VERY WELL DONE!

# Disinfection Alternatives
## A Feasibility Level Design for the Laguna Wastewater Treatment Facility

*prepared for the*

City of Santa Rosa

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*May 10, 2019*

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## List of Acronyms

CCB – Chlorine Contact Basin

DBP – Disinfection Byproduct

DDW – Division of Drinking Water

FEB – Flow Equalization Basin

HRT – Hydraulic Retention Time

LTP- Laguna Wastewater Treatment Facility

NCRWQCB – North Coast Regional Water Quality Control Board

RFP – Request for Proposal

UVT – Ultraviolet Transmittance

WAS WASTE ACTIVATED SLUDGE

WWTP – Wastewater Treatment Plant

# 1 Introduction

## 1.1 Background

This City of Santa Rosa is located 55 miles north of San Francisco in Sonoma County, CA. (Figure 1). Founded in 1833, Santa Rosa has since grown to be the 28th most populous city in California with major industries in health services, retail, and construction (EISR 2019).

Santa Rosa is home to the Laguna Wastewater Treatment Plant (LTP, Figure 2), which treats wastewater for communities and industries within Sonoma County. Originally constructed in 1968, LTP has had many expansions to accommodate changes in volume and treatment standards including major improvements regarding their recycled water reuse program. Each year, 7 billion gallons of wastewater is recycled through irrigation and a geyser recharging program in one of the largest recycled water systems in the world. During normal water years, LTP recycles 100% of their disinfected tertiary treated municipal wastewater (SRCity 2019). To continue this program, the disinfection treatment stage must be maintained to meet standards set by Title 22 of the California Code of Regulations.

In 1998, a Trojan UV4000 system was commissioned as the disinfection system for Santa Rosa with a design flow of 67-mgd (Laguna Staff 2019). In 2012, LTP responded to reports suggesting the Trojan UV4000 system was not performing as originally designed and performed a capacity analysis in accordance with the National Water Research Institute's Ultraviolet Disinfection Guidelines for Drinking Water and Water Reuse. This analysis confirmed that the disinfection capacity was below design, and as such, was de-rated by 35% to 43.1-mgd based on the LTP's lower 10th percentile for UVT of 61% (Laguna Staff 2019). This de-rating has led to increases in operational and mechanical errors as the system has had to be run essentially 35% higher than designed and without any form of redundancy originally provided by additional lamps in each channel that are now being utilized. While the DDW has allowed LTP to continue without redundancy since 2012, additional concerns are building from the UV system's age and Trojan's plan to discontinue replacement components (Laguna Staff 2019).

(Spell out first time

Additionally, stresses in the disinfection system have resulted in numerous disinfection violations in under-dosing occurrences and coliform exceedance. Between February 2014 and April 2018, LTP experienced 28 under-dosing events and 11 coliform exceedance events with causes stemming from equipment failure, capacity exceedance, and operator error (Laguna Staff 2019). Because these violations have drawn concern from staff and regulatory agencies, LTP has begun accepting design proposals in efforts to regain control of their disinfection capacity.

## 1.2 Purpose and Scope

This report is intended to identify design alternatives that would improve the disinfection process at LTP through the year 2040. This is a feasibility level report; meaning the results are only meant to inform LTP what alternatives are worth further development. There are potential future events that were not considered for this analysis including contaminants of emerging concern, direct potable reuse, and climate change, therefore, results from this report should not be analyzed as conclusive. The scope of this analysis includes cost, legal, and environmental components; however, manufacturer and contractor proposals are recommended should this report be consulted upon in the future.

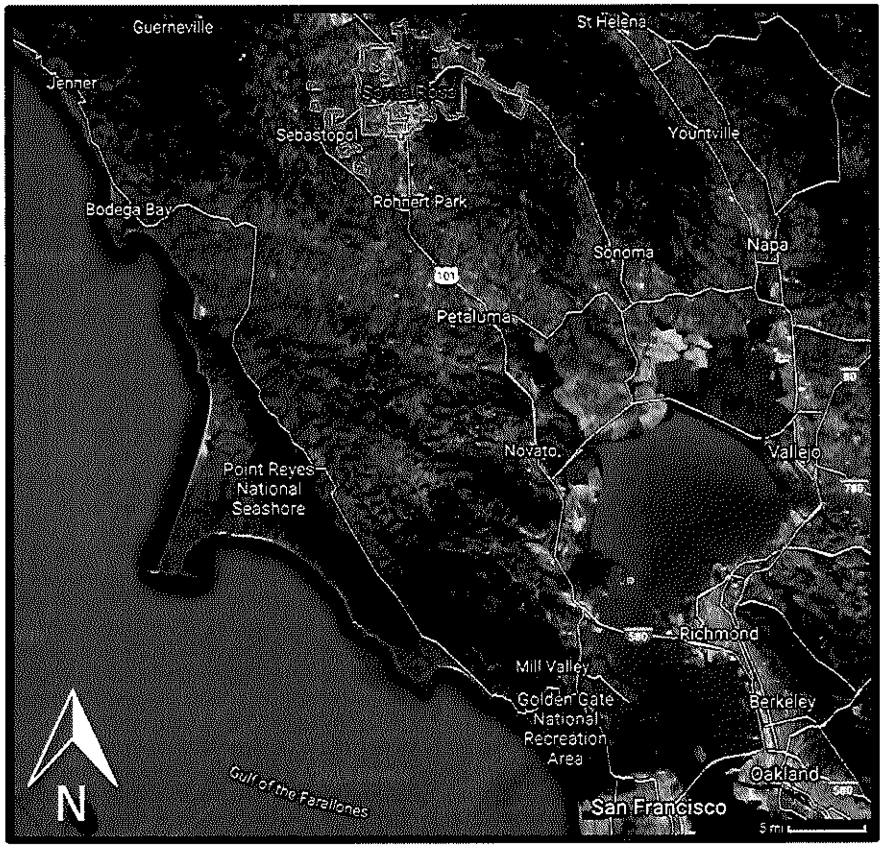


Figure 1: Location of Santa Rosa, CA (Google Maps 2019)..

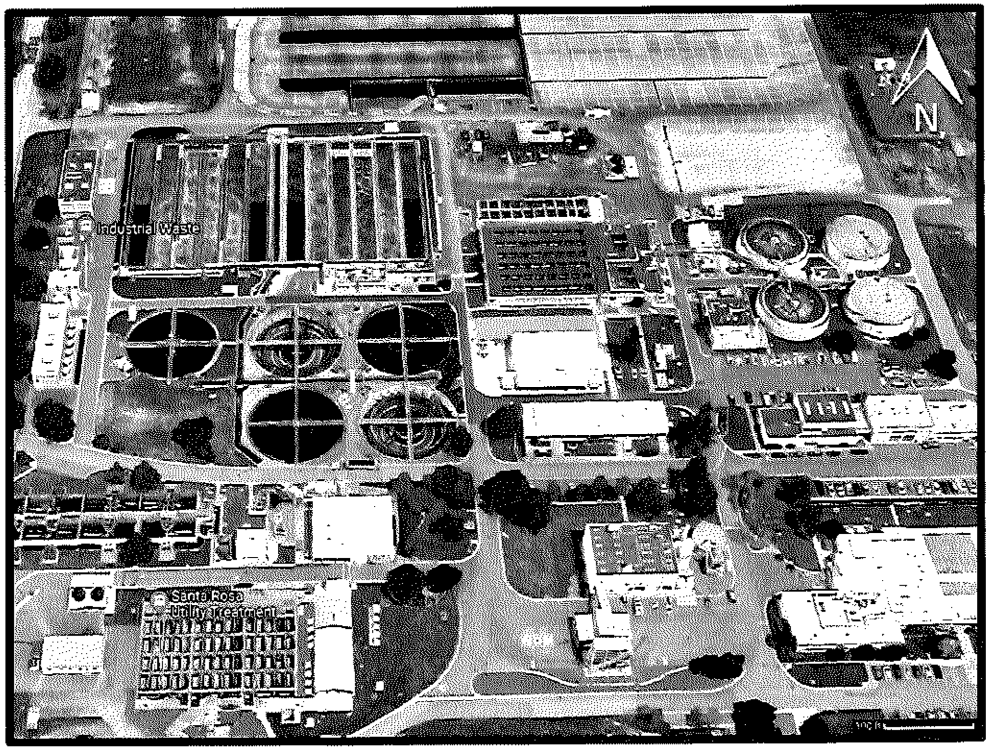


Figure 2: The Laguna Wastewater Treatment Plant (Google Maps 2019).

## 1.3 Objective

The objective of this report is to assist LTP in identifying design alternatives that will assist them in regaining control of their disinfection capacity. Improvements in disinfection will be focused on the following areas:

- Capacity shortfall of the current UV disinfection system
- Coliform compliance
- Managing disinfection byproducts
- Nutrient removals ← ODD THING TO INCLUDE IN DISINFECTION SECTION WITHOU
- Discharge locations and diversions EXPLAINING WHY EARLIER

Recommendations of this report are based on which design alternative best meets these objectives while satisfying criteria set forth by LTP.

# 2 Basis of Design

This section summarizes current and future bases of design for potential alternatives. This information is used to quantify current design parameters and forecast how these parameters will change over the life of the design.

## 2.1 Service Population

The service area for LTP is predominantly residences, businesses, and industries within Santa Rosa, however, additional sewage comes from the communities of Cotati, Rohnert Park, Sebastopol, and other unincorporated parts of Sonoma County. The current municipal service population is approximately 230,000 residents (SRCity 2016). Furthermore, LTP accepts leachate from the Sonoma County Central Landfill, septage from commercial septage haulers, and discharges from groundwater cleanup sites.

Negating sewage from businesses and industries and using an annual population growth rate of 0.7% (Department of Finance 2010), it is estimated that the municipal service population in the year 2040 will be 262,200. It should be noted that effects in population trends due to recent fires in the area were not included in the projection, however, data shows these events have caused some declines in residency (Department of Finance 2018).

## 2.2 Flow Rates

The daily average flow rate for LTP is 20-mgd (RFP 2016). While the current disinfection system can properly treat average daily flows, issues arise when attempting to disinfect wet weather flows. Using a UVT of 61%, it is estimated that the current Trojan UV4000 system has a maximum flow capacity of 43.1-mgd with redundancy and 59.1-mgd without redundancy (Laguna Staff 2019). Redundancy is provided by an additional bank of lamps in each channel and is normally required by the DDW to produce Title 22 recycled water, however, LTP is allowed to continue operations without redundancy provided they adopt adequate operation response plans, adequate supplies of replacement parts, additional operator trainings, and regular DDW inspections (Laguna Staff 2019). The history of disinfection failures at LTP from 2014 to 2018 show a capacity failure rate of approximately 0.3%, or one day per year (Table 1).

Table 1: Disinfection failures at the LTP from 2014 to 2018 (Laguna Staff 2019).

| Excursion Type | Excursion Cause | Occurrences | Total Flow Volume (MG) |
|---|---|---|---|
| UV Under-Dose | Equipment Failure | 19 | 2.4 |
| | Operator Error | 6 | 1.5 |
| | Capacity Exceeded | 4 | 144.3 |
| Coliform Exceedance | Algae or Unknown | 6 | 89.5 |
| | Equipment Failure | 5 | 72.4 |
| Upstream Process Upset | High Turbidity | 2 | 31.4 |
| Sleeve Cleaning Frequency | Programming Error | 4 | 61.9 |
| | Operator Error | 3 | 58.0 |

The peak wet weather flow rate for LTP is 67-mgd (RFP 2016). Wet weather flows are slightly buffered by diverting up to 9-mgd to the West College Wet Weather Facility using temporarily installed pumps. With this diversion, peak flows of 58-mgd can be expected at LTP. Carollo Engineers have performed an evaluation of flow exceedance and found that from 2007 to 2017, peak flows exceeded 58-mgd seven days each year and daily flows exceeded 58-mgd one day every three years (Laguna Staff 2019). Based on these results, the recommended minimum design flow is 58-mgd, resulting in a 15-mgd deficiency in the current UV system.

## 2.3 System Age

The current Trojan UV4000 model was originally commissioned in 1998 and most serviceable equipment has been replaced at least once. The system's age has drawn concerns from operators; especially in periods where redundancy is not provided, however, sourcing replacement parts has not become an issue yet (Laguna Staff 2019). It is expected that Trojan will provide a five year warning should they decide to discontinue service but this should not occur for at least 20 more years. It should be noted that Trojan no longer promotes the UV4000 system as a Title 22 installation.

## 2.4 Projected Changes in Service

The potential for the design flow to change over the next 20 years is minimal due recent sewer lateral replacement programs aimed at reducing I/I. With heavy rain, I/I can nearly quadruple normal influent flows at LTP. Unfortunately, while heavy rain is not frequently experienced, these events are what dictate disinfection design flows (SRCity 2006). Up to 40% of the incoming I/I can be attributed to sewer lateral problems on the private side so the City has been experimenting with ways of improving these laterals via adopting the projects to their own CIP program or requiring owners to improve deficient laterals. Santa Rosa will likely adopt a rebate program or annual fee to cover the cost of sewer ~~later~~ lateral improvements (SRCity 2006).

It should be noted that LTP has future expansion plans that may increase influent flows. These programs include the Laguna Plant Upgrade Project, the Geysers Expansion Project, the Santa Rosa Urban Reuse Project, and the Discharge Compliance Project. Staff and engineers at LTP expect that the increase flows attributed to these projects would only impact recycled and reuse flows and thus, would not affect the surface water discharge rates. Studies have demonstrated that flows into LTP between 21.3- and 25.9-mgd would not results in surface water discharges above the permitted level (NCRWQCB 2013).

### 2.5 Water Conservation Efforts

The California Water Conservation Act was passed in November of 2009, which set a goal in achieving a 20% reduction in per capita water usage by the year 2020 (SRCity 2009). While this could promote water use trends that may affect dry weather inflows as the population increases, these measures are not expected to impact wet weather flows that are predominantly impacted by rainfall. For these reasons, the design will primarily consider current peak flow rates with the assumption that the increases in the peak flow rates due to population and plant expansions will be offset only by reductions in I/I.

## 3 Regulatory Requirements

This section covers water quality, handling, and permitting regulations that are related to recycled water and wastewater discharge with a specific focus on the regulations that are of conflict (Table 1).

### 3.1 Water Quality Standards

Wastewater Facilities that operate by means of surface water discharge into California waters must be in pursuant to Section 402 of the Clean Water Act (CWA), Title 40 of the Code of Federal Regulations (40 CFR), and Chapter 5.5, Division 7 of the California Water Code (WAT). The California Water Control Board (CWCB) works under the authority of the Environmental Protection Agency (EPA) and uses these regulations to codify the Water Quality Control Plan for the North Coast Basin (Basin Plan). The Basin Plan is then used to set limitations for National Pollutant Discharge Elimination System (NPDES) permits, which allow WWTPs to discharge point source pollutants through a case by case basis that is dependent on effluent water quality, quantity, and the receiving water body. Because the NPDES permit for LTP only allows surface water discharges during storm events when high effluent flows make 100% reuse impossible, non-storm water discharges are prohibited without a separate NPDES permit that closely monitors effluent standards (NCRWQCB 2013).

For recycling of disinfected tertiary treated municipal wastewater during normal operations, LTP must obtain a Master Reclamation (MR) permit in pursuant to Article 4, Chapter 4, Division 7 of WAT. Much like NPDES permits, the CWCB works under the authority of the EPA to issue MR permits that follows guidelines under Title 22 of the California Code of Regulations (CCR). Title 22 regulates effluent maximum contaminant levels (MCLs), disinfection standards, filtration rates, and methods used for monitoring and reporting. In addition to the water quality parameters discussed below, the Basin Plan also has constraints related to tastes and odors, floating material, oil and grease, sediments, temperature, pesticides, chemical constituents, and radioactivity that will not be discussed. The Basin Plan has established Title 22 criteria as meeting MCLs in water designated for use as domestic or municipal supply. MCL monitoring and compliance methods are referenced by Division 4, Chapter 15, Articles 4 and 5.5 of Title 22 and a full list of organic and inorganic MCLs (§ 64431 and § 64444) can be referenced in Appendix A.

### 3.1.1 Monitoring Locations

There are 21 monitoring locations that LTP uses to demonstrate compliance with effluent limitations, discharge specifications, and other requirements. A full list of the LTP monitoring stations can be found in Appendix B.

### 3.1.2 Discharges and Reclamation

As dictated in the Basin Plan (Chapter 4, North Coastal Basin Discharge Prohibition No. 3), LTP is only permitted to discharge wastewater effluent into the Russian River under its NPDES permit from October 1 through May 14 of each year, although, this only happens when 100% reclamation is not an option due to abnormally high storm water inflows. When LTP chooses to discharge into the Russian River or its tributaries, the effluent flow cannot exceed five percent of the Russian River's most recent flow measurement. Furthermore, at no point during the discharge period can the total volume of discharged wastewater exceed five percent of the total Russian River volume (Chapter 4, North Coastal Basin Discharge Prohibition No. 4). Comparison flows of the Russian River are taken at the Hacienda Bridge USGS gage (No. 11467000).

All wastewater discharged from LTP is first sent to one of five surface water storage ponds using eight possible discharge locations (Figure 3). The storage ponds are drawn from for Santa Rosa's irrigation distribution system from May 15 through September 30 (Figure 4) and the Geyser Recharge project year-round. The average discharges for irrigation usage and geyser recharge program are 12.1-mgd and 18-mgd, respectively. A summary table of the discharge locations and reclamation sites can be found in Appendix C.

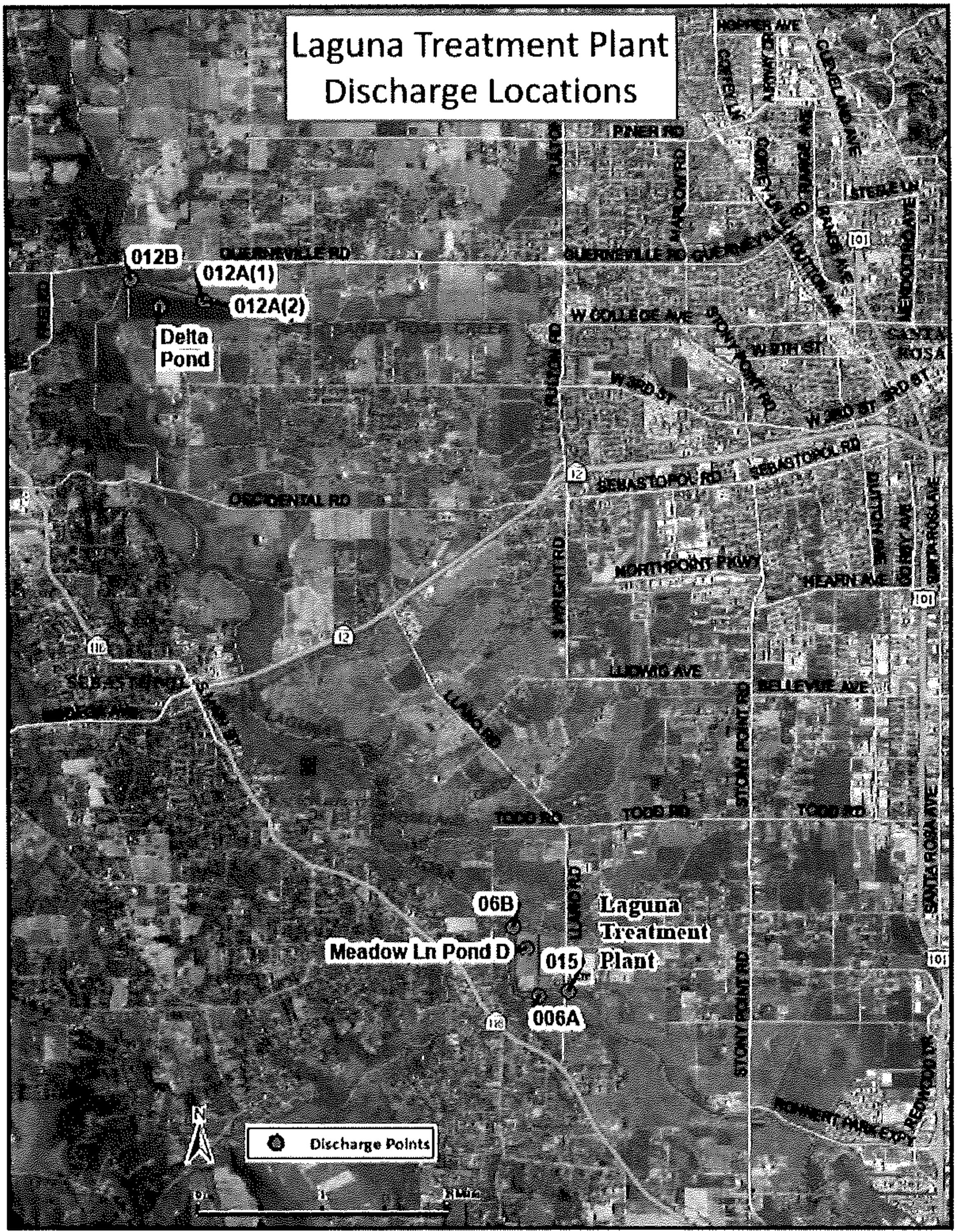
### 3.1.3 Technology-Based Limitations

40 CFR requires that NPDES permits include applicable technology-based limitations (122.44a) that include $BOD_5$, TSS, and pH. Coliforms was also included as a technology-based limitation due to its reflection of technology based effluent standards for tertiary treatment. All technology-based limitations are monitored using station EFF-001. The average weekly and monthly limitations for $BOD_5$ and TSS (Table 2) are shown below. Additionally, the average monthly percent removal for $BOD_5$ and TSS should never be below 85% (40 CFR, 133.102).

Table 2: $BOD_5$ and TSS effluent limitations (NCRWQCB 2013).

| Parameter | Units | Average Monthly | Average Weekly |
|---|---|---|---|
| Biochemical Oxygen Demand 5-day @ 20°C ($BOD_5$) | mg/L | 10 | 15 |
| Total Suspended Solids (TSS) | mg/L | 10 | 15 |

pH is monitored at discharge locations 006A, 006B, 012A(1), 012A(2), 012B, and 015 at monitoring locations EFF-006A, EFF-006B, EFF-012A(1), EFF-012A(2), EFF-012B, and EFF-001, respectively. 40 CFR requires that the pH be maintained between 6.0 and 9.0 (133.102), however, the Basin Plan contains a more stringent limitation on pH of 6.5-8.5.



Map Date: 7/18/2013

Figure 3: Map of the Santa Rosa Water Reclamation System (NCRWQCB 2013).

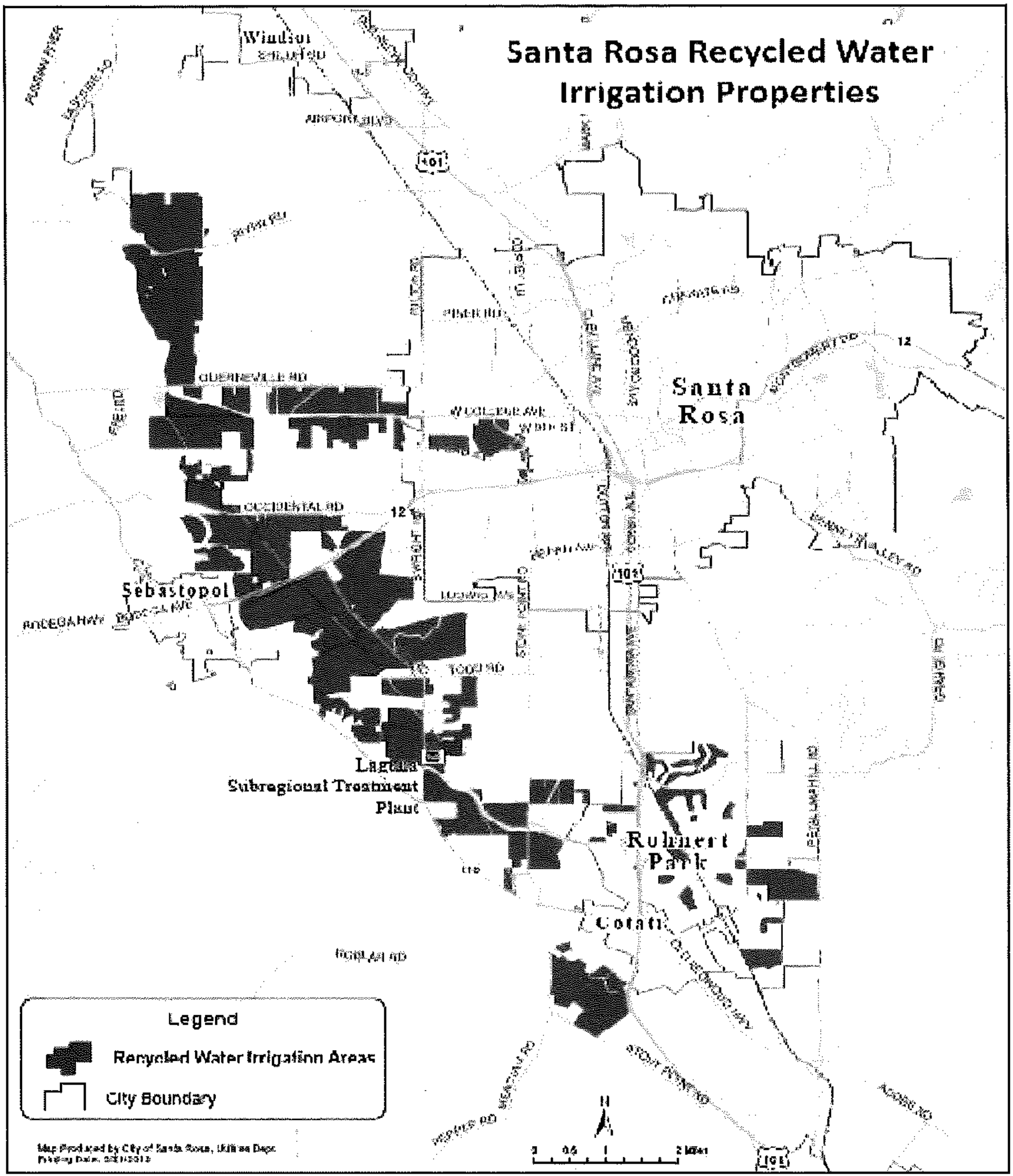


Figure 4: Map of the Santa Rosa Water Irrigation System (NCRWQCB 2013).

NOT REALLY "MEASURED"

LIMITS INCLUDE

~~There are~~ several concentrations that are ~~measured regarding~~ effluent total coliforms at LTP: 1) the median concentration using daily bacteriological results of the proceeding seven days must not exceed 2.2 MPN per 100-mL, 2) the MPN per 100-mL should never exceed 23 in more than one daily result in any 30-day period, and 3) any given daily result should never exceed 240 MPN per 100-mL. Analyzing post-disinfection wastewater for coliform compliance needs to occur at least once a day. These regulations reflect standards set by the Basin Plan (Section 4, Implementation Plan) and Title 22 (§ 60321a).

### 3.1.4 Water Quality-Based Limitations

40 CFR requires that NPDES permits include applicable water quality-based limitations (122.44d) that include DBPs, nutrients, and acute toxicity. DBP limitations (Table 3) are monitored at discharge locations 006A, 006B, 012A(1), and 015 using monitoring locations EFF-006A, EFF-006B, EFF-012A(1), and EFF-001, respectively. A reasonable potential analysis showed that both Chlorodibromomethane and Dichlorobromomethane could impact discharges in a way that would exceed water quality objectives in the Basin Plan. Because there is no numerical limitations for DBPs, average monthly and maximum daily values were established using EPA criteria under CWA Section 304a.

Table 3: DBP effluent limitations (NCRWQCB 2013).

| Parameter | Units | Average Monthly | Maximum Daily |
|---|---|---|---|
| Chlorodibromomethane | µg/L | 0.4 | 1.0 |
| Dichlorobromomethane | µg/L | 0.56 | 1.3 |

Nutrients, such as phosphorus and nitrogen, are monitored at the same locations as pH. Effluent phosphorus concentrations, unlike other water quality-based limitations, is qualitatively expressed as "no net loading." This limitation represents a conservation effort to prevent any further water quality degradation of water bodies in the Laguna de Santa Rosa. The no net loading policy is in accordance with 40 CFR 122.44d.

As mentioned previously, the Basin Plan has established Title 22 criteria as meeting MCLs in water designated for use as domestic or municipal supply. The monthly average MCL for nitrate is 10-mg/L and as such, serves as the limit for LTP. Studies have been done on receiving water ammonia and nitrate concentrations with results showing 0.2- and 0.66-mg/L, respectively (NCRWQCB 2013). Due to these studies, there is no evidence to suggest that these concentrations will exceed water quality-based limitations, and therefore, no effluent limitations for ammonia or nitrate are required.

Measuring the presence of acute toxicity is done with a 96-hour bioassay of undiluted effluent and is considered in compliance with EPA regulations when 1) the minimum for any one bioassay is 70% survival and 2) the median for any three or more consecutive bioassays is at least 90% survival. Due to the lack of numeric water quality objectives related to acute toxicity, this regulation was developed under the guidance of EPA research (NCRWQCB 2013).

### 3.1.5 Tertiary Filtration Rate

The filtration rate of tertiary filters, as measured at monitoring location EFF-001, cannot exceed 5-gpm/ft$^2$ of surface area (Title 22, § 60301.320). Filtration rates that exceed 5-gpm/ft$^2$ can be authorized under recommendation of the DDW if the chosen filtration rate is able to sufficiently demonstrate that recycled water can be properly coagulated and filtered for the removal of pathogens prior to disinfection.

### 3.1.6 Turbidity Standards

Post-tertiary filtered effluent, as measured at monitoring location INT-001B, must not exceed the following turbidity standards prior to entering the disinfection process (Title 22, § 60301.320): 1) an average of 2 NTU during a 24-hour period, 2) 5 NTU more than 5% of the time during a 24-hour period, and 3) 10 NTU at any given time. Should the tertiary effluent exceed 5 NTU for more than 15 minutes, LTP has the ability to divert partially-treated wastewater to storage ponds within the reclamation system (§ 60341). Turbidity monitoring needs to be done continuously to properly meet compliance and diversion requirements.

### 3.1.7 Disinfection Requirements

The following UV disinfection guidelines were established by the DDW and the National Water Research Institute (NWRI) to meet requirements in Title 22, Division 4, Chapter 3:

- The disinfection of tertiary treated wastewater must accomplish inactivation and/or removal of 99.999% of the plaque forming units of F-specific bacteriophage MS2 or polio virus.
- LTP must provide continuous and reliable monitoring of UVT, UV dose, UV power, and turbidity.
- LTP must operate the UV disinfection system at a minimum dose of 100-mJ/cm$^2$ for all recycled uses the require "disinfected tertiary recycled water."
- A UVT (at least 254 nanometers) must never drop below 50%.
- The UV system requires regular operator attention including routine maintenance schedules, alarm systems and component calibrations.
- Under extreme conditions, LTP is required to operate the UV system in accordance with a DDW-approved Emergency Operation, Redundancy, and Response Plan (EORRP).

Should any of these requirements not be met by the UV system, LTP must divert the effluent to City-owned property provided the partially-treated waste complies with the EORRP.

Due to the nature of this report, the Title 22 regulations related to chlorine disinfection deserve some mention as this disinfection method could serve as a viable design alternative. A chlorine disinfection process that aims at producing disinfected tertiary recycled water must have a CT (product of total chlorine residual and modal contact time) greater than 450-mg·min/L at all times with a model contact time of at least 90 minutes (§ 60301.230).

### 3.2 Biosolids Standards

Biosolids are defined as sludge that has been treated, tested, or proven to be capable of being beneficially and legally used as a soil amendment for agricultural, horticultural, and land reclamation activities provided these uses meet specific federal and state regulations (NCRWQCB 2013). In 2016, LTP composted over 9,000 wet tons of biosolids with the four on-site 1,057,000-gallon anaerobic digesters. Compostable biosolids are produced by utilizing a gravity belt thickener and Catonic Mannich style polymers to treat waste activated sludge (WAS). The result is belt press cake biosolids that can either be land applied or composted (SRCity 2016)

LTP biosolids are sampled quarterly for priority pollutants and metals. The handling of biosolids is regulated by 40 CFR, however, the use of biosolids as a land applicant (§ 503) is subject to different requirements than biosolids that is disposed of in a municipal solid waste landfill (§ 258). Furthermore, for the land application of biosolids as a soil amendment in the North Coast Region, LTP is regulated by the State Water Board Water Quality Order No. 2004-0012-DWQ.

### 3.3 Permit Approvals

As stated previously, WWTPs in California that intend on reusing recycled effluent must obtain NPDES and MR permits from the CWCB. All effluent monitoring and potential plant expansions must be reported to the DDW District 18 for approval.

LTP is situated on protected California Tiger Salamander breeding grounds. Tiger Salamanders (*Ambystoma californiese*) are currently threatened due to habitat fragmentation from urban development and farming (Sacramento Fish and Wildlife 2017). Consequently, any impacts from construction or demolition on an area that has not previously been developed at LTP must first be proven to the U.S. Fish and Wildlife Service to not negatively impact Tiger Salamander populations.

In addition to these facility specific permits, project approvals and general permits will be required for construction, demolition, and grading from the City of Santa Rosa's Building and Safety Division and the Santa Rosa Board of Public Utilities.

## 4 Existing Facilities

The current system in place at LTP is tertiary treatment followed by disinfection (Figure 5). Pretreatment is accomplished with perforated plates that separate larger inorganic items such as towels that will damage and clog the ~~proceeding~~ that follow treatment components. Following pretreatment, the wastewater enters grit chambers where materials such as sand is settled. The captured material from the perforated plates and the grit chambers are both sent to the landfill. To settle out organic matter, pretreatment effluent enters primary settling basins where organic matter settles as sludge. This sludge is then removed from the primary clarifiers to feed the bacteria inside the anaerobic digesters. Methane gas, produced by the breakdown of organic matter from anaerobic bacteria, is captured from the digesters and mixed with natural gas to power over one third of the energy required by daily operations at LTP (SRCity 2016).

Primary treated wastewater then enters aeration basins where the water is injected with ~~oxygen~~ air to promote the growth and flocculation of nitrifying bacteria that consume the dissolved organic matter and convert ammonia and nitrite to nitrate. Once the dissolved organic matter has been consumed, the water enters

NITRIFIERS DON'T CONSUME ORGANICS
THAT IS THE JOB OF THE CARBONACEOUS
BACTERIA.

secondary settling tanks where the nitrifying bacteria settles with nitrite oxidizing bacteria that are converting nitrite to nitrogen gas. The nitrogen gas is then released to the atmosphere. The settled bacteria sludge is split to serve as LTPs return activated sludge (RAS) in the aeration basins and to maintain a healthy population of bacteria in the digesters. Secondary treated wastewater is then sent through a four foot filter bed of anthracite coal that traps fine suspended solids and some pathogens, ultimately reducing turbidity for disinfection.

Disinfection is accomplished by the de-rated Trojan UV4000 system discussed earlier. It should be noted that there are three hypochlorination feed locations before tertiary filtration and before and after UV disinfection that are used to clean the pipelines and control for algae.

## 4.1 Additional Facility Details

This section discusses other information that may be relevant to consider when designing disinfection alternatives for LTP.

### 4.1.1 Disinfection Failure Diversions

LTP experienced a variety under-disinfected effluent events in 2016 and 2017 that caused several recycled water diversions to occur (SRCity 2016, 2017). Operators responded to these events by notifying the Geysers operational staff, diverting the suspect water to City-owned property, and lowering the plant flow until UV power could be restored. While the under-disinfected effluent was dealt with properly, diversion structures proceeding tertiary filtration could temporarily store the flow during disinfection failure events until normality is restored and the water could be properly treated. It should be noted that, apart from power disruptions caused by substantial and catastrophic fires in the area on October 9th, 2017, the average time for remedying disinfection related issues is 7.09 minutes.

ANY EVIDENCE THAT COLIFORM STANDARD NOT MET?

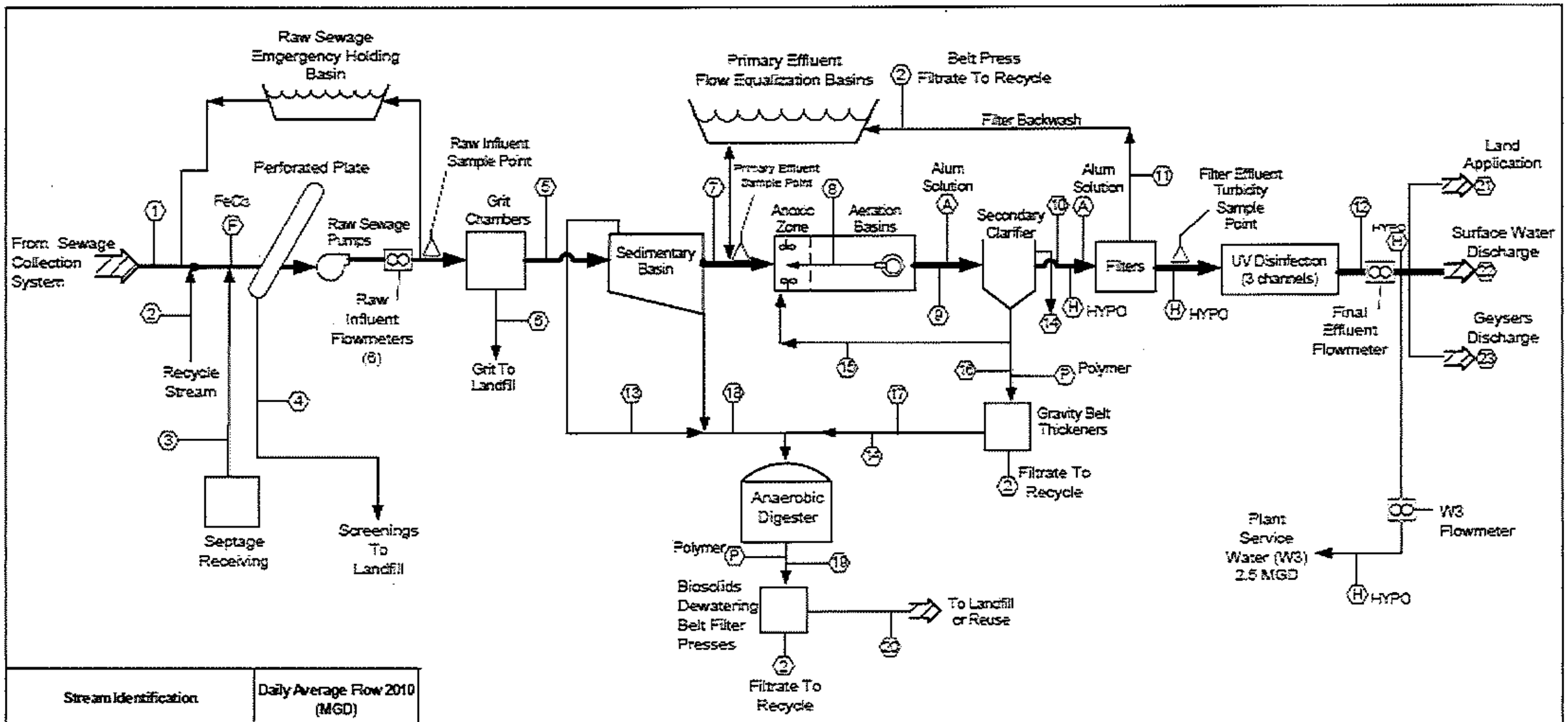
On March 13th, 2016, a tripped breaker caused a power interruption to one UV bank. To combat this loss of power, the other three banks responded by increasing their output to 100%, however, the dose dropped below 99-mJ/cm² for two brief periods over a three-minute interval.

On August 3rd, 2016, an electronic failure caused all three UV gates to close. When attempting to restore flow to the UV system, all three gates were accidently opened simultaneously which resulted in a two-minute period of a 66-mJ/cm² dose.

On October 9th, 2017, one-hour period of under-disinfection occurred due to unavoidable power disruptions due to regional fires. The plant was placed on standby to stabilize power to the UV system.

### 4.1.2 Potential Project Sites

There are four potential LTP project sites that a disinfection system could be located at (Figure 6). L1 is an already developed location where contractor trailers and two back-up hypochlorination tanks are located. Should flow need to be diverted to this location, a 200-ft pipe (P1) must be placed under the service road. L2 is the decommissioned chlorine contact basins that have not been used since 1998, however, the existing concrete is in good working condition. L3 is where the current Trojan UV4000 system is located. L4 is a large undeveloped portion of land that could serve as a disinfection location; however, its lack of development is unattractive due to the regulations that would need to be met to prove a project here would not negatively impact the local Tiger Salamander population.



| Stream Identification | | Daily Average Flow 2010 (MGD) |
|---|---|---|
| ① | Raw Sewage | 20.6 |
| ② | Recycle Stream | 1 |
| ③ | Septage | 0.03 |
| ④ | Screenings | 1.5 |
| ⑤ | Primary Influent | 20.5 |
| ⑥ | Grit | 13 FT³/Day |
| ⑦ | Primary Effluent | 20.6 |
| ⑧ | Mixed Liquor Recycle | 20.6 |
| ⑨ | Aeration Basin Effluent | 30.1 |
| ⑩ | Secondary Effluent | 20.6 |
| ⑪ | Filter Backwash | 1 |
| ⑫ | Plant Effluent | 20.6 |
| ⑬ | Primary Scum | 4600 GPD |
| ⑭ | Secondary Scum | 1200 GPD |
| ⑮ | Recycled Activated Sludge | 9.5 |

| Stream Identification | | Daily Average Flow 2010 (MGD) |
|---|---|---|
| ⑯ | Waste Activated Sludge (WAS) | 0.42 |
| ⑰ | Thickened WAS | 0.09 |
| ⑱ | Primary Sludge | 0.11 |
| ⑲ | Digested Sludge | 0.14 |
| ⑳ | Dewatered Sludge | 0.03 |
| ㉑ | Land Application | 5.3 |
| ㉒ | Surface Water Discharge | 20 Days @ 21 MGD |
| ㉓ | Geysers Discharge | 12.62 |
| Ⓐ | Alum Solution | Standby |
| Ⓕ | FeCl₃ | Standby |
| Ⓗ | HYPO | Standby |
| Ⓟ | Polymer | Standby |

LAGUNA SUBREGIONAL
RECLAMATION FACILITY
ADVANCED TREATMENT

General
PROCESS MASS BALANCE
AND
RECYCLE DIAGRAM

Page:
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Date: Dec 2015

Figure 5: Current Laguna Wastewater Treatment Plant Schematic (SRCity 2016).

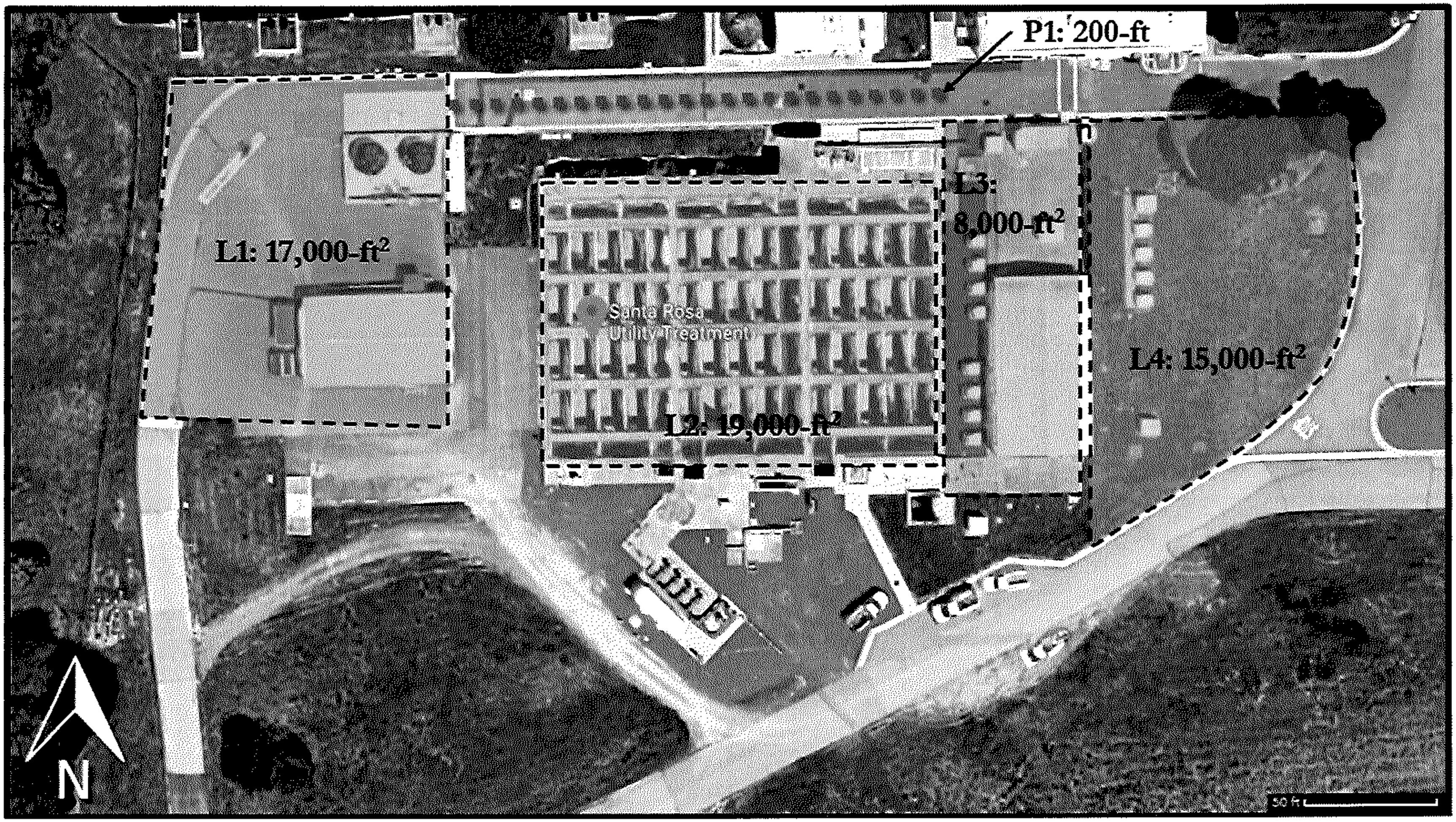

Figure 6: Potential project sites for disinfection upgrades at the Laguna Wastewater Treatment Plant (Google Maps, 2019).

# 5 Preliminary Alternatives

This section discusses relevant design criteria, the screening method used for selecting preferred alternatives, descriptions of each alternative, and the preliminary results chosen for further development.

## 5.1 Criteria

Alternatives were analyzed and compared based on the following criteria (in order of relative ranks) that were developed using LTPs NPDES permit, LTP staff recommendations, and LTPs history of disinfection failures:

1. Capital Cost: the ideal design will minimize capital cost without compromising on disinfection ability or effluent standards
2. Operation and Maintenance Cost: the ideal design will minimize O&M costs over the next 20 years without compromising on disinfection ability or effluent standards
3. Environmental Impacts: the ideal design will hold environmental concerns outlined in Basin Plan paramount as to avoid any further environmental degradation
4. Regulatory Compliance and Permitability: the ideal design will meet current permit standards and anticipate future water quality- and technology-based regulations over the next 20 years
5. Serviceability: the ideal design will optimize automation and maintenance as to maximize ease of service and minimize the overall service time from operators SEEMS LIKE THIS IS CONTAINED IN #2
6. Compatibility with Current Treatment Methods: the ideal design will minimize alterations to the current treatment system and avoid any foreseeable complications that may need to be addressed in the future

## 5.2 Screening Mechanisms

Each criterion above was assigned a weight that was relative to its importance in the decision-making process. Weights for each criteria was assigned using the Rank Order Centroid method (Equation 1). Each alternative was assigned a score from one to five that described how well it met each criterion, five being the most favorable. The total score for each alternative is the sum product of the criterion weight and the criterion score. The alternatives that were considered the most ideal for further analysis were the highest-ranking physical disinfection method and the highest ranking chemical augmentation method.

$$W_i = \sum_{n=1}^{M} \left(\frac{1}{n}\right) \cdot 10 \qquad (1)$$

where:

$W_i$ = weight of $i^{th}$ criterion

$M$ = number of criteria

$n$ = $i^{th}$ criterion

## 5.3 Description of Alternatives

This section lays outs the information regarding relevant design features for each disinfection alternative that was used during preliminary screening.

### 5.3.1 UV Retrofit

The first alternative involves decommissioning the current Trojan UV4000 system in place at L3 and retrofitting the three UV contact channels with a higher rated UV disinfection system. Business would continue as usual, however, the new system would be a Title 22 installation that would likely alleviate redundancy issues and disinfection failures. To address past diversion problems, any disruption in the treatment system that could cause effluent failures would result in the flow being diverted and stored on City-owned property prior to disinfection until normality is restored and the diverted water could be properly treated. It should be noted that all the design alternatives mentioned share the same diversion feature.

The initial cost of this project is dependent on the compatibility of the UV4000 system and the chosen replacement model as the new UV system needs to work with the existing channels to make this alternative feasible. Managing the compatibility of the retrofit is likely to cause construction limitations that may increase capital cost and completion time. Furthermore, limitations may also be present in treatment capacity should the number of possible UV modules be confined by available space. O&M costs, as with any UV disinfection system, is expected to be high, predominately due to the associated power consumption. It should be noted, however, that LTP has a current annual disinfection O&M cost of 2.1$ million due to the additional costs of operator responsiveness, maintenance frequency, and disinfection failures (Laguna Staff 2019).

Operator responsibilities are not expected to increase significantly if this alternative is implemented properly. While there will inevitably be a learning curve and training period with the new UV system, (as with any new piece of equipment) the retrofitted UV system would likely operate with a higher level of automation and with functioning redundancy measures, reducing long term operator tasks.

### 5.3.2 New UV System

The second alternative involves constructing a new stand-alone UV disinfection system at L1. Much like the UV retrofit alternative, business would continue as usual upon completion of the upgrade and the new installation would be specifically designed as a Title 22 installation. Where this alternative differs from the retrofit option is the associated freedom of design and construction methods. Designing a new UV system at L1 allows for 17,000-$ft^2$ of free space to be utilized in whichever way is determined to be most optimal, rather than being confined to design features of the de-rated Trojan system built in 1998.

The initial cost of this alternative is expected to be significant, as with most purchases of major proprietary components. Furthermore, constructing a UV system at L1 requires flow to be diverted to this location using a 200-ft pipe located underneath the service road (P1). The associated O&M costs will also be high due to the power consumption of UV disinfection, however, any improvements in the disinfection process are expected to produce a reduction in the current O&M costs.

Like the UV retrofit alternative, there should be a significant reduction in operator responsibilities once the initial training period is complete and automation can start to handle most daily operations.

### 5.3.3 Hypochlorination

The second alternative involves retrofitting the current UV channels at L3 with a smaller UV system rated at 43-mgd, a supplemental sodium hypochlorite system at L1 to bring the disinfection system up to design capacity, and on-site diversion structures to avoid discharging water that does not meet effluent regulations. During periods of high plant flows, the hypochlorination system would be implemented by separating up to 30-mgd of tertiary filtered water to the already constructed chlorine contact basins at L2 that were decommissioned when LTP switched to UV disinfection. In theory, a 30-mgd capacity would be able to support effluent demand from the geysers (12.1-mgd) and the City's irrigation system (18-mgd).

This alternative would reduce initial cost by utilizing structures that are already in place and utilizing a less expensive UV system. Furthermore, chlorine is readily available and a cheaper disinfectant than UV or ozonation (EPA 1999a). What this parallel system lacks in capital and O&M costs, it makes up for in operator complexity. Running a parallel disinfection system requires heightened operator attention and training; something that is already of concern with an aging UV system. Additionally, hypochlorination use would have to be anticipated and brought to steady-state before high flow events. While the backup hypochlorination system would only be used during peak flows, its operational complexity should be questioned; especially considering operator's responsibilities are already assumed to be high due to the various unrelated issues associated with peak flows.

Chemical disinfection also has its own associated problems including chemical delivery and storage, hazard trainings, response plans, and DBPs that may be harmful to the environment. Hypochlorinated effluent sent to storage ponds would require a low CT value to prevent coliform violations, therefore, dechlorination is not thought to be necessary. Operating without dechlorination would have to be verified by the DDW before implanting this project. The lack of dechlorination is not thought to negatively impact agricultural and urban reclaimed water customers, however, hypochlorinated water could cause a die-off of bio-growth within geyser and reclamation pipes (Laguna Staff 2019). BE SURE IT IS CLEAR THAT THIS COULD BE CONSIDERED A POSITIVE SIDE EFFECT.

### 5.3.4 Ozonation

Much like the third alternative, the final alternative involves UV disinfection, a supplemental ozone system at L1 to bring the disinfection system up to design capacity, and on-site diversion structures. The ozone disinfection would be operated under the same circumstances as the backup hypochlorination system, diverting up to 30-mgd of tertiary treated water to ozone contact channels (also located at L1) when plant flows exceed UV capacity.

Typical ozonation components include feed-gas preparation, ozone generation, ozone contacting, and ozone destruction, which generally have higher associated capital and O&M costs comparatively to other disinfection methods (EPA 1999b). Because this treatment alternative is located at L1, it also has the additional costs of diverting the tertiary filter effluent using P1. Along with high operating costs, this alternative is still subject to the same complexity issues as the hypochlorination alternative, which will ultimately require additional hours of operator trainings, anticipated controlled start-ups, and unfamiliar maintenance requirements. Advantages of ozonation over hypochlorination come in the form of disinfection effectiveness for bacteria and viruses, shorter contact times, and lack of harmful chlorination DBPs, however, ozonation can produce its own set of DBPs that should be monitored. (EPA 1999b).

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The production of ozone for wastewater disinfection is a toxic, corrosive, and expensive process resulting in a very unstable gas. This has multiple implications when considering ozone disinfection design: 1) the ozone gas would have to be produced on-site as it is too unstable for deliveries, 2) ozone disinfection at LTP would require an entirely new closed-loop system that properly disposes of toxic ozone gas, and 3) operator staff would have to be thoroughly trained to use this relatively uncommon disinfection method.

## 5.4 Assignment of Scores

The capitol cost category rates which alternative will have the lowest initial cost while still providing a satisfactory level of disinfection. Hypochlorination was given a score of 5 due to its utilization of the already existing contact basins and a less expensive UV system. Retrofitting the UV system was given a score of 4 while the new UV alternative was given a score of 3.5 due to the relocation at L1 necessary for a new UV system. It is expected that retrofitting would be slightly cheaper than an entirely new system given the construction phase is able to proceed with little complications. Ozonation was given a score of 2 for the capitol cost category due to the projects need for both a small UV system and entirely new ozonation components.

O&M scores were given based on each alternatives ability to minimize annual costs over the next 20 years. Due to the nature of these alternatives, the majority of all disinfection for all alternatives on any given normal flow day will be accomplished by UV. Therefore, the actual O&M cost is not expected to change drastically between alternatives. Ozonation was given the lowest score of 2 simply due to the associated costs with ozone gas production and destruction. Hypochlorination was given a score of 3.5 due to the availability and established market for chlorine as a disinfectant. It is expected that the retrofitted UV system would result in unforeseen mechanical shortfalls that could increase maintenance over a new system. Due to this, the UV retrofit alternative was given a score of 4 and the new UV system was given a score of 5.

The environmental impacts category quantifies how well each alternative caters to current and long-term environmental concerns. Because the UV retrofit and new UV system alternatives are physical processes rather than chemical processes, they produce no DBPs that could negatively impact the surrounding ecosystems or human health. Furthermore, there is no need to require deliveries or on-site generation of toxic chemicals besides what is already required to sustain the existing hypochlorination injection system. For these reasons, both UV alternatives were given a score of 5. Hypochlorination was given a score of 3 while ozonation was given a score of 3.5 due to the lack of chemical deliveries and scarcity of DBPs associated with ozonation.

How well each alternative meets environmental criteria is closely related to how each alternative is expected to meet regulatory and permitability criteria. It is assumed that projects with less environmental stewardship will also have more issues with current regulations and meeting future permit requirements. The new UV alternative scored the highest with a score of 5 due to its propriety design and freedom of construction methods that will likely lead to an efficient system specifically designed around these regulations. UV retrofitting has the potential of handling regulation and permitting problems as well as the new system, however, retrofitting is likely to run into construction and design limitations, so it was given a score of 4. Both hypochlorination and ozone augmentations were given a value of 3 due to the operational complexity of parallel systems that is likely to result in complications and disinfection failures.

Serviceability scores were given based on the level of attention required from operators. Both parallel systems are expected to introduce disinfection complications when chemical and physical processes are occurring simultaneously. Furthermore, ozonation is a relatively fringe disinfection process that will inevitably have a steeper learning curve and more training requirements than hypochlorination. For these reasons, hypochlorination and ozonation alternatives were given scores of 4 and 3, respectively. Serviceability for both UV exclusive alternatives are assumed to be similar, with slight advantages expected in the new system attributed to its freedom of design. UV retrofitting was given a score of 4.5 while the new UV alternative was given a score of 5.

Finally, the compatibility with current treatment methods category quantifies how well each alternative fits within the current treatment system and how many modifications are necessary to carry out the project. The alternative of retrofitting the current UV system was given a score of 5 because there are no additional modifications that need to occur after the UV system is in place. Hypochlorination also scored a value of 5 because it utilizes the already constructed UV channels and chlorine contact basins. Because of the relocation to L1 that is necessary with the new UV system, this alternative was given a value of 3. Ozone augmentation scored the lowest value of 2 due to the same relocation requirements plus the added compatibility issues introduced by a parallel disinfection system.

## 5.5 Screening Results

The scores determined in the preceding section were multiplied by the weight for each criterion to get a relative criterion score for each alternative. Criteria scores were summed in all four alternatives to determine the total weighted score. This information is presented as a matrix of alternatives, categories, and scores (Table 4).

Table 4: Decision matrix containing weights for each criterion and the associated scores for each alternative.

| | | | **Value/Score** | | | |
|---|---|---|---|---|---|---|
| Criteria | Rank | Weight | UV Retrofit | New UV | Retrofit with Hypo | Retrofit with Ozone |
| Capital Cost | 1 | 4.09 | 4<br>16.36 | 3.5<br>14.32 | 5<br>20.45 | 2<br>8.18 |
| O&M Cost | 2 | 2.42 | 4<br>9.68 | 5<br>12.10 | 3.5<br>8.47 | 2<br>4.84 |
| Environmental Impacts | 3 | 1.59 | 5<br>7.95 | 5<br>7.95 | 3<br>4.77 | 3.5<br>5.57 |
| Regulatory Compliance and Permitability | 4 | 1.03 | 4<br>4.12 | 5<br>5.15 | 3<br>3.09 | 3<br>3.09 |
| Serviceability | 5 | 0.61 | 4.5<br>2.75 | 5<br>3.05 | 4<br>2.44 | 3<br>1.83 |
| Compatibility with Current Treatment Methods | 6 | 0.28 | 5<br>1.40 | 3<br>0.84 | 5<br>1.40 | 2<br>0.56 |
| **Total Weighted Score** | | | **42.27** | **43.41** | **40.62** | **24.07** |

The highest ranking physical disinfection method was the new UV system alternative and the highest ranking chemical augmentation was the hypochlorination alternative. These two potential projects were chosen for further analysis which is discussed in the following section.

# 6 Selected Initial Alternatives

This section discusses the overall process, required components, and optional sub-alternatives available for each selected initial alternative.

## 6.1 New UV System Alternative

As mentioned previously, the new UV system will function much like the current one, however, newer systems have configurations that rely on more channels and more banks per channel to maximize flexibility for operators when it comes to maintenance, cleaning, or dealing with problematic scenarios (Laguna Staff 2019). Furthermore, LTP has expressed interest in low-pressure high output lamps (as opposed to the medium pressure lamps being utilized by the current Trojan UV4000) that are thought to produce less algae in the reaction chambers, which could help address some of the disinfection failures related to algae sloughing (Table 1). Evidence also suggests that low pressure lamps are more effective at disinfection due to their operating wavelength in reference to germicidal effectiveness and lack of visible light in comparison to medium pressure lamps (Figure 7).

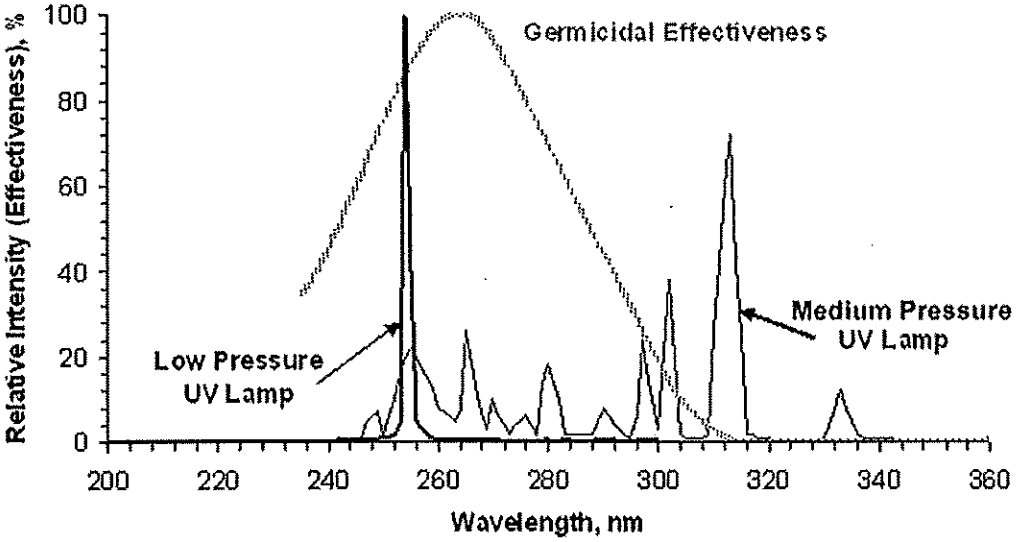

Figure 7: Low pressure and medium pressure UV wavelengths in reference to germicidal effectiveness (AAW 2019).

The general components required for this alternative are a new UV system and diversion storage plus any additional relocations, permitting, and testing requirements. A process schematic (Figure 8) displays how these this alternative would operate with current facilities.

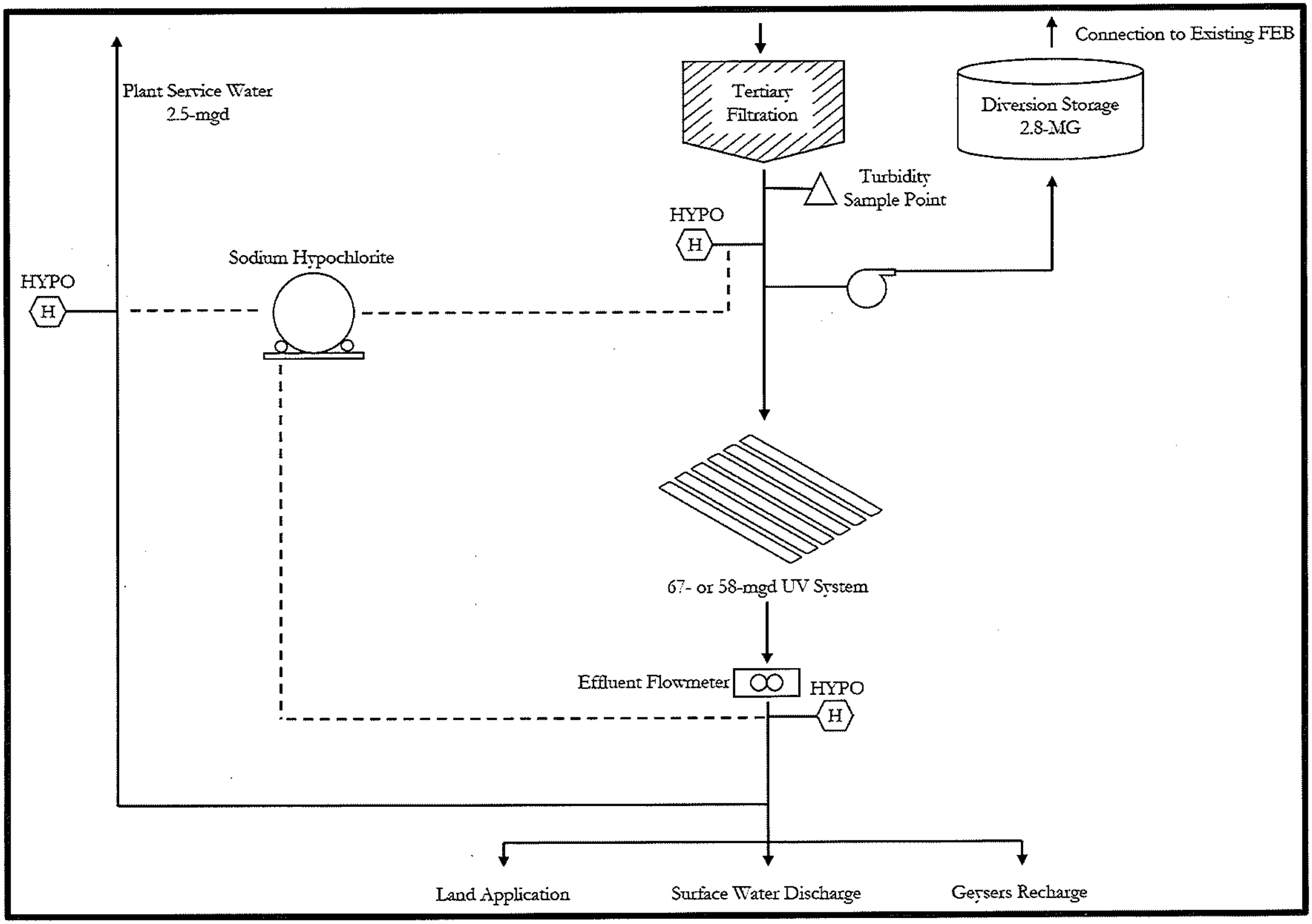

Figure 8: Process schematic for theoretical stand-alone UV disinfection system at LTP.

### 6.1.1 Diversion Storage

Both alternatives require diversion storage prior to disinfection to address the frequency of short-notice and short-duration under-disinfection events. With this capability, operators could divert flow to plant-side storage areas while maintenance is performed, and troubleshooting can occur. The diversion storage design for LTP consists of four main components: 1) a pumping station and wet well proceeding tertiary filtration, 2) HPDE piping leading to the diversion storage, 3) the diversion storage itself, and 4) an overflow to the existing FEB.

Much like the existing Trojan system, the new UV system is expected to have diversion features at its influent that can be routed to a wet well. The pumping station and wet well was sized based on recommendations from a similar Carollo proposal (Carollo 2015) and a Bernoulli conservation of energy analysis. The pumping station needs to be able to support an elevation head of 20-ft plus any friction head introduced by 1300-ft of 42-in HDPE piping. Friction head introduced by minor losses were considered negligible and a pump efficiency of 75% was assumed for this analysis. It was determined that the pumps needed a dynamic head of 31.18-ft at 67-mgd or a combined power of 489-HP. To make up for losses in total combined flowrates of parallel pumps, it is recommended that that pump station be comprised of four 200-HP vertical turbine pumps rated at 40-cfs. Under normal dry-weather conditions, one pump will be sufficient in handling the diversion should any effluent violations occur. Should diversions need to happen under peak wet-weather conditions, three pumps would be allocated to diverting the flow with one pump always available on standby for redundancy. The four vertical turbine pumps would be housed in a 0.5-MG wet well that is assumed to be 10-ft deep. Pump station calculations are included and can be referenced in Appendix D.

As stated previously, there is 1300-ft of 42-in HDPE piping required to divert tertiary treated wastewater to a storage pond located directly next to the existing FEB. This 1300-ft includes the piping required to connect the overflow of the proposed diversion storage to the FEB. Additionally, there will be one $90^0$, one tee, and two $45^0$ fittings to maneuver the piping network through the current treatment facility. Any water that is diverted prior to disinfection would be reintroduced into the aeration basins to continue treatment, much like the effluent from the existing FEB.

One possible modification to the diversion pipe network consists of utilizing part or all of the tertiary filter backwash pipe to divert flow to the storage pond and equalization basin. Utilizing an already established pipe could reduce construction costs associated with excavating and backfilling, however, the feasibility of this sub-alternative should be further researched.

The proposed diversion storage area is approximately 60,000-ft$^2$ with a design storage of 2.8-MG. The actual construction of the storage pond would be much like the existing FEB, consisting mainly of excavation, compaction, and concrete lining costs. At peak wet-weather flow rates with no previous diversion storage, the new pond would provide operators with an additional hour of time to troubleshoot any disinfection failures not including additional time bought by the FEB overflow, which history shows is more than enough time to solve a majority of LTPs under-dosing, upstream process, and sleeve cleaning related disinfection failures.

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### 6.1.2 UV System

A new UV system located at L1 requires that flow be diverted to this location using 200-ft of 42-in HDPE piping and a 90° bend located underneath an established service road. The new installation would be specifically designed for Title 22 purposes and would most likely utilize low-pressure high output lamps, as mentioned previously. There are two sub-alternatives for the stand-alone UV disinfection alternative: 1) a 58-mgd system with supplemental diversion from the West College Pump Station and 2) a 67-mgd system with no diversion offered from the West College Pump Station. While utilizing this pumping station results in capital cost savings, maintaining this facility over the next 20 years will likely introduce increases in O&M so the feasibility of this alternative should be further researched via a cost benefit analysis.

One benefit of the new UV system is the central location for coliform compliance testing as opposed to the three separate testing locations for each channel present in the current system. This will relieve regulatory complexity when it comes to reporting daily, weekly, and monthly concentrations, however, some sort of mechanism for analyzing each channel separately will need to be determined for troubleshooting purposes.

Something that should be considered when selecting a low-pressure high output UV system is the cleaning requirements. While cleaning is expected to be done less due to the slower buildup of salts on the cooler low-pressure bulbs, it will still be a crucial step in maintaining operational efficiency. According to Laguna Staff, there is currently only one manufacturer who uses in-channel chemical cleaning. If not cleaned in-channel, cleaning is required via removing the lamp banks from each channel and soaking them in acid baths. This will most likely be a time-consuming process involving overhead cranes and operator training. Because of the operational complexity that lamp cleaning introduces, the placement of acid baths and available cranes should be carefully considered. Lamp and ballast replacements should introduce the same types of disruptions currently experienced when maintaining these parts on the current system, however, the impact will be proportionally less due to the increase in duty channels and banks.

### 6.1.3 Relocations, Permitting, and Testing

A relocation of the current sodium hypochlorite tanks would need to be performed to make way for the new UV system. This is not expected to introduce a great deal of complexity to the project but their location in reference to pipe injection cleaning locations before and after disinfection should be considered. Additionally, the contractor trailers would need to be moved to an undetermined location or removed entirely.

Permits are required for excavation on undeveloped portions of LTP as their presence needs to be proven less than significant to local Tiger Salamander. General construction permits are also required.

As with any new facility, thorough testing procedures should be implemented throughout the construction phase to identify and prevent any unforeseen operational complexities.

### 6.1.4 UV Sitemap

The proposed design elements for the stand-alone UV system could be implemented with minimal alterations to current facilities. The main alterations stem from excavating, backfilling, compacting, and repaving service roads that need to be removed for the pipe network. The proposed changes for this alternative are included in Figure 9.

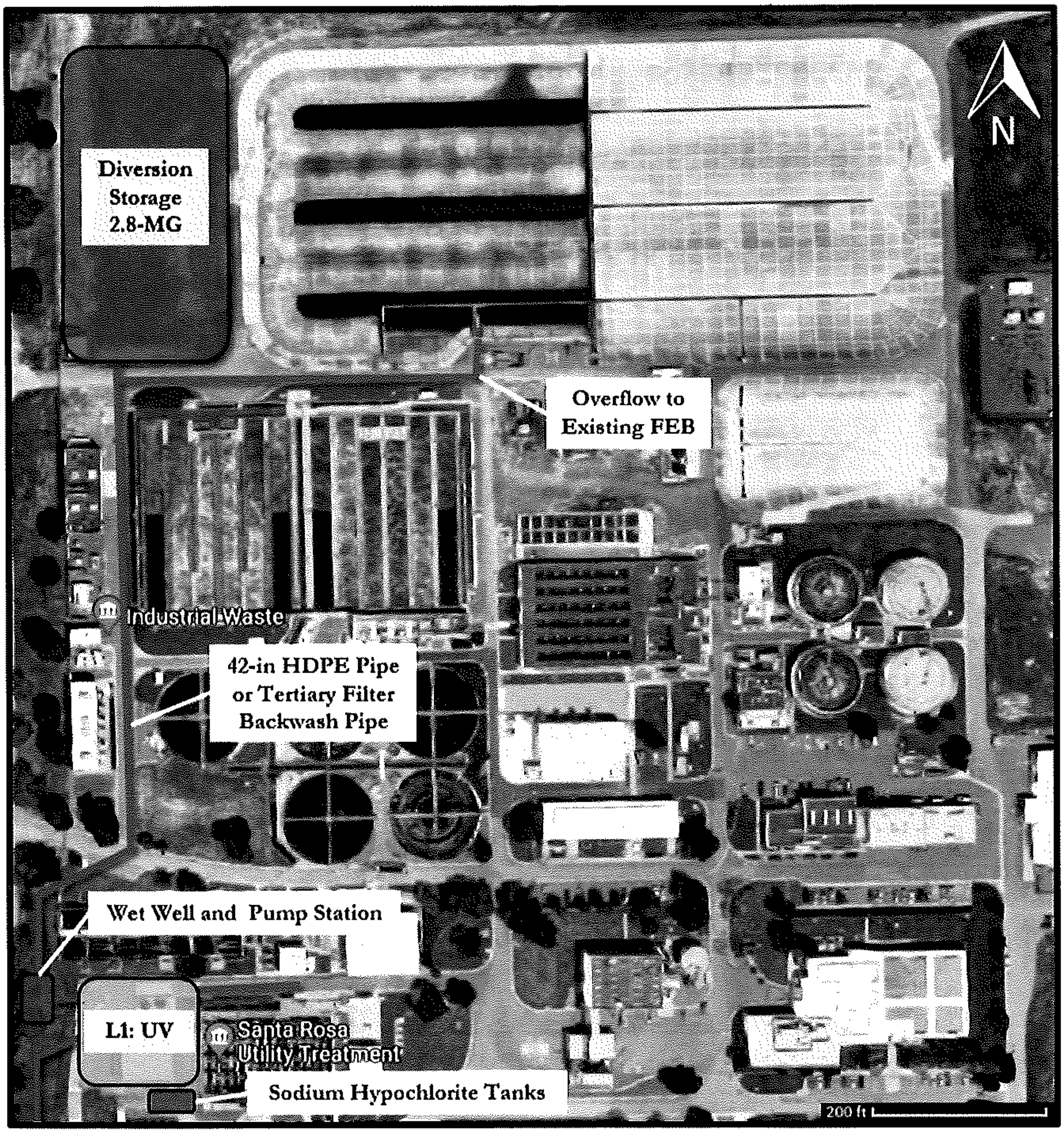

Figure 9: Sitemap for the stand-alone UV disinfection alternative at LTP adapted from Carollo, 2015.

## 6.2 Hypochlorination Alternative

Unlike current disinfection methods at LTP, the hypochlorination alternative would operate by retrofitting the current UV reaction chambers with a small 43-mgd UV system and diverting up to 30-mgd to the three existing CCBs when 43-mgd is expected to be exceeded. As addressed previously, this alternative requires more components as it is a parallel disinfection system as opposed to a stand-alone one. Hypochlorination facilities include the two disinfection units, a repurposed CCB, and a diversion storage system that is almost identical to the stand-alone UV alternative. Each of these components are included in a process schematic (Figure 10) and their significance is discussed in detail below. Additionally, LTP has the option of utilizing on-site generation of sodium hypochlorite to save costs on chemical deliveries. While this design does not directly address on-site generation methods, its feasibility should be further researched.

### 6.2.1 Diversion Storage

The diversion storage, piping network, wet well, and pumping station are almost identical to the previous alternative, however, an additional 387-ft of 42" HDPE and three 45° fittings are required to make up for the change in diversion effluent location. It should be noted that hypochlorinated water that is sent to the diversion storage and reintroduced into the aeration basins has the ability to drastically effect the health of the microorganisms contained in the mixed liquor and should be avoided if possible.

### 6.2.2 UV Retrofit

Retrofitting the current reaction chambers at L3 requires no additional modifications to the influent pipe like the prior alternative. The retrofitted UV system would need to be a Title 22 installation, however, constraints from the existing facilities would most likely prevent the compatibility of a low-pressure high output system. A newer medium-pressure system would most likely be utilized to ease the retrofitting process, however, this introduces the opportunity for another de-rating. Thorough research and case studies should be performed before settling on another medium-pressure system as to ensure the design flowrate is what is advertised from the manufacturer. Once the installation is complete, most daily disinfection related duties are expected to be similar and fully automated.

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### 6.2.3 Hypochlorination Augmentation

The three CCBs used for hypochlorination disinfection have a total volume of 1.42-MG and a HRT of 68-min at 30-mgd. If an efficiency of 75% is used, the design contact time is 51 minutes at the peak flow rate which results in a CT value of 255-mg·min/L assuming a chlorine residual of 5-mg/L. While this CT value and contact time does not fall within Title 22 regulations, Laguna Staff and Carollo Engineers have reasoned that a low CT value caused by higher flow rates will act as a contaminant buffer when sent to storage ponds. Most issues stemming from under-disinfection events such as excess ammonia concentrations that cause the formation of chloramines before free chlorine will be easily recognizable by treatment staff, and as such, can be diverted. The biggest opportunity for failure attributed to hypochlorination is less acute tests, like coliform compliances, which cannot be diverted. A low CT value and opportunities for disinfection failures speak to the high level of training required to bring operator readiness to a level that is adequate at managing a parallel disinfection system.

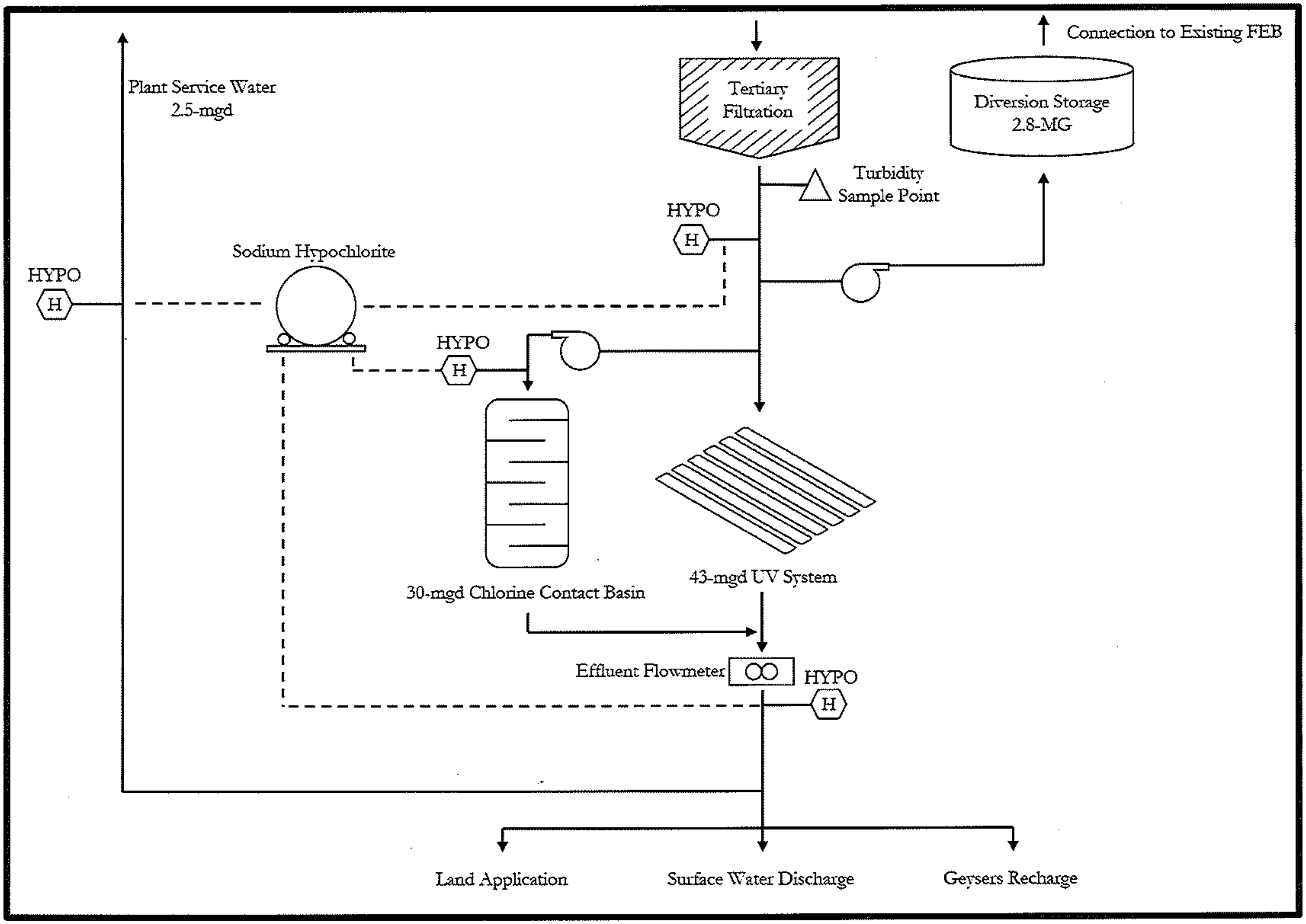

Figure 10: Process schematic for theoretical parallel hypochlorination and UV disinfection system at LTP.

Switching from a stand-alone UV disinfection to a parallel system with hypochlorination, as will be required at flows higher than 43-mgd, will have to be an anticipated event, as discussed earlier. CCBs will be switched online by pumping, as opposed to utilizing a weir, to accommodate drops and rises of 11-mgd caused by backwash phases in tertiary filtration. By utilizing pumps for the CCB, flow fluctuations will only affect UV disinfection, which it is well equipped to handle. If the CCBs were weir actuated, flow fluctuations caused by filter backwashed would affect both disinfection processes, likely leading to residual control problems.

In addition to routing flow to the CCBs before large flow events, chlorine residual analyzers (2 at the influent and 2 at the effluent) need to be calibrated before use. Laguna Staff reports that zeroing and re-spanning analyzers take about 20 minutes per analyzer followed by an 8- to 24-hr stabilization period. During this time, residuals can be expected to be off by 0.5- to 1.0-mg/L. Finally, the chemical system needs about 2-hrs to be brought online. Based on these preparation measures, it is recommended that the CCBs be brought online at least one day before flows are expected to exceed 43-mgd.

History at LTP shows that flows exceeding 43-mgd occur 1.2% of the time, or about 5 days out of the year. A typical dose of liquid sodium hypochlorite at 20-mg/L (EPA 1999a) for five days at 30-mgd equates to approximately 87,046-kg of 15% sodium hypochlorite solution by mass. The requirement to contain that much sodium hypochlorite solution is 22,758-gal. With a 25% safety factor and rounding up for industry standards, it is recommended that two additional 15,000-gal sodium hypochlorite tanks be added to accompany the two that are used to clean various pipes throughout the treatment system. These tanks should also be built within a secondary containment area that can be properly contained in the event of a chemical spill.

LTP has been researching ways to implement hypochlorination without exceeding on DBPs. One method that has been introduced is designating Delta Pond, LTPs largest pond, to receive exclusively UV treated water so that any discharge would have no or few DBPs. While this could potentially be implemented with some success, it introduces challenges to operators when attempting to keep the water in Delta pond at a level that is sufficient enough to take advantage of short discharge seasons. Water is typically transferred from the Meadow Lane ponds to accomplish this, but operators would be inhibited by their desire to prevent hypochlorinated water from entering Delta pond (Laguna Staff 2019). Additionally, if water was to be transferred between ponds, operators would have no practical way of determining when LTP has met or exceeded their DBP limits. It is assumed that LTP would have the ability to comply with their effluent DBP limits should this alternative be implemented.

As mentioned previously, hypochlorinated water entering the geyser pipeline is likely to cause a die-off of biogrowth. While the short- and long-term effects of sending chlorinated water to the geysers is not entirely known, they are expected to manageable. Furthermore, staff at the geysers steamfield have expressed interest in receiving hypochlorinated water as the chlorine residual is likely to clear up some amount of fouling within the steamfield distribution system (Laguna Staff 2019). Hypochlorinated water is not thought to effect agricultural or urban reclaimed water customers either.

There exists some appealing methods of nutrient removal that would be limited should LTP choose to implement hypochlorination. Nitrogen-reducing aeration control methods rely on low levels of ammonia in the secondary effluent. Controlling of the free chlorine residual becomes increasingly more difficult with varying amounts of ammonia in the effluent. Additionally, the chlorine dose would need to increase to compensate for the formation of chloramines before a chlorine residual, increasing the overall cost of chlorine as a disinfectant.

One option that is available for LTP is the utilization of on-site sodium hypochlorite generation facilities. On-site generation allows LTP to receive less deliveries of traditional sodium hypochlorite and modern efficient generation systems have cut down on chemical costs. While this method will reduce the cost of the system over time, it will also introduce more operator responsibilities and trainings. A cost benefit analysis of on-site generation over the next 20 years can be found in the following section.

### 6.2.4 Relocations, Permitting, and Testing

Relocation of the current sodium hypochlorite tanks and the contractor trailer would not be necessary for this alternative. As with the previous alternative, permits are required for excavation on undeveloped portions of LTP, general construction permits will be required, and regular testing procedures should be done throughout the construction phase to identify and prevent any unforeseen operational complexities.

### 6.2.5 Hypochlorination Sitemap

The proposed design elements for the hypochlorination system could be implemented with minor alterations to current facilities. The main alterations stem from excavating, backfilling, compacting, and repaving service roads that need to be removed for the pipe network. Additional alterations are required to update the existing CCBs and install a new hypochlorination distribution system. The proposed changes for this alternative are included in Figure 11.

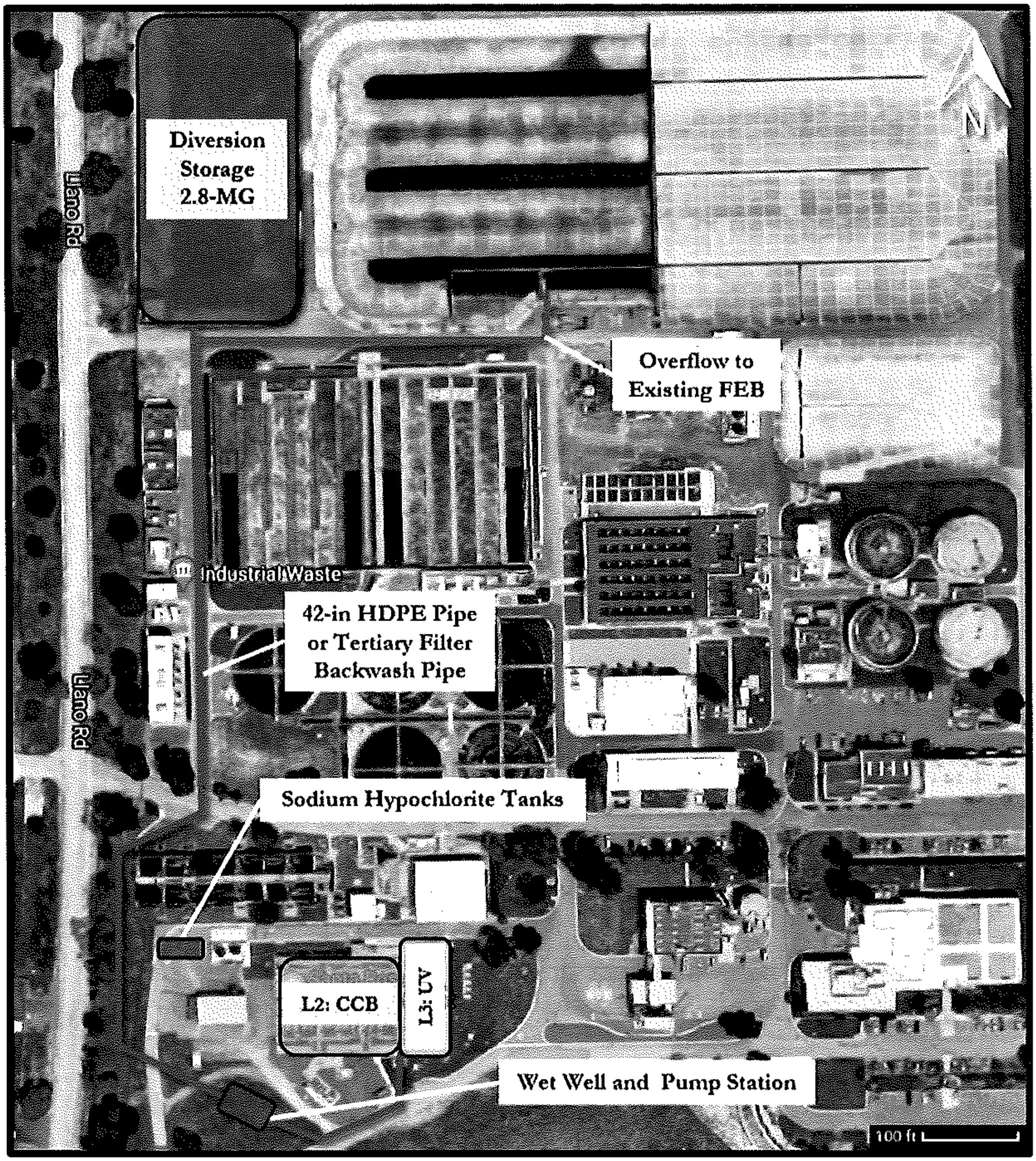

Figure 11: Sitemap for the hypochlorination disinfection alternative at LTP adapted from Carollo, 2015.

# 7 Analysis of Initial Alternatives

This section investigates the associated costs of each alternative. All costs are in 2019 dollars and annualized costs are for a 20-year period at 8.5% interest. Capital and O&M costs were obtained through recommendations from LTP Staff, EPA technology fact sheets, manufacturer estimates, and previous engineering reports. Contractor and supplier bids are recommended should either project be considered for further analysis.

## 7.1 New UV System

### 7.1.1 Capital Costs

Capital costs for the UV alternative include the cost of the system itself and any associated initial costs including construction, installation, permitting, training, and testing (Table 5). Much of the site working is associated with the excavation, compaction, and lining of the diversion storage and excavation, backfill, and repaving of the service road needed for the installation of diversion pipe. Utilizing sections of the tertiary filter overflow pipe was not included in this cost analysis. The cost for the low-pressure high output UV system was estimated by LTP staff with 35% of that cost being associated with the installation of the product. Pump and pipe related costs were estimated by consulting various online suppliers and reports. Testing was assumed to be 1% the cost of the product. Relocation of the hypochlorination tanks is much greater than relocation of the contractor building due to the feed lines that also must be moved and adjusted.

The UV system used for this cost analysis was sized for 67-mgd. As mentioned previously, LTP has the ability to divert up to 9-mgd to an off-site pumping station which would allow the UV system to be sized for 58-mgd. Staff at LTP and Carollo engineers have estimated that the West College pumping station would need $3 million in upgrades to reliably support the treatment facility for the next 20 years. This would allow LTP to save an estimated $3.5 million in capital costs and $0.1 million per year in O&M costs for a total of $8.5 million saved over the life of the project.

### 7.1.2 O/M Costs

O&M costs for the UV alternative are overwhelmingly attributed to the power, labor, and parts needed to support the UV disinfection system. These costs were calculated using a combination of LTP staff estimates and empirically calculated functions based on average flow rates (UNH 2001). While the manufacturer of the UV system should have expected lifespans of each replaceable component, an initial fouling testing phase is recommended to determine the worst-case maintenance frequency and to identify any defects with the system. Replaceable parts considered for this analysis were lamps, sleeves and ballasts.

### 7.1.3 Permitability

Permitting is required to demolish and dispose of the current UV system, demolish existing service roads, and construction of the diversion storage. Additionally, any undeveloped area that requires alterations must go through an extensive permitting process with the U.S. Fish and Wildlife Service. Permitting costs were assumed to be the same as similarly implemented permits in California (SBCPWD 2017). Any alterations to the current facilities must also be verified by the DDW and changes will need to be reflected in LTP's MR permit.

Table 5: Capital Costs for the new UV system alternative.

| UV System | No. | Unit | Unit Cost | Total Cost |
|---|---|---|---|---|
| 67-mgd UV System | 1 | LS | $16,445,000.00 | $16,445,000.00 |
| Install | 1 | LS | $8,855,000.00 | $8,855,000.00 |
| Excavation | 2,963 | CY | $60.00 | $177,780.00 |
| Backfill | 2,963 | CY | $50.00 | $148,150.00 |
| Concrete Road | 2,000 | SF | $25.00 | $50,000.00 |
| HDPE 42" | 200 | LF | $130.00 | $26,000.00 |
| HDPE 42" 90° | 1 | EA | $1,500.00 | $1,500.00 |
| Hypo Relocation | 1 | LS | $200,000.00 | $200,000.00 |
| Contractor Relocation | 1 | LS | $30,000.00 | $30,000.00 |
| Operator Training | 50 | HR | $35.00 | $1,750.00 |
| Testing | 1 | LS | $164,450.00 | $164,450.00 |
| Diversion Storage | | | | |
| Excavation | 34,504 | CY | $60.00 | $2,070,240.00 |
| Compaction | 13,852 | CY | $7.00 | $96,964.00 |
| Concrete Lining | 65,463 | SF | $10.00 | $654,630.00 |
| Concrete Road | 10,254 | SF | $25.00 | $256,350.00 |
| Backfill | 20,652 | CY | $50.00 | $1,032,600.00 |
| HDPE 42" | 1,300 | LF | $130.00 | $169,000.00 |
| HDPE 42" 90° | 1 | EA | $1,500.00 | $1,500.00 |
| HDPE 42" 45° | 2 | EA | $1,500.00 | $3,000.00 |
| HDPE 42" tee | 1 | EA | $1,700.00 | $1,700.00 |
| Permitting | 1 | LS | $75,000 | $75,000.00 |
| Wet Well and Pumping Station | | | | |
| Excavation | 2,476 | CY | $60.00 | $148,560.00 |
| Compaction | 2,476 | CY | $7.00 | $17,332.00 |
| Concrete Lining | 9,884 | SF | $10.00 | $98,840.00 |
| 200-HP VT Pumps | 4 | EA | $45,000.00 | $180,000.00 |
| Testing | 1 | LS | $450.00 | $450.00 |
| Total | | | | $30,905,796.00 |
| Annualized Total (20 years at 8.5%) | | | | $3,265,845.58 |

Table 6: O&M for the new UV system alternative.

| Category | Cost/Year |
|---|---|
| Power | $384,300.00 |
| Labor | $44,100.00 |
| Parts | $201,600.00 |
| Total | $630,000.00 |

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## 7.2 Hypochlorination

### 7.2.1 Construction Costs

Construction costs for the hypochlorination alternative include much of the same costs as the UV system plus the additional costs of augmenting the existing CCBs with components that would allow for 30-mgd of chemical disinfection (**Table 7**). The cost of retrofitting the current UV disinfection system was given by LTP staff and the cost for the hypochlorination system was estimated by referencing EPA technology fact sheets (1999a). Testing was still assumed to be 1% of the cost of the product installed.

The method of sodium hypochlorite treatment that was chosen for this cost analysis was liquid delivery. As mentioned previously, LTP could invest in an on-site hypochlorite generation system should this alternative be chosen. The estimated capital cost for a hypochlorite generation system capable of fulfilling the parallel disinfection needs at LTP is $381,875 with a yearly O&M cost of $2,900 (Westerling 2014). Based on the estimated yearly costs for chemical delivery, on-site generation is expected to cost LTP an additional $325,875 over the entire life of the disinfection system.

### 7.2.2 O&M Costs

Operation and maintenance costs for the hypochlorination system are mainly associated with the 43-mgd UV disinfection system due to the parallel system only being utilized during peak flow events. Power, labor, and parts costs were given by LTP staff and yearly sodium hypochlorite costs were estimated by referencing the EPA technology fact sheet (1999a) and reports related to similar facilities (Westerling 2014). An initial testing phase for the hypochlorination disinfection system should be implemented to identify low-flow zones, calibrate residual analyzers, and dial in an appropriate dosing procedure. Besides the addition of regular sodium hypochlorite solution deliveries, the replaceable parts considered for this analysis were lamps, sleeves, and ballasts for the UV system.

### 7.2.3 Permitability

Permits for the hypochlorination alternative are similar to the stand-alone UV alternative. Additional permits will be needed for the construction and implantation of the hypochlorination feed system, which will require that LTP have an authorized emergency response plan, adequate containment measures, and a sufficient amount of operator readiness in case of a chemical spill. Much like the last alternative, any alteration to the current facility will need to be verified by the DDW and LTP's MR permit will need to reflect the utilization of sodium hypochlorite as a disinfectant.

Table 7: Capital Costs for the hypochlorination alternative.

| UV System | No. | Unit | Unit Cost | Total Cost |
|---|---|---|---|---|
| 43-mgd UV Retrofit | 1 | LS | $10,985,000.00 | $10,985,000.00 |
| Install | 1 | LS | $5,915,000.00 | $5,915,000.00 |
| Operator Training | 100 | HR | $35.00 | $3,500.00 |
| Testing | 1 | LS | $109,850.00 | $109,850.00 |
| Hypo System | | | | |
| 15,000-gal Tank | 2 | EA | $16,000.00 | $32,000.00 |
| Residual Analyzer | 4 | EA | $5,365.00 | $21,460.00 |
| Feeds/Valves/Pumps | 1 | LS | $1,909,589.00 | $1,909,589.00 |
| 30-mgd Basin Upgrades | 1 | LS | $1,909,589.00 | $1,909,589.00 |
| Storage | 2,000 | SF | $200.00 | $400,000.00 |
| Install | 1 | LS | $1,336,712.30 | $1,336,712.30 |
| Diversion Storage | | | | |
| Excavation | 36,308 | CY | $60.00 | $2,178,480.00 |
| Compaction | 13,852 | CY | $7.00 | $96,964.00 |
| Concrete Lining | 65,463 | SF | $10.00 | $654,630.00 |
| Concrete Road | 11,424 | SF | $25.00 | $285,600.00 |
| Backfill | 22,456 | CY | $50.00 | $1,122,800.00 |
| HDPE 42" | 1,787 | LF | $130.00 | $232,310.00 |
| HDPE 42" 90° | 1 | EA | $1,500.00 | $1,500.00 |
| HDPE 42" 45° | 5 | EA | $1,500.00 | $7,500.00 |
| HDPE 42" tee | 1 | EA | $1,700.00 | $1,700.00 |
| Permitting | 1 | LS | 75,000 | $75,000.00 |
| Wet Well and Pumping Station | | | | |
| Excavation | 2,476 | CY | $60.00 | $148,560.00 |
| Compaction | 2,476 | CY | $7.00 | $17,332.00 |
| Concrete Lining | 9,884 | SF | $10.00 | $98,840.00 |
| 200-HP VT Pumps | 4 | EA | $45,000.00 | $180,000.00 |
| Testing | 1 | LS | $450.00 | $450.00 |
| Total | | | | $27,724,366.30 |
| Annualized Total (20 years at 8.5%) | | | | $2,929,660.80 |

Table 8: O&M for the hypochlorination alternative.

| Category | Cost/Year |
|---|---|
| Power | $366,000.00 |
| NaClO | $5,700.00 |
| Labor | $42,000.00 |
| Parts | $192,000.00 |
| Total | $605,700.00 |

### 7.3 Cost Comparison

Costs for each alternative were compared by annualizing the capital costs over the life of the disinfection system (20 years) at an 8.5% interest rate. Annualized costs for each alternative were combined with each respective annual O&M cost to obtain the estimated yearly cost (Table 9). All alternatives have very similar capital and O&M costs, with the stand-alone 67-mgd UV disinfection system being the greatest. The major contributor to capital cost among all alternatives is the investment in a UV system, whether it be new or retrofitted. Similarly, the majority of O&M costs among all alternatives including power, labor, and parts is associated with UV. Investments in the West College Pumping Station are projected to reduce capital and O&M costs more than investments in a parallel disinfection system. This analysis suggests that augmenting a retrofitted UV disinfection system with hypochlorination that is used infrequently results in higher costs than a higher-rated stand-alone UV disinfection system.

Table 9: Cost comparison for each alternative and each sub-alternative.

| | 67-mgd UV System | 58-mgd UV system | Hypochlorination | Hypochlorination w/ Generation |
|---|---|---|---|---|
| Capital Cost | $30,905,796.00 | $27,405,796.00 | $27,724,366.30 | $28,106,241.30 |
| Annualized | $3,265,845.58 | $2,895,997.17 | $2,929,660.80 | $2,970,013.90 |
| O&M | $630,000.00 | $530,000.00 | $605,700.00 | $602,900.00 |
| Total Annual Cost | $3,895,845.58 | $3,425,997.17 | $3,535,360.80 | $3,572,913.90 |

## 8 Conclusions and Recommendations

The recommended alternative is the new stand-alone low-pressure high output UV disinfection system sized at 58-mgd; mainly due to the discussed operational complexities associated with maintaining a parallel disinfection system. This recommendation comes with the assumption that LTP will also invest in the West College Pumping Station, allowing them to buffer their peak wet weather flows. Not only does this allow LTP to invest in a smaller UV disinfection system, but the reduction in costs associated with the 58-mgd UV system are projected to be lower than the costs associated with retrofitting and upgrading the existing UV system and CCBs. However, due to the low variability of cost estimates between alternatives, it is strongly recommended that contractor and supplier bids be sought before any alternative be chosen for further development.

The installation of the UV disinfection system is contingent on approval from the DDW to produce Title 22 water. Upon project completion, it is recommended that LTP perform a capacity and dose response analysis and report their findings to the DDW to avoid any future de-rating issues.

A detailed analysis of the Laguna Wastewater Treatment Facility has suggested that the most practical way of regaining control of their disinfection capacity would be to invest in the West College Pumping Station to buffer up to 9-mgd, construct a low-pressure high output UV disinfection system rated at 58-mgd, and construct a 2.8-MG on-site diversion storage to avoid disinfection failures. The new UV system is expected to reduce failures related to under-dosing, coliform exceedance, and algae sloughing while history has shown that the 2.8-MG diversion storage should allow LTP staff enough time to prevent discharging during most disinfection failure events. This design requires the least annualized cost and will be able to meet all disinfection standards in LTPs MR permit through the year 2040.

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# Appendix A - MCLs

Table 10: Inorganic MCLs (CCR 2017).

| Chemical | Level (mg/L) |
|---|---|
| Aluminum | 1 |
| Antimony | 0.006 |
| Arsenic | 0.01 |
| Asbestos | 7 MFL |
| Barium | 1 |
| Beryllium | 0.004 |
| Cadmium | 0.005 |
| Chromium | 0.05 |
| Cyanide | 0.15 |
| Fluoride | 2 |
| Mercury | 0.002 |
| Nickel | 0.1 |
| Nitrate (as nitrogen) | 10 |
| Nitrate+Nitrite (sum as nitrogen) | 10 |
| Nitrite (as nitrogen) | 1 |
| Perchlorate | 0.006 |
| Selenium | 0.05 |
| Thallium | 0.002 |

Table 11 Volatile Inorganic MCLs (CCR 2017).

| Chemical | Level (mg/L) | Chemical | Level (mg/L) |
|---|---|---|---|
| Benzene | 0.001 | Methyl-tert-butyl ether | 0.013 |
| Carbon Tetrachloride | 0.0005 | Monochlorobenzene | 0.07 |
| 1,2-Dichlorobenzene | 0.6 | Styrene | 0.1 |
| 1,4-Dichlorobenzene | 0.005 | 1,1,2,2-Tetrachloroethane | 0.001 |
| 1,1-Dichloroethane | 0.005 | Tetrachloroethylene | 0.005 |
| 1,2-Dichloroethane | 0.0005 | Toluene | 0.15 |
| 1,1-Dichloroethylene | 0.006 | 1,2,4-Trichlorobenzene | 0.005 |
| cis-1,2-Dichloroethylene | 0.006 | 1,1,1-Trichloroethane | 0.2 |
| trans-1,2-Dichloroethylene | 0.01 | 1,1,2-Trichloroethane | 0.005 |
| Dichloromethane | 0.005 | Trichloroethylene | 0.005 |
| 1,2-Dichloropropane | 0.005 | Trichlorofluoromethane | 0.15 |
| 1,3-Dichloropropene | 0.0005 | 1,1,2-Trichloro-1,2,2-Trifluoroethane | 1.2 |
| Ethylbenzene | 0.3 | Vinyl Chloride | 0.0005 |
| | | Xylenes | 1.75 |

Table 12: Synthetic MCLs (CCR 2017).

| Chemical | Level (mg/L) | Chemical | Level (mg/L) |
|---|---|---|---|
| Alachlor | 0.002 | Heptachlor | 0.00001 |
| Atrazine | 0.001 | Heptachlor Epoxide | 0.00001 |
| Bentazon | 0.018 | Hexachlorobenzene | 0.001 |
| Benzo(a)pyrene | 0.0002 | Hexachlorocyclopentadiene | 0.05 |
| Carbofuran | 0.018 | Lindane | 0.0002 |
| Chlordane | 0.0001 | Methoxychlor | 0.03 |
| 2,4-D | 0.07 | Molinate | 0.02 |
| Dalapon | 0.2 | Oxamyl | 0.05 |
| Dibromochloropropane | 0.0002 | Pentachlorophenol | 0.001 |
| Di(2-ethylhexyl)adipate | 0.4 | Picloram | 0.5 |
| Di(2-ethylhexyl)phthalate | 0.004 | Polychlorinated Biphenyls | 0.0005 |
| Dinoseb | 0.007 | Simazine | 0.004 |
| Diquat | 0.02 | Thiobencarb | 0.07 |
| Endothall | 0.1 | Toxaphene | 0.003 |
| Endrin | 0.002 | 1,2,3-Trichloropropane | 0.000005 |
| Ethylene Dibromide | 0.00005 | 2,3,7,8-TCDD (Dioxin) | 3x10$^{-8}$ |
| Glyphosate | 0.7 | 2,4,5-TP (Silvex) | 0.05 |

# Appendix B – Monitoring Stations

Table 13: List of monitoring stations at LTP and their descriptions (NCRWQCB 2013).

| Discharge/Distribution Point Name | Monitoring Location Name | Monitoring Location Description |
|---|---|---|
| -- | INF-001 | Untreated influent wastewater collected at the plant headworks at a representative point preceding primary treatment. Formerly M-INF. |
| -- | INT-001A | Location for reporting the surface loading rate of the advanced wastewater (AWT) filtration process. The flow rate through the effluent filters is measured at EFF-001. Formerly M-INTA. |
| -- | INT-001B | Treated wastewater immediately following the advanced wastewater (AWT) process and prior to UV disinfection. Formerly M-INTB. |
| -- | INT-002 | Location for calculating UV radiation dose and UV transmittance of the UV Disinfection System. |
| 001 | EFF-001 | Treated wastewater following all treatment and before it enters the Geysers Project distribution system. |
| 002 | EFF-001 | Treated wastewater following all treatment and before it enters the irrigation distribution system. |
| 006A | EFF-006A | Treated wastewater following all treatment and storage in Meadow Lane Pond D, and prior to discharge to the Laguna de Santa Rosa. EFF-006A is also the downstream receiving water monitoring location for 006A. Formerly M-002. |
| 006B | EFF-006B | Treated wastewater following all treatment and storage in Meadow Lane Pond D, and prior to discharge to the confluence of the Laguna de Santa Rosa and Colgan Creek. EFF-006B is also the downstream receiving water monitoring location for 006B. Formerly M-003. |
| 012A(1) | EFF-001 | Treated wastewater that is discharged directly to Santa Rosa Creek from the distribution trunk line rather than being stored in Delta Pond, which is monitored prior to discharge to Santa Rosa Creek. Formerly M-001. |
| 012A(2) | EFF-012A(2) | Treated wastewater following all treatment and storage in Delta Pond, and prior to discharge to Santa Rosa Creek. Formerly M-004. |
| -- | EFF-012B | Treated wastewater following all treatment and storage in Delta Pond, and prior to discharge to the confluence of Santa Rosa Creek and the Laguna de Santa Rosa. Formerly M-005. |
| -- | EFF-001 | Treated wastewater following all treatment but prior to discharge to the Laguna de Santa Rosa, prior to discharge to the reclamation system and prior to storage in Meadow Lane and Delta ponds. Formerly M-001. |
| -- | RSW-006AU | At a point in the Laguna de Santa Rosa just upstream of the D-Pond incline pump discharge. Formerly R-007. |
| -- | RSW-006BU-C | At a point in Colgan Creek upstream of confluence with the Laguna de Santa Rosa. Formerly R-001. |
| -- | RSW-006BU-L | At a point in the Laguna de Santa Rosa upstream of the discharge from Discharge Point 006B. Formerly R-002. |
| -- | RSW-012AU | At a point in Santa Rosa Creek upstream of the discharge from Discharge Point 012A(2). Formerly R-004. |
| -- | RSW-012BU | At a point in Santa Rosa Creek upstream of the discharge from Discharge Point 012B. Formerly R-105. |

| | | |
|---|---|---|
| -- | RSW-012BD-S | At a point in Santa Rosa Creek near confluence with the Laguna de Santa Rosa. Exact location determined by the Model and variable depending on flows. Formerly R-018. |
| -- | RSW-012BD-L | At a point in the Laguna de Santa Rosa approximately 75 feet upstream of confluence of Santa Rosa Creek and Laguna de Santa Rosa. Formerly R-019. |
| -- | RSW-015U | At a point in the Laguna de Santa Rosa approximately 100 feet upstream of Llano Bridge Road. Formerly R-006. |
| -- | BIO-001 | A representative sample of the sludge or biosolids generated when removed for disposal. |

# Appendix C – Discharge Locations and Reclamation Sites

Table 14: Discharge Locations for LTP (NCRWQCB 2013).

| Discharge Point | Effluent Description | Discharge Point Latitude | Discharge Point Longitude | Receiving Water |
|---|---|---|---|---|
| 006A (Meadow Lane Pond D) | Disinfected tertiary treated municipal wastewater | 38° 22' 17" N | 122° 46' 31" W | Laguna de Santa Rosa |
| 006B (Meadow Lane Pond D) | Disinfected tertiary treated municipal wastewater | 38° 22' 17" N | 122° 46' 31" W | Laguna de Santa Rosa |
| 012A (Delta Pond) | Disinfected tertiary treated municipal wastewater | 38° 26' 54" N | 122° 49' 27" W | Santa Rosa Creek |
| 012B (Delta Pond) | Disinfected tertiary treated municipal wastewater | 38° 26' 54" N | 122° 49' 27" W | Santa Rosa Creek |
| 015 | Disinfected tertiary treated municipal wastewater | 38° 22' 17" N | 122° 46' 31" W | Laguna de Santa Rosa |

Table 15: Reclamation sites for LTP (NCRWQCB 2013).

| Discharge Point | Effluent Description | Distribution Point Latitude | Distribution Point Longitude | Use Location |
|---|---|---|---|---|
| 001 | Disinfected tertiary treated municipal wastewater | 38° 45' 46" N | 122° 45' 38" W | Irrigation Distribution System |
| 002 | Disinfected tertiary treated municipal wastewater | See Figure 4 | See Figure 4 | Irrigation Distribution System |

# Appendix D – Calculations

Table 16: Pumping station parameters and required power results.

| Parameters | Value | Unit |
|---|---|---|
| Flow Rate | 67 | mgd |
| Flow Rate | 55877.531 | gpm |
| Flow Rate | 103.66441 | cfs |
| Δh | 20 | ft |
| g | 32.2 | $ft/s^2$ |
| Length | 1300 | ft |
| Diameter | 42 | in |
| Diameter | 3.5 | ft |
| Radius | 1.75 | ft |
| Area | 9.621127502 | $ft^2$ |
| Velocity | 10.77466336 | ft/s |
| Roughness | 0.007 | in |
| Roughness | 0.000583333 | ft |
| Relative Roughness | 1.67E-04 | |
| Density | 1.94 | $slug/ft^3$ |
| Efficiency | 0.75 | |
| Temperature | 20 | °C |
| Dynamic Viscosity | 0.000020895 | $lb{\cdot}s/ft^2$ |
| Specific Gravity | 62.4 | $lb/ft^3$ |
| Pump Specifications | | |
| Re = | 3.50E+06 | |
| f = | 0.014 | |
| $h_f$= | 9.373998867 | ft |
| $E_p$ = | 31.17669096 | ft |
| P = | 268895.1844 | $lb{\cdot}ft/s$ |
| P = | 488.9003352 | HP |