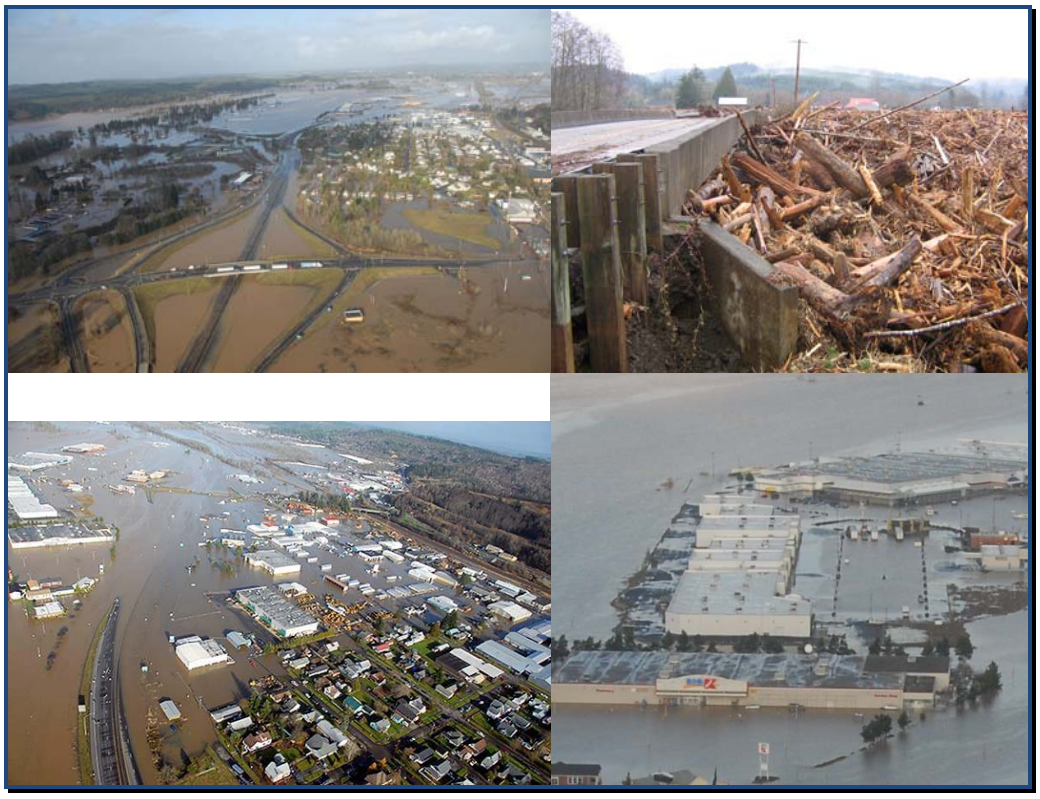
# Chehalis River Basin

# Early Flood Warning Program

## Phase 1. Conceptual Design



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Prepared for: Chehalis River Basin Flood Authority

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# PROJECT BACKGROUND

## . Pro ect Bac ground

The Chehalis River Basin Flood Authority (Flood Authority) is comprised of 11 member agencies including Grays Harbor County, Lewis County, Thurston County, City of Aberdeen, Town of Bucoda, City of Centralia, City of Chehalis, City of Montesano, City of Oakville, Town of Pe Ell, and the Confederated Tribes of the Chehalis Reservation. The Flood Authority was formed in response to a number of historic flooding events with the purpose of developing flood hazard mitigation measures for the Chehalis River Basin. Improvements to the Flood Early Warning capabilities are considered of high importance to the Flood Authority with the goal of improving the communication of flood warnings to the residents of the basin.

The Flood Authority has determined that improvements to the current flood forecasting program for the Chehalis River Basin are needed in order to provide improved flood warning capabilities. Currently, the weather climate forecasting for the basin is performed by the Seattle Office of the National Weather Service (NWS) based on data provided by 13 precipitation gages and hydrological models of the waterways within the basin. River level forecasts are made regularly on six-hour increments and more frequently during flood events. During flood events, a flood warning is issued for a specific river using a 5-stage warning system that includes the following warning or advisories; “Action Stage”, “Flood Stage”, “Moderate Stage”, “Major Stage”, and “Record Stage”. Additionally, the U.S. Geological Survey (USGS) manages 19 stream gage stations that report river levels in real-time and are presented on the USGS web site.

A recent study commissioned by the Flood Authority (ESA Adolfson, March 2009) provided recommendations for improvements to local precipitation and stream monitoring. The purpose of these improvements is to provide representatives of Flood Authority jurisdictions with the information needed to monitor developing flooding conditions on local streams and local flood prone areas. Based on these findings, the Flood Authority engaged a consulting team consisting of WEST Consultants (Prime), Engineered Monitoring Solutions and HDR, Inc. to assist with the design and implementation of the improvements needed to increase the accuracy and timeliness of flood forecasting in the Chehalis Basin.

## . Flood Warning Improvement

An important first step is to distinguish between a flood warning system and a flood threat recognition system. A flood threat recognition system includes the physical and human assets employed to detect the developing flood threat. A flood warning is much more comprehensive. A complete flood warning system includes a broad range of activities as presented in Figure 1-1. The process is circular – beginning and ending with flood preparedness planning. A complete flood warning system must include all of the components to be effective long term. All of these elements must be in place to receive National Weather Service certification as StormReady. This is important because it can help communities reduce their flood insurance rates.

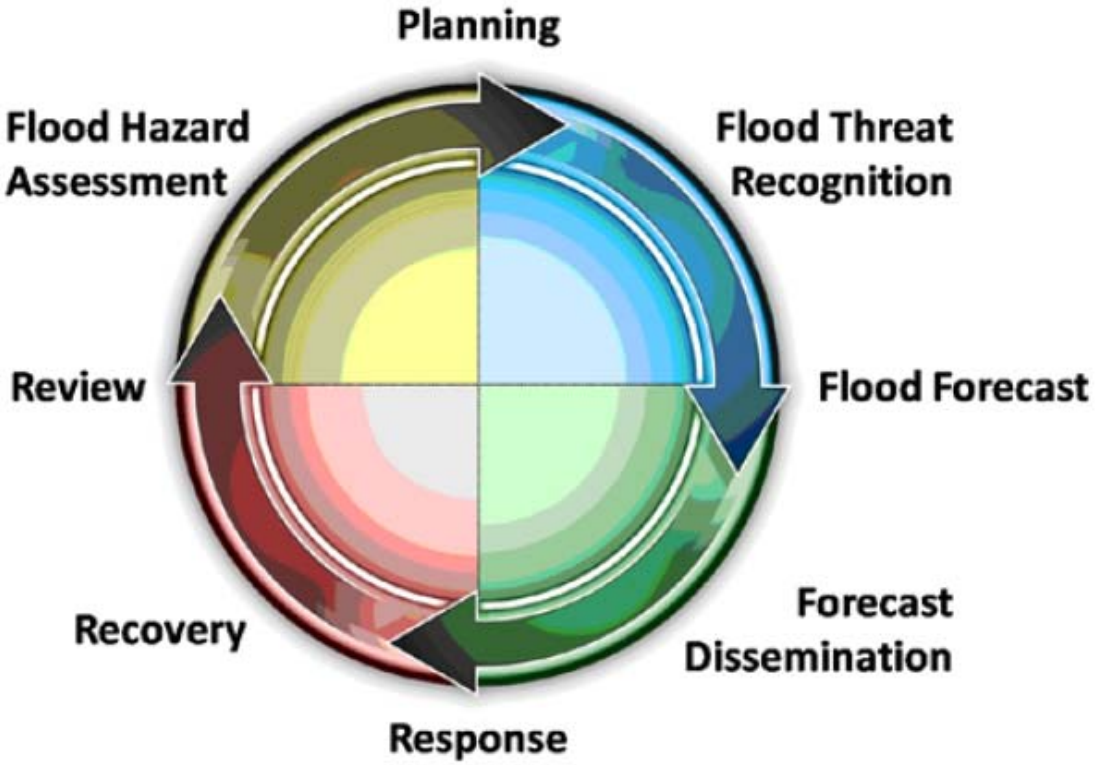


**Figure - . Flood Warning Preparedness Cycle**

The objective of the flood threat recognition system is to maximize the effective response to the flood event by giving those in harm's way more time to respond. If people know what to do, more time typically translates to lower loss of life and lower property losses. Figure 1-2 presents a simplified version of the circular chart in Figure 1-1 overlaid on a hypothetical flood hydrograph.

Available response time is increased by earlier identification of the developing flood threat and completing flood threat recognition tasks, including forecast and dissemination, sooner. As shown in Figure 1-2, flood response occurs on the rising limb of the hydrograph and ends at the peak. (Once the flood peaks, response becomes recovery.) Response time is increased by moving response onset to the left or earlier in time. The only ways to do that are to minimize the amount of time required for recognizing the threat and/or starting the recognition process earlier. Figure 1-2 shows limited time for response near the flood peak. It also shows much improved response time gained by reducing flood threat recognition time and starting the recognition process sooner.

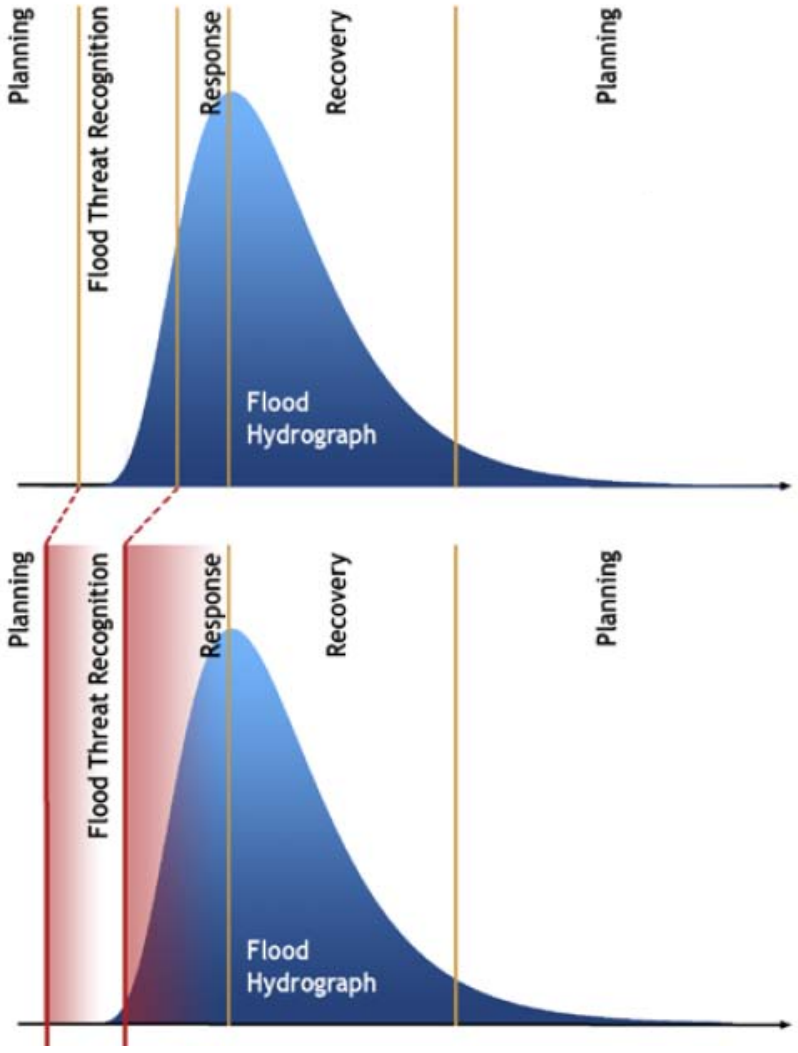


**Figure - . Flood Warning Preparedness Time Line and Improved Flood Forecast Warning**

Proper emergency response planning, both before and after flood events, improves flood response through the efficient interpretation and conversion of information provided by the flood threat recognition system to effective action.

### . System Design Approach

A systematic approach is recommended by the consulting team to provide a design for the improvements that will meet the needs of the Flood Authority, especially in flood threat detection and flood information dissemination. The first phase of the system design involves a needs assessment process to develop and document a better understanding from the individual Flood Authority jurisdictions. This was accomplished in December 2009 by conducting workshop meetings with representatives of each of the Flood Authority jurisdictions. Since most of the data that are used by the Flood Authority jurisdictions to predict flood events are measured and collected by other agencies such as the NWS and the USGS, the project team also contacted those agencies to discuss the improvements desired by the Flood Authority jurisdictions and how they might be accomplished using the existing systems.

The results of the needs assessment efforts were used to develop the objectives and system design criteria for the improvements. These design criteria define the performance requirements of the system improvements. The design criteria will guide the system design effort detailing the recommended improvements including a system layout, selection of equipment and software tools, a plan for implementation, and an estimate of the costs for implementing the improvements.

### . Purpose of the Needs Assessment Report

The purpose of this report is to document the findings of the needs assessment process and to provide a conceptual design for the improvements that could be implemented to meet the needs of the Flood Authority jurisdictions, including a planning level cost estimate. The next phase of work will be to further refine the conceptual design to develop the final system design and implementation strategy.

The needs assessment process began with a series of meetings with the following Flood Authority jurisdictions:

- City of Centralia
- City of Chehalis

- Town of Pe Ell (teleconference)
- Confederated Tribes of the Chehalis Reservation and City of Oakville
- Grays Harbor County
- Lewis County
- Thurston County
- Town of Bucoda (teleconference)

Appendix A contains the meeting minutes or telephone records for each of the needs assessment meetings with representatives of the Flood Authority jurisdictions.

In addition to meeting with representatives of the Flood Authority jurisdictions, the following agencies were contacted to discuss the desired improvements and how the agency might be able to assist the Flood Authority jurisdictions with implementing the improvements.

- National Weather Service River Level Forecast Center – Portland, Oregon
- National Weather Service Weather Forecast Center – Seattle, Washington
- Natural Resources Conservation Service – OR/WA Snow Survey Office
- TransAlta Corporation – Skookumchuck Dam Operations
- United States Geological Survey –Tacoma, Washington Office
- Washington Department of Transportation – Southwest Region Office
- Weyerhauser Corporation - Timberland Operations, Springfield, Oregon

The telephone records for each of the contacts above are presented in Appendix B.

## RESULTS OF THE NEEDS ASSESSMENT

The sections below present the improvements that were identified during the needs assessment meetings with representatives of the Flood Authority jurisdictions. The objectives of the improvements are to assist Flood Authority jurisdictions in improving flood threat detection, improving the accuracy and timeliness of forecasting flood events, estimating the severity of the floods, and improving flood forecast dissemination.

### . River Level Predictions

At the needs assessment meetings, numerous representatives of the Flood Authority jurisdictions indicated the desire for the National Weather Service River Forecast Center to provide additional river level predictions at various areas in the river basin. Additional river level forecast prediction points would assist County and City emergency personnel in forecasting the severity of floods in their areas.

The locations of greatest concern along the Chehalis River where additional river level prediction points are desired are:

- In Centralia at the Mellen Street Bridge
- In the vicinity of unincorporated Adna
- In the vicinity of the City of Elma
- On the main stem of the Chehalis River upstream of the Town of Pe Ell

### . Precipitation Monitoring

Additional precipitation monitoring locations were also identified by representatives of the Flood Authority jurisdictions. They considered these locations to be of high importance for assisting them with estimating the impact of rainfall on the flood levels.

These locations are:

- In the mid elevation areas of the Satsop and Wynoochee River Basins
- On the Skookumchuck River above Skookumchuk Dam
- In the Upper Chehalis Basin on Elk Creek or Rock Creek

### . Snow Pac Monitoring

There are no publicly available data sources for snow pack measurements in the hills surrounding the Chehalis basin. Furthermore, the Natural Resources Conservation Service's (NRCS) SNOTEL network is the primary source for snow pack data in the region but there are no SNOTEL sites that provide data for the Chehalis River drainage area.

Snow pack in the upper Chehalis River basin can have a significant impact for some storm events on flood levels of the river and its tributaries. Several representatives of the Flood Authority jurisdictions indicated that a SNOTEL site on Boistfort Peak would greatly improve the ability to estimate the impact that snow melt may have on the upper Chehalis river basin drainage during a storm event.

### . Improvements to E isting Stream Gages

In addition to precipitation and snow pack measurements, stream gage improvements related to stream level and flow were also identified. The sections below present each of the desired improvements to the existing stream gage network.

#### . . Montesano Stream Gage

The existing USGS stream gage station at Montesano (No. 12035100) is severely influenced by tidal fluctuations. The Flood Authority jurisdictions in this area would like the USGS to make site improvements to the gage that would allow the USGS to calculate river flow at this station taking into consideration the tidal effects.

The installation of an additional new gage located upstream of the tidal influence should also be considered.

#### . . Chehalis River near Doty Stream Gage

Based on the feedback from the needs assessment meetings, it is our understanding that the USGS stream gage on the Chehalis River near Doty (No. 12020000) has been damaged during past flood events, most recently by the December, 2007 flood event. Since the data from this gage are vital to detecting high water river levels during storm events, the City of Centralia recommended that this station be fortified to reduce the likelihood of damage during a flood event (Appendix A).

### . New Stream Gages

Locations for new stream gage monitoring stations were identified by representatives of the Flood Authority jurisdictions. The new monitoring stations would provide data in specific areas to assist in determining flood levels during storm events. These locations are:

- China Creek and Salzer Creek at Centralia
- Big Hanaford Creek and Little Hanaford Creek east of Centralia
- Chehalis River at the confluence with Independence Creek
- South Fork of the Chehalis at Beaver Creek
- Elk Creek upstream of the confluence with the Chehalis River
- Skookumchuck River in the Town of Bucoda at 7$^{th}$ Street Bridge
- Black River upstream of the confluence with the Chehalis River
- Chehalis River between Elma and Montesano
- Mid-level elevations in the Satsop and Wynoochee River basins

### . Integrated Basin-Wide Flood Data and Warning System Interface

During flood events, more coordination is needed between emergency management personnel from multiple agencies at the City, County, and Tribal Management level. During past flooding events, there have been instances where vital information about the flood warnings has not been shared efficiently between the Flood Authority jurisdictions. Sometimes the shared information is conflicting. Additionally, during a flood event, the general public is receiving information about the flood event from multiple sources. This information may or may not be timely and sometimes the information from different sources is in conflict.

Therefore, numerous representatives of the Flood Authority jurisdictions expressed the need for an internet-based, basin-wide, flood information system. This system would provide a single location for information about the river levels, weather data and official flood warnings for the entire basin. The interface would need to be accessible by the Flood Authority jurisdictions and the general public. It should provide current and

forecasted water levels, current and forecasted precipitation levels, weather forecasts, operational data from reservoirs in the basin, and official public address messages (road closures, flood warnings, evacuation notices etc.) issued from each agency within the basin.

### . Notification System Needs

In addition to the flood detection and monitoring system improvements detailed above, flood notification improvements were identified by representatives of the Flood Authority jurisdictions.

#### . . Flood Warning Notification Signage

In addition to a centralized information source for flood warning notifications, representatives of the Flood Authority jurisdictions identified the need for mobile reader-board signage equipment. To help minimize traffic congestion and keep roads clear for emergency personnel during a storm event, mobile reader-boards would be deployed at strategic locations to provide the public with information about road closures and evacuation routes.

#### . . Flood Warning Notification Sirens

During flooding events in the upper sections of the Chehalis river basin, the rivers and streams have experienced rapid increases in water levels compared to the areas in the lower basin. There also are a number of smaller communities in these areas whose evacuation routes become impassible or washed out. Several representatives of the Flood Authority jurisdictions indicated they would like to provide evacuation notification to the population centers of these outlying communities using outdoor sirens. Activation of the sirens would be controlled using radio communications from a central location downstream.

Additionally, the Skookumchuck River has caused flooding in the Town of Bucoda. Representatives of the Flood Authority jurisdictions in this area have indicated the need for an outdoor siren to provide and evacuation notification to the population in and around the Town of Bucoda during a flood event. It is particularly important to have a good response plan, siren testing, and public outreach. The public must understand what the sirens mean (what hazard type) is being warned and the public must understand what actions to take. If they misinterpret the siren, the wrong action can lead to increased risk to life and property.

### . Reservoir Levels and Release Plans

Because the outflows from the Wynoochee and Skookumchuck dams can have a significant impact on the downstream flood levels, several representatives of the Flood Authority jurisdictions expressed the need to receive operational information from these facilities. During flood events, reservoir level and anticipated inflow information is used to estimate the storage capacity of the reservoirs so that the outflow can be managed to reduce the impacts on flooding in the downstream communities. Data related to the planned release rates and outflow quantity is needed for making the downstream flood level predictions.

### . S oo umchuc Dam Failure Warning System

Because of it's proximity to numerous downstream communities, several representatives of the Flood Authority jurisdictions indicated the need for a Failure Warning system on the Skookumchuck Dam. A warning system that would provide notification of a dam breach to the members of the Flood Authority is desired so that emergency response activities such as road closures and evacuations can be coordinated in a timely manner.

## CONCEPTUAL DESIGN FOR PROGRAM IMPROVEMENTS

The previous section presented the needs expressed by representatives of the Flood Authority jurisdictions to help them improve their flood detection and monitoring abilities. This section presents an initial concept for the improvements that might be made and integrated into a basin-wide program to meet those needs. The purpose of this conceptual design and the associated planning level cost estimate is to provide a basis for the Flood Authority jurisdictions to prioritize the improvements for further analysis and design. The next phase of the project will involve developing a design and implementation strategy for the desired improvements.

A primary requirement of a flood warning program is to provide timely access to the appropriate data in the form needed to make decisions. To accomplish this objective for the Flood Authority jurisdictions, the conceptual design includes implementing improvements that would not only improve the data being used for flood monitoring and detection, but would also improve how that data is presented and disseminated.

Typical flood warning programs consist of a number of systems that are integrated to collect, store, evaluate, and present the data; and to allow decision making and providing notification of actions that need to be taken. These systems generally consist of various components including automated monitoring stations for river levels and precipitation, telemetry for communications from the stations to a central location, databases for managing and evaluating the information, and data mining applications used to access data from other data sources, and interfaces to present the processed data along with any alarms or warning messages to the users. The sections below describe a conceptual design for creating a Basin-Wide Flood Warning System for the Chehalis River basin.

### . River Flood Level O servation and Warning System (RFLOWS)

The most common need expressed by representatives of the Flood Authority jurisdictions was for a comprehensive basin-wide flood warning system interface that would collect and present data for the entire basin that could be accessed by all of the Flood Authority jurisdictions and the general public. The conceptual design for these improvements includes a basin-wide River Flood Level Observation and Warning System (RFLOWS). The primary purpose of the RFLOWS would be to collect data from a variety of sources and present it in a single interface. It is also helpful to present the data and emergency notices in a single coordinated web site for the general public to access as well.

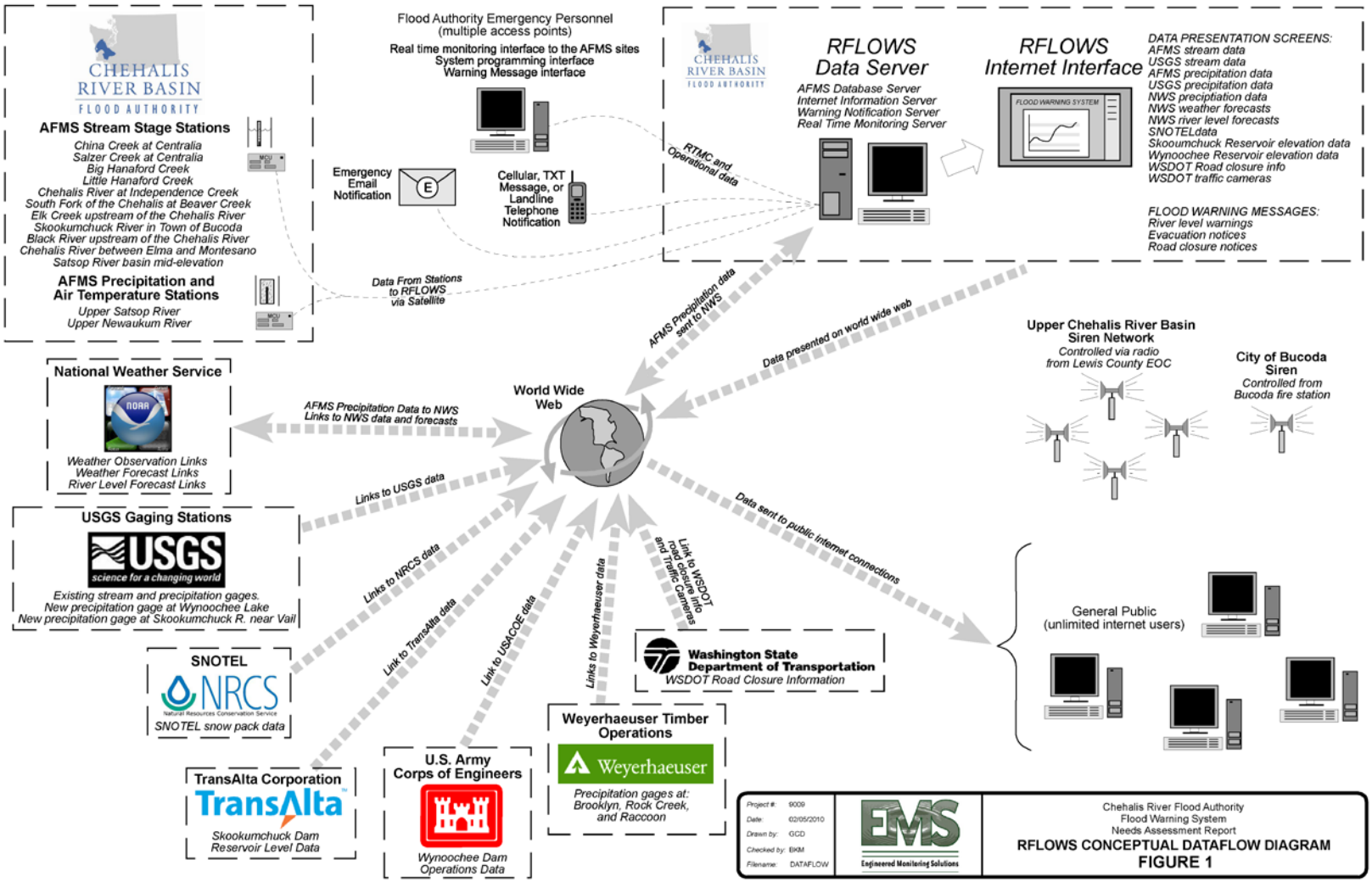


**Figure - . Data Flow**

Figure 3-1, RFLOWS Conceptual Data Flow Diagram, presents the concept of how the data would be collected from each of the various data sources via an RFLOWS Data Server and then presented via the World Wide Web using the RFLOWS Internet Interface. The information collected by the RFLOWS system would include data from various automated systems including:

- AFMS stream stage measurements
- AFMS precipitation and temperature measurements
- USGS gaging station measurements (flow and stage)
- USGS precipitation measurements
- SnoTel snow survey measurements
- NWS weather observations
- NWS weather and river level forecasts
- Skookumchuck reservoir level
- Wynoochee Lake level
- WSDOT road closure information
- Weyerhaeuser precipitation measurements

The measurement locations within the entire river basin would be presented in a graphical map-based format. The graphical interface would consist of an interactive location map and smaller interactive regional maps of the river basin that would assist the users in navigating to the area of interest.

Within each smaller region, the measurement data would be viewed and any emergency warning messages generated would be displayed. Links to the individual agency websites such as the county or state emergency services would be presented as well.

As presented in Figure 3-1, the RFLOWS data server is a primary component of the RFLOWS system. The system design effort in Phase 2 of the project will include an evaluation of the server location and configuration options.

One component of the RFLOWS includes the implementation of an Automated Flood Monitoring System (AFMS) that would consist of automated monitoring stations that are configured with either river level or precipitation sensors (or both) and would be located in various areas of the river basin. These stations would use programmable automated data acquisition equipment to collect and telemeter stream stage and precipitation data to the RFLOWS system. The data collected by the stations would be presented on the RFLOWS internet site along with the other data sources.

Because the AFMS stations would be in remote locations, the data acquisition equipment would be battery powered and solar recharged, and would use satellite telemetry to communicate with the data collection platform in near real time.

The precipitation data collected by the stations would also be transmitted to the NWS for use in their forecast modeling.

### . Real Time Monitoring and Control (RTMC) Screens

In addition to the RFLOWS interface described above, the AFMS has the ability to present the data from the stations to users who are connected to the computer network that includes the RFLOWS data server. This is accomplished via client applications called Real Time Monitoring and Control (RTMC) screens.

The RTMC interface requires a direct network connection to the RFLOWS Data Server and is programmed to access the local monitoring station data directly from the AFMS without an internet connection. Additionally these screens are used to set alarm thresholds for each of the AFMS stations and to monitor the operational data such as battery levels etc. of each station. The conceptual design includes implementing the RTMC client applications on four systems that would have direct network access to the RFLOWS Data Server.

### . River Level Forecasting Improvements

Based on our discussions with the NWS, our understanding is that the river level forecast modeling services provided are limited by their staff resources available to maintain and run the models. They indicated that they are currently running at capacity with the 10 forecast points modeled for the Chehalis River basin. (See Figure 3-2) The NWS also indicated that they would consider moving some of their prediction points to other main stem locations as long as the new locations had 8-10 years of validated flow data and the total number of forecast points did not exceed 10 locations.

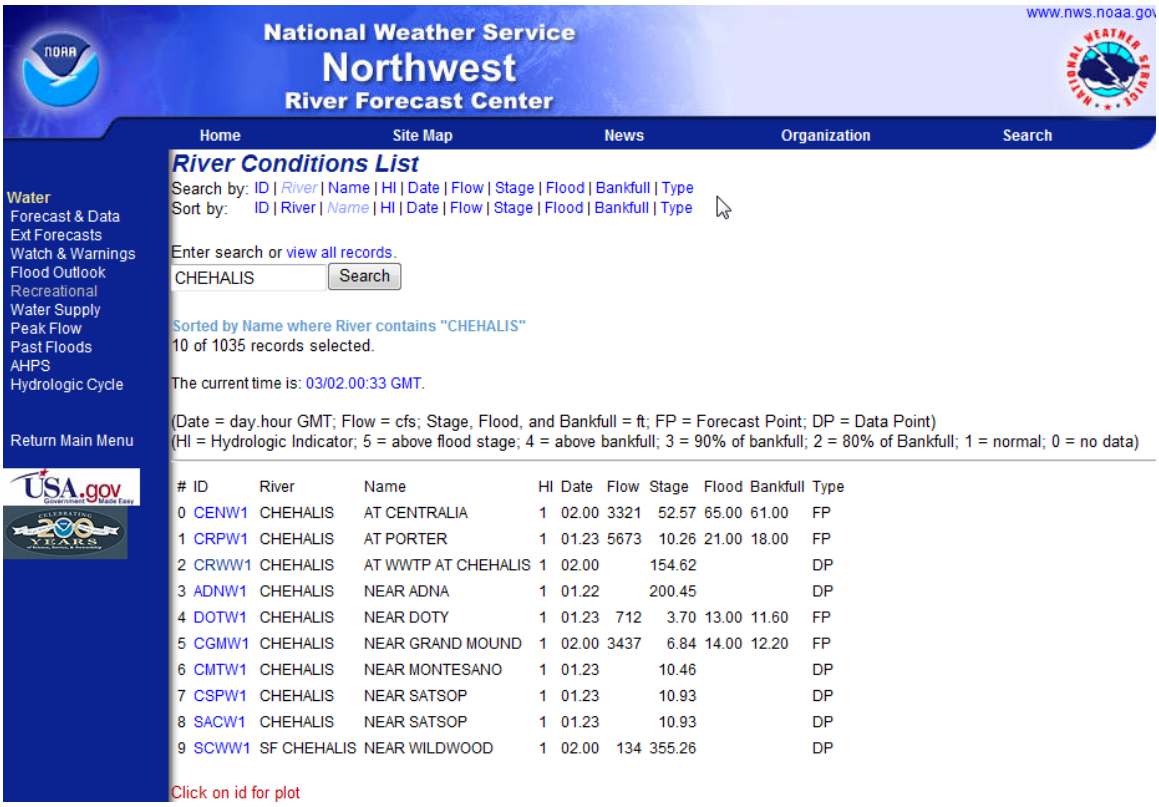


**Figure - . Current NWS River Forecast Points on the Chehalis (http: www.nwrfc.noaa.gov river riverlist.cgi s ey river o ey name ss CHEHALIS)**

We recommend that an analysis of the desired forecast points should be performed to determine if any of the existing locations should be moved to locations that would provide better information about the flood levels. The analysis would involve discussions with representatives of each of the Flood Authority jurisdictions to determine the value of each existing forecast location and whether a different forecast point would be more useful. If higher value prediction points are identified, then those points could be presented to the NWS for consideration. If moving NWS forecast points is not feasible, the analysis should assess the possibility of using water surface modeling techniques to relate flood elevations at existing forecast points to other river locations.

If 8-10 years of data are not presently available for the new desired locations, we recommend establishing an agreement with the NWS that as the data becomes available or their modeling capacity increases, then these locations would be included in their modeling and forecasting efforts.

## . Precipitation Monitoring

New precipitation monitoring locations were identified in the needs assessment for the Satsop and Wynoochee River Basins; on the Skookumchuck River above Skookumchuck Dam; and in the Upper Chehalis Basin on Elk Creek or Rock Creek. Additionally, during discussions with the NWS, improvements to the precipitation sites currently operated by Weyerhauser Corporation were identified.

**Figure - . Upper Wynoochee La e USGS Gage**

### . . Upper Wynoochee River Basin and Upper S oo umchuc River Basin

The USGS operates automated gaging stations at Wynoochee Lake (No. 12035400, Figure 3-3) and on the Skookumchuck River near Vail (No. 012025700). Both of these gaging stations currently collect stage and flow data. To obtain the precipitation data in the upper Wynoochee River basin and the upper Skookumchuck River basin, the conceptual design for these improvements includes contracting with the USGS to add precipitation readings to the existing gaging station infrastructure.

The precipitation data for these stations would be included with the existing USGS rain gage data transfers to the National Weather Service. The National Weather Service would then add this precipitation data to their internet web displays. The RFLOWS system would link to the data from the National Weather Service web site as well.

### . . Upper Satsop River Basin

It is our understanding that there are no automated precipitation gages with data reporting capabilities in the upper Satsop River basin area.

The conceptual design includes a new AFMS precipitation gage station in the upper river basins of each of the three forks of the Satsop River. The new precipitation gage stations would include readings for precipitation and air temperature. The data from these stations would be telemetered to the Flood Authority RFLOWS system using satellite and also automatically transferred to the National Weather Service.

### . . Weyerhaeuser Precipitation Monitoring Improvements

During discussions with the NWS, three precipitation monitoring locations were identified that would help fill in some of the gaps in the precipitation monitoring coverage for the Upper Chehalis River basin. These sites were the Brooklyn, Elk Creek or Rock Creek, and Raccoon Creek sites. Subsequent discussions with Weyerhaeuser Corporation indicated that each of these sites is currently equipped with precipitation monitoring equipment but do not have telemetry to automatically download the data to the NWS forecasting centers. Weyerhaeuser would be willing to allow the Flood Authority to add telemetry to the stations. The conceptual design includes adding satellite telemetry to these sites so that the data could be sent to the NWS forecast centers and presented in the RFLOWS system.

Additionally, Weyerhaeuser indicated that they manually read precipitation sites located throughout the basin that may be helpful to the NWS forecasting center. They agreed to cooperate with the Flood Authority if any of these locations are desired. We recommend that further analysis be conducted on these locations to determine if the sites could be useful to the Flood Warning System.

### . Snow Pac Monitoring

Representatives of the Flood Authority jurisdictions indicated that a snow survey site on Boistfort Peak would greatly improve their ability to estimate the impact that snow melt could have on the upper Chehalis river basin drainage during a storm event.

The NRCS operates a snow survey network of 730 automated SNOTEL sites in 11 western states including Alaska. Based on our discussions with the Portland Office of the NRCS Snow Survey and Water Supply Forecasting Center, we recommend that the Flood Authority enter into a cooperative agreement with the NRCS that would include the implementation of a SNOTEL site on Boisfort Peak.

Once the SNOTEL site is constructed and the snow survey data for the station is added to the NRCS web site, the RFLOWS system would be configured with an internet link for viewing the snow survey data on the NRCS website.

### . Improvements to the Chehalis River Gage Station near Doty

During our discussions with the USGS Office in Tacoma, they indicated that improvements have recently been made to Chehalis River station near Doty. These improvements included moving the telemetry equipment to a higher elevation to avoid

water damage during flooding. The USGS personnel stated that they believe the modifications will improve the reliability of the station during flooding.

### . Local Stream Gage Monitoring Networ

In Section 2 the locations for the desired new automated stream stage monitoring stations were identified including:

- Big Hanaford Creek and Little Hanaford Creek east of Centralia
- Black River upstream of the confluence with the Chehalis River
- Chehalis River at the confluence with Independence Creek
- Chehalis River between Elma and Montesano
- China Creek and Salzer Creek at Centralia
- Elk Creek upstream of the confluence with the Chehalis River
- Mid-level elevations in the Satsop and Wynoochee River basins
- Skookumchuck River in the Town of Bucoda at 7$^{th}$ Street Bridge
- South Fork of the Chehalis at Beaver Creek

We discussed with the USGS the possibility of adding these locations to their real time network and the costs that would be involved in this effort. Based on the costs that would be required to contract with the USGS to add these locations to their system and to maintain them, the conceptual design includes implementing AFMS stream stage stations as described below. The new AFMS stations would be directly integrated with the RFLOWS interface as previously discussed.

The stations would be configured to measure only the stage, and therefore can be constructed for a lower cost and would require relatively little maintenance. Each of the stations would be configured with a water level sensor and automated data acquisition equipment for collecting, reporting, and evaluating alarm levels for stage. If the alarm level is exceeded, then notification would be sent from the station to the RFLOWS interface. The alarm notifications could also be transmitted to emergency response personnel as an audible notification at a 911 dispatch center, a digital voice phone call, text message, or email. The data from the stations would be telemetered by satellite to the RFLOWS system for presentation.

## . Notification System Improvements

The sections below discuss improvements that were identified to provide better notification of the need for action during a flooding event.

### . . Flood Warning Notification Signage Improvements

Our discussions with representatives of the Flood Authority jurisdictions identified improvements to Flood Warning Notification Signage. The desired improvements included implementing mobile sign boards that could be used to notify motorists of highway closures. Representatives of the Flood Authority jurisdictions indicated that the primary needs were two variable message reader boards that could be deployed along Highway 12 in the vicinity of Oakville and west of Rochester. The conceptual design includes two trailer mounted, battery operated, variable message traffic signs that could be placed along Highway 12 to re-route traffic during flood events.


**Figure - . Automated Road Closure Sign. (High Sierra Electronics Inc.)**

An alternative to the mobile traffic sign is a permanent automated road closure sign. (Figure 3-4)

### . . Flood Warning Notification Siren Improvements

Representatives of the Flood Authority jurisdictions indicated there are a number of small communities in the upper regions of the river basin that have minimal warning time for notification of flood events. Additionally, the primary roads and evacuation routes for many of these communities are frequently flooded thus isolating the inhabitants. Representatives of the Flood Authority jurisdictions indicated that a siren network may be helpful for providing an evacuation or warning message to these communities. The conceptual design includes a radio controlled outdoor siren network that would be controlled remotely by a base station at the Lewis County Emergency Management office could be deployed to provide more rapid notification.

Because of variables such as topography, population dispersion, radio telemetry paths, and equipment capability, the final design of the siren system will require a detailed

analysis to determine the exact number of sirens and final locations. For the purposes of the planning level cost estimate, we have assumed that the system will require a minimum of four siren arrays with digital voice capabilities. Additional siren locations may be needed depending on the results of the final program design.

In addition to the siren network for the upper Chehalis River basin, a single siren array within the Town of Bucoda could also be implemented to provide emergency notification messages to the downtown population. The conceptual design includes a digital siren that would have the ability to provide a series of siren wail tones as well as broadcasting a digital voice message to provide information related to the emergency. The siren could be controlled by the City's emergency operations personnel for either a flood event or an identified failure of Skookumchuck Dam.

### . Improved Communication with Reservoir Owners and WSDOT

Both the Wynoochee Lake and Skookumchuck Lake provide storage capacity that can help mitigate downstream flooding. Operational data related to pool level and expected outflow amounts is vital to estimating the flood potential of a storm event. The Flood Authority would like to improve the way that the operational data is communicated during flood events. The sections below present some recommendations regarding how communication of data could be improved for these facilities.

#### . . Wynoochee Dam

The water elevation in the reservoir and discharge is currently being reported in near real time on the U.S. Army Corps of Engineers website. We recommend that a link to this data should be available on the RFLOWS interface (Figure 3-5).

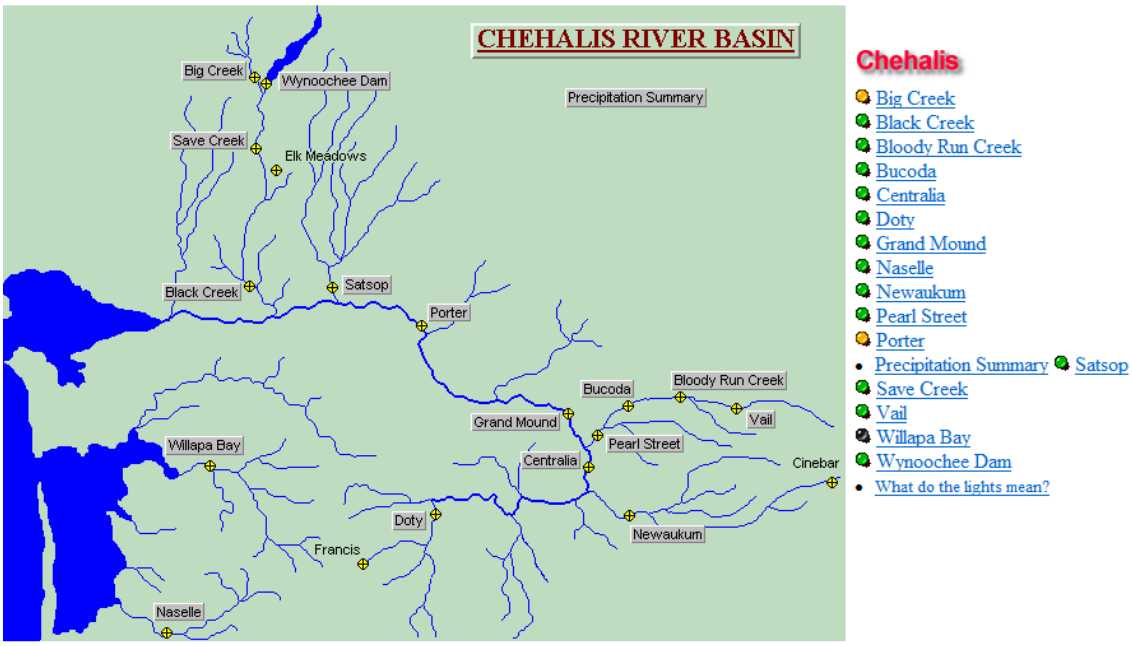


**Figure - . US Army Corps of Engineers We site for the Chehalis River Basin**
**http: www.nwd-wc.usace.army.mil nws hh asins cheh.html**

### . . S oo umchuc Dam

During our meeting with TransAlta, two methods for receiving reservoir level data from the Skookumchuck Reservoir were discussed. The two options were either to establish a link to TransAlta's existing automated reservoir level data via an internet connection to their computer systems or to install a new automated reservoir level. Either option would provide data that would be presented on the RFLOWS website.

As of the date of this report, TransAlta is considering these options and the final configuration will be determined during the design phase of the project.

### . . WSDOT Road Closures

Representatives of the Flood Authority jurisdictions indicated that improvements are needed to receive road closure information in a timelier manner. This is especially relevant in areas where closures of Federal or State roads force vehicular traffic onto local secondary roads that may also be closed due to floods. In our discussions with WSDOT personnel, we understand that the WSDOT has personnel that coordinate closely with the Lewis County Emergency Services personnel when a flood emergency is being managed. Furthermore, we understand that when the decision to close a Federal or State road in the basin is made, it is posted within 5 to 10 minutes on the WSDOT road closure web site.

We recommend providing direct links to the WSDOT road closure information on the RFLOWS interface. The functional requirements of this design will be presented in Phase 2. By providing this information in the same area of the website as other local road closures, both the general public and emergency personnel from the Flood Authority jurisdictions can evaluate how the road closures will impact their areas. See example WSDOT website in Figure 3-6.

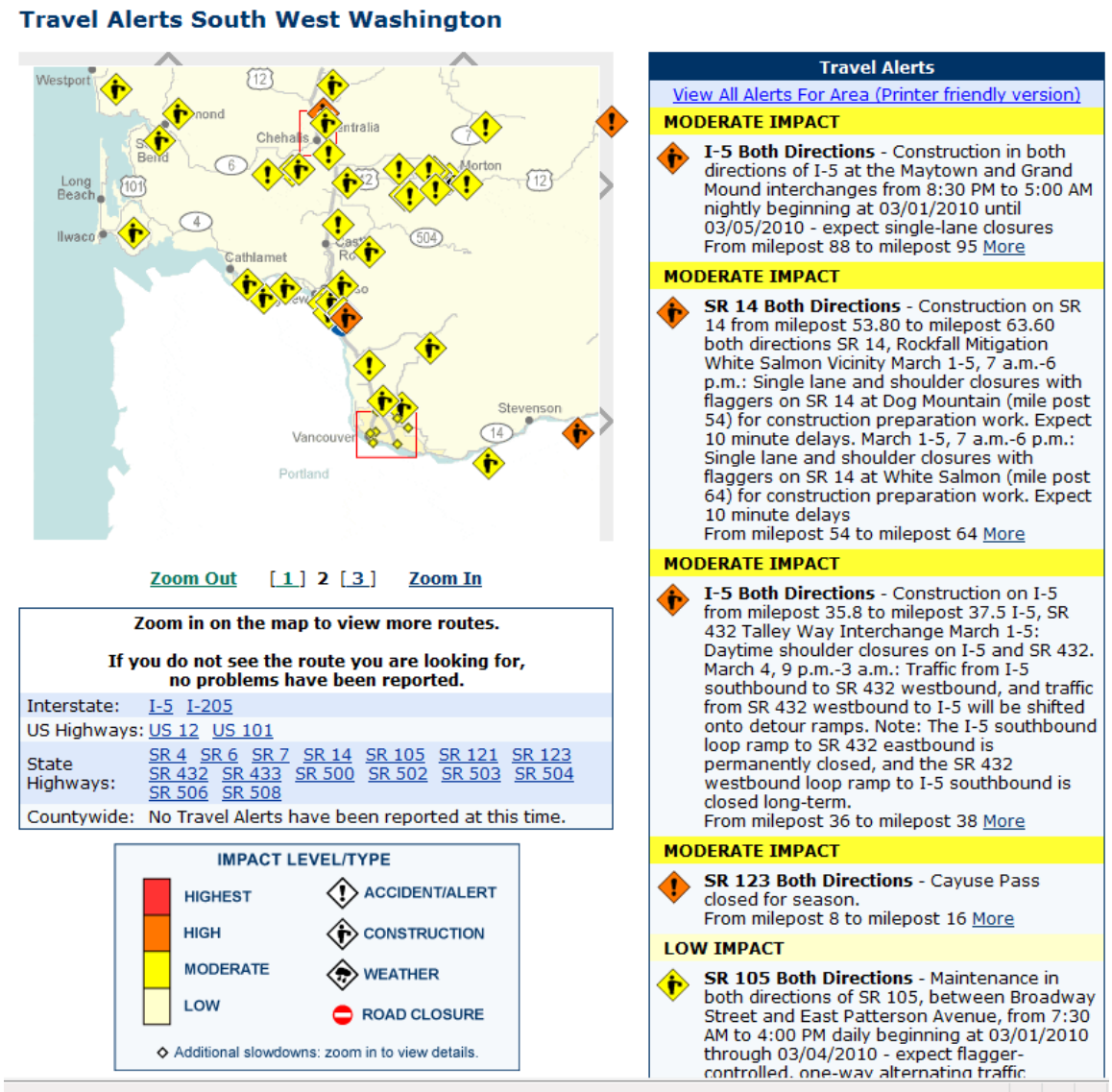


**Figure - . E ample WSDOT Travel Alert We site (http: www.wsdot.wa.gov traffic trafficalerts SouthWest.asp )**

# PLANNING LEVEL COST ESTIMATE

This section of the report provides planning level costs associated with implementing the conceptual design improvements as described in the previous section. Because each of the flood warning program improvements will contain different system components and levels of complexity, for planning purposes the various program improvements have been grouped together into logical units or system improvements.

The costs presented are intended to be used as a budget planning resource to assist the Flood Authority in estimating the level of costs that should be anticipated for implementing the program improvements. A final design of program improvements will be required to determine the specific equipment and installation details that will be needed for the site conditions and the software tools and interfaces that will best serve the Flood Authority jurisdictions. Following the final design, the cost estimate should be refined based on the actual equipment and level of effort that will be required to implement the program.

## . Cost Estimate Assumptions

The sections below present the assumptions that were made in order to estimate the initial (installation) cost of each of the recommended improvements. Estimated annual operation and maintenance costs are not included here.

### . . RFLOWS Implementation

The cost estimate presented for the implementation of the RFLOWS system assumes that a local entity would supply a hardened internet connection and server environment for the server hardware. The estimate includes the cost of procuring and installing the computer server and associated applications to manage and present the RFLOWS data. The effort to develop the web site and deploy an active internet site has also been included in the estimate.

Once the RFLOWS data management server and internet infrastructure is in place, the AFMS stations can be implemented individually or in groups as budgets allow and added to the RFLOWS system in phases.

### . . Precipitation Gage Improvements

The estimate of costs for the improvements to the precipitation gage network are based on three different development approaches including two USGS gages, three AFMS gages, and three Weyerhaeuser gages. The USGS gages include the costs to contract

with the USGS to add precipitation measurements to their existing gages and provide the data via their existing website infrastructure. A link would be provided to the data on the RFLOWS interface. The estimate for the AFMS gages includes the costs to develop and construct three new automated rain gages with satellite telemetry that would be integrated with the RFLOWS system. The estimate for the Weyerhaeuser precipitation gages includes the costs for adding satellite telemetry to the existing data collection equipment located at each of the sites.

### . . SNOTEL Improvements

The costs for the new SNOTEL site at Boisfort Peak include the cost to contract with the NRCS to develop and construct a new snow survey site. The estimate also includes the cost to automate the station with satellite telemetry and adding the data to the NRCS web site.

### . . Stream Monitoring Stations

The estimate for developing 11 new AFMS stage-only stream gage stations includes the costs for the development and implementation of the sites. This includes the cost of monitoring system equipment, telemetry equipment, and the construction costs associated with building the site improvements. The estimate is also based on data collection and satellite telemetry equipment that could be used to calculate flow if a rating curve is developed or monitor weather parameters in the future.

### . . Flood Notification Improvements

The estimated cost for the variable message signs are based on a mobile, trailer mounted, two-line display that are programmable with three different pages of messages to allow for an initial alert message as well as a message indicating what action to take.

The estimated cost for the siren warning systems includes all hardware and software associated with implementing a digital siren system capable of siren wail tones and a recorded voice message. The estimates also include the cost to construct and install the sirens. The siren to be located in the Town of Bucoda assumes a roof mounted siren system while the four sirens for the Upper Chehalis River basin assume a pole mounted configuration. The costs do not include property purchases or leases and any special permits.

## . Cost Estimate

The unit cost estimate ranges in Table 4.2.1 are based on the assumptions presented above. Because the scope of the improvements is conceptual at this time, a range has been included for each of the cost items. During the final design effort, the costs will be refined based on the actual quantities and work effort required to construct the improvements.

**Ta le . . Planning Level Cost Estimate**

| Item | Cost Estimate Range |
|---|---|
| **RFLOWS Implementation** | |
| Deploy RFLOWS data server and RTMC client applications | $35,000 to $45,000 |
| Deploy RFLOWS Internet interface | $25,000 to $35,000 |
| **Precipitation Gage Improvements** | |
| Add precipitation monitoring to an existing USGS gage site | $5,000 to $10,000 |
| Deploy new AFMS precipitation gage station | $15,000 to $25,000 |
| Automate existing Weyerhaeuser precipitation gage | $10,000 to $15,000 |
| **Stream Stage Monitoring Improvements** | |
| Deploy new AFMS stream stage monitoring station | $20,000 to $30,000 |
| **Snow Pack Monitoring Improvements** | |
| NRCS SNOTEL site at Boisfort Peak | $20,000 to $25,000 |
| **Flood Notification Improvements** | |
| Mobile variable message display | $10,000 to $15,000 |
| Siren warning system (single siren and controller) | $45,000 to $55,000 |

Using mid-range unit costs (from Table 4.2.1) and the number of units identified in Section 3, a planning-level estimate of the total program capital cost is on the order of $500,000. Depending on whether the Flood Authority jurisdictions (or perhaps a new Flood Control District) decide to service the equipment themselves or out-source this function, annual operating and maintenance costs would be on the order of 10-25 percent of the capital costs, or $50,000-$125,000 per year. This estimate would be refined in the Phase 2 detailed program design.

# POTENTIAL FUNDING SOURCES

## . Federal Assistance Programs

Potential sources of Federal Flood Warning System (FWS) implementation assistance may be available through the programs of several different agencies: the United States Geological Survey; the National Weather Service; the Corps of Engineers; the Federal Emergency Management Agency; and the Natural Resources Conservation Service (NRCS). Assistance can be provided in various ways including: advisory and consultative, technical assistance, and financial through either study or project cost sharing or grants. In most cases, some support may be available for implementing a FWS, with less available for operations.

### . . United States Geological Survey (USGS)

The USGS is the nation's principal water resources data collection and information agency. In that capacity it coordinates needed data interfaces with all public agencies and provides public access to collected data. In 2006 the USGS streamgaging network consisted of approximately 7,500 streamgages at a total operating cost of about $127 million, which amounts to an average annual cost of approximately $17,000 per streamgage. Of that, approximately 33% of the total cost was provided by the USGS, 21% by other Federal agencies and 46% by State and local cooperating agencies. With regard to FWS, there are two primary USGS programs capable of providing technical and financial support.

- The Cooperative Water Program (CWP) has existed for over 100 years and is the program under which most of the nation's streamflow gages have been installed and under which new ones are installed or modifications made to existing ones to meet FWS and other water resources needs. It is also the principal program under which the USGS can conduct cooperative studies with state, local and other federal agencies. Although the USGS can cost-share up to 50 percent with non-federal participating agencies, due to USGS budget cuts in this program in recent years, it is more normal that non-federal parties would fund higher percentages, up to as much as 90 percent of costs. Other Federal partners pay 100 percent of the costs for any cooperative program with the USGS since federal agencies cannot enter into cost sharing agreements with each other.

- The National Streamflow Information Program (NSIP) is a program that is designed to provide full federal funding for the "backbone core" of gages critical to national streamflow information needs; but also to provide for cooperative operational funding by the stakeholders for the remaining gages of primary interest to the stakeholders.

**Applica ility to Chehalis Basin**

The USGS currently has cooperative agreements under their CWP with about 75 federal, state, tribal, and local agencies in the state. The Washington Departments of Ecology and Natural Resources both have current cooperative agreements with USGS. Several Tribal entities participate in this cooperative program with the USGS. The following local agencies also have cooperative agreements with the USGS under this program:

- Grays Harbor County
- Lewis County
- Thurston County
- City of Centralia

The USGS manages 19 stream gages within the Chehalis River Basin (Figure 5-1), with 17 of the gages being within the CWP with the local cooperator providing some matching funding for the operation and maintenance. The other two gages are fully funded by the USGS under the NSIP. The figure on the following page shows the location of the 19 stream gages operated by the USGS in the Chehalis Basin.

Contacting the USGS for assistance in Washington State through either the CWP or NSIP is through the USGS Washington Water Science Center. This office manages and provides advice for using the gaging program in the state. Requests for assistance may be directed to:

Robert A. Kimbrough
Assistant Director for Hydrologic Surveillance
USGS
Washington Water Science Center
934 Broadway, Suite 300
Tacoma, WA 98402
253 552 1608

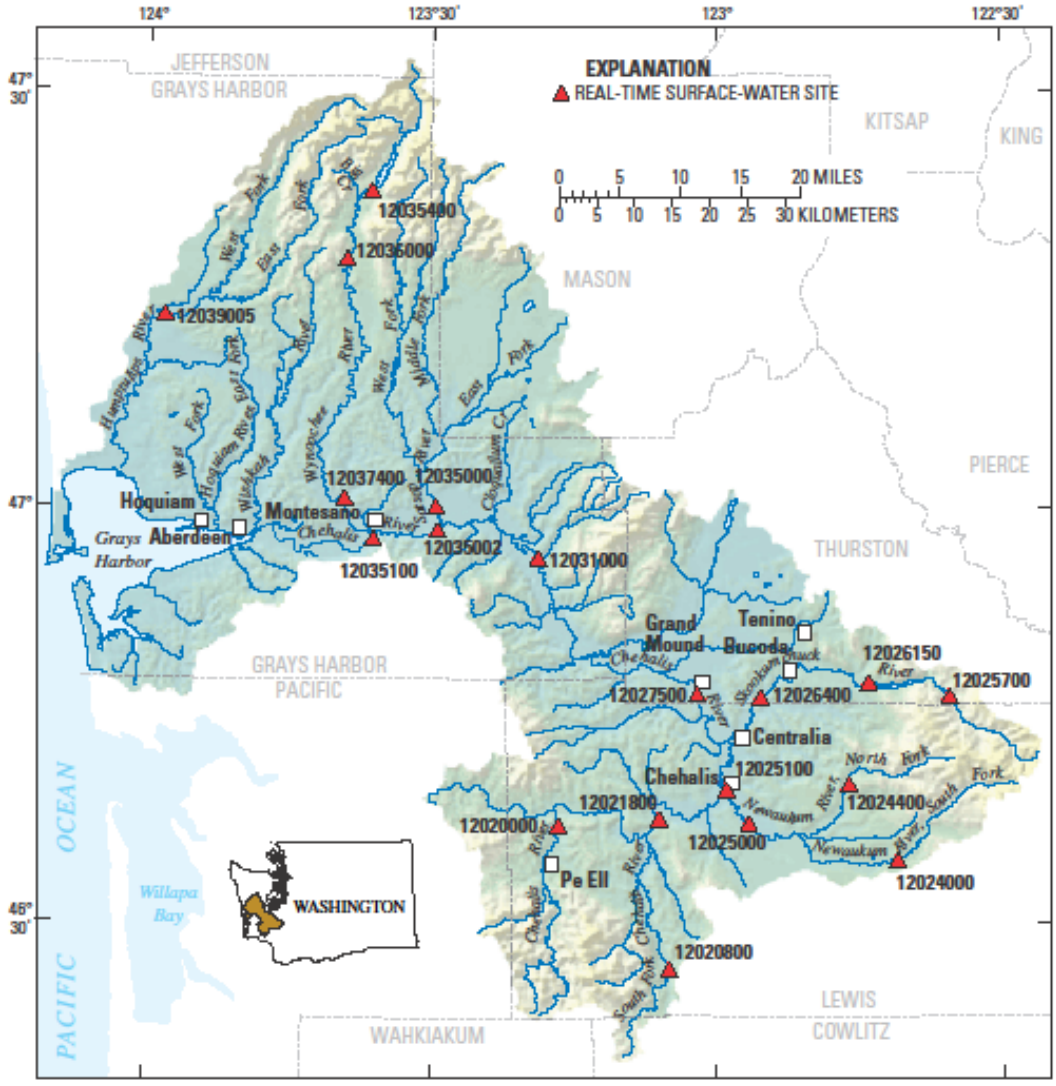


**Figure - . Gauges in Chehalis River Basin**

### . . National Weather Service

The National Weather Service (NWS) provides weather, hydrologic and climate warnings for the nation. NWS data and information forms a national information database and infrastructure for other federal, state and local agencies, the public and the private sector. The NWS provides forecasting technical expertise and encouragement to local, state and federal interests seeking to develop FWS. The agency has produced manuals and guidance on how to plan and implement FWS and is currently focusing on establishing guidance and technical support to increase the use of automatic gages along with associated communications and computer software as part of Automated Flood Warning Systems (AFWS). The agency suggests developing partnerships with other state and local agencies, Federal agencies and public and

private interests to convey other types of data which might be of interest to them as a way to obtain cost sharing. Local weather offices have designated focal points that could be of assistance in identifying gage and technology interfaces for contemplated FWS.

**Grant Programs**

Integrated Flood Observing and Warning System (IFLOWS)

The NWS had administered the Integrated Flood Observing and Warning System (IFLOWS) grants program, providing up to $100,000 per applicant. However, funds are no longer available under this program.

Remote Community Alert Systems Program

The Remote Community Alert Systems Program 2010 represents a NOAA/NWS effort to provide for outdoor alerting technologies in remote communities effectively underserved by commercial mobile service for the purpose of enabling residents of those communities to receive emergency messages. These activities will engage the private sector, academia, county and local governments with their State Government office or Tribal Community Government office in opportunities and technologies to further disseminate emergency messages. This program is a contributing element of the Warning, Alert, and Response Network (WARN) Act. NOAA's program is designed to complement other agency contributions to that national effort.

The Federal Communications Commission has defined a "remote" area to consist of a county with a population density of 100 persons per square mile or less, based on the most recently available Census data. Also, "commercial mobile service" means those services that are required to provide E911 services in accordance with Section 20.18 of the Commission's rules. "Effectively underserved" identifies "remote communities" that do not receive "commercial mobile service" as demonstrated by coverage maps, technical analysis, field tests, or any other reasonable means.

A State Government or a Tribal Community are the only eligible applicants, so any local government that is interested in applying for funding under this program must do so through their State Government.

The closing date for applying for funding under this program for 2010 was February 26, 2010, for a start date of October 1. For 2010 the total funding available was approximately $2 Million, with an estimated 20 grants to be awarded ranging from

$50,000 to $200,000. There is no indication at this time whether any additional funding may be available under this program in future years.

No cost sharing is required under this program and is 100% federally funded through the NOAA/NWS.

**Applica ility to Chehalis Basin**

The NWS manages two gaging stations within the Chehalis River Basin, the Chehalis River at Centralia gage and the Skookumchuck River at Centralia gage.

There is no funding available at this time under either of the grant programs described above. If there are additional open periods for applications for funding under the Remote Community Alert Systems Program, since they meet the definition of a "remote" area based on less than 100 persons per square mile, Lewis County and Grays Harbor County could consider preparing an application for funding with the State of Washington as the applicant on their behalf.

The Seattle office of the NWS handles the majority of the Chehalis River Basin with their area of jurisdiction including Grays Harbor, Lewis, Mason, and Thurston counties. The Portland office of the NWS handles Cowlitz and Pacific counties. Requests for assistance or information relating to the Chehalis River Basin can be directed through either of the following NWS offices:

National Weather Service
Portland Weather Forecast Office
5241 NE 122nd Avenue
Portland OR 97230-1089
(503) 261 9246

National Weather Service
Seattle Weather Forecast Service
7600 Sandpoint Way
Seattle, WA 98115-6349
(206) 526 6087

**. . U.S. Army Corps of Engineers (USACE)**

The USACE is the primary federal agency for developing plans for and implementing federal flood damage reduction projects. It also coordinates with other federal, state and local agencies involved in flood emergencies and projects, provides flood emergency services and exercises permitting authorities for structural measures affecting water resources that may be associated with FWS. Corps assistance for FWS is available through:

- The USACE normal flood damage reduction study and project authorization process, as part of a Water Resources Development Act, can also include FWS,

modify existing projects for FWS inclusion or authorize stand alone FWS, all subject to cost sharing;

- Section 205 of the Flood Control Act of 1948 under the USACE continuing authorities programs provides authority for small flood control projects with a federal cost not exceeding $7 million. These might either include FWS, or possibly be stand-alone FWS, all subject to cost sharing;

- Section 22, Planning Assistance to States program of the Water Resources Development Act of 1974 provides general authority for the USACE to assist requesting states in conducting individual studies supporting state comprehensive water and related resources planning. Assistance can be provided based on availability of funds and 50-50 cost sharing;

- Section 206 of the Flood Control Act of 1960 provides authority for the USACE under its Flood Plain Management Services Program to provide flood plain information and planning assistance to state, county and city governments, as well as to other federal agencies. This can include Hurricane Evacuation and Flood Warning Preparedness studies. Other federal agencies and private citizens may pay the USACE for these services; but non-federal public entities may not. Assistance can be provided based on requests by states or communities and availability of Corps expertise and funds allocated yearly to the various Corps Districts.

Obtaining a study authorization under the USACE normal authorization process is generally facilitated by congressional sponsorship. A study is conducted in two phases: a reconnaissance at 100 percent Federal expense for a maximum of $100,000; and, a second stage cost shared feasibility study. If a project is found feasible and has sufficient National Economic Development Benefits and continuing non-Federal support for cost sharing, a Chief of Engineers Report is prepared as a basis for project authorization. Cost shared preconstruction engineering and design may proceed while seeking project authorization and cost shared construction funding. If the USACE has performed a study in the geographic area before, a new study can be authorized by a resolution ("survey resolution") of either the House Transportation and Infrastructure Committee or the Senate Environment and public works Committee. Most USACE studies are now authorized this way. Requests for assistance in defining study objectives and specific means of authorization should be addressed to the appropriate District Commander.

**Applica ility to Chehalis Basin**

Contacting the USACE for FWS assistance is through one of three District offices in the state, depending on which District's hydrologic boundaries encompass the FWS of interest. All three Districts, Seattle, Portland, and Walla Walla, are within the USACE Northwestern Division. The Seattle District has jurisdiction for all of the Chehalis Basin. Contact information for the Seattle District and the Portland Division offices are shown below:

District Commander
US Army Corps of Engineers
Seattle District
P.O. Box 3755
Seattle, WA 98124-3755
206 764 3742

District Commander
US Army Corps of Engineers
Portland District
P.O. Box 2946
Portland, OR 97208-2946
503 808 5150

Coordination of assistance requests through the Governor's Office to a USACE District Commander may be desirable for referral under the Section 22, Section 205 and Section 206 authorities. Further, with regard to Section 22, the Washington Department of Ecology facilitates statewide watershed planning under ESHB 2514 the Watershed Planning Act (Chapter 90.82 RCW) and would be a logical requesting agent/partner. Congressional support may also often be sought to obtain an earmark for these programs.

### . . Federal Emergency Management Agency

The Federal Emergency Management Agency (FEMA) is the agency of the U.S. Government with overall responsibility for disaster mitigation, preparedness, response and recovery. It has three main types of assistance programs:

- Public Assistance for state and local governments directed at repairing or replacing eligible public facilities and infrastructure. It is subject to a 25 percent non-federal share after a disaster declaration by the President of the United States.

- Individual Assistance providing limited grants to property owners and renters for damage to real and personal property after a disaster declaration by the President of the United States;

- Hazard Mitigation provides grants through several programs for natural hazard mitigation, the majority targeting flood mitigation. A 25 percent non-federal

share is required. These represent the primary possibilities for FEMA FWS grant assistance as follows:

- Pre-Disaster Mitigation Program

  Provides funding for hazard mitigation planning and the implementation of mitigation projects prior to a disaster.

- Hazard Mitigation Grant Program

  Provides grants to states and local governments to implement long-term hazard mitigation measures after a major disaster declaration.

  (states, localities and tribal governments; certain private-nonprofit organizations or institutions; authorized tribal organizations; and Alaska native villages organizations via states).

- Flood Mitigation Assistance Program

  Provides funding to assist states and communities in implementing measures to reduce or eliminate the long-term risk of flood damage to structures insurable under the National Flood Insurance Program.

FEMA is also the lead federal agency for developing the Integrated Public Alert and Warning System (IPAWS). IPAWS is to improve public safety through rapid dissemination of emergency messages to as many people as possible using as many communication devices and technologies as possible. Its goal is an integrated, effective, reliable, flexible and comprehensive alert and warning system. Although no financial assistance is available, some coordinating and technical advice may be available, as well as, lessons learned from pilot programs.

**Applica ility to Chehalis Basin**

The FEMA Regional Office in Bothell has jurisdiction over all of the State of Washington. Requests for funding assistance for all FEMA funding programs including hazard mitigation plans or projects are coordinated at the state level through:

Mark Stewart
State Hazard Mitigation Programs Manager
Washington State Military Department
Emergency Management Division
MS: TA-20, Building 20
Camp Murray, WA 98430
253 512 7072

They are submitted to:

Mark Carey, Mitigation Division Director
Mitigation and Flood Hazard Mapping Division
Region X
Federal Emergency Management Agency
Federal Regional Center
130 228th St. SW
Bothell, WA 98021-8627
425 487 4682

### . . Natural Resources Conservation Service

The Natural Resources Conservation Service (NRCS) is an agency of the federal government with responsibility for providing leadership in a partnership effort to help America's private land owners and managers conserve their soil, water, and other natural resources. As part of their mission to monitor the nation's snowpack, the NRCS has installed hundreds of SNOTEL sites nationwide, with about 70 deployed in Washington State (Figure 5-2). Most of the sites are on federal land. The program is largely limited to flooding in areas where snowmelt is a considerable part of the flood threat.

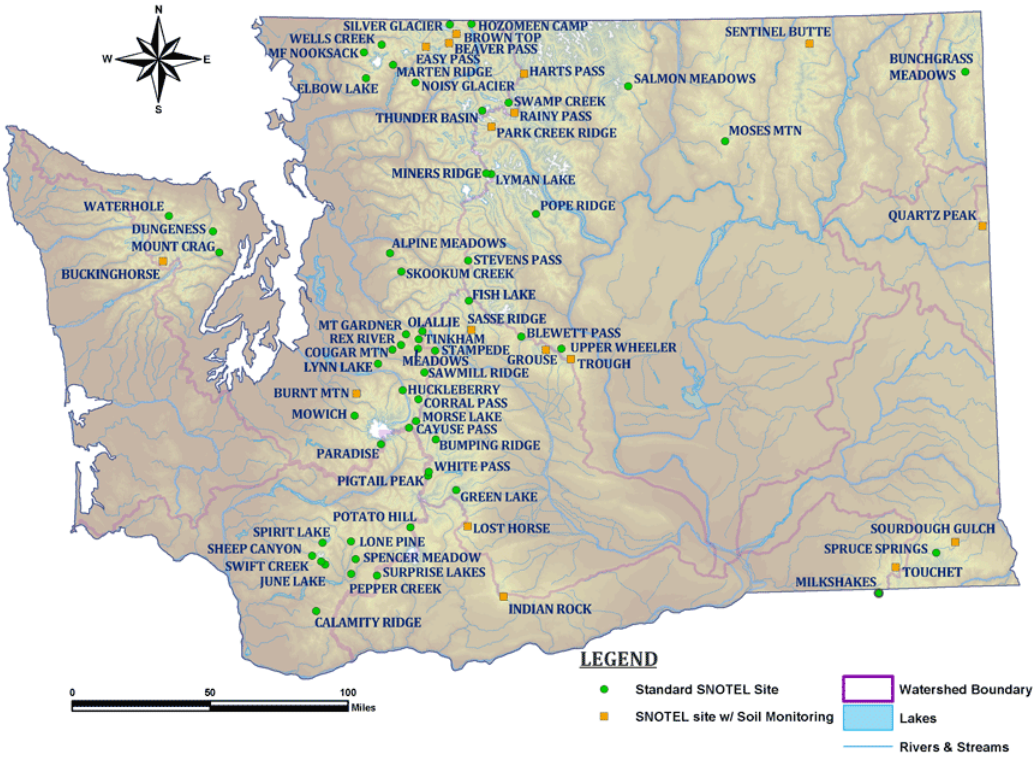


**Figure - . SNOTEL Sites in Washington State**

NRCS does not expect any significant continuing PL 566 (small watersheds) funding in Washington or elsewhere for SNOTEL deployment. Recent authorizations for seven new sites were the result of stimulus funding, not a continuing funding source. Theoretically, with suitable justification, sponsors could request that deactivated sites be reactivated as part of flood warning, but like USACE programs, these would be subject to significant cost sharing. The costs for new SNOTEL installations or upgrades of manual sites would have to be borne by the requesting non-federal agency at this time. However, the NRCS would subsequently operate them as part of their network, since NRCS has the responsibility for monitoring snowpack. Planning and technical assistance for installation of new sites or for upgrading manual sites would be provided at no charge. In the past, the NRCS has partnered with Whatcom and Spokane Counties.

**Applica ility to Chehalis Basin**

There are currently no existing SNOTEL sites in the Chehalis River Basin, since SNOTEL sites are located in the higher elevation portions of the State where snow depths are greater than in the Chehalis Basin. Since the majority of the Chehalis Basin is lower than 3,000 feet in elevation, most areas of the basin do not get snowfall that stays on the ground very long even after an unusual weather event that results in snowfall at lower elevations.

Requests for assistance are coordinated at the state level through:

Larry Johnson
State Conservation Engineer
Spokane, WA
509 323 2955

**. . Summary**

Federal Assistance is available in several forms; for cooperation, for technical and financial assistance, and for federal studies and projects including FWS. Non-Federal cost sharing in effort, and/or cash or related works will be required in all cases for FWS implementation. FWS operation expenses will be largely a local or state responsibility. Although federal assistance is available for FWS, obtaining it will require a clear articulation of the potential benefits at state, local, tribal and federal levels in making requests and applications.

During follow-up correspondence and conversations a number of FWS's were mentioned that might provide some useful insights into both innovative technology and financing arrangements, as well as, cooperative frameworks. Although more study of

the possibilities would be worthwhile before selecting any out of state FWS to examine for insights and lessons learned; some examples demonstrating the range are:

- Findlay, OH – This newer system, with several recent disasters, is being designed with some forward thinking radar, telephone and internet public communication interfaces.

- Lycoming County, PA – This older system appears to remain innovative in technology with automated gauges, reverse 911 calling, and an active community monitoring system. In addition, it is part of an established river basin organization with technical expertise and well established federal and state agency coordinating processes.

- Professional Organizations –There is experience represented in organizations like the National Hydrologic Warning Council, etc. with links to a nationwide network of flood warning systems operating in real time.

## . State Assistance Programs

### . . Department of Ecology

The Stream Hydrology Technical Coordination Team (SH-TCT) of Ecology's Environmental Monitoring and Trends Section provides flow information in support of two Department of Ecology (Ecology) activities. SH-TCT provides timely and accurate instantaneous stream flow for various in-stream actions. These instantaneous stream flows are an integral element in determining the available in-stream resources (for fish) and the available out of stream resources (for people). The driving forces behind the increasing need for accurate and timely stream flow data are The Endangered Species Act (ESA), salmon recovery efforts, and an increased focus on water resource management.

SH-TCT also provides flow information to support water quality monitoring efforts within Ecology.

River/stream discharges are not measured each time water quality information is collected. Instead two methods are used to estimate stream flow at the time of sampling. In some cases, the river stage is measured and recorded when the water quality sample is collected. In addition, at least 6 to 8 times a year, stream flow measurements and the corresponding river/stream stage are recoded. These measurements are made at various stage heights encompassing the recorded stage during the water quality sampling. The instantaneous flow measurements are then

plotted against stage height to develop a rating curve for each measurement site. Ideally, this rating curve covers the full range of the stage heights recorded during the sampling.

SH-TCT makes discharge measurements using two primary methods. Low flows are measured by in-stream wading measurements and high flows (non-wadeable) are measured from a bridge with standard bridge equipment or an Acoustic Doppler Current Profiler (ADCP). The ADCP can be deployed using a tow-raft or for larger applications a jet sled river boat.

Flow measurements and continuous stage records are archived in a stream flow database at the Department of Ecology Headquarters in Olympia, Washington.

### Station Type

The operation of Ecology stream flow stations falls into three types: Telemetry, Stand Alone, and Manual Stage Height. The specific type determines the availability of data for each stream flow station.

### Telemetry

A telemetry station logs stage height every fifteen minutes and transmits this data in three hour blocks to the Department of Ecology Headquarters in Olympia, Washington via a satellite transmitter or a standard dial-up modem. This data is automatically imported into the stream flow database and published to Ecology's web site.

### Stand Alone

A stand-alone station logs data every fifteen minutes and is downloaded periodically (once a month). Data is imported into the stream flow database manually and automatically published to the Ecology web site. Stand-alone stations are typically operated for up to or less than one Water Year (October 1 - September 30). Stream flow data from both active and historic stand-alone stations are included on the Ecology web site.

### Manual Stage Height

A manual-stage-height station does not produce a continuous record but is typically only a single point in time measurement. Stage height is directly read from either a standard staff gage, wire weight gage (WWG) or measured from a reference point (RP). A RP is a point located somewhere over the wetted width of the station cross-section from which a measurement can be made to the water surface. Manual-stage-height measurements

are converted to instantaneous stream flow using a rating table or flow curve. Rating tables or flow curves for each of these stations are built based on the relationship between a series of periodic stage height measurements and their corresponding in-stream flow measurements.

**Access to Data**

Data can be accessed through the Department of Ecology website at the following link for stations that have telemetry data:

https://fortress.wa.gov/ecy/wrx/wrx/flows/regions/state.asp

Current Water Year data provided by the Washington State Department of Ecology – including stream discharge and water level values are automatically generated by remote equipment and have not been reviewed or edited for accuracy. Inaccuracies in the data may be present due to instrument malfunctions or physical changes to the discharge measurement sites. End of water year review may result in significant revisions to the data.

**Applica ility to Chehalis Basin**

This Ecology program could be utilized by accessing the existing available data that is realtime data within the Chehalis River Basin. At the present time, Ecology manages 14 gaging station sites within the Chehalis Basin, however, only two sites have realtime data, Black River at Highway 12 and Wishkah River near Nisson. Each of the two sites with realtime data can be utilized to get current flows which can be used for monitoring and predicting flooding conditions.

Since the Ecology programs that utilize their streamgaging program are primarily concerned about low flows, temperature, and other water quality data, Ecology's streamgaging program is not particularly useful for monitoring or forecasting flood flows. In many cases peak flood flows are not capable of being measured since the flood levels and flood flows exceed the capability of Ecology's monitoring equipment and rating curves.

Expansion of this program could however assist in providing additional sources of data where needed for flood warning systems, if certain modifications were to be made.

**Contacts**

Brad Hopkins, (bhop461@ecy.wa.gov) phone (360) 407-6686

### . . Flood Control Assistance Account Program

This program, administered by the Department of Ecology, assists local governments in reducing flood hazards and damages by providing technical and financial assistance in the development and implementation of comprehensive flood hazard management plans, engineering feasibility studies, physical flood damage reduction projects, acquisition of flood-prone properties, public awareness programs, flood warning systems, and other emergency projects to protect human life and property from flood related events. Eligible local entities must be within a jurisdiction that participates in the National Flood Insurance Program (NFIP).

The program provides up to $4 million per biennium for grants for these activities. State funds can provide up to 75% of the cost of developing a comprehensive flood hazard management plan, and 50% of the cost of a flood damage reduction project. One of the program requirements is that before a flood damage reduction project can be funded for a local entity, the local entity must have an approved comprehensive flood hazard management plan.

**Applica ility to Chehalis Basin**

Ecology has funded the development of comprehensive flood hazard management plans for several local entities within the Chehalis Basin.

### . . Washington Military Department Emergency Management Division

The Hazard Mitigation Grant Program (HMGP), the Pre-Disaster Mitigation Program (PDM) and the Flood Mitigation Assistance Program (FMA), have been the state's best and most significant tools for hazard mitigation in recent years. Since April 1989, the HMGP has provided an aggregate investment of more than $98.7 million for planning and projects designed to reduce or eliminate hazard-caused damage throughout the state. The HMGP has funded the development of numerous Hazard Mitigation Plans for local units of government and a wide range of hazard-reduction projects, ranging from strengthening water towers so they do not fall during earthquakes to purchase of repetitive flood -loss properties. Much smaller investments from the PDM (est. $16.1 million) and the FMA (est. $2.1 million) have paid for mitigation projects, and development of hazard mitigation and flood plans. Additionally, several local jurisdictions have invested their Emergency Management Performance Grant funds in hazard mitigation planning. The state's administrative plan for these three hazard mitigation programs requires all construction-related mitigation projects to support the mitigation goals in the state's current hazard mitigation plan (approved January 2008). Additionally, beginning with the November 2006 flood disaster DR-1671, the state required recipients

of HMGP planning grants eligible to join the NFIP to do so if they were not already members. The purpose for this requirement is that without such membership, the applicant could not obtain a project grant from any of the federally funded mitigation programs.

In order to receive federal funds from any of these programs for projects, the local unit of government must first have adopted a FEMA-approved hazard mitigation plan. The design and implementation of early flood warning programs can be part of individual hazard mitigation plans.

These grants typically provide for 75% funding at the federal level by FEMA, with a 25% local match requirement, up to a half of which is sometimes funded at the State level by the Emergency Management Division. In cases where12.5% State funding is available, the local unit of government is responsible for 12.5% of the total cost for hazard mitigation plans or projects to implement hazard mitigation plans. The local match can be provided either by a cash contribution or in-kind services or a combination of each.

**Applica ility to Chehalis Basin**

FEMA, through the Emergency Management Division, has funded the development of hazard mitigation plans for several local entities within the Chehalis Basin, including Grays Harbor County, Lewis County (including Centralia, Chehalis, and Pe Ell as well as several other local units of government within the County and the Chehalis Basin), and Thurston County (including Bucoda) as well as the cities of Aberdeen, Hoquiam, Westport, Oakville, and Cosmopolis, and the Confederated Tribes of the Chehalis Reservation (Chehalis Tribe).

# IMPLEMENTATION STRATEGY

The next phase of the project is to finalize the design details for the improvements by conducting a design effort that would include site visits to each monitoring location and meeting with representatives of the Flood Authority jurisdictions to further refine the IT integration requirements for the RFLOWS server system. The design details would then be documented in a System Design Report. The purpose of the System Design Report is to document the implementation details and present a look and feel of the system improvements that could be used to build a consensus and prioritize the build-out of the system. The system design report would also include a refined cost estimate and a plan for how the system would be implemented including a breakdown of what resources would be provided by the Flood Authority jurisdictions and by other agencies/entities such as the USGS, NRCS, NWS, TransAlta, Weyerhaeuser, etc. The system improvements would then be constructed based on the System Design Report.

**Chehalis Basin Flood Warning System Improvements**

**CITY OF CENTRALIA**

**NEEDS ASSESSMENT MEETING MINUTES**

**Date:** 12/2/2009

**Location:** Centralia City Hall, Centralia, Washington

**Present:**

Kahle Jennings, Public Works Director, City of Centralia
Carol Hamilton, City Manager's Office, City of Centralia
Paul McFadden, Stormwater, Street & Fleet Operations Manager, City of Centralia
Jan Stemkoski, City Engineer, City of Centralia
Jim Walkowski, Chief, Riverside Fire Authority
Robert Berg, Chief of Police, City of Centralia
Bill Bates, Centralia City Council
Emil Pierson, Community Development Director, City of Centralia
Ray Walton, WEST Consultants
Greg Dutson, Engineered Monitoring Solutions
Jerry Louthain, HDR, Inc.

**Discussion Items:**

Typical Flood Scenarios
Flooding in and adjacent to the City occurs from several sources, with the primary source being the Chehalis River which flows from south to north along the westerly portion of the City. The Skookumchuck River is another major flooding source as it flows from the northeasterly portion of the City through the westerly portion of the City to its confluence with the Chehalis River west of Interstate 5 and just south of the Harrison Street exit from I-5. China Creek also contributes to flooding in the north-central portion of the City as it flows from east to west to the Chehalis River. This small drainage causes localized urban-type flooding through this portion of the City, with some of the creek being free-flowing through a creek bed in the City and some portions in culverts and pipelines under portions of the City. Salzer Creek flows from east to west in the southerly portion of the City with some localized flooding from this source combined with backwater flooding from the Chehalis River during flooding events on the Chehalis River.

The typical flooding scenarios in the City are that flooding occurs first on the smaller drainages of China and Salzer Creeks, followed by flooding from the Skookumchuck River, and then from the Chehalis River. When the Chehalis River reaches flood stage or higher, backwater flooding from the Chehalis causes additional flooding on the lower reaches of each of these tributaries.

Because of the Skookumchuck Dam, which is located at about River Mile 22 on the Skookumchuck River and the reservoir behind the dam, the severity of flooding of the Skookumchuck River is largely based on how full the reservoir is at the beginning of a flood event. This dam and reservoir has no license requirements for flood control, but

does provide some significant benefits to the lowering of flood peaks on the Skookumchuck if the reservoir is low enough to provide storage of flood waters during a flood event.

Data Collecting/Forecasting Methods:

The City uses the predictive model presented in the USACE Chehalis Flood Ground Truthing Project report and floodplain mapping based on the January 1990 flood, showing Chehalis, Newaukum, and Skookumchuck River Flood Phases 1-4, with Phase 4 being the most severe. The City combines this information with NWS weather and river forecast and stream gage data.

Manual level measurements are made at China Creek and Salzer Creek. Flood severity estimates are also based on these unreferenced historical high water marks and observations by City crews.

Notification and Communication Methods:

Flood warnings and evacuation messages are sent via the Cityôs Emergency Operations Center. The city is divided into 4 subsections and unified command posts are established for each section in case EOC is not able to provide coordination.

Notification methods used include radio/TV broadcasts, Cityôs website, HAM radio network (about 20 people), Code Red dialout service (Lewis County system), and the DOT low frequency network.

Improvements Desired:

- Automated local monitoring stations for China Creek, Salzer Creek, Big Hanafordr Creek drainage, Little Hanafordr Creek drainage and on the Newaukum River.
- USGS gage sites at Doty on the Chehalis has been washed out during high flows and needs to be hardened or protected from high flows.
- Dam failure warning systems for the Skookumchuck Dam and Mayfield Hydro projects.
- Precipitation gage upstream of Skookumchuck Dam, in the vicinity of the USGS streamgage, Skookumchuck River near Vail, near River Mile 29.

Other Discussion

NWS correctly predicted the 12/07 event but flood levels rose much faster than normal t (debris dam failures in upper Chehalis River basin). City staff reported that typical times between river crests at Doty gage (near River Mile 102) and City (River Mile 67 at Skookumchuck mouth) are 24-48 hours, but for this flood it was only approximately 16 hours. The Doty gage failed during the 12/07 flood event with the bridge at the gage location being washed out.

They noted that their internet site may receive 10,000 ñhitsòduring a flood event, and is often overwhelmed.

**Chehalis Basin Flood Warning System Improvements**

**CITY OF CHEHALIS**

**NEEDS ASSESSMENT MEETING MINUTES**

**Date:** 12/2/2009

**Location:** Chehalis Community Development Building, Chehalis, WA

**Present:**

Bob Nacht, Community Development Director, City of Chehalis
Bobbi Boone, Community Development Technician, City of Chehalis
Rick Sahlin, Street/Storm Superintendent, City of Chehalis
Kelvin Johnson, Fire Chief, City of Chehalis
Ray Walton, WEST Consultants, Inc.
Greg Dutson, Engineered Monitoring Solutions
Jerry Louthain, HDR, Inc.

**Discussion Items:**

Typical Flood Scenarios

Flooding in and adjacent to the City occurs from several sources, with the primary source being the Chehalis River which flows from the west and south to the north along the westerly portion of the City. The Newaukum River is another major flooding source as it flows from the southeast through the southerly portion of the City to it's confluence with the Chehalis River west of Interstate 5. Coal Creek also contributes to flooding in the north-easterly portion of the City as it flows from east to west to the Chehalis River. Salzer Creek flows from east to west north of the City with some localized flooding from this source combined with backwater flooding from the Chehalis River during flooding events on the Chehalis River.

The typical flooding scenarios in the City are that flooding occurs first on the smaller drainages of Coal and Salzer Creeks, followed by flooding from the Newaukum River, and then from the Chehalis River. When the Chehalis River reaches flood stage or higher, backwater flooding from the Chehalis causes additional flooding on the lower reaches of each of these tributaries.

Data Collecting/Forecasting Methods:

The City contracts with Lewis County Emergency Services to assist with the forecasting and coordination of flood emergencies. The City personnel uses the Lewis County forecasting website for weather and river level forecast information. They review the forecast information and stream gage data and combine the information with local knowledge gathered from field personnel to estimate the flood impacts in their local area. The City also uses the predictive model presented in the USACE Chehalis Flood Ground Truthing Project report and floodplain mapping based on the January 1990 flood,

showing Chehalis, Newaukum, and Skookumchuck River Flood Phases 1-4, with Phase 4 being the most severe. The Fire Chief participates in the Lewis County Emergency Operations Center during flooding events to coordinate flood warning activities for the City.

They use 7 local staff gages for local stream level monitoring. They rely heavily on the USGS gage, Newaukum River near Chehalis, at River Mile 4.1 for their estimating of flood levels from the Newaukum River, and the Chehalis River near Doty, at River Mile 101.8, for the Chehalis River.

Notification and Communication Methods:

All road closure or flood warnings are posted on the City's website and sent to the County for them to include on the county's website as well.

Improvements Desired:

An interface to a basin wide system that would provide stream levels and forecasting info.
An automated redundant gauge at Doty or other upstream location.
An automated gauge for the Chehalis River at the Treatment Plant.
A NWS automated gauge at the Mellen Street bridge.
A real-time monitoring station at Adna that would include flow in cfs so that could be made into a prediction point.

Other Discussion

In addition to the Chehalis River flooding, Salzer Creek and the Newaukum River can have a significant effect on flooding in portions of the City. Salzer Creek does cause some local flooding, primarily in combination with flooding on the Chehalis River.

**Chehalis Basin Flood Warning System Improvements**

**GRAYS HARBOR COUNTY**

**NEEDS ASSESSMENT MEETING MINUTES**

**Date:** 12/1/2009

**Location:** Grays Harbor County, Forestry Building, Montesano, Washington

**Present:**

Terry Willis, Grays Harbor County Commissioner
Chuck Wallace, GHC Deputy Director for Emergency Management
Jeff Nelson, GHC Environmental Health
Garrett Dalan, GHC Environmental Health
Larry Bishop, Citizen
Megan Crowley, Citizen
Ray Walton, WEST Consultants, Inc.
Greg Dutson, Engineered Monitoring Solutions
Jerry Louthain, HDR, Inc.

**Discussion Items:**

Typical Flood Scenarios

In addition to flooding from the mainstem of the Chehalis River, flooding in the Chehalis River Basin portion of Grays Harbor County occurs from two primary tributary sources, the Satsop River and the Wynoochee River and their minor tributaries. Chehalis Basin flooding also occurs on the Wishkah, Hoquiam, and Humptulips Rivers, however most of the County portions of these floodplains have only limited development and relatively minor damages occur. These three river systems also are not direct tributaries to the Chehalis River mainstem as the mouths of these rivers are within the salt water body of Grays Harbor.

Because the County is located in the most downstream portion of the Chehalis Basin, they have a long lead time for notification regarding impending flooding from the mainstem Chehalis River. Typically flooding on the Satsop and Wynoochee Rivers occurs prior to the crest on the Chehalis River reaching the County. When the Chehalis River reaches flood stage or higher, backwater flooding from the Chehalis also causes some additional flooding on the lower reaches of each of these tributaries. Additional flooding also occurs due to high tides near the mouths of these rivers and on the mainstem Chehalis River as far upstream as just upstream of the Satsop River mouth.

Flooding on the Wynoochee River is largely influenced by flow releases from Wynoochee Dam, which is located River Mile 52.

Data Collecting/Forecasting Methods:

The County use the NWS weather and river forecasts that reference the USGS stream gages located at Grand Mound (River Mile 60) and Porter (RM 33) on the Chehalis River. There are two additional gages on the Chehalis River, one near Satsop and one near Montesano, however these gages do not provide reliable readings since they both are influenced by tidewater during high tides on the Chehalis River. They also monitor the University of Washington's website.The gage sites on the Satsop River and Wynoochee River are used as well for monitoring flows on these rivers. One real-time gaging station is located at River Mile 2.3 on the Satsop, and three real-time gages on the Wynoochee at River Miles 5.9 (above Black Creek), 40.6, (above Save Creek)and 51.3 (just below Wynoochee Dam).

Of these two gages, the Satsop gage is relied upon more because the Montesano gage is more influenced by ocean tides.

Outflow condition at Wynoochee Dam is also used to forecast stream levels.

Another matter that was discussed was that the USGS gage at the Humptulips River has been funded for another year.

Notification and Communication Methods:

Messages are provided to the general public via a dial out notification service, the Grays Harbor County website, the Grays Harbor County Emergency Management website, radio and television broadcasts, and at times, a ham radio network.

Grays Harbor County Emergency Management will use National Weather Service forecasts to give a 36-48 hour notification window of impending flooding to the affected areas. Emergency Management initiates the dial out notification service to the areas which will be impacted by the flooding, sends e-mails to the various entities such as Police Chiefs, Fire Chiefs, Citizen Corps Groups and to the local Media and posts the information on the County and Emergency Management websites. In some instances, the Grays Harbor Sheriff's Office will go door to door to warn property owners of impending flooding and the need to evacuate.

Improvements Desired:

- Would like rain gages in the Satsop and Wynoochee River basins, and all gages viewable over the internet.
- Would like outflow flow quantity and reservoir level data from Wynoochee Dam in real time. They would also like the Corps to notify them of future releases when known.
- Would like better coordination and communication from the Corps to use and to inform the public regarding operating procedures at Wynoochee Dam
- Would like a stream gage at Elma to be used for forecasting river levels.

- Additional stage only stream gage stations would be helpful to some local residents.
- Would like the USGS to account for tidal influence levels at the Montesano stream gage.
- Would like better coordination with WSDOT regarding road closures to improve coordination with evacuation routes etc.

Other Discussion

Megan Crowleyvoiced concern over repeated flooding of her commercial horse boarding/training facility and the surrounding area. It was discussed that additional lead time is needed so that she can coordinate the evacuation of her facility. She did indicate that she gets a call from the Corps regarding releases from Wynoochee Dam.

**Chehalis Basin Flood Warning System Improvements**

**LEWIS COUNTY**

**NEEDS ASSESSMENT MEETING MINUTES**

**Date:** 12/3/2009

**Location:** Lewis County Offices, Chehalis, Washington

**Present:**

Fred Chapman, Building Official, Lewis County
Ross McDowell, Deputy Director, Lewis County Sheriff's Office
Gregg Peterson, Curtis, Boistfort Fire District
Ray Walton, WEST Consultants, Inc.
Greg Dutson, Engineered Monitoring Solutions
Jerry Louthain, HDR, Inc.

**Discussion Items:**

Typical Flood Scenarios

Flooding in the Chehalis Basin portion of Lewis County occurs from several sources. The primary source is the Chehalis River, along with the South Fork Chehalis River, which flows from the southwesterly corner of the County in a northerly, then easterly, then northerly direction until it flows into Thurston County just north of the City of Centralia. The Newaukum River, along with its' primary tributaries, the North, Middle, and South Fork of the Newaukum, is another major flooding source in the Chehalis Basin portion of the County. The three main tributaries come out of the hills in eastern Lewis County to form the mainstem Newaukum and from there it flows from the southeast to its' confluence with the Chehalis River west of Interstate 5. The Skookumchuck River is another flooding source, however only a short reach of the Skookumchuck River lies in the County. Approximately a 15-mile reach of the Skookumchuck River lies in Thurston County from Skookumchuck Dam downstream to the County line at approximately River Mile 5. The Skookumchuck then flows for only a few miles to the northeasterly portion of the City of Centralia and then through the westerly portion of the City to it's confluence with the Chehalis River west of Interstate 5 and just south of the Harrison Street exit from I-5.

The typical flooding scenarios in the County are that flooding occurs first on the smaller drainages of the numerous small tributary streams in the County, followed by flooding from the Skookumchuck and Newaukum Rivers, and then from the Chehalis River. When the Chehalis River reaches flood stage or higher, backwater flooding from the Chehalis causes additional flooding on the lower reaches of each of these tributaries.

Data Collecting/Forecasting Methods:

The County uses the predictive model presented in the USACE Chehalis Flood Ground Truthing Project report and floodplain mapping based on the January 1990 flood, showing Chehalis, Newaukum, and Skookumchuck River Flood Phases 1-4, with Phase 4 being the most severe.

County receives alert messages from NWS via email and webinars.

Once on alert, Ross watches NWS climate forecasts and stream gage levels. Riverwatchers (approximately 150 citizens) are also used especially along South Fork Chehalis.

Flood level estimates are then made based on the NWS climate data, local knowledge, and Riverwatcher information.

Notification and Communication Methods:

County utilizes an Emergency Operation Center located in the Sheriff's office. Ross McDowell initiates the activation of the County EOC, which typically becomes operational when a Phase 3 Flood is predicted. CCD STACY Brown is Ross' alternate. Notification is provided via a limited phone tree to local jurisdictions, the County's website, TV/Radio announcements, NOAA radios and a CodeRed dial out service. CodeRED is a system that gives "action to be taken now" notifications and is geographically based.

Boistfort utilizes fire trucks etc. with sirens to alert residents in the community. The County also provides flood notification information to downstream counties and cities within the Chehalis River basin. They receive notifications from EMD using MyStateUSA.

Improvements Desired:

Stream gage at Beaver Creek on the South Fork of the Chehalis
Rain gage on Elk Creek or Rock Creek and Upper Newaukum Basin
Stream gage w/ flow at Elk Creek
Snotel site on Boistfort Peak
Add flow and predictive capabilities to the Adna stream gage
Siren/loud speaker network for upper Chehalis communities

Other Discussion

Outlying communities in Lewis County have very little advance notice of floods. Early detection and notification is much more important in this area of the basin, particularly in the upper Chehalis and South Fork Chehalis basins.

Some concern over the dams located upstream on the Skookumchuck and the Cowlitz Rivers. Ross mentioned that Tacoma City Light has a new Emergency Response Coordinator.

They noted that new streamflow gages are being set up on Elk Creek and Salzer Creek by USGS.

They would like messages broadcast in English and Spanish.

**Chehalis Basin Flood Warning System Improvements**

**THURSTON COUNTY**

**NEEDS ASSESSMENT MEETING MINUTES**

**Date:** 11/30/2009

**Location:** Thurston County Courthouse, Olympia, Washington

**Present:**

Andrew Kinney, Thurston County
Kathy Estes, Thurston County
Mark Swartout, Thurston County
Ray Walton, WEST Consultants, Inc.
Greg Dutson, Engineered Monitoring Solutions

**Discussion Items:**

Typical Flood Scenarios

Flooding in the Chehalis Basin portion of Thurston County occurs from two primary sources, the Skookumchuck River and the Black River and their minor tributaries. Approximately a 15-mile reach of the Skookumchuck River lies in the County from Skookumchuck Dam downstream to the Lewis County line at approximately River Mile 5. The Skookumchuck then flows for only a few miles to the northeasterly portion of the City of Centralia and then through the westerly portion of the City to it's confluence with the Chehalis River west of Interstate 5 and just south of the Harrison Street exit from I-5. There are three active real-time USGS gauging stations on the Skookumchuck River drainage, one upstream of the reservoir, one just downstream of the dam, and one downstream of the Town of Bucoda. The Black River flows from Black Lake located near Olympia, in a southwesterly direction to the southwestern corner of the County near the City of Rochester and the community of Gate. A short reach of the Chehalis River also flows through the southwesterly portion of the County.

The typical flooding scenarios in the County are that flooding occurs first on the smaller drainages of the numerous small tributary streams in the County, followed by flooding from the Black and Skookumchuck River and then the Chehalis River. When the Chehalis River reaches flood stage or higher, backwater flooding from the Chehalis causes additional flooding on the lower reaches of each of these tributaries.

Data Collecting/Forecasting Methods:

Thurston County subscribes to the NWS eWarn system for weather alerts and warnings. NWS pushes the warnings to the county via email and txt.

The county reviews NWS wind, rain, flood elevation predictions, Snotel estimates, CoCoRaHs, freeze estimates, and USGS stream gage readings.

The current weather conditions, current USGS stream gage data, and the NWS predictions are combined with local knowledge of County personnel to make predictions about the severity of the flooding.

Notification and Communication Methods:

Kathy Estes makes decision to activate the EOC along with input from boss.

Media notifications are produced when there is a flood watch from the NWS that could cause localized impacts. Any notifications to the public are also sent to Grays Harbor and Lewis County.

The ALERT telephone service is used to disseminate the warning calls to the general public. About 650 phone numbers included. The County currently pays $1500 to $2000 for each event. The current system does not meet their needs.

River level data is displayed on the county's website at http://www.co.thurston.wa.us/em/Rivers/Chehalis.htm.

Typically, the county has plenty of time to staff up in the event the EOC is activated and use the ALERT system. EOC initiates the notifying of staff to work by e-mail and has worked well in the past.

The County likes using the USGS gaging stations and data.

Improvements Desired:

- Better predictive model for local flooding impacts.
- Improved method for data display and assimilation.
- Expansion of the Riverwatch (local visual observation) network.
- Improved communication regarding status and condition of flood control structures in the basin during events.
- Would like flood inundation mapping capability
- Would like additional gages on the Skookumchuck River located at _____ to improve the prediction models.
- Would like notification system for any potential Skookumchuck Dam failure.

Other Discussion

The county would like to keep the USGS and NWS gages as the back bone of any new monitoring program.

40 minute lead time for inundation from Skookumchuck dam failure. No notification system currently in place.

The predictive model of the Skookumchuck River by NWS is not using side channel input. By the time it reaches the Bucoda gage it's too late – could be solved by additional gages or by updating the model.

Would like to have a notification system based on geographic area that is capable of supporting the needs of other emergencies such as chemical spills, fire, etc.

Would like to develop "threshold" levels for river flooding.

They have a number of levees in the County, but are unsure of ownership. They would like to see better communication of levee failures.

**Chehalis Basin Flood Warning System Improvements**

**TOWN OF BUCODA**

**NEEDS ASSESSMENT MEETING MINUTES (phone interview)**

**Date:** 2/4/2010

**Location:** Phone Interview

**Present:**

Jim Fowler, Bucoda Fire Dept, 360-867-2648,
Greg Dutson, Engineered Monitoring Solutions

**Discussion Items:**

Typical Flood Scenario:

The Skookumchuck River flows roughly north to south through the Town of Bucoda and then dumps into the Chehalis River at Centralia. Flooding occurs in Bucoda when the Chehalis River levels become so high that the Skookumchuck River backs up from its confluence with the Chehalis River. The backup of flow causes the Skookumchuck River levels to rise and flood parts of Bucoda from the south.

Data Collecting/Forecasting Methods:

Typically, the Bucoda emergency personnel will watch weather forecasts and then monitor the USGS river gages (USGS 12026150 and 12026400) along the Skookumchuck River. They will also place a call to Trans-Alta to get the Skookumchuck River reservoir level. Based on the NWS weather forecasts, the readings of the gages and the reservoir level they will then estimate the severity of the flood levels and take appropriate measures.

Notification and Communication Methods:

During flooding events caused by storms, typically they are able to have 24 hours notice of possible flooding. During these events, the City prints up flyers and they are passed out door-to-door to the effected residences (approximately 400). The flyers contain a warning notice of possible flood and the evacuation routes to take.

A breech of the Skookumchuck Dam will cause flooding of 2/3 of the town within two hours of the breech. A siren on top of the fire house will be used as the primary notification method to notify the town of the emergency. The siren is tested nightly with a short audible wail. The plan is to turn the siren on and leave it on in the event of a dam breech. The current siren is over 60 years old.

During flood events, the EOC for the city moves to higher ground up off of 8th street and is operated with generators and radios.

Improvements Desired:

A stage-only automated stream gage on the Skookumchuck River at the 7th Street bridge in Bucoda.
Access to the Skookumchuck Reservoir level data in a near real-time interface.
An improved interface to the USGS gage data, NWS data, and the reservoir level data.
A digital siren with voice message capability to be used to notify the town population during flood events.

Other Discussion:

Jim indicated that the USGS gages along the Skookumchuck River at Bloody Run and Bucoda have been very stable and he was not aware that they had experienced any damage or down time.

**Chehalis Basin Flood Warning System Improvements**

**TOWN OF PE ELL**

**NEEDS ASSESSMENT MEETING MINUTES (phone interview)**

**Date:** 1/4/2010

**Location:** Phone Interview

**Present:**

Delores Lee, Town of Pe Ell
Greg Dutson, Engineered Monitoring Solutions

**Discussion Items:**

Typical Flood Scenarios

The town of Pe Ell is located close to the headwaters of the Chehalis River. Subsequently, the river is flashy in their area but localized flooding within the City limits is minimal.

Data Collecting/Forecasting Methods:

City personnel watch NOAA weather reports and forecasts. Water levels of the Chehalis river are observed manually at the City's water treatment and sewer treatment plants.

Notification and Communication Methods:

If water level in the river gets too high then the City contacts Ross McDowell at Lewis County to let them know that the water is rising.

Once they are in an alarm condition, they monitor the Lewis County website for updates and evacuation notices.

Improvements Desired:

- Would like additional stream gage somewhere upstream of the City to assist with river level monitoring and flood forecasting.

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**Chehalis Basin Flood Warning System Improvements**

**CONFEDERATED TRIBES OF THE CHEHALIS RESERVATION AND CITY OF OAKVILLE**

**NEEDS ASSESSMENT MEETING MINUTES**

**Date:** 12/1/2009

**Location:** Lucky Eagle Casino, Rochester, Washington

**Present:**

Glen Connelly, Environmental Program Specialist Chehalis Tribe
Ralph Wyman, Chief of Police at the Tribal Police Dept.
Mark White, Director of Natural Resources Dept.
Dan Thompson, Oakville Public Works Dept.
Jim Mattheis, Lucky Eagle Casino
Earl McWhorter, Lucky Eagle Casino – TGA
Chuck Wallace, Grays Harbor County, Deputy Director for Emergency Management
Ray Walton, WEST Consultants, Inc.
Greg Dutson, Engineered Monitoring Solutions
Jerry Louthain, HDR, Inc.

**Discussion Items:**

Typical Flood Scenarios

Primary flooding issues are high river levels of the Chehalis River that combine with the Black River to cause backwater flooding into lowland areas near the confluence of these two rivers. Flooding from the Black River typically occurs prior to flooding from the Chehalis River, since there is a much larger drainage basin upstream of the confluence with the Black and Chehalis Rivers. During large flooding events on the Black River, significant flooding can occur from the Black River by itself. The Tribe's Reservation lands include several miles of Chehalis River floodplain, and some flooding occurs all along this reach of the river. Half of Oakville might be flooded during major events.

Data Collecting/Forecasting Methods:

Since flood events for this part of the basin have long times for warning of flooding from the Chehalis River, the emergency management personnel for the Confederated Tribes of the Chehalis Reservation (Tribe) watch long range weather forecasts for flood warnings etc. When an event is forecasted they will monitor the NWS prediction data and any warnings issued from the State EMD. The USGS gaging station at Grand Mound (River Mile 70) is the primary stage measurement that is used for forecasting and early warning detection. They also receive some emails from other counties in the basin.

Ralph Wyman is the point person for the Tribe who reviews the data and field reports to determine the severity of the event and to make decisions to evacuate the tribal lands and the casino properties. The casino needs a three-hour minimum amount of time to evacuate the casino properties, which are totally evacuated, except for a few emergency staff, during a major flooding event from the Chehalis River. This is because the primary access route, State Highway 12, is inundated in both directions from the casino during these major floods. The eastern portion of the reservation, where the casino properties and Tribal Center are located, is situated on higher ground than the surrounding area, so they become an island during major flood events.

The City of Oakville works closely with the Tribe to coordinate flood forecasting and visual observations. The easterly and southerly portion of the City flood during a major event, such as the December 2007 flood. Some flooding also occurs due to flooding from Harris Creek which enters the Chehalis River south and west of the City.

Oakville has a rain gage that is maintained by King 5 news.
Tribe rain gage data goes to Washington Department of Ecology.

Notification and Communication Methods:

Once a decision to evacuate is made, the emergency staff of the Tribe and the City of Oakville use a phone tree and word of mouth to communicate the evacuation notice to the general public. Evacuation and road closure information is also posted on the reader board along Highway 12 at the Anderson Road entrance to the casino.

Improvements Desired:

- Would like additional stream gage somewhere upstream on the Black River to improve flood level forecasting at the confluence of the Black River and the Chehalis River.
- Would like additional stream gage on Chehalis River in the vicinity of the mouth of Independence Creek (near the Thurston/Grays Harbor County line).
- Would like improved communication from Lewis County and WSDOT regarding flood severity and highway closures.
- Would like mobile readerboards to place along Highway 12 during event for improved notification.
- Would like to be able to access central “basin” website with flood data and coordination information.
- Would like access to the Skookumchuck Reservoir levels and a notification system in case of dam break.

Other Discussion

Doppler radar coming to region next year.

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**Chehalis Basin Flood Warning System Improvements**

**NATURAL RESOURCES CONSERVATION SERVICE**

**NEEDS ASSESSMENT MEETING MINUTES (phone interview)**

**Date:** 1/7/2010

**Location:** Phone Interview

**Present:**

Jon Lea, NRCS, Oregon/Washington Snow Survey Manager, 503-414-3267
Greg Dutson, Engineered Monitoring Solutions

**Discussion Items:**

Jonôs group coordinates the construction, maintenance, and operation of the SNOTEL sites in Washington, Oregon and northern California.

NRCS does not have a SNOTEL site within the upper Chehalis River Basin. A SNOTEL site in Boisfort Peak area would be a good addition to their network.

A typical SNOTEL site consists of instrument shelter, rocket style precipitation gage, snow pillow, solar panel, and antenna for telemetry. Meteor burst transmissions (41 MHz) are used for telemetry

Data from the site is collected hourly and transmitted to their Kansas City office where it is disseminated to the regional offices and also posted to the internet via their hardened web host. Their hardened web host includes a failover network and has >99% uptime with maximum down time being 2-3 minutes per outage. All data is transmitted in the Standard Hydrologic Encoded Format (SHEF) and is used by the National Weather Service River forecasting office.

All SNOTEL sites are constructed and maintained by the NRCS through a Cooperative Agreement with a sponsoring organization. Typical costs for the construction of the site are approximately $25,000 depending on the site location and land ownership (public or private) and require a maintenance fee of $3,000 to maintain. Site development and construction is typically a 12-18 month process.

Whatcom County and Pierce County have both installed SNOTEL sites at the upper end of drainage basins and have been very pleased with the increased ability to determine flood impacts from snow melt.

**Chehalis Basin Flood Warning System Improvements**

**NATIONAL WEATHER SERVICE – NORTHWEST RIVER FORECAST CENTER**

**NEEDS ASSESSMENT MEETING MINUTES (phone interview)**

**Date:** 1/26/2010

**Location:** Phone Interview

**Present:**

Harold Opitz, Hydrologist in Charge, NW River Forecast Center, 206-526-6095 x228
Greg Dutson, Engineered Monitoring Solutions

**Discussion Items:**

Haroldôs group is responsible for creating and maintaining the river forecast model used by the National Weather Service (NWS) River Forecasting Center (RFC).

The model used by the RFC is a Conceptual Soil Moisture Model that produces forecasts for 9 or 10 location points. Currently, the number of forecast points for the model is limited by the staff resources he has available to work on the model.

Harold indicated that they would consider adjusting (relocating) some of their forecast points to other mainstem locations as long as the proposed locations had 8-10 years of validated flow data. They have been asked by agencies to move forecasting locations in the past but have been reluctant to do so because of the perceived unstable funding of the new gaging station location.

He suggested adding flow to the prospective locations and coming back the RFC once the historical data is available. Additional data points are always useful and he would like to know as soon as additional data is available.

Harold suggested talking to Brent Bower at the NWS Seattle Weather Forecast Office for information regarding what types of data and locations would be useful for their work.

**Chehalis Basin Flood Warning System Improvements**

**NATIONAL WEATHER SERVICE – SEATTLE WEATHER FORECAST OFFICE**

**NEEDS ASSESSMENT MEETING MINUTES (phone interview)**

**Date:** 1/26/2010

**Location:** Phone Interview

**Present:**

J. Brent Bower, Hydrologic Program Manager/Hydrometeorologist, Seattle Weather Forecast Office, (206) 526-6095 x 228
Greg Dutson, Engineered Monitoring Solutions

**Discussion Items:**

Brentõs grop is responsible for producing wather forecasts for the western Washington region. These include a daily forecast discussion and ñeventòbased discussions. The event based discussions include a 3-day ñOutlookò, a 1 to 2 day ñWatchò, and flood ñWarningòmessages. When forecasts indicate severe weather or incoming storms, the NWS conducts webinars or conference calls to emergency personnel in the area. All forecast and climate related data is presented on the NOAA website at: http://www.wrh.noaa.gov/sew/

Brent identified a number of areas where additional precipitation and weather data would help to fill in gaps in their data. Additional automated precipitation gages would greatly help to further refine their forecasting models resulting in better forecasting capabilities in those areas. Brent faxed a map to us showing the locations where climate data is desired.

Weyerhaeuser Precipitation Gages
Brent indicated that there are three precipitation gages currently owned and operated by Weyerhaeuser Company that would be very helpful to automate and add to the NWS dataset. He suggested contacting Maryanne Reiter at Weyerhaeuser regarding automating the Brooklyn, Rock Creek, and Raccoon Creek gages.

**Chehalis Basin Flood Warning System Improvements**

**TRANSALTA CORPORATION – SKOOKUMCHCK DAM PROJECT**

**NEEDS ASSESSMENT MEETING MINUTES (phone interview)**

**Date:** 2/4/2010

**Location:** Phone interview

**Present:**

Larry Webster, Skookumchuck Dam Operations Supervisor, 360-330-2320
Greg Dutson, Engineered Monitoring Solutions

**Discussion Items:**

Larry is the point of contact for issues related to sharing data from the Skookumchuck Dam project.

The dam currently has automated sensors for measurements such as valve positions, water levels etc. The data is transferred to the powerplant at Centralia via a wireless radio link.

During flood events, emergency managers call the TransAlta office, or in some cases, the operators at the dam for water levels etc. at the project.

Larry indicated that he did not feel there would be a problem supplying the data to the Flood Authority via an ñautomated data transferò If there is a security issue with ñsharingòthe data via a network connection then the Flood Authority may have to investigate installing a new reservoir level sensor and telemetry at the dam for their own use.

Larry will discuss the possible approaches and get back to the Flood Authority with a decision.

On 2/4/09, an email was sent to Larry outlining the possible approaches for sharing the data or installing a new sensor and telemetry.

**Chehalis Basin Flood Warning System Improvements**

**U.S. GEOLOGICAL SURVEY - WASHINGTON WATER SCIENCE CENTER**

**NEEDS ASSESSMENT MEETING MINUTES (phone interview)**

**Date:** 1/211/2010

**Location:** Phone interview and email correspondence

**Present:**

Robert (Bob) Kimbrough, Assistant Director, (253) 552-1608
Greg Dutson, Engineered Monitoring Solutions

**Discussion Items:**

Bob is responsible for the construction and maintenance of the USGS gaging stations in the Chehalis River area. He is stationed in the Tacoma office.

Precipitation Gage Improvements:
The Satsop River near Satsop gage (12035000) has no suitable location for a precipitation gage, as an alternative, he recommends installing the precipitation gage at Wynoochee River above Black Creek (12037400), located about 8 miles west of the Satsop gage. This would run about $1,800 and would have an annual operation cost of $2,140.

Wynoochee River near Grisdale (12035400). He recommends using the existing precipitation gage at Wynoochee Lake, located about 0.5 miles upstream.

To add precipitation to the Skookumchuck River near Vail (12025700) site would be $1,800. Reoccurring annual operation cost and posting of real-time data on the Web would be $2,140.

Adding Flow Ratings to Existing Stations:
Chehalis River at WWTP (12025100). He does not recommend converting this station to report discharge. This particular stretch of the river is unsuitable for obtaining high-flow discharge measurements because of the large amount of water flowing out of the river banks at high stages. The flow results would not be meaningful.

Chehalis River at Centralia (12025500). This station is currently owned and operated by the National Weather Service. Bob indicates that the NWS has expressed interest in having USGS assume operation of the gage, however, funding has not yet been identified. To convert this station to report discharge, he recommends major improvements to existing gage instrumentation. The cost for the gage improvements would be $12,000. The recurring annual costs would be $16,870. It is preferable to have

AC power at this site. If it does not have AC power, there would be an additional cost for having a contractor run power to the gage.

Chehalis River near Adna (12021800). To convert this station to report discharge, a bank-operated cableway would need to be installed enabling USGS personnel to obtain high-flow discharge measurements. The cost to install the cableway would be about $30,000 - $50,000

Upgrading The Montesano Site Stage Measurements To Account For Tidal Influence
Since this reach of the river is affected by tides, traditional streamgaging techniques cannot be applied. Rather than just relating discharge to river stage, discharge would be related to velocity and area. Hydroacoustic technology is used to obtain velocity readings in the river. Acoustic Doppler Profilers are submerged in the water and typically mounted on the river bank or on a pylon. Acoustic devices are relatively expensive and acoustic sites typically cost more to operate. Converting this site to report discharge includes installing an acoustic profiler and constructing a walk-in gage house with elevated pedestal foundation. The installation costs would be around $40,000 with an annual costs of $22,500 to operate the station and post the data to the website.

Improvement for the Stream Gage at Doty:
Chehalis River near Doty (12020000). Throughout it's 70 year history, this gage has typically performed very well. An exception was in December 2007 when the river rose 25 feet and flooded out the electronic instrumentation in the gage house. As a result the gage house was relocated to higher ground in 2008. Additionally, the manned cableway at this site (used to obtain high-flow discharge measurements) was washed out in December 2007. A new cableway was recently purchased using federal stimulus funds, however, the USGS is seeking $10,000 to install the cableway during the summer of 2010.

Typical Costs For New Stage-Only Or Stage/Flow Station
The cost for installing new stage-only sites typically ranges from $15,000-$20,000. Stage/flow sites typically range from $17,000-$24,000, assuming a structure like a bridge exists for obtaining high-flow discharge measurements. If no suitable structure exists nearby, than a cableway would need to be installed. Cableways range from $30,000 - $50,000. The cableway cost is in addition to the $17,000 - $24,000.

Annual costs (for the current federal fiscal year) are:

Daily discharge with real-time data on the web; $16,870 (year-round), $10,800 (seasonal).
Stage-only with real-time stage on the web; $6,870 (year round)
Precipitation with real-time data on the web; $2,140 (year-round)

These costs typically increase about 3-4% per year:

**Chehalis Basin Flood Warning System Improvements**

**WEYERHAEUSER TIMBERLAND OPERATIONS**
**Springfield Oregon Office**

**NEEDS ASSESSMENT MEETING MINUTES (phone interview)**

**Date:** 1/26/2010

**Location:** Initial phone interview and subsequent emails

**Present:**

Maryanne Reiter, Hydrologist, Weyerhaeuser Timberland Operations, 541-746-2511
Greg Dutson, Engineered Monitoring Solutions

**Discussion Items:**

Maryanne is a hydrologist for Weyerhaeuser involved with the precipitation monitoring for their lands in Oregon and Washington. She is closely involved with the sites in the Chehalis River basin area.

She indicated that the Brooklyn, Rock Creek, and Racoon Creek are automated using a tipping bucket rain gage and Onset Hobo dataloggers. There is no telemetry to automatically download the data so each site is visited every 2 to 3 weeks to download the data.

Weyerhaeuser also owns the property at Boisfort Peak and would be interested in working with the Flood Authority and the NRCS for developing a SnoTel site at this location as well.

Maryanne thought that they own property in the area where the other new precip sites are needed as well. They already have a manually read precip station located in the upper Newaukum basin that could be automated as well.

Weyerhaeuser is very interested in adding telemetry to these sites to allow for real-time automated download of the weather data. She will be the initial point of contact for coordinating the effort and working through their internal process for site access issues.

**Chehalis Basin Flood Warning System Improvements**

**WASHINGTON DEPARTMENT OF TRANSPORTATION – SW REGION**

**NEEDS ASSESSMENT MEETING MINUTES (phone interview)**

**Date:** 1/13/2010

**Location:** Phone Interview

**Present:**

Rick Sjolander, SW Region Supervisor, (360) 905-2020
Greg Dutson, Engineered Monitoring Solutions

**Discussion Items:**

Rickôs jurisdiction runs from Oregon border along I-5 corridor to north end of Lewis County. John Nesbitt (360) 357-2612 from the Olympic region is responsible for coordinating road closures along Highway 12.

WSDOT has a representative on the Lewis County EOC to coordinate road closures with the County during storm events.

The road closure information on the WSDOT web site is initiated by the State Secretary of Transportation as soon as the decision to close the road is made. The State Secretary has the final authorization on any road closure.

Road closure information is posted to the WSDOT website within 5-10 minutes of the final authorization to close the road.

Linking to the information on the WSDOT website will provide the most timely road closure reports for the general public and the Flood Authority.