CHEHALIS RIVER WATER RETENTION PROJECT

Phase IIB Feasibility Studies

Scope of Work and Estimated Budgets

Prepared for Lewis County PUD

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November 13, 2009

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Phase IIB - Scope of Work and Estimated Budgets

EES Consulting (EESC) is currently assisting the Chehalis River Basin Flood Authority (Flood Authority) and Lewis County PUD (PUD) with economic, engineering, and environmental studies to determine the feasibility of water retention at two sites on the upper Chehalis River to mitigate flooding, increased summer flow and hydroelectric generation. The water retention concept consists of potential water retention structures on the upper Chehalis and the South Fork of Chehalis River. A Phase IIA geologic study was recently completed and found no fatal flaws regarding construction of the retention facilities. Assuming the Flood Authority and the PUD wish to move forward with Phase IIB, EESC has prepared this Scope of Work and Budgets for Phase IIB as was contemplated when Phase IIA was authorized.

Phase II B is proposed to continue the investigation and gathering of pertinent information on the water retention proposal to provide the best information for the Flood Authority, PUD, agencies, public and other stakeholders. This document presents EESC's outline of anticipated work scope and task budgets to accomplish Phase IIB. To summarize, the total projected budget for Phase IIB is provided below.

Table 1
Cost Estimates for Phase IIB

Economic Tasks	**Description**	**Estimated Budget**
EC 1	Update Damages Estimate	$20,000
EC 2	Army Corps of Engineers Coordination	35,000
EC 3	Value of Fish and Habitat	20,000
EC 4	Update Analysis	50,000
	TOTAL (Phase IIB Economic Tasks)	**$125,000**
Engineering Tasks	**Description**	**Budget**
Eng 1	Refinement of Desired Storage Volume	$7,500
Eng 2	Geotechnical Results Coordination	$12,000
Eng 3	Prepare Conceptual Drawings	$38,300
Eng 4	Reservoir Storage	$7,700
Eng 5	Project Operations	$10,500
Eng 6	Conceptual Construction Cost and Schedule	$24,000
Eng 7	Engineering Management and Client Meetings	$5,000
	TOTAL (Engineering Tasks)	**$105,000**
TOTAL ESTIMATED BUDGET - PHASE IIB TASKS		**$230,000**

The remainder of this document describes the detailed scope of work for the studies and tasks that are recommended to be accomplished in Phase IIB of the feasibility work, together with estimates of the budgets required for these activities.

Phase IIB Economic Analysis Scope of Work and Budget

Introduction

The economic analysis performed in Phase I of the feasibility studies was a high level reconnaissance analysis using available data to determine if the Chehalis River Water Retention project had economic potential. No additional work on the economic analysis was performed during Phase IIA. Phase IIB will focus on updating the analysis with new additional information and input from the U.S. Army Corps of Engineers (Corps) and other stakeholders.

After the Phase I benefit-cost study was circulated, several areas were identified for additional refinement. In addition, consultation with the Corps during Phase I resulted in a plan for updating the benefit-cost analysis so that it follows the methodology required by the Water Resources Development Act (WRDA) for federally funded projects. Specifically, the updated benefit-cost analysis will follow the *Economics and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies* (P&G). In addition to the P&G methodology, a second analysis will be included to examine additional costs and benefits that are important to local, state, and regional interests, in particular the environmental impact of the proposed facilities. This section of the Phase IIB scope of work will address the methodologies to be used and the areas in need of refinement for both proposed analyses.

Analysis 1: P&G Methodology

National Perspective

The Corps' P&G methodology evaluates costs and benefits as they occur across the nation as a whole. With some exceptions, flood control projects are generally chosen based on the results of a benefit-cost analysis from a national perspective, so the Corps' P&G methodology is chosen as the methodology for conducting a benefit-cost analysis for the proposed Chehalis River flood retention structures. Relevant national costs and benefits, attributable to the proposed projects, are described below. These values are monetized; non-monetized values are discussed later in this section.

National Costs

- Capital construction costs
- Operation, maintenance, and replacement
- Permitting costs, such as environmental studies and mitigation and siting

National Benefits

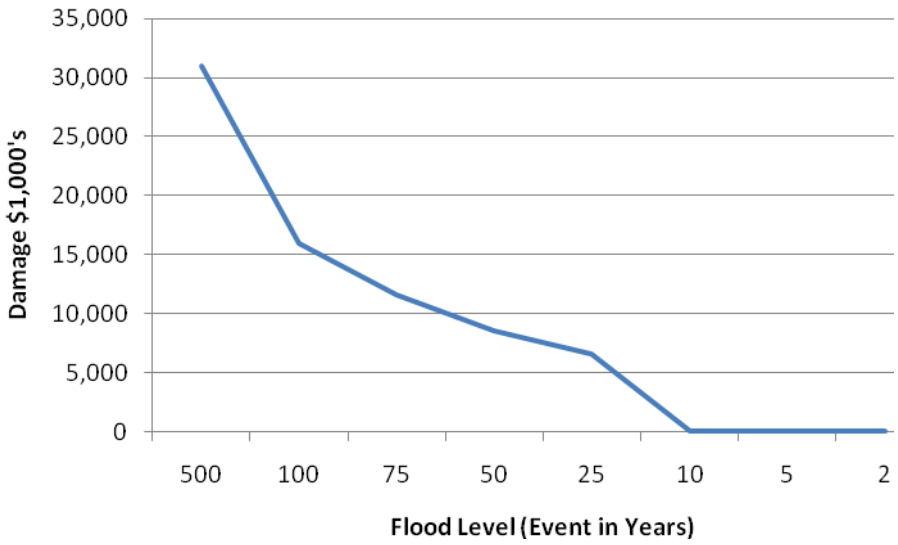
- Reduced estimated annual damage to building structures and contents, agriculture crops and equipment
- Avoided clean-up costs

- Avoided transportation delays or detours
- Avoided infrastructure improvement or operation and maintenance
- Reduced municipal water treatment costs
- Increased availability of water for irrigation or other use
- Value of hydropower and its renewable qualities
- Increased recreation visits

The Corps calculates the value of some of these benefits using complex modeling that results in "damage curves." Benefits include values such as avoided damages to building structures and contents, agriculture products and equipment, avoided clean-up costs, and avoided costs due to transportation delays and detours. A damage curve maps costs against flood levels, such as 500 year, 100 year, or other events. Figure 1 illustrates a sample damage curve.[1] In this example, as flood levels increase, damages increase exponentially. For example, a 25-year flood results in damages near $7 million. At the 100-year flood event, damages total over $15 million. Damage curves are calculated by estimating flood damages across the valley at several flood levels. The Corps may estimate these damages based on surveys of buildings and their heights relative to the flood plain.

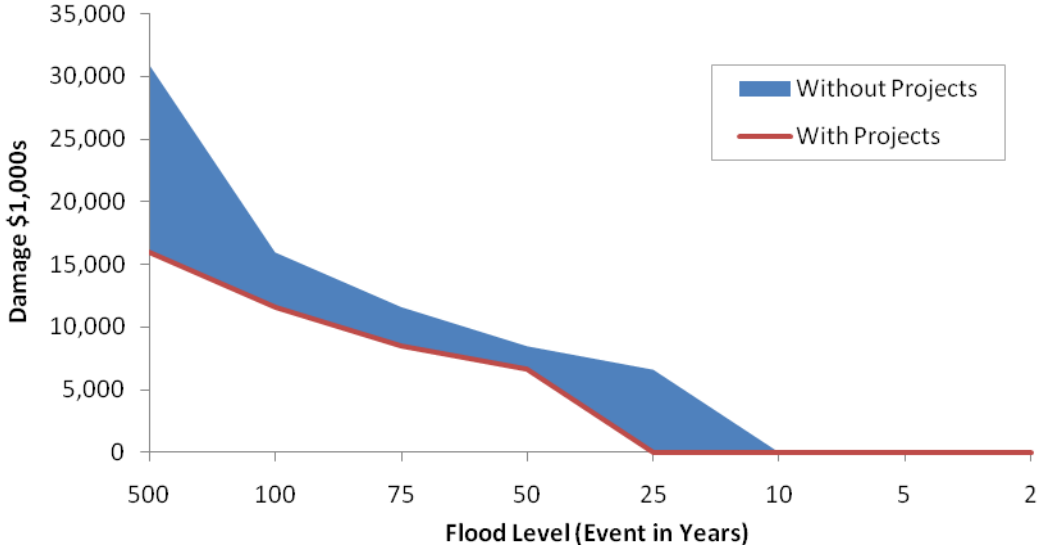
[1] The damage curves in the examples shown have not been smoothed. The U.S. Army Corps of Engineers uses a program to smooth the observations so that the damage curves do not appear to have kinks as shown in the curves in Figures 1 and 2.

Figure 1
Example Damage Curve



Once a flood control project is introduced, the damage curve will shift or change such that damages are reduced in some or all flood events. In the case of the proposed water retention facilities, the damage curve will shift to the left. Figure 2 shows such a sample shift. The benefit (in dollars) of the flood control project is the blue shaded area in Figure 2 (the difference between the curves).

Figure 2
Example of Reduction in Damage Curve



Because of the intensive data requirements for damage curve estimation, EES Consulting, Inc. will look to the Corps for assistance. It should be noted that updated damage curves estimated by the Corps that include the most recent flood events (2007 and 2009) are not available at this

time. In addition, the damage curves estimated in the 2003 Corps report only surveyed properties near the I-5 corridor. The Flood Authority is authorized and has the responsibility to develop a basin wide flood mitigation plan and to assess the benefit of flood mitigation options throughout the basin. Notably, over the past 20 years Chehalis River flooding has resulted in flood damages from Doty to Aberdeen and not just in the I-5 corridor and Chehalis and Centralia. In the event that the Corps might be unable to help estimate damage curves, EES Consulting is prepared to approximate these curves based on the best available information, without conducting exhaustive surveys of the damages to building, contents, or other property.

Regional Perspective

Regional benefits and costs may be included under a separate analysis according to the P&G; however, regional perspectives are not valued as highly as national perspectives when funding decisions are made in practice. The reason the regional perspective is not assigned as much value as the national perspective is because regional costs and benefits often transfer from one region to another. Since the Corps is a federally funded agency, projects must have favorable economics from a national perspective. For this study, however, state and regional benefits are important as stakeholders at the local, state and regional level will play an important part in determining the best overall solution based on a local and regional perspective. Regional benefits and costs include:

- Changes in property values
- Changes in local employment and business income
- Avoided lost business income

Qualitative Costs and Benefits

The P&G methodology is primarily a single purpose flood mitigation model, and therefore does not capture qualitative costs and benefits such as environmental effects. The P&G policy is not to monetize environmental costs and benefits, or other social effects (with the exception of historical properties). These effects are to be discussed qualitatively in the report. Even though the Corps would not strongly emphasize environmental effects, these are important to the flood retention projects due to local, state, and regional interests in improving river habitat. Particularly, there is concern that the repeated Chehalis River Basin flooding and summer water quality issues have been harmful to salmon and steelhead populations. Costs and benefits related to the projects are described below.

Environmental

- Changes in acreage of ecosystem coverage type, including lost terrestrial and riparian habitat, or gained lake/reservoir habitat
- Effects on fish and wildlife, including water quality changes, effects on salmon and steelhead spawning, rearing, and survival, effects of predatory animals resulting from changes in fish populations, and others
- Reduction in carbon dioxide or other air pollutants from possible eventual inclusion of hydropower

Other Social Effects

- Positive effects on historical or cultural properties
- Positive urban and community impacts, such as quality of community life or population distribution
- Beneficial effects on public safety, health, or life

EES Consulting proposes to discuss these environmental effects qualitatively for the first analysis, which follows the P&G methodology.

Summary

The table on the next page summarizes the costs and benefits as they were included in the Phase I study and compares those with proposed methodologies for the Phase IIB analysis.

Table 2		
	Phase I Economic Analysis	**Phase IIB Economic Analysis**
Expected Annual Damage	Projected estimated annual damage based on the 2003 Corps report EAD curves using the 100-year flood event data point.	Use of either damage curves estimated by the Corps or an approximation method.
Project Benefits		
National	**Building Structure & Contents** - Avoided cost of flood damage (expected annual damage) based on FEMA plus additional damages not paid by insurance or FEMA	Estimated annual damage to building structures and contents based on most recent flood events and reduced water levels due to retention facilities.
	Emergency Aid, Housing, and Supplies - Based on 2007 flood event and expectation of a 2007 flood event occurring in the future	Estimate based on damage curves
	I-5 Closure Costs in expected annual damage	Estimated using damage curves
	Avoided cost of raising I-5, DOT costs	Update costs from WA DOT
	Recreation Benefits - based on $/acre foot from other studies	Estimate specific to the Chehalis River Basin based on additional visits from projects
	Hydropower - Valued at market price	Valued at renewable, market price
	Water Quality Benefits to Agriculture and Municipalities - Estimated based on $/acre foot from other studies	Calculate based on reduced production costs
Regional	**Increased Property Values** - Insurance premium benefits used to value.	Refine estimates
	Increased Economic Activity - Washington State Input-Output model used to estimate the additional economic benefit from project construction, operation, and reduced damages	Include in regional analysis only
	Acres of Created Lake Habitat - Qualitative and quantitative analysis, acres of created lake habitat valued using preservation costs in Lewis County	Acres of created lake habitat - Provide qualitative analysis
Qualitative	**Wildlife Habitat and Other Environmental Effects** - Benefit quantified using secondary sources: Fish habitat = # of additional fish X value per fish	Qualitative discussion on total impact
	Other Social Effects - Not Included	Qualitative discussion of incremental effects on historic properties and Indian tribe interests
	Public Safety - Not Included	Qualitative discussion regarding incremental improvements in public safety such as safe drinking water during flood events, physical endangerment, and ability of emergency services to operate.
	Fish Habitat Benefits - Value by estimated increased fish production $/fish from mitigation expenditures in the Columbia River Valley	Provide qualitative analysis

Table 2 (continued)		
	Phase I Economic Analysis	**Phase IIB Economic Analysis**
Project Benefits (Continued)		
Qualitative	**Intrinsic Value** - Based on similar ecosystem contingent valuations $/household	Exclude from all P&G analyses
	Building Structure & Contents - Avoided cost of flood damage (expected annual damage) based on FEMA plus additional damages not paid by insurance or FEMA,	Estimated annual damage to building structures and contents based on most recent flood events and reduced water levels due to retention facilities.
Project Costs		
National	**Capital Construction Costs** - Reconnaissance level cost estimates from EESC Engineers	Update based on EESC Engineer's refined calculations
	Operation, Maintenance, & Replacement - Reconnaissance level cost estimates from EESC Engineers	Update based on EESC Engineer's calculations
Regional	Same as National	Same as National
Qualitative	**Lost Habitat** - Provided qualitative and quantitative analyses based on preservation values in Lewis County	Acres of lost riparian and terrestrial habitat
	Other Social Effects - Not Included	Identify costs to historical or cultural properties
	Public Safety – Not Included	Qualitative discussion regarding incremental improvements in public safety such as safe drinking water during flood events, physical endangerment, and ability of emergency services to operate.
	Environmental Impacts - Qualitative discussion	Identify additional environmental impacts to fish and wildlife habitat and discuss qualitatively

Analysis 2: Alternative Methodology

The secondary analysis proposed to address the additional benefits and costs not normally included in the P&G methodology is outlined as follows. Mainly, the alternative methodology will include monetized environmental quality values. Due to the difficulty in quantifying these costs and benefits, EESC conducted a literature review to approximate these values in Phase I. Environmental costs and benefits were defined as incremental values resulting from the projects. In cases where values for the Pacific Northwest were unavailable, the best available approximations were used, so to be conservative EESC projected the benefits on the low side and projected costs on the high end.

The Flood Authority has contracted with Earth Economics, an environmental economics firm, to help define the value of the affected environment. EESC will work collaboratively with Earth Economics to provide a comprehensive analysis of the projects effects on the environment.

Effects on Ecosystem

Earth Economics monetizes the natural environment according to the theory that natural capital and ecological services provide support to human well-being and economic activity. Examples of goods and services provided by natural capital include clean breathable air, disease prevention, climate maintenance, natural disaster mitigation, reduced erosion, agricultural productivity, plant pollination, and detoxification.

These goods and services are monetized according to several valuation methods depending on the type of good or service. Commonly, avoided cost and a measure of people's willingness to pay are used to value natural capital. The avoided-cost method is the same concept as the avoided flood damages applied to non-environmental capital. The willingness-to-pay method, also known as contingent valuation, is the gathering of values based on hypothetical scenarios. For example, people might state how much they would be willing to pay for increased preservation of beaches and shoreline.

Table 3 below compares the analytical assumptions in Phase I with the proposed analysis for Phase IIB.

In the event that some of the above data is not provided by Earth Economics, EESC is prepared to develop the data from existing resources. Such data development may require additional work which is not included in this scope and budget.

Table 3 Ecosystem Benefits and Costs		
	Phase I Economic Analysis	**Phase IIB: Earth Economics Data Needed***
Benefits		
Recreation	$ per additional acre-foot in summer months via contingent valuation (fishing and shoreline) Poudre River, CO	Number of additional recreational visits/year to the Chehalis River Basin resulting from projects and value for each visitation ($/visit/year) based on recreational activities.
Acres of created lake habitat	2,200 acres, not valued	Valued in terms of goods/services provided to the Chehalis River Basin, $/acre/year
Acres of enhanced riparian habitat	135 acres	Valued in terms of goods/services provided to the Chehalis River Basin, $/acre/year
Quality of Existing Fish and Wildlife Habitat	Measured in terms of value of additional fish production 5% increase in summer/fall migrating salmon and steelhead Valued at wildlife mitigation costs for the Columbia River Basin (BPA)	Valued in terms of total goods/services provided to the Chehalis River Basin (i.e. additional fish production, predators, other habitat enhancements), $/year, without double counting enhanced riparian habitat values above.
Intrinsic Value for Increased Water Quality	$ per household value based on contingent valuation study based in South Platte River basin in Colorado (existence & bequest)	Valuation for intrinsic value of additional summer flow in the Chehalis River Basin, $/year.
Costs		
Acres of Lost terrestrial habitat	2,200 acres valued at $31/acre according to Lewis County Forest Habitat Conservation Plan cost of $4M to conserve 130,000 acres	Valued in terms of goods/services provided to the Chehalis River Basin, $/acre/year
Acres of lost riparian habitat	63.2 acres valued at $31/acre according to Lewis County Forest Habitat Conservation Plan cost of $4M to conserve 130,000 acres	Valued in terms of goods/services provided to the Chehalis River Basin, $/acre/year
Quality of Existing Fish and Wildlife Habitat	Reconnaissance-level study of qualitative costs	Valued in terms of goods/services provided to the Chehalis River Basin (i.e. reduction in fish production, predators, other habitat degradations), $/year

*The above data needs are best-case scenario data requirements. Specific Chehalis River Basin values may be unavailable or prohibitively expensive to estimate.

Task Descriptions for Phase IIB Economic Analyses

- *Task 2B-1—Refine Estimates of Damages from Flooding*

  Within this task, the more generic estimates of the regional and national damages caused by flooding will be refined. Economic losses in the areas of buildings and contents, agriculture, and transportation will be updated via a more global search of the relevant literature.

- *Task 2B-2— Army Corps of Engineers Coordination*

  The Corps calculates the value of some of these benefits using complex modeling that results in "damage curves." A damage curve maps costs against flood levels, such as 500 year, 100 year, or other events. This task would further expand on the cooperation with the Corp and if possible estimated annual damages and probability of occurrence will be calculated in close coordination with the Army Corps of Engineers.

- *Task 2B-3—Update the Value of Increased Number of Fish and Quality/Quantity of Habitat*

  In the Phase I study, only very rough estimates of the value of enhanced fish production were attempted. In Phase IIB, a much more refined analysis will be undertaken from alternative sources to narrow the value associated with increased fisheries resources and improved habitat throughout the Chehalis River Basin. EES Consulting will coordinate with Earth Economics to estimate relevant ecosystem costs and benefits.

- *Task 2B-4—Update Benefit Cost Analysis*

  After the aforementioned improvements in the economic metrics have been made, new Project construction costs determined and permitting needs refined, a new benefit-to-cost analysis will be undertaken. The economic analysis will consist of an assessment that follows the methodologies used by the Army Corps of Engineers as well as the secondary analysis described above. An updated Phase IIB report will also be produced, which includes the findings of the entire Phase II effort and the most recent flood events (2007 and 2009).

Proposed Budget and Schedule

This section of the Phase IIB study cannot be completed until all of the engineering work is completed; however, it is estimated that 2-4 months will be needed to complete the economic analysis once the data is available. The budget for this segment of the Phase IIB benefit cost study is summarized in Table 4.

Table 4
Cost Estimates for Economic Section of Updated Benefit Cost Study

Task	Description	Estimated Costs*
EC 1	Damages	$20,000
EC 2	Army Corps of Engineers Coordination	35,000
EC 3	Value of Fish and Habitat	20,000
EC 4	Update Cost-Benefit Analysis	50,000
	TOTAL	**$125,000**

*Costs include only EESC employee labor and expenses. Additional charges may be incurred with the participation of Earth Economics and/or the Army Corps of Engineers.

Phase IIB Scope of Work and Estimated Budgets for Engineering Concept Development

Introduction

In Phase IIA, EESC and its subcontractor Shannon and Wilson performed site geology and geotechnical reconnaissance to characterize the foundations and abutments for the potential retention structures, develop soils and rock data to help guide conceptual design, and to identify any potential "fatal flaws" associated with either retention site. Seismic refraction subsurface test programs were conducted to estimate depth of overburden and depth of the bedrock under the facility foundations. The results of this work are presented in two reports written by Shannon & Wilson geotechnical consultants: a Geology Report and a Geotechnical Report. Several issues were identified at each potential site, but it was concluded that these issues could be effectively addressed during design. No fatal flaws, such as unsuitable foundations, or active earthquake faults under the potential sites, were identified, with the caveat that these conclusions will eventually need to be confirmed through sub-surface investigations (core drilling, etc.). Based on the results of the Phase IIA studies, beginning work to develop the conceptual layouts and refine construction quantities and costs for the potential retention structures makes sense.

The goal of Phase IIB for the engineering feasibility is to develop conceptual drawings of both facilities showing preferred location, cross-sections, and locations of outlet works and spillways, and then to use these concept drawings to refine construction costs. At the end of Phase IIB engineering work, conceptual cost estimates will be available as input to the cost/benefit analysis

If the Flood Authority, PUD, and other stakeholders believe the results of Phase II warrant continuing the investigation to gather information to better define water retention for flood mitigation, future (Phase III) engineering and environmental activities would include development of more detailed drawings, instream flow studies and conducting sub-surface geotechnical explorations to support final design (Phase IV).

Tasks to complete Phase IIB are as follows:

- *Task 2B-1—Refinement of Desired Storage Volume*

  This task will refine the storage requirements based on prior studies, available data and operational modeling for the Project both with and without a hydropower component. This task will address questions raised in the January 7, 2009 letter from the Washington State Department of Ecology relative gage data and area discharge flows, storage volume requirements for flood control and summer flow augmentation. This work will be needed to perform Task 2B-2.

- *Task 2B-2—Geotechnical Results Coordination*

  Geology and geotechnical findings in Phase 2A developed by Shannon & Wilson will be incorporated into the conceptual design. Several meetings between EESC engineers and

Shannon & Wilson will be conducted to coordinate the design and Shannon & Wilson engineers will review conceptual design.

- *Task 2B-3—Prepare Conceptual Drawings*

  The LiDAR topography (already available) will be used to set the locations of the potential facilities, outlet works and spillways. The crest elevations will be set based on the Project site topography, required storage volume and estimated spillway capacity. A conceptual plan, profile and cross section of each project will be developed and used as the basis for future geotechnical investigations, engineering and other technical studies. The potential footprint will be carried down to actual ground topography. Site plans showing upstream inundation areas at full reservoir level will also be developed. Conceptual arrangements for potential hydropower additions will also be developed.

- *Task 2B-4—Reservoir Storage*

  Relationships of water elevations (stage), storage, and surface areas will be refined using LiDAR topography and the conceptual design drawings. Areas inside map contours will be measured using computer aided drafting software. The areas will be used to calculate volumes at various water levels. Using Excel, the calculated data will be plotted to develop curves of stage versus storage, and stage versus surface area.

- *Task 2B-5—Project Operations*

  Based on the above tasks, a memo will be prepared describing the expected operation of the Projects for water retention and flood control, as well as for instream flow and the optional hydropower production facility. This information will be useful in understanding the potential impacts on downstream aquatic resources.

- *Task 2B-6—Construction Cost and Schedule*

  Based on the information developed in Task 2B-2, an updated conceptual construction cost and schedule will be developed. This information will assist in better understanding Project costs and in refining benefit/cost ratio analyses.

- *Task 2B-7—Engineering Management and Client Meetings*

  This task budget covers EESC internal management and QA/QC processes as well as budget allowance for meetings with the Client and project stakeholders to present findings and recommendations.

Phase IIB Proposed Budget and Schedule

Table 5 presents the Phase IIB proposed tasks and their associated budgets for the engineering concept development tasks.

Table 5
Phase IIB Proposed Engineering Tasks and Estimated Budget

Phase IIB Task #	Description	Budget
Eng 1	Refinement of Desired Storage Volume	$7,500
Eng 2	Geotechnical results Coordination	$12,000
Eng 3	Prepare Conceptual Drawings	$38,300
Eng 4	Reservoir Storage	$7,700
Eng 5	Project Operations	$10,500
Eng 6	Conceptual Construction Cost and Schedule	$24,000
Eng 7	Engineering Management and Client Meetings	$5,000
	TOTAL	**$105,000**

It is anticipated that the above tasks can be completed within five months following the notice to proceed.

Phase IIB – Total Estimated Budget

Based on the provided scope for the economic and engineering work to be performed in Phase IIB, EES Consulting has estimated the total projected budget for Phase IIB.

Table 1 Cost Estimates for Phase IIB		
Economic Tasks	**Description**	**Estimated Budget**
EC 1	Update Damages Estimate	$20,000
EC 2	Army Corps of Engineers Coordination	35,000
EC 3	Value of Fish and Habitat	20,000
EC 4	Update Analysis	50,000
	TOTAL (Phase IIB Economic Tasks)	**$125,000**
Engineering Tasks	**Description**	**Budget**
Eng 1	Refinement of Desired Storage Volume	$7,500
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Eng 4	Reservoir Storage	$7,700
Eng 5	Project Operations	$10,500
Eng 6	Conceptual Construction Cost and Schedule	$24,000
Eng 7	Engineering Management and Client Meetings	$5,000
	TOTAL (Engineering Tasks)	**$105,000**
TOTAL ESTIMATED BUDGET - PHASE IIB TASKS		**$230,000**

It is anticipated that the above tasks can be completed within five months following the notice to proceed.