SCOPE OF WORK
Skagit River, WA
Skagit River Flood Damage Reduction Feasibility Study
Baker River Dams Storage Evaluation

A. Scope of Work. Engineering services to be provided by Skagit County under this delivery order (D.O.) will be to participate in and provide hydraulic engineering expertise for an evaluation of the optimal flood storage that can be utilized for Lower and Upper Baker Dams to reduce flood damages for the Skagit River floodplain.

B. Services to be performed. Skagit County will provide the following services under this D.O. as an in-kind service under the FCSA:

Optimization of Flood Storage Evaluation.
A complete evaluation of flood control utilizing the Baker projects will be performed. This includes the following elements:

1. **Upper Baker Dam Optimization in Isolation**
Determine the benefits that Upper Baker Dam can provide by itself for 3 new conditions. This work will require the following elements:

a. Determine maximum storage that provides noticeable downstream benefits.

b. Modify existing USACE HEC-5 model for 3 new rule curve conditions to include the maximum useful storage and two other conditions between the maximum and the existing condition (i.e., if 100,000 acre-feet is the maximum and existing is 74,000 acre-feet, then 82,500, 91,000 acre-feet, and 100,000 acre-feet could be chosen)

c. Route 10-, 25-, 50-, 75-, 100-, 250-, 500-year flows through the 3 new HEC-5 models to produce the peak flow hydrology at Concrete for the 3 new rule curve conditions.

d. Run the 5% and 95% chance of exceedance inflows for the 10-, 25-, 50-, 75-, 100-, 250-, 500-year events through the 3 new HEC-5 models to characterize the hydrologic uncertainty at Concrete (42 runs).

e. Provide Exceedance Probability Function with Uncertainty data for the Skagit River at Concrete in electronic HEC-FDA format to the Corps of Engineers (Corps).

(**NOTE:** Corps/Tetra Tech will then run the existing condition HEC-FDA model to determine damages, residual damages and damages reduced downstream of Sedro-Woolley).

Corps/Skagit County Decision Point: Do these damages reduced appear large enough to continue evaluating flood storage at Upper Baker? If so, then evaluate whether the dam meets Probable Maximum Flood Standards.

f. Develop the Probable Maximum Flood for Upper Baker Dam to HMR-57 standards.

g. Route Probable Maximum Flood through Upper Baker using the existing condition HEC-5 model developed by the Corps following the guidelines set out in Section 13-5 in EM 1110-2-1417.

h. Evaluate dam structures (spillway, outlet works, etc. with necessary freeboard) to see if they meet USACE standards (see ER 1110-8-2 and Chapter 14 of EM 1110-2-1420 for requirements).

(**NOTE:** If no structural modifications are necessary then move forward with power loss computations by the Corps' Northwestern Division for the 3 new conditions. Seattle District economist will then compute a benefit-to-cost (B/C) ratio. If B/C ratio is positive, then Skagit County will evaluate environmental issues and develop estimates of associated environmental costs.)

(**NOTE:** B/C ratio will need to be recomputed when environmental costs are known).

Corps/Skagit County Decision Point: If current dam needs to be structurally modified to meet the PMF standard, then the following items are required:

i. Determine new spillway design that will meet the structural standards set in EM 1110-2-2400, the hydraulic criteria set in EM 1110-2-1603, and the hydrologic criteria set in EM 1110-2-1420 so that an appropriate cost can be derived for this structure.

j. Design new outlet works that will meet the structural standards set in EM 1110-2-2400, the hydraulic criteria set in EM 1110-2-1602, and the hydrologic criteria set in EM 1110-2-1420 so that an appropriate cost can be derived for this structure.

k. Modify HEC-5 models to reflect changes in the dam due to the PMF improvements and re-run the 3 new rule curve conditions and the existing condition.

l. Route 10-, 25-, 50-, 75-, 100-, 250-, 500-year flows through the 4 new HEC-5 models to produce the peak flow hydrology at Concrete for the 4 new reservoir conditions.

m. Run the 5% and 95% chance of exceedance inflows for the 10-, 25-, 50-, 75-, 100-, 250-, 500-year events through the 4 new HEC-5 models to characterize the hydrologic uncertainty at Concrete (56 runs).

n. Provide Exceedance Probability Function with Uncertainty data for the Skagit River at Concrete in electronic HEC-FDA format to the Corps of Engineers (Corps).

(**NOTE:** Corps/Tetra Tech will then re-run the existing condition HEC-FDA model to determine damages, residual damages and damages reduced downstream of Sedro-Woolley. If these damages reduced exceed the costs of improving the dam to PMF standards, then power loss computations by the Corps' Northwestern Division for the 4 new conditions will be calculated. Seattle District economist will then compute a benefit-to-cost (B/C) ratio. If B/C ratio is positive, then Skagit County will evaluate environmental issues and develop estimates of associated environmental costs.)

(**NOTE:** B/C ratio will need to be recomputed when environmental costs are known).

2. **Lower Baker Dam Optimization in Isolation**

Determine the benefits that Lower Baker Dam can provide by itself for 4 conditions. This work will require the following elements:

a. Collect data to help develop a reservoir routing model for Lower Baker Dam.

b. Develop an existing condition reservoir routing model for Lower Baker Dam. The model must be in a format in which the Corps has free access to, which restricts the analysis to be done with either HEC-5 or HEC-ResSim.

c. Develop the Probable Maximum Flood for inflow to Lower Baker Dam that is not coming from Upper Baker Dam. The PMF is to be developed to HMR-57 standards.

d. Route outflow from HEC-5 existing condition PMF run for Upper Baker Dam and inflow developed in part 2.a above through the Lower Baker Dam model following the guidelines set out in Section 13-5 in EM 1110-2-1417.

e. Evaluate dam structures (spillway, outlet works, etc. with necessary freeboard) to see if they meet Corps standards (see ER 1110-8-2 and Chapter 14 of EM 1110-2-1420 for requirements).

Corps/Skagit County Decision Point: If current dam needs to be altered to meet the PMF standard, a reconvening is necessary to lay out what needs to be modified and what is the best way to get this done. It is likely for Lower Baker Dam that major modifications will be necessary. If this is the case, task 2.r and 2.s below will be necessary to perform first to determine what the structure will look like to perform the rest of the analysis. If no alterations are required, the analysis can start with the following:

f. Develop Rule Curve from the guidelines in Chapter 3 of EM 1110-2-3600 for an improved spillway (one in which the spillway gates are modified so they can be remotely operated).

g. Develop Spillway Regulation Schedule for an improved spillway that makes the current spillway gates operational. This schedule should be developed following Chapter 4 of EM 1110-2-3600.

h. Develop a HEC-5/HEC-ResSim model of Lower Baker Dam with improved spillway.

i. Develop Rule Curve from the guidelines in Chapter 3 of EM 1110-2-3600 for Lower Baker with new outlet works that allows full utilization of the reservoir for flood control.

j. Develop Spillway Regulation Schedule for improved dam with new outlet works. This schedule should be developed following Chapter 4 of EM 1110-2-3600.

k. Develop a HEC-5/HEC-ResSim model of Lower Baker Dam with new outlet works.

l. Develop Rule Curve from the guidelines in Chapter 3 of EM 1110-2-3600 for Lower Baker with new outlet works that only uses half of the space between the bottom of the spillway gates and an empty pool.

m. Develop Spillway Regulation Schedule for improved dam with new outlet works that only uses half of the space between the bottom of the spillway gates and an empty pool. This schedule should be developed following Chapter 4 of EM 1110-2-3600.

n. Develop an additional reservoir model with the new outlet works, which utilizes only half the storage between the bottom of the spillway gates and the bottom of the reservoir.

o. Route 10-, 25-, 50-, 75-, 100-, 250-, 500-year flows through the three new reservoir models to produce the peak flow hydrology at Concrete for the 4 conditions.

p. Run the 5% and 95% chance of exceedance inflows for the 10-, 25-, 50-, 75-, 100-, 250-, 500-year events through the 3 new reservoir models to characterize the hydrologic uncertainty at Concrete (42 runs).

q. Provide Exceedance Probability Function with Uncertainty data for the Skagit River at Concrete in the HEC-FDA format to the Corps of Engineers (Corps).

(**NOTE:** Corps/Tetra Tech will then run the existing condition HEC-FDA model to determine damages, residual damages and damages reduced downstream of Sedro-Woolley).

Corps/Skagit County Decision Point: Are these benefits large enough to continue evaluating flood storage at Lower Baker? If yes, then compute power losses.

(**NOTE:** Power losses will be computed by the Corps' Northwestern Division for 3 new conditions. Benefit-to-cost ratio will be computed by Seattle District).

Corps/Skagit County Decision Point: Do the benefits still largely outweigh the power loss costs presented so far? If yes, then conduct analysis to estimate cost of required modifications to Lower Baker Dam.

r. Determine new spillway design that will meet the structural standards set in EM 1110-2-2400, the hydraulic criteria set in EM 1110-2-1603, and the hydrologic criteria set in EM 1110-2-1420 so that an appropriate cost can be derived for this structure.

s. Design new outlet works that will meet the structural standards set in EM 1110-2-2400, the hydraulic criteria set in EM 1110-2-1602, and the hydrologic criteria set in EM 1110-2-1420 so that an appropriate cost can be derived for this structure.

Corps/Skagit County Decision Point: Do the benefits still outweigh all costs? If yes, then Skagit County will evaluate environmental issues and develop estimates of associated environmental costs.

(**NOTE:** The B/C ratio will need to be recomputed when environmental costs are known).

3. **Use of Upper and Lower Baker Dams in Conjunction**

Determine the benefits that the combined use of Upper and Lower Baker Dams can provide to maximize benefits. This work will require the following elements:

a. Determine which of the Upper and Lower Baker scenarios provide the largest B/C ratio. Keep that dam (first added) scenario constant while changing the other dam (second added) to the three different conditions laid out in the above analyses.

b. Route 10-, 25-, 50-, 75-, 100-, 250-, 500-year flows for all 3 of these conditions.

c. Run the 5% and 95% chance of exceedance inflows for the 10-, 25-, 50-, 75-, 100-, 250-, 500-year events through the 3 reservoir models to characterize the hydrologic uncertainty at Concrete (42 runs).

d. Provide Exceedance Probability Function with Uncertainty data for the Skagit River at Concrete in electronic HEC-FDA format to the Corps of Engineers (Corps).

(**NOTE:** Corps/Tetra Tech will then run the existing condition HEC-FDA model to determine damages, residual damages and damages reduced downstream of Sedro-Woolley).

Corps/Skagit County Decision Point: Are these benefits large enough to continue evaluating flood storage? If yes, then

(**NOTE:** Power losses will be computed by the Corps' Northwestern Division for 3 conditions).

Corps/Skagit County Decision Point: Do the benefits still largely outweigh the Power Loss costs presented so far? If yes, then add in the design costs of the modifications derived in r and s of part 2 or perform this work if not done as part of 2. Do the benefits still outweigh the costs? If yes, then Skagit County will evaluate environmental issues and develop estimates of associated environmental costs.

(**NOTE:** The B/C ratio will need to be recomputed when environmental costs are known).

(**NOTE:** This analysis is designed in a way that the Corps can appropriately respond to the results if additional flood storage is proposed for Upper and/or Lower Baker Dams through the FERC process. It is not designed to meet the standards of a complete alternative analysis for a flood damage reduction study.)

C. Government - Furnished Data and Services. The Corps' Seattle District will furnish the following to Skagit County:

1. Hydrology developed for Skagit River Flood Damage Reduction Study, which includes 10-, 25-, 50-, 75-, 100-, 250-, and 500-year events.

2. Existing Condition HEC-5 Models of Upper Baker Dam.

3. Links to the referenced engineering manuals, regulations, and technical letters are as follows:

EM 1110-2-1417 - http://www.usace.army.mil/publications/eng-manuals/em1110-2-1417/toc.htm
EM 1110-2-1420 - http://www.usace.army.mil/publications/eng-manuals/em1110-2-1420/toc.htm
EM 1110-2-1602 - http://www.usace.army.mil/publications/eng-manuals/em1110-2-1602/toc.htm
EM 1110-2-1603 - http://www.usace.army.mil/publications/eng-manuals/em1110-2-1603/toc.htm
EM 1110-2-1619 - http://www.usace.army.mil/publications/eng-manuals/em1110-2-1619/toc.htm
EM 1110-2-2400 - http://www.usace.army.mil/publications/eng-manuals/em1110-2-2400/toc.htm
EM 1110-2-3600 - http://www.usace.army.mil/publications/eng-manuals/em1110-2-3600/toc.htm
ER 1110-8-2 - http://www.usace.army.mil/publications/eng-regs/er1110-8-2(FR)/toc.htm
ETL 1110-2-537 - http://www.usace.army.mil/publications/eng-tech-ltrs/etl1110-2-537/toc.html

4. Any other engineering manuals, regulations, and standards, which might be needed by Skagit County for completion of this delivery order will be available upon request.

D. Coordination. During the progress of the work, Skagit County shall maintain periodic coordination with the COE to assure the orderly progression and completion of the work. Skagit County shall provide immediate notification to the Contracting Officer, if at any time during the review, certain elements or features of the proposed assumption, design and/or analysis are found to be in error to such a degree that the problem cannot be corrected without wholesale revision to the entire design.

E. Submission. All items furnished to Skagit County will be returned to the COE. All technical analysis and backup materials generated as a result of this work order will be reviewed by the Corps prior to public release.

F. Technical Review. The technical analysis for additional flood control storage will be technically reviewed by the Corps. The Corps will prepare a write-up that details the results of the technical review. Skagit County will address technical review comments provided by the Corps and respond in writing to the review comments and revise the technical analysis as necessary. A back-check will be performed by the Corps to verify that review comments have been appropriately responded to in the technical analysis.

G. Progress Schedule. Time allowances for the completion of this work order are shown below. Skagit County shall furnish sufficient technical, supervisory, and administrative personnel to ensure execution of work in accordance with approved progress schedule. Skagit County shall keep the Corps' Seattle District closely advised at all times concerning the details or problem areas which may adversely affect completion or require extensive revision of the work in accordance with provisions of this work order.

Work Item	Schedule (after NTP)