DAM INFORMATIONAL OVERVIEW

BONNEVILLE DAM

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Water Quality Team
Reservoir Control Center, Columbia Basin Water Management Division
U. S. Army Corps of Engineers Northwestern Division
Portland, Oregon

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SECTION 1: GENERAL

1.1 Project Description

Stream: Columbia River (R.M. 146.1)
Location: Bonneville, Oregon
Owner: U.S. Army Corps of Engineers, Portland District
Project Authorization: 1935 Rivers and Harbors Act. 1935
Authorized Purpose: Power, Navigation
Other Uses: Fisheries, Recreation, Water Quality
Type of Project: Run-of-river
Date of Establishment: June 1938

Bonneville Lock and Dam consists of several dam structures that together complete a span of the Columbia River between the U.S. states of Oregon and Washington at River Mile 146.1. The dam is located 40 miles east of Portland, Oregon, in the Columbia River Gorge. The primary functions of Bonneville Lock and Dam are electrical power generation and river navigation. The dam was built and is managed by the United States Army Corps of Engineers. Electrical power generated at Bonneville is distributed by the Bonneville Power Administration. Bonneville Lock and Dam is named for Army Capt. Benjamin Bonneville, an early explorer credited with charting much of the Oregon Trail.

In 1896, prior to this damming of the river, the Cascade Locks and Canal was constructed, allowing ships to pass the Cascades Rapids, located several miles upstream of Bonneville. During the New Deal, the Army Corps of Engineers constructed a new lock and a powerhouse which were on the south (Oregon) side of Bradford Island, and a spillway on the north (Washington) side. These were started in 1933 and finished in 1937.
Both the cascades and the old lock structure were submerged by the Bonneville Reservoir, also known as Lake Bonneville, the reservoir that formed behind the dam. The original navigation lock at Bonneville was opened in 1938 and was, at that time, the largest single-lift lock in the world. The first powerhouse with units 1 through 10 went into service in 1938.

At the time, America was in the Great Depression, and the dam's construction provided jobs and other economic benefits to the Pacific Northwest. Inexpensive hydroelectricity gave rise, in particular, to a strong aluminum industry.

A second powerhouse(with units 11 through 18 and two fishway units) was started in 1974 and completed in 1982. The second powerhouse was built by widening the river channel on the Washington side, creating Cascades Island between the new powerhouse and the original spillway. The combined electrical output of the two power houses at Bonneville is now over 1 million kilowatts.

Despite its world record size in 1938, Bonneville Lock became the smallest of seven locks built subsequently at different locations upstream on the Columbia and Snake Rivers; eventually a new lock was needed at Bonneville. This new structure was built on the Oregon

shore, opening to ship and barge traffic in 1993. The old lock is still present, but is no longer used.

The dam features fish ladders to help native salmon and steelhead get past the dam on their journey upstream to spawn. The large concentrations of fish swimming upstream serve as a tourist attraction during the spawning season. California Sea Lions are also attracted to the large number of fish, and are often seen around the base of the dam during the spawning season. By 2006, the growing numbers of crafty sea lions and their impact on the salmon population have become worrisome to the Army Corps of Engineers and environmentalists. The dam blocked the migration of white sturgeon to their upstream spawning areas. Sturgeon still spawns in the area below the dam and the lower Columbia River supports a healthy sturgeon population. Small very depressed populations of white sturgeon persist in the various reservoirs upstream.

1.2 Status - History

The first powerhouse with units 1 through 10 went into service in 1938. Construction started on the second powerhouse in 1974 with units 11 through 18 and two fishway units and was completed in 1982.

SECTION 2: regulation

2.1 Water Surface Elevation (ft)

A) Forebay Elevation

Max. flood pool (Q = 2,120,000 cfs) .....105'
Max. controlled flood pool (Q = 1,700,000 cfs) / Full pool ..90'
Max. spillway design operating pool .....82.5' (1)
Max. regulated pool .....77'
Normal operating range .....71.5' to 76.5' (2)(3)
Min. pool .....70'
Max. flood tailwater (Q = 2,120,000 cfs) .....81'
Max. controlled flood tailwater (Q = 1,700,000 cfs).....65'
Standard project flood tailwater (Q = 850,000 cfs) .....45'
Minimum tailwater .....7'

B) Tailwater Elevation

Rate of change
Summer (1 Apr-30 Sep) 60-min limit …….1.5
Normal - 24 hr limit 4.0
Maximum - 24-hr limit (no more than 10 per season) …..... 5.0
Winter (1 Oct-31 Mar) 60-min limit……. 3.0

Normal - 24-hr limit 7.0
Maximum - 24-hr limit (no more than 18 per season)……. 10.0

2.2 Discharge

Minimum instantaneous ..... 80,000[(4)]cfs
Minimum daily average ..... 100,000[(4)]cfs

2.3 Storage in forebay

Maximum Storage …….. 10.0 KSFD/ 1.0 ft
Minimum Storage …… ---

2.4 Power Plant

Combined Totals (Powerhouse 1 & 2)

Number of units .....……...18
Nameplate capacity.....….....1050 MW
Overload capacity .....….....1186 MW
Station service units .....……...4 MW
Fishway units capacity.....……...26.2 MW
Total capacity (Overload + Service units + Fishway units)...……...1216 MW
Hydraulic capacity (1% Max).....……....288,000 cfs
Maximum H/K coefficient …….....4.4 MW/KCFS
Minimum H/K coefficient …….3.7 MW/KCFS

First powerhouse

Number of main units .....……10
Units 1-2.....…....43.2 MW
Units 3-10.....….....54.0 MW
Nameplate capacity.....……518 MW
Overload capacity .....…...…574 MW
Station service units .....……4 MW
Hydraulic capacity (1% Max).....……...136,000 cfs

Second powerhouse

Number of main units .....…….8
Nameplate capacity.....…….532 MW
Overload capacity .....…….612 MW
Fishway units capacity.....….26.2 MW
Hydraulic capacity (1% Max).....….152, 000 cfs
Type of turbines .....….Kaplan adjust.-blade propeller type

2.4 Powerhouse

A) Powerhouse 1

Length (including erection bay & service bay) .....1,027’
Width (U/S face of intake to D/S face of draft tube).....190.0’
Spacing of units - main unit (MU) .....82'
Number of hydro-generating units (MU) .....8 - 60,000 kva
Number of hydro-generating units (MU) .....2 - 48,000 kva
Total rated capacity .....535 MW
Overload capacity .....600 MW
Kaplan type turbines (MU) .....8 - 74,000 hp @ 50.0' head
Kaplan type turbines (MU) .....2 - 66,000 hp @ 50.0' head
Units 1-2 Discharges/turbine at rated head and
full gate output (MU) .....11,400 cfs
Units 3-10 Discharges/turbine at rated head and
full gate output (MU) .....14,700 cfs
Runner diameters (MU) .....280"

B) Powerhouse 2

Length (including erection bay & service bay) .....985.5'
Width (U/S face of intake to D/S face of draft tube).....221.25'
Spacing of units - main unit (MU) .....94'
Fish turbine unit (FTU) .....43'
Elevation centerline turbine distributor (MU) .....0 fmsl
(FTU) .....-29 fmsl
Number of hydro-generating units (MU) .....8 - 70,000 kva
(FTU) .....2 - 13,800 kva
Total rated capacity .....532 MW
Overload capacity .....612 MW
Kaplan type turbines (MU) .....8 - 105,000 hp @ 52.0' head
(FTU) .....2 - 20,700 hp @ 59.0' head
Discharges/turbine at rated head and
full gate output (MU) .....20,000 cfs
(FTU) .....3,400 cfs
Runner diameters (MU) .....330"
(FTU) .....136"
Total plant Hydraulic capacity (1% Max) .....166,800 cfs

2.6 Navigation Lock

Type .....Single lift
Length .....500'
Width .....76'

Vertical lift .....50'-70'
Minimum depth over lower miter gate sill (at __ T.W.) .....21'
Depth over upper sill (pool el. 74') .....34'
Flow through lock …..…….. 400 cfs

2.7 Stilling Basin

Type .....Horizontal apron

SECTION 3: Fish

3.1 Fish Facilities

A) Fish Ladders

Number ……4
Fish Ladder (North Shore) ……...…….. 800 cfs
Cascade Island Fish Ladder …….…...…… 500 cfs
Branch A fish ladder …….…….. 2500 cfs
Branch B fish ladder ……..…..900 cfs

B) Corner Collector

Maximum Flow (cfs) .....5,900 at 76.5’ forebay
Minimum Flow (cfs).....4,400 at 72.5’ forebay
Outlet Water Surface Elevation .....16’
Period of operation.....March – August
Location .....…….…….....South side of Powerhouse 2

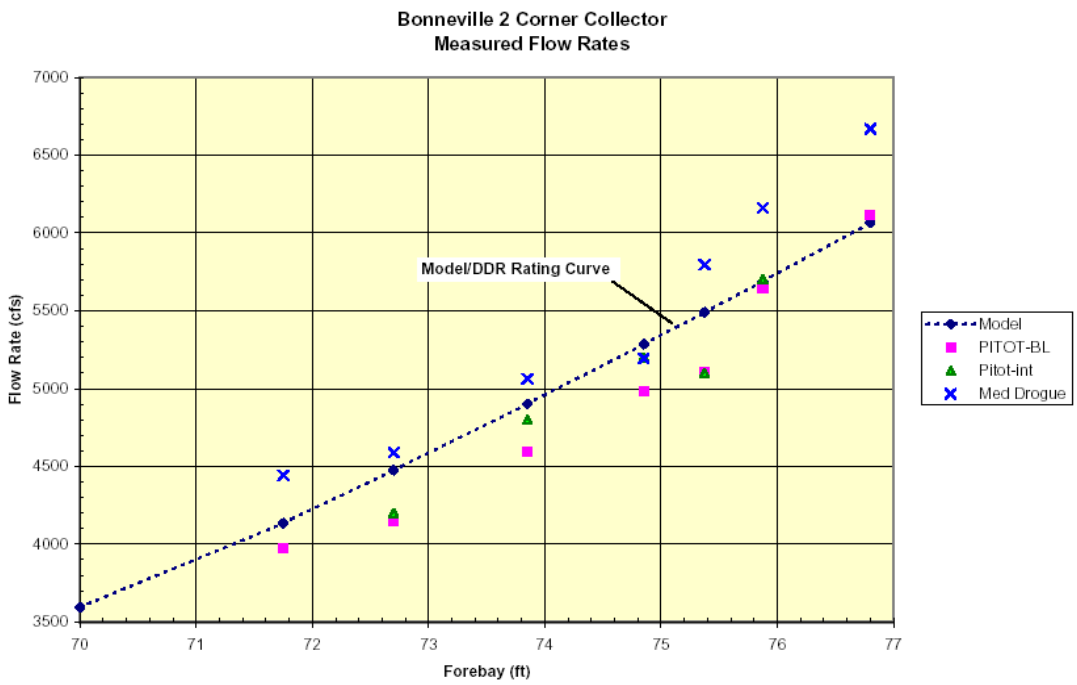

Figure 1: Model Rating Curve Vs. Measured Discharges

C) Behavioral Guidance Structure (BGS)

Total length of BGS …….720’
Number of steel panels creating wall……60
Height of steel panels …….. 10’
Width of steel panels ……12’

Figure 2: BGS panels

Figure 3: BGS Installed

Figure 4: Layout of BGS in forebay

D) Flows in other fish structures

Ice and Trash Sluiceway (IST) – Powerhouse 1 ……..……200 cfs
Downstream Migration Channel (DSM) – Powerhouse 1 ……. 300 cfs
Downstream Migration Channel (DSM) – Powerhouse 2 ……. 500 cfs
Upstream Migrant Transportation Channel (UMT) ……700 cfs

3.2 Removable/Temporary Spillway Weir

None.

Section 4: Water Quality

4.1 Spillway

Type .....Concrete gravity, gate controlled
Length (overall) .....1,450'
Gates .....18 gates - 50' wide sliding, riveted structural steel (operated by either of two 350-ton gantry cranes) or (10 each gate hoist, remotely controlled from Control Room)
Crest elevations .....24'+
Deck elevation .....97'+
Design discharge, (cfs) 1,600,000

4.2 Flow Deflectors

Total number of Bays.....18
Total number of deflectors.....18
Phase 1 (Bays 4-15 and 18), Elevation (ft).....14
Phase 2 (Bays 1-3, and 16-17), Elevation (ft).....7

When there is 12ft or more water over the deflectors, they no longer function. Therefore tailwater elevations of 19 feet or more will cause bays 1-3 and 16-17 to no longer function. And at 26ft elevation, Bays 4-15 and 18 deflectors no long function.

Depth of deflector (ft).....5.9
Length of deflector (ft).....11.0
Toe of deflector (ft).....6

4.3 Water Quality Monitoring Stations

A) Active Gauges

<u>A1. Bonneville Forebay (BON)</u>

River Mile: 146.1 miles
Gauge Elevation: Fixed
Distance Off-Shore: N/A (straight down from edge of concrete wall)
Latitude: 45° 38’ 44.9” N
Longitude: 121° 56’ 25.7” W
Datum: NAD-83
River: Columbia
USGS-ID: 453845121562000
Owner: US Army Corps of Engineers
Gauge Type: Hydrosonde
Data Transmission: GOES Satellite

Dates of Operation: Year Round
Years of Operation: 1986 – Present
River Conditions: Forebay Monitor
Parameters Measured: Barometric Pressure, Total Gas Pressure, and Temperature.
Location: Oregon, USA The gauge is located on the Northern side of the spillway channel on Cascade Island just upstream of spillway #1

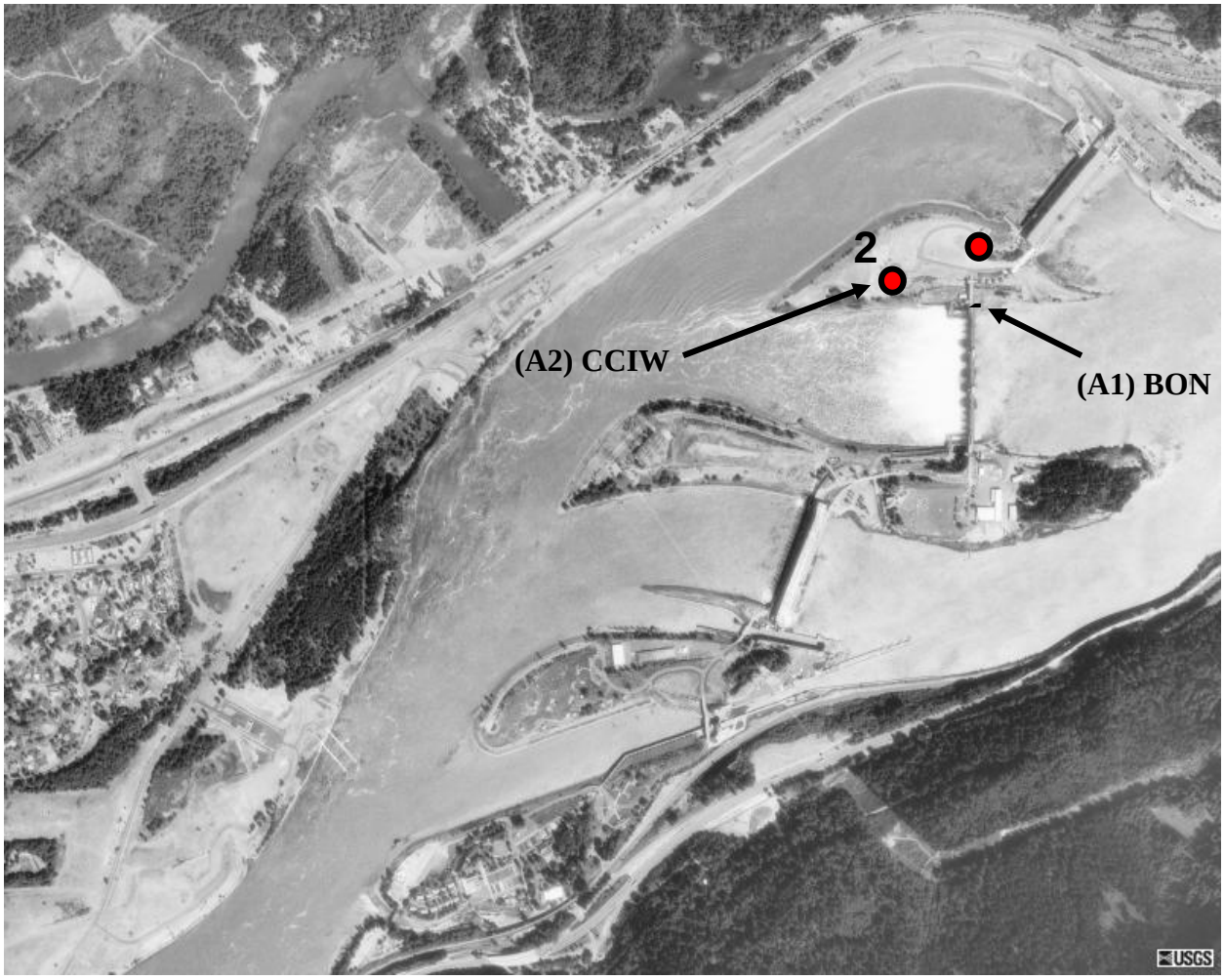

Figure 5: Bonneville dam with locations of the forebay (BON) and tailwater(CCIW) fixed monitoring stations.

Figure 6: Bonneville spillway with location of the forebay fixed monitoring station (BON).

Figure 7: Fixed Monitoring Station at Bonneville Dam Forebay

A2. Cascade Island (CCIW)

River Mile: 145.9 miles
Gauge Elevation: -16 ft msl
Distance Off-Shore: ~ 50 feet
Latitude: 45° 38’ 45.2” N
Longitude: 121° 56’ 47.2” W
Datum: NAD-83
River: Columbia
USGS-ID: 453845121564001
Owner: US Army Corps of Engineers
Gauge Type: Hydrosonde
Data Transmission: GOES Satellite
Dates of Operation: April 1 – Sep 31
Years of Operation: 2004 – Present
River Conditions: Spillway Monitor
Location: Washington, USA
This gauge is located within the Bonneville Dam spillway channel on Cascade Island approx 200 yards downstream of the spill channel.
Parameters Measured: Barometric Pressure, Total Gas Pressure, Temperature

Comments: This gauge is currently used as the Spillway tailrace gauge for management of spill at Bonneville Dam.

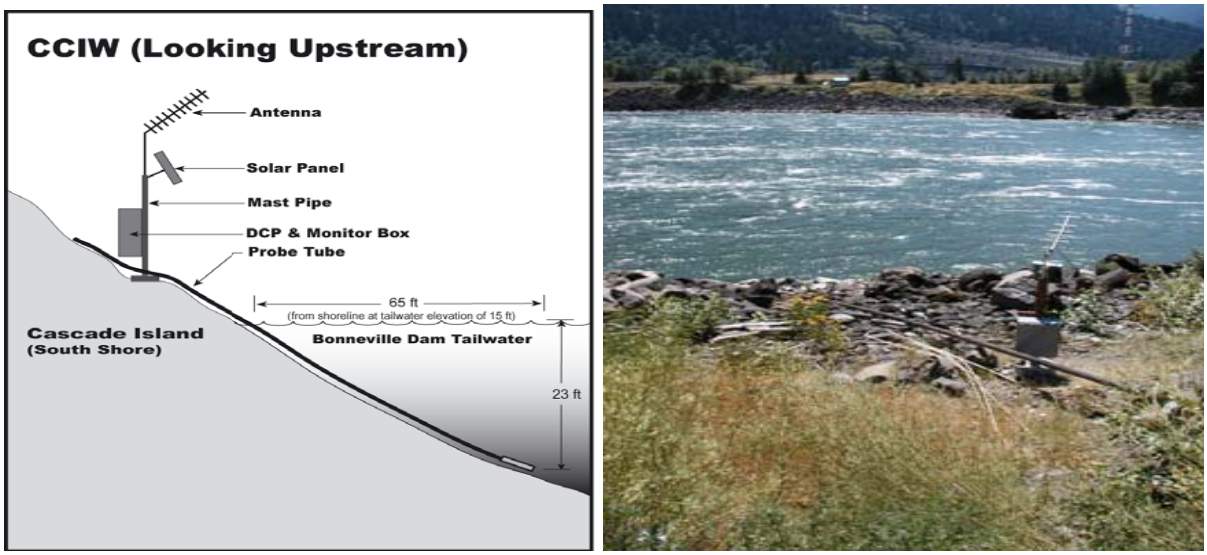

Figure 8: Fixed Monitoring Station at Cascade Island at tailwater of Bonneville Dam

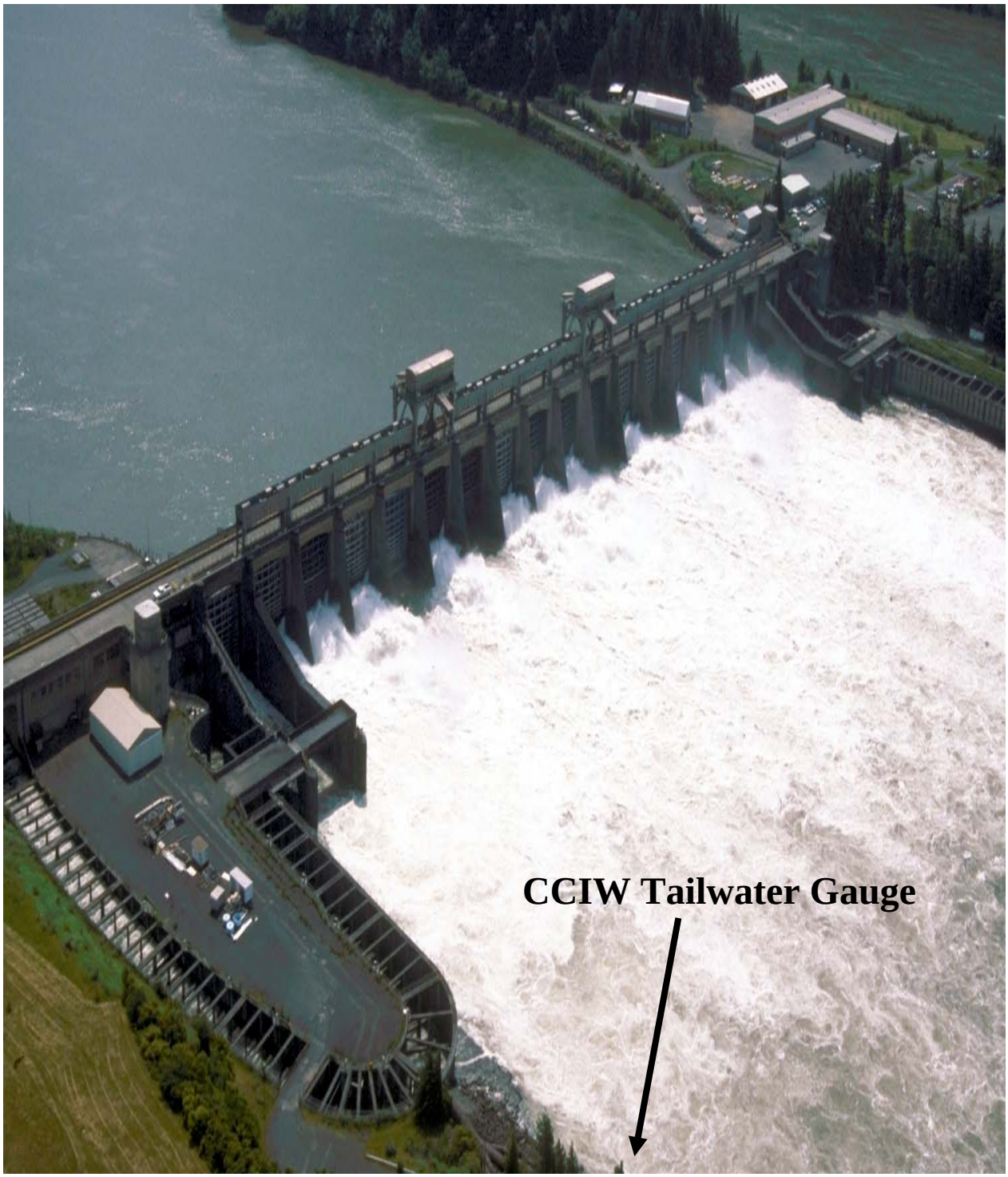

Figure 9: Fixed Monitoring Station at Bonneville Dam Tailwater on Cascade Island

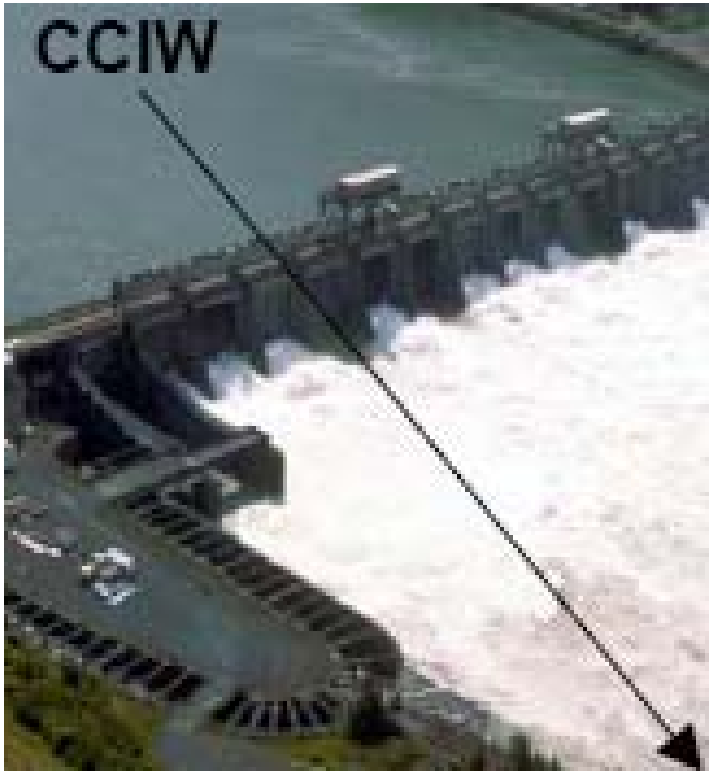

Figure 10 - Location of the Cascade Island fixed monitoring site.

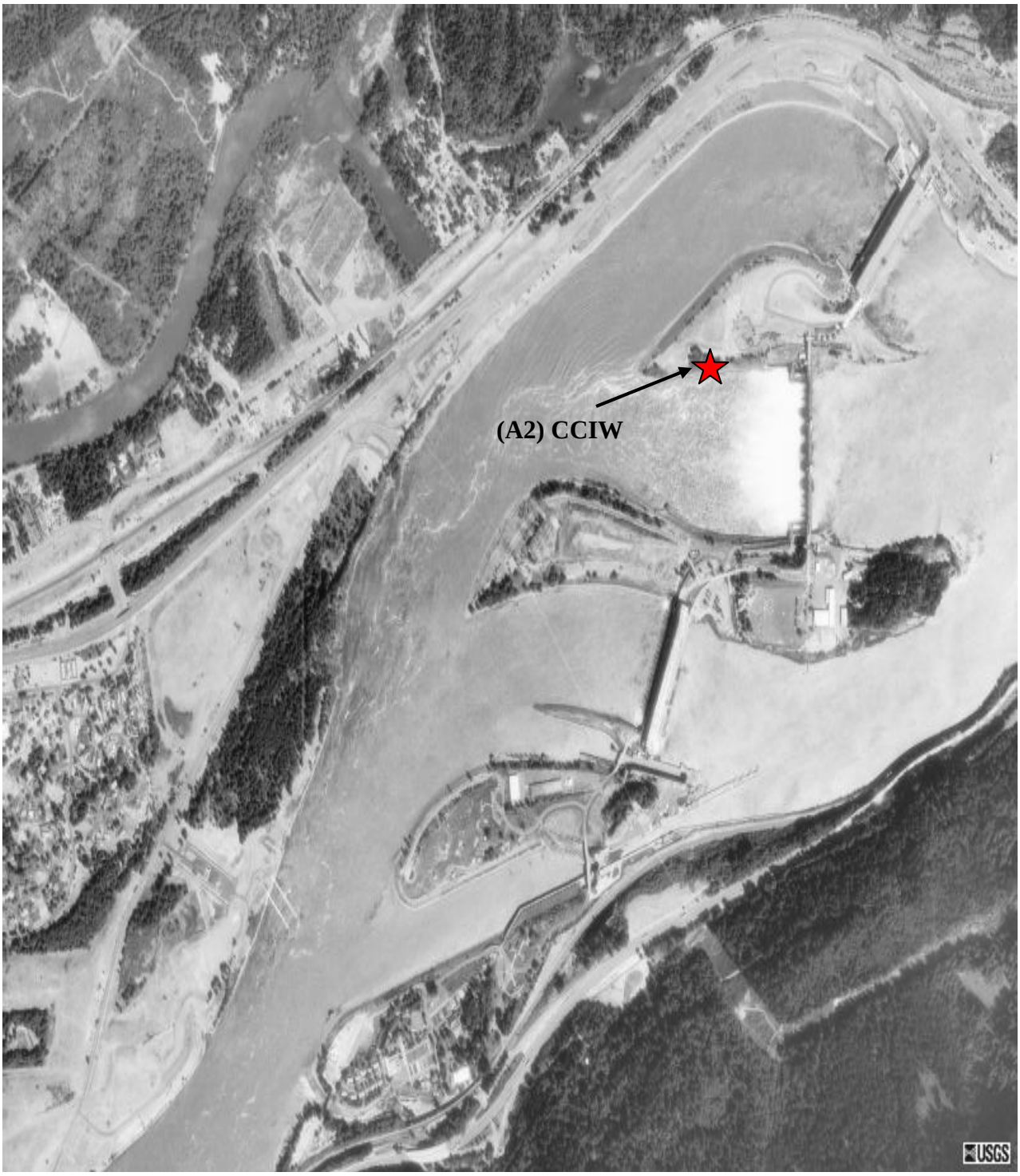

Figure 11: Location of the Cascade Island fixed monitoring site.

A3. Warrendale (WRNO)

River Mile: 140.3
Gauge Elevation: Variable
Distance Off-Shore: _____
Latitude: 45° 36' 29.1" N
Longitude: 122° 02' 19.4" W
Datum: NAD-83
River: Columbia
USGS-ID: 453630122021400
Owner: U.S. Army Corps of Engineers
Gauge Type: Hydrosonde
Data Transmission: GOES Satellite
Dates of Operation: March 1 – 15 May
Years of Operation: 1985 - Present
River Conditions: Mixed River
Parameters Measured: Barometric Pressure, total gas pressure, temperature
Location: Oregon, USA
This gauge is fixed to the Boat dock at "The Fishery" off NE Enquist Pl in Dodson, Oregon (Near Warrendale) approximately 6 miles downstream of Bonneville Dam.

Comment: Up until the 2004 spill season, this gauge was used at the tailwater gauge for Bonneville dam and was operated year round. Currently, this gauge is being used as a fall, winter, and spring TDG monitor only.

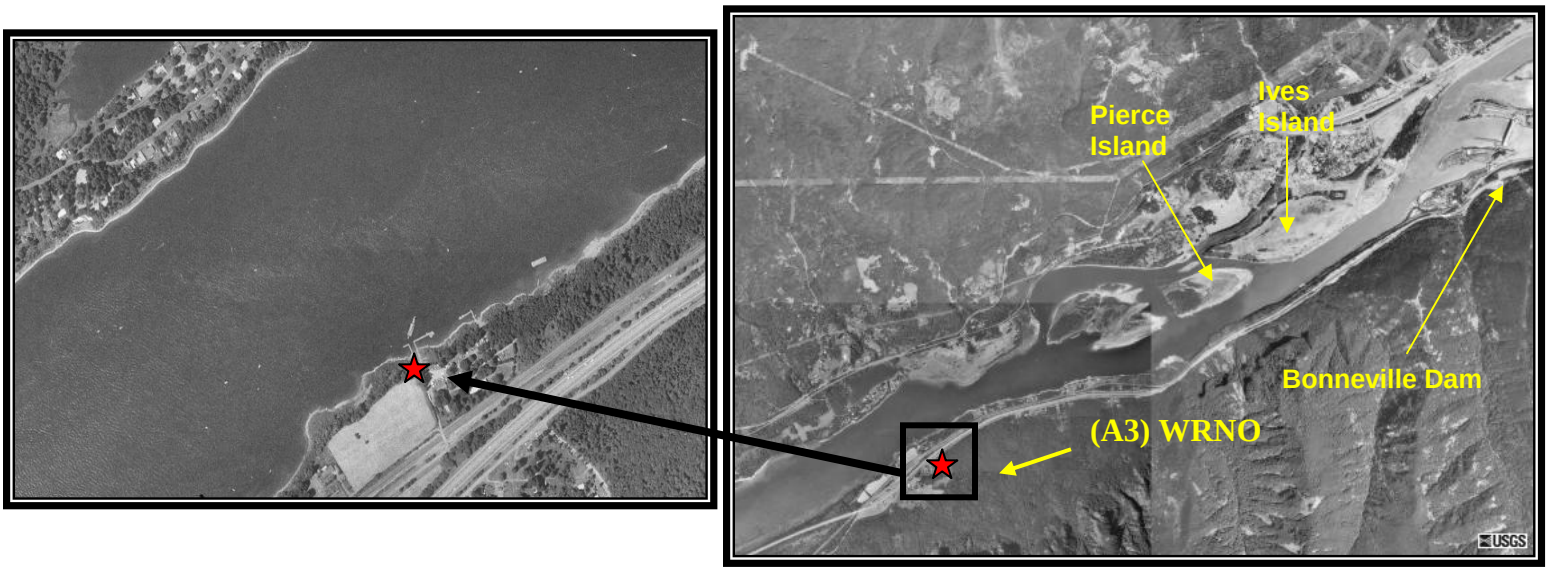

Figure 12: Location of the Warrendale fixed monitoring site, downstream of Bonneville Dam.

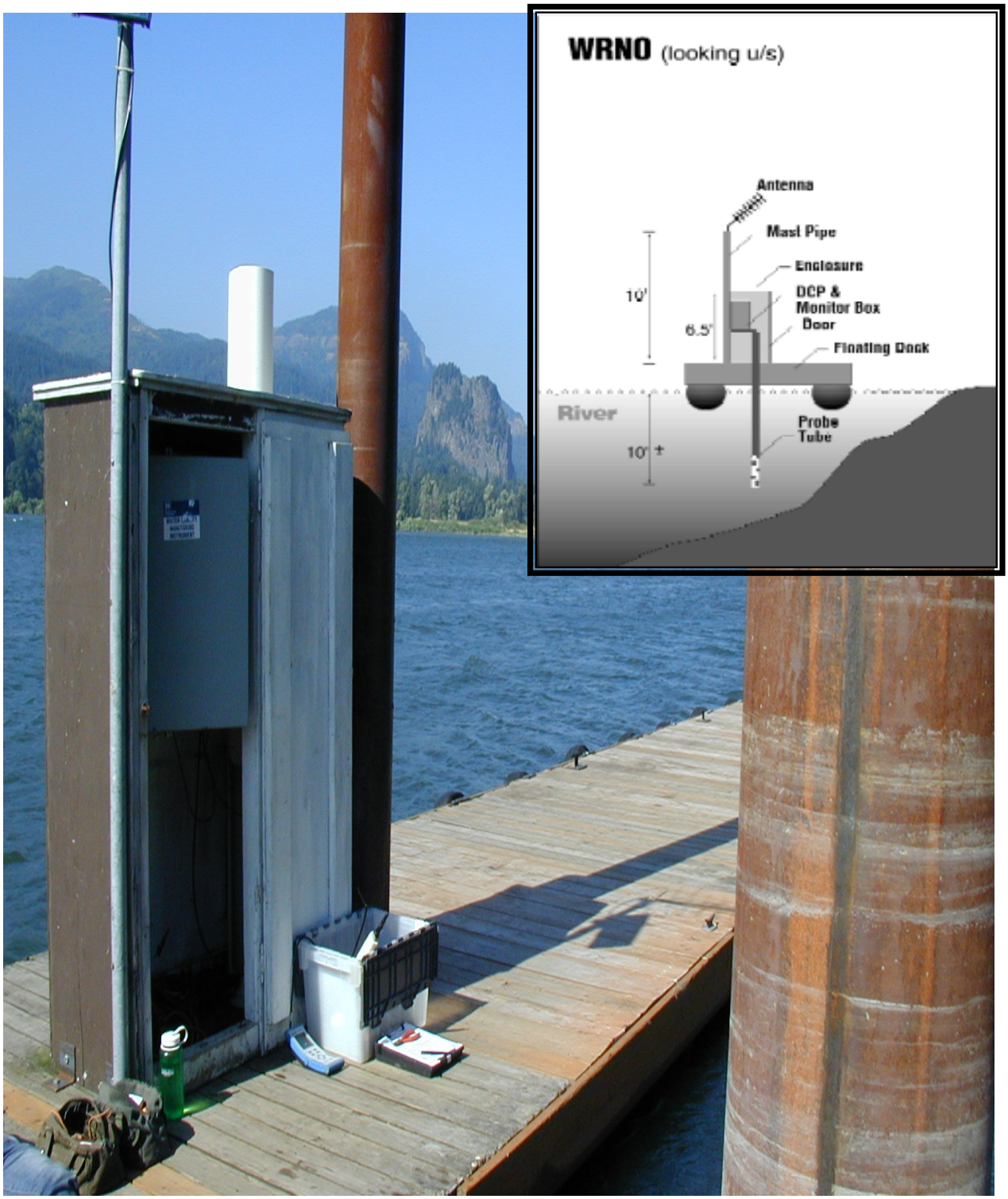

Figure 13: Fixed Monitoring Station at Warrendale.

A4. Camas-Washougal (CWMW)

River Mile: 121.7 miles
Gauge Elevation: variable
Distance Off-Shore: _____
Latitude: 45° 40' 12" N
Longitude: 122° 19' 48" W
Datum: NAD-83
River: Columbia
USGS-ID: 453439122223900
Owner: US Army Corps of Engineers
Gauge Type: Hydrosonde
Data Transmission: GOES Satellite
Dates of Operation: Year Round
Years of Operation: 1993 - Present
River Conditions: Forebay Monitor
Parameters Measured: Barometric Pressure, Total Gas Pressure, and Temperature.
Location: Washington, USA
At the Port of Camas/Washougal (Washington Hwy 14 at S. Second Street, Camas WA). The Camas-Washougal TDG gauge is about 1 mile upstream of the confluence of the Camas-Washougal River. The pulp and paper plant is at the confluences, so the Camas-Washougal gauge is 1 mile upstream of it too. The paper mill is immediately northwest of the confluence.

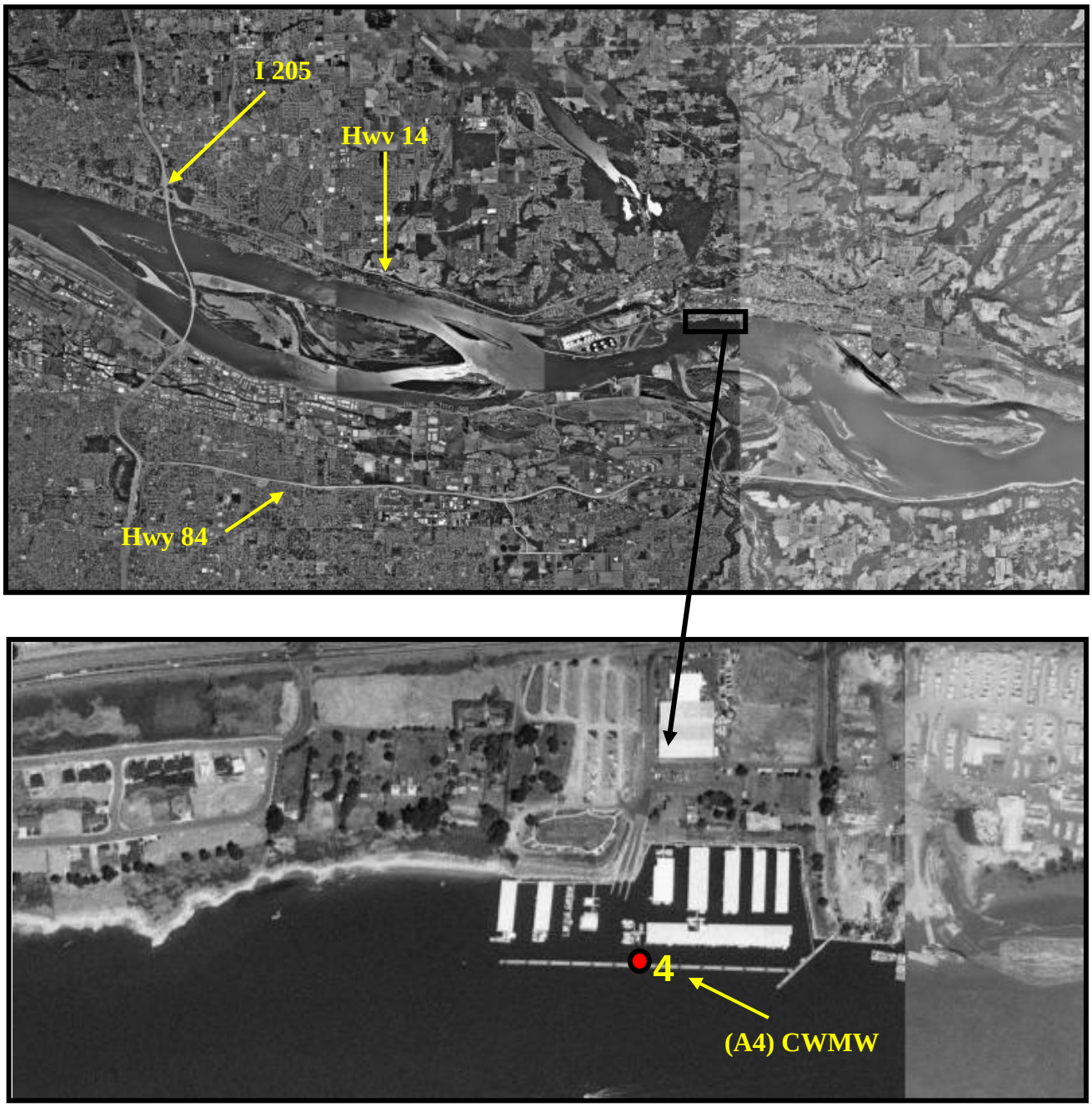

Figure 14: Location of the Camas-Washougal fixed monitoring site.

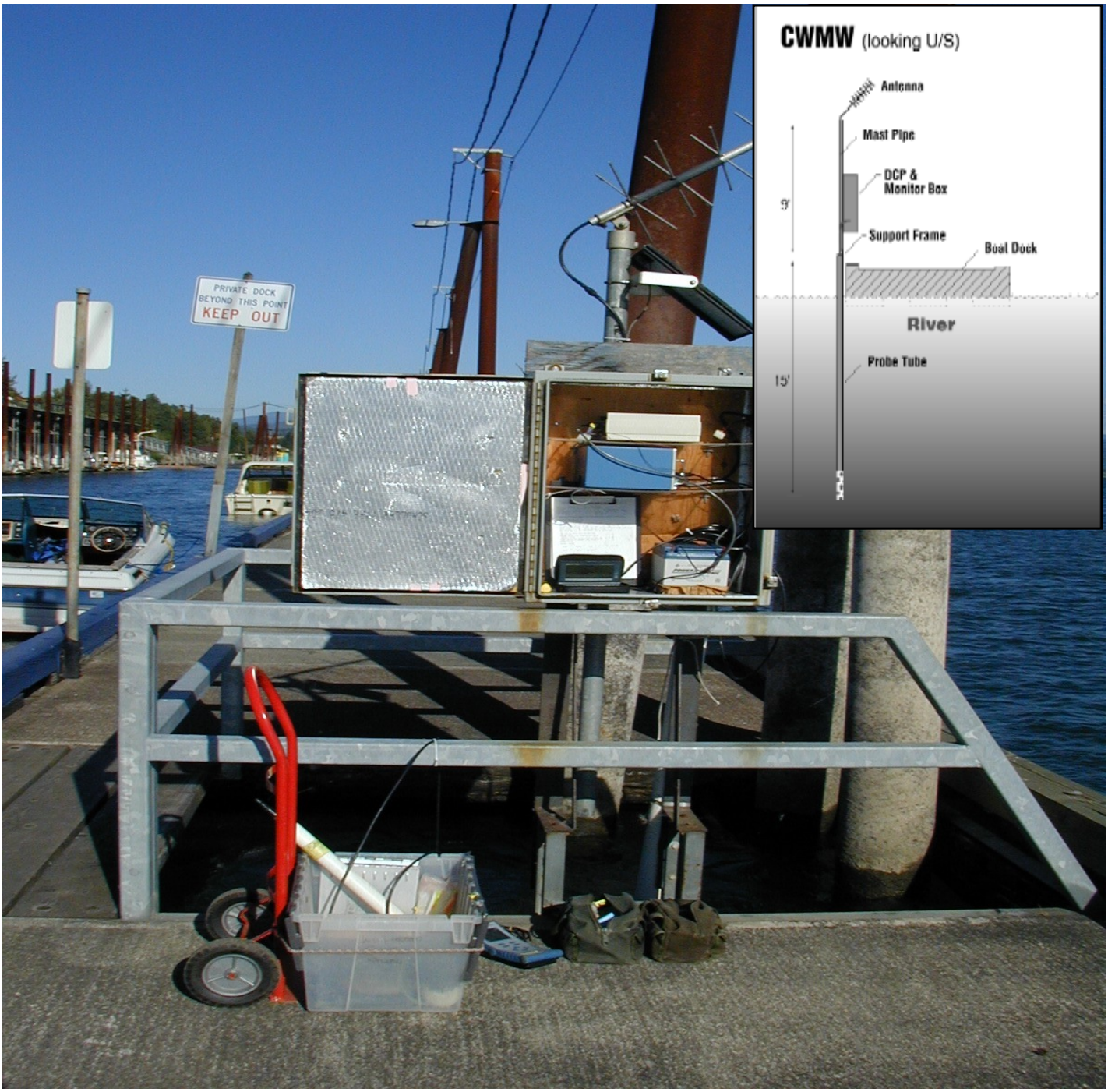

Figure 15: Fixed Monitoring Station at Camas-Washougal.

B) Obsolete Gauges

B1. Kalama (KLAW)

River Mile: 76.9 miles
Gauge Elevation: _____
Distance Off-Shore: _____
Latitude: 45° 15' 0" N
Longitude: 123° 49' 48" W
Datum: NAD-83
River: Columbia
USGS-ID: 455903122500000
Owner: US Army Corps of Engineers
Gauge Type: hydrosonde
Data Transmission: GOES Satellite
Dates of Operation: March - September
Years of Operation: 1993 - 1998
River Conditions: _____
Parameters Measured: Barometric Pressure, Total Dissolved Gas Pressure, and Temperature.
Location: Washington, USA
This gauge is obsolete.

B2. Skamania (SKAW)

River Mile: 140
Gauge Elevation: _____
Distance Off-Shore: _____
Latitude: 45° 36' 51
Longitude: 122° 02' 22
Datum: NAD-83
River: Columbia
USGS-ID: _____
Owner: US Army Corps of Engineers
Gauge Type: Hydrosonde
Data Transmission: GOES Satellite
Dates of Operation: May - September
Years of Operation: 1994 - 2002
River Conditions: _____
Parameters Measured: Barometric Pressure, Total Dissolved Gas Pressure, and Temperature.
Location: Washington, USA
This gauge is obsolete.

B3. Wauna Mill (WANO)

River Mile: 41.9 miles
Gauge Elevation: _____
Distance Off-Shore: _____
Latitude: 46° 30' 0" N
Longitude: 123° 49' 48" W
Datum: NAD-83
River: Columbia
USGS-ID: 460923123235800
Owner: US Army Corps of Engineers
Gauge Type: Hydrosonde
Data Transmission: GOES Satellite
Dates of Operation: 1993 - 1998
Years of Operation: 1993 - 1998
River Conditions: _____
Parameters Measured: Barometric Pressure, Total Dissolved Gas Pressure, and Temperature.
Location: Oregon, USA
This gauge is obsolete.

B4. Corbett (CORB)

River Mile: _____
Gauge Elevation: _____
Distance Off-Shore: _____
Latitude: _____
Longitude: _____
Datum: NAD-83
River: Columbia
USGS-ID: None
Owner: US Army Corps of Engineers
Gauge Type: Hydrosonde
Data Transmission: manually collected
Dates of Operation: _____
Years of Operation: _____
River Conditions: _____
Parameters Measured: Barometric Pressure, Total Dissolved Gas Pressure, and Temperature.
Location: Oregon, USA
This gauge is obsolete and the data resides in either Stew McKinney's computer or one of the contractors computer. We need to get it

Appendix A: Project Schematics

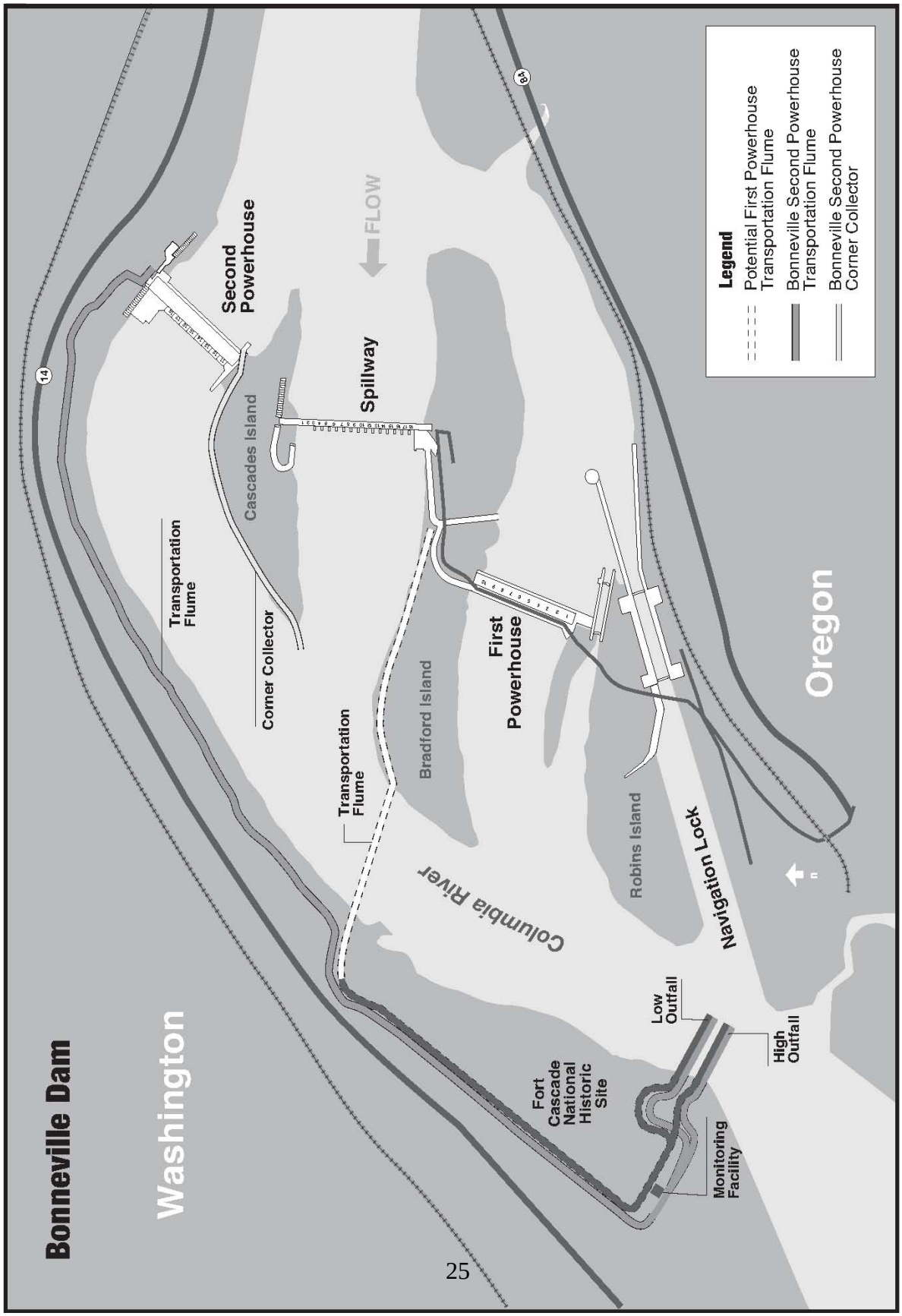

Figure 16: Bonneville juvenile fish passage system

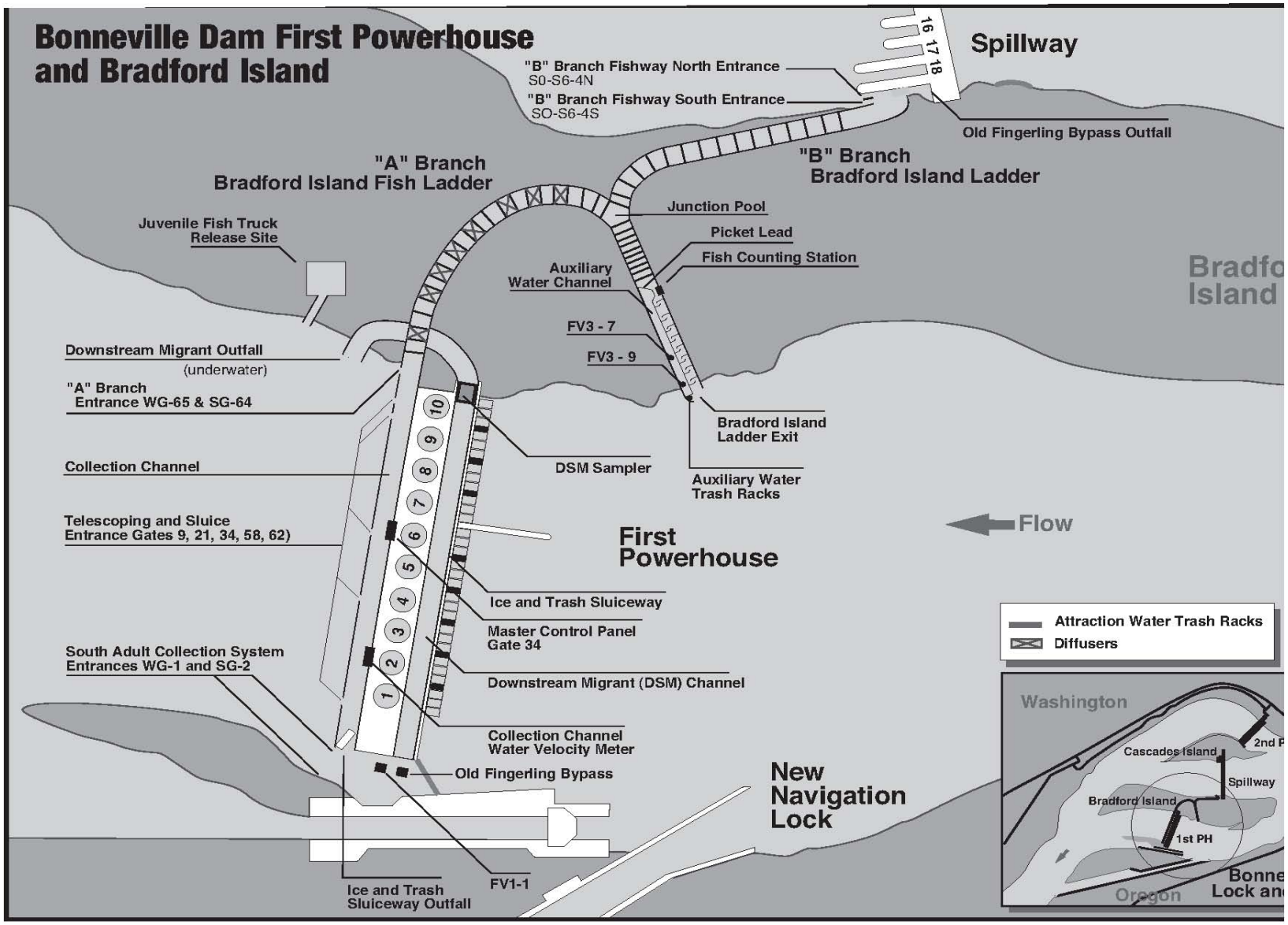

Figure 17: Bonneville Dam first powerhouse and the Bradford Island fish ladder.

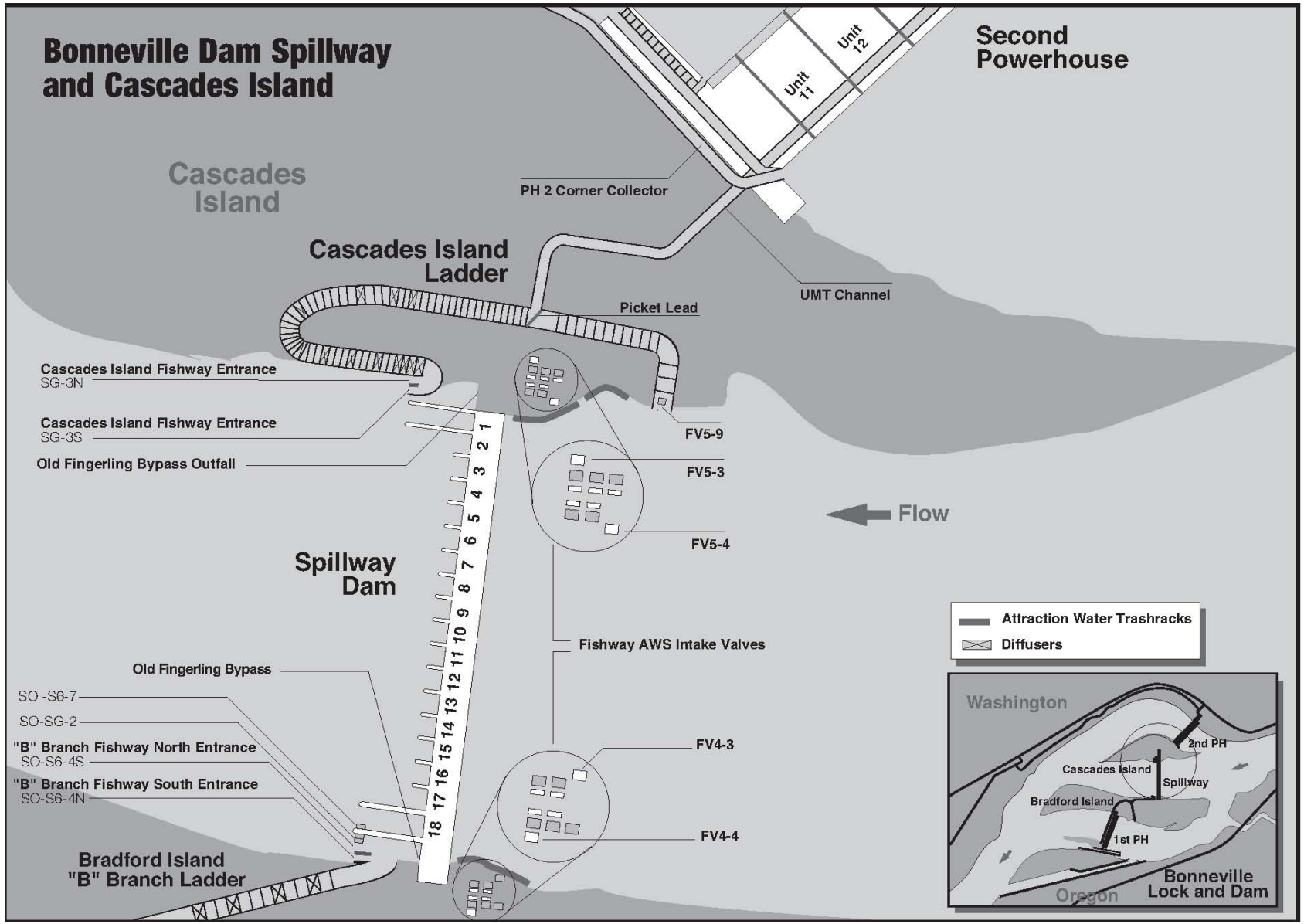

Figure 18: Bonneville Dam spillway, Cascades Island fish ladder, and upstream migrant transportation channel (UMT).

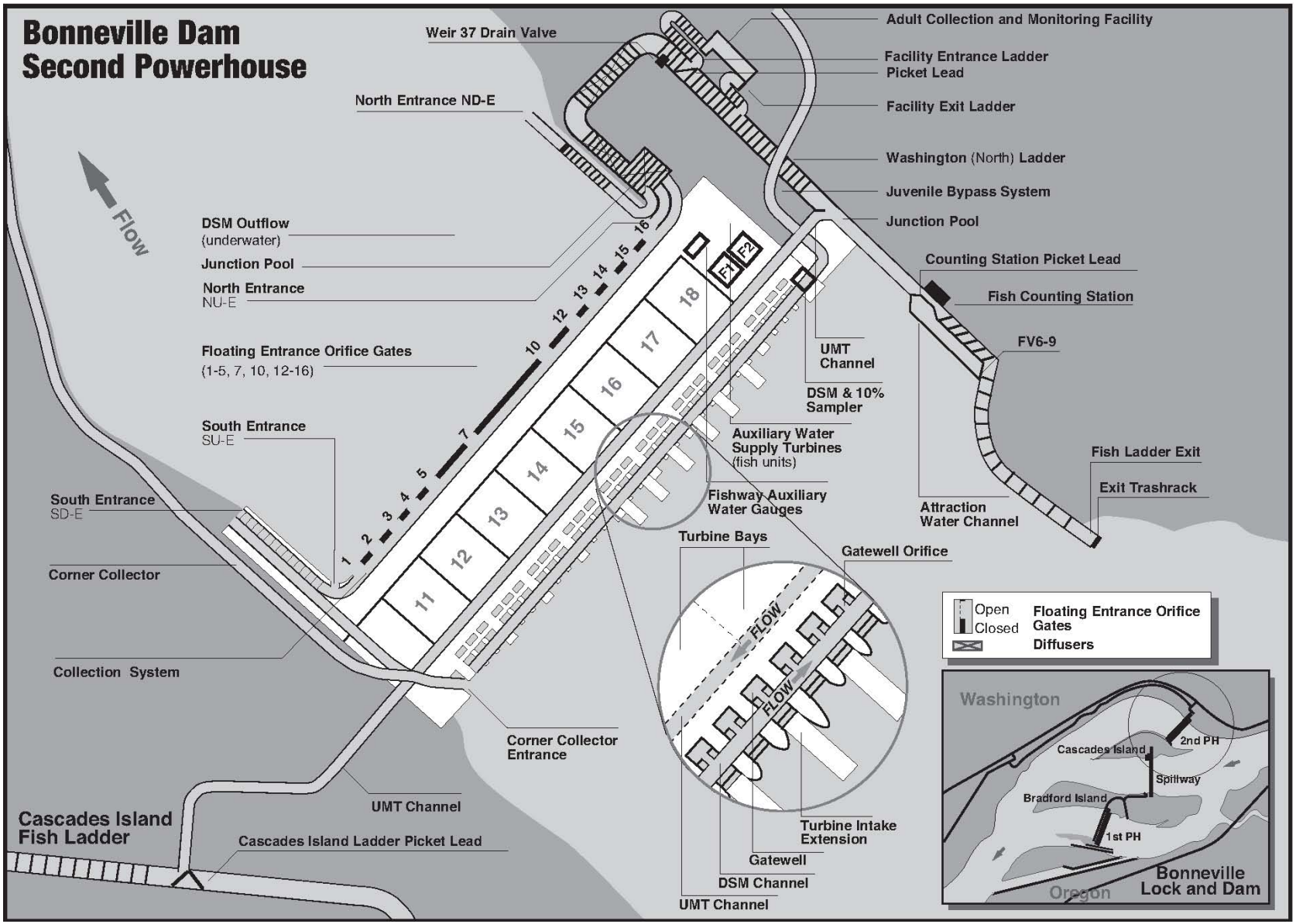

Figure 19: Bonneville Dam second powerhouse and Washington (north) fish ladder.

Appendix B: Notes

The Bonneville Project was authorized for **navigation and hydroelectric power generation.**

Title II of the National Industrial Recovery Act was the vehicle for funding construction of Bonneville Dam. In August 1935, Congress authorized the project under the River and Harbor Act putting it under the regular appropriations process instead of the presidentially-designed emergency funding system. The dam was built by the Corps in accordance with Senate Committee, 73rd Congress, First Session.

In 1971, the Portland District established a position paper called "Operating Restrictions at Bonneville Dam" that discussed operating limits in relation to peaking power, a proposed second powerhouse, the hydrothermal power program and nitrogen. The Portland District has been operating under those criteria, as specified by the U.S. District Court ruling of 17 August 1973 involving the confederated tribes of the Umatilla Indian Reservation vs. Howard Calloway, Secretary of the Army.

(1) Project on free flow 1,420,000 cfs.

(2) Normal operating range will not be exceeded more than 18 days per year.

(3) When inflows are forecasted to exceed 376,000 cfs, maximum forebay will be 75.5 ft until project is on free flow (1,170,000 cfs).

(4) When average weekly inflow is below 125,000 cfs, the minimum instantaneous outflow limit is 70,000 cfs and the minimum daily average discharge limit is 80% of the weekly average inflow.

Appendix C: Glossary

Forebay - The water upstream of / behind the dam.

Tailwater / Tailraise – It is the water surface immediately downstream from a dam or hydroelectric power plant.

Power Plant – It is a place where electricity is generated.

Powerhouse - The part of a hydroelectric dam where the turbine-generators are housed and where power is produced by the action of the water on the turbine blades.

Navigation Lock - A device used for raising and lowering boats between stretches of water of different levels on river and canal waterways.

Stilling Basin - A basin constructed to dissipate the energy of fast-flowing water, eg, from a spillway or bottom outlet, and to protect the river bed from erosion.

Fish Ladder - Structures on or around artificial barriers (such as dams and weirs) built to facilitate diadromous fishes' natural migration. Most fish ladders enable fish to pass around the barriers by swimming and leaping up a series of relatively low steps (hence the term ladder) into the waters on the other side.

Corner Collector – It is a channel through which juvenile fish travel from upstream to downstream.

Behavioral Guidance Structure (BGS) – It is a long steel curtain designed to divert fish (such as salmon and Steelhead) away from the turbines in the powerhouses, and guide them towards the entrance of the Corner Collector.

Ice and Trash Sluiceway (IST) – It is a channel through which debris, such as ice and trash, which has collected in the dam forebay, is released into the tailraise. Juvenile fish also use this outlet to travel downstream during the spring and summer seasons.

Downstream Migration Channel (DSM) – It is a channel used for the passage of juvenile fish from upstream to downstream during the spring and summer seasons. During the winter season, it is used as a fallback passage for adult fish such as Steelhead.

Upstream Migrant Transportation Channel (UMT) – It is a channel used to connect the Cascade Island fish ladder to the Washington shore fish ladder. Adult fishes use these ladders and UMT to travel upstream across the dam.

Spillway - A structure that allows release of excess water from a dam or other hydraulic structure.

Flow Deflector – It is a structure found below the spillway tiers and above the stilling basin of a dam. Its purpose is to deflect off the flow of the spill water at an angle such that the spilling water skims on the surface of the existing water elevation instead of plunging deep into the tailraise. Spill water plunging into the tailraise will increase Total Dissolved Gas (TDG) levels; the deflector serves to reduce the TDG. The flow deflector will not be as effective during high spill periods as the water will spill clear of the deflector.