

## **WATERSHED SCIENCE & ENGINEERING, INC.**

### **Detailed Work Plan:**

This work plan was developed by Watershed Science and Engineering (WSE) in coordination with the Chehalis River Basin Flood Authority (Flood Authority) to define the tasks necessary to develop hydraulic modeling and analysis of the Chehalis River to address the ESHB 2020 requirement “to complete the hydraulic model for the Chehalis river to calculate flood levels, flood damages, and benefits of proposed flood mitigation projects for the lower portions of the river”. In addition, the work plan outlines other tasks that will be conducted to aid the Flood Authority to accomplish its goals and objectives. For each task the work plan outlines the scope, schedule, and budget. A more detailed budget breakdown is provided in Table 1 at the end of this document.

### **Task 1 - Overall Project Management, Stakeholder Involvement, Regular Communication with Flood Authority**

WSE will be responsible to the Flood Authority for the overall management of the model development project. This will include making sure work is completed and delivered in a timely manner and that agreed upon schedules and budgets are met. WSE will administer the contract including providing monthly invoicing and progress reports. In addition, WSE will lead consultant team presentations to the Flood Authority coincident with key milestones and as necessary to keep the Flood Authority fully informed about the status of the work. WSE will also coordinate stakeholder input to the model development project to ensure key objectives are understood and, to the extent possible, met within this project. WEST Consultants will provide support in the form of presentations and communications to the Flood Authority.

WSE will lead this task with support from WEST Consultants.

**Projected Task Completion Date:** This Task will extend through the duration of the Contract with the Flood Authority.

**Task Budget:** \$36,738

### **Task 2 - Initial Basin Reconnaissance**

Conduct targeted field reconnaissance of the basin, contact key stakeholder groups, coordinate with the State technical team, gather information (including topographic and survey data), begin stakeholder involvement process, elicit modeling goals and objectives of key stakeholders, determine extent of past and concurrent modeling efforts (FEMA, USACE, Anchor, WEST Consultants, etc.). (Input from WEST Consultants will be particularly important for working with the USACE to understand their current modeling efforts in the lower Chehalis basin).

WSE will lead this task with support from WEST Consultants.

**Projected Task Completion Date:** October 30, 2011.

**Task Budget:** \$9,428

### **Task 3 - Conduct Adequacy Review of Existing Floodplain Topographic and LiDAR Data**

This task has been deferred. No work is currently planned on this task.

### **Task 4 - Detailed Work Plan Development**

This detailed Work Plan has been developed to guide the remaining tasks in the Chehalis River hydraulic model development project. The Work Plan includes schedule milestones, scope information and estimated costs for each task. Table 1 provides a detailed summary of the level of effort.

This draft Work Plan may be distributed by the Flood Authority to interested agencies and Tribes for review and comment. Any comments received from the agencies and Tribes will be reviewed by the Flood Authority and forwarded to WSE to respond to in a final Work Plan. The Flood Authority shall review and approve the final Work Plan prior to it becoming effective. The final Work Plan shall be incorporated into the Agreement between WSE and Lewis County and shall be subject to all terms and conditions of that Agreement. The Work Plan may subsequently be amended by mutual consent of the parties with the approval of the Flood Authority.

WSE will lead this task with support from WEST Consultants.

***Projected Task Completion Date:*** October 20, 2011.

***Task Budget:*** \$19,690

### **Task 5 - Refine USACE Hydraulic Model to reflect Flood Authority Interest**

WEST Consultants is currently under contract to the USACE to develop a hydraulic model of the Chehalis River (Pe Ell to Montesano with the exception of Grand Mound to Porter) under the Basin-wide General Investigation (GI). The USACE project includes collection of bathymetric survey data for model cross sections in several reaches and the development of hydrologic data for the basin. Based on stakeholder input, the Flood Authority may desire to have the WSE project team modify, enhance, or refine that hydrologic and hydraulic modeling effort to better facilitate modeling and analysis related to key stakeholder objectives.

The following sub-tasks have been identified and included in the detailed work plan:

#### **Task 5a - Obtain new channel survey data for the Chehalis River between Grand Mound**

(RM 60.6) and Porter (RM 33) - The Corps Twin Cities hydraulic model includes cross sections in this reach but the exact location of those cross sections cannot be determined from the available model documentation. A portion of the reach, from RM 41 to Grand Mound, was surveyed by Minister Glaeser in 2001 for the Corps but that survey data is now more than 10 years old and not likely to be representative of current channel conditions. Given these facts, and knowing that a reliable model of this reach is critical for meeting ESHB 2020 requirements, additional survey data collection to support model development for this reach (Task 5b) is needed.

Survey data collection will be conducted by PGS or another sub-consultant.

**Projected Sub-Task Completion Date:** November 15, 2011.

**Sub-Task Budget:** \$38,365.

**Task 5b - Refine model of Chehalis River between Lewis/Thurston County line and Porter -**

This reach is in the Twin Cities hydraulic model and additional model development for this reach is not currently part of the Corps GI study contract. However, the past modeling work by the Corps and/or FEMA did not include georeferencing or otherwise cleaning up this reach of the model. The current model can be used to produce water level information but it cannot be used for automated floodplain mapping. Further, the accuracy and/or reliability of the simulations in this reach of the model have not been evaluated to our knowledge. This task entails developing a new hydraulic model using the cross section data described in Task 5a and the 2002 PSLC LiDAR data. Some level of model validation or calibration will be conducted; however, the validation effort is not expected to be significant.

WEST Consultants will be primarily responsible for this sub-task

**Projected Sub-Task Completion Date:** December 15, 2011.

**Sub-Task Budget:** \$31,873

**Task 5c - Extend Corps Hydraulic Model downstream from Montesano to Aberdeen -** the

GI Study contract includes development of a hydraulic model for the Chehalis River upstream of the confluence with the Wynoochee River at Montesano. The Chehalis River reach downstream of the Wynoochee River confluence is significantly tidally influenced and potentially more hydraulically complex due to significant side channels and backwater channels in the floodplain. The Corps felt that accurately modeling this area would require a 2-dimensional hydraulic model (HEC-RAS is a 1-dimensional model). Despite the complexity involved in the lower reach we believe that this reach could be modeled using HEC-RAS, although the modeling might be subject to greater uncertainty than the less complex reaches upstream. In order to extend the model to Aberdeen additional channel and overbank survey data would also need to be collected. Model development for this reach may require some additional hydrologic analysis to provide inflows for hydraulic model calibration and validation.

WSE will be primarily responsible for this sub-task with survey support from PGS

**Projected Sub-Task Completion Date:** December 15, 2011.

**Sub-Task Budget:** Survey \$17,000 (channel) \$12,500 (overbank), model development \$53,165, Total \$82,665

**Task 5d - Refine hydraulic model of main stem Chehalis River -** as noted previously WEST is currently working with the Corps to develop a hydraulic model of the mainstem Chehalis River from Montesano to Pe Ell. However, the model may not be sufficiently detailed in all locations to meet the needs of the Flood Authority and stakeholders. To the extent that the Flood Authority identifies particular areas of interest for hydraulic modeling along the main stem the intent of this task would be to evaluate the Corps model and refine it as necessary meet the needs of the Flood Authority and stakeholders. This task

will be done in two phases, the first to identify areas of interest for refined hydraulic modeling and specific data requirements and the second to refine the model. The scope for this sub-task will be refined in collaboration with the Flood Authority Project sub-committee following initial information collection.

**Projected Sub-Task Completion Date:** to be determined.

**Sub-Task Budget:** \$ 7,500 (preliminary budget assumed based on available project funding)

**Total Task Budget:** \$160,403

### **Task 6 - Extend Hydraulic Modeling (Including Survey, Hydrology and Hydraulics)**

It is anticipated that the work currently being done by WEST Consultants for the USACE can be leveraged extensively to meet the needs for hydraulic modeling in the lower Chehalis River. If this proves to be true, it will free up resources to allow the Flood Authority to conduct additional modeling efforts to meet stakeholder needs. The detailed work plan developed in Task 4 will define which rivers/reaches will be modeled and whether additional survey and/or hydrologic data development is required.

The following sub-tasks have been identified and included in the detailed work plan:

**Task 6a - Expand or refine Corps hydrology analysis** – This sub-task has been deferred. No work is currently planned on this task.

**Task 6b - Refine/revise/extend hydraulic modeling of tributaries** - (Satsop River, Black River, Skookumchuck River, Newaukum River) – as noted previously the Twin Cities hydraulic model includes tributaries but these may not be in the model correctly. Furthermore the tributary models may be outdated, limited in extent, or poorly configured. The intent of this task would be to evaluate the existing models, refine them as possible, replace them as necessary, and extend them as desired to meet the needs of the Flood Authority and stakeholders. Tributaries within the new model reach downstream of Grand Mound will also be evaluated for additional modeling. This task will be done in two phases, the first to obtain any previous hydraulic modeling and identify additional modeling needs and the second to develop the tributary models. The scope for this sub-task will be refined in collaboration with the Flood Authority Project sub-committee following initial information collection.

**Projected Sub-Task Completion Date:** to be determined.

**Sub-Task Budget:** \$ 60,000 (preliminary budget assumed based on available project funding)

**Task 6c - Review and refine Twin Cities model cross section layout** – This sub-task has been deferred. No work is currently planned on this task.

**Task 6d - Re-cut cross sections using “best available” LiDAR** – This sub-task has been deferred. No work is currently planned on this task.

**Total Task Budget:** \$ 60,000 (preliminary budget assumed based on available project funding)

### **Task 7 - QA/QC Technical Review of WEST Consultants Hydrologic and Hydraulic Modeling**

Under the USACE Contract, WEST Consultants will develop hydrologic data for the Chehalis River basin and calibrate the Baseline Hydraulic Model of Chehalis River. This work is expected to be complete by December 31, 2011. As previously described, the USACE model may be refined and/or expanded under the Flood Authority Contract. To the extent possible, the refined/expanded model will be calibrated by WEST Consultants as part of its work for the USACE. If significant model refinements or modifications make it necessary for additional model calibration to be conducted under the Flood Authority contract, that work would be done under Tasks 5 and 6. Through the USACE work and Tasks 5 and 6 of this contract, baseline hydrologic and hydraulic modeling and analysis will be developed. These baseline analyses will be subject to independent technical review to ensure they adequately meet the needs and objectives of the Flood Authority as defined in the work plan.

WSE will lead this task.

**Projected Task Completion Date:** January 15, 2012.

**Task Budget:** \$ 13,215

### **Task 8 - Technical Evaluation, Reporting of Flood Relief Alternatives to Flood Authority**

A range of possible flood damage reduction projects are under consideration for the upper areas of the Chehalis River. These include (1) upstream storage projects on the Upper Chehalis, South Fork Chehalis and Skookumchuck Dams, (2) USACE proposed levee modifications and (3) combinations of storage and levee projects. WSE will lead this task with support from WEST Consultants for the evaluation of the USACE Levee Project and Skookumchuck storage.

**Task 8a** - Under this sub-task, alternative upstream conditions will be evaluated and compared to the baseline condition. Specific activities shall include definition of alternative upstream conditions, hydraulic modeling and analysis, and reporting of results. The alternative to be modeled under Task 8a includes the proposed upstream retention facility on the main stem Chehalis River above Pe Ell. The hydrologic effect of the upstream retention facility will be determined either from previous analyses or by running the upstream model. The effect of the upstream projects will be input to the lower Chehalis River made as a change in the hydrologic input at the upstream end of the model. The lower Chehalis River model will then be run with the changed hydrologic inputs and differences in terms of simulated water levels at various locations will be tabulated. WEST Consultants is currently under contract to the USACE to conduct an evaluation of the potential downstream effects of the USACE Twin Cities Levee project. The results of that analysis will be integrated into WSE's summary.

**Projected Sub-Task Completion Date:** February 22, 2012.

**Sub-Task Budget:** \$ 18,663

**Task 8b** - WEST is currently under contract with the Corps to simulate the performance of the lower Chehalis River with and without the Twin Cities levee project and

Skookumchuck storage. The Flood Authority contract with WSE includes simulating the lower reach with and without the proposed upstream retention facility on the main stem Chehalis and then comparing the results of these three scenarios (baseline, Corps levee project, upstream retention). The Flood Authority may wish to evaluate additional flood relief alternatives or other scenarios. These may include combinations of the previously described projects or additional new flood relief projects as identified by the Flood Authority and Stakeholders. This task would include hydrologic data development and hydraulic simulation of the alternatives using the models described above and reporting of the impacts/benefits of the alternative. The budget herein assumes that one additional flood relief alternative, similar in scope and complexity to the earlier alternatives, is evaluated. Budget includes allowance for WEST Consultants, assuming additional hydrologic data is required.

***Projected Sub-Task Completion Date:*** February 22, 2012.

***Sub-Task Budget:*** currently \$26,538 (For budget purposes an assumption was made that one additional flood relief alternative, of similar complexity to the ones already being evaluated, would be defined and evaluated. This assumption will be reevaluated over the course of the study as additional information becomes available regarding possible flood relief alternatives)

**Projected Task Completion Date:** February 22, 2012.

**Task Budget:** \$ 45,200

#### **Task 9 - Provide QA/QC Technical Review of WSE Flood Relief Alternatives Analysis**

The flood relief alternatives analyses described in Task 8 will be subject to independent technical review to ensure the needs and objectives of the Flood Authority are adequately met as defined in the Work Plan.

WEST Consultants will review work performed by WSE and WSE will review work performed by WEST Consultants.

***Projected Task Completion Date:*** February 29, 2012.

**Task Budget:** \$ 6,710

#### **Task 10 - Milestone Meetings / Conference Calls with Flood Authority**

WSE will coordinate presentations, communications and information transfer to the Flood Authority at key milestones in the project to ensure Flood Authority members are kept fully informed. The milestones and schedule will be determined during the Work Plan Development in Task 3.

WSE will lead this task with support from WEST Consultants.

***Projected Task Completion Date:*** This Task will extend through the duration of the Contract with the Flood Authority.

**Task Budget:** \$ 19,473

### **Task 11 – Comprehensive Project Report**

WSE will prepare a project report to document the findings of the hydraulic model investigations described above. A draft report will be prepared and submitted to the Flood Authority for review and comment. Upon receipt of comments, a final report will be prepared and distributed.

WSE will lead this task with support from WEST Consultants.

**Projected Task Completion Date:** Draft Report March 15, 2012; Final Report 10 days following receipt of consolidated comments from Flood Authority.

**Task Budget:** \$ 29,105

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### **Optional Tasks:**

Listed below are some additional tasks that may be considered under this project if funding is available and the project schedule allows. These tasks were discussed at the Flood Authority Project subcommittee meeting on October 4, 2011 and at that meeting it was decided to eliminate these tasks from the scope or defer them to a later time. Preliminary budgets were developed for these tasks but these are not currently included in the overall project scope or budget. The scope and budget information is included here for informational purposes only.

#### **Task 3 - Conduct Adequacy Review of Existing Floodplain Topographic and LiDAR Data**

*Considering the stakeholder objectives identified in Task 2 and the topographic information collected or identified during the initial basin reconnaissance, an evaluation will be made of the quality of the topographic data and, in particular, its ability to support the development of work products that achieve the stakeholder objectives. The available topographic data for the lower Chehalis River study reach consists of 2002 LiDAR data. Past experience by WSE evaluating LiDAR data of this vintage has shown that the data is often of very poor quality and that it cannot be used to support detailed floodplain mapping or analysis. This task would entail collecting additional ground survey data in the lower river corridor and performing a statistical analysis of the vertical differences between the field surveyed data and the LiDAR topography. WSE will summarize this information for the Flood Authority allowing a determination to be made as to whether the existing data meets its needs or additional data collection is required.*

*WSE will lead this task. Detailed data analysis will be conducted by 3Di-West. Survey support will be provided by PGS.*

**Projected Task Completion Date:** not currently scheduled.

**Preliminary Task Budget:** \$13,310

**Task 6a - Expand or refine Corps hydrology analysis** - WEST is currently developing hydrologic data for the Chehalis Basin under their contract with the Corps. The current scope of that effort includes developing 1.5- through 500-year event hydrographs as well

as hydrographs for ecologically significant flows at up to 50 locations in the Chehalis River Basin. WEST will also develop flow inputs to the Corps lower Chehalis River hydraulic model corresponding to a 2-, 10-, 20-, 50-, 100-, and 500-year main stem flood. While WEST's work for the Corps comprises a significant effort, it is possible that the Flood Authority or individual stakeholders have some additional locations where they would like to have similar hydrologic data. If that is the case, the Flood Authority may choose to develop those additional data under the WSE contract.

**Projected Sub-Task Completion Date:** no work currently proposed.

**Preliminary Sub-Task Budget:** \$ not currently budgeted

**Task 6c - Review and refine Twin Cities model cross section layout** - The Twin Cities hydraulic model provided to WEST by the Corps includes the main stem Chehalis River from Porter upstream to Doty as well as at least partial hydraulic models for several tributary systems (Black River, Lincoln Creek, Skookumchuck River, Hanford Creek, Salzer Creek, Newuakum River, Dillenbaugh Creek, Stearns Creek, South Fork Chehalis). Unfortunately the setup of the current model includes problem areas such as overlapping cross sections at many of the tributary junctions that prevent it from being used to perform automated floodplain mapping (as might be desirable for the flood warning system). This task would include review and refinement of the cross section layout of the existing hydraulic model to ensure that the model can be used to perform automated floodplain mapping using RAS Mapper. Note that it is not proposed that any additional modeling or analysis be conducted or that any other issues with these models be addressed in this task.

**Projected Sub-Task Completion Date:** not currently scheduled.

**Preliminary Sub-Task Budget:** \$ 12,461

**Task 6d - Re-cut cross sections using "best available" LiDAR** - The overbank geometry in the Twin Cities hydraulic model developed by the Corps and/or FEMA was based on LiDAR data that were collected in 2002 or earlier. More recent LiDAR data were collected in Lewis County in 2005/2006. These data are expected to be generally higher quality than the earlier data. If cross sections in the Lewis County portion of the existing Twin Cities model are found to be appropriately laid out and georeferenced, the overbank areas of these cross sections would be re-cut and blended with the modeled channel data. There are about 295 cross sections in this portion of the model. After updating the cross section overbank geometry data the revised model would be validated using two or more historic high flow events to ensure that the revised model is still adequately accurate. Some level of model recalibration may be required; however, the recalibration effort is not expected to be significant.

**Projected Sub-Task Completion Date:** not currently scheduled.

**Preliminary Sub-Task Budget:** \$ 28,572



Task/Sub Task	Hours by Staff						Subconsultants				Sub-Task Estimate	Task Estimate	Assumptions
	Principal	Senior Engineer	Staff Engineer	Junior Engineer	GIS Technician	Clerical	WEST	3Di	PGS	Disb.			
	\$185.00	\$150.00	\$105.00	\$70.00	\$75.00	\$55.00							
Task 1 - Overall Project Management, Stakeholder Involvement, Regular Communication with Flood Authority	80	16	16			24	\$15,000			\$750		\$36,738	
Task 2 - Initial Basin Reconnaissance, Canvass Stakeholders, Obtain and organize data	24		20				\$2,500			\$250		\$9,428	
Task 3 - Conduct Adequacy Review of Existing Floodplain Topographic and LiDAR Data												\$0	(deferred pending available funding)
Task 4 - Detailed Work Plan Development	40	8	40		16	8	\$5,000					\$19,690	
Task 5 - Refine USACE Hydraulic Model to reflect Flood Authority Interest												\$160,403	
5a - Obtain new channel survey data for the Chehalis River between Grand Mound (RM 60.6) and Porter (RM 33)							\$1,774		\$34,764		\$38,365		(Note that the budgeted option assumes that all new survey data will be collected for this reach. )
5b - Refine model of Chehalis River between Lewis/Thurston County line and Porter							\$30,355				\$31,873		
5c - Extend Corps Hydraulic Model downstream from Montesano to Aberdeen	24	100	240		80		\$1,000		\$29,500		\$82,665		
5d - Refine hydraulic model of main stem Chehalis River											\$7,500		(detailed work plan currently under development - preliminary budget assumed based on available project funding)
Task 6 - Extend Hydraulic Modeling (Including Survey, Hydrology and Hydraulics)												\$60,000	
6a - Expand or refine Corps hydrology analysis											\$0		(deferred pending available funding and identification of data needs)
6b - Refine/revise/extend hydraulic modeling of tributaries											\$60,000		(detailed work plan currently under development - preliminary budget assumed based on available project funding)
6c - Review and refine Twin Cities model cross section layout											\$0		(deferred pending available funding)
6d - Re-cut cross sections using "best available" LiDAR											\$0		(deferred pending available funding)
Task 7 - QA/QC Technical Review of WEST Consultants Hydrologic and Hydraulic Modeling	24	40			16		\$1,500					\$13,215	
Task 8 - Technical Evaluation, Reporting of Flood Relief Alternatives to Flood Authority												\$45,200	
8a - Upstream Storage and Corps Levee Project	16	24	80		40	8				\$250	\$18,663		
8b - Additional Flood Relief Alternative(s)	16	24	120		40	8	\$3,500			\$250	\$26,538		(The budget assumes that one additional flood relief alternative, similar in scope and complexity to the earlier alternatives, is evaluated. Budget includes allowance for WEST Consultants, assuming additional hydrologic data is required.)
Task 9 - Provide QA/QC Technical Review of WSE Flood Relief Alternatives Analysis	4	2	4				\$5,000					\$6,710	
Task 10 - Milestone Meetings / Conference Calls with Flood Authority	40	24	24				\$5,000			\$250		\$19,473	
Task 11 – Comprehensive Project Report	16	24	80		24	24	\$10,000			\$500		\$29,105	
<b>Totals</b>	284	262	624	0	216	80	\$80,629	\$0	\$64,264	\$2,250		\$399,960	