3.4 Cooling System

The proposed STP 3 & 4 cooling systems, operational modes, and component design parameters were determined from the ABWR DCD, site characteristics, and engineering evaluations. The plant cooling systems and the anticipated cooling system modes of operation are described in Subsection 3.4.1. Design data and performance characteristics for the cooling system components are presented in Subsection 3.4.2. The parameters provided are used to evaluate the impacts to the environment from cooling system operation. The environmental interfaces occur at the river intake and discharge structures, the makeup groundwater wells, the Main Cooling Reservoir (MCR), and Ultimate Heat Sink (UHS) cooling towers. Figure 3.4-1 is a general flow diagram of the cooling water systems for STP 3 & 4.

3.4.1 Description and Operational Modes

Cooling system selection for STP 3 & 4 requires consideration of the total amount of waste heat generated by the facility and the impacts of the waste heat on the environment. Site-specific characteristics are used in combination with the ABWR design parameters to provide an evaluation of the impacts to the STP site from the addition of two ABWR units.

3.4.1.1 Normal Plant Cooling

3.4.1.1.1 Circulating Water System

Each unit will use a Circulating Water System (CWS) to transfer up to approximately 8.656×10^9 Btu/hour (1.732×10^{10} Btu/hour for two units) of waste heat during normal plant operation at full station load. The CWS that will be used for STP 3 & 4 is similar to the CWS of STP 1 & 2. The CWS will use the existing 7000-acre MCR for heat dissipation. The exhaust from the plant's steam turbines will be directed to a surface condenser (i.e., main condenser), where waste heat is transferred to the circulating water. The heated circulating water from the main condenser will be discharged to the MCR, where heat content of the circulating water is transferred to the ambient air via evaporative cooling and conduction. After passing through the MCR, the cooled water will be recirculated back to the main condenser, to complete the closed cycle circulating water loop. Makeup water from the Colorado River will be required to replace evaporative water losses, seepage loss, and blowdown discharge from the MCR.

The CWS for STP 3 & 4 will consist of four pumps per unit that circulate water at a nominal rate of 1,200,000 gpm per unit (2,400,000 gpm for both units). The water will be pumped from the MCR through the main condensers and then back to the MCR via a discharge outfall. Figure 3.1-3 shows the location of the STP 3 & 4 circulating water intake and discharge structures. The circulating water temperature will increase by about 14.3°F after passing through the condenser.

The 7000-acre MCR, shown in Figure 3.1-4, is completely enclosed by approximately 12.4 miles of embankment consisting of clay fill that is constructed above natural ground. The approximate elevation of the embankment base varies from elevation 15 feet MSL to 29 feet MSL (Reference 3.4-1) and the elevation of the top of the

embankment varies between 65.75 and 67.0 feet MSL. The MCR contains approximately 202,700 acre-feet of water when at the normal maximum operating level of elevation 49 feet MSL as reflected in STP 1 & 2 FSAR Figure 2.4.8-7. The 49 foot elevation, which is higher than the present procedure limit of 47 feet, will be necessary to support four-plant operation. The increased water volume is to offset the losses resulting from plant-induced evaporation and blowdown. Reference 3.4-3 shows this elevation to be acceptable. Reference 3.4-1 details the sizing basis for the MCR for STP 1 & 2 operation as well as what was then the projected four units operation. Storage in the reservoir is also required to account for the intermittent operation of makeup from the Colorado River due to permit restrictions.

Thermal performance of the 7000-acre reservoir surface has been examined with the addition of STP 3 & 4. This results in an optimized thermal performance (for a total gross heat rejection rate of 3.457×10^{10} Btu/hour under a plant load factor of 100%, in which 1.725×10^{10} Btu/hour heat rejection is for STP 1 & 2 and 1.732×10^{10} Btu/hour is for STP 3 & 4). The plant intake temperatures are evaluated for plant capacity factors of 100% with four units in operation. Results are discussed in Subsection 3.4.2.

Makeup water to and from the MCR will be diverted from the Colorado River using the existing makeup water system, which includes a shoreline pump intake sized for four units, two buried 108-inch diameter makeup water pipelines, and a discharge outfall. The Reservoir Makeup Pumping Facility (RMPF) was designed for a maximum diversion capacity of 1200 cfs and currently has the screening and pumping capacity installed for 600 cfs. For STP 3 & 4 makeup water needs, new pumps and screens for an additional 600 cfs capacity will be installed at existing designated locations within the RMPF. The overall design capacity for maximum diversion of Colorado River water, therefore, remains at 1200 cfs, and results in no need for an increase in maximum diversion flow due to STP 3 & 4, nor any change in existing permitted conditions.

3.4.1.1.2 Turbine Service Water System

Each unit will have a Turbine Service Water (TSW) System to dissipate up to approximately 2.17×10^8 Btu/hour (4.34×10^8 Btu/hour for two units) of waste heat from the closed loop Turbine Building Cooling Water (TCW) System, during normal plant operation at full station load. The TCW system removes heat from the Turbine Island auxiliary equipment and dissipates heat to the TSW system via the TCW heat exchangers. The TSW system for STP 3 & 4 will consist of pumps that circulate water from the MCR at a nominal rate of 40,486 gpm per unit. The water from the MCR will be pumped through the TCW heat exchangers to dissipate heat to atmosphere. The TSW pumps will be located in the circulating water intake structure. The heated water will be returned to the MCR via the CWS return lines. The temperature rise across the heat exchangers is designed to be approximately 10.8°F.

3.4.1.1.3 Reactor Service Water System

Each unit will also have a safety-related Reactor Service Water (RSW) System to provide cooling water to the Reactor Building Cooling Water (RCW) System heat exchangers located in the control building. The RSW system will be designed in three

mechanically and electrically separated divisions to remove heat from the three divisions of the closed-loop RCW system. The gained heat will be dissipated to atmosphere via the UHS mechanical draft cooling towers during normal, shutdown, and emergency operating modes. The reactor service water will be pumped to the RCW heat exchangers for the removal of heat and the heated water returned to the UHS mechanical draft cooling towers. The cooled water will be collected in the UHS basin for return to the pump suction for recirculation through the system. Tables 3.4-1 and 3.4-2 provide nominal reactor service water flows and heat loads in different operating modes for the RSW System.

3.4.1.2 Ultimate Heat Sink

~~The UHS water storage basin is a Seismic Category I cylindrical concrete structure (350 foot internal diameter and 56 foot tall with 5 foot thick wall) built partially below grade. The UHS basin is split by a 4 foot thick divider wall into two symmetric compartments, one compartment dedicated to each unit.~~The UHS water storage basins are Seismic Category I rectangular reinforced concrete structures (280 ft by 132 ft inner dimensions and 83.5 ft tall with 6 ft thick walls) built partially below grade. Each ~~compartment at the~~UHS basin's minimum level holds approximately ~~12,020,000~~16,199,496 gallons of water to meet the unit cooling needs for 30 days operation following a design basis accident with no makeup water and without exceeding the design basis temperature and chemistry limits. ~~A space of 14 acres has been designated to accommodate this structure.~~

The RSW pump house is contiguous with the UHS water storage basin and houses the RSW pumps and associated piping and valves. The cooling towers are contiguous with the UHS structure. Each unit has a counterflow mechanically induced draft cooling tower with six cooling tower cells, of which two cells are dedicated to each of the three RSW divisions. During normal plant operation, all three divisions are in operation utilizing one cooling tower cell per division. When the heat load is increased during cooldown, shutdown or accident, all cooling tower cells are in operation. The cooling tower internals are protected from the effects of tornado generated missiles. The RSW supply and return lines are routed through ~~tunnels~~a tunnel with divisional separation. Cold weather bypass lines are provided for each RSW return line to allow bypassing the cooling tower dedicated cells when the outside temperature is low and cooling tower operation is not required. The heated water from the RSW return line is discharged directly into the UHS water storage basin ~~below~~above the water surface~~ through pipe orifices.~~.

Each unit's evaporation water loss is expected to be about ~~240~~283 gpm during normal conditions and ~~1010~~1061 gpm (maximum) during shutdown conditions. The blowdown flow from the UHS towers will be discharged to the MCR. Makeup water to the UHS cooling towers will be supplied from site groundwater wells, with backup from the MCR at a maximum flow rate of approximately ~~3030~~3,203 gpm (two units) to accommodate a maximum of approximately ~~1010~~1602 gpm-per-unit evaporation rate, approximately ~~500~~529 gpm per-unit blowdown rate, and a drift loss of approximately ~~4~~5 gpm (for both units) for STP 3 & 4 for the UHS cooling tower. Maximum UHS blowdown and makeup rates are based on maintaining three cycles of concentration in the cooling tower.

3.4.1.3 Other Operational Modes

3.4.1.3.1 Station Load Factor

The ABWR units are assumed to operate with a maximum capacity factor of 93% (annualized, the current industry average), taking into consideration scheduled outages and other plant maintenance. For the site, on a long-term basis, an average heat load of approximately 1.61×10^{10} Btu/hour (i.e., 93% of the maximum rated heat load of 1.732×10^{10} Btu/hour) will be dissipated to the atmosphere.

3.4.1.3.2 River Water Temperature

Since STP 1 & 2 began operation, ice blockage that could render the makeup water system inoperable has not occurred. A review of historical air temperature data indicates that the climate in the vicinity of the site is temperate. There is also no record of ice effects. Recorded surface water temperatures at representative Lower Colorado River Authority (LCRA) stations have always been above the freezing point. Thus, it is concluded that there is no risk of ice formation at the river intake system (the RMPF), and deicing controls are not necessary.

3.4.1.3.3 Minimum Operating Water Level

Both RMPF and MCR are not safety-related facilities, nor do they perform any safety-related functions. Plant safe shutdown will not depend on minimum water level in the MCR nor the ability to pump river water to the MCR using the RMPF. Reference 3.4-1 details the minimum operating level at the RMPF. The low-water level is at elevation 0 feet MSL, which corresponds to slack tide conditions since the Colorado River is under estuary and tidal influence that can extend to the river intake location. The design minimum operating level at the RMPF is 1.0 foot below MSL. For STP 3 & 4, this design minimum operating water level for RMPF remains the same since the facility, as designed, will be used and no change to design capacity is required.

The minimum operating level for the MCR is established at 25.5 feet MSL, as described in Reference 3.4-1. The operating requirements are that the power plant will be shut down if and when the reservoir water level drops below elevation 25.5 feet MSL. For STP 3 & 4, this design minimum operating level remains the same.

3.4.1.3.4 Biofouling Treatment

UHS tower makeup water will be obtained primarily from onsite well water to replenish the evaporative, blowdown, and drift losses, with backup water supply from the MCR. While pretreatment of the well water makeup will not be required, the biofouling treatment will be required if the backup water from the MCR is required. In addition, chemical addition to the UHS water will be required to ensure that the fill in the cooling tower remains free of organic deposits.

3.4.2 Component Descriptions

The design data of the cooling system components and their performance characteristics during the anticipated system operation modes is described in this section. Site-specific estimates are used as the basis for discussion.

3.4.2.1 Reservoir Makeup Pumping Facility

The RMPF provides makeup water for the MCR. The impact of STP 3 & 4 is discussed in the circulating water section. The RMPF will function as originally described for STP 1 & 2 (Reference 3.4-1).

The RMPF is required to divert water from the Colorado River into the MCR to makeup for water lost due to station operation, including evaporation, blowdown, and seepage. The system consists of a traveling screen intake structure, siltation basin, a sharp-crested weir, and a 1200 cfs capacity pump station. The screen intake structure consists of coarse trash racks, stop log guides, and multiple sets of traveling water screens. Currently, only trash racks and screens for one half of the intake structure are installed. To support STP 3 & 4, trash racks and screens for the other half of the intake structure will be installed.

After passing through the intake structure screens, water passes through a common siltation basin to settle out coarse and fine sediment that could enter the intake from the Colorado River. Regular maintenance dredging is required to keep the siltation basin, intake structure and pump station operating at optimum. Dredging from the siltation basin will be disposed of on site in the vicinity of the RMPF in accordance with existing permit requirements.

The sharp-crested weir, 210 feet long, is located between the screen intake structure and the pump station. The crest elevation is set at 2.2 feet below MSL, which restricts inflow to the upper strata of river flow to ensure the best available quality of intake water.

The pumping station currently has two pumps of 240 cfs capacity and two of 60 cfs capacity installed and operational, totaling a capacity of 600 cfs, i.e., half of the design capacity of 1200 cfs. To support STP 3 & 4 operation, it will be necessary to complete the installation of pumps.

3.4.2.2 Final Plant Discharge

The MCR discharge is through the existing blowdown facility at the Colorado River downstream of the RMPF. Water is discharged from the MCR through the blowdown facility only when required in order to limit the total dissolved solids concentration buildup in the reservoir. As described in Reference 3.4-1, the blowdown facilities are designed to operate using variable discharge rates ranging from 80 cfs to 308 cfs. Blowdown will be allowed only when the MCR water level is between 40 and 49 feet MSL. The existing Texas Pollutant Discharge Elimination System (TPDES) permit (Reference 3.4-4) states that the MCR can discharge water to the Colorado River at rates that depend on the river flow and season up to a maximum of 200 million gallons per day (MGD). For combined four-unit operation, blowdown operation may be

required at certain points in time. As such the existing blowdown facility design and operational philosophy will not change as a result of STP 3 & 4.

3.4.2.3 MCR CWS Intake Structure and Discharge Outfall

The CWS intake structure for STP 3 & 4 will be located south of the STP 1 & 2 CWS intake, on an existing MCR dike that will be modified. Figure 3.4-2 shows the plan and section view of the CWS pump intake structure. The intake structure will accommodate eight vertical pumps, each rated at 300,000 gpm, with a total circulating water capacity for two units of 2,400,000 gpm. There will be three dual flow screens and multiple trash racks serving each pump. The pump intake will also accommodate three 50% capacity turbine service water pumps per unit, which share pump bays with circulating water pumps. Traveling screens will be cleaned of debris via high-pressure spray water jets supplied by the screen wash pumps, also sharing the CWS pump bays. Trash racks will be cleaned by a set of automatic raking systems per unit. The intake structure will be designed to allow continuous pump operation until MCR water level drops below 25.5 feet MSL, a design low water level condition.

The CWS discharge outfall for STP 3 & 4 is located approximately 1000 feet west of the existing STP 1 & 2 discharge structure. The outfall for STP 3 & 4 is designed to accommodate a total flow of 2,400,000 gpm. There will be six 11-foot-diameter circulating water pipes entering the discharge outfall. Due to the configuration of circulating water pipes passing over the embankment, an overflow weir with a weir crest elevation 34.5 feet MSL will be installed inside the discharge outfall in order to maintain proper siphon when the MCR water level drops toward low water level. Downstream of the discharge outfall, riprap placement will be provided to prevent erosion. Figure 3.4-3 shows the design of the discharge outfall at the MCR.

3.4.2.4 Heat Dissipation System

The 7000-acre MCR is the heat sink for the CWS. The heated circulating water from the main condenser will be discharged to the MCR, where heat content of the circulating water is transferred to the ambient air via evaporative cooling and conduction. After passing through the MCR, the cooled water is recirculated back to the main condenser, to complete the closed cycle circulating water loop. The MCR is not a safety-related structure.

The embankment surrounding the MCR is constructed of compacted clay fill. The embankment has an exterior slope of 3:1 H:V and an interior slope of 2.5:1 H:V on the reservoir side. The top of embankment varies from elevation 65.75 feet MSL to 67.0 feet MSL (Reference 3.4-3). To prevent the possibility of bypass of the cooling process and to promote surface heat transfer by maximizing effective surface cooling areas, an interior dike was constructed of compacted clay fill with 2.5:1 H:V side slopes on both sides.

The normal maximum operating level of the MCR is elevation 49 feet MSL. The elevation of the reservoir bottom varies from a minimum elevation of 15 feet MSL at the south end to a maximum elevation of 29 feet MSL at the north end. This results in a

maximum anticipated reservoir water depth of 37.1 feet. The anticipated minimum reservoir operating level is elevation 28.5 feet MSL.

The average monthly temperature predicted at the intake and discharge structures in the MCR for combined four unit operation for the three years of 2003-2005 (based on historical data) is presented in Table 3.4-3. The design intake temperature for STP 3 & 4 is 100°F.

Blowdown was last used in 1997. The capability is to be retained, as the addition of the heat load from STP 3 & 4 may require this operation. No changes to the design of the blowdown system are required due to the addition of STP 3 & 4.

3.4.3 References

3.4-1 South Texas Project Units 1 and 2 Environmental Report, Section 3.4, Cooling Systems, Amendment 8, September 22, 1975.

3.4-2 Lower Colorado Regional Water Planning Group, Region “K” Water Plan for the Lower Colorado Regional Water Planning Group, 2006.

3.4-3 STP 1 & 2 FSAR Section 2.4.8, Revision 13; “Embankments and Dams,” Section 2.5.6.

3.4-4 Texas Commission on Environmental Quality, Permit to Discharge Wastes under Provisions of Section 402 of the Clean Water Act and Chapter 26 of the Texas Water Code-Texas Pollutant Discharge Elimination System (TPDES) Permit No. WQ0001908000, Austin, Texas, July 21, 2005.

Table 3.4-1 RSW System Flow Rates per Division

Operating Mode	RSW Flow (gpm)	No. of pumps in operation	No. of heat exchangers in operation	Flow through each heat exchanger (gpm)
Normal	14265	1	2	7133
Reactor Shutdown, 4 Hours	21400	2	3	7133
Reactor Shutdown, 24 Hours	21400	2	3	7133
Hot Standby	21400	2	3	7133
Hot Standby LOOP	21400	2	3	7133
LOCA	21400	2	3	7133

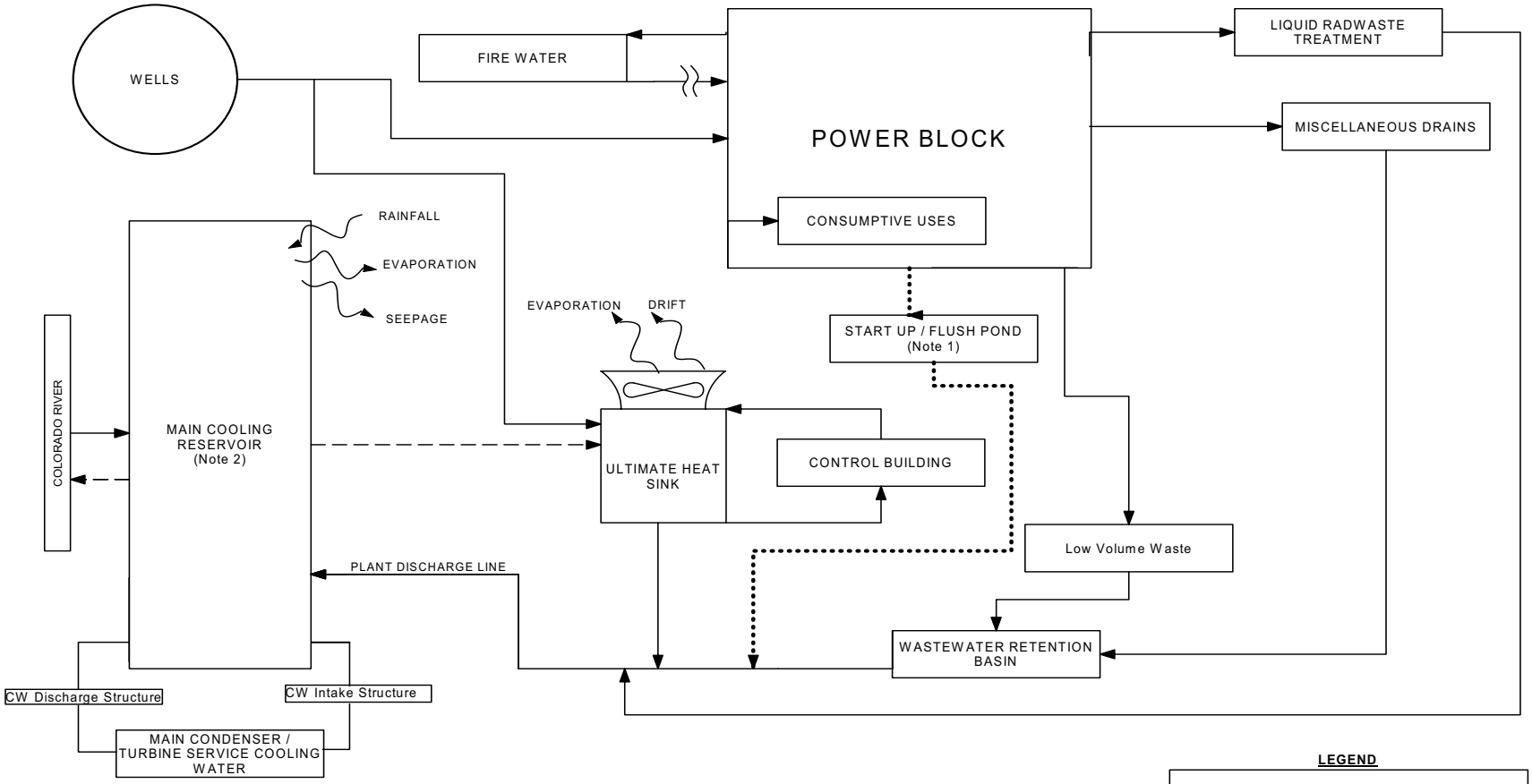
Table 3.4-2 RCW/RSW System Heat Loads

Operating Mode	Division A (Btu/h)	Division B (Btu/h)	Division C (Btu/h)
Normal	3.7E07	4E07	2.5E07
Shutdown 4, hours	1.2E08	1.2E08	1.3E08
Shutdown, 20 hours	5.1E07	5.2E07	4.6E07
Hot Standby	3.7E07	3.8E07	2.5E07
Hot Standby LOOP	7.1E07	7.3E07	4.4E07
LOCA	1.1E08	1.1E08	1.05E08

Table 3.4-3
Average Predicted Monthly MCR Temperature for 2003–2005
(Based on 4-Unit Operation)

	CWS Intake Average Monthly Temperature (^oF)		
	Year		
Month	2003	2004	2005
Jan	70.00	71.3	71.7
Feb	70.82	69.9	72.0
Mar	75.38	78.1	76.7
Apr	80.51	81.8	81.0
May	88.17	85.9	85.8
Jun	93.57	92.2	92.2
Jul	95.88	95.0	94.4
Aug	95.23	94.0	95.0
Sep	91.67	91.8	92.8
Oct	85.80	87.4	85.3
Nov	79.99	78.8	78.7
Dec	71.62	71.3	68.1

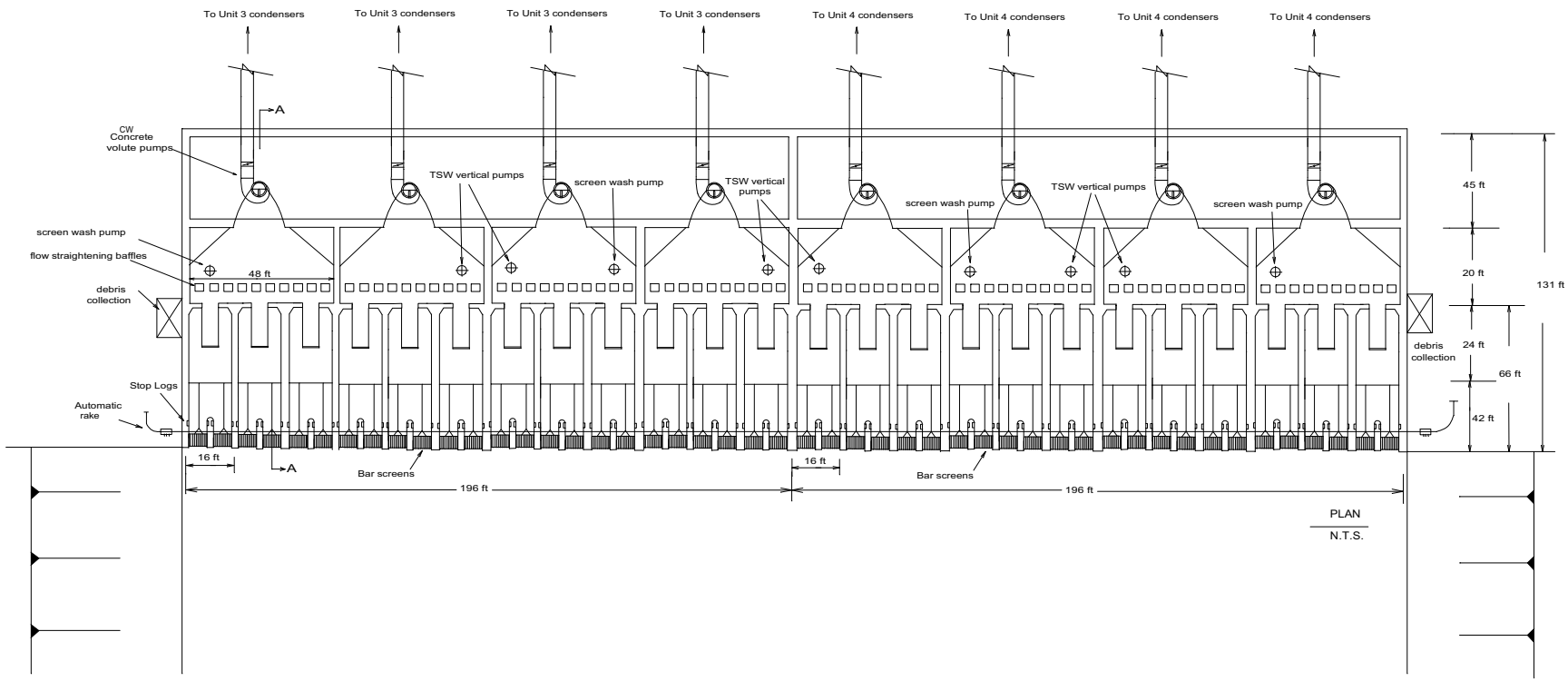
	CWS Discharge Average Monthly Temperature (^oF)		
	Year		
Month	2003	2004	2005
Jan	88.4	89.7	90.0
Feb	89.2	88.3	90.4
Mar	93.7	96.5	95.1
Apr	97.4	98.7	97.9
May	104.6	102.3	102.2
Jun	110.0	108.6	108.6
Jul	112.3	111.4	110.8
Aug	111.6	110.4	111.4
Sep	108.1	108.1	109.2
Oct	103.3	104.9	102.8
Nov	98.3	97.1	97.0
Dec	90.0	89.7	86.4



Notes:

1. Start up cleaning / flushing waste flows are intermittent and will be treated on-site for discharge
2. The main cooling reservoir apart from the above flows, is also used by STP 1 & 2 water systems
3. This diagram represents two units.
4. This diagram is used to illustrate cooling systems flow paths and is not representative of the final piping configuration

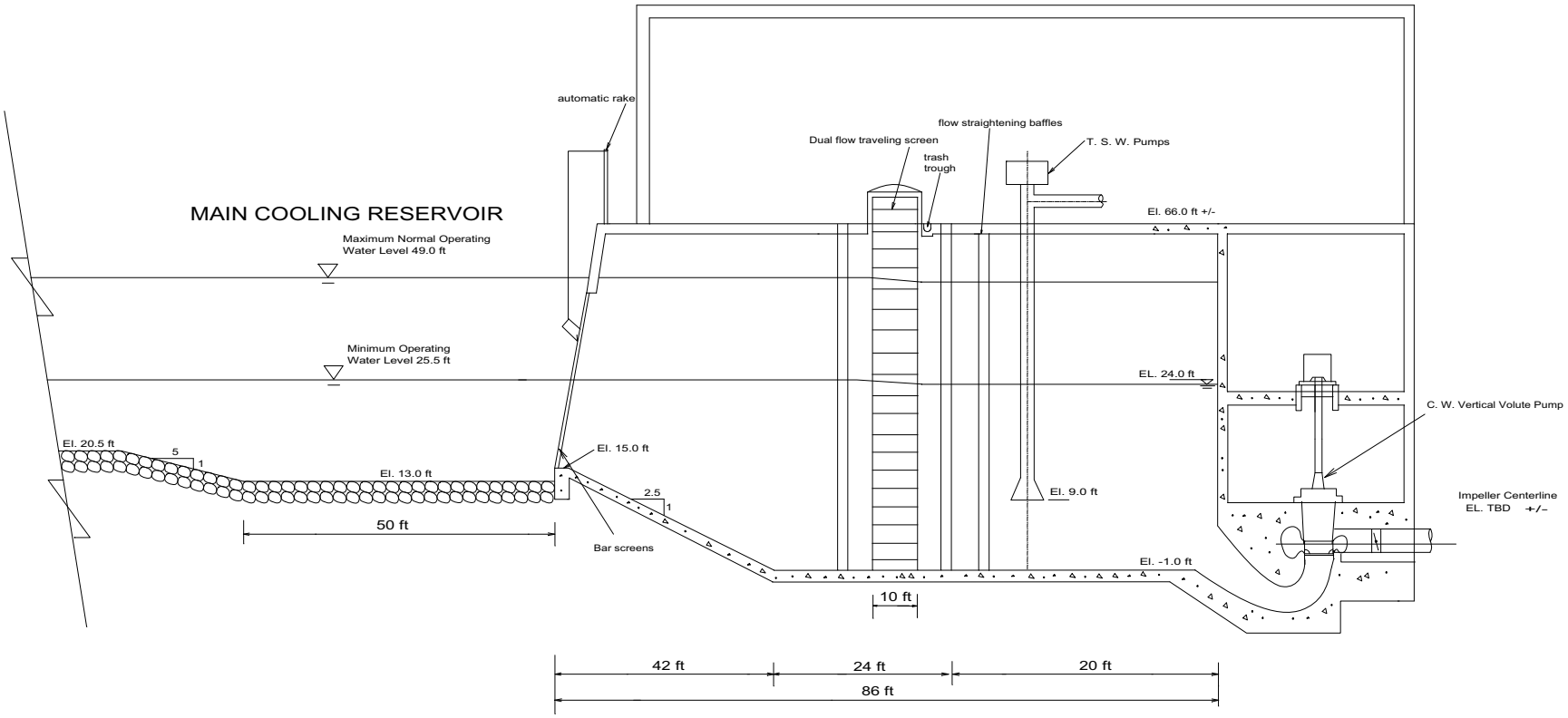
Figure 3.4-1 STP 3 & 4 Cooling Water Flow Diagram



NOTES:

1. Four 25% Circulating Water Concrete Volute Pumps per Unit
2. Total flow 1,200,000 gpm per Unit
3. Three 10 ft basket length dual flow traveling screens per CW pump
4. The face velocity at each dual flow screen is within the design basis limits
5. 2-100% capacity screen wash pumps per unit

Figure 3.4-2 Sheet 1, STP 3 & 4 CWS Intake Structure



Notes:

1. Pump intake model test is required to verify this design.

SECTION A-A

(N.T.S)

Figure 3.4-2 Sheet 2, STP 3 & 4 CWS Intake Structure

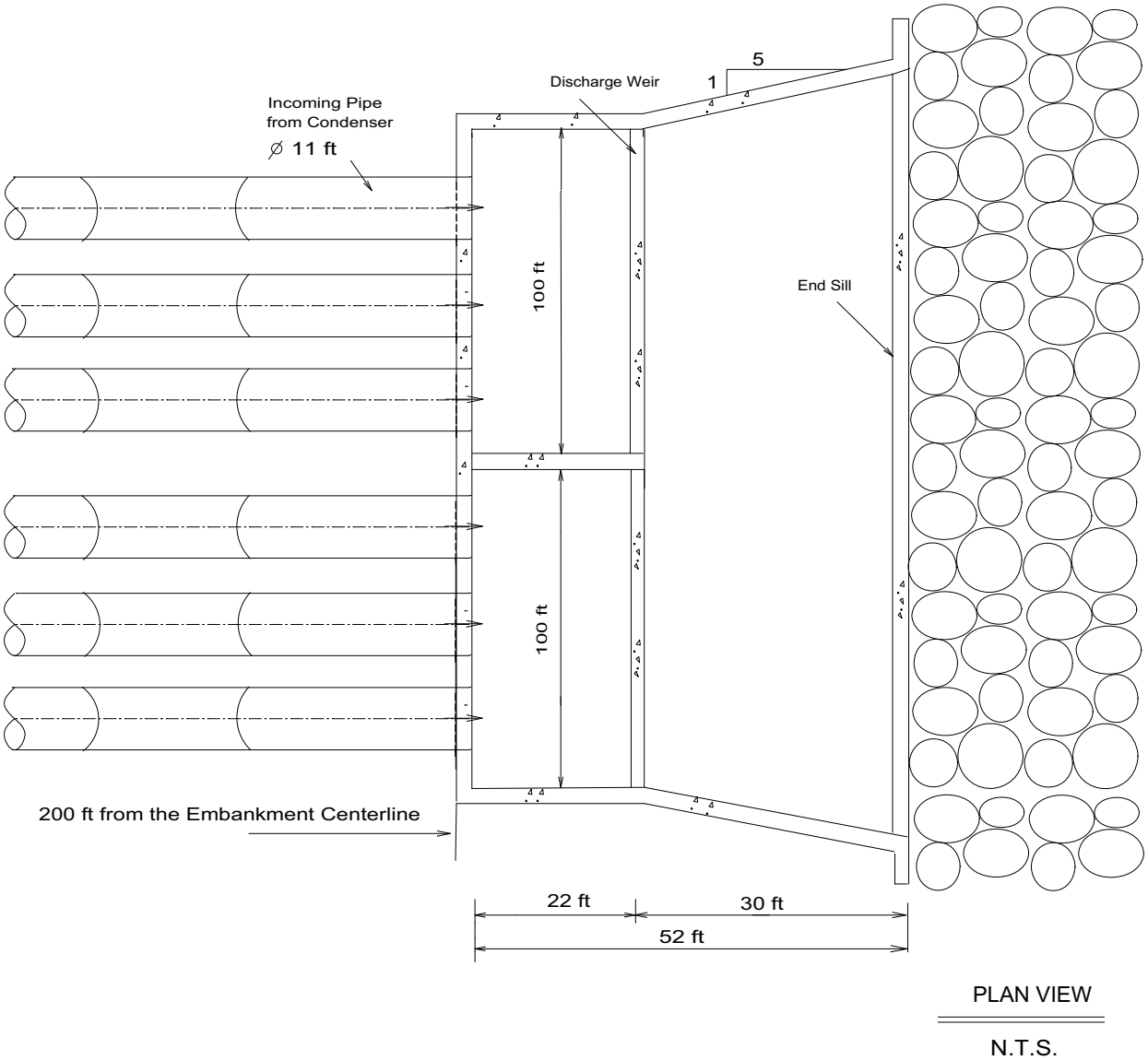


Figure 3.4-3 Sheet 1, STP 3 & 4 CWS Discharge Structure

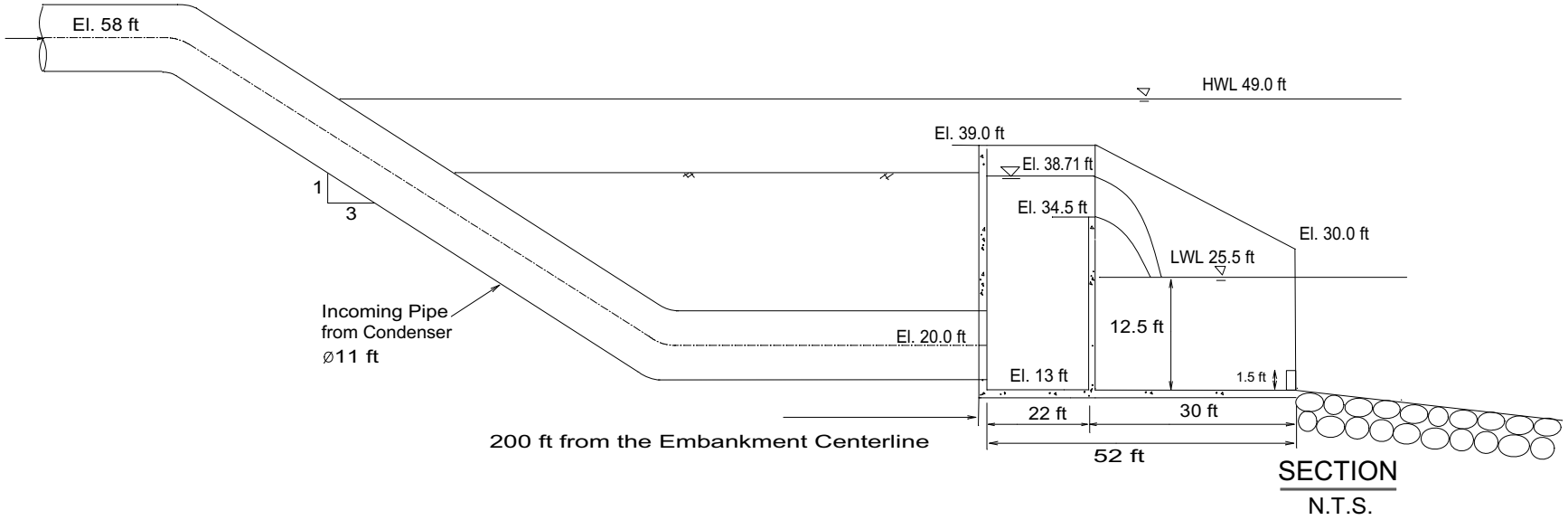


Figure 3.4-3 Sheet 2, STP 3 & 4 CWS Discharge Structure

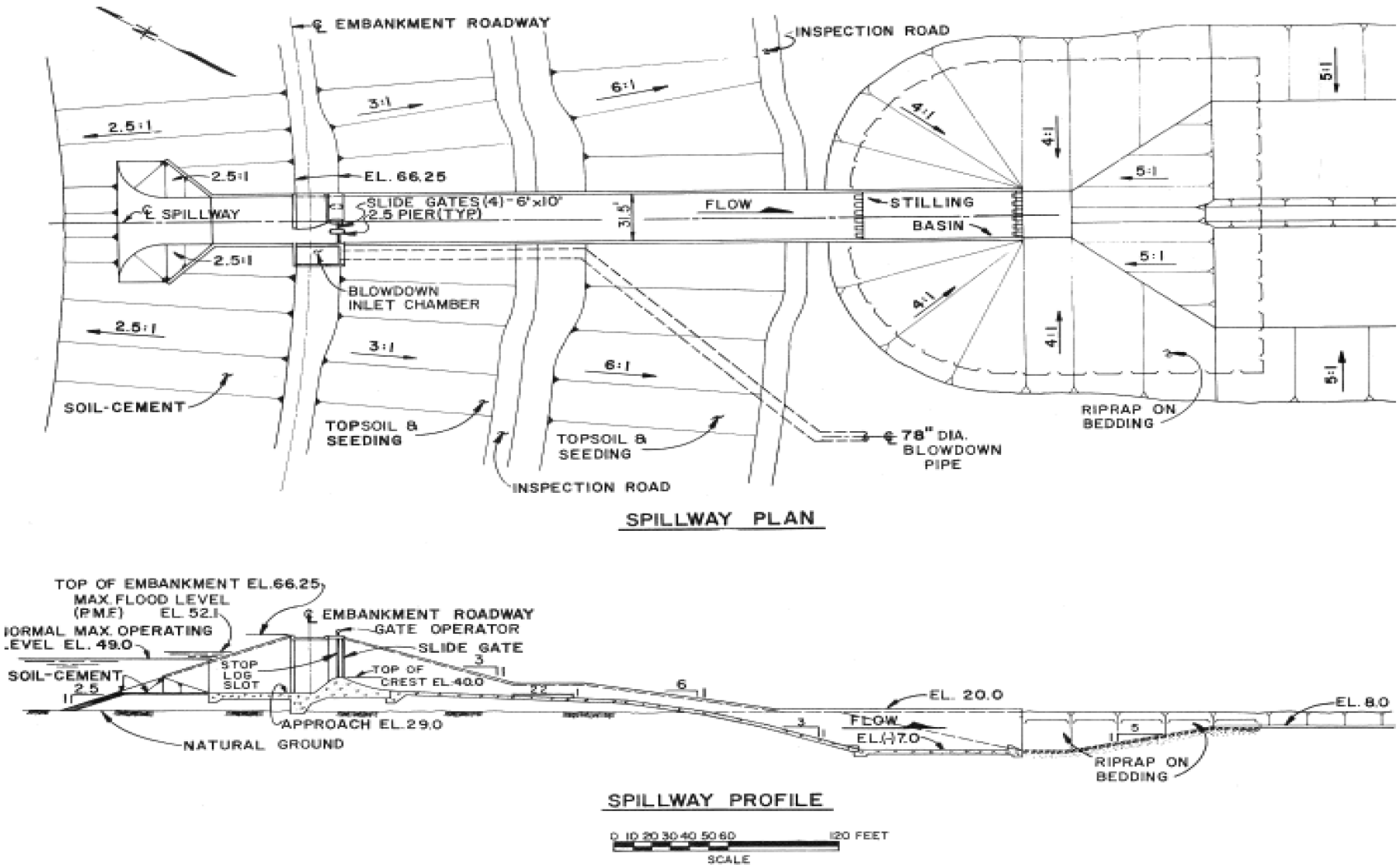


Figure 3.4-4 Sheet 1, STP 3 & 4 Spillway Structure

Source: Reference 3.4-1

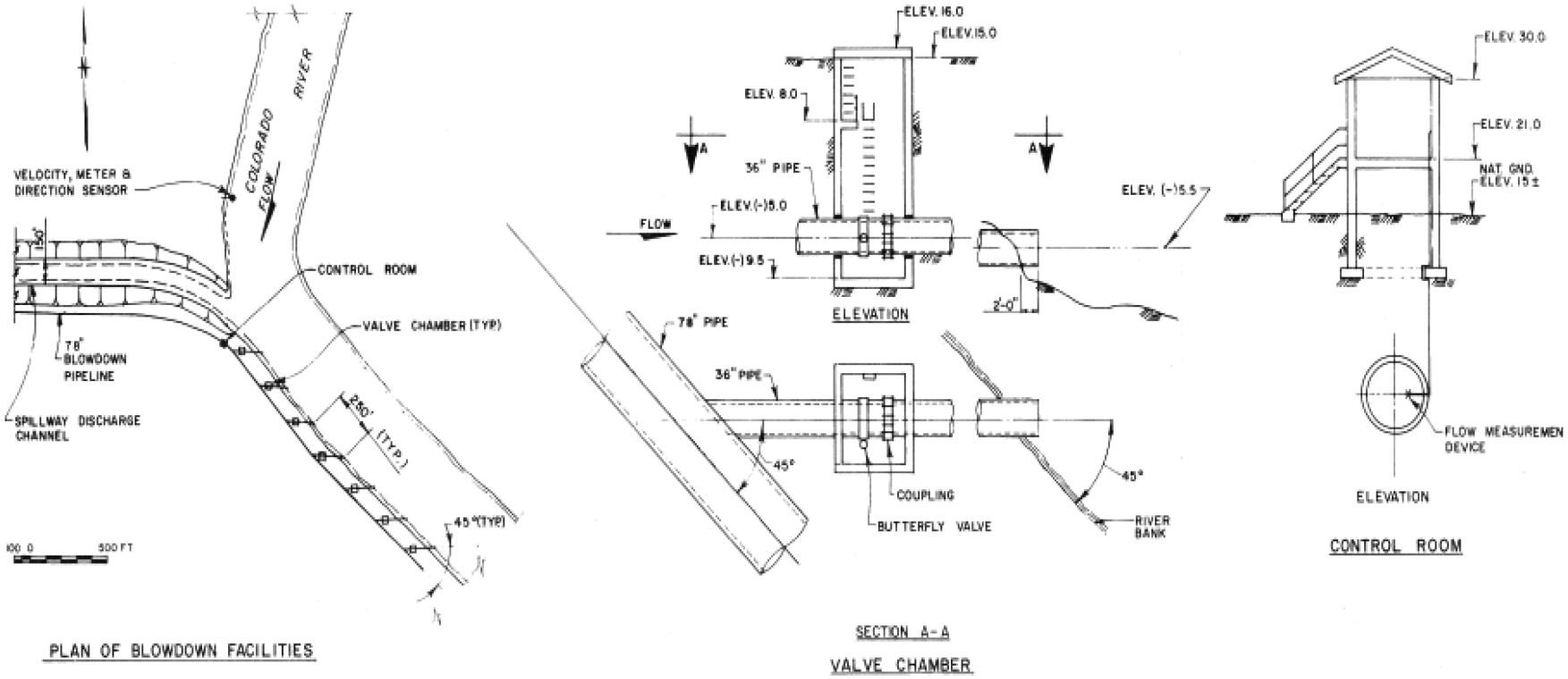


Figure 3.4-4 Sheet 2, STP 3 & 4 Blowdown Structure

Source: Reference 3.4-1

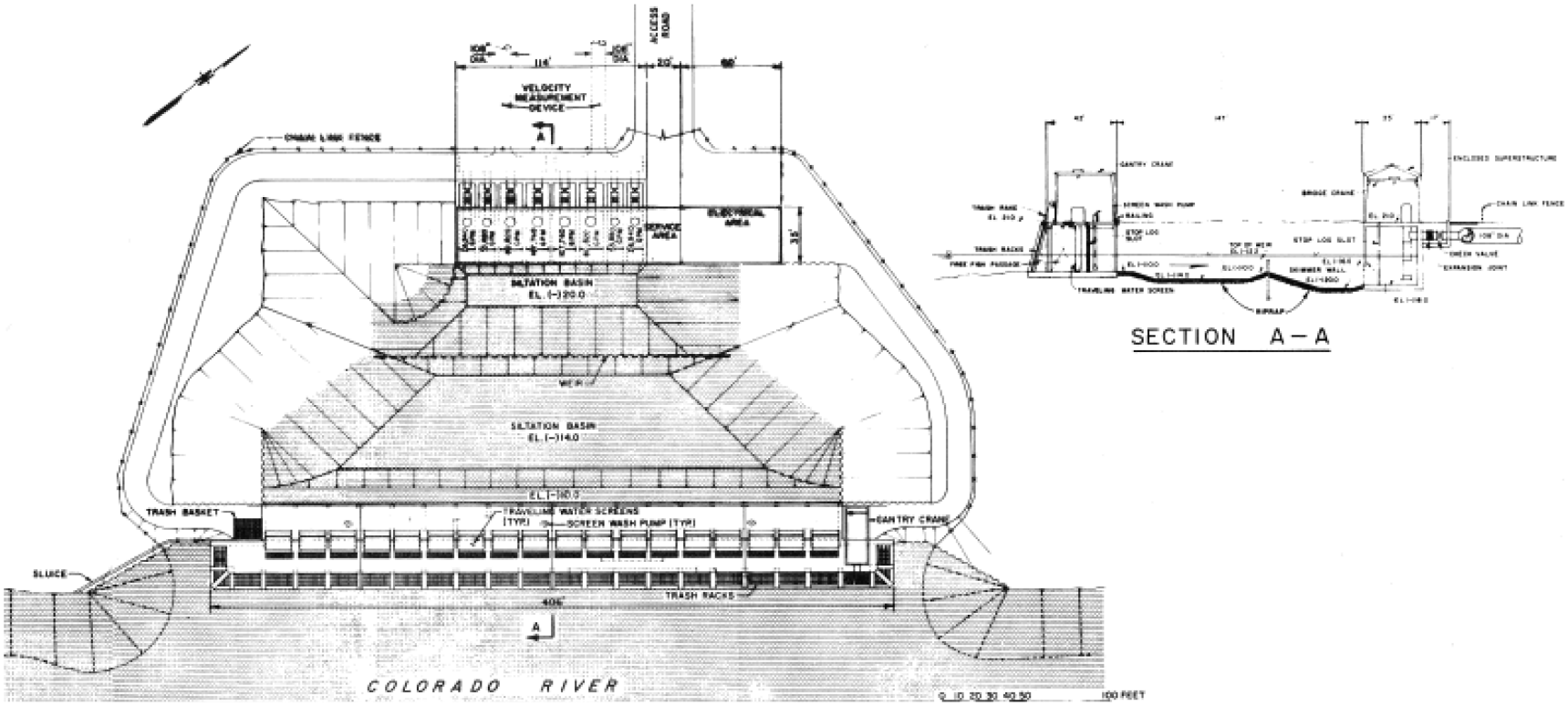


Figure 3.4-5 STP 3 & 4 RMPF Structure

Source: Reference 3.4-1