TETRA TECH

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MEMORANDUM

TO: Ellen Robley, Paint Brush Hills Metropolitan District
Larry Bishop, Woodmen Hills Metropolitan District

FROM: Joseph R. Tamburini, P.E. and H.C. Liang, PhD, Tetra Tech

Cc: John McGinn P.E., JDS Hydro; Mark Nance P.E., Integra Engineering; Connie King Esq., Law Firm of Connie H. King LLC.; Jim Egan P.E., Regulatory Management Inc.

SUBJECT: Paint Brush Hills Wastewater Treatment Facility
Comprehensive Performance Evaluation

EXECUTIVE SUMMARY

The analyses performed by Tetra Tech presented in this memorandum have shown that the existing Paint Brush Hills Metropolitan District (PBHMD) wastewater treatment facility (WWTF) is at, or over, capacity in terms of hydraulic and organic loading as currently designed and operated. The existing WWTF is rated for a capacity of 1.3 MGD and 3,470 pounds of biochemical oxygen demand (BOD) per day. The existing WWTF's actual capacity according to the analysis performed in this Comprehensive Performance Evaluation (CPE) is 0.61 MGD and 1,437 pounds of BOD per day. Therefore, the existing WWTF must be expanded to accommodate existing flows. A two step process can be implemented to most effectively expand the capacity of the existing WWTF; these steps are as follows:

- Step 1: Place the spare lagoon (Cell 3) into service, in series with the existing three lagoons.
- Step 2: Build an advanced activated sludge system.

Step 1 has relatively low capital and annual costs. This step will slightly increase the capacity of the WWTF, and reduce the frequency of effluent 5-day biochemical oxygen demand (BOD) and BOD removal percentage violations. However, this will not increase the capacity of the facility higher than the 2007 and 2008 maximum month flowrate. Therefore, planning for an activated sludge WWTF will need to be undertaken. Tetra Tech will develop preliminary Opinions of Probable Cost (OPCs) for such an expansion in the Composite Correction Program (CCP) document to be completed in the next scope of Tetra Tech's work.

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INTRODUCTION/BACKGROUND

Paint Brush Hills Metropolitan District and Woodmen Hills Metropolitan District (WHMD) jointly own a wastewater treatment facility allocated for treating wastewater from the two districts in addition to wastewater from the Meridian Ranch and other surrounding communities. While jointly owned, the WWTF's discharge permit has been issued to PBHMD under the CDPS Permit Number CO 0047091. Any future reference in this CPE to the PBHMD WWTF is simply due to its permit status; it is understood that PBHMD and WHMD have joint ownership of the facility. Staff from WHMD have been operating and maintaining the facility.

The original WWTF came online in 1988 with a rated capacity of 0.868 MGD. Since this time the WWTF has undergone several small modifications including a headworks upgrade and modifications to the original lagoons. During one of the modifications (approximately 2002), the WWTF was rerated for 1.3 MGD; although there was no increase in lagoon volume, only modifications to the layout of the original lagoons.

Critical issues with the WWTF began to appear in 2007 with an increase in odor complaints and subsequent exceedances of the effluent BOD concentration and overall BOD removal permit limits in 2007 and 2008. The WWTF experienced one effluent pH violation in August 2008 for a low pH value, and a total residual chlorine violation in January 2009 that was above the discharge limit of 0.5 mg/L. These violations were outlined in a May 2009 Notice of Violation (NOV), number MO-090505-1. As required by the NOV, PBHMD retained Tetra Tech to perform this Comprehensive Performance Evaluation (CPE) of the WWTF, and to specifically evaluate the following items:

- System design capacity
- Influent hydraulic and organic loading
- Individual unit processes
- Adequacy of aeration/back-up equipment
- Biosolids buildup
- Process reliability
- Chemical feed system reliability
- Operations and maintenance staffing
- Operator expertise needs
- Process control systems adequacy and functionality
- Managerial and financial systems

Paint Brush Hills Metropolitan District and WHMD provided Tetra Tech with previous reports, communications with the CDPHE, and design drawings of the WWTF for Tetra Tech's review. After an initial document review, two team members from Tetra Tech visited the PBHMD WWTF on June 26, 2009 and provided their assessment of the WWTF as it relates to the current wastewater flow and organic loadings. Following the site visit, members from the Tetra Tech team evaluated two years worth of operating data from the WWTF, as provided by WHMD operations staff. The following is a Comprehensive Performance Evaluation of the WWTF based upon the documents provided, the site visit, and the data provided by WHMD.

EXISTING TREATMENT FACILITY

Lagoon System Overview

Typically, lagoon systems are designed on a flow-through basis. With the exception of the impact caused by occasional algae events, lagoon plants are theoretically capable of achieving secondary treatment effluent quality, which is less than 30 milligrams per liter (mg/L) of BOD. Due to the potential algae impacts, higher levels of total suspended solids (TSS) are possible and accounted for by having a higher TSS limit of less than 75 mg/L.

Typical lagoon treatment processes include biological decomposition by suspended growth microorganisms, settling in a polishing pond, and disinfection in a chlorine contact system. Design standards for lagoon treatment systems include, at a minimum, two aeration cells, a polishing pond, an adequate dissolved air system or other aeration system, a well-designed layout for the inlet and outlet structures, and a proper disinfection system.

Calculations were made to determine the theoretical capacity of the aerated cells at the WWTF using the method recommended by the United States Environmental Protection Agency (EPA, 1983). The limiting time period used for the calculations was during the winter months when water temperatures are lowest. It is necessary to use this worst-case scenario for lagoon operations because this is the period when bacterial action slows and the rate of BOD consumption is slowest. The lowest monthly average water temperature from the two years of data analyzed was 3.14 degrees Celsius, with the lowest three month period ranging between 3.14 and 4.90 degrees Celsius in each of those three months.

Winter months present several process and operational challenges for lagoon systems. In addition to slowing microorganism metabolism, deep snows can interfere with the operation of the aerators and access to the site. Ice build up on the aeration equipment can pose potential problems for the motors. However, if ice cover can be properly maintained over the lagoon, it is generally helpful in the winter since the ice creates a layer of insulation over the pond and allows higher water temperatures to be maintained.

One significant advantage of the aerated lagoon system is that it can accommodate variable daily flows because of long detention times. This essentially creates flow equalization, which is useful to control peak influent flows. Lagoons are also relatively simple and inexpensive systems to operate and maintain.

Existing Facilities Layout and Description

The existing WWTF schematic is illustrated in Figure 1. The four lagoons are labeled Cell 1, Cell 2, Cell 3 and Cell 4. Cells 1 and 2 are aerated and provide biological decomposition of suspended solids while Cell 3 and Cell 4 are polishing ponds and provide settling for the small amount of remaining solids. Both Cell 3 and Cell 4 have the same volume, but have not been in operation simultaneously. Cell 3 is currently offline and being dredged.

The lagoon banks are sloped at roughly three feet horizontal by one foot vertical and provide about three feet of freeboard above the average operating water level. A summary of the lagoon treatment system design parameters is provided in Table 1.

Table 1 – Lagoon System Summary

Parameter	Cell 1	Cell 2	Cell 3	Cell 4	TOTAL
Volume , MG	1.89	4.27	2.60	2.70	11.5
Surface Area, acres	0.75	1.49	1.02	1.02	4.29
Aeration/Mixing, hp	130	135	0	0	265
Basin Liner	Synthetic	Synthetic	Clay	Synthetic	N/A

Influent wastewater enters the facility through a combination of forcemains (from a portion of PBHMD, all of WHMD and Meridian) and gravity sewers (the majority of PBHMD). The influent wastewater enters the facility at a headworks building consisting of a Parkson Hycor rotary drum screen, influent ISCO composite sampler, and Parshall flume flow monitoring device.

Wastewater flows from the headworks facility into Cell 1, which is nearly square but with a concrete baffle wall in the middle of the lagoon creating a plug flow effect. The surface area of Cell 1 is approximately 33,000 square feet (ft^2) at the operating water level, and 12 feet deep. The total storage volume of Cell 1 is approximately 1.89 million gallons (MG). From Cell 1, the water is designed to flow directly into Cell 2. However, operator-initiated modifications allow for some of the flow leaving Cell 1 to be recycled back to the head of Cell 1 as depicted in Figure 1. There was not any conclusive data regarding its effectiveness; although Tetra Tech feels the concept is worthwhile. Cell 1 is lined with a synthetic liner, which appeared in good condition during Tetra Tech's site visit.

Cell 1 had six (6) aspirating type aerators (AireO_2 from Aeration Industries) with a motor size of 20 horsepower (hp) on each unit. Units such as the AireO_2 units perform both mixing and aeration. Mixing is accomplished via a propeller angled into the lagoon allowing for directional mixing depending on where the propeller is positioned. The units in Cell 1 were positioned to provide mixing in the countercurrent direction with the influent flow. Aeration is accomplished utilizing a venturi effect from the propellers to pull air down a draft tube and dissolve into the water and mixed through the basin. These draft tubes are notorious for plugging and most of them had been modified in the field. There were also two (2) additional aspirating aerator units that had 5 hp motors. This equates to a total of 130 hp for mixing and aeration in Cell 1. At the time of the site visit, all aerators in Cell 1 were in operation.

Cell 2 is rectangular in shape with a surface area of 65,000 ft^2 and a total volume of 4.27 MG. Similarly to Cell 1, Cell 2 has baffle walls directing the flow pattern in a plug flow manner. These baffle walls are concrete, with synthetic liner attached to all the sides. There are a total of nine (9) aspirating aerators in Cell 2, each with a motor size of 15 hp for a total capacity of 135 hp for mixing and aeration. At the time of the site visit, all nine aerators were operational. Similarly to the units in Cell 1, the majority of the draft tubes on the aerators had been modified for more reliable operation.

Table 2 – Lagoon Mixing/Aeration Summary

Cell	Power (hp)
Cell 1	130
Cell 2	135
Cell 3	0
Cell 4	minimal
Total	265

Water from Cell 2 flows directly into Cell 4; Cell 3 was out of service at the time of the site visit. There is a fractional horsepower mixer unit at the entrance to Cell 4, but it does not provide any measureable air or mixing. Cell 4 is used as a polishing pond and does not contain any baffle walls. It has a surface area of approximately 44,600 ft^2 at a depth of approximately 12 feet for a total volume of approximately 2.70 MG. Cell 4 was constructed in 2006. Both basins are similar in volume but not in shape as illustrated in Figure 1. There are separate effluent pipes from Cell 2 to Cell 3 and Cell 4, and Cell 3 and Cell 4 cannot currently be operated in series. Cell 4 has an effluent structure with three draw-off locations at different elevations in the lagoon; whereas Cell 3 only has one draw-off location.

From the polishing pond (either Cell 3 or Cell 4) the water flows to a disinfection facility where liquid sodium hypochlorite (for chlorine disinfection) is added. A long, serpentine, concrete tank allows for the appropriate chlorine contact time for proper disinfection. There are currently not any dechlorination facilities at the WWTF, although a project is underway to install a sodium bisulfite dechlorination process. Effluent leaving the WWTF is measured through a second Parshall flume and a second ISCO composite sampler is also located on the effluent, and discharges into an unnamed tributary to Black Squirrel Creek.

EXISTING WWTF CAPACITY ANALYSIS

Permit Limits

The surface water discharge permit limits for the PBHMD WWTF, as presented in the CDPS discharge permit No. CO-0047091, are provided in Table 3.

Table 3 – WWTF Discharge Permit Limits

Parameter	30-day Average	7-day Average	Units
Flow	1.3	N/A	MGD
Effluent BOD	30	45	mg/L
Effluent TSS	75	110	mg/L
Fecal Coliform[1]	2,000	4,000	#/100 mL
E. Coli[2]	126	252	#/100 mL
Total Residual Chlorine[1]	0.5	N/A	mg/L
Total Residual Chlorine[2]	0.011	0.019	mg/L
pH	6.5-9.0	N/A	s.u.

1. Effluent limit valid until 12/31/2010
2. Effluent limit takes effect beginning in 1/1/2011

The following paragraphs will address each of the CDPHE requirements for a complete CPE as outlined in the May 3, 2009 NOV and reiterated previously in the Introduction/Background section of this report.

HYDRAULIC/ORGANIC LOADING AND RELATED SYSTEM DESIGN CAPACITY

An analysis of the overall plant capacity with respect to hydraulic flow, organic loading, and aeration capacity is provided below. Figure 2 shows the influent loading to the WWTF in terms of hydraulic flow and organic (BOD) loading. As seen in Figure 2, there has been an increase in the BOD loading from 2007 to 2008. Figure 3 contains a graph showing the effluent BOD concentration and the WWTF BOD removal percentage for the 2 years of data evaluated. As seen from Figure 3, the effluent BOD concentration is above the permitted value eleven months out of the 24 months evaluated. Some of these violations can be attributed to the increase in BOD loading from 2007 to 2008, however it is not the sole contributing factor as some problems also occurred in 2007.

Hydraulic Flow

Facility operating data for January 2007 through December 2008 indicate that the influent flow rate has increased slightly over the two year period. A summary of the influent flow data is provided in Table 4.

Table 4 – Influent Flow Rate Conditions

Flow Parameter	Value (MGD)
Average	0.67
Average 2007 Flow	0.65
Average 2008 Flow	0.70
Max Month	0.94
Min Month	0.38
Average Summer Flow	0.76
Average Winter Flow	0.61
Standard Deviation	0.14

Throughout the data set, the influent flow appeared to jump up and down without following a seasonal pattern, although the general trend was a slight increase. The increase in influent flowrate was most apparent during 2008 as illustrated in Figure 2. As shown in Table 3, the permitted capacity of the WWTF is only 1.3 MGD, so the maximum month flowrate is under the rated capacity.

An important parameter in determining the required size of the lagoons is the hydraulic retention time (HRT). The HRT is defined as the total volume of the lagoon system divided by the flow rate of the influent wastewater as in Equation 1 below:

$$HRT(days) = \frac{Total\ Volume, V_T\ (MG)}{Flow, Q\ (MGD)} \quad (1)$$

The standard EPA method for calculating capacity assumes that the polishing pond's function is primarily to provide backup capacity and to intercept any overloads or upsets. This method assumes that all treatment must occur in the primary lagoons, which for the PBHMD WWTF are the first two cells. This means that according to the EPA calculation method, the volume of Cell 1 and Cell 2 are used in the HRT calculation and the volume of Cell 4 is not used. However, the polishing pond (Cell 4) at the PBHMD WWTF is providing a large facultative environment for microorganisms in the lagoon to continue treatment, and therefore, should be included in the HRT calculation. Given the total volume in the three online lagoon cells (Cells 1, 2 and 4) of 8.9 MG, the HRT is calculated at various relevant flow rates in Table 5.

Table 5 – Current HRT of Aerated Lagoons

Flow Event	HRT, days
Average, All data	14.2
Average Summer, (2004-2008)	12.3
Average Winter, (2004-2008)	16.1
Maximum Month, All data	9.4
Maximum Month, except for construction incident	10.2

Policy 96-1 from the CDPHE states that aerated lagoon systems have a HRT ranging between 12 and 30 days. The large range in acceptable HRT values is consistent with treatment efficiency differences between warm and cold temperatures. During the summer when the microorganisms are growing faster, less HRT is required to perform the same level of treatment as when the temperatures are colder and the microorganisms (and hence the treatment efficiency) slow down. Therefore, higher HRT is required in the winter than in the summer.

The data in Table 5 shows that the current HRT in the summer is significantly lower than in the winter. This is attributable to higher summer wastewater flows in the summer than in the winter. The higher flows are largely a function of infiltration and inflow, and a slightly higher resident population in the summer. This is typical of most municipal wastewater plants.

The maximum month value occurred in September of 2008 with an average monthly influent flow of 0.94 MGD. The next highest flowrate (and hence the next lowest HRT) occurred the month before, in August, with an influent flowrate of 0.91 MGD. There was evidently some construction problems that occurred the middle of August and into September that may have contributed to an increased flowrate to the facility for an extended period of time. If the higher flows at this period are attributable to a large construction problem, then these values can be possibly taken out. However, the next high flow occurred in August 2007 of 0.86 MGD (or an HRT of 10.2 days), which is not in the timeframe of this incident.

Organic Loading Capacity

Organic loading is the most important factor when analyzing the capacity of a lagoon system. Table 6 presents a summary of the facility influent BOD loading between January 2007 and December 2008.

Table 6 – Organic Loading Conditions

Parameter	BOD, mg/L	BOD, lbs/day
Average	282	1,577
Maximum Month	364	2,784
Minimum Month	185	960
Standard Deviation	55	449

One EPA method for calculating capacity of a lagoon system has historically been based on organic loading to the facility divided by the surface area of the lagoons. Typical organic loading values range from 30 to160 pounds of BOD per acre per day according to EPA text[1]. Works by other authors[2] have shown 90 pounds BOD per acre per day to be optimal, with this value falling in the suggested range from the EPA. The desired surface area of the system can be determined using Equation 2 below:

$$Surface\ Area\ (acres) = \frac{Organic\ Loading}{90\ lbs/ac/day} \quad (2)$$

1 Retrofitting POTW's Handbook, EPA ref 625/6-89/020, July 1989

2 Designing Constructed Wetlands, Donald A. Hammer, Tennessee Valley Authority

From Equation 2, the desired surface area for the WWTF at max month is approximately 31 acres. Since the existing facility's total surface area is only roughly 4.4 acres as noted in Table 1, this analysis indicates that the facility is undersized. However, only using the surface area of the lagoons to determine capacity, as in the above equation, does not take into account lagoon depth. A deeper lagoon will be able to accommodate more biomass, which can consume more organic material. Therefore, a second method for analyzing the capacity of the facility will be utilized, which is more accurate. This method involves determining the retention time required to consume the organic matter and meet the discharge permit limits. Equation 3 describes this method using a temperature-dependent BOD consumption factor, and the influent and effluent BOD concentrations:

$$S_E = \frac{S_i}{(1 + k_T \cdot HRT)}, \quad (3)$$

where S_E is the desired effluent BOD_5 concentration, S_i is the influent BOD concentration and k_T is the BOD consumption factor in a particular lagoon. The S_E value used in the analysis was 30 mg/L, which is the required discharge permit limit for total BOD in the effluent. This means that there was no safety factor included in this analysis, so the capacities determined here are the maximum capacities. The temperature dependence of k_T is modeled using Equation 4[3]:

$$k_T = k \cdot 1.036^{T-20}, \quad (4)$$

where k is the overall BOD consumption factor at 20 degrees Celsius in a particular lagoon, and T is the wastewater temperature in degrees Celsius. This analysis uses a first lagoon k value of 0.5 days $^{-1}$ as suggested in Metcalf & Eddy and as verified using field data from WHMD. Since the most food is available in the first lagoon, this will be the most active lagoon and will have the highest k value. Subsequent lagoons will have much lower k values, with the EPA manual[3] using an unaerated lagoon k value of 2.76 days $^{-1}$. Tetra Tech has assumed a k value in the second aerated lagoon of 4.5 days $^{-1}$ (which is a non-conservative value) and a k value of 2.76 days $^{-1}$ for the unaerated final polishing lagoon. Since the WWTF has three lagoons in series, the equation for determining the final BOD concentration (S_E) is the product of the three individual lagoons as shown in Equation 5.

$$S_E = \frac{S_i}{(1 + k_{1T} \cdot HRT_1)} + \frac{S_i}{(1 + k_{2T} \cdot HRT_2)} + \frac{S_i}{(1 + k_{3T} \cdot HRT_3)} \quad (5)$$

Since the ponds are all different sizes, HRT_1 is different from HRT_2 and HRT_3, but they all can be added together to determine the overall HRT_{TOT}. Therefore, Equation 5 can be determined in terms of the HRT_{TOT} as in Equation 6:

$$S_E = \frac{S_i}{(1 + k_{1T} \cdot 0.21 HRT_{TOT})} + \frac{S_i}{(1 + k_{2T} \cdot 0.48 HRT_{TOT})} + \frac{S_i}{(1 + k_{3T} \cdot 0.30 HRT_{TOT})} \quad (6)$$

3 Municipal Wastewater Stabilization Ponds, EPA ref 625/1-83-015

This third order polynomial can be solved for HRT_{TOT} using Equation 7 and a computer algorithm.

$$\frac{S_I}{S_E} = (.2k_{1T} \cdot .5k_{2T} \cdot .3k_{3T})HRT_{TOT}^3 + (.2k_{1T} \cdot .5k_{2T} + .2k_{1T} \cdot .3k_{3T} + .5k_{2T} \cdot .3k_{3T})HRT_{TOT}^2 + (.2k_{1T} + .5k_{2T} + .3k_{3T})HRT_{TOT} + 1 \quad (7)$$

Solving Equation 7 for HRT_{TOT} represents the required HRT to meet the BOD discharge limit at a given monthly influent BOD concentration (S_I) at a given temperature. Equation 7 was applied to each month in the data set (24 months total) and the resulting HRT values were calculated for each month. The results indicated that the highest required HRT values occurred in the winter months (December through February). The required HRT to meet the discharge limit of 30 mg/L is presented in Table 7 for several conditions.

Table 7 – Required HRT for Current Organic Loading

Condition	Required HRT (days)
Worst Case	16.6
Winter Average	14.5
Summer Average	8.9

Table 7 – Required HRT for Current Organic Loading can be contrasted with Table 5 – Current HRT of Aerated Lagoons to determine how well the facility is currently performing compared to what is required per the EPA, CDPHE, and other design criteria. The "worst case" required HRT value listed in Table 7 represents the HRT necessary at the coldest average month temperature, which for this dataset was January 2008 with a value of 3.14 degrees Celsius. The current average winter HRT was 16.1 days (from Table 5), which is not long enough to meet that "worst case" value of 16.6 days. However, the current winter HRT is above the average required winter HRT value of 14.5 days.

Aeration Capacity

Lagoon design requires two aerated cells and one polishing pond. The second of the aerated lagoons may only be partially aerated to allow settling in the un-aerated portion of the cell. According to the CDPHE, the second lagoon should have oxygen dispersion in the first two-thirds of the cell. Air is provided both for microorganism consumption and also to keep the biological solids in suspension. Mixing in the lagoons is important to maintain the microorganisms and influent organic matter in suspension; however, when determining the amount of aeration in a lagoon, microbial oxygen consumption is the most important factor.

The oxygen requirement for microorganism consumption is typically 1.5 pounds of oxygen per pound of BOD removed[4]. Using the maximum month organic loading of 2784 lbs of BOD/day provided in Table 6, the estimated oxygen requirement is 4,176 pounds of oxygen per day. The actual oxygen transfer efficiency (AOTE) is determined from Equation 8[4]:

4 "Wastewater Engineering, Treatment and Reuse", Metcalf & Eddy, Fourth Edition, McGraw Hill, 2003

$$AOTE = SOTE \cdot \left(\frac{\beta \cdot C_S - C_L}{C_{S20}} \right) \cdot 1.024^{T-20} \cdot \alpha \quad (8)$$

Values used for the parameters in Equation 8 as well as descriptions of these values are provided in Table 8.

Table 8 – Oxygen Transfer Efficiency Variables

Variable	Description	Value	Units	Source
SOTE	Standard O_2 Transfer Efficiency	2.1	lbs O_2/hp-hr	Typical for mechanical aerators
β	Salinity surface tension correction factor	0.95	N/A	Typical, assumed
C_S	O_2 saturation	7.01	mg/L	At site pressure and temp
C_L	Desired O_2 residual	2	mg/L	Per CDPHE
C_{S20}	O_2 saturation at 20 degrees C	9.17	mg/L	At 20 degrees C and 1 atm
T	Water temp, max	27	degrees C	Typical, assumed
α	OTE correction factor	0.85	N/A	Typical for mechanical aerators, assumed

Using these parameters in Equation 8, the actual oxygen transfer efficiency is 1.07 pounds O_2 per hp-hour. This means that with all of the aerators running, the system is capable of producing 6,810 pounds of oxygen per day (lbs O_2/day). Considering the facility requires 4,176 lbs O_2/day, microorganism oxygen consumption requires an aeration capacity of approximately 163 hp. The current facility configuration is supplying a total of 265 hp. Therefore, sufficient aeration capacity exists to satisfy the oxygen requirement for microorganism consumption.

Mixing Capacity

Metcalf and Eddy[5] recommends a minimum mixing requirement of 0.19 to 0.30 hp/1000 ft^3. The existing lagoon cells were designed for a volume of 1,180,000 ft^3, assuming no sludge accumulation in the lagoons. If the lower end of the mixing requirement of 0.20 hp/1000 ft^3 is used with the design lagoon volume, there is a mixing power requirement of 237 hp for the lagoon system. Currently, there is 265 hp installed at the WWTF. Therefore, there is sufficient mixing power in the lagoons to keep the contents of the basins well mixed with the current lagoon configuration.

Capacity Summary

Table 9 summarizes the capacity of the existing WWTF based on hydraulic flow, organic loading in the winter and summer seasons, aeration requirements and mixing requirements.

5 "Wastewater Engineering, Treatment and Reuse", Metcalf & Eddy, Fourth Edition, McGraw Hill, 2003

Table 9 – Capacity Summary

Discharge Permit Requirements	Basis for Capacity	Current Max Month	Percent of Capacity
Influent Flow, MGD	1.3	0.94, 0.86[1]	72.3%, 66.2%[1]
Influent BOD, lbs/day	3,470	2,230[2]	64.3%
Design Capacity Analysis			
Capacity in summer using HRT, days	8.9	9.4, 10.2[1]	95%, 87%[1]
Capacity in winter using HRT, days	14.5	11.1[3]	130%
Aeration Capacity, hp	163	265	62%
Mixing Capacity, hp	244	265	92%

Notes: 1. Max month flow and summer HRT value for all data occurred in September 2008, value without the construction incident occurred in August 2007.

2. Max Month influent BOD value occurred in November 2008

3. Max month winter HRT was in December 2008

The data presented in Table 9 shows that the existing WWTF is at or above capacity in terms of the organic loading in the winter and summer and also in terms of power available for mixing. This means that the existing WWTF needs to be expanded to meet the current organic loading into the facility.

Tetra Tech has used the "Basis for Capacity" column from Table 9 to estimate the capacity of the WWTF in terms of the four main design parameters: Summer HRT, Winter HRT, Oxygen Delivery, and Mixing capability. These capacities are illustrated in Figure 4. The Figure shows that the capacity of the WWTF as it is currently configured with the three lagoons, is limited in capacity by the Winter HRT, which limits the capacity to approximately 0.61 MGD according to Equation 9 below.

$$Capacity\,(MGD) = \frac{Total\ Lagoon\ Volume\,(MG)}{Required\ HRT\,(days)} \qquad (9)$$

For the winter HRT capacity of the WWTF as it is currently configured, Equation 9 becomes:

$$Capacity\,(MGD) = \frac{8.9\ MG}{14.5\ Days} = 0.61\ MGD \qquad (10)$$

For reference, Figure 4 shows the average daily flow to the WWTF of 0.67 MGD and the maximum month flow (for the 2-years of data evaluated) of 0.94 MGD. Both the average daily and maximum month flowrates are above the Winter HRT capacity.

The average BOD concentration into the WWTF was 282 mg/L for the two years of data that were evaluated. Assuming this average BOD concentration, the WWTF capacity of 0.61 MGD equates to an organic loading of 1,437 lbs BOD/day. The equivalent organic loading capacity in the summer is 2,335 lbs BOD/day. The average monthly BOD loading to the WWTF from the 2 years of data analyzed was 1,577 lbs BOD/day and the maximum month BOD loading was

2,784 lbs BOD/day. Both of these values are above the winter capacity BOD loading of 1,437 lbs BOD/day.

Figure 4 also shows the capacity of the WWTF if Cell 3 were placed in service as a fourth total lagoon and second unaerated lagoon. This possible future capacity is illustrated by the pink bars on Figure 4. From the Figure, it can be seen that the limiting capacity with all four lagoons in service is still limited by the Winter HRT at a capacity of approximately 0.79 MGD as determined by Equation 9. It can be noted that this increase in capacity would provide sufficient capacity to meet the average daily flow of 0.67 MGD, but not the maximum month flow 0.94 MGD.

If all lagoons were online, the organic loading capacity would increase to 1,859 lbs BOD/day in the winter and 3,021 lbs BOD/day in the summer. This would increase the BOD loading capacity above the current average BOD loading of 1,577 lbs BOD/day, but it still remains below the maximum month BOD loading.

INDIVIDUAL UNIT PROCESSES

There are essentially four main unit processes at the PBHMD WWTF:

- Headworks
- Lagoons
- Aeration/mixing equipment
- Chlorination

The capacity of each unit process will be discussed and compared the WWTF's existing needs.

Headworks

The headworks consists, primarily, of a screening device and an influent Parshall flume. The screening device is a Parkson Hycor rotating drum screen. It has a rated capacity of 3.26 MGD at peak hour flow. A conservative peaking factor to estimate the peak hour flowrate to the WWTF would be 3.0, meaning that the peak hour flow for the 1.3 MGD rated WWTF would be 3.9 MGD. Therefore, the screen meets the WWTF design average daily flow capacity of 1.3 MGD. The installed Parshall flume has a throat width of 9 inches, which has the capability of measuring influent flowrates between 0.059 and 5.73 MGD under free flow conditions. Since the peak hour flowrate for the facility falls within the flume's range, it is adequately sized for the WWTF.

Lagoons

The capacity of the lagoons was investigated in the previous sections. In summary, the lagoons are under sized to meet the current hydraulic and organic load to the WWTF in the winter. See Figure 4 for an illustration of the system's capacity.

Aeration/Mixing Equipment

As mentioned previously in this report, the facility has a maximum-month oxygen demand of 4,176 lbs O_2/day to treat the BOD in the wastewater influent. With all of the aeration equipment in operation is capable of producing 6,810 lbs O_2/day. Therefore, more than sufficient air is available to biologically treat the BOD in the influent. As illustrated in Figure 4, the estimated capacity of the oxygen delivery equipment is 1.10 MGD, which is greater than the average daily flow of 0.67 MGD and the maximum month flow of 0.94 MGD. Therefore, the WWTF has adequate aeration capacity to meet the current demand at the treatment facility.

During the summer months, the WWTF is able to remove some ammonia, although lagoon systems will never fully nitrify. This carries a high oxygen demand. If the WWTF was able to fully remove ammonia, there would be an additional oxygen demand of 1,440 lbs O_2/day; bringing the total oxygen demand to 5,600 lbs O_2/day. This is still less than the amount of oxygen provided by all of the aeration equipment of 6,810 lbs O_2/day.

According to Metcalf and Eddy[6], the mixing requirement for an aerated lagoon system is a minimum of 0.19 to 0.30 hp/1000 ft^3. The existing lagoon cells were designed for a volume of 1,180,000 ft^3, assuming no sludge accumulation in the lagoons. If the conservative end of the mixing requirement of 0.20 hp/1000 ft^3 is used with the design lagoon volume, there is a mixing power requirement of 244 hp for the lagoon system. Currently, there is 265 hp installed at the WWTF. Therefore, there is sufficient mixing power in the lagoons to keep the contents of the basins well mixed under the existing lagoon configuration.

ADEQUACY OF AERATION/BACK-UP EQUIPMENT

Figure 4 shows that the capacity of the WWTF is not limited by the oxygen delivery, or aeration equipment. The units that are in service provide sufficient oxygen for BOD decomposition and ammonia breakdown if all the aerators are functioning properly and if the oxygen transfer efficiency assumptions from the manufacturer are accurate (especially SOTE of 2.1 pounds of oxygen per horsepower-hour and an alpha factor of 0.85). These units are notorious for being difficult to maintain good aeration. It is generally difficult to keep the draft tube lines from plugging up with sludge. So, as long as the units are well maintained, there is sufficient aeration for the WWTF to operate at approximately 1.10 MGD. To Tetra Tech's knowledge, there are no specific units dedicated as "back-up" units; although, if one of the aerators goes out, there is still sufficient oxygen delivery with the units currently installed to meet the current maximum month flow to the WWTF.

BIOSOLIDS BUILDUP

There did not appear to be excessive biosolids buildup in the lagoons at the time of Tetra Tech's on-site evaluation. The liner bottom could be seen three feet out from the edge of the lagoon, indicating little sludge buildup around the edges, which is the most common location to see a buildup in cases where sludge accumulation is excessive because it cannot be effectively mixed

6 "Wastewater Engineering, Treatment and Reuse", Metcalf & Eddy, Fourth Edition, McGraw Hill, 2003

around the edges. However, Tetra Tech did not get into a boat and measure sludge depths at different locations in the lagoons.

PROCESS RELIABILITY

As mentioned previously, the first two lagoons are aerated using aspirating aerators similar to the Aeration Industries units. These units utilize a propeller positioned at an angle in the basin to mix the basin contents, and an air draft tube to pull air into the mixing jet created by the propeller as means of aeration. These units generally work well for basin mixing. The contents of the lagoons appeared to be well mixed as there was no settling of solids 3 feet from the sides of the lagoons. However, these units are notorious for being poor aerators. It is generally difficult to keep the draft tube lines from plugging up with sludge, and the transfer efficiency does not appear to be as robust as the manufacturers claim.

The operations staff at the WWTF has found similar results with their aspirating aerators and have made modifications to several of the aerators to improve their reliability. The historic dissolved oxygen levels in the first two lagoons indicate that the operators do a good job of keeping these troublesome units in operation. As mentioned previously, all of the aeration units were in service and operating at the time of Tetra Tech's site visit, which was arranged with little notice to the operations staff. Therefore, Tetra Tech concludes that the operations staff has done a good job of keeping the aeration process reliable.

Although the aeration units have been well maintained and are reliable, the process as a whole is not reliable, particularly in the winter. As discussed previously, the capacity of the lagoons is too low to provide a reliable treatment process every month out of the year. As shown in Figure 4, the capacity of the existing treatment facility is limited by the winter HRT, and is estimated at 0.61 MGD, while the average influent flow is 0.67 MGD.

CHEMICAL FEED SYSTEM RELIABILITY

The sodium hypochlorite disinfection system currently installed appears to be reliable since they have met the Fecal Coliform limits for the two years of data we have evaluated. The maximum daily value during that time period was 5,300 #/100mL (permit limit is 12,000 #/100mL), the maximum month value was 2,400 #/100mL (permit limit is 6,000 #/100mL) and they averaged 560 #/100mL during the period. The large fluctuations in the values seem to indicate that the dosing may need to be adjusted to meet the new more stringent E-coli limits, but from the data available, the disinfection system appears to be able to handle that. The WWTF began testing for E-coli in May 2008, and for the first 4 months struggled to determine the chlorine dose necessary to meet the new more stringent E-coli limits when they take effect. However, after the first four months, the E-coli testing data available shows they are averaging 11 #/100mL. Therefore, it appears that the chemical feed system can be operated in a reliable way to meet the new E-coli limits.

A project is currently underway to implement a dechlorination system to reduce the Total Residual Chlorine from the WWTF utilizing sodium bisulfite. Since the construction of this system is not complete, Tetra Tech cannot comment on its reliability.

OPERATIONS AND MAINTENANCE STAFFING

During the onsite visit, Tetra Tech met with two of WHMD's operators, Jerry Jacobson and Gene Cozzolino. Jerry Jacobson is the Operator in Responsible Charge. The operations staff has suggested a few modifications to the lagoon system design, which have been implemented and would likely improve the performance of the WWTF. The first modification is to recycle a portion of the flow leaving Cell 1 and returning it to the head of Cell 1. This recycle stream would be carrying the most active biomass in the system, and by recycling it to the head of Cell 1 provides this active biomass with a high concentration of food from the influent. It is Tetra Tech's opinion that this would enhance treatment. However, the recycle flow did not appear to be sufficient enough to see a significant effect on treatment. Increasing this recycle flowrate is advisable.

The second modification that the operations staff has initiated is to replace the draft tubes on the aerators to be more effective. This has significantly reduced plugging and allowed the aerators to have reduced downtime. In general, the operating equipment appeared to be well maintained at the time of the site visit. All 17 individual aerators in the WWTF design plans were actually in the lagoons, and all were operating; none of them were out for maintenance. This leads us to believe that the operations staff is proactive regarding maintenance.

OPERATOR EXPERTISE NEEDS

Tetra Tech feels that the current operator expertise is sufficient for this lagoon WWTF. If/when the facility is expanded to a more complicated secondary treatment process, such as activated sludge, additional operator training will be required.

PROCESS CONTROL SYSTEMS ADEQUACY AND FUNCTIONALITY

There is little process control that is effective in aerated lagoon facilities. All methods available to enhance the treatment efficiency and capacity of the WWTF have already been implemented. The following is a list of the identified process enhancements:

- Baffled lagoons, plug flow
- Multiple draw-off locations
- Multiple aerated lagoons in series
- Multiple aerators

The first two lagoons have baffle walls in them, creating a true plug flow pattern within the lagoon. This allows for the most bio-efficient configuration for wastewater treatment. The effluent from Cell 4 has three different draw-off locations so operators can discharge the best available water quality.

The operators have begun to take process control samples throughout the lagoons. They record daily the dissolved oxygen (DO), pH and temperature in each lagoon. They take DO readings into and out of each lagoon twice a day to determine if aeration is adequate. It is Tetra Tech's opinion that the little process control that can take place at a lagoon system is occurring at this WWTF.

MANAGERIAL AND FINANCIAL SYSTEMS

This CPE did not provide an in depth analysis of the two District's financial records or accounting processes, nor was this CPE intended to be an audit of either District. Therefore, Tetra Tech did not specifically review the financial standing of either District; however it was communicated that both Districts have limited financial resources. There is expected to be growth in the service area in the near future, so it would be advisable for both Districts to revisit their Tap Fee charges and make sure that they are sustainable and covering the cost of treatment facility expansion and future treatment needs. It is also advisable to investigate the monthly service charges assessed to the connected residents and businesses.

Although the discharge permit is in the name of PBHMD, two districts (PBHMD and WHMD) share in ownership of the WWTF. Tension exists between the districts regarding various issues. WHMD currently operates and maintains the plant and a Joint Operating Committee oversees plant management. However, each District has its own governing board, and retains its own consulting engineer, thus making consensus on plant-related issues very challenging. Additionally, the parties are presently involved in litigation which further complicates these issues.

This CPE has discussed at length that the WWTF has a true capacity much lower than the permitted 1.3 MGD. This capacity rerating came from a URS design, which changed the capacity from 0.868 MGD to 1.3 MGD. However, this upgrade did not expand any of the lagoons, nor did it add any additional lagoons; it simply reconfigured the existing lagoons. It is Tetra Tech's opinion that these facility modifications did not constitute an "expansion". The opinion is supported by the two years of data we have reviewed that show frequent violations with only half of that rated capacity currently coming into the WWTF on an average daily basis.

CONCLUSIONS

This memorandum has shown that the existing Paint Brush Hills WWTF is over capacity in terms of hydraulic and organic loading as currently designed and operated, especially in the winter. Therefore, the existing WWTF must be expanded to meet the current hydraulic and organic loading. A two step process can be implemented to most effectively address the insufficient WWTF capacity; these steps are as follows:

- Step 1: Place the spare lagoon (Cell 3) into service, in series with the existing three lagoons.
- Step 2: Build an advanced activated sludge system.

Step 1 has relatively low capital and annual costs. This step will slightly increase the capacity of the WWTF as illustrated in Figure 4 from 0.61 MGD to 0.79 MGD, and reduce the frequency of effluent BOD concentration and BOD removal percentage violations. However, this will not increase the capacity of the facility higher than the 2007 and 2008 maximum month flowrate of 0.94 MGD. Therefore, planning for an activated sludge WWTF will need to be undertaken. Tetra Tech will develop preliminary Opinions of Probable Cost (OPCs) for such an expansion in the Composite Correction Program (CCP) document to be completed in the next scope of Tetra Tech's work.

END

JRT/HCL/jrt

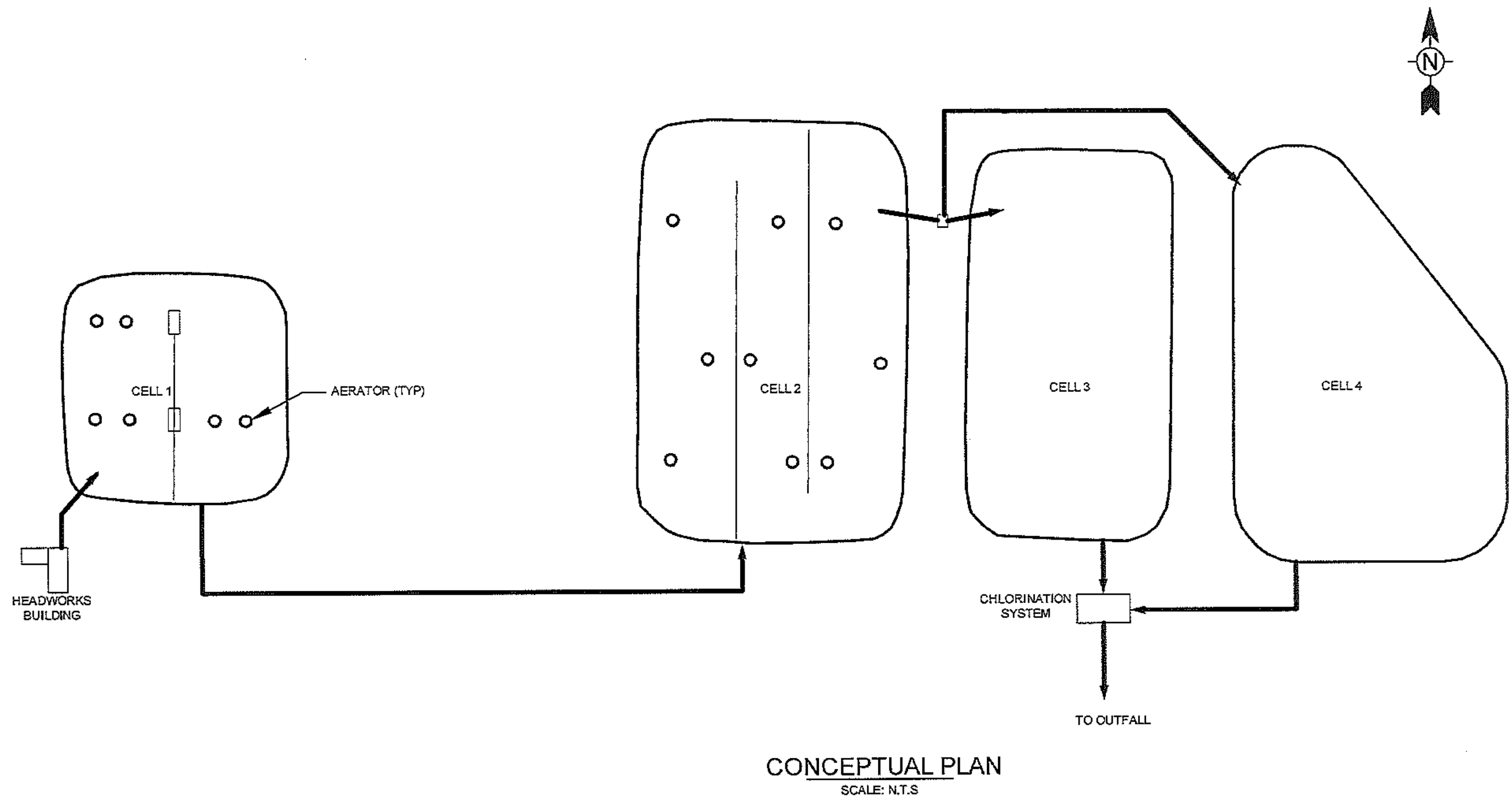

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Figure 1: WWTF Schematic

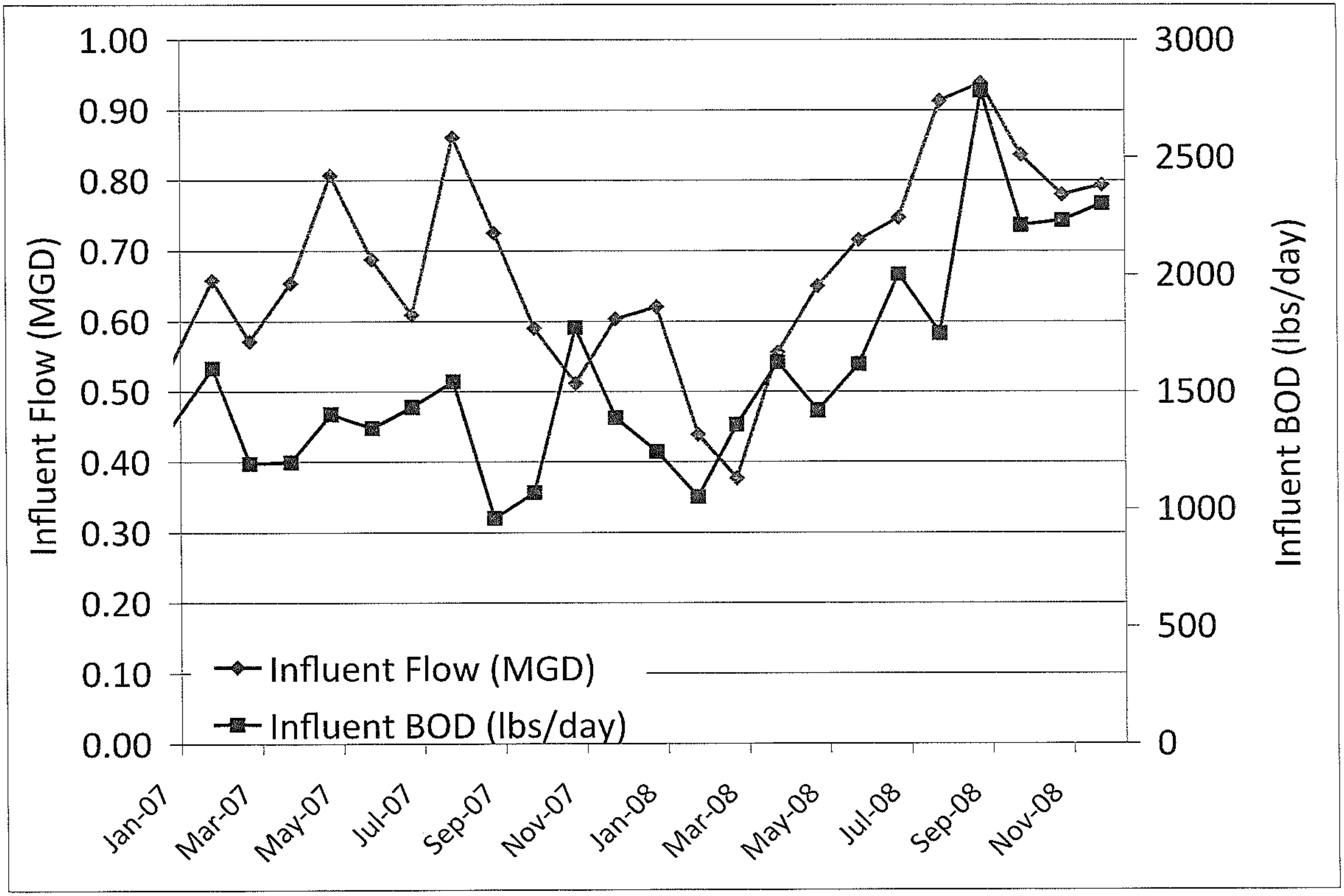

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Figure 2: Influent Loading

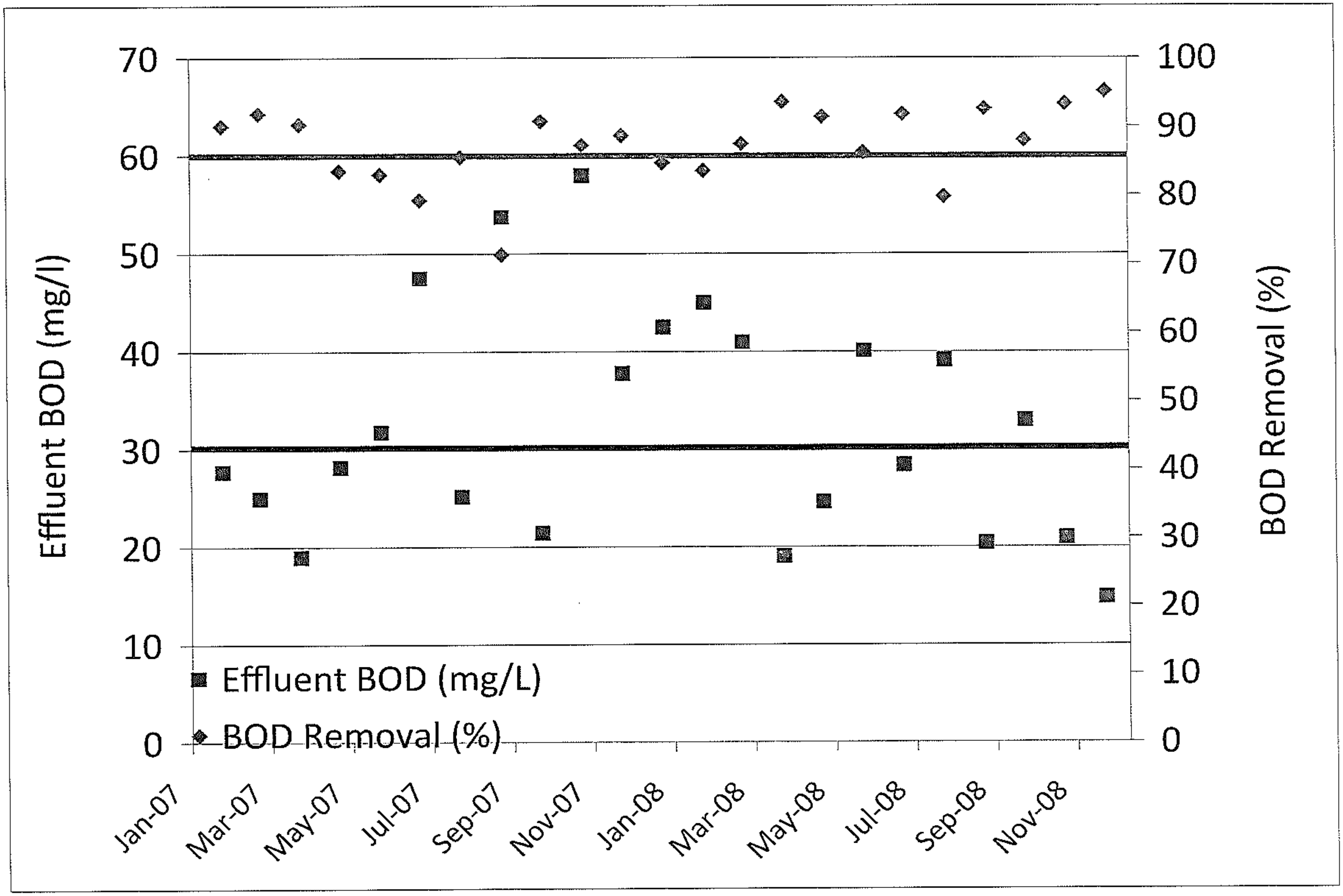

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Figure 3: BOD removal

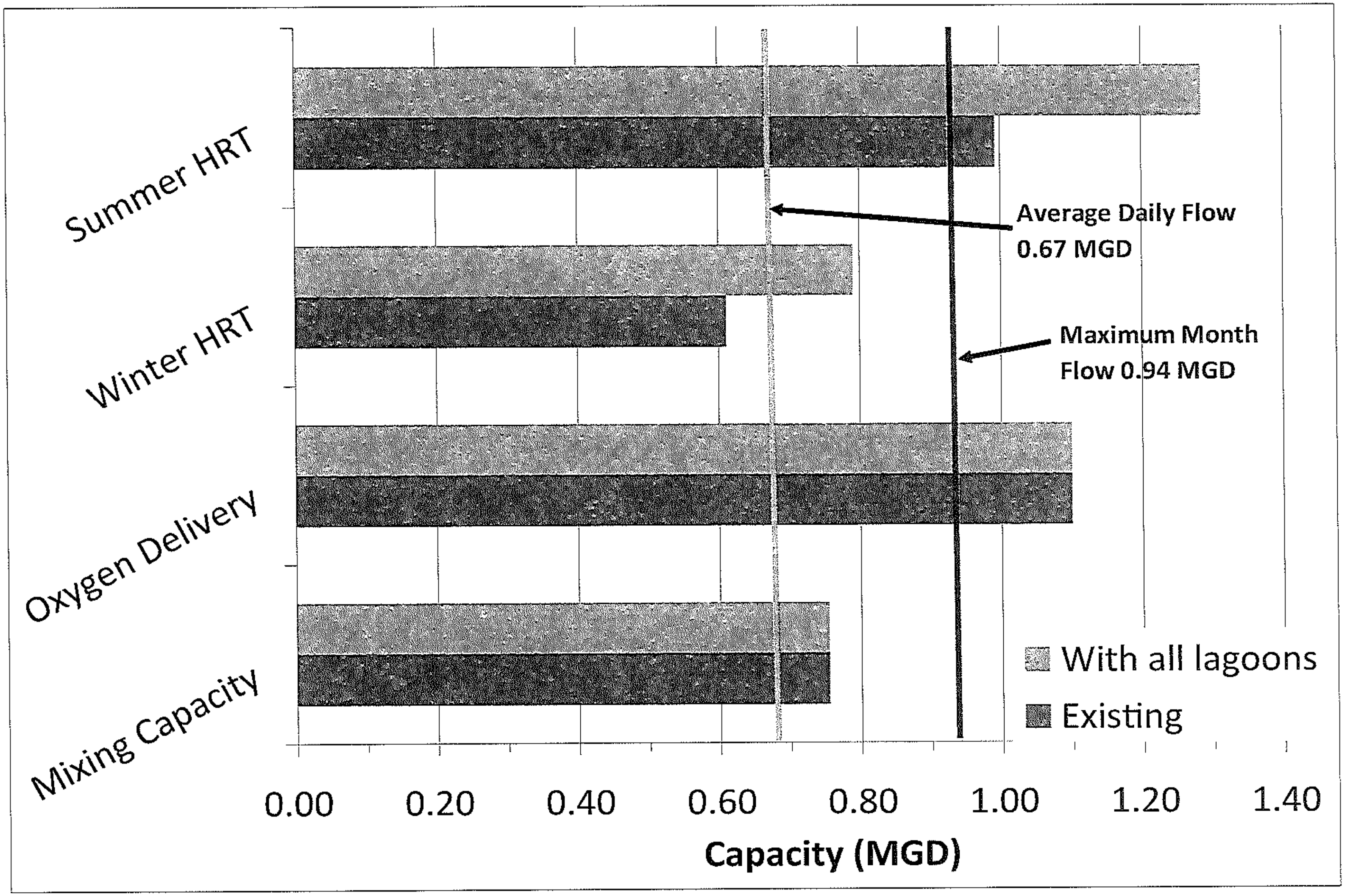

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Figure 4: WWTP Capacity