FINAL

PLATTE RIVER FROM THE LEXINGTON TO ODESSA BRIDGES

SEDIMENT AUGMENTATION EXPERIMENT ALTERNATIVES SCREENING STUDY SUMMARY REPORT

Prepared for

PLATTE RIVER RECOVERY IMPLEMENTATION PROGRAM

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EXECUTIVE SUMMARY

ES-1 Background

In December 2008, the Program's Adaptive Management Working Group developed a sediment augmentation adaptive management experiment, to be implemented in the 2009 – 2013 timeframe, to test the following hypothesis: *Average sediment augmentation near Overton, Nebraska, of 185,000 tons/year (t/y) under the existing flow regime and 225,000 t/y under the flow regime proposed by the Governance Committee achieves a sediment balance to Kearney, Nebraska*. This hypothesis, referred to as Priority Hypothesis Sediment #1 in Program documents, is based on modeling performed by the Bureau of Reclamation (BOR). The Program initiated the Sediment Augmentation Experiment Alternatives Screening Study (Study) to investigate the potential of implementing a Sediment Augmentation Experiment Project (Project) to correct the sediment imbalance in the Platte River reach between the Lexington and Odessa bridges (Project reach). The 32-mile Project reach extends from above the Lexington Bridge, at approximately river mile (RM) 255, to the Odessa Bridge, at RM 224.

The Program will implement the sediment augmentation management action under the FSM strategy developed as part of the Program's Adaptive Management Program (AMP). This systematic process of "learning by doing" involves evaluation of alternative hypotheses by applying an experimental management program and improving management decisions in ecosystems based on knowledge gained from those management actions.

The assumption from Program documents is that sediment can be mechanically placed into the river at a rate that will eliminate the sediment deficiency and restore a balanced sediment budget. The Program has identified a location within the Project reach, just upstream (west) of Nebraska Public Power District's (NPPD's) Cottonwood Ranch, as the preferred location to evaluate the effectiveness of the Project.

ES-2 Baseline Modeling

Baseline steady-state hydraulic and sediment-transport models using the Corps of Engineers (USACE) HEC-RAS program were developed and calibrated for the Project reach. The baseline hydraulic model was developed to evaluate channel capacity and to provide the input for the sediment-transport model. The modeling determined that the average annual sediment deficit in the vicinity of Cottonwood Ranch is approximately 150,000 t/y, which is less than the 185,000 t/y estimate in Priority Hypothesis Sediment #1. In assessing this value, however, it is critical to note that the transport capacities and resulting sediment deficit are highly dependent on the flow volume and patterns from year to year; thus, the deficit also varies by over an order of magnitude from year to year.

ES-3 Identification and Development of Alternatives

The identification and development of alternatives started with the pre-screening of the components which would make up an alternative, listed below. The components were studied to determine a matrix of options that could be assembled into alternatives.

- Augmentation delivery locations
- Sediment sources
- Sediment production and delivery techniques
- Delivery timing
- Augmentation material gradation

These components underwent an initial screening to eliminate options that were determined not feasible, primarily from the standpoint of cost or implementability. Once the initial screening was completed, the options that were retained were assembled into a set of unique sediment augmentation alternatives. Where appropriate, alternatives that did not represent a unique solution, or did not offer some advantage that warranted consideration were eliminated. In addition, the various permutations of each combination were evaluated to determine if a "hybrid" alternative would be feasible. Table ES-1 presents the range of feasible alternatives assembled.

Table ES-1 Range of Feasible Alternatives

Augmentation Delivery Locations	Sediment Sources	Sediment Delivery Technologies	Timing	Augmentation Material Gradation
Cook Tract/ Dyer Property Existing sand and gravel operations at Overton Interchange	Cook Tract/Dyer Property Existing sand and gravel operations	Sand pump Dozers (sand plug)	August 1[1]	D50~0.5 mm[2] D50~1.2 mm[2]

Notes:
[1] Review of modeling results suggest that pumping start dates have relatively little effect on the amount that the sediment deficit is reduced. The August 1 pumping start date was retained for evaluation purposes because it avoids ecologically important timeframes, offers the most flexibility, and some time buffer when compared to a September 1 start date.
[2] If the augmentation delivery location is on the South Channel, then a fine grain material (similar to the OS&G sand piles) is required to avoid excessive aggradation in the vicinity of the discharge location. Conversely, if the augmentation delivery location is downstream of the confluence of the North and South channels, such as OS&G, then a coarser material is required to provide more sediment transport to the deficit at Cottonwood Ranch.

Table ES-2 presents the alternatives that were assembled for further evaluation.

Table ES-2 Alternatives

Alternative	Augmentation Delivery Locations	Sediment Source	Delivery Technology	Analysis Type[3]
1	Cook Tract/Dyer Property (two locations)	Imported[1]	Sand pump	Sediment-transport model
2	Cook Tract/Dyer Property(two locations)	On site[2]	Sand pump	Extrapolated results from sediment-transport model[4]
3	Cook Tract/Dyer Property (two locations)	Imported[1]	Dozer (sand plug)	Hydraulic and sediment-transport modeling
4	Cook Tract/Dyer Property (two locations)	On site[2]	Dozer (sand plug)	Hydraulic and sediment-transport modeling
5	Cook Tract/Dyer Property (two locations) and OS&G (one location)	Imported[1]	Sand pump	Extrapolated results from sediment-transport model[5]
6	Cook Tract/Dyer Property (two locations) and OS&G (one location)	On site[2]/ Imported[1]	Sand pump	Extrapolated results from sediment-transport model[5]
7	Cook Tract/Dyer Property (two locations) and OS&G (one location)	Imported[1]	Dozer (sand plug)	Extrapolated results from hydraulic and sediment-transport model[6]
8	Cook Tract/Dyer Property (two locations) and OS&G (one location)	On site[2]/ Imported[1]	Dozer (sand plug)	Extrapolated results from hydraulic and sediment-transport model[6]

Notes:
[1] Imported from existing sand and gravel operation (purchased). Material from off-site sources would be hauled to the augmentation delivery locations, where it would be temporarily stockpiled prior to being introduced into the river.
[2] Acquired from Program-controlled property. Material from on-site sources would be from a sand pit dredge operation established at or near the augmentation delivery location (discussed in Section 5).
[3] Refer to Appendix B for discussion of modeling and analysis.
[4] Results from sediment-transport modeling of pumping at Sites 1 and 2 were used for evaluating this alternative.
[5] Results from sediment-transport modeling of pumping at Sites 1, 2, and 4 were used for evaluating this alternative.
[6] Results from hydraulic and sediment-transport modeling of dozer options at Cook Tract/Dyer Property and baseline sediment-transport model in the vicinity of OS&G were used for evaluating this alternative.

Once the alternatives were assembled, the baseline model was modified accordingly and used to evaluate the potential response of the river to assess the benefits (i.e., the reduction of the sediment deficit) associated with the various components of each alternative. The alternative modeling included a suite of the identified potential augmentation components, including likely combinations of delivery technologies, augmentation locations, and augmentation material sizes, to assess the combined effects of the various components. Although each underlying component associated with the eight identified alternatives was modeled, the ultimate assembly of each alternative may not have been explicitly modeled. However, results from the model runs were sufficient to evaluate each of the alternatives, either through direct modeling or extrapolation of the results from similar model runs. The modeling effort was an iterative process, with model results helping to inform the development and modification of alternatives in an attempt to identify a range of alternatives that best address the sediment deficit. The modeling concluded that it is unlikely any of the identified alternatives would be 100 percent effective in eliminating the sediment deficit at the Cottonwood Ranch location.

ES-4 Evaluation Criteria

Alternative evaluation criteria were established to allow for the objective side-by-side comparison of the alternatives. The Section 404(b)(1) Guidelines were used as a starting point for identifying the evaluation criteria. A total of eight evaluation criteria in four Section 404(b)(1) Guideline categories were identified, as listed in Table ES-3:

Table ES-3 Evaluation Criteria

Evaluation Criteria	Alternative Evaluation Criteria	Section 404(b)(1) Guidelines Practicability Criteria
1	Cost per ton of delivered sediment	Cost
2	Delivery timing	Existing technology
3	Implementability	Logistics
4	Permittability	Logistics
5	Long-term viability	Logistics
6	On-site sediment availability	Logistics
7	Percent effective	Project purpose
8	Provision of other Program benefits	Project purpose

ES-5 Alternatives Analysis

Each feasible alternative was evaluated against the eight evaluation criteria, and the feasible alternatives were compared side by side, as shown in Table ES-4. None of the alternatives fully meet the Project's need, in that none of the alternatives fully eliminate the sediment deficit. Therefore, the side-by-side comparison allows the reader to better understand the relative advantages and disadvantages of each alternative. The Study points to a reasonable set of alternatives that, if implemented, will allow for a better understanding and improved knowledge of this system. The information and data acquired in the process can be used to enhance the selection of long-term management decisions related to sediment augmentation.

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Table ES-4 Summary of Alternatives Analysis

Evaluation Criteria	1	2	3	4	5	6	7	8
Cost								
Cost per ton delivered	$14.40	$11.83	$17.28	$14.23	$13.38	$11.90	$16.08	$15.43
Existing technology								
Delivery timing	3.5 months	3.5 months	1-2 months	1-2 months	2.3 months	2.3 months	1 month	1 month
Logistics								
Implementability	Low difficulty	Medium difficulty	Low difficulty	Medium difficulty	Low difficulty	Medium difficulty	Low difficulty	Medium difficulty
Permitting	High difficulty	High difficulty	Medium difficulty	Medium difficulty	High difficulty	High difficulty	Medium difficulty	Medium difficulty
Long-term viability	10+ yrs	10+ yrs	10+ yrs	10+ yrs	10+ yrs	10+ yrs	10+ yrs	10+ yrs
On-site sediment availability	No	Yes	No	Yes	No	Partial	No	Partial
Project purpose								
Percent effective	30 – 60	30 – 60	30 – 40 (max.)	30 – 40 (max.)	60 – 80	60 – 80	>40	>40
Provision of other Program benefits	No	Yes	No	Yes	No	Yes	No	Yes

ES-6 Risk and Uncertainty Analysis

Because this type of large-scale sediment augmentation project is unique and includes numerous variables, the Project includes major areas of uncertainty, including the following:

- Unique Project
- Uncertainties identified or related to modeling
- Requirement of a location downstream of the confluence of the North and South Channels
- Availability of augmentation locations downstream of confluence
- Technologies
- Effects on downstream landowners
- Effects on local roads
- Variation in market conditions
- Long-term effects
- Water permits
- Adaptive management process to address uncertainty

ES-7 Conclusions

Modeling results indicated that the location of the augmentation sites relative to Cottonwood Ranch is a significant factor in determining effectiveness in meeting the sediment balance goal. Generally, augmentation sites in closer proximity to Cottonwood Ranch are more effective (i.e., the closer the river is to sediment balance). Two commercial sand and gravel operations are located downstream of the confluence, and it is assumed that a commercial arrangement could be negotiated to use either location as the augmentation site. In addition, Program staff could initiate discussions with other private property owners located in this reach of the Platte River to investigate potential interest or availability of augmentation locations.

The modeling also indicated that particle size is a significant factor in the effectiveness of meeting sediment balance. In general, material that is too coarse may settle out before it reaches the Cottonwood Ranch location (especially if delivered in areas with low hydraulic energy), and finer material flushes through the system. Determining the optimal balance between coarse and fine material in order to achieve the maximum effectiveness and the most cost-effective technology to produce the optimal particle size will require some testing and experimentation.

The modeling evaluated several different configurations for the placement of sediment piles using the dozer options. Some configurations were more effective, but none reached the effectiveness of the sand pump options.

Based on the available modeling, none of the alternatives would likely fully achieve the Project purpose. In order to eliminate the deficit using the readily available augmentation material at the local sand pit operations, the volume of material added to the river would have to be slightly more than doubled due to the amount of the finer gradation material that is flushed downstream. This would essentially double the total 10-year cost and there could be potential impacts on downstream infrastructure (e.g., Kearney Canal Diversion) from the material flushed through the system. The Program is instituting a monitoring plan to evaluate this potential.

ES-8 Recommendations

Given the constraints of the split flow conditions around Jeffrey Island, perennial sediment deficiencies, and augmentation delivery location constraints, none of the identified alternatives would fully achieve sediment balance at Cottonwood Ranch. In addition, as several major uncertainties remain that should be evaluated and tested. Alternatives 6 and 8 have the advantage of incorporating a discharge location downstream of the confluence of the North and South channels while also utilizing some sediment from Project-owned property. Alternatives 6 and 8 also have a relatively low cost per delivered ton of sediment and have the potential to provide other Program benefits. However, even though these alternatives have a high level of effectiveness, they both fall short of fully meeting the Project goal.

Therefore, the recommended action is to design and implement a pilot-scale experiment (to address sediment volume, material size, and augmentation location) based on Alternatives 6 and 8 and to develop a monitoring plan to determine if the experiment is successful. The model would be updated based on the results of the pilot study. A two-dimensional model would also be instructive in understanding pilot study results and further analyzing full-scale sediment augmentation processes. Once the results of the pilot-scale experiment are evaluated and combined with the results of the modeling, a final design for the Sediment Augmentation Experiment Project could be completed. The pilot study would be designed to provide answers to some of the most important areas of uncertainty, including the following:

- Testing to determine the optimal particle size
- Technology to produce the optimal particle size
- Timing and duration of annual augmentation activities
- Effects of reducing some but not 100 percent of the sediment on providing habitat benefits
- Cost associated with the commercial acquisition of sediment
- Timing and difficulty of obtaining required permits for the augmentation
- Optimal location and windrow/sand plug configuration for augmentation
- Potential for adverse downstream effects

As part of the final design, monitoring plan would need to be refined prior to implementation of both the pilot-scale and full-scale implementation of the Project. The monitoring plan would be consistent with the Integrated Monitoring and Research Plan (IMRP) described in the Program's AMP. Specifically, the IMRP's Program Level Monitoring and Research protocol as well as the Research Protocol for NPPD's Cottonwood Ranch would provide guidance in developing the monitoring plan.

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1. INTRODUCTION AND BACKGROUND

1.1 Introduction

The Platte River Recovery Implementation Program (Program or PRRIP), initiated on January 1, 2007, is the result of a Cooperative Agreement between the U.S. Department of the Interior (USDI); the states of Nebraska, Colorado, and Wyoming; water users; and conservation groups. The Program is intended to address issues related to the Endangered Species Act (ESA) and loss of habitat in the Platte River in central Nebraska. This can be achieved by managing certain land and water resources, following the principles of adaptive management (discussed below), to provide benefits for the following four "target species":

- The endangered whooping crane (*Grus americana*)
- The endangered interior least tern (*Sterna antillarum*)
- The endangered pallid sturgeon (*Scaphirhynchus albus*)
- The threatened piping plover (*Charadrius melodus*)

The Program brings together states, the federal government, water users, and environmental groups (Program partners) to work collaboratively to improve and maintain the associated habitat for the target species. The first increment of the Program extends for 13 years, from 2007 to 2019. The long-term goal of the Program is to improve and maintain associated habitats, which includes:

1. Improving and maintaining migrational habitat for whooping cranes and reproductive habitat for least terns and piping plovers
2. Reducing the likelihood of other species found in the area being listed under the ESA
3. Testing the assumption that managing water flow in the central Platte River also improves the pallid sturgeon's lower Platte River habitat

The Program's Governance Committee reviews, directs, and provides oversight for Program activities. Several standing advisory committees assist the Governance Committee as well as the Program's Executive Director's office.

Central to the Program is its Adaptive Management Plan (AMP). Adaptive management is a systematic process of "learning by doing"; the best available science is used to test hypotheses, implement management experiments or actions, learn from the results, and revise actions as required. This process involves applying an experimental management program to evaluate alternative hypotheses and drawing on knowledge gained from those management actions to improve management decisions regarding ecosystems. Adaptive management is used in situations where it is uncertain how actions taken will affect the outcome, yet decisions regarding management actions must be made despite the unknowns. Monitoring and directed research are designed to reduce uncertainty and move decisions forward.

The AMP is centered on priority hypotheses developed jointly by numerous Program partners. The hypotheses reflect different interpretations of how river processes work and the best approach to meeting the Program's long-term goal. To test these hypotheses, the AMP identifies two management strategies:

1. Flow-Sediment-Mechanical (FSM) Strategy (Clear/Level/Pulse)
2. Mechanical Creation and Maintenance Approach (Clear/Level/Plow)

The Sediment Augmentation Experiment Project (Project) evaluated in this summary report is designed as an experiment to test a specific FSM hypothesis developed as part of the Program's AMP.

1.2 Sediment Augmentation Experiment Alternatives Screening Study Background

In December 2008, the Program's Adaptive Management Working Group developed a sediment augmentation adaptive management experiment, to be implemented in the 2009 – 2013 timeframe, to test the following hypothesis: *Average sediment augmentation near Overton, Nebraska, of 185,000 tons/year (t/y) under the existing flow regime and 225,000 t/y under the flow regime proposed by the Governance Committee achieves a sediment balance to Kearney, Nebraska*. This hypothesis, referred to as Priority Hypothesis Sediment #1 in Program documents, is based on modeling performed by the USDI Bureau of Reclamation (BOR) (Murphy et al., 2006). The Program initiated the Sediment Augmentation Experiment Alternatives Screening Study (Study) to investigate the potential of implementing the Project to correct the sediment imbalance in the Platte River reach between the Lexington and Odessa bridges (Project reach). The 32-mile Project reach extends from upstream of the Lexington Bridge, at approximately river mile (RM) 255, to the Odessa Bridge at RM 224. Figure 1-1 shows the general Study location. (Note that figures are at the end of the section.)

The Program will implement the sediment augmentation management action under the FSM strategy. The assumption from Program documents is that sediment can be mechanically placed into the river at a rate that will eliminate the sediment deficiency and restore a balanced sediment budget. The Program has identified a location within the Project reach, just upstream (west) of Nebraska Public Power District's (NPPD's) Cottonwood Ranch, as the preferred location to evaluate the effectiveness of the Project. The Program has acquired property along the South Channel (adjacent to Jeffrey Island) downstream of the Johnson-2 (J-2) Return for sediment augmentation purposes but is also investigating other possible sediment augmentation actions, including the following:

- Augmentation downstream of the Overton Bridge with sandpit material
- Augmentation at Program property upstream of the Overton Bridge with channel and/or overbank sediment
- Mechanical augmentation (island leveling and channel widening) in the channel between Program property upstream of the Overton Bridge and Cottonwood Ranch
- Potential additional augmentation possibilities downstream of the J-2 Return (PRRIP, 2009)

1.3 Purpose and Scope

The purpose of the Study is to verify the sediment deficiency in the Project reach and identify and evaluate the feasibility of implementing a sediment augmentation experiment that will test the hypothesis and help achieve the Program's long-term goal. Section IV of the Program's AMP identifies proposed actions to achieve management objectives on Program lands. Under the FSM strategy, Objective Number 2 is to:

> *"Offset the existing sediment imbalance by increasing sediment inputs to the habitat area from one or more of the following sources: a) sand augmentation through mechanical actions – island and bank clearing and leveling, b) sand augmentation from bank and island actions not directly related to bank cutting and island leveling (an example could be excavation associated with wetland development), or c) reducing imbalance through channel plan form changes, tributary delivery improvements, or flow routing changes."*

The Project specifically addresses source b, sand augmentation from bank and island actions not directly related to bank cutting and island leveling. The Project metric is to achieve sediment balance just upstream of Cottonwood Ranch.

The scope of the Study includes the following:

- Reviewing existing Program data and information
- Evaluating the sediment deficiency estimated by BOR by developing a hydraulic and sediment-transport model
- Conducting supplemental surveying of the river channel, where needed
- Identifying potential sediment augmentation delivery locations, sediment sources, and delivery technologies
- Conducting material sampling and testing
- Identifying and screening sediment augmentation experiment alternatives
- Identifying required permits and conducting early consultation regarding those permits (see **Appendix A**)

1.4 Previous Studies and Available Information

Previous studies and other available information that were reviewed to provide a basis for evaluating the Project include the following:

- Final Environmental Impact Statement (FEIS) completed by BOR and USDI U.S. Fish and Wildlife Service (USFWS) (2006) – As part of the FEIS, BOR conducted one-dimensional sediment-transport modeling using the SedVeg model. Results of the modeling suggested a sediment deficiency in the Platte River system, primarily along the reach from the J-2 Return on the South Channel to the Odessa Bridge. This reach is within the Project reach.
- Rainwater Basin Mapping Project data (USACE, 2009) – The primary data used to develop topographic surfaces of the Study area, shown in Figure 1-1 and described in Section 2, were light detection and ranging (LiDAR) mapping data collected as part of the Rainwater Basin Mapping Project.
- Central Platte River Channel Geomorphology and In-Channel Vegetation Monitoring Program data, collected by Ayres Associates (2009) on behalf of the Program – Survey (channel cross sections), bed and bank material, and other morphologic data are included.
- Nebraska Department of Roads (NDOR) Bridge Survey Data

The BOR analysis completed for the FEIS indicated that the addition of the following quantities of sediment with a D50 particle size of less than 1.00 millimeter (mm) is required downstream of the J-2 Return and upstream of the Overton Bridge to bring the reach into sediment balance: 185,000 t/y of sediment under the existing flow regime (i.e., a range of stream flows having similar bed forms, flow resistance, and means of transporting sediment) and 225,000 t/y under the flow regime proposed by the Governance Committee (Figure 1-2). To verify the sediment imbalance, a baseline sediment-transport model was developed as part of the Study, as discussed in Section 4. It was implied in the FEIS that the addition of a volume of sediment equivalent to the imbalance would bring the reach into sediment balance.

However, modeling conducted as part of the Study (see **Appendix B**) indicated that it is not necessarily a one-to-one correlation; the reason is that introducing new sediment into the reach also has the effect of increasing the transport rate, particularly if the introduced sediment is finer than the existing bed material. Thus, more sediment than the indicated imbalance may be necessary to achieve the equilibrium.

1.5 Coordination with Other Program Projects

1.5.1 Central Nebraska Public Power and Irrigation District's Reregulating Reservoir Project

The Central Nebraska Public Power and Irrigation District (CNPPID) reregulating reservoir project, currently being evaluated, is part of the Program's flow augmentation project for the central Platte River (Olsson, 2010). Several reregulating reservoir alternatives were developed to provide temporary storage for use in creating short-duration high flow (SDHF) events. If constructed, they may generate excess sediment. However, based on borings and the D50 suggested in the FEIS, it does not appear that the favored reregulating reservoir alternatives would likely provide enough excess sediment to sustain the sediment augmentation Project over time. Therefore, they were not considered further.

1.5.2 Habitat Complex Projects

The Program has a number of current or planned habitat projects along the Project reach that have been identified as potential sediment augmentation delivery sites or sources. These include the following:

- Cottonwood Ranch – The Project should not impact the ongoing habitat complex work at Cottonwood Ranch.
- Cook Tract – There are no specific plans for habitat projects on the Cook Tract.
- Dyer Property – There are no specific plans for habitat projects on the Dyer Property.

1.6 Reference Projects

Several sediment augmentation projects and papers were reviewed for the Study. Many of the sediment augmentation projects for which information is available have been conducted in western states, either in steep mountain streams or on major rivers with large dams. Goals for the projects reviewed tend to focus on the development of in-stream habitat, for example fish spawning habitat and increased turbidity and cover for smaller fish species. Mountain stream projects tend to focus on smaller streams and smaller volumes of coarse to larger aggregates. Projects on the larger rivers with large dams such as the Colorado River involve very large quantities of sediment and long sediment transport distances. Many of the projects are directly downstream of dams that provide a significant, reliable source of water in order to alter the magnitude of flows and distribute the augmented sediment.

Two projects for which good comparative information was available are summarized below.

Project – Colorado River Ecosystem Sediment Augmentation

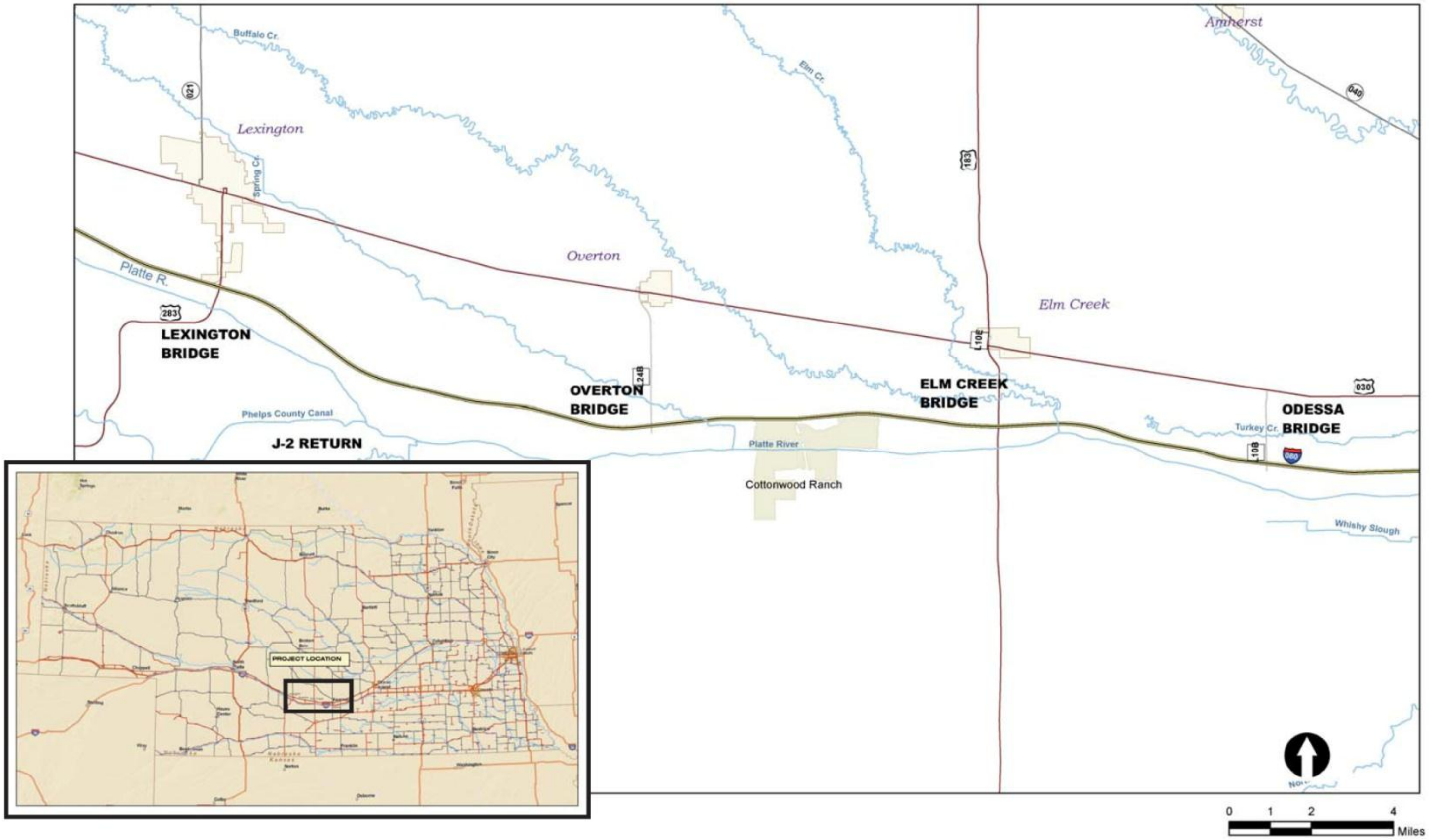
- Entity – BOR
- Location – Glen Canyon Dam, Arizona and Utah
- Description – large western river
- Project goals – seasonally increase turbidity for native and endangered fish, annually increase sand supply to the Colorado River during beach building flows
- Augmentation material – fine sediment (silt and clay-size) and sand
- Augmentation volume – 4.8 million tons annually

- Estimated costs – capital costs $140 to $430 million, annual operating cost of $3.6 to $17 million.

Project – Coarse Sediment Augmentation of the Trinity River, California

- Entity – CALFED (2004)
- Location – Northern California mountains downstream of Lewiston and Trinity dams (6-kilometer reach)
- Description – Mountain river
- Project goals – restore natural fluvial processes; increase and maintain spawning and rearing habitat for salmon
- Augmentation material – coarse sediment (gravel to cobbles)
- Augmentation volume – estimated 100,000-ton initial input followed by annual inputs of approximately 10,000 tons; recent projects included high flow gravel injection of 2,500 tons and 1,000 tons in key areas.
- Estimated cost – $30 per ton

For this Study, however, sediment augmentation is unique in terms of the type of river system, Project goal, type of sediments involved, and magnitude of augmentation proposed. In reviewing the literature and using its knowledge of augmentation, the Study team looked for information that would help understand processes, limitations, and costs. The uniqueness of the river system for this Study limited the amount of useful and comparative information. The Project is located in the central Platte River, a relatively flat, braided river system with generally low flows relative to the overall channel widths. The Project goal is to achieve sediment balance in the river that will result in creation of bed and bar habitat suitable for birds. The estimated annual volume of augmentation material is significantly higher than for many of the mountain stream projects but significantly lower than for some of the large western river projects. A primary conclusion in review of other projects points to little guidance regarding the quantities and grain sizes of material needed to achieve the Project goal.



Study Area

Sediment Augmentation Feasibility Study
Draft Report
Platte River Recovery Implementation Program

Date: Nov. 2010

Figure: 1-1

1

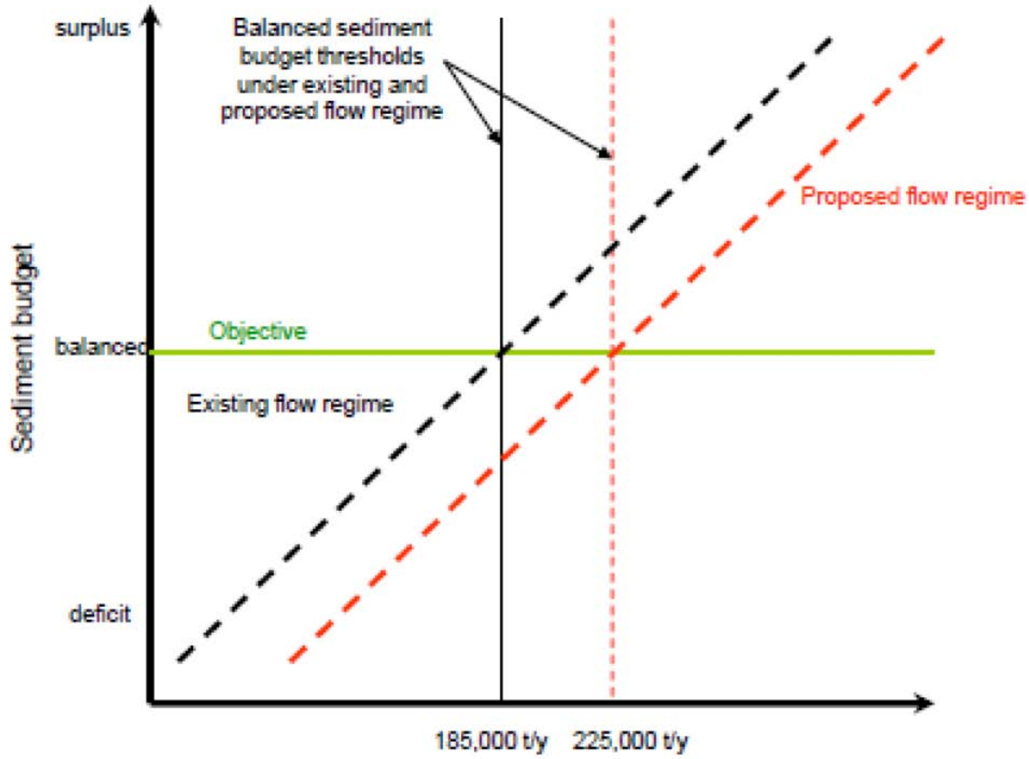


Figure 1-2 Estimated Average Annual Sediment Augmentation near Overton (t/y)

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2. DESCRIPTION OF STUDY AREA

This section discusses the location of the Study area, the Central Platte Habitat Area, the hydrology in the Platte River near Overton, the central Platte River channel, and the Platte River segment targeted for sediment augmentation activity.

2.1 Location

As identified above, the Project reach is between the Lexington and Odessa bridges, a distance of 32 miles, and is located within the Central Platte Habitat Area. The FEIS identifies the Central Platte Habitat Area as the reach of the Platte River from Lexington, Nebraska, to Chapman, Nebraska. Target species in this habitat area include the whooping crane, interior least tern, and piping plover (BOR and USFWS, 2006).

2.2 Hydrology

The average annual flows of the Platte River near Overton decreased from 2.65 million acre-feet per year during the period between 1895 and 1909 to a low of 830,000 acre-feet per year during the period from 1936 to 1969. The mean annual flow of the Platte River near Overton was 1.4 million acre-feet during the period from 1970 to 1998. The duration and magnitude of low to moderate flows (including the mean annual peak flow) influence the width of the river. As flow has decreased over time, a corresponding decrease in the river width has been observed. The FEIS attributed decreased flows to increased water development and use, including agricultural, domestic, commercial, industrial, and mining uses. Agricultural uses for irrigation and livestock account for most of the current water use (BOR and USFWS, 2006).

2.3 Central Platte River Channel

2.3.1 River Form

In the period from 1900 through 1938, the central Platte River channel maintained a predominantly braided form, although the width of the river decreased significantly. Braided river forms are characterized by a series of shallow, interconnected low flow channels within the overall channel. This form provides desirable riverine habitat (i.e., habitat occurring along a river) for whooping crane, interior least tern, and piping plover because there are wide areas of water with unobstructed sight distances and bare sandbars for roosting, nesting, and security from predators (BOR and USFWS, 2006). Figure 2-1 shows an example of a braided river.

Over time, reductions in flow volumes, peak flows, and sediment supply have shifted the river's form from a wide, braided channel to a channel consisting of multiple narrow and deep channels separated by vegetated islands (anastomosed). These changes have led to a decrease in desirable habitat for the target species (BOR and USFWS, 2006).

2.3.2 Channel Width

Earlier works suggest that channel widths along the river have decreased in the Project reach since the 1860s. Most of the channel width reduction occurred between 1900 and 1960. Since 1960, channel width reduction has slowed (BOR and USFWS, 2006).

2.3.3 River Depth

Flow reductions in the central Platte River have resulted in reduced sediment transport. Flow discharged at the J-2 Return, upstream of Overton, contains very little sediment as it enters the river. The sediment imbalance created by this low-sediment return flow causes bed and bank erosion in the channel directly below the J-2 Return discharge point and continuing downstream. Findings in the FEIS indicate that over a 13- to 18-year period from 1989 to 2002, the depth of degradation was about 6 feet near the J-2 Return and decreased over an approximately 18-mile distance in the downstream direction to less than 1 foot.

In degrading river reaches, the rate of bed erosion eventually slows as the slope of the river bed flattens or as the armoring process builds a protective surface of coarse-grained material on the river bed. The process of armoring is not desirable in the Platte River because the coarser grain sizes in the river bed do not support channel geometry as wide as supported by a finer grain size (BOR and USFWS, 2006).

2.3.4 Vegetation

The FEIS cites numerous sources that identify vegetation expansion and loss of open channel area in the central Platte River since the early 1900s. Estimates in the FEIS indicate that the unvegetated portion of the channel between Lexington and Grand Island was reduced to roughly 9,500 acres between 1938 and 1998. By restoring the river to a braided system through sediment augmentation and other measures, greater areas of open channel can be maintained, thereby providing unobstructed views that are preferred by target species (BOR and USFWS, 2006).

2.4 Platte River Segment Targeted for Sediment Augmentation Activity

Although the Project reach is the 32-mile river reach between the Lexington and Odessa bridges, most of the sediment augmentation activity for the Project would be conducted in a much shorter sub-reach between the Lexington Bridge and the Elm Creek Bridge. Note that Cottonwood Ranch is located within this sub-reach, shown in Figure 1-1, above, and discussed in detail in Section 4. Approximately 2 miles downstream of Lexington, flows in the Platte River historically split around Jeffrey Island. The split channels, referred to as the North Channel and the South Channel, rejoin near the east end of the Dyer Property above the Overton Bridge. A sand dam was constructed in the channel upstream of Jeffrey Island to divert flow to the North Channel. This dam effectively keeps river flows in the North Channel under all but the highest flow conditions.

CNPPID's J-2 Return is located on the South Channel and provides the majority of the flow in the South Channel under most flow conditions. The main channel (North Channel) capacity is slightly less than 5,000 cubic feet per second (cfs) upstream of the confluence with the South Channel. The capacity of the Platte River increases to about 6,000 cfs downstream of Jeffrey Island due to the additions from the J-2 Return (see **Appendix B**). Jeffrey Island is privately owned, but most of the island is in a lease-to-own agreement with CNPPID. Vegetation has significantly encroached on the North Channel along the channel margins. The South Channel is generally less vegetated, except for downstream portions in the vicinity of the Program's Cook and Dyer (Cook/Dyer) conservation properties.

Waimakariri River, New Zealand (Wikimedia Commons, Photograph by Greg O'Beirne)

Figure 2-1 Example of Braided River Form

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3. ALTERNATIVE DEVELOPMENT AND EVALUATION METHODOLOGY

This section discusses the methodology used in the Study to identify and screen the alternatives for the sediment augmentation experiment.

3.1 Modeling

Baseline steady-state hydraulic and sediment-transport models using the USACE HEC-RAS program were developed and calibrated for the Project reach. The baseline hydraulic model was developed to evaluate channel capacity and to provide the input for the sediment-transport model. The modeling determined that the average annual sediment deficit in the vicinity of Cottonwood Ranch is approximately 150,000 t/y, which is less than the 185,000 t/y estimate in Priority Hypothesis Sediment #1. In addition, the modeling results suggest that the overall sediment deficit between the Lexington and Odessa bridges is approximately 152,000 t/y. Section 4.2.3 discusses further modeling results. In assessing this value, however, it is critical to note that the transport capacities and resulting sediment deficit are highly dependent on the flow volume and patterns from year to year; thus, the deficit also varies by over an order of magnitude from year to year.

Several experiment alternatives were developed and evaluated for their ability to reduce the 150,000 t/y sediment deficit identified by this Study. The alternatives are described in greater detail in Section 10. Once the alternatives were assembled, the baseline model was modified accordingly and used to evaluate the potential response of the river to assess the benefits (i.e., the reduction of the sediment deficit) associated with the various components of each alternative. The alternative modeling included a suite of the identified potential augmentation components, including likely combinations of delivery technologies, augmentation locations, and augmentation material sizes, to assess the combined effects of the various components. The alternative modeling involved an iterative process wherein initial model results were used to develop subsequent alternatives in an attempt to identify a range of alternatives that best address the sediment deficit. The alternative modeling results were initially used to assess the effects of individual components (e.g., the augmentation material gradation) in the context of the other modeled components (e.g., delivery technology and augmentation location) and were ultimately used to evaluate each of the final alternatives as discussed in Section 10. The modeling efforts and baseline results are discussed in greater detail in Section 4. A detailed technical memorandum, entitled "Hydraulic and Sediment-transport Modeling for the Platte River Sediment Augmentation Feasibility Study, Nebraska," describes the modeling efforts conducted as part of the Study (see **Appendix B**).

The modeling indicated that it is unlikely any of the alternatives would be 100 percent effective in eliminating the sediment deficit at the Cottonwood Ranch. The reason for this conclusion is that more than 150,000 t/y would need to be added based on the available size range of the augmented material with implementation of the augmentation methods for the evaluated alternatives.

3.2 Identification and Screening of Components

The identification and development of alternatives started with the pre-screening of the individual components that make up a complete alternative. The following five major components of a sediment augmentation alternative were evaluated:

1. Sediment augmentation delivery locations – the physical locations on or adjacent to the Platte River where sediment could be discharged into the river such that the deficit at the Cottonwood Ranch location could be addressed. The identification and the screening of the possible sediment augmentation locations are discussed in Section 5.
2. Sediment source – the location or source where appropriate sediment could be acquired for delivery to the river. This includes locations where an available sediment supply could be purchased from an off-site source and those locations where sediment could be mined on

Program-controlled property. The identification and screening of sediment sources is discussed in Section 6.

3. Sediment production and delivery technology – the mechanical or hydraulic mechanism for mining the sediment and actually delivering the sediment to the river. The various delivery technologies and the screening of technologies are discussed in Section 7.
4. Delivery timing – the various delivery timing dates that would be used to begin sediment augmentation activities. Delivery timing is discussed in Section 8.
5. Augmentation material gradation – the various particle gradations that would be used as sediment augmentation material. The augmentation material gradation is discussed in Section 9.

A wide array of options for each of these five components was identified and evaluated to eliminate any component options that were either not feasible or not reasonable.

3.3 Development of Alternatives and Evaluation Criteria

The components that were considered reasonable and feasible were then compiled into a set of complete sediment augmentation alternatives. Where appropriate, alternatives that did not represent a unique solution, or did not offer some type of advantage that warranted consideration, were eliminated. In addition, the various permutations of each combination were evaluated to determine if a "hybrid" alternative would be feasible. Each alternative was described in detail, and a cost per delivered ton of sediment was calculated. Representative alternatives were also modeled, as appropriate, to determine the degree to which the alternative would reduce the sediment deficit. Section 10 describes each of the unique alternatives.

Alternative evaluation criteria were established to enable objective side-by-side comparison of each of the alternatives. The Corps of Engineers (USACE) Section 404(b)(1) Guidelines were used as a starting point for identifying of the evaluation criteria. A total of eight evaluation criteria within the four Section 404(b)(1) Guideline categories were identified. Section 11 describes the process by which the evaluation criteria were developed.

3.4 Screening of Alternatives

Each feasible alternative was evaluated against the eight evaluation criteria, and a side-by-side comparison of each of the feasible alternatives was prepared. Based on the modeling, none of the evaluated alternatives fully meet the need for the Project, in that none of the alternatives fully eliminate the sediment deficit. Therefore, the side-by-side comparison allows the reader to better understand the relative advantages and disadvantages of each alternative. This comparison is presented in Section 12.

3.5 Development of Recommendations

Because this type of large-scale sediment augmentation project is unique and includes numerous variables, the Project includes major areas of uncertainty. Section 13 describes the uncertainties associated with the Project. Recognizing the areas of uncertainty and the Program's adaptive management process, Section 14 identifies the preferred alternative based on the evaluation of the alternatives and discusses the conclusions and recommendations for the Project.

4. BASELINE MODELING AND DESIGN DEVELOPMENT SUMMARY

The baseline steady-state hydraulic and sediment-transport models for the Project reach were developed using USACE's Hydrologic Engineering Centers River Analysis System (HEC-RAS) program. The models were calibrated using measured data to the extent possible. The baseline models were then modified to represent a range of proposed sediment augmentation alternatives. For a detailed technical memorandum describing the modeling efforts conducted as part of the Study, see **Appendix B**.

This section addresses the baseline steady-state hydraulic and sediment-transport model development and results with respect to sediment deficit and surplus volumes, size degradation of eroded and deposited material, and responses to specific hydrologic conditions at key locations.

4.1 Baseline Steady-State Hydraulic Model

4.1.1 Inputs

Steady-state hydraulic model inputs include the following, as described below:

- Geometric data
- Hydraulic structures
- Hydraulic roughness
- Ineffective flow areas
- Downstream boundary conditions

Geometric data – The modeled domain includes the approximately 32-mile reach of the main channel between Lexington and Odessa, and the approximately 8-mile reach of the South Channel along Jeffrey Island below the J-2 Return. The model contains 140 cross sections that extend across the active channel and floodplain. Cross sections were located at hydraulic structures, including the upstream and downstream faces of bridges and the Kearney Canal diversion structure. Cross sections were also located at the Program's Anchor Point survey sections[1], supplemental sections surveyed specifically for the Study, and hydraulic controls (such as constrictions and riffle zones) (Figure 4-1).

The topography for the cross sections was taken from a variety of sources, including the 2009 LiDAR, the Anchor Point surveys, surveys completed for the Study, and fathometer survey information intended to capture the longitudinal main channel thalweg profile.

Hydraulic structures – The model includes four bridge structures: Lexington (U.S. Highway 283), Overton (State Highway 24), Elm Creek (U.S. Highway 183), and Odessa (State Highway 6). As-built bridge plans were obtained from NDOR – Bridges Division and were used to code the bridge piers, abutments, and superstructure into the model using the HEC-RAS bridge data editor. The Kearney Canal diversion structure was also coded into the model based on information from the LiDAR and ground surveys conducted as part of the Study.

Hydraulic roughness – The hydraulic roughness was incorporated into the model using Manning's n-values that vary horizontally across the cross section. Vegetation and land use information from the

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[1] *As part of the Program's Geomorphic Monitoring Program, a systematic sample of points along the river, referred to as "anchor points," has been established. These anchor point cross sections extend laterally across the historic floodplain and incorporate the current main channel as well as all primary split-flow channels. These sections provide for a consistent year-to-year source of topographic and additional data. They were used to supplement other sources of topographic information in the development of the hydraulic and sediment model. (Program, 2009)*

Program's Vegetation Monitoring Program was used to develop the different roughness zones. The roughness zones were then assigned a Manning's n-value based on the vegetation description, field observations, bed material characteristics, past experience with similar rivers, and published values for similar rivers. Roughness values are provided in **Appendix B.**

Ineffective flow areas – Ineffective flow areas were used to ensure that the modeled flow paths are consistent with the actual flow conveyance. Permanent ineffective flow areas were used to block out locations that would not convey flow over the range of modeled flows (e.g., up- and downstream from bridge structures or within the gravel pits), while non-permanent ineffective flow areas were used in overbank flow paths where the area is ineffective at low flows but would become effective at high flows. The HEC-RAS levee feature was used only to define contiguous features that would limit conveyance to the main channel (i.e., the Interstate 80 [I-80] structure).

Downstream boundary conditions – The downstream boundary conditions were established assuming normal depth with a slope of 0.00125, consistent with the average bed slope in the downstream portion of the model. This slope is also consistent with the slope of the water surface at the time of the LiDAR. The downstream boundary of the model is located a sufficient distance downstream from the Odessa Bridge to ensure that error in the assumed starting water surface elevation does not affect the predicted hydraulic conditions within the Project reach.

4.1.2 Calibration

The model was calibrated, to the extent possible, by comparing the water surface elevations predicted by the model with available measured water surface elevations obtained from rating curves at the stream gages, surveyed water surface elevations from a variety of sources, and inferred water surface elevations from the LiDAR. The results are shown in **Appendix B**.

4.1.3 Results

The baseline hydraulic model was executed over a range of steady-state flows that encompass the measured flow regime, and included flows up to 30,000 cfs.

Results from the steady-state hydraulic model were used to evaluate the channel capacity and to provide input to the sediment-transport model. Comparison of the predicted water surface elevations with the top-of-bank elevations indicates the following, although there is significant variability in the data:

- The North channel capacity is slightly less than 3,500 cfs upstream of the confluence with the South Channel (i.e., above the flows delivered by the J-2 Return).
- The channel capacity increases to about 6,000 cfs downstream of Jeffrey Island.

4.2 Baseline Sediment-Transport Model

4.2.1 Inputs

The geometry and other inputs to the steady-state hydraulic model served as the basic framework for the sediment-transport model. Minor modifications to the geometry were made to address limitations in the HEC-RAS Sediment Transport Model as well as other sediment-transport model input (i.e., bed material gradation data, upstream and lateral sediment supplies, and flow hydrographs), as discussed in detail in **Appendix B**.

4.2.2 Calibration

The baseline sediment-transport model was executed using a 12.5-year period of flow record extending from October 1, 1989, to April 1, 2002. This period was selected because it corresponds to the period with the largest amount of data with which to calibrate the model and represents a range of hydrologic data appropriate for this effort.

The model was calibrated, to the extent possible, by comparing the predicted aggradation/degradation trends and changes in bed material size to observed data along the Project reach. The baseline model includes the existing channel geometry and the existing gradation of the bed material; therefore, only the trends in aggradation/degradation and coarsening/fining were considered in calibrating the model. The primary data used to calibrate the model were obtained from repeat cross-sectional surveys conducted by the BOR between 1985 and 2005 (BOR, 2006).

4.2.3 Results

The primary purpose of the model was to address Priority Hypothesis Sediment #1 that a sediment deficiency of 185,000 to 225,000 t/y exists in the Project reach. To evaluate this deficiency, the baseline sediment-transport model was executed over the calibration period of flow record between October 1, 1989, and April 1, 2002, because this period included a reasonable distribution of flows. Results from the baseline model simulation were evaluated to assess the magnitude, distribution, and characteristics of sediment loading along the Project reach under existing conditions. In general, the results indicate that the overall sediment deficit between the Lexington and Odessa bridges is approximately 152,000 t/y over the 12.5-year simulation period.

To evaluate the distribution of this deficit, the Project reach was divided into five subreaches, identified in Table 4-1 and shown in Figure 4-1. The total mass sediment surplus or deficit in each subreach was computed using the cumulative mass flux that enters and exits each subreach at various points during the simulation. The average annual surplus or deficit was quantified by dividing the cumulative differences at the end of the 12.5-year simulation period. Results of the analysis are shown in Table 4-1 and Figure 4-2. Note that the Program's preferred location to evaluate the effectiveness of the Project, just upstream (west) of NPPD's Cottonwood Ranch, is within Subreach 3.

Table 4-1 Total Sediment Deficit and Surplus Volumes in Each Reach

Subreach	Upstream Limit	Downstream Limit	Specific Location	Aggradational/ Degradational	Deficit (-)/ Surplus (+) (t/y)
1	Lexington Bridge	Overton Bridge	North Channel	Slightly to moderately aggradational	+66,400
2	J-2 Return	Overton Bridge	South Channel	Degradational	-96,700
3	Overton Bridge	Elm Creek Bridge	Cottonwood Ranch Reach	Degradational	-108,500
4	Elm Creek Bridge	Kearney Canal diversion structure	Immediately Upstream of Kearney Diversion	Slightly to moderately aggradational	+32,700
5	Kearney Canal diversion structure	Odessa Bridge	Immediately Downstream of Kearney Diversion	Degradational	-46,100
Total Reach					**-152,200**[1]

Note:
[1] *For the purpose of the Study, the sediment deficit for the entire Project reach has been rounded to 152,000 t/y.*

Results also indicate the following:

- In Subreach 1, the most significant amount of aggradation occurred in water year (WY) 1995 due to the high-magnitude flood that occurred during the summer of that year.
- In Subreaches 2 and 3, degradation appears to be most significant during the period between 1996 and 2000 when the runoff volume was relatively large. Upstream of the Kearney Canal diversion structure, deposition occurred in each year of the simulation except 1995, when extreme flooding flushed deposited sediments from the reach, and in 2000, when very little change occurred.
- Subreach 4 is slightly aggradational due to the backwater effects of the Kearney Canal diversion structure.
- In Subreach 5, the degradation is probably affected by the gains and losses that occur in this reach but also mirrors the aggradational trend in Subreach 4, with the largest degradation volumes occurring during years when sediment trapping in Subreach 4 was the largest. Degradation in Subreach 5 tends to be greater during years when the unmeasured gains are large compared to the losses, since no sediment load is associated with the inflow (i.e., WY1996).

HEC-RAS does not segregate the erosion/deposition volumes between the overbanks and the main channel. Because the deficits in the main channel have a significant effect on sandbar development and morphology, the lateral distribution of the sediment deficits or surplus was estimated by computing the change in volume in the overbanks and in the main channel using the channel geometry at the start of the simulation and at various times during the simulation. To compute these volumes, end-area calculations were performed using the average reach length between the up- and downstream cross sections.

The distribution indicates that a significant amount of sediment storage occurs in the overbanks; thus, the main channel deficits are somewhat greater than the total deficits in subreaches that are degradational, and the main channel surplus is somewhat less than the total surplus in subreaches that are aggradational. Results are shown in Table 4-2 and Figure 4-3.

Table 4-2 Main Channel Sediment Deficit and Surplus Volumes in Each Subreach

Subreach	Upstream Limit	Downstream Limit	Specific Location	Aggradational/ Degradational	Deficit (-)/ Surplus (+) (t/y)
1	Lexington Bridge	Overton Bridge	North Channel	Slightly to moderately aggradational	+47,100
2	J-2 Return	Overton Bridge	South Channel	Degradational	-97,700
3	Overton Bridge	Elm Creek Bridge	Cottonwood Ranch Reach	Degradational	-149,800[1]
4	Elm Creek Bridge	Kearney Canal diversion structure	Immediately Upstream of Kearney Diversion	Slightly to moderately aggradational	+7,200
5	Kearney Canal diversion structure	Odessa Bridge	Immediately Downstream of Kearney Diversion	Degradational	-50,300

[1] *For the purpose of the Study, the sediment deficit for Subreach 3 (the reach that includes Cottonwood Ranch) has been rounded to 150,000 t/y.*

4.3 Size Gradation of Eroded and Deposited Material

The baseline model results were processed to evaluate the size of the material that makes up the sediment deficit or surplus. Results of this analysis indicate that, in each of the subreaches, most of the eroded or deposited material is in the medium to coarse sand range (0.25 to 1.0 mm). Results indicate the following:

- In Subreach 1, the deposited material includes about 10 percent very fine to fine sand (<0.25 mm), about 67 percent medium to coarse sand, and about 23 percent in the very coarse sand (VCS) to gravel range (>1 mm).
- Of the depositional reaches, the largest percentage of coarse material (29 percent VCS to gravel) is eroded from Subreach 2 due to the availability of the coarse fractions in the surface material and the relatively high transport capacity in most of the South Channel.
- In Subreach 3, eroded material includes nearly equal parts of fine and coarse material (20 percent less than 0.25 mm and 21 percent greater than 1 mm).
- In Subreach 4, VCS and gravel make up a significant portion (about 32 percent) of the material that is deposited upstream of the Kearney Canal diversion structure.
- In Subreach 5, the deficit is well graded, with 24 percent very fine to fine sand, 51 percent medium to coarse sand, and 25 percent VCS and gravel.

4.4 Responses to Hydrologic Conditions

The baseline model simulation results were used to evaluate the response of the river to specific hydrologic events at key locations. For this evaluation, the mass fluxes across the subreach boundaries and the associated deficit or surplus within the subreach were plotted with the representative flow hydrographs over the simulation period. Results indicate the following:

- In Subreach 1, most of the aggradation occurs during high flow periods that result in significant overbank storage. Nearly half of the cumulative sediment deposition at the end of the simulation occurred during the 1995 flood.
- Because there is no sediment supply to Subreach 2, the rate of degradation in this reach is directly linked to the J-2 Return flows, with the most significant amounts of degradation occurring during high flow release periods.
- In Subreach 3, degradation appears to be largest during sustained high flow periods, with very little change during low flow periods. Short periods of aggradation or no change occurred during the extreme flood events in 1995, 1997, and 1999 due to the large volume of material delivered from Subreach 1.
- In Subreach 4, the largest amount of aggradation tends to occur during high flow periods when the backwater effects from the Kearney Canal diversion structure are most significant, while very little change occurs during low flow periods.
- In Subreach 5, degradation mirrors the aggradational pattern in Subreach 4.

These results were also used to develop relationships between the predicted deficit or surplus and discharge. As expected, the largest volumes of aggradation or degradation occur at the higher discharges when the sediment transport rates are the largest. Results indicate the following:

- In Subreach 1, the surplus increases in a relatively consistent manner with increasing discharge.
- In Subreach 2, the deficit increases in a relatively consistent manner with increasing discharge.

- In Subreach 3, the deficit generally increases with increasing discharge at low to moderate flows (less than about 5,000 cfs), but there is considerable scatter and no consistent trend at higher flows. This behavior is related to both the variability and uncorrelated sediment contributions from the North Channel and the South Channel (i.e., Subreaches 1 and 2, respectively), and hysteresis (i.e., the lagging of an effect behind its cause) during the rising and falling limbs of the hydrograph as finer sediment is depleted from and added to the active bed layer.
- In Subreach 4, upstream of the Kearney Canal diversion structure, most of the aggradation occurs at flows exceeding 2,000 cfs.
- In Subreach 5, degradation appears to be most significant at flows in excess of 1,000 cfs.

4.5 Summary of Baseline Modeling Results

Conclusions from the baseline steady-state hydraulic and sediment-transport modeling results include the following:

- Predicted water surface elevations from the steady-state hydraulic model match the measured data reasonably well.
- Model results suggest that the capacity of the main channel (where there are no split-flow paths) is about 3,500 cfs in the mainstem (i.e., the main course of the river) through Lexington to the channel split around Jeffrey Island (North and South channels around the island). That same capacity continues in the North Channel to the confluence with the South Channel at the downstream end of the island. Downstream of Overton, the channel capacity is about 6,000 cfs.
- Predicted results from the sediment-transport model compare well with observed aggradation/degradation and changes in bed material size trends.
- On an average annual basis, the overall sediment deficit along the reach between the Lexington and Odessa bridges is approximately 152,000 t/y.
- Subreach 1 (the reach between the Lexington and Overton bridges, which includes the North Channel) is moderately aggradational.
- Subreach 4 (the short reach between the Elm Creek Bridge and the Kearney Canal diversion structure) is slightly aggradational.
- Subreaches 2, 3, and 5 (the reaches of the South Channel downstream of the J-2 Return, between the Overton and Elm Creek bridges, and between the Kearney Canal diversion structure and the Odessa Bridge) are degradational.
- Coarsening of the surficial bed material occurs by the end of the simulation along most of the Project reach.

This section provides only a summary of the modeling efforts conducted as part of the Study. The full technical memorandum, “Hydraulic and Sediment-transport Modeling for the Platte River Sediment Augmentation Feasibility Study, Nebraska,” found in **Appendix B**, provides a detailed discussion of the modeling efforts.

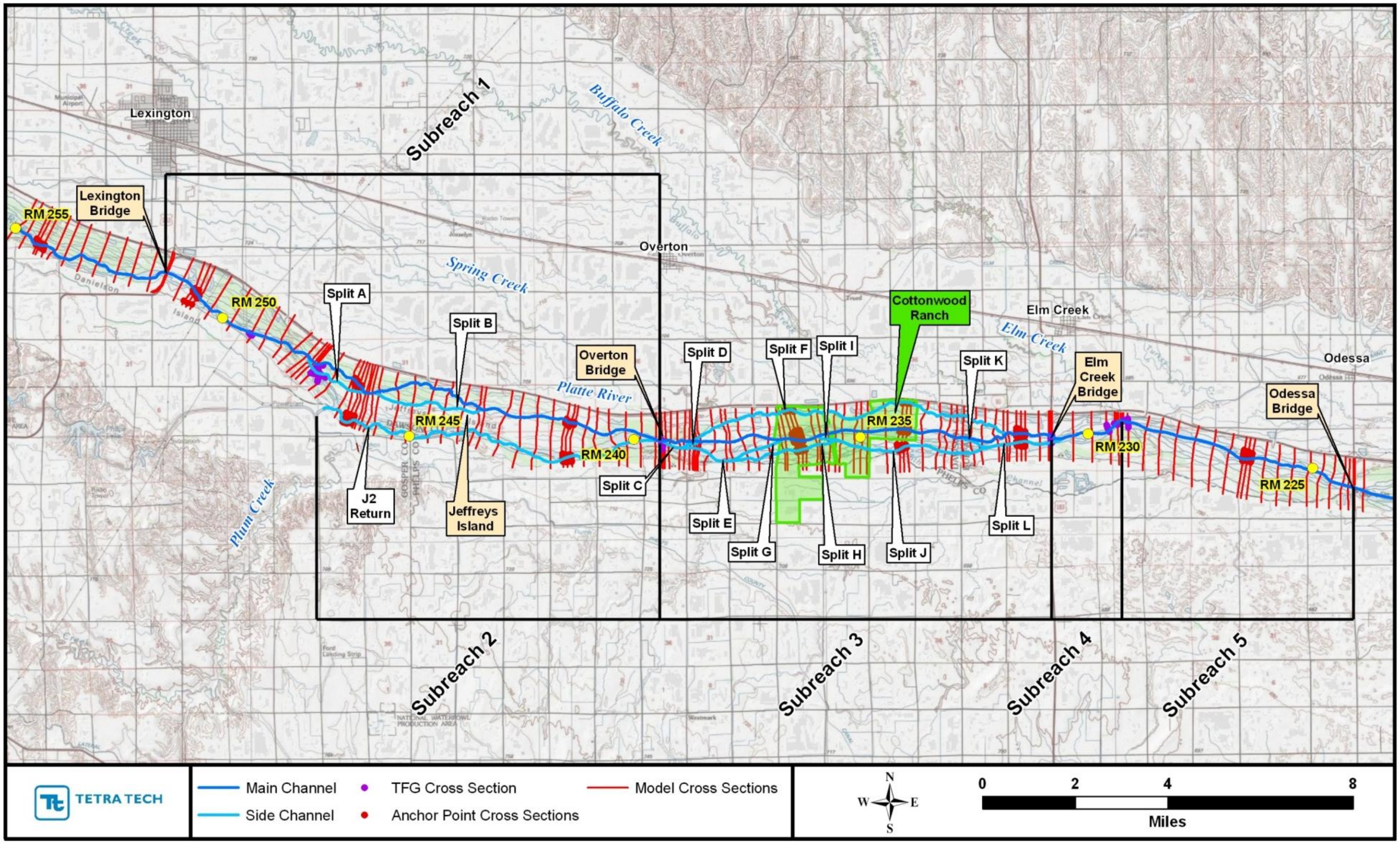

Figure 4-1 Cross Sections Included in the Steady-State Hydraulic Model

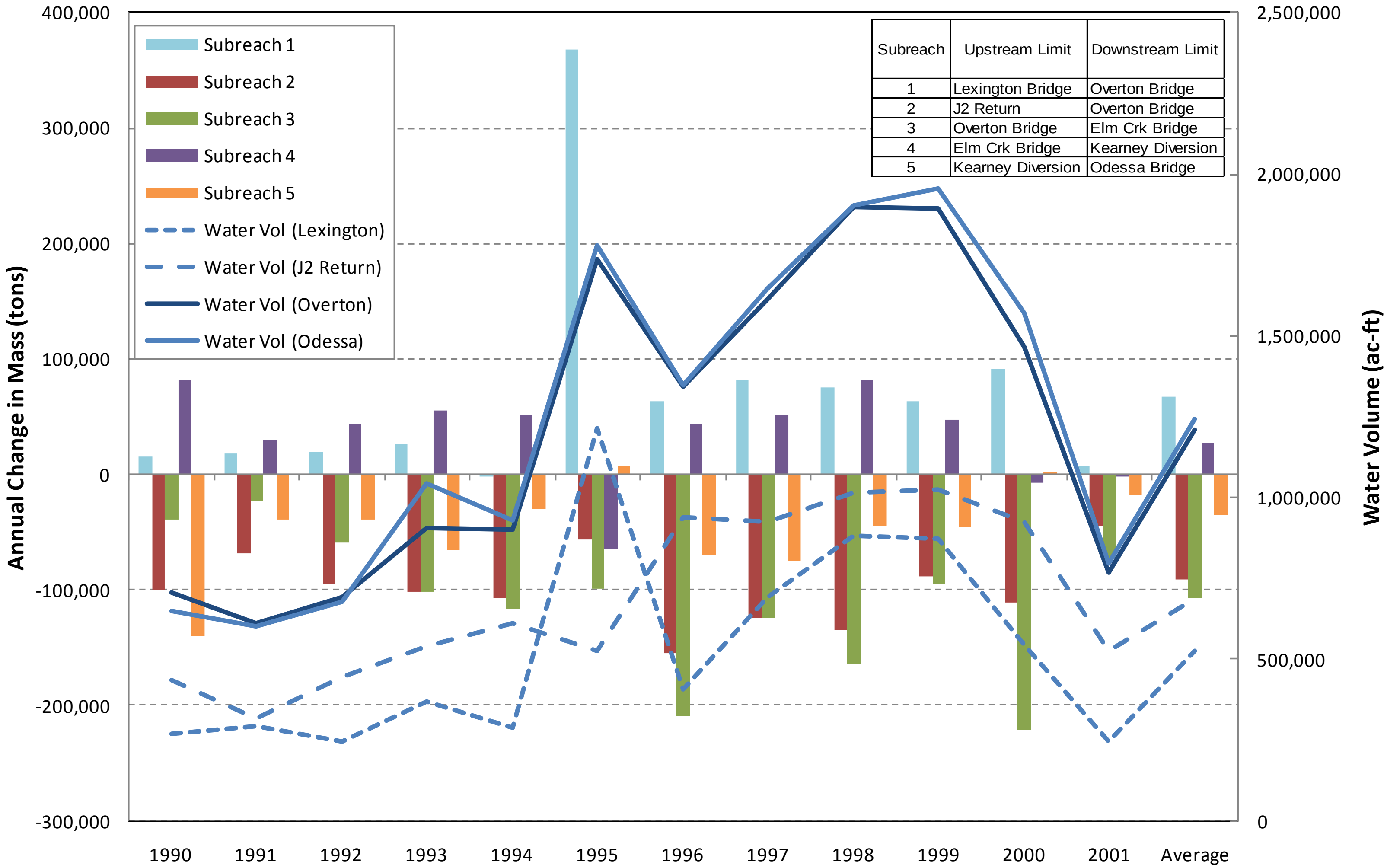

Figure 4-2 Annual Sediment Deficit or Surplus in Each Subreach and Annual Water Volume at Representative Locations along Project Reach

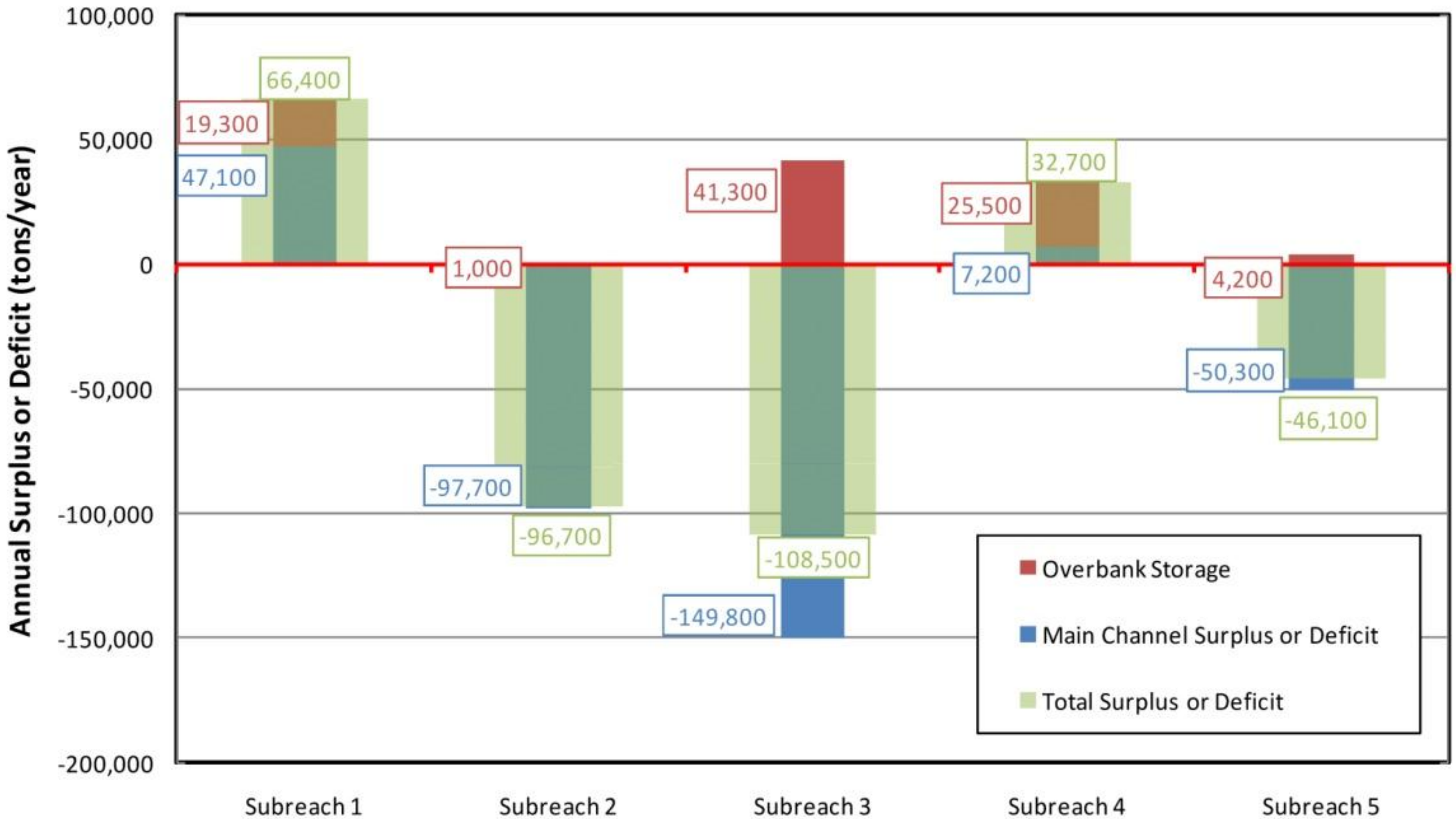

Figure 4-2 Average Annual Total Mass Sediment Deficit or Surplus by Subreach and Estimated Surplus or Deficit in the Main Channel and Overbank

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5. IDENTIFICATION AND INITIAL SCREENING OF SEDIMENT AUGMENTATION DELIVERY LOCATIONS

This section identifies potential delivery locations for sediment augmentation within the Project reach and includes areas owned or leased by the Program or its collaborators and private land in the vicinity of the Project reach.

To meet the long-term goal of the Program, the delivery locations must be in areas where the sediment can be mobilized in the river prior to reaching the upstream end of Cottonwood Ranch. Other requirements include the ability of the location to provide access, staging, and stockpiling. Locations that were not deemed feasible were not carried forward for further analysis.

5.1 Conservation Sites

A conservation property is defined as property owned or controlled, through leases or other arrangements, by the Program or its collaborators (e.g., NPPD, CNPPID, conservation groups). Figure 5-1 shows the location of conservation properties along the Project reach. An initial screening of these conservation properties was conducted to eliminate properties that would not be feasible in achieving the Project goal. The following initial screening criteria were used to eliminate unsuitable properties:

- Location downstream of Cottonwood Ranch
- Significant disruption of the owner's current use of site
- Physical constraints, such as size or configuration
- Location relative to the river (e.g., generally more than 500 feet from the channel)
- Location along the North Channel – Due to the amount of existing vegetation, limited available sites, and potential accumulation of sediment in the channel, augmentation of sediment to the North Channel prior to the rejoining of the North and South channels downstream of Jeffrey Island was screened out during initial screening of augmentation sites. Modeling also indicated that the North Channel is in approximate sediment balance (slightly aggradational), so additional sediment augmentation in the North Channel would likely accumulate in the channel.

Table 5-1 summarizes the conservation properties in the vicinity of the Project reach, the results of the initial screening, and the primary reason(s) that locations were retained for further evaluation as delivery locations or eliminated from further consideration. Figure 5-1 shows the conservation properties in the affected reach.

Table 5-1 Conservation Properties Initially Screened for Delivery Locations

Owner	Retained?		Primary Reason(s) Retained or Eliminated
	Yes	No	
PRRIP			
Cook Tract	X		Located upstream of the Overton Bridge on south side of Platte River; suitable size
Dyer Property	X		Located upstream of the Overton Bridge on south side of Platte River; suitable size
Elm Creek/Morse/ Johnson/Robinson		X	Located off-channel
Bartels		X	Located downstream of Cottonwood Ranch; disruption of current use

Owner	Retained? Yes	Retained? No	Primary Reason(s) Retained or Eliminated
NPPD			
Lexington Sandpit		X	Located upstream of Jeffrey Island
Lexington Island		X	Located upstream of Jeffrey Island; disruption of existing use
Cottonwood Ranch		X	Located downstream of Cottonwood Ranch; disruption of current use
Kearney Canal diversion structure		X	Located downstream
Johnson Sandpit		X	Located downstream of Cottonwood Ranch and off river
CNPPID			
J-2 Return		X	Small size of site
Jeffery Island and Adjacent River		X	Disruption to island and river
Reregulating Reservoir Project		X	Located off-river
Nebraska Game and Parks Commission (NGPC)			
Dogwood Wildlife Management Area (WMA)		X	Located on North Channel; disruption of current use
Blue Hole WMA		X	Located downstream of Cottonwood Ranch; disruption of current use
Sandy Channel State Recreation Area (SRA)		X	Located downstream of Cottonwood Ranch; disruption of current use
Blue Hole East WMA		X	Located downstream of Cottonwood Ranch; disruption of current use
Platte River Whooping Crane Trust (PRWCT)			
Johns Tract		X	Located downstream of Cottonwood Ranch; disruption of current use
Sullwold		X	Located downstream of Cottonwood Ranch; disruption of current use
The Nature Conservancy (TNC)			
Andersen Tract		X	Located off river

Therefore, based on this initial screening, the following conservation properties were retained as potential sediment augmentation delivery locations:

- Cook Tract
- Dyer Property

There are currently no other conservation properties being considered for inclusion in the Project. The Program continues to evaluate potential needs for additional conservation properties. If uses for existing properties change, or the Program acquires control of additional land, those properties may be evaluated for possible inclusion in future sediment augmentation projects.

5.1.1 Cook Tract

The Cook Tract is located 1.5 to 2.5 miles upstream of the Overton Bridge on the south side of the Platte River (Figure 5-1, at the end of this section). The western edge of the property encompasses the area around the east end of Jeffrey Island. The tract includes approximately 130 acres within the river channel and 240 acres of overbank area, for a total area of approximately 370 acres. The overbank areas to the south are primarily farmed or in pasture. The overbank areas to the north are between the overall north and south banks of the river and consist of vegetated islands. A small, unnamed drainage flows into the Platte River at the east end of the property. The southern, rectangular-shaped portion of the Cook Tract is open and undeveloped, with relatively little vegetation. The northeastern portion of the property is more densely vegetated.

There are currently no other Program projects on the Cook Tract. The Cook Tract has been identified primarily for evaluation and use in sediment augmentation projects; however, the site may be evaluated for future potential habitat projects.

5.1.2 Dyer Property

The Dyer Property is located 0.5 to 1.5 miles upstream of the Overton Bridge on the south side of the Platte River (Figure 5-1). It is directly adjacent to the east end of the Cook Tract and has an area of approximately 360 acres. The Dyer Property includes approximately 150 acres within the river channel and 210 overbank acres. There are several sandpits on the east end of the property from previous dredging operations. The overbank areas include farmed areas and pasture as well as the sandpits mentioned above. Overbank areas in the river consist of vegetated islands.

There are no other current Program projects on the Dyer Property. The existing sandpits on the property offer some habitat. The Dyer Property has also been identified primarily for evaluation and use in sediment augmentation projects; however, the site may be evaluated for future potential habitat projects in the channel and/or overbank areas.

5.2 Private Properties

The focus for the Project is on properties owned or controlled (e.g., through leases) by the Program or its collaborators (e.g., NPPD, CNPPID). There were no specific private properties identified as potential sediment augmentation delivery locations, with the exception of privately owned and operated commercial sand and gravel operations in the vicinity of the Project reach, which are discussed below as a separate category of sites. The analysis does not preclude the use of other properties during the implementation phase of sediment augmentation.

5.3 Existing Commercial Sand and Gravel Mining Operations

Commercial sand and gravel mining operations were considered for the potential augmentation delivery locations. Figure 5-2 shows the locations of active sand and gravel mining operations in the vicinity of the Project reach, which are clustered near the I-80 interchanges at Lexington, Overton, and Elm Creek due to the ease of transportation access. All of these operations are pit dredge operations.

Because the Program does not control the private sand and gravel operations, the logistics of their involvement is more complicated. In order for the Program to use a site for augmentation, an agreement would have to be negotiated with the owner prior to use and would likely involve compensation from the Program.

5.3.1 Initial Screening of Commercial Sand and Gravel Mining Operations

An initial screening of these existing commercial sand and gravel mining operations was conducted to eliminate properties that would not be feasible in achieving the Project goal. The following initial screening criteria were used to eliminate unsuitable properties:

- Locations north of I-80
- Location downstream of Cottonwood Ranch
- Significant disruption of the owner's current use of site
- Physical constraints, such as size or configuration
- Location relative to the river (e.g., generally more than 500 feet from the channel)
- Location along the North Channel

Table 5-2 summarizes the existing commercial sand and gravel operations in the vicinity of the Project reach and the results of the initial screening.

Table 5-2 Existing Commercial Sand and Gravel Operations near the Project

Owner	Retained?		Primary Reason(s) Retained or Eliminated
	Yes	No	
Lexington Interchange			
Paulsen, Inc.		X	Located north of I-80
Overton Sand and Gravel Company (OS&G)		X	Less channel area to work within and more potential for negative impacts from modified channel morphology
Overton Interchange			
OS&G	X		Upstream of Cottonwood Ranch
Carl Whitney Sand and Gravel Inc.	X		Upstream of Cottonwood Ranch
Elm Creek Interchange			
Paulsen, Inc.		X	Location downstream of Cottonwood Ranch
T&F Sand and Gravel		X	Location downstream of Cottonwood Ranch

Therefore, based on the initial screening, the following commercial sand and gravel operations were retained as potential sediment augmentation delivery locations:

- Overton Sand and Gravel (Overton Interchange)
- Carl Whitney Sand and Gravel (Overton Interchange)

5.3.2 Operations at the Overton Interchange

There are two sand and gravel pits operating at the Overton interchange, as shown on Figure 5-2. These operations are located approximately 1 to 2 miles upstream of Cottonwood Ranch and are close to the Program's Cook Tract and Dyer Property. Carl Whitney Sand and Gravel is located approximately 0.5 mile east of OS&G and could also be used as an augmentation site. The cost and evaluation would not differ significantly between either location. The two existing sand and gravel pits at the Overton interchange are described in the following sections.

5.3.2.1 Overton Sand and Gravel

The OS&G operation at Overton is south of I-80 and just east of the interchange. The location of the operation, directly adjacent to the river channel, would allow the site to be used as a delivery location. The location would allow for direct discharge into the river from ongoing operations if material gradations and permitting issues allowed. However, direct discharge into the river may have logistical implications in that it would be difficult to control the quantity and quality of material discharged. Direct discharge would also be directly tied to the owner's other operations and not sediment augmentation. Permitting for potential direct discharge will be addressed during the implementation phases of sediment augmentation.

In 2009, the dike separating the OS&G operation from the river was breached, allowing the river to flow into the sand pit. Observations by Program staff and review of aerial photographs post-breach indicate that the sand pit has partially filled with sediment. In its current state, the sand pit is acting as a sediment sink; however, the volume of sediment entering the pit is unknown. As such, the breached sand pit would likely trap a significant amount of the augmented material under alternatives involving augmentation upstream from this location.

5.3.2.2 Carl Whitney Sand and Gravel

The Carl Whitney Sand and Gravel pit is located approximately 0.5 mile east of OS&G. Similar to the OS&G operation, the pit is located adjacent to the river channel. This location would allow the site to be used as a delivery location.

5.4 North Channel Sediment Augmentation Delivery Locations

As stated above, approximately 2 miles downstream of Lexington, flows in the Platte River historically split and flow around Jeffrey Island. The North Channel and South Channel rejoin near the east end of the Dyer Property. A sand dam constructed in the channel upstream of Jeffrey Island diverts flow to the North Channel.

The sediment deficiency analysis by BOR concluded that not all of the sediment deficiency at the Overton Bridge could be mitigated by augmenting in the South Channel alone, as this channel does not carry all of the flow. Detailed analysis of the sediment deficiency conducted for the Project indicates that in order to approach sediment balance at Cottonwood Ranch, some augmentation would have to occur in Subreach 3 downstream of the Overton Bridge.

During the initial evaluation of potential delivery sites, the North Channel around Jeffery Island was screened out from consideration for augmentation based on logistical and flow concerns. These concerns include the following, as described below:

- Vegetation
- Limited opportunities for locating augmentation sites along the North Channel
- Limited ability to carry additional sediment

The North Channel around Jeffrey Island flows through an area with significant stands of vegetation. The vegetation would likely limit the effectiveness of augmentation in this channel because higher flows would be in the adjacent vegetated floodplain. This would cause suspended sediment to more readily settle out rather than being carried downstream.

NPPD's Lexington Sandpit and Lexington Island areas are upstream of where the flow splits around Jeffery Island; however, these areas are primary habitat locations and not suitable for delivery locations. In addition, these areas are at the upstream end of the Project reach; modeling has indicated that the farther upstream the augmentation sites are located, the less effective they are at achieving sediment balance at Cottonwood Ranch because sediment settles out prior to reaching that location. CNPPID has some river access on the north side of Jeffery Island across and slightly upstream of the Cook Tract; however, this area contains a high density of vegetation as well.

Sediment-transport modeling conducted for the Study indicates that this subreach (Subreach 1) is nearly in sediment balance, resulting in limited ability to carry additional sediment.

Therefore, based on these logistical and flow concerns and the results of the sediment-transport modeling, North Channel sites have been eliminated from consideration as delivery locations.

5.5 Summary of Viable Sediment Augmentation Delivery Locations

The sites retained for further evaluation as delivery locations are:

- Cook Tract
- Dyer Property
- OS&G (Overton Interchange)
- Carl Whitney Sand and Gravel (Overton Interchange)

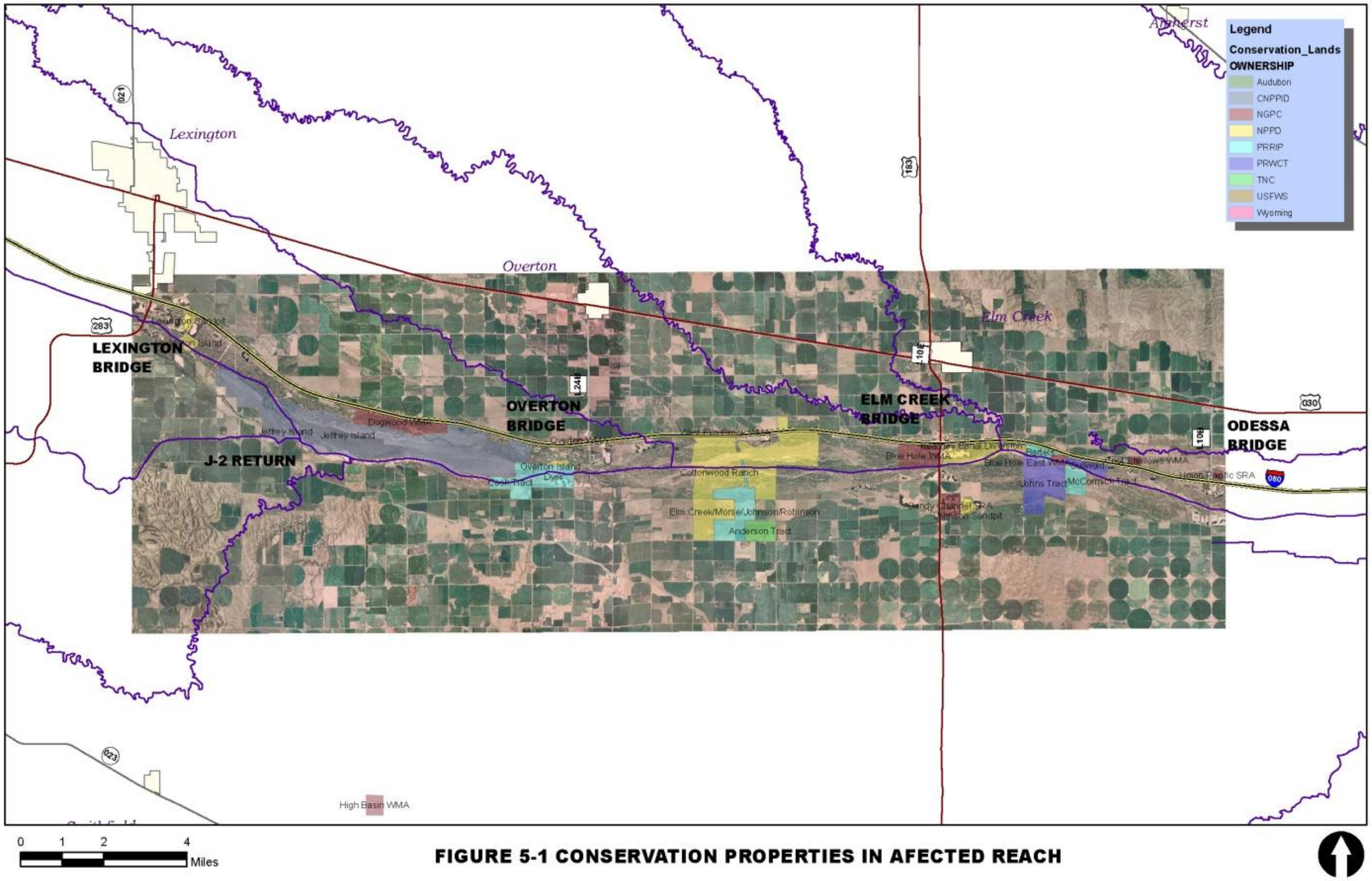
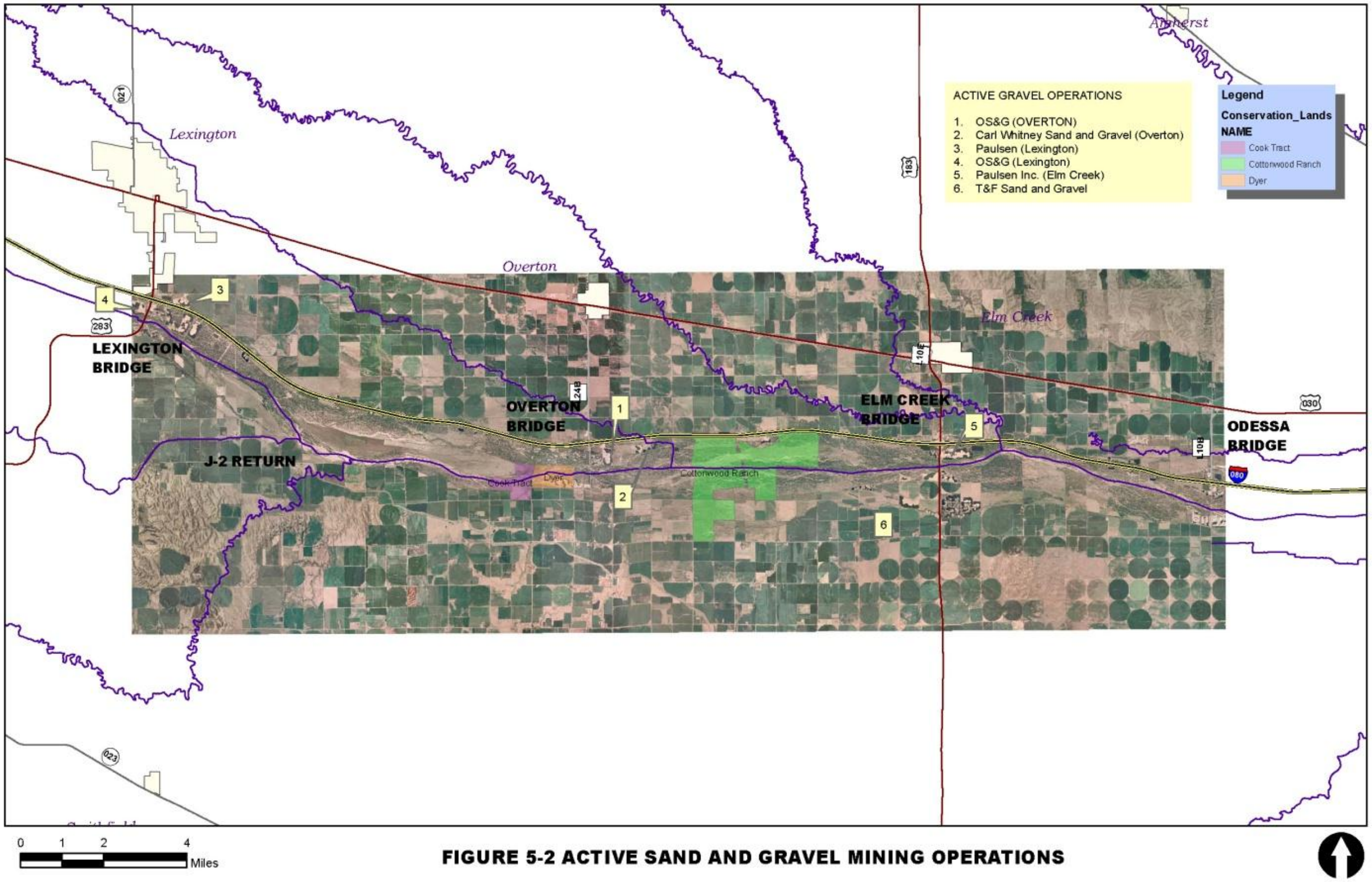


Figure 5-1 Conservation Properties in the Affected Reach



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2 **Figure 5-2 Active Sand and Gravel Mining Operations**

6. IDENTIFICATION AND INITIAL SCREENING OF SEDIMENT SOURCES

This section identifies potential sediment source locations for implementation of the Project. Sites identified include areas owned or leased by the Program or its collaborators as well as private land in the vicinity of the Project reach. Sites that were not deemed feasible were not carried forward for further analysis.

Other considerations for the site evaluations included the ability to provide source material and the physical space requirements to provide access, staging, and stockpiling activities.

6.1 Conservation Sites

An initial screening of conservation properties in the Project reach (Figure 5-1) was conducted to eliminate properties that would not be feasible in achieving the Project goal. The following initial screening criteria were used to eliminate unsuitable properties:

- Lack of viable source material
- Significant disruption of the owner's current use of the site
- Physical constraints, such as size or configuration

Table 6-1 summarizes the conservation properties in the vicinity of the Project reach, the results of the initial screening, and the primary reason(s) that locations were retained for further evaluation as sediment sources or eliminated from further consideration.

Table 6-1 Conservation Properties Screened for Sediment Source Locations

Owner	Retained?		Primary Reason(s) Retained or Eliminated
	Yes	No	
PRRIP			
Cook Tract	X		Suitable source of augmentation material
Dyer Property	X		Suitable source of augmentation material
Elm Creek/Morse/ Johnson/Robinson		X	Location at the extreme downstream end of the Project reach and existing and planned habitat projects make it less feasible due to potential disturbance of created and maintained habitat; more suitable locations closer to the augmentation delivery sites would create less disturbance to habitat projects
Bartels		X	Disruption of current use
NPPD			
Lexington Sandpit		X	Limited source opportunity; closer sources available
Lexington Island		X	Limited source opportunity; closer sources available; disruption of existing use
Cottonwood Ranch		X	Location at the extreme downstream end of the Project reach and existing and planned habitat projects make it less feasible due to potential disturbance of created and maintained habitat; more suitable locations closer to the augmentation delivery sites would create less disturbance to habitat projects.
Kearney Canal diversion structure		X	Source area under private lease; disruption of current use
Johnson Sandpit		X	Limited source opportunity; closer sources available

Owner	Retained?		Primary Reason(s) Retained or Eliminated
	Yes	No	
CNPPID			
J-2 Return		X	No viable source; site too small
Jeffery Island and Adjacent River		X	Disruption to island and river; minimal ability to process material; limited long-term potential
Reregulating Reservoir Project		X	Project is only in feasibility stage; volume of excess material would not sustain long-term source
NGPC			
Dogwood WMA		X	Disruption of current use
Blue Hole WMA		X	Disruption of current use
Sandy Channel SRA		X	Disruption of current use
Blue Hole East WMA		X	Disruption of current use
PRWCT			
Johns Tract		X	Disruption of current use
Sullwold		X	Disruption of current use
TNC			
Andersen Tract		X	Disruption of current use

Therefore, based on this initial screening, the following conservation properties were retained as potential sediment source locations:

- Cook Tract
- Dyer Property

Currently, no other conservation properties are under consideration for inclusion in the Project. The Program continues to evaluate potential needs for additional conservation properties. If uses of existing properties change, or the Program acquires control of additional land, those properties may be evaluated for possible inclusion in future sediment augmentation projects.

6.1.1 Cook Tract

As part of the source material evaluation, two soil borings were collected on the south high bank of the Cook Tract (Section 5.1.1). Soil boring results (**Appendix C**) indicate that source material is available in the subsurface to a depth of approximately 36 feet below ground surface (Figure 6-1). Based on gradation analysis of the soil samples collected, approximately 51 percent of the material is below the 1 mm target size identified in the BOR model and modeling conducted for the Study (**Appendix B**). Based on the gradation, it is estimated that 2.5 to 3 million tons of augmentation material (assuming a material density of 1.4 tons per cubic yard) is available on this site within an approximately 107-acre area identified as a potential source area in the overbank[2]. Therefore, the overbank material appears to provide a suitable

[2] *To calculate the total amount of material available, it was estimated that the specific gravity of the augmentation material was 104 pounds per cubic foot (lb/cf). The value was not adjusted for moisture content; however, it is within the level of error for a feasibility study.*

source of augmentation material if excavated or pumped from a sand mining operation. Figure 6-1 shows overbank source areas on the Cook Tract.

Potential source material is available from features within the high bank river channel on the property. Areas that would typically not be undated from most flows were examined as an additional, albeit likely limited, additional source of augmentation material. Evaluation of source material potential within the river channel was generally limited to material above elevations corresponding to river flows of 1,500 to 2,000 cfs flows in the South Channel. These flows represent a practical maximum elevation for the introduction of sediment into the river and elevations that might serve a future habitat purpose. These elevations are approximately 2,314.5 feet at the west end and 2,311 feet at the east end of the Cook Tract. Figure 6-1 shows the approximate boundaries of the high banks and potential source material within the channel between the high banks. Based on evaluation of cross section and topographic data, it is estimated that there are 100,000 to 400,000 gross tons of material available for augmentation. The material in the river channel is expected to be similar to the material present in the overbank areas, as it is all depositional material. Based on the gradation evaluation of the overbank material, only about half of the material is of sufficient size to provide a transportable sediment source.

Experiments leveling higher macroforms at Cottonwood Ranch using dozers indicated that the effectiveness of mobilizing the sediment pushed into the channels from adjacent higher elevations was dependent on how the material was placed. Some methods were more effective than others. Because of Because of the limited volume of material within the channel and the observations from the experiments at Cottonwood Ranch, the higher macroforms within the channel were not further evaluated as a potential long-term source of augmentation material. If the higher macroforms were leveled in the future, there would likely be some short-term benefit, such as a potential reduction of the amount of augmentation material needed from other sources during those years when macroform leveling occurs.

However, the Cook Track was retained for consideration as a sediment source location for the overbank areas.

6.1.2 Dyer Property

As part of the sediment source evaluation, three soil borings were collected on the Dyer Property, (Section 5.1.2). Soil boring results (**Appendix C**) indicate that source material is available to a depth of approximately 30 feet below ground surface (Figure 6-2). Based on gradation analysis of the soil samples collected, approximately 56 percent of the material is below the 1 mm target size identified in the BOR model and modeling conducted for this Study (**Appendix B**). It is estimated that 1.5 to 2 million tons (assuming a material density of 1.4 tons per cubic yard) of augmentation material is available on this site within an approximately 55-acre area identified as a potential source area[3]. Therefore, the overbank material appears to provide a suitable source of augmentation material if excavated or pumped from a sand mining operation. Figure 6-2 shows overbank source areas on the Dyer Property.

The Dyer Property is more heavily vegetated outside the central portion of the property where the active channel flows. Similar to the Cook property, the higher elevation areas offer a potential limited surface source of augmentation material. As discussed with the Cook Tract, source material is generally limited to elevations above those that would correspond to desired elevations for potential future habitat projects. Those elevations range from approximately 2,309 ft on the west end of the property to 2,305 ft on the east end of the property. The volume of source material available within the channel on the Dyer Property is estimated to be similar or less than that available on the Cook Track. Figure 6-2 shows the boundaries (high banks) of potential surface source material within the channel on the Dyer Property. Similar to the

[3] *To calculate the total amount of material available, it was estimated that the specific gravity of the augmentation material was 104 lb/cf. The value was not adjusted for moisture content; however, it is within the level of error for a feasibility study.*

Cook Tract, the higher macroforms within the channel on the Dyer Property were not further evaluated as a potential long-term source of augmentation material.

The Dyer Property was retained for consideration as a sediment source location for the overbank materials.

6.2 Existing Commercial Sand and Gravel Mining Operations

Existing commercial sand and gravel mining operations were considered for sediment sources for the Project. Figure 5-2 shows the location of the active sand and gravel mining operations in the vicinity of the Project reach, which are clustered near the I-80 interchanges at Lexington, Overton, and Elm Creek due to the ease of transportation access. All of these operations, listed below, are pit dredge operations:

- Lexington Interchange – Paulsen, Inc.
- Lexington Interchange – OS&G
- Overton Interchange – OS&G
- Overton Interchange – Carl Whitney Sand and Gravel
- Elm Creek Interchange – Paulsen, Inc.
- Elm Creek Interchange – T&F Sand and Gravel

Because the Program does not control the private sand and gravel operations, the logistics of their involvement is more complicated. Any of the sand and gravel operations would likely be able to provide sediment source material; however, the material would likely need to be purchased. Hauling costs would also need to be factored into the costs, with the potential for price variability from one producer to the next. Since there are six active sand pit operations in the vicinity of the Project, additional sources on private properties were not considered.

Samples were collected from the sand piles at the six active sand and gravel mining operations listed above and submitted to a laboratory for gradation analyses. Results indicate that, on average, the material appeared to be consistent with the gradations recommended by the BOR (that is, D50<1 mm) to make it a suitable sediment source with minimal, if any, further processing. However, as discussed below in Section 9, the gradation of the augmented material may need to be somewhat coarser than that recommended by the BOR. Results from the sediment-transport model indicate that, if the augmented material is obtained from the sand and gravel mining operations and is not processed, a significant amount of the augmented material would be entrained and flushed through the Project reach, thereby providing minimal benefits to the sediment deficit. As such, it may be necessary to increase the volume of augmented material if this material were used without any processing. There were slight variations between the different operations, likely due to differing products being produced at the time the sand piles were created. This is expected because the sand piles are byproducts of the primary products (e.g., concrete gravel, road gravel, armor coat) with varying gradations.

The sampling results are summarized in Table 6-2. The table shows the estimate of the percentage of available material from the sand pile samples collected at the various operations. Note that the BOR modeling in support of the FEIS indicated that the sediment deficiency was mostly in the size range less than 1 mm in diameter.

Table 6-2 Sand and Gravel Operations – Material Samples

Location	Operation	> 1 mm (%)	<1 mm (%)	< 1 mm and > 0.25 mm (%)	<0.25 mm (%)
Lexington	Paulsen, Inc.	20	80	66	14
Lexington	OS&G	14	86	71	25
Overton	OS&G	18	82	66	16
Overton	Carl Whitney Sand and Gravel	16	84	69	15
Elm Creek	Paulsen, Inc.	23	77	63	14
Elm Creek	T&F Sand and Gravel	19	81	65	16
Average	**Average of all six operations**	**18**	**82**	**67**	**17**

Note: Refer to ***Appendix C*** *for detailed gradation information.*

The sediment-transport model was used to further evaluate the sediment deficit in the Cottonwood Ranch reach. Results indicate that the sediment deficit is mostly in the medium to coarse sand fraction (~60 percent 0.25 mm – 1 mm), while 20 percent is smaller than medium sand (<0.25 mm) and 20 percent falls into the VCS to gravel (>1 mm) range. Based on these refined percentages, there appears to be a deficiency in material in the sand piles in the VCS gravel fraction greater than 1 mm in size as well as the 0.25 mm and smaller fraction.

A large fraction of the fine sand material produced at the local sand pits and available in the stock piles at these operations is less than the 1 mm size identified in the FEIS. Compared to the model results, on average, the fraction of material at the sand pits is slightly lacking in sizes greater than 1 mm (18 percent as opposed to 20 percent) and less than 0.25 mm (17 percent as opposed to 20 percent). The lack of the coarser fraction appears to be more influential as modeling indicates a good portion of the sand material from the pits tends to flush through the system requiring additional material added to the stream to achieve balance. This is described further in the modeling results section. The Paulsen pits at Lexington and Elm Creek and the T&F pit at Elm Creek have the highest percentage of material greater than 1 mm. If coarser material is necessary to meet the Project goal, processing of this material would be required.

The existing sand and gravel operations are retained for further evaluation.

6.3 Summary of Viable Sediment Sources

The following sites were retained for further evaluation as sediment sources:

- Cook Tract
- Dyer Property
- Existing sand and gravel operations at Lexington, Overton, and Elm Creek interchanges

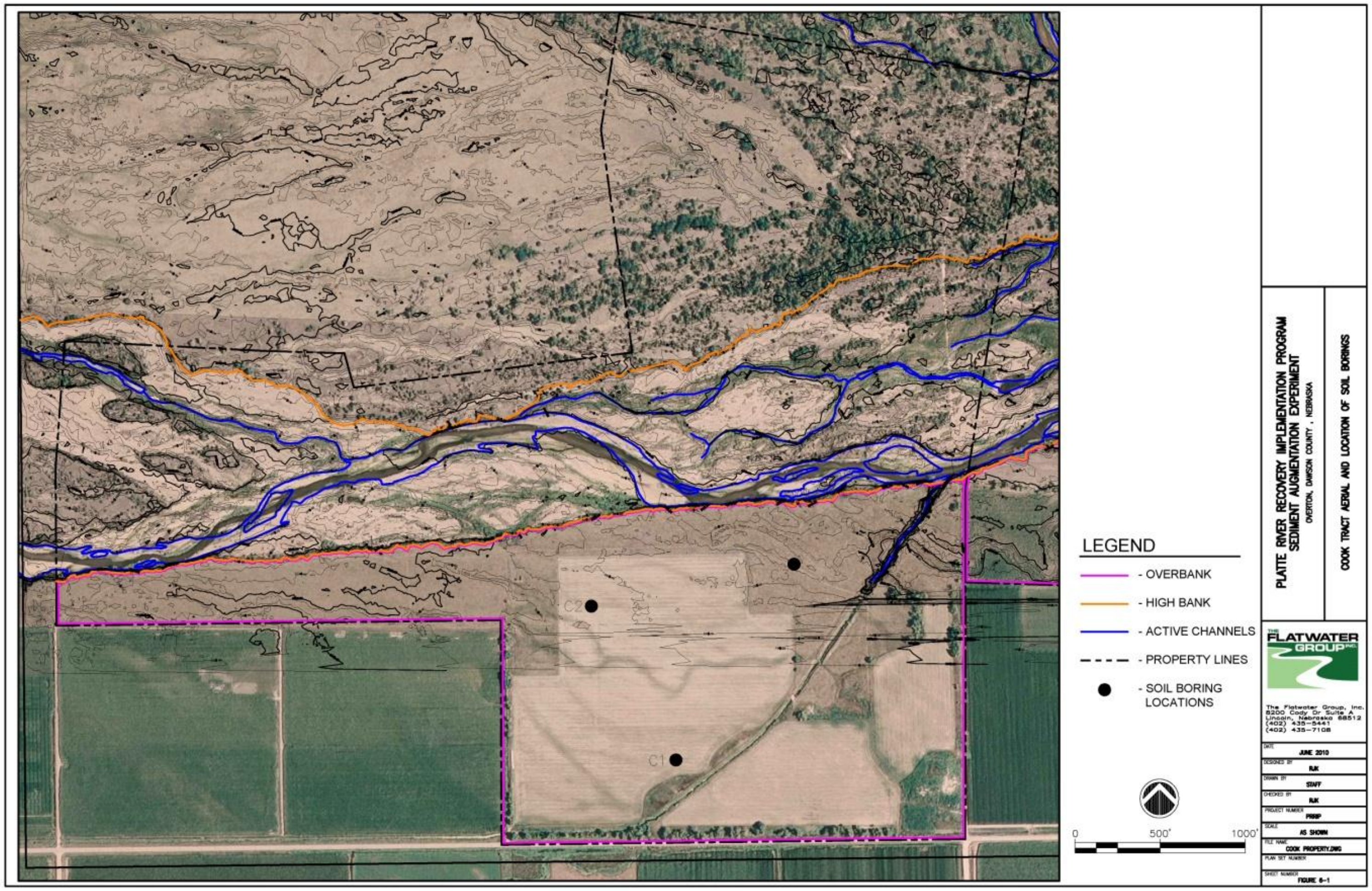

Figure 6-1 Cook Tract and Location of Soil Borings

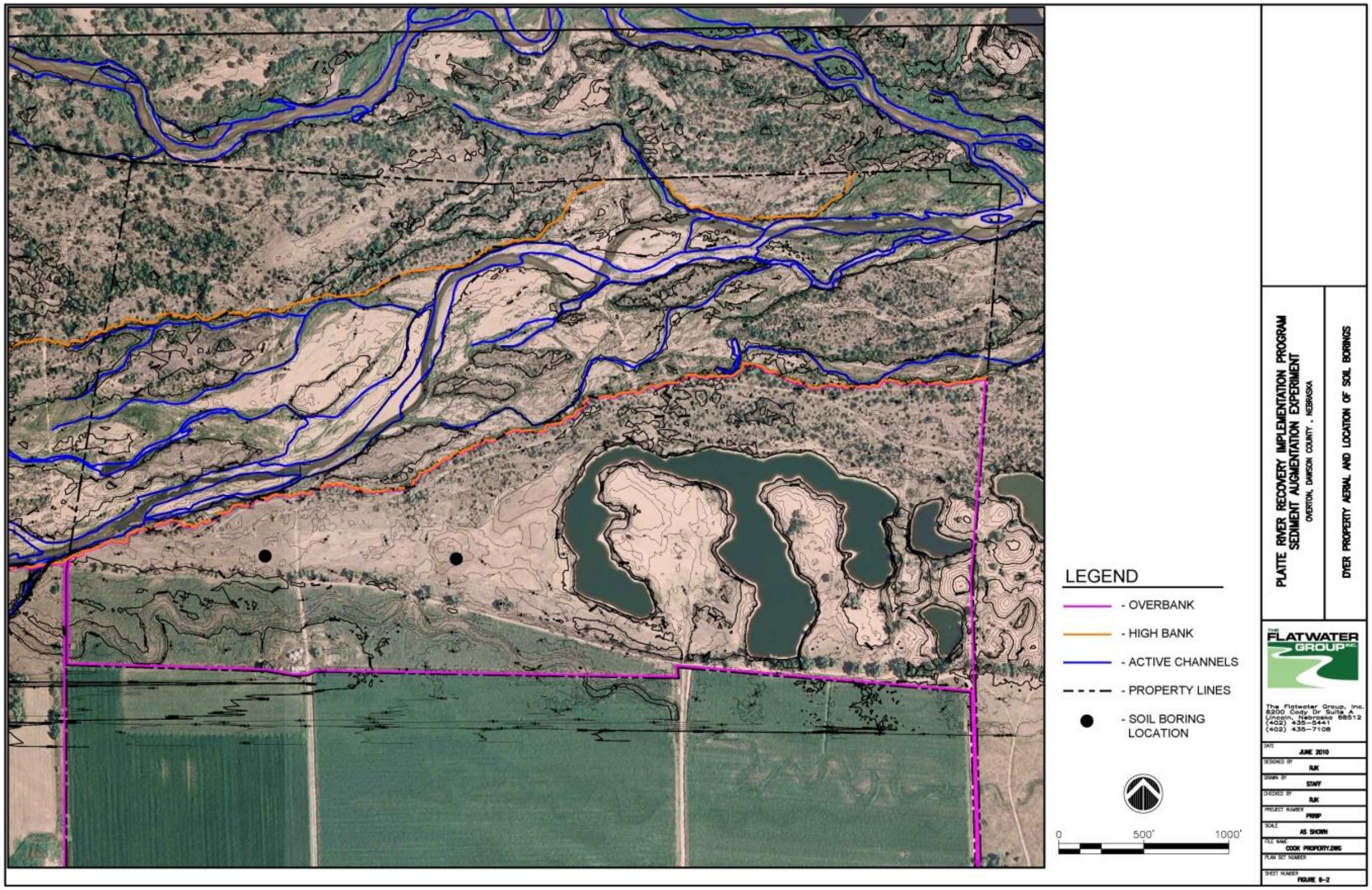

Figure 6-2 Dyer Property and Location of Soil Borings

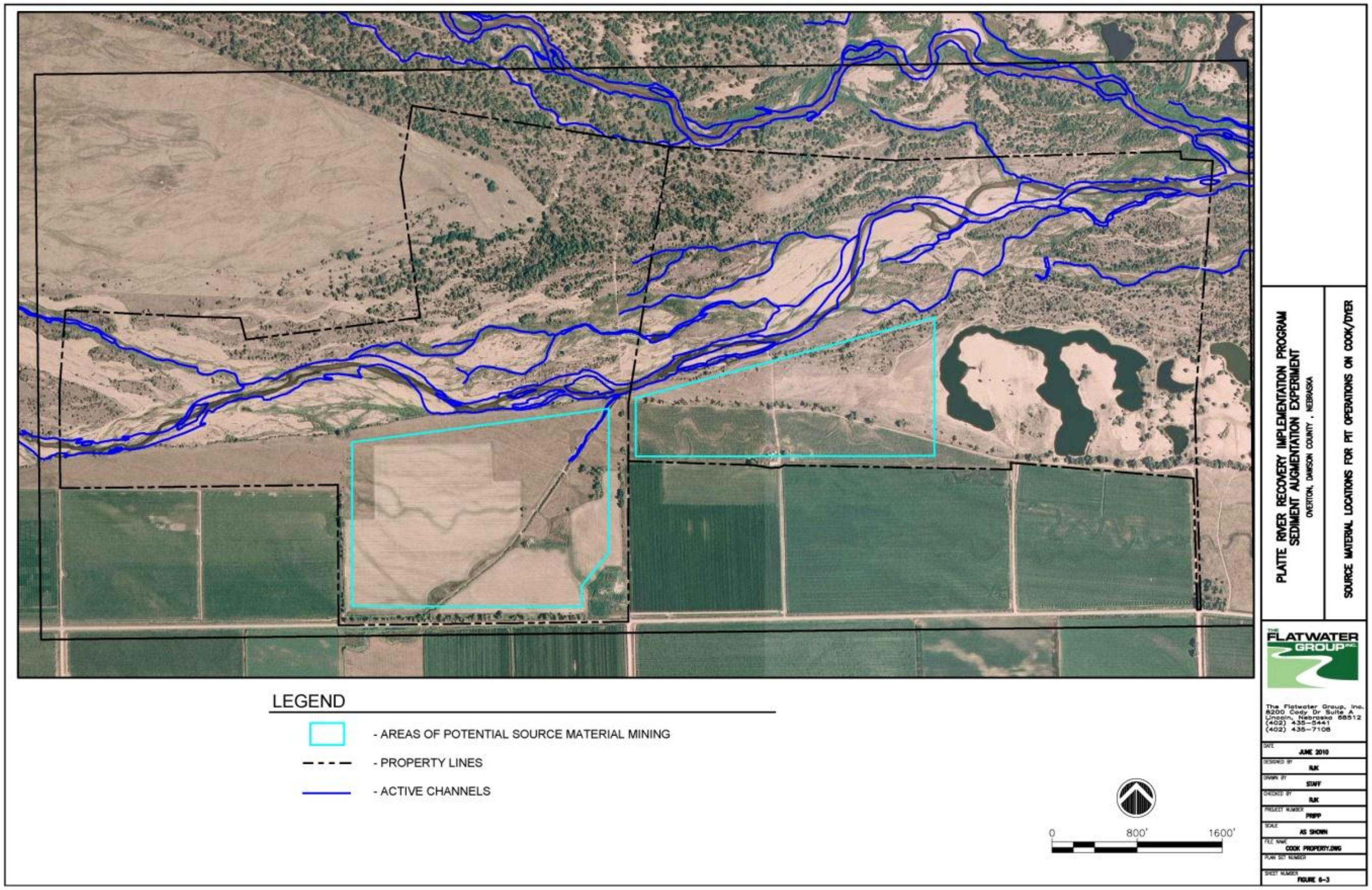

Figure 6-3 Source Material Locations for Pit Operations on Cook/Dyer

7. IDENTIFICATION AND INITIAL SCREENING OF TECHNOLOGIES

This section identifies various sediment production technologies, as well as methods of delivering sediment to the river, that were considered for the development of alternatives. These technologies are the most feasible and likely to be used during implementation of the Project. The Project is results based (i.e., sediment balance at the upstream end of Cottonwood Ranch) and, ultimately, there will be numerous means and methods of achieving those results within the parameters of the final design. The actual technologies used to implement the design will partly depend on how the Project is implemented (e.g., competitive bidding, sole source), the entity selected to implement the Project, and how specific the methods of implementation are dictated by the Program. An initial screening of the available technologies was conducted so that only the technologies that are most likely to be used were considered in the cost evaluation.

7.1 Sediment Production Technologies

The initial screening of sediment production technologies eliminated technologies that would not be feasible in achieving the Project goal. The following initial screening criteria were used to eliminate unsuitable technologies:

- Limited ability to screen out unsuitable material
- Not viable long-term
- Contributor to future sediment deficits
- Limited amount of sediment available
- Not cost-effective
- Ineffective due to shallow groundwater

Table 7-1 summarizes the sediment production technologies evaluated, the results of the initial screening, and the primary reason(s) that technologies were retained for further evaluation as sediment production technologies or eliminated from further consideration.

Table 7-1 Sediment Production Technologies

Sediment Production Technologies	Retained?		Primary Reason(s) Retained or Eliminated
	Yes	No	
Portable River Dredges		X	Limited ability to screen out material that is not optimal; not a viable long-term solution; possible contributor to future sediment deficits; limited amounts of sediment available; other technologies are more cost effective
On-site Pit Dredges	X		Common technology to mine material; efficient and economical; ability to process material at production site
Excavators (hoes, shovels, clam shells, etc.)		X	Due to shallow groundwater, other technologies are more effective
Dozers and Loaders	X		Cost effective for shallow excavations
Off-site Sources	X		Numerous commercial sand and gravel mining operations in vicinity of Project reach

Therefore, based on this initial screening, the following technologies for sediment production were retained:

- On-site pit dredges
- Dozers and loaders
- Off-site sources

7.1.1 On-site Pit Dredges

Off-river pit dredges are the most common method of mining aggregate in the Platte Valley (Figure 7-1). Shallow groundwater and an abundance of material make pit dredges an efficient and economical technology to produce augmentation material. The ability to process material using screens at the production site makes this technology beneficial in producing optimal sized material. The dredged material can be processed to obtain the optimal gradation, identified in the modeling efforts, needed to achieve sediment balance in the reach. There is sufficient space on Program-controlled property to establish a new pit dredging operation, if desirable.

Two of the active dredging operations are located directly adjacent to the river and are upstream of Cottonwood Ranch. These operators have the ability to discharge directly into the river with minimal adjustment to their operations. Direct discharge to the river from a pit dredging operation would only be possible if the gradation of the material discharged fits within the parameters identified during sediment-transport modeling and if permit requirements can be met.

Pit dredging operations result in permanent land disturbance. One or more lakes remain on the property after production ceases. There is also a significant amount of the larger material that would not be used and would need to be stockpiled or removed from the site. These larger fractions may have a beneficial market value, although there are six current private production sites in the immediate vicinity. If pit dredging operations are implemented on Program properties, these would be considerations in determining the final habitat development of the properties.

Therefore, on-site pit dredges were retained as a potential sediment production technology.

7.1.2 Dozers and Loaders

Dozers and loaders are effective at moving material on or near the surface for short distances. Dozers could be used to mine material from sandbars within the river and from adjacent overbank areas. Dozers are retained for inclusion as a sediment production technology for source areas within the river (e.g., existing sandbars) and directly adjacent to the river. While not specifically for sediment augmentation, similar processes have been used to move material into the river for habitat creation at Cottonwood Ranch. Therefore, dozers and loaders were retained as a potential sediment production technology.

7.1.3 Off-site Source

There are numerous privately owned sand and gravel mining operations in the vicinity (within 10 miles) of the Project reach that utilize pit dredges for sediment production (discussed in Section 7.1.1). These sand and gravel mining operations are equally distributed at the upstream, middle, and downstream end of the Project reach and are described in Section 5.3. Hauling augmentation material from these operations to the delivery site or sites is a viable option and is retained for consideration in the development of alternatives.

Therefore, off-site sources were retained as a potential sediment production technology.

7.2 Sediment Delivery Technologies

An initial screening of sediment delivery technologies was conducted to eliminate technologies that would not be feasible in achieving the Project goal. The following initial screening criteria were used to eliminate unsuitable technologies:

- Limited effectiveness
- Higher mobilization costs
- Not viable long term
- Contributor to future sediment deficits
- Limited amount of sediment available
- Not cost-effective
- Ineffective due to shallow groundwater

Table 7-2 summarizes the sediment delivery technologies evaluated, the results of the initial screening, and the primary reason(s) that technologies were retained for further evaluation as sediment delivery technologies or eliminated from further consideration.

Table 7-2 Sediment Delivery Technologies

Sediment Delivery Technologies	Retained?		Primary Reason(s) Retained or Eliminated
	Yes	No	
Dozers and Loaders	X		Traditional method; effective at moving material; cost-effective
Portable Conveyor Systems	X		Common technology
Fixed Conveyor Systems		X	Less available; higher mobilization costs; because of the changing nature of the river channel and the potential for flooding, fixed conveyor systems are not feasible for extending the reach into the river bed
Clamshell or Backhoe		X	Limited effectiveness due to limited reach and lower mobility
Sand Pump/Slurry Pipeline	X		Minimal construction footprint; effective at placing material in river
Portable River Dredges		X	Limited effectiveness; possible contributor to future sediment deficits; other technologies are more cost effective
Pit Dredging Operations Adjacent to River	X		Ability to discharge directly into river

Therefore, based on this initial screening, the following technologies for sediment delivery were retained for consideration in the development of alternatives:

- Dozers and loaders
- Conveyor systems
- Sand pump/slurry pipeline
- Pit dredging operations

7.2.1 Dozers and Loaders

Dozers and loaders are the traditional method of placing and shaping sand and gravel in rivers. Direct access to the river is required for their use. They are effective at moving material on or near the surface. Dozers are effective at delivering material to the river at locations where direct access to the river is available and the material is available locally (e.g., sand bars) or where material can be delivered relatively close (within 500 to 600 feet) to its final disposition. Dozers can traverse rugged and wet terrain.

Dozers would be used to push the material to the desired locations in the channel from stockpiles along the south bank. Access points to the river will need to be constructed to allow dozer access from the high bank down into the river channel. The easiest locations for placement of the material are those areas where the active channel is closer to the south high bank of the river where stockpiles will be located. This will minimize push distance and placement time and therefore minimize cost.

Dozers can be used to place material in numerous configurations, depending on the terrain and needs of a project. Configurations evaluated for this Project include those listed in Table 7-3, which were evaluated using the hydraulic and sediment-transport models (see **Appendix B**):

Table 7-3 Dozer Placement Techniques and Results of Modeling

Dozer Placement Technique	Results of Modeling
Placement of material in windrows along the bank toes	Some scouring of the pile toes would likely result in the sloughing of a relatively limited amount of material into the active channel that would be available for transport, but most of the material in the windrows would remain in-place, with relatively little effect on downstream deficits.
Placement of material in windrows located to increase inundation	The reduced shear stress caused by the windrow configuration would probably not be sufficient to entrain and transport the augmented material.
Placement of material in one concentrated (short-length) sediment plug in overall channel	A relatively large percentage of the augmented material is eroded from the plug; however, a significant portion of this material is deposited upstream from the confluence with the North Channel due to backwater conditions in the area, especially at high flows.
Placement of material in a distributed (long-length) sediment plug in low flow channel	Most of the material that is eroded from the plug is transported through the reach downstream from the plug and delivered to the Overton Bridge; however, during a wet year, a significant portion of the material that is eroded from the sediment plug is deposited in the reach upstream from the confluence.

Therefore, for the purposes of further evaluation of alternatives, placement of material in a distributed (long-length) sediment plug located in the low flow channel bed is retained as a delivery option for consideration in the development of alternatives. Ultimately, there will be numerous means and methods of achieving the desired results within the parameters of the final design. The actual technologies used to implement the design will partly depend on how the Project is implemented (e.g., competitive bidding, sole source), the entity selected to implement the Project, and how specific the methods of implementation are dictated by the Program. These uncertainties are further discussed in Section 13.

7.2.2 Conveyor Systems

Conveyor systems are a common technology for moving and stockpiling large volumes of material. There are a variety of conveyor systems available, from fixed to portable to truck or crane mounted.

Access to the high bank at most augmentation locations is relatively easy, making the use of portable-type conveyors, such as traditional belt-type conveyors and truck-mounted conveyors, feasible for the Project (Figures 7-2 and 7-3). The specific type used would mostly depend on availability. Portable conveyor systems can be designed and constructed to virtually any length; however, the practical distance that material can be delivered from the end run is 200 feet or less. If material is required beyond the reach of the conveyor system, a secondary technology, such as a dozer, would be required to place material at the desired location. Conveyors would likely be used to augment other delivery options and could be used for stockpile management, truck loading, or material processing.

Therefore, for the purposes of further evaluation of alternatives, the use of conveyor systems as a stand-alone delivery technology is eliminated for consideration in the development of alternatives. This option may, however, be feasible when combined with dozers to assist in placement of the material into the river channel from the high bank. Benefits may be realized by getting the material down to the bed of the river more efficiently and reducing dozer travel time and distance.

7.2.3 Sand Pump/Slurry Pipeline

Sand pumps/slurry pipelines (Figures 7-4 and 7-5), hereafter referred to as sand pumps, are practical where there is a good water source. Water from the river is fed through a pump or pumps and combined with augmentation material (sand) fed through a hopper. The hopper can be fitted with a grizzly (screens) and vibrating plate to process the material as necessary and keep out large material that may clog pipelines. The combined sand/water combination is then pumped through a slurry pipeline back into the river at the ultimate point of placement. The length of the discharge pipeline can be easily changed to allow for augmentation at multiple locations. The material delivery rate can also be easily adjusted and timed as necessary to provide a sufficient volume of augmentation material while minimizing aggradation of material at the point of discharge.

The use of sand pumps to deliver sediment would allow sediment to be introduced in slurry form at point locations with minimal disturbance from equipment in the channel. Discharge locations can be adjusted with modifications to the distribution pipeline. The pumping systems are relatively portable and can be moved to various locations if needed.

In order to deliver the required volume of sediment identified in the model in a sufficient timeframe to optimize sediment delivery with the timing of flows in the South Channel, a minimum of two augmentation locations were evaluated. Modeling results indicate that using two or more locations would also allow a greater distribution of material and minimize the potential for negative localized impacts on the flow regime.

Sand pump delivery sites could be set up in any number of locations where there is access to the river. For evaluation purposes, several specific sand pump augmentation sites were identified at various locations within the Project reach, as described below. These locations represent a sound evaluation of the effectiveness for sand pumping and the model results can be reasonably extrapolated to other locations.

- Sand Pump Site 1 (Figure 7-6) – Sand Pump Site 1 is on the west end of the Cook Tract. This location is the farthest upstream and would maximize channel length on Program property downstream of the augmentation site.
- Sand Pump Site 2 (Figure 7-6) – Sand Pump Site 2 is on the west end of the Dyer Property. This location is easily accessible and provides more than 4,000 feet of stream length on Program property downstream of the augmentation site.

- Sand Pump Site 3 (Figure 7-7) – Sand Pump Site 3 is on the east end of the Dyer Property in the vicinity of the existing sandpits.
- Sand Pump Site 4 (Figure 7-8) – Sand Pump Site 4 is downstream of the confluence of the North and South channels on private property at OS&G. For costing and evaluation purposes, OS&G was used as the potential private location. Carl Whitney Sand and Gravel is located approximately 0.5 mile east of OS&G and could also be used as an augmentation location. The cost and evaluation would not differ significantly between either location. In order to use any private property, agreements will need to be negotiated with the private operations.
- Sand Pump Site 5– Sand Pump Site 5 is a non-specific location in close proximity to the active dredging operation. This site can be moved as the operation moves to maintain short haul distances.

Therefore, for the purposes of further evaluation of alternatives, sand pumps are retained as a delivery option for consideration in the development of alternatives.

7.2.4 Pit Dredging Operations Adjacent to River

Pit dredging operations directly adjacent to the river have the ability to discharge material directly into the river (Figure 7-9). Two of the active dredging operations are located directly adjacent to the river and are upstream of Cottonwood Ranch. These operations have the ability to discharge sediment to the river with minimal adjustment to their operations. A new pit dredge operation on Program-controlled property directly adjacent to the river would also have the ability to discharge sediment directly to the river. A permanent sand pit or pits would be created as a result of this operation. These sand pits could have a future habitat benefit.

Direct discharge to the river from a pit dredging operation would be viable only if the proper gradation and volume of the material discharged fits within the parameters identified during sediment-transport modeling or parameters identified by the Program. Larger material could build up in the channel rather quickly if not screened out prior to discharge. Any material screened out would need to be removed from the site, stockpiled, or used in other habitat development projects. The material could also be replaced in the pit upon completion of the Project. There also may be issues with permitting a direct discharge operation.

For evaluation purposes, two pit dredging operation locations were selected, as described below. These locations represent a sound evaluation of the effectiveness of dredging and the model results can be reasonably extrapolated to other locations

- Dyer Property, just west of the existing abandoned sandpits – Approximately 4 to 5 acres of land would need to be made available on the Dyer Property at the initial startup to establish the operation. In addition, 3 to 4 acres of land would be required yearly to provide 150,000 tons of source material on the Dyer Property.
- Cook Tract – Approximately 4 to 5 acres per year would be required as materials are removed and the operation is expanded.

For evaluation purposes, it is assumed that the initial sandpit operation would be established on the Dyer Property just west of the existing sandpits. The sand pit option is discusses in Section 10, Compilation of Alternatives. The actual layout would partly depend on the contractor’s preference.

Because the source material is being generated on Program property and material would not have to be purchased from outside sources, augmentation of material produced on Program property is considered only for delivery locations on Program properties (Cook/Dyer). The incentive for a private sand and gravel operation to allow augmentation locations on their property without having the opportunity to provide the material is low. Also, there would be additional hauling costs to produce the material on Program property and haul it off site to another location.

There are two existing operations directly adjacent to the river and the potential to establish a new pit dredge operation on Program property; therefore, this technology was retained for consideration in the development of alternatives.

Figure 7-1 Pit Dredge

StraightLine of Sandborn, Conveyors and Aggregate Equipment, 12226 Knox Avenue, Sandborn, MN 56083

Figure 7-2 Belt-type Conveyor

Figure 7-3 Truck-mounted Conveyor

Figure 7-4 Sand Pipeline/Sand Pump

Figure 7-5 Slurry Pipeline Delivering Sand

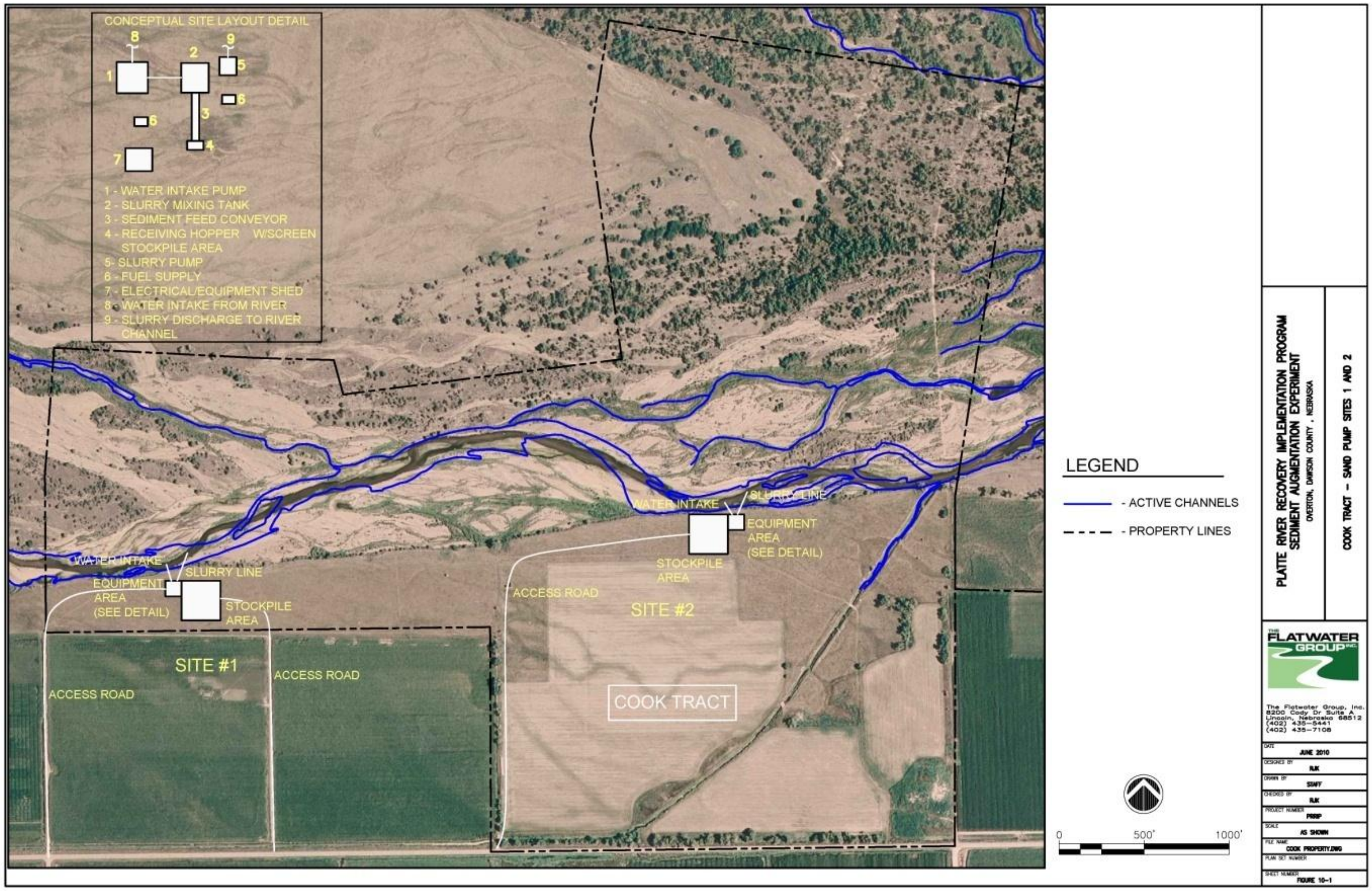

Figure 7-6 Cook Tract – Sand Pump Sites 1 and 2

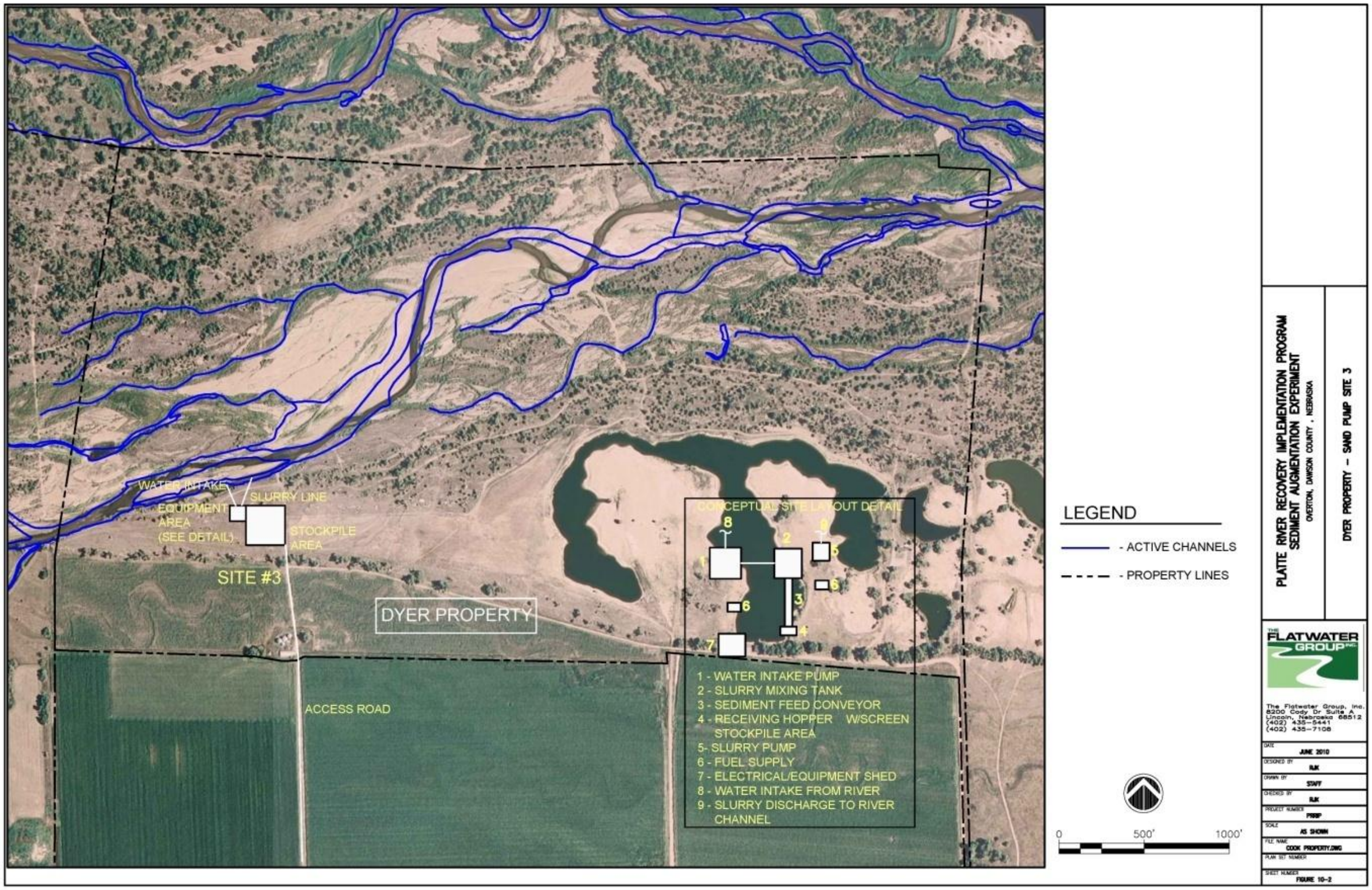

Figure 7-7 Dyer Property – Sand Pump Site 3

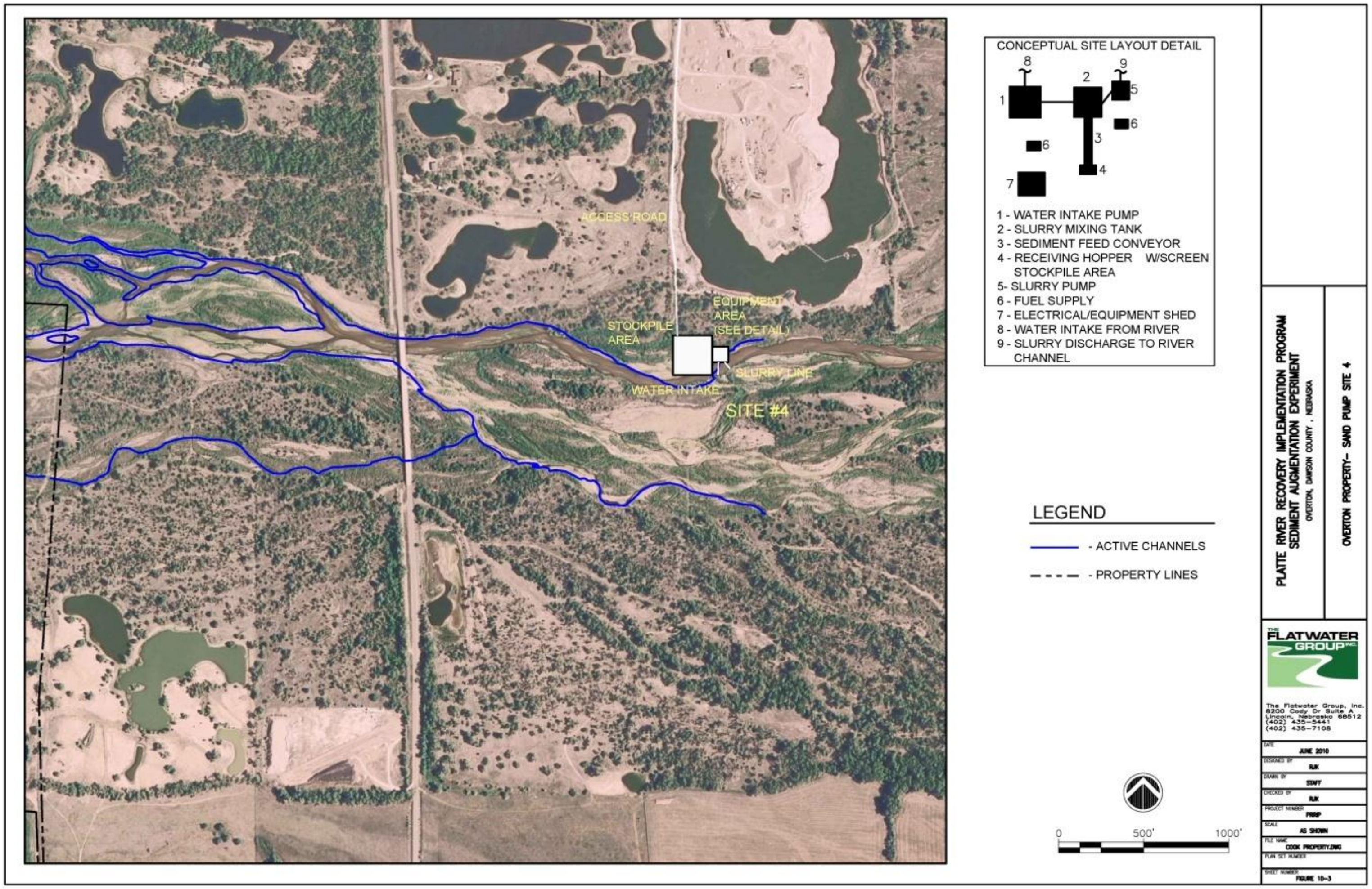

Figure 7-8 OS&G – Sand Pump Site 4

Figure 7-9 Discharging Sediment Directly to River

8. IDENTIFICATION AND INITIAL SCREENING OF DELIVERY TIMING

This section identifies various delivery timing dates that were considered for the development of alternatives. These dates are the most feasible and likely to be used during implementation of the Project. The actual delivery timeframes used to implement the design will partly depend on how the Project is implemented (e.g., competitive bidding, sole source); the entity selected to implement the Project; and how specific the methods of implementation are dictated by the Program. An initial screening was conducted using the delivery timeframes likely to be used for augmentation activities.

To evaluate delivery timing, the calibrated sediment-transport model was used, with sand pumps as the delivery technology implemented. Assumptions used for model development include the following:

- 500 gallon per minute (gpm) pumps
- 25 percent solids
- Pumping completed 5 days/week

To augment 150,000 t/y using these parameters, two pumps would be required for about three months; or three pumps would be required for two months. Preliminary estimates indicate similar durations would be required for placement of the augmented material if dozers were used as the delivery technology.

In the South Channel, flows from the J-2 Return tend to be relatively low during the first month of the pumping in August, increasing to relatively high flows during the last month of pumping in October (Figure 8-1). River flows at the Overton gage are also relatively low during August and increase to moderate levels in October (Figure 8-2). To evaluate the effects of the hydrologic conditions during and after the augmentation period, the sediment load series used to represent the pumping operations was adjusted to start on:

- February 15
- August 1
- September 1

Review of modeling results suggest that pumping start dates have relatively little effect on the amount that the sediment deficit is reduced. The August 1 pumping start date was retained for evaluation purposes as it offers the most flexibility and some time buffer when compared to a September 1 start date.

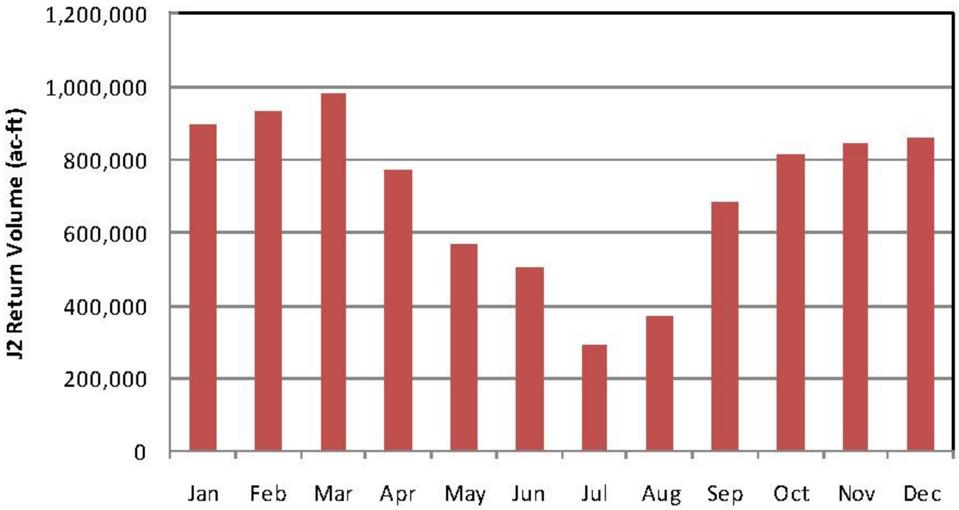

Figure 8-1 Flows from J-2 Return, August through October

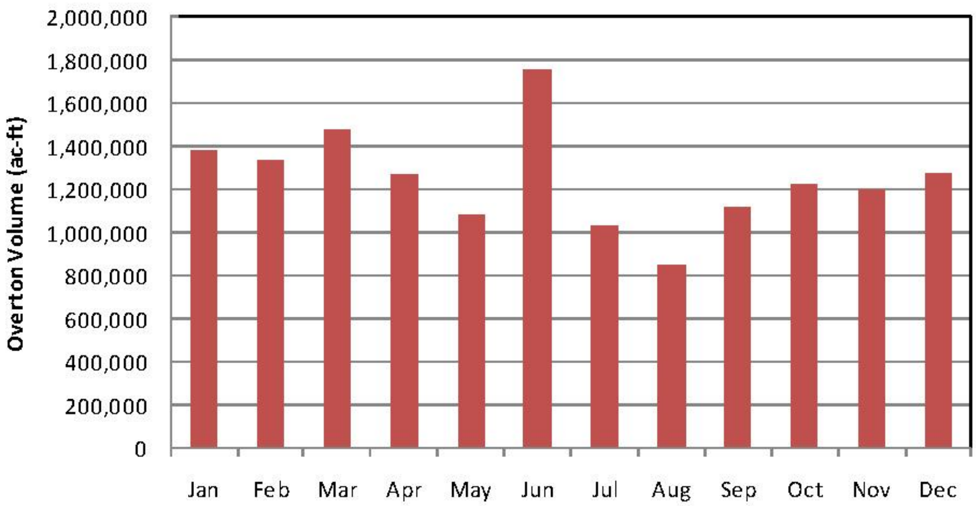

Figure 8-2 Flows at Overton Gage, August through October

9. IDENTIFICATION AND INITIAL SCREENING OF AUGMENTATION MATERIAL GRADATION

As discussed in Section 4.3, the baseline model results were processed to evaluate the gradation of the augmentation material that makes up the surplus or deficit in the Project reach. Results from this analysis indicate that, in each of the subreaches, most of the eroded or deposited material is in the medium to coarse sand range (0.25 to 1.0 mm). However, the gradation of the augmented material that would be required to restore a sediment balance to the Project reach would likely be somewhat coarser, since the gradation of the material in transport is typically somewhat finer than the resident bed material.

To evaluate the effects of the augmentation material gradation on aggradation/degradation, the sediment-transport model simulations for the pumping alternatives were executed with two different gradations of the augmented material, including the following:

- Unprocessed material from OS&G, D50~0.5mm
- Coarser material that is similar to the existing bed material, D50~1.2mm

The gradation of the unprocessed material from OS&G was selected since this material is readily available, while the coarser material that is similar to the existing bed material was selected since this gradation would likely be consistent with the gradation that would be necessary to minimize the augmentation volume (i.e., maintain an augmentation volume of 150,000 t/y). The Project is a results based (i.e., sediment balance at the upstream end of Cottonwood Ranch) and ultimately, there will be numerous means and methods of achieving those results within the parameters of the final design. The actual gradation used will partly depend on how the Project is implemented (e.g., competitive bidding, sole source); the entity selected to implement the Project; and how specific the methods of implementation are dictated by the Program.

As discussed in Section 3, it should be noted that the alternative modeling included a suite of the identified potential augmentation components, including likely combinations of delivery technologies, augmentation locations, and the material sizes identified above, to assess the combined effects of the various components. The alternative modeling results were initially used to assess the effects of the augmentation material gradation in the context of the selected delivery technology (pumping) and augmentation location as discussed in the following subsections, and were ultimately used to evaluate each of the final alternatives as discussed in Section 10.

9.1 Augmentation with Unprocessed Material from OS&G, D50~0.5mm

Under this sediment-transport model simulation, the augmented material would be obtained from OS&G. Two samples were collected from OS&G sand storage piles. The gradation of the augmented material is somewhat finer than the existing channel bed material, with a median grain size (D50) of about 0.5 mm (fine gradation).

Results from these simulations indicate that a significant portion of the relatively fine-grained augmented material would be transported through the Project reach, regardless of pumping location, and only moderately reduced the sediment deficit in any of the degradational reaches.

9.2 Augmentation with Coarser Material that is Similar to Existing Bed Material, D50~1.2mm

Under this sediment-transport model simulation, the gradation of the augmented material was coarsened to more closely resemble the existing bed material. This gradation was developed by averaging the representative gradation of the bed material at the three anchor points in Subreach 3 (the Overton Bridge to the Elm Creek Bridge). The resulting average gradation has a median diameter of about 1.2 mm and includes about 35-percent gravel.

9.3 Summary

Results from these simulations indicate that if coarse material is augmented to the South Channel of Jeffrey Island (Cook Tract/Dyer Property), a significant amount of this material would deposit in the vicinity of the pumps and would not be transported to downstream degradational reaches due to the relatively low hydraulic energies near the pumping locations, thereby reducing the effectiveness of the augmentation. However, if at least one of the pumping operations is relocated to a location in the vicinity of Overton Sand and Gravel (downstream from Jeffrey Island), where the hydraulic energies are somewhat higher, use of the coarser material appears to result in a more significant reduction to the deficit. The temporal patterns of aggradation and degradation are similar to those observed using finer material, but the magnitude of the reduction in degradation is somewhat less.

Therefore, it appears that use of the coarser gradation material could improve the effectiveness of the augmentation, so long as the material is augmented at a location where the hydraulic energy is sufficient to transport the material to the downstream degradational reaches.

In other words, if the augmentation delivery location is on the South Channel, then a fine grain material (similar to the OS&G sand piles) is required to avoid excessive aggradation in the vicinity of the discharge location. Conversely, if the augmentation delivery location is downstream of the confluence of the North and South channels, such as OS&G, then a coarser material is required to provide more sediment transport to the deficit at Cottonwood Ranch.

The optimal augmentation material gradation for sediment augmentation is not known. There may not be an optimal gradation of material that economically meets the goal of eliminating 100 percent of the sediment deficit without causing adverse impacts on local flow conditions (i.e., flooding) or downstream landowners. Section 13 discusses some of the risk and uncertainty associated with quantity and gradation of augmentation material required.

10. COMPILATION OF ALTERNATIVES

The previous sections provided identification and initial screening of various components which will form the basis for alternative development, including the following:

- Sediment augmentation delivery locations
- Sediment sources
- Sediment production and delivery technologies
- Delivery timing
- Augmentation material gradation

A wide array of options for each of these five components was identified and evaluated to eliminate any component options that were either not feasible or not reasonable. The components that were considered reasonable and feasible were then assembled to develop a set of complete sediment augmentation alternatives. Options that were retained after the initial screenings are listed in Table 10-1.

Table 10-1 Options Retained after Initial Screenings

Augmentation Delivery Locations	Sediment Sources	Sediment Delivery Technologies	Timing	Augmentation Material Gradation
Cook Tract/ Dyer Property	Cook Tract/Dyer Property	Sand pump	August 1[1]	D50~0.5 mm[2]
Existing sand and gravel operations at Overton Interchange	Existing sand and gravel operations	Dozers (sand plug)		D50~1.2 mm[2]

Notes:
[1] Review of modeling results suggest that pumping start dates have relatively little effect on the amount that the sediment deficit is reduced. The August 1 pumping start date was retained for evaluation purposes because it avoids ecologically important timeframes, offers the most flexibility, and some time buffer when compared to a September 1 start date.
[2] If the augmentation delivery location is on the South Channel, then a fine grain material (similar to the OS&G sand piles) is required to avoid excessive aggradation in the vicinity of the discharge location. Conversely, if the augmentation delivery location is downstream of the confluence of the North and South channels, such as OS&G, then a coarser material is required to provide more sediment transport to the deficit at Cottonwood Ranch.

Once the initial screenings were completed, the options that were retained were assembled into a set of unique sediment augmentation alternatives. Where appropriate, alternatives that did not represent a unique solution, or did not offer some advantage that warranted consideration were eliminated. In addition, the various permutations of each combination were evaluated to determine if a "hybrid" alternative would be feasible.

There are various combinations of options above that, when assembled, result in a large number of potential alternatives for further evaluation. To reduce this number to a manageable list of comparable, feasible alternatives, the following assumptions were made:

1. To the extent practical, a sufficient volume of sediment will be placed in the river to test whether sediment balance at Cottonwood Ranch can be achieved. Initial alternative evaluation was conducted using the 150,000 t/y average annual sediment deficit in the Cottonwood Ranch reach (modeling Subreach 3) predicted by the baseline sediment-transport model.

2. Sediment augmentation may occur at one or more locations. For evaluation purposes, specific locations were selected for each alternative based on local hydraulic conditions and logistical considerations.
3. For purposes of developing a relative comparison of costs for one technology versus another, a single delivery technology was evaluated for each alternative. This does not preclude the use of a combination of delivery technologies during final design and implementation, if determined to be more efficient.
4. Initial cost estimates assume that sediment would be delivered in the minimum time possible based on the production rates of the equipment assumed for each alternative. This would minimize cost by minimizing labor and equipment expense. Exceptions to this are when the duration of the augmentation period is mandated by the selected delivery technology (i.e., two pumps versus three pumps).
5. As part of the Program's adaptive management approach, alternatives were developed that allow for adjustments over the course of the Project based on ongoing monitoring of the Project. Adjustments may need to be made to the rate of sediment introduction based on river response in habitat creation as well as any adverse impacts such as bank destabilization or increased flooding of downstream landowners.

Based on the assumptions above, the alternatives listed in Table 10-2 were assembled for further evaluation.

Table 10-2 Alternatives

Alternative	Augmentation Delivery Locations	Sediment Source	Delivery Technology	Analysis Type[3]
1	Cook Tract/Dyer Property (two locations)	Imported[1]	Sand pump	Sediment-transport model
2	Cook Tract/Dyer Property(two locations)	On site[2]	Sand pump	Extrapolated results from sediment-transport model[4]
3	Cook Tract/Dyer Property (two locations)	Imported[1]	Dozer (sand plug)	Hydraulic and sediment-transport modeling
4	Cook Tract/Dyer Property (two locations)	On site[2]	Dozer (sand plug)	Hydraulic and sediment-transport modeling
5	Cook Tract/Dyer Property (two locations) and OS&G (one location)	Imported[1]	Sand pump	Extrapolated results from sediment-transport model[5]
6	Cook Tract/Dyer Property (two locations) and OS&G (one location)	On site[2]/ Imported[1]	Sand pump	Extrapolated results from sediment-transport model[5]
7	Cook Tract/Dyer Property (two locations) and OS&G (one location)	Imported[1]	Dozer (sand plug)	Extrapolated results from hydraulic and sediment-transport model[6]
8	Cook Tract/Dyer Property (two locations) and OS&G (one location)	On site[2]/ Imported[1]	Dozer (sand plug)	Extrapolated results from hydraulic and sediment-transport model[6]

Notes:
[1] Imported from existing sand and gravel operation (purchased). Material from off-site sources would be hauled to the augmentation delivery locations, where it would be temporarily stockpiled prior to being introduced into the river.
[2] Acquired from Program-controlled property. Material from on-site sources would be from a sand pit dredge operation established at or near the augmentation delivery location (discussed in Section 5).
[3] Refer to Appendix B for discussion of modeling and analysis.

[4] Results from sediment-transport modeling of pumping at Sites 1 and 2 were used for evaluating this alternative.
[5] Results from sediment-transport modeling of pumping at Sites 1, 2, and 4 were used for evaluating this alternative.
[6] Results from hydraulic and sediment-transport modeling of dozer options at Cook Tract/Dyer Property and baseline sediment-transport model in the vicinity of OS&G were used for evaluating this alternative.

As discussed above, the modeling of the alternatives was carried out to evaluate the effects of individual components (e.g., augmentation material gradation) of the various alternatives in the context of the other components (e.g., delivery technology and location). While all of the underlying components associated with the alternatives listed above were modeled, the ultimate assembly of each alternative may not have been directly modeled. However, results from the available model runs are sufficient to evaluate each of the alternatives, either through direct modeling or extrapolation of the results from similar model runs.

10.1 Alternative 1

Under Alternative 1, sediment would be imported from one or more of the local sand and gravel producers onto the Cook Tract and Dyer Property. This alternative would use two sand pump locations (Sand Pump Sites 1 and 2) to pump sediment into the river. Sediment stockpiles would be established in close proximity to the sand pump operations. Figure 7-6 shows the sand pump locations and a conceptual site layout of the augmentation operations.

10.2 Alternative 2

Under Alternative 2, sediment would be produced on site using a sand pit dredge operation established by a contractor on the Cook Tract and Dyer Property. A sand pit or pits would be created as a result of this operation, which could provide a future habitat benefit. Two sand pump locations (Sand Pump Sites 2 and 5) would be used to pump sediment into the river. Site 5 would be located in close proximity to the on-site sand pit operation to minimize hauling costs. The location would move as the dredging operation moves. Figure 7-6 shows the sand pump locations and a conceptual site layout of the augmentation operations.

10.3 Alternative 3

Under Alternative 3, sediment would be imported from one or more of the local sand and gravel producers to the Cook Tract and Dyer Property. Dozers would be used to push the material to the desired location and configuration in the channel from stockpiles along the south bank.[4] Access points to the river would need to be constructed to allow dozer access from the high bank down into the river channel.

10.4 Alternative 4

Under Alternative 4, sediment would be produced on site using sand pit dredge operations established on the Cook Tract and Dyer Property. A sand pit or pits would be created as a result of this operation, which could provide a future habitat benefit. Dozers would be used to push the material to the desired locations in the channel from stockpiles along the south bank. Access points to the river would need to be constructed to allow dozer access from the high bank down into the river channel.

10.5 Alternative 5

Under Alternative 5, sediment would be imported onto the Cook Tract and Dyer Property from one or more of the local sand and gravel producers. This alternative would use two sand pump locations on

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[4] Using the sediment-transport model, the preferred configuration was developed after several iterations with varying sediment placement configurations (see Appendix B). The preferred configuration is a long-length sand plug.

Program properties (Sand Pump Sites 2 and 3) as well as the augmentation location at OS&G (Sand Pump Site 4). Augmentation material for the sand pump location at OS&G would be obtained from their operations. Material for the sand pumps sites on Cook/Dyer would be obtained from OS&G or other local producers. It should be noted that although OS&G was selected for purposes of this evaluation, other locations are available that would likely produce the same results. Figures 7-6, 7-7, and 7-8 show the locations and conceptual site layouts of the augmentation operations.

10.6 Alternative 6

Under Alternative 6, sediment would be produced on site using sand pit dredge operations established on the Cook Tract and Dyer Property. A sand pit or pits would be created as a result of this operation, which could provide a future habitat benefit. This alternative would use two sand pump locations on Program properties (Sand Pump Sites 2 and 3), supplied by material from the on-site sand pit operation established on Cook/Dyer. In addition, a sand pump location would be established on the OS&G property (Sand Pump Site 4), supplied by sediment obtained from the existing OS&G sand pit operation. It should be noted that while OS&G was selected for the purposes of this evaluation, other locations may be available to establish a sand pump delivery location that would likely produce the same results. Figures 7-6, 7-7, and 7-8 show the locations and conceptual site layouts of the augmentation operations.

10.7 Alternative 7

Under Alternative 7, sediment would be imported from one or more of the local sand and gravel producers on to the Cook Tract and Dyer Property. Dozers would be used to push the material to the desired locations in the channel from stockpiles along the south bank. Access points to the river would need to be constructed to allow dozer access from the high bank down into the river channel. In addition, dozers would be used to push material into the river at OS&G. Material stockpiles and access points would be created on the north bank on the OS&G property. Material at this location would be supplied from the existing OS&G sand pit operation. It should be noted that while OS&G was selected for the purposes of this evaluation, other locations may be available to establish a delivery location that would likely produce the same results.

10.8 Alternative 8

Under Alternative 8, sediment would be produced on site using sand pit dredge operations established on the Cook Tract and Dyer Property. A sand pit or pits would be created as a result of this operation, which could provide a future habitat benefit. Dozers would be used to push the material to the desired locations in the channel from stockpiles along the south bank. Access points to the river would need to be constructed to allow dozer access from the high bank down into the river channel. Similar to Alternative 7, dozers would be used to push material into the river at OS&G. Material stockpiles and access points would be created on the north bank on the OS&G property. Material at this location would be supplied from the existing OS&G sand pit operation. It should be noted that while OS&G was selected for the purposes of this evaluation, other locations may be available to establish a delivery location that would likely produce the same results.

11. ALTERNATIVES ANALYSIS EVALUATION CRITERIA

A set of evaluation criteria was developed to enable a side-by-side comparison of each of the assembled alternatives. The evaluation criteria were developed to allow for the identification of the most cost-effective and efficient Project possible that meets the Project metric of achieving sediment balance at Cottonwood Ranch. This evaluation resulted in development of a list of potential alternatives that could also be considered to address sediment deficiencies at other locations in the river.

One important consideration in assembling the alternatives and establishing evaluation criteria is that this Project will be implemented as an experiment in sediment augmentation developed as part of the Program's AMP. Because there is a level of uncertainty regarding how the river system would react as a result of implementing the augmentation alternatives, this evaluation criteria approach may not necessarily lend itself to a single preferred alternative. Rather, a group of feasible alternatives was developed that, based on the predictive functions within the model, would likely achieve the Project goal. The evaluation and ranking of the alternatives, described below, is a useful exercise to provide the Program with a relative starting point in determining how best to achieve the Project goal and to develop an estimated cost to complete the Project using the various alternatives.

Another consideration when determining how to develop and evaluate the various alternatives is to do so in the context of the USACE Section 404(b)(1) Guidelines (Guidelines), given the importance of permitting the alternatives. The 404(b)(1) considerations are discussed in the following section.

11.1 Relationship of Section 404(b)(1) Guidelines to Evaluation Criteria

The Program proposes to implement the sediment augmentation experiment to rectify the sediment imbalance in the Platte River system within the Project reach. The Project would unavoidably involve the discharge of dredged and/or fill material into the Platte River, which is a water of the U.S.[5], and would therefore require authorization from USACE under Section 404 of the Clean Water Act (Section 404) (USACE, 1985).

In its review of projects that require a Section 404 fill permit, USACE applies the Guidelines, developed jointly by the U.S. Environmental Protection Agency (EPA) and the USACE, to determine whether the proposed activities are permittable under Section 404.[6] One of the primary determinations that USACE must reach under the Guidelines is whether there is a *practicable alternative* to the proposed discharge that would have less adverse impact on the aquatic ecosystem, so long as the alternative would not have other significant adverse environmental impacts. The permittable alternative under this test is frequently referred to as the least environmentally damaging practicable alternative or LEDPA (40 Code of Federal Regulations [CFR] 230.10(a)).[7]

The Guidelines define the term *practicable* to mean available and capable of being done after taking into consideration cost, existing technology, and logistics in light of overall Project purposes (40 CFR 230.10(a)(2)). Consistent with the requirements of the Guidelines, USACE evaluates the practicability of alternatives based on the four general criteria: 1) cost, 2) existing technology, 3) logistics, and 4) project purpose. Because implementing the sediment augmentation experiment will require a Section 404 fill permit, and obtaining the permit will require that the Program identify the LEDPA, the specific criteria

[5] *Waters of the U.S. include lakes, rivers, streams, oxbows, ponds, and wetlands such as prairie potholes, wet meadows, marshes, swamps, and bogs (33 CFR 328.3).*

[6] *The Guidelines, along with the public interest review and other federal laws, are the substantive criteria that USACE uses when reviewing an application to determine whether a Project is permittable.*

[7] *The river is already considered to be in a degraded state. Therefore, any alternative, except for No Action, is intended to improve the aquatic function of the river.*

used to evaluate alternatives have been structured to be consistent with the four general criteria used in the Guidelines.

11.2 Evaluation Criteria

To facilitate the Section 404 fill permit process, the specific criteria used to evaluate the alternatives have been separated into the following four Section 404(b)(1) categories:

1. Cost
2. Existing technology
3. Logistics
4. Project purpose

These evaluation criteria and the specific alternative evaluation criteria are discussed in detail in the following sections. The evaluation criteria are shown in Table 11-1.

11.2.1 Cost

Under cost, one specific evaluation criterion was established. The cost criterion is the "cost per ton of sediment delivered." The criterion is the average cost per ton to acquire and place sediment in the river at the locations identified. The use of a unit cost rather than total cost to evaluate the alternatives allows for easy adjustments to the cost criteria if sediment volumes need to be adjusted.

Project costs include construction costs, material costs, and labor costs. Costs under the Project would be incurred annually, and each year a contractor would be hired to place a specific amount of sediment in the channel at specified locations either under an annual or long-term contract. Generally, both capital and operational costs are considered over a given time period. However, the Program would be contracting out the services required under the Project and would not be acquiring infrastructure or permanent facilities requiring operation or maintenance. Therefore, the Project costs are the estimated annual construction costs, engineering fees, and contingencies, as follows:

- Annual construction costs were estimated using recent earthwork projects in the region, estimates provided by aggregate producers and contractors in the area, and cost indices including RS Means Cost Data references (RSMeans, 2010). All costs were indexed to 2010 costs. Contractor mobilization costs – which include contracting, bonding, establishing the job site, and moving equipment to and from the site – generally range from 2 to 5 percent of the construction cost. For the Project, mobilization was estimated at 2.5 percent of construction cost, before contingencies.

- Engineering fees include construction permitting, engineering design, and construction management fees. Design fees, including permitting for the Project, are estimated at 10 percent. Construction management fees can vary depending on the level of oversight required. For the Project, construction management fees are estimated at 5 percent.

- Contingencies are used to account for uncertainties in the design relative to the status of the design (e.g., conceptual as opposed to final), unforeseen and unpredictable conditions, and variability in the marketplace. Design contingencies at the feasibility/conceptual phase generally range from 20 to 30 percent and can be as high as 50 to 100 percent or more depending on the complexity of the project. Construction contingencies to account for potential additional work that may be identified during construction are generally in the range of 5 to 10 percent of the construction cost. For this Study, a 25 percent contingency was used for the alternatives evaluated.

An escalation factor of 5 percent was used to project costs over a fixed time period of 10 years. To arrive at the cost per ton of sediment delivered, the first-year cost was calculated using the volume of material identified in the alternatives. This volume is an estimated average annual input. The first-year cost was the projected over the 10-year period using the escalation factor. The volume of material delivered in the first year was multiplied by 10 years to get a total volume of material delivered. The 10-year cost was divided by the total volume of sediment delivered to the river over the time period to obtain the cost per ton of sediment delivered.

11.2.2 Existing Technology

Most of the technology constraints were discussed and evaluated in Section 7, Identification and Screening of Technologies. For the evaluation of assembled alternatives, one criterion, delivery timing, was established under the technology category. This criterion evaluates how long it would take to deliver the required volume of sediment at the alternative site or sites. Factors include the following:

- Ability of existing technology to provide usable sediment from on-site sources (i.e., local sediment)
- Ability of existing technology to extract sediment at sufficient rate
- Consideration of the physical constraints

In addition, technologies that provide a faster timeframe for delivery afford the most flexibility in coinciding sediment deliveries with flow variations. The delivery time is the actual working time (i.e., equipment operation time) it would take to deliver 150,000 tons of sediment to the river. Due to seasonal restrictions (such as, duck hunting seasons starting in mid-October, fall whooping crane migration in October and November, and other migratory bird migrations), alternatives that can be implemented in a shorter timeframe have the greatest ability to be implemented and the most flexibility during implementation.

11.2.3 Logistics

The logistics criterion evaluates the logistics of constructing and operating an alternative, the difficulty in obtaining the required authorizations, the time required until startup of the operation, and the time needed to deliver the required volume of sediment at the alternative site or sites. Four specific evaluation criteria were established under the logistics category: 1) implementability, 2) permittability, 3) long-term viability, and 4) on-site sediment availability. Logistics was evaluated qualitatively based on these criteria, and ranked as high, medium, or low.

11.2.3.1 Implementability

Implementability considers the challenges and difficulty in physically implementing an alternative. Factors considered as part of the evaluation of implementability criteria include the following:

- Ease of siting
- Physical space requirements for sediment delivery
- Ramp-up time
- Ease of constructing or setting up equipment
- Startup complexity
- Magnitude of operation and maintenance required

11.2.3.2 Permittability

The permittability evaluation criterion considers the complexity and potential timeframe associated with obtaining any required state and federal authorizations for the Project. The basic assumption is that some form of permit would be required for any of the alternatives. Alternatives that are similar to activities currently authorized by USACE were assumed to be generally less complex and easier to permit than alternatives that involve activities less familiar to the regulatory agencies, or alternatives that might involve more complex state permitting.

11.2.3.3 Long-Term Viability

The long-term viability criterion evaluates how long a particular alternative can be effectively used for sediment augmentation. Availability of source material and long-term access to the delivery location are the factors considered under this criterion. One of the primary considerations is the extent to which the alternative would be viable through the first increment of the Program. A secondary consideration is the extent to which the alternative would be viable for a longer duration.

11.2.3.4 On-site Sediment Availability

The on-site sediment availability criterion evaluates the availability of usable sediment on site (locally) at the delivery location. Sites were evaluated based on how many years of sediment supply were available. Alternatives with higher availability of local sediment will be able to be used for a longer period without supplementing from other sources. Use of material that can be obtained on site on Program-controlled property offers the advantage of eliminating the dependency on resources not controlled by the Program.

11.2.4 Project Purpose

To identify evaluation criteria under the Project purpose, consideration was given to both the specific purpose of the sediment augmentation experiment as well as purpose of the overall Platte River Recovery Implementation Program. Therefore, two evaluation criteria were established under Project purpose: 1) percent effectiveness in meeting the Project goal, and 2) provision of other Program benefits.

11.2.4.1 Percent Effective

The percent effective criterion evaluates the extent to which the alternative meets the established objective of the sediment augmentation experiment. Modeling and analytical analysis suggests that none of the assembled alternatives would likely fully address the sediment deficit. Therefore, the percentage by which an alternative addresses the sediment deficiency becomes an important consideration.

11.2.4.2 Provision of Other Program Benefits

The criterion evaluates each alternative in the context of the overall Program. The extent to which a sediment augmentation alternative may provide secondary Program benefits is considered under this criterion. Examples of secondary benefits include actions or results that occur in conjunction with or while implementing the Project, creating habitat (either directly or indirectly) that meets objectives outlined in the Program’s AMP, and providing a revenue source to the Program.

11.3 Summary of Criteria

Table 11-1 lists the specific criteria used to evaluate each of the assembled sediment augmentation alternatives. The Table also shows the relationship of the specific criteria to the Section 404(b)(1) Guidelines.

Table 11-1 Evaluation Criteria

Evaluation Criteria	Alternative Evaluation Criteria	Section 404(b)(1) Guidelines Practicability Criteria
1	Cost per ton of delivered sediment	Cost
2	Delivery timing	Existing technology
3	Implementability	Logistics
4	Permittability	Logistics
5	Long-term viability	Logistics
6	On-site sediment availability	Logistics
7	Percent effective	Project purpose
8	Provision of other Program benefits	Project purpose

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12. ANALYSIS AND SCORING OF ALTERNATIVES

Each of the alternatives shown in Table 10-2 was evaluated using each of eight criteria listed in Table 11-1, as detailed in the following sections.

12.1 Cost

Alternatives were evaluated based on the cost per ton of sediment delivered to the River. An estimate of the cost per ton of sediment was prepared for each of the alternatives. Section 11 discusses the approach and assumptions used for the cost studies. Additional costing assumptions specific to each alternative are noted on the itemized cost tables in **Appendix D**.

Table 12-1 shows the first-year construction costs for each alternative as well as a projected 10-year cost using an escalation factor of 5 percent per year.

Table 12-1 Alternatives Cost Summary

Alternative	First-Year Cost	10-Year Cost	Cost per Ton
1	$1,717,500	$21,602,300	$14.40
2	$1,410,700	$17,743,500	$11.83
3	$2,061,000	$25,922,100	$17.28
4	$1,697,500	$21,350,600	$14.23
5	$1,595,200	$20,064,500	$13.38
6	$1,419,300	$17,851,800	$11.90
7	$1,917,400	$24,116,500	$16.08
8	$1,839,700	$23,139,900	$15.43

12.2 Existing Technology

Alternatives were evaluated in terms of ability of the technology to provide usable sediment from on-site sources, to extract sediment at a sufficient rate, to operate within the physical constraints that may be present, and to deliver sediment at a rate sufficient to meet the overall Project purpose. Technologies that provide a faster timeframe for delivery provide the most flexibility in coinciding sediment deliveries with flow variations. Two technologies included as part of the alternatives were sand pumps and dozers.

12.2.1 Sand Pumps

Evaluating the timing of the delivery of sediment using sand pumps is highly dependent on the equipment used. Pump technology and pump production rates can vary significantly. To determine the timing of sediment delivery, it was assumed that the average production from the sediment slurry delivery pump(s) is 1,500 gpm with a minimum 25 percent solids content. This equates to a sediment production rate of approximately 150 tons/hour per pump system. Assuming an 8-hour work day and an efficiency rate of 50 minutes/hour (0.83), the daily sediment delivery rate is approximately 1,000 tons/day (5,000 tons/week). Using 5-day work weeks, the delivery time is approximately 6.9 months for one unit. For two sand pump units, the delivery time is just under 3.5 months, and for three units about 2.3 months.

12.2.2 Dozers

Estimating delivery timing is dependent on equipment selected as well as the number of pieces of equipment assigned to the task. Evaluation of delivery timing for these alternatives assumed the use of large 460-horsepower dozers (Caterpillar D9 or equivalent). The preferred configuration of material placement is a long-length sand plug. Including the efficiency and work week assumptions above, delivery time is 1.9 months using one dozer and just under 1 month using two dozers.

12.2.3 Summary

Results of the existing technology analysis are shown in Table 12-2.

Table 12-2 Results of Existing Technology Analysis

Alternative	Delivery Timing	Technology
1	3.5 months	Sand pumps – two locations
2	3.5 months	Sand pumps – two locations
3	1-2 months	Dozers – one to two
4	1-2 months	Dozers – one to two
5	2.3 months	Sand pumps – two locations
6	2.3 months	Sand pumps – three locations
7	1 month	Dozers – two
8	1 month	Dozers – two

12.3 Logistics

Alternatives were evaluated in terms of the ease of construction and operation, the difficulty in obtaining required authorizations, the time required until startup of the operation, and the time needed to deliver the required volume of sediment at the alternative site or sites. Four specific evaluation criteria were established under the logistics category: 1) implementability, 2) permittability, 3) long-term viability, and 4) on-site sediment availability.

12.3.1 Implementability

Implementability considers the challenges and difficulty in physically implementing an alternative. Alternatives were developed using either imported material or on-site material:

- Imported material – Imported material would be purchased from existing sand and gravel operations. Imported material would be hauled to the augmentation delivery locations, where it would be temporarily stockpiled prior to being introduced into the river. Importing sediment using trucks to haul the material to the sites does not pose any unusual implementation problems. Haul distances to the Cook Tract and Dyer Property from the closest sources at the Overton interchange are approximately 3 to 5 miles. Therefore, under these alternatives, implementability is considered to be low in terms of difficulty.
- On-site material – Material that is produced on site from a sandpit dredge operation established at or near the augmentation delivery location would be more difficult to implement. Setting up a sand pit pumping operation has significant equipment mobilization and space requirements. These alternatives rely on an outside contractor setting up a long-term operation on Program property. These alternatives would be the most labor intensive and would require electrical power. A short lead time would be required to establish the dredging operation and to produce

and process the material. Therefore, under these alternatives, implementability is considered to be medium in terms of difficulty.

12.3.2 Permittability

Permittability considers the complexity and potential timeframe associated with obtaining any required state and federal authorizations for the Project. The basic assumption is that some form of permit would be required for any of the alternatives, whether using sand pumps or dozers:

- Sand Pump Alternatives – These alternatives are generally less familiar to the regulatory agencies and may involve more complex state permitting. Sand pump alternatives were assumed to be generally more complex and harder to permit than alternatives that involve activities that are similar to those currently authorized by USACE. Depending on how water is acquired, sand pump alternatives could also involve state water rights issues, which could complicate the approval process. Therefore, under these alternatives, permittability is considered to be high in terms of difficulty.
- Dozer Alternatives – These alternatives are generally similar to activities currently authorized by USACE. These alternatives were assumed to be generally less complex and easier to permit than alternatives that involve activities less familiar to the regulatory agencies, or alternatives that might involve more complex state permitting. Therefore, under these alternatives, permittability is considered to be medium in terms of difficulty.

12.3.3 Long-Term Viability

Long-term viability considers how long a particular alternative can be effectively used for sediment augmentation, through use of imported material or on-site material:

- Imported material – Several alternatives use augmentation material that is imported from local sand and gravel operations. With six operations within 10 miles of the Project site, long-term viability of the source is not an issue.
- On-site material – Based on the results of gradation analysis from samples collected on the Cook Tract and Dyer Property, there is an adequate supply of material and a large enough area to provide an augmentation source over a Project life of 10 years (the approximate time remaining in the first increment of the Program).

12.3.4 On-site Sediment Availability

On-site sediment availability considered the availability of usable sediment on site (locally) at the delivery location. Alternatives with higher availability of local sediment can be used for a longer period without supplementing from other sources. Use of local material offers the advantage of eliminating the dependency on resources not controlled by the Program.

12.3.5 Summary

Results of the logistics analysis are shown in Table 12-3.

Table 12-3 Results of Logistics Analysis

Alternative	Implementability	Permittability	Long-Term Viability	On-site Sediment Availability
1	Low Difficulty	High Difficulty	10+ years	No
2	Medium Difficulty	High Difficulty	10+ years	Yes
3	Low Difficulty	Medium Difficulty	10+ years	No
4	Medium Difficulty	Medium Difficulty	10+ years	Yes
5	Low Difficulty	High Difficulty	10+ years	No
6	Medium Difficulty	High Difficulty	10+ years	Partial
7	Low Difficulty	Medium Difficulty	10+ years	No
8	Medium Difficulty	Medium Difficulty	10+ years	Partial

12.4 Project Purpose

Two evaluation criteria were established under the Project purpose: 1) percent effectiveness in meeting the Project goal, and 2) provision of other Program benefits.

12.4.1 Percent Effective

Alternatives were evaluated in terms of the extent to which the alternative meets the established objective of the sediment augmentation experiment. Modeling results indicated that up to 300,000 t/y of sediment would need to be introduced to the river to achieve sediment balance at Cottonwood Ranch. Therefore, alternatives that introduce 150,000 t/y would likely not achieve sediment balance. In addition, modeling indicated that the South Channel does not provide adequate flow to fully mobilize the introduced sediment. Therefore, alternatives located entirely on the South Channel are less efficient than alternatives that have at least one discharge location downstream of the confluence of the North and South channels.

Modeling and analytical analysis suggests that none of the assembled alternatives would likely fully address the sediment deficit. Therefore, the percentage by which an alternative addresses the sediment deficiency becomes an important consideration.

The percent effective values were obtained by computing the total average annual deficit at the end of the alternative simulation in the vicinity of Cottonwood Ranch (Overton Bridge to Elm Creek Bridge). The percent effective value was then obtained by computing the difference between the deficit under alternative conditions and the deficit under baseline conditions, divided by the baseline deficit. For alternatives that were not explicitly modeled, the deficit volumes were estimated using results from the available model runs. For example, under Alternative 2, the model results from Alternative 1 were used to estimate the sediment deficit, since both of these alternatives involve pumping operations at Site 1, and since the results are likely to be similar if pumping operations are implemented at Site 2 (Alternative 1) or Site 5 (Alternative 2).

12.4.2 Provision of Other Program Benefits

Alternatives were evaluated on the extent to which an alternative would provide secondary Program benefits. Long-term benefits to the Program that may result from this Project include habitat creation and additional revenue sources. These benefits would be realized primarily from establishing an on-site sand pit operation at the Cook Tract and Dyer Property. With this, permanent sand pits would be created as the augmentation material and other intermixed material is removed. At the completion of the 10-year Project period, approximately 30 to 45 acres of sandpits would have been created. These alternatives could help meet the FSM Management Action #3, Mechanical Management Action #1: Sandpit Management. The full benefit of the sandpits created under these alternatives may not be realized until pumping operations cease and there is an opportunity to complete habitat components.

Another benefit that the Program would realize under these alternatives is that the operation could generate revenue for the Program. The independent contractor hired to set up the pumping operation could compensate the Program for the opportunity to pump on contractor property. The Program has realized benefits from similar arrangements at other Program properties.

12.4.3 Summary

Results of the Project purpose analysis are shown in Table 12-4.

Table 12-4 Results of Project Purpose Analysis

Alternative	Percent Effective[1]	Provision of Other Program Benefits
1	30 - 60[1]	No
2	30 - 60[1]	Yes
3	30 (maximum) – 40 (maximum)[3]	No
4	30 (maximum) – 40 (maximum)[3]	Yes
5	60 – 80[4]	No
6	60 – 80[4]	Yes
7	>40[5]	No
8	>40[5]	Yes

Notes:
[1] Estimated based on interpreted results from modeling efforts.
[2] Lower end of range is for coarse (D50 ≈ 1.2 mm) sediment and higher end of range is for fine (D50 ≈ 0.5 mm) sediment
[3] Percent of material eroded from sediment plug based on 1-year dry-year and wet-year simulations. Other alternatives evaluated on full 12.- year simulation period. The actual percent reduction in sediment deficiency in Subreach 3 will be less than the percent of material eroded. Only the coarse material (D50 ≈ 1.2 mm) was modeled for these alternatives. See modeling discussion in Appendix B for further discussion.
[4] Lower end of range is for fine (D50 ≈ 0.5 mm) sediment, and higher end of range is for coarse (D50 ≈ 1.2 mm) sediment
[5] Dozer options for augmentation of material at OS&G or other properties downstream of the confluence of the North and South channels were not evaluated. Based on the results of modeling simulations for other alternatives, the percent effectiveness when augmenting coarse material downstream of the confluence would be expected to be greater than alternatives where augmentation is limited to location upstream of the confluence.

12.5 Summary of Alternative Analysis

Table 12-5 presents a summary of the alternatives analysis conducted for this Study.

Table 12-5 Summary of Alternatives Analysis

Evaluation Criteria	1	2	3	4	5	6	7	8
Cost								
Cost per ton delivered	$14.40	$11.83	$17.28	$14.23	$13.38	$11.90	$16.08	$15.43
Existing technology								
Delivery timing	3.5 months	3.5 months	1-2 months	1-2 months	2.3 months	2.3 months	1 month	1 month
Logistics								
Implementability	Low difficulty	Medium difficulty	Low difficulty	Medium difficulty	Low difficulty	Medium difficulty	Low difficulty	Medium difficulty
Permitting	High difficulty	High difficulty	Medium difficulty	Medium difficulty	High difficulty	High difficulty	Medium difficulty	Medium difficulty
Long-term viability	10+ yrs	10+ yrs	10+ yrs	10+ yrs	10+ yrs	10+ yrs	10+ yrs	10+ yrs
On-site sediment availability	No	Yes	No	Yes	No	Partial	No	Partial
Project purpose								
Percent effective	30 – 60	30 – 60	30 – 40 (max.)	30 – 40 (max.)	60 – 80	60 – 80	>40	>40
Provision of other Program benefits	No	Yes	No	Yes	No	Yes	No	Yes

Note:
[1] See Section 12.4.3 for a summary of effectiveness.

13. RISK AND UNCERTAINTY ANALYSIS

This section identifies specific uncertainties in implementing the Project and some of the risks associated with those uncertainties.

13.1 Unique Project

As stated in Section 1, the Project is unique in terms of the type of river system, Project goal, type of sediments involved, and the magnitude of augmentation proposed. Many of the sediment augmentation projects for which information is available have been conducted in western states, either in steep mountain streams or on large rivers with large dams. Goals for those projects tend to focus on the development of in-stream habitat, for example fish spawning habitat and increased turbidity and cover for smaller fish species. Mountain stream projects, such as the Trinity River projects in northern California, tend to focus on small to medium streams and rivers and smaller volumes of coarse to larger aggregates. Projects on the larger rivers with large dams such as the Colorado River involve very large quantities of sediment and long sediment transport distances. Many of the projects are directly downstream of dams that provide a significant, reliable source of water in order to alter the magnitude of flows and distribute the augmented sediment. However, this Project in the central Platte River is in a relatively flat, braided river system with generally low flows relative to the overall channel widths. The Project goal is to achieve sediment balance in the river that will result in creation of bed and bar habitat suitable for birds. The estimated annual volume of augmentation material is significantly higher than many of the mountain stream projects but significantly lower than some of the large western river projects. There is little guidance regarding the quantities and grain sizes of material needed to achieve the Project goal.

13.2 Uncertainties Identified or Related to the Modeling

The use of hydraulic and sediment-transport models to predict river responses to specific conditions is a commonly accepted and widely used practice to help identify feasible actions that may meet the goals of a project. Ultimately, the hope is that model results translate well to what occurs in the field. Both the hydraulic and sediment-transport model simulations for this Project were generally similar to the observed conditions in the river, indicating a high level of calibration; therefore, they are good predictors of what may be expected in the field. However, several uncertainties were identified during the modeling process. Once again, the modeling of the alternatives was carried out to evaluate the effects of individual components (e.g., material gradation) of the various alternatives in the context of the other components (e.g., delivery technology and location). Although each of the underlying components associated with the selected alternatives was modeled, the ultimate assembly of each alternative may not have been directly modeled. However, results from the available model runs are sufficient to evaluate each of the alternatives, either through direct modeling or extrapolation of the results from model runs with similar Project components.

13.2.1 Sediment Deficit and Particle Size

Initial assumptions on sediment particle size were obtained from the BOR modeling conducted as part of the FEIS. This modeling identified a sediment deficiency within the Project reach estimated at 185,000 to 225,000 t/y (on average), and identified the deficient sediment gradation as a D50 less than 1.00 mm. The general assumption from the BOR modeling was that finer material would be more effective in reducing the sediment deficit. Modeling conducted as part of this Study confirmed that there was a sediment deficit, estimated at 152,000 t/y on average for the entire Project reach and 150,000 t/y on average in the subreach that includes Cottonwood Ranch (Subreach 3). A large majority of the eroded material was smaller than 1 mm in diameter. This reinforced the initial assumptions that a sediment source with a median size of less than 1 mm would be desirable for implementation of the experiment.

Because of the numerous sand and gravel pit mining operations in the Platte Valley, there is an ample supply of fine sand material in "waste" piles at most of the local pits. The material in the sand piles is generally a byproduct of the production of other marketable aggregate gradations such as road gravel and concrete aggregate. Initial assumptions were that since this material was readily available and could be obtained by the Program for a relatively low cost, it would be a good source of augmentation material. Sampling of the sand piles at six of the operations in the vicinity of the Project identified a D50 of approximately 0.50 mm, which is well within the finer D50 range identified by the BOR modeling. Modeling simulations were conducted using the 150,000 t/y sediment deficit in the Cottonwood Ranch subreach as the volume of augmented material. Results of the sediment-transport modeling indicated that the addition of 150,000 t/y of this finer sediment still resulted in a 40,000 to 60,000 t/y deficit in the reach that includes Cottonwood Ranch (Overton Bridge to Elm Creek Bridge; Subreach 3 in the model) under the most favorable alternatives (sand pumping alternatives). The reason that the deficit is not fully addressed is that a significant amount of the finer material flushes through the system without providing any benefit at Cottonwood Ranch. Various iterations of the sand pump and dozer options all resulted in continued sediment deficits using the finer sand material. Further modeling simulations indicated that it was not until 300,000 t/y of the fine material was augmented into the river that the river approached a balanced sediment condition at the upstream end of Cottonwood Ranch. Adding this volume of sediment to the river is likely not feasible from a cost standpoint and could have negative consequences on downstream landowners.

To minimize the problem of the finer sediment flushing through the system, a gradation with larger material was evaluated. Bed material data from samples collected within the Project reach indicated that the existing bed material has a gradation with a D50 of approximately 1.2 mm in diameter and a larger fraction of gravel than the finer material discussed above. Results using the coarser material under the most favorable alternatives (those with at least one augmentation location downstream of the confluence of the North and South channels) indicate that there is significant additional reduction in the sediment deficit in the Cottonwood Ranch subreach (23,000 t/y as opposed to 73,000 t/y), although sediment balance is still not achieved. However, increased deposition of augmented material occurs with the coarser material in the vicinity of the insertion points that are located in areas with low hydraulic energy. Under alternatives using only augmentation locations on Cook/Dyer upstream of the confluence, augmenting with the coarser material would be less effective than using the finer material due to the low hydraulic energy at the insertion points. This deposition could lead to increased flooding or other potentially adverse flow conditions.

The optimal augmentation material gradation for sediment augmentation is not known. There may not be an optimal gradation of material that economically meets the goal of eliminating 100 percent of the sediment deficit without causing adverse impacts on local flow conditions (i.e., flooding) or downstream landowners. In order to alleviate some of the risk and uncertainty associated with quantity of augmentation material needed and what gradations are required, a sediment-transport monitoring program that includes measurements of sediment flux will need to be developed. A sediment budget can then be developed to aid in determining how much and what size of material needs to be added to the river over the long term to sustain habitat for the target species. A pilot study could be developed and incorporated into the Project to determine actual river response to the addition of sediment to the system. In addition, development of a two-dimensional model would be an addition to the existing modeling suite.

13.2.2 Potential Additional Modeling Simulations

Although the range of alternatives and scenarios modeled under this Project provides a thorough evaluation of potential augmentation options, additional modeling efforts may be beneficial to further refine the preferred augmentation alternatives during final design and implementation. Additional modeling scenarios that may be helpful include:

- Determination of the volume of material similar in size and gradation to the existing bed material that would be required to achieve sediment balance at Cottonwood Ranch
- Determination of the effects that material would have on localized bed elevations in the vicinity of the insertion locations
- Determination of the impact of using multiple augmentation locations downstream of the North and South Channel confluence

13.3 Requirement of a Location Downstream of the Confluence of the North and South Channels

Based on the results of the modeling simulations and assuming availability of a coarser sediment supply, augmentation at a location downstream of the confluence of the North and South channels is preferred to augmentation in the South Channel. The reason is that the downstream location more efficiently addresses the sediment deficiency at the upstream end of Cottonwood Ranch. The model simulations provided a reasonable estimate of the effects of augmentation in the South Channel. On the Cook/Dyer properties, the fine sand pit material is more effective at reducing the deficit and bed degradation at Cottonwood Ranch than the coarse gradation found in the existing bed material; the fine gradation is more readily entrained and transported to the downstream degradational reaches than the coarse gradation. However, a significant portion of the finer material is transported through the degradational reaches, thereby limiting the benefits that can be achieved with this material. To achieve sediment balance, the amount of the fine material introduced at these locations needs to be twice the actual modeled deficit.

13.4 Availability of Augmentation Locations Downstream of Confluence

This availability of augmentation locations downstream of the confluence has a direct correlation with the above-mentioned uncertainty related to the augmentation effectiveness at Cook/Dyer. Modeling simulations indicate that the most effective augmentation occurs at locations downstream of the confluence using relatively coarse sand material. The Program does not control any property between the confluence of the North and South channels and Cottonwood Ranch. This results in reliance on the use of private property as an augmentation location. There are two active sand pit operations on the north bank of the river downstream of the Overton Bridge. The Program has been in contact with the owner of OS&G. The assumption in the alternative development and evaluation was that downstream augmentation would be conducted at OS&G. However, the other sand pit, Carl Whitney Sand and Gravel, could also be used. There are also properties on the south side of the river that may be suitable as augmentation sites. As stated above, the more augmentation that occurs downstream of the confluence, the more effective the sediment augmentation is due to increased stream power below the confluence. The number and location of sand pump sites could be tested in the pilot program.

There is also some uncertainty as to the specific arrangement that would need to be made between the Program and private landowners, what properties might be available, and whether any or all of the landowners would be willing to work with the Program.

13.5 Technologies

There are several uncertainties that have been identified with potential production and delivery technologies. If an optimal gradation of the material can be determined, that material will require processing in order to meet the optimal gradation. It may not be practical or cost effective to produce a specific gradation solely for the purpose of augmenting sediment as part of the Project. In the Platte Valley and elsewhere, specific aggregate gradations are generally produced using a series of screens to separate out various sizes of aggregate as it is pumped from the pit. The screens progress from a larger to a smaller diameter as the larger fractions are separated out. The more screens required and the smaller the screen size, the more likely the screens are to plug and the more difficult it is to produce the desired product. The existing technology commonly used to produce aggregates may not be able to effectively differentiate between the small grain sizes needed for this Project. There is effectively little difference between 0.5 mm and 1.0 mm with this technology. Rotary aggregate wash machines and aggregate classifiers (a combination of gravity and air) are used to provide fine aggregate gradations; however, they are not readily available locally (there is only one known operation in the state) and are expensive pieces of equipment to acquire. Also, if a specific aggregate gradation is processed to meet the Project goal, the byproducts left may not be marketable without additional processing. That would make it less attractive for a contractor or would result in higher unit costs.

Sand pumps and slurry pipelines are commonly used to move materials. Though major problems with the use of this technology are not anticipated, there are no analogous projects for comparison on the river.

The use of dozers in the Platte River is not uncommon; however, there are limitations as to where dozers can effectively operate. Dozing macroforms into the channel from on top is much easier than trying to distribute material across active channels as the river continues to flow. The configuration of windrows/sand plugs in the river would affect the productivity and effectiveness of dozers if one of those options is implemented.

13.6 Effects on Downstream Landowners

The effect of the Project on downstream property owners is not known. Some of the augmented sediment will pass through the system and continue downstream, where it will potentially settle out at some point. Landowners in the vicinity of the augmentation could also be affected by flooding that could result from deposition in the vicinity of the insertion points.

13.7 Effects on Local Roads

The assumption is that if imported materials are used, they can be safely transported on the local road network. Truck hauling is not expected to significantly detract from any of the options because there are numerous sand and gravel operations in the vicinity of the Project, resulting in significant continuous truck traffic unrelated to this Project. However, the exact route distance and conditions of the local roads is unknown and could influence the effectiveness of alternatives requiring substantial trucking.

13.8 Variation in Market Conditions

The cost of implementing any augmentation alternative will depend on market conditions at the time. In order to implement the Project, the assumption is that the Program will hire a contractor rather than acquire the equipment and operators necessary to complete the work. The work will be competitively bid, with the lowest qualified bidder selected to complete the work. The bids will be affected by workloads of the firms bidding and how many potentially competing jobs there are at the time. For example, if large road projects are occurring at the same time, the availability of augmentation material, trucks, and/or contractors to do the work may be limited and bids may be higher. For off-site source material, the assumption is that there will be a readily available supply of material to purchase or acquire and a sufficient number of trucks to deliver the material.

Under alternatives in which the source material is produced from pits on Program property, aggregate produced that is not suitable for the Project could be sold on the open market, likely through the contractor selected to set up and operate the sand pit. The Program would be directly competing with other producers, and the amount of compensation to the Program for material taken from their property would depend on the demand for the material. If it is necessary to produce a specific aggregate gradation to meet the Project goal, the byproducts left may be less marketable if they need to undergo additional processing or blending to meet specifications.

13.9 Long-Term Effects

Alternatives were evaluated over a 10-year period that coincides with the end of the Program's first increment. Long-term effects beyond 10 years were not evaluated. If the Project is successful, there is a potential that sediment augmentation will occur for a very long time. The effects of long-term sediment augmentation may need to be evaluated.

13.10 Water Permits

Several alternatives could require the diversion of natural flow from the river. For example, water may be diverted and used to remix and entrain sediment and then discharged back to the river. In those instances, coordination with the Nebraska Department of Natural Resources (DNR) will be required. Nebraska statutes require a permit for all diversions of surface water for irrigation, hydropower, industrial use, municipal use, domestic use, storage, and other uses. The requirements are explained under Nebraska Title 457 – Department of Natural Resources Rules for Surface Water. Because the Study area includes locations that are within a moratorium or stay area, a petition of variance may be required; the petition of variance would describe the operation and address items such as consumptive use offsets. It would be necessary to demonstrate that the Project would be a beneficial use of the water in the public interest. DNR could then issue a permit allowing the natural diversion of water for the Project.

13.11 Adaptive Management Process to Address Uncertainty

The Project is designed as an experiment to test a specific hypothesis (Flow-Sediment-Mechanical Strategy [Clear/Level/Pulse or FSM]) developed as part of the Program's AMP. This systematic process of "learning by doing" involves evaluation of alternative hypotheses by applying an experimental management program and improving management decisions in ecosystems based on knowledge gained from those management actions.

The process of Adaptive Management is used in situations where it is uncertain how actions taken will affect the outcome but decisions regarding management actions must be taken despite the unknowns. Monitoring and directed research are designed to reduce uncertainty and move decisions forward. It is a process of using the best available science to test hypotheses, implement management experiments or actions, learn from the results, and revise actions as required. It should be pointed out that there are no "true" alternatives that will completely resolve Priority Hypothesis Sediment #1. However, the results of this Study point to a reasonable set of alternatives that, if implemented even at some level, will lead to a better understanding and improved knowledge of this system. Information and data acquired in the process can be used to enhance the selection of long-term management decisions related to sediment augmentation.

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14. SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

14.1 Summary

In December 2008, the Program's Adaptive Management Working Group developed a sediment augmentation adaptive management experiment, to be implemented in the 2009 – 2013 timeframe, to test the following hypothesis: *Average sediment augmentation near Overton, Nebraska, of 185,000 tons/year (t/y) under the existing flow regime and 225,000 t/y under the flow regime proposed by the Governance Committee achieves a sediment balance to Kearney, Nebraska*. This hypothesis, referred to as Priority Hypothesis Sediment #1 in Program documents, is based on modeling performed by BOR. The Program initiated the Study to investigate the potential of implementing the Project to correct the sediment imbalance in the Project reach. The 32-mile Project reach extends from above the Lexington Bridge, at approximately RM 255, to the Odessa Bridge, at RM 224 (Figure 1-1).

The Program will implement the sediment augmentation management action under the FSM strategy developed as part of the Program's AMP. This systematic process of "learning by doing" involves evaluation of alternative hypotheses by applying an experimental management program and improving management decisions in ecosystems based on knowledge gained from those management actions.

The assumption from Program documents is that sediment can be mechanically placed into the river at a rate that will eliminate the sediment deficiency and restore a balanced sediment budget. The Program has identified a location within the Project reach, just upstream of NPPD's Cottonwood Ranch, as the preferred location to evaluate the effectiveness of the Project.

Baseline steady-state hydraulic and sediment-transport models using the USACE HEC-RAS program were developed and calibrated for the Project reach. Results from the baseline sediment-transport model indicated that, on an average annual basis, the overall sediment deficit along this reach is approximately 152,000 t/y. The modeling of the alternatives was carried out to evaluate the effects of individual components (such as material gradation) of the various alternatives in the context of the other components (such as delivery technology and location). Although each underlying component associated with the eight identified alternatives was modeled, the ultimate assembly of each alternative may not have been explicitly modeled. However, results from the available model runs were sufficient to evaluate each of the alternatives, either through direct modeling or extrapolation of the results from similar model runs. The modeling effort was an iterative process, with model results helping to inform the development and modification of alternatives in an attempt to identify a range of alternatives that best address the sediment deficit. The modeling concluded that it is unlikely any of the identified alternatives would be 100 percent effective in eliminating the sediment deficit at the Cottonwood Ranch location.

The identification and development of alternatives started with the pre-screening of the components which would make up an alternative, listed below. The components were studied to determine a matrix of options that could be assembled into alternatives.

- Augmentation delivery locations
- Sediment sources
- Sediment production and delivery techniques
- Delivery timing
- Augmentation material gradation

These components underwent an initial screening to eliminate options that were determined not feasible, primarily from the standpoint of cost or implementability. Once the initial screening was completed, the options that were retained were assembled into a set of unique sediment augmentation alternatives.

Where appropriate, alternatives that did not represent a unique solution, or did not offer some advantage that warranted consideration were eliminated. In addition, the various permutations of each combination were evaluated to determine if a "hybrid" alternative would be feasible. Table 14-1 presents the range of feasible alternatives assembled.

Table 14-1 Range of Feasible Alternatives

Augmentation Delivery Locations	Sediment Sources	Sediment Delivery Technologies	Timing	Augmentation Material Gradation
Cook Tract/ Dyer Property	Cook Tract/Dyer Property	Sand pump	August 1[1]	D50~0.5 mm[2]
Existing sand and gravel operations at Overton Interchange	Existing sand and gravel operations	Dozers (sand plug)		D50~1.2 mm[2]

Notes:
[1] Review of modeling results suggest that pumping start dates have relatively little effect on the amount that the sediment deficit is reduced. The August 1 pumping start date was retained for evaluation purposes because it avoids ecologically important timeframes, offers the most flexibility, and some time buffer when compared to a September 1 start date.
[2] If the augmentation delivery location is on the South Channel, then a fine grain material (similar to the OS&G sand piles) is required to avoid excessive aggradation in the vicinity of the discharge location. Conversely, if the augmentation delivery location is downstream of the confluence of the North and South channels, such as OS&G, then a coarser material is required to provide more sediment transport to the deficit at Cottonwood Ranch.

Table 14-2 presents the alternatives that were assembled for further evaluation.

Table 14-2 Alternatives

Alternative	Augmentation Delivery Locations	Sediment Source	Delivery Technology	Analysis Type[3]
1	Cook Tract/Dyer Property (two locations)	Imported[1]	Sand pump	Sediment-transport model
2	Cook Tract/Dyer Property(two locations)	On site[2]	Sand pump	Extrapolated results from sediment-transport model[4]
3	Cook Tract/Dyer Property (two locations)	Imported[1]	Dozer (sand plug)	Hydraulic and sediment-transport modeling
4	Cook Tract/Dyer Property (two locations)	On site[2]	Dozer (sand plug)	Hydraulic and sediment-transport modeling
5	Cook Tract/Dyer Property (two locations) and OS&G (one location)	Imported[1]	Sand pump	Extrapolated results from sediment-transport model[5]
6	Cook Tract/Dyer Property (two locations) and OS&G (one location)	On site[2]/ Imported[1]	Sand pump	Extrapolated results from sediment-transport model[5]
7	Cook Tract/Dyer Property (two locations) and OS&G (one location)	Imported[1]	Dozer (sand plug)	Extrapolated results from hydraulic and sediment-transport model[6]
8	Cook Tract/Dyer Property (two locations) and OS&G (one location)	On site[2]/ Imported[1]	Dozer (sand plug)	Extrapolated results from hydraulic and sediment-transport model[6]

Notes:
[1] Imported from existing sand and gravel operation (purchased). Material from off-site sources would be hauled to

the augmentation delivery locations, where it would be temporarily stockpiled prior to being introduced into the river.
[2] Acquired from Program-controlled property. Material from on-site sources would be from a sand pit dredge operation established at or near the augmentation delivery location (discussed in Section 5).
[3] Refer to Appendix B for discussion of modeling and analysis.
[4] Results from sediment-transport modeling of pumping at Sites 1 and 2 were used for evaluating this alternative.
[5] Results from sediment-transport modeling of pumping at Sites 1, 2, and 4 were used for evaluating this alternative.
[6] Results from hydraulic and sediment-transport modeling of dozer options at Cook Tract/Dyer Property and baseline sediment-transport model in the vicinity of OS&G were used for evaluating this alternative.

Alternative evaluation criteria were established to allow for the objective side-by-side comparison of the alternatives. The Section 404(b)(1) Guidelines were used as a starting point for identifying the evaluation criteria. A total of eight evaluation criteria in four Section 404(b)(1) Guideline categories were identified, as listed in Table 14-3:

Table 14-3 Evaluation Criteria

Evaluation Criteria	Alternative Evaluation Criteria	Section 404(b)(1) Guidelines Practicability Criteria
1	Cost per ton of delivered sediment	Cost
2	Delivery timing	Existing technology
3	Implementability	Logistics
4	Permittability	Logistics
5	Long-term viability	Logistics
6	On-site sediment availability	Logistics
7	Percent effective	Project purpose
8	Provision of other Program benefits	Project purpose

Each feasible alternative was evaluated against the eight evaluation criteria, and the feasible alternatives were compared side by side, as shown in Table 14-4. None of the alternatives fully meet the Project's need, in that none of the alternatives fully eliminate the sediment deficit. Therefore, the side-by-side comparison allows the reader to better understand the relative advantages and disadvantages of each alternative. The Study points to a reasonable set of alternatives that, if implemented, will allow for a better understanding and improved knowledge of this system. The information and data acquired in the process can be used to enhance the selection of long-term management decisions related to sediment augmentation.

Table 14-4 Summary of Alternatives Analysis

Evaluation Criteria	1	2	3	4	5	6	7	8
Cost								
Cost per ton delivered	$14.40	$11.83	$17.28	$14.23	$13.38	$11.90	$16.08	$15.43
Existing technology								
Delivery timing	3.5 months	3.5 months	1-2 months	1-2 months	2.3 months	2.3 months	1 month	1 month
Logistics								
Implementability	Low difficulty	Medium difficulty	Low difficulty	Medium difficulty	Low difficulty	Medium difficulty	Low difficulty	Medium difficulty
Permitting	High difficulty	High difficulty	Medium difficulty	Medium difficulty	High difficulty	High difficulty	Medium difficulty	Medium difficulty
Long-term viability	10+ yrs	10+ yrs	10+ yrs	10+ yrs	10+ yrs	10+ yrs	10+ yrs	10+ yrs
On-site sediment availability	No	Yes	No	Yes	No	Partial	No	Partial
Project purpose								
Percent effective	30 – 60	30 – 60	30 – 40 (max.)	30 – 40 (max.)	60 – 80	60 – 80	>40	>40
Provision of other Program benefits	No	Yes	No	Yes	No	Yes	No	Yes

Note:
[1] See Section 12.4.3 for a summary of effectiveness.

14.2 Conclusions

Modeling results indicated that the location of the augmentation sites relative to Cottonwood Ranch is a significant factor in determining effectiveness in meeting the sediment balance goal. Generally, augmentation sites in closer proximity to Cottonwood Ranch are more effective (i.e., the closer the river is to sediment balance). Two commercial sand and gravel operations are located downstream of the confluence, and it is assumed that a commercial arrangement could be negotiated to use either location as the augmentation site. In addition, Program staff could initiate discussions with other private property owners located in this reach of the Platte River to investigate potential interest or availability of augmentation locations.

The modeling also indicated that particle size is a significant factor in the effectiveness of meeting sediment balance. In general, material that is too coarse may settle out before it reaches the Cottonwood Ranch location (especially if delivered in areas with low hydraulic energy), and finer material flushes through the system. Determining the optimal balance between coarse and fine material in order to achieve the maximum effectiveness and the most cost-effective technology to produce the optimal particle size will require some testing and experimentation.

The modeling evaluated several different configurations for the placement of sediment piles using the dozer options. Some configurations were more effective, but none reached the effectiveness of the sand pump options.

Based on the available modeling, none of the alternatives would likely fully achieve the Project purpose. In order to eliminate the deficit using the readily available augmentation material at the local sand pit operations, the volume of material added to the river would have to be slightly more than doubled due to the amount of the finer gradation material that is flushed downstream. This would essentially double the total 10-year cost and there could be potential impacts on downstream infrastructure (e.g., Kearney Canal Diversion) from the material flushed through the system. The Program is instituting a monitoring plan to evaluate this potential.

14.3 Recommendations

Given the constraints of the split flow conditions around Jeffrey Island, perennial sediment deficiencies, and augmentation delivery location constraints, none of the identified alternatives would fully achieve sediment balance at Cottonwood Ranch. In addition, as discussed in Chapter 13, several major uncertainties remain that should be evaluated and tested. Alternatives 6 and 8 have the advantage of incorporating a discharge location downstream of the confluence of the North and South channels while also utilizing some sediment from Project-owned property. Alternatives 6 and 8 also have a relatively low cost per delivered ton of sediment and have the potential to provide other Program benefits. However, even though these alternatives have a high level of effectiveness, they both fall short of fully meeting the Project goal.

Therefore, the recommended action is to design and implement a pilot-scale experiment (to address sediment volume, material size, and augmentation location) based on Alternatives 6 and 8 and to develop a monitoring plan to determine if the experiment is successful. The model would be updated based on the results of the pilot study. A two-dimensional model would also be instructive in understanding pilot study results and further analyzing full-scale sediment augmentation processes. Once the results of the pilot-scale experiment are evaluated and combined with the results of the modeling, a final design for the Sediment Augmentation Experiment Project could be completed. The pilot study would be designed to provide answers to some of the most important areas of uncertainty, including the following:

- Testing to determine the optimal particle size
- Technology to produce the optimal particle size

- Timing and duration of annual augmentation activities
- Effects of reducing some but not 100 percent of the sediment on providing habitat benefits
- Cost associated with the commercial acquisition of sediment
- Timing and difficulty of obtaining required permits for the augmentation
- Optimal location and windrow/sand plug configuration for augmentation
- Potential for adverse downstream effects

As part of the final design, monitoring plan would need to be refined prior to implementation of both the pilot-scale and full-scale implementation of the Project. The monitoring plan would be consistent with the Integrated Monitoring and Research Plan (IMRP) described in the Program's AMP. Specifically, the IMRP's Program Level Monitoring and Research protocol as well as the Research Protocol for NPPD's Cottonwood Ranch would provide guidance in developing the monitoring plan.

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APPENDIX A

SEDIMENT AUGMENTATION PERMITTING

Appendix A
Sediment Augmentation – Section 404 Strategy

1.1 Permit Background

In April 2006, a Final Environmental Impact Statement (FEIS) was completed by U.S. Department of the Interior (USDI) to address a proposed basinwide, cooperative Platte River Recovery Implementation Program (Program) that would meet obligations under the Endangered Species Act. The Corps of Engineers (USACE) was a cooperating agency in the preparation of the FEIS.

Various concepts were analyzed in the FEIS that would integrate measures to improve the quality of the central Platte River habitat for the four threatened and endangered target species—whooping crane, interior least tern, piping plover, and pallid sturgeon—using the Central and Lower Platte River in Nebraska. Each concept included a sediment augmentation experiment (Project) to rectify the sediment imbalance in the Platte River system. The Project would unavoidably involve the discharge of dredged and/or fill material into the Platte River, which is a water of the U.S.[1], and would therefore require authorization from USACE under Section 404 of the Clean Water Act (Section 404).

The USACE Section 404 regulatory process involves two types of permits: general permits for actions that are similar in nature and will likely have a minor effect on wetlands, and individual permits for discharges not covered by a general permit, typically an action that may have more than minimal impact. A nationwide permit is a form of general permit that authorizes a category of activities throughout the nation and is valid if the conditions applicable to the permit are met. The USACE has stated that, because the Program's mission is to assist in the recovery of targeted threatened and endangered species, activities consistent with the FEIS (such as sediment augmentation) would potentially qualify for coverage under Nationwide Permit 27 – Stream and Wetland Restoration Activities (NWP 27) (see attached USACE, June 23, 2006 letter).

Therefore, the first step in the proposed permitting approach will be to determine if the Project qualifies for authorization under NWP 27. If, for whatever reason, the Project is not authorized under NWP 27, authorization under either a regional general permit or an individual permit will be required.

1.2 Lead Agency Determination

The USACE Omaha District, Nebraska Regulatory Office is responsible for evaluating permit applications on the Platte River in Nebraska on behalf of USACE.

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1 *Waters of the U.S. include lakes, rivers, streams, oxbows, ponds, and wetlands such as prairie potholes, wet meadows, marshes, swamps, and bogs (33 CFR 328.3).*

Because the Program has a history of Bureau of Reclamation (BOR) involvement, USACE has sought clarification concerning any ongoing responsibility that BOR has for the Program in a letter dated June 11, 2010. Responding in letters dated July 9, 2010, and October 19, 2010 (see attached letters), BOR provided clarification of its responsibilities as a federal agency involved in the Program, which indicated:

- USDI provides non-reimbursable funding to the Program, similar to a grant.
- BOR's role is to participate on the Governance Committee and other advisory committees. BOR's role on the committee is the same as that of other participants and does not signify that it is responsible for, or leads, the Program.
- There is no lead federal agency for the Program.

Should the Program seek a Section 404 permit, USACE would be the responsible lead federal agency of the specific permit action. Issues such as compliance with the Endangered Species Act and the National Historic Preservation Act may need to be discussed in the pre-construction notice, as discussed below.

1.3 Section 404 Permitting Process

The following actions are required for Section 404 permitting under NWP 27, in advance of any discharge of fill material:

- Wetland Delineation and Functional Assessment
- Pre-Application Consultation Meetings
- Pre-Construction Notice (PCN) Preparation

1.3.1 Wetland Delineation and Functional Assessment

Section 404 permitting requires completion of wetland delineations of the source location(s) of sediment, the location of sediment introduction into the system, and the potential area of effect of the Project. A functional assessment using the methodology developed for the 2010 in-channel habitat will be used to assess wetland functions of affected wetland areas and anticipated creation of habitat.

1.3.2 Pre-Application Consultation Meetings

Pre-application consultation meetings have been conducted in coordination with USACE and the Section 404 permit commenting agencies. The purpose of the pre-application meetings was to discuss the Project; its potential impacts on aquatic resources; the minimization of effects, the functional change of affected resources in relation to created aquatic resources and habitat; and post-Project monitoring. The following summarizes the two meetings held with USACE, Nebraska Regulatory staff. Information from these meetings helped to form the strategy for preparing the required PCN.

1.3.2.1 December 22, 2009

A pre-application consultation meeting was held on December 22, 2009 with USACE and Program Staff resulting in the following summary points:

- Flow consolidation/sediment augmentation work will require conditions that are different from or additive to those of the NWP 27. The Program will need to demonstrate that the Project will have minimal effect on aquatic resources.
- USACE is concerned about bank stabilization to downstream land owners. If there is an actual or perceived problem, the new action may be identified as the potential cause. Secondary effects need to be considered as part of the evaluation.

- Minimal effect discussion is needed for work other than in-channel habitat. USACE has a history with in-channel work at Cottonwood Ranch. The first set of actions, such as sediment augmentation and flow consolidation, may require additional evaluation to show minimal impact. The Program will need to show that bank erosion is not an issue and to demonstrate that this can be facilitated with existing and proposed monitoring. The Program will also need to document the origin of fill material.

1.3.2.2 March 31, 2010

A pre-application consultation meeting was held on March 31, 2010 with USACE, Section 404 Commenting Agencies, and Program Staff resulting in the following summary points:

- The meeting included a site visit to view potential augmentation sites and source material areas.
- Sediment transport may result in downstream impacts and will need to be evaluated and monitored.
- Program will need to demonstrate in its permit applications that impact on one habitat type is required in order to improve the function of a different habitat type. USACE recognized that a wetland providing a certain functional value in the form of riverine habitat might be changed to provide habitat for threatened and endangered species. Some of the required information is being collected through monitoring of the interior least terns and piping plovers to demonstrate how the areas are being used. The FEIS describes the alternatives that were considered and states why the preferred alternative provides the best opportunity for species recovery.
- U.S. Fish and Wildlife Service (USFWS) indicated that, as long as the Project is consistent with the range of actions covered by the FEIS and the associated biological opinion, the Project should be covered under the Section 7 consultation that occurred during preparation of the FEIS.

1.3.3 Section 404 Permit Pre-Construction Notice

NWP 27 requires that a PCN be submitted to USACE. The PCN must include supplemental information that was identified during pre-application consultation meetings, including the following:

- Demonstration of Minimal Effects – It must be demonstrated that important aquatic and/or terrestrial habitats will not be affected at the sediment source and sediment delivery locations. In addition, Project-related secondary effects must also be considered. Secondary effects of the Project are those that are further removed in time or distance from the direct impacts. USACE is concerned about actual or perceived effects, such as bank stabilization on downstream properties. A review of this and other secondary effects (such as deposition and increased flood hazard) will be necessary to demonstrate that secondary effects of the Project are minimal.
- Demonstration of a Net Increase in Functions – Changes in functions resulting from Project impacts on aquatic resources will also need to be identified. Aquatic resources affected by the Project provide functions to the ecosystem, including species habitat. Similarly, the intent of the Project, and the Program as a whole, is to provide a means to recover targeted threatened and endangered species. A functional assessment that focused on habitat for targeted threatened and endangered species was established for the 2010 in-channel habitat projects. However, specific locations of habitat creation for this Project are not known. Therefore, it will be necessary to estimate the effects (change in function) that returning the Platte River system in this location to a state of sediment balance would have on habitat for targeted species.
- Post-Project Monitoring – The Program's monitoring protocol will provide a means for the physical assessment of pre-existing and post-Project conditions. The Program has developed detailed monitoring protocols at the Project site and other locations. These protocols will be

necessary to demonstrate to USACE that methods are in place not only to monitor success but also to identify potential secondary impacts. Finally, the Program should demonstrate its process in working with adjacent landowners should a real or perceived impact occur. These elements will likely be included as conditions of a permit.

1.4 Section 404(b)(1) Permit Guidelines

In its review of projects that require a Section 404 fill permit, USACE applies the Section 404(b)(1) Guidelines, developed jointly by the U.S. Environmental Protection Agency (EPA) and the USACE, to determine whether the proposed activities are permittable.[2] One of the primary determinations that USACE must reach under the Guidelines is whether there is a *practicable alternative* to the proposed discharge that would have less adverse impact on the aquatic ecosystem, so long as the alternative would not have other significant adverse environmental impacts. The permittable alternative under this test is frequently referred to as the least environmentally damaging practicable alternative or LEDPA (40 Code of Federal Regulations [CFR] 230.10(a)).[3]

The Guidelines define the term *practicable* to mean available and capable of being done after taking into consideration cost, existing technology, and logistics in light of overall Project purposes (40 CFR 230.10(a)(2)). Consistent with the requirements of the Guidelines, USACE evaluates the practicability of alternatives based on the four general criteria: 1) cost, 2) existing technology, 3) logistics, and 4) project purpose. Because implementing the sediment augmentation experiment will unavoidably result in the discharge of sediment into the Platte River, a Section 404 permit will be required. In order to provide USACE with an alternatives evaluation that will fulfill its permitting requirements the Program used the specific 404(b)(1) criteria used to evaluate experiment alternatives in the Study. USACE will be responsible for the 404(b)(1) Guideline evaluation, which will include consideration of alternatives, during the permitting process.

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2 *The Guidelines, along with the public interest review and other federal laws, are the substantive criteria that USACE uses when reviewing an application to determine whether a Project is permittable.*

3 *The river is already considered to be in a degraded state. Therefore, any alternative, except for No Action, is intended to improve the aquatic function of the river.*

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS, OMAHA DISTRICT
106 SOUTH 15TH STREET
OMAHA NE 68102-1618

JUN 23 2006

District Commander

Mr. Curtis Brown, Manager
Platte River EIS Office, PL-100
PO Box 25007
Denver, Colorado 80225

Dear Mr. Brown:

The Omaha District Corps of Engineers' Regulatory Branch has reviewed your agency's Final Environmental Impact Statement (FEIS) for the Platte River Recovery Implementation Program. As you are aware, the Omaha District previously provided comments November 12, 2003 on the preliminary Draft Environmental Impact Statement (DEIS) as well as amended comments to the DEIS in correspondence dated September 14, 2005. Our review of this FEIS was conducted in light of those issues identified, and our concerns have been adequately addressed.

Therefore, this correspondence focuses on the transition of the Corps as a cooperating agency to considerations for future regulatory compliance relative to our permitting authority under the provisions of Section 404 of the Clean Water Act. It is intended to set the stage for future review of site-specific actions associated with flow management/water delivery infrastructure changes and habitat restoration activities within the Central Platte River corridor. We recognize that the programmatic nature of the EIS and a final determination of potential permit requirements can only be accomplished as project proponents proceed toward more detailed feasibility and design phases.

As the Governance Committee proceeds in its project planning, we would wish to maintain dialog in order to determine potential permit requirements, permit application formulation, and identification of additional site-specific information requirements. This coordination, through pre-application consultation, will provide more streamlined permit reviews for those activities under our authority and timely identification of activities not subject to Section 404 permitting. I have enclosed more detailed information regarding future regulatory compliance needs that will assist the Governance Committee in future coordination with this office.

Section 404 of the Clean Water Act: Future Regulatory Compliance Needs

1. NEPA (National Environmental Policy Act) Compliance relative to Reasonable Alternatives associated with the Governance Committee Alternative:

The EIS (Environmental Impact Statement) states that the Governance Committee Alternative is the preferred alternative. This option involves the anticipated raising of Pathfinder Dam. The FEIS states that this proposed action does not appear to require authorization under Section 404. The Omaha District recognizes that the reconnaissance level of information in the EIS is adequate for your purposes and the intent of the EIS. We also appreciate the additional information contained in the Platte River EIS Screening Report in Volume 2 to address our concerns relative to the alternative screening of elements.

If a permit is not needed for the Pathfinder Dam raise then the level of documentation to date is satisfactory. However, if additional design (feasibility level) of the anticipated work reveals that the Pathfinder Modification Project requires authorization in accordance with Section 404 of the Clean Water Act, a more in-depth analysis will be needed to satisfy our permit review process. The FEIS further indicates that additional water supply from this action may be applied to uses other than those of the Recovery plan. In this event, the Corps will need to evaluate the purpose and need for the additional water supply by a more thorough alternatives analysis. Again, this assumes a nexus to Section 404 permitting.

2. Future Permit Requirements:

For habitat restoration within the Central Platte River corridor, the Omaha District believes that the majority of actions to be undertaken to achieve the implementation of your preferred alternative will meet the requirements for authorization under some form of general permit, either Nationwide Permit 27 or through the establishment of a Regional General Permit.

For flow management activities, some actions <u>may</u> require Standard (Individual) permit reviews (e.g., Nebraska Off-stream Reservoir in the Central Platte and Pathfinder Modification) and would require substantially more information. We believe the level of information contained in the FEIS adequately supports the purpose and need for these types of actions and would be relied upon to satisfy any forthcoming Corps standard permit reviews. We intend to tier to the FEIS as much as practical in accordance with 40 CFR 1508.28 for these potential permit actions. We also recognize that either or both of these actions may be modified or designed such that no regulated discharges will occur in waters of the U.S. that are subject to Section 404 of the Clean Water Act. Additionally, it is perceived that hydrologic modification due to re-regulation efforts from existing facilities will not require authorization. However, if regulated discharges of dredge or fill material are needed (this can include the sluicing of sediment from reservoirs) to allow for these hydrologic modifications, then some of permitting will be required.

For site specific actions authorized by the Corps, monitoring and the associated success/failure determinations relative to the goals of the Recovery Program remain the responsibility of the Governance Committee or their appointed representative. The Corps may need to incorporate special conditions in permits on a project specific basis that parallel or overlap these responsibilities. Coordination will be required in such circumstances to ensure each agency addresses their respective procedural/substantive needs.

3. Future Information/Data Needs Associated with Section 404 Permitting:

The level of detail and analysis relative to wetland impacts, monitoring, water quality and hydrological models is considered to be acceptable at the current level (reconnaissance) for your efforts. Please be aware that additional data collection and analysis will be required at the site-specific level for mechanical habitat modifications as well as associated flow alteration activities subject to section 404 permit reviews. A preliminary list of information needed for permit applications includes:

- Site identification and delineation of all waters of the U.S. in project area
- Type of action proposed: mechanical habitat restoration/alteration vs. flow management
- Identification of goals established in the EIS that a site-specific project is to address (e.g., resting habitat, feeding habitat, sediment source, etc.) and actions proposed to achieve those goals (e.g., vegetation conversion or elimination, hydrological modifications, etc.)
- Identification of wetlands/waters acreage to be impacted directly and indirectly by proposed action(s). Classification should follow the Cowardin et. al.(1979) system; complementary land use descriptive information should be used in conjunction with these data
- Documentation that ESA (Endangered Special Act) has been addressed
- Documentation that NHPA (National Historic Preservation
- Act) has been addressed
- For proposed channel change activities, geomorphological data (including plan, profile, and dimensions) and hydraulic analyses (HEC-RAS) may be needed for channel stability determinations.

MB MG
CP

Thank you for the opportunity to comment on the FEIS. We consider our commitments as a cooperating agency to the EIS process completed. Ms. Martha Chieply, Chief, Regulatory Branch, or Mr. Michael Gilbert, Project Manager, can be contacted for continued assistance and coordination.

Sincerely,

Signed

Joel R. Cross
Lieutenant Colonel, Corps of Engineers
District Commander

Copies Furnished:

CENWO-OD-R (Gilbert)
CENWO-OD-RWY (Bilodeau/Peters)
CENWO-OD-RCO (Carey)
CENWO-OD-RNE (Rabbe)

received
7-12-10

United States Department of the Interior

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IN REPLY REFER TO:
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ADM-13.00

JUL 09 2010

Mr. John Moeschen
U.S. Army Corps of Engineers
Nebraska Regulatory Office
Wehrspann Field Office
8901 S. 154th Street
Omaha, NE 68138-3621

Subject: Platte River Recovery Implementation Program Environmental & Regulatory Compliance

Dear Mr. Moeschen:

This is in response to Dr. Jerry Kenny's letter of June 11, 2010, in which he requested that the Bureau of Reclamation provide clarification to the United States Army Corps of Engineers (USACE) on "lead federal agency" responsibilities for Platte River Recovery Implementation Program (Program) activities as they relate to Clean Water Act permitting requirements and compliance with the National Environmental Policy Act and the Endangered Species Act.

The Program is a collaborative effort of its participants to implement actions to help recover listed species. The Program is formally governed and administered by a 10 member Governance Committee (GC) comprised of one representative each from Reclamation, U.S. Fish and Wildlife Service (Service), the states of Colorado, Nebraska, and Wyoming, Colorado Water Users, Downstream Water Users, Upper North Platte Water Users, and two representatives from environmental groups. The GC is responsible for Program implementation.

Reclamation's role in the Program is to participate on the GC and the various advisory committees as one of two representatives for the Secretary of the Interior and the other representative being the Service. The Department of the Interior funding is provided to the Program through Reclamation and is considered to be non-reimbursable funding similar to a grant. Reclamation's role and participation in the GC is the same as the other participants. Reclamation's participation in the Program does not imply or signify that it is responsible for, or leads, the Program.

It has been the intent of the Program since its establishment that all business between the Program and other entities would be conducted through the GC or its' designated representative (i.e. Executive Director). Attachment 2 (Milestones Document) (enclosed) to the Final Program Document clearly demonstrates that the Governance Committee is responsible for regulatory and

environmental compliance as it relates to the implementation of Program land and water activities.

Section 4.4 of the Milestones document states:

> "*The Governance Committee is responsible for acquiring the necessary permits for individual water related activities and for insuring compliance with all relevant local, state and federal laws and regulations.*"

Section 5.2 of the Milestones document states:

> "*The Governance Committee will insure the acquisition of necessary permits for individual land protection and habitat restoration activities and for insuring compliance with all relevant local, state and federal laws and regulations.*"

The GC employs an Executive Director and staff whose role and responsibility is to carry out the day to day operations and other functions of the Program under direction of the GC. Accordingly, the GC working through the Executive Director and his staff is responsible for seeking and acquiring all necessary permits and regulatory compliance documents for the Program. Reclamation's position is that the GC, through its Executive Director, is the designated party for site-specific applications for Clean Water Act regulatory permits and authorizations for Program projects and activities. Therefore, there is no "lead federal agency" for the Program.

If you have any questions regarding this matter, please contact me at 307-261-5671.

Sincerely,

JOHN H. LAWSON

John H. Lawson
Area Manager

Enclosure

cc: Dr. Jerry Kenny
Executive Director
Platte River Recovery Implementation Program
4111 4th Avenue, Suite 6
Kearney, NE 68847

Regional Director, Billings, MT
Attention: GP-1000 (Michael J. Ryan)

Deputy Regional Director, Billings, MT
Attention: GP-1100 (Gary Campbell)

Resource Services, Billings, MT
Attention: GP-4000 (Dan Fritz) (ea w/encl)

PLATTE RIVER RECOVERY IMPLEMENATION PROGRAM

ATTACHMENT 2

MILESTONES DOCUMENT

PLATTE RIVER RECOVERY IMPLEMENTATION PROGRAM
Attachment 2

Milestones Document

December 7, 2005

Table of Contents

I. PURPOSE OF MILESTONES

During the First Increment of the Program, progress toward the Program objectives for Endangered Species Act (ESA) compliance purposes will be measured through the achievement of the Milestones. The Program will continue to serve as the ESA compliance for water related activities upstream of the confluence of the Loup River, Nebraska, so long as the Milestones are being met. The Governance Committee may change the Program's First Increment Milestones, provided such changes are consistent with accomplishing the First Increment Objectives.

II. MILESTONES

The Milestones are as follows:

1. **The Pathfinder Modification Project will be operational and physically and legally capable of providing water to the Program by no later than the end of Year 4 of the First Increment.**

2. **Colorado will complete construction of the Tamarack I and commence full operations by the end of Year 4 of the First Increment.**

3. **CNPPID and NPPD will implement an Environmental Account for Storage Reservoirs on the Platte System in Nebraska as provided in FERC licenses 1417 and 1835.**

4. **The Reconnaissance-Level Water Action Plan, as may be amended by the Governance Committee, will be implemented and capable of providing at least an average of 50,000 acre-feet per year of shortage reduction to target flows, or for other Program purposes, by no later than the end of the First Increment.**

5. **The Land Plan, as may be amended by the Governance Committee, will be implemented to protect and, where appropriate, restore 10,000 acres of habitat by no later than the end of the First Increment.**

6. **The Integrated Monitoring and Research Plan, as may be amended by the Governance Committee, will be implemented beginning Year 1 of the Program.**

7. **The Wyoming Depletions Plan, as may be amended with the approval of the Governance Committee, will be operated during the First Increment of the Program.**

8. **The Colorado Depletions Plan, as may be amended with the approval of the Governance Committee, will be operated during the First Increment of the Program.**

9. **The Nebraska Depletions Plan, as may be amended with the approval of the**

Governance Committee, will be operated during the First Increment of the Program.

10. **The Federal Depletions Plan, as may be amended with the approval of the Governance Committee, will be operated during the First Increment of the Program.**

III. EXPLANATORY MATERIAL AND SCHEDULES

Following are explanatory materials and estimated time frames for anticipated interim steps that will be taken toward meeting each Milestone. The explanatory information and related interim steps and schedules are to be considered as background information and are not to be considered as individual Milestones for purposes of ESA compliance. The scheduling, whether in relation to the Milestones themselves or the explanatory material, is referenced to the term of the First Increment, which is thirteen years.

The explanatory material illustrates progress that all parties expect to see and may form the basis to begin discussions within the Governance Committee concerning whether the Program should adjust or alter its current methods and administrative processes in order to achieve the Milestone using a revised approach.

1. The Pathfinder Modification Project will be operational and physically and legally capable of providing water to the Program by no later than the end of Year 4 of the First Increment.

Explanatory Information

A description of the Wyoming's Pathfinder Modification Project is found in the Program Water Plan (Attachment 5, Section 4). Funding the construction of this project is Wyoming's responsibility. Because Pathfinder Dam and Reservoir are federal facilities, however, the United States Bureau of Reclamation (USBR) is responsible for meeting federal construction specifications and oversight.

1.1. The appropriate party (Wyoming, USBR or Nebraska) is expected to apply for the necessary approvals and permits during Year 1 of the Program. It is expected that such approvals and permits will be obtained in Year 2. The approvals will include appropriate compliance pursuant to the National Environmental Policy Act (NEPA). It is expected that the following approvals and permits will be necessary:

1.1.1. The USBR, with assistance from Wyoming, will seek an amendment to the federal authorization for the Pathfinder Reservoir to allow the water that is stored in the Pathfinder Modification Project to be used for environmental and municipal purposes in a manner consistent with Wyoming law.

1.1.2. The USBR will seek a partial change of use for its water right for Pathfinder Reservoir from the Wyoming Board of Control to allow the water stored in the Pathfinder Modification Project to be used for environmental and municipal purposes.

1.1.3. Wyoming will seek approval from the Wyoming Legislature for the export of water for downstream environmental uses specific to the goals and duration of the Program.

1.1.4. Subject to the appropriate approvals and conveyance losses, Wyoming, in accordance with its law, will assure delivery of the storage water from the Pathfinder Modification Project designated for downstream environmental purposes to the Wyoming/Nebraska state line. A permit will be secured by Wyoming pursuant to Nebraska water law to conduct the designated environmental water to specified locations between the state line and Chapman, Nebraska. Beyond the state line, Nebraska will assure delivery of the water in accordance with the terms of any such permit granted and applicable Nebraska law.

1.2. Project construction will be initiated and completed by no later than the end of Year 3 of the Program. Final operational criteria will be developed by no later than the end of Year 3 of the Program. The Pathfinder Modification Project will be operational and capable of providing water to the Program by no later than the end of Year 4.

1.3. Environmental releases from the Pathfinder Modification Project will be provided in coordination with the FWS Environmental Account Manager in accordance with the stipulation entitled, "Amendment of the 1953 Order to Provide for the Modification of Pathfinder Reservoir."

1.4. Wyoming will develop an annual operations plan for the environmental account in the Pathfinder Modification Project and coordinate those plans with the FWS Environmental Account Manager.

2. Colorado will complete construction of Tamarack I and commence full operations by the end of Year 4 of the First Increment.

Explanatory Information

A description of Colorado's Tamarack I is found in the Program Water Plan (Attachment 5, Section 3). Funding the construction of this project is Colorado's responsibility. It is anticipated that the following tasks will be accomplished leading up to full operation of Tamarack Phase I for Program purposes:

2.1. Colorado will secure any necessary Colorado or federal authorizations and appropriate compliance under the National Environmental Policy Act (NEPA) prior to the end of Year 2 of the Program.

2.2. Colorado will construct and begin operation of 50% of the Tamarack I by the end of Year 2 of the Program.

2.3. Colorado will account for Tamarack I water passing to the Colorado-Nebraska state line. Nebraska initially will rely on accounting to track this water within Nebraska to the associated habitats. The effectiveness of this strategy to accomplish Program objectives will be assessed. In the event that permitting is deemed necessary to protect this water, Colorado will cooperate with Nebraska to enable acquisition of the needed permits.

2.4. Colorado will commence full Tamarack I operations by the end of Year 4, after consultation with the FWS's Environmental Account Manager to help Colorado maximize the benefit of its operations for Program purposes.

2.5. Colorado will develop an annual operations plan and coordinate that plan with the FWS's Environmental Account Manager.

3. CNPPID and NPPD will implement an Environmental Account for Storage Reservoirs on the Platte System in Nebraska as provided in FERC licenses 1417 and 1835.

Explanatory Information

"An Environmental Account for Storage Reservoirs on the Platte River System in Nebraska" (EA Document) is found in the Program Water Plan (Attachment 5, Section 5).

3.1. CNPPID will make contributions to the Environmental Account as set forth in its license, and will make releases from the Environmental Account as requested by the Environmental Account Manager in accordance with CNPPID's FERC-approved Administrative Plan.

3.2. Other water contributions may be provided to the Environmental Account as set forth in "An Environmental Account for Storage Reservoirs on the Platte River System in Nebraska" and as permitted and tracked by the Nebraska Department of Natural Resources (NDNR).

4. The Reconnaissance-Level Water Action Plan, as may be amended by the Governance Committee, will be implemented and capable of providing at least an average of 50,000 acre-feet per year of shortage reduction to target flows, or for other Program purposes, by no later than the end of the First Increment.

Explanatory Information

The terms "reduction in shortage", "target flows", and how water projects are evaluated to determine their contribution to reduction in shortage is described in the Platte River Recovery Implementation Program, Section III.E.

The combined three state water projects (Pathfinder Modification, Tamarack I, and the Nebraska Environmental Account) were evaluated and determined to provide an average reduction in shortage of 80,000 acre-feet per year. The combined effect of the original three projects and the Reconnaissance-Level Water Action Plan is intended to achieve the Program objective of "providing water capable of improving the occurrence of Platte River flows in the central Platte River associated habitats relative to the present occurrence of species and annual pulse target flows.... by an average of 130,000 to 150,000 acre-feet per year as measured at Grand Island...." (Platte River Recovery Implementation Program, Section III.A.3.b.(1)). Therefore, the Reconnaissance-Level Water Action Plan is intended to provide an average of at least 50,000 acre-feet per year reduction in shortage in addition to the three state water projects.

As Reconnaissance-Level Water Action Plan projects move forward from the reconnaissance level, to feasibility, to project implementation, the reduction in shortage credited to an individual project will remain as evaluated and agreed upon by the Governance Committee prior to project implementation, so long as the project is implemented in general and reasonable conformance with the project description. That amount of reduction in shortage for the Reconnaissance-Level Water Action Plan project will be credited towards the completion of Milestone 4, and is not dependent upon annual or day-to-day management decisions made by the Environmental Account Manager or future variations in hydrologic conditions during the First Increment.

The Program's Reconnaissance-Level Water Action Plan is found in the Program Water Plan (Attachment 5, Section 6). The following steps are necessary to implement the Water Plan and are needed to successfully complete Milestone 4.

4.1. The Governance Committee is responsible for allocating funds necessary to implement the Reconnaissance-Level Water Action Plan in accordance with the Program budget, as approved by the signatories and may be revised by the Governance Committee.

4.2. The Governance Committee is responsible for acquiring the necessary permits for individual water related activities and for insuring compliance with all relevant local, state and federal laws and regulations.

4.3. The Governance Committee will determine which projects in the Reconnaissance-Level Water Action Plan are retained through the reconnaissance, feasibility, and implementation level. Water related activities implemented in accordance with the Water Plan will be credited to the Program's long-term objective as set forth in the Platte River Recovery Implementation Program, Section III.A.3.a.(1) and the objective for the First Increment of the Program. As appropriate, the Governance Committee will develop and use protocols to determine what quantities of water are to be credited to the individual projects.

4.4. Recognizing that the initial Reconnaissance-Level Water Action Plan (Attachment 5, Section 6), is based on reconnaissance level project evaluations, the Governance Committee will complete feasibility studies on proposed projects and develop a Water Action Plan, if necessary, by the end of Year 3 of the First Increment.

4.5. This Water Action Plan, as may be amended by the Governance Committee, will be capable of providing at least an average of 25,000 acre-feet per year of shortage reduction to target flows, or for other Program purposes, by the end of Year 8 of the First Increment.

4.6. The Governance Committee will ensure that projects implemented under this Water Action Plan are operated in accordance with approved operating plans and that they are having the intended effects on Program purposes.

4.7. The Governance Committee will ensure that water produced by projects implemented under this Water Action Plan is included in approved tracking and accounting procedures and that these projects are coordinated with other Program activities including other water projects and with the management of the Environmental Account.

5. The Land Plan, as may be amended by the Governance Committee, will be implemented to protect and, where appropriate, restore 10,000 acres of habitat by no later than the end of the First Increment.

Explanatory Information

The Program's Land Plan is found in Attachment 4. The following steps are necessary to implement the Land Plan and are needed to successfully complete Milestone 5.

5.1. The Governance Committee is responsible for allocating the Land Plan funds in accordance with the Program budget, as approved by the signatories and may be revised by the Governance Committee.

5.2. The Governance Committee will insure the acquisition of necessary permits for individual land protection and habitat restoration activities and for insuring compliance with all relevant local, state and federal laws and regulations.

5.3. Land protected in accordance with the Land Plan and land acquired by or on behalf of existing water related activities completing ESA Section 7 consultation prior to the Program will be credited to the Program's long-term objective as set forth in Platte River Recovery Implementation Program, Section III.A.3.a.(2), and the objective for the First Increment of the Program.

5.4. NPPD is responsible for implementing the Cottonwood Ranch Development Plan as approved by FERC, in accordance with Article 407 of the license for Project 1835 and the settlement agreement. The Governance Committee will fund the habitat maintenance plan for the NPPD Cottonwood Ranch Property in accordance with the FERC License and the settlement agreement. The Governance Committee will reimburse NPPD for the Cottonwood Ranch development costs in accordance with the FERC License and the settlement agreement. The Program and this Milestone will be credited for 2,650 acres for the NPPD Cottonwood Ranch Property.

5.5. Management, restoration, and maintenance of Program lands will be accomplished according to the principles of adaptive management, including the identification of a habitat baseline for each parcel and the implementation of monitoring and research activities as described in the Program's Adaptive Management Plan found in Attachment 3.

5.6. A management and restoration plan specific to each parcel of land protected will be prepared within one year of acquisition and implemented as provided in the plan.

5.7. The Land Plan and management and restoration plan will be implemented with the advice of the Land Advisory Committee.

5.8. The Governance Committee will establish a land holding entity in accordance with the Program's Land Plan by the end of Year 1 of the Program.

5.9. Recognizing that restoration plans may require a number of years to complete, the Governance Committee will use its best efforts to protect 10,000 acres of habitat, including the 2,650 acres of habitat with the NPPD Cottonwood Ranch Property, by the end of Year 9 of the First Increment.

6. The Integrated Monitoring and Research Plan, as may be amended by the Governance Committee, will be implemented beginning Year 1 of the Program.

Explanatory Information

6.1. The Program's Integrated Monitoring and Research Plan (Attachment 3, Section 5) will be implemented to conduct biological response monitoring and research of all water and land actions as needed for adaptive management.

6.2. The Program is responsible for allocating the Integrated Monitoring and Research Plan (Attachment 3, Section 5) funds in accordance with the Program budget, as approved by the signatories and may be revised by the Governance Committee.

6.3. All aspects of the Program's Integrated Monitoring and Research Plan will be subject to independent peer review, as approved by the Governance Committee.

6.4. The results of the Program's Integrated Monitoring and Research Plan will be evaluated annually, to determine if the Program is operating as originally envisioned and to determine if management changes are warranted in accordance with the Adaptive Management Plan (Attachment 3).

6.5. Monitoring and research will be conducted to determine the impact of the Program's habitat development and maintenance activities and enable modifications to minimize impacts to the environment and adjoining landowners.

7. The Wyoming Depletions Plan, as may be amended with the approval of the Governance Committee, will be operated during the First Increment of the Program.

Explanatory Information

7.1. Operate Wyoming's Depletions Plan according to Section 7 of the Water Plan (Attachment 5)

8. The Colorado Depletions Plan, as may be amended with the approval of the Governance Committee, will be operated during the First Increment of the Program.

Explanatory Information

8.1. Operate Colorado's Depletions Plan according to Section 9 of the Water Plan (Attachment 5).

9. The Nebraska Depletions Plan, as may be amended with the approval of the Governance Committee, will be operated during the First Increment of the Program.

Explanatory Information

9.1. Operate Nebraska's Depletions Plan according to Section 8 of the Water Plan (Attachment 5).

10. The Federal Depletions Plan, as may be amended with the approval of the Governance Committee, will be operated during the First Increment of the Program.

Explanatory Information

10.1. Operate the Federal Depletions Plan according to Section 10 of the Water Plan (Attachment 5).

United States Department of the Interior
BUREAU OF RECLAMATION
Great Plains Region
Wyoming Area Office
P.O. Box 1630
Mills, Wyoming 82644-1630

TAKE PRIDE IN AMERICA

received 10/22/10

IN REPLY REFER TO:

WY-4007
ADM-13.00

OCT 19 2010

Mr. John Moeschen
U.S. Army Corps of Engineer
Nebraska Regulatory Office
8901 S. 154th Street
Omaha, NE 68138-3621

Subject: Platte River Recovery Implementation Program (Program) Environmental and Regulatory Compliance

Dear Mr. Moeschen:

This is in follow-up to the telephone discussion which took place on Friday, September 24, 2010, which included Bureau of Reclamation, Corps of Engineers (Corps) and U.S. Fish and Wildlife Service (Service) staff and Dr. Jerry Kenny, Executive Director of Platte River Recovery Implementation Program. This response provides additional explanation and clarification to my July 9, 2010, letter.

The questions posed by you on behalf of the Corps were: (1) what is Reclamation's continuing role, if any, as a Federal agency during implementation of the Program and; (2) what Federal agency is responsible for providing project-specific information/data needs associated with Section 404 permitting.

Reclamation was a joint lead agency, along with the U.S. Fish and Wildlife Service, under the National Environmental Policy Act (NEPA) for preparation of the April 2006 Final Environmental Impact Statement (FEIS) for the Program. The September 27, 2006 Platte River Recovery Implementation Program Record of Decision (ROD) signed by then Secretary of the Interior Kempthorne approved the following federal actions: (1) approval of and signature on the Platte River Recovery Implementation Program Cooperative Agreement; (2) funding and implementation of the Program by Reclamation and the Service in coordination with States of Wyoming, Colorado and Nebraska and other participating organizations, and that the Preferred Alternative and the Program approved and adopted implemented in the ROD will be implemented in accordance with the Program Document and the BO and; (3) appointment of the Platte River Recovery Implementation Program Governance Committee to act as the a recovery implementation team pursuant to section 4(f)(2) of the ESA.

The ROD (page 16) states that "*Both Reclamation and the Service are participants in the formulation and implementation of the specific Program actions and will monitor the compliance with federal laws and regulations as needed along with other responsible federal agencies such as EPA and the Corps of Engineers (Corps).*" The ROD (page 18) further states that, "*The FEIS defines and commits to a process for proceeding with analysis of site-specific channel restoration activities pursuant to executive orders 11988 and 11990 and sections 401 and 404 of the Clean Water Act as* *well as other water quality permitting*". This is in reference to pages 7-2 and 7-4 in the FEIS where the Environmental Commitments related to compliance with the Clean Water Act are stated. The process for obtaining site-specific Section 404 permits is defined in this section of the FEIS.

Reclamation's understanding is that implementation of site-specific projects is the responsibility of the Governance Committee consistent with the delegation from the Secretary of the Interior made in the ROD and described in the Final Program Document.

The Program was authorized by Congress in Section 515 of the Consolidated Natural Resources Act of 2008 (P.L. 110-229). Under Public Law 110-229, the Secretary of the Interior, in cooperation with the Governance Committee, was authorized to participate in the Program and carry out any projects and activities that are designated for implementation during the Program's First Increment. Public Law 110-229 also authorized $157.14 million to be appropriated to carry out projects and activities for Program, with adjustments for inflation, and the federal funds that are to be appropriated are to be considered non-reimbursable federal expenditures. The Program's annual appropriation approved by Congress is not an action subject to the procedural requirements of NEPA.

The site-specific projects and activities of the Program are developed and implemented by the Governance Committee through its Executive Director. The agencies/entities proposing the site-specific actions undertake the appropriate environmental compliance including Section 401 and 404 of the Clean Water Act. This is consistent with the with the June 23, 2006, letter from the Corps regarding its comments on the FEIS. The Corps stated in that letter that "*As the Governance Committee proceeds in its project planning, we would wish to maintain dialogue in order to determine potential permit requirements, permit application formulation, and identification of additional site-specific information requirements*." That letter also states that "*For site specific actions authorized by the Corps, monitoring and the associated success/failure determinations relative to the goals of the Recovery Program remain the responsibility of the Governance Committee or their appointed representative*." The Program has acted consistently with that advice provided by the Corps.

We reiterate that Reclamation's role in the Program, as stated in the third paragraph of my July 9, 2010 letter to you, is to participate in the Governance Committee. The Governance Committee, through its Executive Director is responsible for providing the information/data needed by the Corps for permitting. We support an increased effort by the Executive Director to engage in pre-application consultation and coordination with the Corps. This would yield a better understanding of both the scope and nature of proposed projects under the Program and the environmental compliance, including Clean Water Act, needs for those projects.

If you have any questions, please contact me at 307-261-5671.

Sincerely,

JOHN H. LAWSON

John H Lawson
Area Manager

cc: Regional Director, Billings, MT
Attention: GP-1000 (Mike Ryan)

Deputy Regional Director, Billings, MT
Attention: GP-1100 (Gary Campbell)

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DRAFT
Hydraulic and Sediment-transport Modeling for the Platte River Sediment Augmentation Feasibility Study, Nebraska

September 7, 2010

1. INTRODUCTION AND BACKGROUND

In December 2008, the Platte River Recovery Implementation Program's (Program) Adaptive Management Working Group (AMWG) developed a sediment augmentation adaptive management experiment, to be implemented in the 2009-2013 timeframe, to test the hypothesis that "*Average sediment augmentation near Overton of 185,000 tons/year under the existing flow regime and 225,000 tons/year under the GC proposed flow regime achieves a sediment balance to Kearney*". This hypothesis, referred to as Priority Hypothesis Sediment #1 in Program documents (**Figure 1.1**), is based on modeling performed by the USDI Bureau of Reclamation (Murphy et al., 2006) that predicted an average annual transport capacity in the North Channel along Jeffreys Island of 283,000 tons/year (t/yr, existing conditions) to 298,000 t/yr (Governance Committee proposed flow regime), essentially no sediment supply to the South Channel since the flows originate from the Johnson 2 (J-2) Return, 63,000 t/yr of tributary sediment supply to the reach, and transport capacity at RM 230 of 615,000 to 658,000 t/yr, (USDI, 2006, Table 5-RG-3) (**Figure 1.2**). The Program has acquired property along the south channel downstream from the J-2 Return for sediment augmentation purposes, but is also investigating other possible augmentation actions including:

- Adding sediment downstream from Overton Bridge with sandpit spoil,
- Adding sediment at Program property upstream from the Overton Bridge with channel and/or upland sediment,
- Mechanical augmentation in the channel between Program property above the Overton bridge and Cottonwood Ranch through island leveling and channel widening, and
- Potential additional augmentation possibilities below the J-2 Return.

A consultant team led by The Flatwater Group (TFG), with support from Tetra Tech, Inc. (Tetra Tech) and HDR Engineering was retained by the Program to conduct a feasibility study of potential alternatives for implementing sediment augmentation to test the above hypothesis. To support this effort, Tetra Tech developed and calibrated baseline hydraulic and sediment-transport models of the approximately 32-mile reach from just downstream from the Odessa Bridge (~RM 224) to about 3.7 miles upstream from the Lexington Bridge (~RM 255). The models were developed using the Corps of Engineers HEC-RAS program (Version 4.1.0, USACE, 2010), a one-dimensional (1-D), hydraulic model that can be used to perform steady-state, step-backwater modeling, unsteady-flow hydrograph routing, and movable bed sediment-transport modeling. The baseline models were then modified to represent a range of proposed sediment augmentation alternatives. Comparison of results from the baseline and proposed conditions models provides a platform for evaluating the effects of the sediment augmentation alternatives.

2. STEADY STATE HYDRAULIC MODEL

The baseline steady-state hydraulic model was developed to evaluate the existing hydraulic conditions along the project reach, and to provide input to the sediment-transport model.

2.1. Model Development

2.1.1. Geometric Data

The modeled domain includes the approximately 32-mile reach of the main channel, and about 8 miles of the South Channel along Jeffreys Island below the J-2 Return. Ten split-flow paths ranging in length from about 0.3 miles to about 9 miles are included in the model to simulate conditions in the individual, hydraulically separated flow paths (Figure 1.2). The model contains 140 cross sections that extend across the active channel and floodplain, subdivided into 312 cross sections for the separate flow paths, laid out perpendicular to the direction of flow, with an average spacing of about 1,200 feet. Cross sections were located at hydraulic structures, including the up- and downstream faces of bridges, the Kearney Diversion Structure, the Program's Anchor Point survey sections, supplemental sections surveyed by TFG for this study, and hydraulic controls (e.g., constrictions, riffle zones, etc.). Because each of the Anchor Points sites include a group of seven cross sections that are spaced much closer than the typical resolution of the remainder of the model away from the Anchor Points, model cross sections were laid out only at the upstream, middle, and downstream survey section at each site.

The topography for the cross sections was taken from a variety of sources, including 2009 LiDAR mapping, the Anchor Point surveys, TFG surveys, and fathometer survey information intended to capture the longitudinal main-channel thalweg profile. The cross sections were initially cut from a digital terrain model (DTM) of the LiDAR surface that was collected when the flow in the river was in the range of 380 to 400 cfs using HEC-GeoRAS Version 4.2.93 (USACE, 2009) in conjunction with ArcGIS Version 9.3.1 (ESRI, 2009). Because the LiDAR mapping does not include data below the water surface, these cross sections were adjusted to better represent the wetted portion of the channel. Where bathymetric data were available from the cross-sectional surveys, the survey data were used between the survey end points. At locations where only surveyed thalweg data were available, the cross-section points within the wetted portion of the channel were lowered to match the surveyed data (**Figure 2.1**). Cross sections at locations without bathymetric survey data were adjusted by iteratively lowering the wetted surface until the computed water-surface elevation matched the water-surface elevation at the time of the LiDAR surveys. This adjustment is discussed further in Section 2.2 (Model Calibration).

2.1.2. Hydraulic Structures

The model includes four bridge structures at Lexington (U.S. Highway 283), Overton (State Highway 24), Elm Creek (U.S. Highway 183), and Odessa (State Highway 6). As-built bridge plans were obtained from the State of Nebraska Department of Roads—Bridges Division and used to code the bridge piers, abutments, and superstructure into the model using the HEC-RAS bridge data editor. The Kearney Diversion Structure was also coded into the model based on information from the LiDAR and ground surveys conducted by TFG. The flow patterns in the vicinity of this structure are multi-dimensional, with the primary component flowing parallel to the weir toward the Kearney Canal Headworks, and a secondary component that overtops roughly perpendicular to the weir; thus, the conventional HEC-RAS inline structure feature was not used to code this structure into the model. Instead, a series of cross sections was laid out upstream from the structure, oriented along the primary flow path with the right end point at the top of the structure (**Figures 2.2 and 2.3**). The HEC-RAS lateral weir feature, which computes the conveyance across the weir based on the available head, was then used to represent the weir geometry. A total of six cross sections were used to represent the structure, including the downstream section that contains the gate-and-sill geometry. Ineffective flow areas were used at the downstream gate/weir section to eliminate conveyance across the top of the weir, since this conveyance is accounted for in the lateral weir calculations.

2.1.3. Hydraulic Roughness

The hydraulic roughness was incorporated into the model using Manning's *n*-values that vary horizontally along the cross section. Vegetation and land-use information from the Program's Vegetation Monitoring Program was used to develop polygons that represent different roughness zones. The original Monitoring Program polygons include a very dense delineation of vegetation types that would result in more than the maximum 20 roughness zones that can be accommodated in HEC-RAS at many of the cross sections. To reduce the number of roughness zones, the Monitoring Program polygons were simplified by combining them into larger zones that represent the dominant roughness characteristics of the delineated area. HEC-GeoRAS was then used to determine the stationing of the roughness zones along the cross section. These roughness zones were then assigned a Manning's *n*-value based on the vegetation description, field observations, bed-material characteristics, past experience with similar streams, and published values for similar streams (Barnes, 1967; Hicks and Mason, 1991; Arcement and Schneider, 1989) (**Table 2.1**). Roughness values in the overbanks ranged from 0.020 for flat surfaces with no vegetation to 0.12 for densely vegetated areas with irregular topography. Roughness values for the vegetated area within the channel were then assigned by evaluating the aerial photography, topography and vegetation type polygons. Main channel *n*-values ranged from 0.028 for the active, non-vegetated portion of the channel to 0.10 for densely vegetated mid-channel bars and islands.

2.1.4. Other Input Data

Other input to the model included ineffective flow areas, overbank flow paths, and the downstream boundary condition. Ineffective flow areas were used to insure the modeled flow paths are consistent with the actual flow conveyance. Permanent ineffective flow areas were used to block out locations that would not convey flow over the range of modeled flows (e.g., up- and downstream from bridge structures or within the gravel pits), while non-permanent ineffective flow areas were used in overbank flow paths where the area is ineffective at low flows but would become effective at high flows. The HEC-RAS levee feature was only used to define contiguous features that would limit conveyance to the main channel (i.e., the Interstate 80 structure).

Because certain overbank flow paths only convey an appreciable amount of flow at the most extreme flood events, these flow paths were not included in the step-backwater portion of the model. Instead, the flow loss associated with these flow paths, and the subsequent flow returns, were modeled using the HEC-RAS lateral weir feature. The geometry across the top of the flow breakout zone was coded into the lateral weir input editor based on the LiDAR survey data, and the downstream return location was specified. While the lateral weir feature does not provide hydraulic information in the overbank flow channels, it does remove an appropriate amount of flow along the flow breakout zone based on the amount of head that is available to drive the overbank flow and returns that flow at the appropriate location. Lateral weir features were used to model the high-flow overbank flow paths along the left overbank of the North Channel of Jeffreys Island at Sta 1514+80 (~RM 242.5), along the left overbank of the north split-flow channel below Cottonwood Ranch (~RM 233), and along the right overbank upstream from the Kearney Diversion Structure between Sta 856+60 and Sta 824+70 (~RM 229.5).

Table 2.1. HEC-RAS model roughness values.

Vegetation Type/Land Use	Manning's *n*-Value
Agricultural	0.035
Bare Ground/Sparse Vegetation	0.03
Canal/Drainage	0.02
Irrigation Reuse Pit	0.3
Mesic Wet Meadow	0.03
Phragmites	0.1
Riparian Shrubland	0.07
Riparian Woodland	0.11
River Channel	0.028
River Early Successional	0.1
River Shrubland	0.07
Roads	0.02
Rural Developed	0.02
Sand Pit	0.02
Unvegetated Sandbar	0.035
Upland Woodland	0.12
Warmwater Slough	0.08
Xeric Wet Meadow	0.03

The downstream boundary conditions were established assuming normal depth with a slope of 0.00125, consistent with the average bed slope in the downstream portion of the model. This slope is also consistent with the slope of the water surface at the time of the LiDAR surveys. The downstream boundary of the model is located a sufficient distance downstream from the Odessa Bridge to insure that error in the assumed starting water-surface elevation does not affect the predicted hydraulic conditions within the project reach.

2.2. Model Calibration

The steady-state hydraulic model was calibrated, to the extent possible, by comparing the model results with available measured water-surface elevations. The available information included rating curves at the stream gages, surveyed water-surface elevations from a variety of sources, and inferred water-surface elevations from the LiDAR data. The stream gages, operated by the USGS and/or Nebraska Department of Natural Resources, include Platte River at Overton, NE (USGS Gage No. 06768000), Platte River Mid-Ch, Cottonwood Ranch near Elm Creek, NE (USGS Gage No. 06768035), and Platte River South Channel, Cottonwood Ranch near Elm Creek, NE (USGS Gage No. 06768025). Water-surface elevations collected during the Ayres Associates (Ayres) surveys at the Program's Anchor Points and by TFG for this study were also used in the calibration. Discharges at survey locations in the North Channel along Jeffreys Island were estimated by subtracting the J-2 Return flows from the recorded flows at the Overton gage. The Ayres and TFG surveys provide sufficient information to correlate measured water-surface elevations and discharges at a total of 12 sites (**Table 2.2**). The LiDAR survey, conducted on March 17, 2009, when the gaged discharge was between 380 and 400 cfs, provided the most comprehensive water-surface elevation dataset. The water-surface profile at the time of the LiDAR survey was developed by cutting a line along the channel station line from the LiDAR mapping.

Calibration of the model was achieved by refining the cross-section roughness parameters and low-flow channel geometry. As discussed above, the general horizontal distribution of the Manning's *n*-values was originally assigned using information from the Program's Vegetation Monitoring Program. The limits of these roughness zones were adjusted to improve model calibration based on the channel geometry and aerial photography. The model was also calibrated by adjusting the below-water portion of the LiDAR-based cross sections in the secondary flow channels, since no longitudinal bed survey was conducted in these reaches. Adjustments were made by lowering the thalweg of the cross sections in each split-flow reach based on estimates from local ground surveys. These adjustments affected the overall conveyance and, therefore, water-surface elevations in each channel. The predicted results match the three USGS gage rating curves reasonably well at these locations over the range of modeled discharges (**Figures 2.4 through 2.6**).

Table 2.2. Ground survey calibration data.

Source	River Mile	Description	Date	Mean Daily Flow at Overton Gage (cfs)	Average Calibration Elevation Difference* (ft)
Ayres Anchor Point	241.5	AP 35a	7/30/2009	599	-0.33
Ayres Anchor Point	236.5	AP 33b	7/17/2009	507	0.30
Ayres Anchor Point	236.5	AP 33a	7/17/2009	507	-0.91
Ayres Anchor Point	236.5	AP 33c	7/18/2009	744	0.17
Ayres Anchor Point	234	AP 32b	7/19/2009	998	0.41
Ayres Anchor Point	234	AP 32a	7/19/2009	998	0.30
Ayres Anchor Point	234	AP 32c	7/18/2009	744	0.34
Ayres Anchor Point	231.5	AP 31a	7/31/2009	502	0.48
Ayres Anchor Point	231.5	AP 31b	7/31/2009	502	-0.51
TFG	231	Elm Creek Bridge	11/5/2009	2,600	-0.44
TFG	229	Kearney Canal	11/10/2009	1,780	-0.13
Ayres Anchor Point	226.5	AP 29	7/20/2009	472	0.20

*Positive value indicates computed elevation is higher than survey

Predicted water-surface elevations at the 12 ground survey sites ranged from between about 0.5 feet above surveyed elevations to 0.9 feet below with an average of 0.1 feet below (Table 2.2). In considering these results, it is important to note that mean daily flows were used in the evaluation. The gage records indicate that flows varied by up to 1,000 cfs throughout each day of the survey, significantly affecting the water-surface elevations; thus, flow fluctuations from the mean daily value is likely an important component of the indicated differences.

Difference between the predicted water-surface elevations in the main channel and the LiDAR-based elevations averages about 0.5 feet, and ranges from 1.5 feet above the LiDAR-based water surface to 1.7 feet below, with no systematic bias or trend evident in the differences (**Figure 2.7**). Considering that up ±0.5 feet of the error in this comparison could occur in the LiDAR-based surface, the calibration at this flow level is considered to be quite good.

2.3. Model Results

Results from the steady-state hydraulic model were used to evaluate the channel capacity and to provide input to the sediment-transport model, as discussed in the next section. Comparison of the predicted water-surface elevations with the top of bank elevations indicates that, while there is significant variability in the data, the channel capacity is slightly less than 5,000 cfs upstream from the confluence with the South Channel of Jeffreys Island (i.e., above the flows delivered by the J-2 Return) and increases to about 6,000 cfs downstream from Jeffreys Island (**Figure 2.8**).

3. BASELINE SEDIMENT-TRANSPORT MODEL DEVELOPMENT

3.1. HEC-RAS Sediment-Transport Model Limitations

The mobile boundary sediment-transport module of HEC-RAS 4.1 uses computational algorithms similar to the Corps HEC-6 computer program. While HEC-RAS includes enhancements that are not available in HEC-6, there are a number of important limitations in applying the model to the project reach of the Platte River. These limitations include the following:

- The sediment-routing module does not have the capability to optimize split flows; whereas, the steady-state backwater module does include this optimization feature. This is a significant limitation for conditions in the study reach because the model will not automatically pass sediment into the split channels.

- HEC-RAS also appears to limit the sediment-control volume at external and internal boundary conditions. The sediment-transport routines ignore the control volume that occurs across tributary junctions, which translates to over-estimation of aggradation or degradation at the bounding cross sections.

- The sediment data editor in HEC-RAS requires definition of the bed-material gradation at individual cross sections, and interpolates the gradation at intermediate cross sections. This interpolation tool does not function properly when there is more than one model reach.

- HEC-RAS output includes a wide range of variables that can be presented longitudinally at specific time steps or as time series at specific locations, as well as the cross-sectional geometry at various points in the simulation that includes the predicted aggradation or degradation. An input condition is provided to control the frequency at which the updated cross-sectional geometry is reported; however, this control does not function properly and the cross-sectional geometry is reported at every time increment. For the 12.5-year baseline simulation, this frequency of output results in very large output files (>3 GB). For such large files, the HEC-RAS cross-sectional geometry viewer cannot read the entire file; thus, this part of the output is not available during the latter portions of the simulation. The challenges presented by this limitation are discussed further below.

3.2. Model Development

The geometry and other input to the hydraulic model served as the basic framework for the sediment-transport model. Minor modifications to the geometry were made to address the limitations discussed in the previous section. Other sediment-transport model input includes bed-material gradation data, upstream and lateral sediment supplies, and flow hydrographs.

3.2.1. Model Structure and Geometry

Because HEC-RAS currently does not model sediment flow splits, the model structure was modified to remove the flow splits, and each split-flow path was separated into individual tributary reaches that are connected to the primary flow path at the downstream end of the split. As a result, it was necessary to remove flow and sediment from the primary flow path at the flow split and re-insert this flow and sediment load at the upstream limit of the side channel flow path. The specific procedure that was used to develop the flow and sediment-load records is discussed in Section 3.2.4 (Boundary Conditions) below.

3.2.2. Bed-material Data and the Bed Sediment Reservoir

The bed material along the modeled reaches that is available for entrainment and transport is referred to in the model as the *bed sediment reservoir*, defined in HEC-RAS as the horizontal and vertical limits across the cross section where erosion can occur. The horizontal extents are referred to as the movable bed limits, and were originally set using the bank stations that define the geometric limits of the active main channel. At some locations, these limits were extended to include the secondary channels where erosion may occur based on existing and historical aerial photography and a comparison of cross-section survey information (discussed below). Since the alluvium in the study reach is quite deep, a bed sediment reservoir depth of 30 feet was assigned to each cross section to insure that erosion is not artificially limited by this parameter. HEC-RAS also allows the user to specify whether or not deposition of material is permitted outside of the bed sediment reservoir limits. This option was selected since the comparative cross-section surveys and field observations indicate that deposition does occur in the overbanks.

Bed-material data used to define the gradation of the bed sediment reservoir were obtained from the bed- and bar-material samples collected at the Program's Anchor Points. Because numerous samples were collected along the various transects that make up each Anchor Point dataset, the individual gradations were combined to develop representative, composite gradations (**Table 3.1**). The composite gradations were then distributed along the reaches between the Anchor Points to define the gradation of the bed sediment reservoir at each cross section (**Table 3.2**). In split-flow paths where no Anchor Point gradation was available, the composite gradation from the nearest Anchor Point in the primary flow path was adopted.

Table 3.1. Summary of the representative composite Anchor Point gradations.							
Representative Composite Gradation	River Mile	D_{16} (mm)	D_{50} (mm)	D_{84} (mm)	Flow Path	HEC-RAS Reach	Station (ft)*
Primary Flow Path							
AP40	254.4	0.5	1.3	5.1	Primary	Main 1	217000
AP39	250.8	0.5	1.4	5.1	Primary	Main 1	196500
AP37a	246.5	0.5	1.7	12.0	Primary	Main 2	174000
AP35a	241.5	0.5	1.7	11.5	Primary	Main 5	147500
Overton Bridge	239.4	0.8	2.9	9.4	Primary	Main 6	136420
AP33a	236.4	0.4	1.2	4.9	Primary	Main 10	120500
AP32a	234.1	0.4	1.2	3.8	Primary	Main 11	108000
AP31	231.5	0.4	1.2	4.4	Primary	Main 13	94000
AP29	226.4	0.4	1.2	4.3	Primary	Main 14	66500
South Channel Jeffreys Island below J-2 Return							
AP37b	246.5	0.6	2.2	15.4	South Channel Jeffreys Island	J-2	39000
AP35b	241.5	0.5	1.6	10.3	South Channel Jeffreys Island	J-2	11000
Side Channels							
AP33b	236.4	0.4	2.1	6.0	North Channel	Split F	27500
AP32b	234.1	0.3	0.7	1.8	North Channel	Split F	13000
AP32c	234.1	0.5	1.3	3.9	South Channel	Split J	19000
AP33c	236.4	0.6	2.0	7.8	South Channel	Split H	31000

*References the appropriate station line for each HEC-RAS reach.

3.2.3. Hydrologic Data

The sediment-transport module of HEC-RAS requires "Quasi-Unsteady Flow" data that represents the upstream flow hydrograph and hydrographs for gains or losses for the simulation period. The quasi-unsteady flow is input by assigning a time duration to each discharge in the hydrograph, thereby allowing flow fluctuations. It should be noted that the sediment-transport module does not perform unsteady flow or sediment routing, but instead computes sediment-transport conditions (erosion or deposition) under steady flow conditions for each flow-duration increment.

Hydrologic data used to develop the model input files included measured mean daily flows at USGS gages and at the J-2 Return and Kearney Canal (**Table 3.3**). The simulation period for the baseline model run extends from October 1, 1989, through April 1, 2002. This period was selected because comparative cross-sectional survey data are available over this period, and it includes a series of wet and dry water years, with annual volumes at the Overton gage ranging from about 610,000 ac-ft in 1991 to 1,900,000 ac-ft in 1998 and mean daily flows at the Overton gage ranging from about 140 to 14,100 cfs (**Figure 3.1**). Although there are also active gages in the middle and south channels at Cottonwood Ranch, these gages are relatively new and the periods of record are too short to be of use in this simulation.

Table 3.2. Distribution of representative composite bed-material gradations.

Representative Composite Gradation	D_{50} (mm)	HEC-RAS Reaches	Upstream Station (ft)*	Downstream Station (ft)*
AP40	1.3	Main 1 - Main 2	220850	207170
AP39	1.4	Main 1 - Main 2	205410	185130
AP37a	1.7	Main 2 - Main 4	183420	158580
AP37a	1.7	Split A	7890	550
AP37a	1.7	Split B	12450	500
AP35a	1.7	Main 5	157780	137200
AP37b	2.2	J-2	41370	31410
AP35b	1.6	J-2	29000	340
AP35a	1.7	Main 6 - Main 7	136680	133750
AP33a	1.2	Main 7 - Main 8	133070	132210
AP35a	1.7	Splits C and E	47220	43760
AP35a	1.7	Split D	1850	210
AP33c	2.0	Splits E and H	43520	26850
AP33a	1.2	Main 9	131860	122500
AP33b	2.1	Split F	39300	21780
AP32b	0.7	Split F	20700	450
AP33c	2.0	Split G	6130	210
AP33a	1.2	Main 10	121970	115320
AP32a	1.2	Main 11 - Main 12	113900	96100
AP32a	1.2	Split K	3080	810
AP33a	1.2	Split I	2160	400
AP33c	2.0	Split J	26090	9750
AP31	1.2	Split L	7630	1400
AP31	1.2	Main 13	95560	90360
AP31	1.2	Main 14	87860	81650
AP29	1.2	Main 14	81040	52550

*References the station line for each HEC-RAS reach.

Since recorded flow data are available only at specific points within the project reach and the gains and losses can be significant, it was necessary to estimate the flow distribution along the reaches between the gages. In the upstream reach between Lexington Bridge and the downstream end of Jeffreys Island that includes the North Channel along Jeffreys Island, the flow was estimated as the difference between the recorded flows at Overton and the inflows from the J-2 Return. In the downstream reach between the Overton and Odessa gages, flows are affected by tributary contributions, the Kearney Diversion, and other gains and losses. For the period between April 10, 1996, and September 30, 2008, when gage data were available for all of the primary tributary contributions (Spring, Elm and Buffalo Creeks), the gains and losses along this reach were computed by subtracting the outflows (recorded flows at Odessa and at the Kearney Diversion) from the inflows (recorded flows at Overton and the primary tributaries). The measured data were also used to estimate the flows from the tributaries and the unmeasured gains and losses during the period when no measured tributary flow data were available. For the period with measured data at all measurement locations (April 10, 1996, through September 30, 2008), the following were estimated for use in developing the mode input (**Table 3.4**).

Table 3.3. Summary of recorded mean daily flows at key locations along the project reach.

Stream Gage or Location	USGS Gage No.	Period of Record	Comment
Platte River near Overton, Nebr.	06768000	10/1/1930 - Present	Some zero flow measurements
Johnson 2 (J2) Return	NA	10/1/41 - 9/30/98	Numerous recordings of zero flow
Kearney Diversion	NA	10/1/1945 - Present	
Buffalo Creek near Overton, Nebr.	06769000	10/1/49 - 9/30/98; 4/10/96 - Present	Numerous "ice" related data gaps
Elm Creek near Overton, Nebr.	06769500	3/22/96 - Present	Numerous data gaps.
Platte River near Odessa, Nebr.	06770000	10/1/1938-Present	Some zero flow measurements

a. The total volume of gains and losses between Overton and Odessa less the volume diverted to the Kearney Canal (about 1,057 million ac-ft).

b. The measured runoff from Spring Creek (about 259,000 ac-ft), Elm Creek (about 43,000 ac-ft), and Buffalo Creek (about 252,000 ac-ft).

c. The percentage of the overall gains and losses less the Kearney Diversion Canal that is represented by Spring Creek (24.5 percent), Elm Creek (4.1 percent), and Buffalo Creek (23.8 percent).

The following steps were then taken to estimate the tributary flows and unmeasured gains and losses during the period without measured tributary flow data:

1. For the entire period of record between WY1978 and WY2008, the total volume of the gains and losses were computed for the reach between Overton and Odessa, less the volume diverted to the Kearney Canal (about 1,957 million ac-ft).

2. For days with net gain (i.e., the measured flow at Overton exceeds the sum of the measured flow at Odessa plus the Kearney Diversion flow), the estimated flow rate in each of the tributaries was computed using the percentages in Item (a), above.

3. For days with net loss (i.e., the sum of the measured flow at Odessa plus the Kearney Diversion flow exceeds the measured flow at Overton), the tributary flows were set to zero.

4. The resulting non-zero tributary flows were adjusted by a factor that resulted in tributary runoff volume percentages for the entire period that matched those percentages computed for the with-measurement period in Item (c), above.

5. Other gains and losses (similar to the unmeasured gains and losses during the period with measured flows at all available locations) were then computed by subtracting the outflows from the inflows.

Table 3.4. Summary of flow volumes at the gaged locations and the resulting unmeasured gains or losses between the Overton and Odessa gages.

Location	Period with Measured Data at All Locations		Period with Estimated Flows	
	4/10/1998 - 9/30/2008		WY1978 - WY2008	
	Measured Volume (ac-ft)	Percent of Gains/ Losses*	Measured Volume (ac-ft)	Percent of Gains/ Losses*
Overton gage	10,998,000	-	38,136,000	-
Odessa gage	11,011,000	-	37,463,000	-
Gains/Losses	13,000	-	-673,000	-
Kearney Diversion	1,044,000	-	2,630,000	-
Gains/Losses less Kearney Diversion	1,057,000	-	1,957,000	-
Spring Creek	259,000	24.5%	479,000	24.5%
Buffalo Creek	252,000	23.8%	466,000	23.8%
Elm Creek	43,000	4.1%	80,000	4.1%
Unmeasured (Other) Gains/Losses	503,000	47.6%	932,000	47.6%

*Less flow diverted to Kearney Canal.

The final hydrologic input included measured flows at all locations when available, and includes point source gains and losses at each tributary and at the Kearney Diversion, respectively. The unmeasured gains and losses were treated as uniform losses distributed over the longest reaches between split flows or flow returns. These reaches included a 3-mile reach of the middle (primary) channel between Overton and Elm Creek and a 4.6-mile reach between the Kearney Diversion and Odessa. It should be noted that since HEC-RAS requires some flow in each of the modeled reaches, the model input was adjusted to insure a nominal (10 cfs) discharge was available in the primary flow paths such that some flow could be split to the secondary channels during low flow conditions.

3.2.4. Boundary Conditions

Boundary conditions for the sediment-transport model include the downstream hydraulic boundary condition, the upstream sediment supply, and internal hydraulic and sediment boundary conditions that were necessary for the simplified split-flow model layout. Initial sediment-transport simulations indicated the portion of the model between the Kearney Diversion Structure and Odessa Bridge was very sensitive to the downstream hydraulic boundary condition, since the downstream model section was located a relatively short distance downstream from Odessa Bridge. The geometry of the model was, therefore, extended an additional 3,100 feet downstream such that the downstream model cross section was about 0.8 miles below the bridge. The hydraulic boundary condition for the new downstream model limit was estimated assuming normal depth conditions with a slope of 0.0004, consistent with the channel bed slope in this vicinity. For the upstream sediment supply near Lexington Bridge, the HEC-RAS option for computing equilibrium load was selected. This option computes the sediment-transport capacity, by size fraction, at the upstream cross section and uses these loads for the upstream supply. The sediment supply at the J-2 Return in the South Channel of Jeffreys Island was set to zero for the entire simulation, since the J-2 Return delivers no bed-material load to this reach.

Because the mobile boundary sediment-transport module of HEC-RAS is not capable of simulating flow and sediment-load splits at the upstream limits of the split-flow paths, it was necessary to develop input that defines the upstream boundary for each of the secondary flow paths (i.e., the “split” reaches in Figure 1.2). The steady-state hydraulic model was executed over a range of flows up to the peak flow in the WY1978 to WY2008 simulation period, and the HEC-RAS optimization feature was used to determine the split discharge at each split-flow location. This information was then used to develop split discharge versus upstream discharge rating curves at the flow splits (**Figure 3.2**). Because HEC-RAS does not allow outflowing sediment-rating curves, the split discharge rating curves were used to develop time series for the lateral outflows from the primary channels. To insure that the proper flow split was applied, time series were also developed for the inflows to the secondary channels (the ordinates in these time series equal the absolute value of the lateral outflows from the primary channel outflow locations). Although this approach does not address potential changes in the split-flow rating curves that could occur as a result of downstream aggradation or degradation, the method insures flow continuity. The changes in geometry appear to be sufficiently small so that this is not considered to be significant limitation.

The sediment loads that are delivered to the head of the split-flow channels were defined using upstream sediment load series, and the corresponding loads removed from the primary channels were defined using lateral (outflow) sediment load series. These sediment load series were developed through an iterative process using the following steps:

1. The baseline model was executed over a synthetic flow hydrograph (**Figure 3.3**) with flows ranging from 10 to 23,000 cfs (at Overton) and the split-flow input developed from the discharge rating cures in Figure 3.2. No sediment was removed from the primary channels or delivered to the split-flow channels for this run.

2. Output from this model was used to develop sediment-load rating curves upstream from each of the flows splits that represent the local inflowing sediment load.

3. The distribution of the overall sediment load to the downstream branches was initially estimated by assuming that the volume of bed material delivered to the split-flow reach is proportional to the split discharge; thus, the split-flow sediment-rating curves were developed by dividing the inflowing sediment-load rating curve based on the split-flow rating curves in Figure 3.2.

4. The split-flow sediment-rating curves were used to develop sediment load time series at the upstream limit of the split-flow channels and the corresponding sediment outflow from the primary channels for the synthetic flow hydrograph simulation.

5. The baseline model was then revised to include the split sediment loads, and executed over the synthetic flow hydrograph.

Steps 1 through 5 were repeated until no significant change was observed in the split sediment-rating curves developed in Step 3. In many cases, the high-flow portion of the split sediment-rating curves (**Figure 3.4**) were adjusted to limit the volume of sediment entering the split-flow channels to reduce excessive deposition at the head of these reaches, or to improve calibration along the primary reaches. The split sediment-rating curves were then used to develop the sediment load time series at the upstream limit of the split-flow channels and the corresponding outflow from the primary channels for the final baseline model simulation with the hydrologic input discussed in Section 3.2.3.

3.2.5. Sediment-transport Function

HEC-RAS includes the option of seven different bed-material transport capacity equations. An initial assessment of the appropriate transport capacity equation was carried out using the U.S. Army Corps of Engineers SAMWin computer program (Thomas et al., 2002), a software package that, among other features, provides assistance in the selection of sediment-transport formula for a set of input bed-material and geometric data. Input for SAMWin was developed using results from the steady-state hydraulic model and the representative bed-material gradations. Of the available equations, Yang (1973), Engelund-Hansen (1967), and Laursen (Copeland) (1989) were rated among the top three over the range of discharges. Initial test runs during the model calibration phase (discussed below) indicated that the Yang (1973) equation best matches the measured data, and this equation was, therefore, selected for use in the simulations.

3.2.6. Other Model Input

Other model input includes the computation interval, sediment properties, sediment-transport options and parameters, and output control. The overall flow duration associated with the hydrologic (quasi-unsteady flow) input is broken down into smaller computation intervals to insure the effects of changes in bed geometry are appropriately accounted for in the hydraulic computations. As discussed in the HEC-RAS User's Manual (USACE, 2010), *"…smaller computation increments will increase (model) run time, re-computing geometry and hydraulics too infrequently (e.g., computation increments that are too large) is the most common source of model instability."* For this study, the computation interval was determined using procedures outlined in the Corps' Guidelines for the Calibration and Application of Computer Program HEC-6 (USACE, 1992). The resulting time steps range from 6 minutes when the flow at Overton is greater than 10,000 cfs to 12 hours when the flow at Overton is less than 1,000 cfs (**Table 3.5**).

The basic sediment properties were assigned using the HEC-RAS Sediment Data Editor. The default values for specific gravity (2.65), shape factor (0.6), and a dry unit weight (93 pcf) were used for this study. The Exner 5 method was used to compute the active layer thickness since this option is capable of forming a coarse surface layer that simulates armoring. The fall velocity was computed using the default HEC-6 method (also referred to as the Report 12 method). The option to allow deposition in the overbanks (i.e., that portion of the cross section that is outside of the movable bed limits) was selected to account for the potential for overbank storage during extreme flood events.

Table 3.5. Summary of computational increments used for the sediment-transport simulations.

Computational Increment (hours)	Minimum Discharge (cfs)*	Maximum Discharge (cfs)*
12	0	1,000
6	1,000	2,500
4	2,500	5,000
1	5,000	7,500
0.5	7,500	10,000
0.1	10,000	23,000

*Discharge at Overton Gage.

The sediment-transport computation options and tolerances were input using the sediment-transport analysis options window. The Bed Exchange Iterations (referred to as the SPI factor in HEC-6 and HEC-6T) controls the number of iterations in the sorting and armoring algorithms. Other options and tolerances include the minimum bed change before updating the cross-sectional geometry, the minimum cross-section change before re-computation of hydraulic conditions, the volume carry-over option, and cross-section weighting options. These options (**Table 3.6**) were selected based on experience with models for similar sized rivers with similar bed-material characteristics. The local energy slope option was selected for use in the sediment-transport computations since this option is recommended in the HEC-RAS User's Manual.

3.3. Model Calibration

The sediment-transport model was calibrated, to the extent possible, by comparing the predicted aggradation/degradation trends and changes in bed-material size to observed data along the project reach. It should be noted that because the baseline model includes the existing channel geometry and the existing gradation of the bed material, only the trends in aggradation/degradation and coarsening/fining were considered in calibrating the model. (Development of a separate model that included the historical channel geometry and bed-material gradation information was beyond the scope of this feasibility study.)

The primary data used to calibrate the model were obtained from repeat cross-sectional surveys conducted by the BOR between 1985 and 2005 (BOR, 2006). This information was used to compute the mean bed elevation at the time of each survey and the resulting change in mean bed elevation during the various periods between the surveys (**Table 3.7**). For this study, the change in mean bed elevation was computed for only the active channel as defined by the portion of the cross section where aggradation or degradation was indicated by the surveys. The limits for the active channel were then used to define the bank stations in the calibration runs so that the change in mean bed elevation as reported by HEC-RAS could be directly compared to the observed changes. Since most of the mean bed elevation data represents the period between October 1, 1989, and April 1, 2002 (including the datasets from 1989 to 1998 and from 1989 to 2002), the baseline model was executed over this period.

The model was calibrated by making appropriate adjustments to the movable bed limits and the cross-section weighting factors. At the upstream boundary condition above Lexington Bridge, the ineffective flow areas used in the steady-state model were adjusted to achieve a sediment supply that resulted in reasonable calibration in this portion of the model. A comparison of the observed and computed changes in mean bed elevation over the two datasets indicates the predicted trends in aggradation and degradation match the observed trends reasonably well (**Figures 3.5 and 3.6**).

Table 3.6. Summary of HEC-RAS sediment-transport computation options and tolerances selected for the Baseline Model simulation.

Option or Tolerance	Method or Value
Bed exchange iterations per computational increment step (SPI)	20
Minimum bed change before updating cross section (ft)	0.02
Minimum cross-section change before re-computation of hydraulics (ft)	0.02
Perform volume error check and carry over remainder?	Yes
Internal Cross-section Weighting Parameters	
Number of upstream sections to use for averaging hydraulic properties	1
Number of downstream sections to use for averaging hydraulic properties	1
Weight fraction assigned to hydraulic properties at upstream cross section(s)	0.1
Weight fraction assigned to hydraulic properties at main cross section	0.8
Weight fraction assigned to hydraulic properties at downstream cross section(s)	0.1
Upstream Boundary Weighting Parameters	
Number of averaging cross sections to use downstream from the upstream boundary	4
Weight of the upstream boundary	0.25
Weight of the downstream cross sections	0.75
Downstream Boundary Weighting Parameters	
Number of averaging cross sections to use upstream from the downstream boundary	1
Weight of the downstream boundary	1
Weight of the upstream cross sections	0

Table 3.7. Summary of computed changes in mean bed elevation from the BOR repeat cross-section surveys.

Model Reach	Station (ft)	River Mile	Computed Change in Mean Bed Elevation (ft)			
			1985-2000/2001	1989-1998	1989-2002	2001-2005
Primary Flow Path						
Primary	2010+36	251.6		0.97		
Primary	1951+00	250.5		0.02		
Primary	1951+00	250.5			0.2	
Primary	1897+00	249.8			0.05	
Primary	1625+00	244			-1.64	
Primary	1399+00	240.1			-0.8	
Primary	1364+20	239.3		-0.05		
Primary	1364+20	239.3			-0.34	
Primary	1340+00	239			-1.32	
Primary	1251+50	237.5		-0.71		
Primary	1251+50	237.5			-1.2	
Primary	1069+50	233.8		-0.54		
Primary	1069+50	233.8			-0.86	
Primary	904+00	230.8		-0.14		
Primary	904+00	230.8			-0.02	
Primary	780+00	228.7			-0.52	
Primary	720+00	227.4	-0.64*			
Primary	712+00	227.4				0.13
Primary	709+00	227.25				0.16
Primary	596+00	225.1			-0.04	
Primary	537+60	224		0.26		
South Channel Jeffreys Island						
J-2	395+00	246.5			-4.33	
J-2	373+00	246			-1.66	
J-2	255+00	244			-1.02	
J-2	255+00	244	-1.32			
J-2	248+00	243.9	-1.05			
J-2	216+00	243.3	-1.83			
J-2	210+00	243.25	-1.78			
J-2	201+00	243.1	-1.08			
J-2	30+50	240.1			-0.5	
Split-flow Channels						
Split B	35+00	244			-0.19	
Split CEH	457+00	239			-0.64	
Split CEH	357+00	237.5		0.17		
Split CEH	357+00	237.5			-0.08	
Split F	316+00	237.5		-0.13		
Split F	316+00	237.5			-0.55	
Split F	120+00	233.8		-0.05		
Split F	120+00	233.8			-0.13	
Split G	28+00	237.5		1.35		
Split G	28+00	237.5			1.37	
Split J	174+00	233.8		0.1		
Split J	174+00	233.8			-0.09	
Split L	15+20	230.8		-0.43		
Split L	15+20	230.8			-0.61	

*This is the only 1985-2001 data point.

Observed changes in bed-material size were also used to validate the model results. A comparison of bed-material information collected by the BOR in 1989 and data collected in 2009 as part of the Geomorphic Monitoring Program indicates the bed material has coarsened significantly along the project reach (**Figure 3.7**). Although the existing bed-material information indicates the bed is currently quite coarse at a number of locations, the results from the Baseline Model simulation indicate that additional coarsening is likely to occur (**Figure 3.8**). Because the coarsening trend that is predicted by the Baseline Model simulation is generally similar to the observed coarsening, the model results appear to be valid.

The modeled bed material transport rates in the vicinity of Overton Bridge match the measured data reasonably well (**Figure 3.9**). (Note that the measured data points in Figure 3.9 are suspended bed-material load only. The total bed-material load corresponding to these points would be higher, improving the agreement between the modeled and measured data.) The modeled rates were also compared with the bed-material transport capacity rating curve from (Murphy et al., 2006) that is part of the basis for the original 185,000 to 225,000 t/yr deficit estimate. The BOR curve generally predicts lower transport capacities at flows less than 1,000 cfs and higher transport capacities at higher flows.

4. BASELINE MODEL RESULTS

4.1. Deficit and Surplus Volumes

Results from the Baseline Model simulation were evaluated to assess the magnitude, distribution, and characteristics of sediment loading along the project reach under existing conditions. In general, the results indicate that the overall sediment deficit between the Lexington and Odessa Bridges is about 152,000 t/yr over the 12.5-year simulation period. To evaluate the distribution of this deficit, the project reach was divided into five subreaches (**Table 4.1** and Figure 1.2), and the total mass surplus or deficit in each of the subreaches was computed using the cumulative mass flux that enters and exits each subreach at various points during the simulation. The results indicate that Subreaches 1 and 4 are slightly to moderately aggradational, while Subreaches 2, 3 and 5 are degradational (**Figure 4.1**). In Subreach 1, the most significant amount of aggradation occurs in WY1995 due to the high-magnitude flood that occurred during the summer of that year. Degradation in Subreaches 2 and 3 appears to be most significant during the period between 1996 and 2000 when the runoff volume was relatively large. Upstream from the Kearney Diversion Structure, deposition occurs in each year of the simulation except 1995, when extreme flooding flushes deposited sediments from the reach, and in 2000, when very little change is indicated. In Subreach 5, the degradation is probably affected by the gains and losses that occur in this reach, but also mirrors the aggradational trend is Subreach 4, with the largest degradation volumes indicated during years when sediment trapping in Subreach 4 is the largest. Degradation in Subreach 5 tends to be larger during years when the unmeasured gains are large compared to the losses, since no sediment load is associated with the inflow (i.e., WY1996).

The average annual surplus or deficit values were obtained by dividing the cumulative differences at the end of the simulation by the 12.5-year simulation period. The resulting mass surplus or deficit values (**Figure 4.2**) indicate that Subreach 1 is moderately aggradational (66,400 t/yr), Subreaches 2 and 3 are strongly degradational (96,700 and 108,500 t/yr, respectively), and Subreach 5 is moderately degradational (46,100 t/yr). The relatively short subreach between Elm Creek Bridge and the Kearney Diversion is slightly aggradational (32,700 t/yr) due to the backwater effects of the diversion structure.

Table 4.1. Summary of subreaches used to evaluate the baseline model results.		
Subreach	Upstream Limit	Downstream Limit
1	Lexington Bridge	Overton Bridge
2	J-2 Return	Overton Bridge
3	Overton Bridge	Elm Creek Bridge
4	Elm Creek Bridge	Kearney Diversion
5	Kearney Diversion	Odessa Bridge

HEC-RAS does not segregate the erosion/deposition volumes between the overbanks and main channel. Since the deficits in the main channel have a significant effect on sand-bar development and morphology, the lateral distribution of the surplus or deficits was estimated by computing the change in volume in the overbanks and in the main channel using the channel geometry at the start of the simulation and at various times during the simulation. To compute these volumes, end-area calculations were performed using the average reach length between the up- and downstream cross sections. As discussed above, the cross-sectional geometry output cannot be accessed after a certain point in the simulation, presumably because the output file is too large. The end-area calculations were therefore performed using the geometry output on the last accessible simulation date. The resulting change in the main channel, expressed as a percentage of the total surplus or deficit, was then used to estimate the portion of the total surplus or deficit that occurs in the main channel during the latter portion of the simulation when the geometric output could not be accessed.

The distribution indicates that a significant amount of sediment storage occurs in the overbanks; thus, the main-channel deficits are somewhat greater than the total deficits in subreaches that are degradational, and the main-channel surplus is somewhat less than the total surplus in subreaches that are aggradational (Figure 4.2). The main channel surplus in Subreaches 1 and 4 are reduced to 47,100 and 7,200 t/yr, respectively, while the main channel deficit in Subreaches 2, 3 and 5 increases to about 97,700, 149,800 and 50,300 t/yr, respectively.

4.2. Erosion and Deposition Material Size

The baseline model results were also processed to evaluate the size of the material that makes up the surplus or deficit. Results from this analysis indicate that, in each of the subreaches, most of the eroded or deposited material is in the medium to coarse sand range (0.25 to 1.0 mm; **Figures 4.3a through 4.3e**). In Subreach 1, the deposited material includes about 10 percent very fine to fine sand (<0.25 mm), about 67-percent medium to coarse sand, and about 23 percent in the very coarse sand-to-gravel range (>1 mm; Figure 4.3a). Of the depositional reaches, the largest percentage of coarse material (29 percent very coarse sand to gravel) is eroded from Subreach 2 due to the availability of the coarse fractions in the surface material and the relatively high transport capacity in most of the South Channel of Jeffreys Island (Figure 4.3b). Eroded material in Subreach 3 includes nearly equal parts fine and coarse material (20 percent less than 0.25 mm and 21 percent greater than 1 mm; Figure 4.3c). Very coarse sand and gravel make up a significant portion (about 32 percent) of the material that is deposited upstream from the Kearney Diversion Structure in Subreach 4 (Figure 4.3d). The deficit in Subreach 5 is well-graded, with 24-percent very fine to fine sand, 51-percent medium to coarse sand, and 25-percent very coarse sand and gravel (Figure 4.3e).

4.3. Response to Hydrologic Conditions

While the results discussed above generally address aggradation/degradation tendencies that are related to wet and dry conditions on an average annual basis, the response to specific hydrologic events is not explicitly shown in Figures 4.1 and 4.3. The baseline model simulation results were therefore used to evaluate the response to specific hydrologic events at key locations. For this evaluation, the mass fluxes across the subreach boundaries and the associated surplus or deficit were plotted with the representative flow hydrographs over the simulation period (**Figures 4.4a through 4.4e**). In Subreach 1, most of the aggradation occurs during high-flow periods that result in significant overbank storage (Figure 4.4a). Nearly half of the cumulative storage at the end of the simulation occurs during the 1995 flood. Because there is no sediment supply to Subreach 2, the rate of degradation in this reach is directly linked to the J-2 Return flows, with the most significant amounts of degradation occurring during high-flow release periods (Figure 4.4b). Degradation in Subreach 3 appears to be largest during sustained high-flow periods, with very little change during low-flow periods (Figure 4.4c). Short periods of aggradation or no change occur during the extreme flood events in 1995, 1997 and 1999 due to the large volume of material delivered from Subreach 1. In Subreach 4, most aggradation tends to occur during the high-flow periods when the backwater effects from the Kearney Diversion are most significant, while very little change occurs during low-flow periods (Figure 4.4d). Degradation in the downstream subreach follows a similar pattern (Figure 4.4e).

These results were also used to develop relationships between the predicted surplus or deficit and discharge (**Figure 4.5**). To limit the output files to a manageable size, the model reports time series output on every 10^{th} day of the simulation. The relationships were, therefore, developed using the average discharge during each 10-day period and the corresponding average surplus or deficit at the end of each 10-day period. As expected, the largest volumes of aggradation or degradation occur at the higher discharges when the sediment-transport rates are the largest. The results in Subreaches 1 and 2 indicate that the surplus and deficit, respectively, increase in a relatively consistent manner with increasing discharge. In Subreach 3, the deficit generally increases with increasing discharge at low to moderate flows (less than about 5,000 cfs), but there is considerable scatter and no consistent trend at higher flows. This behavior is related to both the variability and uncorrelated sediment contributions from the North and South Channels of Jeffreys Island (i.e., Subreaches 1 and 2, respectfully), and hysteresis during the rising and falling limbs of the hydrograph as finer sediment is depleted from and added to the active bed layer. In the aggradational Subreach 4, upstream from the Kearney Diversion Structure, most of the aggradation occurs at flows exceeding 2,000 cfs. Degradation between the Kearney Diversion Structure and Odessa Bridge (Subreach 5) appears to be most significant at flows in excess of 1,000 cfs.

5. SEDIMENT AUGMENTATION ALTERNATIVES EVALUATION

The alternatives identified in the Feasibility Study general fall into two categories: (1) Sand Pump Options, and (2) Dozer Options. The initial goal of the sediment-transport modeling was to simulate each of the three primary alternatives (**Table 5.1**). Based on preliminary evaluations of selected alternatives, it was determined that additional simulations were necessary to assess variations of the initially selected alternatives. These variations are also summarized in Table 5.1. The following sections summarize the predicted total surplus or deficit, as well as the estimated in-channel surplus or deficit, for each of the simulations. The total surplus or deficit was computed using the total mass flux entering and exiting each subreach.

As discussed in Section 4.1, the in-channel surplus or deficit was computed by estimating the volume of overbank storage at the end of the simulation based on end-area calculations that were performed using the geometry output on the last accessible simulation date, since this information is not directly available from the model output.

Table 5.1. Summary of alternatives selected for evaluation, and the variations of the base alternative.

Alternative Identification	Description	Variations
1A	2 sand pumps located in the South Channel of Jeffreys Island (one at west end of Cook (Site 1) and one near the Cook/Dyer property boundary (Site 2).	i. Fine Gradation (D_{50}~0.5 mm), pumping starts August 1.
		ii. Coarse Gradation (D_{50}~1.2 mm), pumping starts August 1.
		iii. Coarse Gradation (D_{50}~1.2 mm), pumping starts September 1.
		iv. Coarse Gradation (D_{50}~1.2 mm), pumping starts February 15.
1D	3 sand pumps with the first two located at Sites 1 and 2 as identified in Alternative 2A, and the third located below the berm breach at Overton Sand and Gravel (Site 4).	i. Fine Gradation (D_{50}~0.5 mm), pumping starts August 1.
		ii. Coarse Gradation (D_{50}~1.2 mm), pumping starts August 1.
		iii. Coarse Gradation (D_{50}~1.2 mm), pumping starts September 1.
		iv. Coarse Gradation (D_{50}~1.2 mm), pumping starts February 15.
		v. Fine Gradation (D_{50}~0.5 mm) with volume increased to 300,000 tons/year, pumping starts August 1.
2A	Augmented material placed on the Cook and Dyer properties using bull dozers.	i. Windrows placed along the bank toes.
		ii. Revised location of wndrows for increased inundation.
		iii. Concentrated (short-length) sediment plug in overall channel.
		iv. Distributed (long-length) sediment plug in low-flow channel.

5.1. Alternative 1A

Alternative 1A involves sediment augmentation using two pumps located in the South Channel of Jeffreys Island at the west end of the Cook Property (Site 1) and at the Cook/Dyer Property Boundary (Site 2) (**Figure 5.1**). Variations of this alternative included augmentation with material from Overton Sand and Gravel (OS&G), augmentation with coarser material that is similar to the existing bed material, and various pump start dates (August 1, September 1 and February 15).

5.1.1. Alternative 1A-i

Under this alternative, the augmented material would be imported from OS&G. The gradations of two samples collected from OS&G sand storage piles are very similar, and the average of these two gradations was used for the augmented material for this alternative (**Figure 5.2**). The gradation of the augmented material is somewhat finer than the existing channel bed material, with a median grain size (D_{50}) of about 0.5 mm.

A sediment pumping program was developed under the assumption that 500-gpm pumps would be used and that the pumped slurry would contain 25-percent solids. Based on a bulked specific weight of the sediment of 93 pcf and pumps that operate continuously 5 days per week, each of the two pumps would deliver about 1,120 tons/day (5,600 tons/week). Under this alternative, the sediment pumping would occur over an approximately 3-month period each year between August 1 and November 2 until a total of 150,000 tons (75,000 tons at each pump) of material was injected into the river. These sediment load series were then used to define a point source input to the model using the lateral sediment inflow time series data editor.

Results from this simulation indicate that some portion of the augmented material is deposited at or below the pump outfalls in the South Channel of Jeffreys Island (**Figure**

5.3). The total sediment deficit in this subreach is reduced from about 97,000 t/yr under baseline conditions to about 74,000 t/yr under Alternative 1A-i, indicating that about 23,000 t/yr of additional storage occurs along the overall subreach (**Table 5.2**). While a significant portion of the reduction in sediment deficit is associated with deposition of the augmented material in the vicinity of the pumps, at least some of the deficit reduction occurs upstream from the pumps due to the decreased velocities caused by the aggradation at the outfalls. The indicated storage of material in the vicinity of the pumps is reasonable, since this portion of Subreach 2 is essentially in balance with the upstream sediment supply under existing (baseline) conditions.

As expected, the local ability of the channel to transport the augmented material is affected by both the local hydraulics and the hydrologic conditions during and after the pumping period. Below Pump Site 1 (Cook West), aggradation occurs throughout each of the pumping periods, but most of the deposited material is evacuated during the 2- to 4-month period following the pumping (**Figure 5.4**). Downstream from Pump Site 2 at the Cook/Dyer property boundary, where the energy gradient is slightly higher, the magnitude of the aggradation is somewhat less than at the upstream site, and net degradation occurs during the non-pumping periods (**Figure 5.5**).

Table 5.2. Predicted total and average annual surplus or deficit in each of the subreaches under baseline and Alternative 1A-i conditions.

Subreach	Subreach Description	Alternative 1A-i			Baseline Conditions		
		Total Change in Mass (tons)[1]	Total Change in Mass (t/yr)[1]	In-Channel Change in Mass (t/yr)[2]	Total Change in Mass (tons)[1]	Total Change in Mass (t/yr)[1]	In-Channel Change in Mass (t/yr)[2]
1	Lexington - Overton, North Channel	840,000	67,000	48,000	830,000	66,000	47,000
2	J-2 Return - Overton, South Channel	-923,000	-74,000	-75,000	-1,209,000	-97,000	-98,000
3	Overton - Elm Ck	-543,000	-43,000	-60,000	-1,356,000	-109,000	-150,000
4	Elm Ck - Kearney Div.	279,000	22,000	5,000	408,000	33,000	7,000
5	Kearney Div - Odessa	-307,000	-25,000	-27,000	-576,000	-46,000	-50,000

[1]Based on total mass flux over the 12.5-year simulation (including overbank storage).
[2]Based on estimated volume of storage in overbanks (see text for explanation).

The introduced sediment has very little impact on conditions in the North Channel of Jeffreys Island (Subreach 1), since this subreach is located upstream from the augmentation operations (**Figure 5.6** and Table 5.2). Assuming that most of the reduction in sediment deficit in Subreach 1 is associated with deposition of the augmented material, about 130,000 t/yr of the augmented material is delivered to Subreach 3. Of this amount, the total sediment deficit in Subreach 3 is reduced from about 109,000 t/yr under baseline conditions to about 43,000 t/yr under this alternative. About 20,000 tons of the augmented material is deposited in the vicinity of the pumps, about 66,000 tons is deposited between the Overton and Elm Creek Bridges, and the remainder of the 150,000 tons of introduced sediment is flushed through this critical reach. Annual sediment storage upstream from the Kearney Diversion Structure (Subreach 4) is slightly reduced from about 33,000 tons under baseline conditions to about 22,000 tons under Alternative 1A-i due to the net smaller size of the material being supplied from the upstream reaches that is more readily transported through the backwater zone. The total annual deficit in Subreach 5 is reduced by about 21,000 tons, indicating the remainder of the augmented material (about 51,000 t/yr) passes through the project reach into the downstream river.

The reduction in in-channel deficits in the degradational reaches are somewhat greater than the total due to increased sediment storage in the overbanks that occurs with the increased sediment-transport rates under this alternative (Table 5.2 and Figure 5.4). The annual in-channel deficit in Subreach 3 is reduced from 150,000 tons under baseline conditions to about 60,000 tons. In Subreach 5, the annual in-channel deficit is reduced by nearly 50 percent from 50,000 tons to about 27,000 tons. In the aggradational reach upstream from the Kearney Diversion Structure, the in-channel surplus is slightly reduced by about 2,000 t/yr.

The most significant effect of the sediment augmentation under this alternative occurs in Subreach 3. A comparison of the predicted changes in mean bed elevation at the end of the 12.5-year simulations indicates that channel downcutting in the vicinity of Cottonwood Ranch decreases from as much as 3 feet under baseline conditions to a maximum of about 1.4 feet under this alternative (**Figure 5.7**). The effects of the individual pumping events dampen in the downstream direction, with identifiable temporal effects (i.e., some degree of aggradation during the pumping operations followed by a period of degradation) in the upstream portions of Subreach 3 (**Figures 5.8 and 5.9**). At and below Cottonwood Ranch, no identifiable temporal effect is evident during the pumping period; instead, the decrease in the amount of degradation tends to occur more uniformly over longer periods (**Figures 5.10 through 5.12**).

5.1.2. Alternative 1A-ii

Because a significant portion of the relatively fine-grained augmented material used for Alternative 1A-i was transported through the project reach and did not eliminate the sediment deficit in any of the degradational reaches, the augmented material was coarsened under Alternative 1A-ii to a gradation similar to the existing bed material in the reach between Overton and Elm Creek (Subreach 3). This gradation was developed by averaging the representative gradation of the bed material at the three anchor points in this reach (Anchor Points 31, 32a, and 33a; Figure 5.2). The resulting average gradation has a median diameter of about 1.2 mm and includes about 35-percent gravel. The remainder of the input for this alternative (i.e., the sediment load series that represent the pumping operations) was identical to that used for Alternative 1A-i.

Results from this simulation indicate that a significant amount of the augmented material is deposited in the vicinity of the pumping operations (**Figure 5.13**). Again, this is to be expected since the pumps under this alternative are located in an area of the South Channel of Jeffreys Island that is currently in balance with the upstream sediment supply. The addition of relatively coarse material causes the overall sediment supply to be somewhat larger than the transport capacity in this area, causing the indicated deposition. Similar to the results from Alternative 1A-i, the amount of degradation upstream from the pumps is less than that observed under baseline conditions due to the increased baselevel associated with the deposition in the vicinity of the pumps. The predicted deficit in the South Channel is about 97,000 t/yr under baseline conditions, but the Alternative 1A-ii simulation indicates a slight surplus of about 1,000 t/yr; thus, the volume that comprises both the deposition of the augmented material and the reduced upstream degradation is about 98,000 t/yr. Since the augmented material makes up most of this volume, nearly two-thirds of the augmented material is trapped in the South Channel. A significant amount of aggradation occurs below each of the pumps during the operation period, only a portion of which is eroded during the months following pump operation (Figures 5.4 and 5.5). The post-pumping erosion at Pump Site 1 tends to be the most significant when the J-2 Return flows are high (i.e., WY1996), which results in increased supply to the river in the vicinity of Pump Site 2, reducing the potential for erosion at this location.

Because a significant portion of the augmented material is trapped in the South Channel under this alternative, the benefits to the degradational reaches are considerably less than those under Alternative 1A-i (**Figure 5.14**). The in-channel annual deficit in Subreach 3 is only reduced to about 102,000 tons, and the in-channel deficit in Subreach 5 is reduced to about 43,000 tons (compared to 150,000 and 50,000 tons, respectively, under baseline conditions; **Table 5.3**). The associated reduction in degradation depth is also relatively small, decreasing by about 0.2 to 1.0 feet in the vicinity of Cottonwood Ranch (**Figure 5.15**). There is essentially no change from baseline conditions in the volume of material stored upstream from the Kearney Diversion Structure. The temporal patterns of aggradation and degradation are similar to those observed under Alternative 1A-i, but the magnitude of the reduction in degradation is somewhat less (Figures 5.8 through 5.12).

5.1.3. Alternatives 1A-iii and 1A-iv

The effectiveness of the augmentation plan evaluated in the simulations for Alternatives 1A-i and 1A-ii is linked to the hydrologic conditions during and shortly after the pump operation period. In the South Channel of Jeffreys Island, flows from the J-2 Return tend to be relatively low during the first month of the pumping in August, increasing to relatively high flows during the last month of pumping in October (**Figure 5.16**). River flows at the Overton gage are also relatively low during August, and increase to moderate levels in October (**Figure 5.17**). To evaluate the effects of the hydrologic conditions during and after the augmentation period, the sediment load series used to represent the pumping operations was adjusted to start on September 1 (Alternative 1A-iii) and February 15 (Alternative 1A-iv). These dates were selected because relatively high flows tend to occur during the 3-month pumping period and to avoid the potential problems that would occur with operating the pumps during the winter months when temperatures are typically below freezing. Both simulations were executed using coarser material that is representative of the existing bed material (i.e., the gradation used for the augmented material in Alternative 1A-ii; Figure 5.2).

The various pumping start dates appear to have relatively little effect on the aggradation/ degradation volumes under the Alternative 1A augmentation plan (**Figure 5.18**). The most significant effect occurs under Alternative 1A-iv with the February 15 pumping start date. The relatively low flows that are delivered from the J-2 Return in the spring and early summer months after the pumping period are not as capable of transporting the augmented material as the flows that follow the pumping period with the August 1 and September 1 start dates, resulting in additional deposition of the augmented material in the South Channel of Jeffreys Island. The additional storage of material below the pumps translates to a reduced sediment supply to Subreach 3, causing increased degradation in this reach.

Table 5.3. Predicted total and average annual surplus or deficit in each of the subreaches under baseline and Alternative 1A-ii conditions.							
Subreach	Subreach Description	Alternative 1A-ii			Baseline Conditions		
		Total Change in Mass (tons)[1]	Total Change in Mass (t/yr)[1]	In-Channel Change in Mass (t/yr)[2]	Total Change in Mass (tons)[1]	Total Change in Mass (t/yr)[1]	In-Channel Change in Mass (t/yr)[2]
1	Lexington-Overton, North Channel	837,000	67,000	48,000	830,000	66,000	47,000
2	J-2 Return-Overton, South Channel	10,000	1,000	1,000	-1,209,000	-97,000	-98,000
3	Overton - Elm Ck	-917,000	-73,000	-102,000	-1,356,000	-109,000	-150,000
4	Elm Ck - Kearney Diversion	373,000	30,000	7,000	408,000	33,000	7,000
5	Kearney Diversion - Odessa	-492,000	-39,000	-43,000	-576,000	-46,000	-50,000

[1]Based on total mass flux over the 12.5-year simulation (including overbank storage).
[2]Based on estimated volume of storage in overbanks (see text for explanation).

5.2. Alternative 1D

Alternative 1D is similar to Alternative 1A except an additional pump is proposed on the left bank below the breached pit at Overton Sand and Gravel (Site 4; Figure 5.1). Variations of this alternative included augmentation with material from Overton Sand and Gravel (OS&G), augmentation with coarser material that is similar to the existing bed material, various pump start dates (August 1, September 1, and February 15), and increasing the augmentation volume to 300,000 t/yr using material from OS&G.

5.2.1. Alternative 1D-i

The fine gradation (D_{50} ~0.5 mm) that represents the likely material that would be available from OS&G was used for the gradation of the augmented material under Alternative 1D-i (Figure 5.2). Because this alternative includes three pumps, the sediment-load series used to represent the pumping operations was adjusted accordingly. The sediment-load series were developed using the same assumptions that were applied in developing the Alternative 1A simulations (pump rates of 500 gpm with 25-percent solids, bulked sediment-specific weight of 93 pcf, sediment-pumping rates of 1,120 t/day, etc.). With three pumps operating at 5 days/week, the pumps would need to operate over an approximately 2-month period to inject 150,000 tons of material into the river. Under this alternative, the pumps start operating on August 1 of each simulation year, and the pumping period extends through October 2.

Although the general patterns of erosion and deposition under this alternative are similar to those observed under Alternative 1A-i, there are important differences in evaluating the effects of the third pump at OS&G. The reduced volume of material that is injected in the South Channel of Jeffreys Island results in less aggradation in the vicinity of the pumps than occurs under Alternative 1A-i, with most of the aggradation occurring below Pumping Site 1 (**Figure 5.19**; Figures 5.4 and 5.5).

Downstream from the pump at Site 4 (OS&G), some aggradation occurs during the pumping periods, but most of the deposited material is re-entrained during the months following pumping operations (Figure 5.8). Compared to the Alternative 1A-i results, slightly less degradation occurs in the upstream portions of Subreach 3, but there is slightly more degradation in the downstream portion of this reach (**Figures 5.20**; Figures 5.8 through 5.12). Despite these differences, the net degradation in this subreach is essentially the same under these two alternatives (**Table 5.4 and Figure 5.21**). Again, compared to Alternative 1A-i, the increased erosion in the downstream end of Subreach 3 results in slightly larger volumes of aggradation upstream from the Kearney Diversion Structure in Subreach 4, reducing the sediment supply and slightly increasing the degradation in Subreach 5.

Table 5.4. Predicted total and average annual surplus or deficit in each of the subreaches under baseline conditions and Alternatives 1A-i and 1D-i.

Subreach	Subreach Description	Alternative 1D-i			Alternative 1A-i			Baseline Conditions		
		Total Change in Mass (tons)[1]	Total Change in Mass (t/yr)[1]	In-Channel Change in Mass (t/yr)[2]	Total Change in Mass (tons)[1]	Total Change in Mass (t/yr)[1]	In-Channel Change in Mass (t/yr)[2]	Total Change in Mass (tons)[1]	Total Change in Mass (t/yr)[1]	In-Channel Change in Mass (t/yr)[2]
1	Lexington - Overton, N Chnl.	816,000	65,000	46,000	840,000	67,000	48,000	830,000	66,000	47,000
2	J2 Return - Overton, S Chnl.	-1,076,000	-86,000	-87,000	-923,000	-74,000	-75,000	-1,209,000	-97,000	-98,000
3	Overton - Elm Ck	-533,000	-43,000	-59,000	-543,000	-43,000	-60,000	-1,356,000	-109,000	-150,000
4	Elm Ck - Kearney Div.	504,000	40,000	9,000	279,000	22,000	5,000	408,000	33,000	7,000
5	Kearney Div - Odessa	-370,000	-30,000	-32,000	-307,000	-25,000	-27,000	-576,000	-46,000	-50,000

[1] Based on total mass flux over the 12.5-year simulation (including overbank storage).
[2] Based on estimated volume of storage in overbanks (see text for explanation).

5.2.2. Alternative 1D-ii

Alternative 1D-ii is similar to Alternative 1D-i except the gradation of the augmented material was coarsened to match the existing bed material, as in the Alternative 1A-ii simulation (D_{50} ~1.2 mm).

Results from this simulation indicate that a significant portion of the material that is injected in the South Channel of Jeffreys Island is deposited in the vicinity of the pumps, although the aggradation volumes are somewhat less than under Alternative 1A-ii due to the reduced augmentation volume at these pumps (**Figure 5.22**; Figures 5.4 and 5.5). The total annual volume of degradation in the South Channel is reduced from 97,000 tons under baseline conditions to 36,000 tons under this alternative, indicating that about 61,000 tons of material is either deposited in the vicinity of the pumps or is not eroded from the upstream reaches due to increased baselevels.

The most significant effect of this alternative occurs in Subreach 3, where the total annual deficit is reduced to 23,000 tons, compared to 73,000 and 109,000 tons under Alternative 1A-ii and baseline conditions, respectfully (**Figure 5.23 and Table 5.5**). Similarly, the annual in-channel deficit is reduced to about 31,000 tons, compared to 102,000 and 150,000 tons under Alternative 1A-ii and baseline conditions, respectively. Maximum degradation depths in the vicinity of Cottonwood Ranch decrease to about 1.3 feet, compared to nearly 2 feet under Alternative 1A-ii and nearly 3 feet under baseline conditions (**Figure 5.24**). A significant factor in the relative effectiveness of this alternative is the high-energy gradients and associated shear stresses in the vicinity of Pumping Site 4 (OS&G). In most years, all of the material that is augmented at this location is eventually entrained and delivered to the downstream portions of this subreach (Figure 5.8). Similar to the above alternatives, the temporal effects of the pumping are dampened in the downstream direction, but the magnitude of the degradation is significantly reduced at most locations (Figures 5.9 through 5.12). The amount of aggradation in Subreach 4 and degradation in Subreach 5 is similar to the results from Alternative 1A-ii.

Table 5.5. Predicted total and average annual surplus or deficit in each of the subreaches under baseline conditions and Alternatives 1A-i and 1D-i.

Subreach	Subreach Description	Alternative 1D-ii			Alternative 1A-ii			Baseline Conditions		
		Total Change in Mass (tons)[1]	Total Change in Mass (t/yr)[1]	In-Channel Change in Mass (t/yr)[2]	Total Change in Mass (tons)[1]	Total Change in Mass (t/yr)[1]	In-Channel Change in Mass (t/yr)[2]	Total Change in Mass (tons)[1]	Total Change in Mass (t/yr)[1]	In-Channel Change in Mass (t/yr)[2]
1	Lexington - Overton, N Chnl.	936,000	75,000	53,000	837,000	67,000	48,000	830,000	66,000	47,000
2	J2 Return - Overton, S Chnl.	-455,000	-36,000	-37,000	10,000	1,000	1,000	-1,209,000	-97,000	-98,000
3	Overton - Elm Ck	-281,000	-23,000	-31,000	-917,000	-73,000	-102,000	-1,356,000	-109,000	-150,000
4	Elm Ck - Kearney Div.	344,000	28,000	6,000	373,000	30,000	7,000	408,000	33,000	7,000
5	Kearney Div - Odessa	-551,000	-44,000	-48,000	-492,000	-39,000	-43,000	-576,000	-46,000	-50,000

[1] Based on total mass flux over the 12.5-year simulation (including overbank storage).
[2] Based on estimated volume of storage in overbanks (see text for explanation).

5.2.3. Alternatives 1D-iii and 1D-iv

Alternatives 1D-iii and 1D-iv were developed to evaluate the effects of the hydrologic conditions during and after the pumping periods in a manner similar to Alternatives 1A-iii and 1A-iv. The sediment load series used to represent the pumping operations was adjusted to start on September 1 (Alternative 1D-iii) and February 15 (Alternative 1D-iv), and both simulations were executed using the coarse augmented material that is representative of the existing bed material (i.e., the gradation used for the augmented material in Alternative 1D-ii; Figure 5.2).

While the total difference in the aggradation and degradation volumes in each of the subreaches is relatively small, the differences are significant compared to the results from Alternative 1D-ii because the deficit in Subreach 3 has been significantly reduced from baseline conditions (**Figure 5.25**). The total annual deficit in this subreach with pump operations beginning August 1 (Alternative 1D-ii) is about 23,000 tons, which could be reduced to 17,000 if pumping starts on September 1 (Alternative 1D-iii), and reduced even further to 14,000 by starting the pumping on February 15 (Alternative 1D-iv). The largest benefit occurs with the February 15 start date since this simulation has the highest total flow below the confluence with the South Channel during and after the pumping periods (Figure 5.17). The annual in-channel deficit decreases from about 31,000 tons with the August 1 start date to about 23,000 and 20,000 tons with the September 1 and February 15 start dates, respectively.

5.2.4. Alternatives 1D-v

Alternative 1D-v was developed to determine the approximate annual volume of augmented material that would be required to eliminate the sediment deficit in Subreach 3 under the assumption that the material would be obtained from OS&G, with no screening to increase the sediment size. Based on the Alternative 1D-i results, the transport capacity in the vicinity of the pump outfalls varies significantly with discharge but is generally lower downstream from the pumps in the South Channel. Therefore, it is likely that any increase in the pumping volume at these two sites would result in increased deposition below the pumps with limited effects farther downstream, while increased augmentation at OS&G would have a more direct benefit in the target reach due to the higher transport capacities in this part of the reach. Under the assumption that aggradation in the South Channel would be acceptable, the pumping locations were not adjusted under this alternative so that the model results could be directly compared to those from Alternative 1D-i. An annual augmentation volume of 300,000 tons was used for this simulation, with 200,000 tons injected at the two pumps in the South Channel (Pumping Sites 1 and 2) and 100,000 tons at OS&G (Pumping Site 4). The sediment-load series for the three pumps were adjusted by doubling the input capacity of each pump to 2,240 t/day with no change in the duration of pumping.

The analysis indicates that, as expected, a significant amount of the material augmented in the South Channel deposits downstream from the pumps (**Figure 5.26**). The total annual deficit in this reach is reduced from 97,000 tons under baseline conditions to 18,000 tons under this alternative, with the remaining approximately 79,000 tons representing either augmented material that is deposited downstream from the pumps or a reduction in degradation upstream from the pumps. In Subreach 3, the total annual deficit decreases to about 5,000 tons (**Table 5.6** and **Figure 5.27**). In channel annual deficits along this subreach decrease from about 150,000 tons under baseline conditions to only 7,000 tons under this alternative. It should be noted that the deficit through Cottonwood Ranch is somewhat higher than the overall subreach deficit, since aggradation occurs at some locations downstream from the OS&G pump and in the downstream portions of this subreach above Elm Creek (**Figure 5.28**). The maximum degradation depth through Cottonwood Ranch is about 1 foot, compared to about 3 feet under baseline conditions.

5.3. Alternative 2A

Alternative 2A involves placing augmented material along the South Channel of Jeffreys Island using dozers, under the assumption that the material would be available for entrainment and transport to the downstream degradational reaches. Variations of this alternative included placement of the material in windrows along the bank toes, revised windrows located to increase inundation, placement of the material in one sediment plug, and placement of the material in a contiguous windrow located along the low-flow channel bed. Under each variation of this alternative, it was assumed that 150,000 tons of material with gradation consistent with the existing bed material in Subreach 3 (i.e., D_{50} ~1.2 mm) would be placed each year.

Table 5.6. Predicted total and average annual surplus or deficit in each of the subreaches under baseline conditions and Alternatives 1D-i and 1D-v.

Subreach	Subreach Description	Alternative 1D-v			Alternative 1D-i			Baseline Conditions		
		Total Change in Mass (tons)[1]	Total Change in Mass (t/yr)[1]	In-Channel Change in Mass (t/yr)[2]	Total Change in Mass (tons)[1]	Total Change in Mass (t/yr)[1]	In-Channel Change in Mass (t/yr)[2]	Total Change in Mass (tons)[1]	Total Change in Mass (t/yr)[1]	In-Channel Change in Mass (t/yr)[2]
1	Lexington - Overton, N Chnl.	922,000	74,000	52,000	816,000	65,000	46,000	830,000	66,000	47,000
2	J2 Return - Overton, S Chnl.	-219,000	-18,000	-18,000	-1,076,000	-86,000	-87,000	-1,209,000	-97,000	-98,000
3	Overton - Elm Ck	-68,000	-5,000	-7,000	-533,000	-43,000	-59,000	-1,356,000	-109,000	-150,000
4	Elm Ck - Kearney Div.	416,000	33,000	7,000	504,000	40,000	9,000	408,000	33,000	7,000
5	Kearney Div - Odessa	-228,000	-18,000	-20,000	-370,000	-30,000	-32,000	-576,000	-46,000	-50,000

[1] Based on total mass flux over the 12.5-year simulation (including overbank storage).
[2] Based on estimated volume of storage in overbanks (see text for explanation).

5.3.1. Alternative 2A-i

Alternative 2A-i involves placement of the augmented material in windrow piles that would be located along the toes of the banks in the vicinity of the Cook and Dyer properties in the South Channel of Jeffreys Island (**Figure 5.29**). The extent of the windrow piles shown in Figure 5.29 was based on an assumed windrow height of 3 feet with the total width perpendicular to the direction of flow varying, depending on access conditions. At locations where access conditions allow for windrow construction on only the left (north) bank (Sta 123+00 to Sta 132+00 and Sta 61+00 to Sta 90+00), the width of the piles is about 210 feet, and the width of the windrows would be about 70 feet where windrows could be constructed on both banks (Sta 94+00 to Sta 120+00).

The windrow piles were incorporated into the steady-state hydraulic model geometry to evaluate the hydraulic conditions (i.e., depth, velocity, shear stress, etc.) that would be occurring immediately after construction of the windrows. For this analysis, it was assumed that the windrows would have a uniform depth of 3 feet above the existing ground surface (**Figures 5.30 through 5.32**). While the actual windrow piles would likely have a more uniform finished surface, the assumed geometry should have a similar effect on the hydraulic conditions. At most locations, the windrow piles are not sufficiently inundated over the range of typical flows delivered by the J-2 Return to cause significant entrainment of the augmented material (Figures 5.30 through 5.32). (During the baseline simulation period from October 1, 1989, to April 1, 2002, mean daily discharges from the J-2 Return of 500, 1,000, 1,500 and 2,000 cfs were equaled or exceeded about 69, 43, 22 and 0 percent of the time, respectfully.) Some scouring of the pile toes would likely result in the sloughing of a relatively limited amount of material into the active channel that would be available for transport, but most of the material in the windrows would remain in-place, with relatively little effect on downstream deficits.

5.3.2. Alternative 2A-ii

Because the layout of the windrow piles under Alternative 2A-i resulted in insufficient inundation to mobilize significant portions of the augmented material, the windrow configuration was revised to improve the potential for inundation (**Figure 5.33**). Under this alternative, the windrow piles were spread out to reduce the overall pile height, and the piles were relocated to the lower-elevation portions of the active channel(s). For the upstream reach, between

Sta 123+00 to Sta 132+00, a pile height of 1.8 feet and pile width of 280 feet was used. Windrow piles in the middle reach between Sta 94+00 to Sta 120+00 had a pile height of 1.2 feet and width of 200 feet. Two windrow pile strips were used in the downstream reach (Sta 61+00 to Sta 90+00) with a pile height of 1.6 feet and width of 200 feet.

Results from the steady-state hydraulic model with the windrow pile geometry indicate that typical flows from the J-2 Return will inundate most of the windrow piles (**Figures 5.34 through 5.36**). The windrow piles cause increased water-surface elevations of up to 2.3 feet compared to baseline (existing) conditions, but there appears to be no risk of increased flooding since flows up to 2,000 cfs are contained in the overall channel (**Figure 5.37**). However, the windrows do create localized backwater zones that generally reduce the total shear stress, especially near the downstream limit of the piles (**Figure 5.38**). Because the transport capacity in this reach is already relatively low under baseline conditions, the reduced shear stress caused by the windrow configuration under this alternative would probably not be sufficient to entrain and transport the augmented material. As such, this alternative was not evaluated using the sediment-transport model.

5.3.3. Alternative 2A-iii

The above evaluation of Alternatives 2A-i and 2A-ii, coupled with the results from the baseline conditions sediment-transport model, suggest that the transport capacity will not be sufficient to evacuate the augmented material due to the relatively low hydraulic energy along this reach. Alternative 2A-iii was, therefore, developed to evaluate the potential for construction of a dozed sediment plug that would cause high hydraulic energies across the downstream face of the plug, creating a head cut that would incise through the augmented material. The location of the sediment plug (**Figure 5.39**) was selected based on a number of criteria, including:

- hydraulic conditions that result in relatively high sediment-transport capacity under baseline conditions,
- high-flow conveyance that is limited to a single, well-defined channel and that is not flanked by overbank flow paths,
- high channel capacity so that the plug will not cause increased flooding, and,
- reasonable construction access.

The selected location for the sediment plug has an overall channel width of about 860 feet. If the sediment plug was constructed with a maximum height (measured from the thalweg) of 9 feet, the crest length would need to be about 770 feet for a plug volume of 150,000 tons. The average depth of the plug is about 4.4 feet, since a significant portion extends across the shallower floodplain surface along the left bank.

The plug geometry was incorporated into the steady-state hydraulic model to insure that the plug would not cause significant overbank flooding. No overbank flooding is anticipated at flows less than 2,000 cfs (**Figure 5.40**).

Because the geometry for the sediment plug can only be incorporated into the sediment-transport model at the beginning of a simulation, two separate simulations were made to evaluate the effects of this alternative during a typical dry year (WY1991) and a typical wet year (WY1999) (**Figure 5.41**). To directly compare the results from these simulations to baseline conditions, the baseline simulations were re-run over these same periods. (Results from these simulations should not be directly compared with the simulations for the other alternatives or with the overall baseline model run that included the full 12.5-year period). For the dry year simulations, about 90,000 tons of material is eroded from the sediment plug, while only about 84,000 tons is eroded from the plug under wet conditions (**Figure 5.42**). The wet conditions results occur because of increased armoring during the first three months of the simulation. Although a relatively large percentage of the augmented material is eroded from the plug, a significant portion of this material is deposited upstream from the confluence with the North Channel due to backwater conditions in this area, especially at high flows (Figure 5.41). Of the material eroded from the plug and from the short degradational reach below the plug, about 32,000 tons is deposited in the backwater zone if the plug is constructed at the beginning of a dry year, while the wet year simulation indicates that about 71,000 tons would be deposited (Figure 5.42).

5.3.4. Alternative 2A-iv

Based on the results from the sediment plug option evaluated under Alternative 2A-iii, it appears that, although a significant portion of the augmented material is eroded from the plug, most of this material is deposited upstream from the confluence with the North Channel; thus, the benefits to downstream degradational reaches are somewhat limited. The configuration of the dozed material under Alternative 2A-iv was, therefore, developed to evaluate the effects of a more distributed sediment plug. The dozed material in this option was placed in the low-flow channel, with a uniformly sloping top surface having maximum elevation that would not force flows into the overbank flow paths. With an average plug depth of about 3 feet, the length of the plug would need to be about 6,800 feet. It was assumed that the downstream limit of the plug would be located near the middle of the Dyer Property (Sta 57+00) for constructability purposes, consistent with the downstream limit of the windrows evaluated under Alternative 2A-i (**Figures 5.43 and 5.44**). To increase the hydraulic energy that would be available to scour the augmented material, it was assumed that the heads of the overbank high-flow channels would be blocked.

For this alternative, the total volume of the augmented material that is eroded during the 1-year simulations is less than that under Alternative 2A-iii, with about 47,000 and 60,000 tons of eroded material for the dry and wet years, respectively (**Figure 5.45**). Under dry conditions, the backwater effect upstream from the confluence with the North Channel of Jeffreys Island is relatively limited (Figure 5.44); thus, most of the material that is eroded from the plug is transported through the reach downstream from the plug and delivered to Overton Bridge. However, during a wet year, a significant portion of the material that is eroded from the sediment plug is deposited in the reach upstream from the confluence since backwater conditions are more extensive during high-flow conditions.

6. SHORT-DURATION HIGH FLOWS EVALUATION

An evaluation of Short Duration High Flows (SDHF) was carried out to determine their potential effects on sediment-transport conditions in the project reach. To facilitate the evaluation, a typical SDHF hydrograph was developed using information presented in Appendix B of the PRRIP and USFWS (2009). This appendix includes a breakdown of the 2009 hydrograph into a natural-flow component and the releases from the Environmental Account (EA) in Lake McConaughy. For this evaluation, the EA portion of the 2009 hydrograph was developed for the upstream flows at Lexington and at the upstream limit of the South Channel of Jeffreys Island (i.e., the flow delivered by the J-2 Return) during the SDHF period between April 16 and April 20 (**Figure 6.1.**) The 2009 EA contribution to the SDHF was about 1,200 cfs at Lexington and about 2,000 cfs below the J-2 Return. This hydrograph was then added to the natural portion of the hydrograph that occurred during the SDHF period of a typical dry year (WY 2002) and a typical wet year (WY 1998). The resulting hydrographs were then added to the end of the baseline model simulations that were executed for the period between WY1997 through WY2001, plus the 1.5-year period that includes the SDHF flow (i.e., October 1, 2001, through April 1, 2003, for the dry-year simulation and October 1, 1997, through April 1, 1999, for the wet-year simulation). The model was not executed over the entire 12.5-year baseline simulation period because of the challenges associated with accessing the predicted channel geometry during the latter portions of long simulations, as discussed in Section 3.1. To facilitate direct comparison, the baseline models were also executed over the shorter simulation periods with the natural hydrographs.

For purposes of evaluating the effects of the SDHF hydrographs, only the portion of the model results for the 1.5-year period at the end of the simulation that includes the SDHF were summarized. These results generally indicate that the SDHF would have relatively little effect on the overall sediment balance along the project reach. The simulation results for dry conditions indicate that degradation in Subreach 1 decreases by a small amount for a short time after the SDHF, but degradation increases from 6,600 tons under baseline conditions to about 8,700 tons one year after the SDHF (**Figures 6.2a and 6.2b**). In the South Channel of Jeffreys Island (Subreach 2), degradation decreases slightly in the 2-month period following the SDHF, but degradation increases slightly from 63,000 to 64,000 tons one year following the SDHF (**Figures 6.3a and 6.3b**). Downstream from the confluence of the North and South Channels in Subreach 3, the SDHF causes increased degradation for a short time, followed by a period reduced degradation that results in a benefit of about 1,800 tons one year after the SDHF (**Figures 6.4a and 6.4b**). In Subreach 4, the degradation is slightly reduced during the 5-month period following the SDHF, while increased degradation occurs over the remainder of the simulation (**Figures 6.5a and 6.5b**). This trend is mirrored in the downstream subreach, where essentially no aggradation or degradation is indicated at the end of the simulation (**Figures 6.6a and 6.6b**). Compared to the overall aggradation/degradation volumes, the changes associated with the SDHF are relatively small.

The wet-year simulation also indicates that the effects of the SDHF would be relatively small. In Subreach 1, a short period of reduced aggradation occurs after the SDHF, but a slight increase in aggradation occurs during the remainder of the simulation (**Figures 6.7a and 6.7b**). Degradation in the South Channel of Jeffreys Island increases immediately after the SDHF, but the increased degradation at the end of the simulation represents less than 1 percent of the total degradation volume (**Figures 6.8a and 6.8b**). Interestingly, the results in Subreach 3 indicate that, except for the period immediately after the SDHF, relatively little change occurs until about five months after the SDHF, at which point degradation volumes gradually decrease (**Figures 6.9a and 6.9b**). This occurs because the South Channel delivers sediment at essentially the same rate as under baseline conditions during the period between May and October, after which the increased degradation volumes cause an increase in the supply of relatively coarse sediment to Subreach 3. Upstream from the Kearney Diversion Structure in Subreach 4, a slight increase in aggradation occurs during the year following the SDHF, but there is essentially no change over baseline conditions by the end of the simulation (**Figures 6.10a and 6.10b**). Degradation in the downstream subreach increases slightly, with the most significant increase occurring immediately after the SDHF (**Figures 6.11a and 6.11b**). Consistent with the results from the dry-year SDHF simulations, the changes associated with the SDHF are relatively small compared to the overall aggradation/degradation volumes.

7. SUMMARY AND CONCLUSIONS

Baseline steady-state hydraulic and sediment-transport models were developed for the reach of the Platte River from above the Lexington Bridge (~RM 255) to the Odessa Bridge (RM 224). The geometry for the steady-state hydraulic model was based on mapping developed using 2009 LiDAR survey data and the most recent cross-sectional surveys that included the Programs Geomorphic Monitoring Program (Anchor Point) cross sections and cross sections surveyed specifically for this study. The model was calibrated using surveyed water-surface elevations and the rating curves at USGS gages. Predicted water-surface elevations match the measured data reasonably well. Results from the model indicate that the capacity of the main channel in areas where there are no split-flow paths is about 3,500 cfs in the mainstem through Lexington and in the North Channel of Jeffreys Island (above the confluence with the South Channel of Jeffreys Island), and about 6,000 cfs downstream from Overton. The calibrated hydraulic model was used as the basis for the sediment-transport model that incorporates bed-material information collected as part of the Geomorphic Monitoring Program. The baseline model was executed using a 12.5-year period of flow record extending from October 1, 1989, to April 1, 2002. This period was selected because it corresponds to the period with the largest amount of data with which to calibrate the model. Predicted results from the sediment-transport model compare well with observed aggradation/degradation and changes in bed-material size trends.

Results from the baseline sediment-transport model indicate that, on an average annual basis, the overall sediment deficit along the reach between the Lexington and Odessa Bridges is approximately 152,000 t/yr. The reach between Lexington and Overton that includes the North Channel of Jeffreys Island is moderately aggradational (between 47,000 and 66,000 t/yr), while the reaches of the South Channel of Jeffreys Island below the J-2 Return, between Overton and Elm Creek Bridges, and between the Kearney Diversion and Odessa Bridge are degradational (97,000, 108,000 and 46,000 t/yr, respectively). Some sediment storage occurs in the short reach between the Elm Creek Bridge and the Kearney Diversion (33,000 t/yr). Coarsening of the surficial bed material occurs by the end of the simulation along most of the project reach.

The baseline sediment-transport model was modified to represent the sediment augmentation pumping alternatives (Alternatives 1A and 1D). Alternative 1A involves sediment augmentation using pumps located in the downstream portion of the South Channel of Jeffreys Island, while Alterative 1D includes an additional pump at OS&G. Based on the results from the baseline model run, it was assumed that an annual augmentation volume of 150,000 tons would be required. Variations of these alternatives include:

- Augmented material obtained from OS&G (i.e., the “fine” material with D_{50} ~0.5 mm),
- Augmented material that is representative of the existing bed material in the vicinity of Cottonwood Ranch (i.e., the “coarse” material with D_{50} ~1.2 mm),
- Annual pump operation period that begins August 1,
- Annual pump operation period that begins September 1,
- Annual pump operation period that begins February 15, and
- 300,000 t/yr of augmented material (using the “fine” material obtained from OS&G).

Results from these simulations were then compared to the baseline simulation results to provide a framework for evaluating the effects of the alternatives. In general, the gradation of the material used for the augmentation and the location of the pumps appears to have the most significant impact in the downstream degradational reaches, while the period during which pumps are operated has significant, but somewhat less impact. Each of the simulations indicate that some of the material that is added in the South Channel of Jeffreys Island will deposit just downstream from the pumps, reducing the effectiveness of the augmentation. This deposition is most significant when the augmented material is relatively coarse (i.e., material that represents the existing bed material). Results from the simulations using material obtained from OS&G indicate that a significant portion of the augmented material will be flushed through the project reach. Alternative 1D options with coarse augmented material cause the greatest decrease in the deficit in the critical reach between the Overton and Elm Creek Bridges, reducing the annual in-channel deficit to as little as 20,000 tons (**Figure 7.1**). The annual in-channel deficit for Alternative 1D would decrease to about 7,000 tons if fine material is injected at a rate of 300,000 t/yr.

Alternative 2A involves placement of augmented material in static piles along the downstream portion of the South Channel using dozers. This alternative was developed under the assumption that this material could be entrained and transported to the downstream degradational reaches. The augmented material for this alternative was assumed to have a gradation similar to the existing med material gradation (D_{50} ~1.2 mm), since use of the fine material would likely result in pass-through conditions. Variations to this alternative include:

- Augmented material placed in windrow piles along the channel banks,
- Augmented material placed in windrow piles along the channel bed),
- Augmented material placed across the overall channel along a relatively short reach (i.e., a short sediment plug), and
- Augmented material placed across the low-flow channel and distributed along a relatively long reach (i.e., a distributed sediment plug).

The effectiveness of the windrow piles was evaluated by incorporating the piles into the steady-state hydraulic model geometry. Results from these models indicate that the windrow piles would not be sufficiently inundated over the range of typically occurring flows if they are placed along the bank toes, and the hydraulic energy and associated shear stresses would not be sufficient to entrain and transport the material if the windrows are constructed along the channel bed. To evaluate the effectiveness of variations in the shape and location of the introduced sediment, 1-year sediment-transport simulations were performed that incorporated the geometry and gradation of the plugs. These simulations were executed over that represent dry and wet hydrologic conditions (WY1991 and WY1999, respectively). The results from these models were then compared to baseline model simulations that were executed over the same periods. These comparisons indicate that a moderate amount of the material in the sediment plug would be eroded during the year following construction, but a significant portion of this material would be deposited in the backwater zone upstream from the confluence with the North Channel, especially during high-flow periods. This deposition limits the effectiveness of the Alternative 2A option.

An evaluation of Short Duration High Flows (SDHF) was also carried out to evaluate the effects of these flows on sediment-transport conditions along the project reach. This evaluation included sediment-transport simulations of with- and without SDHF hydrographs under dry and wet conditions. Results from these analyses indicate the SDHF will have a relatively minor benefit to degradational areas, with degradation volumes in the Overton to Elm Creek reach decreasing by 3.5 to 4.5 percent of the total degradation volume one year after the SDHF.

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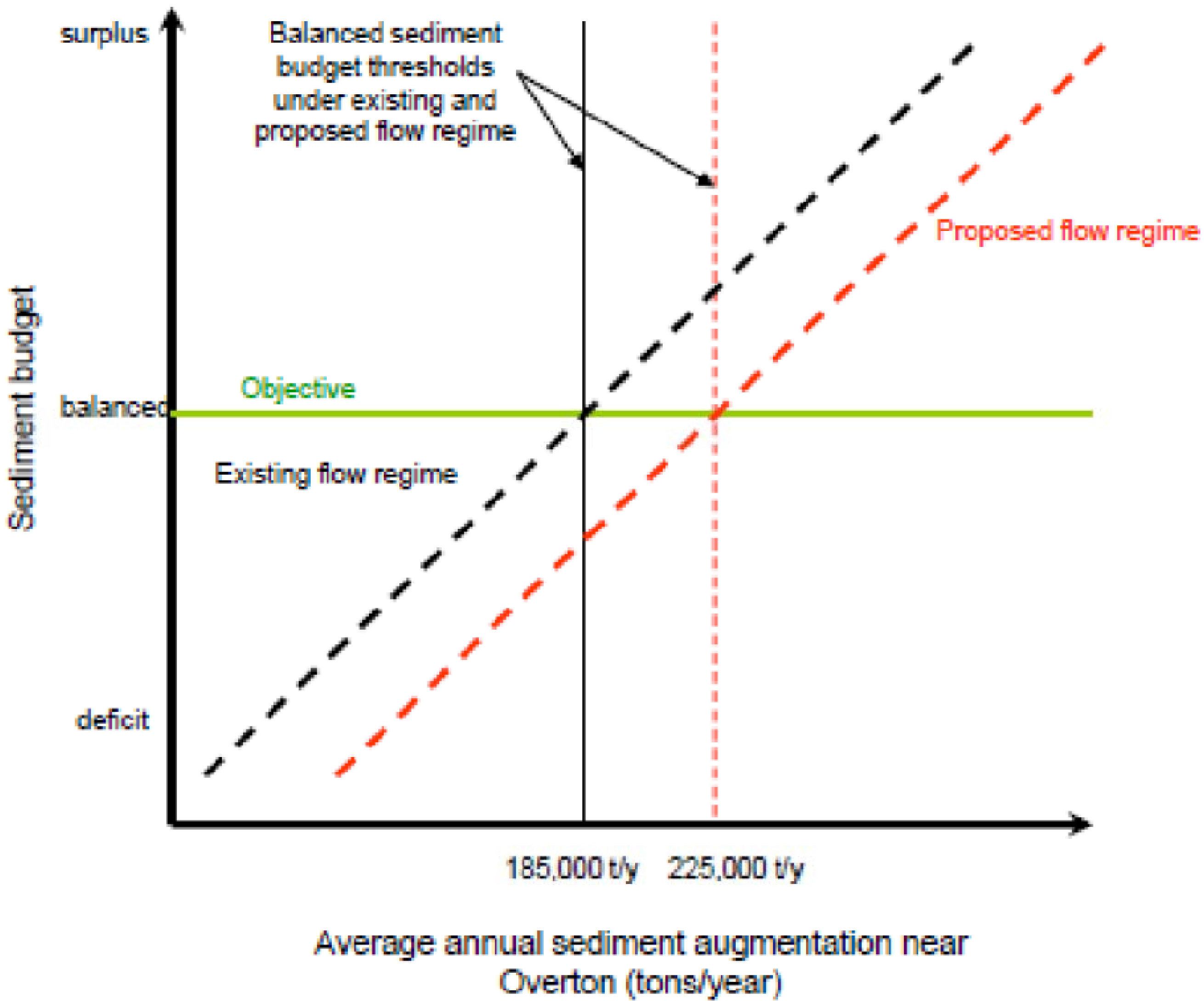


Figure 1.1. Conceptual illustration of Priority Hypothesis Sediment #1.

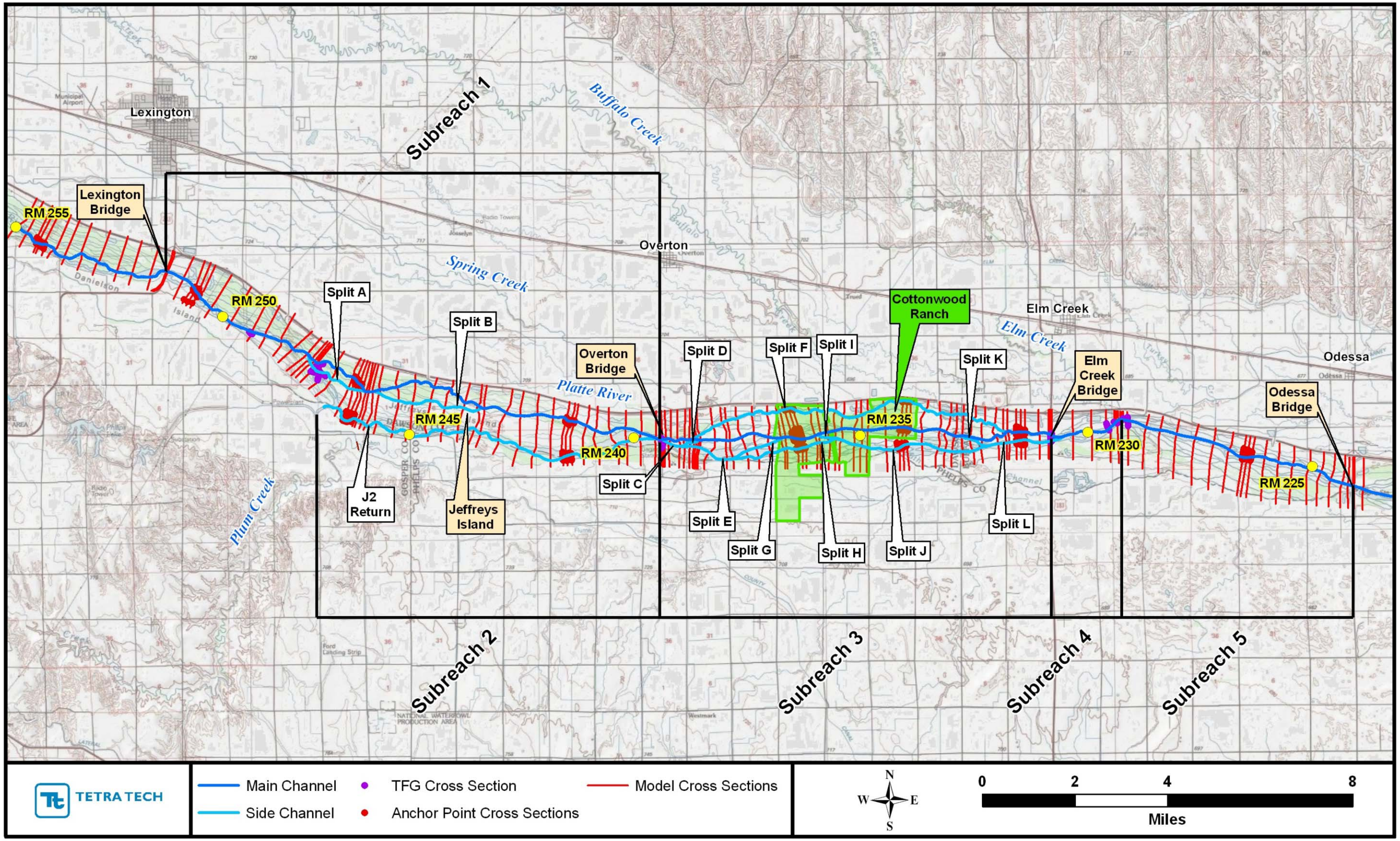


Figure 1.2. General sitemap showing the location of the model cross sections and primary features along the study reach. Also shown are the locations of the surveyed cross sections and the modeled split-flow reaches.

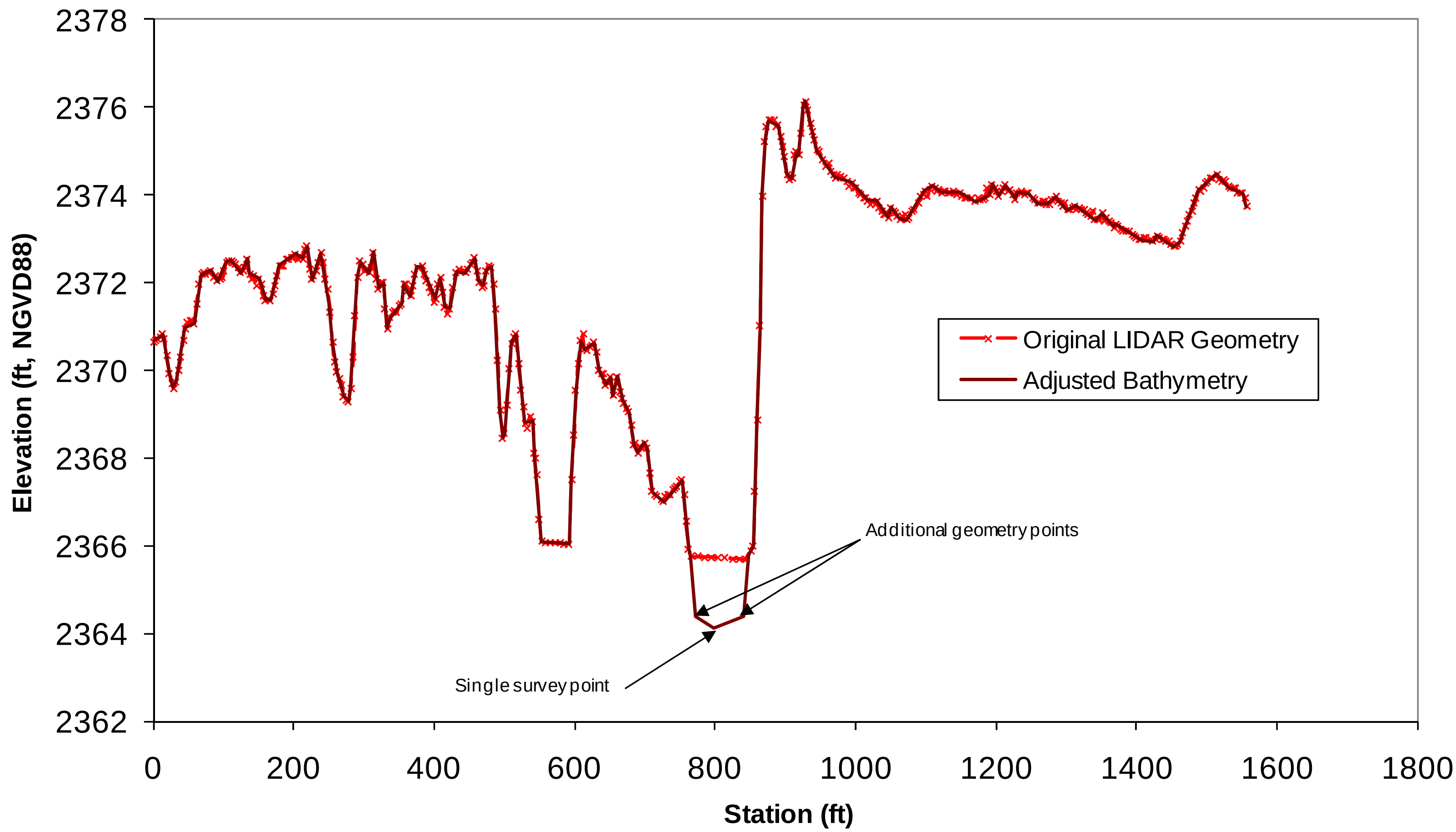


Figure 2.1. Typical model cross-section illustrating how the bathymetric survey data were incorporated into the LIDAR topography.

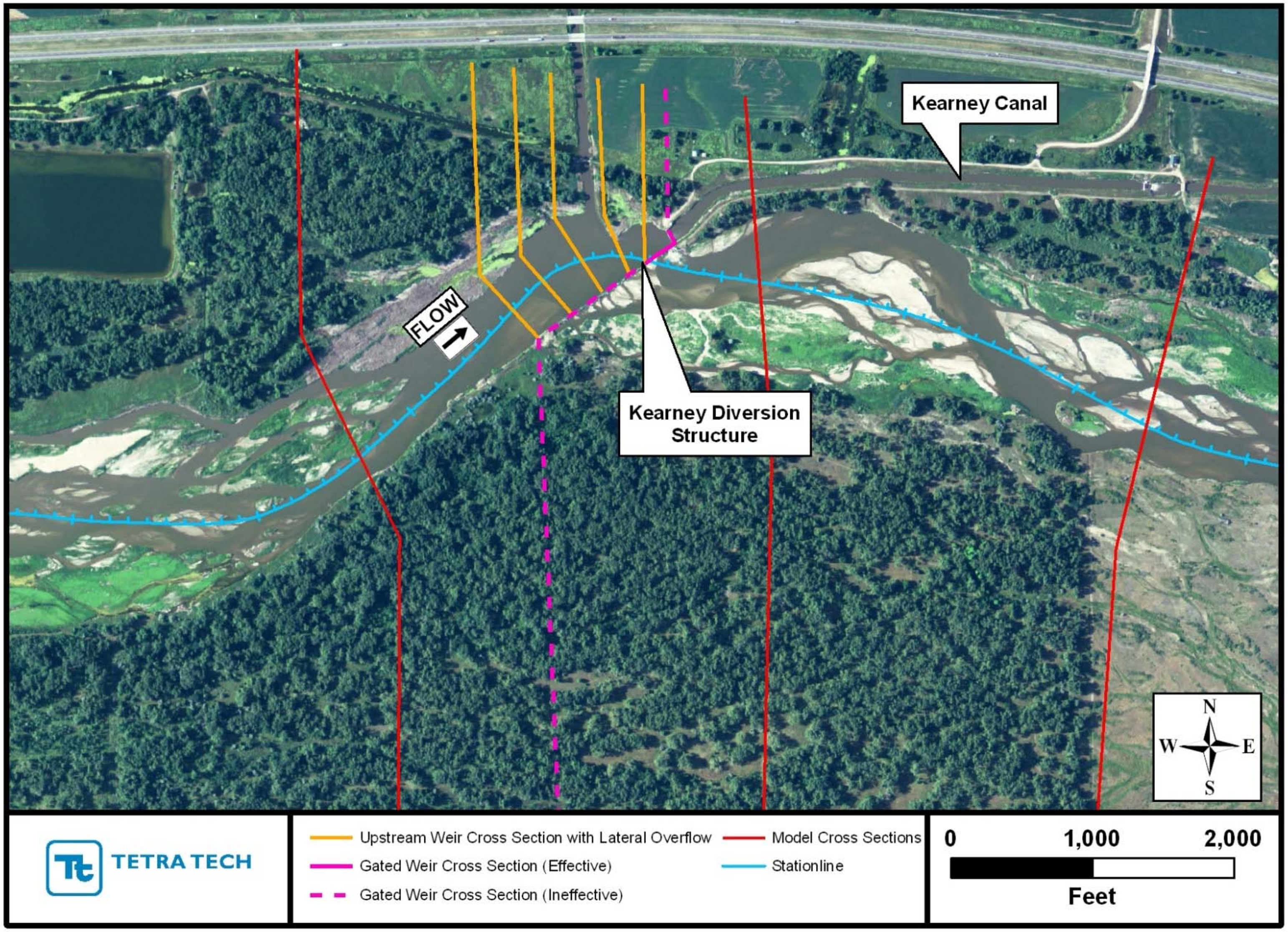


Figure 2.2. Aerial photograph showing the location and orientation of the cross sections used to model the Kearney Diversion.

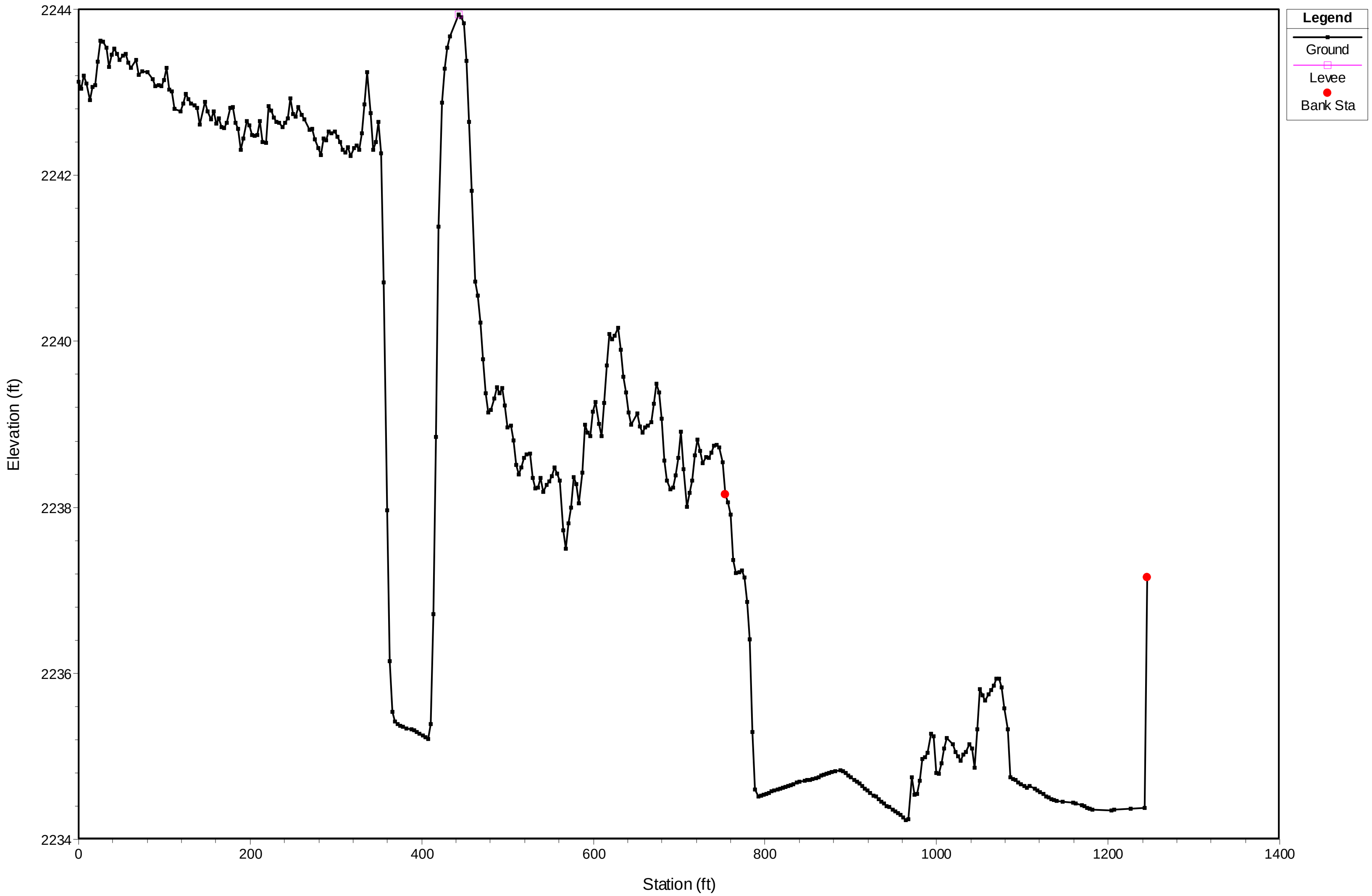


Figure 2.3. Example of cross section (River Station 82007) oriented with the primary direction of flow. The right limit of the cross section represents the elevation of the Kearney Diversion Weir that was modeled using the HEC-RAS lateral weir feature.

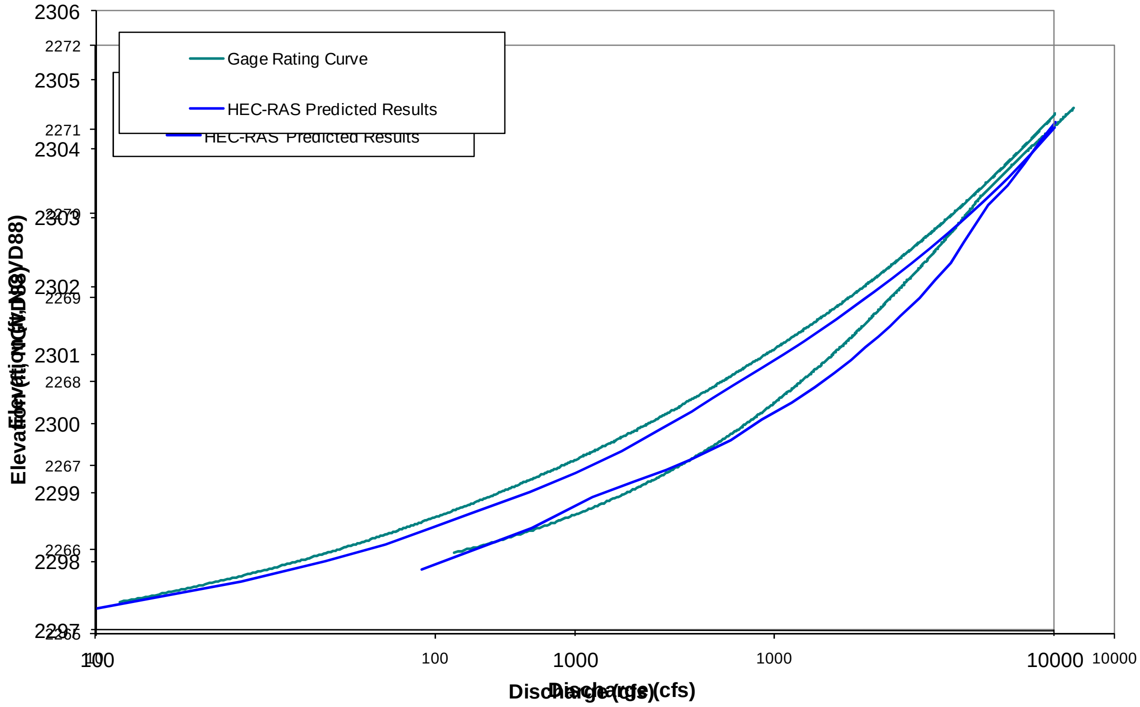


Figure 2.4. Comparison of HEC-RAS predicted results with published rating curve for the Platte River at Overton gage (USGS Gage No. 06768000).

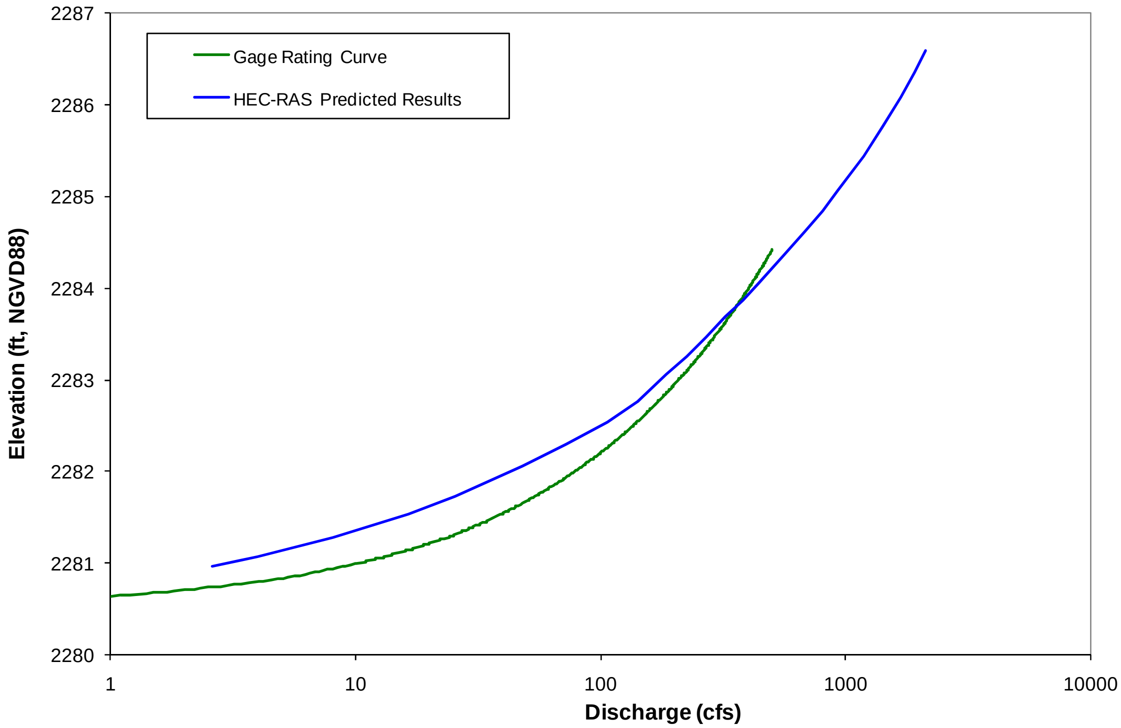


Figure 2.5. Comparison of HEC-RAS predicted results with published rating curve for the Platte River South Channel gage at Cottonwood Ranch (USGS Gage No. 06768025).

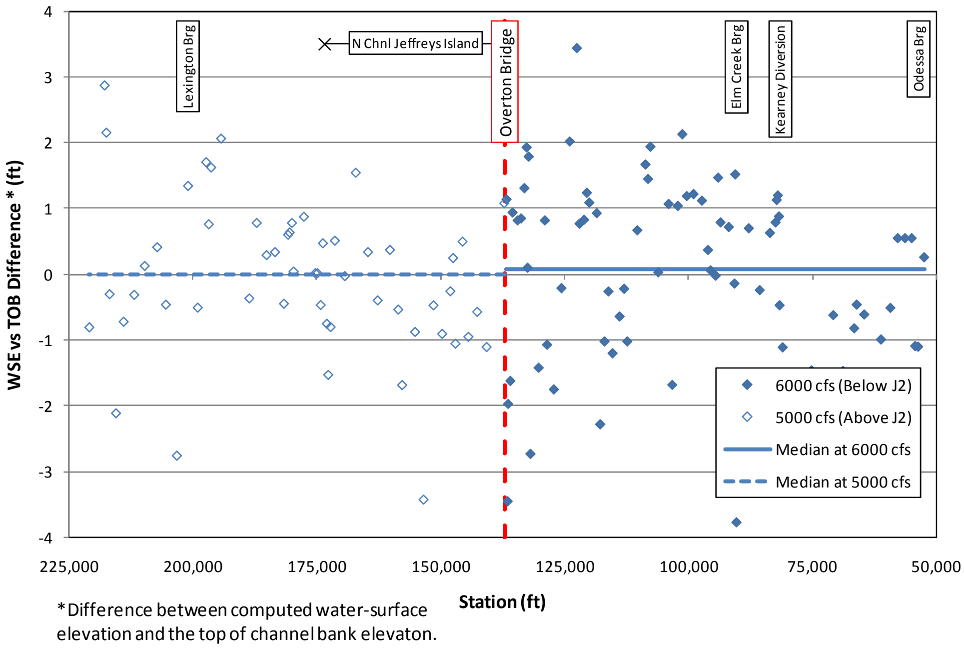


Figure 2.6. Comparison of HEC-RAS predicted results with published rating curve for the Platte River Middle Channel gage at Cottonwood Ranch (USGS Gage No. 06768035).

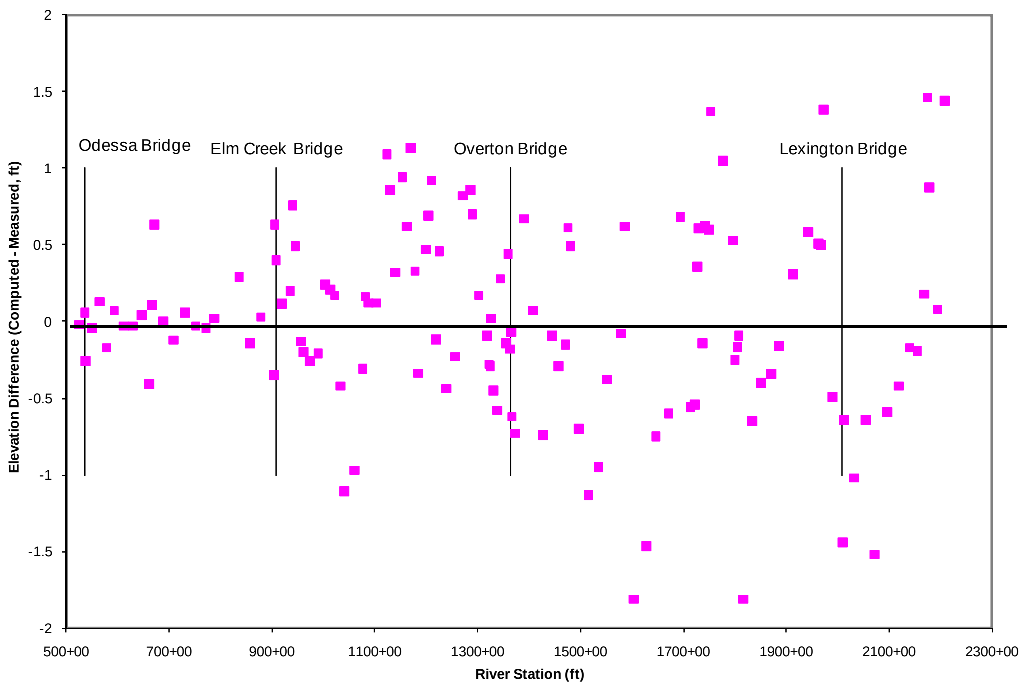


Figure 2.7. Distribution of elevation differences between HEC-RAS computed results and LIDAR surface topography along the main channel. Positive values indicate compute results are higher than surveyed.

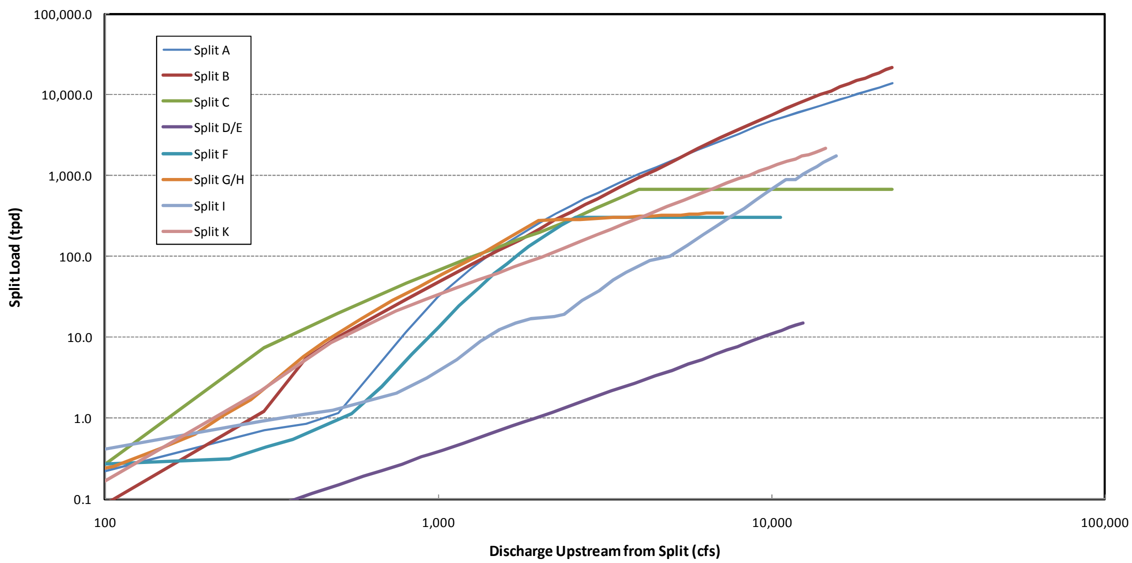


Figure 2.8. Computed difference between the computed water surface elevation and top of bank elevations for discharges of 5,000 cfs (above the J-2 Return flows) and 6,000 cfs (below the J-2 Return Flows) for the channel capacity evaluation.

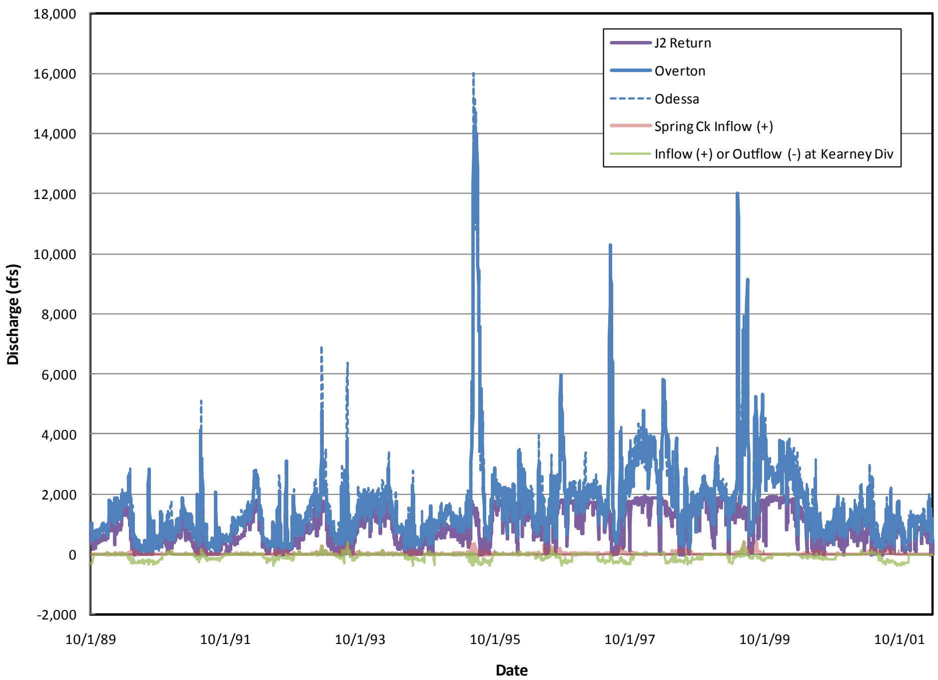


Figure 3.1. Recorded hydrographs at key locations along the project reach for the simulation period between October 1, 1989 and April 1, 2002.

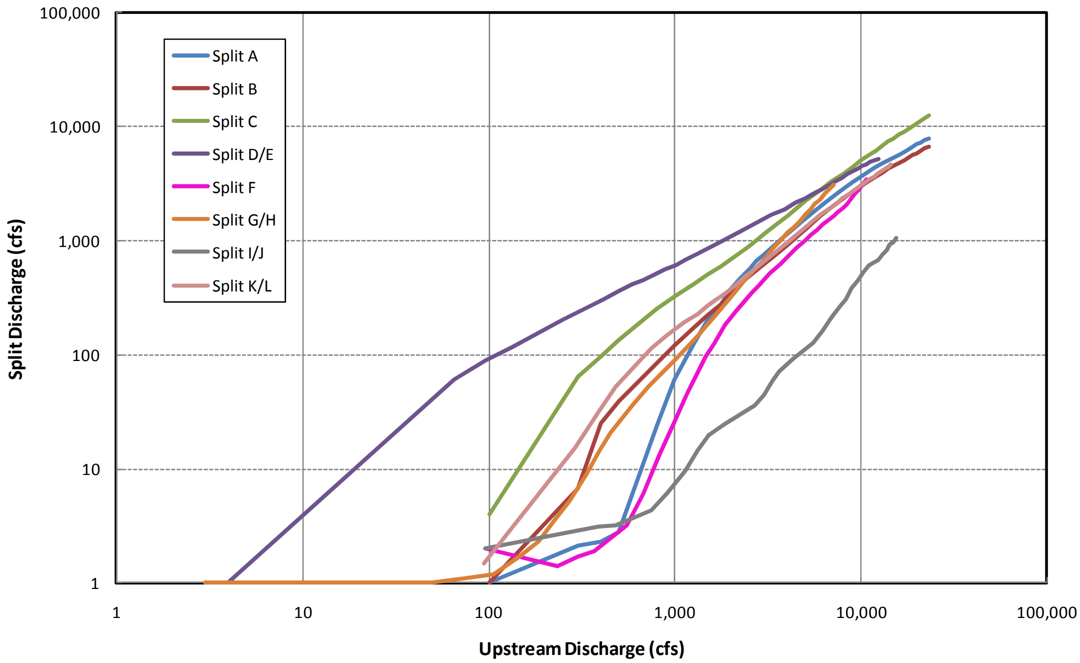


Figure 3.2. Split discharge rating curves used to define the flow delivered to the head of the secondary channels and the outflow from the primary channels at the split-flow locations.

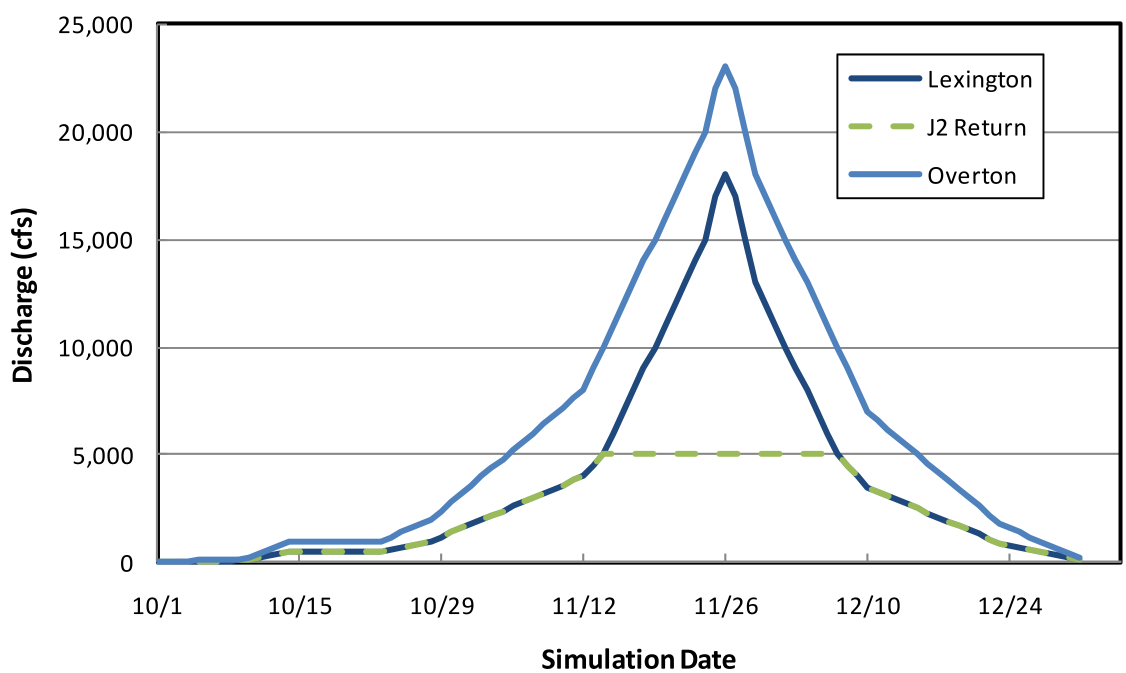


Figure 3.3. Synthetic flow hydrograph used to develop the sediment load rating curves for the flow split locations.

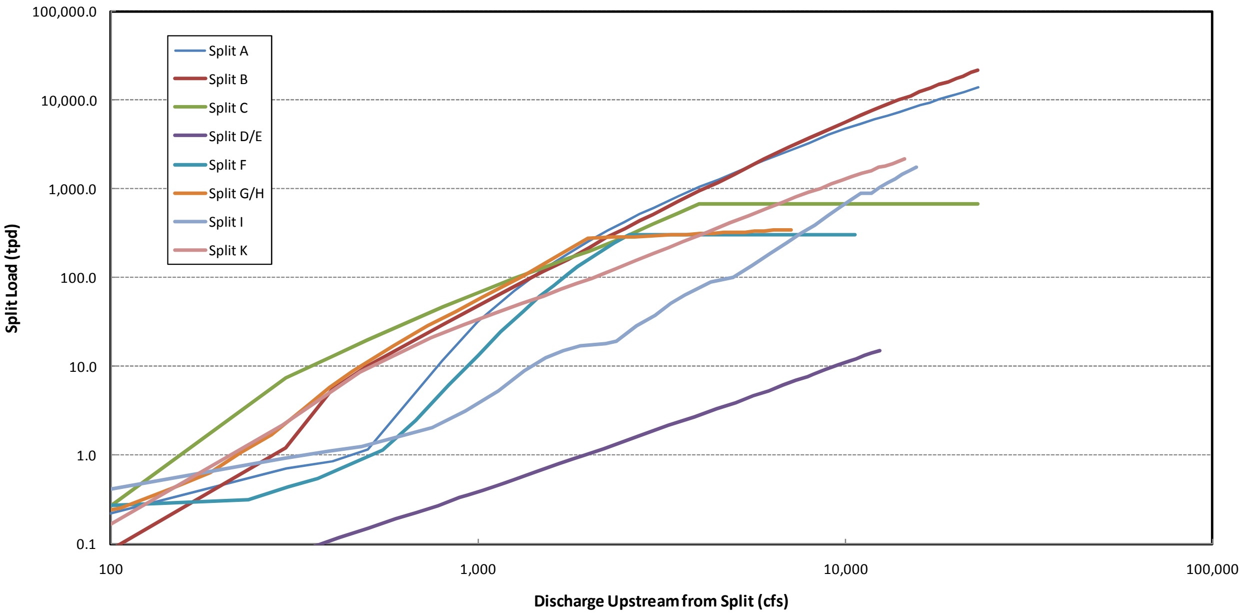


Figure 3.4. Split bed material sediment rating curves used to develop the sediment load time series representing the upstream sediment supply to the split flow reaches and the corresponding sediment outflow from the primary channels.

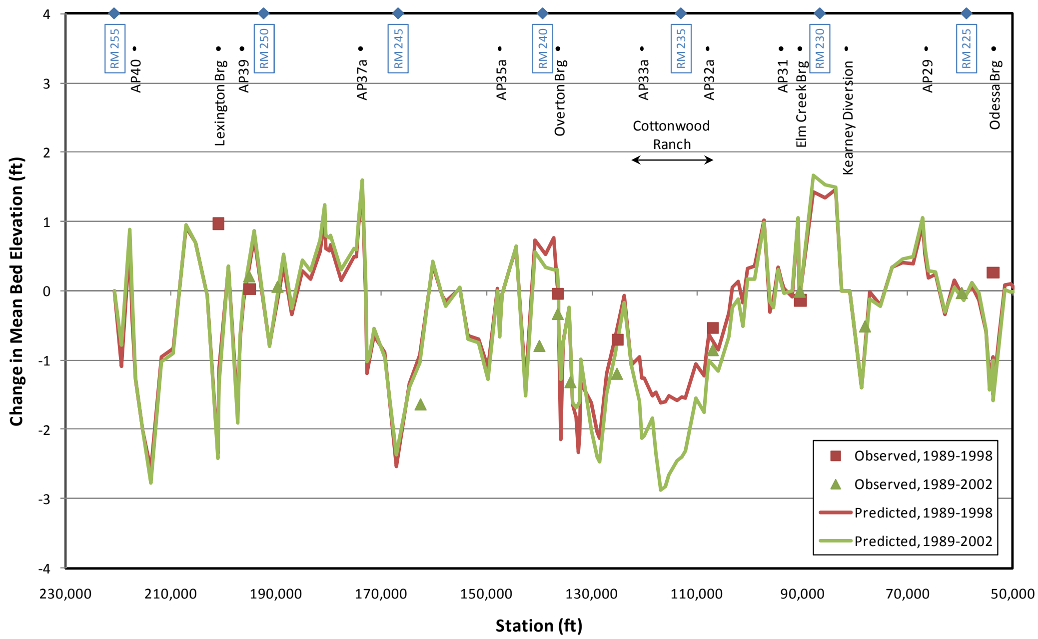


Figure 3.5. Comparison of observed changes in mean bed elevation and the changes predicted by the sediment-transport model along the primary flow path for the periods between 1989 and 1998 and between 1989 and 2002.

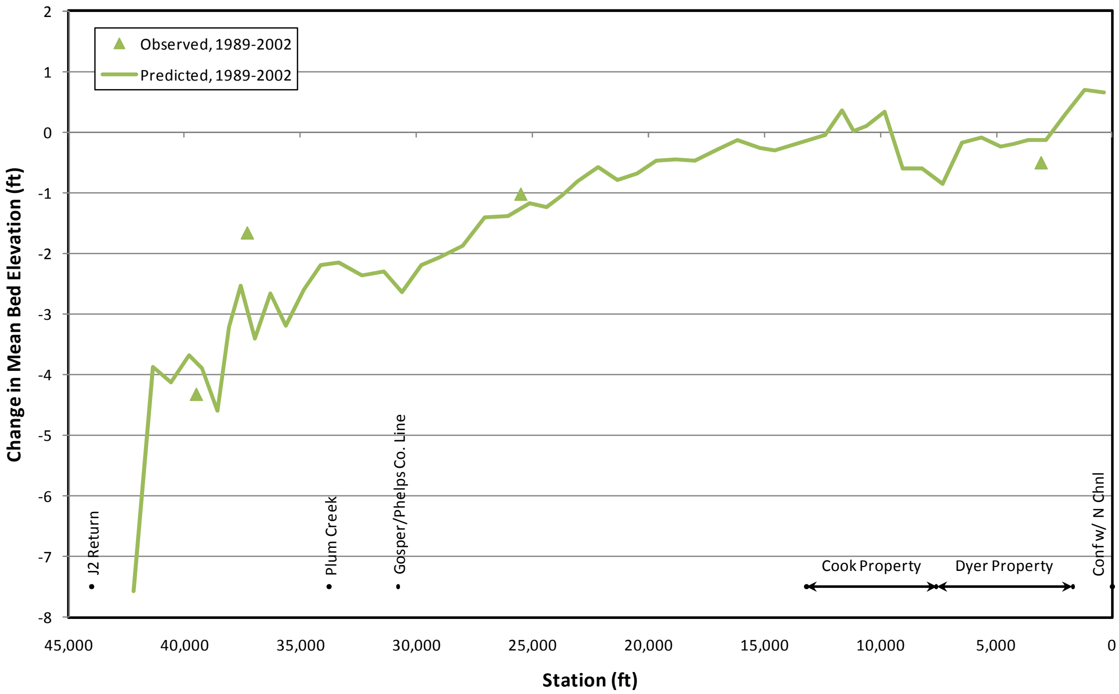


Figure 3.6. Comparison of observed changes in mean bed elevation and the changes predicted by the sediment-transport model along the South Channel of Jeffries Island for the period between 1989 and 2002.

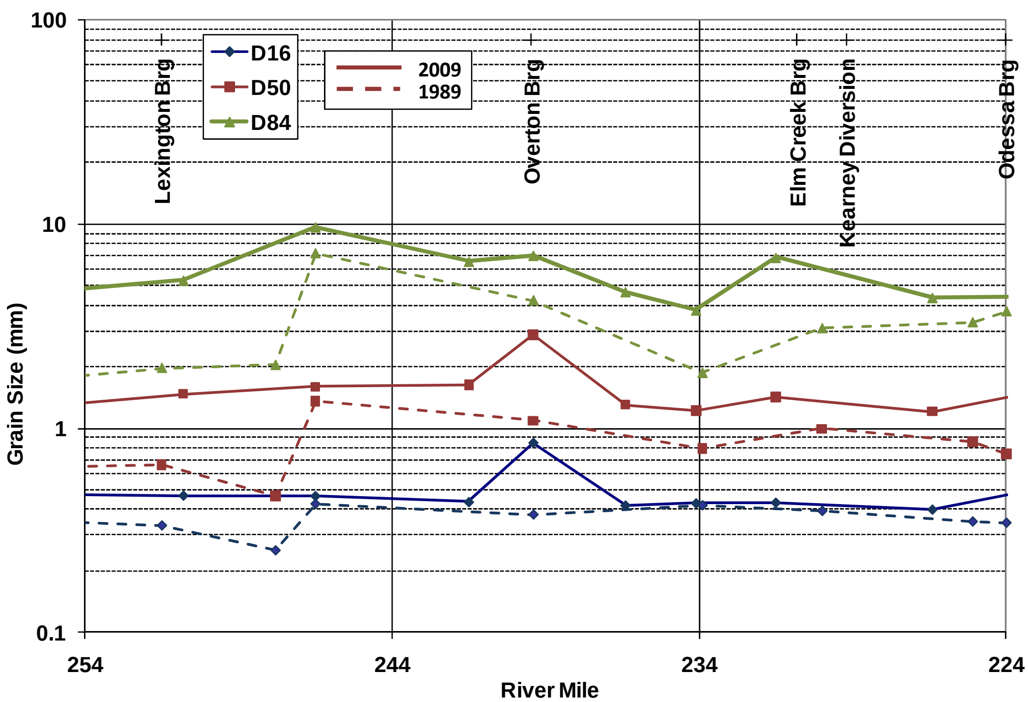


Figure 3.7. Longitudinal bed material characteristics (D16, D50 and D84) of samples collected by the BOR in 1989 and for the Geomorphic Monitoring Program in 2009.

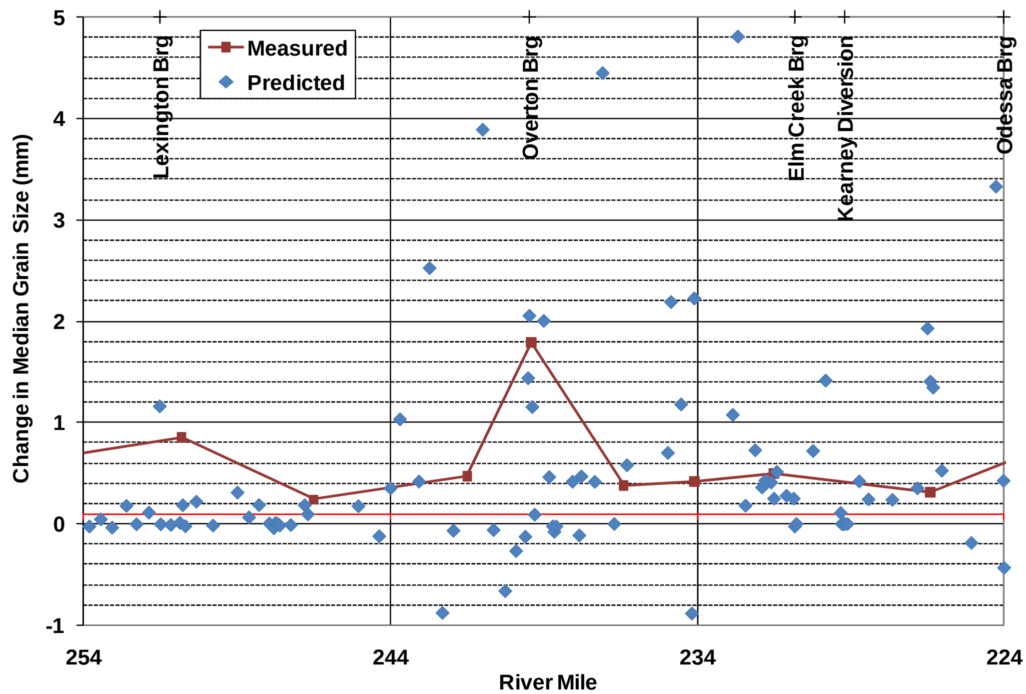


Figure 3.8. Comparison of measured change in median grain size along the primary flow path with the change predicted by the Baseline Model simulation.

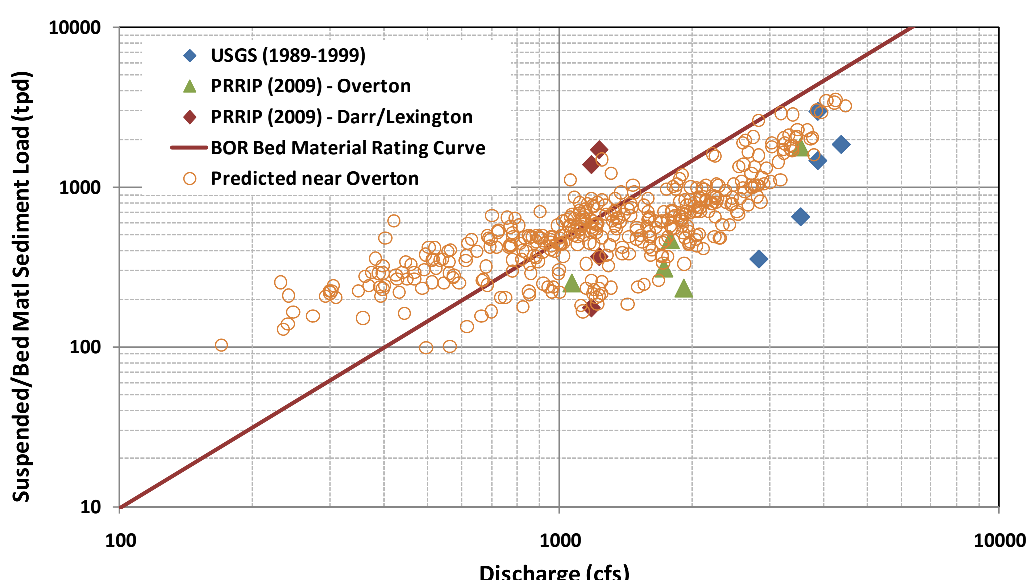


Figure 3.9. Comparison of measured bed material and suspended load data and bed material rates predicted by the baseline sediment-transport model. Also shown is the BOR bed-material rating curve (Murphy et al., 2006).

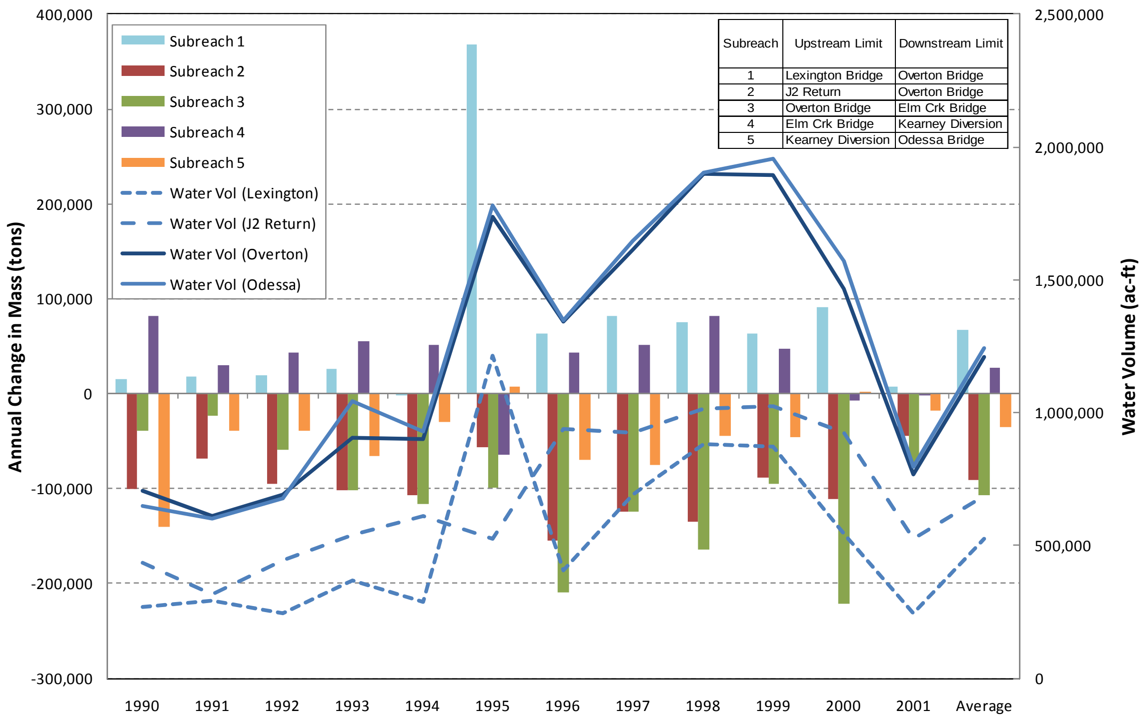


Figure 4.1. Annual surplus or deficit in each of the subreaches, and the annual water volume at representative locations along the project reach.

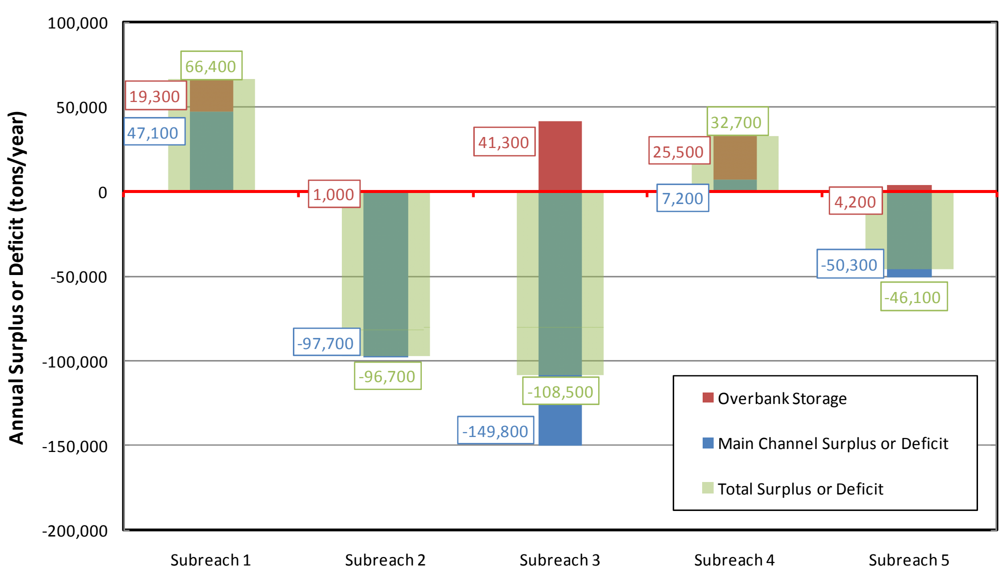


Figure 4.2. Average annual total mass surplus or deficit by subreach, and the estimated surplus or deficit in the main channel and overbanks.

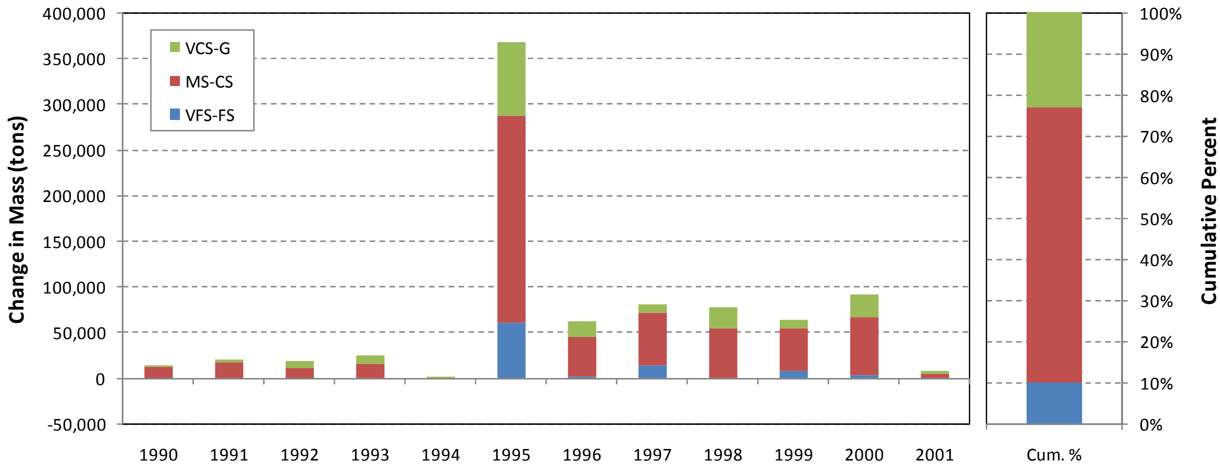


Figure 4.3a. Annual mass eroded or deposited along Subreach 1 by size fraction, and the cumulative percentage at the end of the simulation.

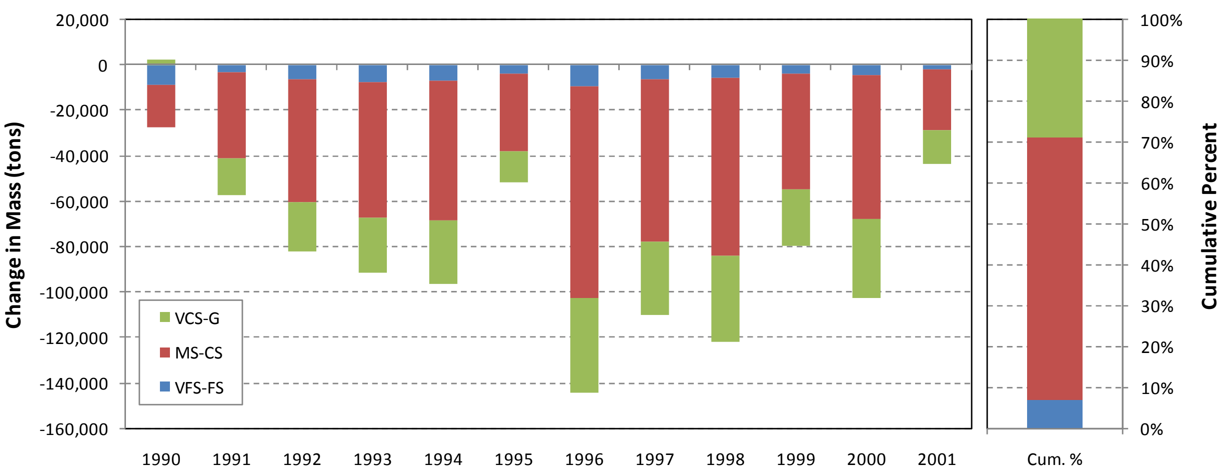


Figure 4.3b. Annual mass eroded or deposited along Subreach 2 by size fraction, and the cumulative percentage at the end of the simulation.

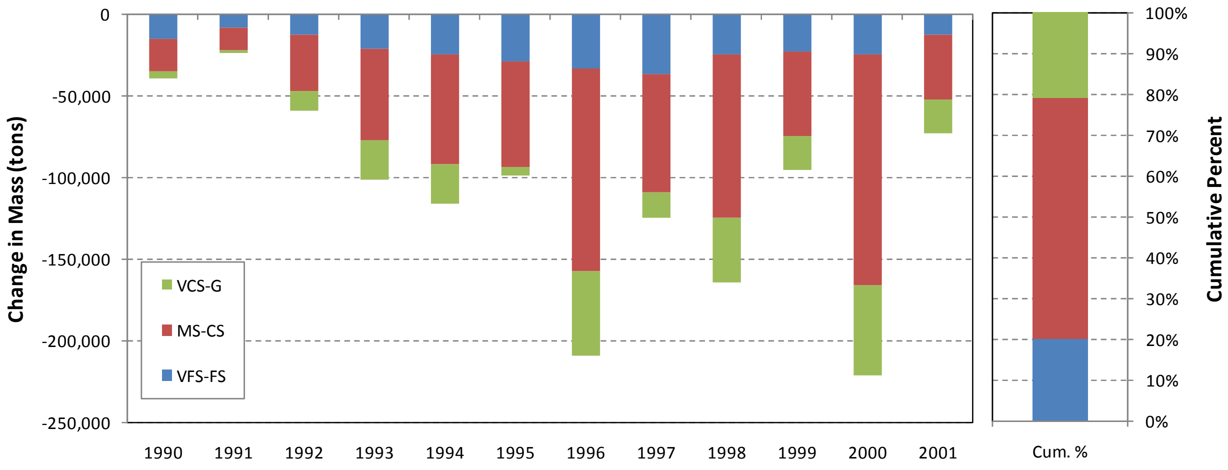


Figure 4.3c. Annual mass eroded or deposited along Subreach 3 by size fraction, and the cumulative percentage deposited at the end of the simulation.

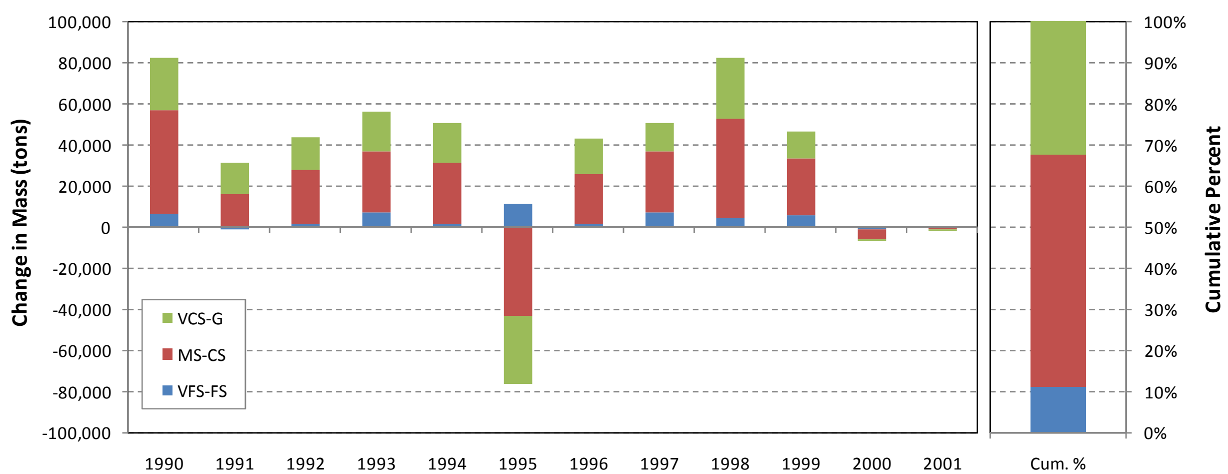


Figure 4.3d. Annual mass eroded or deposited along Subreach 4 by size fraction, and the cumulative percentage at the end of the simulation.

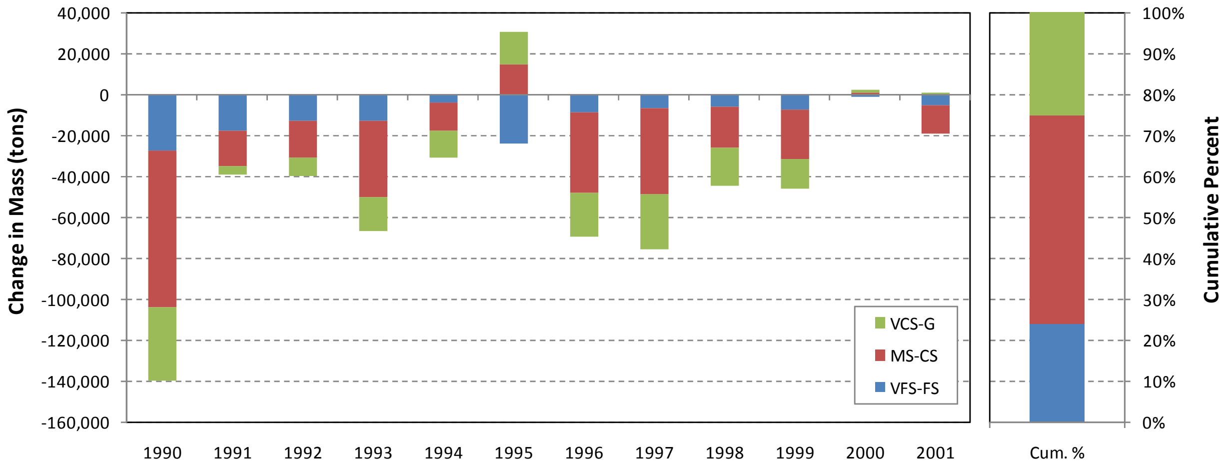


Figure 4.3e. Annual mass eroded or deposited along Subreach 5 by size fraction, and the cumulative percentage at the end of the simulation.

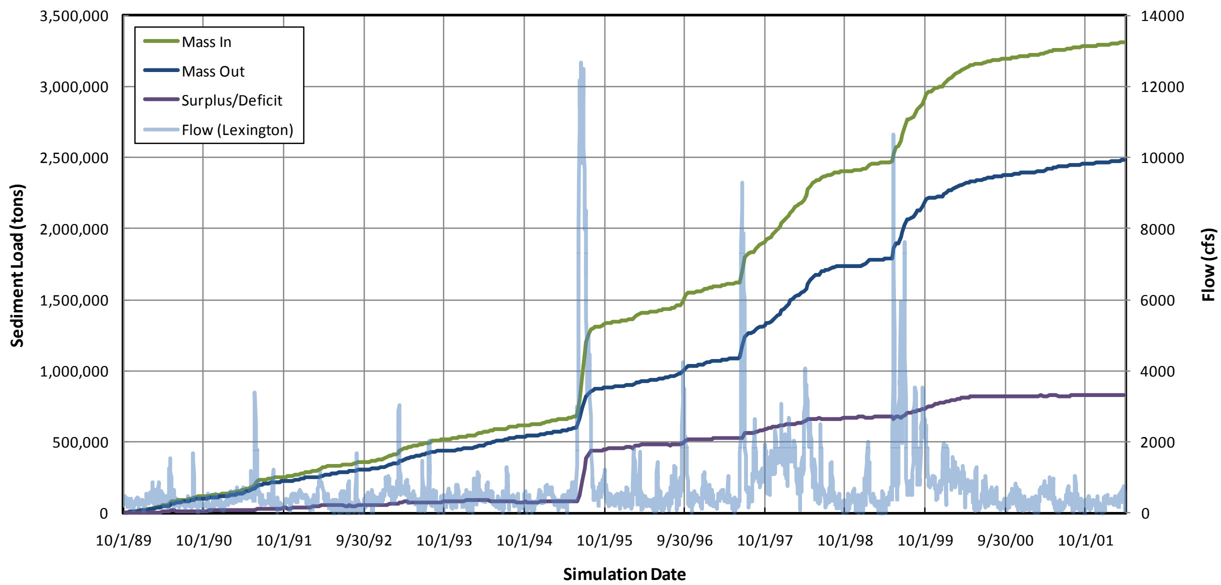


Figure 4.4a. Mass fluxes at the up and downstream limits of Subreach 1 and the resulting bed-material surplus or deficit during the 12.5-year baseline model simulation. Also shown is the flow hydrograph at Lexington.

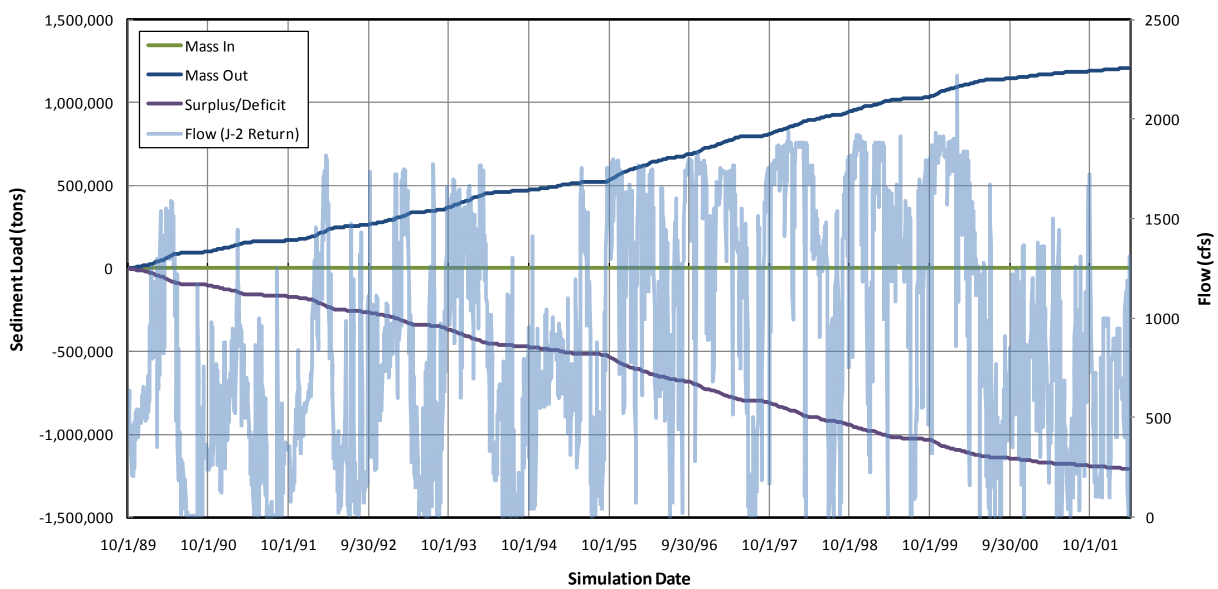


Figure 4.4b. Mass fluxes at the up and downstream limits of Subreach 2 and the resulting bed-material surplus or deficit during the 12.5-year baseline model simulation. Also shown is the J2 Return flow hydrograph.

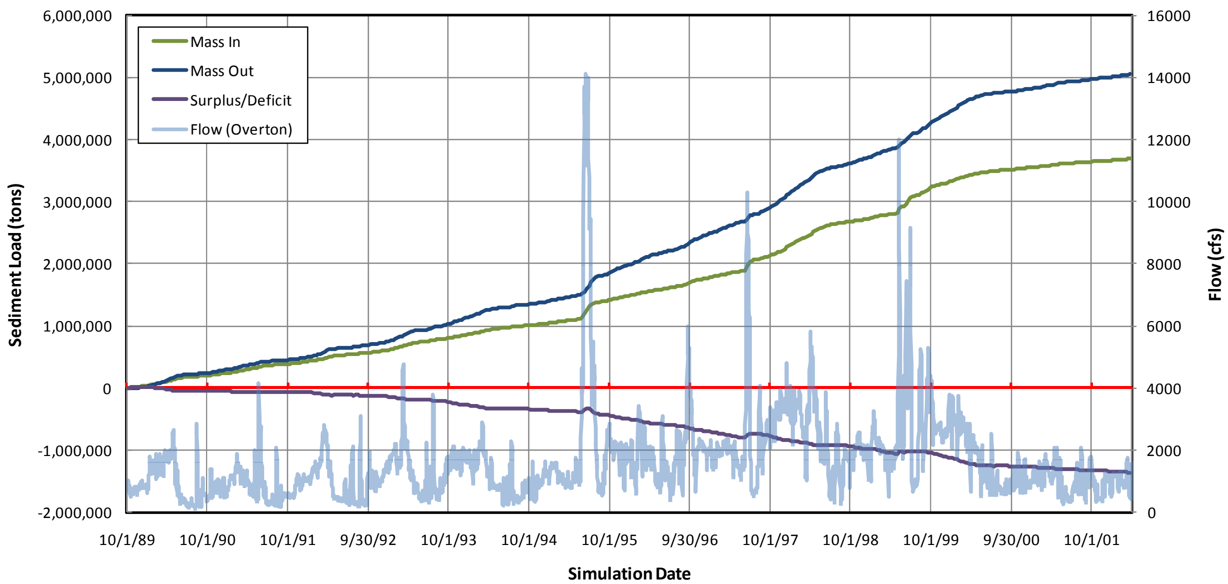


Figure 4.4d. Mass fluxes at the up and downstream limits of Subreach 4 and the resulting bed-material surplus or deficit during the 12.5-year baseline model simulation. Also shown is the flow hydrograph at Lexington.

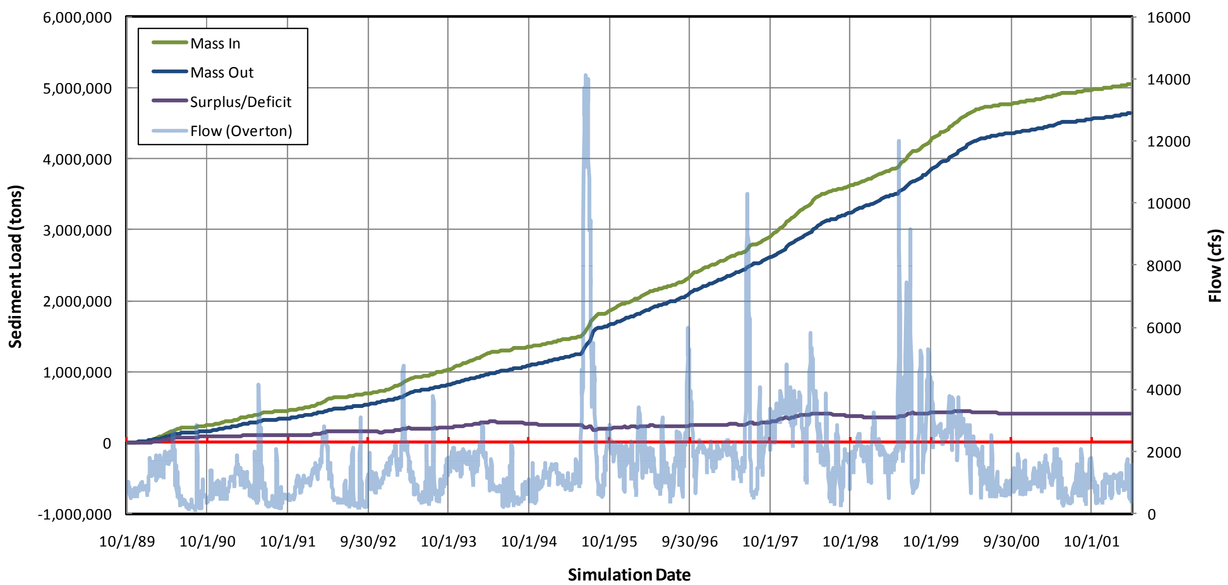


Figure 4.4e. Mass fluxes at the up and downstream limits of Subreach 5 and the resulting bed-material surplus or deficit during the 12.5-year baseline model simulation. Also shown is the flow hydrograph at Odessa.

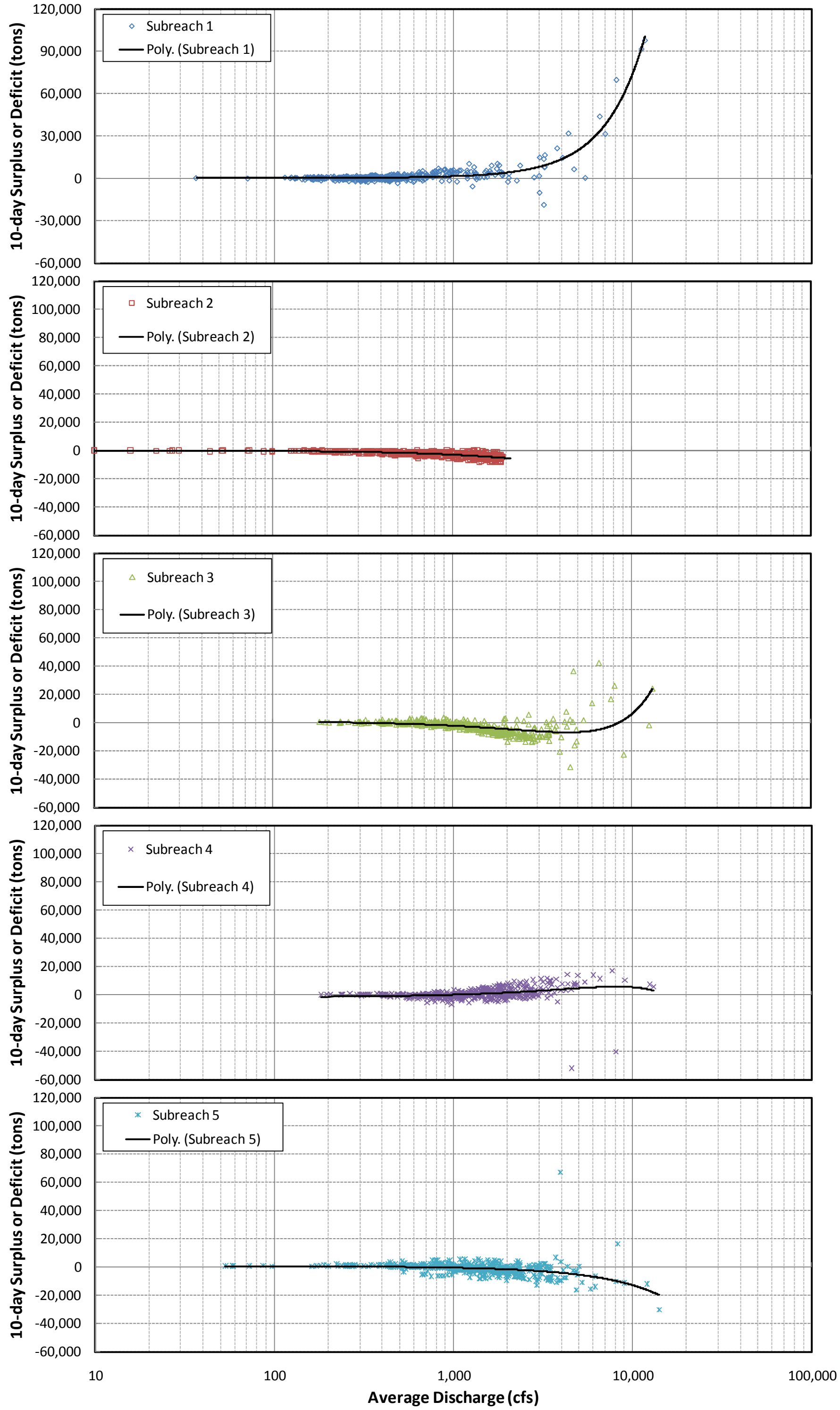
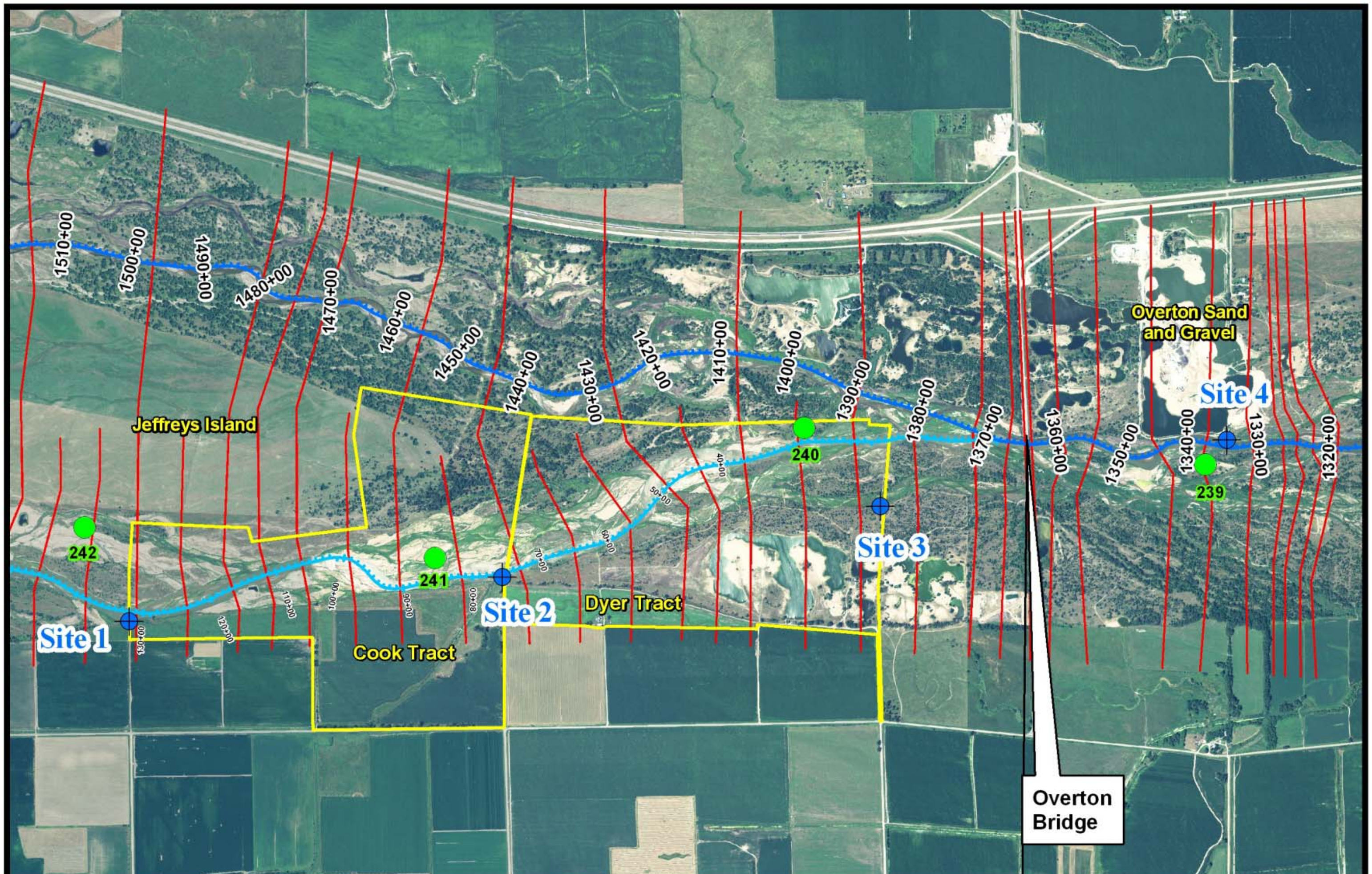


Figure 4.5. Predicted mass of aggradation or degradation during each 10-day output increment as function of the average discharge for each of the subreaches.



Sand Pump Locations

Main Channel Station line

South Channel Station line

Model Cross Sections

River Mile

Sand Pump Locations

N W E S

0 2,000 4,000

Feet

Figure 5.1. Aerial photograph showing the locations of the sand pumps that were evaluated under Alternatives 1A and 1D.

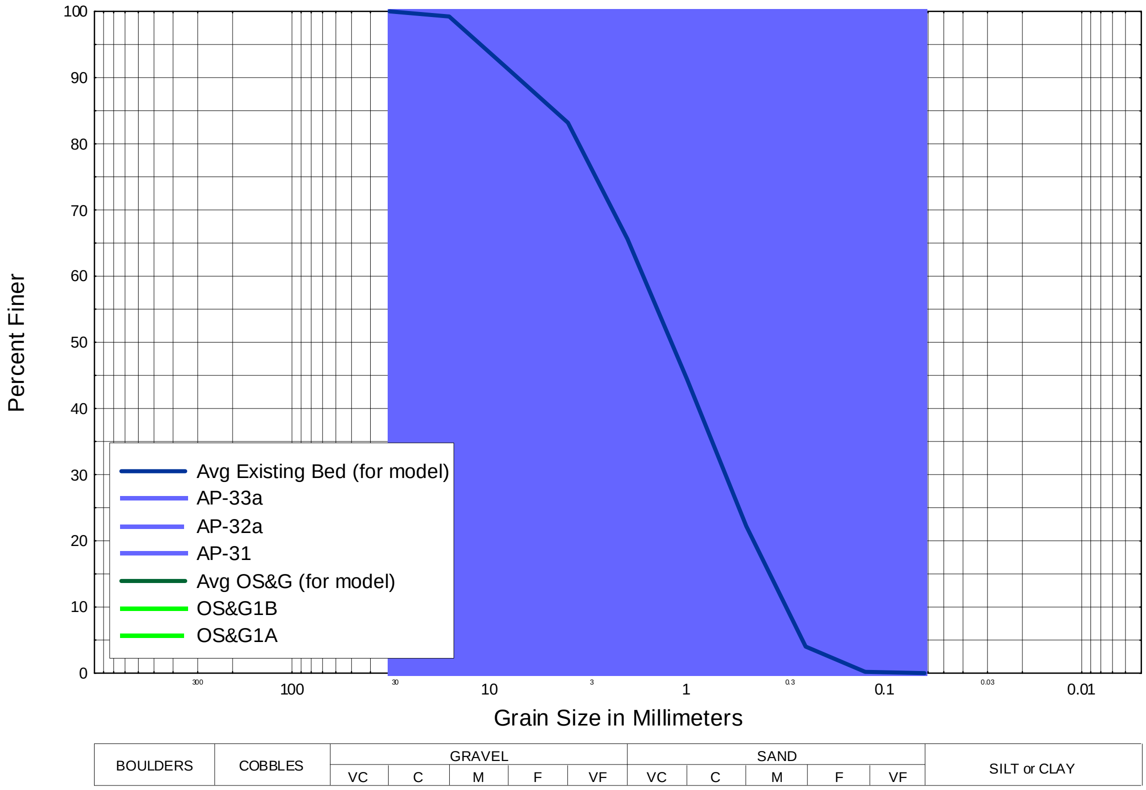


Figure 5.2. Gradation curves from the samples collected at the Program's Monitoring Anchor Points and at Overton Sand and Gravel. Also shown are the gradations used to represent the augmented material in the simulations for the evaluated alternatives.

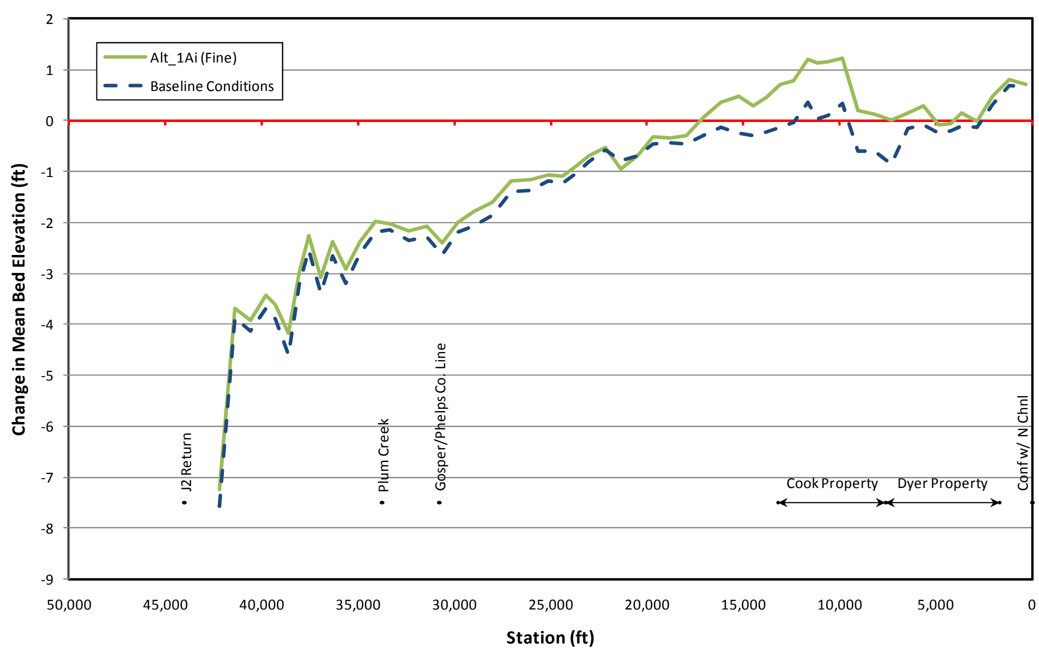


Figure 5.3. Predicted change in mean bed elevation in the South Channel of Jeffreys Island at the end of the baseline conditions and Alternative 1A-i simulations.

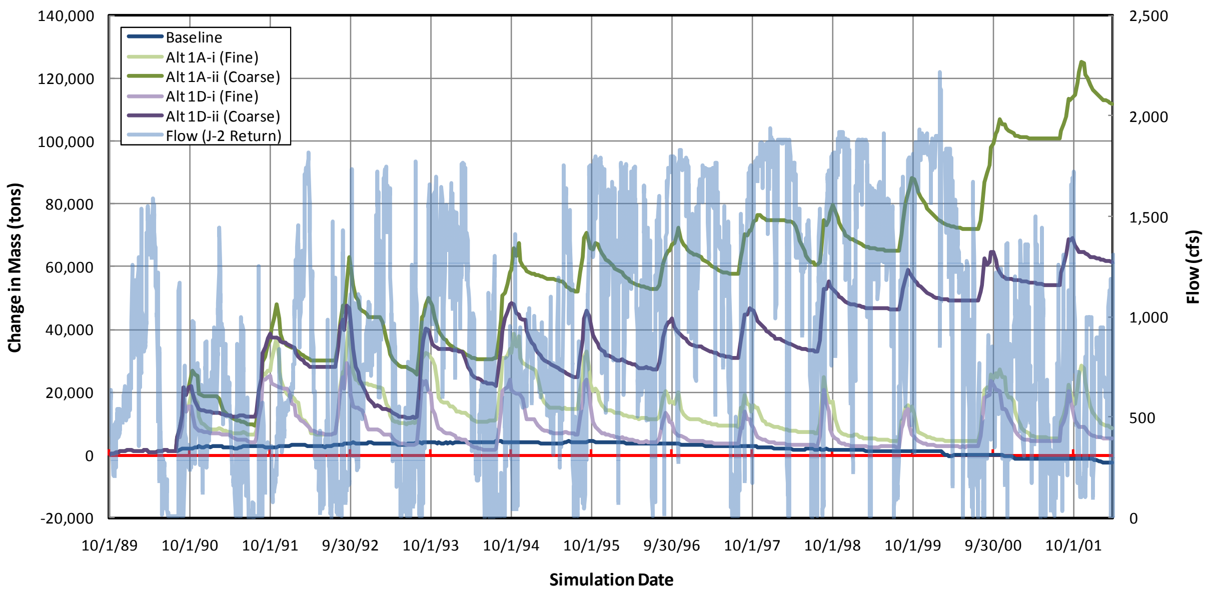


Figure 5.4. Computed change in mass over the simulation period below Pumping Site 1 (Cook West) in the South Channel of Jeffreys Island under baseline conditions and under Alternatives 1A-i, 1A-ii, 1D-i, and 1D-ii. Also shown is the hydrograph at this location.

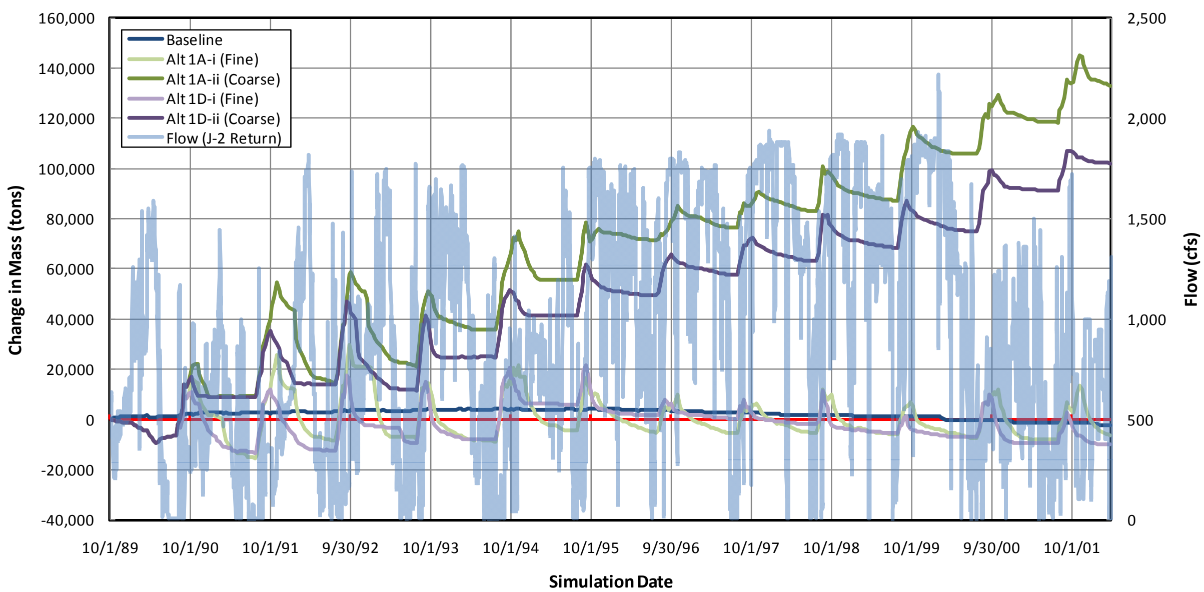


Figure 5.5. Computed change in mass over the simulation period below Pumping Site 2 (Cook/Dyer property boundary) in the South Channel of Jeffreys Island under baseline conditions and under Alternatives 1A-i, 1A-ii, 1D-i, and 1D-ii. Also shown is the hydrograph at this location.

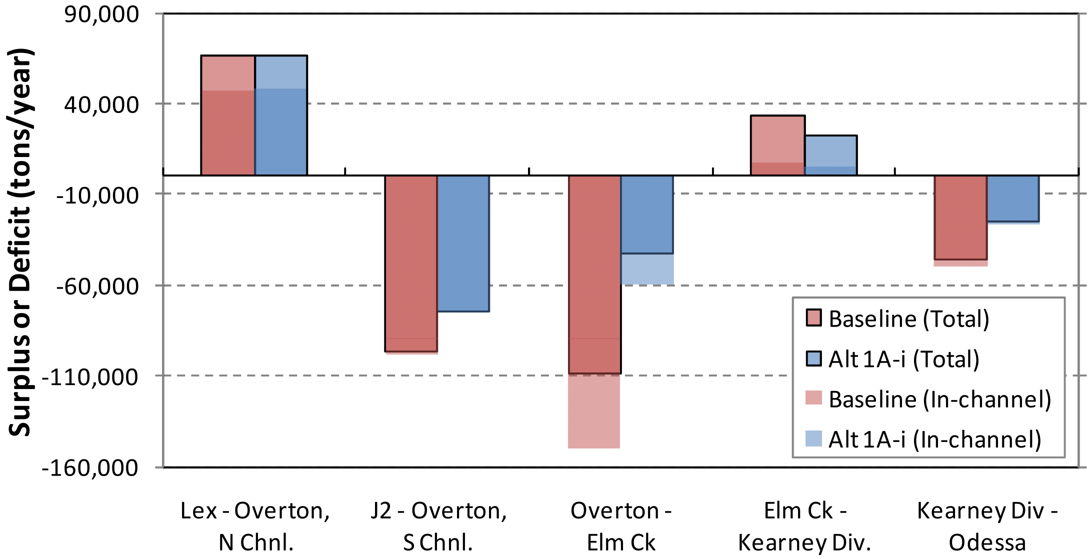


Figure 5.6. Comparison of total and in-channel surplus or deficit by subreach under baseline and Alternative 1A-i conditions.

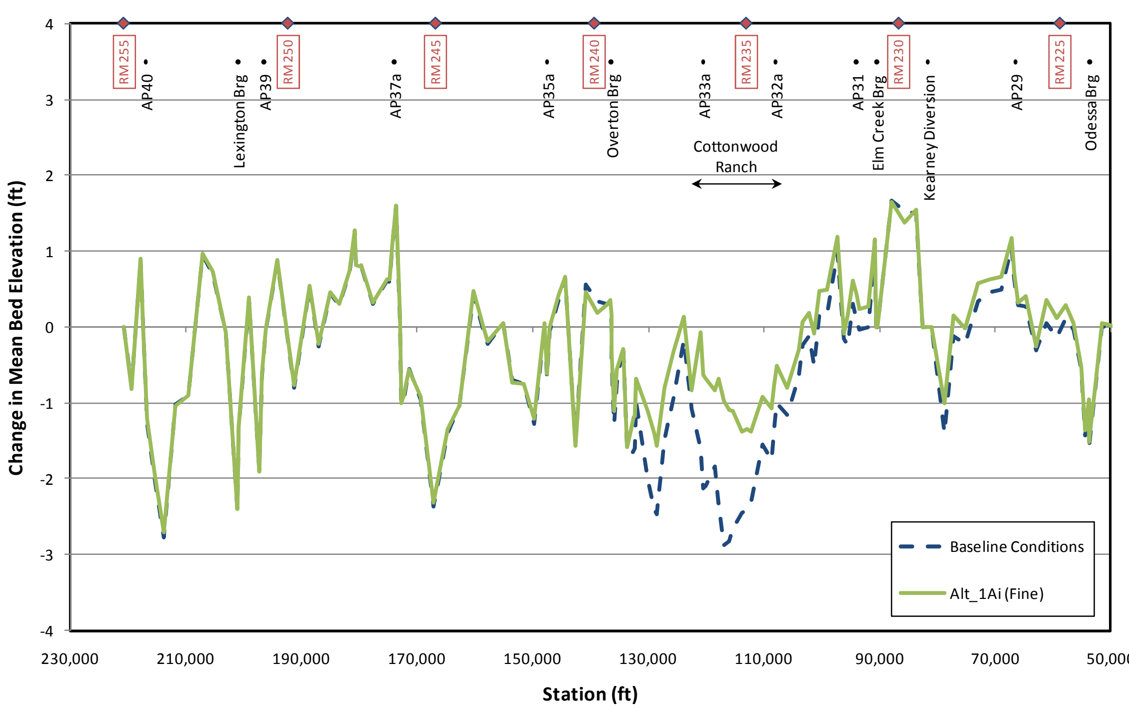


Figure 5.7. Predicted change in mean bed elevation in the main channel along the project reach (including the North Channel of Jeffreys Island) at the end of the baseline conditions and Alternative 1A-i simulations.

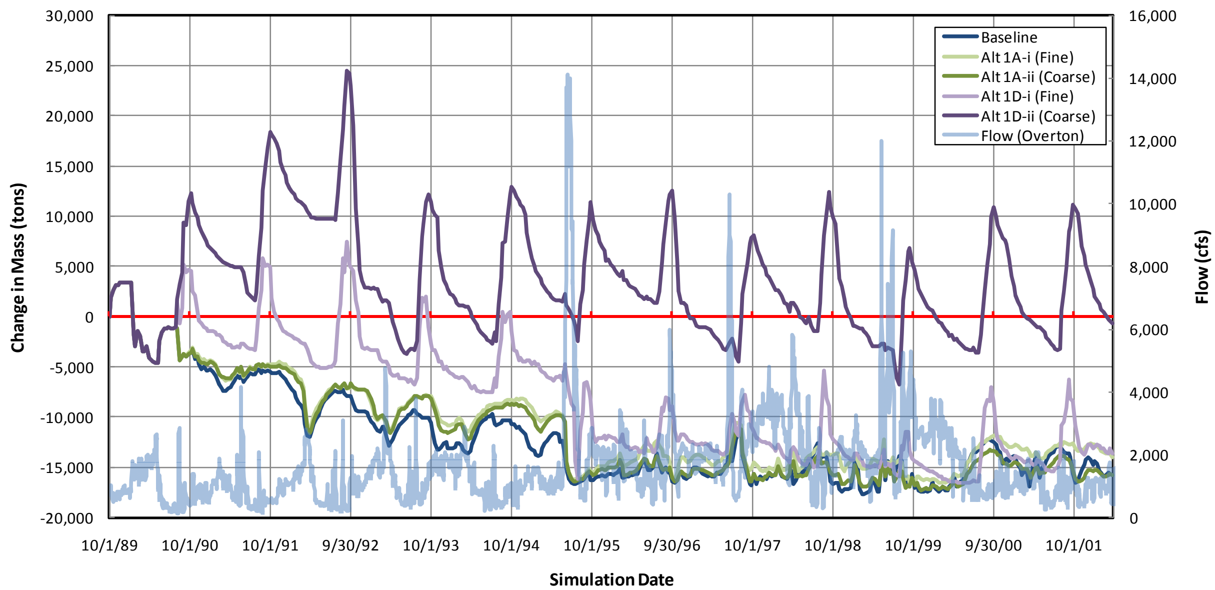


Figure 5.8. Computed change in mass over the simulation period below Pumping Site 4 (Overton Sand and Gravel) under baseline conditions and under Alternatives 1A-i, 1A-ii, 1D-i, and 1D-ii. Also shown is the hydrograph at the Overton gage.

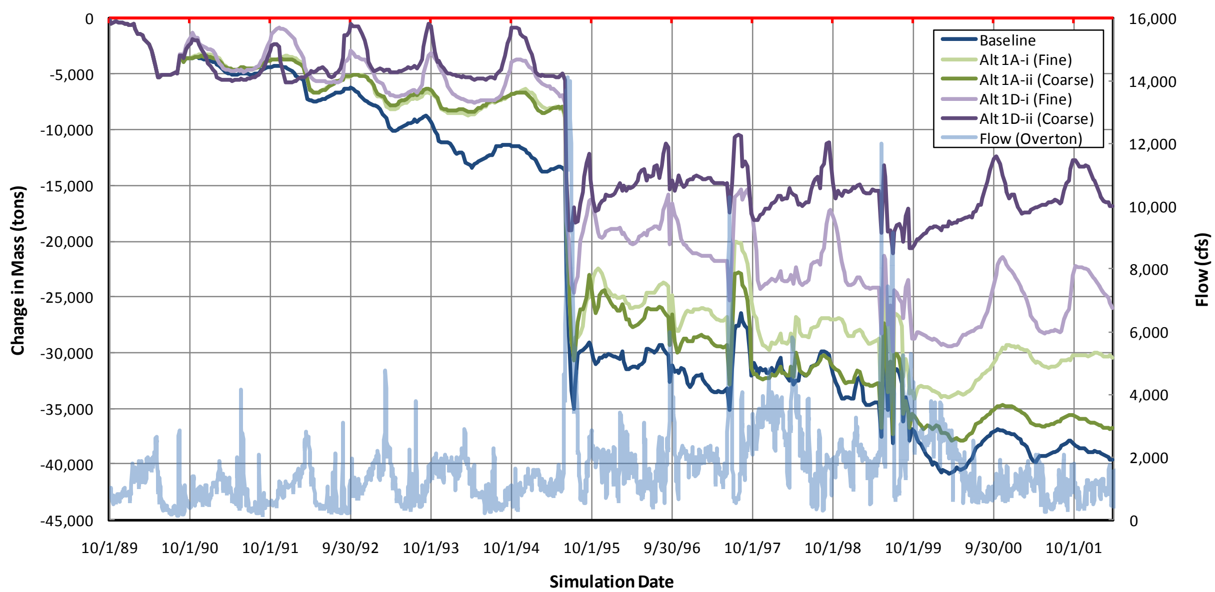


Figure 5.9. Computed change in mass over the simulation period at a location midway between Overton Bridge and Cottonwood Ranch (Station 128958) under baseline conditions and under Alternatives 1A-i, 1A-ii, 1D-i, and 1D-ii. Also shown is the hydrograph at the Overton gage.

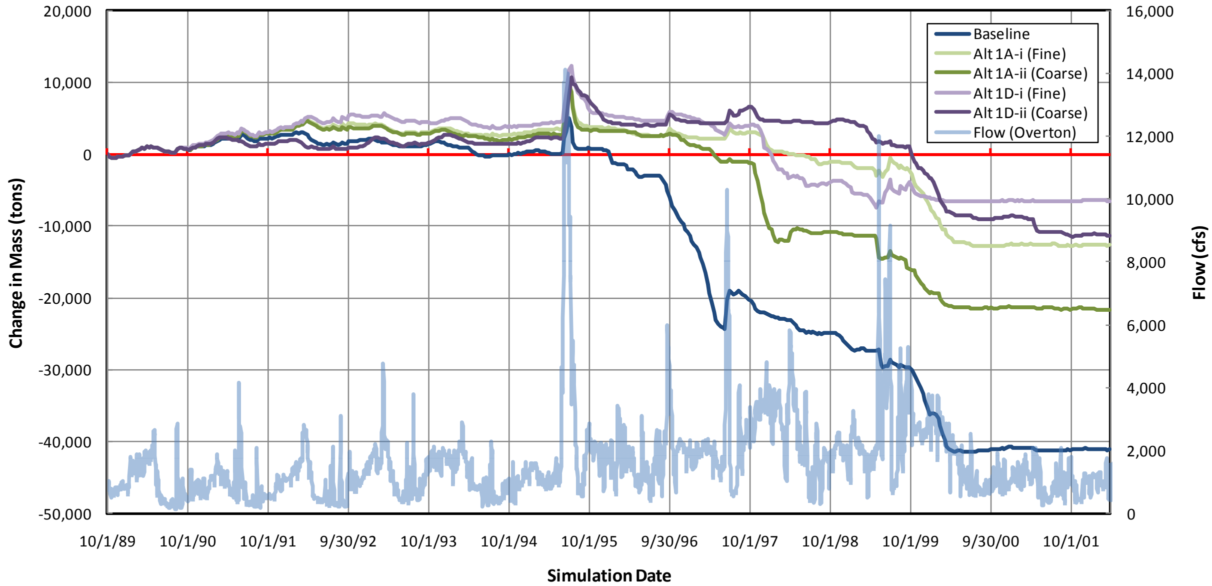


Figure 5.10. Computed change in mass over the simulation period near the upstream limit of Cottonwood Ranch (Station 120488; Anchor Point 33.4b) under baseline conditions and under Alternatives 1A-i, 1A-ii, 1D-i, and 1D-ii. Also shown is the hydrograph at the Overton gage.

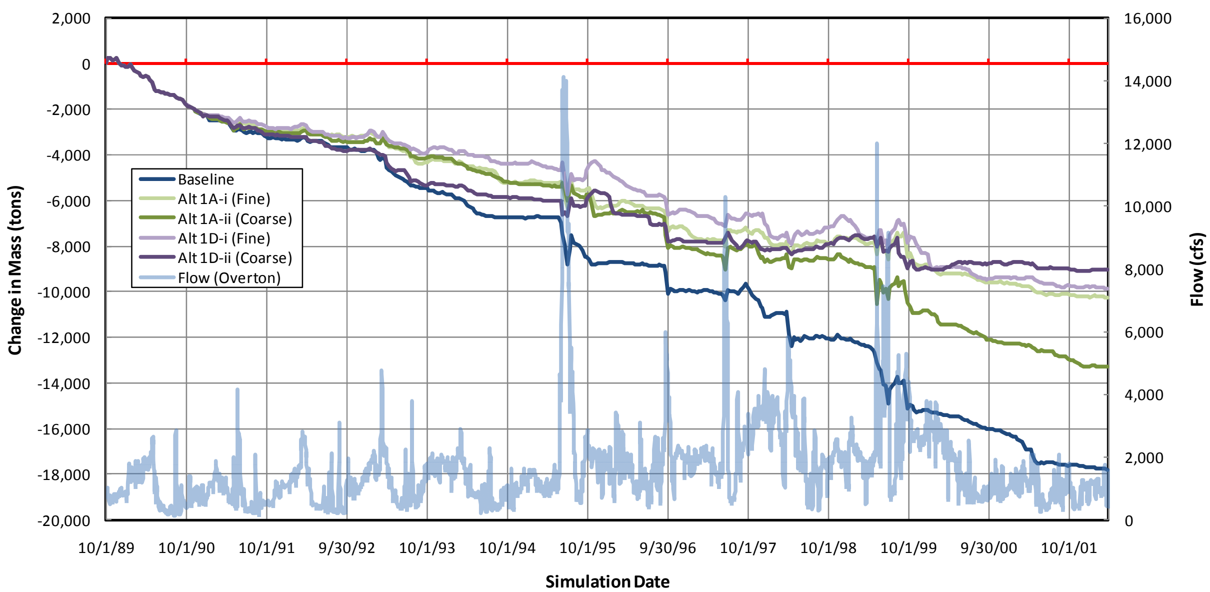


Figure 5.11. Computed change in mass over the simulation period near the downstream limit of Cottonwood Ranch (Station 108164; Anchor Point 32.4b) under baseline conditions and under Alternatives 1A-i, 1A-ii, 1D-i, and 1D-ii. Also shown is the hydrograph at the Overton gage.

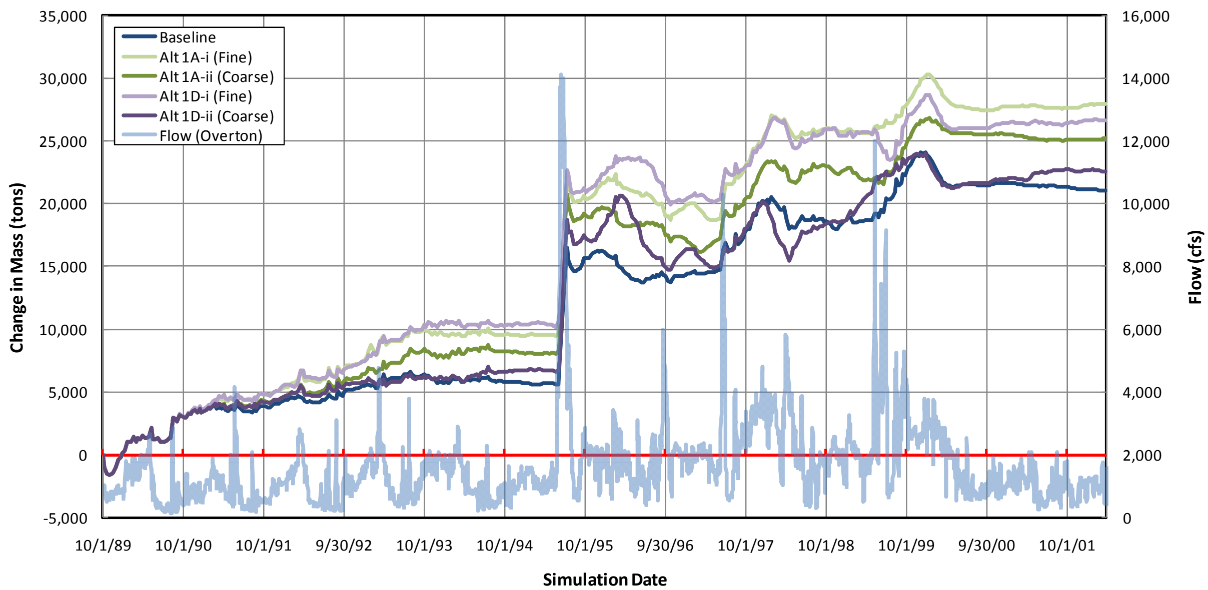


Figure 5.12. Computed change in mass over the simulation period at a location midway about 0.7 miles upstream from Elm Creek Bridge (Station 108164; Anchor Point 31.4a) under baseline conditions and under Alternatives 1A-i, 1A-ii, 1D-i, and 1D-ii. Also shown is the hydrograph at the Overton gage.

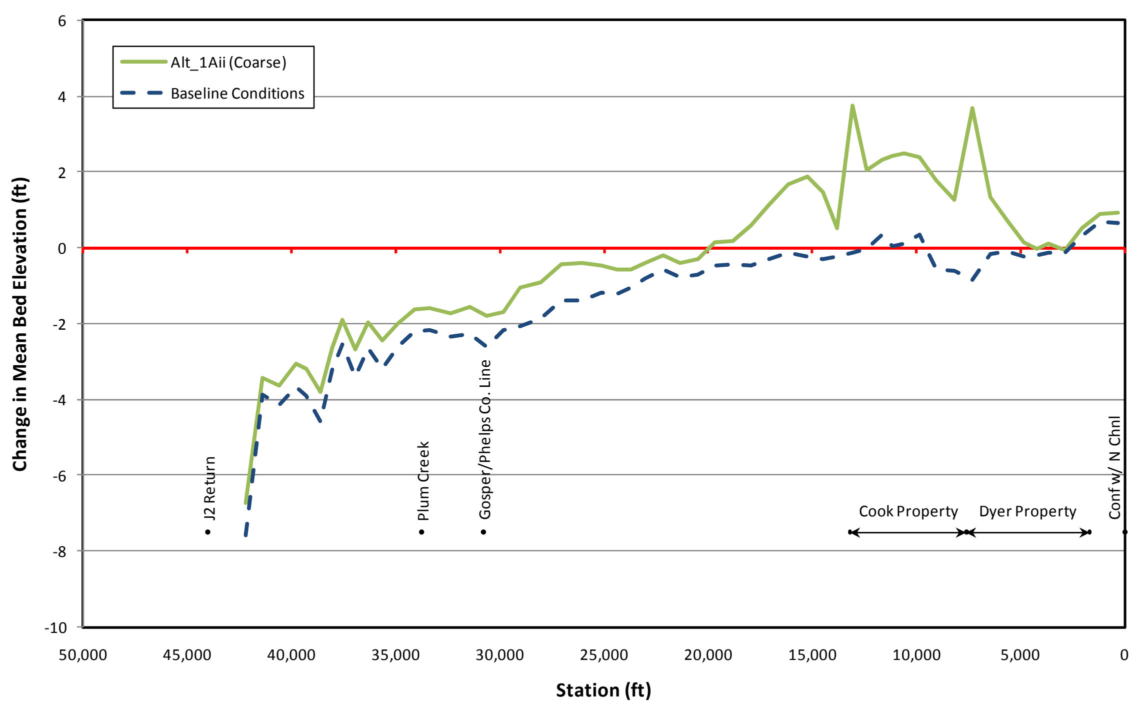


Figure 5.13. Predicted change in mean bed elevation in the South Channel of Jeffreys Island at the end of the baseline conditions and Alternative 1A-ii simulations.

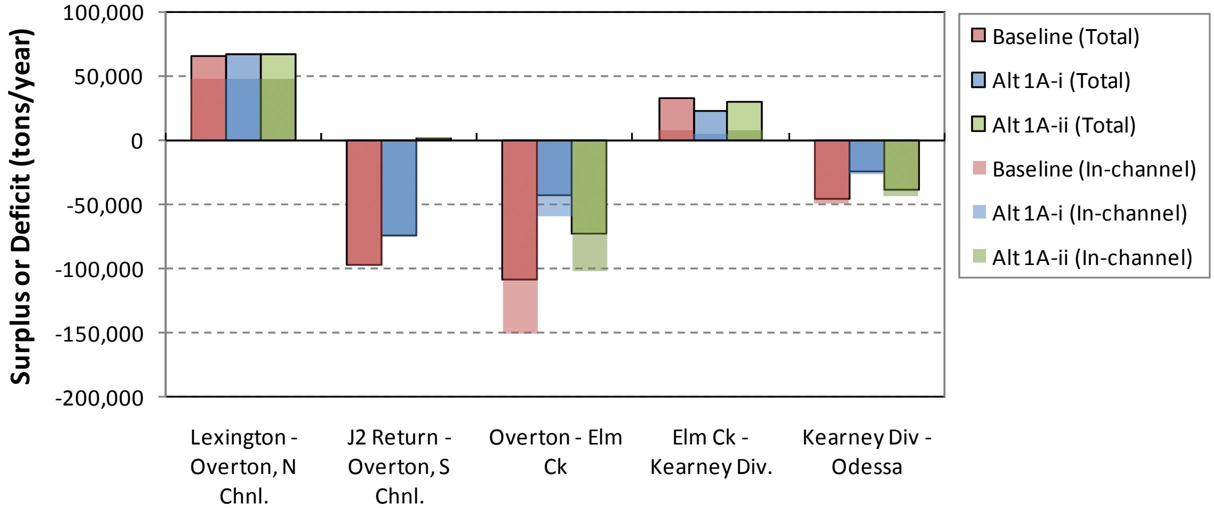


Figure 5.14. Comparison of total and in-channel surplus or deficit by subreach under baseline, Alternative 1A-i, and Alternative 1A-ii conditions.

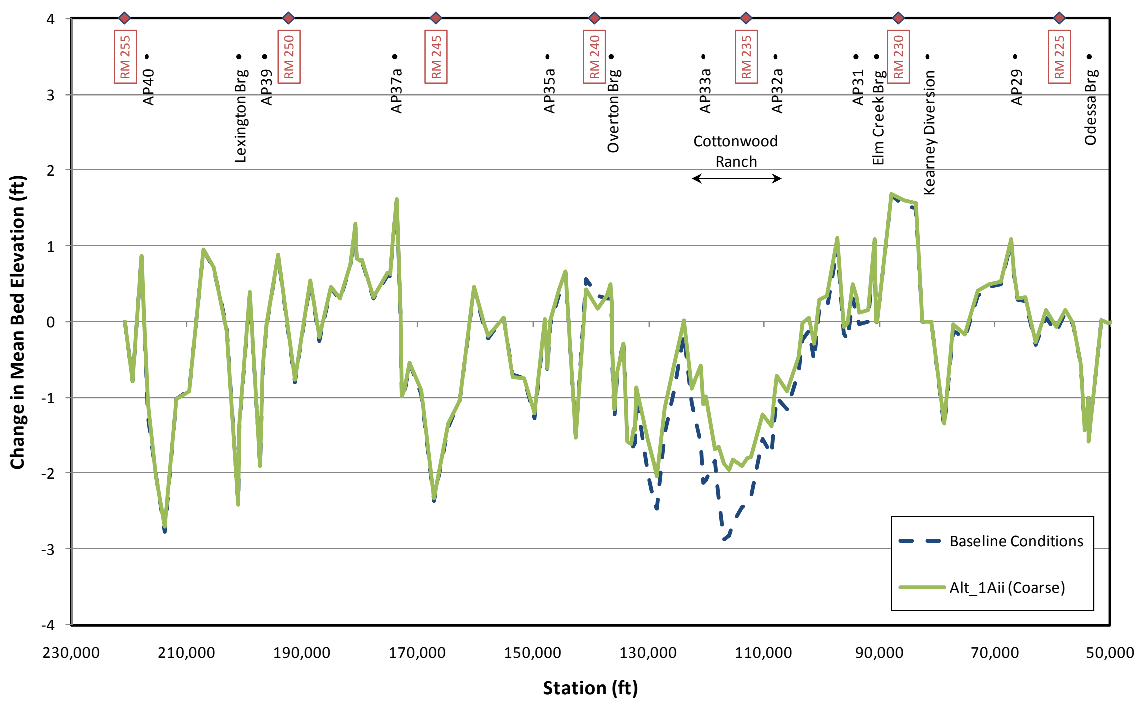


Figure 5.15. Predicted change in mean bed elevation in the main channel along the project reach (including the North Channel of Jeffreys Island) at the end of the baseline conditions and Alternative 1A-ii simulations.

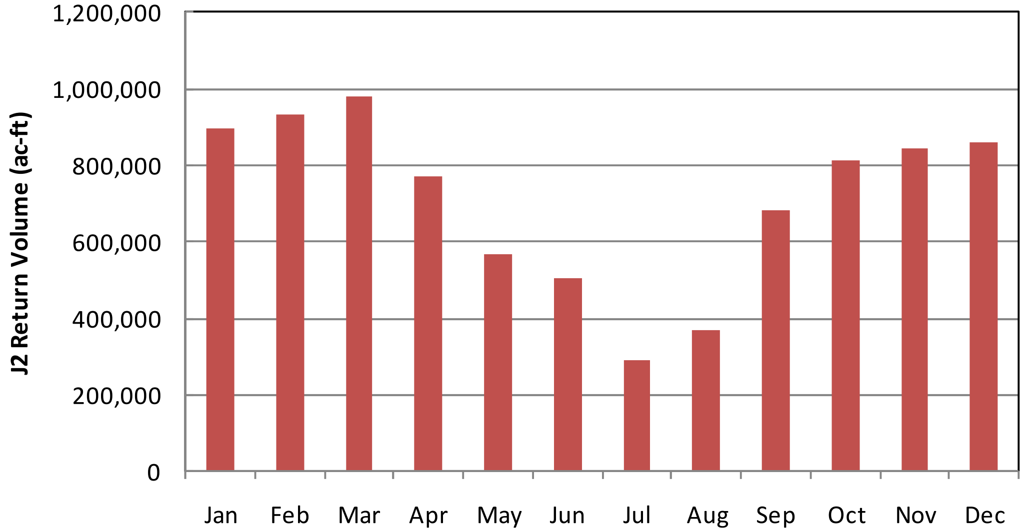


Figure 5.16. Average monthly flow volume from the J2 Return for the simulation period between 10/1/89 and 4/1/02.

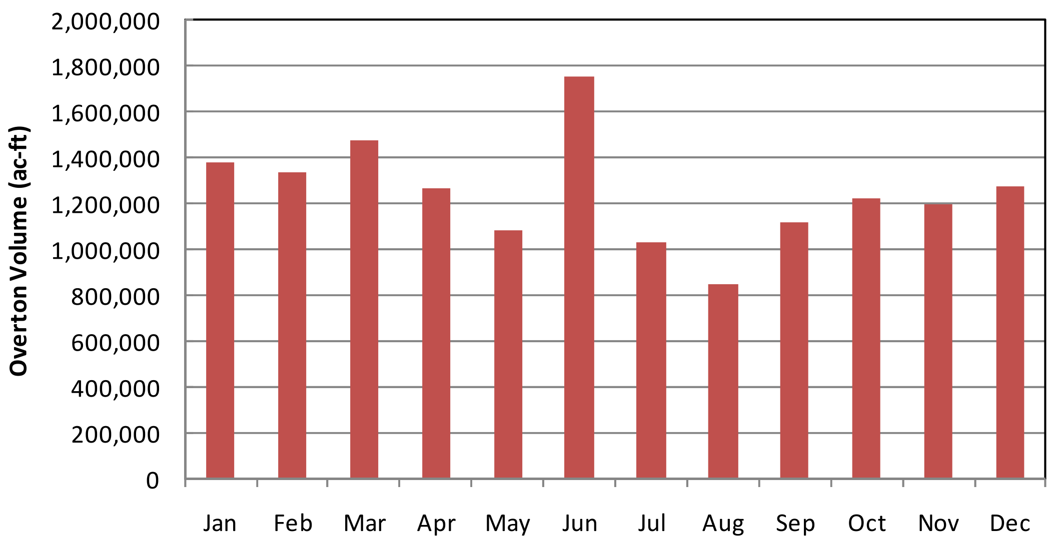


Figure 5.17. Average monthly flow volume at the Overton gage for the simulation period between 10/1/89 and 4/1/02.

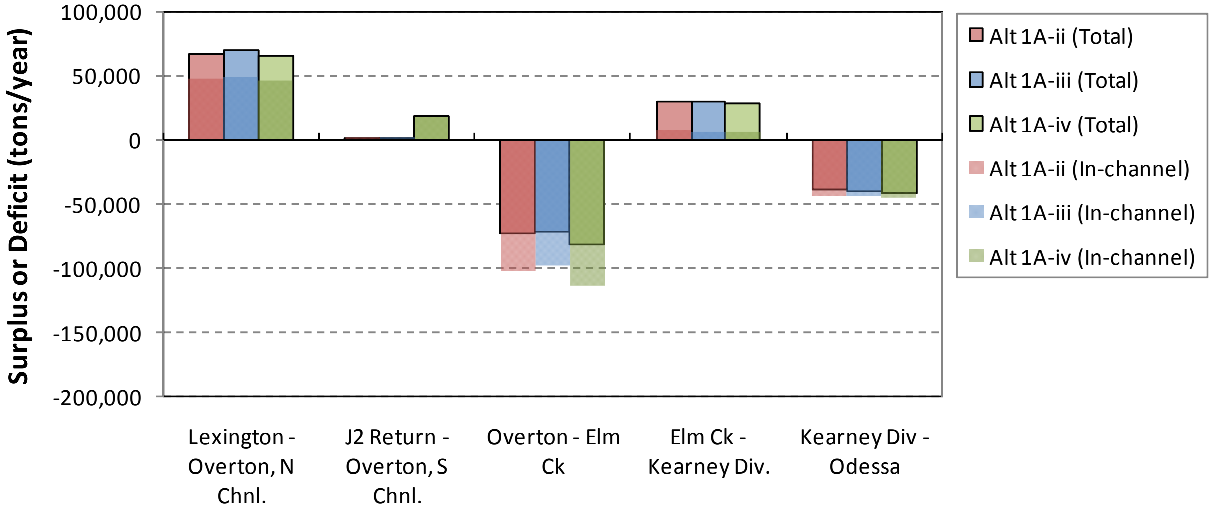


Figure 5.18. Comparison of total and in-channel surplus or deficit by subreach under Alternatives 1A-ii, 1A-iii, and 1A-iv.

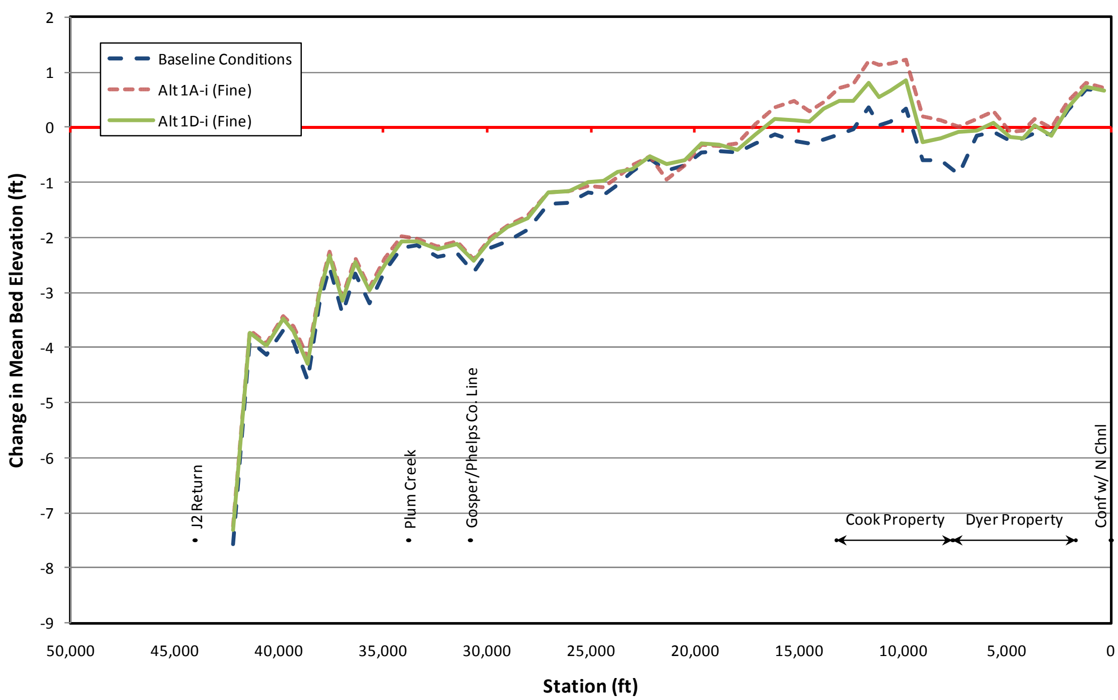


Figure 5.19. Predicted change in mean bed elevation in the South Channel of Jeffreys Island at the end of the simulations for baseline conditions and Alternatives 1A-i and 1D-i.

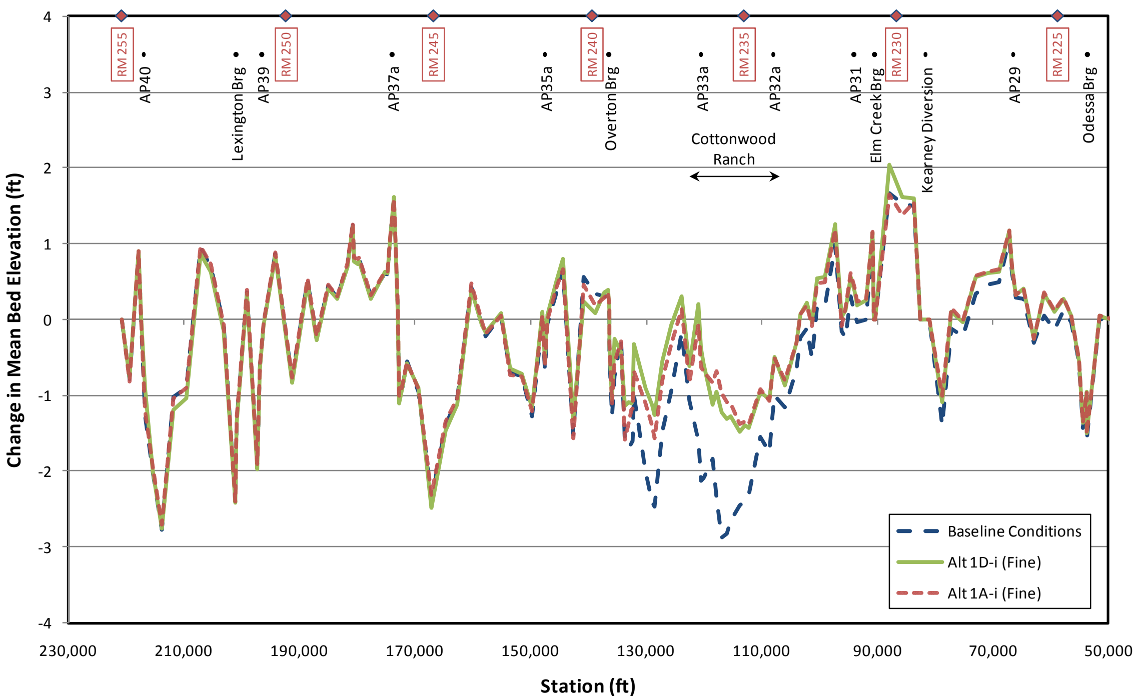


Figure 5.20. Predicted change in mean bed elevation in the main channel along the project reach (including the North Channel of Jeffreys Island) at the end of the simulations for baseline conditions and Alternatives 1A-i and 1D-i.

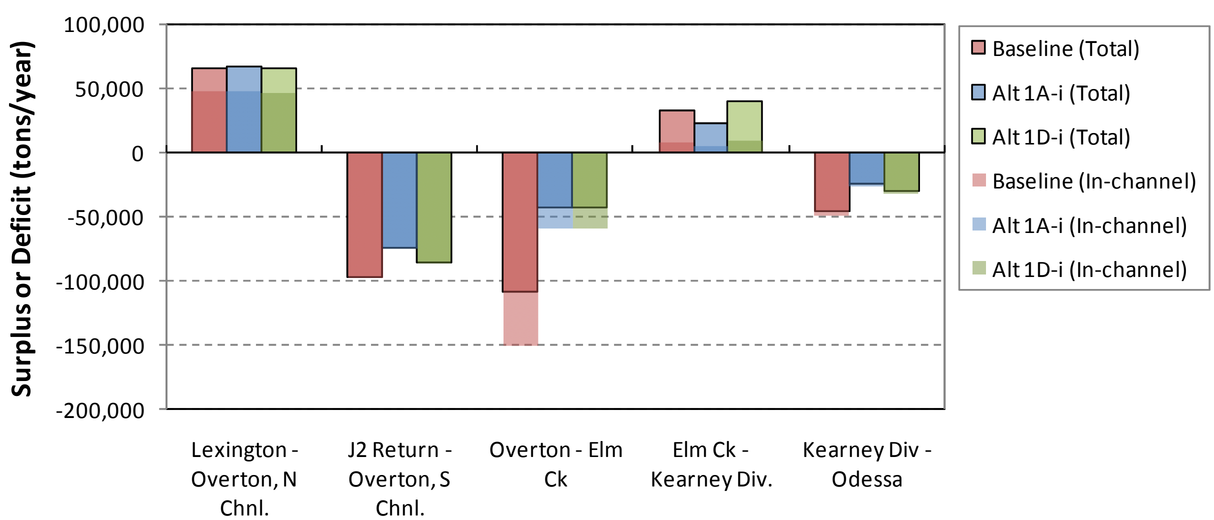


Figure 5.21. Comparison of total and in-channel annual surplus or deficit by subreach under baseline, Alternative 1A-i, and Alternative 1D-i conditions.

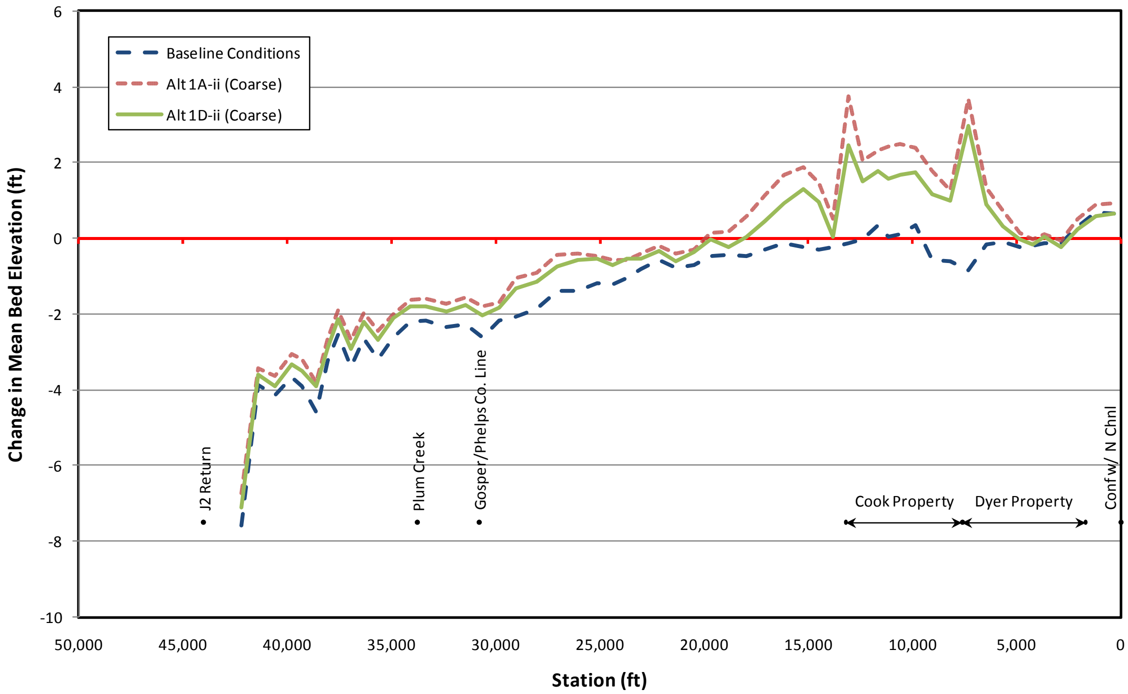


Figure 5.22. Predicted change in mean bed elevation in the South Channel of Jeffreys Island at the end of the simulations for baseline conditions and Alternatives 1A-ii and 1D-ii.

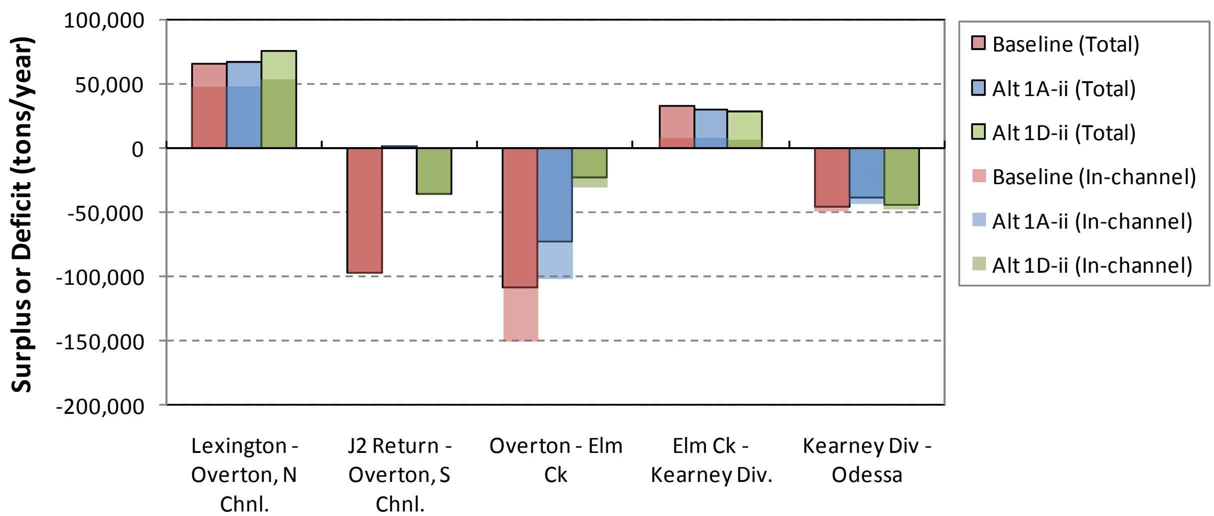


Figure 5.23. Comparison of total and in-channel annual surplus or deficit by subreach under baseline, Alternative 1A-i, and Alternative 1D-i conditions.

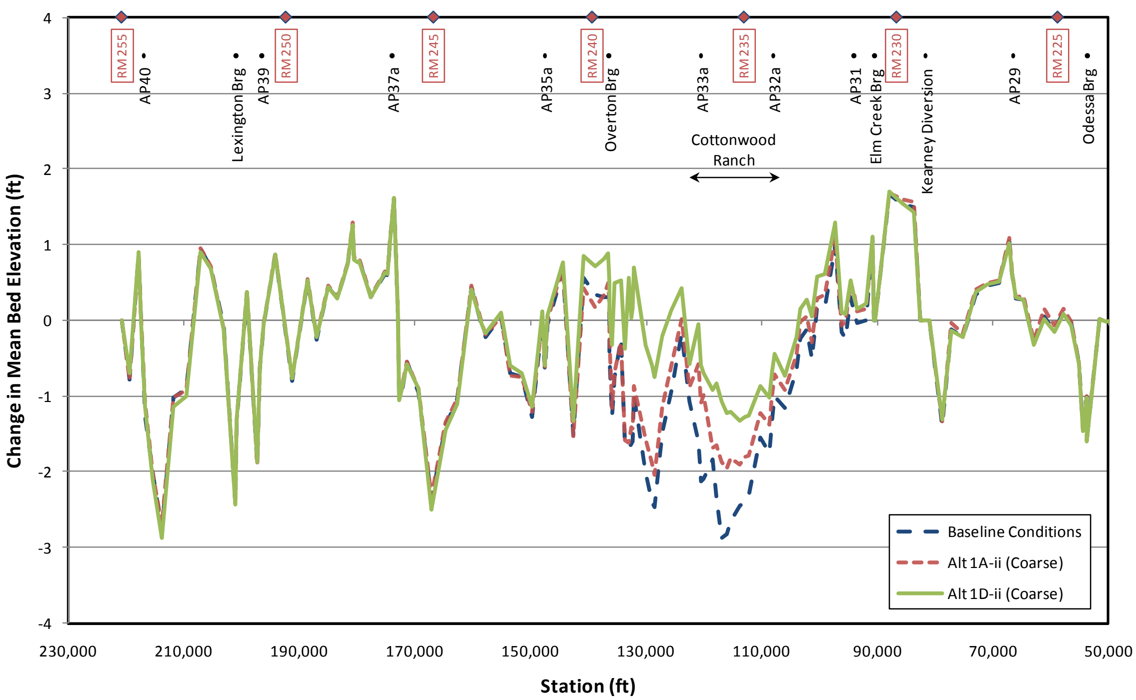


Figure 5.24. Predicted change in mean bed elevation in the main channel along the project reach (including the North Channel of Jeffreys Island) at the end of the simulations for baseline conditions and Alternatives 1A-ii and 1D-ii.

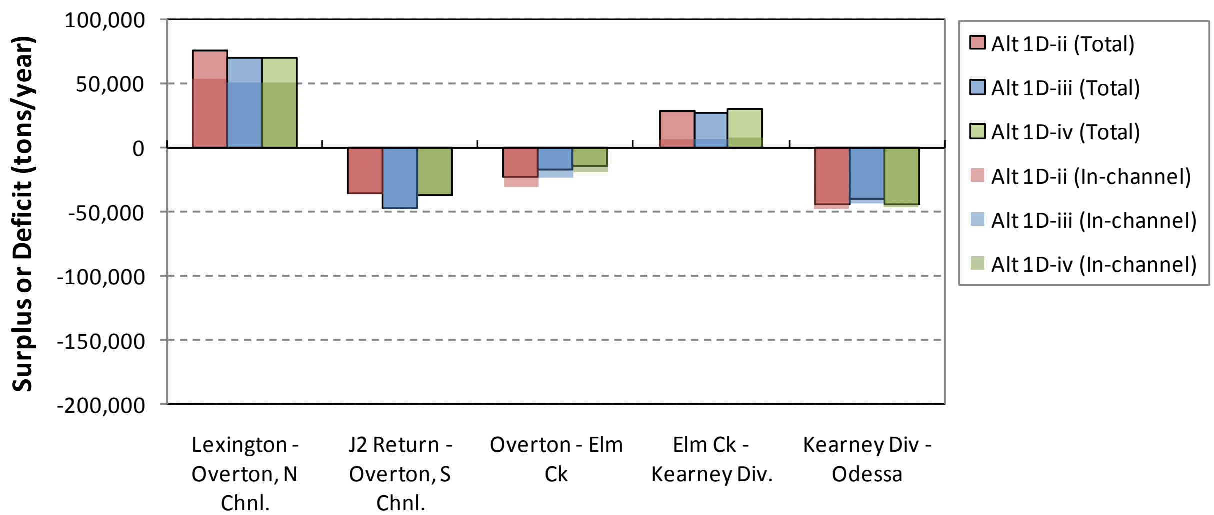


Figure 5.25. Comparison of total and in-channel surplus or deficit by subreach under Alternatives 1D-ii, 1D-iii, and 1D-iv.

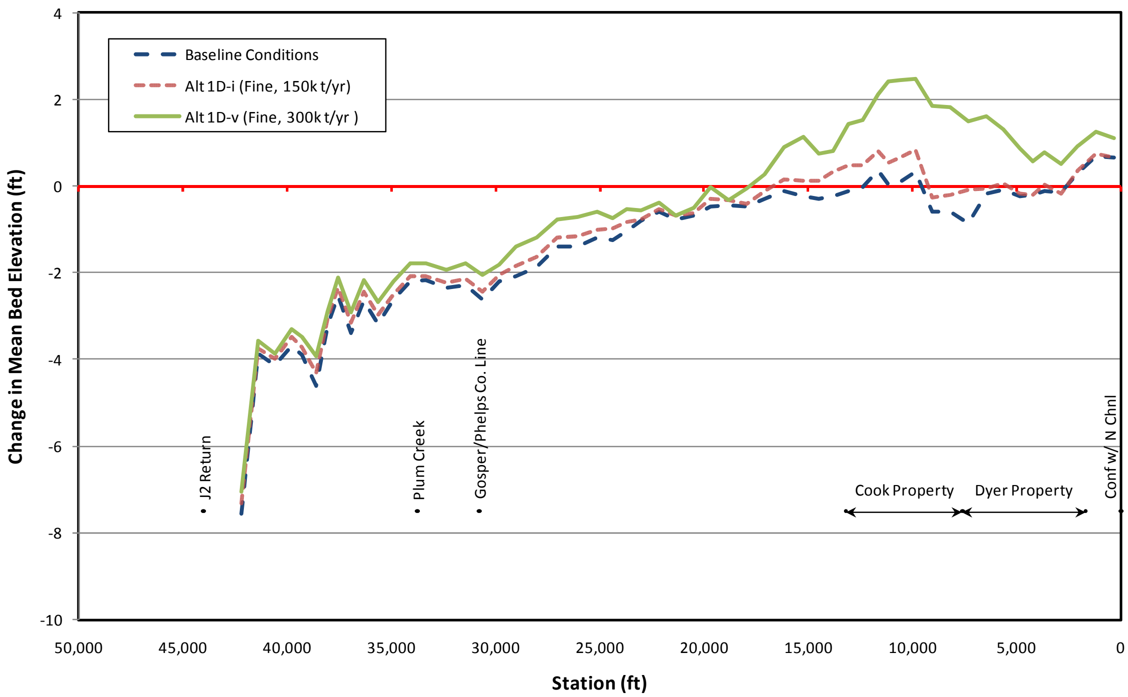


Figure 5.26. Predicted change in mean bed elevation in the South Channel of Jeffreys Island at the end of the simulations for baseline conditions and Alternatives 1D-i and 1D-v.

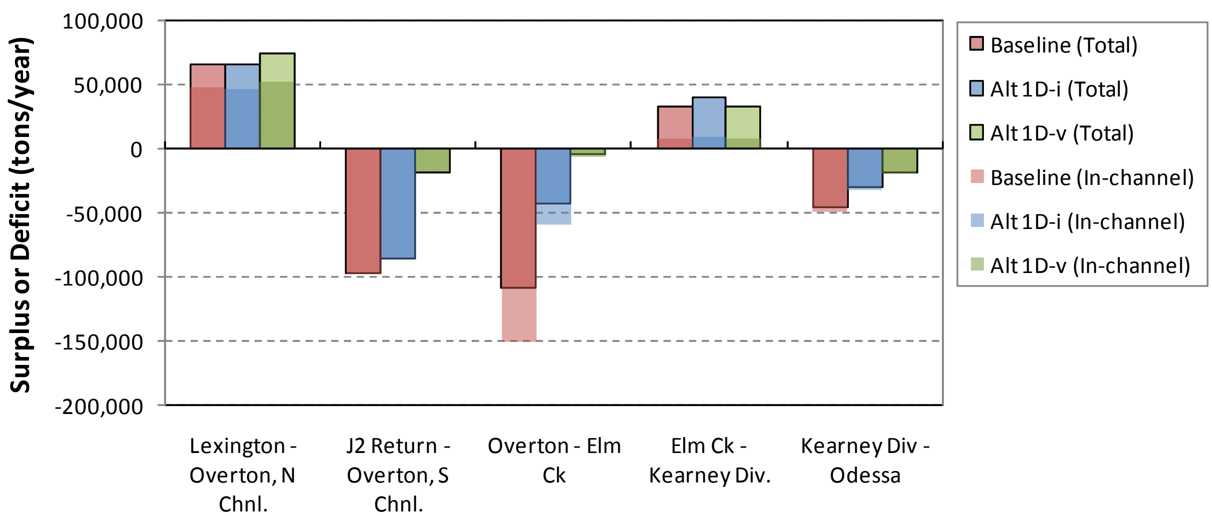


Figure 5.27. Comparison of total and in-channel annual surplus or deficit by subreach under baseline, Alternative 1D-i, and Alternative 1D-v conditions.

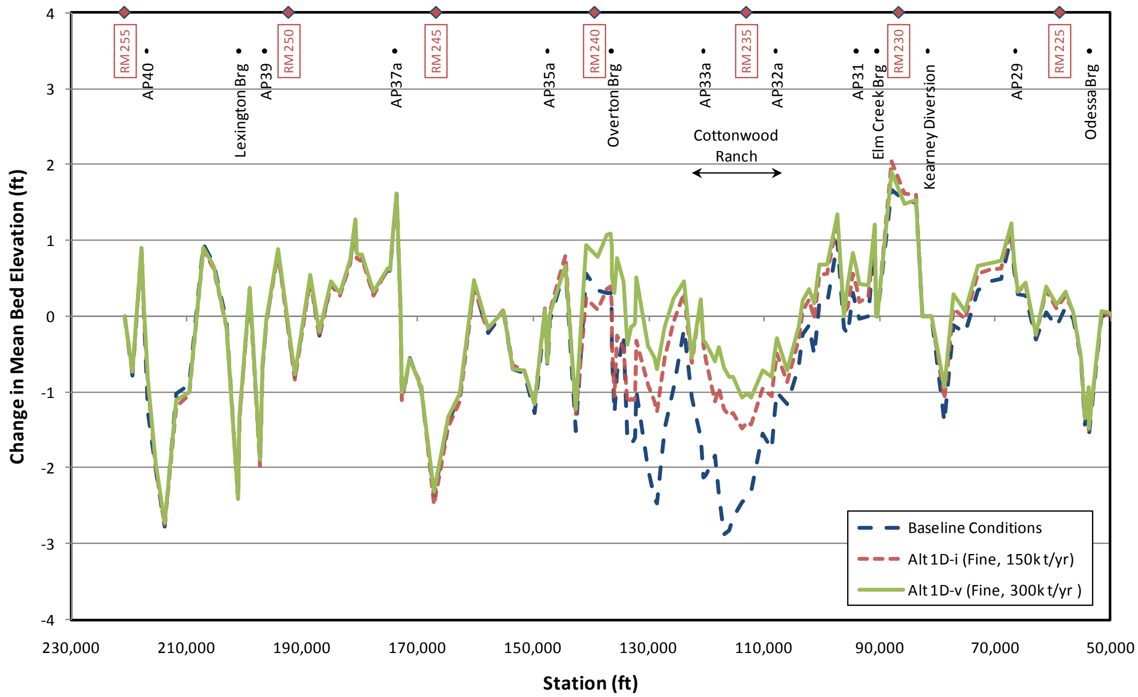


Figure 5.28. Predicted change in mean bed elevation in the main channel along the project reach (including the North Channel of Jeffreys Island) at the end of the simulations for baseline conditions and Alternatives 1A-i and 1D-i.

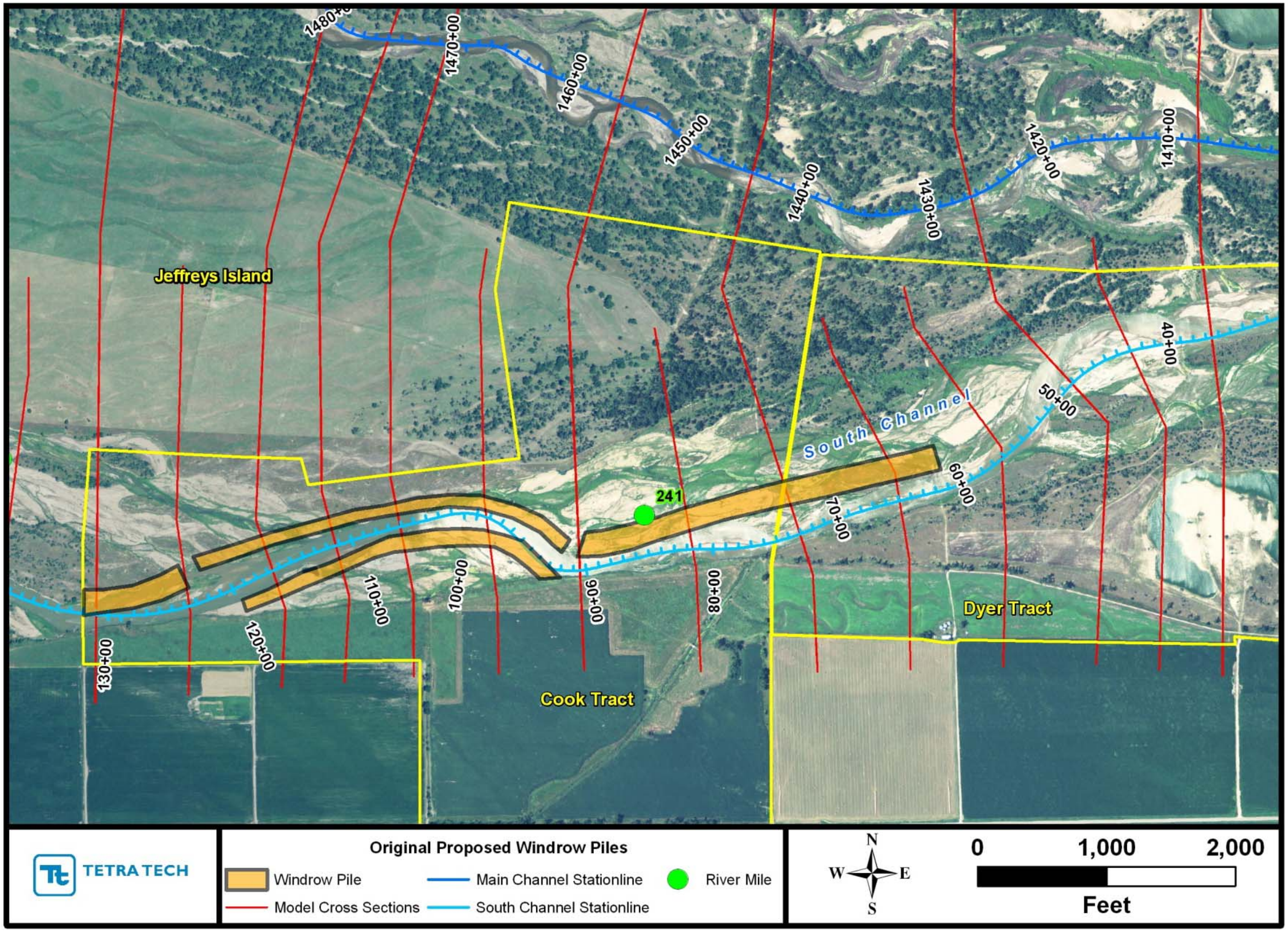


Figure 5.29. Aerial photograph showing the locations of the windrow piles under Alternative 2A-i.

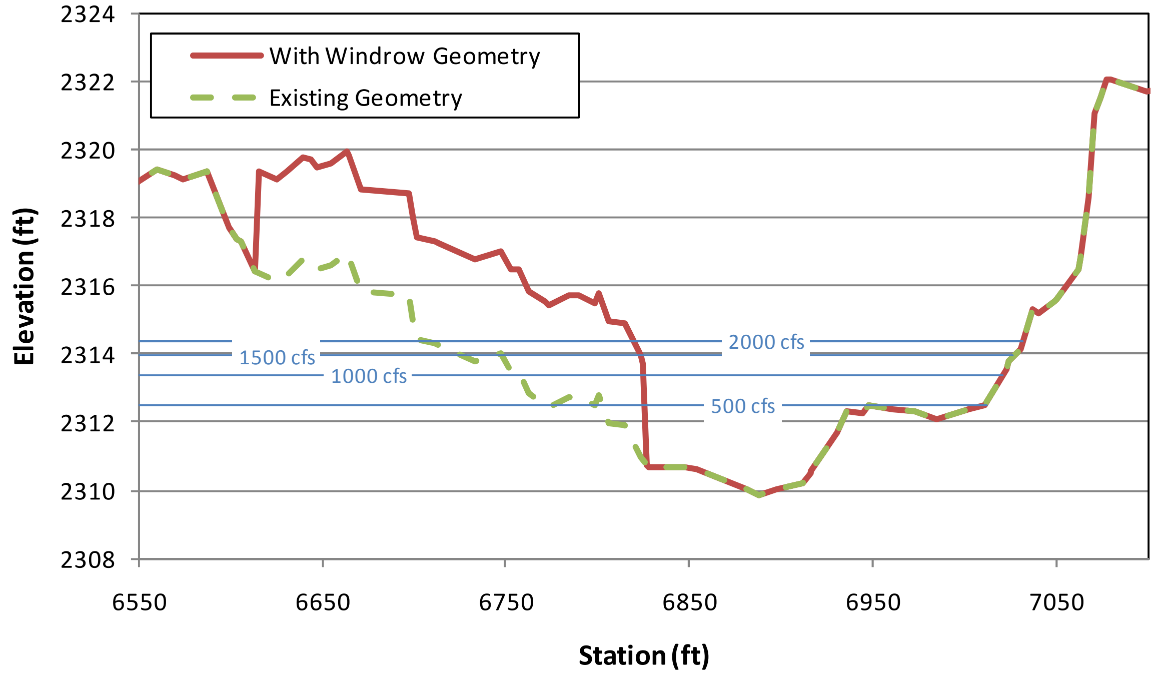


Figure 5.30. Cross-sectional geometry at River Station 123+80 in the South Channel of Jeffreys Island showing the geometry with- and without the windrow pile under Alternative 2A-i. Also shown are computed water-surface elevations under the with-windrow geometry at various discharges.

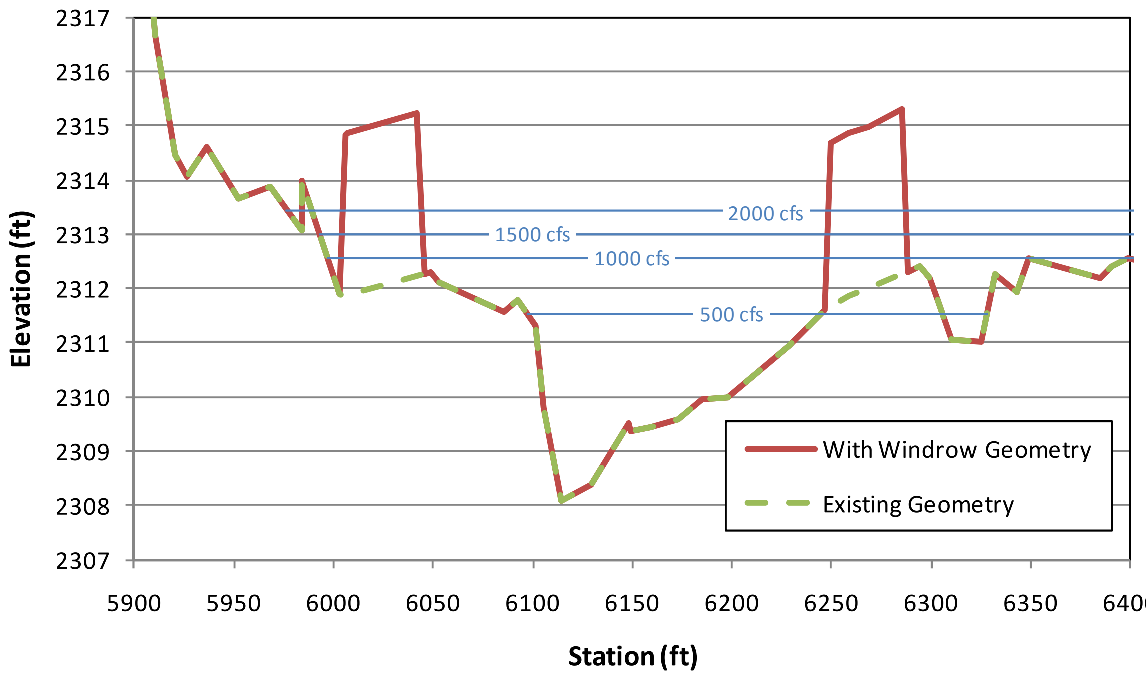


Figure 5.31. Cross-sectional geometry at River Station 111+30 in the South Channel of Jeffreys Island showing the geometry with- and without the windrow pile under Alternative 2A-i. Also shown are computed water-surface elevations under the with-windrow geometry at various discharges.

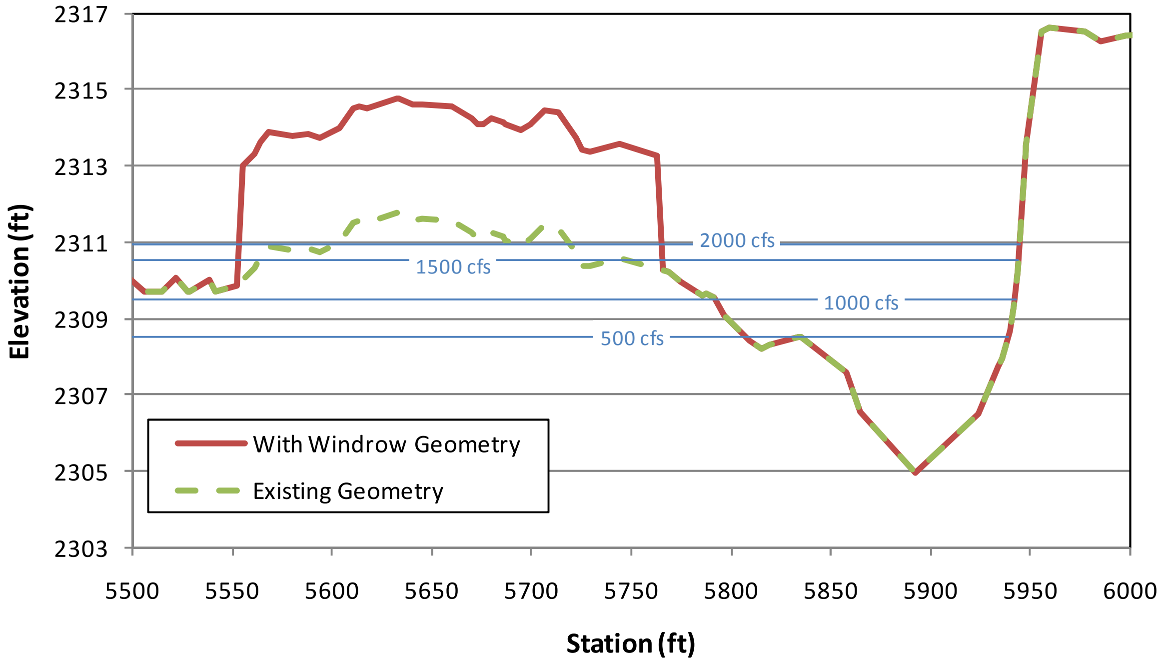


Figure 5.32. Cross-sectional geometry at River Station 81+80 in the South Channel of Jeffreys Island showing the geometry with- and without the windrow pile under Alternative 2A-i. Also shown are computed water-surface elevations under the with-windrow geometry at various discharges.

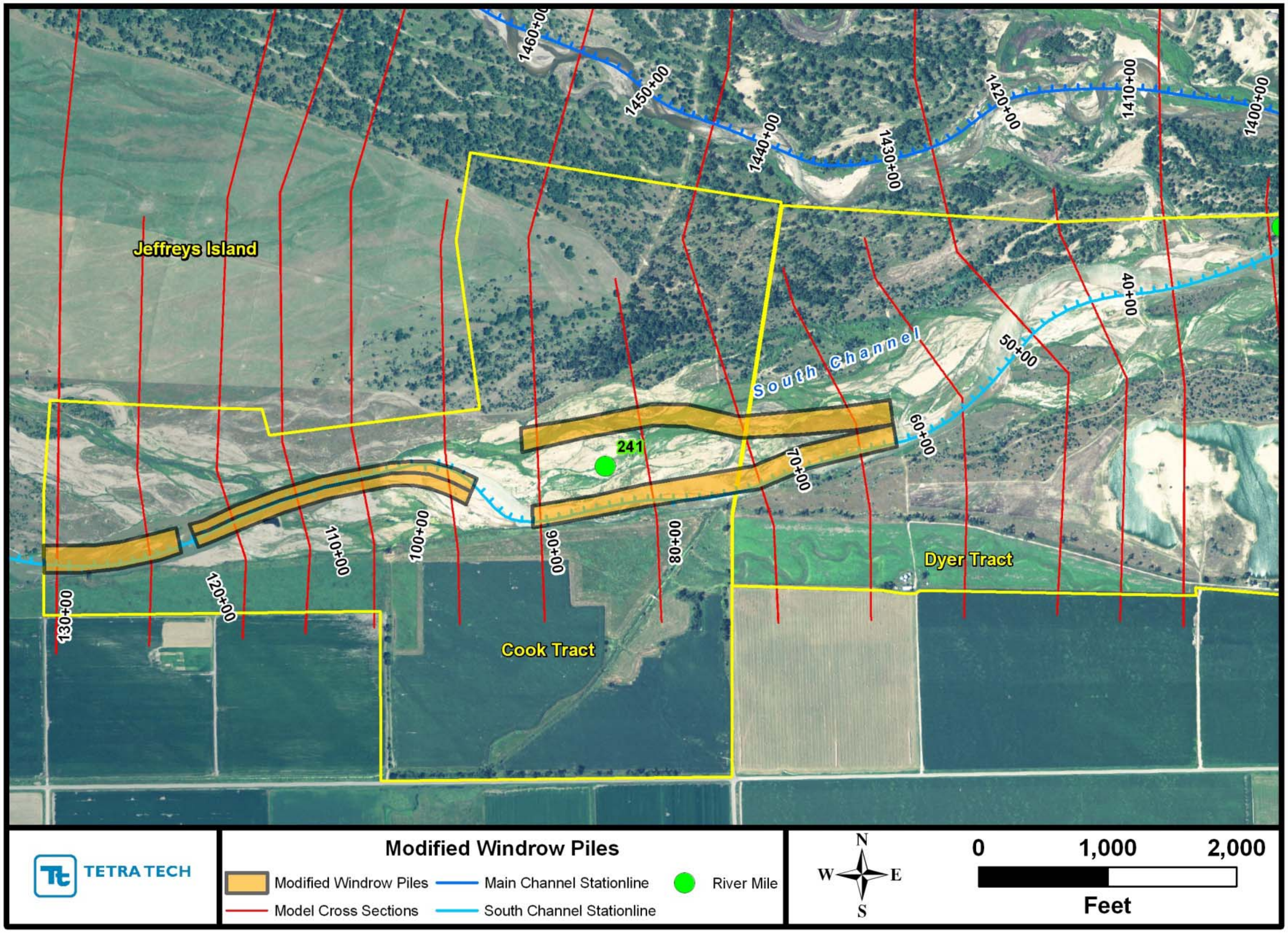


Figure 5.33. Aerial photograph showing the locations of the windrow piles under Alternative 2A-i.

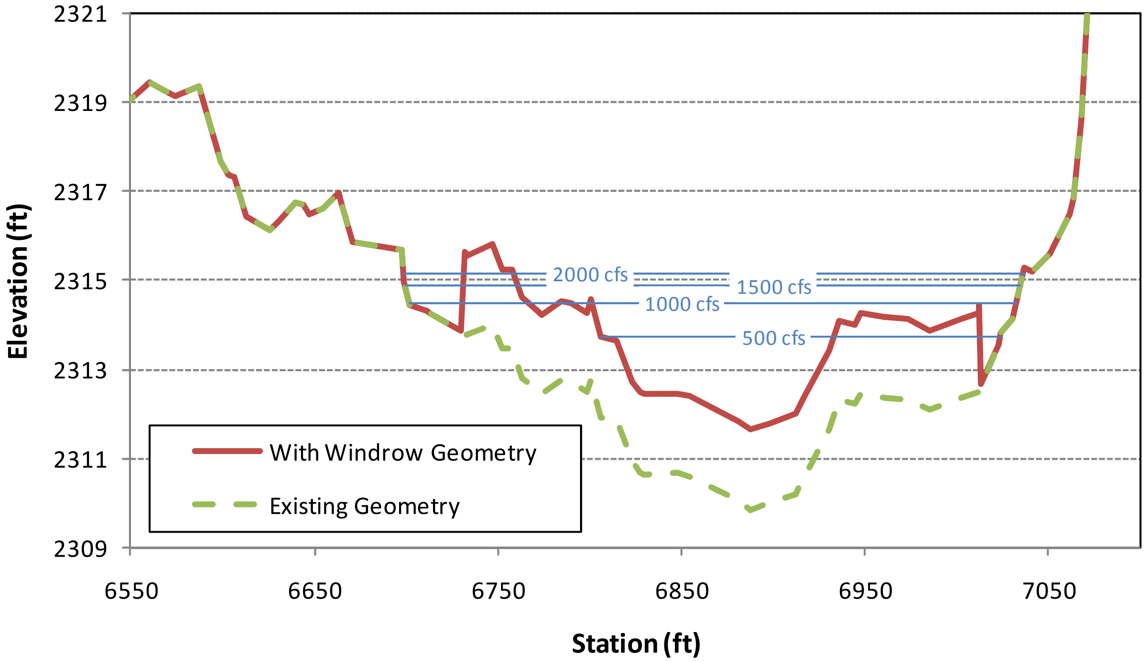


Figure 5.34. Cross-sectional geometry at River Station 123+80 in the South Channel of Jeffreys Island showing the geometry with- and without the windrow pile under Alternative 2A-ii. Also shown are computed water-surface elevations under the with-windrow geometry at various discharges.

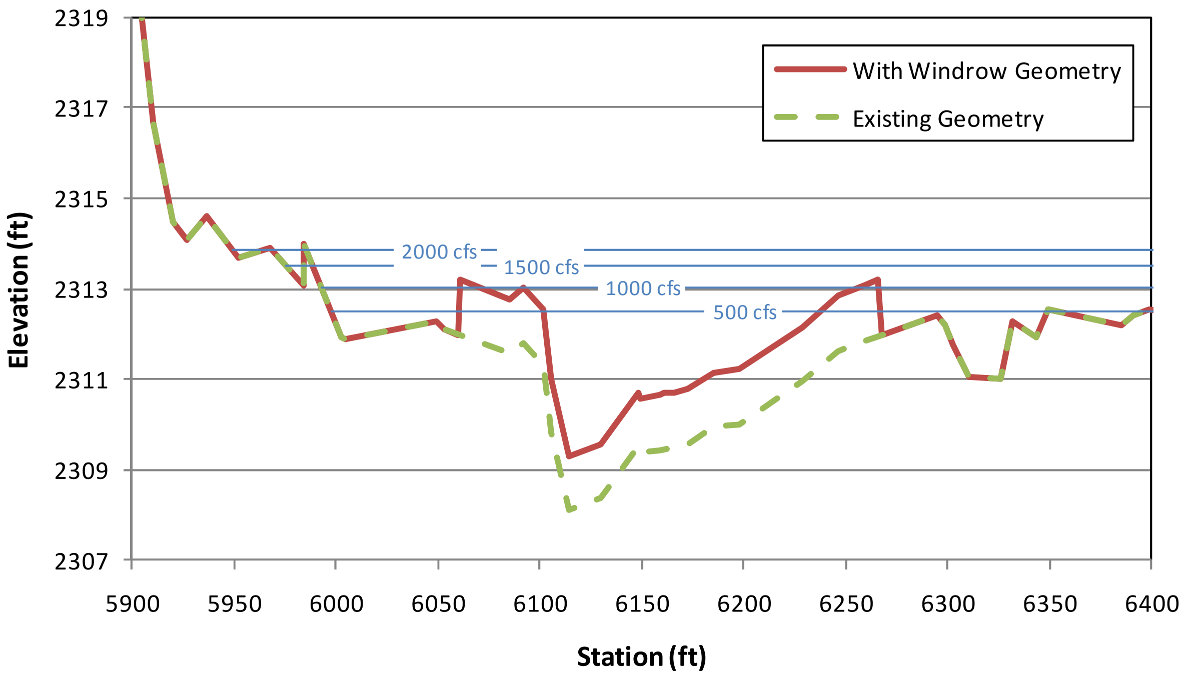


Figure 5.35. Cross-sectional geometry at River Station 111+30 in the South Channel of Jeffreys Island showing the geometry with- and without the windrow pile under Alternative 2A-ii. Also shown are computed water-surface elevations under the with-windrow geometry at various discharges.

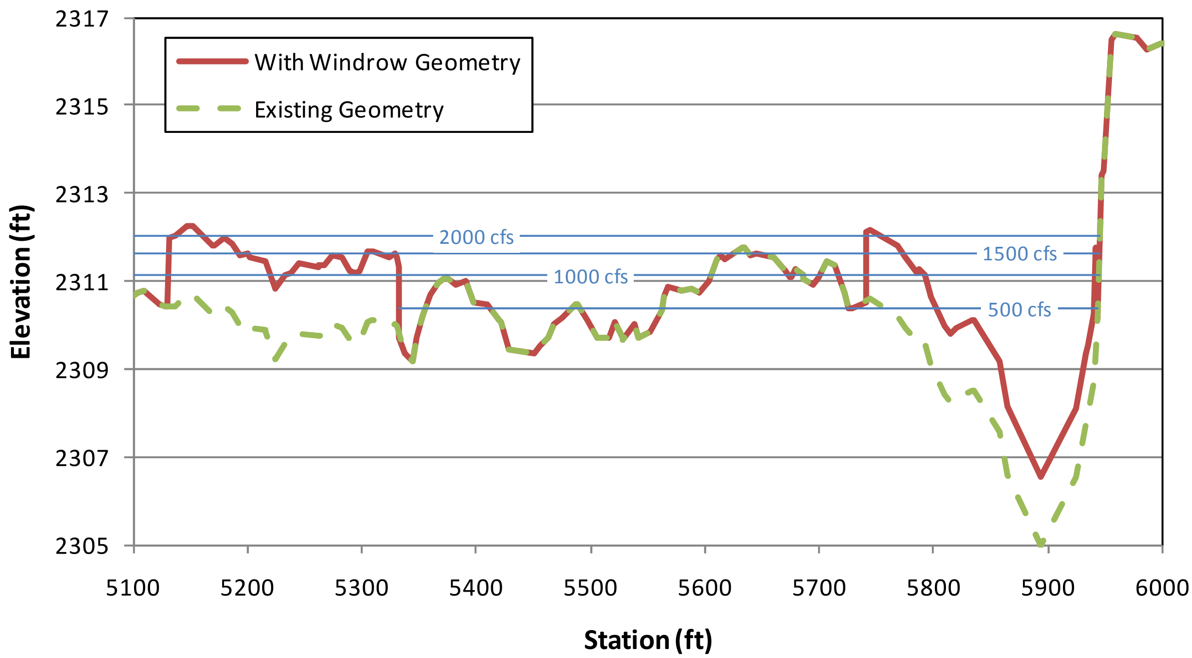


Figure 5.36. Cross-sectional geometry at River Station 123+80 in the South Channel of Jeffreys Island showing the geometry with- and without the windrow pile under Alternative 2A-ii. Also shown are computed water-surface elevations under the with-windrow geometry at various discharges.

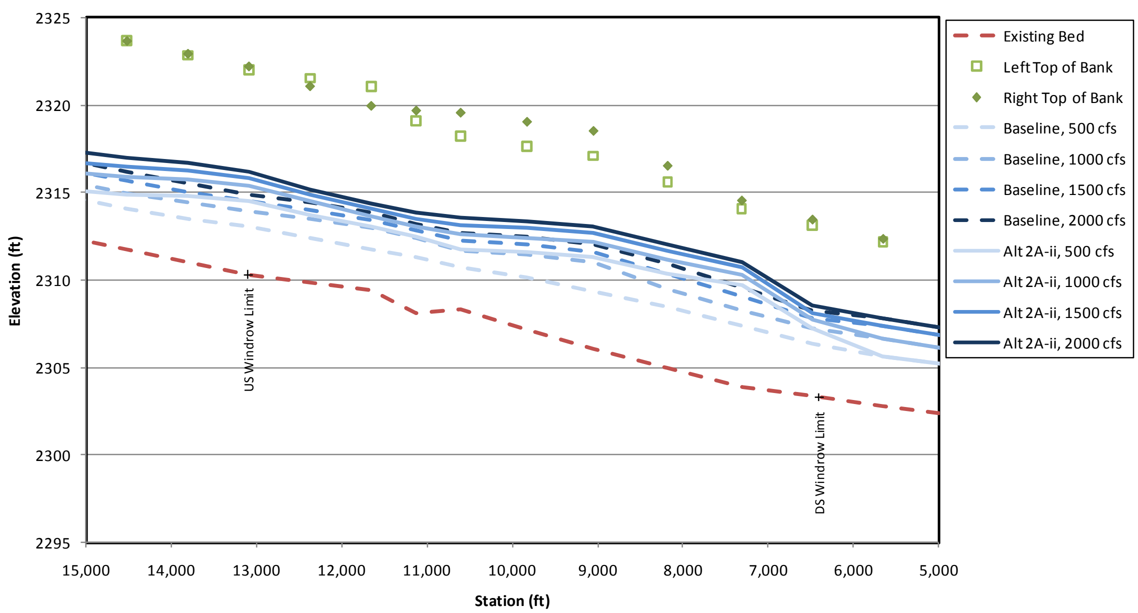


Figure 5.37. Predicted water-surface elevation profiles from the steady-state hydraulic model in the vicinity of the proposed windrow piles along the South Channel of Jeffries Island under baseline and Alternative 2A-ii conditions.

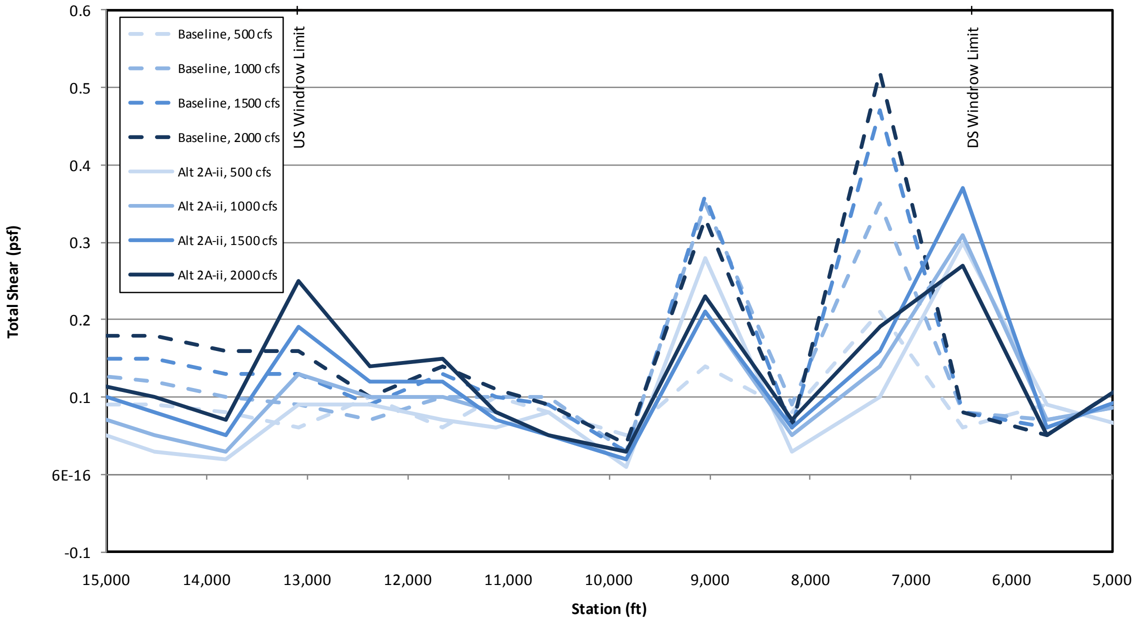


Figure 5.38. Computed total shear from the steady-state hydraulic model in the vicinity of the proposed windrow piles along the South Channel of Jeffries Island under baseline and Alternative 2A-ii conditions.

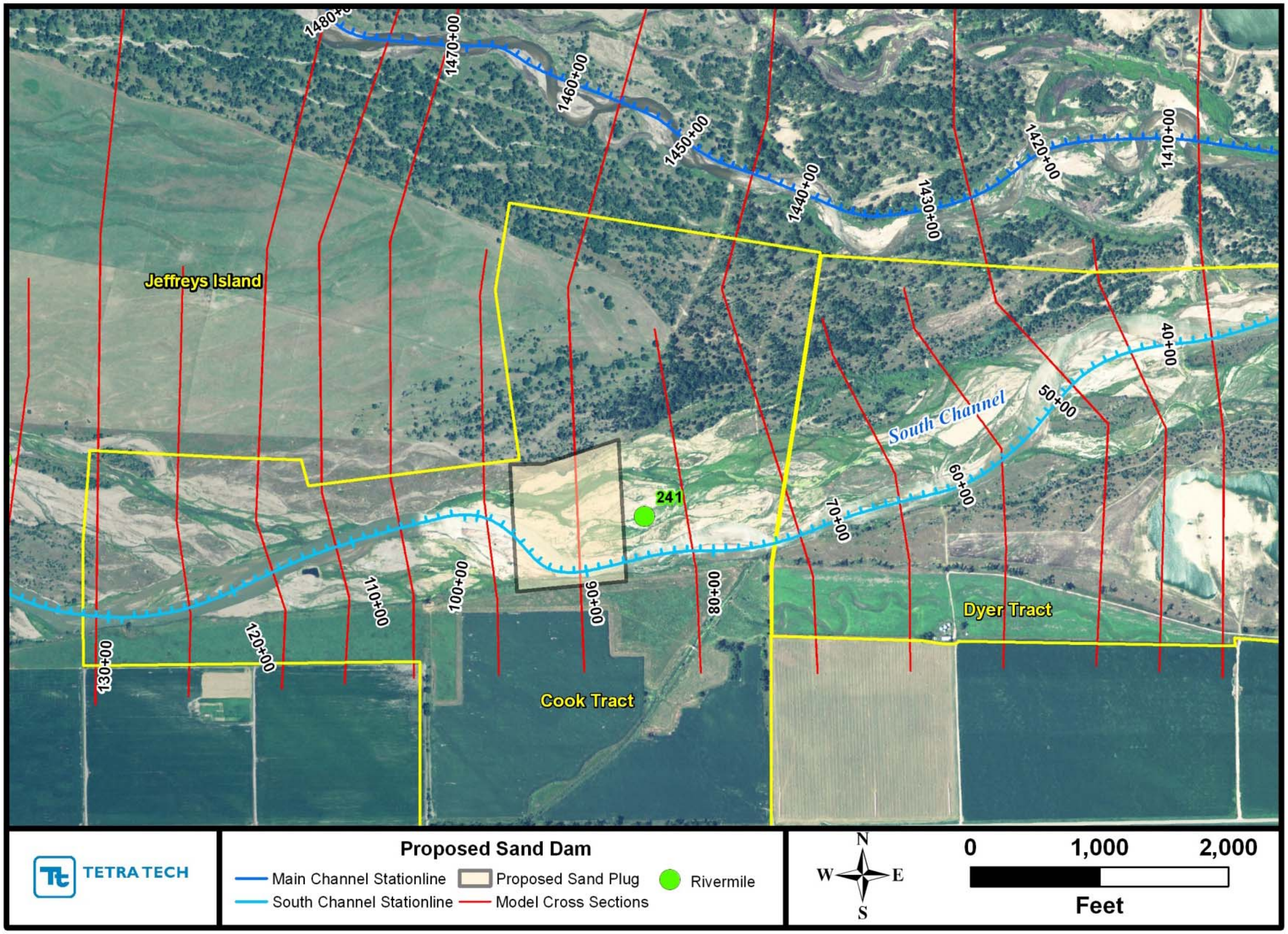


Figure 5.39. Aerial photograph showing the location of the sediment plug evaluated under Alternative 2A-iii.

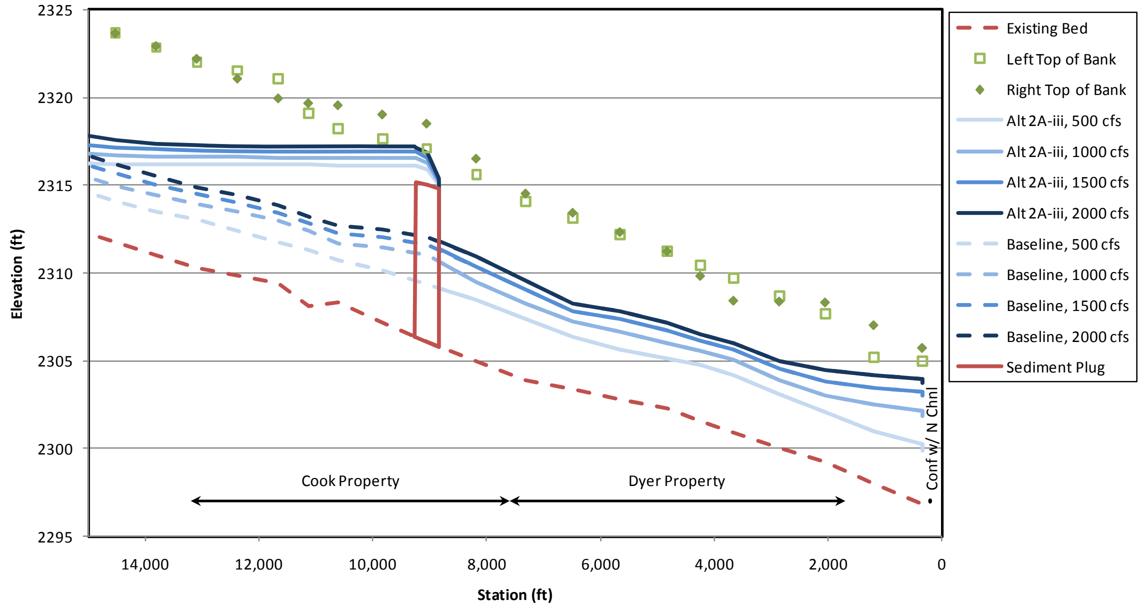


Figure 5.40. Computed water-surface profiles from the steady-state hydraulic model in the vicinity of the sediment plug under baseline and Alternative 2A-iii conditions.

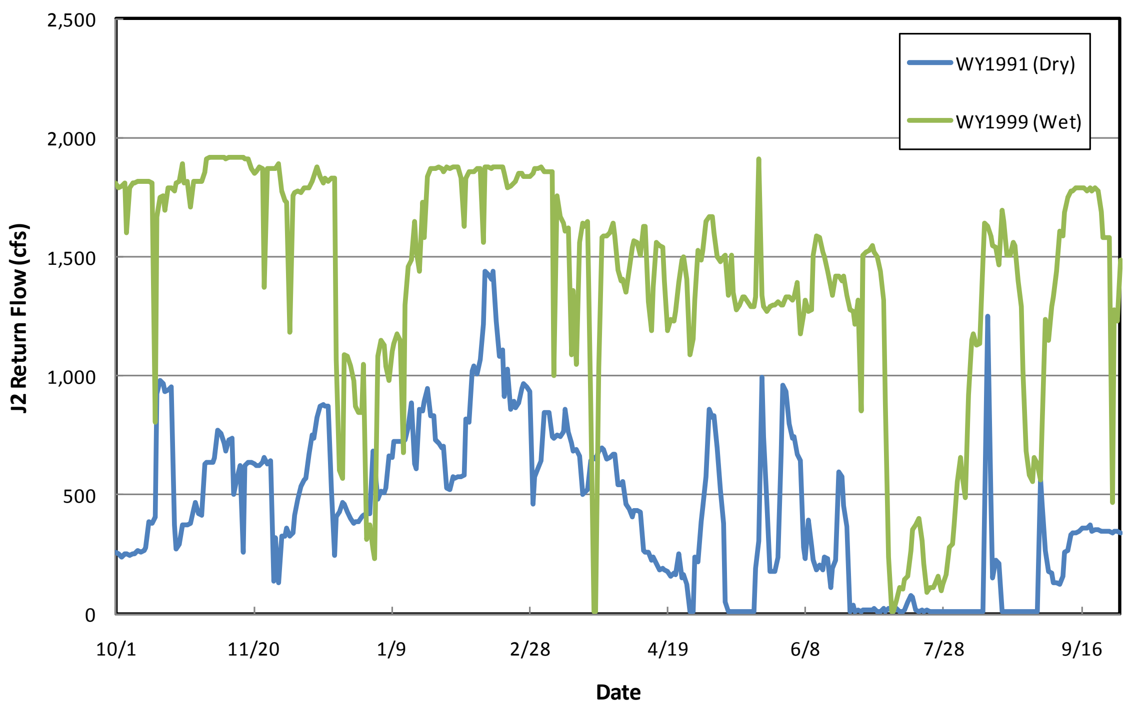


Figure 5.41. Flow delivered by the J-2 Return to the South Channel of Jeffreys Island under a typical dry (WY1991) and wet (WY 1999) year.

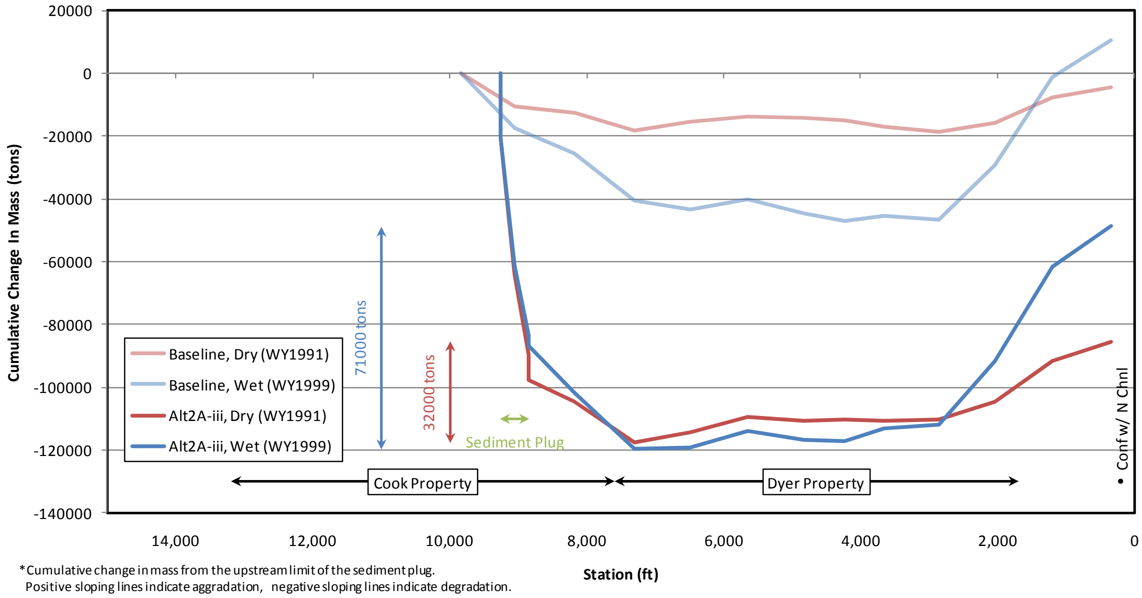


Figure 5.42. Predicted cumulative change in mass from a location at the upstream limit of the sediment plug at the end of the baseline and Alternative 2A-iii simulations for the dry (WY1991) and wet (WY1999) simulations.

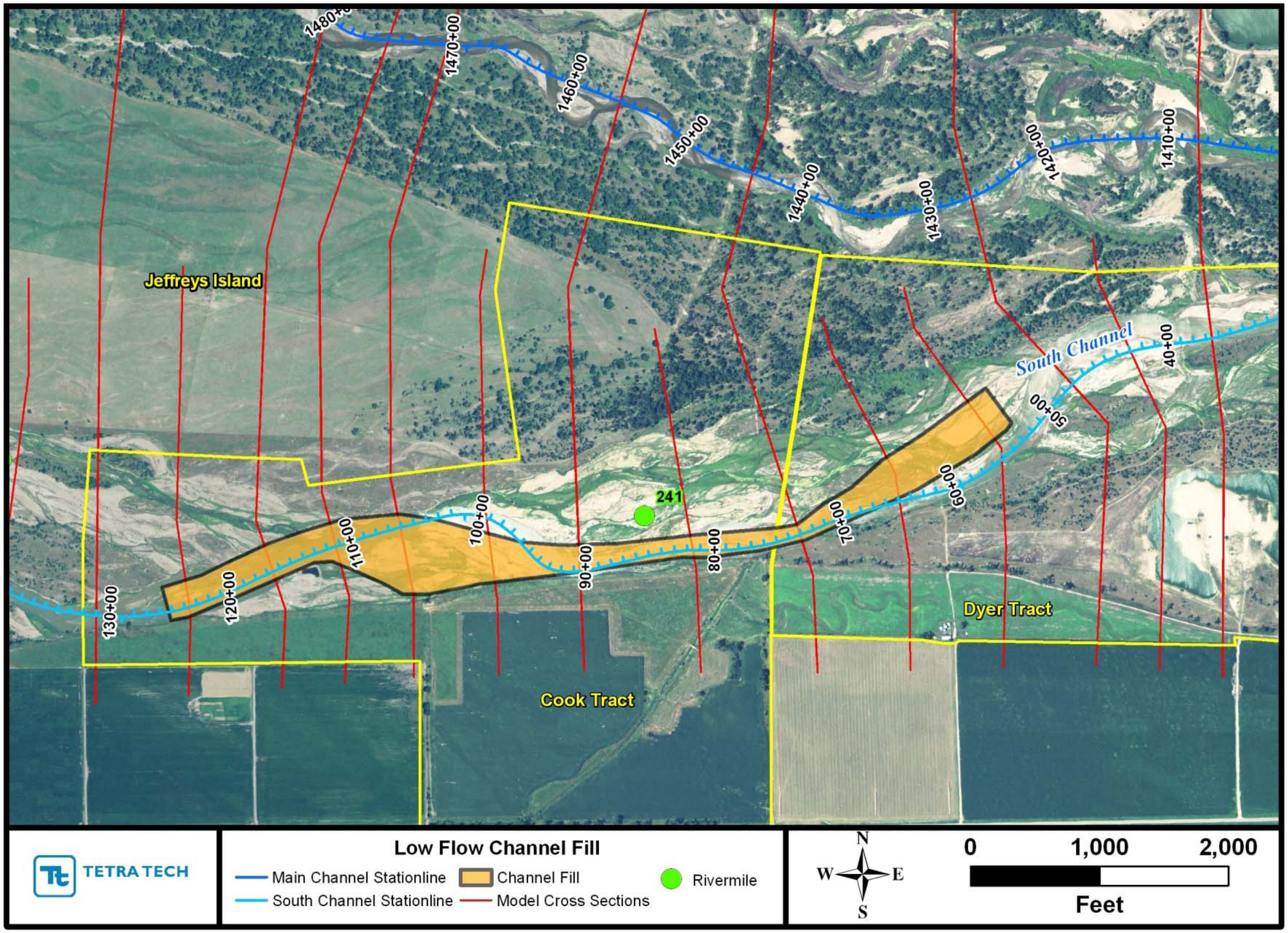


Figure 5.43. Aerial photograph showing the location of the distributed sediment plug evaluated under Alternative 2A-iv.

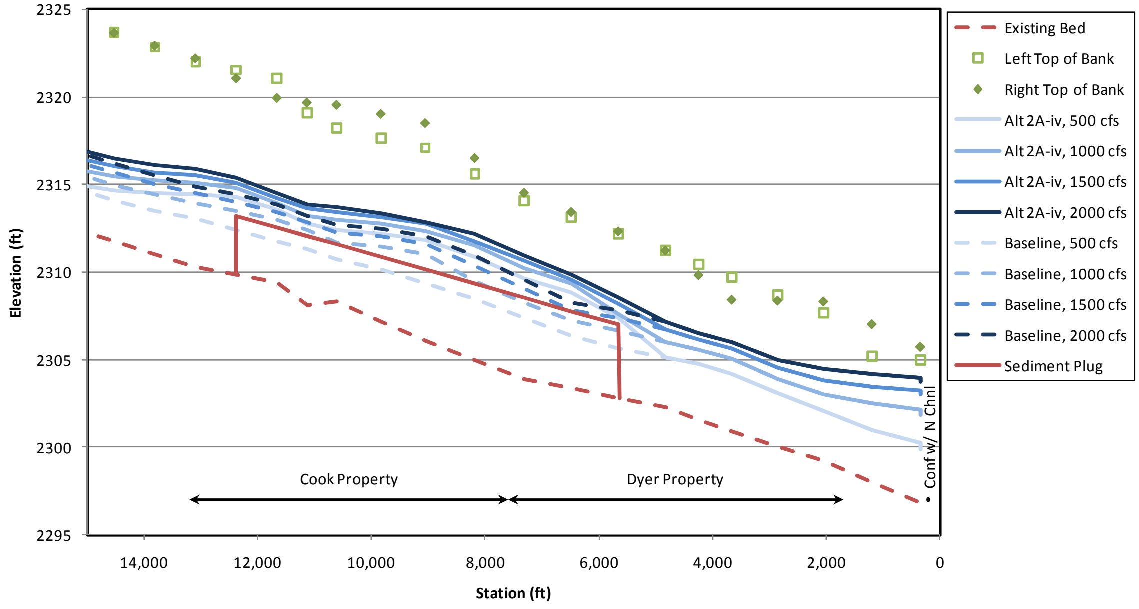


Figure 5.44. Predicted water-surface profiles from the steady-state hydraulic models in the vicinity of the sediment plug for baseline and Alternative 2A-iv conditions.

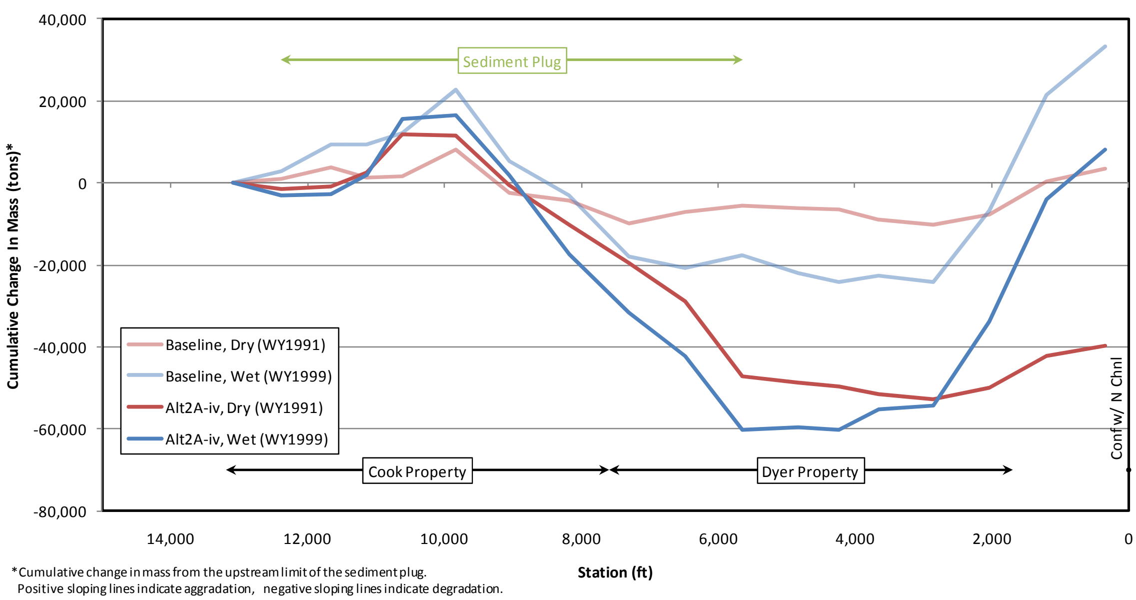


Figure 5.45. Predicted cumulative change in mass from a location at the upstream limit of the sediment plug at the end of the baseline and Alternative 2A-iv simulations for the dry (WY1991) and wet (WY1999) simulations.

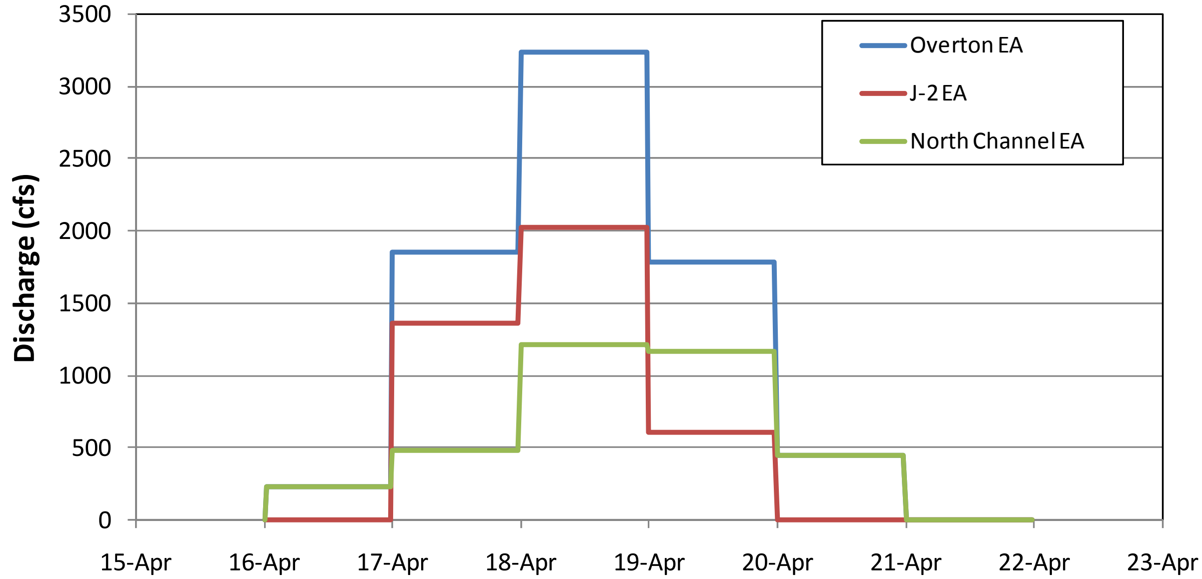


Figure 6.1. Environmental Account (EA) hydrograph for the 1999 SDHF.

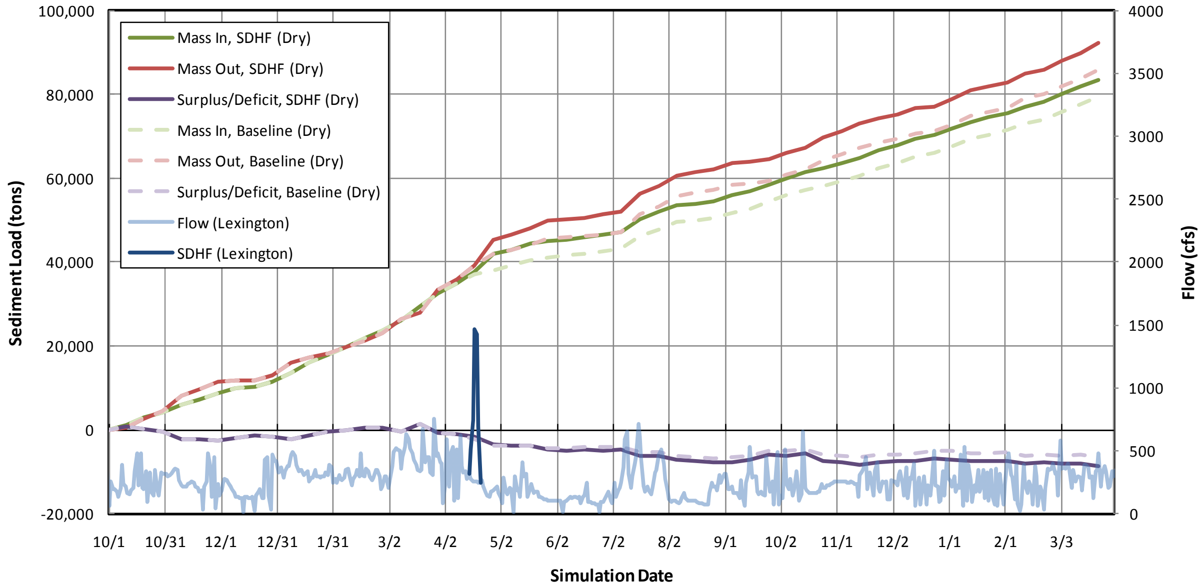


Figure 6.2a. Computed mass entering and exiting Subreach 1 and the resulting mass of aggradation or degradation during the 1.5-year dry period (10/1/01-4/1/03) that included the SDHF hydrograph under baseline and with-SDHF conditions. Also shown is the baseline and with-SDHF hydrograph at Lexington

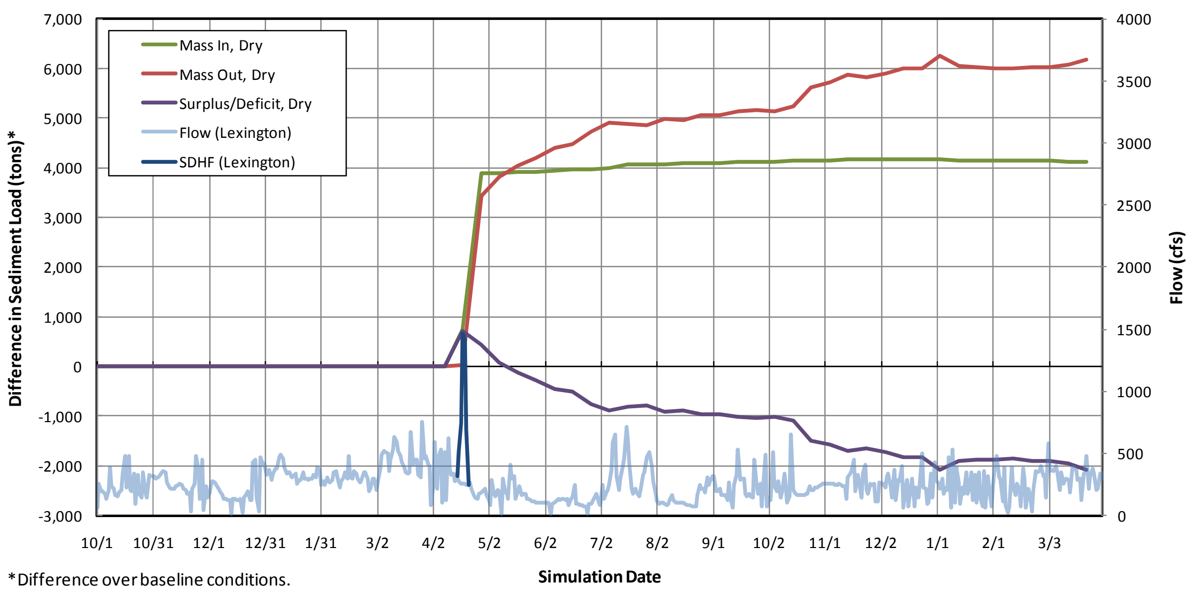


Figure 6.2b. Computed change in mass entering and exiting Subreach 1 and the resulting change in mass of aggradation or degradation over baseline conditions during the 1.5-year dry period (10/1/01-4/1/03) that included the SDHF hydrograph. Also shown is the baseline and with-SDHF hydrograph at Lexington.

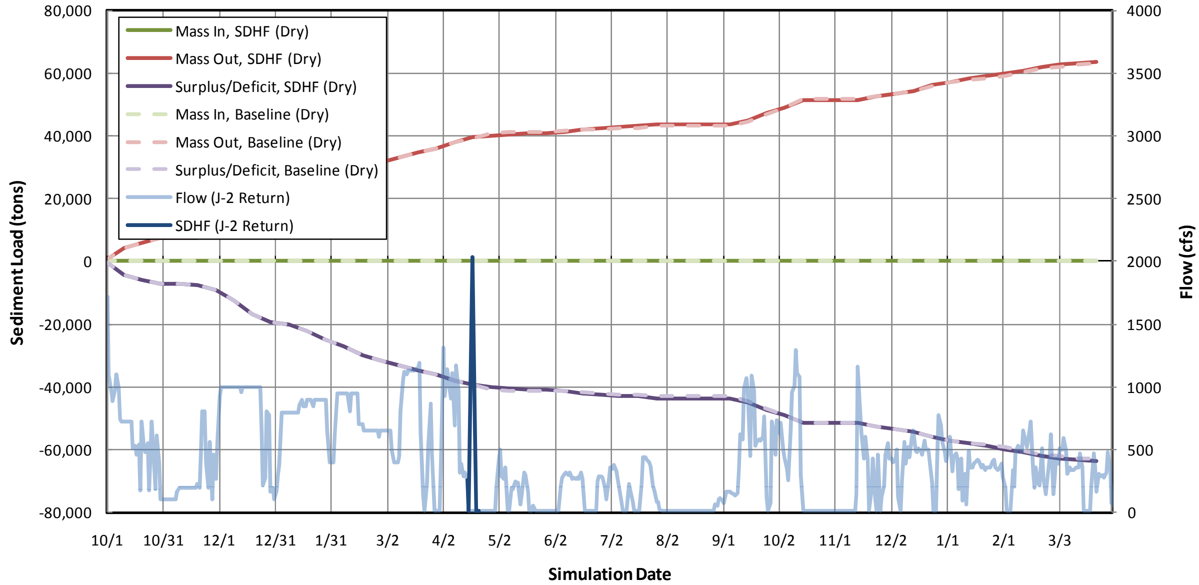


Figure 6.3a. Computed mass entering and exiting Subreach 2 and the resulting mass of aggradation or degradation during the 1.5-year dry period (10/1/01-4/1/03) that included the SDHF hydrograph under baseline and with-SDHF conditions. Also shown is the baseline and with-SDHF hydrograph below the J-2 Return.

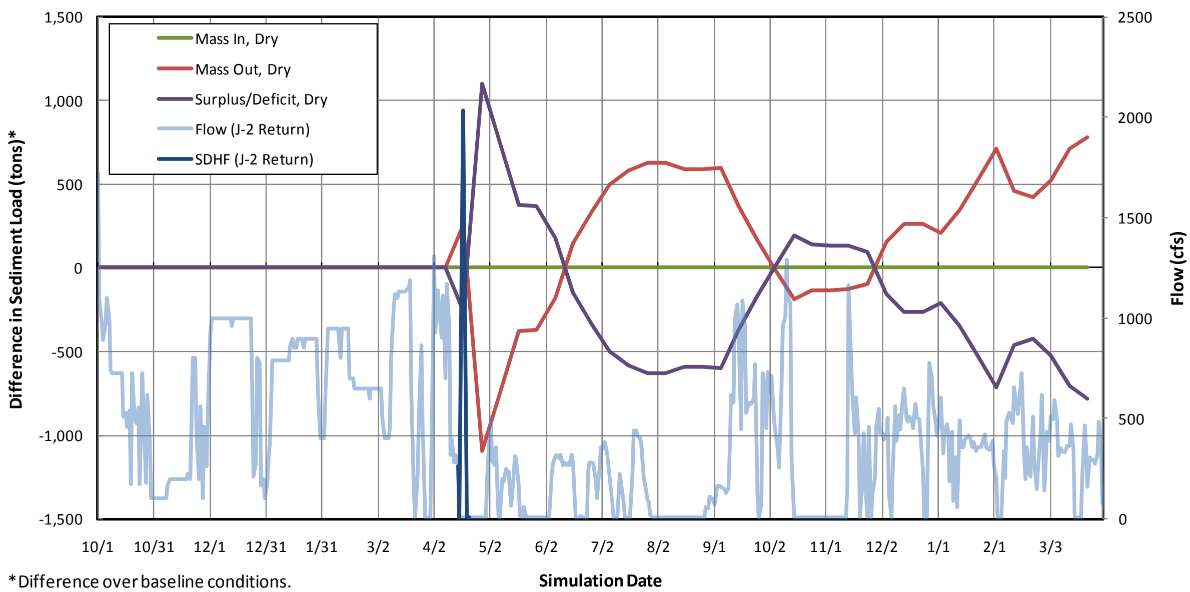


Figure 6.3b. Computed change in mass entering and exiting Subreach 2 and the resulting change in mass of aggradation or degradation over baseline conditions during the 1.5-year dry period (10/1/01-4/1/03) that included the SDHF hydrograph. Also shown is the baseline and with-SDHF hydrograph below the J-2 Return.

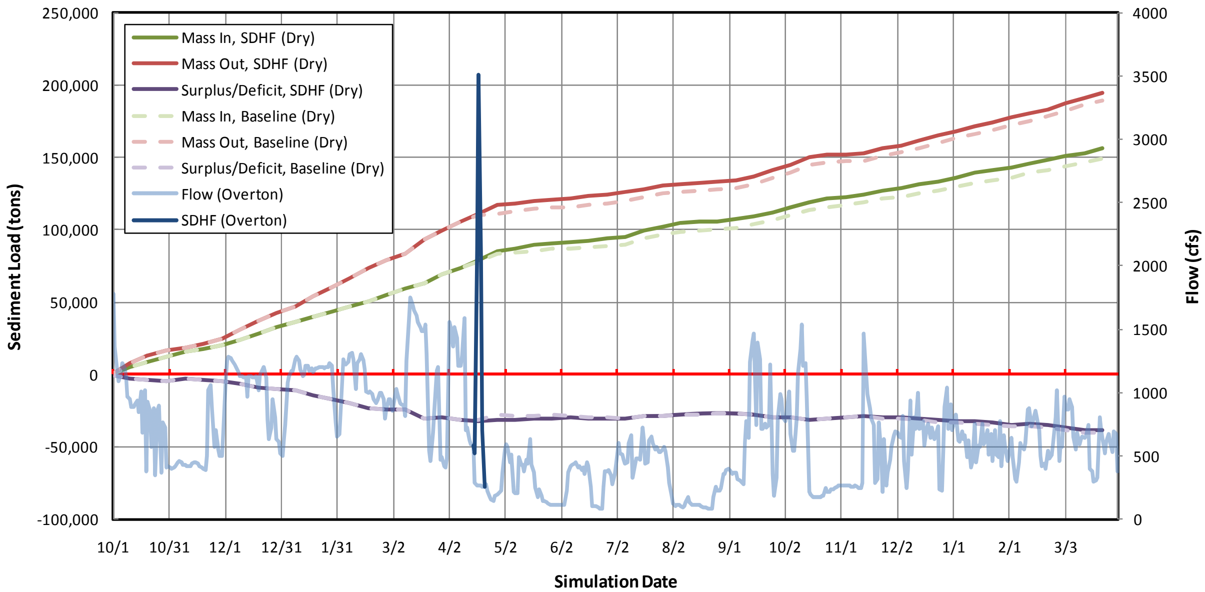


Figure 6.4a. Computed mass entering and exiting Subreach 3 and the resulting mass of aggradation or degradation during the 1.5-year dry period (10/1/01-4/1/03) that included the SDHF hydrograph under baseline and with-SDHF conditions. Also shown is the baseline and with-SDHF hydrograph at Overton.

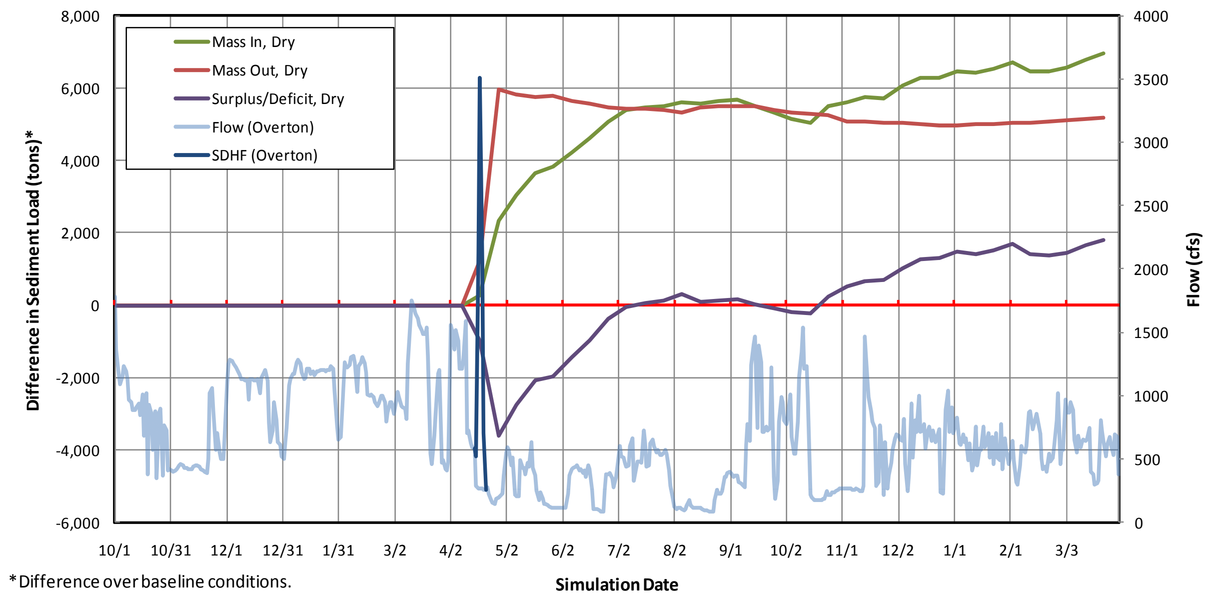


Figure 6.4b. Computed change in mass entering and exiting Subreach 3 and the resulting change in mass of aggradation or degradation over baseline conditions during the 1.5-year dry period (10/1/01-4/1/03) that included the SDHF hydrograph. Also shown is the baseline and with-SDHF hydrograph at Overton.

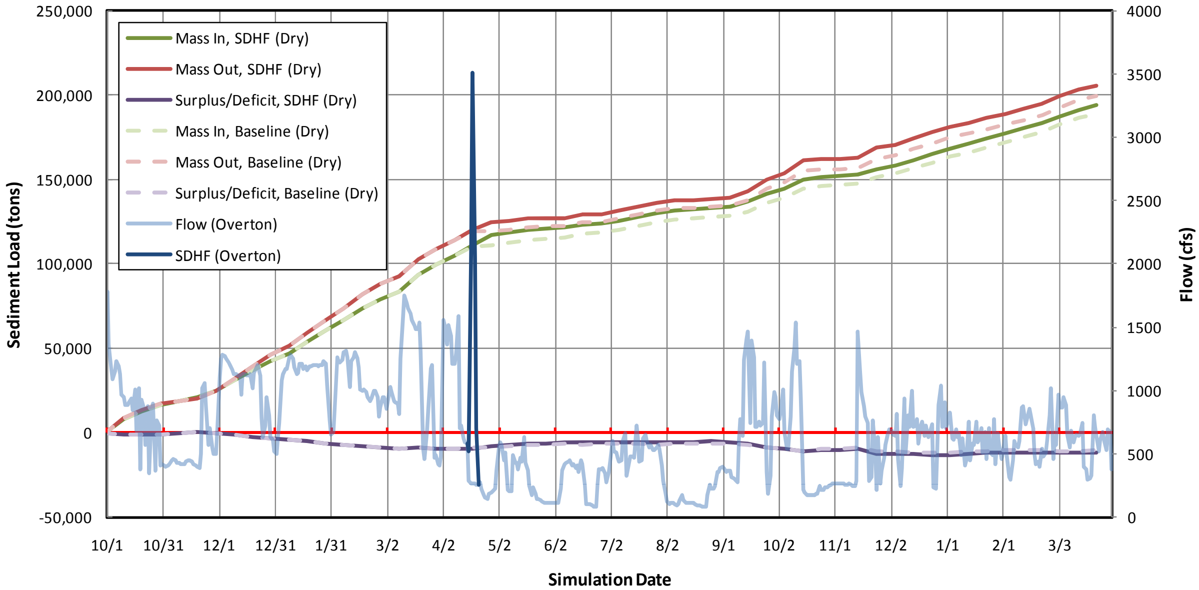


Figure 6.5a. Computed mass entering and exiting Subreach 4 and the resulting mass of aggradation or degradation during the 1.5-year dry period (10/1/01-4/1/03) that included the SDHF hydrograph under baseline and with-SDHF conditions. Also shown is the baseline and with-SDHF hydrograph at Overton.

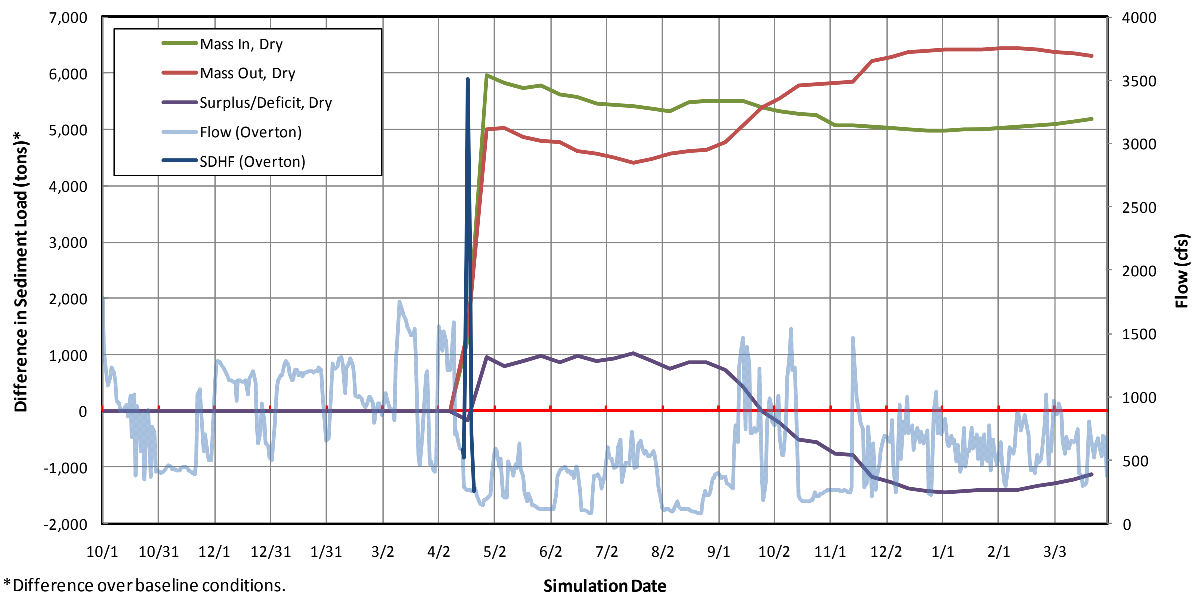


Figure 6.5b. Computed change in mass entering and exiting Subreach 4 and the resulting change in mass of aggradation or degradation over baseline conditions during the 1.5-year dry period (10/1/01-4/1/03) that included the SDHF hydrograph. Also shown is the baseline and with-SDHF hydrograph at Overton.

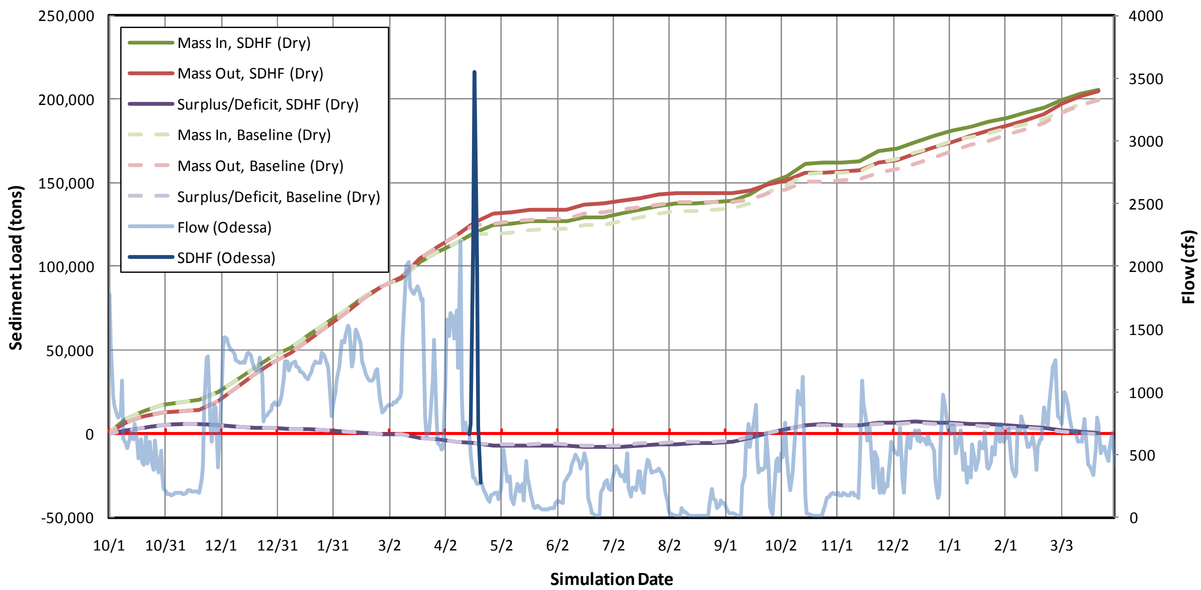


Figure 6.6a. Computed mass entering and exiting Subreach 5 and the resulting mass of aggradation or degradation during the 1.5-year dry period (10/1/01-4/1/03) that included the SDHF hydrograph under baseline and with-SDHF conditions. Also shown is the baseline and with-SDHF hydrograph at Odessa.

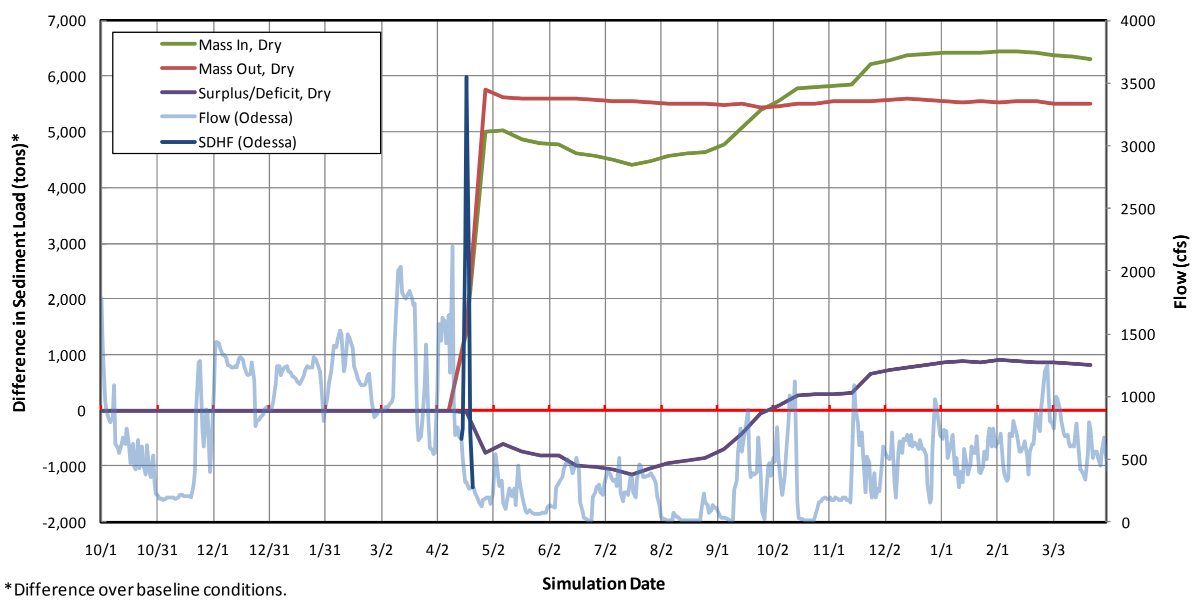


Figure 6.6b. Computed change in mass entering and exiting Subreach 5 and the resulting change in mass of aggradation or degradation over baseline conditions during the 1.5-year dry period (10/1/01-4/1/03) that included the SDHF hydrograph. Also shown is the baseline and with-SDHF hydrograph at Odessa.

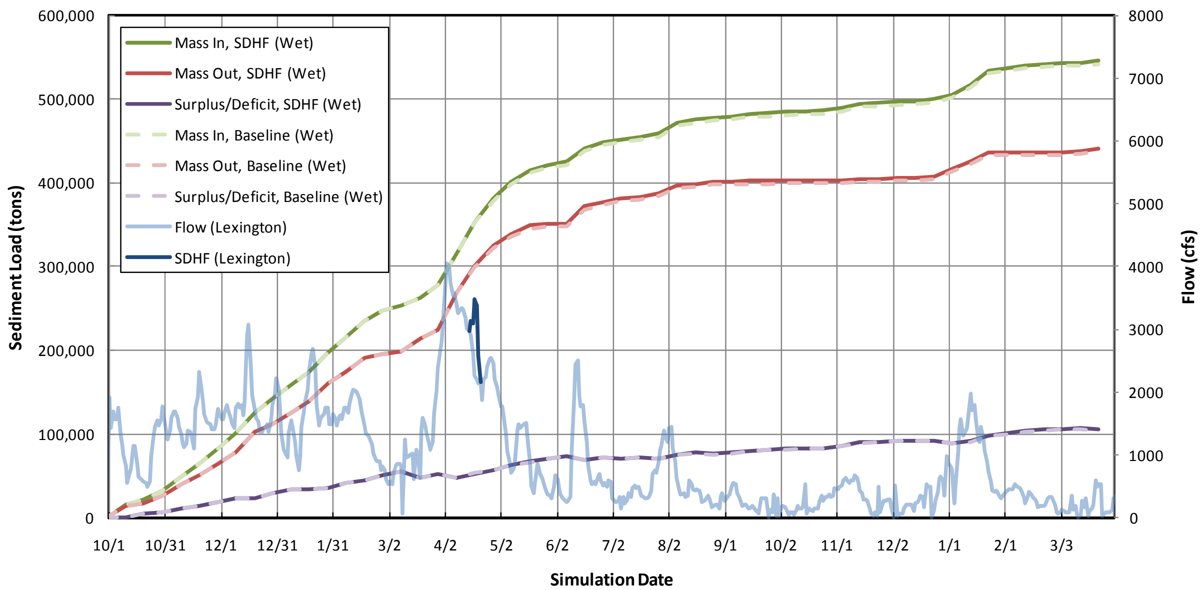


Figure 6.7a. Computed mass entering and exiting Subreach 1 and the resulting mass of aggradation or degradation during the 1.5-year wet period (10/1/97-4/1/99) that included the SDHF hydrograph under baseline and with-SDHF conditions. Also shown is the baseline and with-SDHF hydrograph at Lexington.

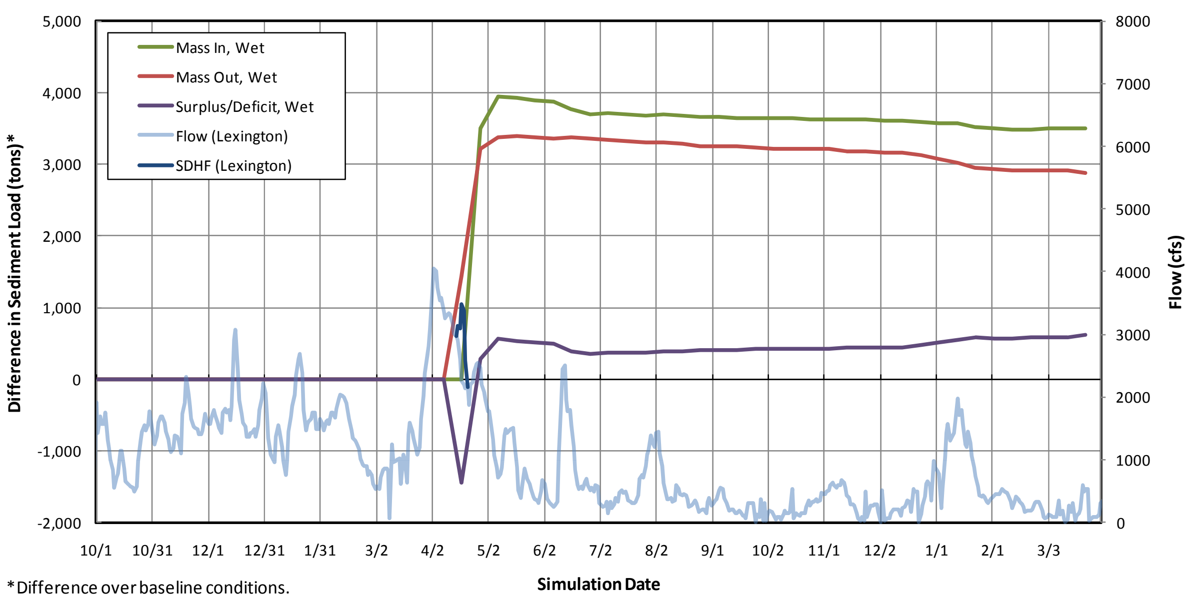


Figure 6.7b. Computed change in mass entering and exiting Subreach 1 and the resulting change in mass of aggradation or degradation over baseline conditions during the 1.5-year wet period (10/1/97-4/1/99) that included the SDHF hydrograph. Also shown is the baseline and with-SDHF hydrograph at Lexington.

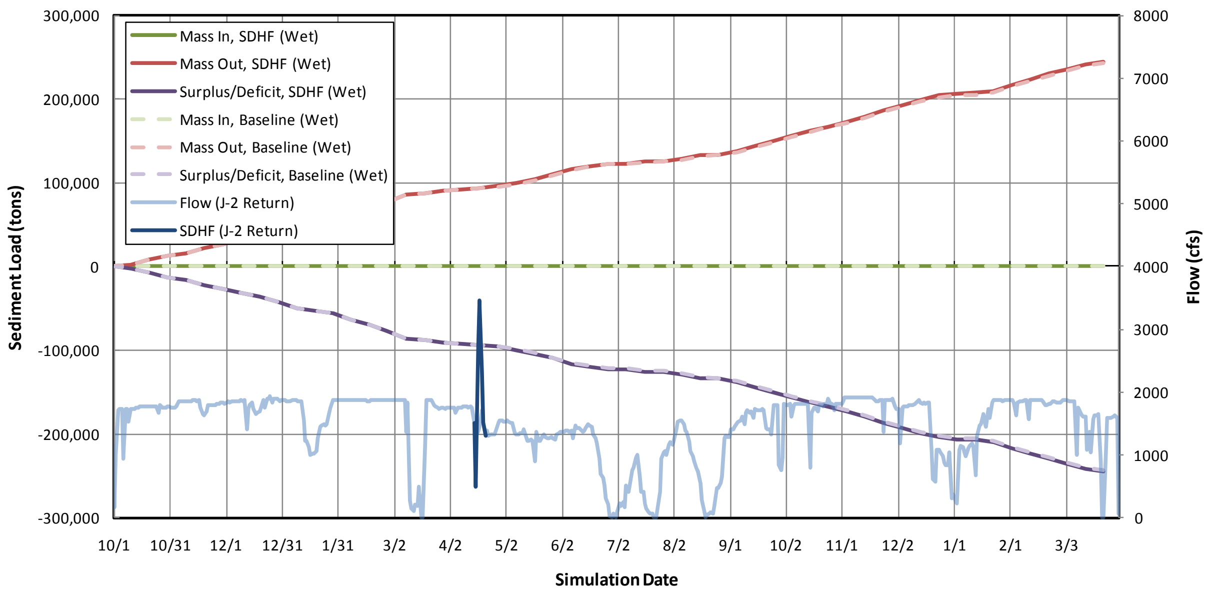


Figure 6.8a. Computed mass entering and exiting Subreach 2 and the resulting mass of aggradation or degradation during the 1.5-year wet period (10/1/97-4/1/99) that included the SDHF hydrograph under baseline and with-SDHF conditions. Also shown is the baseline and with-SDHF hydrograph below the J-2 Return.

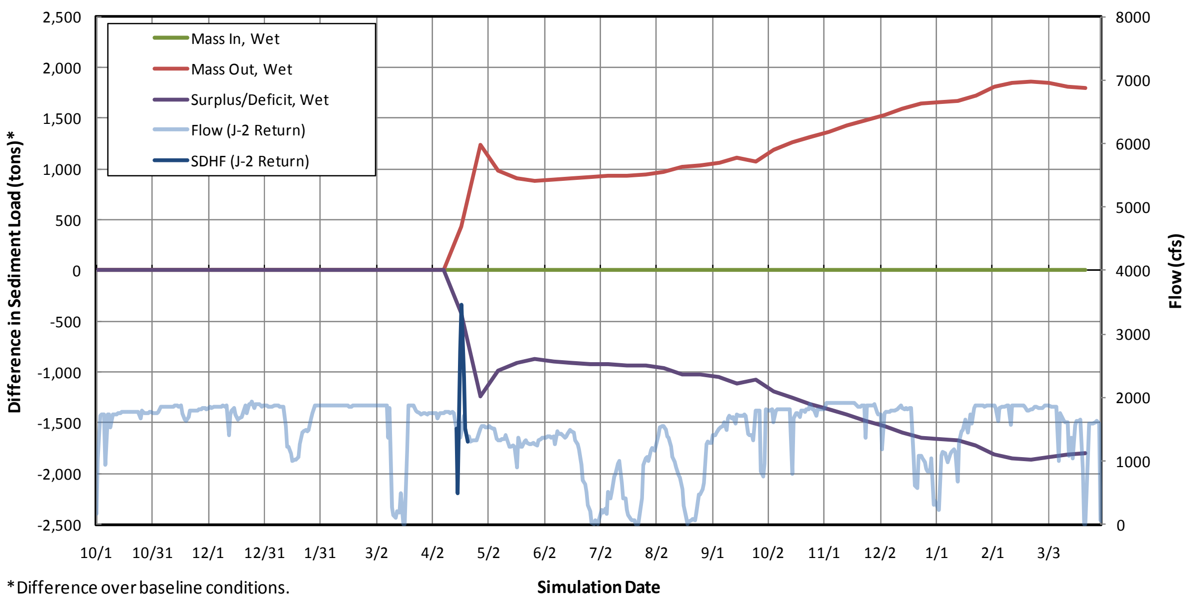


Figure 6.8b. Computed change in mass entering and exiting Subreach 2 and the resulting change in mass of aggradation or degradation over baseline conditions during the 1.5-year wet period (10/1/97-4/1/99) that included the SDHF hydrograph. Also shown is the baseline and with-SDHF hydrograph below the J-2 Return.

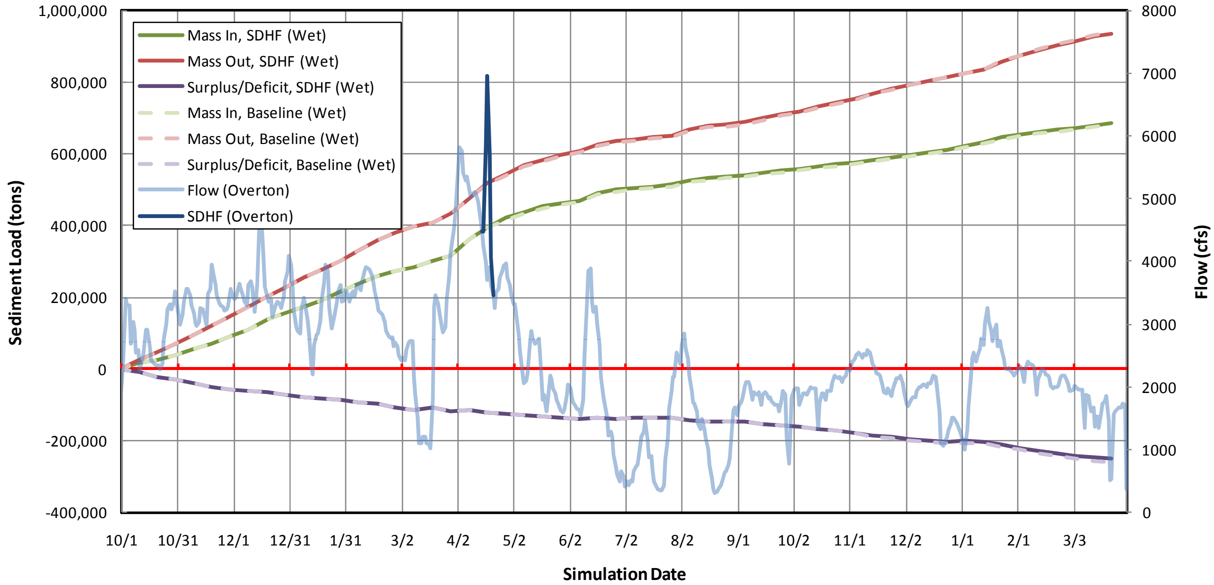


Figure 6.9a. Computed mass entering and exiting Subreach 3 and the resulting mass of aggradation or degradation during the 1.5-year wet period (10/1/97-4/1/99) that included the SDHF hydrograph under baseline and with-SDHF conditions. Also shown is the baseline and with-SDHF hydrograph at Overton.

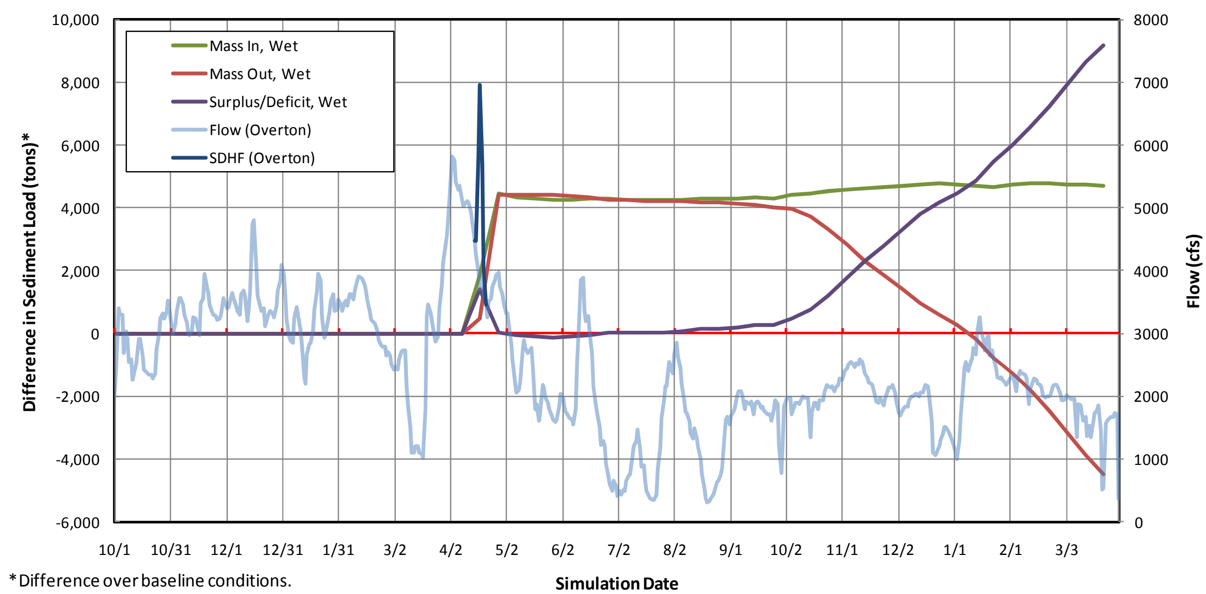


Figure 6.9b. Computed change in mass entering and exiting Subreach 3 and the resulting change in mass of aggradation or degradation over baseline conditions during the 1.5-year wet period (10/1/97-4/1/99) that included the SDHF hydrograph. Also shown is the baseline and with-SDHF hydrograph at Overton.

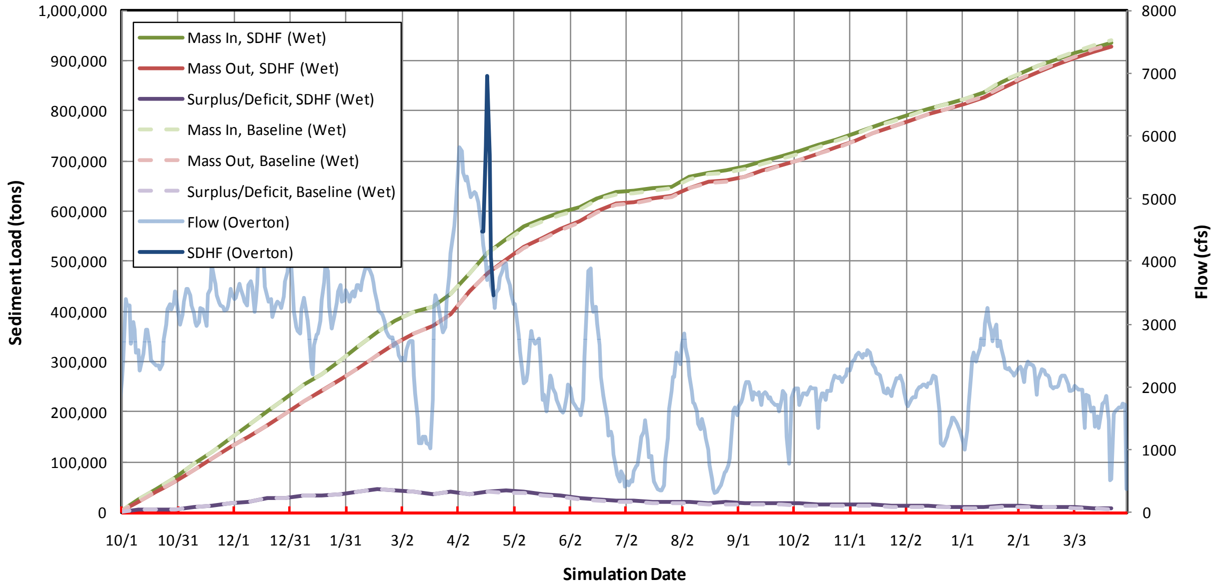


Figure 6.10a. Computed mass entering and exiting Subreach 4 and the resulting mass of aggradation or degradation during the 1.5-year wet period (10/1/97-4/1/99) that included the SDHF hydrograph under baseline and with-SDHF conditions. Also shown is the baseline and with-SDHF hydrograph at Overton.

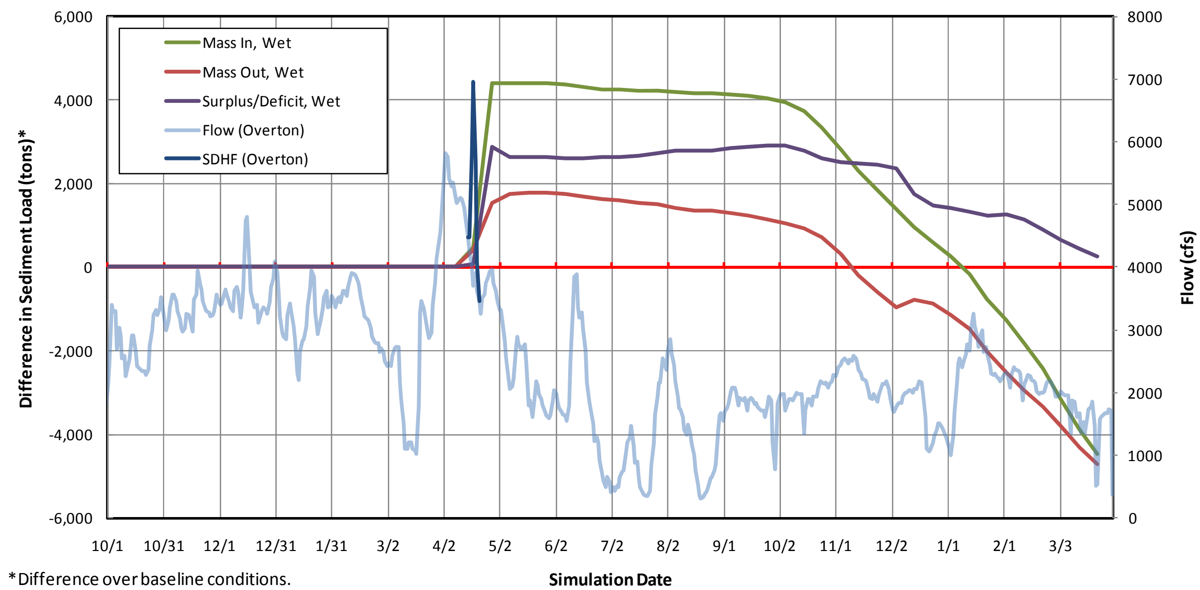


Figure 6.10b. Computed change in mass entering and exiting Subreach 4 and the resulting change in mass of aggradation or degradation over baseline conditions during the 1.5-year wet period (10/1/97-4/1/99) that included the SDHF hydrograph. Also shown is the baseline and with-SDHF hydrograph at Overton.

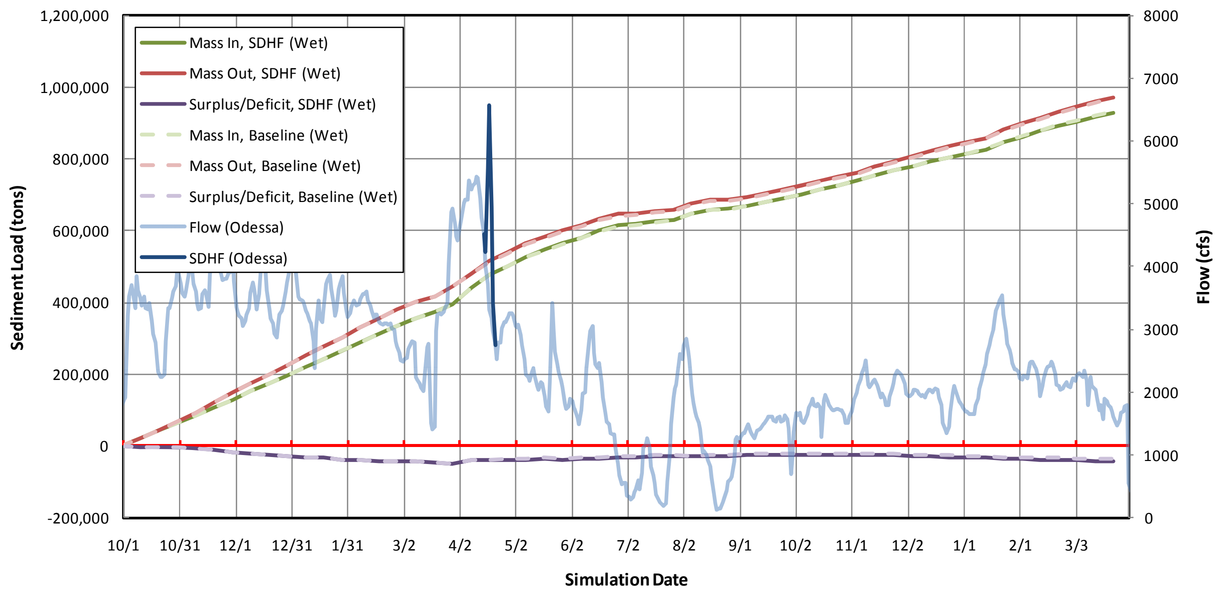


Figure 6.11a. Computed mass entering and exiting Subreach 5 and the resulting mass of aggradation or degradation during the 1.5-year wet period (10/1/97-4/1/99) that included the SDHF hydrograph under baseline and with-SDHF conditions. Also shown is the baseline and with-SDHF hydrograph at Odessa.

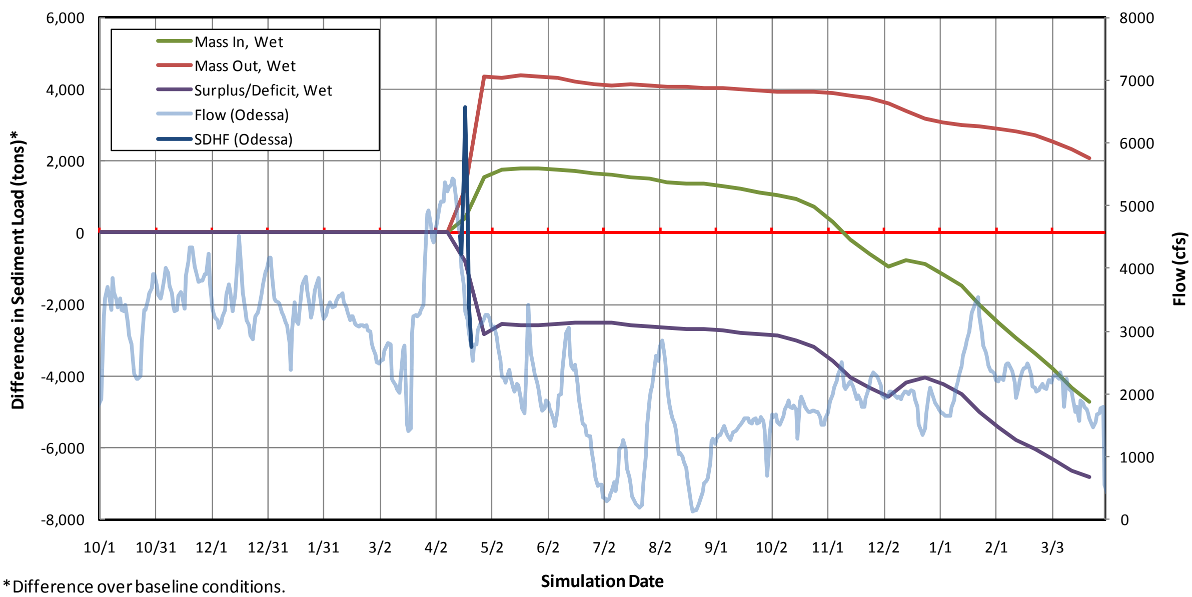


Figure 6.11b. Computed change in mass entering and exiting Subreach 5 and the resulting change in mass of aggradation or degradation over baseline conditions during the 1.5-year wet period (10/1/97-4/1/99) that included the SDHF hydrograph. Also shown is the baseline and with-SDHF hydrograph at Odessa.

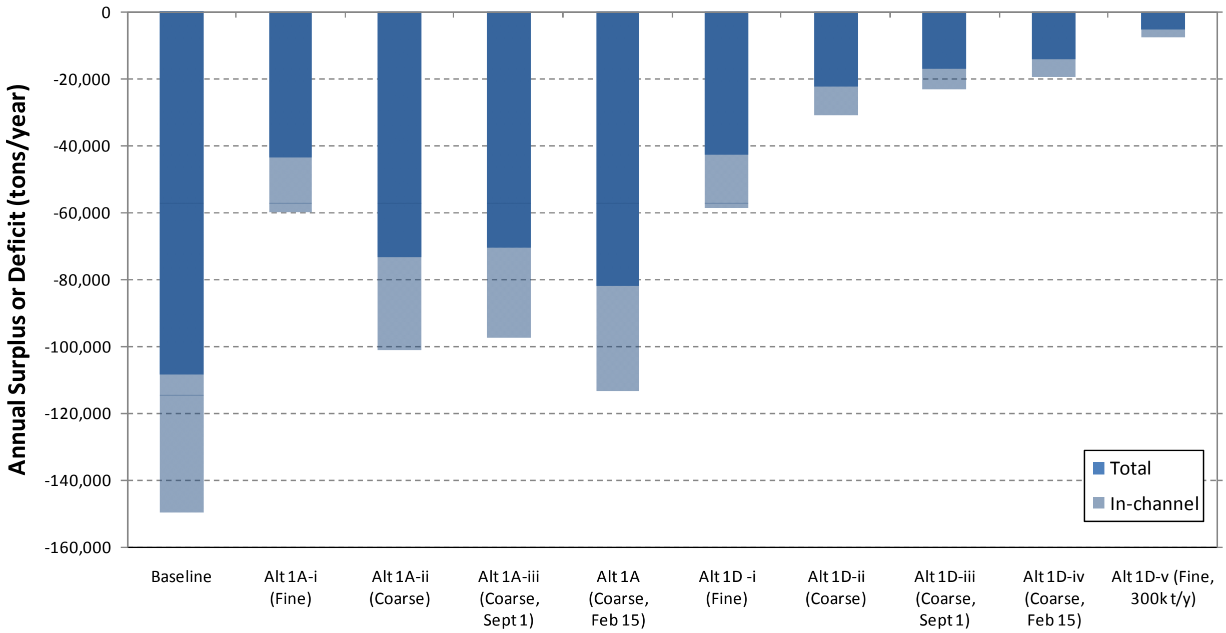


Figure 7.1. Predicted annual total and in-channel deficit in the reach between the Overton and Elm Creek Bridges from the sediment-transport simulations of the pumping alternatives (Alternatives 1A and 1D).

APPENDIX C

SOIL BORINGS
AND
GRADATION ANALYSIS

Contract Exploration Drilling Inc.	SOIL BORING LOG
Field Location of Boring:	Project No.: Date: 4/12/2010 Boring No.: C-1
	Client: Flatwater Group
	Location: Cook Habitat, Overton, NE Sheet 1
	Logged By: R. Kuehn Driller: R. Kuehn of 1
	Drilling Method and Equipment: 4 1/4" ID H.S.A.

Drilling Start Date ______ Finish ______ Water Level and Date 5.5'

Depth Below Surface	Sample Screening: Interval	Percent Recovery	Spoon blow Count 6" - 6" - 6" - 6" (N)	Soil Description	Soil Type	Well Construction: Casing Type, Depth of Casing, Well Screen Interval, Screen Pack Type, Seal Interval, Seal Type, Surface Construction, Well Details
				Cornfield		
				1.5' Developed zone roots.	Sandy Silty	
				Recent Alluvium, lean clay, trace of fine sand, dark brown, moist.	Clay	
	3' - 5'			3.5' -	3.5'	
5	SS-1			Fine, medium & some coarse sand, light reddish brown, wet.	Sand	5
10						10
	13' - 15'					
15	SS-2					15
20						20
	23' - 25'					
	SS-3					
30						30
				34.5'	34.5'	
	33' - 35'			Weathered clay stone, light pink	Sandy Silty	
	SS-4			35' Bottom of Hole	Clay	
40						40
50						50

Contract Exploration Drilling Inc.	SOIL BORING LOG
Field Location of Boring:	Project No.: ____ Date: 4/12/2010 Boring No.: C-2
	Client: Flatwater Group
	Location: Cook Habitat, Overton, NE Sheet 1
	Logged By: R. Kuehn Driller: R. Kuehn of 1
	Drilling Method and Equipment: 4 1/4" ID H.S.A.

Drilling Start Date ____ Finish ____ Water Level and Date 6.5'

Depth Below Surface	Sample Screening: Interval	Percent Recovery	Spoon blow Count 6" - 6" - 6" - 6" (N)	Soil Description	Soil Type	Well Construction: Casing Type, Depth of Casing, Well Screen Interval, Screen Pack Type, Seal Interval, Seal Type, Surface Construction, Well Details
				Cornfield		
				1' Developed zone roots.	Sandy Silty Clay	
				Recent Alluvium, lean clay with trace of fine sand, dark brown, moist.		
	3' - 5'			3.5'	3.5'	
5	SS-1			Clean fine, meidum & coarse sand with some fine to medium gravel, light reddish brown, wet.	Sand	5
10						10
	13' - 15'					
15	SS-2					15
20						20
	23' - 25'					
	SS-3					
30						30
				33.5'	33.5'	
	33' - 35'			Clay stone,light reddish brown, moist.	Sandy Silty Clay	
	SS-4			35' Bottom of Hole		
40						40
50						50

Contract Exploration Drilling Inc.	**SOIL BORING LOG**
Field Location of Boring:	Project No.: ______ Date: 4/12/2010 Boring No.: C-3 Client: Flatwater Group Location: Cook Habitat, Overton, NE Sheet 1 Logged By: R. Kuehn Driller: R. Kuehn of 1 Drilling Method and Equipment: 4 1/4" ID H.S.A.

Drilling Start Date ______ Finish ______ Water Level and Date 5.5'

Depth Below Surface	Sample Screening: Interval	Percent Recovery	Spoon blow Count 6" - 6" - 6" - 6" (N)	Soil Description	Soil Type	Well Construction: Casing Type, Depth of Casing, Well Screen Interval, Screen Pack Type, Seal Interval, Seal Type, Surface Construction, Well Details
				Cornfield		
				1' Developed zone roots.	Sandy Silty Clay	
				Recent Alluvium, lean clay with trace of fine sand, dark brown, moist.		
	3' - 5'			3.5'	3.5'	
5	SS-1			Clean fine, meidum & coarse sand with some fine to medium gravel, light reddish brown, wet.	Sand	5
10						10
	13' - 15'					
15	SS-2					15
20						20
	23' - 25'					
	SS-3					
30						30
				33.5'	33.5'	
	33' - 35'			Clay stone,light reddish brown, moist.	Sandy Silty Clay	
	SS-4			35' Bottom of Hole		
40						40
50						50

Contract Exploration Drilling Inc.	SOIL BORING LOG					
Field Location of Boring:	Project No.:		Date:	4/12/2010	Boring No.:	C-4
	Client:	Flatwater Group				
	Location:	Cook Habitat, Overton, NE			Sheet	1
	Logged By:	R. Kuehn	Driller:	R. Kuehn	of	1
	Drilling Method and Equipment:	4 1/4" ID H.S.A.				

Drilling Start Date ______ Finish ______ Water Level and Date 4.5'

Depth Below Surface	Sample Screening: Interval	Percent Recovery	Spoon blow Count 6" - 6" - 6" - 6" (N)	Soil Description	Soil Type	Well Construction: Casing Type, Depth of Casing, Well Screen Interval, Screen Pack Type, Seal Interval, Seal Type, Surface Construction, Well Details
				Cornfield		
				.5' Developed zone roots.	Sand	
				Recent Alluvium, fine, medium & coarse sand with fine to medium gravel, light reddish brown, wet.		
5	3' - 5' SS-1					5
10						10
15	13' - 15' SS-2					15
20						20
	23' - 25' SS-3					
30						30
				36'	36'	
	33' - 35' SS-4			Clay stone, weathered, light pink, moist.	Sandy Silty Clay	
				36' Bottom of Hole		
40						40
50						50

Contract Exploration Drilling Inc.	SOIL BORING LOG
Field Location of Boring:	Project No.: Date: 4/13/2010 Boring No.: C-5 Client: Flatwater Group Location: Cook Habitat, Overton, NE Sheet 1 Logged By: R. Kuehn Driller: R. Kuehn of 1 Drilling Method and Equipment: 4 1/4" ID H.S.A.

Drilling Start Date ______ Finish ______ Water Level and Date 5.5'

Depth Below Surface	Sample Screening: Interval	Percent Recovery	Spoon blow Count 6" - 6" - 6" - 6" (N)	Soil Description	Soil Type	Well Construction: Casing Type, Depth of Casing, Well Screen Interval, Screen Pack Type, Seal Interval, Seal Type, Surface Construction, Well Details
				Cornfield		
				1' Developed zone roots.	Sandy Silty Clay	
				Recent Alluvium, lean clay, trace of fine sand, dark brown, moist.	2'	
	3' - 5'			2' ------------------------------	Sand	
5	SS-1			Clean fine, medium & some coarse sand, with some fine to medium gravel, light reddish brown, wet.		5
10						10
	13' - 15'					
15	SS-2					15
	18' - 20'					
20	SS-3					20
30						30
				36'	36'	
	33' - 35'			Weathered clay stone, light pink	Sandy Silty	
	SS-4			36' Bottom of Hole	Clay	
40						40
50						50

SEDIMENT AUGMENTATION EXPERIMENT ALTERNATIVES SCREENING SUMMARY REPORT

Grain Size Analasis

Site	Location	Date	Sample ID	Depth (ft)	D_{50}		% < 1mm	% < #200		Available Material <1mm		
Cook		4/12/2010	C1-1	3-5	0.332		76.3	21.2	0.0	% of hole	% < 1mm (net)	Factored
Cook		4/12/2010	C1-2	13-15	0.380		75.8	2.3	2.3	0.048387	55.1	2.66371
Cook		4/12/2010	C1-3	23-25	0.938		52.9	0.4	0.4	0.322581	73.5	23.72043
Cook		4/12/2010	C1-3 DUP	23-25	0.940		52.5	1.7	1.7			
Cook		4/12/2010	C1-4	33-35	0.073	< #200	95.4	56.0	0.0	0.322581	51.7	16.66398
										0.306452	39.4	12.0793
										1		55.12742
Cook		4/12/2010	C2-1	3-5	0.477		75.4	3.0	3.0			
Cook		4/12/2010	C2-2	13-15	1.110		47.1	3.8	3.8	0.05	72.4	3.620833
Cook		4/12/2010	C2-2 DUP	13-15	1.120		47.1	3.8	3.8			
Cook		4/12/2010	C2-3	23-25	0.969		50.8	4.0	4.0	0.333333	43.3	14.42778
Cook		4/12/2010	C2-4	33-35	0.730		58.8	6.6	6.6	0.333333	46.8	15.61111
										0.283333	52.2	14.77583
										1		48.43556
Cook		4/12/2010	C3-1	3-5	0.541		66.7	3.3	3.3			
Cook		4/12/2010	C3-1 DUP	3-5	0.509		70.4	3.7	3.7			
Cook		4/12/2010	C3-2	13-15	0.792		56.7	2.4	2.4	0.05	65.0	3.252083
Cook		4/12/2010	C3-3	23-25	1.400		40.8	2.3	2.3	0.333333	54.3	18.08889
Cook		4/12/2010	C3-4	33-35	0.905		54.2	1.7	1.7	0.333333	38.5	12.84444
Average					0.7		61.4	7.7	2.6 without outliers	0.283333	52.5	14.86556
										1		49.05097
Dyer		4/13/2010	C4-1	3-5	0.602		71.3	1.3				
Dyer		4/13/2010	C4-1 DUP	3-5	0.617		71.3	1.2				
Dyer		4/13/2010	C4-2	13-15	0.796		61.7	1.5		0.126761	70	8.873239
Dyer		4/13/2010	C4-3	23-25	1.120		45.8	2.5		0.28169	60.2	16.94836
Dyer		4/13/2010	C4-3 DUP	23-25	1.240		41.7	2.2				
Dyer		4/13/2010	C4-4	33-35	0.634		69.6	3.1		0.28169	41.4	11.66197
										0.309859	66.5	20.60047
										1		58.08404
Dyer		4/13/2010	C5-1	3-5	0.752		56.3	2.2				
Dyer		4/13/2010	C5-2	13-15	0.687		58.8	2.9		0.088235	54.1	4.769118
Dyer		4/13/2010	C5-2 DUP	13-15	0.939		51.7	2.6				
Dyer		4/13/2010	C5-3	23-25	0.703		64.6	2.5		0.294118	52.5	15.42892
Dyer		4/13/2010	C5-4	33-35	0.873		53.8	4.1		0.294118	62.1	18.2598
Average					0.815		58.8	2.4		0.323529	49.7	16.06324
										1		54.52108

Samples from Sandpit Piles at Active S&G Operations

Site	Location	Date	Sample ID	Depth (ft)	D_{50}	% < 1mm	% <0.25 mm	% < #200
OS & G East	Overton	5/5/2010	W-1A	--	0.499	79.6	17.0	1.3
OS & G West	Overton	5/5/2010	W-1B	--	0.498	83.8	15.0	0.9
Whitney	Overton	5/5/2010	W-2	--	0.449	85.0	16.0	1.0
Whitney	Overton	5/5/2010	W-2 DUP	--	0.473	83.8	15.0	0.9
Paulsen	Lexington	5/5/2010	W-3	--	0.510	80.4	14.0	1.7
OS & G	Lexington	5/5/2010	W-4	--	0.347	96.3	25.0	1.3
Paulsen	Elm Creek	5/5/2010	W-5	--	0.513	77.1	15.0	0.9
T & F	Elm Creek	5/5/2010	W-6	--	0.461	83.3	17.0	1.4
T & F	Elm Creek	5/5/2010	W-6 DUP	--	0.507	78.3	14.0	1.0
Average					0.473	83.1	16.4	1.2

APPENDIX D

COST TABLES

Appendix D
Cost Tables

Table B-1
Preliminary Estimate of Probable Construction Costs
Alternative 1
Augmentation of Imported Material at Two Locations on Cook/Dyer using Sand Pumps

Sand Pump Site 1 (Cook)

Item	Description	Quantity	Unit	Unit Cost	Total
1	Mobilization	1	LS	$15,176.25	$15,176.25
2	Temporary Facilities	4	month	$500.00	$2,000.00
3	Site Preparation	1	LS	$800.00	$800.00
4	Construct Water Intake Sump	1	LS	$500.00	$500.00
5	Water Supply Pump	75	day	$355.29	$26,646.60
6	Intake Piping (100 feet)	75	day	$31.15	$2,336.25
7	Feed Conveyor	75	day	$85.00	$6,375.00
8	Screening Plant	75	day	$553.94	$41,545.20
9	Receiving Mixing Sump,	75	day	$100.00	$7,500.00
10	Slurry Pump	75	day	$355.29	$26,646.60
11	Discharge Piping (500 feet)	75	day	$155.75	$11,681.25
12	Generator Set (250 kW)	75	day	$714.85	$53,613.60
13	Equipment Operators (1)	75	day	$120.00	$9,000.00
14	FE Loader	75	day	$558.74	$41,905.65
15	Augmentation Material	75,000	ton	$3.00	$225,000.00
16	Haul Material to Site (9.3 mrt)	75,000	ton	$1.72	$129,000.00
17	Stockpile Management	75,000	ton	$0.30	$22,500.00
18	**Direct Cost Subtotal**				**$622,226.40**
19	Design and Engineering Support			10.00%	$62,222.64
20	Construction Management			5.00%	$31,111.32
21	Contingency			25.00%	$155,556.60
22	**Indirect Cost Subtotal**				**$248,890.56**
23	Total Estimated Construction Costs				**$871,116.97**
24	Cost per Cubic Yard Delivered				**$11.61**

Assumptions:
Equipment costs are contractor owning and operating costs.
Costs per pump system
1/2 of material delivered by system at Site 1 (west end of Cook)
3.5-month delivery time

Table B-1
Preliminary Estimate of Probable Construction Costs
Alternative 1
Augmentation of Imported Material at Two Locations on Cook/Dyer using Sand Pumps (continued)

Sand Pump Site 2 (Dyer)

Item	Description	Quantity	Unit	Unit Cost	Total
1	Mobilization	1	LS	$14,745.00	$14,745.00
2	Temporary Facilities	4	month	$500.00	$2,000.00
3	Site Preparation	1	LS	$800.00	$800.00
4	Construct Water Intake Sump	1	LS	$500.00	$500.00
5	Water Supply Pump	75	day	$355.29	$26,646.60
6	Intake Piping (100 feet)	75	day	$31.15	$2,336.25
7	Feed Conveyor	75	day	$85.00	$6,375.00
8	Screening Plant	75	day	$553.94	$41,545.20
9	Receiving Mixing Sump,	75	day	$100.00	$7,500.00
10	Slurry Pump	75	day	$355.29	$26,646.60
11	Discharge Piping (500 feet)	75	day	$155.75	$11,681.25
12	Generator Set (250 kW)	75	day	$714.85	$53,613.60
13	Equipment Operators (1)	75	day	$120.00	$9,000.00
14	FE Loader	75	day	$558.74	$41,905.65
15	Augmentation Material	75,000	ton	$3.00	$225,000.00
16	Haul Material to Site (7.6 mrt)	75,000	ton	$1.49	$111,750.00
17	Stockpile Management	75,000	ton	$0.30	$22,500.00
18	**Direct Cost Subtotal**				**$604,545.15**
19	Design and Engineering Support			10.00%	$60,454.52
20	Construction Management			5.00%	$30,227.26
21	Contingency			25.00%	$151,136.29
22	**Indirect Cost Subtotal**				**$241,818.06**
23	Total Estimated Construction Costs				**$846,363.22**
24	Cost per Cubic Yard Delivered				**$11.28**

Assumptions:
Equipment costs are contractor owning and operating costs.
Costs per pump system
1/2 of material delivered by system at Site 2 (middle of Dyer)
3.5-month delivery time

1-year Cost	
Total Alternative 1 Cost	**$1,717,480.18**
Average Cost per Cubic Yard Delivered	**$11.45**
10-year Cost	
Total 10-year Cost (5% annual escalation)	**$21,602,293.96**
Average Cost per Cubic Yard Delivered	**$14.40**

Table B-2
Preliminary Estimate of Probable Construction Costs
Alternative 2
Augmentation of On-site Material at Two Locations on Cook/Dyer Using Sand Pumps

On-site Dredging Operation (Cook/Dyer)

Item	Description	Quantity	Unit	Unit Cost	Total
1	Mobilization	1	LS	$10,000.00	$10,000.00
2	Temporary Facilities	4	month	$500.00	$2,000.00
3	Stripping Overburden (2 feet)	5	acre	$4,000.00	$20,000.00
4	Production Costs	150,000	ton	$1.79	$268,500.00
5	FE Loader	75	day	$558.74	$41,905.50
6	Stockpile Management	150,000	ton	$0.30	$45,000.00
7	**Direct Cost Subtotal**				**$387,405.50**
8	Design and Engineering Support			10.00%	$38,740.55
9	Construction Management			5.00%	$19,370.28
10	Contingency			25.00%	$96,851.38
11	**Indirect Cost Subtotal**				**$154,962.20**
12	Total Estimated Construction Costs				**$542,367.70**
13	Cost per Cubic Yard Delivered				**$3.62**

Assumptions:
Equipment costs are contractor owning and operating costs.
Augmentation material cost limited to production cost as part of agreement with operator

Table B-2
Preliminary Estimate of Probable Construction Costs
Alternative 2
Augmentation of On-site Material at Two Locations on Cook/Dyer Using Sand Pumps (continued)

Sand Pump Site 2 (Dyer)

Item	Description	Quantity	Unit	Unit Cost	Total
1	Mobilization	1	LS	$7,901.25	$7,901.25
2	Temporary Facilities	4	month	$500.00	$2,000.00
3	Site Preparation	1	LS	$800.00	$800.00
4	Construct Water Intake Sump	1	LS	$500.00	$500.00
5	Water Supply Pump	75	day	$355.29	$26,646.60
6	Intake Piping (100 feet)	75	day	$31.15	$2,336.25
7	Feed Conveyor	75	day	$85.00	$6,375.00
8	Screening Plant	75	day	$553.94	$41,545.20
9	Receiving Mixing Sump,	75	day	$100.00	$7,500.00
10	Slurry Pump	75	day	$355.29	$26,646.60
11	Discharge Piping (500 feet)	75	day	$155.75	$11,681.25
12	Generator Set (250 kW)	75	day	$714.85	$53,613.60
13	Equipment Operators (1)	75	day	$120.00	$9,000.00
14	FE Loader	75	day	$558.74	$41,905.65
15	Augmentation Material	75,000	ton	$0.00	$0.00
16	Haul Material to Site (1.5 mrt)	75,000	ton	$0.84	$63,000.00
17	Stockpile Management	75,000	ton	$0.30	$22,500.00
18	**Direct Cost Subtotal**				**$323,951.40**
19	Design and Engineering Support			10.00%	$32,395.14
20	Construction Management			5.00%	$16,197.57
21	Contingency			25.00%	$80,987.85
22	**Indirect Cost Subtotal**				**$129,580.56**
23	Total Estimated Construction Costs				**$453,531.97**
24	Cost per Cubic Yard Delivered				**$6.05**

Assumptions:
Equipment costs are contractor owning and operating costs.
Costs per pump system
1/2 of material delivered by system at Site 2 (EAST end of Cook)
3.5-month delivery time

Table B-2
Preliminary Estimate of Probable Construction Costs
Alternative 2
Augmentation of On-site Material at Two Locations on Cook/Dyer Using Sand Pumps (continued)

Sand Pump Site 5 (near location of on-site sandpit at Cook/Dyer)

Item	Description	Quantity	Unit	Unit Cost	Total
1	Mobilization	1	LS	$7,226.25	$7,226.25
2	Temporary Facilities	4	month	$500.00	$2,000.00
3	Site Preparation	1	LS	$800.00	$800.00
4	Construct Water Intake Sump	1	LS	$500.00	$500.00
5	Water Supply Pump	75	day	$355.29	$26,646.60
6	Intake Piping (100 feet)	75	day	$31.15	$2,336.25
7	Feed Conveyor	75	day	$85.00	$6,375.00
8	Screening Plant	75	day	$553.94	$41,545.20
9	Receiving Mixing Sump,	75	day	$100.00	$7,500.00
10	Slurry Pump	75	day	$355.29	$26,646.60
11	Discharge Piping (500 feet)	75	day	$155.75	$11,681.25
12	Generator Set (250 kW)	75	day	$714.85	$53,613.60
13	Equipment Operators (1)	75	day	$120.00	$9,000.00
14	FE Loader	75	day	$558.74	$41,905.65
15	Augmentation Material	75,000	ton	$0.00	$0.00
16	Haul Material to Site (1,000 ft rt)	75,000	ton	$0.48	$36,000.00
17	Stockpile Management	75,000	ton	$0.30	$22,500.00
18	**Direct Cost Subtotal**				**$296,276.40**
19	Design and Engineering Support			10.00%	$29,627.64
20	Construction Management			5.00%	$14,813.82
21	Contingency			25.00%	$74,069.10
22	**Indirect Cost Subtotal**				**$118,510.56**
23	Total Estimated Construction Costs				**$414,786.97**
24	Cost per Cubic Yard Delivered				**$5.53**

Assumptions:
Equipment costs are contractor owning and operating costs.
Costs per pump system
1/2 of material delivered by system at Site 5 (located near dredging operation)
3.5-month delivery time

1-year Cost
Total Alternative 2 Cost **$1,410,686.63**
Average Cost per Cubic Yard Delivered **$9.40**

10-year Costs
Total 10-year Cost (5% annual escalation) **$17,743,475.37**
Average Cost per Cubic Yard Delivered **$11.83**

Table B-3
Preliminary Estimate of Probable Construction Costs
Alternative 3
Augmentation of Imported Material on Cook/Dyer using Dozers

Item	**Description**	**Quantity**	**Unit**	**Unit Cost**	**Total**
1	Mobilization	1	LS	$35,904.64	$35,904.64
2	Temporary Facilities	2	month	$500.00	$1,000.00
3	Site Preparation	1	LS	$12,500.00	$12,500.00
4	Tree Removal	1	LS	$5,000.00	$5,000.00
5	Excavate/Doze Material	150,000	ton	$4.04	$605,357.14
6	Augmentation Material	150,000	ton	$3.00	$450,000.00
7	Haul Material to Site (8.9 mrt)	150,000	ton	$1.93	$289,500.00
8	Stockpile Management	150,000	ton	$0.30	$45,000.00
9	Equipment Operators (1)	41	day	$120.00	$4,920.00
10	FE Loader	41	day	$558.74	$22,908.42
11	**Direct Cost Subtotal**				**$1,472,090.20**
12	Design and Engineering Support			10.00%	$147,209.02
13	Construction Management			5.00%	$73,604.51
14	Contingency			25.00%	$368,022.55
15	**Indirect Cost Subtotal**				**$588,836.08**
16	Total Estimated Construction Costs				**$2,060,926.29**
17	Cost per Cubic Yard Delivered				**$13.74**

Assumptions:
Equipment costs are contractor owning and operating costs.
Stockpiles every 500 feet on bank
Average Push Distance = 460 ft
1.9 month delivery time

1-year Cost
Total Alternative 3 Cost **$2,060,926.29**
Average Cost per Cubic Yard Delivered **$13.74**

10-year Cost
Total 10-year Cost (5% annual escalation) **$25,922,124.73**
Average Cost per Cubic Yard Delivered **$17.28**

Table B-4
Preliminary Estimate of Probable Construction Costs
Alternative 4
Augmentation of On-site Material on Cook/Dyer Using Dozers

On-site Dredging Operation (Cook/Dyer)

Item	Description	Quantity	Unit	Unit Cost	Total
1	Mobilization	1	LS	$10,000.00	$10,000.00
2	Temporary Facilities	2	month	$500.00	$750.00
3	Stripping Overburden (2 feet)	5	acre	$4,000.00	$20,000.00
4	Production Costs	150,000	ton	$1.79	$268,500.00
5	Equipment Operators (1)	32	day	$120.00	$3,840.00
6	FE Loader	41	day	$558.74	$22,908.34
7	Stockpile Management	150,000	ton	$0.30	$45,000.00
8	**Direct Cost Subtotal**				**$370,998.34**
9	Design and Engineering Support			10.00%	$37,099.83
10	Construction Management			5.00%	$18,549.92
11	Contingency			25.00%	$92,749.59
12	**Indirect Cost Subtotal**				**$148,399.34**
13	Total Estimated Construction Costs				**$519,397.68**
14	Cost per Cubic Yard Delivered				**$3.46**

Assumptions:
Equipment costs are contractor owning and operating costs.
Augmentation material cost limited to production cost as part of agreement with operator.

Table B-4
Preliminary Estimate of Probable Construction Costs
Alternative 4
Augmentation of On-site Material on Cook/Dyer Using Dozers (continued)

Delivery Option (Cook/Dyer)

Item	Description	Quantity	Unit	Unit Cost	Total
1	Mobilization	1	LS	$19,871.43	$19,871.43
2	Temporary Facilities	2	month	$500.00	$1,000.00
3	Site Preparation	1	LS	$12,500.00	$12,500.00
4	Tree Removal	1	LS	$5,000.00	$5,000.00
5	Excavate/Doze Material	150,000	CY	$4.04	$605,357.14
6	Augmentation Material	150,000	ton	$0.00	$0.00
7	Haul Material to Site (1.5 mrt)	150,000	ton	$0.84	$126,000.00
8	Stockpile Management	150,000	ton	$0.30	$45,000.00
9	Equipment Operators (1)	32	day	$120.00	$3,840.00
10	FE Loader	41	day	$558.74	$22,908.42
11	**Direct Cost Subtotal**				**$841,476.99**
12	Design and Engineering Support			10.00%	$84,147.70
13	Construction Management			5.00%	$42,073.85
14	Contingency			25.00%	$210,369.25
15	**Indirect Cost Subtotal**				**$336,590.80**
16	Total Estimated Construction Costs				**$1,178,067.79**
17	Cost per Cubic Yard Delivered				**$7.85**

Assumptions:
Equipment costs are contractor owning and operating costs.
Stockpiles every 500 feet on bank
Average Push Distance = 460 ft
1.9 month delivery time

1-year Cost
Total Alternative 4 Cost **$1,697,465.47**
Average Cost per Cubic Yard Delivered **$11.32**

10-year Cost
Total 10-year Cost (5% annual escalation) **$21,350,550.89**
Average Cost per Cubic Yard Delivered **$14.23**

Table B-5
Preliminary Estimate of Probable Construction Costs
Alternative 5
Augmentation of Imported Material at Two Locations on Cook/Dyer and One Location on Private Property (OS&G) Using Sand Pumps

Sand Pump Site 2 (Dyer)

Item	Description	Quantity	Unit	Unit Cost	Total
1	Mobilization	1	LS	$9,838.75	$9,838.75
2	Temporary Facilities	3	month	$500.00	$1,250.00
3	Site Preparation	1	LS	$800.00	$800.00
4	Construct Water Intake Sump	1	LS	$500.00	$500.00
5	Water Supply Pump	50	day	$355.29	$17,764.40
6	Intake Piping (100 feet)	50	day	$31.15	$1,557.50
7	Feed Conveyor	50	day	$85.00	$4,250.00
8	Screening Plant	50	day	$553.94	$27,696.80
9	Receiving-Mixing Sump,	50	day	$100.00	$5,000.00
10	Slurry Pump	50	day	$355.29	$17,764.40
11	Discharge Piping (500 feet)	50	day	$155.75	$7,787.50
12	Generator Set (250 kW)	50	day	$714.85	$35,742.40
13	Equipment Operators (1)	50	day	$120.00	$6,000.00
14	FE Loader	50	day	$558.74	$27,937.10
15	Augmentation Material	50,000	ton	$3.00	$150,000.00
16	Haul Material to Site (7.6 mrt)	50,000	ton	$1.49	$74,500.00
17	Stockpile Management	50,000	ton	$0.30	$15,000.00
18	**Direct Cost Subtotal**				**$403,388.85**
19	Design and Engineering Support			10.00%	$40,338.89
20	Construction Management			5.00%	$20,169.44
21	Contingency			25.00%	$100,847.21
22	**Indirect Cost Subtotal**				**$161,355.54**
23	Total Estimated Construction Costs				**$564,744.39**
24	Cost per Cubic Yard Delivered				**$11.29**

Assumptions:
Equipment costs are contractor owning and operating costs.
Costs per pump system
1/3 of material delivered by system at Site 2 (middle of Dyer)
2.3-month delivery time

Table B-5
Preliminary Estimate of Probable Construction Costs
Alternative 5
Augmentation of Imported Material at Two Locations on Cook/Dyer and One Location on Private Property (OS&G) Using Sand Pumps (continued)

Sand Pump Site 3 (Dyer)

Item	Description	Quantity	Unit	Unit Cost	Total
1	Mobilization	1	LS	$9,563.75	$9,563.75
2	Temporary Facilities	3	month	$500.00	$1,250.00
3	Site Preparation	1	LS	$800.00	$800.00
4	Construct Water Intake Sump	1	LS	$500.00	$500.00
5	Water Supply Pump	50	day	$355.29	$17,764.40
6	Intake Piping (100 feet)	50	day	$31.15	$1,557.50
7	Feed Conveyor	50	day	$85.00	$4,250.00
8	Screening Plant	50	day	$553.94	$27,696.80
9	Receiving-Mixing Sump	50	day	$100.00	$5,000.00
10	Slurry Pump	50	day	$355.29	$17,764.40
11	Discharge Piping (500 feet)	50	day	$155.75	$7,787.50
12	Generator Set (250 kW)	50	day	$714.85	$35,742.40
13	Equipment Operators (1)	50	day	$120.00	$6,000.00
14	FE Loader	50	day	$558.74	$27,937.10
15	Augmentation Material	50,000	ton	$3.00	$150,000.00
16	Haul Material to Site (5.9 mrt)	50,000	ton	$1.27	$63,500.00
17	Stockpile Management	50,000	ton	$0.30	$15,000.00
18	**Direct Cost Subtotal**				**$392,113.85**
19	Design and Engineering Support			10.00%	$39,211.39
20	Construction Management			5.00%	$19,605.69
21	Contingency			25.00%	$98,028.46
22	**Indirect Cost Subtotal**				**$156,845.54**
23	Total Estimated Construction Costs				**$548,959.39**
24	Cost per Cubic Yard Delivered				**$10.98**

Assumptions:
Equipment costs are contractor owning and operating costs.
Costs per pump system
1/3 of material delivered by system at Site 3 (east end of Dyer)
2.3-month delivery time

Table B-5
Preliminary Estimate of Probable Construction Costs
Alternative 5
Augmentation of Imported Material at Two Locations on Cook/Dyer and One Location on Private Property (OS&G) Using Sand Pumps (continued)

Sand Pump Site 4 (OS&G)

Item	Description	Quantity	Unit	Unit Cost	Total
1	Mobilization	1	LS	$8,388.75	$8,388.75
2	Temporary Facilities	3	month	$500.00	$1,250.00
3	Site Preparation	1	LS	$800.00	$800.00
4	Construct Water Intake Sump	1	LS	$500.00	$500.00
5	Water Supply Pump	50	day	$355.29	$17,764.40
6	Intake Piping (100 feet)	50	day	$31.15	$1,557.50
7	Feed Conveyor	50	day	$85.00	$4,250.00
8	Screening Plant	50	day	$553.94	$27,696.80
9	Receiving Mixing Sump,	50	day	$100.00	$5,000.00
10	Slurry Pump	50	day	$355.29	$17,764.40
11	Discharge Piping (500 feet)	50	day	$155.75	$7,787.50
12	Generator Set (250 kW)	50	day	$714.85	$35,742.40
13	Equipment Operators (1)	50	day	$120.00	$6,000.00
14	FE Loader	50	day	$558.74	$27,937.10
15	Augmentation Material	50,000	ton	$3.00	$150,000.00
16	Haul Material to Site (1000 ft rt)	50,000	ton	$0.48	$24,000.00
17	Stockpile Management	50,000	ton	$0.15	$7,500.00
18	**Direct Cost Subtotal**				**$343,938.85**
19	Design and Engineering Support			10.00%	$34,393.89
20	Construction Management			5.00%	$17,196.94
21	Contingency			25.00%	$85,984.71
22	**Indirect Cost Subtotal**				**$137,575.54**
23	Total Estimated Construction Costs				**$481,514.39**
24	Cost per Cubic Yard Delivered				**$9.63**

Assumptions:
Equipment costs are contractor owning and operating costs.
Costs per pump system
1/3 of material delivered by system at Site 4 (assumed OS&G)
2.3-month delivery time

1-year Cost	
Total Alternative 5 Cost	**$1,595,218.18**
Average Cost per Cubic Yard Delivered	**$10.63**
10-year Cost	
Total 10-year Cost (5% annual escalation)	**$20,064,494.75**
Average Cost per Cubic Yard Delivered	**$13.38**

Table B-6
Preliminary Estimate of Probable Construction Costs
Alternative 6
Augmentation of On-site Material at Two Locations on Cook/Dyer
and Imported Material at One Location on Private Property (OS&G) using Sand Pumps

On-site Dredging Operation

Item	Description	Quantity	Unit	Unit Cost	Total
1	Mobilization	1	LS	$10,000.00	$10,000.00
2	Temporary Facilities	3	month	$500.00	$1,500.00
3	Stripping Overburden (2 feet)	5	acre	$4,000.00	$20,000.00
4	Production Costs	100,000	ton	$1.79	$179,000.00
5	FE Loader	50	day	$558.74	$27,937.10
6	Stockpile Management	100,000	ton	$0.30	$30,000.00
7	**Direct Cost Subtotal**				**$268,437.10**
8	Design and Engineering Support			10.00%	$26,843.71
9	Construction Management			5.00%	$13,421.86
10	Contingency			25.00%	$67,109.28
11	**Indirect Cost Subtotal**				**$107,374.84**
12	Total Estimated Construction Costs				**$375,811.94**
13	Cost per Cubic Yard Delivered				**$3.76**

Assumptions:
Equipment costs are contractor owning and operating costs.
Augmentation material cost limited to production cost as part of agreement with operator.

Table B-6
Preliminary Estimate of Probable Construction Costs
Alternative 6
Augmentation of On-site Material at Two Locations on Cook/Dyer
and Imported Material at One Location on Private Property (OS&G) using Sand Pumps (continued)

Sand Pump Site 3 (Cook/Dyer)

Item	Description	Quantity	Unit	Unit Cost	Total
1	Mobilization	1	LS	$4,964.22	$4,964.22
2	Temporary Facilities	3	month	$500.00	$1,250.00
3	Site Preparation	1	LS	$800.00	$800.00
4	Construct Water Intake Sump	1	LS	$500.00	$500.00
5	Water Supply Pump	50	day	$355.29	$17,764.50
6	Intake Piping (100 feet)	50	day	$31.51	$1,575.50
7	Feed Conveyor	50	day	$85.00	$4,250.00
8	Screening Plant	50	day	$553.94	$27,697.00
9	Receiving-Mixing Sump	50	day	$100.00	$5,000.00
10	Slurry Pump	50	day	$355.29	$17,764.50
11	Discharge Piping (500 feet)	50	day	$155.75	$7,787.50
12	Generator Set (250 kW)	50	day	$714.85	$35,742.50
13	Equipment Operators (1)	50	day	$120.00	$6,000.00
14	FE Loader	50	day	$558.74	$27,937.10
15	Augmentation Material	50,000	ton	$0.00	$0.00
16	Haul Material to Site (1500 ft rt)	50,000	ton	$0.59	$29,500.00
17	Stockpile Management	50,000	ton	$0.30	$15,000.00
18	**Direct Cost Subtotal**				**$203,532.82**
19	Design and Engineering Support			10.00%	$20,353.28
20	Construction Management			5.00%	$10,176.64
21	Contingency			25.00%	$50,883.20
22	**Indirect Cost Subtotal**				**$81,413.13**
23	Total Estimated Construction Costs				**$284,945.94**
24	Cost per Cubic Yard Delivered				**$5.70**

Assumptions:
Equipment costs are contractor owning and operating costs.
Costs per pump system
1/3 of material delivered by system at Site 3 (east end of Dyer)
Material cost is equal to production cost on Program property.
2.3-month delivery time

Table B-6
Preliminary Estimate of Probable Construction Costs
Alternative 6
Augmentation of On-site Material at Two Locations on Cook/Dyer
and Imported Material at One Location on Private Property (OS&G) using Sand Pumps (continued)

Sand Pump Site 5 (near location of on-site sandpit at Cook/Dyer)

Item	Description	Quantity	Unit	Unit Cost	Total
1	Mobilization	1	LS	$4,826.25	$4,826.25
2	Temporary Facilities	3	month	$500.00	$1,250.00
3	Site Preparation	1	LS	$800.00	$800.00
4	Construct Water Intake Sump	1	LS	$500.00	$500.00
5	Water Supply Pump	50	day	$355.29	$17,764.40
6	Intake Piping (100 feet)	50	day	$31.15	$1,557.50
7	Feed Conveyor	50	day	$85.00	$4,250.00
8	Screening Plant	50	day	$553.94	$27,696.80
9	Receiving Mixing Sump,	50	day	$100.00	$5,000.00
10	Slurry Pump	50	day	$355.29	$17,764.40
11	Discharge Piping (500 feet)	50	day	$155.75	$7,787.50
12	Generator Set (250 kW)	50	day	$714.85	$35,742.40
13	Equipment Operators (1)	50	day	$120.00	$6,000.00
14	FE Loader	50	day	$558.74	$27,937.10
15	Augmentation Material	50,000	ton	$0.00	$0.00
16	Haul Material to Site (1000 ft rt)	50,000	ton	$0.48	$24,000.00
17	Stockpile Management	50,000	ton	$0.30	$15,000.00
18	**Direct Cost Subtotal**				**$197,876.35**
19	Design and Engineering Support			10.00%	$19,787.64
20	Construction Management			5.00%	$9,893.82
21	Contingency			25.00%	$49,469.09
22	**Indirect Cost Subtotal**				**$79,150.54**
23	Total Estimated Construction Costs				**$277,026.89**
24	Cost per Cubic Yard Delivered				**$5.54**

Assumptions:
Equipment costs are contractor owning and operating costs.
Costs per pump system
1/3 of material delivered by system at Site 5 (location varies - generally located near dredging operation)
Material cost is equal to production cost on Program property.
2.3-month delivery time

Table B-6
Preliminary Estimate of Probable Construction Costs
Alternative 6
Augmentation of On-site Material at Two Locations on Cook/Dyer
and Imported Material at One Location on Private Property (OS&G) using Sand Pumps (continued)

Sand Pump Site 4 (OS&G)

Item	Description	Quantity	Unit	Unit Cost	Total
1	Mobilization	1	LS	$8,388.75	$8,388.75
2	Temporary Facilities	3	month	$500.00	$1,250.00
3	Site Preparation	1	LS	$800.00	$800.00
4	Construct Water Intake Sump	1	LS	$500.00	$500.00
5	Water Supply Pump	50	day	$355.29	$17,764.40
6	Intake Piping (100 feet)	50	day	$31.15	$1,557.50
7	Feed Conveyor	50	day	$85.00	$4,250.00
8	Screening Plant	50	day	$553.94	$27,696.80
9	Receiving Mixing Sump,	50	day	$100.00	$5,000.00
10	Slurry Pump	50	day	$355.29	$17,764.40
11	Discharge Piping (500 feet)	50	day	$155.75	$7,787.50
12	Generator Set (250 kW)	50	day	$714.85	$35,742.40
13	Equipment Operators (1)	50	day	$120.00	$6,000.00
14	FE Loader	50	day	$558.74	$27,937.10
15	Augmentation Material	50,000	ton	$3.00	$150,000.00
16	Haul Material to Site (1000 ft rt)	50,000	ton	$0.48	$24,000.00
17	Stockpile Management	50,000	ton	$0.15	$7,500.00
18	**Direct Cost Subtotal**				**$343,938.85**
19	Design and Engineering Support			10.00%	$34,393.89
20	Construction Management			5.00%	$17,196.94
21	Contingency			25.00%	$85,984.71
22	**Indirect Cost Subtotal**				**$137,575.54**
23	Total Estimated Construction Costs				**$481,514.39**
24	Cost per Cubic Yard Delivered				**$9.63**

Assumptions:
Equipment costs are contractor owning and operating costs.
Costs per pump system
1/3 of material delivered by system at Site 4 (assumed OS&G)
Material purchased from property owner (assume OS&G)
2.3-month delivery time

1-year Cost
Total Alternative 6 Cost **$1,419,299.17**
Average Cost per Cubic Yard Delivered **$9.46**

10-year Cost
Total 10-year Cost (5% annual escalation) **$17,851,803.01**
Average Cost per Cubic Yard Delivered **$11.90**

Table B-7
Preliminary Estimate of Probable Construction Costs
Alternative 7
Augmentation of Imported Material on Cook/Dyer using Dozers

Augmentation on Cook/Dyer

Item	Description	Quantity	Unit	Unit Cost	Total
1	Mobilization	1	LS	$23,868.81	$23,868.81
2	Temporary Facilities	1	month	$500.00	$500.00
3	Site Preparation	1	LS	$12,500.00	$12,500.00
4	Tree Removal	1	LS	$5,000.00	$5,000.00
5	Excavate/Doze Material	100,000	ton	$4.04	$403,571.43
6	Augmentation Material	100,000	ton	$3.00	$300,000.00
7	Haul Material to Site (8.9 mrt)	100,000	ton	$1.93	$193,000.00
8	Stockpile Management	100,000	ton	$0.30	$30,000.00
9	Equipment Operators (1)	15	day	$120.00	$1,800.00
10	FE Loader	15	day	$558.74	$8,381.13
11	**Direct Cost Subtotal**				**$978,621.37**
12	Design and Engineering Support			10.00%	$97,862.14
13	Construction Management			5.00%	$48,931.07
14	Contingency			25.00%	$244,655.34
15	**Indirect Cost Subtotal**				**$391,448.55**
16	Total Estimated Construction Costs				**$1,370,069.92**
17	Cost per Cubic Yard Delivered				**$13.70**

Assumptions:
Equipment costs are contractor owning and operating costs.
2/3 of material delivered at Cook/Dyer
Stockpiles every 500 feet on bank
Assumed average push distance = 460 ft
1-month delivery time

Table B-7
Preliminary Estimate of Probable Construction Costs
Alternative 7
Augmentation of Imported Material on Cook/Dyer using Dozers (continued)

Augmentation at OS&G

Item	Description	Quantity	Unit	Unit Cost	Total
1	Mobilization	1	LS	$9,534.85	$9,534.85
2	Temporary Facilities	1	month	$500.00	$500.00
3	Site Preparation	1	LS	$12,500.00	$12,500.00
4	Tree Removal	1	LS	$5,000.00	$5,000.00
5	Excavate/Doze Material	50,000	ton	$3.39	$169,642.86
6	Augmentation Material	50,000	ton	$3.00	$150,000.00
7	Haul Material to Site (1,000 ft rt)	50,000	ton	$0.48	$24,000.00
8	Stockpile Management	50,000	ton	$0.30	$15,000.00
9	Equipment Operators (1)	7	day	$120.00	$840.00
10	FE Loader	7	day	$558.74	$3,911.19
11	**Direct Cost Subtotal**				**$390,928.90**
12	Design and Engineering Support			10.00%	$39,092.89
13	Construction Management			5.00%	$19,546.45
14	Contingency			25.00%	$97,732.23
15	**Indirect Cost Subtotal**				**$156,371.56**
16	Total Estimated Construction Costs				**$547,300.46**
17	Cost per Cubic Yard Delivered				**$10.95**

Assumptions:
Equipment costs are contractor owning and operating costs.
1/3 of material delivered at OS&G
Imported source is OS&G
Stockpiles every 500 feet on bank
Assumed Push Distance = 375 ft
1-month delivery time

1-year Cost
Total Alternative 7 Cost **$1,917,370.38**
Average Cost per Cubic Yard Delivered **$12.78**

10-year Cost
Total 10-year Cost (5% annual escalation) **$24,116,492.96**
Average Cost per Cubic Yard Delivered **$16.08**

Table B-8
Preliminary Estimate of Probable Construction Costs
Alternative 8
Augmentation of On-site Material on Cook/Dyer
and Imported Material on Private Property (OS&G) Using Dozers

On-site Dredging Operation (Cook/Dyer)

Item	Description	Quantity	Unit	Unit Cost	Total
1	Mobilization	1	LS	$10,000.00	$10,000.00
2	Temporary Facilities	2	month	$500.00	$750.00
3	Stripping Overburden (2 feet)	5	acre	$4,000.00	$20,000.00
4	Production Costs	100,000	ton	$1.79	$179,000.00
5	FE Loader	22	day	$558.74	$12,292.32
6	Stockpile Management	100,000	ton	$0.30	$30,000.00
7	**Direct Cost Subtotal**				**$252,042.32**
8	Design and Engineering Support			10.00%	$25,204.23
9	Construction Management			5.00%	$12,602.12
10	Contingency			25.00%	$63,010.58
11	**Indirect Cost Subtotal**				**$100,816.93**
12	Total Estimated Construction Costs				**$352,859.25**
13	Cost per Cubic Yard Delivered				**$3.53**

Assumptions:
Equipment costs are contractor owning and operating costs.
Augmentation material cost limited to production cost as part of agreement with operator

Table B-8
Preliminary Estimate of Probable Construction Costs
Alternative 8
Augmentation of On-site Material on Cook/Dyer
and Imported Material on Private Property (OS&G) Using Dozers (continued)

Augmentation on Cook/Dyer

Item	**Description**	**Quantity**	**Unit**	**Unit Cost**	**Total**
1	Mobilization	1	LS	$16,368.81	$16,368.81
2	Temporary Facilities	1	month	$500.00	$500.00
3	Site Preparation	1	LS	$12,500.00	$12,500.00
4	Tree Removal	1	LS	$5,000.00	$5,000.00
5	Excavate/Doze Material	100,000	ton	$4.04	$403,571.43
6	Augmentation Material	100,000	ton	$0.00	$0.00
7	Haul Material to Site (8.9 mrt)	100,000	ton	$1.93	$193,000.00
8	Stockpile Management	100,000	ton	$0.30	$30,000.00
9	Equipment Operators (1)	15	day	$120.00	$1,800.00
10	FE Loader	15	day	$558.74	$8,381.13
11	**Direct Cost Subtotal**				**$671,121.37**
12	Design and Engineering Support			10.00%	$67,112.14
13	Construction Management			5.00%	$33,556.07
14	Contingency			25.00%	$167,780.34
15	**Indirect Cost Subtotal**				**$268,448.55**
16	Total Estimated Construction Costs				**$939,569.92**
17	Cost per Cubic Yard Delivered				**$9.40**

Assumptions:
Equipment costs are contractor owning and operating costs.
2/3 of material delivered at Cook/Dyer
Stockpiles every 500 feet on bank
Assumed average push distance = 460 ft
1-month delivery time

Table B-8
Preliminary Estimate of Probable Construction Costs
Alternative 8
Augmentation of On-site Material on Cook/Dyer
and Imported Material on Private Property (OS&G) Using Dozers (continued)

Augmentation at OS&G

Item	**Description**	**Quantity**	**Unit**	**Unit Cost**	**Total**
1	Mobilization	1	LS	$9,534.85	$9,534.85
2	Temporary Facilities	1	month	$500.00	$500.00
3	Site Preparation	1	LS	$12,500.00	$12,500.00
4	Tree Removal	1	LS	$5,000.00	$5,000.00
5	Excavate/Doze Material	50,000	ton	$3.39	$169,642.86
6	Augmentation Material	50,000	ton	$3.00	$150,000.00
7	Haul Material to Site (1,000 mrt)	50,000	ton	$0.48	$24,000.00
8	Stockpile Management	50,000	ton	$0.30	$15,000.00
9	Equipment Operators (1)	7	day	$120.00	$840.00
10	FE Loader	7	day	$558.74	$3,911.19
11	**Direct Cost Subtotal**				**$390,928.90**
12	Design and Engineering Support			10.00%	$39,092.89
13	Construction Management			5.00%	$19,546.45
14	Contingency			25.00%	$97,732.23
15	**Indirect Cost Subtotal**				**$156,371.56**
16	Total Estimated Construction Costs				**$547,300.46**
17	Cost per Cubic Yard Delivered				**$10.95**

Assumptions:
Equipment costs are contractor owning and operating costs.
1/3 of material delivered at OS&G
Imported source is OS&G
Stockpiles every 500 feet on bank
Assumed Push Distance = 375 ft
1-month delivery time

1-year Cost	
Total Alternative 7 Cost	**$1,839,729.64**
Average Cost per Cubic Yard Delivered	**$12.26**
10-year Cost	
Total 10-year Cost (5% annual escalation)	**$23,139,935.42**
Average Cost per Cubic Yard Delivered	**$15.43**

APPENDIX E

RESPONSE TO COMMENTS ON

DRAFT
PLATTE RIVER FROM THE LEXINGTON TO ODESSA BRIDGES SEDIMENT AUGMENTATION EXPERIMENT ALTERNATIVES SCREENING STUDY SUMMARY REPORT

COMMENT AND RESPONSE INTRODUCTION

This appendix addresses comments received on the Draft Sediment Augmentation Experiment Alternatives Screening Study. The section includes comments from the U.S. Fish and Wildlife Service and meeting minutes from the 13 January 2011 workshop held in Kearney where the report was presented to the PRRIP TAC. The responses to the comments reflect discussion and clarifications made during the 13 January workshop. Modifications to the final report as a result of a comment response are noted.

USFWS Technical Advisory Committee comments on "Draft-Sediment Augmentation Experiment Alternatives Screening Study"

January 7, 2011

General comments:

Comment 1: When reviewing the sediment transport, TAC and Program staff should think in terms of habitat creation and maintenance, not just maintaining sediment balance. Physical Process Hypothesis #2 in the Adaptive Management Plan states that between Lexington and Chapman, eliminating the sediment imbalance in eroding reaches will:

• Reduce net erosion of the river bed;

• Increase the sustainability of a braided river;

• Contribute to channel widening;

• Shift the river over time to a relatively stable condition, in contrast to present conditions where reaches vary longitudinally between degrading, aggrading, and stable conditions; and

• Reduce the potential for degradation in the north channel of Jeffrey Island resulting from headcuts.

Sediment-related priority hypothesis links the maintenance of a sediment balance to an increase in the braiding index (Sediment Hypothesis #2). A braiding index of greater than 3 is then linked to an increase in active channel width per a 2,000 cfs reference flow (Sediment Hypothesis #3), and an increase in sandbar area per a 1,200 cfs reference flow (Sediment Hypothesis #4).

Arresting channel degradation is one benefit from maintaining a sediment balance via sediment augmentation. The fining of the Platte River bedload was an additional benefit of sediment augmentation that would allow for easier mobilization of sediment within vegetated islands. Bedloads of a certain grain size distribution may be needed to build sandbars that are suitable for least tern and piping plover nesting.

Summary - We recognize that the researchers for the Sediment Augmentation Experiment Alternatives Screening Study (Augmentation Study) were not tasked to incorporate all of these benefits when developing a prescription for sediment augmentation. However, the TAC and Program staff should recognize that a final prescription for sediment augmentation must address all of the above benefits.

Response: Comment noted. No changes to document required.

Comment 2. The potential for on and off-site impacts are important considerations when developing sediment augmentation alternatives. The Service encourages the Program to avoid adverse impacts to federally listed species, state listed species, species of conservation concern, vegetation communities of ecological importance, jurisdictional wetlands, non-jurisdictional wetlands, and impacts to downstream landowners. The potential for on and off-site impacts is an important component of the U.S. Army Corps of Engineers (COE) permitting process and should be considered under the Permitting criterion in the Augmentation Study.

The COE document on Stream Impact Assessment/functional assessment could be used to balance out the positive benefits (habitat creation, maintenance, etc.) of this project vs. the potential negative impacts (i.e. would this contribute to coarsening, are their impacts to downstream landowners' property, impact to wetlands, etc.). Investigating potential impacts and developing monitoring to assess positive/negative effects will be important considerations in permitting. Ultimately, a project will only be permitted if it is determined to be the least environmentally damaging practicable alternative. Another thing to point COE toward is other systems across the United States where this type of activity is being used routinely to offset anthropogenic effects of water management. The Sacramento district routinely permits "spawning gravel injection" projects under nationwide permit (NWP) #27 (Rabbe was a project manager on a number of these). These were done at many sites every year to benefit listed species and mitigate the effect of altered flow regimes and sediment or "spawning gravel" imbalances caused by man-made structures. NWP #27 must have the specific goal of improving the aquatic habitat. It cannot have more than minimal impact individually or cumulatively, and may require additional terms and special conditions in addition to the general conditions of NWP#27. It also must have a net increase in aquatic functions and services. The COE can require an individual permit if it feels there is more than minimal impact or potential public interest review concerns. The biggest concern they will likely have is the potential to impact downstream landowners. Using historic examples where man-made or natural high flow events (under an imbalanced sediment load) caused damage to landowners from erosion, down cutting, etc. can help strengthen our case as well.

Summary - Augmentation Study should incorporate the potential for on and off-site impacts when ranking sediment augmentation alternatives using the Permitting criterion. Permittability should be based on practicability and environmental impacts. Investigating the additional impacts listed above for each alternative could help in accurately predicting permittability.

Response: Concur with comment. Offsite and downstream impacts will be an important consideration during the permitting phase of the project.

Comment 3. It may be difficult to correctly develop a prescription for sediment augmentation when evaluating historic hydrographs. Sediment transport should be estimated for different modeled release points (i.e., J-2 Re-Regulating Reservoir, Elm Creek Reservoir, CNPPID Bypass, etc.). Augmentation Study evaluated flow release patterns associated with the 2009 flow routing test in Appendix B. However, magnitudes for Short Duration High Flows (SDHF) are in the 6,000 to 8,000 cfs range, and these flows are dependent on the aforementioned flow augmentation strategies. The concern regarding this uncertainty is with the prioritization of sediment source location and not the quantities of sediment needed to offset deficits. For example, both the Elm Creek Reservoir and CNPPID Re-Regulation Reservoir may be used to augment SDHF or shortages to target flows. Both provide flows without corresponding sediment load. Furthermore, the outlet for the Elm Creek Reservoir is near the Elm Creek bridge downstream of Cottonwood Ranch. A feasible sediment augmentation alternative in the Augmentation Study may not remain as feasible when water projects come online.

Summary - This consideration does not warrant changes to the Augmentation Study. Rather, TAC and Program staff should consider future operations when developing preferred sediment augmentation alternatives.

Response: Comment noted. No changes to document required.

Comment 4. The recommendation based on modeling of using sediments with a D50 courser than 1mm is of concern to the Service. Historic data from the COE (1931), Smith (1971), Kirscher (1981), USBR 1989 as published by Holburn (2006), and Kinzel (1999) points toward significant coarsening of sediment grain sizes throughout the entire reach. This report indicates material too coarse may settle out before Cottonwood Ranch and finer material would flush through the system. Sediment gradation alternatives are prioritized based on the ability to achieve sediment balance at or within Cottonwood Ranch. The Service has previously indicated and currently maintains the position that sediment augmentation is a tool to correct the sediment size and load needed to offset an imbalance that is currently impacting target species and their habitat. Though the scope of this feasibility report and ensuing project focuses on metrics to achieve sediment balance (i.e. sediment load) at Cottonwood Ranch, it is well known throughout other systems and was explicitly stated in the EIS (EIS, page 4-36) that the ability to build sandbars increases with: 1) increasing annual peak discharge, 2) cumulative sand transport, and 3) with the fineness of the bed-material. It may be helpful to have a separate goal (or implement additional projects/research) to reverse the coarsening trend that Ayres has pointed toward in two years of geomorphology monitoring (referencing 1989 BOR data) and that recognized from historic data. The augmentation of sediments that are coarser than that described in the EIS or BO may not realize benefits comparable to that envisioned under the FSM strategy.

Summary - This consideration may not warrant changes to the Augmentation Study. TAC and Program staff should attempt to maximize learning by conducting other passive adaptive management experiments designed to examine the above considerations. These could be incorporated within the constructs of this study (by selecting alternatives that would accomplish multiple purposes) or by initiating independent studies directed at these additional considerations.

Response: <u>The feasibility report recommended a pilot study. One component of the pilot study will be the implementation of a monitoring plan. The comment is noted. No changes to document required</u>.

Comment 5. The AMP identified that sediment can be offset by various sources: a) sand augmentation through mechanical actions – island and bank clearing and leveling, b) sand augmentation from bank and island actions not directly related to bank cutting and island leveling (an example could be excavation associated with wetland development), or c) reducing imbalance through channel plan form changes, tributary delivery improvements, or flow routing changes." Augmentation Study only focuses on source b), but the Augmentation Study RFP requested an evaluation of all three sediment augmentation sources.

Additionally, the feasibility results suggest difficulty in permitting and ability to deliver the targeted amount within the next few years. Alternatives 6 and 8 are both able to deliver >40% effectiveness with alternative 6 potentially providing 60-80%. Based off this, it appears that both alternatives scoring the highest have the potential to offset more than 40% and collectively, they have a combined estimate of 100%.

Summary - Augmentation Study researchers should consider sources a) and c) as alternatives in the Augmentation Study in addition to evaluating the effectiveness of combining alternatives as identified within the study.

Response: All three sources were evaluated. Only those sources that were the most promising based on potential sediment availability on specific lands that the Program has access to were carried through to alternative development.

The combination of the efficiencies of two alternatives is not necessarily a linear comparison. The combined alternatives would need to be modeled to determine the combined efficiency. Modeling conducted during development of this report covered a range of scenarios that allowed development of a group of viable alternatives. No changes to the document required.

Comment 6. There may be spatial and temporal aspects of sediment transport that Augmentation Study may not capture. The Augmentation Study concludes that using a D50 of 0.5 mm (i.e. high percentage of fine sediments) would likely result in a majority of the sediment to stay suspended and be transported through the target reach. This may be true when evaluating sediment transport using yearly time intervals. However, seasonal differences in sediment transport may show differences in how sediments with D50 of 0.5 mm move through the system. It is possible that a portion of the fine sediments would not be transported as a result of low summer flows, but would eventually migrate through the system as flows increased in the fall. This seasonal deposition of fine sediments may result in a beneficial but temporary means of creating and/or maintaining habitats.

One limitations of the 1-D modeling is the inability to model sandbars. The conclusion that a majority of the sediment would be transported through the target reach using a D50 of 0.5 mm (i.e. high percentage of fine sediments) would only apply if sediments remained available in the water column. In other braided river systems visited by the Service, high flows create bedforms that become sandbars as flows recede in the summer. These emergent sandbars could represent a source of fine sediment that would not be available for immediate transport.

Summary – The Service does not know to what extent the above considerations represent limitations in the scope of work and limitations in modeling. If limitations in the scope of work and modeling are realized, then the Service looks forward to working with the group to address these limitations when developing and ranking sediment augmentation alternatives. The Service recognizes that consideration of these limitations (if warranted) may be supplemental to the Augmentation Study.

Response: The modeling considers the seasonal variability in flows and the effects of this variability on sediment transport rates by including mean daily flows in the hydrologic input for the 12.5-year simulation; thus, the results should reflect storage of fine sediment during low-flow periods and removal of the stored material during high-flow periods. While the model does not explicitly model the sandbar building process, the storage and removal of fine sediment should be adequately accounted for on an overall mass balance basis. The effects of emergent sandbars during low flows should be considered in detail in subsequent monitoring and modeling efforts. If it is determined that this is a significant issue with respect to the overall mass balance, methods should be developed to incorporate a routine into the model that would approximate the effect of the process. No changes to the document required.

Comment 6. This report concludes that using a D50 of 0.5 mm (i.e. high percentage of fine sediments) would likely result in a majority of the sediment to stay suspended and be transported through the target reach. Given the high transport rate of fine materials, the Service seeks to learn if these fines may be instrumental in downstream bar formation/channel geomorphology and pallid sturgeon habitat creation/maintenance in the lower Central Platte or Lower Platte/Missouri River. It was recognized within the 2009 geomorphology monitoring report that there was little to no suspended sediments below 5,000 cfs and thus, no need to sample for suspended sediments below those flows. Augmenting sediment of finer gradations would contribute to increasing suspended sediments below 5,000 cfs. This would likely restore conditions closer to those reported historically by early settlers (i.e. “exceedingly muddy”, James Evans, 1850). The benefits of sediment augmentation were intended to extend beyond the project reach of Cottonwood Ranch. Sediment coarsening has occurred throughout the entire program area and contributing finer sediments that may wash throughout the system (not settle at Cottonwood Ranch) could be beneficial to the target species and other ecologically important species. For example, the Pallid Sturgeon Information Review identified the potential importance of turbidity in pallid sturgeon ecology in the lower Platte River. Furthermore, use of coarse sediment gradations may contribute to more permanent bar formations that are detrimental to ephemeral bars needed for braiding conditions.

Response: The comment is noted. No changes to document required.

Specific Comments for Augmentation Report

Page 4 line 22- This only reviews other projects for applicability to quantities and grain sizes. It may be helpful to broaden the scope of how we relate other examples to our circumstances and use them to assist in proceeding with COE permitting (i.e. how did other COE districts make a case that their project should be permitted under a NWP#27).

Response: Given the stated goal of reducing sediment, the project review was appropriate. No changes to document required.

Page 23- Many of the proposed alternatives are below or at the end of subreach 2 or far from subreach 5 where sediment imbalances occur. What does the modeling show will happen (to sediment load and size) at the rest of the reaches outside of reach 3 where Cottonwood Ranch is?

Response: While the specific goal for this project was achieving sediment balance at Cottonwood Ranch, the five model subreaches were delineated to evaluate anticipated aggradation or degradation on a subreach basis. The results of this evaluation are presented in Section 4 of Appendix B "Hydraulic and Sediment-transport Modeling for the Platte River Sediment Augmentation Feasibility Study, Nebraska." No changes to the document required.

Page 27 section 5.3- Private operations weren't looked into with much detail. This feasibility analysis should have looked at all our options in depth. Discounting private sand and gravel operations simply because they "would likely involve compensation" is not a thorough evaluation of these options. There are many questions for these that should have been investigated such as "what level of compensation would be involved?".

Response: Private operations were looked at (Overton Sand and Gravel, Carl Whitney Sand and Gravel) both as source and potential augmentation locations. There were no specific private properties other than the sand and gravel operations although it was recognized that there could be potential source or augmentation location possibilities in the future. No changes to document required.

Page 34- See general comment 5. Reregulating reservoir should be tabled for future consideration and not removed from consideration. We understand feasibility cannot be performed yet, but we should list it as a site for future consideration. The south channel below J-2 is the most degraded stretch of river within the Central Platte and it would be beneficial from a habitat standpoint to attempt to improve habitat as far up stream as possible (i.e. J-2 reregulating reservoir?).

Response: Comment noted. Any of the sites or projects such as the J-2 Reregulating Reservoir could be and will likely have to be re-evaluated in the future regarding impacts to sediment balance. No changes to document required.

Page 35- See general comment 5. In channel sediment augmentation (leveling high macroforms) serves multiple purposes such as: 1) sediment source and 2) increasing unobstructed widths, bare sand area and 3) increasing characteristics more toward suitable target species habitat. The amount may be small but the benefits serve multiple purposes. Was macroform leveling investigated throughout the Jeffery Island property? Why was this thrown out for Cook property? Cook macroform leveling might not provide much volume but it is easily permittable and the benefits go beyond putting sediment in the river. Same goes for Dyer in-channel macroforms. Short term augmentation options are still options and shouldn't be thrown out. The analysis shows that no one option is capable of providing 100% of the project need. Therefore, we will have to use a combination of projects and considering in channel macroforms should figure into the equation.

Response: Jeffrey Island is currently privately owned and under lease to NPPD. Leveling Jeffrey Island could cause drastic changes in that stretch of river and the impacts to landowners would need to be thoroughly thought out and mitigated. Leveling of macroforms was evaluated as part of this project; however, there is not a long-term sediment source available so it was screened out. The goal of the project was specifically to provide enough sediment source material annually to add to the river so that sediment balance was achieved at a specific location just upstream of Cottonwood Ranch. The report states at the end of the paragraph that if macroforms were leveled onsite, a reduction in augmentation of sediment at other areas may be realized. No changes to document required.

Page 35- Are the volume estimates for Cook and Dyer (2.5-3 million and 1.5-2 million) the amount left after course sediment is removed? If approximately 50% is unusable, it makes a big difference. If so, present the numbers for in-channel sediment estimates to coincide. In other words, does the 100,000-400,000 in channel estimate relative to the out of channel estimates or do we need to shave off 50% of that estimate to compare the two equally?

Response: The volumes of available sediment stated on Cook and Dyer in the report are gross volumes. The last sentence states that the amount available for transport would be approximately half of that. To compare the two equally, you would need to use half of the gross volume. The discussion under the Dyer and Cook sections refer to "augmentation material" which is material in the useable size range. No changes to document required.

Page 36- See general comment 1 and 4. The geomorphology and vegetation report completed by Ayers suggests the "wash" load sediments are defined as those less than 0.0625 MM. This is significantly smaller than 1mm. The majority of our sediment used (<1mm) for augmentation will not be anywhere near the 0.0625mm threshold. There is a disconnect between wash load as defined within the geomorphology monitoring reports and the results of the modeling reported here (0.0625 mm vs. 0.25-1.0 mm). Furthermore, fines that wash through the Cottonwood Ranch reach have the potential to benefit by being deposited elsewhere within the Central Platte. To achieve sediment balance at Cottonwood Ranch, it may simply take longer and/or require more sediment if a higher percentage of sediment is transported through this reach.

Response: "Wash load" as defined in this comment and the finer material evaluated as part of the project (0.5 mm) are two different things. The gradations selected for evaluations were based on the most practical available material. The average gradation of the "waste" or unused material at the sandpits has a D50 of approximately 0.5 mm. That

material is readily available and is in the size range (i.e., D50 smaller than the 1.0 mm) suggested in the EIS. The "coarser" 1.2 mm gradation was based on a D50 of the bed samples collected as part of the Ayers study. In other words, that is the size of material currently moving in the bed. Regarding the last part of the comment, the report states that modeling indicated approximately 300,000 tons of the finer (D50 = 0.5 mm) material, or double the modeled deficit, would need to be added to achieve balance. No changes to document required.

Page 42, section 7.1.1- This section points out that pit dredges are efficient and economical to produce optimum sized material using screens at production site. Page 77 indicates that the existing technology (i.e. screen for optimum particle size) makes any additional processing for specific gradation impractical.

Response: The statement is in reference to additional processing of the 0.5 mm material that has already been screened and is in the stockpiles. Further screening would likely be impractical and inefficient due to the material's already small size. It may be possible to use a series of screens on newly mined material that could produce some variation in the D50; however, the typical mechanical screening processes may not differentiate the gradational sizes at this smaller end of the useable aggregate sizes. No changes to document required.

Page 46, 7.2.4- See general comment 1 and 4. "Direct discharge is only possible if the proper gradation fits within the parameters identified during sediment transport modeling"… Need to add "OR parameters identified by the program". The program participants and the TAC have input on the decisions that ultimately determine on the ground actions.

Response: Text will be clarified.

Page 55- How do modeling results suggest that pumping start date has little effect on the amount that the sediment deficit is reduced? The analysis showed that historically the deficits and excesses were eroded and deposited based on different high flow events or high annual flows. Knowing there is a big difference in the river flows of August 1 to February 15, this suggestion raises questions.

Response: There is some variation but not enough that modifying the start date had a significant impact of achieving sediment balance at Cottonwood Ranch. There may other reasons you would put material in at different times of the year, but that evaluation was not part of this project. No changes to document required.

Page 57- section 9.2- See comment 1and 4 regarding concerns for this alternative.

Response: See responses to comments 1 and 4.

Page 58- Use of coarse material would make both Cook and Dyer infeasible due to the low hydraulic energy. These sites are prime candidates for augmentation of finer material.

Response: That is the conclusion that is drawn in the report. Finer material placed at Cook/Dyer would require approximately 300,000 tons be augmented to nearly eliminate the

152,000 ton deficit. Coarser material is more effective downstream of the confluence because there is more stream power and less of the material will flush through the system. No changes to document required.

Page 59- Existing Sand and gravel operations at Overton should not be limited to a gradation of D50-1.2. A D50 of 0.5 is modeled to require larger volumes and/or take longer to eliminate the sediment deficit. The TAC and Program staff should not eliminate this option based on General Comment 1.

Response: The limitation was specifically related to the goal of achieving sediment balance at the upstream end of Cottonwood Ranch. See response to comment above. No changes to document required.

Page 64- It appears the evaluation criteria focused on a practicability evaluation? How did "Least **environmentally damaging** practicable alternative" get narrowed to only practicability? There needed to be an environmental impact criterion in this screening. This alternatives analysis should address the biggest concern that the COE will likely have (environmental damage and impacts to downstream landowners). There needs to be a lot of discussions with the COE before we are able to move forward with these. A pre-application meeting should happen now presenting a lot of these screening results. Early feedback from COE may have led us to dismiss a number of alternatives or show increased feasibility of others.

Response: The comment is correct that the feasibility screening criteria was focused on eliminating alternatives that were not practicable using criteria that would be consistent with the 404(b)(1) Guidelines. The feasibility report did not attempt to conduct a complete 404(b)(1) analysis which will be required during the permitting phase. Instead, the feasibility study was structured so that it would help support the permitting process and feed into the Corps of Engineer's 404(b)(1) analysis. As suggested in the comment, the Program has initiated pre-application consultation with the Corps of Engineers. Appendix A, Section 1.4 will be updated to reflect the comment and to clarify that there are other element so of the 404 (b)(1) Guidelines that will need to be evaluated during the permitting process.

Page 66- "Provision of Other Program Benefits" mentions creating habitat (either directly or indirectly). The report never once mentions creating habitat in the river with the sediment (as this was also not within the stated project purpose). It only uses abandoned sand mining operations which would provide pits for potential habitats at some point in the future. Sediment augmentation is part of the FSM strategy, not the MCM. This was intended to be a key component in building habitat naturally out in the river. River habitat isn't mentioned while OCSW habitat (which is part of the MCM strategy) is listed as a potential benefit. The "Provision of Other Program Benefits" should include benefits for the target species within the river as described in general comments 1 and 6.

Response: Comment noted. As noted in the comment, this was not within the stated project goal. It is hoped that as a consequence of achieving sediment balance that habitat creation will be improved or sustained. No changes to document required.

Page 67- Least environmental damage… not considered again relative to the 404(b)1 guidelines.

Response: Comment is correct, Appendix A, Section 1.4 has been revised to clarify that the Corps of Engineers will be conducting a 404 (b)(1) Guideline analysis as part of the permit evaluation process. In addition, footnote #7, on page 63 will be updated to clarify that the 404(b)(1) evaluation will be completed during the permit evaluation process.

Page 71- Have any recent discussions with the COE occurred (like during feasibility screening)? There is no feedback on the feasibility of any different alternatives here. Permitting was used as screening criteria, yet it does not appear the COE has had recent input related to feasibility and permittability of any of these alternatives (preferred techniques, methods, etc.). We need another pre-application meeting to discuss alternatives not involving those that have been previously permitted at Cottonwood Ranch. Has the COE indicated which of these alternatives might be considered under a NWP #27? Using dozers to do this type of work has been routinely authorized under a nationwide permit in other districts. Alternatives that could be authorized using a nationwide permit should be considered low difficulty. The Service would appreciate being included in the any pre-application meetings with the COE.

Response: We agree with the comment. Additional pre-application consultation meetings will be required with the Corps of Engineers and the U.S. Fish and Wildlife Service will be invited to participate in future pre-application consultation meetings.

Page 72, line 10- Service interpretation of modeling indicates that flow in the South Channel is capable of mobilizing sediment, but a finer gradation of sediment is necessary to be able to fully mobilize the sediment.

Response: This is recognized and discussed in detail in the report and modeling appendix. No changes to document required.

Page 73- Sandpits don't help meet the FSM management strategy. See other program benefits above. There are a multitude of target species benefits from sediment augmentation, as described in general comments 1 and 6, that go beyond offsetting a volume deficit at Cottonwood Ranch. These benefits represent aspects of the criterion "Provision of Other Program Benefits".

Response: Regardless of the strategy, the sandpits would be a direct benefit from mining sediment onsite for the purpose of achieving the goal of the project, which is sediment balance at Cottonwood Ranch. No changes to document required.

Page 75, line 9 and 17- See general comment 1 and 4. The goal to "eliminate sediment deficit at Cottonwood Ranch" does not reflect the overall purpose of sediment augmentation. Line 17 states a project goal different than that outlined throughout the rest of this product. If the intended result is to build habitat, there is disconnect between that and achieving sediment balance at Cottonwood Ranch.

Response: Line nine refers to the fact that most of the projects available for comparison had the stated goals of creating instream habitat (e.g., spawning habitat) and that the Sediment Augmentation is different in that the stated goal is to achieve sediment balance.

It is hoped that by achieving sediment balance, instream habitat may be improved or maintained in a more favorable condition. No changes to document required.

Page 77- This is not consistent with previous assertion that it is easy and economical to screen sediment for our desired size. What are the costs associated with screening for coarse vs. fine sediment?

Response: The 0.5 mm gradation is readily available as a by-product of production of other aggregates so in that sense, it is economical and easily acquired. There is a difference between using material that is "left over" from another process and specifically designing a system to differentiate very small variations in aggregate size at the small end of the scale. The practicality of specifically producing products that differentiate between 0.5 mm, 1.0 mm, and 1.2 mm, for example may not be easy or economical. No changes to document required.

Page 85-86- There are no recommendations as to the scale of the pilot study here. In the AMP implementation plan and mock report, the first two years are projected at 25%. It's not clear what that is in relation to. Is it referring to a 25% reduction in sediment deficit or 25% of a defined volume needed for offset? According to the modeling, the volume needed will change drastically based on gradation of sediment used.

Good suggestion of refining monitoring plan. This will be the key to successfully being able to implement augmentation on a full scale.

Response: The scope of the pilot project is being developed and will include monitoring plan refinement.

Specific Comments for Appendix A-

1.3.2.2- Range of alternatives considered in the FEIS/FBO did not include course gradation augmentation.

Response: Coarse is a relative term. In this report, the coarse material was the existing bed load material with an average D50 of 1.2 mm which only slightly larger than the 1.0 mm recommended in the FEIS. The fine material was the 0.5 mm material at the sand pits. No changes to document required.

1.3.3- We need to get across to COE that without sediment augmentation, any future high flows will create a need for downstream landowners to perform bank stabilizations as degrading areas will continue further down cutting and erosion. Do I understand that a PCN has only been done for in-channel work at Cottonwood Ranch?

1.4- See discussion above about "least environmentally damaging practicable alternative".

Response: See response to comment pertaining to page 64 above.

Specific Comments for Appendix B, C, D -

Page 17- Points out that significant coarsening is likely to continue. This justifies previous concerns with sediment augmentation gradation.

Response: Comment Noted. No changes to document required.

Page 81- See general comment 3 regarding SDHF magnitudes.

Response: See response to comment 3.

PLATTE RIVER RECOVERY IMPLEMENTATION PROGRAM
Technical Advisory Committee (TAC)
Sediment Augmentation Feasibility Analysis Report Workshop Minutes

ED Office – Kearney, NE
January 13, 2010

Attendees

Chad Smith − ED Office
Dave Baasch − ED Office
Jason Farnsworth − ED Office
Steve Smith – ED Office (Teleconference)
Mike Besson – Wyoming (Chair)
Brock Merrill – Bureau of Reclamation
Suzanne Sellers – Colorado Water Conservation Board
Kevin Urie – Colorado Water Users (teleconference)
Bob Mussetter – Tetra Tech
Tom Riley – Flatwater Group
Rick Krushenisky – Flatwater Group
Pat Engelbert − HDR
John Morton – HDR
Jim Jenniges – Nebraska Public Power District
Mark Peyton – Central Nebraska Public Power & Irrigation District
Mike Drain – Central Nebraska Public Power & Irrigation District
Jeff Runge – U.S. Fish and Wildlife Service
Matt Rabbe – U.S. Fish and Wildlife Service
Mike Fritz – Nebraska Game and Parks Commission
Pat Golte – Nebraska Department of Natural Resources
Mark Czaplewski – Central Platte Natural Resource District
Rich Walters – The Nature Conservancy

Welcome and Administrative

Besson welcomed everyone to the meeting and the group proceeded with a roll call.

Sediment Augmentation Feasibility Analysis Report

Engelbert led the discussion, introduced the core group of people that worked on the project, and walked through background information for the Sediment Augmentation Feasibility Analysis Report. Mussetter discussed the base-line modeling behind the analyses. Engelbert discussed sediment augmentation locations, sources, production and delivery technologies, delivery timing, and material gradation. Riley discussed evaluation criteria (cost, existing technology, logistics, and project purpose), alternative analyses, and risk and uncertainty analyses.

Recommendations:

- Pilot-scale study based on alternatives 6 & 8
- Develop monitoring plan
- Update model based on findings
- Develop final design

Besson asked how we get a handle on annual variability in sediment deficit. Mussetter stated we could introduce sediment at a rate the river can transport or stockpile sediment in the channel so it's available when the flows are there to transport it. Mussetter stated a key uncertainty is how best to augment sediment so the river can transport it. Farnsworth said we may have to tier it so we add a consistent amount annually and add more when needed. Fritz asked if the amount of sediment added needed to be determined on a real-time basis. Mussetter said it will be tough to add enough sediment during periods of high flow if sediment is not stock piled in the channel. Drain stated NPPD stock pile sediment below the diversion dam that is removed during periods of high flow. Besson asked how much sediment would be needed if the actual material size needed was <1.2mm. Mussetter stated they analyzed a scenario using 0.5mm sediment and it appeared to be over 300,000 tons of material and still didn't fill the hole. Drain asked if the amount of sediment we will augment will offset the deficits during years the river is not at a low deficit level. Mussetter stated the amount we plan to add would be more than enough to offset the deficit, but during other years it may require 250,000 tons of sediment. Farnsworth stated NPPD put sediment in the channel during drought years and Jenniges stated he thought it was about 120,000-130,000 tons of sediment during 2005-2009 and it seemed the material was stored on the bed of the channel and was moved downstream when flows were high. Krushenisky stated stockpiling didn't appear to meet sediment balance at Cottonwood Ranch, but the river may have been in balance further downstream.

Jenniges asked what we need to do to offset the deficit and if the only reason we couldn't was because we didn't want to put in 300,000 tons of material. Mussetter stated we may run into downstream effects with that much material. Peyton asked if we could move the equilibrium point upstream if we added material even if we don't meet sediment balance at Cottonwood Ranch. Mussetter said he thought it would take time to move equilibrium, but in the mean time the holes would be filling in. Besson asked how many other types of service water uses were in this reach of the river. Farnsworth stated Kearney Canal was the last water right other than ground-water wells downstream. Riley stated there would be a certain amount of sediment that would be deposited on the banks and vegetated islands during periods of high flow as Jenniges described. Runge asked if we could cooperate with NGO's and others so we don't get deposition of material out of the channel (i.e., could we mechanically widen channels). Mussetter said widening channels would definitely increase the capacity of the channel. Runge asked if sediment size impacts our ability to build sandbar macroforms. Mussetter stated we could build bars with an overload of any sized material and would build slower moving sandbars with courser material. Rabbe asked what would happen to coarsening if we put finer material in the system. Mussetter stated we could make the channel bed less course by adding finer material. Runge asked how adding 'clear' water from reservoirs (SDHF) would affect the system. Mussetter stated SDHFs will not impact sediment transport to a large extent where the durations were so short. Jenniges asked that if we balance the sediment deficit aren't we just stopping degradation rather than filling the holes. Riley stated we would need more than 185,000 tons of sediment to offset the deficit and cause agradation in the channel. Smith stated that if we want to increase the braiding index we need to add more sediment so we can agrade the channels and increase the braiding index.

BREAK

Morton discussed permitting issues with sediment augmentation and stated implementing a pilot study under an individual permit would make it easier for the Program to obtain a regional general permit for full implementation of sediment augmentation in the future. Besson asked what track we should pursue to allow us to conduct a pilot study and the timeframe for getting required permit. Morton stated we should attempt to obtain an individual permit for the pilot study and a regional permit when full implementation takes place and it would be a 6-12 month process for obtaining the permits. Rabbe asked Jenniges what type of permit NPPD had for their Cottonwood Ranch Permit and Jenniges stated they were operating under a regional permit that expired 13 December, 2010. Rabbe asked if they thought the Corp would react more favorably to dozing islands than other potential options for implementing sediment. Morton said the Corp is more familiar with that approach so they may react more favorably to that approach. Rabbe asked if they are pursuing multiple options to augment sediment and Morton stated they Sed-Aug team need to meet with ED Office staff to discuss potential options and would decide how to proceed from there. Jenniges asked how much sediment they would try to permit (150,000 or 300,000 tons). Morton said they would try to permit enough sediment for the pilot study, but didn't have a specific number in mind yet. Farnsworth stated we could get 50,000 at Cottonwood Ranch through channel widening and could add more at Dyer. Smith stated that if the TAC is comfortable with implementing a pilot study then the Sed-Aug team could finalize the feasibility report and draft the pilot study design and pursue permitting. Drain stated we should give the GC background information (cost, feasibility, etc) on implementing a pilot study and for full implementation of sediment augmentation. Jenniges asked if doing a pilot study was to monitor downstream affects or for permitting. Morton stated the pilot study would be easier to permit but that the pilot study would help learn a lot about sediment augmentation. Jenniges stated it would be 2013 before we could implement a pilot study and 2016 before full implementation. Besson asked how and how much we would implement sediment during the pilot study. Farnsworth stated he thinks we need about 100,000 tons sediment implemented with pumps. Smith stated time is an issue for the Program because we still need to build re-regulation reservoirs to be able to implement a SDHF. Jenniges asked if NPPD should look at permitting the 50,000 tons at Cottonwood Ranch or if the Program would permit that activity. Farnsworth stated the Program would try to permit all the work if possible, but may need NPPD to permit the Cottonwood Ranch work if the Corp won't permit the work for the Program. Besson stated we need more detail from ED Office staff and Sediment Augmentation group. Farnsworth stated we would have impact triggers so that when a threshold is met we would stop and assess the problem. Runge stated flow bypass at North Platte could contribute sediment to the central Platte. Rabbe asked if the sediment by North Platte could be mobilized or if vegetation would trap the sediment. Walters stated the vegetation below North Platte was sprayed. Farnsworth said the North Channel was in balance so wouldn't transport more sediment.

Besson asked if we had a timeline for presenting this information to the GC. Smith stated we may have the Sed-Aug team put together a presentation for the GC meeting in March and discuss the pilot study idea with the GC. Jenniges stated the TAC could review the pilot study plan and then present the information to the ISAC to get their feedback prior to going to the GC.

Closing Business

Final comments on Sediment Augmentation Feasibility Analysis Report are due 1 February, 2011.

ED Office staff will meet with the Sediment Augmentation team to discuss Final Report and a design for a Pilot Study.