**U.S. Army Corps**
**of Engineers**
Portland District

# Hydrologic and Hydraulic Analysis Summary Report For Columbia River Channel Improvement, Webb Wildlife Mitigation Project

May 23, 2005

Patrick S. O'Brien, PE
Hydrologic, Coastal, & River Engineering Section
US Army Corps of Engineers, Portland District

**HYDROLOGIC AND HYDRAULIC MODELING SUMMARY REPORT**
**FOR CRCI -WEBB WETLAND MITIGATION PROJECT**
**TABLE OF CONTENTS**

## LIST OF FIGURES



## LIST OF TABLES

**HYDROLOGIC AND HYDRAULIC MODELING SUMMARY REPORT**
**CRCIP WEBB WETLAND MITIGATION PROJECT**

# 1. BACKGROUND

## 1.1 Project Purpose

The Webb Wildlife Mitigation Project is intended (in conjunction with other mitigation projects) to produce sufficient Average Annual Habitat Units (AAHU's) to offset AAHU losses as a result of the Columbia River Channel Improvement Project (CRCIP).

## 1.2 Project Location

The project is located within the Webb District Improvement Company; a diking district located in Columbia County, Oregon about 5 ½ miles northwest of Clatskanie (Figure 1). The district is bounded by the Columbia River (RM 46-47.5) on the north, by Midland Channel and Westport Slough on the east and south, and a borrow pit channel on the west. The District covers 733 acres of rural agricultural and pasture and is protected by 4.5 miles of levees. Midland Channel and Westport Slough separate the district from the Midland and Marshland Drainage Districts. The levee along the borrow pit channel separates the district from Woodson Drainage District and forms a contiguous boundary with the Westland District Improvement Company. The borrow pit channel has been plugged off from the Columbia River and Westport Slough by two closure embankments on the slough and one at Columbia River mile 46.0. Interior ground elevations vary from 1.0 to 7.0 feet NGVD (National Geodetic Vertical Datum 1929).

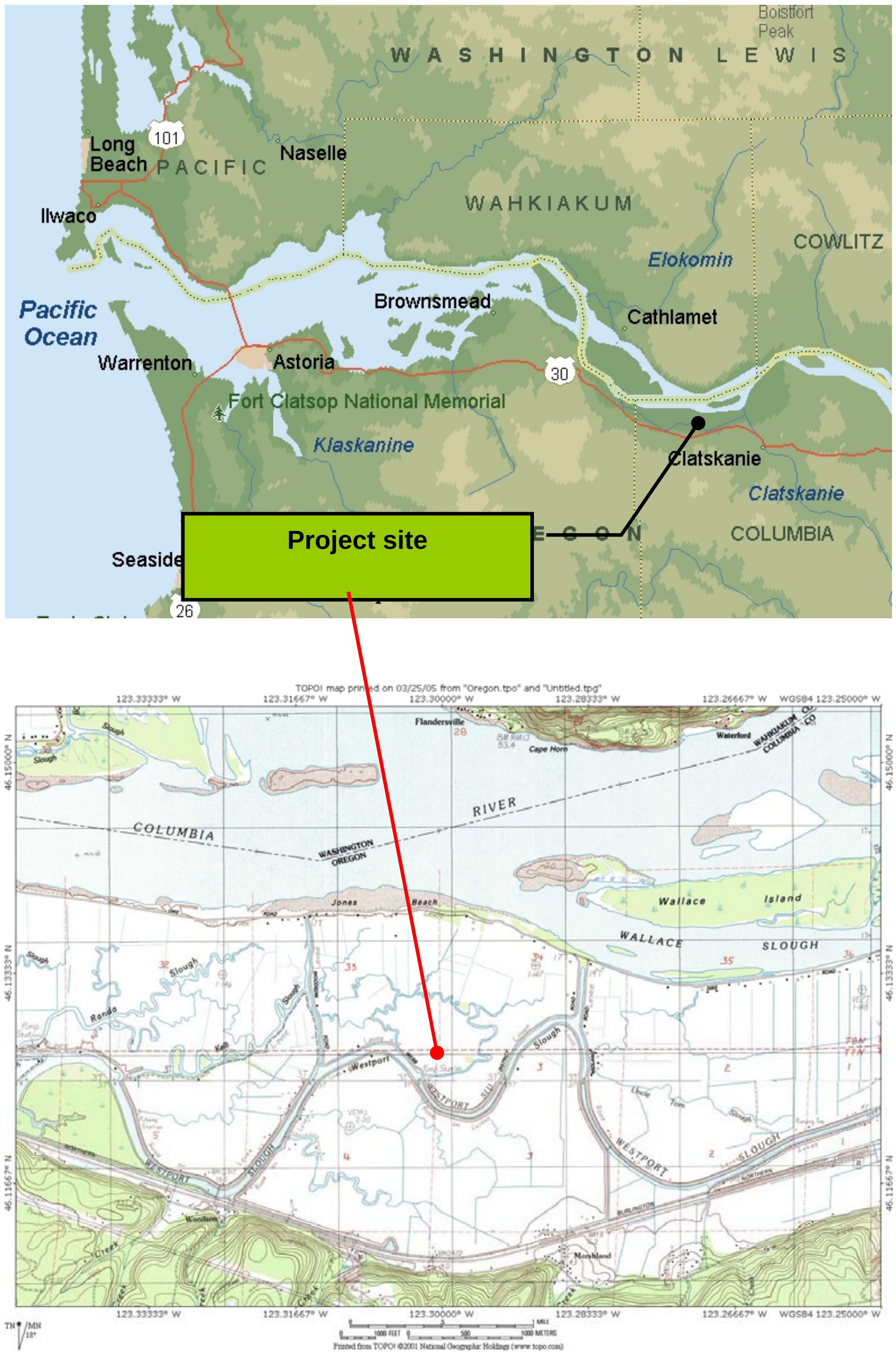



**Figure 1. Vicinity Map**

## 2. MANAGED WETLAND FEATURES AND OPERATION

### 2.1 Project Description

A 74 acre managed wetland will be constructed on property owned by the Port of Portland within the 733-acre Webb District Improvement Company. The inclusion of three fish filters brings the total to 76 acres enclosed by the interior levee. Several water control structures (Figure 1) will be used to fill the site with tidal waters from Westport Slough and maintain a water depth of 3 to 4.5 feet in the wetland. Tidal water will be circulated through the wetland and distributory channels and subsequently discharged to the main drainage channel via two outlet structures. The excess water from the wetland ultimately will be discharged back into Westport Slough through the District's tidegates and/or the pump station.

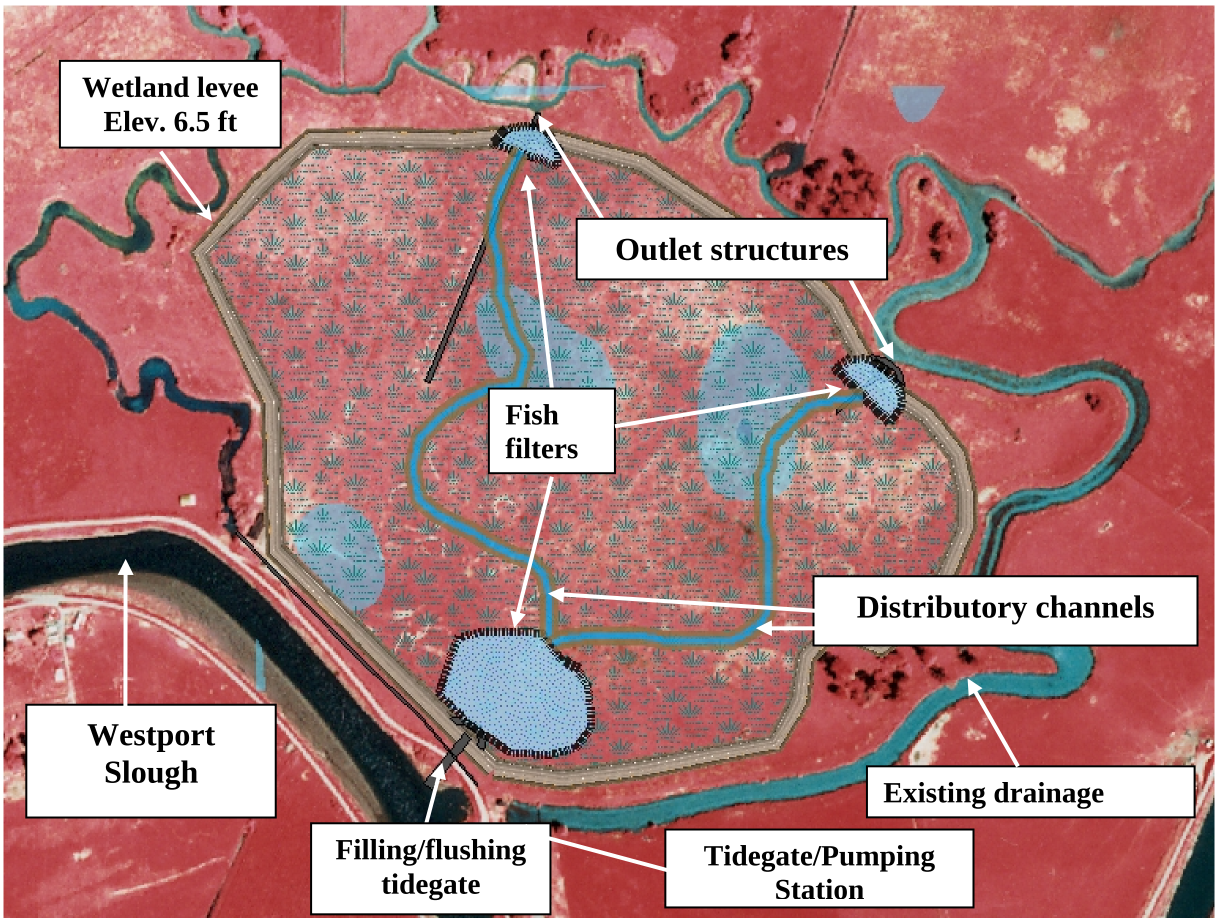



**Figure 2 – Water Control Features for Webb Wildlife Mitigaton Managed Wetland**

## 2.2 Design features for managed wetland

The managed wetland created for the wildlife mitigation project will utilize a levee interior to the flood control levee to impound the water, a filling/flushing tidegate for water provision from Westport Slough and distributory channels plus two water control structures to flush tidal water through the wetland. Water from the managed wetland would be discharged to the perimeter slough and then via tidegates and/or an expulsion pump to Westport Slough. Table 1 contains pertinent data describing the structures.

**Table 1 - Water control and structural features for managed wetland**

| | **Structure** | **Quantity/Size** | **U/S invert (ft)** | **D/S invert (ft)** | **Notes** |
|---|---|---|---|---|---|
| 1 | Levee (surrounding wetland) | ~7100 LF | n/a | n/a | Crest Elev. 6.5 ft<br>levee encloses 76 acres |
| 2 | Distributory channels | ~3700 LF | 0 | -0.5 | Two, u/s invert on Westport Slough end of wetland |
| 3 | Replacement culverts (for replacement of 3 existing District culverts) [with item 4] | 4 – 60” culverts<br>~124 LF each | -1.5 | -2.0 | Culvert inverts raised 3.5 feet from existing. This will allow for more efficient drainage and maintenance. Pipe will be CMP.<br>124 ft culvert length (same as existing - from as built drawings); headwall structure for mounting tidegates |
| 4 | Tidegates (for replacement of 3 existing tidegates) [with item 3] | 4; to be fitted on 60” culverts | | | Side-opening, mount on headwall |
| 5 | Filling/Flushing tidegate for managed wetland [with item 6] | 60” culvert<br>~205 LF each | 0 | -0.5 | CMP |

| | Structure | Quantity/Size | U/S invert (ft) | D/S invert (ft) | Notes |
|---|---|---|---|---|---|
| 6 | Exterior Tidegate for filling/flushing tidgeate (Westport Slough or flood side) [with item 5] | 60” | | | Combination headgate and tidegate. Normal operation will be as headgate partially closed to pass a controlled flow volume. Will operate as normal tidegate during flood events. |
| 7 | Interior Tidegate for filling/flushing tidgeate (wetland side) | 60” | | | Combination headgate and tidegate. Interior tidegate will be side opening. Normal operation will be in tidegate mode. Tidegate will open on high tide in Westport Slough; close on ebb tide to trap water in wetland. Headgate can be opened during flood events to discharge water. |
| 8 | Fish Filter at Interior Tidegate | TBD CY | NA | NA | Fish filter constructed of 6” open rock. Location on interior of managed wetland levee. |
| 9 | Outlet structure #1 and Fish Filter | 24-in CMP with riser; culvert length to be determined; Fish Filter TBD | 0.0 | -0.5 | Riser pipe with stoplogs to 5.5 ft. Stoplogs may be 2” x 4” or 2”x 6”. Fish filter constructed of 6” open rock and interior to managed wetland levee. |
| 10 | Overflow structure #1 (rectangular weir) | 20-ft rectangular weir | n/a | n/a | Weir crest shall be 5.5 ft. |
| 11 | Outlet structure #2 and Fish Filter | 24-in CMP with riser; culvert length to be determined; Fish Filter TBD | 0.0 | -0.5 | Riser pipe with stoplogs to 5.5 ft. Stoplogs may be 2” x 4” or 2”x 6”. Fish filter constructed of 6” open rock. Location on interior of managed wetland levee. |

| | Structure | Quantity/Size | U/S invert (ft) | D/S invert (ft) | Notes |
|---|---|---|---|---|---|
| 12 | Overflow structure #2 (rectangular weir) | 20 ft rectangular weir | n/a | n/a | Weir crest shall be 5.5 ft. |

*2.2.1 Wetland Levee*

An interior levee will be constructed to enclose the 74-acre wetland plus the two acres associated with the fish filters. The wetland levee will lay interior to the flood control levee, power lines and the potable water line. The levee will be constructed with native soil to an elevation of 6.5 feet. Figure 3 shows a typical levee section.

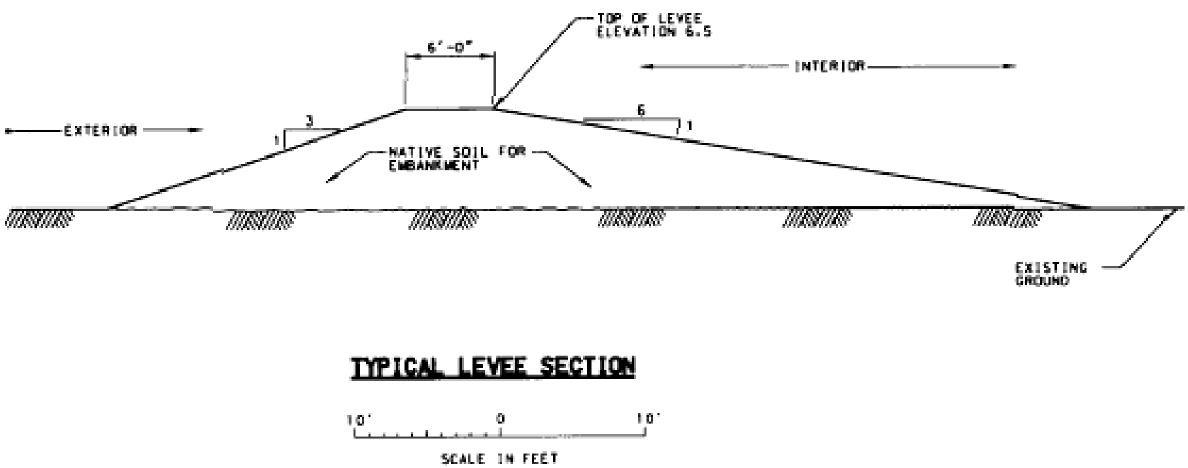



**Figure 3 - Typical Levee Cross Section**

*2.2.2 Distributory Channels*

The two distributory channels (Figure 4) are designed to convey and distribute water through the managed wetland. The channels are designed with an invert (bottom) elevation of zero feet. The channels and wetland will receive water from the filling/flushing tidegate as the water surface elevation of Westport Slough exceeds 3 feet during the tide cycle in summer and 4.5 feet in winter. The interior tidegate will close when the water surface elevation of Westport Slough falls below that of the managed wetland when the tide ebbs. The channels will be 30 feet wide with 1V:2H side slopes. Borrow soil from construction of these channels will be used to construct portions of the interior levee.

**Figure 4 - Summer water level at 3. 0 feet with distributory channels**

### *2.2.3 Filling/Flushing Tidegate*

The filling/flushing conduit (Figures 5 and 6) is a structure consisting of a 205 foot long, 60 inch diameter culvert with specialized tidegates and headgates on each end. The specialized tidegates and headgates allow the filling/flushing tidegate to perform several functions:

1. Delivery of a controlled volume of water to the managed wetland through a daily tidal cycle.
2. Raise the water level in the managed wetland from 3 to 4.5 feet in late summer and fall.
3. Lower the water level in the managed wetland from 4.5 to 3 feet in late spring.
4. Drain the wetland for anticipated severe flood conditions.

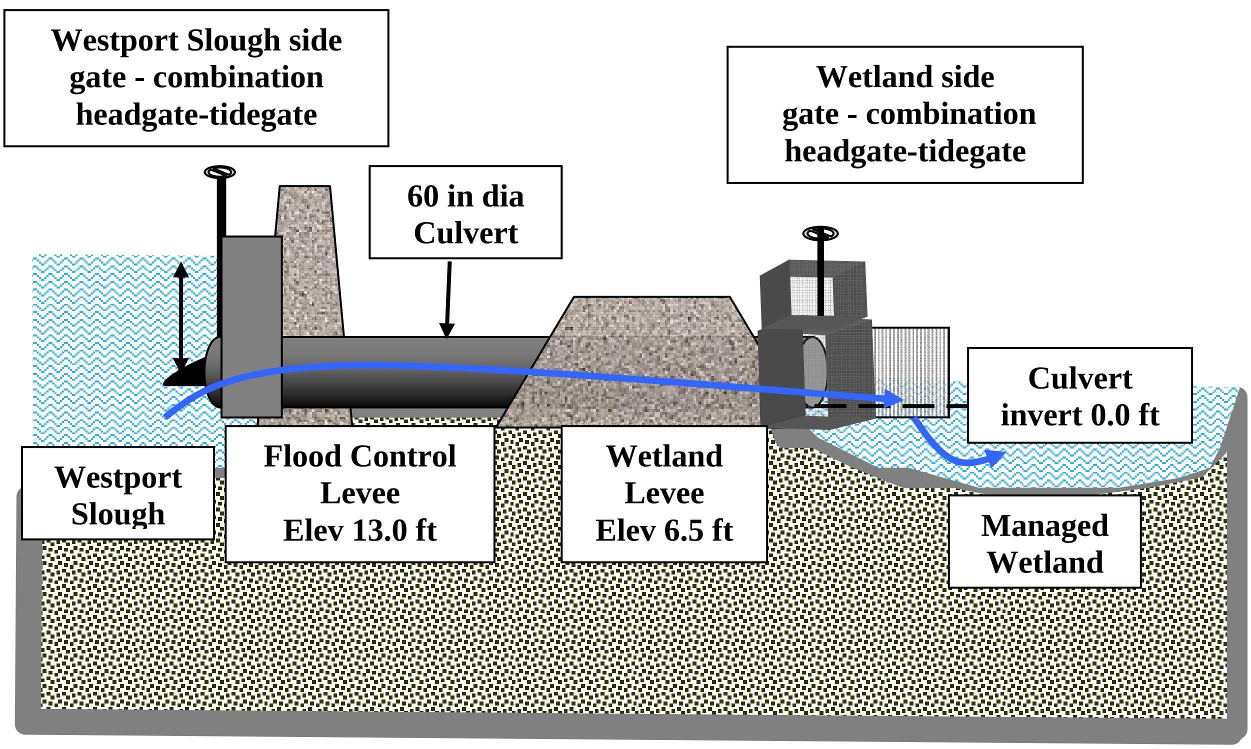



**Figure 5 – Filling/Flushing tidegate – typical operation during Westport Slough flood tide**

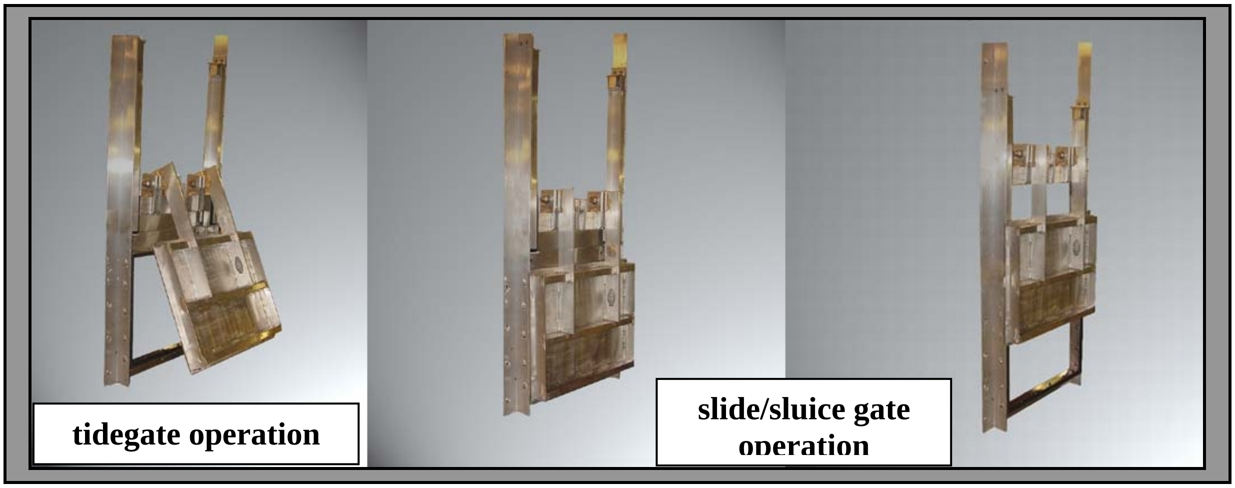



**Figure 6 – Filling/Flushing Tidegate – Operational modes.**

Each end of the filling/flushing tidegate supports identical combination slidegate /tidegate water control structure (Figure 6). The exterior headgate may be locked down and the slide gate operated to provide water to the wetland. When the exterior tide gate is in the locked position, the slide gate may be raised or lowered to adjust the desired amount of water to pass from Westport Slough to the managed wetland. When the slide gate is lowered (closed or partially closed) and the headgate unlocked, the structure functions as a typical tidegate.

Under the normal filling/flushing cycle, the Westport Slough side slidegate will be raised to allow a controlled volume of water into the wetland. The volume of water entering the managed wetland may be adjusted by raising or lowering the slidegate. Water will flow into the wetland as long as the Westport Slough water level exceeds the water level in the wetland. The tidegate on the wetland side will be operated in the normal tidegate mode during infill operations, allowing water into the wetland as the tide raises the water level in Westport Slough. As the tide falls and the water level in Westport Slough drops, the tidegate will close trapping the water transferred from Westport Slough. This process will be repeated through each tidal cycle providing a continuous source of fresh water into the wetland.

For flood events, the interior and exterior slide gates can be lowered and locked into position. The interior tide gate would be locked in the open position while the exterior (Westport Slough) tidegate would operate in a normal tidegate mode to expel waters from the interior. Through this operational scenario, the managed wetland can be drained prior to a flood event if determined necessary.

### *2.2.4 Fish Filters*

The fish filters are porous rock structures (6” open rock) that allow water flow into and out of the managed wetland while preventing fish from entering the managed wetland. Some species of fish, particularly the common carp are destructive to wetlands. Carp forage by rooting through the substrate, re-suspending bottom sediment and lessening light penetration required for plant photosynthesis, and uprooting aquatic plants. This activity would produce poor water quality and prevent the establishment of wetland vegetation. Figure 7 shows a typical fish filter of the type proposed for the managed wetland. The vertical riser for the water control structure is in the right center of Figure 7.

**Figure 7 – Typical rock fish filter**

*2.2.5 Outlet Structures*

Two outlet structures (Figure 8) connect the managed wetland to the main drainage channel (perimeter slough). The outlet structures consist of a 24-inch diameter culvert connected to a riser pipe.

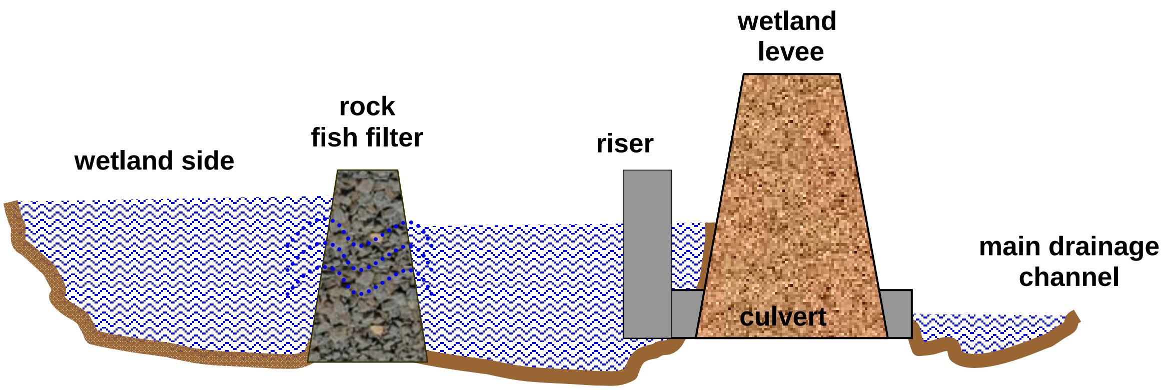



**Figure 8 – Outlet struture connecting wetland to main drainage channel**

The riser pipe (Figure 9) is fitted with stop logs to limit drainage below a preset elevation; under the normal winter operation that elevation is 4.5 feet. The stop logs are set at 3.0 feet for summer operation, allowing the wetland to drain and maintain a 3.0 foot water elevation. The stop logs can be removed to approximately the culvert invert elevation of 0 feet to facilitate drainage of the wetland if necessary.


**Figure 9 – Typical riser pipe – stop log water control feature**

*2.2.6 Main Tidegate replacement*

The main tidegate (Figure 10) located at the terminus of the main drainage channel was constructed in 1949. The drainage structure consists of three 48-inch diameter corrugated metal pipes (CMP) culverts. The culverts are 124 feet long and are fitted with the older style top-hinged tidegates. Levee inspections of the Webb District Improvement Company have found the main tidegate structure in poor condition. Several sinkholes were observed on the interior side of the levee, indicating that the one or more of the culverts have filled in due to corrosion of the corrugated metal pipe. The condition of the culverts has begun to threaten the levee integrity and prevents the drainage structure from operating to its designed capacity.

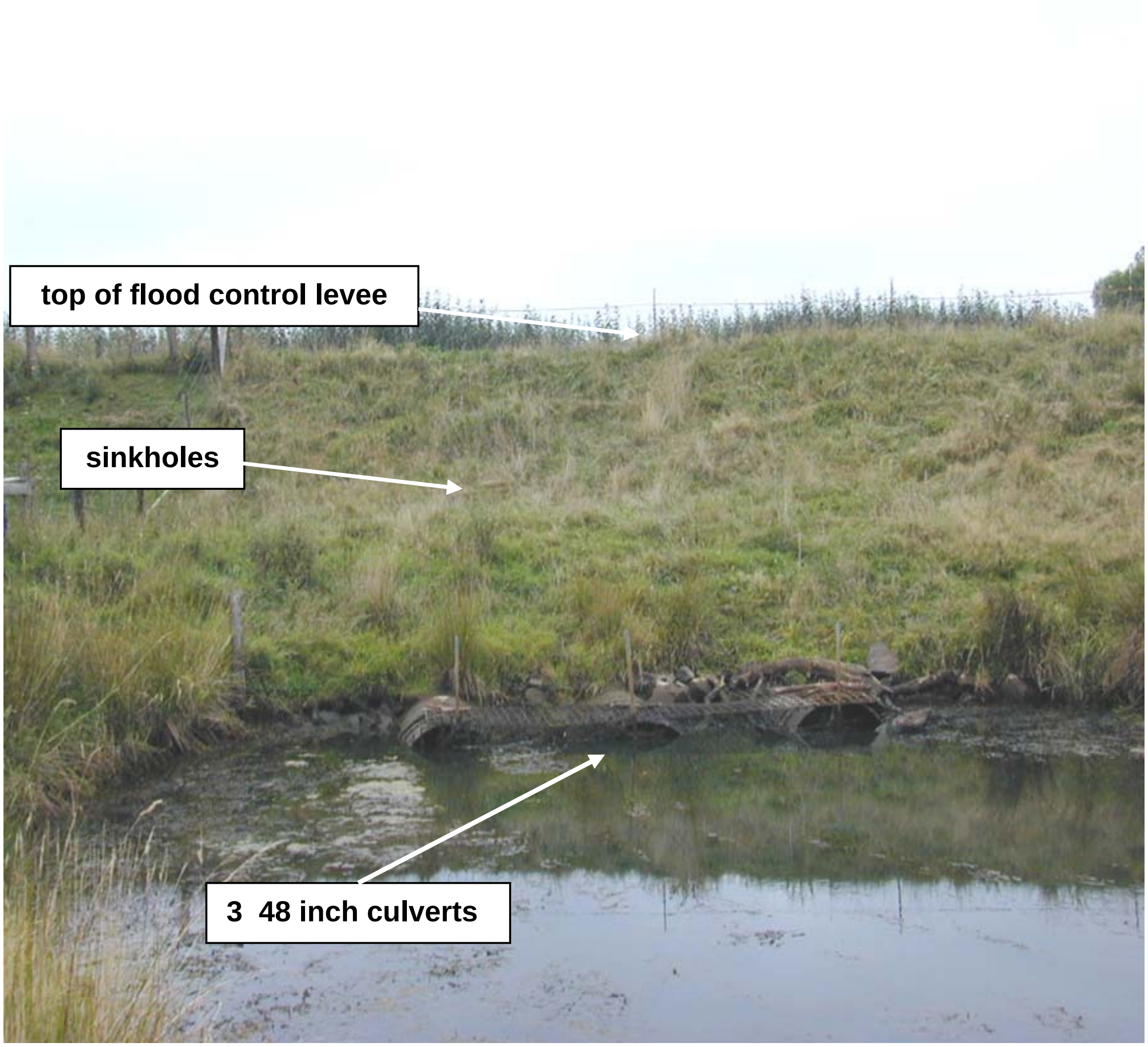



**Figure 10 – Webb District Improvement Company main outlets. Interior view of culverts.**

A 21,800 gallon per minute pump station currently provides most of the drainage capacity for the District. The replacement outlet structure (Figure 10a) would consist of four 60” diameter culverts fitted with side-hinged tidegates.

The proposed replacement tidegate is set at a higher invert (-1.5 feet interior, -2.0 feet Westport Slough) than the existing invert (-5.0 feet interior, -5.5 feet Westport Slough). The higher invert would mean that most of the tidegate will be visible at low tides.  The replacement tidegate will have a concrete headwall on the Westport Slough side.  Access to the headwall will be provided for maintenance and adjustment of the tidegates as needed.  The lowest water levels in Westport Slough occur at negative low tides at an elevation of -1.5 feet.

The replacement tidegate will allow gravity drainage of the interior slough down to the culvert invert at -1.5.

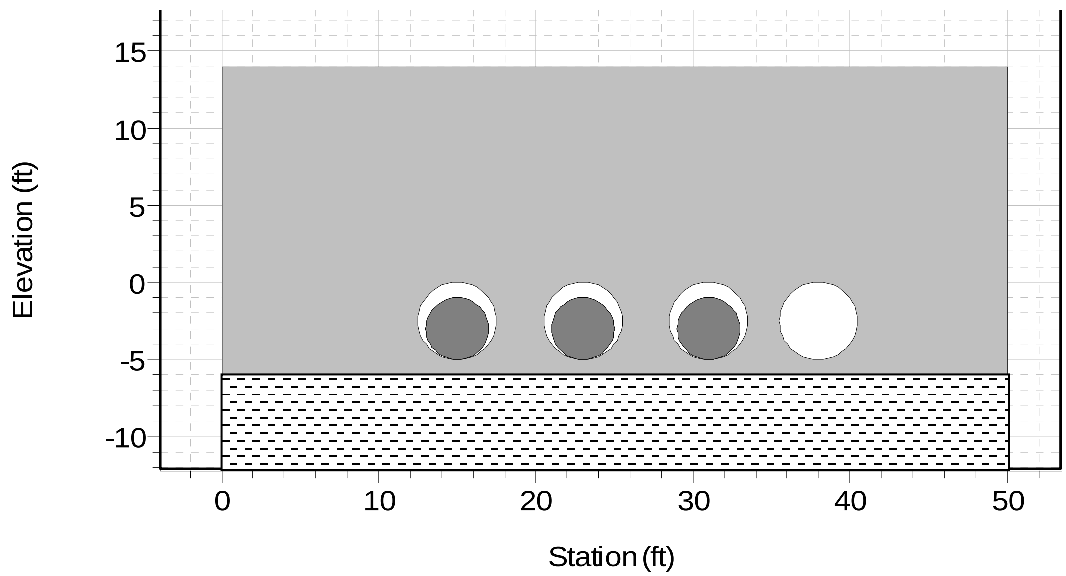



**Figure 10a - Replacement tidegate (4 60” culverts - white) compared with existing (3 48” culverts - gray). The invert of the replacement tidegate will be 3.5 feet higher than shown.**

The side-hinged tidegate is more efficient in discharging water than the top hinged tidegate. Side hinged gates open wider and for longer periods with less interior water pressure required to open than equivalently sized top hinged gates (*Charland 2001*). The number of replacement culverts, their increased size and the replacement tidegate type will substantially increase the drainage capacity of the replacement tidegates over the existing tidegates. The replacement tidegates are also designed to pass the additional tidal water flushed through the wetland and discharged to the main drainage channel and still provide the same level of flood protection. We anticipate that flood protection would actually be increased and that there should be less reliance on use of the pump station to discharge waters from the District than occurs under the current condition.

## 2.3 Managed Wetland Operation

### *2.3.1 Seasonal operation*

Winter water levels in the wetland would be maintained at approximately 4.5 feet (target elevation) from mid December to mid May. Water levels would be lowered gradually in spring-early summer (approximately mid-May to July1) to a target level of 3.0 feet for the summer months to facilitate growth and development of wetland plant communities (Figure 11). These wetland plant communities would be expected to vary by elevation band. The managed wetland would be gradually flooded beginning in Sept-October and ending around December 1st when the target elevation of 4.5 feet is attained. Gradual flooding would allow waterfowl and other species to more efficiently use the forage resources of the wetland compared to an abrupt filling to elevation 4.5 feet. Some fluctuation over the target elevations may occur with tidal flushing through the tidegate structure.

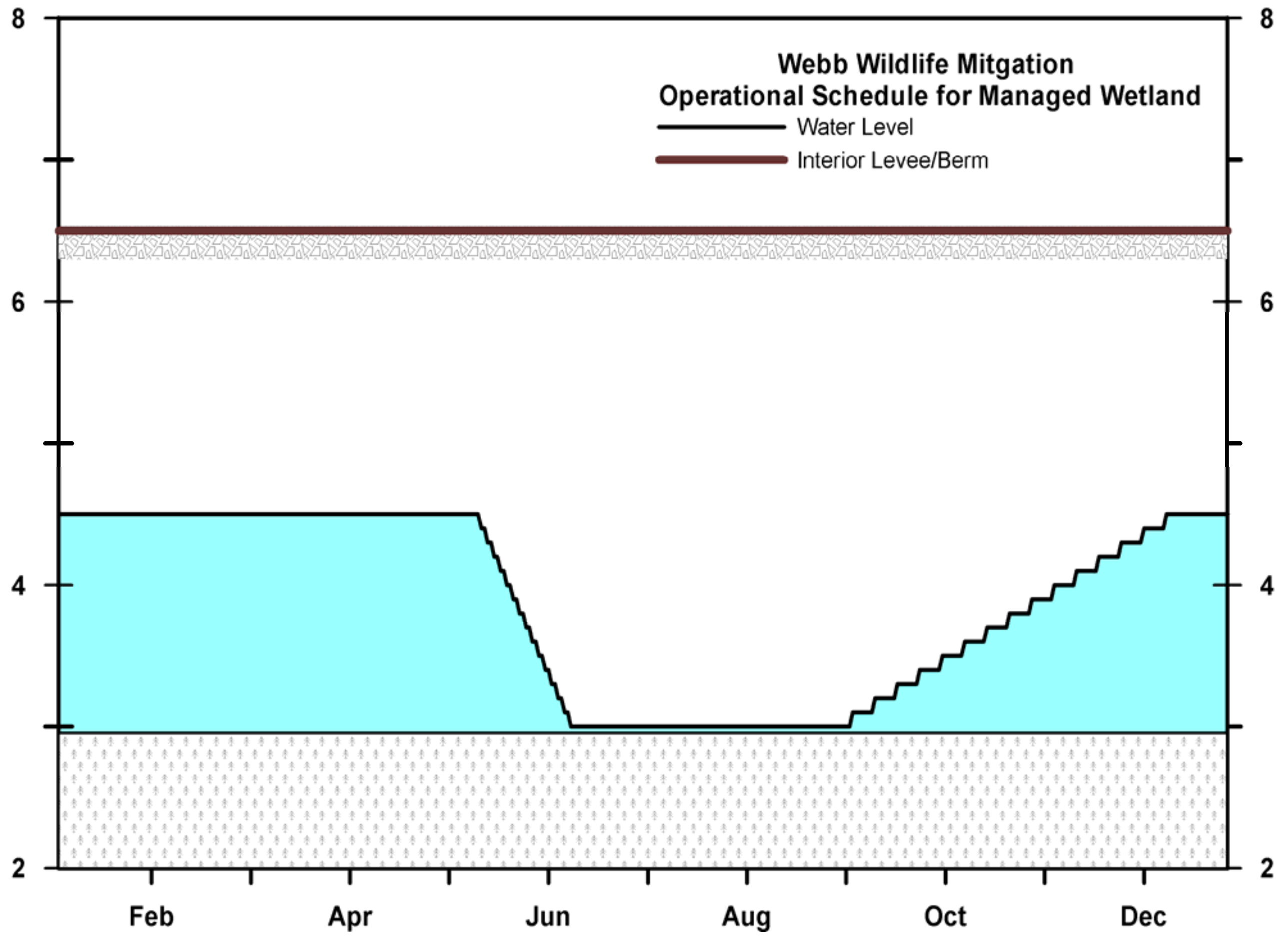



**Figure 11 – Target water levels for managed wetland.**

The flow patterns through the wetland for the winter high water period are shown in Figure 12. Water levels in the managed wetland are controlled by the stoplog elevation (4.5 feet) as set by the riser pipe connections in the outlet structures. Water enters the filling/flushing tidegate from Westport Slough during high tide periods that exceed 4.5’. Westport Slough water levels above 4.5 feet will push water into the wetland through the filling/flushing tidegate. Flow will exit through the porous rock fish filter at the inlet location, raising the water level in the wetland. As the water level rises, flow through the two outlet structures will discharge into the main drainage channel as the interior water level recedes back to 4.5 feet. Water entering the main drainage channel through the outlet structures will be discharged through the main tidegate during the normal tidal cycle at low tide.

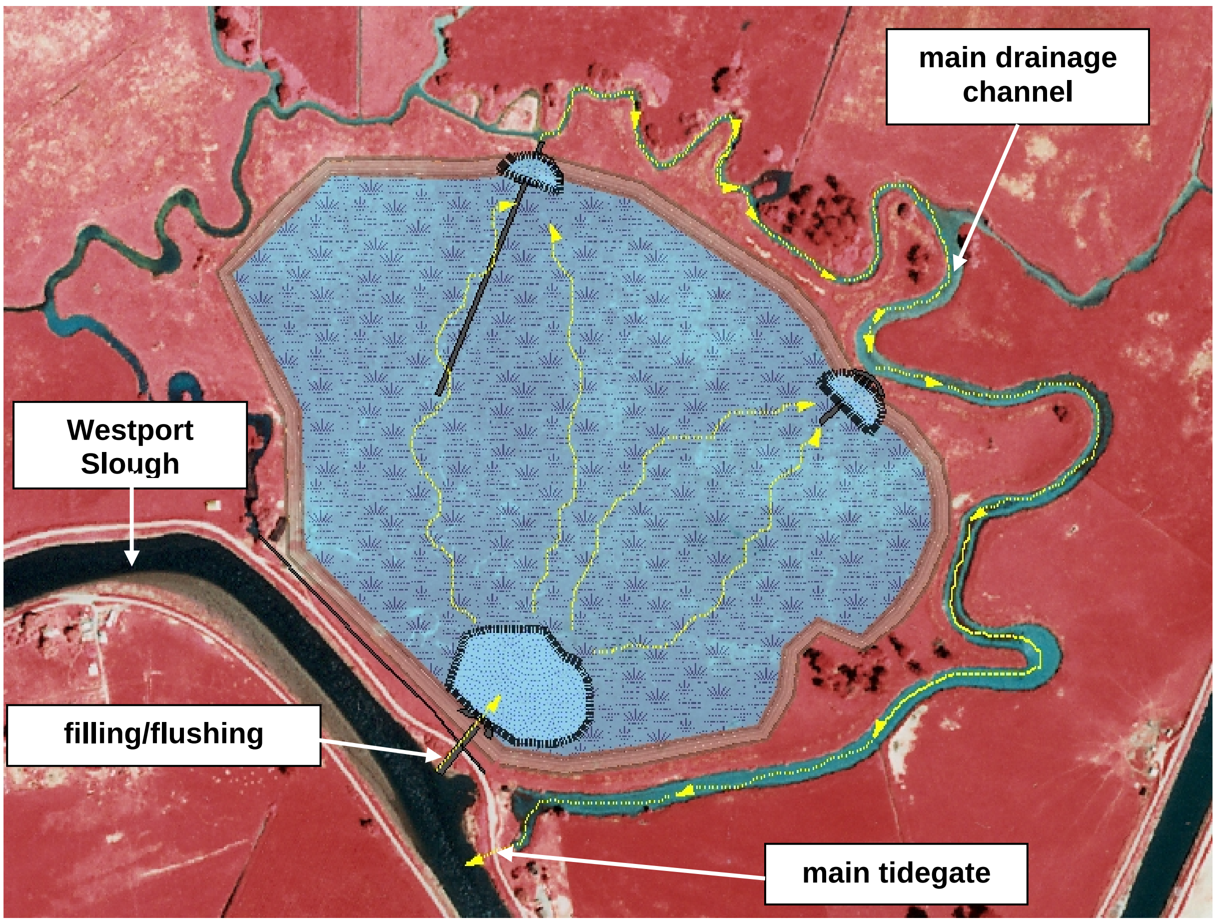



**Figure 12 – Typical flow patterns through wetland during winter high water level**

### *2.3.2 Summer flow pattern*

The summer flow pattern through the wetland is shown in Figure 13. When the wetland is drained to a water level of 3.0 feet most of the water will be in the distributory channels and fish filters with some pondage expected at locations where site elevation is less than 3.0 feet.

Water will enter through the filling/flushing tidegate and fill the fish filter. The fish filter will drain into to the two distributory channels, filling them to 3.0 foot water level or slightly higher, depending upon inflow volume during the a particular tidal cycle. The water depth in the channels will be approximately 3 feet deep, since the channels will be created with an invert of 0.0. The channels will have a slight slope to the two outlet structures, draining through the fish filters. The riser pipes stop log will be set to 3.0 feet which will allow that water level to be maintained in the distributory channels and managed wetland. Some exceedance of the 3.0 level may occur depending on the high tide elevation, duration of inflow, inflow volume and volume of water that can be discharged through the outlet structures. This will provide for a minor fluctuation in water surface elevation above 3.0 feet in the managed wetland. Evaporation and ground infiltration would be expected to cause the water level in the managed wetland to drop below 3.0 feet on occasion. Ultimately, water imported to the managed wetland will be exported through the outlet structures into the main drainage channel and out through the main tidegate into Westport Slough.

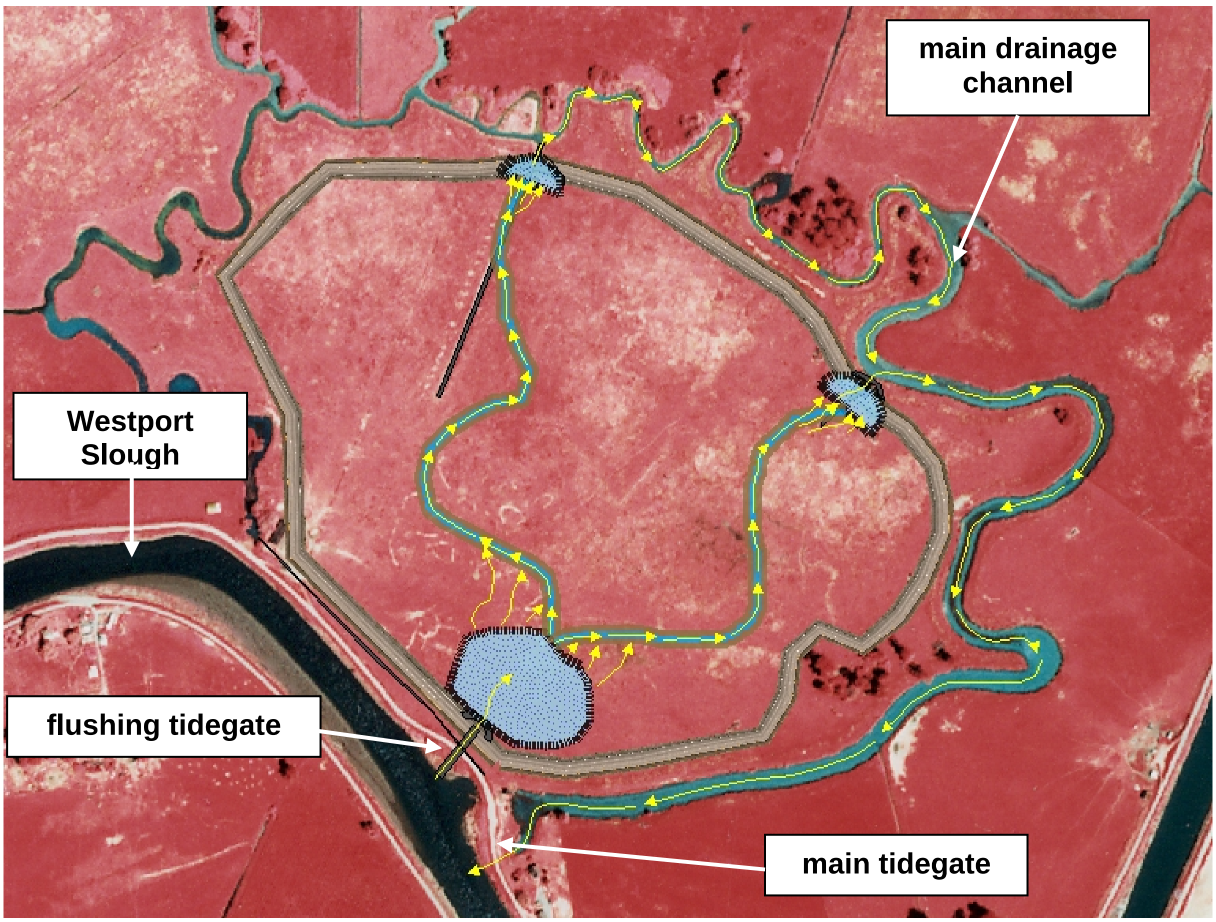



**Figure 13 – Typical flow patterns through wetland during summer low water level**

## 3. Hydrology and Climatology

### 3.1 Climatology

*3.1.1 Average temperature and rainfall*

Rainfall data for Clatskanie, OR located 4.7 miles east-southeast of the project site is presented in Table 2 below. Average daily high temperatures range between 44.2 and 74.2 degrees Fahrenheit, Average daily low temperatures range between 33.4 and 53.2 degrees. On average there are 179 days per year with rainfall amounts equal or above 0.01 inches, 118 days equal or above 0.10 inches, 36 days equal or above 0.50 inches and 11 days equal or above 1.0 inches.

**Table 2 - Table 2 – Rainfall data for Clatskanie, OR (sta 351643), period of record 1948 to 2004.**

| Month | Mean (in.) | High (in.) | Year | Low (in.) | Year |
|---|---|---|---|---|---|
| **January** | 9.18 | 18.56 | 1953 | 0.38 | 1985 |
| **February** | 6.73 | 16.74 | 1999 | 0.68 | 1993 |
| **March** | 6.26 | 13.51 | 1956 | 0.52 | 1965 |
| **April** | 3.91 | 9.54 | 1991 | 1.00 | 1956 |
| **May** | 2.51 | 5.58 | 1960 | 0.34 | 1992 |
| **June** | 1.74 | 3.83 | 1984 | 0.32 | 1951 |
| **July** | 0.70 | 3.02 | 1983 | 0.00 | 1958 |
| **August** | 1.08 | 4.03 | 1977 | 0.04 | 1986 |
| **September** | 2.15 | 7.43 | 1978 | 0.01 | 1975 |
| **October** | 4.57 | 11.14 | 1955 | 0.24 | 1987 |
| **November** | 8.66 | 18.39 | 1973 | 0.92 | 1976 |
| **December** | 9.57 | 17.94 | 1970 | 2.55 | 1976 |

| Season | Mean (in.) | High (in.) | Year | Low (in.) | Year |
|---|---|---|---|---|---|
| **Annual** | 57.07 | 75.96 | 1950 | 37.68 | 1985 |
| **Winter** | 25.49 | 42.53 | 1999 | 8.47 | 1977 |
| **Spring** | 12.68 | 21.32 | 1960 | 6.01 | 1965 |
| **Summer** | 3.52 | 7.02 | 1968 | 1.05 | 1970 |
| **Fall** | 15.38 | 28.16 | 1955 | 3.86 | 1993 |

*Source – Western Regional Climate Center http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?orclat*

### *3.1.2 Extreme and long duration rainfall*

Table 3 contains 7 and 10-day duration frequency based rainfall totals for the project area. Rainfall rates are computed from the data.

**Table 3 -Extreme and long duration rainfall for the Webb District Improvement Company near Clatskanie, OR.**

| | 7-Day | | | 10-Day | | |
|---|---|---|---|---|---|---|
| **return period** | **(in)** | **(in/day)** | **(in/hr)** | **(in)** | **(in/day)** | **(in/hr)** |
| 2 yr | 9 | 1.29 | 0.054 | 12 | 1.20 | 0.500 |
| 5 yr | 12 | 1.71 | 0.071 | 13 | 1.30 | 0.542 |
| 10 yr | 13 | 1.86 | 0.077 | 15 | 1.50 | 0.625 |
| 25 yr | 14 | 2.00 | 0.083 | 16 | 1.60 | 0.667 |
| 50 yr | 15 | 2.14 | 0.089 | 18 | 1.80 | 0.750 |
| 100 yr | 16 | 2.29 | 0.095 | 20 | 2.00 | 0.833 |

*Source – Weather Bureau Technical Paper 49, "Two to Ten-day Precipitation for Return Periods of 2 to 100 years in the Contiguous United States", December 1964*

## 3.2 Hydrology

### *3.2.1 Drainage*

The proposed managed wetland and associated fish filters comprises 76 acres inside of the 733 acre Webb District Improvement Company. The District is surrounded by flood control levees, with the area inside the levees comprising the total drainage area (Figure 14). A system of smaller drainage ditches and canals (dark blue lines in Fig 14) feed the main drainage channel (light blue line in Fig 14). This channel was once a tidal slough, and contains several oxbow or cutoff channels, which provide additional areas for water to pond before being released through the main drainage outlet on Westport Slough. Gravity drainage is constrained by the tidal cycle with water released into Westport Slough during low tide. Natural low water level in the interior sloughs would mirror those of Westport Slough along with fluctuations caused by tidal influence.

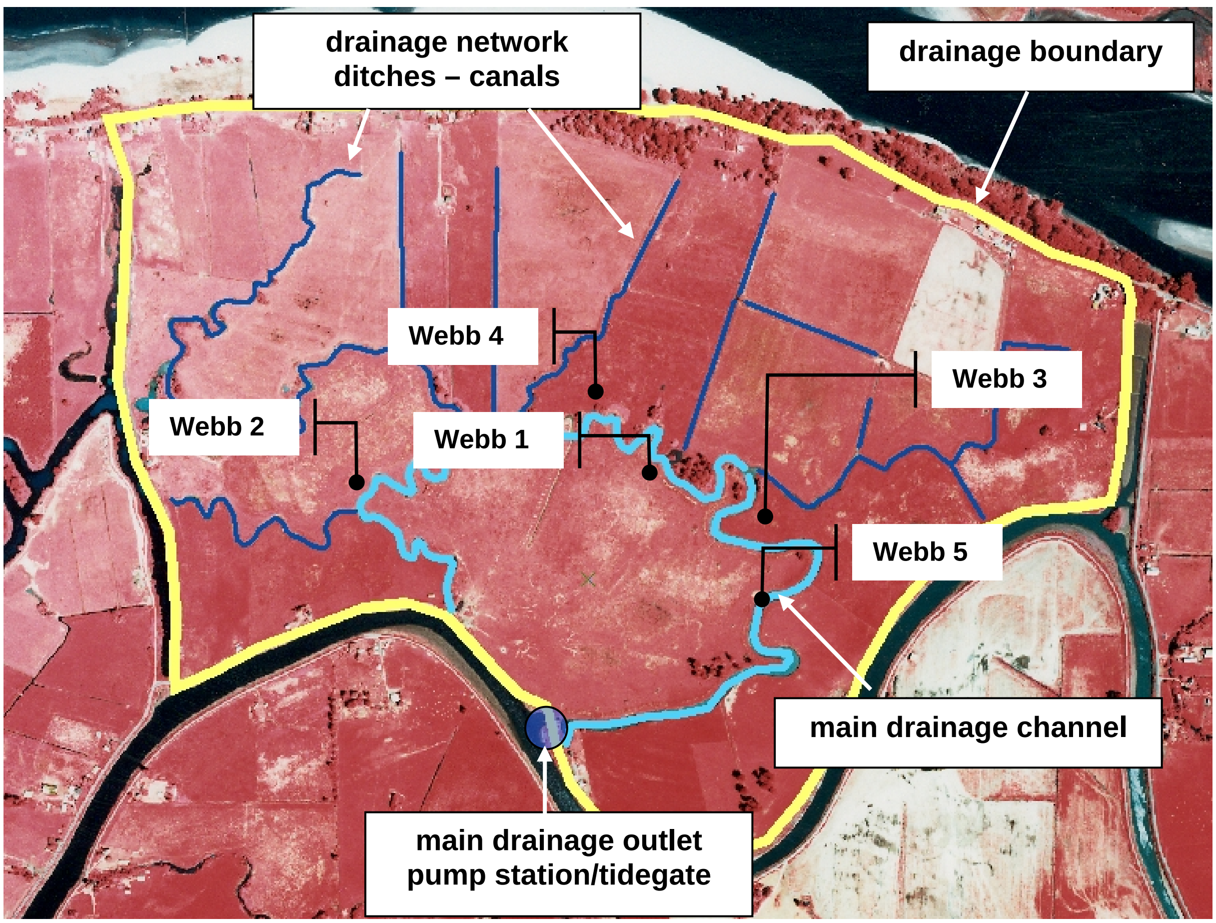


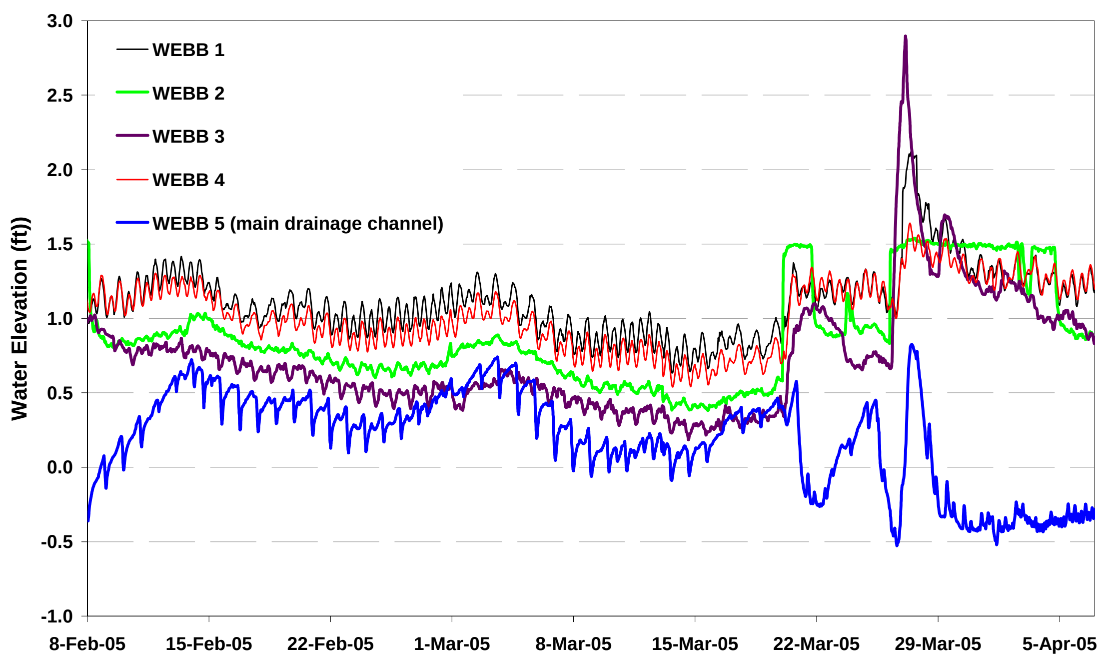

**Figure 14 – Drainage boundary and patterns for the Webb District Improvement Company. Locations of pizeometers measuring ground water levels are also shown.**

### *3.2.2 Soils and Land Use*

The soils found in the project area are primarily made up of clays and clay-silty loams. Most of the area is pasture and heavily grazed by cattle. The Hydrologic Soils Group (HSG) classification used by the National Resource Conservation Service classifies soils into four groups based on their runoff potential. The four Hydrologic Soils Groups are A, B, C and D. "A" type soils generally have the smallest runoff potential and "D" type soils the greatest. The prevailing HSG for the project area is classified as "C" based on field observation, groundwater data, and drill logs data from soil samples. Group C soils are sandy clay loam. They have low infiltration rates when thoroughly wetted and consist chiefly of soils with a layer that impedes downward movement of water and soils with moderately fine to fine structure. Some areas also contained group B and D soils.

### *3.2.3 Groundwater*

Data collected from 5 piezometers located in ground water monitoring wells installed in the project area show evidence of a high groundwater table. The data suggest a rapid response to water levels in the main drainage channel and tidal cycle.




| INSTRUMENT | GROUND ELEVATION | INSTRUMENT | TOP OF WATER |
|---|---|---|---|
| WEBB 1 | 2.65 | WEBB 5 | -0.44' |
| WEBB 2 | 1.62 | | |
| WEBB 3 | 4.42 | | |
| WEBB 4 | 3.01 | | |

**Figure 15 – Pizometer data 2/8 thru 4/5/2005**

## 3.3 Hydrologic Modeling and Analysis

A hydraulic model, HEC-RAS was developed to design and analyze the performance of the water control features and drainage modifications proposed for the managed wetland. In order to evaluate performance of the system, flow data computed from a hydrologic model, MGSFlood was used as input to the HEC RAS model.

### *3.3.1 MGSFlood model*

MGSFlood is a general, continuous, rainfall-runoff computer model developed specifically for stormwater facility design in Western Washington. The program uses the Hydrological Simulation Program-Fortran (HSPF) routine for computing runoff from rainfall. The program meets the requirements of the 2001 Washington State Department of Ecology Stormwater Management Manual for Western Washington. The use of the MGSFlood model for hydrologic analysis was limited to development of rainfall-runoff simulations representing pre and post project conditions. Results of the simulations were used to develop flood frequency and duration statistics. Selected timeseries output representing extreme events was used to test the design performance in the HEC RAS model.

### *3.3.2 MGSFlood model inputs – precipitation*

MGSFlood uses multi-year inputs of hourly precipitation and evaporation to compute a multi-year timeseries of runoff from the site. Precipitation data from Longview, WA was used to compute flow data from the project area. Although Longview, WA is close to the project area, rainfall amounts and rates may vary due to the local topography. To transfer the Longview, WA hourly rainfall to the project site 17 miles west, a simple scaling factor is applied to adjust the rainfall record. The current approach for applying the scaling factor, as recommended in the *Stormwater Management Manual for Western Washington* is to compute the scaling factor as the ratio of the 25-year 24-hour precipitation for the target and source sites. For the project area at Webb District Improvement Company and Longview, WA:

$$\textbf{Scale Factor} = P_{25\ TargetSite}/P_{25\ SourceGage}$$

where: $P_{25\ Webb}$= 25-year 24-hour precipitation at the project site of interest
5.25 inches

$P_{25\ Longview,\ WA}$= 25-year 24-hour precipitation at the source gage
4.21 inches

The values of the 25-year 24-hour precipitation were obtained from NOAA Atlas #2. The period of record for the Longview, WA data was 10/01/1954 through 10/01/1998, 44 years.

### *3.3.3 MGSFlood model inputs – watershed and land use*

The MGSFlood project watershed must be defined in terms of subbasins, and the stream network within the watershed is described by a series of node connections. Land use parameters are assigned for each subbasin and the program computes runoff for each node separately. Figure 16 shows the MGSFlood model watershed and nodes for the Webb Diking District.

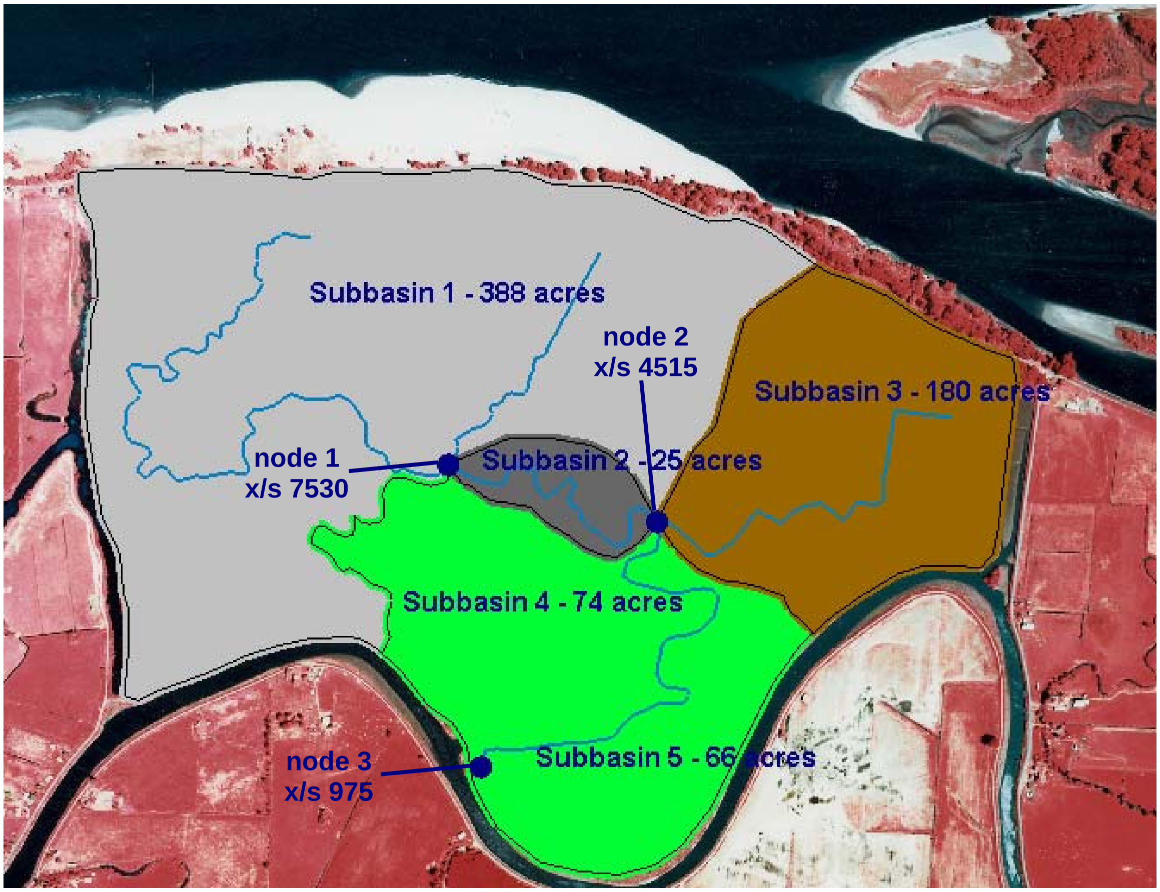



**Figure 16 – MGSFlood hydrologic model schematic.**

Node 3 represents the main drainage outlet (pump station and tidegates).

Nodes are used to collect runoff from the tributary area for a given subbasin and from the nodes of upstream subbasins. There is no attenuation of flow from subbasins to nodes and from one node to the next node as the hydrographs from the subbasins are translated directly to the receiving node without hydraulic routing. The node locations correspond to locations in the HEC RAS model where flow hydrograph input is required. Computed runoff from the MGSFlood model can be used to test the design features for the managed wetland the HEC RAS model. The corresponding HEC RAS inflow points are also identified.

### *3.3.4 MGSFlood results*

Flow frequency statistics are computed and presented in Table 4.

**Table 4 - Flow frequency data for Webb District Improvement Company. Exceedence probability computed using generalized extreme value distribution.**

| **Annual Probability Percent Exceeded** | **Pre development Runoff (cfs)** | Post development Runoff (cfs) |
|---|---|---|
| 90 | 31.4 | **28.1** |
| 50 | 62.8 | **56.2** |
| 20 | 102.7 | **91.9** |
| 10 | 133.0 | **119.1** |
| 4 | 176.4 | **158.0** |
| 2 | 212.8 | **190.6** |
| 1 | 252.8 | **226.4** |
| 0.5 | 297.0 | 266.0 |

The pre development condition represents the without project condition. The post development condition represents the drainage with the 76-acre managed wetland and associated fish filter areas. The post development condition also assumes that runoff from the wetland will not be immediately directed into the drainage system. Runoff from the 76-acre wetland and fish filter areas would accumulate in the wetland, discharge would be controlled by the outlet water control structures. Thus, runoff for the wetland is delayed, accounting for the lower post development flow frequency statistics.