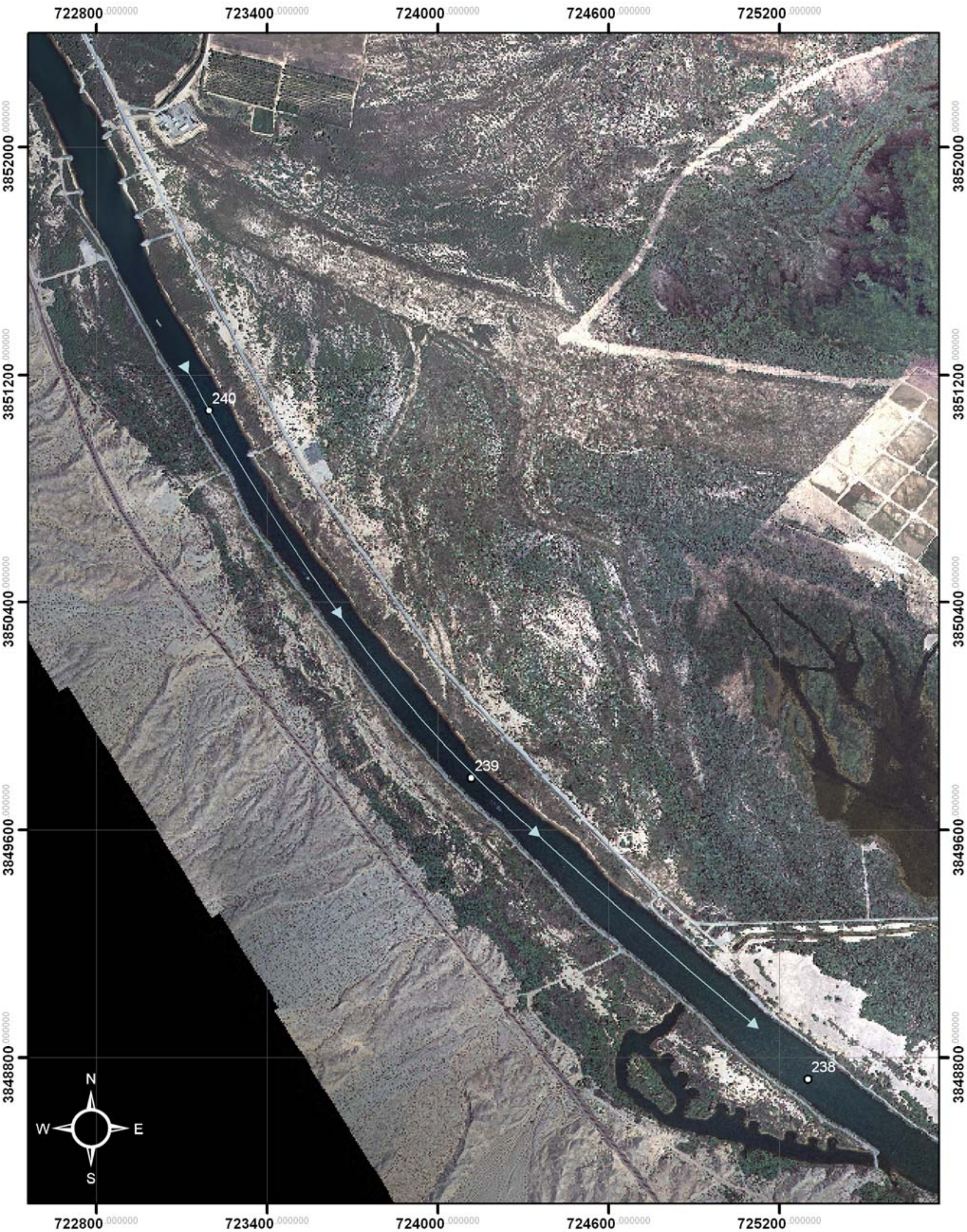
Appendices

A. *Aerial Photos of the Project Area*
B. *Bankline Stabilization Design Plan and Screening of Alternatives*
C. *Correspondence Related to Regulatory Consultation and Public Involvement*
D. *CWA Section 404 Permit (Dredge and Fill) Authorization and CWA Section 401 Water Quality Certification*

APPENDIX A
Aerial Photos of the Project Area

Appendix A

Project Area - Overview



Project Area - Plate 1 (Upstream Limit)

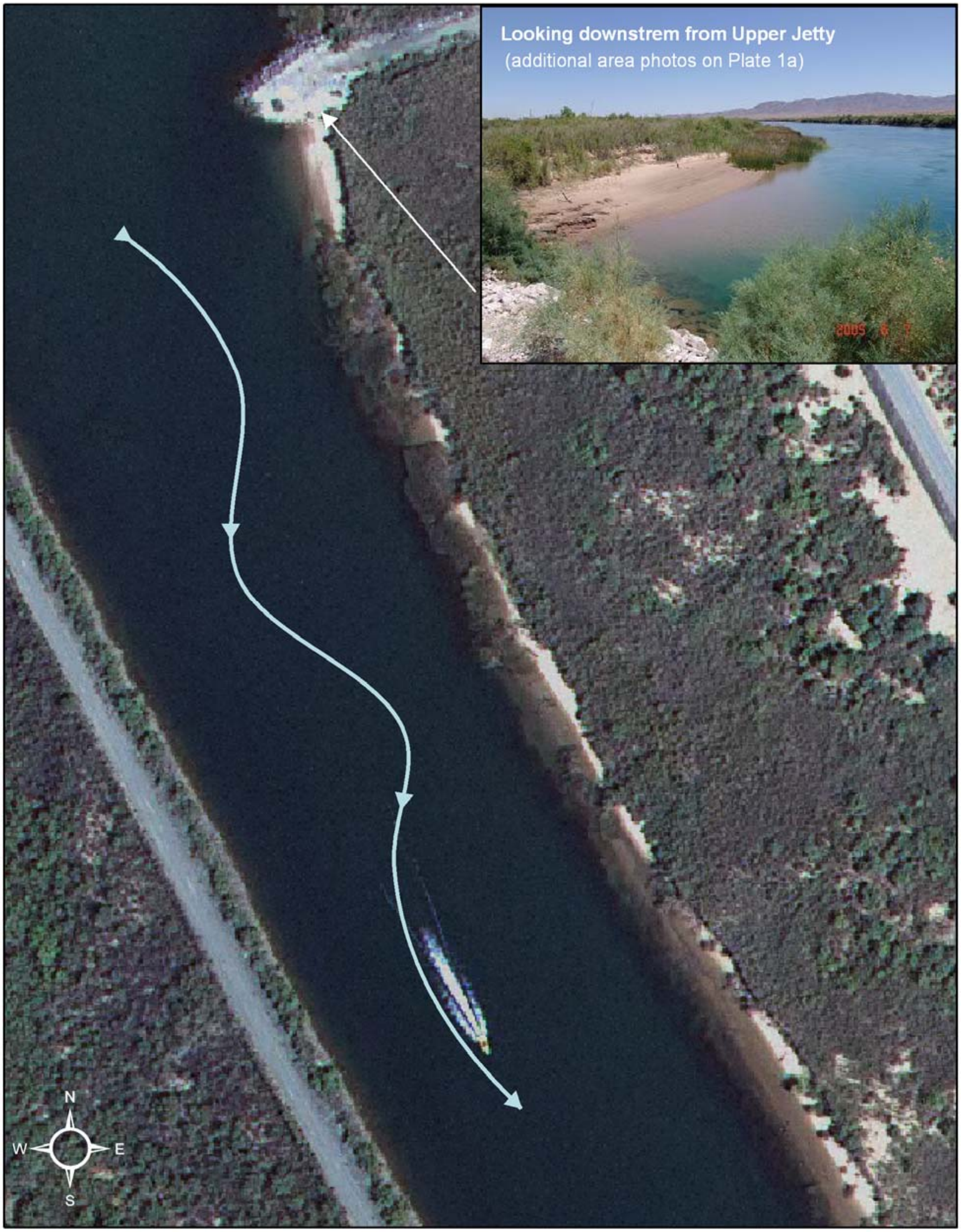
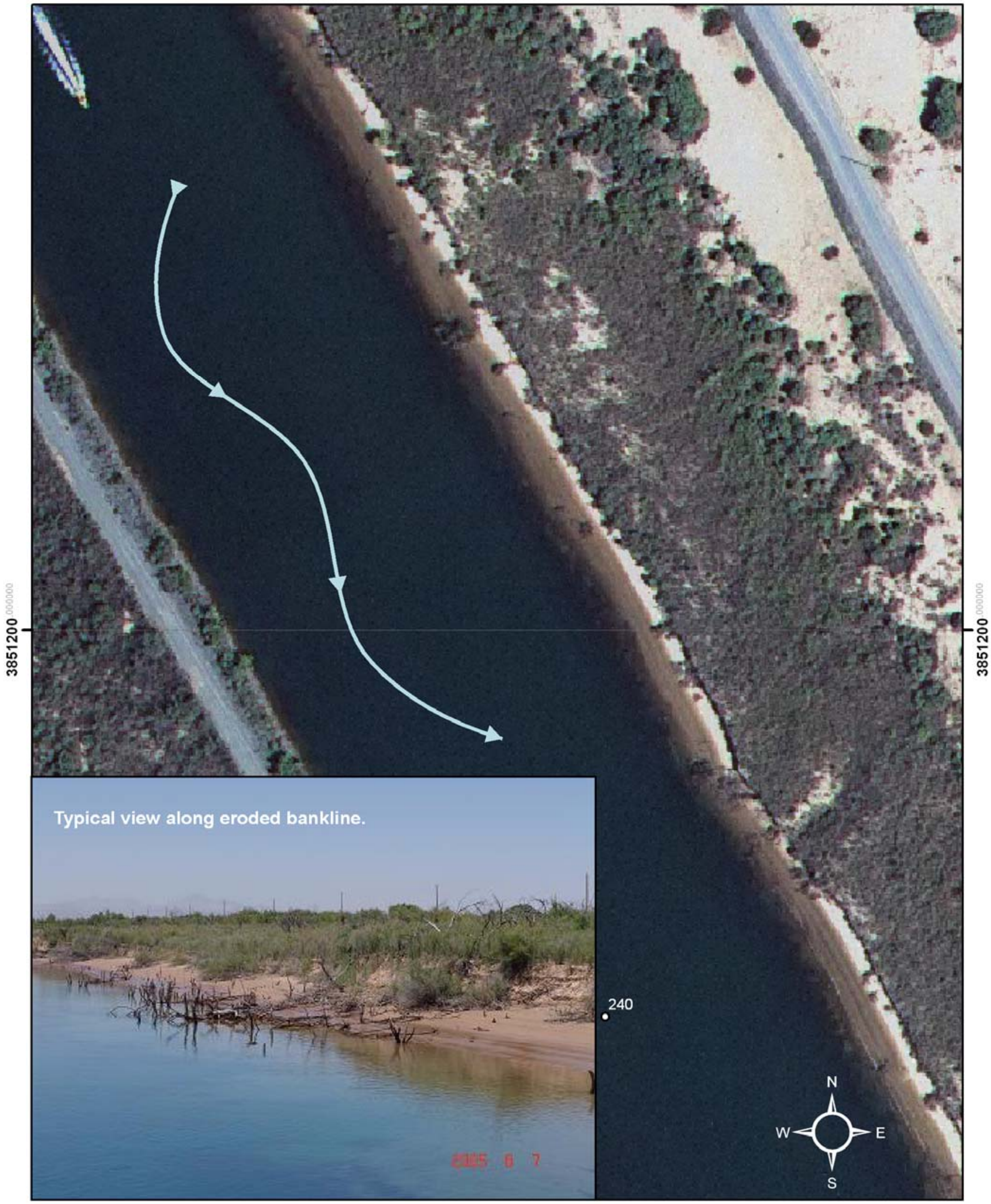


Plate 1a - Bulrush Patch

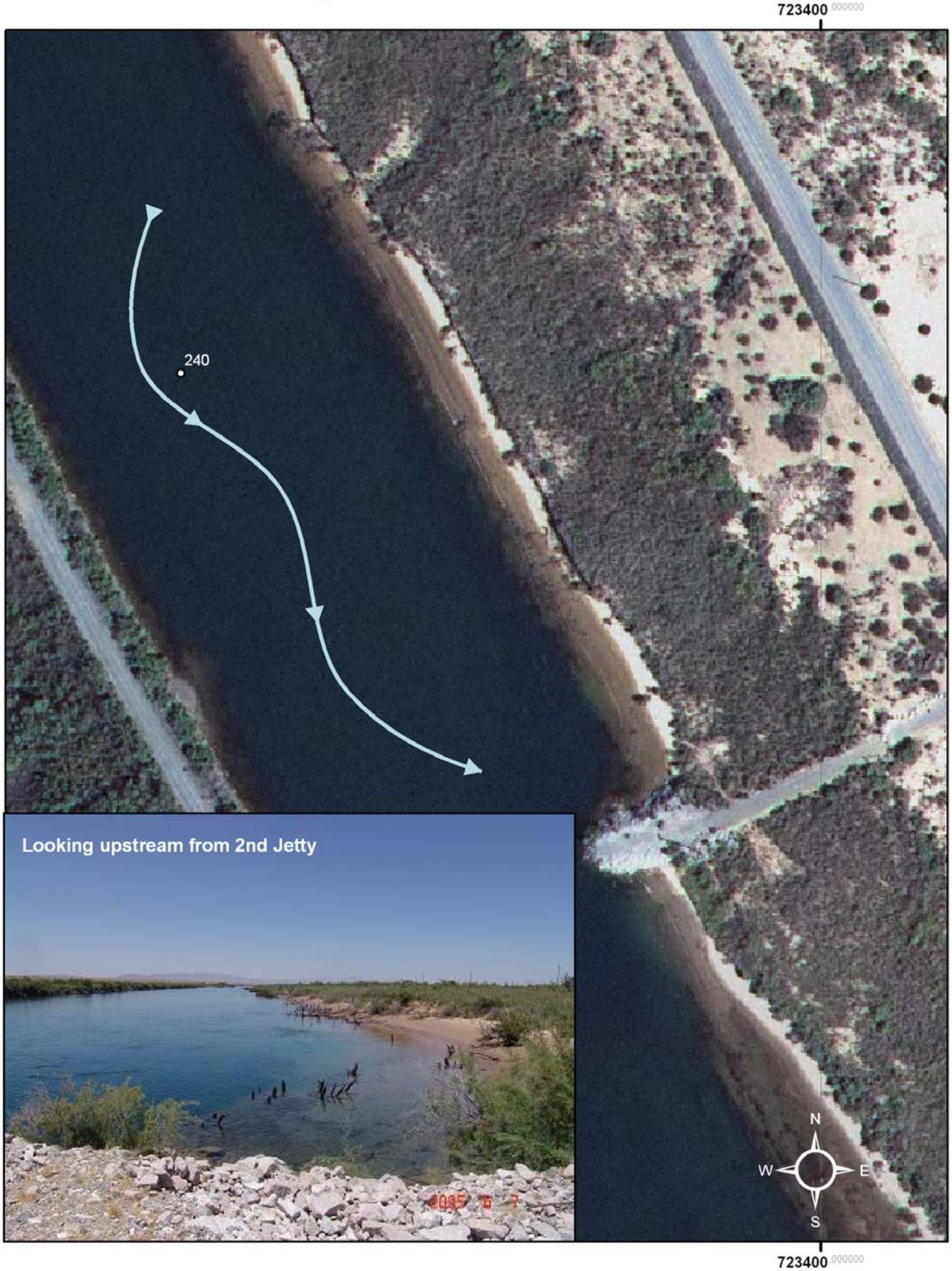
Looking downstream at patch of Bulrush; this area will be avoided and monitored.

Looking upstream from center of river at patch of Bulrush; to be avoided and monitored.

Project Area - Plate 2



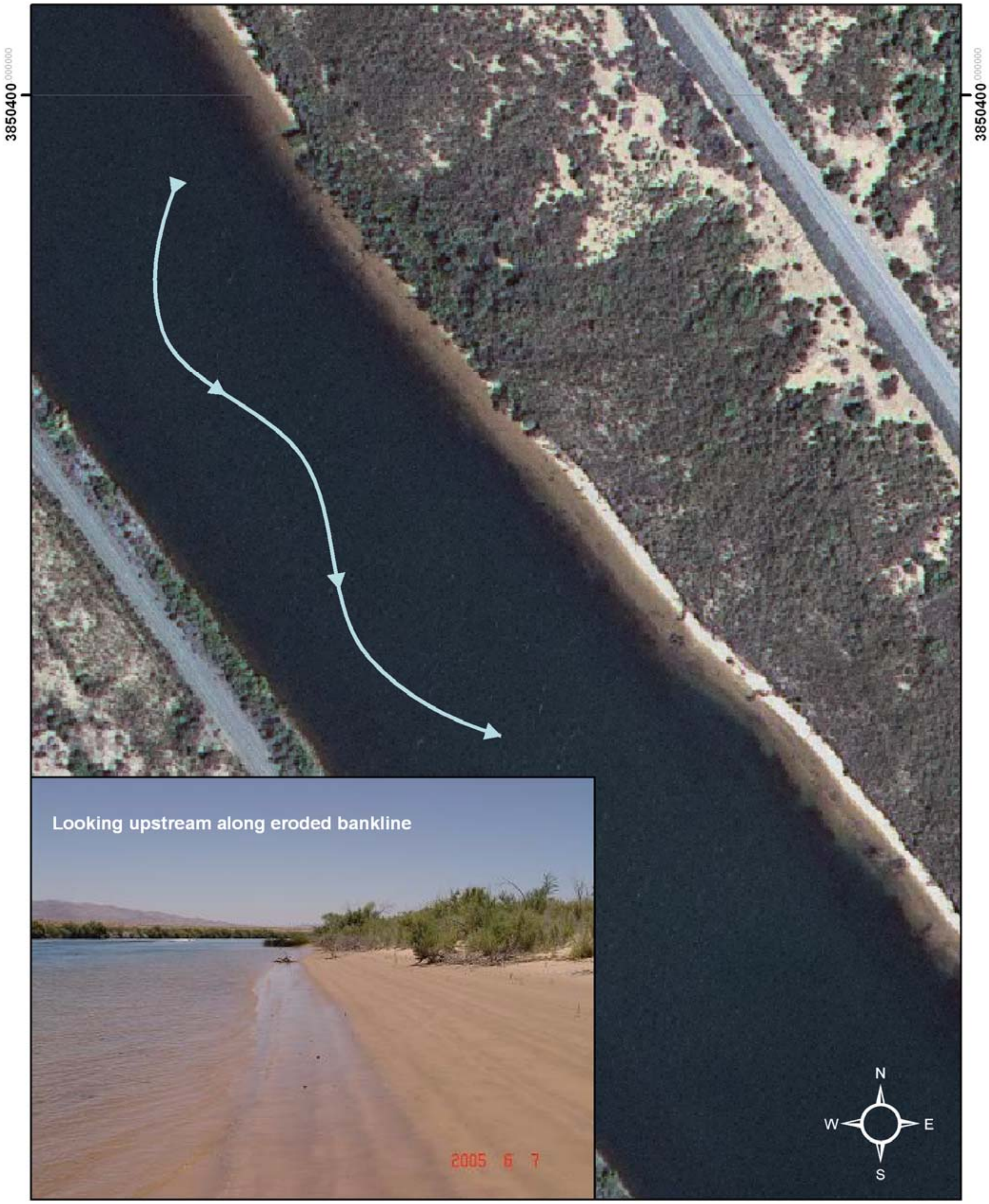
Project Area - Plate 3



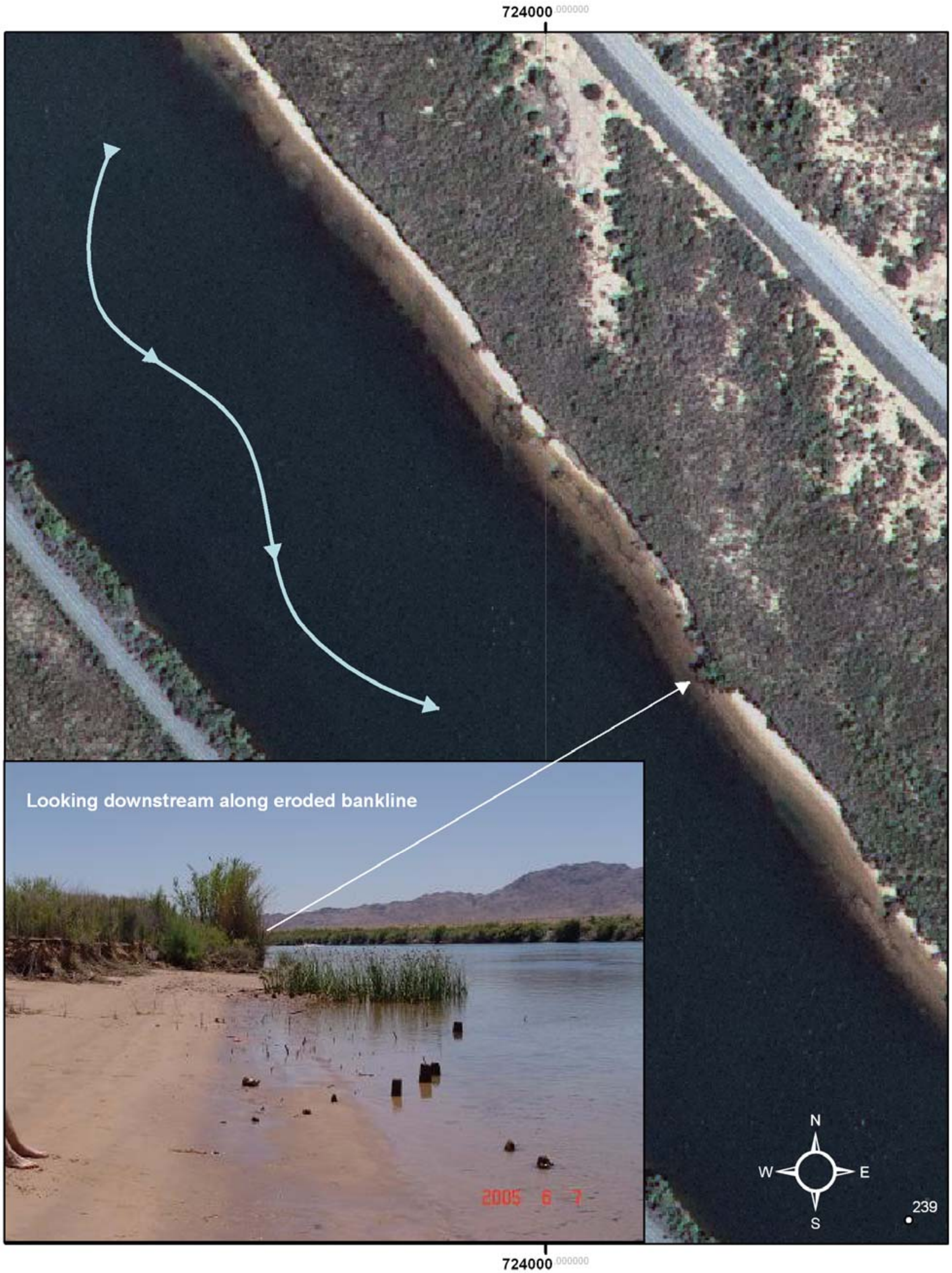
Project Area - Plate 4

Project Area - Plate 5

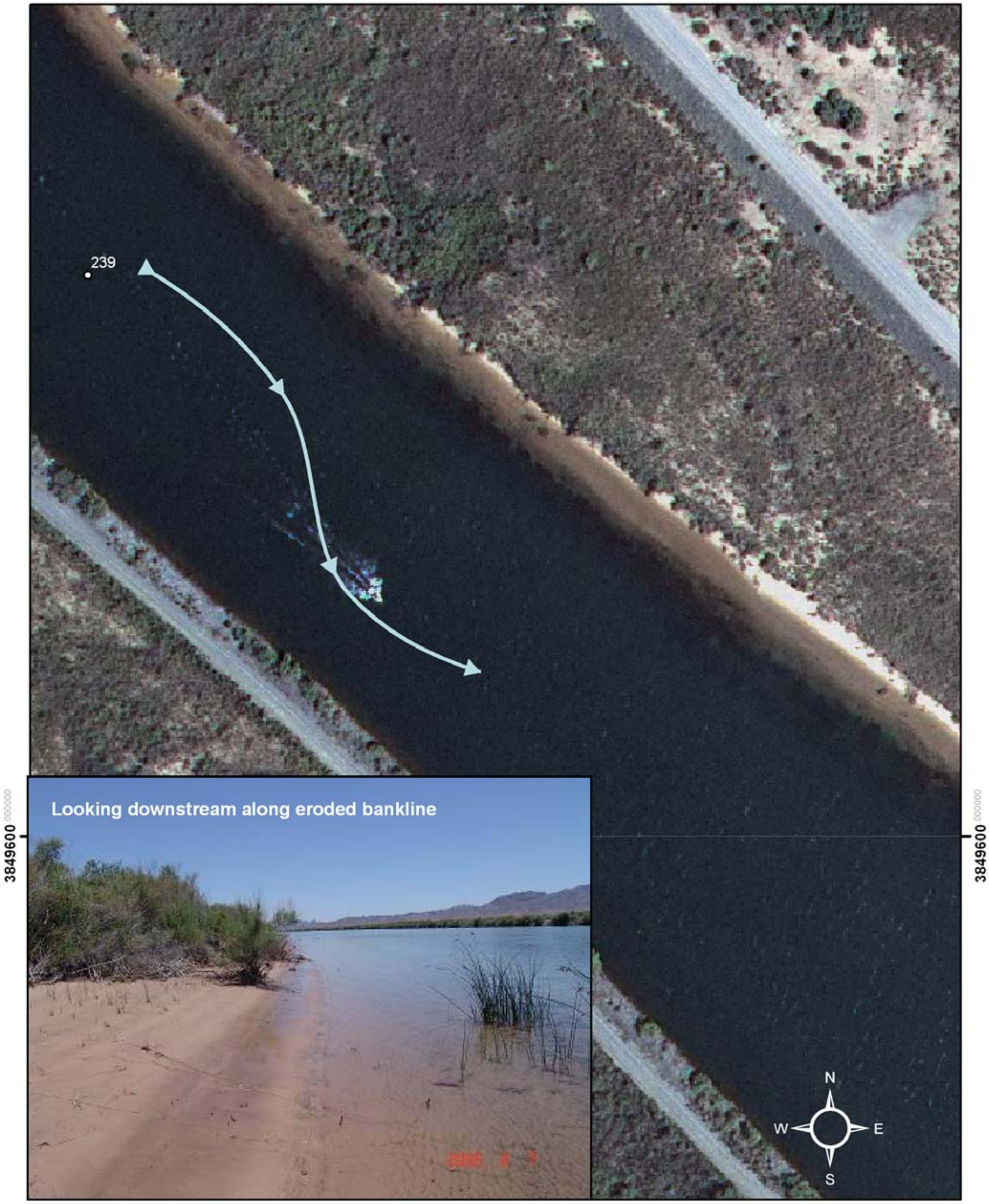
Project Area - Plate 6



Project Area - Plate 7



Project Area - Plate 8



Project Area - Plate 9

Project Area - Plate 10

APPENDIX B
Bankline Stabilization Design Plan and Screening of Alternatives

Appendix B

29 November 2005

MEMORANDUM

Needles-Topock Erosion Protection, Screening of Alternatives

This memorandum is intended to overview possible bank protection alternatives that could be utilized along the Needles-Topock bankline. The information included in this document will supplement a more complete discussion of this reach of river and the proposed project impacts included in the Environmental Assessment. It compares alternatives that provide the most beneficial and practicable solution. The project area is along the Arizona bankline between River Mile 238.5 and 240.5.

STUDY AREA HISTORY

The project lies in what is considered the Mohave Valley Maintenance Division of the Reclamation's Lower Colorado River Region. In this area, the river flows through an alluvial valley from 2 to 5 miles wide.

All available data indicates that the channel bottom elevation in this reach of the river had been gradually increasing (aggrading) prior to the construction of Boulder and Parker Dams. After completion of Boulder and Parker Dams in the late 1930's, aggradation increased appreciably. The rapid increase in aggradation and change in flow characteristics caused the river to loose its historic character or regimen.

Perhaps the area impacted greatest was the reach between the Topock Gorge and Needles. Because of the increase in sediment delivery and the downstream water surface control or backwater caused by Parker Dam, the river became extremely braded and followed no single course creating a swamp covering the entire southern end of the valley in the 1940's. As a result, heavy vegetation started growing throughout this part of the valley creating an even greater constriction to flow. Sediment deposition propagated upstream reducing channel capacity and increasing the watersurface elevation. This rise in watersurface elevation increased the flood risk to the city of Needles, the surrounding agriculture, and other forms of infrastructure like the Rail line.

To reverse the impacts caused by the rise in watersurface elevation, Reclamation developed a channel rectification plan for much of the lower Colorado River. The first segment of river channelized was the reach between Topock Gorge and Needles.

The river channel was originally dredged to be about 200 to 300 feet wide with the expectation the river would widen to a width of 400 to 450 feet wide for a flow of 15,000 cfs. The channel has reached the original design width and the channel banks need to be stabilized.

BANKLINE EROSION

There are two primary factors causing erosion along this reach of river. They are erosion caused by the force of the river flow and erosion caused by boat wave action. Boat wave action is currently causing the majority of the erosion observed, but bank stabilization for boat wave action could be compromised by higher flows if the design is not tied into the top of bank.

The original design for this segment of the river was intended to reach a channel width of 400 to 450 ft with a slope of about 1.25 ft per mile of river. Significant differences in channel configuration cause discontinuity in channel stability. That is, if the channel geometry or slope changes enough, sediment transport capacity changes. With a change, more or less sediment could leave a reach than enters it. To maintain the original channel design intent, the effective channel width must be kept between 400 to 450 feet.

Another reason for maintaining this channel width is that it is consistent with the width of the existing channel immediately upstream of the project area. As shown in Figure 1, the channel width at the existing jetties is about 400 to 450 ft. Cross sections between the jetties are wider in some locations upstream of the project, but the width at the jetties is consistent with the original design channel width.

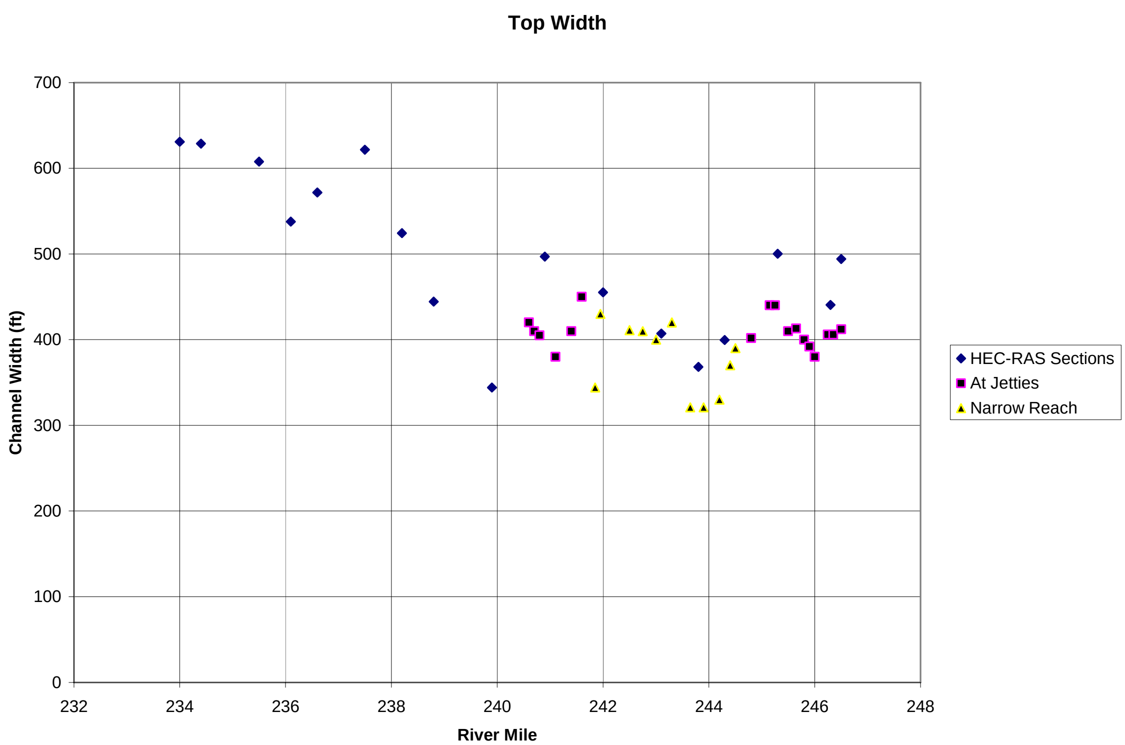


Figure 1. Channel Width in Vicinity of Project (R.M. 238.5 to 240.5)

BANKLINE STABILIZATION OBJECTIVES

1. Stop Boat Wave Erosion

The erosion along the banklines in this reach is primarily being caused by boat wave action which is evident from aerial photography. This aerial photography along with surveys demonstrates that a shelf has developed along the Arizona bankline as shown with the arrow in Figure 2 and Figure 3. River flow velocity is not sufficient to cause significant bank erosion and the river would likely stabilize if it were the only factor.

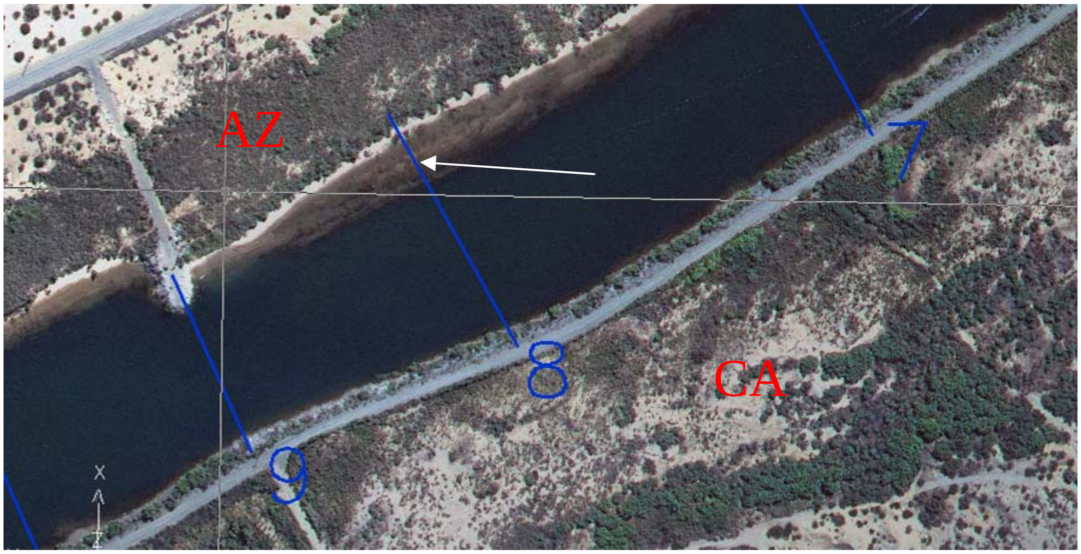


Figure 1. Shelf on Arizona Bankline

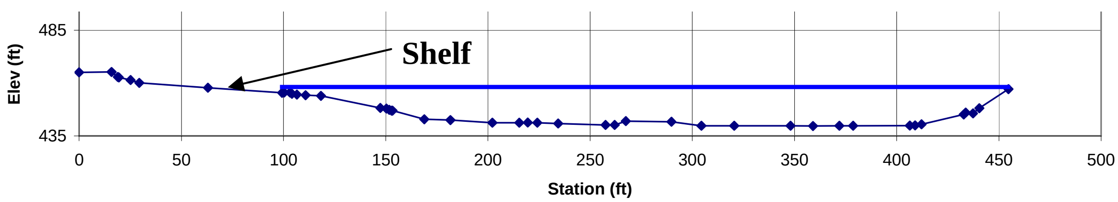


Figure 2. Cross Section 8

There is a significant amount of boat traffic on the river. Boats range in size and can run the river at relatively high speeds. Through the study reach there is no speed limit and high speed boats run this section of river. One of the more significant causes of boat wave action is tour boats running from Laughlin to Lake Havasu. These boats exceed 30 ft in length and can travel at speeds in excess of 40 mph. Using an equation from research performed by Champaign Water Resources Center[1], the boat wave height from this type of boat could approach 2 ft. The erosion potential caused by these size waves exceeds that for any other river action. Therefore boat wave action will be the major factor in deciding the appropriate bank protection measure.

2. <u>Stabilize Bankline for Bank-full Flow.</u>

The channel through the study reach is capable of conveying the predicted 100-year flood flow of about 43,000 cfs. To insure significant erosion does not occur during bank full flow events stabilization will be required up to the top of the existing banks.

[1] "University of Illinois at Urbana-Champaign Water Resources Center Report Number 107, Development of Criteria for Shore Protection Against Wind-Generated Waves for Lakes and Ponds in Illinois", Nani G. Bhowmik, 1976. Equation 18.

3. <u>Do Not Adversely Effect Levee Design Flow.</u>
The design capacity of the channel and levees was originally 70,000 cfs. Any actions performed as part of this project should not adversely affect flood flows which exceed the bank full channel capacity.

4. <u>Design Feasibility.</u>
The design must be constructible. Alternatives may or may not require different levels of difficulty to construct. Feasibility of construction will be an objective of the selected project.

5. <u>Available Technology.</u>
The selected alternative should use proven technology whenever possible. Typically, emerging technology is not considered for maintenance efforts. One was considered during this analysis because there was potential for the concept technically.

6. <u>Non-Damaging.</u>
Each alternative was evaluated for impacts on existing wetland habitat and water of the U.S. In most of the study reach, very little wetland habitat exists. Where there were some wetland vegetation, steps will be taken to avoid and minimize impacts where practicable.

7. <u>Cost.</u>
The desire will be to select an alternative that satisfies, to the degree possible, all objectives for the least cost.

8. <u>Environmental Enhancement.</u>
As stated previously, there is not significant wetland habitat in much of the reach. Although the Lower Colorado River Multi-Species Conservation Program (MSCP) should cover any impacts this project may have on the wetland habitat, an objective of the project would be to improve the fish and wildlife habitat along the river when possible.

SELECTION OF ALTERNATIVE

Each alternative considered here is rated on a 1 to 5 scale at increments of 1 for each of the 8 categories. The final score for each alternative was the sum of the ratings on each of the objectives. The total possible score was 40 points. In this particular case, one alternative had a score that was considerably higher than any other and achieved the purpose and need of this project as well as any other. Therefore it was considered most appropriate for this particular location.

The score for each category provides an assessment of an alternatives performance for the category. The following is the relationship that was used between the numerical score and the performance level for every category except cost:

1- Poor
2- Fair
3- Good

4- Very Good
5- Excellent

The score for cost was based on relative expense of each alternative. The lowest cost alternatives were assigned the highest score of 5 and the highest cost alternatives were assigned the lowest score of 1. Those alternatives with intermediate costs were assigned a score between 2 and 4 depending on the relative expense of the alterative when compared to the least cost alternative.

ALTERNATIVES CONSIDERED

1. Intermittent Bankline Protection (Flow Deflection).

Flow deflection is a means of redirecting high velocity flow away from erodible areas. The primary form of flow deflection that has been used with success on the Lower Colorado River has been straight jetties and L-jetties. Because of the success of this means of bank protection and the fact that they are used both at the upstream and downstream end of the project reach, L-jetties and straight jetties were considered most appropriate for this reach of river if flow deflection were chosen.

A. Straight Jetties.

A number of straight jetty configurations were considered. The primary characteristic of the jetties that were varied was the number and spacing of the jetties. The straight jetty design that was studied most had 10 jetties spaced at 1,000 feet (Figure 4).

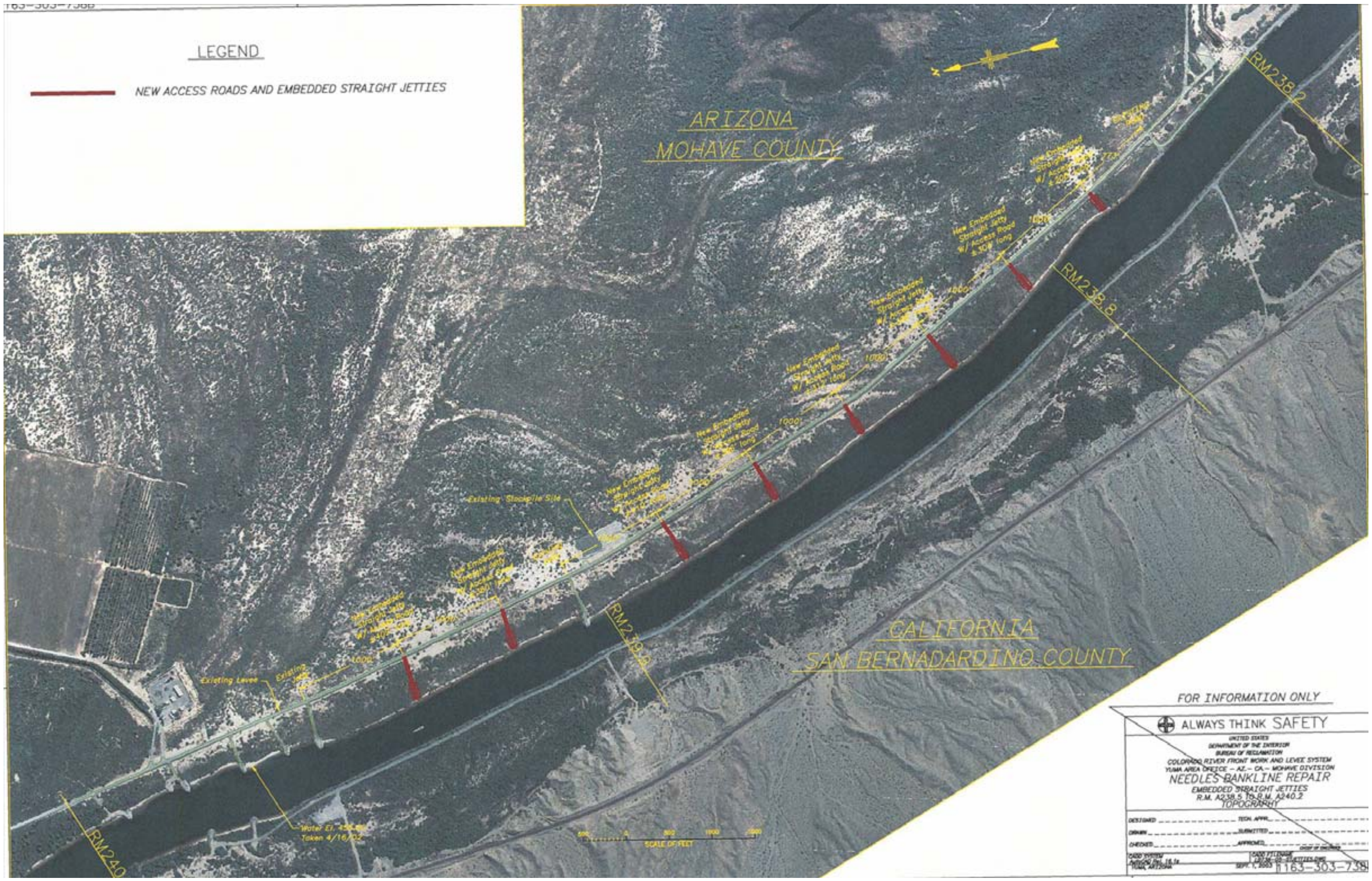


Figure 4. Straight Jetty Concept

To insure the jetties will function for at least 50 years, they will need to be designed so that wave action does not erode behind the structure of the jetties. From comparing the cross section at R.M. 239 it appears that the channel has widened about 60 ft in a 25 year time span. Therefore it will be assumed that the jetties should extend into the existing bank about 120 feet. The cross section for the jetty is shown in Figure 5.

Jetties in general are intended to protect banks from erosion caused by river flows. Often these flows are being directed towards the banks at issue. This is not the case within the project area. Flows are relatively parallel to the banks and are not extremely erosive even at bank full flow.

In addition the river alignment has remained relatively stable over the last 25 years. Although the channel has degraded and widened, it has not migrated and there is no evidence to indicate it will unless subjected to a flow greater than bank full.

Straight jetties provide minimal protection from boat wave action. Since boat waves have a large lateral component, jetties are not effective in dissipating the boat wave energy before impacting the bank.

The estimated cost to implement this project was estimated to be about 5% less than the proposed project. The total cost for this effort is estimated to be about $1,112,000. However, this alternative rated relatively low at 29 out of 40 points or about 73% of the total points possible.

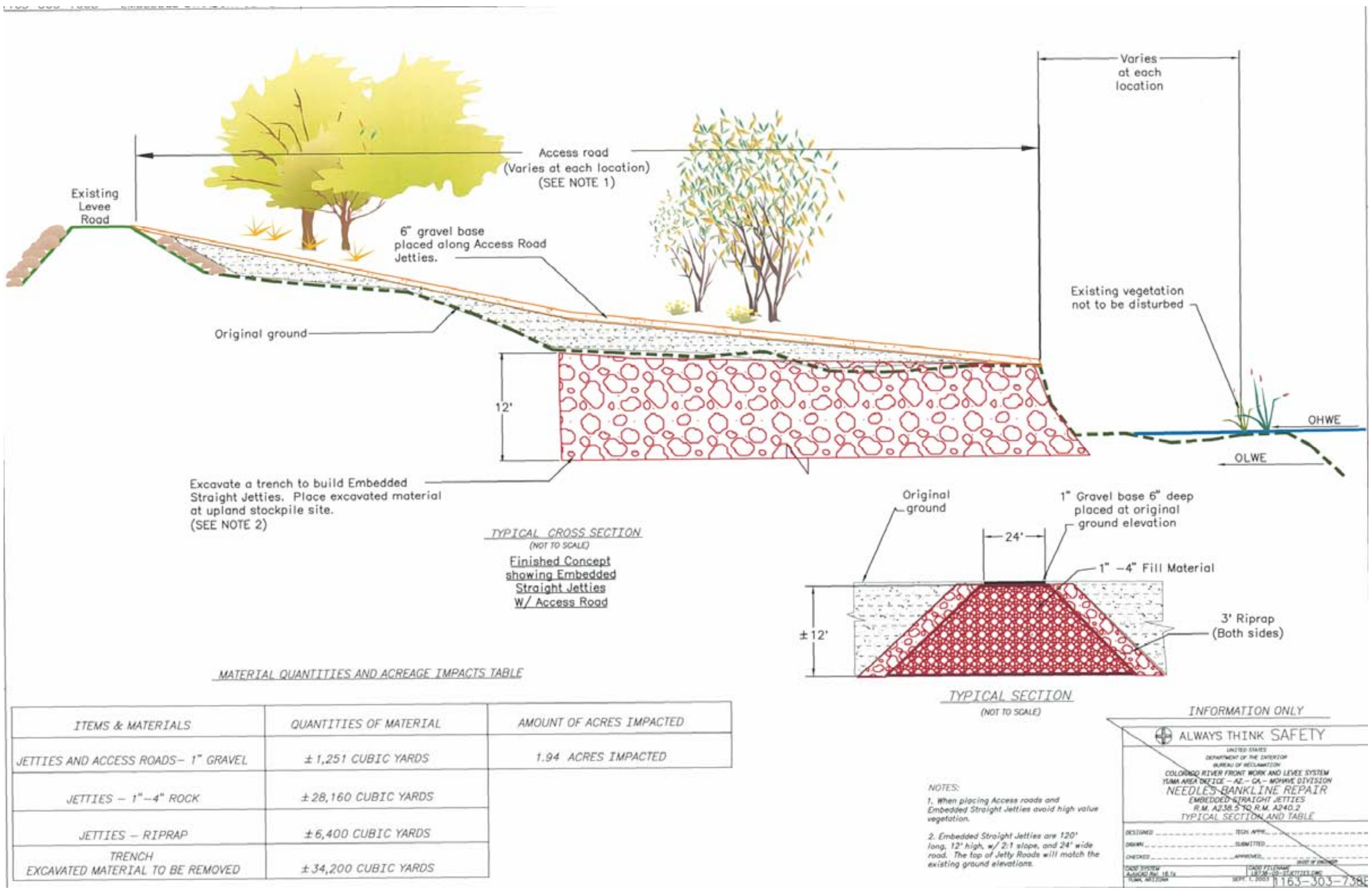
Objectives Assessment Summary – Straight Jetties

1. Control Boat Wave Erosion/ Prevent Channel Widening	2. Protect Channel at Bank Full Flow	3. Does Not Adv. Effect Levee Design Flow	4. Design Feas.	5. Avail. Tech.	6. Non-Dam.	7. Cost	8. Enhance Env.	Total	Survive Screening?
1	3	5	5	5	4	5	1	29	No

B. L-Jetties

Since the channel does not need to be narrowed in most of the reach, L jetties would serve little purpose. It would be possible to design a hybrid L jetty essentially creating thick straight jetties which would reduce the number of jetties, but increase the material required to construct the structure. The primary benefit of performing this type of design is that it could be used to reduce impacts to the shoreline in certain locations. Figures 6 and 7 demonstrate the use of the hybrid jetties.

The estimated cost to implement this project was estimated to be about 85% more than the proposed project. The total cost for this effort is estimated to be about $2,150,000. In addition this alternative rated relatively low again at 29 or about 73% of the total score possible of 40.



ITEMS & MATERIALS	QUANTITIES OF MATERIAL	AMOUNT OF ACRES IMPACTED
JETTIES AND ACCESS ROADS– 1" GRAVEL	± 1,251 CUBIC YARDS	1.94 ACRES IMPACTED
JETTIES – 1"–4" ROCK	± 28,160 CUBIC YARDS	
JETTIES – RIPRAP	± 6,400 CUBIC YARDS	
TRENCH EXCAVATED MATERIAL TO BE REMOVED	± 34,200 CUBIC YARDS	

Figure 5. Jetty Design

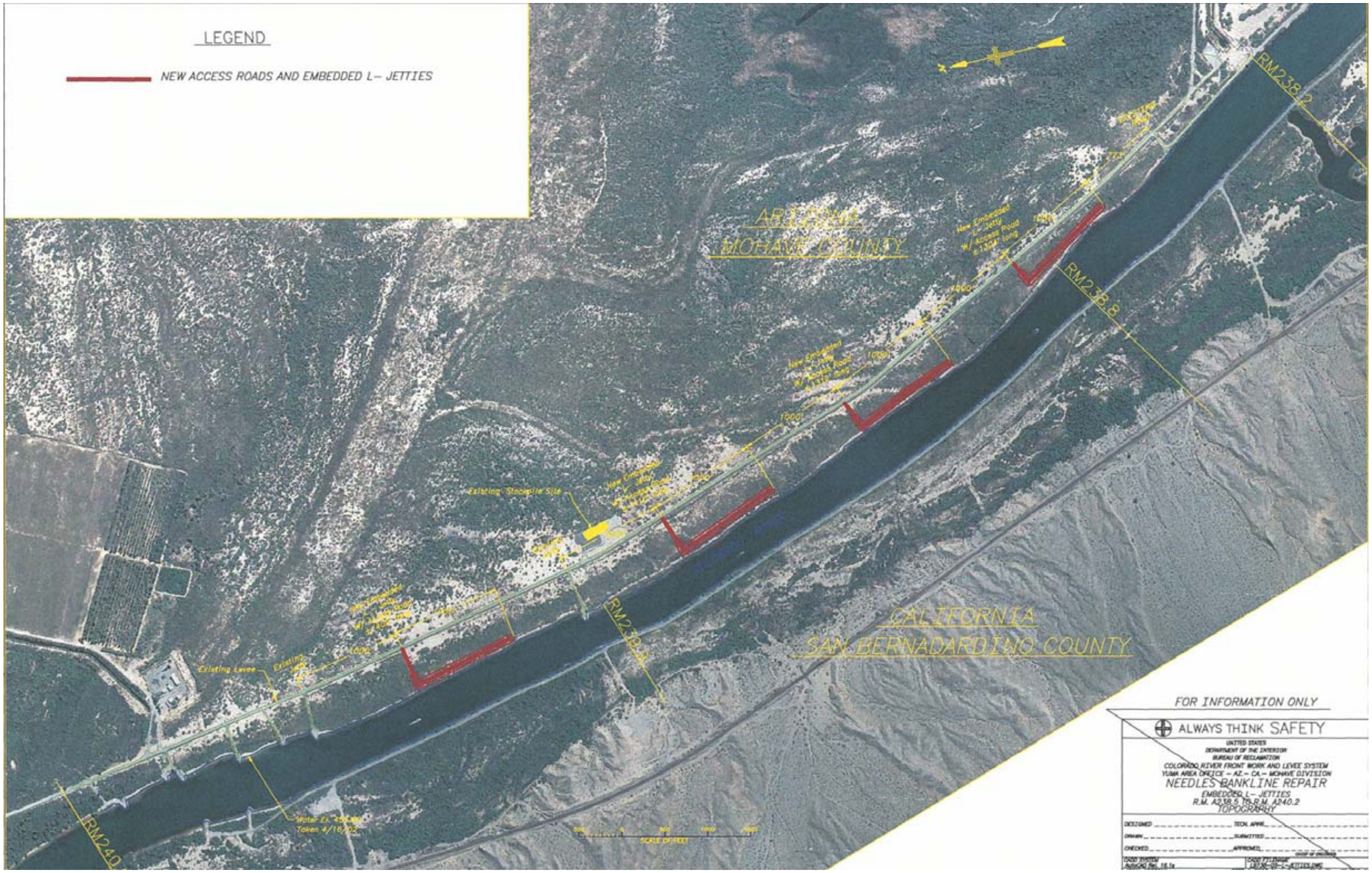
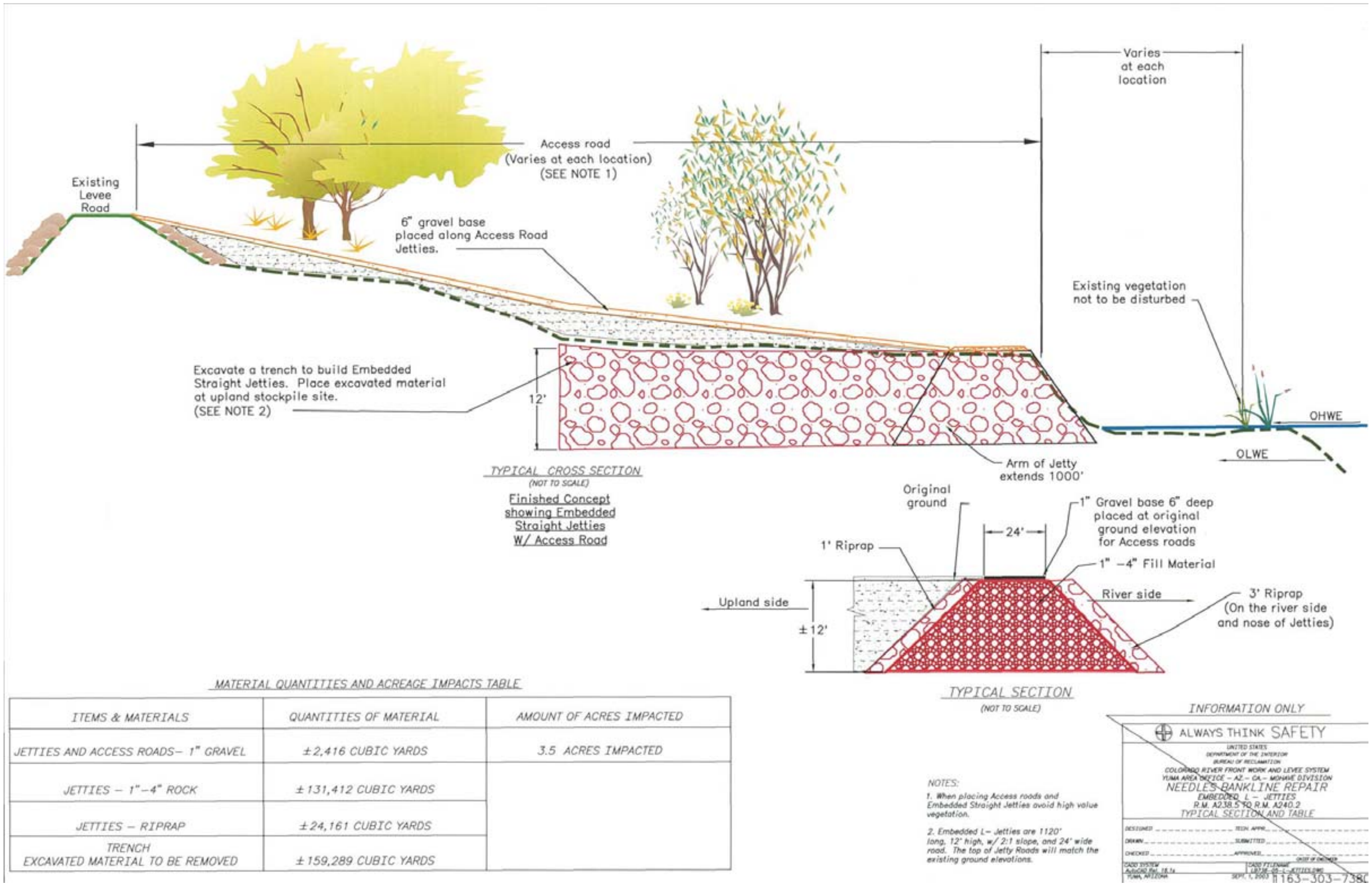


Figure 6. L-Jetty Concept



MATERIAL QUANTITIES AND ACREAGE IMPACTS TABLE

ITEMS & MATERIALS	QUANTITIES OF MATERIAL	AMOUNT OF ACRES IMPACTED
JETTIES AND ACCESS ROADS– 1" GRAVEL	±2,416 CUBIC YARDS	3.5 ACRES IMPACTED
JETTIES – 1"–4" ROCK	±131,412 CUBIC YARDS	
JETTIES – RIPRAP	±24,161 CUBIC YARDS	
TRENCH EXCAVATED MATERIAL TO BE REMOVED	±159,289 CUBIC YARDS	

Figure 7. L-Jetty Design

Objectives Assessment Summary – L-Jetties

1. Control Boat Wave Erosion/ Prevent Channel Widening	2. Protect Channel at Bank Full Flow	3. Does Not Adv. Effect Levee Design Flow	4. Design Feas.	5. Avail. Tech.	6. Non-Dam.	7. Cost	8. Enhance Env.	Total	Survive Screening?
3	4	5	5	5	3	3	1	29	No

2. Continuous Bankline Protection

In order to protect the bankline for both boat wave action and bank full flows, some level of protection will be required from the Ordinary Low Watersurface (OLW) profile up to the top of bank. Since the greatest erosion potential is from boat waves, the more resistant bank cover will need to be placed lower on the bankline.

The type and amount of cover required to protect from erosion due to river flow, even at bank full, is relatively minor. For elevations that aren't subject to constant boat wave action, a good layer of vegetation would likely prevent erosion due to river flows. To insure success, a 6 inch layer of 1 to 2 inch D50 gravel with pole plantings through the gravel is recommended.

More aggressive means of bank protection would be required to prevent further erosion due to boat wave action. As stated previously, the larger jetboats are capable of generating about 2 ft waves. A number of proven techniques have been utilized to provide bankline protection from aggressive erosion processes whether they be by boat wave, flow impingement, or by other means. A few of the accepted bank protection practices are shown in Figures 8 to 12:

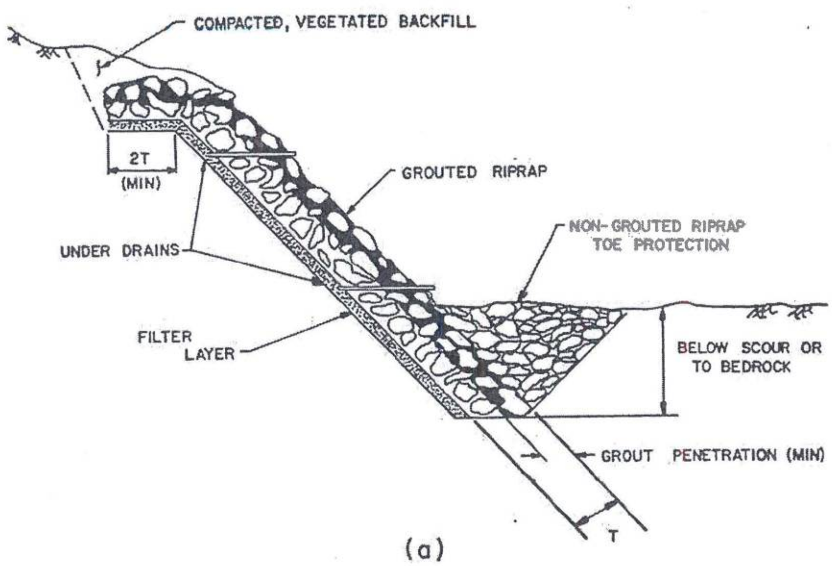


Figure 8. Grouted Riprap

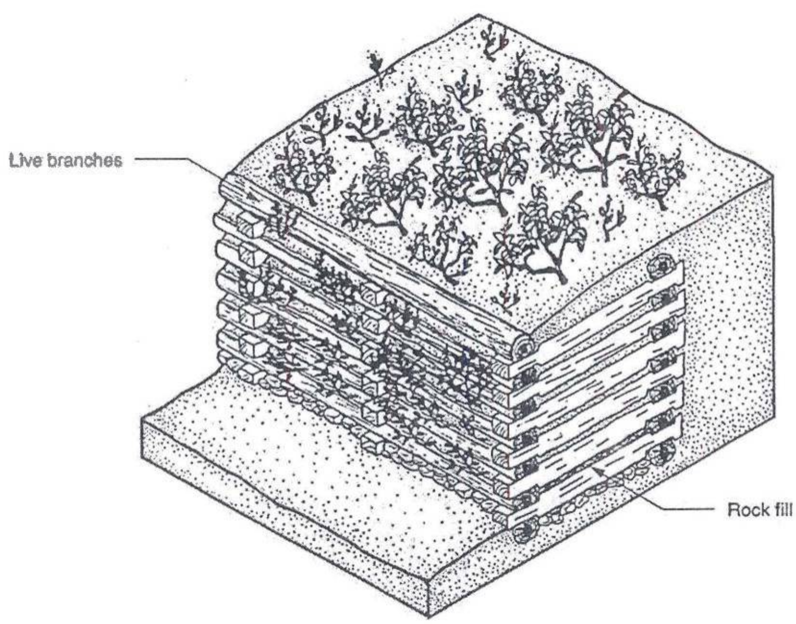


Figure 9. Crib Wall

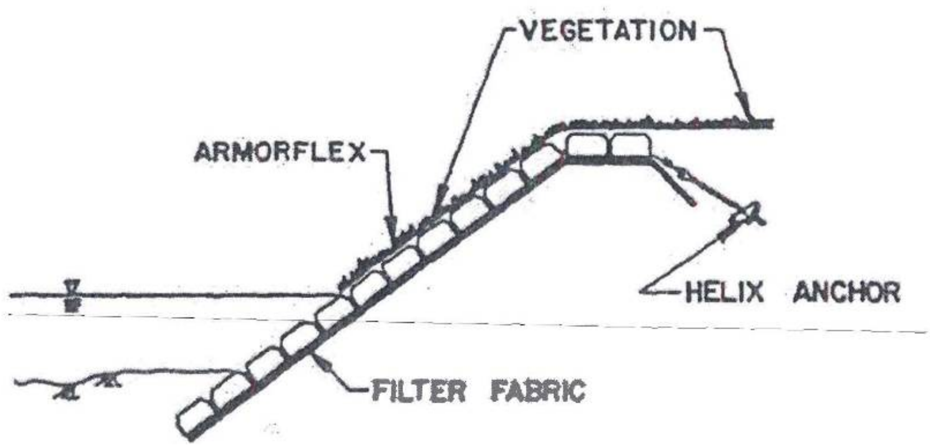


Figure 10. Articulated Concrete Block (Closed or Open Cell)

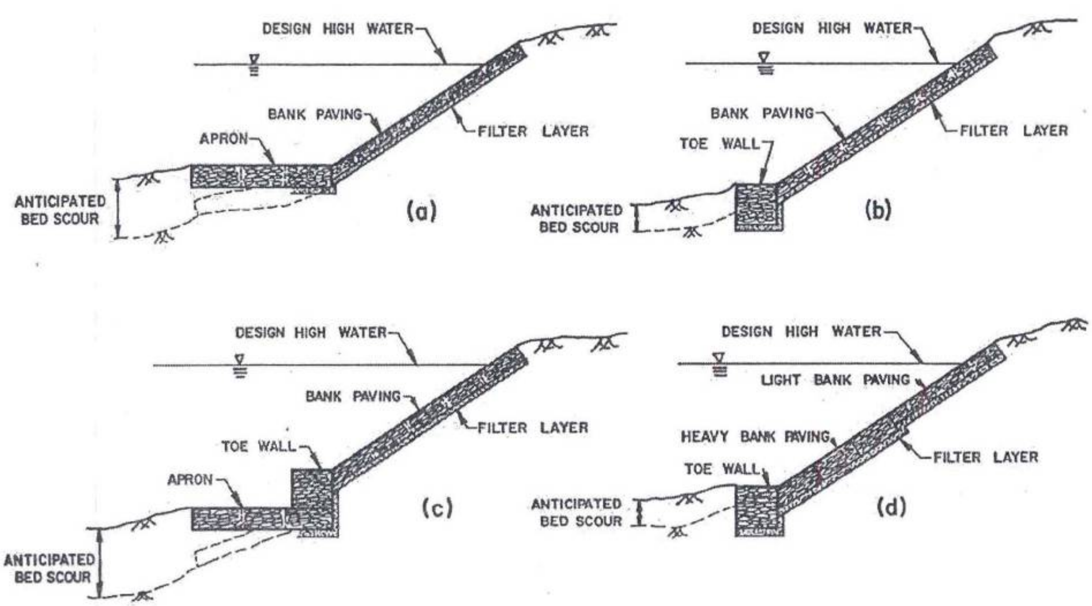


Figure 11. Rock and Wire Mattress (Gabions)

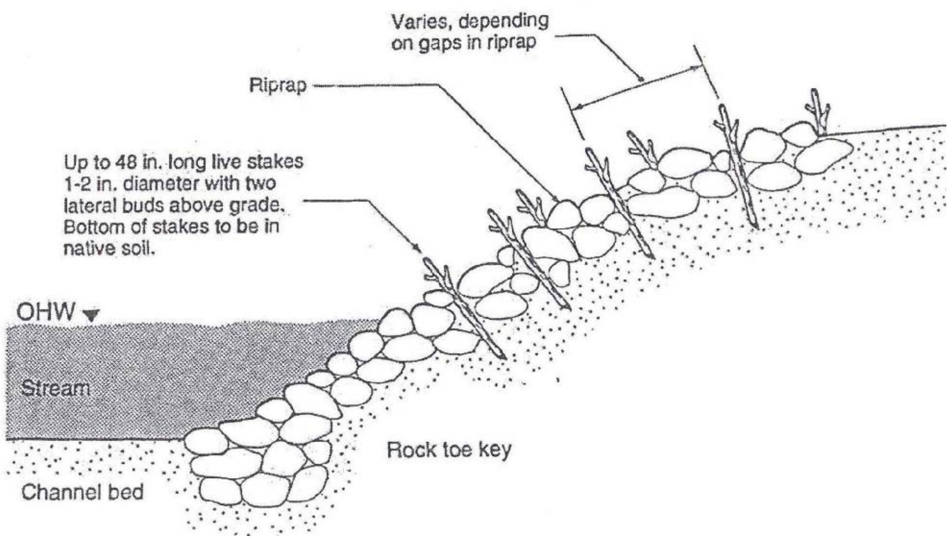


Figure 12. Rock and Vegetation

The examples of bank protection methods included are not all inclusive, but represent the majority of established methods. All methods shown could be conducted at this location and would have similar environmental impacts. All the methods shown can be constructed on the site and use existing technology.

The total cost for each bankline alternative was not developed. Preliminary screening was performed by comparing the cost of materials per lineal ft of each of the different methods considered. As a result the total cost was only computed for the method considered to have the best potential within the group of continuous bank protection methods.

The primary factor that differentiates the methods is cost of implementation, impact to the existing environment, and potential for environmental enhancement. The rock and vegetation method was selected as the most appropriate method for the following reasons:

- Grouted Rock. Smaller rock could be used and grouted, but grouted rock is not flexible and therefore would have a greater chance of failure. The grouted rock would only be required to a level of about 2 feet above the OHW then gravel size material could be used above that elevation. This would allow vegetation to be planted on the upper portion of the banks. No vegetation would be attempted in the grouted section. Since the erosional forces are not that great, there is no benefit in grouting rock when rock alone would suffice. The method was considered inappropriate for this site. Cost per lineal foot is estimated to be approximately $120.

Objectives Assessment Summary – Grouted Rock

1. Control Boat Wave Erosion/ Prevent Channel Widening	2. Protect Channel at Bank Full Flow	3. Does Not Adv. Effect Levee Design Flow	4. Design Feas.	5. Avail. Tech.	6. Non-Dam.	7. Cost	8. Enhance Env.	Total	Survive Screening?
5	5	5	5	5	1	3	1	30	No

- Timber Crib Walls (Figure 13). A disadvantage of crib walls along streams and rivers is that they deteriorate over time and would likely need to be replaced before other means of bank protection. This project would likely lose some of the advantages of crib walls because rock material would need to be used as backfill immediately behind the logs to prevent the native soil from eroding between the crib logs. In addition, substantial toe protection would still be required. Cost per linear foot for materials is estimated to be approximately $140 over 25 years and $210 over 50 years assuming some of the structure would need to be replaced. Due to a variety of considerations which included cost, this method was considered inappropriate for the site.

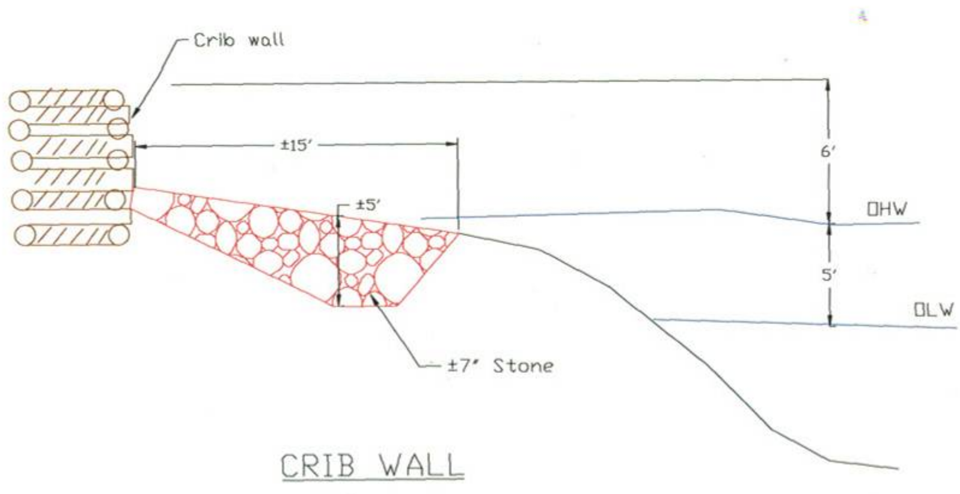


Figure13. Live Crib Wall Concept

Objectives Assessment Summary – Live Crib Wall

1. Control Boat Wave Erosion/ Prevent Channel Widening	2. Protect Channel at Bank Full Flow	3. Does Not Adv. Effect Levee Design Flow	4. Design Feas.	5. Avail. Tech.	6. Non-Dam.	7. Cost	8. Enhance Env.	Total	Survive Screening?
5	5	5	5	3	3	1	3	32	No

- Articulated Concrete Block (Figure 14). This method of bank protection has been used with good success. It, like the grouted rock alternative, could be used to an elevation of 2 ft above the OHW mark. Large vegetative growth is not encouraged within the block because of the damage to the block that it causes. Cost per linear foot for materials is estimated to be approximately $230. Due to a variety of considerations which included cost, this method was considered inappropriate for the site.

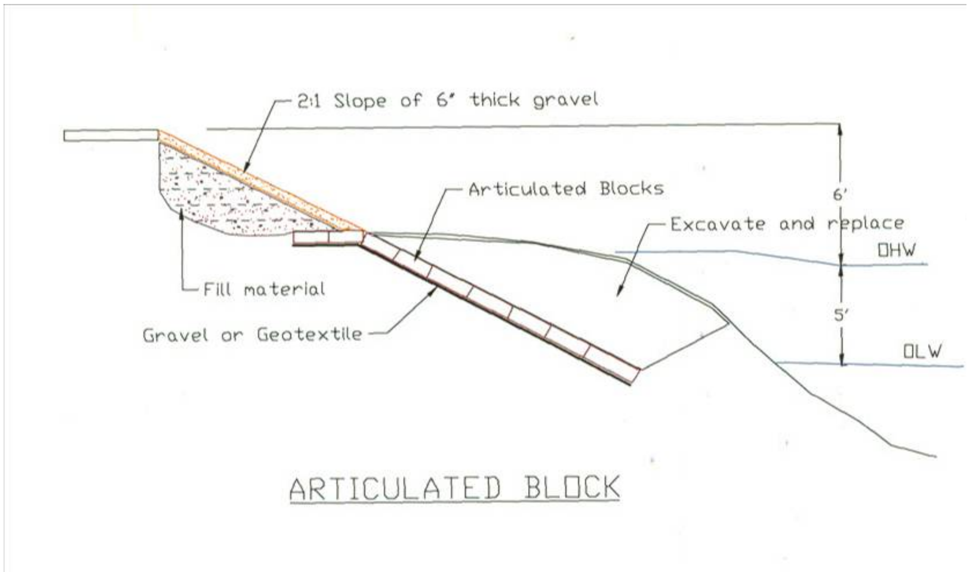


Figure 14. Articulated Concrete Block Concept

Objectives Assessment Summary – Articulated Concrete Block

1. Control Boat Wave Erosion/ Prevent Channel Widening	2. Protect Channel at Bank Full Flow	3. Does Not Adv. Effect Levee Design Flow	4. Design Feas.	5. Avail. Tech.	6. Non-Dam.	7. Cost	8. Enhance Env.	Total	Survive Screening?
5	5	5	5	5	2	1	1	29	No

- Rock and Wire Mattress – Gabion (Figure 15). By wrapping rock with fencing, smaller size material can be used for bank protection. Rock and wire mattress would provide some flexibility, but not as great as the larger rock cover. Since relatively small rock is required to stabilize the bank, rock and wire mattress are not cost effective. Cost per linear foot for materials is estimated to be approximately $140. This method of stabilization was screened also from further consideration.

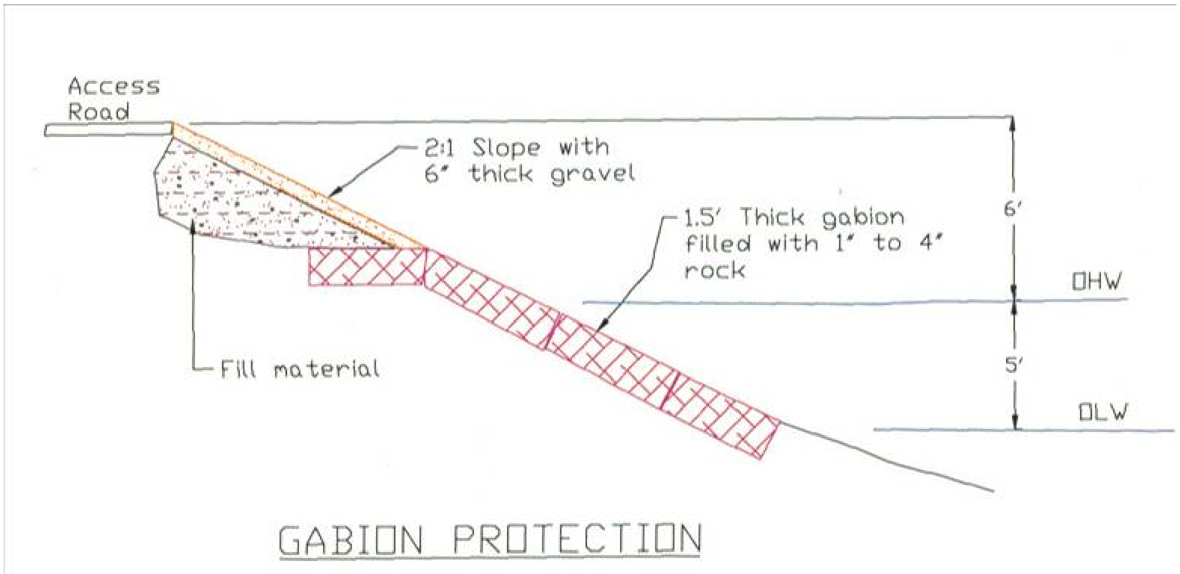


Figure 15. Rock and Wire Mattress Concept

Objectives Assessment Summary – Wire Mattress Concept (Gabion)

1. Control Boat Wave Erosion/ Prevent Channel Widening	2. Protect Channel at Bank Full Flow	3. Does Not Adv. Effect Levee Design Flow	4. Design Feas.	5. Avail. Tech.	6. Non-Dam.	7. Cost	8. Enhance Env.	Total	Survive Screening?
5	5	5	5	5	2	3	1	31	No

- Rock with Vegetation (Figure 16). Erosion is being caused primarily by boat waves. The size of rock required to protect the shoreline from 2 ft waves has a D50 of 6 inches[2]. Rock will provide a flexible protective layer that vegetation can be planted through above the ordinary high water. Cost per linear foot for the cost of the rock and vegetation planting is estimated to be approximately $70.

[2] U.S. Army Corps of Engineers EM 1110-2-1614 "Design of Coastal Revetments, Seawalls, and Bulkheads"

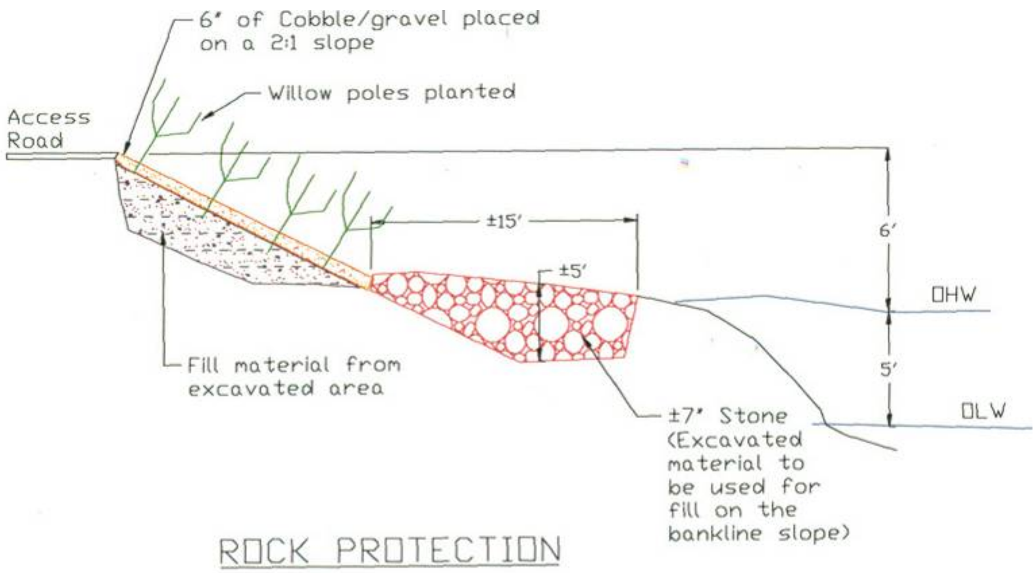


Figure 16. Rock Bank Protection Concept

Because the upper bank is lightly covered with small rock, there is opportunity to plant through the protective rock layer. Since willows and cottonwood appear to grow along the top of the vertical bank in some locations, they should grow well lower on a stable bankline. With time, the entire upper bankline is expected to be covered with vegetation.

Objectives Assessment Summary – Rock and Vegetation

1. Control Boat Wave Erosion/ Prevent Channel Widening	2. Protect Channel at Bank Full Flow	3. Does Not Adv. Effect Levee Design Flow	4. Design Feas.	5. Avail. Tech.	6. Non-Dam.	7. Cost	8. Enhance Env.	Total	Survive Screening?
5	5	5	5	5	3	5	4	37	Yes

3. <u>New Technology-Wave Attenuation.</u>

Wave attenuators could be used to break the boat wave energy before impacting the bank. These type of devices have been used in harbors, around docks, and to protect shoreline from erosion. This concept has been used for years in harbors and docks, but is not common for shore protection.

Block shapes have been developed to dissipate wave energy. A couple different types are shown below in Figure 17. The configuration used is dependent on its purpose and location and is, to some degree, based on experience. Therefore, the arrangement may need to be adjusted once in place. This can be performed relatively easily.

Figure 17. Wave Attenuators

The intent would be to remove the wave attenuators once the bankline stabilizes with vegetation. So that the attenuators could be removed as soon as possible, the bankline should be sloped back and vegetated as shown in Figure 18. Although smaller rock is still used in the design, the rock is not sized to counter the wave action alone. The intent would be for vegetation and rock to accomplish erosion control in combination. This appears to be a reasonable assumption based on other banklines that have stabilized when vegetation has established in front of the bankline. This solution may not be as effective where there is no shelf in front of the bankline.

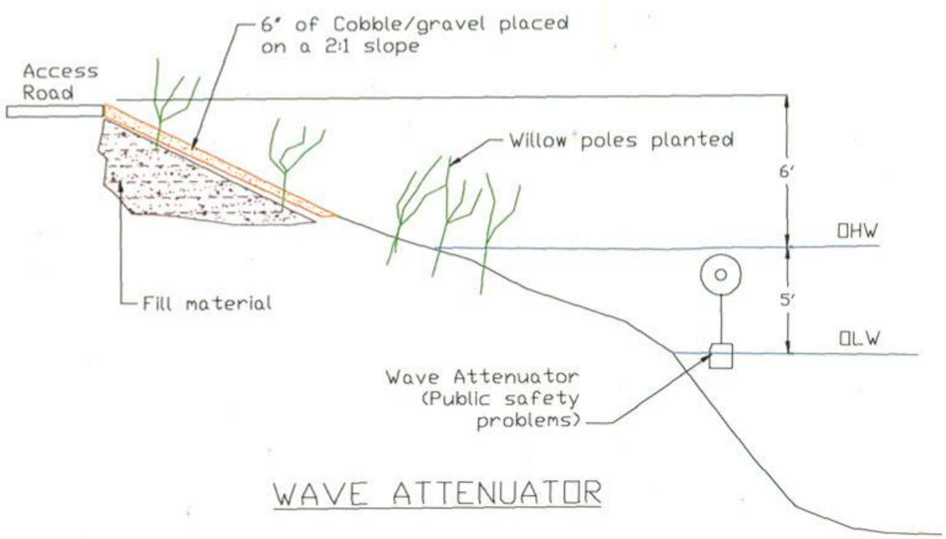


Figure 18. Wave Attenuator Concept

Wave attenuation for control of bank erosion has been used in some areas, but has primarily been used in marinas. The primary drawback in situations of bank protection is cost. Where considerable wave action is present, the rock material typically required to protect the bank may be large enough that the cost for wave attenuation is competitive. For this project the only way the wave attenuators would be cost effective is if very few of the blocks were required. The cost of a block is in the vicinity of $75. Therefore, in order for the wave attenuators to compete, the number of blocks would need to be minimized. The number of blocks and arrangement would potentially need to be adjusted before the optimal configuration would be determined. One drawback is that the attenuators would need to be visible at night and there is a strong likelihood that they would be vandalized and stolen. Because of the experimental nature of the devices and problems related to the isolation of the site, this concept was screened out as well. The estimated material cost per lineal ft for this alternative is estimated to be approximately $100.

Objectives Assessment Summary – Wave Attenuation with Stabilization

1. Control Boat Wave Erosion/ Prevent Channel Widening	2. Protect Channel at Bank Full Flow	3. Does Not Adv. Effect Levee Design Flow	4. Design Feas.	5. Avail. Tech.	6. Non-Dam.	7. Cost	8. Enhance Env.	Total	Survive Screening?
4	5	5	2	2	4	4	4	30	No

COMPARISON OF ALTERNATIVES

Table 1 summarizes the alternatives considered.

Table 1. Comparison Of Alternatives

Alts.	Objectives								
	1. Control Boat Wave Erosion/ Prevent Channel Widening	2. Protect Channel at Bank Full Flow	3. Does Not Adv. Effect Levee Design Flow	4. Design Feas.	5. Avail. Tech.	6. Non-Dam.	7. Cost	8. Enhance Env.	Total	Survive Screening?
St. Jetties	1	3	5	5	5	4	5	1	29	No
L-Jetties	3	4	5	5	5	3	3	1	29	No
**Grouted Rock	5	5	5	5	5	1	3	1	30	No
**Live Crib Wall	5	5	5	5	3	3	1	3	32	No
**Articulated Con. Block	5	5	5	5	5	2	1	3	29	No
**Gabion	5	5	5	5	5	2	3	3	31	No
Rock and Veg.	5	5	5	5	5	3	5	4	37	Yes
**Wave Att.	4	5	5	2	2	4	4	4	30	No

**Screened prior to computing total costs.

RELATIONSHIP OF ALTERNATIVES TO PROPOSALS FROM VALUE PLANNING STUDY

A Value Planning study was performed in September of 2003 by Reclamation staff to evaluate the alternative selected at that time. The results of that study are documented in their final report dated October 23, 2003[3]. The alternative that was reviewed in 2003 was more structural than the one that is currently proposed. It consisted of a bankline road with a number of straight jetties. All structures were to be lined with riprap. The value planning study was primarily intended to provide proposals which reduced the cost of the project. Because all the proposals which modified the design, proposals 2 through 4,

[3] Value Planning Final Report, Needles/Topock Bankline Stabilization and Restoration Project

were much more structural than the alternatives described in this document, they all would cause considerably more impact than the one proposed here. The only proposal that will be implemented as part of the selected project is Proposal 1. The following is a summary of the proposals provided by Reclamation staff.

From the value planning phase of the study, variations of alternatives discussed in this document were suggested. The following summarizes those proposals:

Proposal 1. Contract for Work to be Done During Winter
This proposal would make construction easier to accomplish, but cost savings were not quantified. YAO will attempt to construct the project during low water to simplify construction.

Proposal 2. Build Armored Bankline Road (No Jetties)
The bankline road was to be built slightly higher than the existing bankline, the levee toe was to extend slightly into the river, and be covered with the typical riprap bank protection which consists of rock with a D50 of about 1.5 feet. This proposal would meet all the design criteria, but the size of rock used is larger than necessary and the design channel slope is homogenous. In addition, planting through the riprap layer would not be practical. Therefore the concept as proposed was considered more structural than necessary.

Proposal 3. Build Armored Bankline Road with 3 L-Jetties
Again this proposal met all the objectives, but was even more structural. The advantage of the L-Jetties was that they created a backwater environment that could be utilized for restoration. The problem with the jetties was that they pinched the river to a width that was inconsistent with work done just upstream of the current project. Therefore the concept as proposed was rejected.

Proposal 4. Build Armored Bankline Road and the Center L-Jetty
This variation of the originally alternative is very similar to that chosen. The rock protection and bankline were proposed to be the same as described in the first proposal, but this proposal included an L-Jetty. This alternative was adopted with some additional modifications.

FINAL RECOMMENDED PROJECT CONFIGURATION

The selected alternative is a refinement of Proposal 4. As shown in Figure 19, bankline protection is proposed along the Arizona side of the project reach. However, the method used to protect the bank is the Rock with Vegetation concept described in section 2 where smaller rock is used and only extends down to the Ordinary Low Water elevation as shown in Figure 20. In addition, the bankline is not raised and the access road along the bankline follows the existing bank elevation. The bankline will not be straightened. Instead the bank will be laid back along the existing alignment so that the resulting bank alignment will be irregular and as natural as possible.

Another difference between Proposal 4 from the planning study and the selected alternative is avoidance of two areas with bulrush growth along the banks. The first is near the upstream end of the project and covers about 100 feet of bankline and the second is near the center of the project and covers an area 200 to 330 ft in length. In both cases, the bank protection will be placed between the bulrush and existing vertical bank. Effort will be made to minimize the impact to the bulrush growth along the bank to the extent possible.

The cost of this project is one of the lowest at a total of about $1,170,000. In addition this alternative rated the highest given the 8 screening criteria for this evaluation. Out of 40 points this alternative was rated at 37 or about 93% of the total points possible. For these reasons it was considered best suited for this particular location.

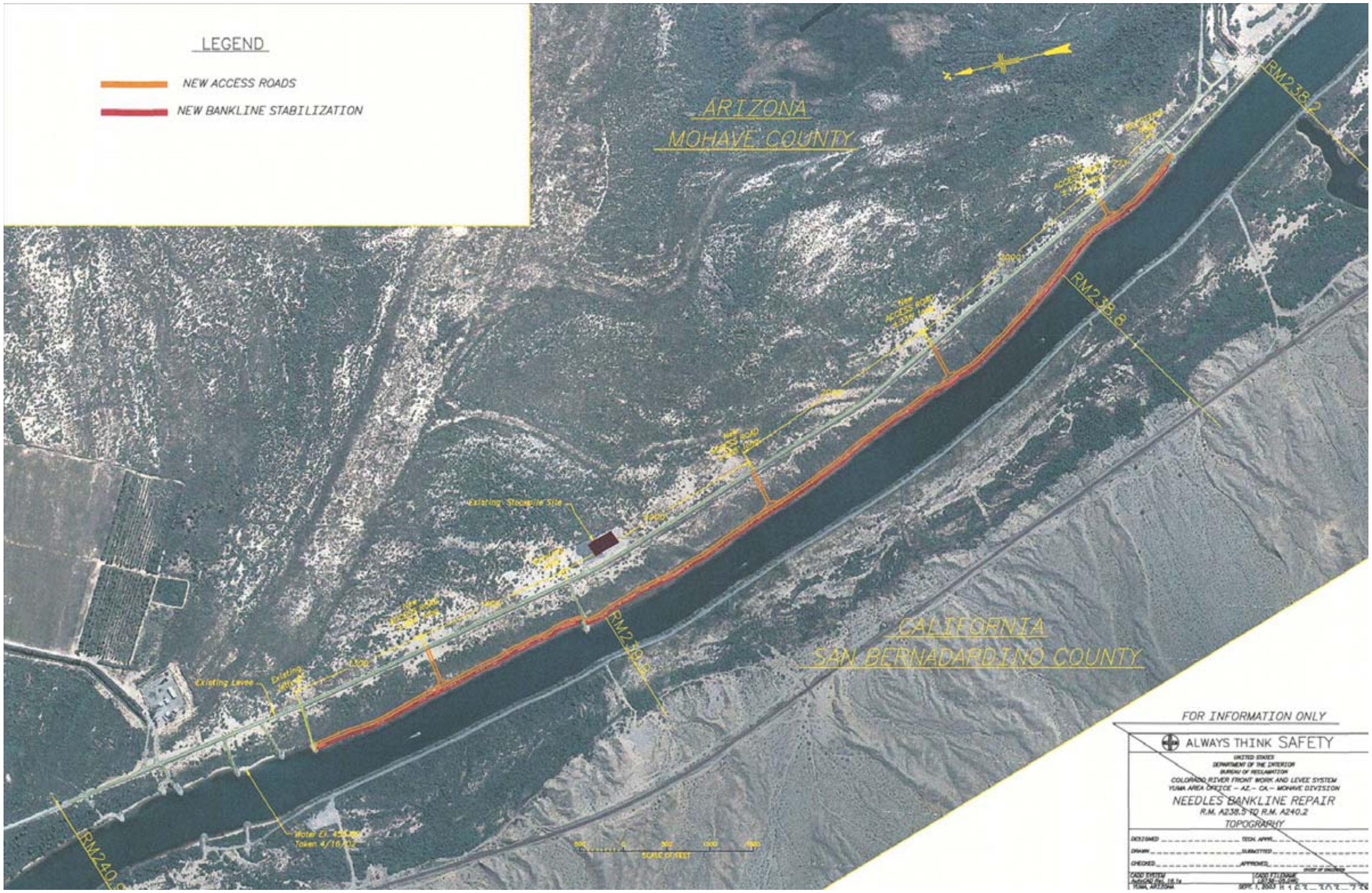
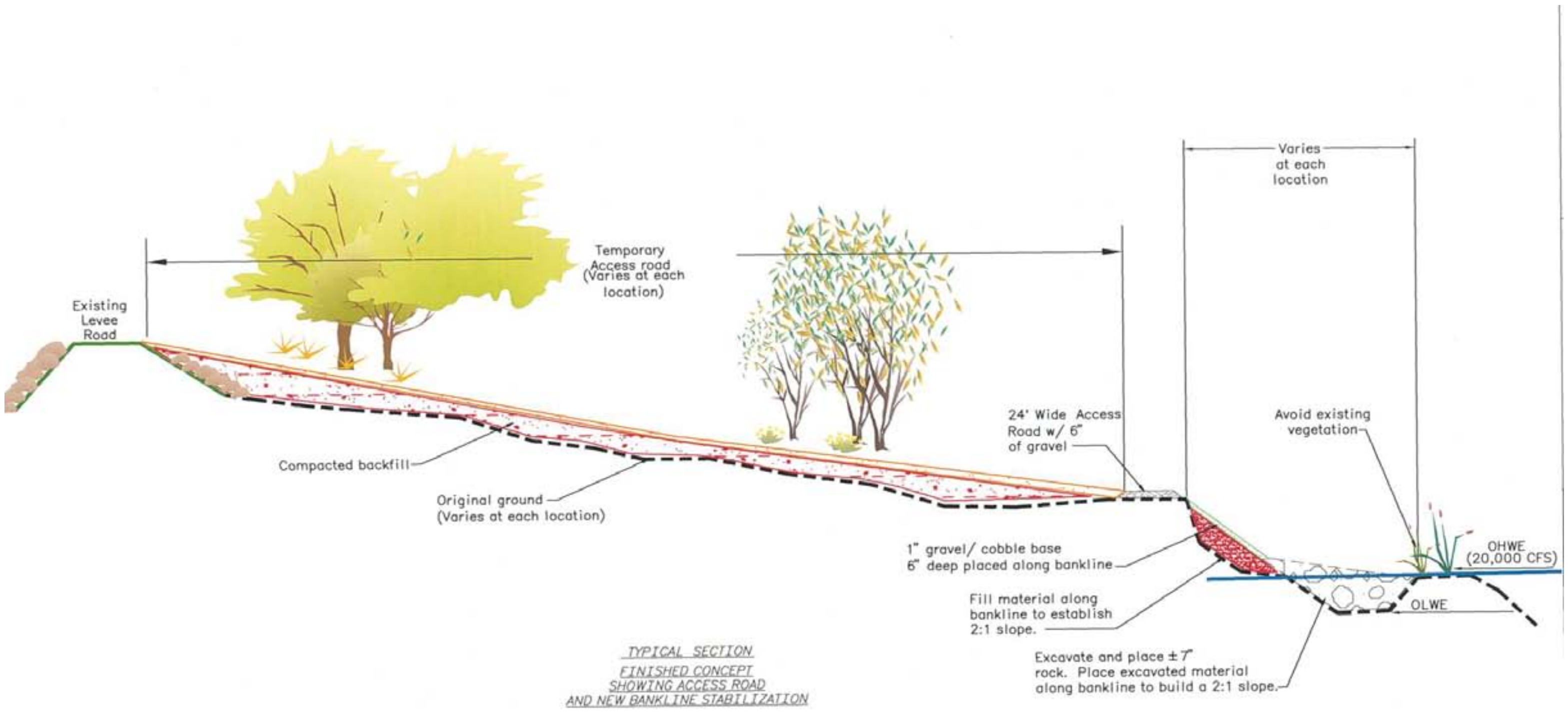


Figure 19. Bankline Protection Concept



TYPICAL SECTION
FINISHED CONCEPT
SHOWING ACCESS ROAD
AND NEW BANKLINE STABILIZATION

MATERIAL QUANTITIES AND ACREAGE IMPACTS TABLE

ITEMS & MATERIALS	QUANITIES OF MATERIAL	AMOUNT OF ACRES IMPACTED
ACCESS ROADS– 1" GRAVEL, 6" DEEP	±5,224 CUBIC YARDS	6.4 ACRES IMPACTED
BANKLINE STABILIZATION – 1" GRAVEL/ COBBLE, 6" DEEP	±4,340 CUBIC YARDS	5.4 ACRES IMPACTED
BANKLINE STABILIZATION – 7" – STONE	±27,128 CUBIC YARDS	3.4 ACRES IMPACTED
FILL MATERIAL FOR ACCESS ROADS	±3,290 CUBIC YARDS	

NOTES:

1. When placing Access roads avoid high value vegetation.
2. Access roads will follow existing bankline, and existing grade.

FOR INFORMATION ONLY

ALWAYS THINK SAFETY

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
COLORADO RIVER FRONT WORK AND LEVEE SYSTEM
YUMA AREA OFFICE – AZ.– CA.– MOHAVE DIVISION
NEEDLES BANKLINE REPAIR
R.M. A238.5 TO R.M. A240.2
TYPICAL SECTION AND TABLE

1163-303-7384

Figure 20. Bankline Protection Design