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# HYDRAULIC AND SCOUR ANALYSIS FOR THE PROPOSED MCKELLIPS ROAD BRIDGE OVER THE SALT RIVER

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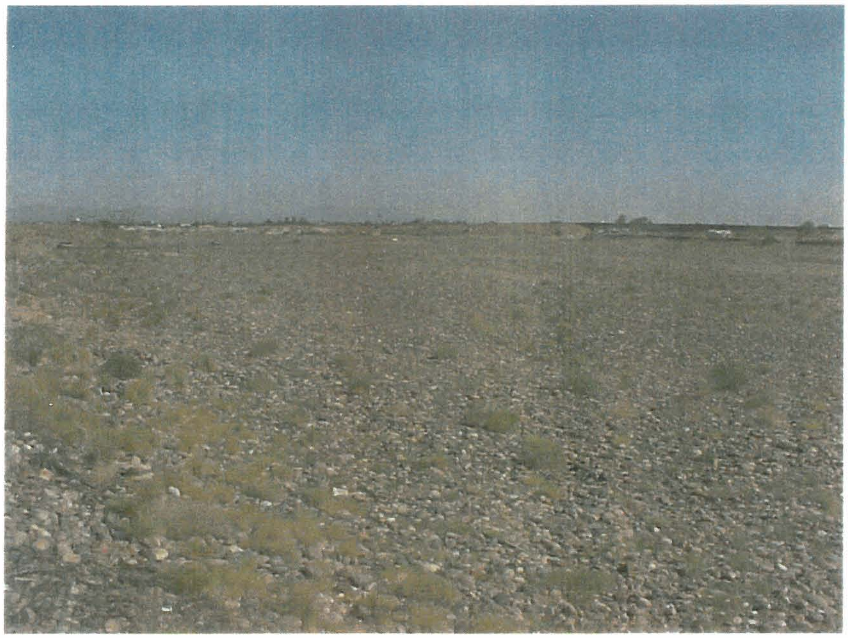

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# I. INTRODUCTION

## 1.1 Authorization

This report was authorized by Parsons Brinkerhoff, for use in conjunction with the design of a proposed roadway and bridge structure that will replace the existing two-lane McKellips Road at-grade crossing of the Salt River. The proposed bridge will cross the Salt River at a location along the existing roadway alignment.

Tetra Tech, Inc., Infrastructure Southwest Group (TTISG), acting as a subconsultant to Parsons Brinkerhoff, has conducted a hydraulic and scour analyses for the proposed bridge as a part of the bridge foundation design analysis.

## 1.2 Purpose

The primary tasks associated with the hydraulic and scour analysis for the proposed McKellips Road bridge are:

a) Collect and review all available information related to the topographic, hydrologic, hydraulic, sediment transport, and geomorphic conditions at the site. Data will include topographic maps, plans for existing and proposed projects near the project site, engineering studies and mining plans in the vicinity of the project site, aerial photographs, and soils data;

b) Perform geomorphic analysis of study reach, including analysis of historical data, to predict channel characteristics with respect to lateral migration, low-flow channel locations, and sedimentation trends;

c) Perform hydraulic analysis, including split-flow analysis in vicinity of proposed bridge, to establish water surface elevations and hydraulic characteristics for both existing and proposed conditions for both the 100-year design discharge and 500-year superflood discharge;

d) Evaluate total scour at the proposed bridge location including long-term aggradation/degradation, general scour, local scour (pier and abutment), contraction scour, bend scour, bed forms, and impacts associated with sand and gravel mining. Local scour will be determined using the procedures and methodologies provided in the FHWA Hydraulic Engineering Circular No. 18. General scour will be determined using a sediment-transport model. Armoring conditions will also be established. Total pier scour and abutment scour toe-downs will be calculated for both the design (100-year) and superflood (500-year) conditions; and

e) Construction drawings of the abutment bank protection will be prepared based on the results of this hydraulic and scour analysis. Both existing and proposed projects in the area will be considered in the final design. All final drawings and specifications will be in metric units.

## 1.3 Project Description

The proposed McKellips Road bridge over the Salt River is located at the southernmost boundary of the Salt River Pima-Maricopa Indian Community within Section 4, Township 1 North, Range 5 East, G&SRB&M, Maricopa County, Arizona. The proposed bridge will be located along the existing alignment of the McKellips Road at-grade crossing of the Salt River. The at-grade crossing is a fully operational roadway when there is no surface flow within the Salt River. During flow events, the McKellips Road at-grade crossing must be closed to traffic, requiring the routing of traffic to adjacent roadways. There are two existing bridges in the immediate vicinity, located both downstream and upstream of the McKellips Road at-grade crossing. The existing Alma School Road bridge is located approximately 450 meters (1476 feet) downstream (west). The existing Country Club Road bridge is located approximately 1200 meters (3937 feet) upstream (east). Figure 1, Location Map, shows the location of the existing roadway crossings along the Salt River.

The existing Alma School Road crossing contains two structures, spanning both the northern main channel of the Salt River and a southern overflow channel. The southern overflow channel is obstructed by an earthen dike near the McKellips Road at-grade crossing and only conveys flood waters during very large flow events. The dike serves to protect the existing sand and gravel operations that are located to the west within the southern overflow channel. The hydraulic analysis, which is presented later in this report, provides information on the quantities of breakout flow which enter the southern channel during larger flow events.

This project reach of the Salt River has experienced significant amounts of historical sand and gravel mining. Current mining activities continue both upstream and downstream of the proposed bridge location. Due to the sand and gravel mining and the potential for significant headcutting, the existing Alma School Road bridge has been protected by a grade control structure installed by the Maricopa County Department of Transportation. This grade control structure, scheduled to be further reinforced in the future, serves to stabilize the channel bottom just downstream of the proposed McKellips Road bridge.

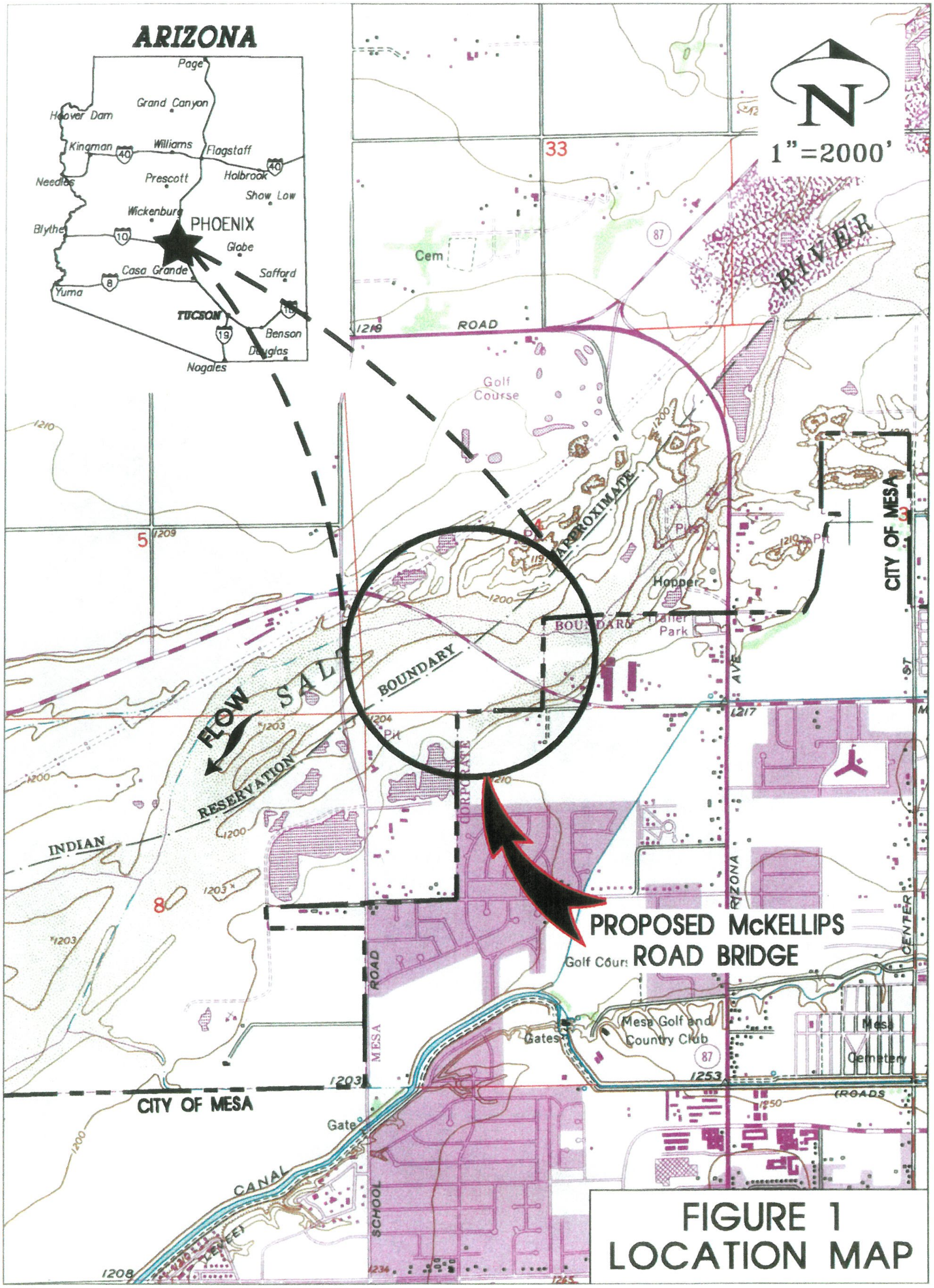



FIGURE 1
LOCATION MAP

The proposed bridge structure will be approximately 583 meters (1913 feet) long and 33 meters (108 feet) wide, and will be built along the existing roadway alignment. Abutment bank protection will be designed and constructed in order to (1) protect the proposed bridge abutments from erosion, (2) direct flow in the Salt River through the bridge opening abutment in a more streamlined manner, and (3) tie into existing bank protection. The existing topographic condition will be maintained at the location of flow breakout into the southern channel just downstream of the proposed bridge location. In addition, it was assumed for the purpose of the scour analysis that the existing grade control structure at Alma School Road will withstand both the design flow and the superflood.

## 1.4 Hydraulic Design Criteria and Approach

The hydraulic design of the proposed bridge is based upon the following criteria:

a) the bridge will be designed under the International System of Measurement (SI);

b) the study reach will extend approximately 1.47 kilometers (0.92 miles) downstream of the Alma School Road bridge to 0.30 kilometers (0.92 miles) upstream of the Country Club Road bridge;

c) flow values for use in the hydraulic and scour analysis of the proposed McKellips Road bridge were provided by Maricopa County and documented in the scope of work. The design (100-year) discharge of 6,230 cms (220,000 cfs) and superflood (500-year) discharge of 9,770 cms (345,000 cfs) were used for all calculations;

d) the final hydraulic analyses will provide parameters needed in order to evaluate stream forces on the bridge for future hydraulic conditions;

e) the design (100-year) and superflood (500-year) discharges will be modeled such that existing split flows into the southern overflow channel will be maintained. Split flows, which breakout from the main channel and are conveyed through the southern overflow channel, will be calculated for both existing and future conditions. Since the flow breakout occurs near the upstream limit of the proposed bridge, a reduced discharge will result in the main channel through the bridge area. The design water surface elevations and scour depths will be based on this reduced discharge;

f) the abutment scour resulting from the design flow event hydraulic analysis will be used to design the toe-down elevation for the bank protection. The long-term degradation component will also be included;

g) due to the presence of sand and gravel mining operations upstream of the study reach, and in order to account for the unknown extent (i.e., depth, volume, and location) and impacts of potential future sand and gravel mining operations along the study reach, the long-term degradation component will be based upon (1) the depth to armor of the Salt River at the bridge site during passage of the design flow event, (2) potential sand and gravel mining located within 213 meters (700 feet) of the upstream limit of the proposed bridge, and (3) the grade control structure at the Alma School Road bridge;

h) the potential local impacts (e.g., headcutting, tailcutting, etc.) associated with future sand and gravel mining pits and their location, relative to the proposed bridge and appurtenances, should be controlled through the Floodplain Management Regulations and Floodplain Use Permit process administered by the Flood Control District of Maricopa County.

i) the total scour depths will be referenced to the lowest elevation in the river bottom as depicted in the current bridge site topography;

j) the split-flow condition near the proposed bridge will consider the impact of assuming that (1) the existing dike is stable and remains during both the design flow event and the superflood, and (2) the existing dike fails during the design flow event and the superflood. The most conservative scenario will be used to establish design water surface elevations and scour depths.

It is also noted that the long-term degradation component of total scour will be computed using the so-called "dominant-discharge" value for the particular river system under investigation. Historically, the 10-year flow event has been considered as the dominant discharge for the Salt River. As the result of potential unforeseeable effects of sand and gravel mining operations within and along the study reach of the Salt River, the 100-year (design) flow event, rather than the 10-year flood, was selected as the representative flood for characterizing the long-term degradation component of total scour in the vicinity of the proposed McKellips Road bridge over the Salt River.

# II. FLUVIAL GEOMORPHOLOGY

The stability and sediment transport characteristics of the Salt River within the study reach were evaluated using a three-level approach. Level I consisted of a qualitative geomorphic assessment of the existing river conditions; Level II utilized an engineering-geomorphic approach; and Level III of the analyses employed a physical-process mathematical model to predict the general response of the river to the design flood.

## 2.1 Level I: Qualitative Geomorphic Analysis

### 2.1.1 Sinuosity

Leopold, Wolman, and Miller (1964) utilize a sinuosity ratio (defined as the thalweg length divided by the valley length) as the criterion to classify river patterns. Through observations that were made on several natural river systems, their study concluded that river systems with a sinuosity ratio equal to or greater than 1.5 are classified as meandering, while those with a sinuosity ratio of less than 1.5 are classified as braided or straight. A review made of the historical aerial photographic records of the Maricopa County Department of Transportation (see Section 2.1.2, below) indicates that the Salt River through the reach studied for the proposed McKellips Road bridge has a sinuosity ratio of approximately 1.2, and should therefore also be classified as braided or straight.

Sinuosity values for the Salt River along reaches located farther downstream also indicate a braided or straight classification. The concept report (SLA, 1994) for the flood mitigation study for the 91$^{st}$ Avenue Wastewater Treatment Plant includes an analysis of the Salt River for the reach between 67$^{th}$ and 115$^{th}$ Avenues. This report concluded that the subject reach of the Salt River has a sinuosity ratio of 1.2. An analysis of the Salt River in the vicinity of 51st Avenue (SLA, 1999) also indicated a sinuosity value of 1.2.

### 2.1.2 Historical Aerial Photographs

Seven sets of historical aerial photographs along the study reach of the Salt River were reviewed. Four sets of photographs—dated March 1949, December 1957, January 1970, and January 1979—were obtained at a scale of 1" = 910'. The other two sets of photographs—dated January 1964, November 1988, and February 1998—are available at scales of 1" = 400', 1" = 1200', and 1" = 417', respectively. Examination of these seven sets of photographs confirms that a braided/straight channel condition has existed over the 49-year period of record covered by the aerial photographs.

The following paragraphs summarize the changes in land use, lateral migration, vegetation, and sediment-transport characteristics that appear over the period of record referenced above.

**Land-Use Changes**. Agricultural and sand and gravel mining are the two dominant land uses located adjacent to and within the Salt River along the study reach over the period of record. However, urban growth in the Phoenix metropolitan area has rapidly approached the study reach from the south. Scattered residential subdivisions appear south of the river in the earliest photographs, with the number of subdivisions and density of urbanization steadily increasing over time. The recently constructed Red Mountain Freeway/Loop 202 forms the northern boundary for urbanization, just south of the Salt River.

Roadway and bridge construction along the study reach also reflect the effects of urbanization. A review of the aerial photographs shows an at-grade crossing at Country Club Road , with a realignment appearing by 1957. The 1957 photo also shows a dirt road along the Alma School Road alignment. Country Club Road was paved by 1964. By 1970, McKellips Road and Alma School Road were both constructed and paved along their current alignments. The 1979 photo shows that all three roadways were apparently destroyed by a flow event within the Salt River. By 1988, the roadways were all reconstructed, with the current bridges in place at both Country Club Road and Alma School Road.

The southern boundary of Salt River Pima-Maricopa Indian Community, located to the north of the Salt River, generally lies within the river bed along the project reach. Historic land uses on the reservation have been primarily agricultural and sand and gravel mining along the project reach. Significant sand and gravel mining operations have been operating on both sides of the reservation boundary over the period of record, and continue to the present day. Sand and gravel mining operations represent the most significant land use to be considered during the design of the proposed McKellips Road bridge. A detailed chronology of mining operations in the area, along with the corresponding impacts to the river system, have been previously documented for the area (SLA, 1989).

**Vegetation Changes**. Most of the study area is sparsely covered with vegetation because of the arid climate and the extensive agricultural activities which have occurred since the early 1900s. The Salt River was once a perennial stream, prior to the construction of upstream water-supply and flood-control dams. Historical records indicate that the Salt River was a wide, braided watercourse that supported considerable vegetation immediately adjacent to the river channel. Upon completion of the six upstream dams on the Salt and Verde Rivers, a considerable time period passed without any significant flow occurring in the Salt River at the location of the project. Prior to April 1965, the Salt River was virtually dry for more than twenty years (SLA, 1999). The 1957 aerial photographs indicate that vegetation density was relatively significant within the immediate vicinity of the Salt River channel, especially within the general vicinity of the channel thalweg. By 1964, aerial photographs show a marked reduction in vegetation density within the existing river channel. 1970 aerial photographs demonstrate a continuing trend in reductions in vegetation density.

**Lateral Migration**. The review of the historical aerial photographs for the years between 1949 and 1998 shows that no significant streambank lateral migration occurred within the study reach during that time period. The dominant channel morphology has essentially remained constant. The main high-flow channel, approximately 300 meters (984 feet) wide in the vicinity of Alma School Road, has been essentially in the same location. The low-flow channel has more of a meandering pattern, but has also remained fairly constant over this time period. Just upstream of Alma School Road, the main channel splits into a southern and northen branch. The alignments of these two channel segments have also remained constant, although it appears that the primary low-flow channel has shifted from the southern to the northern channel over the period of record. This change appears to be the result of sand and gravel operations blocking flow in the southern channel, rather than any natural geomorphic channel response.

The split-flow condition, with results in an intermediate "island" between the northern and southern channels, was easily distinguishable on the 1949 photographs. At that time, the southern channel appeared to be the primary channel. By 1957, sand and gravel mining had been initiated in the southern channel, with both mining and processing facilities present. These sand and gravel mining activities have expanded continuously up until the present. By 1970, the southern channel became difficult to visually distinguish as being part of the Salt River channel. Sometime between 1979 and 1988, a diversion dike was constructed at the point where the southern channel splits from the northern channel. The dike has served to direct the majority of flows into the northern channel, isolating the southern channel from all but the largest of flow events (see Table 2.1). Future lateral migration will be limited by both existing and proposed bank protection projects on both the southern and northern banks, as well as by the controlled nature of flow events which are regulated by the system of six upstream dams.

**Sand and Gravel Mining Impacts**. In general, extraction of sands and gravels from the streambeds of channels lead to both short-term and long-term river instability. Excessive sand and gravel removal from river channels can cause instability of a river system by inducing general scour, headcutting, and lateral migration whenever the removal of such material occurs at a rate which is greater than the upstream sediment supply.

Historical sand and gravel mining has dominated this reach of the Salt River. The 1949 aerial photograph shows evidence of minor sand and gravel mining near the Country Club Road at-grade crossing. In the 1957 aerial photograph, in-stream excavations were expanded in the vicinity of Country Club Road and were also initiated within the southern channel at Alma School Road. The 1964 and 1970 aerial photographs show widespread sand and gravel operations within the southern channel at Alma School and further upstream in the vicinity of Country Club Road. The 1979 aerial photograph shows evidence of a recent major flow event which transformed the Salt River back to more of a riverine environment. In the 1979 photo, all of the sand and gravel mining areas appear to be filled in with either sediment or storm water. The McKellips Road, Country Club Road, and Alma School Road paved at-grade crossings appear to have been washed out, with reconstruction activities underway. A check of the flow records shows that significant flow events were recorded In March and December of 1978 (FEMA, 1993). By 1988, most of the sand and gravel operations appear further downstream, beginning about 1 kilometer (0.6 miles) west of Alma School Road and continuing downstream to the Pima/Price Road alignment.

Historical mining activities were documented along the Salt River for the time period prior to 1986 (SLA, 1989). Mining quantities and channel degradation were determined for four separate reaches. For the five-mile reach between Hayden Road and Country Club Road, 58.5 million tons of material were excavated between 1962 and 1986. While average channel degradation was estimated to be 7.2 feet, the maximum channel degradation was estimated to be 14 to 16 feet west of Alma School Road.

Currently, there are several active sand and gravel mining operations located within the study reach. In-channel operations are located approximately 1 kilometer (0.6 miles) downstream of the Alma School Road bridge; with mining and processing facilities located within the entire length of the southern channel. Additional operations continue further upstream, approximately 0.5 kilometer (0.31 mile) east of the Country Club Road bridge.

A detailed assessment of the impacts that sand and gravel mining activities can have upon a river channel were previously evaluated for a project located on the Salt River adjacent to the Sky Harbor International Airport (Chen, 1980). Consideration of the general results of the physical model studies conducted for that project, applied to the project reach, can provide some guidelines for future sand and gravel mining in the area. In general, both headcutting (upstream from an excavation) and tailcutting (downstream from an excavation) can potentially represent serious problems and present a long-term threat to the structural stability of both bridges and bank protection measures.

Due to many unknown factors such as location, size, and number of future sand and gravel activities, as well as cumulative impacts associated with numerous flow events, a conservative approach is warranted with respect to future sand and gravel mining in the vicinity of the proposed McKellips Road bridge. Based on a review of the physical model studies of sand and gravel mining in the Salt River, it is recommended that mining be entirely prohibited within the main (northern) channel between Alma School Road and the proposed McKellips Road bridge.

Using tailcut profiles developed as a part of the physical model studies, mining limits upstream of the proposed McKellips Road bridge can be established given a potential depth of mining of 18.3 meters (60 feet) and a maximum allowable tailcut depth of 1.52 meters (5 feet) at the most upstream pier. For the Salt River channel located upstream of the proposed McKellips Road bridge, mining should be no closer than 213 meters (700 feet). To allow for this level of mining, (1) depths of excavation beyond that distance should be limited to 18.3 meters (60 feet), and (2) an additional toe-down of 1.52 meters (5 feet) should be incorporated into the bridge design (see Section 3.3.3, below).

An evaluation of sand and gravel activities downstream of Alma School Road, and further upstream in the vicinity of the Country Club Road bridge, were not considered as part of this analysis. Sand and gravel mining in these areas are also a concern, and should be regulated as a part of management of erosion hazards in the respective areas.

**Site Investigation**. Field visits were made to the site of the proposed McKellips Road bridge in order to assess existing geomorphic factors and to identify physical controls that might affect horizontal or vertical channel movement. The visits also provided an opportunity for a ground-level inspection of the channel geometry, channel pattern, and bed-material composition.

As noted previously, there are several active sand and gravel extraction operations located both upstream and downstream of the bridge site. Active mining is occurring downstream of the existing Alma School Road bridge within the main channel. The southern overflow channel at Alma School Road bridge contains sand and gravel processing facilities, along with settling ponds with standing water and vegetative growth. Wash water from the processing facilities has eroded a small active channel within the southern overflow channel which discharges downstream. Mining activity at the Alma School site is extremely active, with significant truck traffic noted along haul roads within the southern riverbed.

**Channel Characteristics**. Site investigations and a review of historical aerial photographs show a primarily straight/braided channel pattern through the project reach, with two channel branches which form the dominant geomorphic feature over the period of record. The two channel branches, which have been a continuous feature from about McKellips Road downstream to Alma School Road, have served to split large flow events into the main northern channel and a southern overflow channel. The channel morphology has been further controlled by sand and gravel mining activities throughout the period of record, resulting in a degraded channel which has stayed within the historical lateral limits of the channel banks. An earthen dike, constructed at the entrance to the southern channel branch, has served to isolate that area from the majority of flow events and has allowed sand and gravel facilities to be expanded within the historical channel boundaries of the southern channel. Sand and gravel mining downstream of Alma School Road has also degraded the channel, necessitating the installation of a grade control structure at Alma School Road in order to protect the bridge from any potential failure from undermining.

## 2.2 Level II: Quantitative Geomorphic Analyses

### 2.2.1 Hydraulic Analyses

The U.S. Army Corps of Engineers' computer program HEC-2 was used to calculate the existing and proposed hydraulic conditions for the Salt River throughout the study reach. Both the design (100-year) and superflood (500-year) discharges were modeled. All of the HEC-2 input and output files are included in Appendix A of this report.

The hydraulic analyses for both existing and proposed conditions included an analysis of potential flow breakout into the southern overflow channel near the southern abutment of the proposed bridge. The Salt River splits into a northern branch (main channel) and a southern branch (overflow channel) just downstream of McKellips Road. The two branches, which coalesce back into one channel approximately 550 meters (1800 feet) downstream of Alma School Road, define an area of high ground between the two respective branches which has been observable on aerial photographs for the entire 49-year period of record. Both the southern and northern channels are bridged at Alma School Road.

Sand and gravel mining activities in the southern overflow channel necessitated the construction of an earthen dike at the entrance to the southern overflow channel, protecting the sand and gravel operations from all but the largest flow events. Over time, sand and gravel mining operations within the southern channel have resulted in significant changes to the channel morphology. Based on the 1998 topographic maps, there is an area of high ground within the southern overflow channel upstream of the Alma School Road bridge. A pond, with wetland vegetation fed by wash water from sand and gravel processing, currently exists in this area of high ground. The high ground is a major blockage to flow and creates an area of backwater within the southern overflow channel.

For the purpose of the hydraulic analysis, consideration of the potential failure of the earthen dike was included in order to assess the potential range of water surface elevations in the vicinity of the proposed bridge. Both the earthen dike and area of high ground are potential hydraulic controls for split flow into the southern overflow channel. A separate hydraulic model for the southern overflow channel was created in order to analyze the effects of these potential hydraulic controls on the split flow into the southern overflow channel and resultant discharge within the main channel of the Salt River. Both the design and superflood discharges were evaluated.

**Threshold Discharges for Flow into the Southern Overflow Channel**. An analysis of the split flow, using the split-flow option within the HEC-2 model, was conducted. Several scenarios were considered. The threshold discharges within the main channel where flow initially breaks out into the southern overflow channel were calculated for "with-dike" and "without-dike" conditions for both existing and proposed conditions. Results are tabulated in Table 2.1.

**Table 2.1: Threshold Overtopping Flows in Main Channel for Initial Flow into Southern Overflow Channel**

| | Discharge |
|---|---|
| Existing Conditions, With Dike | 85000 cfs (2407 cms) |
| Existing Conditions, Without Dike | 3000 cfs (85 cms) |
| Future Conditions, With Dike | 74000 cfs (2096 cms) |
| Future Conditions, Without Dike | 2500 cfs (762 cms) |

**Split-Flow Discharges for the Design Flow and Superflood.** Split-flow discharges, for both the design and superflood discharge, were determined using the HEC-2 split-flow option. Corresponding water surface profiles within the southern overflow channel, at the location of the split flow, were then determined using the separate hydraulic model for the southern channel. Results, summarized in Table 2.2a and Table 2.2b, indicate that any split-flow discharge from the main channel into the southern overflow channel is "drowned out" by backwater in the southern overflow channel (i.e, the water surface elevation at the upstream limit of the southern overflow channel is higher than the water surface elevation in the main channel). The backwater creates hydraulic conditions where the split-flow option of the HEC–2 model can not be used to determine the flow splits for each respective channel branch. An alternative approach is therefore warranted.

**Table 2.2a: Comparison of Water Surface Elevations for Main Channel and Southern Overflow Channel for Design Discharge of 220,000 cfs (6230 cms)**

| | Main Channel | | Overflow Channel | |
|---|---|---|---|---|
| | Discharge | Average WSEL[1] | Discharge | Backwater WSEL[2] |
| Existing Conditions, With Dike | 195212 cfs (5528 cms) | 1209.0 ft (368.5 m) | 24788 cfs (702 cms) | 1211.9 ft (369.4 m) |
| Existing Conditions, Without Dike | 158351 cfs (4484 cms) | 1206.5 ft (367.7 m) | 61649 cfs (1746 cms) | 1215.8 ft (370.6 m) |
| Future Conditions, With Dike | 191283 cfs (5417 cms) | 1209.6 ft (368.7 m) | 28717 cfs (813 cms) | 1212.6 ft (369.6 m) |
| Future Conditions, Without Dike | 154834 cfs (4385 cms) | 1207.0 ft (367.9 m) | 65166 cfs (1845 cms) | 1216.1 ft (370.7 m) |

Note: [1]Average WSEL refers to the average water surface elevation at the split-flow location between cross sections 16 and 17
[2]WSEL for overflow channel section corresponds to split-flow location in main channel

**Table 2.2b: Comparison of Water Surface Elevations for Main Channel and Southern Overflow Channel for Superflood Discharge of 9770 cms (345,000 cfs)**

| | Main Channel | | Overflow Channel | |
|---|---|---|---|---|
| | Discharge | Average WSEL[1] | Discharge | Backwater WSEL[2] |
| Existing Conditions, With Dike | 293188 cfs (8302 cms) | 1212.9 ft (369.7 m) | 51812 cfs (1467 cms) | 1214.9 ft (370.3 m) |
| Existing Conditions, Without Dike | 245881 cfs (6963 cms) | 1211.2 ft (369.2 m) | 99119 cfs (2807 cms) | 1218.6 ft (371.4 m) |
| Future Conditions, With Dike | 286217 cfs (8105 cms) | 1213.8 ft (370.0 m) | 58783 cfs (1665 cms) | 1215.5 ft (370.5 m) |
| Future Conditions, Without Dike | 239611 cfs (6785 cms) | 1211.9 ft (369.4 m) | 105389cfs (2984 cms) | 1219.1 ft (371.6 m) |

Note: [1]Average WSEL refers to the average water surface elevation at the split-flow location between cross sections 16 and 17
[2]WSEL for overflow channel section corresponds to split-flow location in main channel

**Split-Flow Discharges for Backwater Conditions.** Since the split-flow option of the HEC-2 model proved inappropriate, an alternative approach was warranted. The hydraulic model for the main channel, with the split-flow option removed, and the separate hydraulic model for the southern overflow channel were utilized to determine the respective flow splits for both the design and superflood discharges. An iterative approach, using multiple profile HEC-2 runs, was used to compare the computed water surface elevation at the entrance to the overflow channel in each respective model. When the water surface elevation in the main channel model at the split-flow location (average of cross sections 16 and 17) matched the water surface elevation in the southern overflow channel model at the same location (cross section 49.5), then the appropriate flow split was determined. There was no effect caused by the existing earthen dike at the entrance to the southern overflow channel because of the extreme backwater conditions created by topographic conditions further downstream in the southern overflow channel. Results, summarized in Table 2.3, are tabulated in more detail in Appendix B.

**Table 2.3: Split-Flow Discharges for Backwater Conditions**

| | Discharge | Main Channel | Southern Overflow Channel | Waters Surface Elevation at Split Flow |
|---|---|---|---|---|
| Existing Conditions | Design Discharge (220000 cfs) (6230 cms) | 206,000 cfs (5833 cms) | 14,000 cfs (396 cms) | 1209.7 ft (368.7 m) |
| | Superflood (345000 cfs) (9770 cms) | 305,000 cfs (8637 cms) | 40,000 cfs (1133 cms) | 1213.6 ft (369.9 m) |
| Future Conditions | Design Discharge (220000 cfs) (6230 cms) | 203,000 cfs (5749 cms) | 17,000 cfs (481 cms) | 1210.4 ft (368.9 m) |
| | Superflood (345000 cfs) (9770 cms) | 298,000 cfs (8439 cms) | 47,000 cfs (1331 cms) | 1214.5 ft (370.2 m) |

**Topographic Data Set**. The HEC-2 cross-section data were taken from the topographic mapping prepared for this study. The topographic mapping was prepared by Kenney Aerial Mapping, Inc., from aerial photography flown in 1998. The cross-section information used begins approximately 1.47 kilometers (0.91 miles) downstream of the existing Alma School Road bridge and ends approximately 0.30 kilometers (0.19 miles) upstream from the existing Country Club Road bridge. Appendix C contains the HEC-2 Cross Section Location Map.

**Hydraulic Parameters**. The starting water surface elevation, Manning's roughness coefficients, energy-loss coefficients, and ineffective flow areas were all selected according to standard values and applications. The starting water surface elevation was based on normal depth. The choice of starting water surface elevation is inconsequential, because the critical areas are located much further upstream. The existing FEMA HEC-2 model for the area was reviewed to insure roughness coefficients were selected consistently. Energy-loss coefficients were selected according to guidelines within the HEC-2 manual (USACE, 1991). Ineffective flow areas were based on the delineation of conveyance areas according to 1:1 contractions and 2:1 expansions from applicable topographic controls.

### 2.2.2 Scour Analyses

The analyses to determine the potential impact on the bridge due to scour were made in accordance to the methodologies outlined in the HEC-18 manual, developed by the Federal Highway Administration, and the "Drainage Design Manual for Maricopa County, Volumes I, II, and III."

Total scour at a bridge crossing is comprised of the following components:

1. General Scour, which includes:
   (a) Flow contraction at the bridge (single-event scour);
   (b) Sediment-transport variation along the river (single-event scour).

2. Local Scour, which includes:
   (a) Pier scour (single-event scour);
   (b) Abutment scour (single-event scour).

3. Scour Limited by Armoring/Incipient-Motion Controls, which includes
   (a) (single-event and/or multiple-event scour).

4. Long-Term Scour, which includes:
   (a) Long-term degradation due to sediment imbalance (multiple-event scour).

The procedures used to compute total scour are specified in HEC-18. These procedures, as well as the methods used to evaluate armoring/incipient-motion controls, are contained within Appendix D.

## 2.3 Level III: Physical-Process Modeling

An approximation of the amount of scour (or deposition) that could occur in a given reach of a river channel during the passage of a flood event may be determined by the application of the sediment transport continuity concept. The change that may occur, as scour or deposition, in a given reach will depend on the difference between its sediment transport capacity and the amount of sediment supplied by the upstream reach. The change in the volume of sediment over the length and width of a given reach gives an indication of the potential change in the channel bed.

### 2.3.1 QUASED Hydraulic and Sediment Routing Program

The QUASED computer program (SLA, 1981) was utilized in order to estimate the extent of scour or deposition that is likely to occur during the passage of the design flow event. QUASED is a quasi-dynamic sediment routing procedure developed for the purpose of determining scour or deposition in a river system. QUASED uses data from a U.S. Army Corps of Engineers HEC-2 model base as its hydraulic computational platform in conjunction with the established sediment transport equations of Meyer-Peter, Muller, and Einstein's integration of the suspended sediment load. Within QUASED, channel geometry, hydraulic parameters, and bed-material volumes are updated after each time step of the flow hydrograph. A six-hour time step was used for the sediment routing analysis. This required 40 time steps in order to model the design hydrograph for the Salt River at the bridge site.

### 2.3.2 Armoring Potential

The occurrence of "armoring" within a river channel refers to the process whereby a layer of coarse, non-moving sediments forms on the surface of the streambed. The presence of large, coarse material of sufficient quantity in a river channel creates the opportunity for an armor layer to develop that will inhibit degradation of the streambed. In the armoring process, the finer, transportable materials that are present in the bed will be sorted out. Degradation will proceed at a progressively slower rate until an armor layer of appropriate composition and thickness is formed which will control further degradation. Armoring will have the potential to occur whenever there are large, coarse sediments of sufficient quantity in the streambed which cannot be transported by the anticipated discharges. In fact, the presence of coarse sediments creates an opportunity for protection of the streambed from scour during even large discharges, depending upon the size and quantity of the large, coarse sediments which are present in the river channel.

Therefore, the control of scour by streambed armoring is most applicable where large, coarse materials that cannot be transported by the anticipated discharges are present in the streambed, and where there is enough of these materials so that an armor layer can develop.

# III. BRIDGE HYDRAULIC AND SCOUR ANALYSES

As mentioned above, the U.S. Army Corps of Engineers' HEC-2 computer program was utilized in order to establish the hydraulic conditions present in the Salt River at the project site during passage of the design (100-year) flood and the superflood (500-year).

## 3.1 Proposed Bridge Structure

The existing crossing of the Salt River at McKellips Road is a 2-lane at-grade crossing. The proposed bridge structure will be approximately 583 meters (1913 feet) long and 33 meters (108 feet) wide, and will be built along the existing roadway alignment. The proposed bridge structure will be supported by thirteen pier bents (3 piers per bent). The piers are proposed to be 1.83 meters (6 ft.) in diameter. Skew angles vary slightly for each bent, ranging from 24 to 34 degrees. The depth of the drilled shaft foundations will be determined using the results of the analyses presented in this report.

## 3.2 Detailed Hydraulic Analyses

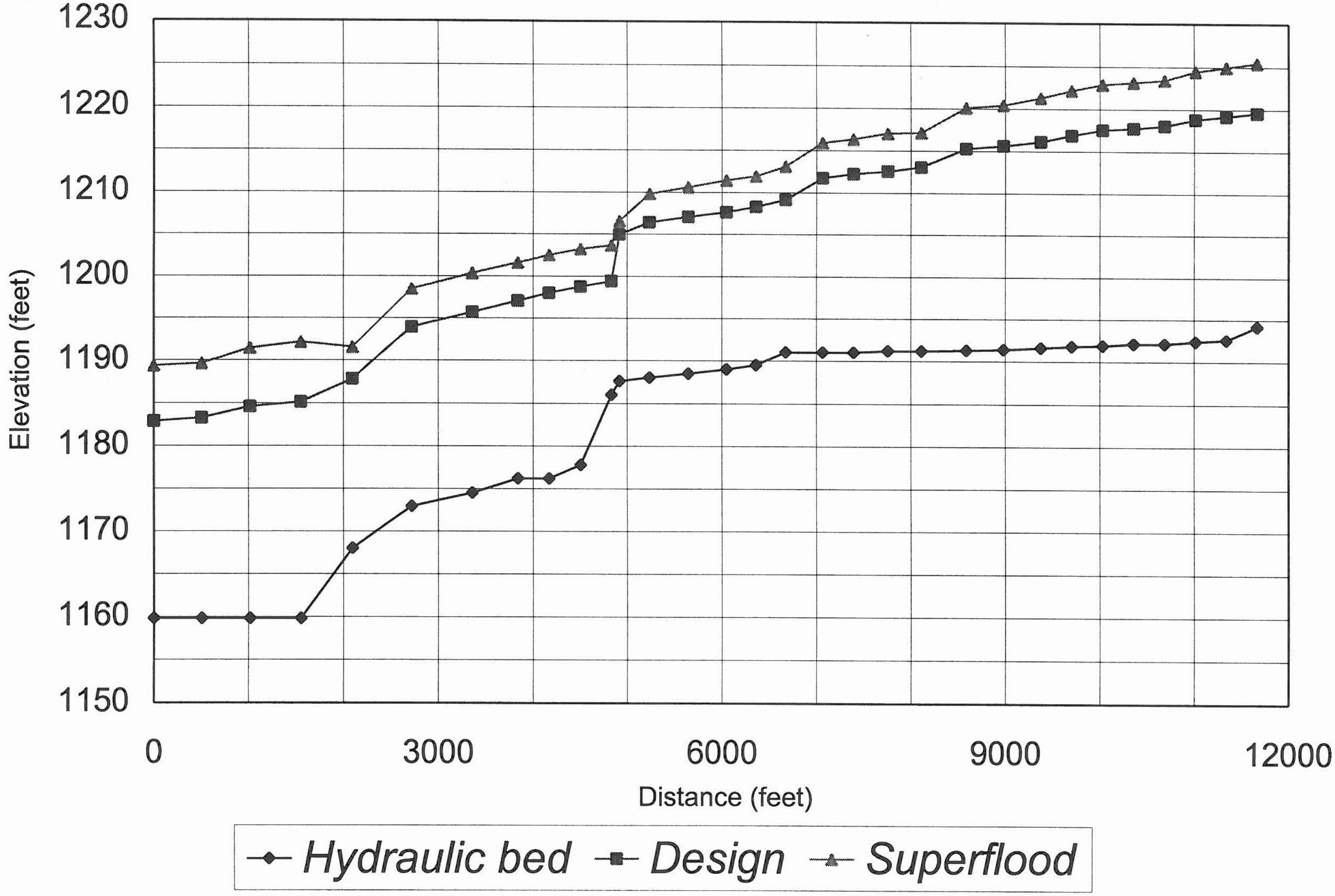
Detailed hydraulic analyses were performed for the proposed bridge structure for both the design and superflood flow events. As discussed in Section 2.2.1 of this report, two separate HEC-2 computer models were developed in order to determine the flow split between the main channel and the southern overflow channel. Based on the results of that analysis, hydraulic parameters were calculated for both existing and future conditions along the study reach.

To account for potential debris accumulation, 0.61 meters (2 ft.) of debris was assumed to build up on each side of a pier. The piers are to be 1.83 meters (6 ft.) in diameter. Due to the extreme 45-degree skew of the proposed bridge, the proposed bridge was modeled by incorporating the pier obstructions as GR points in the model. Each of the thirteen pier bents (3 piers per bent) were coded as a single obstruction, with all flow between individual piers assumed to be ineffective. Widths of the pier bent, along with debris accumulation on each edge, were adjusted for skew. Skew angles vary slightly for each bent, ranging from 24 to 34 degrees.

The existing bridge at Alma School Road was modeling based on data obtained from the Maricopa County as-built bridge plans. To account for potential debris accumulation, 0.61 meters (2 ft.) of debris was assumed to build up on each side of a pier. The bridge at Country Club Road was not modeled.

Table 3.1 summarizes water surface elevations and hydraulic parameters for future conditions for the design (100-year) flow event. Complete results of the HEC-2 computer analyses, for both existing and future conditions, are presented in Appendix A. Figure 2 depicts the 100-year water surface profile.

# FIGURE 2: SALT RIVER PROFILES NEAR McKELLIPS ROAD

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| TABLE 3.1: HYDRAULIC PARAMETERS FOR FUTURE CONDITIONS, DESIGN FLOW EVENT (100-YR) | | | | | | | |
|---|---|---|---|---|---|---|---|
| Section Number | Water Surface Elevation (ft) | Depth (ft) | Channel Velocity (ft/s) | Energy Slope times 10,000 (ft/ft) | Froude Number | Topwidth (ft) | Distance to Downstream Section (ft) |
| 1 | 1182.88 | 23.08 | 10.13 | 10 | 0.39 | 1060.4 | 0 |
| 2 | 1183.24 | 23.44 | 10.82 | 10.52 | 0.4 | 1009.09 | 505 |
| 3 | 1184.58 | 24.78 | 7.65 | 4.89 | 0.28 | 1252.26 | 509 |
| 4 | 1185.1 | 25.3 | 6.44 | 4.02 | 0.25 | 1634.99 | 535 |
| 5 | 1187.82 | 19.82 | 20.35 | 80.4 | 1.01 | 797.15 | 545 |
| 6 | 1193.95 | 21.05 | 14.08 | 25.94 | 0.6 | 855.28 | 623 |
| 7 | 1195.71 | 21.21 | 13.99 | 27.58 | 0.62 | 915.65 | 640 |
| 8 | 1197.05 | 20.85 | 13.93 | 26.89 | 0.61 | 909.56 | 482 |
| 9 | 1198 | 21.8 | 13.76 | 26.08 | 0.6 | 914.64 | 328 |
| 10 | 1198.76 | 20.96 | 14.34 | 30.09 | 0.64 | 919.17 | 335 |
| 11 | 1199.41 | 13.41 | 17.42 | 55.52 | 0.85 | 895.14 | 328 |
| 11.5 | 1204.95 | 17.35 | 13.21 | 22.82 | 0.57 | 923.27 | 84 |
| 12 | 1206.38 | 18.38 | 11.61 | 17.57 | 0.5 | 1097.92 | 318 |
| 13 | 1207.06 | 18.56 | 11.74 | 17.09 | 0.5 | 993.56 | 410 |
| 14 | 1207.61 | 18.61 | 13.21 | 24.74 | 0.6 | 1720.86 | 404 |
| 15 | 1208.27 | 18.77 | 14.11 | 29.93 | 0.65 | 946.07 | 312 |
| 16 | 1209.14 | 18.14 | 14.48 | 31.54 | 0.67 | 904.12 | 312 |
| 17 | 1211.73 | 20.73 | 11.06 | 15.89 | 0.47 | 1035.61 | 394 |
| 18 | 1212.22 | 21.22 | 11.01 | 12.98 | 0.44 | 1024.87 | 328 |
| 19 | 1212.53 | 21.33 | 12.62 | 30.33 | 0.63 | 1384.32 | 361 |
| 20 | 1213.03 | 21.83 | 14.15 | 23.64 | 0.59 | 1192.83 | 354 |
| 21 | 1215.27 | 23.97 | 10.69 | 12.4 | 0.43 | 1133.65 | 476 |
| 22 | 1215.62 | 24.22 | 11.4 | 14.15 | 0.46 | 1021.26 | 394 |
| 23 | 1216.13 | 24.53 | 11.62 | 14.16 | 0.46 | 1310.06 | 394 |
| 24 | 1216.89 | 25.09 | 10.7 | 11.14 | 0.41 | 1303.73 | 328 |
| 25 | 1217.56 | 25.66 | 9.62 | 7.96 | 0.35 | 1238.64 | 328 |
| 26 | 1217.75 | 25.65 | 10.08 | 9.93 | 0.39 | 1285.03 | 328 |
| 27 | 1218.05 | 25.95 | 10.32 | 11.74 | 0.42 | 1183.4 | 328 |
| 28 | 1218.81 | 26.41 | 9.03 | 9.15 | 0.37 | 1369.51 | 328 |
| 29 | 1219.18 | 26.58 | 8.78 | 8.42 | 0.35 | 1608.47 | 328 |
| 30 | 1219.61 | 25.41 | 8.24 | 8.23 | 0.35 | 1561.83 | 328 |

## 3.3 Bridge Scour Analyses

The following paragraphs present the methodologies, assumptions, and results of the scour analyses conducted for the proposed McKellips Road bridge over the Salt River. Several scour components were considered in determining the total scour potential for the proposed new bridge during the passage of the design flow event. The detailed computations supporting the scour components described below are provided in Appendix D. In general, the methodologies outlined in Hydraulic Engineering Circular No. 18 (metric version) were used for computing the scour components considered applicable to the study reach of the Salt River.

### 3.3.1 General Scour

General scour addresses the vertical lowering of the river channel over relatively short periods of time, that is, the scour associated with the passage of a single flood event. General scour magnitudes along the overall study reach which encompasses the site of the proposed new bridge were computed using the QUASED sediment-routing program. Input/output files for the QUASED model are presented in Appendix E.

The QUASED computer program models the amount of bed material that is transported or deposited in a channel reach based on the result of the interaction of two processes. The first is the sediment-transport capacity of the reach and the second is the supply of bed-material sediment that enters the reach. The first process is determined in part by the hydraulic conditions of the channel under study, which are a direct result of the discharge, channel configuration, channel resistance, and the sediment sizes which are present. The second process is determined by upstream channel hydraulics, as well as the nature of the upstream watershed, including the dominant land uses and any changes (e. g., urban development) to which it may be subjected. Two analyses were conducted for both the design flow event and the superflood under the following assumptions: (1) sediment supply into the bridge reach was available, based upon upstream transport capacity; and (2) no sediment supply into the bridge reach was available (to account for potential sand and gravel mining within the upstream portions of the study reach). Representative sediment sizes for these two analyses were based upon sediment data obtained from the test pits excavated upstream of and downstream from the existing roadway crossing (see Appendix F).

The assumed condition of no sediment inflow from the upstream channel reach resulted in the greatest scour depths through the bridge reach. For the design flow event, the QUASED model predicted that at the bridge site the river channel would experience slight degradation, on the order of 0.44 meters (1.45 feet) for a maximum. Just upstream of the bridge site, maximum degradation was predicted to be 0.56 meters (1.84 feet).

For the superflood, the QUASED model predicted that at the bridge site the river channel would experience slightly more degradation, on the order of 0.74 meters (2.43 feet) for a maximum. Just upstream of the bridge site, maximum degradation was predicted to be 0.87 meters (2.84 feet).

Contraction scour at the bridge was analyzed using methods found within HEC-18. Contraction scour is a special case of general scour that occurs whenever the area of flow is reduced at bridge crossings, thus causing the average velocity of flow and the local shear stress to increase within the constriction. In addition, contraction scour is generally increased when channel discharge is increased as all overbank flows are directed under a bridge using diversion structures such as spur dikes. The proposed McKellips Road bridge represents a unique situation where contraction scour is not significant (assumed to be zero) due to (1) the channel actually is slightly wider through the bridge reach, as compared to the approach reach; and (2) the channel discharge is reduced through the bridge reach due to breakout flow into the southern overflow channel.

### 3.3.2 Local Scour

Local scour due to the presence of bridge piers and abutments was also analyzed for both the design and superflood events. The pier-scour computations were performed based on the methodologies outlined in the HEC-18 manual. Debris, as noted previously, was assumed to accumulate around the bridge piers from the water surface to the streambed level. Due to the spacing of the piers (more than five times the pier diameter), the skew of each pier bent with respect to the direction of flow was not a factor in the local scour calculations. The analyses predicted that the scour at the piers would be 7.38 meters (24.21 feet) for the design flow event, and 8.25 meters (27.07 feet) for the superflood event. (Note that the procedures used to arrive at these estimates implicitly include a factor for bed-form scour in the factor of safety that is applied.)

Local scour at the abutments will result from the changes in direction and velocity of the local flows caused by either (1) the abutment projecting into the flow of the watercourse, (2) flow being intercepted and forced toward the center of the channel by the abutment, or (3) a combination of these two conditions. Both the northern and southern abutments are located at or behind the alignment of the channel banks, and as a result are (1) not projected into the main flow path and (2) not acting to divert overbank flow into the main channel area.

The north abutment will be exposed to flow at the point where the existing north bank ends just upstream of the existing at-grade roadway. Calculations for the south abutment assume that the existing earthen channel banks are eroded, thus exposing the south abutment to flow from the main channel. Abutment scour calculations indicate that the scour at the north abutment will approach 9.62 meters (31.56 feet) for the design flow event, and 10.69 meters (35.07 feet) for the superflood. For the south abutment, scour is calculated to be 13.14 meters (43.11 feet) for the design flow event, and 17.75 meters (58.23 feet) for the superflood.

### 3.3.3 Long-Term Degradation

Long-term degradation is the result of natural or man-made conditions that affect the overall stability of the reach of the river channel. The changes might either be lowering (degradation) of the streambed, due to a deficit in the sediment supply into the reach, or the raising (aggradation) of the streambed, due to an excess of sediment transported into the reach during the passage of flow events. The depth of any long-term degradation is typically controlled by either streambed armoring or the equilibrium slope of the characteristic sediment sizes. The long-term bed profiles along the study reach for the McKellips Road bridge will be controlled by (1) the grade control structure at Alma School Road, (2) armoring of the streambed, or (3) future sand and gravel mining in the area.

The presence of large, coarse material of sufficient quantity in a river channel creates the opportunity for an armor layer to develop that will inhibit degradation caused by such influences as channelization and sand and gravel mining. In the armoring process, the finer, transportable materials that are present in the riverbed will be sorted out. Degradation will proceed at a progressively slower rate until an armor layer of appropriate composition and thickness is formed which will control further degradation. This method is applicable where there are large, coarse materials in the streambed that cannot be transported by the anticipated discharges, and where there is enough of these materials present so that an armor layer can develop. In general, an armoring layer can be expected if the streambed material is large enough to resist transport by the anticipated discharges.

In the vicinity of McKellips Road, an armor layer has already formed. The observed armor layer can be compared to the computed armor layer, using both the sediment sampling sieve analyses of (1) the underlying bed material and (2) the armor layer. Accordingly, the methodologies adopted by the Bureau of Reclamation and others (see Appendix D) were used to analyze the potential for development of an armor layer at the bridge site. Because of the potential for sand and gravel mining to occur in the future along the study reach, the design discharge (100-year flow event), rather than a 10-year flood, was used to characterize the armoring potential of the channel for purposes of estimating long-term degradation at the bridge. The analyses performed predicts that, based on the available sediment data for the study reach, an armor layer of thickness 0.61 meters (2.00 feet) should develop in the streambed. Based on the sediment sampling data, the existing armor layer is about 0.76 meters (2.5 feet) thick.

Using the existing flow line, the lowest elevation of the existing armor layer in the vicinity of the proposed bridge is at elevation 1188.5 feet. The grade control at Alma School Road is at an elevation of 1186.0 feet. Consequently, the armor layer would control bed degradation before the channel bed ever drops to the elevation of the grade control structure.

An additional factor was included to account for sand and gravel mining in the immediate vicinity of the proposed bridge. As stated in Section 2.1.2 of this report, future sand and gravel mining upstream of the proposed McKellips Road bridge will not be permitted closer than 213 meters (700 feet) from the upstream limit of the proposed bridge. Depths of excavation beyond that distance will be limited to a maximum of 18.3 meters (60 feet). To allow for this level of mining, 1.52 meters (5 feet) of potential channel degradation should be incorporated into the bridge foundation design as the controlling factor for long-term channel degradation.

### 3.3.4 Total Scour Determination

The total scour at the proposed McKellips Road bridge was determined by a summation of the various calculated scour components, and then applying a factor of safety in order to account for the potential for nonuniform flow distribution to occur through the bridge during the passage of a design or superflood event. The factor of safety was set equal to 30% of the total single-event scour components (i.e., the sum of the pier scour plus general scour). The total scour then becomes the sum of the computed scour for a single event plus the computed long-term degradation, which is based upon a consideration of both bed armoring and future sand and gravel mining. For the design event, total scour depth at the piers is predicted to be 11.84 meters (38.85 feet). For the superflood, the total scour depth at the piers is predicted to be 13.37 meters (43.86 feet). The computed scour values are presented in Table 3.2. Scour elevations are presented in Table 3.3.

| TABLE 3.2—SUMMARY TABLE OF SCOUR VALUES | | |
|---|---|---|
| Type of Scour | Design Scour Depth (meters) | Superflood Scour Depth (meters) |
| (1) Pier Scour | 7.38 | 8.25 |
| (2) General Scour | 0.56 | 0.87 |
| (3) Safety Factor (30% of 1+2) | 2.38 | 2.73 |
| (4) Long-Term Degradation (sand/gravel mining) | 1.52 | 1.52 |
| Total Pier Scour (1+2+3+4) | 11.84 38.8 ft | 13.37 43.8 ft |
| Scour at North Abutment | 9.62 31.5 ft | 10.69 35.1 ft |
| Scour at South Abutment | 13.14 43.1 ft | 17.75 58.2 ft |

| TABLE 3.3: DESIGN SCOUR ELEVATIONS | | |
|---|---|---|
| | **Design (100-yr) Discharge** | **Superflood (500-yr) Discharge** |
| Pier (based on bed elevation at section 13) | 350.42 m (1149.66 ft) | 348.89 m (1144.64 ft) |
| North Abutment (based on bed elevation at section 13) | 352.64 m (1156.94 ft) | 351.57 m (1153.43 ft) |
| South Abutment (based on bed elevation at section 17) | 349.88 m (1147.89 ft) | 345.27 m (1132.77 ft) |

(When establishing the m.s.l. scour elevation below the streambed for the piers and abutments, said elevation should be measured from the thalweg (i.e., lowest existing point) of the streambed at the bridge.)

### 3.5 Determination of Bridge Low-Chord Elevation

The bridge low-chord elevation should be based upon the calculated water-surface elevation, determined by the river hydraulic analysis for the design flow event, plus a freeboard value to account for wave heights, superelevation, and debris accumulation, should any of these be present during the passage of the design flow event. Because the study reach for this project is relatively straight, superelevation was not a consideration in the determination of the bridge low-chord elevation.

During the design flow event, the hydraulic regime in the study reach, and throughout the proposed bridge structure, is subcritical. Since the flow is predicted to be subcritical flow, with small dunes as the likely bed form, water surface undulations are predicted to be out of phase with the bed surface. Consequently, surface wave heights were not considered as affecting the bridge low-chord elevation of the bridge.

As required by the scope of work, a minimum freeboard of 0.9 meters (3 feet) is required. At the north abutment (cross section 14), the design water surface elevation (including freeboard) is 369.00 meters (1210.61 feet). At the south abutment (cross section 18), the design water surface elevation (including freeboard) is 370.40 meters (1215.22 feet). Proposed bridge low-chord elevations, defined by the design (100-year) discharge with freeboard, are tabulated in Table 3.4. Superflood (500-year) water surface elevations are included for comparison.

**TABLE 3.4: DESIGN WATER SURFACE ELEVATIONS**

| | Design (100-yr) Discharge Low-Chord Elevation (includes freeboard) | Superflood (500-yr) Discharge Water Surface Elevation (no freeboard) |
|---|---|---|
| North Abutment | 368.83 m (1210.6 ft) ✓ | 369.24 m (1211.4 ft) |
| South Abutment | 370.40 m (1215.22 ft) ✓ | 370.76 m (1216.4 ft) |

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# APPENDIX A
# HEC-2 COMPUTER ANALYSIS
# INPUT/OUTPUT FILES

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100-YEAR FLOW EVENT

| SECNO | CWSEL | DEPTH | 10K*S | FRCH | TOPWI | STCHL | STCHR | CHN TW | QCH | VCH | ACH (QCH/ VCH) | HYD DEPTH | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1182.9 | 23.1 | 10 | 0.39 | 1060 | 328 | 1368 | 1040 | 219752 | 10.1 | 21693 | | |
| 2 | 1183.2 | 23.4 | 10.52 | 0.4 | 1009 | 328 | 1276 | 948 | 219821 | 10.8 | 20316 | | |
| 3 | 1184.6 | 24.8 | 4.89 | 0.28 | 1252 | 328 | 1568 | 1240 | 219848 | 7.7 | 28738 | | |
| 4 | 1185.1 | 25.3 | 4.02 | 0.25 | 1635 | 328 | 2106 | 1778 | 220000 | 6.4 | 34161 | | |
| 5 | 1187.8 | 19.8 | 80.4 | 1.01 | 797 | 328 | 1224 | 896 | 203000 | 20.4 | 9975 | | |
| 6 | 1194.0 | 21.1 | 25.94 | 0.6 | 855 | 328 | 1273 | 945 | 203000 | 14.1 | 14418 | | |
| 7 | 1195.7 | 21.2 | 27.58 | 0.62 | 916 | 328 | 1266 | 938 | 203000 | 14.0 | 14510 | | |
| 8 | 1197.1 | 20.9 | 26.89 | 0.61 | 910 | 3319 | 4280 | 961 | 203000 | 13.9 | 14573 | | |
| 9 | 1198.0 | 21.8 | 26.08 | 0.6 | 915 | 3435 | 4420 | 984 | 203000 | 13.8 | 14753 | | |
| 10 | 1198.8 | 21.0 | 30.09 | 0.64 | 919 | 3527 | 4511 | 984 | 203000 | 14.3 | 14156 | | |
| 11 | 1199.4 | 13.4 | 55.52 | 0.85 | 895 | 3538 | 4458 | 920 | 203000 | 17.4 | 11653 | | |
| 11.5 | 1205.0 | 17.4 | 22.82 | 0.57 | 923 | 3604 | 4521 | 916 | 202997 | 13.2 | 15367 | | |
| 12 | 1206.4 | 18.4 | 17.57 | 0.5 | 1098 | 3547 | 4630 | 1083 | 202989 | 11.6 | 17484 | | |
| 13 | 1207.1 | 18.6 | 17.09 | 0.5 | 994 | 3609 | 4613 | 1004 | 203000 | 11.7 | 17291 | | |
| North → 14 | 1207.6 | 18.6 | 24.74 | 0.6 | 1721 | 3786 | 4797 | 1011 | 202788 | 13.2 | 15351 | 15.2 | Proposed McKellips Bridge |
| 15 | 1208.3 | 18.8 | 29.93 | 0.65 | 946 | 3481 | 4462 | 981 | 202714 | 14.1 | 14367 | 15.2 | Proposed McKellips Bridge |
| 16 | 1209.1 | 18.1 | 31.54 | 0.67 | 904 | 3355 | 4308 | 953 | 202617 | 14.5 | 13993 | 15.5 | Proposed McKellips Bridge |
| 17 | 1211.7 | 20.7 | 15.89 | 0.47 | 1036 | 3314 | 4744 | 1431 | 219913 | 11.1 | 19884 | 19.2 | Proposed McKellips Bridge |
| | | 19.1 | 25.5 | | | | | | 207008 | 13.2 | | 16.3 | Average Hydraulics |
| South → 18 | 1212.2 | 21.2 | 12.98 | 0.44 | 1025 | 3281 | 4416 | 1135 | 219988 | 11.0 | 19981 | 19.5 | Approach sections |
| 19 | 1212.5 | 21.3 | 30.33 | 0.63 | 1384 | 164 | 1601 | 1437 | 220000 | 12.6 | 17433 | 12.6 | Approach sections |
| 20 | 1213.0 | 21.8 | 23.64 | 0.59 | 1193 | 4259 | 5148 | 889 | 218942 | 14.2 | 15473 | 17.4 | Approach sections |
| 21 | 1215.3 | 24.0 | 12.4 | 0.43 | 1134 | 3947 | 5063 | 1116 | 218277 | 10.7 | 20419 | 18.3 | Approach sections |
| | | 22.1 | 19.8 | | | | | | 219302 | 12.1 | | 16.9 | Average Hydraulics |
| 22 | 1215.6 | 24.2 | 14.15 | 0.46 | 1021 | 4147 | 5164 | 1017 | 219832 | 11.4 | 19283 | | |
| 23 | 1216.1 | 24.5 | 14.16 | 0.46 | 1310 | 4370 | 5325 | 955 | 217524 | 11.6 | 18720 | | |
| 24 | 1216.9 | 25.1 | 11.14 | 0.41 | 1304 | 4603 | 5581 | 978 | 217625 | 10.7 | 20339 | | |
| 25 | 1217.6 | 25.7 | 7.96 | 0.35 | 1239 | 4587 | 5581 | 994 | 218582 | 9.6 | 22722 | | |
| 26 | 1217.8 | 25.7 | 9.93 | 0.39 | 1285 | 4495 | 5558 | 1063 | 218517 | 10.1 | 21678 | | |
| 27 | 1218.1 | 26.0 | 11.74 | 0.42 | 1183 | 4459 | 5581 | 1122 | 219917 | 10.3 | 21310 | | |
| 28 | 1218.8 | 26.4 | 9.15 | 0.37 | 1370 | 4386 | 5692 | 1306 | 219945 | 9.0 | 24357 | | |
| 29 | 1219.2 | 26.6 | 8.42 | 0.35 | 1608 | 4439 | 5751 | 1312 | 219306 | 8.8 | 24978 | | |
| 30 | 1219.6 | 25.4 | 8.23 | 0.35 | 1562 | 4304 | 5873 | 1569 | 219980 | 8.2 | 26697 | | |

500-YEAR FLOW EVENT

| SECNO | CWSEL | DEPTH | 10K*S | FRCH | TOPWI | STCHL | STCHR | CHN TW | QCH | VCH | ACH (QCH/ VCH) | HYD DEPTH | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1189.3 | 29.5 | 10.05 | 0.41 | 1068 | 328 | 1368 | 1040 | 343845 | 12.1 | 28417 | | |
| 2 | 1189.6 | 29.8 | 11.2 | 0.43 | 1051 | 328 | 1276 | 948 | 341415 | 13.0 | 26222 | | |
| 3 | 1191.4 | 31.6 | 5.11 | 0.3 | 1377 | 328 | 1568 | 1240 | 342886 | 9.2 | 37149 | | |
| 4 | 1192.1 | 32.3 | 3.89 | 0.25 | 1693 | 328 | 2106 | 1778 | 345000 | 7.5 | 45817 | | |
| 5 | 1191.6 | 23.6 | 74.3 | 1.01 | 811 | 328 | 1224 | 896 | 298000 | 23.0 | 12973 | | |
| 6 | 1198.5 | 25.6 | 26.27 | 0.63 | 884 | 328 | 1273 | 945 | 298000 | 16.3 | 18327 | | |
| 7 | 1200.3 | 25.8 | 25.72 | 0.62 | 923 | 328 | 1266 | 938 | 298000 | 15.9 | 18766 | | |
| 8 | 1201.6 | 25.4 | 25.87 | 0.62 | 929 | 3319 | 4280 | 961 | 298000 | 15.9 | 18742 | | |
| 9 | 1202.5 | 26.3 | 25.35 | 0.62 | 932 | 3435 | 4420 | 984 | 298000 | 15.8 | 18885 | | |
| 10 | 1203.2 | 25.4 | 28.58 | 0.65 | 941 | 3527 | 4511 | 984 | 298000 | 16.3 | 18282 | | |
| 11 | 1203.6 | 17.6 | 47.75 | 0.82 | 912 | 3538 | 4458 | 920 | 298000 | 19.3 | 15472 | | |
| 11.5 | 1206.5 | 18.9 | 36.32 | 0.73 | 1236 | 3604 | 4521 | 916 | 297426 | 17.7 | 16813 | | |
| 12 | 1209.8 | 21.8 | 20.03 | 0.55 | 1627 | 3547 | 4630 | 1083 | 293440 | 14.0 | 21035 | | |
| 13 | 1210.6 | 22.1 | 19.28 | 0.54 | 1602 | 3609 | 4613 | 1004 | 291438 | 14.0 | 20817 | | |
| 14 | 1211.4 | 22.4 | 26.77 | 0.6 | 1969 | 3786 | 4797 | 1011 | 280665 | 14.8 | 19015 | 18.8 | Proposed McKellips Bridge |
| 15 | 1211.9 | 22.4 | 37.07 | 0.68 | 1539 | 3481 | 4462 | 981 | 291470 | 16.4 | 17729 | 18.1 | Proposed McKellips Bridge |
| 16 | 1213.1 | 22.1 | 36.99 | 0.68 | 1637 | 3355 | 4308 | 953 | 289225 | 16.5 | 17486 | 18.3 | Proposed McKellips Bridge |
| 17 | 1215.9 | 24.9 | 22.39 | 0.53 | 2065 | 3314 | 4744 | 1431 | 332751 | 13.6 | 24413 | 17.1 | Proposed McKellips Bridge |
| | | 22.9 | 30.8 | | | | | | 298528 | 15.3 | | 18.1 | Average Hydraulics |
| 18 | 1216.4 | 25.4 | 16.97 | 0.51 | 1053 | 3281 | 4416 | 1135 | 344519 | 14.3 | 24160 | 23.0 | Approach sections |
| 19 | 1217.1 | 25.9 | 27.24 | 0.62 | 1412 | 164 | 1601 | 1437 | 345000 | 14.5 | 23777 | 16.8 | Approach sections |
| 20 | 1217.1 | 25.9 | 28.72 | 0.66 | 1307 | 4259 | 5148 | 889 | 332302 | 17.5 | 19043 | 21.4 | Approach sections |
| 21 | 1220.1 | 28.8 | 14.45 | 0.48 | 1197 | 3947 | 5063 | 1116 | 340352 | 13.3 | 25590 | 22.9 | Approach sections |
| | | 26.5 | 21.8 | | | | | | 340543 | 14.9 | | 21.0 | Average Hydraulics |
| 22 | 1220.4 | 29.0 | 16.79 | 0.51 | 1328 | 4147 | 5164 | 1017 | 343156 | 14.2 | 24132 | | |
| 23 | 1221.3 | 29.7 | 15.12 | 0.49 | 1319 | 4370 | 5325 | 955 | 329189 | 13.9 | 23649 | | |
| 24 | 1222.2 | 30.4 | 12.15 | 0.45 | 1384 | 4603 | 5581 | 978 | 330709 | 13.0 | 25498 | | |
| 25 | 1222.9 | 31.0 | 9.32 | 0.4 | 1300 | 4587 | 5581 | 994 | 335529 | 12.0 | 28031 | | |
| 26 | 1223.2 | 31.1 | 10.99 | 0.43 | 1297 | 4495 | 5558 | 1063 | 335584 | 12.3 | 27328 | | |
| 27 | 1223.4 | 31.3 | 12.47 | 0.45 | 1231 | 4459 | 5581 | 1122 | 342432 | 12.5 | 27351 | | |
| 28 | 1224.5 | 32.1 | 9.33 | 0.39 | 1375 | 4386 | 5692 | 1306 | 343335 | 10.8 | 31732 | | |
| 29 | 1225.0 | 32.4 | 8.21 | 0.37 | 1640 | 4439 | 5751 | 1312 | 335950 | 10.3 | 32553 | | |
| 30 | 1225.4 | 31.2 | 7.95 | 0.35 | 1660 | 4304 | 5873 | 1569 | 343209 | 9.6 | 35788 | | |

Tetra Tech, Inc.
Infrastructure Southwest Group

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**********************************************                    ***************************************
*  HEC-2 WATER SURFACE PROFILES              *                    *  U.S. ARMY CORPS OF ENGINEERS       *
**********************************************                    ***************************************

                                    X     X  XXXXXXX   XXXXX             XXXXX
                                    X     X  X        X     X           X     X
                                    X     X  X        X                       X
                                    XXXXXXX  XXXX     X        XXXXX     XXXXX
                                    X     X  X        X                 X
                                    X     X  X        X     X           X
                                    X     X  XXXXXXX   XXXXX            XXXXXXX
1
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                                                                  THIS RUN EXECUTED 27MAR00     08:51:31
 *************************************
  HEC-2 WATER SURFACE PROFILES

  Version   4.6.2;  May 1991
 *************************************


 T1  FUTURE CONDITIONS, DESIGN (100-YR) AND SUPERFLOOD (500-YR) DISCHARGE
 T2  PROPOSED MCKELLIPS ROAD BRIDGE ACROSS THE SALT RIVER NEAR MESA, ARIZONA
 T3      FUTURE 100-YR

 J1  ICHECK    INQ       NINV      IDIR      STRT      METRIC    HVINS     Q         WSEL      FQ

        0         2         0         0     0.001         0         0         0    1175.0         0

 J2  NPROF     IPLOT     PRFVS     XSECV     XSECH     FN        ALLDC     IBW       CHNIM     ITRACE

        1         0        -1         0         0         0        -0         0         0        15


 J3  VARIABLE CODES FOR SUMMARY PRINTOUT

       38         1        43        13        14        15        55        26        56         8
        4        68         0        38         1         2         3        11        12        42
        5        33        39        53        54

 J6  IHLEQ     ICOPY     SUBDIV    STRTDS    RMILE

        1


 NC     0.040     0.040     0.035       0.1       0.3
 QT         2    220000    345000

 X1       1.0         6       328      1368         0         0         0         0         0         0
 GR    1182.7     328.0    1169.6     453.0    1159.8     472.0    1159.8    1345.0    1174.5    1368.0
 GR    1186.0      1396


 X1       2.0         7       328      1276       505       505       505         0         0         0
 GR    1194.2     328.0    1159.8     440.0    1159.8    1257.0    1177.8    1276.0    1182.7      1296
 GR    1182.7      1371    1190.9      1398


 X1       3.0        11       328      1568       509       509       509         0         0         0
 GR    1194.2     328.0    1171.2     358.0    1164.7     443.0    1164.7     486.0    1159.8     495.0
 GR    1159.8    1489.0    1164.7    1542.0    1177.8    1568.0    1186.0      1598    1187.7      1696
 GR    1213.9      1783

  Section 4 common to both main channel and south overflow channel

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 X1       4.0         7       328      2106       535       535       535         0         0         0
 GR    1194.2     328.0    1171.2     358.0    1159.8     699.0    1159.8    1181.0    1164.7    1335.0
 GR    1164.7    1834.0    1204.1    2106.0

  Continue along main channel
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QT        2      203000      298000

   Ignore insignificant weir flow over left bank at section 5

X1      5.0          8        328      1224       545       545       545         0         0         0
GR   1184.4      328.0     1172.9     344.0    1172.9     427.0    1179.4     545.0    1177.8     761.0
GR   1168.0     1017.0     1168.0    1050.0    1213.9    1224.0


X1      6.0          7        328      1273       623       623       623         0         0         0
GR   1200.8      328.0     1177.8     367.0    1172.9     699.0    1172.9    1040.0    1190.9    1060.0
GR   1187.6     1165.0     1210.6    1273.0

   Ignore insignificant weir flow over left bank at section 7


X1      7.0         10        328      1266       640       640       640         0         0         0
GR   1192.6      328.0     1179.4     374.0    1176.2     443.0    1174.5     676.0    1178.5     745.0
GR   1175.5      873.0     1176.2     928.0    1186.0    1020.0    1187.6    1230.0    1209.0    1266.0


X1      8.0       22.0     3318.7    4280.1       482       482       482       0.0       0.0       0.0
GR   1207.4     3318.7     1189.4    3361.4    1184.4    3399.1    1177.9    3428.6    1177.9    3579.6
GR   1176.2     3615.7     1176.2    3701.0    1184.4    3730.5    1184.4    3797.8    1181.2    3894.5
GR   1177.9     3922.4     1176.2    4007.7    1176.2    4035.6    1184.4    4116.0    1186.1    4193.1
GR   1187.7     4234.1     1210.7    4280.1    1212.3    4319.4    1210.7    4339.1    1205.8    4363.7
GR   1205.8     5384.1     1207.4    5416.9       0.0       0.0       0.0       0.0       0.0       0.0


X1        9       32.0     3435.2    4419.5       263       427       328       0.0       0.0       0.0
GR   1217.3     3356.5     1217.3    3435.2    1204.1    3461.5    1187.7    3484.4    1186.1    3514.0
GR   1181.2     3527.1     1181.2    3563.2    1179.5    3586.1    1177.9    3641.9    1176.2    3684.6
GR   1176.2     3733.8     1177.9    3763.3    1182.8    3792.8    1184.4    3828.9    1184.4    3966.7
GR   1182.8     4009.4     1181.2    4078.3    1176.2    4111.1    1176.2    4180.0    1181.2    4196.4
GR   1182.8     4225.9     1184.4    4298.1    1186.1    4350.6    1189.4    4363.7    1212.3    4419.5
GR   1212.3     4455.6     1205.8    4475.3    1205.8    4600.0    1207.4    4875.6    1207.4    4911.7
GR   1205.8     5184.0     1207.4    5210.2       0.0       0.0       0.0       0.0       0.0       0.0


X1       10       23.0     3527.1    4511.4       328       345       335       0.0       0.0       0.0
GR   1209.0     3527.1     1197.6    3559.9    1181.2    3592.7    1181.2    3822.4    1182.8    3874.9
GR   1184.4     3907.7     1184.4    4038.9    1186.1    4127.5    1181.2    4170.2    1177.8    4219.4
GR   1182.8     4265.3     1184.4    4429.4    1186.1    4445.8    1189.4    4455.6    1212.3    4504.8
GR   1214.0     4511.4     1214.0    4534.3    1212.3    4537.6    1207.4    4557.3    1207.4    4914.9
GR   1209.0     4974.0     1207.4    5000.2    1207.4    5115.1       0.0       0.0       0.0       0.0

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NC                                   0.3       0.5

  CROSS SECTION AND BRIDGE GEOMETRY ADJUSTED FOR 12 DEGREE SKEW

    DOWNSTREAM FACE OF ALMA SCHOOL ROAD BRIDGE
X1       11          8       3543      4482       114       590       328      0.98         0         0
X3       10
GR   1209.0       3281     1209.0    3310.0    1207.3    3389.0    1207.3    3543.0    1186.0    3589.0
GR   1186.0     4449.0     1204.1    4482.0    1205.7    4803.0

     SPECIAL BRIDGE INPUT BETWEEN DOWNSTREAM AND UPSTREAM SECTIONS
     15 2.5-FT PIERS WITH 2 FT OF DEBRIS (EACH SIDE), PIERS ON SKEW
     AREA AND BOTTOM WIDTH ADJUSTED FOR 12 DEGREE SKEW

SB     1.05       1.56        2.6                 854      97.5     15757         2    1187.6    1186.0

     UPSTREAM FACE OF ALMA SCHOOL ROAD BRIDGE
X1     11.5          8       3609      4544        84        84        84      0.98         0         0
X2                              1    1204.6    1208.7
X3       10

     BRIDGE TABLE TO DEFINE TOP OF ROADWAY PROFILE
     WEIR SECTION RAISED 2.7 FT. ON BRIDGE TO ACCOUNT FOR CONCRETE BARRIER
BT      -16       3379     1210.6              3560.0    1210.6              3609.0    1210.0
BT              3726.1     1210.1              3959.7    1210.1              4018.2    1210.0
BT              4135.2     1209.9              4193.7    1209.8              4252.2    1209.6
BT              4310.7     1209.5              4369.2    1209.3              4427.7    1209.1
BT              4486.2     1208.9              4544.0    1208.7              4544.0    1206.0
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BT             4856.0     1205.7
GR   1210.6    3383.0     1210.6     3560.0     1205.7     3609.0     1187.6     3642.0     1187.6     4514.0
GR   1204.1    4544.0     1205.7     4560.0     1205.7     4862.0


X1       12      12.0     3546.8     4629.5        404        213        318        0.0        0.0        0.0
GR   1222.2    3369.6     1222.2     3546.8     1192.6     3618.9     1189.4     3651.8     1188.0     3750.2
GR   1188.0    4485.1     1189.4     4531.1     1199.2     4567.2     1205.8     4629.5     1207.4     4777.1
GR   1207.4    5167.6     1209.0     5203.7        0.0        0.0        0.0        0.0        0.0        0.0

NC                                      0.1        0.3

X1       13      15.0     3609.1     4613.1        410        410        410        0.0        0.0        0.0
GR   1210.7    3281.0     1210.7     3609.1     1194.3     3638.6     1191.0     3671.4     1189.4     3789.6
GR   1188.5    3838.8     1188.5     4426.1     1189.4     4534.3     1191.0     4557.3     1194.3     4583.6
GR   1209.0    4613.1     1214.0     4632.8     1214.0     4659.0     1207.4     4682.0     1207.4     5262.7

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NC                                      0.3        0.5

   CODE BRIDGE PIERS AS GR POINTS FOR SECTIONS 14 THROUGH 17

X1       14        26     3786.3     4796.8        404        404        404        0.0        0.0        0.0
GR   1209.0    3281.0     1209.0     3405.7     1207.4     3418.8     1207.4     3727.2     1205.8     3786.3
GR   1194.3    3812.5     1192.6     3838.8     1191.0     3874.9     1191.0     3983.1     1189.4     4035.6
GR   1189.0    4058.6     1189.0     4219.4     1189.4     4229.2     1189.4     4578.7       1209     4578.7
GR     1209    4633.4     1189.4     4633.4     1189.4     4659.4       1209     4659.4       1209     4710.6
GR     1191    4710.6     1191.0     4741.0     1192.6     4757.5     1207.4     4796.8     1207.4     5243.0
GR   1209.0    5249.6

X1       15        27     3481.1     4462.2        312        312        312        0.0        0.0        0.0
X3                                                        4478.6       1210
GR   1209.0    3343.3     1207.4     3425.4     1205.8     3481.1     1195.9     3500.8     1194.3     3517.2
GR   1191.0    3599.3     1189.5     3664.9     1189.5     3681.3     1189.5     3988.2       1210     3988.2
GR     1210    4035.8     1189.5     4035.8       1190     4086.8       1210     4086.8       1210     4129.3
GR     1190    4129.3       1191     4174.8       1210     4174.8       1210     4217.3       1191     4217.3
GR   1191.0    4406.4     1209.0     4462.2     1210.0     4478.6     1209.0     4498.3     1207.4     4501.5
GR   1207.4    4875.6     1209.0     4882.1

X1       16        31     3354.8     4308.0        312        312        312        0.0        0.0        0.0
GR   1207.4    3281.0     1207.4     3354.8     1191.0     3389.3       1191     3580.8       1211     3580.8
GR     1211    3623.3       1191     3623.3       1191     3678.8       1211     3678.8       1211     3721.3
GR     1191    3721.3       1191     3771.8       1211     3771.8       1211     3814.3       1191     3814.3
GR   1191.0    4235.8     1210.7     4308.0     1210.7     4390.0     1212.3     4435.9     1214.0     4462.2
GR   1222.2    4573.7     1227.1     4642.6     1227.1     4672.1     1222.2     4695.1     1214.0     4714.8
GR   1214.0    4783.7     1210.7     4790.3     1209.0     4829.6     1210.7     4911.7     1210.7     5193.8
GR   1212.3    5256.2

  Return to full discharge above southern overflow channel

QT        2    220000     345000

X1       17        32     3313.8     4744.3        394        394        394        0.0        0.0        0.0
X3                                     3566
GR   1214.0    3281.0     1205.8     3310.5     1204.1     3313.8     1194.3     3343.3     1194.3     3625.5
GR     1193    3652.8       1214     3652.8       1214     3695.3       1193     3695.3       1191     3741.8
GR     1214    3741.8       1214     3784.3       1191     3784.3       1191     3840.8       1214     3840.8
GR     1214    3883.3       1191     3883.3       1191     3925.8       1214     3925.8       1214     3968.3
GR     1191    3968.3     1191.0     4642.6     1192.6     4652.5     1195.9     4695.1     1209.0     4744.3
GR   1210.7    4764.0     1215.6     4800.1     1218.9     4888.7     1218.9     5000.2     1214.0     5082.3
GR   1212.3    5193.8     1212.3     5873.0

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X1       18      15.0     3281.0     4416.2        328        328        328        0.0        0.0        0.0
X3                                     3405
GR   1212.3    3281.0     1205.8     3297.4     1197.6     3323.7     1192.6     3346.6     1191.0     3405.7
GR   1191.0    3970.0     1192.6     3983.1     1192.6     4265.3     1195.9     4350.6     1199.2     4373.6
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GR  1210.7    4416.2    1214.0    4445.8    1217.3    4462.2    1217.3    4560.6    1218.9    4570.4

NC                                   0.1       0.3

X1      19        11       164      1601       433       358       361
GR  1222.1       164    1212.3       213    1212.3       653    1191.2       696    1191.2      1115
GR  1195.9      1161    1195.9      1204    1192.6      1342    1194.2      1411    1199.1      1549
GR  1213.9      1601

X1      20      18.0    4258.7    5147.9       351       367       354
GR  1230.4    3645.2    1232.0    3746.9    1232.0    3812.5    1214.0    3845.3    1212.3    3976.6
GR  1210.7    4258.7    1191.2    4298.1    1191.2    4659.0    1191.2    4682.0    1191.2    4757.5
GR  1197.5    4872.3    1191.2    4924.8    1204.1    4970.7    1205.8    5010.1    1202.5    5019.9
GR  1205.8    5095.4    1214.0    5115.1    1217.3    5147.9

X1      21      15.0    3947.0    5062.6       574       312       476
GR  1214.0    3625.5    1222.2    3674.7    1220.5    3812.5    1220.5    3861.7    1202.5    3947.0
GR  1197.6    4009.4    1191.3    4035.6    1191.3    4409.7    1191.3    4458.9    1191.3    4573.7
GR  1197.6    4609.8    1199.2    4685.3    1202.5    4836.2    1205.8    4990.4    1236.9    5062.6

X1      22        15      4147    5164.3       558       246       394
GR    1227      3907    1220.5      3917    1218.8      3944    1218.8      4104    1210.6      4147
GR  1191.4    4153.7    1191.4    4186.6    1191.4    4570.4    1191.4    4718.1    1200.8    4757.5
GR  1201.9    4826.4    1200.8    4875.6    1202.5    5052.7    1218.9    5164.3    1220.5    5249.6

  Ineffective flow beyond left end point for sections 23, 24, and 25

X1      23        11    4370.3    5325.1       443       328       394       0.0       0.0
GR  1213.5      4006    1213.5      4308    1214.0    4370.3    1191.6    4409.7    1191.6    4803.4
GR  1195.9    4905.1    1199.2    4993.7    1203.1    5072.4    1198.2    5220.1    1200.8    5266.0
GR  1218.9    5325.1

X1      24        11      4603    5581.0       427       262       328       0.0       0.0
GR    1214      4275      1214      4603    1191.8    4665.6    1192.2    4813.2    1191.8    4901.8
GR  1191.8    5056.0    1195.9    5282.4    1199.2    5400.5    1200.8    5489.1    1217.3    5581.0
GR  1222.2    5659.7

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X1      25        10    4586.8    5581.0       328       328       328       0.0       0.0
GR  1214.0      4432    1214.0    4586.8    1191.9    4685.3    1191.9    5016.6    1191.9    5131.5
GR  1191.9    5252.9    1192.6    5394.0    1200.8    5515.4    1215.6    5581.0    1218.9    5731.9

  Ineffective flow beyond right end point for section 26

X1      26        19      4495      5558       328       328       328         0         0         0
GR  1227.0    4495.0    1205.7    4541.0    1200.8    4567.0    1200.8    4813.0    1199.1    4862.0
GR  1195.9    4957.0    1194.2    5020.0    1192.1    5062.0    1192.1    5128.0    1192.1    5187.0
GR  1192.1    5397.0    1192.1    5426.0    1199.1    5492.0    1200.8    5518.0    1212.3    5558.0
GR  1213.9    5587.0    1215.5    5590.0    1216.4    5646.0      1214      5800

X1      27        17      4459      5581       328       328       328         0         0         0
GR  1218.8    4459.0    1207.3    4491.0    1205.7    4511.0    1205.7    4747.0    1202.4    4856.0
GR  1199.1    4938.0    1194.2    5144.0    1192.1    5203.0    1192.1    5243.0    1192.1    5266.0
GR  1192.1    5400.0    1192.1    5420.0    1192.1    5502.0    1197.5    5545.0    1215.5    5581.0
GR  1217.2    5604.0      1219      5690

X1      28        18      4386      5692       262       394       328         0         0         0
GR  1220.5    4386.0    1207.3    4429.0    1205.7    4488.0    1205.7    4954.0    1200.8    4984.0
GR  1199.1    5036.0    1197.5    5056.0    1194.2    5095.0    1194.2    5207.0    1192.6    5262.0
GR  1192.4    5344.0    1192.4    5407.0    1192.4    5489.0    1192.4    5502.0    1192.6    5561.0
GR  1197.5    5643.0    1217.2    5692.0    1218.8    5761.0

X1      29        19      4439      5751       328       328       328         0         0         0
GR  1221.4    4413.0    1220.5    4439.0    1205.7    4501.0    1205.7    4938.0    1204.1    4990.0
GR  1197.5    5052.0    1195.9    5108.0    1194.2    5187.0    1192.6    5213.0    1192.6    5266.0
GR  1194.2    5292.0    1194.2    5453.0    1192.6    5512.0    1192.6    5620.0    1194.2    5653.0
```

```
 GR   1197.5     5695.0     1217.2     5751.0     1217.2     5856.0     1218.5     6053.0


 X1       30         19       4304       5873        328        328        328          0          0          0
 GR   1222.1     4304.0     1205.7     4682.0     1207.3     4734.0     1207.3     4856.0     1202.4     4865.0
 GR   1200.8     4977.0     1195.9     5023.0     1194.2     5131.0     1194.2     5249.0     1195.9     5282.0
 GR   1197.5     5302.0     1197.5     5446.0     1195.9     5469.0     1195.9     5673.0     1197.5     5705.0
 GR   1199.1     5791.0     1200.8     5823.0     1218.5     5873.0     1220.5     5964.0

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    27MAR00      08:51:31                                                                                       PAGE    7


     SECNO      DEPTH      CWSEL      CRIWS      WSELK      EG         HV         HL         OLOSS      L-BANK ELEV
     Q          QLOB       QCH        QROB       ALOB       ACH        AROB       VOL        TWA        R-BANK ELEV
     TIME       VLOB       VCH        VROB       XNL        XNCH       XNR        WTN        ELMIN      SSTA
     SLOPE      XLOBL      XLCH       XLOBR      ITRIAL     IDC        ICONT      CORAR      TOPWID     ENDST


 *PROF 1

 IHLEQ = 1.  THEREFORE FRICTION LOSS (HL) IS CALCULATED AS A FUNCTION OF
 PROFILE TYPE, WHICH CAN VARY FROM REACH TO REACH.  SEE DOCUMENTATION FOR
 DETAILS.

 CCHV=     .100 CEHV=     .300
 *SECNO 1.000
 3280 CROSS SECTION      1.00 EXTENDED       .18 FEET

      1.000      23.08    1182.88        .00    1175.00    1184.47       1.59        .00        .00    1182.70
   220000.0         .0   219752.3      247.8         .0    21695.6       85.5         .0         .0    1174.50
        .00        .00      10.13       2.90       .000       .035       .040       .000    1159.80     328.00
    .001000         0.         0.         0.          0          0          5        .00    1060.40    1388.40


 FLOW DISTRIBUTION FOR SECNO=      1.00          CWSEL=    1182.88

 STA=      328.    1368.    1388.
   PER Q=      99.9        .1
    AREA=  21695.6      85.5
     VEL=      10.1       2.9
   DEPTH=      20.9       4.2

 *SECNO 2.000
      2.000      23.44    1183.24        .00        .00    1185.06       1.82        .52        .07    1194.20
   220000.0         .0   219820.8      179.2         .0    20318.8      100.7      244.6       12.0    1177.80
        .01        .00      10.82       1.78       .000       .035       .040       .000    1159.80     363.69
    .001052       505.       505.       505.          2          0          0        .00    1009.09    1372.78


 FLOW DISTRIBUTION FOR SECNO=      2.00          CWSEL=    1183.24

 STA=      364.    1276.    1296.    1371.    1373.
   PER Q=      99.9        .1        .0        .0
    AREA=  20318.8      59.8      40.5        .5
     VEL=      10.8       2.5        .8        .5
   DEPTH=      22.3       3.0        .5        .3

 *SECNO 3.000
1
    27MAR00      08:51:31                                                                                       PAGE    8


     SECNO      DEPTH      CWSEL      CRIWS      WSELK      EG         HV         HL         OLOSS      L-BANK ELEV
     Q          QLOB       QCH        QROB       ALOB       ACH        AROB       VOL        TWA        R-BANK ELEV
     TIME       VLOB       VCH        VROB       XNL        XNCH       XNR        WTN        ELMIN      SSTA
     SLOPE      XLOBL      XLCH       XLOBR      ITRIAL     IDC        ICONT      CORAR      TOPWID     ENDST


 3301 HV CHANGED MORE THAN HVINS


 3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE,  KRATIO =  1.47

      3.000      24.78    1184.58        .00        .00    1185.49        .91        .34        .09    1194.20
   220000.0         .0   219847.8      152.2         .0    28747.3       84.1      532.4       25.2    1177.80
        .03        .00       7.65       1.81       .000       .035       .040       .000    1159.80     340.55
    .000489       509.       509.       509.          2          0          0        .00    1252.26    1592.80
```

```
 FLOW DISTRIBUTION FOR SECNO=      3.00          CWSEL=   1184.58

 STA=      341.     1568.     1593.
   PER Q=      99.9        .1
    AREA=  28747.3      84.1
     VEL=       7.6       1.8
   DEPTH=      23.4       3.4

 *SECNO 4.000
      4.000      25.30   1185.10       .00       .00   1185.75       .64       .24       .03   1194.20
   220000.0         .0  220000.0        .0        .0   34145.4        .0     919.1      42.9   1204.10
        .05        .00      6.44       .00      .000      .035      .000      .000   1159.80    339.86
    .000402       535.      535.      535.         2         0         0       .00   1634.99   1974.86


 FLOW DISTRIBUTION FOR SECNO=      4.00          CWSEL=   1185.10

 STA=      340.     2106.
   PER Q=     100.0
    AREA=  34145.4
     VEL=       6.4
   DEPTH=      20.9

 *SECNO 5.000
 3280 CROSS SECTION      5.00 EXTENDED      3.42 FEET


 3301 HV CHANGED MORE THAN HVINS

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    27MAR00      08:51:31                                                                                    PAGE    9


      SECNO      DEPTH      CWSEL      CRIWS      WSELK      EG         HV         HL         OLOSS      L-BANK ELEV
      Q          QLOB       QCH        QROB       ALOB       ACH        AROB       VOL        TWA        R-BANK ELEV
      TIME       VLOB       VCH        VROB       XNL        XNCH       XNR        WTN        ELMIN      SSTA
      SLOPE      XLOBL      XLCH       XLOBR      ITRIAL     IDC        ICONT      CORAR      TOPWID     ENDST


 3685 20 TRIALS ATTEMPTED WSEL,CWSEL
 3693 PROBABLE MINIMUM SPECIFIC ENERGY
 3720 CRITICAL DEPTH ASSUMED
      5.000      19.82   1187.82   1187.82       .00   1194.26      6.43      4.38      -.35   1184.40
   203000.0         .0  203000.0        .0        .0    9975.2        .0    1195.1      58.2   1213.90
        .06        .00     20.35       .00      .000      .035      .000      .000   1168.00    328.00
    .008040       545.      545.      545.        20        15         0       .00    797.15   1125.15


 FLOW DISTRIBUTION FOR SECNO=      5.00          CWSEL=   1187.82

 STA=      328.     1224.
   PER Q=     100.0
    AREA=   9975.2
     VEL=      20.4
   DEPTH=      12.5

 *SECNO 6.000

 3301 HV CHANGED MORE THAN HVINS


 3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE,  KRATIO =  1.76

      6.000      21.05   1193.95       .00       .00   1197.03      3.08      2.44       .34   1200.80
   203000.0         .0  203000.0        .0        .0   14413.7        .0    1369.5      70.0   1210.60
        .07        .00     14.08       .00      .000      .035      .000      .000   1172.90    339.60
    .002594       623.      623.      623.         2         0         0       .00    855.28   1194.87


 FLOW DISTRIBUTION FOR SECNO=      6.00          CWSEL=   1193.95

 STA=      340.     1273.
   PER Q=     100.0
    AREA=  14413.7
     VEL=      14.1
   DEPTH=      16.9

 *SECNO 7.000
 3280 CROSS SECTION      7.00 EXTENDED      3.11 FEET
```

| SECNO | DEPTH | CWSEL | CRIWS | WSELK | EG | HV | HL | OLOSS | L-BANK ELEV |
|---|---|---|---|---|---|---|---|---|---|
| Q | QLOB | QCH | QROB | ALOB | ACH | AROB | VOL | TWA | R-BANK ELEV |
| TIME | VLOB | VCH | VROB | XNL | XNCH | XNR | WTN | ELMIN | SSTA |
| SLOPE | XLOBL | XLCH | XLOBR | ITRIAL | IDC | ICONT | CORAR | TOPWID | ENDST |
| 7.000 | 21.21 | 1195.71 | .00 | .00 | 1198.75 | 3.04 | 1.71 | .00 | 1192.60 |
| 203000.0 | .0 | 203000.0 | .0 | .0 | 14512.4 | .0 | 1582.0 | 83.0 | 1209.00 |
| .09 | .00 | 13.99 | .00 | .000 | .035 | .000 | .000 | 1174.50 | 328.00 |
| .002758 | 640. | 640. | 640. | 3 | 0 | 0 | .00 | 915.65 | 1243.65 |

FLOW DISTRIBUTION FOR SECNO= 7.00 CWSEL= 1195.71

STA= 328. 1266.
PER Q= 100.0
AREA= 14512.4
VEL= 14.0
DEPTH= 15.8

*SECNO 8.000

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 8.000 | 20.85 | 1197.05 | .00 | .00 | 1200.07 | 3.01 | 1.31 | .00 | 1207.40 |
| 203000.0 | .0 | 203000.0 | .0 | .0 | 14575.2 | .0 | 1742.9 | 93.1 | 1210.70 |
| .10 | .00 | 13.93 | .00 | .000 | .035 | .000 | .000 | 1176.20 | 3343.25 |
| .002689 | 482. | 482. | 482. | 2 | 0 | 0 | .00 | 909.56 | 4252.81 |

FLOW DISTRIBUTION FOR SECNO= 8.00 CWSEL= 1197.05

STA= 3343. 4280.
PER Q= 100.0
AREA= 14575.2
VEL= 13.9
DEPTH= 16.0

*SECNO 9.000

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 9.000 | 21.80 | 1198.00 | .00 | .00 | 1200.94 | 2.94 | .87 | .01 | 1217.30 |
| 203000.0 | .0 | 203000.0 | .0 | .0 | 14752.6 | .0 | 1853.4 | 99.9 | 1212.30 |
| .10 | .00 | 13.76 | .00 | .000 | .035 | .000 | .000 | 1176.20 | 3470.02 |
| .002608 | 263. | 328. | 427. | 2 | 0 | 0 | .00 | 914.64 | 4384.66 |

FLOW DISTRIBUTION FOR SECNO= 9.00 CWSEL= 1198.00

STA= 3470. 4420.
PER Q= 100.0
AREA= 14752.6
VEL= 13.8
DEPTH= 16.1



| SECNO | DEPTH | CWSEL | CRIWS | WSELK | EG | HV | HL | OLOSS | L-BANK ELEV |
|---|---|---|---|---|---|---|---|---|---|
| Q | QLOB | QCH | QROB | ALOB | ACH | AROB | VOL | TWA | R-BANK ELEV |
| TIME | VLOB | VCH | VROB | XNL | XNCH | XNR | WTN | ELMIN | SSTA |
| SLOPE | XLOBL | XLCH | XLOBR | ITRIAL | IDC | ICONT | CORAR | TOPWID | ENDST |

*SECNO 10.000

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 10.000 | 20.96 | 1198.76 | .00 | .00 | 1201.96 | 3.19 | .94 | .08 | 1209.00 |
| 203000.0 | .0 | 203000.0 | .0 | .0 | 14156.2 | .0 | 1964.5 | 107.0 | 1214.00 |
| .11 | .00 | 14.34 | .00 | .000 | .035 | .000 | .000 | 1177.80 | 3556.55 |
| .003009 | 328. | 335. | 345. | 2 | 0 | 0 | .00 | 919.17 | 4475.72 |

FLOW DISTRIBUTION FOR SECNO= 10.00 CWSEL= 1198.76

STA= 3557. 4511.
PER Q= 100.0
AREA= 14156.2
VEL= 14.3
DEPTH= 15.4

CCHV= .300 CEHV= .500

```
*SECNO 11.000

3301 HV CHANGED MORE THAN HVINS


3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA=      1207.30 ELREA=      1204.10

     11.000      13.41   1199.41        .00        .00   1204.12       4.71       1.40        .76   1207.30
   203000.0         .0  203000.0         .0         .0   11651.7         .0     2061.7      113.8   1204.10
        .11        .00     17.42        .00       .000      .035       .000       .000    1186.00   3554.46
    .005552       114.      328.       590.          2         0          0        .00     895.14   4449.60


FLOW DISTRIBUTION FOR SECNO=     11.00          CWSEL=    1199.41

STA=     3554.     4458.
  PER Q=     100.0
   AREA=   11651.7
    VEL=      17.4
  DEPTH=      13.0

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    SECNO       DEPTH       CWSEL      CRIWS      WSELK      EG         HV         HL         OLOSS      L-BANK ELEV
    Q           QLOB        QCH        QROB       ALOB       ACH        AROB       VOL        TWA        R-BANK ELEV
    TIME        VLOB        VCH        VROB       XNL        XNCH       XNR        WTN        ELMIN      SSTA
    SLOPE       XLOBL       XLCH       XLOBR      ITRIAL     IDC        ICONT      CORAR      TOPWID     ENDST


SPECIAL BRIDGE

5227 DOWNSTREAM ELEV IS     1195.28 , NOT    1199.41 HYDRAULIC JUMP OCCURS DOWNSTREAM (IF LOW FLOW CONTROLS)

SB   XK          XKOR        COFQ        RDLEN       BWC         BWP         BAREA       SS          ELCHU       ELCHD
      1.05        1.56        2.60         .00      854.00       97.50    15757.00        2.00     1187.60     1186.00

*SECNO 11.500

3301 HV CHANGED MORE THAN HVINS


3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE,  KRATIO =  1.56

CLASS B LOW FLOW

3420 BRIDGE W.S.=     1199.73 BRIDGE VELOCITY=      20.07      CALCULATED CHANNEL AREA=       9469.

  EGPRS       EGLWC        H3         QWEIR        QLOW       BAREA     TRAPEZOID       ELLC        ELTRD       WEIRLN
                                                                          AREA
   1203.43    1207.66        .00         0.     203000.     15757.     13439.      1204.60     1208.70          0.


3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA=      1205.70 ELREA=      1204.10

     11.500      17.35   1204.95        .00        .00   1207.66       2.71       3.54        .00   1205.70
   203000.0         .0  202996.5        3.5         .0   15361.8        3.5     2087.7      115.6   1204.10
        .12        .00     13.21       1.00       .000      .035       .040       .000    1187.60   3605.82
    .002282        84.       84.        84.          0         0          0        .00     923.27   4529.10


FLOW DISTRIBUTION FOR SECNO=     11.50          CWSEL=    1204.95

STA=     3606.     4521.     4529.
  PER Q=     100.0        .0
   AREA=   15361.8       3.5
    VEL=      13.2       1.0
  DEPTH=      16.8        .4

*SECNO 12.000
1
    27MAR00      08:51:31                                                                                    PAGE   13


    SECNO       DEPTH       CWSEL      CRIWS      WSELK      EG         HV         HL         OLOSS      L-BANK ELEV
    Q           QLOB        QCH        QROB       ALOB       ACH        AROB       VOL        TWA        R-BANK ELEV
    TIME        VLOB        VCH        VROB       XNL        XNCH       XNR        WTN        ELMIN      SSTA
```

```
     SLOPE      XLOBL      XLCH       XLOBR      ITRIAL     IDC        ICONT      CORAR      TOPWID     ENDST


 3301 HV CHANGED MORE THAN HVINS

     12.000      18.38   1206.38        .00        .00    1208.48       2.09        .63        .19    1222.20
   203000.0         .0  202989.3       10.7         .0    17478.3       15.7     2207.7      122.9    1205.80
        .12        .00     11.61        .68       .000       .035       .040       .000    1188.00    3585.33
    .001757       404.       318.       213.          2          0          0        .00    1097.92    4683.25


 FLOW DISTRIBUTION FOR SECNO=     12.00          CWSEL=    1206.38

 STA=    3585.    4630.    4683.
   PER Q=     100.0        .0
     AREA=  17478.3      15.7
      VEL=     11.6        .7
    DEPTH=     16.7        .3

 CCHV=     .100 CEHV=      .300
 *SECNO 13.000
     13.000      18.56   1207.06        .00        .00    1209.20       2.14        .71        .01    1210.70
   203000.0         .0  203000.0         .0         .0    17294.3         .0     2371.4      132.7    1209.00
        .13        .00     11.74        .00       .000       .035       .000       .000    1188.50    3615.65
    .001709       410.       410.       410.          2          0          0        .00     993.56    4609.21


 FLOW DISTRIBUTION FOR SECNO=     13.00          CWSEL=    1207.06

 STA=    3616.    4613.
   PER Q=     100.0
     AREA=  17294.3
      VEL=     11.7
    DEPTH=     17.4

 CCHV=     .300 CEHV=      .500
 *SECNO 14.000

 3265 DIVIDED FLOW


 3301 HV CHANGED MORE THAN HVINS

1
    27MAR00       08:51:31                                                                                     PAGE   14


     SECNO      DEPTH      CWSEL      CRIWS      WSELK      EG         HV         HL         OLOSS      L-BANK ELEV
     Q          QLOB       QCH        QROB       ALOB       ACH        AROB       VOL        TWA        R-BANK ELEV
     TIME       VLOB       VCH        VROB       XNL        XNCH       XNR        WTN        ELMIN      SSTA
     SLOPE      XLOBL      XLCH       XLOBR      ITRIAL     IDC        ICONT      CORAR      TOPWID     ENDST


     14.000      18.61   1207.61        .00        .00    1210.32       2.71        .83        .28    1205.80
   203000.0      152.3  202787.5       60.2      123.9    15349.7       92.9     2523.8      145.3    1207.40
        .14       1.23     13.21        .65       .040       .035       .040       .000    1189.00    3417.10
    .002474       404.       404.       404.          2          0          0        .00    1720.86    5243.86


 FLOW DISTRIBUTION FOR SECNO=     14.00          CWSEL=    1207.61

 STA=    3417.    3727.    3786.    4797.    5243.
   PER Q=       .0        .1     99.9        .0
     AREA=     64.1      59.6  15349.7      92.8
      VEL=       .6       1.9     13.2        .6
    DEPTH=       .2       1.0     17.0        .2

 *SECNO 15.000

 3265 DIVIDED FLOW


 3470 ENCROACHMENT STATIONS=        .0    4478.6  TYPE=       1  TARGET=      4478.599
     15.000      18.77   1208.27        .00        .00    1211.35       3.09        .85        .19    1205.80
   203000.0      285.6  202714.4         .0      111.5    14368.2         .0     2631.4      154.9    1209.00
        .15       2.56     14.11        .00       .040       .035       .000       .000    1189.50    3381.24
    .002993       312.       312.       312.          0          0          0        .00     946.07    4459.91
```

```
 FLOW DISTRIBUTION FOR SECNO=     15.00          CWSEL=    1208.27

 STA=    3381.     3425.     3481.     4462.
   PER Q=        .0        .1      99.9
    AREA=      19.0      92.5   14368.2
     VEL=       1.2       2.8      14.1
   DEPTH=        .4       1.7      17.0

 *SECNO 16.000

 3265 DIVIDED FLOW

 3280 CROSS SECTION     16.00 EXTENDED      1.74 FEET

     16.000     18.14   1209.14       .00       .00   1212.39      3.25       .96       .08   1207.40
   203000.0     383.2  202616.5        .3     128.7   13992.3        .7    2733.8     161.5   1210.70
        .15      2.98     14.48       .36      .040      .035      .040      .000   1191.00   3281.00
    .003154      312.      312.      312.         2         0         0       .00    904.12   4836.58
```



```
     SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS     L-BANK ELEV
     Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA       R-BANK ELEV
     TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN     SSTA
     SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID    ENDST

 FLOW DISTRIBUTION FOR SECNO=     16.00          CWSEL=    1209.14

 STA=    3281.     3355.     4308.
   PER Q=        .2      99.8
    AREA=     128.7   13992.3
     VEL=       3.0      14.5
   DEPTH=       1.7      17.1

 *SECNO 17.000

 3265 DIVIDED FLOW


 3301 HV CHANGED MORE THAN HVINS


 3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE,  KRATIO =  1.53


 3470 ENCROACHMENT STATIONS=     3566.0    5873.0  TYPE=       1  TARGET=     -3566.000
     17.000     20.73   1211.73       .00       .00   1213.63      1.90       .83       .41 100000.00
   220000.0        .0  219912.7      87.3        .0   19880.0      41.0    2887.8     170.3   1209.00
        .16       .00     11.06      2.13      .000      .035      .040      .000   1191.00   3566.00
    .001589      394.      394.      394.         3         0         0       .00   1035.61   4771.61

 FLOW DISTRIBUTION FOR SECNO=     17.00          CWSEL=    1211.73

 STA=    3566.     4744.     4764.     4772.
   PER Q=     100.0        .0        .0
    AREA=   19880.0      37.1       3.9
     VEL=      11.1       2.3        .9
   DEPTH=      19.7       1.9        .5

 *SECNO 18.000

 3470 ENCROACHMENT STATIONS=     3405.0    4570.4  TYPE=       1  TARGET=     -3405.000
     18.000     21.22   1212.22       .00       .00   1214.11      1.88       .47       .01 100000.00
   220000.0        .0  219988.4      11.6        .0   19977.9      10.4    3038.0     178.0   1210.70
        .17       .00     11.01      1.11      .000      .035      .040      .000   1191.00   3405.00
    .001298      328.      328.      328.         2         0         0       .00   1024.87   4429.87
```



```
     SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS     L-BANK ELEV
     Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA       R-BANK ELEV
     TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN     SSTA
```

```
     SLOPE      XLOBL      XLCH       XLOBR      ITRIAL     IDC        ICONT      CORAR      TOPWID     ENDST

 FLOW DISTRIBUTION FOR SECNO=      18.00          CWSEL=    1212.22

 STA=     3405.     4416.     4430.
   PER Q=      100.0        .0
    AREA=   19977.9       10.4
     VEL=       11.0        1.1
   DEPTH=       19.8         .8

 CCHV=      .100 CEHV=      .300
 *SECNO 19.000

 3301 HV CHANGED MORE THAN HVINS


 3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE,  KRATIO =    .65

      19.000      21.33    1212.53        .00        .00    1215.00       2.47        .72        .18    1222.10
    220000.0         .0   220000.0         .0         .0    17438.6         .0     3193.1      188.0    1213.90
         .18        .00      12.62        .00       .000       .035       .000       .000    1191.20     211.86
     .003033       433.       361.       358.          2          0          0        .00    1384.32    1596.18

 FLOW DISTRIBUTION FOR SECNO=      19.00          CWSEL=    1212.53

 STA=       212.     1601.
   PER Q=      100.0
    AREA=   17438.6
     VEL=       12.6
   DEPTH=       12.6

 *SECNO 20.000

 3301 HV CHANGED MORE THAN HVINS

      20.000      21.83    1213.03        .00        .00    1216.13       3.09        .94        .19    1210.70
    220000.0     1058.5   218941.5         .0      453.4    15477.4         .0     3328.7      198.5    1217.30
         .19       2.33      14.15        .00       .040       .035       .000       .000    1191.20    3919.94
     .002364       351.       354.       367.          2          0          0        .00    1192.83    5112.78
```



```
     SECNO      DEPTH      CWSEL      CRIWS      WSELK      EG         HV         HL         OLOSS      L-BANK ELEV
     Q          QLOB       QCH        QROB       ALOB       ACH        AROB       VOL        TWA        R-BANK ELEV
     TIME       VLOB       VCH        VROB       XNL        XNCH       XNR        WTN        ELMIN      SSTA
     SLOPE      XLOBL      XLCH       XLOBR      ITRIAL     IDC        ICONT      CORAR      TOPWID     ENDST

 FLOW DISTRIBUTION FOR SECNO=      20.00          CWSEL=    1213.03

 STA=     3920.     4259.     5148.
   PER Q=         .5       99.5
    AREA=      453.4   15477.4
     VEL=        2.3      14.1
   DEPTH=        1.3      18.1

 *SECNO 21.000

 3265 DIVIDED FLOW

 3280 CROSS SECTION      21.00 EXTENDED       1.28 FEET


 3301 HV CHANGED MORE THAN HVINS

      21.000      23.97    1215.27        .00        .00    1217.03       1.76        .78        .13    1202.50
    220000.0     1722.7   218277.3         .0      391.9    20424.3         .0     3530.4      211.6    1236.90
         .20       4.40      10.69        .00       .040       .035       .000       .000    1191.30    3625.50
     .001240       574.       476.       312.          2          0          0        .00    1133.65    5012.41

 FLOW DISTRIBUTION FOR SECNO=      21.00          CWSEL=    1215.27

 STA=     3626.     3947.     5063.
   PER Q=         .8       99.2
```

```
    AREA=    391.9  20424.3
     VEL=      4.4     10.7
   DEPTH=      1.2     19.2

 *SECNO 22.000
    22.000     24.22   1215.62       .00       .00   1217.63      2.02       .52       .08   1210.60
  220000.0     168.2  219831.8        .0      66.0   19278.4        .0    3712.9     221.6   1218.90
       .21      2.55     11.40       .00      .040      .035      .000      .000   1191.40   4120.69
   .001415      558.      394.      246.         2         0         0       .00   1021.26   5141.96


 FLOW DISTRIBUTION FOR SECNO=     22.00          CWSEL=    1215.62
```



```
     SECNO      DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS     L-BANK ELEV
     Q          QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA       R-BANK ELEV
     TIME       VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN     SSTA
     SLOPE      XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID    ENDST


 STA=    4121.    4147.    5164.
   PER Q=        .1     99.9
    AREA=     66.0  19278.4
     VEL=      2.5     11.4
   DEPTH=      2.5     19.4

 *SECNO 23.000
 3280 CROSS SECTION     23.00 EXTENDED      2.63 FEET

    23.000     24.53   1216.13       .00       .00   1218.21      2.07       .56       .02   1214.00
  220000.0    2475.6  217524.4        .0     943.2   18718.9        .0    3889.9     232.3   1218.90
       .22      2.62     11.62       .00      .040      .035      .000      .000   1191.60   4006.00
   .001416      443.      394.      328.         0         0         0       .00   1310.06   5316.06


 FLOW DISTRIBUTION FOR SECNO=     23.00          CWSEL=    1216.13

 STA=    4006.    4308.    4370.    5325.
   PER Q=      1.0       .2     98.9
    AREA=    794.8    148.4  18718.9
     VEL=      2.6      2.5     11.6
   DEPTH=      2.6      2.4     19.8

 *SECNO 24.000
 3280 CROSS SECTION     24.00 EXTENDED      2.89 FEET

    24.000     25.09   1216.89       .00       .00   1218.65      1.76       .41       .03   1214.00
  220000.0    2375.0  217625.0        .0     948.9   20344.3        .0    4046.2     242.9   1217.30
       .23      2.50     10.70       .00      .040      .035      .000      .000   1191.80   4275.00
   .001114      427.      328.      262.         2         0         0       .00   1303.73   5578.73


 FLOW DISTRIBUTION FOR SECNO=     24.00          CWSEL=    1216.89

 STA=    4275.    4603.    5581.
   PER Q=      1.1     98.9
    AREA=    948.9  20344.3
     VEL=      2.5     10.7
   DEPTH=      2.9     20.9
```



```
     SECNO      DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS     L-BANK ELEV
     Q          QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA       R-BANK ELEV
     TIME       VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN     SSTA
     SLOPE      XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID    ENDST


 *SECNO 25.000
 3280 CROSS SECTION     25.00 EXTENDED      3.56 FEET

    25.000     25.66   1217.56       .00       .00   1218.99      1.43       .30       .03   1214.00
  220000.0    1326.8  218582.3      90.9     551.2   22721.8      87.9    4214.3     252.5   1215.60
       .24      2.41      9.62      1.03      .040      .035      .040      .000   1191.90   4432.00
   .000796      328.      328.      328.         2         0         0       .00   1238.64   5670.64
```

```
 FLOW DISTRIBUTION FOR SECNO=     25.00          CWSEL=   1217.56

 STA=    4432.     4587.     5581.     5671.
   PER Q=       .6      99.4        .0
    AREA=    551.2  22721.8      87.9
     VEL=      2.4       9.6       1.0
   DEPTH=      3.6      22.9       1.0

 *SECNO 26.000
 3280 CROSS SECTION     26.00 EXTENDED       3.75 FEET

     26.000      25.65    1217.75        .00        .00   1219.32      1.57       .29       .04   1227.00
   220000.0         .0   218517.1     1482.9         .0   21676.4     638.5    4386.3     262.0   1212.30
        .25        .00      10.08       2.32       .000      .035      .040      .000   1192.10   4514.97
    .000993       328.       328.       328.          2         0         0       .00   1285.03   5800.00


 FLOW DISTRIBUTION FOR SECNO=     26.00          CWSEL=   1217.75

 STA=    4515.     5558.     5587.     5646.     5800.
   PER Q=      99.3        .2        .1        .4
    AREA=  21676.4     135.0     110.2     393.3
     VEL=     10.1       3.3       1.8       2.2
   DEPTH=     20.8       4.7       1.9       2.6

 *SECNO 27.000
     27.000      25.95    1218.05        .00        .00   1219.70      1.65       .35       .03   1218.80
   220000.0         .0   219917.1       82.9         .0   21300.3      56.2    4550.7     271.3   1215.50
        .26        .00      10.32       1.48       .000      .035      .040      .000   1192.10   4461.09
    .001174       328.       328.       328.          0         0         0       .00   1183.40   5644.49


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     SECNO      DEPTH      CWSEL      CRIWS      WSELK      EG         HV         HL         OLOSS      L-BANK ELEV
     Q          QLOB       QCH        QROB       ALOB       ACH        AROB       VOL        TWA        R-BANK ELEV
     TIME       VLOB       VCH        VROB       XNL        XNCH       XNR        WTN        ELMIN      SSTA
     SLOPE      XLOBL      XLCH       XLOBR      ITRIAL     IDC        ICONT      CORAR      TOPWID     ENDST


 FLOW DISTRIBUTION FOR SECNO=     27.00          CWSEL=   1218.05

 STA=    4461.     5581.     5604.     5644.
   PER Q=    100.0        .0        .0
    AREA=  21300.3      39.0      17.2
     VEL=     10.3       1.8        .7
   DEPTH=     19.0       1.7        .4

 *SECNO 28.000
 3280 CROSS SECTION     28.00 EXTENDED        .01 FEET

     28.000      26.41    1218.81        .00        .00   1220.08      1.27       .34       .04   1220.50
   220000.0         .0   219945.0       55.0         .0   24355.7      56.2    4723.1     281.0   1217.20
        .27        .00       9.03        .98       .000      .035      .040      .000   1192.40   4391.49
    .000915       262.       328.       394.          2         0         0       .00   1369.51   5761.00


 FLOW DISTRIBUTION FOR SECNO=     28.00          CWSEL=   1218.81

 STA=    4391.     5692.     5761.
   PER Q=    100.0        .0
    AREA=  24355.7      56.2
     VEL=      9.0       1.0
   DEPTH=     18.7        .8

 *SECNO 29.000
 3280 CROSS SECTION     29.00 EXTENDED        .68 FEET

     29.000      26.58    1219.18        .00        .00   1220.37      1.19       .29       .01   1220.50
   220000.0         .0   219306.2      693.8         .0   24974.1     469.8    4910.8     292.2   1217.20
        .28        .00       8.78       1.48       .000      .035      .040      .000   1192.60   4444.53
    .000842       328.       328.       328.          2         0         0       .00   1608.47   6053.00


 FLOW DISTRIBUTION FOR SECNO=     29.00          CWSEL=   1219.18

 STA=    4445.     5751.     5856.     6053.
```

```
    PER Q=     99.7        .2        .2
     AREA=  24974.1     207.9     262.0
      VEL=      8.8       1.7       1.3
    DEPTH=     19.1       2.0       1.3

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      SECNO      DEPTH      CWSEL      CRIWS      WSELK      EG         HV         HL         OLOSS      L-BANK ELEV
      Q          QLOB       QCH        QROB       ALOB       ACH        AROB       VOL        TWA        R-BANK ELEV
      TIME       VLOB       VCH        VROB       XNL        XNCH       XNR        WTN        ELMIN      SSTA
      SLOPE      XLOBL      XLCH       XLOBR      ITRIAL     IDC        ICONT      CORAR      TOPWID     ENDST


 *SECNO 30.000
     30.000     25.41    1219.61        .00        .00    1220.66      1.05        .27        .01    1222.10
   220000.0        .0   219980.0       20.0         .0    26695.0      27.8     5107.2      304.2    1218.50
        .29       .00       8.24        .72       .000       .035      .040       .000    1194.20    4361.49
    .000823      328.       328.       328.          2          0         0        .00    1561.83    5923.32


 FLOW DISTRIBUTION FOR SECNO=      30.00           CWSEL=    1219.61

 STA=     4361.     5873.     5923.
   PER Q=     100.0        .0
    AREA=   26695.0      27.8
     VEL=       8.2        .7
   DEPTH=      17.7        .6

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 T1  FUTURE CONDITIONS, DESIGN (100-YR) AND SUPERFLOOD (500-YR) DISCHARGE
 T2  PROPOSED MCKELLIPS ROAD BRIDGE ACROSS THE SALT RIVER NEAR MESA, ARIZONA
 T3       FUTURE 500-YR

 J1  ICHECK     INQ        NINV       IDIR       STRT       METRIC     HVINS      Q          WSEL       FQ

        0          3          0          0      0.001          0          0          0     1175.0          0

 J2  NPROF      IPLOT      PRFVS      XSECV      XSECH      FN         ALLDC      IBW        CHNIM      ITRACE

        2          0         -1          0          0          0         -0          0          0         15

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      SECNO      DEPTH      CWSEL      CRIWS      WSELK      EG         HV         HL         OLOSS      L-BANK ELEV
      Q          QLOB       QCH        QROB       ALOB       ACH        AROB       VOL        TWA        R-BANK ELEV
      TIME       VLOB       VCH        VROB       XNL        XNCH       XNR        WTN        ELMIN      SSTA
      SLOPE      XLOBL      XLCH       XLOBR      ITRIAL     IDC        ICONT      CORAR      TOPWID     ENDST


 *PROF 2

 IHLEQ = 1.  THEREFORE FRICTION LOSS (HL) IS CALCULATED AS A FUNCTION OF
 PROFILE TYPE, WHICH CAN VARY FROM REACH TO REACH.  SEE DOCUMENTATION FOR
 DETAILS.

 CCHV=      .100 CEHV=      .300
 *SECNO 1.000
 3280 CROSS SECTION      1.00 EXTENDED      6.63 FEET

      1.000     29.53    1189.33        .00    1175.00    1191.60      2.27        .00        .00    1182.70
   345000.0        .0   343845.1     1155.0         .0    28408.5     254.3         .0         .0    1174.50
        .00       .00      12.10       4.54       .000       .035      .040       .000    1159.80     328.00
    .001005        0.         0.         0.          0          0         5        .00    1068.00    1396.00


 FLOW DISTRIBUTION FOR SECNO=       1.00           CWSEL=    1189.33

 STA=      328.     1368.     1396.
   PER Q=      99.7        .3
    AREA=   28408.5     254.3
     VEL=      12.1       4.5
   DEPTH=      27.3       9.1
```

```
 *SECNO 2.000
     2.000     29.83   1189.63       .00       .00   1192.24      2.61       .54       .10   1194.20
  345000.0        .0  341415.2    3584.9        .0   26215.5     786.4     322.7      12.3   1177.80
       .01       .00     13.02      4.56      .000      .035      .040      .000   1159.80    342.88
   .001120      505.      505.      505.         2         0         0       .00   1050.94   1393.82


 FLOW DISTRIBUTION FOR SECNO=      2.00          CWSEL=    1189.63

 STA=     343.    1276.    1296.    1371.    1394.
   PER Q=      99.0       .3       .7       .1
    AREA=  26215.5    187.6    519.8     79.1
     VEL=      13.0      5.4      4.5      2.8
   DEPTH=      28.1      9.4      6.9      3.5

 *SECNO 3.000
1
     27MAR00       08:51:31                                                                                PAGE   24


      SECNO      DEPTH      CWSEL      CRIWS      WSELK      EG         HV         HL         OLOSS      L-BANK ELEV
      Q          QLOB       QCH        QROB       ALOB       ACH        AROB       VOL        TWA        R-BANK ELEV
      TIME       VLOB       VLCH       VROB       XNL        XNCH       XNR        WTN        ELMIN      SSTA
      SLOPE      XLOBL      XLCH       XLOBR      ITRIAL     IDC        ICONT      CORAR      TOPWID     ENDST


 3301 HV CHANGED MORE THAN HVINS


 3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE,  KRATIO =  1.48

     3.000     31.61   1191.41       .00       .00   1192.73      1.31       .36       .13   1194.20
  345000.0        .0  342885.7    2114.3        .0   37169.0     755.9     702.0      26.5   1177.80
       .03       .00      9.23      2.80      .000      .035      .040      .000   1159.80    331.63
   .000511      509.      509.      509.         2         0         0       .00   1376.71   1708.34


 FLOW DISTRIBUTION FOR SECNO=      3.00          CWSEL=    1191.41

 STA=     332.    1568.    1598.    1696.    1708.
   PER Q=      99.4       .3       .3       .0
    AREA=  37169.0    285.5    447.5     22.9
     VEL=       9.2      3.7      2.3      1.2
   DEPTH=      30.1      9.5      4.6      1.9

 *SECNO 4.000
     4.000     32.33   1192.13       .00       .00   1193.01       .88       .24       .04   1194.20
  345000.0        .0  345000.0        .0        .0   45830.7        .0    1216.3      45.3   1204.10
       .05       .00      7.53       .00      .000      .035      .000      .000   1159.80    330.70
   .000389      535.      535.      535.         2         0         0       .00   1692.64   2023.34


 FLOW DISTRIBUTION FOR SECNO=      4.00          CWSEL=    1192.13

 STA=     331.    2106.
   PER Q=     100.0
    AREA=  45830.7
     VEL=       7.5
   DEPTH=      27.1

 *SECNO 5.000
 3280 CROSS SECTION      5.00 EXTENDED      7.16 FEET


 3301 HV CHANGED MORE THAN HVINS

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     27MAR00       08:51:31                                                                                PAGE   25


      SECNO      DEPTH      CWSEL      CRIWS      WSELK      EG         HV         HL         OLOSS      L-BANK ELEV
      Q          QLOB       QCH        QROB       ALOB       ACH        AROB       VOL        TWA        R-BANK ELEV
      TIME       VLOB       VLCH       VROB       XNL        XNCH       XNR        WTN        ELMIN      SSTA
      SLOPE      XLOBL      XLCH       XLOBR      ITRIAL     IDC        ICONT      CORAR      TOPWID     ENDST


 7185 MINIMUM SPECIFIC ENERGY
 3720 CRITICAL DEPTH ASSUMED
     5.000     23.56   1191.56   1191.56       .00   1199.75      8.19      4.05       .27   1184.40
```

```
    298000.0        .0  298000.0        .0        .0   12976.2        .0    1584.2      61.0   1213.90
         .05       .00     22.97       .00      .000      .035      .000      .000   1168.00    328.00
     .007430      545.      545.      545.         3        19         0       .00    811.30   1139.30


  FLOW DISTRIBUTION FOR SECNO=      5.00          CWSEL=    1191.56

  STA=      328.    1224.
    PER Q=     100.0
     AREA=   12976.2
      VEL=      23.0
    DEPTH=      16.0

  *SECNO 6.000

  3301 HV CHANGED MORE THAN HVINS


  3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE,  KRATIO =  1.68

       6.000     25.57   1198.47       .00       .00   1202.57      4.10      2.42       .41   1200.80
    298000.0        .0  298000.0        .0        .0   18331.0        .0    1808.1      73.1   1210.60
         .06       .00     16.26       .00      .000      .035      .000      .000   1172.90    331.96
     .002627      623.      623.      623.         3         0         0       .00    884.07   1216.02


  FLOW DISTRIBUTION FOR SECNO=      6.00          CWSEL=    1198.47

  STA=      332.    1273.
    PER Q=     100.0
     AREA=   18331.0
      VEL=      16.3
    DEPTH=      20.7

  *SECNO 7.000
  3280 CROSS SECTION      7.00 EXTENDED      7.74 FEET

       7.000     25.84   1200.34       .00       .00   1204.25      3.92      1.66       .02   1192.60
    298000.0        .0  298000.0        .0        .0   18766.6        .0    2080.6      86.4   1209.00
         .07       .00     15.88       .00      .000      .035      .000      .000   1174.50    328.00
     .002572      640.      640.      640.         3         0         0       .00    923.43   1251.43
```



```
     SECNO      DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS     L-BANK ELEV
     Q          QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA       R-BANK ELEV
     TIME       VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN     SSTA
     SLOPE      XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID    ENDST

  FLOW DISTRIBUTION FOR SECNO=      7.00          CWSEL=    1200.34

  STA=      328.    1266.
    PER Q=     100.0
     AREA=   18766.6
      VEL=      15.9
    DEPTH=      20.3

  *SECNO 8.000
       8.000     25.37   1201.57       .00       .00   1205.50      3.93      1.24       .00   1207.40
    298000.0        .0  298000.0        .0        .0   18741.6        .0    2288.1      96.6   1210.70
         .08       .00     15.90       .00      .000      .035      .000      .000   1176.20   3332.50
     .002587      482.      482.      482.         1         0         0       .00    929.37   4261.87


  FLOW DISTRIBUTION FOR SECNO=      8.00          CWSEL=    1201.57

  STA=     3332.    4280.
    PER Q=     100.0
     AREA=   18741.6
      VEL=      15.9
    DEPTH=      20.2

  *SECNO 9.000
       9.000     26.28   1202.48       .00       .00   1206.35      3.86       .84       .01   1217.30
    298000.0        .0  298000.0        .0        .0   18890.5        .0    2429.8     103.6   1212.30
         .09       .00     15.78       .00      .000      .035      .000      .000   1176.20   3463.76
```

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    .002535      263.       328.       427.          2          0          0        .00     931.82   4395.58


  FLOW DISTRIBUTION FOR SECNO=       9.00           CWSEL=    1202.48

  STA=     3464.     4420.
    PER Q=     100.0
     AREA=  18890.5
      VEL=      15.8
    DEPTH=      20.3

 *SECNO 10.000
      10.000     25.40    1203.20        .00        .00    1207.33       4.12        .90        .08    1209.00
    298000.0        .0   298000.0        .0         .0    18286.4         .0     2572.8      110.8    1214.00
         .09       .00      16.30        .00       .000       .035       .000       .000    1177.80    3543.78
     .002858      328.       335.       345.          2          0          0        .00     941.48    4485.26
```

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1
    27MAR00       08:51:31                                                                              PAGE    27

       SECNO      DEPTH      CWSEL      CRIWS      WSELK      EG         HV         HL         OLOSS      L-BANK ELEV
       Q          QLOB       QCH        QROB       ALOB       ACH        AROB       VOL        TWA        R-BANK ELEV
       TIME       VLOB       VCH        VROB       XNL        XNCH       XNR        WTN        ELMIN      SSTA
       SLOPE      XLOBL      XLCH       XLOBR      ITRIAL     IDC        ICONT      CORAR      TOPWID     ENDST


  FLOW DISTRIBUTION FOR SECNO=      10.00           CWSEL=    1203.20

  STA=     3544.     4511.
    PER Q=     100.0
     AREA=  18286.4
      VEL=      16.3
    DEPTH=      19.4

 CCHV=      .300 CEHV=      .500
 *SECNO 11.000

 3301 HV CHANGED MORE THAN HVINS


 3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA=      1207.30 ELREA=      1204.10

      11.000     17.64    1203.64        .00        .00    1209.40       5.76       1.25        .82    1207.30
    298000.0        .0   298000.0        .0         .0    15474.2         .0     2699.9      117.8    1204.10
         .10       .00      19.26        .00       .000       .035       .000       .000    1186.00    3545.51
     .004775      114.       328.       590.          2          0          0        .00     911.65    4457.16


  FLOW DISTRIBUTION FOR SECNO=      11.00           CWSEL=    1203.64

  STA=     3546.     4458.
    PER Q=     100.0
     AREA=  15474.2
      VEL=      19.3
    DEPTH=      17.0


 SPECIAL BRIDGE

 5227 DOWNSTREAM ELEV IS     1197.98 , NOT     1203.64 HYDRAULIC JUMP OCCURS DOWNSTREAM (IF LOW FLOW CONTROLS)

 SB  XK         XKOR       COFQ       RDLEN      BWC        BWP        BAREA      SS         ELCHU      ELCHD
        1.05       1.56       2.60        .00     854.00      97.50   15757.00       2.00    1187.60    1186.00

 *SECNO 11.500
  PRESS FLOW BECAUSE EGLWC OF     1215.60   EXCEEDS 1.5 DEPTH
 3280 CROSS SECTION      11.50 EXTENDED        .84 FEET
```

```
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       SECNO      DEPTH      CWSEL      CRIWS      WSELK      EG         HV         HL         OLOSS      L-BANK ELEV
       Q          QLOB       QCH        QROB       ALOB       ACH        AROB       VOL        TWA        R-BANK ELEV
       TIME       VLOB       VCH        VROB       XNL        XNCH       XNR        WTN        ELMIN      SSTA
       SLOPE      XLOBL      XLCH       XLOBR      ITRIAL     IDC        ICONT      CORAR      TOPWID     ENDST
```

3301 HV CHANGED MORE THAN HVINS

PRESSURE AND WEIR FLOW, Weir Submergence Based on TRAPEZOIDAL Shape

| EGPRS | EGLWC | H3 | QWEIR | QPR | BAREA | TRAPEZOID AREA | ELLC | ELTRD | WEIRLN |
|---|---|---|---|---|---|---|---|---|---|
| 1212.30 | 1215.60 | .00 | 16218. | 281713. | 15757. | 13439. | 1204.60 | 1208.70 | 1477. |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 11.500 | 18.93 | 1206.53 | .00 | .00 | 1211.38 | 4.85 | 1.98 | .00 | 1205.70 |
| 298000.0 | 4.3 | 297425.7 | 570.1 | 3.4 | 16815.7 | 273.1 | 2731.3 | 119.9 | 1204.10 |
| .10 | 1.25 | 17.69 | 2.09 | .040 | .035 | .040 | .000 | 1187.60 | 3596.29 |
| .003632 | 84. | 84. | 84. | 4 | 0 | 2 | .00 | 1236.13 | 4832.42 |

FLOW DISTRIBUTION FOR SECNO= 11.50 CWSEL= 1206.53

```
STA=    3596.    3604.    4521.    4536.    4832.
  PER Q=       .0     99.8       .0       .2
   AREA=      3.4  16815.7     25.7    247.4
    VEL=      1.2     17.7      3.1      2.0
  DEPTH=       .4     18.4      1.6       .8
```

*SECNO 12.000
3280 CROSS SECTION 12.00 EXTENDED .78 FEET

3301 HV CHANGED MORE THAN HVINS

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 12.000 | 21.78 | 1209.78 | .00 | .00 | 1212.76 | 2.98 | .82 | .56 | 1222.20 |
| 298000.0 | .0 | 293440.4 | 4559.5 | .0 | 21036.6 | 1454.0 | 2873.7 | 129.3 | 1205.80 |
| .11 | .00 | 13.95 | 3.14 | .000 | .035 | .040 | .000 | 1188.00 | 3577.06 |
| .002003 | 404. | 318. | 213. | 3 | 0 | 0 | .00 | 1626.64 | 5203.70 |

FLOW DISTRIBUTION FOR SECNO= 12.00 CWSEL= 1209.78

```
STA=    3577.    4630.    4777.    5168.    5204.
  PER Q=     98.5       .6       .9       .0
   AREA=  21036.6    468.9    928.2     56.9
    VEL=     13.9      3.6      3.0      2.2
  DEPTH=     20.0      3.2      2.4      1.6
```



| SECNO | DEPTH | CWSEL | CRIWS | WSELK | EG | HV | HL | OLOSS | L-BANK ELEV |
|---|---|---|---|---|---|---|---|---|---|
| Q | QLOB | QCH | QROB | ALOB | ACH | AROB | VOL | TWA | R-BANK ELEV |
| TIME | VLOB | VCH | VROB | XNL | XNCH | XNR | WTN | ELMIN | SSTA |
| SLOPE | XLOBL | XLCH | XLOBR | ITRIAL | IDC | ICONT | CORAR | TOPWID | ENDST |

CCHV= .100 CEHV= .300
*SECNO 13.000

3265 DIVIDED FLOW

3280 CROSS SECTION 13.00 EXTENDED 3.19 FEET

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 13.000 | 22.09 | 1210.59 | .00 | .00 | 1213.57 | 2.98 | .81 | .00 | 1210.70 |
| 298000.0 | .0 | 291438.4 | 6561.6 | .0 | 20818.9 | 1873.7 | 3086.3 | 144.5 | 1209.00 |
| .12 | .00 | 14.00 | 3.50 | .000 | .035 | .040 | .000 | 1188.50 | 3609.30 |
| .001928 | 410. | 410. | 410. | 2 | 0 | 0 | .00 | 1601.86 | 5262.70 |

FLOW DISTRIBUTION FOR SECNO= 13.00 CWSEL= 1210.59

```
STA=    3609.    4613.    4682.    5263.
  PER Q=     97.8       .0      2.2
   AREA=  20818.9     22.7   1851.1
    VEL=     14.0      2.0      3.5
  DEPTH=     20.7       .3      3.2
```

CCHV= .300 CEHV= .500
*SECNO 14.000
3280 CROSS SECTION 14.00 EXTENDED 2.39 FEET

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 14.000 | 22.39 | 1211.39 | .00 | .00 | 1214.60 | 3.20 | .92 | .11 | 1205.80 |

```
   298000.0    8667.8  280665.0    8667.2    1851.8   19020.8    1800.0    3296.7     161.0   1207.40
        .12      4.68     14.76      4.82      .040      .035      .040      .000   1189.00   3281.00
    .002677      404.      404.      404.         1         0         0       .00   1968.60   5249.60


 FLOW DISTRIBUTION FOR SECNO=     14.00          CWSEL=   1211.39

 STA=    3281.    3406.    3419.    3727.    3786.    4797.    5243.    5250.
   PER Q=       .3       .1      2.0       .5     94.2      2.9       .0
    AREA=    297.6     41.7   1229.5    282.9  19020.8   1778.9     21.0
     VEL=      3.4      4.1      4.8      5.5     14.8      4.8      3.3
   DEPTH=      2.4      3.2      4.0      4.8     18.8      4.0      3.2

 *SECNO 15.000
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     SECNO      DEPTH      CWSEL      CRIWS      WSELK      EG         HV         HL         OLOSS      L-BANK ELEV
     Q          QLOB       QCH        QROB       ALOB       ACH        AROB       VOL        TWA        R-BANK ELEV
     TIME       VLOB       VCH        VROB       XNL        XNCH       XNR        WTN        ELMIN      SSTA
     SLOPE      XLOBL      XLCH       XLOBR      ITRIAL     IDC        ICONT      CORAR      TOPWID     ENDST


 3280 CROSS SECTION     15.00 EXTENDED      2.92 FEET


 3301 HV CHANGED MORE THAN HVINS


 3470 ENCROACHMENT STATIONS=         .0    4478.6  TYPE=      1  TARGET=     4478.599
     15.000     22.42   1211.92       .00       .00   1216.04      4.11       .98       .45   1205.80
   298000.0    3664.4  291470.2    2865.4     601.9   17728.4     815.0    3446.5     173.6   1209.00
        .13      6.09     16.44      3.52      .040      .035      .040      .000   1189.50   3343.30
    .003707      312.      312.      312.         2         0         0       .00   1538.80   4882.10


 FLOW DISTRIBUTION FOR SECNO=     15.00          CWSEL=   1211.92

 STA=    3343.    3425.    3481.    4462.    4479.    4498.    4876.    4882.
   PER Q=       .5       .7     97.8       .1       .0       .9       .0
    AREA=    305.5    296.4  17728.4     39.7     37.9    725.0     12.5
     VEL=      5.3      6.9     16.4      4.1      3.5      3.5      2.9
   DEPTH=      3.7      5.3     18.1      2.4      1.9      1.9      1.9

 *SECNO 16.000

 3265 DIVIDED FLOW

 3280 CROSS SECTION     16.00 EXTENDED      5.67 FEET

     16.000     22.07   1213.07       .00       .00   1217.20      4.13      1.16       .01   1207.40
   298000.0    2859.6  289224.5    5915.9     418.2   17490.4    1432.4    3584.3     185.0   1210.70
        .13      6.84     16.54      4.13      .040      .035      .040      .000   1191.00   3281.00
    .003699      312.      312.      312.         2         0         0       .00   1637.40   5256.20


 FLOW DISTRIBUTION FOR SECNO=     16.00          CWSEL=   1213.07

 STA=    3281.    3355.    4308.    4390.    4436.    4830.    4912.    5194.    5256.
   PER Q=      1.0     97.1       .3       .1       .2       .4       .9       .1
    AREA=    418.2  17490.4    194.1     71.9    136.6    264.1    667.8     97.8
     VEL=      6.8     16.5      4.0      3.0      4.7      4.9      4.0      3.0
   DEPTH=      5.7     18.3      2.4      1.6       .3      3.2      2.4      1.6

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     SECNO      DEPTH      CWSEL      CRIWS      WSELK      EG         HV         HL         OLOSS      L-BANK ELEV
     Q          QLOB       QCH        QROB       ALOB       ACH        AROB       VOL        TWA        R-BANK ELEV
     TIME       VLOB       VCH        VROB       XNL        XNCH       XNR        WTN        ELMIN      SSTA
     SLOPE      XLOBL      XLCH       XLOBR      ITRIAL     IDC        ICONT      CORAR      TOPWID     ENDST


 *SECNO 17.000

 3265 DIVIDED FLOW

 3280 CROSS SECTION     17.00 EXTENDED      3.61 FEET
```

```
 3301 HV CHANGED MORE THAN HVINS


 3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE,  KRATIO =  1.49


 3470 ENCROACHMENT STATIONS=      3566.0     5873.0   TYPE=       1   TARGET=     -3566.000
      17.000      24.91    1215.91       .00       .00    1218.70      2.79       1.10        .40  100000.00
    345000.0         .0   332750.6   12249.4        .0    24413.6    3008.2     3795.8      201.7    1209.00
         .14        .00      13.63      4.07      .000       .035      .040       .000    1191.00    3566.00
     .002239       394.       394.      394.         3          0         0        .00    2065.01    5873.00


 FLOW DISTRIBUTION FOR SECNO=      17.00          CWSEL=   1215.91

 STA=    3566.    4744.    4764.    4800.    5082.    5194.    5873.
   PER Q=      96.4       .2       .1       .0       .3      2.9
    AREA=  24413.6    119.3     99.5     31.8    307.5   2450.2
     VEL=     13.6      5.8      3.4      1.7      3.5      4.1
   DEPTH=     20.7      6.1      2.8       .1      2.8      3.6

 *SECNO 18.000

 3470 ENCROACHMENT STATIONS=      3405.0     4570.4   TYPE=       1   TARGET=     -3405.000
      18.000      25.36    1216.36       .00       .00    1219.52      3.15        .63        .18  100000.00
    345000.0         .0   344519.0     481.0        .0    24164.7     132.7     3990.5      213.4    1210.70
         .15        .00      14.26      3.62      .000       .035      .040       .000    1191.00    3405.00
     .001697       328.       328.      328.         2          0         0        .00    1052.55    4457.55


 FLOW DISTRIBUTION FOR SECNO=      18.00          CWSEL=   1216.36

 STA=    3405.    4416.    4446.    4458.
   PER Q=      99.9       .1       .0
    AREA=  24164.7    118.8     13.9
     VEL=     14.3      3.9      1.7
   DEPTH=     23.9      4.0      1.2

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      SECNO      DEPTH      CWSEL      CRIWS      WSELK      EG         HV         HL         OLOSS      L-BANK ELEV
      Q          QLOB       QCH        QROB       ALOB       ACH        AROB       VOL        TWA        R-BANK ELEV
      TIME       VLOB       VCH        VROB       XNL        XNCH       XNR        WTN        ELMIN      SSTA
      SLOPE      XLOBL      XLCH       XLOBR      ITRIAL     IDC        ICONT      CORAR      TOPWID     ENDST


 CCHV=      .100 CEHV=      .300
 *SECNO 19.000
 3280 CROSS SECTION     19.00 EXTENDED      3.16 FEET

      19.000      25.86    1217.06       .00       .00    1220.33      3.27        .78        .03    1222.10
    345000.0         .0   345000.0        .0        .0    23779.4        .0     4189.7      223.7    1213.90
         .16        .00      14.51       .00      .000       .035      .000       .000    1191.20     189.21
     .002724       433.       361.      358.         2          0         0        .00    1411.79    1601.00


 FLOW DISTRIBUTION FOR SECNO=      19.00          CWSEL=   1217.06

 STA=      189.     1601.
   PER Q=     100.0
    AREA=  23779.4
     VEL=     14.5
   DEPTH=     16.8

 *SECNO 20.000

 3301 HV CHANGED MORE THAN HVINS

      20.000      25.93    1217.13       .00       .00    1221.71      4.57        .99        .39    1210.70
    345000.0    12697.6   332302.4        .0    2125.5    19045.3        .0     4372.3      234.7    1217.30
         .16       5.97      17.45       .00      .040       .035      .000       .000    1191.20    3839.57
     .002872       351.       354.      367.         2          0         0        .00    1306.77    5146.35


 FLOW DISTRIBUTION FOR SECNO=      20.00          CWSEL=   1217.13

 STA=    3840.    3977.    4259.    5148.
```

```
   PER Q=        .8       2.9      96.3
    AREA=     533.4    1592.1   19045.3
     VEL=       5.0       6.3      17.4
   DEPTH=       3.9       5.6      21.5

 *SECNO 21.000

 3265 DIVIDED FLOW

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      SECNO       DEPTH       CWSEL       CRIWS       WSELK       EG          HV          HL          OLOSS       L-BANK ELEV
      Q           QLOB        QCH         QROB        ALOB        ACH         AROB        VOL         TWA         R-BANK ELEV
      TIME        VLOB        VCH         VROB        XNL         XNCH        XNR         WTN         ELMIN       SSTA
      SLOPE       XLOBL       XLCH        XLOBR       ITRIAL      IDC         ICONT       CORAR       TOPWID      ENDST


 3280 CROSS SECTION      21.00 EXTENDED       6.10 FEET


 3301 HV CHANGED MORE THAN HVINS


 3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE,  KRATIO =  1.41

      21.000      28.80   1220.10        .00        .00   1222.81       2.72        .92        .19   1202.50
    345000.0     4648.2  340351.8         .0      845.1   25581.6         .0     4635.7      249.0   1236.90
         .17       5.50     13.30        .00       .040      .035       .000       .000    1191.30   3625.50
     .001445       574.      476.       312.          3         0          0        .00    1196.55   5023.59


 FLOW DISTRIBUTION FOR SECNO=      21.00           CWSEL=    1220.10

 STA=     3626.     3662.     3947.     5063.
   PER Q=        .1       1.3      98.7
    AREA=     111.5     733.6   25581.6
     VEL=       2.7       5.9      13.3
   DEPTH=       3.0       2.6      23.8

 *SECNO 22.000
      22.000      29.03   1220.43        .00        .00   1223.55       3.12        .62        .12   1210.60
    345000.0     1764.2  343156.4       79.4      528.2   24138.2       62.4     4869.5      260.9   1218.90
         .18       3.34     14.22       1.27       .040      .035       .040       .000    1191.40   3918.11
     .001679       558.      394.       246.          2         0          0        .00    1327.74   5245.86


 FLOW DISTRIBUTION FOR SECNO=      22.00           CWSEL=    1220.43

 STA=     3918.     4104.     4147.     5164.     5246.
   PER Q=        .2        .3      99.5        .0
    AREA=     281.9     246.4   24138.2      62.4
     VEL=       2.0       4.8      14.2       1.3
   DEPTH=       1.5       5.7      23.7        .8

 *SECNO 23.000
 3280 CROSS SECTION      23.00 EXTENDED       7.81 FEET

      23.000      29.71   1221.31        .00        .00   1224.20       2.89        .63        .02   1214.00
    345000.0    15811.0  329189.0         .0     2830.2   23652.1         .0     5103.0      273.2   1218.90
         .19       5.59     13.92        .00       .040      .035       .000       .000    1191.60   4006.00
     .001512       443.      394.       328.          2         0          0        .00    1319.10   5325.10


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      SECNO       DEPTH       CWSEL       CRIWS       WSELK       EG          HV          HL          OLOSS       L-BANK ELEV
      Q           QLOB        QCH         QROB        ALOB        ACH         AROB        VOL         TWA         R-BANK ELEV
      TIME        VLOB        VCH         VROB        XNL         XNCH        XNR         WTN         ELMIN       SSTA
      SLOPE       XLOBL       XLCH        XLOBR       ITRIAL      IDC         ICONT       CORAR       TOPWID      ENDST


 FLOW DISTRIBUTION FOR SECNO=      23.00           CWSEL=    1221.31

 STA=     4006.     4308.     4370.     5325.
   PER Q=       3.8        .8      95.4
    AREA=    2359.1     471.1   23652.1
```

```
      VEL=       5.6       5.6      13.9
    DEPTH=       7.8       7.6      24.8

 *SECNO 24.000
 3280 CROSS SECTION     24.00 EXTENDED      8.17 FEET

     24.000     30.37   1222.17       .00       .00   1224.69      2.52       .45       .04   1214.00
   345000.0   13845.2  330709.2     445.6    2679.5   25504.1     190.4    5315.6     284.1   1217.30
        .19      5.17     12.97      2.34      .040      .035      .040      .000   1191.80   4275.00
    .001215      427.      328.      262.         2         0         0       .00   1384.21   5659.21


 FLOW DISTRIBUTION FOR SECNO=     24.00          CWSEL=    1222.17

 STA=    4275.    4603.    5581.    5659.
   PER Q=       4.0      95.9        .1
    AREA=    2679.5   25504.1     190.4
     VEL=       5.2      13.0       2.3
   DEPTH=       8.2      26.1       2.4

 *SECNO 25.000
 3280 CROSS SECTION     25.00 EXTENDED      8.90 FEET

     25.000     31.00   1222.90       .00       .00   1225.07      2.17       .35       .03   1214.00
   345000.0    6460.8  335528.6    3010.6    1377.1   28026.5     852.0    5536.3     294.2   1215.60
        .20      4.69     11.97      3.53      .040      .035      .040      .000   1191.90   4432.00
    .000932      328.      328.      328.         2         0         0       .00   1299.90   5731.90


 FLOW DISTRIBUTION FOR SECNO=     25.00          CWSEL=    1222.90

 STA=    4432.    4587.    5581.    5732.
   PER Q=       1.9      97.3        .9
    AREA=    1377.1   28026.5     852.0
     VEL=       4.7      12.0       3.5
   DEPTH=       8.9      28.2       5.6

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      SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS     L-BANK ELEV
      Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA       R-BANK ELEV
      TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN     SSTA
      SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID    ENDST


 *SECNO 26.000
 3280 CROSS SECTION     26.00 EXTENDED      9.15 FEET

     26.000     31.05   1223.15       .00       .00   1225.43      2.29       .33       .03   1227.00
   345000.0        .0  335584.2    9415.8        .0   27333.4    1943.7    5760.5     303.9   1212.30
        .21       .00     12.28      4.84      .000      .035      .040      .000   1192.10   4503.32
    .001099      328.      328.      328.         2         0         0       .00   1296.68   5800.00


 FLOW DISTRIBUTION FOR SECNO=     26.00          CWSEL=    1223.15

 STA=    4503.    5558.    5587.    5590.    5646.    5800.
   PER Q=      97.3        .5        .0        .5       1.7
    AREA=   27333.4     291.4      25.3     403.1    1223.9
     VEL=      12.3       5.7       4.7       4.6       4.7
   DEPTH=      25.9      10.0       8.4       7.2       7.9

 *SECNO 27.000
 3280 CROSS SECTION     27.00 EXTENDED      4.64 FEET

     27.000     31.34   1223.44       .00       .00   1225.86      2.42       .38       .04   1218.80
   345000.0        .0  342432.1    2567.9        .0   27350.0     622.3    5976.0     313.5   1215.50
        .22       .00     12.52      4.13      .000      .035      .040      .000   1192.10   4459.00
    .001247      328.      328.      328.         2         0         0       .00   1231.00   5690.00


 FLOW DISTRIBUTION FOR SECNO=     27.00          CWSEL=    1223.44

 STA=    4459.    5581.    5604.    5690.
   PER Q=      99.3        .2        .5
    AREA=   27350.0     163.1     459.2
     VEL=      12.5       4.8       3.9
   DEPTH=      24.4       7.1       5.3
```

*SECNO 28.000
3280 CROSS SECTION 28.00 EXTENDED 5.66 FEET

3301 HV CHANGED MORE THAN HVINS

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 28.000 | 32.06 | 1224.46 | .00 | .00 | 1226.27 | 1.81 | .35 | .06 | 1220.50 |
| 345000.0 | .0 | 343335.1 | 1665.0 | .0 | 31726.1 | 445.8 | 6203.3 | 323.4 | 1217.20 |
| .23 | .00 | 10.82 | 3.73 | .000 | .035 | .040 | .000 | 1192.40 | 4386.00 |
| .000933 | 262. | 328. | 394. | 2 | 0 | 0 | .00 | 1375.00 | 5761.00 |

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| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| SECNO | DEPTH | CWSEL | CRIWS | WSELK | EG | HV | HL | OLOSS | L-BANK ELEV |
| Q | QLOB | QCH | QROB | ALOB | ACH | AROB | VOL | TWA | R-BANK ELEV |
| TIME | VLOB | VCH | VROB | XNL | XNCH | XNR | WTN | ELMIN | SSTA |
| SLOPE | XLOBL | XLCH | XLOBR | ITRIAL | IDC | ICONT | CORAR | TOPWID | ENDST |

FLOW DISTRIBUTION FOR SECNO= 28.00 CWSEL= 1224.46

| | | | |
|---|---|---|---|
| STA= | 4386. | 5692. | 5761. |
| PER Q= | 99.5 | .5 | |
| AREA= | 31726.1 | 445.8 | |
| VEL= | 10.8 | 3.7 | |
| DEPTH= | 24.3 | 6.5 | |

*SECNO 29.000
3280 CROSS SECTION 29.00 EXTENDED 6.46 FEET

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 29.000 | 32.36 | 1224.96 | .00 | .00 | 1226.57 | 1.62 | .29 | .02 | 1220.50 |
| 345000.0 | 256.9 | 335949.5 | 8793.5 | 104.2 | 32552.2 | 2215.0 | 6455.7 | 334.8 | 1217.20 |
| .23 | 2.47 | 10.32 | 3.97 | .040 | .035 | .040 | .000 | 1192.60 | 4413.00 |
| .000821 | 328. | 328. | 328. | 2 | 0 | 0 | .00 | 1640.00 | 6053.00 |

FLOW DISTRIBUTION FOR SECNO= 29.00 CWSEL= 1224.96

| | | | | | |
|---|---|---|---|---|---|
| STA= | 4413. | 4439. | 5751. | 5856. | 6053. |
| PER Q= | .1 | 97.4 | 1.0 | 1.6 | |
| AREA= | 104.2 | 32552.2 | 814.6 | 1400.4 | |
| VEL= | 2.5 | 10.3 | 4.2 | 3.9 | |
| DEPTH= | 4.0 | 24.8 | 7.8 | 7.1 | |

*SECNO 30.000
3280 CROSS SECTION 30.00 EXTENDED 4.94 FEET

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 30.000 | 31.24 | 1225.44 | .00 | .00 | 1226.86 | 1.42 | .27 | .02 | 1222.10 |
| 345000.0 | .0 | 343208.5 | 1791.5 | .0 | 35771.9 | 540.2 | 6723.7 | 347.2 | 1218.50 |
| .24 | .00 | 9.59 | 3.32 | .000 | .035 | .040 | .000 | 1194.20 | 4304.00 |
| .000795 | 328. | 328. | 328. | 2 | 0 | 0 | .00 | 1660.00 | 5964.00 |

FLOW DISTRIBUTION FOR SECNO= 30.00 CWSEL= 1225.44

| | | | |
|---|---|---|---|
| STA= | 4304. | 5873. | 5964. |
| PER Q= | 99.5 | .5 | |
| AREA= | 35771.9 | 540.2 | |
| VEL= | 9.6 | 3.3 | |
| DEPTH= | 22.8 | 5.9 | |

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THIS RUN EXECUTED 27MAR00 08:51:31

*************************************
HEC-2 WATER SURFACE PROFILES

Version 4.6.2; May 1991
*************************************

NOTE- ASTERISK (*) AT LEFT OF CROSS-SECTION NUMBER INDICATES MESSAGE IN SUMMARY OF ERRORS LIST

FUTURE 100-YR

SUMMARY PRINTOUT

| | SECNO | CWSEL | Q | QLOB | QCH | QROB | VLOB | VCH | VROB | DEPTH | TOPWID | FRCH |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1.000 | 1182.88 | 220000.00 | .00 | 219752.30 | 247.75 | .00 | 10.13 | 2.90 | 23.08 | 1060.40 | .39 |
| | 1.000 | 1189.33 | 345000.00 | .00 | 343845.10 | 1154.97 | .00 | 12.10 | 4.54 | 29.53 | 1068.00 | .41 |
| | 2.000 | 1183.24 | 220000.00 | .00 | 219820.80 | 179.20 | .00 | 10.82 | 1.78 | 23.44 | 1009.09 | .40 |
| | 2.000 | 1189.63 | 345000.00 | .00 | 341415.20 | 3584.87 | .00 | 13.02 | 4.56 | 29.83 | 1050.94 | .43 |
| * | 3.000 | 1184.58 | 220000.00 | .00 | 219847.80 | 152.19 | .00 | 7.65 | 1.81 | 24.78 | 1252.26 | .28 |
| * | 3.000 | 1191.41 | 345000.00 | .00 | 342885.70 | 2114.29 | .00 | 9.23 | 2.80 | 31.61 | 1376.71 | .30 |
| | 4.000 | 1185.10 | 220000.00 | .00 | 220000.00 | .00 | .00 | 6.44 | .00 | 25.30 | 1634.99 | .25 |
| | 4.000 | 1192.13 | 345000.00 | .00 | 345000.00 | .00 | .00 | 7.53 | .00 | 32.33 | 1692.64 | .25 |
| * | 5.000 | 1187.82 | 203000.00 | .00 | 203000.00 | .00 | .00 | 20.35 | .00 | 19.82 | 797.15 | 1.01 |
| * | 5.000 | 1191.56 | 298000.00 | .00 | 298000.00 | .00 | .00 | 22.97 | .00 | 23.56 | 811.30 | 1.01 |
| * | 6.000 | 1193.95 | 203000.00 | .00 | 203000.00 | .00 | .00 | 14.08 | .00 | 21.05 | 855.28 | .60 |
| * | 6.000 | 1198.47 | 298000.00 | .00 | 298000.00 | .00 | .00 | 16.26 | .00 | 25.57 | 884.07 | .63 |
| | 7.000 | 1195.71 | 203000.00 | .00 | 203000.00 | .00 | .00 | 13.99 | .00 | 21.21 | 915.65 | .62 |
| | 7.000 | 1200.34 | 298000.00 | .00 | 298000.00 | .00 | .00 | 15.88 | .00 | 25.84 | 923.43 | .62 |
| | 8.000 | 1197.05 | 203000.00 | .00 | 203000.00 | .00 | .00 | 13.93 | .00 | 20.85 | 909.56 | .61 |
| | 8.000 | 1201.57 | 298000.00 | .00 | 298000.00 | .00 | .00 | 15.90 | .00 | 25.37 | 929.37 | .62 |
| | 9.000 | 1198.00 | 203000.00 | .00 | 203000.00 | .00 | .00 | 13.76 | .00 | 21.80 | 914.64 | .60 |
| | 9.000 | 1202.48 | 298000.00 | .00 | 298000.00 | .00 | .00 | 15.78 | .00 | 26.28 | 931.82 | .62 |
| | 10.000 | 1198.76 | 203000.00 | .00 | 203000.00 | .00 | .00 | 14.34 | .00 | 20.96 | 919.17 | .64 |
| | 10.000 | 1203.20 | 298000.00 | .00 | 298000.00 | .00 | .00 | 16.30 | .00 | 25.40 | 941.48 | .65 |
| | 11.000 | 1199.41 | 203000.00 | .00 | 203000.00 | .00 | .00 | 17.42 | .00 | 13.41 | 895.14 | .85 |
| | 11.000 | 1203.64 | 298000.00 | .00 | 298000.00 | .00 | .00 | 19.26 | .00 | 17.64 | 911.65 | .82 |

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| | SECNO | CWSEL | Q | QLOB | QCH | QROB | VLOB | VCH | VROB | DEPTH | TOPWID | FRCH |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| * | 11.500 | 1204.95 | 203000.00 | .00 | 202996.50 | 3.52 | .00 | 13.21 | 1.00 | 17.35 | 923.27 | .57 |
| * | 11.500 | 1206.53 | 298000.00 | 4.27 | 297425.70 | 570.05 | 1.25 | 17.69 | 2.09 | 18.93 | 1236.13 | .73 |
| | 12.000 | 1206.38 | 203000.00 | .00 | 202989.30 | 10.72 | .00 | 11.61 | .68 | 18.38 | 1097.92 | .50 |
| | 12.000 | 1209.78 | 298000.00 | .00 | 293440.40 | 4559.54 | .00 | 13.95 | 3.14 | 21.78 | 1626.64 | .55 |
| | 13.000 | 1207.06 | 203000.00 | .00 | 203000.00 | .00 | .00 | 11.74 | .00 | 18.56 | 993.56 | .50 |
| | 13.000 | 1210.59 | 298000.00 | .00 | 291438.40 | 6561.60 | .00 | 14.00 | 3.50 | 22.09 | 1601.86 | .54 |
| | 14.000 | 1207.61 | 203000.00 | 152.32 | 202787.50 | 60.21 | 1.23 | 13.21 | .65 | 18.61 | 1720.86 | .60 |
| | 14.000 | 1211.39 | 298000.00 | 8667.81 | 280665.00 | 8667.21 | 4.68 | 14.76 | 4.82 | 22.39 | 1968.60 | .60 |
| | 15.000 | 1208.27 | 203000.00 | 285.57 | 202714.40 | .00 | 2.56 | 14.11 | .00 | 18.77 | 946.07 | .65 |
| | 15.000 | 1211.92 | 298000.00 | 3664.36 | 291470.20 | 2865.44 | 6.09 | 16.44 | 3.52 | 22.42 | 1538.80 | .68 |
| | 16.000 | 1209.14 | 203000.00 | 383.23 | 202616.50 | .27 | 2.98 | 14.48 | .36 | 18.14 | 904.12 | .67 |
| | 16.000 | 1213.07 | 298000.00 | 2859.60 | 289224.50 | 5915.90 | 6.84 | 16.54 | 4.13 | 22.07 | 1637.40 | .68 |
| * | 17.000 | 1211.73 | 220000.00 | .00 | 219912.70 | 87.26 | .00 | 11.06 | 2.13 | 20.73 | 1035.61 | .47 |
| * | 17.000 | 1215.91 | 345000.00 | .00 | 332750.60 | 12249.38 | .00 | 13.63 | 4.07 | 24.91 | 2065.01 | .53 |
| | 18.000 | 1212.22 | 220000.00 | .00 | 219988.40 | 11.59 | .00 | 11.01 | 1.11 | 21.22 | 1024.87 | .44 |
| | 18.000 | 1216.36 | 345000.00 | .00 | 344519.00 | 481.00 | .00 | 14.26 | 3.62 | 25.36 | 1052.55 | .51 |
| * | 19.000 | 1212.53 | 220000.00 | .00 | 220000.00 | .00 | .00 | 12.62 | .00 | 21.33 | 1384.32 | .63 |
| | 19.000 | 1217.06 | 345000.00 | .00 | 345000.00 | .00 | .00 | 14.51 | .00 | 25.86 | 1411.79 | .62 |
| | 20.000 | 1213.03 | 220000.00 | 1058.51 | 218941.50 | .00 | 2.33 | 14.15 | .00 | 21.83 | 1192.83 | .59 |
| | 20.000 | 1217.13 | 345000.00 | 12697.62 | 332302.40 | .00 | 5.97 | 17.45 | .00 | 25.93 | 1306.77 | .66 |
| | 21.000 | 1215.27 | 220000.00 | 1722.73 | 218277.30 | .00 | 4.40 | 10.69 | .00 | 23.97 | 1133.65 | .43 |
| * | 21.000 | 1220.10 | 345000.00 | 4648.23 | 340351.80 | .00 | 5.50 | 13.30 | .00 | 28.80 | 1196.55 | .48 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 22.000 | 1215.62 | 220000.00 | 168.22 | 219831.80 | .00 | 2.55 | 11.40 | .00 | 24.22 | 1021.26 | .46 |
| 22.000 | 1220.43 | 345000.00 | 1764.23 | 343156.40 | 79.40 | 3.34 | 14.22 | 1.27 | 29.03 | 1327.74 | .51 |
| 23.000 | 1216.13 | 220000.00 | 2475.63 | 217524.40 | .00 | 2.62 | 11.62 | .00 | 24.53 | 1310.06 | .46 |
| 23.000 | 1221.31 | 345000.00 | 15811.00 | 329189.00 | .00 | 5.59 | 13.92 | .00 | 29.71 | 1319.10 | .49 |
| 24.000 | 1216.89 | 220000.00 | 2374.95 | 217625.00 | .00 | 2.50 | 10.70 | .00 | 25.09 | 1303.73 | .41 |
| 24.000 | 1222.17 | 345000.00 | 13845.16 | 330709.20 | 445.62 | 5.17 | 12.97 | 2.34 | 30.37 | 1384.21 | .45 |
| 25.000 | 1217.56 | 220000.00 | 1326.79 | 218582.30 | 90.87 | 2.41 | 9.62 | 1.03 | 25.66 | 1238.64 | .35 |
| 25.000 | 1222.90 | 345000.00 | 6460.79 | 335528.60 | 3010.63 | 4.69 | 11.97 | 3.53 | 31.00 | 1299.90 | .40 |
| 26.000 | 1217.75 | 220000.00 | .00 | 218517.10 | 1482.86 | .00 | 10.08 | 2.32 | 25.65 | 1285.03 | .39 |
| 26.000 | 1223.15 | 345000.00 | .00 | 335584.20 | 9415.77 | .00 | 12.28 | 4.84 | 31.05 | 1296.68 | .43 |
| 27.000 | 1218.05 | 220000.00 | .00 | 219917.10 | 82.91 | .00 | 10.32 | 1.48 | 25.95 | 1183.40 | .42 |
| 27.000 | 1223.44 | 345000.00 | .00 | 342432.10 | 2567.90 | .00 | 12.52 | 4.13 | 31.34 | 1231.00 | .45 |



| SECNO | CWSEL | Q | QLOB | QCH | QROB | VLOB | VCH | VROB | DEPTH | TOPWID | FRCH |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 28.000 | 1218.81 | 220000.00 | .00 | 219945.00 | 55.00 | .00 | 9.03 | .98 | 26.41 | 1369.51 | .37 |
| 28.000 | 1224.46 | 345000.00 | .00 | 343335.10 | 1664.96 | .00 | 10.82 | 3.73 | 32.06 | 1375.00 | .39 |
| 29.000 | 1219.18 | 220000.00 | .00 | 219306.20 | 693.83 | .00 | 8.78 | 1.48 | 26.58 | 1608.47 | .35 |
| 29.000 | 1224.96 | 345000.00 | 256.94 | 335949.50 | 8793.52 | 2.47 | 10.32 | 3.97 | 32.36 | 1640.00 | .37 |
| 30.000 | 1219.61 | 220000.00 | .00 | 219980.00 | 19.97 | .00 | 8.24 | .72 | 25.41 | 1561.83 | .35 |
| 30.000 | 1225.44 | 345000.00 | .00 | 343208.50 | 1791.49 | .00 | 9.59 | 3.32 | 31.24 | 1660.00 | .35 |



FUTURE 100-YR

SUMMARY PRINTOUT

| | SECNO | CWSEL | CRIWS | EG | HL | OLOSS | ELMIN | 10*KS | K*CHSL | XLCH | SSTA | ENDST |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1.000 | 1182.88 | .00 | 1184.47 | .00 | .00 | 1159.80 | 10.00 | .00 | .00 | 328.00 | 1388.40 |
| | 1.000 | 1189.33 | .00 | 1191.60 | .00 | .00 | 1159.80 | 10.05 | .00 | .00 | 328.00 | 1396.00 |
| | 2.000 | 1183.24 | .00 | 1185.06 | .52 | .07 | 1159.80 | 10.52 | .00 | 505.00 | 363.69 | 1372.78 |
| | 2.000 | 1189.63 | .00 | 1192.24 | .54 | .10 | 1159.80 | 11.20 | .00 | 505.00 | 342.88 | 1393.82 |
| * | 3.000 | 1184.58 | .00 | 1185.49 | .34 | .09 | 1159.80 | 4.89 | .00 | 509.00 | 340.55 | 1592.80 |
| * | 3.000 | 1191.41 | .00 | 1192.73 | .36 | .13 | 1159.80 | 5.11 | .00 | 509.00 | 331.63 | 1708.34 |
| | 4.000 | 1185.10 | .00 | 1185.75 | .24 | .03 | 1159.80 | 4.02 | .00 | 535.00 | 339.86 | 1974.86 |
| | 4.000 | 1192.13 | .00 | 1193.01 | .24 | .04 | 1159.80 | 3.89 | .00 | 535.00 | 330.70 | 2023.34 |
| * | 5.000 | 1187.82 | 1187.82 | 1194.26 | 4.38 | -.35 | 1168.00 | 80.40 | 15.05 | 545.00 | 328.00 | 1125.15 |
| * | 5.000 | 1191.56 | 1191.56 | 1199.75 | 4.05 | .27 | 1168.00 | 74.30 | 15.05 | 545.00 | 328.00 | 1139.30 |
| * | 6.000 | 1193.95 | .00 | 1197.03 | 2.44 | .34 | 1172.90 | 25.94 | 7.87 | 623.00 | 339.60 | 1194.87 |
| * | 6.000 | 1198.47 | .00 | 1202.57 | 2.42 | .41 | 1172.90 | 26.27 | 7.87 | 623.00 | 331.96 | 1216.02 |
| | 7.000 | 1195.71 | .00 | 1198.75 | 1.71 | .00 | 1174.50 | 27.58 | 2.50 | 640.00 | 328.00 | 1243.65 |
| | 7.000 | 1200.34 | .00 | 1204.25 | 1.66 | .02 | 1174.50 | 25.72 | 2.50 | 640.00 | 328.00 | 1251.43 |
| | 8.000 | 1197.05 | .00 | 1200.07 | 1.31 | .00 | 1176.20 | 26.89 | 3.53 | 482.00 | 3343.25 | 4252.81 |
| | 8.000 | 1201.57 | .00 | 1205.50 | 1.24 | .00 | 1176.20 | 25.87 | 3.53 | 482.00 | 3332.50 | 4261.87 |
| | 9.000 | 1198.00 | .00 | 1200.94 | .87 | .01 | 1176.20 | 26.08 | .00 | 328.00 | 3470.02 | 4384.66 |
| | 9.000 | 1202.48 | .00 | 1206.35 | .84 | .01 | 1176.20 | 25.35 | .00 | 328.00 | 3463.76 | 4395.58 |
| | 10.000 | 1198.76 | .00 | 1201.96 | .94 | .08 | 1177.80 | 30.09 | 4.78 | 335.00 | 3556.55 | 4475.72 |
| | 10.000 | 1203.20 | .00 | 1207.33 | .90 | .08 | 1177.80 | 28.58 | 4.78 | 335.00 | 3543.78 | 4485.26 |
| | 11.000 | 1199.41 | .00 | 1204.12 | 1.40 | .76 | 1186.00 | 55.52 | 25.00 | 328.00 | 3554.46 | 4449.60 |
| | 11.000 | 1203.64 | .00 | 1209.40 | 1.25 | .82 | 1186.00 | 47.75 | 25.00 | 328.00 | 3545.51 | 4457.16 |
| * | 11.500 | 1204.95 | .00 | 1207.66 | 3.54 | .00 | 1187.60 | 22.82 | 19.05 | 84.00 | 3605.82 | 4529.10 |
| * | 11.500 | 1206.53 | .00 | 1211.38 | 1.98 | .00 | 1187.60 | 36.32 | 19.05 | 84.00 | 3596.29 | 4832.42 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 12.000 | 1206.38 | .00 | 1208.48 | .63 | .19 | 1188.00 | 17.57 | 1.26 | 318.00 | 3585.33 | 4683.25 |
| 12.000 | 1209.78 | .00 | 1212.76 | .82 | .56 | 1188.00 | 20.03 | 1.26 | 318.00 | 3577.06 | 5203.70 |
| 13.000 | 1207.06 | .00 | 1209.20 | .71 | .01 | 1188.50 | 17.09 | 1.22 | 410.00 | 3615.65 | 4609.21 |
| 13.000 | 1210.59 | .00 | 1213.57 | .81 | .00 | 1188.50 | 19.28 | 1.22 | 410.00 | 3609.30 | 5262.70 |
| 14.000 | 1207.61 | .00 | 1210.32 | .83 | .28 | 1189.00 | 24.74 | 1.24 | 404.00 | 3417.10 | 5243.86 |
| 14.000 | 1211.39 | .00 | 1214.60 | .92 | .11 | 1189.00 | 26.77 | 1.24 | 404.00 | 3281.00 | 5249.60 |
| 15.000 | 1208.27 | .00 | 1211.35 | .85 | .19 | 1189.50 | 29.93 | 1.60 | 312.00 | 3381.24 | 4459.91 |
| 15.000 | 1211.92 | .00 | 1216.04 | .98 | .45 | 1189.50 | 37.07 | 1.60 | 312.00 | 3343.30 | 4882.10 |



| | SECNO | CWSEL | CRIWS | EG | HL | OLOSS | ELMIN | 10*KS | K*CHSL | XLCH | SSTA | ENDST |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 16.000 | 1209.14 | .00 | 1212.39 | .96 | .08 | 1191.00 | 31.54 | 4.81 | 312.00 | 3281.00 | 4836.58 |
| | 16.000 | 1213.07 | .00 | 1217.20 | 1.16 | .01 | 1191.00 | 36.99 | 4.81 | 312.00 | 3281.00 | 5256.20 |
| * | 17.000 | 1211.73 | .00 | 1213.63 | .83 | .41 | 1191.00 | 15.89 | .00 | 394.00 | 3566.00 | 4771.61 |
| * | 17.000 | 1215.91 | .00 | 1218.70 | 1.10 | .40 | 1191.00 | 22.39 | .00 | 394.00 | 3566.00 | 5873.00 |
| | 18.000 | 1212.22 | .00 | 1214.11 | .47 | .01 | 1191.00 | 12.98 | .00 | 328.00 | 3405.00 | 4429.87 |
| | 18.000 | 1216.36 | .00 | 1219.52 | .63 | .18 | 1191.00 | 16.97 | .00 | 328.00 | 3405.00 | 4457.55 |
| * | 19.000 | 1212.53 | .00 | 1215.00 | .72 | .18 | 1191.20 | 30.33 | .55 | 361.00 | 211.86 | 1596.18 |
| | 19.000 | 1217.06 | .00 | 1220.33 | .78 | .03 | 1191.20 | 27.24 | .55 | 361.00 | 189.21 | 1601.00 |
| | 20.000 | 1213.03 | .00 | 1216.13 | .94 | .19 | 1191.20 | 23.64 | .00 | 354.00 | 3919.94 | 5112.78 |
| | 20.000 | 1217.13 | .00 | 1221.71 | .99 | .39 | 1191.20 | 28.72 | .00 | 354.00 | 3839.57 | 5146.35 |
| | 21.000 | 1215.27 | .00 | 1217.03 | .78 | .13 | 1191.30 | 12.40 | .21 | 476.00 | 3625.50 | 5012.41 |
| * | 21.000 | 1220.10 | .00 | 1222.81 | .92 | .19 | 1191.30 | 14.45 | .21 | 476.00 | 3625.50 | 5023.59 |
| | 22.000 | 1215.62 | .00 | 1217.63 | .52 | .08 | 1191.40 | 14.15 | .25 | 394.00 | 4120.69 | 5141.96 |
| | 22.000 | 1220.43 | .00 | 1223.55 | .62 | .12 | 1191.40 | 16.79 | .25 | 394.00 | 3918.11 | 5245.86 |
| | 23.000 | 1216.13 | .00 | 1218.21 | .56 | .02 | 1191.60 | 14.16 | .51 | 394.00 | 4006.00 | 5316.06 |
| | 23.000 | 1221.31 | .00 | 1224.20 | .63 | .02 | 1191.60 | 15.12 | .51 | 394.00 | 4006.00 | 5325.10 |
| | 24.000 | 1216.89 | .00 | 1218.65 | .41 | .03 | 1191.80 | 11.14 | .61 | 328.00 | 4275.00 | 5578.73 |
| | 24.000 | 1222.17 | .00 | 1224.69 | .45 | .04 | 1191.80 | 12.15 | .61 | 328.00 | 4275.00 | 5659.21 |
| | 25.000 | 1217.56 | .00 | 1218.99 | .30 | .03 | 1191.90 | 7.96 | .30 | 328.00 | 4432.00 | 5670.64 |
| | 25.000 | 1222.90 | .00 | 1225.07 | .35 | .03 | 1191.90 | 9.32 | .30 | 328.00 | 4432.00 | 5731.90 |
| | 26.000 | 1217.75 | .00 | 1219.32 | .29 | .04 | 1192.10 | 9.93 | .61 | 328.00 | 4514.97 | 5800.00 |
| | 26.000 | 1223.15 | .00 | 1225.43 | .33 | .03 | 1192.10 | 10.99 | .61 | 328.00 | 4503.32 | 5800.00 |
| | 27.000 | 1218.05 | .00 | 1219.70 | .35 | .03 | 1192.10 | 11.74 | .00 | 328.00 | 4461.09 | 5644.49 |
| | 27.000 | 1223.44 | .00 | 1225.86 | .38 | .04 | 1192.10 | 12.47 | .00 | 328.00 | 4459.00 | 5690.00 |
| | 28.000 | 1218.81 | .00 | 1220.08 | .34 | .04 | 1192.40 | 9.15 | .91 | 328.00 | 4391.49 | 5761.00 |
| | 28.000 | 1224.46 | .00 | 1226.27 | .35 | .06 | 1192.40 | 9.33 | .91 | 328.00 | 4386.00 | 5761.00 |
| | 29.000 | 1219.18 | .00 | 1220.37 | .29 | .01 | 1192.60 | 8.42 | .61 | 328.00 | 4444.53 | 6053.00 |
| | 29.000 | 1224.96 | .00 | 1226.57 | .29 | .02 | 1192.60 | 8.21 | .61 | 328.00 | 4413.00 | 6053.00 |
| | 30.000 | 1219.61 | .00 | 1220.66 | .27 | .01 | 1194.20 | 8.23 | 4.88 | 328.00 | 4361.49 | 5923.32 |
| | 30.000 | 1225.44 | .00 | 1226.86 | .27 | .02 | 1194.20 | 7.95 | 4.88 | 328.00 | 4304.00 | 5964.00 |



SUMMARY OF ERRORS AND SPECIAL NOTES

```
WARNING SECNO=     3.000  PROFILE=  1  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=     3.000  PROFILE=  2  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

CAUTION SECNO=     5.000  PROFILE=  1  CRITICAL DEPTH ASSUMED
CAUTION SECNO=     5.000  PROFILE=  1  PROBABLE MINIMUM SPECIFIC ENERGY
CAUTION SECNO=     5.000  PROFILE=  1  20 TRIALS ATTEMPTED TO BALANCE WSEL
CAUTION SECNO=     5.000  PROFILE=  2  CRITICAL DEPTH ASSUMED
CAUTION SECNO=     5.000  PROFILE=  2  MINIMUM SPECIFIC ENERGY
```

```
WARNING SECNO=      6.000  PROFILE=  1  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=      6.000  PROFILE=  2  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

CAUTION SECNO=     11.500  PROFILE=  1  HYDRAULIC JUMP D.S.
WARNING SECNO=     11.500  PROFILE=  1  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
CAUTION SECNO=     11.500  PROFILE=  2  HYDRAULIC JUMP D.S.

WARNING SECNO=     17.000  PROFILE=  1  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
WARNING SECNO=     17.000  PROFILE=  2  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

WARNING SECNO=     19.000  PROFILE=  1  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

WARNING SECNO=     21.000  PROFILE=  2  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE
```

# APPENDIX B
# SPLIT-FLOW DATA

## EXPLANATION FOR SPLIT-FLOW DATA

Thirteen different HEC-2 files, all with multiple profiles, were utilized to model the various scenarios and determine the split-flow conditions which exist in the vicinity of the proposed McKellips Road bridge. Because of the number of files, and the size of each, these files were not printed for inclusion in this appendix. As a substitute, the EXCEL spreadsheets which were used to compile the results of the hydraulic analyses are included within this appendix. Hydraulic data were tabulated from the HEC-2 output file (*.OUT) using SUMPO, and the corresponding SUMPO file (*.SMP) imported directly into EXCEL for compilation.

Proposed McKellips Road Bridge
Salt River, Arizona

2/15/2000

Discharge Analysis for Southern Overflow Channel
Design Discharge of 220,000 cfs
Weir Section at Sections 16 and 17 "Drowned Out" by Backwater
Dike at Entrance to Southern Overflow Channel has no Effect on Backwater
Iterative Analysis to Match Water Surface Elevations at Entrance to Southern Overflow Channel

**ENGLISH UNITS (CFS AND FEET)**

EXISTING CONDITIONS

| SOUTHERN OVERFLOW | | | MAIN CHANNEL | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| SECNO | Q | BACKWATER CWSEL | AVE CHN CWSEL | SECNO | Q | CWSEL | SECNO | Q | CWSEL |
| 49.5 | 7000 | 1207.6 | 1210.1 | 16 | 213000 | 1209.2 | 17.0 | 220000 | 1211.0 |
| 49.5 | 8000 | 1208.0 | 1210.1 | 16 | 212000 | 1209.2 | 17.0 | 220000 | 1210.9 |
| 49.5 | 9000 | 1208.3 | 1210.0 | 16 | 211000 | 1209.1 | 17.0 | 220000 | 1210.9 |
| 49.5 | 10000 | 1208.6 | 1209.9 | 16 | 210000 | 1209.1 | 17.0 | 220000 | 1210.8 |
| 49.5 | 11000 | 1208.8 | 1209.9 | 16 | 209000 | 1209.0 | 17.0 | 220000 | 1210.7 |
| 49.5 | 12000 | 1209.1 | 1209.8 | 16 | 208000 | 1209.0 | 17.0 | 220000 | 1210.7 |
| 49.5 | 13000 | 1209.3 | 1209.7 | 16 | 207000 | 1208.9 | 17.0 | 220000 | 1210.6 |
| 49.5 | 14000 | 1209.6 | 1209.7 | 16 | 206000 | 1208.8 | 17.0 | 220000 | 1210.5 |
| 49.5 | 15000 | 1209.9 | 1209.6 | 16 | 205000 | 1208.8 | 17.0 | 220000 | 1210.4 |

FUTURE CONDITIONS

| SOUTHERN OVERFLOW | | | MAIN CHANNEL | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| SECNO | Q | BACKWATER CWSEL | AVE CHN CWSEL | SECNO | Q | CWSEL | SECNO | Q | CWSEL |
| 49.5 | 7000 | 1207.6 | 1211.1 | 16 | 213000 | 1209.7 | 17.0 | 220000 | 1212.5 |
| 49.5 | 8000 | 1208.0 | 1211.0 | 16 | 212000 | 1209.6 | 17.0 | 220000 | 1212.4 |
| 49.5 | 9000 | 1208.3 | 1211.0 | 16 | 211000 | 1209.6 | 17.0 | 220000 | 1212.4 |
| 49.5 | 10000 | 1208.6 | 1210.9 | 16 | 210000 | 1209.5 | 17.0 | 220000 | 1212.3 |
| 49.5 | 11000 | 1208.8 | 1210.8 | 16 | 209000 | 1209.5 | 17.0 | 220000 | 1212.2 |
| 49.5 | 12000 | 1209.1 | 1210.8 | 16 | 208000 | 1209.4 | 17.0 | 220000 | 1212.1 |
| 49.5 | 13000 | 1209.3 | 1210.7 | 16 | 207000 | 1209.4 | 17.0 | 220000 | 1212.1 |
| 49.5 | 14000 | 1209.6 | 1210.6 | 16 | 206000 | 1209.3 | 17.0 | 220000 | 1212.0 |
| 49.5 | 15000 | 1209.9 | 1210.6 | 16 | 205000 | 1209.3 | 17.0 | 220000 | 1211.9 |
| 49.5 | 16000 | 1210.1 | 1210.5 | 16 | 204000 | 1209.2 | 17.0 | 220000 | 1211.8 |
| 49.5 | 17000 | 1210.3 | 1210.4 | 16 | 203000 | 1209.1 | 17.0 | 220000 | 1211.7 |
| 49.5 | 18000 | 1210.6 | 1210.4 | 16 | 202000 | 1209.1 | 17.0 | 220000 | 1211.7 |
| 49.5 | 19000 | 1210.8 | 1210.3 | 16 | 201000 | 1209.0 | 17.0 | 220000 | 1211.6 |
| 49.5 | 20000 | 1211.0 | 1210.2 | 16 | 200000 | 1209.0 | 17.0 | 220000 | 1211.5 |

Proposed McKellips Road Bridge
Salt River, Arizona

2/15/2000

Discharge Analysis for Southern Overflow Channel
*Superflood Discharge of 345,000 cfs*
Weir Section at Sections 16 and 17 "Drowned Out" by Backwater
Dike at Entrance to Southern Overflow Channel has no Effect on Backwater
Iterative Analysis to Match Water Surface Elevations at Entrance to Southern Overflow Channel

**ENGLISH UNITS (CFS AND FEET)**

EXISTING CONDITIONS

| SOUTHERN OVERFLOW | | | MAIN CHANNEL | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| SECNO | Q | BACKWATER CWSEL | AVE CHN CWSEL | SECNO | Q | CWSEL | SECNO | Q | CWSEL |
| 49.5 | 32000 | 1212.7 | 1214.0 | 16 | 313000 | 1213.1 | 17.0 | 345000 | 1215.0 |
| 49.5 | 33000 | 1212.8 | 1214.0 | 16 | 312000 | 1213.0 | 17.0 | 345000 | 1214.9 |
| 49.5 | 34000 | 1212.9 | 1213.9 | 16 | 311000 | 1213.0 | 17.0 | 345000 | 1214.9 |
| 49.5 | 35000 | 1213.0 | 1213.9 | 16 | 310000 | 1212.9 | 17.0 | 345000 | 1214.8 |
| 49.5 | 36000 | 1213.2 | 1213.8 | 16 | 309000 | 1212.9 | 17.0 | 345000 | 1214.8 |
| 49.5 | 37000 | 1213.3 | 1213.8 | 16 | 308000 | 1212.8 | 17.0 | 345000 | 1214.7 |
| 49.5 | 38000 | 1213.4 | 1213.7 | 16 | 307000 | 1212.8 | 17.0 | 345000 | 1214.6 |
| 49.5 | 39000 | 1213.5 | 1213.7 | 16 | 306000 | 1212.8 | 17.0 | 345000 | 1214.6 |
| 49.5 | 40000 | 1213.6 | 1213.6 | 16 | 305000 | 1212.7 | 17.0 | 345000 | 1214.5 |
| 49.5 | 41000 | 1213.7 | 1213.6 | 16 | 304000 | 1212.7 | 17.0 | 345000 | 1214.5 |
| 49.5 | 42000 | 1213.9 | 1213.5 | 16 | 303000 | 1212.6 | 17.0 | 345000 | 1214.4 |
| 49.5 | 43000 | 1214.0 | 1213.5 | 16 | 302000 | 1212.6 | 17.0 | 345000 | 1214.3 |
| 49.5 | 44000 | 1214.1 | 1213.4 | 16 | 301000 | 1212.5 | 17.0 | 345000 | 1214.3 |
| 49.5 | 45000 | 1214.2 | 1213.3 | 16 | 300000 | 1212.5 | 17.0 | 345000 | 1214.2 |

FUTURE CONDITIONS

| SOUTHERN OVERFLOW | | | MAIN CHANNEL | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| SECNO | Q | BACKWATER CWSEL | AVE CHN CWSEL | SECNO | Q | CWSEL | SECNO | Q | CWSEL |
| 49.5 | 45000 | 1214.2 | 1214.6 | 16 | 300000 | 1213.2 | 17.0 | 345000 | 1216.1 |
| 49.5 | 46000 | 1214.3 | 1214.6 | 16 | 299000 | 1213.2 | 17.0 | 345000 | 1216.0 |
| 49.5 | 47000 | 1214.4 | 1214.5 | 16 | 298000 | 1213.1 | 17.0 | 345000 | 1215.9 |
| 49.5 | 48000 | 1214.5 | 1214.4 | 16 | 297000 | 1213.0 | 17.0 | 345000 | 1215.8 |
| 49.5 | 49000 | 1214.6 | 1214.4 | 16 | 296000 | 1213.0 | 17.0 | 345000 | 1215.8 |
| 49.5 | 50000 | 1214.7 | 1214.3 | 16 | 295000 | 1212.9 | 17.0 | 345000 | 1215.7 |
| 49.5 | 51000 | 1214.8 | 1214.3 | 16 | 294000 | 1212.9 | 17.0 | 345000 | 1215.6 |
| 49.5 | 52000 | 1214.9 | 1214.2 | 16 | 293000 | 1212.8 | 17.0 | 345000 | 1215.6 |
| 49.5 | 53000 | 1215.0 | 1214.1 | 16 | 292000 | 1212.8 | 17.0 | 345000 | 1215.5 |
| 49.5 | 54000 | 1215.1 | 1214.1 | 16 | 291000 | 1212.8 | 17.0 | 345000 | 1215.4 |
| 49.5 | 55000 | 1215.2 | 1214.0 | 16 | 290000 | 1212.7 | 17.0 | 345000 | 1215.3 |
| 49.5 | 56000 | 1215.3 | 1214.0 | 16 | 289000 | 1212.7 | 17.0 | 345000 | 1215.3 |
| 49.5 | 57000 | 1215.4 | 1213.9 | 16 | 288000 | 1212.6 | 17.0 | 345000 | 1215.2 |
| 49.5 | 58000 | 1215.4 | 1213.8 | 16 | 287000 | 1212.6 | 17.0 | 345000 | 1215.1 |

Tetra Tech, Inc.
Infrastructure Southwest Group

Proposed McKellips Road Bridge
Salt River, Arizona

2/7/2000

HEC-2 Split-Flow Analysis for Southern Overflow Channel *(ASSUMES NO BACKWATER FROM SOUTHERN OVERFLOW CHANNEL)*
Weir Section between Cross Sections 16 and 17
Determine Split Flows and Water Surface Elevations with and without Dike at Entrance to Southern Overflow Channel

**ENGLISH UNITS (CFS AND FEET)**

EXISTING CONDITIONS, WITH DIKE

| TOTAL Q | SECNO | Q | CWSEL | SECNO | Q | CWSEL | AVE CWSEL | SPLIT FLOW |
|---|---|---|---|---|---|---|---|---|
| 345000 | 16 | 293188 | 1212.1 | 17 | 345000 | 1213.7 | 1212.9 | 51812 |
| 220000 | 16 | 195212 | 1208.2 | 17 | 220000 | 1209.7 | 1209.0 | 24788 |
| 160000 | 16 | 149083 | 1205.6 | 17 | 160000 | 1207.1 | 1206.3 | 10917 |
| 100000 | 16 | 99238 | 1202.4 | 17 | 100000 | 1203.7 | 1203.0 | 762 |
| 88000 | 16 | 87966 | 1201.6 | 17 | 88000 | 1202.9 | 1202.2 | 34 |
| 86000 | 16 | 85992 | 1201.4 | 17 | 86000 | 1202.7 | 1202.1 | 8 |
| 85000 | 16 | 84998 | 1201.4 | 17 | 85000 | 1202.6 | 1202.0 | 2 |
| 84000 | 16 | 84000 | 1201.3 | 17 | 84000 | 1202.6 | 1201.9 | 0 |
| 83000 | 16 | 83000 | 1201.2 | 17 | 83000 | 1202.5 | 1201.8 | 0 |

FUTURE CONDITIONS, WITH DIKE

| TOTAL Q | SECNO | Q | CWSEL | SECNO | Q | CWSEL | AVE CWSEL | SPLIT FLOW |
|---|---|---|---|---|---|---|---|---|
| 345000 | 16 | 286217 | 1212.5 | 17 | 345000 | 1215.0 | 1213.8 | 58783 |
| 220000 | 16 | 191284 | 1208.5 | 17 | 220000 | 1210.8 | 1209.6 | 28717 |
| 160000 | 16 | 145981 | 1205.9 | 17 | 160000 | 1208.1 | 1207.0 | 14019 |
| 100000 | 16 | 97822 | 1202.8 | 17 | 100000 | 1204.7 | 1203.7 | 2178 |
| 90000 | 16 | 89120 | 1202.1 | 17 | 90000 | 1204.0 | 1203.1 | 880 |
| 80000 | 16 | 79870 | 1201.5 | 17 | 80000 | 1203.2 | 1202.3 | 130 |
| 75000 | 16 | 74991 | 1201.1 | 17 | 75000 | 1202.8 | 1201.9 | 9 |
| 74000 | 16 | 73997 | 1201.0 | 17 | 74000 | 1202.7 | 1201.9 | 3 |
| 73000 | 16 | 73000 | 1200.9 | 17 | 73000 | 1202.6 | 1201.8 | 0 |

EXISTING CONDITIONS, WITHOUT DIKE

| TOTAL Q | SECNO | Q | CWSEL | SECNO | Q | CWSEL | AVE CWSEL | SPLIT FLOW |
|---|---|---|---|---|---|---|---|---|
| 345000 | 16 | 245881 | 1211.0 | 17 | 345000 | 1211.4 | 1211.2 | 99119 |
| 220000 | 16 | 158351 | 1206.1 | 17 | 220000 | 1206.8 | 1206.5 | 61649 |
| 160000 | 16 | 115583 | 1203.5 | 17 | 160000 | 1204.3 | 1203.9 | 44417 |
| 100000 | 16 | 72444 | 1200.4 | 17 | 100000 | 1201.3 | 1200.8 | 27556 |
| 50000 | 16 | 36588 | 1197.3 | 17 | 50000 | 1198.1 | 1197.7 | 13412 |
| 5000 | 16 | 4581 | 1192.8 | 17 | 5000 | 1193.4 | 1193.1 | 419 |
| 4000 | 16 | 3809 | 1192.6 | 17 | 4000 | 1193.2 | 1192.9 | 191 |
| 3000 | 16 | 2967 | 1192.3 | 17 | 3000 | 1192.9 | 1192.6 | 33 |
| 2000 | 16 | 2000 | 1192.1 | 17 | 2000 | 1192.6 | 1192.3 | 0 |

FUTURE CONDITIONS, WITHOUT DIKE

| TOTAL Q | SECNO | Q | CWSEL | SECNO | Q | CWSEL | AVE CWSEL | SPLIT FLOW |
|---|---|---|---|---|---|---|---|---|
| 345000 | 16 | 239611 | 1211.5 | 17 | 345000 | 1212.3 | 1211.9 | 105389 |
| 220000 | 16 | 154834 | 1206.4 | 17 | 220000 | 1207.5 | 1207.0 | 65166 |
| 160000 | 16 | 112663 | 1203.8 | 17 | 160000 | 1204.9 | 1204.3 | 47337 |
| 100000 | 16 | 70222 | 1200.7 | 17 | 100000 | 1201.8 | 1201.3 | 29778 |
| 50000 | 16 | 35206 | 1197.6 | 17 | 50000 | 1198.6 | 1198.1 | 14794 |
| 5000 | 16 | 4407 | 1192.9 | 17 | 5000 | 1193.6 | 1193.2 | 593 |
| 4000 | 16 | 3687 | 1192.7 | 17 | 4000 | 1193.3 | 1193.0 | 313 |
| 3000 | 16 | 2914 | 1192.5 | 17 | 3000 | 1193.0 | 1192.7 | 86 |
| 2500 | 16 | 2481 | 1192.3 | 17 | 2500 | 1192.9 | 1192.6 | 19 |
| 2000 | 16 | 2000 | 1192.1 | 17 | 2000 | 1192.7 | 1192.4 | 0 |

Proposed McKellips Road Bridge 2/7/2000
Salt River, Arizona

Backwater Water Surface Elevations for Southern Overflow Channel
Discharges from Main Channel Split-Flow Analysis

| SECNO | Q | CWSEL |
|---|---|---|
| | | |
| 49.5 | 51812 | 1214.9 |
| 49.5 | 24788 | 1211.9 |
| 49.5 | 99119 | 1218.6 |
| 49.5 | 61649 | 1215.8 |
| 49.5 | 58783 | 1215.5 |
| 49.5 | 28717 | 1212.6 |
| 49.5 | 105389 | 1219.1 |
| 49.5 | 65166 | 1216.1 |

# APPENDIX C
## HEC-2 CROSS SECTION
## LOCATION MAP


# HYDRAULIC ANALYSIS for McKELLIPS ROAD at the SALT RIVER

## HEC-2 CROSS SECTION LOCATION MAP

TETRA TECH, INC.
INFRASTRUCTURE SOUTHWEST GROUP
Formerly Simons, Li and Associates, Inc.
110 S. Church Ave., Suite 2170, Tucson, AZ 85701
(520) 884-9594 FAX (520) 884-5254

PROJ. No.: PAZ-PBQD-006
DATE : 4/7/00
SCALE HORIZ. :
VERT. :
SHEET NO. : 1 OF 1

DESIGNED BY : LKR
DRAWN BY : CRT
CHK'D BY (DESIGN) : LKR
CHK'D BY (FIELD ENG'R) :
FIELD BOOK NO. :

| NO. | REVISION | APPV'D. | DATE |
|---|---|---|---|
| | | | |

C:\PAZ\PBQD006\SETUP.dwg

# APPENDIX D
# SCOUR CALCULATIONS

# MCKELLIPS ROAD BRIDGE OVER THE SALT RIVER
# SCOUR ANALYSIS

## I. PROJECT APPROACH

THIS SCOUR ANALYSIS HAS BEEN CONDUCTED ACCORDING TO THE PARAMETERS SPECIFIED WITHIN THE SCOPE OF WORK FOR THIS PROJECT. THE FOLLOWING SUMMARIZES THE APPROACH THAT WILL BE USED TO DETERMINE THE SCOUR DEPTHS.

A. BOTH THE DESIGN (100-YEAR) FLOOD OF 6230 CMS (220,000 CFS) AND THE SUPERFLOOD (500-YEAR) OF 9770 CMS (345,000 CFS) WILL BE UTILIZED TO CALCULATE SCOUR PARAMETERS. THE EXISTING SPLIT-FLOW CONDITION AT THE SOUTH BANK NEAR THE PROPOSED BRIDGE WILL BE MAINTAINED. AS A RESULT, DISCHARGES WILL DECREASE THROUGH THE CHANNEL REACH WHERE THE PROPOSED BRIDGE WILL BE LOCATED. THE BRIDGE REACH CONSISTS OF CROSS-SECTIONS 14, 15, 16, & 17.

B. THE HYDRAULIC MODEL WAS CONSTRUCTED TO MOST ACCURATELY MODEL THE DESIGN (100-YEAR) DISCHARGE. IN SOME CASES, THE SUPERFLOOD DISCHARGE WILL EXCEED ENDPOINTS OF THE CROSS SECTIONS, BUT NOT TO THE DEGREE THAT THE VALIDITY OF THE MODEL IS COMPROMISED. THE SUPERFLOOD HYDRAULIC ANALYSIS WILL BE USED IN ORDER TO DETERMINE THE TOTAL SUPERFLOOD PIER SCOUR. THIS SCOUR MAGNITUDE WILL BE USED TO CHECK THE STRUCTURAL CAPACITY OF THE BRIDGE PIERS.

C. THE LONG-TERM DEGRADATION COMPONENT WILL BE COMPUTED CONSIDERING (1) THE ARMORING DEPTH FOR THE DESIGN FLOOD, (2) THE EXISTING GRADE CONTROL STRUCTURE LOCATED AT ALMA

SCHOOL ROAD, AND (3) PROJECTED IMPACTS (I.E., DEPTH, VOLUME, AND LOCATION) OF POTENTIAL FUTURE SAND AND GRAVEL MINING OPERATIONS WITHIN THE SALT RIVER.

D. THE TOTAL SCOUR DEPTHS WILL BE REFERENCED TO THE LOWEST ELEVATION IN THE RIVER BOTTOM, AS DEPICTED IN THE CURRENT BRIDGE SITE TOPOGRAPHY.

## II. DESIGN (100-YEAR) FLOOD ANALYSIS

### A. GENERAL SCOUR—ARMORING CONTROL METHOD

THE PRESENCE OF LARGE, COARSE MATERIAL OF SUFFICIENT QUANTITY IN A RIVER CHANNEL CREATES THE OPPORTUNITY FOR AN ARMOR LAYER TO DEVELOP THAT WILL INHIBIT DEGRADATION CAUSED BY SUCH INFLUENCES AS CHANNELIZATION AND SAND AND GRAVEL MINING. IN THE ARMORING PROCESS, THE FINER, TRANSPORTABLE MATERIALS THAT ARE PRESENT IN THE RIVERBED WILL BE SORTED OUT. DEGRADATION WILL PROCEED AT A PROGRESSIVELY SLOWER RATE UNTIL AN ARMOR LAYER OF APPROPRIATE COMPOSITION AND THICKNESS IS FORMED WHICH WILL CONTROL FURTHER DEGRADATION. THIS METHOD IS APPLICABLE WHERE THERE ARE LARGE, COARSE MATERIALS IN THE STREAMBED THAT CANNOT BE TRANSPORTED BY THE ANTICIPATED DISCHARGES, AND WHERE THERE IS ENOUGH OF THESE MATERIALS PRESENT SO THAT AN ARMOR LAYER CAN DEVELOP. IN GENERAL, AN ARMORING LAYER CAN BE EXPECTED IF THE STREAMBED MATERIAL IS LARGE ENOUGH TO RESIST TRANSPORT BY THE ANTICIPATED DISCHARGES.

AT MCKELLIPS ROAD, AN ARMOR LAYER HAS ALREADY FORMED. THE OBSERVED ARMOR LAYER CAN BE COMPARED TO THE COMPUTED ARMOR LAYER, USING BOTH THE SEDIMENT SIEVE ANALYSES OF (1) THE UNDERLYING BED MATERIAL AND (2) THE ARMOR LAYER.

THE ARMOR LAYER WILL FORM AS FOLLOWS:

$$y_a = y - y_d$$

WHERE,

$y_a$ = THICKNESS OF THE ARMORING LAYER

$y$ = DEPTH FROM ORIGINAL STREAMBED TO BOTTOM OF ARMORING LAYER

$y_d$ = DEPTH FROM ORIGINAL STREAMBED TO TOP OF ARMORING LAYER (DEGRADATION)

BY DEFINITION,

$$y_a = (\Delta p)y$$

WHERE,

$\Delta p$ = DECIMAL PERCENTAGE OF MATERIAL LARGER THAN ARMORING SIZE

COMBINING THE ABOVE EQUATIONS, THE DEPTH OF GRADATION CAN BE DETERMINED BY,

$$y_d = y_a\left(\frac{1}{\Delta p} - 1\right)$$

THE DEPTH OF THE ARMORING LAYER VARIES WITH PARTICLE SIZE. FOR USE IN DESIGN, IT IS ASSUMED THAT THE ARMORING LAYER VARIES BY THREE PARTICLE DIAMETERS. <u>ALTHOUGH</u>

ARMORING HAS BEEN OBSERVED TO OCCUR WITH LESS THAN THREE PARTICLE DIAMETERS, VARIABILITY OF CHANNEL BED MATERIAL AND OCCURRENCE OF PEAK DESIGN DISCHARGES DICTATE THE USE OF A THICKER ARMOR LAYER.

THE DETERMINATION OF THE DEPTH WHERE THE ARMOR LAYER WILL INHIBIT FURTHER DEGRADATION OF THE STREAMBED IS CALCULATED BASED UPON SOME FORM OF INCIPIENT MOTION APPROACH, SUCH AS:

(1) THE MEYER-PETER, MULLER METHOD
(2) THE COMPETENT BOTTOM VELOCITY METHOD
(3) THE CRITICAL TRACTIVE FORCE METHOD
(4) THE SHIELDS DIAGRAM METHOD
(5) THE YANG INCIPIENT MOTION METHOD

DESIGN PARAMETERS FROM HEC-2 ANALYSIS;

THE DESIGN (100-YEAR) DISCHARGE: Q = 6230 CMS (220,000 CFS) FROM THE HEC-2 MODEL RUN, THE MAXIMUM DEPTH OF FLOW IN THE CHANNEL AT THE BRIDGE (CROSS SECTION NUMBERS 14, 15, 16, & 17) WILL BE:

$d = 19.1$ FT.

$d = 5.82$ M.

THROUGH THE BRIDGE SECTIONS, THE MAXIMUM VELOCITY CAN BE DETERMINED BY THE FOLLOWING RELATIONSHIP:

$$V_{MAX} = \left(\frac{Y_{MAX}}{Y_H}\right)^{2/3} V_{AVE} = V_{MAX} = \left(\frac{19.1}{16.3}\right)^{2/3} (13.2).$$

$$V_{MAX} = 14.7 \text{ FT./SEC.} = 4.48 \text{ M / S.}$$

THE ENERGY GRADIENT (= AVERAGE ENERGY GRADIENT IN THE VICINITY OF THE BRIDGE) IS:

$\bar{S} = 0.003$ (SEE ATTACHED SPREADSHEET)

(1) <u>MEYER-PETER, MULLER METHOD</u>

DETERMINATION OF NON-TRANSPORTABLE SIZE THAT WILL FORM THE ARMOR LAYER IS GIVEN BY THE FOLLOWING RELATIONSHIP:

$$D = \frac{\bar{S}\ d}{K\left[\dfrac{n_s}{(D_{90})^{1/6}}\right]^{3/2}}$$

WHERE, $D_{90}$ = 48 mm (THE AVERAGE $D_{90}$ BASED ON SIEVE ANALYSES AT SITES IN THE VICINITY OF THE PROPOSED BRIDGE (I.E., SITES 1, 2, 3, 6, & 7)

K = 0.058 (METRIC SYSTEM)

$n_s$ = MANNING'S COEFFICIENT FOR PARTICLE ROUGHNESS (I.E., "SKIN" FRICTION)

FROM VARIOUS STUDIES, THE FOLLOWING RELATIONSHIPS HAVE BEEN PROPOSED TO DETERMINE MANNING'S COEFFICIENT:

1. $D_{90} = 48 \text{ mm} = 1.89 \text{ in.}$

$$n_s = \frac{(D_{90})^{1/6}}{44.4}$$

$$n_s = \frac{(1.89'')^{1/6}}{44.4}$$

$$n_s = 0.025$$

2. $D_{50} = 9 \text{ mm} = 0.030 \text{ ft}$

$$n_s = 0.04(D_{50})^{1/6}$$

$$n_s = 0.04(0.030)^{1/6}$$

$$n_s = 0.022$$

3. $D_{75} = 27\ mm = 1.06\ in.$

$$n_s = \frac{(D_{75})^{1/6}}{39}$$

$$n_s = \frac{(1.06)^{1/6}}{39}$$

$$n_s = 0.026$$

USE AVERAGE MANNING'S COEFFICIENT, $n_s = \underline{\underline{0.024}}$.

CONSEQUENTLY,

$$D = \frac{0.003(5.82)}{0.058(\frac{0.024}{48^{1/6}})^{3/2}}.$$

$$D \approx 214\ mm.$$

(2) <u>COMPETENT BOTTOM VELOCITY METHOD</u>

$$V_b = 0.7\ V_m.$$

$$V_b = 0.7(4.48).$$

$$V_b = 3.14\ M/S.$$

$$D=41.6V_b^{2}.$$

$$D=(41.6)(3.14)^{2}.$$

$$D=410\,mm.$$

## (3) CRITICAL TRACTIVE FORCE METHOD

$$t_c=g_w d\overline{S}.$$

$$t_c=1(5.82)(0.003)(1X10^{6}\,g/m^{3}).$$

$$t_c=17{,}460\,g/m^{2}.$$

AND FROM FIGURE A-20, BUREAU OF RECLAMATION'S DESIGN OF SMALL DAMS (CURVE FOR COARSE, NON-COHESIVE MATERIALS):

$$D \approx 220\ mm$$

(4) SHIELD'S DIAGRAM METHOD

FROM SHIELD'S DIAGRAM FOR MATERIAL > 1 mm AND REYNOLD'S NUMBER 0> 500:

$$\frac{T_c}{(g_s - g_w)\ D} = 0.06.$$

$$D = \frac{1(5.82)(0.003)}{(2.65 - 1)(0.06)}.$$

$$D = 0.176 \text{ M} = 176 \text{ mm.}$$

(5) YANG'S INCIPIENT MOTION METHOD

YANG'S INCIPIENT MOTION CRITERIA FOR SHEAR VELOCITY FOR REYNOLD'S NUMBER > 70, WHERE THE CRITICAL VELOCITY FOR BEGINNING OF MOTION IS GIVEN BY:

$$V_c = 6.19(y_1)^{1/6}(D_{50})^{1/3}.$$

$$V_c = 6.19(5.82)^{1/6}(0.009)^{1/3}.$$

$$V_c = 1.76 \text{ M/S.}$$

CONSEQUENTLY, ONE OBTAINS:

$$D = 0.0216\ V_c^{2}.$$

$$D = 0.0216(1.76)^2.$$

$$D = 0.067M = 67\ mm.$$

SUMMARY OF RESULTS:

THE RESULTS OF THE VARIOUS METHODS PRODUCE VALUES RANGING FROM A HIGH OF D = 410 MM TO A LOW OF D = 67 MM, WITH TWO OF THE METHODS VARYING CONSIDERABLY FROM THE OTHERS. THIS MAY BE THE RESULT OF NOT KNOWING THE TRUE BOTTOM VELOCITY ADJACENT TO THE BED AT THE TIME OF SEDIMENT MOTION. THE MEAN RESULT OF THE FIVE METHODS YIELDS:

$$D = \frac{214 + 410 + 220 + 176 + 67}{5}. \qquad \text{(METHOD 1)}$$

$$D \approx 217\ mm.$$

ELIMINATING THE HIGH AND LOW OUTLIERS, RESULTS IN:

$$D = \frac{214 + 220 + 176}{3}. \qquad \text{(METHOD 2)}$$

$$D \approx 203\ mm.$$

GIVEN THE TWO METHODS UTILIZED, AND BASED UPON FIELD OBSERVATIONS OF THE STREAMBED AND THE APPLICATION OF SOUND ENGINEERING JUDGMENT, METHOD 2 IS DEEMED TO BE MOST REASONABLE METHOD TO USE, AND CONSEQUENTLY A VALUE OF $D_a \approx 203$ MM IS ADOPTED AS THE DESIGN VALUE FOR THE ARMORING SIZE, AND THEREFORE THE SIZE TO SUBSEQUENTLY USE FOR COMPUTING THE DEPTH TO ARMOR LAYER CREATED BY THE CRITICAL FLOOD.

A COMPARISON OF THE PRECEDING DESIGN VALUE WITH PARTICLE SIZES IN THE OBSERVED ARMOR LAYER YIELDS COMPARABLE RESULTS. BASED UP THE CONVERSION OF ROCK COUNTS OF SEDIMENT TEST PITS 2, 3, & 6 TO EQUIVALENT SEDIMENT SIZES, BY WEIGHT, THE $D_{50}$ OF THE EXISTING ARMOR LAYER IS COMPUTED TO BE APPROXIMATELY 203 MM.

DETERMINATION OF ARMOR DEPTH

THE DEPTH OF ARMORING CAN BE DETERMINED BY:

$$y_d = y_a\left(\frac{1}{\Delta p} - 1\right)$$

ASSUMING THE THICKNESS OF THE ARMOR LAYER IS EQUIVALENT TO THREE LAYERS OF THE COMPUTED ARMORING SIZE, THEN:

$$y_a = 3(0.203) = 0.609 \text{ M.}$$

FROM THE SIEVE ANALYSES OF THE ARMOR LAYER,

$$\Delta p = 0.50.$$

$$y_d = 0.609\left(\frac{1}{0.5} - 1\right).$$

$$y_d = 0.609 \text{ M}.$$

BASED UPON SEDIMENT SAMPLING OF THE ARMOR LAYER AT SEVERAL SITES ALONG THE RIVER BED, THE AVERAGE ARMOR LAYER THICKNESS WAS MEASURED TO BE APPROXIMATELY 2.5 FEET (0.762 M). NO MATERIAL COARSER THAN 152.4 MM WAS FOUND IN THE UNDERLYING, SUB-SURFACE LAYER OF THE CHANNEL (2 FEET TO 6 FEET BELOW THE CHANNEL INVERT).

B. GENERAL SCOUR—LIVE-BED CONTRACTION SCOUR

REFERENCE: FEDERAL HIGHWAY ADMINISTRATION, HYDRAULIC ENGINEERING CIRCULAR NO. 18, "EVALUATING SCOUR AT BRIDGES," NOVEMBER 1995 (THIRD EDITION). THE LIVE-BED CONTRACTION SCOUR IS GIVEN BY LAURSEN'S EQUATION:

$$\frac{y_2}{y_1} = \left(\frac{Q_2}{Q_1}\right)^{0.857}\left(\frac{W_1}{W_2}\right)^{k_1}\left(\frac{n_2}{n_1}\right)^{k_2}.$$

WHERE:

$y_s = y_2 - y_1$ = AVERAGE SCOUR DEPTH.
$y_1$ = AVERAGE DEPTH, UPSTREAM MAIN CHANNEL.
$y_2$ = AVERAGE DEPTH, CONTRACTED SECTION.
$W_1$ = BOTTOM WIDTH, UPSTEAM MAIN CHANNEL.
$W_2$ = BOTTOM WIDTH, CONTRACTED CHANNEL.
$Q_1$ = DISCHARGE UPSTREAM CHANNEL.
$Q_2$ = DISCHARGE CONTRACTED CHANNEL.
$n_1$ = MANNING'S COEFFICIENT,UPSTREAM CHANNEL.
$n_2$ = MANNING'S COEFFICIENT, CONTRACTED CHANNEL.
$k_1$ AND $k_2$ = EXPONENTS DEPENDING ON MODE OF BED. MATERIAL TRANSPORT.

FROM THE HEC-2 RUN FOR THE DESIGN DISCHARGE (6230 CMS) AND PREVIOUS SOIL DESIGN PARAMETERS:

SOIL PARAMETERS:

SEDIMENT SIZE: $D_{50} = 9\ mm$.

HYDRAULIC PARAMETERS:

ENERGY GRADIENT: $s = 0.003$ M/M.

AVERAGE DEPTH: $y_1 = 5.82$ M.

FLOW IN MAIN CHANNEL, EXCLUDING OVERBANK FLOW:

$$Q_1 = 6210 \text{ CMS.}$$

FLOW THROUGH BRIDGE OPENING:

$$Q_2 = 5862 \text{ CMS.}$$

BOTTOM WIDTH, UPSTREAM MAIN CHANNEL:

$$W = 262 \text{ M.}$$

BOTTOM WIDTH CONTRACTED SECTION:

$$W_2 = 273 \text{ M.}$$

SINCE THE UNIQUE SITUATION EXISTS WHERE (1) THE CHANNEL WIDTH THROUGH THE BRIDGE REACH IS WIDER THAN THE APPROACH REACH, AND (2)THE DESIGN DISCHARGE ACTUALLY DECLINES THROUGH THE BRIDGE REACH BECAUSE OF THE FLOW BREAKOUT TO THE SOUTH, CONTRACTION SCOUR IS CONSIDERED TO BE NOT APPLICABLE.

C. LOCAL SCOUR AT PIERS

HEC-18 RECOMMENDS USING THE CSU EQUATION TO DETERMINE BOTH LIVE-BED AND CLEAR-WATER PIER SCOUR.

$$\frac{y_s}{a} = 2\, K_1 K_2 K_3 K_4 \left(\frac{y_1}{a}\right)^{0.35} (F_1)^{0.43}$$

WHERE,

$y_s$ = SCOUR DEPTH.
$y_1$ = FLOW DEPTH DIRECTLY UPSTREAM OF PIER.
$K_1$ = CORRECTION FACTOR FOR PIER NOSE SHAPE.
$K_2$ = CORRECTION FACTOR FOR ANGLE OF ATTACK.
$K_3$ = CORRECTION FACTOR FOR BED CONDITION.
$K_4$ = CORRECTION FACTOR FOR $D_{50}$ PARTICLE SIZE.
$a$ = PIER WIDTH.
$L$ = LENGTH OF PIER.
$F_1$ = FROUDE NUMBER.
$V_1$ = MEAN VELOCITY DIRECTLY UPSTREAM OF PIER.

| CORRECTION FACTOR $K_1$ FOR PIER NOSE SHAPE | |
|---|---|
| SHAPE OF PIER NOSE | $K_1$ |
| SQUARE NOSE | 1.1 |
| ROUND NOSE | 1.0 |
| CIRCULAR CYLINDER | 1.0 |
| SHARP NOSE | 0.9 |
| GROUP OF CYLINDERS | 1.0 |

THE CORRECTION FACTOR $K_1$ SHOULD BE DETERMINED FOR ANGLES OF ATTACK OF UP TO 5 DEGREES. FOR GREATER ANGLES, $K_1$ = 1.00 SHOULD BE USED.

| CORRECTION FACTOR $K_2$ FOR ANGLE OF ATTACK | | | |
|---|---|---|---|
| ANGLE | L/a = 4 | L/a = 8 | L/a = 12 |
| 0 | 1.0 | 1.0 | 1.0 |
| 15 | 1.5 | 2.0 | 2.5 |
| 30 | 2.0 | 2.75 | 3.5 |
| 45 | 2.3 | 3.3 | 4.3 |
| 90 | 2.5 | 3.9 | 5.0 |

IF L/a IS LARGER THAN 12, THEN USE A VALUE FOR L/a = 12 AS A MAXIMUM. ALSO, ANGLE = SKEW ANGLE OF FLOW; AND L = LENGTH OF PIER.

| CORRECTION FACTOR $K_3$ FOR BED CONDITION | | |
|---|---|---|
| BED CONDITION | DUNE HEIGHT (FT) | $K_3$ |
| CLEAR-WATER SCOUR | N/A | 1.1 |
| PLANE BED & ANTIDUNE FLOW | N/A | 1.1 |
| SMALL DUNES | $10 > H > 2$ | 1.1 |
| MEDIUM DUNES | $30 > H > 10$ | 1.1 TO 1.2 |
| LARGE DUNES | $H > 30$ | |

NOTE THAT IF $D_{50}$ IS LESS THAN 60 mm, $K_4 = 1.00$.
THEREFORE, SINCE, $D_{50} = 9$ mm, $K_4 = 1.00$.

IT IS RECOMMENDED THAT THE RATIO $\frac{y_s}{a}$ BE AS FOLLOWS:

$$\frac{y_s}{a} \leq 2.4 \text{ FOR } F \leq 0.8$$

$$\frac{y_s}{a} \leq 3.0 \text{ FOR } F > 0.8$$

THE DESIGN PARAMETERS WILL BE AS FOLLOWS:

$y_1$ = 5.82 M

$$F_1 = \frac{v_{1(MAX)}}{\sqrt{g\ d_1}} = \frac{4.48}{\sqrt{9.81(5.82)}} = 0.59$$

$K_1$ = 1.1 (BLUNT PIER, DUE TO DEBRIS)

$K_2$ = 1.0 (ANGLE OF ATTACK NOT APPLICABLE SINCE PIER SPACING (40 FT.) IS MORE THAN FIVE TIMES GREATER THAN PIER DIAMETER)

$K_3$ = 1.1 (SMALL DUNES)

$K_4$ = 1.0

a = 1.83 + 1.22 (0.61 M OF DEBRIS, EA. SIDE)

a = 3.05 M

$$\frac{y_s}{a} = 2(1.1)(1.0)(1.1)(1.0)\left(\frac{5.82}{3.05}\right)^{0.35}(0.59)^{0.43}.$$

$$\frac{y_s}{a} = 2.42.$$

$$\therefore\ y_s = 2.42(3.05).$$

$$y_s = 7.38\ M.$$

## D. LOCAL SCOUR AT ABUTMENTS

HEC-18 RECOMMENDS THAT FOUNDATION DEPTHS FOR ABUTMENTS BE SET AT LEAST SIX FEET BELOW THE STREAMBED, INCLUDING LONG-TERM DEGRADATION, CONTRACTION SCOUR, AND LATERAL STREAM MIGRATION. USING FROEHLICH'S LIVE-BED SCOUR EQUATION:

$$\frac{y_s}{y_a} = 2.27\ K_1\ K_2\left(\frac{a'}{y_a}\right)^{0.43}(F_1^{0.61}) + 1.$$

WHERE,

$K_1$ = COEFFICIENT FOR ABUTMENT SHAPE.

$K_2$ = COEFFICIENT FOR ANGLE OF EMBANKMENT.

$$K_2 = \left(\frac{q}{90}\right)^{0.13}$$

$q < 90$ IF EMBANKMENT POINTS DOWNSTREAM.

$q > 90$ IF EMBANKMENT POINTS UPSTREAM.

$a'$ = LENGTH OF ABUTMENT PROJECTED NORMAL TO FLOW.

$A_e$ = FLOW AREA OBSTRUCTED BY EMBANKMENT.

$$F = \frac{V_e}{\sqrt{g y_a}}$$ FROUDE NO. APPROACH FLOW UPSTREAM OF ABUTMENT.

$$V_e = \frac{Q_e}{A_e}.$$

$Q_e$ = FLOW OBSTRUCTED, ABUTMENT + APPROACH EMBANKMENT.

$y_a$ = AVE. DEPTH OF FLOW ON FLOODPLAIN.

$y_s$ = SCOUR DEPTH.

| ABUTMENT SHAPE COEFFICIENT | |
|---|---|
| DESCRIPTION | $K_1$ |
| VERTICAL-WALL ABUTMENT | 1.00 |
| VERTICAL-WALL ABUTMENT WITH WING WALLS | 0.82 |
| SPILL-THROUGH ABUTMENT | 0.55 |

GIVEN THE SITE-SPECIFIC FACTORS SUCH AS (1) THE EXISTING ARMOR LAYER; (2) THE COARSE SIZES OF PARTICLES PRESENT IN THE SUB-SURFACE OF THE STREAMBED; AND (3) THE FACT THAT BOTH

ABUTMENTS ARE SET BACK FROM THE MAIN FLOW PATH, IN ORDER TO OBTAIN REALISTIC AND REASONABLE ABUTMENT-SCOUR RESULTS IT WAS DETERMINED THAT FROEHLICH'S LIVE-BED SCOUR EQUATION WOULD PRODUCE RESULTS TOO LARGE, AND THEREFORE SHOULD BE MODIFIED BY REMOVING THE ENVELOPE SAFETY FACTOR OF "+1" THAT FROELICH ADDED TO THE EQUATION. NOTE THAT THE FACTOR "+1" WAS INCORPORATED INTO THE EQUATION BY FROELICH SO THAT IT WOULD "ENVELOP" 98% OF THE OBSERVED DATA FOR LARGE RIVER SYSTEMS. THE MODIFIED FROEHLICH'S LIVE-BED SCOUR EQUATION THUS READS AS FOLLOWS:

$$\frac{y_s}{y_a} = 2.27\ K_1\ K_2 \left(\frac{a'}{y_a}\right)^{0.43} (F_1^{0.61}).$$

THEN, USING THE PRECEDING EQUATION, FOR THE NORTH ABUTMENT (I.E., AT CROSS-SECTION NO. 14) WE OBTAIN:

$$V_{e(MAX)} = 4.61\ M/S$$

$$F_e = \frac{4.61}{\sqrt{9.81(5.67)}}$$

$$F_e = 0.62$$

ASSUMING SPILL-THROUGH ABUTMENTS, $K_1=0.55$, AND FOR AN ABUTMENT SKEWED AT 43 DEGREES, $K_2=0.908$.

$$\frac{y_s}{5.67} = (2.27)(0.55)(0.908)\left(\frac{28.5}{5.67}\right)^{0.43}(0.62)^{0.61}.$$

$$y_s = 9.62 \text{ M.}$$

FOR THE SOUTH ABUTMENT (I.E., AT CROSS-SECTION NO. 17):

$$V_{e(MAX)} = 3.56 \text{ M/S}$$

$$F_e = \frac{3.56}{\sqrt{9.81(6.31)}}.$$

$$F_e = 0.45.$$

ASSUMING SPILL-THROUGH ABUTMENTS, $K_1 = 0.55$, AND FOR AN ABUTMENT SKEWED AT 42 DEGREES, $K_2 = 0.906$.

$$\frac{y_s}{6.31} = (2.27)(0.55)(0.906)\left(\frac{81}{6.31}\right)^{0.43}(0.45)^{0.61}$$

$$y_s = 13.14 \text{ M}$$

## III. SUPER FLOOD ANALYSIS—CONDITION 2

### A. ARMOR-CONTROL METHOD

DETERMINATION OF THE DEPTH WHERE THE ARMOR WILL INHIBIT ANY FURTHER DEGRADATION OF THE STREAMBED WILL BE CALCULATED AS BEFORE, WHERE THE DESIGN PARAMETERS WILL BE AS FOLLOWS:

SUPER FLOOD DISCHARGE:

$$Q_{SF} = 345{,}000 \text{ CFS} = 9{,}770 \text{ CMS.}$$

CHANNEL MAXIMUM DEPTH:

22.9 FEET = 6.98 M.

MAXIMUM VELOCITY:

$$V_{MAX} = \left(\frac{Y_{MAX}}{Y_H}\right)^{2/3} V_{AVE} = V_{MAX} = \left(\frac{22.9}{18.10}\right)^{2/3} (15.3).$$

$$V_{MAX} = 17.91 \text{ FT./SEC.} = 5.46 \text{ M/S.}$$

ENERGY GRADIENT IN THE VICINITY OF THE BRIDGE SECTION:

$$S = 0.002 \quad \text{M/M.}$$

(1) MEYER-PETER, MULLER METHOD

$$D = \frac{0.002(6.98)}{0.058\left[\frac{0.024}{(48)^{1/6}}\right]^{3/2}}.$$

$$D = 171 \text{ MM.}$$

(2) COMPETENT BOTTOM VELOCITY

$$V_b = 0.7\, V_M.$$

$$V_b = 0.7(5.46).$$

$$V_b = 3.82 \text{ M/S.}$$

$$D = 41.6\,(V_b)^2.$$

$$D = 41.6(3.82)^2.$$

$$D = 607 \text{ MM.}$$

(3) CRITICAL TRACTIVE FORCE METHOD

$$t_c = g_w(d)\bar{S}.$$

$$t_c = 1(6.98)(0.002)(1 \times 10^6).$$

$$t_c = 13{,}960 \text{ g/m}^2.$$

FROM EXTRAPOLATION OF FIGURE A-20 IN THE BUREAU OF RECLAMATION'S PUBLICATION DESIGN OF SMALL DAMS (CURVE FOR COARSE, NON-COHESIVE MATERIALS):

$$D \approx 180 \text{ MM.}$$

(4) SHIELD'S DIAGRAM METHOD

$$\frac{T_c}{(g_s - g_w)D} = 0.06.$$

$$D = \frac{1(6.98)(0.002)}{(2.65 - 1.00)(0.06)}.$$

$$D = 0.141 \text{ M} = 141 \text{ MM}.$$

(5) YANG'S INCIPIENT MOTION METHOD

$$V_c = 6.19(y_1)^{1/6}(D_{50})^{1/3}.$$

$$V_c = 6.19(6.98)^{1/6}(0.009)^{1/3}.$$

$$V_c = 1.81 \text{ M/S}.$$

$$D = 0.0216(V_c)^2.$$

$$D = 0.0216(1.81)^2$$

$$D = 0.071 \text{ M} = 71 \text{ MM}.$$

SUMMARY OF RESULTS:

THE AVERAGE OF THE FIVE METHODS YIELDS:

$$D = \frac{171 + 607 + 180 + 141 + 71}{5}. \quad \text{(METHOD 1)}$$

$$D = 234 \text{ MM}.$$

THE AVERAGE, WHEN ELIMINATING THE HIGH AND LOW VALUES, YIELDS:

$$D = \frac{171 + 180 + 141}{3}. \qquad \text{(METHOD 2)}$$

$$D = 164 \text{ MM.}$$

THE AVERAGE, WHEN ELIMINATING THE TWO LOWEST VALUES AND HIGHEST VALUE YIELDS:

$$D = \frac{171 + 180}{2}. \qquad \text{(METHOD 3)}$$

$$D = 176 \text{ MM.}$$

GIVEN THE THREE METHODS USED, FROM ENGINEERING JUDGEMENT METHOD 3 IS DEEMED TO BE MOST SUITABLE, AND A VALUE OF $D_a \approx 176$ MM IS ADOPTED AS A REASONABLE VALUE FOR THE ARMOR SIZE OF THE SUPERFLOOD.

DETERMINATION OF ARMOR DEPTH

ASSUMING AN ARMOR LAYER WITH A THICKNESS OF THREE TIMES THE CALCULATED ARMORING SIZE

$$y_a = 3(0.176) = 0.528 \text{ M.}$$

BY EVALUATING THE SEDIMENT DATA EXTRACTED FROM THE EXISTING, COARSE SURFACE LAYER ALONG THE SUBJECT REACH:

$$p \approx 37\%.$$

$$\Delta p = 1.00 - 0.37 = 0.63.$$

$$y_d = 0.528\left(\frac{1}{0.63} - 1\right).$$

$$y_d = 0.31 \text{ M}.$$

THESE RESULTS INDICATE THAT, ESSENTIALLY, ONLY A VERY MINOR AMOUNT OF ARMORING WILL OCCUR DURING PASSAGE OF THE SUPERFLOOD, SINCE THE MAJORITY OF THE PARTICLE SIZES PRESENT ON THE BED SURFACE ARE OF SUFFICIENT SIZE TO RESIST MOVEMENT. HOWEVER, THE SCOUR DEPTH DETERMINED FOR THE CRITICAL (DESIGN) DISCHARGE, I.E., $Y_d = 0.61$ M, WILL BE USED FOR ESTIMATING LONG-TERM SCOUR UNDER CONDITIONS OF ARMOR CONTROL.

B. <u>GENERAL SCOUR - LIVE-BED CONTRACTION SCOUR</u>

SINCE, AS WITH THE CRITICAL DESIGN FLOOD, THE UNIQUE SITUATION ALSO EXISTS WITH THE SUPERFLOOD WHERE (1) THE CHANNEL WIDTH THROUGH THE BRIDGE REACH IS WIDER THAN THE APPROACH REACH, AND (2)THE DESIGN DISCHARGE ACTUALLY DECLINES THROUGH THE BRIDGE REACH BECAUSE OF THE FLOW BREAKOUT TO THE SOUTH, CONTRACTION SCOUR IS CONSIDERED TO BE NOT APPLICABLE.

## C. LOCAL SCOUR AT PIERS

THE DESIGN PARAMETERS WILL BE AS FOLLOWS:

$$y_1 = 6.98 \text{ M.}$$

$$F_1 = \frac{5.46}{\sqrt{9.81(6.98)}} = 0.66.$$

$K_1$ = 1.1 (BLUNT PIER, DUE TO DEBRIS).

$K_2$ = 1.0.

$K_3$ = 1.1 (SMALL DUNES).

$K_4$ = 1.0 ($D_{50}$ IS LESS THAN 60 mm).

$a$ = 3.05 M.

$$\frac{y_s}{a} = 2(1.1)(1.0)(1.0)(1.1)\left(\frac{6.98}{3.05}\right)^{0.35}(0.66)^{0.43}.$$

$$y_s = 2.70(3.05).$$

$$y_s = 8.25 \text{ M.}$$

## D. LOCAL SCOUR AT ABUTMENTS

AS BEFORE, WITH THE CRITICAL DESIGN FLOOD, WE HAVE THE FOLLOWING RELATIONSHIP TO COMPUTE ABUTMENT SCOUR DURING THE PASSAGE OF THE SUPERFLOOD:

$$\frac{y_s}{y_a} = 2.27\ K_1\ K_2 \left(\frac{a'}{y_a}\right)^{0.43} (F_1^{0.61}).$$

THEN, USING THE PRECEDING EQUATION, FOR THE NORTH ABUTMENT (I.E., AT CROSS-SECTION NO. 14) WE OBTAIN:

$$V_{e(MAX)} = 5.07\ M/S$$

$$F_e = \frac{5.07}{\sqrt{9.81(6.83)}}$$

$$F_e = 0.62$$

ASSUMING SPILL-THROUGH ABUTMENTS, $K_1$=0.55 , AND FOR AN ABUTMENT SKEWED AT 43 DEGREES, $K_2$=0.908.

$$\frac{y_s}{6.83} = (2.27)(0.55)(0.908)\left(\frac{28.5}{6.83}\right)^{0.43} (0.62)^{0.61}.$$

$$y_s = 10.69\ M.$$

FOR THE SOUTH ABUTMENT (I.E., AT CROSS-SECTION NO. 17):

$$V_{e(MAX)} = 5.33\ M/S$$

$$F_e = \frac{5.33}{\sqrt{9.81(7.59)}}$$

$$F_e = 0.62$$

ASSUMING SPILL-THROUGH ABUTMENTS, $K_1$ = 0.55, AND FOR AN ABUTMENT SKEWED AT 42 DEGREES, $K_2$=0.906.

$$\frac{y_s}{7.59} = (2.27)(0.55)(0.906)\left(\frac{81}{7.59}\right)^{0.43}(0.62)^{0.61}.$$

$y_s = 17.75$ M

## IV. GENERAL (SHORT-TERM) SCOUR (SEDIMENT-TRANSPORT ANALYSIS)

TO DETERMINE THE GENERAL (SHORT-TERM) SCOUR PROCESSES THAT MAY BE PRESENT ALONG THE SALT RIVER DURING A MAJOR RUNOFF EVENT, SUCH AS THE CRITICAL DESIGN OR SUPERFLOOD DISCHARGES, THE "QUASI-DYNAMIC" SEDIMENT ROUTING MODEL[1] (QUASED) WAS RUN UNDER TWO SEPARATE CONDITIONS FOR THIS SECTION OF THE RIVER.

1. FUTURE CONDITIONS, UTILIZING SEDIMENT DATA OBTAINED FOR THE RIVER IN THE VICINITY OF THE PROPOSED McKELLIPS ROAD BRIDGE.

2. FUTURE CONDITIONS, ASSUMING NO SEDIMENT INFLOW INTO THE BRIDGE REACH BECAUSE OF THE POSSIBILITY THAT SAND AND GRAVEL MINING OPERATIONS MAY INTERCEPT SEDIMENT SUPPLY FROM THE UPSTREAM REACHES OF THE SALT RIVER.

IT SHOULD BE NOTED THAT THE QUASED MODELING FOR THE PRECEDING TWO CONDITIONS WAS BASED UPON THE USE OF THE SEDIMENT DATA FROM THE PARENT MATERIAL, WHICH LIES IMMEDIATELY BELOW THE MUCH COARSER SURFACE LAYER THAT EXISTS ALONG THE SUBJECT REACH OF THE SALT RIVER. ACCORDINGLY, THE RESULTS OF THE QUASED MODELS SHOULD BE CONSIDERED CONSERVATIVE.

[1] "QUASI-DYNAMIC SEDIMENT R OUTING MODEL," SIMONS, LI & ASSOC., INC., JUNE 1981

THE ANALYSES INDICATE THAT, IN THE ABSENCE OF THE COARSE SURFACE LAYER, THE SALT RIVER IN THIS AREA WILL BE SUBJECTED TO (GENERAL) SCOUR PROCESSES DURING THE PASSAGE OF BOTH THE DESIGN AND SUPERFLOOD DISCHARGES. AS EXPECTED, GREATER SCOUR DEPTHS RESULTED FOR THE CONDITION OF NO SEDIMENT INFLOW. FOR THE DESIGN FLOOD, MAXIMUM (GENERAL) SCOUR OF 0.56 METERS IS EXPECTED, WITH 0.87 METERS OF SCOUR EXPECTED DURING PASSAGE OF A SUPERFLOOD.

BECAUSE OF THE RELATIVELY MINOR MAGNITUDE OF SINGLE-EVENT SCOUR DURING PASSAGE OF THE DESIGN AND SUPERFLOOD DISCHARGES, AND GIVEN THE FACT THAT DEPTH-TO-ARMOR CALCULATIONS PRODUCE RESULTS FOR THIS REACH OF THE SALT RIVER WHICH ARE COMPARABLE TO THE QUASED-COMPUTED SINGLE-EVENT SCOUR COMPONENT, ADDING AN ADDITIONAL SCOUR COMPONENT TO ACCOUNT FOR GENERAL SCOUR CONDITIONS IN THE FINAL SCOUR ANALYSES PROVIDES A SMALL AMOUNT OF CONSERVATISM (I.E., SAFETY FACTOR) IN THE DESIGN ASSUMPTIONS USED TO ESTIMATE TOTAL SCOUR OCCURRING DURING THE PASSAGE OF A SINGLE, DESIGN FLOW EVENT.

## IV. IMPACTS OF SAND AND GRAVEL MINING

AN ADDITIONAL FACTOR WAS INCLUDED TO ACCOUNT FOR SAND AND GRAVEL MINING IN THE IMMEDIATE VICINITY OF THE PROPOSED BRIDGE. FUTURE SAND AND GRAVEL MINING UPSTREAM OF THE PROPOSED MCKELLIPS ROAD BRIDGE WILL NOT BE PERMITTED CLOSER THAN 213 METERS (700 FEET) FROM THE UPSTREAM LIMIT OF THE PROPOSED BRIDGE. DEPTHS OF EXCAVATION BEYOND THAT DISTANCE WILL BE LIMITED TO A MAXIMUM OF 18.3 METERS (60 FEET). TO ALLOW

FOR THIS LEVEL OF MINING, AN ADDITIONAL 1.52 METERS (5 FEET) OF POTENTIAL CHANNEL DEGRADATION SHOULD BE INCORPORATED INTO THE BRIDGE DESIGN.

SUMMARY TABLE OF RESULTS OBTAINED:

| SCOUR ANALYSIS - McKELLIPS ROAD BRIDGE | | |
|---|---|---|
| SCOUR COMPONENT | DESIGN | SUPERFLOOD |
| 1. GENERAL SCOUR (FROM FLOW CONTRACTION AT BRIDGE) | 0.00 M | 0.00 M |
| 2. GENERAL SCOUR (FROM SEDIMENT-TRANSPORT VARIATION ALONG RIVER) | 0.56 M | 0.87 M |
| 3. PIER SCOUR | 7.38 M | 8.25 M |
| 4. SINGLE-EVENT SCOUR DEPTH[1] | 7.94 M | 9.12 M |
| 5. FACTOR OF SAFETY (30%) | 2.38 M | 2.73 M |
| 6. LONG-TERM SCOUR (CONTROLLED BY SAND/GRAVEL EXCAVATION) | 1.52 M | 1.52 M |
| 7. TOTAL SCOUR AT PIERS SUPPORTING MCKELLIPS ROAD BRIDGE | 38.8 ft 11.84 M | 44 ft 13.37 M |
| 8. ABUTMENT SCOUR AT MCKELLIPS ROAD BRIDGE | 9.62 M 32' (north) 13.14 M 43' (south) | 10.69 M 35' (north) 17.75 M 58' (south) |

NOTE 1: COMPONENT (4) EQUALS THE SUM OF (1) + (2) + (3).
NOTE 2: TOTAL SCOUR AT PIERS SUPPORTING MCKELLIPS BRIDGE EQUALS THE SUM OF (4) + (5) + (6).

# APPENDIX E
# QUASED SEDIMENT ROUTING INPUT/OUTPUT FILES

100-YEAR EVENT
NO SEDIMENT INFLOW (ASSUMES PIT CAPTURE OF ALL SEDIMENT)

THE FOLLOWING TABLE LISTS THE MINIMUM AND MAXIMUM BED ELEVATIONS (COLUMNS 3 & 4), THE MAXIMUM DEGRADATION AND AGGRADATION WITH RESPECT TO THE INITIAL BED ELEVATION (COLUMNS 5 & 6) THAT OCCURS AT EACH SECTION DURING THE HYDROGRAPH, AND THE NET CHANGE ("NETCH", COLUMN 7) IN BED ELEVATION THAT OCCURS AT EACH SECTION DURING THE HYDROGRAPH

| (1) REACH | (2) SECNO | (3) MIN | (4) MAX | (5) DEG | (6) AGG | (7) NETCH |
|---|---|---|---|---|---|---|
| 1 | 30.00 | 1192.92 | 1194.20 | 1.28 | .00 | -1.28 |
| 1 | 29.00 | 1191.14 | 1192.60 | 1.46 | .00 | -1.46 |
| 1 | 28.00 | 1190.66 | 1192.40 | 1.74 | .00 | -1.70 |
| 1 | 27.00 | 1190.26 | 1192.10 | 1.84 | .00 | -1.80 |
| 1 | 26.00 | 1190.46 | 1192.10 | 1.64 | .00 | -1.61 |
| 2 | 25.00 | 1190.55 | 1191.90 | 1.35 | .00 | -1.35 |
| 2 | 24.00 | 1190.36 | 1191.80 | 1.44 | .00 | -1.40 |
| 2 | 23.00 | 1190.17 | 1191.60 | 1.43 | .00 | -1.43 |
| 2 | 22.00 | 1189.86 | 1191.40 | 1.54 | .00 | -1.50 |
| 2 | 21.00 | 1190.03 | 1191.30 | 1.27 | .00 | -1.27 |
| 3 | 20.00 | 1189.36 | 1191.20 | 1.84 | .00 | -1.84 |
| 3 | 19.00 | 1189.67 | 1191.20 | 1.53 | .00 | -1.53 |
| 3 | 18.00 | 1189.55 | 1191.00 | 1.45 | .00 | -1.45 |
| 3 | 17.00 | 1189.60 | 1191.00 | 1.40 | .00 | -1.40 |
| 3 | 16.00 | 1189.23 | 1191.00 | 1.77 | .00 | -1.77 |
| 4 | 15.00 | 1189.50 | 1189.50 | .00 | .00 | .00 |
| 4 | 14.00 | 1189.00 | 1189.00 | .00 | .00 | .00 |
| 4 | 13.00 | 1188.50 | 1188.50 | .00 | .00 | .00 |
| 4 | 12.00 | 1188.00 | 1188.00 | .00 | .00 | .00 |
| 4 | 11.00 | 1186.00 | 1186.00 | .00 | .00 | .00 |
| 5 | 10.00 | 1173.88 | 1177.80 | 3.92 | .00 | -3.92 |
| 5 | 9.00 | 1171.85 | 1176.20 | 4.35 | .00 | -4.35 |
| 5 | 8.00 | 1171.75 | 1176.20 | 4.45 | .00 | -4.45 |
| 6 | 7.00 | 1171.55 | 1174.52 | 2.95 | .02 | -2.95 |
| 6 | 6.00 | 1169.70 | 1172.92 | 3.20 | .02 | -3.20 |
| 6 | 5.00 | 1164.65 | 1168.03 | 3.35 | .03 | -3.33 |
| 7 | 4.00 | 1159.80 | 1161.04 | .00 | 1.24 | 1.24 |
| 7 | 3.00 | 1159.80 | 1161.41 | .00 | 1.61 | 1.60 |
| 7 | 2.00 | 1159.80 | 1162.05 | .00 | 2.25 | 2.25 |
| 7 | 1.00 | 1159.80 | 1161.83 | .00 | 2.03 | 2.03 |

100-YEAR EVENT
REACH 1 IS SUPPLY REACH

THE FOLLOWING TABLE LISTS THE MINIMUM AND MAXIMUM BED ELEVATIONS (COLUMNS 3 & 4), THE MAXIMUM DEGRADATION AND AGGRADATION WITH RESPECT TO THE INITIAL BED ELEVATION (COLUMNS 5 & 6) THAT OCCURS AT EACH SECTION DURING THE HYDROGRAPH, AND THE NET CHANGE ("NETCH", COLUMN 7) IN BED ELEVATION THAT OCCURS AT EACH SECTION DURING THE HYDROGRAPH

| (1) REACH | (2) SECNO | (3) MIN | (4) MAX | (5) DEG | (6) AGG | (7) NETCH |
|---|---|---|---|---|---|---|
| 1 | 30.00 | 1194.20 | 1194.20 | .00 | .00 | .00 |
| 1 | 29.00 | 1192.60 | 1192.60 | .00 | .00 | .00 |
| 1 | 28.00 | 1192.40 | 1192.40 | .00 | .00 | .00 |
| 1 | 27.00 | 1192.10 | 1192.10 | .00 | .00 | .00 |
| 1 | 26.00 | 1192.10 | 1192.10 | .00 | .00 | .00 |
| 2 | 25.00 | 1191.26 | 1191.92 | .64 | .02 | -.23 |
| 2 | 24.00 | 1191.15 | 1191.82 | .65 | .02 | -.29 |
| 2 | 23.00 | 1190.92 | 1191.65 | .68 | .05 | -.24 |
| 2 | 22.00 | 1190.76 | 1191.42 | .64 | .02 | -.21 |
| 2 | 21.00 | 1190.73 | 1191.35 | .57 | .05 | -.16 |
| 3 | 20.00 | 1189.82 | 1191.20 | 1.38 | .00 | -1.06 |
| 3 | 19.00 | 1190.07 | 1191.20 | 1.13 | .00 | -.88 |
| 3 | 18.00 | 1189.90 | 1191.00 | 1.10 | .00 | -.90 |
| 3 | 17.00 | 1189.96 | 1191.00 | 1.04 | .00 | -.84 |
| 3 | 16.00 | 1189.67 | 1191.00 | 1.33 | .00 | -1.09 |
| 4 | 15.00 | 1189.50 | 1189.50 | .00 | .00 | .00 |
| 4 | 14.00 | 1189.00 | 1189.00 | .00 | .00 | .00 |
| 4 | 13.00 | 1188.50 | 1188.50 | .00 | .00 | .00 |
| 4 | 12.00 | 1188.00 | 1188.00 | .00 | .00 | .00 |
| 4 | 11.00 | 1186.00 | 1186.00 | .00 | .00 | .00 |
| 5 | 10.00 | 1174.24 | 1177.80 | 3.56 | .00 | -3.56 |
| 5 | 9.00 | 1172.22 | 1176.20 | 3.98 | .00 | -3.98 |
| 5 | 8.00 | 1172.07 | 1176.20 | 4.13 | .00 | -4.13 |
| 6 | 7.00 | 1171.84 | 1174.52 | 2.66 | .02 | -2.66 |
| 6 | 6.00 | 1170.01 | 1172.92 | 2.89 | .02 | -2.89 |
| 6 | 5.00 | 1164.75 | 1168.04 | 3.25 | .04 | -3.21 |
| 7 | 4.00 | 1159.80 | 1161.83 | .00 | 2.03 | 2.03 |
| 7 | 3.00 | 1159.80 | 1162.38 | .00 | 2.58 | 2.58 |
| 7 | 2.00 | 1159.80 | 1163.33 | .00 | 3.53 | 3.53 |
| 7 | 1.00 | 1159.80 | 1163.01 | .00 | 3.21 | 3.21 |

500-YEAR EVENT
NO SEDIMENT INFLOW (ASSUMES PIT CAPTURE OF ALL SEDIMENT)

THE FOLLOWING TABLE LISTS THE MINIMUM AND MAXIMUM BED ELEVATIONS (COLUMNS 3 & 4), THE MAXIMUM DEGRADATION AND AGGRADATION WITH RESPECT TO THE INITIAL BED ELEVATION (COLUMNS 5 & 6) THAT OCCURS AT EACH SECTION DURING THE HYDROGRAPH, AND THE NET CHANGE ("NETCH", COLUMN 7) IN BED ELEVATION THAT OCCURS AT EACH SECTION DURING THE HYDROGRAPH

| (1) REACH | (2) SECNO | (3) MIN | (4) MAX | (5) DEG | (6) AGG | (7) NETCH |
|---|---|---|---|---|---|---|
| 1 | 30.00 | 1192.40 | 1194.20 | 1.80 | .00 | -1.80 |
| 1 | 29.00 | 1190.52 | 1192.60 | 2.08 | .00 | -2.08 |
| 1 | 28.00 | 1190.16 | 1192.40 | 2.24 | .00 | -2.20 |
| 1 | 27.00 | 1189.66 | 1192.10 | 2.44 | .00 | -2.41 |
| 1 | 26.00 | 1189.66 | 1192.10 | 2.44 | .00 | -2.40 |
| 2 | 25.00 | 1189.71 | 1191.90 | 2.19 | .00 | -2.19 |
| 2 | 24.00 | 1189.56 | 1191.80 | 2.24 | .00 | -2.24 |
| 2 | 23.00 | 1189.30 | 1191.60 | 2.30 | .00 | -2.30 |
| 2 | 22.00 | 1189.15 | 1191.40 | 2.25 | .00 | -2.24 |
| 2 | 21.00 | 1189.28 | 1191.30 | 2.02 | .00 | -2.02 |
| 3 | 20.00 | 1188.36 | 1191.20 | 2.84 | .00 | -2.84 |
| 3 | 19.00 | 1189.10 | 1191.20 | 2.10 | .00 | -2.10 |
| 3 | 18.00 | 1188.57 | 1191.00 | 2.43 | .00 | -2.40 |
| 3 | 17.00 | 1188.87 | 1191.00 | 2.13 | .00 | -2.10 |
| 3 | 16.00 | 1188.35 | 1191.00 | 2.65 | .00 | -2.65 |
| 4 | 15.00 | 1189.50 | 1189.50 | .00 | .00 | .00 |
| 4 | 14.00 | 1189.00 | 1189.00 | .00 | .00 | .00 |
| 4 | 13.00 | 1188.50 | 1188.50 | .00 | .00 | .00 |
| 4 | 12.00 | 1188.00 | 1188.00 | .00 | .00 | .00 |
| 4 | 11.00 | 1186.00 | 1186.00 | .00 | .00 | .00 |
| 5 | 10.00 | 1172.68 | 1177.80 | 5.12 | .00 | -5.12 |
| 5 | 9.00 | 1171.00 | 1176.20 | 5.20 | .00 | -5.20 |
| 5 | 8.00 | 1170.62 | 1176.20 | 5.58 | .00 | -5.58 |
| 6 | 7.00 | 1170.19 | 1174.50 | 4.31 | .00 | -4.31 |
| 6 | 6.00 | 1168.32 | 1172.90 | 4.58 | .00 | -4.58 |
| 6 | 5.00 | 1163.11 | 1168.00 | 4.89 | .00 | -4.89 |
| 7 | 4.00 | 1159.80 | 1161.67 | .00 | 1.87 | 1.87 |
| 7 | 3.00 | 1159.80 | 1162.22 | .00 | 2.42 | 2.40 |
| 7 | 2.00 | 1159.80 | 1163.13 | .00 | 3.33 | 3.33 |
| 7 | 1.00 | 1159.80 | 1162.87 | .00 | 3.07 | 3.07 |

500-YEAR EVENT
REACH 1 IS SUPPLY REACH

THE FOLLOWING TABLE LISTS THE MINIMUM AND MAXIMUM BED ELEVATIONS (COLUMNS 3 & 4), THE MAXIMUM DEGRADATION AND AGGRADATION WITH RESPECT TO THE INITIAL BED ELEVATION (COLUMNS 5 & 6) THAT OCCURS AT EACH SECTION DURING THE HYDROGRAPH, AND THE NET CHANGE ("NETCH", COLUMN 7) IN BED ELEVATION THAT OCCURS AT EACH SECTION DURING THE HYDROGRAPH

| (1) REACH | (2) SECNO | (3) MIN | (4) MAX | (5) DEG | (6) AGG | (7) NETCH |
|---|---|---|---|---|---|---|
| 1 | 30.00 | 1194.20 | 1194.20 | .00 | .00 | .00 |
| 1 | 29.00 | 1192.60 | 1192.60 | .00 | .00 | .00 |
| 1 | 28.00 | 1192.40 | 1192.40 | .00 | .00 | .00 |
| 1 | 27.00 | 1192.10 | 1192.10 | .00 | .00 | .00 |
| 1 | 26.00 | 1192.10 | 1192.10 | .00 | .00 | .00 |
| 2 | 25.00 | 1190.69 | 1191.93 | 1.21 | .03 | -.89 |
| 2 | 24.00 | 1190.59 | 1191.83 | 1.21 | .03 | -.89 |
| 2 | 23.00 | 1190.49 | 1191.64 | 1.11 | .04 | -.57 |
| 2 | 22.00 | 1190.25 | 1191.43 | 1.15 | .03 | -.79 |
| 2 | 21.00 | 1190.35 | 1191.34 | .95 | .04 | -.44 |
| 3 | 20.00 | 1189.29 | 1191.20 | 1.91 | .00 | -1.41 |
| 3 | 19.00 | 1189.75 | 1191.20 | 1.45 | .00 | -1.04 |
| 3 | 18.00 | 1189.45 | 1191.00 | 1.55 | .00 | -1.29 |
| 3 | 17.00 | 1189.60 | 1191.00 | 1.40 | .00 | -1.29 |
| 3 | 16.00 | 1189.19 | 1191.00 | 1.81 | .00 | -1.59 |
| 4 | 15.00 | 1189.50 | 1189.50 | .00 | .00 | .00 |
| 4 | 14.00 | 1189.00 | 1189.00 | .00 | .00 | .00 |
| 4 | 13.00 | 1188.50 | 1188.50 | .00 | .00 | .00 |
| 4 | 12.00 | 1188.00 | 1188.00 | .00 | .00 | .00 |
| 4 | 11.00 | 1186.00 | 1186.00 | .00 | .00 | .00 |
| 5 | 10.00 | 1173.11 | 1177.80 | 4.69 | .00 | -4.69 |
| 5 | 9.00 | 1171.43 | 1176.20 | 4.77 | .00 | -4.77 |
| 5 | 8.00 | 1171.11 | 1176.20 | 5.09 | .00 | -5.09 |
| 6 | 7.00 | 1170.51 | 1174.50 | 3.99 | .00 | -3.99 |
| 6 | 6.00 | 1168.63 | 1172.90 | 4.27 | .00 | -4.27 |
| 6 | 5.00 | 1163.29 | 1168.00 | 4.71 | .00 | -4.71 |
| 7 | 4.00 | 1159.80 | 1163.27 | .00 | 3.47 | 3.47 |
| 7 | 3.00 | 1159.80 | 1164.13 | .00 | 4.33 | 4.31 |
| 7 | 2.00 | 1159.80 | 1165.82 | .00 | 6.02 | 6.02 |
| 7 | 1.00 | 1159.80 | 1165.35 | .00 | 5.55 | 5.55 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 40 | 7 | 0 | 0.4 | | | | | | |
| 0 | 5 | 12239 | 10509 | 0 | | | | | |
| 0 | 5 | 10509 | 8777 | 0 | | | | | |
| 0 | 5 | 8777 | 7046 | 0 | | | | | |
| 0 | 5 | 7046 | 5312 | 1 | | | | | |
| 0 | 3 | 5312 | 3598 | 0 | | | | | |
| 0 | 3 | 3598 | 1821 | 0 | | | | | |
| 0 | 4 | 1821 | 0 | 0 | | | | | |
| 10 | | | | | | | | | |
| 0.149 | 0.421 | 0.838 | 1.683 | 3.888 | 8.980 | 15.554 | 21.997 | 31.109 | 76.200 |
| 600 | 600 | 600 | 600 | 600 | 600 | 600 | | | |
| 0.072 | 0.106 | 0.098 | 0.058 | 0.109 | 0.101 | 0.101 | 0.078 | 0.127 | 0.150 |
| 0.072 | 0.106 | 0.098 | 0.058 | 0.109 | 0.101 | 0.101 | 0.078 | 0.127 | 0.150 |
| 0.072 | 0.106 | 0.098 | 0.058 | 0.109 | 0.101 | 0.101 | 0.078 | 0.127 | 0.150 |
| 0.072 | 0.106 | 0.098 | 0.058 | 0.109 | 0.101 | 0.101 | 0.078 | 0.127 | 0.150 |
| 0.072 | 0.106 | 0.098 | 0.058 | 0.109 | 0.101 | 0.101 | 0.078 | 0.127 | 0.150 |
| 0.072 | 0.106 | 0.098 | 0.058 | 0.109 | 0.101 | 0.101 | 0.078 | 0.127 | 0.150 |
| 0.072 | 0.106 | 0.098 | 0.058 | 0.109 | 0.101 | 0.101 | 0.078 | 0.127 | 0.150 |
| 0.072 | 0.088 | 0.093 | 0.046 | 0.056 | 0.069 | 0.065 | 0.048 | 0.073 | 0.391 |
| 0.072 | 0.088 | 0.093 | 0.046 | 0.056 | 0.069 | 0.065 | 0.048 | 0.073 | 0.391 |
| 0.072 | 0.088 | 0.093 | 0.046 | 0.056 | 0.069 | 0.065 | 0.048 | 0.073 | 0.391 |
| 0.072 | 0.088 | 0.093 | 0.046 | 0.056 | 0.069 | 0.065 | 0.048 | 0.073 | 0.391 |
| 0.072 | 0.088 | 0.093 | 0.046 | 0.056 | 0.069 | 0.065 | 0.048 | 0.073 | 0.391 |
| 0.072 | 0.088 | 0.093 | 0.046 | 0.056 | 0.069 | 0.065 | 0.048 | 0.073 | 0.391 |
| 0.072 | 0.088 | 0.093 | 0.046 | 0.056 | 0.069 | 0.065 | 0.048 | 0.073 | 0.391 |
| 6.0 | 6.0 | 6.0 | 6.0 | 6.0 | 6.0 | 6.0 | 6.0 | 6.0 | 6.0 |
| 6.0 | 6.0 | 6.0 | 6.0 | 6.0 | 6.0 | 6.0 | 6.0 | 6.0 | 6.0 |
| 6.0 | 6.0 | 6.0 | 6.0 | 6.0 | 6.0 | 6.0 | 6.0 | 6.0 | 6.0 |
| 6.0 | 6.0 | 6.0 | 6.0 | 6.0 | 6.0 | 6.0 | 6.0 | 6.0 | 6.0 |
| 18117 | 18117 | 18699 | 19504 | 25006 | 33998 | 37799 | 44421 | 61955 | 76002 |
| 83204 | 108032 | 149142 | 198617 | 220000 | 181037 | 168020 | 166498 | 142879 | 119886 |
| 98548 | 85397 | 65893 | 41870 | 41065 | 26885 | 26080 | 23755 | 22769 | 22769 |
| 22411 | 22411 | 20935 | 20667 | 20175 | 20175 | 18520 | 17714 | 17714 | 17714 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| 0 | | | | | | | | | |

QUASED INPUT FILE

100-YR FLOW

NO SEDIMENT INFLOW

```
    40        7        0      0.4
     0        5    12239    10509        0
     0        5    10509     8777        0
     0        5     8777     7046        0
     0        5     7046     5312        1
     0        3     5312     3598        0
     0        3     3598     1821        0
     0        4     1821        0        0
    10
 0.149    0.421    0.838    1.683    3.888    8.980   15.554   21.997   31.109   76.200
   600      600      600      600      600      600      600
 0.072    0.106    0.098    0.058    0.109    0.101    0.101    0.078    0.127    0.150
 0.072    0.106    0.098    0.058    0.109    0.101    0.101    0.078    0.127    0.150
 0.072    0.106    0.098    0.058    0.109    0.101    0.101    0.078    0.127    0.150
 0.072    0.106    0.098    0.058    0.109    0.101    0.101    0.078    0.127    0.150
 0.072    0.106    0.098    0.058    0.109    0.101    0.101    0.078    0.127    0.150
 0.072    0.106    0.098    0.058    0.109    0.101    0.101    0.078    0.127    0.150
 0.072    0.106    0.098    0.058    0.109    0.101    0.101    0.078    0.127    0.150
 0.072    0.088    0.093    0.046    0.056    0.069    0.065    0.048    0.073    0.391
 0.072    0.088    0.093    0.046    0.056    0.069    0.065    0.048    0.073    0.391
 0.072    0.088    0.093    0.046    0.056    0.069    0.065    0.048    0.073    0.391
 0.072    0.088    0.093    0.046    0.056    0.069    0.065    0.048    0.073    0.391
 0.072    0.088    0.093    0.046    0.056    0.069    0.065    0.048    0.073    0.391
 0.072    0.088    0.093    0.046    0.056    0.069    0.065    0.048    0.073    0.391
 0.072    0.088    0.093    0.046    0.056    0.069    0.065    0.048    0.073    0.391
   6.0      6.0      6.0      6.0      6.0      6.0      6.0      6.0      6.0      6.0
   6.0      6.0      6.0      6.0      6.0      6.0      6.0      6.0      6.0      6.0
   6.0      6.0      6.0      6.0      6.0      6.0      6.0      6.0      6.0      6.0
   6.0      6.0      6.0      6.0      6.0      6.0      6.0      6.0      6.0      6.0
 18117    18117    18699    19504    25006    33998    37799    44421    61955    76002
 83204   108032   149142   198617   220000   181037   168020   166498   142879   119886
 98548    85397    65893    41870    41065    26885    26080    23755    22769    22769
 22411    22411    20935    20667    20175    20175    18520    17714    17714    17714
     0        0        0        0        0        0        0        0        0        1
     0
```

QUASED INPUT FILE
100 - YR FLOW
SUPPLY = UPSTREAM REACH

```
    40        7        0      0.4
     0        5    12239    10509        0
     0        5    10509     8777        0
     0        5     8777     7046        0
     0        5     7046     5312        1
     0        3     5312     3598        0
     0        3     3598     1821        0
     0        4     1821        0        0
    10
 0.149    0.421    0.838    1.683    3.888    8.980   15.554   21.997   31.109   76.200
   600      600      600      600      600      600      600
 0.072    0.106    0.098    0.058    0.109    0.101    0.101    0.078    0.127    0.150
 0.072    0.106    0.098    0.058    0.109    0.101    0.101    0.078    0.127    0.150
 0.072    0.106    0.098    0.058    0.109    0.101    0.101    0.078    0.127    0.150
 0.072    0.106    0.098    0.058    0.109    0.101    0.101    0.078    0.127    0.150
 0.072    0.106    0.098    0.058    0.109    0.101    0.101    0.078    0.127    0.150
 0.072    0.106    0.098    0.058    0.109    0.101    0.101    0.078    0.127    0.150
 0.072    0.106    0.098    0.058    0.109    0.101    0.101    0.078    0.127    0.150
 0.072    0.088    0.093    0.046    0.056    0.069    0.065    0.048    0.073    0.391
 0.072    0.088    0.093    0.046    0.056    0.069    0.065    0.048    0.073    0.391
 0.072    0.088    0.093    0.046    0.056    0.069    0.065    0.048    0.073    0.391
 0.072    0.088    0.093    0.046    0.056    0.069    0.065    0.048    0.073    0.391
 0.072    0.088    0.093    0.046    0.056    0.069    0.065    0.048    0.073    0.391
 0.072    0.088    0.093    0.046    0.056    0.069    0.065    0.048    0.073    0.391
 0.072    0.088    0.093    0.046    0.056    0.069    0.065    0.048    0.073    0.391
   6.0      6.0      6.0      6.0      6.0      6.0      6.0      6.0      6.0      6.0
   6.0      6.0      6.0      6.0      6.0      6.0      6.0      6.0      6.0      6.0
   6.0      6.0      6.0      6.0      6.0      6.0      6.0      6.0      6.0      6.0
   6.0      6.0      6.0      6.0      6.0      6.0      6.0      6.0      6.0      6.0
 28410    28410    29323    30586    39214    53315    59276    69660    97157   119185
130479   169414   233883   311468   345000   283899   263485   261099   224061   188003
154541   133919   103332    65661    64398    42161    40898    37251    35706    35706
 35145    35145    32830    32409    31638    31638    29042    27780    27780    27780
     0        0        0        0        0        0        0        0        1        0
     0
```

QUASED INPUT FILE

500-YR FLOW

NO SEDIMENT INFLOW

```
    40        7        0      0.4
     0        5    12239    10509        0
     0        5    10509     8777        0
     0        5     8777     7046        0
     0        5     7046     5312        1
     0        3     5312     3598        0
     0        3     3598     1821        0
     0        4     1821        0        0
    10
 0.149    0.421    0.838    1.683    3.888    8.980   15.554   21.997   31.109   76.200
   600      600      600      600      600      600      600
 0.072    0.106    0.098    0.058    0.109    0.101    0.101    0.078    0.127    0.150
 0.072    0.106    0.098    0.058    0.109    0.101    0.101    0.078    0.127    0.150
 0.072    0.106    0.098    0.058    0.109    0.101    0.101    0.078    0.127    0.150
 0.072    0.106    0.098    0.058    0.109    0.101    0.101    0.078    0.127    0.150
 0.072    0.106    0.098    0.058    0.109    0.101    0.101    0.078    0.127    0.150
 0.072    0.106    0.098    0.058    0.109    0.101    0.101    0.078    0.127    0.150
 0.072    0.106    0.098    0.058    0.109    0.101    0.101    0.078    0.127    0.150
 0.072    0.088    0.093    0.046    0.056    0.069    0.065    0.048    0.073    0.391
 0.072    0.088    0.093    0.046    0.056    0.069    0.065    0.048    0.073    0.391
 0.072    0.088    0.093    0.046    0.056    0.069    0.065    0.048    0.073    0.391
 0.072    0.088    0.093    0.046    0.056    0.069    0.065    0.048    0.073    0.391
 0.072    0.088    0.093    0.046    0.056    0.069    0.065    0.048    0.073    0.391
 0.072    0.088    0.093    0.046    0.056    0.069    0.065    0.048    0.073    0.391
 0.072    0.088    0.093    0.046    0.056    0.069    0.065    0.048    0.073    0.391
   6.0      6.0      6.0      6.0      6.0      6.0      6.0      6.0      6.0      6.0
   6.0      6.0      6.0      6.0      6.0      6.0      6.0      6.0      6.0      6.0
   6.0      6.0      6.0      6.0      6.0      6.0      6.0      6.0      6.0      6.0
   6.0      6.0      6.0      6.0      6.0      6.0      6.0      6.0      6.0      6.0
 28410    28410    29323    30586    39214    53315    59276    69660    97157   119185
130479   169414   233883   311468   345000   283899   263485   261099   224061   188003
154541   133919   103332    65661    64398    42161    40898    37251    35706    35706
 35145    35145    32830    32409    31638    31638    29042    27780    27780    27780
     0        0        0        0        0        0        0        0        0        1
     0
```

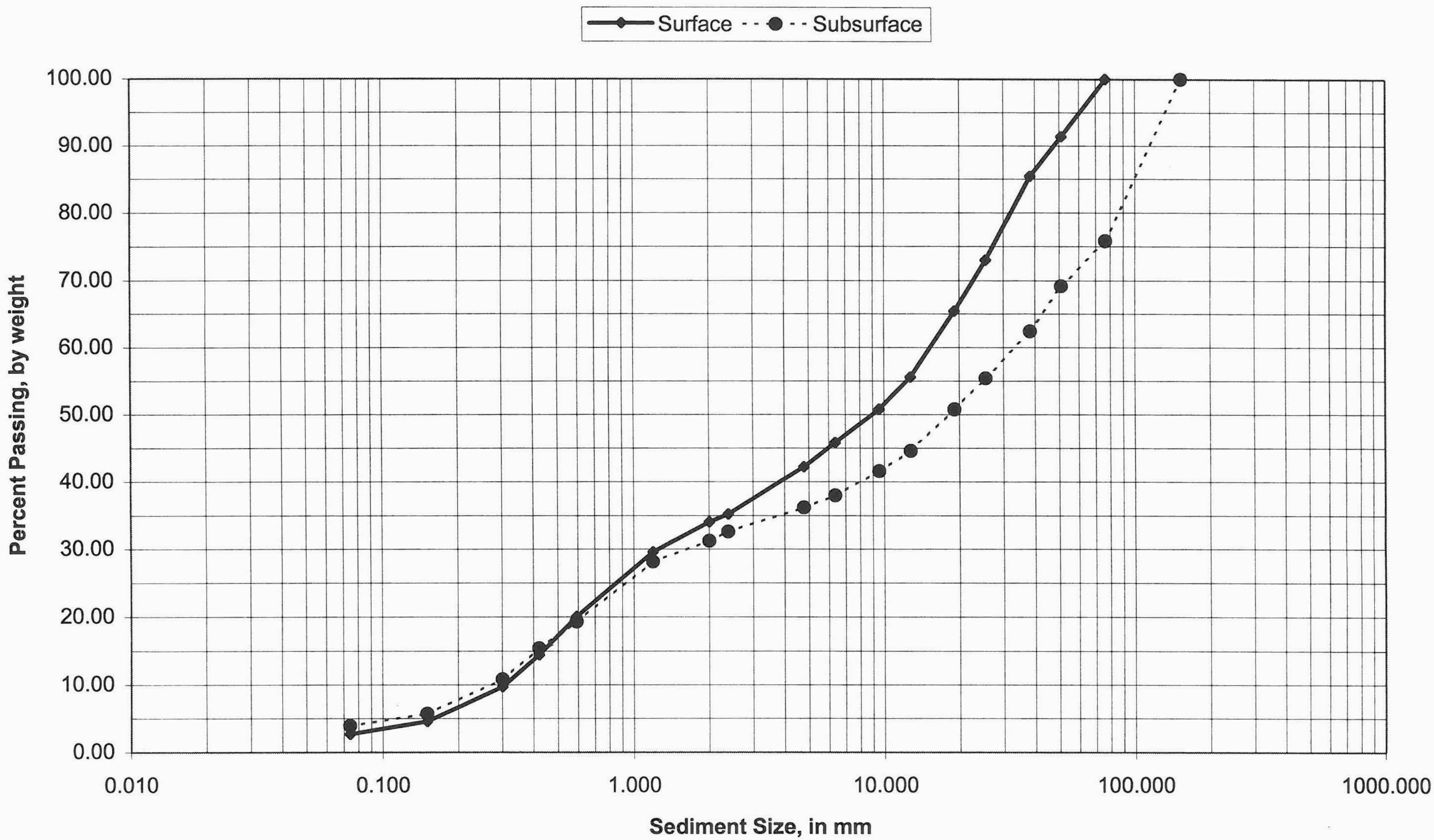
QUASED INPUT FILE

500-YR FLOW

SUPPLY = UPSTREAM REACH

## APPENDIX F
## SEDIMENT SAMPLING DATA

## SEDIMENT GRADATION CURVES FOR SALT RIVER AT MCKELLIPS RD.



## SALT RIVER IN VICINITY OF MCKELLIPS ROAD

### SURFACE LAYER SEDIMENT GRADATION CHART:

| Sediment Size (in mm) | Percent Passing (by weight) |
|---|---|
| 0.074 | 2.68 |
| 0.150 | 4.54 |
| 0.300 | 9.72 |
| 0.420 | 14.42 |
| 0.590 | 20.04 |
| 1.190 | 29.58 |
| 2.000 | 34.04 |
| 2.380 | 35.20 |
| 4.760 | 42.20 |
| 6.350 | 45.80 |
| 9.530 | 50.80 |
| 12.700 | 55.60 |
| 19.050 | 65.40 |
| 25.400 | 73.00 |
| 38.100 | 85.40 |
| 50.800 | 91.40 |
| 76.200 | 100.00 |
| 152.400 | |
| | |
| | |

| Percent in Interval | Percent in 10 Intervals | Unitized Percents | Bottom of Interval | Top of Interval | Geometric Mean |
|---|---|---|---|---|---|
| 1.9 | | | | | |
| 5.2 | 7.0 | 7.2 | 0.074 | 0.3 | 0.149 |
| 4.7 | | | | | |
| 5.6 | 10.3 | 10.6 | 0.3 | 0.59 | 0.421 |
| 9.5 | 9.5 | 9.8 | 0.59 | 1.19 | 0.838 |
| 4.5 | | | | | |
| 1.2 | 5.6 | 5.8 | 1.19 | 2.38 | 1.683 |
| 7.0 | | | | | |
| 3.6 | 10.6 | 10.9 | 2.38 | 6.35 | 3.888 |
| 5.0 | | | | | |
| 4.8 | 9.8 | 10.1 | 6.35 | 12.7 | 8.980 |
| 9.8 | 9.8 | 10.1 | 12.7 | 19.05 | 15.554 |
| 7.6 | 7.6 | 7.8 | 19.05 | 25.4 | 21.997 |
| 12.4 | 12.4 | 12.7 | 25.4 | 38.1 | 31.109 |
| 6.0 | | | | | |
| 8.6 | | | | | |
| 0.0 | 14.6 | 15.0 | 38.1 | 152.4 | 76.200 |
| 97.3 | | 100.0 | | | |

### SUBSURFACE LAYER SEDIMENT GRADATION CHART:

| Sediment Size (in mm) | Percent Passing (by weight) |
|---|---|
| 0.074 | 3.90 |
| 0.150 | 5.72 |
| 0.300 | 10.82 |
| 0.420 | 15.38 |
| 0.590 | 19.30 |
| 1.190 | 28.16 |
| 2.000 | 31.22 |
| 2.380 | 32.60 |
| 4.760 | 36.20 |
| 6.350 | 38.00 |
| 9.530 | 41.60 |
| 12.700 | 44.60 |
| 19.050 | 50.80 |
| 25.400 | 55.40 |
| 38.100 | 62.40 |
| 50.800 | 69.20 |
| 76.200 | 75.80 |
| 152.400 | 100.00 |
| | |
| | |

| Percent in Interval | Percent in 10 Intervals | Unitized Percents | Bottom of Interval | Top of Interval | Geometric Mean |
|---|---|---|---|---|---|
| 1.8 | | | | | |
| 5.1 | 6.9 | 7.2 | 0.074 | 0.3 | 0.149 |
| 4.6 | | | | | |
| 3.9 | 8.5 | 8.8 | 0.3 | 0.59 | 0.421 |
| 8.9 | 8.9 | 9.3 | 0.59 | 1.19 | 0.838 |
| 3.1 | | | | | |
| 1.4 | 4.4 | 4.6 | 1.19 | 2.38 | 1.683 |
| 3.6 | | | | | |
| 1.8 | 5.4 | 5.6 | 2.38 | 6.35 | 3.888 |
| 3.6 | | | | | |
| 3.0 | 6.6 | 6.9 | 6.35 | 12.7 | 8.980 |
| 6.2 | 6.2 | 6.5 | 12.7 | 19.05 | 15.554 |
| 4.6 | 4.6 | 4.8 | 19.05 | 25.4 | 21.997 |
| 7.0 | 7 | 7.3 | 25.4 | 38.1 | 31.109 |
| 6.8 | | | | | |
| 6.6 | | | | | |
| 24.2 | 37.6 | 39.1 | 38.1 | 152.4 | 76.200 |
| 96.1 | | 100.0 | | | |