U.S. Army Corps
of Engineers
Seattle District

Centralia Flood Damage Reduction Project
Chehalis River, Washington
General Reevaluation Report

Appendix C:

Levee Plan and Civil Design

June 2003

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TABLES

PLATES

(attached in a separate binding)

1. DESCRIPTION OF THE LEVEE PLAN

1.1 The Levee Plan

The levee plan consists of several components, including a levee/floodwall system and modifications to the existing Skookumchuck Dam for flood control storage. The proposed levee system includes levees along the Chehalis River and its tributaries Dillenbaugh Creek, Salzer Creek, and the Skookumchuck River.

1.2 Levee / Floodwall System

Design of the levee/floodwall system took advantage of opportunities to maximize levee setbacks, allowing floodplain and channel connectivity for environmental purposes. The plan also utilizes floodwalls where traffic control barriers could serve multi-purposes or where it was necessary to reduce the project footprint. The setback levee alignment would protect existing residential and commercial structures, highway and other transportation infrastructure from flooding while not encouraging new floodplain development. Proposed protection would extend along the Chehalis River from approximately river mile (RM) 75 to RM 64, as well as along most of the lower 2 miles of both Dillenbaugh Creek and Salzer Creek. In addition, levee protection will be provided on the Skookumchuck River for backwater effects of the Chehalis River. The affected reach is approximately 2 miles upstream on the Skookumchuck River to the confluence with Coffee Creek.

The levee system is intended to protect against the base 100-year Chehalis River flood level with a minimum 95 percent reliability performance. The 100-year protection is coordinated with the Federal Emergency Management Agency (FEMA) flood maps, so that they will be compatible. (See the General Reevaluation Report (GRR) for further details on plan formulation and risk-based flood management analysis.) This protection also extends to the tributaries of the Chehalis River. The Chehalis backwater flooding is prevented from going upstream on the following tributaries: Dillenbaugh Creek, Salzer Creek, China Creek, Coal Creek and the Skookumchuck River.

2. BASIS OF DESIGN FOR LEVEE PLAN

2.1 SETBACK LEVEE SYSTEM

2.1.1 Background

The levee alternative has been evolving over the last 27 years and builds upon the findings of the many studies of various river sections completed over this period, as well as a study of the entire basin completed in 1979, the Centralia-Chehalis Flood Control Study. That study saw several public meetings and reviews of a comprehensive levee alignment.

The current levee alternative incorporates many improvements on the 1979 design, including modifications to Skookumchuck Dam, reconfiguration of levee alignments to maximize levee setbacks, coordination with the Washington State Department of Transportation (WSDOT) to lower construction costs by combining the levee with the I-5 corridor where possible, and incorporation of ecosystem restoration features to address important fish and wildlife habitat needs in the study area.

Several major floods occurring since the 1979 design have helped refine the design in this study. The 1986, 1991, and in particular the 1996 floods provided valuable benchmarks to calibrate the numerical model with actual flood data. The 1996 flood provided high water close to a 100-year event. These floods also provided more data to update and refine the 100-year flood level, which is now also being used as a basis for design of this levee system.

2.1.2 Design Philosophy

In reviewing the work of previous studies, considering the increased importance placed on environmental concerns, and conducting site visits with shareholders, it became apparent that much coordination was necessary. This made it important to incorporate as many concerns as possible early in the design effort to avoid impacts later in the study. To facilitate the expedited study some guiding design principles were considered throughout the project. These principals also correlate to the project criteria and include:

- Avoid environmental impacts to the maximum extent possible
- Minimize the environmental impact as much as possible
- Minimize the initial construction and long term maintenance
- Provide a minimum of a 50 year project life
- Minimize project-induced damages, both within the project area and downstream
- Avoid inundating or excavating hazardous materials

- Maximize the transportation corridor benefits
- Maximize local infrastructure benefits
- Incorporate restoration opportunities into project

In addition, a general assumption in the levee system design was that it would provide 100-year protection from flooding of the Chehalis River. This includes protection from Chehalis River backwater on the tributaries, including on Dillenbaugh Creek, Salzer Creek, China Creek, Coal Creek and the Skookumchuck River.

2.1.3 Levee Design Criteria

The standard Corps levee design consists of a 12-foot top width and 2:1 side slopes (2 horizontal to 1 vertical). The fill material must meet the gradation specification and be compacted to Corps standards for levees discussed in paragraph 2.1.3.2. A 6-inch layer of gravel will be placed on the top surface to provide access during flood events and for maintenance. Both sides of the levee will be hydroseeded with grass with 4 inches of topsoil over compacted embankment material. Most levees are set back levees, which will not require rock bank protection. For those few areas that do require bank protection, the protection will include 30-inch minus riprap about 3 feet thick, with a 1-foot layer of quarry spalls between the riprap and compacted embankment material.

The concrete floodwall design has a spread footing buried below existing grade; only the vertical portion of the floodwall will be visible after construction. The base width will vary with the height to a maximum of approximately 20 feet and a top width of approximately 1 foot. They will often serve as traffic barriers along the road right-of-way. As a general rule if the levee or berm along the highway was less than 1.5 feet, a floodwall was used instead of the standard earthen levee.

Environmental impacts were identified and then avoided in the design to the maximum extent possible. Unavoidable impacts were minimized, with design modifications; for example, changing from a levee to a floodwall in certain areas of concern to reduce the footprint of the structure. A mitigation plan was prepared as part of the Environmental Impact Statement (EIS).

2.1.3.1 Hydrologic and Hydraulic Modeling

The design is based in part on the results of hydrologic and hydraulic modeling of the Chehalis River and tributaries conducted as part of this study. One-dimensional, unsteady flow, UNET software was used to develop the flood model employed in determining water surface elevations and maximum channel velocity. This flood model consisted of the upper Chehalis river basin from Pe Ell (RM 101.80) to Porter (RM 33.28). The topographic maps used to develop this model were provided by the U.S. Army Corps of Engineers (the Corps, USACE), Seattle District, and are based on aerial photography taken in August 1999 at a scale of 1 inch to 200 feet, with 2-foot contour intervals. The flood model was calibrated against the February 1996 flood event. The modeling effort and its results are described in further detail in the Hydrology and Hydraulics Appendix to this General Reevaluation Report (Appendix A).

2.1.3.2 Geotechnical Investigations

General. Geotechnical studies for the project to date have consisted of subsurface explorations along the various proposed levee alignments, flow net analyses to aid in estimating seepage in the levee embankments and foundations, and settlement calculations for the various foundations. Exploration boring logs of earlier subsurface investigations performed by others within the project area were obtained from WSDOT and Hart Crowser (under contract to Pacific International Engineering). Criteria have been established for levee design and an assessment has been made of construction material.

Geology. The Chehalis Valley occupies the southernmost portion of the Puget Sound Lowland of western Washington and a swath through the subdued coast range to the river mouth at Grays Harbor. A broad, flat valley floor surrounded by subdued and deeply weathered hills of Tertiary sandstone, shale, and basaltic lavas generally characterizes the valley.

Prior to Pleistocene glaciation of the Puget Lowlands, the upper portion of the Chehalis River drained north into Puget Sound and the lower portion drained the western flank of the subdued coast range. The advance of ice south into the Puget Lowland reaches an area just north of Grand Mound. Not only was the Chehalis River diverted westward by this event, but all the drainage from the west slope of the Cascade Range and the eastern slope on the Olympic Mountains was diverted southward along the margins of the ice mass, thence westward via the Black and lower Chehalis Rivers to the sea. Sea level was several hundred feet lower at this time and the extended lower Chehalis River, swollen with ice meltwaters and most of the drainage from the Puget Lowland, was rapidly deepened, and controlled by this lowered base level. The heavily laden glacial meltwater stream built a fan of coarse detritus (sand, gravel, and boulders) across the old valley just north of Centralia and deposited the coarse material downstream. The fan impounded a lake in the upper valley south of Centralia in which fine-grained sediments (sand, silt, and clay) were deposited. Coincident with ice melting worldwide, sea level and, therefore, the base level of the Chehalis River rose, providing an extensive estuarine area in the downstream reaches for the accumulation of fine-grained sediments over the coarse-grained glacial outwash.

The stream, therefore, occupies an inherited valley, largely a product of concentrated glacial meltwater. The valley can be geologically divided into three segments, which reflect the geologic history, characteristics of materials beneath the valley floor, and the stream gradient. The downstream segment from the mouth of the river at Grays Harbor to Oakville (RM 45) is that portion of the river under more or less direct influence of the tidal base level. The valley floor is underlain by a substantial thickness of fine-grained estuarine and alluvial sediments overlying, in part inter-fingering with, coarser grained glacial outwash sands and gravels. The stream is highly sinuous and has a gradient of less than 1 foot per mile, often about 0.5 foot per mile in this reach except between RM 19 and 21 where the detrital fan of a major tributary, the Satsop River, has caused a steepening of gradient to 4.4 feet per mile. A less significant steepening (1.6 feet per mile) for about 5 miles downstream from the confluence of Porter Creek with the Chehalis Valley is presumably caused by the addition of detritus from that stream.

Between Oakville and Centralia (RM 67.5) the valley floor is underlain by a substantial thickness of glacial outwash consisting of coarse gravel, cobbles, and sand, locally with a thin mantle of fine-grained material over bank alluvium. The gradient of the river is between 4 and 5 feet per mile throughout this reach and the stream is considerably less sinuous. The stream is generally shallow throughout this reach with rapids and riffles being common due to the heavy cobble pavement of the channel and the presence of glacial outwash and braided channel bars. Upstream from Centralia, and south to beyond Chehalis, the valley is underlain by a thick sequence of soft glacial lake sediments consisting of silts, clays, and fine sands mantled by over bank alluvium. The stream is again highly sinuous with a gradient of about 1 foot per mile. The gradient of its major tributary, the Skookumchuck River, is crudely controlled by the passage of the stream across the coarse-grained outwash fan northwest of Centralia. The project area is in this reach of the Chehalis and Skookumchuck Rivers.

The Skookumchuck River between Bucoda and Centralia occupies an old ice meltwater channel cut during the maximum advance of Pleistocene ice. The valley floor, while mantled by fine-grained material (fine sand and silt) over bank alluvium, is underlain by coarse glacial outwash (sand, gravel, and cobbles) locally interbedded with glacial lake deposits as the Chehalis Valley is approached. The stream in this segment has a highly variable gradient (4.7 to 22 feet per mile) and sinuosity reflecting its adjustment to an inherited valley.

Soils

a. Subsurface Exploration. Subsurface exploration by the Corps' Seattle District consisted of six rotary drill holes (78-RD-1 through 6) drilled in March and April 1978 and 24 power auger holes (79-PA-2 through 21 and 79-PA-23 through 26) drilled in April 1979, all drilled for the September 1982 Interim Feasibility Report. Forty-one boring logs (numbered 1 through 41) of holes drilled by others in the general vicinity of the proposed work were obtained from WSDOT. Approximate locations are shown on Plate GT-1. All boring logs are shown on plates GT-2 thru GT-6. In addition to the subsurface exploration noted above, additional foundation exploration performed by Hart Crowser under contract to Pacific International Engineering was reviewed and confirmed the general foundation conditions.

Subsurface investigations by the Corps of Engineers generally included Standard Penetration Tests (SPT) using a 2-inch-diameter split-spoon sampler and a 140-pound hammer dropped 30 inches. These tests were usually made at 5-foot increments of depth to provide SPT "N" values and disturbed samples for classification. Samples were visually classified in the field according to the "Unified Soils Classification System" and retained in quart-sized jars. Disturbed samples of the more granular materials were also taken with a 3-inch-diameter split-spoon sampler.

To determine the character of the foundation materials rotary drill holes were drilled by the Corps to depths ranging from 41.4 to 70.5 feet and the power auger drill holes were drilled by the Corps to depths ranging from 10.5 to 19.2 feet. Rotary drill holes were held open by 4-inch-diameter steel casing. Power auger drill holes were drilled with uncased 12-inch-diameter hollow stem augers using a truck-mounted power auger. In most cases the power auger drill holes caved in below the groundwater level, preventing the auger from advancing deeper.

b. Foundation Conditions. Foundation soils in the project area are generally composed of glacial outwash materials (sands and gravels) and latchstring sediments (clays, silts, and fine sands.) Organic and wood debris also exist in some areas. In most areas, the proposed levee system would be founded on sands having loose-to-medium relative densities and soft-to-medium dense clays and silts. In a few areas the foundation is relatively dense where gravel deposits exist. The new levee embankment load on the fine-grained foundation soils is calculated to cause post-construction settlement between 7 and 14 inches; therefore, the levees will be overbuilt by 1 foot to allow for this ultimate settlement. The surficial, highly organic soils encountered in a few borings at the south end of the project should be removed from the levee foundation to avoid excessive foundation settlement and embankment stability problems. Undetected, shallow, highly compressible soils may exist in some other areas of the project that would require the same treatment.

Construction Materials

a. Borrow Sources. Potential sources for levee embankment materials are located within 10 miles of the project location. Rock for riprap is potentially available about 20 miles west of Chehalis. All stripped material beneath the levee alignment suitable for topsoil would be stockpiled for later use on embankment slopes. Sampling and testing of all borrow material will be conducted during final design phase.

b. Concrete and Asphalt. Asphalt paving will be designed and constructed according to WSDOT Standards. Specifications for Portland cement concrete structures will be in accordance with WSDOT Standards, American Society for Testing and Materials, and/or American Concrete Institute Standards. Asphalt and Portland cement concrete would be obtained from local and/or nearby asphalt plants and ready-mix concrete companies.

I-5 Freeway Assessment

An assessment of the freeway embankment material will be done to verify that the use of the freeway as a levee will not affect the integrity of the roadway or embankment. Permeability check may include borings at locations where the freeway road elevation is 3 feet or more above the 100-year flood elevation. These areas will not have a levee protecting them from flooding.

2.1.3.3 Survey & Mapping

Engineering surveys were conducted as part of this study in 1999 through 2000. Aerial photographic/topographic surveys were used to develop 2-foot contour maps of the entire basin. These contours were then used to develop a digital terrain model used to calculate levee quantities. Bathymetry cross-sectional river survey was completed in 2000, and input to the UNET Model. High water marks from the 1996 flood event, which was approximately a 100-year event, were surveyed. These high water marks and aerial photographs were used to calibrate the UNET model. These data points combined helped field-verify the project datum used for this project, the National Geodetic Vertical Datum (NGVD) 1988. Other sources of data were used, specifically WSDOT datum, which is approximately a 4-foot difference in datum. Permanent survey monuments will be added to the drawings during the plans and specifications phase of the project.

2.1.3.4 Structural Design

The structural design effort has been concentrated on the dam. For the levee plan it has been at the conceptual level. For cost estimating purposes standard designs for common items were used. For example, two designs were used for generic floodwalls (traffic barriers): one for the majority of floodwalls, which were for heights below 5 feet; the other for floodwalls with heights above 5 feet, borrowed from another project. Minimum facilities to provide interior flood relief were designed per EM 1110-2-1413, Hydrologic Analysis of Interior Areas. Standard culvert flap gates were used, but in the next phase environmental considerations will be incorporated. This will complicate the design effort. For example, since the flap gates on several culverts will only need to be used during extreme events, they could be designed to stay open until a certain flood elevation is reached similar to a tide gate in tidal water. These items will be site-specific designed in the next phase.

Features in the levee plan that will require additional work include the following: flap-gated culverts, flood control boxes, sluice-gated box culverts, bridge abutment modifications, floodwalls that also serve as either crash barriers on the highway or retaining walls of various heights from 1 to 20 feet high, sewer main crossings, flood gates for floodwall, temporary floodwall such as a stop log structure.

Environmental mitigation and restoration projects may require structural features, which will also be designed in this next phase.

2.2 RELOCATIONS

2.2.1 Roads

Several roads in the project area may be raised or relocated on top of the proposed levee sections. The local sponsors will review the options and determine what is best for the local community. Typically the options are to build a wall or levee parallel to an existing road.

Real estate becomes a cost factor since the existing road right-of-way is publicly owned and a levee would require new real estate to be purchased. In some areas this real estate appears to be wetlands. In these areas the preference would be to use the existing road. Similarly, if the road was an important access route, such as Hospital Road, raising the road has community benefits by maintaining critical emergency routes open during a major flood event.

2.2.2 Driveways

Raising a road or placing a levee near residences will require work on personal driveways to either ramp up and over or establish a flood fight plan that includes closing off these low driveways with flood gates or sandbags.

2.2.3 Utilities

Existing utilities will be considered in the detailed design after coordinating with local utility owners. Major utility issues have been avoided.

2.2.4 Dillenbaugh Creek

The creek bed becomes a ditch along and paralleling I-5 between the Rice Road interchange north to the Burlington Northern-Santa Fe (BNSF) Railroad. This area in particular and possibly other reaches further south on Dillenbaugh Creek will need to be relocated. This area is under study for WSDOT freeway widening project and may be built before this flood control project. To accommodate this possibility, the toe of the levee alignment was moved to a location 78 feet from the existing freeway centerline. Placing the levee here will require the creek to be relocated. A detailed design of this feature and costs have not been included in this appendix.

3. DETAILED DESCRIPTIONS BY REACH

The following sections provide specific details by levee design reach and by station. The length, average height of the top elevation, the average width at the toe of the levee, and type of structure are shown by sub-reaches.

A general map showing the location of the various study reaches is provided as Plates C-1 and C-2. More specific details are shown on Plates C-3 through C-57. (Note that the levee design reaches are different from the study reaches presented in other parts of the General Reevaluation Report).

3.1 CHEHALIS REACH

3.1.1 Reach 1 - Fords Prairie

The levee starts at Galvin Road in the Fords Prairie area (Township 14 North (T14N) section 39). It is approximately one-half mile east of the Galvin Bridge over the Chehalis River at approximately RM 64.

The levee heads south following the high ground plateau area surrounding a dairy and the Port of Centralia Industrial Area. It then crosses a Port of Centralia and Ecology nature trail from Russell Road to the Chehalis River. It continues south along the edge of a riparian buffer protecting a residential neighborhood, where there is a pasture on one side and tree farm on the riverside of the levee. The levee continues south until it crosses a trail, which is an extension of Mayberry Road. It continues south on the inside of the riparian buffer around the high school and Washington State Fish and Wildlife Bird Farm. The levee comes within 1800 feet of the water's edge at the Bird Farm.

The levee then heads east following the Bird Farm fence line through a commercial quarry area and crosses Oakland Avenue, just behind the houses on Southgate Drive. The levee continues east following the property line to Bryden Avenue; this area has a new drainage channel on the east side of Bryden with culverts going under Bryden Avenue. The proposed levees are compatible with, and would be located on the landward side of, the new drainage channel.

The levee then heads north for approximately 800 feet on the east side of Bryden Avenue, continuing north to the high school track and stadium. (A potential option is to build the levee over the existing 24-foot wide Bryden Avenue and repave.) The levee turns east behind the stadium, past the flood proofed water pump station, and across the paved parking area. It then turns north and follows the fence line of the baseball fields, swinging east behind the backstop, crossing a gravel access road, and then turning to the north. This alignment leaves the baseball fields, soccer fields and historic buildings (The Borst Family Farm near the confluence of the Skookumchuck and Chehalis River and a log Fortress north of Borst Lake) on the riverside of the levee. The alignment comes within 250 feet of Borst Lake and becomes a floodwall along the west edge of the property line of the Fort Borst Park entrance road. Ending at the east end of Borst Avenue near the Harrison Avenue I-5 interchange. At approximately a 100-year event minor flood fighting with sand bags may be used to cross Borst Avenue to an existing Texaco Gas Station floodwall which heads east. Another minor flood fight area to close is a 75-foot gap between the floodwall and the I-5 southbound on-ramp.

The I-5 southbound lanes then become a part of the flood protection system, by possibly adding a layer of impervious material to the freeway embankment. At interstate milepost 82.47 it is proposed that a flap gate be installed to the west end or the Borst Lake side of the 36-inch concrete culvert which connects Hayes Lake on the east side of the interstate.

The levee continues south to the right bank of the Skookumchuck River and ties into the bridge abutment. From the left bank of the Skookumchuck River, near the confluence of the Chehalis River, the levee heads south crossing a 5-foot boxed culvert, which drains China Creek, the culvert will be flap-gated on the riverside at the existing sewage treatment plant. Minimum facilities to provide interior flood relief were designed per EM 1110-2-1413 and will not increase interior flooding.

TABLE 1: REACH 1

Plan view:	Plates C-1, C-3, C 15 through C-22
Cross-Sectional Views:	Plate C-13
Station 0+00 to Station 78+50	Cross-section A - typical new levee over soil
Comments:	The levee starts at Galvin Road
Station 78+50 to Station 81+50: Station 138+00 to Station 139+00	Cross-section C - typical new levee over road
Station 81+50 to Station 126+75	Cross-section A - typical new levee over soil
Station 126+75 to Station 133+90 Station 135+40 to Station 138+00 Station 139+00 t0 Station 142+65	Cross-section B - typical new floodwall
Length:	14,676 feet
Avg. Height:	5.5 feet
Avg. Width:	34 feet
Fill Quantity:	69266 cubic yards (cy)

3.1.2 Reach 2, Sewage Treatment Facility

The City of Centralia is removing the existing sewage treatment facility after a new facility is built, scheduled for completion prior to construction of this proposed project. The levee design incorporates the proposed future pump station, which will be based around a flood-proofed structure to house the proposed pumps. The construction of this project has also avoided interfering with proposed and existing sewer mains. This section consists of a floodwall that connects the freeway to the existing treatment facility.

The proposed wall is not expected to impact and will not involve any excavation of hazardous material in this area. From the floodwall, the levee is built to the south connecting with Mellen Street, with a small berm or floodwall that ties into high ground about 200 feet east of the Mellen Street Bridge right bank abutment. This reach of flood control structure will allow for WSDOT to modify the proposed interchange widening project. It will also prevent Chehalis backwater from flooding the Mellen Street underpass area. This will also maintain a critical access route to the hospital.

TABLE 2: REACH 2

Plan view:	Plates C-1 and C-4, C-23
Cross-Sectional Views:	Plate C-13
Station 0+00 to Station 6+30:	Cross-section B - typical new floodwall
Station 6+30 to Station 7+04:	Cross-section C - typical new levee over road
Length:	658 feet
Avg. Height:	5.1 feet
Avg. Width:	33 feet
Fill Quantity:	2779 cy

3.1.3 Reach 3, Mellon Street Bridge to Salzer Creek Bridge

This reach of levee begins as a floodwall approximately 200 feet east and 300 feet south of the Mellon Street Bridge abutment and heads south along the riverside of Airport Road right-of-way, which is an arterial road paralleling I-5, until it reaches a commercial area. At this point the Chehalis River makes a horseshoe bend at RM 68.5. Active erosion is occurring on the outside bend. WSDOT has developed a conceptual idea of placing a series of rock groins or bendway weirs in this area. This area will require further investigation due to lack of space between the river and the freeway. The design needs to accommodate flood protection, an arterial road and any freeway widening in this particular area.

Current design for this area is a vertical wall to minimize the footprint and any impacts on wetlands. Riprap, bank protection or groins are possible solutions proposed for this area. From this area, the levee changes to an earthen levee along Airport Road right-of-way. The levee crosses Airport Road and is built along the I-5 right-of-way. Before intersecting with the Salzer Creek Bridge abutment, the levee changes to a 700-foot long floodwall. All culverts will be extended and flap-gated on the riverside; these include the following:

TABLE 3: CULVERTS IN REACH 3

Types of Culverts	RM Locations
12-inch culvert	milepost 81.27
18-inch concrete culvert	milepost 81.10
12-inch culvert	milepost 81.05
36-inch concrete culvert	milepost 80.78
12-inch culvert	milepost 80.72

Minimum facilities to provide interior flood relief were designed to pass the local system design event with no increase in interior flooding as specified in EM 1110-2-1413.

TABLE 4: REACH 3

Plan view:	Plates C-1 and C-5, C-24, C-26, C-27
Cross-Sectional Views:	Plate C-1
Station 0+00 to Station 7+00:	Cross-section B - typical new floodwall
Station 7+00 to Station 37+00:	Cross-section A - typical new levee over soil

Station 37+00 to Station 43+50	Cross-section B - typical new floodwall
Station 43+50 to Station 73+05	Cross-section A - typical new levee over soil
Length:	7305 feet
Avg. Height:	9.2 feet
Avg. Width:	49 feet
Fill Quantity:	79422 cy

3.2 SALZER REACH

3.2.1 Reach 4, Salzer Creek Right Bank

This reach of setback levees ends (Station 124+74) at the I-5 and Salzer Creek Bridge intersection at milepost 80.22. The levee then extends northward to the county transfer station (closed landfill area). The levee alignment then turns eastward on the edge of an existing forest area, as selected by the landowner, to eliminate inundation of the capped hazardous material area. The levee is set back farther away from Salzer Creek than the existing levee. This will minimize the impact to the Salzer Creek floodplain. Then the levees cross the railroad tracks and tie into the existing County Fairground levee, which was built to FEMA standards, so only minor effort to modify this levee is anticipated.

The levees will cross National Avenue and then follow Salzer Creek north to NE Kresky Avenue where it becomes a wall along the west side of the road. The floodwall will have openings for local shopping center traffic. These openings may have floodgates to close during major events or rely on flood fight efforts such as sandbagging. The floodwall continues until you reach one block south of Fair Street where minor flood fighting across Kresky and around two commercial buildings may be required. The alignment then heads northward in the general alignment of Pacific Avenue until it reaches the edge of a residential area at which point it turns eastward one block to the next county road. The alignment continues to switch northward and then eastward to until it ties to the high ground of Summa Street, start of the levee (Station 0+00).

TABLE 5: REACH 4

Plan view:	Plates C-1 and C-6
Cross-Sectional Views:	Plate C-13
Station 0+00 to Station 40+50	Cross-section A - typical new levee over soil
Station 40+50 to Station 61+00	Cross-section B - typical new floodwall
Station 61+00 to Station 79+50	Cross-section A - typical new levee over soil
Station 79+50 to Station 80+30	No Cross-section. Flood fight
Station 80+30 to Station 104+30	Cross-section E - typical new levee over existing levee
Station 104+30 to Station 105+30	Cross-section D - railroad intersection
Station 105+30 to Station 122+70	Cross-section A - typical new levee on soil
Station 122+70 to Station 123+10	Cross-section D - railroad intersection
Station 123+10 to Station 124+74	Cross section A - typical new levee on soil
Length:	12,599 feet
Avg. Height:	7.1 feet
Avg. Width:	40 feet
Fill Quantity:	86875 cy

3.2.2 Reach 5, Salzer Creek Left Bank

This reach starts at the south Salzer Creek Bridge abutment. At the abutment the levee will require riprap for stream bank protection until it crosses the railroad tracks. The levee then parallels the railroad south to Station 47+70 where it turns eastward and crosses the railroad tracks continuing eastward until it crosses Coal Creek at station 57+00 where a minimum facility flap-gated culvert will be installed. The levee then ties in with an existing levee system. It then crosses National Avenue. The current flood fight plan is to temporarily place ecology blocks across the road. The existing blocks are stored on site. The levee beyond this point is a floodwall, for the entire reach between National Avenue and NE Kresky Avenue. The floodwall is placed around the perimeter of a paved parking area.

TABLE 6: REACH 5

Plan view:	Plates C-2 and C-7
Cross-Sectional Views:	Plate C-13
Station 0+00 to Station 1+60:	Cross-section A - typical new levee on soil
Station 1+60 to Station 2+00	Cross-section D - railroad intersection
Station 2+00 to Station 47+70	Cross-section A - typical new levee on soil
Station 47+70 to Station 47+85	Cross-section D - railroad intersection
Station 47+85 to 57+50	Cross-section A - typical new levee on soil
Station 57+50 to 62+30	Cross-section E - typical new levee over existing levee
Length:	6,212 feet
Avg. Height:	7.3 feet
Avg. Width:	41 feet
Fill Quantity:	34037 cy

3.2.3 Reach 6, Coal Creek

This reach starts at National Avenue and heads east to Kresky Avenue. It consists of raising an existing floodwall around the perimeter of an existing parking lot.

TABLE 7: REACH 6

Plan view:	Plates C-2 and C-7
Cross-Sectional Views:	Plate C-13
Station 0+00 to Station 9+76:	Cross-section B - typical new floodwall
Length:	976 feet
Avg. Height:	7.5 feet
Avg. Width:	18 feet

3.3 DILLENBAUGH REACH

3.3.1 Reach 7A, Salzer Creek to Airport

This reach starts at the left bank of Salzer Creek Bridge abutment on the west side of I-5. The I-5 bridge abutment will require riprap bank protection. A 3-foot high wall will be placed on the shoulder of the southbound lanes to provide flood protection, to station 11+00. This wall will extend south of the existing riparian buffer and then the cross section will change to a standard levee from the freeway to Airport Road. The levee will parallel Airport Road heading south until it connects with an existing levee around the perimeter of the airport. This forms an area between Airport Road and the freeway that is surrounded by levee. This area is set aside for proposed for WSDOT infiltration ponds. From here the existing Airport levee will be widened and raised on the landward side of the existing levee. This will require some modification to the existing Airport pump station, which pumps local drainage and floodwaters over the top of the levee during major flood events. Potentially contaminated ground exists near the Airport World War II-vintage buildings. Excavation in this area will be monitored carefully if it cannot be avoided. The existing access road over the top of the levee will need to be relocated, possibly requiring a new ramp alignment. This levee section parallels northwest Airport Way to the south until it reaches the intersection of Arizona Avenue and Airport Way.

TABLE 8: REACH 7A

Plan view:	Plates C-2 and C-8
Cross-Sectional Views:	Plate C-13
Station 0+00 to Station 11+00:	Cross-section A - typical new levee over soil
Station 11+00 to Station 102+80:	Cross-section E - typical new levee over an existing levee
Length:	12,726 feet
Avg. Height:	8.8 feet
Avg. Width:	10280 feet
Fill Quantity:	123296 cy

3.3.2 Reach 7B

At this point a new levee will be built on the north side of NW Airport Way. This forms the south leg of the Airport levee. The existing levee is on the south side of Airport Way, and it will be removed out of consideration for environmentally sensitive area. The south leg of the levee travels from Arizona Way to NW Louisiana Avenue, at which point the flood control structure must cross the intersection of NW Louisiana Avenue and the NW West Street ramp. The flood control structure continues along the south bounds lanes of Louisiana Avenue, which is a frontage road paralleling I-5. An option for this reach would be to place the levee over an existing road, which would tie in with proposed WSDOT interchange improvements, and include modifying the interchange access ramp.

TABLE 9: REACH 7B

Plan view:	Plates C-2 and C-8
Cross-Sectional Views:	Plate C-13
Station 102+80 to Station 118+80:	Cross-section A - typical new levee over soil
Station 118+80 to Station 139+53	Cross-section C - typical new levee over existing road (including intersection)
Length:	1,305 feet
Avg. Height:	4 feet
Avg. Width:	28 feet
Fill Quantity:	3832 cy

3.3.3 Reach 8, SR-6 to Railroad Underpass

This reach of setback levees starts along the I-5 and SR-6 interchange southbound on-ramp. The flood control structure starts as a wall along the right shoulder of the road until it reaches Dillenbaugh Creek Bridge. There will be a flood control box between the bridge abutments tied in by the floodwall with a low-flow fish passage capability. During a major flood the control box is designed to close off the Chehalis backwater from going up Dillenbaugh Creek under the freeway. The flood control box will not increase interior flooding per EM 1110-2-1413. The alignment continues south as a typical levee until it reaches the Chehalis Railroad underpass. At this location a flood fight plan will include installing stop logs and sand bags between the two concrete wall sections tying into the ends of the levee section on both sides of the railroad track.

TABLE 10: REACH 8

Station 0+00 to Station 0+40	Cross-section B - typical new floodwall
Station 0+40 to Station 1+20:	Flood Control Box on Dillenbaugh Creek
Station 1+20 to Station 4+10	Cross Section B - typical new floodwall
Station 4+10 to Station 19+20	Cross-section F - typical new levee
Station 19+20 to Station 19+70:	Cross-section D - Railroad intersection
Station 19+70 to Station 20+50	Cross-section A - (tie into I-5)
Length:	1,911 feet
Avg. Height:	8.6 feet
Avg. Width:	46 feet
Fill Quantity:	14000 cy

3.3.4 Reach 9A, Dillenbaugh Creek

This reach starts on the north side of the I-5 bridge abutment at RM 0.5 on Dillenbaugh Creek. The levee alignment crosses two BNSF Railroad tracks and Dillenbaugh Creek. The location where the levee crosses the railroad tracks will continue to require flood fighting, which includes stop logs and sand bags across the tracks. During major flood events the flood control box would stop the flow of Dillenbaugh Creek, isolating it to the west side of the freeway. Simultaneously the flood control box at Reach 8 would prevent Dillenbaugh Creek from flowing east to west and from entering the Chehalis River.

These flood control boxes would be used only in a major flood event to maintain the inundation of the marsh and wetland area on the east side of I-5 to the zero damage line. The main purpose is to prevent Chehalis backwater from flooding the interstate and the City of Chehalis. Flood elevations in this area would be controlled to a maximum zero damage line, in other words the flood would not get higher than the zero damage line during a major event. The flood control boxes are designed to pass the local system design event with no increase in interior flooding during low exterior stages, per EM 1110-2-1413. Interior drainage will be further evaluated in the next phase design of the project. This levee alignment is offset 78 feet away from the existing I-5 centerline to allow for widening of the I-5 interchange. This will require the relocation of Dillenbaugh Creek by either WSDOT or this project.

TABLE 11: REACH 9A

Plan view:	Plates C-2 and C-10
Cross-Sectional Views:	Plates C-13
Structural Details Flood Control	Flood Control Box
Station 0+00 to Station 2+20:	Cross-section A - typical new levee on soil
Station 2+20 to Station 2+70	Cross-section D - railroad intersection
Station 2+70 to Station 2+86	Cross-section A - typical new levee
Station 2+86 to 3+66	Flood Control Box
Station 3+66 to Station 29+46	Cross-section A - typical new levee over soil
Length:	185 feet
Avg. Height:	6.9 feet
Avg. Width:	40 feet
Fill Quantity:	1228 cy

TABLE 12: REACH 9B

Length:	60 feet
Avg. Height:	2.8 feet
Avg. Width:	23 feet
Fill Quantity:	111 cy

TABLE 13: REACH 9C

Length:	2581 feet
Avg. Height:	10.1 feet
Avg. Width:	52 feet
Fill Quantity:	30946 cy

3.3.5 Reach 10 Dillenbaugh South

This reach will be a short wall along the southbound on ramp and the interchange area**.** It will not impact any wetlands and will not require any relocation of Dillenbaugh Creek. This reach will not be necessary if the Rice Road interchange is improved prior to construction of this project.

TABLE 14: REACH 10

Plan view:	Plates C-2 and C-10
Cross-Sectional Views:	Plate C-13
Station 0+00 to Station 17+50:	Cross-section B - typical new floodwall
Length:	1750 feet
Avg. Height:	1 foot
Avg. Width: (below ground)	10 feet

3.4 SKOOKUMCHUCK REACH

The levee protection provided by the levee system on the Skookumchuck River is principally for protection of the backwater effects of the Chehalis River. This effect reaches approximately 2.0 miles upstream to the confluence of Coffee Creek and the Skookumchuck River.

3.4.1 Reach 11, West Reynolds Avenue to BNSF Railroad

This reach of levee starts at West Reynolds Avenue, near the intersection of BNSF Railroad, Chehalis Western Railroad and I-5 underpass. The levee ties into West Reynolds Avenue at the 100-year plus 3-foot elevation so no flood fighting across Reynolds Avenue will be necessary. The levee section runs south, parallel and adjacent to BNSF Railroad tracks to a distance of approximately 200 feet from the Skookumchuck River. There is an optional cross-section for this entire reach; the optional design would be to utilize the existing railroad embankment. Placing an impervious layer of material on the east side of the railroad embankment would accomplish this. Work in this reach would also include raising the curb elevation of West River Road to a height of 4 inches or 0.3 feet (floodwall elevation). Also the high ground between BNSF and Chehalis Western Railroad tracks will need a small berm to bring its elevation to the required level of protection.

TABLE 15: REACH 11

Plan view	Plates C-1 and C-12
Cross-sectional Views:	Plate C-13
Station 0+00 to Station 20+60:	Cross-section A - typical levee on soil (option - railroad embankment upgrade)
Station 20+60 to Station 20+90	Cross-section railroad
Station 20+90 to Station 23+30	Cross-section A - typical levee on soil
Length:	2,331 feet
Avg. Height:	2.9 feet
Avg. Width:	24 feet
Fill Quantity	4059 cy

3.4.2 Reach 12, Chehalis Western Railroad to Harrison Street Bridge

3.4.2.1 Reach 12A, Chehalis Western Railroad to Borst Park

Reach 12A starts on the west side of the Chehalis Western Railroad, approximately 200 feet away from the edge of the Skookumchuck River. The levee starts as a typical levee over soil until it reaches an existing driveway at which point the levee takes advantage of the existing road elevation and footprint. However because the Skookumchuck River makes a 180 degree, or horseshoe, bend at this point, it will require riprap bank protection for approximately 200 linear feet of levee section. The intent in general is to setback the levee as close as possible to the residential houses. This gives the river more room to meander and some diversity along the shoreline, where it is currently constricted. Real estate investigations will be done in the next phase to determine the optimum levee alignment in this area. As currently designed, several residential and one commercial structure are left on the riverside of the levee. A possible non-structural solution or flood fight plan will be devised in the next phase of the project. The levee follows the high ground and it becomes a levee over the existing road through Borst Park, until it reaches I-5 embankment approximately 100 feet north of the Skookumchuck River.

3.4.2.2 Reach 12B, Borst Park to Harrison Street Bridge

Reach 12B is a floodwall and ties in to the Harrison Street right bank bridge abutment. It is assumed that some maintenance of the existing riprap will be necessary.

TABLE 16: REACH 12

Plan view:	Plates C-1 and C-11, C-50, 51,52,53
Cross-Sectional Views:	Plate C-13
Station 0+00 to Station 3+50	Cross-section A - typical levee over soil
Station 3+50 to Station 5+00	Cross-section C - typical new levee over road
Station 5+00 to 7+00	Typical new levee over road plus riprap
Station 7+00 to Station 7+70	Cross-section C - typical new levee over road
Station 7+70 to Station 24+00	Cross-section A - typical new levee over soil
Station 24+00 to Station 31+50	Cross-section C - typical new levee over road
Station 31+50 to Station 38+34	Cross-section A - typical new levee over soil
Length:	3834 feet
Avg. Height:	5 feet
Avg. Width:	32 feet
Fill Quantity:	15595 cy

3.4.3 Reach 13, Harrison Street Bridge to I-5 Right Bank

This reach starts on the right bank just downstream side of Harrison Street Bridge, and involves placing a floodwall from the bridge to an existing commercial flood proof building. It uses the building as a part of the flood control system and connects one building from one side of the parking lot to the next building and crosses Bridge Street. It then follows the perimeter of Hayes Lake utilizing existing high ground, floodwalls and flood proof buildings as part of the flood control system. The floodwall will continue between the last building and the freeway along the edge of an existing access road tying into I-5. A possible alternative alignment to take advantage of high ground would be to have a floodwall along the south side of Harrison Avenue from West High Street to the Harrison Street Bridge; however several openings would be required in the wall to allow access to the commercial buildings on Harrison Avenue.

TABLE 18: REACH 13

Plan view:	Plates C-1 and C-12, 52,53
Cross-Sectional Views:	Plate C-13
Station 0+00 to Station 30+50:	Cross-section B - typical new floodwall
Length:	3050 feet
Avg. Height:	5.7 feet
Avg. Width:	16 feet

3.4.4 Reach 14, Left Bank I-5 to Harrison Street Bridge

Reach 14 starts 100 yards south of the I-5 bridge abutment on the left bank of the Skookumchuck River. The levee alignment heads east following high ground contours with wetlands on both sides of the levee until it reaches the residential neighborhood. The levee continues to follow the high ground contours and then ties into a berm behind a Nursing Home.

From this point the alignment continues northeastward, following the contour line associated with the existing ordinary high waterline of the Skookumchuck River and ties into Denny Way. The embankment for Denny Way will require riprap bank protection plus a floodwall built along the riverside of the road. The floodwall will be built from Denny Way to Latona Street, where the cross-section will change to a typical earthen levee section. This levee will be built on top of an existing riprap embankment. The alignment continues from Latona Street to Harrison Street Bridge. From the upstream side of the Harrison Street Bridge, a short floodwall will be built on the left bank along First Street, continuing one block west of M Street. At this point it ties into existing high ground. The existing pavement on First Street to M Street and along M Street heading northward approximately one block will not require any modifications.

TABLE 19: REACH 14

Plan view:	Plate C-12, C-54
Cross-Sectional Views:	Plate C-13
Station 0+00 to Station 13+00:	Cross-section A - typical new levee over soil
Station 13+00 to Station 17+00	Cross-section B - typical new floodwall
Station 17+00 to Station 18+50	Cross-section C - typical new levee over road
Station 18+50 to Station 20+90	Cross-Section A - typical levee over soil
Length:	2,082 feet
Avg. Height:	6.6 feet
Avg. Width:	38 feet
Fill Quantity	12858 cy

3.4.5 Reach 15, Harrison Street Bridge to Chehalis Western Railroad

Reach 15 alignment begins at the Harrison Street Bridge along W First Street and turns north on M Street. M Street, which is a gravel road, will be raised for a distance of 1500 feet until it reaches an existing raised driveway (station 25+00). A new levee will be built to surround a residential neighborhood and tie into an existing Chehalis Western Railroad embankment approximately 200 feet away from the edge of the Skookumchuck River.

TABLE 20: REACH 15

Plan view:	Plates C-1 and C-55, 56
Cross-Sectional Views:	Plate C-13
Station 0+00 to Station 25+40	Cross-section C - typical levee over road
Station 25+40 to Station 38+40	Cross-section A - typical levee over soil
Length:	3,843 feet
Avg. Height:	3.4 feet
Avg. Width:	24.6 feet
Fill Quantity	9118 cy

3.4.6 Reach 16, Chehalis Western Railroad to Existing Left Bank Levee

3.4.6.1 Reach 16A, Chehalis Western Railroad to BNSF Railroad

Reach 16A is a levee section connecting high ground near the Chehalis Western Railroad to the BNSF Railroad embankment; it is approximately 500 feet from the edge of the Skookumchuck River. Flood fight operations consisting of sandbags may be necessary to cross the railroad tracks connecting to reach 16B.

3.4.6.2 Reach 16B, BNSF Railroad to Existing Levee Left Bank

Reach 16B follows an existing ridgeline along the Skookumchuck River floodway. The levee is aligned as close as possible to an existing residential area, where it will tie into an existing levee built to FEMA standards near the intersection of West 7th Street and G Street. In this reach several existing storm drain outlets will need to have flap gates installed to prevent floodwaters from backing up the storm drain system. The outlets are designed to meet the minimum facilities specifications as described in EM 1110-2-1413. There will not be any increase to interior flooding during low exterior stages as a result of the project.

TABLE 21: REACH 16

Plan view:	Plates C-1 and C-57, 58
Cross-Sectional Views:	Plate C-13
Station 0+00 to Station 8+70:	Cross-section A - typical levee over soil
Station 8+70 to Station 9+10	Flood Fight Railroad Crossing
Station 9+10 to Station 34+14	Cross-section A - typical levee over soil
Length:	3,419 feet
Avg. Height:	3.2 feet
Avg. Width:	21 feet
Fill Quantity	1162 cy

4. INTERIOR DRAINAGE IMPROVEMENTS

At the minimum, the mainline project levee will include “minimum facilities” to provide interior flood relief such that, during low exterior stages (gravity conditions), the local storm drainage system functions essentially as it would without the levee in place, for floods up to that of the storm sewer design, as specified in EM 1110-2-1413. The minimum facilities are designed so that no additional interior flooding will be caused by the levee project. Therefore, additional formal ponding areas are not required on the landward side of the levee.

Additionally, the local community may choose to construct interior flooding improvements to provide a greater level of protection at some locations. Potential local betterment projects are described in the following sections.

4.1 China Creek

The existing China Creek discharge overflows into Plumber Lake during flood events. Proposed minimum facilities design on China Creek consists of adding a control structure for the 5-foot box culvert under I-5 to prevent Chehalis backwater from entering the China Creek basin.

A possible upgrade the local community may consider is a culvert placed in the proposed levee allowing the floodwaters in Plumber Lake to drain into the Skookumchuck River. Because the Skookumchuck River is controlled by the Skookumchuck Dam, several feet of head difference between China Creek and the Chehalis River will allow China Creek to drain naturally for a longer period of time. A flap gate will be added to the riverside of the proposed culvert between Plumber Lake and Skookumchuck River, to prevent the Chehalis River backwater from traveling up the river into Plumber Lake.

A more elaborate investigation of China Creek involving possible embankment dams, upstream diversion, ring dikes around containment ponds and pumping or draining of China Creek water to the Skookumchuck River is being completed by the City of Centralia. This investigation will be conducted in the next phase of the project to determine if the China Creek drainage qualifies for federal interest under Corps authorities. Interior drainage problems from China Creek, flowing from the railroad grade and high ground, flows south to Salzer Road which acts as a levee. An existing culvert system that goes under Salzer Road may require modifications, such as extending it to the riverside of the proposed Salzer Creek levee, in Reach 6. This would allow China Creek floodwater to drain into Salzer Creek Basin without creating a ponded area on the landward side of the proposed Salzer Creek right bank levee.

4.2 Dillenbaugh Creek

Existing local runoff drains into Dillenbaugh Creek and marsh area on the east side of I-5 as well as through culverts through I-5, and under the I-5 overpasses for the Chehalis Western Railroad and Dillenbaugh Creek.

Further investigation will be done in the next phase of study to assure that the flood control boxes shut off flow in Dillenbaugh Creek at two locations, one for flow to the east and one for flow to the west directions. The minimum facilities design of the flood control boxes allows for floodwaters from Dillenbaugh Creek, Chehalis River backwater and interior drainage to fill the area east of I-5 up to the zero damage line or flood stage for this area. A flood response plan will be developed and a specific water surface elevation will dictate when the gates on the flood control box need to be closed. The elevation is approximately 1 foot below the estimated 100-year flood elevation. Therefore it will take a major flood before the gates are closed. In any case, the impacts to local interior flooding would not increase as a result of this project, and no formal ponding areas are needed.

4.3 SCAMMON CREEK

The existing drainage system is conveyed through a culvert under Cook Road. The proposed levee and associated flap-gated culvert will not create additional interior flood damages. Chehalis backwater will be prevented from flooding a church and residential area on the south side of Cook Road.

The local community may choose to upgrade the level of protection for Cook Road in the next phase of the study. Cook Road is a main access route to the hospital. Further analysis is needed to determine if the road would be raised and/or combined with a floodwall and/or a small pump station to allow access during a 100-year event.

4.4 COAL CREEK

Existing conditions at Coal Creek include routing of the creek through a concrete box culvert around an industrial park and leveed commercial area. The proposed levee and associated flap-gated culvert through the levee would not create additional interior flood damages. Backwater from the Chehalis River and Salzer Creek floodwaters will be eliminated by the flap-gated culvert. Local betterment projects were not identified for this drainage system.

5. MITIGATION

The SR-6 Floodplain Reconnection Feature adds significant mitigation benefits while also providing additional incidental flood damage reduction benefits. This feature includes a 400-foot wide excavation of SR-6, with an invert elevation of 179 feet. This feature, in combination with several wetland areas, reconnection of an oxbow, enhancement of Scheuber ditch to reconnect the floodplain with the river downstream of SR-6, several riparian zones and a back channel area, are proposed for this restoration plan. (For further details, see the EIS.)

5.1 State Route 6 Floodplain Reconnection

The feature includes a 400-foot wide excavation of SR-6. This would involve excavating and grading approximately 65,000 cubic yards of material, and elevating the roadway to provide clearance for reconnecting the floodplain by providing overbank flows, an environmental condition of significant importance to fish and wildlife species in the study area. Several limiting factors were identified during the study. They included loss of floodplain connectivity, loss of riparian zone, and altered hydrologic regime. The restoration proposed for this project focuses on these factors, such as reconnection of the floodplain and creation/enhancement of wetlands and riparian zones.

Restoration/mitigation actions at SR-6 will include a bridge or culvert crossing at SR-6 to allow floodwaters to flow across the historic floodplain to the north and will be combined with a year-round connection from the Chehalis River to the oxbow south of SR-6, an annually flooded wetland complex (approximately 80 acres) north of SR-6 that also receives water from an unnamed tributary. The restoration/mitigation actions will also include a new channel connecting the oxbow through the wetlands to Scheuber Ditch, channel meandering, and a 200-foot wide riparian restoration along Scheuber Ditch, a backwater wetland complex at the outlet of Scheuber Ditch into the Chehalis River that is connected year-round.

The floodplain along Scheuber Road would also provide storage of flood flows when flows on the Chehalis River at RM 77 exceed the annual flood magnitude. Flood flows bypassing through the SR-6 overflow site to the floodplain would not return to the river until the flows reach the north end of the floodplain bypass and storage area. Returning flows would discharge first through the existing Scheuber drainage ditch and then over the low-lying overbank area between RM 71.6 and RM 72.4 of the Chehalis River. This bypass flow is beneficial to both flood control and environmental restoration aspects of this project. Modifications to the banks of the Chehalis River in the area where the bypass flows re-enter the river channel may be required. These modifications could include armoring of the banks on both sides of the river to protect from possible head cutting or erosion opposite the bank from the cross flows. Reshaping of the Scheuber ditch side of the river to allow for smooth transition flow back into the river is another possible modification.

The design consists of using pre-cast concrete box culverts to bridge the SR-6 opening. The design would consist of supporting the roadway on concrete piles, which suit the site considering the opening width and the likelihood of poor soils. The structure would consist of a relatively thin pre-cast concrete slab supported on pile bents at 20- to 30-foot spacing.

6. CONSTRUCTION CONSIDERATIONS

6.1 HAUL ROADS

Temporary construction haul roads will be a minimum of 12 feet wide for one-way traffic and 24 feet wide for two-way traffic. Filter fabric and a minimum of 1.5 feet of pit run gravel will be placed over the fabric. Existing commercial quarries will be used as a source of gravel. Depending on the quality of excavation material, it may also be used for these roads. Costs are included to remove all the fill material used to build the temporary haul road and transport it to a disposal area. Silt fencing would be provided as necessary.

Existing roads used for haul roads will be surveyed before and after the project and restored to pre-project existing conditions. The local sponsor will select routes for the truck haul. Hours of operation will be specified to minimize traffic and noise problems.

The top of levee or the footprint of the levee will be used as much as possible during construction to minimize road construction impacts and costs.

Temporary or permanent access ramps will be made at all road crossings and driveways. In addition, work will be coordinated with the railroads for high traffic crossing areas.

Safety precautions will also be coordinated with WSDOT for construction immediately adjacent to I-5.

6.2 MATERIALS

Levee Fill: Materials for the levee will consist of compactable-engineered fill, meeting standard Corps of Engineers specifications, as discussed in the Geotechnical Investigations section.

Gravel: All gravel materials will be from existing commercial quarries. Clean gravels will be used when in or near the water to reduce siltation in the rivers. A gradation specification will describe what percentage of fine material is allowable.

Rip Rap: Rock source for the riprap bank protection will be approved during the bid process. This requires the contractor to demonstrate that the quality of the rock meets Corps standards, including a freeze thaw test and specific gravity. Rock will be quantified in units of tons in the cost estimate. But the drawings will indicate the number of cubic yards of rock. A conversion of 1.65 tons per cubic yards will be used. The dimensions of the rock will also be specified and field-checked during construction. The length shall not exceed 3 times its width. All riprap will be placed or keyed into the bank protection by a hydraulic excavator with a thumb, rather than end dumped by a truck.

6.3 DISPOSAL

Recycling or using as much of the excavated material as possible will minimize disposal of unsuitable or excess material. Excavated material will be sorted to usable topsoil, levee fill material and unsatisfactory material, including any contaminated soil encountered. Any wet material will require dewatering before transporting on the highway. The topsoil will be placed on the slopes of the levee prior to hydroseeding. The suitable fill material will be mixed with imported engineered filled material and will be used as levee fill material. All unsatisfactory material will be removed from the project and all contaminated soil will be disposed of properly, meeting State requirements.

6.4 FISH WINDOWS

In-water construction will occur only during the fish windows, which will be clearly specified for each river or tributary. In general this will be coordinated with the appropriate agencies to consider the latest changes in the endangered species list or other regulation changes.

Very little in-water work will be necessary and will be scheduled during appropriate fish windows. Current water-construction period closure is from February 15 to July 15. This should not present a scheduling problem since a very small percentage of work will be in-water construction.

7. OPERATION, MAINTENANCE, REPAIR & REHABILITATION (OMR&R)

The local sponsor, who is responsible for maintenance of the entire project, will be provided with an Operation, Maintenance, Repair and Rehabilitation Manual (OMR&R) at the time that the project is accepted and turned over to the local sponsor. The manual will specify what maintenance and estimated rehabilitation is required to meet federal standards. A cost estimate and time schedule will be included for budgeting and planning purposes. It also specifies the consequences of not doing the prescribed maintenance. If the federal government feels the project is in jeopardy of not functioning due to lack of maintenance, the government will do the work and bill the local sponsor for the effort.

For the levee system, a minimum of an annual inspection, preferably an inspection after each major flood event, by locals will be performed and results submitted to the Corps documenting levee conditions and any repairs or maintenance required or completed. Periodic government inspections will also be done to check that basic federal standards are being maintained, including:

- no trees over 4-inch diameter;
- grassed side slopes;
- drainage features operate correctly;
- annual mowing to allow for ease of inspection,
- maintained level gravel access road on top of the levee; and
- riprap rock sections will be monitored to assure bank protection, erosion control. Annually the local sponsor must submit a levee survey to verify the condition of the levee to maintain eligibility for Federal assistance after a major disaster.

For cost estimating purposes the OMR&R costs for levees are approximately $5,000 per year, per mile of levee. In addition, it is assumed that 50 percent of the rock will be replaced at year 25.

The government will identify any deficiencies in the maintenance or condition of the levee. A specific checklist of work items will be given to the local sponsor spelling out what is required to bring the project back into compliance, thus making the flood control structure eligible for federal assistance when major rehabilitation is needed or in the event that flood damage occurs. This includes eligibility for federal funds thru FEMA after a catastrophic disaster.

The OMR&R will also include a Flood Fight Plan. Since flood fight efforts are an integral part of the levee system, it becomes critical that the necessary equipment, materials and personnel are available. In addition the plan must specify where flood fight actions need to take place, when to take these actions, and who will be responsible for flood fighting.

This flood fight plan will need to be updated annually with points of contact, material and equipment inventory changes. Problem areas need to be identified and monitored. These documented problem areas should then be incorporated into the next year's maintenance plan. This will allow for the in-water work to be done at low-flow conditions, which is not only safer and cheaper, but a more environmentally friendly way to accomplish the work.

8. DESIGN AND CONSTRUCTION SCHEDULE

8.1 DESIGN

The design for the levee plan is at the 35 percent level. Plans and specifications will be continued in PED, which will be completed in December 2003. During the process, additional ITRs will be conducted at 65 percent and 90 percent. Design of the environmental mitigation and restoration features were done at a concept level. They will be brought up to an equal design level at the 65 percent review. At that point a government cost estimate will also be done.

Design work by WSDOT will also be done in the next phase as part of this project. A major design effort will be for required for the unique solution to flood problems at the I-5 bridges over Salzer Creek. Because WSDOT will be working on other related projects within the study area, close coordination between projects will be necessary. For example widening of all interchange areas and water runoff treatment designs can be directly incorporated into this project’s flood control and mitigation designs.

Design coordination with the cities of Centralia and Chehalis to develop a plan for utilities will be refined with more specifics in the next phase. Special design features may include vaults or tunnels where the proposed levee crosses over the new sewer mains under construction to avoid any differential settlement problems.

Plans and specification writers will be added to the team at the 65 percent level to expedite the design completion and improve quality of the bid package.

Additional detailed coordination on environmental issues, such as avoiding wetlands, will be studied in more detail as the design progresses.

Geotechnical and HTRW investigations will provide more data input to the design as the information becomes available.

A 25 percent quantity contingency was used at this level of design. This contingency will be reduced as this additional information becomes available, particularly information from the property owners involved.

8.2 CONSTRUCTION SCHEDULE

The construction schedule for the levee plan is shown below. It is assumed that any construction necessary for mitigation or restoration features would also be completed in this time frame. The construction schedule for the recommended plan may include a separate contract for work on Skookumchuck Dam. That schedule may differ from the construction below for the levee plan.

Description	Dates
Chief's Report	Dec 02
All Permits Received	Aug 03
Project Cooperation Agreement Signed With Sponsor	Aug 03
Corps Receives Construction Funding	Dec 03
Sponsor Completes Real Estate Acquisition	Jan 04
Corps Advertises Construction Contract	Feb 04
Construction Contract Award (First Contract)	Apr 04
Contract Notice To Proceed	May 04
Approve Contractors Plans (Safety, Health and Environmental Protection)	Jun 04
Construction Contract Physically Complete (Last Contract)	Sep 06
Project Construction Physically Complete	Jul 07
Project Fiscally Complete	Sep 07
Final Acceptance & Transfer to Local Sponsor	Sep 07

9. COST ESTIMATE

Preliminary cost estimates have been developed for the alternatives modeled. All costs are presented in 2002 dollars and exclude interest during construction. The estimates include contractor's overhead and profit, sales tax, engineering and planning, and a cost contingency appropriate to this phase of studies. The quantities also included a 25 percent contingency, mainly to cover possible changes to the levee alignment.

The estimated costs are preliminary only, and are contingent upon approval of the selected design by resource agencies and other interested parties. Mitigation and restoration costs are detailed elsewhere but would be included in the final project costs. The final project costs for the recommended plan would depend on final design details and price factors, and could vary from the estimates presented here.

Quantity estimates were made from work items and materials for the main components of the recommended design. Approximate unit prices were developed by the local sponsor's contracted cost estimator and compared with previous cost estimates by the Corps, bid prices from similar projects, and quotes from manufacturers and contractors. Construction work was assumed to be limited to 8 hours a day, 5 days a week

Mitigation costs have not been included in the estimated construction costs. The level of mitigation, or the exact nature of habitat improvements required will be developed and refined as the design progresses. The preliminary estimated costs for mitigation or habitat improvements, and their associated annual maintenance costs have been developed. During the next phase these cost estimates will be refined along with the mitigation design costs. Mitigation costs would include additional land acquisition, as well as permitting, engineering, and construction costs.

The project construction period would take about 2 years total calendar time. The production is based on working 8 months a year, April through November, for two working seasons.

Preliminary cost estimates have been developed for the various Skookumchuck Dam Modification alternatives. All costs are presented in 2002 dollars and exclude interest during construction. The estimates include contractor's overhead and profit, sales tax, and a construction contingency appropriate to this phase of studies.

It should be noted that the estimated costs are preliminary only, and are for comparison so that a cost-effective design alternative can be selected. The final project costs for the proposed design would depend on final design details and price factors, and could vary from the estimates presented here.

Quantity estimates were made from work items and materials for the main components of the proposed design. Approximate unit prices were developed from previous cost estimates by the Corps and WSDOT, bid prices from similar projects, quotes from manufacturers and contractors, and from current R.S. Means construction cost guides. Construction work was assumed to be limited to 8 hours a day, 5 days a week.

For the cost estimates, it was assumed that carefully controlled blasting would be used for all rock excavation. It is not known at this time whether there would be concerns with blasting adjacent to the dam. If mechanical excavation methods are required, excavation costs could increase significantly.

Mobilization and demobilization costs were taken as 5 percent of the direct cost subtotal. Sales tax was applied only to materials and equipment rental and not to labor costs. Contractor overhead and profit was taken as 25 percent of the direct cost with mobilization and sales tax added. A 25 percent construction contingency was then added to come up with a total direct cost.

Total project costs would include any costs associated with land acquisition, easements, mitigation, planning, permitting, engineering, and construction management. These costs have been developed by the local sponsor and checked by the Corps and are presented in the Cost Engineering Appendix D.

Annual operation and maintenance costs were also estimated for each of the alternatives. A 50-year project life was used with a discount rate of 6 percent and an inflation rate of 2.5 percent. Labor rates, including all overhead costs, were assumed to be $75 per hour. Maintenance costs were estimated to range from approximately $9,000 to $11,000 per year for each of the alternatives. Operation costs were estimated to be approximately $108,000 per year for each of the alternatives.

State Route 6 Floodplain Reconnection consists of the excavation of approximately 65,000 cubic yards to construct a 400-foot wide excavation of SR-6. Material to be excavated would be primarily river silts and clays. The silts and clay would likely be saturated when excavated, and could be very hard to transport and place in a disposal area. Consideration of on-site disposal to create habitat would be completed in the next study phase.

The excavation would probably be done with hydraulic excavators and on-highway haul units. Production would vary due to the material type, but would be about 125 bucket cubic yards per hour average per excavator. Three trucks per excavator would be required. No dewatering of the excavation was considered. A temporary bypass of SR-6 would be constructed using temporary fill material.

The structure would be a concrete elevated roadway, with a length of about 400 feet. The structure, a trestle, would consist of concrete piles with relatively short spans. This structure would support a roadway consistent with the existing SR-6.

The temporary road construction would be done with a stabilization fabric under-layment, and 1.5 to 4 feet of fill material. Costs are included to remove all the fill material and transport it to a disposal area. Silt fencing would be provided as necessary.

Costs to relocate the sewage treatment plant are not included since plans are underway to do this; nor are any costs associated with structure demolition or cleanup. Costs associated with minor land acquisition, easements, or mitigation is included under Real Estate Costs.

10. SPECIAL CONSIDERATIONS

10.1 WSDOT

Washington State Department of Transportation (WSDOT) has several projects proposed for the project study area. They have been mandated to improve all of their interchange areas by raising and widening, underpass clearance, bridge clearance. In addition to these structural considerations, there are new regulations that state they must not only consider the quality of the surface water drainage, but also quantity. In other words they may need more ponding areas adjacent to I-5, within the project area. Particularly at river, creek or existing culvert crossings.

These considerations are being coordinated as WSDOT's projects and this flood control project evolve. By working these projects together, costs and environmental impacts can be reduced.

Another major consideration is at the I-5 bridges over Salzer Creek. By WSDOT making modifications to the existing bridge, such as attaching floodwalls and closing the gap between the north and southbound lanes, the need to have a large pump and expensive station on Salzer creek is eliminated. In addition, long-term maintenance costs, which would be borne by the local sponsor, would also be eliminated.

10.2 SEWAGE TREATMENT

The existing sewage treatment plant project at Mellon Street is under construction. It will take several years to complete the plant modifications and associated sewer main plumbing project. The design accommodates this future and ongoing plans. Specific details of sewer main crossings by the flood control levees will be coordinated in the next phase.

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PLATES (66 SHEETS)

Plates are bound separately (attached).

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