City of Riverside

WASTEWATER COLLECTION AND TREATMENT FACILITIES INTEGRATED MASTER PLAN

VOLUME 4: WASTEWATER TREATMENT SYSTEM
CHAPTER 12: PRIMARY EFFLUENT EQUALIZATION

FINAL
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PRIMARY EFFLUENT EQUALIZATION

12.1 PURPOSE

The purpose of this chapter is to evaluate alternatives for primary effluent equalization. This includes a comparison of equalization basin liner, cover and cleaning alternatives, and development of a basin layout that will meet the peak flow storage requirement for the Regional Water Quality Control Plant (RWQCP) at an annual average daily flow of 52.2 mgd.

12.2 CONCLUSIONS AND RECOMMENDATIONS

- Primary effluent equalization will be used to provide better control for downstream processes and a reduction in project costs for the Membrane Bioreactors (MBRs). In addition, the reduction in project costs for the MBR facility is more than the project cost of providing primary effluent equalization.
- Two equalization basins with a total volume of 12.1 MG will be required based on the Riverside wet-weather diurnal curves.
- Hypalon liners will be used for the basin liner material because of its lower cost compared to concrete and better durability than polypropylene. The total project cost for the equalization basins is estimated to be $10.4 million for the hypalon-lined basins.
- Basin covers will not be used because of cost and cleaning issues. To minimize odors, the basins will need to be dewatered and cleaned daily.

12.3 BACKGROUND

The purpose of an equalization system is to balance upstream fluctuating flows and reduce the maximum flow requirement for the downstream facilities. As described in Volume 4, Chapter 7 – Secondary Treatment, a 32-mgd capacity MBR facility was chosen for the Plant 1 secondary expansion. If primary effluent equalization is used, the size of the MBR facilities will be reduced because a lower peak flow is applied to the membranes. This reduces MBR capital costs. Because primary effluent equalization can reduce MBR capital costs and provide better process control for downstream facilities, MBR costs are included in evaluation of alternatives with equalization and without equalization.

12.4 PRIMARY EQUALIZATION ADVANTAGES/DISADVANTAGES

The primary advantage of having primary effluent equalization is to achieve better process control for both secondary and tertiary treatment. However, because primary effluent contains more organics and suspended solids, primary effluent equalization basins need more attention for basin cleaning than tertiary influent equalization basins. In addition, primary effluent equalization basins have a potential to produce odors. The Inland Empire Utilities Agency (IEUA) Regional Plant No. 1 (RP-1) facility is located directly adjacent to a residential and commercial area and operates primary effluent equalization basins. Historically, the RP-1 facility received numerous complaints related to the equalization basins. After improved management of the basins, which included adding aeration to the basins and daily emptying and water cannon wash down, the complaints have stopped.

12.5 DESIGN CRITERIA

The equalization basin will be sized to limit the peak wet-weather flow downstream of the primary clarifiers to approximately 78 mgd. This is equivalent to reducing the wet-weather peaking factor from 2.2 to approximately 1.5 during storm flow conditions. Under normal operating conditions, the peaking factor will be reduced to less than 1.5. The equalization basin is sized assuming it will be completely emptied and washed down every day. The sizing also includes a 20-percent safety factor to accommodate operational contingencies.

12.6 EQUALIZATION VOLUME

In Volume 4, Chapter 8 – Tertiary Treatment, tertiary influent equalization was discussed. The method to determine the equalization volume for tertiary influent, which is the accumulated volume above the wet-weather peak average daily flow, also applies for primary effluent. Because the RWQCP diurnal flow is not available, diurnal curves from the City of Riverside's (City's) Collection System Master Plan are used. During data collection for the Collection System Master Plan, two flow meters were located close to the RWQCP. The location of these meters (Meters 7 and 8) and their respective diurnal flow curves are shown on Figure 12.1. Because these curves are more representative of the RWQCP diurnal flows, they are used for the primary effluent equalization evaluation.

To determine the average daily influent flow during a wet-weather peak day, the RWQCP influent flow data for the last 6 years was used as presented on Figure 12.2. The figure shows that the average daily flow for the highest peak day occurred in February 2005, at 46.5 mgd. During the entire 6-year data timeframe, the average daily flow was 31.2 mgd. The ratio of the maximum average daily flow (46.5 mgd) to the overall average daily flow (31.2 mgd) is approximately 1.5. Applying the 1.5 ratio to the projected 2025 annual average daily flow of 52.2 mgd results in a peak wet-weather average daily flow of approximately 78 mgd. Figure 12.3 shows the simulated diurnal curves with an average daily flow of 78 mgd.

Assuming the equalization basins are emptied every day, the maximum required volume should be the accumulated volume above the daily average flow of 78 mgd and below the simulated diurnal curves during a wet-weather peak day. The required volumes are 10.1 MG and 8.8 MG for the two curves, respectively. Using the larger required volume from the adopted curves and including a 20-percent safety factor as an operational contingency, the total designed equalization volume is 12.1 MG.

To provide operational flexibility, two equalization basins would be provided as presented in Table 12.1. Ideally, the basins would be roughly the same size. However, due to existing piping constraints, one basin will be larger than the other.

Table 12.1 Primary Effluent Equalization Basins
Wastewater Collection and Treatment Facilities Integrated Master Plan
City of Riverside

Equalization Basin	Side Slope	Water Depth(1)	Basin Volume
EQ No. 1	2:1	18 feet	2.6 MG
EQ No. 2	2:1	18 feet	9.5 MG
Total Required Volume			**10.1 MG**
Total Designed Volume(2)			**12.1 MG**

Notes:
(1) Dependent on geotechnical conditions.
(2) Includes 20-percent operational safety factor.

12.7 SITE LAYOUT

A proposed layout for two equalization basins is shown on Figure 12.4. Demolition of the abandoned Plant 1 secondary clarifiers and the abandoned chlorine contact basins is required to provide space for the basins. The dimensions of the basins should be determined during the preliminary design based on a geotechnical investigation. For this Integrated Master Plan, assuming the groundwater level is the same as the area of the existing tertiary equalization basins, and referring to the hydraulic conditions detailed in Volume 4, Chapter 13 – Proposed Expansion Plan and Site Layout, the depth for the equalization basins is limited to 18 feet.

12.8 BASIN LINERS

The primary effluent equalization basins will be lined to prevent seepage into the surrounding soil and groundwater. Basin liners can be soil cement, synthetic geomembrane, or concrete. Because soil cement lacks the ability to be high-pressure washed and has a short useful life, it is not evaluated. Among the different types of geomembrane liners, hypalon and polypropylene are considered best for this application.

Hypalon lasts longer and costs more than polypropylene. Concrete and shotcrete are more costly, but last longer than geomembranes. For the construction of basin walls, shotcrete is much easier to apply than concrete; therefore, shotcrete walls are much cheaper than concrete walls. Table 12.2 lists a comparison of basin liner alternatives.

Table 12.2 Comparison of Basin Liner Alternatives
Wastewater Collection and Treatment Facilities Integrated Master Plan
City of Riverside

	Hypalon	Polypropylene	Concrete	Shotcrete	SWCB[(1)]
Ability to Support Concrete Cover	–	–	+	+	+
Ability to Drive On	–	–	+	+	+
UV Protection	0	0	+	+	+
Life Expectancy	30 years	20 years	50 years	50 years	50 years
Direct Cost[(2)]	\$220 K	\$160 K	\$1,200 K	\$780 K	\$1,000 K
Equivalent Uniform Annual Cost[(3)]	\$16 K	\$14 K	\$77 K	\$ 49 K	\$65 K

Ratings:
+ = Positive comparative characteristic.
– = Negative comparative characteristic.
0 = Neutral comparative characteristic.

Notes:
(1) Shotcrete walls with concrete bottom.
(2) Includes material and installation costs; does not include excavation or demolition.
(3) Based on a discount rate of 6 percent per year.

12.9 BASIN COVERS

As previously stated, primary effluent equalization basins have the potential to produce odors. One method to control odors is to cover the equalization basins. If they were covered, either a concrete or floating cover would be used. A concrete cover would have to be supported by concrete columns and concrete basins. A floating cover is supported by the water and does not need extra support. Figure 12.5 shows a schematic and a photograph of a floating basin cover installation. Floating basin covers are typically made of geomembrane materials, such as hypalon or polypropylene. Hypalon is a more durable material and costs more than polypropylene.

Table 12.3 presents a non-economic comparison of cover and non-cover alternatives.

Table 12.3 Non-Economic Comparison of Equalization Basin Cover
Wastewater Collection and Treatment Facilities Integrated Master Plan
City of Riverside

	No Cover	Concrete Cover	Floating Cover
Surface Aeration Required	–	+	+
Odor Scrubbing Required	+	–	+
Concrete Basin Required for Cover Support	+	–	+
Water Cannon Compatibility for Cleaning	+	–	–

Ratings:
+ = Positive comparative characteristic.
– = Negative comparative characteristic.
0 = Neutral comparative characteristic.

Table 12.4 presents a cost comparison of the basin cover alternatives. On an equivalent uniform annual cost basis, floating covers are much more cost effective than concrete covers.

Table 12.4 Comparison of Basin Cover Alternatives
Wastewater Collection and Treatment Facilities Integrated Master Plan
City of Riverside

	Concrete(1)	Hypalon	Polypropylene
Unit Cost(2)	$23/sf	$5/sf	$4/sf
Life Expectancy	50 years	30 years	20 years
Direct Cost(2)	$2,840,000	$650,000	$520,000
Equivalent Uniform Annual Cost(3)	$180,000	$47,000	$45,000

Notes:
(1) Concrete cover costs do not include odor-scrubbing costs.
(2) Includes material and installation costs.
(3) Based on a discount rate of 6 percent per year.

12.10 BASIN CLEANING AND ODOR CONTROL

12.10.1 Basin Cleaning

Based on the experience at the IEUA RP-1 facility, sediment from the primary effluent is expected to accumulate at a rate of about 1/4 inch per day. Because of this, the basins must be cleaned frequently. Similar to the existing tertiary influent equalization basins, water cannons can be used to clean the basin bottom daily if the basin has no cover. If a basin is covered, an alternate cleaning method is required. Robot cleaners, as shown on Figure 12.6, with camera and remote control can be an option.

These robot cleaners can go under water, brush the basin bottom, and suck out the sediment. The disadvantages of the robot cleaners are that they have not been used in wastewater treatment applications and more operator attention is required. The comparison of the two cleaning alternatives is presented in Table 12.5.

Table 12.5 Comparison of Basin Cleaning Alternatives
Wastewater Collection and Treatment Facilities Integrated Master Plan
City of Riverside

	Water Cannon	Robot Cleaner
Compatibility with Basin Cover	–[1]	+
Recycled Water Requirement	–	+
Out-of-Service Requirement	–	+
Equipment Reliability	+	–
Operator Attention Requirement	+	–[2]

Ratings:
+ = Positive comparative characteristic.
– = Negative comparative characteristic.
0 = Neutral comparative characteristic.

Notes:
(1) Cover must be removed to use water cannon.
(2) Would require continuous operator attention (8 hours/day).

12.10.2 Odor Control

Based on the IEUA RP-1 facility, for uncovered primary effluent equalization basins, surface aeration and daily cleaning is recommended. If the basins need to be covered, either a concrete cover or a floating cover should be considered. If a concrete cover is used, the foul air under the cover should be scrubbed before release to the atmosphere. The floating cover alternative does not require foul air treatment because the cover is in contact with the water surface.

12.11 COST COMPARISON OF EQUALIZATION BASINS

Because hypalon and polypropylene have similar properties and costs, and hypalon provides a better warranty, hypalon is used to represent the low-cost cover/liner alternative material. Similarly, because concrete and shotcrete have similar properties, but different costs, concrete is used as the liner/cover material to represent the high-cost alterative material. If other alternatives are considered, their costs will be between the hypalon and concrete costs.

Table 12.6 presents a cost comparison of the primary effluent equalization basin alternatives.

Table 12.6 Total Project Cost of Primary Effluent Equalization Basins
Wastewater Collection and Treatment Facilities Integrated Master Plan
City of Riverside

Liner Cover	Hypalon None(1)	Concrete None(1)	Hypalon Hypalon	Concrete Hypalon	Concrete Concrete(2)
Capital Cost(3)	$8,000,000	$10,500,000	$9,800,000	$12,300,000	$44,200,000
Total Project Cost	$10,400,000	$13,600,000	$12,800,000	$15,900,000	$57,500,000
Annual O&M Cost(4)	$119,000	$119,000	$196,000	$196,000	$320,000
Equivalent Uniform Annual Cost(5)	$780,000	$980,000	$1,040,000	$1,230,000	$3,970,000

Notes:
(1) Non-cover alternative includes surface aerator and water cannon costs.
(2) Concrete cover alternative includes biofilter costs.
(3) Includes demolition, excavation, and secondary pump station construction costs.
(4) Includes basin cleaning and odor control costs.
(5) Based on a discount rate of 6 percent per year.

12.12 LIFE-CYCLE COST ANALYSIS

Because primary effluent equalization basins can reduce MBR capital costs, the total life-cycle costs for alternate MBR facilities, with and without primary effluent equalization, are compared in Table 12.7.

Table 12.7 Life-Cycle Cost for Equalization and MBR
Wastewater Collection and Treatment Facilities Integrated Master Plan
City of Riverside

	Without Equalization	Hypalon Basin w/o Cover	Concrete Basin w/o Cover
MBR Project Cost(1)	$132,300,000	$116,500,000	$116,500,000
MBR Annual O&M Cost	$1,620,000	$1,620,000	$1,620,000
MBR Replacement Cost (2)	$6,600,000	$5,800,000	$5,800,000
MBR Life-Cycle Cost(3)	**$172,200,000**	**$154,900,000**	**$154,900,000**
Equalization Project Cost	$0	$10,400,000	$13,600,000
Equalization Annual O&M Cost	$0	$119,000	$119,000
Equalization Life-Cycle Cost(3)	**$0**	**$12,500,000**	**$15,600,000**
Total Life-Cycle Cost(3)	**$172,200,000**	**$167,400,000**	**$170,500,000**

Notes:
(1) Includes Plant 1 aeration basin modifications, MBR tank modifications, fine screens, MBR equipment and installation, blowers retrofit, and sludge pumping upgrade (see Volume 4, Chapter 7 – Secondary Treatment for details).
(2) Membranes need to be replaced every 7 years.
(3) At present value, assuming a life-cycle period of 19 years, a discount rate of 6 percent, and an escalation rate of 6 percent for the first 5 years and 4 percent thereafter.

As presented in Table 12.7, the reduction in project costs for the MBR facility with equalization is more than the project costs of providing primary effluent equalization for both non-cover alternatives.

12.13 SUMMARY

At the project meeting on February 21, 2007, the alternative and cost information for the various basin liner, cover, and cleaning alternatives were discussed. To help improve downstream process control and reduce the cost of the MBR secondary expansion, the City has decided to install primary effluent equalization basins. Because the City intends to operate the basins to minimize odor control by adding aeration and daily emptying and cleaning, covers will not be installed on those basins. In order to minimize life-cycle costs, the basin liner material will be hypalon. The total project cost of hypalon-lined basins is estimated to be $10.4 million.