TECHNICAL MEMORANDUM

MWH

BUILDING A BETTER WORLD

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Date: February 1, 2016

Reference:

Subject: Treatment and Operations Scenarios for Meeting Lower Nutrient Discharge Limits for the Augmentation Flow to the Malibu Creek

INTRODUCTION

The Las Virgenes-Triunfo Joint Powers Authority (JPA) own and operate the Tapia Water Reclamation Facility (Tapia) that discharges part of the year to Malibu Creek. Tapia currently treats approximately 7 MGD which is reused or sent to the Los Angeles River (Outfall 005), Malibu Creek (outfall 001, 002, 003), or to JPA operated spray fields. Reuse of 60-70 percent of the tertiary effluent produced annually is achieved through an extensive recycled water system. Although the facility is permitted for a capacity of 16.1 MGD, nutrient removal planning efforts over the last 10 years have considered 12 MGD as the required maximum capacity for the foreseeable future.

Discharge to Malibu Creek and the Los Angeles River are regulated under NPDES permit CA0056014 issued by the Los Angeles Regional Water Quality Control Board (RWQCB) in 2010. According to Tapia's NPDES permit discharge of treated water to Malibu Creek is allowed from November 16th to April 14th each year, with the rest of the year referred to as the prohibition period. During the prohibition period, discharges are only allowed for emergency situations (where there is a pipe break or other malfunction in infrastructure), for extreme wet weather flows, or for the purpose of maintaining minimum flows in Malibu Creek as set forth in the NPDES guidelines (augmentation flows). From November 16th through April 14th, excess Tapia flows not consumed by the JPA's recycled water customers have been discharged to one of the three other outfalls, with the majority going to the Malibu Creek outfalls.

Past water quality requirements for discharge to Malibu Creek included monthly limitations for nitrogen compounds of 3.1 mg/L ammonia, 8 mg/L nitrate plus nitrite, and 3 mg/L phosphorous. New, more stringent nutrient summertime requirements of 1.0 mg/L total nitrogen (TN) and 0.1 mg/L total phosphorus (TP) have been proposed as the Total Maximum Daily Loads for Nutrients in the Malibu Creek Watershed by the United States Environmental Protection Agency, Region 9.

At the request of Las Virgenes Municipal Water District (LVMWD), MWH prepared a technical memorandum (TM) in 2013 to summarize the modifications required for the treatment facilities to meet the lower TN and TP nutrient limitations for the total flow discharged into Malibu Creek by Tapia throughout the year. Since 2013, the JPA has embarked on an extensive outreach project with local stakeholders and MWH to explore alternatives that would allow them to recover the majority of flows treated at Tapia through storage or reuse. While several of these alternatives have shown promise, the RWQCB has expressed that augmentation flows during the prohibition period may still be necessary, and that the new, more stringent TN and TP limitations would apply to these flows. As such, LVMWD has requested MWH to evaluate various options to meet TN and TP limits for the augmentation flows.

The purpose of this TM is to evaluate three different options to meet TN and TP limits for the Malibu Creek augmentation flow of up to 1 million gallons per day (MGD), and an average yearly total of roughly 28 million gallons (MG). Three different options with corresponding design criteria and cost estimates are discussed in this TM; two of these options include treating the secondary effluent to a higher standard while the third option analyzes use of imported potable water for augmenting Malibu Creek flows.

BACKGROUND

In 2002 MWH completed the Nutrient Reduction Master Plan which evaluated three nutrient removal scenarios and recommended alternatives to upgrade Tapia WRF for implementation in phases for each of the scenarios. Phase 1 provided for average effluent total inorganic nitrogen (TIN) of 8 mg/L at a capacity of 12 MGD and was intended to be an interim measure. Phase 2 increased the capacity of the Phase 1 facilities to 16.1 MGD which was and remains the permitted capacity of Tapia. Phase 3 was proposed by JPA staff at that time to reflect potential lower future effluent nitrogen and phosphorus at 2.5 mg/L TIN, which is the sum of ammonia, nitrate plus nitrite, and 0.4 mg/L TP. This phase was based on the conversion of Tapia into a 16.1 MGD membrane bioreactor (MBR) process.

Following completion of the 2002 report, a project was undertaken to implement interim modifications at Tapia to improve nitrogen removal down to 8-10 mg/L TIN but at minimum capital cost and only for the then current flows (rather than at a capacity of 12 or 16 MGD). This work was completed in 2003 and included electrical upgrades as well as process modifications.

In 2005, MWH provided an update to the Master Plan that identified needed facilities to achieve very low nutrient levels of 1 mg/L TN and 0.1 mg/L TP for discharge to Malibu Creek that were being proposed by the RWQCB and instead instituted limits for ammonia and nitrate plus nitrite that are equivalent to a TN limitation of 11 mg/L (8mg/L NO_2+NO_3 and 3.1 mg/L NH_3).

In 2007, MWH provided another update to the Nutrient Reduction Master Plan that updated the results from the 2002 report based on then current conditions of wastewater characteristics and at a foreseeable future capacity of 12 MGD. The update also included permit limitations including 8 mg/L nitrate plus nitrite to be implemented in 2010.

In 2013, MWH prepared a TM entitled "Nutrient Reduction Measures for Low Total Nitrogen and Phosphorous - UPDATE" for the JPA. That document provided an assessment of the potential requirements for treatment facilities to incorporate the more stringent discharge limitations of 1 mg/L TN and 0.1 mg/L TP to Malibu Creek as indicated by the RWQCB. That document considered the full flow of the Tapia WWTP (12 MGD) as the required treatment capacity.

In 2015, the JPA began a stakeholder driven process to explore options of how to stop sending any flows to Malibu Creek in the future. This work was an extension of multiple previous studies commissioned by the JPA, including studies to build a new Seasonal Storage reservoir to hold recycled water during winter months (periods of low recycled water demand), for use in summer months when demand exceeded the supply from Tapia. The options explored in this multi-stage facilitation project included building new storage, utilizing storage in reservoirs that were underutilized outside of the JPA service area, and employing Advanced Water Treatment for indirect potable reuse of the recycled water.

While the stakeholder driven project has honed in on two very promising scenarios that would allow the JPA to no longer send the majority of flows to Malibu Creek, augmentation flows may still be required by the RWQCB, flows that would be subject to the more stringent discharge limitations of 1 mg/L TN and 0.1 mg/L TP. These flows would be far less than the amount of flow considered in the 2013 study as they would only include those needed during times when Malibu Creek was below 2.5 cubic feet per second (cfs) of total flow. Due to the potential of low TN and TP limits being implemented for the Malibu Creek discharge, JPA requested MWH to prepare a TM summarizing various options to meet these limits. MWH evaluated two different treatment options and a potable water augmentation option, findings from which are discussed in following sections.

OPTIONS TO ACHIEVE COMPLIANCE

In order to comply with TN and TP limits for discharge to Malibu creek, treated water flow of up to 650 gpm (0.94 MGD) may be required. Three different options were evaluated by MWH to meet the TN and TP limits:

Option 1 – Treat secondary effluent with a Membrane Bio Reactor (MBR) process and Reverse Osmosis (RO)

Option 2 – Treat secondary effluent with Micro/Ultrafiltration (MF/UF), RO and Ion Exchange (IX)

Option 3 – Supply imported potable water to Malibu Creek through the Las Virgenes MWD distribution system supplied by the Metropolitan Water Districts of Southern California (Metropolitan).

Each of these options are described in detail in the following sections, and planning level capital and operations and maintenance (O&M) costs for implementation of each option are presented. The 3-stage RO systems designed for wastewater desalination typically operate at a recovery of 85%. Therefore, the feed flow for the RO system will be 765 gpm (1.1 MGD) to produce treated water flow of 650 gpm. The MF/UF system used to provide pretreatment for the RO system is typically operated at recovery of 95% and is therefore sized to treat 805 gpm (1.16 MGD) of secondary effluent. The MBR process used in Option 1 typically operates at 90% recovery and is therefore sized to treat 850 gpm (1.22 MGD) of secondary effluent. It should be noted that either secondary effluent or unchlorinated filtered effluent can be used as a feed to the MF/UF and MBR systems.

Option 1 – Membrane Bioreactor - Reverse Osmosis

A treatment train consisting of MBR and RO processes can be utilized to meet the more stringent TN and TP limits for Tapia discharge. Considering that the RO process will only achieve 60-80% removal of nitrogen species, a biological process upstream of the RO system will be necessary to achieve the TN and TP limits of 1.0 and 0.1 mg/L, respectively. A two-stage MBR process consisting of pre-anoxic and aerobic/membrane basins can be utilized to achieve the required TN and TP limits in concert with the RO.

Figure 1 below shows the process schematic of the treatment train for Option 1. Since Tapia produces fully nitrified effluent (ammonia <0.2 mg/L-N), the secondary effluent will be fed to a pre-anoxic zone for denitrification. Due to lack of carbon source in the secondary effluent, methanol will be added to the pre-anoxic zone at a rate of 40 gpd to achieve effluent nitrate concentrations of <0.5 mg/L-N. A total of five membrane cassettes will be required to treat a target influent flow-rate of 1.22 MGD, which will be required to achieve a product (RO permeate) flow-rate of 0.94 MGD.

The MBR effluent will be fed to the RO system which will achieve almost complete phosphorus removal (<0.1 mg/L-P) and lower the effluent TN concentration to < 1 mg/L-N. Sulfuric acid and antiscalant will be added to the RO feed to minimize $CaPO_4$ and $CaCO_3$ scaling. The RO system will be designed as a 3-stage system with a total recovery of 85%. Final effluent will be stabilized to pH of 8.0 by adding lime in the conveyance line to the Malibu Creek. **Table 1** shows the key design parameters for the unit processes for Option 1. It is estimated that a footprint of 4,000-5,000 ft^2 will be required for Option 1.

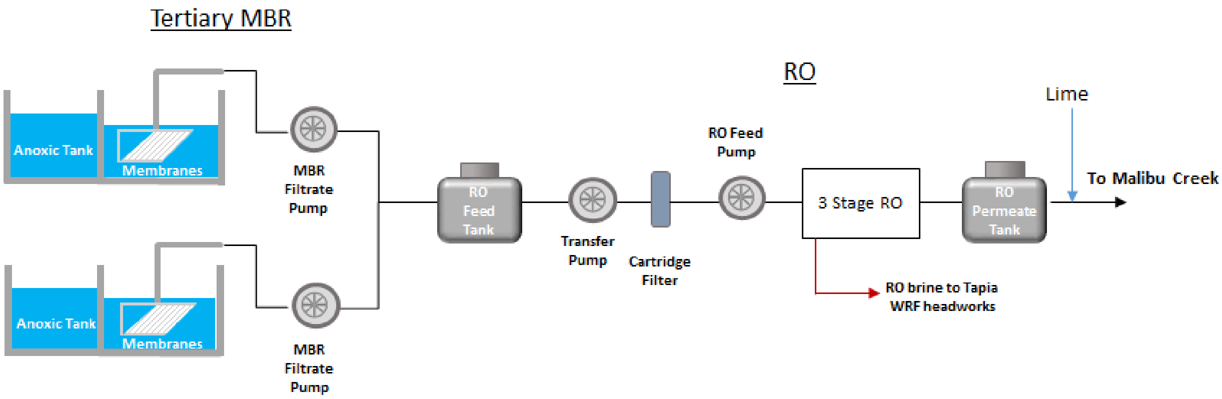

Figure 1 – Process Schematic of the Treatment Train for Option 1.

Table 1 – Process Parameters for Each Unit Process for Option 1.

Membrane Bioreactor		
Bioreactor		
Feed Flow-rate	850	gpm
Feed Nitrate Concentration	10	mg/L-N
Methanol Feed Rate	40	gpd
Design SRT	10	days
HRT		
Pre-anoxic	1.2	hours
Aerobic/Membrane	0.8	hours
Total Volume	2.0	hours
Total Volume	100,000	gallons
Membrane Tank MLSS	11,000	mg/L
Membrane Filtration		
Membrane Gross Flux	14	gfd
Membrane Filtrate Recovery	90	%
Membrane Cassettes Required	5	
Reverse Osmosis		
Feed Flow-rate	765	gpm
Stage 1		
Flux	11.2	gfd
Number of Elements	120	
Stage 2		
Flux	10.5	gfd
Number of Elements	60	
Stage 3		
Flux	8.5	gfd
Number of Elements	36	
Overall Recovery	85	%

Figure 2 below shows a schematic of the new facility needed for Option 1 and Option 2 at Tapia WRF, which are both estimated to be between 4,000 and 5,000 square ft. The building shown in the figure is a 60 ft. by 84 ft. footprint drawn to scale. **Figure 2** also shows the required piping for Option 1 and Option 2, which is the same for either treatment process.

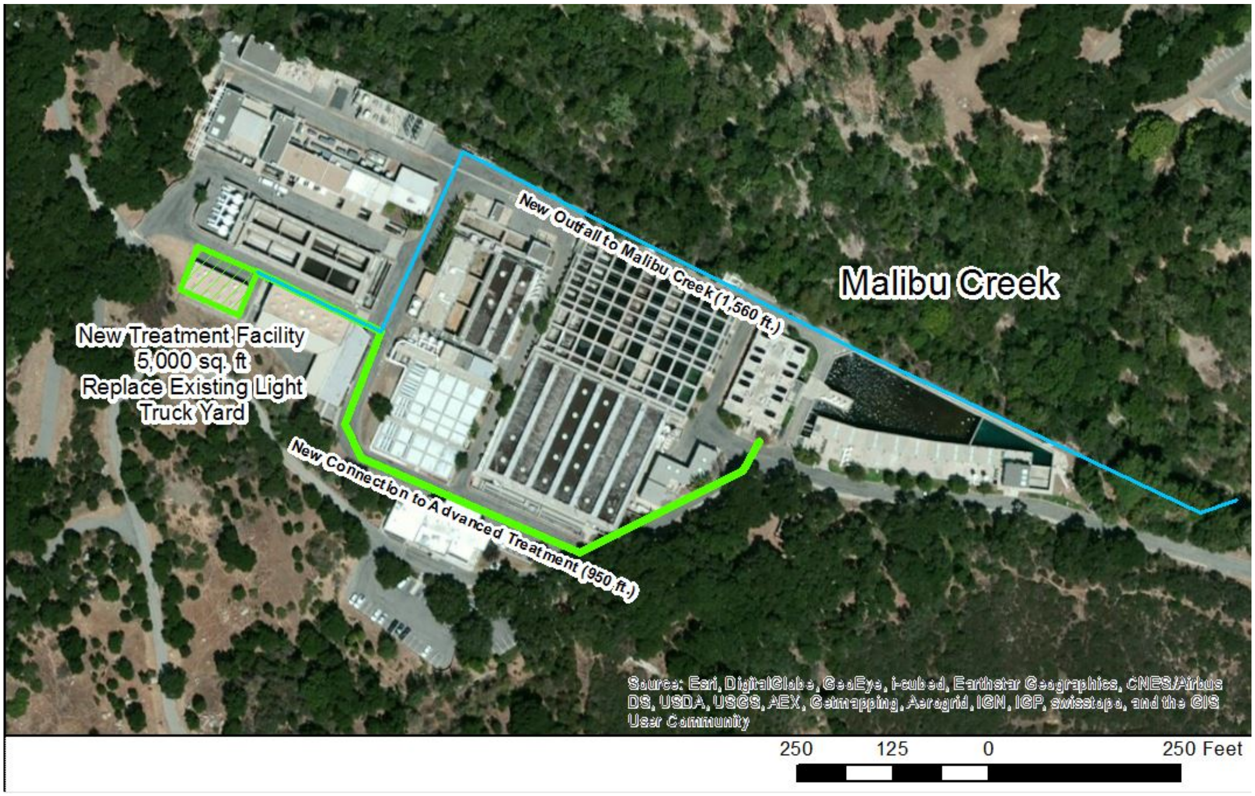

Figure 2 – Map Layout of Treatment Facility for Option 1 and Option 2.

Table 2 shows the capital cost estimates developed for Option 1. It should be noted that the cost estimates are Class V estimates and have a confidence level of -50% to +100%. The operation and maintenance (O&M) costs for Option 1 are shown in **Table 3**; the maintenance costs were assumed to be 1% of the total construction cost and adjusted for operation of 4 months a year. Although the proposed facility would be built at the Tapia WRF and is of a relatively small scale, some additional labor cost would be incurred either for an additional staff or training existing staff, which has been included in the O&M costs.

Table 2 – Capital Cost Estimate for Treatment Option 1.

Category	Cost
Sitework	$ 300,000
Canopy ($60/sq.ft. for 4,000 sq. ft.)	$ 240,000
Concrete ($45/sq.ft. for 4,000 sq. ft.)	$ 180,000
Conveyance Pipeline ($225/LF for 2,510 ft., 12" diameter pipe)	$ 565,000
Process Equipment	$ 2,025,000
Subtotal	**$ 3,310,000**
Electrical and I&C (20% of subtotal)	$ 662,000
Mechanical Installation (10% of subtotal)	$ 331,000
Overhead/Profit (15% of subtotal)	$ 496,000
Contingency (20% of subtotal)	$ 662,000
Total Construction Cost	**$ 5,461,000**
Design, Engineering and Administration Fees (20% of total construction cost)	$ 1,092,000
TOTAL	**$ 6,553,000**

Table 3 – Operation and Maintenance Costs for Treatment Option 1.

Category	Cost
Power	$ 33,300
Labor	$ 30,000
Chemical	$ 15,500
Consumables	$ 13,300
Maintenance	$ 15,100
Total	$ 107,200

Option 2 – Micro/Ultrafiltration – Reverse Osmosis – Ion Exchange

A second treatment option to achieve the water quality goals would be a process train consisting of MF/UF, RO and ion-exchange. Lack of biological process in this train provides an advantage of relatively quicker start-ups and shutdowns compared to Option 1. The MF/UF system will provide required pretreatment for the RO system with respect to particulate removal. RO system will provide approximately 60-80% removal of nitrogen species and almost complete removal of phosphate (<0.1 mg/L).

The residual nitrate in the RO permeate (< 2 mg/L-N) will be removed by an ion-exchange process downstream of the RO, thereby achieving the final effluent TN and TP goals of 1.0 and 0.1 mg/L, respectively. Approximately, 75% of the RO permeate will be treated using ion-exchange (~500 gpm) and blended with the remaining stream to meet the TN goal of 1.0 mg/L-N. The ion-exchange resins will be regenerated every 30 days. The salt waste brine (7,000 gallons of approximately 5% sodium chloride solution per regeneration) will be stored in an equalization tank, if necessary, so it can be gradually disposed to the headworks without causing a substantial increase in the chloride concentration in the effluent.

Treated effluent will be stabilized to a pH of 8.0 by adding lime in the conveyance line to the Malibu Creek. **Figure 3** shows the process schematic of the treatment train whereas **Table 4** shows the process parameters for each unit process for Option 2. It is estimated that the Option 2 will require approximately 4,000-5,000 ft^2 of space as shown previously on **Figure 2**.

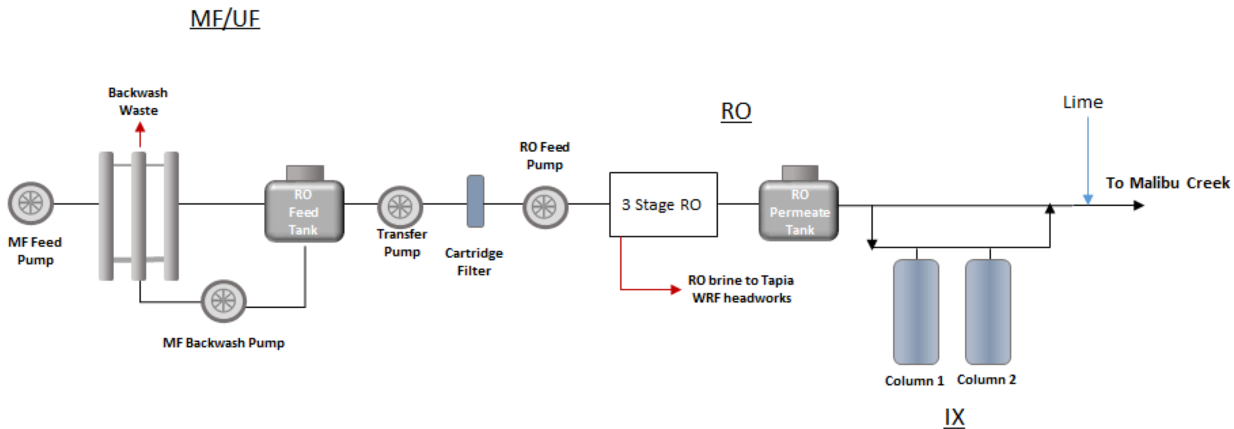

Figure 3 – Process Schematic of the Treatment Train for Option 2.

Table 4 – Process Parameters for Each Unit Process for Option 2.

Microfiltration		
Feed Flow-rate	805	gpm
Membrane Gross Flux	42	gfd
Membrane Filtrate Recovery	95	%
Membrane Area per Module	775	ft^2
Membrane Modules Required	36	
Reverse Osmosis		
Feed Flow-rate	765	gpm
Stage 1		
Flux	11.2	gfd
Number of Elements	120	
Stage 2		
Flux	10.5	gfd
Number of Elements	60	
Stage 3		
Flux	8.5	gfd
Number of Elements	36	
Overall Recovery	85	%
Ion-exchange		
Feed Flow-rate	500	gpm
Feed Nitate Concentration	1.6	mg/L-N
Lead Vessel	1	
Lag Vessel	1	
Vessel Diameter	10	ft
Resin Depth	4	ft
Resin Volume Per Vessel	314	ft^3
Total EBCT	9	min
Loading Rate	6	gpm/ft^2
Volumetric Flow	1.6	gpm/ft^3

Table 5 shows the capital cost estimates developed for Option 1. It should be noted that the cost estimates are Class V estimates and may vary from -50% to +100%. The operation and maintenance (O&M) costs for Option 2 are shown in **Table 6**; the maintenance costs were assumed to be 1% of the total construction cost and adjusted for operation of 4 months a year. Since the proposed facility would be built at the Tapia WRF and is of a relatively small scale, no additional labor cost has been included in the O&M costs.

Table 5 – Capital Cost Estimate for Treatment Option 2.

Category	Cost	
Sitework	$	300,000
Canopy ($60/sq.ft. for 4,000 sq. ft.)	$	300,000
Concrete ($45/sq.ft. for 4,000 sq. ft.)	$	225,000
Conveyance Pipeline ($225/LF for 2,510 ft., 12" diameter pipe)	$	565,000
Process Equipment	$	1,989,000
Subtotal	**$**	**3,379,000**
Electrical and I&C (20% of subtotal)	$	676,000
Mechanical Installation (10% of subtotal)	$	338,000
Overhead/Profit (15% of subtotal)	$	507,000
Contingency (20% of subtotal)	$	676,000
Total Construction Cost	**$**	**5,575,000**
Design, Engineering and Administration Fees (20% of total construction cost)	$	1,115,000
TOTAL	**$**	**6,690,000**

Table 6 – Operation and Maintenance Costs for Treatment Option 2.

Category	Cost	
Power	$	24,100
Labor	$	30,000
Chemical	$	16,100
Consumables	$	35,300
Maintenance	$	16,100
Total	$	121,600

Option 3 – Malibu Creek Augmentation with Potable Water

An alternative to the treatment options would be use of potable water to augment Malibu Creek. LVMWD will use potable water purchased from Metropolitan to augment the flow to Malibu Creek. **Figure 4** illustrates the location of the proposed pipeline to supply water to the creek. For a maximum flow of 1 MGD, an 18-inch diameter pipe is recommended and the estimated length of pipe required is approximately 1,200 ft. An 18-inch diameter pipe was selected to provide sufficient contact time for breakpoint chlorination. Based on the construction cost of $250 per liner foot of pipe, the construction cost estimate is summarized in **Table 7**.

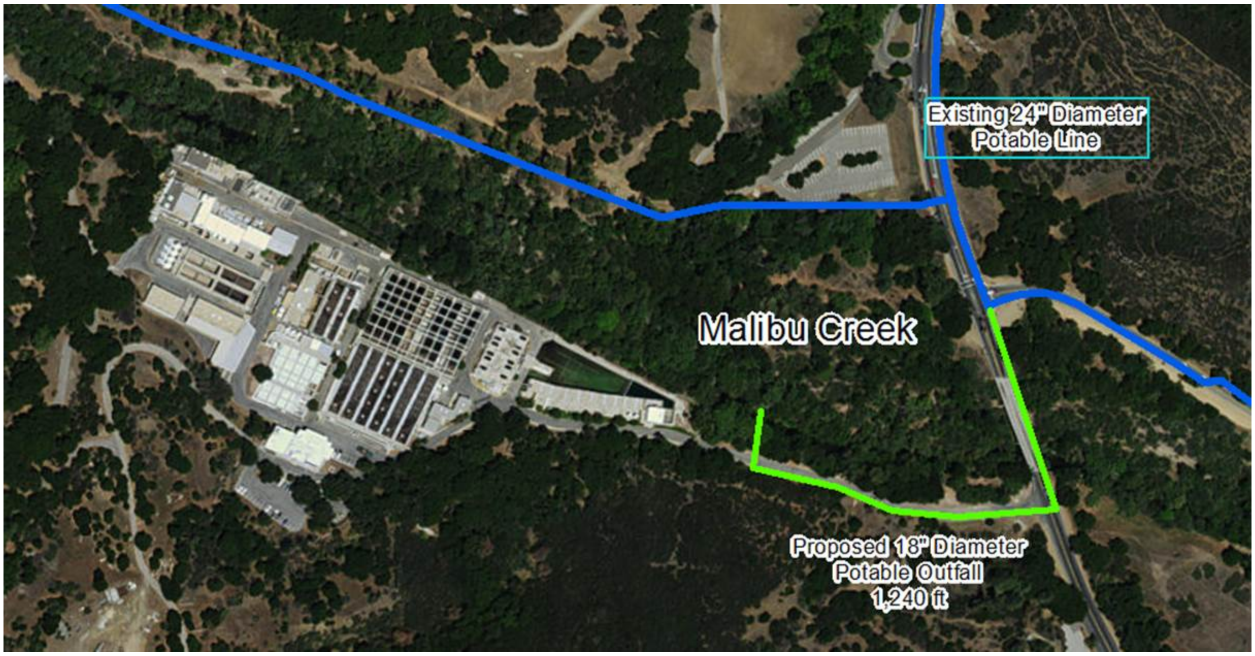

Figure 4 – Proposed 18" pipeline to carry potable water to Malibu Creek.

Table 7 – Capital Cost for the Option 3.

1,200 ft. 18" diameter Pipeline ($250/linear ft.)	$300,000
Pressure Reducing Valve	$50,000
Analyzers, Injection Systems for Breakpoint Chlorination and Chlorine Neutralization	$100,000
Contingency 25%	$87,500
Engineering and Administration 10%	$35,000
Total Capital Cost	**$572,500**

Volume of Water Required

Between 2013 and 2015, LVMWD released much higher amounts of augmentation flow to Malibu Creek than in previous years due to drought conditions in Southern California. Since 2007, the maximum amount released in a single year to meet endangered species flow requirements was approximately 84 MG, which occurred in 2013. The maximum flow released in a single month during that period was in September 2013 at 23.5 MG. Historical augmentation flows to Malibu Creek are shown in **Table 8**. Based on average augmentation flows from 2007 to 2015, LVMWD should anticipate approximately 28 MG of water per year to release to Malibu Creek.

The Jensen Plant, operated by Metropolitan Water District (MWD), provided an average of 76% of the potable water delivered to Las Virgenes during 2014-2015, whereas the remaining water was supplied by MWD's Weymouth Plant. During this period, the average ammonia and nitrate concentrations in the Jensen Plant effluent were 0.51 and 0.75 mg/L-N respectively, whereas those concentrations for the Weymouth Plant effluent were 0.54 and 0.22 mg/L-N, respectively. The ammonia concentrations in these effluents cause the TN concentration to get close or exceed the TN limit for the Malibu Creek and therefore treatment of the potable water is required.

Considering the simplicity of treatment, breakpoint chlorination would be an ideal treatment for removal of ammonia. Based on the maximum flow of 650 gpm anticipated in the 18" pipeline, the retention time in the pipe would be approximately 25 minutes. For 0.6 mg/L-N of ammonia concentration in the potable water, a chlorine dose of 6.5 mg/L would be sufficient. The residual free chlorine will be quenched using sodium bisulfite. The total chemical cost is estimated to be approximately $5,000 per year. The sodium hypochlorite will be added at the beginning of the proposed 18" pipeline to the Malibu Creek whereas sodium bisulfite will be added just before the end of the pipeline. Following the removal of ammonia, it is anticipated that the TN limits of less than 1 mg/L will be met.

Table 8 – Historical Augmentation Flow Released to Malibu Creek.

	Augmented Flow (MG)								
	2007	2008	2009	2010	2011	2012	2013	2014	2015
April 15th-30th	0	0	0	0	0	0	0	0	0
May	0	0	0	0	0	0	1.97	0	0
June	0	0	0	0	0	0	6.34	5.92	3.50
July	0	0	0.92	0	0	0	15.39	13.27	11.69
August	0	0	0	0	0	0	14.73	16.76	17.19
September	0.55	0.58	5.67	0	0	0	23.54	17.72	17.45
October	0	0	2.58	0	0	0	15.9	16.97	18.35
November 1st-14th	0	0	0	0	0	0	6.21	8.28	8.17
Total Flow (MG)	0.55	0.58	9.17	0	0	0	84.08	78.92	76.35
					Average Flow (MG) 2007-2015				**27.74**

Based on LVMWD's fiscal year 2015-16 budget, the unit cost of water imported from Metropolitan is $1,155 per acre-foot. This cost takes into account variable costs from MWD based on projected purchases. **Table 9** summarizes the estimated cost of potable water plus the treatment cost based on the maximum annual flow released from 2007-2015 (84 MG) over a 10 year period. It is assumed that the Metropolitan imported water cost will have an inflation value of 4% escalating each year, which is displayed in **Table 9** for a period of 10 years.

Table 9 – Estimated Escalated Annual Cost of Imported Water Plus Treatment Cost for Malibu Creek Augmentation.

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Imported Water Cost	$301,900	$314,000	$326,500	$339,600	$353,200	$367,300	$382,000	$397,300	$413,100	$429,700
Unit Cost (per MG)	$3,545	$3,687	$3,834	$3,988	$4,147	$4,313	$4,486	$4,665	$4,852	$5,046

SUMMARY

Table 10 summarizes the capital and annual costs for all three options. The capital cost for implementing treatment options to meet the stringent TN and TP limits of 1.0 and 0.1 mg/L, respectively range from $6.55 to $6.69M whereas the cost to construct a pipeline to augment the Malibu Creek costs roughly $572K. The O&M costs for the treatment options 1 and 2 are expected to be approximately $77.2K and $91.6K, respectively. On the contrary, the cost to purchase the required potable water from Metropolitan and provide breakpoint chlorination on site is estimated at $296.9K for the first year. Despite a higher annual cost for purchasing potable water compared to the O&M costs for the treatment options, the substantially higher capital costs for the treatment options make them less attractive.

Table 10 – Capital and O&M Costs for Evaluated Options.

	Capital Cost	Annual Cost
Option 1: MBR-RO	$ 6,553,000	$ 77,200
Option 2: MF/UF-RO-IX	$ 6,690,000	$ 91,600
Option 3: Potable Water + Breakpoint Chlorination	$ 572,000	$ 296,900