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April 26, 2010

Mr. Christopher Meyer
Project Manager
Attn: Docket No. 08-AFC-5
California Energy Commission
1516 Ninth Street
Sacramento, CA 95814-5512

Subject: Imperial Valley Solar (formerly Solar Two) (08-AFC-5)
Applicant's Submittal of Sediment Transport Analysis

Dear Mr. Meyer:

On behalf of Imperial Valley Solar (formerly Solar Two), LLC, URS Corporation Americas (URS) hereby submits the Applicant's Sediment Transport Analysis.

I certify under penalty of perjury that the foregoing is true, correct, and complete to the best of my knowledge. I also certify that I am authorized to submit on behalf of Imperial Valley Solar, LLC.

Sincerely,

Angela Leiba
Project Manager

AL: ml

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Sediment Study for Three Washes at Solar Two Project Site in Imperial County, California

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January 2010

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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.

EXECUTIVE SUMMARY

The proposed Solar Two Project is on the Bureau of Land Management property south of Plaster City in Imperial County. Sediment study of three major washes (Wash K, Wash C, and Wash G) at the Solar Two project site has been made in order to assess the project impacts and to develop mitigation measures for the proposed Solar Two project. The FLUVIAL-12 computer model was employed to simulate the hydraulics of flow, velocity, sediment transport, sediment delivery and potential stream channel changes along these washes. The modeling study covers the 10- and 100-yr floods for the pre-project (existing) conditions and the post-project (proposed) conditions.

The current plan for the project includes solar units on pedestals, road crossings, culverts, sediment basins, vegetation trimming, etc. The effects of these features on the washes have been quantified. The Army Corps of Engineers has suggested that the proposed sediment basins be modeled separately from the proposed project infrastructure. This allows the Corps and the EPA to assess the full direct and indirect impacts of the infrastructure on stream hydrology and sediment transport.

The study provides representative sediment transport modeling to assess 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. General scour is simulated in computer modeling; local scour is calculated using FEMA-adopted formulas.

It is also necessary to determine consequences of increased or decreased sediment delivery downstream. Possible consequences could include excess sediment deposition upstream of the existing railroad and culvert crossings along the north side of the project, or excess sediment delivery toward the east and the Westside Main Canal, or downstream channel degradation affecting existing infrastructure and channel morphology. In order to minimize the impacts, it would be ideal if the project causes no substantial changes to the sediment delivery. Otherwise, adverse impacts should be mitigated.

Characteristics of Flood Flow – Floods in the desert generally occur as flash floods with the discharge rises and falls rapidly. The flow depths in the washes at the peak 100-yr flood are less than 1 foot except in proposed debris basins (or sediment basins). The velocities at the peak flood disharge vary from low to moderate; they are generally lower than 3 feet per second.

Potential Stream Channel Changes - From the simulated stream channel changes, it can be concluded that the channel reaches for Washes K, C and G are not subject to substantial changes in channel bed profiles for the existing and proposed conditions. Changes in bed elevation due to general scour are less than 1 foot during the 100-yr flood. Such changes are even less during the 10-yr flood. However, the refill in sediment basins may exceed one foot. The solar units are supported on 2-foot cylindrical pedestals. For a pedestal in a wash, the total scour is the general scour plus the local scour at the pedestal base. The maximum local scour that occurs under the worst combination of flow depth and flow velocity has been computed to be 4.2 feet during the 100-yr flood.

Potential Impacts of Road Crossings, Culverts, and Sediment Basins - Sediment delivery is the total amount of sediment delivered passing a channel station during the passage of the flood event. The modeled results show that sediment deliveries vary along these washes. An increasing delivery toward downstream indicates erosion while a decreasing delivery toward downstream means sediment deposition. For the existing conditions, the spatial variations of sediment delivery along a wash are due to the non-uniform channel geometry along the wash. A natural stream is always adjusting its geometry toward dynamic equilibrium with uniform sediment delivery along the stream channel. However, a true equilibrium may never be attained during a changing discharge.

The differences in sediment delivery between the existing and proposed conditions are related to the difference in channel roughness, road crossings, culverts and sediment basins. The case of road crossings without sediment basins is first discussed. The road crossings are rigid structures not subject to erosion. Areas along the wash with high velocities are usually subject to erosion. Road crossings located at such areas are physical constraints for erosion; they thus modify the pattern of sediment transport along the wash. Such modifications include sediment deposition upstream of road crossings and erosion downstream of the road crossings. Road crossings located in low flow velocity areas that are subject to sediment deposition have little or no effects on sediment transport. The natural washes have formed in geological time; they have already established an approximate equilibrium in sediment transport. Potential stream channels are not subject to major changes under existing conditions. The at-grade road crossings are set at the existing channel bed grade; therefore, they will not cause major changes to the sediment pattern. Potential sediment deposition and erosion induced by the at-grade road crossings are not substantial in magnitude. Of course, this does not apply to road crossings with raised grades.

In the long-term, sediment transport and delivery along a wash is governed by the sediment supply from its watershed. An alluvial stream is a dynamic system; it undergoes constant adjustments in geometry in response to the water and sediment inflow from the watershed. With the presence of road crossings, the channel will adjust its geometry by deposition and erosion. The adjustment is always toward establishing uniform sediment transport along the channel. In the long-term, sediment delivery toward the downstream area of the project site is controlled by the water and sediment inflow from the watershed. Such inflow quantities are not impacted by the at-grade road crossings in the long-term.

For the proposed conditions with sediment basins, the pattern of sediment delivery will be substantially changed at the sediment basins as substantial amounts of sediment are detained in the basins to result in a deficit of sediment transport toward downstream. The sediment basins located near the downstream end of a channel reach will detain all the inflow sediment during the 100-yr event; they will thus cut off sediment delivery toward downstream of the project site. The long-term impacts of sediment basins depend on sediment basin maintenance. If the sediment basins are not maintained by re-dredging, they will eventually be refilled and then the sediment impacts will disappear. However, if the sediment basins are maintained periodically by dredging, then the periodical export of sediment from the wash system will have long-term impacts on sediment delivery along the wash as well as sediment delivery toward downstream.

Recommendations for Impact mitigation - The study report provides representative sediment transport modeling to assess potential stream channel changes as well as an assessment of whether the project is likely to increase or decrease sediment delivery toward downstream. It is necessary to determine consequences of increased or decreased sediment delivery downstream. Possible consequences could include excess sediment deposition upstream of the existing railroad and culvert crossings along the north side of the project, or excess sediment delivery toward the east and the Westside Main Canal, or downstream channel degradation affecting existing infrastructure and channel morphology. In order to minimize the impacts, it would be ideal if the project causes no substantial changes to the sediment delivery. Otherwise, adverse impacts should be mitigated.

Sediment impacts may be mitigated by different methods. Basically, the road crossings, sediment basins, culverts, vegetation, buildings, etc. all affect sediment transport. In order to mitigate adverse impacts, modifications to these structures are considered. Based on the results of this study, the following mitigations for project impacts are recommended:

(1) Deletion of all sediment basins - The study has shown that the sediment basins will have short-term and long-term effects in reducing sediment flow along a wash and toward downstream. It is recommended all sediment basins be deleted from the proposed plan.

(2) Modification of Lifeline Crossing in Wash G – Under the proposed plan, the 24-foot Lifeline Crossing has five 3-foot culverts for cross drainage. The top of roadway is about 5 feet above the channel bed elevation. This road crossing together with the two adjacent sediment basins will have major effects in reducing sediment flow along the stream channel. It is recommended that this crossing be changed into an at-grade road crossing with all the culverts removed.

(3) Structural design for pedestals – Pedestals supporting solar units may be located in a wash. The maximum scour, including general scour and local scour, has been determined be no greater than 5 feet. In the structural design for the pedestals, the total scour depth of five feet should be considered.

Sediment Study for Three Washes at Solar Two Project Site in Imperial County, California

I. INTRODUCTION

The proposed Solar Two Project is on the Bureau of Land Management property south of Plaster City in Imperial County. Fig. 1 shows a Google image of the Solar Two project site and its adjacent area. Fig. 2 shows the drainage basin map of the project site prepared by RMT. The Evan Hewes Highway is the north boundary and Interstate 8 is the south boundary of the project site.

Sediment study of three major washes (Wash K, Wash G, and Wash G) at the Solar Two project site has been made in order to assess the project impacts and to develop mitigation measures for the proposed Solar Two project. The FLUVIAL-12 computer model was employed to simulate the hydraulics of flow, velocity, sediment transport, sediment delivery and potential stream channel changes along these washes.

The modeling study covers the following flood conditions: (1) the 100-yr flood and (2) the 10-yr flood. The scope of work covers the two following physical conditions of the washes:

(1) Pre-project or existing conditions, and

(2) Post-project or proposed conditions.

The current plan for the project includes solar units on pedestals, road crossings, culverts, sediment basins, vegetation trimming, etc. The effects of these features on the washes will be quantified. The Army Corps of Engineers has suggested that the proposed sediment basins be modeled separately from the proposed project infrastructure. This allows the Corps and the EPA to assess the full direct and indirect impacts of the infrastructure on stream hydrology and sediment transport.

The study report provides representative sediment transport modeling to assess potential stream channel changes (aggradation or degradation) as well as an assessment of whether the project is likely to increase or decrease sediment delivery toward downstream. It is necessary to determine consequences of increased or decreased sediment delivery downstream. Possible consequences could include excess sediment deposition upstream of the existing railroad and culvert crossings along the north side of the project, or excess sediment delivery toward the east and the Westside Main Canal, or downstream channel degradation affecting existing infrastructure and channel morphology. In order to minimize the impacts, it would be ideal if the project causes no substantial changes to the sediment delivery. Otherwise, adverse impacts should be mitigated.

The study provides 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. General scour is simulated in computer modeling; local scour is calculated using FEMA-adopted formulas. Such scour information is used to assess impacts on the structural stability of the solar units in a wash. It is also a consideration 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).

Fig. 1 Google image of the Solar Two project general area

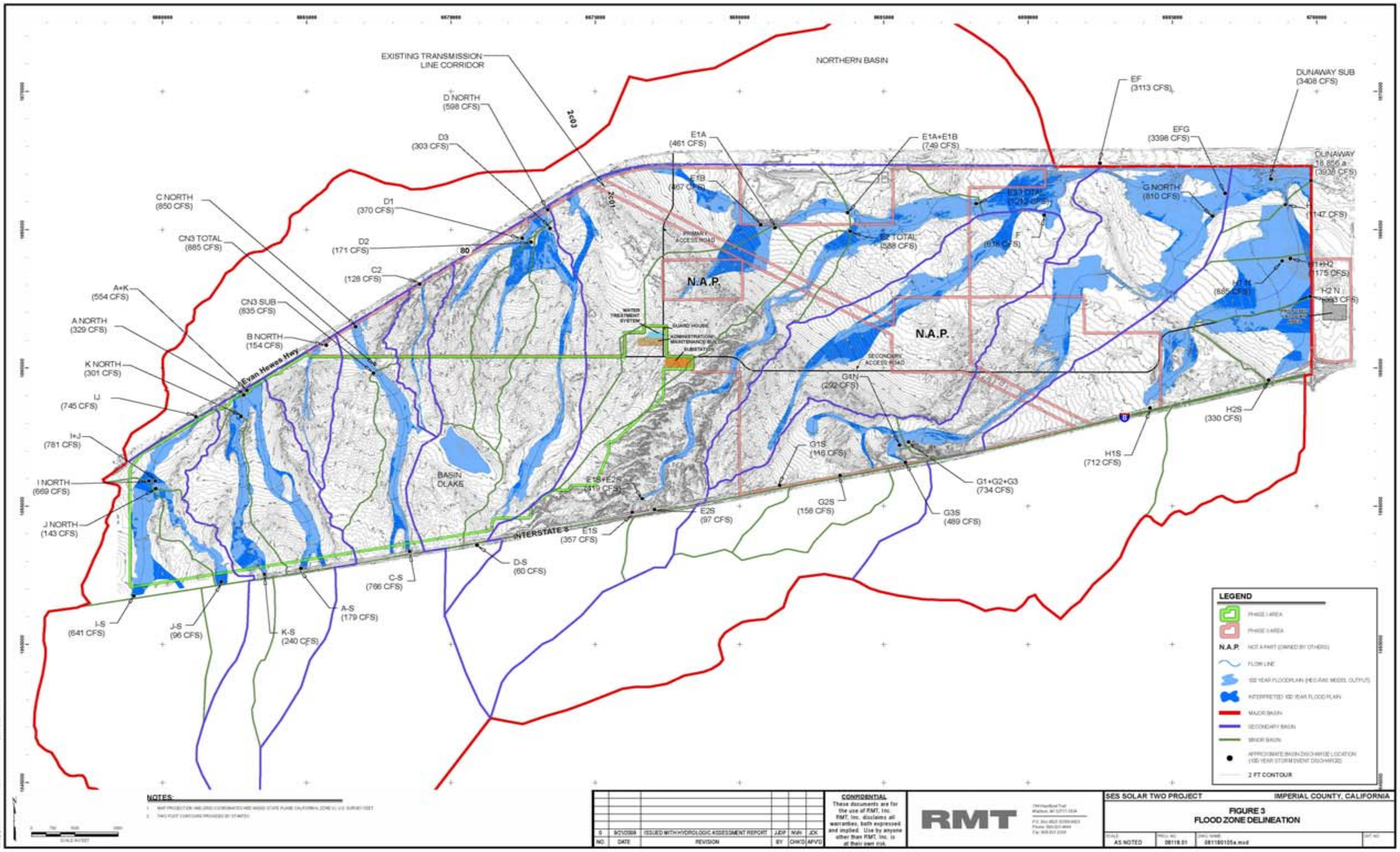


Fig. 2 Drainage map of Solar Two project site by RMT

II. FLOOD HYDROLOGY

A hydrology study for the project site was made by Stantec and subsequently by RMT. The study has provided the flood discharges for the washes. The Federal design standard is the 100-yr flood, which is also the base flood as used by FEMA. The sediment modeling study is based on the 10- and 100-yr flood discharges from the hydrology study. The hydrograph is assumed to be triangular in shape with a total duration of 6 hours and its peak discharge located at the mid point. The discharge varies along a wash as it increases gradually from upstream toward downstream. The range of discharge variation for each wash is listed in Table 1. Sediment transport in a stream channel is related to the discharge and sediment characteristics. Grain size distribution for the stream channels is shown in Fig. 3.

Table 1. Range of peak flood discharge for the washes

Drainage basin	Range of 10-yr flood discharge, cfs	Range of 100-yr flood discharge, cfs
Wash C	246 – 284	777 – 885
Wash K	77 – 97	240 – 305
Wash G	237 – 261	748 – 845

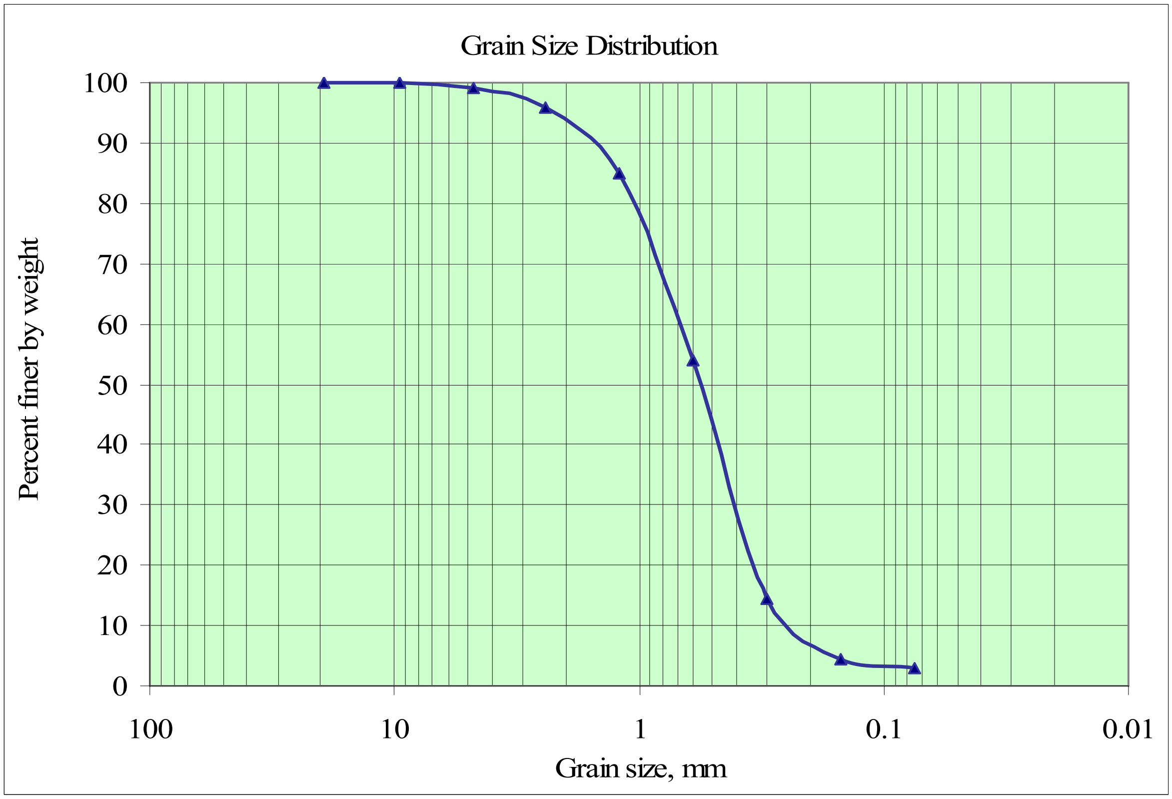


Fig. 3. Grain size distribution of sediment sample

III. FEATURES OF PROPOSED PROJECT

The proposed project includes certain features that may have effects on the flow and sediment transport in the washes. Such features include channel roughness, road crossings, culverts, and sediment basins as described below.

The channel roughness will be affected by the changes in vegetation and structural supports for the solar units. Existing vegetation in the washes will be trimmed or removed; the channel roughness will be reduced because of this change. The channel roughness will also be affected by the structural supports (or pedestals) for the solar units that will be scattered in the washes with a low density (one 2-foot diameter post on 0.28 acre of land area). In the modeling study, the roughness coefficient, in terms of Manning's *n*, of 0.03 is used for the existing conditions. For the post-project conditions, the *n* value of 0.025 is used to reflect the reduced vegetation and scattered pedestals.

The washes will have road crossings with concrete cut-off wall for each on the downstream side. Since the concrete structure is non-erodible, such road crossings will act like grade control structures in the washes. Most of the road crossings are to be at grade with the exception of one over Wash G at the Lifeline crossing. The at-grade road crossings will have no culverts, but the Lifeline crossing is elevated above the channel bed provided with five 36-inch pipe culverts.

Sediment basins in the washes have also been proposed; they are usually located on the upstream side of a road crossing with a few exceptions. Engineering plans for the sediment basins are shown in Figs. 4 and 5

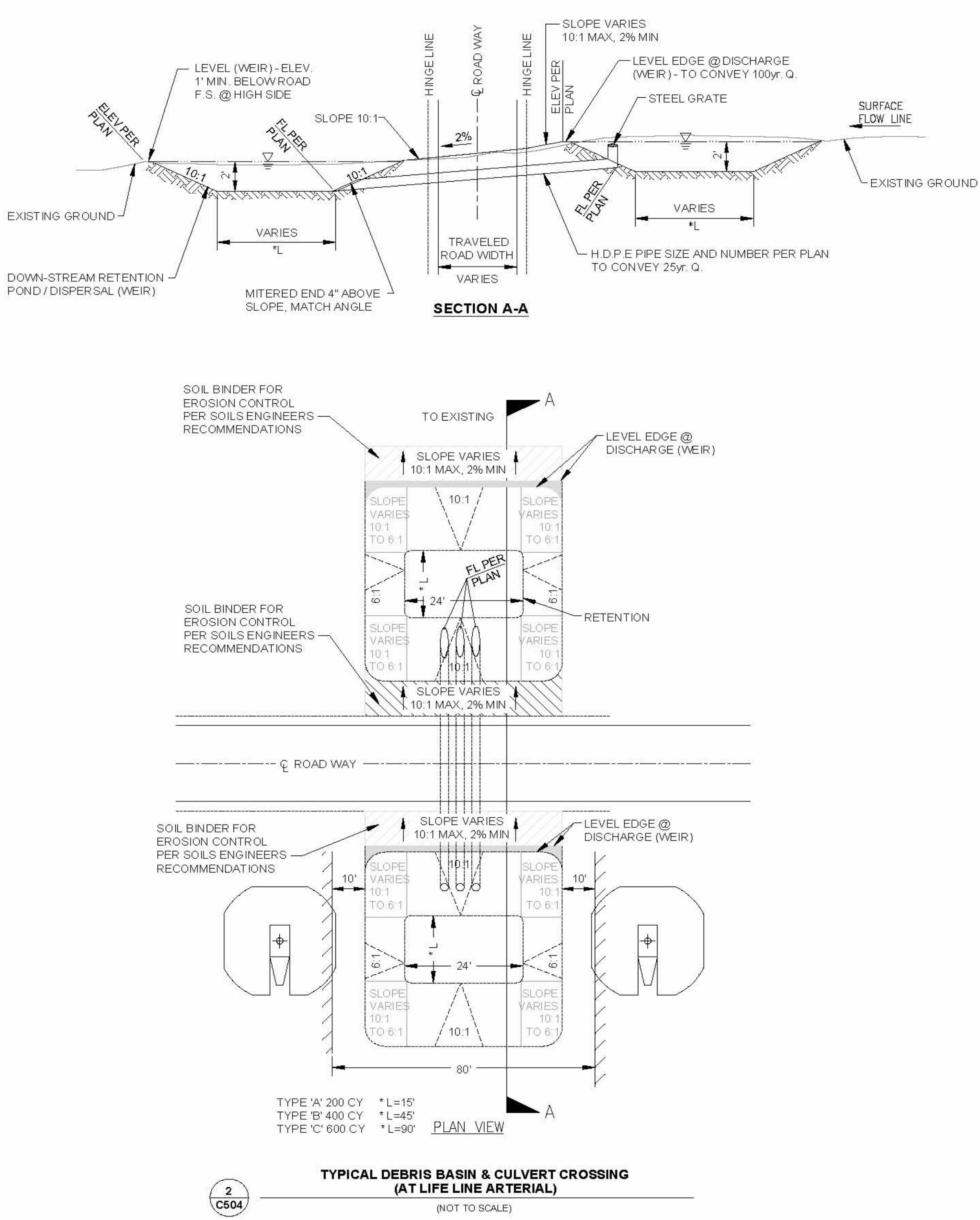


Fig. 4. Engineering plans for sediment basins

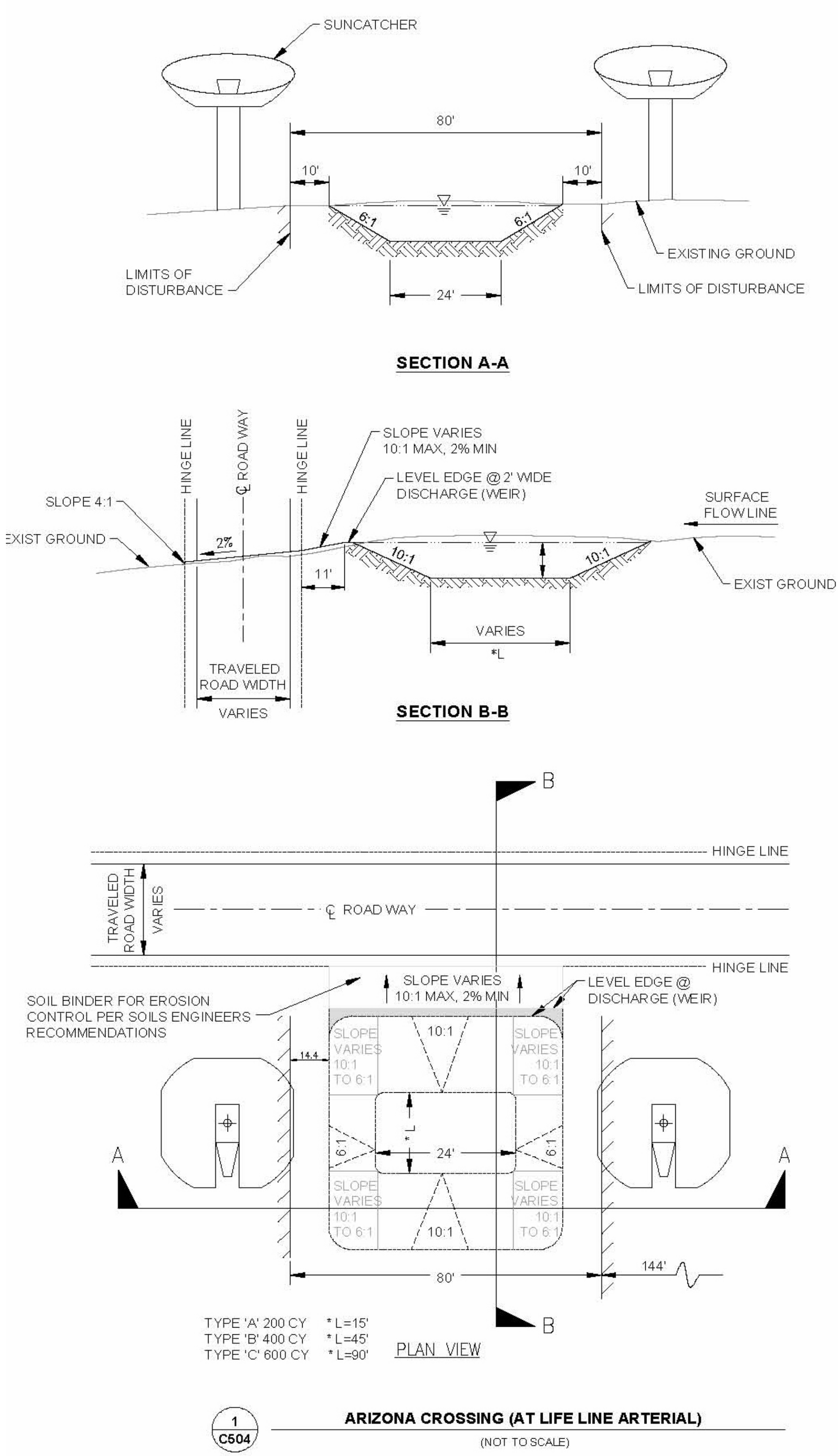


Fig. 5. Engineering plans for sediment basins

IV. MODELING HYDRAULICS OF FLOW, SEDIMENT TRANSPORT, 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.

Selection of Engelund-Hansen Formula – A sediment transport formula is employed in the computer model. The Engelund-Hansen formula (1967) was selected for the study for the following reasons:

(1) The selection was based on the most extensive evaluation of formulas made by Brownlie

(1981, see Fig. 6); the Engelund-Hansen formula has the best correlation with field data.

(2) The Engelund-Hansen formula was used in many studies in this region. The results of these studies were verified by field data.

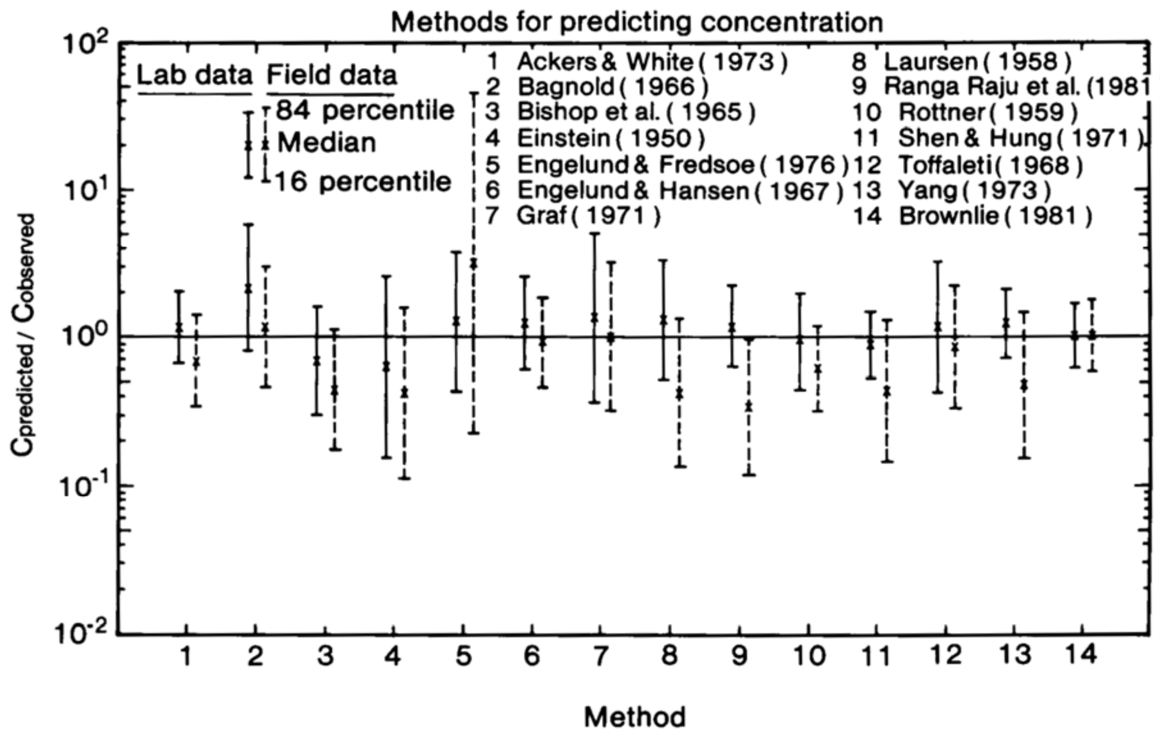


Fig. 6. Evaluation of sediment transport formulas by Brownlie

Engelund-Hansen Formula - Engelund and Hansen applied Bagnold's stream power concept and the similarity principle to obtain their sediment transport equation:

$$f' \varphi = 0.1 (\tau_*)^{5/2} \tag{1}$$

with $$f' = \frac{2gRS}{U^2} \tag{2}$$

$$\varphi = \frac{q_s}{\gamma_s [(s-1) g d^3]^{1/2}}, \qquad \tau_* = \frac{\tau_o}{(\gamma_s - \gamma) d} \tag{3}$$

where f' is the friction factor, d is the median fall diameter of the bed material, φ is the dimensionless sediment discharge, s is the specific gravity of sediment, and τ_* is the dimensionless shear stress or the Shields stress. Substituting Eqs. 2 and 3 into Eq. 1 yields

$$C_s = 0.05 \frac{s}{s-1} \frac{US}{[(s-1)gd]^{1/2}} \left[\frac{RS}{(s-1)\,d}\right]^{1/2} \quad (4)$$

where C_s (= Q_s/Q) is the sediment concentration by weight. This equation relates sediment concentration to the *U-S* product (which is the rate of energy expenditure per unit weight of water) and the *R-S* product (which is the shear stress). Strictly speaking, the Engelund-Hansen formula should be applied to streams with a dune bed in accordance with the similarity principle. However, it can be applied to upper flow regime with particle size greater than 0.15 mm without serious error.

Simulation of Sediment Delivery - Sediment delivery is defined as the cumulative amount of sediment that has been delivered passing a certain channel section for a specified period of time, that is,

□

$$Y = \int_T Q_s \, dt \quad (5)$$

where Y is sediment delivery (yield); Q_s is sediment discharge; t is time; and T is the duration. The sediment discharge Q_s pertains only to bed-material load of sand, gravel and cobble. Fine sediments of clay and silt constituting the wash load may not be computed by a sediment transport formula. Sediment delivery is widely employed by hydrologists for watershed management; it is used herein to keep track of sediment supply and removal along the channel reach.

Spatial variations in sediment delivery are manifested as channel storage or depletion of sediment associated stream channel changes since the sediment supply from upstream may be different from the removal. The spatial variation of sediment delivery depicts the erosion and deposition along a stream reach. A decreasing delivery in the downstream direction, i.e. negative gradient for the delivery-distance curve, signifies that sediment load is partially stored in the channel to result in a net deposition. On the other hand, an increasing delivery in the downstream direction (positive gradient for the delivery-distance curve) indicates sediment removal from the channel boundary or net scour. A uniform sediment delivery along the channel (horizontal curve) indicates sediment balance, i.e., zero storage or depletion. Channel reaches with net sediment storage or depletion may be designated in each figure on the basis of the gradient. From the engineering viewpoint, it is best to achieve a uniform delivery, the non-silt and non-scour condition, for dynamic equilibrium.

V. MODELING STUDY FOR WASH K

Wash K, located in the western part of the project site, is the smallest of the three washes under study. Fig. 7 is a map of the wash and Fig. 8 shows the locations of channel cross sections used to define the stream channel geometry. The flow in the wash is from south toward north. The downstream limit of study is Evan Hewes Highway and the upstream limit is Interstate 8.

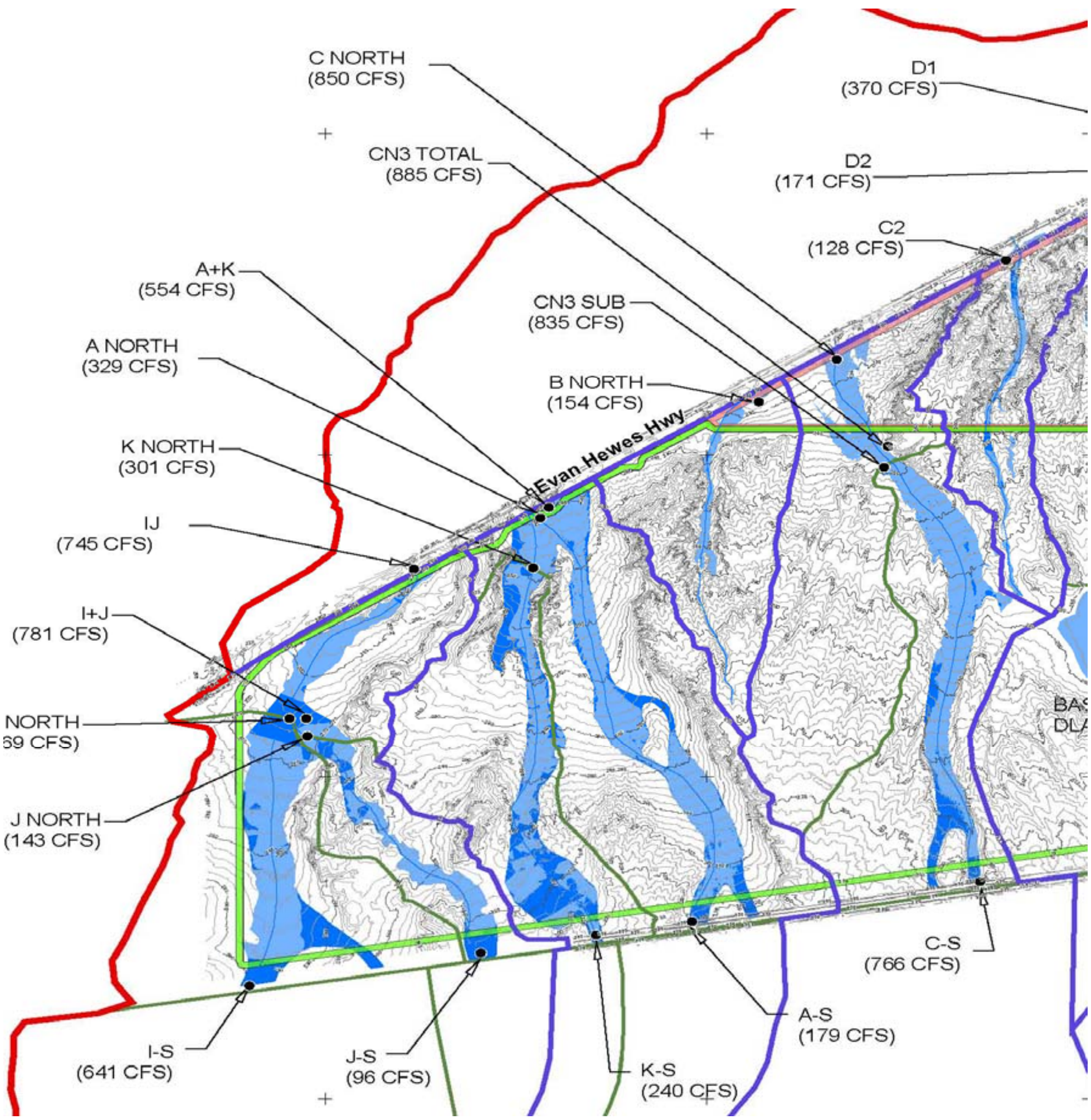


Fig. 7. Map of western project site showing Washes K and C and vicinities

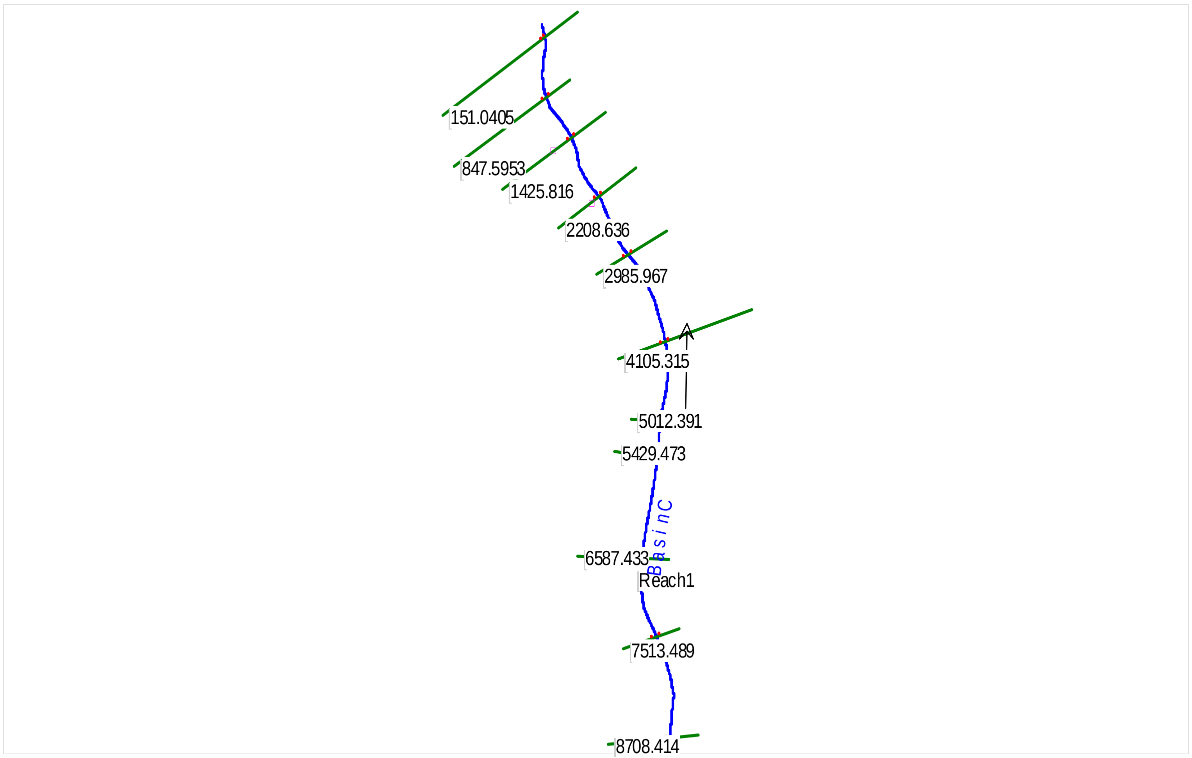


Fig. 8. Cross section lines for Wash K

For the proposed conditions, this wash will have at-grade road crossings at the following locations:

(1) 24-foot at-grade road crossing with concrete cut-off wall near downstream end of study reach,

(2) 24-foot at-grade road crossing with concrete cut-off wall at channel station 1858.5,

(3) 24-foot at-grade road crossing with concrete cut-off wall at channel station 5957, and

(4) 10-foot at-grade road crossing at upstream end of study reach.

The road crossings with concrete cut-off walls on the downstream side are rigid structures that are not subject to erosion; they will act like grade control structures for the stream bed. In addition to the road crossings, sediment basins have been proposed at the following locations:

(1) Type A sediment basin with a capacity of 200 cubic yards on the upstream side of at-grade road crossing near the downstream end of study reach,

(2) Type B sediment basin with a capacity of 400 cubic yards on the upstream side of at-grade road crossing at channel station 1858.5, and

(3) Type C sediment basin with a capacity of 600 cubic yards on the upstream side of at-grade road crossing near the upstream end of study reach.

Modeling study of Wash K covers the existing (pre-project) conditions and proposed (post-project) conditions of the wash. Computer input/output listings for the modeling study are attached to the report. Sample output listings for the 10- and 100-yr floods under the proposed conditions with road crossings and sediment basins are listed in Tables 2 and 3. The modeled results are described below. Some selected results are presented in graphical forms.

The legends for Tables 2 and 3 are given below:

SECTION: Channel station,

W.S.ELEV.: Computed water-surface elevation,

WIDTH: Width of channel at water surface,

DEPTH: Water depth,

Q: Discharge of flow,

V: Flow velocity,

SLOPE: energy gradient,

D50: Median sediment size,

QS/Q: Sediment concentration based on ratio of sediment load to water discharge in 1000 ppm by weight,

FR: Froude number,

SED. YIELD: Sediment delivery passing a channel station from the initial time.

Table 2: Output listings at the peak 10-yr discharge – proposed conditions with road crossings and sediment basins

SECTION	W.S.ELEV. FT	WIDTH FT	DEPTH FT	Q CFS	V FPS	SLOPE	D50 MM	QS/Q 1000 PPM	FR	SED. YIELD TONS
41.959	238.39	34.6	2.09	96	3.74	0.006454	0.57	0.00	0.76	0.482E-01
62.000	238.75	162.7	2.85	96	0.64	0.000125	0.57	0.00	0.12	0.482E-01
77.000	238.76	162.9	2.56	96	0.66	0.000145	0.52	0.01	0.12	0.676E-01
97.000	238.76	162.8	0.83	96	1.27	0.001256	0.52	0.24	0.33	0.120E+02
282.500	240.76	173.4	0.67	96	2.22	0.008806	0.57	2.25	0.78	0.457E+02
511.000	243.36	211.2	0.48	96	1.99	0.007916	0.59	1.32	0.73	0.440E+02
707.800	245.76	168.5	0.36	96	2.24	0.008739	0.56	1.42	0.78	0.295E+02
1169.900	251.13	238.2	0.64	93	2.29	0.015493	0.57	3.06	0.97	0.453E+02
1418.700	254.48	94.1	0.48	93	3.08	0.012101	0.61	5.21	0.96	0.422E+02
1843.500	260.18	234.9	0.28	93	2.05	0.010459	0.60	2.75	0.82	0.206E+02
1858.500	260.32	255.5	0.42	93	1.18	0.001845	0.57	0.02	0.37	0.116E+00
1892.500	260.38	264.1	0.48	93	0.99	0.001076	0.57	0.02	0.29	0.116E+00
1912.500	260.39	107.4	2.49	93	0.91	0.000245	0.56	0.02	0.16	0.116E+00
1957.500	260.40	113.5	1.76	93	1.13	0.000542	0.51	0.10	0.23	0.352E+00
1977.500	260.40	107.2	0.54	93	2.82	0.010720	0.57	3.66	0.89	0.470E+02
2233.000	264.30	141.4	0.42	93	2.59	0.011658	0.59	3.54	0.90	0.473E+02
2710.900	270.20	221.0	0.31	88	2.12	0.011665	0.59	3.07	0.86	0.295E+02
3090.700	275.10	170.0	0.50	88	1.97	0.006490	0.55	0.75	0.68	0.121E+02
3607.800	281.80	177.7	0.40	88	2.10	0.008455	0.55	1.89	0.76	0.313E+02
4174.400	289.33	195.1	0.63	88	1.92	0.007150	0.58	1.38	0.70	0.361E+02
4505.900	292.83	118.8	0.53	82	2.10	0.005417	0.58	0.74	0.64	0.287E+02
4985.600	298.23	261.3	0.33	82	1.68	0.007430	0.55	1.48	0.68	0.150E+02
5377.200	302.13	248.4	0.43	82	1.79	0.008472	0.57	0.03	0.73	0.214E+02
5570.900	304.15	337.6	0.25	82	1.89	0.015452	0.59	3.31	0.93	0.288E+02
5942.400	308.21	411.8	0.21	82	1.43	0.007968	0.59	1.07	0.67	0.154E+02
5957.400	308.31	448.1	0.31	79	0.79	0.001287	0.47	0.13	0.29	0.104E+01
6456.700	312.91	149.0	0.41	79	1.95	0.006095	0.52	2.98	0.66	0.286E+02
6989.600	319.91	80.8	0.52	79	2.90	0.010085	0.87	6.46	0.88	0.658E+02
6989.600	320.76	207.4	1.36	79	0.52	0.000116	0.57	0.00	0.11	0.000E+00

Table 3: Output listings at the peak 100-yr discharge – proposed conditions with road crossings and sediment basins

SECTION	W.S.ELEV. FT	WIDTH FT	DEPTH FT	Q CFS	V FPS	SLOPE	D50 MM	QS/Q 1000 PPM	FR	SED. YIELD TONS
41.959	239.29	44.0	2.99	304	4.96	0.005181	0.57	0.00	0.74	0.230E+00
62.000	239.93	197.0	4.03	304	0.82	0.000081	0.57	0.00	0.10	0.230E+00
77.000	239.94	197.0	3.95	304	0.82	0.000081	0.55	0.01	0.10	0.254E+00
97.000	239.93	196.8	1.87	304	1.12	0.000229	0.49	0.03	0.17	0.493E+01
282.500	241.03	303.4	1.05	304	2.86	0.009286	0.55	2.84	0.85	0.159E+03
511.000	243.64	280.4	0.75	304	2.58	0.005960	0.56	4.34	0.70	0.160E+03
707.800	245.97	273.5	0.60	304	3.28	0.012782	0.60	6.58	0.99	0.188E+03
1169.900	251.37	416.6	0.86	294	2.56	0.010316	0.54	3.09	0.86	0.134E+03
1418.700	254.86	129.8	0.93	294	3.72	0.007553	0.68	3.11	0.84	0.231E+03
1843.500	260.36	262.0	0.53	294	2.94	0.008753	0.66	3.36	0.84	0.114E+03
1858.500	260.52	285.6	0.62	294	2.22	0.003856	0.56	0.76	0.57	0.120E+02
1892.500	260.64	309.4	0.73	294	1.77	0.002034	0.55	0.85	0.43	0.128E+02
1912.500	260.65	153.4	2.21	294	2.44	0.002313	0.53	1.69	0.48	0.218E+02
1957.500	260.75	162.9	1.47	294	3.03	0.005146	0.53	5.58	0.69	0.531E+02
1977.500	260.85	175.9	1.01	294	3.09	0.006093	0.54	6.59	0.74	0.150E+03
2233.000	264.55	161.8	0.69	294	3.88	0.011649	0.59	9.12	1.00	0.172E+03
2710.900	270.45	278.9	0.56	278	2.65	0.007333	0.55	1.85	0.76	0.131E+03
3090.700	275.35	238.8	0.77	278	2.87	0.007737	0.54	2.88	0.79	0.156E+03
3607.800	282.05	503.4	0.68	278	2.53	0.013711	0.58	2.62	0.95	0.169E+03
4174.400	289.50	236.3	0.81	278	3.32	0.012455	0.58	6.14	0.98	0.143E+03
4505.900	293.07	140.9	0.79	259	3.67	0.009485	0.57	4.63	0.91	0.174E+03
4985.600	298.35	270.2	0.49	259	3.06	0.012431	0.63	5.70	0.96	0.160E+03
5377.200	302.35	306.9	0.65	259	2.41	0.006644	0.58	1.52	0.72	0.648E+02
5570.900	304.35	430.1	0.45	259	2.19	0.007561	0.55	1.66	0.74	0.563E+02
5942.400	308.35	465.9	0.38	259	2.12	0.007495	0.61	1.62	0.73	0.789E+02
5957.400	308.47	513.7	0.44	249	1.50	0.002880	0.44	0.99	0.47	0.207E+02
6456.700	313.17	191.4	0.66	249	2.97	0.007473	0.57	6.38	0.79	0.188E+03
6989.600	320.17	128.5	0.93	249	3.87	0.010573	1.89	7.00	0.96	0.309E+03
6989.600	321.32	276.4	1.92	249	0.87	0.000200	0.57	0.00	0.15	0.000E+00

Potential Changes in Channel Geometry – Selected modeled results on potential stream channel changes for Wash K are presented in graphical forms. More results are in the computer input/output listings. Fig. 9 shows longitudinal profiles of the stream channel during the 100-yr flood for the existing conditions. Fig. 10 shows longitudinal profiles of the stream channel during the 100-yr flood for the proposed conditions with road crossings and sediment basins. Because of the shallow flow depth and small changes in channel bed profile, the water-surface and channel bed profiles nearly overlap in the figures. More detailed changes near a proposed road crossing and sediment basin are shown in Fig. 11. The longitudinal and cross-sectional changes (see Fig. 12) near the sediment basin are used to show how sediment settles in the basins starting from the upstream basin entrance and it progresses gradually toward downstream. For the sediment basin near channel station 1920, the basin is almost filled to the top at the end of the flood event. The sediment basin near the downstream end of the channel reach is only slightly refilled during the 100-yr flood. These graphical results are for the 100-yr flood, the changes are less in magnitude during the 10-yr flood.

From the simulated changes in channel bed profiles, the following conclusions may be stated. The channel reach for Wash K is not subject to substantial changes in channel bed profiles for the existing and proposed conditions. Changes in bed elevation are less than 1 foot during the 100-yr flood. However, the refill in sediment basins may exceed one foot.

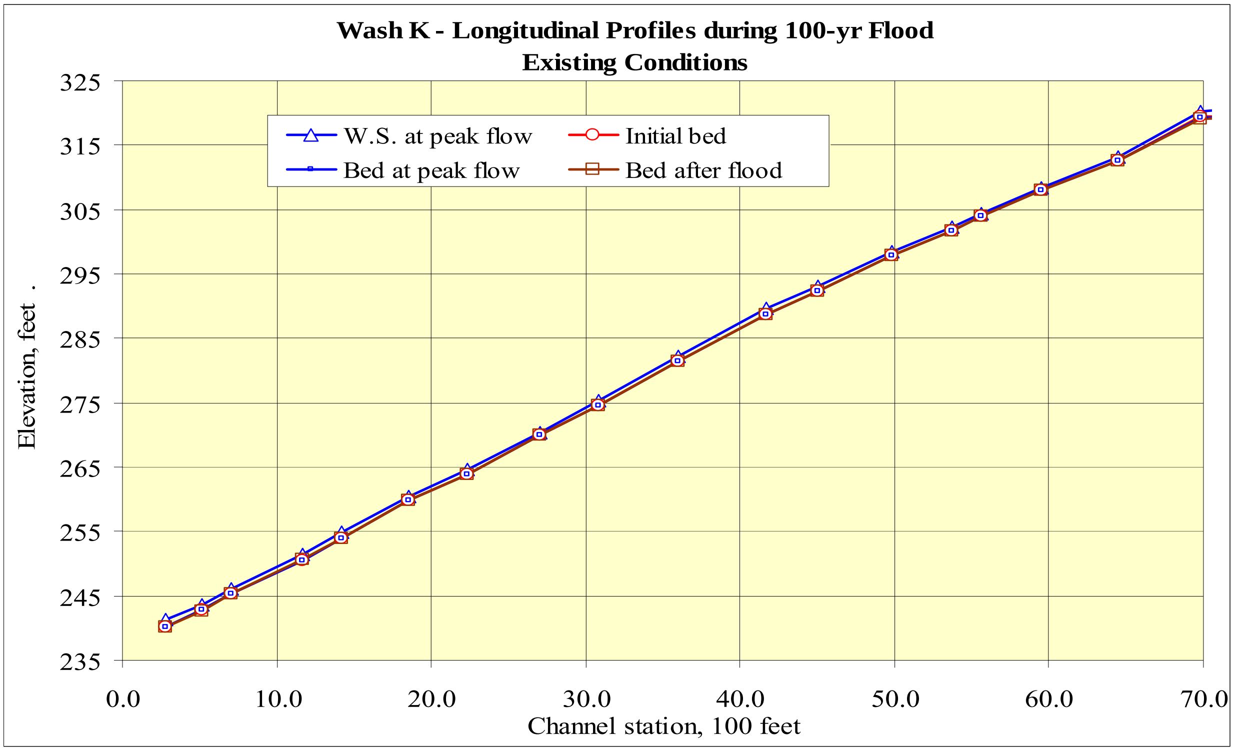


Fig. 9. Water-surface and channel bed profile changes during 100-yr flood for Wash K – existing conditions

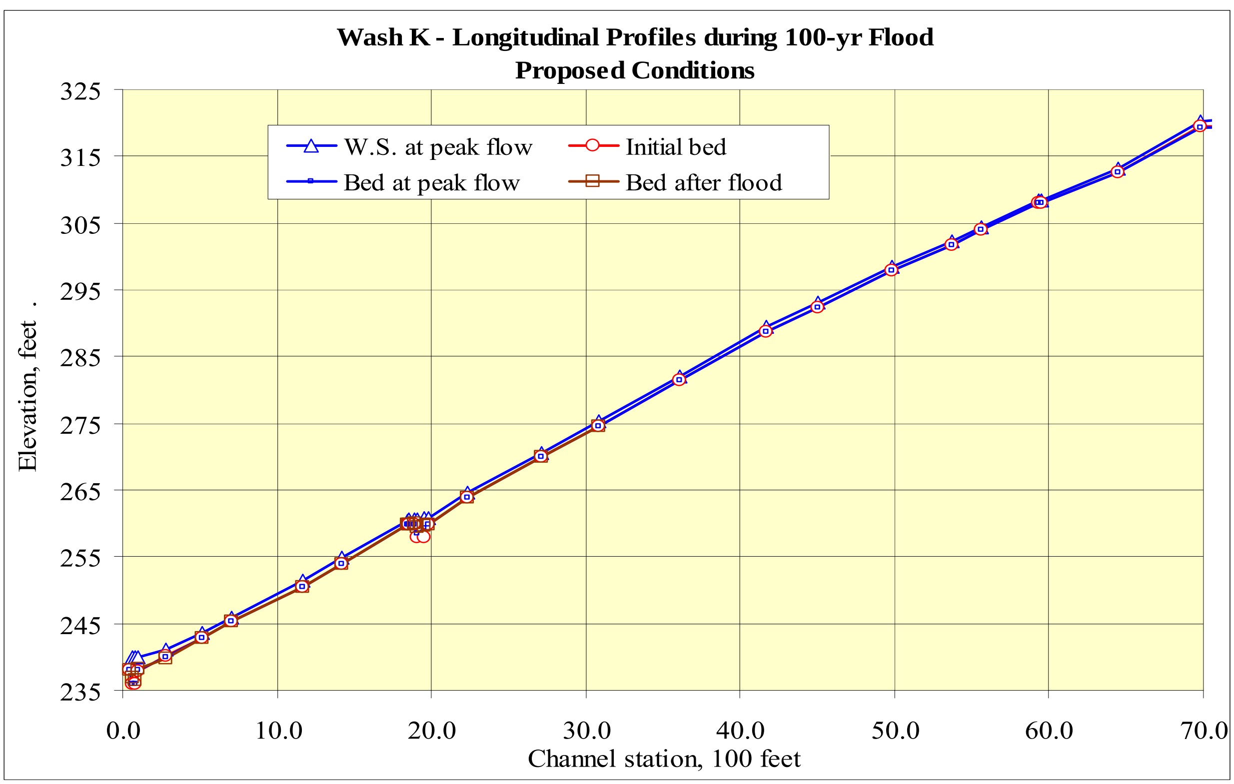
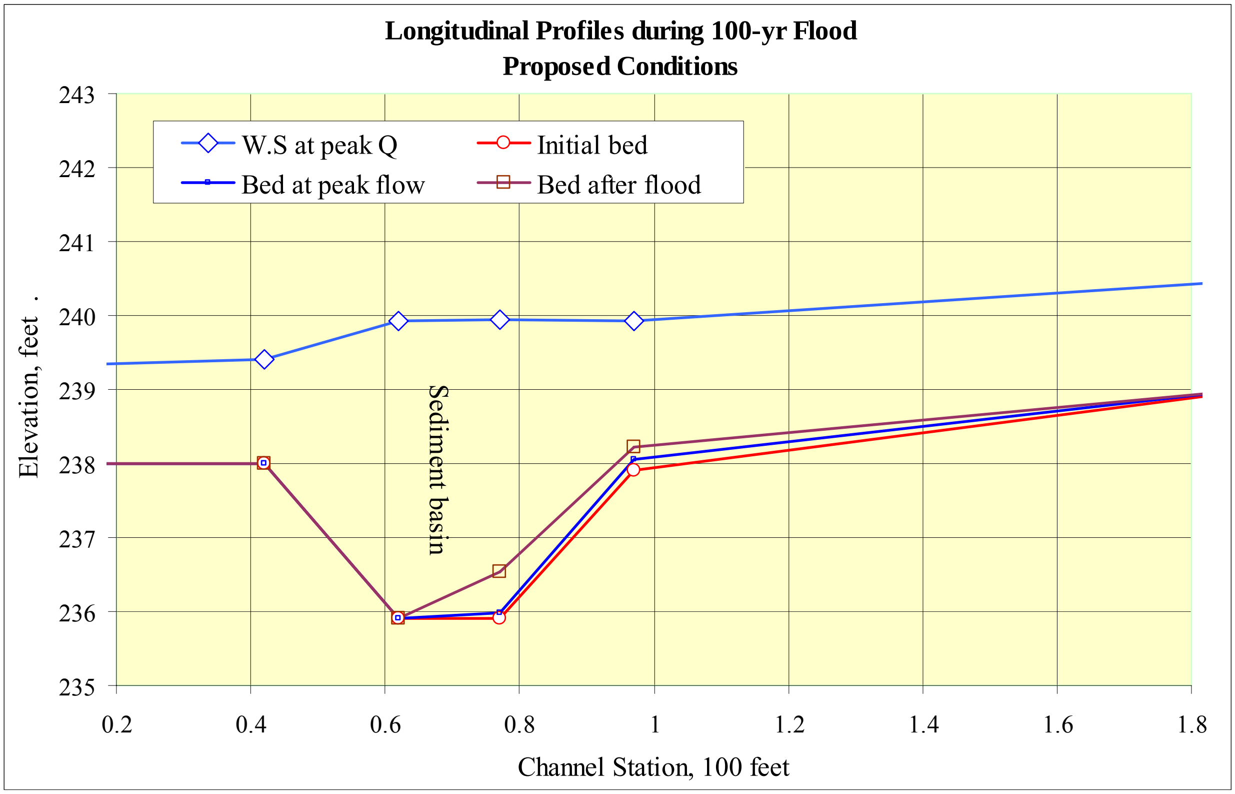


Fig. 10. Water-surface and channel bed profile changes during 100-yr flood for Wash K – proposed conditions with road crossings and sediment basins



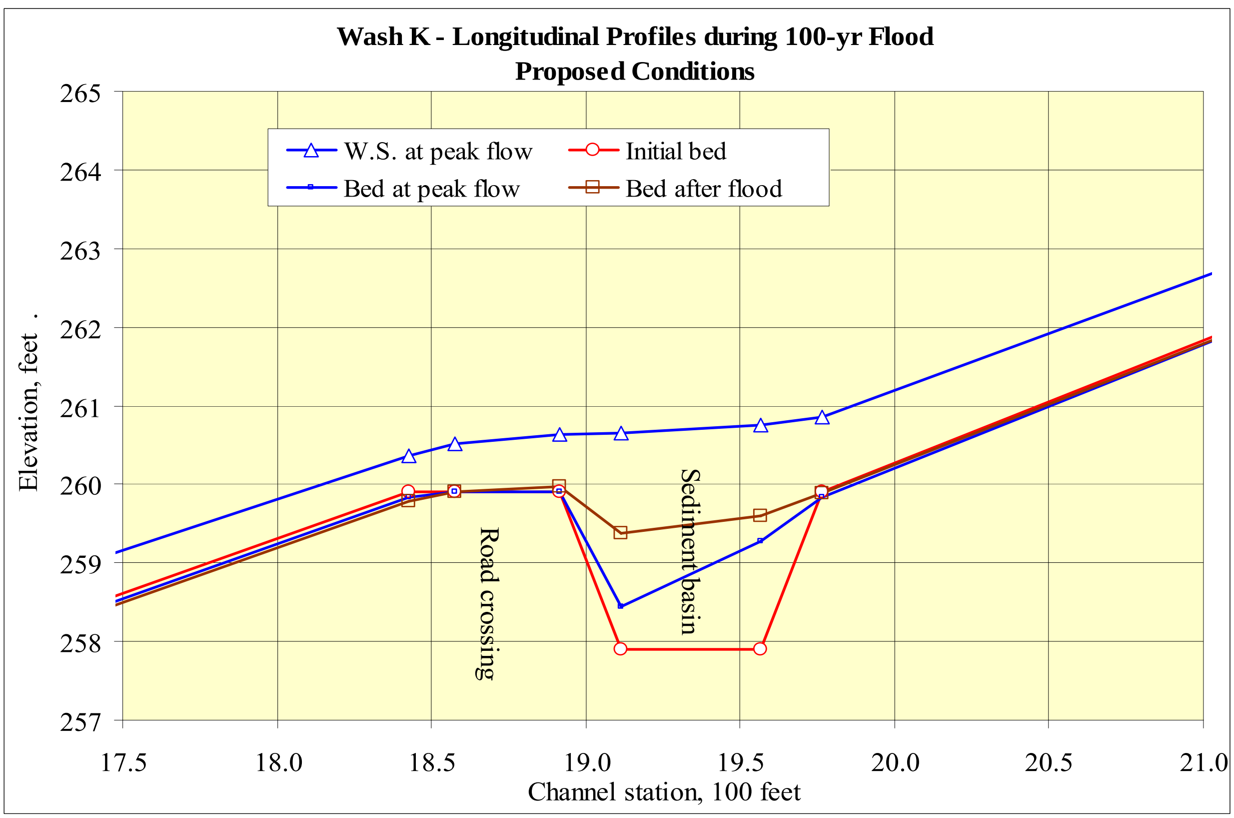
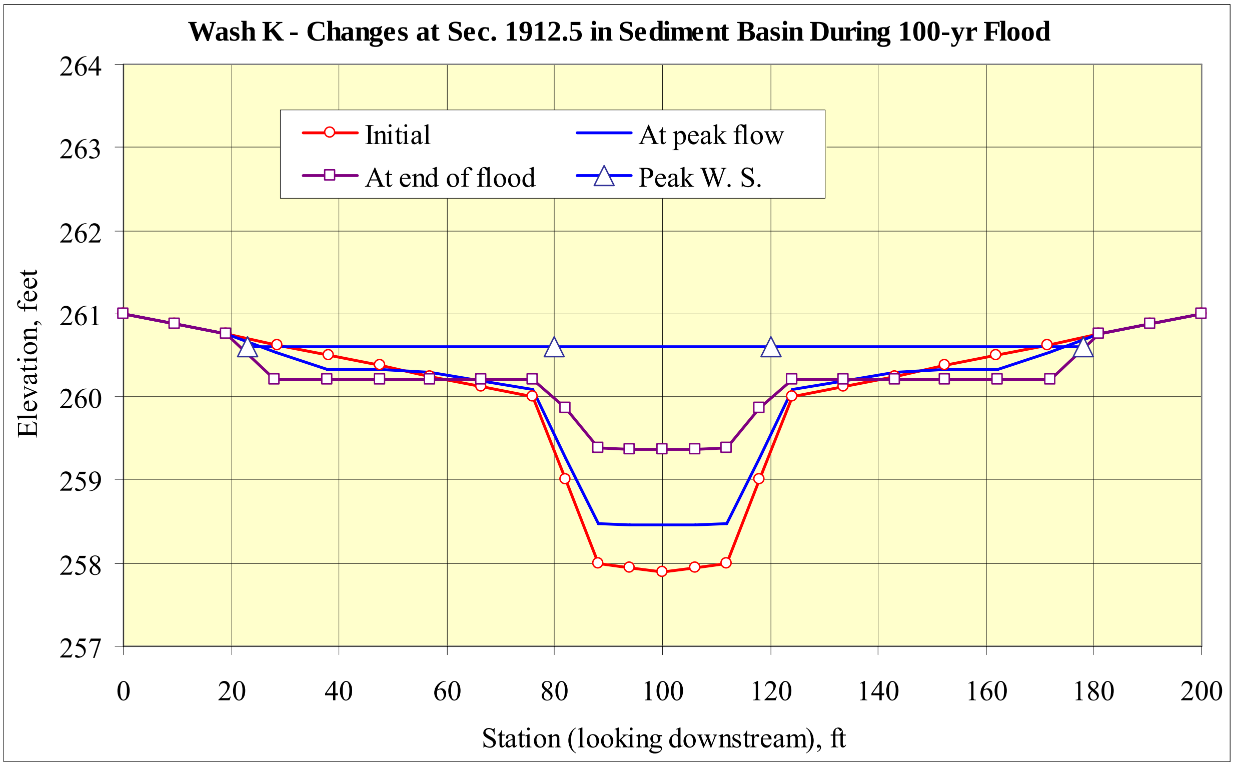


Fig. 11. Water-surface and channel bed profile changes during 100-yr flood for Wash K – proposed conditions with road crossings and sediment basins



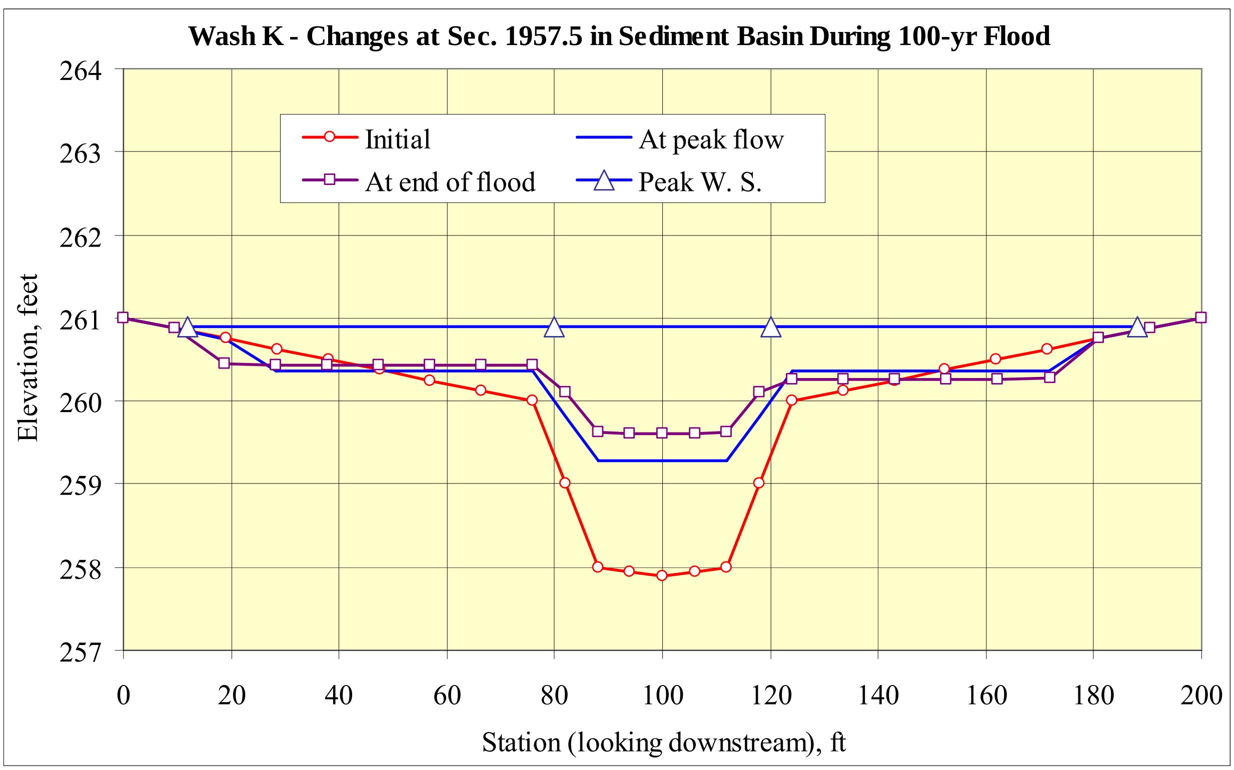


Fig. 12. Sample cross-sectional changes near sediment basin

Spatial Variations of Flow Velocity - Spatial variations of flow velocities at the peak 100-yr flood are shown in Fig. 13. The figure covers the three following conditions: (1) existing conditions of stream channel, (2) proposed conditions with road crossings, and (3) proposed conditions with road crossings and sediment basins.

The results show that the flow velocities are lower than 3 feet per second for the wash during the peak 100-yr flood except at the downstream end through the culvert for Evan Hewes Highway. The differences in velocities between the existing and proposed conditions are related to the difference in channel roughness, road crossings and sediment basins. These road crossings cause back water and velocity reduction. Major velocity reductions are caused by the sediment basins.

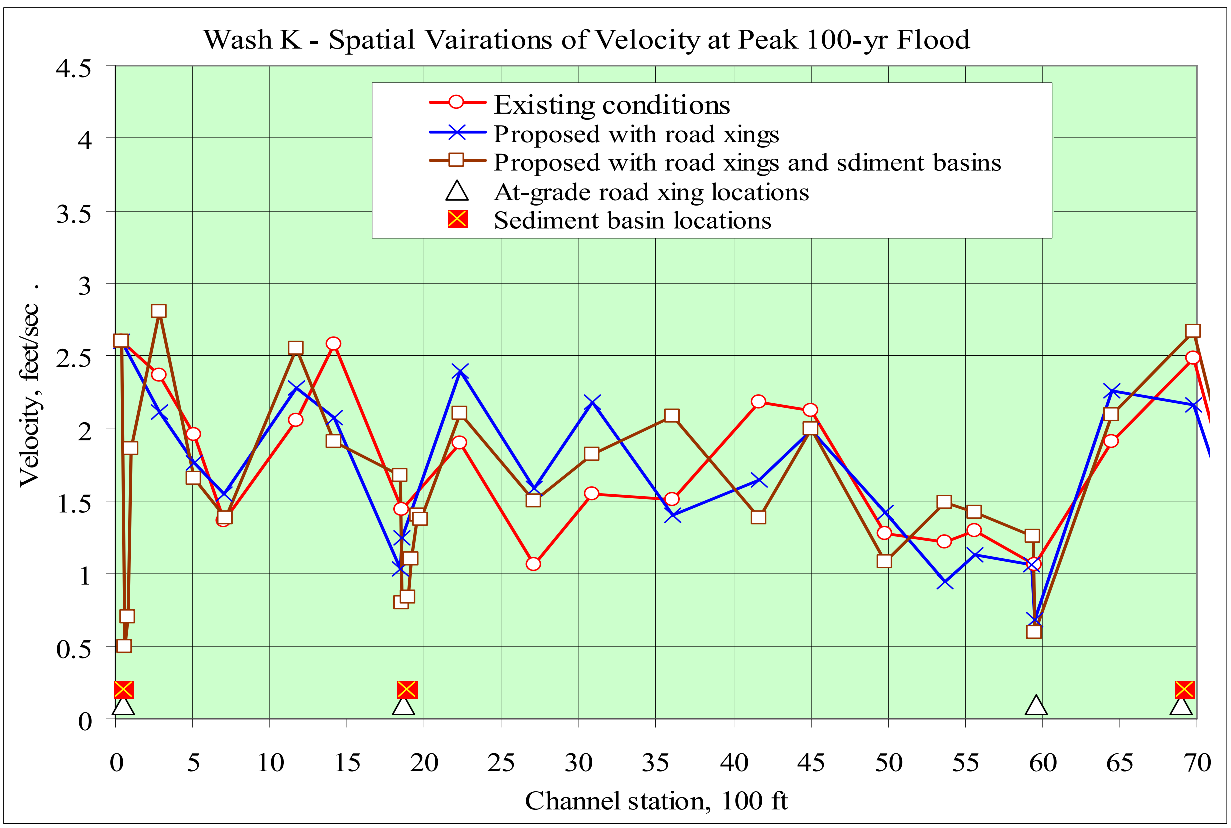


Fig. 13. Spatial variations of flow velocity at peak 100-yr flood for existing and proposed conditions

Spatial Variations of Sediment Delivery - Spatial variations of sediment deliveries during the 100-yr flood are shown in Fig. 14. Sediment delivery refers to the total amount of sediment delivered passing a channel station during the passage of a flood event. The figure covers the three following conditions: (1) existing conditions of stream channel, (2) proposed conditions with road crossings, and (3) proposed conditions with road crossings and sediment basins.

The results show that sediment deliveries vary along the wash. An increasing delivery toward downstream indicates erosion while a decreasing delivery toward downstream means sediment deposition. For the existing conditions, the spatial variations are due to the variation in channel geometry along the wash. Each natural stream undergoes continuous changes toward establishing dynamic equilibrium, which means uniform sediment transport along the channel, although the true equilibrium may never be attained during the changing flood discharge.

The differences in sediment deliveries between the existing and proposed conditions are related to the difference in channel roughness, road crossings and sediment basins. The road crossings cause reductions of flow velocity and sediment delivery. Major sediment delivery reductions are caused by the sediment basins.

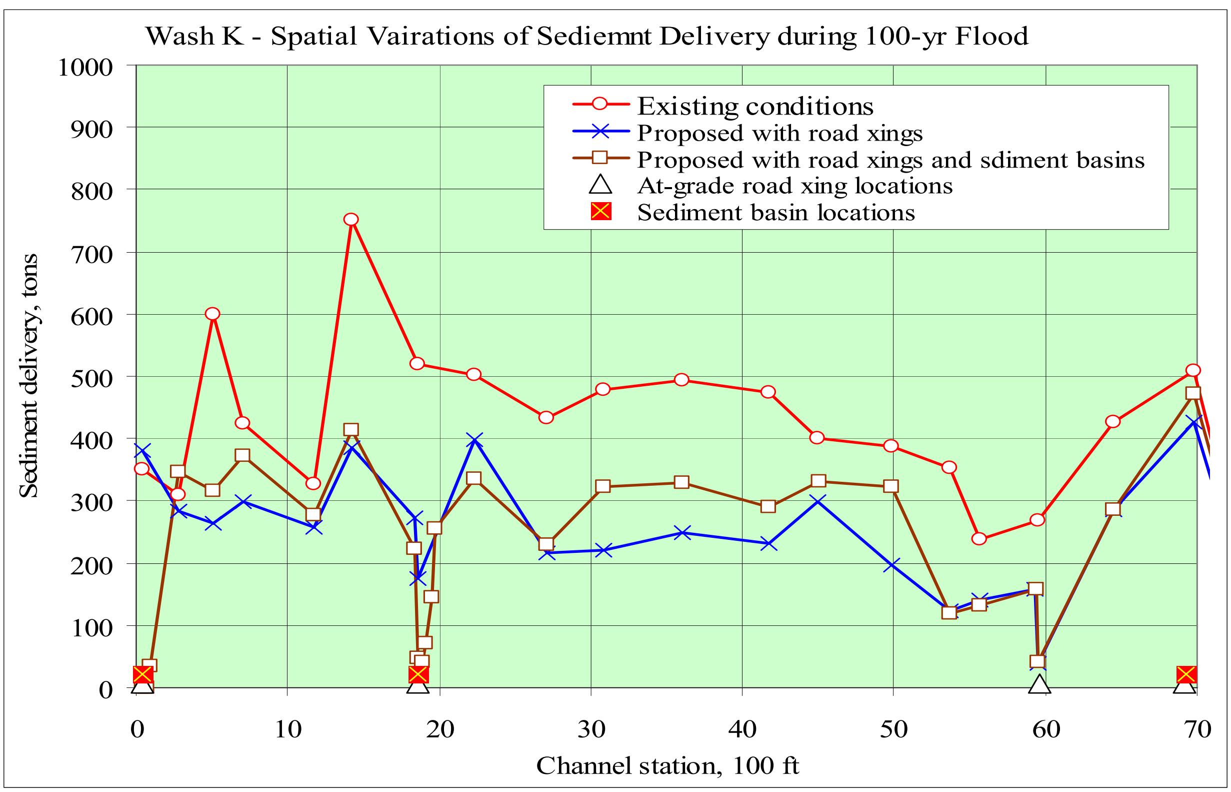


Fig. 14. Spatial variations of sediment deliveries during 100-yr flood for Wash K

In order to assess the sediment delivery toward the area downstream of the project site, total sediment deliveries by the 10- and 100-yr floods for the existing and proposed conditions are summarized in Table 4. From the plotted and tabulated results, it can be seen that the road crossings will modify the pattern of sediment delivery along the channel and change the delivery toward downstream of the project site. The road crossings together with sediment basins will reduce downstream sediment delivery to almost nothing since a proposed sediment basin is located at the downstream end. These results are based on individual flood events. It is also very important to look at the long-term effects on sediment delivery due to the road crossings and sediment basins. The long-term sediment effects will be described in a later section of the report.

Table 4. Sediment deliveries toward downstream out of project site for Wash K

Case	Sediment delivery toward downstream by 10-yr flood, tons	Sediment delivery toward downstream by 100-yr flood, tons
Existing conditions	68.7	351
Proposed with road crossings	47.9	381
Proposed with road crossings and sediment basins	0	0.5

VI. MODELING STUDY FOR WASH C

Wash C is located in the western part of the project site as shown in Fig. 7. Fig. 15 shows the locations of channel cross sections used to define the stream channel geometry. The flow in the wash is from south toward north. The downstream limit of study is Evan Hewes Highway and the upstream limit is Interstate 8.

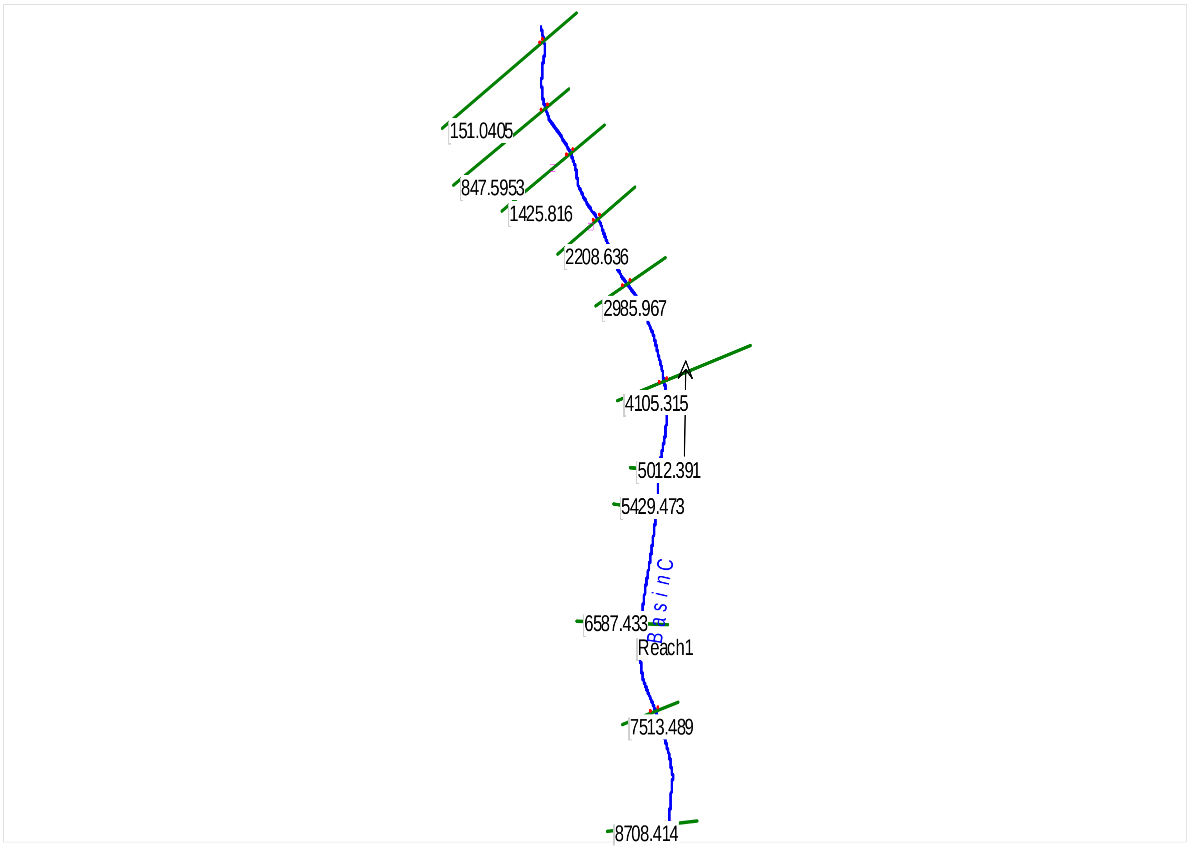


Fig. 15. Cross section lines for Wash C

For the proposed conditions, at-grade road crossings will be installed at the following locations:

(1) 24-foot at-grade road crossing with concrete cut-off wall near downstream end of study reach,

(2) 24-foot at-grade road crossing with concrete cut-off wall at channel station 1425.8,

(3) 24-foot at-grade road crossing with concrete cut-off wall at channel station 5012.4, and

(4) 24-foot at-grade road crossing at upstream end of study reach.

In addition to the road crossings, the proposed conditions also include four sediment basins at the following locations:

(1) Type A sediment basin with a capacity of 200 cubic yards on the upstream side of at-grade road crossing near the downstream end of study reach,

(2) Type B sediment basin with a capacity of 400 cubic yards on the upstream side of at-grade road crossing at channel station 1425.8,

(3) Type B sediment basin with a capacity of 400 cubic yards on the upstream side of at-grade road crossing at channel station 5012.4, and

(4) Type C sediment basin with a capacity of 600 cubic yards on the upstream side of at-grade road crossing near the upstream end of study reach.

Potential Changes in Channel Geometry - Modeled results for Wash C are included in computer input/output listings attached to the report. Selected results are presented in graphical forms. These results are described below. Fig. 16 shows longitudinal profiles of the stream channel during the 100-yr flood for the existing conditions. Fig. 17 shows longitudinal profiles of the stream channel during the 100-yr flood for the proposed conditions with road crossings and sediment basins. Because of the shallow flow depths and small changes in channel bed profile, the water-surface and channel bed profiles nearly overlap. For this reason, longitudinal profiles for the short channel reach near a proposed road crossing and sediment basin are shown in Fig. 18 for the 100-yr flood. The longitudinal and cross-sectional changes near the sediment basin are used to show how sediment settles in the basins starting from the upstream basin entrance and it progresses gradually toward downstream. The modeled results show that potential changes in stream channel geometry are small; they are less than one foot in bed elevation except at the sediment basins. For a natural channel cross section, its potential changes during the 100-yr flood are exemplified in Fig. 19 for section 5,000. These graphical results are for the 100-yr flood, the changes are less in magnitude during the 10-yr flood.

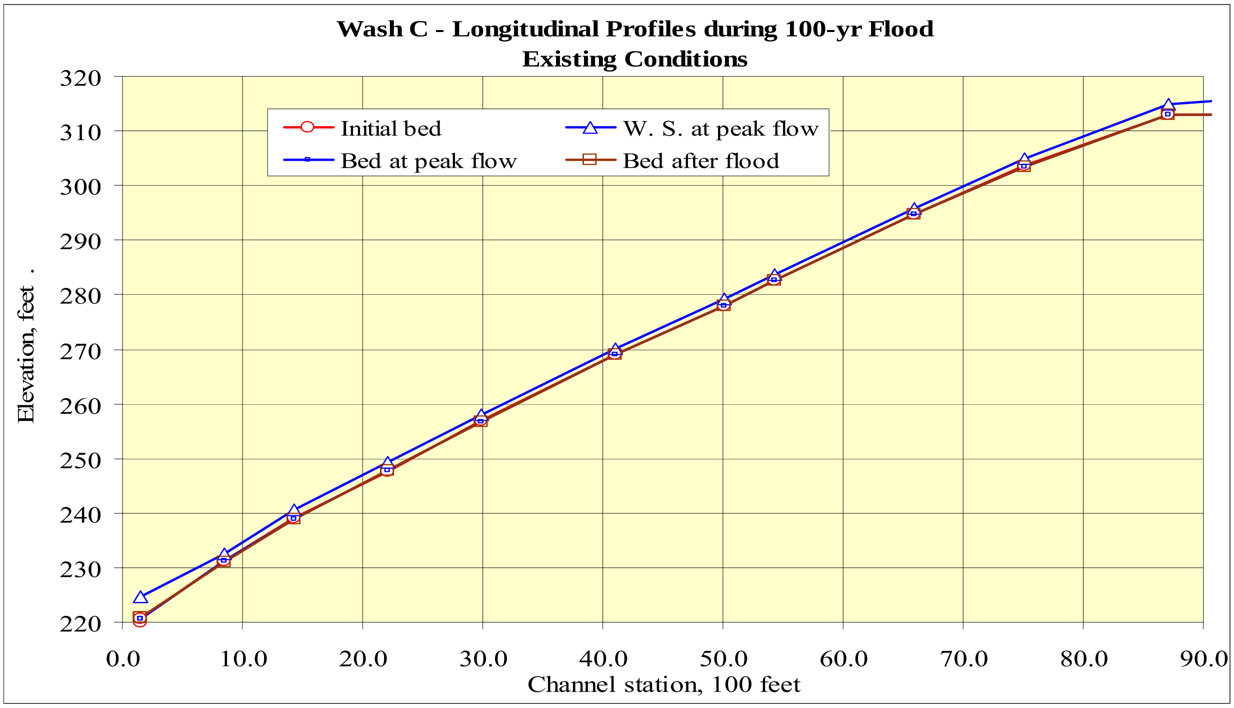


Fig. 16. Water-surface and channel bed profile changes during 100-yr flood for Wash C – existing conditions

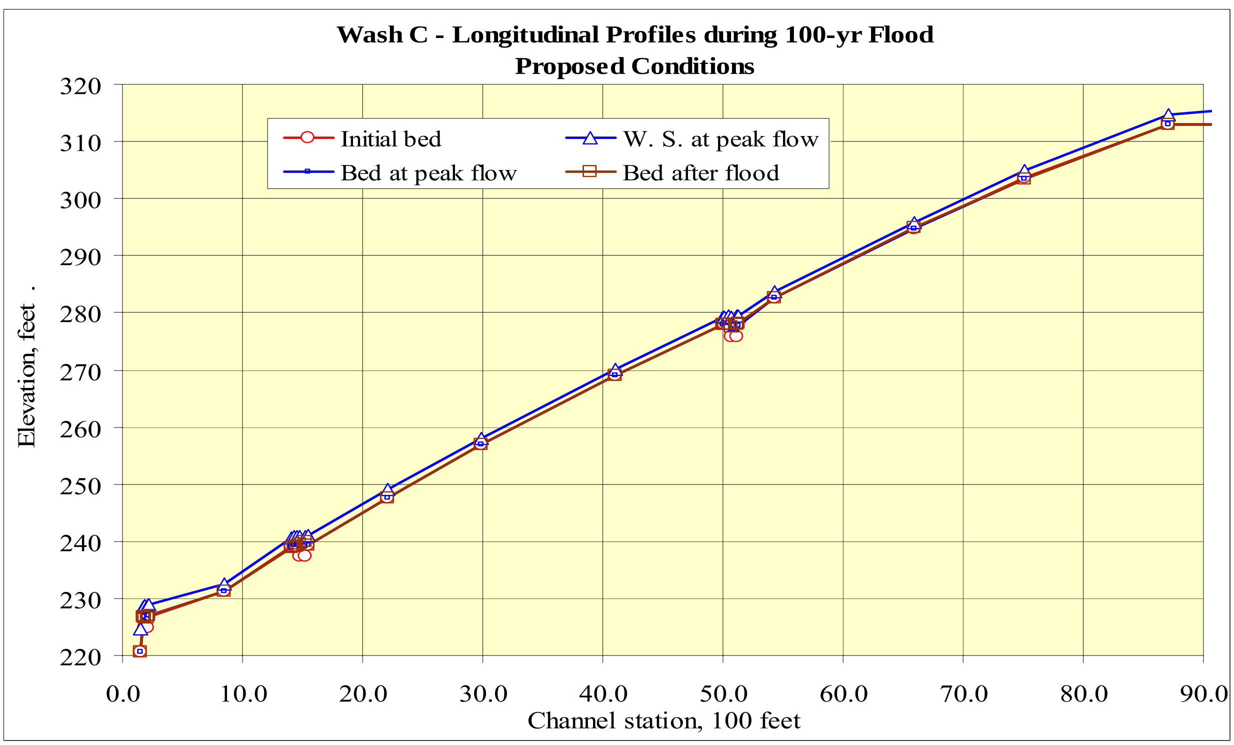


Fig. 17. Water-surface and channel bed profile changes during 100-yr flood for Wash C – proposed conditions with road crossings and sediment basins

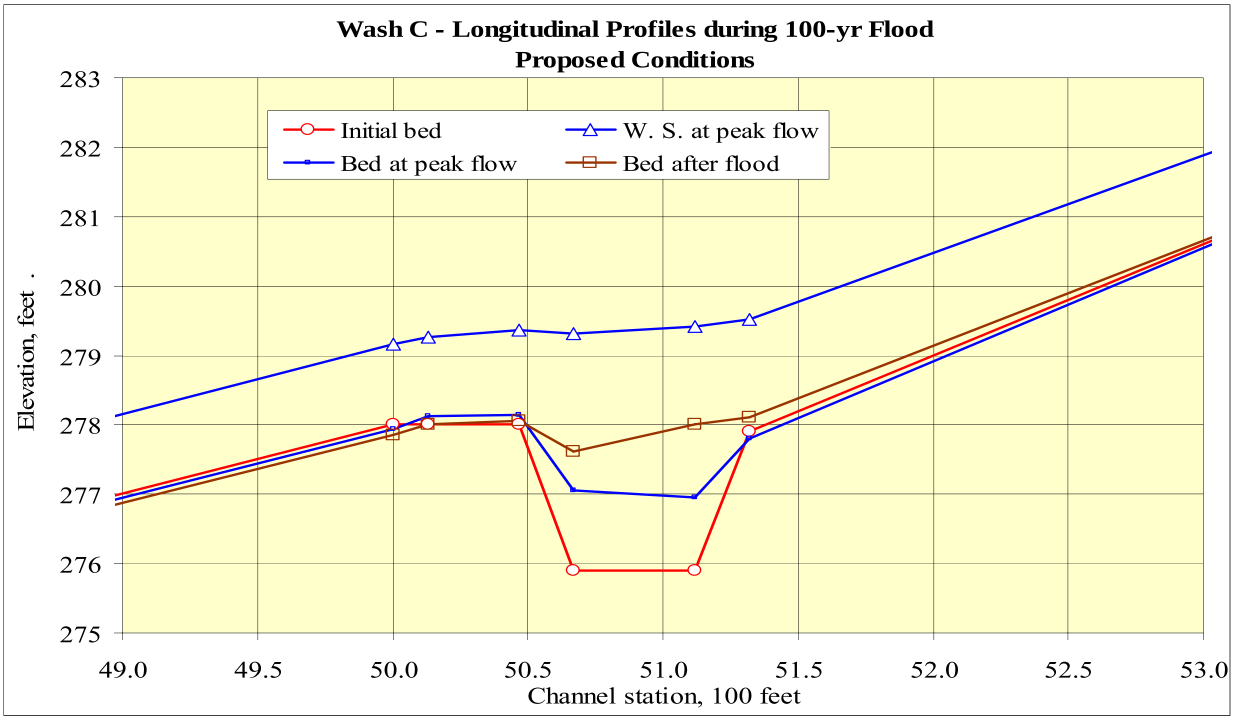


Fig. 18. Water-surface and channel bed profile changes during 100-yr flood for Wash C – proposed conditions with road crossings and sediment basins

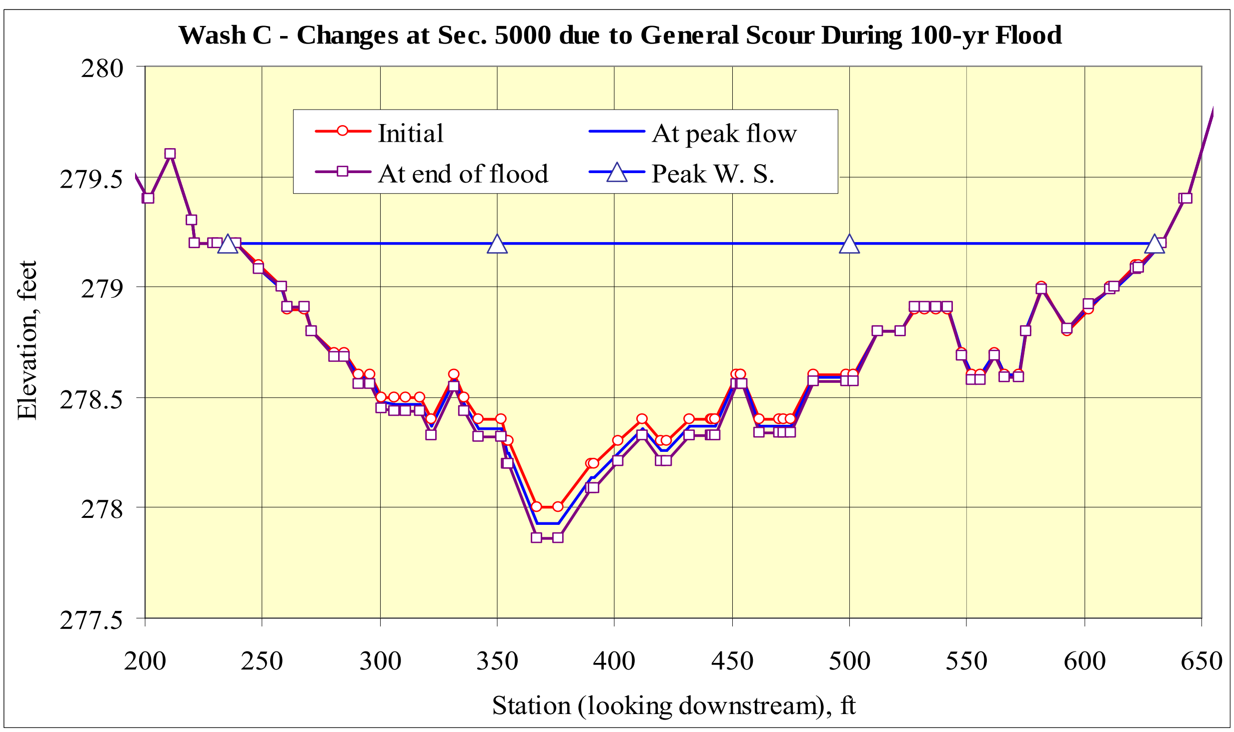


Fig. 19. Sample cross-sectional changes – proposed conditions with road crossings and sediment basins

From the simulated changes in stream channel geometry, the following conclusions may be stated. The channel reach for Wash C is not subject to substantial changes in channel bed profiles for the existing and proposed conditions. Changes in bed elevation are less than 1 foot during the 100-yr flood. However, the refill in sediment basins may exceed one foot.

Spatial Variations of Flow Velocity - Spatial variations of flow velocities at the peak 10 and 100-yr floods are shown in Figs. 20 and 21, respectively. These figures cover the three following conditions: (1) existing conditions of stream channel, (2) proposed conditions with road crossings, and (3) proposed conditions with road crossings and sediment basins.

The results show that the flow velocities are lower than 3 feet per second along the entire wash during the peak 100-yr flood under the existing conditions. However, the flow velocity may exceed 3 feet per second over certain road crossings. Sediment transport rate is directly related to the velocity. Velocities lower than 3 feet per second indicate low rate of sediment transport at the peak discharge.

The differences in velocity between the existing and proposed conditions are related to the difference in channel roughness, road crossings and sediment basins. These road crossings cause back water and velocity reduction. Major velocity reductions are caused by the sediment basins.

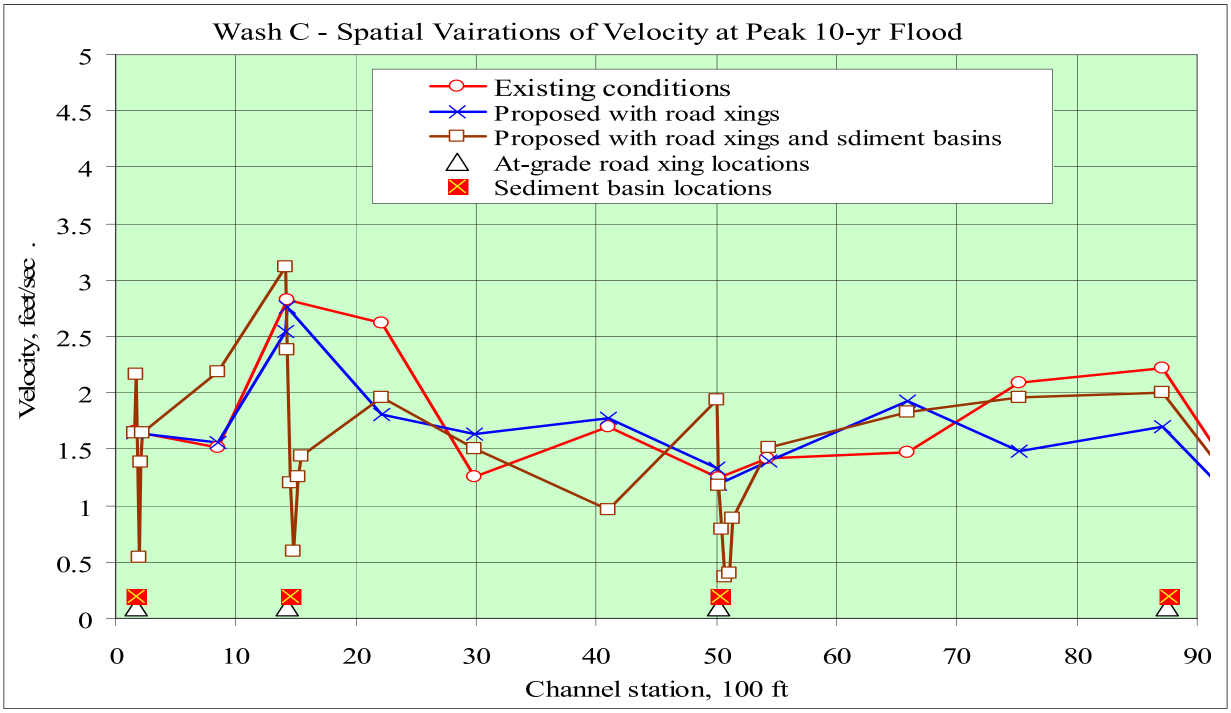


Fig. 20. Spatial variations of flow velocity at peak 10-yr flood for existing and proposed conditions

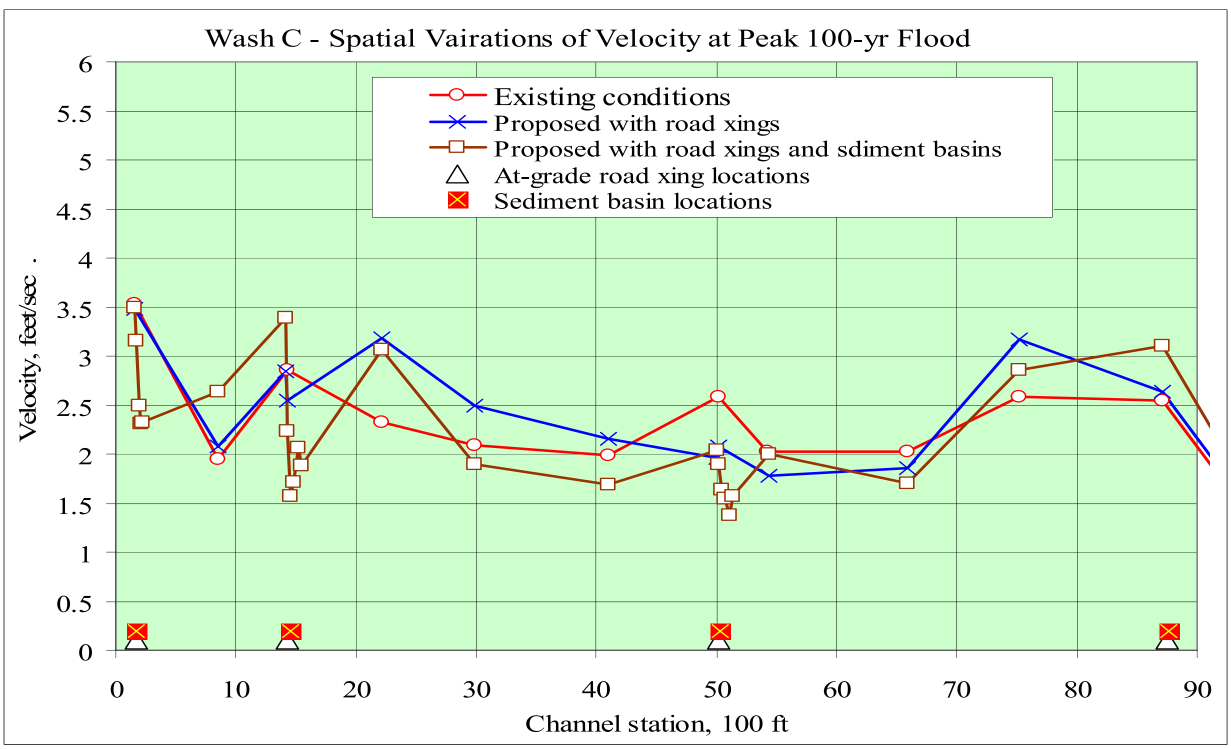


Fig. 21. Spatial variations of flow velocity at peak 100-yr flood for existing and proposed conditions

Spatial Variations of Sediment Delivery - Spatial variations of sediment deliveries by the 10- and 100-yr floods are shown in Fig. 22 and 23, respectively. Sediment delivery refers to the total amount of sediment delivered passing a channel station during the passage of a flood event. The figures cover the three following conditions: (1) existing conditions of stream channel, (2) proposed conditions with road crossings, and (3) proposed conditions with road crossings and sediment basins.

The results show that the sediment delivery varies along the wash. An increasing delivery toward downstream indicates erosion while a decreasing delivery toward downstream means sediment deposition. For the existing conditions, the spatial variations are due to the variation in channel geometry along the wash. Each natural stream undergoes continuous changes toward establishing dynamic equilibrium, which means uniform sediment delivery, although the true equilibrium may never be attained under the changing flood discharge.

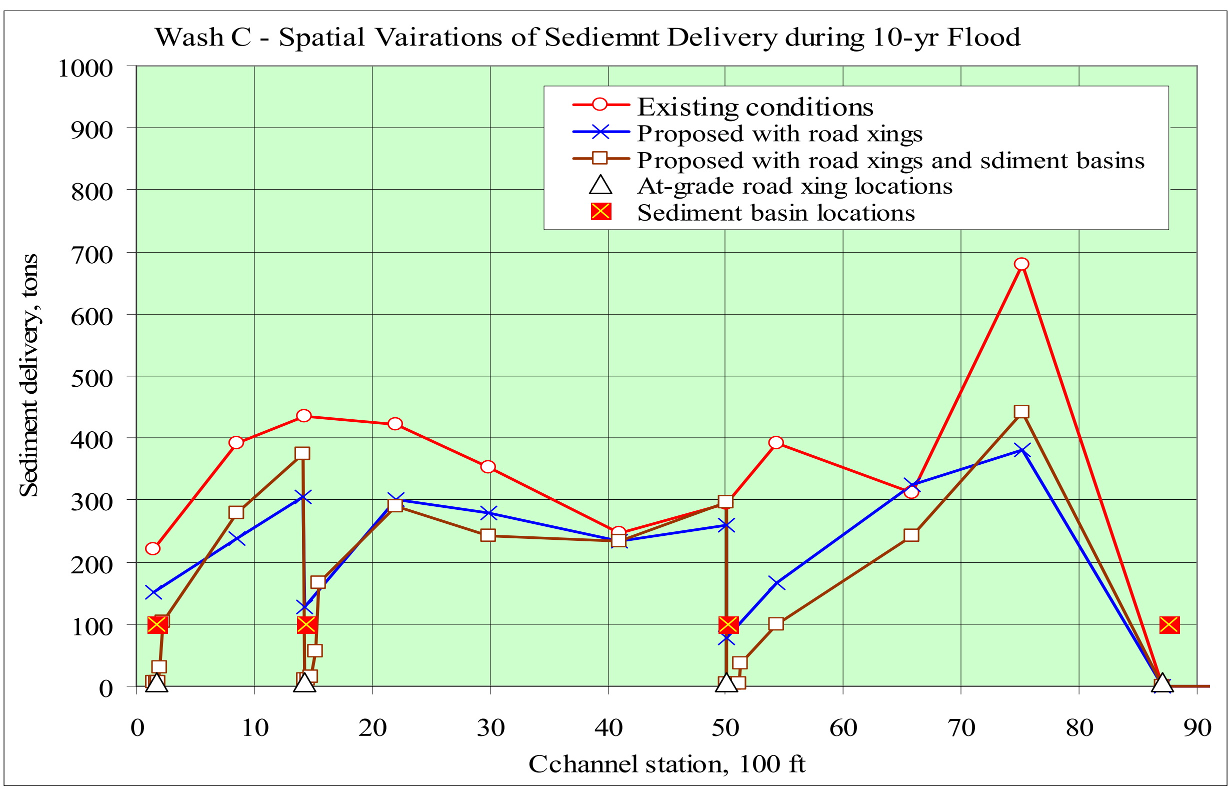


Fig. 22. Spatial variations of sediment deliveries during 10-yr flood for Wash C

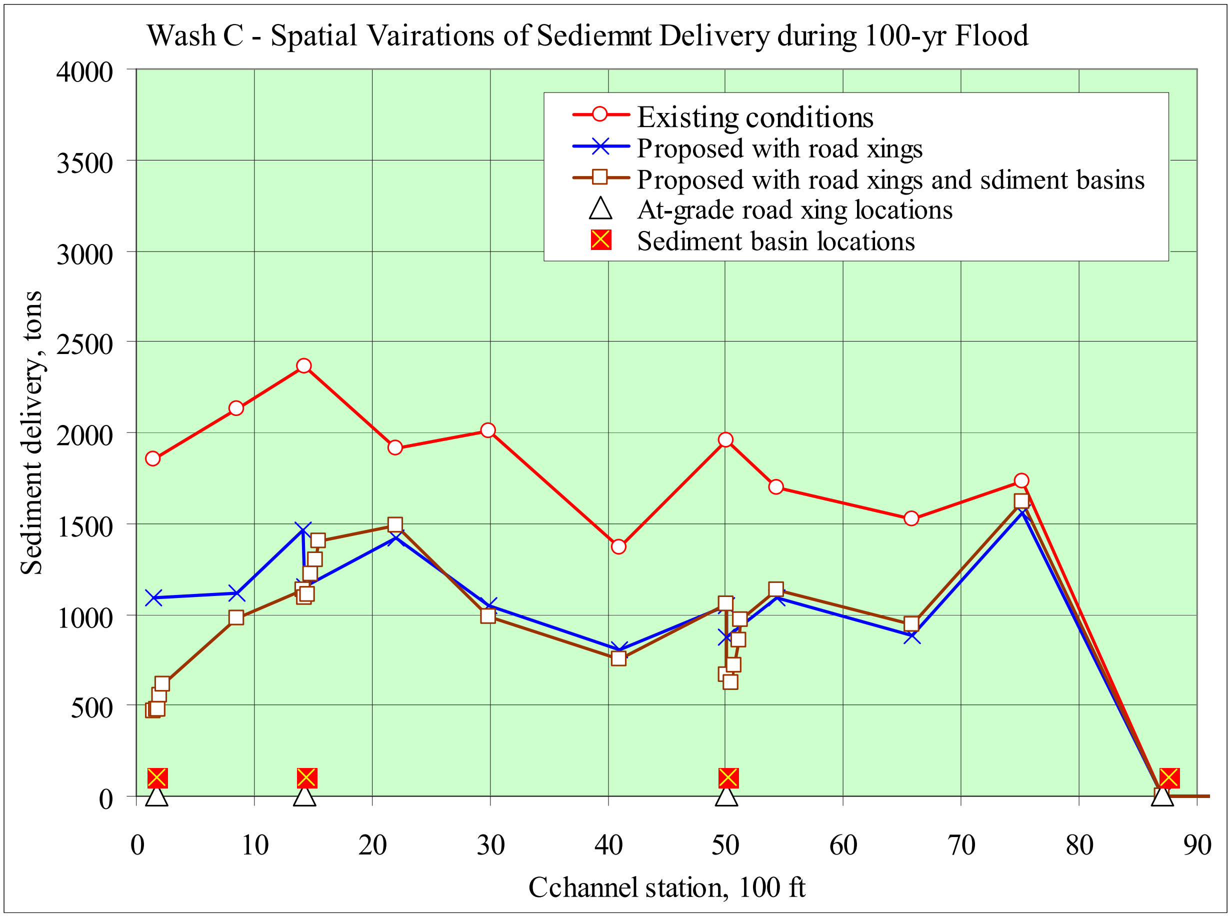


Fig. 23. Spatial variations of sediment deliveries during 100-yr flood for Wash C

The differences in sediment delivery between the existing and proposed conditions are related to the difference in channel roughness, road crossings and sediment basins. The road crossings cause reductions of flow velocity and sediment delivery. Major sediment delivery reductions are caused by the sediment basins.

In order to assess the sediment delivery toward the area downstream of the project site, total sediment deliveries by the 10- and 100-yr floods for these cases are summarized in Table 5. From the plotted and tabulated results, it can be seen that the road crossings will modify the pattern of sediment delivery along the channel and change the delivery toward downstream of the project site. The road crossings will cause a large reduction of sediment delivery toward the downstream area. Sediment basins together with the road crossings will cause major reduction of downstream sediment delivery. These results are explained below. The proposed road crossing at station 1425.8 is located at an area with high flow velocity as well as high rate of sediment transport under existing conditions. This area is also subject to erosion since more sediment would be removed from this section than the sediment supply from upstream. The proposed road crossings will protect this section against erosion; its backwater effect will also induce sediment deposition on its upstream side and erosion on its downstream side. This road crossing, being close to the downstream end of the channel reach, will thus reduce sediment delivery to the downstream area.

Table 5. Sediment deliveries toward downstream out of project site for Wash C

Case	Sediment delivery toward downstream by 10-yr flood, tons	Sediment delivery toward downstream by 100-yr flood, tons
Existing conditions	221	1850
Proposed with road crossings	151	1090
Proposed with road crossings and sediment basins	6.5	470

VII. SEDIMENT MODELING OF WASH G

Wash G is located in the eastern part of the project site. Fig. 24 is a map of the wash and Fig. 25 shows the locations of channel cross sections used to define the stream channel geometry. The flow in the wash is from southwest toward northeast. The downstream limit of study is Evan Hewes Highway and the upstream limit is Interstate 8.

For the proposed conditions, road crossings will be installed at the following locations:

(1) 24-foot at-grade road crossing with concrete cut-off wall at channel station 2948,

(2) 24-foot 5-foot above grade Lifeline crossing at channel station 11000,

(3) 24-foot at-grade road crossing with concrete cut-off wall at channel station 12740,

(4) 24-foot at-grade road crossing at upstream end of study reach.

In addition to the road crossings, four sediment basins will be instated at the following locations:

(1) Type C sediment basin with a capacity of 600 cubic yards near the downstream end of study reach,

(2) Type A sediment basin with a capacity of 200 cubic yards on the downstream side of Lifeline crossing,

(3) Type C sediment basin with a capacity of 600 cubic yards on the upstream side of Lifeline crossing,

(4) Type A sediment basin with a capacity of 200 cubic yards near the upstream end of study channel reach.

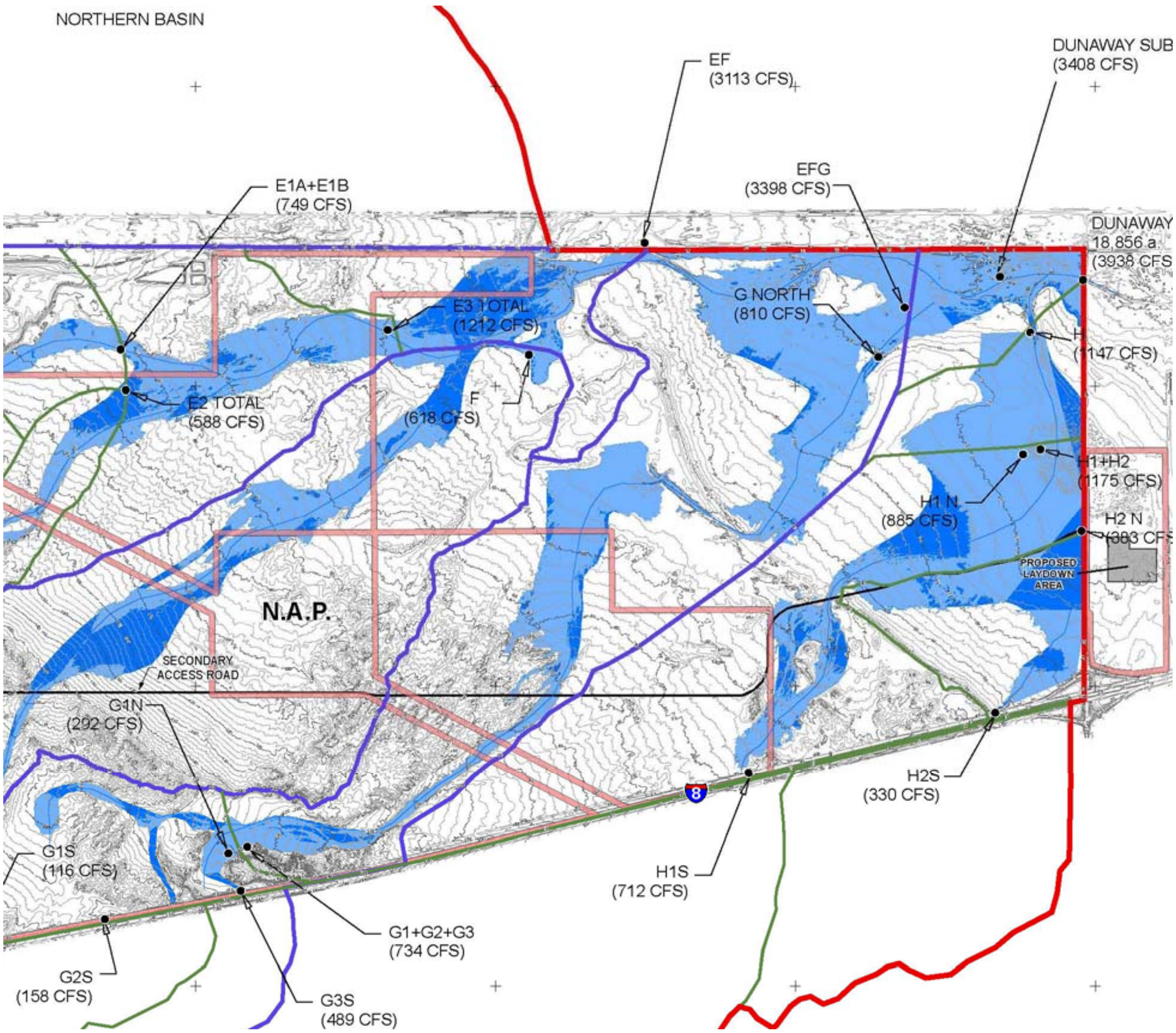


Fig. 24. Map of Wash G and vicinities

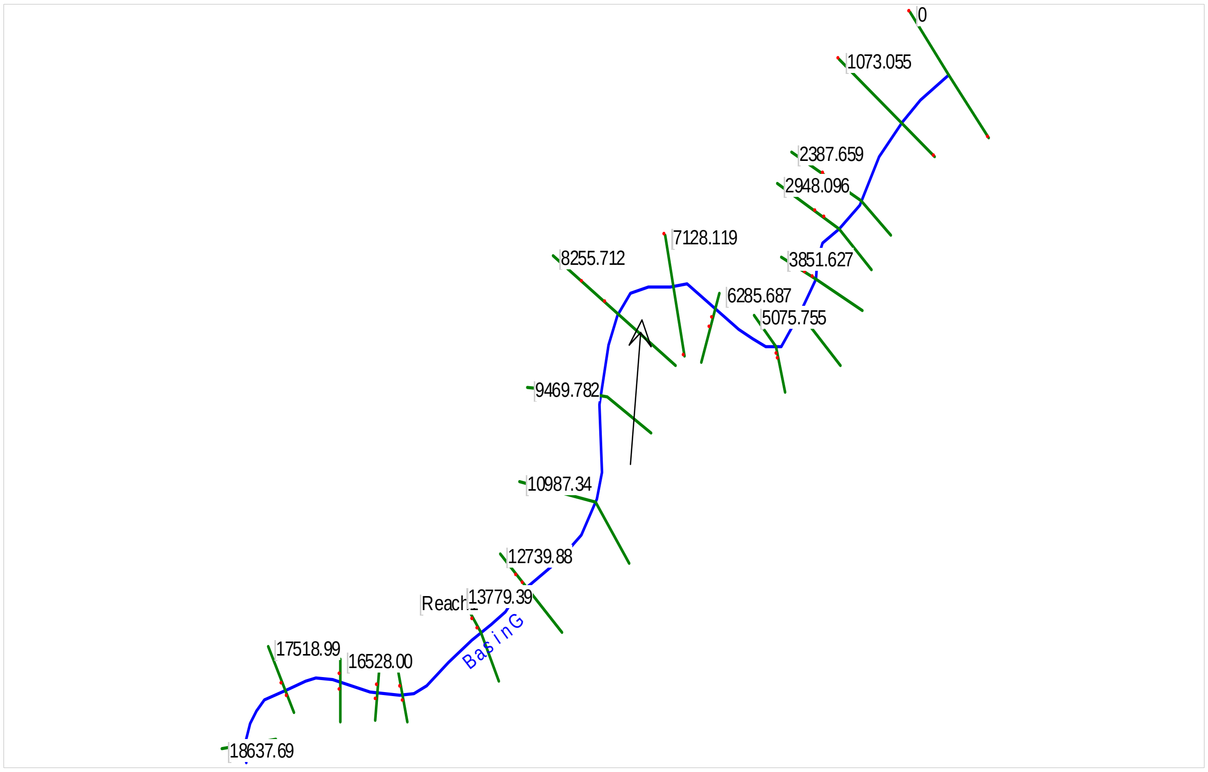


Fig. 25. Cross sections for Wash G

Potential Changes in Channel Geometry - Modeled results for Wash G are given in the computer input/output listings attached to the report. Selected results are presented in graphical forms. These results are described below. Fig. 26 shows longitudinal profiles of the stream channel during the 100-yr flood for the existing conditions. Fig. 27 shows longitudinal profiles of the stream channel during the 100-yr flood for the proposed conditions with road crossings and sediment basins. Because of the shallow flow depths and small changes in channel bed profile, the water-surface and channel bed profiles nearly overlap. Longitudinal profiles of shorter channel reaches for the proposed conditions near the Lifeline crossing and sediment basins are presented in Fig. 28 for the 10-yr flood and in Fig. 29 for the 100-yr flood. The longitudinal profile changes near the sediment basins are used to show how sediment settles in the basins starting from the upstream basin entrance and it progresses gradually toward downstream. There is more sediment refill during the 100-yr flood than during the 10-yr flood. Changes at natural channel sections are exemplified in Fig. 30 for sections 5076 and 17918.

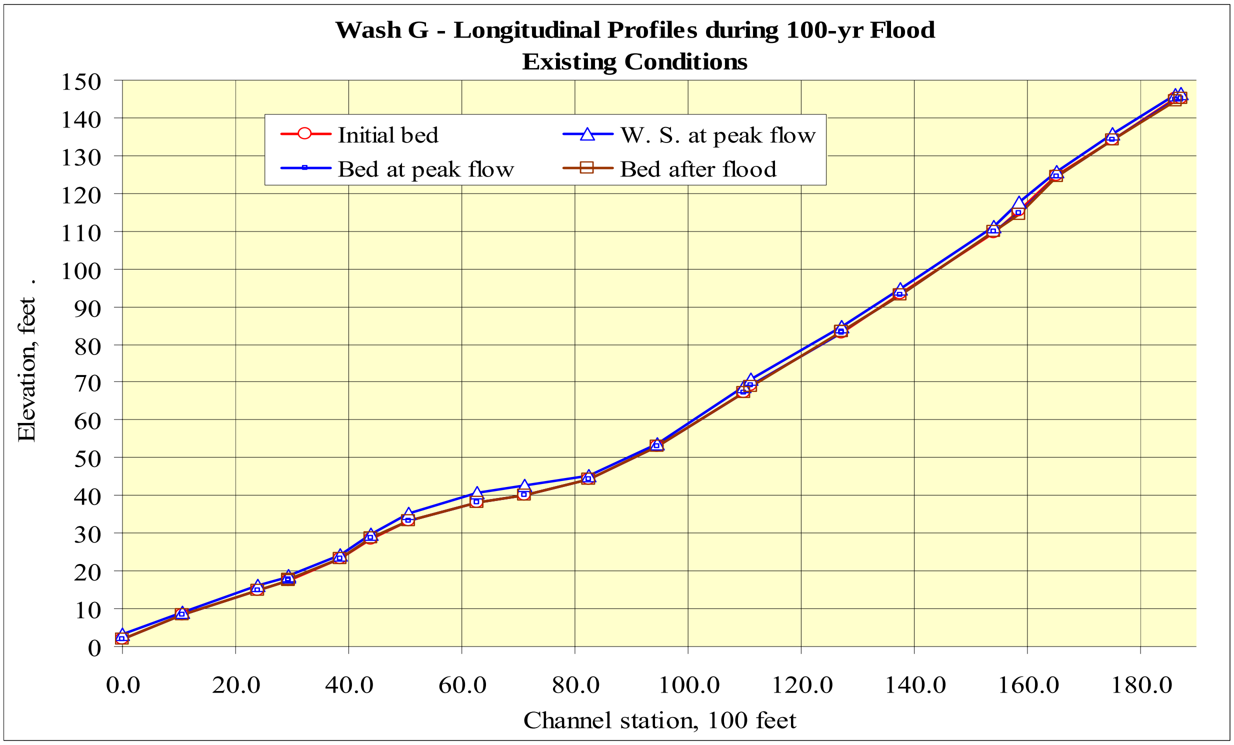


Fig. 26. Water-surface and channel bed profile changes during 100-yr flood for Wash C – existing conditions

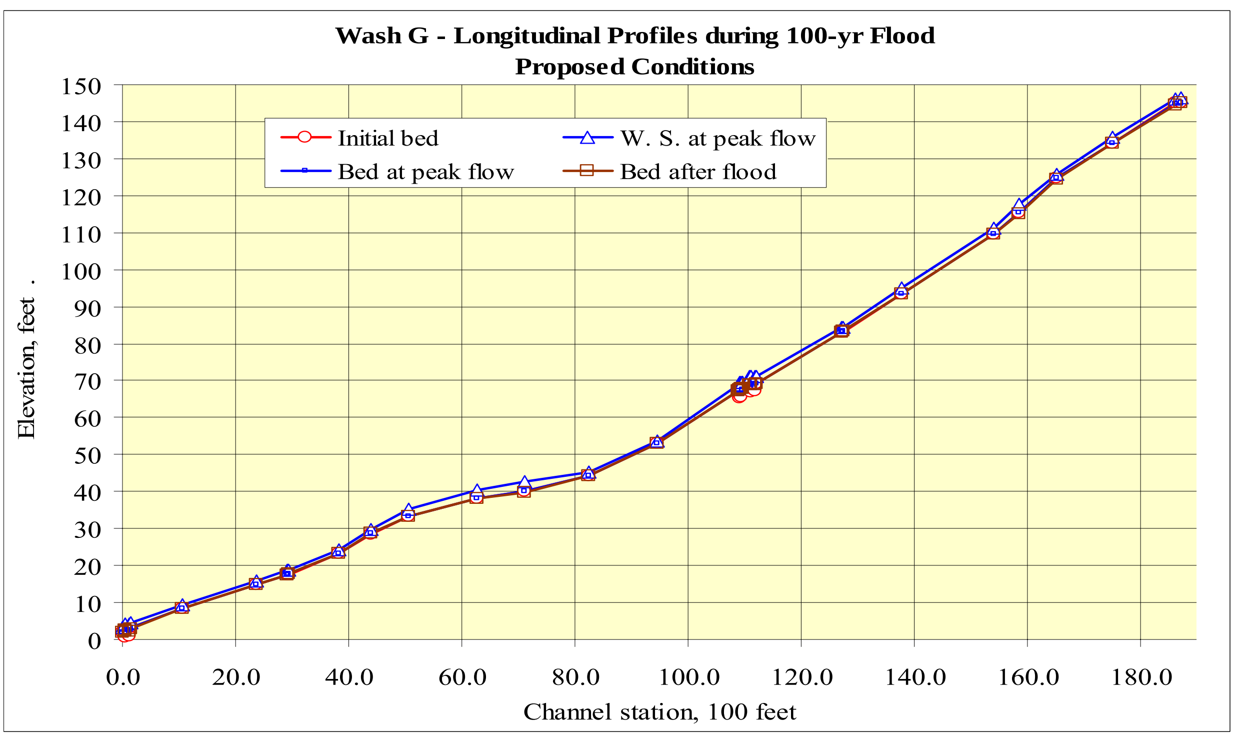


Fig. 27. Water-surface and channel bed profile changes during 100-yr flood for Wash C – proposed conditions with road crossings and sediment basins

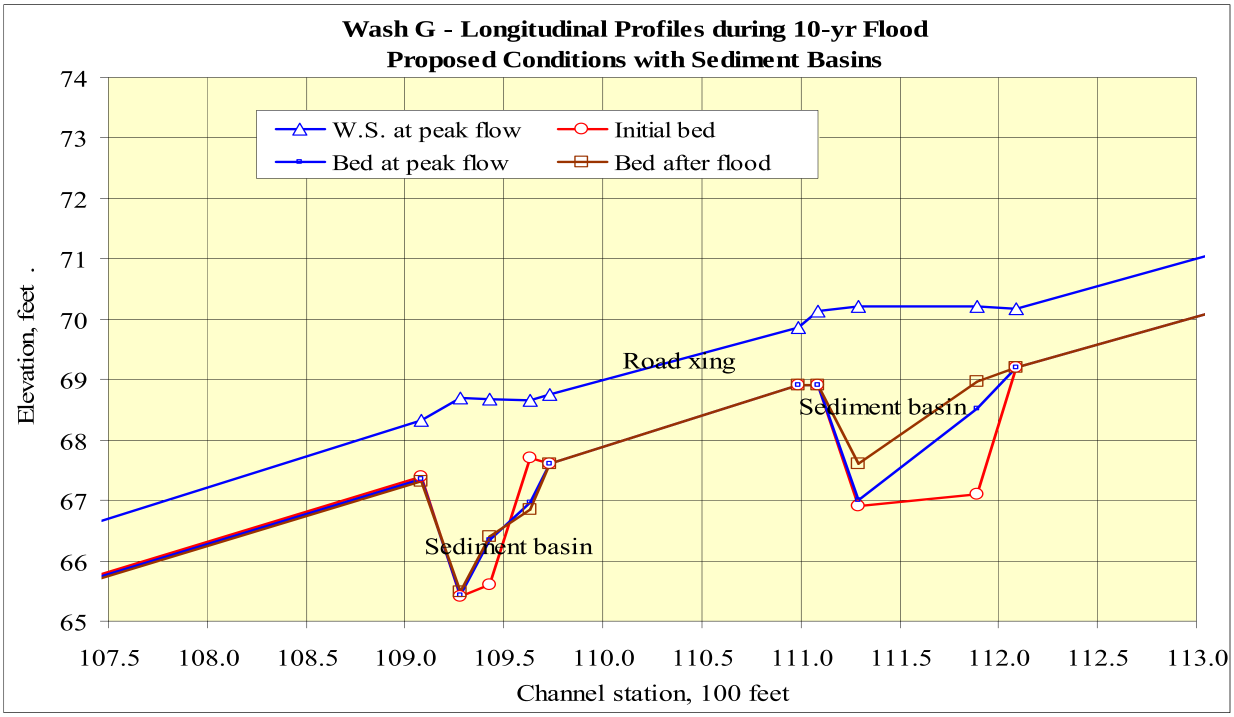


Fig. 28. Water-surface and channel bed profile changes during 10-yr flood for Wash G – proposed conditions with road crossings and sediment basins

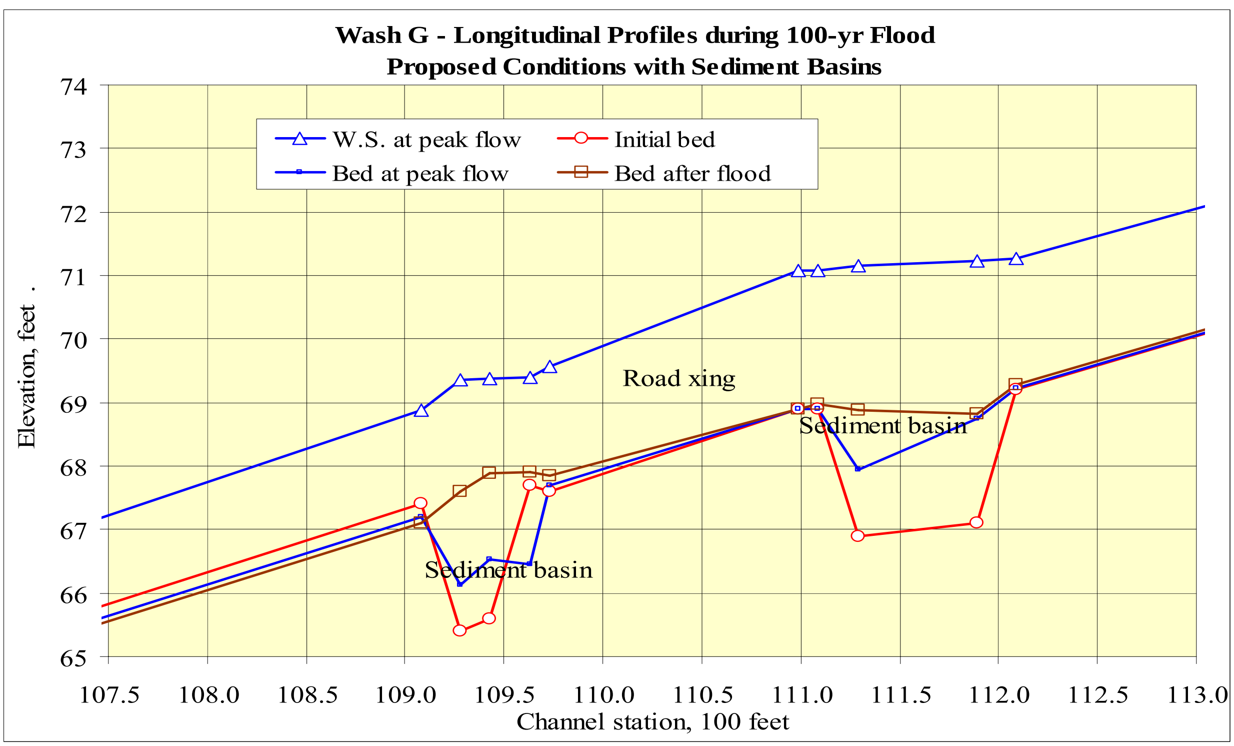
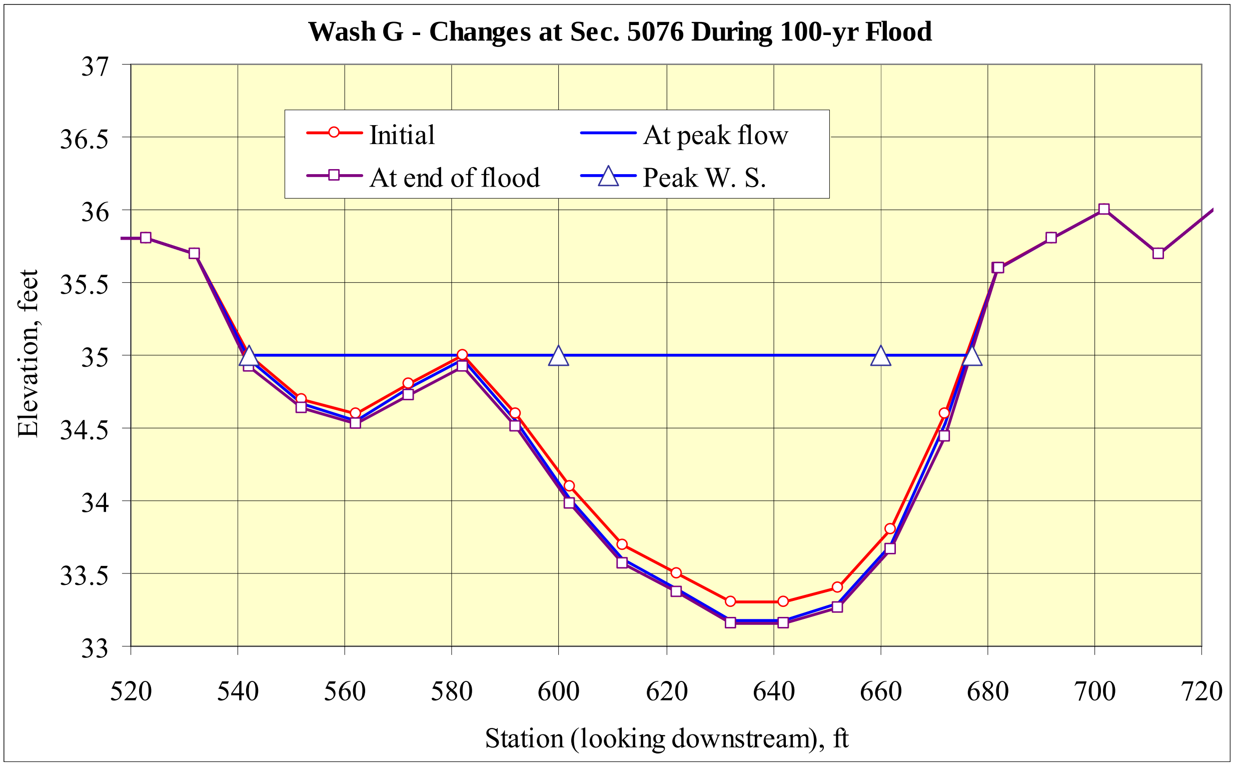


Fig. 29. Water-surface and channel bed profile changes during 100-yr flood for Wash C – proposed conditions with road crossings and sediment basins



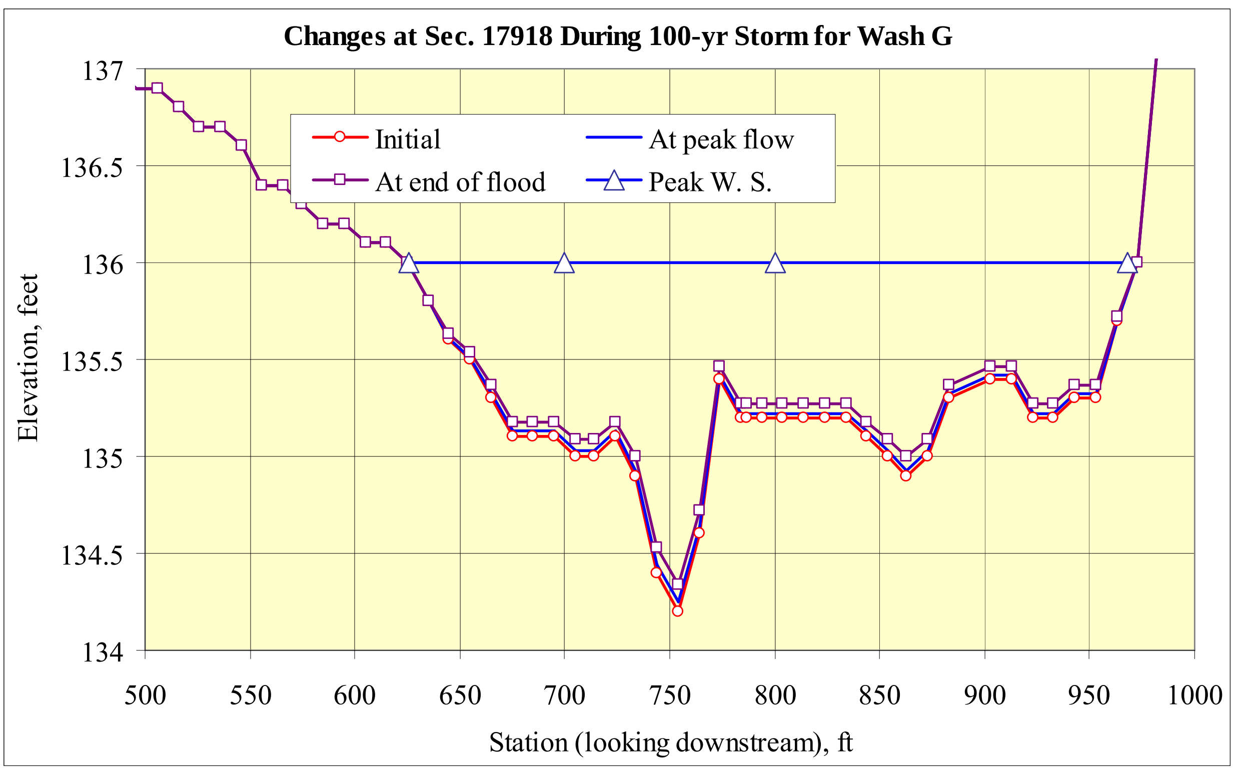


Fig. 30. Sample cross-sectional changes – proposed conditions with road crossings and sediment basins

Spatial Variations of Flow Velocity - Spatial variations of flow velocities at the peak 100-yr flood are shown in Fig. 31. This figure covers the three following conditions: (1) existing conditions of stream channel, (2) proposed conditions with road crossings, and (3) proposed conditions with road crossings and sediment basins.

The results show that the flow velocities vary substantially along the wash under existing conditions, with high velocities near station 16000 and at the downstream end through the culvert for Evan Hewes Highway. The differences in velocity between the existing and proposed conditions are related to the difference in channel roughness, road crossings and sediment basins. These road crossings cause back water and velocity reduction. Major velocity reductions are caused by the sediment basins.

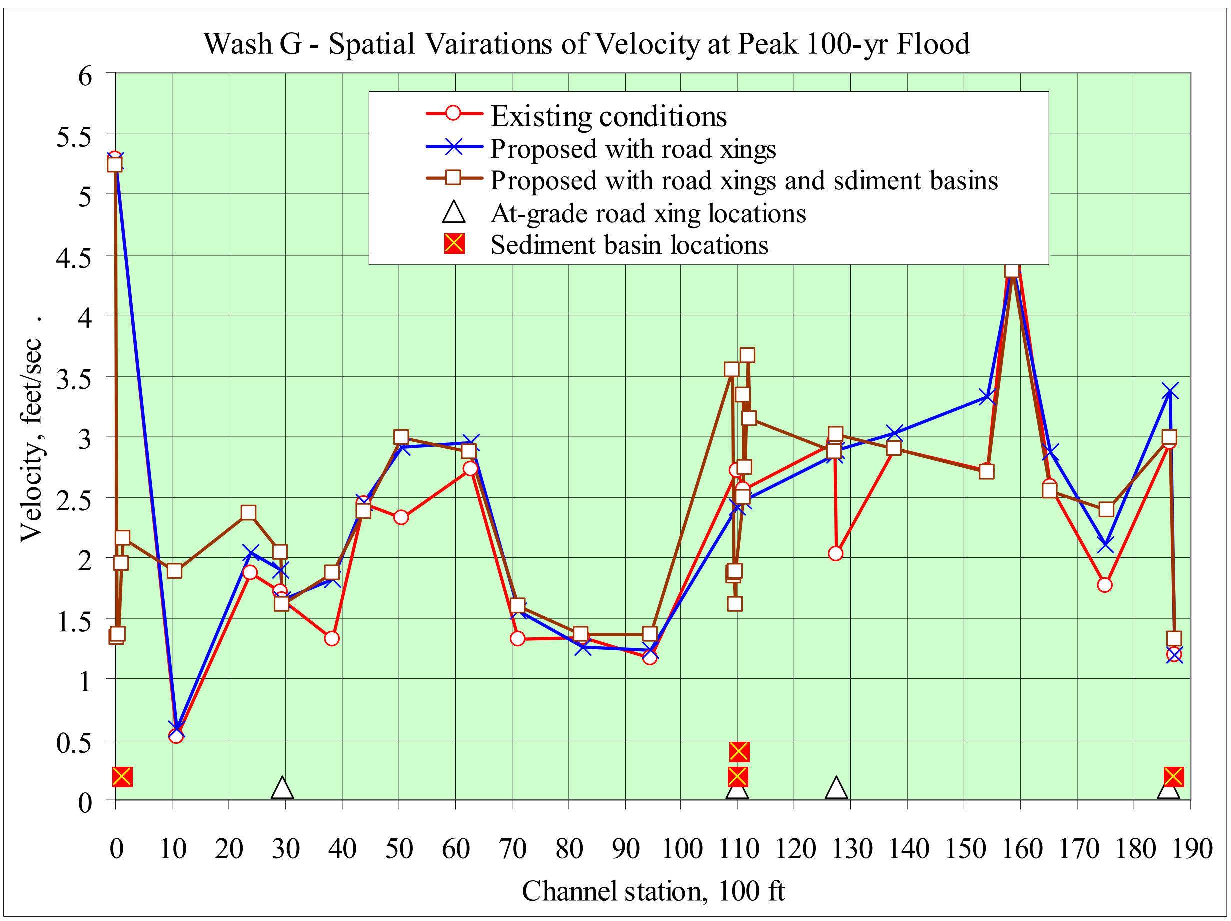


Fig. 31. Spatial variations of sediment delivery during 100-yr flood for existing and proposed conditions

Spatial Variations of Sediment Delivery - Spatial variations of sediment deliveries by the 100-yr flood are shown in Fig. 32. Sediment delivery is the total amount of sediment delivered passing a channel station during the passage of the flood event. The figure covers the three following conditions: (1) existing conditions of stream channel, (2) proposed conditions with road crossings, and (3) proposed conditions with road crossings and sediment basins.

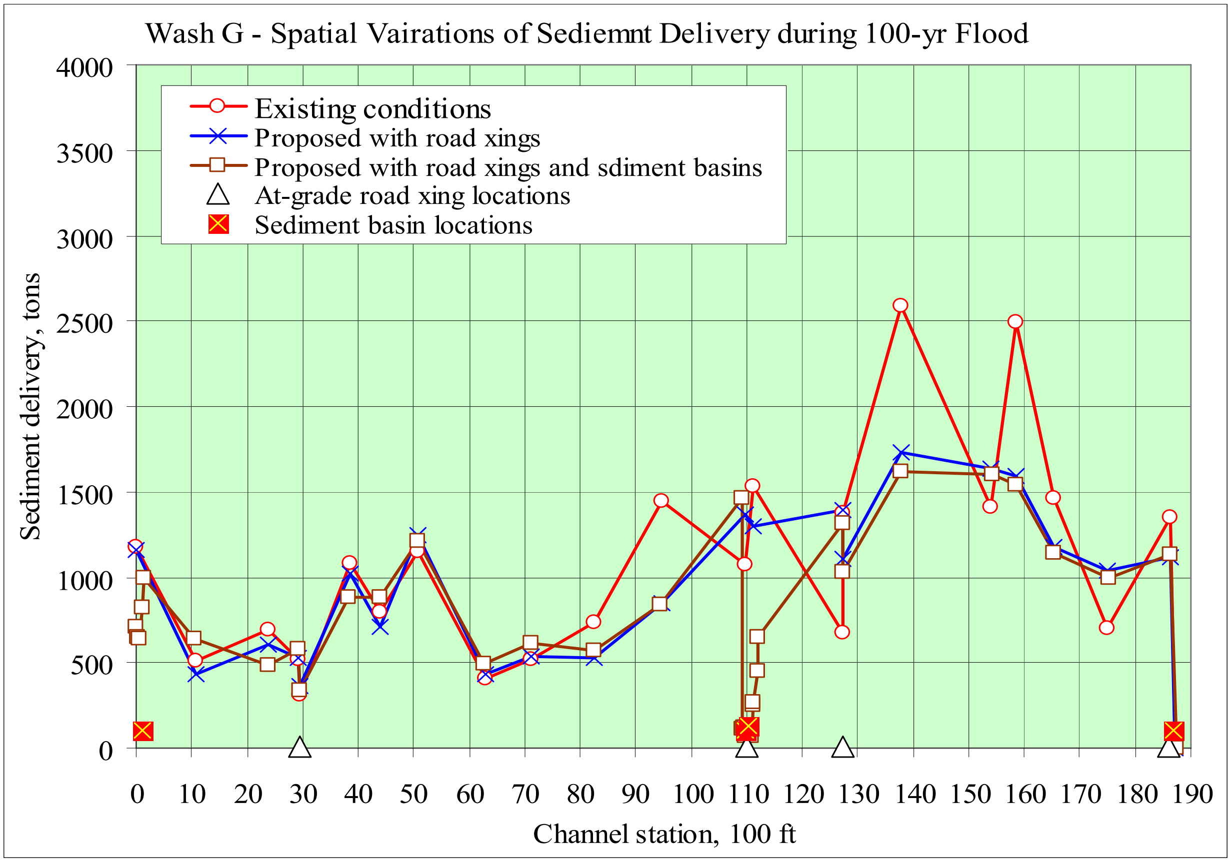


Fig. 32. Spatial variations of flow velocity at peak 100-yr flood for existing and proposed conditions

The results show that the sediment deliveries vary along the wash. An increasing delivery toward downstream indicates erosion while a decreasing delivery toward downstream means sediment deposition. For the existing conditions, the spatial variations are due to the variation in channel geometry along the wash. The areas near stations 14000 and 16000 have higher sediment deliveries, indicating more sediment will be eroded from these areas. The downstream channel reach has lower sediment deliveries, indicating lower sediment transport rates.

The differences in sediment deliveries between the existing and proposed conditions are related to the difference in channel roughness, road crossings and sediment basins. The road crossings cause reductions of flow velocity and sediment delivery. Major sediment delivery reductions are caused by the sediment basins. The proposed road crossing at station 11000 (Lifeline Road crossing) is raised above the channel bed; it has two sediment basins, with one on each side of the road crossing. This road crossing together with the sediment basins will have the major effect on reducing sediment delivery toward downstream.

In order to assess the sediment delivery toward the area downstream of the project site, total sediment deliveries by the 10- and 100-yr floods for these cases are summarized in Table 6. From the plotted and tabulated results, it can be seen that the road crossings will modify the pattern of sediment delivery along the channel and change the delivery toward downstream of the project site. The proposed sediment basin near the downstream end will cause major sediment delivery reduction to the downstream area. The road crossing near station 3000 is located at an area with low sediment transport; it is also subject to sediment deposition. This road crossing has very little effects on sediment delivery toward downstream. The road crossings and sediment basins located in the upper reaches of the wash will not affect the sediment delivery toward downstream in the short term.

Table 6. Sediment deliveries toward downstream out of project site for Wash G

Case	Sediment delivery toward downstream by 10-yr flood, tons	Sediment delivery toward downstream by 100-yr flood, tons
Existing conditions	3.0	1180
Proposed with road crossings	3.2	1160
Proposed with road crossings and sediment basins	9.6	697

VIII. LONG TERM EFFECTS OF ROAD CROSSINGS AND SEDIMENT BASINS ON SEDIMENT DELIVERY

The road crossings will modify the pattern of sediment delivery along the wash as well as sediment delivery toward downstream. These changes have been evaluated based on individual flood events. It is also very important to look at the long term effects on sediment delivery due to the road crossings and sediment basins.

Long-Term Effects of Road Crossings - The case of road crossings without sediment basins is first discussed. The road crossings are rigid structures not subject to erosion. Areas along the wash with high velocities are usually subject to erosion. Road crossings located in such areas are physical constraints for erosion; they thus modify the pattern of sediment transport along the wash. Such modifications include sediment deposition upstream of road crossings and erosion downstream of the road crossings. Road crossings located in low flow velocity areas that are subject to sediment deposition have little or no effects on sediment transport. The natural washes have formed in geological time; they have already established an approximate equilibrium in sediment transport. These stream channels are not subject to major changes under existing conditions. The road crossings are set at the existing channel bed grade; therefore, they will not cause major changes in sediment pattern. Potential sediment deposition and erosion induced by the at-grade road crossings are not considered substantial in magnitude. Of course, this does not apply to road crossings with raised grades.

In the long-term, sediment transport and delivery along a wash is governed by the sediment supply from its watershed. An alluvial stream is a dynamic system; it undergoes constant adjustment in geometry in response to the water and sediment inflow from the watershed. With the presence of road crossings, the channel will adjust its geometry by deposition and erosion. The adjustment is always toward establishing uniform sediment transport along the channel. In the long-term, sediment delivery toward the downstream area of the project site is controlled by the water and sediment inflow from the watershed. Such inflow quantities are not impacted by the at-grade road crossings.

Long-Term Effects of Sediment Basins - For the proposed conditions with road crossings and sediment basins, the pattern of sediment delivery will be substantially changed at the sediment basins as substantial amounts of sediment are detained in the basins to result in a deficit of sediment transport toward downstream. The sediment basin located near the downstream end of a channel reach will detain all the inflow sediment during the 100-yr event; it will thus cut off sediment delivery toward downstream of the project site. The long-term impacts of sediment basins depend on sediment basin maintenance. If the sediment basins are not maintained by re-dredging, it will eventually be refilled and then the sediment impacts will disappear. However, if the sediment basins are maintained periodically by dredging, then the periodical export of sediment from the wash system will have long-term impacts on sediment delivery along the wash as well as sediment delivery toward downstream.

IX. LOCAL SCOUR AT STRUCTURAL SUPPORTS FOR SOLAR UNITS.

The solar units are supported on cylindrical pedestals with a diameter of 2 feet. For a pedestal in a wash, the total scour is the general scour plus the local scour at the pedestal base. General scour is due to the imbalance in sediment transport along the wash, local scour is caused by a local obstruction to flow, such as the pedestal, as exemplified in Fig. 33.

Fig. 33. Local scour around a bridge pier

The magnitude of local scour may be estimated using certain established formulas. The Federal Highway Administration has adopted the following equation (Federal Highway Administrant, 2001) for round-nosed piers/bents or cylindrical piers/bents.

$$Y_s/Y_1 = 2.0\ K_1\ K_2\ (b/Y_1)^{0.65}\ \mathbf{F}^{0.43} \tag{6}$$

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 pedestal in place.

The maximum depth of local scour at a pedestal was computed using Eq. 6. For the proposed conditions, pertinent parameters for the flow hydraulics are taken from the output listings of FLUVIAL-12 at the peak 100-yr discharge. The maximum total scour at the pedestals is the general scour plus the local scour. The maximum local scour occurs under the worst combination of flow depth and flow velocity. The location for maximum local scour was identified to be at station 15860 for Wash G. From the output listings for Wash G, the flow data at the peak 100-yr flood discharge are as follows:

Flow velocity: 4.92 feet/sec

Flow depth: 2.44 feet

Froude: 0.96

The local scour depth computed using these data is 4.2 feet.

X. RECOMMENDATIONS FOR IMPACT MITIGATION

The study report provides representative sediment transport modeling to assess potential stream channel changes (aggradation or degradation) as well as an assessment of whether the project is likely to increase or decrease sediment delivery toward downstream. It is necessary to determine consequences of increased or decreased sediment delivery downstream. Possible consequences could include excess sediment deposition upstream of the existing railroad and culvert crossings along the north side of the project, or excess sediment delivery toward the east and the Westside Main Canal, or downstream channel degradation affecting existing infrastructure and channel morphology. In order to minimize the impacts, it would be ideal if the project causes no substantial changes to the sediment delivery. Otherwise, adverse impacts should be mitigated.

Sediment impacts may be mitigated by different methods. Basically, the road crossings, sediment basins, culverts, vegetation, buildings, etc. all affect sediment transport. In order to mitigate adverse impacts, modifications to these structures are considered. Based on the results of this study, the following mitigations for project impacts are recommended:

(1) Deletion of all sediment basins - The study has shown that the sediment basins will have short-term and long-term effects in reducing sediment flow along a wash and toward downstream. It is recommended all sediment basins be deleted from the proposed plan.

(2) Modification of Lifeline Crossing in Wash G – Under the proposed plan, the 24-foot Lifeline Crossing has five 3-foot culverts for cross drainage. The top of roadway is about 5 feet above the channel bed elevation. This road crossing together with the two adjacent sediment basins will have major effects in reducing sediment flow along the stream channel. It is recommended that this crossing be changed into an at-grade road crossing with all the culverts removed.

(3) Structural design for pedestals – Pedestals supporting solar units may be located in a wash. The maximum scour, including general scour and local scour, has been determined be no greater than 5 feet. In the structural design for the pedestals, the total scour depth of five feet should be

considered.

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Chang, H. H., *Fluvial Processes in River Engineering*, John Wiley & Sons, New York, NY, 1988, 432 pp.

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Federal Highway Administration, Evaluating Scour at Bridges, Hydraulic Engineering Circular No. 18, 2001. APPENDIX A. INPUT/OUTPUT DESCRIPTIONS FOR FLUVIAL-12

APPENDIX A. 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, it 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 value between 0 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 output 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	±	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 FOR THE
IMPERIAL VALLEY SOLAR PROJECT
(formerly known as SES Solar Two Project)
IMPERIAL VALLEY SOLAR, LLC

Docket No. 08-AFC-5
PROOF OF SERVICE
(Revised 3/9/10)

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DECLARATION OF SERVICE

I, Corinne Lytle, declare that on April 26, 2010, I served and filed copies of the attached, Applicant's Submittal of a Sediment Transport Analysis.
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:
[http://www.energy.ca.gov/sitingcases/solartwo/index.html].

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-5
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: ____________
CORINNE LYTLE

*indicates change