HPO Evaluation

Technical Memorandum No. 1
Process Evaluation

City of Tampa
Wastewater Department

FINAL – January 2012

GREELEY AND HANSEN

Section 6 Summary and Recommendations

Section 5 described the results of process modeling for several alternatives to maintain or replace the existing HPO system. Of the conventional activated sludge systems evaluated, Alternative 3 is recommended, which would allow continued wasting of the nitrification WAS to the carbonaceous stage. It was shown under Alternative 5 that the total installed horsepower could be reduced by 50 bhp per reactor, without the recycling of the nitrification WAS. However, this is a relatively small reduction and the greater installed horsepower provides greater flexibility. In addition, Alternative 6 (Praxair I-SO™) was shown to be a viable option with some advantages. Thus, the viable options are Alternatives 1, 2, 3, and 6, which are compared in Table 6-1.

Table 6-1
Comparisons of Carbonaceous Stage Alternatives at the Median Conditions

Alternative	No. of Reactors	SRT (day)	Aeration Horsepower Installed for Each Reactor (bhp)					HPO Req'd (tpd)
			1	2	3	4	Total	
Alternative 1 – HPO/Cryogenic	2	0.52	100	75	60	60	295	55
Alternative 2 – HPO/VPSA	2	0.52	100	75	60	60	295	55
Alternative 3 - CAS	2	0.55	200	150	150	150	650	-
Alternative 6 – Praxair I-SO™	2	0.55	75	50	50	50	225	35

Alternatives 1 and 2 are almost identical in terms of process performance and aeration. The evaluation in Section 5 shows that the process will operate almost the same whether the oxygen supply is 95% (cryogenic) or 90% (VPSA). Alternative 3 requires over twice the aeration horsepower, but would not require the power now required to generate oxygen. Alternative 3 could also be operated with two reactors. Alternative 6 has the lowest installed aerator horsepower and would also require the generation of less oxygen than Alternatives 1 or 2.

It is explained in Section 5 that increasing the number of reactors in service for the carbonaceous stage would not decrease the horsepower requirement, since it is not recommended to decrease the MLSS concentration below the present 1400 mg/L, which would result in a higher SRT with additional reactors in service.

All four alternatives appear to be feasible from a process perspective.

HPO Evaluation

Technical Memorandum No. 2 Comparison of Alternative Processes

City of Tampa
Wastewater Department

FINAL – January 2012

GREELEY AND HANSEN

Section 3 Estimated Costs of Improvements

The estimated costs of improvements have been calculated utilizing the budgetary equipment costs provided by the various aerator and oxygen generation system manufacturers. In addition, electrical supply costs have been based on an analysis of power supply needs of available equipment. The calculations for the cost estimate of each alternative are included in Appendix A. The detailed basis of cost estimate is included in Appendix B, which provides the assumptions used in the calculations and also the data provided by the manufacturers.

Life-cycle cost comparisons are based on an Equivalent Annual Cost (EAC) basis. Estimates of capital costs include the estimated construction cost plus an allowance for engineering and administration. Capital costs are amortized for a period of 20 years at a rate of interest of 5%. Annual O&M costs are based on comparative power demands and other annual costs. The EAC is the sum of the amortized capital cost and the annual O&M cost. Table 3-1 compares the alternatives. The data bars shown in Table 3-1 represent the value in the respective cell; a longer bar represents higher cost.

Two options are shown for Alternative 1, showing a range of cost for upgrading the cryogenic trains between $500,000 and $3.5 million. Several options are shown for Alternative 2, distinguishing between manufacturers of VPSA equipment and whether the oxygen supply approach is based on Purchase of Equipment (POE) or Purchase of Gas (POG). For Alternative 3, two options are shown based on use of constant speed drives or variable speed drives for the aerators, distinguishing between the electrical requirements for the two options.

3.1 Discussion on Cost Estimates for the Alternatives

The initial and amortized capital costs are higher for Alternatives 1A, 2A-1 and 2C and are lower for the Purchase of Gas (POG) Alternatives. In the case of the POG Alternatives, the annual O&M cost is relatively high, as it includes the high annual fee to the gas supplier. Even though the capital cost for Alternative 2B is lowest, the O&M cost is highest due to higher power consumption than alternative 2A-2 (Air Products). In case of Alternative 3, the capital cost is higher than the POG Alternatives due to the cost of replacement of the aerators with high horsepower aerators, but this cost is not as high as Alternatives 1A, 2A-1 and 2C.

The Alternative with lowest EAC is 3A – CAS with Constant Speed. Alternative 1B shows the EAC for the reduced rehabilitation cost of the existing cryogenic system. The cost of rehabilitation is shown at the low end, $500,000, but the EAC is still 6% higher than the lowest EAC alternative. Thus, conventional aeration is lower in cost even with a less conservative estimate of rehabilitation costs for the cryogenic alternative.

For the Alternative 3B, additional capital cost for installation of VFDs and the related electrical modifications is included. But there is a potential to lower the power cost, as the aerator speed could be reduced depending on the influent requirements. This could consequently reduce the operating cost and EAC of Alternative 3B, but this would be difficult to estimate quantitatively.

Table 3-1
Summary of Cost Estimates for Alternatives

Alt.	Description	Initial Capital Cost	Amortized Capital Cost	Annual O&M Cost	Equivalent Annual Cost	% Above Lowest EAC
1A	HPO/Cryogenic/ $3.5M Rehab Cost	$8,313,000	$657,000	$1,011,000	$1,668,000	26%
1B	HPO/Cryogenic/ $500,000 Rehab Cost	$3,698,000	$297,000	$1,011,000	$1,308,000	6%
2A-1	HPO/VPSA/Air Products (POE)[3]	$8,975,000	$721,000	$820,000	$1,541,000	20%
2A-2	HPO/VPSA/Air Products (POG)[4]	$3,828,000	$308,000	$1,596,000	$1,904,000	35%
2B	HPO/VPSA/Praxair (POG)	$3,548,000	$285,000	$1,715,000	$2,000,000	38%
2C	HPO/VPSA/PCI (POE)	$9,973,000	$801,000	$1,024,000	$1,825,000	32%
3A	CAS/Constant Speed Drives	$5,977,000	$480,000	$755,000	$1,235,000	0%
3B	CAS/Variable Speed Drives	$6,393,000	$513,000	$755,000	$1,268,000	3%

3.2 Discussion on Other Factors Affecting the Alternatives

Along with cost analysis, other factors such as reliability, process effectiveness, availability of manufactures to provide competitive environment and effect on other plant facilities are discussed for all the Alternatives. Each of these alternatives can be designed to provide reliability of service. Alternative 1A and 1B involve rehabilitation of the existing cryogenic system. The only difference between the two alternatives is the capital cost for rehabilitation. The City has been using this system for the past 34 years and it has proven process effectiveness. The alternatives may be considered equivalent in terms of reliability and effectiveness. Each alternative can be bid within a competitive environment.

Table 3-2 shows the comparison between the various alternatives with respect to the average power consumption at full capacity. This power consumption includes the power required for the aerators in two reactors and power consumed by the oxygen generation equipment.

[3] Purchase of Equipment
[4] Purchase of Gas

Table 3-2
Comparison of Power Consumption for Alternatives

Alt.	Description	Average Power Consumption at Full Capacity (kwh/year)	Annual Cost of Power ($)
1A	HPO/Cryogenic/ $3.5M Rehab Cost	11,065,000	$863,000
1B	HPO/Cryogenic/ $500,000 Rehab Cost	11,065,000	$863,000
2A-1	HPO/VPSA/Air Products (POE)	8,334,000	$650,000
2A-2	HPO/VPSA/Air Products (POG)	8,334,000	$650,000
2B	HPO/VPSA/Praxair (POG)	9,783,000	$763,000
2C	HPO/VPSA/PCI (POE)	10,872,000	$848,000
3A	CAS/Constant Speed Drives	8,090,000	$631,000
3B	CAS/Variable Speed Drives	8,090,000	$631,000

As seen in Table 3-2, the power consumption of Alternative 1 is highest. The pure oxygen alternatives are all based on producing 55 tpd. It is possible that this could be reduced, particularly in the case of the VPSA systems, given that they have greater turndown capability. The existing cryogenic system is operated to provide about 95% pure oxygen to the first zone of the reactors, while the vent gas oxygen purity is about 60%. If tighter, automatic controls could be implemented on an oxygen generation system, it could be reasonable to lower the oxygen purity in the vent gas to on the order of 45%, which is the level that was originally recommended for UNOX systems. Technical Memorandum No. 1 shows the estimated process results with a vent purity of 45%, which would allow the facility to be operated at a lower oxygen production rate. This could lower the power consumption, particularly for the group of options under Alternative 2.

Several additional points are as follows:

- Purchase of Gas options, under Alternative 2, have a higher apparent EAC. In addition, the Purchase of Gas options would require a long-term contract with a single supplier. Praxair advises that this is the only way that they would provide a VPSA facility. However, this could be pursued with them more thoroughly if the Alternative 2 approach is selected by the City.

- Another option for using a pure oxygen approach would be the purchase of LOX instead of on-site generation. Currently the City purchases backup supply of LOX for $118.34 per ton. If bid in bulk, it is likely a lower cost could be negotiated. The cost of LOX would need to be about $30.70 per ton to reduce the pure oxygen approach to be equivalent to the lowest EAC alternative (Alternative 3A). It is unlikely that the City could purchase LOX for a price as low as $30.70 per ton.

- The Conventional Aeration System does not involve complicated oxygen generation techniques, thus reducing the total power consumption and dependability on oxygen generation equipment and manufacturer. Although higher horsepower aerators are required for this alternative, power will be consumed only for operating the aerators. As seen in Table 3-2, Alternatives 3A and 3B consume least power.

- Under Alternative 3A or 3B, Reactors 4 – 6 would no longer be available, since the doubling of the horsepower for Reactors 1 – 3 would take up all electrical capacity serving the aerators. Additional equipment would need to be provided to make Reactors 4 – 6 functional.

3.3 Recommendations

As shown in Table 3-1, Alternative 3A and 3B have the lowest comparative EACs and can be considered equivalent. The operating cost of Alternative 3B could be lower, if experience shows that operating the aerators at a lesser speed was feasible under certain circumstances and during low load periods of the day. A design decision could be made to determine whether or not to provide variable speed capability.

It is recommended that the City implement Alternative 3A or 3B, converting the existing reactors to conventional aeration.