Las Virgenes – Triunfo Joint Powers Authority
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January 19, 2011

Call and Notice of Special Meeting of the Governing Board of the
Las Virgenes - Triunfo Joint Powers Authority

A Special Meeting of the Governing Board of the Joint Powers Authority is hereby called, and notice of said Meeting is hereby given for 4:00 p.m. Monday, January 24, 2011 at Oak Park Library, 899 North Kanan Road, Oak Park, California 91377 to consider the following:

1 Call to Order and Roll Call

2 Tapia WRF Alternative Disinfection

3 Adjourn

By Order of the Board of Directors
CHARLES CASPARY, Chair

John R. Mundy
Administering Agent General Manager
Joint Powers Authority

c: Each Director

January 24, 2011 JPA Board Meeting

TO: Board of Directors

FROM: Facilities and Operations

Subject **Tapia Water Reclamation Facility Alternative Disinfection Study: RWQCB Work Plan**

SUMMARY

On September 2, 2010, the Regional Water Quality Control Board (RWQCB) approved the renewal of the National Pollutant Discharge Elimination System (NPDES) permit for the Tapia WRF. The new permit included a Cease and Desist Order (CDO) and Time Schedule Order (TSO) to assure a reduction in the concentrations of constituents known as disinfection by products (DBPs). The CDO addresses one DBP, dichlorobromomethane (DCBM), which has a final effluent limit of 46 μg/L and an interim limit of 62 μg/L. The TSO addresses the sum of the concentrations of four DBPs, dichlorobromomethane (DCBM), dibromochloromethane (DBCM), chloroform and bromoform. The sum of the concentrations of these four constituents is called the total trihalomethanes, or TTHMs. The TTHM interim limit is 154 μg/L and the final limit is 80 μg/L. TTHM limits only apply to discharge to the Los Angeles River (due to Title 22 regulations), while DCBM limits apply to both Malibu Creek and Los Angeles River discharge (due to California Toxic Rule regulations).

Both the CDO and TSO give the same compliance schedule. Since the alternative disinfection technology requires substantial planning, construction and permitting, final effluent limits must be met by September 3, 2014. The CDO and TSO also require the submittal of reports and updates to the RWQCB. The submittal of a work plan to evaluate, select and implement an alternative disinfection technology is due by February 2, 2011. The work plan is required to include:

1. A time schedule that ends as soon as possible but no later than September 2, 2014.
2. A description of the alternative disinfection technology to be utilized.
3. A schedule for the design and installation of the alternative disinfection technology.
4. A schedule to optimize and evaluate the performance of the alternative disinfection technology with a deadline no later than September 2, 2014.

At the December 6, 2010, JPA meeting, the Tapia WRF Alternative Disinfection Study was awarded to MWH. MWH has completed a technical memorandum (attached) which evaluates four different alternative disinfection technologies as well as a hybrid using two of the technologies. The technologies evaluated are ultra-violet disinfection, ozone, mixed oxidants and modified chlorination. The hybrid system consists of ultra-violet disinfection and modified chlorination. These technologies were screened using the following criteria:

- Extent of facility modifications.
- Ability to meet future regulations.

- Impact upon operations.
- Space requirements.
- Capital cost.
- Operations and maintenance cost.
- Ability to meet permit compliance schedule.
- Impact upon effluent water quality.

The screening resulted in the decision to further consider either modified chlorination or the hybrid system. Both of these alternatives will meet final permit limits and can be implemented within the required time frame. The recommendation of MWHs' technical memorandum is sufficient to complete the required work plan by the February 2, 2011, deadline. However, the JPA needs to further consider the capital, O&M and long term costs of the two alternatives. These alternatives will be further evaluated at the February 7, 2011, JPA meeting.

FINANCIAL IMPACT

The FY 2010-11 budget provides funding in the amount of $50,000.00 for this study under CIP Job No. 10457, Tapia Alternative Disinfection Study. Each JPA partner is allocated with a cost split of 70.6% for LVMWD and 29.4% for Triunfo.

Brett Dingman, Reclamation Manager, prepared this report.

1/19/11

David R. Lippman — Date
Director, Facilities and Operations

1/19/11

John R. Mundy — Date
General Manager

TECHNICAL MEMORANDUM

To:	Brett Dingman	**Date:**	January 18, 2011
From:	Roger Stephenson Sarah Munger Jamal Awad	**Reference:**	1010371
Subject:	Concept-Level Evaluation of Disinfection Alternatives for Tapia DRAFT	**Client:**	Las Virgenes Municipal Water District/Triunfo Sanitation District Joint Powers Authority

INTRODUCTION

The Las Virgenes Municipal Water District/Triunfo Sanitation District Joint Powers Authority (JPA) operates the Tapia Water Reclamation Facility (Tapia). In September 2010, a new National Pollutant Discharge Elimination System (NPDES) permit for Tapia was adopted. The new NPDES permit includes a cease and desist order (CDO) for the discharge of Dichlorobromomethane (DCBM) to the Los Angeles River and Malibu Creek and a Time Schedule Order (TSO) for Total Trihalomethanes (TTHMs) for discharged to the Los Angeles River. The JPA has entered into a contract with MWH to investigate alternative disinfection technologies that may be implemented to reduce the DCBM and TTHMs in Tapia's treated effluent. The purpose of this Technical Memorandum is to document the investigation into the four alternative disinfection technologies that may be implemented at Tapia namely mixed oxidants, ultraviolet light (UV), ozone and chloramination.

BACKGROUND

Tapia uses the following treatment processes: coarse screening, grit removal, primary sedimentation, activated sludge secondary treatment, filtration, chlorination, and dechlorination. Tapia uses an activated sludge process with nitrification and denitrification (NDN) with secondary clarification. The tertiary treatment process consists of filtration through anthracite media. Chlorination and dechlorination are accomplished through the use of sodium hypochlorite and sodium bisulfite. A general process flow diagram for the treatment plant is shown on **Figure 1**. The filtration and disinfection facilities are illustrated in more detail on **Figure 2**.

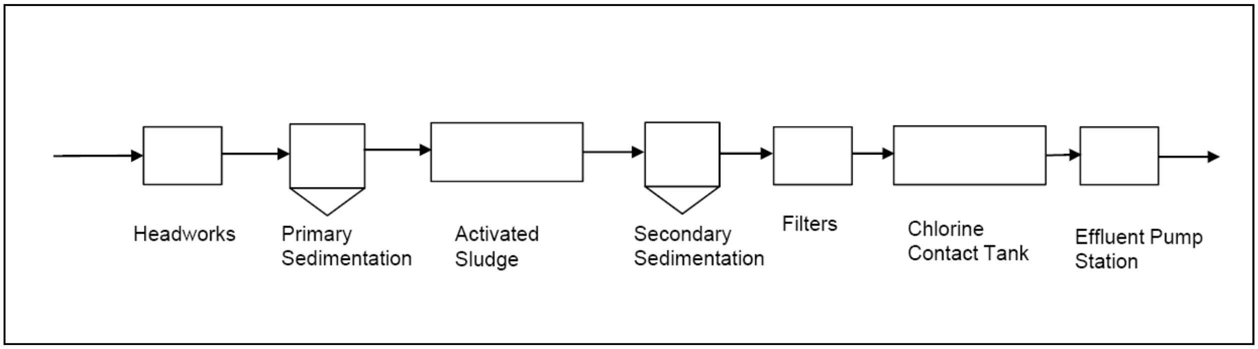

Figure 1
Tapia Process Flow Diagram

Tapia currently treats approximately 9.5 mgd, which is reused or discharged to the Los Angeles River (outfall 005) or Malibu Creek (outfall 001). Reuse of 60 percent of the tertiary effluent produced annually is achieved through an extensive recycled water system. Although the facility is rated at 16.1 mgd, nutrient removal planning efforts over the last 10 years have considered 12 mgd as the necessary maximum capacity for the foreseeable future. Non-recycled effluent is disposed of by discharging to the Los Angeles River (outfall 005), Malibu Creek (outfall 001) or by the use of JPA operated spray fields. The Malibu Creek discharge is only allowed from November 15th to April 15th each year. Discharge to Malibu Creek and the Los Angeles River are regulated under a NPDES permit issued by the Los Angeles Regional Water Quality Control Board (Regional Board).

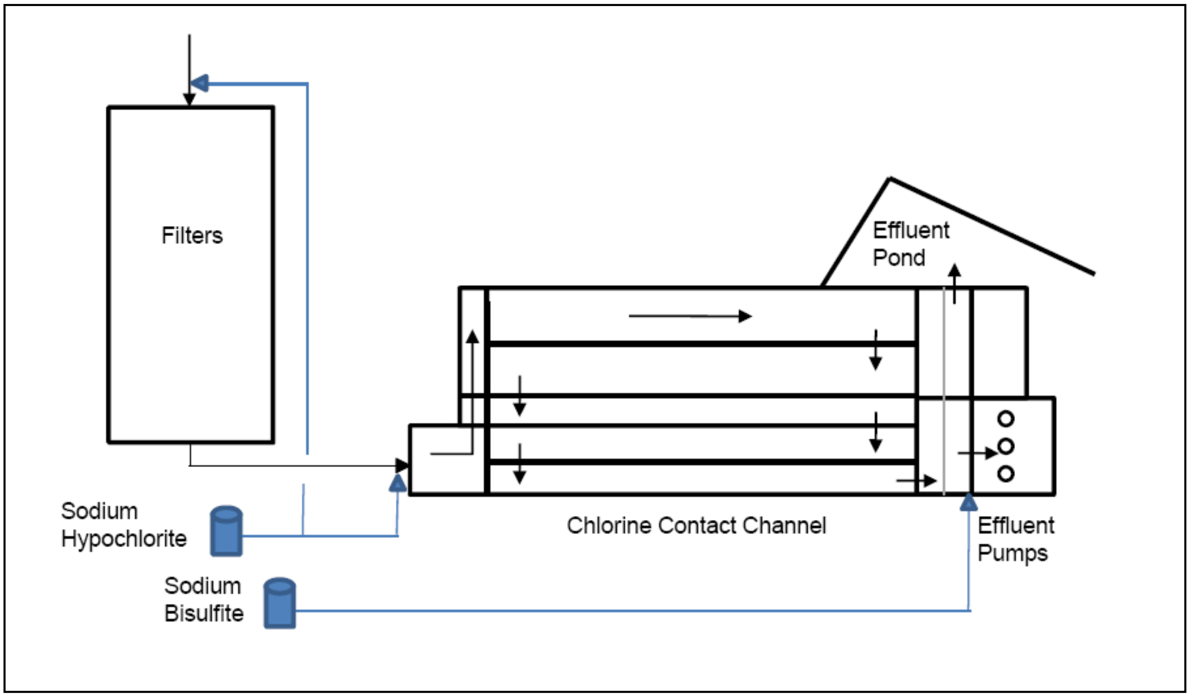

Figure 2
Tertiary Process Flow Diagram

When chlorine is added to wastewater it oxidizes organic matter and this results in the formation of disinfection by-products that include THMs. There are four trihalomethane (THM) compounds that are regulated under the NPDES permit: Dichlorobromomethane (DCBM), dibromochloromethane (DBCM), chloroform, and bromoform. The TTHM limit set forth in the NPDES permit is the sum of these four THMs.

The Regional Water Quality Control Board adopted an NPDES permit for the Tapia WRF in 2005 that included an interim average monthly effluent limit for DCBM of 62 mg/l and a final limit of 46 mg/l. DCBM levels were in compliance with both the interim and final limit and trending downward until April of 2008 when construction of the BNR upgrades at Tapia WRF and Rancho Las Virgenes Composting Facility began. New BNR facilities were placed into service in August and September of 2009 and construction was completed in October 2009. DCBM levels have remained at elevated levels since the completion of BNR construction. As a part of the 2010 NPDES permit issued by the RWQCB, a Cease and Desist Order for DCBM and a Time Schedule Order for TTHM were issued. TTHM limits only apply to L.A. River Discharge while DCBM limits apply to all discharge points. **Figure 3** and **4** present DCBM and TTHM concentrations, respectively, from 2005 to the present.

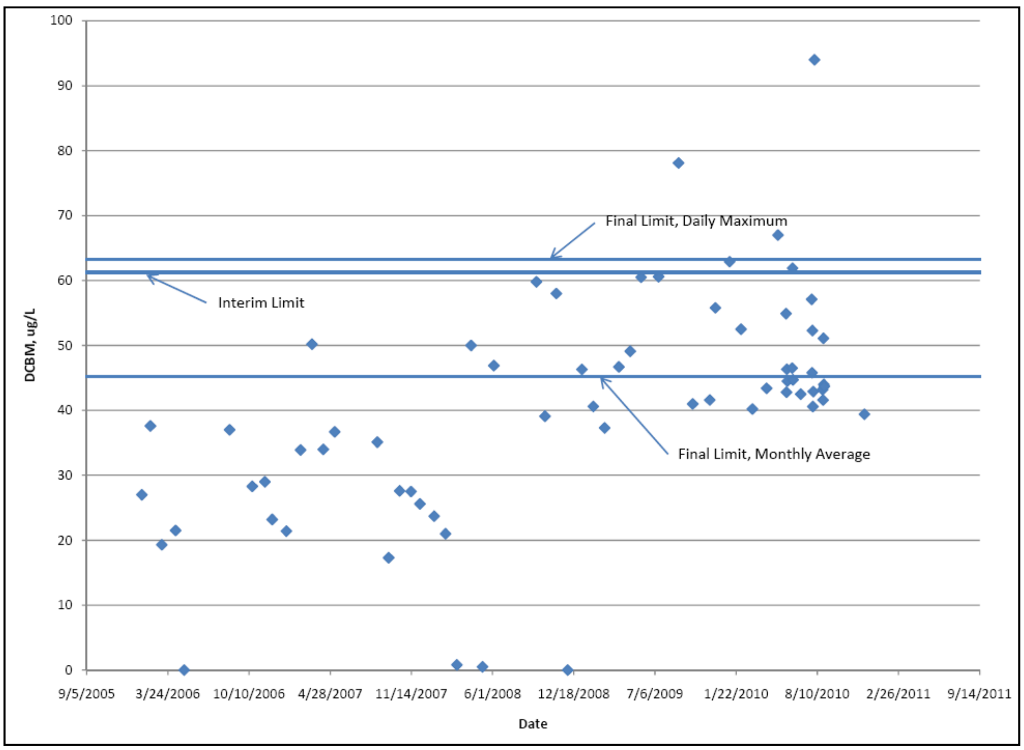

Figure 3
Plant Effluent Data for DCBM

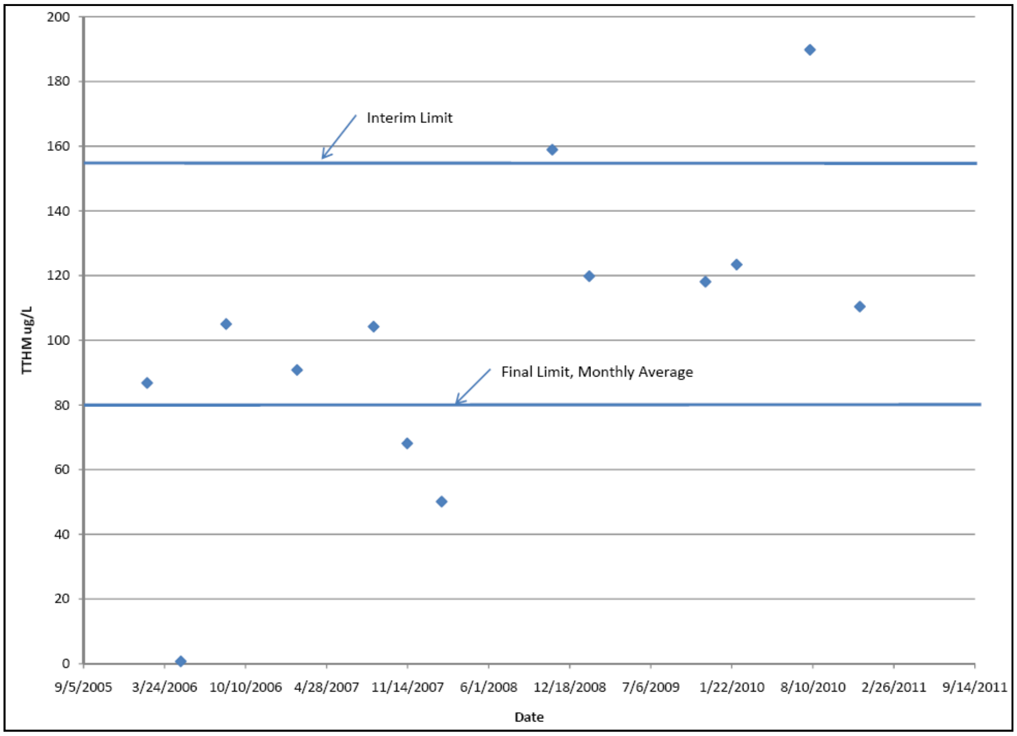

Figure 4
Plant Effluent Data for TTHM

The interim and final limits of the 2010 permit are tabulated in **Table 1** below. The final limit for discharge of TTHM to the Los Angeles River is the current drinking water standard for that parameter. TTHMs in drinking water are regulated by the EPA through the Stage 1 Disinfectants and Disinfection Byproducts Rule.

Table 1
Tapia Discharge Limits for DCBM and TTHM

Discharge	**Interim Limit, µg/L**	**Final Limit, Monthly Average, µg/L**	**Final Limit, Daily Maximum, µg/L**
Los Angeles River			
DCBM	62	46	64
TTHM	154	80*	N/A
Malibu Creek			
DCBM	62	46	64
TTHM	N/A	N/A	N/A

*80 **µ**g/L = Drinking Water Standard

Both the CDO and the TSO have common schedules for compliance with options based upon the technology selected. Easy-to-implement technologies, which require a process change or replacement without substantial construction and permitting, such as mixed oxidants as specifically indicated in Regional Board documentation, would have required a work plan to be submitted for approval by December 2, 2010. That work plan was to have included a schedule to optimize and evaluate the performance of the technology by March 2, 2012.

Technologies that require design, construction, permitting, and other substantial activities, require a work plan to be submitted for approval by February 2, 2011 and include a schedule to optimize and evaluate the performance of the technology by September 2, 2014.

The JPA has considered the use of UV disinfection in the past and that was the purpose of two prior studies, one conducted in 1994 and the other in 1998. The 1994 study recommended a low pressure, low intensity system. That study recommended that the UV disinfection system be installed in the chlorine contact channels. In 1998, disinfection alternatives were further evaluated. That study recommended that a medium pressure UV system be installed in the chlorine contact channels. Based on visits to local installations by JPA staff, medium pressure technology was eliminated as a viable option. That resulted in the conversion from the then gaseous chlorine and sulfur dioxide system to the use of bulk liquid sodium hypochlorite and sodium bisulfite.

The purpose of this Technical Memorandum is to document the current investigation into four alternative disinfection technologies that may be implemented to reduce the DCBM and TTHM: mixed oxidants, UV, ozone and chloramination. A fifth alternative that results from combining UV disinfection with continued use of the existing disinfection system is also presented.

DISINFECTION TECHNOLOGIES

There are two basic methods that can be used to reduce effluent THMs at Tapia: (1) implement an alternative disinfection technology, or (2) modify the existing chlorination practice. Alternative disinfection technologies that will be considered are UV and ozone. The use of mixed oxidants and chloramination are both modifications to the existing practices at Tapia. The Regional Board specifically indicated the use of "mixed oxidants", as an example alternative. The generation of mixed oxidants is achieved through the electrolytic generation of chlorine and, therefore, is a modification to the existing chlorination practice. These four alternatives are presented and discussed below with an assessment of their positive and negative attributes.

UV Disinfection

UV disinfection uses UV light radiation to penetrate the cell wall of the organism and destroy the cell's ability to reproduce. The source of UV radiation is either a medium-pressure or low-pressure mercury arc lamp with low or high output. There are various configurations for UV systems that are characterized by the type of UV lamp employed, and whether the UV reactor is an enclosed unit within a pipeline (in-line), or configured within an open channel. UV lamps are either:

- Medium pressure (MP)
- Low pressure, high output (LPHO), or
- Low pressure, low intensity (LPLI).

An LPHO, open channel system is shown on **Figure 5**.

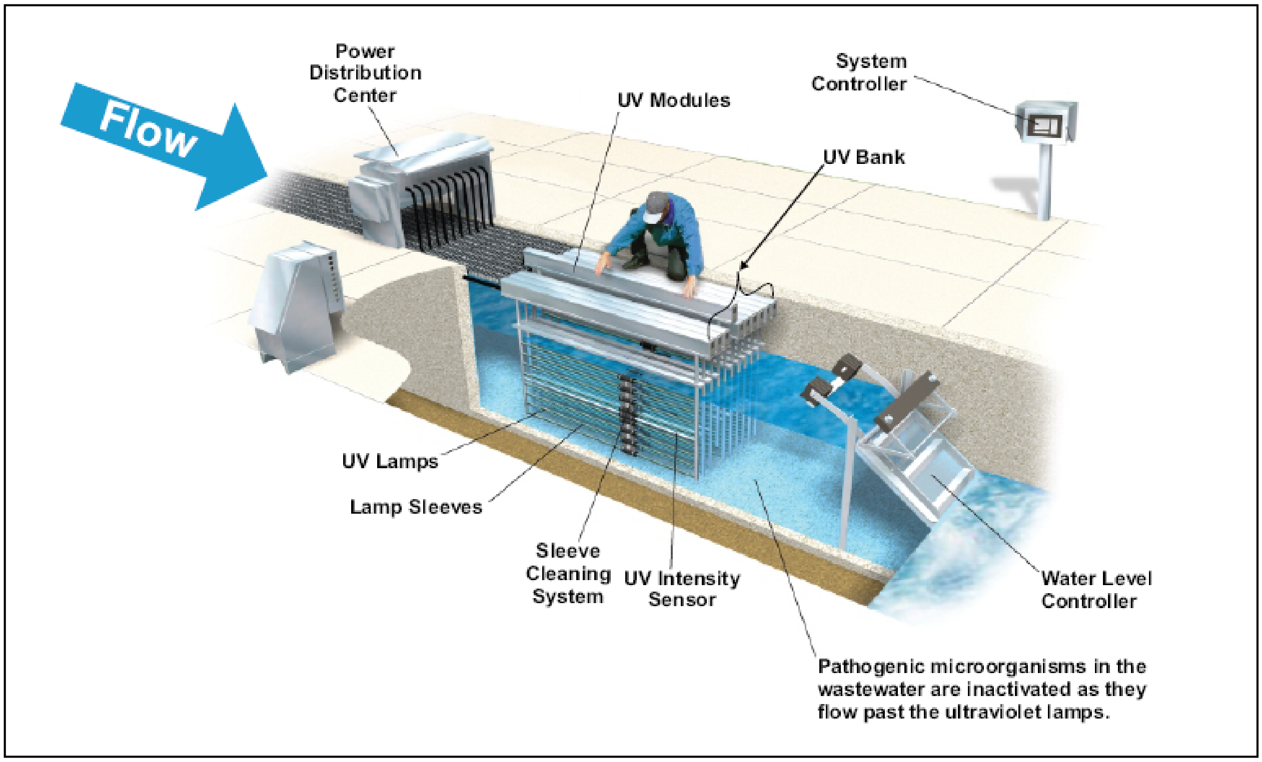

Figure 5
Open Channel UV Process

A UV system must go through a validation and acceptance procedure approved by the California Department of Public Health (CDPH) to verify that the UV system is meeting the disinfection requirements for compliance with the California Recycled Water Criteria of Title 22 of the State Code. Some of the UV systems have already been conditionally accepted by CDPH and are listed in "Treatment Technology Report for Recycled Water" issued by the State of California Department of Public Health, Division of Drinking Water and Environmental Management (2009).

The LPLI in-channel systems have been in use locally for nearly two decades and represent the first UV technology applied to wastewater disinfection. These systems are composed of racks or banks of UV lamps that consume 88 watts per lamp. They have a limited ability to change the amount of UV radiation emitted: each bank of lamps is either on or off. These systems were not developed with mechanical, self-cleaning features. Given the limited flexibility of these systems, LPLI UV systems are limited to very small facilities (e.g., <1 mgd) and are not considered an option for Tapia.

LPHO open channel UV systems are currently in use in California. This system would consist of mercury lamps, a reactor and the ballasts, which all make up a module. The module would be placed in a channel with flow parallel to the length of the module. The high output system uses lamps of 250 to 500 watt per lamp. The high output system also allow the bulbs to dim to reduce power consumption if there is a drop in flow or an increase in water clarity.

LPHO, in-line UV systems are currently being developed, but have not yet been tested and certified by the CDPH for Title 22 disinfection applications such as at Tapia. Although such in-line systems offer the potential for reduced structural costs and improved hydraulics, the necessary modifications to incorporate an in-line system within the existing facilities at Tapia might outweigh these benefits Further, until the CDPH has certified the system and bioassay testing is conducted, there is no definitive basis to design such a system for specific requirements. The status of in-line UV systems, however, should be monitored for application in the future as that technology matures.

Recently a LPHO system was introduced to the market that uses a 1000 watt lamp, rather than the conventional 250 -350 watt lamp. This system would save in construction costs, as well as power consumption. Unfortunately, this system has not been certified by CDPH and is currently undergoing bioassay testing.

MP UV systems are more suitable for water treatment than for recycled water applications because the required UV dose is lower for water treatment disinfection and therefore fewer lamps are required. Several disadvantages make MP UV systems a poor choice for application at Tapia. First, currently only one medium pressure, in-line UV system has been approved for Title 22 regulations, and high costs would be required for getting other system approved. Second, the medium pressure system is not as energy efficient and less operationally cost effective because they operate at higher temperatures. Third, but not the least significant, is that part of the spectrum of wavelengths produced by medium pressure lamps is conducive to the growth of algae that can degrade the effectiveness of UV disinfection. At the doses needed for recycled water production and with the presence of nutrients, algae growth within a medium pressure UV reactor is a chronic problem.

LPHO open-channel UV system represent the most current and applicable UV technology that could be employed at Tapia, and is the recommended technology to compare to other disinfection alternatives for this study.

Ozone

Ozone (O_3) and its associated free radicals, such as the hydroxyl radical, are strong oxidants which can oxidize many organic and inorganic compounds. This results in ozone being an effective oxidant as well as a disinfectant. Ozone is effective against bacteria and viruses, and provides some protection against microbial cysts and eggs. Recent research has also shown that ozone effectively removes a large number endocrine disrupting compounds (EDCs) and pharmaceuticals and personal care products (PPCPs) that are not removed by biological treatment processes. Similar to chlorine disinfection, ozone disinfection depends on the ozone residual and the reaction time. The ability to maintain the dissolved ozone concentration is critical to achieve disinfection and factors that accelerate ozone decomposition are undesirable because the ozone residual dissipates fasters requiring an increase in ozone dose and therefore increases operating costs. Due to safety concerns it is recommended that ozonation system equipment be isolated in its own room with heating and ventilation system and separate exterior entrances.

Ozone is effective at inactivating bacteria, viruses, parasites and parasite cysts in a relatively short contact time. Other advantages of ozone are; rapid decomposition, no chlorinated disinfection byproduct formation, minimal regrowth of microorganisms, little increase in total dissolved solids (TDS), and the potential to oxidize trace organic pollutants of emerging concern such as PPCPs and EDCs.

An ozone disinfection process requires an oxygen supply system, ozone generators, power supply units, ozone gas concentration monitors, contact tanks, ozone off-gas handling and residual ozone gas destruction system, and the associated monitoring equipment. A general process flow diagram is shown on **Figure 6**.

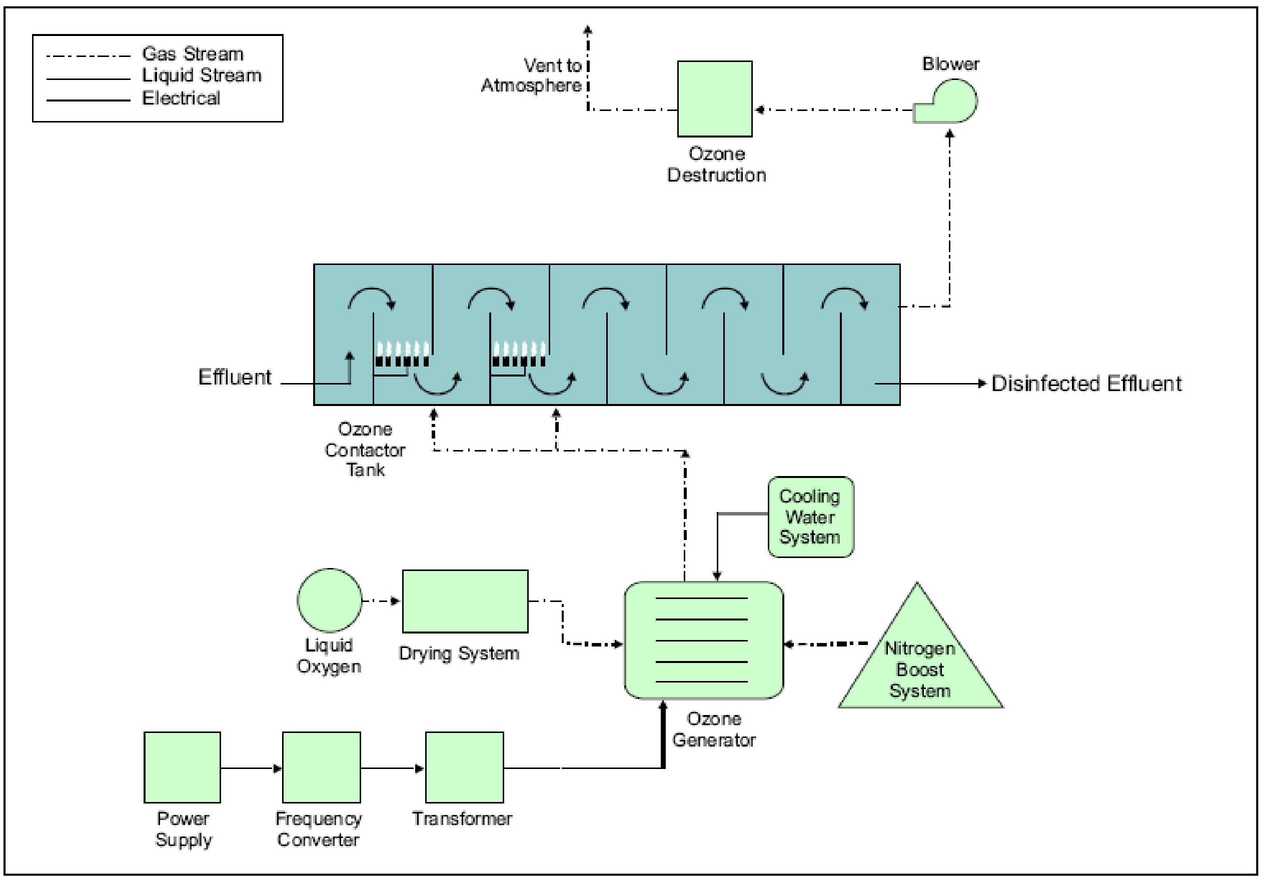

Figure 6
Ozone Disinfection Process

An ozone system would require significant area, which is difficult to accommodate on a site as constrained at Tapia. Other disadvantages include: ozone is reactive and corrosive which requires the use of corrosion resistant materials and the treatment of concrete surfaces, no sustainable disinfection residual, and the system is relatively complex to operate and maintain.

The use of ozone has the potential to generate disinfection byproducts, such as bromate, which are potentially harmful to human health and the low ozone dosages may not effectively inactivate some viruses, spores and cysts. Finally CDPH has not approved ozone as a disinfection technology and there would be considerable costs associated with the testing for CDPH approval.

Mixed Oxidants

Mixed oxidants as a disinfection process is one that is similar to the existing chlorination process employed at Tapia, except that in addition to hypochlorite, other constituents, such as ozone, are present in small amounts, hence the term “mixed oxidants.”

Sodium hypochlorite can be generated using an electrolytic process with equipment that would be located at Tapia. This is referred to as on-site hypochlorite generation. The process uses high purity, food-grade salt that is dissolved forming brine and fed to hypochlorite generators. The hypochlorite that is produced is at a concentration of 0.8 percent versus the 12 percent hypochlorite solutions available in bulk. Other constituents such as chlorine, chlorine dioxide, hydrogen peroxide, ozone and hydroxyl radicals, are claimed to be present in small amounts, hence the term “mixed oxidants.” This system requires a water softener, salt storage/brine tanks, brine feed pumps hypochlorite generators, hypochlorite day tanks, metering pumps, an acid cleaning system and an emergency power system. A general equipment illustration is presented as **Figure 7**.

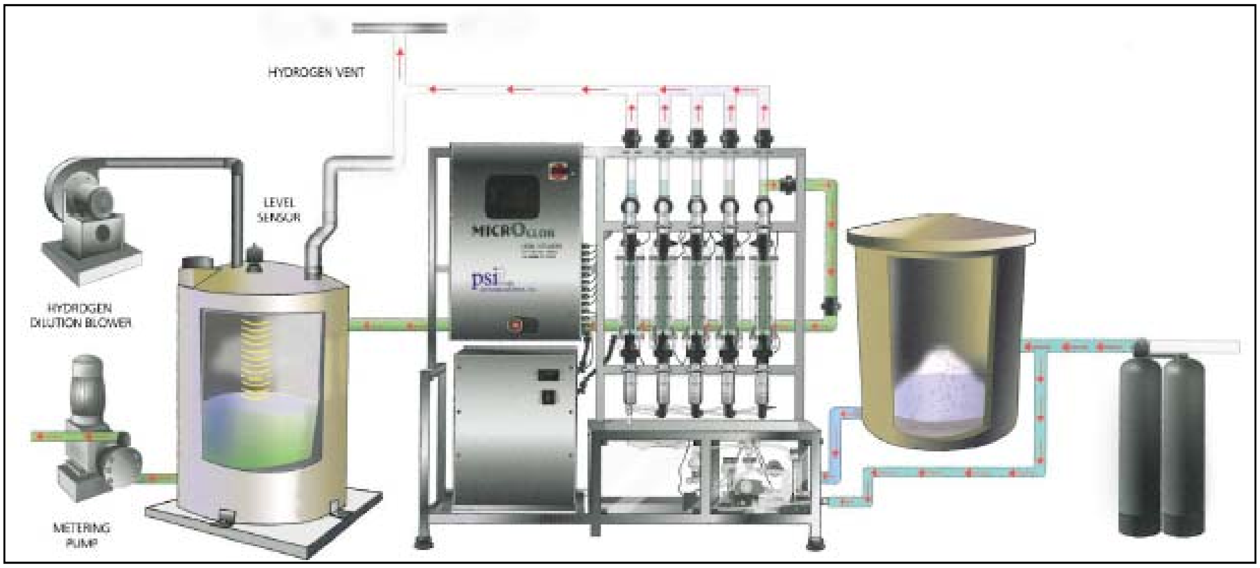

Figure 7
On-Site Sodium Hypochlorite Generation System

This system would require significant area for salt and brine storage, which is difficult to accommodate on a site as constrained as Tapia. Another disadvantage to this system is that the salt would have to be trucked to Tapia. Testing should be conducted to confirm TTHM reduction with this approach.

On-site sodium hypochlorite generation was included in the 1998 Alternative Disinfection Evaluation, and at the time, this alternative was assumed to be cost prohibitive when compared to trucking sodium hypochlorite on site.

The Regional Board specifically identified “mixed oxidants” as an option that requires a process change or replacement without substantial construction and permitting activities. Under this option JPA would have been required to submit a work plan to the Regional Board by December 2, 2010. However, given the time frame required by the Regional Board and the amount of equipment that would need to be provided, the use of mixed oxidants is not recommended for further consideration.

Modified Chlorination

The existing disinfection facilities at Tapia consist of bulk sodium hypochlorite storage and feed systems and a chlorine contact tank. Sodium bisulfite is used for dechlorination prior to discharge. THM formation during chlorination is a function of the presence of precursor compounds, the chlorine dose and the contact time. Chlorination in the presence of ammonia produces chloramines. These compounds are disinfectants, but they are less effective than free chlorine. Chloramines do, however, limit the formation of THMs. Currently the Tapia activated sludge process completely nitrifies and without ammonia in the effluent, only free chlorine is present. THM formation can be controlled by limiting the free chlorine dose or contact time, by the introduction of chloramines, or by a combination.

MWH conducted bench tests on secondary effluent from Tapia collected before and after filtration. Tests were conducted with the addition of preformed chloramines to represent a case with minimum TTHM formation. The results, **Figure 8**, represent, from left to right; 1) the addition of 15 mg/L NH_2Cl (as CL_2), 2) chlorine addition prior to filtration with 7.5 mg/L free chlorine, and then the addition of 7.5 mg/L NH_2Cl, and 3) chloramine addition prior to filtration with 7.5 mg/L NH_2Cl, and then 7.5 mg/L free chlorine post filtration.

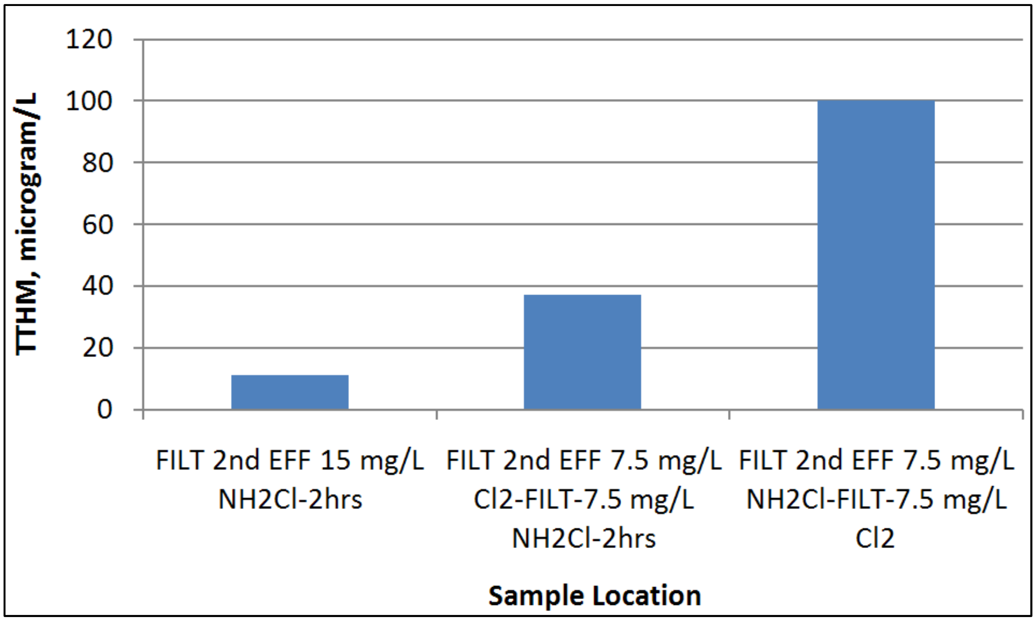

Figure 8
Bench-scale TTHM Formation Results

These results demonstrate that disinfection with only chloramines quite effectively limits the formation of THMs. This is, however, not a viable solution for two primary reasons. First, because chloramines are not as effective as free chlorine, greater contact time or much higher dosage might be required for equivalent bacterial or virus removals compared to free chlorine. Second, when the effluent is dechlorinated prior to discharge, the nitrogen component of chloramines is released as ammonia in the amount of roughly 1 mg/L NH_3 per mg/L NH_2Cl and the effluent ammonia limits would be exceeded.

These data do, however, show that with the sequential addition of free chlorine pre filtration, followed by the addition of chloramine post filtration, TTHM formation was limited to 40 mg/L. This is referred to as modified chlorination, which has brought both the TTHM and DCBM to within the permit limits.

Adding chlorine pre filtration, and chloramines post filtration, is an approach to control disinfection byproducts that is termed “sequential chlorination” by the Los Angeles County Sanitation Districts (LACSD) and is a process to which they hold a recently issued patent. Though patented, it is understood that LACSD’s intent is that sequential chlorination can be used by public agencies for the good of the public without the payment of royalties.

Modified chlorination as envisioned for Tapia would allow for chloramines addition either pre or post filtration. The advantages are minimum impact to the existing treatment process, minimum additional equipment required, low cost, and it would allow for a combined-chlorine residual but limit THM formation while not jeopardizing ammonia discharge limitations.

The disadvantages of modified chlorination are that it is weaker than other disinfectants, has the potential to form NDMA, and the addition of ammonia may enhance biofilm growth in transmission lines. The concern over the addition of ammonia exceeding permit limits may be mitigated by monitoring the ammonia levels in the effluent through the use of an ammonia analyzer. Adjustments can be made to the dosing location or the amount as the ammonia approaches the permit limits. **Figure 9** presents effluent ammonia data for the past year at Tapia. With the exceptions of a few spikes, the effluent ammonia concentrations have remained well below the limits.

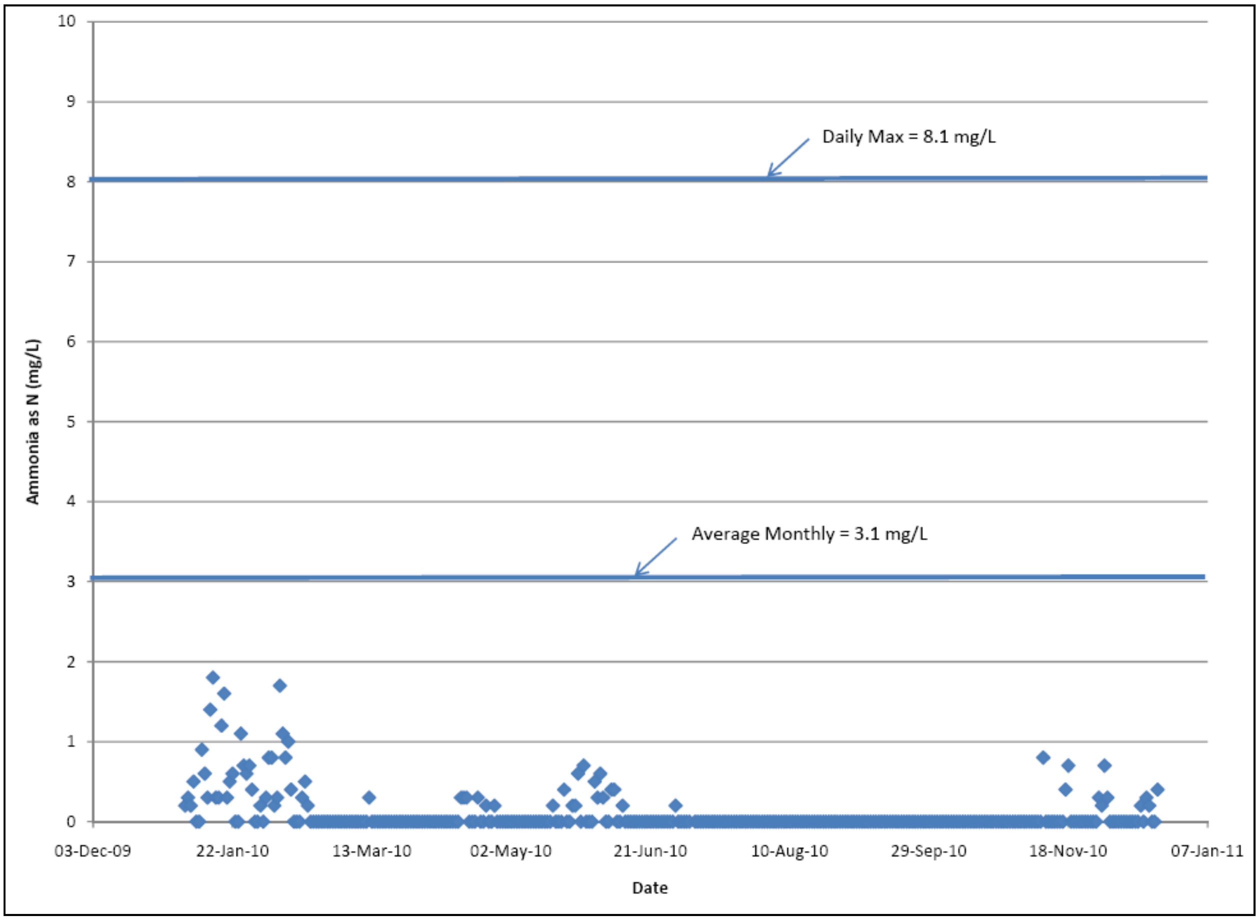

Figure 9
2010 Effluent Ammonia Data

Facilities that would be required for modified chlorination include ammonia storage and feed facilities, on-line analysis instrumentation to achieve stable operation, and adequate mixing at the points of ammonia and chlorine injection. A general layout of the modified chlorination system is illustrated by **Figure 10**.

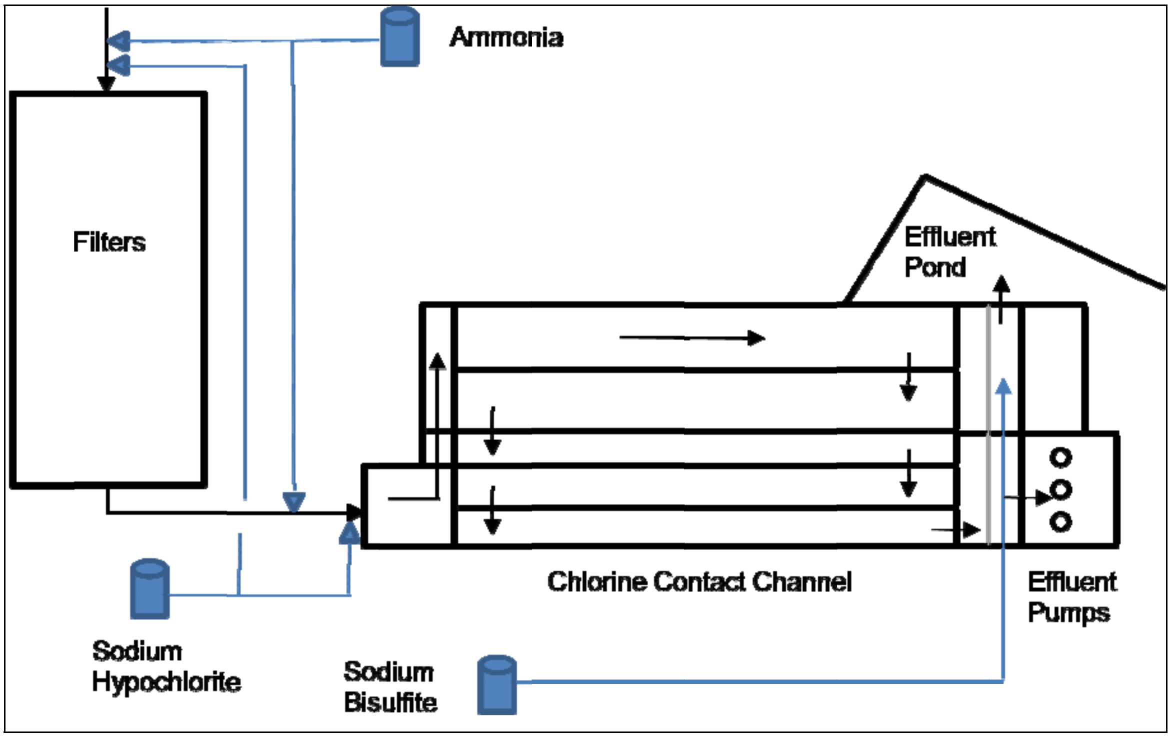

Figure 10
Modified Chlorination Process Flow Diagram

Hybrid UV and Modified Chlorination

During the review of the four alternative disinfection technologies, a fifth option emerged as a combination of two of the disinfection technologies. The hybrid option would combine the use of UV disinfection with modified chlorination. This system would use UV disinfection to treat the typical daily flow and use the modified chlorination to disinfect peak flows. The UV system would be installed in two of the existing chlorine contact channels.

The configuration of the hybrid system is shown as **Figure 11**. The flow split between the UV and the remaining chlorine contact tank may be accomplished through the installation of a weir or a gate. In the event of a peak flow event the base flow would still pass through the UV system, while the additional flow passes through the chlorine contact tank. This system also adds redundancy. In the event that the UV system needs to be taken offline for maintenance purposes, the chlorine contact tank could disinfect the plant effluent with minimal interruption to the treatment process.

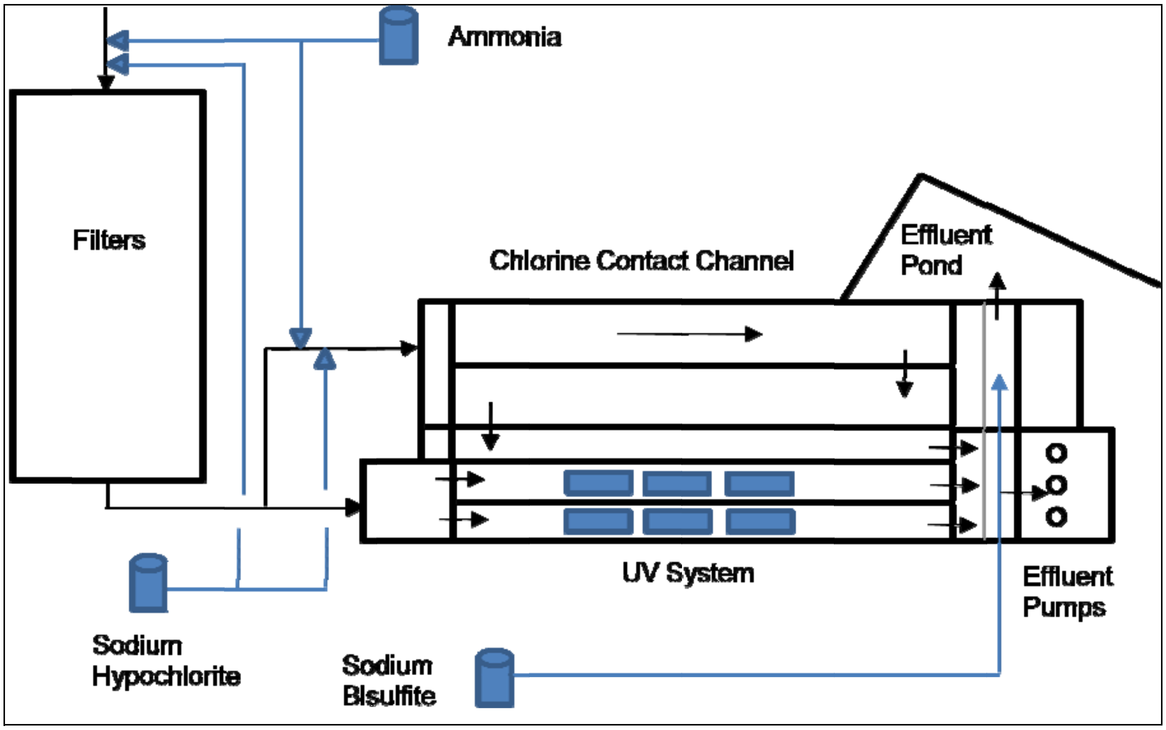

Figure 11
UV and Modified Chlorination Process Flow Diagram

OPINION OF PROBABLE CONSTRUCTION COST (OPCC)

An OPCC was developed for each of the alternative disinfection technologies, as well as the hybrid option. This OPCC was developed using previous cost estimates for Tapia as well as information from other disinfection systems that would be similar if they were applied to Tapia. The operation and maintenance costs were calculated based on a flow of 9 mgd. These costs are summarized in **Table 2** below. These estimated costs are detailed in subsequent memorandum.

Table 2
Opinion of Probable Costs

	UV	**Ozone**	**Mixed Oxidants**	**Modified Chlorination**	**Hybrid**
Capital Cost	$ 6,330,000	$ 10,210,000	$ 4,650,000	$ 800,000	$ 4,300,000
O&M Cost	$ 293,900	$ 358,400	$ 437,440	$ 565,900	$ 353,350

The present worth of each alternative was calculated for a 20 year period at an interest rate of 5 percent. This present worth was calculated assuming that the flow for the treatment plant would increase from 9 mgd to 12 mgd over the 20 year period. These costs are summarized in **Table 3**.

Table 3
Present Worth Analysis

Alternative	UV	Ozone	Mixed Oxidants	Modified Chlorination	Hybrid
20 yr Present Worth	$ 10,474,500	$ 15,264,400	$ 10,819,500	$ 8,781,100	$ 9,283,500

EVALUATION OF ALTERNATIVES

Each of the alternative disinfection technologies were evaluated against a set of screening criteria, which included non-economic factors as well as costs. These criteria are described in greater detail below.

Facility Modifications –accounts for the extent of modifications or construction that would be required to implement the disinfection alternative at Tapia.

Future Regulations – accounts for the ability or flexibility of the disinfection alternative to address compounds that may become regulated in the future, such as NDMA, PPCP or EDCs.

Water Quality Impacts – accounts for ability of the disinfection alternative technology to disinfect the effluent without forming other disinfection by-products.

Operation Impacts - accounts for the change in the operation of the facility once the disinfection alternative has been installed, for example additional samples to be taken, analyzers to monitor, or additional reporting costs.

Reliability – accounts for the ability of the alternative disinfection technology to disinfect to the appropriate level in the event of a power outage or a peak flow event.

Capital Cost – accounts for the relative capital cost of the disinfection alternatives.

O & M Cost – accounts for the relative annual operation and maintenance cost of the disinfection alternatives.

These criteria were assessed for each disinfection alternative and quantified in **Table 4** using a positive or negative sign. A positive sign if a technology required less modifications or a negative sign if a technology had a significant capital cost, as examples.

Table 4
Screening Criteria Summary

Criteria	UV	Ozone	Mixed Oxidants	Modified Chlorination	Hybrid
Facility Modifications	+	-	-	+	+
Future Regulations	+	+	-	-	+
Water Quality Impacts	+	+	-	-	+
Operation Impacts	+	-	-	+	+
Reliability	+	-	-	+	+
Capital Cost	-	-	-	+	+
O & M Cost	-	-	-	+	+
+ = Positive Comparative Result - = Negative Comparative Result					

CONCLUSION

Based on the above, neither ozone nor mixed oxidants appear to be an appropriate fit for implementation at Tapia. UV and modified chlorination are both viable options that will achieve the THM requirements set forth by the Regional Board. Of the alternative disinfection technologies evaluated, modified chlorination has the lowest present worth. The combined hybrid option of the UV and modified chlorination has a similar present worth to the modified chlorination option but has the overall best attributes. It is recommended the hybrid alternative combining UV with modified chlorination be considered further for implementation to achieve permit compliance.