UPPER CAVE CREEK/APACHE WASH

Watercourse Master Plan

Attachment 8: Alternatives Analysis Report

Flood Control District of Maricopa County

April 2001

UPPER CAVE CREEK
&
APACHE WASH
WATERCOURSE MASTER PLAN

ATTACHMENT 8

Book 1 of 1

Alternatives Analysis Report

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ATTACHMENT 8
ALTERNATIVES ANALYSIS REPORT

8-1. 0 INTRODUCTION

To assist in understanding the technical content of this report, a glossary of terms is provided in Section 8-7.0. Words or phrases that appear in italics throughout the text are defined in the glossary.

8-1.1 Study Description

The Upper Cave Creek/Apache Wash Watercourse Master Plan (WCMP) Study was undertaken to examine the benefits, opportunities, and weaknesses of various flood control solutions, including full-structural, soft-structural, and nonstructural measures, and recommend a management plan. The study examines the *watercourses* as components of the overall watershed system. The primary goals of the WCMP are:

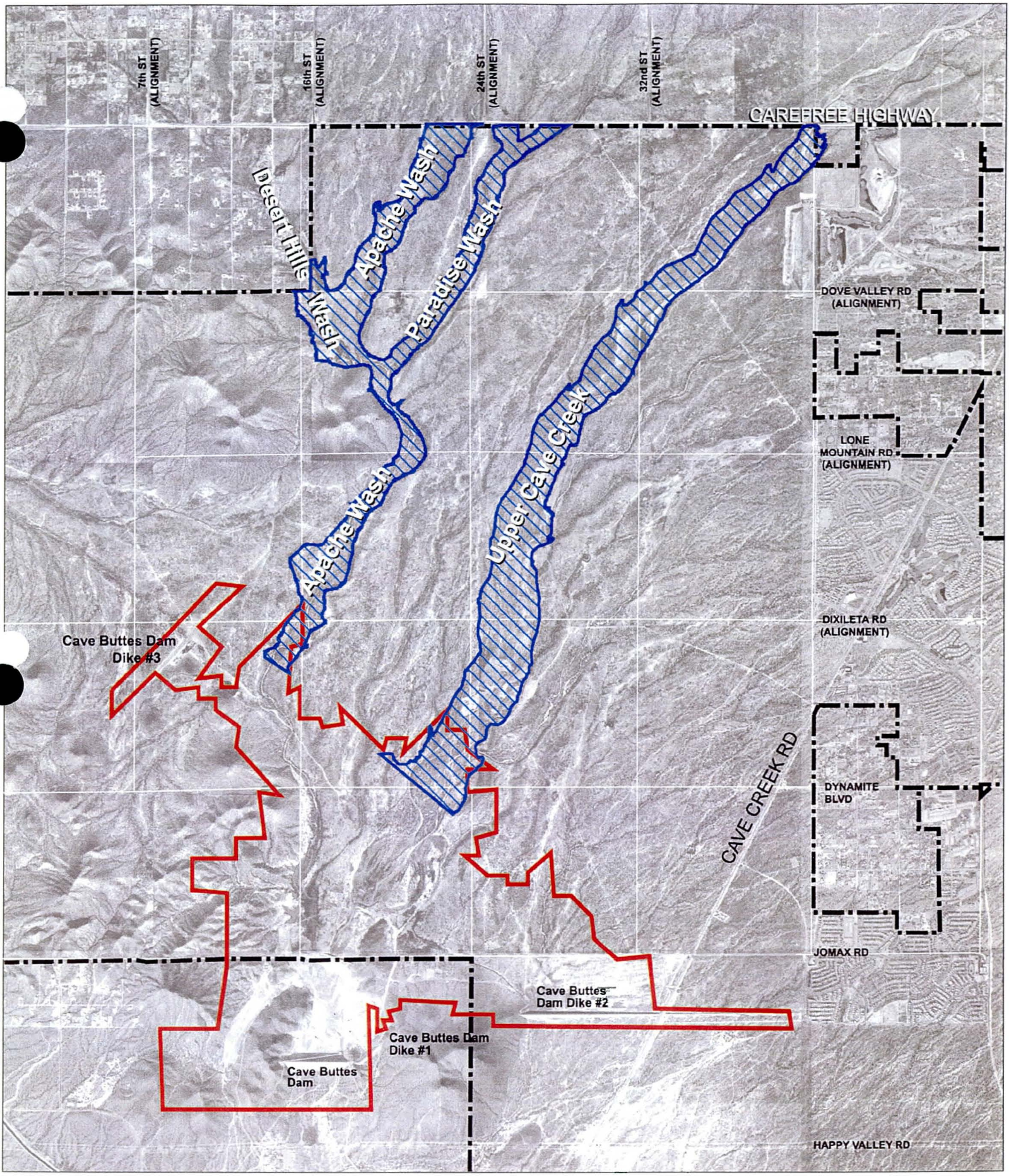
- Protect existing and future residents from the 100-year flood event and possible damages associated with potential lateral migration of the *watercourses*.
- Consider structural and nonstructural alternatives.
- Reduce public funds spent on flood control and emergency management.
- Consider sensitive habitats and cultural resources in the evaluation of alternatives.
- Consider multiple-use activities for floodplain areas.
- Consider landscape aesthetics and desired landscape character of floodplain areas.

The study limits include the main stems of Upper Cave Creek and Apache Wash, along with the Apache Wash tributaries Paradise Wash and Desert Hills Wash, between the Cave Buttes Dam impoundment area on the south and the Carefree Highway/City of Phoenix corporate limit on the north, in north-central Maricopa County. A map of the study area is presented on Figure 8-1.1.

The study was a joint effort of the City of Phoenix and the Flood Control District of Maricopa County. The Flood Control District of Maricopa County awarded the contract to Tetra Tech, Inc., Infrastructure Southwest Group, in April 1998.

8-1.2 Purpose

The purpose of the alternatives analysis is to formulate and evaluate a range of plans for providing flood and *erosion* control, determine the costs and benefits of each, identify



Key

- FEMA 100-Year Floodplain
- City of Phoenix Corporate Boundary
- Cave Buttes Dam Impoundment

FIGURE 8-1.1
STUDY AREA

opportunities for nonstructural solutions, and recommend a preferred watercourse management alternative for regulating the study watercourses. It was anticipated that some structural control measures may be required in a nonstructural solution, however, the objective was to minimize their use.

8-1.3 Authority

This WCMP is conducted in accordance with the Floodplain Regulations for Maricopa County and Section 48-3609.01 of the Arizona Revised Statutes. The combination of the Severe and Lateral-Migration *Erosion* Hazard Areas, as defined by this study, represents the "*Erosion* Control Zone" as defined by the Floodplain Regulations of Maricopa County. Land within this *erosion* hazard zone or the *FEMA 100-year floodplain* is subject to flood and/or *erosion* hazards that threaten public safety. Accordingly, any development on such lands must be compatible with the potential hazards or be protected from those hazards through the construction of structural flood and/or *erosion* control features. A line has been established on each side of each *watercourse* to delineate these hazardous areas and allow them to be regulated. The line follows the floodplain boundary or the Lateral Migration Erosion Hazard Zone boundary, whichever is farther from the *main channel,* and is designated the "Regulatory Line." In addition to delineating the hazardous area, the Regulatory Line is used as the basis for computing the area of land that must be purchased or regulated to implement a given alternative and/or the area of land that can be reclaimed from the floodplain, or the Lateral Migration Erosion Hazard Zone, as a result of implementing a given alternative. The Regulatory Line is shown on Figure 8-1.2.

8-1.4 Approach

Alternatives for providing flood control and *erosion* protection were identified. A traditional flood control alternative was developed to provide a baseline from which to judge the benefits, opportunities, and weaknesses of other alternatives. Non-traditional flood control alternatives were developed based upon the investigation and determination of potential lateral migration and *scour* along the study watercourses and compared to the traditional alternative. Accordingly, the non-traditional flood control alternatives go beyond traditional floodplain management strategies by protecting adjacent properties from the 100-year flood event and the possible damages associated with the potential lateral migration and *scour*.

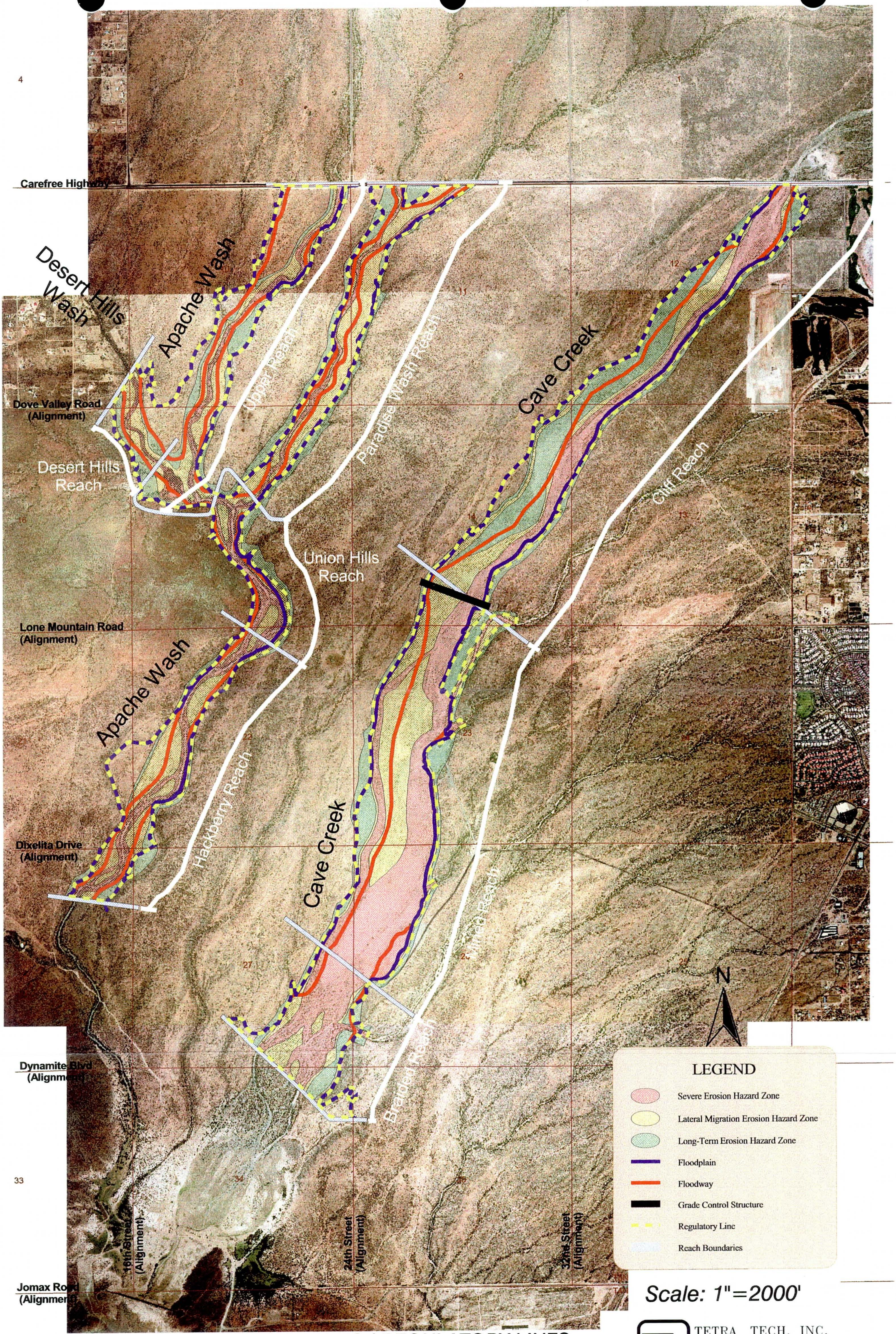
Limits of allowable encroachment within the regulatory area of each watercourse in the study area were defined for each alternative. The type and extent of structural features needed to allow the proposed encroachment were then identified by each alternative. *Scour* analyses were conducted on the necessary structural features to determine design parameters. Conceptual designs were developed with the structural quantities, costs, benefits, and habitat impacts defined. Criteria and procedures were developed to evaluate the alternatives and recommendations for implementation were made accordingly.

The Upper Cave Creek and Apache Wash watercourse systems were divided into reaches for detailed evaluation and analysis. The reaches were selected based on a combination of similar hydraulic, geomorphic, biological, and landscape characteristics. Upper Cave Creek was divided into three reaches. Starting at the downstream study limit and proceeding upstream, there are: the Braided Reach, the Mined Reach, and the Cliff Reach. Apache Wash and its two tributaries, Paradise Wash and Desert Hills Wash, are referred to herein as the Apache Wash System. The Apache Wash System was divided into five reaches. Again, starting at the downstream limit on Apache Wash and proceeding upstream along the main channel, they are: the Hackberry Reach, the Union Hills Reach, the Upper Reach, the Desert Hills Reach and the Paradise Reach. The names selected for Upper Cave Creek and the main stem of Apache Wash reflect the dominating feature or characteristic within the reach. For example, the Mined Reach of Upper Cave Creek reflects the past and present mining activities, while the Union Hills Reach of Apache Wash reflects the prominent hill on the west side of the watercourse. The reaches are presented on Figure 8-1.2.

8-1.5 Assumptions, Limitations, Constraints

The following assumptions are used in the alternatives analysis:

- All structural improvements associated with a given alternative are assumed to be constructed at one time for cost estimating and evaluation purposes (i.e., no piecemeal construction).
- Encroachments will be accomplished through the use of earthen levees with three feet of freeboard above the 100-year water surface and suitable bank protection armor.
- The bed and bank materials of the watercourses are assumed to be erodible to the full depth of estimated *scour* and *erosion*, unless there is obvious evidence to the contrary.
- Any future bridge foundations will be designed to accommodate the recommended alternative, in accordance with the recommendations made herein.



STUDY REACHES / REGULATORY LINES

FIGURE 8-1.2

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8-2. 0 FORMULATION OF ALTERNATIVES

8-2.1 General

The alternatives were formulated through a combination of consultation and meetings with stakeholders, a planning retreat, input from the public through a public meeting process, and presentations to the City of Phoenix and the Desert View Village Planning Committee. The alternatives considered ranged from a totally natural, undisturbed *watercourse*, to a full traditional approach with encroachment to the *FEMA 100-year floodway* limit. All alternatives were to consider reclamation and re-vegetation of the areas disturbed by human activities. The selection criteria developed for the alternatives is as follows:

- A traditional armored levee with encroachment into the *FEMA 100-year floodplain* and full development of the floodway fringe area.
- No structural features located in the floodplain except those required to preserve the natural integrity of the *watercourse*.
- A combination of the preceding alternatives that would incorporate structural features, where necessary, to accommodate selected areas reclaimed from the floodway fringe area. This alternative is to minimize cumulative impacts resulting from encroachment.

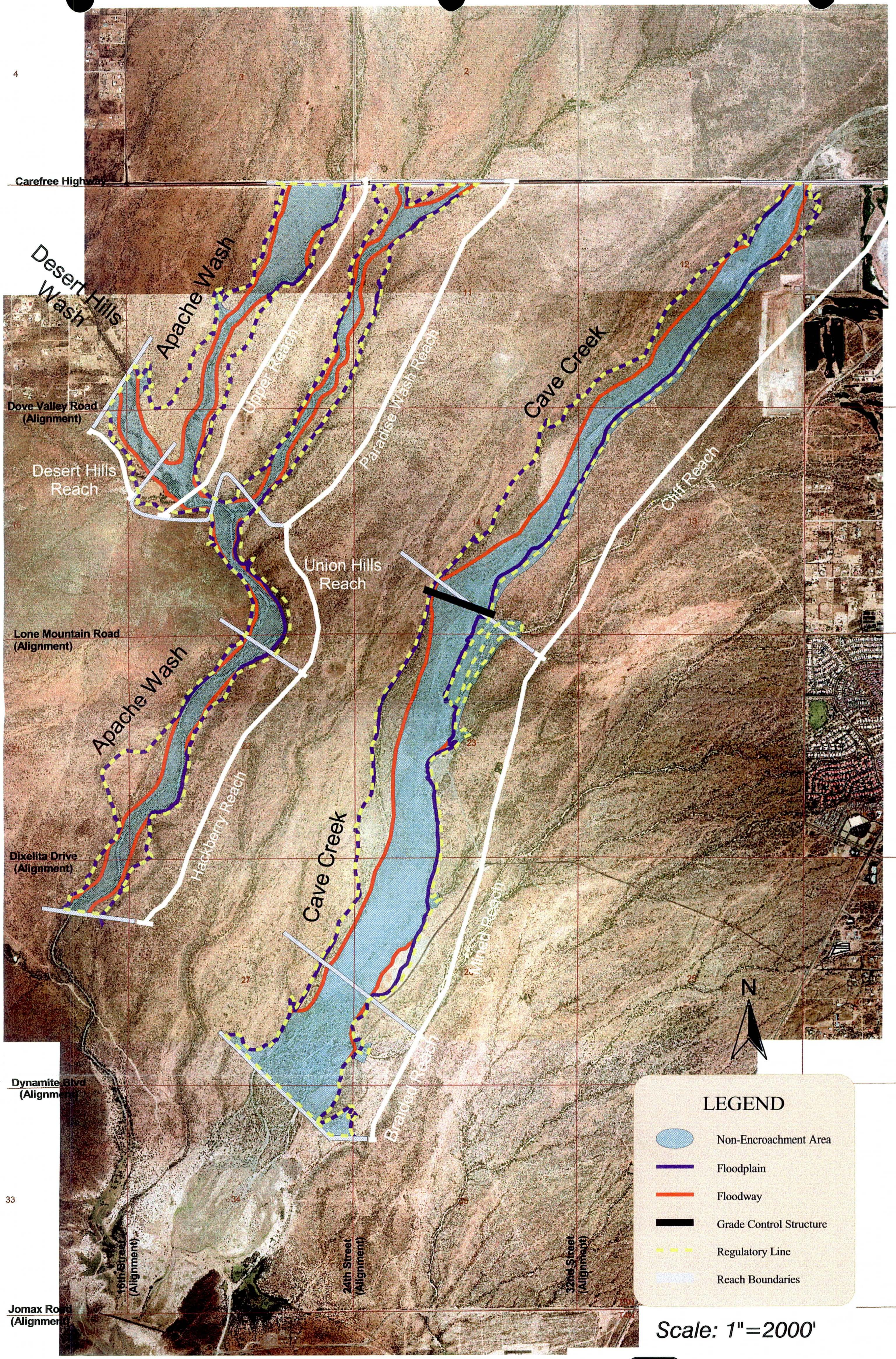
8-2.2 Selected Alternatives

After receiving input from the stakeholders and the affected public, a Full-Structural Alternative, a Soft-Structural Alternative, and a Nonstructural alternative were selected for more detailed development. A overview of each selected alternative follows.

8-2.2.1 *Full-Structural*

The Full-Structural Alternative reflects the traditional approach to floodplain management that allows encroachment to the regulatory floodway, as defined by the Federal Emergency Management Agency (FEMA). Unless the current floodway limit is modified through the appropriate regulatory process, it represents the maximum allowable encroachment into the floodplain and provides the maximum amount of land for development. The proposed encroachment limits are shown in Figure 8-2.1 for this alternative.

Encroachments into floodplains are typically accomplished using earthen fill material or, if the volume of fill is excessive, through the construction of earthen levees. In either case, the channel side of the fill or levee embankment should be protected from erosion by placing suitable armor material on the bank. The armor material should extend above the 100-year water-surface elevation a minimum of one foot for fill and three feet for



FULL-STRUCTURAL ALTERNATIVE: NON-ENCROACHMENT AREA

FIGURE 8-2.1

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levees. Examples of suitable bank protection armor considered in this study include rock riprap; rock-filled wire baskets, commonly referred to as gabions or gabion mattresses; or cement stabilized alluvium (CSA), which is a coarser version of the more common soil cement. To compare the effectiveness of the alternatives considered in this study, it was assumed that levees would be constructed to provide the desired encroachments.

For the Full-Structural Alternative, the proposed levees effectively follow the existing regulatory floodway boundaries along each *watercourse,* resulting in a relatively smooth alignment. The levees are to be constructed of earthen embankment material, compacted to 95 percent of maximum density, with three feet of freeboard above the 100-year water surface, as required by FEMA. A minimum ten-foot top width and 2:1 side slopes are recommended. The *channel* side of the levee is provided with bank protection to prevent *erosion* and *channel* migration. Refer to Figure 8-2.2 for a typical section of the proposed levee.

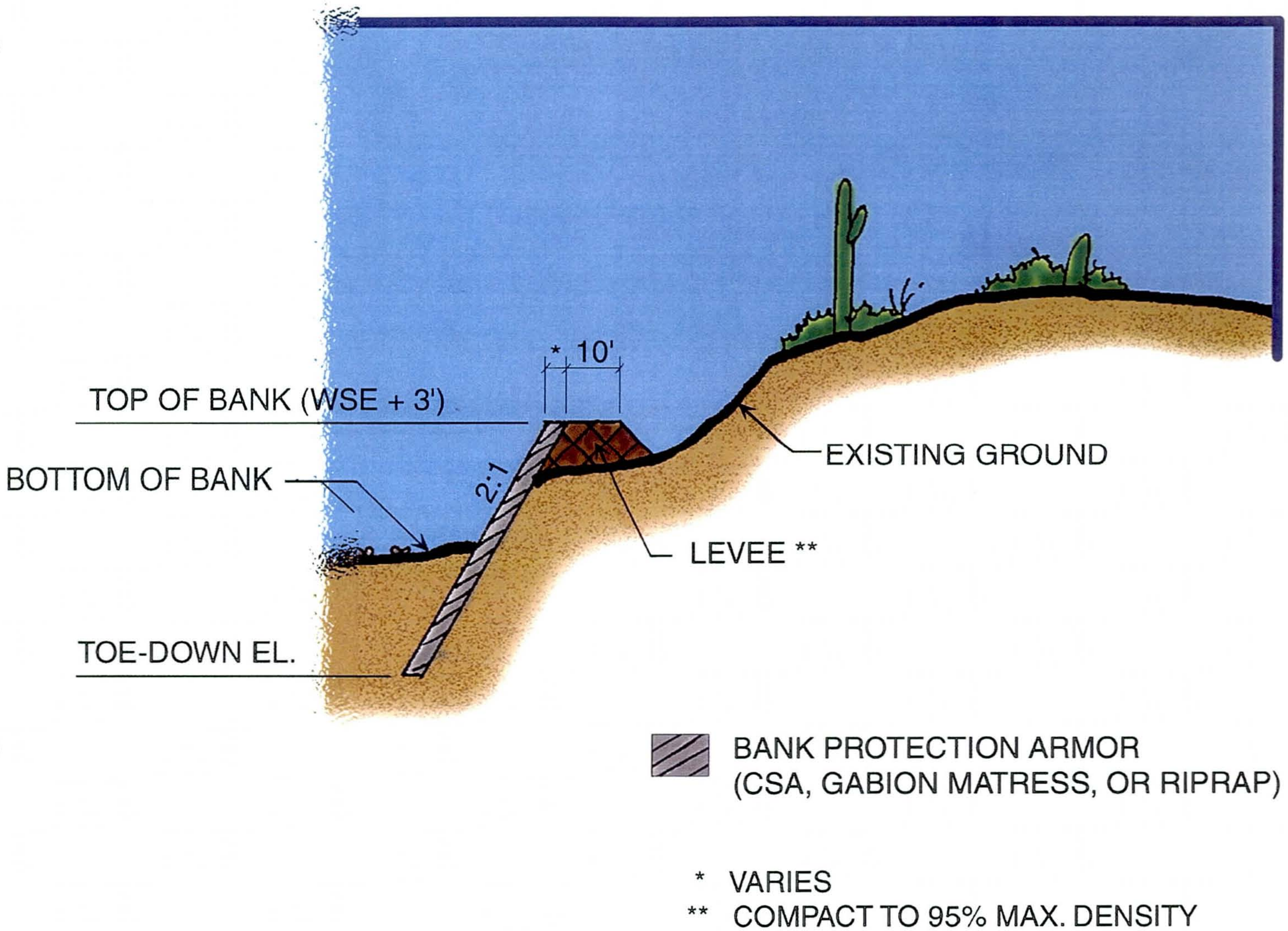
A grade control structure is also proposed at the north end of the Mined Reach on Upper Cave Creek to prevent *head-cut*ting from occurring in an upstream direction from the sand and gravel mining area. If *head-cut*ting is allowed to propagate upstream, the proposed bank protection would need to be much deeper, increasing costs and the disruption to the environment during construction. A number of different construction materials and design configurations can be used for such structures. However, for this alternative, it has been assumed that cement stabilized alluvium (CSA), constructed on 2:1 slopes with a 10-foot top width, will be used. Immediately after construction, only the top portion of the structure within the *main channel* area will be visible. Refer to Figure 8-2.3 for a conceptual drawing of the proposed grade-control structure for the Full-Structural Alternative.

8-2.2.2.1.1 Advantages/Disadvantages

The primary advantage of the Full-Structural Alternative is that it maximizes the amount of land available for development in the current *FEMA 100-year floodway fringe* area. The primary disadvantages are that it does so at a high construction cost and with some risk to the public. The finished product typically has an unnatural appearance and function, and results in significant disturbance of reparian habitat and cultural features.

8-2.2.1 *Soft-Structural*

The Soft-Structural Alternative contains both encroachments into the *FEMA 100-year floodway fringe* and areas that are left in their natural state. Where encroachments into the floodway fringe are proposed, levees, similar to those described in the Full-Structural Alternative, are used. For this alternative, the extent of encroachment is also controlled through the implementation of a regulatory setback distance. The setback distance is generally based on engineering and geomorphic estimates of the lateral migration potential, as defined by the limits of the Lateral Migration Erosion Hazard Zone. (Reference Attachment 5 of the WCMP Report for a full discussion on the development



TYPICAL LEVEE SECTION

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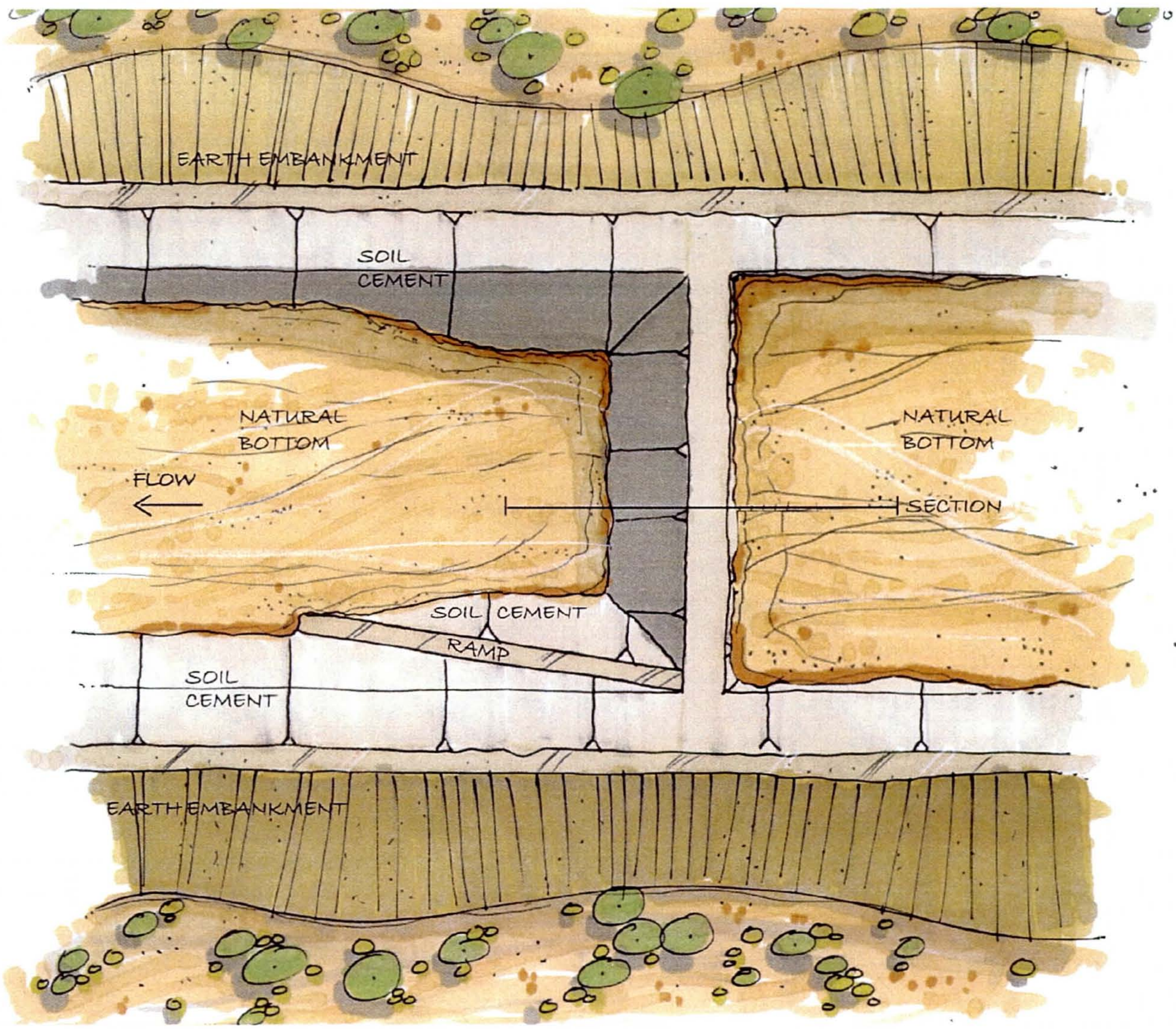
FIGURE 8-2.2

FULL-STRUCTURAL ALTERNATIVE: TYPICAL LEVEE SECTION



PLAN VIEW

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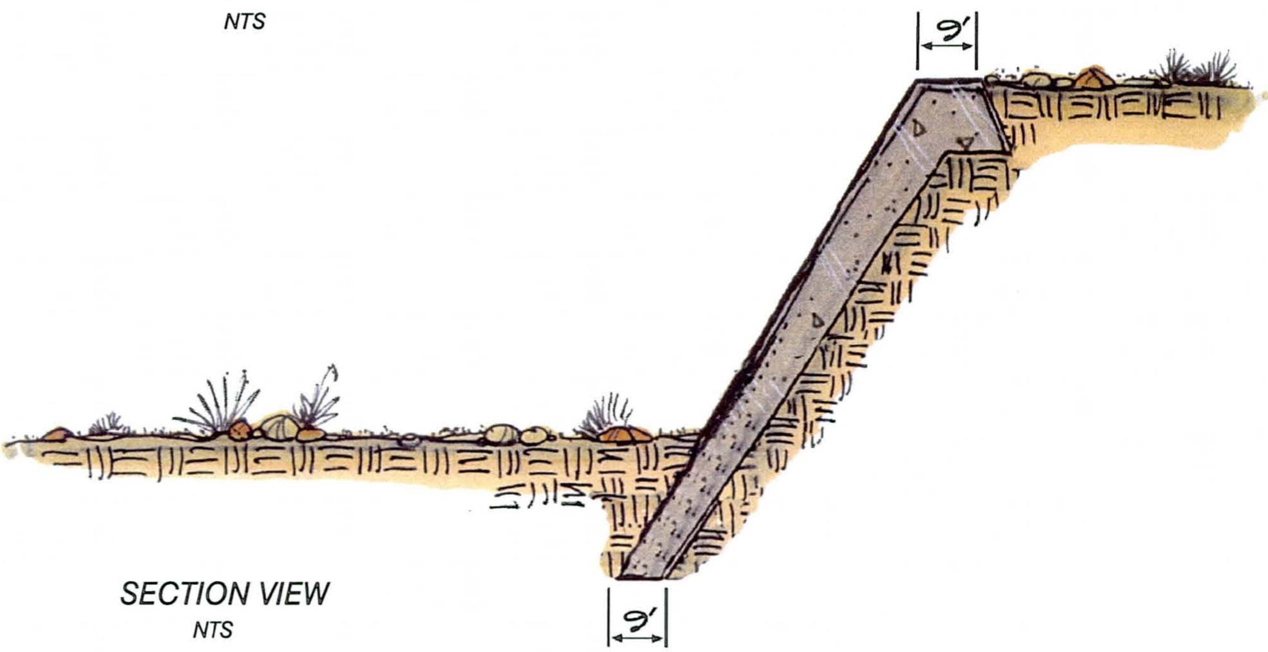

SECTION VIEW

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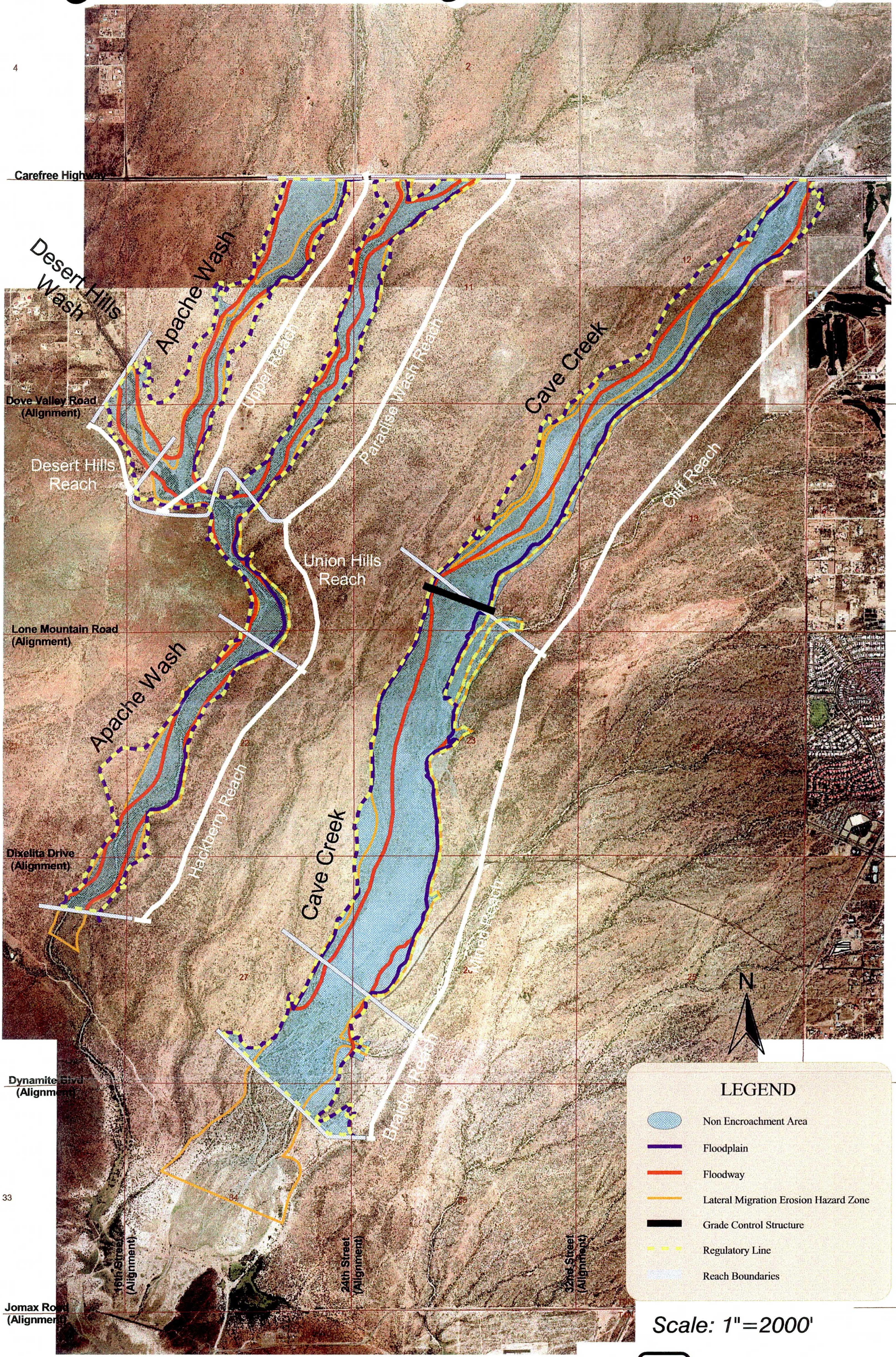
FIGURE 8-2.3

FULL-STRUCTURAL ALTERNATIVE: GRADE CONTROL STRUCTURE



SOFT-STRUCTURAL ALTERNATIVE: NON-ENCROACHMENT AREA

FIGURE 8-2.4

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of the Lateral Migration Erosion Hazard Zone.) The proposed setback distance is defined by the non-encroachment limits shown in Figure 8-2.4 for this alternative.

When the Lateral Migration Erosion Hazard Zone boundary is within the shallower, lower velocity areas of the floodway fringe, a levee embankment, with three feet of bank protection armor below grade (toe-down), is assumed. If the Lateral-Migration *Erosion* Hazard Zone boundary is close to the Floodway boundary, the same full-depth bank protection is proposed as for the Full-Structural Alternative. The three-foot toe-down is referred to as Minimum-Depth Bank Protection, while the full-depth toe-down is referred to as Maximum-Depth Bank Protection. Refer to Figure 8-2.5 for a typical section of the proposed Minimum and Maximum-Depth Bank Protection. The magnitude of the full-depth toe-down is defined by the total design *scour* described later in this report. This alternative also includes a grade control structure, described in the Nonstructural Alternative section that follows.

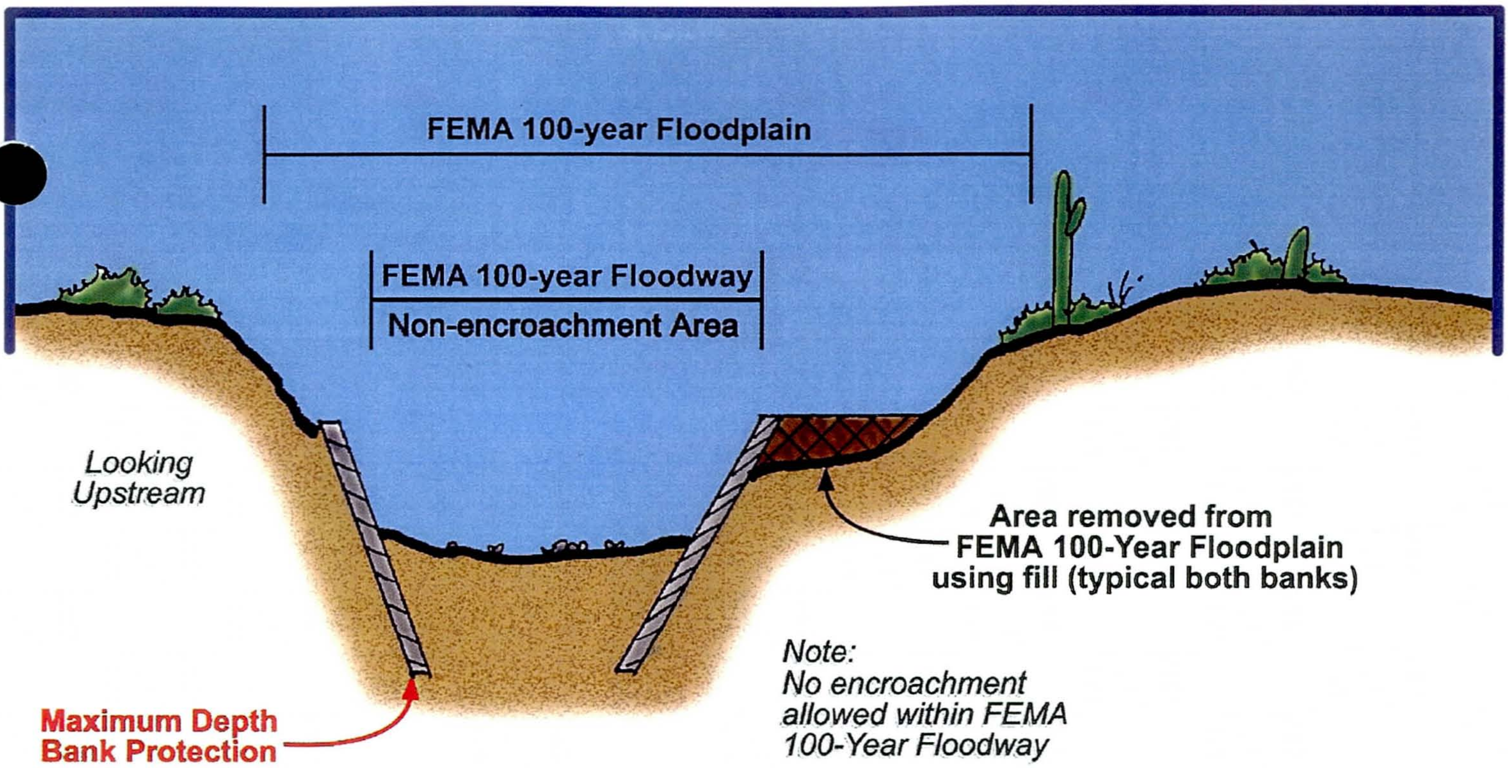
8-2.2.2.1 Advantages/Disadvantages

The advantages and disadvantages of this alternative lie in the fact that it is a compromise solution that neither maximizes the amount of developable land, nor the amount of undisturbed, natural area along the *watercourses*. The alternative defines the minimum area the watercourses need to function naturally over a 60-year period and does not produce significant cumulative impacts within a reach or upstream or downstream of the study limits.

8-2.2.3 *Nonstructural*

As the name implies, the Nonstructural Alternative contains virtually no structural features in the floodplain. However, there is one exception. The grade-control structure described in the Full-Structural Alternative is also needed at the same location for this alternative to protect the integrity and, hence, the natural characteristics of the Upper Cave Creek *watercourse* upstream of the mining area. For this alternative, however, the design of the grade-control structure will be more environmentally sensitive. As with the Full-Structural Alternative, the structure will not be visible for most of its length immediately after construction. However, as the structure is impacted by flow events more area may become exposed at various locations along its length. Under this alternative, the structure will be constructed of pneumatically-place concrete with very mild side slopes. The surface will appear to be a natural cobble-lined feature, similar to the steeper heavily cobbled *reach*es of the natural watercourse. The alignment of the structure will not be linear, and the exposed face will vary in slope and contain pockets that will trap soil so native plants can take root. The concrete will be colored to match the native soil coloration, and boulders and cobbles will be hand-placed along the alignment. Refer to Figure 8-2.6 for a typical section of the proposed grade-control structure for the Nonstructural and Soft-Structural Alternatives.

Other than the grade-control structure described above, this alternative effectively leaves the study *watercourse*s in their natural (albeit existing) state and controls the allowable



TYPICAL MAXIMUM-DEPTH BANK PROTECTION

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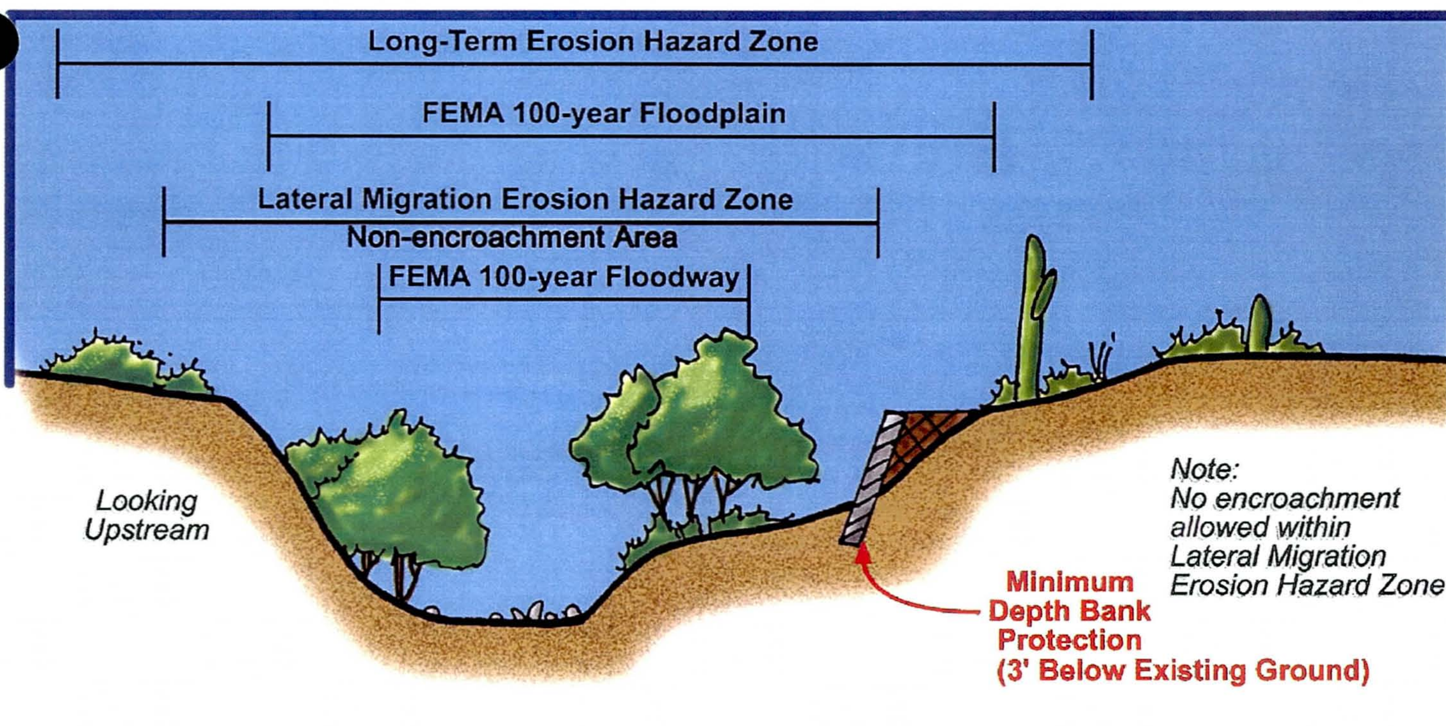

TYPICAL MINIMUM-DEPTH BANK PROTECTION

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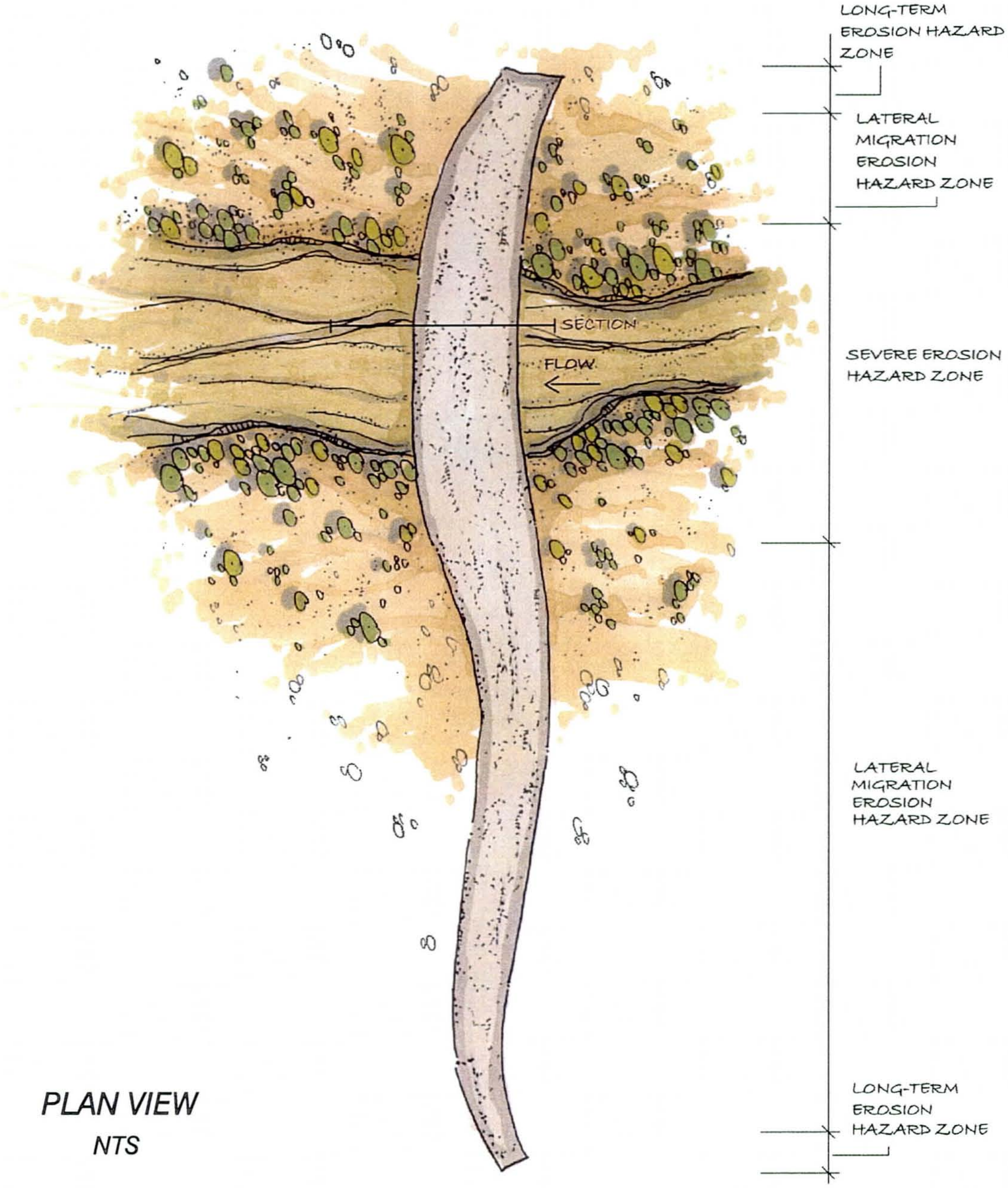
FIGURE 8-2.5

MAXIMUM VS. MINIMUM-DEPTH BANK PROTECTION



PLAN VIEW
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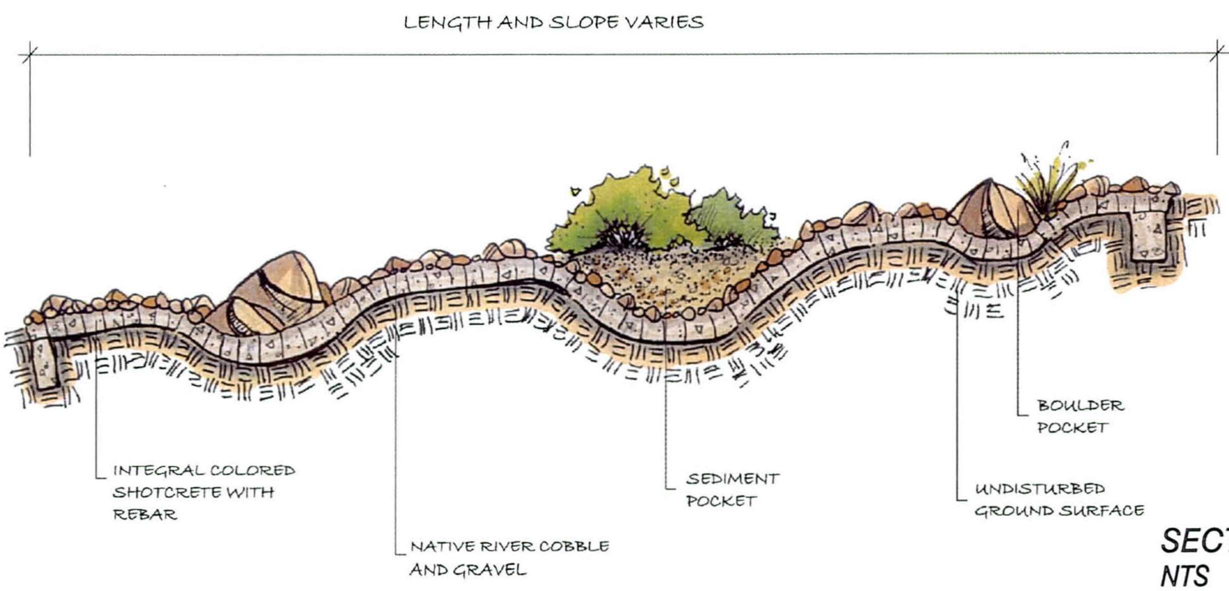


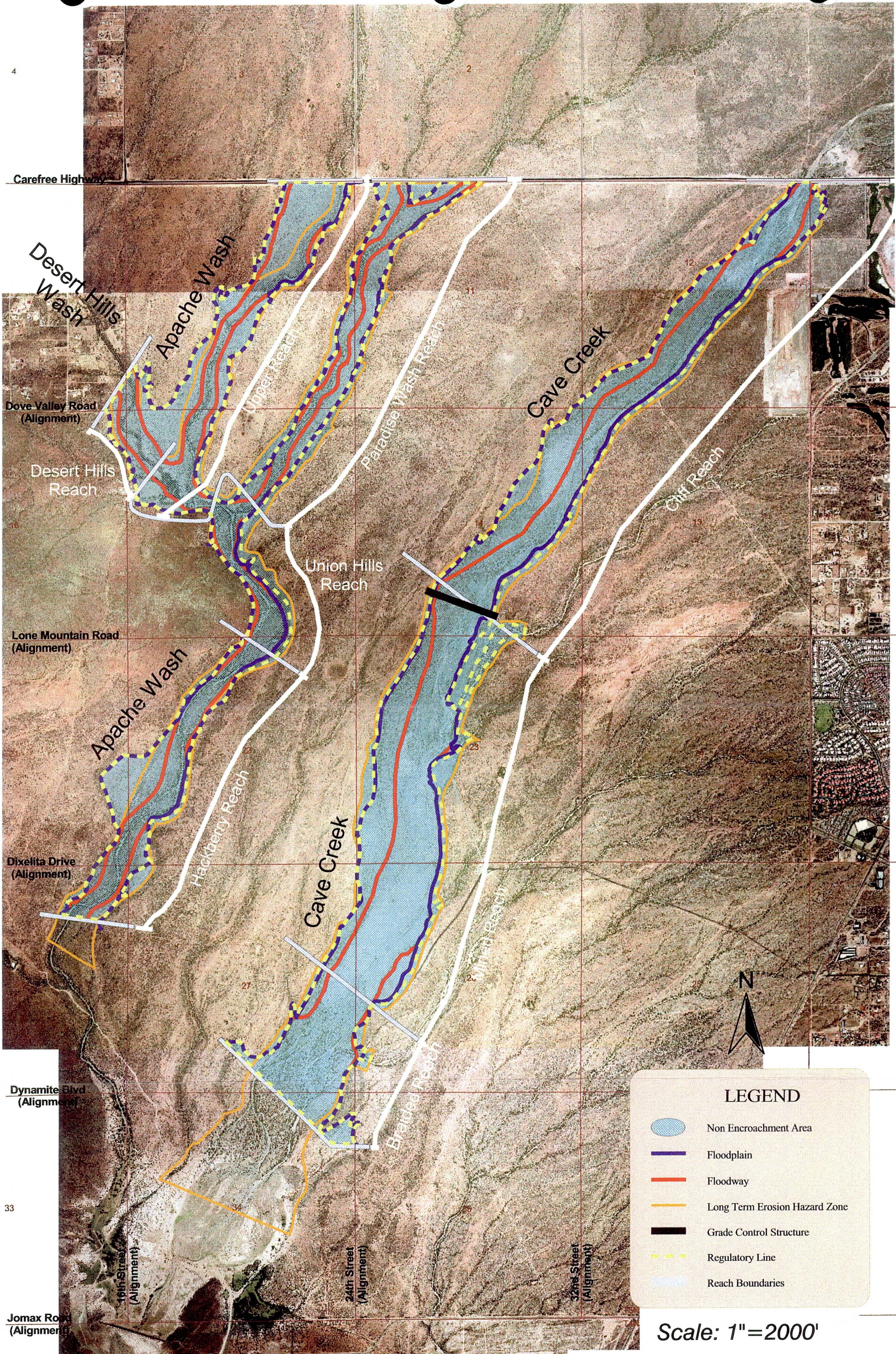
SECTION VIEW
NTS

FIGURE 8-2.6
SOFT/NONSTRUCTURAL ALTERNATIVES: GRADE-CONTROL STRUCTURE

encroachment for development through the implementation of a regulatory setback distance. The setback distance is generally based on engineering and geomorphic estimates of the long-term lateral migration potential, as defined by the limits of the Long-Term *Erosion* Hazard Zone. (Reference Attachment 5 of the WCMP Report for a full discussion on the development of the Long-Term *Erosion* Hazard Zone.) The proposed setback distance is defined by the non-encroachment limits shown in Figure 8-2.7 for this alternative.

8-2.2.3.1 Advantages/Disadvantages

The primary advantage of the Nonstructural Alternative is that the maintenance costs are minimum, and it effectively leaves the *watercourse* corridors in their natural state. The primary disadvantage is that it minimizes the amount of land available for development.



NONSTRUCTURAL ALTERNATIVE: NON-ENCROACHMENT AREA

FIGURE 8-2.7

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8-3. 0 NON-ENCROACHMENT AREAS

The proposed *non-encroachment areas,* which are illustrated in Figures 8-2.1, 8-2.4, and 8-2.7 for the Full-Structural, Soft-Structural, and Nonstructural Alternatives, respectively, have been discussed previously in general terms. This section of the report will discuss the exceptions to the general encroachment limits that define the n*on-encroachment area* of each alternative. Each alternative will be addressed separately. The exceptions will be identified by watercourse and *reach*, and will be described in detail, beginning at the downstream study limit.

8-3.1 Full-Structural Alternative

As previously discussed, the encroachment limit for the Full-Structural Alternative generally follows the FEMA floodway boundary. The exceptions to this limit are described below and shown on Figure 8-2.1.

Table 8-3.1 contains a summary of the land acreage, by *reach*, associated with the *non-encroachment area* for this alternative, as well as the area of floodplain and floodway, the land area reclaimed from the floodplain or the Lateral Migration Erosion Hazard Zone (i.e., the regulatory area) under this alternative, and the area of the Severe *Erosion* Hazard Zone.

8-3.1.1 Upper Cave Creek

There are no exceptions in the Braided Reach.

8-3.1.1.1 Mined Reach

A minor tributary enters Upper Cave Creek from the east at the upper end of the Mined Reach for which no floodplain or floodway has been defined. A very narrow peninsula of land exists between this tributary and Upper Cave Creek in this area. Given the narrowness of the peninsula, the flow from the tributary could potentially impact the back side of any bank protection provided along Upper Cave Creek. To avoid this concern and ensure development would not occur on this peninsula, the limit of the *non-encroachment area* was extended to the Long-Term *Erosion* Hazard Zone boundary in this area.

8-3.1.1.2 Cliff Reach

The east bank of the Cliff Reach is nearly vertical, very high (over 20 feet in some areas) and is environmentally sensitive. The cliff provides habitat for a number of animal species. Construction of bank protection along this cliff would result in destruction of the cliff face, and destruction of the sensitive habitat. The topography above the cliff is sufficiently flat to support insurable structures, however, without bank protection, the watercourse has the potential to undermine the cliff and cause it to collapse in block-type failures. To ensure public safety, the limit of the *non-encroachment area* along the

Table 8-3.1 FULL-STRUCTURAL ALTERNATIVE: SUMMARY OF AREAS

Area (acres) / Watercourse	Non-Encroachment Area	FEMA 100-year Floodplain	Reclaimed Land	FEMA 100-year Floodway	Severe Erosion Hazard Zone
UPPER CAVE CREEK					
Braided	129.7	137.8	7.6	125.1	76.3
Mined	279.2	343.2	101.6	239.3	214.2
Cliff	230.0	297.9	114.9	183.0	97.1
Sub-System Total	**638.9**	**778.9**	**224.0**	**547.4**	**387.5**
APACHE WASH					
Hackberry	87.5	150.5	63.4	83.5	43.9
Union Hills	47.4	50.6	3.2	44.0	26.1
Upper Apache	120.9	200.6	79.3	118.7	33.8
Wash Total	**255.8**	**401.7**	**145.9**	**246.3**	**103.8**
PARADISE WASH					
Wash Total	**62.1**	**132.7**	**66.5**	**62.1**	**24.4**
DESERT HILLS WASH					
Wash Total	**32.3**	**57.4**	**23.9**	**26.0**	**5.3**
Sub-System Total	**350.2**	**591.8**	**236.3**	**334.4**	**133.5**
ALTERNATIVE TOTALS	**989.1**	**1370.7**	**460.3**	**881.8**	**521.1**

majority of this *reach* was moved from the FEMA floodway to the Long-Term Erosion Hazard Zone boundary.

8-3.1.2 *Apache Wash*

There are no exceptions in the Hackberry or Upper Apache Reaches.

8-3.1.2.1 *Union Hills Reach*

The west bank of the Union Hills Reach is rock-faced, very steep, and considered non-*erodible.* Because of the steep terrain, it is very unlikely that development would occur in this area and, as a result, there is no need to encroach to the floodway limit. To be conservative, the limit of the *non-encroachment area* for the *Full-Structural Alternative* on the west side of this *reach* was moved from the *FEMA 100-year floodway* to the *FEMA 100-year floodplain.*

8-3.1.3 *Paradise Wash*

There are no exceptions for Paradise Wash.

8-3.1.4 *Desert Hills Wash*

There are no exceptions for Desert Hills Wash.

8-3.2 Soft-Structural Alternative

As previously discussed, the encroachment limit for the Soft-Structural Alternative generally follows the Lateral-Migration *Erosion* Hazard Zone boundary. However, there are two general exceptions to this criterion. First, there are numerous areas where the Lateral Migration Erosion Hazard Zone boundary is located at or very near the *FEMA 100-year floodplain* boundary. In these instances, bank protection is not considered economically feasible, but the potential for flood damage remains. To prevent flood damage in these areas, the non-encroachment limit was set at the Lateral Migration Erosion Hazard Zone boundary or the *FEMA 100-year floodplain* boundary, whichever is farther from the main channel.

The second general exception concerns the occasions when the Lateral Migration Erosion Hazard Zone boundary is inside the FEMA 100-year floodway boundary. When this occurs, the encroachment limit is moved to the floodway boundary, since FEMA regulations do not allow encroachment into the floodway. Exceptions to these modified criteria are described below and shown on Figure 8-2.4.

Table 8-3.3 contains a summary of the land acreage, by *reach*, associated with the *non-encroachment area* for this alternative, as well as the area of floodplain and floodway, the land area reclaimed from the regulatory area under this alternative, and the area of the Lateral-Migration *Erosion* Hazard Zone.

8-3.2.1 Upper Cave Creek

There are no exceptions in the Braided Reach.

8-3.2.1. 1 Mined Reach

Because the future geometry of the Mined Reach is unknown due to the ongoing mining activities, the non-encroachment limit in this *reach* was placed at the Lateral Migration Erosion Hazard Zone boundary or the *FEMA 100-year floodplain* boundary, whichever is farther from the main channel. This was done on both the east and west sides. There is an exception to this criteria in the area adjacent to the minor tributary entering at the top of the *reach* from the east. As described for the Full-Structural Alternative, there is a lack of floodplain/floodway information for this tributary and potential *erosion* hazards exist on both sides of the narrow peninsula of land between the creek and this tributary. Therefore, to ensure public safety, the non-encroachment limit was moved to the Long-Term *Erosion* Hazard Zone boundary from the confluence of this tributary to the upstream *reach* limit.

8-3.2.1. 2 Cliff Reach

As discussed for the Full-Structural Alternative, the east bank of the Cliff Reach is nearly vertical, very high (over 20 feet in some areas) and is environmentally sensitive. The cliff provides habitat for a number of animal species. The Lateral Migration Erosion Hazard Zone boundary is relatively close to the face of the cliff. The topography above the cliff is sufficiently flat to support insurable structures, however, the watercourse has the potential to undermine the cliff and cause it to collapse in block-type failures. Therefore, to ensure public safety, the non-encroachment limit of the Soft-Structural Alternative, along the majority of this *reach*, was moved from the Lateral-Migration *Erosion* Hazard Zone boundary to the Long-Term *Erosion* Hazard Zone boundary.

To avoid encroaching into a culturally sensitive area along the west bank at the upper end of the *reach*, the non-encroachment limit was set coincident with the Long-Term *Erosion* Hazard Zone boundary.

8-3.2.2 Apache Wash

There are no exceptions in the Hackberry or Upper Apache Reaches.

8-3.2.2.1 Union Hills Reach

The west bank of the Union Hills Reach is rock-faced, very steep, and considered non-erodible. Because of the steep terrain, it is very unlikely that development would occur in this area and, as a result, there is no need to encroach to the Lateral Migration Erosion Hazard Zone boundary which is effectively coincident with the *FEMA 100-year floodway* limit. To be conservative, the limit of the *non-encroachment area* for the Soft-Structural

Alternative on the west side of this *reach* was moved from the Lateral-Migration *Erosion* Hazard Zone boundary/*FEMA 100-year floodway* to the Long-Term *Erosion* Hazard Zone boundary.

8-3.2.3 *Paradise Wash*

There are no exceptions for Paradise Wash.

8-3.2.4 *Desert Hills Wash*

There are no exceptions for Desert Hills Wash.

Table 8-3.2 SOFT-STRUCTURAL ALTERNATIVE: SUMMARY OF AREAS

Watercourse \ Area (acres)	Non-Encroachment Area	FEMA 100-year Floodplain	Reclaimed Land	FEMA 100-year Floodway	Lateral-Migration Erosion Hazard Zone
UPPER CAVE CREEK					
Braided	137.1	137.8	1.0	125.1	28.8
Mined	397.7	343.2	0.0	239.3	149.4
Cliff	307.8	297.9	44.7	183.0	87.9
Sub-System Total	**842.6**	**778.9**	**45.7**	**547.4**	**266.0**
APACHE WASH					
Hackberry	124.8	150.5	34.1	83.5	73.8
Union Hills	60.7	50.6	0.1	44.0	29.9
Upper Apache	152.5	200.6	52.0	118.7	62.9
Wash Total	**338.0**	**401.7**	**86.2**	**246.3**	**166.6**
PARADISE WASH					
Wash Total	**127.2**	**132.7**	**11.8**	**62.1**	**96.2**
DESERT HILLS WASH					
Wash Total	**32.4**	**57.4**	**23.8**	**26.0**	**15.6**
Sub-System Total	**497.6**	**591.8**	**121.8**	**334.4**	**278.3**
ALTERNATIVE TOTALS	**1340.2**	**1370.7**	**167.5**	**881.8**	**544.4**

8-3.3 Nonstructural Alternative

As previously discussed, the encroachment limit for the Nonstructural Alternative generally follows the Long-Term *Erosion* Hazard Zone boundary. The exceptions are described below and shown on Figure 8-2.7.

At several locations, the *FEMA 100-year floodplain* extends beyond the Long-Term *Erosion* Hazard Zone boundary. Therefore, to ensure the study *watercourses* are sustained in their natural state, with no structural features constructed in the future, the non-encroachment boundary for this alternative is located along the Long-Term *Erosion* Hazard Zone or the *FEMA 100-year floodplain* whichever is farther from the main channel. This criteria is applied consistently through all *reach*es on all watercourses in the study. The resulting non-encroachment boundary represents the lateral limits of the study area for each watercourse. This is significant since this boundary is used as the reference for determining the acreage of wildlife habitat and archeological resources impacted by the Full- and Soft-Structural Alternatives. These impacts will be described later in this report.

Table 8-3.3 contains a summary of the land area, by *reach*, associated with the *non-encroachment area* for this alternative, as well as, the area of floodplain and floodway, the land area reclaimed from the regulatory area under this alternative, and the area of the Long-Term *Erosion* Hazard Zone.

Table 8-3.3 NONSTRUCTURAL ALTERNATIVE: SUMMARY OF CHARACTERISTIC AREAS

Area (acres) / Watercourse	Non-Encroachment Area	FEMA 100-year Floodplain	Reclaimed Land	FEMA 100-year Floodway	Long-Term Erosion Hazard Zone
UPPER CAVE CREEK					
Braided	147.0	137.8	0	125.1	28.9
Mined	438.1	343.2	0	239.3	74.6
Cliff	364.8	297.9	0	183.0	167.9
Sub-System Total	**949.9**	**778.9**	**0**	**547.4**	**271.4**
APACHE WASH					
Hackberry	178.4	150.5	0	83.5	36.1
Union Hills	78.6	50.6	0	44.0	22.6
Upper Apache	213.4	200.6	0	118.7	47.0
Wash Total	**470.4**	**401.7**	**0**	**246.3**	**105.7**
PARADISE WASH					
Wash Total	**189.2**	**132.7**	**0**	**62.1**	**66.3**
DESERT HILLS WASH					
Wash Total	**58.1**	**57.4**	**0**	**26.0**	**16.9**
Sub-System Total	**717.7**	**591.8**	**0**	**334.4**	**188.9**
ALTERNATIVE TOTALS	**1667.6**	**1370.7**	**0**	**881.8**	**460.3**

8-4.0 CONCEPTUAL DESIGN ANALYSES

8-4.1 General

Conceptual design analyses are required to determine the costs and benefits of the selected alternatives. To determine costs for structural components, basic design parameters must be defined, through various types of analyses, so conceptual designs can be developed. The necessary design parameters include the height of the levees, the depth and thickness of the bank protection armor, and the depth of grade control features. The benefits include the amount of land protected from flood and *erosion* hazards, as well as the amount of habitat and cultural resources preserved. Once the costs and benefits are determined, judgements on the effectiveness of the individual alternatives can be made.

8-4.2 Base Data

To conduct the various design analyses described below, extensive use was made of existing hydrologic, hydraulic, and sediment transport analyses completed for this study. These analyses, along with the associated base data and support information, such as mapping and sediment gradation data, are documented in the following reports:

- Hydrology Report (Attachment 3)
- Hydraulics and Sediment Report (Attachment 4)
- Lateral Stability Assessment Report (Attachment 5)

8-4.3 Scour Analyses

As the erosive action of flowing water removes and transports sediment during a storm event, alluvial channels migrate horizontally, as well as vertically. To contain the potential lateral movement or migration, armor protection is placed on the levee embankment. To ensure this armor does not fail during the storm event, it must be designed and built sufficiently strong to prevent it from being swept away by the flood waters, and sufficiently deep to prevent erosion or scour from undermining it. This section describes the various *scour* analyses conducted to define the necessary design depth for the proposed bank protection. The *scour* analyses were conducted using worst-case, main-channel hydraulics. The worst-case *hydraulics* were generated by applying the greater of the existing and future conditions, 100-year discharges to the *channel* geometry with encroachments, as described in Section 8-3.

The depth to which bank protection must be built to prevent the proposed levees from being undermined by *scour* is dependent upon the *scour* that may occur in the *channel* over the life of the structure. The total potential *scour* needed for design is the summation of the estimated single-event *scour* components and long-term *degradation*. The single-event *scour* components are those that could occur during the passage of the 100-year design flood event. The components that make up the maximum single-event *scour* depth in this study are: general *scour*, bed-form *scour*, bend *scour*, and local drop *scour* downstream of the proposed grade control structure.

The long-term *degradation* is the potential *channel* lowering that could occur as a result of a series of storms over the life of the proposed improvements. The estimate of long-term *degradation* is based on the dominant discharge that is primarily responsible for the geometric shape of alluvial *channels*. In the Southwestern United States, the 10-year flood event has generally been identified as the dominant discharge. Because of the dynamic nature of alluvial *channels*, all *scour* depths are referenced to the low point in the *channel* cross-section (thalweg).

8-4.3.1 *Single-Event Scour*

Hydraulic parameters taken from the encroached, 100-year HEC-RAS model for the Full-Structural and Soft-Structural Alternatives were used to compute the magnitude of the single-event *scour* components. Since all *scour* depths were referenced to the existing thalweg, no low-flow *scour* component was necessary. Other than the proposed grade control structure on Upper Cave Creek, there are no structures crossing the *watercourses* below the Carefree Highway and above Cave Creek Dam. Three possible corridors have been identified for a future east-west arterial roadway through the study area. The potential impact of local bridge pier scour on the depth of the proposed bank protection was not considered in the scour analyses.

General *scour* is the general lowering of the *channel* bed due to the hydraulic shear force that acts on and transports sediment particles during a flood event. The magnitude of the shear force at any particular location varies with the flow magnitude and the hydraulic parameters, which, in turn, vary with *channel* geometry. The maximum general *scour* depths in this study were estimated using the U.S. Army Corps of Engineers' HEC-6 sediment transport model (re: Attachment 4).

The bed-form *scour* component reflects the potential development of dunes or anti-dunes on the *channel* bed during the design flood. The trough of these bed forms extends below the plane of the *channel* bed and, therefore, must be included in the total *scour* estimate. Since the flow velocities are near critical at numerous locations during the 100-year event, Kennedy's method (1963) for estimating the bed-form *scour*, due to the formation of anti-dunes, was used in this study. The depth of the trough is half the amplitude of the anti-dune, which is proportional to the velocity of flow in the *channel.*

Bend *scour* is due to secondary flow currents produced by the super-elevation of the water surface that occurs along the outside of a *channel* bend. This *scour* component can be very significant depending on the *channel hydraulics*, the radius of the bend, and the width of the *channel.* The method developed by Zeller (1981) was used to estimate the bend *scour* in this study.

Because of the dynamic and non-uniform nature of flow distribution in alluvial *channels*, it is possible that the maximum *hydraulics* derived from the HEC-RAS models for the existing *channel* conditions may not represent the worst case during a particular flood event. Therefore, a 30 percent safety factor is added to the summation of the above single-event *scour* estimates. Example hand computations that demonstrate the methods described above are contained in Appendix A.

8-4.3.2 *Long-Term Degradation*

The depth of long-term *degradation* used in this study is the lesser estimate resulting from an equilibrium slope analysis and an armoring analysis. The equilibrium slope is defined as the slope at which the sediment transport capacity is equal to the incoming sediment supply. When this relationship is satisfied the *channel* neither degrades nor aggrades. The armoring analysis determines whether there is sufficient coarse material in the *channel* to form an armor layer that will resist movement and inhibit further *degradation* of the *channel*. These analyses were conducted using the encroached, 10-year *channel hydraulics* (i.e., dominant discharge).

The equilibrium slope and armoring analyses were conducted using the methods described in the U.S. Bureau of Reclamation publication, "Computing *Degradation* and Local *Scour*," (1984). The Schoklitsch, Meyer-Peter Muller, and Shields methods were averaged to compute the equilibrium slopes for each watercourse, while the Meyer-Peter Muller, Shields, Yang, and Competent Bottom Velocity methods were averaged to determine the armoring depths for each watercourse. Example hand computations that demonstrate the methods described above are contained in Appendix A.

The results of these analyses indicate that sufficient coarse material is present within the watercourses of the study area to form an armor layer after relatively minor amounts of *degradation*. In general, this precludes the need to construct grade control structures along the *channel*s to control long-term *degradation*. However, due to the varying width of the natural *channel*s and the unknown depth to rock along the *channel*s, a detailed economic analysis should be conducted during final design of any structural alternative that may be implemented to determine the least cost combination of bank protection and grade control features.

For this study, the total *scour* estimate used to specify the design depth of bank protection is a combination of the single-event *scour* estimates, described above, and the long-term *degradation* due to *channel* armoring. The total *scour* defines the design depth (toe-down) of the proposed bank protection. Since it is possible that the *main channel* may be located at, or in time migrate to a point immediately adjacent to a proposed levee, the design depth for the bank protection is referenced to the low point in the *main channel* (thalweg).

8-4.3.3 *Summary of Results*

<u>Full-Structural Alternative</u>

Table 8-4.1 summarizes the total *scour* estimates by *reach* for the Full-Structural Alternative. The minimum scour depths estimated for the study area range from 3.0-7.0 feet. The maximum scour depths range from 7.5 to 26.4 feet. Maximum values over 14 feet are anomalies typically isolated to a single cross-section located in bends or old mining pits within the *reach*. Detailed summary tables containing the analysis results for each *scour* component, cross-section-by-cross-section, are provided in Appendix A.

Table 8-4.1 FULL-STRUCTURAL ALTERNATIVE: SUMMARY OF TOTAL SCOUR DEPTHS

	Minimum Scour Depth (ft)	Maximum Scour Depth (ft)	Weighted Average Scour Depth (ft)
UPPER CAVE CREEK			
Braided	3.3	8.9	6.1
Mined	3.0	16.0	6.6
Cliff	4.1	17.8	9.4
APACHE WASH			
Hackberry	6.6	17.7	10.6
Union Hills	7.0	26.4	12.4
Upper Apache	3.0	21.5	9.2
PARADISE WASH	3.0	7.5	5.5
DESERT HILLS WASH	3.0	7.9	6.1

Soft-Structural Alternative

Table 8-4.2 summarizes the total *scour* estimates by *reach* for the Soft-Structural Alternative. The minimum scour depths estimated for the study area range from 3.0-6.7 feet. The maximum scour depths range from 8.1 to 24.7 feet. Maximum values over 14 feet are anomalies typically isolated to a single cross-section located in bends or old mining pits within the *reach*. Detailed summary tables containing the analysis results for each *scour* component, cross-section-by-cross-section, are provided in Appendix A.

Table 8-4.2 SOFT-STRUCTURAL ALTERNATIVE: SUMMARY OF TOTAL SCOUR DEPTHS

	Minimum Scour Depth (ft)	Maximum Scour Depth (ft)	Weighted Average Scour Depth (ft)
UPPER CAVE CREEK			
Braided	3.3	9.0	5.7
Mined	3.0	15.8	6.3
Cliff	3.5	23.9	9.5
APACHE WASH			
Hackberry	5.6	19.2	10.3
Union Hills	6.7	24.7	11.9
Upper Apache	3.1	21.6	9.4
PARADISE WASH	3.0	8.1	5.1
DESERT HILLS WASH	3.0	10.4	7.3

8-4.4 Bank Protection Analysis

The height of the proposed levees will be three feet above the 100-year water surface elevation as computed by the fully-encroached HEC-RAS models (re: Attachment 4), plus additional height for superelevation, when a levee is located on the outside of a significant bend. The three feet represents a freeboard or safety factor that will be provided on all levees. The super-elevation was determined in conjunction with computing the bend *scour* component of the total *scour* depth discussed previously. The method outlined in Volume 2 of the Maricopa County Drainage Design Manual was used to determine superelevation around *channel* bends. Example computations are contained in Appendix A.

8-4.4.1 *Armor Options*

Three types of armor were evaluated for the proposed bank protection – Cement Stabilized Alluvium (CSA), *gabion mattress*es, and loose *riprap*. CSA is a coarse soil cement composed of local sands and gravels mixed with cement and compacted in-place, similar to roller-compacted concrete. *Gabion mattress*es are essentially wire baskets filled with rock that allow smaller rock to provide suitable *erosion* protection. They are typically manufactured in 6, 9, 12, and 18-inch thicknesses. The economy of one type of armor over the other is generally dependent on scale. For short lengths of bank protection, the installation cost tends to favor *riprap*. For long lengths, the cost favors CSA, assuming suitable material is available to manufacture it on site. *Gabion mattress*es fall in between.

Maintenance costs are typically the greatest for *riprap*, followed by *gabion mattress*, and CSA. CSA is effectively maintenance free if designed and constructed correctly.

The D_{50} size for the rock *riprap* bank protection was computed using a method developed by the US Bureau of Reclamation. The maximum D_{50} size within a specific *reach* was used to compute quantities for the entire *reach*. The minimum thickness of the *riprap* layer for the *reach* is 1.5 times the maximum D_{50} size, as suggested by Volume 2 of the Maricopa County Drainage Design Manual, rounded up to the next half-foot increment. The thickness of the *gabion mattress* was computed using a standard method developed by the US Army Corps of Engineers. The thickness of the mattress used for a given *reach* is 2/3 of the D_{50} rock size used for the *riprap*, rounded to the next highest manufactured size combination. The typical thicknesses manufactured are 6-inch, 9-inch, 12-inch, and 18-inch. The horizontal thickness of the CSA bank protection is a standard 9 feet, as requested by the Flood Control District. Example hand computations that demonstrate the methods described above are contained in Appendix A.

8-4.4.2 *Summary of Results*

Full-Structural Alternative

Tables 8-4.3 and 8-4.4 summarize the results of the armor analyses for the *riprap* and *gabion mattress* options, by *reach*, for the Full-Structural Alternative. The minimum thickness of riprap protection ranges from 3.5 to 6.5 feet for the study area, while the minimum thickness of gabion mattress ranges from 21 to 36 inches. Detailed summary tables containing the analysis results, cross-section-by-cross-section, are provided in Appendix A.

Table 8-4.3 FULL-STRUCTURAL ALTERNATIVE: RIPRAP THICKNESS REQUIREMENTS

	Minimum D50 (ft)	Maximum D50 (ft)	1.5 * Maximum D50 (ft)	Minimum Riprap Thickness (ft)
UPPER CAVE CREEK				
Braided	1.0	3.2	4.8	5.0
Mined	0.7	3.4	5.1	5.5
Cliff	0.9	3.8	5.7	6.0
APACHE WASH				
Hackberry	1.8	4.1	6.2	6.5
Union Hills	1.8	4.2	6.3	6.5
Upper Apache	0.2	3.3	5.0	5.0
PARADISE WASH	0.3	2.6	3.9	4.0
DESERT HILLS WASH	1.1	2.3	3.5	3.5

Table 8-4.4 FULL-STRUCTURAL ALTERNATIVE: GABION MATTRESS THICKNESS REQUIREMENTS

	Maximum D50 (ft)	2/3 * Maximum D50 (ft)	2/3 * Maximum D50 (in)	Gabion Mattress Thickness (in)
UPPER CAVE CREEK				
Braided	3.2	2.1	25.6	27
Mined	3.4	2.3	27.2	30
Cliff	3.8	2.5	30.4	33
APACHE WASH				
Hackberry	4.1	2.7	32.8	33
Union Hills	4.2	2.8	33.6	36
Upper Apache	3.3	2.2	26.4	27
PARADISE WASH	2.6	1.7	20.8	21
DESERT HILLS WASH	2.3	1.5	18.4	21

Soft-Structural Alternative

Tables 8-4.5 and 8-4.6 summarize the results of the armor analyses for the *riprap* and *gabion mattress* options, by *reach*, for the Soft-Structural Alternative. The minimum thickness of riprap protection ranges from 3.0 to 6.5 feet for the study area, while the minimum thickness of gabion mattress ranges from 18 to 36 inches. Detailed summary tables containing the analysis results cross-section-by-cross-section are provided in Appendix A.

Table 8-4.5 SOFT-STRUCTURAL ALTERNATIVE: RIPRAP THICKNESS REQUIREMENTS

	Minimum D50 (ft)	Maximum D50 (ft)	1.5 * Maximum D50 (ft)	Minimum Riprap Thickness (ft)
UPPER CAVE CREEK				
Braided	1.0	3.2	4.8	5.0
Mined	0.8	3.5	5.3	5.5
Cliff	0.3	3.8	5.7	6.0
APACHE WASH				
Hackberry	1.2	3.5	5.3	5.5
Union Hills	1.9	4.2	6.3	6.5
Upper Apache	0.2	3.5	5.3	5.5
PARADISE WASH	0.3	3.0	4.5	4.5
DESERT HILLS WASH	1.1	2.0	3.0	3.0

**Table 8-4.6 SOFT-STRUCTURAL ALTERNATIVE:
GABION MATTRESS THICKNESS REQUIREMENTS**

	D50 (ft)	2/3 * Maximum D50 (ft)	2/3 * Maximum D50 (in)	Gabion Mattress Thickness (in)
UPPER CAVE CREEK				
Braided	3.2	2.1	25.6	27
Mined	3.5	2.3	28	30
Cliff	3.8	2.5	30.4	33
APACHE WASH				
Hackberry	3.5	2.3	28	30
Union Hills	4.2	2.8	33.6	36
Upper Apache	3.5	2.3	28	30
PARADISE WASH	3.0	2.0	24	27
DESERT HILLS WASH	2.0	1.3	16	18

8-4.5 Sand and Gravel Mining Operations

There is one active sand and gravel mining lease within the study area, and it is located in the Mined Reach of Upper Cave Creek. Wheeler Construction is permitted to mine sands and gravels within 500 feet of either side of the *channel* centerline, between the upstream and downstream lease limits, through May, 2005. The lease limits are shown on Figure 8-4.1. Because it is not possible to predict the actual extent of mining that will be present at the time the selected management alternative is implemented, assumptions were made in this regard. Based on previous permit information, it is assumed that the mining area will be continuous, extend to the upstream lease limit, and be at least five feet below the low point of the existing Upper Cave Creek *channel*. The resulting drop in the *channel* bed will effectively produce a headcut. If left uncontrolled, the headcut will propagate upstream, erode the *channel* bottom, and potentially impact the stability of the *channel* banks. To prevent this from occurring, a grade-control structure is proposed for all three alternatives. The proposed grade-control structure and the analysis conducted to determine their depths are described in the following section for each alternative.

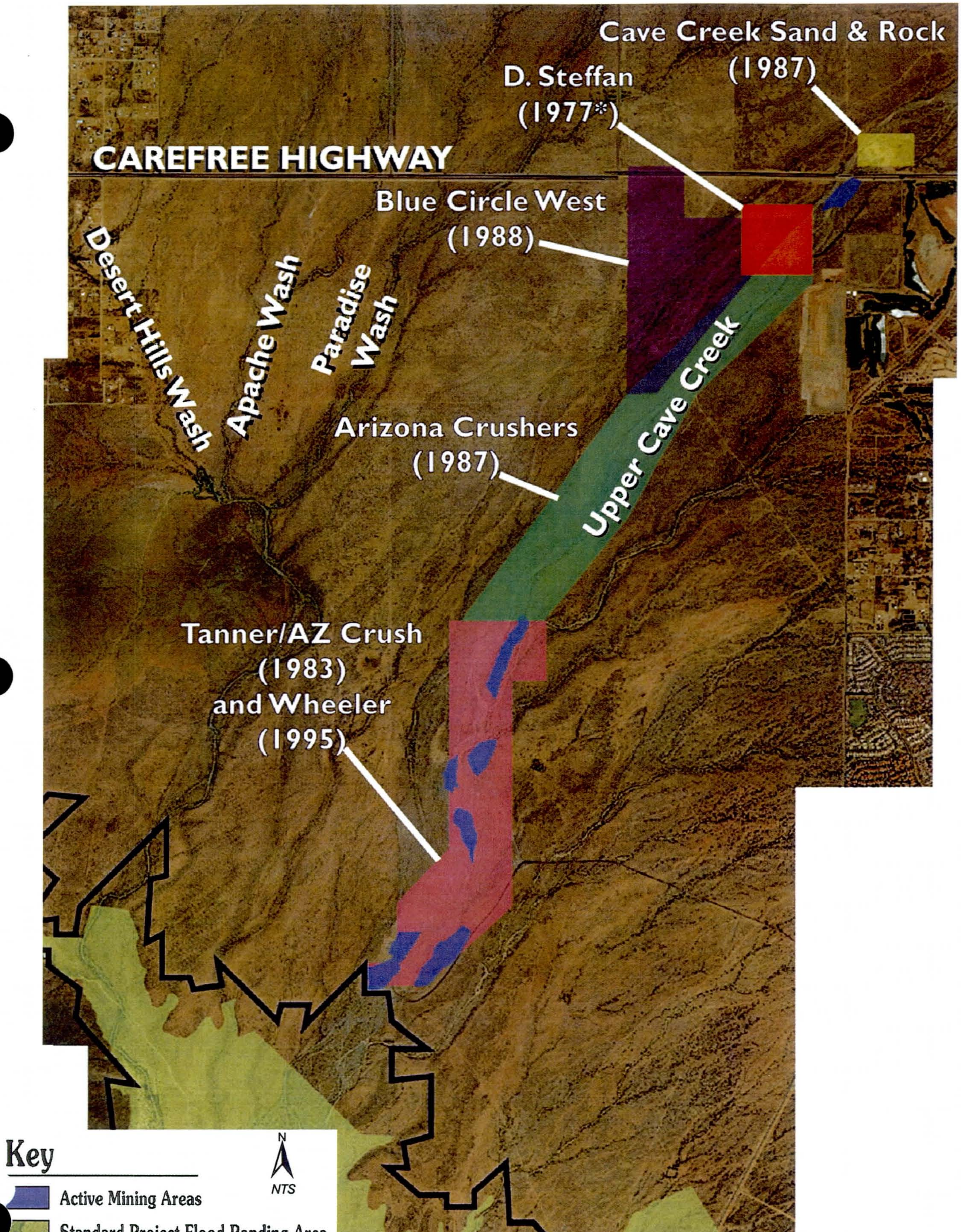


FIGURE 8-4.1
SAND AND GRAVEL MINING LEASE AREAS

8-4.6 Grade-Control Structures

A grade-control structure is proposed at the upstream end of the Mined Reach on Upper Cave Creek for all three alternatives. It will extend across the full width of the floodplain and will be anchored into proposed bank protection or non-erodible material at the ends. This structure is necessary to prevent *head-cut*ting from occurring in an upstream direction outside the mined area. If allowed to progress upstream, the toe-down depths required for bank protection would be increased and habitat would be adversely affected. This would likely be more expensive than the cost of the grade-control structure and cause greater disruption to the environment during construction. The structure will not be visible for most of its length immediately after construction. However, as the structure is impacted by flow events more area may become exposed at various locations along its length.

Although other materials can be used, Cement Stabilized Alluvium (CSA) is proposed for constructing the grade-control structure in the Full-Structural Alternative. Refer to Figure 8-2.3 and the concept plans in Appendix E for a plan view and typical section of the proposed grade-control structure for the Full-Structural Alternative. For the Nonstructural and Soft-Structural Alternative, the design of the grade-control structure will be much more environmentally sensitive. Under these alternatives, the structure will be constructed of pneumatically-place concrete with very mild side slopes. The surface will appear to be a natural cobble-lined feature, similar to the steeper heavily cobbled *reach*es of the natural watercourse. The alignment of the structure will not be linear, the exposed face will vary in slope and contain pockets that will trap soil so native plants can take root. The concrete will be colored to match the native soil, and boulders and cobbles will be hand-placed along the alignment. The surface texture will be similar to the natural *watercourse* bottom. Refer to Figure 8-2.6 and the concept plans in Appendix E for a plan view and typical section of the grade control structure proposed for the Soft-Structural and Nonstructural Alternatives.

The depth of the downstream side of this grade-control structure, and hence the adjacent bank protection, was determined by estimating the local drop *scour* using the U.S. Bureau of Reclamation method for unsubmerged *channel* drops (1977). This method indicates that approximately 12.9 feet of drop *scour* can be expected on the downstream side of the proposed grade-control structures for the 100-year event. Because of the dynamic and non-uniform nature of flow distribution in alluvial *channel*s, a 30 percent safety factor is added to the unit discharge used to compute the drop *scour*. Hand computations that demonstrate the method described above are provided in Appendix A.

8-5. 0 CONCEPTUAL DESIGN

The conceptual design discussed in this section reflects the levees and bank protection proposed to physically establish the allowable encroachment limits (defined by the *non-encroachment areas* described in Section 8-3) for each alternative. Additional analyses will be required before a final design can be completed for any of the structural features presented herein. For example, the grade-control structures will require stability analyses to determine their susceptibility to uplift, overturning, and sliding forces. Analyses to determine the potential for failure due to "piping" under the grade-control structures or abrasion of the structure surface will also be required. Also, the conceptual bank protection design does not identify a minimum toe-down depth, nor does it account for the future extent and depth of the sand and gravel mining operations or the effects of local scour associated with any future bridge crossings.

The proposed conceptual design is described in detail for each of the selected alternatives for each *watercourse* in the study. Each alternative is then quantified in terms of construction costs, land costs, benefits, and potential impacts. The net cost of a given alternative is defined by the estimated construction and land acquisition costs necessary to provide the desired flood and *erosion* protection, less the benefits (negative costs). Benefits are defined by the value of land reclaimed from the floodplain and protected from the potential flood and *erosion* hazards. Intangible benefits are also realized through the preservation of the natural environment and culturally sensitive areas and are quantified in terms of land acreage. Tables summarizing this information are provided for each alternative.

The in-place unit costs used to compute the costs and benefits associated with each alternative are described below. A range of unit cost is used for items that have a significant difference in quantity from alternative to alternative. The value of land was assumed to be an average of $50,000 per acre. Embankment costs were estimated to be $5 per cubic yard. Excavation costs were estimated to be $2-3 per cubic yard. Where bank protection is provided, three options for armor were evaluated, i.e., *riprap*, *gabion mattress*es, and CSA. The cost of bank protection armor was estimated to be $30-35 per cubic yard for *riprap* (includes filter fabric), $60-65 per cubic yard for gabions (includes filter fabric), and $15-30 per cubic yard for CSA, depending on total quantity. Cement for CSA was assumed to be $100 per ton. The quantities of levee embankment, excavation, and bank protection armor were estimated using the average-end-area method. The unit cost of the reinforced, colored, pneumatically-placed concrete for soft-structural and nonstructural grade control structure was estimated to be $94 per square yard. This cost includes the labor-intensive work of incorporating large boulders, forming pockets, and placing a finish layer of gravel and cobbles on the surface of the "environmentally friendly" grade-control structure proposed for the Soft-Structural and Nonstructural Alternatives.

8-5.1 Full-Structural Alternative

A *reach*-by-*reach* description of the proposed features associated with the Full-Structural Alternative on the study watercourses follows. All bank protection associated with this alternative is maximum-depth, as defined by the scour analyses described earlier. In areas where levees are not needed, but bank protection is proposed, the bank protection is specified to prevent *erosion* of the natural banks. This usually occurs where the FEMA floodway is coincident with the floodplain. *Channel* access ramps are provided for maintenance purposes at approximately 2000-foot intervals, as requested by the Flood Control District. Ramps are also proposed under the future bridge crossings to provide continuity and safety for possible future trails along the *watercourse*s. The *reach*es will be addressed beginning at the downstream study limit. More detail on the proposed structural features associated with this alternative can be obtained from the concept plans included as Appendix E. The station numbers referenced in the following text are taken from the concept plans.

8-5.1.1 *Upper Cave Creek*

Braided Reach

The FEMA floodway is coincident with the floodplain in the lower portion of this reach. The floodplain boundary reflects the US Army Corps of Engineers' Standard Project Flood pool elevation. This flood was used to design the Cave Buttes Dam.

Bank protection begins immediately upstream of the first minor tributary on both sides of the creek and continues upstream to the *reach* boundary (Sta. 132). A continuous levee is necessary to make the encroachment on the west side of the creek. On the east side, the bank protection alternates between a levee section and the natural bank. As mentioned previously, armor protection along a natural bank is provided to prevent loss of land due to *erosion.*

Mined Reach

Bank protection continues along the levee that is provided along the west side of the creek. The levee is continuous through the *reach* and follows the floodway alignment. On the east side, a short section of levee (Sta. 133 to 147, right) is provided to reclaim the floodway fringe area at the downstream end of the *reach.* The bank protection then armors the natural bank and continues upstream to the third tributary which enters the watercourse from the east (Sta. 193, right). A break is provided in the bank protection to allow flow from the second tributary to enter the creek (Sta. 157, right).

In addition to the levees and bank protection, this alternative provides a grade control structure at the upstream end of the Mined Reach (Sta. 225). This structure is required to prevent headcutting, induced by the mining excavations, from propagating upstream. As mentioned previously, for the sake of estimating costs for this alternative, it is assumed that this structure will be constructed of CSA. Because of differences in unit cost, the estimated cost of this structure ranges from $512,000 for the CSA bank protection option to $775,000 for the *riprap* and *gabion mattress* bank protection options. Refer to the Full-Structural Concept Plans included as Appendix E to this report for more details on the proposed grade-control structure.

Cliff Reach

Bank protection continues along the levee that is provided along the west side of the creek. The levee is continuous through the *reach* and follows the floodway alignment. As mentioned previously, the east bank of the Cliff Reach is environmentally sensitive and no bank protection is provided on this side for most of the reach. However, there is a section of levee and bank protection provided from where the floodway breaks away from the floodplain and the cliff (Sta. 337, right) to the Carefree Highway (upstream study limit).

Table 8-5.1 summarizes the estimated quantities and costs for bank protection, excavation, levee embankment, and grade control construction, by armor type for Upper Cave Creek. A breakdown of the costs for each *reach* can be found in Appendix D.

8-5.1.2 *Apache Wash*

Hackberry Reach

On the east side of the watercourse, bank protection begins along the floodway boundary immediately at the downstream study limit (Sta. 100) and continues upstream to the *reach* boundary (Sta 178). Levee embankment is required where the floodway boundary is not coincident with the floodplain boundary. On the west side, bank protection and a near-continuous levee is necessary for approximately 5,300 feet to make the encroachment.

Union Hills Reach

As described previously, no bank protection is provided along the west side of this *reach* due to the presence of rock associated with the Union Hills. On the east side, the bank protection is continuous and alternates between levee sections, required to make the encroachment, and the natural bank. The protection against the natural bank is provided to prevent loss of land due to *erosion*.

Upper Apache Reach

On the east side of the watercourse, bank protection is provided continuously through the *reach*. The *floodplain encroachment* on this side of the watercourse will require a levee embankment in conjunction with the bank protection. There are three sections where the floodway and floodplain are coincident, and the bank protection will be placed against the existing bank, i.e., Sta. 226 to 233, Sta. 277 to 284, and Sta. 296 to 300.

On the west side of the watercourse, bank protection is also provided continuously through the *reach*. The *floodplain encroachment* on this side of the watercourse will require a continuous levee embankment, in conjunction with the bank protection. One

Table 8-5.1 FULL-STRUCTURAL ALTERNATIVE: CONSTRUCTION COSTS FOR UPPER CAVE CREEK

Item	Unit Price	Left Bank Quantity (yd^3)	Left Bank Cost	Right Bank Quantity (yd^3)	Right Bank Cost	Total Quantity (yd^3)	Total Cost
Riprap Revetment							
Excavation Total (yd^3)	$2	578,056	$1,156,112	263,350	$526,700	841,406	$1,682,812
Borrow Total (yd^3)	$5	226,186	$1,130,930	24,719	$123,595	250,905	$1,254,525
Riprap Total (yd^3)	$30	278,183	$8,345,496	93,844	$2,815,323	372,027	$11,160,819
Grade Control Structure							
CSA Total (yd^3)	$30	17,500	$525,000			17,500	$525,000
CSA Cement Total (tons)	$100	2,500	$250,000			2,500	$250,000
Total Cost			**$11,407,538**		**$3,465,618**		**$14,873,156**
Gabion Mattress Revetment							
Excavation Total (yd^3)	$2	578,056	$1,156,112	263,350	$526,700	841,406	$1,682,812
Borrow Total (yd^3)	$5	226,186	$1,130,930	24,719	$123,595	250,905	$1,254,525
Gabion Total (yd^3)	$60	127,014	$7,620,834	42,686	$2,561,148	169,700	$10,181,982
Grade Control Structure							
CSA Total (yd^3)	$30	$17,500	$525,000	0	$0	17,500	$525,000
CSA Cement Total (tons)	$100	$2,500	$250,000	0	$0	2,500	$250,000
Total Cost			**$10,682,876**		**$3,211,443**		**$13,894,319**
CSA Revetment							
Excavation Total (yd^3)	$2	578,056	$1,156,112	263,350	$526,700	841,406	$1,682,812
Borrow Total (yd^3)	$5	226,186	$1,130,930	24,719	$123,595	250,905	$1,254,525
CSA Total (yd^3)	$15	194,444	$2,916,665	68,199	$1,022,991	262,644	$3,939,656
CSA Cement Total (tons)	$100	27,563	$2,756,260	9,667	$966,720	37,230	$3,722,980
Grade Control Structure							
CSA Total (yd^3)	$15	17,500	$262,500	0	$0	17,500	$262,500
CSA Cement Total (tons)	$100	2,500	$250,000	0	$0	2,500	$250,000
Total Cost			**$8,472,467**		**$2,640,006**		**$11,112,473**

break in the levee is provided at Sta. 265 to allow flow from a minor tributary to enter the watercourse.

Table 8-5.2 summarizes the estimated quantities and costs for bank protection, excavation, and levee embankment, by armor type, for Apache Wash. Recall that some areas along the watercourse do not require a levee, but need bank protection to protect existing banks from *erosion*. A breakdown of the costs for each reach can be found in Appendix D.

8-5.1.3 *Paradise Wash*

To allow encroachment to the FEMA floodway boundary along Paradise Wash, levee embankment is necessary in most areas. On the east side of the watercourse, bank protection is provided continuously through the *reach*. Levee embankment is required in all areas except Sta. 106 to 114 and Sta. 180 to 200.

On the west side of the watercourse, bank protection is provided continuously through the *reach*. Levee embankment is provided, in conjunction with the bank protection, except from Sta. 119 to 129. Bank protection is also provided on the levee and natural bank between the confluence of the east and west branches of Paradise Wash and the Carefree Highway.

Table 8-5.3 summarizes the estimated quantities and costs for bank protection, excavation, and levee embankment, by armor type, for Paradise Wash. Again, recall that some areas along the watercourse do not require a levee, but need bank protection to protect existing banks from *erosion*.

8-5.1.4 *Desert Hills Wash*

To allow encroachment to the FEMA floodway boundary along Desert Hills Wash, levee embankment and bank protection are necessary on both sides of the watercourse for the full length of the *reach*.

Table 8-5.4 summarizes the estimated quantities and costs for bank protection, excavation, and levee embankment, by armor type, for Desert Hills Wash.

Table 8-5.2 FULL-STRUCTURAL ALTERNATIVE: CONSTRUCTION COSTS FOR APACHE WASH

Item	Unit Price	Left Bank Quantity (yd^3)	Left Bank Cost	Right Bank Quantity (yd^3)	Right Bank Cost	Total Quantity (yd^3)	Total Cost
Riprap Revetment							
Excavation Total (yd^3)	$2	305,400	$610,800	485,386	$970,772	790,786	$1,581,572
Borrow Total (yd^3)	$5	42,327	$211,635	77,537	$387,685	119,864	$599,320
Riprap Total (yd^3)	$30	124,154	$3,724,620	225,887	$6,776,610	350,041	$10,501,230
Total Cost			**$4,547,055**		**$8,135,067**		**$12,682,122**
Gabion Mattress Revetment							
Excavation Total (yd^3)	$2	305,400	$610,800	485,386	$970,772	790,786	$1,581,572
Borrow Total (yd^3)	$5	42,327	$211,635	77,537	$387,685	119,864	$599,320
Gabion Total (yd^3)	$60	54,054	$3,243,240	99,201	$5,952,060	153,255	$9,195,300
Total Cost			**$4,065,675**		**$7,310,517**		**$11,376,192**
CSA Revetment							
Excavation Total (yd^3)	$2	305,400	$610,800	485,386	$970,772	790,786	$1,581,572
Borrow Total (yd^3)	$5	42,327	$211,635	77,537	$387,685	119,864	$599,320
CSA Total (yd^3)	$15	87,418	$1,311,270	154,378	$2,315,666	241,796	$3,626,936
CSA Cement Total (tons)	$100	12,392	$1,239,200	21,883	$2,188,300	34,275	$3,427,500
Total Cost			**$3,372,905**		**$5,862,423**		**$9,235,328**

Table 8-5.3 FULL-STRUCTURAL ALTERNATIVE: CONSTRUCTION COSTS FOR PARADISE WASH

Item	Unit Price	Left Bank Quantity (yd^3)	Left Bank Cost	Right Bank Quantity (yd^3)	Right Bank Cost	Total Quantity (yd^3)	Total Cost
Riprap Revetment							
Excavation (yd^3)	$2	102,883	$205,766	75,874	$151,748	178,757	$357,514
Borrow Material (yd^3)	$5	34,163	$170,815	15,289	$76,445	49,452	$247,260
Riprap Revetment (yd^3)	$30	28,764	$862,920	29,231	$876,930	57,995	$1,739,850
Total Cost			**$1,239,501**		**$1,105,123**		**$2,344,624**
Gabion Mattress Revetment							
Excavation (yd^3)	$2	102,883	$205,766	75,874	$151,748	178,757	$357,514
Borrow Material (yd^3)	$5	34,163	$170,815	15,289	$76,445	49,452	$247,260
Gabion Revetment (yd^3)	$60	12,584	$755,040	12,789	$767,340	25,373	$1,522,380
Total Cost			**$1,131,621**		**$995,533**		**$2,127,154**
CSA Revetment							
Excavation (yd^3)	$2	102,883	$205,766	75,874	$151,748	178,757	$357,514
Borrow Material (yd^3)	$5	34,163	$170,815	15,289	$76,445	49,452	$247,260
CSA Revetment (yd^3)	$15	28,943	$434,145	29,413	$441,195	58,356	$875,340
CSA Cement (tons)	$100	4,103	$410,300	4,169	$416,900	8,272	$827,200
Total Cost			**$1,221,026**		**$1,086,288**		**$2,307,314**

8-5.2 Soft-Structural Alternative

A combination of maximum-depth and minimum-depth bank protection is required to allow the prescribed encroachment into the *FEMA 100-year floodplain* for this alternative. When the encroachment is at or near the floodway boundary, maximum-depth (i.e., full-depth) bank protection is proposed. When the encroachment is away from the floodway boundary (shallower depths, lower velocities), minimum-depth (three-foot toe-down) bank protection is proposed.

A *reach*-by-*reach* description of the proposed structural features associated with the Soft-Structural Alternative on study *watercourse*s follows. The *reach*es will be addressed beginning at the downstream study limit. More detail on the proposed structural features associated with this alternative can be obtained by referencing the concept plans included as Appendix E. The station numbers referenced in the following text are taken from the concept plans.

8-5.2.1 *Upper Cave Creek*

Braided Reach

No structural features are required or proposed in this *reach* for this alternative.

Mined Reach

This alternative provides a grade-control structure at the upstream end of the Mined Reach (Sta. 225) to prevent headcutting, due to the mining excavations, from propagating upstream. As mentioned previously, for the purpose of estimating cost, it is assumed that this structure will be constructed of pneumatically-place, reinforced concrete. The cost of this structure has been estimated to be $2.2M. Refer to the Soft-Structural Concept Plans included as Appendix E to this report for more details on the proposed grade-control structure.

Cliff Reach

A levee with minimum-depth bank protection is proposed to make the prescribed encroachment from Sta. 245 to 269 along the west side of the watercourse. The Lateral Migration Erosion Hazard Zone boundary encroaches into the floodplain in this *reach*. Farther upstream, the boundary encroaches into the floodway. Since encroachment into the floodway is not allowed by FEMA regulations, maximum-depth bank protection is provided along the floodway boundary from Sta. 286 to 330.

As described in Section 8-3, the encroachment limit along the east side of the watercourse follows the Long-Term *Erosion* Hazard Zone boundary for most of the *reach*. However, from where the cliff begins to disappear (Sta. 337) to the Carefree Highway (Sta. 356), the encroachment limit follows the floodway boundary. Consequently, a short section of levee with maximum-depth bank protection is proposed along this section of the *reach*.

Table 8-5.4 FULL-STRUCTURAL ALTERNATIVE: CONSTRUCTION COSTS FOR DESERT HILLS WASH

Item	Unit Price	Left Bank Quantity (yd^3)	Left Bank Cost	Right Bank Quantity (yd^3)	Right Bank Cost	Total Quantity (yd^3)	Total Cost
Riprap Revetment							
Excavation (yd^3)	$2	31,411	$62,822	23,920	$47,840	55,331	$110,662
Borrow Material (yd^3)	$5	19,189	$95,945	10,599	$52,995	29,788	$148,940
Riprap Revetment (yd^3)	$30	15,520	$465,600	10,612	$318,360	26,132	$783,960
Total Cost			**$624,367**		**$419,195**		**$1,043,562**
Gabion Mattress Revetment							
Excavation (yd^3)	$2	31,411	$62,822	23,920	$47,840	55,331	$110,662
Borrow Material (yd^3)	$5	19,189	$95,945	10,599	$52,995	29,788	$148,940
Gabion Revetment (yd^3)	$60	7,760	$465,600	5,306	$318,360	13,066	$783,960
Total Cost			**$624,367**		**$419,195**		**$1,043,562**
CSA Revetment							
Excavation (yd^3)	$2	31,411	$62,822	23,920	$47,840	55,331	$110,662
Borrow Material (yd^3)	$5	19,189	$95,945	10,599	$52,995	29,788	$148,940
CSA Revetment (yd^3)	$15	17,848	$267,720	12,204	$183,060	30,052	$450,780
CSA Cement (tons)	$100	2,530	$253,000	1,730	$173,000	4,260	$426,000
Total Cost			**$679,487**		**$456,895**		**$1,136,382**

Table 8-5.5 summarizes the approximate quantities and costs for bank protection, excavation, and levee embankment construction required by armor type for Upper Cave Creek. A breakdown of the costs for each *reach* can be found in Appendix D.

8-5.2.2 *Apache Wash*

Hackberry Reach

Along the east side of the watercourse, the encroachment limit is coincident with the floodway beginning at the downstream limit of the *reach* (Sta. 101) and continuing upstream for approximately 1000 feet (Sta. 111). Levee embankment along with maximum-depth bank protection is recommended along this length. From approximately Sta. 114 to 129, the encroachment limit is within the shallow floodplain area. Accordingly, a levee with minimum-depth bank protection is recommended.

Along the west side of the *reach* from Sta. 123 to 153, the encroachment is again within the shallow floodplain area, and levee embankment with minimum-depth bank protection is recommended.

Union Hills Reach

No structural features are required or proposed in this *reach* for this alternative.

Upper Reach

Because the Lateral-Migration *Erosion* Hazard Zone boundary effectively follows or is inside the *FEMA 100-year floodway*, the encroachment limit on the west side of the watercourse for the Soft-Structural Alternative is identical to that for the Full-Structural Alternative. Therefore, levee embankment and maximum-depth bank protection are provided from Sta. 230 to 263 and Sta. 266 to 300. As with the Full-Structural Alternative, a break in the levee is provided at Sta. 265 to allow flow from a minor tributary to enter the watercourse.

Except for one area, the encroachment limit on the east side of the watercourse effectively follows the *FEMA 100-year floodplain* boundary and no bank protection or levee embankment is required. The exception is the area between Sta. 256 and 276 where the encroachment limit coincides with the FEMA Floodway boundary. Levee embankment with maximum-depth bank protection is provided along this section of the watercourse.

Table 8-5.6 summarizes the approximate quantities and costs for bank protection, excavation, and levee embankment construction required by armor type for Apache Wash. A breakdown of the costs for each *reach* can be found in Appendix D.

Table 8-5.5 SOFT-STRUCTURAL ALTERNATIVE: CONSTRUCTION COSTS FOR UPPER CAVE CREEK

Item	Unit Price	Left Bank Quantity (yd³)	Left Bank Cost	Right Bank Quantity (yd³)	Right Bank Cost	Total Quantity (yd³)	Total Cost
Riprap Revetment							
Excavation Total (yd³)	$3	148,757	$446,271	46,692	$140,076	195,449	$586,347
Borrow Total (yd³)	$5	39,711	$198,555	26,739	$133,695	66,450	$332,250
Riprap Total (yd³)	$35	78,686	$2,754,010	21,340	$746,900	100,026	$3,500,910
Grade Control Structures							
Reinforced Concrete (yd²)	$94	23,578	$2,216,332			23,578	$2,216,332
Total Cost			**$5,615,168**		**$1,020,671**		**$6,635,839**
Gabion Mattress Revetment							
Excavation Total (yd³)	$3	148,757	$446,271	46,692	$140,076	195,449	$586,347
Borrow Total (yd³)	$5	39,711	$198,555	26,739	$133,695	66,450	$332,250
Gabion Total (yd³)	$65	36,064	$2,344,160	9,781	$635,765	45,845	$2,979,925
Grade Control Structures							
Reinforced Concrete (yd²)	$94	23,578	$2,216,332			$23,578	$2,216,332
Total Cost			**$5,205,318**		**$909,536**		**$6,114,854**
CSA Revetment							
Excavation Total (yd³)	$3	148,757	$446,271	46,692	$140,076	195,449	$586,347
Borrow Total (yd³)	$5	39,711	$198,555	26,739	$133,695	66,450	$332,250
CSA Total (yd³)	$15	52,784	$791,760	14,316	$214,740	67,100	$1,006,500
CSA Cement Total (tons)	$100	7,482	$748,200	2,029	$202,900	9,511	$951,100
Grade Control Structures							
Reinforced Concrete (yd²)	$94	23,578	$2,216,332			$23,578	$2,216,332
Total Cost			**$4,401,118**		**$691,411**		**$5,092,529**

Table 8-5.6 SOFT-STRUCTURAL ALTERNATIVE: CONSTRUCTION COSTS FOR APACHE WASH

Item	Unit Price	Left Bank Quantity (yd^3)	Left Bank Cost	Right Bank Quantity (yd^3)	Right Bank Cost	Total Quantity (yd^3)	Total Cost
Riprap Revetment							
Excavation Total (yd^3)	$3	181,295	$543,885	79,363	$238,089	260,658	$781,974
Borrow Total (yd^3)	$5	25,818	$129,090	19,819	$99,095	45,637	$228,185
Riprap Total (yd^3)	$35	73,061	$2,557,135	40,784	$1,427,440	113,845	$3,984,575
Total Cost			**$3,230,110**		**$1,764,624**		**$4,994,734**
Gabion Mattress Revetment							
Excavation Total (yd^3)	$3	181,295	$543,885	79,363	$238,089	260,658	$781,974
Borrow Total (yd^3)	$5	25,818	$129,090	19,819	$99,095	45,637	$228,185
Gabion Total (yd^3)	$65	33,209	$2,158,585	18,538	$1,204,970	51,747	$3,363,555
Total Cost			**$2,831,560**		**$1,542,154**		**$4,373,714**
CSA Revetment							
Excavation Total (yd^3)	$3	181,295	$543,885	79,363	$238,089	260,658	$781,974
Borrow Total (yd^3)	$5	25,818	$129,090	19,819	$99,095	45,637	$228,185
CSA Total (yd^3)	$15	53,466	$801,990	29,846	$447,690	83,312	$1,249,680
CSA Cement Total (tons)	$100	7,579	$757,900	4,230	$423,000	11,809	$1,180,900
Total Cost			**$2,232,865**		**$1,207,874**		**$3,440,739**

8-5.2.3 *Paradise Wash*

The encroachment limit on the east side of the watercourse effectively follows the *FEMA 100-year floodplain* boundary and no bank protection or levee embankment is required. This also holds true for the west side of the watercourse, except for the area between Sta. 165 to 187. In this location, the encroachment limit coincides with the FEMA Floodway boundary. Therefore, levee embankment and maximum-depth bank protection is provided.

Table 8-5.7 summarizes the approximate quantities and costs, by armor type, for bank protection, excavation, and levee embankment construction required for Paradise Wash.

8-5.2.4 *Desert Hills Wash*

Because the Lateral-Migration *Erosion* Hazard Zone boundary is inside the FEMA Floodway, the encroachment limit on the east side of Desert Hills Wash is identical to that for the Full-Structural Alternative. Consequently, the same levee embankment and maximum-depth bank protection proposed for the Full-Structural Alternative are provided from Sta. 106+50 to 130+50 for this alternative.

The proposed encroachment limit is coincident with the FEMA Floodway boundary for most of the west side of the watercourse. An exception is the short section between Sta. 103 and 109 at the confluence with Apache Wash. Here the encroachment limit diverges from the floodway. However, since this area is in a confluence area, as well as on the outside of a bend, maximum-depth bank protection is provided. Consequently, a levee with maximum-depth bank protection is provided along the entire west side.

Table 8-5.8 summarizes the approximate quantities and costs, by armor type, for bank protection, excavation, and levee embankment construction required for Desert Hills Wash.

8-5.3 Nonstructural Alternative

The only structural feature associated with this alternative is the environmentally "friendly" grade-control structure proposed at the upstream end of the Mined Reach (Sta. 225) on Upper Cave Creek. This structure is required to prevent headcutting from the mining excavation and preserve the natural integrity of the existing *channel*. As mentioned previously, for the sake of cost estimating, it is assumed that this structure will be built of pneumatically-placed, reinforced concrete. The cost of this structure has been estimated to be $2.2M. For more details on this grade-control structure refer to the grade-control details provided in the Soft-Structural Concept Plans included as Appendix E to this report.

Table 8-5.7 CONSTRUCTION COSTS FOR PARADISE WASH SOFT-STRUCTURAL ALTERNATIVE:

Table 8-5.8 SOFT-STRUCTURAL ALTERNATIVE: CONSTRUCTION COSTS FOR DESERT HILLS WASH

Item	Unit Price	Left Bank Quantity (yd³)	Left Bank Cost	Right Bank Quantity (yd³)	Right Bank Cost	Total Quantity (yd³)	Total Cost
Riprap Revetment							
Excavation (yd³)	$3	39,567	$118,701	29,870	$89,610	69,437	$208,311
Borrow Material (yd³)	$5	18,629	$93,145	10,599	$52,995	29,228	$146,140
Riprap Revetment (yd³)	$35	14,279	$499,765	9,880	$345,800	24,159	$845,565
Total Cost			**$711,611**		**$488,405**		**$1,200,016**
Gabion Mattress Revetment							
Excavation (yd³)	$3	39,567	$118,701	29,870	$89,610	69,437	$208,311
Borrow Material (yd³)	$5	18,629	$93,145	10,599	$52,995	29,228	$146,140
Gabion Revetment (yd³)	$65	7,140	$464,100	4,940	$321,100	12,080	$785,200
Total Cost			**$675,946**		**$463,705**		**$1,139,651**
CSA Revetment							
Excavation (yd³)	$3	39,567	$118,701	29,870	$89,610	69,437	$208,311
Borrow Material (yd³)	$5	18,629	$93,145	10,599	$52,995	29,228	$146,140
CSA Revetment (yd³)	$15	19,458	$291,870	13,255	$198,825	32,713	$490,695
CSA Cement (tons)	$100	2,716	$271,600	1,879	$187,900	4,595	$459,500
Total Cost			**$775,316**		**$529,330**		**$1,304,646**

8-5.4 Summary of Construction Costs

From inspecting Tables 8-5.1 through 8-5.8, it can be seen that the most economical armor type depends upon the length of protection required. For example, when the length of bank protection is relatively long, such as for the Full-Structural Alternative on Upper Cave Creek and Apache Wash, CSA is the most economical armor to use. However, when the length is relatively short, such as for the Full-Structural Alternative on Desert Hills Wash, riprap is competitive. Gabion mattresses are the economical choice for Paradise Wash, which requires an intermediate length of bank protection.

Since a basic assumption of the master plan study is that any bank protection in the recommended alternative would be built simultaneously, the construction costs are summarized by alternative in the following sections for the entire study area.

8-5.4.1 *Full-Structural Alternative*

Table 8-5.9 summarizes the approximate total construction costs, by armor type, for bank protection, excavation, levee embankment, and grade-control construction required for the entire study area. Sufficient length of bank protection is required in this alternative to make CSA the most economical armor option at an estimated cost of $23.8M.

8-5.4.2 *Soft-Structural Alternative*

Table 8-5.10 summarize the approximate total construction costs, by armor type, for bank protection, excavation, levee embankment, and grade-control construction required for the entire study area. Again, sufficient length of bank protection is required in this alternative to make CSA the most economical armor option at an estimated cost of $10.4M.

8-5.4.3 *Nonstructural Alternative*

As described previously, the only construction cost associated with the Nonstructural Alternative is for the "environmentally friendly" grade-control structure. The cost of this reinforced concrete structure is estimated to be $2.2M.

8-5.5 Summary of Land Costs, Benefits, and Impacts

A land cost is defined as property that must be purchased to implement a given alternative because disallowing development on it would be considered a "taking." A land benefit is defined as property reclaimed and made available for development typically through the construction of a levee or fill and bank protection. Land inside (on the *channel* side) of the "Regulatory Line," but outside the *non-encroachment area* for a

Table 8-5.9 FULL-STRUCTURAL ALTERNATIVE: CONSTRUCTION COSTS FOR STUDY AREA

Item	Unit Price	Left Bank Quantity (yd^3)	Left Bank Cost	Right Bank Quantity (yd^3)	Right Bank Cost	Total Quantity (yd^3)	Total Cost
Riprap Revetment							
Excavation (yd^3)	$2	1,017,750	$2,035,500	848,530	$1,697,060	1,866,280	$3,732,560
Borrow Material (yd^3)	$5	321,865	$1,609,325	128,144	$640,720	450,009	$2,250,045
Riprap Revetment (yd^3)	$30	446,621	$13,398,636	359,574	$10,787,223	806,195	$24,185,859
Grade Control Structures							
CSA Total (yd^3)	$30	17,500	$525,000				
CSA Cement Total (tons)	$100	2,500	$250,000				
Total Cost			**$17,818,461**		**$13,125,003**		**$30,943,464**
Gabion Mattress Revetment							
Excavation (yd^3)	$2	1,017,750	$2,035,500	848,530	$1,697,060	1,866,280	$3,732,560
Borrow Material (yd^3)	$5	321,865	$1,609,325	128,144	$640,720	450,009	$2,250,045
Gabion Revetment (yd^3)	$60	201,412	$12,084,714	159,982	$9,598,908	361,394	$21,683,622
Grade Control Structures							
CSA Total (yd^3)	$30	17,500	$525,000				
CSA Cement Total (tons)	$100	2,500	$250,000				
Total Cost			**$16,504,539**		**$11,936,688**		**$28,441,227**
CSA Revetment							
Excavation (yd^3)	$2	1,017,750	$2,035,500	848,530	$1,697,060	1,866,280	$3,732,560
Borrow Material (yd^3)	$5	321,865	$1,609,325	128,144	$640,720	450,009	$2,250,045
CSA Revetment (yd^3)	$15	328,653	$4,929,800	264,194	$3,962,912	592,847	$8,892,711
CSA Cement (tons)	$100	46,588	$4,658,760	37,449	$3,744,920	84,037	$8,403,680
Grade Control Structures							
CSA Total (yd^3)	$15	17,500	$262,500				
CSA Cement Total (tons)	$100	2,500	$250,000				
Total Cost			**$13,745,885**		**$10,045,612**		**$23,791,496**

Table 8-5.10 SOFT-STRUCTURAL ALTERNATIVE: CONSTRUCTION COSTS FOR STUDY AREA

Item	Unit Price	Left Bank Quantity (yd^3)	Left Bank Cost	Right Bank Quantity (yd^3)	Right Bank Cost	Total Quantity (yd^3)	Total Cost
Riprap Revetment							
Excavation (yd^3)	$3	390,988	$1,172,964	155,925	$467,775	546,913	$1,640,739
Borrow Material (yd^3)	$5	93,695	$468,475	57,157	$285,785	150,852	$754,260
Riprap Revetment (yd^3)	$35	181,558	$6,354,530	72,004	$2,520,140	253,562	$8,874,670
Grade Control Structures							
Reinforced Concrete (yd^2)	$94	23,578	$2,216,332				
Total Cost			**$10,212,301**		**$3,273,700**		**$13,486,001**
Gabion Mattress Revetment							
Excavation (yd^3)	$3	390,988	$1,172,964	155,925	$467,775	546,913	$1,640,739
Borrow Material (yd^3)	$5	93,695	$468,475	57,157	$285,785	150,852	$754,260
Gabion Revetment (yd^3)	$65	84,179	$5,471,635	33,259	$2,161,835	117,438	$7,633,470
Grade Control Structures							
Reinforced Concrete (yd^2)	$94	23,578	$2,216,332				
Total Cost			**$9,329,406**		**$2,915,395**		**$12,244,801**
CSA Revetment							
Excavation (yd^3)	$3	390,988	$1,172,964	155,925	$467,775	546,913	$1,640,739
Borrow Material (yd^3)	$5	93,695	$468,475	57,157	$285,785	150,852	$754,260
CSA Revetment (yd^3)	$15	139,601	$2,094,015	57,417	$861,255	197,018	$2,955,270
CSA Cement (tons)	$100	19,746	$1,974,600	8,138	$813,800	27,884	$2,788,400
Grade Control Structures							
Reinforced Concrete (yd^2)	$94	23,578	$2,216,332				
Total Cost			**$7,926,386**		**$2,428,615**		**$10,355,001**

given alternative, is considered a benefit. Land outside the "Regulatory Line," but inside the *non-encroachment area* for a given alternative, is land that must be purchased. The net land cost is the estimated cost to purchase the land, less any benefit available for land reclaimed from the regulatory area. A unit price of $50,000 per acre is used to make the estimates.

Impacts are defined as areas of medium- and high-value habitat or areas of cultural/archeological significance that would be potentially lost or disrupted by development. The degree of impact to these resources is measured using land area as the indicator. The less land impacted by an alternative, the better. Because it contains no encroachment into the watercourse areas, it is assumed that the Nonstructural Alternative has "zero" impacts. The area between the *non-encroachment area* boundaries for the Nonstructural Alternative and the Soft-Structural Alternative represents the total impact area for the Soft-Structural Alternative, while the area between the *non-encroachment area* boundaries for the Nonstructural Alternative and the Full-Structural Alternative represents the total impact area for the Full-Structural Alternative. The total impact areas are comprised of low-, medium-, and high-value habitat.

8-5.5.1 *Full-Structural Alternative*

Table 8-5.11 summarizes the land costs, land benefits, and acres of resource impacts associated with the Full-Structural Alternative by *reach*. The costs represent land to be purchased. The benefits represent land reclaimed from the regulatory area.

8-5.5.2 *Soft-Structural Alternative*

Table 8-5.12 summarizes the land costs, land benefits, and acres of resource impacts associated with the Soft-Structural Alternative by *reach*. The costs represent land to be purchased. The benefits represent land reclaimed from the regulatory area.

8-5.5.3 *Nonstructural Alternative*

To allow the study *watercourse* to be sustained in its natural state, the non-encroachment limit for this alternative is located along the Long-Term *Erosion* Hazard Zone boundary or the *FEMA 100-year floodplain* boundary, whichever is farther from the main channel. This criterion is applied consistently through all *reach*es of all *watercourse*s. However, since the Flood Control District has determined that the potential erosion outside the Lateral-Migration *Erosion* Hazard Zone does not constitute a threat to public safety, this alternative will require the acquisition of land outside the "Regulatory Line," but not inside the *non-encroachment area* for this alternative. The estimated cost associated with the acquisition of these properties is summarized by *reach* in Table 8-5.13 below. There are no impacts or reclaimed lands associated with this alternative.

Table 8-5.11 FULL-STRUCTURAL ALTERNATIVE: LAND COSTS, BENEFITS AND IMPACTS

	COST ESTIMATE					IMPACTS (ACRES)			
	AREA RECLAIMED (ACRES)	LAND BENEFIT	AREA PURCHASED (ACRES)	PURCHASE COST	NET LAND COST	ARCHEOLOGICAL AREA	LOW VALUE HABITAT	MEDIUM VALUE HABITAT	HIGH VALUE HABITAT
UPPER CAVE CREEK									
Braided	8.6	$429,290	1.7	$85,975	-$343,315	3	2	10	5
Mined	119.3	$5,965,805	19.8	$987,695	-$4,978,110	0	52	53	52
Cliff	118.0	$5,898,180	25.0	$1,251,795	-$4,646,385	52	25	62	48
System Total	**245.9**	**$12,293,275**	**46.5**	**$2,325,465**	**-$9,967,810**	**55**	**79**	**125**	**105**
APACHE WASH									
Hackberry	70.5	$3,525,740	0.0	$0	-$3,525,740	0	55	18	17
Union Hills	12.2	$610,975	0.0	$0	-$610,975	0	19	8	4
Upper	81.9	$4,094,905	0.0	$0	-$4,094,905	0	71	13	10
Wash Total	**164.6**	**$8,231,620**	**0.0**	**$0**	**-$8,231,620**	**0**	**145**	**39**	**31**
PARADISE WASH									
Wash Total	**77.8**	**$3,889,935**	**0.0**	**$0**	**-$3,889,935**	**0**	**42**	**53**	**24**
DESERT HILLS WASH									
Wash Total	**25.6**	**$1,281,895**	**0.0**	**$0**	**-$1,281,895**	**0**	**22**	**1**	**1**
System Total	**268.1**	**$13,403,450**	**0.0**	**$0**	**-$13,403,450**	**0**	**209**	**93**	**56**
ALT. TOTAL	**513.9**	**$25,696,725**	**46.5**	**$2,325,465**	**-$23,371,260**	**55**	**288**	**218**	**161**

Land Cost = $50,000 per acre

Table 8-5.12 SOFT-STRUCTURAL ALTERNATIVE: LAND COSTS, BENEFITS, AND IMPACTS

	COST ESTIMATE					IMPACTS (ACRES)			
	AREA RECLAIMED (ACRES)	LAND BENEFIT	AREA PURCHASED (ACRES)	PURCHASE COST	NET LAND COST	ARCHEOLOGICAL AREA	LOW VALUE HABITAT	MEDIUM VALUE HABITAT	HIGH VALUE HABITAT
UPPER CAVE CREEK									
Braided	1.2	$60,515	1.7	$85,970	$25,455	2	0	5	5
Mined	0.2	$12,335	19.1	$957,370	$945,035	0	19	13	8
Cliff	44.7	$2,234,325	29.6	$1,479,810	-$754,515	13	3	33	21
System Total	**46.1**	**$2,307,175**	**50.5**	**$2,523,150**	**$215,975**	**15**	**22**	**51**	**34**
APACHE WASH									
Hackberry	33.7	$1,683,320	0.4	$21,910	-$1,661,410	0	38	6	9
Union Hills	0.1	$6,480	1.3	$63,440	$56,960	0	11	5	2
Upper	50.3	$2,514,100	0.0	$1,535	-$2,512,565	0	57	3	2
Wash Total	**84.1**	**$4,203,900**	**1.7**	**$86,885**	**-$4,117,015**	**0**	**106**	**14**	**13**
PARADISE WASH									
Wash Total	**12.4**	**$620,880**	**0.0**	**$0**	**-$620,880**	**0**	**22**	**26**	**10**
DESERT HILLS WASH									
Wash Total	**25.5**	**$1,277,165**	**0.0**	**$0**	**-$1,277,165**	**0**	**22**	**1**	**1**
System Total	**122.0**	**$6,101,945**	**1.7**	**$86,885**	**-$6,015,060**	**0**	**150**	**41**	**24**
ALT. TOTAL	**168.2**	**$8,409,120**	**52.2**	**$2,610,035**	**-$5,799,085**	**15**	**172**	**92**	**58**

Land Cost = $50,000 per acre

Table 8-5.13 NON - STRUCTURAL ALTERNATIVE: LAND COSTS, BENEFITS, AND IMPACTS

	COST ESTIMATE					IMPACTS (ACRES)			
	AREA RECLAIMED (ACRES)	LAND BENEFIT	AREA PURCHASED (ACRES)	PURCHASE COST	NET LAND COST	ARCHEOLOGICAL AREA	LOW VALUE HABITAT	MEDIUM VALUE HABITAT	HIGH VALUE HABITAT
UPPER CAVE CREEK									
Braided	0	$0	10.5	$524,930	$524,930	0	0	0	0
Mined	0	$0	59.2	$2,958,235	$2,958,235	0	0	0	0
Cliff	0	$0	41.9	$2,095,100	$2,095,100	0	0	0	0
System Total	**0**	**$0**	**111.6**	**$5,578,265**	**$5,578,265**	**0**	**0**	**0**	**0**
APACHE WASH									
Hackberry	0	$0	20.6	$1,029,605	$1,029,605	0	0	0	0
Union Hills	0	$0	19.0	$950,965	$950,965	0	0	0	0
Upper	0	$0	10.8	$541,510	$541,510	0	0	0	0
Wash Total	**0**	**$0**	**50.4**	**$2,522,080**	**$2,522,080**	**0**	**0**	**0**	**0**
PARADISE WASH									
Wash Total	**0**	**$0**	**49.6**	**$2,478,265**	**$2,478,265**	**0**	**0**	**0**	**0**
DESERT HILLS WASH									
Wash Total	**0**	**$0**	**0.3**	**$13,815**	**$13,815**	**0**	**0**	**0**	**0**
System Total	**0**	**$0**	**100.3**	**$5,014,160**	**$5,014,160**	**0**	**0**	**0**	**0**
ALT. TOTAL	**0**	**$0**	**211.8**	**$10,592,425**	**$10,592,425**	**0**	**0**	**0**	**0**

Land Cost = $50,000 per acre

In terms of land cost and benefits, the Full-Structural Alternative is the most economical based on both absolute and net land costs. However, this economy is gained at the expense of habitat and archeological resources. In terms of impact to wildlife habitat and archeological resources, the Nonstructural Alternative is the best choice since it impacts "zero" acres of these resources.

8-5.6 Summary of Net Costs and Impacts

Tables 8-5.14 through 8-5.20 summarize the total net costs and resource impacts for each alternative, by bank protection armor type and watercourse reach. The total net costs account for the construction costs for the bank protection type being considered, as well as the land costs and benefits described previously.

8-5.6.1 *Full-Structural Alternative*

Tables 8-5.14 through 8-5.16 contain the total net costs and resource impacts for the Full-Structural Alternative using riprap, gabion mattress, and CSA bank protection options, respectively.

8-5.6.2 *Soft-Structural Alternative*

Tables 8-5.17 through 8-5.19 contain the total net costs and resource impacts for the Soft-Structural Alternative using riprap, gabion mattress, and CSA bank protection options, respectively.

8-5.6.3 *Nonstructural Alternative*

Table 8-5.20 contains the total net costs and resource impacts for the Nonstructural Alternative. Recall that the only structural feature associated with this alternative is the reinforced concrete grade-control structure, and that there are no impacts with this alternative.

Table 8-5.14 FULL-STRUCTURAL ALTERNATIVE: RIPRAP BANK PROTECTION NET COST

	NET COST ESTIMATE				IMPACTS (ACRES)				
	TOTAL CONSTRUCTION COST	LAND PURCHASE COST	RECLAIMED LAND BENEFIT	NET COST	ARCHEOLOGICAL AREA	LOW VALUE HABITAT	MEDIUM VALUE HABITAT	HIGH VALUE HABITAT	TOTAL IMPACT AREA
UPPER CAVE CREEK									
Braided	$974,677	$85,975	$429,290	$631,362	3	2	10	5	20
Mined	$5,939,043	$987,695	$5,965,805	$960,933	0	52	53	52	157
Cliff	$7,184,436	$1,251,795	$5,898,180	$2,538,051	52	25	62	48	187
Grade Control	$775,000			$775,000					
System Total	**$14,873,156**	**$2,325,465**	**$12,293,275**	**$4,905,346**	**55**	**79**	**125**	**105**	**364**
APACHE WASH									
Hackberry	$6,203,362	$0	$3,525,740	$2,677,622	0	55	18	17	90
Union Hills	$1,412,944	$0	$610,975	$801,969	0	19	8	4	31
Upper	$5,065,816	$0	$4,094,905	$970,911	0	71	13	10	94
Wash Total	**$12,682,122**	**$0**	**$8,231,620**	**$4,450,502**	**0**	**145**	**39**	**31**	**215**
PARADISE WASH									
Wash Total	**$2,344,624**	**$0**	**$3,889,935**	**-$1,545,311**	**0**	**42**	**53**	**24**	**119**
DESERT HILLS WASH									
Wash Total	**$1,043,562**	**$0**	**$1,281,895**	**-$238,333**	**0**	**22**	**1**	**1**	**24**
System Total	**$16,070,308**	**$0**	**$13,403,450**	**$2,666,858**	**0**	**209**	**93**	**56**	**358**
ALT. TOTAL	**$30,943,464**	**$2,325,465**	**$25,696,725**	**$7,572,204**	**55**	**288**	**218**	**161**	**722**

Table 8-5.15 **FULL-STRUCTURAL ALTERNATIVE: GABION MATTRESS BANK PROTECTION NET COST**

	NET COST ESTIMATE				IMPACTS (ACRES)				
	TOTAL CONSTRUCTION COST	LAND PURCHASE COST	RECLAIMED LAND BENEFIT	NET COST	ARCHEOLOGICAL AREA	LOW VALUE HABITAT	MEDIUM VALUE HABITAT	HIGH VALUE HABITAT	TOTAL IMPACT AREA
UPPER CAVE CREEK									
Braided	$895,060	$85,975	$429,290	$551,745	3	2	10	5	20
Mined	$5,513,262	$987,695	$5,965,805	$535,152	0	52	53	52	157
Cliff	$6,710,997	$1,251,795	$5,898,180	$2,064,612	52	25	62	48	187
Grade Control	$775,000			$775,000					
System Total	**$13,894,319**	**$2,325,465**	**$12,293,275**	**$3,926,509**	**55**	**79**	**125**	**105**	**364**
APACHE WASH									
Hackberry	$5,393,752	$0	$3,525,740	$1,868,012	0	55	18	17	90
Union Hills	$1,321,054	$0	$610,975	$710,079	0	19	8	4	31
Upper	$4,661,386	$0	$4,094,905	$566,481	0	71	13	10	94
Wash Total	**$11,376,192**	**$0**	**$8,231,620**	**$3,144,572**	**0**	**145**	**39**	**31**	**215**
PARADISE WASH									
Wash Total	**$2,127,154**	**$0**	**$3,889,935**	**-$1,762,781**	**0**	**42**	**53**	**24**	**119**
DESERT HILLS WASH									
Wash Total	**$1,043,562**	**$0**	**$1,281,895**	**-$238,333**	**0**	**22**	**1**	**1**	**24**
System Total	**$14,546,908**	**$0**	**$13,403,450**	**$1,143,458**	**0**	**209**	**93**	**56**	**358**
ALT. TOTAL	**$28,441,227**	**$2,325,465**	**$25,696,725**	**$5,069,967**	**55**	**288**	**218**	**161**	**722**

Table 8-5.16 FULL-STRUCTURAL ALTERNATIVE: CSA BANK PROTECTION NET COST

	NET COST ESTIMATE				IMPACTS (ACRES)				
	TOTAL CONSTRUCTION COST	LAND PURCHASE COST	RECLAIMED LAND BENEFIT	NET COST	ARCHEOLOGICAL AREA	LOW VALUE HABITAT	MEDIUM VALUE HABITAT	HIGH VALUE HABITAT	TOTAL IMPACT AREA
UPPER CAVE CREEK									
Braided	$801,807	$85,975	$429,290	$458,492	3	2	10	5	20
Mined	$4,588,690	$987,695	$5,965,805	-$389,420	0	52	53	52	157
Cliff	$5,209,476	$1,251,795	$5,898,180	$563,091	52	25	62	48	187
Grade Control	$512,500			$512,500					
System Total	**$11,112,473**	**$2,325,465**	**$12,293,275**	**$1,144,663**	**55**	**79**	**125**	**105**	**364**
APACHE WASH									
Hackberry	$4,109,972	$0	$3,525,740	$584,232	0	55	18	17	90
Union Hills	$937,845	$0	$610,975	$326,870	0	19	8	4	31
Upper	$4,187,511	$0	$4,094,905	$92,606	0	71	13	10	94
Wash Total	**$9,235,328**	**$0**	**$8,231,620**	**$1,003,708**	**0**	**145**	**39**	**31**	**215**
PARADISE WASH									
Wash Total	**$2,307,314**	**$0**	**$3,889,935**	**-$1,582,621**	**0**	**42**	**53**	**24**	**119**
DESERT HILLS WASH									
Wash Total	**$1,136,382**	**$0**	**$1,281,895**	**-$145,513**	**0**	**22**	**1**	**1**	**24**
System Total	**$12,679,024**	**$0**	**$13,403,450**	**-$724,426**	**0**	**209**	**93**	**56**	**358**
ALT. TOTAL	**$23,791,497**	**$2,325,465**	**$25,696,725**	**$420,237**	**55**	**288**	**218**	**161**	**722**

Table 8-5.17 SOFT-STRUCTURAL ALTERNATIVE: RIPRAP BANK PROTECTION NET COST

	NET COST ESTIMATE				IMPACTS (ACRES)				
	TOTAL CONSTRUCTION COST	LAND PURCHASE COST	RECLAIMED LAND BENEFIT	NET COST	ARCHEOLOGICAL AREA	LOW VALUE HABITAT	MEDIUM VALUE HABITAT	HIGH VALUE HABITAT	TOTAL IMPACT AREA
UPPER CAVE CREEK									
Braided	$0	$85,970	$60,515	$25,455	2	0	5	5	12
Mined	$0	$957,370	$12,335	$945,035	0	19	13	8	40
Cliff	$4,419,507	$1,479,810	$2,234,325	$3,664,992	13	3	33	21	70
Grade Control	$2,216,332			$2,216,332					
System Total	**$6,635,839**	**$2,523,150**	**$2,307,175**	**$6,851,814**	**15**	**22**	**51**	**34**	**122**
APACHE WASH									
Hackberry	$1,386,138	$21,910	$1,683,320	-$275,272	0	38	6	9	53
Union Hills	$0	$63,440	$6,480	$56,960	0	11	5	2	18
Upper	$3,608,596	$1,535	$2,514,100	$1,096,031	0	57	3	2	62
Wash Total	**$4,994,734**	**$86,885**	**$4,203,900**	**$877,719**	**0**	**106**	**14**	**13**	**133**
PARADISE WASH									
Wash Total	**$655,412**	**$0**	**$620,880**	**$34,532**	**0**	**22**	**26**	**10**	**58**
DESERT HILLS WASH									
Wash Total	**$1,200,016**	**$0**	**$1,277,165**	**-$77,149**	**0**	**22**	**1**	**1**	**24**
System Total	**$6,850,162**	**$86,885**	**$6,101,945**	**$835,102**	**0**	**150**	**41**	**24**	**215**
ALT. TOTAL	**$13,486,001**	**$2,610,035**	**$8,409,120**	**$7,686,916**	**15**	**172**	**92**	**58**	**337**

Table 8-5.18 SOFT-STRUCTURAL ALTERNATIVE: GABION MATTRESS BANK PROTECTION NET COST

	NET COST ESTIMATE				IMPACTS (ACRES)				
	TOTAL CONSTRUCTION COST	LAND PURCHASE COST	RECLAIMED LAND BENEFIT	NET COST	ARCHEOLOGICAL AREA	LOW VALUE HABITAT	MEDIUM VALUE HABITAT	HIGH VALUE HABITAT	TOTAL IMPACT AREA
UPPER CAVE CREEK									
Braided	$0	$85,970	$60,515	$25,455	2	0	5	5	12
Mined	$0	$957,370	$12,335	$945,035	0	19	13	8	40
Cliff	$3,898,522	$1,479,810	$2,234,325	$3,144,007	13	3	33	21	70
Grade Control	$2,216,332			$2,216,332					
System Total	**$6,114,854**	**$2,523,150**	**$2,307,175**	**$6,330,829**	**15**	**22**	**51**	**34**	**122**
APACHE WASH									
Hackberry	$1,203,328	$21,910	$1,683,320	-$458,082	0	38	6	9	53
Union Hills	$0	$63,440	$6,480	$56,960	0	11	5	2	18
Upper	$3,170,386	$1,535	$2,514,100	$657,821	0	57	3	2	62
Wash Total	**$4,373,714**	**$86,885**	**$4,203,900**	**$256,699**	**0**	**106**	**14**	**13**	**133**
PARADISE WASH									
Wash Total	**$616,582**	**$0**	**$620,880**	**-$4,298**	**0**	**22**	**26**	**10**	**58**
DESERT HILLS WASH									
Wash Total	**$1,139,651**	**$0**	**$1,277,165**	**-$137,514**	**0**	**22**	**1**	**1**	**24**
System Total	**$6,129,947**	**$86,885**	**$6,101,945**	**$114,887**	**0**	**150**	**41**	**24**	**215**
ALT. TOTAL	**$12,244,801**	**$2,610,035**	**$8,409,120**	**$6,445,716**	**15**	**172**	**92**	**58**	**337**

Table 8-5.19 SOFT-STRUCTURAL ALTERNATIVE: CSA BANK PROTECTION NET COST

	NET COST ESTIMATE				IMPACTS (ACRES)				
	TOTAL CONSTRUCTION COST	LAND PURCHASE COST	RECLAIMED LAND BENEFIT	NET COST	ARCHEOLOGICAL AREA	LOW VALUE HABITAT	MEDIUM VALUE HABITAT	HIGH VALUE HABITAT	TOTAL IMPACT AREA
UPPER CAVE CREEK									
Braided	$0	$85,970	$60,515	$25,455	2	0	5	5	12
Mined	$0	$957,370	$12,335	$945,035	0	19	13	8	40
Cliff	$2,876,197	$1,479,810	$2,234,325	$2,121,682	13	3	33	21	70
Grade Control	$2,216,332			$2,216,332					
System Total	**$5,092,529**	**$2,523,150**	**$2,307,175**	**$5,308,504**	**15**	**22**	**51**	**34**	**122**
APACHE WASH									
Hackberry	$928,658	$21,910	$1,683,320	-$732,752	0	38	6	9	53
Union Hills	$0	$63,440	$6,480	$56,960	0	11	5	2	18
Upper	$2,512,081	$1,535	$2,514,100	-$484	0	57	3	2	62
Wash Total	**$3,440,739**	**$86,885**	**$4,203,900**	**-$676,276**	**0**	**106**	**14**	**13**	**133**
PARADISE WASH									
Wash Total	**$517,087**	**$0**	**$620,880**	**-$103,793**	**0**	**22**	**26**	**10**	**58**
DESERT HILLS WASH									
Wash Total	**$1,304,646**	**$0**	**$1,277,165**	**$27,481**	**0**	**22**	**1**	**1**	**24**
System Total	**$5,262,472**	**$86,885**	**$6,101,945**	**-$752,588**	**0**	**150**	**41**	**24**	**215**
ALT. TOTAL	**$10,355,001**	**$2,610,035**	**$8,409,120**	**$4,555,916**	**15**	**172**	**92**	**58**	**337**

Table 8-5.20 NONSTRUCTURAL ALTERNATIVE NET COST

	NET COST ESTIMATE				IMPACTS (ACRES)			
	TOTAL CONSTRUCTION COST	LAND PURCHASE COST	RECLAIMED COST BENEFIT	NET COST	ARCHEOLOGICAL AREA	LOW VALUE HABITAT	MEDIUM VALUE HABITAT	HIGH VALUE HABITAT
UPPER CAVE CREEK								
Braided	$0	$524,930	$0	$524,930	0	0	0	0
Mined	$0	$2,958,235	$0	$2,958,235	0	0	0	0
Cliff	$0	$2,095,100	$0	$2,095,100	0	0	0	0
Grade Control	$2,216,332			$2,216,332				
System Total	**$2,216,332**	**$5,578,265**	**$0**	**$7,794,597**	**0**	**0**	**0**	**0**
APACHE WASH					0	0	0	0
Hackberry	$0	$1,029,605	$0	$1,029,605	0	0	0	0
Union Hills	$0	$950,965	$0	$950,965	0	0	0	0
Upper	$0	$541,510	$0	$541,510	0	0	0	0
Wash Total	**$0**	**$2,522,080**	**$0**	**$2,522,080**	**0**	**0**	**0**	**0**
PARADISE WASH								
Wash Total	**$0**	**$2,478,265**	**$0**	**$2,478,265**	**0**	**0**	**0**	**0**
DESERT HILLS WASH								
Wash Total	**$0**	**$13,815**	**$0**	**$13,815**	**0**	**0**	**0**	**0**
System Total	**$0**	**$5,014,160**	**$0**	**$5,014,160**	**0**	**0**	**0**	**0**
ALT. TOTAL	**$2,216,332**	**$10,592,425**	**$0**	**$12,808,757**	**0**	**0**	**0**	**0**

8-5.7 Summary of Results

Table 8-5.21 below summarizes the total net costs and resource impacts for all alternatives and bank protection options considered for the entire study area. The total net costs account for the construction costs for the bank protection type being considered, as well as the land costs and benefits described previously.

If cost was the sole criterion, the alternative of choice would be the Full-Structural Alternative with CSA bank protection. It has the lowest total net cost at an estimated $0.4M. However, this alternative has the highest total amount of habitat and archeological impacts with 722 acres. In terms of least habitat and archeological impacts, the Nonstructural Alternative would be the alternative of choice since it impacts "zero" of these acres. The next section of this report will describe the criteria and process used to evaluate the three alternatives and identify the recommended alternative.

Table 8-5.21 COMPARISON OF NET COSTS AND IMPACTS

	Riprap ($Millions)	Gabion Mattress ($Millions)	CSA ($Millions)	Impacts (Acres)
Full-Structural Alternative	7.6	5.1	0.4	722
Soft-Structural Alternative	7.7	6.4	4.6	337
Nonstructural Alternative	0	0	12.8*	0

* no CSA required. Only structural cost is for reinforced concrete grade-control structure.

8-6. 0 EVALUATION OF ALTERNATIVES

8-6.1 Criteria and Procedure

The evaluation of the proposed watercourse management alternatives was accomplished by measuring how successful each alternative is at achieving the goals of the WCMP by applying criteria that are indicators that the goals are met. The evaluation of the management alternatives is based on three, weighted criterion - Public Safety Impacts, weighted a 10; Social/Environmental Impacts, weighted a 9; and Economic Impacts, weighted an 8. The weighting factor represents the "relative importance" of each criterion in the evaluation process. The weighting factors were measured on a scale of 1 to 10, where a score of 10 represented highest importance. The criteria and weighting factors were developed through application of a value engineering process, with consensus reached between the consultant team and representatives of the District.

A rating system was used to measure the effectiveness of each alternative at meeting each criterion. The rating system ranged from 1 to 5. A value of 1 represented a "very low" rating at meeting the goals of the WCMP, a value of 2 represented a "low" rating, a value of 3 represented a "moderate" rating, a value of 4 represented a "high" rating, and a value of 5 represented a "very high" rating. The highest total score possible for an alternative was 135. The evaluation criteria and weights of importance are listed in Table 8-6.1.

Table 8-6.1

CRITERIA & WEIGHTING FACTORS FOR EVALUATION OF WATERCOURSE MANAGEMENT ALTERNATIVES

Evaluation Criteria	Weighting Factor (0-10)	Maximum Possible Score *
Public safety	10	50
Social and environmental	9	45
Economic	8	40
Maximum Possible Score for an Alternative:		**135**

* Maximum Possible Score = Weighting Factor x Rating Factor of 5

The evaluation for Upper Cave Creek was done separately from the Apache Wash system. The evaluation for the Apache Wash system included Desert Hills Wash and Paradise Wash.

Each evaluation criterion is made up of several elements. The elements provide a means of measuring the effectiveness of the alternative being evaluated, relative to the WCMP goals. For each alternative, the effectiveness is quantified by assigning a rating factor of one (1) to five (5) to each element, with five being the most effective. Because traditional floodplain management policy allows encroachment to the *FEMA 100-year floodway* limit, the Full-Structural Alternative was selected as the standard to which all other alternatives are compared.

Each element is defined and the rating range is described. A benchmark rating is then assigned to the Full-Structural Alternative, and the other two alternatives are typically measured against the Full-Structural Alternative and rated accordingly. Some of the elements carry more weight than others. For this reason, the element ratings are totaled and normalized to provide a score between one (1) and five (5) for each criterion. The normalized score is then multiplied by the criterion weight to determine the criterion score. Finally, the three criterion scores are added to provide the total alternative score.

8-6.2 Elements and Ratings

The ratings for the elements described below account for the general assumption that the land use and landscape character that exists today will not exist when the pressure to develop the study area becomes great enough to implement the selected management alternative. At the time of implementation, it is assumed that the land use will have changed to reflect the low-density residential area (1-2 units/acre) used as the baseline for this study, and that the infrastructure necessary to support such land use will be in place.

8-6.2.1 *Public Safety*

The public safety criterion is based on evaluating the threat for loss of human life and possible damage to homes and property resulting from implementation of a given alternative. This criterion is an indicator of how well the proposed management alternative will succeed in reducing or eliminating life threatening, or potentially life threatening, flood and erosion related hazards, as well as reducing the potential for flood and erosion related damage to public and private properties. This criterion is also an indicator of how well the proposed management alternative will succeed in achieving overall public safety.

The evaluation of the public safety criterion is based on the effectiveness of each alternative in satisfying the ten (10) elements described below. The elements account for various types of risk, hazards, and impacts associated with development encroaching into natural watercourses. All the elements under the public safety criterion were assumed to have equal weight.

Cumulative Encroachment Impacts. It is a well-known fact that removing the storage capacity in channel over-bank areas by placing earthen fill or levees can effectively increase peak discharges in a natural watercourse. This element is included to rate the three alternatives in this regard. The HEC-1 hydrologic models used to estimate the runoff rates and volumes from the Apache Wash and Upper Cave Creek watersheds were modified to reflect the loss of over-bank storage and rerun for the structural alternatives to quantify the increase in peak 100-year discharges. The greater the encroachment, the greater the increase in peak discharge, and the less effective the alternative will be at meeting the WCMP goals.

Using the modified HEC-1 results, a relative scale was developed to rate the alternatives. An alternative with no increase in the 100-year peak discharge is rated a five (5), an increase of 5 percent is rated a three (3), and an increase of 10 percent or greater is rated a one (1).

The Full-Structural Alternative produced a 5.1 percent increase in 100-year peak discharge at the downstream study limit for Upper Cave Creek and a 7.7 percent increase at the downstream study limit for Apache Wash. The alternative was given ratings of three (3) and two (2), respectively.

The Soft-Structural Alternative produced a 2.8 percent increase in 100-year peak discharge at the downstream study limit for Upper Cave Creek and a 4.9 percent increase at the downstream study limit for Apache Wash. The alternative was given ratings of four (4) and three (3), respectively.

The Nonstructural Alternative does not encroach upon the FEMA 100-year floodplain on any of the watercourses within the study area, therefore, it is rated a five (5) for both the Upper Cave Creek and Apache Wash watercourse systems.

Localized Erosion Impacts. Because the proposed levee encroachments into the *FEMA 100-year floodplain* may begin and/or end between the cross-sections used to define hydraulic design parameters, the actual hydraulics at these locations may be more severe than those predicted. Consequently, a potential exists for localized erosion to occur in excess of that used to design the bank protection at these begin/end levee locations, referred to as terminals. The additional erosion could potentially undermine the proposed bank protection and cause it to fail. The potential for this to occur is assumed to be proportional to the number of levee terminals associated with a given alternative. The more terminals, the greater the potential for this type of failure to occur, and the less effective the alternative. Alternatives that include frequent bank protection terminals are rated a one (1), while alternatives with no bank protection terminals are rated a five (5).

The Full-Structural Alternative contains continuous bank protection where it encroaches to the *FEMA 100-year floodway* limit. Consequently, it contains relatively few levee terminals and is rated a four (4) for both Upper Cave Creek and the Apache Wash system. The Soft-Structural Alternative contains more discontinuous sections of bank protection. Consequently, it is rated a three (3) for both Upper Cave Creek and Apache Wash. The Nonstructural Alternative contains no bank protection, therefore, it is rated a five (5) for both Upper Cave Creek and the Apache Wash system.

Hydrologic Modeling Uncertainty. This element accounts for the possibility that the rate of runoff was underestimated for the design event, due to an underestimation of the rainfall intensity, the degree of imperviousness in the watershed, travel time, and other modeling uncertainties. The net effect would be an underestimation of flood levels. Because the conveyance area is reduced, the magnitude of the underestimated flood levels is greater for alternatives that include encroachments into the 100-year floodplain. Therefore, the measure of the effectiveness of a given alternative is based on the degree of encroachment. The greater the encroachment, the greater the threat to public safety. Alternatives that include full, continuous channelization and high levees to maximize the degree of encroachment are rated a one (1), while alternatives with no encroachment into the 100-year floodplain are rated a five (5).

The Full-Structural Alternative contains continuous bank protection and encroaches to the *FEMA 100-year floodway* limit along all watercourses in the study area. However, the FEMA floodway can be narrower through greater encroachment or channelization. Based on these characteristics, the Full-Structural Alternative is rated a three (3) for both the Upper Cave Creek and Apache Wash watercourse systems.

Since the Soft-Structural Alternative contains less bank protection, fewer levees, and a lesser degree of encroachment along all watercourses than the Full-Structural Alternative, it is rated a four (4) for both the Upper Cave Creek and Apache Wash watercourse systems.

The Nonstructural Alternative does not encroach upon the *FEMA 100-year floodplain* on any of the watercourses within the study area, therefore, it is rated a five (5) for both the Upper Cave Creek and Apache Wash watercourse systems.

Hydraulic Modeling Uncertainty. This element accounts for the potential of underestimating or overestimating intractable factors, such as the roughness of the channel and over-bank areas, for the watercourses within the study area. The primary consequence of underestimating roughness is actual flood levels that are higher than predicted. The primary consequence of overestimating roughness is actual velocities higher than predicted, which would, in turn, result in greater scour depths than predicted. Since greater scour depths could affect the stability of structural features, the threat to the general public is assumed to be proportional to the amount and extent of structural features and the degree of encroachment associated with a given alternative. Therefore, the measure of effectiveness is based on the amount and extent of structural features and the degree of encroachment. Alternatives that include continuous levees and a maximum degree of encroachment would be rated a one (1), while alternatives with no encroachment into the 100-year floodplain are rated a five (5).

The Full-Structural Alternative encroaches to the *FEMA 100-year floodway* limit along all watercourses in the study area. However, the *FEMA 100-year floodway* could be narrower, so greater encroachment is possible. Also, the Full-Structural Alternative does not contain continuous levees. Based on these characteristics, the Full-Structural Alternative is rated a three (3) for both the Upper Cave Creek and Apache Wash watercourse systems.

Since the Soft-Structural Alternative contains fewer levees, and a lesser degree of encroachment along all watercourses than the Full-Structural Alternative, it is rated a four (4) for both the Upper Cave Creek and Apache Wash watercourse systems.

The Nonstructural Alternative does not encroach upon the *FEMA 100-year floodplain* on any of the watercourses within the study area, therefore, it is rated a five (5) for both the Upper Cave Creek and Apache Wash watercourse systems.

Development Opportunity. This element represents the amount of land reclaimed from the *FEMA 100-year floodplain* by a given alternative and, thereby, made available for potential development. The effectiveness of a given alternative, relative to the public safety criteria, is based on the degree of encroachment into the floodplain. The greater the degree of encroachment, the greater the development opportunity, and the greater the risk of damage during a 100-year flood event. To measure effectiveness for this element, the amount of land reclaimed from the floodplain was computed as a percentage of the total floodplain area for each alternative for both Upper Cave Creek and the Apache Wash system. The higher the percentage, the lower the rating will be for a given alternative.

The proposed encroachment for the Full-Structural Alternative reclaimed approximately 30 percent of the total floodplain area of Upper Cave Creek and approximately 45 percent of the total floodplain area of the Apache Watercourse system. For the Soft-Structural Alternative, the values were approximately 6 percent and 21 percent, respectively. There is no encroachment associated with the Nonstructural Alternative. Using this data and other pertinent information, a relative rating was selected for each alternative, as described below.

Because greater encroachments are possible on both watercourses, the Full-Structural Alternative was not rated less than two (2). Since the percent of floodplain area reclaimed is similar for both Upper Cave Creek and Apache Wash (30 percent vs. 45 percent), this alternative was rated a two (2) for both watercourse systems.

The amount of floodplain reclaimed by the Soft-Structural Alternative is less than that for the Full-Structural Alternative. Since the percent of floodplain area reclaimed from Upper Cave Creek is significantly less than that from Apache Wash for this alternative (6 percent vs. 21 percent), Upper Cave Creek was rated a four (4), while Apache Wash was rated a three (3).

Since there is no encroachment associated with the Nonstructural Alternative, it was rated a five (5) for both Upper Cave Creek and Apache Wash.

Risk of Failure. This element accounts for the risk that a structural feature may fail during a flood event. The measure of risk is assumed to be proportional to the length of levees included in the alternative being evaluated, i.e., the more levees the higher the inherent risk of a failure. An alternative that needs continuous levees to provide the desired encroachment would be rated a one (1), while an alternative with no levees would receive a rating of five (5). The length of levees was measured for each alternative and a relative rating was selected, as described below.

The Full-Structural Alternative contains approximately 27,000 feet of levee along Upper Cave Creek and approximately 46,000 feet of levee along the Apache Wash system. This alternative was given ratings of three (3) and two (2), respectively.

The Soft-Structural Alternative contains approximately 9,000 feet of levee along Upper Cave Creek and approximately 21,000 feet of levee along the Apache Wash system. The alternative was given ratings of four (4) and three (3), respectively.

Since there is no encroachment associated with the Nonstructural Alternative, no levees are proposed and the alternative was rated a five (5) for both Upper Cave Creek and Apache Wash.

Flood Events Greater Than Design. This element accounts for the fact that flood magnitudes greater than those used for analysis or design are expected in the long term. When such floods occur, some degree of failure or damage can be expected for any alternative. The measure of the threat to public safety is assumed to be proportional to the degree of encroachment into the *FEMA 100-year floodplain*, i.e., the greater the encroachment, the greater the threat. Since the occurrence of such an event represents a threat to public safety for all alternatives, the highest rating given for this element is a four (4). An alternative that includes the maximum possible encroachment into the *FEMA 100-year floodplain* would be rated a one (1). An alternative whose *non-encroachment area* extends beyond the *FEMA 100-year floodplain* at all locations would receive a rating of five (5).

The Full-Structural Alternative encroaches to the *FEMA 100-year floodway* limit along all watercourses in the study area. However, the *FEMA 100-year floodway* does not reflect the allowable one-foot rise in water-surface, therefore, greater encroachment is possible. For this reason, the Full-Structural Alternative is rated a two (2) for both the Upper Cave Creek and Apache Wash watercourse systems.

The proposed encroachment into the floodplain by the Soft-Structural Alternative is both less severe and less frequent than the Full-Structural Alternative, but greater than the Nonstructural Alternative. For this reason, the Soft-Structural Alternative is rated a three (3) for both the Upper Cave Creek and Apache Wash watercourse systems.

The Nonstructural Alternative does not encroach upon the *FEMA 100-year floodplain* on any of the watercourses within the study area, however, the encroachment area does not extend beyond the *FEMA 100-year floodplain* at all locations. Therefore, the alternative is rated a four (4) for both the Upper Cave Creek and Apache Wash watercourse systems.

Flood Events Less Than Design. This element accounts for the level of protection provided to the public for flood magnitudes less than those used for analysis and design. The 10-year flood event was used to evaluate the alternatives in this regard. The results of the evaluation indicate that all alternatives have been designed to provide sufficient protection against flood events less than design through a combination of bank protection and setback distances. Consequently, all alternatives are rated a five (5) for both Upper Cave Creek and the Apache Wash system.

Emergency Response. This element accounts for the ease of access to the main channel at any point along the watercourses in the study area, for a given alternative, should an emergency response be necessary. Barriers to such access can be man-made, such as levees, or natural topography. For this element, it is assumed that the street infrastructure, or other available access to the study area, is the same for all alternatives. The effectiveness of this element was measured according to the percent of channel (both banks) occupied by levees for each alternative. An alternative with no obstruction to access would be rated a five (5), while an alternative with continuous levees and no access ramps to the channel areas would be rated a one (1).

For the Full-Structural Alternative, access to the channel is limited to the locations where ramps are provided in the proposed levees (approximately every 2000 feet). A higher degree of encroachment is possible, therefore, levees could occupy a higher percentage of the channel and further limit free access. For these reasons, the Full-Structural Alternative is not rated less than two (2). Access is restricted along approximately 53 percent of the Cave Creek channel and 69 percent of the Apache Wash system. Consequently, this alternative was given a relative rating of two (2) for both the Cave Creek and Apache Wash systems.

For the Soft-Structural Alternative, access is obstructed along approximately 18 percent of the Cave Creek channel and 32 percent of the Apache Wash system. This alternative was given a relative rating of four (4) for the Cave Creek system and three (3) for the Apache Wash system.

Since the Nonstructural Alternative contains no man-made obstructions to access, the alternative was given a rating of five (5) for both the Cave Creek and Apache Wash systems.

Incidental Use. This element accounts for the potential threat to public safety due to incidental uses of the watercourse areas. Examples of such uses might be walking, hiking, camping, or horseback riding. Since it is anticipated that incidental uses will be encouraged as a result of the WCMP, the potential for injury exists for all alternatives. Therefore, the maximum rating possible is limited to a four (4). The potential for injury is greater for alternatives containing structural features. For example, a person is more prone to injury on steep bank protection than a mild natural slope. Accordingly, the measure of the threat, due to structural features, is assumed to be proportional to the length of bank protection associated with a given alternative. The more bank protection, the lower the rating assigned to the alternative. An alternative with full channelization and bank protection is consider worst-cast and would receive a rating of one (1).

The Full-Structural Alternative is not fully channelized, however, it provides approximately 34,000 feet of bank protection along Cave Creek and approximately 60,000 feet of bank protection along the Apache Wash system. Consequently, the alternative was given relative ratings of three (3) and two (2), respectively.

The Soft-Structural Alternative provides approximately 9,000 feet of bank protection along Cave Creek and approximately 23,000 feet of bank protection along the Apache Wash system. This alternative was rated a four (4) and three (3), respectively.

The Nonstructural Alternative contains no bank protection, however, incidental use of the washes is expected. Therefore, the alternative was rated a four (4) for both the Cave Creek and Apache Wash systems.

The ratings for the public safety criterion are summarized on Table 8-6.2 which follows.

Table 8-6.2
RATING FOR PUBLIC SAFETY CRITERION

Evaluation Criteria	Full-Structural	Soft-Structural	Nonstructural
(1)	(2)	(3)	(4)
Upper Cave Creek			
Cumulative encroachment impacts	3	4	5
Local erosion impacts	4	3	5
Hydrologic modeling uncertainty	3	4	5
Hydraulic modeling uncertainty	3	4	5
Development opportunity	2	4	5
Risk of failure	3	4	5
Flood events greater than design storm	2	3	4
Flood events less than design storm	5	5	5
Emergency response	2	4	5
Incidental use	3	4	4
Average Rating for Upper Cave Creek:	**3.0**	**3.9**	**4.8**
Apache, Paradise and Desert Hills Washes			
Cumulative encroachment impacts	2	3	5
Local erosion impacts	4	3	5
Hydrologic modeling uncertainty	3	4	5
Hydraulic modeling uncertainty	3	4	5
Development opportunity	2	3	5
Risk of failure	2	3	5
Flood events greater than design storm	2	3	4
Flood events less than design storm	5	5	5
Emergency response	2	3	5
Incidental use	2	3	4
Average Rating for Apache Wash System:	**2.7**	**3.4**	**4.8**

8-6.2.2 *Social/Environmental*

The evaluation of the Social/Environmental criterion is based on the effectiveness of each alternative in satisfying the six (6) elements described below. The importance of these elements to the overall criterion varies. Therefore, each element is weighted on a scale of one (1) to ten (10) according to the consensus reached between the consultant team and representatives of the Flood Control District.

Community Acceptance. This element is weighted a nine (9). It accounts for the input received from the public involvement process and the fact that the study area location is primarily within the City of Phoenix Sonoran Preserve. Funding for the City of Phoenix Sonoran Preserve Master Plan was approved by 80% of the voters in 1999, indicating the broad support for preservation in the City. The Sonoran Preserve Master Plan evolved through an extensive four-year public involvement process. The Sonoran Preserve

Master Plan proposes the preservation of approximately 20,000 acres of desert and the natural hydrologic processes within that area, and has the force of policy by action of the City Council. This reflects the nationwide trend towards promoting non-structural approaches and ecosystem preservation, as witnessed by the removal of flood control structures in many parts of the country. Federal agencies such as the U.S. Army Corps of Engineers and the U.S. Bureau of Reclamation have, in recent years, significantly changed their focus from hard engineering solutions to include non-structural alternatives, preservation of natural hydrologic functions, and ecosystem restoration. The specific input from the public involvement process was that the preservation of watercourses and their associated habitat is more important than maximizing developable land by destroying the natural hydrologic processes, which results from encroaching into watercourses.

The effectiveness of the alternatives in meeting community acceptance is measured by the amount of land preserved in its natural state as a percentage of the total study area. The total study area is represented by the *non-encroachment area* for the Non-Structural Alternative. An alternative that preserves this entire zone would be rated a five (5), while an alternative that includes the maximum credible encroachment would be rated a one (1).

The Full-Structural Alternative preserves approximately 67 percent of the study area in the Cave Creek corridor and approximately 49 percent in the Apache Wash system. Even though less than half of the study area is preserved in the Apache Wash system, the degree of encroachment could be more severe than what is being proposed for this alternative. For this reason the alternative was given a relative rating of three (3) for Cave Creek and two (2) for the Apache Wash system.

The Soft-Structural Alternative preserves approximately 89 percent of the study area in the Cave Creek corridor and approximately 69 percent in the Apache Wash system. This alternative was rated a four (4) for Cave Creek and a three (3) for the Apache Wash system.

The Nonstructural alternative preserves 100 percent of the study area. As a result, the alternative is rated a five (5) for both the Cave Creek and Apache Wash systems.

Complexity of Environmental Permitting. This element is also weighted a nine (9). It focuses on the acquisition of the US Army Corps of Engineers 404 Permits and 401 Water Quality Certifications. The alternatives are measured based on the potential for needing a 404 Permit, the level of 404 Permit required (Nationwide vs. Individual), and the level of mitigation necessary to gain federal approval to construct the alternative. To evaluate this element, it is assumed that alternatives with structural features will cause disturbance to the land within the Waters of the United States. The more extensive the structural features, the lower the rating. As an example, constructing a wide, rectangular, concrete channel would place fill within the Waters of the United States, require an Individual 404 Permit and 401 Water Quality Certification, and require extensive mitigation measures to replace the relatively high-value habitat and vegetation associated with the undisturbed desert riparian wash. On a scale of one to five, an alternative supporting this type of structure would be rated as a one (1). Alternatives that do not include structural features would be rated a five (5).

The Full-Structural Alternative includes the construction of levees and bank protection along both sides of all the washes in the study area. However, as much of the main channel area as possible is left in its natural state. No lining of the channel bed is proposed. For this reason, this alternative was rated a two (2) for both the Cave Creek and Apache Wash systems.

The Soft-Structural Alternative contains significantly less bank protection and, therefore, less disruption to the area within the Waters of the U.S. As a result, this alternative was rated a three (3) for both the Cave Creek and Apache Wash systems.

The Nonstructural Alternative does not contain levees or bank protection on either the Cave Creek or the Apache Wash systems. However, the Nonstructural Alternative does contain a grade-control structural on Cave Creek, which would require a 404 Permit. Consequently, this alternative was rated a four (4) on Cave Creek and a five (5) on Apache Wash.

Impact on Wildlife Habitat. This element is weighted a six (6). It accounts for the potential impact on wildlife habitat by the proposed alternatives and how well the proposed management alternative will succeed in preserving or restoring the natural riparian environment found along the study watercourses. The most important indicator of this is the ability of a given alternative to preserve wildlife habitat or minimize disruption to existing habitat.

The measure of the impact is quantitative and based on the quality and acreage of wildlife habitat involved. The rating selected for a given alternative is based on the percent of combined high- and medium-value habitat potentially lost to development, relative to the total acreage of such habitat within the Cave Creek and Apache Wash corridors. The total acreage is that within the *non-encroachment area* of the Nonstructural Alternative. Alternatives that include full channelization would receive a rating of one (1) because they would potentially impact all wildlife habitat within the study area. Alternatives that do not impact any wildlife habitat within the study area would be rated a five (5).

The Full-Structural Alternative potentially impacts approximately 38 percent of the existing medium- and high-quality habitat in the Upper Cave Creek corridor and approximately 40 percent in the Apache Wash corridor. Since this alternative does not include channelization and the encroachment could be more severe than that proposed, the alternative is rated a three (3) for both the Upper Cave Creek and Apache Wash systems.

The Soft-Structural Alternative potentially impacts approximately 14 percent of the existing medium- and high-quality habitat in the Upper Cave Creek corridor and approximately 17 percent in the Apache Wash corridor. Since this is less than half the area impacted by the Full-Structural Alternative, the alternative is rated a four (4) for both the Upper Cave Creek and Apache Wash systems.

The Nonstructural alternative does not impact any of the wildlife habitat in the study area. As a result, the alternative is rated a five (5) for both the Upper Cave Creek and Apache Wash systems.

Visual Resource and Aesthetic Compatibility. This element is weighted a five (5). It is an indicator of the overall appearance projected by the alternatives. The visual resource and aesthetic compatibility criterion is based on the goals of the Sonoran Preserve Master Plan. The key goal is maintaining the visual qualities and character identified in the Sonoran Preserve Master Plan.

This element evaluates the relative degree of contrast between the various components of the alternatives and their setting in the landscape. Visual contrast is based on spatial dominance, visual compatibility, color, line, and form. The standard used to measure the compatibility of a given alternative is the construction of a wide, rectangular, concrete channel. Such a channel would spatially dominate the setting, have a high degree of contrast in terms of color, line, and form, and would not be visually compatible with the surrounding natural desert vegetation and landforms. A structure of this type would be rated as a one (1). Alternatives that do not include structural features would be rated a five (5).

The Full-Structural Alternative includes the construction of levees and bank protection along both sides of all the watercourses in the study area. However, as much of the main channel area as possible is left in its natural state. No concrete lining is included and more levees would be necessary, if a higher degree of encroachment were proposed. For these reasons, this alternative is rated a three (3) for both the Upper Cave Creek and Apache Wash systems.

The Soft-Structural Alternative contains significantly less bank protection and fewer levees when compared to the Full-Structural Alternative. Therefore, the alternative results in less visual contrast. For this reason, the alternative is rated a four (4) for both the Upper Cave Creek and Apache Wash systems.

The Nonstructural Alternative does not contain levees or bank protection on either the Upper Cave Creek or the Apache Wash systems. Consequently, this alternative was rated a five (5) for both the Upper Cave Creek and the Apache Wash systems.

Multi-use Opportunities. This element is weighted a four (4). It is an indicator of the potential for using the *non-encroachment area* for uses other than flood and erosion control. Examples of such uses included passive and active recreation, trails, and open space. The effectiveness of the criterion is based on the extent of multi-use opportunities that result from implementing a given alternative.

The alternatives were assessed based on their ability to accommodate multi-use trails/pathways, their compatibility with other potential recreation facilities in terms of access, and user's experience on the trail/pathway. The standard used to evaluate the alternatives is a combination of channel type and available access. Multi-use opportunities associated with a wide, rectangular, concrete channel with limited access points would be rated as a one (1) due to the limitations in accommodating equestrian use, the restriction on potential connections to other recreation facilities, and the less than desirable user experience. Alternatives that permit unlimited access to a natural channel environment would be rated a five (5).

As stated previously, the Full-Structural Alternative includes the construction of levees along both sides of all the watercourses in the study area. However, as much of the main channel area as possible is left in its natural state. No concrete lining is included and longer levees would be necessary, if a higher degree of encroachment were proposed. Ramps are proposed at approximately 2000-foot intervals to provide access to the channel bottom. Based on these characteristics, this alternative is rated a two (2) for both the Upper Cave Creek and Apache Wash systems.

The Soft-Structural Alternative contains significantly less length of levees when compared to the Full-Structural Alternative. Under this alternative, however, Upper Cave Creek would contain approximately half the length of levee, measured as a percent of the total bank length (18% vs. 32%), when compared to the Apache Watercourse system. To account for this, the alternative is rated a four (4) for Upper Cave Creek and a three (3) for the Apache Wash system.

The Nonstructural Alternative proposes natural channel areas without structural features that would obstruct access. Consequently, this alternative was rated a five (5) for both the Upper Cave Creek and the Apache Wash systems.

Impact on Cultural Resources. This element is also weighted a four (4). It accounts for the potential impact on cultural resources by a given alternative. It is also an indicator of how well the alternatives will succeed in preserving cultural resources. The measurement of the potential impact is based on the acreage of known cultural resources potentially lost due to development, as a percentage of the total acreage of known cultural resources along the Upper Cave Creek and Apache Wash corridors. The total acreage of known cultural resources is that contained within the *non-encroachment area* of the Nonstructural Alternative. An alternative that impacts all of the known cultural resources would be rated a one (1), while an alternative that impacts none of the known cultural resources would be rated a five (5).

The Full-Structural Alternative impacts approximately 52 percent of the known cultural resource areas along Upper Cave Creek, but does not impact any areas identified along the Apache Wash system. Since the degree of encroachment could be more severe than that proposed by the Full-Structural Alternative, the alternative was given a relative rating of two (2) for the Upper Cave Creek watercourse. Since there was no impact, it was rated a five (5) for the Apache Wash system.

The Soft-Structural Alternative impacts approximately 14 percent of the known cultural resource areas along Upper Cave Creek, but also does not impact any areas identified along the Apache Wash system. Since over 70 percent less acreage is impacted by this alternative, compared with the Full-Structural Alternative, it was rated a four (4) on the Upper Cave Creek watercourse. Since there was no impact, it was rated a five (5) for the Apache Wash system.

The Nonstructural Alternative does not impact cultural resources on either watercourse. Therefore, it was rated a five (5) for both the Upper Cave Creek and Apache Wash systems.

8-6.2.3 *Economic Criteria*

The evaluation of the economic criterion is based on the effectiveness of each alternative in satisfying two (2) elements that will be described below. The importance of these elements to the overall criterion also varies. Again, each element is weighted on a scale of one (1) to ten (10) according to the consensus reached between the consultant team and representatives of the Flood Control District.

Implementation Cost. This element is weighted an eight (8). This element represents the estimated cost of the proposed management alternative to the public, either through increased development costs passed onto future residents of the area who will directly benefit from the improvements (local public) or the costs to the general public. This cost considers the structural improvements necessary to implement the proposed management alternative (a positive cost), the value of land within the *Regulatory Line* reclaimed from the floodplain by the structural improvements (a negative cost, i.e. benefit), and the value of land outside the *Regulatory Line* that must be obtained to implement the alternative (a positive cost). Added together, these costs represent the total net cost of the alternative, as described in Section 5.

The effectiveness of a given alternative is measured by using the total net cost. The lower the net cost, the higher the rating for the alternative. The alternative with the lowest net cost in either the Upper Cave Creek or the Apache Wash system is rated a five (5), while the alternative with the highest net cost is rated one (1). The CSA bank protection is the least costly armor type for both Upper Cave Creek and Apache Wash. Therefore, the cost of this option is used in the evaluation process. The derivation of these costs is described in Section 5 of this attachment.

For the Full-Structural Alternative, the net cost is estimated to be \$1.1M for Upper Cave Creek and \$-0.7M for the Apache Wash system. The alternative was rated a four (4) and a five (5), respectively.

For the Soft-Structural Alternative, the net cost is estimated to be \$5.3M for Upper Cave Creek and \$-0.8M for the Apache Wash system. The alternative was rated a two (2) and a five (5), respectively.

For the Nonstructural Alternative, the net cost is estimated to be \$7.8M for Upper Cave Creek and \$5.0M for the Apache Wash system. The alternative was rated a one (1) and a two (2), respectively.

Maintenance Cost. This element is weighted a one (1). It accounts for the potential maintenance costs associated with the structural components of the three alternatives. It has been assumed that such costs are proportional to the length of bank protection proposed for a given alternative. The greater the bank protection length, the higher the potential maintenance cost and the lower the rating. However, since more severe encroachment is possible, it is also assumed that maintenance costs can be greater than those expected for the Full-Structural Alternative proposed. Therefore, the Full-Structural Alternative is not rated less than a two (2). An alternative with no bank protection would be rated a five (5).

The Full-Structural Alternative requires construction of approximately 34,000 lineal feet of bank protection for Upper Cave Creek and approximately 60,000 lineal feet for the Apache Wash system. Therefore, the alternative was rated a three (3) for Upper Cave Creek and a two (2) for the Apache Wash system.

The Soft-Structural Alternative calls for approximately 9,000 lineal feet of bank protection for Upper Cave Creek and approximately 23,000 lineal feet for the Apache Wash system. This alternative was rated a four (4) and a three (3), respectively.

Since there is no bank protection associated with the Nonstructural Alternative for either Upper Cave Creek or the Apache Wash system, the alternative was rated a five (5) for both.

8-6.3 Summary of Results

The scoring results for each alternative by watercourse one shown in Tables 8-6.3 through 8-6.5. A summary of scoring for the Upper Cave Creek and Apache, Paradise and Desert Hills Washes alternatives is shown in Table 8-6.6.

Table 8-6.3
SCORING FOR FULL-STRUCTURAL ALTERNATIVE

Evaluation Criteria	Rating (1-5)	Weighting Factor	Score [(2)x(3)]
(1)	(2)	(3)	(4)
UPPER CAVE CREEK			
Public Safety Criteria			
Public safety	3	10	30.0
Totals:	---	10	30.0
Composite Public Safety Criteria Rating (Score/Sum of weighting factors):			3.0
Economic Criteria			
Implementation cost	4	8	32.0
Maintenance cost	3	1	3.0
Totals:	---	9.0	35.0
Composite Economic Criteria Rating (Score/Sum of weighting factors):			3.9
Social and Environmental Criteria			
Community acceptance	3	9	27.0
Complexity of environmental permitting	2	9	18.0
Impact on wildlife habitat	3	6	18.0
Visual resource and aesthetic compatibility	3	5	15.0
Multi-use opportunities	2	4	8.0
Impact on cultural resources	2	4	8.0
Totals:	---	37.0	94.0
Composite Social and Environmental Criteria Rating (Score/Sum of weighting factors):			2.5
APACHE, PARADISE AND DESERT HILLS WASHES			
Public Safety Criteria			
Public safety	2.7	10	27.0
Totals:	---	10	27.0
Composite Public Safety Criteria Rating (Score/Sum of weighting factors):			2.7
Economic Criteria			
Implementation cost	5	8	40.0
Maintenance cost	2	1	2.0
Totals:	---	9.0	42.0
Composite Economic Criteria Rating (Score/Sum of weighting factors):			4.7
Social and Environmental Criteria:			
Community acceptance	2	9	18.0
Complexity of environmental permitting	2	9	18.0
Impact on wildlife habitat	3	6	18.0
Visual resource and aesthetic compatibility	3	5	15.0
Multi-use opportunities	2	4	8.0
Impact on cultural resources	5	4	20.0
Totals:	---	37.0	97.0
Composite Social and Environmental Criteria Rating (Score/Sum of weighting factors):			2.6

Table 8-6.4
SCORING FOR SOFT-STRUCTURAL ALTERNATIVE

Evaluation Criteria	Rating (1-5)	Weighting Factor	Score [(2)x(3)]
(1)	(2)	(3)	(4)
UPPER CAVE CREEK			
Public Safety Criteria			
Public safety	3.9	10	39.0
Totals:	---	10	39.0
Composite Public Safety Criteria Rating (Score/Sum of weighting factors):			3.9
Economic Criteria			
Implementation cost	2	8	16.0
Maintenance cost	4	1	4.0
Totals:	---	9.0	20.0
Composite Economic Criteria Rating (Score/Sum of weighting factors):			2.2
Social and Environmental Criteria			
Community acceptance	4	9	36.0
Complexity of environmental permitting	3	9	27.0
Impact on wildlife habitat	4	6	24.0
Visual resource and aesthetic compatibility	4	5	20.0
Multi-use opportunities	4	4	16.0
Impact on cultural resources	4	4	16.0
Totals:	---	37.0	139.0
Composite Social and Environmental Criteria Rating (Score/Sum of weighting factors):			3.8
APACHE, PARADISE AND DESERT HILLS WASHES			
Public Safety Criteria			
Public safety	3.4	10	34.0
Totals:	---	10	34.0
Composite Public Safety Criteria Rating (Score/Sum of weighting factors):			3.4
Economic Criteria			
Implementation cost	5	8	40.0
Maintenance cost	3	1	3.0
Totals:	---	9.0	43.0
Composite Economic Criteria Rating (Score/Sum of weighting factors):			4.8
Social and Environmental Criteria:			
Community acceptance	3	9	27.0
Complexity of environmental permitting	3	9	27.0
Impact on wildlife habitat	4	6	24.0
Visual resource and aesthetic compatibility	4	5	20.0
Multi-use opportunities	3	4	12.0
Impact on cultural resources	5	4	20.0
Totals:	---	37.0	130.0
Composite Social and Environmental Criteria Rating (Score/Sum of weighting factors):			3.5

Table 8-6.5
SCORING FOR NONSTRUCTURAL ALTERNATIVE

Evaluation Criteria	Rating (1-5)	Weighting Factor	Score [(2)x(3)]
(1)	(2)	(3)	(4)
UPPER CAVE CREEK			
Public Safety Criterion			
Public safety	4.8	10	48.0
Totals:	---	10	48.0
Composite Public Safety Criterion Rating (Score/Sum of weighting factors):			4.8
Economic Criteria			
Implementation cost	1	8	8.0
Maintenance cost	5	1	5.0
Totals:	---	9.0	13.0
Composite Economic Criterion Rating (Score/Sum of weighting factors):			1.4
Social and Environmental Criterion			
Community acceptance	5	9	45.0
Complexity of environmental permitting	4	9	36.0
Impact on wildlife habitat	5	6	30.0
Visual resource and aesthetic compatibility	5	5	25.0
Multi-use opportunities	5	4	20.0
Impact on cultural resources	5	4	20.0
Totals:	---	37.0	176.0
Composite Social and Environmental Criterion Rating (Score/Sum of weighting factors):			4.8
Apache, Paradise and Desert Hills Washes			
Public Safety Criterion			
Public safety	4.8	10	48.0
Totals:	---	10	48.0
Composite Public Safety Criterion Rating (Score/Sum of weighting factors):			4.8
Economic Criterion			
Implementation cost	2	8	16.0
Maintenance cost	5	1	5.0
Totals:	---	9.0	21.0
Composite Economic Criterion Rating (Score/Sum of weighting factors):			2.3
Social and Environmental Criterion:			
Community acceptance	5	9	45.0
Complexity of environmental permitting	5	9	45.0
Impact on wildlife habitat	5	6	30.0
Visual resource and aesthetic compatibility	5	5	25.0
Multi-use opportunities	5	4	20.0
Impact on cultural resources	5	4	20.0
Totals:	---	37.0	185.0
Composite Social and Environmental Criterion Rating (Score/Sum of weighting factors):			5.0

Table 8-6.6

SUMMARY OF SCORING FOR UPPER CAVE CREEK, APACHE, PARADISE & DESERT HILLS WASHES ALTERNATIVES

Evaluation Criteria (1)	Weighting Factor (2)	Full-Structural Rating (3)	Full-Structural Score* (4)	Soft-Structural Rating (5)	Soft-Structural Score* (6)	Nonstructural Rating (7)	Nonstructural Score* (8)
Upper Cave Creek							
Public Safety Criterion	10	3.0	30.0	3.9	39.0	4.8	48.0
Economic Criterion	8	3.9	31.2	2.2	17.6	1.4	11.2
Social and Environmental Criterion	9	2.5	22.5	3.8	34.2	4.8	43.2
Total Scores for Upper Cave Creek:	**---**	**---**	**83.7**	**---**	**90.8**	**---**	**102.4**
Apache, Paradise and Desert Hills Washes							
Public Safety Criterion	10	2.7	27.0	3.4	34.0	4.8	48.0
Economic Criterion	8	4.7	37.6	4.8	38.4	2.3	18.4
Social and Environmental Criterion	9	2.6	23.4	3.5	31.5	5.0	45.0
Total Scores for Apache Wash System:	**---**	**---**	**88.0**	**---**	**103.9**	**---**	**111.4**
Watercourse Master Plan							
Public Safety Criterion	---	---	57.0	---	73.0	---	96.0
Economic Criterion	---	---	68.8	---	56.0	---	29.6
Social and Environmental Criterion	---	---	45.9	---	65.7	---	88.2
Watercourse Master Plan Total Scores :	**---**	**---**	**171.7**	**---**	**194.7**	**---**	**213.8**

*Score = Weighting Factor x Rating Factor

8-6.3.1 Recommended Watercourse Master Plan

The recommended management plan for the WCMP is the Nonstructural Alternative. The most important criterion for evaluation of the WCMP alternatives is public safety. The Nonstructural Alternative achieved a total score of 96, as compared to scores of 57 and 73 for the Full-Structural and Soft-Structural Alternatives, respectively. This alternative achieved a total score of 102.4 out of a possible 135 points for Upper Cave Creek, a total score of 111.4 points for the Apache Wash system, and a combined total of 213.8 points for the WCMP study area. These total scores exceeded the scores for the other two alternatives. The Nonstructural Alternative is clearly the most successful at meeting the WCMP goals. A key factor supporting the Nonstructural Alternative is that it also meets the corresponding goals of the Sonoran Preserve Master Plan.

The State land included within the *non-encroachment area* of the Non-Structural Alternative, which is the vast majority of the area, is entirely within the land slated for purchase under the Arizona Preserve Initiative. However, an API designation does not guarantee preservation. The API designation is only good for a maximum of 7 years. After that time frame, the State Land Department is free to place the land on the open market for development. If sold, the State Land Department must sell the land at market value. It is recommended that the land within the *non-encroachment area* of the Nonstructural Alternative be designated a very high priority for acquisition under the

API. Successful implementation of the Nonstructural Alternative is contingent upon the and acquisition, or if land acquisition becomes infeasible, upon regulatory control of that area through such methods as zoning and density transfers.

8-7. 0 GLOSSARY

100-year Flood - A flood with a 100-year recurrence interval. The 100-year flood for the study area results from an average of 5.0-inches of precipitation over the entire watershed within a 24-hour period. The 2-year and 10-year floods result from 24-hour precipitations of 2.3-inches and 3.4-inches, respectively.

Acre-feet - An acre-foot of sediment is an acre of land covered by sediment 1 foot deep.

Aggradation - Aggradation is the progressive raising, over time, of a channel bed in a reach due to sedimentation.

Avulsion - An avulsion occurs when the main channel relocates to another part of the floodplain during a flood. This movement may occur suddenly as a result of a single large storm, although a series of floods over a long period of time may also contribute to the avulsive process.

Bajada - A broad, continuous sloping plain, formed by progressive sediment deposition, extending from the base of a mountain range.

Bed-form scour - The bed-form scour component accounts for the dynamic changes that occur in the shape of a moveable channel bed during passage of a flood. The bed of a sand and gravel channel actually forms wave-like anti-dunes with accompanying troughs, which migrate during a flood event. The trough depth must be included in the estimate of total scour depth.

Braided Watercourse - A braided watercourse is one which contains multiple channels that interconnect with each other. The floodplain of a braided watercourse is typically broader than other types of watercourses.

Channel - For the purpose of this study, a channel is defined as the portion of a cross section of a watercourse that carries stormwater. A channel is characterized by its bed and banks. The channel bed is made up of sand, gravel and/or cobbles. The channel banks may be heavily vegetated or have exposed soils. A watercourse cross section can have multiple channels. These channels may vary in elevation in relation to each other.

Computer Models - Computer models are used in this study to simulate natural functions for existing watershed and watercourse conditions, and to predict future watershed and watercourse conditions. The following computer models are used in this study:

Hydrology: US Army Corps of Engineers HEC-1 program.
Hydraulics: US Army Corps of Engineers HEC-2 and HEC-RAS programs.
Sediment Transport: US Army Corps of Engineers HEC-6 program.

Degradation - Degradation is the progressive lowering, over time, of the channel bed in a reach due to erosion.

Ephemeral Watercourse - An ephemeral watercourse is one in which runoff occurs only in direct response to precipitation. An ephemeral watercourse does not have water flowing in it year round.

Erosion - For the purpose of this study, erosion is defined as the natural process of flowing water removing soil, sand, gravel, or cobbles within a watercourse. Erosion has the effect of changing the watercourse geometry and increasing conveyance capacity. Erosion occurs naturally along all watercourses, but can be accelerated by human activities such as removal of bank vegetation, sand and gravel mining, or urbanization.

Existing Watershed Conditions - For the purpose of this study, existing watershed conditions are defined as the watershed conditions at the beginning of the WCMP project in April 1998.

FEMA Base Flood Elevation - The FEMA Base Flood Elevation (BFE) is the elevation of the 100-year water surface elevation at the location in question.

FEMA 100-year Floodway Fringe - The FEMA 100-year floodway fringe is defined by FEMA as the area inside the FEMA 100-year floodplain and outside the FEMA 100-year floodway. According to FEMA regulations, buildings or other obstructions to flow can be constructed in the FEMA 100-year floodway fringe provided the structures used for human habitation are raised above the BFE.

FEMA 100-year Floodplain - The FEMA 100-year floodplain is defined by FEMA as an area that is flooded by a 100-year recurrence interval storm. The area so defined is based on existing watershed and watercourse conditions at the time of the study. It does not include the effects, over time, of erosion and sedimentation in the watercourse.

FEMA 100-year Floodway - The FEMA 100-year floodway is defined by FEMA as a regulatory area that is reserved for conveyance of floodwaters, in which buildings or other obstructions are not allowed. The FEMA 100-year floodway limits are established by determining the amount of fill that can be placed in the FEMA 100-year floodplain without increasing the 100-year depth of flow by more than 1-foot.

Floodplain Encroachment - Floodplain encroachment, as defined by FEMA, means that development, including residential or commercial improvements, could be constructed within the FEMA 100-year floodway fringe. This could be accomplished using fill to raise building floor elevations above the FEMA 100-year floodplain elevation, or constructing levees to isolate the FEMA 100-year floodway fringe from the FEMA 100-year floodway.

Future Watershed Conditions - For the purpose of this study, future watershed conditions are defined as the watershed conditions resulting from future build-out development of the watershed in accordance with the 1995 MAG General Land Use Plan.

Gabion mattress - A gabion mattress is a wire basket filled with rock that is used as a structural measure for erosion protection.

Geomorphology - Geomorphology is the study of earth landforms and the processes that shape and change them.

Habitat Value - Habitat value refers to the suitability of the landscape for wildlife. Relative habitat values were determined for the study area and were assigned as high, medium, and low.

Head-cut - For the purpose of this study, a head-cut is defined as the upstream migration of a steep drop in the channel bottom. Such a drop can materialize through a sudden increase in the slope of a channel that can be natural or human-induced, which in turn increases the velocity and the erosive potential of the flowing water. This could impact a watercourse for miles. The head-cut can also be created directly through human activities, such as in-stream sand and gravel mining.

Hydraulics - For the purposes of this project, hydraulics is defined as the study of the ability of the watercourse to carry storm water. The hydraulic models are used to estimate the depth, width, velocity, energy, and travel time of flow through the study area.

Hydrology - For the purposes of this project, hydrology is defined as the study of surface water runoff from the contributing watersheds. The hydrology models are used to estimate watershed runoff volumes and peak flow rates in relation to time during storm events, for both existing and future watershed conditions.

Lateral Channel Migration - For the purpose of this study, lateral channel migration is defined as the movement of a channel within its floodplain through the processes of bank erosion or channel avulsions. Bank erosion is a natural process whereby soil material is removed from the channel banks during floods.

Main Channel - The main channel is defined as a channel that is continuous throughout the watercourse and carries the most flow.

Natural Angle of Repose - The maximum angle of slope that can be maintained by the soil material in a channel bank.

Non-Encroachment Area - For the purpose of this study, a non-encroachment area is the area within a watercourse management alternative where no floodplain encroachment is allowed. The uses permitted within the non-encroachment area are:

Drainage and stormwater conveyance, in an undisturbed desert state.

Open-space, unimproved (undisturbed desert with native landscape enhancements/restoration permitted).

Open-space, improved (limited to passive and active recreational activities including hiking/riding trails and similar activities within a desert landscape).

Reach - For the purpose of this study, a reach is defined as a portion of a watercourse in which watercourse characteristics are similar throughout the reach. Reaches can be defined based on hydrologic, hydraulic or geomorphologic similarities, or on similarities in biologic, visual, or landscape characteristics.

Recurrence Interval - A recurrence interval storm or flood is defined as a storm or flood that has a specific probability of occurring within any given year. For example, the 100-year recurrence interval storm or flood has a 1% probability of being equaled or exceeded in any given year. The other two recurrence interval storms or floods considered in this study are the 2-year (50% probability) and 10-year (10% probability).

Regulatory Line - The FEMA 100-year floodplain limits or Lateral Migration Erosion Hazard Zone limits, whichever is further from the main channel.

Riprap - A bank protection measure composed of fractured rock of differing sizes.

Scour - For the purpose of this study, scour is defined as a lowering of the channel bed by erosion. Scour occurs at natural or man-made obstructions to flow, or at channel banks. Examples of natural obstructions are trees in the channel, or constrictions in the channel. Man-made obstructions include bridge piers and grade-control structures.

Sediment Yield - Sediment yield is the amount of soil (mainly silt, sand and some gravel) that erodes from the watershed and enters the watercourse system.

Sedimentation - For the purpose of this study, sedimentation is defined as the natural process of flowing water depositing soil, sand, gravel and cobbles in the watercourse or on the floodplain. Deposition in the main channel has the effect of changing the shape and dimensions of the channel and decreasing its conveyance capacity.

Soil Cement - Soil cement is a structural erosion protection method that consists of mixing cement with native soils and water, and compacting it in place, and in layers to form a material that is resistant to erosion.

Watercourse - For the purpose of this study, a watercourse is defined as the entire length of a wash to be studied, including the width necessary for the watercourse to function naturally. This includes the watercourse channels, over-bank floodplains, and the area the watercourse has occupied in recent geologic time (<10,000 years).

Watercourse Conditions - The watercourse conditions used in hydraulic modeling are the main channel geometry (i.e., depth, width and slope) and its floodplain (areas outside the main channel that carry water), and roughness (resistance to flow). The main channel and floodplain make up the watercourse cross section.

Watershed Conditions - A watershed is the land contributing area that collects rainfall and directs it to a watercourse. The primary watershed conditions used in hydrologic modeling are the percentage of contributing area that is impervious to rainfall, the vegetative cover, soil characteristics relating to the ability to absorb and store water, and the ability of the watershed to collect and convey stormwater runoff.

8-8. 0 APPENDICES

A. Example Scour Computations
B. Earthwork Quantities
C. Armor Quantities
D. Construction Cost Estimates
E. Concept Plans

Design Event Scour Depth **Cross Section 27.226**

$Z_t = 1.3 * (Z_{gs} + Z_a + Z_{bs} + Z_{ls} + Z_{lft})$

- Z_t = Design Event Scour Depth (ft)
- 1.3 = Factor of Safety
- Z_{gs} = General Scour Depth (ft)
- Z_a = Anti-dune Trough Depth (ft)
- Z_{bs} = Bend Scour (ft)
- Z_{ls} = Local Scour Depth (ft)
- Z_{lft} = Low Flow Thalweg Depth (ft)

Z_{gs} = General Scour Depth (ft)

Z_{gs} = 2.5 ft — From HEC-6 Analysis (Figure 2 - Attached) Interpolated From a Peak to Peak Straight Line

Z_a = Anti-dune Trough Depth (ft)

$Z_a = 0.0137 * Vm2$ — Simons, Li and Associates (1982) p. 11.30

V_m = Average Velocity of Flow (ft/s)

V_m = 12.5 ft/s — HEC-RAS 100-Year Channel Velocity w/Encroachments

Z_a = 2.2 ft/s

Z_{bs} = Bend Scour (ft)

$$Z_{bs} = \frac{0.0685 * Y_{max} * (V_m^{0.8})}{Y_h^{0.4} * S_e^{0.3}} * \left[2.1 * \left(\frac{\sin^2(alpha/2)}{\cos alpha}\right)^{0.2} - 1\right]$$

Zeller (1981)

Y_{max} = Max Depth of Flow Immmediately Upsteam of Bend (ft)

Y_{max} = 9.1 ft — HEC-RAS 100-Year Maximum Channel Depth w/ Encroachments

V_m = Average Velocity of Flow (ft/s)

V_m = 12.5 ft/s — HEC-RAS 100-Year Channel Velocity w/ Encroachments

Y_h = Hydraulic Depth Immediately Upstream of Bend (ft)

Y_h = 6.4 ft — HEC-RAS 100-Year Hydraulic Channel Depth w/ Encroachments

S_e = Energy Slope Immediately Upstream of Bend (ft/ft)

S_e = 0.0117 ft/ft — HEC-RAS 100-Year E.G. Slope w/ Encroachments

alpha = Angle Formed By the Projection of the Channel Centerline from the Point of Curvature to a Line Tangent to the Outer Bank

alpha = 22 degrees — Topographic Mapping

Z_{bs} = 0.8 ft

Z_{ls} = Local Scour Depth (ft)

Zls = 0 ft — No Local Scour Depth

Z_{lft} = Low Flow Thalweg Depth (ft)

Z_{lft} = 0 ft

Scour Depths Referenced to Existing Thalweg Elevation

Z_{lt} = Left Bank Design Event Scour Depth (ft)

Z_t = 7.1 ft

Z_{rt} = Right Bank Design Event Scour Depth (ft)

Z_t = 6.0 ft

No Bend Scour Component on Right Side

Superelevation

Used Later to Determine Top of Bank Elevation

h_{del} = Superelevation at Outside Bank Around Channel Bends (ft)

$$h_{del} = \frac{V_T^2 * T}{g * r_c}$$

Chow p.448 & FCDMC Drainage Design p. 6-20

V_T = Average Velocity of Flow (ft/s) — HEC-RAS 100-Year Velocity w/Encroachments

V_T = 11.9 ft/s

T = Width of the Channel (ft) — HEC-RAS 100-Year Top Width w/Encroachments

T = 549.8 ft

g = Acceleration of Gravity (ft/s^2)

g = 32.2 ft/s^2

r_c = Radius of Curvature (ft)

$$r_c = \frac{T * \cos(alpha)}{4 * \sin^2(alpha/2)}$$

alpha = Angle Formed By the Projection of the Channel Centerline from the Point of Curvature to a Line Tangent to the Outer Bank

alpha = 22 degrees — Topographic Mapping

r_c = 3500 ft

h_{del} = Superelevation in Bank Around Channel Bends (ft)

h_{del} = 0.70 ft

Long Term Armoring — **Cross Section 27.226**

Determine the Long Term Armoring Depth using the USBR 'Computing Degredation and Local Scour Method'. Find the Average Individual Particle Size, D_c for four methods: Meyer-Peter Muller, Competent Bottom Velocity, Shields Method, and Yang's Incipient Motion.

Meyer-Peter Muller (Bedload Transport Equation) — 'Computing Degredation and Local Scour,' p. 9

$$D_c = \frac{d * S}{K * ((n_s / (D_{90}^{1/6}))^{3/2})}$$

d = Mean Water Depth at Dominant Discharge (ft) — HEC-RAS 10-Year Hydraulic Channel Depth w/Encroachments

d = 2.75 ft

S = Slope of Energy Gradient (ft/ft) — HEC-RAS 10-Year E.G. Slope w/Encroachments

S = 0.0137 ft/ft

K = 0.19 inch-pound units — 'Computing Degredation and Local Scour,' p. 9 Constant

K = 0.19

D_{90} = Particle Size Where 90% of Material by Weight is Finer — From Grain Size Distribution of Bed (Curve Attached)

D_{90} = 235 mm

n_s = Manning's Coefficient for Particle Roughness (Skin Friction) Average of 3 Representative Grain Sizes

$n_s = (D_{90}^{1/6}) / 44.4$ — Strickler (1923)

D_{90} = 235 mm — From Grain Size Distribution of Bed (Curve Attached)

D_{90} = 9.3 in

n_s = 0.033

$n_s = 0.04 * (D_{50}^{1/6})$ — Anderson (1970)

D_{50} = 7.7 mm — From Grain Size Distribution of Bed (Curve Attached)

D_{50} = 0.03 ft

n_s = 0.021

$n_s = (D_{75}^{1/6}) / 39$ — Lane and Carlson (1953)

D_{75} = 65 mm — From Grain Size Distribution of Bed (Curve Attached)

D_{75} = 2.6 in

n_s = 0.030

Average n_s = 0.028

D_c = 165.8 mm

Competent Bottom Velocity — 'Computing Degredation and Local Scour,' p. 10

$D_c = 1.88 * V_m^2$

V_m = Mean Channel Velocity (ft/s)

V_m = 7.7 ft/s — HEC-RAS 10-Year Channel Velocity w/Encroachments

D_c = 112.0 mm

Shield's Method — 'Computing Degredation and Local Scour,' p. 12

$$T_* = \frac{T_c}{(gamma_s - gamma_w) * D_c} = 0.06$$

T_* = Dimensionless Shear Stress

T_* = 0.06 — When R_*, Boundary Reynolds Number, is greater than 500

T_c = Ciritcal Shear Stress (lb/ft^2) — 'Computing Degredation and Local Scour,' p. 12 & Simons and Senturk p. 77 & 263

$T_c = gamma_w * d * S$

$gamma_w$ = Specific Weight of Water

$gamma_w$ = 62.4 lb/ft^3

d = Mean Water Depth at Dominant Discharge (ft) — HEC-RAS 10-Year Hydraulic Channel Depth w/Encroachments

d = 2.75 ft

S = Slope of Energy Gradient (ft/ft) — HEC-RAS 10-Year E.G. Slope w/Encroachments

S = 0.0137 ft/ft

T_c = 2.35 lb/ft^2

$gamma_s$ = Specific Weight of Particle

$gamma_s$ = 165 lb/ft^3

$gamma_w$ = Specific Weight of Water

$gamma_w$ = 62.4 lb/ft^3

Rearranging and Solving for

D_c = Diameter of Partice (ft)

D_c = 0.38 ft

D_c = 116.5 mm

Confirm Boundary Reynolds Number, R_*, > 500 — 'Computing Degredation and Local Scour,' p.12-13

$R_* = (U_* * D_c) / v$

v = Kinematic Viscosity (ft^2/s)

v = 0.00001 ft^2/s

U_* = Shear Velocity (ft/s)

$U_* = (T_c/(gamma_w/g))^{1/2}$ — Simons and Senturk p. 78

$U_* = (g * R * S_e)^{1/2}$ — Simons and Senturk p. 264

R = Hydraulic Radius = Hydraulic Depth in Wide Channels

U_* = 1.1 ft/s

R_* = 38,994

R_* > 500 Using T_* = 0.06 OK

Yang's Incipient Motion — 'Computing Degradation and Local Scour,' p. 14

$D_c = 0.00659 * V_{cr}^2$

V_{cr} = Velocity at incipient motion ft/s — HEC-RAS 10-Year Channel Velocity w/Encroachments

V_{cr} = 7.7 ft/s

D_c = 0.39 ft

D_c = 119.7 mm

D_c (Average of Four Methods)

D_c = 128.5 mm

p_{del} = Percentage of Bed Material Larger than D_c — From Grain Size Distribution of Bed (Curve Attached)

p_{del} = 17 %

Find Depth to Armor

$y_d = y_a * ((1 / p_{del}) - 1)$ — 'Computing Degradation and Local Scour,' p. 14

y_d = Depth to Armoring Layer

p_{del} = Percentage of Bed Material Larger than D_c

p_{del} = 17 % = 0.17

y_a = Thickness of the Amoring Layer

$y_a = 2 * D_c$ or 0.5' Whichever is smaller — 'Computing Degradation and Local Scour,' p. 15

y_a = 257.0 mm > 0.5' (152 mm)

y_a = 152.4 mm

Depth to Armoring

y_d =	**2.4**	**ft**

Equilibrium Slope **Cross Section 27.226**

Determine the Equilibrium Slope using the USBR 'Computing Degredation and Local Scour Method'
Find the Average Equilibrium Slope, S_{eq} for three methods: Schoklitsch Method, Meyer-Peter Muller, and Shield's Diagram Method.

Schoklitsch Equilibrium Slope — 'Computing Degredation and Local Scour,' p. 18

$$S_{eq} = K * \left(\frac{D_m * B}{Q}\right)^{3/4}$$

K = 0.00174 inch-pound units
K = 0.00174

B = Channel Width (ft) — HEC-RAS 10-Year Main Channel Width w/Encroachments
B = 414.8 ft

Q = Dominant Discharge (cfs) — HEC-RAS 10-Year Main Channel Discharge w/Encroachments
Q = 8800 cfs

D_m = Mean Particle Size (mm)

D_m = Mean Particle Size (mm) — Simons and Senturk p. 172

$$D_m = \frac{\text{Sum } (del_i * D_i)}{100}$$

del_i = Portion of Percentage Shown on the Grain Size Distribution Curve
del_i = 10 (%)

D_i = Mean Sample Size According to del_i increment

From Grain Size Distribution of Bed (Curve Attached)

D_0 = 0 mm
Ave D_i = 0.35 mm
D_{10} = 0.7 mm
Ave D_i = 1.1 mm
D_{20} = 1.5 mm
Ave D_i = 2 mm
D_{30} = 2.5 mm
Ave D_i = 3.65 mm
D_{40} = 4.8 mm
Ave D_i = 6.25 mm
D_{50} = 7.7 mm
Ave D_i = 12.85 mm
D_{60} = 18 mm
Ave D_i = 30 mm
D_{70} = 42 mm
Ave D_i = 67 mm
D_{80} = 92 mm
Ave D_i = 163.5 mm

D_{90} = 235 mm

Ave D_i = 442.5 mm

D_{100} = 650 mm

D_m = Mean Particle Size (mm)

D_m = 72.9 mm

Schoklitsch Equilibrium Slope

S_{eq} = 0.004 ft/ft

Meyer-Peter Muller Equilibrium Slope Method — 'Computing Degradation and Local Scour,' p. 18

$$S_{eq} = \frac{K * \left(\frac{Q}{Q_b}\right) * \left(\frac{n_s}{D_{90}^{1/6}}\right)^{3/2} * D_m}{d}$$

K = 0.19 inch-pound units — 'Computing Degradation and Local Scour,' p. 18

K = 0.19 — Constant

Q = Total Flow (cfs) — HEC-RAS 10-Year Total Discharge

Q = 8800 cfs — w/Encroachments

Q_b = Flow Over Bed (cfs) — HEC-RAS 10-Year Main Channel Discharge

Q_b = 8800 cfs — w/Encroachments

n_s = Manning's Coefficient for Particle Roughness (Skin Friction) Average of Three Methods

Average n_s = 0.028 — See Average n_s, p. 3

D_{90} = Particle Size Where 90% of Material by Weight is Finer — From Grain Size Distribution of Bed (Curve Attached)

D_{90} = 235 mm

D_m = Mean Particle Size (mm)

D_m = 72.9 mm

d = Mean Water Depth at Dominant Discharge (ft) — HEC-RAS 10-Year Hydraulic Channel Depth w/Encroachments

d = 2.75 ft

Meyer-Peter Muller Equilibrium Slope

S_{eq} = 0.006 ft/ft

Shield's Method

'Computing Degredation and Local Scour,' p. 19

$$S_{eq} = \frac{T_c}{gamma_w * d}$$

T_c = Ciritcal Shear Stress (lb/ft^2)

T_c = T. * ($gamma_s$ - $gamma_w$) * D_m

T. = Dimensionless Shear Stress

T. = 0.06 — When R., Boundary Reynolds Number, > 500

$gamma_s$ = Specific Weight of Particle

$gamma_s$ = 165 lb/ft^3

$gamma_w$ = Specific Weight of Water

$gamma_w$ = 62.4 lb/ft^3

D_m = Mean Particle Size (mm)

D_m = 72.9 mm

D_m = 0.24 ft

T_c = 1.5 lb/ft^2

d = Mean Water Depth at Dominant Discharge (ft) — HEC-RAS 10-Year Hydraulic Channel Depth with floodway encroachments

d = 2.75 ft

Shield's Diagram Equilibrium Slope

S_{eq} = 0.0086 ft/ft

Confirm Boundary Reynolds Number, R., > 500

R. = (U. * D_c) / v

v = Kinematic Viscosity (ft^2/s)

v = 0.00001 ft^2/s

U. = Shear Velocity (ft/s)

U. = $((S_{eq} * R * g))^{1/2}$

R = Hydraulic Radius = Hydraulic Depth in Wide Channels

R = d = Mean Water Depth at Dominant Discharge (ft)

d = 2.75 ft

U. = 0.87

R. = 19311

R. > 500 Using T. = 0.06 OK

Average S_{eq}

S_{eq} = 0.00634 ft/ft

Bank Protection Design **Cross Section 27.226**

TOB_L = Left Top of Bank Elevation (ft)

$TOB_L = WSE + h_{del} + F_b$

WSE = Encroached 100 Year WSE (ft)

WSE = 1743.9 ft

h_{del} = Superelevation at Outside Bank Around Channel Bend (ft)

h_{del} = 0.70 ft — See Superelevation Height p. 2

F_b = Freeboard

F_b = 3 ft — Levee Alternative

TOB_L = Left Top of Bank Elevation (ft)

TOB_L = 1747.6 ft

TOB_R = Right Top of Bank Elevation (ft)

$TOB_R = WSE + h_{del} + F_b$

WSE = Encroached 100 Year WSE (ft)

WSE = 1743.9 ft

h_{del} = Superelevation at Outside Bank Around Channel Bend (ft)

h_{del} = 0 ft — No Bends

F_b = Freeboard

F_b = 3 ft — Levee Alternative

TOB_R = Right Bank Top of Bank Elevation (ft)

TOB_R = 1746.9 ft

TOE_L = Left Bank Toe Down Elevation (ft)

$TOE_L = \text{Min RAS} - D_{lt}$

Min RAS = Minimum HEC-RAS Elevation (ft)' — HEC-RAS Minimum Elev at Cross Section (Thalweg)

Min RAS = 1734.8 ft

D_{lt} = Left Bank Total Degradation (ft)

$D_{lt} = Z_{lt} + y_d$

Z_{lt} = Left Bank Design Event Scour Depth (ft)

Z_{lt} = 7.1 ft — See Left Bank Design Event Scour Depth p. 2

y_d = Long Term Armoring Depth (ft)

y_d = 2.4 ft — See Long Term Armoring Depth p. 5

D_{lt} = 9.5 ft

TOE_L = Left Bank Toe Down Elevation (ft)

TOE_L = 1725.3 ft

TOE_R = Right Bank Toe Down Elevation (ft)

TOE_R = Min RAS - D_{rt}

Min RAS = Minimum HEC-RAS Elevation (ft)'

Min RAS = 1734.8 ft

D_{rt} = Right Bank Total Degredation (ft)

$D_{rt} = Z_{rt} + y_d$

Z_{rt} = Right Bank Design Event Scour Depth (ft)

Z_{rt} = 6.0 ft — See Right Bank Design Event Scour Depth p. 2

y_d = Long Term Armoring Depth (ft)

y_d = 2.4 ft — See Long Term Armoring Depth p. 5

D_{rt} = 8.4 ft

TOE_R = Right Bank Toe Down Elevation (ft)

TOE_R = 1726.4 ft

LL_s = Left Bank Slope Length (ft) — 2:1 Bank Side Slopes

$LL_s = ((TOB_L - TOE_L)^2 + ((TOB_L - TOE_L)*2)^2)^{1/2}$

LL_s = 49.8 ft

RL_s = Right Bank Slope Length (ft) — 2:1 Bank Side Slopes

$RL_s = ((TOB_R - TOE_R)^2 + ((TOB_R - TOE_R)*2)^2)^{1/2}$

RL_s = 45.8 ft

D_{50} = Dumped Riprap Median Particle Size (ft)

$D_{50} = 0.0122 * V_a^{2.06}$ — USBR-EM-25 (1974, Curve B)

V_a = Average Velocity (ft/s)

V_a = 12.5 ft/s — HEC-RAS 100-Year Channel Velocity w/ Encroachments

D_{50} = 2.2 ft

T_r = Riprap Layer Thickness (ft)

$T_r = 1.5 * D_{50}$ — FCDMC Drainage Design Man. Table 2 p.6-40 Rounded to the Nearest 1/2 Foot (1' Min.)

T_r = 3.5 ft

T_g = Gabion Thickness (ft)

T_g = 2/3 * D_{50} of Dumped Riprap (ft) — US Army Corps of Engineers Standard Design Practice

T_g = 1.5 ft

T_g = 18 in — Adjusted to Nearest Manufactured Size

CSA Layer Thickness, T_{CSA} (ft)

T_{CSA} = 9.0 ft — Standard CSA Layer Thickness

Bank Protection Volume

Riprap Bank Protection

R_{LF} = Left Bank Riprap Volume per Length (yd^3/ft)

V_{LF} = LL_S * Tr

LL_s = Left Bank Slope Length (ft)

LLs = 49.8 ft — See Left Bank Slope Length p. 10

T_r = Riprap Layer Thickness (ft)

T_r = 1.5 * Reach Ave D_{50}

Maximum Ave D_{50} = 3.4 ft — Average Over Entire Mined Reach

T_r = 5.5 ft

R_{LF} = 273.8 ft^3/ft of length

R_{LF} = 10.1 yd^3/ft of bank

R_{RF} = Right Bank Riprap Volume per Length (yd^3/ft)

V_{RF} = LL_S * Tr

RL_s = Right Bank Slope Length (ft)

RL_s = 45.8 ft — See Right Bank Slope Length p. 10

T_r = Riprap Layer Thickness (ft)

T_r = 1.5 * Reach Ave D_{50}

Maximum Ave D_{50} = 3.4 ft — Average Over Entire Mined Reach

T_r = 5.5 ft

R_{RF} = 251.9 ft^3/ft of length

R_{RF} = 9.3 yd^3/ft of bank

Gabion Bank Protection

G_L = Left Bank Gabion Volume per Length (yd^3/ft)

$G_L = LL_S * T_g$

LLs = 49.8 ft — See Left Bank Slope Length p. 10

T_g = Gabion Thickness (ft)

$T_g = 2/3 * \text{Reach Ave } D_{50}$ (ft) — US Army Corps of Engineers Standard Design Practice

Maximum Ave D_{50} = 3.4 ft — Average Over Entire Mined Reach

T_g = 2.3 ft

T_g = 27 in

T_g = 30 in — Adjusted to Nearest Manufactured Size

G_L = 124.5 ft^3/ft of length

G_L = 4.6 yd^3/ft of bank

G_R = Right Bank Gabion Volume per Length (yd^3/ft)

$G_R = RL_S * T_g$

RLs = 45.8 ft — See Right Bank Slope Length p. 10

T_g = Gabion Thickness (ft)

$T_g = 2/3 * \text{Reach Ave } D_{50}$ (ft)

Maximum Ave D_{50} = 3.4 ft

T_g = 2.3 ft

T_g = 27 in

T_g = 30 in — Adjusted to Nearest Manufactured Size

G_R = 114.5 ft^3/ft of length

G_R = 4.2 yd^3/ft of bank

CSA Bank Protection

CSA_L = Left Bank CSA Volume per Length (yd^3/ft)

$CSA_L = H * T_{CSA}$

H = Levee Height (ft)

$H = TOB_L - TOE_L$ — See TOB and TOE p. 9 + 10

H = 22.3 ft

T_{CSA} = CSA Layer Thickness (ft)

T_{CSA} = 9.0 ft — Standard CSA Layer Thickness

CSA_L = 200.4 ft^3/ft of length

CSA_L = 7.4 yd^3/ft of bank

CSA_R = Right Bank CSA Volume per Length (yd^3/ft)

$CSA_R = H * T_{CSA}$

H = Levee Height (ft)

$H = TOB_R - TOE_R$

H = 20.5 ft

See TOB and TOE p. 9 + 10

T_{CSA} = CSA Layer Thickness (ft)

T_{CSA} = 9.0 ft

CSA_R = 184.2 ft^3/ft of length

CSA_R = 6.8 yd^3/ft of bank

Scour Below Grade Control Structure **Cross Section 27.320**

Determine the Toe Down Depth of the Grade Control Structure.

$Z_{lsf} = 1.32 * q^{0.54} * H_t^{0.225} - TW$ USBR Design of Small Dams (1977)

Z_{lsf} = Depth of Scour due to Free Overfall Drop
q = Discharge per Unit Width of Channel Bottom (cfs/ft)

$q = \frac{Q}{W} * 1.3$ 30% Factor of Safety

Q = 35,800 cfs HEC-RAS 100-Year Discharge
W = 774 ft HEC-RAS 100-Year Channel Top Width @ 27.366
q = 60.1 cfs/ft

H_t = Total Drop in Head (ft) From U/S Energy Elevation (EG) to D/S EG
US EG = 1747.3 ft HEC-RAS 100-Year EG Elevation
DS EG = 1740.2 ft HEC-RAS 100-Year EG Elevation
H_t = 7.1 ft

TW = D/S Tailwater Depth (ft)
TW = 5.8 ft HEC-RAS 100-Year D/S Channel Hydraulic Depth

Z_{lsf} = 12.9 ft

x_{sce} = Horizontal Length to Z_{lsf} Depth (ft)
$x_{sce} = 6.0 * Z_{lsf}$

x_{sce} = 77.7 ft

L_s = Horizontal Length of Scour Hole (ft)
$L_s = 12 * Z_{lsf}$

L_s = 155.3 ft

BRAIDED REACH QUANTITIES

OK 12/28/2007 DEJ

EMBANKMENT R

AVE TOB ABOVE MIN RAS ELEV = 14.8'

TOB = MIN RAS + 14.8 = 1647.3 + 14.8 = 1662.1'

ΔH = 1662.1 − 1660.5 = 1.6' ≈ 2'

W_1 = 10' W_2 = 10 + 2(2)(2) = 18'

A = 2'(10+18)/2 = **28 ft³/ft**

EXCAVATION 2

AVE TOTAL DEGRADATION = 7.5'

AVE TOE = 1647.3 − 7.5 = 1639.8

ΔH = 1659.5 − 1639.8 = 20'

W_1 = 10' W_2 = 10' + 20(2) + 20(1.5) = 80'

A = 20(10+80)/2 = **900 ft³/ft**

EMBANKMENT L

AVE TOB ABOVE MIN RAS ELEV = 14.8'

TOB = 1647.3 + 14.8 = 1662.1'

ΔH = 1662.1 − 1661 = 1.1 ≈ 1'

W_1 = 10' W_2 = 10' + 1(2)(2) = 14'

A = 1(10+14)/2 = **12 ft³/ft**

ASL Consulting Engineers

SHEET NO ______ OF ______

ENGINEER DEJ DATE 8/15/2000 JOB NO 73500.0001 BY

SUBJECT CAVE CREEK QUANTITIES CHECKED BY

OFFICE ______ TELEPHONE ______

BRAIDED REACH QUANTITIES

(OK)

EXCAVATION L

AVE TOTAL DEGREDATION = 7.5

TOE = 1647.3 - 7.5 = 1639.8'

ΔH = 1658.5 - 1639.8' = 18.7' ≈ 19'

$w_1 = 10$ $w_2 = 10' + 19(2) + 19(1.5) = 76.5'$

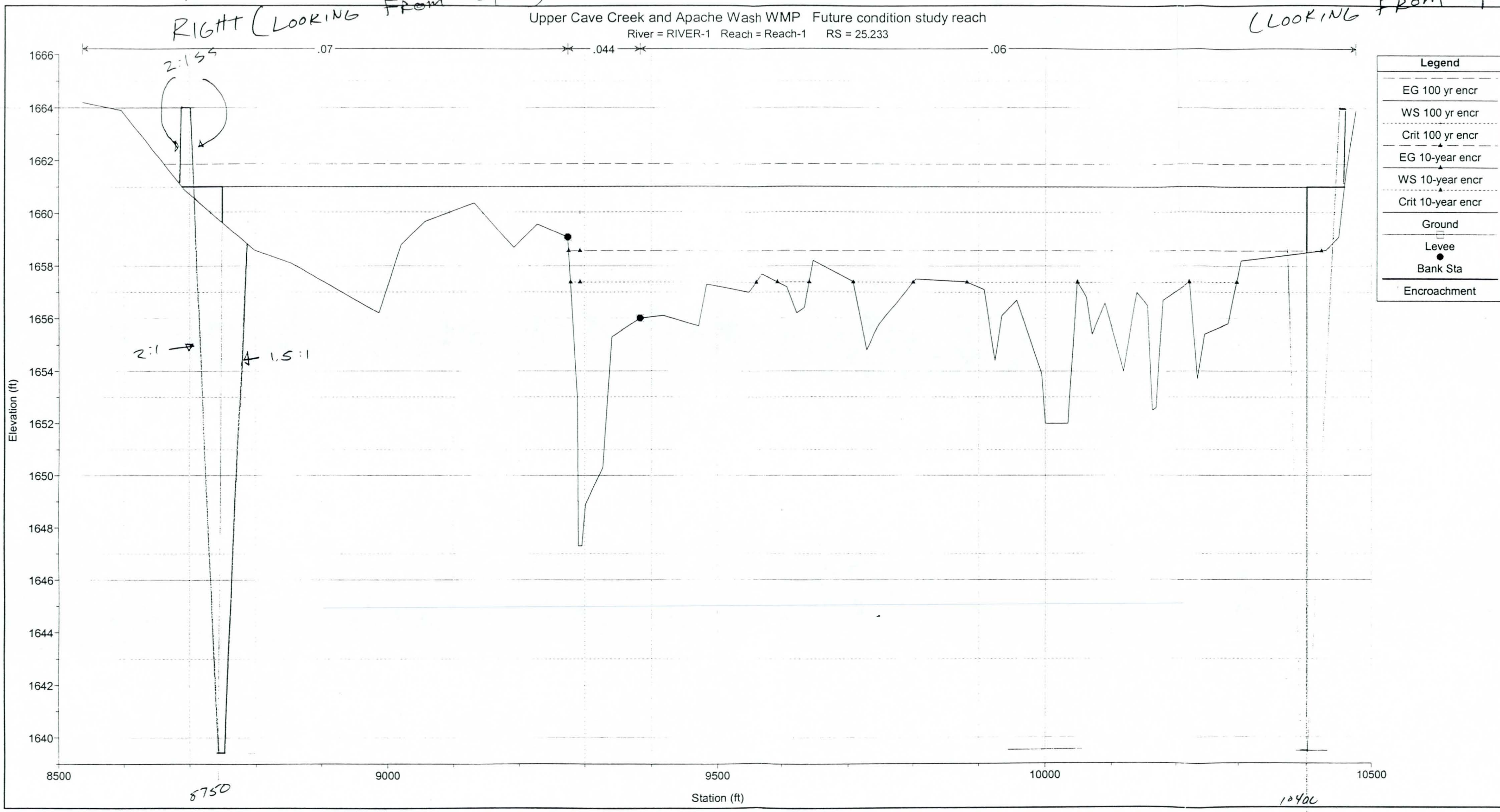
A = 19(10 + 76.5)/2 = 821.75 ft²/ft

REACH LENGTH = (25.338 - 24.919) * (5280) = 2212'

ITEM	AREA ft³/ft	LENGTH ft	CONVERSION yd³/ft³	VOLUME (YD³)
EMBANKMENT R	28	765	1 yd³ / 27 ft³	793
EXCAVATION R	900	1200	↓	40,000
EMBANKMENT L	12	1500	↓	667
EXCAVATION L	821.75	1500	↓	45,653

REDONE 1/18/01

AVERAGE SECTION



EX QUANTITIES

LEVEE TOB = 1664.0

FILL TOB = 1662.0

TOE DOWN = 1639.6

FULL STRUCTURAL - CAVE CREEK
MINED REACH QUANTITIES

EMBANKMENT R
TYPICAL SECTION RS = 25.644

AVE TOB ABOVE MIN RAS = 14.5

TOB = 14.5 + MIN RAS = 14.5 + 1669.8 = 1684.3

ΔH = TOB - EXISTING GROUND = 1684.3 - 1680 = 4.3

≈ 4.5

$W_1 = 10'$ $W_2 = 10 + 4.5(2)(2) = 28'$

AVE END AREA = $4.5(10+28)/2$ = <u>85.5 ft³/ft</u>

EXCAVATION R
AVE TOTAL DEGREDATION = 6.5'

TOE = MIN RAS - 6.5' = 1669.8 - 6.5 = 1663.3

ΔH = EXISTING GROUND - TOE = 1680 - 1663.3 = 16.7'

$W_1 = 10'$ $W_2 = 10' + 2(16.7) + 1.5(16.7) = 68.45'$

AVE END AREA = $16.7(10+68.45)/2$ = <u>655 ft³/ft</u>

SIMONS, LI & ASSOCIATES, INC.

CLIENT ______ JOB NO. ______ PAGE ______
PROJECT ______ DATE CHECKED ______ DATE ______
DETAIL ______ CHECKED BY ______ COMPUTED BY ______

CAVE CREEK - FULL STRUCTURAL
MINED REACH QUANTITIES

EMBANKMENT L

AVE TOB ABOVE MIN RAS = 14.5

TOB = 14.5 + MIN RAS = 14.5 + 1669.8 = 1684.3

ΔH = TOB - EXISTING GROUND = 1684.3 - 1674 = 10.3 ≈ 10.5

$W_1 = 10'$ $W_2 = 10 + 10.5(2)(2) = 52'$

AVE END AREA = 10.5(10+52)/2 = 325.5 ft²/ft

EXCAVATION L

AVE TOTAL DEGREDATION = 6.6'

TOE = MIN RAS - 6.6 = 1669.8 - 6.6 = 1663.2

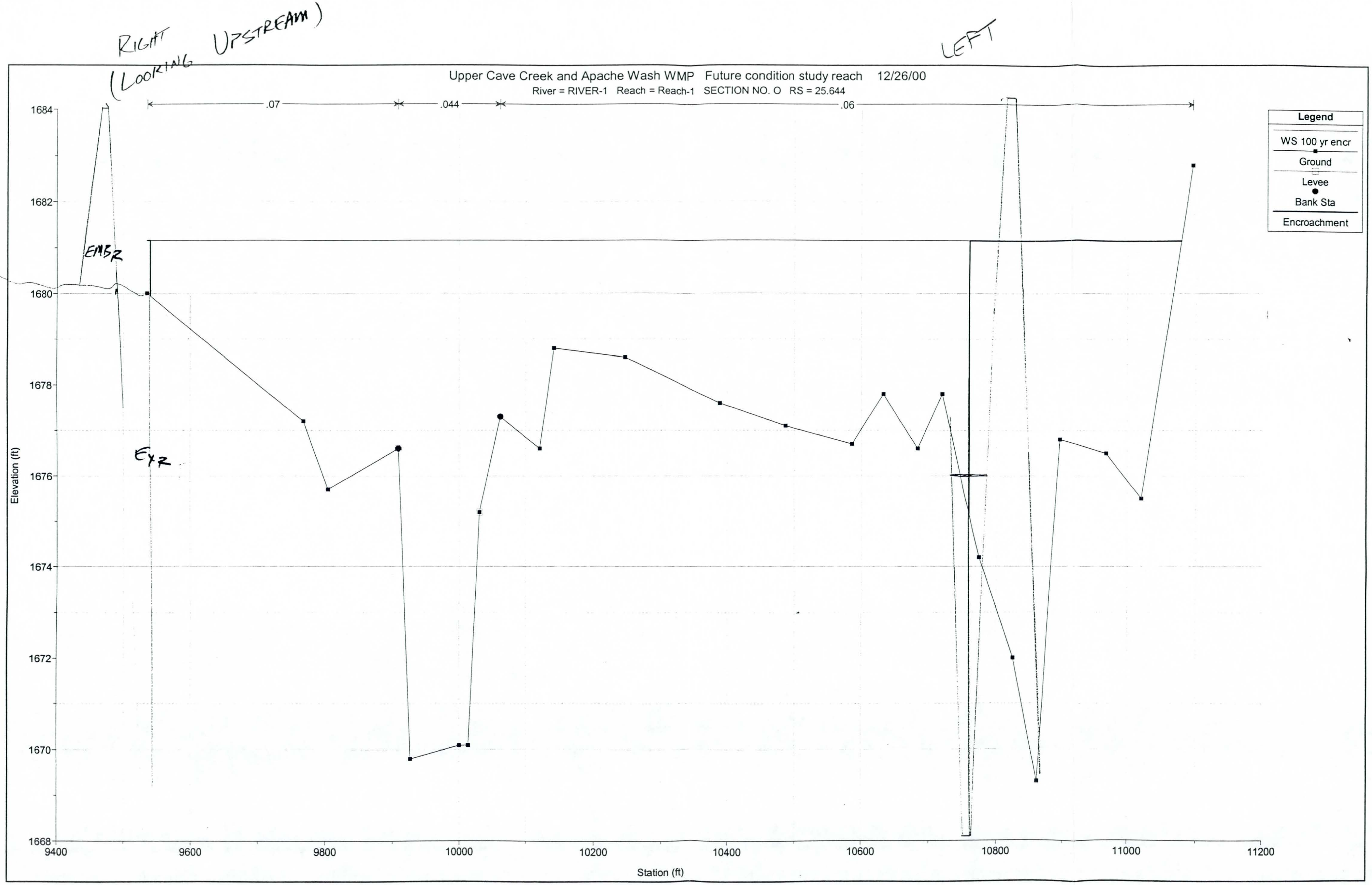
ΔH = EXISTING GROUND - TOE = 1676 - 1663.2 = 12.8 ≈ 13'

$W_1 = 10'$ $W_2 = 10 + 13(2) + 13(1.5) = 55.5$

AVE END AREA = 13(10+55.5)/2 = 425.75 ft²/ft

FULL STRUCTURAL
CAVE CREEK - MINED REACH

	AREA (ft^3/ft)	LENGTH (ft)	CONVERSION yd/ft^3	VOLUME (YD^3)
EMB R	85.5	1,490	1/27	4,718
EX R	655	6,468	↓	156,910
EMB L	325.5	10,000	↓	120,556
EX L	425.75	10,000	↓	157,685



TOB = 1684.2

TOE = 1662.0

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FULL STRUCTURAL ALT.

CAVE CREEK QUANTITIES CLIFF REACH

LEFT SIDE

EMBANKMENT - SAME AS TEAM - 252 ft^3/ft

EXCAVATION - SAME AS TEAM - 821.75 ft^3/ft

RIGHT SIDE

USE LEFT SIDE UNIT VOLUME

	AREA ft^3/ft	LENGTH ft	CONVERSION yd/ft^3	VOLUME (YD^3)
EMBANKMENT L	252	~~12,910~~ 11,246	1/27	~~120,493~~ 104,963
EX L	821.75	~~12,910~~ 12,312	↓	~~392,918~~ 374,718
EMBANK R	252	~~1895~~ 2058	↓	17,687 19,208
EX R	821.75	~~1895~~ 2183	↓	57,675 66,440

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SHEET NO ______ OF ______

ENGINEER DEJ DATE 8/14/2000 JOB NO 2350 0001 BY ______

SUBJECT APACHE WASH QUANTITIES CHECKED BY ______

OFFICE ______ TELEPHONE ______

HACKBERRY REACH STATION 0.75

EMBANKMENT R

AVE TOB ABOVE HEC-RAS MIN = 13.3'

AVE TOTAL DEGREDATION 10.5

TOB = MIN RAS + 13.3 = 1666.0 + 13.3 = 1679.3

$\Delta H = 5'$

$W_1 = 10'$ $W_2 = 10' + 5(2)(2) = 30'$

$A = 5(10+30)/2 =$ 100 ft³/ft

EXCAVATION R

TOE = 1666.0 − 10.5 = 1655.5'

$\Delta H = 1674 - 1655.5 = 18.5'$

$W_1 = 10'$ $W_2 = 10 + 18.5(2) + 18.5(1.5) = 74.8$

$A = 18.5(10' + 74.8')/2 =$ 784 ft³/ft

EMBANKMENT L

AVE TOB ABOVE MIN RAS = 13.2

AVE TOTAL DEGREDATION = 10.4

TOB = 1666.0 + 13.2 = 1679.2'

TOE = 1666.0 − 10.4 = 1655.6'

$\Delta H = 5'$

A = 100 ft³/ft

FULL STRUCTURAL ALTERNATIVE

APACHE WASH - HACKBERRY REACH

EXCAVATION L

$\Delta H = 1673 - 1655.4 = 17.6'$

$W_1 = 10 \quad W_2 = 10 + 17.6(2) + 17.6(1.5) = 71.6'$

$A = 17.6(10 + 71.6)/2 = 718 \text{ ft}^3/\text{ft}$

LENGTHS

LEFT SIDE 100+00 - 153+00 = 5300'

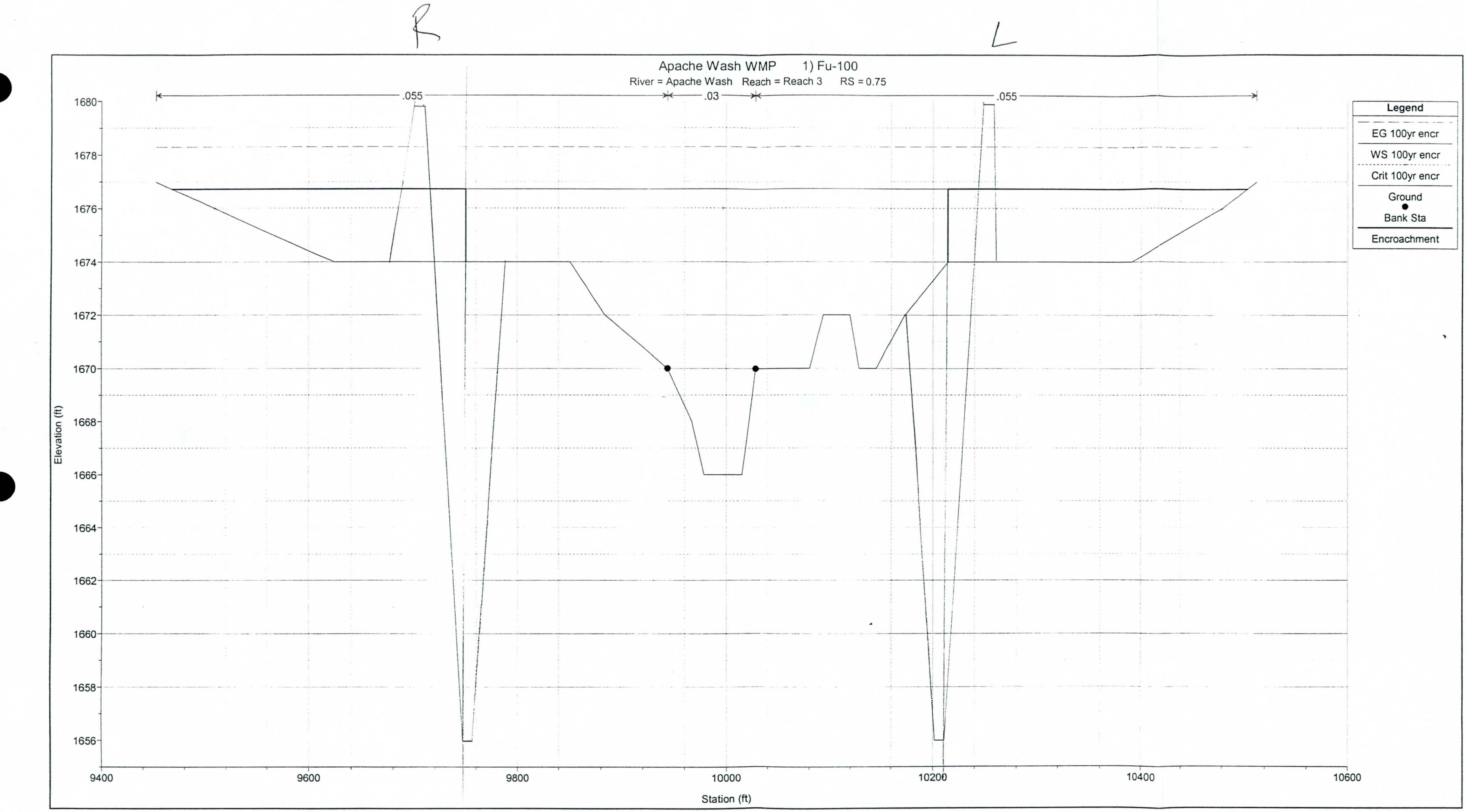
RIGHT SIDE EX 100+00 - 180+00 = 8000

RIGHT SIDE EMB 100+00 - 128+00 = 2800

145+00 - 168+00 = 2300

5100

HACKBERRY	LENGTH	AREA	CONV.	VOLUME
EMB L	100	~~5300~~ 5027	1/27	~~19,630~~ 18,619
EX L	718	~~5300~~ 5202	↓	~~140,941~~ 138,335
EMB R	100	~~5100~~ 4829	↓	~~18,889~~ 17,885
EX R	784	~~8000~~ 8296	↓	~~232,296~~ 240,891


R
L
Apache Wash WMP 1) Fu-100
River = Apache Wash Reach = Reach 3 RS = 0.75
.055
.03
.055
Legend
EG 100yr encr
WS 100yr encr
Crit 100yr encr
Ground
Bank Sta
Encroachment
Elevation (ft)
1680
1678
1676
1674
1672
1670
1668
1666
1664
1662
1660
1658
1656
9400
9600
9800
10000
10200
10400
10600
Station (ft)

FULL STRUCTURAL QUANTITIES

APACHE WASH - UNION HILLS REACH

RIGHT SIDE TYPICAL SECTION 2.08

EMBANKMENT

AVE TOB ABOVE MIN RAS = ~~13.5~~ 13.1

TOB = MIN RAS + ~~14.6~~ 13.1 = 1710 + ~~13.5~~ 13.1 = 1723.~~5~~1

ΔH = ~~6~~ 5'

w_1 = 10' W_2 = ~~6~~ 5 (2)(2) + 10 = ~~34~~' 30'

A = 6(10 + ~~34~~ 30)/2 = ~~132 ft³/ft~~ 120 ft³/ft

LENGTH = 187+00 - 195+00 = 800'

EXCAVATION

AVE DEGRADATION = ~~13.2~~' 12.4'

TOE = 1710 D - ~~13.2~~ 12.4 = ~~1696.8~~' 1697.6

ΔH = EX GROUND - TOE = 1710 - 1696.8 = ~~13.2~~ 12.4

W_1 = 10' W_2 = 10 + 13.2 (1.5) + 13.2 (2) = ~~56.2~~ 53.4

A_1 = ~~13.2~~ 12.4 (10 + ~~56.2~~ 53.4)/2 = ~~436.9 ft³/ft~~ 393.1 ft³/ft

A_2 W = 52.5

H = 1718 - 1710 = 8

A_2 = 52.5 (8) = 420 ft³/ft

A_T = A_1 + A_2 = ~~436.9~~ 393.1 + 420 = ~~856.92~~ 813.1 ft³/ft

DEJ
1/16/01

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FULL STRUCTURAL ALT

APACHE WASH - UNION HILLS REACH

LENGTHS

RIGHT SIDE

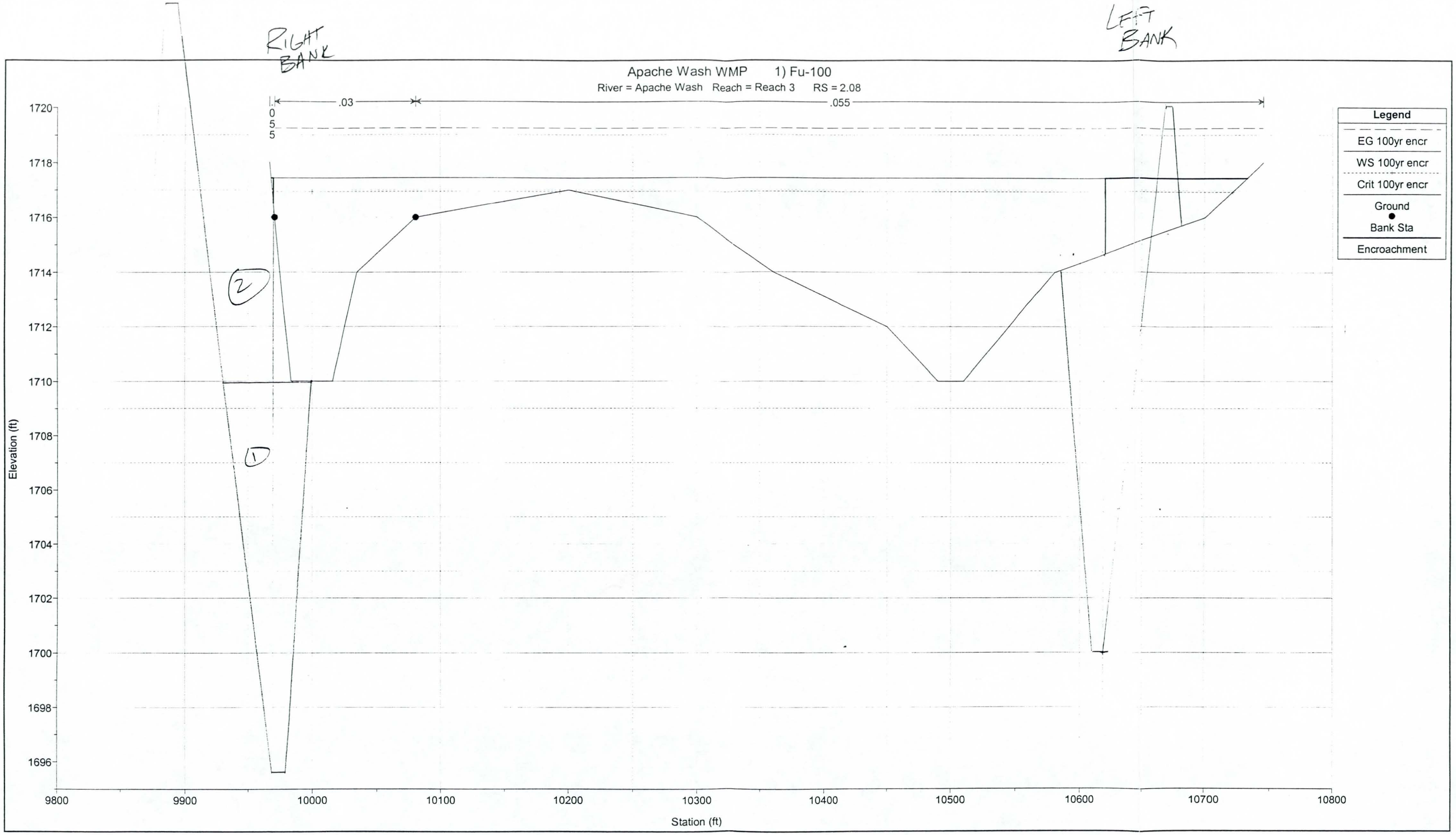
EMB
187+00 - 195+00 = 800'

EX

180+00 - 212+00 = 3200'

	LENGTH	AREA	CONV	VOLUME (yd^3)
EMBR	~~132~~ 120	~~800~~ 1162	1/27	~~3911~~ 5164
EXR	~~856.9~~ 813.1	3200	↓	~~101,561~~ 96,367

DJ
1/16/01


RIGHT BANK
LEFT BANK
Apache Wash WMP 1) Fu-100
River = Apache Wash Reach = Reach 3 RS = 2.08
.055
.03
.055
Legend
EG 100yr encr
WS 100yr encr
Crit 100yr encr
Ground
Bank Sta
Encroachment
Elevation (ft)
Station (ft)
1720
1718
1716
1714
1712
1710
1708
1706
1704
1702
1700
1698
1696
9800
9900
10000
10100
10200
10300
10400
10500
10600
10700
10800
2
1

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SHEET NO ______ OF ______

ENGINEER DEJ DATE 8/14/2000 JOB NO 23500001 BY

SUBJECT APACHE WMP QUANTITIES CHECKED BY

OFFICE ______ TELEPHONE ______

UPPER REACH QUANTITIES

EMBANKMENT R

AVE TOB ABOVE MIN RAS ELEV = 11.6'

TOB = MIN RAS + 11.6 = 1785.5 + 11.6 = 1797.2

ΔH = 1797.2 − 1789 = 8.2' ≈ 8'

W_1 = 10 W_2 = 10 + 8(2)(2) = 42' OK

A = 8'(10 + 42)/2 = 208 ft³/ft

EXCAVATION R

AVE TOTAL DEGREDATION = ~~8.6~~ 9.2

TOE = 1785.5 − ~~8.6~~ 9.2 = 1776.~~9~~3

ΔH = 1788 − 1776.~~9~~3 = 11.7 ~~≈ 11'~~ ≈ 12

W_1 = 10' W_2 = 10' + ~~11~~ 12(2) + ~~11~~ 12(1.5) = ~~48.5'~~ 62'

A = 12'(10' + ~~48.5'~~ 62)/2 = ~~321.75 ft³/ft~~

432 ft³/ft

EMBANKMENT L

AVE TOB ABOVE MIN RAS ELEV = 11.5

TOB = 1785.5 + 11.5 = 1797

ΔH = 1797 − 1792.5 = 4.5'

W_1 = 10 W_2 = 10' + 4.5(2)(2) = 28' OK

A = 5(10 + 28)/2 = 95 ft³/ft

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FULL STRUCTURAL ALT
APACHE WASH – UPPER REACH

EXL TOTAL ALT DEGRADATION = 9.6' OK

TOE = 1785.5 − 9.6 = 1775.9

ΔH = 1792 − 1775.9 = 16.1 ≈ 16'

$W_1 = 10$ $W_2 = 10 + 16(2) + 16(1.5) = 66$

A = 16(10+66)/2 = 608 ft³/ft

LENGTHS

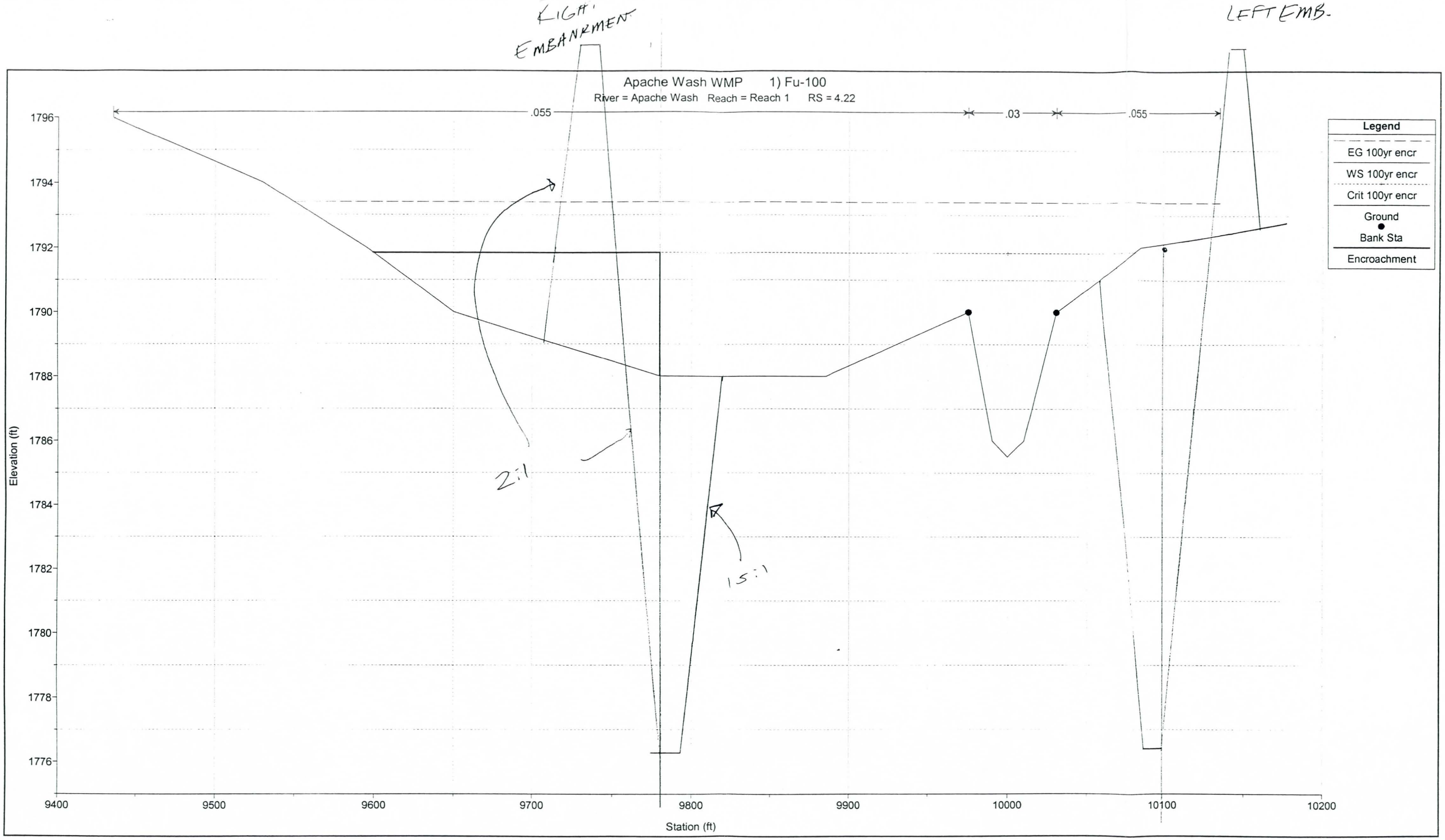
EMBR 212+00 − 227+00 = 1500
233+00 − 278+00 = 4500
284+00 − 340+00 = 5600
11,600

EXL 212+00 − 340+00 − 12,800

EXR 230+00 − 340+00 = 11,000

EMR 11,000

	AREA	LENGTH	CONV	VOLUME
EMBL	95	~~11,600~~ 6738	1/27	~~40,815~~ 23,708
EXL	608	~~12,800~~ 7419	↓	~~288,237~~ 167,065
EMBR	208	~~11,000~~ 7073	↓	~~84,741~~ 54,488
EXR	~~321.75~~ 432	~~11,000~~ 9258	↓	~~131,083~~ 148,128



RIGHT EMBANKMENT
LEFT EMB.
Apache Wash WMP 1) Fu-100
River = Apache Wash Reach = Reach 1 RS = 4.22
.055
.03
.055
Legend
EG 100yr encr
WS 100yr encr
Crit 100yr encr
Ground
Bank Sta
Encroachment
2:1
1.5:1
Elevation (ft)
Station (ft)

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SHEET NO. ______ OF ______

ENGINEER DEJ DATE 8/11/2000 JOB NO. 2350-AHC1

SUBJECT APACHE COST ESTIMATE QUANTITIES CHECKED BY ______

OFFICE ______ TELEPHONE ______

PARADISE WASH QUANTITIES

EMBANKMENT R

AVE TOB HEIGHT ABOVE MIN RAS ELEV = 9.2'

AVE TOTAL DEGRADATION = 5.3'

AT XS 183

TOB = MIN RAS + 9.2 = 1806.2 + 9.2 = 1815.4'

ΔH = 1815.4 − 1812 = 3.4 ≈ 3.5'

W_1 = 10' W_2 = 10' + 3.5'(2)(2) = 24'

A = 3.5'(10' + 24')/2 = 59.5 ft^3/ft OK

EXCAVATION R

TOE_R = 1806.2 − 5.3 = 1800.9'

EXR1 B = 20'
H = 10'

A = ½ BH = ½ (20')(10') = 100 ft^3/ft

EXR2 H = 10'
B = 20'

A = 10 (20)/2 = 100 ft^3/ft

A_T = 200 ft^3/ft OK

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SHEET NO ______ OF ______

ENGINEER AEJ DATE 2/11/ JOB NO. 2350-001 BY

SUBJECT APACHE COST ESTIMATE CHECKED BY

QUANTITIES

OFFICE ______ TELEPHONE ______

PARADISE WASH

LEFT AVE TOB ABOVE MIN RAS = 9.3' OK

AVE TOTAL DEGREDATION = 5.5'

EMBANKMENT L

TOB = MIN RAS + 9.3 = 1806 + 9.3 = 1815.3

$\Delta H = 5'$

$w_1 = 10'$ $W_2 = 10 + 5(2)(2) = 30'$

$A = 5(10 + 30')/2 = \underline{100 ft^3/ft}$ OK

EXCAVATION L

TOE = 1806 - 5.5 = 1800.5'

$\Delta H = 1810 - 1800.5 = 9.5$

$W_1 = 10'$ $W_2 = 10 + 9.5(2) + 9.5(1.5) = 43.2$

$A = 9.5(10 + 43.25)/2 = \underline{252.9 ft^3/ft}$

OK

LENGTHS

~~EMB R 100+00 - 106+00 = 600~~

~~114+00 - 180+00 = 6600~~

~~185+00 - 187+00 = 200~~

~~7400~~

~~EX R 100+00 - 201+00 = 10,100~~

~~EMB L 100+00 - 119+00 = 1900~~

~~129+00 - 195+00 = 6600~~

~~189+00 - 199+00 = 1000~~

~~9,500~~

EX L 100+00 - 195+00 = 9500

189+00 - 203+00 = 1,400

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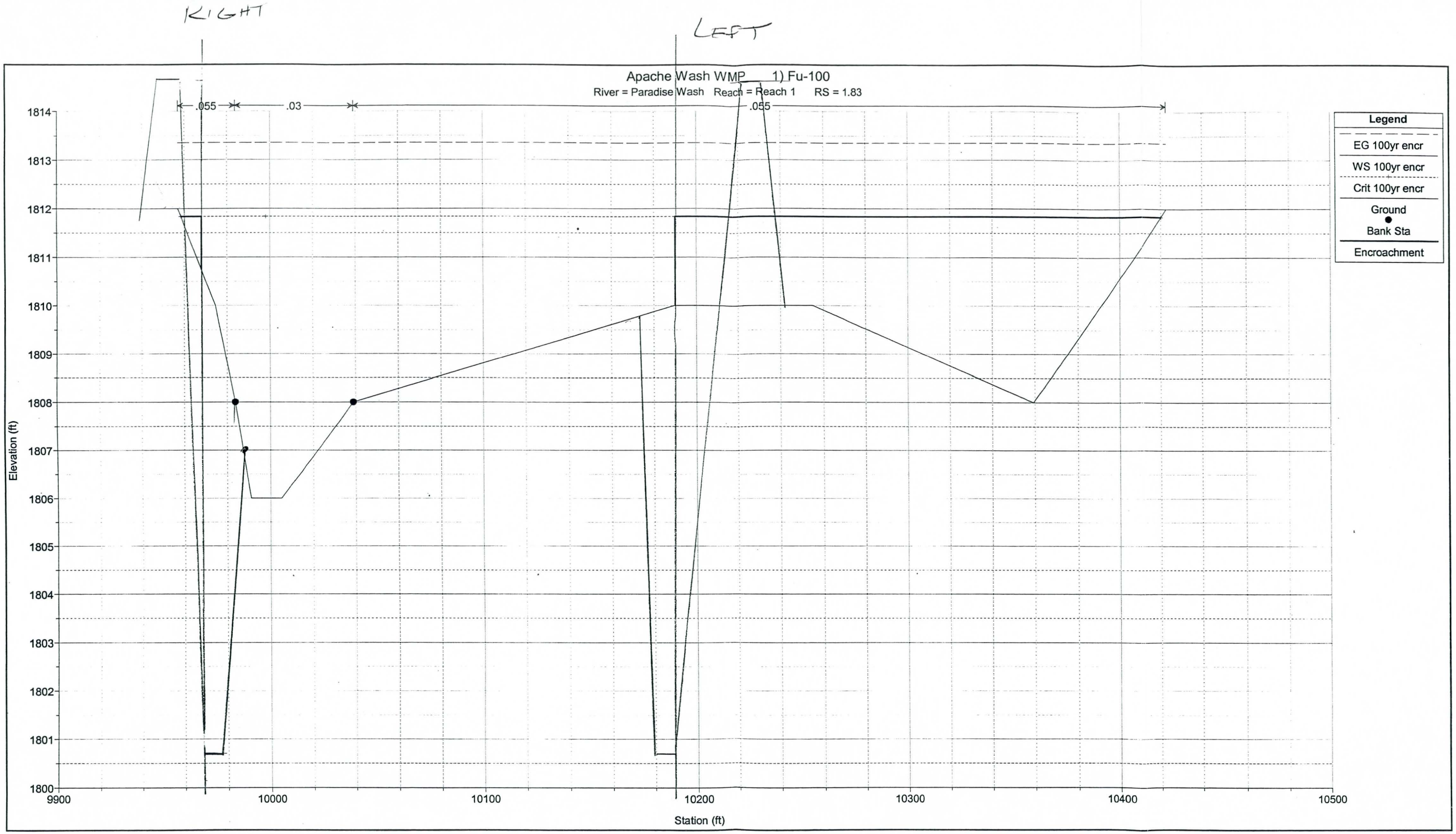
	AREA	LENGTH	CONV	VOLUME
EMBR	59.5	~~2400~~ 6,938	1/27	~~16,307~~ 15,289
EXR	200	~~10,100~~ 10,243	↓	~~74,815~~ 75,874
EMBL	100	~~9500~~ 9,224	↓	~~35,185~~ 34,163
EXL	2529	~~10,900~~ 10,984	↓	~~102,097~~ 102,883



KIGHT
LEFT
Apache Wash WMP 1) Fu-100
River = Paradise Wash Reach = Reach 1 RS = 1.83
.055
.03
.055
Legend
EG 100yr encr
WS 100yr encr
Crit 100yr encr
Ground
Bank Sta
Encroachment
Elevation (ft)
1814
1813
1812
1811
1810
1809
1808
1807
1806
1805
1804
1803
1802
1801
1800
Station (ft)
9900
10000
10100
10200
10300
10400
10500

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CLIENT ____ JOB NO. ____ PAGE ____
PROJECT ____ DATE CHECKED ____ DATE ____
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FULL STRUCTURAL

DESERT HILLS WASH QUANTITIES
TYPICAL SECTION RS = 0.64
EMBANKMENT R

AVE TOB ABOVE MIN RAS = 10.9

TOB = 10.9 + MIN RAS = 10.9 + 1742 = 1752.9

ΔH = TOB - EX. GROUND = 1752.9 - 1747 = 5.9 ≈ 6'

AVE END AREA

W_1 = 10' W_2 = 10 + 6(2)(2) = 34

END AREA = 6(10+34)/2 = <u>132 ft^3/ft</u>

EXCAVATION R

AVE TOTAL DEGRADATION = 6.1'

TOE = MIN RAS - 6.1' = 1742 - 6.1 = 1735.9

ΔH = EX GROUND - TOE = 1746.5 - 1735.9 = 10.6 ≈ 10.5

W_1 = 10' W_2 = 10 + 10.5(2) + 10.5(1.5) = 46.75

AVE END AREA = 10.5(10+46.75)/2 = <u>297.9 ft^3</u>

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CLIENT ________ JOB NO. ________ PAGE ________
PROJECT ________ DATE CHECKED ________ DATE ________
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FULL STRUCTURAL QUANTITIES
DESERT HILLS WASH

EMB_L TOB = SAME AS RIGHT SIDE = 1752.9

$\Delta H = 1752.9 - 1746 = 6.9 \approx 7'$

$W_1 = 10' \quad W_2 = 10 + 7(2)(2) = 38'$

AVE END AREA $= 7(10+38)/2 = \underline{168\ ft^3/ft}$

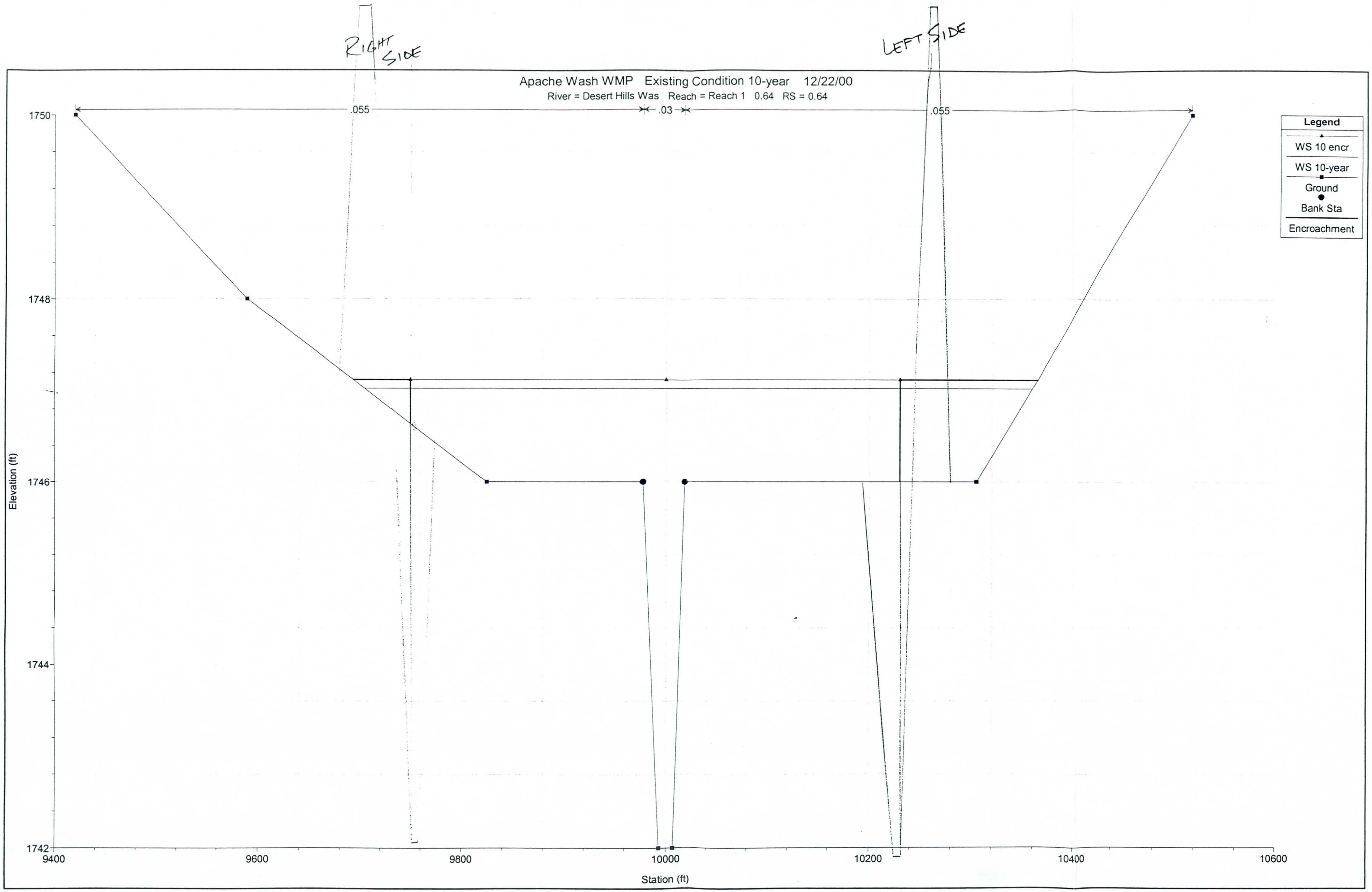
EX_L TOE = SAME AS RIGHT SIDE = 1735.9

$\Delta H = 1746 - 1735.9 = 10.1 \approx 10'$

$W_1 = 10 \quad W_2 = 10 + 10(2) + 10(1.5) = 45$

AVE END AREA $= 10(10+45)/2 = \underline{275\ ft^3/ft}$

	END AREA	LENGTH	CONVERSION	VOLUME (YD^3)
EMB R	132	2168	1/27	10,599
EX R	297.9	2168	↓	23,920
EMB L	168	3084	↓	19,189
EX L	275	3084	↓	31,411



RIGHT SIDE
LEFT SIDE
Apache Wash WMP Existing Condition 10-year 12/22/00
River = Desert Hills Was Reach = Reach 1 0.64 RS = 0.64
.055
.03
.055
Legend
WS 10 encr
WS 10-year
Ground
Bank Sta
Encroachment
1750
1748
1746
1744
1742
Elevation (ft)
9400
9600
9800
10000
10200
10400
10600
Station (ft)

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CLIENT: FCD | JOB NO. 2350001 | PAGE
PROJECT: CAVE CREEK | DATE CHECKED | DATE 1/16/01
DETAIL: QUANTITIES | CHECKED BY | COMPUTED BY

FULL STRUCTURAL

DESIGN GRADE CONTROL STRUCTURE

$Z_{LSF} = 1.32 * q^{0.54} * H_t^{0.225} - TW$

Z_{LSF} = DEPTH OF SCOUR DUE TO FREE OVERFALL (ft)
q = UNIT DISCHARGE (ft³/ft)
H_t = TOTAL DROP IN HEAD (ft)
TW = TAILWATER DEPTH (ft)

$q = \frac{Q}{W} * 1.3$ 30% FS

Q = 35,800 cfs RAS 100 YR DISCHARGE
W = 773' RAS 100 YR TOP WIDTH

$q = \frac{35,800 \text{ cfs}}{773 \text{ ft}} * 1.3 = 60.1$

H_t = U/S EG ELEV − D/S EG ELEV
= 1747.3 − 1740.2 = 7.1'

$H_t = 7.1$
TW = 5.8

$Z_{LSF} = 1.32 * 60.1^{0.54} * 7.1^{0.225} - 5.8'$
Z_{LSF} = 12.9 ft

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X_{sce} = HORIZONTAL LENGTH TO MAX Z_{LSF} DEPTH

$X_{sce} = 6 * Z_{LSF} = 6 * 12.9 = 77.6$

$X_{sce} = 78'$

L_S = HORIZONTAL LENGTH OF SCOUR HOLE

$L_S = 12 * Z_{LSF} = 12 * 12.9 = 155.2$

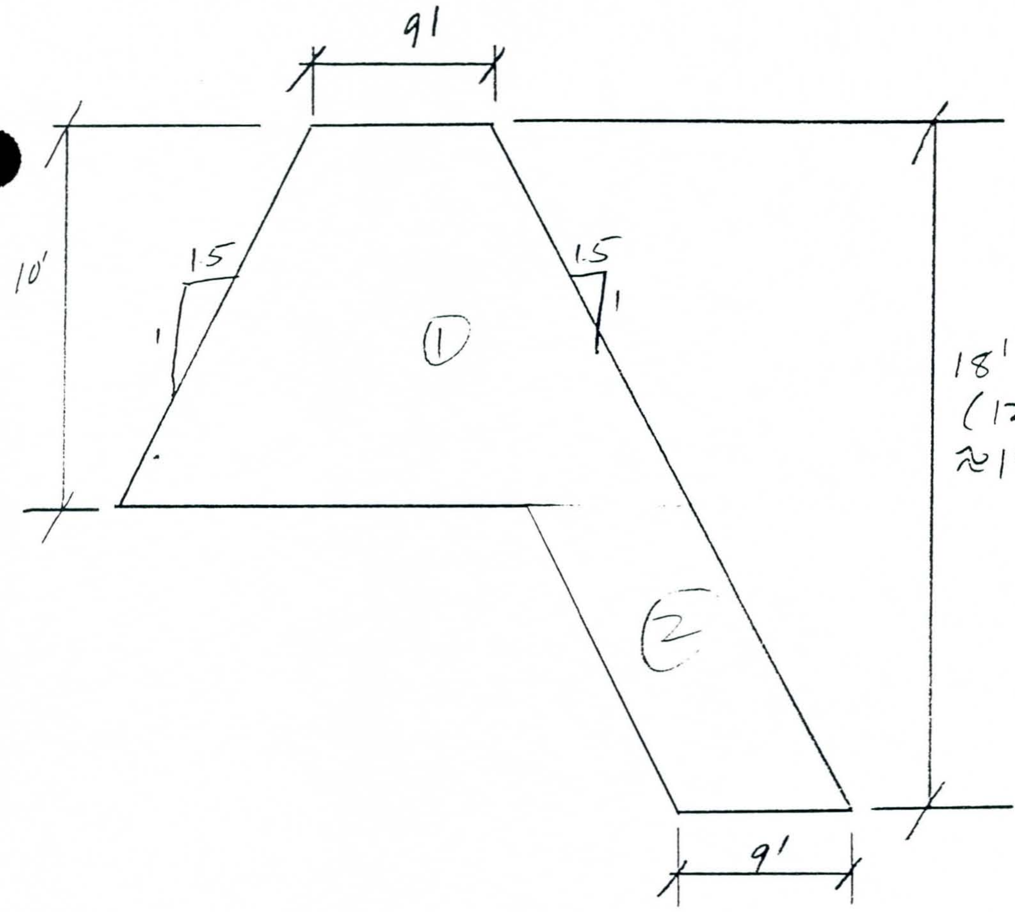
$L_S = 156'$

DETERMINE CSA QUANTITY FOR GGS

TOP WIDTH = 9'

U/S TOE DOWN DOWN DEPTH = 10'

TOTAL DROP = 12.9+5 = 17.9



AVERAGE END AREA

A_1 $H = 10$

$W_1 = 9'$ $W_2 = 10' + 2(9)(1.5) = 37'$

$A_1 = 10(9+37)/2 = 230 \text{ ft}^3/\text{ft}$

A_2 $H = 8'$

$W = 9'$

$A_2 = 8' * 9' * \frac{1'}{1'} = 72 \text{ ft}^3/\text{ft}$

$A_T = 230 + 72 = 302 \text{ ft}^3/\text{ft}$

GCS WIDTH

W = FLOODPLAIN WIDTH + 5(TOTAL DROP) * 2 SIDES

$W = 1381 + 5(18)(2)$ (ORIGINAL RAS FP WIDTH)

$W = 1561'$

$\text{VOLUME} = A_T * W = 302 \text{ ft}^3/\text{ft} * 1561' * \frac{1 \text{ yd}^3}{27 \text{ ft}^3}$

$V = 17,460 \text{ yd}^3$

VOLUME = 17,500 yd³

CSA CEMENT = 7% OF CSA

$$\text{CEMENT} = 17{,}460\ yd^3 * 0.07 * \frac{27\ ft^3}{1\ yd^3} * 150\ \frac{lb}{ft^2}$$

$$* \frac{1\ ton}{2000\ lb} = 2475\ \text{tons}$$

CEMENT = 2500 tons

HEC-RAS Plan: Future River: RIVER-1 Reach: Reach-1 (Continued)

Reach	River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl	Q Channel	Ch Sta L	Ch Sta R
		(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)		(cfs)	(ft)	(ft)
Reach-1	27.693	35800.00	1756.30	1774.96	1774.96	1778.20	0.007229	15.32	3079.71	500.51	0.88	31475.63	9961.10	10195.80
Reach-1	27.693	8800.00	1756.30	1766.11	1766.11	1769.07	0.010976	13.79	638.04	107.18	1.00	8800.00	9961.10	10195.80
Reach-1	27.693	2300.00	1756.30	1762.31	1761.88	1763.50	0.009386	8.76	262.46	78.27	0.84	2300.00	9961.10	10195.80
Reach-1	27.604	35800.00	1754.20	1767.51	1766.98	1770.58	0.005926	14.38	3004.91	556.89	0.81	34140.73	9740.20	10014.40
Reach-1	27.604	35800.00	1754.20	1768.68	1766.84	1771.12	0.004111	12.83	3258.74	437.82	0.68	34065.73	9740.20	10014.40
Reach-1	27.604	8800.00	1754.20	1762.23	1760.77	1763.16	0.004204	7.75	1136.02	226.54	0.61	8800.00	9740.20	10014.40
Reach-1	27.604	2300.00	1754.20	1758.38	1757.96	1759.07	0.008850	6.67	344.85	151.46	0.78	2300.00	9740.20	10014.40
Reach-1	27.502	35800.00	1748.80	1765.01	1765.01	1767.26	0.004926	13.65	4678.95	1057.45	0.74	27391.89	9947.50	10150.40
Reach-1	27.502	35800.00	1748.80	1765.38	1765.38	1768.37	0.005610	14.87	3508.40	640.58	0.79	30919.04	9947.50	10150.40
Reach-1	27.502	8800.00	1748.80	1757.48	1757.13	1759.72	0.009339	11.99	733.78	137.53	0.91	8800.00	9947.50	10150.40
Reach-1	27.502	2300.00	1748.80	1754.37	1753.55	1755.06	0.006069	6.68	344.13	112.84	0.67	2300.00	9947.50	10150.40
Reach-1	27.417	35800.00	1744.80	1757.10	1757.10	1759.63	0.012360	14.21	3328.58	705.57	0.91	27226.89	9942.80	10200.80
Reach-1	27.417	35800.00	1744.80	1757.82	1757.82	1760.96	0.012331	15.04	2985.02	630.63	0.92	31582.91	9942.80	10200.80
Reach-1	27.417	8800.00	1744.80	1751.95	1751.91	1753.92	0.018278	11.28	780.09	196.93	1.00	8800.00	9942.80	10200.80
Reach-1	27.417	2300.00	1744.80	1749.25	1749.25	1750.28	0.022731	8.15	282.23	137.02	1.00	2300.00	9942.80	10200.80
Reach-1	27.366	35800.00	1742.30	1751.89	1751.89	1754.45	0.013630	13.48	3076.28	781.23	0.93	31910.83	9737.60	10110.10
Reach-1	27.366	35800.00	1742.30	1752.64	1752.64	1755.19	0.011085	13.04	3109.31	773.70	0.86	34469.76	9737.60	10110.10
Reach-1	27.366	8800.00	1742.30	1748.33	1747.92	1749.37	0.013828	8.19	1073.96	357.66	0.83	8800.00	9737.60	10110.10
Reach-1	27.366	2300.00	1742.30	1746.61	1744.96	1746.91	0.006835	4.40	522.59	261.22	0.55	2300.00	9737.60	10110.10
Reach-1	27.32	35800.00	1743.00	1745.85	1745.85	1747.27	0.020030	9.60	3748.02	1328.63	1.00	35659.29	9694.13	11000.00
Reach-1	27.32	35800.00	1743.00	1745.85	1745.85	1747.29	0.020193	9.62	3721.86	1305.87	1.00	35800.00	9694.13	11000.00
Reach-1	27.32	8800.00	1743.00	1744.12	1744.12	1744.68	0.027503	6.03	1460.18	1305.87	1.00	8800.00	9694.13	11000.00
Reach-1	27.32	2300.00	1743.00	1743.46	1743.46	1743.69	0.036926	3.85	597.30	1305.87	1.00	2300.00	9694.13	11000.00
Reach-1	27.316	35800.00	1735.00	1739.67	1737.84	1740.20	0.003809	5.83	6191.78	1343.27	0.47	35569.43	9694.13	11000.00
Reach-1	27.316	35800.00	1735.00	1739.72	1737.84	1740.23	0.003692	5.77	6250.65	1343.62	0.47	35567.27	9694.13	11000.00
Reach-1	27.316	8800.00	1735.00	1736.89	1736.12	1737.08	0.004761	3.56	2479.98	1320.98	0.46	8777.02	9694.13	11000.00
Reach-1	27.316	2300.00	1735.00	1735.84	1735.46	1735.91	0.004910	2.10	1095.86	1312.57	0.40	2297.33	9694.13	11000.00
Reach-1	27.265	35800.00	1733.44	1738.42	1736.63	1739.07	0.004338	6.48	5575.09	1139.82	0.51	35508.98	9900.00	11000.00
Reach-1	27.265	35800.00	1733.44	1738.48	1736.64	1739.13	0.004304	6.47	5535.85	1100.00	0.51	35800.00	9900.00	11000.00
Reach-1	27.265	8800.00	1733.44	1735.51	1734.70	1735.74	0.004996	3.87	2276.14	1100.00	0.47	8800.00	9900.00	11000.00
Reach-1	27.265	2300.00	1733.44	1734.36	1733.98	1734.45	0.005782	2.42	951.57	1040.20	0.45	2300.00	9900.00	11000.00
Reach-1	27.226	35800.00	1732.25	1737.37	1735.64	1738.11	0.004769	6.92	5228.08	1042.52	0.54	35471.94	9928.40	10930.00
Reach-1	27.226	35800.00	1732.25	1737.43	1735.65	1738.17	0.004734	6.91	5184.43	1001.60	0.53	35800.00	9928.40	10930.00
Reach-1	27.226	8800.00	1732.25	1734.41	1733.59	1734.67	0.005239	4.07	2161.78	1001.60	0.49	8800.00	9928.40	10930.00
Reach-1	27.226	2300.00	1732.25	1733.22	1732.80	1733.31	0.005205	2.38	967.11	1000.83	0.43	2300.00	9928.40	10930.00
Reach-1	27.169	35800.00	1730.51	1735.84	1734.10	1736.64	0.004941	7.24	5007.82	961.70	0.55	35428.28	9850.90	10770.00
Reach-1	27.169	35800.00	1730.51	1735.91	1734.11	1736.72	0.004898	7.22	4960.92	919.10	0.55	35800.00	9850.90	10770.00

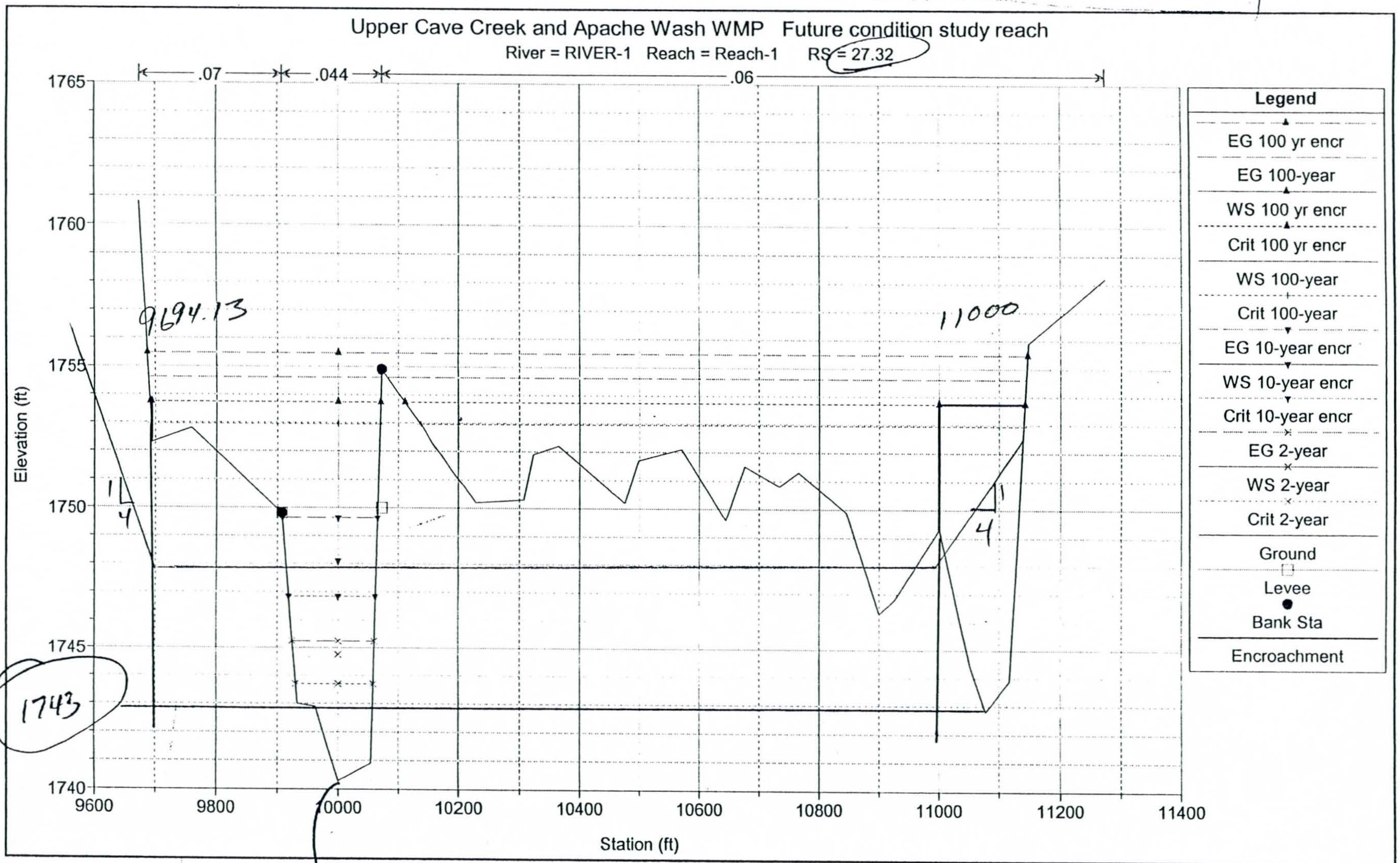
MWE, LTD

WATER RESOURCE CONSULTANTS

WRC ENGINEERING

KIOWA ENG. CORP

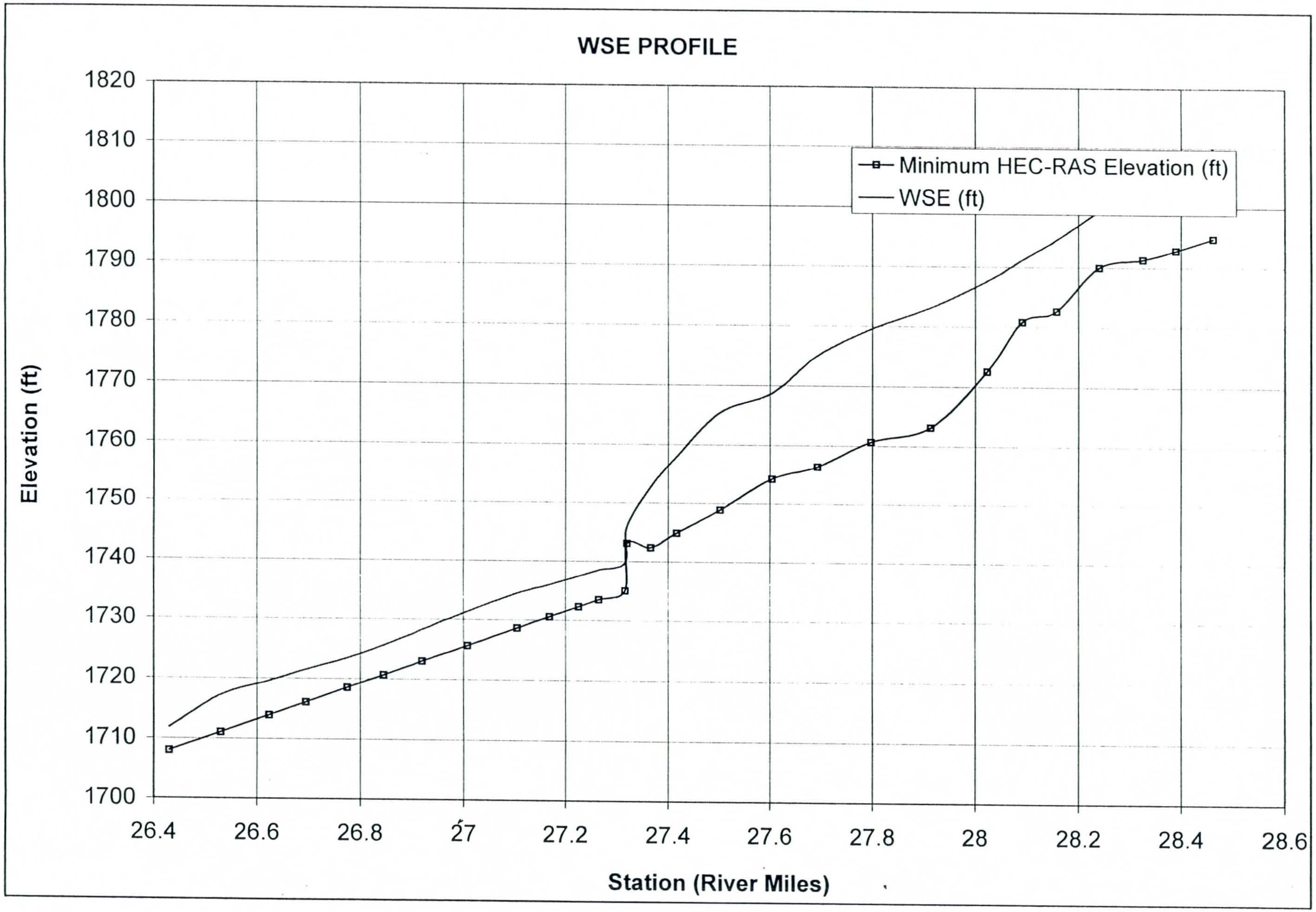
McLAUGHLIN WATER ENGINEERS, LTD



INVERT = 1740.3 − 4.5 = 1735.8

US SEQ = 0.005143

DS SEQ = 0.005783


WSE PROFILE
Minimum HEC-RAS Elevation (ft)
WSE (ft)
Elevation (ft)
1820
1810
1800
1790
1780
1770
1760
1750
1740
1730
1720
1710
1700
26.4
26.6
26.8
27
27.2
27.4
27.6
27.8
28
28.2
28.4
28.6
Station (River Miles)

Scour Below Grade Control Structure **Cross Section 27.320**

Determine the Toe Down Depth of the Grade Control Structure.

$Z_{lsf} = 1.32 * q^{0.54} * H_t^{0.225} - TW$ USBR Design of Small Dams (1977)

q = Discharge per Unit Width of Channel Bottom (cfs/ft)

$q = \frac{Q}{w}$

Q = 35,800 cfs — HEC-RAS 100-Year Discharge

W = ~~1306 ft~~ 774' — HEC-RAS 100-Year Channel Top Width ~~@ 27.346~~ w/Encroachments

q = ~~27.4~~ cfs/ft

46.2 x 1.3 = 60 ~~cfs/ft~~. 30% Safety Factor

H_t = Total Drop in Head (ft) — From U/S Energy Elevation (EG) to D/S EG

US EG = ~~1747.3 ft~~ 1745.2 (±) — HEC-RAS 100-Year EG Elevation

DS EG = 1740.2 ft — HEC-RAS 100-Year EG Elevation

H_t = ~~7.1~~ 5 ft

TW = D/S Tailwater Depth (ft)

TW = 4.7 ft — HEC-RAS 100-Year D/S Channel Hydraulic Depth

Z_{lsf} = ~~7.6 ft~~ 12.6 ft. scour depth

x_{sce} = Horizontal Length to Z_{lsf} Depth (ft)

$x_{sce} = 6.0 * Z_{lsf}$

x_{sce} = ~~45.4 ft~~ 75.6'

L_s = Horizontal Length of Scour Hole (ft)

$L_s = 12 * Z_{lsf}$

L_s = ~~90.8 ft~~ 151.2'

Total Drop = 12.6 + 5.0 = 17.6 ft.

~~El @ Crest = 1740.3~~

~~El @ Toe = 1722.4~~

SOFT STRUCTURAL
QUANTITY TOTALS

3' TOE DOWNS + FULL DEPTH TOE DOWNS
EARTHWORK ADDITIONS

CAVE CREEK

CLIFF REACH

LEFT SIDE 3' TOE DOWNS

EXCAVATION = 3916 yd^3

EMBANKMENT = 3049 yd^3

LEFT SIDE FULL DEPTH TOE DOWNS

EXCAVATION = 144,841 yd^3

EMBANKMENT = 36,662 yd^3

TOTAL

EX = 3916 + 144,841 = 148,757 yd^3 ✓

EMB = 3049 + 36,662 = 39,711 yd^3 ✓

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CLIENT: FCD | JOB NO: 25500001 | PAGE: 1
PROJECT: CAVE/APACHE WIND | DATE CHECKED: | DATE: 1/17/91
DETAIL: QUANTITIES | CHECKED BY: | COMPUTED BY: EFT

SOFT STRUCTURAL QUANTITIES

3' + FULL DEPTH EARTHWORK ADDITIONS

APACHE WASH

HACKBERRY REACH

LEFT SIDE 3' TOE DOWNS

EXCAVATION = 5053

EMBANKMENT = 6409

FULL DEPTH

EX = 0

EMB = 0

LEFT SIDE TOTALS

EX = 5053 yd^3 ✓

EMB = 6409 yd^3 ✓

RIGHT SIDE

3'

EX = 2,096

EMB = 1,877

FULL DEPTH

EX = 48,292

EMB = 1,086

RIGHT TOTAL QUANTITIES

EX = 2,096 + 48,292 = 50,388 ✓

EMB = 1,877 + 1,086 = 2,963 ✓

3' TOE DOWN EARTHWORK QUANTITIES

Cave Creek Left Side

Station	Existing Ground Elevation (ft)	Top of Bank Elevation (ft)	Embankment Height (ft)	Rounded Embankment Height (ft)	Average Unit Volume (ft^3/ft)	Length (ft)	Embankment Volume (yd^3)	Toe Down Depth (ft)	Average Unit Volume (ft^3/ft)	Excavation Volume (yd^3)
24500	1770	1771.7	1.7	2	14	547.0	283.6	3	45.8	926.9
25047	1775	1778	3	3	24	549.0	488.0	3	45.8	930.3
25596	1778	1782.5	4.5	5	50	612.0	1133.3	3	45.8	1037.0
26208	1781	1786.1	5.1	5	50	581.0	1075.9	3	45.8	984.5
26789	1784	1790.5	6.5	7	84	22.0	68.4	3	45.8	37.3
26811										
						Subtotal	**3049.3**			**3915.9**

Apache Wash Left Side

Station	Existing Ground Elevation (ft)	Top of Bank Elevation (ft)	Embankment Height (ft)	Rounded Embankment Height (ft)	Average Unit Volume (ft^3/ft)	Length (ft)	Embankment Volume (yd^3)	Toe Down Depth (ft)	Average Unit Volume (ft^3/ft)	Excavation Volume (yd^3)
12300	1673.5	1678.2	4.7	5	50	393.0	727.8	3	45.8	665.9
12693	1674	1679.7	5.7	6	66	211.0	515.8	3	45.8	357.5
12904	1678	1681.7	3.7	4	36	475.0	633.3	3	45.8	804.9
13379	1682	1687.5	5.5	6	66	792.0	1936.0	3	45.8	1342.0
14171	1685	1691.3	6.3	6	66	528.0	1290.7	3	45.8	894.7
14699	1689	1695.3	6.3	6	66	475.0	1161.1	3	45.8	804.9
15174	1694	1697.8	3.8	4	36	108.0	144.0	3	45.8	183.0
15282										
						Subtotal	**6408.7**			**5052.8**

Apache Wash Right Side

Station	Existing Ground Elevation (ft)	Top of Bank Elevation (ft)	Embankment Height (ft)	Rounded Embankment Height (ft)	Average Unit Volume (ft^3/ft)	Length (ft)	Embankment Volume (yd^3)	Toe Down Depth (ft)	Average Unit Volume (ft^3/ft)	Excavation Volume (yd^3)
11500	1669	1672.7	3.7	4	36	375.0	500.0	3	45.8	635.4
11875	1671.5	1675.4	3.9	4	36	423.0	564.0	3	45.8	716.8
12298	1673.5	1678.2	4.7	5	50	210.0	388.9	3	45.8	355.8
12508	1675	1679.7	4.7	5	50	229.0	424.1	3	45.8	388.0
12737										
						Subtotal	**1877.0**			**2096.0**
						Total	**11335.0**			**11064.7**

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CLIENT ______ JOB NO. ______ PAGE ______
PROJECT ______ DATE CHECKED ______ DATE ______
DETAIL ______ CHECKED BY ______ COMPUTED BY ______

TEAM ALT

CAVE CREEK QUANTITIES

CLIFF REACH

EMBANKMENT

LEFT SIDE = 286+00 – 330+00

(28.390 – 29.258)

TYPICAL SECTION = 28.75

AVE TOB ABOVE RAS MIN ELEV = ~~18.1~~ 17.4 (SS)

~~TOB = MIN RAS + 18.1~~ = 1808.3 + ~~18.1~~ 17.4 = ~~1826.4~~ 1825.7

ΔH = TOB – EXISTING GROUND = ~~1826.4~~ 1825.7 – 1817.5 = ~~8.9~~ 8.2 ≈ 8

W_1 = 10' W_2 = 8(2)(2) + 10 = ~~46~~ 42

AVE END AREA = 8(10 + ~~46~~ 42)/2 = ~~252 ft³/ft~~ 208 ft³/ft

EXCAVATION

AVE TOTAL DEGRADATION = ~~9.8'~~ 9.5 (SS)

TOE = MIN RAS – 9.8' = 1808.3 – ~~9.8~~ 9.5 = 1798.~~5~~8

ΔH = EXIST GROUND – TOE = 1817.5 – 1798.8 = 19' OK

W_1 = 10' W_2 = 10 + 19(2) + 19(1.5) = 76.5

AVE END AREA = 19(10 + 76.5)/2 = 821.75 OK

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1/17/01

TEAM ALTERNATIVE

CAVE CREEK CLIFF REACH
RIGHT SIDE 337+00 - 356+00
(29.351 - 29.710)

TYPICAL SECTION 29.601

EMBANKMENT

AVE TOB ABOVE MIN RAC = ~~13.5'~~ 17.3 (SS)

TOB = MIN RAS + 13.5 = 1849.9 + ~~13.5~~ 17.3 = ~~1863.4~~ 1867.2

ΔH = TOB - EXISTING GROUND = ~~1863.4~~ 1867.2 - 1856 = ~~7.4~~ 11.2 ≈ 11

W₁ = 10' W₂ = ~~7~~ 11 (2)(2) + 10 = ~~40~~ 54

AVE END AREA = ~~7~~ 11 (10 + ~~40~~ 54) / 2 = ~~175 ft³/ft~~

352 ft³/ft

EXCAVATION

AVE TOTAL DEGRADATION = ~~6'~~ 9.3 (SS)

TOE = MIN RAC - 6' = 1849.9 - ~~6'~~ 9.3 = ~~1843.6~~ 1840.6

ΔH = EXISTING GROUND - TOE = 1856 - ~~1843.8~~ 1840.6 = ~~12.2 ≈ 13~~ 15.4 ≈ 15.5

~~W₁ = 10' W₂ = 13(2) + 13(1.5) + 10 = 55.5'~~

~~AVE END AREA = 13(10 + 55.5)/2 = 425.75 ft³/ft~~

W₁ = 10' W₂ = 15.5(1.5) + 15.5(2) + 10 = 64.25

A = 15.5(10 + 64.25)/2 = 575.4 ft³/ft

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CLIENT ______ JOB NO. ______ PAGE ______
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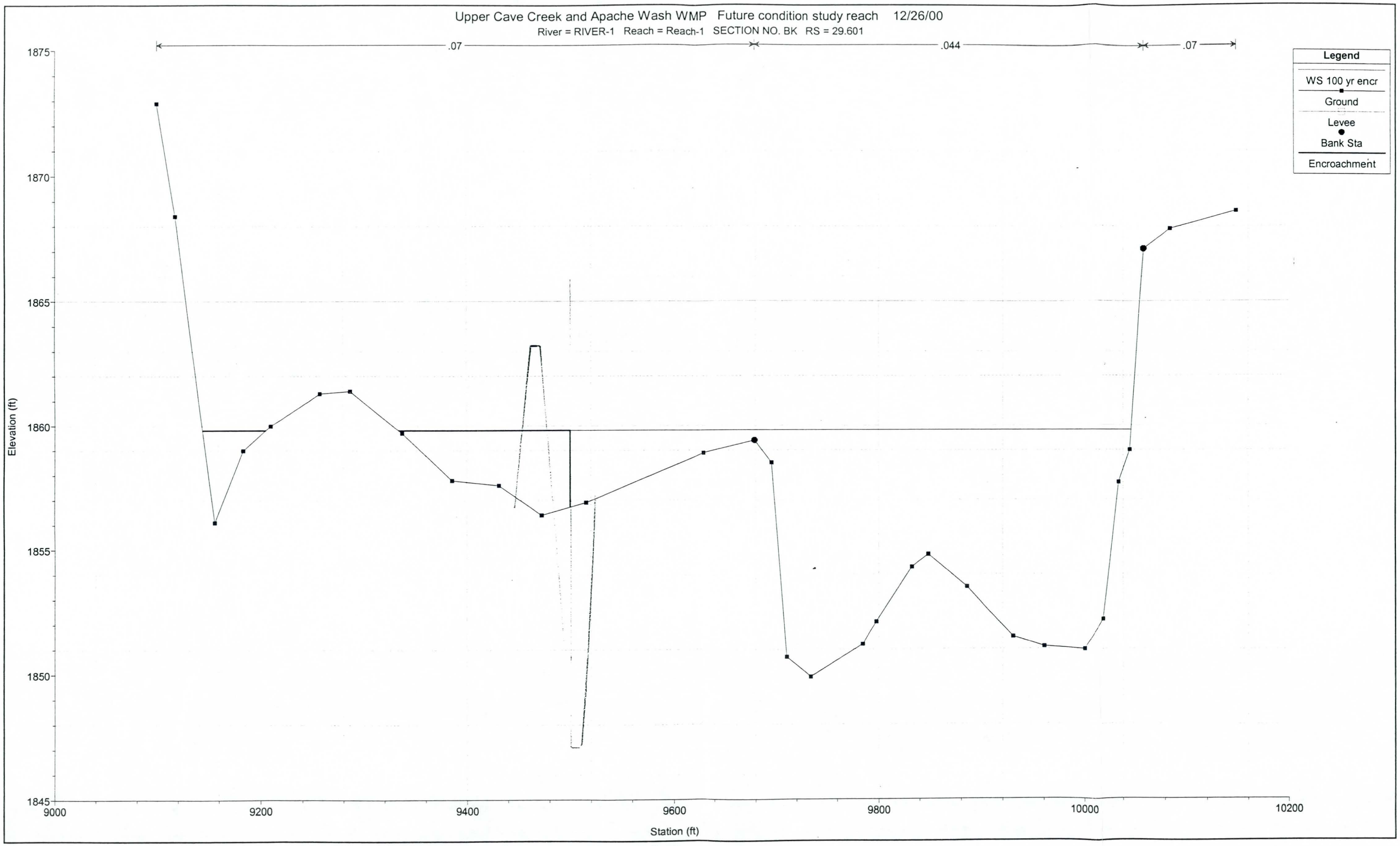
TEAM ALTERNATIVE
CAVE CREEK QUANTITIES
FULL DEPTH TOE DOWNS
CLIFF REACH

Added to 3' TOE Down

	AREA (ft^3/ft)	LENGTH (ft)	CONVERSION yd^3/ft^3	VOLUME (Yd^3)
EMBANKMENT L	~~252~~ 208	~~4690~~ 4759	1/27	~~43,773~~ 36,662
EXCAVATION L	821.75	~~4690~~ 4759	↓	~~154,451~~ 144,841
EMBANKMENT R	~~187.5~~ 352	~~1172~~ ~~2191~~ 2051	↓	~~8,139~~ 26,739 ✓
EXCAVATION R	~~425.75~~ 575.4	~~1172~~ 2191	↓	~~18,481~~ 46,692 ✓



MIN RAS = 1849.9

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CLIENT	JOB NO.	PAGE
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TEAM ALTERNATIVE

APACHE WASH HACKBERRY REACH

RIGHT SIDE 101+00 – 111+00
(0.200 - 0.430)

TYPICAL SECTION 0.20

EMBANKMENT R

AVE TOB ABOVE MIN RAS = 13.~~9~~1

TOB = MIN RAS + 13.9 = 1646 + 13.~~9~~ = 1659.~~9~~'

ΔH = TOB – EX GROUND = 1659.~~9~~ – 1658 = ~~2~~1'

w_1 = 10' W_2 = 1~~2~~(2)(2) + 10 = ~~18~~ 14

AVE END AREA = 2(10+~~18~~ 14)/2 = ~~28~~ 24 ft²/ft

EXCAVATION R =

AVE TOTAL DEGREDATION = 10.~~7~~

TOE = MIN RAS – 10.1 = 1646 – 10.2 = 1635.~~8~~

ΔH = EX GROUND – TOE = 1658 – 1635.~~8~~ = 22.0 ≈ 22

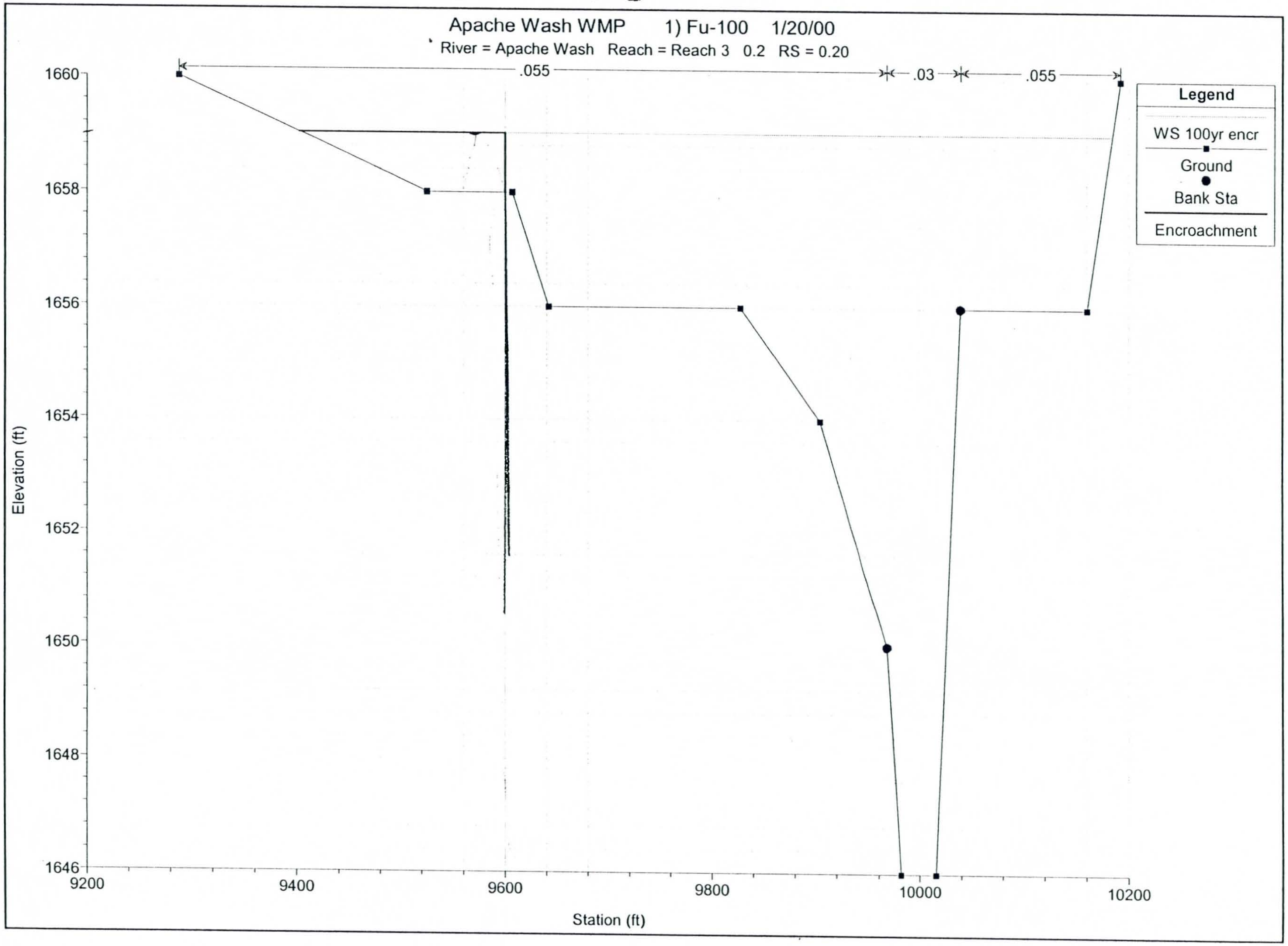
w_1 = ~~20~~' W_2 = 10 + 22(2) + 22(1.5) = 87'

AREA = 22(10' + 87')/2 = 1067 ft²/ft

	LENGTH	AREA	CONVERSION	VOLUME (YD³)
EMB R	~~1225~~ 1222	~~28~~ 24	1/27	1270 1086
EX R	~~1225~~ 1222	1067	↓	48,410 48,292

ADDED TO 3' TOE DOWNS

RIGHT SIDE
(LOOKING U/S)



SOFT STRUCTURAL ALTERNATIVE QUANTITIES
APACHE WASH
TYPICAL SECTION 4.22

EMB$_L$

AVE TOB ABOVE MIN RAS = 11.3

TOB = 11.3 + 1785.5 = 1796.8

ΔH = TOB - EX GROUND = 1796.8 - 1792.5 = 4.3 ≈ 4.5

AVE END AREA = 4.5 [10 + (10 + (4.5*2*2))] / 2 = 85.5 ft²

EX$_L$

AVE DEGRADATION = 9.4

TOE = 1785.5 - 9.4 = 1776.1

ΔH = 1792.5 - 1776.1 = 16.4 ≈ 16.5

$W_1 = 10'$ $W_2 = 10 + 16.5(2) + 16.5(1.5) = 67.75$

$A = 16.5(10 + 67.75)/2 = 641.4$ ft²/ft

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CLIENT ____ JOB NO. ____ PAGE ____
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EMR

TOB = 1796.8

ΔH = 1796.8 − 1788.5 = 8.3 ≈ 8.5

A = 8.5 [10 + {10 + 8.5(2)2}] / 2 = 229.5 ft³/ft

EXR

AVE DEGRADATION = 9.0'

TOE = 1785.5 − 9.0 = 1776.5

ΔH = 1788.5 − 1776.5 = 12'

AVE END AREA

W_1 = 10' W_2 = 10 + 12(2) + 12(1.5) = ~~48'~~ 52'

A = 12(10 + 52) / 2 = 372 ft³/ft

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CLIENT
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SOFT STRUCTURAL
APACHE WASH
UPPER REACH

	AREA ft^3/ft	LENGTH ft	CONVERSION yd^3/ft^3	VOLUME (yd^3)
EMB L	85.5	6129	1/27	19,409 ✓
EX L	641.4	7419	↓	176,242 ✓
EMB R	229.5	1983	↓	16,856 ✓
EX R	372	2103	↓	28,975 ✓

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CLIENT FCD | JOB NO. 2355C0001 | PAGE 1/1
PROJECT CAVE/APACHE WMP | DATE CHECKED | DATE 1/17/01
DETAIL QUANTITIES | CHECKED BY | COMPUTED BY DET

SOFT STRUCTURAL QUANTITIES

PARADISE WASH

TYPICAL SECTION 1.23 (SAME AS FULL STRUCTURA

EMBANKMENT L

AVE TOB ABOVE MIN RAS . 9.1

TOB = 9.1 + MIN RAS = 9.1 + 1806 = 1815.1

ΔH = TOB − EXISTING GROUND = 1815.1 − 1810 = 5.1 ≈ 5

AVE END AREA = 5 [10 + (10+5(2)(2))] / 2 = 100 ft³/ft

EXCAVATION L

AVE TOTAL DEGRADATION = 5.1

TOE = MIN RAS − 5.1 = 1806 − 5.1 = 1801.9

ΔH = EX GROUND − TOE = 1810 − 1801.9 = 8.1 ≈ 8

W_1 = 10' W_2 = 10 + 8(2+15) = 38

A = 8(10+38)/2 = 192 ft³/ft

	AREA	LENGTH	CONVERSION	VOLUME (Yd 3)
EMB L	100	2575	1/27	9,537
EX L	192	3005	↓	21,369

SOFT STRUCTURE QUANTITIES
DESERT HILLS WASH
TYPICAL SECTION 0.64 (SAME AS FS)

EMBANKMENT R

AVE TOB ABOVE MIN RAS = 10.8

TOB = 10.8 + MIN RAS = 10.8 + 1742 = 1752.8

ΔH = TOB − EXISTING GROUND = 1752.8 − 1747 = 5.8 ≈ 6

AVE END AREA

$A = 6[10 + (10 + 6(2)(2))]/2 = 132\ ft^3/ft$

EXCAVATION R

AVE TOTAL DEGRADATION = 7.3

TOE = MIN RAS − 7.3 = 1742 − 7.3 = 1734.7

ΔH = EX GROUND − TOE = 1746.5 − 1734.7 = 11.8 ≈ 12

$W_1 = 10'$ $W_2 = 10 + 12(2) + 12(1.5) = 52$

$A = 12(10 + 52)/2 = 372\ ft^3/ft$

SOFT STRUCTURAL QUANTITIES
DESERT HILLS WASH
TYPICAL SECTION RS = 0.64 (SAME AS FS)

EMB L

TOB = 1752.8

ΔH = TOB − Ex GROUND = 1752.8 − 1746 = 6.8 ≈ 7'

AVE END AREA = 7[10 + (10 + 7(2)(2))]/2 = 168 ft³/ft

EX L

TOE = 1734.7

ΔH = EX GROUND − TOE = 1746 − 1734.7 = 11.3 ≈ 11.5

AVE END AREA

W1 = 10'   W2 = 10 + 11.5(2) + 11.5(1.5) = 50.25'

A = 11.5(10 + 50.25)/2 = 346.4 ft³/ft

	AREA	Length	CONVERSION	VOLUME (Yd³)
EMB R	132	2168	1/27	10,599 ✓
EX R	372	2168	↓	29,870 ✓
EMB L	168	2994	↓	18,629 ✓
EX L	346.4	3084	↓	39,567 ✓

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CLIENT: FCD
PROJECT: CAVE / APACHE WMP
DETAIL: QUANTITIES
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DATE 1/1?/01
COMPUTED BY DFJ

SOFT & NON STRUCTURAL GRADE CONTROL STR

ESTIMATE SHOT CRETE QUANTITY & COST

10:1 SLOPE

$H = 18'$

$L_S = 18(10) = 180$

WIDTH = 450'

$A = 180' * 450' = 81{,}000\ ft^2$

6:1 SLOPE

$L_S = 18(6) = 108$

$W = 900'$

$A = 108' * 900' = 97{,}200\ ft^2$

4:1 SLOPE

$L_S = 18(4) = 72'$

$W = 250'$

$A = 72' * 250' = 18{,}000$

$A_T = 81{,}000\ ft^2 + 97{,}200\ ft^2 + 18{,}000\ ft^2 = 196{,}200\ ft^2$

$A_T = 21{,}800\ yd^2$

$\$ = 94 / yd^2$

Cost = $ 2,049,200

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CLIENT FCD	JOB NO. 23500001	PAGE 1
PROJECT CAVE WMP	DATE CHECKED	DATE 1/10/01
DETAIL QUANTITIES	CHECKED BY	COMPUTED BY DEJ

UPSTEAM FACE

H = 10' DEEP

W = 450 + 900 + 250 = 1600'

A = 10 * 1600 = 16000 ft² = 1778 yd²

$ - 94 / yd³

COST = $167,111

TOTAL COST = $167,111 + $2,049,200

COST = $2,216,311

A_T = 1778 + 21,800 = 23,578 yd²

Assume ~~*~~ (*) 5000 sq ft./day

~~100 sq.~~ (*) $20/s.yd. – 4" shotcrete (high est.)

Sq. yd → 3' x 3' (x 1/3') = 3 cu.ft. = 0.11 yd³

$20/0.11 yds → $180/cy.

Conc., Steel, Color → $180/c.y.

5000 (1.5) = 7500 ft³ = 280 yd³/day

$50,000/day ~~[illegible]~~

$60/hr. Super – $500/day (8 hrs.)

3-30/hr. 3-Laborer – $750/day

120/hr. Backhoe – $1000/day.

→ 2250/day

Rock Materials 90% on-site native mat'ls

$52,250/5000 ft² (day) = $10.45/ft² ($94/yd²)

190,600 sq ft. (10.45) = $1,991,700

(21,200 sq. yds.)

$2M

10,589 ~~11,344~~ yd³ shotcrete → $190

~~[illegible]~~

~~5,000 Sq. Ft / Day~~

Backhoe $120/hr

Super $60

3-Labors $30

~~Materials~~

handplaced Boulders / Cobble

gravel / cobble surface

Conc / Steel $150 cu. yd.

(Color)

$20/sq 4" / ft 2

Team GCS - (Shot Crete 18")

Grade Control length ~ 1300 ft.
Drop ~ 17.6 ft.

~~11.6~~
~~1.7~~
~~13.3~~

10:1 — 4.2 / 13.4 = .313
8:1 — 7.6 / 13.4 = .567
5:1 — 1.6 / 13.4 = .119
13.4

10:1 - 31% (1300) = 403'
8:1 - 57% 741'
5:1 - 12% 156'
1300'

Slope lengths
10:1 - 10.05 (17.6) = 176.9'
8:1 - 8.06 (17.6) = 141.9'
5:1 - 5.10 (17.6) = 89.7'

Vols		ft³	Yd³
10:1 —	177 (403) 1.5	= 106,996	3963
8:1 —	142 (741) 1.5	= 157,833	5846
5:1 —	90 (156) 1.5	= 21,060	780
			10,589 c.y

Toe Downs 10' (1.5) 1300 = 19,500 722

11,311 c.y.

$300 ~~@ 300 =~~ → $3,393,300
$350 ~~@ 350~~ → 3,958,850 $3.5M

CAVE CREEK - STRUCTURAL ALTERNATIVE

Item	Unit Price	Left Bank Quantity ~~(yd³)~~	Left Bank Cost	Right Bank Quantity (yd³)	Right Bank Cost	Total Quantity ~~(yd³)~~	Total Cost
CAVE CREEK - STRUCTURAL ALTERNATIVE TOTALS							
Riprap Revetment							
Excavation Total (yd^3)	$3	799,402	$2,398,206	276,863	$830,589	1,076,265	$3,228,795
Borrow Total (yd^3)	$5	125,998	$629,990	19,981	$99,905	145,979	$729,895
Riprap Total (yd^3)	$35 ✓	288,742	$10,105,970	136,431	$4,775,085	425,173	$14,881,055
Grade Control Structures	30						
CSA Total (yd^3)	~~$15~~	17,500	$262,500			17,500	$262,500
CSA Cement Total (tons)	$100	2,480	$248,000			2,480	$248,000
Total Cost			**$13,644,666**		**$5,705,579**		**$19,350,245**
Gabion Revetment							
Excavation Total (yd^3)	$3	799,402	$2,398,206	276,863	$830,589	1,076,265	$3,228,795
Borrow Total (yd^3)	$5	125,998	$629,990	19,981	$99,905	145,979	$729,895
Gabion Total (yd^3)	$65 ✓	130,146	$8,459,490	54,052	$3,513,380	184,198	$11,972,870
Grade Control Structures	30						
CSA Total (yd^3)	~~$15~~	17,500	$262,500			17,500	$262,500
CSA Cement Total (tons)	$100	2,480	$248,000			2,480	$248,000
Total Cost			**$11,998,186**		**$4,443,874**		**$16,442,060**
CSA Revetment							
Excavation Total (yd^3)	$3	799,402	$2,398,206	276,863	$830,589	1,076,265	$3,228,795
Borrow Total (yd^3)	$5	125,998	$629,990	19,981	$99,905	145,979	$729,895
CSA Total (yd^3)	$15 ✓	204,806	$3,072,090	102,606	$1,539,090	307,412	$4,611,180
CSA Cement Total (tons)	$100 ✓	29,032	$2,903,200	14,545	$1,454,500	43,677	$4,357,700
						324,912	
Grade Control Structures							
CSA Total (yd^3)	$15 ✓	17,500	$262,500			17,500	$262,500
CSA Cement Total (tons)	$100 ✓	2,480	$248,000			2,480	$248,000
Total Cost			**$9,513,986**		**$3,924,084**		**$13,438,070**

- 9r CSA
- % cement
- unit costs.

$40+

510,500 / 17,500 = $29.17 too low!

$ ~40+

$29.17

9,479,380 / 324,912 = $29.1 ok

12/28/00
DEJ

CAVE CREEK - TEAM ALTERNATIVE

Item	Unit Price	Left Bank Quantity (yd^3)	Left Bank Cost	Right Bank Quantity (yd^3)	Right Bank Cost	Total Quantity (yd^3)	Total Cost
CAVE CREEK - TEAM ALTERNATIVE TOTALS							
Riprap Revetment							
Excavation Total (yd^3)	$3	158,498	$475,494	18,481	$55,443	176,979	$530,937
Borrow Total (yd^3)	$5	47,099	$235,495	8,139	$40,695	55,238	$276,190
Riprap Total (yd^3)	$35	79,290	$2,775,150	21,442	$750,470	100,732	$3,525,620
Grade Control Structures							
CSA Total (yd^3)	$15	0	$0			0	$0
CSA Cement Total (tons)	$100	0	$0			0	$0
Total Cost			**$3,486,139**		**$846,608**		**$4,332,747**
Gabion Revetment							
Excavation Total (yd^3)	$3	158,498	$475,494	18,481	$55,443	176,979	$530,937
Borrow Total (yd^3)	$5	47,099	$235,495	8,139	$40,695	55,238	$276,190
Gabion Total (yd^3)	$65	39,645	$2,576,925	10,721	$696,865	50,366	$3,273,790
Grade Control Structures							
CSA Total (yd^3)	$15	0	$0			0	$0
CSA Cement Total (tons)	$100	0	$0			0	$0
Total Cost			**$3,287,914**		**$793,003**		**$4,080,917**
CSA Revetment							
Excavation Total (yd^3)	$3	158,498	$475,494	18,481	$55,443	176,979	$530,937
Borrow Total (yd^3)	$5	47,099	$235,495	8,139	$40,695	55,238	$276,190
CSA Total (yd^3)	$15	53,189	$797,835	14,384	$215,760	67,573	$1,013,595
CSA Cement Total (tons)	$100	7,540	$754,000	2,039	$203,900	9,579	$957,900
Grade Control Structures							
CSA Total (yd^3)	$15	0	$0			0	$0
CSA Cement Total (tons)	$100	0	$0			0	$0
Total Cost			**$2,262,824**		**$515,798**		**$2,778,622**

SKUNK CREEK: FULL STRUCTURAL ALTERNATIVE - EARTHWORK

Soil Cement Bank Protection

Reach Name	Excavation Along Right Bank in cubic yards										Reach Excavation	Reach Borrow
	Levee Option					Floodplain Fill Option						
	Excavation	Embankment	Protection	Backfill	Borrow	Excavation	Embankment	Protection	Backfill	Borrow		
Knoll Reach	49,706	6,475	12,826	40,568	-10,163	50,303	14,232	11,261	42,946	-18,136	100,009	-28,299
Cut Bank Reach	166,766	48,554	57,164	120,562	-59,514	178,344	141,943	51,949	139,034	-154,582	345,110	-214,097
Greasewood Reach	56,086	12,460	17,151	42,829	-16,353	59,204	80,996	15,669	47,888	-85,350	115,290	-101,703
Braided Reach	45,234	32,503	23,879	23,490	-34,638	48,793	160,975	20,857	30,730	-163,769	94,027	-198,407
Totals:	**317,792**	**99,991**	**111,020**	**227,449**	**-120,668**	**336,644**	**398,146**	**99,737**	**260,598**	**-421,837**	**654,436**	**-542,505**

Reach Name	Excavation Along Left Bank in cubic yards										Reach Excavation	Reach Borrow
	Levee Option					Floodplain Fill Option						
	Excavation	Embankment	Protection	Backfill	Borrow	Excavation	Embankment	Protection	Backfill	Borrow		
Knoll Reach	34,588	10,206	13,629	23,055	-12,302	35,389	9,871	12,062	25,660	-12,204	69,977	-24,506
Cut Bank Reach	173,616	36,721	55,274	130,176	-48,556	179,593	53,903	50,089	142,455	-66,854	353,209	-115,409
Greasewood Reach	52,609	14,445	18,830	37,157	-17,823	53,049	110,350	17,230	39,401	-113,932	105,658	-131,755
Braided Reach	67,527	19,381	26,360	45,283	-23,498	71,854	35,360	23,071	53,661	-40,238	139,381	-63,735
Totals:	**328,340**	**80,753**	**114,093**	**235,672**	**-102,178**	**339,885**	**209,484**	**102,451**	**261,177**	**-233,227**	**668,225**	**-335,405**

225K

Swell Factor: 0%

Shrinkage Factor: 10%

Levee

C = 166,545 (166,766)

F = 45,230.5 (48,554)

-7%

Fill

C = 183,620.6 (178,344)

+3%

~~138,405~~

F = 124,363.3 (141,943)

-12%

cm x 1.3 = CY

17,500 @ 30

$/cm

$34 * 10,000 cm = $340,000
x * 13,000 CY = 340,000 x = $26

24,700 cm (1.3) = 39,000 CY.

17,500 @ 30 = $525,000
248,000

773,000 / 17,500 = $44

sla
SIMONS, LI & ASSOCIATES, INC.

CLIENT________ JOB NO.________ PAGE________
PROJECT________ DATE CHECKED________ DATE________
DETAIL________ CHECKED BY________ COMPUTED BY________

CP SHOTCRETE (6") $14.00

1997 ADOT SHOTCRETE 70 yd² $115.00

1997 ADOT	CONCRETE	LINED DITCH	(4")	435 yd²	$36	$45	$40
	"	"	"	173 yd²	$21	$15	$36
	"	"	(6")	44,983 yd²	$25	$25	$30
	"	"	"	6,901 yd²	$38	$65	$100
	"	"	"	910 yd²	$38	$25	$40
	"	"	"	76,134²	$25	$32	$34.50
1995			(3")	18 yd²		$50	
			(6")	375 yd²	20	36	50
	"	"	"	210 yd²	65	80	100
				100 yd²	65	70	100

1995 ADOT SHOTCRETE		170 yd²	100	40	104.53	
SHOTCRETE	(3")	700 yd²	$13	$16	$22.50	
SHOTCRETE	(4")	315	$25	$28	$30	
"	"	2,174	18	25	15	
"	6"	499	31.29	33	30	
"	"	480	31.39	33	30	

Reach	Center Stationing ID (River miles)	Left Bank Stationing (ft)	Right Bank Stationing (ft)	HEC-RAS 100 Year Flow Velocity (fps) *1	Average Hydraulic Depth, V_m (fps) *1	Left Bank Top of Bank Elev (ft) *2	Right Bank Top of Bank Elev (ft) *2	Left Bank Toe Down Elev. (ft) *3	Right Bank Toe Down Elev. (ft) *3	Left Bank Slope Length (ft) *4	Right Bank Slope Length (ft) *4	USBR Dumped Riprap Median Riprap Particle Size, D_{50} (ft) *5	USBR Riprap Layer Thickness (ft) *6	Left Bank USBR Riprap Volume per Length (ft^3/ft) *7	Right Bank USBR Riprap Volume per Length (ft^3/ft) *7	Left Bank Riprap Volume (yd^3)	Right Bank Riprap Volume (yd^3)	USBR Total Riprap Volume, (yd^3) *8
		10500	10500															
Braided Reach	24.919			8.6	8.0	1651.1	1651.1	1630.4	1630.4	46.3	46.3	1.0	5.0	231.3	231.3	0.0	0.0	0.0
	25.010			9.1	7.8	1653.1	1653.1	1636.9	1636.9	36.3	36.3	1.2	5.0	181.5	181.5	0.0	0.0	0.0
	25.099	11700		14.9	5.0	1657.8	1657.8	1628.3	1628.3	65.9	65.9	3.2	5.0	329.6	329.6	2174.2	0.0	2174.2
	25.180	11878	12000	8.8	7.7	1662.8	1662.8	1644.3	1644.3	41.4	41.4	1.1	5.0	207.2	207.2	2148.0	1212.2	3360.1
	25.233	12158	12158	11.3	7.9	1664.0	1664.0	1638.4	1638.4	57.3	57.3	1.8	5.0	286.7	286.7	5213.9	5213.9	10427.8
	25.326	12649	12649	14.1	7.6	1668.0	1668.0	1646.6	1646.6	48.0	48.0	2.8	5.0	239.8	239.8	562.7	562.7	1125.4
	25.338	12712	12712	13.9	7.7	1672.1	1672.1	1648.7	1648.7	52.3	52.3	2.8	5.0	261.5	261.5	4724.0	4724.0	9447.9
		13200	13200															
									Average	49.6	49.6	3.2						
										Quantity/Total						14822.7	11712.7	26535.5
Mined Reach	25.458	13200	13200	8.6	6.4	1676.2	1676.2	1662.4	1662.4	30.8	30.8	1.0	5.5	169.1	169.1	2931.6	2931.6	5863.1
	25.519	13668	13668	10.9	5.4	1678.4	1678.4	1663.0	1663.0	34.5	34.5	1.7	5.5	189.9	189.9	2265.9	2265.9	4531.7
	25.580	13990	13990	11.3	7.5	1681.2	1681.2	1663.8	1663.8	38.8	38.8	1.8	5.5	213.5	213.5	2672.4	2672.4	5344.8
	25.644	14328	14328	14.0	9.2	1684.2	1684.2	1662.0	1662.0	49.6	49.6	2.8	5.5	272.6	272.6	2931.5	2931.5	5863.0
	25.699	14618	14618	14.0	11.7	1686.5	1686.5	1663.0	1663.0	52.5	52.5	2.8	5.5	288.7	288.7	2879.6	2879.6	5759.3
	25.750	14888	14888	8.5	9.8	1689.2	1689.2	1667.3	1667.3	48.9	48.9	1.0	5.5	269.2	269.2	4895.3	4895.3	9790.6
	25.843	15379	15379	11.4	8.0	1690.2	1690.2	1668.1	1668.1	49.4	49.4	1.8	5.5	271.6	271.6	4036.8	4036.8	8073.6
	25.919	15780	15780	13.5	7.0	1693.6	1693.6	1666.5	1666.5	60.5	60.5	2.6	5.5	332.7	332.7	8133.3	8133.3	16266.6
	26.044	16440	16440	10.8	7.3	1699.0	1699.0	1678.8	1678.8	45.3	45.3	1.6	5.5	248.9	248.9	4526.9	4526.9	9053.7
	26.137	16931	16931	11.0	7.8	1702.2	1702.2	1680.3	1680.3	49.1	49.1	1.7	5.5	269.9	269.9	5384.3	5384.3	10768.6
	26.239	17470	17470	12.1	5.6	1705.8	1705.8	1683.7	1683.7	49.4	49.4	2.1	5.5	271.8	271.8	5102.9	5102.9	10205.8
	26.335	17976	17976	7.0	7.7	1709.5	1709.5	1692.6	1692.6	37.8	37.8	0.7	5.5	207.8	207.8	3861.3	3861.3	7722.5
	26.430	18478	18478	11.5	7.0	1710.9	1710.9	1692.0	1692.0	42.3	42.3	1.9	5.5	232.7	232.7	4504.5	4504.5	9009.0
	26.529	19001	19001	14.3	7.3	1715.5	1715.5	1695.4	1695.4	44.8	44.8	2.9	5.5	246.6	246.6	4533.1	4533.1	9066.2
	26.623	19497	19497	8.7	9.8	1720.6	1720.6	1699.9	1699.9	46.3	46.3	1.1	5.5	254.5	254.5	3583.8	1610.9	5194.7
	26.695	19877	19668	15.4	8.1	1724.5	1724.5	1698.0	1698.0	59.2	59.2	3.4	5.5	325.7	325.7	5095.5	0.0	5095.5
	26.775	20300		12.3	9.9	1729.4	1729.4	1706.1	1706.1	52.2	52.2	2.1	5.5	286.8	286.8	3926.7	0.0	3926.7
	26.845	20669		10.7	9.2	1732.1	1732.1	1711.1	1711.1	46.9	46.9	1.6	5.5	257.9	257.9	3833.5	0.0	3833.5
	26.921	21071		10.3	8.3	1734.4	1734.4	1715.6	1715.6	42.0	42.0	1.5	5.5	231.0	231.0	3930.0	0.0	3930.0
	27.008	21530		10.0	7.7	1736.8	1736.8	1718.7	1718.7	40.6	40.6	1.4	5.5	223.1	223.1	4274.8	0.0	4274.8
	27.106	22047		13.3	5.5	1740.8	1740.8	1718.8	1718.8	49.1	49.1	2.5	5.5	270.0	270.0	3326.2	0.0	3326.2
	27.169	22380		9.6	7.4	1745.2	1745.2	1728.6	1728.6	37.2	37.2	1.3	5.5	204.7	204.7	2281.3	0.0	2281.3
	27.226	22681		12.5	6.4	1747.6	1746.9	1725.2	1726.3	50.0	46.0	2.2	5.5	275.2	253.2	2098.6	0.0	2098.6
	27.265	22887		13.2	9.3	1753.6	1753.2	1719.7	1721.4	75.8	71.1	2.5	5.5	417.0	391.0	4836.1	0.0	4836.1
		23200																
									Average	47.2	46.8	3.4						
										Quantity/Total						95845.7	60270.1	156115.8
Cliff Reach	27.320	23000		12.9	10.9	1756.9	1756.7	1727.8	1729.4	65.1	60.9	2.4	6.0	390.6	365.7	6078.9	0.0	6078.9
	27.366	23420		8.0	10.1	1758.9	1758.7	1735.1	1736.5	53.2	49.6	0.9	6.0	319.3	297.4	3184.6	0.0	3184.6
	27.417	23689		15.0	8.2	1761.5	1760.8	1730.5	1732.2	69.2	64.0	3.2	6.0	415.3	384.2	6903.7	0.0	6903.7
	27.502	24138		14.9	10.9	1768.4	1768.4	1738.4	1738.4	67.1	67.1	3.2	6.0	402.8	402.8	8035.1	0.0	8035.1
	27.604	24677		12.8	11.0	1771.7	1771.7	1746.3	1746.3	56.8	56.8	2.3	6.0	341.0	341.0	5934.3	0.0	5934.3
	27.693	25147		15.3	9.5	1778.0	1778.0	1738.5	1738.5	88.4	88.4	3.4	6.0	530.6	530.6	10790.4	0.0	10790.4
	27.797	25696		15.0	11.0	1782.4	1782.4	1748.2	1748.2	76.5	76.5	3.2	6.0	459.2	459.2	10417.3	0.0	10417.3
	27.913	26308		13.9	9.4	1786.1	1786.1	1753.6	1753.6	72.6	72.6	2.8	6.0	435.6	435.6	9370.2	0.0	9370.2
	28.023	26889		12.7	9.1	1790.5	1790.5	1763.3	1763.3	60.9	60.9	2.3	6.0	365.1	365.1	4855.1	0.0	4855.1
	28.091	27248		11.6	6.5	1794.1	1794.1	1771.7	1771.7	50.1	50.1	1.9	6.0	300.5	300.5	3878.5	0.0	3878.5
	28.157	27597		11.7	6.9	1797.5	1797.5	1775.8	1775.8	48.5	48.5	1.9	6.0	290.8	290.8	4776.3	0.0	4776.3
	28.241	28040		13.5	6.5	1802.4	1802.4	1780.0	1780.0	50.0	50.0	2.6	6.0	300.2	300.2	4990.3	0.0	4990.3
	28.326	28489		14.8	9.9	1807.4	1807.4	1782.2	1782.2	56.3	56.3	3.2	6.0	337.9	337.9	4229.4	0.0	4229.4
	28.390	28827		15.0	10.3	1810.2	1810.2	1782.1	1782.1	62.8	62.8	3.2	6.0	376.9	376.9	5307.4	0.0	5307.4
	28.462	29207		15.4	11.7	1812.8	1812.8	1786.0	1786.0	59.8	59.8	3.4	6.0	359.0	359.0	6529.8	0.0	6529.8
	28.555	29698		15.9	11.7	1817.3	1817.3	1786.6	1786.6	68.7	68.7	3.6	6.0	412.1	412.1	8219.1	0.0	8219.1
	28.657	30237		14.0	9.8	1821.1	1821.1	1792.5	1792.5	63.9	63.9	2.8	6.0	383.7	383.7	6978.2	0.0	6978.2
	28.750	30728		14.7	10.2	1824.6	1824.6	1798.7	1798.7	57.8	57.8	3.1	6.0	347.0	347.0	6582.0	0.0	6582.0
	28.847	31240		15.2	12.2	1829.5	1829.5	1802.5	1802.5	60.4	60.4	3.3	6.0	362.3	362.3	6164.2	0.0	6164.2
	28.934	31699		14.8	10.5	1833.2	1833.2	1803.7	1803.7	66.1	66.1	3.1	6.0	396.4	396.4	6046.3	0.0	6046.3
	29.012	32111		15.4	12.2	1836.8	1836.8	1808.8	1808.8	62.6	62.6	3.4	6.0	375.8	375.8	8671.6	0.0	8671.6
	29.130	32734		16.3	12.6	1841.3	1841.3	1809.7	1809.7	70.7	70.7	3.8	6.0	424.4	424.4	10622.3	0.0	10622.3
	29.258	33410	33500	14.0	10.1	1846.3	1846.3	1822.3	1822.3	53.7	53.7	2.8	6.0	322.4	322.4	5863.0	4787.4	10650.4
	29.351	33901	33901	8.2	8.6	1851.5	1851.5	1831.0	1831.0	45.9	45.9	0.9	6.0	275.4	275.4	1939.0	1939.0	3878.0
	29.387	34091	34091	8.4	7.2	1852.4	1852.4	1834.7	1834.7	39.5	39.5	1.0	6.0	236.8	236.8	4909.6	4909.6	9819.2
	29.493	34651	34651	8.5	5.8	1856.2	1856.2	1838.8	1838.8	39.0	39.0	1.0	6.0	233.8	233.8	2057.5	2057.5	4115.0
	29.538	34888	34888	11.8	4.8	1858.3	1858.3	1838.6	1838.6	43.9	43.9	2.0	6.0	263.6	263.6	3248.0	3248.0	6495.9
	29.601	35221	35221	13.5	7.1	1862.8	1862.8	1842.2	1842.2	46.1	46.1	2.6	6.0	276.5	276.5	932.3	3352.2	4284.5
	29.663	35312	35548	14.1	8.6	1868.6	1868.6	1845.2	1845.2	52.4	52.4	2.8	6.0	314.2	314.2	0.0	1567.3	1567.3
	29.710		35683															
									Average	58.9	58.5	3.8						
										Quantity/Total						167514.5	21861.0	189375.6
															Total	278182.9	93843.9	372026.8

Center Stationing ID (River miles)	Necessary USBR Gabion Thickness (in) *9	Manufactured Gabion Size (in) *9	Left Bank USBR Gabion Volume per Length (ft^3/ft) *7	Right Bank USBR Gabion Volume per Length (ft^3/ft) *7	Left Bank Gabion Volume (yd^3)	Right Bank Gabion Volume (yd^3)	Total Gabion Volume, (yd^3) *8	Standard CSA Layer Thickness (ft)	Height of Left Bank (ft) *10	Left Bank Volume per Length (ft^3/ft) *7	Height of Right Bank (ft) *10	Right Bank Volume per Length (ft^3/ft) *7	Left Bank CSA Volume (yd^3)	Right Bank CSA Volume (yd^3)	Total Volume of CSA (yd^3) *8	Left Bank CSA Cement (tons) *11	Right Bank CSA Cement (tons) *11	Total CSA Cement (tons) *11
24.919	25.4	27	104.1	104.1	0.0	0.0	0.0	9	20.7	186.2	20.7	186.2	0.0	0.0	0.0	0.0	0.0	0.0
25.010	25.4	27	81.7	81.7	0.0	0.0	0.0	9	16.2	146.1	16.2	146.1	0.0	0.0	0.0	0.0	0.0	0.0
25.099	25.4	27	148.3	148.3	978.4	0.0	978.4	9	29.5	265.4	29.5	265.4	1750.2	0.0	1750.2	248.1	0.0	248.1
25.180	25.4	27	93.3	93.3	966.6	545.5	1512.1	9	18.5	166.8	18.5	166.8	1729.1	975.8	2704.8	245.1	138.3	383.4
25.233	25.4	27	129.0	129.0	2346.3	2346.3	4692.5	9	25.6	230.8	25.6	230.8	4197.1	4197.1	8394.2	594.9	594.9	1189.9
25.326	25.4	27	107.9	107.9	253.2	253.2	506.4	9	21.4	193.0	21.4	193.0	453.0	453.0	905.9	64.2	64.2	128.4
25.338	25.4	27	117.7	117.7	2125.8	2125.8	4251.6	9	23.4	210.5	23.4	210.5	3802.7	3802.7	7605.4	539.0	539.0	1078.1
Average									22.2		22.2							
Quantity/Total					6670.2	5270.7	11941.0						11932.1	9428.6	21360.6	1691.4	1336.5	3027.9
25.458	27.2	30	76.9	76.9	1332.5	1332.5	2665.1	9	13.8	123.8	13.8	123.8	2145.3	2145.3	4290.7	304.1	304.1	608.2
25.519	27.2	30	86.3	86.3	1029.9	1029.9	2059.9	9	15.4	139.0	15.4	139.0	1658.2	1658.2	3316.3	235.0	235.0	470.1
25.580	27.2	30	97.1	97.1	1214.7	1214.7	2429.5	9	17.4	156.3	17.4	156.3	1955.7	1955.7	3911.4	277.2	277.2	554.4
25.644	27.2	30	123.9	123.9	1332.5	1332.5	2665.0	9	22.2	199.5	22.2	199.5	2145.3	2145.3	4290.5	304.1	304.1	608.2
25.699	27.2	30	131.2	131.2	1308.9	1308.9	2617.9	9	23.5	211.3	23.5	211.3	2107.3	2107.3	4214.7	298.7	298.7	597.4
25.750	27.2	30	122.4	122.4	2225.1	2225.1	4450.3	9	21.9	197.0	21.9	197.0	3582.4	3582.4	7164.8	507.8	507.8	1015.6
25.843	27.2	30	123.5	123.5	1834.9	1834.9	3669.8	9	22.1	198.8	22.1	198.8	2954.2	2954.2	5908.3	418.8	418.8	837.5
25.919	27.2	30	151.2	151.2	3696.9	3696.9	7393.9	9	27.1	243.5	27.1	243.5	5952.0	5952.0	11903.9	843.7	843.7	1687.4
26.044	27.2	30	113.1	113.1	2057.7	2057.7	4115.3	9	20.2	182.2	20.2	182.2	3312.8	3312.8	6625.6	469.6	469.6	939.2
26.137	27.2	30	122.7	122.7	2447.4	2447.4	4894.8	9	21.9	197.5	21.9	197.5	3940.2	3940.2	7880.5	558.5	558.5	1117.1
26.239	27.2	30	123.6	123.6	2319.5	2319.5	4639.0	9	22.1	198.9	22.1	198.9	3734.3	3734.3	7468.6	529.3	529.3	1058.7
26.335	27.2	30	94.5	94.5	1755.1	1755.1	3510.2	9	16.9	152.1	16.9	152.1	2825.7	2825.7	5651.4	400.5	400.5	801.1
26.430	27.2	30	105.8	105.8	2047.5	2047.5	4095.0	9	18.9	170.3	18.9	170.3	3296.4	3296.4	6592.8	467.3	467.3	934.5
26.529	27.2	30	112.1	112.1	2060.5	2060.5	4121.0	9	20.1	180.5	20.1	180.5	3317.3	3317.3	6634.7	470.2	470.2	940.5
26.623	27.2	30	115.7	115.7	1629.0	732.2	2361.2	9	20.7	186.3	20.7	186.3	2622.6	1178.9	3801.5	371.8	167.1	538.9
26.695	27.2	30	148.0	148.0	2316.2	0.0	2316.2	9	26.5	238.4	26.5	238.4	3728.9	0.0	3728.9	528.6	0.0	528.6
26.775	27.2	30	130.4	130.4	1784.8	0.0	1784.8	9	23.3	209.9	23.3	209.9	2873.5	0.0	2873.5	407.3	0.0	407.3
26.845	27.2	30	117.2	117.2	1742.5	0.0	1742.5	9	21.0	188.8	21.0	188.8	2805.4	0.0	2805.4	397.7	0.0	397.7
26.921	27.2	30	105.0	105.0	1786.4	0.0	1786.4	9	18.8	169.0	18.8	169.0	2876.0	0.0	2876.0	407.7	0.0	407.7
27.008	27.2	30	101.4	101.4	1943.1	0.0	1943.1	9	18.1	163.2	18.1	163.2	3128.3	0.0	3128.3	443.4	0.0	443.4
27.106	27.2	30	122.7	122.7	1511.9	0.0	1511.9	9	22.0	197.6	22.0	197.6	2434.1	0.0	2434.1	345.0	0.0	345.0
27.169	27.2	30	93.0	93.0	1036.9	0.0	1036.9	9	16.6	149.8	16.6	149.8	1669.4	0.0	1669.4	236.6	0.0	236.6
27.226	27.2	30	125.1	115.1	953.9	0.0	953.9	9	22.4	201.4	20.6	185.3	1535.8	0.0	1535.8	217.7	0.0	217.7
27.265	27.2	30	189.6	177.7	2198.2	0.0	2198.2	9	33.9	305.2	31.8	286.2	3539.1	0.0	3539.1	501.7	0.0	501.7
Average									21.1		20.9							
Quantity/Total					43566.2	27395.5	70961.7						70140.2	44105.9	114246.2	9942.4	6252.0	16194.4
27.320	30.5	33	179.0	167.6	2786.2	0.0	2786.2	9	29.1	262.0	27.3	245.3	4077.9	0.0	4077.9	578.0	0.0	578.0
27.366	30.5	33	146.4	136.3	1459.6	0.0	1459.6	9	23.8	214.2	22.2	199.5	2136.3	0.0	2136.3	302.8	0.0	302.8
27.417	30.5	33	190.4	176.1	3164.2	0.0	3164.2	9	31.0	278.6	28.6	257.7	4631.2	0.0	4631.2	656.5	0.0	656.5
27.502	30.5	33	184.6	184.6	3682.8	0.0	3682.8	9	30.0	270.2	30.0	270.2	5390.1	0.0	5390.1	764.1	0.0	764.1
27.604	30.5	33	156.3	156.3	2719.9	0.0	2719.9	9	25.4	228.7	25.4	228.7	3980.9	0.0	3980.9	564.3	0.0	564.3
27.693	30.5	33	243.2	243.2	4945.6	0.0	4945.6	9	39.5	355.9	39.5	355.9	7238.4	0.0	7238.4	1026.0	0.0	1026.0
27.797	30.5	33	210.5	210.5	4774.6	0.0	4774.6	9	34.2	308.1	34.2	308.1	6988.1	0.0	6988.1	990.6	0.0	990.6
27.913	30.5	33	199.6	199.6	4294.7	0.0	4294.7	9	32.5	292.2	32.5	292.2	6285.7	0.0	6285.7	891.0	0.0	891.0
28.023	30.5	33	167.3	167.3	2225.2	0.0	2225.2	9	27.2	244.9	27.2	244.9	3256.9	0.0	3256.9	461.7	0.0	461.7
28.091	30.5	33	137.7	137.7	1777.6	0.0	1777.6	9	22.4	201.6	22.4	201.6	2601.8	0.0	2601.8	368.8	0.0	368.8
28.157	30.5	33	133.3	133.3	2189.1	0.0	2189.1	9	21.7	195.1	21.7	195.1	3204.0	0.0	3204.0	454.2	0.0	454.2
28.241	30.5	33	137.6	137.6	2287.2	0.0	2287.2	9	22.4	201.4	22.4	201.4	3347.6	0.0	3347.6	474.5	0.0	474.5
28.326	30.5	33	154.9	154.9	1938.5	0.0	1938.5	9	25.2	226.7	25.2	226.7	2837.2	0.0	2837.2	402.2	0.0	402.2
28.390	30.5	33	172.8	172.8	2432.6	0.0	2432.6	9	28.1	252.9	28.1	252.9	3560.3	0.0	3560.3	504.7	0.0	504.7
28.462	30.5	33	164.6	164.6	2992.8	0.0	2992.8	9	26.8	240.9	26.8	240.9	4380.3	0.0	4380.3	620.9	0.0	620.9
28.555	30.5	33	188.9	188.9	3767.1	0.0	3767.1	9	30.7	276.4	30.7	276.4	5513.6	0.0	5513.6	781.5	0.0	781.5
28.657	30.5	33	175.9	175.9	3198.3	0.0	3198.3	9	28.6	257.4	28.6	257.4	4681.1	0.0	4681.1	663.5	0.0	663.5
28.750	30.5	33	159.0	159.0	3016.8	0.0	3016.8	9	25.9	232.8	25.9	232.8	4415.3	0.0	4415.3	625.9	0.0	625.9
28.847	30.5	33	166.1	166.1	2825.3	0.0	2825.3	9	27.0	243.1	27.0	243.1	4135.1	0.0	4135.1	586.1	0.0	586.1
28.934	30.5	33	181.7	181.7	2771.2	0.0	2771.2	9	29.5	265.9	29.5	265.9	4056.0	0.0	4056.0	574.9	0.0	574.9
29.012	30.5	33	172.2	172.2	3974.5	0.0	3974.5	9	28.0	252.1	28.0	252.1	5817.1	0.0	5817.1	824.6	0.0	824.6
29.130	30.5	33	194.5	194.5	4868.5	0.0	4868.5	9	31.6	284.7	31.6	284.7	7125.6	0.0	7125.6	1010.1	0.0	1010.1
29.258	30.5	33	147.8	147.8	2687.2	2194.2	4881.4	9	24.0	216.3	24.0	216.3	3933.0	3211.5	7144.5	557.5	455.2	1012.7
29.351	30.5	33	126.2	126.2	888.7	888.7	1777.4	9	20.5	184.8	20.5	184.8	1300.7	1300.7	2601.5	184.4	184.4	368.8
29.387	30.5	33	108.6	108.6	2250.2	2250.2	4500.5	9	17.7	158.9	17.7	158.9	3293.5	3293.5	6586.9	466.8	466.8	933.7
29.493	30.5	33	107.2	107.2	943.0	943.0	1886.1	9	17.4	156.8	17.4	156.8	1380.2	1380.2	2760.4	195.6	195.6	391.3
29.538	30.5	33	120.8	120.8	1488.6	1488.6	2977.3	9	19.7	176.9	19.7	176.9	2178.8	2178.8	4357.6	308.8	308.8	617.7
29.601	30.5	33	126.7	126.7	427.3	1536.4	1963.7	9	20.6	185.5	20.6	185.5	625.4	2248.7	2874.1	88.6	318.8	407.4
29.663	30.5	33	144.0	144.0	0.0	718.4	718.4	9	23.4	210.8	23.4	210.8	0.0	1051.4	1051.4	0.0	149.0	149.0
Average									26.3		26.1							
Quantity/Total					76777.5	10019.6	86797.1						112372.2	14664.8	127037.0	15928.8	2078.7	18007.5
Total					127013.9	42685.9	169699.8						194444.5	68199.3	262643.8	27562.5	9667.3	37229.8

Reach	Center Stationing ID (River miles)	Left Bank Stationing (ft)	Right Bank Stationing (ft)	HEC-RAS 100 Year Flow Velocity (fps) *1	Average Hydraulic Depth, V_m (fps) *1	Left Bank Top of Bank Elev (ft) *2	Right Bank Top of Bank Elev (ft) *2	Left Bank Toe Down Elevation (ft) *3	Right Bank Toe Down Elevation (ft) *3	Left Bank Slope Length (ft) *4	Right Bank Slope Length (ft) *4	USBR Dumped Riprap Median Riprap Particle Size, D_{50} (ft) *5	USBR Riprap Layer Thickness (ft) *6	Left Bank USBR Riprap Volume per Length (ft^3/ft) *7	Right Bank USBR Riprap Volume per Length (ft^3/ft) *7	Left Bank Riprap Volume (yd^3)	Right Bank Riprap Volume (yd^3)	USBR Total Riprap Volume, (yd^3) *8	Necessary USBR Gabion Thickness (in) *9	Manufactured Gabion Size (in) *9	Left Bank USBR Gabion Volume per Length (ft^3/ft) *7	Right Bank USBR Gabion Volume per Length (ft^3/ft) *7	Left Bank Gabion Volume (yd^3)	Right Bank Gabion Volume (yd^3)	Total Gabion Volume, (yd^3) *8	Standard CSA Layer Thickness (ft)	Height of Left Bank (ft) *10	Left Bank Volume per Length (ft^3/ft) *7	Height of Right Bank (ft) *10	Right Bank Volume per Length (ft^3/ft) *7	Left Bank CSA Volume (yd^3)	Right Bank CSA Volume (yd^3)	Total Volume of CSA (yd^3) *8	Left Bank CSA Cement (tons) *11	Right Bank CSA Cement (tons) *11	Total CSA Cement (tons) *11
		10000	10000																																	
Hackberry Reach	0.200	10000	10000	14.2	11.0	1662.0	1662.0	1635.0	1635.0	60.4	60.4	2.9	6.5	392.8	392.8	9985.4	9985.4	19970.8	32.5	33	166.2	166.2	4224.6	4224.6	8449.2	9	27.0	243.2	27.0	243.2	6183.1	6183.1	12366.3	876.5	876.5	1752.9
	0.330	10686	10686	13.8	7.2	1664.5	1664.5	1642.4	1642.4	49.3	49.3	2.7	6.5	320.6	320.6	6269.3	6269.3	12538.6	32.5	33	135.6	135.6	2652.4	2652.4	5304.8	9	22.1	198.5	22.1	198.5	3882.1	3882.1	7764.1	550.3	550.3	1100.6
	0.430	11214	11214	14.1	7.3	1667.8	1667.8	1644.2	1644.2	52.9	52.9	2.8	6.5	343.6	343.6	7391.3	7391.3	14782.7	32.5	33	145.4	145.4	3127.1	3127.1	6254.2	9	23.6	212.8	23.6	212.8	4576.9	4576.9	9153.7	648.8	648.8	1297.5
	0.540	11795	11795	15.3	9.1	1672.7	1672.7	1647.2	1647.2	57.0	57.0	3.4	6.5	370.4	370.4	6518.9	6518.9	13037.8	32.5	33	156.7	156.7	2758.0	2758.0	5516.0	9	25.5	229.4	25.5	229.4	4036.6	4036.6	8073.3	572.2	572.2	1144.4
	0.630	12270	12270	14.7	7.7	1675.4	1675.4	1653.3	1653.3	49.4	49.4	3.1	6.5	320.8	320.8	5019.0	5019.0	10038.0	32.5	33	135.7	135.7	2123.4	2123.4	4246.8	9	22.1	198.7	22.1	198.7	3107.9	3107.9	6215.7	440.5	440.5	881.1
	0.710	12693	12693	16.0	10.3	1678.2	1678.2	1652.8	1652.8	56.8	56.8	3.7	6.5	368.9	368.9	2885.6	2885.6	5771.1	32.5	33	156.1	156.1	1220.8	1220.8	2441.6	9	25.4	228.4	25.4	228.4	1786.8	1786.8	3573.6	253.3	253.3	506.6
	0.750	12904	12904	12.8	9.4	1679.7	1679.7	1656.0	1656.0	52.9	52.9	2.3	6.5	343.9	343.9	6052.1	6052.1	12104.2	32.5	33	145.5	145.5	2560.5	2560.5	5121.0	9	23.7	212.9	23.7	212.9	3747.6	3747.6	7495.1	531.2	531.2	1062.4
	0.840	13379	13379	16.8	8.4	1681.7	1681.7	1652.3	1652.3	65.6	65.6	4.1	6.5	426.7	426.7	12516.9	12516.9	25033.8	32.5	33	180.5	180.5	5295.6	5295.6	10591.2	9	29.4	264.2	29.4	264.2	7750.7	7750.7	15501.4	1098.7	1098.7	2197.3
	0.990	14171	14171	12.2	6.3	1687.5	1687.9	1671.4	1668.8	36.1	42.7	2.1	6.5	234.5	277.3	4585.7	5422.8	10008.5	32.5	33	99.2	117.3	1940.1	2294.3	4234.4	9	16.1	145.2	19.1	171.7	2839.6	3357.9	6197.5	402.5	476.0	878.5
	1.090	14699	14699	15.5	8.1	1691.3	1691.3	1668.4	1668.4	51.1	51.1	3.5	6.5	332.4	332.4	5850.7	5850.7	11701.4	32.5	33	140.6	140.6	2475.3	2475.3	4950.6	9	22.9	205.8	22.9	205.8	3622.9	3622.9	7245.8	513.5	513.5	1027.1
	1.180	15174	15174	14.1	11.0	1695.3	1695.3	1672.2	1672.2	51.6	51.6	2.8	6.5	335.6	335.6	343.0	5905.8	6248.8	32.5	33	142.0	142.0	145.1	2498.6	2643.7	9	23.1	207.8	23.1	207.8	212.4	3657.0	3869.4	30.1	518.4	548.5
	1.270	15202	15650	11.3	9.9	1697.8	1697.8	1674.8	1674.8	51.5	51.5	1.8	6.5	334.4	334.4	0.0	6540.2	6540.2	32.5	33	141.5	141.5	0.0	2767.0	2767.0	9	23.0	207.1	23.0	207.1	0.0	4049.8	4049.8	0.0	574.1	574.1
	1.370		16178	14.4	7.5	1699.9	1699.9	1678.0	1678.0	49.0	49.0	3.0	6.5	318.7	318.7	0.0	6232.6	6232.6	32.5	33	134.8	134.8	0.0	2636.9	2636.9	9	21.9	197.4	21.9	197.4	0.0	3859.4	3859.4	0.0	547.1	547.1
	1.470		16706	14.8	10.4	1704.3	1704.3	1677.8	1677.8	59.3	59.3	3.1	6.5	385.7	385.7	0.0	6788.9	6788.9	32.5	33	163.2	163.2	0.0	2872.2	2872.2	9	26.5	238.9	26.5	238.9	0.0	4203.8	4203.8	0.0	595.9	595.9
	1.560		17181	15.1	9.2	1706.4	1706.4	1679.5	1679.5	60.1	60.1	3.3	6.5	390.9	390.9	0.0	3057.9	3057.9	32.5	33	165.4	165.4	0.0	1293.7	1293.7	9	26.9	242.1	26.9	242.1	0.0	1893.5	1893.5	0.0	268.4	268.4
	1.600		17392	14.9	10.9	1707.6	1707.6	1682.2	1682.2	56.9	56.9	3.2	6.5	369.5	369.5	0.0	4335.9	4335.9	32.5	33	156.3	156.3	0.0	1834.4	1834.4	9	25.4	228.8	25.4	228.8	0.0	2684.9	2684.9	0.0	380.6	380.6
	1.660		17709	15.3	8.3	1708.5	1708.5	1685.5	1685.5	51.5	51.5	3.4	6.5	334.7	334.7	0.0	5889.9	5889.9	32.5	33	141.6	141.6	0.0	2491.9	2491.9	9	23.0	207.2	23.0	207.2	0.0	3647.1	3647.1	0.0	517.0	517.0
	1.750		18184	14.7	8.8	1711.3	1711.3	1689.2	1689.2	49.4	49.4	3.1	6.5	321.0	321.0	0.0	1331.7	1331.7	32.5	33	135.8	135.8	0.0	563.4	563.4	9	22.1	198.8	22.1	198.8	0.0	824.6	824.6	0.0	116.9	116.9
	1.810		18296	12.5	10.4	1713.7	1713.7	1690.7	1690.7	51.5	51.5	2.2	6.5	334.7	334.7	0.0	0.0	0.0	32.5	33	141.6	141.6	0.0	0.0	0.0	9	23.0	207.2	23.0	207.2	0.0	0.0	0.0	0.0	0.0	0.0
	1.850			11.6	9.5	1714.3	1714.3	1692.9	1692.9	47.8	47.8	1.9	6.5	310.7	310.7	0.0	0.0	0.0	32.5	33	131.5	131.5	0.0	0.0	0.0	9	21.4	192.4	21.4	192.4	0.0	0.0	0.0	0.0	0.0	0.0
									Average	53.0	53.3	4.1															23.7		23.9							
										Quantity/Total						67418.0	107994.9	175412.9					28523.0	45690.1	74213.1						41746.5	66872.5	108618.9	5917.6	9479.2	15396.7
Union Hills Reach	1.880		18000	13.8	8.0	1714.8	1714.8	1692.3	1692.3	50.3	50.3	2.7	6.5	327.2	327.2	0.0	7678.1	7678.1	33.4	36	151.0	151.0	0.0	3543.7	3543.7	9	22.5	202.6	22.5	202.6	0.0	4754.4	4754.4	0.0	673.9	673.9
	2.000		18634	12.6	5.6	1717.7	1718.4	1701.5	1698.0	36.2	45.5	2.2	6.5	235.3	296.0	0.0	4630.7	4630.7	33.4	36	108.6	136.6	0.0	2137.3	2137.3	9	16.2	145.7	20.4	183.3	0.0	2867.4	2867.4	0.0	406.5	406.5
	2.080		19056	14.9	4.7	1720.4	1721.4	1699.9	1695.6	45.8	57.8	3.2	6.5	298.0	375.7	0.0	6612.0	6612.0	33.4	36	137.5	173.4	0.0	3051.7	3051.7	9	20.5	184.5	25.8	232.6	0.0	4094.3	4094.3	0.0	580.4	580.4
	2.170		19531	13.5	6.7	1724.1	1725.1	1705.7	1701.6	41.1	52.4	2.6	6.5	267.1	340.5	0.0	4661.3	4661.3	33.4	36	123.3	157.2	0.0	2151.4	2151.4	9	18.4	165.4	23.4	210.9	0.0	2886.3	2886.3	0.0	409.1	409.1
	2.240		19901	14.9	7.9	1726.4	1726.4	1705.3	1705.3	47.1	47.1	3.2	6.5	306.0	306.0	0.0	5385.9	5385.9	33.4	36	141.2	141.2	0.0	2485.8	2485.8	9	21.1	189.5	21.1	189.5	0.0	3335.1	3335.1	0.0	472.7	472.7
	2.330		20376	17.0	9.3	1730.1	1730.1	1704.4	1704.4	57.4	57.4	4.2	6.5	372.9	372.9	0.0	5104.9	5104.9	33.4	36	172.1	172.1	0.0	2356.1	2356.1	9	25.7	230.9	25.7	230.9	0.0	3161.0	3161.0	0.0	448.1	448.1
	2.400		20746	13.4	11.5	1733.0	1733.0	1710.9	1710.9	49.5	49.5	2.5	6.5	321.8	321.8	0.0	4404.6	4404.6	33.4	36	148.5	148.5	0.0	2032.9	2032.9	9	22.1	199.2	22.1	199.2	0.0	2727.4	2727.4	0.0	386.6	386.6
	2.470		21115	15.1	10.1	1734.4	1734.4	1705.2	1705.2	65.4	65.4	3.3	6.5	425.1	425.1	0.0	1335.0	1335.0	33.4	36	196.2	196.2	0.0	616.1	616.1	9	29.2	263.2	29.2	263.2	0.0	826.7	826.7	0.0	117.2	117.2
	2.520		21200	11.3	11.2	1736.3	1736.3	1713.4	1713.4	51.2	51.2	1.8	6.5	332.8	332.8	0.0	0.0	0.0	33.4	36	153.6	153.6	0.0	0.0	0.0	9	22.9	206.1	22.9	206.1	0.0	0.0	0.0	0.0	0.0	0.0
	2.600			13.7	9.3	1737.9	1740.0	1709.9	1697.6	62.7	94.7	2.7	6.5	407.6	615.5	0.0	0.0	0.0	33.4	36	188.1	284.1	0.0	0.0	0.0	9	28.0	252.4	42.3	381.1	0.0	0.0	0.0	0.0	0.0	0.0
									Average	50.7	57.1	4.2															22.7		25.5							
										Quantity/Total						0.0	39812.5	39812.5					0.0	18375.0	18375.0						0.0	24652.7	24652.7	0.0	3494.5	3494.5
Upper Reach	2.730		21200	15.1	9.5	1741.4	1745.0	1718.5	1706.5	51.3	85.9	3.3	5.0	256.3	429.7	0.0	7563.0	7563.0	26.1	27	115.3	193.4	0.0	3403.3	3403.3	9	22.9	206.3	38.4	345.9	0.0	6088.1	6088.1	0.0	863.0	863.0
	2.820		21675	4.1	7.5	1745.7	1745.1	1717.1	1725.6	63.9	43.7	0.2	5.0	319.6	218.3	0.0	2134.2	2134.2	26.1	27	143.8	98.2	0.0	960.4	960.4	9	28.6	257.3	19.5	175.7	0.0	1718.0	1718.0	0.0	243.5	243.5
	2.870		21939	4.0	6.3	1745.9	1745.3	1717.8	1725.9	62.8	43.4	0.2	5.0	314.1	217.1	0.0	1273.7	1273.7	26.1	27	141.3	97.7	0.0	573.2	573.2	9	28.1	252.8	19.4	174.8	0.0	1025.3	1025.3	0.0	145.3	145.3
	2.900		22098	5.6	4.5	1746.6	1745.4	1722.0	1729.0	54.9	36.7	0.4	5.0	274.5	183.4	0.0	717.4	717.4	26.1	27	123.5	82.5	0.0	322.8	322.8	9	24.5	220.9	16.4	147.6	0.0	577.5	577.5	0.0	81.9	81.9
	2.920		22203	4.9	3.6	1746.0	1746.0	1726.0	1726.0	44.7	44.7	0.3	5.0	223.4	223.4	0.0	2184.6	2184.6	26.1	27	100.5	100.5	0.0	983.1	983.1	9	20.0	179.9	20.0	179.9	0.0	1758.6	1758.6	0.0	249.3	249.3
	2.970	23000	22467	3.9	3.2	1747.2	1747.2	1733.0	1733.0	31.8	31.8	0.2	5.0	158.8	158.8	3104.7	3104.7	6209.3	26.1	27	71.4	71.4	1397.1	1397.1	2794.2	9	14.2	127.8	14.2	127.8	2499.2	2499.2	4998.4	354.3	354.3	708.5
	3.070	23528	22995	12.3	6.6	1751.6	1751.6	1731.8	1731.8	44.3	44.3	2.2	5.0	221.3	221.3	2597.1	2597.1	5194.2	26.1	27	99.6	99.6	1168.7	1168.7	2337.4	9	19.8	178.2	19.8	178.2	2090.6	2090.6	4181.2	296.3	296.3	592.7
	3.130	23845	23312	11.9	6.6	1753.4	1753.4	1734.2	1734.2	42.8	42.8	2.0	5.0	214.2	214.2	3351.5	3351.5	6703.1	26.1	27	96.4	96.4	1508.2	1508.2	3016.4	9	19.2	172.5	19.2	172.5	2697.9	2697.9	5395.9	382.4	382.4	764.9
	3.210	24267	23734	12.0	5.6	1756.0	1756.0	1736.8	1736.8	42.9	42.9	2.0	5.0	214.3	214.3	4610.8	4610.8	9221.6	26.1	27	96.5	96.5	2074.9	2074.9	4149.7	9	19.2	172.5	19.2	172.5	3711.6	3711.6	7423.3	526.1	526.1	1052.2
	3.320	24848	24315	12.1	5.4	1759.7	1759.7	1740.0	1740.0	44.2	44.2	2.1	5.0	220.8	220.8	3454.1	3454.1	6908.1	26.1	27	99.4	99.4	1554.3	1554.3	3108.6	9	19.7	177.7	19.7	177.7	2780.5	2780.5	5560.9	394.1	394.1	788.3
	3.400	25270	24738	12.9	6.6	1763.3	1763.3	1742.0	1742.0	47.7	47.7	2.4	5.0	238.4	238.4	3729.6	3729.6	7459.2	26.1	27	107.3	107.3	1678.3	1678.3	3356.6	9	21.3	191.9	21.3	191.9	3002.3	3002.3	6004.5	425.6	425.6	851.1
	3.480	25693	25160	14.4	7.5	1766.8	1766.8	1746.4	1746.4	45.7	45.7	3.0	5.0	228.5	228.5	1787.5	1787.5	3575.0	26.1	27	102.8	102.8	804.4	804.4	1608.8	9	20.4	184.0	20.4	184.0	1438.9	1438.9	2877.8	204.0	204.0	407.9
	3.520	25904	25371	14.4	8.1	1768.5	1768.5	1746.5	1746.5	49.1	49.1	3.0	5.0	245.7	245.7	3844.1	3844.1	7688.3	26.1	27	110.6	110.6	1729.9	1729.9	3459.7	9	22.0	197.8	22.0	197.8	3094.5	3094.5	6188.9	438.6	438.6	877.3
	3.600	26326	25794	12.9	7.6	1771.3	1771.3	1750.7	1750.7	46.2	46.2	2.4	5.0	230.8	230.8	3108.4	2256.9	5365.3	26.1	27	103.9	103.9	1398.8	1015.6	2414.4	9	20.6	185.8	20.6	185.8	2502.2	1816.8	4319.0	354.7	257.5	612.2
	3.650	26690	26058	10.6	7.2	1772.8	1772.8	1753.5	1753.5	43.2	43.2	1.6	5.0	216.2	216.2	-3123.1	4228.2	1105.1	26.1	27	97.3	97.3	-1405.4	1902.7	497.3	9	19.3	174.0	19.3	174.0	-2514.0	3403.6	889.6	-356.4	482.5	126.1
	3.750	26300	26586	13.9	8.1	1776.1	1776.1	1753.9	1753.9	49.7	49.7	2.8	5.0	248.3	248.3	1456.5	1456.5	2913.0	26.1	27	111.7	111.7	655.4	655.4	1310.9	9	22.2	199.9	22.2	199.9	1172.5	1172.5	2345.0	166.2	166.2	332.4
	3.780	26458	26744	11.8	5.3	1777.4	1777.4	1752.2	1752.2	56.4	56.4	2.0	5.0	282.2	282.2	4414.2	4414.2	8828.5	26.1	27	-127.0	127.0	1986.4	1986.4	3972.8	9	25.2	227.1	25.2	227.1	3553.4	3553.4	7106.8	503.7	503.7	1007.4
	3.860	26881	27166	12.6	5.6	1780.7	1780.7	1760.5	1760.5	45.2	45.2	2.3	5.0	225.8	225.8	4415.7	4415.7	8831.4	26.1	27	101.6	101.6	1987.1	1987.1	3974.1	9	20.2	181.8	20.2	181.8	3554.6	3554.6	7109.2	503.9	503.9	1007.7
	3.960	27409	27694	9.3	4.0	1785.4	1785.4	1766.4	1766.4	42.5	42.5	1.2	5.0	212.7	212.7	3743.2	3743.2	7486.4	26.1	27	95.7	95.7	1684.4	1684.4	3368.9	9	19.0	171.2	19.0	171.2	3013.2	3013.2	6026.4	427.1	427.1	854.2
	4.050	27884	28170	14.0	5.5	1788.6	1788.6	1770.4	1770.4	40.6	40.6	2.8	5.0	203.2	203.2	2383.9	2383.9	4767.8	26.1	27	91.4	91.4	1072.8	1072.8	2145.5	9	18.2	163.6	18.2	163.6	1919.0	1919.0	3838.0	272.0	272.0	544.0
	4.110	28201	28486	10.6	4.7	1791.9	1791.9	1774.8	1774.8	38.3	38.3	1.6	5.0	191.5	191.5	4120.2	4120.2	8240.3	26.1	27	86.2	86.2	1854.1	1854.1	3708.2	9	17.1	154.2	17.1	154.2	3316.7	3316.7	6633.3	470.1	470.1	940.3
	4.220	28782	29067	13.4	4.7	1794.8	1794.8	1776.6	1776.6	40.8	40.8	2.5	5.0	203.8	203.8	398.6	398.6	797.2	26.1	27	91.7	91.7	179.4	179.4	358.7	9	18.2	164.1	18.2	164.1	320.9	320.9	641.7	45.5	45.5	91.0
	4.230	28834	29120	11.9	5.8	1796.2	1796.2	1778.1	1778.1	40.4	40.4	2.0	5.0	202.2	202.2	3163.6	3163.6	6327.3	26.1	27	91.0	91.0	1423.6	1423.6	2847.3	9	18.1	162.8	18.1	162.8	2546.7	2546.7	5093.4	361.0	361.0	722.0
	4.310	29257	29542	14.4	8.0	1800.5	1800.5	1779.3	1779.3	47.3	47.3	3.0	5.0	236.6	236.6	4164.7	4164.7	8329.4	26.1	27	106.5	106.5	1874.1	1874.1	3748.2	9	21.2	190.5	21.2	190.5	3352.5	3352.5	6705.0	475.2	475.2	950.4
	4.400	29732	30018	12.6	7.1	1803.9	1803.9	1787.6	1787.6	36.6	36.6	2.3	5.0	182.8	182.8	2010.3	2980.9	4991.2	26.1	27	82.2	82.2	904.6	1341.4	2246.0	9	16.3	147.1	16.3	147.1	1618.3	2399.6	4017.8	229.4	340.1	569.5
	4.490	30029	30458	11.4	5.8	1806.6	1806.6	1779.5	1779.5	60.6	60.6	1.8	5.0	303.2	303.2	0.0	0.0	0.0	26.1	27	136.4	136.4	0.0	0.0	0.0	9	27.1	244.0	27.1	244.0	0.0	0.0	0.0	0.0	0.0	0.0
	4.560			6.1	7.5	1811.0	1811.0	1785.4	1785.4	57.3	57.3	0.5	5.0	286.3	286.3	0.0	0.0	0.0	26.1	27	128.8	128.8	0.0	0.0	0.0	9	25.6	230.4	25.6	230.4	0.0	0.0	0.0	0.0	0.0	0.0
	4.600																																			
									Average	47.1	46.2	3.3															21.1		20.7							
										Quantity/Total						56735.7	78079.0	134814.7					25531.1	35135.6	60666.6						45671.4	62852.4	108523.7	6473.9	8909.3	15383.2
															Total	124153.7	225886.4	350040.1					54054.0	99200.7	153254.7						87417.8	154377.5	241795.3	12391.5	21883.0	34274.5

	Center Stationing ID (River miles)	Left Bank Stationing (ft)	Right Bank Stationing (ft)	HEC-RAS 100 Year Flow Velocity (fps) [1]	Average Hydraulic Depth, V_m (fps) [1]	Left Bank Top of Bank Elev - Levee Option (ft) [2]	Right Bank Top of Bank Elev - Levee Option (ft) [2]	Left Bank Toe Down Elevation (ft) [3]	Right Bank Toe Down Elevation (ft) [3]	Left Bank Slope Length (ft) [4]	Right Bank Slope Length (ft) [4]	USBR Dumped Riprap Median Riprap Particle Size, D_{50} (ft) [5]	USBR Riprap Layer Thickness (ft) [6]	Left Bank USBR Riprap Volume per Length (ft^3/ft) [7]	Right Bank USBR Riprap Volume per Length (ft^3/ft) [7]	Left Bank Riprap Volume (yd^3)	Right Bank Riprap Volume (yd^3)	USBR Total Riprap Volume, (yd^3) [8]	Necessary USBR Gabion Thickness (in) [9]	Manufactured Gabion Size (in) [9]	Left Bank USBR Gabion Volume per Length (ft^3/ft) [7]	Right Bank USBR Gabion Volume per Length (ft^3/ft) [7]	Left Bank Gabion Volume (yd^3)	Right Bank Gabion Volume (yd^3)	Total Gabion Volume, (yd^3) [8]	Standard CSA Layer Thickness (ft)	Height of Left Bank (ft) [10]	Left Bank Volume per Length (ft^3/ft) [7]	Height of Right Bank (ft) [10]	Right Bank Volume per Length (ft^3/ft) [7]	Left Bank CSA Volume (yd^3)	Right Bank CSA Volume (yd^3)	Total Volume of CSA (yd^3) [8]	Left Bank CSA Cement (tons) [11]	Right Bank CSA Cement (tons) [11]	Total CSA Cement (tons) [11]
Paradise Wash Reach		10000	10000																																	
	0.040	10000	10000	5.0	9.7	1740.1	1740.1	1723.0	1723.0	38.2	38.2	0.3	4.0	152.9	152.9	2691.9	2691.9	5383.7	20.7	21	66.9	66.9	1177.7	1177.7	2355.4	9	17.1	153.9	17.1	153.9	2708.6	2708.6	5417.3	383.9	383.9	767.9
	0.130	10475	10475	11.5	5.3	1740.8	1740.8	1725.1	1725.1	35.2	35.2	1.9	4.0	140.7	140.7	1100.8	1100.8	2201.7	20.7	21	61.6	61.6	481.6	481.6	963.2	9	15.7	141.6	15.7	141.6	1107.7	1107.7	2215.4	157.0	157.0	314.0
	0.170	10686	10686	12.9	6.8	1742.3	1742.3	1726.3	1726.3	35.7	35.7	2.4	4.0	142.7	142.7	3069.1	3069.1	6138.1	20.7	21	62.4	62.4	1342.7	1342.7	2685.4	9	16.0	143.6	16.0	143.6	3088.2	3088.2	6176.4	437.8	437.8	875.5
	0.280	11267	11267	12.1	4.3	1747.2	1747.0	1732.0	1732.1	34.0	33.4	2.1	4.0	136.0	133.6	1595.2	1567.7	3162.9	20.7	21	59.5	58.5	697.9	685.9	1383.8	9	15.2	136.8	14.9	134.4	1605.1	1577.5	3182.6	227.5	223.6	451.1
	0.340	11584	11584	12.0	3.5	1750.6	1750.5	1737.8	1737.8	28.7	28.4	2.0	4.0	115.0	113.4	2248.0	2218.3	4466.2	20.7	21	50.3	49.6	983.5	970.5	1954.0	9	12.9	115.7	12.7	114.1	2262.0	2232.1	4494.1	320.6	316.4	637.0
	0.440	12112	12112	12.0	4.4	1754.6	1754.6	1741.3	1741.3	29.7	29.7	2.0	4.0	118.6	118.6	2087.9	2087.9	4175.8	20.7	21	51.9	51.9	913.5	913.5	1826.9	9	13.3	119.4	13.3	119.4	2100.9	2100.9	4201.8	297.8	297.8	595.6
	0.530	12587	12587	12.7	5.4	1758.7	1758.7	1744.0	1744.0	32.8	32.8	2.3	4.0	131.3	131.3	2311.2	2311.2	4622.4	20.7	21	57.5	57.5	1011.1	1011.1	2022.3	9	14.7	132.1	14.7	132.1	2325.6	2325.6	4651.2	329.7	329.7	659.3
	0.620	13062	13062	11.5	5.6	1763.1	1763.1	1747.9	1747.9	34.0	34.0	1.9	4.0	136.1	136.1	2660.6	2660.6	5321.1	20.7	21	59.5	59.5	1164.0	1164.0	2328.0	9	15.2	136.9	15.2	136.9	2677.1	2677.1	5354.3	379.5	379.5	759.0
	0.720	13590	13590	13.2	4.8	1766.2	1766.2	1752.0	1752.0	31.8	31.8	2.5	4.0	127.3	127.3	1991.4	1991.4	3982.8	20.7	21	55.7	55.7	871.2	871.2	1742.5	9	14.2	128.1	14.2	128.1	2003.8	2003.8	4007.6	284.0	284.0	568.1
	0.800	14013	14013	13.2	4.8	1770.2	1770.2	1756.0	1756.0	31.8	31.8	2.5	4.0	127.0	127.0	2235.2	2235.2	4470.4	20.7	21	55.6	55.6	977.9	977.9	1955.8	9	14.2	127.8	14.2	127.8	2249.1	2249.1	4498.3	318.8	318.8	637.6
	0.890	14488	14488	13.5	7.4	1775.1	1775.1	1756.6	1756.6	41.3	41.3	2.6	4.0	165.0	165.0	1936.6	1936.6	3873.1	20.7	21	72.2	72.2	847.2	847.2	1694.5	9	18.5	166.1	18.5	166.1	1948.6	1948.6	3897.2	276.2	276.2	552.4
	0.950	14805	14805	8.6	6.6	1777.2	1777.5	1763.0	1760.8	31.8	37.2	1.0	4.0	127.0	148.9	2235.4	2620.5	4855.9	20.7	21	55.6	65.1	978.0	1146.5	2124.5	9	14.2	127.8	16.6	149.8	2249.3	2636.9	4886.1	318.8	373.8	692.6
	1.040	15280	15280	9.3	5.4	1779.1	1778.9	1764.2	1766.1	33.3	28.7	1.2	4.0	133.3	114.8	2085.8	1796.0	3881.8	20.7	21	58.3	50.2	912.5	785.7	1698.3	9	14.9	134.2	12.8	115.5	2098.8	1807.2	3906.0	297.5	256.2	553.7
	1.120	15702	15702	11.4	5.4	1782.4	1782.4	1766.6	1766.6	35.4	35.4	1.8	4.0	141.5	141.5	2490.4	2490.4	4980.8	20.7	21	61.9	61.9	1089.5	1089.5	2179.1	9	15.8	142.4	15.8	142.4	2505.9	2505.9	5011.8	355.2	355.2	710.4
	1.210	16178	16178	12.0	6.2	1785.5	1785.5	1770.7	1770.7	33.2	33.2	2.1	4.0	132.8	132.8	1558.2	1558.2	3116.5	20.7	21	58.1	58.1	681.7	681.7	1363.5	9	14.8	133.6	14.8	133.6	1567.9	1567.9	3135.9	222.3	222.3	444.5
	1.270	16494	16494	11.5	5.3	1787.8	1787.8	1773.7	1773.7	31.5	31.5	1.9	4.0	126.0	126.0	2463.7	2463.7	4927.4	20.7	21	55.1	55.1	1077.9	1077.9	2155.7	9	14.1	126.8	14.1	126.8	2479.1	2479.1	4958.1	351.4	351.4	702.8
	1.370	17022	17022	11.5	5.1	1791.8	1791.3	1774.5	1776.6	38.5	32.8	1.9	4.0	154.2	131.3	2713.2	2311.3	5024.5	20.7	21	67.4	57.5	1187.0	1011.2	2198.2	9	17.2	155.1	14.7	132.1	2730.1	2325.7	5055.8	387.0	329.7	716.7
	1.460	17498	17498	11.5	5.4	1795.1	1794.7	1779.0	1780.8	36.1	31.0	1.9	4.0	144.3	124.0	2257.1	1940.2	4197.3	20.7	21	63.1	54.3	987.5	848.8	1836.3	9	16.1	145.2	13.9	124.8	2271.2	1952.3	4223.4	321.9	276.7	598.7
	1.540	17920	17920	8.3	3.9	1797.4	1797.4	1787.0	1787.0	23.3	23.3	1.0	4.0	93.0	93.0	4613.1	2001.0	6614.1	20.7	21	40.7	40.7	2018.2	875.4	2893.7	9	10.4	93.6	10.4	93.6	4641.9	2013.4	6655.3	658.0	285.4	943.4
	1.650	19259	18501	11.5	4.6	1804.1	1804.1	1791.1	1791.1	29.1	29.1	1.9	4.0	116.5	116.5	-4138.9	2278.7	-1860.1	20.7	21	51.0	51.0	-1810.8	997.0	-813.8	9	13.0	117.3	13.0	117.3	-4164.6	2292.9	-1871.7	-590.3	325.0	-265.3
	1.750	18300	19029	11.1	4.2	1808.8	1808.8	1794.9	1794.9	31.1	31.1	1.7	4.0	124.4	124.4	1946.4	1946.4	3892.9	20.7	21	54.4	54.4	851.6	851.6	1703.1	9	13.9	125.2	13.9	125.2	1958.6	1958.6	3917.1	277.6	277.6	555.3
	1.830	18722	19451	12.0	5.1	1814.8	1814.8	1800.8	1800.8	31.3	31.3	2.0	4.0	125.4	125.4	2206.5	2206.5	4413.1	20.7	21	54.9	54.9	965.4	965.4	1930.7	9	14.0	126.2	14.0	126.2	2220.3	2220.3	4440.6	314.7	314.7	629.5
	1.920	19198	19926	11.4	4.5	1818.5	1818.5	1804.7	1804.7	30.8	30.8	1.8	4.0	123.3	123.3	1929.2	1446.0	3375.2	20.7	21	54.0	54.0	844.0	632.6	1476.6	9	13.8	124.1	13.8	124.1	1941.2	1455.0	3396.2	275.2	206.2	481.4
	2.000	19620	20243	12.8	6.2	1823.8	1823.8	1807.2	1807.2	37.2	37.2	2.3	4.0	148.8	148.8	2231.7	0.0	2231.7	20.7	21	65.1	65.1	976.4	0.0	976.4	9	16.6	149.7	16.6	149.7	2245.6	0.0	2245.6	318.3	0.0	318.3
	2.001	20025																																		
									Average	**33.2**	**32.7**	**2.6**															**14.8**		**14.5**							
											Quantity/Total					**28763.7**	**29230.8**	**57994.5**					**12584.1**	**12788.5**	**25372.6**						**28942.9**	**29412.9**	**58355.8**	**4102.7**	**4169.3**	**8271.9**
															Total	**28763.7**	**29230.8**	**57994.5**					**12584.1**	**12788.5**	**25372.6**						**28942.9**	**29412.9**	**58355.8**	**4102.7**	**4169.3**	**8271.9**

[1] All hydraulic parameters from HEC-RAS Apache1.prj

[2] Top of Bank = WSE + Superelevation + 3'

[3] Minimum HEC-RAS Elevation - HEC-6 Design Scour Depth - Armoring Depth

[4] Slope Length = $((\text{Top of Bank} - \text{Toe Down})^2 + ((\text{Top of Bank} - \text{Toe Down}) * 2)^2)^{0.5}$

[5] USBR D_{50} from USGS WRI Report 86-4128 Figure 38

$D_{50} = 0.0122 * V_a^{2.06}$

[6] Layer Thickness = 1.5 * D_{50} (1' Minimum) Drainage Design for MC Volume II Table 6.4 pg.6-40
Rounded up to the Nearest Half-Foot

[7] Volume per Length = Slope Length * Layer Thickness

[8] ((Suceeding Station No. - Station No.) * 5280 * (L Bank + R Bank Volume per Length)) / 27

[9] Used COT Method of 2/3 * Dumped D_{50}, 1' Minimum (FHWA HEC-11 Table 5 p. 84)

[10] Height of Bank = Top of Bank - Toe Down

[11] CSA Cement = Volume of CSA * 7%

Density of Cement = 150 lb/ft^3

	Center Stationing ID (River miles)	Left Bank Stationing (ft)	Right Bank Stationing (ft)	HEC-RAS 100 Year Flow Velocity (fps) [*1]	Average Hydraulic Depth, V_m (fps) [*1]	Left Bank Top of Bank Elev - Levee Option (ft) [*2]	Right Bank Top of Bank Elev - Levee Option (ft) [*2]	Left Bank Toe Down Elevation (ft) [*3]	Right Bank Toe Down Elevation (ft) [*3]	Left Bank Slope Length (ft) [*4]	Right Bank Slope Length (ft) [*4]	USBR Dumped Riprap Median Riprap Particle Size, D_{50} (ft) [*5]	USBR Riprap Layer Thickness (ft) [*6]	Left Bank USBR Riprap Volume per Length (ft^3/ft) [*7]	Right Bank USBR Riprap Volume per Length (ft^3/ft) [*7]	Left Bank Riprap Volume (yd^3)	Right Bank Riprap Volume (yd^3)	USBR Total Riprap Volume, (yd^3) [*8]	Necessary USBR Gabion Thickness (in) [*9]	Manufactured Gabion Size (in) [*9]	Left Bank USBR Gabion Volume per Length (ft^3/ft) [*7]	Right Bank USBR Gabion Volume per Length (ft^3/ft) [*7]	Left Bank Gabion Volume (yd^3)	Right Bank Gabion Volume (yd^3)	Total Gabion Volume, (yd^3) [*8]	Standard CSA Layer Thickness (ft)	Height of Left Bank (ft) [*10]	Left Bank Volume per Length (ft^3/ft) [*7]	Height of Right Bank (ft) [*10]	Right Bank Volume per Length (ft^3/ft) [*7]	Left Bank CSA Volume (yd^3)	Right Bank CSA Volume (yd^3)	Total Volume of CSA (yd^3) [*8]	Left Bank CSA Cement (tons) [*11]	Right Bank CSA Cement (tons) [*11]	Total CSA Cement (tons) [*11]
Desert Hills Wash Reach		10000	10600																																	
	0.386	10000	10600	9.9	7.2	1748.5	1748.5	1733.3	1733.3	34.1	34.1	1.4	3.5	119.2	119.2	326.5	326.5	652.9	18.4	21	59.6	59.6	163.2	163.2	326.5	9	15.2	137.1	15.2	137.1	375.4	375.4	750.8	53.2	53.2	106.4
	0.400	10074	10674	10.5	6.3	1749.0	1749.0	1733.0	1733.0	35.8	35.8	1.5	3.5	125.5	125.5	1962.9	1962.9	3925.7	18.4	21	62.7	62.7	981.4	981.4	1962.9	9	16.0	144.3	16.0	144.3	2257.3	2257.3	4514.5	320.0	320.0	639.9
	0.480	10496	11096	8.9	7.2	1750.6	1750.6	1737.0	1737.0	30.4	30.4	1.1	3.5	106.4	106.4	1665.1	1665.1	3330.3	18.4	21	53.2	53.2	832.6	832.6	1665.1	9	13.6	122.4	13.6	122.4	1914.9	1914.9	3829.8	271.4	271.4	542.9
	0.560	10919	11519	10.2	7.4	1751.5	1751.5	1733.1	1733.1	41.1	41.1	1.5	3.5	144.0	144.0	2252.6	2252.6	4505.1	18.4	21	72.0	72.0	1126.3	1126.3	2252.6	9	18.4	165.6	18.4	165.6	2590.4	2590.4	5180.8	367.2	367.2	734.4
	0.640	11341	11941	12.5	6.4	1752.7	1752.7	1734.1	1734.1	41.6	41.6	2.2	3.5	145.5	145.5	2276.2	2276.2	4552.3	18.4	21	72.7	72.7	1138.1	1138.1	2276.2	9	18.6	167.3	18.6	167.3	2617.5	2617.5	5235.0	371.0	371.0	742.1
	0.720	11764	12364	12.7	6.7	1754.7	1754.7	1736.5	1736.5	40.6	40.6	2.3	3.5	142.1	142.1	2501.3	2129.1	4630.4	18.4	21	71.1	71.1	1250.7	1064.5	2315.2	9	18.2	163.4	18.2	163.4	2876.5	2448.4	5324.9	407.7	347.1	754.8
	0.810	12239	12768	9.6	7.0	1757.0	1757.0	1738.5	1738.5	41.4	41.4	1.3	3.5	144.9	144.9	4535.5	0.0	4535.5	18.4	21	72.4	72.4	2267.7	0.0	2267.7	9	18.5	166.6	18.5	166.6	5215.7	0.0	5215.7	739.3	0.0	739.3
	0.811	13084																																		
									Average	**37.9**	**37.9**	**2.3**															**16.9**		**16.9**							
										Quantity/Total						**15520.0**	**10612.3**	**26132.3**					**7760.0**	**5306.1**	**13066.1**						**17847.6**	**12203.9**	**30051.5**	**2529.9**	**1729.9**	**4259.8**
															Total	**15520.0**	**10612.3**	**26132.3**					**7760.0**	**5306.1**	**13066.1**						**17847.6**	**12203.9**	**30051.5**	**2529.9**	**1729.9**	**4259.8**

[*1] All hydraulic parameters from HEC-RAS Apache1.prj

[*2] Top of Bank = WSE + Superelevation + 3'

[*3] Minimum HEC-RAS Elevation - HEC-6 Design Scour Depth - Armoring Depth

[*4] Slope Length = $((\text{Top of Bank} - \text{Toe Down})^2 + ((\text{Top of Bank} - \text{Toe Down}) * 2)^2)^{0.5}$

[*5] USBR D_{50} from USGS WRI Report 86-4128 Figure 38

$D_{50} = 0.0122 * V_a^{2.06}$

[*6] Layer Thickness = 1.5 * D_{50} (1' Minimum) Drainage Design for MC Volume II Table 6.4 pg.6-40
Rounded to the Nearest Half-Foot

[*7] Volume per Length = Slope Length * Layer Thickness

[*8] ((Suceeding Station No. - Station No.) * 5280 * (L Bank + R Bank Volume per Length)) / 27

[*9] Used COT Method of 2/3 * Dumped D_{50} 1' Minimum (FHWA HEC-11 Table 5 p. 84)

[*10] Height of Bank = Top of Bank - Toe Down

[*11] CSA Cement = Volume of CSA * 7%
Density of Cement = 150 lb/ft^3

Stationing ID (River miles)	Maximum WSE (ft) *2	Left Bank Superelevation Freeboard (ft)	Right Bank Superelevation Freeboard (ft)	Left Top of Bank Elevation (ft) *1	Right Top of Bank Elevation (ft) *1	HEC-RAS Minimum Elevation (ft) *2	HEC-6 General Scour Depth (ft)	Antidune Trough Depth (ft)	Left Bank Bend Scour Depth, Z_{bs} (ft)	Right Bank Bend Scour Depth, Z_{bs} (ft)	Left Bank HEC-6 Design Scour Depth (ft) *3	Right Bank HEC-6 Design Scour Depth (ft) *3	Depth to Armoring, y_d (ft)	Left Bank Total Degredeation (ft) *4	Right Bank Total Degredeation (ft) *4	Left Bank Toe Down Elevation (ft) *5	Right Bank Toe Down Elevation (ft) *5	HEC-RAS Min Elevation - 10' (ft)	Left Top of Bank - Toe Down (ft)	Right Top of Bank - Toe Down (ft)	Left Reach Average Total Degredation (ft)	Right Reach Average Total Degredation (ft)	Left TOB - HEC-RAS Min Elevation	Right TOB - HEC-RAS Min Elevation	Left Reach Average TOB Above RAS Min (ft)	Right Reach Average TOB Above RAS Min (ft)	
24.919	1648.1	0	0	1651.1	1651.1	1634.9	0.7	1.0	0	0	2.2	2.2	2.3	4.5	4.5	1630.4	1630.4	1624.9	20.7	20.7			16.2	16.2			
25.010	1650.1	0	0	1653.1	1653.1	1640.2	0.8	1.1	0	0	2.5	2.5	0.8	3.3	3.3	1636.9	1636.9	1630.2	16.2	16.2			12.9	12.9			
25.099	1654.8	0	0	1657.8	1657.8	1646.0	8.0	3.0	0	0	14.3	14.3	3.3	17.7	17.7	1628.3	1628.3	1636.0	29.5	29.5			11.8	11.8			
25.180	1659.8	0	0	1662.8	1662.8	1647.7	0.7	1.1	0	0	2.3	2.3	1.1	3.4	3.4	1644.3	1644.3	1637.7	18.5	18.5			15.1	15.1			
25.233	1661.0	0	0	1664.0	1664.0	1647.3	0.7	1.8	0	0	3.2	3.2	5.8	8.9	8.9	1638.4	1638.4	1637.3	25.6	25.6	3.3	3.3	16.7	16.7			Min
25.326	1665.0	0	0	1668.0	1668.0	1653.0	0.6	2.7	0	0	4.3	4.3	2.1	6.4	6.4	1646.6	1646.6	1643.0	21.4	21.4	17.7	17.7	15.0	15.0			Max
25.338	1669.1	0	0	1672.1	1672.1	1656.6	0.6	2.7	0	0	4.2	4.2	3.7	7.9	7.9	1648.7	1648.7	1646.6	23.4	23.4	7.5	7.5	15.5	15.5	14.7	14.7	Ave
25.458	1673.2	0	0	1676.2	1676.2	1665.5	0.5	1.0	0	0	2.0	2.0	1.1	3.1	3.1	1662.4	1662.4	1655.5	13.8	13.8			10.7	10.7			
25.519	1675.4	0	0	1678.4	1678.4	1668.3	0.6	1.6	0	0	2.9	2.9	2.4	5.3	5.3	1663.0	1663.0	1658.3	15.4	15.4			10.1	10.1			
25.580	1678.2	0	0	1681.2	1681.2	1668.9	0.6	1.8	0	0	3.1	3.1	2.0	5.1	5.1	1663.8	1663.8	1658.9	17.4	17.4			12.3	12.3			
25.644	1681.2	0	0	1684.2	1684.2	1669.8	0.7	2.7	0	0	4.4	4.4	3.3	7.8	7.8	1662.0	1662.0	1659.8	22.2	22.2			14.4	14.4			
25.699	1683.5	0	0	1686.5	1686.5	1669.4	0.6	2.7	0	0	4.2	4.2	2.1	6.4	6.4	1663.0	1663.0	1659.4	23.5	23.5			17.1	17.1			
25.750	1686.2	0	0	1689.2	1689.2	1671.6	0.3	1.0	0	0	1.7	1.7	2.6	4.3	4.3	1667.3	1667.3	1661.6	21.9	21.9			17.6	17.6			
25.843	1687.2	0	0	1690.2	1690.2	1673.5	0.5	1.8	0	0	2.9	2.9	2.4	5.4	5.4	1668.1	1668.1	1663.5	22.1	22.1			16.7	16.7			
25.919	1690.6	0	0	1693.6	1693.6	1678.4	0.6	2.5	0	0	4.0	4.0	7.8	11.9	11.9	1666.5	1666.5	1668.4	27.1	27.1			15.2	15.2			
26.044	1696.0	0	0	1699.0	1699.0	1684.3	0.8	1.6	0	0	3.1	3.1	2.4	5.5	5.5	1678.8	1678.8	1674.3	20.2	20.2			14.7	14.7			
26.137	1699.2	0	0	1702.2	1702.2	1685.7	0.9	1.7	0	0	3.3	3.3	2.1	5.4	5.4	1680.3	1680.3	1675.7	21.9	21.9			16.5	16.5			
26.239	1702.8	0	0	1705.8	1705.8	1692.8	1.1	2.0	0	0	4.0	4.0	5.1	9.1	9.1	1683.7	1683.7	1682.8	22.1	22.1			13.0	13.0			
26.335	1706.5	0	0	1709.5	1709.5	1695.6	0.9	0.7	0	0	2.0	2.0	0.3	3.0	3.0	1692.6	1692.6	1685.6	16.9	16.9			13.9	13.9			
26.430	1707.9	0	0	1710.9	1710.9	1697.5	0.8	1.8	0	0	3.4	3.4	2.1	5.5	5.5	1692.0	1692.0	1687.5	18.9	18.9			13.4	13.4			
26.529	1712.5	0	0	1715.5	1715.5	1702.6	0.7	2.8	0	0	4.5	4.5	2.6	7.2	7.2	1695.4	1695.4	1692.6	20.1	20.1			12.9	12.9			
26.623	1717.6	0	0	1720.6	1720.6	1703.9	1.3	1.0	0	0	3.0	3.0	1.0	4.0	4.0	1699.9	1699.9	1693.9	20.7	20.7			16.7	16.7			
26.695	1721.5	0	0	1724.5	1724.5	1709.5	1.7	3.2	0	0	6.4	6.4	5.1	11.5	11.5	1698.0	1698.0	1699.5	26.5	26.5			15.0	15.0			
26.775	1726.4	0	0	1729.4	1729.4	1712.7	1.4	2.1	0	0	4.5	4.5	2.1	6.6	6.6	1706.1	1706.1	1702.7	23.3	23.3			16.7	16.7			
26.845	1729.1	0	0	1732.1	1732.1	1717.0	1.2	1.6	0	0	3.6	3.6	2.3	5.9	5.9	1711.1	1711.1	1707.0	21.0	21.0			15.1	15.1			
26.921	1731.4	0	0	1734.4	1734.4	1720.2	0.8	1.4	0	0	2.9	2.9	1.7	4.6	4.6	1715.6	1715.6	1710.2	18.8	18.8			14.2	14.2			
27.008	1733.8	0	0	1736.8	1736.8	1723.0	0.6	1.4	0	0	2.6	2.6	1.8	4.3	4.3	1718.7	1718.7	1713.0	18.1	18.1			13.8	13.8			
27.106	1737.8	0	0	1740.8	1740.8	1725.7	0.5	2.4	0	0	3.8	3.8	3.1	6.9	6.9	1718.8	1718.8	1715.7	22.0	22.0			15.1	15.1			
27.169	1742.2	0	0	1745.2	1745.2	1732.1	0.4	1.3	0	0	2.1	2.1	1.4	3.5	3.5	1728.6	1728.6	1722.1	16.6	16.6	3.0	3.0	13.1	13.1			Min
27.226	1743.9	0.7	0	1747.6	1746.9	1734.8	2.5	2.2	0.8	0	7.1	6.0	2.4	9.6	8.5	1725.2	1726.3	1724.8	22.4	20.6	16.0	14.3	12.8	12.1			Max
27.265	1750.2	0.4	0	1753.6	1753.2	1735.7	3.5	2.4	1.3	0	9.4	7.7	6.6	16.0	14.3	1719.7	1721.4	1725.7	33.9	31.8	6.6	6.5	17.9	17.5	14.5	14.5	Ave
27.320	1753.7	0.2	0	1756.9	1756.7	1740.3	3.5	2.3	1.2	0	9.1	7.5	3.3	12.5	10.9	1727.8	1729.4	1730.3	29.1	27.3			16.6	16.4			
27.366	1755.7	0.2	0	1758.9	1758.7	1742.3	3.0	0.9	1.1	0	6.5	5.0	0.7	7.2	5.8	1735.1	1736.5	1732.3	23.8	22.2			16.6	16.4			
27.417	1757.8	0.7	0	1761.5	1760.8	1744.8	2.2	3.1	1.2	0	8.5	6.9	5.8	14.3	12.6	1730.5	1732.2	1734.8	31.0	28.6			16.7	16.0			
27.502	1765.4	0	0	1768.4	1768.4	1748.8	1.5	3.1	0	0	5.9	5.9	4.5	10.4	10.4	1738.4	1738.4	1738.8	30.0	30.0			19.6	19.6			
27.604	1768.7	0	0	1771.7	1771.7	1754.2	2.2	2.2	0	0	5.8	5.8	2.1	7.9	7.9	1746.3	1746.3	1744.2	25.4	25.4			17.5	17.5			
27.693	1775.0	0	0	1778.0	1778.0	1756.3	3.2	3.2	0	0	8.3	8.3	9.5	17.8	17.8	1738.5	1738.5	1746.3	39.5	39.5			21.7	21.7			
27.797	1779.4	0	0	1782.4	1782.4	1760.6	3.9	3.1	0	0	9.1	9.1	3.3	12.4	12.4	1748.2	1748.2	1750.6	34.2	34.2			21.8	21.8			
27.913	1783.1	0	0	1786.1	1786.1	1763.1	3.0	2.6	0	0	7.3	7.3	2.1	9.5	9.5	1753.6	1753.6	1753.1	32.5	32.5			23.0	23.0			
28.023	1787.5	0	0	1790.5	1790.5	1772.5	2.3	2.2	0	0	5.9	5.9	3.3	9.2	9.2	1763.3	1763.3	1762.5	27.2	27.2			18.0	18.0			
28.091	1791.1	0	0	1794.1	1794.1	1780.8	1.7	1.8	0	0	4.6	4.6	4.5	9.1	9.1	1771.7	1771.7	1770.8	22.4	22.4			13.3	13.3			
28.157	1794.5	0	0	1797.5	1797.5	1782.6	1.9	1.9	0	0	4.9	4.9	1.9	6.8	6.8	1775.8	1775.8	1772.6	21.7	21.7			14.9	14.9			
28.241	1799.4	0	0	1802.4	1802.4	1789.9	2.0	2.5	0	0	5.8	5.8	4.0	9.9	9.9	1780.0	1780.0	1779.9	22.4	22.4			12.5	12.5			
28.326	1804.4	0	0	1807.4	1807.4	1791.3	2.1	3.0	0	0	6.6	6.6	2.4	9.1	9.1	1782.2	1782.2	1781.3	25.2	25.2			16.1	16.1			
28.390	1807.2	0	0	1810.2	1810.2	1792.8	1.7	3.1	0	0	6.2	6.2	4.5	10.7	10.7	1782.1	1782.1	1782.8	28.1	28.1			17.4	17.4			
28.462	1809.8	0	0	1812.8	1812.8	1794.8	1.6	3.3	0	0	6.3	6.3	2.4	8.8	8.8	1786.0	1786.0	1784.8	26.8	26.8			18.0	18.0			
28.555	1814.3	0	0	1817.3	1817.3	1799.4	1.3	3.4	0	0	6.2	6.2	6.6	12.8	12.8	1786.6	1786.6	1789.4	30.7	30.7			17.9	17.9			
28.657	1818.1	0	0	1821.1	1821.1	1800.5	1.3	2.7	0	0	5.2	5.2	2.8	8.0	8.0	1792.5	1792.5	1790.5	28.6	28.6			20.6	20.6			
28.750	1821.6	0	0	1824.6	1824.6	1808.3	1.3	2.9	0	0	5.5	5.5	4.0	9.6	9.6	1798.7	1798.7	1798.3	25.9	25.9			16.3	16.3			
28.847	1826.5	0	0	1829.5	1829.5	1811.9	1.5	3.2	0	0	6.1	6.1	3.3	9.4	9.4	1802.5	1802.5	1801.9	27.0	27.0			17.6	17.6			
28.934	1830.2	0	0	1833.2	1833.2	1815.5	1.7	3.0	0	0	6.1	6.1	5.8	11.8	11.8	1803.7	1803.7	1805.5	29.5	29.5			17.7	17.7			
29.012	1833.8	0	0	1836.8	1836.8	1818.7	1.8	3.2	0	0	6.6	6.6	3.3	9.9	9.9	1808.8	1808.8	1808.7	28.0	28.0			18.1	18.1			
29.130	1838.3	0	0	1841.3	1841.3	1821.0	1.2	3.6	0	0	6.3	6.3	5.1	11.3	11.3	1809.7	1809.7	1811.0	31.6	31.6			20.3	20.3			
29.258	1843.3	0	0	1846.3	1846.3	1828.7	0.5	2.7	0	0	4.2	4.2	2.3	6.4	6.4	1822.3	1822.3	1818.7	24.0	24.0			17.6	17.6			
29.351	1848.5	0	0	1851.5	1851.5	1835.9	0.7	0.9	0	0	2.1	2.1	2.8	4.9	4.9	1831.0	1831.0	1825.9	20.5	20.5			15.6	15.6			
29.387	1849.4	0	0	1852.4	1852.4	1838.8	0.7	1.0	0	0	2.2	2.2	1.9	4.1	4.1	1834.7	1834.7	1828.8	17.7	17.7			13.6	13.6			
29.493	1853.2	0	0	1856.2	1856.2	1843.4	1.3	1.0	0	0	3.0	3.0	1.7	4.6	4.6	1838.8	1838.8	1833.4	17.4	17.4	4.1	4.1	12.8	12.8			Min
29.538	1855.3	0	0	1858.3	1858.3	1845.5	1.5	1.9	0	0	4.4	4.4	2.4	6.9	6.9	1838.6	1838.6	1835.5	19.7	19.7	17.8	17.8	12.8	12.8			Max
29.601	1859.8	0	0	1862.8	1862.8	1849.9	1.8	2.5	0	0	5.6	5.6	2.1	7.7	7.7	1842.2	1842.2	1839.9	20.6	20.6	9.4	9.2	12.9	12.9	17.1	17.0	Ave
29.710	1865.6	0	0	1868.6	1868.6	1853.9	2.5	2.3	0	0	6.3	6.3	2.4	8.7	8.7	1845.2	1845.2	1843.9	23.4	23.4			14.7	14.7			
29.715																											
													Average	8.0	7.9				23.8	23.6							

*1 Top of Levee = HEC-RAS WSE + Superel. + 3'
*2 All hydraulic parameters from HEC-RAS Caveck.prj
Existing (Worst case) hydraulics.
*3 Left or Right Bank Design Scour Depth = (HEC-6 General Scour + Anti-dune Trough Depth + Right or Left Bend Scour Depth) * 1.3
*4 Total Degredation = Design Scour Depth + Armoring Depth. Minimum 3'
*5 Toe Down Elevation = Minimum HEC-RAS Elevation - Total Degredation

Stationing ID (River Miles)	Reach Code	Design Discharge, Q (cfs) *1	Average Channel Velocity, V_m (fps)	Maximum Depth Main Channel, Y_{max}, (ft)	Main Channel Hydraulic Depth, Y_h (ft)	Energy Slope, S_e (ft/ft)	HEC-6 General Scour Depth, HEC-6 Z_{gs} (ft) *4	Anti-dune Trough Depth, Z_a (ft) *5	Left Bank Angle of Channel Bend in degrees	Right Bank Angle of Channel Bend in degrees	Left Bank Bend Scour Depth, Z_{bs} (ft) *6	Right Bank Bend Scour Depth, Z_{bs} (ft) *6	Full Flow Velocity *2	Full Flow Channel Top Width, T (ft) *2	Left Bank Radius of Curve, r_c *9	Right Bank Radius of Curve, r_c *9	Left Bank Superelevation, del h (ft) *10	Right Bank Superelevation, del h (ft) *10	Left Bank HEC 6 Design Scour Depth, Z_t (ft) *8	Right Bank HEC-6 Design Scour Depth, Z_t (ft) *8	Average HEC-6 Left Bank Design Scour Depth	Average HEC-6 Right Bank Design Scour Depth
24.919	Braided	41400	8.55	13.24	7.98	0.00419	0.7	1.0	0	0	0	0	5.3	1457.3	0	0	0	0	2.2	2.2	4.7	4.7
25.01	Braided	41400	9.11	9.89	7.8	0.00473	0.8	1.1	0	0	0	0	6.6	1327.2	0	0	0	0	2.5	2.5		
25.099	Braided	41400	14.87	8.8	4.98	0.02305	8	3.0	0	0	0	0	9.2	1285.8	0	0	0	0	14.3	14.3		
25.18	Braided	41400	8.81	12.15	7.72	0.00451	0.7	1.1	0	0	0	0	5.3	1560.1	0	0	0	0	2.3	2.3		
25.233	Braided	41400	11.32	13.72	7.94	0.00769	0.7	1.8	0	0	0	0	6.1	1650.0	0	0	0	0	3.2	3.2		
25.326	Braided	39700	14.09	11.99	7.63	0.01172	0.6	2.7	0	0	0	0	8.4	1077.2	0	0	0	0	4.3	4.3		
25.338	Braided	39700	13.91	12.55	7.74	0.01120	0.6	2.7	0	0	0	0	8.3	1120.0	0	0	0	0	4.2	4.2		
25.46	Mined	39700	8.55	8.69	6.4	0.00540	0.5	1.0	0	0	0	0	5.8	1245.6	0	0	0	0	2.0	2.0	3.8	3.7
25.519	Mined	39700	10.92	7.13	5.4	0.01107	0.6	1.6	0	0	0	0	7.3	1179.0	0	0	0	0	2.9	2.9		
25.58	Mined	39700	11.32	9.27	7.5	0.00769	0.6	1.8	0	0	0	0	6.8	1151.0	0	0	0	0	3.1	3.1		
25.644	Mined	39700	14.03	11.36	9.24	0.00907	0.7	2.7	0	0	0	0	7.6	1220.0	0	0	0	0	4.4	4.4		
25.699	Mined	39700	13.95	14.06	11.7	0.00663	0.6	2.7	0	0	0	0	7.5	1201.3	0	0	0	0	4.2	4.2		
25.75	Mined	39700	8.45	14.61	9.81	0.00308	0.3	1.0	0	0	0	0	4.9	1372.0	0	0	0	0	1.7	1.7		
25.843	Mined	39700	11.35	13.75	8.04	0.00716	0.5	1.8	0	0	0	0	6.5	1443.0	0	0	0	0	2.9	2.9		
25.919	Mined	39700	13.49	12.17	7.03	0.01207	0.6	2.5	0	0	0	0	8.0	1304.0	0	0	0	0	4.0	4.0		
26.044	Mined	39700	10.75	11.72	7.27	0.00762	0.8	1.6	0	0	0	0	6.5	1336.0	0	0	0	0	3.1	3.1		
26.137	Mined	39700	10.98	13.54	7.82	0.007102	0.9	1.7	0	0	0	0	7.5	1202.0	0	0	0	0	3.3	3.3		
26.239	Mined	39700	12.12	9.99	5.55	0.013615	1.1	2.0	0	0	0	0	8.9	1119.0	0	0	0	0	4.0	4.0		
26.335	Mined	39700	7.02	10.89	7.67	0.002887	0.9	0.7	0	0	0	0	6.4	1009.0	0	0	0	0	2.0	2.0		
26.43	Mined	39700	11.48	10.38	7.03	0.008705	0.8	1.8	0	0	0	0	11.3	588.9	0	0	0	0	3.4	3.4		
26.529	Mined	39700	14.25	9.94	7.27	0.012788	0.7	2.8	0	0	0	0	14.1	469.7	0	0	0	0	4.5	4.5		
26.62	Mined	39700	8.7	13.66	9.79	0.00322	1.3	1.0	0	0	0	0	8.7	485.1	0	0	0	0	3.0	3.0		
26.695	Mined	39700	15.39	11.96	8.05	0.013986	1.7	3.2	0	0	0	0	12.6	520.1	0	0	0	0	6.4	6.4		
26.775	Mined	39700	12.25	13.66	9.9	0.006448	1.4	2.1	0	0	0	0	10.3	653.5	0	0	0	0	4.5	4.5		
26.845	Mined	39700	10.69	12.12	9.2	0.005284	1.2	1.6	0	0	0	0	9.1	841.8	0	0	0	0	3.6	3.6		
26.921	Mined	35800	10.26	11.23	8.27	0.005613	0.8	1.4	0	0	0	0	10.3	422.1	0	0	0	0	2.9	2.9		
27.008	Mined	35800	10.01	10.81	7.71	0.005865	0.6	1.4	0	0	0	0	10.0	495.9	0	0	0	0	2.6	2.6		
27.106	Mined	35800	13.26	12.13	5.52	0.016076	0.5	2.4	0	0	0	0	13.3	488.7	0	0	0	0	3.8	3.8		
27.169	Mined	35800	9.56	10.1	7.41	0.005618	0.4	1.3	0	0	0	0	9.5	566.0	0	0	0	0	2.1	2.1		
27.226	Mined	35800	12.53	9.07	6.44	0.011661	2.5	2.2	22	0	0.8	0	11.9	549.8	3500.6	0	0.7	0	7.1	6.0		
27.265	Mined	35800	13.2	14.51	9.3	0.008399	3.5	2.4	22	0	1.3	0	8.8	968.6	6166.9	0	0.4	0	9.4	7.7		
27.32	Cliff	35800	12.89	13.43	10.89	0.006295	3.5	2.3	22	0	1.2	0	7.2	1266.3	8061.9	0	0.2	0	9.1	7.5	5.9	5.7
27.366	Cliff	35800	7.98	13.36	10.12	0.002663	3	0.9	22	0	1.1	0	6.0	1232.3	7845.8	0	0.2	0	6.5	5.0		
27.417	Cliff	35800	15.04	13.02	8.22	0.012331	2.2	3.1	22	0	1.2	0	12.0	630.6	4015.0	0	0.7	0	8.5	6.9		
27.502	Cliff	35800	14.94	16.56	10.93	0.005651	1.5	3.1	0	0	0	0	10.3	639.3	0	0	0	0	5.9	5.9		
27.604	Cliff	35800	12.81	14.5	11	0.004087	2.2	2.2	0	0	0	0	11.0	438.1	0	0	0	0	5.8	5.8		
27.693	Cliff	35800	15.33	18.66	9.53	0.00723	3.2	3.2	0	0	0	0	11.6	499.8	0	0	0	0	8.3	8.3		
27.797	Cliff	35800	15.01	18.85	11	0.005779	3.9	3.1	0	0	0	0	10.0	628.3	0	0	0	0	9.1	9.1		
27.913	Cliff	35800	13.89	19.95	9.36	0.005968	3	2.6	0	0	0	0	12.6	479.5	0	0	0	0	7.3	7.3		
28.023	Cliff	35800	12.71	15.01	9.13	0.007872	2.3	2.2	0	0	0	0	12.1	435.8	0	0	0	0	5.9	5.9		
28.091	Cliff	35800	11.58	10.33	6.47	0.009949	1.7	1.8	0	0	0	0	11.6	478.1	0	0	0	0	4.6	4.6		
28.16	Cliff	35800	11.66	11.94	6.86	0.009303	1.9	1.9	0	0	0	0	10.9	551.4	0	0	0	0	4.9	4.9		
28.241	Cliff	35800	13.47	9.5	6.54	0.013082	2	2.5	0	0	0	0	11.8	589.0	0	0	0	0	5.8	5.8		
28.326	Cliff	35800	14.83	13.08	9.92	0.006185	2.1	3.0	0	0	0	0	10.7	598.7	0	0	0	0	6.6	6.6		
28.39	Cliff	35800	14.96	14.41	10.34	0.006057	1.7	3.1	0	0	0	0	9.6	650.1	0	0	0	0	6.2	6.2		
28.46	Cliff	35800	15.43	14.97	11.71	0.005534	1.6	3.3	0	0	0	0	10.4	582.4	0	0	0	0	6.3	6.3		
28.555	Cliff	35800	15.86	14.92	11.69	0.005841	1.3	3.4	0	0	0	0	11.2	505.4	0	0	0	0	6.2	6.2		
28.657	Cliff	35800	13.97	17.56	9.75	0.005798	1.3	2.7	0	0	0	0	11.6	500.4	0	0	0	0	5.2	5.2		
28.75	Cliff	35800	14.66	13.33	10.15	0.005878	1.3	2.9	0	0	0	0	11.6	648.6	0	0	0	0	5.5	5.5		
28.847	Cliff	35800	15.19	14.58	12.2	0.005041	1.5	3.2	0	0	0	0	10.0	648.4	0	0	0	0	6.1	6.1		
28.93	Cliff	35800	14.77	14.67	10.47	0.005771	1.7	3.0	0	0	0	0	10.1	652.6	0	0	0	0	6.1	6.1		
29.012	Cliff	35800	15.4	15.12	12.24	0.005251	1.8	3.2	0	0	0	0	9.4	649.2	0	0	0	0	6.6	6.6		
29.13	Cliff	36000	16.27	17.28	12.56	0.005854	1.2	3.6	0	0	0	0	9.8	590.7	0	0	0	0	6.3	6.3		
29.258	Cliff	36000	14.02	14.61	10.08	0.008184	0.5	2.7	0	0	0	0	14.0	254.8	0	0	0	0	4.2	4.2		
29.351	Cliff	36000	8.16	12.6	8.62	0.004433	0.7	0.9	0	0	0	0	7.5	614.7	0	0	0	0	2.1	2.1		
29.387	Cliff	36000	8.42	10.63	7.16	0.005991	0.7	1.0	0	0	0	0	7.7	726.0	0	0	0	0	2.2	2.2		
29.493	Cliff	36000	8.46	9.8	5.78	0.007859	1.3	1.0	0	0	0	0	8.1	833.6	0	0	0	0	3.0	3.0		
29.538	Cliff	36000	11.75	9.79	4.79	0.019441	1.5	1.9	0	0	0	0	11.5	725.8	0	0	0	0	4.4	4.4		
29.601	Cliff	36000	13.48	9.91	7.05	0.011926	1.8	2.5	0	0	0	0	12.4	548.0	0	0	0	0	5.6	5.6		
29.663	Cliff	36000	14.05	12.34	8.61	0.010221	2.1	2.7	0	0	0	0	13.6	450.0	0	0	0	0	6.2	6.2		
29.71	Cliff	36000	13.04	11.67	9.39	0.006465	2.5	2.3	0	0	0	0	13.0	294.1	0	0	0	0	6.3	6.3		

Stationing ID (River Miles)	ASL Reach Code	Average Depth of Flow, d (ft) [*1 *2]	Energy Slope, S_e (ft/ft)	*n* Value for Stream Bed [*3]	90% Finer Particle Size, D_{90} (mm) [*4]	M-P, Muller Individual Particle Size, D_c (mm) [*5]	Average Channel Velocity, V_m (fps)	Competent Bottom Velocity Armor Size, Dc (mm) [*6]	Critical Shear Stress, T_c (lb/ft^2) [*7]	Shield's Diagram D_c (ft) [*8]	Shields Diagram Dc (mm)	Shear Velocity, U_* (fps) [*9]	Boundary Reynolds No., R_* [*10]	Yang's Incipient Motion, D_c (ft) [*11]	Yang's Incipient Motion, D_c (mm)	Average Individual Particle Size, D_c (mm)	Percentage of Bed Material Larger than D_c, del p (Seive-Boulder Count Combo) [*12]	Thickness to Armoring Layer, y_a (mm) [*13]	Depth to Armoring, y_d (ft) Seive - Boulder Count Combo [*14]	Ave Depth to Armoring by Reaches (Seive-Boulder Sediment Combo)
24.919	Braided	6.96	0.003895	0.028	235	119.3	7.5	105.8	1.7	0.27	83.8	0.934	23772	0.371	113.0	105.4	18	152.4	2.28	2.7
25.01	Braided	4.4	0.0030	0.028	235	57.8	4.9	45.9	0.8	0.13	40.5	0.650	8007	0.161	49.0	48.3	28	96.6	0.81	
25.099	Braided	2.9	0.0190	0.028	235	240.5	9.4	164.4	3.4	0.55	168.8	1.327	68043	0.576	175.6	187.3	13	152.4	3.35	
25.18	Braided	4.14	0.0041	0.028	235	74.1	5.53	57.5	1.1	0.17	52.0	0.736	11640	0.202	61.4	61.3	26	122.5	1.14	
25.233	Braided	4.52	0.0161	0.028	235	321.1	11.27	238.8	4.6	0.74	225.5	1.533	104982	0.837	255.1	260.1	8	152.4	5.75	
25.326	Braided	5.02	0.005251	0.028	235	116.0	7.13	95.6	1.6	0.27	81.4	0.921	22793	0.335	102.1	98.8	19	152.4	2.13	
25.338	Braided	4.69	0.011159	0.028	235	230.3	9.95	186.1	3.3	0.53	161.7	1.298	63766	0.652	198.9	194.2	12	152.4	3.67	
25.458	Mined	3.21	0.00524	0.028	235	74.0	5.31	53.0	1.0	0.17	52.0	0.736	11618	0.186	56.6	58.9	26	117.8	1.10	2.8
25.519	Mined	2.55	0.015557	0.028	235	174.6	7.85	115.9	2.5	0.40	122.6	1.130	42081	0.406	123.8	134.2	17	152.4	2.44	
25.58	Mined	4.58	0.0055	0.028	235	110.8	6.89	89.2	1.6	0.26	77.8	0.901	21293	0.313	95.4	93.3	20	152.4	2.00	
25.644	Mined	5.9	0.007775	0.028	235	201.9	9.64	174.7	2.9	0.46	141.7	1.215	52326	0.612	186.7	176.2	13	152.4	3.35	
25.699	Mined	8	0.003003	0.028	235	105.7	7.28	99.6	1.5	0.24	74.2	0.880	19832	0.349	106.5	96.5	19	152.4	2.13	
25.75	Mined	5.99	0.006186	0.028	235	163.1	8.6	139.0	2.3	0.38	114.5	1.092	37988	0.487	148.6	141.3	16	152.4	2.63	
25.843	Mined	4.95	0.006833	0.028	235	148.8	8.03	121.2	2.1	0.34	104.5	1.044	33130	0.425	129.5	126.0	17	152.4	2.44	
25.919	Mined	4.8	0.016796	0.028	235	354.8	12.33	285.8	5.0	0.82	249.1	1.611	121916	1.002	305.4	298.8	6	152.4	7.83	
26.044	Mined	5.37	0.006361	0.028	235	150.3	8.05	121.8	2.1	0.35	105.5	1.049	33623	0.427	130.2	127.0	17	152.4	2.44	
26.137	Mined	5.47	0.004825	0.028	235	116.1	7.14	95.8	1.6	0.27	81.5	0.922	22836	0.336	102.4	99.0	19	152.4	2.13	
26.239	Mined	4.67	0.014786	0.028	235	303.9	11.22	236.7	4.3	0.70	213.3	1.491	96637	0.830	252.9	251.7	9	152.4	5.06	
26.335	Mined	4.25	0.001746	0.028	235	32.7	3.69	25.6	0.5	0.08	22.9	0.489	3404	0.090	27.3	27.1	34	54.3	0.35	
26.43	Mined	3.14	0.008649	0.028	235	119.5	6.71	84.6	1.7	0.28	83.9	0.935	23836	0.297	90.4	94.6	19	152.4	2.13	
26.529	Mined	4.07	0.009457	0.028	235	169.4	8.34	130.8	2.4	0.39	118.9	1.113	40217	0.458	139.7	139.7	16	152.4	2.63	
26.623	Mined	4.58	0.003186	0.028	235	64.2	5.24	51.6	0.9	0.15	45.1	0.685	9388	0.181	55.2	54.0	27	108.0	0.96	
26.695	Mined	4.2	0.01668	0.028	235	308.3	11.16	234.1	4.4	0.71	216.4	1.502	98755	0.821	250.2	252.3	9	152.4	5.06	
26.775	Mined	4.74	0.005661	0.028	235	118.1	7.09	94.5	1.7	0.27	82.9	0.930	23410	0.331	101.0	99.1	19	152.4	2.13	
26.845	Mined	3.81	0.008138	0.028	235	136.4	7.39	102.7	1.9	0.31	95.8	0.999	29077	0.360	109.7	111.2	18	152.4	2.28	
26.921	Mined	3.57	0.005981	0.028	235	94.0	6.08	69.5	1.3	0.22	66.0	0.829	16617	0.244	74.3	75.9	23	151.8	1.67	
27.008	Mined	3.27	0.006986	0.028	235	100.5	6.19	72.0	1.4	0.23	70.6	0.858	18389	0.253	77.0	80.0	22	152.4	1.77	
27.106	Mined	2.95	0.016484	0.028	235	214.0	8.85	147.2	3.0	0.49	150.2	1.251	57111	0.516	157.3	167.2	14	152.4	3.07	
27.169	Mined	3.32	0.005742	0.028	235	83.9	5.68	60.7	1.2	0.19	58.9	0.783	14018	0.213	64.8	67.1	24	134.1	1.39	
27.226	Mined	2.75	0.013711	0.028	235	165.9	7.72	112.0	2.4	0.38	116.5	1.102	38994	0.393	119.7	128.5	17	152.4	2.44	
27.265	Mined	4.34	0.018092	0.028	235	345.5	11.8	261.8	4.9	0.80	242.6	1.590	117180	0.918	279.7	282.4	7	152.4	6.64	
27.32	Cliff	5.91	0.008343	0.028	235	217.0	9.95	186.1	3.1	0.50	152.3	1.260	58312	0.652	198.9	188.6	13	152.4	3.35	3.5
27.366	Cliff	4.99	0.002455	0.028	235	53.9	4.83	43.9	0.8	0.12	37.8	0.628	7221	0.154	46.9	45.6	29	91.2	0.73	
27.417	Cliff	3.95	0.018438	0.028	235	320.5	11.31	240.5	4.5	0.74	225.0	1.531	104678	0.843	256.9	260.7	8	152.4	5.75	
27.502	Cliff	5.34	0.0093	0.028	235	218.5	11.98	269.8	3.1	0.50	153.4	1.265	58942	0.946	288.3	232.5	10	152.4	4.50	
27.604	Cliff	5.01	0.004211	0.028	235	92.8	7.75	112.9	1.3	0.21	65.2	0.824	16320	0.396	120.6	97.9	19	152.4	2.13	
27.693	Cliff	5.95	0.010976	0.028	235	287.4	13.79	357.5	4.1	0.66	201.8	1.450	88886	1.253	382.0	307.2	5	152.4	9.50	
27.797	Cliff	4.87	0.008699	0.028	235	186.4	10.8	219.3	2.6	0.43	130.9	1.168	46440	0.769	234.3	192.7	13	152.4	3.35	
27.913	Cliff	4.87	0.00452	0.028	235	96.9	7.86	116.1	1.4	0.22	68.0	0.842	17394	0.407	124.1	101.3	19	152.4	2.13	
28.023	Cliff	5	0.0102	0.028	235	224.4	9.7	176.9	3.2	0.52	157.6	1.281	61340	0.620	189.0	187.0	13	152.4	3.35	
28.091	Cliff	3.3	0.019521	0.028	235	283.5	10.36	201.8	4.0	0.65	199.0	1.440	87079	0.707	215.6	225.0	10	152.4	4.50	
28.157	Cliff	3.67	0.006578	0.028	235	106.2	6.47	78.7	1.5	0.24	74.6	0.882	19977	0.276	84.1	85.9	21	152.4	1.88	
28.241	Cliff	3.26	0.018923	0.028	235	271.5	10.19	195.2	3.8	0.63	190.6	1.409	81602	0.684	208.6	216.5	11	152.4	4.05	
28.326	Cliff	5.48	0.004512	0.028	235	108.8	8.57	138.1	1.5	0.25	76.4	0.892	20707	0.484	147.5	117.7	17	152.4	2.44	
28.39	Cliff	5.93	0.008204	0.028	235	214.1	12.02	271.6	3.0	0.49	150.3	1.252	57149	0.952	290.2	231.6	10	152.4	4.50	
28.462	Cliff	7.13	0.003828	0.028	235	120.1	9.27	161.6	1.7	0.28	84.3	0.937	24015	0.566	172.6	134.6	17	152.4	2.44	
28.555	Cliff	5.3	0.011064	0.028	235	258.0	13.02	318.7	3.7	0.59	181.2	1.374	75626	1.117	340.5	274.6	7	152.4	6.64	
28.657	Cliff	5.82	0.005187	0.028	235	132.8	9.39	165.8	1.9	0.31	93.3	0.986	27935	0.581	177.1	142.2	15	152.4	2.83	
28.75	Cliff	4.11	0.011182	0.028	235	202.2	11.15	233.7	2.9	0.47	142.0	1.216	52473	0.819	249.7	206.9	11	152.4	4.05	
28.847	Cliff	5.66	0.006673	0.028	235	166.2	10.59	210.8	2.4	0.38	116.7	1.103	39093	0.739	225.3	179.7	13	152.4	3.35	
28.934	Cliff	4.93	0.011302	0.028	235	245.2	12.6	298.5	3.5	0.56	172.1	1.339	70048	1.046	318.9	258.7	8	152.4	5.75	
29.012	Cliff	5.85	0.006557	0.028	235	168.8	10.65	213.2	2.4	0.39	118.5	1.111	40011	0.747	227.8	182.1	13	152.4	3.35	
29.13	Cliff	5.69	0.009246	0.028	235	231.5	12.32	285.4	3.3	0.53	162.5	1.302	64267	1.000	304.9	246.1	9	152.4	5.06	
29.258	Cliff	5.13	0.005701	0.028	235	128.7	7.51	106.0	1.8	0.30	90.4	0.970	26637	0.372	113.3	109.6	18	152.4	2.28	
29.351	Cliff	2.72	0.017531	0.028	235	209.8	7.59	108.3	3.0	0.48	147.3	1.239	55457	0.380	115.7	145.3	15	152.4	2.83	
29.387	Cliff	3.53	0.007681	0.028	235	119.3	5.97	67.0	1.7	0.27	83.8	0.934	23778	0.235	71.6	85.4	21	152.4	1.88	
29.493	Cliff	2.62	0.009474	0.028	235	109.2	5.48	56.5	1.5	0.25	76.7	0.894	20828	0.198	60.3	75.7	23	151.3	1.66	
29.538	Cliff	2.16	0.018922	0.028	235	179.9	6.81	87.2	2.6	0.41	126.3	1.147	44007	0.306	93.2	121.6	17	152.4	2.44	
29.601	Cliff	3.96	0.006805	0.028	235	118.6	6.95	90.8	1.7	0.27	83.3	0.932	23560	0.318	97.0	97.4	19	152.4	2.13	
29.663	Cliff	4.01	0.008737	0.028	235	154.2	7.9	117.3	2.2	0.36	108.2	1.062	34926	0.411	125.4	126.3	17	152.4	2.44	
29.71	Cliff	4.56	0.005293	0.028	235	106.2	7.39	102.7	1.5	0.24	74.6	0.882	19971	0.360	109.7	98.3	19	152.4	2.13	

Cave Creek/Apache Wash watercourse Master Plan

	Size (mm)	Size (ft)	Size (in.)
D_{90} =	235	0.771	9.25
D_{50} =	7.6	0.025	0.30
D_{75} =	65	0.213	2.56

Method	Equation		
	$n_s=(D_{90}^{1/6}) / 44.4$ (D_{90} in inches)	n_s =	0.033
Anderson	$n_s=0.0395 * (D_{50}^{1/6})$ (D_{50} in feet)	n_s =	0.021
Lane	$n_s=(D_{75}^{1/6}) / 39$ (D_{75} in inches)	n_s =	0.030
			0.028

CAVE CREEK EQUILIBRIUM SLOPE CALCULATIONS

Station ID (River Miles)	Reach Code	Mean Particle Size, (mm) *1	Channel Width (ft) *2	Dominant Discharge, Q (cfs) *2	Schoklitsch, S_L (ft/ft) *3	90% Finer Particle Size, D_{90} (mm) *1	*n* Value for Cross Section *2	Average Depth of Flow, d (ft) *2	M-P,M S_L (ft/ft) *4	Shields S_L (ft/ft) *5	Shear Velocity, U* (fps) *6	Boundary Reynolds No. *7	Average S_L (ft/ft)	Average S_L by Reach	Average Invert Slope by Reach *8	Distance Between Grade Control Structures (ft) *9
24.919	Braided	73	118.23	6178	0.002236	235	0.028	6.96	0.00238	0.003408	0.8739	19380.6	0.002676	0.004117	0.009809	879
25.010	Braided	73	413.83	8918	0.004345	235	0.028	4.36	0.00380	0.005440	0.8739	19380.6	0.004530			
25.099	Braided	73	144.79	3888	0.003684	235	0.028	2.87	0.00578	0.008265	0.8739	19380.6	0.005910			
25.180	Braided	73	200.20	4576	0.004157	235	0.028	4.14	0.00401	0.005729	0.8739	19380.6	0.004631			
25.233	Braided	73	105.1	5355	0.002279	235	0.028	4.52	0.00367	0.005248	0.8739	19380.6	0.003732			
25.326	Braided	73	162.7	5826	0.002969	235	0.028	5.02	0.00330	0.004725	0.8739	19380.6	0.003666			
25.338	Braided	73	176.6	8244	0.002433	235	0.028	4.69	0.00354	0.005058	0.8739	19380.6	0.003676			
25.458	Mined	73	150.3	2560	0.005183	235	0.028	3.21	0.00517	0.007389	0.8739	19380.6	0.005914	0.004458	0.007358	1724
25.519	Mined	73	155	3100	0.004595	235	0.028	2.55	0.00651	0.009302	0.8739	19380.6	0.006801			
25.580	Mined	73	147.1	4644	0.003263	235	0.028	4.58	0.00362	0.005179	0.8739	19380.6	0.004021			
25.644	Mined	73	152.7	8690	0.002097	235	0.028	5.9	0.00281	0.004020	0.8739	19380.6	0.002976			
25.699	Mined	73	146.1	8511	0.002061	235	0.028	8	0.00207	0.002965	0.8739	19380.6	0.002367			
25.750	Mined	73	125.7	6472	0.002261	235	0.028	5.99	0.00277	0.003960	0.8739	19380.6	0.002997			
25.843	Mined	73	151.45	6014	0.002747	235	0.028	4.95	0.00335	0.004792	0.8739	19380.6	0.003630			
25.919	Mined	73	124.91	7396	0.002036	235	0.028	4.8	0.00346	0.004942	0.8739	19380.6	0.003478			
26.044	Mined	73	114.89	4965	0.002578	235	0.028	5.37	0.00309	0.004417	0.8739	19380.6	0.003361			
26.137	Mined	73	239.04	9325.33	0.002784	235	0.028	5.47	0.00303	0.004336	0.8739	19380.6	0.003384			
26.239	Mined	73	170.79	8940.92	0.002233	235	0.028	4.67	0.00355	0.005079	0.8739	19380.6	0.003621			
26.335	Mined	73	621.87	9762.42	0.005510	235	0.028	4.25	0.00390	0.005581	0.8739	19380.6	0.004998			
26.430	Mined	73	465.79	9800	0.004423	235	0.028	3.14	0.00528	0.007554	0.8739	19380.6	0.005754			
26.529	Mined	73	288.96	9800	0.003092	235	0.028	4.07	0.00408	0.005828	0.8739	19380.6	0.004332			
26.623	Mined	73	408.71	9800	0.004010	235	0.028	4.58	0.00362	0.005179	0.8739	19380.6	0.004270			
26.695	Mined	73	188.42	8825.71	0.002427	235	0.028	4.2	0.00395	0.005648	0.8739	19380.6	0.004008			
26.775	Mined	73	281.38	9445.32	0.003116	235	0.028	4.74	0.00350	0.005004	0.8739	19380.6	0.003873			
26.845	Mined	73	328.76	9251	0.003557	235	0.028	3.81	0.00435	0.006226	0.8739	19380.6	0.004712			
26.921	Mined	73	405.12	8800	0.004319	235	0.028	3.57	0.00465	0.006644	0.8739	19380.6	0.005203			
27.008	Mined	73	433.77	8800	0.004546	235	0.028	3.27	0.00507	0.007254	0.8739	19380.6	0.005624			
27.106	Mined	73	336.73	8800	0.003760	235	0.028	2.95	0.00562	0.008041	0.8739	19380.6	0.005808			
27.169	Mined	73	466.16	8800	0.004798	235	0.028	3.32	0.00500	0.007145	0.8739	19380.6	0.005646			
27.226	Mined	73	414.75	8800	0.004396	235	0.028	2.75	0.00603	0.008625	0.8739	19380.6	0.006351			
27.265	Mined	73	171.96	8800	0.002271	235	0.028	4.34	0.00382	0.005465	0.8739	19380.6	0.003853			
27.320	Cliff	73	149.61	8800	0.002046	235	0.028	5.91	0.00281	0.004014	0.8739	19380.6	0.002955	0.004038	0.009100	988
27.366	Cliff	73	363.9	8776.31	0.003993	235	0.028	4.99	0.00332	0.004753	0.8739	19380.6	0.004024			
27.417	Cliff	73	196.89	8800	0.002514	235	0.028	3.95	0.00420	0.006005	0.8739	19380.6	0.004240			
27.502	Cliff	73	137.59	8800	0.001921	235	0.028	5.34	0.00311	0.004442	0.8739	19380.6	0.003157			
27.604	Cliff	73	226.53	8800	0.002793	235	0.028	5.01	0.00331	0.004734	0.8739	19380.6	0.003613			
27.693	Cliff	73	107.18	8800	0.001593	235	0.028	5.95	0.00279	0.003987	0.8739	19380.6	0.002789			
27.797	Cliff	73	167.21	8800	0.002224	235	0.028	4.87	0.00341	0.004871	0.8739	19380.6	0.003500			
27.913	Cliff	73	229.93	8800	0.002824	235	0.028	4.87	0.00341	0.004871	0.8739	19380.6	0.003700			
28.023	Cliff	73	181.59	8800	0.002366	235	0.028	5	0.00332	0.004744	0.8739	19380.6	0.003476			
28.091	Cliff	73	257.56	8800	0.003075	235	0.028	3.3	0.00503	0.007188	0.8739	19380.6	0.005097			
28.157	Cliff	73	370.68	8800	0.004040	235	0.028	3.67	0.00452	0.006463	0.8739	19380.6	0.005008			
28.241	Cliff	73	264.8	8800	0.003140	235	0.028	3.26	0.00509	0.007276	0.8739	19380.6	0.005168			
28.326	Cliff	73	187.53	8800	0.002424	235	0.028	5.48	0.00303	0.004328	0.8739	19380.6	0.003260			
28.390	Cliff	73	123.52	8800	0.001772	235	0.028	5.93	0.00280	0.004000	0.8739	19380.6	0.002857			
28.462	Cliff	73	133.17	8800	0.001875	235	0.028	7.13	0.00233	0.003327	0.8739	19380.6	0.002509			
28.555	Cliff	73	127.46	8800	0.001814	235	0.028	5.3	0.00313	0.004475	0.8739	19380.6	0.003140			
28.657	Cliff	73	161	8800	0.002162	235	0.028	5.82	0.00285	0.004076	0.8739	19380.6	0.003029			
28.750	Cliff	73	192.3	8800	0.002470	235	0.028	4.11	0.00404	0.005771	0.8739	19380.6	0.004092			
28.847	Cliff	73	146.83	8800	0.002017	235	0.028	5.66	0.00293	0.004191	0.8739	19380.6	0.003046			
28.934	Cliff	73	141.77	8800	0.001965	235	0.028	4.93	0.00336	0.004811	0.8739	19380.6	0.003380			
29.012	Cliff	73	141.33	8800	0.001960	235	0.028	5.85	0.00284	0.004055	0.8739	19380.6	0.002950			
29.130	Cliff	73	129.87	9100	0.001794	235	0.028	5.69	0.00292	0.004169	0.8739	19380.6	0.002959			
29.258	Cliff	73	236.21	9100	0.002810	235	0.028	5.13	0.00323	0.004624	0.8739	19380.6	0.003556			
29.351	Cliff	73	425.67	8784.54	0.004488	235	0.028	2.72	0.00610	0.008721	0.8739	19380.6	0.006436			
29.387	Cliff	73	428.43	9028.74	0.004418	235	0.028	3.53	0.00470	0.006720	0.8739	19380.6	0.005279			
29.493	Cliff	73	632.88	9100	0.005885	235	0.028	2.62	0.00633	0.009053	0.8739	19380.6	0.007090			
29.538	Cliff	73	619.52	9100	0.005792	235	0.028	2.16	0.00768	0.010981	0.8739	19380.6	0.008151			
29.601	Cliff	73	330.41	9100	0.003615	235	0.028	3.96	0.00419	0.005990	0.8739	19380.6	0.004598			
29.663	Cliff	73	287.2	9100	0.003254	235	0.028	4.01	0.00414	0.005915	0.8739	19380.6	0.004435			
29.710	Cliff	73	269.78	9100	0.003105	235	0.028	4.56	0.00364	0.005202	0.8739	19380.6	0.003981			

HEC-RAS Plan: Future River: RIVER-1 Reach: Reach-1

Reach	River Sta	Profile	Min Ch El	W.S. Elev	Q Total	Vel Chnl	Max Chl Dpth	Hydr Depth C	E.G. Slope	Sta W.S. Lft	Top W Chnl	Sta W.S. Rgt	Vel Total	Top Width
			(ft)	(ft)	(cfs)	(ft/s)	(ft)	(ft)	(ft/ft)	(ft)	(ft)	(ft)	(ft/s)	(ft)
Reach-1	24.525	100 yr encr	1623.90	1632.6	41400.00	6.39	8.74	6.46	0.003004	8863.03	232.80	11416.59	4.04	2553.56
Reach-1	24.646	100 yr encr	1626.00	1636.1	41400.00	13.86	10.13	7.48	0.011638	8810.00	165.60	10973.25	7.52	2163.25
Reach-1	24.752	100 yr encr	1629.20	1641.1	41400.00	9.70	11.89	7.73	0.005513	8724.78	161.30	10189.03	5.78	1464.26
Reach-1	24.845	100 yr encr	1635.30	1644.7	41400.00	14.69	9.36	7.60	0.013083	8680.11	112.69	10056.14	7.84	1376.03
Reach-1	24.919	100 yr encr	1634.90	1648.1	41400.00	8.55	13.24	7.98	0.004189	8549.03	160.57	10006.28	5.32	1457.25
Reach-1	25.01	100 yr encr	1640.20	1650.1	41400.00	9.11	9.89	7.80	0.004725	8664.33	424.60	10033.72	6.60	1327.21
Reach-1	25.099	100 yr encr	1646.00	1654.8	41400.00	14.87	8.80	4.98	0.023052	8914.00	162.60	10301.49	9.16	1285.75
Reach-1	25.18	100 yr encr	1647.70	1659.8	41400.00	8.81	12.15	7.72	0.004509	8930.76	200.20	10490.87	5.31	1560.11
Reach-1	25.233	100 yr encr	1647.30	1661.0	41400.00	11.32	13.72	7.94	0.007690	8750.00	109.30	10400.00	6.14	1650.00
Reach-1	25.326	100 yr encr	1653.00	1665.0	39700.00	14.09	11.99	7.63	0.011720	9182.81	162.70	10260.00	8.43	1077.19
Reach-1	25.388	100 yr encr	1656.60	1669.1	39700.00	13.91	12.55	7.74	0.011196	9330.00	176.60	10450.00	8.31	1120.00
Reach-1	25.458	100 yr encr	1665.50	1673.2	39700.00	8.55	8.69	6.40	0.005398	9584.42	150.30	10830.00	5.80	1245.58
Reach-1	25.519	100 yr encr	1668.30	1675.4	39700.00	10.92	7.13	5.40	0.011070	9571.00	155.00	10750.00	7.33	1179.00
Reach-1	25.58	100 yr encr	1668.90	1678.2	39700.00	11.32	9.27	7.50	0.007690	9639.00	147.10	10790.00	6.81	1151.00
Reach-1	25.644	100 yr encr	1669.80	1681.2	39700.00	14.03	11.36	9.24	0.009071	9540.00	152.70	10760.00	7.60	1220.00
Reach-1	25.699	100 yr encr	1669.40	1683.5	39700.00	13.95	14.06	11.70	0.006633	9588.50	146.10	10789.80	7.45	1201.30
Reach-1	25.75	100 yr encr	1671.60	1686.2	39700.00	8.45	14.61	9.81	0.003075	9578.00	160.60	10950.00	4.87	1372.00
Reach-1	25.843	100 yr encr	1673.50	1687.2	39700.00	11.35	13.75	8.04	0.007159	9657.04	186.10	11100.00	6.54	1442.96
Reach-1	25.919	100 yr encr	1678.40	1690.6	39700.00	13.49	12.17	7.03	0.012071	9846.00	189.00	11150.00	8.00	1304.00
Reach-1	26.044	100 yr encr	1684.30	1696.0	39700.00	10.75	11.72	7.27	0.007617	9934.00	142.80	11270.00	6.51	1336.00
Reach-1	26.137	100 yr encr	1685.70	1699.2	39700.00	10.98	13.54	7.82	0.007102	9988.00	304.03	11210.00	7.45	1202.04
Reach-1	26.239	100 yr encr	1692.80	1702.8	39700.00	12.12	9.99	5.55	0.013615	9931.00	348.30	11050.00	8.86	1119.00
Reach-1	26.335	100 yr encr	1695.60	1706.5	39700.00	7.02	10.89	7.67	0.002887	9641.00	692.40	10650.00	6.38	1009.00
Reach-1	26.43	100 yr encr	1697.50	1707.9	39700.00	11.48	10.38	7.03	0.008705	9781.12	489.93	10747.58	11.26	588.92
Reach-1	26.529	100 yr encr	1702.60	1712.5	39700.00	14.25	9.94	7.27	0.012788	9791.21	382.49	10422.46	14.09	469.66
Reach-1	26.623	100 yr encr	1703.90	1717.6	39700.00	8.70	13.66	9.79	0.003220	9641.05	466.08	10600.00	8.69	485.12
Reach-1	26.695	100 yr encr	1709.50	1721.5	39700.00	15.39	11.96	8.05	0.013986	9810.17	243.28	10887.75	12.55	520.11
Reach-1	26.775	100 yr encr	1712.70	1726.4	39700.00	12.25	13.66	9.90	0.006448	9914.15	297.38	10950.00	10.27	653.48
Reach-1	26.845	100 yr encr	1717.00	1729.1	39700.00	10.69	12.12	9.20	0.005284	9663.95	356.15	10700.00	9.08	841.75
Reach-1	26.921	100 yr encr	1720.20	1731.4	35800.00	10.26	11.23	8.27	0.005613	9726.09	422.07	10148.16	10.26	422.07
Reach-1	27.008	100 yr encr	1723.00	1733.8	35800.00	10.01	10.81	7.71	0.005865	9698.42	463.46	10329.40	9.96	495.92
Reach-1	27.106	100 yr encr	1725.70	1737.8	35800.00	13.26	12.13	5.52	0.016076	9773.58	488.67	10262.25	13.26	488.67
Reach-1	27.169	100 yr encr	1732.10	1742.2	35800.00	9.56	10.10	7.41	0.005618	9869.83	504.99	10531.40	9.49	566.03
Reach-1	27.226	100 yr encr	1734.80	1743.9	35800.00	12.53	9.07	6.44	0.011661	9929.17	433.77	10928.70	11.94	549.83
Reach-1	27.265	100 yr encr	1735.70	1750.2	35800.00	13.20	14.51	9.30	0.008399	9959.80	204.40	11000.00	8.80	968.63
Reach-1	27.32	100 yr encr	1740.30	1753.7	35800.00	12.89	13.43	10.89	0.006295	9694.13	163.27	11000.00	7.15	1266.27
Reach-1	27.366	100 yr encr	1742.30	1755.7	35800.00	7.98	13.36	10.12	0.002663	9738.63	371.47	11000.00	6.02	1232.33
Reach-1	27.417	100 yr encr	1744.80	1757.8	35800.00	15.04	13.02	8.22	0.012331	9878.99	255.45	10890.00	11.99	630.63
Reach-1	27.502	100 yr encr	1748.80	1765.4	35800.00	14.94	16.56	10.93	0.005651	9960.71	189.69	10600.00	10.25	639.29
Reach-1	27.604	100 yr encr	1754.20	1768.7	35800.00	12.81	14.50	11.00	0.004087	9772.54	241.86	10210.60	10.96	438.06
Reach-1	27.693	100 yr encr	1756.30	1775.0	35800.00	15.33	18.66	9.53	0.007230	9980.25	215.55	10480.00	11.63	499.75
Reach-1	27.797	100 yr encr	1760.60	1779.4	35800.00	15.01	18.85	11.00	0.005779	9976.70	181.60	10605.00	10.04	628.30
Reach-1	27.913	100 yr encr	1763.10	1783.1	35800.00	13.89	19.95	9.36	0.005968	9970.47	269.93	10450.00	12.56	479.53
Reach-1	28.023	100 yr encr	1772.50	1787.5	35800.00	12.71	15.01	9.13	0.007872	9772.25	304.85	10208.00	12.08	435.76
Reach-1	28.091	100 yr encr	1780.80	1791.1	35800.00	11.58	10.33	6.47	0.009949	9666.86	478.14	10145.00	11.58	478.14
Reach-1	28.157	100 yr encr	1782.60	1794.5	35800.00	11.66	11.94	6.86	0.009303	9623.60	431.60	10175.00	10.89	551.40
Reach-1	28.241	100 yr encr	1789.90	1799.4	35800.00	13.47	9.50	6.54	0.013082	9675.97	374.53	10265.00	11.78	589.03
Reach-1	28.326	100 yr encr	1791.30	1804.4	35800.00	14.83	13.08	9.92	0.006185	9836.34	213.76	10435.00	10.72	598.66
Reach-1	28.39	100 yr encr	1792.80	1807.2	35800.00	14.96	14.41	10.34	0.006057	9879.93	183.67	10530.00	9.64	650.07
Reach-1	28.462	100 yr encr	1794.80	1809.8	35800.00	15.43	14.97	11.71	0.005534	9892.63	168.57	10475.00	10.42	582.37
Reach-1	28.555	100 yr encr	1799.40	1814.3	35800.00	15.86	14.92	11.69	0.005841	9944.60	166.80	10450.00	11.16	505.40
Reach-1	28.657	100 yr encr	1800.50	1818.1	35800.00	13.97	17.56	9.75	0.005798	9949.65	247.35	10450.00	11.58	500.35
Reach-1	28.75	100 yr encr	1808.30	1821.6	35800.00	14.66	13.33	10.15	0.005878	9901.41	227.59	10550.00	11.55	648.59
Reach-1	28.847	100 yr encr	1811.90	1826.5	35800.00	15.19	14.58	12.20	0.005041	9911.57	165.33	10560.00	9.97	648.43
Reach-1	28.934	100 yr encr	1815.50	1830.2	35800.00	14.77	14.67	10.47	0.005771	9857.38	197.52	10510.00	10.07	652.62
Reach-1	29.012	100 yr encr	1818.70	1833.8	35800.00	15.40	15.12	12.24	0.005251	9940.76	150.54	10590.00	9.44	649.24
Reach-1	29.13	100 yr encr	1821.00	1838.3	36000.00	16.27	17.28	12.56	0.005854	9971.96	134.74	10562.63	9.84	590.67
Reach-1	29.258	100 yr encr	1828.70	1843.3	36000.00	14.02	14.61	10.08	0.008184	9794.05	254.80	10048.85	14.02	254.80
Reach-1	29.351	100 yr encr	1835.90	1848.5	36000.00	8.16	12.60	8.62	0.004433	9695.00	455.20	10309.72	7.47	614.72
Reach-1	29.387	100 yr encr	1838.80	1849.4	36000.00	8.42	10.63	7.16	0.005991	9570.00	537.40	10296.02	7.71	726.02
Reach-1	29.493	100 yr encr	1843.40	1853.2	36000.00	8.46	9.80	5.78	0.007859	9300.00	711.60	10133.57	8.10	833.57
Reach-1	29.538	100 yr encr	1845.50	1855.3	36000.00	11.75	9.79	4.79	0.019441	9327.06	634.20	10052.85	11.48	725.79
Reach-1	29.601	100 yr encr	1849.90	1859.8	36000.00	13.48	9.91	7.05	0.011926	9500.00	368.97	10047.97	12.42	547.97
Reach-1	29.663	100 yr encr	1850.90	1863.2	36000.00	14.05	12.34	8.61	0.010221	9650.00	296.10	10100.00	13.56	450.00
Reach-1	29.71	100 yr encr	1853.90	1865.6	36000.00	13.04	11.67	9.39	0.006465	9738.86	294.14	10033.00	13.04	294.14
Reach-1	29.715		Bridge											

HEC-RAS Plan: Future River: RIVER-1 Reach: Reach-1

Reach	River Sta	Profile	Q Total	W.S. Elev	Hydr Depth C	E.G. Slope	Mann Wtd Chnl	Vel Chnl	Top W Chnl	Q Channel	Froude # Chl	Shear Chan
			(cfs)	(ft)	(ft)	(ft/ft)		(ft/s)	(ft)	(cfs)		(lb/sq ft)
Reach-1	24.525	10 encr	10100.00	1628.9	3.30	0.003000	0.044	4.07	196.18	2635.05	0.40	0.61
Reach-1	24.646	10 encr	10100.00	1632.2	3.51	0.015948	0.044	9.79	165.60	5687.20	0.92	3.47
Reach-1	24.752	10 encr	10100.00	1637.2	5.30	0.005277	0.044	7.36	122.58	4780.31	0.56	1.71
Reach-1	24.845	10 encr	10100.00	1642.4	5.70	0.007627	0.044	9.27	106.30	5615.59	0.68	2.65
Reach-1	24.919	10 encr	10100.00	1644.6	6.96	0.003895	0.044	7.50	118.23	6177.78	0.50	1.63
Reach-1	25.01	10 encr	10100.00	1646.5	4.36	0.003010	0.044	4.94	413.83	8917.57	0.42	0.82
Reach-1	25.099	10 encr	10100.00	1652.4	2.87	0.019042	0.044	9.35	144.79	3887.71	0.97	3.38
Reach-1	25.18	10 encr	10100.00	1656.3	4.14	0.004068	0.044	5.53	200.20	4576.27	0.48	1.04
Reach-1	25.233	10 encr	10100.00	1657.4	4.52	0.016144	0.044	11.27	105.10	5354.75	0.93	4.29
Reach-1	25.326	10 encr	9800.00	1662.4	5.02	0.005251	0.044	7.13	162.70	5825.69	0.56	1.63
Reach-1	25.388	10 encr	9800.00	1666.1	4.69	0.011159	0.044	9.95	176.60	8243.64	0.81	3.24
Reach-1	25.458	10 encr	9800.00	1670.0	3.21	0.005240	0.044	5.31	150.30	2559.71	0.52	1.05
Reach-1	25.519	10 encr	9800.00	1672.6	2.55	0.015557	0.044	7.85	155.00	3099.60	0.87	2.47
Reach-1	25.58	10 encr	9800.00	1675.3	4.58	0.005500	0.044	6.89	147.10	4644.03	0.57	1.57
Reach-1	25.644	10 encr	9800.00	1677.8	5.90	0.007775	0.044	9.64	152.70	8689.63	0.70	2.83
Reach-1	25.699	10 encr	9800.00	1679.8	8.00	0.003003	0.044	7.28	146.10	8510.65	0.45	1.46
Reach-1	25.75	10 encr	9800.00	1680.9	5.99	0.006186	0.044	8.60	125.70	6472.06	0.62	2.25
Reach-1	25.843	10 encr	9800.00	1683.0	4.95	0.006833	0.044	8.03	151.45	6014.43	0.64	2.08
Reach-1	25.919	10 encr	9800.00	1685.9	4.80	0.016796	0.044	12.33	124.91	7395.90	0.99	4.96
Reach-1	26.044	10 encr	9800.00	1692.8	5.37	0.006361	0.044	8.05	114.89	4965.13	0.61	2.05
Reach-1	26.137	10 encr	9800.00	1695.4	5.47	0.004825	0.044	7.14	239.04	9325.33	0.54	1.60
Reach-1	26.239	10 encr	9800.00	1698.7	4.67	0.014786	0.044	11.22	170.79	8940.92	0.92	4.17
Reach-1	26.335	10 encr	9800.00	1702.4	4.25	0.001746	0.044	3.69	621.87	9762.42	0.32	0.46
Reach-1	26.43	10 encr	9800.00	1703.7	3.14	0.008649	0.044	6.71	465.79	9800.00	0.67	1.68
Reach-1	26.529	10 encr	9800.00	1708.1	4.07	0.009457	0.044	8.34	288.96	9800.00	0.73	2.39
Reach-1	26.623	10 encr	9800.00	1711.4	4.58	0.003186	0.044	5.24	408.71	9800.00	0.43	0.91
Reach-1	26.695	10 encr	9800.00	1715.8	4.20	0.016680	0.044	11.16	188.42	8825.71	0.96	4.26
Reach-1	26.775	10 encr	9800.00	1720.8	4.74	0.005661	0.044	7.09	281.38	9445.32	0.57	1.65
Reach-1	26.845	10 encr	9800.00	1723.2	3.81	0.008138	0.044	7.39	328.76	9251.00	0.67	1.92
Reach-1	26.921	10 encr	8800.00	1726.5	3.57	0.005981	0.044	6.08	405.12	8800.00	0.57	1.33
Reach-1	27.008	10 encr	8800.00	1729.1	3.27	0.006986	0.044	6.19	433.77	8800.00	0.60	1.42
Reach-1	27.106	10 encr	8800.00	1733.9	2.95	0.016484	0.044	8.85	336.73	8800.00	0.91	3.00
Reach-1	27.169	10 encr	8800.00	1737.7	3.32	0.005742	0.044	5.68	466.16	8800.00	0.55	1.19
Reach-1	27.226	10 encr	8800.00	1740.0	2.75	0.013711	0.044	7.72	414.75	8800.00	0.82	2.34
Reach-1	27.265	10 encr	8800.00	1744.2	4.34	0.018092	0.044	11.80	171.96	8800.00	1.00	4.73
Reach-1	27.32	10 encr	8800.00	1748.1	5.91	0.008343	0.044	9.95	149.61	8800.00	0.72	3.02
Reach-1	27.366	10 encr	8800.00	1750.4	4.99	0.002455	0.044	4.83	363.90	8776.31	0.38	0.75
Reach-1	27.417	10 encr	8800.00	1751.9	3.95	0.018438	0.044	11.31	196.89	8800.00	1.00	4.46
Reach-1	27.502	10 encr	8800.00	1757.5	5.34	0.009300	0.036	11.98	137.59	8800.00	0.91	3.03
Reach-1	27.604	10 encr	8800.00	1762.2	5.01	0.004211	0.036	7.75	226.53	8800.00	0.61	1.29
Reach-1	27.693	10 encr	8800.00	1766.1	5.95	0.010976	0.036	13.79	107.18	8800.00	1.00	3.90
Reach-1	27.797	10 encr	8800.00	1772.7	4.87	0.008699	0.036	10.80	167.21	8800.00	0.86	2.55
Reach-1	27.913	10 encr	8800.00	1777.4	4.87	0.004520	0.036	7.86	229.93	8800.00	0.63	1.34
Reach-1	28.023	10 encr	8800.00	1780.8	5.00	0.010200	0.044	9.70	181.59	8800.00	0.76	3.05
Reach-1	28.091	10 encr	8800.00	1786.0	3.30	0.019521	0.044	10.36	257.56	8800.00	1.01	3.96
Reach-1	28.157	10 encr	8800.00	1790.8	3.67	0.006578	0.044	6.47	370.68	8800.00	0.59	1.49
Reach-1	28.241	10 encr	8800.00	1794.9	3.26	0.018923	0.044	10.19	264.80	8800.00	0.99	3.84
Reach-1	28.326	10 encr	8800.00	1799.0	5.48	0.004512	0.036	8.57	187.53	8800.00	0.65	1.53
Reach-1	28.39	10 encr	8800.00	1800.3	5.93	0.008204	0.036	12.02	123.52	8800.00	0.87	2.95
Reach-1	28.462	10 encr	8800.00	1803.3	7.13	0.003828	0.036	9.27	133.17	8800.00	0.61	1.65
Reach-1	28.555	10 encr	8800.00	1806.0	5.30	0.011064	0.036	13.02	127.46	8800.00	1.00	3.59
Reach-1	28.657	10 encr	8800.00	1811.3	5.82	0.005187	0.036	9.39	161.00	8800.00	0.69	1.82
Reach-1	28.75	10 encr	8800.00	1814.5	4.11	0.011182	0.036	11.15	192.30	8800.00	0.97	2.85
Reach-1	28.847	10 encr	8800.00	1819.1	5.66	0.006673	0.036	10.59	146.83	8800.00	0.78	2.32
Reach-1	28.934	10 encr	8800.00	1822.7	4.93	0.011302	0.036	12.60	141.77	8800.00	1.00	3.43
Reach-1	29.012	10 encr	8800.00	1826.9	5.85	0.006557	0.036	10.65	141.33	8800.00	0.78	2.33
Reach-1	29.13	10 encr	9100.00	1831.1	5.69	0.009246	0.036	12.32	129.87	9100.00	0.91	3.16
Reach-1	29.258	10 encr	9100.00	1837.8	5.13	0.005701	0.044	7.51	236.21	9100.00	0.58	1.80
Reach-1	29.351	10 encr	9100.00	1842.3	2.72	0.017531	0.050	7.59	425.67	8784.54	0.81	2.93
Reach-1	29.387	10 encr	9100.00	1844.8	3.53	0.007681	0.050	5.97	428.43	9028.74	0.56	1.66
Reach-1	29.493	10 encr	9100.00	1849.6	2.62	0.009474	0.050	5.48	632.88	9100.00	0.60	1.54
Reach-1	29.538	10 encr	9100.00	1852.6	2.16	0.018922	0.050	6.81	619.52	9100.00	0.82	2.54
Reach-1	29.601	10 encr	9100.00	1856.1	3.96	0.006805	0.044	6.95	330.41	9100.00	0.61	1.67
Reach-1	29.663	10 encr	9100.00	1858.5	4.01	0.008737	0.044	7.90	287.20	9100.00	0.70	2.16
Reach-1	29.71	10 encr	9100.00	1860.2	4.56	0.005293	0.040	7.39	269.78	9100.00	0.61	1.49
Reach-1	29.715		Bridge									

Stationing ID (River miles)	Maximum WSE (ft) *2	Left Bank Superelevation Freeboard (ft)	Right Bank Superelevation Freeboard (ft)	Left Top of Bank Elevation (ft) *1	Right Top of Bank Elevation (ft) *1	HEC-RAS Minimum Elevation (ft) *2	HEC-6 General Scour Depth (ft)	Antidune Trough Depth (ft)	Left Bank Bend Scour Depth, Z_{bs} (ft)	Right Bank Bend Scour Depth, Z_{bs} (ft)	Left Bank HEC-6 Design Scour Depth (ft) *3	Right Bank HEC-6 Design Scour Depth (ft) *3	Depth to Armoring, y_a (ft)	Left Bank Total Degredeation (ft) *4	Right Bank Total Degredeation (ft) *4	Left Bank Toe Down Elevation (ft) *5	Right Bank Toe Down Elevation (ft) *5	HEC-RAS Min Elevation - 10' (ft)	Left Reach Average Total Degredation (ft)	Right Reach Average Total Degredation (ft)	Left TOB - HEC-RAS Min Elevation	Right TOB - HEC-RAS Min Elevation	Left Reach Average TOB Above RAS Min (ft)	Right Reach Average TOB Above RAS Min (ft)	Summary
0.200	1659.0	0	0	1662.0	1662.0	1646.0	0.6	2.8	0	0	4.4	4.4	6.6	11.0	11.0	1635.0	1635.0	1636.0			16.0	16.0			
0.330	1661.5	0	0	1664.5	1664.5	1652.2	1.0	2.6	0	0	4.7	4.7	5.1	9.8	9.8	1642.4	1642.4	1642.2			12.3	12.3			
0.430	1664.8	0	0	1667.8	1667.8	1655.0	1.2	2.7	0	0	5.1	5.1	5.8	10.8	10.8	1644.2	1644.2	1645.0			12.8	12.8			
0.540	1669.7	0	0	1672.7	1672.7	1660.0	1.5	3.2	0	0	6.1	6.1	6.6	12.8	12.8	1647.2	1647.2	1650.0			12.7	12.7			
0.630	1672.4	0	0	1675.4	1675.4	1664.0	1.8	2.9	0	0	6.2	6.2	4.5	10.7	10.7	1653.3	1653.3	1654.0			11.4	11.4			
0.710	1675.2	0	0	1678.2	1678.2	1664.0	1.2	3.5	0	0	6.1	6.1	5.1	11.2	11.2	1652.8	1652.8	1654.0			14.2	14.2			
0.750	1676.7	0	0	1679.7	1679.7	1666.0	1.0	2.2	0	0	4.2	4.2	5.8	10.0	10.0	1656.0	1656.0	1656.0			13.7	13.7			
0.840	1678.7	0	0	1681.7	1681.7	1670.0	0.5	3.9	0	0	5.7	5.7	12.0	17.7	17.7	1652.3	1652.3	1660.0			11.7	11.7			
0.990	1684.5	0	0.4	1687.5	1687.9	1678.0	0.5	2.0	0	2.0	3.3	5.9	3.3	6.6	9.2	1671.4	1668.8	1668.0			9.5	9.9			
1.090	1688.3	0	0	1691.3	1691.3	1680.0	0.5	3.3	0	0	4.9	4.9	6.6	11.6	11.6	1668.4	1668.4	1670.0			11.3	11.3			
1.180	1692.3	0	0	1695.3	1695.3	1680.0	0.7	2.7	0	0	4.4	4.4	3.3	7.8	7.8	1672.2	1672.2	1670.0			15.3	15.3			
1.270	1694.8	0	0	1697.8	1697.8	1684.0	0.9	1.8	0	0	3.5	3.5	5.8	9.2	9.2	1674.8	1674.8	1674.0			13.8	13.8			
1.370	1696.9	0	0	1699.9	1699.9	1688.0	1.0	2.8	0	0	5.0	5.0	5.1	10.0	10.0	1678.0	1678.0	1678.0			11.9	11.9			
1.470	1701.3	0	0	1704.3	1704.3	1690.0	1.3	3.0	0	0	5.6	5.6	6.6	12.2	12.2	1677.8	1677.8	1680.0			14.3	14.3			
1.560	1703.4	0	0	1706.4	1706.4	1692.0	1.4	3.1	0	0	5.9	5.9	6.6	12.5	12.5	1679.5	1679.5	1682.0			14.4	14.4			
1.600	1704.6	0	0	1707.6	1707.6	1692.0	1.4	3.0	0	0	5.8	5.8	4.0	9.8	9.8	1682.2	1682.2	1682.0			15.6	15.6			
1.660	1705.5	0	0	1708.5	1708.5	1696.0	1.0	3.2	0	0	5.5	5.5	5.1	10.5	10.5	1685.5	1685.5	1686.0			12.5	12.5			
1.750	1708.3	0	0	1711.3	1711.3	1698.0	0.7	2.9	0	0	4.7	4.7	4.0	8.8	8.8	1689.2	1689.2	1688.0	6.6	7.1	13.3	13.3			Min
1.810	1710.7	0	0	1713.7	1713.7	1700.0	0.6	2.2	0	0	3.6	3.6	5.8	9.3	9.3	1690.7	1690.7	1690.0	17.7	17.7	13.7	13.7			Max
1.850	1711.3	0	0	1714.3	1714.3	1700.0	0.5	1.8	0	0	3.0	3.0	4.0	7.1	7.1	1692.9	1692.9	1690.0	10.5	10.6	14.3	14.3	13.2	13.3	Average
1.880	1711.8	0	0	1714.8	1714.8	1702.1	0.5	2.6	0	0	4.1	4.1	5.8	9.8	9.8	1692.3	1692.3	1692.1			12.7	12.7			
2.000	1714.7	0	0.7	1717.7	1718.4	1708.5	0.4	2.2	0	2.7	3.3	6.8	3.7	7.0	10.5	1701.5	1698.0	1698.5			9.2	9.9			
2.080	1717.4	0	1.0	1720.4	1721.4	1710.0	0.3	3.0	0	3.3	4.4	8.7	5.8	10.1	14.4	1699.9	1695.6	1700.0			10.4	11.4			
2.170	1721.1	0	1.0	1724.1	1725.1	1714.0	0.4	2.5	0	3.1	3.8	7.9	4.5	8.3	12.4	1705.7	1701.6	1704.0			10.1	11.1			
2.240	1723.4	0	0	1726.4	1726.4	1714.0	0.5	3.0	0	0	4.6	4.6	4.0	8.7	8.7	1705.3	1705.3	1704.0			12.4	12.4			
2.330	1727.1	0	0	1730.1	1730.1	1717.0	0.6	3.9	0	0	5.9	5.9	6.6	12.6	12.6	1704.4	1704.4	1707.0			13.1	13.1			
2.400	1730.0	0	0	1733.0	1733.0	1718.0	0.8	2.4	0	0	4.2	4.2	2.9	7.1	7.1	1710.9	1710.9	1708.0			15.0	15.0			
2.470	1731.4	0	0	1734.4	1734.4	1720.0	1.0	3.1	0	0	5.3	5.3	9.5	14.8	14.8	1705.2	1705.2	1710.0	7.0	7.1	14.4	14.4			Min
2.520	1733.3	0	0	1736.3	1736.3	1721.0	1.0	1.7	0	0	3.6	3.6	4.0	7.6	7.6	1713.4	1713.4	1711.0	14.8	26.4	15.3	15.3			Max
2.600	1734.9	0	2.1	1737.9	1740.0	1724.0	1.0	2.6	0	9.4	4.6	16.9	9.5	14.1	26.4	1709.9	1697.6	1714.0	10.0	12.4	13.9	16.0	12.7	13.1	Average
2.730	1738.4	0	3.6	1741.4	1745.0	1728.0	1.1	3.1	0	9.2	5.5	17.4	4.0	9.5	21.5	1718.5	1706.5	1718.0			13.4	17.0			
2.820	1742.1	0.6	0	1745.7	1745.1	1730.0	0.9	0.2	6.5	0	10.0	1.5	3.0	12.9	4.4	1717.1	1725.6	1720.0			15.7	15.1			
2.870	1742.3	0.6	0	1745.9	1745.3	1732.0	0.6	0.2	6.2	0	9.2	1.1	5.1	14.2	6.1	1717.8	1725.9	1722.0			13.9	13.3			
2.900	1742.4	1.2	0	1746.6	1745.4	1734.0	0.6	0.4	5.4	0	8.3	1.3	3.7	12.0	5.0	1722.0	1729.0	1724.0			12.6	11.4			
2.920	1743.0	0	0	1746.0	1746.0	1734.0	0.7	0.3	0	0	1.3	1.3	6.6	8.0	8.0	1726.0	1726.0	1724.0			12.0	12.0			
2.970	1744.2	0	0	1747.2	1747.2	1736.0	1.0	0.2	0	0	1.6	1.6	1.4	3.0	3.0	1733.0	1733.0	1726.0			11.2	11.2			
3.070	1748.6	0	0	1751.6	1751.6	1741.0	1.1	2.1	0	0	4.1	4.1	5.1	9.2	9.2	1731.8	1731.8	1731.0			10.6	10.6			
3.130	1750.4	0	0	1753.4	1753.4	1742.0	1.2	1.9	0	0	4.1	4.1	3.7	7.8	7.8	1734.2	1734.2	1732.0			11.4	11.4			
3.210	1753.0	0	0	1756.0	1756.0	1746.0	1.2	2.0	0	0	4.1	4.1	5.1	9.2	9.2	1736.8	1736.8	1736.0			10.0	10.0			
3.320	1756.7	0	0	1759.7	1759.7	1750.0	1.3	2.0	0	0	4.3	4.3	5.8	10.0	10.0	1740.0	1740.0	1740.0			9.7	9.7			
3.400	1760.3	0	0	1763.3	1763.3	1752.0	1.0	2.3	0	0	4.3	4.3	5.8	10.0	10.0	1742.0	1742.0	1742.0			11.3	11.3			
3.480	1763.8	0	0	1766.8	1766.8	1755.0	1.0	2.8	0	0	5.0	5.0	3.7	8.6	8.6	1746.4	1746.4	1745.0			11.8	11.8			
3.520	1765.5	0	0	1768.5	1768.5	1756.0	1.0	2.8	0	0	5.0	5.0	4.5	9.5	9.5	1746.5	1746.5	1746.0			12.5	12.5			
3.600	1768.3	0	0	1771.3	1771.3	1760.0	0.5	2.3	0	0	3.6	3.6	5.8	9.3	9.3	1750.7	1750.7	1750.0			11.3	11.3			
3.650	1769.8	0	0	1772.8	1772.8	1762.0	0.6	1.5	0	0	2.8	2.8	5.8	8.5	8.5	1753.5	1753.5	1752.0			10.8	10.8			
3.750	1773.1	0	0	1776.1	1776.1	1764.0	0.7	2.7	0	0	4.4	4.4	5.8	10.1	10.1	1753.9	1753.9	1754.0			12.1	12.1			
3.780	1774.4	0	0	1777.4	1777.4	1766.0	7.0	1.9	0	0	11.6	11.6	2.2	13.8	13.8	1752.2	1752.2	1756.0			11.4	11.4			
3.860	1777.7	0	0	1780.7	1780.7	1770.0	0.7	2.2	0	0	3.7	3.7	5.8	9.5	9.5	1760.5	1760.5	1760.0			10.7	10.7			
3.960	1782.4	0	0	1785.4	1785.4	1774.0	0.8	1.2	0	0	2.6	2.6	5.1	7.6	7.6	1766.4	1766.4	1764.0			11.4	11.4			
4.050	1785.6	0	0	1788.6	1788.6	1779.0	1.1	2.7	0	0	4.9	4.9	3.7	8.6	8.6	1770.4	1770.4	1769.0			9.6	9.6			
4.110	1788.9	0	0	1791.9	1791.9	1782.0	1.2	1.5	0	0	3.6	3.6	3.7	7.2	7.2	1774.8	1774.8	1772.0			9.9	9.9			
4.220	1791.8	0	0	1794.8	1794.8	1785.5	1.6	2.4	0	0	5.3	5.3	3.7	8.9	8.9	1776.6	1776.6	1775.5			9.3	9.3			
4.230	1793.2	0	0	1796.2	1796.2	1786.0	1.3	1.9	0	0	4.2	4.2	3.7	7.9	7.9	1778.1	1778.1	1776.0			10.2	10.2			
4.310	1797.5	0	0	1800.5	1800.5	1788.0	1.0	2.8	0	0	5.0	5.0	3.7	8.7	8.7	1779.3	1779.3	1778.0			12.5	12.5			
4.400	1800.9	0	0	1803.9	1803.9	1792.3	0.5	2.2	0	0	3.5	3.5	1.3	4.7	4.7	1787.6	1787.6	1782.3	3.0	3.0	11.6	11.6			Min
4.490	1803.6	0	0	1806.6	1806.6	1796.0	6.5	1.8	0	0	10.8	10.8	5.8	16.5	16.5	1779.5	1779.5	1786.0	16.5	21.5	10.6	10.6			Max
4.560	1808.0	0	0	1811.0	1811.0	1799.0	6.5	0.5	0	0	9.1	9.1	4.5	13.6	13.6	1785.4	1785.4	1789.0	9.6	9.2	12.0	12.0	11.5	11.5	Average
4.600	Culvert																								

*1 Top of Levee = HEC-RAS WSE + Superelevation + 3'

*2 All hydraulic parameters from HEC-RAS Apache1.prj
Existing (Worst case) hydraulics.

*3 Left or Right Bank Design Scour Depth = (HEC-6 General Scour + Anti-dune Trough Depth + Right or Left Bend Scour Depth) * 1.3

*4 Total Degredation = Design Scour Depth + Armoring Depth. Minimum 3'

*5 Toe Down Elevation = Minimum HEC-RAS Elevation - Total Degredation

Stationing ID (River Miles)	Reach Code	Design Discharge, Q (cfs) *1	Average Channel Velocity, V_m (fps)	Maximum Depth Main Channel, Y_{max} (ft)	Main Channel Hydraulic Depth, Y_h (ft)	Energy Slope, S_e (ft/ft)	HEC-6 General Scour Depth, HEC-6 Z_{gs} (ft) *4	Anti-dune Trough Depth, Z_a (ft) *5	Left Bank Angle of Channel Bend in degrees	Right Bank Angle of Channel Bend in degrees	Left Bank Bend Scour Depth, Z_{bs} (ft) *6	Right Bank Bend Scour Depth, Z_{bs} (ft) *6	Full Flow Velocity *2	Full Flow Channel Top Width, T (ft) *2	Left Bank Radius of Curve, r_c *9	Right Bank Radius of Curve, r_c *9	Left Bank Superelevation, del h (ft) *10	Right Bank Superelevation, del h (ft) *10	Left Bank HEC 6 Design Scour Depth, Z_t (ft) *8	Right Bank HEC-6 Design Scour Depth, Z_t (ft) *8	Reach Average Left Bank HEC-6 Design Scour Depth	Reach Average Left Bank HEC-6 Design Scour Depth
0.2	Hackberry	17944	14.22	13.03	10.99	0.00354	0.6	2.8	0	0	0	0	6.9	584.3	0	0	0	0	4.4	4.4	4.9	5.0
0.33	Hackberry	17944	13.82	9.26	7.16	0.00568	1	2.6	0	0	0	0	9.8	390.0	0	0	0	0	4.7	4.7		
0.43	Hackberry	17944	14.08	9.83	7.31	0.00578	1.2	2.7	0	0	0	0	8.4	468.0	0	0	0	0	5.1	5.1		
0.54	Hackberry	17944	15.34	9.67	9.06	0.00526	1.5	3.2	0	0	0	0	7.5	500.0	0	0	0	0	6.1	6.1		
0.63	Hackberry	17944	14.67	8.44	7.67	0.00592	1.8	2.9	0	0	0	0	7.6	518.0	0	0	0	0	6.2	6.2		
0.71	Hackberry	17944	16.01	11.18	10.32	0.00479	1.2	3.5	0	0	0	0	8.0	420.0	0	0	0	0	6.1	6.1		
0.75	Hackberry	17944	12.78	10.72	9.44	0.00338	1	2.2	0	0	0	0	7.0	464.0	0	0	0	0	4.2	4.2		
0.84	Hackberry	17944	16.77	8.67	8.39	0.00681	0.5	3.9	0	0	0	0	8.6	395.0	0	0	0	0	5.7	5.7		
0.99	Hackberry	17944	12.17	6.54	6.25	0.00530	0.5	2.0	0	30	0	2.0	6.2	615.5	0	1989.5	0	0.4	3.3	5.9		
1.09	Hackberry	17944	15.5	8.29	8.08	0.00610	0.5	3.3	0	0	0	0	7.7	504.9	0	0	0	0	4.9	4.9		
1.18	Hackberry	17944	14.08	12.25	10.95	0.00338	0.7	2.7	0	0	0	0	7.7	490.0	0	0	0	0	4.4	4.4		
1.27	Hackberry	17944	11.34	10.76	9.85	0.00250	0.9	1.8	0	0	0	0	6.8	410.0	0	0	0	0	3.5	3.5		
1.37	Hackberry	17944	14.36	8.94	7.5	0.00578	1	2.8	0	0	0	0	8.1	489.5	0	0	0	0	5.0	5.0		
1.47	Hackberry	17944	14.81	11.33	10.41	0.00401	1.3	3.0	0	0	0	0	7.4	490.0	0	0	0	0	5.6	5.6		
1.56	Hackberry	17944	15.05	11.45	9.24	0.00494	1.4	3.1	0	0	0	0	8.2	443.1	0	0	0	0	5.9	5.9		
1.6	Hackberry	17944	14.91	12.57	10.93	0.00384	1.4	3.0	0	0	0	0	7.4	430.1	0	0	0	0	5.8	5.8		
1.66	Hackberry	17944	15.3	9.54	8.3	0.00575	1	3.2	0	0	0	0	8.8	390.0	0	0	0	0	5.5	5.5		
1.75	Hackberry	17944	14.67	10.28	8.82	0.00488	0.7	2.9	0	0	0	0	9.3	365.7	0	0	0	0	4.7	4.7		
1.81	Hackberry	17944	12.53	10.74	10.35	0.00287	0.6	2.2	0	0	0	0	6.3	462.2	0	0	0	0	3.6	3.6		
1.85	Hackberry	17944	11.57	11.27	9.48	0.00274	0.5	1.8	0	0	0	0	5.9	577.6	0	0	0	0	3.0	3.0		
1.88	Union Hills	17944	13.84	9.66	8.04	0.00488	0.5	2.6	0	0	0	0	7.0	637.1	0	0	0	0	4.1	4.1	4.4	6.8
2.00	Union Hills	17944	12.55	6.19	5.64	0.00641	0.4	2.2	0	36	0	2.7	6.7	791.0	0	1675.4	0	0.7	3.3	6.8		
2.08	Union Hills	17944	14.92	7.44	4.65	0.01196	0.3	3.0	0	36	0	3.3	8.3	650.0	0	1376.7	0	1.0	4.4	8.7		
2.17	Union Hills	17944	13.52	7.1	6.71	0.00590	0.4	2.5	0	36	0	3.1	8.1	451.0	0	955.2	0	1.0	3.8	7.9		
2.24	Union Hills	17944	14.91	9.39	7.86	0.00582	0.5	3.0	0	0	0	0	10.4	305.0	0	0	0	0	4.6	4.6		
2.33	Union Hills	17944	16.98	10.07	9.27	0.00612	0.6	3.9	0	0	0	0	12.1	210.6	0	0	0	0	5.9	5.9		
2.4	Union Hills	17944	13.37	12.01	11.48	0.00283	0.8	2.4	0	0	0	0	9.0	244.3	0	0	0	0	4.2	4.2		
2.47	Union Hills	17944	15.07	11.39	10.07	0.00434	1	3.1	0	0	0	0	8.2	365.9	0	0	0	0	5.3	5.3		
2.52	Union Hills	17944	11.25	12.31	11.16	0.00215	1	1.7	0	0	0	0	5.6	535.0	0	0	0	0	3.6	3.6		
2.6	Union Hills	17944	13.7	10.91	9.32	0.00402	1	2.6	0	55	0	9.4	6.7	648.6	0	436.2	0	2.1	4.6	16.9		
2.73	Upper	13890	15.07	10.44	9.48	0.00471	1.1	3.1	0	55	0	9.2	8.8	293.0	0	197.1	0	3.6	5.5	17.4	5.1	4.7
2.82	Upper	13890	4.06	12.08	7.49	0.00099	0.9	0.2	55	0	6.5	0	3.5	615.0	413.6	0	0.6	0	10.0	1.5		
2.87	Upper	13890	3.99	10.3	6.3	0.00082	0.6	0.2	55	0	6.2	0	3.5	752.6	506.1	0	0.6	0	9.2	1.1		
2.9	Upper	13890	5.6	8.41	4.46	0.00269	0.6	0.4	55	0	5.4	0	5.0	682.8	459.2	0	1.2	0	8.3	1.3		
2.92	Upper	13890	4.92	9.04	3.62	0.00457	0.7	0.3	0	0	0	0	4.7	865.8	0	0	0	0	1.3	1.3		
2.97	Upper	13890	3.87	8.25	3.21	0.00347	1	0.2	0	0	0	0	3.9	1125.9	0	0	0	0	1.6	1.6		
3.07	Upper	7727	12.34	7.57	6.6	0.00512	1.1	2.1	0	0	0	0	5.9	410.0	0	0	0	0	4.1	4.1		
3.13	Upper	7727	11.93	8.41	6.56	0.00490	1.2	1.9	0	0	0	0	5.5	468.0	0	0	0	0	4.1	4.1		
3.21	Upper	7727	11.98	7.01	5.63	0.00593	1.2	2.0	0	0	0	0	6.3	390.0	0	0	0	0	4.1	4.1		
3.32	Upper	7727	12.1	6.71	5.37	0.00649	1.3	2.0	0	0	0	0	6.5	375.0	0	0	0	0	4.3	4.3		
3.4	Upper	7727	12.92	8.28	6.64	0.00551	1	2.3	0	0	0	0	6.5	340.0	0	0	0	0	4.3	4.3		
3.48	Upper	7727	14.36	8.8	7.48	0.00609	1	2.8	0	0	0	0	7.2	270.0	0	0	0	0	5.0	5.0		
3.52	Upper	7727	14.37	9.51	8.12	0.00542	1	2.8	0	0	0	0	7.4	241.0	0	0	0	0	5.0	5.0		
3.6	Upper	7727	12.86	8.3	7.57	0.00477	0.5	2.3	0	0	0	0	6.5	269.0	0	0	0	0	3.6	3.6		
3.65	Upper	7727	10.62	7.78	7.21	0.00335	0.6	1.5	0	0	0	0	5.6	290.0	0	0	0	0	2.8	2.8		
3.75	Upper	7727	13.91	9.1	8.12	0.00512	0.7	2.7	0	0	0	0	7.2	260.0	0	0	0	0	4.4	4.4		
3.78	Upper	7727	11.84	8.37	5.28	0.00647	7	1.9	0	0	0	0	7.8	276.0	0	0	0	0	11.6	11.6		
3.86	Upper	7403	12.62	7.71	5.59	0.00678	0.7	2.2	0	0	0	0	7.3	326.8	0	0	0	0	3.7	3.7		
3.96	Upper	7403	9.26	8.37	3.96	0.00563	0.8	1.2	0	0	0	0	6.5	555.7	0	0	0	0	2.6	2.6		
4.05	Upper	7403	13.97	6.65	5.52	0.00829	1.1	2.7	0	0	0	0	7.3	295.2	0	0	0	0	4.9	4.9		
4.11	Upper	7403	10.61	6.89	4.67	0.00595	1.2	1.5	0	0	0	0	7.9	318.0	0	0	0	0	3.6	3.6		
4.22	Upper	7403	13.37	6.33	4.65	0.00960	1.6	2.4	0	0	0	0	7.7	300.5	0	0	0	0	5.3	5.3		
4.23	Upper	7403	11.92	7.24	5.78	0.00575	1.3	1.9	0	0	0	0	6.9	267.0	0	0	0	0	4.2	4.2		
4.31	Upper	7403	14.41	9.49	8.02	0.00549	1	2.8	0	0	0	0	8.2	194.0	0	0	0	0	5.0	5.0		
4.4	Upper	7403	12.59	8.64	7.09	0.00487	0.5	2.2	0	0	0	0	6.2	311.0	0	0	0	0	3.5	3.5		
4.49	Upper	7403	11.4	7.57	5.76	0.00517	6.5	1.8	0	0	0	0	8.4	273.0	0	0	0	0	10.8	10.8		
4.56	Upper	7403	6.06	9.01	7.54	0.00101	6.5	0.5	0	0	0	0	4.8	272.0	0	0	0	0	9.1	9.1		
Culvert								0.0	0	0	0	0	11.5	634.2	0	0	0	0	0.0	0.0		

*1 All hydraulic parameters from HEC-RAS Apache1.prj

*4 Extracted from Stantec HEC-6 analysis graphs. Interpolated from peak to peak Straight Line. Worst Case between Future and Existing Conditions.

*5 Anti-dune scour depth from SLA, 1982 (COT 6.09 and Fuller Report) $Z_a = 0.0137 * V_m^{2.}$

If Za > 0.5 * Yh, then Za = 0.5 * Yh

*6 Bend Scour Depth From Zeller, 1981 (COT Drainage Design and FP Mgmt 6.11 and Fuller Report)

$Z_{gs} = ((0.0685 * Y_{max} * V_m^{0.8})/(Y_h^{0.4} * S_e^{0.3})) * ((2.1 * (((\sin^2(alpha/2)) / (\cos alpha))^{0.2})) - 1)$

alpha = degree of bend

Erosion Will Occur on Outside Bank. Right and Left Bank Looking Upstream (Opposite of HEC-RAS)

*8 $Z_t = 1.3 * (\text{HEC-6 } Z_{gs} + Z_a + Z_{bs} + Z_{ls} + Z_{lft})$ Used to calculate toe down elevation

1.3 = Factor of Safety

Z_{ls} = Local Scour = 0

Z_{lft} = Low Flow Thalweg Scour = 0

*9 Radius of Curve from Zeller 1981 (COT Drainage Design and FP Mgmt 6.11)

$r_c / T = \cos alpha / (4 * \sin^2(alpha/2))$

r_c = Radius of Curve

T = Full Floodway Width (As opposed to main channel widhth)

*10 Chow's Simplified Method of Determining Superelevation (p.448)

Also the preferred method in Maricopa Drainage and Design Manual (p. 6-20)

$h = (V^2 * T) / (g * r_c)$

V = Full Floodway Velocity (As opposed to Main Channel Velocity)

Cave Creek/Apache Wash Watercourse Master Plan

Stationing (River Miles)	Reach Code	Average Depth of Flow, d (ft) *1 *2	Energy Slope, S_e (ft/ft)	*n* Value for Stream Bed *3	90% Finer Particle Size, D_{90} (mm) *4	M-P, Muller Individual Particle Size, D_c (mm) *5	Average Channel Velocity, V_m (fps)	Competent Bottom Velocity Armor Size, Dc (mm) *6	Critical Shear Stress, T_c (lb/ft^2) *7	Shield's Diagram D_c (ft) *8	Shields Diagram Dc (mm)	Shear Velocity, U_* (fps) *9	Boundary Reynolds No., R_* *10	Yang's Incipient Motion, D_c (ft) *11	Yang's Incipient Motion, D_c (mm)	Average Individual Particle Size, D_c (mm)	Reach Average D_c (mm)	Percentage of Bed Material Larger than D_c, del p (Seive-Boulder Count Combo) *12	Thickness to Armoring Layer, y_a (mm) *13	Depth to Armoring, y_d (ft) Seive - Boulder Count Combo *14	Reach Ave Depth to Armoring (Seive Boulder Sediment Combo)
0.2	Hackberry	5.3	0.0050	0.026	100	103.9	10.4	203.3	1.6	0.27	81.3	0.921	22736	0.713	217.3	151.4	124.8	7	152.4	6.64	5.6
0.33	Hackberry	3.1	0.0069	0.026	100	84.4	8.7	142.6	1.3	0.22	66.1	0.830	16669	0.500	152.4	111.4		9	152.4	5.06	
0.43	Hackberry	3.6	0.0072	0.026	100	101.9	9.8	179.8	1.6	0.26	79.8	0.912	22105	0.630	192.1	138.4		8	152.4	5.75	
0.54	Hackberry	5.0	0.0053	0.026	100	102.8	10.3	197.9	1.6	0.26	80.4	0.916	22376	0.694	211.4	148.1		7	152.4	6.64	
0.63	Hackberry	4.4	0.0043	0.026	100	75.0	8.6	140.3	1.2	0.19	58.7	0.782	13948	0.492	149.9	106.0		10	152.4	4.50	
0.71	Hackberry	5.7	0.0034	0.026	100	77.7	9.2	157.7	1.2	0.20	60.8	0.796	14706	0.553	168.5	116.2		9	152.4	5.06	
0.75	Hackberry	4.0	0.0060	0.026	100	95.7	9.7	175.4	1.5	0.25	74.9	0.884	20110	0.615	187.4	133.4		8	152.4	5.75	
0.84	Hackberry	4.1	0.0092	0.026	100	147.8	12.0	272.1	2.3	0.38	115.7	1.098	38585	0.954	290.7	206.6		4	152.4	12.00	
0.99	Hackberry	2.9	0.0052	0.026	100	59.6	7.2	98.0	0.9	0.15	46.7	0.697	9882	0.344	104.7	77.2		13	152.4	3.35	
1.09	Hackberry	4.2	0.0062	0.026	100	103.8	10.2	193.7	1.6	0.27	81.3	0.920	22726	0.679	206.9	146.4		7	152.4	6.64	
1.18	Hackberry	5.5	0.0025	0.026	100	53.1	7.6	107.7	0.8	0.14	41.6	0.658	8311	0.378	115.1	79.4		13	152.4	3.35	
1.27	Hackberry	3.4	0.0072	0.026	100	97.7	9.6	171.5	1.5	0.25	76.5	0.893	20738	0.601	183.2	132.2		8	152.4	5.75	
1.37	Hackberry	3.8	0.0059	0.026	100	88.1	9.2	158.4	1.4	0.23	68.9	0.848	17754	0.555	169.3	121.2		9	152.4	5.06	
1.47	Hackberry	4.9	0.0056	0.026	100	107.5	10.5	208.5	1.7	0.28	84.1	0.936	23928	0.731	222.7	155.7		7	152.4	6.64	
1.56	Hackberry	4.5	0.0058	0.026	100	103.4	10.1	192.9	1.6	0.27	81.0	0.919	22595	0.676	206.1	145.9		7	152.4	6.64	
1.6	Hackberry	6.5	0.0023	0.026	100	59.6	8.2	126.1	0.9	0.15	46.6	0.697	9877	0.442	134.7	91.8		11	152.4	4.05	
1.66	Hackberry	4.03	0.0055	0.026	100	87.0	9.23	160.2	1.4	0.22	68.1	0.843	17431	0.561	171.1	121.6		9	152.4	5.06	
1.75	Hackberry	4.28	0.0038	0.026	100	63.7	7.96	119.1	1.0	0.16	49.8	0.721	10912	0.418	127.3	90.0		11	152.4	4.05	
1.81	Hackberry	5.14	0.0045	0.026	100	91.4	9.84	182.0	1.4	0.23	71.5	0.863	18766	0.638	194.5	134.9		8	152.4	5.75	
1.85	Hackberry	4.86	0.0031	0.026	100	59.8	7.91	117.6	0.9	0.15	46.8	0.699	9944	0.412	125.7	87.5		11	152.4	4.05	
1.88	Union Hills	3.83	0.0063	0.026	100	94.8	9.57	172.2	1.5	0.24	74.2	0.880	19838	0.604	184.0	131.3	121.6	8	152.4	5.75	5.6
2	Union Hills	2.35	0.0073	0.026	100	67.7	7.47	104.9	1.1	0.17	53.0	0.743	11957	0.368	112.1	84.4		12	152.4	3.67	
2.08	Union Hills	3.05	0.0082	0.026	100	98.5	9.29	162.3	1.6	0.25	77.1	0.896	20999	0.569	173.4	127.8		8	152.4	5.75	
2.17	Union Hills	3.05	0.0064	0.026	100	77.2	8.33	130.5	1.2	0.20	60.4	0.793	14559	0.457	139.4	101.8		10	152.4	4.50	
2.24	Union Hills	3.82	0.0042	0.026	100	63.5	7.83	115.3	1.0	0.16	49.7	0.720	10858	0.404	123.1	87.9		11	152.4	4.05	
2.33	Union Hills	3.79	0.0073	0.026	100	108.8	10.19	195.2	1.7	0.28	85.2	0.942	24389	0.684	208.6	149.5		7	152.4	6.64	
2.4	Union Hills	5.25	0.0023	0.026	100	48.5	7.22	98.0	0.8	0.12	38.0	0.629	7261	0.344	104.7	72.3		14	144.6	2.91	
2.47	Union Hills	4.52	0.0075	0.026	100	134.0	11.62	253.8	2.1	0.34	104.9	1.045	33309	0.890	271.2	191.0		5	152.4	9.50	
2.52	Union Hills	5.94	0.0025	0.026	100	58.8	7.98	119.7	0.9	0.15	46.0	0.692	9678	0.420	127.9	88.1		11	152.4	4.05	
2.6	Union Hills	3.88	0.0087	0.026	100	133.1	11.24	237.5	2.1	0.34	104.2	1.042	32991	0.833	253.8	182.1		5	152.4	9.50	
2.73	Upper	3.34	0.0052	0.026	100	68.5	7.87	116.4	1.1	0.18	53.6	0.748	12187	0.408	124.4	90.8	100.9	11	152.4	4.05	4.3
2.82	Upper	5.07	0.0025	0.026	100	50.1	7.25	98.8	0.8	0.13	39.2	0.639	7614	0.346	105.6	73.4		14	146.8	2.96	
2.87	Upper	5.02	0.0039	0.026	100	76.5	8.93	149.9	1.2	0.20	59.9	0.790	14371	0.526	160.2	111.6		9	152.4	5.06	
2.9	Upper	3.29	0.0051	0.026	100	66.5	7.73	112.3	1.1	0.17	52.1	0.737	11650	0.394	120.0	87.7		12	152.4	3.67	
2.92	Upper	2.92	0.0096	0.026	100	111.1	9.76	179.1	1.8	0.29	87.0	0.952	25164	0.628	191.3	142.1		7	152.4	6.64	
2.97	Upper	4.77	0.0019	0.026	100	35.8	6	67.7	0.6	0.09	28.0	0.540	4595	0.237	72.3	50.9		19	101.9	1.42	
3.07	Upper	3.09	0.0089	0.026	100	108.4	9.67	175.8	1.7	0.28	84.8	0.940	24236	0.616	187.8	139.2		9	152.4	5.06	
3.13	Upper	2.71	0.0061	0.026	100	64.7	7.4	102.9	1.0	0.17	50.7	0.727	11189	0.361	110.0	82.1		12	152.4	3.67	
3.21	Upper	3.37	0.0061	0.026	100	80.8	8.59	138.7	1.3	0.21	63.3	0.812	15616	0.486	148.2	107.8		9	152.4	5.06	
3.32	Upper	3.4	0.0069	0.026	100	92.5	9.13	156.7	1.5	0.24	72.4	0.869	19112	0.549	167.4	122.3		8	152.4	5.75	
3.4	Upper	2.58	0.0096	0.026	100	98.2	9.07	154.7	1.6	0.25	76.8	0.895	20893	0.542	165.2	123.7		8	152.4	5.75	
3.48	Upper	2.89	0.0058	0.026	100	66.6	7.6	108.6	1.1	0.17	52.2	0.737	11684	0.381	116.0	85.9		12	152.4	3.67	
3.52	Upper	3.26	0.0062	0.026	100	79.4	8.45	134.2	1.3	0.20	62.1	0.805	15186	0.471	143.4	104.8		10	152.4	4.50	
3.6	Upper	3.84	0.0067	0.026	100	101.2	9.65	175.1	1.6	0.26	79.3	0.909	21880	0.614	187.0	135.7		8	152.4	5.75	
3.65	Upper	4.11	0.0061	0.026	100	99.3	9.69	176.5	1.6	0.26	77.8	0.900	21267	0.619	188.6	135.6		8	152.4	5.75	
3.75	Upper	3.74	0.0063	0.026	100	93.2	9.26	161.2	1.5	0.24	72.9	0.872	19313	0.565	172.2	124.9		8	152.4	5.75	
3.78	Upper	3.71	0.0032	0.026	100	47.4	6.72	84.9	0.7	0.12	37.1	0.622	7016	0.298	90.7	65.0		16	130.1	2.24	
3.86	Upper	3.99	0.0063	0.026	100	99.5	9.62	174.0	1.6	0.26	77.9	0.901	21312	0.610	185.9	134.3		8	152.4	5.75	
3.96	Upper	2.45	0.0091	0.026	100	88.0	8.48	135.2	1.4	0.23	68.9	0.848	17744	0.474	144.4	109.1		9	152.4	5.06	
4.05	Upper	2.48	0.0070	0.026	100	68.4	7.49	105.5	1.1	0.18	53.6	0.747	12161	0.370	112.7	85.0		12	152.4	3.67	
4.11	Upper	2.31	0.0075	0.026	100	68.7	7.46	104.6	1.1	0.18	53.8	0.749	12230	0.367	111.8	84.7		12	152.4	3.67	
4.22	Upper	2.85	0.0056	0.026	100	63.0	7.4	102.9	1.0	0.16	49.3	0.717	10744	0.361	110.0	81.3		12	152.4	3.67	
4.23	Upper	1.61	0.0116	0.026	100	73.6	7.28	99.6	1.2	0.19	57.6	0.775	13553	0.349	106.5	84.3		12	152.4	3.67	
4.31	Upper	2.39	0.0074	0.026	100	70.1	7.56	107.4	1.1	0.18	54.9	0.756	12616	0.377	114.8	86.8		12	152.4	3.67	
4.4	Upper	2.86	0.0034	0.026	100	37.9	5.7	61.1	0.6	0.10	29.7	0.556	5022	0.214	65.3	48.5		20	97.0	1.27	
4.49	Upper	3.38	0.0072	0.026	100	96.3	9.3	162.6	1.5	0.25	75.4	0.886	20304	0.570	173.7	127.0		8	152.4	5.75	
4.56	Upper	3.07	0.0064	0.026	100	77.3	8.24	127.6	1.2	0.20	60.5	0.794	14599	0.447	136.4	100.5		10	152.4	4.50	
Culvert	Upper	2.15	0.0056				6.12														
		2.24	0.0078				7.5														

	Size (mm)	Size (ft)	Size (in.)
D_{90} =	100	0.328	3.94
D_{50} =	11	0.036	0.43
D_{75} =	37	0.121	1.46

Method	Equation		
	$n_s=(D_{90}^{1/6})$ / 44.4 (D_{90} in inches)	n_s =	0.028
Anderson	n_s=0.0395 * $(D_{50}^{1/6})$ (D_{50} in feet)	n_s =	0.023
Lane	$n_s=(D_{75}^{1/6})$ / 39 (D_{75} in inches)	n_s =	0.027
			0.026

Station ID (River Miles)	Reach Code	Mean Particle Size, (mm)	Channel Width (ft) [2]	Dominant Discharge, Q (cfs) [2]	Schoklitsch, S_L (ft/ft) [3]	90% Finer Particle Size, D_{90} (mm) [1]	*n* Value for Cross Section [2]	Average Depth of Flow, d (ft) [2]	M-P,M S_L (ft/ft) [4]	Shields S_L (ft/ft) [5]	Shear Velocity, U* (fps) [6]	Boundary Reynolds No. [7]	Average S_L (ft/ft)	Average S_L by Reach	Average Invert Slope by Reach [8]	Distance Between Grade Control Structures (ft) [9]
0.200	Hackberry	40	63.33	3464.67	0.001376	100	0.026103	5.26	0.00193	0.002059	0.5906	7176.0	0.001787	0.00225	0.006324	1228
0.330	Hackberry	40	123.47	3313.2	0.002347	100	0.026103	3.08	0.00329	0.003517	0.5906	7176.0	0.003052			
0.430	Hackberry	40	92.93	3267.83	0.001917	100	0.026103	3.6	0.00282	0.003009	0.5906	7176.0	0.002580			
0.540	Hackberry	40	62.02	3148.68	0.001455	100	0.026103	4.95	0.00205	0.002188	0.5906	7176.0	0.001897			
0.630	Hackberry	40	76.79	2908.45	0.001813	100	0.026103	4.39	0.00231	0.002467	0.5906	7176.0	0.002196			
0.710	Hackberry	40	55.65	2929.19	0.001416	100	0.026103	5.74	0.00177	0.001887	0.5906	7176.0	0.001690			
0.750	Hackberry	40	83.90	3273.29	0.001773	100	0.026103	4.04	0.00251	0.002681	0.5906	7176.0	0.002321			
0.840	Hackberry	40	55.00	2689.06	0.001497	100	0.026103	4.06	0.00250	0.002668	0.5906	7176.0	0.002220			
0.990	Hackberry	40	56.38	1177.26	0.002833	100	0.026103	2.89	0.00351	0.003748	0.5906	7176.0	0.003363			
1.090	Hackberry	40	66.00	2817.99	0.001657	100	0.026103	4.21	0.00241	0.002573	0.5906	7176.0	0.002212			
1.180	Hackberry	40	83.00	3440.46	0.001694	100	0.026103	5.48	0.00185	0.001976	0.5906	7176.0	0.001840			
1.270	Hackberry	40	103.00	3377.3	0.002020	100	0.026103	3.43	0.00295	0.003158	0.5906	7176.0	0.002711			
1.370	Hackberry	40	98.12	3382.57	0.001945	100	0.026103	3.76	0.00270	0.002881	0.5906	7176.0	0.002507			
1.470	Hackberry	40	68.04	3477.9	0.001448	100	0.026103	4.85	0.00209	0.002233	0.5906	7176.0	0.001924			
1.560	Hackberry	40	77.24	3535.61	0.001573	100	0.026103	4.52	0.00224	0.002396	0.5906	7176.0	0.002070			
1.600	Hackberry	40	57.21	3032.59	0.001409	100	0.026103	6.47	0.00157	0.001674	0.5906	7176.0	0.001550			
1.660	Hackberry	40	81.89	3047.21	0.001837	100	0.026103	4.03	0.00252	0.003225	0.6469	7860.9	0.002526			
1.750	Hackberry	40	102.26	3478.47	0.001965	100	0.026103	4.28	0.00237	0.003037	0.6469	7860.9	0.002457			
1.810	Hackberry	40	59.95	3031.06	0.001460	100	0.026103	5.14	0.00197	0.002529	0.6469	7860.9	0.001987			
1.850	Hackberry	40	86.55	3326.12	0.001793	100	0.026103	4.86	0.00209	0.002674	0.6469	7860.9	0.002184			
1.880	Union Hills	40	90.00	3300.18	0.001857	100	0.026103	3.83	0.00265	0.003394	0.6469	7860.9	0.002632	0.00276	0.005761	1665
2.000	Union Hills	40	135.00	2369.12	0.003228	100	0.026103	2.35	0.00431	0.005531	0.6469	7860.9	0.004357			
2.080	Union Hills	40	62.93	1784.31	0.002252	100	0.026103	3.05	0.00332	0.004261	0.6469	7860.9	0.003279			
2.170	Union Hills	40	107.72	2734.19	0.002447	100	0.026103	3.05	0.00332	0.004261	0.6469	7860.9	0.003344			
2.240	Union Hills	40	115.85	3465.35	0.002164	100	0.026103	3.82	0.00265	0.003402	0.6469	7860.9	0.002740			
2.330	Union Hills	40	85.00	3280.26	0.001787	100	0.026103	3.79	0.00267	0.003429	0.6469	7860.9	0.002630			
2.400	Union Hills	40	84.10	3189.38	0.001811	100	0.026103	5.25	0.00193	0.002476	0.6469	7860.9	0.002072			
2.470	Union Hills	40	65.55	3447.49	0.001417	100	0.026103	4.52	0.00224	0.002875	0.6469	7860.9	0.002178			
2.520	Union Hills	40	71.17	3374.33	0.001532	100	0.026103	5.94	0.00171	0.002188	0.6469	7860.9	0.001809			
2.600	Union Hills	40	82.03	3573	0.001632	100	0.026103	3.88	0.00261	0.003350	0.6469	7860.9	0.002531			
2.730	Upper	40	100.00	2626.4	0.002385	100	0.026103	3.34	0.00303	0.003891	0.6469	7860.9	0.003104	0.00333	0.007348	1245
2.820	Upper	40	65.00	2388.07	0.001855	100	0.026103	5.07	0.00200	0.002564	0.6469	7860.9	0.002139			
2.870	Upper	40	64.55	2897.54	0.001596	100	0.026103	5.02	0.00202	0.002589	0.6469	7860.9	0.002068			
2.900	Upper	40	56.00	1424.3	0.002444	100	0.026103	3.29	0.00308	0.003951	0.6469	7860.9	0.003158			
2.920	Upper	40	52.00	1481.97	0.002244	100	0.026103	2.92	0.00347	0.004451	0.6469	7860.9	0.003389			
2.970	Upper	40	44.00	1258.9	0.002237	100	0.026103	4.77	0.00212	0.002725	0.6469	7860.9	0.002362			
3.070	Upper	40	49.55	1482	0.002164	100	0.026103	3.09	0.00328	0.004206	0.6469	7860.9	0.003217			
3.130	Upper	40	72.00	1444.09	0.002920	100	0.026103	2.71	0.00374	0.004796	0.6469	7860.9	0.003819			
3.210	Upper	40	48.16	1394.48	0.002217	100	0.026103	3.37	0.00301	0.003857	0.6469	7860.9	0.003027			
3.320	Upper	40	46.49	1442.26	0.002105	100	0.026103	3.4	0.00298	0.003823	0.6469	7860.9	0.002970			
3.400	Upper	40	63.45	1482	0.002605	100	0.026103	2.58	0.00393	0.005038	0.6469	7860.9	0.003857			
3.480	Upper	40	64.99	1426.15	0.002730	100	0.026103	2.89	0.00351	0.004497	0.6469	7860.9	0.003578			
3.520	Upper	40	45.00	1238.43	0.002303	100	0.026103	3.26	0.00311	0.003987	0.6469	7860.9	0.003133			
3.600	Upper	40	33.42	1240.25	0.001841	100	0.026103	3.84	0.00264	0.003385	0.6469	7860.9	0.002622			
3.650	Upper	40	35.10	1397.54	0.001746	100	0.026103	4.11	0.00247	0.003162	0.6469	7860.9	0.002458			
3.750	Upper	40	34.14	1182.44	0.001938	100	0.026103	3.74	0.00271	0.003475	0.6469	7860.9	0.002708			
3.780	Upper	40	45.00	1122.57	0.002479	100	0.026103	3.71	0.00273	0.003503	0.6469	7860.9	0.002905			
3.860	Upper	40	37.35	1434.66	0.001794	100	0.026103	3.99	0.00254	0.003257	0.6469	7860.9	0.002530			
3.960	Upper	40	64.26	1335.13	0.002844	100	0.026103	2.45	0.00414	0.005305	0.6469	7860.9	0.004095			
4.050	Upper	40	64.78	1205.61	0.003089	100	0.026103	2.48	0.00409	0.005241	0.6469	7860.9	0.004139			
4.110	Upper	40	73.04	1261.17	0.003267	100	0.026103	2.31	0.00439	0.005626	0.6469	7860.9	0.004427			
4.220	Upper	40	43.07	909.59	0.002809	100	0.026103	2.85	0.00356	0.004560	0.6469	7860.9	0.003642			
4.230	Upper	40	107.35	1262	0.004359	100	0.026103	1.61	0.00630	0.008073	0.6469	7860.9	0.006242			
4.310	Upper	40	48.34	874.48	0.003155	100	0.026103	2.39	0.00424	0.005438	0.6469	7860.9	0.004278			
4.400	Upper	40	50.03	816.5	0.003408	100	0.026103	2.86	0.00354	0.004544	0.6469	7860.9	0.003832			
4.490	Upper	40	39.21	1233.31	0.002084	100	0.026103	3.38	0.00300	0.003845	0.6469	7860.9	0.002976			
4.560	Upper	40	40.00	1011.76	0.002454	100	0.026103	3.07	0.00330	0.004234	0.6469	7860.9	0.003330			
Culvert	Upper		95.88	1262												
			140.00	1261.99												

HEC-RAS Plan: Fu-100

Reach	River Sta	Profile	Min Ch El	W.S. Elev	Q Total	Vel Chnl	Max Chl Dpth	Hydr Depth C	E.G. Slope	Sta W.S. Lft	Top W Chnl	Sta W.S. Rgt	Vel Total	Top Width
			(ft)	(ft)	(cfs)	(ft/s)	(ft)	(ft)	(ft/ft)	(ft)	(ft)	(ft)	(ft/s)	(ft)
Reach 3	0.20	100yr encr	1646.00	1659.0	17944.00	14.22	13.03	10.99	0.003537	9600.00	71.66	10184.31	6.93	584.31
Reach 3	0.33	100yr encr	1652.20	1661.5	17944.00	13.82	9.26	7.16	0.005684	9900.00	144.22	10290.02	9.77	390.02
Reach 3	0.43	100yr encr	1655.00	1664.8	17944.00	14.08	9.83	7.31	0.005776	9900.00	110.00	10368.00	8.41	468.00
Reach 3	0.54	100yr encr	1660.00	1669.7	17944.00	15.34	9.67	9.06	0.005255	9840.00	62.02	10340.00	7.50	500.00
Reach 3	0.63	100yr encr	1664.00	1672.4	17944.00	14.67	8.44	7.67	0.005923	9662.00	76.79	10180.00	7.58	518.00
Reach 3	0.71	100yr encr	1664.00	1675.2	17944.00	16.01	11.18	10.32	0.004792	9730.00	55.65	10150.00	7.95	420.00
Reach 3	0.75	100yr encr	1666.00	1676.7	17944.00	12.78	10.72	9.44	0.003382	9750.00	83.90	10214.00	7.00	464.00
Reach 3	0.84	100yr encr	1670.00	1678.7	17944.00	16.77	8.67	8.39	0.006814	9885.00	55.00	10280.00	8.64	395.00
Reach 3	0.99	100yr encr	1678.00	1684.5	17944.00	12.17	6.54	6.25	0.005303	9934.46	56.38	10550.00	6.22	615.54
Reach 3	1.09	100yr encr	1680.00	1688.3	17944.00	15.50	8.29	8.08	0.006104	9925.12	66.00	10430.00	7.69	504.88
Reach 3	1.18	100yr encr	1680.00	1692.3	17944.00	14.08	12.25	10.95	0.003375	9885.00	83.00	10375.00	7.68	490.00
Reach 3	1.27	100yr encr	1684.00	1694.8	17944.00	11.34	10.76	9.85	0.002495	9880.00	103.00	10290.00	6.84	410.00
Reach 3	1.37	100yr encr	1688.00	1696.9	17944.00	14.36	8.94	7.50	0.005777	9560.00	98.12	10049.47	8.10	489.47
Reach 3	1.47	100yr encr	1690.00	1701.3	17944.00	14.81	11.33	10.41	0.004010	9570.00	68.04	10060.00	7.38	490.00
Reach 3	1.58	100yr encr	1692.00	1703.4	17944.00	15.05	11.45	9.24	0.004936	9610.00	77.24	10053.08	8.16	443.08
Reach 3	1.60	100yr encr	1692.00	1704.6	17944.00	14.91	12.57	10.93	0.003838	9610.00	57.21	10040.08	7.39	430.08
Reach 3	1.68	100yr encr	1696.00	1705.5	17944.00	15.30	9.54	8.30	0.005752	9860.00	81.89	10250.00	8.82	390.00
Reach 3	1.75	100yr encr	1698.00	1708.3	17944.00	14.67	10.28	8.82	0.004875	9955.31	102.26	10321.00	9.34	365.69
Reach 3	1.81	100yr encr	1700.00	1710.7	17944.00	12.53	10.74	10.35	0.002869	9947.84	59.95	10410.00	6.26	462.16
Reach 3	1.85	100yr encr	1700.00	1711.3	17944.00	11.57	11.27	9.48	0.002736	9822.37	86.55	10400.00	5.92	577.63
Reach 3	1.88	100yr encr	1702.10	1711.8	17944.00	13.84	9.66	8.04	0.004875	9772.88	90.00	10410.00	6.95	637.12
Reach 3	2.00	100yr encr	1708.50	1714.7	17944.00	12.55	6.19	5.64	0.006411	9969.00	135.00	10760.00	6.72	791.00
Reach 3	2.08	100yr encr	1710.00	1717.4	17944.00	14.92	7.44	4.65	0.011960	9970.00	109.44	10620.00	8.26	650.00
Reach 3	2.17	100yr encr	1714.00	1721.1	17944.00	13.52	7.10	6.71	0.005901	9834.00	107.72	10285.00	8.11	451.00
Reach 3	2.24	100yr encr	1714.00	1723.4	17944.00	14.91	9.39	7.86	0.005819	9850.00	115.85	10155.00	10.39	305.00
Reach 3	2.33	100yr encr	1717.00	1727.1	17944.00	16.98	10.07	9.27	0.006122	9830.00	85.00	10040.61	12.09	210.61
Reach 3	2.40	100yr encr	1718.00	1730.0	17944.00	13.37	12.01	11.48	0.002834	9800.00	84.10	10044.27	9.03	244.27
Reach 3	2.47	100yr encr	1720.00	1731.4	17944.00	15.07	11.39	10.07	0.004342	9944.08	65.55	10310.00	8.20	365.92
Reach 3	2.52	100yr encr	1721.00	1733.3	17944.00	11.25	12.31	11.16	0.002152	9850.00	71.17	10385.00	5.61	535.00
Reach 3	2.60	100yr encr	1724.00	1734.9	17944.00	13.70	10.91	9.32	0.004018	9800.00	83.92	10448.57	6.72	648.57
Reach 2	2.73	100yr encr	1728.00	1738.4	13890.00	15.07	10.44	9.48	0.004711	9787.00	64.55	10080.00	8.79	293.00
Reach 2	2.82	100yr encr	1730.00	1742.1	13890.00	4.06	12.08	7.49	0.000985	9678.97	316.00	10294.00	3.47	615.03
Reach 2	2.87	100yr encr	1732.00	1742.3	13890.00	3.99	10.30	6.30	0.000821	9732.43	506.00	10485.00	3.54	752.57
Reach 2	2.90	100yr encr	1734.00	1742.4	13890.00	5.60	8.41	4.46	0.002694	9786.23	491.00	10469.00	5.04	682.77
Reach 2	2.92	100yr encr	1734.00	1743.0	13890.00	4.92	9.04	3.62	0.004570	9889.24	690.00	10755.00	4.71	865.76
Reach 2	2.97	100yr encr	1736.00	1744.2	13890.00	3.87	8.25	3.21	0.003474	9972.13	1118.00	11098.00	3.87	1125.87
Reach 1	3.07	100yr encr	1741.00	1748.6	7727.00	12.34	7.57	6.60	0.005118	9740.00	48.16	10150.00	5.85	410.00
Reach 1	3.13	100yr encr	1742.00	1750.4	7727.00	11.93	8.41	6.56	0.004903	9600.00	49.47	10068.00	5.51	468.00
Reach 1	3.21	100yr encr	1746.00	1753.0	7727.00	11.98	7.01	5.63	0.005931	9780.00	64.09	10170.00	6.33	390.00
Reach 1	3.32	100yr encr	1750.00	1756.7	7727.00	12.10	6.71	5.37	0.006488	9800.00	64.99	10175.00	6.50	375.00
Reach 1	3.4	100yr encr	1752.00	1760.3	7727.00	12.92	8.28	6.64	0.005508	9800.00	47.00	10140.00	6.46	340.00
Reach 1	3.48	100yr encr	1755.00	1763.8	7727.00	14.36	8.80	7.48	0.006093	9900.00	33.42	10170.00	7.21	270.00
Reach 1	3.52	100yr encr	1756.00	1765.5	7727.00	14.37	9.51	8.12	0.005416	9900.00	35.10	10141.00	7.35	241.00
Reach 1	3.6	100yr encr	1760.00	1768.3	7727.00	12.86	8.30	7.57	0.004765	9891.00	34.14	10160.00	6.45	269.00
Reach 1	3.65	100yr encr	1762.00	1769.8	7727.00	10.62	7.78	7.21	0.003346	9900.00	45.00	10190.00	5.61	290.00
Reach 1	3.75	100yr encr	1764.00	1773.1	7727.00	13.91	9.10	8.12	0.005122	9960.00	37.35	10220.00	7.15	260.00
Reach 1	3.78	100yr encr	1766.00	1774.4	7727.00	11.84	8.37	5.28	0.006471	9950.00	82.28	10226.00	7.83	276.00
Reach 1	3.86	100yr encr	1770.00	1777.7	7403.00	12.62	7.71	5.59	0.006777	9950.00	67.77	10330.00	7.26	326.76
Reach 1	3.96	100yr encr	1774.00	1782.4	7403.00	9.26	8.37	3.96	0.005625	9877.35	174.64	10433.00	6.52	555.65
Reach 1	4.05	100yr encr	1779.00	1785.6	7403.00	13.97	6.65	5.52	0.008291	9968.60	43.07	10263.82	7.28	295.22
Reach 1	4.11	100yr encr	1782.00	1788.9	7403.00	10.61	6.89	4.67	0.005951	9975.00	129.32	10293.00	7.92	318.00
Reach 1	4.22	100yr encr	1785.50	1791.8	7403.00	13.37	6.33	4.65	0.009599	9780.00	55.00	10080.46	7.71	300.46
Reach 1	4.23	100yr encr	1786.00	1793.2	7403.00	11.92	7.24	5.78	0.005748	9830.00	50.03	10097.00	6.87	267.00
Reach 1	4.31	100yr encr	1788.00	1797.5	7403.00	14.41	9.49	8.02	0.005493	9920.00	39.21	10114.00	8.17	194.00
Reach 1	4.4	100yr encr	1792.30	1800.9	7403.00	12.59	8.64	7.09	0.004873	9938.00	40.00	10249.00	6.22	311.00
Reach 1	4.49	100yr encr	1796.00	1803.6	7403.00	11.40	7.57	5.76	0.005172	9910.00	98.72	10183.00	8.38	273.00
Reach 1	4.56	100yr encr	1799.00	1808.0	7403.00	6.06	9.01	7.54	0.001014	9944.00	140.00	10216.00	4.77	272.00
Reach 1	4.575		Culvert											

HEC-RAS Plan: Fu-10

Reach	River Sta	Profile	Q Total	W.S. Elev	Hydr Depth C	E.G. Slope	Mann Wtd Chnl	Vel Chnl	Top W Chnl	Q Channel	Froude # Chl	Shear Chan
			(cfs)	(ft)	(ft)	(ft/ft)		(ft/s)	(ft)	(cfs)		(lb/sq ft)
Reach 3	0.20	10 encr	3573.00	1652.5	5.26	0.005003	0.030	10.40	63.33	3464.67	0.80	1.60
Reach 3	0.33	10 encr	3573.00	1656.9	3.08	0.006947	0.030	8.71	123.47	3313.20	0.87	1.33
Reach 3	0.43	10 encr	3573.00	1660.4	3.60	0.007174	0.030	9.78	92.93	3267.83	0.91	1.59
Reach 3	0.54	10 encr	3573.00	1665.6	4.95	0.005260	0.030	10.26	62.02	3148.68	0.81	1.58
Reach 3	0.63	10 encr	3573.00	1669.2	4.39	0.004328	0.030	8.64	76.79	2908.45	0.73	1.17
Reach 3	0.71	10 encr	3573.00	1670.6	5.74	0.003429	0.030	9.16	55.65	2929.19	0.67	1.20
Reach 3	0.75	10 encr	3573.00	1671.3	4.04	0.006002	0.030	9.66	83.90	3273.29	0.85	1.50
Reach 3	0.84	10 encr	3573.00	1674.3	4.06	0.009222	0.030	12.03	55.00	2689.06	1.05	2.32
Reach 3	0.99	10 encr	3573.00	1681.2	2.89	0.005225	0.030	7.22	56.38	1177.26	0.75	0.93
Reach 3	1.09	10 encr	3573.00	1684.4	4.21	0.006249	0.030	10.15	66.00	2817.99	0.87	1.63
Reach 3	1.18	10 encr	3573.00	1686.8	5.48	0.002455	0.030	7.57	83.00	3440.46	0.57	0.83
Reach 3	1.27	10 encr	3573.00	1688.3	3.43	0.007216	0.030	9.55	103.00	3377.30	0.91	1.54
Reach 3	1.37	10 encr	3573.00	1693.2	3.76	0.005935	0.030	9.18	98.12	3382.57	0.83	1.38
Reach 3	1.47	10 encr	3573.00	1695.8	4.85	0.005614	0.030	10.53	68.04	3477.90	0.84	1.68
Reach 3	1.56	10 encr	3573.00	1698.7	4.52	0.005798	0.030	10.13	77.24	3535.61	0.84	1.59
Reach 3	1.60	10 encr	3573.00	1700.1	6.47	0.002333	0.030	8.19	57.21	3032.59	0.57	0.92
Reach 3	1.66	10 encr	3573.00	1701.3	4.03	0.005470	0.030	9.23	81.89	3047.21	0.81	1.36
Reach 3	1.75	10 encr	3573.00	1703.7	4.28	0.003769	0.030	7.96	102.26	3478.47	0.68	1.00
Reach 3	1.81	10 encr	3573.00	1705.5	5.14	0.004505	0.030	9.84	59.95	3031.06	0.77	1.43
Reach 3	1.85	10 encr	3573.00	1706.6	4.86	0.003120	0.030	7.91	86.55	3326.12	0.63	0.94
Reach 3	1.88	10 encr	3573.00	1707.5	3.83	0.006274	0.030	9.57	90.00	3300.18	0.86	1.49
Reach 3	2.00	10 encr	3573.00	1711.4	2.35	0.007296	0.030	7.47	135.00	2369.12	0.86	1.07
Reach 3	2.06	10 encr	3573.00	1714.1	3.05	0.008183	0.030	9.29	62.93	1784.31	0.94	1.53
Reach 3	2.17	10 encr	3573.00	1717.4	3.05	0.006410	0.030	8.33	107.72	2734.19	0.84	1.22
Reach 3	2.24	10 encr	3573.00	1719.3	3.82	0.004209	0.030	7.83	115.85	3465.35	0.71	1.00
Reach 3	2.33	10 encr	3573.00	1721.6	3.79	0.007276	0.030	10.19	85.00	3280.26	0.92	1.70
Reach 3	2.40	10 encr	3573.00	1723.8	5.25	0.002342	0.030	7.22	84.10	3189.38	0.55	0.76
Reach 3	2.47	10 encr	3573.00	1725.8	4.52	0.007510	0.030	11.62	65.55	3447.49	0.96	2.09
Reach 3	2.52	10 encr	3573.00	1728.1	5.94	0.002507	0.030	7.98	71.17	3374.33	0.58	0.90
Reach 3	2.60	10 encr	3573.00	1729.4	3.88	0.008693	0.030	11.24	82.03	3573.00	1.01	2.06
Reach 2	2.67	10 encr	3085.00	1733.0	3.34	0.005199	0.030	7.87	100.00	2626.40	0.76	1.06
Reach 2	2.70	10 encr	3085.00	1733.8	5.07	0.002503	0.030	7.25	65.00	2388.07	0.57	0.78
Reach 2	2.73	10 encr	3085.00	1734.0	5.02	0.003861	0.030	8.93	64.55	2897.54	0.70	1.19
Reach 1	2.82	10 encr	1482.00	1736.1	3.29	0.005122	0.030	7.73	56.00	1424.30	0.75	1.03
Reach 1	2.87	10 encr	1482.00	1738.0	2.92	0.009643	0.030	9.76	52.00	1481.97	1.01	1.71
Reach 1	2.90	10 encr	1482.00	1739.9	4.77	0.001900	0.030	6.00	44.00	1258.90	0.48	0.55
Reach 1	2.92	10 encr	1482.00	1739.7	3.09	0.008887	0.030	9.67	49.55	1482.00	0.97	1.65
Reach 1	2.97	10 encr	1482.00	1742.4	2.71	0.006053	0.030	7.40	72.00	1444.09	0.79	1.01
Reach 1	3.07	10 encr	1482.00	1745.3	3.37	0.006079	0.030	8.59	48.16	1394.48	0.83	1.26
Reach 1	3.13	10 encr	1482.00	1747.0	3.40	0.006894	0.030	9.13	46.49	1442.26	0.87	1.42
Reach 1	3.21	10 encr	1482.00	1749.9	2.58	0.009641	0.030	9.07	63.45	1482.00	1.00	1.53
Reach 1	3.32	10 encr	1482.00	1754.2	2.89	0.005842	0.030	7.60	64.99	1426.15	0.79	1.04
Reach 1	3.4	10 encr	1482.00	1757.3	3.26	0.006168	0.030	8.45	45.00	1238.43	0.83	1.23
Reach 1	3.48	10 encr	1482.00	1760.2	3.84	0.006680	0.030	9.65	33.42	1240.25	0.87	1.54
Reach 1	3.52	10 encr	1482.00	1761.5	4.11	0.006124	0.030	9.69	35.10	1397.54	0.84	1.51
Reach 1	3.6	10 encr	1482.00	1764.5	3.74	0.006311	0.030	9.26	34.14	1182.44	0.84	1.42
Reach 1	3.65	10 encr	1482.00	1766.3	3.71	0.003239	0.030	6.72	45.00	1122.57	0.61	0.74
Reach 1	3.75	10 encr	1482.00	1769.0	3.99	0.006317	0.030	9.62	37.35	1434.66	0.85	1.51
Reach 1	3.78	10 encr	1482.00	1770.8	2.45	0.009105	0.030	8.48	64.26	1335.13	0.95	1.37
Reach 1	3.86	10 encr	1262.00	1774.5	2.48	0.006992	0.030	7.49	64.78	1205.61	0.84	1.06
Reach 1	3.96	10 encr	1262.00	1778.2	2.31	0.007535	0.030	7.46	73.04	1261.17	0.86	1.08
Reach 1	4.05	10 encr	1262.00	1783.0	2.85	0.005602	0.030	7.40	43.07	909.59	0.77	0.99
Reach 1	4.11	10 encr	1262.00	1785.5	1.61	0.011577	0.030	7.28	107.35	1262.00	1.01	1.15
Reach 1	4.22	10 encr	1262.00	1789.2	2.39	0.007435	0.030	7.56	48.34	874.48	0.86	1.09
Reach 1	4.23	10 encr	1262.00	1790.3	2.86	0.003362	0.030	5.70	50.03	816.50	0.59	0.59
Reach 1	4.31	10 encr	1262.00	1792.9	3.38	0.007220	0.030	9.30	39.21	1233.31	0.89	1.48
Reach 1	4.4	10 encr	1262.00	1796.9	3.07	0.006380	0.030	8.24	40.00	1011.76	0.83	1.20
Reach 1	4.49	10 encr	1262.00	1799.9	2.15	0.005551	0.030	6.12	95.88	1262.00	0.74	0.74
Reach 1	4.56	10 encr	1262.00	1802.1	2.24	0.007843	0.030	7.50	140.00	1261.99	0.88	1.09
Reach 1	4.575		Culvert									

Stationing ID (River miles)	Maximum WSE (ft) [2]	Left Bank Superelevation Freeboard (ft)	Right Bank Superelevation Freeboard (ft)	Left Top of Bank Elevation (ft) [1]	Right Top of Bank Elevation (ft) [1]	HEC-RAS Minimum Elevation (ft) [2]	HEC-6 General Scour Depth (ft)	Antidune Trough Depth (ft)	Left Bank Bend Scour Depth, Z_{bs} (ft)	Right Bank Bend Scour Depth, Z_{bs} (ft)	Left Bank HEC-6 Design Scour Depth (ft) [3]	Right Bank HEC-6 Design Scour Depth (ft) [3]	Depth to Armoring, y_d (ft)	Left Bank Total Degredeation (ft) [4]	Right Bank Total Degredeation (ft) [4]	Left Bank Toe Down Elevation (ft) [5]	Right Bank Toe Down Elevation (ft) [5]	HEC-RAS Min Elevation - 10' (ft)	Left Ave Total Degredation	Right Ave Total Degredation	Left TOB - HEC-RAS Min Elevation	Right TOB - HEC-RAS Min Elevation
0.040	1737.1	0	0	1740.1	1740.1	1726.0	0.4	0.3	0	0	0.9	0.9	0.2	3.0	3.0	1723.0	1723.0	1716.0			14.1	14.1
0.130	1737.8	0	0	1740.8	1740.8	1732.0	1.5	1.8	0	0	4.3	4.3	2.6	6.9	6.9	1725.1	1725.1	1722.0			8.8	8.8
0.170	1739.3	0	0	1742.3	1742.3	1732.0	1.3	2.3	0	0	4.6	4.6	1.0	5.7	5.7	1726.3	1726.3	1722.0			10.3	10.3
0.280	1744.0	0.2	0	1747.2	1747.0	1738.0	0.8	2.0	0.1	0	3.8	3.7	2.3	6.0	5.9	1732.0	1732.1	1728.0			9.2	9.0
0.340	1747.5	0.1	0	1750.6	1750.5	1744.0	0.6	2.0	0.0	0	3.4	3.3	2.8	6.2	6.2	1737.8	1737.8	1734.0			6.6	6.5
0.440	1751.6	0	0	1754.6	1754.6	1746.0	0.7	2.0	0	0	3.4	3.4	1.3	4.7	4.7	1741.3	1741.3	1736.0			8.6	8.6
0.530	1755.7	0	0	1758.7	1758.7	1750.0	0.7	2.2	0	0	3.7	3.7	2.3	6.0	6.0	1744.0	1744.0	1740.0			8.7	8.7
0.620	1760.1	0	0	1763.1	1763.1	1754.0	0.7	1.8	0	0	3.3	3.3	2.8	6.1	6.1	1747.9	1747.9	1744.0			9.1	9.1
0.720	1763.2	0	0	1766.2	1766.2	1758.0	0.7	2.4	0	0	4.0	4.0	2.0	6.0	6.0	1752.0	1752.0	1748.0			8.2	8.2
0.800	1767.2	0	0	1770.2	1770.2	1762.0	0.7	2.4	0	0	4.0	4.0	2.0	6.0	6.0	1756.0	1756.0	1752.0			8.2	8.2
0.890	1772.1	0	0	1775.1	1775.1	1764.0	0.6	2.5	0	0	4.0	4.0	3.3	7.4	7.4	1756.6	1756.6	1754.0			11.1	11.1
0.950	1774.2	0	0.3	1777.2	1777.5	1766.0	0.5	1.0	0	2.0	1.9	4.5	0.7	3.0	5.2	1763.0	1760.8	1756.0			11.2	11.5
1.040	1775.9	0.2	0	1779.1	1778.9	1770.0	0.3	1.2	1.4	0	3.8	1.9	2.0	5.8	3.9	1764.2	1766.1	1760.0			9.1	8.9
1.120	1779.4	0	0	1782.4	1782.4	1772.0	0.2	1.8	0	0	2.6	2.6	2.8	5.4	5.4	1766.6	1766.6	1762.0			10.4	10.4
1.210	1782.5	0	0	1785.5	1785.5	1776.0	0.3	2.0	0	0	2.9	2.9	2.4	5.3	5.3	1770.7	1770.7	1766.0			9.5	9.5
1.270	1784.8	0	0	1787.8	1787.8	1778.0	0.3	1.8	0	0	2.7	2.7	1.6	4.3	4.3	1773.7	1773.7	1768.0			9.8	9.8
1.370	1788.3	0.5	0	1791.8	1791.3	1782.0	0.3	1.8	1.6	0	4.8	2.8	2.6	7.5	5.4	1774.5	1776.6	1772.0			9.8	9.3
1.460	1791.7	0.4	0	1795.1	1794.7	1786.0	0.4	1.8	1.4	0	4.8	2.9	2.3	7.0	5.2	1779.0	1780.8	1776.0			9.1	8.7
1.540	1794.4	0	0	1797.4	1797.4	1790.0	0.4	0.9	0	0	1.7	1.7	0.8	3.0	3.0	1787.0	1787.0	1780.0			7.4	7.4
1.650	1801.1	0	0	1804.1	1804.1	1796.0	0.5	1.8	0	0	2.9	2.9	2.0	4.9	4.9	1791.1	1791.1	1786.0			8.1	8.1
1.750	1805.8	0	0	1808.8	1808.8	1800.0	0.5	1.7	0	0	2.8	2.8	2.3	5.1	5.1	1794.9	1794.9	1790.0			8.8	8.8
1.830	1811.8	0	0	1814.8	1814.8	1806.0	0.5	2.0	0	0	3.2	3.2	2.0	5.2	5.2	1800.8	1800.8	1796.0			8.8	8.8
1.920	1815.5	0	0	1818.5	1818.5	1810.0	0.6	1.8	0	0	3.0	3.0	2.3	5.3	5.3	1804.7	1804.7	1800.0	3.0	3.0	8.5	8.5
2.000	1820.8	0	0	1823.8	1823.8	1814.0	1.0	2.2	0	0	4.2	4.2	2.6	6.8	6.8	1807.2	1807.2	1804.0	7.5	7.4	9.8	9.8
																		Average	5.5	5.4	9.3	9.3

[1] Top of Levee = HEC-RAS WSE + Superelevation + 3'

[2] All hydraulic parameters from HEC-RAS Apache1.prj
Existing (Worst case) hydraulics.

[3] Left or Right Bank Design Scour Depth = (HEC-6 General Scour + Anti-dune Trough Depth + Right or Left Bend Scour Depth) * 1.3

*4 Total Degredation = Design Scour Depth + Armoring Depth. Minimum 3'

[5] Toe Down Elevation = Minimum HEC-RAS Elevation - Total Degredation

Stationing ID (River Miles)	Reach Code	Design Discharge, Q (cfs) [*1]	Average Channel Velocity, V_m (fps)	Maximum Depth Main Channel, Y_{max}, (ft)	Main Channel Hydraulic Depth, Y_h (ft)	Energy Slope, S_e (ft/ft)	HEC-6 General Scour Depth, HEC-6 Z_{gs} (ft) [*4]	Anti-dune Trough Depth, Z_a (ft) [*5]	Left Bank Angle of Channel Bend in degrees	Right Bank Angle of Channel Bend in degrees	Left Bank Bend Scour Depth, Z_{bs} (ft) [*6]	Right Bank Bend Scour Depth, Z_{bs} (ft) [*6]	Full Flow Velocity [*2]	Full Flow Channel Top Width, T (ft) [*2]	Left Bank Radius of Curve, r_c [*9]	Right Bank Radius of Curve, r_c [*9]	Left Bank Superelevation, del h (ft) [*10]	Right Bank Superelevation, del h (ft) [*10]	Left Bank HEC 6 Design Scour Depth, Z_t (ft) [*8]	Right Bank HEC-6 Design Scour Depth, Z_t (ft) [*8]	Left Bank Reach Average HEC-6 Design Scour Depth	Right Bank Reach Average HEC-6 Design Scour Depth
0.04	Paradise	5992	5.0	11.1	9.7	0.00051	0.35	0.3	0	0	0	0	2.4	545.0	0	0	0	0	0.9	0.9	3.4	3.2
0.13	Paradise	5992	11.5	5.8	5.3	0.00594	1.5	1.8	0	0	0	0	7.2	259.5	0	0	0	0	4.3	4.3		
0.17	Paradise	5992	12.9	7.3	6.8	0.00533	1.3	2.3	0	0	0	0	7.9	186.8	0	0	0	0	4.6	4.6		
0.28	Paradise	5992	12.1	6.0	4.3	0.00867	0.8	2.0	18	0	0.1	0	7.3	271.0	2633.0	0	0.2	0	3.8	3.7		
0.34	Paradise	5992	12.0	3.5	3.5	0.01112	0.6	2.0	18	0	0.0	0	6.1	415.3	4035.1	0	0.1	0	3.4	3.3		
0.44	Paradise	5992	12.0	5.6	4.4	0.00832	0.65	2.0	0	0	0	0	6.5	266.0	0	0	0	0	3.4	3.4		
0.53	Paradise	5992	12.7	5.7	5.4	0.00699	0.65	2.2	0	0	0	0	7.5	228.0	0	0	0	0	3.7	3.7		
0.62	Paradise	5992	11.5	6.1	5.6	0.00544	0.7	1.8	0	0	0	0	6.9	270.0	0	0	0	0	3.3	3.3		
0.72	Paradise	5992	13.2	5.2	4.8	0.00880	0.7	2.4	0	0	0	0	7.0	262.0	0	0	0	0	4.0	4.0		
0.8	Paradise	5992	13.2	5.2	4.8	0.00900	0.7	2.4	0	0	0	0	6.8	280.0	0	0	0	0	4.0	4.0		
0.89	Paradise	5992	13.5	8.1	7.4	0.00553	0.6	2.5	0	0	0	0	8.1	170.0	0	0	0	0	4.0	4.0		
0.95	Paradise	5992	8.6	8.2	6.6	0.00249	0.45	1.0	0	28	0	2.0	6.0	250.0	0	942.9	0	0.3	1.9	4.5		
1.04	Paradise	5992	9.3	5.9	5.4	0.00384	0.3	1.2	28	0	1.4	0	5.1	302.8	1142.0	0	0.2	0	3.8	1.9		
1.12	Paradise	5992	11.4	7.4	5.4	0.00572	0.2	1.8	0	0	0	0	7.6	277.2	0	0	0	0	2.6	2.6		
1.21	Paradise	5992	12.0	6.5	6.2	0.00534	0.25	2.0	0	0	0	0	5.6	381.0	0	0	0	0	2.9	2.9		
1.27	Paradise	5992	11.5	6.8	5.3	0.00587	0.3	1.8	0	0	0	0	9.0	190.0	0	0	0	0	2.7	2.7		
1.37	Paradise	5992	11.5	6.3	5.1	0.00617	0.3	1.8	28	0	1.6	0	7.6	203.0	765.6	0	0.5	0	4.8	2.8		
1.46	Paradise	5992	11.5	5.7	5.4	0.00583	0.4	1.8	28	0	1.4	0	6.8	288.0	1086.1	0	0.4	0	4.8	2.9		
1.54	Paradise	5992	8.3	4.4	3.9	0.00459	0.4	0.9	0	0	0	0	7.3	256.0	0	0	0	0	1.7	1.7		
1.65	Paradise	5401	11.5	5.1	4.6	0.00698	0.45	1.8	0	0	0	0	5.8	358.1	0	0	0	0	2.9	2.9		
1.75	Paradise	5401	11.1	5.8	4.2	0.00758	0.5	1.7	0	0	0	0	5.9	366.0	0	0	0	0	2.8	2.8		
1.83	Paradise	5401	12.0	5.8	5.1	0.00676	0.5	2.0	0	0	0	0	7.3	222.0	0	0	0	0	3.2	3.2		
1.92	Paradise	5401	11.4	5.5	4.5	0.00710	0.55	1.8	0	0	0	0	9.0	172.0	0	0	0	0	3.0	3.0		
2	Paradise	5401	12.8	6.8	6.2	0.00592	1	2.2	0	0	0	0	6.9	214.3	0	0	0	0	4.2	4.2		

[*1] All hydraulic parameters from HEC-RAS Apache1.prj

[*3] When the general scour depth is negative (aggradation), the general scour component = 0

[*4] Extracted from Stantec HEC-6 analysis graphs. Interpolated from peak to peak Straight Line.
Worst Case between Future and Existing Conditions.

[*5] Anti-dune scour depth from SLA, 1982 (COT 6.09 and Fuller Report) $Z_a = 0.0137 * V_m^2$
If Za > 0.5 * Yh, then Za = 0.5 * Yh

[*6] Bend Scour Depth From Zeller, 1981 (COT Drainage Design and FP Mgmt 6.11 and Fuller Report)

$Z_{gs} = ((0.0685 * Y_{max} * V_m^{0.8})/(Y_h^{0.4} * S_e^{0.3})) * ((2.1 * (((\sin^2(alpha/2)) / (\cos alpha))^{0.2})) -1)$

alpha = degree of bend

Erosion Will Occur on Outside Bank. Right and Left Bank Looking Upstream (Opposite of HEC-RAS)

[*8] $Z_t = 1.3 * (\text{HEC-6 } Z_{gs} + Z_a + Z_{bs} + Z_{ls} + Z_{lft})$ Used to calculate toe down elevation

1.3 = Factor of Safety

Z_{ls} = Local Scour = 0

Z_{lft} = Low Flow Thalweg Scour = 0

[*9] Radius of Curve from Zeller 1981 (COT Drainage Design and FP Mgmt 6.11)

$r_c / T = \cos alpha / (4 * \sin^2(alpha/2))$

r_c = Radius of Curve

T = Full Floodway Width (As opposed to main channel widhth)

[*10] Chow's Simplified Method of Determining Superelevation (p.448)

Also the preferred method in Maricopa Drainage and Design Manual (p. 6-20)

$h = (V^2 * T) / (g * r_c)$

V = Full Floodway Velocity (As opposed to Main Channel Velocity)

Stationing ID (River Miles)	Reach Code	Average Depth of Flow, d (ft) *1 *2	Energy Slope, S_e (ft/ft)	*n* Value for Stream Bed *3	90% Finer Particle Size, D_{90} (mm) *4	M-P, Muller Individual Particle Size, D_c (mm) *5	Average Channel Velocity, V_m (fps)	Competent Bottom Velocity Armor Size, Dc (mm) *6	Critical Shear Stress, T_c (lb/ft^2) *7	Shield's Diagram D_c (ft) *8	Shields Diagram Dc (mm)	Shear Velocity, U. (fps) *9	Boundary Reynolds No., R. *10	Yang's Incipient Motion, D_c (ft) *11	Yang's Incipient Motion, D_c (mm)	Average Individual Particle Size, D_c (mm)	Reach Average D_c (mm)	Percentage of Bed Material Larger than D_c, del p (Seive-Boulder Count Combo) *12	Thickness to Armoring Layer, y_a (mm) *13	Depth to Armoring, y_d (ft) Seive - Boulder Count Combo *14	Ave Depth to Armoring by Reaches (Seive-Boulder Sediment Combo)
0.04	Paradise	4.6	0.0009	0.028	150	15.6	4.0	30.7	0.3	0.04	12.6	0.362	1380	0.108	32.8	22.9	78.6	50	45.8	0.15	2.0
0.13	Paradise	2.2	0.0088	0.028	150	74.6	7.9	115.9	1.2	0.20	60.0	0.791	14413	0.406	123.8	93.6		16	152.4	2.63	
0.17	Paradise	3.7	0.0027	0.028	150	38.5	6.1	70.6	0.6	0.10	31.0	0.568	5350	0.248	75.5	53.9		26	107.8	1.01	
0.28	Paradise	2.2	0.0078	0.028	150	66.5	7.4	102.4	1.1	0.18	53.5	0.747	12140	0.359	109.4	83.0		18	152.4	2.28	
0.34	Paradise	1.6	0.0127	0.028	150	79.3	7.7	112.3	1.3	0.21	63.7	0.815	15780	0.394	120.0	93.8		15	152.4	2.83	
0.44	Paradise	2.2	0.0057	0.028	150	49.1	6.4	75.8	0.8	0.13	39.5	0.642	7701	0.266	81.0	61.4		24	122.7	1.27	
0.53	Paradise	2.8	0.0058	0.028	150	62.7	7.5	104.6	1.0	0.17	50.4	0.725	11102	0.367	111.8	82.4		18	152.4	2.28	
0.62	Paradise	2.0	0.0098	0.028	150	74.9	7.7	112.6	1.2	0.20	60.2	0.792	14487	0.395	120.3	92.0		15	152.4	2.83	
0.72	Paradise	2.4	0.0061	0.028	150	56.8	6.9	90.3	0.9	0.15	45.7	0.690	9583	0.316	96.5	72.3		19	144.6	2.02	
0.8	Paradise	2.8	0.0055	0.028	150	59.2	7.2	98.5	1.0	0.16	47.6	0.704	10189	0.345	105.3	77.7		20	152.4	2.00	
0.89	Paradise	3.3	0.0077	0.028	150	97.0	9.2	160.5	1.6	0.26	78.0	0.902	21363	0.563	171.5	126.7		13	152.4	3.35	
0.95	Paradise	2.6	0.0034	0.028	150	34.5	5.5	56.0	0.6	0.09	27.7	0.538	4527	0.196	59.9	44.5		30	89.1	0.68	
1.04	Paradise	2.4	0.0065	0.028	150	59.8	7.1	94.8	1.0	0.16	48.1	0.708	10351	0.332	101.3	76.0		20	152.0	1.99	
1.12	Paradise	2.0	0.0106	0.028	150	79.6	7.9	117.9	1.3	0.21	64.0	0.817	15897	0.413	126.0	96.9		15	152.4	2.83	
1.21	Paradise	3.2	0.0054	0.028	150	65.7	7.8	113.2	1.1	0.17	52.9	0.742	11917	0.397	121.0	88.2		17	152.4	2.44	
1.27	Paradise	2.3	0.0061	0.028	150	52.9	6.6	82.9	0.9	0.14	42.6	0.666	8610	0.291	88.6	66.7		22	133.5	1.55	
1.37	Paradise	2.29	0.0083	0.028	150	73.1	7.8	114.4	1.2	0.19	58.7	0.782	13964	0.401	122.2	92.1		16	152.4	2.63	
1.46	Paradise	2.43	0.0070	0.028	150	65.3	7.5	104.6	1.1	0.17	52.5	0.740	11810	0.367	111.8	83.6		18	152.4	2.28	
1.54	Paradise	1.6	0.0069	0.028	150	42.1	5.6	57.9	0.7	0.11	33.9	0.594	6115	0.203	61.9	48.9		28	97.9	0.83	
1.65	Paradise	2.51	0.0062	0.028	150	59.6	7.2	96.1	1.0	0.16	47.9	0.707	10284	0.337	102.7	76.6		20	152.4	2.00	
1.75	Paradise	2.09	0.0086	0.028	150	68.8	7.4	103.8	1.1	0.18	55.3	0.759	12751	0.364	110.9	84.7		18	152.4	2.28	
1.83	Paradise	2.38	0.0065	0.028	150	59.8	7.1	95.0	1.0	0.16	48.1	0.708	10347	0.333	101.5	76.1		20	152.3	2.00	
1.92	Paradise	1.98	0.0087	0.028	150	66.4	7.3	99.1	1.1	0.18	53.4	0.746	12101	0.347	105.9	81.2		18	152.4	2.28	
2	Paradise	2.93	0.0074	0.028	150	83.1	8.6	140.3	1.3	0.22	66.8	0.834	16928	0.492	149.9	110.0		16	152.4	2.63	

*1 All hydraulic parameters from HEC-RAS Apache1.prj

Hydraulic Parameters are From Main Channel Between Overbanks

*3 Skin Friction Average

*4 From JEF H&G Sediment Analysis

*5 Meyer-Peter, Muller (Bedload Transport Equation) From USBR 'Computing Degradation and Local Scour' p.9

$D_c = (d * S_e) / (K * ((n/(D_{90}^{1/6}))^{3/2}))$

*6 Competent Bottom Velocity Equation From From USBR 'Computing Degradation and Local Scour' p.10

$D_c = 1.88 * (V_m^2)$

*7 T_c = gammaw * d * S_e . Can also extract from HEC-RAS Analysis Data

*8 Shield's Diagram Equation From USBR 'Computing Degradation and Local Scour' p.12

$D_c = T_c / (gamma_s - gamma_w) * T$

$gamma_s$ = Specific Weight of Particle = 165 lb/ft^3

$gamma_w$ = Specific Weight of Water = 62.4 lb/ft^3

T = Dimensionless Shear Stress = 0.06 for particles > 1.0mm and R > 500

Fuller used T = 0.05, M-P, Muller recommends T = 0.047. T = 0.06 is generally accepted in completely rough boundary (Simons and Senturk, P. 387)

*9 U. = Shear Velocity = $(T_c/(gamma_w/g))^{0.5}$ or = $(g * R * S_e)^{1/2}$ from Simons and Senturk, P. 78 & 264

R = Hydraulic Radius = d in wide channels

10 R = U. * D_c / v

v = Kinematic Viscosity = 0.0000108 ft^2/sec

When R. > 500 T = 0.06 on Shields Diagram

*11 Yang's Incipient Motion Equation From USBR 'Computing Degradation and Local Scour' p.14

*12 From Graph of Fuller Sediment Analysis Averaged over Entire Length of Cave Creek.

*13 $y_a = 2 * D_c$ or 0.5' whichver is smaller

*14 $y_d = y_a * ((1/\text{del } p)-1)$ - Depth to Armoring not Reached when y_d > 25'

	Size (mm)	Size (ft)	Size (in.)
D_{90} =	150	0.492	5.91
D_{50} =	23	0.075	0.91
D_{75} =	57	0.187	2.24

Method	Equation		
	$n_s=(D_{90}^{1/6}) / 44.4$ (D_{90} in inches)	n_s =	0.030
Anderson	$n_s=0.0395 * (D_{50}^{1/6})$ (D_{50} in feet)	n_s =	0.026
Lane	$n_s=(D_{75}^{1/6}) / 39$ (D_{75} in inches)	n_s =	0.029
			0.028

Station ID (River Miles)	Reach Code	Mean Particle Size, (mm) [1]	Channel Width (ft) [2]	Dominant Discharge, Q (cfs) [2]	Schoklitsch, S_L (ft/ft) [3]	90% Finer Particle Size, D_{90} (mm) [1]	*n* Value for Cross Section [2]	Average Depth of Flow, d (ft) [2]	M-P,M S_L (ft/ft) [4]	Shields S_L (ft/ft) [5]	Shear Velocity, U* (fps) [6]	Boundary Reynolds No. [7]	Average S_L (ft/ft)	Average S_L by Reach	Average Invert Slope by Reach [8]	Distance Between Grade Control Structures (ft) [9]
0.040	Paradise	50	62.07	1165.77	0.003626	150	0.028432	4.64	0.00280	0.003501	0.7233	10986.0	0.003311	0.00541	0.008503	1614
0.130	Paradise	50	69.13	1193.17	0.003864	150	0.028432	2.2	0.00592	0.007385	0.7233	10986.0	0.005721			
0.170	Paradise	50	48.20	1092.78	0.003149	150	0.028432	3.7	0.00352	0.004391	0.7233	10986.0	0.003686			
0.280	Paradise	50	59.62	977.02	0.004017	150	0.028432	2.22	0.00586	0.007318	0.7233	10986.0	0.005732			
0.340	Paradise	50	45.08	569.01	0.004886	150	0.028432	1.63	0.00798	0.009967	0.7233	10986.0	0.007612			
0.440	Paradise	50	35.85	506.67	0.004488	150	0.028432	2.23	0.00584	0.007285	0.7233	10986.0	0.005870			
0.530	Paradise	50	52.00	1080.89	0.003361	150	0.028432	2.79	0.00466	0.005823	0.7233	10986.0	0.004616			
0.620	Paradise	50	64.00	986.35	0.004206	150	0.028432	1.99	0.00654	0.008164	0.7233	10986.0	0.006303			
0.720	Paradise	50	40.00	671.73	0.003944	150	0.028432	2.42	0.00538	0.006713	0.7233	10986.0	0.005345			
0.800	Paradise	50	38.57	783.24	0.003420	150	0.028432	2.8	0.00465	0.005802	0.7233	10986.0	0.004623			
0.890	Paradise	50	40.46	1219	0.002544	150	0.028432	3.26	0.00399	0.004984	0.7233	10986.0	0.003840			
0.950	Paradise	50	85.70	1218.52	0.004468	150	0.028432	2.61	0.00499	0.006225	0.7233	10986.0	0.005226			
1.040	Paradise	50	43.61	744.8	0.003894	150	0.028432	2.41	0.00540	0.006741	0.7233	10986.0	0.005345			
1.120	Paradise	50	78.85	1219	0.004196	150	0.028432	1.95	0.00667	0.008332	0.7233	10986.0	0.006401			
1.210	Paradise	50	37.46	916.75	0.002973	150	0.028432	3.15	0.00413	0.005158	0.7233	10986.0	0.004088			
1.270	Paradise	50	80.78	1219	0.004273	150	0.028432	2.27	0.00573	0.007157	0.7233	10986.0	0.005721			
1.370	Paradise	50	55.15	985.25	0.003765	150	0.028432	2.29	0.00568	0.007095	0.7233	10986.0	0.005514			
1.460	Paradise	50	65.56	1188.76	0.003723	150	0.028432	2.43	0.00536	0.006686	0.7233	10986.0	0.005255			
1.540	Paradise	50	34.12	302.61	0.006366	150	0.028432	1.6	0.00813	0.010154	0.7233	10986.0	0.008218			
1.650	Paradise	50	49.00	877.7	0.003758	150	0.028432	2.51	0.00518	0.006473	0.7233	10986.0	0.005138			
1.750	Paradise	50	53.24	825.32	0.004188	150	0.028432	2.09	0.00623	0.007773	0.7233	10986.0	0.006063			
1.830	Paradise	50	55.32	936.49	0.003920	150	0.028432	2.38	0.00547	0.006826	0.7233	10986.0	0.005405			
1.920	Paradise	50	74.51	1071.44	0.004431	150	0.028432	1.98	0.00657	0.008205	0.7233	10986.0	0.006403			
2.000	Paradise	50	38.83	981.46	0.002902	150	0.028432	2.93	0.00444	0.005545	0.7233	10986.0	0.004296			

[1] Mean Particle Diameter (mm) From Simons and Senturk p. 172

[2] All hydraulic parameters from HEC-RAS Apache1.prj
Hydraulic Parameters are From Main Channel Between Overbanks.

[3] Schoklitsch Equation for Zero Bedload Transport From USBR 'Computing Degradation and Local Scour' p.18 and Fuller Report
$S_L = K * ((D_M * B / Q)^{.75})$
K = 0.00174
D_M = Mean Particle Diameter (mm) From Simons and Senturk p. 172
B = Channel Width (ft) = HEC-RAS Top of Channel Width
Q = Flow Over Main Channel

[4] Meyer-Peter, Muller Equation From USBR 'Computing Degradation and Local Scour' p.18 and Fuller Report
$S_L = K * (Q/Q_B) * ((n/(D_{90}^{1/6}))^{1.5}) * D_M / d$
K = 0.19
Q/Q_B = Total Flow Divided by Flow Over Bed of Channel = 1 in Wide Channels
D_{90} = Particle Size (mm) For Which 90% of Material by Weight is Finer From JEF Report
d = Mean Depth (ft) = HEC-RAS Hydraulic Depth Over Entire Cross Section

[5] Shield's Diagram Equation From USBR 'Computing Degradation and Local Scour' p.18-19 and Fuller Report
$T_* = T_c / (gamma_s - gamma_w) * D_M$
T_* = Dimensionless Shear Stress = 0.06 for particles > 1.0mm and R > 500
$T_c = gamma_w * d * S_L$
$gamma_s$ = Specific Weight of Particle = 165 lb/ft^3
$gamma_w$ = Specific Weight of Water = 62.4 lb/ft^3
Fuller used T = 0.055, M-P, Muller recommends T = 0.047. T = 0.06 is generally accepted in completely rough boundary (Simons and Senturk, P. 387)

[6] U_* = Shear Velocity = $(g * R * S_L)^{1/2}$ or $(T_c/(gamma_w/g))^{0.5}$ from USBR & Simons and Senturk, P. 78 & 384
R = Hydraulic Radius = Mean Hydraulic Depth, d in wide channels

[7] $R_* = U_* * D_{50} / v$ to Determine if R_* >500
D_M in feet
v = Kinematic Viscosity = 0.0000108 ft^2/sec
When R_* > 500 T = 0.06 on Shields Diagram

[8] (Min RAS Elev @ Beginning Sta. - Min RAS Elev @ Ending Sta.)/((Beginning Sta. No. - Ending Sta. No.) * 5280)
Altered if slope did not fit existing profile.

[9] Height of Drop / (Invert Slope - Equilibrium Slope)
Height of Drop Between Structures = 5'

HEC-RAS Plan: Fu-100 River: Paradise Wash Reach: Reach 1

Reach	River Sta	Profile	Min Ch El	W.S. Elev	Q Total	Vel Chnl	Max Chl Dpth	Hydr Depth C	E.G. Slope	Sta W.S. Lft	Top W Chnl	Sta W.S. Rgt	Vel Total	Top Width
			(ft)	(ft)	(cfs)	(ft/s)	(ft)	(ft)	(ft/ft)	(ft)	(ft)	(ft)	(ft/s)	(ft)
Reach 1	0.04	100yr encr	1726.00	1737.1	5992.00	5.03	11.07	9.71	0.000508	9705.00	62.07	10250.00	2.36	545.00
Reach 1	0.13	100yr encr	1732.00	1737.8	5992.00	11.51	5.82	5.26	0.005941	9960.50	69.13	10220.00	7.15	259.50
Reach 1	0.17	100yr encr	1732.00	1739.3	5992.00	12.88	7.30	6.78	0.005326	9963.20	48.20	10150.00	7.91	186.80
Reach 1	0.28	100yr encr	1738.00	1744.0	5992.00	12.13	5.96	4.31	0.008673	9814.00	64.00	10085.00	7.32	271.00
Reach 1	0.34	100yr encr	1744.00	1747.5	5992.00	12.01	3.48	3.48	0.011120	9905.00	45.08	10320.31	6.05	415.31
Reach 1	0.44	100yr encr	1746.00	1751.6	5992.00	11.95	5.58	4.35	0.008324	9900.00	35.85	10166.00	6.53	266.00
Reach 1	0.53	100yr encr	1750.00	1755.7	5992.00	12.67	5.72	5.40	0.006994	9880.00	52.00	10108.00	7.45	228.00
Reach 1	0.62	100yr encr	1754.00	1760.1	5992.00	11.53	6.08	5.63	0.005443	9900.00	64.00	10170.00	6.89	270.00
Reach 1	0.72	100yr encr	1758.00	1763.2	5992.00	13.19	5.24	4.84	0.008802	9800.00	40.00	10062.00	7.02	262.00
Reach 1	0.80	100yr encr	1762.00	1767.2	5992.00	13.17	5.19	4.75	0.009000	9870.00	38.57	10150.00	6.82	280.00
Reach 1	0.89	100yr encr	1764.00	1772.1	5992.00	13.46	8.07	7.39	0.005533	9930.00	40.68	10100.00	8.10	170.00
Reach 1	0.95	100yr encr	1766.00	1774.2	5992.00	8.61	8.21	6.58	0.002488	9870.00	85.70	10120.00	5.98	250.00
Reach 1	1.04	100yr encr	1770.00	1775.9	5992.00	9.33	5.86	5.36	0.003835	9750.00	43.61	10052.78	5.05	302.78
Reach 1	1.12	100yr encr	1772.00	1779.4	5992.00	11.43	7.41	5.38	0.005722	9640.00	79.85	10031.00	7.59	277.23
Reach 1	1.21	100yr encr	1776.00	1782.5	5992.00	12.04	6.50	6.17	0.005341	9750.00	37.46	10131.00	5.60	381.00
Reach 1	1.27	100yr encr	1778.00	1784.8	5992.00	11.47	6.76	5.29	0.005869	9960.00	88.61	10150.00	9.03	190.00
Reach 1	1.37	100yr encr	1782.00	1788.3	5992.00	11.53	6.28	5.14	0.006172	9866.00	61.59	10069.00	7.55	203.00
Reach 1	1.46	100yr encr	1786.00	1791.7	5992.00	11.53	5.67	5.35	0.005828	9891.02	65.56	10179.00	6.81	287.98
Reach 1	1.54	100yr encr	1790.00	1794.4	5992.00	8.29	4.40	3.94	0.004591	9972.00	34.12	10228.00	7.31	256.00
Reach 1	1.65	100yr encr	1796.00	1801.1	5401.00	11.47	5.12	4.64	0.006984	9915.00	49.00	10273.06	5.78	358.06
Reach 1	1.75	100yr encr	1800.00	1805.8	5401.00	11.07	5.78	4.16	0.007580	9940.00	58.43	10306.00	5.86	366.00
Reach 1	1.83	100yr encr	1806.00	1811.8	5401.00	12.01	5.84	5.09	0.006764	9968.00	55.32	10190.00	7.25	222.00
Reach 1	1.92	100yr encr	1810.00	1815.5	5401.00	11.35	5.47	4.53	0.007104	9928.00	90.00	10100.00	9.02	172.00
Reach 1	2.00	100yr encr	1814.00	1820.8	5401.00	12.78	6.76	6.21	0.005923	9965.67	38.83	10180.00	6.94	214.33
Reach 1	2.07	100yr encr	1821.00	1824.3	5401.00	10.76	3.32	3.04	0.010734	9956.80	90.96	10270.00	6.92	313.20
Reach 1	2.14	100yr encr	1824.00	1828.0	5401.00	11.68	4.02	4.02	0.008689	9965.20	46.80	10219.00	6.70	253.80
Reach 1	2.23	100yr encr	1826.00	1833.1	5401.00	12.37	7.14	6.45	0.005244	9937.00	43.64	10150.00	7.00	213.00

HEC-RAS Plan: Fu-10 River: Paradise Wash Reach: Reach 1

Reach	River Sta	Profile	Q Total	W.S. Elev	Hydr Depth C	E.G. Slope	Mann Wtd Chnl	Vel Chnl	Top W Chnl	Q Channel	Froude # Chl	Shear Chan
			(cfs)	(ft)	(ft)	(ft/ft)		(ft/s)	(ft)	(cfs)		(lb/sq ft)
Reach 1	0.04	10 encr	1219.00	1732.0	4.64	0.000876	0.030	4.04	62.07	1165.77	0.33	0.25
Reach 1	0.13	10 encr	1219.00	1734.8	2.20	0.008827	0.030	7.85	69.13	1193.17	0.93	1.21
Reach 1	0.17	10 encr	1219.00	1736.2	3.70	0.002711	0.030	6.13	48.20	1092.78	0.56	0.62
Reach 1	0.28	10 encr	1219.00	1741.7	2.22	0.007802	0.030	7.38	59.62	977.02	0.87	1.07
Reach 1	0.34	10 encr	1219.00	1745.6	1.63	0.012656	0.030	7.73	45.08	569.01	1.07	1.29
Reach 1	0.44	10 encr	1219.00	1749.5	2.23	0.005734	0.030	6.35	35.85	506.67	0.75	0.79
Reach 1	0.53	10 encr	1219.00	1753.1	2.79	0.005849	0.030	7.46	52.00	1080.89	0.79	1.01
Reach 1	0.62	10 encr	1219.00	1756.4	1.99	0.009792	0.030	7.74	64.00	986.35	0.97	1.21
Reach 1	0.72	10 encr	1219.00	1760.8	2.42	0.006113	0.030	6.93	40.00	671.73	0.78	0.91
Reach 1	0.80	10 encr	1219.00	1765.2	2.80	0.005504	0.030	7.24	38.57	783.24	0.76	0.95
Reach 1	0.89	10 encr	1219.00	1767.9	3.26	0.007744	0.030	9.24	40.46	1219.00	0.90	1.49
Reach 1	0.95	10 encr	1219.00	1770.2	2.61	0.003438	0.030	5.46	85.70	1218.52	0.60	0.55
Reach 1	1.04	10 encr	1219.00	1772.9	2.41	0.006462	0.030	7.10	43.61	744.80	0.81	0.96
Reach 1	1.12	10 encr	1219.00	1776.0	1.95	0.010631	0.030	7.92	78.85	1219.00	1.00	1.28
Reach 1	1.21	10 encr	1219.00	1779.5	3.15	0.005431	0.030	7.76	37.46	916.75	0.77	1.05
Reach 1	1.27	10 encr	1219.00	1781.5	2.27	0.006068	0.030	6.64	80.78	1219.00	0.78	0.86
Reach 1	1.37	10 encr	1219.00	1785.2	2.29	0.008303	0.030	7.80	55.15	985.25	0.91	1.18
Reach 1	1.46	10 encr	1219.00	1788.7	2.43	0.006998	0.030	7.46	65.56	1188.76	0.84	1.06
Reach 1	1.54	10 encr	1219.00	1792.1	1.60	0.006853	0.030	5.55	34.12	302.61	0.77	0.67
Reach 1	1.65	10 encr	1075.00	1799.0	2.51	0.006178	0.030	7.15	49.00	877.70	0.80	0.96
Reach 1	1.75	10 encr	1075.00	1803.5	2.09	0.008563	0.030	7.43	53.24	825.32	0.91	1.10
Reach 1	1.83	10 encr	1075.00	1809.1	2.38	0.006542	0.030	7.11	55.32	936.49	0.81	0.97
Reach 1	1.92	10 encr	1075.00	1812.5	1.98	0.008729	0.030	7.26	74.51	1071.44	0.91	1.07
Reach 1	2.00	10 encr	1075.00	1817.5	2.93	0.007378	0.030	8.64	38.83	981.46	0.89	1.33
Reach 1	2.07	10 encr	1075.00	1822.5	1.23	0.008406	0.030	5.21	90.96	582.63	0.83	0.64
Reach 1	2.14	10 encr	1075.00	1825.8	1.82	0.010426	0.030	7.54	46.80	641.83	0.98	1.18
Reach 1	2.23	10 encr	1075.00	1829.4	2.75	0.008097	0.030	8.71	43.64	1046.13	0.93	1.38

Stationing ID (River miles)	Maximum WSE (ft) *2	Left Bank Superelevation Freeboard (ft)	Right Bank Superelevation Freeboard (ft)	Left Top of Bank Elevation (ft) *1	Right Top of Bank Elevation (ft) *1	HEC-RAS Minimum Elevation (ft) *2	HEC-6 General Scour Depth (ft)	Antidune Trough Depth (ft)	Left Bank Bend Scour Depth, Z_{bs} (ft)	Right Bank Bend Scour Depth, Z_{bs} (ft)	Left Bank HEC-6 Design Scour Depth (ft) *3	Right Bank HEC-6 Design Scour Depth (ft) *3	Depth to Armoring, y_d (ft)	Left Bank Total Degredeation (ft) *4	Right Bank Total Degredeation (ft) *4	Left Bank Toe Down Elevation (ft) *5	Right Bank Toe Down Elevation (ft) *5	HEC-RAS Min Elevation - 10' (ft)	Average Total Degredation (ft)	TOB - HEC-RAS Min Elevation	Ave TOB - HEC-RAS Min Elevation	
0.386	1745.5	0	0	1748.5	1748.5	1738.0	0.6	1.3	0	0	2.5	2.5	2.2	4.7	4.7	1733.3	1733.3	1728.0		10.5		
0.400	1746.0	0	0	1749.0	1749.0	1738.0	0.2	1.5	0	0	2.2	2.2	2.9	5.0	5.0	1733.0	1733.0	1728.0		11.0		
0.480	1747.6	0	0	1750.6	1750.6	1740.0	0.0	1.1	0	0	1.4	1.4	1.0	3.0	3.0	1737.0	1737.0	1730.0		10.6		
0.560	1748.5	0	0	1751.5	1751.5	1740.0	0.0	1.4	0	0	1.8	1.8	5.1	6.9	6.9	1733.1	1733.1	1730.0		11.5		
0.640	1749.7	0	0	1752.7	1752.7	1742.0	0.0	2.1	0	0	2.8	2.8	5.1	7.9	7.9	1734.1	1734.1	1732.0	3.0	10.7		Min
0.720	1751.7	0	0	1754.7	1754.7	1744.0	0.1	2.2	0	0	3.0	3.0	4.5	7.5	7.5	1736.5	1736.5	1734.0	7.9	10.7		Max
0.810	1754.0	0	0	1757.0	1757.0	1746.0	0.1	1.3	0	0	1.8	1.8	5.8	7.5	7.5	1738.5	1738.5	1736.0	6.1	11.0	10.9	Average

*1 Top of Levee = HEC-RAS WSE + Superel. + 3'.

*2 All hydraulic parameters from HEC-RAS Apache1.prj
Existing (Worst case) hydraulics.

*3 Left or Right Bank Design Scour Depth = (HEC-6 General Scour + Anti-dune Trough Depth + Right or Left Bend Scour Depth) * 1.3

*4 Total Degredation = Design Scour Depth + Armoring Depth. Minimum 3'

*5 Toe Down Elevation = Minimum HEC-RAS Elevation - Total Degredation

Stationing ID (River Miles)	Fuller Reach Code	Design Discharge, Q (cfs) *1	Average Channel Velocity, V_m (fps)	Maximum Depth Main Channel, Y_{max}, (ft)	Main Channel Hydraulic Depth, Y_h (ft)	Energy Slope, S_e (ft/ft)	HEC-6 General Scour Depth, HEC-6 Z_{gs} (ft) *4	Anti-dune Trough Depth, Z_a (ft) *5	Left Bank Angle of Channel Bend in degrees	Right Bank Angle of Channel Bend in degrees	Left Bank Bend Scour Depth, Z_{bs} (ft) *6	Right Bank Bend Scour Depth, Z_{bs} (ft) *6	Full Flow Velocity *2	Full Flow Channel Top Width, T (ft) *2	Left Bank Radius of Curve, r_c *9	Right Bank Radius of Curve, r_c *9	Left Bank Superelevation, del h (ft) *10	Right Bank Superelevation, del h (ft) *10	Left Bank HEC-6 Design Scour Depth, Z_t (ft) *8	Right Bank HEC-6 Design Scour Depth, Z_t (ft) *8	Left Bank Reach Average HEC-6 Design Scour Depth	Right Bank Reach Average HEC-6 Design Scour Depth
0.386	1	10761	9.9	7.5	7.2	0.00298	0.63	1.3	0	0	0	0	3.5	1016.7	0	0	0	0	2.5	2.5	2.2	2.2
0.4	1	10761	10.5	8.0	6.3	0.00393	0.17	1.5	0	0	0	0	5.1	540.0	0	0	0	0	2.2	2.2		
0.48	1	10761	8.9	7.6	7.2	0.00240	0	1.1	0	0	0	0	4.1	556.0	0	0	0	0	1.4	1.4		
0.56	1	10761	10.2	8.5	7.4	0.00314	0	1.4	0	0	0	0	4.4	571.0	0	0	0	0	1.8	1.8		
0.64	1	10761	12.5	7.7	6.4	0.00564	0.04	2.1	0	0	0	0	5.8	480.0	0	0	0	0	2.8	2.8		
0.72	1	10761	12.7	7.7	6.7	0.00576	0.06	2.2	0	0	0	0	6.2	385.0	0	0	0	0	3.0	3.0		
0.81	1	10761	9.6	8.0	7.0	0.00320	0.1	1.3	0	0	0	0	4.4	600.0	0	0	0	0	1.8	1.8		

*1 All hydraulic parameters from HEC-RAS Apache1.prj

*3 When the general scour depth is negative (aggradation), the general scour component = 0

*4 Extracted from Stantec HEC-6 analysis graphs. Interpolated from peak to peak Straight Line.
Worst Case between Future and Existing Conditions.

*5 Anti-dune scour depth from SLA, 1982 (COT 6.09 and Fuller Report) $Z_a = 0.0137 * V_m^2$
If Za > 0.5 * Yh, then Za = 0.5 * Yh

*6 Bend Scour Depth From Zeller, 1981 (COT Drainage Design and FP Mgmt 6.11 and Fuller Report)
$Z_{gs} = ((0.0685 * Y_{max} * V_m^{0.8})/(Y_h^{0.4} * S_e^{0.3})) * ((2.1 * (((\sin^2(alpha/2)) / (\cos alpha))^{0.2})) -1)$
alpha = degree of bend
Erosion Will Occur on Outside Bank. Right and Left Bank Looking Upstream (Opposite of HEC-RAS)

*8 $Z_t = 1.3 * (\text{HEC-6 } Z_{gs} + Z_a + Z_{bs} + Z_{ls} + Z_{lft})$ Used to calculate toe down elevation
1.3 = Factor of Safety
Z_{ls} = Local Scour = 0
Z_{lft} = Low Flow Thalweg Scour = 0

*9 Radius of Curve from Zeller 1981 (COT Drainage Design and FP Mgmt 6.11)
$r_c / T = \cos alpha / (4 * \sin^2(alpha/2))$
r_c = Radius of Curve
T = Full Floodway Width (As opposed to main channel widhth)

*10 Chow's Simplified Method of Determining Superelevation (p.448)
Also the preferred method in Maricopa Drainage and Design Manual (p. 6-20)
$h = (V^2 * T) / (g * r_c)$
V = Full Floodway Velocity (As opposed to Main Channel Velocity)

SKIN FRICTION CALCULATIONS

Cave Creek/Apache Wash
Watercourse Master Plan

2350-0001-003

	Size (mm)	Size (ft)	Size (in.)
D_{90} =	85	0.279	3.35
D_{50} =	16	0.052	0.63
D_{75} =	44	0.144	1.73

Method	Equation		
	$n_s=(D_{90}^{1/6}) / 44.4$ (D_{90} in inches)	n_s =	0.028
Anderson	$n_s=0.0395 * (D_{50}^{1/6})$ (D_{50} in feet)	n_s =	0.024
Lane	$n_s=(D_{75}^{1/6}) / 39$ (D_{75} in inches)	n_s =	0.028
			0.027

Station ID (River Miles)	Reach Code	Mean Particle Size, (mm) [1]	Channel Width (ft) [2]	Dominant Discharge, Q (cfs) [2]	Schoklitsch, S_L (ft/ft) [3]	90% Finer Particle Size, D_{90} (mm) [1]	*n* Value for Cross Section [2]	Average Depth of Flow, d (ft) [2]	M-P,M S_L (ft/ft) [4]	Shields S_L (ft/ft) [5]	Shear Velocity, U* (fps) [6]	Boundary Reynolds No. [7]	Average S_L (ft/ft)	Average S_L by Fuller Reach Code	Average Invert Slope by ASL Reach Code [8]	Distance Between Grade Control Structures (ft) [9]
0.386	Desert Hills	33	32.0	902.4	0.001958	85	0.026605	4.2	0.00213	0.002547	0.5876	5890.5	0.002211	0.00231	0.003573	3969
0.400	Desert Hills	33	55.3	1333.7	0.002200	85	0.026605	3.4	0.00260	0.003117	0.5876	5890.5	0.002641			
0.480	Desert Hills	33	33.0	788.6	0.002218	85	0.026605	4.2	0.00211	0.002529	0.5876	5890.5	0.002287			
0.560	Desert Hills	33	32.6	1121.3	0.001686	85	0.026605	4.5	0.00201	0.002410	0.5876	5890.5	0.002036			
0.640	Desert Hills	33	40.3	1212.5	0.001865	85	0.026605	3.8	0.00235	0.002807	0.5876	5890.5	0.002339			
0.720	Desert Hills	33	29.8	870.7	0.001906	85	0.026605	3.9	0.00232	0.002771	0.5876	5890.5	0.002331			
0.810	Desert Hills	33	34.5	1038.7	0.001862	85	0.026605	3.8	0.00236	0.002829	0.5876	5890.5	0.002352			

*1 Mean Particle Diameter (mm) From Simons and Senturk p. 172

*2 All hydraulic parameters from HEC-RAS Apache1.prj
Hydraulic Parameters are From Main Channel Between Overbanks.

*3 Schoklitsch Equation for Zero Bedload Transport From USBR 'Computing Degradation and Local Scour' p.18 and Fuller Report

$S_L = K * ((D_M * B / Q)^{.75})$

K = 0.00174

D_M = Mean Particle Diameter (mm) From Simons and Senturk p. 172

B = Channel Width (ft) = HEC-RAS Top of Channel Width

Q = Flow Over Main Channel

*4 Meyer-Peter, Muller Equation From USBR 'Computing Degradation and Local Scour' p.18 and Fuller Report

$S_L = K * (Q/Q_B) * ((n/(D_{90}^{1/6}))^{1.5}) * D_M / d$

K = 0.19

Q/Q_B = Total Flow Divided by Flow Over Bed of Channel = 1 in Wide Channels

D_{90} = Particle Size (mm) For Which 90% of Material by Weight is Finer From JEF Report

d = Mean Depth (ft) = HEC-RAS Hydraulic Depth Over Entire Cross Section

*5 Shield's Diagram Equation From USBR 'Computing Degradation and Local Scour' p.18-19 and Fuller Report

$T_* = T_c / (gamma_s - gamma_w) * D_M$

T_* = Dimensionless Shear Stress = 0.06 for particles > 1.0mm and R > 500

$T_c = gamma_w * d * S_L$

$gamma_s$ = Specific Weight of Particle = 165 lb/ft^3

$gamma_w$ = Specific Weight of Water = 62.4 lb/ft^3

Fuller used T = 0.055, M-P, Muller recommends T = 0.047. T = 0.06 is generally accepted in completely rough boundary (Simons and Senturk, P. 387)

*6 U_* = Shear Velocity = $(g * R * S_L)^{1/2}$ or $(T_c/(gamma_w/g))^{0.5}$ from USBR & Simons and Senturk, P. 78 & 384

R = Hydraulic Radius = Mean Hydraulic Depth, d in wide channels

*7 $R^* = U_* * D_{50} / v$ to Determine if $R^* > 500$

D_M in feet

v = Kinematic Viscosity = 0.0000108 ft^2/sec

When $R_* > 500$ T = 0.06 on Shields Diagram

*8 (Min RAS Elev @ Beginning Sta. - Min RAS Elev @ Ending Sta.)/((Beginning Sta. No. - Ending Sta. No.) * 5280)

Altered if slope did not fit existing profile.

*9 Height of Drop / (Invert Slope - Equilibrium Slope)

Height of Drop Between Structures = 5'

HEC-RAS Plan: Fu-100 River: Desert Hills Was Reach: Reach 1

Reach	River Sta	Profile	Min Ch El	W.S. Elev	Q Total	Vel Chnl	Max Chl Dpth	Hydr Depth C	E.G. Slope	Sta W.S. Lft	Top W Chnl	Sta W.S. Rgt	Vel Total	Top Width
			(ft)	(ft)	(cfs)	(ft/s)	(ft)	(ft)	(ft/ft)	(ft)	(ft)	(ft)	(ft/s)	(ft)
Reach 1	0.386	100yr encr	1738.00	1745.5	10761.00	9.85	7.45	7.20	0.002983	9443.04	32.00	10459.78	3.50	1016.74
Reach 1	0.40	100yr encr	1738.00	1746.0	10761.00	10.47	8.04	6.28	0.003931	9580.00	55.26	10120.00	5.06	540.00
Reach 1	0.48	100yr encr	1740.00	1747.6	10761.00	8.94	7.55	7.21	0.002403	9758.00	33.04	10314.00	4.10	556.00
Reach 1	0.56	100yr encr	1740.00	1748.5	10761.00	10.17	8.51	7.40	0.003140	9513.00	32.58	10084.00	4.44	571.00
Reach 1	0.64	100yr encr	1742.00	1749.7	10761.00	12.50	7.68	6.35	0.005637	9750.00	40.30	10230.00	5.81	480.00
Reach 1	0.72	100yr encr	1744.00	1751.7	10761.00	12.72	7.66	6.67	0.005756	9950.00	29.79	10335.00	6.22	385.00
Reach 1	0.81	100yr encr	1746.00	1754.0	10761.00	9.57	8.00	6.97	0.003204	9750.00	34.45	10350.00	4.39	600.00
Reach 1	0.90	100yr encr	1748.00	1755.8	10761.00	14.40	7.77	7.37	0.006229	9750.00	21.14	10200.00	5.98	450.00
Reach 1	0.99	100yr encr	1748.00	1758.2	10761.00	10.14	10.22	8.76	0.002970	9750.00	24.54	10175.00	4.83	425.00

HEC-RAS Plan: Fu-10 River: Desert Hills Was Reach: Reach 1

Reach	River Sta	Profile	Q Total	W.S. Elev	Hydr Depth C	E.G. Slope	Mann Wtd Chnl	Vel Chnl	Top W Chnl	Q Channel	Froude # Chl	Shear Chan
			(cfs)	(ft)	(ft)	(ft/ft)		(ft/s)	(ft)	(cfs)		(lb/sq ft)
Reach 1	0.04	10 encr	2140.00	1735.8	4.79	0.004501	0.030	9.27	46.00	2042.36	0.75	1.31
Reach 1	0.09	10 encr	2140.00	1737.5	4.55	0.001147	0.030	4.56	68.00	1410.65	0.38	0.32
Reach 1	0.19	10 encr	2140.00	1738.6	3.92	0.003841	0.030	7.55	50.00	1481.72	0.67	0.93
Reach 1	0.22	10 encr	2140.00	1739.1	3.79	0.004534	0.030	8.03	59.00	1796.90	0.73	1.06
Reach 1	0.31	10 encr	2140.00	1740.7	3.92	0.004113	0.030	7.71	48.00	1451.47	0.69	0.97
Reach 1	0.386	10 encr	2140.00	1742.5	4.21	0.002811	0.030	6.69	32.00	902.40	0.57	0.71
Reach 1	0.40	10 encr	2140.00	1743.2	3.44	0.003950	0.030	7.02	55.26	1333.69	0.67	0.84
Reach 1	0.48	10 encr	2140.00	1744.6	4.24	0.001936	0.030	5.63	33.04	788.64	0.48	0.50
Reach 1	0.56	10 encr	2140.00	1745.6	4.45	0.003581	0.030	7.74	32.58	1121.26	0.65	0.94
Reach 1	0.64	10 encr	2140.00	1747.2	3.82	0.004389	0.030	7.87	40.30	1212.47	0.71	1.02
Reach 1	0.72	10 encr	2140.00	1748.9	3.87	0.004183	0.030	7.55	29.79	870.74	0.68	0.94
Reach 1	0.81	10 encr	2140.00	1750.8	3.79	0.004993	0.030	7.96	34.45	1038.69	0.72	1.07
Reach 1	0.90	10 encr	2140.00	1753.1	4.70	0.004554	0.030	9.12	21.14	905.56	0.74	1.28
Reach 1	0.99	10 encr	2140.00	1754.9	5.44	0.002301	0.030	6.50	24.54	868.37	0.49	0.65

Stationing ID (River miles)	Maximum WSE (ft) [2]	Left Bank Superelevation Freeboard (ft)	Right Bank Superelevation Freeboard (ft)	Left Top of Bank Elevation (ft) [1]	Right Top of Bank Elevation (ft) [1]	HEC-RAS Minimum Elevation (ft) [2]	HEC-6 General Scour Depth (ft)	Antidune Trough Depth (ft)	Left Bank Bend Scour Depth, Z_{bs} (ft)	Right Bank Bend Scour Depth, Z_{bs} (ft)	Left Bank HEC-6 Design Scour Depth (ft) [3]	Right Bank HEC-6 Design Scour Depth (ft) [3]	Depth to Armoring, y_d (ft)	Left Bank Total Degredeation (ft) [4]	Right Bank Total Degredeation (ft) [4]	Extent of Left Toe Down [6]	Left Bank Toe Down Elevation (ft) [5]	Extent of Right Toe Down [6]	Right Bank Toe Down Elevation (ft) [5]	HEC-RAS Min Elevation - 10' (ft)	Left Top of Bank - Toe Down (ft)	Right Top of Bank - Toe Down (ft)	Left Reach Average Total Degredation (ft)	Right Reach Average Total Degredation (ft)	Left TOB RAS Min Elevation	Right TOB RAS Min Elevation	Left Reach Average TOB Above RAS Min (ft)	Right Reach Average TOB Above RAS Min (ft)	
24.919	1648.1	0	0	1651.1	1651.1	1634.9	0.7	1.0	0	0	2.2	2.2	2.3	4.5	4.5	No Armor	1630.4	No Armor	1630.4	1624.9	20.7	20.7			16.2	16.2			
25.010	1650.1	0	0	1653.1	1653.1	1640.2	0.8	1.1	0	0	2.5	2.5	0.8	3.3	3.3	No Armor	1636.9	No Armor	1636.9	1630.2	16.2	16.2			12.9	12.9			
25.099	1654.8	0	0	1657.8	1657.8	1646.0	8.0	3.0	0	0	14.3	14.3	3.3	17.7	17.7	No Armor	1628.3	No Armor	1628.3	1636.0	29.5	29.5			11.8	11.8			
25.180	1659.8	0	0	1662.8	1662.8	1647.7	0.7	1.1	0	0	2.3	2.3	1.1	3.4	3.4	No Armor	1644.3	No Armor	1644.3	1637.7	18.5	18.5			15.1	15.1			
25.233	1661.0	0	0	1664.0	1664.0	1647.3	0.7	1.8	0	0	3.2	3.2	5.8	9.0	9.0	No Armor	1638.3	No Armor	1638.3	1637.3	25.7	25.7	3.3	3.3	16.7	16.7			Min
25.326	1664.9	0	0	1667.9	1667.9	1653.0	0.6	2.1	0	0	3.5	3.5	1.9	5.4	5.4	No Armor	1647.6	No Armor	1647.6	1643.0	20.3	20.3	17.7	17.7	14.9	14.9			Max
25.338	1668.5	0	0	1671.5	1671.5	1656.6	0.6	2.3	0	0	3.8	3.8	2.4	6.3	6.3	No Armor	1650.3	No Armor	1650.3	1646.6	21.2	21.2	7.1	7.1	14.9	14.9	14.6	14.6	Average
25.458	1672.4	0	0	1675.4	1675.4	1665.5	0.5	0.9	0	0	1.8	1.8	0.8	3.0	3.0	No Armor	1662.5	No Armor	1662.5	1655.5	12.9	12.9			9.9	9.9			
25.519	1674.6	0	0	1677.6	1677.6	1668.3	0.6	1.1	0	0	2.3	2.3	1.8	4.0	4.0	No Armor	1664.3	No Armor	1664.3	1658.3	13.3	13.3			9.3	9.3			
25.580	1677.2	0	0	1680.2	1680.2	1668.9	0.6	1.6	0	0	2.8	2.8	1.6	4.4	4.4	No Armor	1664.5	No Armor	1664.5	1658.9	15.7	15.7			11.3	11.3			
25.644	1680.2	0	0	1683.2	1683.2	1669.8	0.7	2.5	0	0	4.2	4.2	4.5	8.7	8.7	No Armor	1661.1	No Armor	1661.1	1659.8	22.1	22.1			13.4	13.4			
25.699	1682.7	0	0	1685.7	1685.7	1669.4	0.6	2.4	0	0	4.0	4.0	2.1	6.1	6.1	No Armor	1663.3	No Armor	1663.3	1659.4	22.4	22.4			16.3	16.3			
25.750	1685.3	0	0	1688.3	1688.3	1671.6	0.3	1.1	0	0	1.9	1.9	3.7	5.5	5.5	No Armor	1666.1	No Armor	1666.1	1661.6	22.2	22.2			16.7	16.7			
25.843	1686.6	0	0	1689.6	1689.6	1673.5	0.5	2.1	0	0	3.3	3.3	2.4	5.8	5.8	No Armor	1667.7	No Armor	1667.7	1663.5	21.9	21.9			16.1	16.1			
25.919	1690.3	0	0	1693.3	1693.3	1678.4	0.6	2.2	0	0	3.6	3.6	5.8	9.3	9.3	No Armor	1669.1	No Armor	1669.1	1668.4	24.2	24.2			14.9	14.9			
26.044	1695.2	0	0	1698.2	1698.2	1684.3	0.8	1.2	0	0	2.6	2.6	2.3	4.9	4.9	No Armor	1679.4	No Armor	1679.4	1674.3	18.8	18.8			13.9	13.9			
26.137	1698.3	0	0	1701.3	1701.3	1685.7	0.9	1.4	0	0	3.0	3.0	2.3	5.3	5.3	No Armor	1680.4	No Armor	1680.4	1675.7	20.9	20.9			15.6	15.6			
26.239	1701.8	0	0	1704.8	1704.8	1692.8	1.1	1.2	0	0	3.0	3.0	4.0	7.1	7.1	No Armor	1685.7	No Armor	1685.7	1682.8	19.1	19.1			12.0	12.0			
26.335	1705.1	0	0	1708.1	1708.1	1695.6	0.9	0.8	0	0	2.3	2.3	0.5	3.0	3.0	No Armor	1692.6	No Armor	1692.6	1685.6	15.5	15.5			12.5	12.5			
26.430	1707.5	0	0	1710.5	1710.5	1697.5	0.8	1.7	0	0	3.2	3.2	1.9	5.1	5.1	No Armor	1692.4	No Armor	1692.4	1687.5	18.1	18.1			13.0	13.0			
26.529	1712.2	0	0	1715.2	1715.2	1702.6	0.7	2.4	0	0	4.0	4.0	2.6	6.7	6.7	No Armor	1695.9	No Armor	1695.9	1692.6	19.3	19.3			12.6	12.6			
26.623	1716.7	0	0	1719.7	1719.7	1703.9	1.3	1.1	0	0	3.1	3.1	1.0	4.1	4.1	No Armor	1699.8	No Armor	1699.8	1693.9	19.9	19.9			15.8	15.8			
26.695	1720.4	0	0	1723.4	1723.4	1709.5	1.7	3.3	0	0	6.5	6.5	4.5	11.0	11.0	No Armor	1698.5	No Armor	1698.5	1699.5	24.9	24.9			13.9	13.9			
26.775	1725.8	0	0	1728.8	1728.8	1712.7	1.4	1.8	0	0	4.2	4.2	2.1	6.3	6.3	No Armor	1706.4	No Armor	1706.4	1702.7	22.4	22.4			16.1	16.1			
26.845	1728.2	0	0	1731.2	1731.2	1717.0	1.2	1.9	0	0	4.1	4.1	2.3	6.4	6.4	No Armor	1710.6	No Armor	1710.6	1707.0	20.6	20.6			14.2	14.2			
26.921	1731.4	0	0	1734.4	1734.4	1720.2	0.8	1.4	0	0	2.9	2.9	1.7	4.5	4.5	No Armor	1715.7	No Armor	1715.7	1710.2	18.7	18.7			14.2	14.2			
27.008	1733.7	0	0	1736.7	1736.7	1723.0	0.6	1.4	0	0	2.6	2.6	1.8	4.4	4.4	No Armor	1718.6	No Armor	1718.6	1713.0	18.1	18.1			13.7	13.7			
27.106	1737.9	0	0	1740.9	1740.9	1725.7	0.5	2.3	0	0	3.6	3.6	3.1	6.6	6.6	No Armor	1719.1	No Armor	1719.1	1715.7	21.8	21.8			15.2	15.2			
27.169	1742.0	0	0	1745.0	1745.0	1732.1	0.4	1.1	0	0	2.0	2.0	1.4	3.4	3.4	No Armor	1728.7	No Armor	1728.7	1722.1	16.3	16.3	3.0	3.0	12.9	12.9			Min
27.226	1743.6	0.6	0	1747.2	1746.6	1734.8	2.5	2.1	0.8	0	7.0	6.0	2.4	9.5	8.4	No Armor	1725.3	No Armor	1726.4	1724.8	21.9	20.2	15.8	14.2	12.4	11.8			Max
27.265	1749.0	0.4	0	1752.4	1752.0	1735.7	3.5	2.3	1.2	0	9.1	7.5	6.6	15.8	14.2	No Armor	1719.9	No Armor	1721.5	1725.7	32.5	30.5	6.3	6.2	16.7	16.3	13.9	13.8	Average
27.320	1753.0	0.2	0	1756.2	1756.0	1740.3	3.5	2.3	1.2	0	9.1	7.5	3.3	12.4	10.9	No Armor	1727.9	No Armor	1729.4	1730.3	28.3	26.6			15.9	15.7			
27.366	1754.9	0.2	0	1758.1	1757.9	1742.3	3.0	0.9	1.1	0	6.4	5.1	0.6	7.0	5.6	No Armor	1735.3	No Armor	1736.7	1732.3	22.8	21.2			15.8	15.6			
27.417	1757.1	0.6	0	1760.7	1760.1	1744.8	2.2	2.8	1.2	0	8.0	6.5	5.8	13.7	12.2	No Armor	1731.1	No Armor	1732.6	1734.8	29.6	27.5			15.9	15.3			
27.502	1765.0	0	0	1768.0	1768.0	1748.8	1.5	2.5	0	0	5.3	5.3	4.5	9.8	9.8	No Armor	1739.0	No Armor	1739.0	1738.8	29.0	29.0			19.2	19.2			
27.604	1767.5	0	0	1770.5	1770.5	1754.2	2.2	2.8	0	0	6.5	6.5	2.1	8.7	8.7	3'	1767.0	No Armor	1745.5	1744.2	3.5	25.0			16.3	16.3			
27.693	1774.6	0	0	1777.6	1777.6	1756.3	3.2	2.8	0	0	7.8	7.8	9.5	17.3	17.3	3'	1772.0	No Armor	1739.0	1746.3	5.6	38.6			21.3	21.3			
27.797	1781.9	0	0	1784.9	1784.9	1760.6	3.9	7.2	0	0	14.4	14.4	9.5	23.9	23.9	3'	1775.0	No Armor	1736.7	1750.6	9.9	48.2			24.3	24.3			
27.913	1791.2	0	0	1794.2	1794.2	1763.1	3.0	0.3	0	0	4.3	4.3	2.1	6.4	6.4	3'	1778.0	No Armor	1756.7	1753.1	16.2	37.5			31.1	31.1			
28.023	1791.3	0	0	1794.3	1794.3	1772.5	2.3	0.6	0	0	3.8	3.8	3.3	7.1	7.1	3'	1781.0	No Armor	1765.4	1762.5	13.3	28.9			21.8	21.8			
28.091	1791.8	0	0	1794.8	1794.8	1780.8	1.7	1.1	0	0	3.6	3.6	4.5	8.1	8.1	3'	1785.0	No Armor	1772.7	1770.8	9.8	22.1			14.0	14.0			
28.157	1793.9	0	0	1796.9	1796.9	1782.6	1.9	1.8	0	0	4.8	4.8	1.9	6.7	6.7	3'	1791.0	No Armor	1775.9	1772.6	5.9	21.0			14.3	14.3			
28.241	1799.2	0	0	1802.2	1802.2	1789.9	2.0	2.0	0	0	5.2	5.2	4.0	9.2	9.2	3'	1994.0	No Armor	1780.7	1779.9	-191.8	21.5			12.3	12.3			
28.326	1803.9	0	0	1806.9	1806.9	1791.3	2.1	2.5	0	0	6.0	6.0	2.4	8.5	8.5	No Armor	1782.8	No Armor	1782.8	1781.3	24.1	24.1			15.6	15.6			
28.390	1806.9	0	0	1809.9	1809.9	1792.8	1.7	2.8	0	0	5.8	5.8	4.5	10.3	10.3	No Armor	1782.5	No Armor	1782.5	1782.8	27.4	27.4			17.1	17.1			
28.462	1810.0	0	0	1813.0	1813.0	1794.8	1.6	3.0	0	0	6.0	6.0	2.4	8.4	8.4	Full Depth	1786.4	No Armor	1786.4	1784.8	26.6	26.6			18.2	18.2			
28.555	1814.3	0	0	1817.3	1817.3	1799.4	1.3	3.4	0	0	6.1	6.1	6.6	12.8	12.8	Full Depth	1786.6	No Armor	1786.6	1789.4	30.7	30.7			17.9	17.9			
28.657	1818.0	0	0	1821.0	1821.0	1800.5	1.3	2.7	0	0	5.2	5.2	2.6	7.8	7.8	Full Depth	1792.7	No Armor	1792.7	1790.5	28.3	28.3			20.5	20.5			
28.750	1821.6	0	0	1824.6	1824.6	1808.3	1.3	2.9	0	0	5.4	5.4	4.0	9.5	9.5	Full Depth	1798.8	No Armor	1798.8	1798.3	25.8	25.8			16.3	16.3			
28.847	1826.5	0	0	1829.5	1829.5	1811.9	1.5	3.1	0	0	6.0	6.0	3.3	9.4	9.4	Full Depth	1802.5	No Armor	1802.5	1801.9	27.0	27.0			17.6	17.6			
28.934	1830.2	0	0	1833.2	1833.2	1815.5	1.7	3.0	0	0	6.1	6.1	5.8	11.8	11.8	Full Depth	1803.7	No Armor	1803.7	1805.5	29.5	29.5			17.7	17.7			
29.012	1833.5	0	0	1836.5	1836.5	1818.7	1.8	3.5	0	0	6.9	6.9	3.3	10.2	10.2	Full Depth	1808.5	No Armor	1808.5	1808.7	28.0	28.0			17.8	17.8			
29.130	1838.3	0	0	1841.3	1841.3	1821.0	1.2	3.6	0	0	6.2	6.2	5.1	11.3	11.3	Full Depth	1809.7	No Armor	1809.7	1811.0	31.6	31.6			20.3	20.3			
29.258	1843.3	0	0	1846.3	1846.3	1828.7	0.5	2.7	0	0	4.2	4.2	2.3	6.5	6.5	Full Depth	1822.2	No Armor	1822.2	1818.7	24.1	24.1			17.6	17.6			
29.351	1848.5	0	0	1851.5	1851.5	1835.9	0.7	0.9	0	0	2.1	2.1	2.8	4.9	4.9	Full Depth	1831.0	No Armor	1831.0	1825.9	20.5	20.5			15.6	15.6			
29.387	1849.5	0	0	1852.5	1852.5	1838.8	0.7	0.8	0	0	1.9	1.9	1.6	3.5	3.5	No Armor	1835.3	No Armor	1835.3	1828.8	17.2	17.2			13.7	13.7			
29.493	1852.8	0	0	1855.8	1855.8	1843.4	1.3	1.1	0	0	3.1	3.1	1.8	4.9	4.9	No Armor	1838.5	Full Depth	1838.5	1833.4	17.3	17.3	3.5	3.5	12.4	12.4			Min
29.538	1855.3	0	0	1858.3	1858.3	1845.5	1.5	1.9	0	0	4.4	4.4	2.4	6.8	6.8	No Armor	1838.7	Full Depth	1838.7	1835.5	19.6	19.6	23.9	23.9	12.8	12.8			Max
29.601	1859.8	0	0	1862.8	1862.8	1849.9	1.8	2.5	0	0	5.6	5.6	2.1	7.7	7.7	No Armor	1842.2	Full Depth	1842.2	1839.9	20.6	20.6	9.5	9.3	12.9	12.9	17.4	17.3	Average
29.710	1864.7	0	0	1867.7	1867.7	1853.9	2.5	2.8	0	0	6.8	6.8	2.1	9.0	9.0	No Armor	1844.9	Full Depth	1844.9	1843.9	22.8	22.8			13.8	13.8			
29.715																													
													Average	7.9	7.8						17.3	23.3							

[1] Top of Bank = HEC-RAS WSE + Superel. + 3'

[2] All hydraulic parameters from HEC-RAS Caveck.prj
Existing (Worst case) hydraulics.

[3] Left or Right Bank Design Scour Depth = (HEC-6 General Scour + Anti-dune Trough Depth + Right or Left Bend Scour Depth) * 1.3

[4] Total Degredation = Design Scour Depth + Armoring Depth. Minimum 3'

[5] Toe Down Elevation = Minimum HEC-RAS Elevation - Total Degredation

[6] Toe Down Extent is Determined According to Location of FP/FW Relative to Long Term Armoring Line
If the Toe is Close to the Floodplain, the Armoring Will Extend Down 3' Below Thalweg

Station ID (River Miles)	Reach Code	Design Discharge, Q (cfs) *1	Average Channel Velocity, V_m (fps)	Maximum Depth Main Channel, Y_{max}, (ft)	Main Channel Hydraulic Depth, Y_h (ft)	Energy Slope, S_e (ft/ft)	HEC-6 General Scour Depth, HEC-6 Z_{gs} (ft) *4	Anti-dune Trough Depth, Z_a (ft) *5	Left Bank Angle of Channel Bend in degrees	Right Bank Angle of Channel Bend in degrees	Left Bank Bend Scour Depth, Z_{bs} (ft) *6	Right Bank Bend Scour Depth, Z_{bs} (ft) *6	Full Flow Velocity *2	Full Flow Channel Top Width, T (ft) *2	Left Bank Radius of Curve, r_c *9	Right Bank Radius of Curve, r_c *9	Left Bank Superelevation, del h (ft) *10	Right Bank Superelevation, del h (ft) *10	Left Bank HEC 6 Design Scour Depth, Z_t (ft) *8	Right Bank HEC-6 Design Scour Depth, Z_t (ft) *8	Average HEC-6 Left Bank Design Scour Depth	Average HEC-6 Right Bank Design Scour Depth
24.919	Braided	41400	8.55	13.24	7.98	0.00419	0.7	1.0	0	0	0	0	5.3	1457.3	0	0	0	0	2.2	2.2	4.6	4.6
25.01	Braided	41400	9.11	9.89	7.8	0.00473	0.8	1.1	0	0	0	0	6.6	1327.2	0	0	0	0	2.5	2.5		
25.099	Braided	41400	14.87	8.8	4.98	0.02305	8	3.0	0	0	0	0	9.2	1285.8	0	0	0	0	14.3	14.3		
25.18	Braided	41400	8.78	12.13	7.7	0.00449	0.7	1.1	0	0	0	0	5.4	1521.7	0	0	0	0	2.3	2.3		
25.233	Braided	41400	11.34	13.71	7.93	0.00773	0.7	1.8	0	0	0	0	6.1	1671.8	0	0	0	0	3.2	3.2		
25.326	Braided	39700	12.41	11.87	7.51	0.00929	0.6	2.1	0	0	0	0	7.1	1333.0	0	0	0	0	3.5	3.5		
25.338	Braided	39700	13.06	11.86	7.05	0.01117	0.6	2.3	0	0	0	0	7.5	1390.8	0	0	0	0	3.8	3.8		
25.46	Mined	39700	8.17	11.87	5.55	0.00597	0.5	0.9	0	0	0	0	5.7	1389.8	0	0	0	0	1.8	1.8	3.6	3.5
25.519	Mined	39700	9.16	13.03	4.6	0.00963	0.6	1.1	0	0	0	0	6.5	1422.8	0	0	0	0	2.3	2.3		
25.58	Mined	39700	10.72	11.31	6.54	0.00829	0.6	1.6	0	0	0	0	6.4	1385.6	0	0	0	0	2.8	2.8		
25.644	Mined	39700	13.51	10.87	8.25	0.00977	0.7	2.5	0	0	0	0	7.1	1509.0	0	0	0	0	4.2	4.2		
25.699	Mined	39700	13.35	13.32	10.96	0.00663	0.6	2.4	0	0	0	0	6.8	1485.5	0	0	0	0	4.0	4.0		
25.75	Mined	39700	9.06	13.68	8.88	0.00404	0.3	1.1	0	0	0	0	5.0	1634.0	0	0	0	0	1.9	1.9		
25.843	Mined	39700	12.28	13.13	7.42	0.00931	0.5	2.1	0	0	0	0	6.8	1653.4	0	0	0	0	3.3	3.3		
25.919	Mined	39700	12.57	11.9	6.76	0.01105	0.6	2.2	0	0	0	0	7.2	1539.0	0	0	0	0	3.6	3.6		
26.044	Mined	39700	9.47	10.87	6.43	0.00692	0.8	1.2	0	0	0	0	5.6	1798.2	0	0	0	0	2.6	2.6		
26.137	Mined	39700	10.23	12.58	6.99	0.007148	0.9	1.4	0	0	0	0	6.2	1823.2	0	0	0	0	3.0	3.0		
26.239	Mined	39700	9.47	8.97	4.51	0.010866	1.1	1.2	0	0	0	0	6.5	1855.7	0	0	0	0	3.0	3.0		
26.335	Mined	39700	7.81	9.52	6.5	0.004443	0.9	0.8	0	0	0	0	6.3	1477.2	0	0	0	0	2.3	2.3		
26.43	Mined	39700	11.06	9.98	6.66	0.008659	0.8	1.7	0	0	0	0	9.8	781.8	0	0	0	0	3.2	3.2		
26.529	Mined	39700	13.25	9.6	6.92	0.011789	0.7	2.4	0	0	0	0	11.4	707.1	0	0	0	0	4.0	4.0		
26.62	Mined	39700	8.79	12.8	9.06	0.003631	1.3	1.1	0	0	0	0	7.8	790.2	0	0	0	0	3.1	3.1		
26.695	Mined	39700	15.5	10.92	7.1	0.016239	1.7	3.3	0	0	0	0	12.2	624.2	0	0	0	0	6.5	6.5		
26.775	Mined	39700	11.56	13.09	9.42	0.006124	1.4	1.8	0	0	0	0	9.0	779.2	0	0	0	0	4.2	4.2		
26.845	Mined	39700	11.91	11.16	8.31	0.007511	1.2	1.9	0	0	0	0	10.1	849.2	0	0	0	0	4.1	4.1		
26.921	Mined	35800	10.09	11.18	8.22	0.005469	0.8	1.4	0	0	0	0	9.4	635.2	0	0	0	0	2.9	2.9		
27.008	Mined	35800	10.14	10.67	7.58	0.006156	0.6	1.4	0	0	0	0	10.0	559.4	0	0	0	0	2.6	2.6		
27.106	Mined	35800	12.82	12.2	5.6	0.014755	0.5	2.3	0	0	0	0	12.3	624.7	0	0	0	0	3.6	3.6		
27.169	Mined	35800	9.1	9.94	7.25	0.005238	0.4	1.1	0	0	0	0	8.3	768.7	0	0	0	0	2.0	2.0		
27.226	Mined	35800	12.37	8.8	6.18	0.011989	2.5	2.1	22	0	0.8	0	11.1	662.9	4220.1	0	0.6	0	7.0	6.0		
27.265	Mined	35800	12.95	13.31	7.05	0.011416	3.5	2.3	22	0	1.2	0	8.9	979.4	6235.3	0	0.4	0	9.1	7.5		
27.32	Cliff	35800	12.95	12.65	10.18	0.006945	3.5	2.3	22	0	1.2	0	7.1	1381.4	8794.8	0	0.2	0	9.1	7.5	5.7	5.6
27.366	Cliff	35800	8.09	12.63	9.39	0.003014	3	0.9	22	0	1.1	0	5.9	1176.4	7489.4	0	0.2	0	6.4	5.1		
27.417	Cliff	35800	14.21	12.3	7.54	0.01236	2.2	2.8	22	0	1.2	0	10.8	705.6	4492.1	0	0.6	0	8.0	6.5		
27.502	Cliff	35800	13.64	16.21	10.54	0.004918	1.5	2.5	0	0	0	0	7.7	1057.5	0	0	0	0	5.3	5.3		
27.604	Cliff	35800	14.39	13.31	9.89	0.00593	2.2	2.8	0	0	0	0	11.9	556.8	0	0	0	0	6.5	6.5		
27.693	Cliff	35800	14.36	18.33	9.18	0.006648	3.2	2.8	0	0	0	0	8.7	986.5	0	0	0	0	7.8	7.8		
27.797	Cliff	35800	22.91	21.35	16.37	0.009695	3.9	7.2	0	0	0	0	22.9	95.5	0	0	0	0	14.4	14.4		
27.913	Cliff	35800	4.74	28.1	16.94	0.000319	3	0.3	0	0	0	0	2.9	1004.9	0	0	0	0	4.3	4.3		
28.023	Cliff	35800	6.7	18.83	12.89	0.001392	2.3	0.6	0	0	0	0	4.6	1030.3	0	0	0	0	3.8	3.8		
28.091	Cliff	35800	8.91	11.05	7	0.005293	1.7	1.1	0	0	0	0	7.2	960.0	0	0	0	0	3.6	3.6		
28.16	Cliff	35800	11.43	11.29	6.22	0.010188	1.9	1.8	0	0	0	0	8.7	1128.3	0	0	0	0	4.8	4.8		
28.241	Cliff	35800	11.99	9.29	6.34	0.010793	2	2.0	0	0	0	0	8.6	1096.4	0	0	0	0	5.2	5.2		
28.326	Cliff	35800	13.57	12.57	9.36	0.005567	2.1	2.5	0	0	0	0	8.0	967.0	0	0	0	0	6.0	6.0		
28.39	Cliff	35800	14.18	14.11	10.07	0.005636	1.7	2.8	0	0	0	0	8.1	887.2	0	0	0	0	5.8	5.8		
28.46	Cliff	35800	14.84	15.17	11.9	0.005017	1.6	3.0	0	0	0	0	9.4	707.1	0	0	0	0	6.0	6.0		
28.555	Cliff	35800	15.79	14.93	11.67	0.005793	1.3	3.4	0	0	0	0	11.0	515.2	0	0	0	0	6.1	6.1		
28.657	Cliff	35800	13.96	17.53	9.72	0.005808	1.3	2.7	0	0	0	0	11.5	512.3	0	0	0	0	5.2	5.2		
28.75	Cliff	35800	14.5	13.32	10.14	0.005751	1.3	2.9	0	0	0	0	11.1	683.8	0	0	0	0	5.4	5.4		
28.847	Cliff	35800	15.15	14.58	12.1	0.005045	1.5	3.1	0	0	0	0	9.9	655.6	0	0	0	0	6.0	6.0		
28.93	Cliff	35800	14.76	14.68	10.43	0.005774	1.7	3.0	0	0	0	0	10.1	647.1	0	0	0	0	6.1	6.1		
29.012	Cliff	35800	15.92	14.8	11.89	0.005805	1.8	3.5	0	0	0	0	10.2	550.2	0	0	0	0	6.9	6.9		
29.13	Cliff	36000	16.17	17.33	12.53	0.005764	1.2	3.6	0	0	0	0	9.8	592.4	0	0	0	0	6.2	6.2		
29.258	Cliff	36000	14.08	14.57	10.02	0.008309	0.5	2.7	0	0	0	0	14.1	255.1	0	0	0	0	4.2	4.2		
29.351	Cliff	36000	8.09	12.6	8.53	0.004351	0.7	0.9	0	0	0	0	7.4	624.0	0	0	0	0	2.1	2.1		
29.387	Cliff	36000	7.44	10.71	7.07	0.00469	0.7	0.8	0	0	0	0	6.9	810.6	0	0	0	0	1.9	1.9		
29.493	Cliff	36000	8.91	9.44	5.43	0.009485	1.3	1.1	0	0	0	0	8.4	896.5	0	0	0	0	3.1	3.1		
29.538	Cliff	36000	11.63	9.84	4.84	0.018834	1.5	1.9	0	0	0	0	11.4	727.5	0	0	0	0	4.4	4.4		
29.601	Cliff	36000	13.55	9.88	7.02	0.01213	1.8	2.5	0	0	0	0	12.5	546.1	0	0	0	0	5.6	5.6		
29.663	Cliff	36000	11.48	12.69	8.3	0.006985	2.1	1.8	0	0	0	0	11.0	531.8	0	0	0	0	5.1	5.1		
29.71	Cliff	36000	14.2	10.75	8.31	0.008791	2.5	2.8	0	0	0	0	14.2	305.1	0	0	0	0	6.8	6.8		

Station ID (River Miles)	Reach Code	Average Depth of Flow, d (ft) *1 *2	Energy Slope, S_e (ft/ft)	*n* Value for Stream Bed *3	90% Finer Particle Size, D_{90} (mm) *4	M-P, Muller Individual Particle Size, D_c (mm) *5	Average Channel Velocity, V_m (fps)	Competent Bottom Velocity Armor Size, Dc (mm) *6	Critical Shear Stress, T_c (lb/ft²) *7	Shield's Diagram D_c (ft) *8	Shields Diagram Dc (mm)	Shear Velocity, U_* (fps) *9	Boundary Reynolds No., R_* *10	Yang's Incipient Motion, D_c (ft) *11	Yang's Incipient Motion, D_c (mm)	Average Individual Particle Size, D_c (mm)	Percentage of Bed Material Larger than D_c del p (Seive-Boulder Count Combo) *12	Thickness to Armoring Layer, y_a (mm) *13	Depth to Armoring, y_d (ft) Seive - Boulder Count Combo *14	Ave Depth to Armoring by Reaches (Seive-Boulder Sediment Combo)
24.919	Braided	6.96	0.0039	0.028	235	119.3	7.5	105.8	1.7	0.27	83.8	0.934	23772	0.371	113.0	105.4	18	152.4	2.28	2.5
25.01	Braided	4.4	0.0030	0.028	235	57.8	4.9	45.9	0.8	0.13	40.5	0.650	8007	0.161	49.0	48.3	28	96.6	0.81	
25.099	Braided	2.9	0.0190	0.028	235	240.5	9.4	164.4	3.4	0.55	168.8	1.327	68043	0.576	175.6	187.3	13	152.4	3.35	
25.18	Braided	4.14	0.0041	0.028	235	74.1	5.53	57.5	1.1	0.17	52.0	0.736	11640	0.202	61.4	61.3	26	122.5	1.14	
25.233	Braided	4.52	0.0161	0.028	235	321.1	11.27	238.8	4.6	0.74	225.5	1.533	104982	0.837	255.1	260.1	8	152.4	5.75	
25.326	Braided	4.87	0.00476	0.028	235	102.0	6.66	83.4	1.4	0.24	71.6	0.864	18803	0.292	89.1	86.5	21	152.4	1.88	
25.338	Braided	4.12	0.01472	0.028	235	266.9	10.47	206.1	3.8	0.61	187.4	1.398	79575	0.722	220.2	220.2	17	152.4	2.44	
25.458	Mined	2.55	0.00579	0.028	235	65.0	4.8	43.3	0.9	0.15	45.6	0.690	9560	0.152	46.3	50.1	28	100.1	0.84	2.6
25.519	Mined	2.21	0.0108	0.028	235	105.1	5.94	66.3	1.5	0.24	73.8	0.877	19644	0.233	70.9	79.0	22	152.4	1.77	
25.58	Mined	3.74	0.00537	0.028	235	88.3	5.94	66.3	1.3	0.20	62.0	0.804	15142	0.233	70.9	71.9	23	143.8	1.58	
25.644	Mined	4.83	0.0127	0.028	235	270.0	10.77	218.1	3.8	0.62	189.5	1.406	80932	0.764	233.0	227.6	10	152.4	4.50	
25.699	Mined	6.92	0.00377	0.028	235	114.8	7.41	103.2	1.6	0.26	80.6	0.917	22451	0.362	110.3	102.2	19	152.4	2.13	
25.75	Mined	5.5	0.00967	0.028	235	233.9	10.15	193.7	3.3	0.54	164.3	1.308	65284	0.679	206.9	199.7	12	152.4	3.67	
25.843	Mined	4.93	0.0067	0.028	235	145.4	7.93	118.2	2.1	0.34	102.1	1.032	32001	0.414	126.3	123.0	17	152.4	2.44	
25.919	Mined	4.77	0.01499	0.028	235	314.7	11.59	252.5	4.5	0.72	221.0	1.518	101869	0.885	269.8	264.5	8	152.4	5.75	
26.044	Mined	4.77	0.00598	0.028	235	125.5	7.22	98.0	1.8	0.29	88.1	0.958	25645	0.344	104.7	104.1	18	152.4	2.28	
26.137	Mined	5.03	0.00586	0.028	235	129.7	7.44	104.1	1.8	0.30	91.1	0.974	26959	0.365	111.2	109.0	18	152.4	2.28	
26.239	Mined	4.26	0.01341	0.028	235	251.3	10.07	190.6	3.6	0.58	176.4	1.356	72678	0.668	203.7	205.5	11	152.4	4.05	
26.335	Mined	3.63	0.00272	0.028	235	43.4	4.15	32.4	0.6	0.10	30.5	0.563	5214	0.113	34.6	35.2	32	70.4	0.49	
26.43	Mined	3.11	0.00803	0.028	235	109.9	6.42	77.5	1.6	0.25	77.2	0.897	21030	0.272	82.8	86.8	21	152.4	1.88	
26.529	Mined	3.97	0.0096	0.028	235	167.7	8.26	128.3	2.4	0.39	117.7	1.108	39614	0.450	137.0	137.7	16	152.4	2.63	
26.623	Mined	4.46	0.00341	0.028	235	66.8	5.32	53.2	0.9	0.15	46.9	0.699	9967	0.187	56.8	56.0	27	111.9	0.99	
26.695	Mined	4.25	0.01497	0.028	235	280.0	10.66	213.6	4.0	0.65	196.6	1.431	85503	0.749	228.3	229.6	10	152.4	4.50	
26.775	Mined	4.6	0.00601	0.028	235	121.6	7.16	96.4	1.7	0.28	85.4	0.943	24463	0.338	103.0	101.6	19	152.4	2.13	
26.845	Mined	3.78	0.00834	0.028	235	138.7	7.45	104.3	2.0	0.32	97.4	1.007	29806	0.366	111.5	113.0	18	152.4	2.28	
26.921	Mined	3.58	0.00595	0.028	235	93.7	6.07	69.3	1.3	0.22	65.8	0.828	16549	0.243	74.0	75.7	23	151.4	1.66	
27.008	Mined	3.27	0.007	0.028	235	100.7	6.2	72.3	1.4	0.23	70.7	0.858	18432	0.253	77.2	80.2	22	152.4	1.77	
27.106	Mined	2.95	0.01646	0.028	235	213.7	8.84	146.9	3.0	0.49	150.0	1.250	56981	0.515	157.0	166.9	14	152.4	3.07	
27.169	Mined	3.32	0.00575	0.028	235	84.0	5.68	60.7	1.2	0.19	58.9	0.784	14037	0.213	64.8	67.1	24	134.2	1.39	
27.226	Mined	2.75	0.01371	0.028	235	165.8	7.72	112.0	2.4	0.38	116.4	1.102	38968	0.393	119.7	128.5	17	152.4	2.44	
27.265	Mined	4.34	0.0181	0.028	235	345.6	11.8	261.8	4.9	0.80	242.7	1.590	117229	0.918	279.7	282.4	7	152.4	6.64	
27.32	Cliff	5.91	0.00834	0.028	235	216.9	9.95	186.1	3.1	0.50	152.3	1.260	58301	0.652	198.9	188.6	13	152.4	3.35	3.7
27.366	Cliff	4.98	0.00213	0.028	235	46.6	4.49	37.9	0.7	0.11	32.7	0.584	5802	0.133	40.5	39.4	31	78.8	0.58	
27.417	Cliff	3.96	0.01827	0.028	235	318.4	11.28	239.2	4.5	0.73	223.5	1.526	103635	0.839	255.6	259.2	8	152.4	5.75	
27.502	Cliff	5.33	0.00934	0.028	235	219.1	11.99	270.3	3.1	0.50	153.8	1.266	59166	0.947	288.8	233.0	10	152.4	4.50	
27.604	Cliff	5.01	0.0042	0.028	235	92.7	7.75	112.9	1.3	0.21	65.1	0.824	16279	0.396	120.6	97.8	19	152.4	2.13	
27.693	Cliff	5.95	0.01098	0.028	235	287.4	13.79	357.5	4.1	0.66	201.8	1.450	88886	1.253	382.0	307.2	5	152.4	9.50	
27.797	Cliff	7.57	0.00875	0.028	235	291.5	14.1	373.8	4.1	0.67	204.6	1.460	90792	1.310	399.3	317.3	5	152.4	9.50	
27.913	Cliff	4.9	0.00441	0.028	235	95.0	7.79	114.1	1.3	0.22	66.7	0.834	16895	0.400	121.9	99.4	19	152.4	2.13	
28.023	Cliff	4.99	0.0103	0.028	235	226.1	9.74	178.4	3.2	0.52	158.7	1.286	62031	0.625	190.6	188.4	13	152.4	3.35	
28.091	Cliff	3.3	0.01952	0.028	235	283.5	10.36	201.8	4.0	0.65	199.0	1.440	87079	0.707	215.6	225.0	10	152.4	4.50	
28.157	Cliff	3.67	0.00658	0.028	235	106.2	6.47	78.7	1.5	0.24	74.6	0.882	19977	0.276	84.1	85.9	21	152.4	1.88	
28.241	Cliff	3.26	0.01892	0.028	235	271.5	10.19	195.2	3.8	0.63	190.6	1.409	81602	0.684	208.6	216.5	11	152.4	4.05	
28.326	Cliff	5.48	0.00451	0.028	235	108.8	8.57	138.1	1.5	0.25	76.4	0.892	20707	0.484	147.5	117.7	17	152.4	2.44	
28.39	Cliff	5.93	0.0082	0.028	235	214.1	12.02	271.6	3.0	0.49	150.3	1.252	57149	0.952	290.2	231.6	10	152.4	4.50	
28.462	Cliff	7.13	0.00383	0.028	235	120.1	9.27	161.6	1.7	0.28	84.3	0.937	24015	0.566	172.6	134.6	17	152.4	2.44	
28.555	Cliff	5.3	0.01107	0.028	235	258.1	13.02	318.7	3.7	0.59	181.2	1.374	75647	1.117	340.5	274.6	7	152.4	6.64	
28.657	Cliff	5.82	0.00519	0.028	235	132.8	9.39	165.8	1.9	0.31	93.3	0.986	27935	0.581	177.1	142.2	16	152.4	2.63	
28.75	Cliff	4.11	0.01118	0.028	235	202.2	11.15	233.7	2.9	0.47	142.0	1.216	52473	0.819	249.7	206.9	11	152.4	4.05	
28.847	Cliff	5.66	0.00667	0.028	235	166.2	10.59	210.8	2.4	0.38	116.7	1.103	39093	0.739	225.3	179.7	13	152.4	3.35	
28.934	Cliff	4.93	0.0113	0.028	235	245.2	12.6	298.5	3.5	0.56	172.1	1.339	70048	1.046	318.9	258.7	8	152.4	5.75	
29.012	Cliff	5.85	0.00656	0.028	235	168.8	10.65	213.2	2.4	0.39	118.5	1.111	40011	0.747	227.8	182.1	13	152.4	3.35	
29.13	Cliff	5.69	0.00925	0.028	235	231.5	12.32	285.4	3.3	0.53	162.5	1.302	64267	1.000	304.9	246.1	9	152.4	5.06	
29.258	Cliff	5.13	0.0057	0.028	235	128.7	7.51	106.0	1.8	0.30	90.4	0.970	26637	0.372	113.3	109.6	18	152.4	2.28	
29.351	Cliff	2.71	0.01745	0.028	235	208.1	7.57	107.7	3.0	0.48	146.1	1.234	54783	0.378	115.1	144.3	15	152.4	2.83	
29.387	Cliff	3.22	0.00727	0.028	235	103.1	5.49	56.7	1.5	0.24	72.4	0.868	19087	0.199	60.5	73.2	23	146.3	1.61	
29.493	Cliff	2.57	0.01022	0.028	235	115.6	5.61	59.2	1.6	0.27	81.1	0.920	22671	0.207	63.2	79.8	22	152.4	1.77	
29.538	Cliff	2.19	0.01793	0.028	235	172.8	6.69	84.1	2.5	0.40	121.3	1.124	41437	0.295	89.9	117.0	17	152.4	2.44	
29.601	Cliff	3.95	0.00692	0.028	235	120.2	6.98	91.6	1.7	0.28	84.4	0.938	24058	0.321	97.9	98.5	19	152.4	2.13	
29.663	Cliff	3.6	0.00831	0.028	235	131.7	7.2	97.5	1.9	0.30	92.5	0.982	27568	0.342	104.1	106.4	19	152.4	2.13	
29.71	Cliff	4.43	0.0057	0.028	235	111.1	7.54	106.9	1.6	0.26	78.0	0.902	21370	0.375	114.2	102.6	19	152.4	2.13	

	Size (mm)	Size (ft)	Size (in.)
D_{90} =	235	0.771	9.25
D_{50} =	7.6	0.025	0.30
D_{75} =	65	0.213	2.56

Method	Equation		
	$n_s=(D_{90}^{1/6}) / 44.4$ (D_{90} in inches)	n_s =	0.033
Anderson	$n_s=0.0395 * (D_{50}^{1/6})$ (D_{50} in feet)	n_s =	0.021
Lane	$n_s=(D_{75}^{1/6}) / 39$ (D_{75} in inches)	n_s =	0.030
			0.028

Station ID (River Miles)	Reach Code	Mean Particle Size, (mm) *1	Channel Width (ft) *2	Dominant Discharge, Q (cfs) *2	Schoklitsch, S_L (ft/ft) *3	90% Finer Particle Size, D_{90} (mm) *1	*n* Value for Cross Section *2	Average Depth of Flow, d (ft) *2	M-P,M S_L (ft/ft) *4	Shields S_L (ft/ft) *5	Shear Velocity, U* (fps) *6	Boundary Reynolds No. *7	Average S_L (ft/ft)	Average S_L by Reach	Average Invert Slope by Reach *8	Distance Between Grade Control Structures (ft) *9
24.919	Braided	73	118.23	6178	0.002236	235	0.028	6.96	0.00238	0.003408	0.8739	19380.6	0.002676	0.004204	0.009809	892
25.010	Braided	73	413.83	8918	0.004345	235	0.028	4.36	0.00380	0.005440	0.8739	19380.6	0.004530			
25.099	Braided	73	144.79	3888	0.003684	235	0.028	2.87	0.00578	0.008265	0.8739	19380.6	0.005910			
25.180	Braided	73	200.20	4576	0.004157	235	0.028	4.14	0.00401	0.005729	0.8739	19380.6	0.004631			
25.233	Braided	73	105.1	5355	0.002279	235	0.028	4.52	0.00367	0.005248	0.8739	19380.6	0.003732			
25.326	Braided	73	162.7	5273	0.003199	235	0.028	4.87	0.00341	0.004871	0.8739	19380.6	0.003825			
25.338	Braided	73	154.74	6671	0.002583	235	0.028	4.12	0.00403	0.005757	0.8739	19380.6	0.004122			
25.458	Mined	73	150.3	1840	0.006639	235	0.028	2.55	0.00651	0.009302	0.8739	19380.6	0.007482	0.004756	0.007358	1922
25.519	Mined	73	153.08	2007	0.006307	235	0.028	2.21	0.00751	0.010733	0.8739	19380.6	0.008182			
25.580	Mined	73	147.1	3266	0.004249	235	0.028	3.74	0.00444	0.006342	0.8739	19380.6	0.005009			
25.644	Mined	73	132.62	6906	0.002242	235	0.028	4.83	0.00343	0.004911	0.8739	19380.6	0.003529			
25.699	Mined	73	146.1	7484	0.002269	235	0.028	6.92	0.00240	0.003428	0.8739	19380.6	0.002698			
25.750	Mined	73	116.84	6519	0.002129	235	0.028	5.5	0.00302	0.004313	0.8739	19380.6	0.003153			
25.843	Mined	73	150.96	5893	0.002783	235	0.028	4.93	0.00336	0.004811	0.8739	19380.6	0.003653			
25.919	Mined	73	124.2	6866	0.002144	235	0.028	4.77	0.00348	0.004973	0.8739	19380.6	0.003531			
26.044	Mined	73	109.28	3762	0.003058	235	0.028	4.77	0.00348	0.004973	0.8739	19380.6	0.003836			
26.137	Mined	73	223.82	8372.88	0.002873	235	0.028	5.03	0.00330	0.004716	0.8739	19380.6	0.003629			
26.239	Mined	73	164.17	7042.02	0.002593	235	0.028	4.26	0.00389	0.005568	0.8739	19380.6	0.004018			
26.335	Mined	73	618.97	9325.21	0.005683	235	0.028	3.63	0.00457	0.006534	0.8739	19380.6	0.005596			
26.430	Mined	73	465.66	9285.47	0.004605	235	0.028	3.11	0.00533	0.007627	0.8739	19380.6	0.005855			
26.529	Mined	73	282.67	9261.8	0.003173	235	0.028	3.97	0.00418	0.005975	0.8739	19380.6	0.004442			
26.623	Mined	73	406.49	9641.87	0.004043	235	0.028	4.46	0.00372	0.005318	0.8739	19380.6	0.004360			
26.695	Mined	73	189.68	8603.68	0.002486	235	0.028	4.25	0.00390	0.005581	0.8739	19380.6	0.003990			
26.775	Mined	73	281.03	9256.37	0.003161	235	0.028	4.6	0.00361	0.005156	0.8739	19380.6	0.003974			
26.845	Mined	73	328.59	9235.15	0.003560	235	0.028	3.78	0.00439	0.006275	0.8739	19380.6	0.004741			
26.921	Mined	73	405.14	8800	0.004319	235	0.028	3.58	0.00463	0.006626	0.8739	19380.6	0.005193			
27.008	Mined	73	433.75	8800	0.004546	235	0.028	3.27	0.00507	0.007254	0.8739	19380.6	0.005624			
27.106	Mined	73	336.9	8800	0.003761	235	0.028	2.95	0.00562	0.008041	0.8739	19380.6	0.005808			
27.169	Mined	73	466.14	8800	0.004798	235	0.028	3.32	0.00500	0.007145	0.8739	19380.6	0.005646			
27.226	Mined	73	414.75	8800	0.004396	235	0.028	2.75	0.00603	0.008625	0.8739	19380.6	0.006351			
27.265	Mined	73	171.96	8800	0.002271	235	0.028	4.34	0.00382	0.005465	0.8739	19380.6	0.003853			
27.320	Cliff	73	149.61	8800	0.002046	235	0.028	5.91	0.00281	0.004014	0.8739	19380.6	0.002955	0.004016	0.009100	984
27.366	Cliff	73	363.88	8128.26	0.004229	235	0.028	4.98	0.00333	0.004763	0.8739	19380.6	0.004108			
27.417	Cliff	73	196.93	8800	0.002514	235	0.028	3.96	0.00419	0.005990	0.8739	19380.6	0.004231			
27.502	Cliff	73	137.53	8800	0.001921	235	0.028	5.33	0.00311	0.004450	0.8739	19380.6	0.003161			
27.604	Cliff	73	226.54	8800	0.002793	235	0.028	5.01	0.00331	0.004734	0.8739	19380.6	0.003613			
27.693	Cliff	73	107.18	8800	0.001593	235	0.028	5.95	0.00279	0.003987	0.8739	19380.6	0.002789			
27.797	Cliff	73	82.41	8800	0.001308	235	0.028	7.57	0.00219	0.003133	0.8739	19380.6	0.002211			
27.913	Cliff	73	230.54	8800	0.002830	235	0.028	4.9	0.00339	0.004841	0.8739	19380.6	0.003685			
28.023	Cliff	73	180.87	8800	0.002359	235	0.028	4.99	0.00332	0.004753	0.8739	19380.6	0.003479			
28.091	Cliff	73	257.56	8800	0.003075	235	0.028	3.3	0.00503	0.007188	0.8739	19380.6	0.005097			
28.157	Cliff	73	370.68	8800	0.004040	235	0.028	3.67	0.00452	0.006463	0.8739	19380.6	0.005008			
28.241	Cliff	73	264.8	8800	0.003140	235	0.028	3.26	0.00509	0.007276	0.8739	19380.6	0.005168			
28.326	Cliff	73	187.53	8800	0.002424	235	0.028	5.48	0.00303	0.004328	0.8739	19380.6	0.003260			
28.390	Cliff	73	123.52	8800	0.001772	235	0.028	5.93	0.00280	0.004000	0.8739	19380.6	0.002857			
28.462	Cliff	73	133.17	8800	0.001875	235	0.028	7.13	0.00233	0.003327	0.8739	19380.6	0.002509			
28.555	Cliff	73	127.46	8800	0.001814	235	0.028	5.3	0.00313	0.004475	0.8739	19380.6	0.003140			
28.657	Cliff	73	161.01	8800	0.002162	235	0.028	5.82	0.00285	0.004076	0.8739	19380.6	0.003029			
28.750	Cliff	73	192.3	8800	0.002470	235	0.028	4.11	0.00404	0.005771	0.8739	19380.6	0.004092			
28.847	Cliff	73	146.83	8800	0.002017	235	0.028	5.66	0.00293	0.004191	0.8739	19380.6	0.003046			
28.934	Cliff	73	141.77	8800	0.001965	235	0.028	4.93	0.00336	0.004811	0.8739	19380.6	0.003380			
29.012	Cliff	73	141.33	8800	0.001960	235	0.028	5.85	0.00284	0.004055	0.8739	19380.6	0.002950			
29.130	Cliff	73	129.87	9100	0.001794	235	0.028	5.69	0.00292	0.004169	0.8739	19380.6	0.002959			
29.258	Cliff	73	236.21	9100	0.002810	235	0.028	5.13	0.00323	0.004624	0.8739	19380.6	0.003556			
29.351	Cliff	73	428.52	8786.27	0.004510	235	0.028	2.71	0.00612	0.008753	0.8739	19380.6	0.006461			
29.387	Cliff	73	510.43	9028.61	0.005038	235	0.028	3.22	0.00515	0.007366	0.8739	19380.6	0.005852			
29.493	Cliff	73	631.13	9100	0.005873	235	0.028	2.57	0.00645	0.009230	0.8739	19380.6	0.007186			
29.538	Cliff	73	621.08	9100	0.005803	235	0.028	2.19	0.00757	0.010831	0.8739	19380.6	0.008069			
29.601	Cliff	73	330.31	9100	0.003614	235	0.028	3.95	0.00420	0.006005	0.8739	19380.6	0.004606			
29.663	Cliff	73	351.33	9100	0.003785	235	0.028	3.6	0.00461	0.006589	0.8739	19380.6	0.004994			
29.710	Cliff	73	272.3	9100	0.003126	235	0.028	4.43	0.00374	0.005354	0.8739	19380.6	0.004075			

Reach	Center Stationing ID (River miles)	Left Bank Stationing (ft)	Right Bank Stationing (ft)	HEC-RAS 100 Year Flow Velocity (fps) [1]	Average Hydraulic Depth, V_m (fps) [1]	Left Top of Bank Elev (ft) [2]	Right Top of Bank Elev (ft) [2]	Left Bank Toe Down Elev (ft) [3]	Right Bank Toe Down Elev (ft) [3]	Left Bank Slope Length (ft) [4]	Right Bank Slope Length (ft) [4]	USBR Dumped Riprap Median Riprap Particle Size, D_{50} (ft) [5]	USBR Riprap Layer Thickness (ft) [6]	Left Bank USBR Riprap Volume per Length (ft^3/ft) [7]	Right Bank USBR Riprap Volume per Length (ft^3/ft) [7]	Left Bank Riprap Volume (yd^3)	Right Bank Riprap Volume (yd^3)	USBR Total Riprap Volume, (yd^3) [8]	Necessary USBR Gabion Thickness (in) [9]	Manufactured Gabion Size (in) [9]	Left Bank USBR Gabion Volume per Length (ft^3/ft) [7]	Right Bank USBR Gabion Volume per Length (ft^3/ft) [7]	Left Bank Gabion Volume (yd^3)	Right Bank Gabion Volume (yd^3)	Total Gabion Volume, (yd^3) [8]	Standard CSA Layer Thickness (ft)	Height of Left Bank (ft) [10]	Left Bank Volume per Length (ft^3/ft) [7]	Height of Right Bank (ft) [10]	Right Bank Volume per Length (ft^3/ft) [7]	Left Bank CSA Volume (yd^3)	Right Bank CSA Volume (yd^3)	Total Volume of CSA (yd^3) [8]	Left Bank CSA Cement (tons) [11]	Right Bank CSA Cement (tons) [11]	Total CSA Cement (tons) [11]
		10400	10400																																	
Braided Reach	24.919			8.6	8.0	1651.1	1651.1	1630.4	1630.4	46.3	46.3	1.0	5.0	231.3	231.3	0.0	0.0	0.0	25.4	27	104.1	104.1	0.0	0.0	0.0	9	20.7	186.2	20.7	186.2	0.0	0.0	0.0	0.0	0.0	0.0
	25.010			9.1	7.8	1653.1	1653.1	1636.9	1636.9	36.3	36.3	1.2	5.0	181.5	181.5	0.0	0.0	0.0	25.4	27	81.7	81.7	0.0	0.0	0.0	9	16.2	146.1	16.2	146.1	0.0	0.0	0.0	0.0	0.0	0.0
	25.099			14.9	5.0	1657.8	1657.8	1628.3	1628.3	65.9	65.9	3.2	5.0	329.6	329.6	0.0	0.0	0.0	25.4	27	148.3	148.3	0.0	0.0	0.0	9	29.5	265.4	29.5	265.4	0.0	0.0	0.0	0.0	0.0	0.0
	25.180			8.8	7.7	1662.8	1662.8	1644.3	1644.3	41.4	41.4	1.1	5.0	207.1	207.1	0.0	0.0	0.0	25.4	27	93.2	93.2	0.0	0.0	0.0	9	18.5	166.7	18.5	166.7	0.0	0.0	0.0	0.0	0.0	0.0
	25.233			11.3	7.9	1664.0	1664.0	1638.3	1638.3	57.4	57.4	1.8	5.0	286.8	286.8	0.0	0.0	0.0	25.4	27	129.1	129.1	0.0	0.0	0.0	9	25.7	230.9	25.7	230.9	0.0	0.0	0.0	0.0	0.0	0.0
	25.326			12.4	7.5	1667.9	1667.9	1647.6	1647.6	45.4	45.4	2.2	5.0	227.0	227.0	0.0	0.0	0.0	25.4	27	102.2	102.2	0.0	0.0	0.0	9	20.3	182.7	20.3	182.7	0.0	0.0	0.0	0.0	0.0	0.0
	25.338			13.1	7.1	1671.5	1671.5	1650.3	1650.3	47.3	47.3	2.4	5.0	236.6	236.6	0.0	0.0	0.0	25.4	27	106.5	106.5	0.0	0.0	0.0	9	21.2	190.4	21.2	190.4	0.0	0.0	0.0	0.0	0.0	0.0
									Average	**48.6**	**48.6**	**3.2**															**21.7**		**21.7**							
										Quantity/Total						**0.0**	**0.0**	**0.0**					**0.0**	**0.0**	**0.0**						**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Mined Reach	25.458			8.2	5.6	1675.4	1675.4	1662.5	1662.5	28.8	28.8	0.9	5.5	158.6	158.6	0.0	0.0	0.0	27.6	30	72.1	72.1	0.0	0.0	0.0	9	12.9	116.1	12.9	116.1	0.0	0.0	0.0	0.0	0.0	0.0
	25.519			9.2	4.6	1677.6	1677.6	1664.3	1664.3	29.8	29.8	1.2	5.5	164.1	164.1	0.0	0.0	0.0	27.6	30	74.6	74.6	0.0	0.0	0.0	9	13.3	120.1	13.3	120.1	0.0	0.0	0.0	0.0	0.0	0.0
	25.580			10.7	6.5	1680.2	1680.2	1664.5	1664.5	35.1	35.1	1.6	5.5	193.2	193.2	0.0	0.0	0.0	27.6	30	87.8	87.8	0.0	0.0	0.0	9	15.7	141.4	15.7	141.4	0.0	0.0	0.0	0.0	0.0	0.0
	25.644			13.5	8.3	1683.2	1683.2	1661.1	1661.1	49.3	49.3	2.6	5.5	271.3	271.3	0.0	0.0	0.0	27.6	30	123.3	123.3	0.0	0.0	0.0	9	22.1	198.5	22.1	198.5	0.0	0.0	0.0	0.0	0.0	0.0
	25.699			13.4	11.0	1685.7	1685.7	1663.3	1663.3	50.1	50.1	2.5	5.5	275.3	275.3	0.0	0.0	0.0	27.6	30	125.1	125.1	0.0	0.0	0.0	9	22.4	201.5	22.4	201.5	0.0	0.0	0.0	0.0	0.0	0.0
	25.750			9.1	8.9	1688.3	1688.3	1666.1	1666.1	49.7	49.7	1.1	5.5	273.3	273.3	0.0	0.0	0.0	27.6	30	124.2	124.2	0.0	0.0	0.0	9	22.2	200.0	22.2	200.0	0.0	0.0	0.0	0.0	0.0	0.0
	25.843			12.3	7.4	1689.6	1689.6	1667.7	1667.7	48.9	48.9	2.1	5.5	269.1	269.1	0.0	0.0	0.0	27.6	30	122.3	122.3	0.0	0.0	0.0	9	21.9	196.9	21.9	196.9	0.0	0.0	0.0	0.0	0.0	0.0
	25.919			12.6	6.8	1693.3	1693.3	1669.1	1669.1	54.2	54.2	2.2	5.5	298.2	298.2	0.0	0.0	0.0	27.6	30	135.5	135.5	0.0	0.0	0.0	9	24.2	218.2	24.2	218.2	0.0	0.0	0.0	0.0	0.0	0.0
	26.044			9.5	6.4	1698.2	1698.2	1679.4	1679.4	42.1	42.1	1.3	5.5	231.4	231.4	0.0	0.0	0.0	27.6	30	105.2	105.2	0.0	0.0	0.0	9	18.8	169.3	18.8	169.3	0.0	0.0	0.0	0.0	0.0	0.0
	26.137			10.2	7.0	1701.3	1701.3	1680.4	1680.4	46.8	46.8	1.5	5.5	257.2	257.2	0.0	0.0	0.0	27.6	30	116.9	116.9	0.0	0.0	0.0	9	20.9	188.2	20.9	188.2	0.0	0.0	0.0	0.0	0.0	0.0
	26.239			9.5	4.5	1704.8	1704.8	1685.7	1685.7	42.6	42.6	1.3	5.5	234.6	234.6	0.0	0.0	0.0	27.6	30	106.6	106.6	0.0	0.0	0.0	9	19.1	171.7	19.1	171.7	0.0	0.0	0.0	0.0	0.0	0.0
	26.335			7.8	6.5	1708.1	1708.1	1692.6	1692.6	34.7	34.7	0.8	5.5	190.6	190.6	0.0	0.0	0.0	27.6	30	86.6	86.6	0.0	0.0	0.0	9	15.5	139.5	15.5	139.5	0.0	0.0	0.0	0.0	0.0	0.0
	26.430			11.1	6.7	1710.5	1710.5	1692.4	1692.4	40.5	40.5	1.7	5.5	222.6	222.6	0.0	0.0	0.0	27.6	30	101.2	101.2	0.0	0.0	0.0	9	18.1	162.9	18.1	162.9	0.0	0.0	0.0	0.0	0.0	0.0
	26.529			13.3	6.9	1715.2	1715.2	1695.9	1695.9	43.1	43.1	2.5	5.5	236.9	236.9	0.0	0.0	0.0	27.6	30	107.7	107.7	0.0	0.0	0.0	9	19.3	173.4	19.3	173.4	0.0	0.0	0.0	0.0	0.0	0.0
	26.623			8.8	9.1	1719.7	1719.7	1699.8	1699.8	44.4	44.4	1.1	5.5	244.2	244.2	0.0	0.0	0.0	27.6	30	111.0	111.0	0.0	0.0	0.0	9	19.9	178.7	19.9	178.7	0.0	0.0	0.0	0.0	0.0	0.0
	26.695			15.5	7.1	1723.4	1723.4	1698.5	1698.5	55.7	55.7	3.5	5.5	306.1	306.1	0.0	0.0	0.0	27.6	30	139.1	139.1	0.0	0.0	0.0	9	24.9	224.0	24.9	224.0	0.0	0.0	0.0	0.0	0.0	0.0
	26.775			11.6	9.4	1728.8	1728.8	1706.4	1706.4	50.2	50.2	1.9	5.5	275.9	275.9	0.0	0.0	0.0	27.6	30	125.4	125.4	0.0	0.0	0.0	9	22.4	201.9	22.4	201.9	0.0	0.0	0.0	0.0	0.0	0.0
	26.845			11.9	8.3	1731.2	1731.2	1710.6	1710.6	46.0	46.0	2.0	5.5	252.9	252.9	0.0	0.0	0.0	27.6	30	115.0	115.0	0.0	0.0	0.0	9	20.6	185.1	20.6	185.1	0.0	0.0	0.0	0.0	0.0	0.0
	26.921			10.1	8.2	1734.4	1734.4	1715.7	1715.7	41.9	41.9	1.4	5.5	230.2	230.2	0.0	0.0	0.0	27.6	30	104.6	104.6	0.0	0.0	0.0	9	18.7	168.4	18.7	168.4	0.0	0.0	0.0	0.0	0.0	0.0
	27.008			10.1	7.6	1736.7	1736.7	1718.6	1718.6	40.4	40.4	1.4	5.5	222.4	222.4	0.0	0.0	0.0	27.6	30	101.1	101.1	0.0	0.0	0.0	9	18.1	162.8	18.1	162.8	0.0	0.0	0.0	0.0	0.0	0.0
	27.106			12.8	5.6	1740.9	1740.9	1719.1	1719.1	48.9	48.9	2.3	5.5	268.7	268.7	0.0	0.0	0.0	27.6	30	122.1	122.1	0.0	0.0	0.0	9	21.8	196.6	21.8	196.6	0.0	0.0	0.0	0.0	0.0	0.0
	27.169			9.1	7.3	1745.0	1745.0	1728.7	1728.7	36.4	36.4	1.2	5.5	200.3	200.3	0.0	0.0	0.0	27.6	30	91.1	91.1	0.0	0.0	0.0	9	16.3	146.6	16.3	146.6	0.0	0.0	0.0	0.0	0.0	0.0
	27.226			12.4	6.2	1747.2	1746.6	1725.3	1726.4	48.9	45.2	2.2	5.5	269.1	248.6	0.0	0.0	0.0	27.6	30	122.3	113.0	0.0	0.0	0.0	9	21.9	196.9	20.2	181.9	0.0	0.0	0.0	0.0	0.0	0.0
	27.265			13.0	7.1	1752.4	1752.0	1719.9	1721.5	72.6	68.2	2.4	5.5	399.2	374.8	0.0	0.0	0.0	27.6	30	181.4	170.4	0.0	0.0	0.0	9	32.5	292.1	30.5	274.3	0.0	0.0	0.0	0.0	0.0	0.0
									Average	**45.0**	**44.7**	**3.5**															**20.1**		**20.0**							
										Quantity/Total						**0.0**	**0.0**	**0.0**					**0.0**	**0.0**	**0.0**						**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Cliff Reach	27.320			13.0	10.2	1756.2	1756.0	1727.9	1729.4	63.4	59.4	2.4	6.0	380.3	356.6	0.0	0.0	0.0	30.4	33	174.3	163.5	0.0	0.0	0.0	9	28.3	255.1	26.6	239.2	0.0	0.0	0.0	0.0	0.0	0.0
	27.366			8.1	9.4	1758.1	1757.9	1735.3	1736.7	51.0	47.5	0.9	6.0	305.8	285.0	0.0	0.0	0.0	30.4	33	140.2	130.6	0.0	0.0	0.0	9	22.8	205.1	21.2	191.2	0.0	0.0	0.0	0.0	0.0	0.0
	27.417			14.2	7.5	1760.7	1760.1	1731.1	1732.6	66.1	61.5	2.9	6.0	396.9	369.0	0.0	0.0	0.0	30.4	33	181.9	169.1	0.0	0.0	0.0	9	29.6	266.2	27.5	247.6	0.0	0.0	0.0	0.0	0.0	0.0
	27.502	24500		13.6	10.5	1768.0	1768.0	1739.0	1739.0	64.8	64.8	2.7	6.0	388.6	388.6	1105.3	0.0	1105.3	30.4	33	178.1	178.1	506.6	0.0	506.6	9	29.0	260.7	29.0	260.7	741.5	0.0	741.5	105.1	0.0	105.1
	27.604	24577		14.4	9.9	1770.5	1770.5	1767.0	1745.5	7.8	55.9	3.0	6.0	47.0	335.1	817.3	0.0	817.3	30.4	33	21.5	153.6	374.6	0.0	374.6	9	3.5	31.5	25.0	224.8	548.2	0.0	548.2	77.7	0.0	77.7
	27.693	25047		14.4	9.2	1777.6	1777.6	1772.0	1739.0	12.5	86.4	3.0	6.0	75.1	518.3	1528.0	0.0	1528.0	30.4	33	34.4	237.6	700.3	0.0	700.3	9	5.6	50.4	38.6	347.7	1025.0	0.0	1025.0	145.3	0.0	145.3
	27.797	25596		22.9	16.4	1784.9	1784.9	1775.0	1736.7	22.1	107.8	7.7	6.0	132.8	646.9	3013.0	0.0	3013.0	30.4	33	60.9	296.5	1381.0	0.0	1381.0	9	9.9	89.1	48.2	434.0	2021.2	0.0	2021.2	286.5	0.0	286.5
	27.913	26208		4.7	16.9	1794.2	1794.2	1778.0	1756.7	36.2	83.9	0.3	6.0	217.3	503.5	4675.3	0.0	4675.3	30.4	33	99.6	230.8	2142.9	0.0	2142.9	9	16.2	145.8	37.5	337.8	3136.3	0.0	3136.3	444.6	0.0	444.6
	28.023	26789		6.7	12.9	1794.3	1794.3	1781.0	1765.4	29.7	64.7	0.6	6.0	178.4	388.2	144.6	0.0	144.6	30.4	33	81.8	177.9	66.3	0.0	66.3	9	13.3	119.7	28.9	260.4	97.0	0.0	97.0	13.7	0.0	13.7
	28.091	26811		8.9	7.0	1794.8	1794.8	1785.0	1772.7	21.9	49.5	1.1	6.0	131.5	296.8	0.0	0.0	0.0	30.4	33	60.3	136.0	0.0	0.0	0.0	9	9.8	88.2	22.1	199.1	0.0	0.0	0.0	0.0	0.0	0.0
	28.157			11.4	6.2	1796.9	1796.9	1791.0	1775.9	13.2	46.9	1.8	6.0	79.2	281.4	0.0	0.0	0.0	30.4	33	36.3	129.0	0.0	0.0	0.0	9	5.9	53.1	21.0	188.8	0.0	0.0	0.0	0.0	0.0	0.0
	28.241			12.0	6.3	1802.2	1802.2	1994.0	1780.7	428.9	48.1	2.0	6.0	2573.3	288.5	0.0	0.0	0.0	30.4	33	1179.4	132.2	0.0	0.0	0.0	9	-191.8	-1726.2	21.5	193.6	0.0	0.0	0.0	0.0	0.0	0.0
	28.326			13.6	9.4	1806.9	1806.9	1782.8	1782.8	53.8	53.8	2.6	6.0	322.7	322.7	0.0	0.0	0.0	30.4	33	147.9	147.9	0.0	0.0	0.0	9	24.1	216.5	24.1	216.5	0.0	0.0	0.0	0.0	0.0	0.0
	28.390	28640		14.2	10.1	1809.9	1809.9	1782.5	1782.5	61.2	61.2	2.9	6.0	367.5	367.5	6356.8	0.0	6356.8	30.4	33	168.4	168.4	2913.5	0.0	2913.5	9	27.4	246.5	27.4	246.5	4264.2	0.0	4264.2	604.5	0.0	604.5
	28.462	29107		14.8	11.9	1813.0	1813.0	1786.4	1786.4	59.6	59.6	3.2	6.0	357.5	357.5	6501.0	0.0	6501.0	30.4	33	163.8	163.8	2979.6	0.0	2979.6	9	26.6	239.8	26.6	239.8	4361.0	0.0	4361.0	618.2	0.0	618.2
	28.555	29598		15.8	11.7	1817.3	1817.3	1786.6	1786.6	68.6	68.6	3.6	6.0	411.5	411.5	8208.6	0.0	8208.6	30.4	33	188.6	188.6	3762.3	0.0	3762.3	9	30.7	276.1	30.7	276.1	5506.5	0.0	5506.5	780.5	0.0	780.5
	28.657	30137		14.0	9.7	1821.0	1821.0	1792.7	1792.7	63.2	63.2	2.8	6.0	379.5	379.5	6901.7	0.0	6901.7	30.4	33	173.9	173.9	3163.3	0.0	3163.3	9	28.3	254.6	28.3	254.6	4629.8	0.0	4629.8	656.3	0.0	656.3
	28.750	30628		14.5	10.1	1824.6	1824.6	1798.8	1798.8	57.6	57.6	3.0	6.0	345.9	345.9	6560.9	0.0	6560.9	30.4	33	158.5	158.5	3007.1	0.0	3007.1	9	25.8	232.0	25.8	232.0	4401.2	0.0	4401.2	623.9	0.0	623.9
	28.847	31140		15.2	12.1	1829.5	1829.5	1802.5	1802.5	60.3	60.3	3.3	6.0	362.0	362.0	6159.3	0.0	6159.3	30.4	33	165.9	165.9	2823.0	0.0	2823.0	9	27.0	242.9	27.0	242.9	4131.8	0.0	4131.8	585.7	0.0	585.7
	28.934	31599		14.8	10.4	1833.2	1833.2	1803.7	1803.7	66.1	66.1	3.1	6.0	396.3	396.3	6045.2	0.0	6045.2	30.4	33	181.6	181.6	2770.7	0.0	2770.7	9	29.5	265.9	29.5	265.9	4055.3	0.0	4055.3	574.8	0.0	574.8
	29.012	32011		15.9	11.9	1836.5	1836.5	1808.5	1808.5	62.6	62.6	3.7	6.0	375.7	375.7	8668.6	0.0	8668.6	30.4	33	172.2	172.2	3973.1	0.0	3973.1	9	28.0	252.0	28.0	252.0	5815.0	0.0	5815.0	824.3	0.0	824.3
	29.130	32634		16.2	12.5	1841.3	1841.3	1809.7	1809.7	70.6	70.6	3.8	6.0	423.6	423.6	12000.4	0.0	12000.4	30.4	33	194.1	194.1	5500.2	0.0	5500.2	9	31.6	284.2	31.6	284.2	8050.1	0.0	8050.1	1141.1	0.0	1141.1
	29.258	33399		14.1	10.0	1846.3	1846.3	1822.2	1822.2	53.8	53.8	2.8	6.0	322.8	322.8	0.0	0.0	0.0	30.4	33	147.9	147.9	0.0	0.0	0.0	9	24.1	216.5	24.1	216.5	0.0	0.0	0.0	0.0	0.0	0.0
	29.351		33650	8.1	8.5	1851.5	1851.5	1831.0	1831.0	45.9	45.9	0.9	6.0	275.2	275.2	0.0	3475.5	3475.5	30.4	33	126.1	126.1	0.0	1593.0	1593.0	9	20.5	184.6	20.5	184.6	0.0	2331.5	2331.5	0.0	330.5	330.5
	29.387		33991	7.4	7.1	1852.5	1852.5	1835.3	1835.3	38.5	38.5	0.8	6.0	230.8	230.8	0.0	4784.2	4784.2	30.4	33	105.8	105.8	0.0	2192.8	2192.8	9	17.2	154.8	17.2	154.8	0.0	3209.4	3209.4	0.0	454.9	454.9
	29.493		34551	8.9	5.4	1855.8	1855.8	1838.5	1838.5	38.6	38.6	1.1	6.0	231.8	231.8	0.0	2039.8	2039.8	30.4	33	106.2	106.2	0.0	934.9	934.9	9	17.3	155.5	17.3	155.5	0.0	1368.3	1368.3	0.0	194.0	194.0
	29.538		34788	11.6	4.8	1858.3	1858.3	1838.7	1838.7	43.8	43.8	1.9	6.0	263.0	263.0	0.0	3239.7	3239.7	30.4	33	120.5	120.5	0.0	1484.9	1484.9	9	19.6	176.4	19.6	176.4	0.0	2173.3	2173.3	0.0	308.1	308.1
	29.601		35121	13.6	7.0	1862.8	1862.8	1842.2	1842.2	46.2	46.2	2.6	6.0	276.9	276.9	0.0	3357.7	3357.7	30.4	33	126.9	126.9	0.0	1538.9	1538.9	9	20.6	185.8	20.6	185.8	0.0	2252.4	2252.4	0.0	319.3	319.3
	29.663		35448	11.5	8.3	1867.7	1867.7	1844.9	1844.9	50.9	50.9	1.9	6.0	305.5	305.5	0.0	4443.5	4443.5	30.4	33	140.0	140.0	0.0	2036.6	2036.6	9	22.8	205.0	22.8	205.0	0.0	2980.8	2980.8	0.0	422.5	422.5
	29.710		35841																																	
									Average	**60.7**	**59.2**	**3.8**															**13.9**		**26.5**							
										Quantity/Total						**78685.9**	**21340.4**	**100026.4**					**36064.4**	**9781.0**	**45845.4**						**52784.1**	**14315.6**	**67099.7**	**7482.1**	**2029.2**	**9511.4**
															Total	**78685.9**	**21340.4**	**100026.4**					**36064.4**	**9781.0**	**45845.4**						**52784.1**	**14315.6**	**67099.7**	**7482.1**	**2029.2**	**9511.4**

Reach	Center Stationing ID (River miles)	Left Bank Stationing (ft)	Right Bank Stationing (ft)	HEC-RAS 100 Year Flow Velocity (fps) *1	Average Hydraulic Depth, V_m (fps) *1	Left Top of Bank Elev (ft) *2	Right Top of Bank Elev (ft) *2	Left Bank Toe Down Elevation (ft) *3	Right Bank Toe Down Elevation (ft) *3	Left Bank Slope Length (ft) *4	Right Bank Slope Length (ft) *4	USBR Dumped Riprap Median Riprap Particle Size, D_{50} (ft) *5	USBR Riprap Layer Thickness (ft) *6	Left Bank USBR Riprap Volume per Length (ft^3/ft) *7	Right Bank USBR Riprap Volume per Length (ft^3/ft) *7	Left Bank Riprap Volume (yd^3)	Right Bank Riprap Volume (yd^3)	USBR Total Riprap Volume, (yd^3) *8	Necessary USBR Gabion Thickness (in) *9	Manufactured Gabion Size (in) *9	Left Bank USBR Gabion Volume per Length (ft^3/ft) *7	Right Bank USBR Gabion Volume per Length (ft^3/ft) *7	Left Bank Gabion Volume (yd^3)	Right Bank Gabion Volume (yd^3)	Total Gabion Volume, (yd^3) *8	Standard CSA Layer Thickness (ft)	Height of Left Bank (ft) *10	Left Bank Volume per Length (ft^3/ft) *7	Height of Right Bank (ft) *10	Right Bank Volume per Length (ft^3/ft) *7	Left Bank CSA Volume (yd^3)	Right Bank CSA Volume (yd^3)	Total Volume of CSA (yd^3) *8	Left Bank CSA Cement (tons) *11	Right Bank CSA Cement (tons) *11	Total CSA Cement (tons) *11
		10000	10000																																	
Hackberry Reach	0.200		10000	13.9	11.3	1662.3	1662.3	1635.1	1635.1	60.7	60.7	2.8	5.5	334.1	334.1	0.0	8492.9	8492.9	28.0	30	151.9	151.9	0.0	3860.4	3860.4	9	27.2	244.5	27.2	244.5	0.0	6215.1	6215.1	0.0	881.0	881.0
	0.330		10686	13.6	7.3	1664.6	1664.6	1642.6	1642.6	49.3	49.3	2.6	5.5	271.0	271.0	0.0	5375.8	5375.8	28.0	30	123.2	123.2	0.0	2443.5	2443.5	9	22.0	198.3	22.0	198.3	0.0	3934.0	3934.0	0.0	557.6	557.6
	0.430		11222	12.1	7.4	1667.9	1667.9	1645.1	1645.1	51.0	51.0	2.1	5.5	280.4	280.4	0.0	2886.6	2886.6	28.0	30	127.4	127.4	0.0	1312.1	1312.1	9	22.8	205.2	22.8	205.2	0.0	2112.4	2112.4	0.0	299.4	299.4
	0.540		11500	13.9	8.7	1672.3	1672.3	1649.6	1666.0	50.8	14.1	2.7	5.5	279.5	77.5	0.0	2210.8	2210.8	28.0	30	127.0	35.2	0.0	1004.9	1004.9	9	22.7	204.5	6.3	56.7	0.0	1617.8	1617.8	0.0	229.3	229.3
	0.630	12300	12270	14.3	7.6	1675.3	1675.3	1653.5	1668.5	48.7	15.2	2.9	5.5	267.6	83.6	3893.6	1308.3	5201.9	28.0	30	121.7	38.0	1769.8	594.7	2364.5	9	21.8	195.9	6.8	61.2	2849.3	957.4	3806.8	403.9	135.7	539.6
	0.710	12693	12693	14.9	10.5	1678.3	1678.3	1670.5	1670.5	17.4	17.4	3.2	5.5	95.9	95.9	750.4	157.0	907.4	28.0	30	43.6	43.6	341.1	71.4	412.5	9	7.8	70.2	7.8	70.2	549.1	114.9	664.0	77.8	16.3	94.1
	0.750	12904	12737	12.8	9.1	1679.4	1679.4	1671.0	1672.0	18.8	16.5	2.3	5.5	103.3	91.0	1818.2	0.0	1818.2	28.0	30	47.0	41.4	826.5	0.0	826.5	9	8.4	75.6	7.4	66.6	1330.6	0.0	1330.6	188.6	0.0	188.6
	0.840	13379		19.2	7.7	1681.0	1681.0	1675.0	1680.0	13.4	2.2	5.4	5.5	73.8	12.3	2164.5	0.0	2164.5	28.0	30	33.5	5.6	983.9	0.0	983.9	9	6.0	54.0	1.0	9.0	1584.0	0.0	1584.0	224.5	0.0	224.5
	0.990	14171		9.4	6.4	1687.7	1687.9	1679.0	1669.9	19.5	40.1	1.2	5.5	107.0	220.7	2092.4	0.0	2092.4	28.0	30	48.6	100.3	951.1	0.0	951.1	9	8.7	78.3	17.9	161.5	1531.2	0.0	1531.2	217.0	0.0	217.0
	1.090	14699		13.9	7.7	1690.9	1690.9	1682.0	1669.3	19.9	48.4	2.8	5.5	109.5	266.2	1926.4	0.0	1926.4	28.0	30	49.8	121.0	875.6	0.0	875.6	9	8.9	80.1	21.6	194.8	1409.8	0.0	1409.8	199.8	0.0	199.8
	1.180	15174		13.1	10.6	1694.9	1694.9	1686.0	1673.2	19.9	48.5	2.4	5.5	109.5	266.9	436.2	0.0	436.2	28.0	30	49.8	121.3	198.3	0.0	198.3	9	8.9	80.1	21.7	195.3	319.2	0.0	319.2	45.2	0.0	45.2
	1.270	15282		13.7	8.6	1696.5	1696.5	1691.0	1673.7	12.3	50.9	2.7	5.5	67.6	280.0	0.0	0.0	0.0	28.0	30	30.7	127.3	0.0	0.0	0.0	9	5.5	49.5	22.8	204.9	0.0	0.0	0.0	0.0	0.0	0.0
	1.370			14.4	7.5	1700.0	1700.0	1698.0	1678.0	4.5	49.3	3.0	5.5	24.6	271.2	0.0	0.0	0.0	28.0	30	11.2	123.3	0.0	0.0	0.0	9	2.0	18.0	22.0	198.4	0.0	0.0	0.0	0.0	0.0	0.0
	1.470			14.3	10.6	1704.5	1704.5	1678.0	1678.0	59.2	59.2	2.9	5.5	325.7	325.7	0.0	0.0	0.0	28.0	30	148.1	148.1	0.0	0.0	0.0	9	26.5	238.4	26.5	238.4	0.0	0.0	0.0	0.0	0.0	0.0
	1.560			14.4	9.2	1706.4	1706.4	1679.9	1679.9	59.4	59.4	3.0	5.5	326.5	326.5	0.0	0.0	0.0	28.0	30	148.4	148.4	0.0	0.0	0.0	9	26.5	238.9	26.5	238.9	0.0	0.0	0.0	0.0	0.0	0.0
	1.600			15.2	10.7	1707.3	1707.3	1682.0	1682.0	56.6	56.6	3.3	5.5	311.2	311.2	0.0	0.0	0.0	28.0	30	141.4	141.4	0.0	0.0	0.0	9	25.3	227.7	25.3	227.7	0.0	0.0	0.0	0.0	0.0	0.0
	1.660			15.5	8.3	1708.5	1708.5	1685.4	1685.4	51.7	51.7	3.5	5.5	284.4	284.4	0.0	0.0	0.0	28.0	30	129.3	129.3	0.0	0.0	0.0	9	23.1	208.2	23.1	208.2	0.0	0.0	0.0	0.0	0.0	0.0
	1.750			14.2	9.1	1711.5	1711.5	1689.9	1689.9	48.4	48.4	2.9	5.5	266.2	266.2	0.0	0.0	0.0	28.0	30	121.0	121.0	0.0	0.0	0.0	9	21.6	194.8	21.6	194.8	0.0	0.0	0.0	0.0	0.0	0.0
	1.810			12.7	10.3	1713.7	1713.7	1690.6	1690.6	51.6	51.6	2.3	5.5	283.9	283.9	0.0	0.0	0.0	28.0	30	129.0	129.0	0.0	0.0	0.0	9	23.1	207.8	23.1	207.8	0.0	0.0	0.0	0.0	0.0	0.0
	1.850			11.5	9.5	1714.3	1714.3	1693.6	1693.6	46.2	46.2	1.9	5.5	254.0	254.0	0.0	0.0	0.0	28.0	30	115.5	115.5	0.0	0.0	0.0	9	20.7	185.9	20.7	185.9	0.0	0.0	0.0	0.0	0.0	0.0
	1.880																																			
									Average	38.0	41.8	3.5															17.0		18.7							
										Quantity/Total						13081.6	20431.4	33513.0					5946.2	9287.0	15233.2						9573.2	14951.8	24524.9	1357.0	2119.4	3476.4
Union Hills Reach	1.880			13.7	8.0	1714.7	1714.7	1692.4	1692.4	49.9	49.9	2.7	6.5	324.4	324.4	0.0	0.0	0.0	33.5	36	149.7	149.7	0.0	0.0	0.0	9	22.3	200.9	22.3	200.9	0.0	0.0	0.0	0.0	0.0	0.0
	2.000			12.6	5.6	1717.7	1718.3	1701.8	1698.3	35.5	44.8	2.2	6.5	230.9	291.0	0.0	0.0	0.0	33.5	36	106.6	134.3	0.0	0.0	0.0	9	15.9	143.0	20.0	180.2	0.0	0.0	0.0	0.0	0.0	0.0
	2.080			14.3	4.7	1720.5	1721.3	1700.2	1695.9	45.4	56.9	2.9	6.5	294.9	369.8	0.0	0.0	0.0	33.5	36	136.1	170.7	0.0	0.0	0.0	9	20.3	182.6	25.4	229.0	0.0	0.0	0.0	0.0	0.0	0.0
	2.170			13.8	6.6	1724.0	1724.8	1705.6	1701.5	41.2	52.0	2.7	6.5	267.6	338.2	0.0	0.0	0.0	33.5	36	123.5	156.1	0.0	0.0	0.0	9	18.4	165.7	23.3	209.4	0.0	0.0	0.0	0.0	0.0	0.0
	2.240			14.7	7.9	1726.5	1726.5	1706.2	1706.2	45.5	45.5	3.1	6.5	295.8	295.8	0.0	0.0	0.0	33.5	36	136.5	136.5	0.0	0.0	0.0	9	20.3	183.1	20.3	183.1	0.0	0.0	0.0	0.0	0.0	0.0
	2.330			17.0	9.3	1730.1	1730.1	1704.4	1704.4	57.4	57.4	4.2	6.5	373.2	373.2	0.0	0.0	0.0	33.5	36	172.2	172.2	0.0	0.0	0.0	9	25.7	231.1	25.7	231.1	0.0	0.0	0.0	0.0	0.0	0.0
	2.400			13.2	11.6	1733.1	1733.1	1711.3	1711.3	48.7	48.7	2.5	6.5	316.2	316.2	0.0	0.0	0.0	33.5	36	146.0	146.0	0.0	0.0	0.0	9	21.8	195.8	21.8	195.8	0.0	0.0	0.0	0.0	0.0	0.0
	2.470			14.9	10.1	1734.5	1734.5	1706.9	1706.9	61.6	61.6	3.2	6.5	400.7	400.7	0.0	0.0	0.0	33.5	36	184.9	184.9	0.0	0.0	0.0	9	27.6	248.1	27.6	248.1	0.0	0.0	0.0	0.0	0.0	0.0
	2.520			11.5	11.1	1736.2	1736.2	1713.3	1713.3	51.2	51.2	1.9	6.5	332.6	332.6	0.0	0.0	0.0	33.5	36	153.5	153.5	0.0	0.0	0.0	9	22.9	205.9	22.9	205.9	0.0	0.0	0.0	0.0	0.0	0.0
	2.600			13.6	9.4	1737.9	1739.9	1711.6	1699.3	58.9	90.8	2.6	6.5	382.8	589.9	0.0	0.0	0.0	33.5	36	176.7	272.3	0.0	0.0	0.0	9	26.3	237.0	40.6	365.3	0.0	0.0	0.0	0.0	0.0	0.0
	2.730																																			
									Average	49.5	55.9	4.2															22.1		25.0							
										Quantity/Total						0.0	0.0	0.0					0.0	0.0	0.0						0.0	0.0	0.0	0.0	0.0	0.0
Upper Reach	2.730			15.5	9.3	1741.3	1744.9	1718.2	1706.4	51.6	86.1	3.5	5.5	283.8	473.7	0.0	0.0	0.0	28.0	30	129.0	215.3	0.0	0.0	0.0	9	23.1	207.7	38.5	346.7	0.0	0.0	0.0	0.0	0.0	0.0
	2.820			3.8	7.5	1745.6	1745.1	1717.9	1726.4	61.8	41.7	0.2	5.5	339.9	229.4	0.0	0.0	0.0	28.0	30	154.5	104.3	0.0	0.0	0.0	9	27.6	248.7	18.7	167.9	0.0	0.0	0.0	0.0	0.0	0.0
	2.870			3.6	6.3	1745.7	1745.3	1718.9	1726.9	59.9	41.1	0.2	5.5	329.3	225.8	0.0	0.0	0.0	28.0	30	149.7	102.6	0.0	0.0	0.0	9	26.8	241.0	18.4	165.3	0.0	0.0	0.0	0.0	0.0	0.0
	2.900			3.8	4.6	1745.9	1745.5	1720.7	1727.2	56.5	40.9	0.2	5.5	311.0	225.0	0.0	0.0	0.0	28.0	30	141.3	102.3	0.0	0.0	0.0	9	25.3	227.6	18.3	164.6	0.0	0.0	0.0	0.0	0.0	0.0
	2.920			4.1	3.3	1745.8	1745.8	1726.1	1726.1	43.9	43.9	0.2	5.5	241.7	241.7	0.0	0.0	0.0	28.0	30	109.9	109.9	0.0	0.0	0.0	9	19.7	176.9	19.7	176.9	0.0	0.0	0.0	0.0	0.0	0.0
	2.970	23000		4.4	2.8	1746.9	1746.9	1732.9	1732.9	31.2	31.2	0.3	5.5	171.9	171.9	3360.8	0.0	3360.8	28.0	30	78.1	78.1	1527.6	0.0	1527.6	9	14.0	125.8	14.0	125.8	2459.5	0.0	2459.5	348.6	0.0	348.6
	3.070	23528		12.0	6.4	1751.4	1751.4	1731.3	1731.3	45.1	45.1	2.0	5.5	247.8	247.8	2907.5	0.0	2907.5	28.0	30	112.6	112.6	1321.6	0.0	1321.6	9	20.1	181.3	20.1	181.3	2127.7	0.0	2127.7	301.6	0.0	301.6
	3.130	23845		11.5	6.4	1753.3	1753.3	1734.0	1734.0	43.1	43.1	1.9	5.5	236.9	236.9	3705.8	0.0	3705.8	28.0	30	107.7	107.7	1684.5	0.0	1684.5	9	19.3	173.3	19.3	173.3	2711.9	0.0	2711.9	384.4	0.0	384.4
	3.210	24267		11.2	5.1	1755.5	1755.5	1738.2	1738.2	38.8	38.8	1.8	5.5	213.3	213.3	4588.3	0.0	4588.3	28.0	30	97.0	97.0	2085.6	0.0	2085.6	9	17.3	156.1	17.3	156.1	3357.7	0.0	3357.7	476.0	0.0	476.0
	3.320	24848		11.2	4.9	1759.3	1759.3	1741.0	1741.0	40.8	40.8	1.8	5.5	224.7	224.7	3514.7	0.0	3514.7	28.0	30	102.1	102.1	1597.6	0.0	1597.6	9	18.3	164.4	18.3	164.4	2572.1	0.0	2572.1	364.6	0.0	364.6
	3.400	25270		11.2	6.5	1763.2	1763.2	1743.4	1743.4	44.2	44.2	1.8	5.5	243.2	243.2	3805.3	0.0	3805.3	28.0	30	110.6	110.6	1729.7	0.0	1729.7	9	19.8	178.0	19.8	178.0	2784.7	0.0	2784.7	394.7	0.0	394.7
	3.480	25693		12.4	7.2	1766.6	1766.6	1746.9	1746.9	44.0	44.0	2.2	5.5	241.8	241.8	1891.5	0.0	1891.5	28.0	30	109.9	109.9	859.8	0.0	859.8	9	19.7	177.0	19.7	177.0	1384.2	0.0	1384.2	196.2	0.0	196.2
	3.520	25904	27600	12.5	8.2	1768.6	1768.6	1747.4	1747.4	47.3	47.3	2.2	5.5	260.4	260.4	4073.9	3394.9	7468.8	28.0	30	118.4	118.4	1851.8	1543.1	3394.9	9	21.2	190.6	21.2	190.6	2981.3	2484.4	5465.7	422.6	352.2	774.8
	3.600	26326	27952	13.9	7.1	1770.9	1770.9	1750.1	1750.1	46.4	46.4	2.8	5.5	255.3	255.3	2495.9	2495.9	4991.8	28.0	30	116.0	116.0	1134.5	1134.5	2269.0	9	20.8	186.8	20.8	186.8	1826.5	1826.5	3653.0	258.9	258.9	517.8
	3.650	26590	28216	10.7	7.2	1772.7	1772.7	1753.4	1753.4	43.1	43.1	1.6	5.5	237.2	237.2	874.9	4637.9	5512.8	28.0	30	107.8	107.8	397.7	2108.1	2505.8	9	19.3	173.6	19.3	173.6	640.2	3394.0	4034.3	90.8	481.1	571.9
	3.750	26690	28744	14.1	8.1	1776.0	1776.0	1754.5	1754.5	48.1	48.1	2.8	5.5	264.4	264.4	-3819.6	1551.3	-2268.2	28.0	30	120.2	120.2	-1736.2	705.2	-1031.0	9	21.5	193.5	21.5	193.5	-2795.2	1135.3	-1659.9	-396.2	160.9	-235.3
	3.780	26300	28902	11.0	5.5	1777.6	1777.6	1752.5	1752.5	56.1	56.1	1.7	5.5	308.4	308.4	4825.0	4825.0	9650.1	28.0	30	140.2	140.2	2193.2	2193.2	4386.4	9	25.1	225.7	25.1	225.7	3531.0	3531.0	7062.0	500.5	500.5	1001.0
	3.860	26722	29325	12.0	5.7	1780.8	1780.8	1760.8	1760.8	44.7	44.7	2.0	5.5	246.1	246.1	4812.9	3447.4	8260.3	28.0	30	111.9	111.9	2187.7	1567.0	3754.7	9	20.0	180.1	20.0	180.1	3522.1	2522.8	6044.9	499.3	357.6	856.9
	3.960	27250	29703	9.3	4.0	1785.4	1785.4	1766.4	1766.4	42.5	42.5	1.2	5.5	233.9	233.9	4117.5	0.0	4117.5	28.0	30	106.3	106.3	1871.6	0.0	1871.6	9	19.0	171.2	19.0	171.2	3013.2	0.0	3013.2	427.1	0.0	427.1
	4.050	27726		13.9	5.5	1788.7	1788.7	1770.4	1770.4	40.8	40.8	2.8	5.5	224.5	224.5	2633.9	0.0	2633.9	28.0	30	102.0	102.0	1197.2	0.0	1197.2	9	18.3	164.3	18.3	164.3	1927.5	0.0	1927.5	273.2	0.0	273.2
	4.110	28042		10.8	4.6	1791.9	1791.9	1774.7	1774.7	38.4	38.4	1.6	5.5	211.4	211.4	4548.3	0.0	4548.3	28.0	30	96.1	96.1	2067.4	0.0	2067.4	9	17.2	154.7	17.2	154.7	3328.5	0.0	3328.5	471.8	0.0	471.8
	4.220	28623		12.4	4.3	1794.4	1794.4	1777.4	1777.4	38.1	38.1	2.2	5.5	209.6	209.6	409.9	0.0	409.9	28.0	30	95.3	95.3	186.3	0.0	186.3	9	17.0	153.4	17.0	153.4	299.9	0.0	299.9	42.5	0.0	42.5
	4.230	28676		12.3	5.1	1795.6	1795.6	1778.0	1778.0	39.4	39.4	2.1	5.5	216.9	216.9	3392.7	0.0	3392.7	28.0	30	98.6	98.6	1542.2	0.0	1542.2	9	17.6	158.7	17.6	158.7	2482.8	0.0	2482.8	351.9	0.0	351.9
	4.310	29098		12.5	7.9	1800.3	1800.3	1780.6	1780.6	44.2	44.2	2.2	5.5	242.9	242.9	4274.2	0.0	4274.2	28.0	30	110.4	110.4	1942.8	0.0	1942.8	9	19.7	177.7	19.7	177.7	3127.9	0.0	3127.9	443.4	0.0	443.4
	4.400	29574		15.6	6.2	1803.0	1803.0	1785.8	1785.8	38.4	38.4	3.5	5.5	211.4	211.4	3565.4	0.0	3565.4	28.0	30	96.1	96.1	1620.7	0.0	1620.7	9	17.2	154.7	17.2	154.7	2609.2	0.0	2609.2	369.9	0.0	369.9
	4.490	30029		11.6	5.7	1806.5	1806.5	1779.4	1779.4	60.6	60.6	1.9	5.5	333.1	333.1	0.0	0.0	0.0	28.0	30	151.4	151.4	0.0	0.0	0.0	9	27.1	243.8	27.1	243.8	0.0	0.0	0.0	0.0	0.0	0.0
	4.560			6.1	7.5	1811.0	1811.0	1785.4	1785.4	57.3	57.3	0.5	5.5	315.0	315.0	0.0	0.0	0.0	28.0	30	143.2	143.2	0.0	0.0	0.0	9	25.6	230.5	25.6	230.5	0.0	0.0	0.0	0.0	0.0	0.0
	4.600																																			
									Average	46.2	45.4	3.5															20.6		20.3							
										Quantity/Total						59978.8	20352.5	80331.3					27263.1	9251.1	36514.2						43892.7	14894.0	58786.8	6221.8	2111.2	8333.0
															Total	73060.4	40783.9	113844.3					33209.3	18538.1	51747.4						53465.9	29845.8	83311.7	7578.8	4230.6	11809.4

Reach	Center Stationing ID (River miles)	Left Bank Stationing (ft)	Right Bank Stationing (ft)	HEC-RAS 100 Year Flow Velocity (fps) *1	Average Hydraulic Depth, V_m (fps) *1	Left Top of Bank Elev (ft) *2	Right Top of Bank Elev (ft) *2	Left Bank Toe Down Elevation (ft) *3	Right Bank Toe Down Elevation (ft) *3	Left Bank Slope Length (ft) *4	Right Bank Slope Length (ft) *4	USBR Dumped Riprap Median Riprap Particle Size, D_{50} (ft) *5	USBR Riprap Layer Thickness (ft) *6	Left Bank USBR Riprap Volume per Length (ft^3/ft) *7	Right Bank USBR Riprap Volume per Length (ft^3/ft) *7	Left Bank Riprap Volume (yd^3)	Right Bank Riprap Volume (yd^3)	USBR Total Riprap Volume, (yd^3) *8
Paradise Wash Reach		10000	10000															
	0.040			5.0	9.7	1740.1	1740.1	1723.0	1723.0	38.2	38.2	0.3	4.5	172.1	172.1	0.0	0.0	0.0
	0.130			10.0	5.0	1740.6	1740.6	1725.8	1725.8	33.0	33.0	1.4	4.5	148.5	148.5	0.0	0.0	0.0
	0.170			10.4	6.8	1742.3	1742.3	1727.5	1727.5	33.1	33.1	1.5	4.5	149.1	149.1	0.0	0.0	0.0
	0.280			11.0	4.6	1747.3	1747.2	1732.4	1732.5	33.2	32.8	1.7	4.5	149.6	147.6	0.0	0.0	0.0
	0.340			11.9	3.2	1750.3	1750.2	1738.2	1738.3	27.0	26.7	2.0	4.5	121.4	120.0	0.0	0.0	0.0
	0.440			10.0	4.1	1754.3	1754.3	1742.1	1742.1	27.2	27.2	1.4	4.5	122.4	122.4	0.0	0.0	0.0
	0.530			11.6	5.1	1758.4	1758.4	1744.5	1744.5	31.1	31.1	1.9	4.5	139.9	139.9	0.0	0.0	0.0
	0.620			10.0	5.3	1762.8	1762.8	1749.0	1749.0	30.8	30.8	1.4	4.5	138.4	138.4	0.0	0.0	0.0
	0.720			11.6	4.1	1765.5	1765.5	1753.0	1753.0	28.0	28.0	1.9	4.5	126.0	126.0	0.0	0.0	0.0
	0.800			11.1	4.6	1770.0	1770.0	1756.7	1756.7	29.6	29.6	1.7	4.5	133.3	133.3	0.0	0.0	0.0
	0.890			10.5	7.1	1774.8	1774.8	1757.9	1757.9	37.8	37.8	1.6	4.5	170.0	170.0	0.0	0.0	0.0
	0.950			9.7	5.6	1776.2	1776.4	1763.0	1760.7	29.5	35.1	1.3	4.5	132.8	158.1	0.0	0.0	0.0
	1.040			8.6	5.1	1778.7	1778.6	1764.7	1766.4	31.5	27.3	1.0	4.5	141.5	122.7	0.0	0.0	0.0
	1.120			10.2	4.8	1781.8	1781.8	1767.1	1767.1	32.9	32.9	1.4	4.5	148.2	148.2	0.0	0.0	0.0
	1.210			11.1	5.9	1785.3	1785.3	1771.2	1771.2	31.5	31.5	1.7	4.5	141.9	141.9	0.0	0.0	0.0
	1.270	16500		9.6	5.7	1788.1	1788.1	1774.5	1774.5	30.4	30.4	1.3	4.5	136.7	136.7	2644.9	0.0	2644.9
	1.370	17022		12.8	4.8	1791.5	1791.0	1774.1	1776.1	38.9	33.3	2.3	4.5	175.2	150.0	3082.7	0.0	3082.7
	1.460	17498		11.5	5.4	1795.1	1794.7	1779.1	1781.0	35.7	30.7	1.9	4.5	160.8	138.0	2515.1	0.0	2515.1
	1.540	17920		8.3	4.1	1797.5	1797.5	1787.0	1787.0	23.5	23.5	0.9	4.5	105.7	105.7	2272.7	0.0	2272.7
	1.650	18501		11.5	4.7	1804.1	1804.1	1791.1	1791.1	29.1	29.1	1.9	4.5	131.0	131.0	2561.8	0.0	2561.8
	1.750	19029		11.2	4.1	1808.8	1808.8	1794.9	1794.9	31.2	31.2	1.8	4.5	140.3	140.3	2195.4	0.0	2195.4
	1.830	19451		10.7	4.6	1814.3	1814.3	1801.3	1801.3	29.0	29.0	1.6	4.5	130.4	130.4	259.8	0.0	259.8
	1.920	19505		9.8	4.5	1818.5	1818.5	1805.6	1805.6	28.9	28.9	1.3	4.5	129.9	129.9	0.0	0.0	0.0
	2.000			14.6	6.6	1824.2	1824.2	1805.9	1805.9	41.0	41.0	3.0	4.5	184.6	184.6	0.0	0.0	0.0
	2.001																	
									Average	**31.8**	**31.3**	**3.0**						
										Quantity/Total						**15532.4**	**0.0**	**15532.4**
															Total	**15532.4**	**0.0**	**15532.4**

Center Stationing ID (River miles)	Necessary USBR Gabion Thickness (in) *9	Manufactured Gabion Size (in) *9	Left Bank USBR Gabion Volume per Length (ft^3/ft) *7	Right Bank USBR Gabion Volume per Length (ft^3/ft) *7	Left Bank Gabion Volume (yd^3)	Right Bank Gabion Volume (yd^3)	Total Gabion Volume, (yd^3) *8	Standard CSA Layer Thickness (ft)	Height of Left Bank (ft) *10	Left Bank Volume per Length (ft^3/ft) *7	Height of Right Bank (ft) *10	Right Bank Volume per Length (ft^3/ft) *7	Left Bank CSA Volume (yd^3)	Right Bank CSA Volume (yd^3)	Total Volume of CSA (yd^3) *8	Left Bank CSA Cement (tons) *11	Right Bank CSA Cement (tons) *11	Total CSA Cement (tons) *11
0.040	24.3	27	86.0	86.0	0.0	0.0	0.0	9	17.1	153.9	17.1	153.9	0.0	0.0	0.0	0.0	0.0	0.0
0.130	24.3	27	74.2	74.2	0.0	0.0	0.0	9	14.8	132.8	14.8	132.8	0.0	0.0	0.0	0.0	0.0	0.0
0.170	24.3	27	74.5	74.5	0.0	0.0	0.0	9	14.8	133.3	14.8	133.3	0.0	0.0	0.0	0.0	0.0	0.0
0.280	24.3	27	74.8	73.8	0.0	0.0	0.0	9	14.9	133.8	14.7	132.0	0.0	0.0	0.0	0.0	0.0	0.0
0.340	24.3	27	60.7	60.0	0.0	0.0	0.0	9	12.1	108.6	11.9	107.3	0.0	0.0	0.0	0.0	0.0	0.0
0.440	24.3	27	61.2	61.2	0.0	0.0	0.0	9	12.2	109.5	12.2	109.5	0.0	0.0	0.0	0.0	0.0	0.0
0.530	24.3	27	70.0	70.0	0.0	0.0	0.0	9	13.9	125.2	13.9	125.2	0.0	0.0	0.0	0.0	0.0	0.0
0.620	24.3	27	69.2	69.2	0.0	0.0	0.0	9	13.8	123.8	13.8	123.8	0.0	0.0	0.0	0.0	0.0	0.0
0.720	24.3	27	63.0	63.0	0.0	0.0	0.0	9	12.5	112.7	12.5	112.7	0.0	0.0	0.0	0.0	0.0	0.0
0.800	24.3	27	66.7	66.7	0.0	0.0	0.0	9	13.3	119.3	13.3	119.3	0.0	0.0	0.0	0.0	0.0	0.0
0.890	24.3	27	85.0	85.0	0.0	0.0	0.0	9	16.9	152.0	16.9	152.0	0.0	0.0	0.0	0.0	0.0	0.0
0.950	24.3	27	66.4	79.1	0.0	0.0	0.0	9	13.2	118.8	15.7	141.4	0.0	0.0	0.0	0.0	0.0	0.0
1.040	24.3	27	70.8	61.3	0.0	0.0	0.0	9	14.1	126.6	12.2	109.7	0.0	0.0	0.0	0.0	0.0	0.0
1.120	24.3	27	74.1	74.1	0.0	0.0	0.0	9	14.7	132.6	14.7	132.6	0.0	0.0	0.0	0.0	0.0	0.0
1.210	24.3	27	71.0	71.0	0.0	0.0	0.0	9	14.1	126.9	14.1	126.9	0.0	0.0	0.0	0.0	0.0	0.0
1.270	24.3	27	68.4	68.4	1322.5	0.0	1322.5	9	13.6	122.3	13.6	122.3	2365.7	0.0	2365.7	335.3	0.0	335.3
1.370	24.3	27	87.6	75.0	1541.3	0.0	1541.3	9	17.4	156.7	14.9	134.2	2757.2	0.0	2757.2	390.8	0.0	390.8
1.460	24.3	27	80.4	69.0	1257.5	0.0	1257.5	9	16.0	143.8	13.7	123.4	2249.5	0.0	2249.5	318.9	0.0	318.9
1.540	24.3	27	52.8	52.8	1136.4	0.0	1136.4	9	10.5	94.5	10.5	94.5	2032.8	0.0	2032.8	288.1	0.0	288.1
1.650	24.3	27	65.5	65.5	1280.9	0.0	1280.9	9	13.0	117.2	13.0	117.2	2291.4	0.0	2291.4	324.8	0.0	324.8
1.750	24.3	27	70.2	70.2	1097.7	0.0	1097.7	9	13.9	125.5	13.9	125.5	1963.6	0.0	1963.6	278.3	0.0	278.3
1.830	24.3	27	65.2	65.2	129.9	0.0	129.9	9	13.0	116.6	13.0	116.6	232.4	0.0	232.4	32.9	0.0	32.9
1.920	24.3	27	65.0	65.0	0.0	0.0	0.0	9	12.9	116.2	12.9	116.2	0.0	0.0	0.0	0.0	0.0	0.0
2.000	24.3	27	92.3	92.3	0.0	0.0	0.0	9	18.3	165.1	18.3	165.1	0.0	0.0	0.0	0.0	0.0	0.0
2.001																		
									14.3		**14.1**							
					7766.2	**0.0**	**7766.2**						**13892.6**	**0.0**	**13892.6**	**1969.3**	**0.0**	**1969.3**
					7766.2	**0.0**	**7766.2**						**13892.6**	**0.0**	**13892.6**	**1969.3**	**0.0**	**1969.3**

*1 All hydraulic parameters from HEC-RAS Apache1.prj

*2 Top of Bank = WSE + Superelevation + 3'

*3 Minimum HEC-RAS Elevation - HEC-6 Design Scour Depth - Armoring Depth

*4 Slope Length = ((Top of Bank - Toe Down)^2 + ((Top of Bank - Toe Down) * 2)^2)$^{0.5}$

*5 USBR D_{50} from USGS WRI Report 86-4128 Figure 38

$D_{50} = 0.0122 * V_a^{2.06}$

*6 Layer Thickness = 1.5 * Reach Max D_{50} - Drainage Design for MC Volume II Table 6.4 pg.6-40
Rounded Up to the Nearest 1/2 foot

*7 Volume per Length = Slope Length * Layer Thickness

*8 ((Suceeding Station No. - Station No.) * 5280 * (L Bank + R Bank Volume per Length)) / 27

*9 Used COT Method of 2/3 * Dumped D_{50}, 1' Minimum (FHWA HEC-11 Table 5 p. 84)

*10 Height of Bank = Top of Bank - Toe Down

*11 CSA Cement = Volume of CSA * 7%
Density of Cement = 150 lb/ft^3

Reach	Center Stationing ID (River miles)	Left Bank Stationing (ft)	Right Bank Stationing (ft)	HEC-RAS 100 Year Flow Velocity (fps) [1]	Average Hydraulic Depth, V_m (fps) [1]	Left Top of Bank Elev (ft) [2]	Right Top of Bank Elev (ft) [2]	Left Bank Toe Down Elevation (ft) [3]	Right Bank Toe Down Elevation (ft) [3]	Left Bank Slope Length (ft) [4]	Right Bank Slope Length (ft) [4]	USBR Dumped Riprap Median Riprap Particle Size, D_{50} (ft) [5]	USBR Riprap Layer Thickness (ft) [6]	Left Bank USBR Riprap Volume per Length (ft^3/ft) [7]	Right Bank USBR Riprap Volume per Length (ft^3/ft) [7]	Left Bank Riprap Volume (yd^3)	Right Bank Riprap Volume (yd^3)	USBR Total Riprap Volume, (yd^3) [8]
Desert Hills Wash Reach		10000	10600															
	0.386	10000	10600	10.6	7.2	1748.4	1748.4	1733.0	1733.0	34.5	34.5	1.6	3.0	103.4	103.4	283.0	283.0	565.9
	0.400	10074	10674	10.0	6.4	1749.2	1749.2	1733.5	1733.5	35.1	35.1	1.4	3.0	105.3	105.3	1647.7	1647.7	3295.4
	0.480	10496	11096	8.9	7.2	1750.6	1750.6	1737.0	1737.0	30.4	30.4	1.1	3.0	91.2	91.2	1427.3	1427.3	2854.5
	0.560	10919	11519	10.2	7.4	1751.5	1751.5	1730.3	1730.3	47.3	47.3	1.4	3.0	142.0	142.0	2221.9	2221.9	4443.8
	0.640	11341	11941	11.8	6.4	1752.7	1752.7	1731.6	1731.6	47.1	47.1	2.0	3.0	141.3	141.3	2211.2	2211.2	4422.3
	0.720	11764	12364	11.5	6.5	1754.5	1754.5	1733.7	1733.7	46.5	46.5	1.9	3.0	139.4	139.4	2453.7	2088.6	4542.3
	0.810	12239	12768	9.9	6.6	1756.7	1756.7	1737.5	1737.5	43.0	43.0	1.4	3.0	128.9	128.9	4034.6	0.0	4034.6
	0.811	13084																
									Average	**40.6**	**40.6**	**2.0**						
										Quantity/Total						**14279.3**	**9879.5**	**24158.9**
															Total	**14279.3**	**9879.5**	**24158.9**

Center Stationing ID (River miles)	Necessary USBR Gabion Thickness (in) [9]	Manufactured Gabion Size (in) [9]	Left Bank USBR Gabion Volume per Length (ft^3/ft) [7]	Right Bank USBR Gabion Volume per Length (ft^3/ft) [7]	Left Bank Gabion Volume (yd^3)	Right Bank Gabion Volume (yd^3)	Total Gabion Volume, (yd^3) [8]	Standard CSA Layer Thickness (ft)	Height of Left Bank (ft) [10]	Left Bank Volume per Length (ft^3/ft) [7]	Height of Right Bank (ft) [10]	Bank Volume per Length (ft^3/ft) [7]	Left Bank CSA Volume (yd^3)	Right Bank CSA Volume (yd^3)	Total Volume of CSA (yd^3) [8]	Left Bank CSA Cement (tons) [11]	Right Bank CSA Cement (tons) [11]	Total CSA Cement (tons) [11]
0.386	15.8	18	51.7	51.7	141.5	141.5	283.0	9	15.4	138.7	15.4	138.7	379.6	379.6	759.3	53.8	53.8	107.6
0.400	15.8	18	52.7	52.7	823.8	823.8	1647.7	9	15.7	141.3	15.7	141.3	2210.6	2210.6	4421.2	313.4	313.4	626.7
0.480	15.8	18	45.6	45.6	713.6	713.6	1427.3	9	13.6	122.4	13.6	122.4	1914.9	1914.9	3829.8	271.4	271.4	542.9
0.560	15.8	18	71.0	71.0	1110.9	1110.9	2221.9	9	21.2	190.5	21.2	190.5	2981.0	2981.0	5962.0	422.6	422.6	845.1
0.640	15.8	18	70.7	70.7	1105.6	1105.6	2211.2	9	21.1	189.6	21.1	189.6	2966.6	2966.6	5933.1	420.5	420.5	841.0
0.720	15.8	18	69.7	69.7	1226.9	1044.3	2271.2	9	20.8	187.0	20.8	187.0	3292.0	2802.1	6094.2	466.6	397.2	863.8
0.810	15.8	18	64.4	64.4	2017.3	0.0	2017.3	9	19.2	172.9	19.2	172.9	5413.0	0.0	5413.0	767.3	0.0	767.3
0.811																		
Average									**18.1**		**18.1**							
Quantity/Total					**7139.7**	**4939.8**	**12079.4**						**19157.7**	**13254.8**	**32412.5**	**2715.6**	**1878.9**	**4594.5**
Total					**7139.7**	**4939.8**	**12079.4**						**19157.7**	**13254.8**	**32412.5**	**2715.6**	**1878.9**	**4594.5**

[1] All hydraulic parameters from HEC-RAS Apache1.prj

[2] Top of Bank = WSE + Superelevation + 3'

[3] Minimum HEC-RAS Elevation - HEC-6 Design Scour Depth - Armoring Depth

[4] Slope Length = $((\text{Top of Bank} - \text{Toe Down})^2 + ((\text{Top of Bank} - \text{Toe Down}) * 2)^2)^{0.5}$

[5] USBR D_{50} from USGS WRI Report 86-4128 Figure 38

$D_{50} = 0.0122 * V_a^{2.06}$

[6] Layer Thickness = 1.5 * Reach Max D_{50} - Drainage Design for MC Volume II Table 6.4 pg.6-40 Rounded Up to the Nearest 1/2 Foot

[7] Volume per Length = Slope Length * Layer Thickness

[8] ((Suceeding Station No. - Station No.) * 5280 * (L Bank + R Bank Volume per Length)) / 27

[9] Used COT Method of 2/3 * Dumped D_{50} 1' Minimum (FHWA HEC-11 Table 5 p. 84)

[10] Height of Bank = Top of Bank - Toe Down

[11] CSA Cement = Volume of CSA * 7%

Density of Cement = 150 lb/ft^3

HEC-RAS Plan: Team Alt100F River: RIVER-1 Reach: Reach-1

Reach	River Sta	Profile	Min Ch El	W.S. Elev	Q Total	Vel Chnl	Max Chl Dpth	Hydr Depth C	E.G. Slope	Sta W.S. Lft	Top W Chnl	Sta W.S. Rgt	Vel Total
			(ft)	(ft)	(cfs)	(ft/s)	(ft)	(ft)	(ft/ft)	(ft)	(ft)	(ft)	(ft/s)
Reach-1	24.525	100 yr encr	1623.90	1632.6	41400.00	6.39	8.74	6.46	0.003004	8863.03	232.80	11416.59	4.04
Reach-1	24.646	100 yr encr	1626.00	1636.1	41400.00	13.86	10.13	7.48	0.011638	8810.00	165.60	10973.25	7.52
Reach-1	24.752	100 yr encr	1629.20	1641.1	41400.00	9.70	11.89	7.73	0.005513	8724.78	161.30	10189.03	5.78
Reach-1	24.845	100 yr encr	1635.30	1644.7	41400.00	14.69	9.36	7.60	0.013083	8680.11	112.69	10056.14	7.84
Reach-1	24.919	100 yr encr	1634.90	1648.1	41400.00	8.55	13.24	7.98	0.004189	8549.03	160.57	10006.28	5.32
Reach-1	25.01	100 yr encr	1640.20	1650.1	41400.00	9.11	9.89	7.80	0.004725	8664.33	424.60	10033.72	6.60
Reach-1	25.099	100 yr encr	1646.00	1654.8	41400.00	14.87	8.80	4.98	0.023052	8914.00	162.60	10301.49	9.16
Reach-1	25.18	100 yr encr	1647.70	1659.8	41400.00	8.78	12.13	7.70	0.004488	8931.33	200.20	10453.04	5.35
Reach-1	25.233	100 yr encr	1647.30	1661.0	41400.00	11.34	13.71	7.93	0.007732	8785.36	109.30	10457.14	6.11
Reach-1	25.326	100 yr encr	1653.00	1664.9	39700.00	12.41	11.87	7.51	0.009285	9186.09	162.70	10519.11	7.14
Reach-1	25.388	100 yr encr	1656.60	1668.5	39700.00	13.06	11.86	7.05	0.011169	9321.99	176.60	10712.83	7.52
Reach-1	25.458	100 yr encr	1665.50	1672.4	39700.00	8.17	11.87	5.55	0.005966	9596.69	150.30	10986.47	5.72
Reach-1	25.519	100 yr encr	1668.30	1674.6	39700.00	9.16	13.03	4.60	0.009629	9568.99	155.00	10991.80	6.52
Reach-1	25.58	100 yr encr	1668.90	1677.2	39700.00	10.72	11.31	6.54	0.008293	9636.84	147.10	11022.48	6.42
Reach-1	25.644	100 yr encr	1669.80	1680.2	39700.00	13.51	10.87	8.25	0.009773	9535.30	152.70	11044.31	7.09
Reach-1	25.699	100 yr encr	1669.40	1682.7	39700.00	13.35	13.32	10.96	0.006634	9620.47	146.10	11105.92	6.75
Reach-1	25.75	100 yr encr	1671.60	1685.3	39700.00	9.06	13.68	8.88	0.004035	9575.67	160.60	11209.65	4.97
Reach-1	25.843	100 yr encr	1673.50	1686.6	39700.00	12.28	13.13	7.42	0.009313	9658.88	186.10	11312.30	6.78
Reach-1	25.919	100 yr encr	1678.40	1690.3	39700.00	12.57	11.90	6.76	0.011051	9857.85	189.00	11396.89	7.19
Reach-1	26.044	100 yr encr	1684.30	1695.2	39700.00	9.47	10.87	6.43	0.006920	9934.13	142.67	11732.33	5.55
Reach-1	26.137	100 yr encr	1685.70	1698.3	39700.00	10.23	12.58	6.99	0.007148	9988.45	299.04	11858.22	6.16
Reach-1	26.239	100 yr encr	1692.80	1701.8	39700.00	9.47	8.97	4.51	0.010866	9929.78	349.52	11814.19	6.50
Reach-1	26.335	100 yr encr	1695.60	1705.1	39700.00	7.81	9.52	6.50	0.004443	9640.67	671.36	11465.33	6.32
Reach-1	26.43	100 yr encr	1697.50	1707.5	39700.00	11.06	9.98	6.66	0.008659	9778.94	488.11	11231.08	9.84
Reach-1	26.529	100 yr encr	1702.60	1712.2	39700.00	13.25	9.60	6.92	0.011789	9789.43	383.37	11158.01	11.39
Reach-1	26.623	100 yr encr	1703.90	1716.7	39700.00	8.79	12.80	9.06	0.003631	9640.25	459.71	11116.23	7.75
Reach-1	26.695	100 yr encr	1709.50	1720.4	39700.00	15.50	10.92	7.10	0.016239	9779.01	254.50	11501.27	12.17
Reach-1	26.775	100 yr encr	1712.70	1725.8	39700.00	11.56	13.09	9.42	0.006124	9914.51	294.70	11591.28	9.02
Reach-1	26.845	100 yr encr	1717.00	1728.2	39700.00	11.91	11.16	8.31	0.007511	9666.95	353.15	11265.99	10.06
Reach-1	26.921	100 yr encr	1720.20	1731.4	35800.00	10.09	11.18	8.22	0.005469	9725.85	422.23	10895.60	9.44
Reach-1	27.008	100 yr encr	1723.00	1733.7	35800.00	10.14	10.67	7.58	0.006156	9698.67	463.10	10794.07	9.95
Reach-1	27.106	100 yr encr	1725.70	1737.9	35800.00	12.82	12.20	5.60	0.014755	9773.39	489.07	10844.96	12.27
Reach-1	27.169	100 yr encr	1732.10	1742.0	35800.00	9.10	9.94	7.25	0.005238	9869.33	504.80	10987.78	8.27
Reach-1	27.226	100 yr encr	1734.80	1743.6	35800.00	12.37	8.80	6.18	0.011989	9928.58	433.48	11074.33	11.13
Reach-1	27.265	100 yr encr	1735.70	1749.0	35800.00	12.95	13.31	7.05	0.011416	9925.49	238.71	11169.15	8.86
Reach-1	27.32	100 yr encr	1740.30	1753.0	35800.00	12.95	12.65	10.18	0.006945	9692.79	162.25	11140.23	7.07
Reach-1	27.366	100 yr encr	1742.30	1754.9	35800.00	8.09	12.63	9.39	0.003014	9738.55	371.43	11135.83	5.91
Reach-1	27.417	100 yr encr	1744.80	1757.1	35800.00	14.21	12.30	7.54	0.012360	9880.87	254.29	11078.79	10.76
Reach-1	27.502	100 yr encr	1748.80	1765.0	35800.00	13.64	16.21	10.54	0.004918	9959.96	190.44	11017.45	7.65
Reach-1	27.604	100 yr encr	1754.20	1767.5	35800.00	14.39	13.31	9.89	0.005930	9774.48	239.92	10871.05	11.92
Reach-1	27.693	100 yr encr	1756.30	1774.6	35800.00	14.36	18.33	9.18	0.006648	9979.86	215.94	11046.70	8.68
Reach-1	27.797	100 yr encr	1760.60	1781.9	35800.00	22.91	21.35	16.37	0.009695	9973.61	95.46	10069.07	22.91
Reach-1	27.913	100 yr encr	1763.10	1791.2	35800.00	4.74	28.10	16.94	0.000319	9958.41	281.99	10963.29	2.94
Reach-1	28.023	100 yr encr	1772.50	1791.3	35800.00	6.70	18.83	12.89	0.001392	9770.58	306.51	10800.90	4.57
Reach-1	28.091	100 yr encr	1780.80	1791.8	35800.00	8.91	11.05	7.00	0.005293	9665.18	491.36	10863.85	7.21
Reach-1	28.157	100 yr encr	1782.60	1793.9	35800.00	11.43	11.29	6.22	0.010188	9624.09	431.11	11015.42	8.66
Reach-1	28.241	100 yr encr	1789.90	1799.2	35800.00	11.99	9.29	6.34	0.010793	9676.84	373.66	10773.27	8.56
Reach-1	28.326	100 yr encr	1791.30	1803.9	35800.00	13.57	12.57	9.36	0.005567	9835.09	215.01	10802.10	8.03
Reach-1	28.39	100 yr encr	1792.80	1806.9	35800.00	14.18	14.11	10.07	0.005636	9880.53	183.07	10767.70	8.12
Reach-1	28.462	100 yr encr	1794.80	1810.0	35800.00	14.84	15.17	11.90	0.005017	9892.40	168.80	10599.52	9.42
Reach-1	28.555	100 yr encr	1799.40	1814.3	35800.00	15.79	14.93	11.67	0.005793	9944.26	167.14	10459.48	11.03
Reach-1	28.657	100 yr encr	1800.50	1818.0	35800.00	13.96	17.53	9.72	0.005808	9949.67	247.33	10462.01	11.46
Reach-1	28.75	100 yr encr	1808.30	1821.6	35800.00	14.50	13.32	10.14	0.005751	9901.42	227.58	10585.19	11.09
Reach-1	28.847	100 yr encr	1811.90	1826.5	35800.00	15.15	14.58	12.10	0.005045	9910.27	166.63	10565.83	9.91
Reach-1	28.934	100 yr encr	1815.50	1830.2	35800.00	14.76	14.68	10.43	0.005774	9856.31	198.59	10503.39	10.10
Reach-1	29.012	100 yr encr	1818.70	1833.5	35800.00	15.92	14.80	11.89	0.005805	9940.20	151.10	10490.44	10.24
Reach-1	29.13	100 yr encr	1821.00	1838.3	36000.00	16.17	17.33	12.53	0.005764	9971.09	135.61	10563.47	9.77
Reach-1	29.258	100 yr encr	1828.70	1843.3	36000.00	14.08	14.57	10.02	0.008309	9793.64	255.12	10048.75	14.08
Reach-1	29.351	100 yr encr	1835.90	1848.5	36000.00	8.09	12.60	8.53	0.004351	9685.58	464.62	10309.60	7.41
Reach-1	29.387	100 yr encr	1838.80	1849.5	36000.00	7.44	10.71	7.07	0.004690	9485.77	621.63	10296.38	6.88
Reach-1	29.493	100 yr encr	1843.40	1852.8	36000.00	8.91	9.44	5.43	0.009485	9235.05	711.60	10131.51	8.37
Reach-1	29.538	100 yr encr	1845.50	1855.3	36000.00	11.63	9.84	4.84	0.018834	9326.09	634.20	10053.55	11.36
Reach-1	29.601	100 yr encr	1849.90	1859.8	36000.00	13.55	9.88	7.02	0.012130	9501.79	368.92	10047.92	12.52
Reach-1	29.663	100 yr encr	1850.90	1863.6	36000.00	11.48	12.69	8.30	0.006985	9646.86	374.76	10178.66	11.00
Reach-1	29.71	100 yr encr	1853.90	1864.7	36000.00	14.20	10.75	8.31	0.008791	9742.75	305.06	10047.81	14.20
Reach-1	29.715		Bridge										

HEC-RAS Plan: Team Alt 10F River: RIVER-1 Reach: Reach-1

Reach	River Sta	Profile	Q Total	W.S. Elev	Hydr Depth C	E.G. Slope	Mann Wtd Chnl	Vel Chnl	Top W Chnl	Q Channel	Froude # Chl	Shear Chan
			(cfs)	(ft)	(ft)	(ft/ft)		(ft/s)	(ft)	(cfs)		(lb/sq ft)
Reach-1	24.525	10 yr encr	10100.00	1628.9	3.30	0.003000	0.044	4.07	196.18	2635.05	0.40	0.61
Reach-1	24.646	10 yr encr	10100.00	1632.2	3.51	0.015948	0.044	9.79	165.60	5687.20	0.92	3.47
Reach-1	24.752	10 yr encr	10100.00	1637.2	5.30	0.005277	0.044	7.36	122.58	4780.31	0.56	1.71
Reach-1	24.845	10 yr encr	10100.00	1642.4	5.70	0.007627	0.044	9.27	106.30	5615.59	0.68	2.65
Reach-1	24.919	10 yr encr	10100.00	1644.6	6.96	0.003895	0.044	7.50	118.23	6177.78	0.50	1.63
Reach-1	25.01	10 yr encr	10100.00	1646.5	4.36	0.003010	0.044	4.94	413.83	8917.57	0.42	0.82
Reach-1	25.099	10 yr encr	10100.00	1652.4	2.87	0.019042	0.044	9.35	144.79	3887.71	0.97	3.38
Reach-1	25.18	10 yr encr	10100.00	1656.3	4.14	0.004068	0.044	5.53	200.20	4576.27	0.48	1.04
Reach-1	25.233	10 yr encr	10100.00	1657.4	4.52	0.016144	0.044	11.27	105.10	5354.75	0.93	4.29
Reach-1	25.326	10 yr encr	9800.00	1662.2	4.87	0.004761	0.044	6.66	162.70	5273.33	0.53	1.44
Reach-1	25.388	10 yr encr	9800.00	1665.0	4.12	0.014724	0.044	10.47	154.74	6671.31	0.91	3.76
Reach-1	25.458	10 yr encr	9800.00	1669.4	2.55	0.005792	0.044	4.80	150.30	1840.22	0.53	0.92
Reach-1	25.519	10 yr encr	9800.00	1672.2	2.21	0.010802	0.044	5.94	153.08	2007.13	0.71	1.49
Reach-1	25.58	10 yr encr	9800.00	1674.4	3.74	0.005366	0.044	5.94	147.10	3265.88	0.54	1.25
Reach-1	25.644	10 yr encr	9800.00	1676.0	4.83	0.012702	0.044	10.77	132.62	6905.55	0.86	3.78
Reach-1	25.699	10 yr encr	9800.00	1678.7	6.92	0.003771	0.044	7.41	146.10	7484.07	0.50	1.59
Reach-1	25.75	10 yr encr	9800.00	1679.9	5.50	0.009666	0.044	10.15	116.84	6518.69	0.76	3.23
Reach-1	25.843	10 yr encr	9800.00	1682.9	4.93	0.006704	0.044	7.93	150.96	5892.64	0.63	2.03
Reach-1	25.919	10 yr encr	9800.00	1685.9	4.77	0.014994	0.044	11.59	124.20	6865.55	0.94	4.39
Reach-1	26.044	10 yr encr	9800.00	1692.0	4.77	0.005978	0.044	7.22	109.28	3761.97	0.58	1.72
Reach-1	26.137	10 yr encr	9800.00	1694.6	5.03	0.005861	0.044	7.44	223.82	8372.88	0.58	1.79
Reach-1	26.239	10 yr encr	9800.00	1698.1	4.26	0.013405	0.044	10.07	164.17	7042.02	0.86	3.46
Reach-1	26.335	10 yr encr	9800.00	1701.8	3.63	0.002716	0.044	4.15	618.97	9325.21	0.38	0.61
Reach-1	26.43	10 yr encr	9800.00	1703.7	3.11	0.008033	0.044	6.42	465.66	9285.47	0.64	1.55
Reach-1	26.529	10 yr encr	9800.00	1708.0	3.97	0.009598	0.044	8.26	282.67	9261.80	0.73	2.36
Reach-1	26.623	10 yr encr	9800.00	1711.3	4.46	0.003405	0.044	5.32	406.49	9641.87	0.44	0.94
Reach-1	26.695	10 yr encr	9800.00	1715.9	4.25	0.014974	0.044	10.66	189.68	8603.68	0.91	3.88
Reach-1	26.775	10 yr encr	9800.00	1720.6	4.60	0.006007	0.044	7.16	281.03	9256.37	0.59	1.70
Reach-1	26.845	10 yr encr	9800.00	1723.2	3.78	0.008339	0.044	7.45	328.59	9235.15	0.68	1.95
Reach-1	26.921	10 yr encr	8800.00	1726.5	3.58	0.005948	0.044	6.07	405.14	8800.00	0.57	1.32
Reach-1	27.008	10 yr encr	8800.00	1729.0	3.27	0.006997	0.044	6.20	433.75	8800.00	0.60	1.42
Reach-1	27.106	10 yr encr	8800.00	1733.9	2.95	0.016459	0.044	8.84	336.90	8800.00	0.91	3.00
Reach-1	27.169	10 yr encr	8800.00	1737.7	3.32	0.005747	0.044	5.68	466.14	8800.00	0.55	1.19
Reach-1	27.226	10 yr encr	8800.00	1740.0	2.75	0.013705	0.044	7.72	414.75	8800.00	0.82	2.34
Reach-1	27.265	10 yr encr	8800.00	1744.2	4.34	0.018097	0.044	11.80	171.96	8800.00	1.00	4.73
Reach-1	27.32	10 yr encr	8800.00	1748.1	5.91	0.008342	0.044	9.95	149.61	8800.00	0.72	3.02
Reach-1	27.366	10 yr encr	8800.00	1750.4	4.98	0.002126	0.044	4.49	363.88	8128.26	0.35	0.65
Reach-1	27.417	10 yr encr	8800.00	1751.9	3.96	0.018269	0.044	11.28	196.93	8800.00	1.00	4.43
Reach-1	27.502	10 yr encr	8800.00	1757.5	5.33	0.009341	0.036	11.99	137.53	8800.00	0.92	3.04
Reach-1	27.604	10 yr encr	8800.00	1762.2	5.01	0.004204	0.036	7.75	226.54	8800.00	0.61	1.29
Reach-1	27.693	10 yr encr	8800.00	1766.1	5.95	0.010976	0.036	13.79	107.18	8800.00	1.00	3.90
Reach-1	27.797	10 yr encr	8800.00	1771.4	7.57	0.008750	0.036	14.10	82.41	8800.00	0.90	3.81
Reach-1	27.913	10 yr encr	8800.00	1777.4	4.90	0.004406	0.036	7.79	230.54	8800.00	0.62	1.32
Reach-1	28.023	10 yr encr	8800.00	1780.8	4.99	0.010297	0.044	9.74	180.87	8800.00	0.77	3.08
Reach-1	28.091	10 yr encr	8800.00	1786.0	3.30	0.019521	0.044	10.36	257.56	8800.00	1.01	3.96
Reach-1	28.157	10 yr encr	8800.00	1790.8	3.67	0.006578	0.044	6.47	370.68	8800.00	0.59	1.49
Reach-1	28.241	10 yr encr	8800.00	1794.9	3.26	0.018923	0.044	10.19	264.80	8800.00	0.99	3.84
Reach-1	28.326	10 yr encr	8800.00	1799.0	5.48	0.004512	0.036	8.57	187.53	8800.00	0.65	1.53
Reach-1	28.39	10 yr encr	8800.00	1800.3	5.93	0.008204	0.036	12.02	123.52	8800.00	0.87	2.95
Reach-1	28.462	10 yr encr	8800.00	1803.3	7.13	0.003828	0.036	9.27	133.17	8800.00	0.61	1.65
Reach-1	28.555	10 yr encr	8800.00	1806.0	5.30	0.011066	0.036	13.02	127.46	8800.00	1.00	3.59
Reach-1	28.657	10 yr encr	8800.00	1811.3	5.82	0.005187	0.036	9.39	161.01	8800.00	0.69	1.82
Reach-1	28.75	10 yr encr	8800.00	1814.5	4.11	0.011182	0.036	11.15	192.30	8800.00	0.97	2.85
Reach-1	28.847	10 yr encr	8800.00	1819.1	5.66	0.006673	0.036	10.59	146.83	8800.00	0.78	2.32
Reach-1	28.934	10 yr encr	8800.00	1822.7	4.93	0.011302	0.036	12.60	141.77	8800.00	1.00	3.43
Reach-1	29.012	10 yr encr	8800.00	1826.9	5.85	0.006557	0.036	10.65	141.33	8800.00	0.78	2.33
Reach-1	29.13	10 yr encr	9100.00	1831.1	5.69	0.009246	0.036	12.32	129.87	9100.00	0.91	3.16
Reach-1	29.258	10 yr encr	9100.00	1837.8	5.13	0.005701	0.044	7.51	236.21	9100.00	0.58	1.80
Reach-1	29.351	10 yr encr	9100.00	1842.3	2.71	0.017453	0.050	7.57	428.52	8786.27	0.81	2.92
Reach-1	29.387	10 yr encr	9100.00	1844.8	3.22	0.007273	0.050	5.49	510.43	9028.61	0.54	1.45
Reach-1	29.493	10 yr encr	9100.00	1849.6	2.57	0.010220	0.050	5.61	631.13	9100.00	0.62	1.63
Reach-1	29.538	10 yr encr	9100.00	1852.6	2.19	0.017929	0.050	6.69	621.08	9100.00	0.80	2.44
Reach-1	29.601	10 yr encr	9100.00	1856.1	3.95	0.006918	0.044	6.98	330.31	9100.00	0.62	1.69
Reach-1	29.663	10 yr encr	9100.00	1858.5	3.60	0.008312	0.044	7.20	351.33	9100.00	0.67	1.85
Reach-1	29.71	10 yr encr	9100.00	1860.1	4.43	0.005700	0.040	7.54	272.30	9100.00	0.63	1.57
Reach-1	29.715		Bridge									

Stationing ID (River miles)	Maximum WSE (ft) [*2]	Left Bank Superelevation Freeboard (ft)	Right Bank Superelevation Freeboard (ft)	Left Top of Bank Elevation (ft) [*1]	Right Top of Bank Elevation (ft) [*1]	HEC-RAS Minimum Elevation (ft) [*2]	HEC-6 General Scour Depth (ft)	Antidune Trough Depth (ft)	Left Bank Bend Scour Depth, Z_{bs} (ft)	Right Bank Bend Scour Depth, Z_{bs} (ft)	Left Bank HEC-6 Design Scour Depth (ft) [*3]	Right Bank HEC-6 Design Scour Depth (ft) [*3]	Depth to Armoring, y_a (ft)	Left Bank Total Degredation (ft) [*4]	Right Bank Total Degredation (ft) [*4]	Extent of Left Toe Down [*6]	Left Bank Toe Down Elevation (ft) [*5]	Extent of Right Toe Down [*6]	Right Bank Toe Down Elevation (ft) [*5]	HEC-RAS Min Elevation - 10' (ft)	Left Reach Average Total Degredation (ft)	Right Reach Average Total Degredation (ft)	Left TOB - HEC-RAS Min Elevation	Right TOB - HEC-RAS Min Elevation	Left Reach Average TOB Above RAS Min (ft)	Right Reach Average TOB Above RAS Min (ft)	
0.200	1659.3	0	0	1662.3	1662.3	1646.0	0.6	2.6	0	0	4.2	4.2	6.6	10.9	10.9	No Armor	1635.1	Full Depth	1635.1	1636.0			16.3	16.3			
0.330	1661.6	0	0	1664.6	1664.6	1652.2	1.0	2.5	0	0	4.6	4.6	5.1	9.6	9.6	No Armor	1642.6	Full Depth	1642.6	1642.2			12.4	12.4			
0.430	1664.9	0	0	1667.9	1667.9	1655.0	1.2	2.0	0	0	4.1	4.1	5.8	9.9	9.9	No Armor	1645.1	Full Depth	1645.1	1645.0		10.1	12.9	12.9		13.9	
0.540	1669.3	0	0	1672.3	1672.3	1660.0	1.5	2.6	0	0	5.4	5.4	5.1	10.4	10.4	No Armor	1649.6	3'	1666.0	1650.0			12.3	12.3			
0.630	1672.3	0	0	1675.3	1675.3	1664.0	1.8	2.8	0	0	6.0	6.0	4.5	10.5	10.5	No Armor	1653.5	3'	1668.5	1654.0			11.3	11.3			
0.710	1675.3	0	0	1678.3	1678.3	1664.0	1.2	3.0	0	0	5.5	5.5	5.1	10.6	10.6	3'	1670.5	3'	1670.5	1654.0			14.3	14.3			
0.750	1676.4	0	0	1679.4	1679.4	1666.0	1.0	2.2	0	0	4.2	4.2	5.8	9.9	9.9	3'	1671.0	3'	1672.0	1656.0			13.4	13.4			
0.840	1678.0	0	0	1681.0	1681.0	1670.0	0.5	5.1	0	0	7.2	7.2	12.0	19.2	19.2	3'	1675.0	3'	1680.0	1660.0			11.0	11.0			
0.990	1684.7	0	0.2	1687.7	1687.9	1678.0	0.5	1.2	0	1.9	2.2	4.7	3.3	5.6	8.1	3'	1679.0	No Armor	1669.9	1668.0			9.7	9.9			
1.090	1687.9	0	0	1690.9	1690.9	1680.0	0.5	2.7	0	0	4.1	4.1	6.6	10.7	10.7	3'	1682.0	No Armor	1669.3	1670.0			10.9	10.9			
1.180	1691.9	0	0	1694.9	1694.9	1680.0	0.7	2.3	0	0	4.0	4.0	2.8	6.8	6.8	3'	1686.0	No Armor	1673.2	1670.0			14.9	14.9			
1.270	1693.5	0	0	1696.5	1696.5	1684.0	0.9	2.6	0	0	4.5	4.5	5.8	10.3	10.3	3'	1691.0	No Armor	1673.7	1674.0			12.5	12.5			
1.370	1697.0	0	0	1700.0	1700.0	1688.0	1.0	2.8	0	0	5.0	5.0	5.1	10.0	10.0	3'	1698.0	No Armor	1678.0	1678.0			12.0	12.0			
1.470	1701.5	0	0	1704.5	1704.5	1690.0	1.3	2.8	0	0	5.3	5.3	6.6	12.0	12.0	No Armor	1678.0	No Armor	1678.0	1680.0			14.5	14.5			
1.560	1703.4	0	0	1706.4	1706.4	1692.0	1.4	2.8	0	0	5.5	5.5	6.6	12.1	12.1	No Armor	1679.9	No Armor	1679.9	1682.0			14.4	14.4			
1.600	1704.3	0	0	1707.3	1707.3	1692.0	1.4	3.2	0	0	6.0	6.0	4.0	10.0	10.0	No Armor	1682.0	No Armor	1682.0	1682.0			15.3	15.3			
1.660	1705.5	0	0	1708.5	1708.5	1696.0	1.0	3.3	0	0	5.6	5.6	5.1	10.6	10.6	No Armor	1685.4	No Armor	1685.4	1686.0			12.5	12.5			
1.750	1708.5	0	0	1711.5	1711.5	1698.0	0.7	2.7	0	0	4.5	4.5	3.7	8.1	8.1	No Armor	1689.9	No Armor	1689.9	1688.0	5.6	6.4	13.5	13.5			Min
1.810	1710.7	0	0	1713.7	1713.7	1700.0	0.6	2.2	0	0	3.6	3.6	5.8	9.4	9.4	No Armor	1690.6	No Armor	1690.6	1690.0	19.2	19.2	13.7	13.7			Max
1.850	1711.3	0	0	1714.3	1714.3	1700.0	0.5	1.8	0	0	3.0	3.0	3.3	6.4	6.4	No Armor	1693.6	No Armor	1693.6	1690.0	10.2	10.3	14.3	14.3	13.1	13.1	Average
1.880	1711.7	0	0	1714.7	1714.7	1702.1	0.5	2.6	0	0	4.0	4.0	5.8	9.7	9.7	No Armor	1692.4	No Armor	1692.4	1692.1			12.6	12.6			
2.000	1714.7	0	0.6	1717.7	1718.3	1708.5	0.4	2.2	0	2.7	3.3	6.8	3.3	6.7	10.2	No Armor	1701.8	No Armor	1698.3	1698.5			9.2	9.8			
2.080	1717.5	0	0.8	1720.5	1721.3	1710.0	0.3	2.8	0	3.3	4.0	8.4	5.8	9.8	14.1	No Armor	1700.2	No Armor	1695.9	1700.0			10.5	11.3			
2.170	1721.0	0	0.8	1724.0	1724.8	1714.0	0.4	2.6	0	3.1	3.9	8.0	4.5	8.4	12.5	No Armor	1705.6	No Armor	1701.5	1704.0			10.0	10.8			
2.240	1723.5	0	0	1726.5	1726.5	1714.0	0.5	3.0	0	0	4.5	4.5	3.3	7.8	7.8	No Armor	1706.2	No Armor	1706.2	1704.0			12.5	12.5			
2.330	1727.1	0	0	1730.1	1730.1	1717.0	0.6	4.0	0	0	5.9	5.9	6.6	12.6	12.6	No Armor	1704.4	No Armor	1704.4	1707.0			13.1	13.1			
2.400	1730.1	0	0	1733.1	1733.1	1718.0	0.8	2.4	0	0	4.1	4.1	2.5	6.7	6.7	No Armor	1711.3	No Armor	1711.3	1708.0			15.1	15.1			
2.470	1731.5	0	0	1734.5	1734.5	1720.0	1.0	3.0	0	0	5.2	5.2	7.8	13.1	13.1	No Armor	1706.9	No Armor	1706.9	1710.0			14.5	14.5			
2.520	1733.2	0	0	1736.2	1736.2	1721.0	1.0	1.8	0	0	3.6	3.6	4.0	7.7	7.7	No Armor	1713.3	No Armor	1713.3	1711.0	6.7	6.7	15.2	15.2			Min
2.600	1734.9	0	2.0	1737.9	1739.9	1724.0	1.0	2.5	0	9.4	4.6	16.8	7.8	12.4	24.7	No Armor	1711.6	No Armor	1699.3	1714.0	13.1	24.7	13.9	15.9			Max
2.730	1738.3	0	3.6	1741.3	1744.9	1728.0	1.1	3.3	0	9.1	5.7	17.6	4.0	9.8	21.6	No Armor	1718.2	No Armor	1706.4	1718.0	9.5	12.8	13.3	16.9	12.7	13.4	Average
2.820	1742.1	0.5	0	1745.6	1745.1	1730.0	0.9	0.2	6.6	0	9.9	1.4	2.1	12.1	3.6	No Armor	1717.9	No Armor	1726.4	1720.0			15.6	15.1			
2.870	1742.3	0.4	0	1745.7	1745.3	1732.0	0.6	0.2	6.1	0	9.0	1.0	4.0	13.1	5.1	No Armor	1718.9	No Armor	1726.9	1722.0			13.7	13.3			
2.900	1742.5	0.4	0	1745.9	1745.5	1734.0	0.6	0.2	5.0	0	7.6	1.0	5.8	13.3	6.8	No Armor	1720.7	No Armor	1727.2	1724.0			11.9	11.5			
2.920	1742.8	0	0	1745.8	1745.8	1734.0	0.7	0.2	0	0	1.2	1.2	6.6	7.9	7.9	Full Depth	1726.1	No Armor	1726.1	1724.0			11.8	11.8			
2.970	1743.9	0	0	1746.9	1746.9	1736.0	1.0	0.3	0	0	1.6	1.6	1.4	3.1	3.1	Full Depth	1732.9	No Armor	1732.9	1726.0			10.9	10.9			
3.070	1748.4	0	0	1751.4	1751.4	1741.0	1.1	2.0	0	0	4.0	4.0	5.8	9.7	9.7	Full Depth	1731.3	No Armor	1731.3	1731.0			10.4	10.4			
3.130	1750.3	0	0	1753.3	1753.3	1742.0	1.2	1.8	0	0	3.9	3.9	4.0	8.0	8.0	Full Depth	1734.0	No Armor	1734.0	1732.0			11.3	11.3			
3.210	1752.5	0	0	1755.5	1755.5	1746.0	1.2	1.7	0	0	3.8	3.8	4.0	7.8	7.8	Full Depth	1738.2	No Armor	1738.2	1736.0			9.5	9.5			
3.320	1756.3	0	0	1759.3	1759.3	1750.0	1.3	1.7	0	0	3.9	3.9	5.1	9.0	9.0	Full Depth	1741.0	No Armor	1741.0	1740.0			9.3	9.3			
3.400	1760.2	0	0	1763.2	1763.2	1752.0	1.0	1.7	0	0	3.5	3.5	5.1	8.6	8.6	Full Depth	1743.4	No Armor	1743.4	1742.0			11.2	11.2			
3.480	1763.6	0	0	1766.6	1766.6	1755.0	1.0	2.1	0	0	4.0	4.0	4.0	8.1	8.1	Full Depth	1746.9	No Armor	1746.9	1745.0			11.6	11.6			
3.520	1765.6	0	0	1768.6	1768.6	1756.0	1.0	2.1	0	0	4.1	4.1	4.5	8.6	8.6	Full Depth	1747.4	Full Depth	1747.4	1746.0			12.6	12.6			
3.600	1767.9	0	0	1770.9	1770.9	1760.0	0.5	2.7	0	0	4.1	4.1	5.8	9.9	9.9	Full Depth	1750.1	Full Depth	1750.1	1750.0			10.9	10.9			
3.650	1769.7	0	0	1772.7	1772.7	1762.0	0.6	1.6	0	0	2.8	2.8	5.8	8.6	8.6	Full Depth	1753.4	Full Depth	1753.4	1752.0			10.7	10.7			
3.750	1773.0	0	0	1776.0	1776.0	1764.0	0.7	2.7	0	0	4.4	4.4	5.1	9.5	9.5	Full Depth	1754.5	Full Depth	1754.5	1754.0			12.0	12.0			
3.780	1774.6	0	0	1777.6	1777.6	1766.0	7.0	1.7	0	0	11.3	11.3	2.2	13.5	13.5	Full Depth	1752.5	Full Depth	1752.5	1756.0			11.6	11.6			
3.860	1777.8	0	0	1780.8	1780.8	1770.0	0.7	2.0	0	0	3.5	3.5	5.8	9.2	9.2	Full Depth	1760.8	Full Depth	1760.8	1760.0			10.8	10.8			
3.960	1782.4	0	0	1785.4	1785.4	1774.0	0.8	1.2	0	0	2.6	2.6	5.1	7.6	7.6	Full Depth	1766.4	Full Depth	1766.4	1764.0			11.4	11.4			
4.050	1785.7	0	0	1788.7	1788.7	1779.0	1.1	2.7	0	0	4.9	4.9	3.7	8.6	8.6	Full Depth	1770.4	No Armor	1770.4	1769.0			9.7	9.7			
4.110	1788.9	0	0	1791.9	1791.9	1782.0	1.2	1.6	0	0	3.6	3.6	3.7	7.3	7.3	Full Depth	1774.7	No Armor	1774.7	1772.0			9.9	9.9			
4.220	1791.4	0	0	1794.4	1794.4	1785.5	1.6	2.1	0	0	4.8	4.8	3.3	8.1	8.1	Full Depth	1777.4	No Armor	1777.4	1775.5			8.9	8.9			
4.230	1792.6	0	0	1795.6	1795.6	1786.0	1.3	2.1	0	0	4.4	4.4	3.7	8.0	8.0	Full Depth	1778.0	No Armor	1778.0	1776.0			9.6	9.6			
4.310	1797.3	0	0	1800.3	1800.3	1788.0	1.0	2.2	0	0	4.1	4.1	3.3	7.4	7.4	Full Depth	1780.6	No Armor	1780.6	1778.0			12.3	12.3			
4.400	1800.0	0	0	1803.0	1803.0	1792.3	0.5	3.3	0	0	5.0	5.0	1.5	6.5	6.5	Full Depth	1785.8	No Armor	1785.8	1782.3	3.1	3.1	10.7	10.7			Min
4.490	1803.5	0	0	1806.5	1806.5	1796.0	6.5	1.8	0	0	10.8	10.8	5.8	16.6	16.6	Full Depth	1779.4	No Armor	1779.4	1786.0	16.6	21.6	10.5	10.5			Max
4.560	1808.0	0	0	1811.0	1811.0	1799.0	6.5	0.5	0	0	9.1	9.1	4.5	13.6	13.6	Full Depth	1785.4	No Armor	1785.4	1789.0	9.4	9.0	12.0	12.0	11.3	11.3	Average
4.600	Culvert																										

Station ID (River Miles)	Reach Code	Design Discharge, Q (cfs) *1	Average Channel Velocity, V_m (fps)	Maximum Depth Main Channel, Y_{max}, (ft)	Main Channel Hydraulic Depth, Y_h (ft)	Energy Slope, S_e (ft/ft)	HEC-6 General Scour Depth, HEC-6 Z_{gs} (ft) *4	Anti-dune Trough Depth, Z_a (ft) *5	Left Bank Angle of Channel Bend in degrees	Right Bank Angle of Channel Bend in degrees	Left Bank Bend Scour Depth, Z_{bs} (ft) *6	Right Bank Bend Scour Depth, Z_{bs} (ft) *6	Full Flow Velocity *2	Full Flow Channel Top Width, T (ft) *2	Left Bank Radius of Curve, r_c *9	Right Bank Radius of Curve, r_c *9	Left Bank Superelevation, del h (ft) *10	Right Bank Superelevation, del h (ft) *10	Left Bank HEC 6 Design Scour Depth, Z_t (ft) *8	Right Bank HEC-6 Design Scour Depth, Z_t (ft) *8	Reach Average Left Bank HEC-6 Design Scour Depth	Reach Average Left Bank HEC-6 Design Scour Depth
0.2	Hackberry	17944	13.9	13.31	11.28	0.00327	0.6	2.6	0	0	0	0	6.1	817.2	0	0	0	0	4.2	4.2	4.7	4.8
0.33	Hackberry	17944	13.57	9.36	7.26	0.00538	1	2.5	0	0	0	0	9.4	427.1	0	0	0	0	4.6	4.6		
0.43	Hackberry	17944	12.05	9.9	7.39	0.00417	1.2	2.0	0	0	0	0	6.3	706.7	0	0	0	0	4.1	4.1		
0.54	Hackberry	17944	13.86	9.29	8.68	0.00454	1.5	2.6	0	0	0	0	5.7	861.1	0	0	0	0	5.4	5.4		
0.63	Hackberry	17944	14.26	8.34	7.57	0.00570	1.8	2.8	0	0	0	0	6.6	724.8	0	0	0	0	6.0	6.0		
0.71	Hackberry	17944	14.88	11.31	10.46	0.00407	1.2	3.0	0	0	0	0	6.6	606.6	0	0	0	0	5.5	5.5		
0.75	Hackberry	17944	12.75	10.42	9.14	0.00352	1	2.2	0	0	0	0	6.4	630.9	0	0	0	0	4.2	4.2		
0.84	Hackberry	17944	19.2	7.97	7.69	0.01004	0.5	5.1	0	0	0	0	9.2	540.6	0	0	0	0	7.2	7.2		
0.99	Hackberry	17944	9.4	6.68	6.39	0.00307	0.5	1.2	0	30	0	1.9	4.3	981.2	0	3171.2	0	0.2	2.2	4.7		
1.09	Hackberry	17944	13.92	7.92	7.71	0.00525	0.5	2.7	0	0	0	0	5.8	870.0	0	0	0	0	4.1	4.1		
1.18	Hackberry	17944	13.09	11.93	10.63	0.00304	0.7	2.3	0	0	0	0	6.1	769.3	0	0	0	0	4.0	4.0		
1.27	Hackberry	17944	13.71	9.49	8.58	0.00438	0.9	2.6	0	0	0	0	7.6	560.2	0	0	0	0	4.5	4.5		
1.37	Hackberry	17944	14.4	8.98	7.54	0.00576	1	2.8	0	0	0	0	7.9	528.1	0	0	0	0	5.0	5.0		
1.47	Hackberry	17944	14.32	11.47	10.55	0.00368	1.3	2.8	0	0	0	0	6.7	599.0	0	0	0	0	5.3	5.3		
1.56	Hackberry	17944	14.38	11.41	9.2	0.00454	1.4	2.8	0	0	0	0	7.1	586.5	0	0	0	0	5.5	5.5		
1.6	Hackberry	17944	15.24	12.31	10.67	0.00414	1.4	3.2	0	0	0	0	6.8	592.9	0	0	0	0	6.0	6.0		
1.66	Hackberry	17944	15.49	9.52	8.27	0.00591	1	3.3	0	0	0	0	8.5	470.6	0	0	0	0	5.6	5.6		
1.75	Hackberry	17944	14.16	10.51	9.05	0.00439	0.7	2.7	0	0	0	0	8.3	494.2	0	0	0	0	4.5	4.5		
1.81	Hackberry	17944	12.66	10.69	10.3	0.00295	0.6	2.2	0	0	0	0	6.1	520.6	0	0	0	0	3.6	3.6		
1.85	Hackberry	17944	11.51	11.26	9.47	0.00271	0.5	1.8	0	0	0	0	5.8	619.4	0	0	0	0	3.0	3.0		
1.88	Union Hills	17944	13.65	9.63	8.02	0.00477	0.5	2.6	0	0	0	0	6.7	695.8	0	0	0	0	4.0	4.0	4.3	6.7
2.00	Union Hills	17944	12.58	6.17	5.61	0.00648	0.4	2.2	0	36	0	2.7	6.6	845.5	0	1790.7	0	0.6	3.3	6.8		
2.08	Union Hills	17944	14.32	7.46	4.67	0.01094	0.3	2.8	0	36	0	3.3	7.5	764.6	0	1619.5	0	0.8	4.0	8.4		
2.17	Union Hills	17944	13.8	7	6.61	0.00628	0.4	2.6	0	36	0	3.1	7.4	619.1	0	1311.3	0	0.8	3.9	8.0		
2.24	Union Hills	17944	14.71	9.46	7.93	0.00560	0.5	3.0	0	0	0	0	9.7	378.6	0	0	0	0	4.5	4.5		
2.33	Union Hills	17944	17.01	10.14	9.34	0.00609	0.6	4.0	0	0	0	0	11.8	233.2	0	0	0	0	5.9	5.9		
2.4	Union Hills	17944	13.19	12.12	11.6	0.00272	0.8	2.4	0	0	0	0	8.9	244.8	0	0	0	0	4.1	4.1		
2.47	Union Hills	17944	14.86	11.46	10.14	0.00418	1	3.0	0	0	0	0	7.9	403.4	0	0	0	0	5.2	5.2		
2.52	Union Hills	17944	11.45	12.25	11.1	0.00225	1	1.8	0	0	0	0	5.6	560.3	0	0	0	0	3.6	3.6		
2.6	Union Hills	17944	13.62	10.94	9.35	0.00395	1	2.5	0	55	0	9.4	6.6	680.3	0	457.6	0	2.0	4.6	16.8		
2.73	Upper	13890	15.54	10.28	9.33	0.00512	1.1	3.3	0	55	0	9.1	8.8	321.4	0	216.1	0	3.6	5.7	17.6	4.9	4.5
2.82	Upper	13890	3.81	12.13	7.54	0.00083	0.9	0.2	55	0	6.6	0	3.2	683.5	459.7	0	0.5	0	9.9	1.4		
2.87	Upper	13890	3.64	10.32	6.33	0.00067	0.6	0.2	55	0	6.1	0	3.0	921.3	619.6	0	0.4	0	9.0	1.0		
2.9	Upper	13890	3.84	8.51	4.57	0.00122	0.6	0.2	55	0	5.0	0	3.1	1095.9	737.1	0	0.4	0	7.6	1.0		
2.92	Upper	13890	4.09	8.76	3.34	0.00351	0.7	0.2	0	0	0	0	3.9	1075.6	0	0	0	0	1.2	1.2		
2.97	Upper	13890	4.38	7.87	2.83	0.00522	1	0.3	0	0	0	0	4.4	1126.1	0	0	0	0	1.6	1.6		
3.07	Upper	7727	12.01	7.39	6.41	0.00504	1.1	2.0	0	0	0	0	5.3	512.1	0	0	0	0	4.0	4.0		
3.13	Upper	7727	11.5	8.26	6.41	0.00469	1.2	1.8	0	0	0	0	4.9	619.4	0	0	0	0	3.9	3.9		
3.21	Upper	7727	11.21	6.52	5.13	0.00587	1.2	1.7	0	0	0	0	5.1	620.3	0	0	0	0	3.8	3.8		
3.32	Upper	7727	11.17	6.28	4.94	0.00618	1.3	1.7	0	0	0	0	5.1	633.5	0	0	0	0	3.9	3.9		
3.4	Upper	7727	11.17	8.16	6.53	0.00422	1	1.7	0	0	0	0	4.3	733.6	0	0	0	0	3.5	3.5		
3.48	Upper	7727	12.35	8.57	7.24	0.00471	1	2.1	0	0	0	0	4.9	598.8	0	0	0	0	4.0	4.0		
3.52	Upper	7727	12.48	9.57	8.18	0.00405	1	2.1	0	0	0	0	5.2	481.4	0	0	0	0	4.1	4.1		
3.6	Upper	7727	13.93	7.86	7.13	0.00605	0.5	2.7	0	0	0	0	6.6	318.3	0	0	0	0	4.1	4.1		
3.65	Upper	7727	10.74	7.72	7.15	0.00346	0.6	1.6	0	0	0	0	5.4	353.4	0	0	0	0	2.8	2.8		
3.75	Upper	7727	14.09	9.05	8.06	0.00531	0.7	2.7	0	0	0	0	7.3	260.7	0	0	0	0	4.4	4.4		
3.78	Upper	7727	10.99	8.63	5.53	0.00523	7	1.7	0	0	0	0	7.0	360.8	0	0	0	0	11.3	11.3		
3.86	Upper	7403	11.97	7.83	5.7	0.00592	0.7	2.0	0	0	0	0	6.5	426.9	0	0	0	0	3.5	3.5		
3.96	Upper	7403	9.26	8.36	3.96	0.00563	0.8	1.2	0	0	0	0	6.5	555.6	0	0	0	0	2.6	2.6		
4.05	Upper	7403	13.93	6.66	5.53	0.00822	1.1	2.7	0	0	0	0	7.3	295.4	0	0	0	0	4.9	4.9		
4.11	Upper	7403	10.77	6.85	4.63	0.00620	1.2	1.6	0	0	0	0	8.0	334.2	0	0	0	0	3.6	3.6		
4.22	Upper	7403	12.35	5.93	4.25	0.00924	1.6	2.1	0	0	0	0	6.3	458.7	0	0	0	0	4.8	4.8		
4.23	Upper	7403	12.26	6.58	5.12	0.00716	1.3	2.1	0	0	0	0	6.0	429.2	0	0	0	0	4.4	4.4		
4.31	Upper	7403	12.54	9.33	7.86	0.00427	1	2.2	0	0	0	0	5.7	383.2	0	0	0	0	4.1	4.1		
4.4	Upper	7403	15.6	7.71	6.17	0.00902	0.5	3.3	0	0	0	0	8.1	270.7	0	0	0	0	5.0	5.0		
4.49	Upper	7403	11.57	7.54	5.73	0.00537	6.5	1.8	0	0	0	0	8.4	304.0	0	0	0	0	10.8	10.8		
4.56	Upper	7403	6.09	9.01	7.54	0.00102	6.5	0.5	0	0	0	0	4.6	325.7	0	0	0	0	9.1	9.1		
Culvert								0.0	0	0	0	0	11.5	634.2	0	0	0	0	0.0	0.0		

Station ID (River Miles)	Reach Code	Average Depth of Flow, d (ft) [1] [2]	Energy Slope, S_e (ft/ft)	*n* Value for Stream Bed [3]	90% Finer Particle Size, D_{90} (mm) [4]	M-P, Muller Individual Particle Size, D_c (mm) [5]	Average Channel Velocity, V_m (fps)	Competent Bottom Velocity Armor Size, Dc (mm) [6]	Critical Shear Stress, T_c (lb/ft^2) [7]	Shield's Diagram D_c (ft) [8]	Shields Diagram D_c (mm)	Shear Velocity, U_* (fps) [9]	Boundary Reynolds No., R_* [10]	Yang's Incipient Motion, D_c (ft) [11]	Yang's Incipient Motion, D_c (mm)	Average Individual Particle Size, D_c (mm)	Reach Average D_c (mm)	Percentage of Bed Material Larger than D_c, del p (Seive-Boulder Count Combo) [12]	Thickness to Armoring Layer, y_a (mm) [13]	Depth to Armoring, y_d (ft) Seive - Boulder Count Combo [14]	Ave Depth to Armoring by Reaches (Seive-Boulder Sediment Combo)
0.2	Hackberry	5.1	0.0050	0.026	100	99.7	10.1	192.2	1.6	0.26	78.1	0.902	21395	0.674	205.3	143.8	118.7	7	152.4	6.64	5.4
0.33	Hackberry	2.9	0.0074	0.026	100	85.6	8.7	142.6	1.4	0.22	67.0	0.836	17014	0.500	152.4	111.9		9	152.4	5.06	
0.43	Hackberry	3.5	0.0069	0.026	100	96.2	9.5	168.6	1.5	0.25	75.3	0.886	20283	0.591	180.1	130.1		8	152.4	5.75	
0.54	Hackberry	4.8	0.0046	0.026	100	85.7	9.3	163.0	1.4	0.22	67.1	0.836	17037	0.571	174.1	122.5		9	152.4	5.06	
0.63	Hackberry	4.2	0.0044	0.026	100	73.1	8.5	134.9	1.2	0.19	57.2	0.772	13414	0.473	144.1	102.3		10	152.4	4.50	
0.71	Hackberry	5.6	0.0032	0.026	100	70.6	8.7	142.0	1.1	0.18	55.3	0.759	12744	0.498	151.7	104.9		9	152.4	5.06	
0.75	Hackberry	3.8	0.0063	0.026	100	95.1	9.6	171.5	1.5	0.24	74.4	0.881	19922	0.601	183.2	131.0		8	152.4	5.75	
0.84	Hackberry	3.9	0.0091	0.026	100	141.5	11.7	257.8	2.2	0.36	110.8	1.074	36157	0.904	275.4	196.4		4	152.4	12.00	
0.99	Hackberry	2.8	0.0054	0.026	100	59.4	7.2	96.6	0.9	0.15	46.5	0.696	9831	0.339	103.3	76.4		13	152.4	3.35	
1.09	Hackberry	3.9	0.0069	0.026	100	107.3	10.2	195.6	1.7	0.28	84.0	0.936	23889	0.686	209.0	149.0		7	152.4	6.64	
1.18	Hackberry	5.4	0.0022	0.026	100	47.3	7.1	95.3	0.7	0.12	37.0	0.621	6993	0.334	101.8	70.4		14	140.7	2.84	
1.27	Hackberry	3.2	0.0077	0.026	100	97.5	9.4	167.5	1.5	0.25	76.3	0.892	20680	0.587	179.0	130.1		8	152.4	5.75	
1.37	Hackberry	3.5	0.0064	0.026	100	89.4	9.2	157.7	1.4	0.23	70.0	0.854	18169	0.553	168.5	121.4		9	152.4	5.06	
1.47	Hackberry	4.7	0.0051	0.026	100	96.0	9.9	185.0	1.5	0.25	75.2	0.885	20218	0.648	197.7	138.5		7	152.4	6.64	
1.56	Hackberry	4.2	0.0062	0.026	100	103.7	10.0	188.8	1.6	0.27	81.2	0.920	22685	0.662	201.7	143.8		7	152.4	6.64	
1.6	Hackberry	6.2	0.0023	0.026	100	56.9	8.0	118.8	0.9	0.15	44.5	0.681	9216	0.417	127.0	86.8		11	152.4	4.05	
1.66	Hackberry	3.88	0.0055	0.026	100	83.8	8.99	151.9	1.3	0.22	65.6	0.827	16472	0.533	162.3	115.9		9	152.4	5.06	
1.75	Hackberry	4.12	0.0036	0.026	100	59.0	7.62	109.2	0.9	0.15	46.2	0.694	9745	0.383	116.6	82.8		12	152.4	3.67	
1.81	Hackberry	4.87	0.0048	0.026	100	92.9	9.84	182.0	1.5	0.24	72.7	0.871	19243	0.638	194.5	135.5		8	152.4	5.75	
1.85	Hackberry	4.72	0.0029	0.026	100	54.9	7.54	106.9	0.9	0.14	43.0	0.669	8733	0.375	114.2	79.7		13	152.4	3.35	
1.88	Union Hills	3.61	0.0066	0.026	100	94.6	9.47	168.6	1.5	0.24	74.0	0.878	19756	0.591	180.1	129.3	115.1	8	152.4	5.75	5.2
2	Union Hills	2.25	0.0071	0.026	100	63.5	7.18	96.9	1.0	0.16	49.7	0.720	10865	0.340	103.5	78.4		13	152.4	3.35	
2.08	Union Hills	3.07	0.0081	0.026	100	98.2	9.28	161.9	1.6	0.25	76.9	0.895	20896	0.568	173.0	127.5		8	152.4	5.75	
2.17	Union Hills	2.92	0.0065	0.026	100	75.0	8.15	124.9	1.2	0.19	58.7	0.782	13962	0.438	133.4	98.0		10	152.4	4.50	
2.24	Union Hills	3.69	0.0040	0.026	100	58.6	7.49	105.5	0.9	0.15	45.9	0.692	9647	0.370	112.7	80.7		13	152.4	3.35	
2.33	Union Hills	3.62	0.0073	0.026	100	103.7	9.87	183.1	1.6	0.27	81.2	0.920	22682	0.642	195.7	140.9		7	152.4	6.64	
2.4	Union Hills	5.04	0.0023	0.026	100	46.0	6.97	91.3	0.7	0.12	36.0	0.613	6703	0.320	97.6	67.7		15	135.5	2.52	
2.47	Union Hills	4.42	0.0069	0.026	100	120.4	10.97	226.2	1.9	0.31	94.3	0.991	28378	0.793	241.7	170.7		6	152.4	7.83	
2.52	Union Hills	5.63	0.0026	0.026	100	57.1	7.79	114.1	0.9	0.15	44.7	0.683	9280	0.400	121.9	84.5		11	152.4	4.05	
2.6	Union Hills	3.71	0.0087	0.026	100	127.6	10.93	224.6	2.0	0.33	99.9	1.021	30980	0.787	240.0	173.0		6	152.4	7.83	
2.73	Upper	3.1	0.0056	0.026	100	68.1	7.76	113.2	1.1	0.18	53.3	0.746	12084	0.397	121.0	88.9	98.7	11	152.4	4.05	4.3
2.82	Upper	4.92	0.0022	0.026	100	42.4	6.64	82.9	0.7	0.11	33.2	0.588	5928	0.291	88.6	61.8		16	123.5	2.13	
2.87	Upper	4.86	0.0034	0.026	100	65.0	8.19	126.1	1.0	0.17	50.9	0.728	11263	0.442	134.7	94.2		11	152.4	4.05	
2.9	Upper	2.9	0.0082	0.026	100	93.6	8.98	151.6	1.5	0.24	73.2	0.874	19441	0.531	162.0	120.1		8	152.4	5.75	
2.92	Upper	2.81	0.0098	0.026	100	108.5	9.58	172.5	1.7	0.28	84.9	0.941	24271	0.605	184.3	137.6		7	152.4	6.64	
2.97	Upper	4.56	0.0020	0.026	100	36.4	6	67.7	0.6	0.09	28.5	0.545	4712	0.237	72.3	51.2		19	102.4	1.43	
3.07	Upper	3.05	0.0082	0.026	100	99.2	9.23	160.2	1.6	0.25	77.7	0.900	21223	0.561	171.1	127.0		8	152.4	5.75	
3.13	Upper	2.5	0.0070	0.026	100	69.2	7.55	107.2	1.1	0.18	54.2	0.751	12364	0.376	114.5	86.3		11	152.4	4.05	
3.21	Upper	3.33	0.0054	0.026	100	71.2	8.06	122.1	1.1	0.18	55.8	0.762	12914	0.428	130.5	94.9		11	152.4	4.05	
3.32	Upper	3.25	0.0071	0.026	100	91.5	9.02	153.0	1.4	0.24	71.6	0.864	18802	0.536	163.4	119.9		9	152.4	5.06	
3.4	Upper	2.54	0.0085	0.026	100	85.5	8.45	134.2	1.4	0.22	66.9	0.835	16988	0.471	143.4	107.5		9	152.4	5.06	
3.48	Upper	2.67	0.0070	0.026	100	73.6	7.89	117.0	1.2	0.19	57.6	0.775	13562	0.410	125.0	93.3		11	152.4	4.05	
3.52	Upper	3.15	0.0061	0.026	100	75.5	8.2	126.4	1.2	0.19	59.1	0.785	14092	0.443	135.1	99.0		10	152.4	4.50	
3.6	Upper	3.67	0.0069	0.026	100	100.4	9.52	170.4	1.6	0.26	78.6	0.905	21606	0.597	182.0	132.9		8	152.4	5.75	
3.65	Upper	3.86	0.0067	0.026	100	101.5	9.71	177.3	1.6	0.26	79.5	0.910	21977	0.621	189.4	136.9		8	152.4	5.75	
3.75	Upper	3.64	0.0061	0.026	100	87.5	8.93	149.9	1.4	0.22	68.5	0.845	17574	0.526	160.2	116.5		9	152.4	5.06	
3.78	Upper	3.55	0.0034	0.026	100	47.7	6.68	83.9	0.8	0.12	37.3	0.624	7078	0.294	89.6	64.6		16	129.3	2.23	
3.86	Upper	3.71	0.0072	0.026	100	105.0	9.76	179.1	1.7	0.27	82.2	0.926	23121	0.628	191.3	139.4		8	152.4	5.75	
3.96	Upper	2.38	0.0093	0.026	100	87.4	8.4	132.7	1.4	0.22	68.4	0.844	17555	0.465	141.7	107.6		9	152.4	5.06	
4.05	Upper	2.42	0.0071	0.026	100	68.0	7.44	104.1	1.1	0.17	53.2	0.745	12036	0.365	111.2	84.1		12	152.4	3.67	
4.11	Upper	2.3	0.0074	0.026	100	66.7	7.34	101.3	1.1	0.17	52.2	0.738	11711	0.355	108.2	82.1		12	152.4	3.67	
4.22	Upper	2.81	0.0056	0.026	100	61.5	7.29	99.9	1.0	0.16	48.2	0.709	10373	0.350	106.7	79.1		13	152.4	3.35	
4.23	Upper	1.6	0.0116	0.026	100	73.5	7.25	98.8	1.2	0.19	57.6	0.775	13543	0.346	105.6	83.9		12	152.4	3.67	
4.31	Upper	2.36	0.0068	0.026	100	63.0	7.15	96.1	1.0	0.16	49.3	0.717	10737	0.337	102.7	77.8		13	152.4	3.35	
4.4	Upper	2.69	0.0040	0.026	100	42.6	5.98	67.2	0.7	0.11	33.4	0.590	5982	0.236	71.8	53.8		19	107.5	1.50	
4.49	Upper	3.27	0.0076	0.026	100	97.5	9.29	162.3	1.5	0.25	76.3	0.892	20677	0.569	173.4	127.4		8	152.4	5.75	
4.56	Upper	3.01	0.0064	0.026	100	76.0	8.15	124.9	1.2	0.20	59.5	0.788	14247	0.438	133.4	98.5		10	152.4	4.50	
Culvert	Upper	2.12	0.0055				6.05														
		2.18	0.0079				7.39														

	Size (mm)	Size (ft)	Size (in.)
D_{90} =	100	0.328	3.94
D_{50} =	11	0.036	0.43
D_{75} =	37	0.121	1.46

Method	Equation		
	$n_s = (D_{90}^{1/6}) / 44.4$ (D_{90} in inches)	n_s =	0.028
Anderson	$n_s = 0.0395 * (D_{50}^{1/6})$ (D_{50} in feet)	n_s =	0.023
Lane	$n_s = (D_{75}^{1/6}) / 39$ (D_{75} in inches)	n_s =	0.027
			0.026

Station ID (River Miles)	Reach Code	Mean Particle Size, (mm) *1	Channel Width (ft) *2	Dominant Discharge, Q (cfs) *2	Schoklitsch, S_L (ft/ft) *3	90% Finer Particle Size, D_{90} (mm) *1	*n* Value for Cross Section *2	Average Depth of Flow, d (ft) *2	M-P,M S_L (ft/ft) *4	Shields S_L (ft/ft) *5	Shear Velocity, U* (fps) *6	Boundary Reynolds No. *7	Average S_L (ft/ft)	Average S_L by Reach	Average Invert Slope by Reach *8	Distance Between Grade Control Structures (ft) *9
0.200	Hackberry	40	62.69	3200.08	0.001449	100	0.026103	5.05	0.00201	0.002145	0.5906	7176.0	0.001867	0.00236	0.006324	1260
0.330	Hackberry	40	119.06	3053.52	0.002428	100	0.026103	2.94	0.00345	0.003684	0.5906	7176.0	0.003187			
0.430	Hackberry	40	91.06	3021.9	0.002002	100	0.026103	3.51	0.00289	0.003086	0.5906	7176.0	0.002658			
0.540	Hackberry	40	62.02	2750.77	0.001610	100	0.026103	4.76	0.00213	0.002275	0.5906	7176.0	0.002005			
0.630	Hackberry	40	76.79	2756.03	0.001887	100	0.026103	4.24	0.00239	0.002554	0.5906	7176.0	0.002277			
0.710	Hackberry	40	55.65	2712.32	0.001500	100	0.026103	5.61	0.00181	0.001931	0.5906	7176.0	0.001746			
0.750	Hackberry	40	83.90	3060.78	0.001864	100	0.026103	3.82	0.00265	0.002835	0.5906	7176.0	0.002451			
0.840	Hackberry	40	55.00	2536.43	0.001564	100	0.026103	3.94	0.00257	0.002749	0.5906	7176.0	0.002295			
0.990	Hackberry	40	56.38	1134.59	0.002913	100	0.026103	2.81	0.00361	0.003854	0.5906	7176.0	0.003458			
1.090	Hackberry	40	66.00	2651.56	0.001734	100	0.026103	3.94	0.00257	0.002749	0.5906	7176.0	0.002352			
1.180	Hackberry	40	83.00	3167.61	0.001802	100	0.026103	5.36	0.00189	0.002021	0.5906	7176.0	0.001905			
1.270	Hackberry	40	103.00	3123.67	0.002142	100	0.026103	3.21	0.00316	0.003374	0.5906	7176.0	0.002891			
1.370	Hackberry	40	98.12	3168.25	0.002043	100	0.026103	3.52	0.00288	0.003077	0.5906	7176.0	0.002667			
1.470	Hackberry	40	68.04	3203.11	0.001540	100	0.026103	4.74	0.00214	0.002285	0.5906	7176.0	0.001988			
1.560	Hackberry	40	77.24	3270.25	0.001667	100	0.026103	4.23	0.00240	0.002561	0.5906	7176.0	0.002208			
1.600	Hackberry	40	57.21	2825.21	0.001486	100	0.026103	6.21	0.00163	0.001744	0.5906	7176.0	0.001621			
1.660	Hackberry	40	81.89	2856.86	0.001928	100	0.026103	3.88	0.00261	0.003350	0.6469	7860.9	0.002630			
1.750	Hackberry	40	102.26	3207.94	0.002088	100	0.026103	4.12	0.00246	0.003155	0.6469	7860.9	0.002568			
1.810	Hackberry	40	59.95	2875.54	0.001518	100	0.026103	4.87	0.00208	0.002669	0.6469	7860.9	0.002089			
1.850	Hackberry	40	86.55	3085.3	0.001897	100	0.026103	4.72	0.00215	0.002754	0.6469	7860.9	0.002266			
1.880	Union Hills	40	90.00	3078.83	0.001957	100	0.026103	3.61	0.00281	0.003600	0.6469	7860.9	0.002788	0.00287	0.005761	1731
2.000	Union Hills	40	135.00	2177.7	0.003438	100	0.026103	2.25	0.00450	0.005777	0.6469	7860.9	0.004573			
2.080	Union Hills	40	59.01	1680.67	0.002245	100	0.026103	3.07	0.00330	0.004234	0.6469	7860.9	0.003260			
2.170	Union Hills	40	107.72	2561.53	0.002570	100	0.026103	2.92	0.00347	0.004451	0.6469	7860.9	0.003497			
2.240	Union Hills	40	115.85	3199.7	0.002297	100	0.026103	3.69	0.00275	0.003522	0.6469	7860.9	0.002855			
2.330	Union Hills	40	85.00	3038.88	0.001893	100	0.026103	3.62	0.00280	0.003590	0.6469	7860.9	0.002761			
2.400	Union Hills	40	84.10	2954.38	0.001918	100	0.026103	5.04	0.00201	0.002579	0.6469	7860.9	0.002169			
2.470	Union Hills	40	65.55	3177.24	0.001507	100	0.026103	4.42	0.00229	0.002941	0.6469	7860.9	0.002247			
2.520	Union Hills	40	71.17	3118.05	0.001625	100	0.026103	5.63	0.00180	0.002309	0.6469	7860.9	0.001911			
2.600	Union Hills	40	80.92	3280	0.001723	100	0.026103	3.71	0.00273	0.003503	0.6469	7860.9	0.002653			
2.730	Upper	40	100.00	2403.79	0.002549	100	0.026103	3.1	0.00327	0.004193	0.6469	7860.9	0.003337	0.00346	0.007348	1287
2.820	Upper	40	65.00	2124.75	0.002024	100	0.026103	4.92	0.00206	0.002642	0.6469	7860.9	0.002242			
2.870	Upper	40	64.55	2570.23	0.001746	100	0.026103	4.86	0.00209	0.002674	0.6469	7860.9	0.002169			
2.900	Upper	40	52.59	1370	0.002400	100	0.026103	2.9	0.00350	0.004482	0.6469	7860.9	0.003459			
2.920	Upper	40	50.92	1370	0.002343	100	0.026103	2.81	0.00361	0.004625	0.6469	7860.9	0.003525			
2.970	Upper	40	44.00	1203.43	0.002314	100	0.026103	4.56	0.00222	0.002850	0.6469	7860.9	0.002462			
3.070	Upper	40	48.68	1370	0.002265	100	0.026103	3.05	0.00332	0.004261	0.6469	7860.9	0.003283			
3.130	Upper	40	72.00	1360.12	0.003054	100	0.026103	2.5	0.00405	0.005199	0.6469	7860.9	0.004102			
3.210	Upper	40	48.16	1293.17	0.002346	100	0.026103	3.33	0.00304	0.003903	0.6469	7860.9	0.003098			
3.320	Upper	40	45.92	1346.56	0.002196	100	0.026103	3.25	0.00312	0.003999	0.6469	7860.9	0.003105			
3.400	Upper	40	62.67	1343.38	0.002778	100	0.026103	2.54	0.00399	0.005117	0.6469	7860.9	0.003962			
3.480	Upper	40	64.99	1369.1	0.002815	100	0.026103	2.67	0.00380	0.004868	0.6469	7860.9	0.003826			
3.520	Upper	40	45.00	1163.99	0.002413	100	0.026103	3.15	0.00322	0.004126	0.6469	7860.9	0.003252			
3.600	Upper	40	33.40	1166.36	0.001927	100	0.026103	3.67	0.00276	0.003541	0.6469	7860.9	0.002743			
3.650	Upper	40	35.10	1315.44	0.001827	100	0.026103	3.86	0.00263	0.003367	0.6469	7860.9	0.002607			
3.750	Upper	40	34.14	1108.72	0.002034	100	0.026103	3.64	0.00278	0.003571	0.6469	7860.9	0.002796			
3.780	Upper	40	45.00	1067.81	0.002574	100	0.026103	3.55	0.00286	0.003661	0.6469	7860.9	0.003030			
3.860	Upper	40	37.35	1350.03	0.001877	100	0.026103	3.71	0.00273	0.003503	0.6469	7860.9	0.002704			
3.960	Upper	40	62.32	1244.51	0.002930	100	0.026103	2.38	0.00426	0.005461	0.6469	7860.9	0.004216			
4.050	Upper	40	64.65	1165.97	0.003162	100	0.026103	2.42	0.00419	0.005371	0.6469	7860.9	0.004240			
4.110	Upper	40	71.66	1209.54	0.003323	100	0.026103	2.3	0.00441	0.005651	0.6469	7860.9	0.004460			
4.220	Upper	40	43.07	883.69	0.002871	100	0.026103	2.81	0.00361	0.004625	0.6469	7860.9	0.003701			
4.230	Upper	40	104.60	1210	0.004412	100	0.026103	1.6	0.00633	0.008123	0.6469	7860.9	0.006290			
4.310	Upper	40	47.85	807.36	0.003324	100	0.026103	2.36	0.00429	0.005507	0.6469	7860.9	0.004375			
4.400	Upper	40	50.03	803.42	0.003450	100	0.026103	2.69	0.00377	0.004832	0.6469	7860.9	0.004016			
4.490	Upper	40	39.21	1190.1	0.002140	100	0.026103	3.27	0.00310	0.003975	0.6469	7860.9	0.003071			
4.560	Upper	40	40.00	980.81	0.002512	100	0.026103	3.01	0.00337	0.004318	0.6469	7860.9	0.003399			
Culvert	Upper															

HEC-RAS Plan: Team Alt100F

Reach	River Sta	Min Ch El	W.S. Elev	Q Total	Vel Chnl	Max Chl Dpth	Hydr Depth C	E.G. Slope	Sta W.S. Lft	Top W Chnl	Sta W.S. Rgt	Vel Total	Top Width
		(ft)	(ft)	(cfs)	(ft/s)	(ft)	(ft)	(ft/ft)	(ft)	(ft)	(ft)	(ft/s)	(ft)
Reach 3	0.20	1646.00	1659.3	17944.00	13.90	13.31	11.28	0.003265	9369.34	71.66	10186.50	6.07	817.16
Reach 3	0.33	1652.20	1661.6	17944.00	13.57	9.36	7.26	0.005378	9865.71	144.22	10292.79	9.43	427.08
Reach 3	0.43	1655.00	1664.9	17944.00	12.05	9.90	7.39	0.004169	9866.75	110.00	10573.40	6.34	706.65
Reach 3	0.54	1660.00	1669.3	17944.00	13.86	9.29	8.68	0.004544	9707.51	62.02	10568.58	5.71	861.07
Reach 3	0.63	1664.00	1672.3	17944.00	14.26	8.34	7.57	0.005702	9475.95	76.79	10200.79	6.60	724.84
Reach 3	0.71	1664.00	1675.3	17944.00	14.88	11.31	10.46	0.004068	9543.40	55.65	10150.04	6.61	606.64
Reach 3	0.75	1666.00	1676.4	17944.00	12.75	10.42	9.14	0.003518	9583.16	83.90	10214.05	6.39	630.89
Reach 3	0.84	1670.00	1678.0	17944.00	19.20	7.97	7.69	0.010040	9882.76	55.00	10454.68	9.16	540.57
Reach 3	0.99	1678.00	1684.7	17944.00	9.40	6.68	6.39	0.003071	9933.62	56.38	10914.78	4.32	981.16
Reach 3	1.09	1680.00	1687.9	17944.00	13.92	7.92	7.71	0.005247	9926.24	66.00	10796.20	5.84	869.96
Reach 3	1.18	1680.00	1691.9	17944.00	13.09	11.93	10.63	0.003038	9875.92	83.00	10645.24	6.09	769.33
Reach 3	1.27	1684.00	1693.5	17944.00	13.71	9.49	8.58	0.004380	9800.58	103.00	10360.79	7.57	560.21
Reach 3	1.37	1688.00	1697.0	17944.00	14.40	8.98	7.54	0.005763	9521.53	98.12	10049.64	7.92	528.11
Reach 3	1.47	1690.00	1701.5	17944.00	14.32	11.47	10.55	0.003684	9495.07	68.04	10094.02	6.71	598.95
Reach 3	1.56	1692.00	1703.4	17944.00	14.38	11.41	9.20	0.004538	9466.21	77.24	10052.70	7.12	586.50
Reach 3	1.60	1692.00	1704.3	17944.00	15.24	12.31	10.67	0.004141	9443.16	57.21	10036.01	6.77	592.85
Reach 3	1.66	1696.00	1705.5	17944.00	15.49	9.52	8.27	0.005913	9797.31	81.89	10267.92	8.49	470.60
Reach 3	1.75	1698.00	1708.5	17944.00	14.16	10.51	9.05	0.004387	9954.75	102.26	10448.91	8.25	494.16
Reach 3	1.81	1700.00	1710.7	17944.00	12.66	10.69	10.30	0.002950	9947.97	59.95	10468.60	6.07	520.62
Reach 3	1.85	1700.00	1711.3	17944.00	11.51	11.26	9.47	0.002714	9822.42	86.55	10441.76	5.77	619.35
Reach 3	1.88	1702.10	1711.7	17944.00	13.65	9.63	8.02	0.004766	9772.99	90.00	10468.74	6.68	695.75
Reach 3	2.00	1708.50	1714.7	17944.00	12.58	6.17	5.61	0.006481	9967.87	135.00	10813.33	6.59	845.45
Reach 3	2.08	1710.00	1717.5	17944.00	14.32	7.46	4.67	0.010944	9968.11	109.44	10732.75	7.54	764.64
Reach 3	2.17	1714.00	1721.0	17944.00	13.80	7.00	6.61	0.006278	9821.85	107.72	10440.95	7.44	619.10
Reach 3	2.24	1714.00	1723.5	17944.00	14.71	9.46	7.93	0.005602	9804.29	115.85	10182.85	9.67	378.56
Reach 3	2.33	1717.00	1727.1	17944.00	17.01	10.14	9.34	0.006088	9807.53	85.00	10040.71	11.78	233.19
Reach 3	2.40	1718.00	1730.1	17944.00	13.19	12.12	11.60	0.002722	9799.69	84.10	10044.51	8.90	244.82
Reach 3	2.47	1720.00	1731.5	17944.00	14.86	11.46	10.14	0.004183	9943.90	65.55	10347.30	7.85	403.40
Reach 3	2.52	1721.00	1733.2	17944.00	11.45	12.25	11.10	0.002247	9849.96	71.17	10410.30	5.62	560.34
Reach 3	2.60	1724.00	1734.9	17944.00	13.62	10.94	9.35	0.003952	9768.58	83.92	10448.93	6.60	680.34
Reach 2	2.73	1728.00	1738.3	13890.00	15.54	10.28	9.33	0.005122	9783.41	64.55	10104.77	8.84	321.35
Reach 2	2.82	1730.00	1742.1	13890.00	3.81	12.13	7.54	0.000832	9678.33	316.00	10361.80	3.17	683.47
Reach 2	2.87	1732.00	1742.3	13890.00	3.64	10.32	6.33	0.000671	9732.07	506.00	10653.37	3.02	921.30
Reach 2	2.90	1734.00	1742.5	13890.00	3.84	8.51	4.57	0.001216	9784.24	491.00	10926.05	3.07	1095.92
Reach 2	2.92	1734.00	1742.8	13890.00	4.09	8.76	3.34	0.003509	9894.84	690.00	10970.44	3.92	1075.60
Reach 2	2.97	1736.00	1743.9	13890.00	4.38	7.87	2.83	0.005217	9974.38	1118.00	11100.48	4.37	1126.10
Reach 1	3.07	1741.00	1748.4	7727.00	12.01	7.39	6.41	0.005035	9637.11	48.16	10149.17	5.30	512.06
Reach 1	3.13	1742.00	1750.3	7727.00	11.50	8.26	6.41	0.004693	9473.09	49.47	10092.53	4.89	619.44
Reach 1	3.21	1746.00	1752.5	7727.00	11.21	6.52	5.13	0.005871	9620.93	64.09	10241.23	5.11	620.30
Reach 1	3.32	1750.00	1756.3	7727.00	11.17	6.28	4.94	0.006178	9626.49	64.99	10259.99	5.11	633.50
Reach 1	3.4	1752.00	1760.2	7727.00	11.17	8.16	6.53	0.004219	9490.47	47.00	10224.11	4.34	733.64
Reach 1	3.48	1755.00	1763.6	7727.00	12.35	8.57	7.24	0.004705	9637.71	33.42	10236.53	4.93	598.82
Reach 1	3.52	1756.00	1765.6	7727.00	12.48	9.57	8.18	0.004046	9686.57	35.10	10167.97	5.24	481.40
Reach 1	3.6	1760.00	1767.9	7727.00	13.93	7.86	7.13	0.006049	9842.22	34.14	10160.52	6.63	318.30
Reach 1	3.65	1762.00	1769.7	7727.00	10.74	7.72	7.15	0.003457	9836.62	45.00	10190.03	5.35	353.41
Reach 1	3.75	1764.00	1773.0	7727.00	14.09	9.05	8.06	0.005310	9959.28	37.35	10220.00	7.25	260.72
Reach 1	3.78	1766.00	1774.6	7727.00	10.99	8.63	5.53	0.005225	9865.77	82.28	10226.61	6.96	360.84
Reach 1	3.86	1770.00	1777.8	7403.00	11.97	7.83	5.70	0.005924	9854.18	67.77	10330.01	6.46	426.88
Reach 1	3.96	1774.00	1782.4	7403.00	9.26	8.36	3.96	0.005628	9877.36	174.64	10433.00	6.52	555.64
Reach 1	4.05	1779.00	1785.7	7403.00	13.93	6.66	5.53	0.008222	9968.56	43.07	10264.01	7.26	295.44
Reach 1	4.11	1782.00	1788.9	7403.00	10.77	6.85	4.63	0.006201	9974.33	129.32	10308.50	7.99	334.17
Reach 1	4.22	1785.50	1791.4	7403.00	12.35	5.93	4.25	0.009242	9610.63	55.00	10069.37	6.25	458.73
Reach 1	4.23	1786.00	1792.6	7403.00	12.26	6.58	5.12	0.007155	9666.90	50.03	10096.12	6.04	429.22
Reach 1	4.31	1788.00	1797.3	7403.00	12.54	9.33	7.86	0.004271	9767.42	39.21	10150.57	5.71	383.15
Reach 1	4.4	1792.30	1800.0	7403.00	15.60	7.71	6.17	0.009015	9939.92	40.00	10210.64	8.09	270.72
Reach 1	4.49	1796.00	1803.5	7403.00	11.57	7.54	5.73	0.005369	9905.34	98.72	10209.33	8.39	303.99
Reach 1	4.56	1799.00	1808.0	7403.00	6.09	9.01	7.54	0.001024	9914.30	140.00	10240.00	4.62	325.70
Reach 1	4.575	Culvert											

HEC-RAS Plan: Team Alt10 F

Reach	River Sta	Profile	Q Total	W.S. Elev	Hydr Depth C	E.G. Slope	Mann Wtd Chnl	Vel Chnl	Top W Chnl	Q Channel	Froude # Chl	Shear Chan
			(cfs)	(ft)	(ft)	(ft/ft)		(ft/s)	(ft)	(cfs)		(lb/sq ft)
Reach 3	0.20	10-yr encr	3280.00	1652.2	5.05	0.005004	0.030	10.11	62.69	3200.08	0.79	1.53
Reach 3	0.33	10-yr encr	3280.00	1656.6	2.94	0.007378	0.030	8.71	119.06	3053.52	0.89	1.35
Reach 3	0.43	10-yr encr	3280.00	1660.3	3.51	0.006948	0.030	9.47	91.06	3021.90	0.89	1.51
Reach 3	0.54	10-yr encr	3280.00	1665.4	4.76	0.004561	0.030	9.31	62.02	2750.77	0.75	1.32
Reach 3	0.63	10-yr encr	3280.00	1669.0	4.24	0.004366	0.030	8.47	76.79	2756.03	0.73	1.14
Reach 3	0.71	10-yr encr	3280.00	1670.5	5.61	0.003189	0.030	8.69	55.65	2712.32	0.65	1.09
Reach 3	0.75	10-yr encr	3280.00	1671.1	3.82	0.006308	0.030	9.55	83.90	3060.78	0.86	1.49
Reach 3	0.84	10-yr encr	3280.00	1674.2	3.94	0.009100	0.030	11.71	55.00	2536.43	1.04	2.22
Reach 3	0.99	10-yr encr	3280.00	1681.1	2.81	0.005355	0.030	7.17	56.38	1134.59	0.75	0.93
Reach 3	1.09	10-yr encr	3280.00	1684.1	3.94	0.006903	0.030	10.20	66.00	2651.56	0.91	1.68
Reach 3	1.18	10-yr encr	3280.00	1686.7	5.36	0.002237	0.030	7.12	83.00	3167.61	0.54	0.74
Reach 3	1.27	10-yr encr	3280.00	1688.1	3.21	0.007696	0.030	9.44	103.00	3123.67	0.93	1.54
Reach 3	1.37	10-yr encr	3280.00	1693.0	3.52	0.006438	0.030	9.16	98.12	3168.25	0.86	1.41
Reach 3	1.47	10-yr encr	3280.00	1695.7	4.74	0.005134	0.030	9.92	68.04	3203.11	0.80	1.50
Reach 3	1.56	10-yr encr	3280.00	1698.4	4.23	0.006212	0.030	10.02	77.24	3270.25	0.86	1.59
Reach 3	1.60	10-yr encr	3280.00	1699.9	6.21	0.002321	0.030	7.95	57.21	2825.21	0.56	0.88
Reach 3	1.66	10-yr encr	3280.00	1701.1	3.88	0.005471	0.030	8.99	81.89	2856.86	0.80	1.31
Reach 3	1.75	10-yr encr	3280.00	1703.6	4.12	0.003631	0.030	7.62	102.26	3207.94	0.66	0.92
Reach 3	1.81	10-yr encr	3280.00	1705.3	4.87	0.004835	0.030	9.84	59.95	2875.54	0.79	1.46
Reach 3	1.85	10-yr encr	3280.00	1706.5	4.72	0.002946	0.030	7.54	86.55	3085.30	0.61	0.86
Reach 3	1.88	10-yr encr	3280.00	1707.3	3.61	0.006638	0.030	9.47	90.00	3078.83	0.88	1.49
Reach 3	2.00	10-yr encr	3280.00	1711.3	2.25	0.007149	0.030	7.18	135.00	2177.70	0.84	1.00
Reach 3	2.08	10-yr encr	3280.00	1714.0	3.07	0.008103	0.030	9.28	59.01	1680.67	0.93	1.52
Reach 3	2.17	10-yr encr	3280.00	1717.3	2.92	0.006511	0.030	8.15	107.72	2561.53	0.84	1.18
Reach 3	2.24	10-yr encr	3280.00	1719.2	3.69	0.004027	0.030	7.49	115.85	3199.70	0.69	0.92
Reach 3	2.33	10-yr encr	3280.00	1721.4	3.62	0.007258	0.030	9.87	85.00	3038.88	0.91	1.62
Reach 3	2.40	10-yr encr	3280.00	1723.6	5.04	0.002313	0.030	6.97	84.10	2954.38	0.55	0.72
Reach 3	2.47	10-yr encr	3280.00	1725.7	4.42	0.006902	0.030	10.97	65.55	3177.24	0.92	1.88
Reach 3	2.52	10-yr encr	3280.00	1727.8	5.63	0.002572	0.030	7.79	71.17	3118.05	0.58	0.88
Reach 3	2.60	10-yr encr	3280.00	1729.2	3.71	0.008718	0.030	10.93	80.92	3280.00	1.00	1.98
Reach 2	2.67	10-yr encr	2710.00	1732.8	3.10	0.005570	0.030	7.76	100.00	2403.79	0.78	1.06
Reach 2	2.70	10-yr encr	2710.00	1733.6	4.92	0.002183	0.030	6.64	65.00	2124.75	0.53	0.66
Reach 2	2.73	10-yr encr	2710.00	1733.8	4.86	0.003390	0.030	8.19	64.55	2570.23	0.65	1.01
Reach 1	2.82	10-yr encr	1370.00	1735.5	2.90	0.008175	0.030	8.98	52.59	1370.00	0.93	1.45
Reach 1	2.87	10-yr encr	1370.00	1737.9	2.81	0.009782	0.030	9.58	50.92	1370.00	1.01	1.67
Reach 1	2.90	10-yr encr	1370.00	1739.6	4.56	0.002021	0.030	6.00	44.00	1203.43	0.50	0.56
Reach 1	2.92	10-yr encr	1370.00	1739.6	3.05	0.008241	0.030	9.23	48.68	1370.00	0.93	1.51
Reach 1	2.97	10-yr encr	1370.00	1742.2	2.50	0.007013	0.030	7.55	72.00	1360.12	0.84	1.08
Reach 1	3.07	10-yr encr	1370.00	1745.3	3.33	0.005420	0.030	8.06	48.16	1293.17	0.78	1.11
Reach 1	3.13	10-yr encr	1370.00	1746.8	3.25	0.007134	0.030	9.02	45.92	1346.56	0.88	1.41
Reach 1	3.21	10-yr encr	1370.00	1749.9	2.54	0.008531	0.030	8.45	62.67	1343.38	0.93	1.34
Reach 1	3.32	10-yr encr	1370.00	1754.0	2.67	0.006984	0.030	7.89	64.99	1369.10	0.85	1.15
Reach 1	3.4	10-yr encr	1370.00	1757.2	3.15	0.006073	0.030	8.20	45.00	1163.99	0.81	1.17
Reach 1	3.48	10-yr encr	1370.00	1760.0	3.67	0.006931	0.030	9.52	33.40	1166.36	0.88	1.52
Reach 1	3.52	10-yr encr	1370.00	1761.2	3.86	0.006665	0.030	9.71	35.10	1315.44	0.87	1.55
Reach 1	3.6	10-yr encr	1370.00	1764.4	3.64	0.006089	0.030	8.93	34.14	1108.72	0.82	1.33
Reach 1	3.65	10-yr encr	1370.00	1766.1	3.55	0.003405	0.030	6.68	45.00	1067.81	0.62	0.75
Reach 1	3.75	10-yr encr	1370.00	1768.7	3.71	0.007173	0.030	9.76	37.35	1350.03	0.89	1.59
Reach 1	3.78	10-yr encr	1370.00	1770.7	2.38	0.009306	0.030	8.40	62.32	1244.51	0.96	1.35
Reach 1	3.86	10-yr encr	1210.00	1774.4	2.42	0.007116	0.030	7.44	64.65	1165.97	0.84	1.06
Reach 1	3.96	10-yr encr	1210.00	1778.1	2.30	0.007352	0.030	7.34	71.66	1209.54	0.85	1.04
Reach 1	4.05	10-yr encr	1210.00	1782.9	2.81	0.005550	0.030	7.29	43.07	883.69	0.77	0.96
Reach 1	4.11	10-yr encr	1210.00	1785.5	1.60	0.011644	0.030	7.25	104.60	1210.00	1.01	1.15
Reach 1	4.22	10-yr encr	1210.00	1789.2	2.36	0.006762	0.030	7.15	47.85	807.36	0.82	0.98
Reach 1	4.23	10-yr encr	1210.00	1790.1	2.69	0.004017	0.030	5.98	50.03	803.42	0.64	0.66
Reach 1	4.31	10-yr encr	1210.00	1792.7	3.27	0.007554	0.030	9.29	39.21	1190.10	0.91	1.50
Reach 1	4.4	10-yr encr	1210.00	1796.9	3.01	0.006402	0.030	8.15	40.00	980.81	0.83	1.18
Reach 1	4.49	10-yr encr	1210.00	1799.8	2.12	0.005505	0.030	6.05	94.17	1210.00	0.73	0.73
Reach 1	4.56	10-yr encr	1210.00	1802.0	2.18	0.007888	0.030	7.39	140.00	1210.00	0.88	1.07
Reach 1	4.575		Culvert									

Station ID (River miles)	Maximum WSE (ft) *2	Left Bank Superelevation Freeboard (ft)	Right Bank Superelevation Freeboard (ft)	Left Top of Bank Elevation (ft) *1	Right Top of Bank Elevation (ft) *1	HEC-RAS Minimum Elevation (ft) *2	HEC-6 General Scour Depth (ft)	Antidune Trough Depth (ft)	Left Bank HEC-6 Design Scour Depth (ft) *3	Right Bank HEC-6 Design Scour Depth (ft) *3	Depth to Armoring, y_d (ft)	Left Bank Total Degredeation (ft) *4	Right Bank Total Degredeation (ft) *4	Extent of Left Toe Down *6	Left Bank Toe Down Elevation (ft) *5	Extent of Right Toe Down *6	Right Bank Toe Down Elevation (ft) *5	HEC-RAS Min Elevation - 10' (ft)	Left Ave Total Degredation	Right Ave Total Degredation	Left TOB - HEC-RAS Min Elevation	Right TOB - HEC-RAS Min Elevation
0.040	1737.1	0	0	1740.1	1740.1	1726.0	0.4	0.3	0.9	0.9	0.2	3.0	3.0	No Armor	1723.0	No Armor	1723.0	1716.0			14.1	14.1
0.130	1737.6	0	0	1740.6	1740.6	1732.0	1.5	1.4	3.7	3.7	2.4	6.2	6.2	No Armor	1725.8	No Armor	1725.8	1722.0			8.6	8.6
0.170	1739.3	0	0	1742.3	1742.3	1732.0	1.3	1.5	3.6	3.6	0.9	4.5	4.5	No Armor	1727.5	No Armor	1727.5	1722.0			10.3	10.3
0.280	1744.2	0.1	0	1747.3	1747.2	1738.0	0.8	1.7	3.3	3.2	2.3	5.6	5.5	No Armor	1732.4	No Armor	1732.5	1728.0			9.3	9.2
0.340	1747.2	0.1	0	1750.3	1750.2	1744.0	0.6	1.9	3.3	3.3	2.4	5.8	5.7	No Armor	1738.2	No Armor	1738.3	1734.0			6.3	6.2
0.440	1751.3	0	0	1754.3	1754.3	1746.0	0.7	1.4	2.6	2.6	1.2	3.9	3.9	No Armor	1742.1	No Armor	1742.1	1736.0			8.3	8.3
0.530	1755.4	0	0	1758.4	1758.4	1750.0	0.7	1.8	3.2	3.2	2.3	5.5	5.5	No Armor	1744.5	No Armor	1744.5	1740.0			8.4	8.4
0.620	1759.8	0	0	1762.8	1762.8	1754.0	0.7	1.4	2.7	2.7	2.3	5.0	5.0	No Armor	1749.0	No Armor	1749.0	1744.0			8.8	8.8
0.720	1762.5	0	0	1765.5	1765.5	1758.0	0.7	1.8	3.3	3.3	1.7	5.0	5.0	No Armor	1753.0	No Armor	1753.0	1748.0			7.5	7.5
0.800	1767.0	0	0	1770.0	1770.0	1762.0	0.7	1.7	3.1	3.1	2.1	5.3	5.3	No Armor	1756.7	No Armor	1756.7	1752.0			8.0	8.0
0.890	1771.8	0	0	1774.8	1774.8	1764.0	0.6	1.5	2.7	2.7	3.3	6.1	6.1	No Armor	1757.9	No Armor	1757.9	1754.0			10.8	10.8
0.950	1773.2	0	0.2	1776.2	1776.4	1766.0	0.5	1.3	2.3	4.6	0.7	3.0	5.3	No Armor	1763.0	No Armor	1760.7	1756.0			10.2	10.4
1.040	1775.6	0.1	0	1778.7	1778.6	1770.0	0.3	1.0	3.5	1.7	1.9	5.3	3.6	No Armor	1764.7	No Armor	1766.4	1760.0			8.7	8.6
1.120	1778.8	0	0	1781.8	1781.8	1772.0	0.2	1.4	2.1	2.1	2.8	4.9	4.9	No Armor	1767.1	No Armor	1767.1	1762.0			9.8	9.8
1.210	1782.3	0	0	1785.3	1785.3	1776.0	0.3	1.7	2.5	2.5	2.3	4.8	4.8	No Armor	1771.2	No Armor	1771.2	1766.0			9.3	9.3
1.270	1785.1	0	0	1788.1	1788.1	1778.0	0.3	1.3	2.0	2.0	1.4	3.5	3.5	Full Depth	1774.5	No Armor	1774.5	1768.0			10.1	10.1
1.370	1788.0	0.5	0	1791.5	1791.0	1782.0	0.3	2.2	5.3	3.3	2.6	7.9	5.9	Full Depth	1774.1	No Armor	1776.1	1772.0			9.5	9.0
1.460	1791.7	0.4	0	1795.1	1794.7	1786.0	0.4	1.8	4.8	2.9	2.1	6.9	5.0	Full Depth	1779.1	No Armor	1781.0	1776.0			9.1	8.7
1.540	1794.5	0	0	1797.5	1797.5	1790.0	0.4	0.9	1.7	1.7	0.8	3.0	3.0	Full Depth	1787.0	No Armor	1787.0	1780.0			7.5	7.5
1.650	1801.1	0	0	1804.1	1804.1	1796.0	0.5	1.8	2.9	2.9	2.0	4.9	4.9	Full Depth	1791.1	No Armor	1791.1	1786.0			8.1	8.1
1.750	1805.8	0	0	1808.8	1808.8	1800.0	0.5	1.7	2.9	2.9	2.3	5.1	5.1	Full Depth	1794.9	No Armor	1794.9	1790.0			8.8	8.8
1.830	1811.3	0	0	1814.3	1814.3	1806.0	0.5	1.6	2.7	2.7	2.0	4.7	4.7	Full Depth	1801.3	No Armor	1801.3	1796.0			8.3	8.3
1.920	1815.5	0	0	1818.5	1818.5	1810.0	0.6	1.3	2.4	2.4	2.0	4.4	4.4	Full Depth	1805.6	No Armor	1805.6	1800.0	3.0	3.0	8.5	8.5
2.000	1821.2	0	0	1824.2	1824.2	1814.0	1.0	2.9	5.1	5.1	3.1	8.1	8.1	Full Depth	1805.9	No Armor	1805.9	1804.0	8.1	8.1	10.2	10.2
																		Average	5.1	5.0	9.1	9.1

*1 Top of Bank = HEC-RAS WSE + Superel. + 3'
*2 All hydraulic parameters from HEC-RAS Apache1.prj
Existing (Worst case) hydraulics.
*3 Left or Right Bank Design Scour Depth = (HEC-6 General Scour + Anti-dune Trough Depth + Right or Left Bend Scour Depth) * 1.3
*4 Total Degredation = Design Scour Depth + Armoring Depth. Minimum 3'
*5 Toe Down Elevation = Minimum HEC-RAS Elevation - Total Degredation
*6 Toe Down Extent is Determined According to Location of FP/FW Relative to Long Term Armoring Line
If the Toe is Close to the Floodplain, the Armoring Will Extend Down 3' Below Thalweg

Stationing ID (River Miles)	Reach Code	Design Discharge, Q (cfs) *1	Average Channel Velocity, V_m (fps)	Maximum Depth Main Channel, Y_{max}, (ft)	Main Channel Hydraulic Depth, Y_h (ft)	Energy Slope, S_e (ft/ft)	HEC-6 General Scour Depth, HEC-6 Z_{gs} (ft) *4	Anti-dune Trough Depth, Z_a (ft) *5	Left Bank Angle of Channel Bend in degrees	Right Bank Angle of Channel Bend in degrees	Left Bank Bend Scour Depth, Z_{bs} (ft) *6	Right Bank Bend Scour Depth, Z_{bs} (ft) *6	Full Flow Velocity *2	Full Flow Channel Top Width, T (ft) *2	Left Bank Radius of Curve, r_c *9	Right Bank Radius of Curve, r_c *9	Left Bank Superelevation, del h (ft) *10	Right Bank Superelevation, del h (ft) *10	Left Bank HEC 6 Design Scour Depth, Z_t (ft) *8	Right Bank HEC-6 Design Scour Depth, Z_t (ft) *8	Reach Average Left Bank HEC-6 Design Scour Depth	Reach Average Right Bank HEC 6 Design Scour Depth
0.04	Paradise	5992	5.01	11.07	9.71	0.00050	0.35	0.3	0	0	0	0	2.4	529.1	0	0	0	0	0.9	0.9	3.0	2.9
0.13	Paradise	5992	9.96	5.56	5	0.00476	1.5	1.4	0	0	0	0	4.7	580.2	0	0	0	0	3.7	3.7		
0.17	Paradise	5992	10.38	7.29	6.78	0.00346	1.3	1.5	0	0	0	0	4.4	573.4	0	0	0	0	3.6	3.6		
0.28	Paradise	5992	10.98	6.19	4.55	0.00663	0.8	1.7	18	0	0.1	0	5.8	469.2	4558.6	0	0.1	0	3.3	3.2		
0.34	Paradise	5992	11.85	3.21	3.21	0.01208	0.6	1.9	18	0	0.0	0	5.6	535.0	5197.8	0	0.1	0	3.3	3.3		
0.44	Paradise	5992	9.98	5.31	4.09	0.00631	0.65	1.4	0	0	0	0	4.5	536.1	0	0	0	0	2.6	2.6		
0.53	Paradise	5992	11.57	5.45	5.12	0.00626	0.65	1.8	0	0	0	0	5.3	493.6	0	0	0	0	3.2	3.2		
0.62	Paradise	5992	9.96	5.75	5.3	0.00440	0.7	1.4	0	0	0	0	4.5	643.3	0	0	0	0	2.7	2.7		
0.72	Paradise	5992	11.6	4.48	4.08	0.00856	0.7	1.8	0	0	0	0	4.9	613.6	0	0	0	0	3.3	3.3		
0.8	Paradise	5992	11.14	5.01	4.57	0.00679	0.7	1.7	0	0	0	0	4.4	667.2	0	0	0	0	3.1	3.1		
0.89	Paradise	5992	10.51	7.76	7.08	0.00357	0.6	1.5	0	0	0	0	4.1	646.0	0	0	0	0	2.7	2.7		
0.95	Paradise	5992	9.74	7.24	5.61	0.00394	0.45	1.3	0	28	0	1.8	5.4	577.3	0	2177.5	0	0.2	2.3	4.6		
1.04	Paradise	5992	8.58	5.62	5.12	0.00344	0.3	1.0	28	0	1.4	0	3.8	574.9	2168.3	0	0.1	0	3.5	1.7		
1.12	Paradise	5992	10.15	6.82	4.79	0.00527	0.2	1.4	0	0	0	0	5.2	533.4	0	0	0	0	2.1	2.1		
1.21	Paradise	5992	11.12	6.26	5.92	0.00482	0.25	1.7	0	0	0	0	4.2	706.0	0	0	0	0	2.5	2.5		
1.27	Paradise	5992	9.63	7.13	5.66	0.00377	0.3	1.3	0	0	0	0	5.5	631.2	0	0	0	0	2.0	2.0		
1.37	Paradise	5992	12.75	5.96	4.82	0.00823	0.3	2.2	28	0	1.6	0	7.6	261.0	984.3	0	0.5	0	5.3	3.3		
1.46	Paradise	5992	11.51	5.68	5.36	0.00580	0.4	1.8	28	0	1.5	0	6.8	288.2	1087.0	0	0.4	0	4.8	2.9		
1.54	Paradise	5992	8.25	4.53	4.06	0.00436	0.4	0.9	0	0	0	0	6.3	402.2	0	0	0	0	1.7	1.7		
1.65	Paradise	5401	11.46	5.12	4.65	0.00697	0.45	1.8	0	0	0	0	5.8	361.4	0	0	0	0	2.9	2.9		
1.75	Paradise	5401	11.16	5.77	4.14	0.00775	0.5	1.7	0	0	0	0	5.9	378.1	0	0	0	0	2.9	2.9		
1.83	Paradise	5401	10.7	5.31	4.57	0.00621	0.5	1.6	0	0	0	0	5.2	443.2	0	0	0	0	2.7	2.7		
1.92	Paradise	5401	9.76	5.46	4.51	0.00527	0.55	1.3	0	0	0	0	5.9	396.7	0	0	0	0	2.4	2.4		
2	Paradise	5401	14.55	7.16	6.61	0.00707	1	2.9	0	0	0	0	9.7	115.8	0	0	0	0	5.1	5.1		

*1 All hydraulic parameters from HEC-RAS Apache1.prj

*4 Extracted from Stantec HEC-6 analysis graphs. Interpolated from peak to peak Straight Line. Worst Case between Future and Existing Conditions.

*5 Anti-dune scour depth from SLA, 1982 (COT 6.09 and Fuller Report) $Z_a = 0.0137 * V_m^2$

If Za > 0.5 * Yh, then Za = 0.5 * Yh

*6 Bend Scour Depth From Zeller, 1981 (COT Drainage Design and FP Mgmt 6.11 and Fuller Report)

$Z_{gs} = ((0.0685 * Y_{max} * V_m^{0.8})/(Y_h^{0.4} * S_e^{0.3})) * ((2.1 * (((\sin^2(alpha/2)) / (\cos alpha))^{0.2})) -1)$

alpha = degree of bend

Erosion Will Occur on Outside Bank. Right and Left Bank Looking Upstream (Opposite of HEC-RAS)

*8 $Z_t = 1.3 * (\text{HEC-6 } Z_{gs} + Z_a + Z_{bs} + Z_{ls} + Z_{lft})$ Used to calculate toe down elevation

1.3 = Factor of Safety

Z_{ls} = Local Scour = 0

Z_{lft} = Low Flow Thalweg Scour = 0

*9 Radius of Curve from Zeller 1981 (COT Drainage Design and FP Mgmt 6.11)

$r_c / T = \cos alpha / (4 * \sin^2(alpha/2))$

r_c = Radius of Curve

T = Full Floodway Width (As opposed to main channel widhth)

*10 Chow's Simplified Method of Determining Superelevation (p.448)

Also the preferred method in Maricopa Drainage and Design Manual (p. 6-20)

$h = (V^2 * T) / (g * r_c)$

V = Full Floodway Velocity (As opposed to Main Channel Velocity)

[illegible]tioning [illegible]D (River Miles)	Reach Code	Average Depth of Flow, d (ft) *1 *2	Energy Slope, S_e (ft/ft)	*n* Value for Stream Bed *3	90% Finer Particle Size, D_{90} (mm) *4	M-P, Muller Individual Particle Size, D_c (mm) *5	Average Channel Velocity, V_m (fps)	Competent Bottom Velocity Armor Size, Dc (mm) *6	Critical Shear Stress, T_c (lb/ft^2) *7	Shield's Diagram D_c (ft) *8	Shields Diagram D_c (mm)	Shear Velocity, U. (fps) *9	Boundary Reynolds No., R. *10	Yang's Incipient Motion, D_c (ft) *11	Yang's Incipient Motion, D_c (mm)	Average Individual Particle Size, D_c (mm)	Reach Average D_c (mm)	Percentage of Bed Material Larger than D_c, del p (Seive-Boulder Count Combo) *12	Thickness to Armoring Layer, y_a (mm) *13	Depth to Armoring, y_d (ft) Seive - Boulder Count Combo *14	Ave Depth to Armoring by Reaches (Seive-Boulder Sediment Combo)
0.04	Paradise	4.3	0.0010	0.028	150	16.5	4.1	31.8	0.3	0.04	13.3	0.372	1498	0.111	33.9	23.9	76.4	48	47.7	0.17	2.0
0.13	Paradise	2.1	0.0091	0.028	150	73.9	7.8	113.2	1.2	0.19	59.4	0.787	14196	0.397	121.0	91.9		17	152.4	2.44	
0.17	Paradise	3.6	0.0026	0.028	150	36.7	6.0	66.8	0.6	0.10	29.5	0.555	4975	0.234	71.3	51.1		27	102.2	0.91	
0.28	Paradise	2.2	0.0080	0.028	150	66.6	7.4	102.1	1.1	0.18	53.5	0.747	12151	0.358	109.1	82.8		18	152.4	2.28	
0.34	Paradise	1.6	0.0127	0.028	150	77.3	7.6	108.3	1.3	0.20	62.2	0.805	15214	0.380	115.7	90.9		17	152.4	2.44	
0.44	Paradise	2.2	0.0057	0.028	150	48.1	6.3	73.7	0.8	0.13	38.7	0.635	7471	0.258	78.7	59.8		24	119.6	1.24	
0.53	Paradise	2.7	0.0060	0.028	150	62.5	7.4	102.9	1.0	0.16	50.2	0.724	11042	0.361	110.0	81.4		18	152.4	2.28	
0.62	Paradise	2.0	0.0094	0.028	150	70.7	7.5	105.2	1.1	0.19	56.9	0.770	13304	0.369	112.4	86.3		18	152.4	2.28	
0.72	Paradise	2.4	0.0060	0.028	150	54.8	6.8	86.4	0.9	0.14	44.1	0.678	9079	0.303	92.3	69.4		21	138.8	1.71	
0.8	Paradise	2.7	0.0056	0.028	150	59.1	7.2	97.5	1.0	0.16	47.5	0.704	10166	0.342	104.1	77.1		19	152.4	2.13	
0.89	Paradise	3.2	0.0072	0.028	150	89.6	8.9	147.6	1.5	0.24	72.1	0.867	18973	0.517	157.7	116.7		13	152.4	3.35	
0.95	Paradise	2.5	0.0037	0.028	150	35.0	5.5	55.8	0.6	0.09	28.2	0.542	4632	0.196	59.7	44.7		30	89.3	0.68	
1.04	Paradise	2.4	0.0062	0.028	150	56.8	6.9	89.8	0.9	0.15	45.7	0.690	9569	0.315	95.9	72.0		20	144.1	1.89	
1.12	Paradise	1.9	0.0114	0.028	150	82.6	8.0	121.2	1.3	0.22	66.4	0.832	16797	0.425	129.5	100.0		15	152.4	2.83	
1.21	Paradise	3.1	0.0052	0.028	150	62.1	7.5	106.0	1.0	0.16	49.9	0.721	10932	0.372	113.3	82.8		18	152.4	2.28	
1.27	Paradise	2.2	0.0062	0.028	150	52.4	6.6	81.4	0.9	0.14	42.1	0.663	8486	0.285	87.0	65.7		23	131.5	1.44	
1.37	Paradise	2.24	0.0082	0.028	150	70.6	7.66	110.3	1.1	0.19	56.8	0.769	13278	0.387	117.9	88.9		16	152.4	2.63	
1.46	Paradise	2.36	0.0070	0.028	150	63.3	7.3	100.2	1.0	0.17	50.9	0.729	11275	0.351	107.0	80.4		19	152.4	2.13	
1.54	Paradise	1.52	0.0071	0.028	150	41.5	5.46	56.0	0.7	0.11	33.4	0.590	5982	0.196	59.9	47.7		28	95.4	0.80	
1.65	Paradise	2.42	0.0064	0.028	150	59.6	7.11	95.0	1.0	0.16	47.9	0.707	10282	0.333	101.5	76.0		20	152.0	2.00	
1.75	Paradise	2.05	0.0088	0.028	150	69.2	7.45	104.3	1.1	0.18	55.6	0.762	12872	0.366	111.5	85.2		18	152.4	2.28	
1.83	Paradise	2.3	0.0067	0.028	150	59.4	7.04	93.2	1.0	0.16	47.8	0.706	10236	0.327	99.6	75.0		20	149.9	1.97	
1.92	Paradise	1.94	0.0084	0.028	150	62.8	7.03	92.9	1.0	0.17	50.5	0.726	11131	0.326	99.3	76.4		20	152.4	2.00	
2	Paradise	2.82	0.0075	0.028	150	81.6	8.51	136.1	1.3	0.22	65.6	0.827	16470	0.477	145.5	107.2		14	152.4	3.07	

*1 All hydraulic parameters from HEC-RAS Apache1.prj

[illegible]ydraulic Parameters are From Main Channel Between Overbanks

[illegible]kin Friction Average

*4 From JEF H&G Sediment Analysis

*5 Meyer-Peter, Muller (Bedload Transport Equation) From USBR 'Computing Degradation and Local Scour' p.9

$D_c = (d * S_e) / (K * ((n/(D_{90}^{1/6}))^{3/2}))$

*6 Competent Bottom Velocity Equation From From USBR 'Computing Degradation and Local Scour' p.10

$D_c = 1.88 * (V_m^2)$

*7 T_c = gammaw * d * S_e . Can also extract from HEC-RAS Analysis Data

*8 Shield's Diagram Equation From USBR 'Computing Degradation and Local Scour' p.12

$D_c = T_c$ / (gamma$_s$ - gamma$_w$) * T

gamma$_s$ = Specific Weight of Particle = 165 lb/ft^3

gamma$_w$ = Specific Weight of Water = 62.4 lb/ft^3

T = Dimensionless Shear Stress = 0.06 for particles > 1.0mm and R > 500

Fuller used T = 0.05, M-P, Muller recommends T = 0.047. T = 0.06 is generally accepted in completely rough boundary (Simons and Senturk, P. 387)

*9 U. = Shear Velocity = $(T_c/(\text{gamma}_w/g))^{0.5}$ or = $(g * R * S_e)^{1/2}$ from Simons and Senturk, P. 78 & 264

R = Hydraulic Radius = d in wide channels

10 R = U. * D_c / *v*

v = Kinematic Viscosity = 0.0000108 ft^2/sec

When R. > 500 T = 0.06 on Shields Diagram

*11 Yang's Incipient Motion Equation From USBR 'Computing Degradation and Local Scour' p.14

*12 From Graph of Fuller Sediment Analysis Averaged over Entire Length of Cave Creek.
Using graph altered to reflect percent passing by weight.

*13 $y_a = 2 * D_c$ or 0.5' whichver is smaller

*14 $y_d = y_a * ((1/\text{del p})-1)$ - Depth to Armoring not Reached when y_d > 25'

	Size (mm)	Size (ft)	Size (in.)
D_{90} =	150	0.492	5.91
D_{50} =	23	0.075	0.91
D_{75} =	57	0.187	2.24

Method	Equation		
	$n_s = (D_{90}^{1/6}) / 44.4$ (D_{90} in inches)	n_s =	0.030
Anderson	$n_s = 0.0395 * (D_{50}^{1/6})$ (D_{50} in feet)	n_s =	0.026
Lane	$n_s = (D_{75}^{1/6}) / 39$ (D_{75} in inches)	n_s =	0.029
			0.028

Station ID (River Miles)	Reach Code	Mean Particle Size, (mm) [1]	Channel Width (ft) [2]	Dominant Discharge, Q (cfs) [2]	Schoklitsch, S_L (ft/ft) [3]	90% Finer Particle Size, D_{90} (mm) [1]	*n* Value for Cross Section [2]	Average Depth of Flow, d (ft) [2]	M-P,M S_L (ft/ft) [4]	Shields S_L (ft/ft) [5]	Shear Velocity, U* (fps) [6]	Boundary Reynolds No. [7]	Average S_L (ft/ft)	Average S_L by Reach	Average Invert Slope by Reach [8]	Distance Between Grade Control Structures (ft) [9]
0.040	Paradise	50	62.07	1105.34	0.003774	150	0.028432	4.34	0.00300	0.003743	0.7233	10986.0	0.003505	0.00557	0.008503	1704
0.130	Paradise	50	69.13	1131.21	0.004021	150	0.028432	2.11	0.00617	0.007700	0.7233	10986.0	0.005963			
0.170	Paradise	50	48.20	1038.74	0.003271	150	0.028432	3.61	0.00361	0.004500	0.7233	10986.0	0.003792			
0.280	Paradise	50	58.37	937.28	0.004079	150	0.028432	2.18	0.00597	0.007453	0.7233	10986.0	0.005834			
0.340	Paradise	50	45.08	543.99	0.005053	150	0.028432	1.59	0.00818	0.010218	0.7233	10986.0	0.007819			
0.440	Paradise	50	35.85	488.04	0.004616	150	0.028432	2.18	0.00597	0.007453	0.7233	10986.0	0.006013			
0.530	Paradise	50	52.00	1038.14	0.003464	150	0.028432	2.7	0.00482	0.006017	0.7233	10986.0	0.004767			
0.620	Paradise	50	64.00	931.62	0.004390	150	0.028432	1.95	0.00667	0.008332	0.7233	10986.0	0.006465			
0.720	Paradise	50	40.00	646.78	0.004057	150	0.028432	2.39	0.00545	0.006798	0.7233	10986.0	0.005433			
0.800	Paradise	50	38.57	759.51	0.003500	150	0.028432	2.74	0.00475	0.005929	0.7233	10986.0	0.004726			
0.890	Paradise	50	40.31	1150	0.002650	150	0.028432	3.22	0.00404	0.005045	0.7233	10986.0	0.003913			
0.950	Paradise	50	85.70	1149.96	0.004667	150	0.028432	2.46	0.00529	0.006604	0.7233	10986.0	0.005520			
1.040	Paradise	50	43.61	714.11	0.004019	150	0.028432	2.37	0.00549	0.006855	0.7233	10986.0	0.005455			
1.120	Paradise	50	75.78	1150	0.004255	150	0.028432	1.89	0.00689	0.008596	0.7233	10986.0	0.006579			
1.210	Paradise	50	37.46	872.17	0.003087	150	0.028432	3.1	0.00420	0.005241	0.7233	10986.0	0.004175			
1.270	Paradise	50	78.99	1150	0.004390	150	0.028432	2.21	0.00589	0.007351	0.7233	10986.0	0.005877			
1.370	Paradise	50	54.66	939.42	0.003876	150	0.028432	2.24	0.00581	0.007253	0.7233	10986.0	0.005646			
1.460	Paradise	50	65.56	1127.17	0.003875	150	0.028432	2.36	0.00551	0.006884	0.7233	10986.0	0.005424			
1.540	Paradise	50	33.84	279.81	0.006710	150	0.028432	1.52	0.00856	0.010688	0.7233	10986.0	0.008653			
1.650	Paradise	50	49.00	842.7	0.003874	150	0.028432	2.42	0.00538	0.006713	0.7233	10986.0	0.005322			
1.750	Paradise	50	52.66	805.16	0.004231	150	0.028432	2.05	0.00635	0.007925	0.7233	10986.0	0.006168			
1.830	Paradise	50	55.32	895.33	0.004055	150	0.028432	2.3	0.00566	0.007064	0.7233	10986.0	0.005592			
1.920	Paradise	50	73.93	1007.57	0.004612	150	0.028432	1.94	0.00671	0.008374	0.7233	10986.0	0.006565			
2.000	Paradise	50	38.83	931.31	0.003019	150	0.028432	2.82	0.00461	0.005761	0.7233	10986.0	0.004465			

[1] Mean Particle Diameter (mm) From Simons and Senturk p. 172

[2] All hydraulic parameters from HEC-RAS Apache1.prj
Hydraulic Parameters are From Main Channel Between Overbanks.

[3] Schoklitsch Equation for Zero Bedload Transport From USBR 'Computing Degradation and Local Scour' p.18

$S_L = K * ((D_M * B / Q)^{.75})$
K = 0.00174
D_M = Mean Particle Diameter (mm) From Simons and Senturk p. 172
B = Channel Width (ft) = HEC-RAS Top of Channel Width
Q = Flow Over Main Channel

[4] Meyer-Peter, Muller Equation From USBR 'Computing Degradation and Local Scour' p.18

$S_L = K * (Q/Q_B) * ((n/(D_{90}^{1/6}))^{1.5}) * D_M / d$
K = 0.19
Q/Q_B = Total Flow Divided by Flow Over Bed of Channel = 1 in Wide Channels
D_{90} = Particle Size (mm) For Which 90% of Material by Weight is Finer From JEF Report
d = Mean Depth (ft) = HEC-RAS Hydraulic Depth Over Entire Cross Section

[5] Shield's Diagram Equation From USBR 'Computing Degradation and Local Scour' p.18-19

$T_* = T_c / (gamma_s - gamma_w) * D_M$
T_* = Dimensionless Shear Stress = 0.06 for particles > 1.0mm and R > 500
$T_c = gamma_w * d * S_L$
$gamma_s$ = Specific Weight of Particle = 165 lb/ft^3
$gamma_w$ = Specific Weight of Water = 62.4 lb/ft^3
Fuller used T = 0.055, M-P, Muller recommends T = 0.047. T = 0.06 is generally accepted in completely rough boundary (Simons and Senturk, P. 387)

[6] U_* = Shear Velocity = $(g * R * S_L)^{1/2}$ or $(T_c/(gamma_w/g))^{0.5}$ from USBR & Simons and Senturk, P. 78 & 384
R = Hydraulic Radius = Mean Hydraulic Depth, d in wide channels

[7] $R^* = U_* * D_{50} / v$ to Determine if R^* >500
D_M in feet
v = Kinematic Viscosity = 0.0000108 ft^2/sec
When R_* > 500 T = 0.06 on Shields Diagram

[8] (Min RAS Elev @ Beginning Sta. - Min RAS Elev @ Ending Sta.)/((Beginning Sta. No. - Ending Sta. No.) * 5280)
Altered if slope did not fit existing profile.

[9] Height of Drop / (Invert Slope - Equilibrium Slope)
Height of Drop Between Structures = 5'

Stationing ID (River miles)	Maximum WSE (ft) *2	Left Bank Superelevation Freeboard (ft)	Right Bank Superelevation Freeboard (ft)	Left Top of Bank Elevation (ft) *1	Right Top of Bank Elevation (ft) *1	HEC-RAS Minimum Elevation (ft) *2	HEC-6 General Scour Depth (ft)	Antidune Trough Depth (ft)	Left Bank Bend Scour Depth, Z_{bs} (ft)	Right Bank Bend Scour Depth, Z_{bs} (ft)	Left Bank HEC-6 Design Scour Depth (ft) *3	Right Bank HEC-6 Design Scour Depth (ft) *3	Depth to Armoring, y_d (ft)	Left Bank Total Degredeation (ft) *4	Right Bank Total Degredeation (ft) *4	Extent of Left Toe Down *6	Left Bank Toe Down Elevation (ft) *5	Extent of Right Toe Down *6	Right Bank Toe Down Elevation (ft) *5	HEC-RAS Min Elevation - 10' (ft)	Average Total Degredation (ft)	TOB - HEC-RAS Min Elevation	Ave TOB - HEC-RAS Min Elevation	
0.386	1745.4	0	0	1748.4	1748.4	1738.0	0.6	1.5	0	0	2.8	2.8	2.2	5.0	5.0	Full	1733.0	Full	1733.0	1728.0		10.4		
0.400	1746.2	0	0	1749.2	1749.2	1738.0	0.2	1.4	0	0	2.0	2.0	2.5	4.5	4.5	Full	1733.5	Full	1733.5	1728.0		11.2		
0.480	1747.6	0	0	1750.6	1750.6	1740.0	0.0	1.1	0	0	1.4	1.4	0.9	3.0	3.0	Full	1737.0	Full	1737.0	1730.0		10.6		
0.560	1748.5	0	0	1751.5	1751.5	1740.0	0.0	1.4	0	0	1.8	1.8	7.8	9.7	9.7	Full	1730.3	Full	1730.3	1730.0		11.5		
0.640	1749.7	0	0	1752.7	1752.7	1742.0	0.0	1.9	0	0	2.5	2.5	7.8	10.4	10.4	Full	1731.6	Full	1731.6	1732.0	3.0	10.7		Min
0.720	1751.5	0	0	1754.5	1754.5	1744.0	0.1	1.8	0	0	2.4	2.4	7.8	10.3	10.3	Full	1733.7	Full	1733.7	1734.0	10.4	10.5		Max
0.810	1753.7	0	0	1756.7	1756.7	1746.0	0.1	1.3	0	0	1.9	1.9	6.6	8.5	8.5	Full	1737.5	Full	1737.5	1736.0	7.3	10.7	10.8	Average

*1 Top of Levee = HEC-RAS WSE + Superel. + 3'

*2 All hydraulic parameters from HEC-RAS Apache1.prj
Existing (Worst case) hydraulics.

*3 Left or Right Bank Design Scour Depth = (HEC-6 General Scour + Anti-dune Trough Depth + Right or Left Bend Scour Depth) * 1.3

*4 Total Degredation = Design Scour Depth + Armoring Depth. Minimum 3'

*5 Toe Down Elevation = Minimum HEC-RAS Elevation - Total Degredation

*6 Toe Down Extent is Determined According to Location of FP/FW Relative to Long Term Armoring Line
If the Toe is Close to the Floodplain, the Armoring Will Extend Down 3' Below Thalweg

Stationing ID (River Miles)	Reach Code	Design Discharge, Q (cfs) *1	Average Channel Velocity, V_m (fps)	Maximum Depth Main Channel, Y_{max}, (ft)	Main Channel Hydraulic Depth, Y_h (ft)	Energy Slope, S_e (ft/ft)	HEC-6 General Scour Depth, HEC-6 Z_{gs} (ft) *4	Anti-dune Trough Depth, Z_a (ft) *5	Left Bank Angle of Channel Bend in degrees	Right Bank Angle of Channel Bend in degrees	Left Bank Bend Scour Depth, Z_{bs} (ft) *6	Right Bank Bend Scour Depth, Z_{bs} (ft) *6	Full Flow Velocity *2	Full Flow Channel Top Width, T (ft) *2	Left Bank Radius of Curve, r_c *9	Right Bank Radius of Curve, r_c *9	Left Bank Superelevation, del h (ft) *10	Right Bank Superelevation, del h (ft) *10	Left Bank HEC 6 Design Scour Depth, Z_t (ft) *8	Right Bank HEC-6 Design Scour Depth, Z_t (ft) *8	Left Bank Reach Average HEC-6 Design Scour Depth	Right Bank Reach Average HEC-6 Design Scour Depth
0.386	Desert Hills	10761	10.58	7.44	7.19	0.00345	0.63	1.5	0	0	0	0	4.8	497.8	0	0	0	0	2.8	2.8	2.1	2.1
0.4	Desert Hills	10761	10.01	8.19	6.44	0.00348	0.17	1.4	0	0	0	0	4.9	541.3	0	0	0	0	2.0	2.0		
0.48	Desert Hills	10761	8.9	7.57	7.23	0.00238	0	1.1	0	0	0	0	4.1	556.2	0	0	0	0	1.4	1.4		
0.56	Desert Hills	10761	10.16	8.51	7.41	0.00313	0	1.4	0	0	0	0	4.4	571.0	0	0	0	0	1.8	1.8		
0.64	Desert Hills	10761	11.81	7.71	6.37	0.00500	0.04	1.9	0	0	0	0	5.4	511.0	0	0	0	0	2.5	2.5		
0.72	Desert Hills	10761	11.54	7.51	6.52	0.00487	0.06	1.8	0	0	0	0	5.5	467.2	0	0	0	0	2.4	2.4		
0.81	Desert Hills	10761	9.88	7.65	6.62	0.00366	0.1	1.3	0	0	0	0	3.9	904.8	0	0	0	0	1.9	1.9		

*1 All hydraulic parameters from HEC-RAS Apache1.prj

*4 Extracted from Stantec HEC-6 analysis graphs. Interpolated from peak to peak Straight Line.
Worst Case between Future and Existing Conditions.

*5 Anti-dune scour depth from SLA, 1982 (COT 6.09 and Fuller Report) $Z_a = 0.0137 * V_m^2$
If Za > 0.5 * Yh, then Za = 0.5 * Yh

*6 Bend Scour Depth From Zeller, 1981 (COT Drainage Design and FP Mgmt 6.11 and Fuller Report)

$Z_{gs} = ((0.0685 * Y_{max} * V_m^{0.8})/(Y_h^{0.4} * S_e^{0.3})) * ((2.1 * (((\sin^2(alpha/2)) / (\cos alpha))^{0.2})) - 1)$

alpha = degree of bend

Erosion Will Occur on Outside Bank. Right and Left Bank Looking Upstream (Opposite of HEC-RAS)

*8 $Z_t = 1.3 * (\text{HEC-6 } Z_{gs} + Z_a + Z_{bs} + Z_{ls} + Z_{lft})$ Used to calculate toe down elevation

1.3 = Factor of Safety

Z_{ls} = Local Scour = 0

Z_{lft} = Low Flow Thalweg Scour = 0

*9 Radius of Curve from Zeller 1981 (COT Drainage Design and FP Mgmt 6.11)

$r_c / T = \cos alpha / (4 * \sin^2(alpha/2))$

r_c = Radius of Curve

T = Full Floodway Width (As opposed to main channel widhth)

*10 Chow's Simplified Method of Determining Superelevation (p.448)

Also the preferred method in Maricopa Drainage and Design Manual (p. 6-20)

$h = (V^2 * T) / (g * r_c)$

V = Full Floodway Velocity (As opposed to Main Channel Velocity)

Stationing ID (River Miles)	Reach Code	Average Depth of Flow, d (ft) *1 *2	Energy Slope, S_e (ft/ft)	*n* Value for Stream Bed *3	90% Finer Particle Size, D_{90} (mm) *4	M-P, Muller Individual Particle Size, D_c (mm) *5	Average Channel Velocity, V_m (fps)	Competent Bottom Velocity Armor Size, Dc (mm) *6	Critical Shear Stress, T_c (lb/ft^2) *7	Shield's Diagram D_c (ft) *8	Shields Diagram Dc (mm)	Shear Velocity, U_* (fps) *9	Boundary Reynolds No., R_* *10	Yang's Incipient Motion, D_c (ft) *11	Yang's Incipient Motion, D_c (mm)	Average Individual Particle Size, D_c (mm)	Reach Average D_c (mm)	Bed Material Larger than D_c, del p (Seive-Boulder Count Combo) *12	Thickness to Armoring Layer, y_a (mm) *13	Depth to Armoring, y_d (ft) Seive - Boulder Count Combo *14	Armoring by Reaches (Seive-Boulder Sediment Combo)
0.386	Desert Hills	4.1	0.0029	0.027	85	43.9	6.7	84.1	0.7	0.12	36.9	0.620	6941	0.295	89.9	63.7	73.3	16	127.4	2.19	5.1
0.4	Desert Hills	3.4	0.0038	0.027	85	47.6	6.8	87.4	0.8	0.13	39.9	0.645	7822	0.307	93.4	67.1		15	134.2	2.49	
0.48	Desert Hills	4.1	0.0020	0.027	85	30.0	5.6	58.7	0.5	0.08	25.2	0.512	3917	0.206	62.8	44.2		24	88.3	0.92	
0.56	Desert Hills	4.4	0.0034	0.027	85	55.5	7.5	106.0	0.9	0.15	46.5	0.696	9841	0.372	113.3	80.3		6	152.4	7.83	
0.64	Desert Hills	3.8	0.0041	0.027	85	56.2	7.5	105.2	1.0	0.15	47.2	0.701	10042	0.369	112.4	80.2		6	152.4	7.83	
0.72	Desert Hills	3.7	0.0042	0.027	85	56.9	7.3	100.7	1.0	0.16	47.8	0.706	10237	0.353	107.6	78.3		6	152.4	7.83	
0.81	Desert Hills	3.7	0.0055	0.027	85	74.6	8.2	126.1	1.3	0.21	62.6	0.808	15357	0.442	134.7	99.5		7	152.4	6.64	

*1 All hydraulic parameters from HEC-RAS Apache1.prj

*2 Hydraulic Parameters are From Main Channel Between Overbanks

*3 Skin Frictin Average

*4 From JEF H&G Sediment Analysis

*5 Meyer-Peter, Muller (Bedload Transport Equation) From USBR 'Computing Degradation and Local Scour' p.9

$D_c = (d * S_e) / (K * ((n/(D_{90}^{1/6}))^{3/2}))$

*6 Competent Bottom Velocity Equation From From USBR 'Computing Degradation and Local Scour' p.10

$D_c = 1.88 * (V_m^2)$

*7 T_c = gammaw * d * S_e . Can also extract from HEC-RAS Analysis Data

*8 Shield's Diagram Equation From USBR 'Computing Degradation and Local Scour' p.12

$D_c = T_c / (\text{gamma}_s - \text{gamma}_w) * T$

gamma_s = Specific Weight of Particle = 165 lb/ft^3

gamma_w = Specific Weight of Water = 62.4 lb/ft^3

T = Dimensionless Shear Stress = 0.06 for particles > 1.0mm and R > 500

Fuller used T = 0.05, M-P, Muller recommends T = 0.047. T = 0.06 is generally accepted in completely rough boundary (Simons and Senturk, P. 387)

*9 U_* = Shear Velocity = $(T_c/(\text{gamma}_w/g))^{0.5}$ or = $(g * R * S_e)^{1/2}$ from Simons and Senturk, P. 78 & 264

R = Hydraulic Radius = d in wide channels

*10 $R^* = U_* * D_c / v$

v = Kinematic Viscosity = 0.0000108 ft^2/sec

When R_* > 500 T = 0.06 on Shields Diagram

*11 Yang's Incipient Motion Equation From USBR 'Computing Degradation and Local Scour' p.14

*12 From Graph of Fuller Sediment Analysis Averaged over Entire Length of Cave Creek.

Using graph altered to reflect percent passing by weight.

*13 $y_a = 2 * D_c$ or 0.5' whichver is smaller

*14 $y_d = y_a * ((1/\text{del p})-1)$ - Depth to Armoring not Reached when y_d > 25'

HEC-RAS Plan: Team Alt100F River: Paradise Wash Reach: Reach 1

Reach	River Sta	Min Ch El	W.S. Elev	Q Total	Vel Chnl	Max Chl Dpth	Hydr Depth C	E.G. Slope	Sta W.S. Lft	Top W Chnl	Sta W.S. Rgt	Vel Total	Top Width
		(ft)	(ft)	(cfs)	(ft/s)	(ft)	(ft)	(ft/ft)	(ft)	(ft)	(ft)	(ft/s)	(ft)
Reach 1	0.04	1726.00	1737.1	5992.00	5.01	11.07	9.71	0.000502	9734.55	62.07	10263.68	2.38	529.13
Reach 1	0.13	1732.00	1737.6	5992.00	9.96	5.56	5.00	0.004759	9960.09	69.13	10540.26	4.72	580.17
Reach 1	0.17	1732.00	1739.3	5992.00	10.38	7.29	6.78	0.003463	9959.87	48.20	10533.28	4.39	573.42
Reach 1	0.28	1738.00	1744.2	5992.00	10.98	6.19	4.55	0.006629	9778.19	64.00	10247.38	5.79	469.19
Reach 1	0.34	1744.00	1747.2	5992.00	11.85	3.21	3.21	0.012081	9783.25	45.08	10318.24	5.55	534.98
Reach 1	0.44	1746.00	1751.3	5992.00	9.98	5.31	4.09	0.006308	9630.25	35.85	10166.33	4.54	536.07
Reach 1	0.53	1750.00	1755.4	5992.00	11.57	5.45	5.12	0.006262	9616.94	52.00	10110.57	5.29	493.63
Reach 1	0.62	1754.00	1759.8	5992.00	9.96	5.75	5.30	0.004399	9594.74	64.00	10238.00	4.45	643.26
Reach 1	0.72	1758.00	1762.5	5992.00	11.60	4.48	4.08	0.008564	9461.96	40.00	10075.60	4.85	613.64
Reach 1	0.80	1762.00	1767.0	5992.00	11.14	5.01	4.57	0.006794	9639.02	38.57	10306.24	4.44	667.22
Reach 1	0.89	1764.00	1771.8	5992.00	10.51	7.76	7.08	0.003566	9589.19	40.68	10235.14	4.10	645.95
Reach 1	0.95	1766.00	1773.2	5992.00	9.74	7.24	5.61	0.003939	9627.40	85.70	10204.74	5.36	577.33
Reach 1	1.04	1770.00	1775.6	5992.00	8.58	5.62	5.12	0.003442	9476.43	43.61	10051.33	3.77	574.90
Reach 1	1.12	1772.00	1778.8	5992.00	10.15	6.82	4.79	0.005267	9351.90	79.85	10032.36	5.24	533.42
Reach 1	1.21	1776.00	1782.3	5992.00	11.12	6.26	5.92	0.004819	9434.90	37.46	10140.86	4.24	705.96
Reach 1	1.27	1778.00	1785.1	5992.00	9.63	7.13	5.66	0.003774	9549.70	88.61	10180.89	5.46	631.19
Reach 1	1.37	1782.00	1788.0	5992.00	12.75	5.96	4.82	0.008226	9808.03	61.59	10069.00	7.63	260.97
Reach 1	1.46	1786.00	1791.7	5992.00	11.51	5.68	5.36	0.005802	9890.94	65.56	10179.16	6.80	288.22
Reach 1	1.54	1790.00	1794.5	5992.00	8.25	4.53	4.06	0.004359	9909.90	34.12	10312.07	6.33	402.17
Reach 1	1.65	1796.00	1801.1	5401.00	11.46	5.12	4.65	0.006968	9911.63	49.00	10273.06	5.76	361.42
Reach 1	1.75	1800.00	1805.8	5401.00	11.16	5.77	4.14	0.007749	9927.89	58.43	10305.97	5.88	378.08
Reach 1	1.83	1806.00	1811.3	5401.00	10.70	5.31	4.57	0.006210	9963.04	55.32	10406.19	5.19	443.15
Reach 1	1.92	1810.00	1815.5	5401.00	9.76	5.46	4.51	0.005272	9927.71	90.00	10324.44	5.85	396.73
Reach 1	2.00	1814.00	1821.2	5401.00	14.55	7.16	6.61	0.007069	9960.34	38.83	10076.18	9.68	115.84
Reach 1	2.07	1821.00	1824.7	5401.00	4.82	3.71	3.43	0.001831	9955.42	90.96	10737.75	2.57	782.33
Reach 1	2.14	1824.00	1827.3	5401.00	10.77	3.31	3.31	0.009581	9964.72	46.80	10671.76	4.51	707.04
Reach 1	2.23	1826.00	1833.1	5401.00	10.46	7.07	6.38	0.003806	9928.16	43.64	10555.06	4.15	626.90

HEC-RAS Plan: Team Alt10 F River: Paradise Wash Reach: Reach 1

Reach	River Sta	Profile	Q Total	W.S. Elev	Hydr Depth C	E.G. Slope	Mann Wtd Chnl	Vel Chnl	Top W Chnl	Q Channel	Froude # Chl	Shear Chan
			(cfs)	(ft)	(ft)	(ft/ft)		(ft/s)	(ft)	(cfs)		(lb/sq ft)
Reach 1	0.04	10-yr encr	1150.00	1731.7	4.34	0.000989	0.030	4.11	62.07	1105.34	0.35	0.26
Reach 1	0.13	10-yr encr	1150.00	1734.7	2.11	0.009111	0.030	7.76	69.13	1131.21	0.94	1.20
Reach 1	0.17	10-yr encr	1150.00	1736.1	3.61	0.002647	0.030	5.96	48.20	1038.74	0.55	0.59
Reach 1	0.28	10-yr encr	1150.00	1741.6	2.18	0.007950	0.030	7.37	58.37	937.28	0.88	1.07
Reach 1	0.34	10-yr encr	1150.00	1745.6	1.59	0.012662	0.030	7.59	45.08	543.99	1.06	1.26
Reach 1	0.44	10-yr encr	1150.00	1749.4	2.18	0.005748	0.030	6.26	35.85	488.04	0.75	0.77
Reach 1	0.53	10-yr encr	1150.00	1753.0	2.70	0.006022	0.030	7.40	52.00	1038.14	0.79	1.00
Reach 1	0.62	10-yr encr	1150.00	1756.4	1.95	0.009441	0.030	7.48	64.00	931.62	0.94	1.14
Reach 1	0.72	10-yr encr	1150.00	1760.8	2.39	0.005971	0.030	6.78	40.00	646.78	0.77	0.88
Reach 1	0.80	10-yr encr	1150.00	1765.2	2.74	0.005616	0.030	7.20	38.57	759.51	0.77	0.95
Reach 1	0.89	10-yr encr	1150.00	1767.9	3.22	0.007244	0.030	8.86	40.31	1150.00	0.87	1.38
Reach 1	0.95	10-yr encr	1150.00	1770.1	2.46	0.003704	0.030	5.45	85.70	1149.96	0.61	0.56
Reach 1	1.04	10-yr encr	1150.00	1772.9	2.37	0.006236	0.030	6.91	43.61	714.11	0.79	0.91
Reach 1	1.12	10-yr encr	1150.00	1775.8	1.89	0.011379	0.030	8.03	75.78	1150.00	1.03	1.33
Reach 1	1.21	10-yr encr	1150.00	1779.4	3.10	0.005210	0.030	7.51	37.46	872.17	0.75	0.99
Reach 1	1.27	10-yr encr	1150.00	1781.4	2.21	0.006173	0.030	6.58	78.99	1150.00	0.78	0.85
Reach 1	1.37	10-yr encr	1150.00	1785.1	2.24	0.008208	0.030	7.66	54.66	939.42	0.90	1.14
Reach 1	1.46	10-yr encr	1150.00	1788.7	2.36	0.006986	0.030	7.30	65.56	1127.17	0.84	1.02
Reach 1	1.54	10-yr encr	1150.00	1792.0	1.52	0.007109	0.030	5.46	33.84	279.81	0.78	0.66
Reach 1	1.65	10-yr encr	1010.00	1798.9	2.42	0.006407	0.030	7.11	49.00	842.70	0.81	0.96
Reach 1	1.75	10-yr encr	1010.00	1803.4	2.05	0.008785	0.030	7.45	52.66	805.16	0.92	1.11
Reach 1	1.83	10-yr encr	1010.00	1809.0	2.30	0.006721	0.030	7.04	55.32	895.33	0.82	0.96
Reach 1	1.92	10-yr encr	1010.00	1812.4	1.94	0.008426	0.030	7.03	73.93	1007.57	0.89	1.01
Reach 1	2.00	10-yr encr	1010.00	1817.4	2.82	0.007527	0.030	8.51	38.83	931.31	0.89	1.31
Reach 1	2.07	10-yr encr	1010.00	1822.5	1.21	0.008230	0.030	5.09	90.96	558.77	0.82	0.62
Reach 1	2.14	10-yr encr	1010.00	1825.8	1.76	0.010444	0.030	7.39	46.80	610.43	0.98	1.15
Reach 1	2.23	10-yr encr	1010.00	1829.4	2.68	0.007874	0.030	8.44	43.64	985.29	0.91	1.31

SKIN FRICTION CALCULATIONS

	Size (mm)	Size (ft)	Size (in.)
D_{90} =	85	0.279	3.35
D_{50} =	16	0.052	0.63
D_{75} =	44	0.144	1.73

Method	Equation		
	$n_s=(D_{90}^{1/6}) / 44.4$ (D_{90} in inches)	n_s =	0.028
Anderson	$n_s=0.0395 * (D_{50}^{1/6})$ (D_{50} in feet)	n_s =	0.024
Lane	$n_s=(D_{75}^{1/6}) / 39$ (D_{75} in inches)	n_s =	0.028
			0.027

Station ID (River Miles)	Reach Code	Mean Particle Size, (mm) [1]	Channel Width (ft) [2]	Dominant Discharge, Q (cfs) [2]	Schoklitsch, S_L (ft/ft) [3]	90% Finer Particle Size, D_{90} (mm) [1]	*n* Value for Cross Section [2]	Average Depth of Flow, d (ft) [2]	M-P,M S_L (ft/ft) [4]	Shields S_L (ft/ft) [5]	Shear Velocity, U* (fps) [6]	Boundary Reynolds No. [7]	Average S_L (ft/ft)	Average S_L by Fuller Reach Code	Average Invert Slope by ASL Reach Code [8]	Distance Between Grade Control Structures (ft) [9]
0.386	Desert Hills	33	32.00	883.79	0.001989	85	0.026605	4.13	0.00217	0.002596	0.5876	5890.5	0.002252	0.00238	0.003573	4174
0.400	Desert Hills	33	55.26	1270.52	0.002282	85	0.026605	3.37	0.00266	0.003182	0.5876	5890.5	0.002708			
0.480	Desert Hills	33	33.04	764.56	0.002271	85	0.026605	4.14	0.00216	0.002590	0.5876	5890.5	0.002342			
0.560	Desert Hills	33	32.58	1074.71	0.001741	85	0.026605	4.39	0.00204	0.002443	0.5876	5890.5	0.002075			
0.640	Desert Hills	33	40.30	1130.76	0.001965	85	0.026605	3.75	0.00239	0.002859	0.5876	5890.5	0.002405			
0.720	Desert Hills	33	29.79	808.7	0.002014	85	0.026605	3.71	0.00242	0.002890	0.5876	5890.5	0.002440			
0.810	Desert Hills	33	34.45	1036.35	0.001865	85	0.026605	3.67	0.00244	0.002922	0.5876	5890.5	0.002410			

[1] Mean Particle Diameter (mm) From Simons and Senturk p. 172

[2] All hydraulic parameters from HEC-RAS Apache1.prj
Hydraulic Parameters are From Main Channel Between Overbanks.

[3] Schoklitsch Equation for Zero Bedload Transport From USBR 'Computing Degradation and Local Scour' p.18
$S_L = K * ((D_M * B / Q)^{.75})$
K = 0.00174
D_M = Mean Particle Diameter (mm) From Simons and Senturk p. 172
B = Channel Width (ft) = HEC-RAS Top of Channel Width
Q = Flow Over Main Channel

[4] Meyer-Peter, Muller Equation From USBR 'Computing Degradation and Local Scour' p.18
$S_L = K * (Q/Q_B) * ((n/(D_{90}^{1/6}))^{1.5}) * D_M / d$
K = 0.19
Q/Q_B = Total Flow Divided by Flow Over Bed of Channel = 1 in Wide Channels
D_{90} = Particle Size (mm) For Which 90% of Material by Weight is Finer From JEF Report
d = Mean Depth (ft) = HEC-RAS Hydraulic Depth Over Entire Cross Section

[5] Shield's Diagram Equation From USBR 'Computing Degradation and Local Scour' p.18-19
$T_* = T_c / (gamma_s - gamma_w) * D_M$
T_* = Dimensionless Shear Stress = 0.06 for particles > 1.0mm and R > 500
$T_c = gamma_w * d * S_L$
$gamma_s$ = Specific Weight of Particle = 165 lb/ft^3
$gamma_w$ = Specific Weight of Water = 62.4 lb/ft^3
Fuller used T = 0.055, M-P, Muller recommends T = 0.047. T = 0.06 is generally accepted in completely rough boundary (Simons and Senturk, P. 387)

[6] U_* = Shear Velocity = $(g * R * S_L)^{1/2}$ or $(T_c/(gamma_w/g))^{0.5}$ from USBR & Simons and Senturk, P. 78 & 384
R = Hydraulic Radius = Mean Hydraulic Depth, d in wide channels

[7] $R^* = U_* * D_{50} / v$ to Determine if $R^* > 500$
D_M in feet
v = Kinematic Viscosity = 0.0000108 ft^2/sec
When $R_* > 500$ T = 0.06 on Shields Diagram

[8] (Min RAS Elev @ Beginning Sta. - Min RAS Elev @ Ending Sta.)/((Beginning Sta. No. - Ending Sta. No.) * 5280)
Altered if slope did not fit existing profile.

[9] Height of Drop / (Invert Slope - Equilibrium Slope)
Height of Drop Between Structures = 5'

HEC-RAS Plan: Team Alt100F River: Desert Hills Was Reach: Reach 1

Reach	River Sta	Min Ch El	W.S. Elev	Q Total	Vel Chnl	Max Chl Dpth	Hydr Depth C	E.G. Slope	Sta W.S. Lft	Top W Chnl	Sta W.S. Rgt	Vel Total	Top Width
		(ft)	(ft)	(cfs)	(ft/s)	(ft)	(ft)	(ft/ft)	(ft)	(ft)	(ft)	(ft/s)	(ft)
Reach 1	0.386	1738.00	1745.4	10761.00	10.58	7.44	7.19	0.003447	9641.89	32.00	10139.65	4.82	497.76
Reach 1	0.40	1738.00	1746.2	10761.00	10.01	8.19	6.44	0.003475	9579.99	55.26	10121.28	4.85	541.29
Reach 1	0.48	1740.00	1747.6	10761.00	8.90	7.57	7.23	0.002377	9757.74	33.04	10313.97	4.08	556.23
Reach 1	0.56	1740.00	1748.5	10761.00	10.16	8.51	7.41	0.003126	9512.99	32.58	10084.00	4.44	571.01
Reach 1	0.64	1742.00	1749.7	10761.00	11.81	7.71	6.37	0.004999	9750.22	40.30	10261.18	5.44	510.96
Reach 1	0.72	1744.00	1751.5	10761.00	11.54	7.51	6.52	0.004874	9913.97	29.79	10381.13	5.46	467.16
Reach 1	0.81	1746.00	1753.7	10761.00	9.88	7.65	6.62	0.003664	9750.00	34.45	10654.77	3.88	904.77
Reach 1	0.90	1748.00	1755.6	10761.00	15.10	7.61	7.21	0.007051	9750.00	21.14	10200.00	6.22	450.00
Reach 1	0.99	1748.00	1758.3	10761.00	10.05	10.26	8.80	0.002897	9750.00	24.54	10175.00	4.79	425.00

HEC-RAS Plan: Team Alt10 F River: Desert Hills Was Reach: Reach 1

Reach	River Sta	Profile	Q Total	W.S. Elev	Hydr Depth C	E.G. Slope	Mann Wtd Chnl	Vel Chnl	Top W Chnl	Q Channel	Froude # Chl	Shear Chan
			(cfs)	(ft)	(ft)	(ft/ft)		(ft/s)	(ft)	(cfs)		(lb/sq ft)
Reach 1	0.04	10-yr encr	1990.00	1735.5	4.41	0.005308	0.030	9.53	46.00	1932.86	0.80	1.42
Reach 1	0.09	10-yr encr	1990.00	1737.3	4.32	0.001239	0.030	4.58	68.00	1346.87	0.39	0.33
Reach 1	0.19	10-yr encr	1990.00	1738.5	3.84	0.003819	0.030	7.42	50.00	1423.83	0.67	0.90
Reach 1	0.22	10-yr encr	1990.00	1739.0	3.70	0.004443	0.030	7.82	59.00	1706.97	0.72	1.01
Reach 1	0.31	10-yr encr	1990.00	1740.6	3.82	0.004170	0.030	7.63	48.00	1398.06	0.69	0.96
Reach 1	0.386	10-yr encr	1990.00	1742.4	4.13	0.002889	0.030	6.69	32.00	883.79	0.58	0.72
Reach 1	0.40	10-yr encr	1990.00	1743.1	3.37	0.003834	0.030	6.82	55.26	1270.52	0.66	0.79
Reach 1	0.48	10-yr encr	1990.00	1744.5	4.14	0.001968	0.030	5.59	33.04	764.56	0.48	0.50
Reach 1	0.56	10-yr encr	1990.00	1745.5	4.39	0.003430	0.030	7.51	32.58	1074.71	0.63	0.89
Reach 1	0.64	10-yr encr	1990.00	1747.1	3.75	0.004070	0.030	7.48	40.30	1130.76	0.68	0.93
Reach 1	0.72	10-yr encr	1990.00	1748.7	3.71	0.004167	0.030	7.32	29.79	808.70	0.67	0.90
Reach 1	0.81	10-yr encr	1990.00	1750.7	3.67	0.005520	0.030	8.19	34.45	1036.35	0.75	1.14
Reach 1	0.90	10-yr encr	1990.00	1753.1	4.67	0.004133	0.030	8.65	21.14	853.29	0.71	1.15
Reach 1	0.99	10-yr encr	1990.00	1754.8	5.31	0.002400	0.030	6.53	24.54	851.53	0.50	0.66

SOFT STRUCTURAL ALTERNATIVE CONSTRUCTION COST TOTALS - ENTIRE STUDY AREA

Item	Unit Price	Left Bank Quantity (yd^3)	Left Bank Cost	Right Bank Quantity (yd^3)	Right Bank Cost	Total Quantity (yd^3)	Total Cost
Riprap Revetment							
Excavation (yd^3)	$3	390,988	$1,172,964	155,925	$467,775	546,913	$1,640,739
Borrow Material (yd^3)	$5	93,695	$468,475	57,157	$285,785	150,852	$754,260
Riprap Revetment (yd^3)	$35	181,558	$6,354,530	72,004	$2,520,140	253,562	$8,874,670
Grade Control Structures							
Reinforced Concrete (yd^2)	$94	23,578	$2,216,332				
Total Cost			**$10,212,301**		**$3,273,700**		**$13,486,001**
Gabion Mattress Revetment							
Excavation (yd^3)	$3	390,988	$1,172,964	155,925	$467,775	546,913	$1,640,739
Borrow Material (yd^3)	$5	93,695	$468,475	57,157	$285,785	150,852	$754,260
Gabion Revetment (yd^3)	$65	84,179	$5,471,635	33,259	$2,161,835	117,438	$7,633,470
Grade Control Structures							
Reinforced Concrete (yd^2)	$94	23,578	$2,216,332				
Total Cost			**$9,329,406**		**$2,915,395**		**$12,244,801**
CSA Revetment							
Excavation (yd^3)	$3	390,988	$1,172,964	155,925	$467,775	546,913	$1,640,739
Borrow Material (yd^3)	$5	93,695	$468,475	57,157	$285,785	150,852	$754,260
CSA Revetment (yd^3)	$15	139,601	$2,094,015	57,417	$861,255	197,018	$2,955,270
CSA Cement (tons)	$100	19,746	$1,974,600	8,138	$813,800	27,884	$2,788,400
Grade Control Structures							
Reinforced Concrete (yd^2)	$94	23,578	$2,216,332				
Total Cost			**$7,926,386**		**$2,428,615**		**$10,355,001**

CAVE CREEK - SOFT STRUCTURAL ALTERNATIVE

Item	Unit Price	Left Bank Quantity (yd^3)	Left Bank Cost	Right Bank Quantity (yd^3)	Right Bank Cost	Total Quantity (yd^3)	Total Cost
CAVE CREEK - SOFT STRUCTURAL ALTERNATIVE TOTALS							
Riprap Revetment							
Excavation Total (yd^3)	$3	148,757	$446,271	46,692	$140,076	195,449	$586,347
Borrow Total (yd^3)	$5	39,711	$198,555	26,739	$133,695	66,450	$332,250
Riprap Total (yd^3)	$35	78,686	$2,754,010	21,340	$746,900	100,026	$3,500,910
Grade Control Structures							
Reinforced Concrete (yd^2)	$94	23,578	$2,216,332			23,578	$2,216,332
Total Cost			**$5,615,168**		**$1,020,671**		**$6,635,839**
Gabion Mattress Revetment							
Excavation Total (yd^3)	$3	148,757	$446,271	46,692	$140,076	195,449	$586,347
Borrow Total (yd^3)	$5	39,711	$198,555	26,739	$133,695	66,450	$332,250
Gabion Total (yd^3)	$65	36,064	$2,344,160	9,781	$635,765	45,845	$2,979,925
Grade Control Structures							
Reinforced Concrete (yd^2)	$94	23,578	$2,216,332			$23,578	$2,216,332
Total Cost			**$5,205,318**		**$909,536**		**$6,114,854**
CSA Revetment							
Excavation Total (yd^3)	$3	148,757	$446,271	46,692	$140,076	195,449	$586,347
Borrow Total (yd^3)	$5	39,711	$198,555	26,739	$133,695	66,450	$332,250
CSA Total (yd^3)	$15	52,784	$791,760	14,316	$214,740	67,100	$1,006,500
CSA Cement Total (tons)	$100	7,482	$748,200	2,029	$202,900	9,511	$951,100
Grade Control Structures							
Reinforced Concrete (yd^2)	$94	23,578	$2,216,332			$23,578	$2,216,332
Total Cost			**$4,401,118**		**$691,411**		**$5,092,529**

CAVE CREEK - SOFT STRUCTURAL ALTERNATIVE

Item	Unit Price	Left Bank Quantity (yd^3)	Left Bank Cost	Right Bank Quantity (yd^3)	Right Bank Cost	Total Quantity (yd^3)	Total Cost
Braided Reach							
Excavation (yd^3)	$3	0	$0	0	$0	0	$0
Borrow Material (yd^3)	$5	0	$0	0	$0	0	$0
Riprap Revetment (yd^3)	$35	0	$0	0	$0	0	$0
Riprap Reach Subtotal			**$0**		**$0**		**$0**
Excavation (yd^3)	$3	0	$0	0	$0	0	$0
Borrow Material (yd^3)	$5	0	$0	0	$0	0	$0
Gabion Revetment (yd^3)	$65	0	$0	0	$0	0	$0
Gabion Mattress Reach Subtotal			**$0**		**$0**		**$0**
Excavation (yd^3)	$3	0	$0	0	$0	0	$0
Borrow Material (yd^3)	$5	0	$0	0	$0	0	$0
CSA Revetment (yd^3)	$15	0	$0	0	$0	0	$0
CSA Cement (tons)	$100	0	$0	0	$0	0	$0
CSA Reach Subtotal			**$0**		**$0**		**$0**

CAVE CREEK - SOFT STRUCTURAL ALTERNATIVE

Item	Unit Price	Left Bank Quantity (yd^3)	Left Bank Cost	Right Bank Quantity (yd^3)	Right Bank Cost	Total Quantity (yd^3)	Total Cost
Mined Reach							
Excavation (yd^3)	$3	0	$0	0	$0	0	$0
Borrow Material (yd^3)	$5	0	$0	0	$0	0	$0
Riprap Revetment (yd^3)	$35	0	$0	0	$0	0	$0
Riprap Reach Subtotal			**$0**		**$0**		**$0**
Excavation (yd^3)	$3	0	$0	0	$0	0	$0
Borrow Material (yd^3)	$5	0	$0	0	$0	0	$0
Gabion Revetment (yd^3)	$65	0	$0	0	$0	0	$0
Gabion Mattress Reach Subtotal			**$0**		**$0**		**$0**
Excavation (yd^3)	$3	0	$0	0	$0	0	$0
Borrow Material (yd^3)	$5	0	$0	0	$0	0	$0
CSA Revetment (yd^3)	$15	0	$0	0	$0	0	$0
CSA Cement (tons)	$100	0	$0	0	$0	0	$0
CSA Reach Subtotal			**$0**		**$0**		**$0**

CAVE CREEK - SOFT STRUCTURAL ALTERNATIVE

Item	Unit Price	Left Bank Quantity (yd^3)	Left Bank Cost	Right Bank Quantity (yd^3)	Right Bank Cost	Total Quantity (yd^3)	Total Cost
Cliff Reach							
Excavation (yd^3)	$3	148,757	$446,271	46,692	$140,076	195,449	$586,347
Borrow Material (yd^3)	$5	39,711	$198,555	26,739	$133,695	66,450	$332,250
Riprap Revetment (yd^3)	$35	78,686	$2,754,010	21,340	$746,900	100,026	$3,500,910
Riprap Reach Subtotal			**$3,398,836**		**$1,020,671**		**$4,419,507**
Excavation (yd^3)	$3	148,757	$446,271	46,692	$140,076	195,449	$586,347
Borrow Material (yd^3)	$5	39,711	$198,555	26,739	$133,695	66,450	$332,250
Gabion Revetment (yd^3)	$65	36,064	$2,344,160	9,781	$635,765	45,845	$2,979,925
Gabion Mattress Reach Subtotal			**$2,988,986**		**$909,536**		**$3,898,522**
Excavation (yd^3)	$3	148,757	$446,271	46,692	$140,076	195,449	$586,347
Borrow Material (yd^3)	$5	39,711	$198,555	26,739	$133,695	66,450	$332,250
CSA Revetment (yd^3)	$15	52,784	$791,760	14,316	$214,740	67,100	$1,006,500
CSA Cement (tons)	$100	7,482	$748,200	2,029	$202,900	9,511	$951,100
CSA Reach Subtotal			**$2,184,786**		**$691,411**		**$2,876,197**

APACHE WASH - SOFT STRUCTURAL ALTERNATIVE

Item	Unit Price	Left Bank Quantity (yd^3)	Left Bank Cost	Right Bank Quantity (yd^3)	Right Bank Cost	Total Quantity (yd^3)	Total Cost
APACHE WASH - SOFT STRUCTURAL ALTERNATIVE TOTALS							
Riprap Revetment							
Excavation Total (yd^3)	$3	181,295	$543,885	79,363	$238,089	260,658	$781,974
Borrow Total (yd^3)	$5	25,818	$129,090	19,819	$99,095	45,637	$228,185
Riprap Total (yd^3)	$35	73,061	$2,557,135	40,784	$1,427,440	113,845	$3,984,575
Total Cost			**$3,230,110**		**$1,764,624**		**$4,994,734**
Gabion Mattress Revetment							
Excavation Total (yd^3)	$3	181,295	$543,885	79,363	$238,089	260,658	$781,974
Borrow Total (yd^3)	$5	25,818	$129,090	19,819	$99,095	45,637	$228,185
Gabion Total (yd^3)	$65	33,209	$2,158,585	18,538	$1,204,970	51,747	$3,363,555
Total Cost			**$2,831,560**		**$1,542,154**		**$4,373,714**
CSA Revetment							
Excavation Total (yd^3)	$3	181,295	$543,885	79,363	$238,089	260,658	$781,974
Borrow Total (yd^3)	$5	25,818	$129,090	19,819	$99,095	45,637	$228,185
CSA Total (yd^3)	$15	53,466	$801,990	29,846	$447,690	83,312	$1,249,680
CSA Cement Total (tons)	$100	7,579	$757,900	4,230	$423,000	11,809	$1,180,900
Total Cost			**$2,232,865**		**$1,207,874**		**$3,440,739**

APACHE WASH - SOFT STRUCTURAL ALTERNATIVE

Item	Unit Price	Left Bank Quantity (yd^3)	Left Bank Cost	Right Bank Quantity (yd^3)	Right Bank Cost	Total Quantity (yd^3)	Total Cost
Hackberry Reach							
Excavation (yd^3)	$3	5,053	$15,159	50,388	$151,164	55,441	$166,323
Borrow Material (yd^3)	$5	6,409	$32,045	2,963	$14,815	9,372	$46,860
Riprap Revetment (yd^3)	$35	13,082	$457,870	20,431	$715,085	33,513	$1,172,955
Riprap Reach Subtotal			**$505,074**		**$881,064**		**$1,386,138**
Excavation (yd^3)	$3	5,053	$15,159	50,388	$151,164	55,441	$166,323
Borrow Material (yd^3)	$5	6,409	$32,045	2,963	$14,815	9,372	$46,860
Gabion Revetment (yd^3)	$65	5,946	$386,490	9,287	$603,655	15,233	$990,145
Gabion Mattress Reach Subtotal			**$433,694**		**$769,634**		**$1,203,328**
Excavation (yd^3)	$3	5,053	$15,159	50,388	$151,164	55,441	$166,323
Borrow Material (yd^3)	$5	6,409	$32,045	2,963	$14,815	9,372	$46,860
CSA Revetment (yd^3)	$15	9,573	$143,595	14,952	$224,280	24,525	$367,875
CSA Cement (tons)	$100	1,357	$135,700	2,119	$211,900	3,476	$347,600
CSA Reach Subtotal			**$326,499**		**$602,159**		**$928,658**

APACHE WASH - SOFT STRUCTURAL ALTERNATIVE

Item	Unit Price	Left Bank Quantity (yd^3)	Left Bank Cost	Right Bank Quantity (yd^3)	Right Bank Cost	Total Quantity (yd^3)	Total Cost
Union Hills Reach							
Excavation (yd^3)	$3	0	$0	0	$0	0	$0
Borrow Material (yd^3)	$5	0	$0	0	$0	0	$0
Riprap Revetment (yd^3)	$35	0	$0	0	$0	0	$0
Riprap Reach Subtotal			**$0**		**$0**		**$0**
Excavation (yd^3)	$3	0	$0	0	$0	0	$0
Borrow Material (yd^3)	$5	0	$0	0	$0	0	$0
Gabion Revetment (yd^3)	$65	0	$0	0	$0	0	$0
Gabion Mattress Reach Subtotal			**$0**		**$0**		**$0**
Excavation (yd^3)	$3	0	$0	0	$0	0	$0
Borrow Material (yd^3)	$5	0	$0	0	$0	0	$0
CSA Revetment (yd^3)	$15	0	$0	0	$0	0	$0
CSA Cement (tons)	$100	0	$0	0	$0	0	$0
CSA Reach Subtotal			**$0**		**$0**		**$0**

APACHE WASH - SOFT STRUCTURAL ALTERNATIVE

Item	Unit Price	Left Bank Quantity (yd^3)	Left Bank Cost	Right Bank Quantity (yd^3)	Right Bank Cost	Total Quantity (yd^3)	Total Cost
Upper Reach							
Excavation (yd^3)	$3	176,242	$528,726	28,975	$86,925	205,217	$615,651
Borrow Material (yd^3)	$5	19,409	$97,045	16,856	$84,280	36,265	$181,325
Riprap Revetment (yd^3)	$35	59,979	$2,099,265	20,353	$712,355	80,332	$2,811,620
Riprap Reach Subtotal			**$2,725,036**		**$883,560**		**$3,608,596**
Excavation (yd^3)	$3	176,242	$528,726	28,975	$86,925	205,217	$615,651
Borrow Material (yd^3)	$5	19,409	$97,045	16,856	$84,280	36,265	$181,325
Gabion Revetment (yd^3)	$65	27,263	$1,772,095	9,251	$601,315	36,514	$2,373,410
Gabion Mattress Reach Subtotal			**$2,397,866**		**$772,520**		**$3,170,386**
Excavation (yd^3)	$3	176,242	$528,726	28,975	$86,925	205,217	$615,651
Borrow Material (yd^3)	$5	19,409	$97,045	16,856	$84,280	36,265	$181,325
CSA Revetment (yd^3)	$15	43,893	$658,395	14,894	$223,410	58,787	$881,805
CSA Cement (tons)	$100	6,222	$622,200	2,111	$211,100	8,333	$833,300
CSA Reach Subtotal			**$1,906,366**		**$605,715**		**$2,512,081**

PARADISE WASH - SOFT STRUCTURAL ALTERNATIVE TOTALS

Item	Unit Price	Left Bank Quantity (yd^3)	Left Bank Cost	Right Bank Quantity (yd^3)	Right Bank Cost	Total Quantity (yd^3)	Total Cost
Riprap Revetment							
Excavation (yd^3)	$3	21,369	$64,107	0	$0	21,369	$64,107
Borrow Material (yd^3)	$5	9,537	$47,685	0	$0	9,537	$47,685
Riprap Revetment (yd^3)	$35	15,532	$543,620	0	$0	15,532	$543,620
Total Cost			**$655,412**		**$0**		**$655,412**
Gabion Mattress Revetment							
Excavation (yd^3)	$3	21,369	$64,107	0	$0	21,369	$64,107
Borrow Material (yd^3)	$5	9,537	$47,685	0	$0	9,537	$47,685
Gabion Revetment (yd^3)	$65	7,766	$504,790	0	$0	7,766	$504,790
Total Cost			**$616,582**		**$0**		**$616,582**
CSA Revetment							
Excavation (yd^3)	$3	21,369	$64,107	0	$0	21,369	$64,107
Borrow Material (yd^3)	$5	9,537	$47,685	0	$0	9,537	$47,685
CSA Revetment (yd^3)	$15	13,893	$208,395	0	$0	13,893	$208,395
CSA Cement (tons)	$100	1,969	$196,900	0	$0	1,969	$196,900
Total Cost			**$517,087**		**$0**		**$517,087**

DESERT HILLS WASH - SOFT STRUCTURAL ALTERNATIVE TOTALS

Item	Unit Price	Left Bank Quantity (yd^3)	Left Bank Cost	Right Bank Quantity (yd^3)	Right Bank Cost	Total Quantity (yd^3)	Total Cost
Riprap Revetment							
Excavation (yd^3)	$3	39,567	$118,701	29,870	$89,610	69,437	$208,311
Borrow Material (yd^3)	$5	18,629	$93,145	10,599	$52,995	29,228	$146,140
Riprap Revetment (yd^3)	$35	14,279	$499,765	9,880	$345,800	24,159	$845,565
Total Cost			**$711,611**		**$488,405**		**$1,200,016**
Gabion Mattress Revetment							
Excavation (yd^3)	$3	39,567	$118,701	29,870	$89,610	69,437	$208,311
Borrow Material (yd^3)	$5	18,629	$93,145	10,599	$52,995	29,228	$146,140
Gabion Revetment (yd^3)	$65	7,140	$464,100	4,940	$321,100	12,080	$785,200
Total Cost			**$675,946**		**$463,705**		**$1,139,651**
CSA Revetment							
Excavation (yd^3)	$3	39,567	$118,701	29,870	$89,610	69,437	$208,311
Borrow Material (yd^3)	$5	18,629	$93,145	10,599	$52,995	29,228	$146,140
CSA Revetment (yd^3)	$15	19,458	$291,870	13,255	$198,825	32,713	$490,695
CSA Cement (tons)	$100	2,716	$271,600	1,879	$187,900	4,595	$459,500
Total Cost			**$775,316**		**$529,330**		**$1,304,646**

FULL STRUCTURAL ALTERNATIVE CONSTRUCTION COST TOTALS - ENTIRE STUDY AREA

Item	Unit Price	Left Bank Quantity (yd^3)	Left Bank Cost	Right Bank Quantity (yd^3)	Right Bank Cost	Total Quantity (yd^3)	Total Cost
Riprap Revetment							
Excavation (yd^3)	$2	1,017,750	$2,035,500	848,530	$1,697,060	1,866,280	$3,732,560
Borrow Material (yd^3)	$5	321,865	$1,609,325	128,144	$640,720	450,009	$2,250,045
Riprap Revetment (yd^3)	$30	446,621	$13,398,636	359,574	$10,787,223	806,195	$24,185,859
Grade Control Structures							
CSA Total (yd^3)	$30	17,500	$525,000				
CSA Cement Total (tons)	$100	2,500	$250,000				
Total Cost			**$17,818,461**		**$13,125,003**		**$30,943,464**
Gabion Mattress Revetment							
Excavation (yd^3)	$2	1,017,750	$2,035,500	848,530	$1,697,060	1,866,280	$3,732,560
Borrow Material (yd^3)	$5	321,865	$1,609,325	128,144	$640,720	450,009	$2,250,045
Gabion Revetment (yd^3)	$60	201,412	$12,084,714	159,982	$9,598,908	361,394	$21,683,622
Grade Control Structures							
CSA Total (yd^3)	$30	17,500	$525,000				
CSA Cement Total (tons)	$100	2,500	$250,000				
Total Cost			**$16,504,539**		**$11,936,688**		**$28,441,227**
CSA Revetment							
Excavation (yd^3)	$2	1,017,750	$2,035,500	848,530	$1,697,060	1,866,280	$3,732,560
Borrow Material (yd^3)	$5	321,865	$1,609,325	128,144	$640,720	450,009	$2,250,045
CSA Revetment (yd^3)	$15	328,653	$4,929,800	264,194	$3,962,912	592,847	$8,892,711
CSA Cement (tons)	$100	46,588	$4,658,760	37,449	$3,744,920	84,037	$8,403,680
Grade Control Structures							
CSA Total (yd^3)	$15	17,500	$262,500				
CSA Cement Total (tons)	$100	2,500	$250,000				
Total Cost			**$13,745,885**		**$10,045,612**		**$23,791,496**

CAVE CREEK - FULL STRUCTURAL ALTERNATIVE

Item	Unit Price	Left Bank Quantity (yd^3)	Left Bank Cost	Right Bank Quantity (yd^3)	Right Bank Cost	Total Quantity (yd^3)	Total Cost
CAVE CREEK - FULL STRUCTURAL ALTERNATIVE TOTALS							
Riprap Revetment							
Excavation Total (yd^3)	$2	578,056	$1,156,112	263,350	$526,700	841,406	$1,682,812
Borrow Total (yd^3)	$5	226,186	$1,130,930	24,719	$123,595	250,905	$1,254,525
Riprap Total (yd^3)	$30	278,183	$8,345,496	93,844	$2,815,323	372,027	$11,160,819
Grade Control Structure							
CSA Total (yd^3)	$30	17,500	$525,000			17,500	$525,000
CSA Cement Total (tons)	$100	2,500	$250,000			2,500	$250,000
Total Cost			**$11,407,538**		**$3,465,618**		**$14,873,156**
Gabion Mattress Revetment							
Excavation Total (yd^3)	$2	578,056	$1,156,112	263,350	$526,700	841,406	$1,682,812
Borrow Total (yd^3)	$5	226,186	$1,130,930	24,719	$123,595	250,905	$1,254,525
Gabion Total (yd^3)	$60	127,014	$7,620,834	42,686	$2,561,148	169,700	$10,181,982
Grade Control Structure							
CSA Total (yd^3)	$30	$17,500	$525,000	0	$0	17,500	$525,000
CSA Cement Total (tons)	$100	$2,500	$250,000	0	$0	2,500	$250,000
Total Cost			**$10,682,876**		**$3,211,443**		**$13,894,319**
CSA Revetment							
Excavation Total (yd^3)	$2	578,056	$1,156,112	263,350	$526,700	841,406	$1,682,812
Borrow Total (yd^3)	$5	226,186	$1,130,930	24,719	$123,595	250,905	$1,254,525
CSA Total (yd^3)	$15	194,444	$2,916,665	68,199	$1,022,991	262,644	$3,939,656
CSA Cement Total (tons)	$100	27,563	$2,756,260	9,667	$966,720	37,230	$3,722,980
Grade Control Structure							
CSA Total (yd^3)	$15	17,500	$262,500	0	$0	17,500	$262,500
CSA Cement Total (tons)	$100	2,500	$250,000	0	$0	2,500	$250,000
Total Cost			**$8,472,467**		**$2,640,006**		**$11,112,473**

CAVE CREEK - FULL STRUCTURAL ALTERNATIVE

Item	Unit Price	Left Bank Quantity (yd^3)	Left Bank Cost	Right Bank Quantity (yd^3)	Right Bank Cost	Total Quantity (yd^3)	Total Cost
Braided Reach							
Excavation (yd^3)	$2	45,653	$91,306	40,000	$80,000	85,653	$171,306
Borrow Material (yd^3)	$5	667	$3,335	793	$3,965	1,460	$7,300
Riprap Revetment (yd^3)	$30	14,823	$444,681	11,713	$351,390	26,536	$796,071
Riprap Reach Subtotal			**$539,322**		**$435,355**		**$974,677**
Excavation (yd^3)	$2	45,653	$91,306	40,000	$80,000	85,653	$171,306
Borrow Material (yd^3)	$5	667	$3,335	793	$3,965	1,460	$7,300
Gabion Revetment (yd^3)	$60	6,670	$400,212	5,271	$316,242	11,941	$716,454
Gabion Mattress Reach Subtotal			**$494,853**		**$400,207**		**$895,060**
Excavation (yd^3)	$2	45,653	$91,306	40,000	$80,000	85,653	$171,306
Borrow Material (yd^3)	$5	667	$3,335	793	$3,965	1,460	$7,300
CSA Revetment (yd^3)	$15	11,932	$178,982	9,429	$141,429	21,361	$320,411
CSA Cement (tons)	$100	1,691	$169,140	1,337	$133,650	3,028	$302,790
CSA Reach Subtotal			**$442,763**		**$359,044**		**$801,807**

CAVE CREEK - FULL STRUCTURAL ALTERNATIVE

Item	Unit Price	Left Bank Quantity (yd^3)	Left Bank Cost	Right Bank Quantity (yd^3)	Right Bank Cost	Total Quantity (yd^3)	Total Cost
Mined Reach							
Excavation (yd^3)	$2	157,685	$315,370	156,910	$313,820	314,595	$629,190
Borrow Material (yd^3)	$5	120,556	$602,780	4,718	$23,590	125,274	$626,370
Riprap Revetment (yd^3)	$30	95,846	$2,875,380	60,270	$1,808,103	156,116	$4,683,483
Riprap Reach Subtotal			**$3,793,530**		**$2,145,513**		**$5,939,043**
Excavation (yd^3)	$2	157,685	$315,370	156,910	$313,820	314,595	$629,190
Borrow Material (yd^3)	$5	120,556	$602,780	4,718	$23,590	125,274	$626,370
Gabion Revetment (yd^3)	$60	43,566	$2,613,972	27,396	$1,643,730	70,962	$4,257,702
Gabion Mattress Reach Subtotal			**$3,532,122**		**$1,981,140**		**$5,513,262**
Excavation (yd^3)	$2	157,685	$315,370	156,910	$313,820	314,595	$629,190
Borrow Material (yd^3)	$5	120,556	$602,780	4,718	$23,590	125,274	$626,370
CSA Revetment (yd^3)	$15	70,140	$1,052,100	44,106	$661,590	114,246	$1,713,690
CSA Cement (tons)	$100	9,942	$994,240	6,252	$625,200	16,194	$1,619,440
CSA Reach Subtotal			**$2,964,490**		**$1,624,200**		**$4,588,690**

CAVE CREEK - FULL STRUCTURAL ALTERNATIVE

Item	Unit Price	Left Bank Quantity (yd³)	Left Bank Cost	Right Bank Quantity (yd³)	Right Bank Cost	Total Quantity (yd³)	Total Cost
Cliff Reach							
Excavation (yd³)	$2	374,718	$749,436	66,440	$132,880	441,158	$882,316
Borrow Material (yd³)	$5	104,963	$524,815	19,208	$96,040	124,171	$620,855
Riprap Revetment (yd³)	$30	167,515	$5,025,435	21,861	$655,830	189,376	$5,681,265
Riprap Reach Subtotal			**$6,299,686**		**$884,750**		**$7,184,436**
Excavation (yd³)	$2	374,718	$749,436	66,440	$132,880	441,158	$882,316
Borrow Material (yd³)	$5	104,963	$524,815	19,208	$96,040	124,171	$620,855
Gabion Revetment (yd³)	$60	76,778	$4,606,650	10,020	$601,176	86,797	$5,207,826
Gabion Mattress Reach Subtotal			**$5,880,901**		**$830,096**		**$6,710,997**
Excavation (yd³)	$2	374,718	$749,436	66,440	$132,880	441,158	$882,316
Borrow Material (yd³)	$5	104,963	$524,815	19,208	$96,040	124,171	$620,855
CSA Revetment (yd³)	$15	112,372	$1,685,583	14,665	$219,972	127,037	$1,905,555
CSA Cement (tons)	$100	15,929	$1,592,880	2,079	$207,870	18,008	$1,800,750
CSA Reach Subtotal			**$4,552,714**		**$656,762**		**$5,209,476**

APACHE WASH - FULL STRUCTURAL ALTERNATIVE

Item	Unit Price	Left Bank Quantity (yd³)	Left Bank Cost	Right Bank Quantity (yd³)	Right Bank Cost	Total Quantity (yd³)	Total Cost
APACHE WASH - FULL STRUCTURAL ALTERNATIVE TOTALS							
Riprap Revetment							
Excavation Total (yd³)	$2	305,400	$610,800	485,386	$970,772	790,786	$1,581,572
Borrow Total (yd³)	$5	42,327	$211,635	77,537	$387,685	119,864	$599,320
Riprap Total (yd³)	$30	124,154	$3,724,620	225,887	$6,776,610	350,041	$10,501,230
Total Cost			**$4,547,055**		**$8,135,067**		**$12,682,122**
Gabion Mattress Revetment							
Excavation Total (yd³)	$2	305,400	$610,800	485,386	$970,772	790,786	$1,581,572
Borrow Total (yd³)	$5	42,327	$211,635	77,537	$387,685	119,864	$599,320
Gabion Total (yd³)	$60	54,054	$3,243,240	99,201	$5,952,060	153,255	$9,195,300
Total Cost			**$4,065,675**		**$7,310,517**		**$11,376,192**
CSA Revetment							
Excavation Total (yd³)	$2	305,400	$610,800	485,386	$970,772	790,786	$1,581,572
Borrow Total (yd³)	$5	42,327	$211,635	77,537	$387,685	119,864	$599,320
CSA Total (yd³)	$15	87,418	$1,311,270	154,378	$2,315,666	241,796	$3,626,936
CSA Cement Total (tons)	$100	12,392	$1,239,200	21,883	$2,188,300	34,275	$3,427,500
Total Cost			**$3,372,905**		**$5,862,423**		**$9,235,328**

APACHE WASH - FULL STRUCTURAL ALTERNATIVE

Item	Unit Price	Left Bank Quantity (yd^3)	Left Bank Cost	Right Bank Quantity (yd^3)	Right Bank Cost	Total Quantity (yd^3)	Total Cost
Hackberry Reach							
Excavation (yd^3)	$2	138,335	$276,670	240,891	$481,782	379,226	$758,452
Borrow Material (yd^3)	$5	18,619	$93,095	17,885	$89,425	36,504	$182,520
Riprap Revetment (yd^3)	$30	67,418	$2,022,540	107,995	$3,239,850	175,413	$5,262,390
Riprap Reach Subtotal			**$2,392,305**		**$3,811,057**		**$6,203,362**
Excavation (yd^3)	$2	138,335	$276,670	240,891	$481,782	379,226	$758,452
Borrow Material (yd^3)	$5	18,619	$93,095	17,885	$89,425	36,504	$182,520
Gabion Revetment (yd^3)	$60	28,523	$1,711,380	45,690	$2,741,400	74,213	$4,452,780
Gabion Mattress Reach Subtotal			**$2,081,145**		**$3,312,607**		**$5,393,752**
Excavation (yd^3)	$2	138,335	$276,670	240,891	$481,782	379,226	$758,452
Borrow Material (yd^3)	$5	18,619	$93,095	17,885	$89,425	36,504	$182,520
CSA Revetment (yd^3)	$15	41,747	$626,205	66,873	$1,003,095	108,620	$1,629,300
CSA Cement (tons)	$100	5,918	$591,800	9,479	$947,900	15,397	$1,539,700
CSA Reach Subtotal			**$1,587,770**		**$2,522,202**		**$4,109,972**

APACHE WASH - FULL STRUCTURAL ALTERNATIVE

Item	Unit Price	Left Bank Quantity (yd^3)	Left Bank Cost	Right Bank Quantity (yd^3)	Right Bank Cost	Total Quantity (yd^3)	Total Cost
Union Hills Reach							
Excavation (yd^3)	$2	0	$0	96,367	$192,734	96,367	$192,734
Borrow Material (yd^3)	$5	0	$0	5,164	$25,820	5,164	$25,820
Riprap Revetment (yd^3)	$30	0	$0	39,813	$1,194,390	39,813	$1,194,390
Riprap Reach Subtotal			**$0**		**$1,412,944**		**$1,412,944**
Excavation (yd^3)	$2	0	$0	96,367	$192,734	96,367	$192,734
Borrow Material (yd^3)	$5	0	$0	5,164	$25,820	5,164	$25,820
Gabion Revetment (yd^3)	$60	0	$0	18,375	$1,102,500	18,375	$1,102,500
Gabion Mattress Reach Subtotal			**$0**		**$1,321,054**		**$1,321,054**
Excavation (yd^3)	$2	0	$0	96,367	$192,734	96,367	$192,734
Borrow Material (yd^3)	$5	0	$0	5,164	$25,820	5,164	$25,820
CSA Revetment (yd^3)	$15	0	$0	24,653	$369,791	24,653	$369,791
CSA Cement (tons)	$100	0	$0	3,495	$349,500	3,495	$349,500
CSA Reach Subtotal			**$0**		**$937,845**		**$937,845**

APACHE WASH - FULL STRUCTURAL ALTERNATIVE

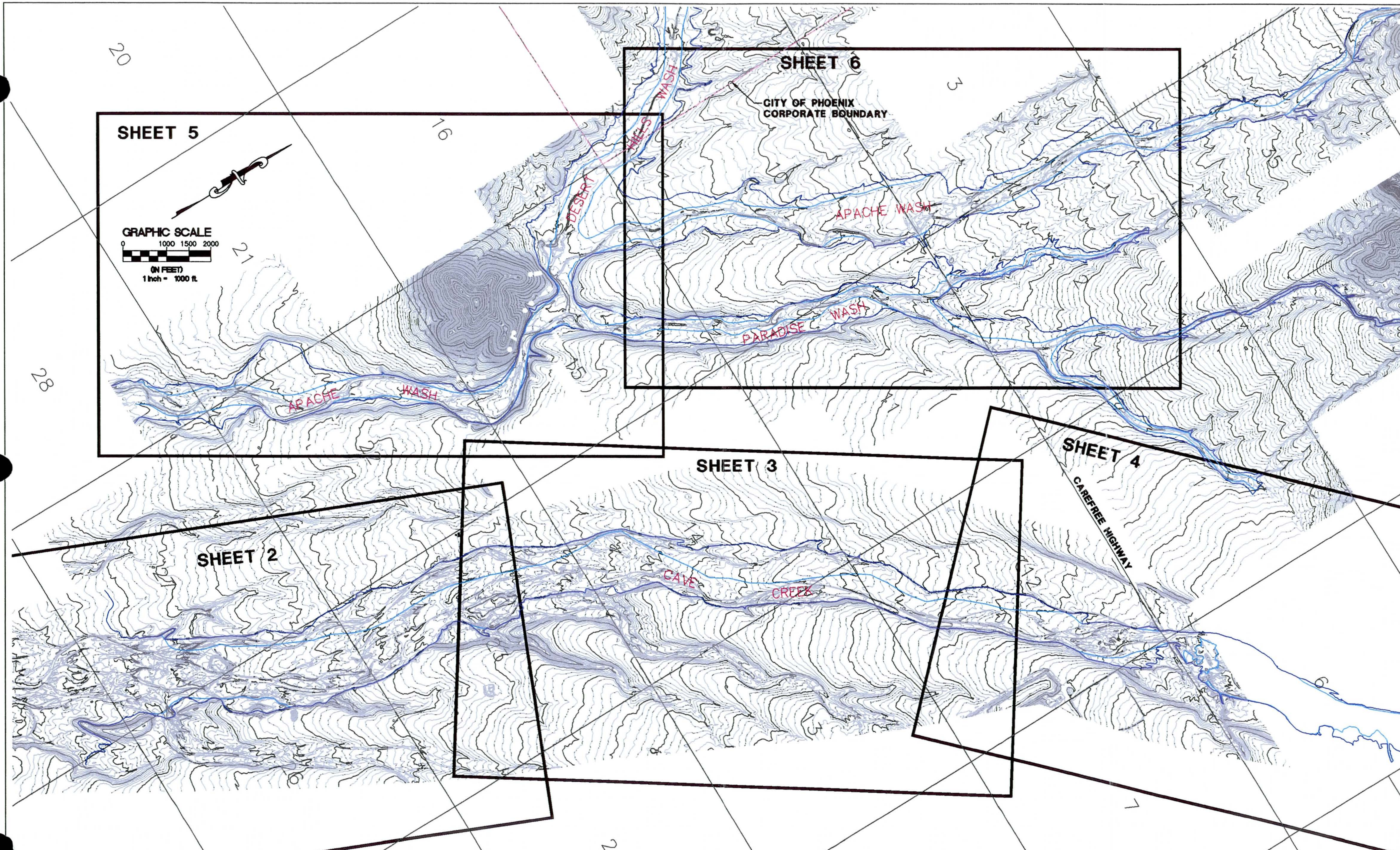
Item	Unit Price	Left Bank Quantity (yd^3)	Left Bank Cost	Right Bank Quantity (yd^3)	Right Bank Cost	Total Quantity (yd^3)	Total Cost
Upper Reach							
Excavation (yd^3)	$2	167,065	$334,130	148,128	$296,256	315,193	$630,386
Borrow Material (yd^3)	$5	23,708	$118,540	54,488	$272,440	78,196	$390,980
Riprap Revetment (yd^3)	$30	56,736	$1,702,080	78,079	$2,342,370	134,815	$4,044,450
Riprap Reach Subtotal			**$2,154,750**		**$2,911,066**		**$5,065,816**
Excavation (yd^3)	$2	167,065	$334,130	148,128	$296,256	315,193	$630,386
Borrow Material (yd^3)	$5	23,708	$118,540	54,488	$272,440	78,196	$390,980
Gabion Revetment (yd^3)	$60	25,531	$1,531,860	35,136	$2,108,160	60,667	$3,640,020
Gabion Mattress Reach Subtotal			**$1,984,530**		**$2,676,856**		**$4,661,386**
Excavation (yd^3)	$2	167,065	$334,130	148,128	$296,256	315,193	$630,386
Borrow Material (yd^3)	$5	23,708	$118,540	54,488	$272,440	78,196	$390,980
CSA Revetment (yd^3)	$15	45,671	$685,065	62,852	$942,780	108,523	$1,627,845
CSA Cement (tons)	$100	6,474	$647,400	8,909	$890,900	15,383	$1,538,300
CSA Reach Subtotal			**$1,785,135**		**$2,402,376**		**$4,187,511**

PARADISE WASH - FULL STRUCTURAL ALTERNATIVE TOTALS

Item	Unit Price	Left Bank Quantity (yd^3)	Left Bank Cost	Right Bank Quantity (yd^3)	Right Bank Cost	Total Quantity (yd^3)	Total Cost
Riprap Revetment							
Excavation (yd^3)	$2	102,883	$205,766	75,874	$151,748	178,757	$357,514
Borrow Material (yd^3)	$5	34,163	$170,815	15,289	$76,445	49,452	$247,260
Riprap Revetment (yd^3)	$30	28,764	$862,920	29,231	$876,930	57,995	$1,739,850
Total Cost			**$1,239,501**		**$1,105,123**		**$2,344,624**
Gabion Mattress Revetment							
Excavation (yd^3)	$2	102,883	$205,766	75,874	$151,748	178,757	$357,514
Borrow Material (yd^3)	$5	34,163	$170,815	15,289	$76,445	49,452	$247,260
Gabion Revetment (yd^3)	$60	12,584	$755,040	12,789	$767,340	25,373	$1,522,380
Total Cost			**$1,131,621**		**$995,533**		**$2,127,154**
CSA Revetment							
Excavation (yd^3)	$2	102,883	$205,766	75,874	$151,748	178,757	$357,514
Borrow Material (yd^3)	$5	34,163	$170,815	15,289	$76,445	49,452	$247,260
CSA Revetment (yd^3)	$15	28,943	$434,145	29,413	$441,195	58,356	$875,340
CSA Cement (tons)	$100	4,103	$410,300	4,169	$416,900	8,272	$827,200
Total Cost			**$1,221,026**		**$1,086,288**		**$2,307,314**

DESERT HILLS WASH - FULL STRUCTURAL ALTERNATIVE TOTALS

Item	Unit Price	Left Bank Quantity (yd^3)	Left Bank Cost	Right Bank Quantity (yd^3)	Right Bank Cost	Total Quantity (yd^3)	Total Cost
Riprap Revetment							
Excavation (yd^3)	$2	31,411	$62,822	23,920	$47,840	55,331	$110,662
Borrow Material (yd^3)	$5	19,189	$95,945	10,599	$52,995	29,788	$148,940
Riprap Revetment (yd^3)	$30	15,520	$465,600	10,612	$318,360	26,132	$783,960
Total Cost			**$624,367**		**$419,195**		**$1,043,562**
Gabion Mattress Revetment							
Excavation (yd^3)	$2	31,411	$62,822	23,920	$47,840	55,331	$110,662
Borrow Material (yd^3)	$5	19,189	$95,945	10,599	$52,995	29,788	$148,940
Gabion Revetment (yd^3)	$60	7,760	$465,600	5,306	$318,360	13,066	$783,960
Total Cost			**$624,367**		**$419,195**		**$1,043,562**
CSA Revetment							
Excavation (yd^3)	$2	31,411	$62,822	23,920	$47,840	55,331	$110,662
Borrow Material (yd^3)	$5	19,189	$95,945	10,599	$52,995	29,788	$148,940
CSA Revetment (yd^3)	$15	17,848	$267,720	12,204	$183,060	30,052	$450,780
CSA Cement (tons)	$100	2,530	$253,000	1,730	$173,000	4,260	$426,000
Total Cost			**$679,487**		**$456,895**		**$1,136,382**



NO.	REVISIONS	DATE	BY	CHK.

2350TM01mod.DWG

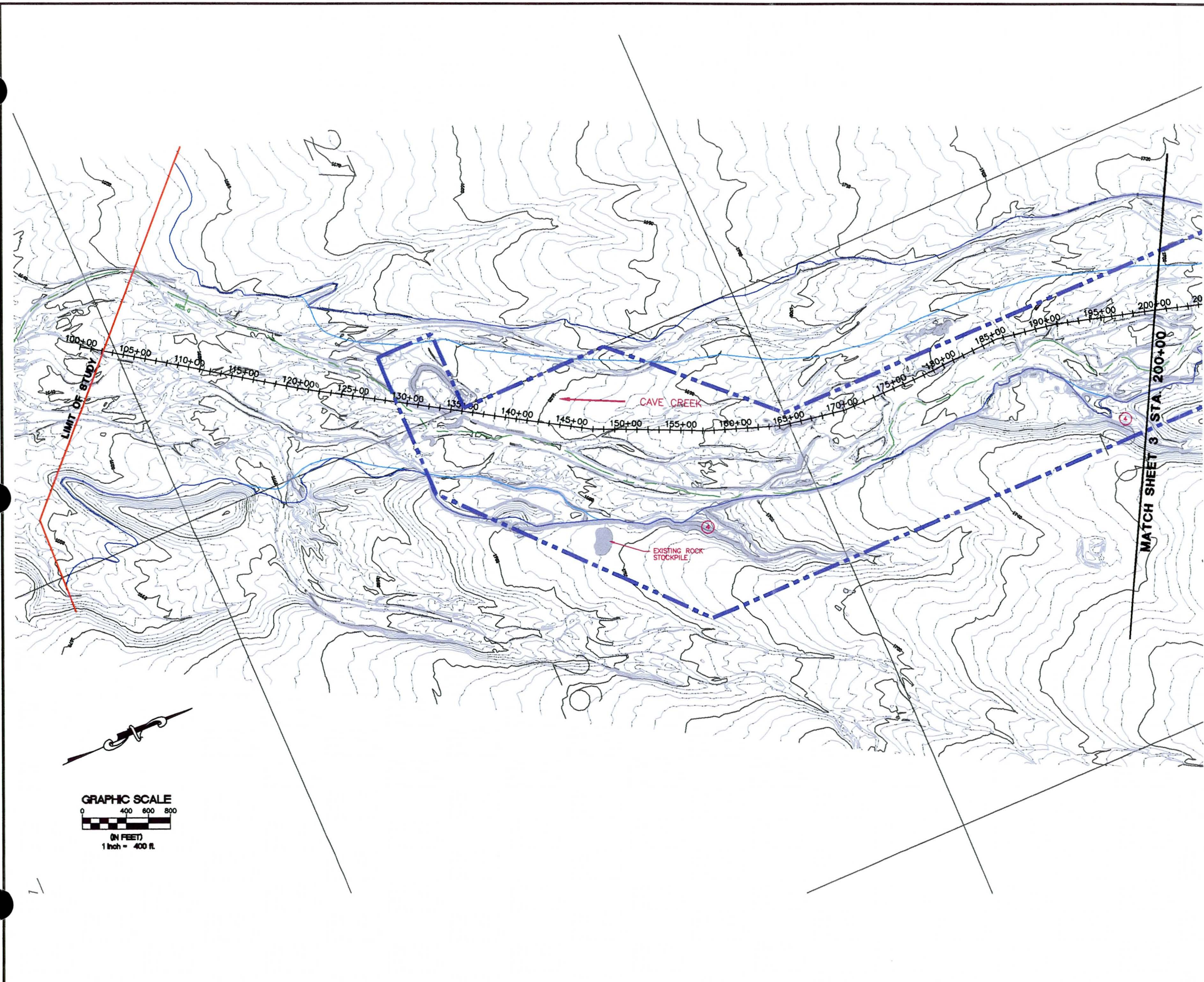
TETRA TECH, INC.
INFRASTRUCTURE SOUTHWEST GROUP
301 North 44th Street, Suite 125, Phoenix, AZ 85008
(602) 629-1100 FAX (602) 629-1186

UPPER CAVE CREEK AND APACHE WASH WATERCOURSE MASTER PLAN
FCD 97-45

JOB NO.	23500001
DESIGNED BY:	DEJ
DRAWN BY:	CBC
CHECKED BY:	BSB
APPROVED BY:	BSB
DATE:	12/15/00

CONCEPTUAL PLAN
SOFT-STRUCTURAL ALTERNATIVE
INDEX SHEET

SCALE: HORIZ: 1"= 1000'
CONT. INTERVAL = 2'
DRAWING NO. SS01
SHEET NO. 1 OF: 8



CONSTRUCTION NOTES

1. PROVIDE BANK PROTECTION. BACKFILL TO ORIGINAL GROUND SEE DETAIL SHEET 7
2. PROVIDE NATIVE VEGETATION. FINISH GRADING AND VEGETATION SHOULD APPEAR NATURAL.
3. PROVIDE CHANNEL ACCESS RAMP. (LOCATION APPROXIMATE) SEE DETAIL SHEET 7
4. PROVIDE RIPRAP PROTECTION IN TRIBUTARY CHANNEL USING EXISTING STOCKPILED ROCK, AS DIRECTED BY ENGINEER.

GENERAL NOTES

1. CONTRACTOR SHALL LOCATE AND PROTECT ALL EXISTING UTILITIES AS REQUIRED, PRIOR TO START OF CONSTRUCTION.

LEGEND

- FLOW DIRECTION
- 100 YEAR FLOODPLAIN
- FLOODWAY
- THALWEG
- TOE DOWN
- LEVEE
- DAYLIGHT LINE
- 150+00 CHANNEL BASELINE
- MINING EASEMENT
- POTENTIAL FUTURE ROADWAY LOCATION

NO.	REVISION	BY	DATE
3			
2			
1			

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

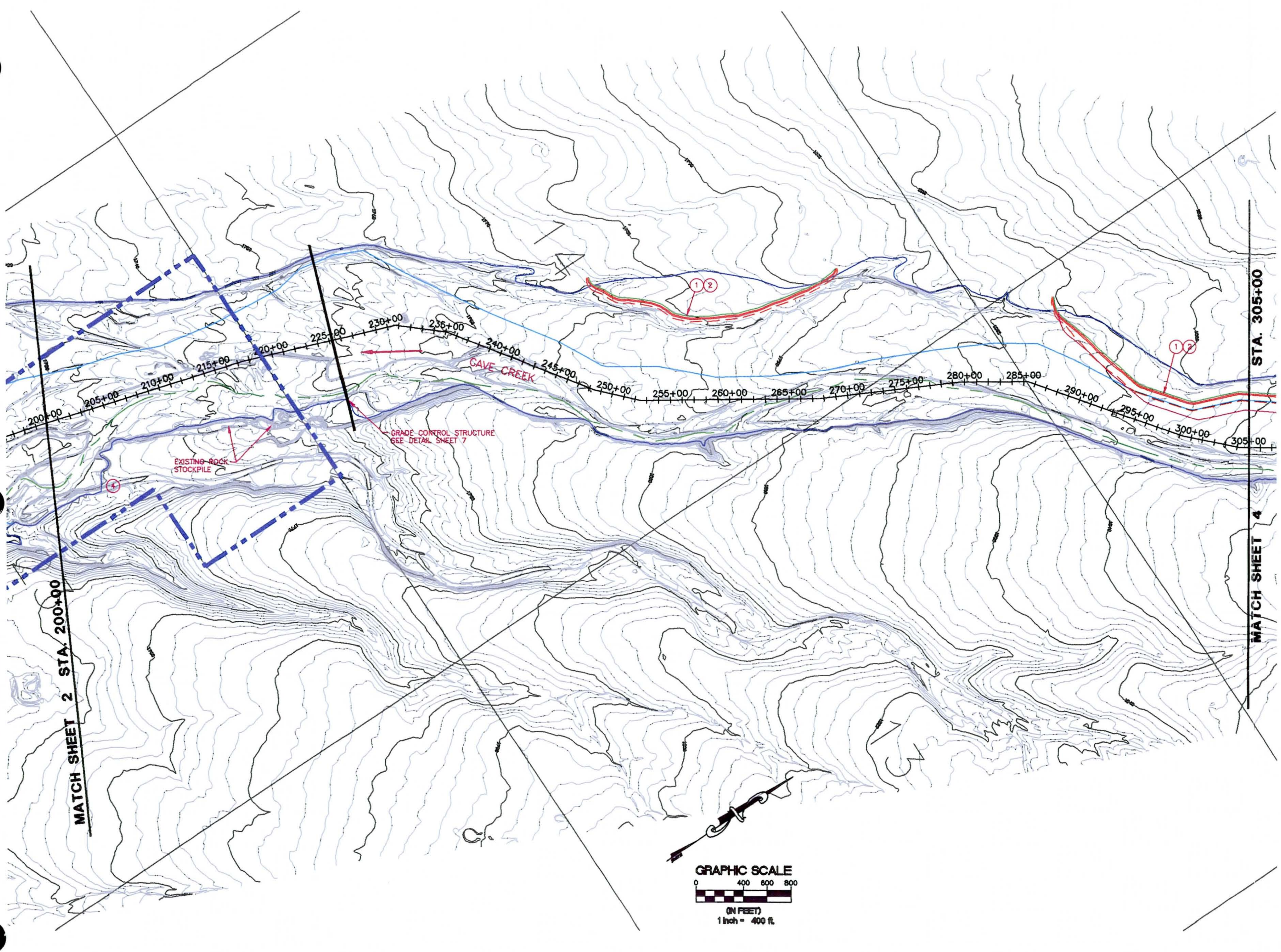
UPPER CAVE CREEK AND APACHE WASH WATERCOURSE MASTER PLAN FCD 97-45

TETRA TECH, INC.
INFRASTRUCTURE SOUTHWEST GROUP
301 North 44th Street, Suite 125, Phoenix, AZ 85008
(602) 629-1100 FAX (602) 629-1186

CONCEPTUAL PLAN

SOFT-STRUCTURAL ALTERNATIVE

DWG NO.	2350TM02.DWG	DRAWN BY:	CBC/DJS
JOB NO.	2350001	CHECKED BY:	BB
DESIGNED BY:	BB	SHEET:	2 OF 8



CONSTRUCTION NOTES

1. PROVIDE BANK PROTECTION. BACKFILL TO ORIGINAL GROUND SEE DETAIL SHEET 7
2. PROVIDE NATIVE VEGETATION. FINISH GRADING AND VEGETATION SHOULD APPEAR NATURAL.
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GENERAL NOTES

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LEGEND

- FLOW DIRECTION
- 100 YEAR FLOODPLAIN
- FLOODWAY
- THALWEG
- TOE DOWN
- LEVEE
- DAYLIGHT LINE
- 150+00 CHANNEL BASELINE
- MINING EASEMENT

NO.	REVISION	BY	DATE
3			
2			
1			

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

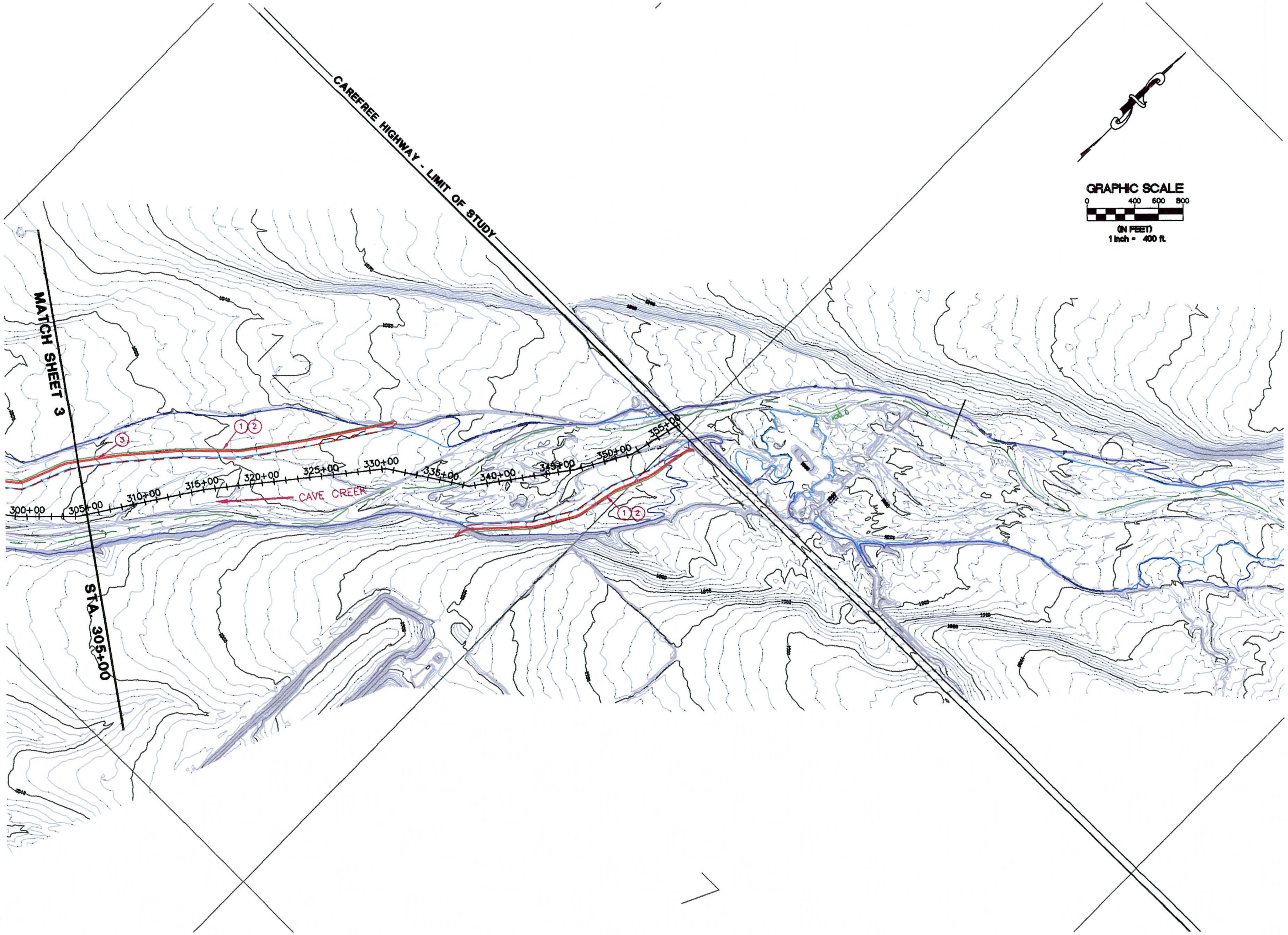
UPPER CAVE CREEK AND APACHE WASH WATERCOURSE MASTER PLAN FCD 97-45

TETRA TECH, INC.
INFRASTRUCTURE SOUTHWEST GROUP
501 North 44th Street, Suite 125, Phoenix, AZ 85008
(602) 629-1100 FAX (602) 629-1186

CONCEPTUAL PLAN

SOFT-STRUCTURAL ALTERNATIVE

DWG NO.	2350TM03.DWG	DRAWN BY:	CBC/DJS
JOB NO.	2350001	CHECKED BY:	BB
DESIGNED BY:	BB	SHEET:	3 OF 8



CONSTRUCTION NOTES

1. PROVIDE BANK PROTECTION. BACKFILL TO ORIGINAL GROUND SEE DETAIL SHEET 7
2. PROVIDE NATIVE VEGETATION. FINISH GRADING AND VEGETATION SHOULD APPEAR NATURAL.
3. PROVIDE CHANNEL ACCESS RAMP. (LOCATION APPROXIMATE) SEE DETAIL SHEET 7

GENERAL NOTES

1. CONTRACTOR SHALL LOCATE AND PROTECT ALL EXISTING UTILITIES AS REQUIRED, PRIOR TO START OF CONSTRUCTION.

LEGEND

- FLOW DIRECTION
- 100 YEAR FLOODPLAIN
- FLOODWAY
- THALWEG
- TOE DOWN
- LEVEE
- DAYLIGHT LINE
- 150+00 CHANNEL BASELINE

NO.	REVISION	BY	DATE
3			
2			
1			

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

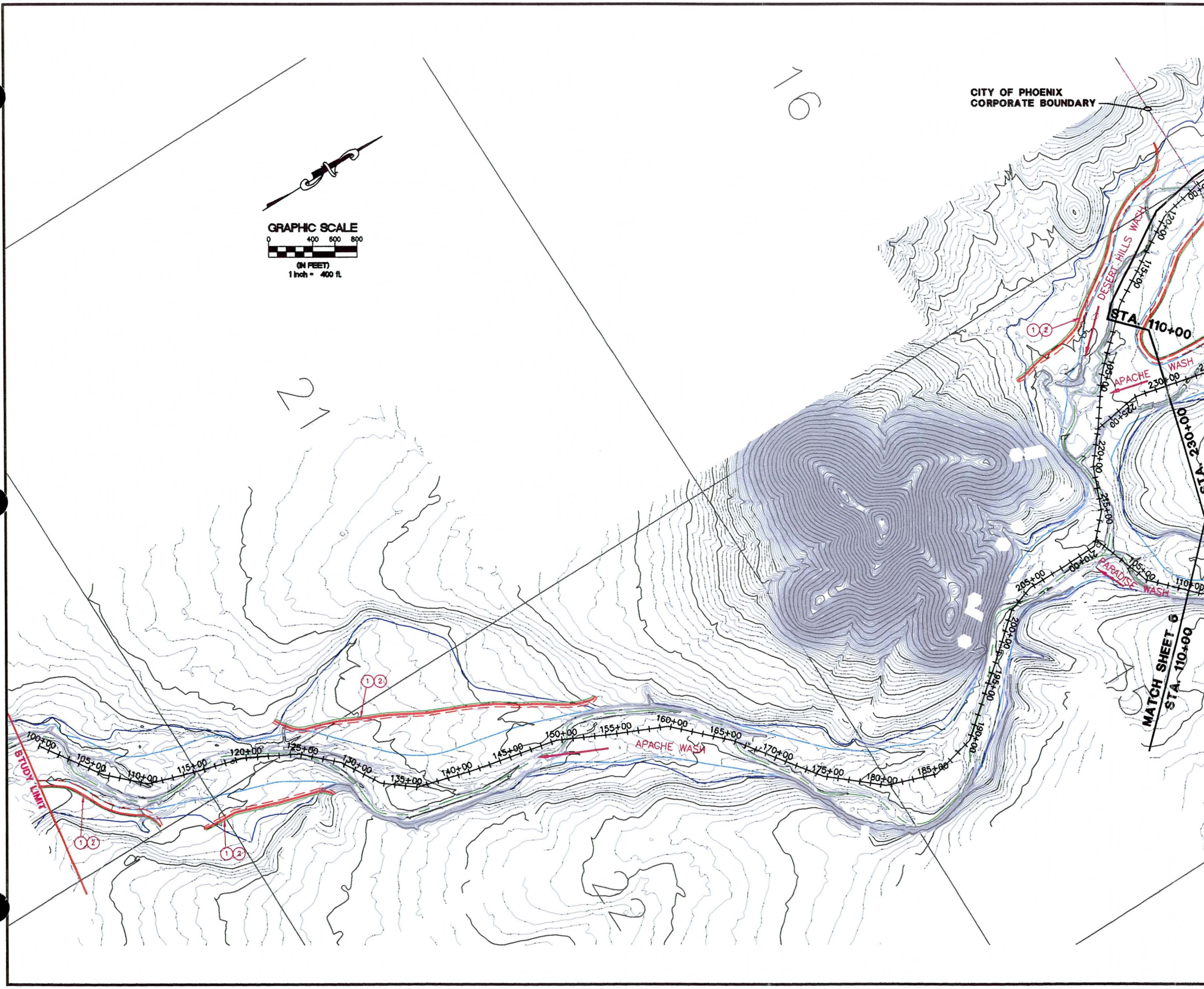
UPPER CAVE CREEK AND APACHE WASH WATERCOURSE MASTER PLAN FCD 97-45

TETRA TECH, INC.
INFRASTRUCTURE SOUTHWEST GROUP
501 North 44th Street, Suite 125, Phoenix, AZ 85008
(602) 629-1100 FAX (602) 629-1186

CONCEPTUAL PLAN

SOFT-STRUCTURAL ALTERNATIVE

DWG NO.	2350TM04.DWG	DRAWN BY:	CBC/DJS
JOB NO.	2350001	CHECKED BY:	BB
DESIGNED BY:	BB	SHEET:	4 OF 8



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- FLOW DIRECTION
- 100 YEAR FLOODPLAIN
- FLOODWAY
- THALWEG
- TOE DOWN
- LEVEE
- DAYLIGHT LINE
- 150+00 CHANNEL BASELINE
- POTENTIAL FUTURE ROADWAY LOCATION

NO.	REVISION	BY	DATE
3			
2			
1			

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

UPPER CAVE CREEK AND APACHE WASH WATERCOURSE MASTER PLAN FCD 97-45

TETRA TECH, INC.
INFRASTRUCTURE SOUTHWEST GROUP
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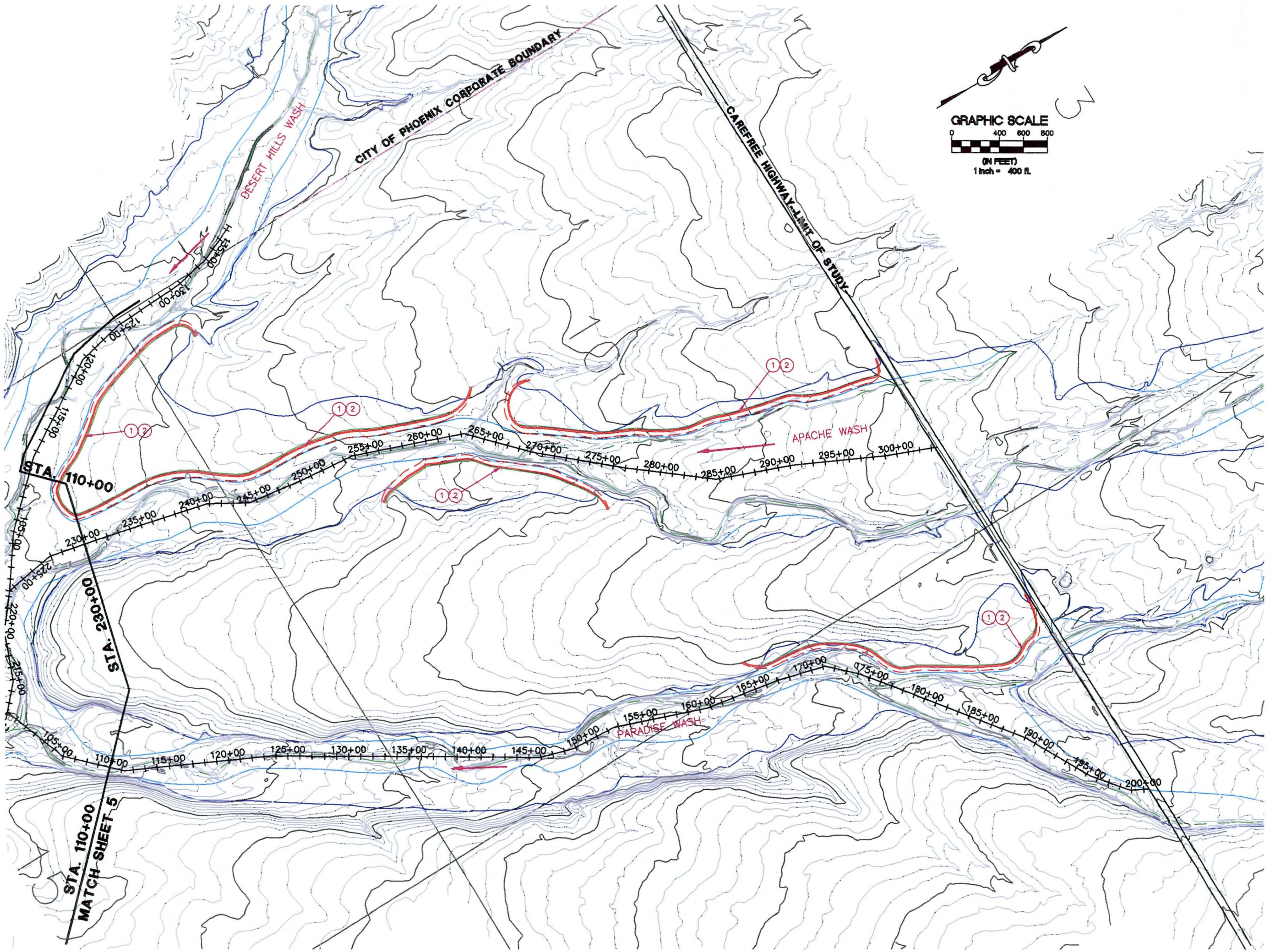
CONCEPTUAL PLAN

SOFT-STRUCTURAL ALTERNATIVE

DWG NO.	2350TM05.DWG	DRAWN BY:	CBC/DJS
JOB NO.	2350001	CHECKED BY:	BB
DESIGNED BY:	BB	SHEET:	5 OF 8



CONSTRUCTION NOTES

(1) PROVIDE BANK PROTECTION. BACKFILL TO ORIGINAL GROUND SEE DETAIL SHEET 7

(2) PROVIDE NATIVE VEGETATION. FINISH GRADING AND VEGETATION SHOULD APPEAR NATURAL.

(3) PROVIDE CHANNEL ACCESS RAMP. (LOCATION APPROXIMATE) SEE DETAIL SHEET 7

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- FLOW DIRECTION
- 100 YEAR FLOODPLAIN
- FLOODWAY
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- LEVEE
- DAYLIGHT LINE
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NO.	REVISION	BY	DATE
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FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

UPPER CAVE CREEK AND APACHE WASH WATERCOURSE MASTER PLAN FCD 97-45

TETRA TECH, INC.
INFRASTRUCTURE SOUTHWEST GROUP
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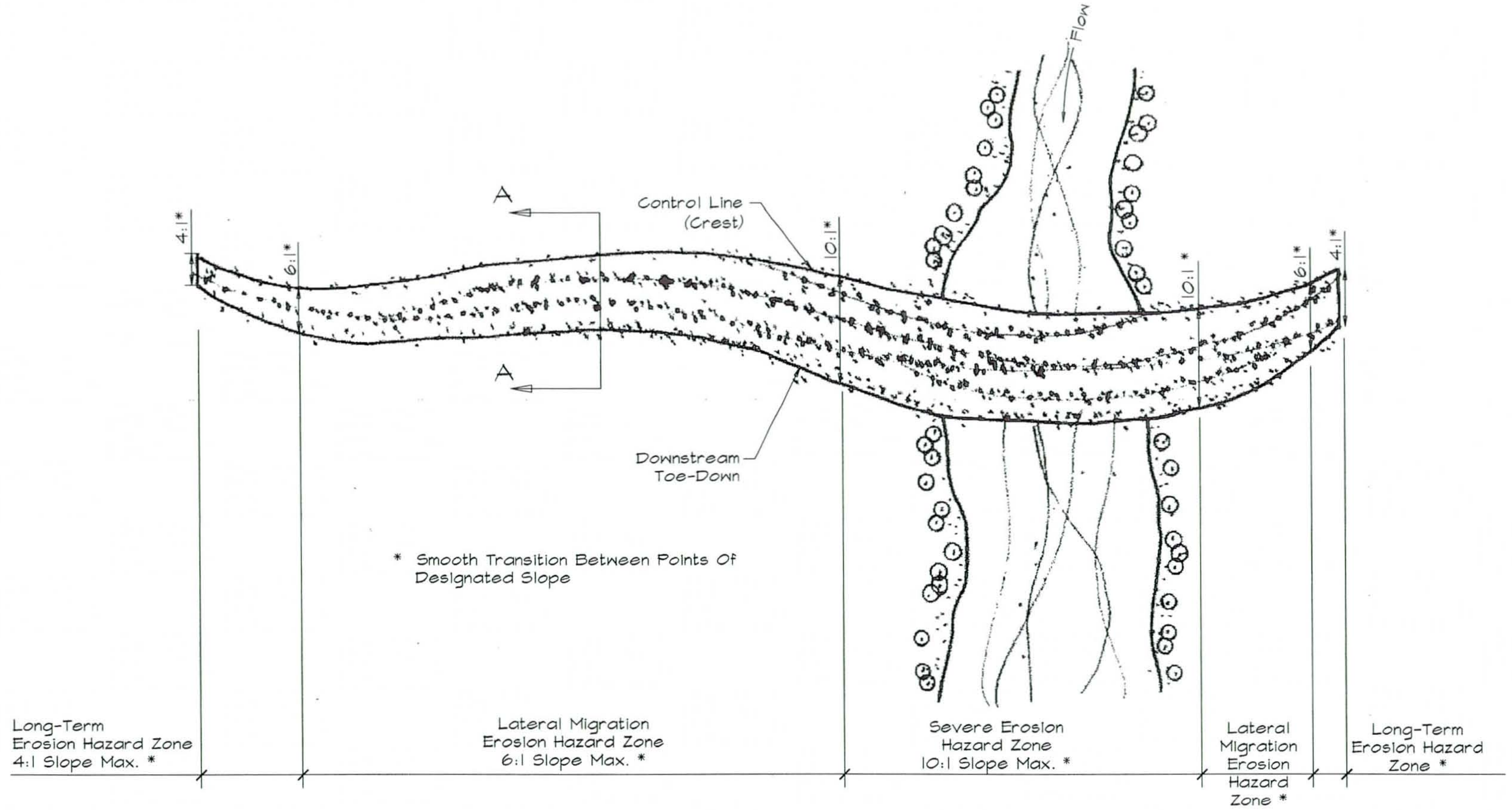
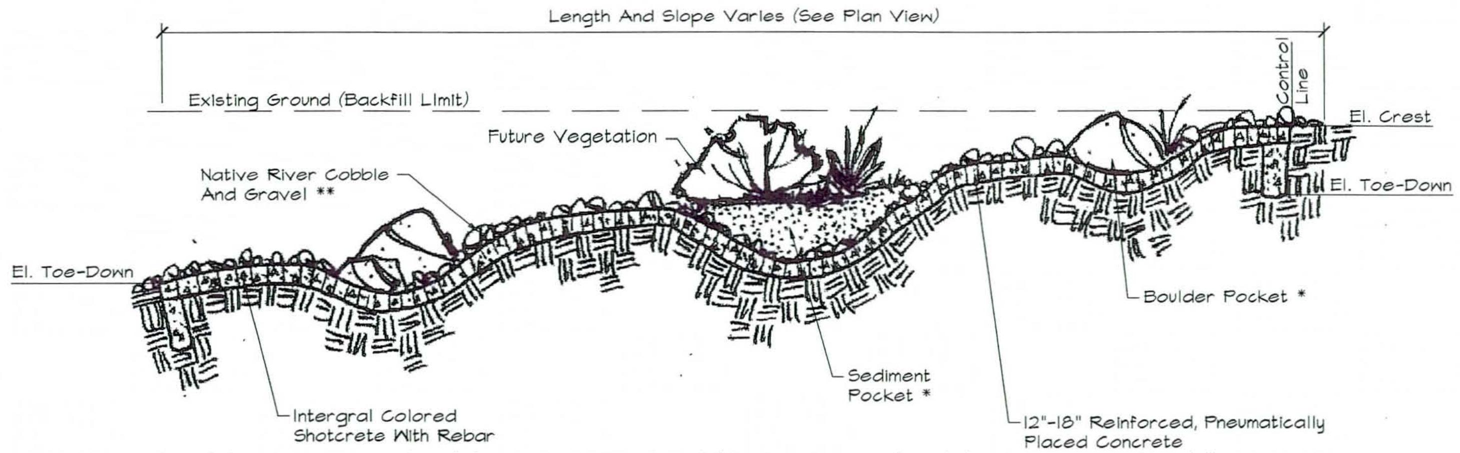
CONCEPTUAL PLAN

SOFT-STRUCTURAL ALTERNATIVE

DWG NO.	2350TM06.DWG	DRAWN BY:	CBC/DJS
JOB NO.	2350001	CHECKED BY:	BB
DESIGNED BY:	BB	SHEET:	6 OF 8



PLAN VIEW NTS



SECTION A-A NTS

* Sediment/Boulder Pockets - Approximate Dimensions And Densities:

SIZE	LENGTH	WIDTH	DEPTH	DENSITY
Small	5'	3'	1.5'	6/5000 Sq. Ft.
Medium	10'	8'	3'	4/5000 Sq. Ft.
Large	15'	12'	5'	2/5000 Sq. Ft.

Pocket Shape To Be Irregular And Distribution Of Pockets Should Mimic Natural Patterns. Boulders Should Be From Local Sources.

** Surface Of Finished Concrete To Be Covered With Embedded Cobbles And Gravel.

CONSTRUCTION NOTES

1. PLACE CONCRETE PER M.A.G. SPEC. 525.
2. REINFORCING STEEL SHALL BE NO. 5 BARS, GRADE 60, UNLESS OTHERWISE NOTED.

GENERAL NOTES

1. CONTRACTOR SHALL LOCATE AND PROTECT ALL EXISTING UTILITIES AS REQUIRED, PRIOR TO START OF CONSTRUCTION.

LEGEND

NO.	REVISION	BY	DATE
3			
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FLOOD CONTROL DISTRICT OF MARICOPA COUNTY
ENGINEERING DIVISION

UPPER CAVE CREEK AND APACHE WASH WATERCOURSE MASTER PLAN
FCD 97-45

TETRA TECH, INC.
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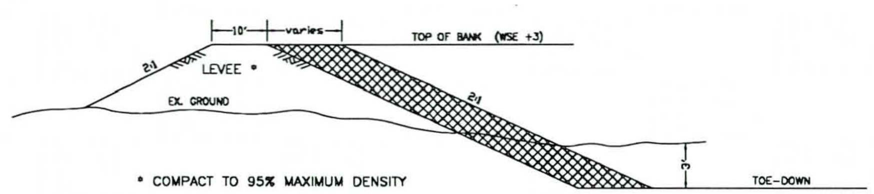
CONCEPTUAL GRADE CONTROL STRUCTURE

SOFT-STRUCTURAL ALTERNATIVE

DWG NO.	2350TM07.DWG	DRAWN BY:	CBC/DJS
JOB NO.	2350001	CHECKED BY:	BB
DESIGNED BY:	DEJ	SHEET:	7 OF 8

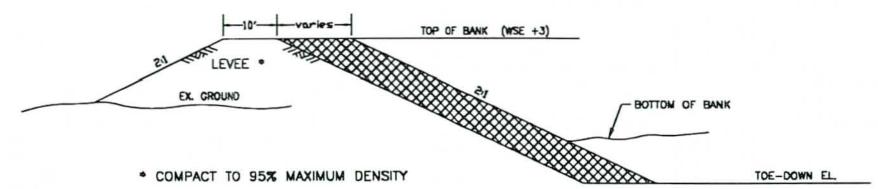


* COMPACT TO 95% MAXIMUM DENSITY

BANK PROTECTION ARMOR
(CSA, GABION MATTRESS, OR RIPRAP)

MINIMUM-DEPTH BANK PROTECTION SECTION

N.T.S.



* COMPACT TO 95% MAXIMUM DENSITY

BANK PROTECTION ARMOR
(CSA, GABION MATTRESS, OR RIPRAP)

FULL-DEPTH BANK PROTECTION SECTION

N.T.S.

MINIMUM-DEPTH BANK PROTECTION	
CAVE CREEK	STA. 245+00 TO 269+00 LEFT
APACHE WASH	STA. 114+00 TO 129+00 RIGHT STA. 123+00 TO 153+00 LEFT

FULL-DEPTH BANK PROTECTION	
CAVE CREEK	STA. 286+00 TO 330+00 LEFT STA. 337+00 TO 356+00 RIGHT
APACHE WASH	STA. 101+00 TO 111+00 RIGHT STA. 230+00 TO 263+00 LEFT STA. 256+00 TO 276+00 RIGHT STA. 266+00 TO 300+00 LEFT
PARADISE WASH	STA. 165+00 TO 187+00 LEFT
DESERT HILLS WASH	STA. 103+00 TO 124+00 LEFT STA. 106+50 TO 130+50 RIGHT

CONSTRUCTION NOTES

1. CONSTRUCT LEVEE EMBANKMENT PER M.A.G. SPEC. 211.

GENERAL NOTES

1. CONTRACTOR SHALL LOCATE AND PROTECT ALL EXISTING UTILITIES AS REQUIRED, PRIOR TO START OF CONSTRUCTION.

LEGEND

NO.	REVISION	BY	DATE
3			
2			
1			

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY
ENGINEERING DIVISION

UPPER CAVE CREEK AND APACHE WASH WATERCOURSE MASTER PLAN
FCD 97-45

TETRA TECH, INC.
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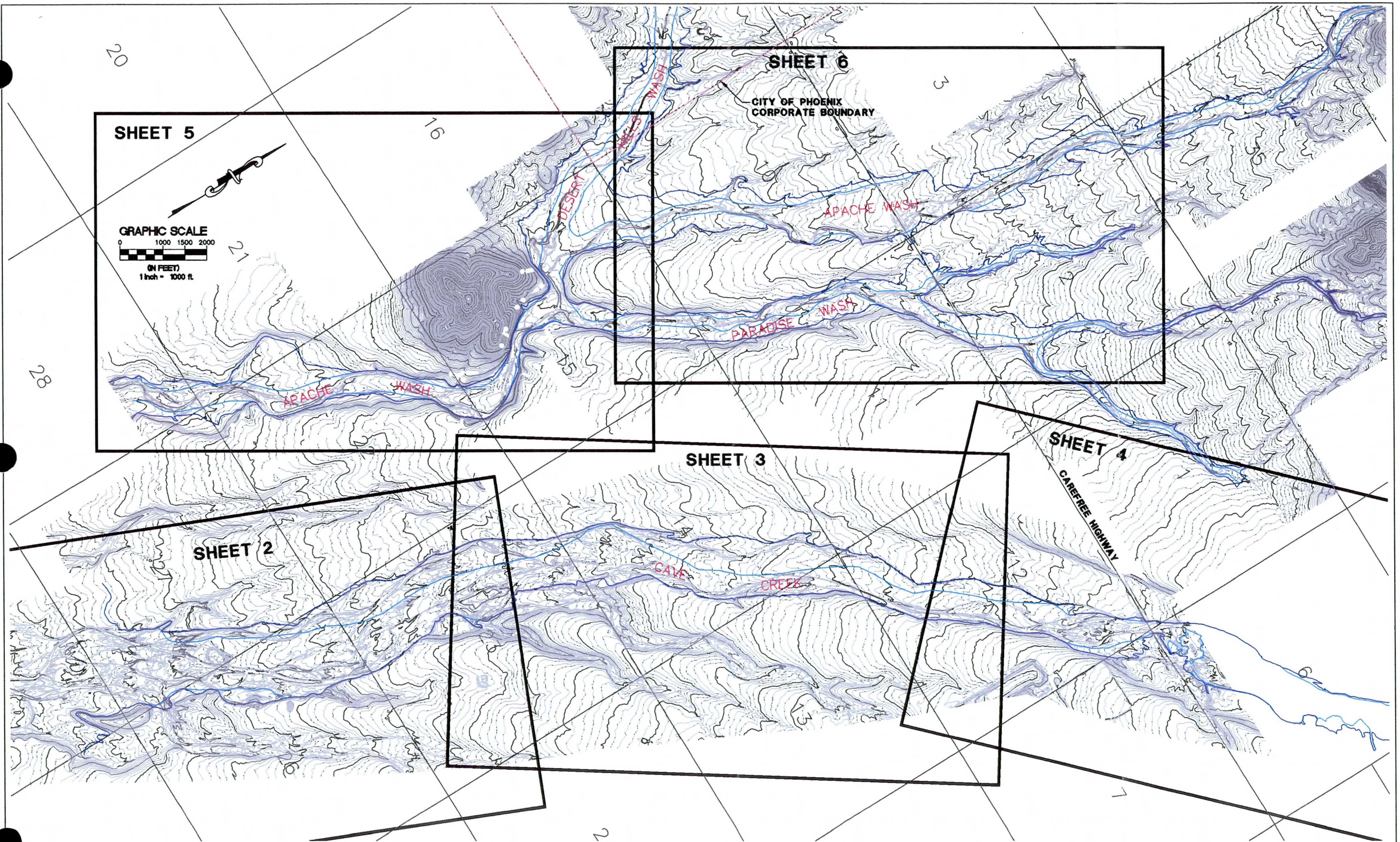
CONCEPTUAL DETAILS

SOFT-STRUCTURAL ALTERNATIVE

DWG NO.	2350TM08.DWG	DRAWN BY:	CBC/DJS
JOB NO.	2350001	CHECKED BY:	BB
DESIGNED BY:	BB	SHEET:	8 OF 8



NO.	REVISIONS	DATE	BY	CHK.

2350BP01mod.DWG

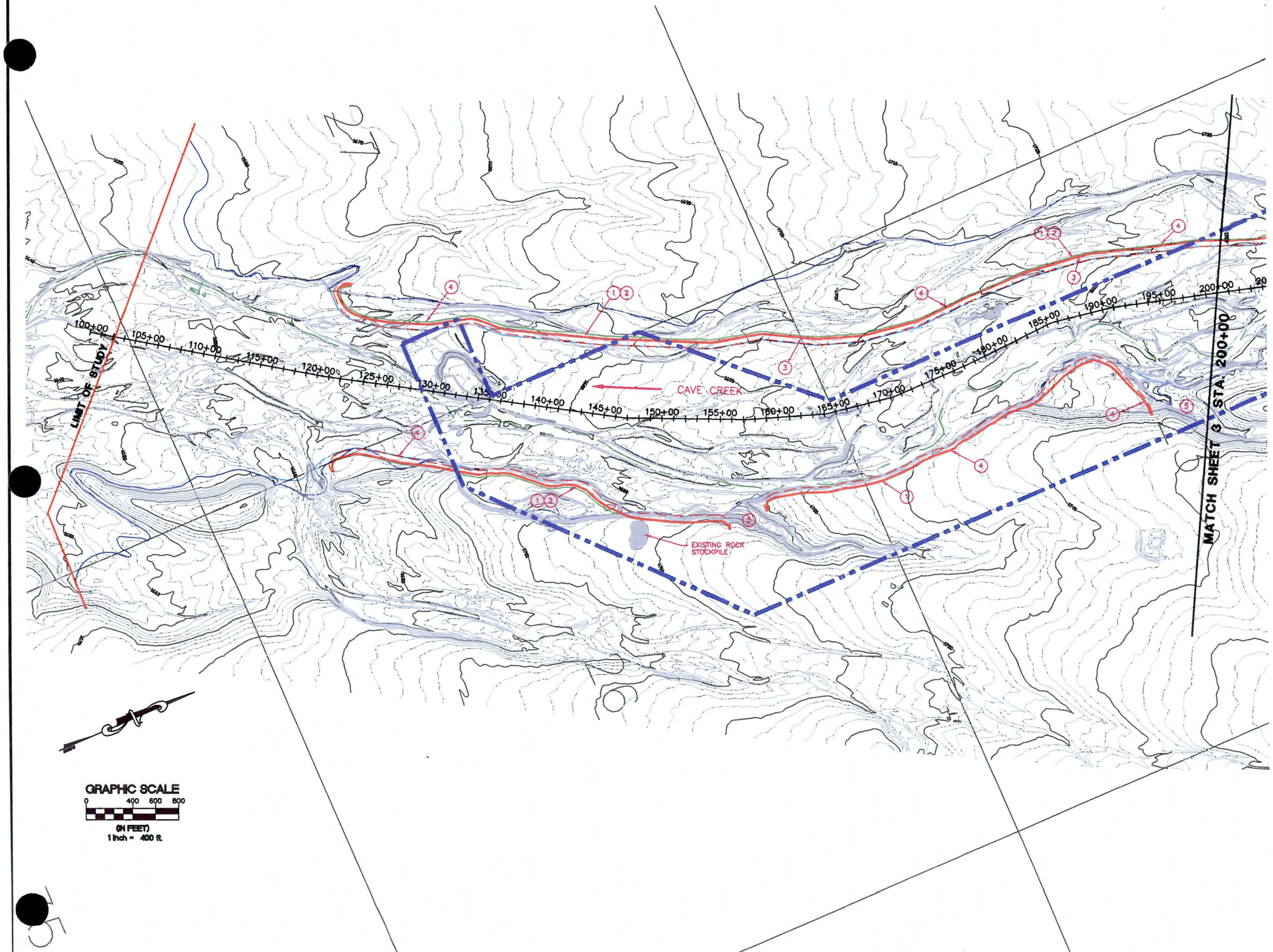
TETRA TECH, INC.
INFRASTRUCTURE SOUTHWEST GROUP
501 North 44th Street, Suite 125, Phoenix, AZ 85008
(602) 629-1100 FAX (602) 629-1186

UPPER CAVE CREEK AND APACHE WASH WATERCOURSE MASTER PLAN
FCD 97-45

JOB NO.	23500001
DESIGNED BY:	DEJ
DRAWN BY:	CBC
CHECKED BY:	BSB
APPROVED BY:	BSB
DATE:	8/14/00

CONCEPTUAL PLAN
FULL-STRUCTURAL ALTERNATIVE
INDEX SHEET

SCALE: HORIZ: 1"= 1000'
CONT. INTERVAL = 2'
DRAWING NO. BP01
SHEET NO. 1 OF: 8



CONSTRUCTION NOTES

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2. PROVIDE NATIVE VEGETATION. FINISH GRADING AND VEGETATION SHOULD APPEAR NATURAL.
3. PROVIDE CHANNEL ACCESS RAMP. (LOCATION APPROXIMATE) SEE DETAIL SHEET 7
4. PROVIDE UNDERPASS RAMP. (LOCATION APPROXIMATE) SEE DETAIL SHEET 7.
5. PROVIDE RIPRAP PROTECTION IN TRIBUTARY CHANNEL USING EXISTING STOCKPILED ROCK, AS DIRECTED BY ENGINEER.

GENERAL NOTES

1. CONTRACTOR SHALL LOCATE AND PROTECT ALL EXISTING UTILITIES AS REQUIRED, PRIOR TO START OF CONSTRUCTION.

LEGEND

- FLOW DIRECTION
- 100 YEAR FLOODPLAIN
- FLOODWAY
- THALWEG
- TOE DOWN
- LEVEE
- DAYLIGHT LINE
- 150+00 CHANNEL BASELINE
- MINING EASEMENT
- POTENTIAL FUTURE ROADWAY LOCATION

NO.	REVISION	BY	DATE
3			
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1			

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY
ENGINEERING DIVISION

UPPER CAVE CREEK AND APACHE WASH WATERCOURSE MASTER PLAN
FCD 97-45

TETRA TECH, INC.
INFRASTRUCTURE SOUTHWEST GROUP
301 North 44th Street, Suite 125, Phoenix, AZ 85008
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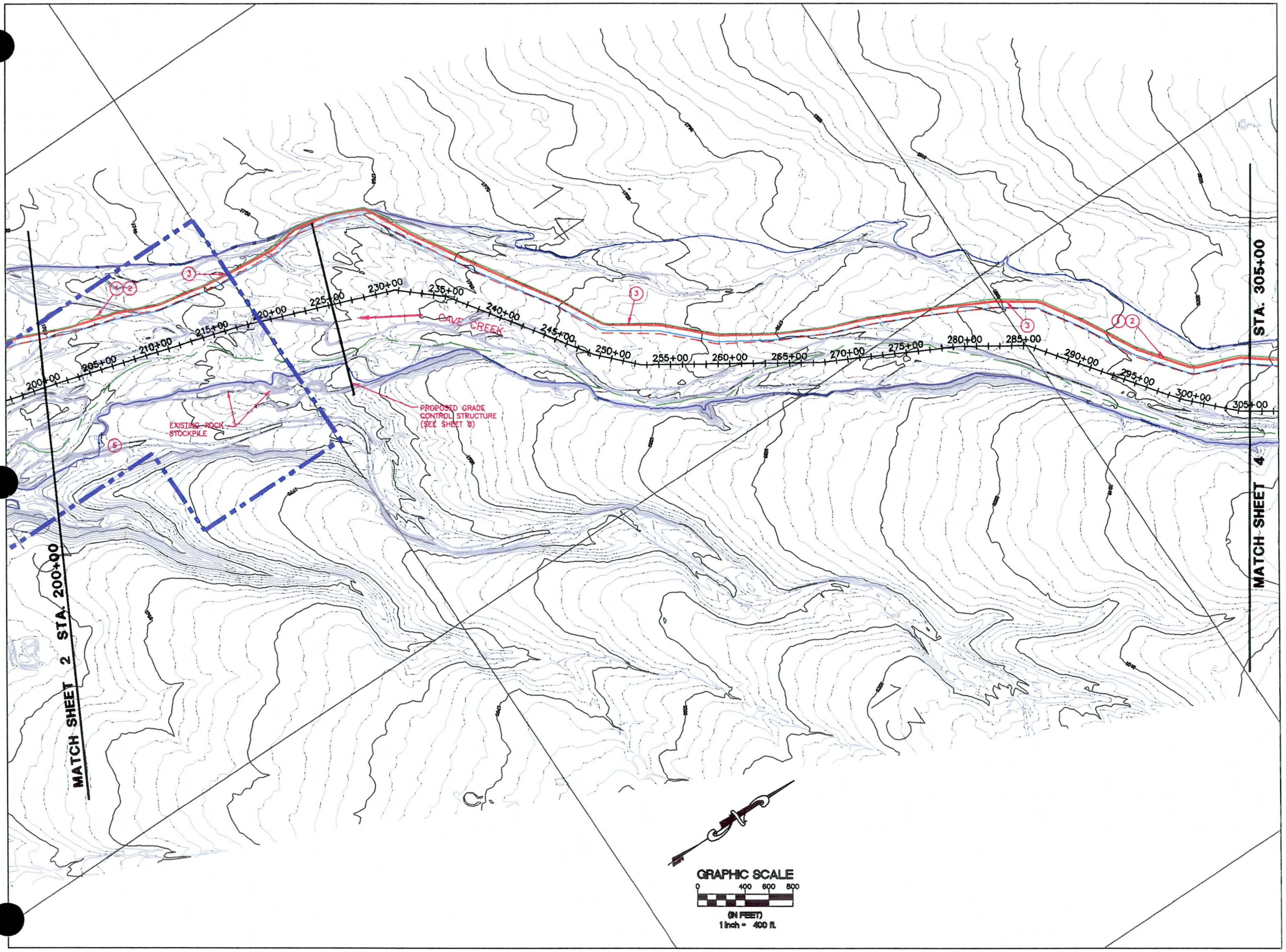
CONCEPTUAL PLAN

FULL-STRUCTURAL ALTERNATIVE

DWG NO.	2350BP02mod.DWG	DRAWN BY:	CBC/DJS
JOB NO.	2350001	CHECKED BY:	BB
DESIGNED BY:	BB	SHEET:	2 OF 8



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FLOW DIRECTION
100 YEAR FLOODPLAIN
FLOODWAY
THALWEG
TOE DOWN
LEVEE
DAYLIGHT LINE
150+00 CHANNEL BASELINE
MINING EASEMENT

NO.	REVISION	BY	DATE
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FLOOD CONTROL DISTRICT OF MARICOPA COUNTY
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CONCEPTUAL PLAN

FULL-STRUCTURAL ALTERNATIVE

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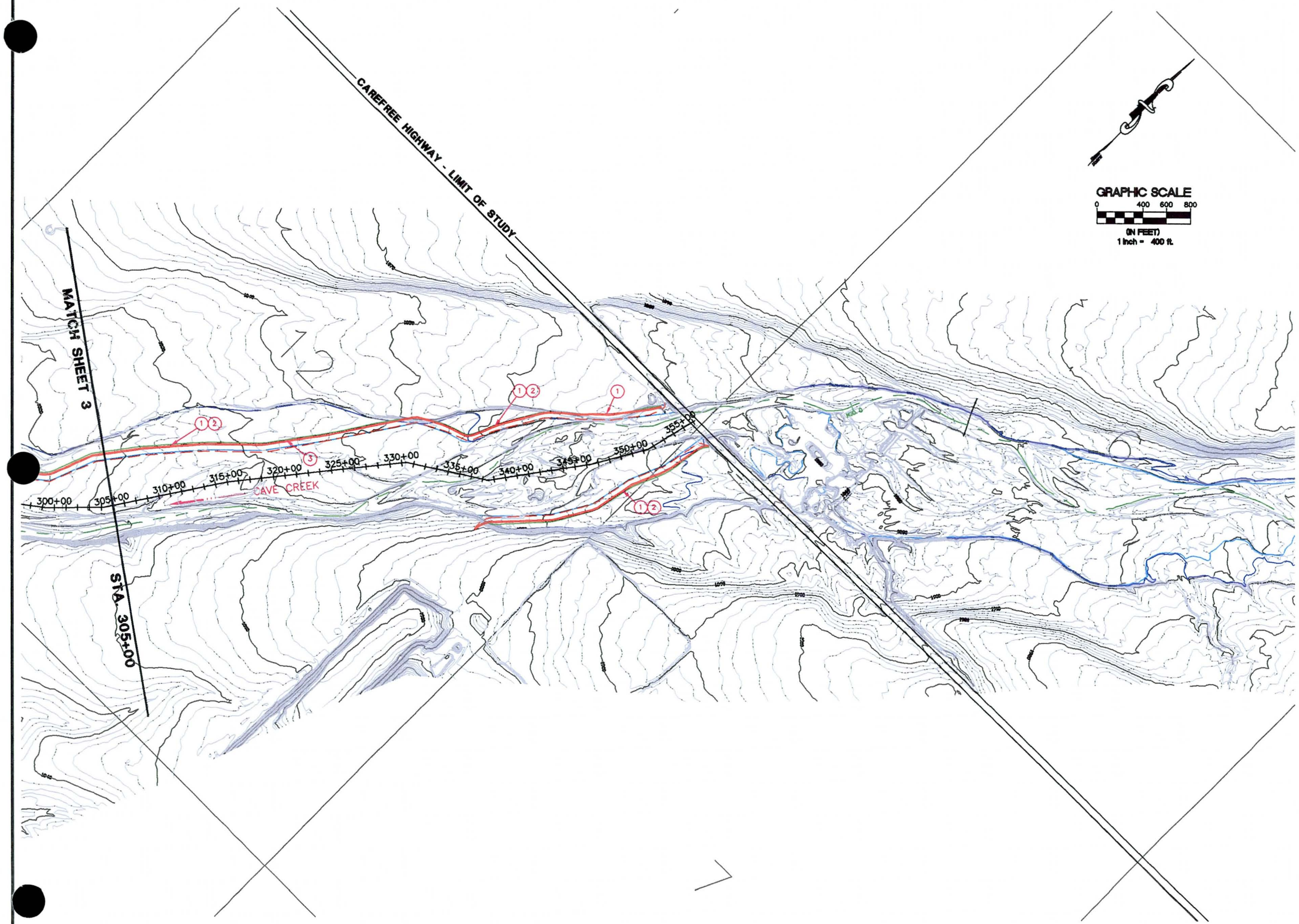
DESIGNED BY:	BB	SHEET:	3 OF 8



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FLOW DIRECTION
100 YEAR FLOODPLAIN
FLOODWAY
THALWEG
TOE DOWN
LEVEE
DAYLIGHT LINE
150+00 CHANNEL BASELINE

NO.	REVISION	BY	DATE
3			
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FLOOD CONTROL DISTRICT OF MARICOPA COUNTY
ENGINEERING DIVISION

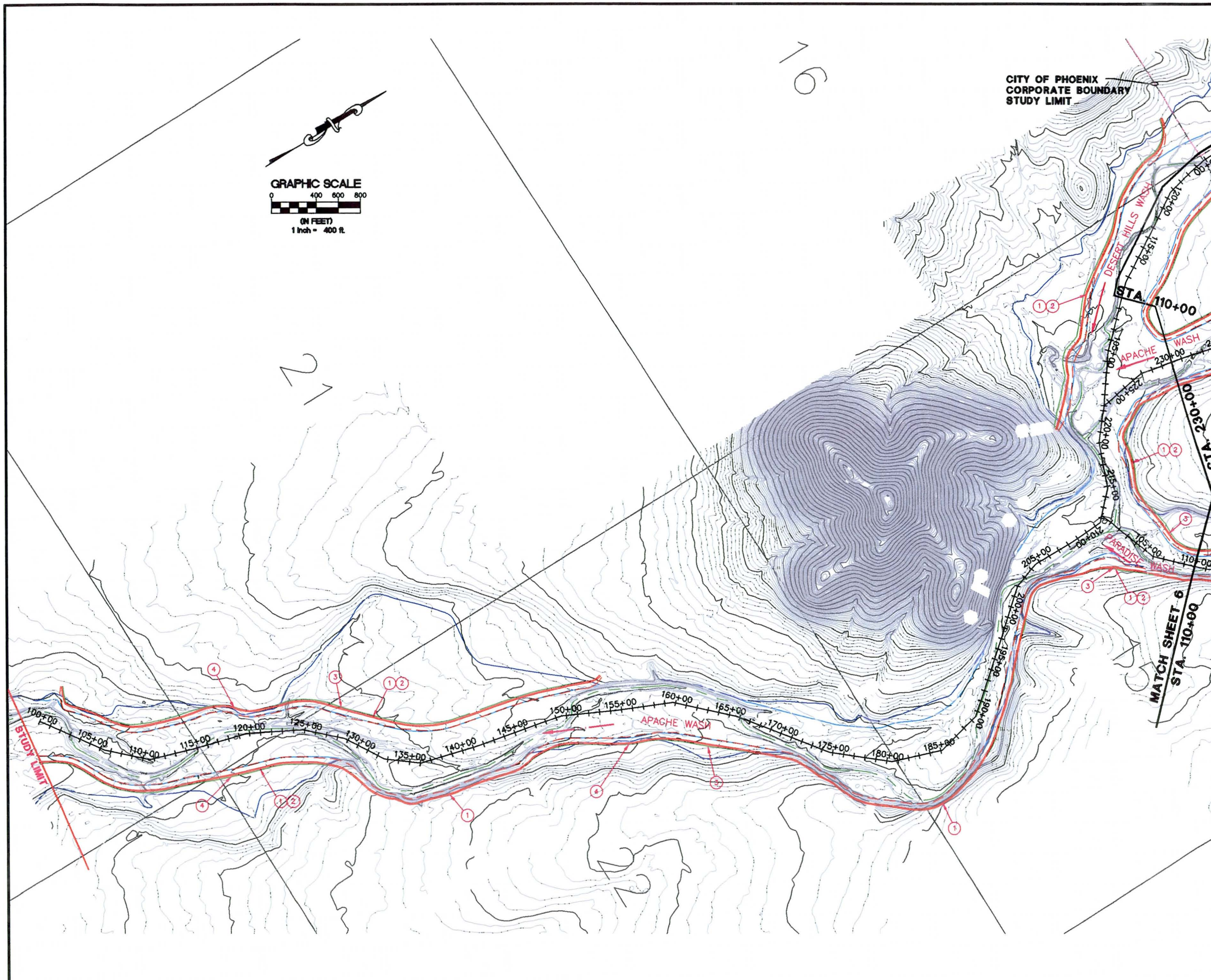
UPPER CAVE CREEK AND APACHE WASH WATERCOURSE MASTER PLAN
FCD 97-45

TETRA TECH, INC.
INFRASTRUCTURE SOUTHWEST GROUP
301 North 44th Street, Suite 125, Phoenix, AZ 85008
(602) 629-1100 FAX (602) 629-1186

CONCEPTUAL PLAN

FULL-STRUCTURAL ALTERNATIVE

DWG NO.	2350BP04mod.DWG	DRAWN BY:	CBC/DJS
JOB NO.	2350001	CHECKED BY:	BB
DESIGNED BY:	BB	SHEET:	4 OF 8



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NO.	REVISION	BY	DATE
3			
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FLOOD CONTROL DISTRICT OF MARICOPA COUNTY
ENGINEERING DIVISION

UPPER CAVE CREEK AND APACHE WASH WATERCOURSE MASTER PLAN
FCD 97-45

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CONCEPTUAL PLAN

FULL-STRUCTURAL ALTERNATIVE

DWG NO.	2350BP05mod.DWG	DRAWN BY:	CBC/DJS
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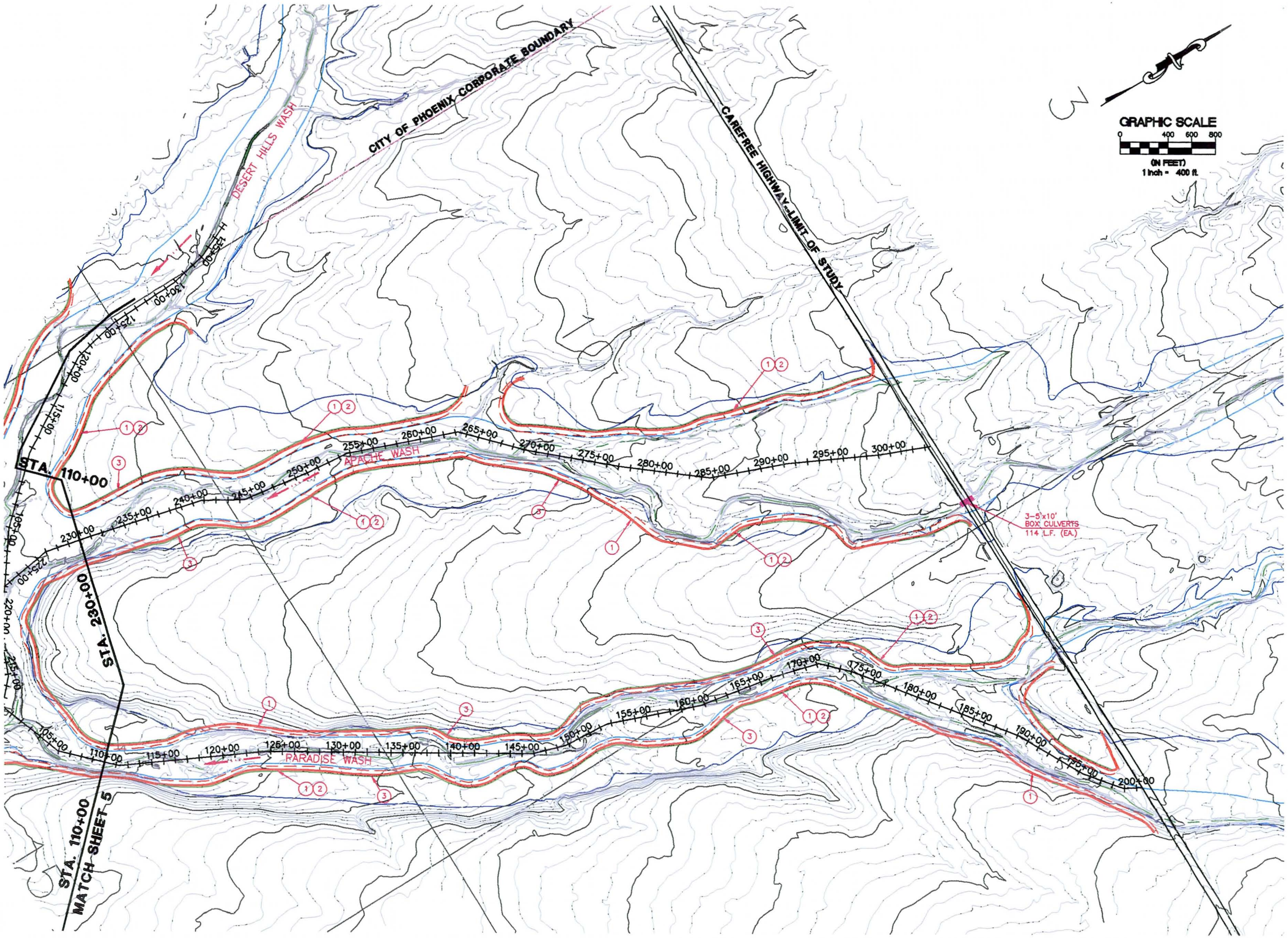

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FLOOD CONTROL DISTRICT OF MARICOPA COUNTY
ENGINEERING DIVISION

UPPER CAVE CREEK AND APACHE WASH WATERCOURSE MASTER PLAN FCD 97-45

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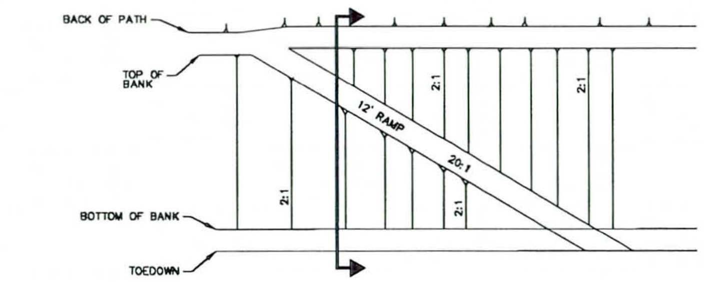
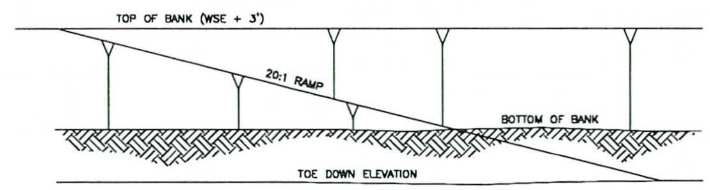
CONCEPTUAL PLAN

FULL-STRUCTURAL ALTERNATIVE

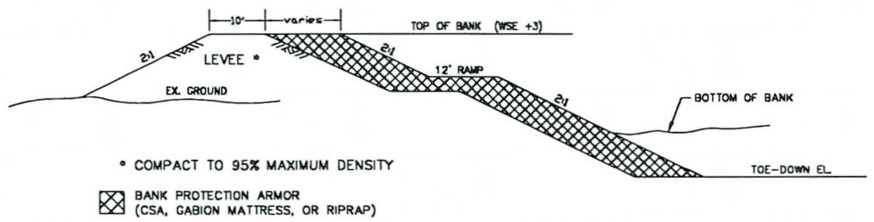
DWG NO.	2350BP06mod.DWG	DRAWN BY:	CBC/DJS
JOB NO.	2350001	CHECKED BY:	BB
DESIGNED BY:	BB	SHEET:	6 OF 8



CHANNEL ACCESS RAMP–PLAN VIEW
N.T.S.



CHANNEL ACCESS RAMP–ELEVATION VIEW
N.T.S.



TYPICAL ACCESS RAMP SECTION
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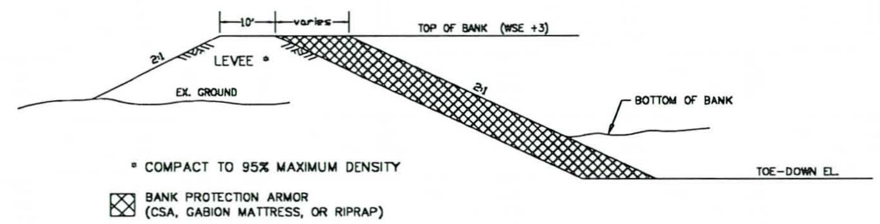

TYPICAL BANK PROTECTION SECTION
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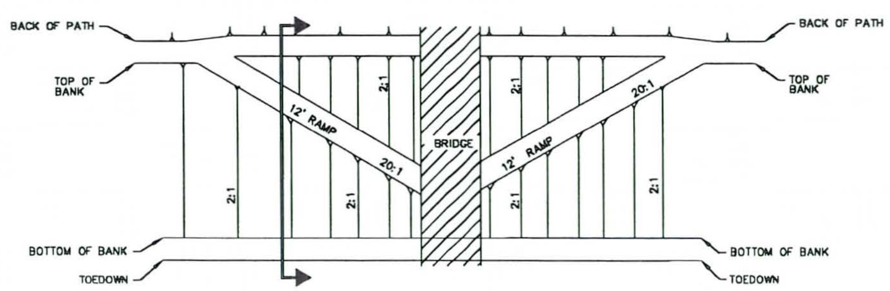
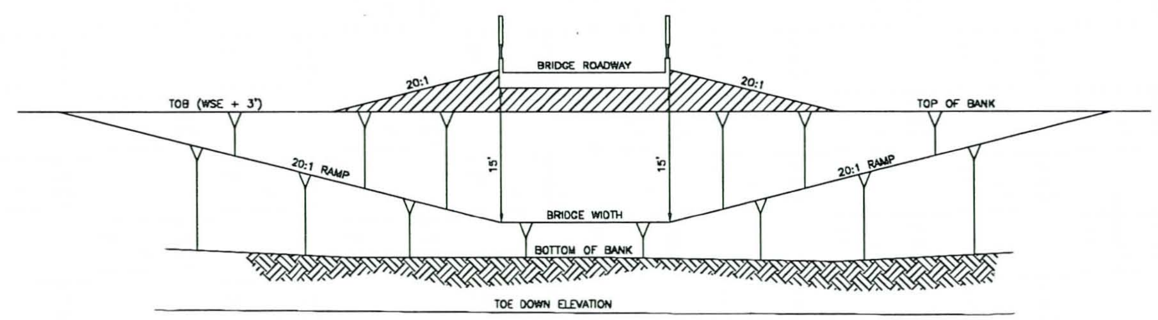


UNDERPASS RAMP–PLAN VIEW
N.T.S.



UNDERPASS RAMP–ELEVATION VIEW
N.T.S.

◯ CONSTRUCTION NOTES ◯

1. CONSTRUCT LEVEE EMBANKMENT PER M.A.G. SPEC. 211.
2. UNDERPASS RAMPS TO BE LOCATED AT BRIDGE CROSSINGS, BOTH SIDES OF CHANNEL.
3. CHANNEL ACCESS RAMP TO BE LOCATED AT APPROX. 2000' INTERVALS, BOTH SIDES OF CHANNEL.

GENERAL NOTES

1. CONTRACTOR SHALL LOCATE AND PROTECT ALL EXISTING UTILITIES AS REQUIRED, PRIOR TO START OF CONSTRUCTION.

LEGEND

NO.	REVISION	BY	DATE
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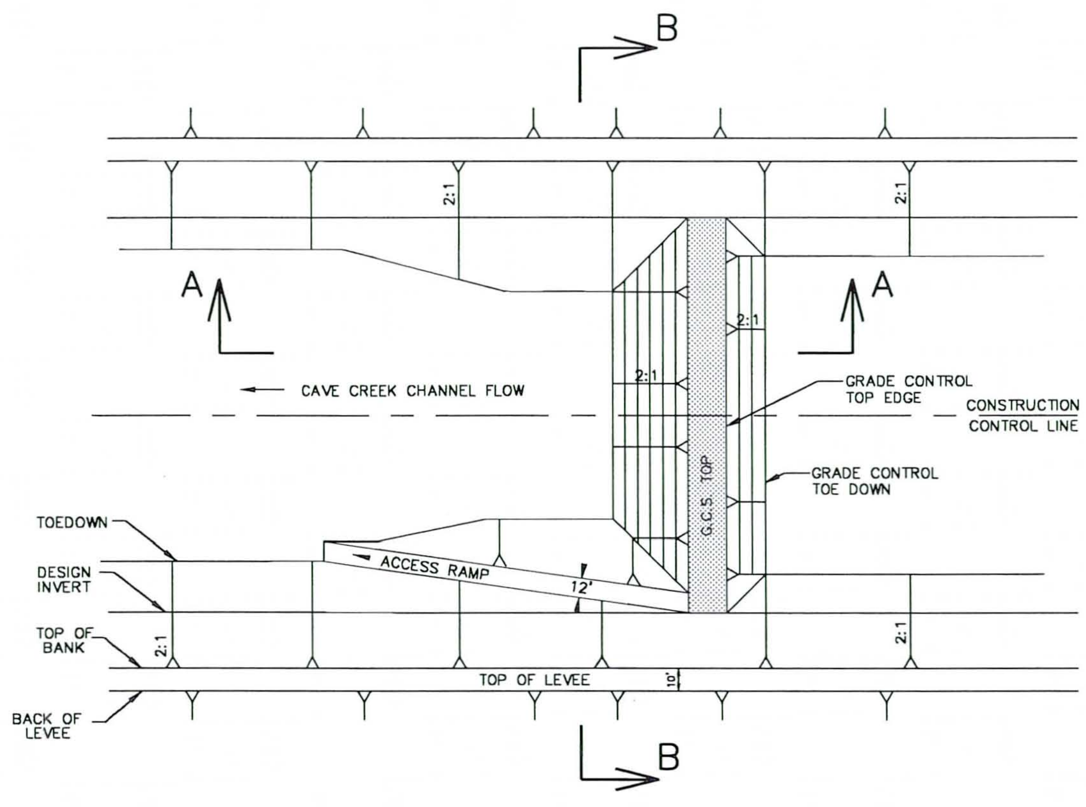
FLOOD CONTROL DISTRICT OF MARICOPA COUNTY
ENGINEERING DIVISION

UPPER CAVE CREEK AND APACHE WASH WATERCOURSE MASTER PLAN
FCD 97-45

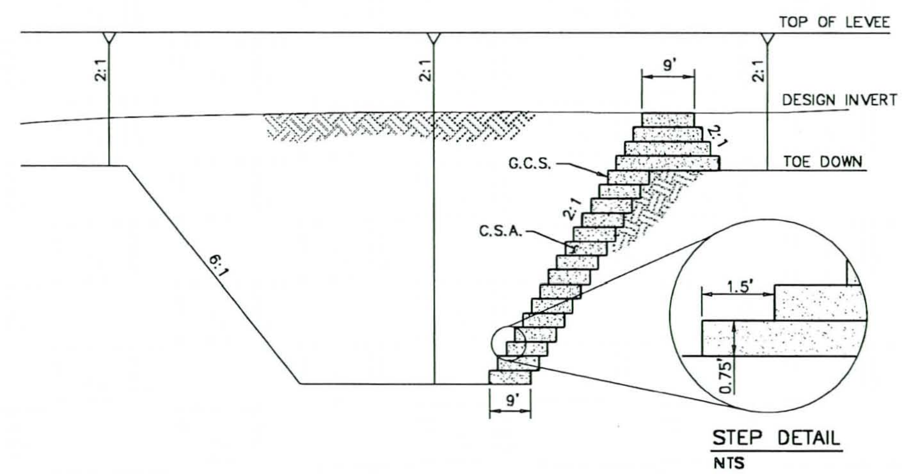
TETRA TECH, INC.
INFRASTRUCTURE SOUTHWEST GROUP
501 North 44th Street, Suite 125, Phoenix, AZ 85008
(602) 629-1100 FAX (602) 629-1186

CONCEPTUAL PLAN
FULL-STRUCTURAL ALTERNATIVE
TYPICAL SECTIONS

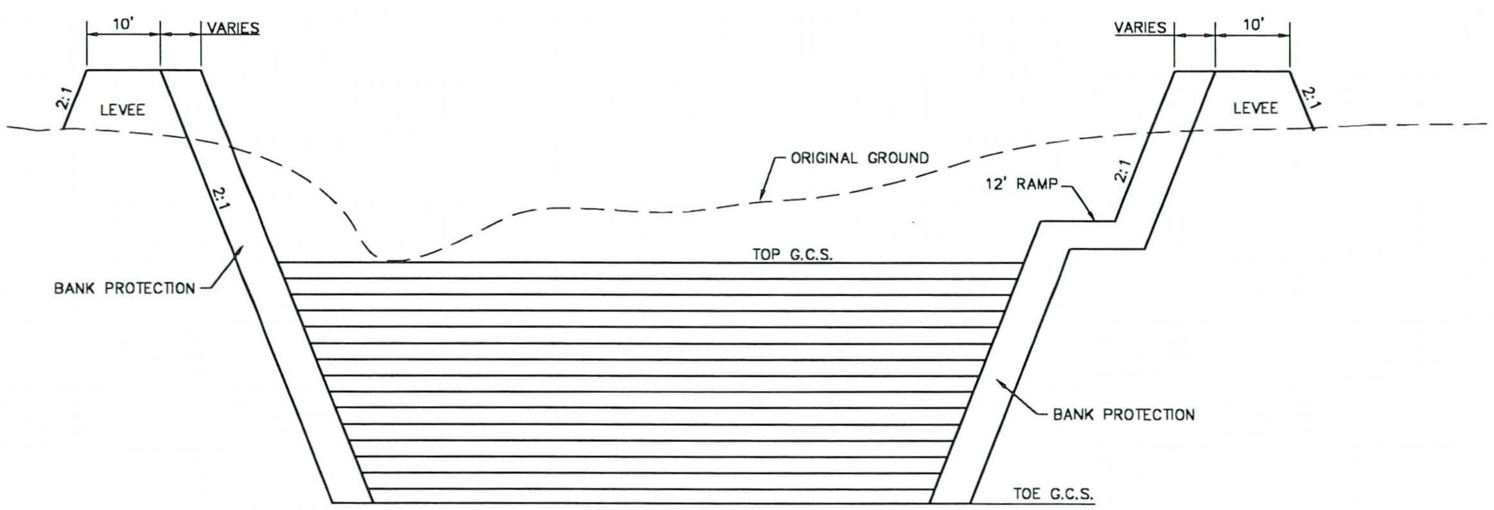
DWG NO.	2350BP07.DWG	DRAWN BY:	CBC/DJS
JOB NO.	2350001	CHECKED BY:	BB
DESIGNED BY:	BB	SHEET:	7 OF 8



PLAN VIEW
NTS



TYPICAL SECTION
SECTION A–A
NTS



ELEVATION VIEW LOOKING UPSTREAM
SECTION B–B
NTS

CONSTRUCTION NOTES

1. PLACE CSA PER M.A.G. SPEC. 222 (MDOT SUPPLEMENT)

GENERAL NOTES

1. CONTRACTOR SHALL LOCATE AND PROTECT ALL EXISTING UTILITIES AS REQUIRED, PRIOR TO START OF CONSTRUCTION.

LEGEND

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FLOOD CONTROL DISTRICT OF MARICOPA COUNTY
ENGINEERING DIVISION

UPPER CAVE CREEK AND APACHE WASH WATERCOURSE MASTER PLAN
FCD 97-45

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CONCEPTUAL PLAN
FULL-STRUCTURAL ALTERNATIVE
CSA GRADE-CONTROL STRUCTURE

DWG NO.	2350BP08.DWG	DRAWN BY:	CBC/DJS
JOB NO.	2350001	CHECKED BY:	BB
DESIGNED BY:	BB	SHEET:	8 OF 8