. **Case I** is selected to represent the scenario with the proposed training structure and two jetties in place. The same river discharge (19,000 cfs) and dam face water surface elevation (283.5 ft) are used. This way, flow hydraulics can be analyzed and compared between Baseline Case and Case I so that the impact of the proposed structures can be assessed.

The effect of river discharge on flow hydraulics with and without the training structure is important, particularly under flood conditions. Therefore, two more scenarios are simulated corresponding to a river discharge of 42,500 cfs, which is the maximum discharge recorded that occurred on June 20, 1983. **Case II** is the scenario under existing conditions while **Case III** is the one with the training structure and two jetties in place. The water surface elevation at the Diversion Dam face has to be known for the three-dimensional simulation and it was estimated to be 283.5ft at a discharge of 42,500cfs according to YAO engineer's analysis.

It is noted that the river bathymetry is assumed to be unaltered after the training structure and jetties are in place for Case I and Case III simulations. This was due to two reasons: firstly, the bed erosion and deposition processes are not modeled; secondly, a comparison of the hydraulic flow changes with and without the structures under the fixed bed condition is useful to represent conditions during and immediately following construction. In reality, it is likely that the proposed training structure would cause the existing point bar to be either partially or completely eroded. By holding river bathymetry constant, Case I can be used to evaluate the sensitivity on river hydraulics at the project site if the point bar is removed. Therefore, two more cases were added and simulated during the course of the project. **Case IV** is the same as Case I except that the point bar on the left bank near the Diversion Dam is removed - this allows for the evaluation of the effect of removing the point bar. After consultation with YAO engineers, it was decided that Case IV would be modeled by removing a majority of the point bar down to a bed level of 271.0 ft. The final case, designated as **Case V**, is essentially the same as Case IV except that the two jetties are not installed. The rationale for the addition of Case V will be discussed later in the report.

All six scenarios simulated in this project are listed and compared in Table 1.

Table 1. Comparison of All Cases Simulated

Case ID	Discharge (cfs)	With Training Structure?	With Two Jetties?	Point Bar Removed?
Baseline Case	19,000	NO	NO	NO
Case I	19,000	YES	YES	NO
Case II	42,500	NO	NO	NO
Case III	42,500	YES	YES	NO
Case IV	19,000	YES	YES	YES
Case V	19,000	YES	NO	YES

Mesh Development

In a numerical simulation of the real world, the simulation domain (i.e., the study area) is selected first, e.g., a section of a river reach for this project. Then a mesh needs to be developed which is a network of discrete points covering the selected solution domain and represents the topography of the river and the geometry of the hydraulic structures. Mesh development for representation of the problem is an important step in applying the three-dimensional hydraulic model. The present project used a mesh-generation procedure that combines the use of SMS software and U^2RANS's own mesh manipulation tools.

The solution domain simulated starts from the face of the Palo Verde Diversion Dam and extends about 8,400 ft upstream. The river width ranges from about 700 ft to 1,000 ft. The majority of the simulated domain has recent detailed bathymetry survey data, available in AutoCAD files from the YAO, and is shown in Figure 4. However, only three cross-sectional survey sections were available for the upstream portion of the river reach. Figure 4 clearly contrasts the density of survey points near the Diversion Dam versus the three cross-sectional survey lines upstream. The surveyed x-y-z data points are extracted from the AutoCAD bathymetry file, and then imported into SMS for mesh development. The bathymetry elevation of each mesh point on the bed was obtained by linear interpolation from the survey data points and is also shown in Figure 4. This step ensures that the surveyed bathymetric data is accurately represented by the numerical model.

It should be pointed out that the river reach under study experiences regular draw-downs for maintenance of the Diversion Dam. For example, the Dam was drawn down to a very low water level during the site trip of the project team on January 6-7, 2004. It was observed that the draw-down had a big impact on the local bathymetry of the river reach under study and the bathymetry during draw-down may be quite different from the data used for this project. Despite this, it is expected that the overall bathymetric characteristics would return to those surveyed once the water level is back to the normal operating conditions (283.5ft).

While every attempt was made to accurately model river bathymetry, nonetheless, river bathymetry is a dynamic element. However, it is believed that the mesh development and modeling process represents the river hydraulics within the limits of the accuracy of the models and the current state-of-the-practice.

Final meshes were developed for all scenarios. For cases under existing conditions (no training structure and jetties), the 3D mesh consists of 197,757 mesh points with 21 vertical points, while the mesh for cases with the training structure has 238,917 mesh points and 21 vertical points. The mesh distribution is not uniform in all directions - point density was increased around important areas such as structures and point bars. On average, mesh elements have a streamwise spacing of about 40 ft, a lateral width of around 15 ft, and a vertical depth up to 2 ft. Plan views of Baseline Case and Case I meshes are shown in Figure 5. The mesh system selection is based on extensive past experiences and is deemed adequate for obtaining accurate solutions for the present project.

Both plan and perspective views of the model bathymetry are displayed in Figures 6 and 7, respectively, for Baseline Case and Case I (jetties are not shown for Case I). Figure 8 shows the comparison of bathymetry between Case I and Case IV so that the extent of the point bar removal can be examined visually.

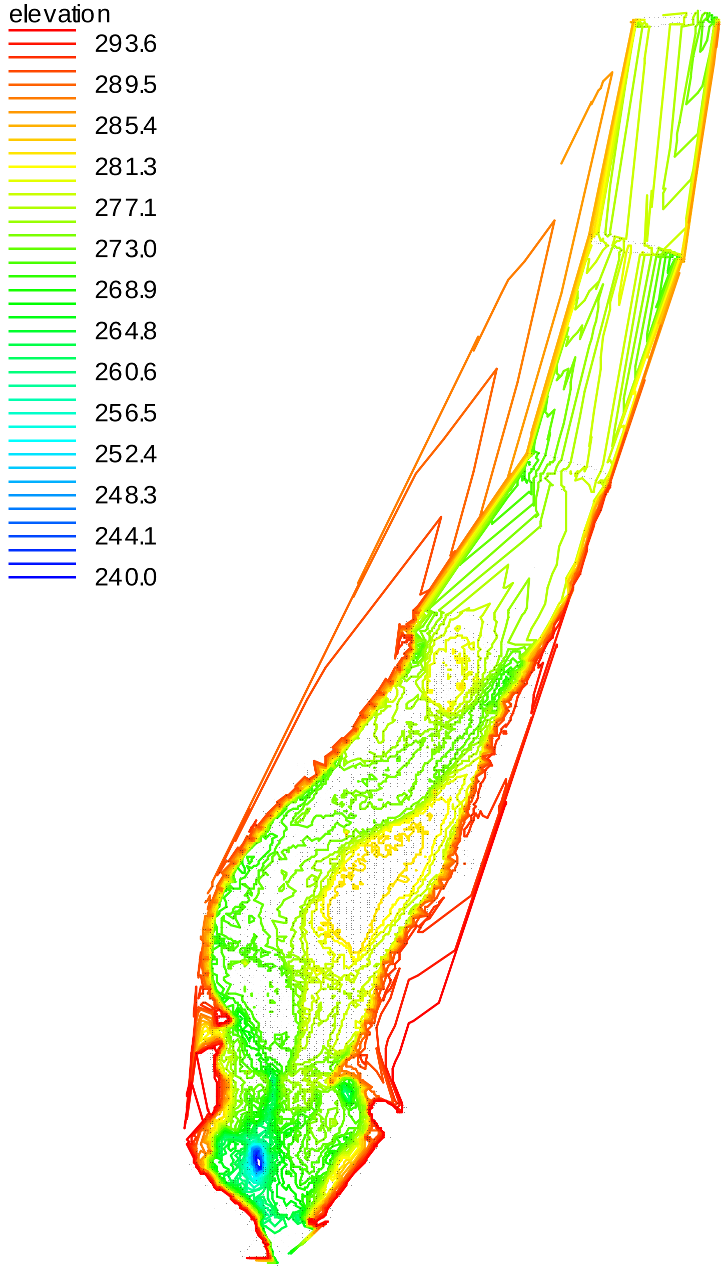
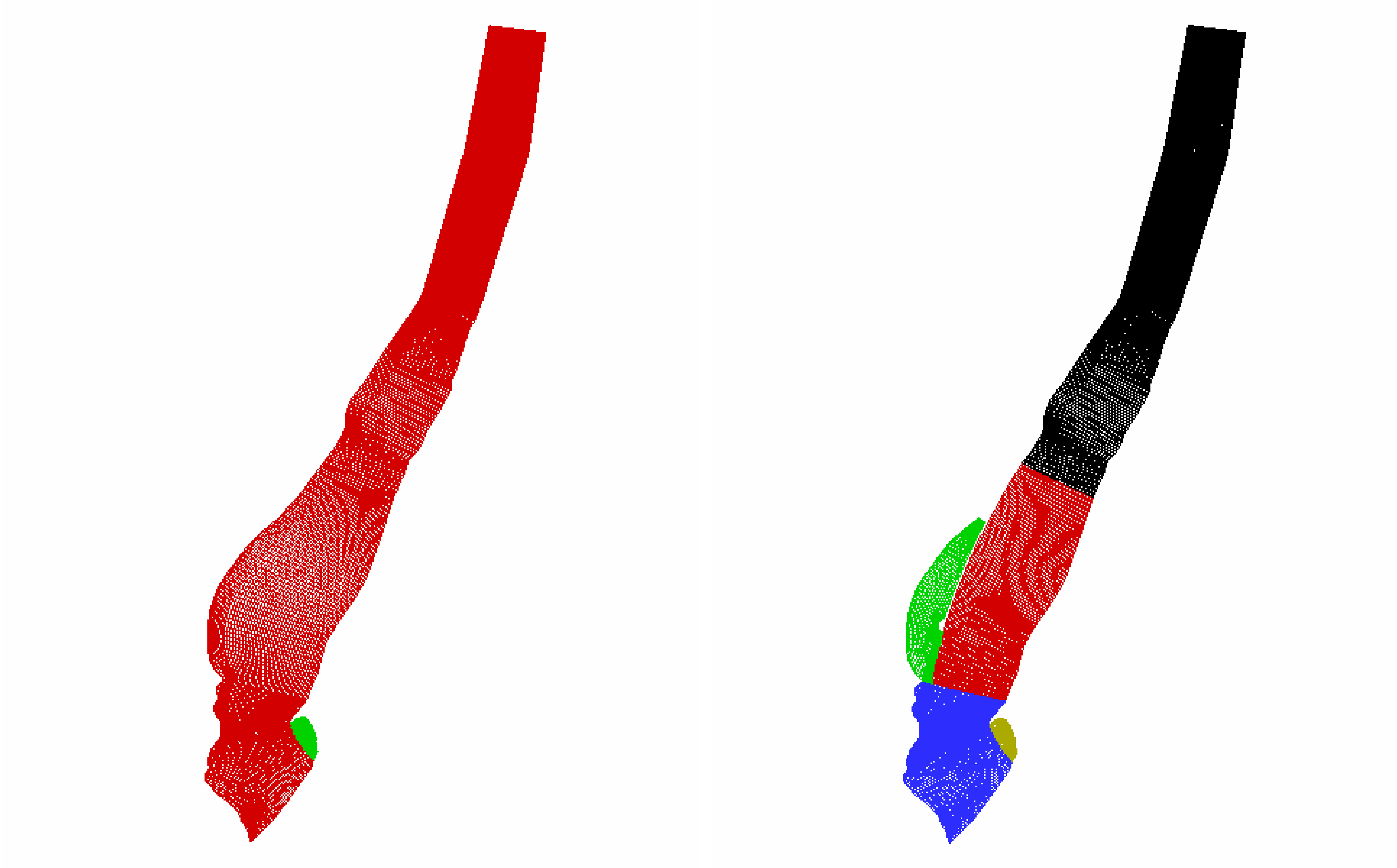
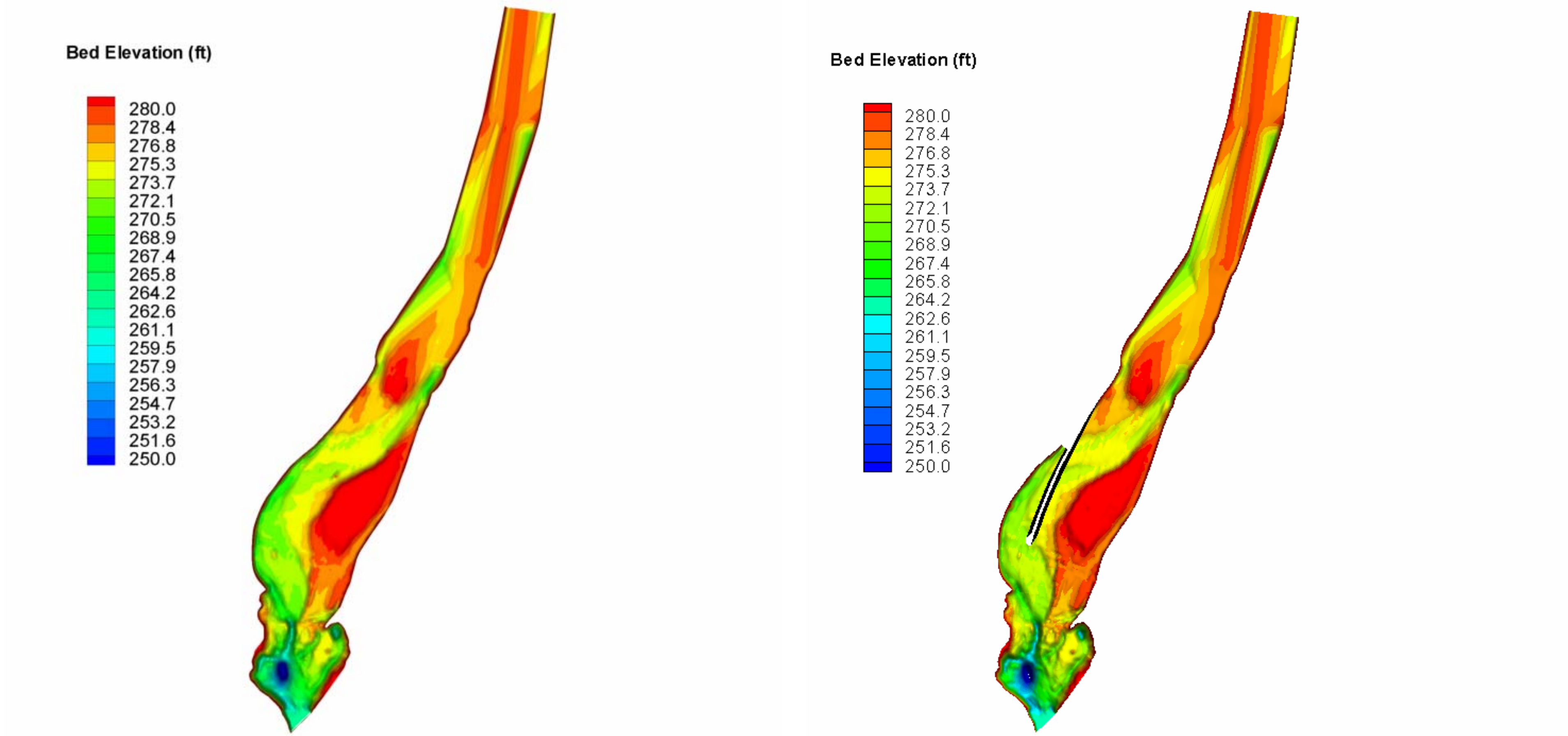


Figure 4. Field Surveyed Bathymetry Data (black points are survey points; contours show the bed elevation in feet based on the raw survey data)



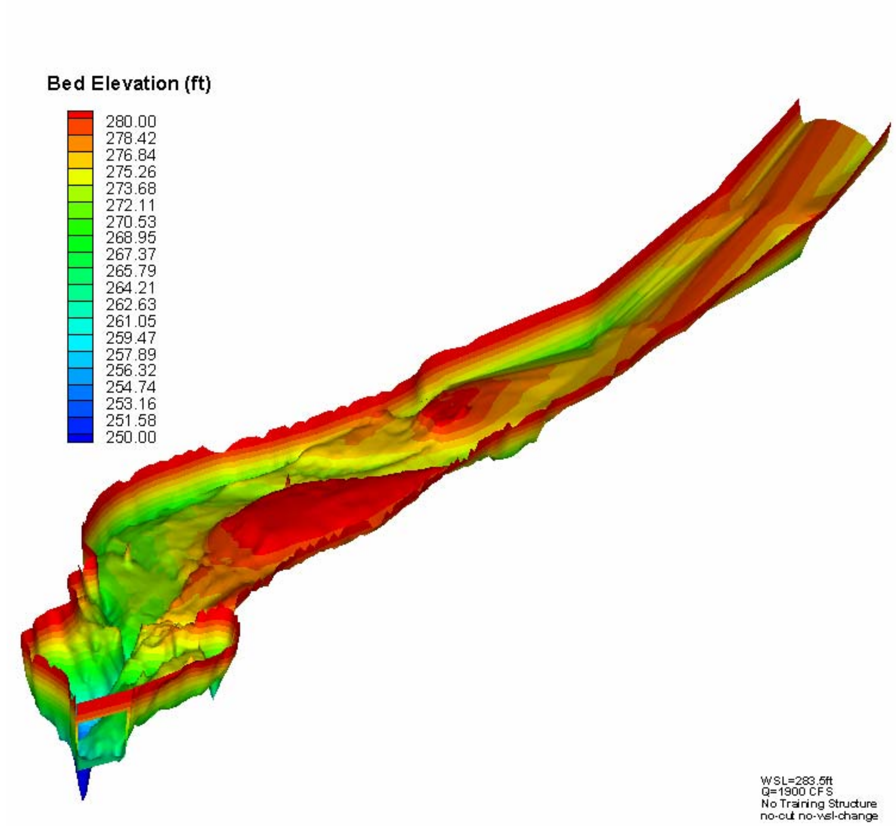
(a) Mesh for Baseline Case **(b) Mesh for Case I**

Figure 5. Plan Views of Meshes Used for the Present Study (different colors represent mesh blocks)

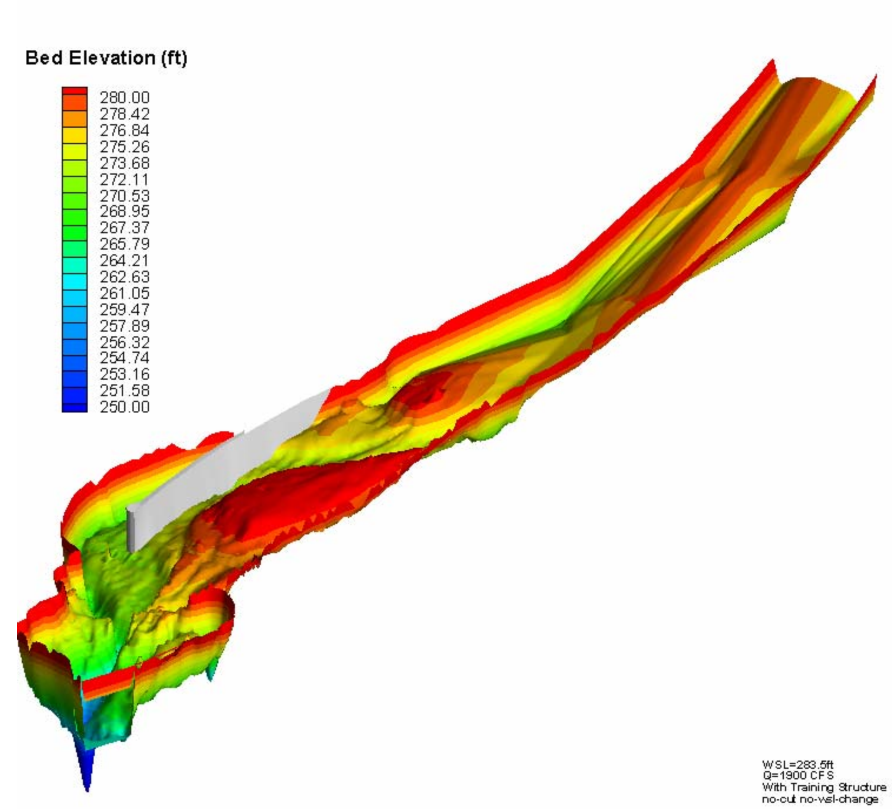


(a) Baseline Case **(b) Case I**

Figure 6. Plan Views of the Model Bathymetry for the Simulated River Reach

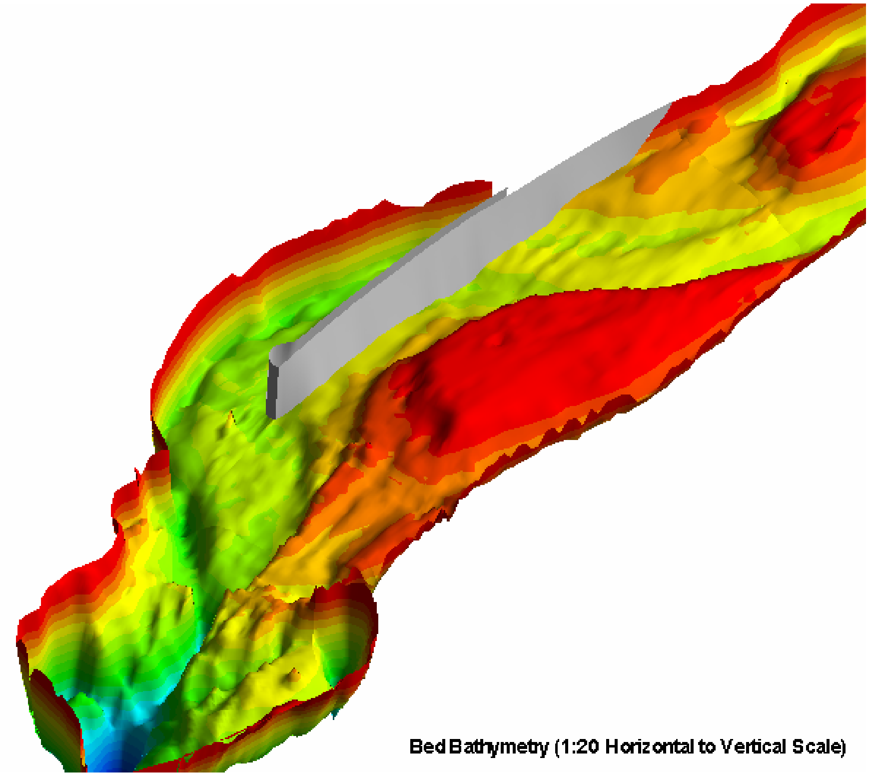


(a) Baseline Case

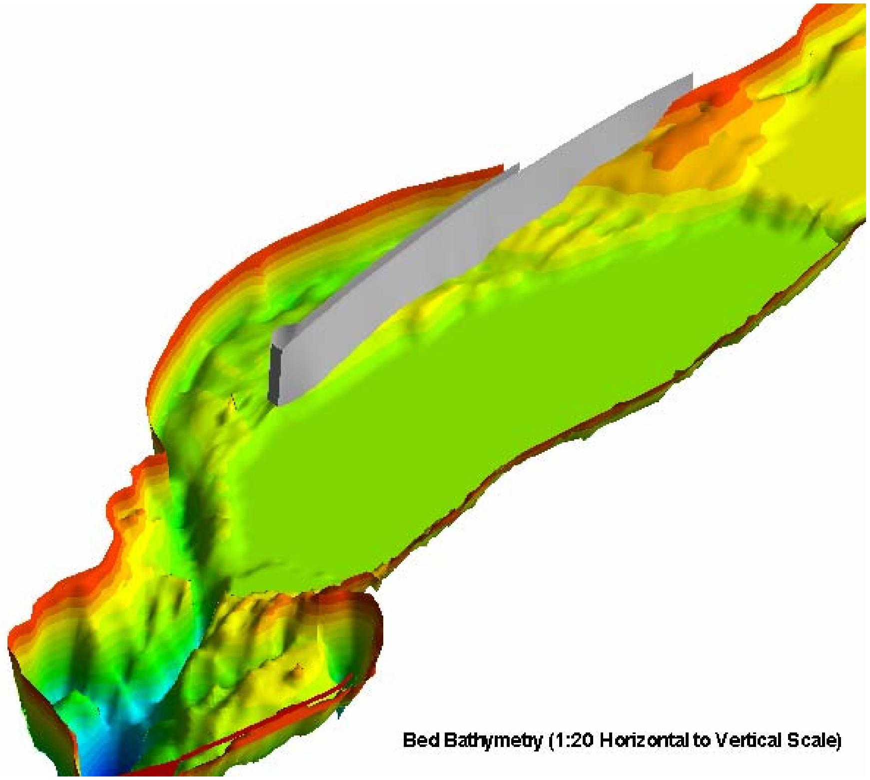


(b) Case I

Figure 7. 3D Perspective Views of the Model Bathymetry for the Simulated River Reach



(a) Case I



(b) Case IV

Figure 8. Comparison of Model Bathymetry for the Simulated River Reach with and without Point Bar

4. Results and Discussion

This section presents and discusses the model simulation results, as well as the implications of the results. All results are displayed from Figure 9 through Figure 32. The velocity field is examined first as the magnitude of velocity provides important information about the impact on the potential erosion and deposition characteristics by the proposed structures. It also helps pinpoint possible negative impacts by the project on the existing banks and Diversion Dam. The flow pattern is then analyzed to identify if any eddy structures are developed or strengthened as a result of the project. Eddies frequently dictate localized scouring characteristics and may have large impact on bank erosion and potential Diversion Dam undercutting. Finally, other useful hydraulic variables, such as the water surface elevation change, secondary flows, and bed shear stresses, are presented.

Velocity Field

The predicted velocity magnitude at the water surface for a flow discharge of 19,000 cfs is plotted in Figure 9 for the Baseline Case and Case I. The same results are also displayed in 3D perspective views in Figure 10. It is clearly shown that the flow under existing conditions undergoes a typical pattern of bendway flow near the Diversion Dam. Presence of the point bar on the left bank diverts the water to flow mainly on the right bank just upstream of a naturally-occurring bend (see Figure 2a). This flow pattern is the main cause for accelerated California-side bank erosion observed in aerial photos of Figure 2. Continued bank erosion is anticipated if it is kept untreated. The bulk flow velocity (i.e., the cross-sectional area weighted velocity) in the bend region is about 5 ft/s, while flow at the point bar is almost stagnant. The same velocity near the right bank of the bend region is approximately 8 ft/s with the 42,500 cfs discharge. This estimated velocity should be taken into consideration if riprap is used instead of the proposed training structure. However, more studies under different discharges and water surface levels are recommended if the riprap becomes an option.

It is noted that flow on the upstream section of the river reach, where the two jetties are proposed, is impacted by local bathymetry (shown in Figures 6 and 7), resulting in higher velocity on the right bank for the baseline case. Caution needs to be exercised, however, as the local bathymetry in this area is based on only three cross-sectional survey profiles.

With the proposed training structure and two jetties in place, the flow pattern for Q=19,000 cfs is plotted in Figure 9b, assuming the point bar stays. The flow is strongly influenced by the point bar in that very high velocities are created on both banks at the bend region. This is obviously detrimental to the integrity of the left bank and possibly the training structure and should be taken into consideration during the initial construction period. However, it is anticipated that the point bar will be eroded over time once the training structure is in place. Therefore, the above results are not representative of long-term conditions.

In order to show the effect of point bar erosion, one more case is simulated (Case IV) with the point bar removed as described in Section 3 (see Figure 8). A comparison of results with and without the point bar is shown in Figure 11. Once the point bar is removed, the higher velocity flows remain in the river center; this is expected to be a more representative flow pattern over time.

The above simulated results provide quantitative information for flow characteristics under existing conditions and justify the project concept of the training structure and two upstream jetties to prevent continuing bank erosion. This flow patterns after the placement of the training structure and jetties are quite different with and without the presence of the point bar. To see if this overall flow pattern remains for discharges other than 19,000 cfs and to examine the effect of an increased discharge, simulation with 42,500cfs discharge is also carried out and results are shown in Figures 12 and 13. Note that the water surface elevation remains at 283.5ft for the discharge. It is seen that the flow pattern for the 42,500cfs discharge is very similar to that of 19,000cfs case. In the plots, the velocity scale is increased from 6.6 ft/s in Figs.9 and 10 to 14.76 ft/s in Figs. 11 and 12, a factor of 2.236 increase. This is such as the ratio of 42,500cfs to 19,000cfs is 2.236. The velocity results show that the overall rate of velocity increase for 42,500cfs is less than 2.236. This points to increased water surface elevation for the higher discharge case, a direct consequence of increased flow resistance.

If extreme flood happens, the water surface elevation may rise above the designed 283.5ft level. Under such conditions, the point bar will be completely submerged and water pattern will be quite different. It can be inferred the point bar will be submerged and eroded. However, the occurrence of such a high flood is infrequent, and it is expected that the point bar will be redeveloped once the discharge is back to the normal level if no training structure is constructed.

The velocity magnitude results from the modeling can also be used to evaluate the impact of installing the two jetties upstream. Figures 9b, 11b and 12b show that the jetties are successful in pushing the flow away from the right bank. However, potential detrimental impacts are also revealed. Higher velocities are present if the point bar is eroded as shown in Figure 11b. Higher left bank velocity might cause accelerated left bank erosion not present under existing conditions. Results in Figure 11 also indicate the appearance of a sinuous (meandering) flow motion which is possibly harmful to both the training structure and banks. This sinuous flow is induced by the proposed two jetties. Based on these results, it is recommended that the two jetties be either modified in their design, or removed from the project, to avoid the sinuous flow motion. One suggested design alternative for the two jetties includes using jetties shorter in length than the original design. If jetties are removed from the project, reinforced riprap may need to be considered on the right bank at the jetty location due to high velocity at that location.

In order to check if the two jetties are responsible for the above mentioned flow features, an additional simulation is carried out with the following conditions: Q=19,000cfs, the training structure is in place but two jetties are removed, and the point bar is removed. This case is the same as Case IV except that two jetties are removed and is designated as Case V in this report. A comparison of results with and without the jetties is shown in Figure 14. It is seen that the flow is more uniform and does not induce the high velocities along the left bank and the sinuous motion. If shorter jetties are preferred to riprap bank protection, additional model runs may be used to determine the appropriate jetty length that would provide protection to the right bank without inducing bank erosion on the opposite left bank.

Flow Pattern Analysis

The next modeling results considered are the different flow patterns or eddies predicted to develop - these are examined to investigate potential effects. Flow streamlines and velocity vectors are plotted for this purpose and are displayed from Figure 15 to Figure 20.

An examination of the results shows that eddies are present under existing conditions, but some of them strengthen and new eddies develop once the training structure is installed. Of particular concern is the eddy (Eddy #1) developed behind the training structure once installed (see Figure15b, 16, 17b). This eddy will cause sediment deposition at the mouth between the end of the training structure and the right bank, limiting flow in and out of the backwater created by the training structure. A sill at the mouth of the backwater could reduce the amount of sedimentation that occurs, but the success of this measure depends on the suspended sediment concentration. It is encouraging that this eddy is much weaker once the point bar has eroded as shown in Figure 16b. However, it is realized that the point bar bathymetry was assumed in the simulation. Point bar removal would be better simulated using a good three-dimensional sediment model. Despite the sediment deposition potential, this eddy is not a concern for the right bank erosion as the erosion potential of any eddy developed behind the training structure is significantly less than the erosion potential of the river on the right bank without the training structure in place.

Another eddy of concern (Eddy #2) is the one located on the right bank near the Diversion Dam intake. This eddy becomes stronger with the training structure in place (see Figs.15 and 17), though the strength could be lowered with the point bar eroded. During the site trip, it was noticed that the existing riprap at this location is not in good shape (see Figure 21); it is recommended that this location be strengthened with new riprap because a stronger eddy may result in higher erosion potential.

The final eddy of concern (Eddy #3) is the one located in front of the embankment on the left side of the spillway gates. The hydraulic modeling predicts, once the training structure is in place, the formation of a stronger eddy in front of the dam embankment to the left side of the spillway gates as shown in Figures 15, 16 and 17. A current photo of the area is shown in Figure 22; a strong eddy present at this location may be potentially harmful to the integrity of the Diversion Dam embankment due to possibility of local scour development. Since armoring of this area was done to prevent further erosion, in the future only monitoring should be required to insure that there are no potential impacts to dam embankment stability or integrity.

Back Water Effect

The proposed training structure has the potential to constrict the existing river channel, resulting in an increase in river stage upstream. Therefore, the backwater effect due to the training structure is examined by comparing the water surface elevation changes. These results may be useful to check if the stage change will impact upstream facilities and operations that are not covered under the current study area.

In Figure 23, the water surface elevation results are compared between Baseline and Case-I with a river discharge of 19,000 cfs. For all cases, the water surface elevation increases from the Diversion Dam face to upstream. For example, the change for the Baseline case is about 0.8 ft while the increase is 1.4 ft for Case-I. This suggests a net increase of 0.6 ft in water surface elevation at the upstream location (about 8,000 ft) due to the presence of the training structure and jetties.

It is noted, however, that the above result is based on the assumption that the point bar remains after the installation of the training structure. A more realistic comparison should consider the scenario of the eroded point bar. For this purpose, the calculated water surface elevations are shown for cases with the point bar removed, one with jetties and another without jetties (see Figure 24). It is seen that the net change of the water surface elevation upstream is almost negligible between Figures 23(a) and 24(a), and the upstream water surface elevation is reduced by about 0.25 ft between Figures 23(a) and 24(b). Therefore, it can be concluded that the backwater effect due to the training structure is not a concern. Without the jetties, a slight reduction in the water surface elevation is predicted, indicating increased water conveyance.

For completeness, the predicted water surface elevations are also displayed in Figure 25 for Case II and Case III with the flow discharge of 42,500 cfs. Note that the point bar remains for both cases. Similar to the results of Q=19,000 cfs in Figure 23, an increase of the upstream water surface elevation is predicted with the training structure and jetties in place. But it is anticipated that the water surface elevation change should be negligible or much reduced if the point bar is eroded and no jetties are installed.

Secondary Flows

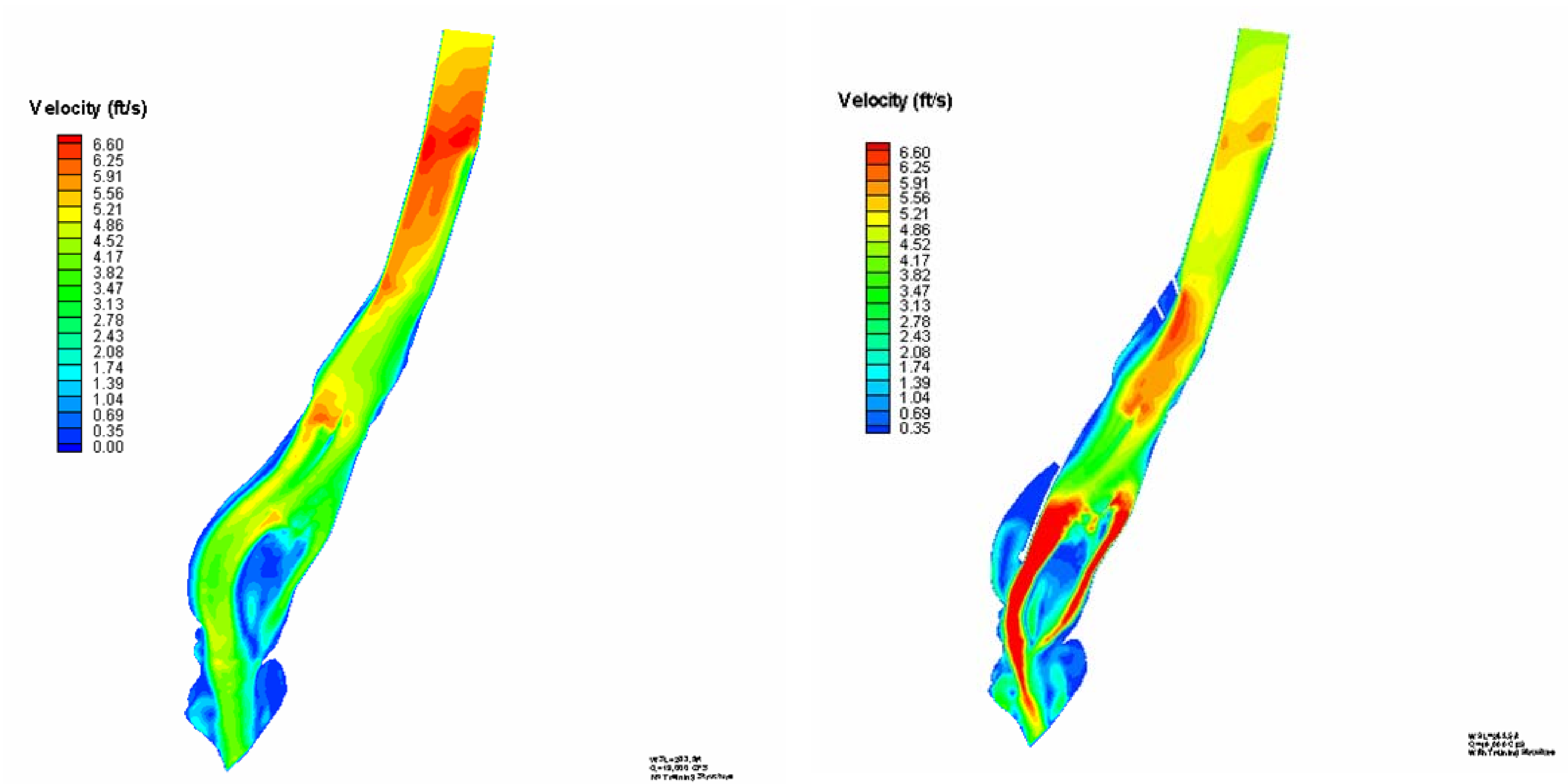
U^2RANS is a fully three-dimensional flow model and secondary flows can be captured and analyzed. Display of the secondary flow is problematic, however, as it totally depends on the normal direction of the selected cross-section. Figures 26 to 28 show sample secondary flow velocities for three cases: Baseline, Case I and Case V. In Figure 26, the secondary flow velocity is displayed on one cross section within the bend region with the existing conditions. As expected, the water mostly flows towards the right bank on the surface while away from the bank near the bed, typical of secondary flows within a bend. Figures 27 and 28 are similar plots at the same location for scenarios with the training structure and with and without the point bar.

Figures 29 to 31 show the cross sectional views of the velocity distribution on cross sections along the river reach for all six cases. The location of the maximum velocity can be clearly seen.

Shear Stress Analysis in the Vicinity of the Training Structure

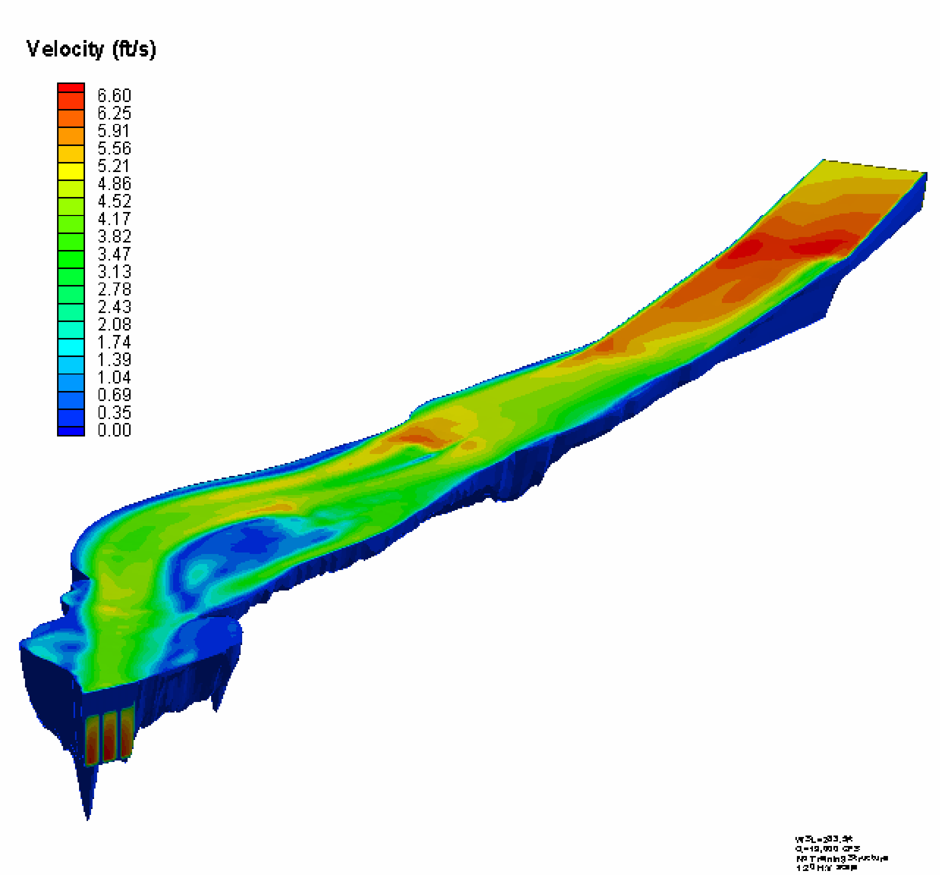
Locations of high bed shear stress provide an indication of areas that are more susceptible to erosion. Shear stress distributions on the river bed are displayed in Figures 32 to 34 for all cases. Under existing conditions the high stress is along the bend, as expected, for both discharges (Figure 32). If the river meander migration is allowed to continue, it is expected that the point bar would continue to persist. When the training structure is installed, a very high shear stress is predicted if the point bar remains intact (Figure 33), which is a further confirmation that the sand bar is likely to be partially or completely eroded. Once the point bar is eroded, the shear stress is reduced as shown in Figure 34. Again, sinuous flow pattern can be clearly seen if the two jetties are constructed; while more uniform and reduced stress flow is evident if jetties are not present.

In all cases where the training structure is present, bed shear stress distribution along the scallop is generally reduced, especially at the upstream end of the scallop and along its toe, both of which are critical locations for controlling or preventing further erosion of the bank.

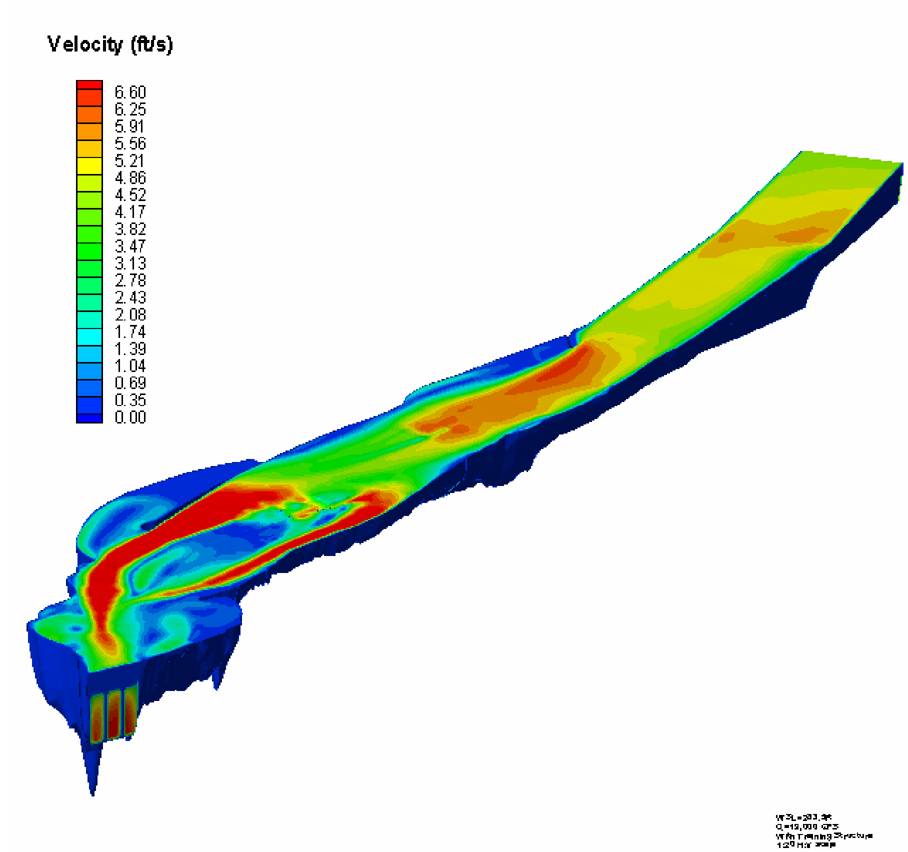


(a) Baseline Case without Training Structure **(b) CASE I with Training Structure**

Figure 9. Plan Views of the Velocity Magnitude at the Water Surface for Q=19,000 cfs Scenario

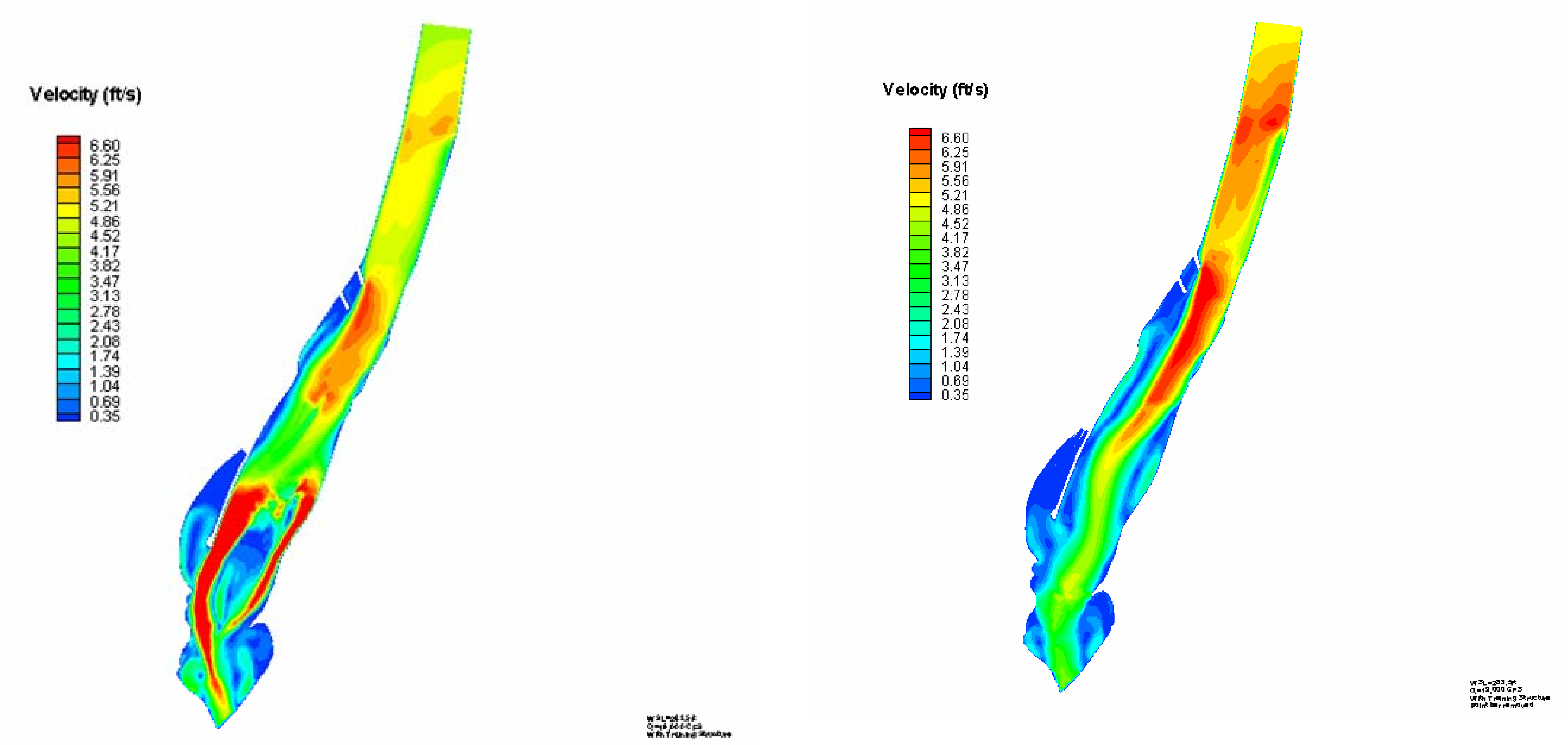


(a) Baseline Case without Training Structure



(b) Case I with Training Structure

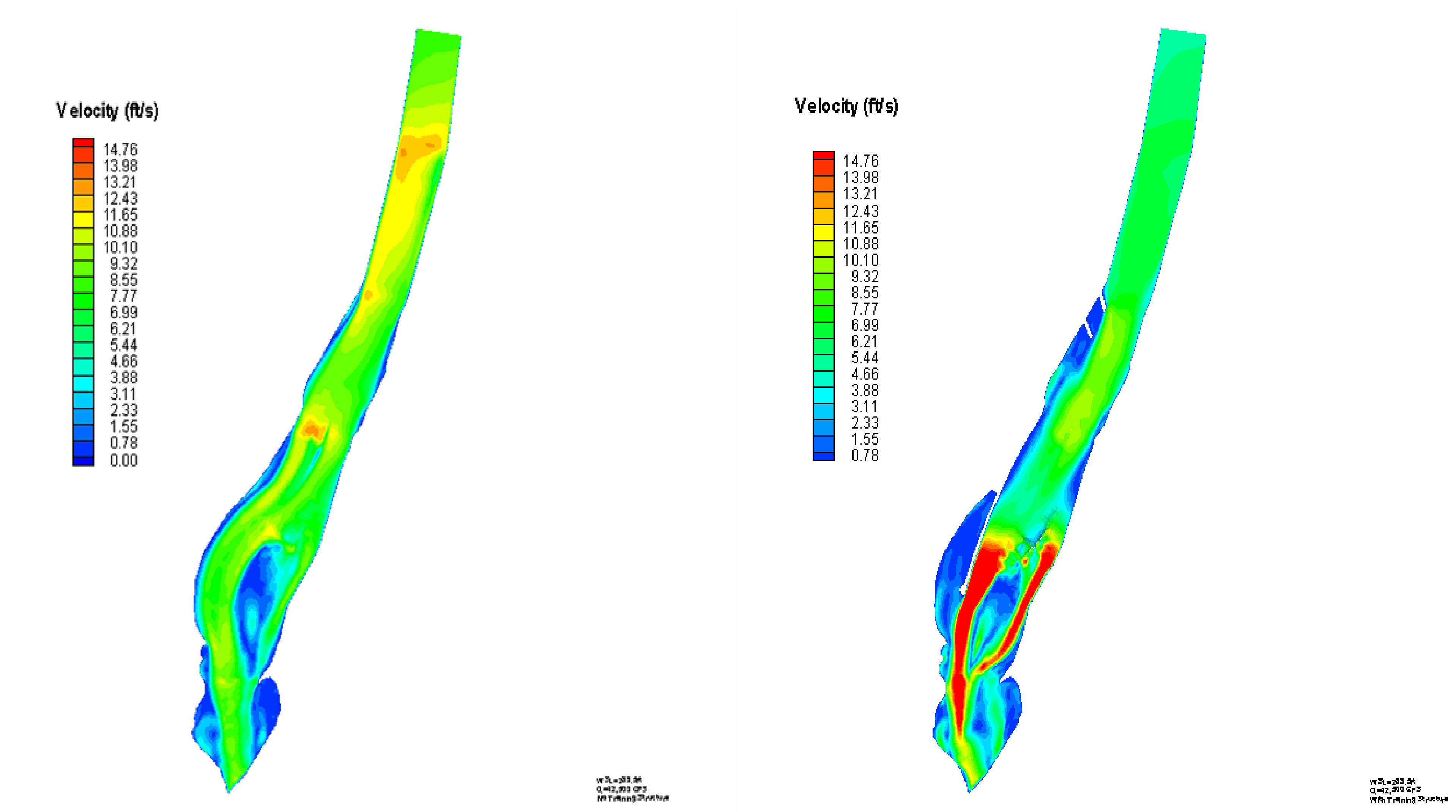
Figure 10. Perspective Views of the Velocity Magnitude at the Water Surface for Q=19,000 cfs Scenario



(a) Case I with Point Bar in Place

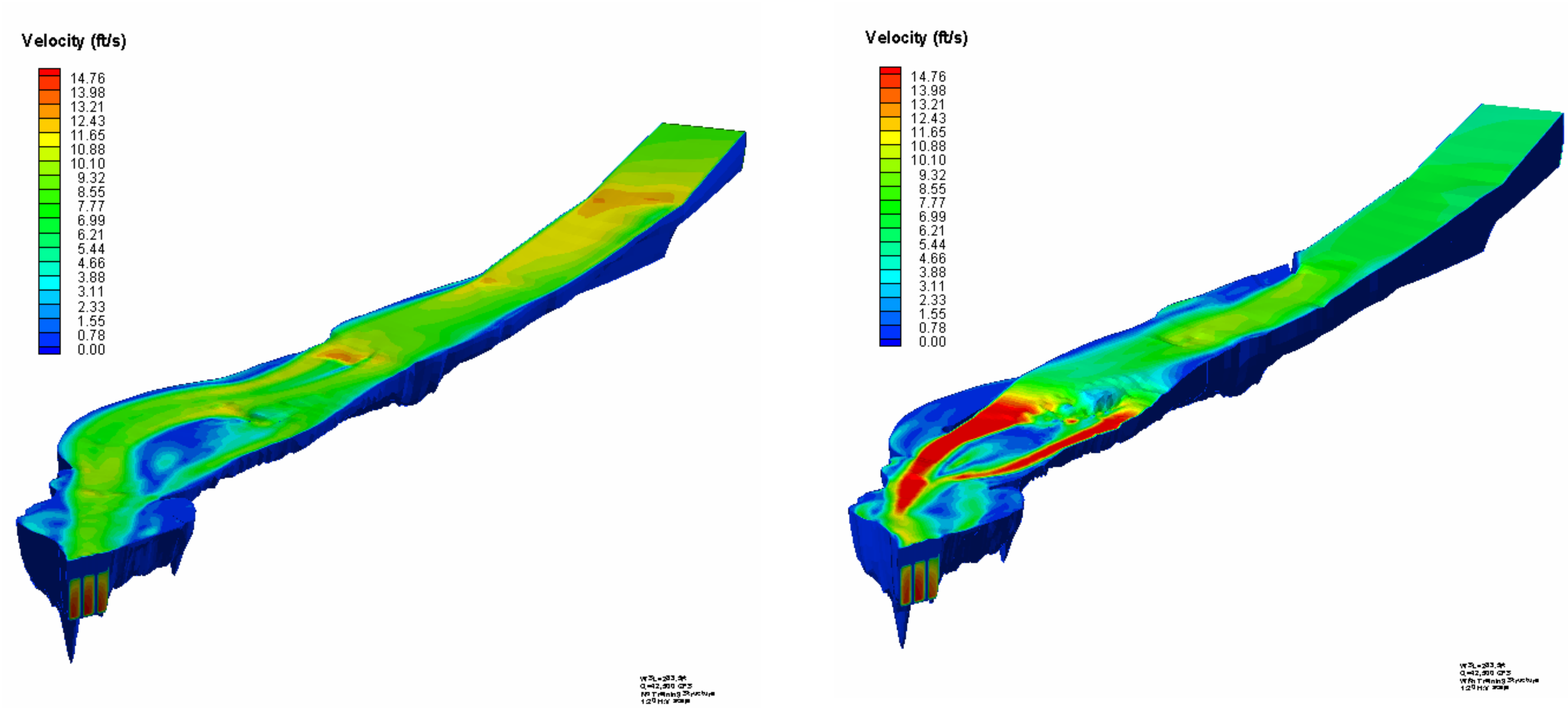
(b) Case IV with Point Bar Removed

Figure 11. **Plan Views of the Velocity Magnitude at the Water Surface for Q=19,000 cfs Scenario**



(a) Case II without Training Structure **(b) Case III with Training Structure**

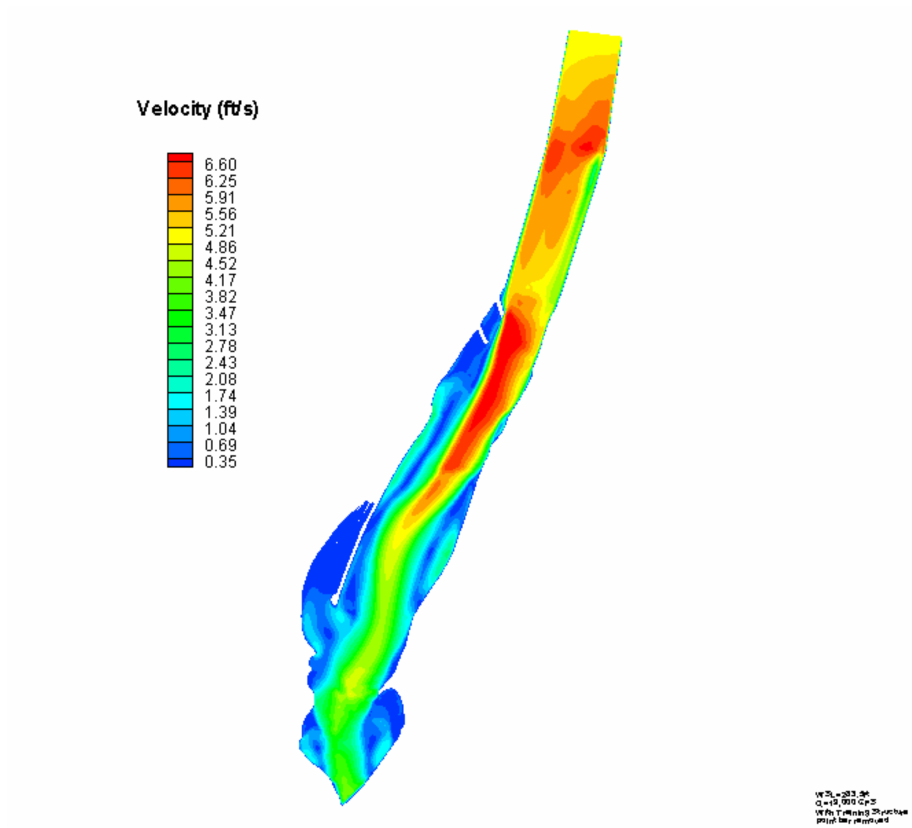
Figure 12. Plan Views of the Velocity Magnitude at the Water Surface for Q=42,500 cfs Scenario



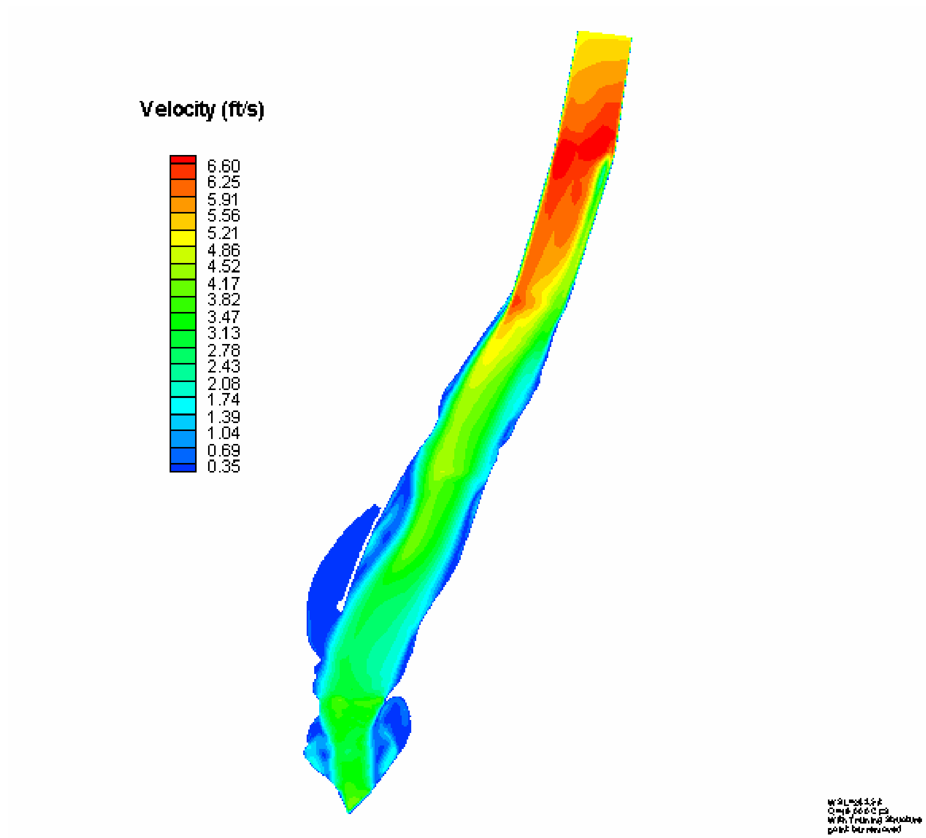
(a) Case II without Training Structure

(b) Case III with Training Structure

Figure 13. Perspective Views of the Velocity Magnitude at the Water Surface for Q=42,500 cfs Scenario

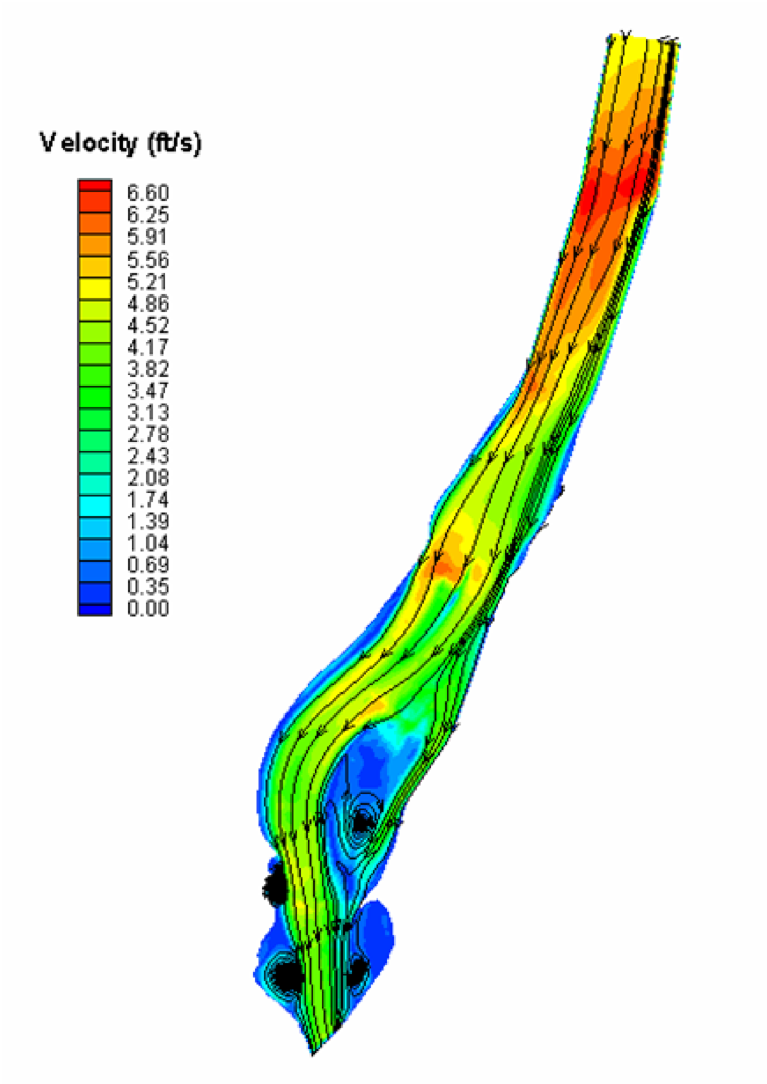


(a) Case IV with Jetties in Place

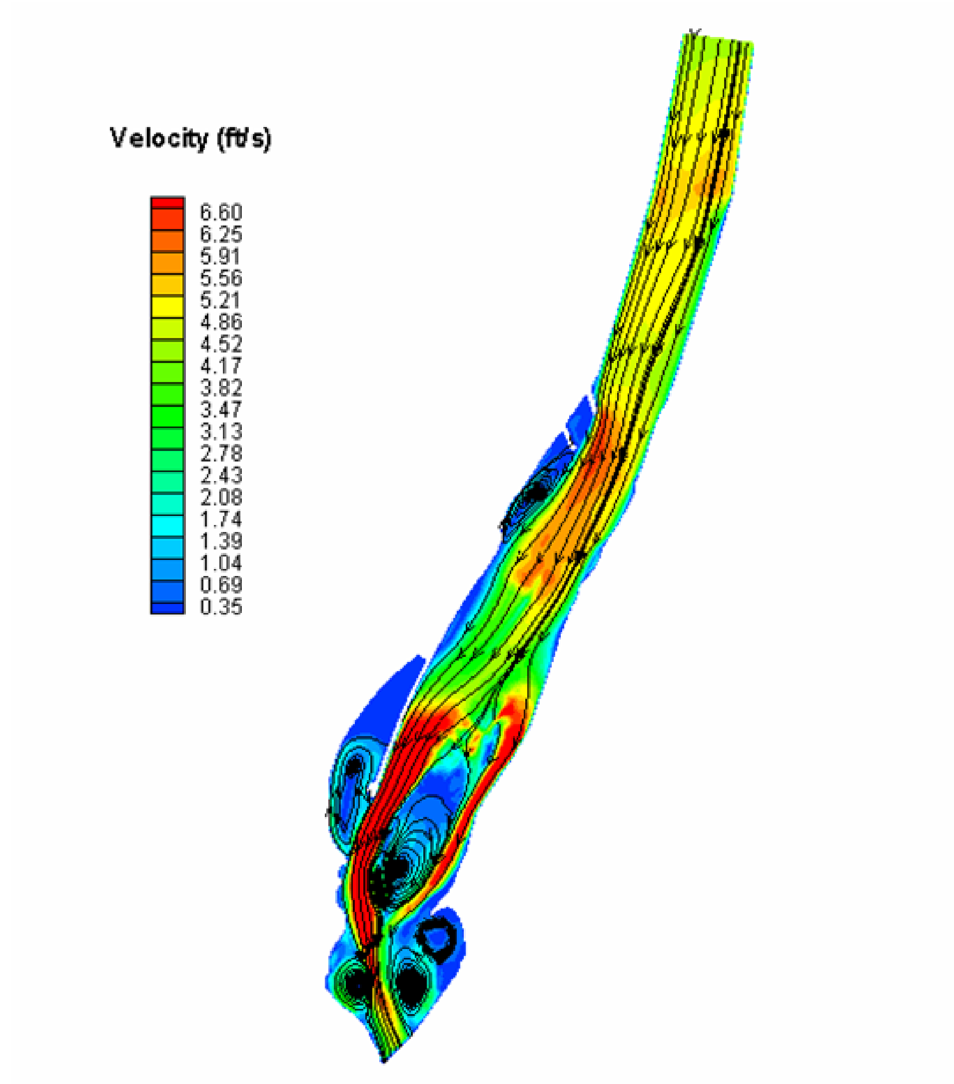


(b) Case V with Jetties Removed

Figure 14. Plan Views of the Velocity Magnitude at the Water Surface for Q=19,000 cfs Scenario with Point Bar Removed

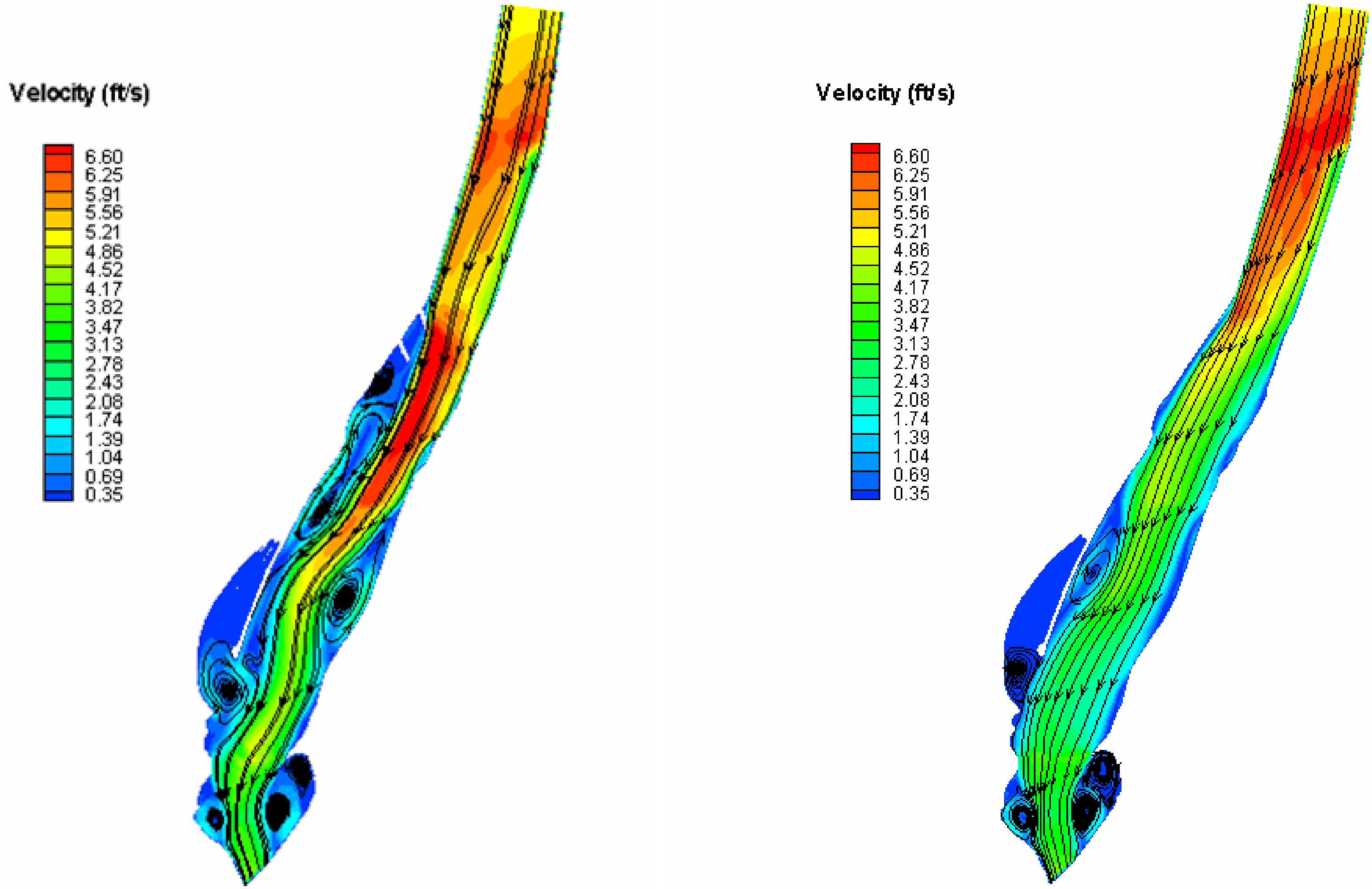


(a) Baseline Case without Training Structure



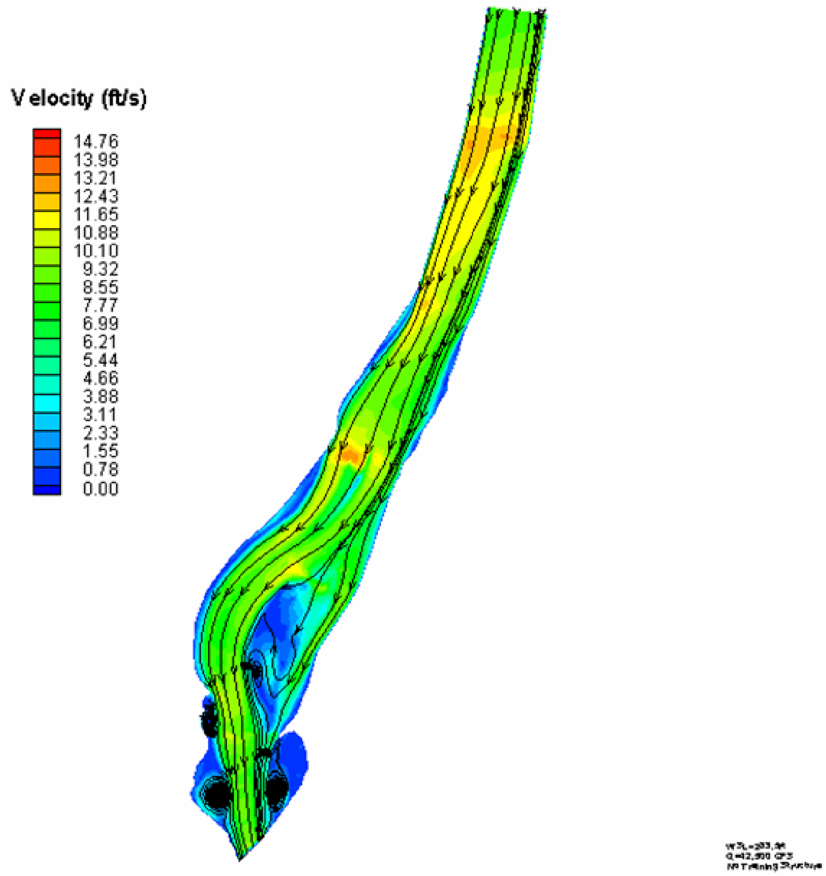
(b) Case I with Training Structure and Point Bar in Place

Figure 15. Plan Views of Flow Streamlines at the Water Surface for Q=19,000 cfs Scenario

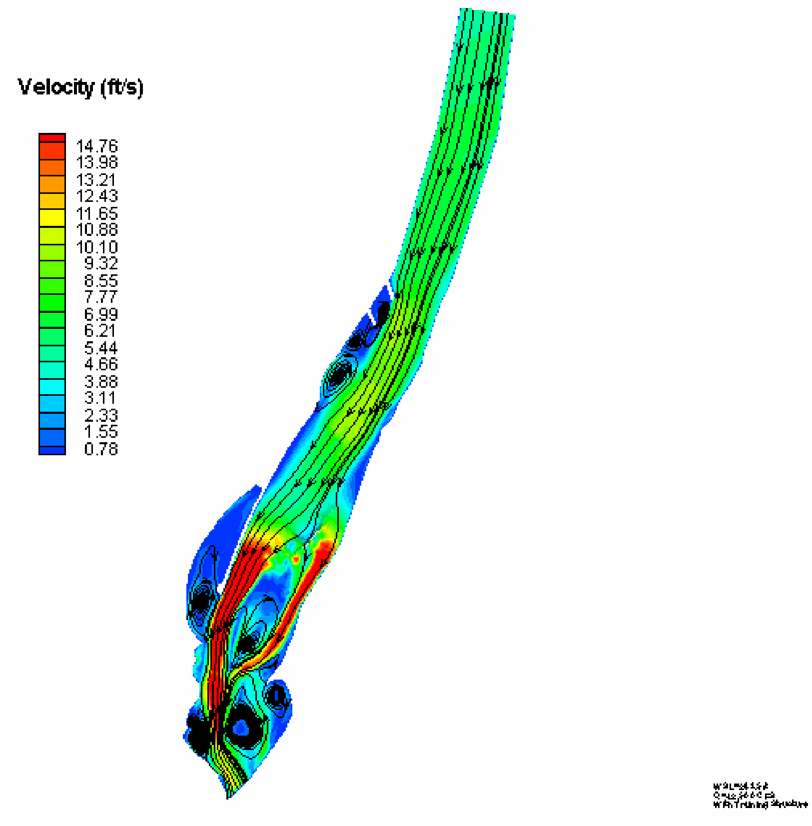


(a) Case IV with Jetties in Place **(b) Case V with Jetties Removed**

Figure 16. Plan Views of Flow Streamlines at the Water Surface for Q=19,000 cfs with Training Structure and Point Bar Removed.

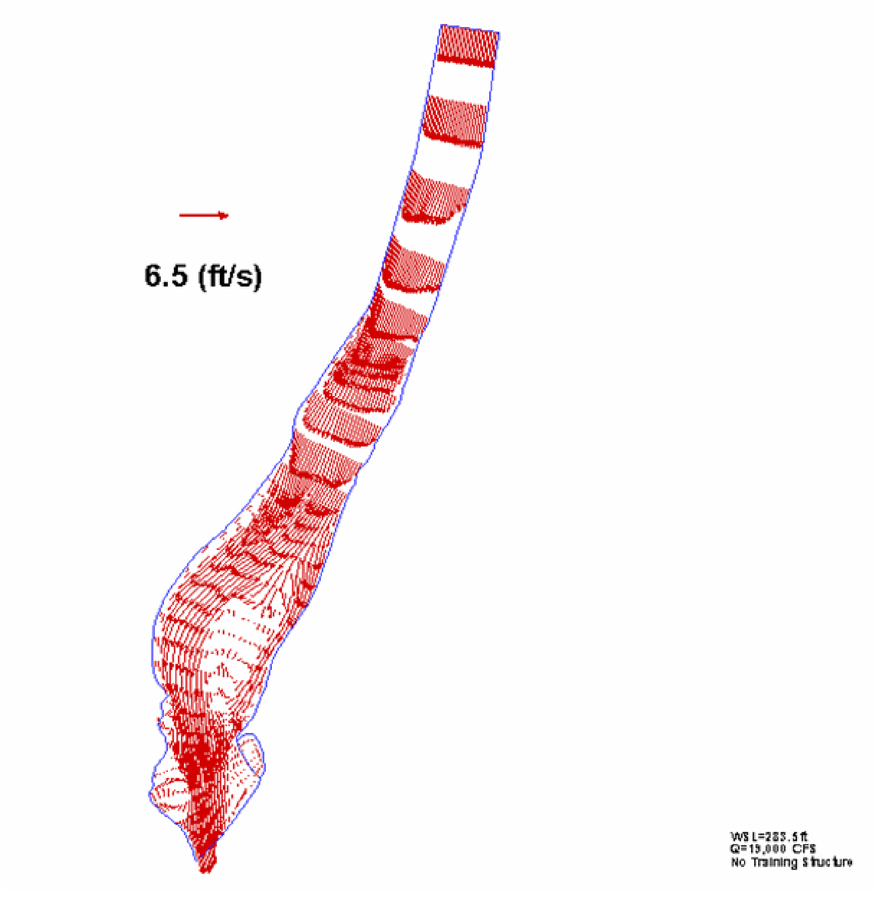


(a) Case II without Training Structure

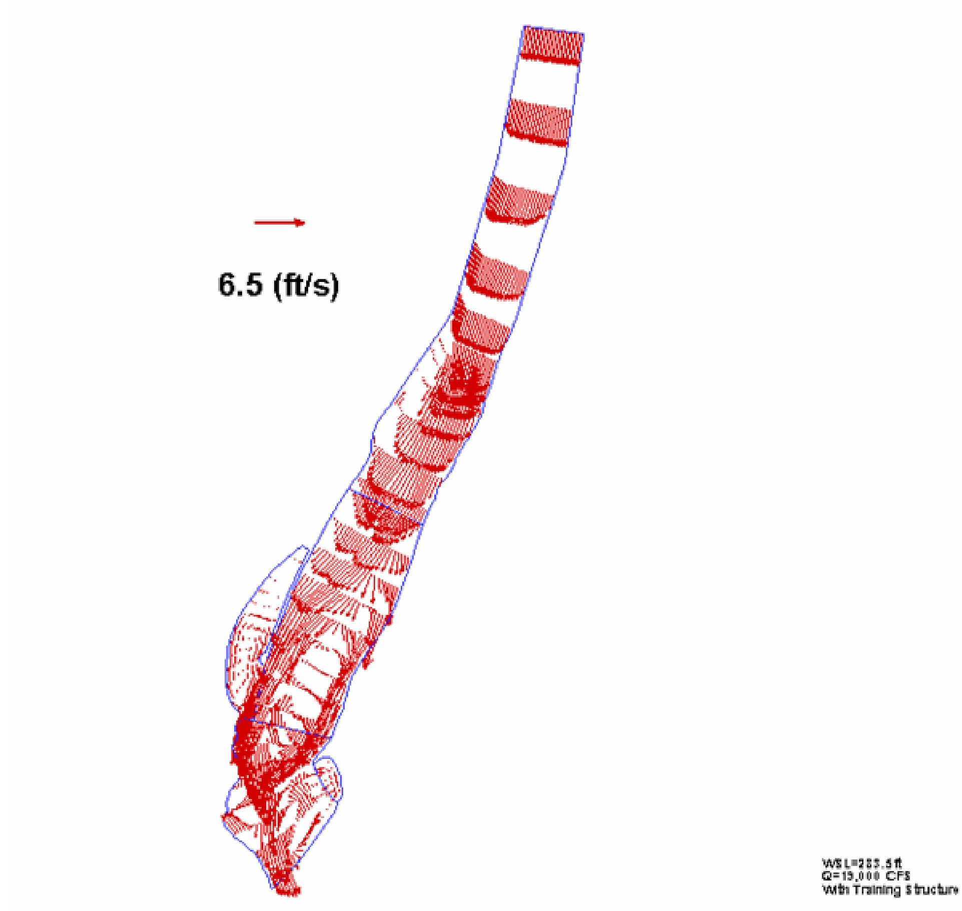


(b) Case III with Training Structure

Figure 17. **Plan Views of Flow Streamlines at the Water Surface for Q=42,500 cfs Scenario**

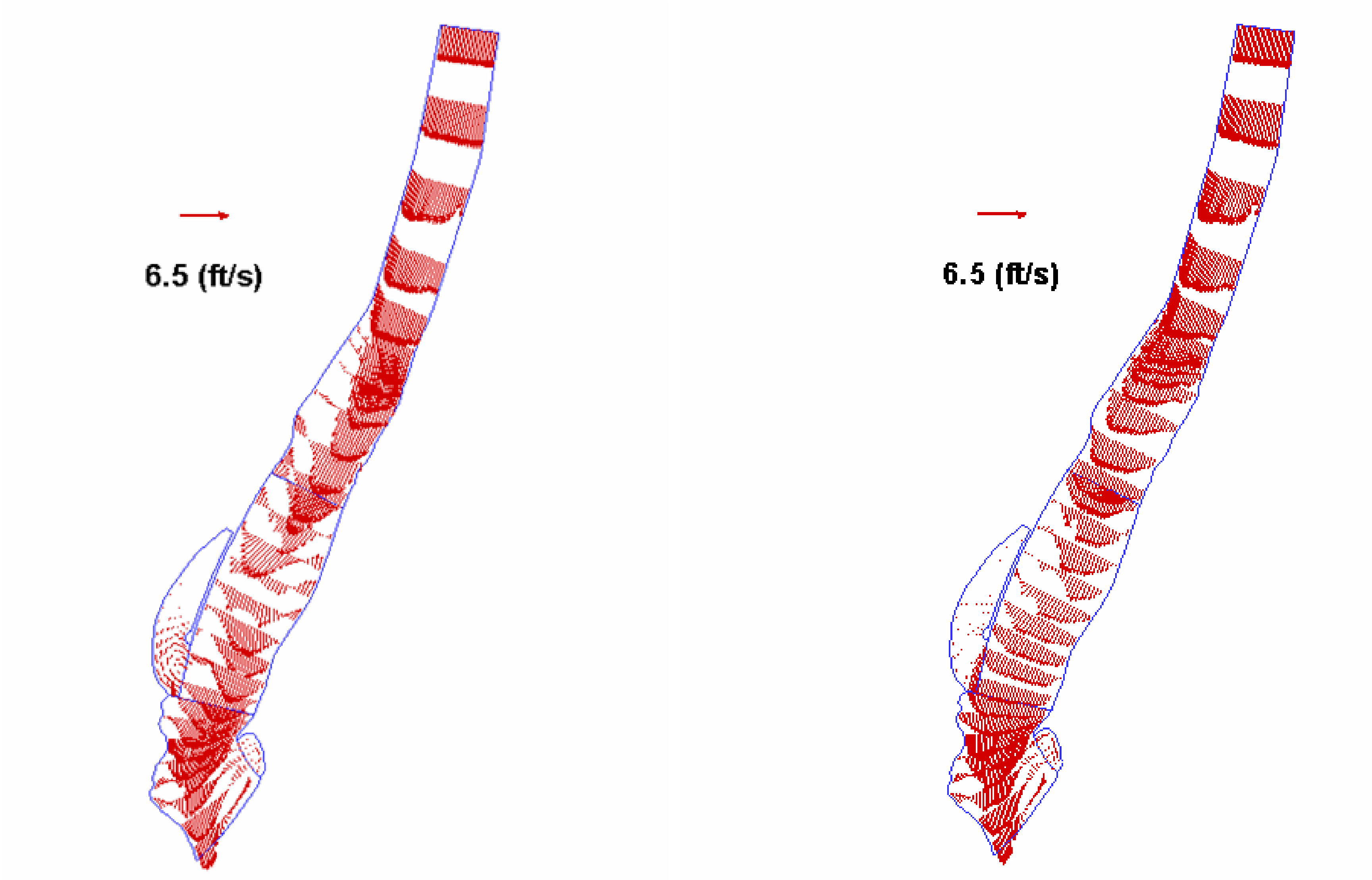


(a) Baseline Case without Training Structure



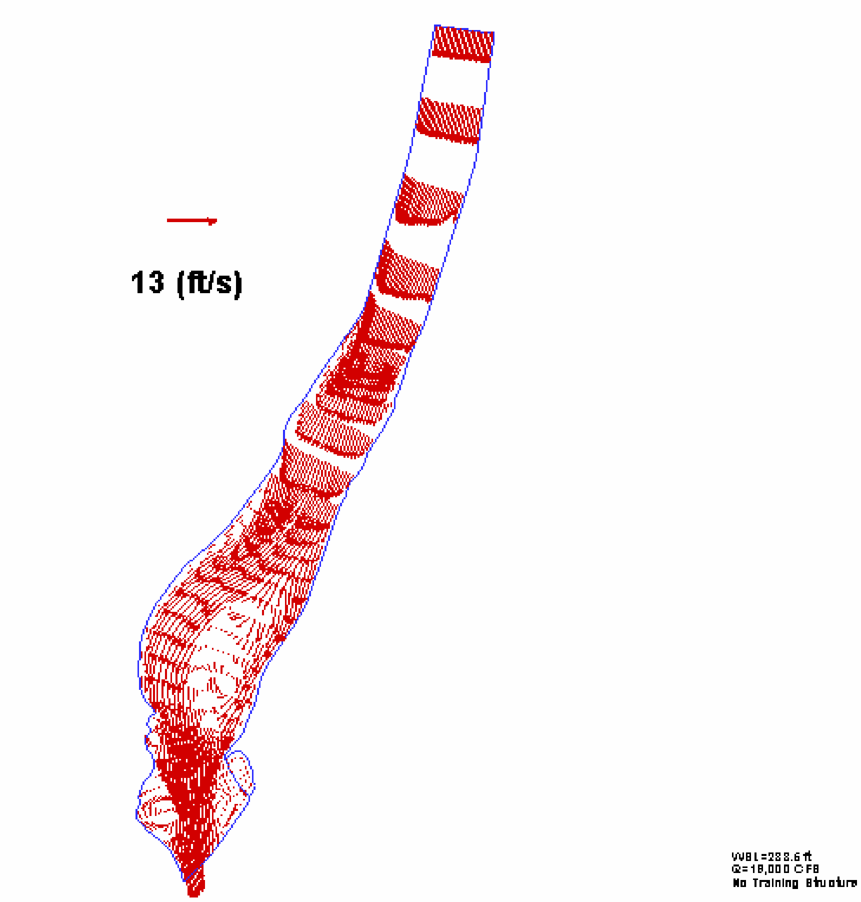
(b) Case I with Training Structure

Figure 18. Plan Views of Velocity Vector on Water Surface for Q=19,000 cfs Scenario

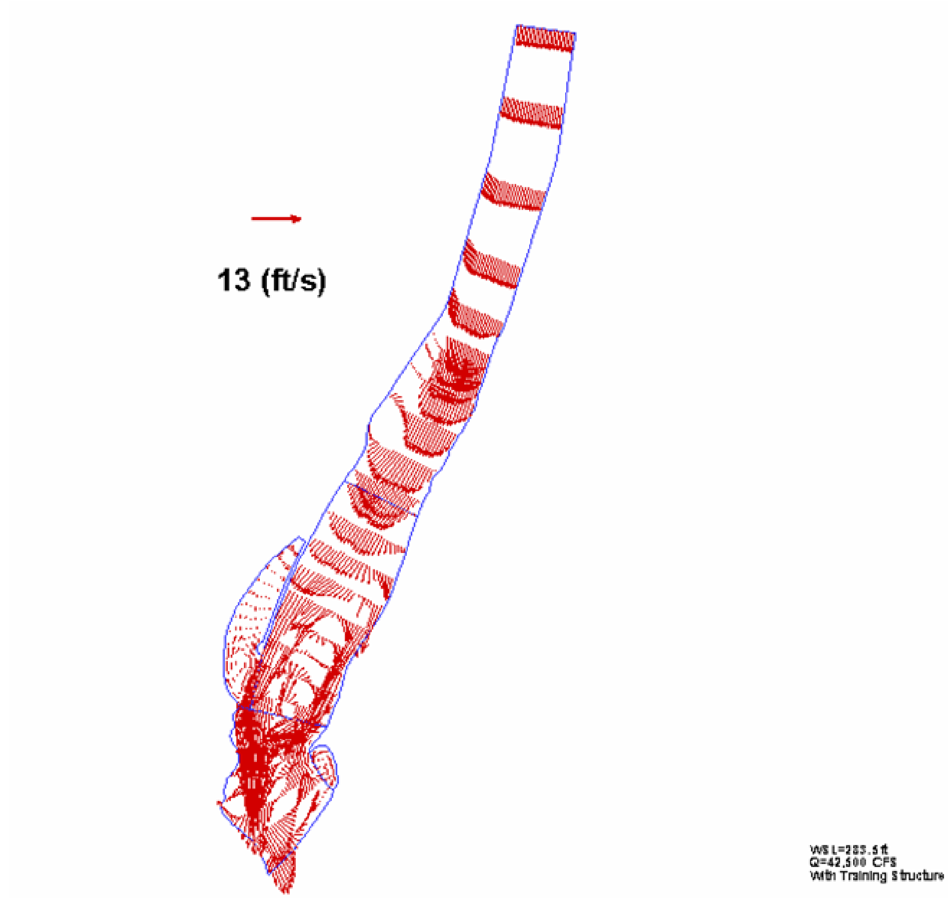


(a) Case IV with Jetties in Place **(b) Case V with Jetties Removed**

Figure 19. Plan Views of Velocity Vector on Water Surface for Q=19,000 cfs with Training Structure and Point Bar Removed.



(a) Case II without Training Structure

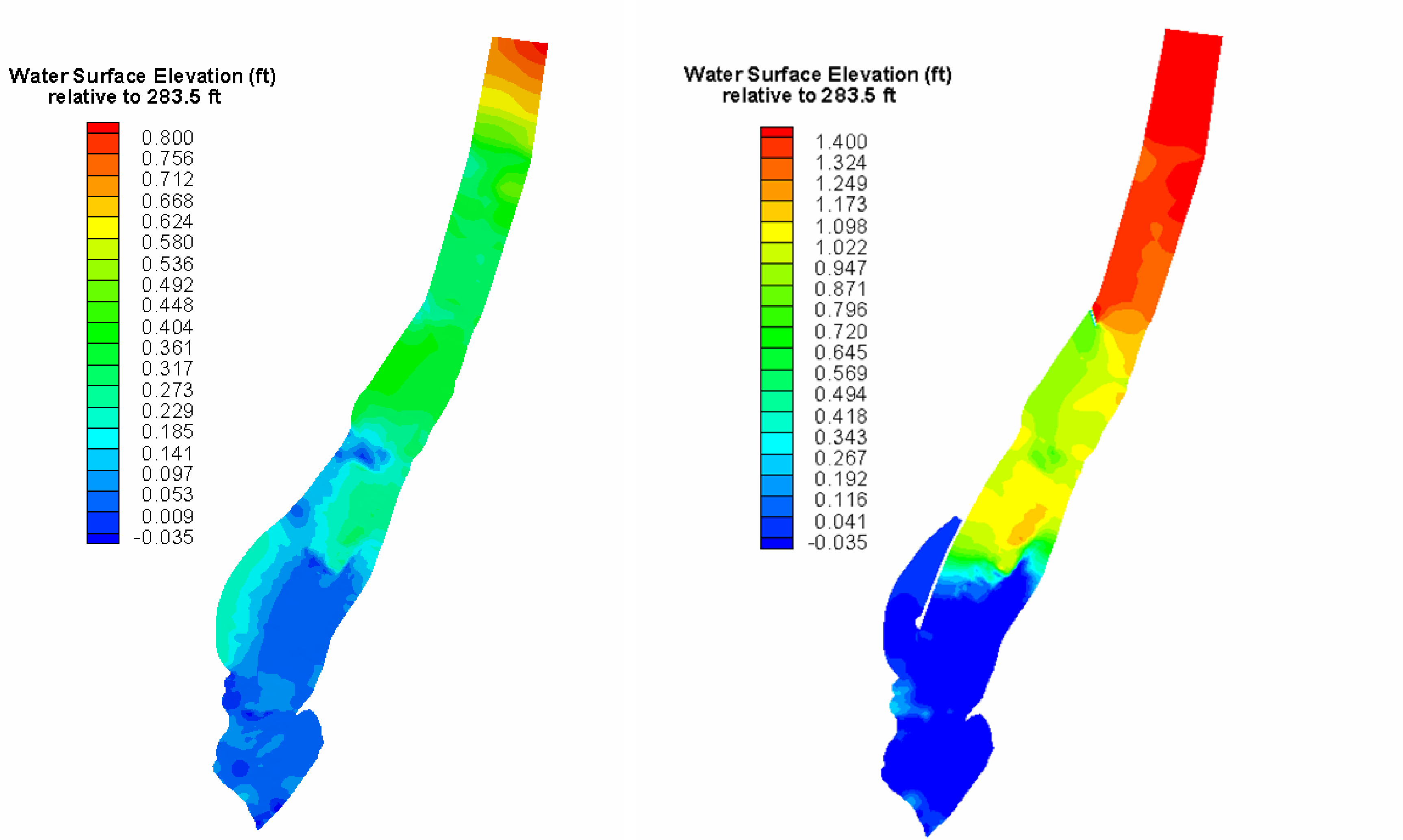


(b) Case III with Training Structure

Figure 20. Plan Views of Velocity Vector on Water Surface for Q=42,500 cfs Scenario

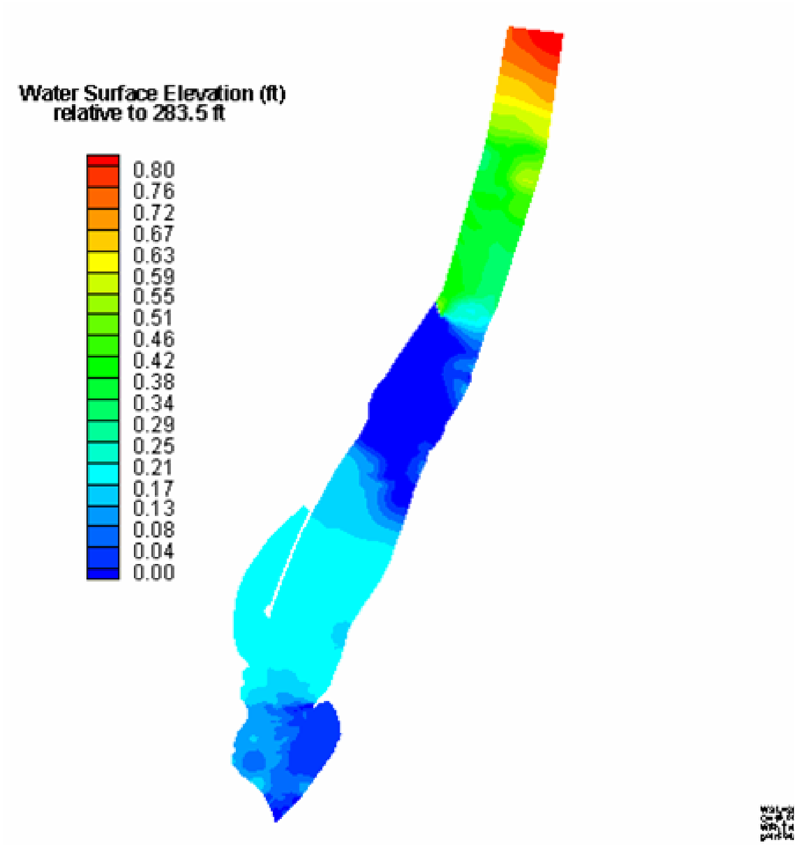
Figure 21. Photo Showing the Current Bank and Riprap Conditions on the Right Bank in Front of the Intake

Figure 22. **Photo Showing the Current Condition of the Embankment at the Diversion Dam**

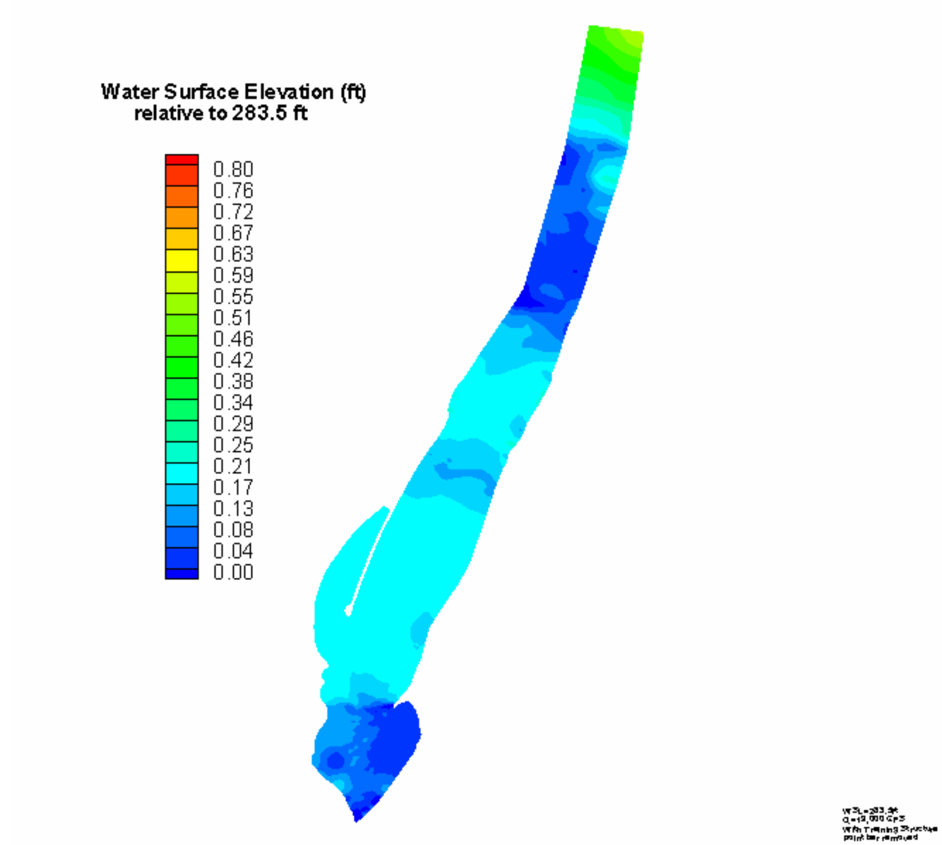


(a) Baseline Case (No Training Structure) **(b) Case I (With Training Structure)**

Figure 23. Plan Views of Water Surface Elevation for Q=19,000 cfs (With Point Bar)

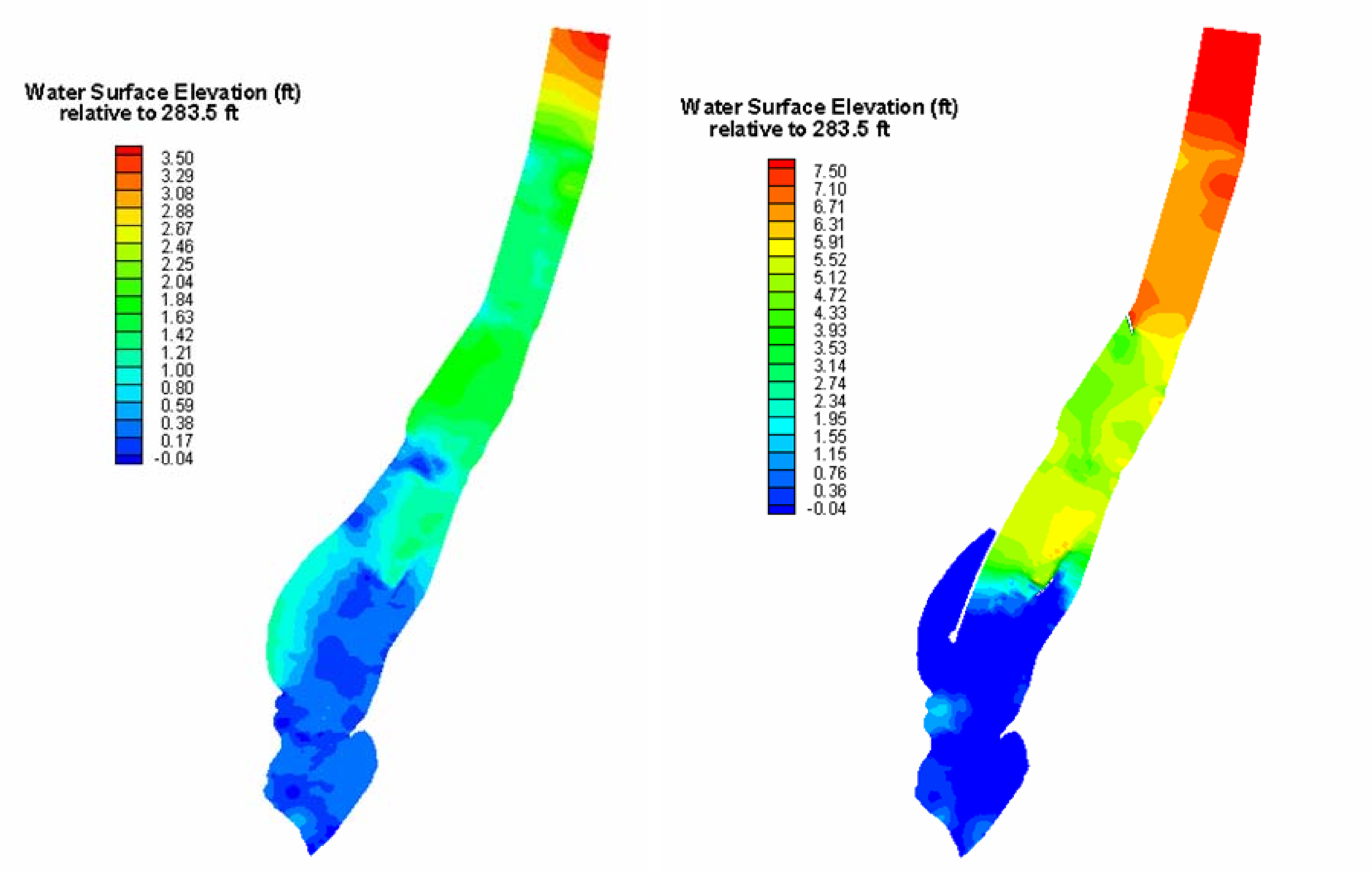


(a) Case IV (With Training Structure and Jetties)



(b) Case V (With Training Structure but No Jetties)

Figure 24. **Plan Views of Water Surface Elevation for Q=19,000 cfs (No Point Bar)**



(a) Case II (No Training Structure) **(b) Case III (With Training Structure)**

Figure 25. Plan Views of Water Surface Elevation for Q=42,500 cfs (With Point Bar)

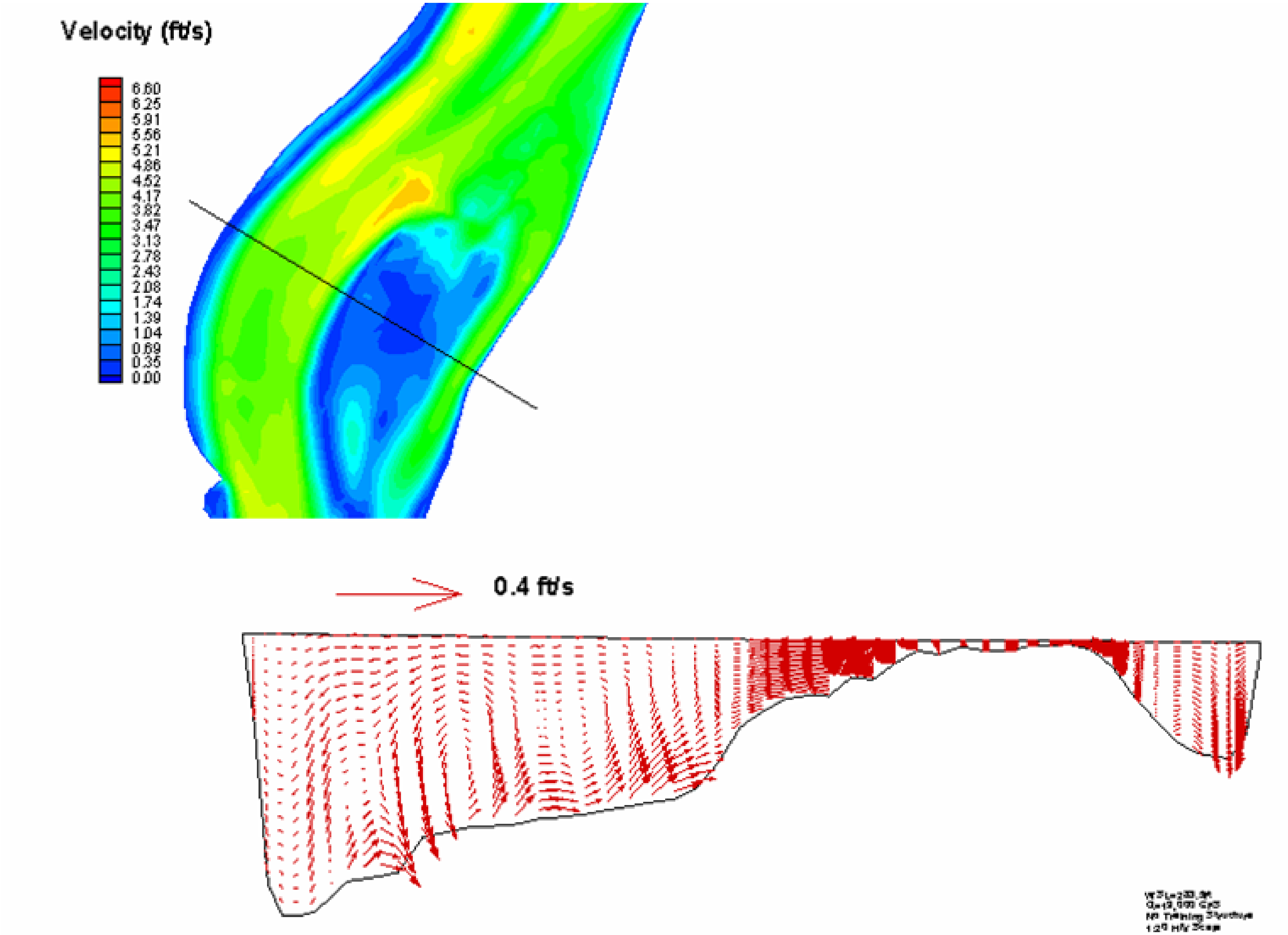


Figure 26. **Secondary Flow Velocity for Baseline Case (Q=19,000 cfs without Training Structure)**

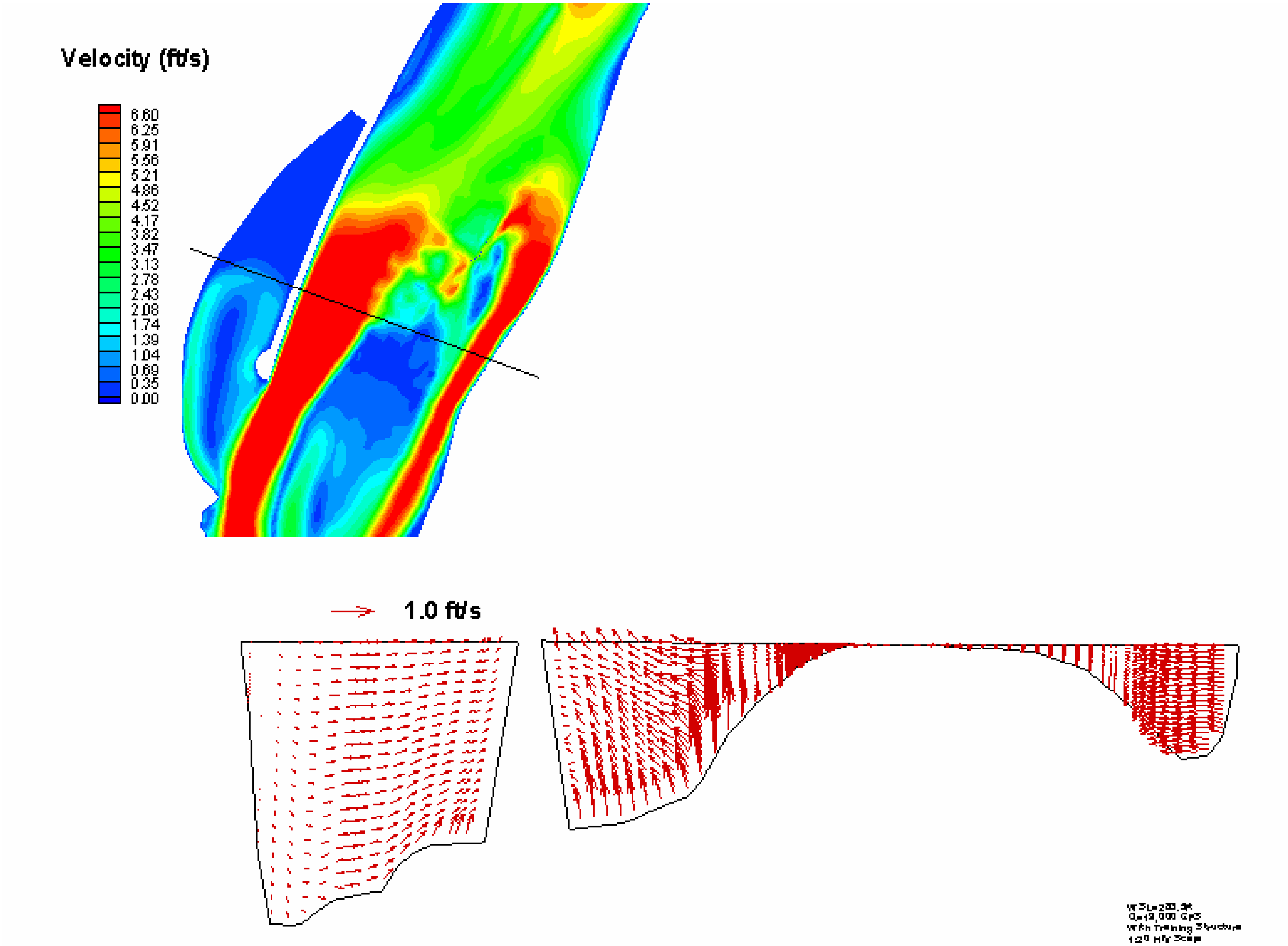


Figure 27. Secondary Flow Velocity for Case I (Q=19,000 cfs with Training Structure)

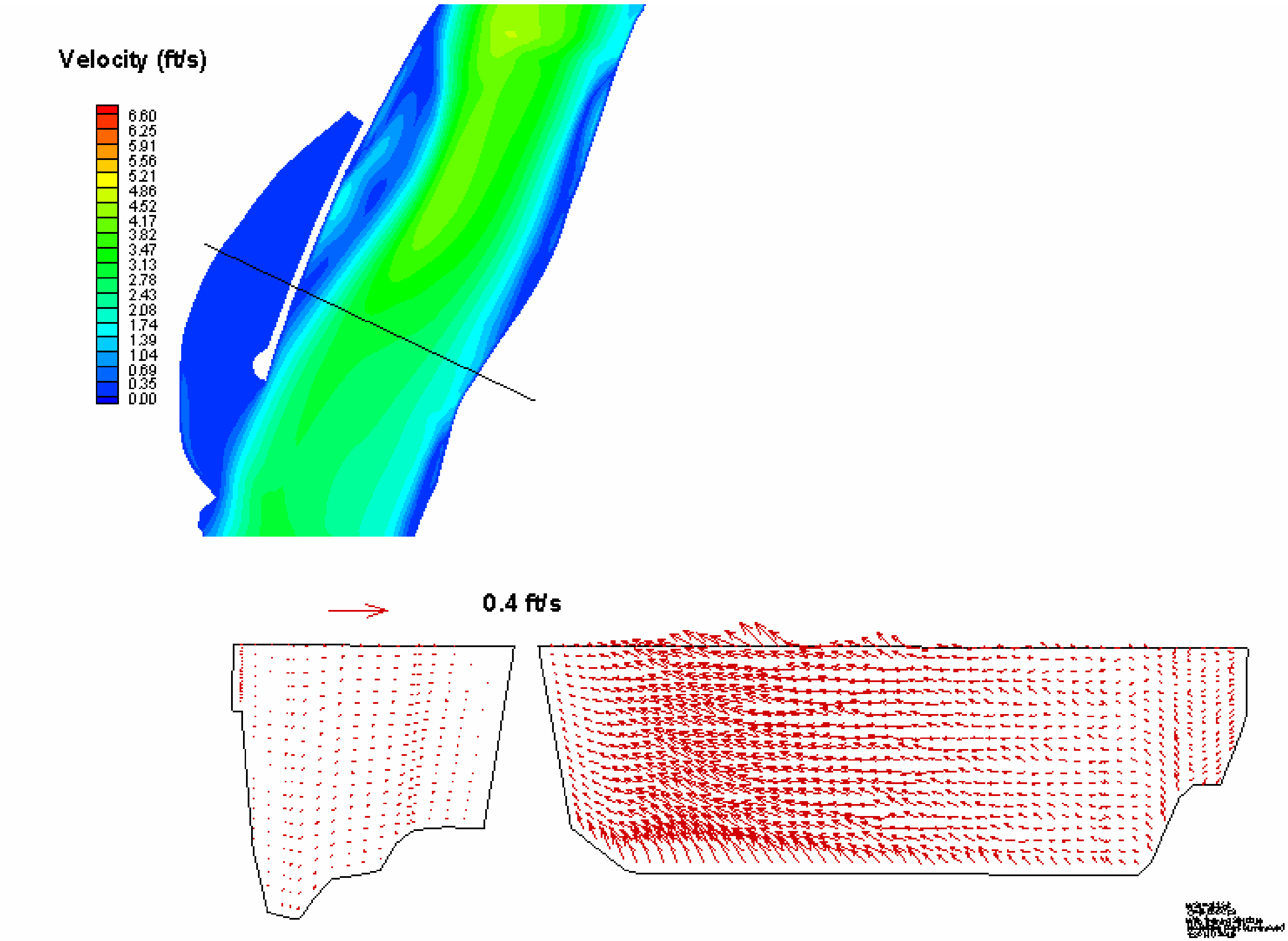
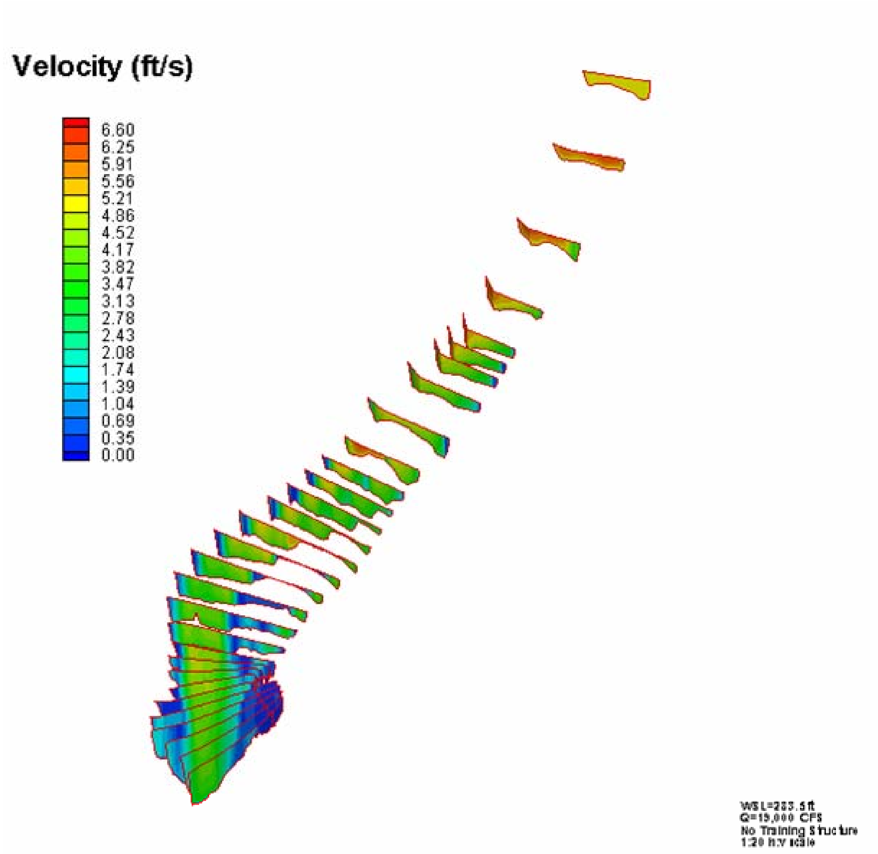
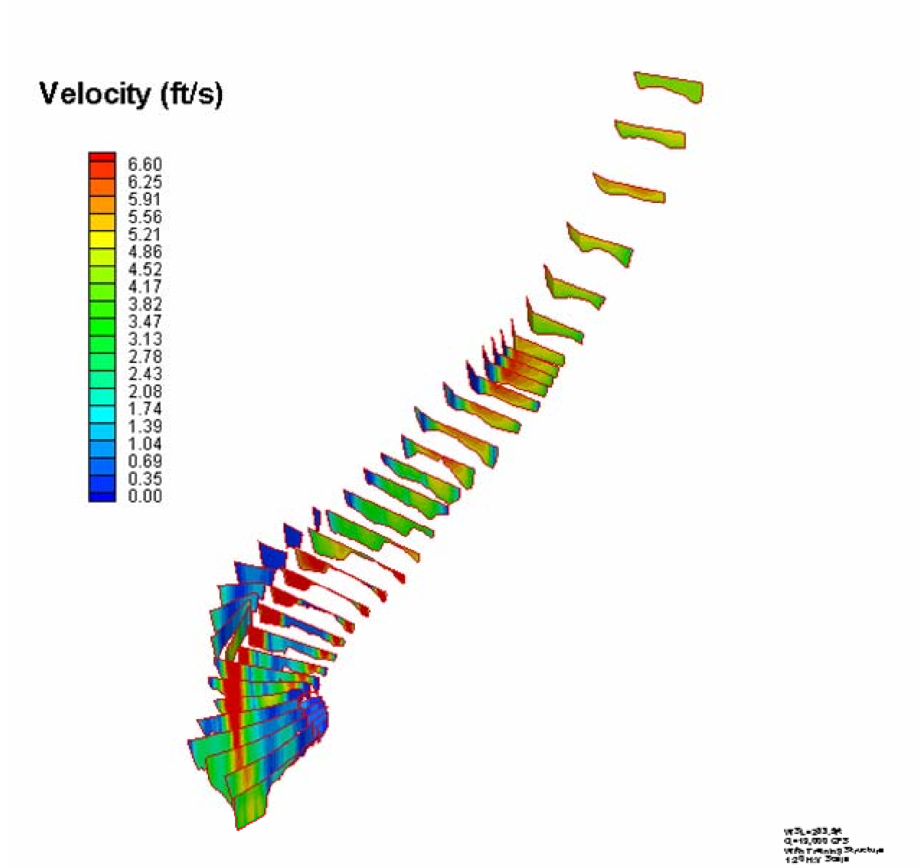


Figure 28. **Secondary Flow Velocity for Case V (Q=19,000 cfs with Training Structure, No Point Bar)**

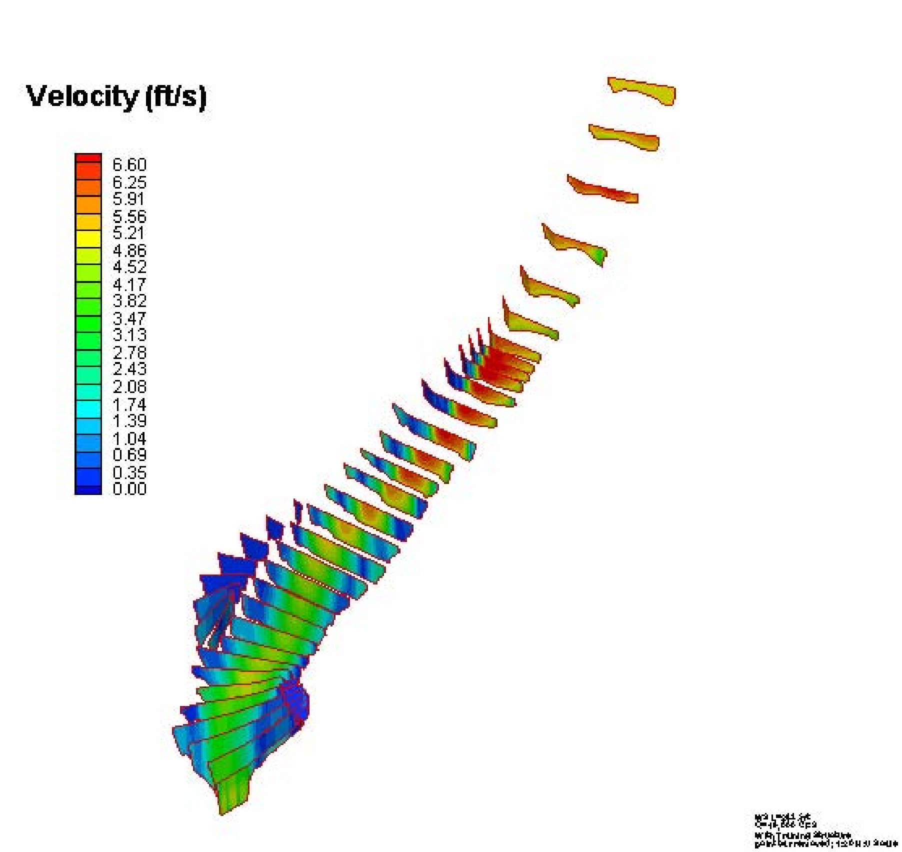


(a) Baseline Case without Training Structure

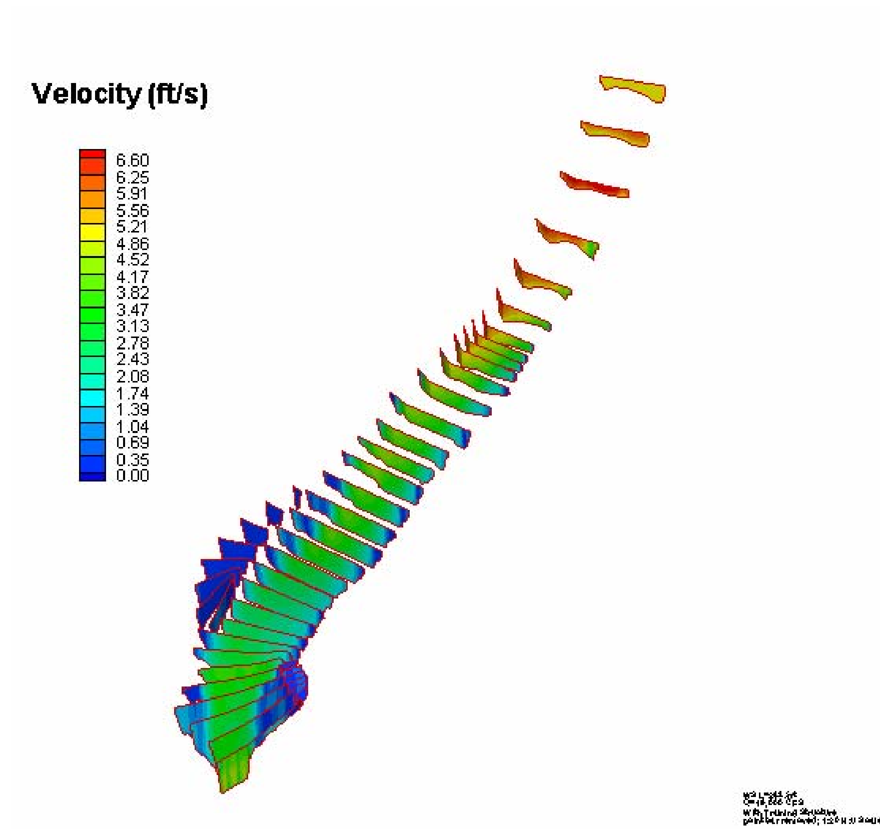


(b) Case I without Training Structure

Figure 29. Cross Sectional Views of Velocity Magnitude for Q=19,000 cfs

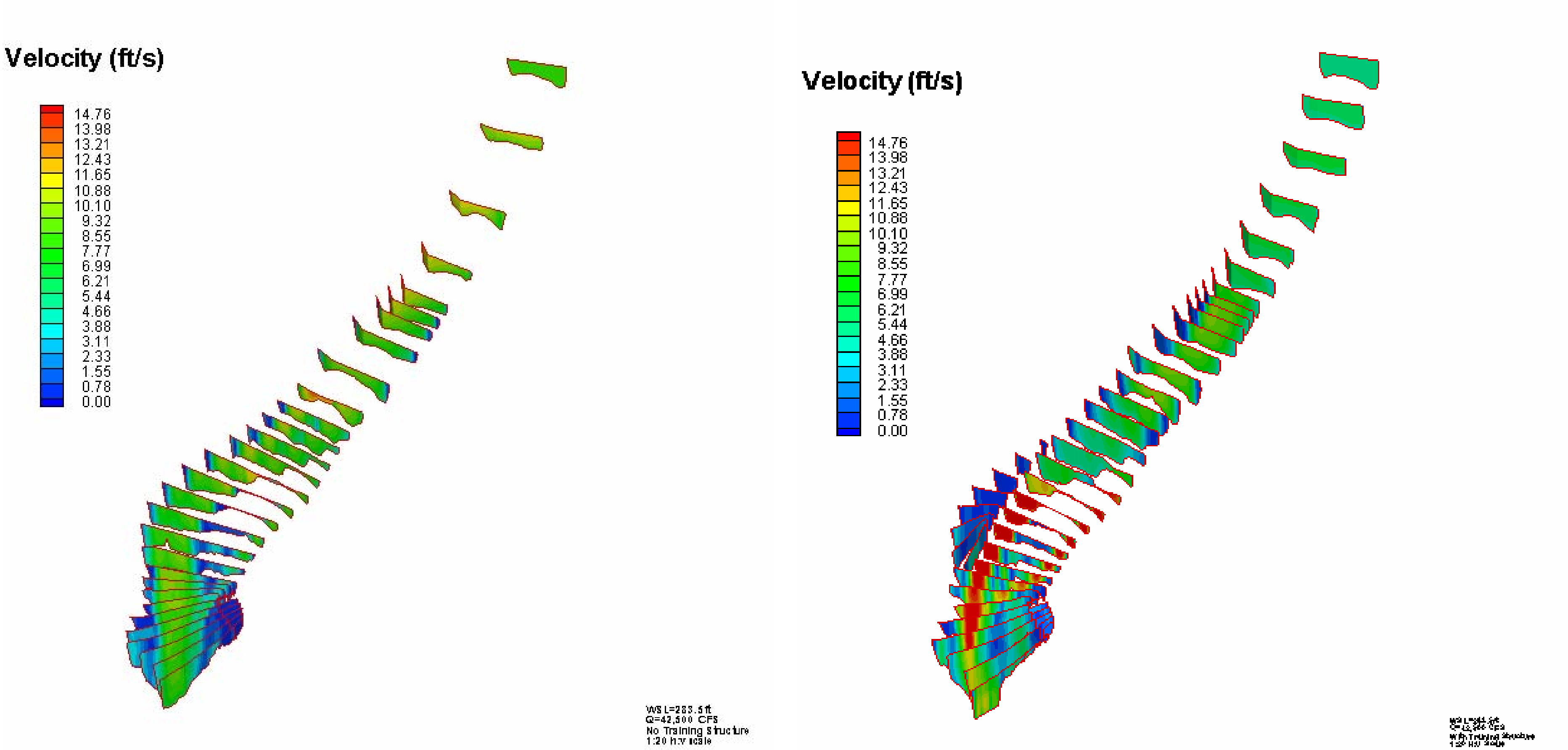


(a) Case IV with Jetties in Place



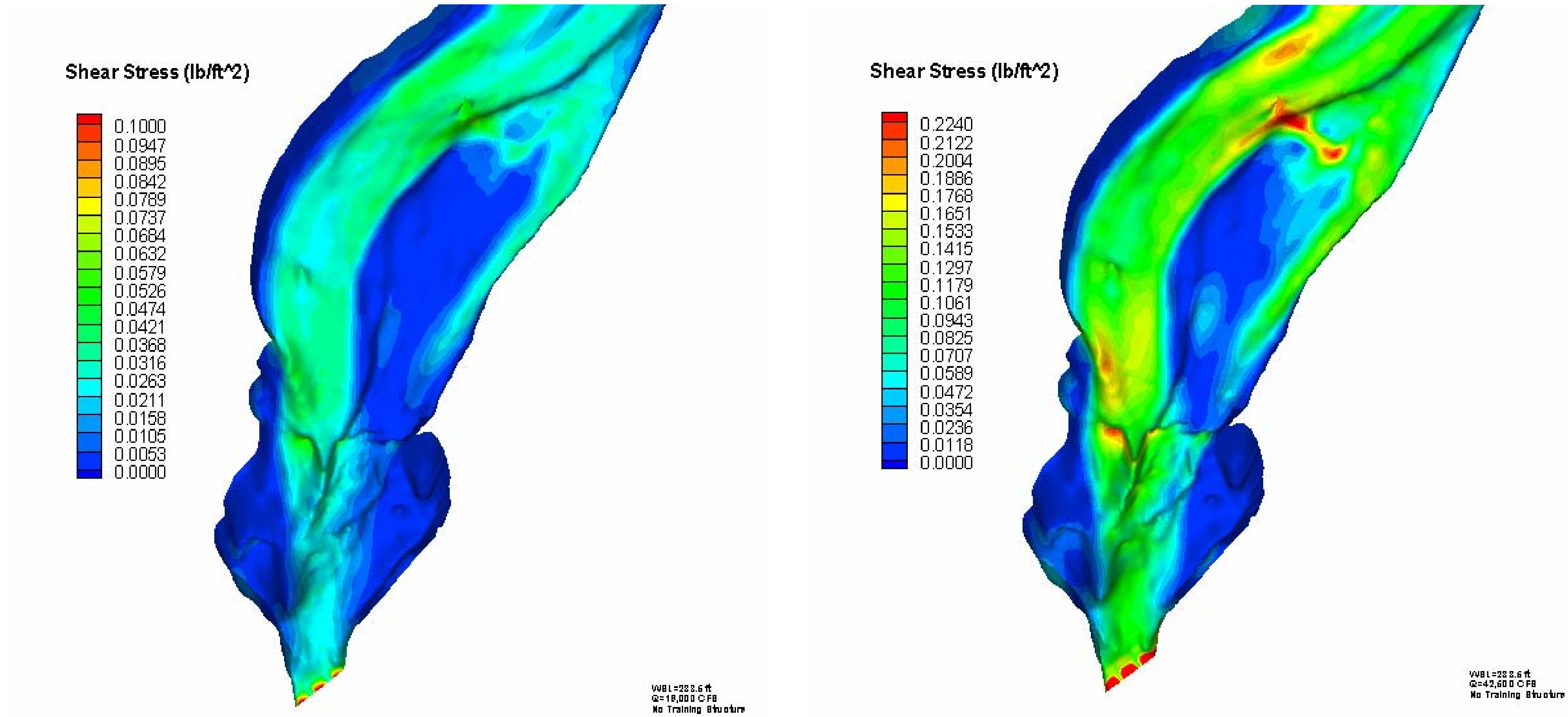
(b) Case V with Jetties Removed

Figure 30. Cross Sectional Views of Velocity Magnitude for Q=19,000 cfs with Point Bar Removed



(a) Case II without Training Structure **(b) Case III with Training Structure**

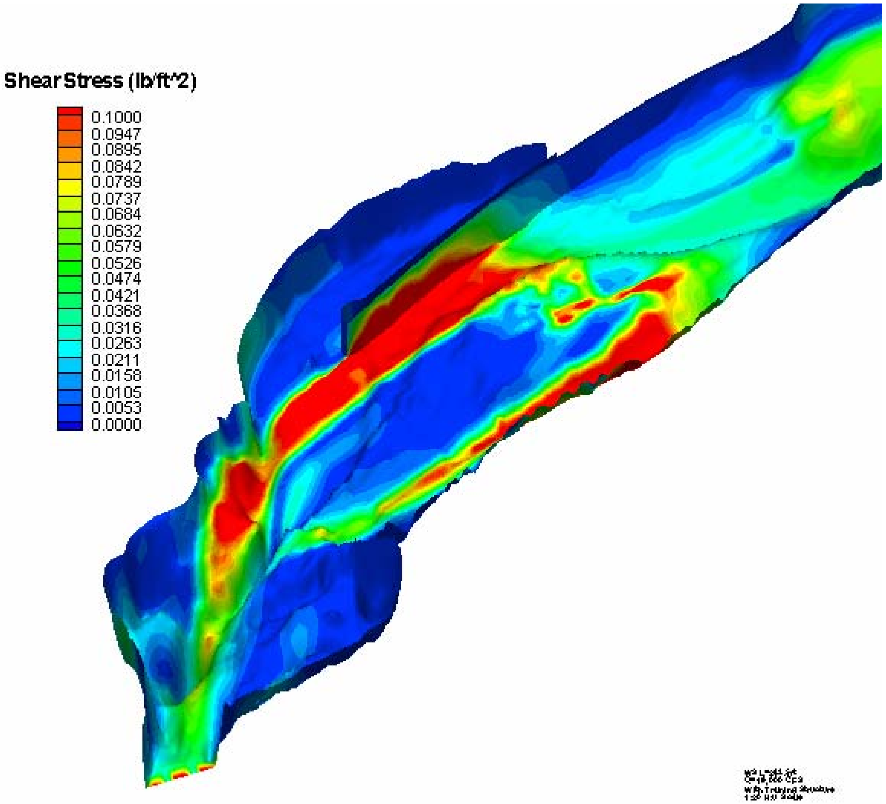
Figure 31. Cross Sectional Views of Velocity Magnitude for Q=42,500 cfs



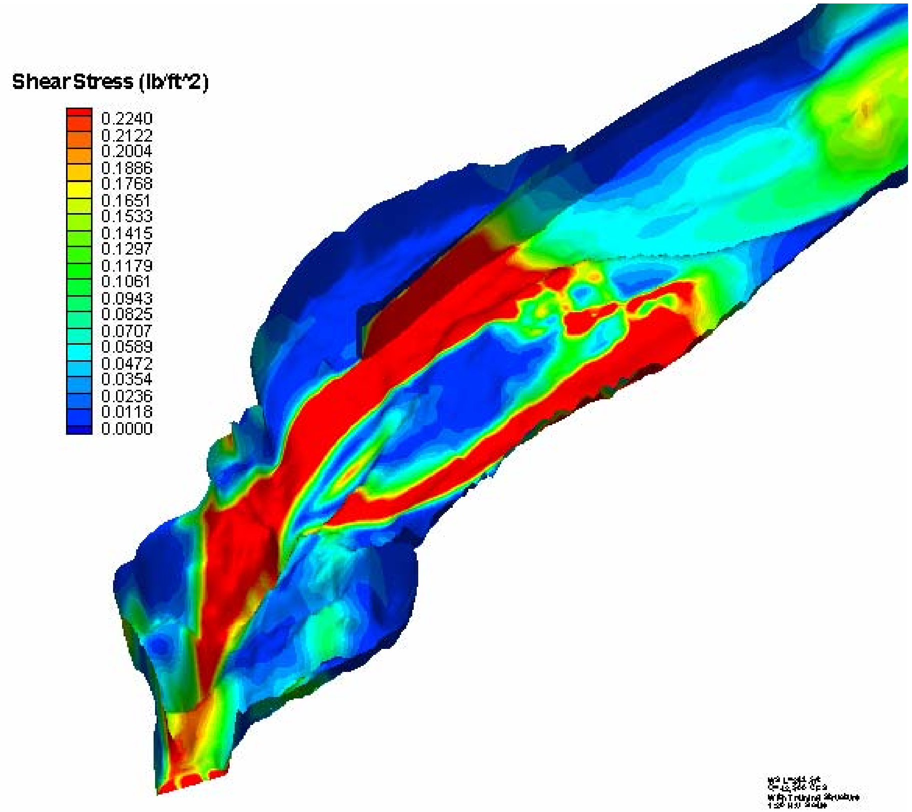
(a) Baseline Case with Q=19,000 cfs

(b) Case II with Q=42,500 cfs

Figure 32. Bed Shear Stress Distributions Under Existing Conditions

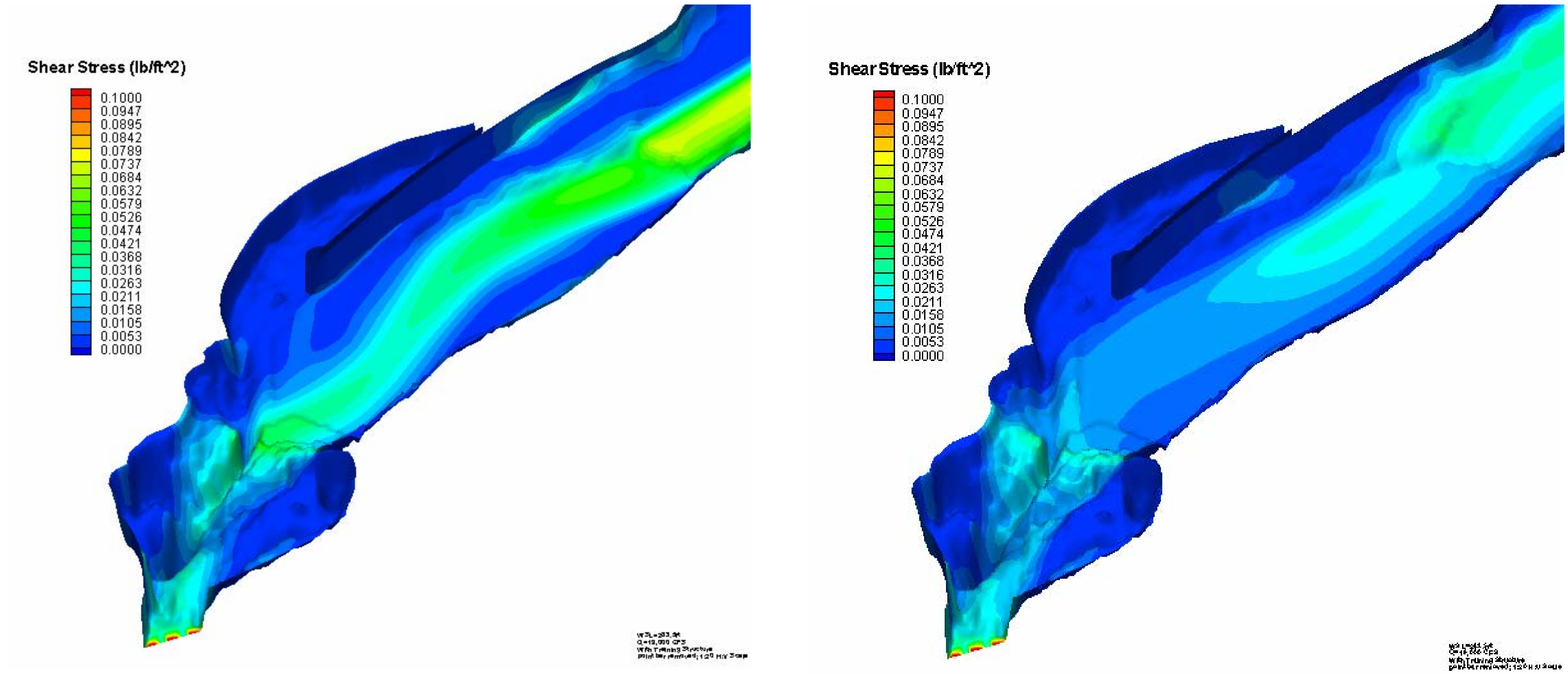


(a) Case I with Q=19,000 cfs



(b) Case III with Q=42,500 cfs

Figure 33. Bed Shear Stress Distributions with Training Structure and Point Bar in Place



(a) Case IV with Jetties in Place

(b) Case V with Jetties Removed

Figure 34. Bed Shear Stress Distributions with Training Structure in Place but Point Bar Removed (Q=19,000 cfs)

5. Concluding Remarks

A three-dimensional flow analysis has been carried out to evaluate the hydraulic impact of the training structure and jetties proposed for the Lower Colorado River upstream of the Palo Verde Diversion Dam near Blythe, California. The three-dimensional model is an accurate and reliable hydraulic flow prediction method based on years of our experience using the U^2RANS model, but the results of this study are subject to the accuracy of following assumptions:

(1) The bathymetric data for the river reach selected cannot be guaranteed to accurately represent the current river topography. River bathymetry may constantly change due to draw-downs, continuing deposition and erosion, or higher than normal flows. However, the current surveyed bathymetric dataset is expected to be representative of the general bathymetric features.

(2) The upstream portion of the reach simulated has only three surveyed cross sectional profiles; as a result, the geometry in this area may not be accurate.

(3) Under installed training structure conditions, the point bar is assumed to remain in place for some cases, and its removal is assumed for others. It is anticipated, though, that the bathymetry at the point bar location will change once the training structure is constructed and operated for a period of time.

A total of six cases are simulated representing scenarios under existing conditions and installed structure conditions, with different river discharges for a normal high flow (19,000 cfs) and flood flow (42,000 cfs), and assumed point bar and jetty conditions. Table 1 lists the detail of each case.

Based on the simulation results obtained for all six cases, the following conclusions can be drawn:

(1) The model confirms that the flow regime near the Diversion Dam under existing conditions has a pattern typically observed at many river meanders. This meander bend is mainly responsible for the accelerated bank erosion observed on the California side (right side) of the river and the point bar on the opposite left bank. If left untreated, the bank erosion at the meander bend is expected to continue.

(2) The bulk river flow velocity along the outside of the meander bend is about 5 ft/s near the right bank at a river discharge of 19,000 cfs and approximately 8 ft/s with 42,5 cfs discharge under existing conditions. This velocity magnitude should be taken into consideration if riprap is being considered instead of the training structure. Velocities associated with other river discharges may be obtained if necessary using the current model.

(3) The flow on the upstream section of the river reach, at the proposed location of the two jetties, currently has a higher velocity on the right bank, due to the local bathymetry. Either riprap reinforcement or installation of jetties as currently proposed may need to be considered.

(4) If the two jetties are constructed as proposed, they do help to divert flow away from the right bank. However, installation of the two jetties will probably lead to potential problems. The two jetties, as modeled, are predicted to cause high flow along the left bank, potentially leading to local bank erosion. In addition, the jetties induce a sinuous (meandering) motion to the river which continues downstream once the point bar near the proposed training structure is eroded. Such motion could result in further erosion and deposition along the river reach having a negative impact on the training structure and river banks. Either of two options is recommended: the jetties are not installed but the riprap along the right bank at the location is reinforced; or jetties shorter than what is currently proposed are used. The second option of shorter jetties would need further modeling to determine if an optimum length exists.

(5) With the proposed training structure in place and the point bar remaining, very high velocities could be created on both banks at the training structure location. This scenario is likely to occur during and immediately following the construction of the training structure. This situation is dependent upon the magnitude of the river flow and how much erosion of the point bar has occurred. The high velocities may potentially cause stability problems to the training structure and the left bank. This scenario is unlikely to be sustained over time as the point bar would be eroded due to the presence of higher velocities.

(6) It is found that an eddy (Eddy #1) will develop behind the training structure. The magnitude, extent, and impacts of the eddy are likely dependent upon the magnitude the river flows. The eddy may cause sediment deposition at the mouth of the backwater between the end of the training structure and the right bank and may limit flow in and out of the backwater. A sill at the mouth is an option but its success depends on the suspended sediment concentration. Additional analysis of local flow conditions would be required to provide design details for this option.

(7) An existing eddy (eddy #2), located on the right bank immediately upstream of the canal headwork intake, is strengthened if the training structure is installed. During the site trip, it was noticed that the existing riprap at the location is not in good shape and might need to be reinforced.

(8) The hydraulic modeling also predicts, once the training structure is in place, the formation of a stronger eddy (Eddy #3) in front of the dam embankment to the left side of the spillway gates. The magnitude and impacts of this eddy are again likely dependent upon the magnitude of flow occurring in the river. Since armoring of this area was done to prevent further erosion, in the future only monitoring should be required to insure that there are no potential impacts to dam embankment stability or integrity.

Below is a list of possible future analyses that could be performed to provide additional information related to the project:

(1) Different design options related to jetty length could be further evaluated, as well as different options for design of the training structure.

(2) More river discharges could be simulated for more detailed evaluations for some scenarios.

(3) The current study is limited to a hydraulic analysis without consideration of sediment transport. A one-dimensional sediment analysis could be carried out to evaluate the impact of the proposed structures. GSTAR-1D model, developed by the Sedimentation and River Hydraulics Group, could be used for this purpose.

(4) The development of a three-dimensional erosion and sediment model is under discussion at the Sedimentation and River Hydraulics Group. Once available, more accurate modeling could be carried out concerning the point bar removal, suspended sediment transport, and sediment impact to the downstream river and canal. Development of this model, however, needs support from Reclamation offices both in terms of specific project applications and funding.

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