Tessera Solar™
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September 16, 2010

Mr. Christopher Meyer
CEC Project Manager
Attn: Docket No. 08-AFC-13
California Energy Commission
1516 Ninth Street
Sacramento, CA 95814-5512

Re: Calico Solar (formerly Solar One) Project (08-AFC-13) Response to BNSF September 15, 2010 Submittal

Dear Mr. Meyer:

Tessera Solar has received a copy of the letter submitted yesterday afternoon by Steven Lamb on behalf of BNSF. Mr. Lamb requests copies of "the reports, studies, and any and all underlying raw data provided to Staff in this matter by Applicant in relation to the hydrology of the site." We have reviewed our records and compiled the following list of documents provided to CEC Staff that meet the description in Mr. Lamb's letter:

1. Applicant's Submittal Revised Drainage Figures Requested by CEC, docketed on September 14, 2010.

2. Applicant's Submittal of Potential Detention Basin Removal Analysis (Chang, September, 2010) docketed on September 10, 2010; the data and analysis summarized in this report is provided in Sediment Study For Washes At Calico Solar Project Site in San Bernardino County (Chang, July 2010) is attached.

3. Proposed Revisions to Soil and Water-8, docketed on September 10, 2010, docketed on September 10, 2010.

4. Applicant's Submittal of Updated Detention Basin Specifications and Figures, docketed on August 18, 2010.

5. Applicant's Submittal of Clarification to Responses to CEC 6-4-10 Email, docketed on June 16, 2010.

6. Applicant's Response to CEC Email Dated June 4th 2010, docketed on June 14, 2010.

7. Applicant's Submittal of Alternative Layout #2 and SunCatcher Layout docketed on June 3, 2010.

8. Applicant's Submittal of Information Requested at the April 16 Workshop, docketed April 20, 2010.

9. Existing Condition Hydrologic and Hydraulic Study for Solar One (Phase 1 and 2) Project Site, Hutt-Zollars (April 23, 2009), docketed on January 8, 2010.

10. Responses to CEC and BLM DR, Set 2, Part 2, docketed on December 4, 2009.

11. Applicant's Response to CEC and BLM Data Request 81: Drainage, Erosion and Sediment Control Plan (draft dated August 2009), docketed August 31, 2009.

12. Data Adequacy Responses 54, submitted April 6, 2009.

13. AFC, Section 3, Project Description and Location, submitted December 1, 2008.

14. AFC, Appendix N, Initial Drainage Report (Stantec Consulting, October, 2008), submitted December 1, 2008.

I certify under penalty of perjury that the foregoing is true, correct, and complete to the best of my knowledge.

Sincerely,

Felicia L. Bellows
Vice President of Development

ATTACHMENT

SEDIMENT STUDY FOR WASHES AT CALICO SOLAR PROJECT SITE IN SAN BERNARDINO COUNTY

SEDIMENT STUDY FOR WASHES AT CALICO SOLAR PROJECT SITE IN SAN BERNARDINO COUNTY

Prepared for Tessera Energy

Prepared by Howard H. Chang, Ph.D., P.E.
July 2010

CHANG Consultants Hydraulic and Hydrologic Engineering Erosion and Sedimentation	P.O. Box 9492 6001 Avenida Alteras Rancho Santa Fe, CA 92067-4492 TEL: (858) 756-9050, (858) 692-0761 FAX: (858) 756-9460

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EXECUTIVE SUMMARY

There are two major drainage systems at the Calico Solar project site; these are: (1) small washes on the alluvial fan, and (2) washes along the railroad track and south of the railroad track. SunCatchers and related facilities will be installed at the Calico Solar project site. Some of them will be located in the desert washes. For the sake of protecting the SunCatchers and other environmental considerations, the installation of SunCatchers is subject to certain restrictions. The restrictions related to the flow and sediment include: (1) Storm water flow depths around the SunCatcher cannot exceed 1.5 ft, (2) The maximum allowable scour depth around the SunCatcher pedestal is 4 ft, and (3) Sediment deposition within the SunCatcher field during a 100-year event cannot exceed 6 inches as Tessera Solar does not have earth moving equipment on site and an increase in the ground height above 6 inches will interfere with the dish movement and operation.

A sediment study for the Calico Solar project site has been made to provide the dynamics of stream flow and potential stream channel changes including general scour and local scour. General scour is due to the imbalance in sediment transport. Local scour is caused by local obstructions to flow, such as the pedestals supporting SunCatchers. The study provides the required information for SunCatcher installation.

Washes on Alluvial Fan – The alluvial fan north of the railroad track has an average slope of about 5%. Water and sediment on the alluvial fan are supplied from the northern hills. The general terrain is flat with only minor land features. Such a landform has formed by continued sediment deposition Storm flows on the generally flat terrain occur primarily as sheet flow, characterized by shallow depth and low velocity. Sheet flow area can be used for SunCatcher field. Well defined washes on the alluvial fan are few in number; they are small in size and shallow in depth. Modeling study of sediment processes for a small wash has been made using the FLUVIAL-12 model. The results show that the channel bed is subject to limited changes but sediment deposition can exceed 6 inches along channel reach with water depth exceeding one foot. SunCatchers should avoid washes on the alluvial fan if the height for both banks for such a wash exceeds 1 foot. This restriction for SunCatchers supersedes other restrictions.

The properties north of the railroad track, except for small areas near the bridge openings, have a generally flat terrain, on which storm flows occur as sheet flow. These areas can be used to develop SunCatcher fields.

Topographic maps for the project site do not have sufficient details for indentifying the small washes on the alluvial fan. Such washes shall be indentified by a field survey before the plan is finalized.

Washes South of Railroad Track - The railroad track south of the alluvial fan is a flow barrier. As the flow from the alluvial fan reaches the railroad track, it splits into two parts: one part flows along the railroad track toward west; the other part passes through several bridge openings under the railroad track. Storm flow along the north side of the railroad track covers a large width in the form of sheet flow. As the storm water passes through the narrow bridge openings, it may form a well defined wash south of the railroad track. Such small wash channels are characterized by shallow depths; they gradually dissipate into sheet flow after some distance on the flat terrain.

The discharge of flood flows through the bridge openings to the south side is controlled by the size of the bridge openings. Such flows were not determined in the Hiitt-Zollars hydrology study. South of the railroad track, a part of flood flows stays in small channels and another part spreads out to the flat terrain as sheet flow. The effective discharge for a wash in this case is the bankfull discharge for the stream channel.

In order to assess the potential stream channel changes, modeling sediment processes was made for stream 100 as a sample case. The study is intended to determine if SunCatchers may be placed or excluded from such washes. The wash is predicted to undergo changes with both scour and deposition. For wash reaches with the height of both banks greater than 1.5 feet, the flow depths can be greater than 1.5 feet; the depths of sediment deposition can exceed 6 inches. Based on these findings, SunCatchers should be kept away from stream washes if the height of both banks exceeds 1.5 feet.

The southern properties have alluvial fans and more confined valleys. The alluvial fan areas with sheet flow can be developed into SunCatcher fields.

Streams in More Confined Valleys South of Railroad Track - Several streams south of the railroad track are in more confined valleys. The are capable of carrying the 100-yr flood without significant overflow to the overbank area. These valley streams gradually change into sheet flow toward downstream as they reach the broad and flat floodplain. Modeling of sediment transport and potential stream channel changes were made for stream 20B in confined valley as a sample. Simulated channel changes based on the 100-yr flood are characterized by both scour and deposition in the channel. For channel areas with a flow depth greater than 1.5 feet, the depth of sediment deposition can exceed 6 inches. Thus, SunCatcher should be kept away from such areas.

Local Scour – The depths of local scour around SunCatcher pedestals have been calculated. SunCatchers can not be installed in areas with the local scour depth exceeding 4 feet. For all cases evaluated, installation of SunCatchers is restricted by the flow depth or by the depth of sediment deposition, but not restricted by local scour.

GLOSSARY OF TERMS

Aggradation: A rise in channel bed elevation, usually caused by sediment deposition.

Alluvial: Relating to, composed of, or found in alluvium

Bank protection: A structure placed on a riverbank to protect the bank against erosion. Such structures are usually made of riprap stones, revetments, dikes, etc.

Bed load: That part of the sediment load that travels in contact with the bed by rolling, sliding and saltation. It is also the coarser portion of the sediment load.

Channel reach: Any stretch of the channel.

Channelization: To make a channel.

Cross sections: Channel sections that are perpendicular to the flow direction that are used to define the river channel geometry for a river study.

Degradation: A lowering of the channel-bed elevation usually caused by erosion.

Drainage basin: A surface area from which rainfall drains toward a single point.

Drop structure: A rigid structure erected across a river channel through which there is a drop in channel-bed elevation.

Erodible boundary model: A model that considers the changes in channel boundary, including channel-bed scour and fill, changes in channel width and changes related to channel curvature.

Erodible bed model: A model that only considers the changes in channel-bed level by assuming that channel width does not change.

Field calibration: The correlation of modeling results using field data. It usually involves fine adjustments of certain parameters used in modeling to improve the correlation.

Flood hydrograph: A relationship showing how the flood discharge varies with time during its occurrence.

Fluvial processes: Processes that are caused by stream action, including sediment transport, flood flow, erosion, deposition, and river channel changes.

Grade control structure: A rigid structure constructed across a river channel used to stabilize the bed elevation at the location. A drop structure is also a grade control structure.

Head cutting: Channel-bed erosion occurring upstream of a sand or gravel pit or any other depression.

Model: For this study, a model is computer software developed to simulate the hydraulics of flow, sediment transport and river channel changes.

Pit capture: A stream is diverted from its normal course into a pit of lower elevation

Scour (general and local): Erosion or removal of material caused by stream action. General scour is caused by the imbalance (non-uniformity) in sediment transport along a river channel. Local scour is caused by any local obstruction to flow, such as bridge piers, abutments, tree trunks, etc.

Sediment delivery: The cumulative amount of sediment that is delivered passing a river section in a specified period of time.

Sediment transport/replenishment: Sediment transport is the movement of sediment by flow measured usually in volume or weight per unit time. Replenishment is sediment supply to make up any previous deficit.

Study channel reach: A river channel reach that is covered in a study. Such a reach is defined by a series of cross sections taken along the channel.

Suspended load: Sediment load that travels in suspension, consisting of the finer portion of the transported sediment.

Tractive force: The force exerted by the flow on the channel boundary or on any object in the river channel, usually measured in force per unit surface area.

SEDIMENT STUDY FOR WASHES AT CALICO SOLAR PROJECT SITE IN SAN BERNARDINO COUNTY

I. INTRODUCTION

The proposed Solar One project is on the Bureau of Land Management property at Calico in San Bernardino County along both sides of the BNSF railroad as shown in Figures 1 and 2. There are two major drainage systems at the Calico Solar project site; these are: (1) small washes on the alluvial fan north of the railroad track, and (2) washes along the railroad track and south of the railroad track. SunCatchers and related facilities will be installed at the Calico Solar project site. Some of them will be located in the desert washes.

Previous studies of the project site by Phillip Williams & Associates and WEST Consultants have the focus on fluvial geomorphology. These studies concluded that significant threats due to erosion, sedimentation, debris flow, etc. exist for SunCatchers placed on the alluvial fan. While they noted that mitigation methods are available, such measures are not provided in the study.

For the sake of protecting the SunCatchers and other environmental considerations, the project site has the following usual site restrictions:

(1) Storm water flow depths around the SunCatcher cannot exceed 1.5 ft.
(2) The maximum allowable scour depth around the pedestal is 4 ft.
(3) The storm water flow in the major washes on site must be maintained, but the storm water can be detained to reduce the peak flows.
(4) Sediment deposition within the SunCatcher field during a 100 year event cannot exceed 6 inches as Tessera Solar does not have earth moving equipment on site and an increase in the ground height above 6 inches will interfere with the dish movement and operation.
(5) The original detention/debris basin system as recommended in the Huitt-Zollars report cannot be constructed as a result of the project area reduction, as depicted on the URS illustrations transmitted yesterday.
(6) The storm water management areas have been reduced to the linear areas as illustrated on the drawings transmitted yesterday.
(7) The San Bernardino County Hydrology Manual, latest edition, is to be used as the basis for developing all hydrology investigations.
(8) The design must comply with San Bernardino County floodplain ordinances and FEMA requirements.
(9) SunCatcher field alterations/restrictions must be coordinated with Tessera Solar and Mortenson Construction.
(10) Any and all changes to the drainage system cannot adversely affect the BNSF Railroad, nor there any encroachment within the BNSF right of way.
(11) The drainage solutions need to be as simple as practicable as this is a remote location and all non-native material needs to be imported.

Hydrology and hydraulic studies for the project site are provided by Huitt and Zollars of Ontario, Califronia. The hydrology study was based on the AES method and the hydraulic modeling study was made using the HEC-RAS model. Certain potential problems have also been identified. While these studies suggested that alternatives exist for managing the risks for the project, such alternatives have not been provided. Of course, any effort to develop alternatives for SunCatcher protection and project impact mitigation will require quantitative information on the flow and sediment dynamics.

A sediment study for the Calico Solar project has been made and the study results will be used as the bases for developing measures for SunCatcher protection and project impact mitigation. This study has been made to provide potential stream channel changes including general scour and local scour. General scour is due to the imbalance in sediment transport. Local scour is caused by local obstructions to flow, such as the pedestals supporting SunCatchers. Such scour information will be used to assess the stability of the solar units in a wash. It will also be used to determine and evaluate site modifications (avoidance measures such as removing infrastructure/SunCatchers from large streams) and mitigation (impact minimization measures such as additions/redesigned sediment basins).

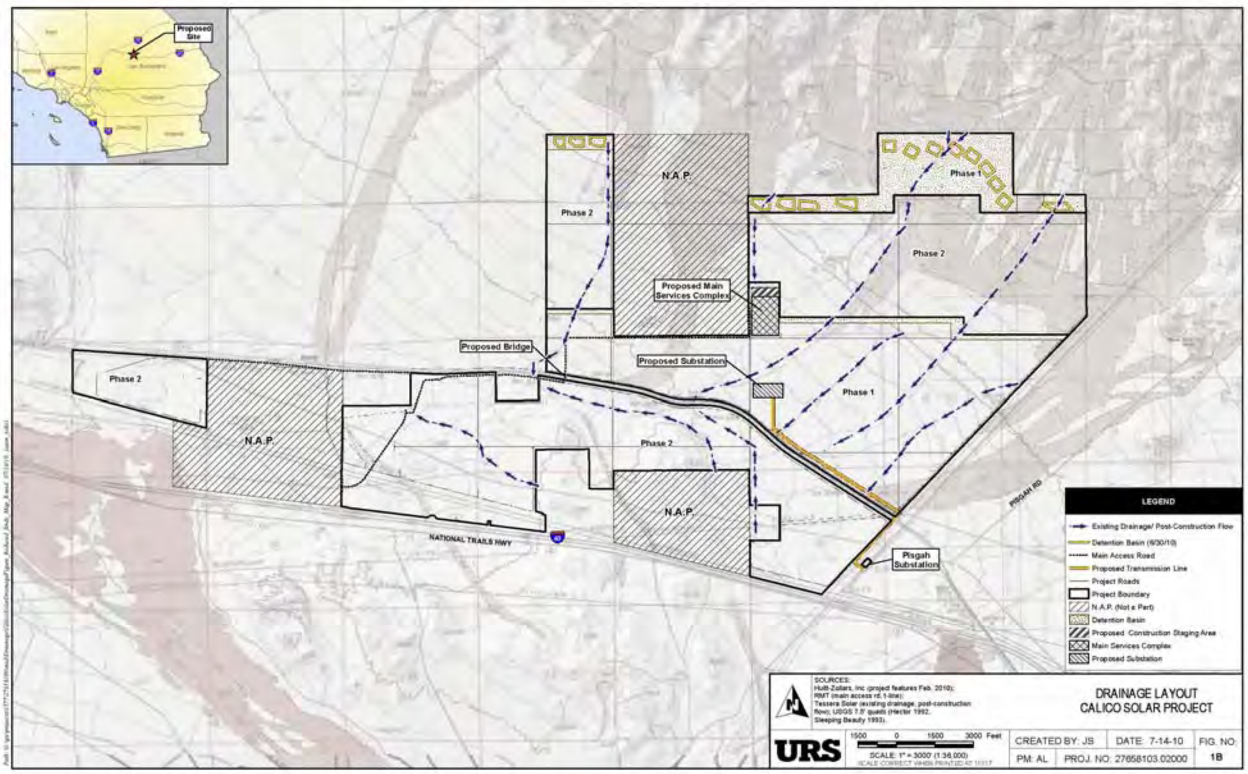


Figure 1. Solar one project site

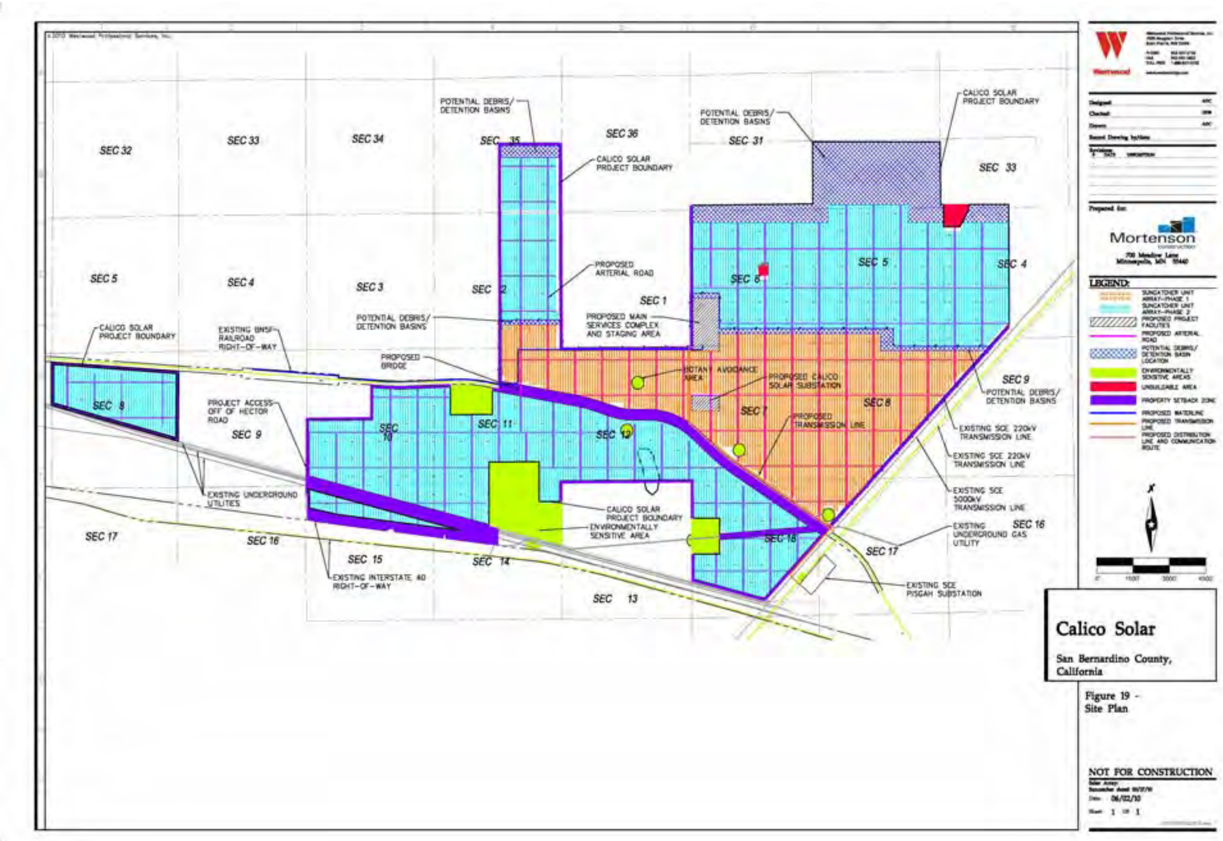


Figure 2. Plans for Solar one project site

II. MODELING STUDY FOR SEDIMENT FLOW AND STREAM CHANNEL CHANGES

Stream channel scour consists of general scour and local scour. General scour is related to the sediment supplied to and transported out of a channel reach. Local scour is due to a local obstruction to flow by a bridge pier/bent, abutment, or a structural support for the solar panel. The total scour is the general scour plus the local scour at the pier or structural support.

To determine general scour, it is necessary to consider the sediment supply by flow to the channel reach and sediment removal out of the reach. Sediment delivery in a stream channel and supply to the subject area is related to the flood hydrograph, channel geometry, and sediment characteristics, etc. To account for these factors, it will require mathematical simulation of the hydraulics of stream flow, sediment transport and stream channel changes.

Mathematical Model for General Scour - The FLUVIAL-12 model (Chang, 1988) is employed for this project. For a given flood hydrograph, the FLUVIAL model simulates spatial and temporal variations in water-surface elevation, sediment transport and channel geometry. Scour and fill of the stream bed are coupled with width variation in the prediction of stream channel changes. Computations are based on finite difference approximations to energy and mass conservation that are representative of open channel flow.

The model simulates the inter-related changes in channel-bed profile and channel width, based upon a stream's tendency to seek uniformities in sediment discharge and power expenditure. At each time step, scour and fill of the channel bed are computed based on the spatial variation in sediment discharge along the channel. Channel-bed corrections for scour and fill will reduce the non-uniformity in sediment discharge. Width changes are also made at each time step, resulting in a movement toward uniformity in power expenditure along the channel. Because the energy gradient is a measure of the power expenditure, uniformity in power expenditure also means a uniform energy gradient or linear water surface profile. A stream channel may not have a uniform power expenditure or linear water-surface profile, but it is constantly adjusting itself toward that direction. The model was calibrated using 12 sets of stream data.

A sediment transport formula is employed in the FLUVIAL-12 model. In this case, the Engelund-Hansen formula (Engelund and Hansen, 1967) is used based on past experiences.

Input data for the model include the grain size distribution of the bed material (see Figure 3) and the 100-yr flood hydrograph as shown in Figure 4.

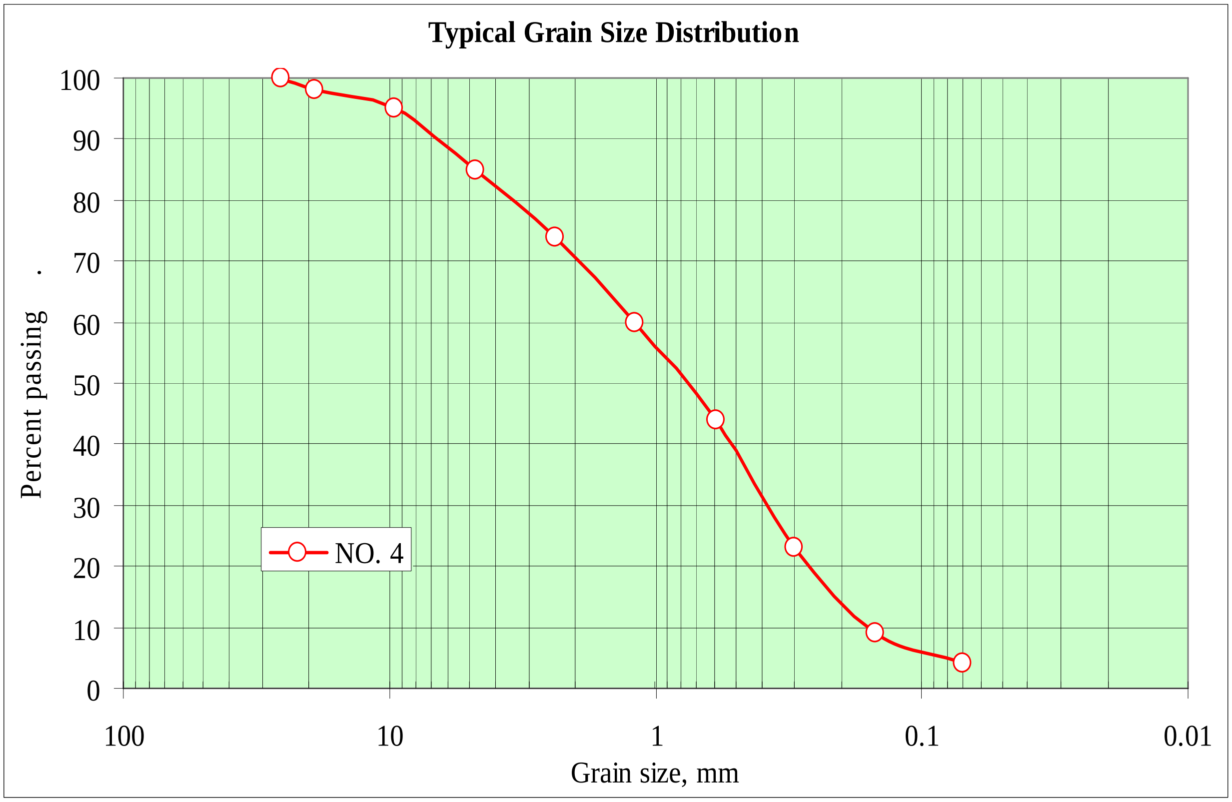


Figure 3. Grain size distribution of sediment sample

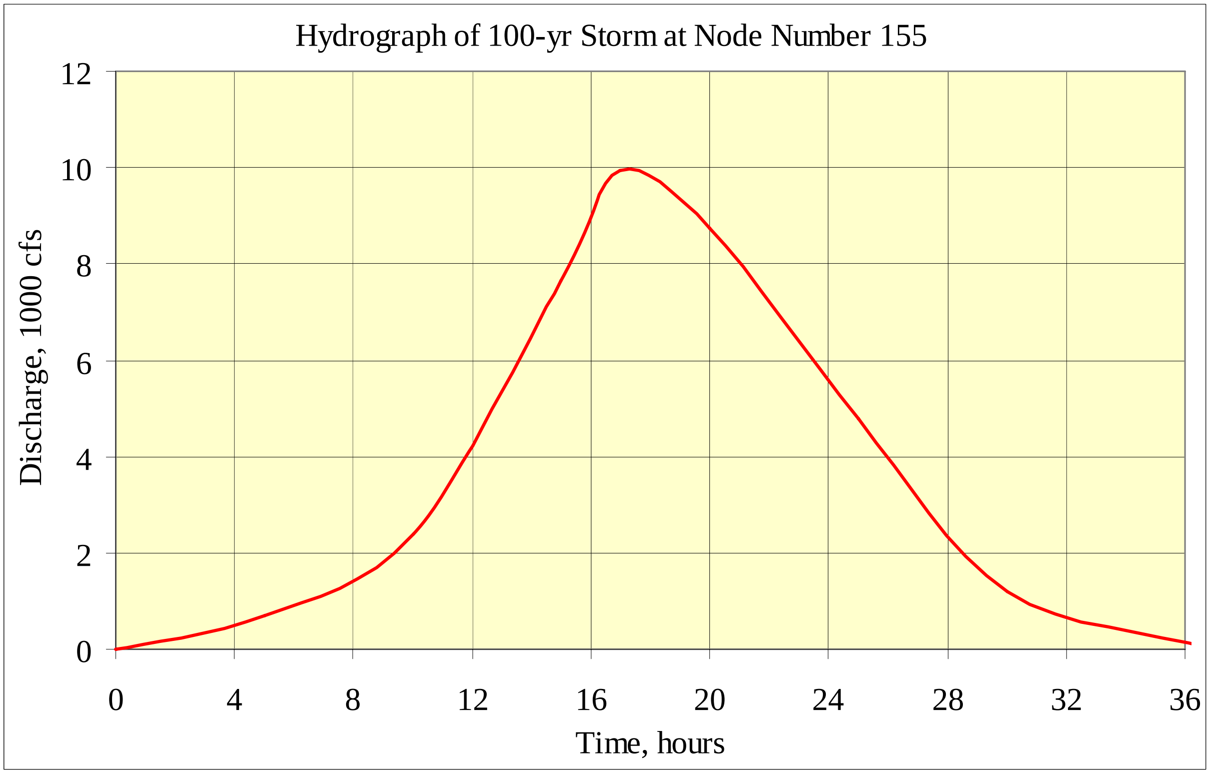


Figure 4. Typical hydrograph of the 100-yr flood at the project site

Dominant Discharge or Bankfull Discharge - Bankfull discharge refers to the flow discharge in a stream channel when water level reaches the top of the stream bank. Bankfull discharge is also called the dominant discharge or channel forming discharge in fluvial geomorphology (Leopold, et al, 1964) since it is the maximum discharge that can be handled by the stream channel. For a desert wash in a broad plain, if the total discharge exceeds the bankfull stage, the flow would spread out to the adjacent floodplain. A wash generally has a wide and flat adjacent floodplain, the overbank flow is very shallow and it has no direct effects on the wash channel. For a stream channel of varied bank height, bankfull discharge is limited by lower bank height since the discharge will overflow the top of the lower bank. In other words, the effective discharge for such a wash is the bankfull discharge. But for a wash in a more confined valley, the effective discharge is the entire flow discharge. The duration of the flow is based on the flood hydrograph provided by Huitt and Zollars.

III. COMPUTATION OF LOCAL SCOUR AROUND SUNCATCHER PEDESTALS

In alluvial streams, the scour around bridge piers, abutments, and other local obstructions is first initiated by the interference to flow and sediment transport. Figure 5 shows the local scour around a bridge pier taken soon after a storm. SunCatchers may be installed in certain washes at the Solar One project site. The pedestal supporting a SunCatcher induces local scour during the storm flow.

Figure 5. Local scour around bridge pier

During a storm flow, local scour is first initiated by the pedestal's interference to flow and sediment transport as illustrate in Figure 6. The erodible bed deforms until it reaches an equilibrium scour configuration for which the rate of sediment supplied to the scour area is balanced by the rate of transport out of the area, that is, $(Q_s)_{in} = (Q_s)_{out}$. Sediment transport through a scour hole is also affected by the horseshoe vortices, which, as a turbulent motion, increase the particle mobility. The sediment rate is an inverse function of the particle size. Because sediment rates flowing into and out of a scour area change with the size, at nearly the same proportion, the scour depth is not significantly affected by the sediment size which is therefore missing in most formulas for local scour.

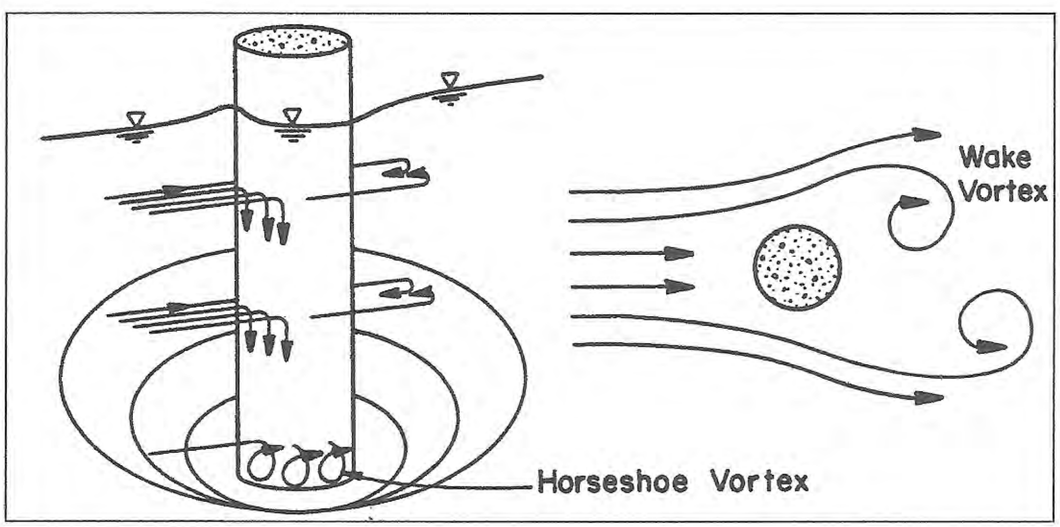


Figure 6. Interference to flow by a pier (After Federal Highway Administration, 2006)

The scour hole shaped like an inverted cone changes in size with the flow, it normally reaches the maximum during the peak flow and it becomes partially refilled during the receding stage of the storm flow.

Different formulas have been developed for predicting local scour around bridge piers. Despite the large number, such formulas contain a limited number of variables, namely, approach flow depth, effective pier width, Froude number, shear stress, and critical shear stress. The Federal Highway Administration (2004) recommends the CSU formula, which was also employed in this study

For piers of a bridge, the total scour is the general scour plus the local scour at the piers. The magnitude of local scour around bridge piers/bents may be estimated using certain established formulas. The Federal Highway Administration has adopted the following equation (see Hydraulic Engineering Circular No. 18, FHWA, 2004) for round-nosed piers/bents or cylindrical piers/bents.

$$Y_s/Y_1 = 2.0\ K_1\ K_2\ (b/Y_1)^{0.65}\ F^{0.43} \tag{1}$$

where Y = depth of local scour measured from the mean bed elevation, in feet;
K_1 = correction for pier/bent nose shape, equal to 1 for circular piers/bents and 1.1 for rectangular piers/bents;
K_2 = correction factor for angle of attack, equal to 1 for zero skew;
b = projected pier/bent width;
Y_1 = approach flow depth;
F = Froude number = $V//gY_1$; and
V = velocity of approach flow.

The required hydraulic information for this equation is included in the FLUVIAL-12 output with the pier in place. The depths of local scour at the SunCatcher pedestals were computed using Equation 1.

IV. SMALL WASHES ON THE ALLUVIAL FAN

The alluvial fan north of the railroad track has an average slope of about 5%. Water and sediment on the alluvial fan are supplied from the northern hills. The general terrain is flat with only minor land features as shown in Figures 7 and 8. Such a landform has formed by continued sediment deposition. Storm flows on the generally flat terrain occur primarily as sheet flows. There exists no valid method for modeling sediment flow on such areas.

Figure 7. View of northern alluvial fan toward south.
The terrain is generally flat with only minor features

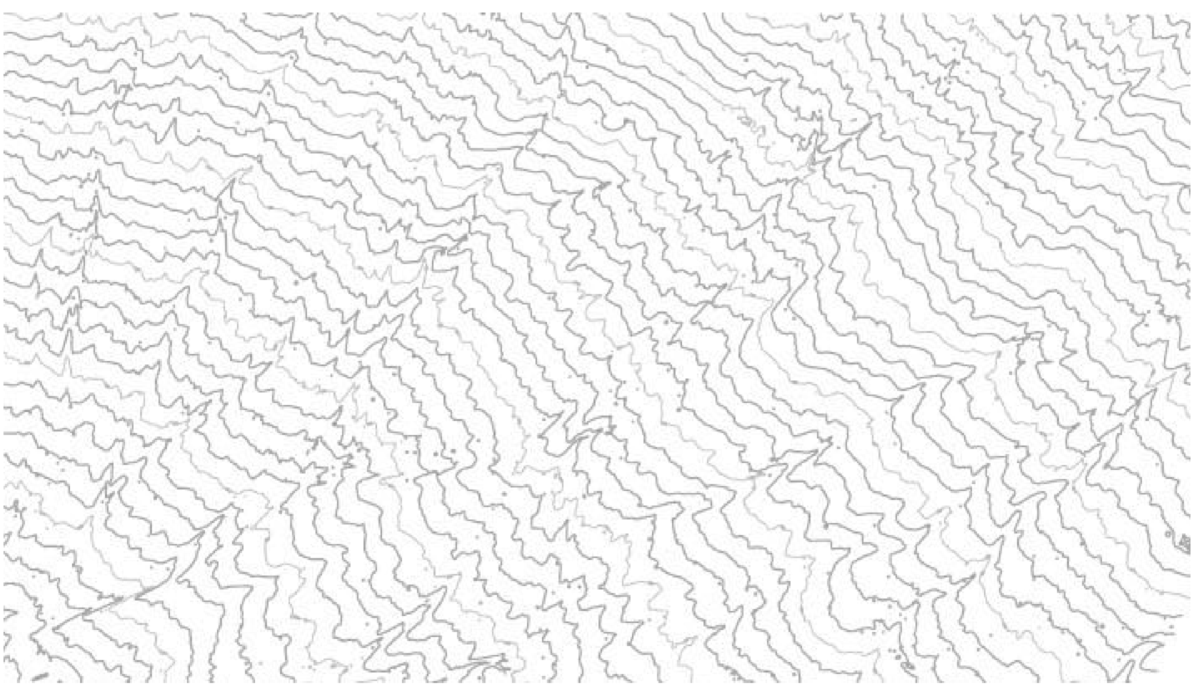


Figure 8. Topography of typical alluvial fan area

Well defined washes on the alluvial fan are few in number and they are also small in size. Figures 9 and 10 show such small washes that are located near the east side of the alluvial fan. Such washes have gradually-varied widths with an average width of about 10 feet; they are shallow in depth with bank height of around one foot although the bank height can exceed 2 feet in certain areas. Modeling study of sediment processes for the small wash shown in Figure 9 has been made using the FLUVIAL-12 model. The selected stream reach is located about half way from the railroad track to the north project boundary and near the east project boundary on the alluvial fan. The short study stream reach has a slope of 5%, an average width of 10 feet and a bank height varying between 1 to 2 feet.

Figure 9. A wash on alluvial fan viewed toward downstream (south)

Figure 10. A wash on alluvial fan viewed toward upstream (north)

Modeling Sediment Processes of Typical Wash on Alluvial Fan - Sediment transport and stream dynamics for the sample wash shown in Figure 9 was simulated using the FLUVIAL-12 model. Results of the modeling study for the small wash are presented in Figures 11, 12 and 13. Figure 11 shows the water-surface and stream bed changes during the 100-yr storm. Figures 12 and 13 show the simulated changes at sample channel cross sections. It cam be seen that the channel bed is subject to changes during the 100-yr storm in the small wash with gradually-varied channel geometry and flow. Such changes are also related to the generally sandy bed material which is quite mobile during storms. The channel bed undergoes both aggradation and degradation. If aggradation raises the water level to overtop the channel bank, then a part of the discharge would overflow the channel bank to result in a reduction of the discharge for the channel reach. However, if aggradation occurs along a reach with greater bank height, than there would be no discharge reduction for the channel. The sample results show that channel bed aggradation can exceed 6 inches along channel reach with taller banks.

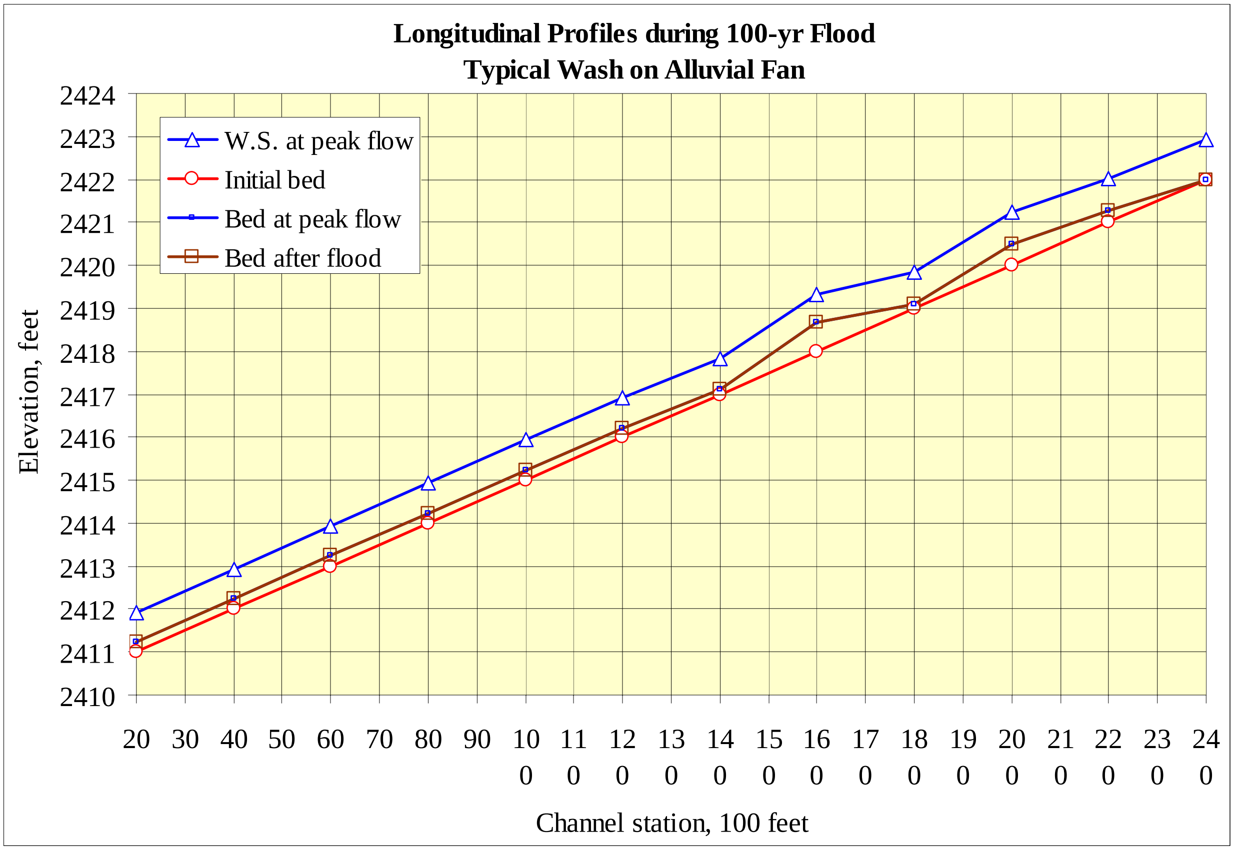


Figure 11. Water-surface and channel bed profile changes during 100-yr flood for sample wash

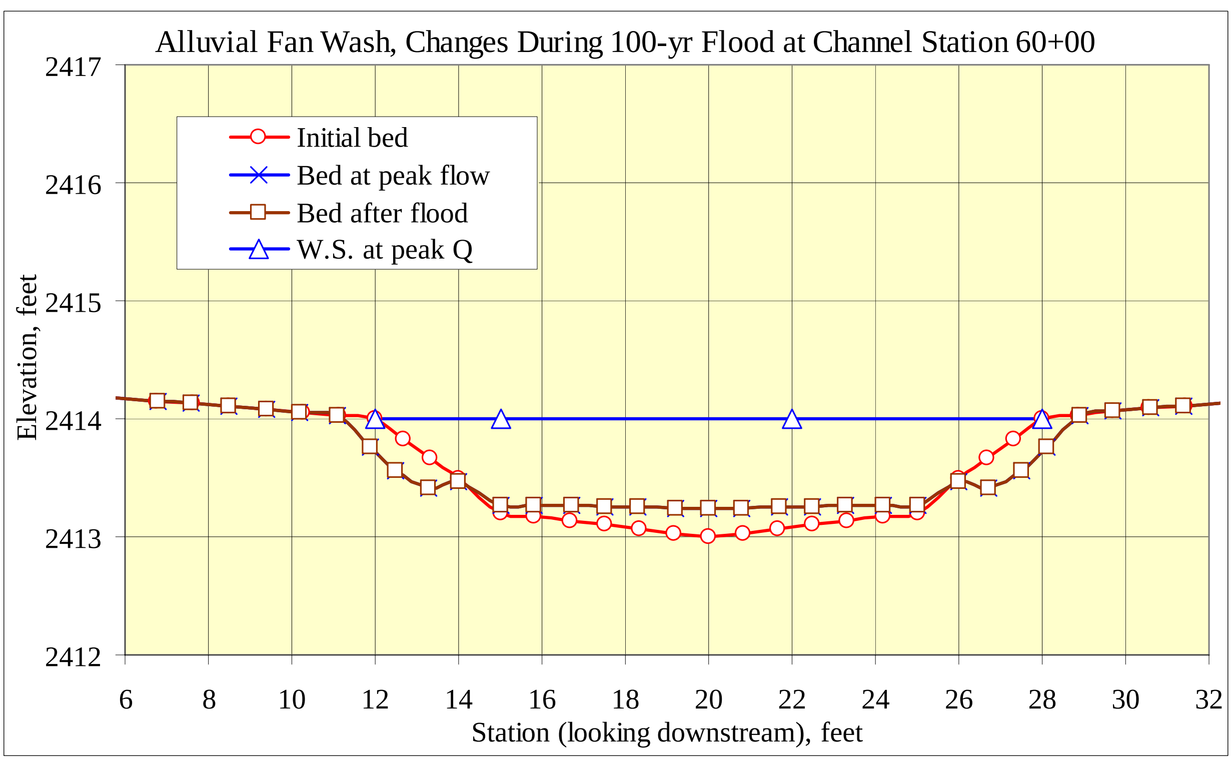
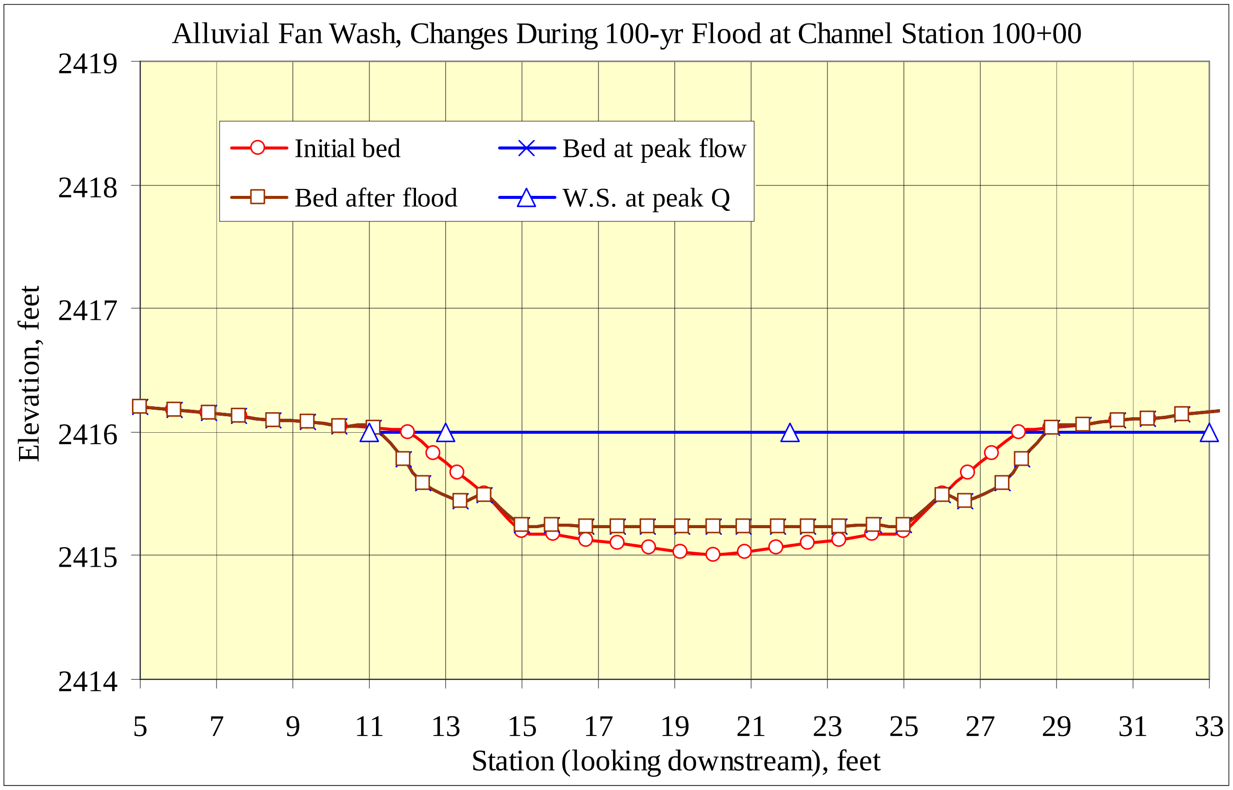


Figure 12. Simulated changes for a sample channel cross section



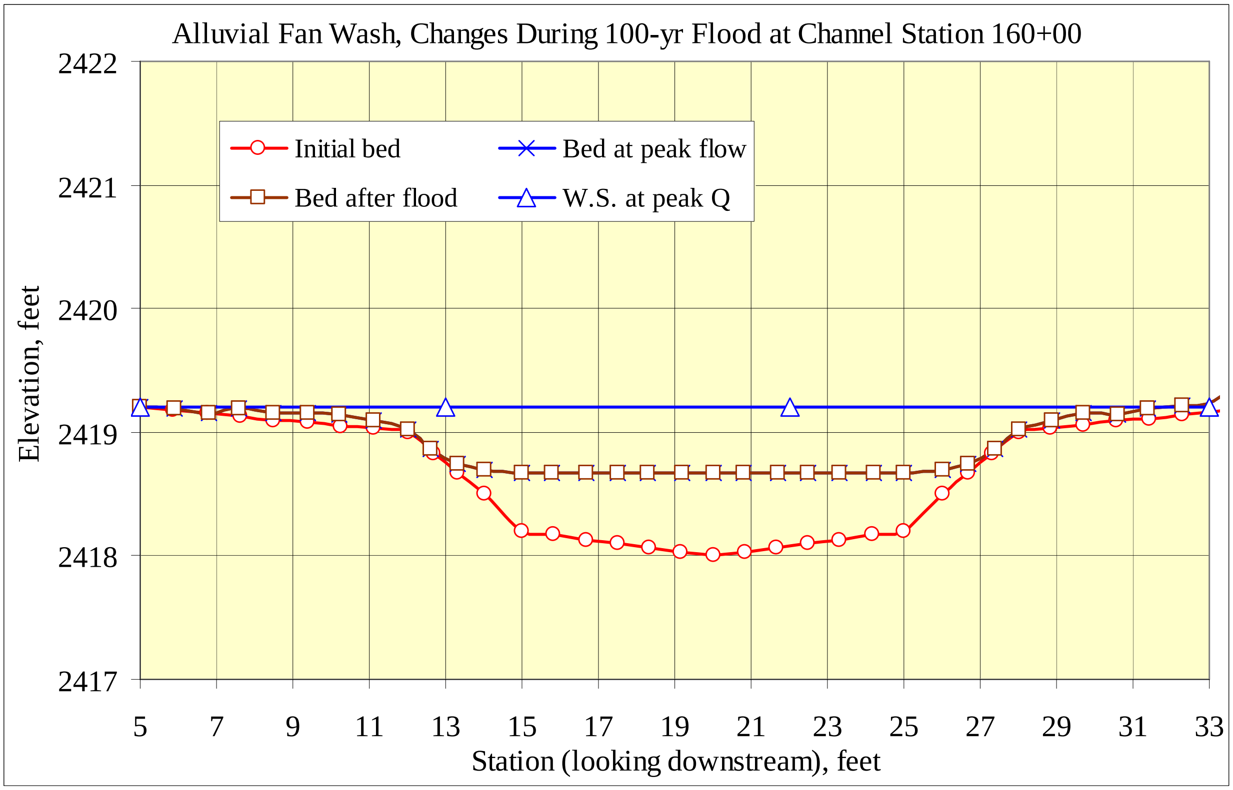


Figure 13. Simulated changes for sample channel cross sections

Computation of Local Scour on Alluvial Fan – The basic information on the hydraulics of flow is required in order to compute the depth of local scour. Because of the steep slope for the terrain, the flow on the alluvial fan is nearly critical with the Froude number very close to 1. Substituting the value of 1 for the Froude number into Equation 1 yields:

$$Y_s/Y_1 = 2.0\ K_1\ K_2\ (b/Y_1)^{0.65}$$

In which, K_1 = 1 for circular piers/bents; K_2= 1 for zero skew; b = 2 feet for projected pedestal diameter. The above equation can be reduced as follows:

$$Y_s = 3.14\ Y_1^{0.35}$$

This equation relates the local scour depth Y_s as a unique function of the flow depth Y_1. The computed local scour depths for several flow depths are listed below.

Flow depths Feet	Local scour depths Feet
1.00	3.14
2.00	4.00
3.00	4.61

Restrictions for SunCatchers on Alluvial Fan – The installation of SunCatchers at the project site are subject to certain restrictions. These restrictions are also for maintaining the SunCatcher safety. From the results of modeling study for the typical alluvial fan wash and local scour computations, the following restrictions for SunCatchers can be identified.

- From the consideration of local scour depth, SunCathers must avoid washes with the water depth exceeding 2 feet since the local scour depth can be greater than 4 feet.

- SunCatchers should be kept away from washes with the bank height exceeding 1.5 feet, since the depths of flow may exceed 1.5 feet in such washes. This restriction supersedes the previous restriction.

- SunCatchers should avoid washes on the alluvial fan if the bank height for such washes exceeds 1 foot. It has been demonstrated in the modeling study that the depth of sediment deposition in such washes can exceed 6 inches. This restriction supersedes the previous restrictions.

The topographic maps for the project site do not have sufficient details for indentifying the small washes on the alluvial fan. Such washes shall be indentified by a field survey before the plan is finalized.

V. SURFACE WATER FLOW NEAR RAILROAD TRACK

Surface water flow on the northern alluvial fan follows a south westerly direction as shown in Figure 8. The railroad track south of the alluvial fan is a flow barrier. As the flow from the alluvial fan reaches the railroad track, it splits into two parts: one part flows along the railroad track toward west; the other part passes through several bridge openings under the railroad track to the south side of the track. From east to west, bridge openings under the railroad track are labeled according to the mile posts as follows:

RR Bridge No. 1: 713.3
RR Bridge No. 2: 711.9
RR Bridge No. 3: 710.8
RR Bridge No. 4: 710.1
RR Bridge No. 5: 709.5
RR Bridge No. 6: 709.4
RR Bridge No. 7: 708.7
RR Bridge No. 8: 708.5
RR Bridge No. 9: 707.7

Pictures of certain bridges are shown in Figures 14 to 25. Water flow is from north to south through these openings except it is from south to north through Bridge Number 2. After passing through these bridge openings, water flow turns toward west along the railroad track.

Figure 14. Bridge at mile post 708.5 viewed toward north

Figure 15. Bridge at mile post 708.7 viewed toward north

Figure 16. Bridge at mile post 709.4 viewed toward north

Figure 17. View toward southeast of channel downstream of bridge 709.4.
This channel has been enlarged by excavation.
It gradually vanishes to from sheet flow after about 1,000 feet.

Figure 18. Bridge at mile post 709.5 viewed toward north

Figure 19. Bridge at mile post 710.1 viewed toward north

Figure 20. Bridge at mile post 710.8 viewed toward north

Figure 21. Bridge at mile post 711.9 viewed toward south

Figure 22. View of stream 100 before reaching bridge 711.9 from south

Figure 23. View of stream 100 as it becomes smaller toward upstream

Figure 24. View toward upstream of stream 100 channel

Figure 25. View toward downstream (east) of stream 100 on north side of railroad track

Storm flow along the north side of the railroad track covers a large width in the form of sheet flow. As the storm water passes through the narrow bridge openings, it may forms a well defined channel on the south side of the railroad track. The small channel through bridge opening 711.9 as shown in Figures 22, 23, 24 and 26 is the largest among the small wash channels south of the railroad track. This channel has an approximate length of 2,000 feet, its width is the about 35 feet at the downstream end and it becomes gradually smaller toward upstream. The bank height also varies from about 3.5 feet at the downstream end to almost nothing at the upstream entrance.

The discharge of flood flows from the northern alluvial fan to the area south of the railroad track is controlled by the size of the bridge openings. Such flows were not determined in the Huitt-Zollars hydrology study. A part of flood flow south of the railroad occur stays in the small channels and another part spreads out to the flat terrain as sheet flow. In this study, modeling of sediment processes in stream 100 through bridge 711.9 is used as a sample. The effective discharge in this case is the bankfull discharge for the stream channel.

Modeling of Fluvial Processes for Sample Wash Channel near Railroad Track - In order to assess the potential stream channel changes, modeling sediment processes was made for stream 100 south of the railroad track as a sample case. The study channel reach from channel station 150+00 to 174+00 is shown in Figure 26. The downstream limit at channel station 150+00 is near the south entrance of RR Bridge Number 2. The study is intended to determine if SunCatchers may be placed or excluded from such washes.

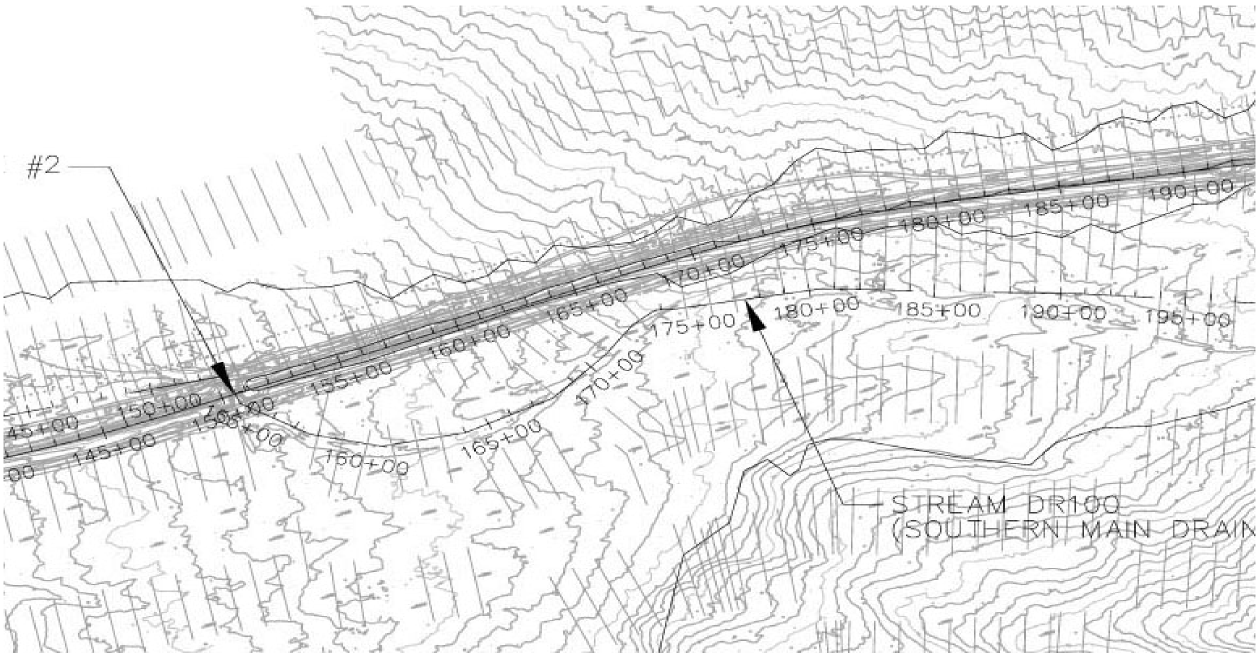


Figure 26. Map for Stream 100 located south of the railroad track.
This wash channel enters RR Bridge No. 2 from the south.

Simulated changes at sample channel cross sections during the 100-yr flood are shown in Figure 27. It can be seen that the wash has shallow flow depth and its cross sections are predicted to undergo changes with both scour and deposition. Those sections along the lower reach are predicted to undergo channel bed scour but those along the upper reach are predicted to undergo sediment deposition. These figures depict the patterns of channel changes characterized by occur along the thalweg but sediment deposition on both sides. Since the flow depths can be greater than 1.5 feet and the depths of sediment deposition can be greater than 6 inches; therefore, SunCatchers should be kept away from such stream washes.

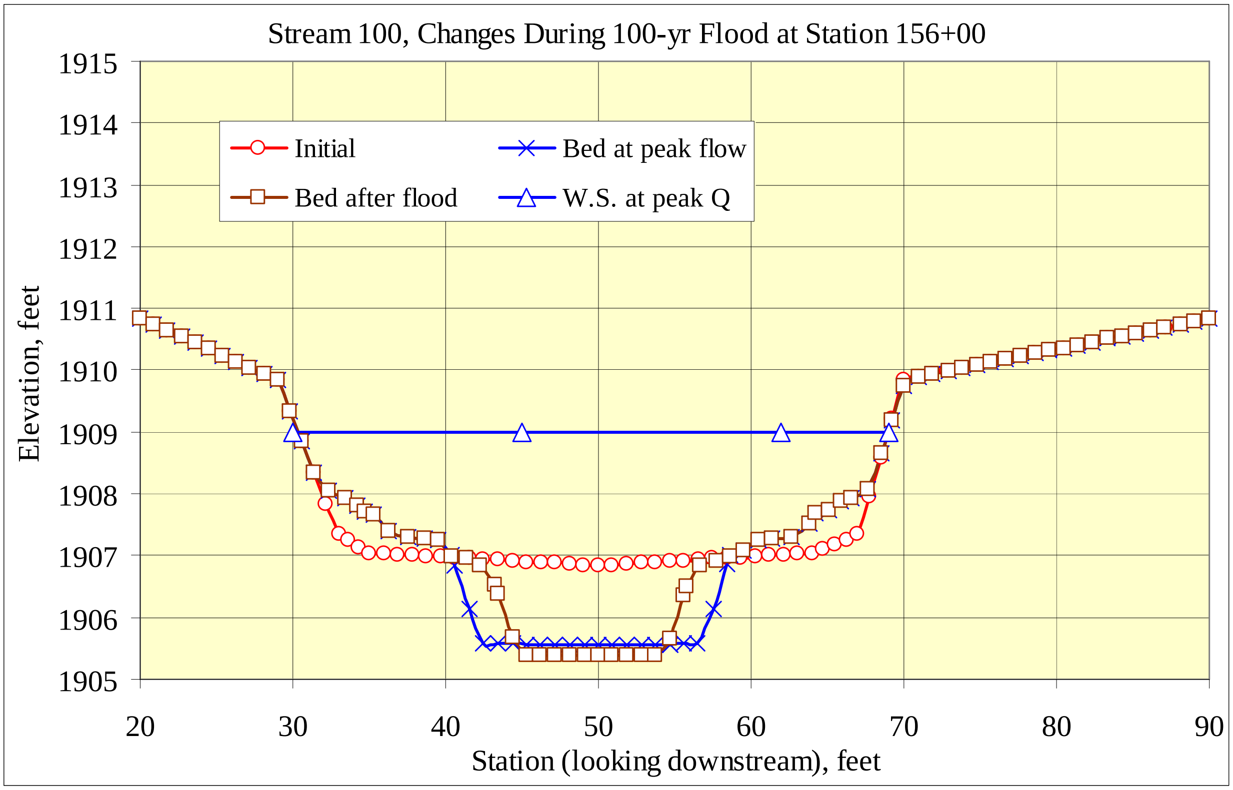
From the modeling results for stream 100, restrictions for SunCatchers in areas near the railroad track are determined.

- SunCatchers should avoid well-defined washes with bank height exceeding 1.5 feet, since the flow depth in such washes can exceed the limit of 1.5 feet.

- SunCatchers should be kept away from washes with bank height exceeding 1.5 feet since the depth of sediment deposition can exceed 6 inches in such washes. This restriction is no different from the previous restriction.

These restrictions apply to washes adjacent to the railroad track; they also apply to other washes south of the railroad track that are located in broad floodplains. Such washes include stream 10L, 10K, 10F, stream 101 and lower reaches of streams 20B, 10S, and 10P.

The topographic maps for the project site do not have sufficient details for indentifying the small washes on the alluvial fan. Such washes shall be indentified by a field survey before the plan is finalized.



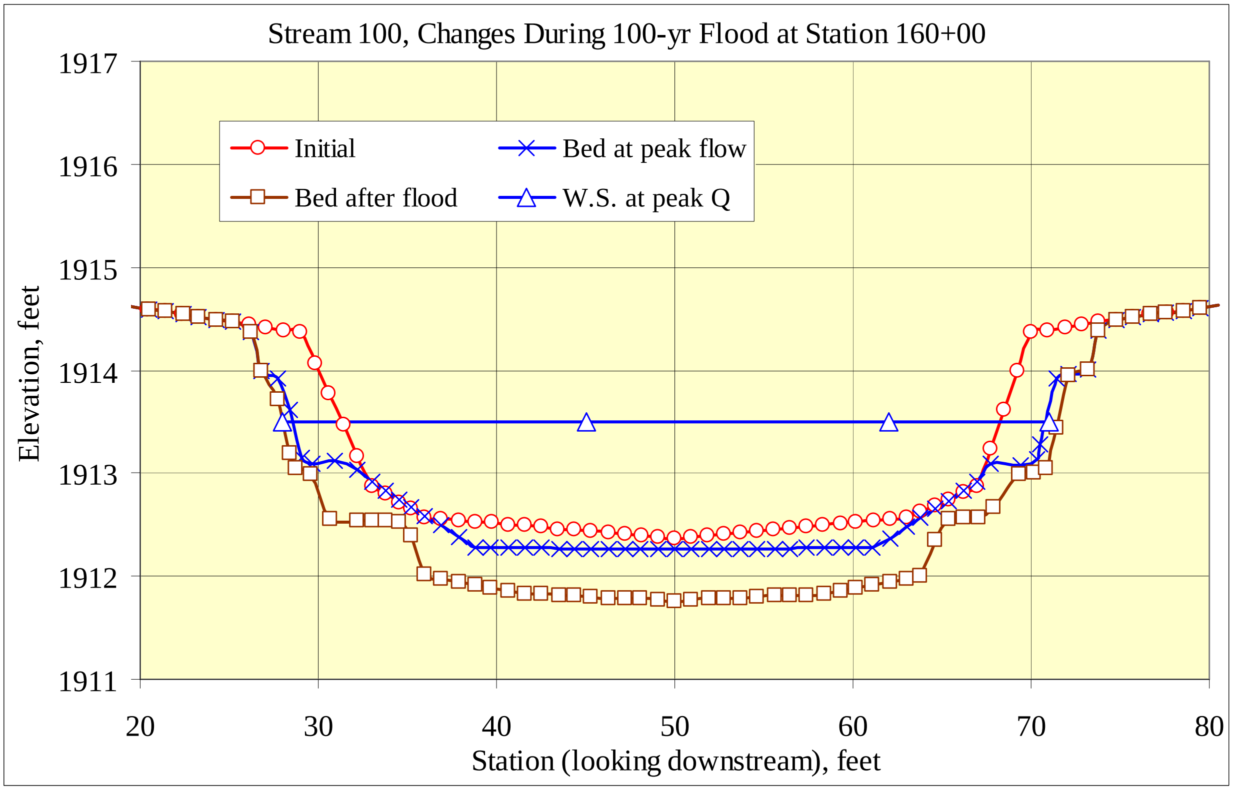
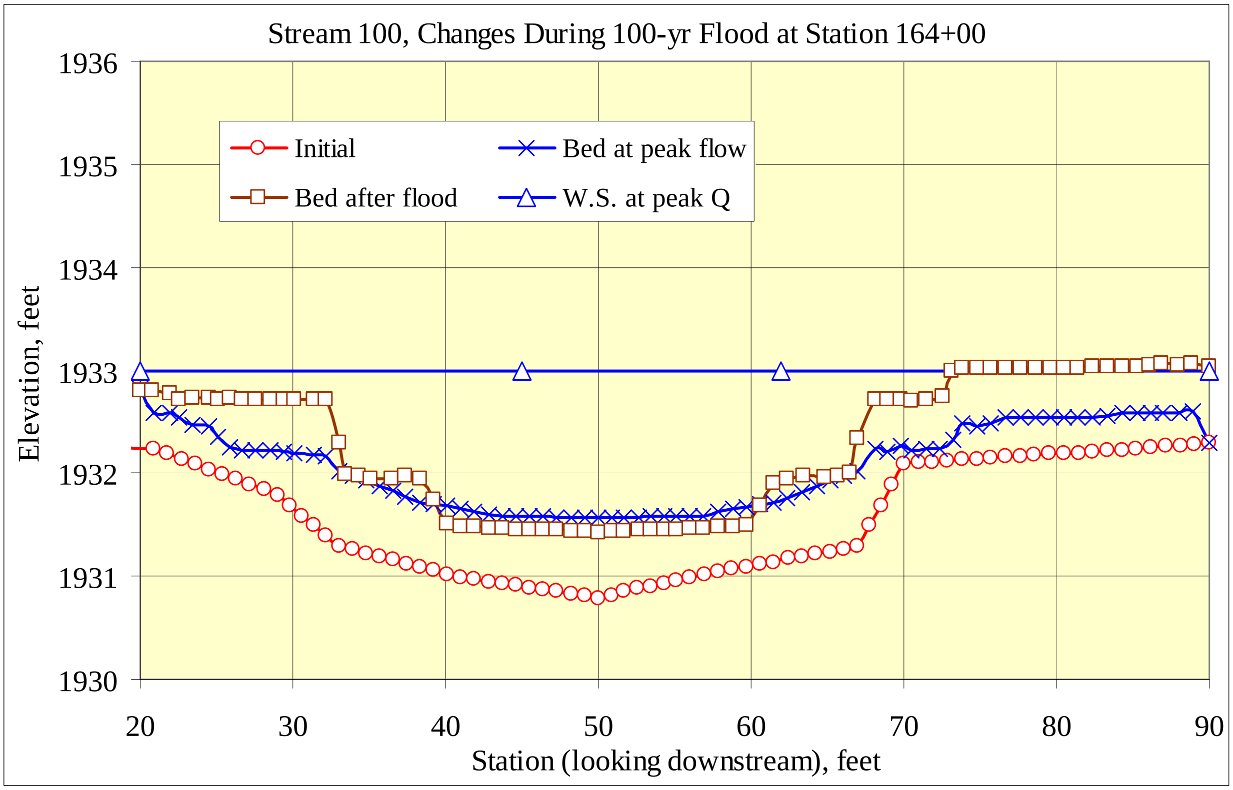


Figure 27. Simulated changes during 100-yr flood at sample cross sections along stream 100



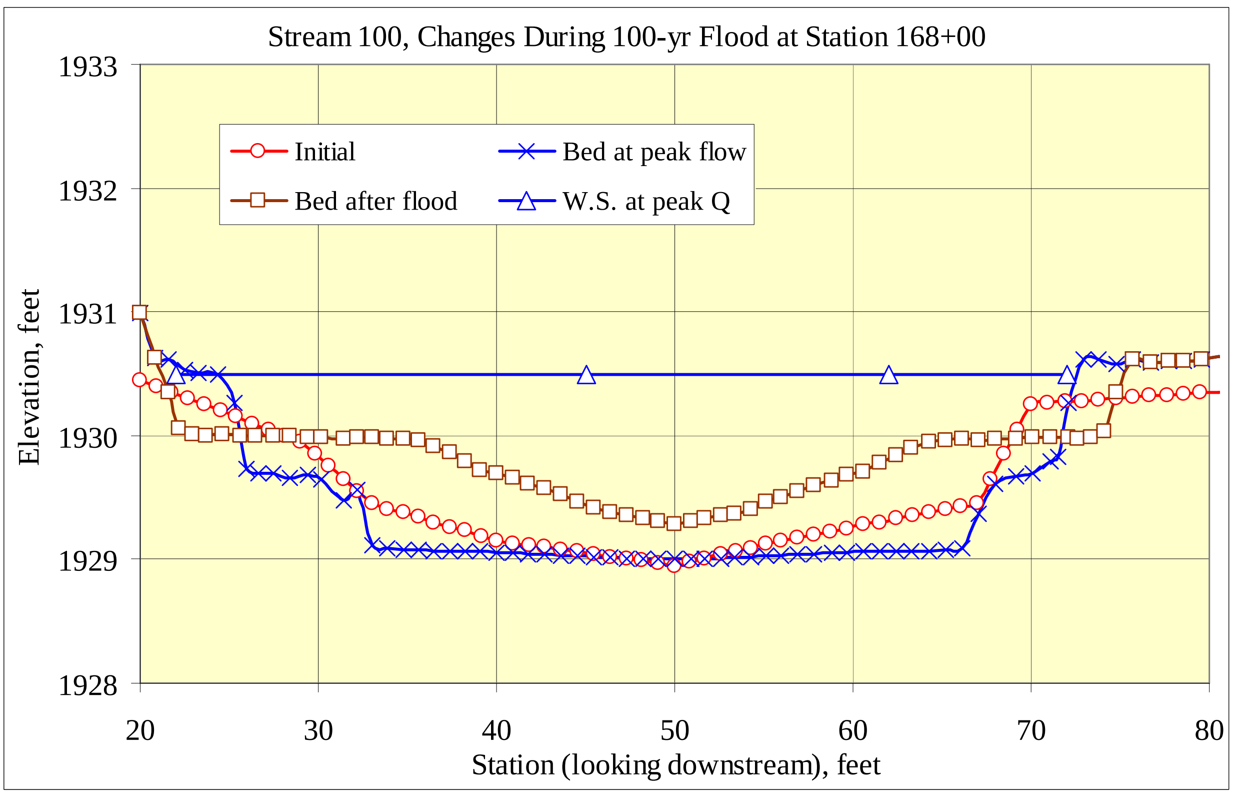


Figure 27 (continued). Simulated changes during 100-yr flood at sample cross sections along stream 100

Local Scour Consideration – The basic information on the hydraulics of flow is required in order to compute the depth of local scour. The general terrain along the railroad track has a moderately steep slope. The surface flow has an average Froude number of about 0.85. Substituting the value of 0.85 for the Froude number into Equation 1 yields:

$$Y_s/Y_1 = 1.865\ K_1\ K_2\ (b/Y_1)^{0.65}$$

In which, K_1 = 1 for circular piers/bents; K_2= 1 for zero skew; b = 2 feet for projected pedestal diameter. The above equation can be reduced as follows:

$$Y_s = 2.93\ Y_1^{0.35}$$

This equation relates the local scour depth Y_s as a unique function of the flow depth Y_1. The computed local scour depths for several flow depths are listed below.

Flow depths Feet	Local scour depths Feet
1.00	2.93
2.00	3.73
3.00	4.30

From the consideration of local scour depth, SunCatchers must avoid wash areas where the water depth exceeds about 2 feet since the local scour depth would be greater than 4 feet. However, this restriction is superseded by other restrictions.

The channels through railroad Bridge Nos. 3, 4, 5, and 7 are very small. Other washes in the eastern part of the project site include streams 10L, 10K, 10P and 101 are shown in Figure 28. Such washes are characterized by shallow depths located in a broad floodplain. The stream dynamics is governed by the bankfull discharge since any flow exceeding the bankfull stage would spread out to a wide area outside the wash. The physical nature of these washes is similar to those washes along the railroad track. The restrictions for SunCatchers applicable to those washes along the railroad track are also applicable to streams 10L 10K, 10P and 101.

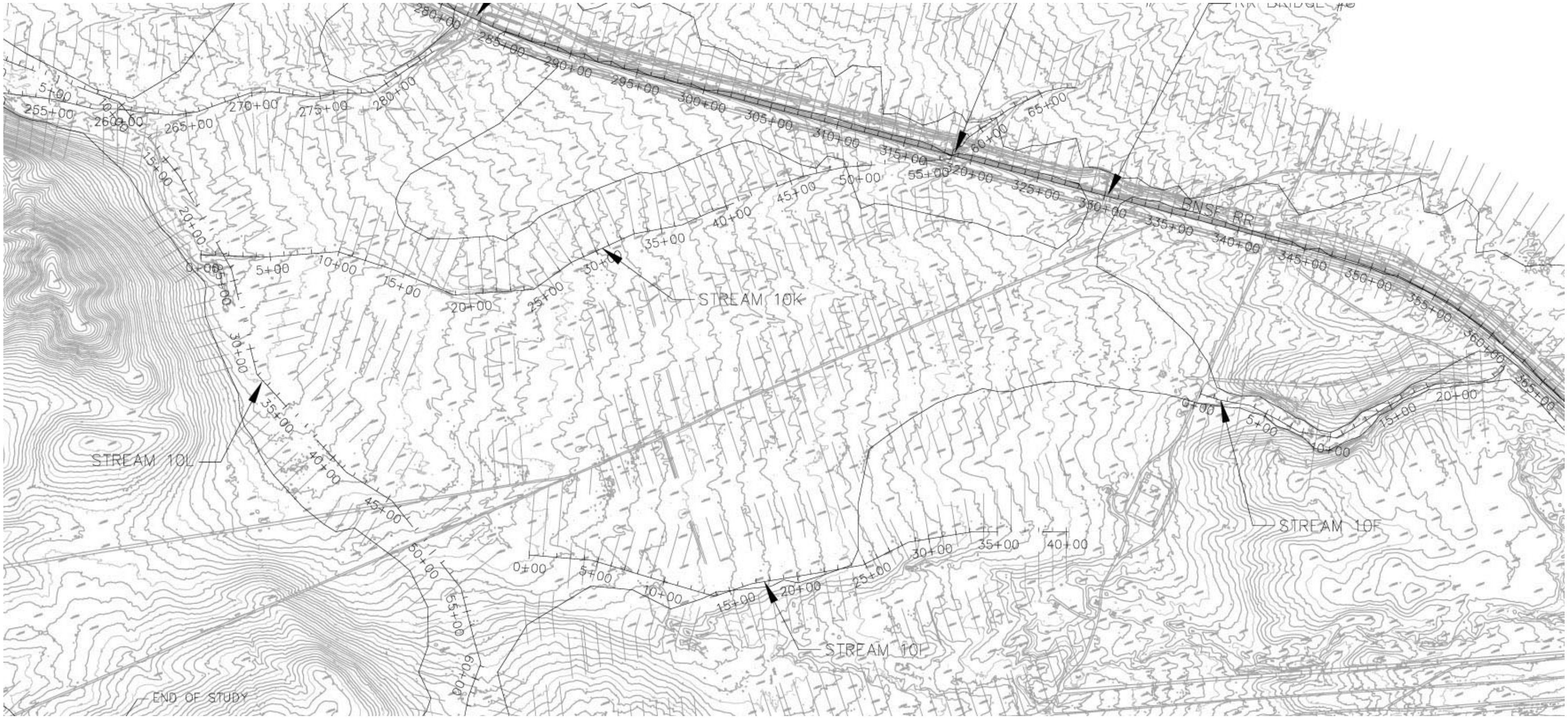


Figure 28. Map for washes south of the railroad track.

VI. MODELING OF SEDIMENT PROCESSES ALONG WASHES IN CONFINED VALLEYS NORTH OF HIGHWAY 40

The project site has small washes located north of Highway 40; their flows generally follow the northwesterly direction. In the Huitt-Zollars study, these washes are designated as stream 20B, stream 10S, and stream 10P. Topographic map for stream 20B is shown in Figure 29. Streams 10S and 10P are shown in Figure 30. Each map also shows the channel stations that are used to define the stream channel geometry. The 100-flood discharges for these washes in more confined valleys are listed below.

Table 1. List of 100-yr flood discharges for streams north of Highway 40

Drainage basin	100-yr flood discharge CFS
20B	1,042
10S	1,274
10P	1,714

The upper reaches for streams 20B, 10S, and 10P are in more confined valleys; their lower reaches gradually change into sheet flows. Streams 10L and 101 do not have a well-defined channel and the flow occurs primarily as sheet flow over a large area. For streams 20B, 10S, and 10P located in confined valleys, sediment transport and stream dynamics are governed by the 100-yr flood.

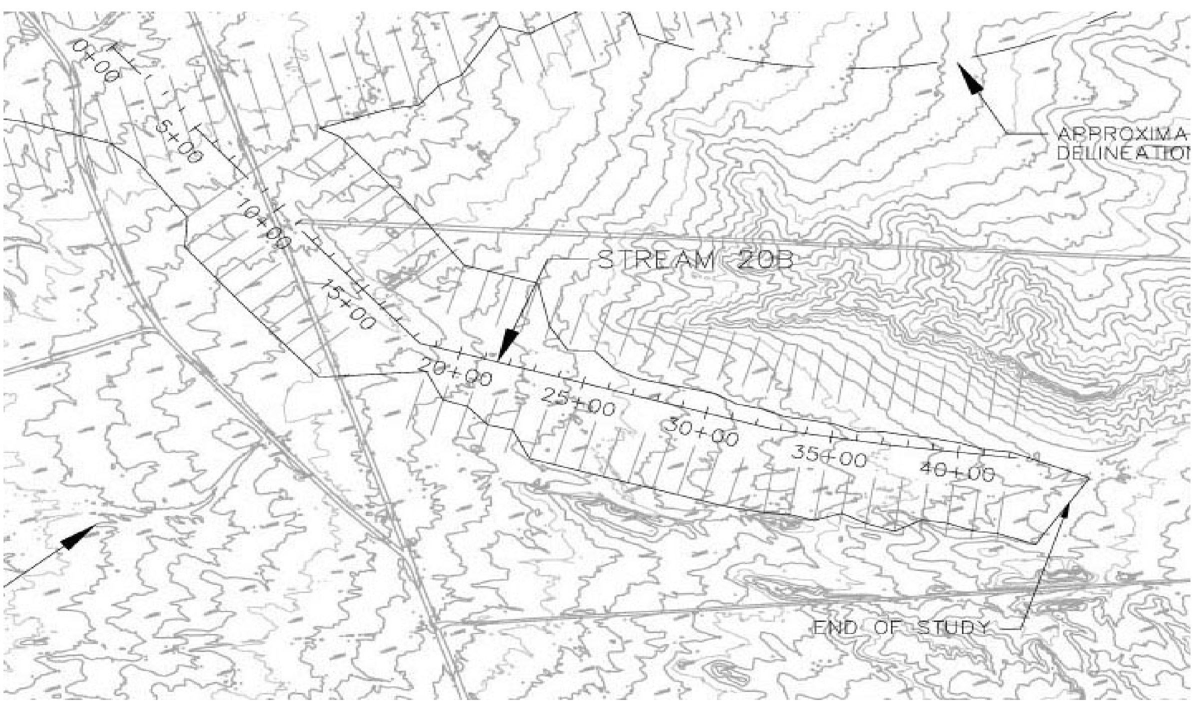


Figure 29. Topographic map for stream 20B located north of Highway 40

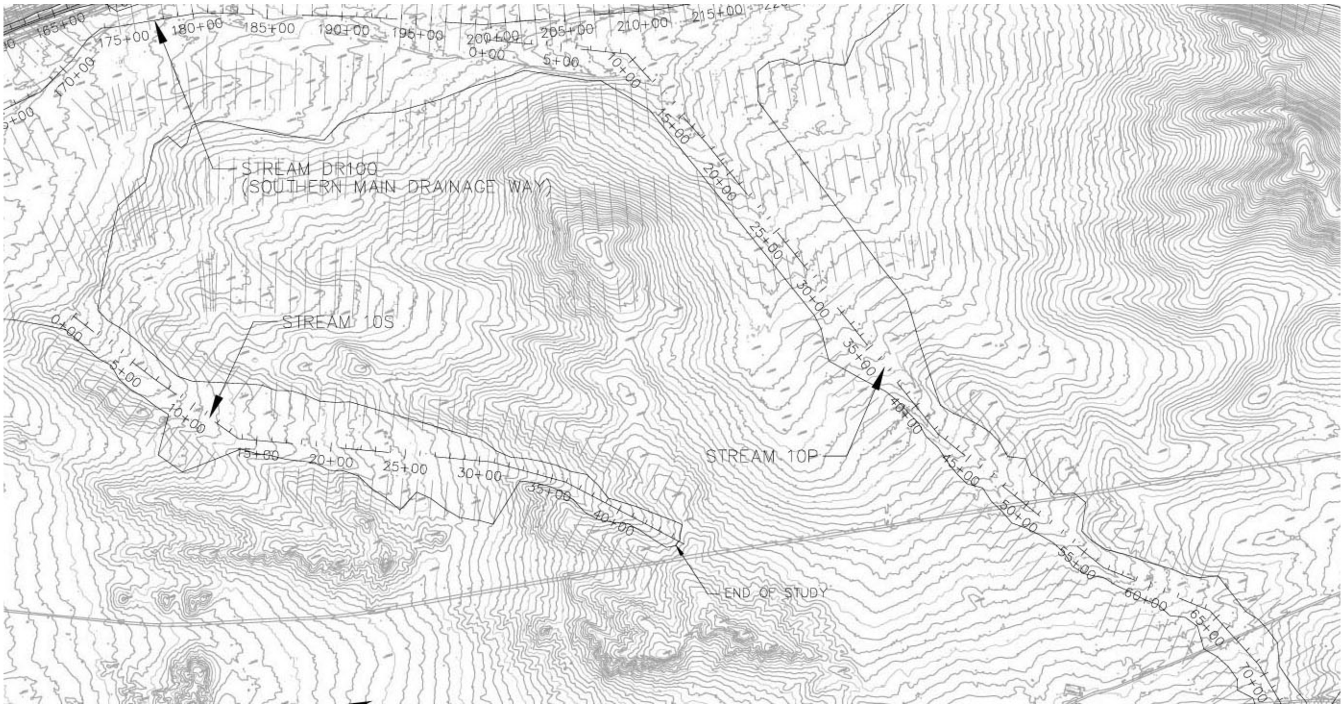


Figure 30. Topographic map showing washes labeled as streams 10S and 10P

In order to assess potential stream channel changes, modeling sediment processes was made for stream 20B as a sample case. The study is intended to determine if any SunCatchers may be placed or excluded from wash-affected areas. Simulated water-surface and channel-bed profile changes during the 100-yr flood for stream 20B are shown in Figure 31. The changes in cross-sectional profiles at sample channel stations are shown in Figure 32. It can be seen that the wash has shallow flow depths and its thalweg will be lowered by channel-bed degradation. These figures depict the pattern of channel changes characterized by occur along the thalweg but sediment deposition on both sides. Since the depths of sediment deposition are generally greater than 6 inches, it therefore follows that SunCatchers should stay away from the wash areas with sediment deposition exceeding 6 inches. The simulated results also show that areas with sediment deposition exceeding 6 inches are at least one-half foot below the peak water-surface level.

Another condition for the installation of SunCatchers states that storm water flow depths around the SunCatcher cannot exceed 1.5 ft. It can be seen from the figures that the center portion of all sections has the water depth exceeding the 1.5-foot limit. In summary, the restrictions for SunCatcher placement are as follows:

- SunCatchers should avoid the center part of such channels with water depth exceeding 1.5 feet. The water depth is the difference from the computed water-surface elevation listed in Table 2 minus the local ground elevation.

- SunCatchers should be kept away from areas along the sides of a channel where the local ground elevation is more than one foot below the water surface elevation listed in Table

2. This is because sediment deposition can exceed 6 inches in such areas. This restriction supersedes the above restriction.

Local scour around pedestals does not restrict the placement of SunCatchers. The restrictions obtained for stream 20B are also applicable to streams 10S and 10P.

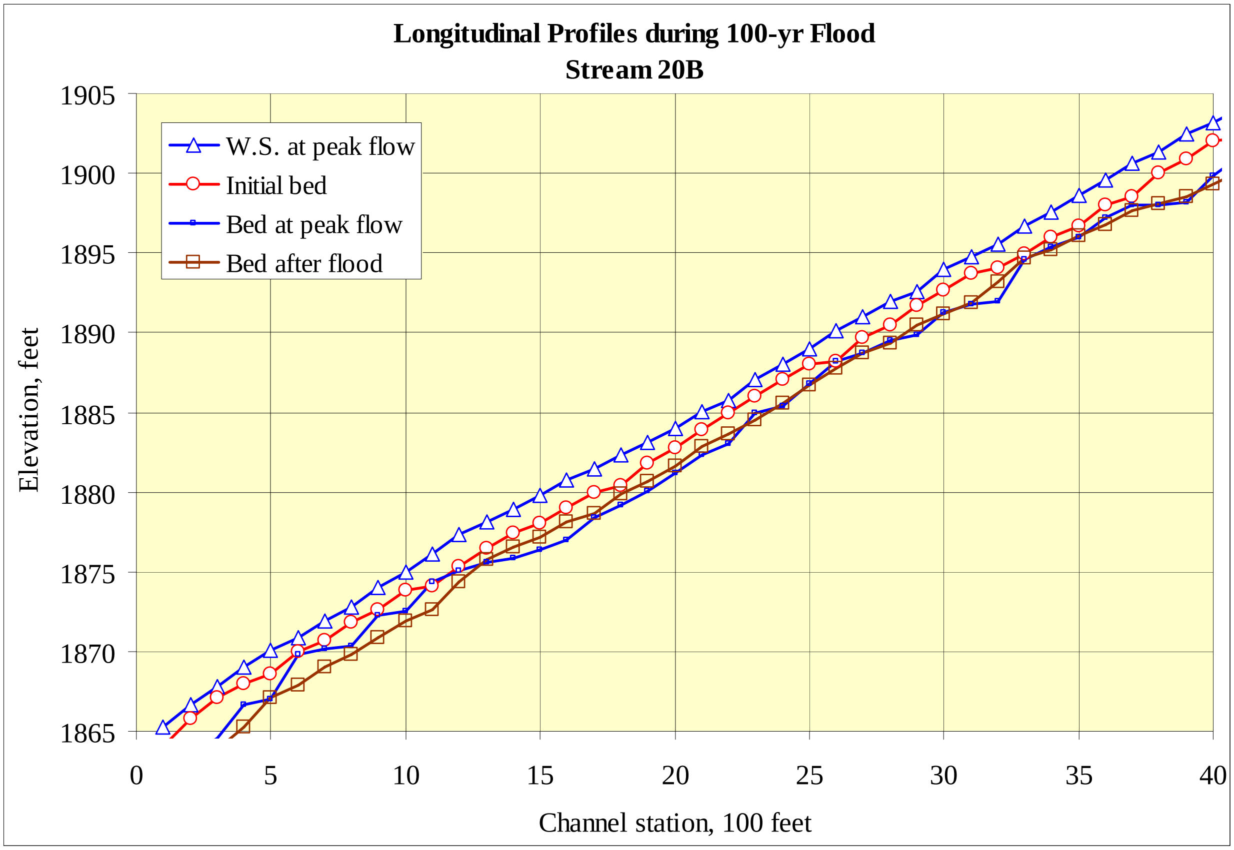
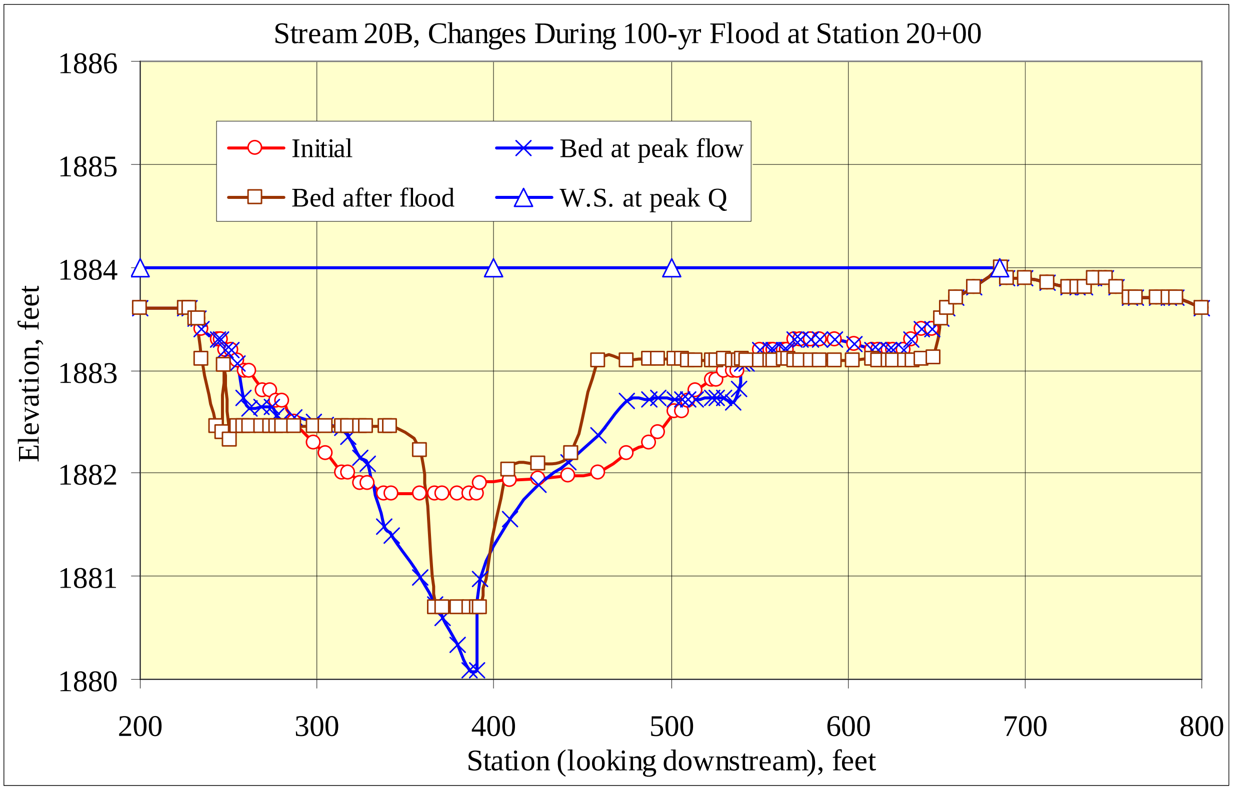


Figure 30. Water-surface and channel bed profile changes during 100-yr flood for stream 20B



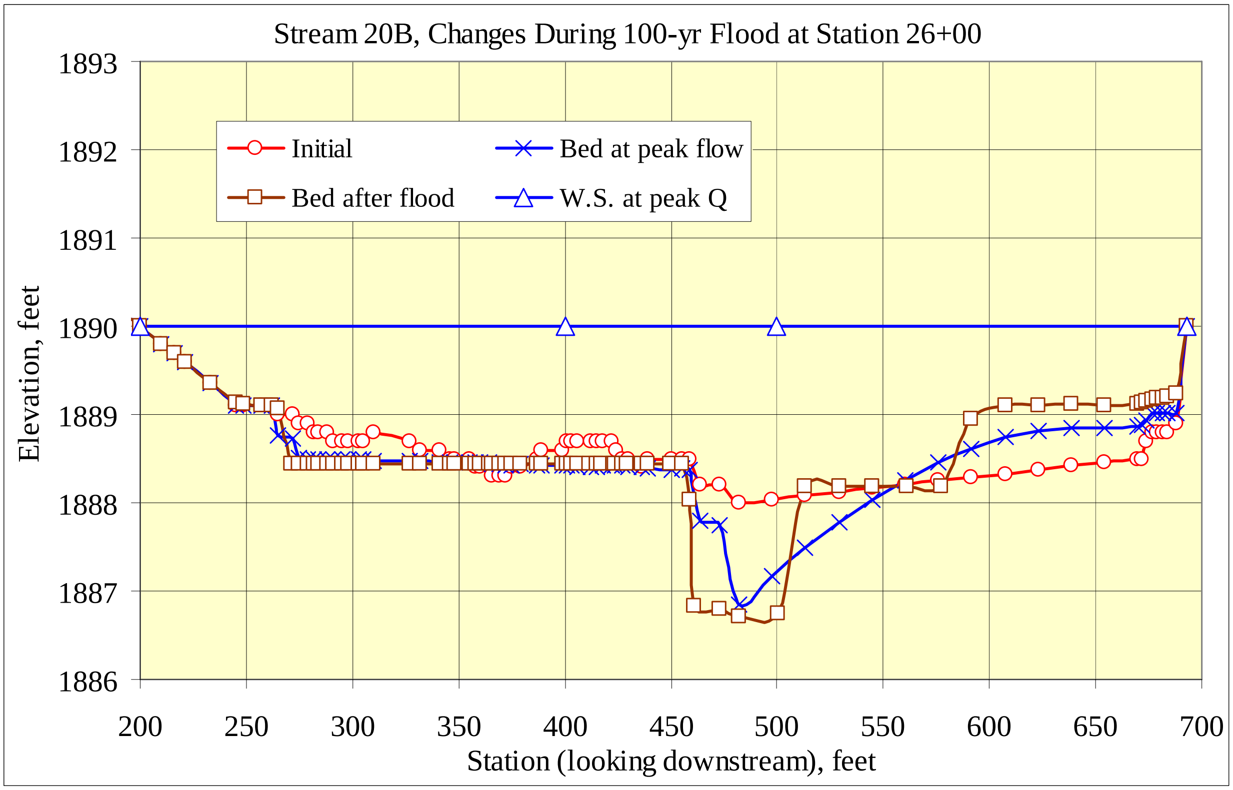
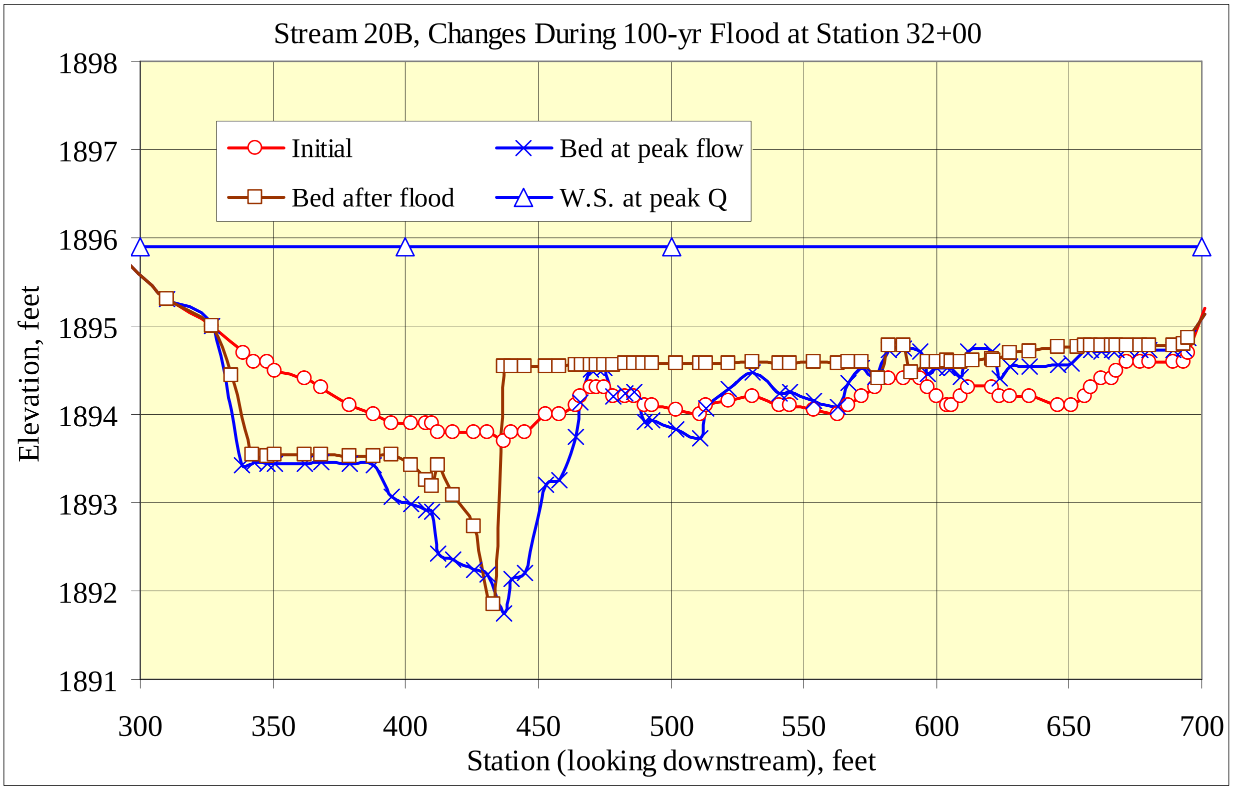


Figure 31. Simulated cross sectional changes at sample cross sections along steam 20B



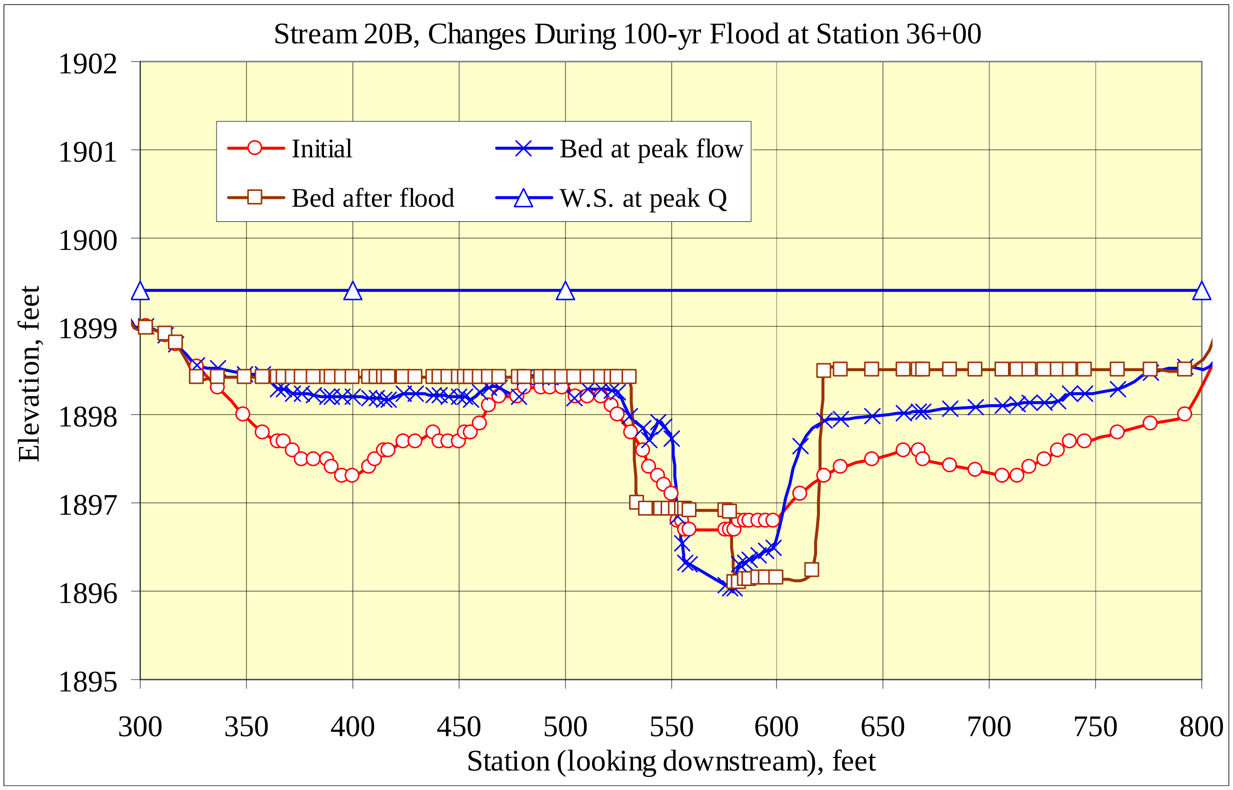


Figure 31(continued). Simulated cross sectional changes at sample cross sections along steam 20B

Table 2. List of parameters from the hydraulic study by Huitt and Zollars

Stream 20B

River Sta	Min Ch El (ft)	W.S. Elev (ft)	Vel (ft/s)	Top Width (ft)
4200	1904.00	1905.35	3.92	355.95
4100	1902.00	1904.22	4.42	383.69
4000	1902.00	1903.46	3.23	378.72
3900	1900.75	1902.49	4.20	384.00
3800	1900.00	1901.58	3.48	373.55
3700	1898.50	1900.51	4.85	396.69
3600	1898.00	1899.39	3.54	376.30
3500	1896.66	1898.28	4.17	447.12
3400	1896.07	1897.52	2.22	442.89
3300	1895.47	1896.56	3.75	458.38
3200	1894.59	1895.91	2.76	478.55
3100	1893.74	1894.98	3.34	473.12
3000	1892.65	1894.07	3.12	497.36
2900	1891.70	1893.12	3.35	481.37
2800	1890.50	1891.93	3.81	483.78
2700	1889.64	1890.91	3.11	479.22
2600	1888.21	1889.97	4.02	495.77
2500	1888.00	1889.19	2.99	557.16
2400	1887.10	1888.23	3.43	528.82
2300	1886.00	1887.24	3.13	412.11
2200	1884.99	1886.16	3.64	442.52
2100	1883.94	1885.18	3.06	597.92
2000	1882.80	1883.99	3.67	512.24
1900	1881.73	1883.09	2.64	481.25
1600	1880.00	1881.02	2.21	442.22
1500	1878.00	1879.99	3.70	309.70
1400	1877.40	1879.09	3.56	413.23
1300	1876.48	1878.15	3.47	596.04
1200	1875.23	1876.91	4.22	507.80
1100	1874.00	1875.97	3.15	487.66
1000	1874.00	1875.02	3.05	590.03
900	1872.51	1874.01	3.10	648.08
800	1872.00	1872.71	3.32	585.67

Stream 10S

River Sta	Min Ch El (ft)	W.S. Elev (ft)	Vel (ft/s)	Top Width (ft)
4400	2021.20	2023.24	7.72	183.80
4300	2017.30	2019.08	9.55	148.11
4200	2014.37	2016.42	6.87	144.15
4100	2011.90	2014.02	7.65	126.72
4000	2008.58	2010.65	9.41	139.97
3900	2005.47	2007.89	7.76	155.06
3800	2002.20	2004.61	8.67	150.28
3700	1999.52	2001.80	7.13	187.67
3600	1996.22	1998.31	8.32	140.99
3500	1992.93	1994.73	9.75	125.48
3400	1989.90	1991.87	6.75	149.80
3300	1986.74	1988.60	8.38	146.90
3200	1983.72	1985.28	0.33	454.86
3100	1980.84	1982.62	7.04	478.75
3000	1978.44	1980.15	7.10	538.96
2900	1973.43	1974.44	8.98	251.03
2800	1971.63	1973.34	4.35	359.51
2700	1970.12	1971.74	4.34	393.96
2600	1968.17	1970.07	4.73	363.24
2500	1967.06	1968.41	4.44	360.86
2400	1965.42	1966.98	4.29	289.92
2300	1963.79	1966.01	4.29	236.39
2200	1962.07	1964.55	6.38	185.10
2100	1960.64	1963.04	6.02	289.76
2000	1959.17	1961.06	6.64	217.62
1900	1958.00	1959.71	4.74	386.94
1800	1956.70	1958.19	4.32	441.99
1700	1954.94	1956.71	4.47	460.39
1600	1953.44	1954.90	5.22	436.97
1500	1951.94	1953.62	3.85	459.81
1400	1950.47	1952.00	5.45	438.05
1200	1947.16	1949.22	5.57	532.55
1100	1945.52	1947.41	6.13	494.09
1000	1943.50	1946.11	4.11	480.04
900	1943.61	1945.29	4.18	274.13
800	1942.05	1943.73	5.32	249.15
700	1940.50	1942.66	4.32	253.62
600	1940.00	1941.76	4.26	276.36
500	1939.01	1940.61	4.53	273.70
400	1937.15	1938.75	5.75	238.75
300	1934.80	1936.38	5.95	253.66
200	1931.62	1933.42	5.66	234.70

100	1929.92	1931.59	5.61	240.00
0	1927.38	1929.59	5.69	274.35

Stream 10P

River Sta	Min Ch El (ft)	W.S. Elev (ft)	Vel (ft/s)	Top Width (ft)
7400	2048.00	2050.35	6.58	249.78
7300	2046.34	2049.03	5.16	330.50
7200	2045.63	2047.44	6.01	298.09
7100	2043.83	2045.88	5.04	264.88
7000	2042.06	2044.39	6.16	324.19
6900	2040.57	2042.82	5.66	363.27
6800	2039.35	2041.00	5.90	361.62
6700	2037.45	2039.28	5.30	360.90
6600	2036.00	2037.42	5.76	372.81
6400	2032.45	2034.23	4.99	366.12
6300	2030.73	2032.54	5.54	284.40
6200	2029.08	2031.15	5.13	292.45
6100	2027.48	2029.42	6.18	245.30
6000	2026.00	2027.97	5.31	254.89
5900	2024.08	2026.30	6.24	216.97
5800	2022.53	2025.09	5.59	234.91
5600	2019.83	2022.55	6.66	204.95
5500	2018.39	2021.23	6.15	213.44
5400	2017.15	2019.43	6.99	186.81
5300	2015.60	2017.70	6.02	344.61
5200	2014.17	2016.29	5.47	359.84
5100	2012.63	2014.63	5.86	292.18
5000	2010.31	2013.00	6.39	342.32
4900	2008.68	2011.24	6.35	324.73
4800	2007.50	2009.69	5.89	366.14
4700	2005.78	2007.75	6.44	267.38
4600	2003.94	2006.19	5.69	340.09
4500	2002.43	2004.51	6.22	353.69
4400	2000.69	2002.68	5.97	320.71
4300	1998.62	2000.71	6.08	263.31
4200	1997.03	1999.59	5.12	240.98
4100	1996.00	1997.80	6.85	188.16
4000	1994.00	1996.23	8.28	178.48
3900	1992.00	1995.09	6.05	185.26
3800	1990.86	1993.32	7.13	205.08
3700	1989.35	1991.06	8.49	411.71
3600	1987.75	1989.31	6.31	309.26
3500	1986.17	1987.96	6.98	433.00

3400	1984.59	1986.21	3.83	667.79
3300	1983.15	1984.48	4.33	622.85
3200	1981.80	1983.01	4.08	574.29
3100	1980.20	1981.51	4.33	553.01

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Federal Highway Administration, "Hydraulic Engineering Record, No. 18", 2006.

Leopold, L. B., Wolman, M. G., and Miller, J. P., *Fluvial Processes in Geomorphology*, W. H. Freeman, San Francisco, California, 1964, 522 pp.

APPENDIX. INPUT/OUTPUT DESCRIPTIONS FOR FLUVIAL-12

I. INPUT DESCRIPTION

The basic data requirements for a modeling study include (1) topographic maps of the river reach from the downstream end to the upstream end of study, (2) digitized data for cross sections in the HEC-2 format with cross-sectional locations shown on the accompanying topographic maps, (3) flow records or flood hydrographs and their variations along the study stream reach, if any, and (4) size distributions of sediment samples along the study reach. Additional data are required for special features of a study river reach.

The HEC-2 format for input data is used in all versions of the FLUVIAL model. Data records for HEC-2 pertaining to cross-sectional geometry (X1 and GR), job title (T1, T2, and T3), and end of job (EJ), are used in the FLUVIAL model. If a HEC-2 data file is available, it is not necessary to delete the unused records except that the information they contain are not used in the computation. For the purpose of water- and sediment-routing, additional data pertaining to sediment characteristics, flood hydrograph, etc., are required and supplied by other data records. Sequential arrangement of data records are given in the following.

Records	Description of Record Type
T1,T2,T3	Title Records
G1	General Use Record
G2	General Use Records for Hydrographs
G3	General Use Record
G4	General Use Record for Selected Cross-Sectional Output
G5	General Use Record
G6	General Use Record for Selecting Times for Summary Output
G7	General Use Record for Specifying Erosion Resistant Bed Layer
GS	General Use Records for Initial Sediment Compositions
GB	General Use Records for Time Variation of Base-Level
GQ	General Use Records for Stage-Discharge Relation of Downstream Section
GI	General Use Records for Time Variation of Sediment Inflow
X1	Cross-Sectional Record
XF	Record for Specifying Special Features of a Cross Section
GR	Record for Ground Profile of a Cross Section
SB	Record for Special Bridge Routine
BT	Record for Bridge Deck Definition
EJ	End of Job Record

Variable locations for each input record are shown by the field number. Each record has an input format of (A2, F6.0, 9F8.0). Field 0 occupying columns 1 and 2 is reserved for the required record identification characters. Field 1 occupies columns 3 to 8; Fields 2 to 10 occupy 8 columns each. The data records are tabulated and described in the following.

T1, T2, T3 Records - These three records are title records that are required for each job.

Field	Variable	Value	Description
0	IA	T1	Record identification characters
1-10	None		Numbers and alphameric characters for title

G1 Record - This record is required for each job, used to enter the general parameters listed below. This record is placed right after the T1, T2, and T3 records.

Field	Variable	Value	Description
0	IA	G1	Record identification characters
1	TYME	+	Starting time of computation on the hydrograph, in hours
2	ETIME	+	Ending time of computation on the hydrograph, in hours
3	DTMAX	+	Maximum time increment Δt allowed, in seconds
4	ISED	1	Select Graf's sediment transport equation.
		2	Select Yang's unit stream power equation. The sediment size is between 0.063 and 10 mm.
		3	Select Engelund-Hansen sediment equation.
		4	Select Parker gravel equation.
		5	Select Ackers-White sediment equation.
		6	Select Meyer-Peter Muller equation for bed load.
5	BEF	+	Bank erodibility factor for the study reach. This value is used for each section unless otherwise specified in Field 9 of the XF and 1 may be used.
6	IUC	0	English units are used in input and output.
		1	Metric units are used in input and output.
7 sec-	CNN	+	Manning's *n* value for the study reach. This value is used for a tion unless otherwise specified in Field 4 of the XF record. If bed roughness is computed based upon alluvial bedforms as specified in Field 5 of the G3 record, only an approximate *n* value needs to be entered here.
8	PTM1	+	First time point in hours on the hydrograph at which summary out-put and complete cross-sectional output are requested. It is usually

			the peak time, but it may be left blank if no output is requested.
9	PTM2	+	Second time point on the hydrograph in hours at which summary usually the time just before the end of the simulation. This field may be left blank if no output is needed.
10	KPF	+	Frequency of printing summary output, in number of time steps.

G2 Records - These records are required for each job, used to define the flow hydrograph(s) in the channel reach. The first one (or two) G2 records are used to define the spatial variation in water discharge along the reach; the succeeding ones are employed to define the time variation(s) of the discharge. Up to 10 hydrographs, with a maximum of 120 points for each, are currently dimensioned. See section II for tributaries. These records are placed after the G1 record.

Field	Variable	Value	Description
First G2			
0	IA	G2	Record identification characters
1	IHP1	+	Number of last cross section using the first (downstream most) hydrograph. The number of section is counted from downstream to upstream with the downstream section number being one. See also section II.
2	NP1	+	Number of points connected by straight segments used to define
3	IHP2	+	Number of last section using the second hydrograph if any. Otherwise leave it blank.
4	NP2	+	Number of points used to define the second hydrograph if any. Otherwise leave it blank.
5	IHP3	+	Number of last section using the third hydrograph if any. Otherwise leave it blank.
6	NP3	+	Number of points used to define the third hydrograph if any. Otherwise leave it blank.
7	IHP4	+	Number of last section using the fourth hydrograph if any. Otherwise leave it blank.
8	NP4	+	Number of points used to define the fourth hydrograph if any. Otherwise leave it blank.

9	IHP5	+	Number of last section using the fifth hydrograph if any. Otherwise leave it blank.
10	NP5	+	Number of points used to define the fifth hydrograph if any. Otherwise leave it blank.

Second G2: Note that this record is used only if more than 5 hydrographs are used for the job. It is necessary to place a negative sign in front of NP5 located in the 10th field of the first G2 record as a means to specify that more than 5 hydrographs are used.

0	IA	G2	Record identification characters
1	IHP6	+	Number of last cross section using the sixth hydrograph if any. Otherwise leave it blank.
2	NP6	+	Number of points connected by straight segments used to define
3	IHP7	+	Number of last section using the seventh hydrograph if any. Otherwise leave it blank.
4	NP7	+	Number of points used to define the seventh hydrograph
5	IHP8	+	Number of last section using the eighth hydrograph if any. Otherwise leave it blank.
6	NP8	+	Number of points used to define the eighth hydrograph
7	IHP9	+	Number of last section using the ninth hydrograph if any. Otherwise leave it blank.
8	NP9	+	Number of points used to define the ninth hydrograph
9	IHP10	+	Number of last section using the tenth hydrograph if any. Otherwise leave it blank.
10	NP10	+	Number of points used to define the tenth hydrograph

Succeeding G2 Record(s)

1	Q11, Q21 Q31	+	Discharge coordinate of point 1 for each hydrograph, in ft^3/sec or m^3/sec
2	TM11,TM21 TM31	+	Time coordinate of point 1 for each hydrograph, in hours
3	Q12, Q22 Q32	+	Discharge coordinate of point 2 for each hydrograph, in cfs or cms

4	TM12,TM22 TM32	+	Time coordinate of point 2 for each hydrograph, in hours

Continue with additional discharge and time coordinates. Note that time coordinates must be in increasing order.

G3 Record - This record is used to define required and optional river channel features for a job as listed below. This record is placed after the G2 records.

Field	Variable	Value	Description
0	IA	G3	Record identification characters
1	S11	+	Slope of the downstream section, required for a job
2	BSP	0	One-on-one slope for rigid bank or bank protection
		+	Slope of bank protection in BSP horizontal units on 1 vertical unit. for all cross sections unless otherwise specified in Field 8 of the XF record for a section.
3	DSOP	0	Downstream slope is allowed to vary during simulation.
		1	Downstream slope is fixed at S11 given in Field 1.
4	TEMP	0	Water temperature is 15^{o}C.
		+	Water temperature in degrees Celsius
5	ICNN	0	Manning's n defined in Field 7 of the G1 record or those in Field 4 of the XF records are used.
		1	Brownlie's formula for alluvial bed roughness is used to calculate Manning's n in the simulation.
6	TDZAMA	0	Thickness of erodible bed layer is 100 ft (30.5 m).
		+	Thickness of erodible bed layer in ft or m. This value is applied to
7	SPGV	0	Specific gravity of sediment is 2.65.
		+	Specific gravity of sediment
8	KGS	0	The number of size fractions for bed material is 5.
		+	The number of size fractions for bed material. It maximum value is 8.
9	PHI	0	The angle of repose for bed material is 36^{o}.
		+	Angle of repose for bed material

G4 Record - This is an optional record used to select cross sections (up to 4) to be included at each summary output. Each cross section is identified by its number which is counted from the downstream section. This record also contains other options; it is placed after the G3 record.

Field	Variable	Value	Description
0	IA	G4	Record identification characters
1	IPLT1	+	Number of cross section
2	IPLT2	+	Number of cross section
3	IPLT3	+	Number of cross section
4	IPLT4	+	Number of cross section
5	IEXCAV	+	A positive integer indicates number of cross section where sand/gravel excavation occurs.
6	GIFAC	+	A non-zero constant is used to modify sediment inflow at the upstream section.
7	PZMIN	0	Minimum bed profile during simulation run is not requested.
		1	Output file entitled TZMIN for minimum bed profile is requested.
10	REXCAV	+	A non-zero value specifies rate of sand/gravel excavation at Section IEXCAV.

G5 Record - This is an optional record used to specify miscellaneous options, including unsteady-flow routing for the job based upon the dynamic wave, bend flow characteristics. If the unsteady flow option is not used, the water-surface profile for each time step is computed using the standard-step method. When the unsteady flow option is used, the downstream water-surface elevation must be specified using the GB records.

Field	Variable	Value	Description
0	IA	G5	Record identification characters
1	DT	0	The first time step is 100 seconds.
		+	Size of the first time step in seconds.
2	IROUT	0	Unsteady water routing is not used; water-surface profiles are computed using standard-step method.
		1	Unsteady water-routing based upon the dynamic wave is used to compute stages and water discharges at all cross sections for each

3	PQSS	0	No output of gradation of sediment load
		3	Gradation of sediment load is included in output in 1,000 ppm by weight.
5	TSED	0	Rate of tributary sediment inflow is 1 times the discharge ratio.
		+	Rate of tributary sediment inflow is TSED times the discharge ratio.
6	PTV	0	No output of transverse distribution of depth-averaged velocity
		1	Transverse distribution of depth-averaged velocity is printed. The velocity distribution is for bends with fully developed transverse flow.
10	DYMAX	0	No GR points are inserted for cross sections.
		+	Maximum value of spacing between adjacent points at a cross

G6 Record - This is an optional record used to select time points for summary output. Up to 30 time points may be specified. The printing frequency (KPF) in Field 10 of the G1 Record may be suppressed by using a large number such as 9999.

Field	Variable	Value	Description
First G6 Record			
0	IA	G6	Record identification characters
1	NKPS	+	Number of time points
Succeeding G6 Record(s)			
0	IA	G6	Record identification characters
1	SPTM(1)	+	First time point, in hours
2	SPTM(2)	+	Second time point, in hours

Continue with additional time points.

G7 Record - This is an optional record used to specify erosion resistant bed layer, such as a caliche layer, that has a lower rate of erosion.

Field	Variable	Value	Description
First G7 Record			
0	IA	G7	Record identification characters

1	KG7	+	Number of time points used to define the known erosion rate in relation to flow velocity
2	THICK	+	Thickness of erosion resistant layer, in feet

Succeeding G7 Record(s)

0	IA	G7	Record identification characters
1	ERATE(1)	+	Erosion rate, in feet per hour
2	G7V(2)	+	Velocity, in feet per second

Continue with additional time points.

GS Record - At least two GS records are required for each job, used to specify initial bed-material compositions in the channel at the downstream and upstream cross sections. The first GS record is for the downstream section; it should be placed before the first X1 record and after the G4 record, if any. The second GS record is for the upstream section; it should be placed after all cross-sectional data and just before the EJ record. Additional GS records may be inserted between two cross sections within the stream reach, with the total number of GS records not to exceed 15. Each GS record specifies the sediment composition at the cross section located before the record. From upstream to downstream, exponential decay in sediment size is assumed for the initial distribution. Sediment composition at each section is represented by five size fractions.

Field	Variable	Value	Description
0	IA	GS	Record identification characters
1	DFF	+	Geometric mean diameter of the smallest size fraction in mm
2	PC	+	Fraction of bed material in this size range

Continue with other DFF's and PC's.

GB Records - These optional records are used to define time variation of stage (water-surface elevation) at a cross section. The first set of GB records is placed before all cross section records (X1); it specifies the downstream stage. When the GB option is used, it supersedes other methods for determining the downstream stage. Other sets of GB records may be placed in other parts of the data set; each specifies the time variation of stage for the cross section immediately following the GB records.

Field	Variable	Value	Description

First GB Record

0	IA	GB	Record identification characters
1	KBL	+	Number of points used to define base-level changes

Succeeding GB Record(s)

0	IA	GB	Record identification characters
1	BSLL(1)	+	Base level of point 1, in ft or m
2	TMBL(1)	+	Time coordinate of point 1, in hours
3	BSLL(2)	+	Base level of point 2, in ft or m
4	TMBL(2)	+	Time coordinate of point 2, in hours

Continue with additional elevations and time coordinates, in the increasing order of time.

GQ Records - These optional records are used to define stage-discharge relation at the downstream section. The GQ input data may not used together with the GB records.

Field	Variable	Value	Description
First GQ Record			
0	IA	GQ	Record identification characters
1	KQL	+	Number of points used to define base-level changes
Succeeding GQ Record(s)			
0	IA	GQ	Record identification characters
1	BSLL(1)	+	Base level of point 1, in ft or m
2	TMQ(1)	+	Discharge of point 1, in cfs or cms
3	BSLL(2)	+	Base level of point 2, in ft or m
4	TMQ(2)	+	Discharge of point 2, in cfs or cms

Continue with additional elevations and discharges, in the increasing order of discharge.

GI Records - These optional records are used to define time variation of sediment discharge entering the study reach through the upstream cross section. The GI input data, if included, will supersede other methods for determining sediment inflow. The sediment inflow is classified into the two following cases: (1) specified inflow at the upstream section, such as by a rating curve; and (2) sediment feeding, such as from a dambreach or a sediment feeder. These two cases are distinguished by DXU in Field 2 of this record. For the first case, sediment discharge at the upstream section is computed using size fractions of bed-material at the section, but for the second case, the size fractions of feeding material need to be specified using the PCU values in this record. The upstream section does not change in geometry for the first case but it may undergo scour or fill for the second case.

Field	Variable	Value	Description
First GI Record			
0	IA	GI	Record identification characters
1	KGI	+	Number of points used to define time variation of sediment inflow.
2	DXU	+ or 0	Channel distance measured from the upstream section to the and KGI signify case 2, for which PCU values are required.
3-10	PCU	+	Size fractions of inflow material. The number of size fractions is given in Field 8 of the G3 record and the sizes for the fractions are given in the second GS record.
Succeeding GI Record(s)			
0	IA	GI	Record identification characters
1	QSU(1)	+	Sediment discharge of point 1, in cubic ft or m (net volume) per second
2	TMGI(1)	+	Time coordinate of point 1, in hours
3	QSO(2)	+	Sediment discharge of point 2
4	TMGI(2)	+	Time coordinate of point 2.

Continue with additional sediment discharges and time coordinates, in the increasing order of time coordinates.

X1 Record - This record is required for each cross section (175 cross sections can be used for the study reach); it is used to specify the cross-sectional geometry and program options applicable to that cross-section. Cross sections are arranged in sequential order starting from downstream.

Field	Variable	Value	Description
0	IA	X1	Record identification characters

1	SECNO	+	Original section number from the map
2	NP	+	Total number of stations or points on the next GR records for
7	DX	+	Length of reach between current cross section and the next down-stream section along the thalweg, in feet or meters
8	YFAC	0	Cross-section stations are not modified by the factor YFAC.
		+	Factor by which all cross-section stations are multiplied to increase or decrease area. It also multiplies YC1, YC2 and CPC in the XF record, and applies to the CI record.
9	PXSECE	0	Vertical or Z coordinate of GR points are not modified.
		±	Constant by which all cross-section elevations are raised or lowered
10	NODA	0	Cross section is subject to change.
		1	Cross section is not subject to change.

XF Record - This is an optional record used to specify special features of a cross section.

Field	Variable	Value	Description
0	IA	XF	Record identification characters
1	YC1	0	Regular erodible left bank
		+	Station of rigid left bank in ft or m, to the left of which channel dinates in GR records but not the first Y coordinate.
2	YC2	0	Regular erodible right bank
	+		Station of rigid right bank, to the right of which channel is non-erodible. Note: This station is located at toe of rigid bank; its value must be equal to one of the Y coordinates in GR records but not the last Y coordinate.
3	RAD	0	Straight channel with zero curvature
		+	Radius of curvature at channel centerline in ft or m. Center of radius is on same side of channel where the station (Y-coordinate) starts.
		-	Radius of curvature at channel centerline in ft or m. Center of radius is on opposite side of zero station. Note: RAD is used only if concave bank is rigid and so specified using the XF record. RAD produces a transverse bed scour due to curvature.
4	CN	0	Roughness of this section is the same as that given in Field 7 of the G1 record.

		+	Manning's *n* value for this section
5	CPC	0	Center of thalweg coincides with channel invert at this section.
		+	Station (Y-coordinate) of the thalweg in ft or m
6	IRC	0	Regular erodible cross section
		1	Rigid or nonerodible cross section such as drop structure or road crossing. There is no limit on the total number of such cross sections.
8	BSP	0	Slope of bank protection is the same as that given in Field 2 of the G3 record.
		+	Slope of bank protection at this section in BSP horizontal units
		5	Slope of rigid bank is defined by the GR coordinates.
9	BEFX	0	Bank erodibility factor is defined in Field 5 of the G1 record.
		+	A value between 0.1 and 1.0 for BEFX specifies the bank erodibility factor at this section.
	RWD	+	RWD is the width of bank protection of a small channel in the specified by a value greater than 1 (ft or m) in this field. When RWD is used, BEFX is not specified.
10	TDZAM	0	Erodible bed layer at this section is defined by TDZAMA in Field
		+	Thickness of erodible bed layer in ft or m. Only one decimal place is allowed for this number.
	ENEB	$\pm$	Elevation of non-erodible bed, used to define the crest elevation of a grade-control structure which may be above or below the existing channel bed. In order to distinguish it from TDZAM, ENEB must have the value of 1 at the second decimal place. For example, the ENEB value of 365 should be inputted as 365.01 and the ENEB value of -5.2 should be inputted as -5.21. When ENEB is specified, it supersedes TDZAM and TDZAMA

CI Record - This is an optional record used to specify channel improvement options due to excavation or fill. The excavation option modifies the cross-sectional geometry by trapezoidal excavation. Those points lower than the excavation level are not filled. The fill option modifies the cross-sectional geometry by raising the bed elevations to a prescribed level. Those points higher than the fill level are not lowered. Excavation and fill can not be used at the same time. This record should be placed after the X1 and XF records but before the GR records. The variable ADDVOL in Field 10 of this record is used to keep track of the total volume of excavation or fill along a channel reach. ADDVOL specifies the initial volume of fill or excavation. A value greater or less than 0.1 needs to be entered in this field to keep track of the total volume of fill or excavation until another ADDVOL is defined.

Field	Variable	Value	Description
0	IA	G5	Record identification characters
1	CLSTA	+	Station of the centerline of the trapezoidal excavation, expressed according to the stations in the GR records, in feet or meter.
2	CELCH	+	Elevation of channel invert for trapezoidal channel, in feet or meters.
4	XLSS	+	Side slope of trapezoidal excavation, in XLSS horizontal units for 1 vertical unit.
5	ELFIL	+	Fill elevation on channel bed, in feet or meters.
6	BW	+	Bed width of trapezoidal channel, in feet or meters. This width is measured along the cross section line; therefore, a larger value should be used if a section is skewed.
10	ADDVOL	0	Volume of excavation or fill, if any, is added to the total volume already defined.
		+	Initial volume of fill on channel bed, in cubic feet or cubic meters.
		-	Initial volume of excavation from channel bed, in cubic feet or meters.

GR Record - This record specifies the elevation and station of each point for a digitized cross section; it is required for each X1 record.

Field	Variable	Value	Description
0	IA	GR	Record identification characters
1	Z1	"	Elevation of point 1, in ft or m. It may be positive or negative.
2	Y1	"	Station of point 1, in ft or m
3	Z2	"	Elevation of point 2, in ft or m
4	Y2	"	Station of point 2, in ft or m

Continue with additional GR records using up to 79 points to describe the cross section. Stations should be in increasing order.

SB Record - This special bridge record is used to specify data in the special bridge routine. This record is used together with the BT and GR records for bridge hydraulics. This record is placed between cross sections that are upstream and downstream of the bridge.

Field	Variable	Value	Description
0	IA	SB	Record identification characters
1	XK	+	Pier shape coefficient for pier loss
2	XKOR	+	Total loss coefficient for orifice flow through bridge opening
3	COFQ	+	Discharge coefficient for weir flow overtopping bridge roadway
4	IB	+	Bridge index, starting with 1 from downstream toward upstream
5	BWC	+	Bottom width of bridge opening including any obstruction
6	BWP	0	No obstruction (pier) in the bridge
		i	Total width of obstruction (piers)
7	BAREA	+	Net area of bridge opening below the low chord in square feet
9	ELLC	+	Elevation of horizontal low chord for the bridge
10	ELTRD	+	Elevation of horizontal top-of-roadway for the bridge

BT Record - This record is used to compute conveyance in the bridge section. The BT data defines the top-of -roadway and the low chord profiles of bridge. The program uses the BT, SB and GR data to distinguish and to compute low flow, orifice flow and weir flow.

Field	Variable	Value	Description
0	IA	BT	Record identification characters
1	NRD	+	Number of points defining the bridge roadway and bridge low chord
			to be read on the BT records
2	RDST(1)	+	Roadway station corresponding to RDEL(1) and XLCEL(1)
3	RDEL(1)	+	Top of roadway elevation at station RDST(1)
4	XLCEL(1)	+	Low chord elevation at station RDST(1)
5	RDST(2)	+	Roadway station corresponding to RDEL(2) and XLCEL(2)

6	RDEL(2)	+	Top of roadway elevation at station RDST(2)
7	XLCEL(2)	+	Low chord elevation at station RDST(2)

Continue with additional sets of RDST, RDEL, and XLCEL.

EJ Record - This record is required following the last cross section for each job. Each group of records beginning with the T1 record is considered as a job.

Field	Variable	Value	Description
0	IA	EJ	Record identification characters
1-10			Not used

II. OUTPUT DESCRIPTION

Output of the model include initial bed-material compositions, time and spatial variations of the water-surface profile, channel width, flow depth, water discharge, velocity, energy gradient, median sediment size, and bed-material discharge. In addition, cross-sectional profiles are printed at different time intervals.

Symbols used in the output are generally descriptive, some of them are defined below:

SECTION	Cross section
TIME	Time on the hydrograph
DT	Size of the time step or Δt in sec
W.S.ELEV	Water-surface elevation in ft or m
WIDTH	Surface width of channel flow in ft or m
DEPTH	Depth of flow measured from channel invert to water surface in ft or m
Q	Discharge of flow in cfs or cms
V	Mean velocity of a cross-section in fps or mps
SLOPE	Energy gradient
D50	Median size or d_{50} of sediment load in mm
QS	Bed-material discharge for all size fractions in cfs or cms
FR	Froude number at a cross section
N	Manning's roughness coefficient
SED.YIELD	Bulk volume or weight of sediment having passed a cross section since beginning of simulation, in cubic yards or tons.
WSEL	Water-surface elevation, in ft or m
Z	Vertical coordinate (elevation) of a point on channel boundary at a cross-section, in ft or m
Y	Horizontal coordinate (station) of a point on channel boundary at a cross-section, in ft or m

DZ	Change in elevation during the current time step, in ft or m
TDZ	Total or accumulated change in elevation, in ft or m

BEFORE THE ENERGY RESOURCES CONSERVATION AND DEVELOPMENT COMMISSION OF THE STATE OF CALIFORNIA
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APPLICATION FOR CERTIFICATION	**Docket No. 08-AFC-13**
For the CALICO SOLAR (Formerly SES Solar One)	**PROOF OF SERVICE** ***(Revised 8/9/10)***

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DECLARATION OF SERVICE

I, Darin Neufeld, declare that on September 16, 2010, I served and filed copies of the attached Applicant's Submittal of Response to BNSF September 15, 2010 Submittal. The original document, filed with the Docket Unit, is accompanied by a copy of the most recent Proof of Service list, located on the web page for this project at: [www.energy.ca.gov/sitingcases/solarone].

The documents have been sent to both the other parties in this proceeding (as shown on the Proof of Service list) and to the Commission's Docket Unit, in the following manner:

(*Check all that Apply*)

FOR SERVICE TO ALL OTHER PARTIES:

__X__ sent electronically to all email addresses on the Proof of Service list;

_____ by personal delivery;

__X__ by delivering on this date, for mailing with the United States Postal Service with first-class postage thereon fully prepaid, to the name and address of the person served, for mailing that same day in the ordinary course of business; that the envelope was sealed and placed for collection and mailing on that date to those addresses NOT marked "email preferred."

AND

FOR FILING WITH THE ENERGY COMMISSION:

__X__ sending an original paper copy and one electronic copy, mailed and emailed respectively, to the address below (***preferred method***);

OR

_____ depositing in the mail an original and 12 paper copies, as follows:

CALIFORNIA ENERGY COMMISSION
Attn: Docket No. 08-AFC-13
1516 Ninth Street, MS-4
Sacramento, CA 95814-5512
docket@energy.state.ca.us

I declare under penalty of perjury that the foregoing is true and correct, that I am employed in the county where this mailing occurred, and that I am over the age of 18 years and not a party to the proceeding.

Original Signed By
Darin Neufeld

*indicates change