

Facilities Plan Amendment

<b>Date:</b>	March 17, 2023	<b>Jacobs Engineering Group Inc.</b>
<b>Project name:</b>	SSSD Facilities Plan Amendment – MBBR Process Alternative	377 SW Century Drive, Suite 201 Bend, Oregon 97702
<b>Project no:</b>	Task Order 01	PO Box 936 Bend, Oregon 97709
<b>Client:</b>	South Suburban Sanitary District	United States
<b>Prepared by:</b>	Corey Klibert/Jacobs	T +1.541.318.4716
<b>Reviewed by:</b>	Brady Fuller/Jacobs; Bill Leaf/Jacobs	www.jacobs.com
<b>Revision no:</b>	1	

1. Introduction

1.1 Background

South Suburban Sanitary District (Owner; District) has recently submitted a Wastewater Treatment Plant (WWTP) Facilities Plan (November 2022) to Oregon Department of Environmental Quality (DEQ) describing certain improvements to the SSSD treatment facility to address the District's discharge to the Klamath River governed by the DEQ Final NPDES Permit No. 100700. Several alternative process technologies and discharge configurations were evaluated. The District prefers to evaluate one more process alternative and prepare update recommendations in a Facilities Plan Amendment, in the form of a Technical Memorandum.

1.2 Objectives

The objective of this study is to identify cost, layout, and process performance characteristics for implementing the Moving Bed Biofilm Reactor (MBBR) technology to treat lagoon effluent, followed by a solids separation process to meet the effluent discharge requirements as outlined in the November 2022 Facilities Plan. This alternative will be compared with alternatives in the November 2022 Facilities Plan submitted to DEQ. The study included the following elements:

- Evaluation of equipment and treatment process facilities required to implement MBBR technology on lagoon effluent
- Capital and O&M cost estimates for the MBBR process alternative



RENEWS: 12-31-2023

## 2. Facilities Plan Amendment

This report section is intended to augment Chapter 5 of the Facilities Plan with the addition of Alternative 1C – Moving Bed Biofilm Reactor to the alternatives that upgrade the WWTP for Klamath River Surface Water Discharge. The following section presents Alternative 1C and would correspond to Section 5.1.4 in the Facilities Plan. This alternative would not share all of the components common to Alternatives 1A and 1B that were enumerated in Section 5.1.1, however. The differences in those assumptions between Alternative 1C and the others have been noted below where they occur. Numbering of sections and subsections below has been set to correspond with where they would fit into the existing Facilities Plan.

### (Facilities Plan) Section 5.1.4: Alternative 1C – Moving Bed Biofilm Reactor

In general, the MBBR process consists of a series of tank reactors which are partially filled with small, buoyant free-moving plastic biofilm carriers (biomedia). The biomedia provide surface area upon which bacterial biofilms can grow. The biofilm removes soluble organics and nutrients (including ammonia ( $\text{NH}_3\text{-N}$ ) and nitrate ( $\text{NO}_3\text{-N}$ )) through a combination of aerobic and anoxic biological degradation. The amount of  $\text{NH}_3\text{-N}$  removal is directly related to the bulk-liquid dissolved oxygen concentration within the bioreactor.

Biological treatment in MBBR reactors takes place nearly entirely at the biofilms, with no appreciable suspended biomass in the bulk liquid phase (in this way, they operate similar to conventional trickling filter wastewater treatment processes). The media provides a large overall surface area that results in a high biomass inventory and a small overall site footprint compared to activated sludge processes. Additional benefits of the MBBR process are as follows:

- works well at removing ammonia at colder temperatures when other technologies are less effective,
- can be easily integrated to the existing processes at a WWTP,
- is stable under variations to loading, and
- is easy to operate, requiring limited operational control and oversight.

Aeration is typically provided by a combination of blowers and coarse-bubble diffusers, which impart both dissolved oxygen and mixing to the aerobic reactors. Anoxic reactors are mixed with mechanical mixers. Supplemental carbon would be provided to meet the carbon demands of denitrification. Submerged media retention sieves (stainless steel screens, typically) located near the top of the aerobic tanks allow effluent to exit the reactor while retaining the media in the tanks; anoxic zones have a screen wall with air scour along the bottom of the tanks. Dissolved oxygen sensors, air control valves and air flow meters provide the ability to control the aeration system, and ammonia/nitrate sensing instruments can be installed to control nutrient removal performance in the aerobic and anoxic reactors.

A schematic of the proposed treatment system for Alternative 1C – MBBR at the SSSD treatment plant is provided in Figure 2-1 below and a conceptual layout is presented in Figure 2-2 on the following page.

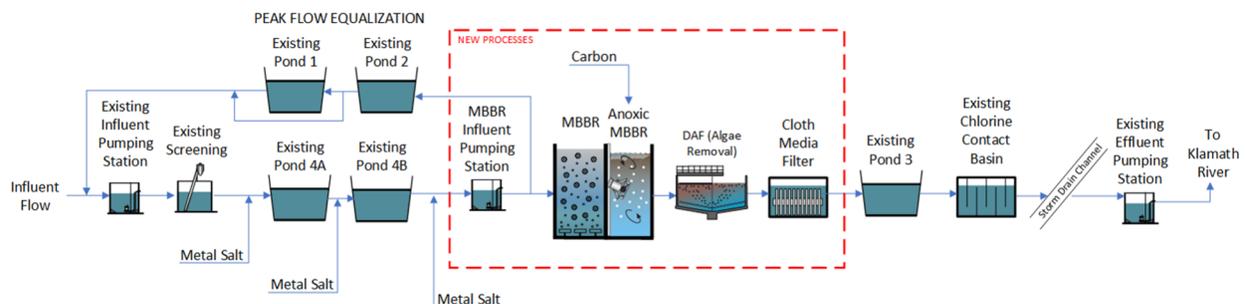


Figure 2-1. Process flow diagram for MBBR Alternative for surface water discharge.

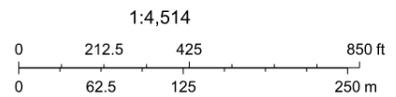


Figure 2-2. Conceptual layout of Alternative 1C – MBBR Process.

### FP Section 5.1.4.1: Alternative 1C Peak Flow Treatment and Storage

In this alternative, effluent from the existing lagoon treatment in Ponds 4A and 4B would be pumped by a new MBBR Influent Pump Station to the new MBBR reactors. The MBBR Influent Pump Station would also be configured to divert flows to Ponds 1 and 2 to attenuate flow to the MBBR process to a maximum of 3.0 million gallons per day (mgd) (or approximately 2,100 gallons per minute (gpm)). This approach differs from Alternatives 1A and 1B, which would repurpose the existing treatment Ponds 4A and 4B for peak flow equalization. Ponds 1 and 2 could be configured to equalize either raw influent flow or effluent flow from Ponds 4A and 4B prior to being routed to the MBBR reactors. Diverting effluent from Pond 4B would require additional piping from the MBBR pump station in Pond 4B to Pond 1 and/or 2 as well as automatic flow control valves at the MBBR pump station. Flow control structures and pipelines would be constructed to connect Ponds 1 and 2 with the existing raw influent pump station and each other.

As described in Section 5.1.1.1 of the Facilities Plan, the total annual volume of water entering the WWTP during a very wet year (such as 2017) that exceeds the design flowrate (3.0 mgd) of the proposed treatment alternatives has been estimated to be approximately 42 million gallons (Mgal). As presented in Table 3-1 in Section 3.1.2.8 (Unit Process Summary) of the Facilities Plan, Ponds 1 and 2 have storage capacities of 34 Mgal and 37 Mgal respectively, indicating sufficient capacity to handle the projected influent flows exceeding the capacity of 3.0 mgd treatment system.

According to Section 5.1.1.2 of the Facilities Plan, ponds utilized as storage facilities for treated wastewater would need to exhibit of minimum coefficient of permeability of  $1.0 \times 10^{-7}$  centimeters per second (cm/s). Solids were removed from Pond 1 in 2021, and permeability testing of this pond was performed in 2022 and passed DEQ seepage requirements. Ponds 2 and 3 are expected to undergo solids removal and subsequent permeability testing in the next few years. Depending on the outcome of the permeability testing, the ponds may be required to be retrofitted with high-density polyethylene (HDPE) liners if the existing liners were found to be overly permissive.

Table 2-1 presents the flow equalization design criteria for Alternative 1C. A summary of the flow equalization water balance is presented in Section 5.1.1.1 of the Facilities Plan, and a detailed analysis is included as Appendix C to that report.

**Table 5-2. Alternative 1C Flow Equalization Design Criteria**

Item	Value	Units
Design Year	2045	--
River discharge	None <sup>(a)</sup>	--
<b>Design Flows</b>		
Maximum daily flow to MBBR treatment system	3.0	mgd
Total annual flow volume of bypass to pond system (wet year) <sup>(b)</sup>	42.0	Mgal
Total annual flow volume of bypass to pond system (average year) <sup>(b)</sup>	25.4	Mgal
Average annual rainfall (Wet Year)	20.3	inches
Average annual rainfall (Average Year)	13.7	inches
<b>Storage requirements</b>		
Total Storage in Ponds 1 and 2	218.7	ac-ft
Storage required in Ponds 1 and 2 (42 MGal = 128.9 ac-ft)	128.9	ac-ft

<sup>(a)</sup> Discharge will only occur from downstream of the MBBR in the liquids flow stream at the WWTP

<sup>(b)</sup> Total annual peak flow bypass volumes based on water balance presented in Section 5.1.1.1 of the 2021 Facilities Plan

### **FP Section 5.1.4.2: Temperature Attenuation**

The temperature of the raw influent wastewater during the winter months decreases while the wastewater is being treated in Ponds 4A and 4B. The MBBR process would be designed to function at a minimum temperature of 5 degrees Celsius (41 degrees Fahrenheit) to optimize capital and operating costs of the facility, as the required size and capital cost of the facility rises quickly with decreasing wastewater design temperature due to biological kinetics. A boiler/heat exchanger system would be provided to maintain MBBR temperature above the minimum operating temperature under extremely cold conditions, while not being used in other conditions. The boiler system is part of the proposed vendor package, but use of additive heat is not a common in municipal wastewater treatment, and should be re-evaluated in the design. This boiler/heat exchanger system is included in the vendor cost proposal.

Pond 3 would serve as a post-treatment temperature attenuation step prior to disinfection and effluent discharge to the Klamath River similar to Alternative 1A Membrane Bioreactor Treatment. No major improvements would be needed to allow for the use of Pond 3 for temperature attenuation downstream of the surface water discharge treatment facilities, as described in Section 5.1.1.2 of the Facilities Plan. Because the MBBR process can operate at such low temperatures and does not appreciably increase wastewater temperature through internal processes, Pond 3 would provide sufficient surface area for temperature attenuation in extremely cold weather. During critical shoulder seasons (typically early fall) where the TMDL has imposed excess thermal load (ETL) criteria, utilization of the existing secondary treatment in Ponds 4A and 4B, combined with the post-MBBR attenuation step in Pond 3, should result in effluent temperatures similar to current levels, which are well under the ETL criteria as demonstrated in Section 4.2.5 of the Facilities Plan. As a result, no additional temperature analyses were performed in the evaluation of Alternative 1C.

### **FP Section 5.1.4.3: Influent Pump Station and Screening (Existing)**

Alternative 1C – MBBR would utilize the existing influent pump station and headworks facility according to the current operating strategy, discharging flows to Ponds 4A for treatment.

As presented in Section 5.1.1.3 of the Facilities Plan, the existing raw sewage pump station was designed with an ultimate buildout capacity of 30 mgd. The four existing pumps have a capacity of 2,550 gpm each so the firm capacity of the pump station is 7,650 gpm, or 11 mgd with one pump out of service and total capacity of 14.7 mgd. With the peak wet weather flow (PWWF) capacity projected at 6.8 mgd, the Facilities Plan determined that the existing pump station has more than adequate capacity to handle the 2045 flows.

Section 5.1.1.4 presents the capacity of the existing mechanically raked bar screen as 21 mgd, sufficient to meet year 2045 flows. However, the Facilities Plan does recommend in Section 5.3.2 for the installation of a new multirake bar screen system to allow for the existing headworks to continue to serve the WWTP, relocating the existing screen to the bypass channel, which currently has no screens.

Ancillary improvements recommended in Section 5.1.1.5 of the Facilities Plan would be common to Alternative 1C, consisting of the following:

- Installation of a new wet well spray system at the Influent Pump Station
- Replacement of the blower used for aeration of the channel downstream of the bar screens in the headworks
- Replacement of the headworks sump pump
- Ventilation improvements to the headworks
- Asphalt repaving in several areas of the site

### FP Section 5.1.4.4: Secondary Treatment (Existing)

Alternative 1C would continue the use of Ponds 4A and 4B for secondary treatment upstream of the MBBR. The Facilities Plan recommends in Section 5.3.2.2 that if Ponds 4A and 4B are to continue to be used for secondary treatment, they should be retrofitted with HDPE liners.

### FP Section 5.1.4.5: Moving Bed Biofilm Reactor

The proposed MBBR facility at the WWTP would consist of two trains operating in parallel, each with two nitrifying aerobic zones in series followed by one or more anoxic zones for denitrification sized for 1.5 mgd. The process would be sized to provide full redundancy to take one train offline during the dry-weather season, with both trains in service during the wet-weather season. A blower facility would be located nearby to house the aeration blowers and boiler system. Chemical storage of supplemental carbon and coagulants/flocculants for chemical phosphorus removal (described in Section 2.5 below) could be located in either a separate room of the blower building or a separate building, as shown in the site layout of the MBBR facility presented in Figure 2-3 on the following page. Solids separation for chemical phosphorus removal would be located nearby. Design criteria for the MBBR process are presented in Table 5-3 below.

**Table 5-3. MBBR Flow/Loads**

*Based on lagoon effluent data from 2021 to 2022*

Parameter	Units	Value
<b>Flows</b>		
Average annual flow	mgd	2.3
Maximum flow	mgd	3.0
<b>BOD</b>		
Average dry weather loading	lb/d	240
Average wet weather loading	lb/d	283
Maximum month dry weather loading	lb/d	791
Maximum month wet weather loading	lb/d	567
<b>TSS</b>		
Average dry weather loading	lb/d	375
Average wet weather loading	lb/d	637
Maximum month dry weather loading	lb/d	917
Maximum month wet weather loading	lb/d	1,632
<b>Total Nitrogen</b>		
Average dry weather loading	lb/d	136
Average wet weather loading	lb/d	268
Maximum month dry weather loading	lb/d	329
Maximum month wet weather loading	lb/d	418
<b>Ammonia</b>		
Average dry weather loading	lb/d	17
Average wet weather loading	lb/d	136
Maximum month dry weather loading	lb/d	67
Maximum month wet weather loading	lb/d	311
<b>Total Kjeldahl Nitrogen</b>		
Average dry weather loading	lb/d	90
Average wet weather loading	lb/d	270

## Technical Memorandum

---

Parameter	Units	Value
Maximum month dry weather loading	lb/d	95
Maximum month wet weather loading	lb/d	561
<b>Total Phosphorus</b>		
Average dry weather loading	lb/d	63.4
Average wet weather loading	lb/d	60.0
Maximum month dry weather loading	lb/d	162
Maximum month wet weather loading	lb/d	165

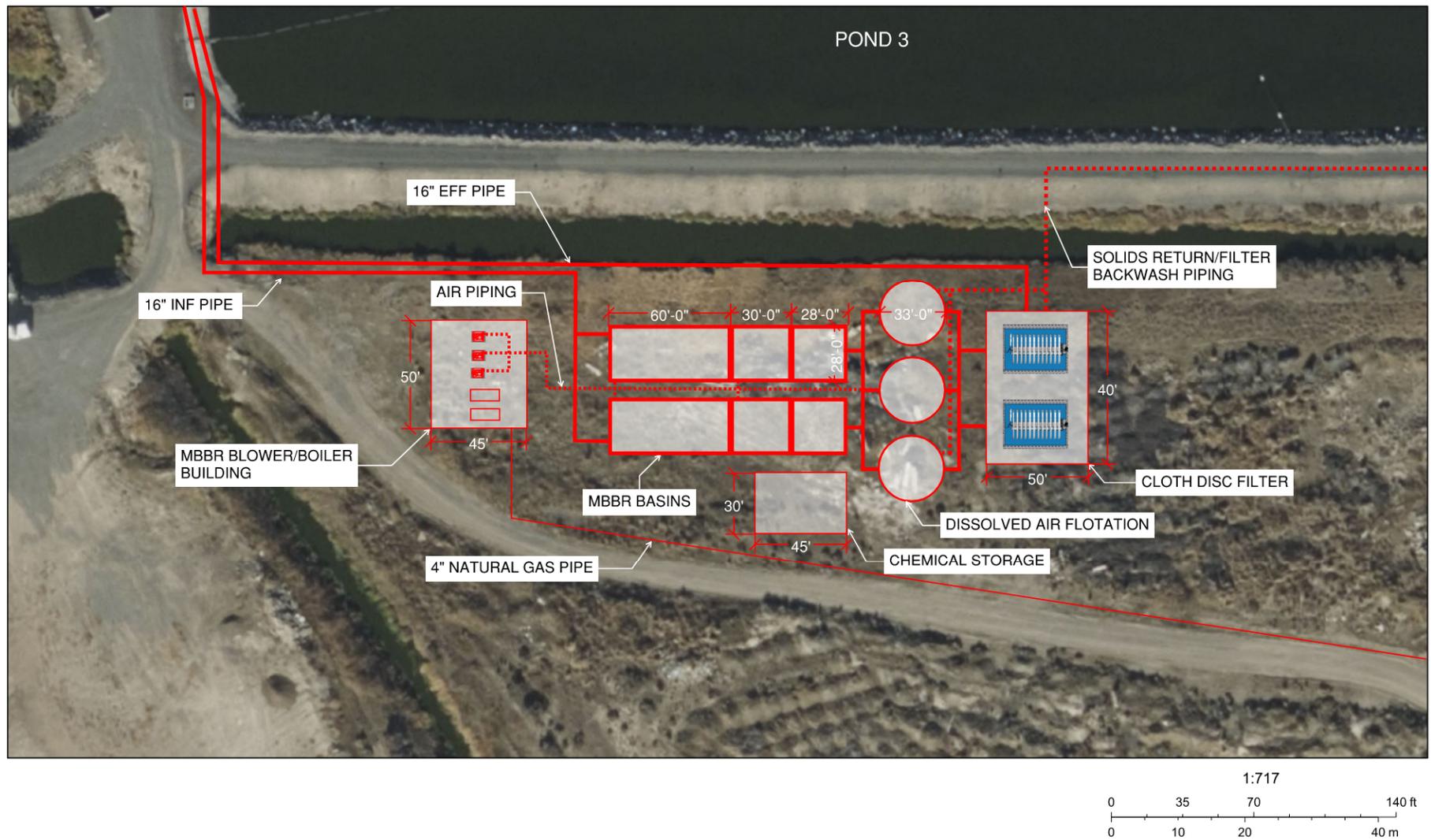


Figure 2-3. Alternative 1C – MBBR facilities layout.

### **FP Section 5.1.4.6: Phosphorus Removal**

The Facilities Plan indicates in Section 4.2.2 that the existing secondary treatment system in Ponds 4A and 4B does not currently remove phosphorus to a sufficient degree to meet permit limits. Alternative 1C would require an additional phosphorus removal process following nitrogen removal in the MBBR reactors. Results of a treatability study, presented in *Bench Evaluation of AASI Cloth Media Filter Technology with OptiFiber PES-14® Polyester Pile Media for Reducing Total Phosphorus of Lagoon Effluent for Triplepoint SSSD* (Aqua-Aerobic Systems, Inc., 2022), demonstrated that cloth media filtration with chemical coagulation could remove nearly all soluble phosphorus from the existing secondary effluent but was not able to remove algae-bound phosphorus. To remove algae upstream of cloth disc filtration, the Facilities Plan in Section 5.3.2.4 recommends dissolved air flotation (DAF). The proposed DAF would consist of three, 33-foot diameter tanks under a canopy, each with a 1.5 mgd capacity. It is recommended that additional options for algae prevention/control be considered alongside DAF separation, such as mixing/additional aeration in the ponds, commercially available ultrasonic algae control devices or covers over the ponds. DAF sizing (based on 2021 Facilities Plan) should also be validated in design.

For the purposes of this level of analysis, Alternative 1C is assumed to utilize chemical addition of coagulant (alum) followed by a DAF unit and cloth disc filters. Alternate options for phosphorus removal can be considered in later stages of design.

### **FP Section 5.1.4.7: Solids Management**

Solids generated in the MBBR process generally slough from the media and are discharged in the effluent, contributing to a marginal increase in effluent total suspended solids, which can be removed in downstream solids separation processes, such as the proposed cloth media filters. As a result, the MBBR process does not require waste solids recycle to the ponds. Ponds 4A and 4B will continue to provide secondary treatment, generating the bulk of plant biosolids. It is assumed that the current approach of periodic solids removal by third-party contractor will be maintained under Alternative 1C. The cloth disk filters do produce a solids waste stream from back washing, and Alternative 1C proposes to route backwash flows (including accumulated solids) to the existing Influent Pump Station. The DAF unit will also generate waste solids in the form of algae, which would optimally be discharged to a drying bed or geotextile dewatering bag rather than be recycled to headworks in order to avoid recirculation of problematic organisms (and bound orthophosphate forms). The Facilities Plan estimated that roughly 770 pounds of dry DAF solids would be generated per day, equating to 467 wet tons per year of dewatered solids (30 percent total solids).

### **FP Section 6.1.1.2a: Capital Costs for Alternative 1C – MBBR Process**

This section presents the capital costs for Alternative 1C based on the proposed improvements described above. Because Alternative 1C does not share all of the common facilities and proposed upgrades assumed for Alternatives 1A and 1B, all improvements required for Alternative 1C are delineated in Table 6-2a below.

**Table 6-2a. Estimated Capital Costs for Alternative 1C – MBR Process**

Description	Cost, dollars
Condition Repairs	\$555,000
Pond 2/3 Solids Removal	\$810,000
Pond 2/3 Solar Bees	\$220,000
Pond 4A/4B Rehab (Solids Removal and HDPE liner)	\$6,740,000
MBBR Influent Pump Station	\$1,510,000
MBBR Basins	\$5,840,000
MBBR Blower/Boiler Building	\$1,170,000
DAF (Algae Removal)	\$4,030,000
Algae Drying Bed	\$1,330,000
Cloth Disk Filter	\$1,460,000
Chemical Storage	\$560,000
Sitework (yard piping/pond conveyance structures)	\$2,620,000
<b>SUBTOTAL</b>	<b>\$26,845,000</b>
Project Phase-Level OPCC Contingency (20 percent)	\$5,369,000
<b>Engineer's Preliminary Opinion of Probable Costs</b>	<b>\$32,214,000</b>
Changes and Unforeseen Conditions During Construction (5 percent)	\$1,610,700
Engineering Design, Environmental Planning and Studies, Construction Management, ESDC, and Legal and Admin Costs (25 percent)	\$8,053,500
<b>Engineer's Preliminary Opinion of Probable Total Capital Cost</b>	<b>\$41,878,200</b>

### **FP Section 6.1.2.1a: O&M Costs for Alternative 1C – MBBR Process**

Development of O&M costs for Alternative 1C incorporated the assumptions presented in Section 6.1.2 of the Facilities Plan for unit costs of various parameters including electricity, labor, solids handling, and materials and services.

A summary of the estimated O&M costs for this alternative is provided in Table 6-7a.

**Table 6-7a. Estimated O&M Costs for Alternative 1C – MBBR Process**

Description	Cost, \$1,000
<b>Existing Costs<sup>(a,b)</sup></b>	
Utilities	220
Labor	270
Chemicals	--
Materials and Services	320
Capital Outlay	350
Total Existing Annual O&M	\$1,160
<b>Additional Costs<sup>(a)</sup></b>	
Energy <sup>(c)</sup>	315
Labor <sup>(d)</sup>	100
Chemicals	160
Materials and Services <sup>(e)</sup>	95
Solids Disposal	8
Total Additional Annual O&M	\$678
Grand Total Annual O&M	\$1,838

(a) December 2021 dollars (12,480 20-City Average ENR).

(b) Based on FY 2020/2021 budgeted costs.

(c) Based on an energy cost of \$0.085 per kWh.

(d) Labor costs assume 1 additional chief plant operator.

(e) Materials and services cost based on 1 percent of mechanical equipment value plus 15 percent of labor costs.

### FP Section 6.1.3: Comparison of Lifecycle Costs

The capital, O&M, and lifecycle cost estimates for each alternative are summarized in Table 6-11. As shown in the table, Alternative 1C has the lowest estimated lifecycle costs.

Description	Capital Cost, \$ mil	Annual O&M, \$ mil	Present Worth of O&M, \$ mil	Lifecycle Cost, \$ mil
1A – Klamath River Surface Water Discharge – MBR Treatment <sup>a</sup>	74	3.1	49.1	123
1B – Klamath River Surface Water Discharge – E3 Water LLC Treatment System <sup>a</sup>	70	3.9	62.9	132
1C – MBBR Process <sup>e</sup>	42	1.9	29.3	71.2
2A and 2B – Irrigation District Surface Water Discharge <sup>a</sup>	74/70	3.1/3.9	49.1/62.9	123/132
3A – Class A Recycled Water for Agricultural Irrigation with Onsite Storage – Chlorine Disinfection <sup>a</sup>	122	2.0	32.6	155
3B – Class A Recycled Water for Agricultural Irrigation with Onsite Storage - UV Disinfection <sup>a</sup>	121	2.0	31.7	153
4 – Class A Recycled Water for Irrigation with Offsite Storage – Chlorine Disinfection <sup>a</sup>	< 122	< 2.0	< 32.6	< 155

(a) December 2021 dollars (12,480 20-City Average ENR).

(b) 20-year present worth at an annual discount rate of 2.25 percent.

(c) Costs for Alternatives 2A and 2B are assumed to be the same as Alternative 1A and 1B, respectively. It is assumed that any costs for conveyance to an alternative discharge location would be borne by the water user.

(d) Costs for Alternative 4 are expected to be lower than Alternative 3A because the discharge pipeline can be use

(e) February 2023 dollars (13,176 20-City Average ENR).