Design Review Committee Briefing #9

Subject: Secondary Treatment Business Case Evaluation

Date: November 9, 2018

The Issue

The secondary treatment process serves as the primary means for removing carbon, suspended solids, nitrogen, and phosphorus. The configuration and performance of the secondary treatment system is integral in achieving the required effluent discharge requirements for the Nampa Wastewater Treatment Plant (WWTP). The Preliminary Design Technical Team conducted a business case evaluation (BCE) on the preferred secondary treatment approach. That analysis is described in the briefing.

Background and Analysis

The alternatives considered as part of this BCE are described in the following list and process configurations are provided in the attached figures. These alternatives can be split into two categories: process reconfiguration or process intensification.

- **Alternative 1 – Expand Existing Process:** Alternative 1 involves expanding the current Anaerobic/Oxic (AO) configuration of the aeration basins to treat the future flows and loads. This involves constructing a fourth aeration basin, a fourth final clarifier, a new blower building with new, larger blowers, and tertiary filters.
- **Alternative 2 – Simultaneous Nitrificaton Denitrification (SND):** Alternative 2 involves reconfiguring the secondary process to conduct simultaneous nitrification and denitrification (SND). SND involves decreasing the dissolved oxygen concentration to allow for denitrification to occur within the sludge floc. This greatly reduces the air and carbon required and efficiently removes nitrogen. This alternative requires two additional aeration basins, a fourth final clarifier, and tertiary filters. A new blower building is not required. Additional mechanical mixing in the aeration basins is also required due to lower air addition.
- **Alternative 3 – Membrane Bioreactor (MBR):** Alternative 3 involves installing a membrane bioreactor. This eliminates the need for a fourth aeration basin, all final clarifiers, and tertiary filters. A primary effluent screening facility must also be constructed upstream of the membrane bioreactor to prevent debris from damaging the system.
- **Alternative 4 – BioMag:** Alternative 4 involves installing a BioMag ballasted sedimentation system. BioMag is an intensification technology where magnetite is added to the mixed liquor to increase the concentration and therefore settleability. This removes the need for a fourth clarifier and fourth aeration basin but requires increased mixing for anaerobic and anoxic zones in the existing aeration basins.
- **Alternative 5 – Bardenpho Configuration:** Alternative 5 involves reconfiguring the aeration basins to a Bardenpho configuration. This would require diffusers, mixers, and walls in the existing aeration basins to be altered. This configuration would require a carbon source for the second stage anoxic zone, would not save a significant quantity of air, would not reduce the number of aeration basins and would generate a higher quantity of solids.
- **Alternative 6 - Mainstream Annamox:** Alternative 6 involves implementing mainstream anammox. A specifically designed reactor to support the growth of specialized anammox bacteria and is constructed to allow direct conversion of ammonia to nitrogen gas. This process reduces air requirements by 25 percent and carbon by 40 percent. However, there are no full-scale main stream anammox systems in operation. Bench and pilot scale tests have not been shown to achieve full ammonia conversion.

- **Alternative 7 – Integrated Fixed Film Activated Sludge (IFAS):** Alternative 7 involves IFAS intensification where IFAS media is added to the mixed liquor and biomass grows on the media, increasing the capacity of the activated sludge system. The system requires additional mixing to ensure the media remains suspended, conversion of the existing fine-pore aeration system to a coarse bubble aeration system, additional air due to lower oxygen transfer efficiency of the coarse bubble aeration system, and effluent screens to ensure the media remains in the bioreactor. This system reduces the required aeration basin volume by approximately 15%, but does not save construction of an aeration basin. A fourth clarifier and tertiary filters are still required.
- **Alternative 8 – Nereda:** This alternative involves the installation of Nereda technology. In this process, biomass is grown as granules in which the three process zones are present in each granule. The process operates in an sequencing batch reactor configuration with three stages: simultaneous fill and draw, aeration, and fast settling. No clarification is required, and solids production is reduced. However, it requires conversion to an SBR, the same or more aeration basin volume, and has potential scale-up issues.
- **Alternative 9 – inDENSE:** Alternative 9 involves installation of inDENSE technology in the secondary process system. inDENSE involves installing hydrocyclones to select dense floc and return them to the aeration basin while the lighter solids are wasted. inDENSE can improve settleability and biological phosphorus performance. However, there is no benefit to aeration basin sizing or air requirements and tertiary filters are still required.

Alternatives 5, 6, 7, 8 and 9 were considered fatally flawed as they did not meet the City's level of service goals; therefore, Alternatives 1, 2, 3, and 4 were carried forward for further analysis in the BCE process.

Capital costs, operating and maintenance (O&M) costs, and repair and replacement (R&R) costs were estimated for each of the alternatives. Capital costs were developed from vendor quotes and cost estimates for the required investments for each alternative, which include both the secondary treatment system and the tertiary filters. Alternative 1 had the lowest capital cost while Alternative 3 had the highest capital cost, with an overall spread of nearly $17M. The O&M costs encompass the expected costs associated with labor, power, and chemical usage for each alternative. Alternative 4's higher O&M cost is largely driven by the annual cost for replacing lost magnetite. R&R costs are a direct reflection of the expected useful life of the capital improvements for each alternative. Of note, the R&R costs for Alternatives 3 and 4 are higher than the other alternatives due to the increased mechanical equipment needed to support these alternatives.

Risk and benefit costs for each alternative were also developed, such as regulatory, technical, or financial risks/benefits. The primary risks captured in this evaluation were NPDES permit violations (from process failure), risk associated with lower effluent total phosphorus limits, and operational risks. Alternatives 3 and 4 exhibited higher risk costs as a result of concerns with process failure (Alternative 3) and operation risks (Alternative 4). Alternative 2 was the only option with an identified benefit cost associated with potential energy incentives due to the decreased energy demand.

Table 1 presents the results of the secondary treatment process BCE. The BCE results indicated Alternative 1 has the lowest cost of asset ownership driven primarily by lower capital and risk costs as compared to other alternatives. The sensitivity of this decision to various input parameters was also tested; none were identified that would change the preferred alternative.

Table 1. Secondary Treatment Approach BCE Total Net Present Value Summary[1,2]

Alternative	Capital	Benefits	O&M	Risks	R&R	NPV
Alternative 1: Expand Existing	$81,986,000		$22,082,000	$1,067,000	$43,020,000	($159,423,000)
Alternative 2: SND	$88,042,000	$593,000	$20,150,000	$2,267,000	$43,370,000	($165,013,000)

Alternative 3: MBR	$98,680,000		$26,874,000	$2,140,000	$60,345,000	($202,727,000)
Alternative 4: BioMag	$91,964,000		$30,584,000	$1,475,000	$58,080,000	($196,048,000)

[1]Cells highlighted in green indicate the lowest cost alternative for the conditions shown.

[2]Total costs are shown in 2018 dollars, represent the period 2021 through 2040, and are rounded to the nearest $1,000

NPV = net present value

Potential Consequences

The Design Review Committee should be aware of the potential consequences of each alternative that may not be readily apparent from the BCE results. The primary consequences from this evaluation are described in further detail below:

- Alternatives 2, 3, and 4 would increase the operational complexity of the secondary treatment process, thereby increasing the demands for the operation staff. While the magnitude of this increase varies by alternative, each would require more specialized skillsets within the operations group. By selecting Alternative 1, the City avoids the need to add more specialized operations staff for the secondary treatment process.
- By pursuing Alternative 3 the City would not need to install tertiary filters because of the performance of the MBR. However, even when the costs of both secondary and tertiary treatment system were considered, which was the approach taken for the BCE, this did not result in a capital costs savings. Alternative 1 also allows for potential cost savings resulting from higher effluent total phosphorus limits that can be negotiated with the reuse permit, which Alternative 3 would not.
- Alternatives 3 and 4 would provide additional capacity beyond the projections and that provided by Alternative 1 as they both intensify the existing secondary treatment process. In other words, more treatment can be achieved within the same volume because they allow for increase concentrations of the bacteria performing the treatment. The value of this capacity was not quantified in this analysis as it is not required through 2040. However, there could be potential capital cost savings outside of the analysis period (i.e. post 2040).

Recommendation

The Preliminary Design Technical Team recommends moving forward with Alternative 1 – Expand Existing. This alternative has the lowest capital cost and NPV under the range of inputs considered. This recommendation is consistent with the assumptions from the Facility Plan, so the overall capital allocations for the Phase II/III Upgrades is unchanged because of this decision.

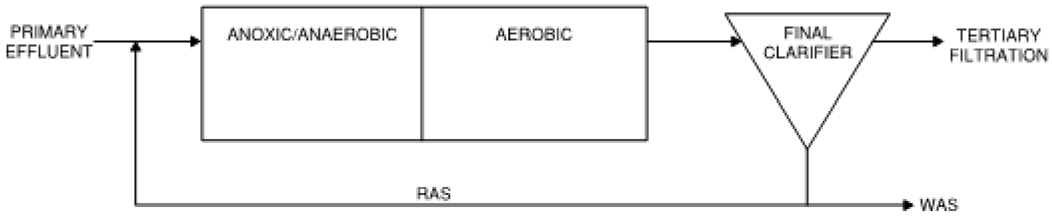

Figure 1. Alternative 1 Process Flow Diagram

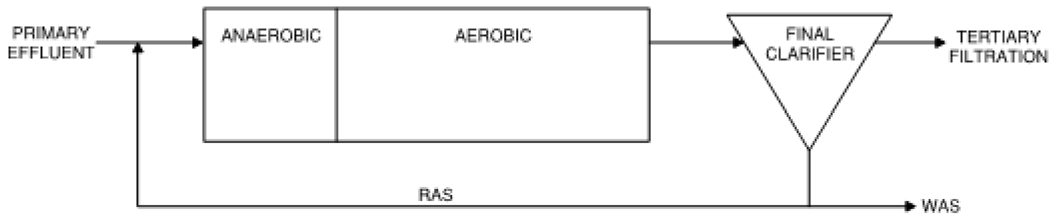

Figure 2. Alternative 2 Process Flow Diagram

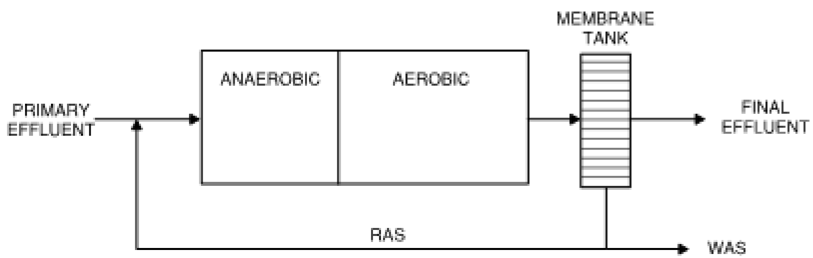

Figure 3. Alternative 3 Process Flow Diagram

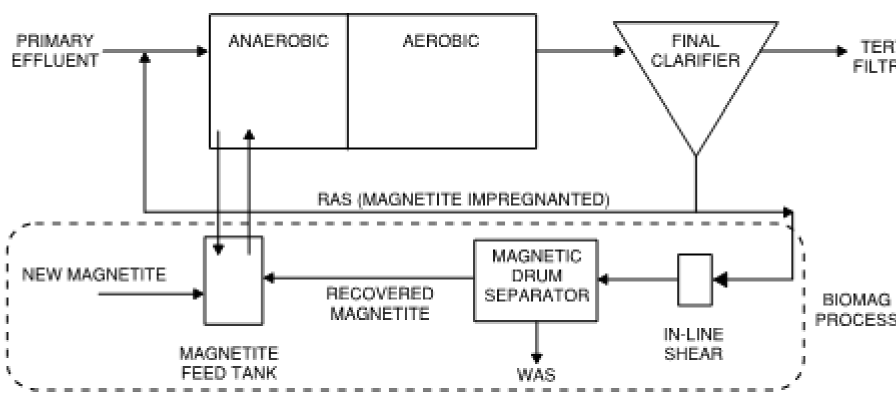

Figure 4. Alternative 4 Process Flow Diagram

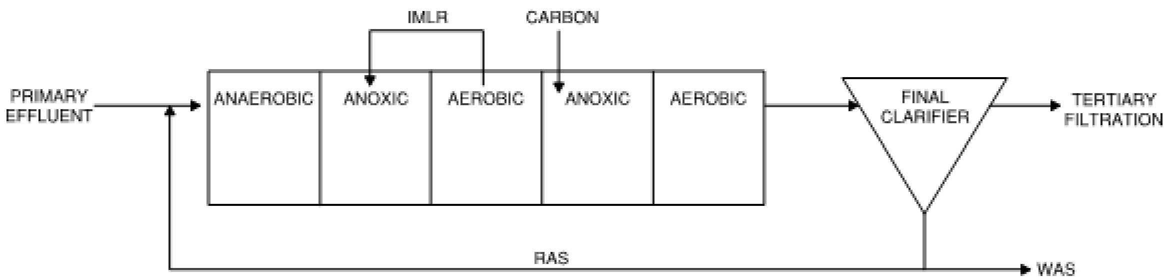

Figure 5. Alternative 5 Process Flow Diagram

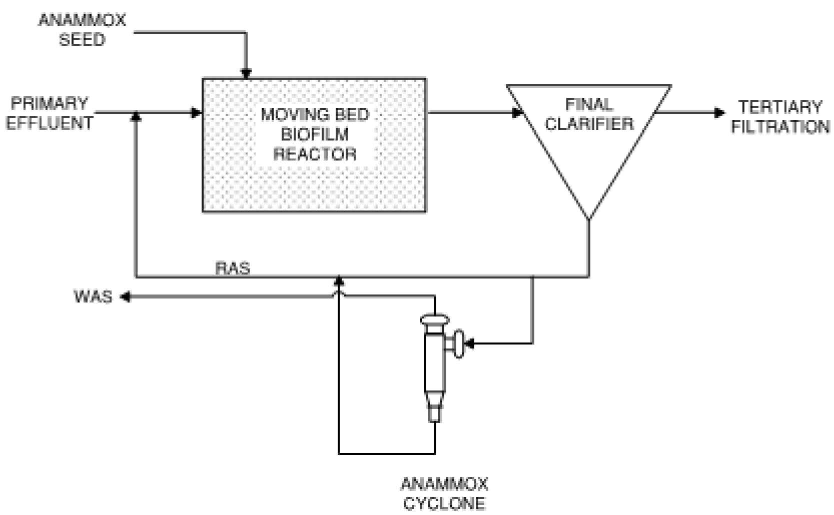

Figure 6. Alternative 6 Process Flow Diagram

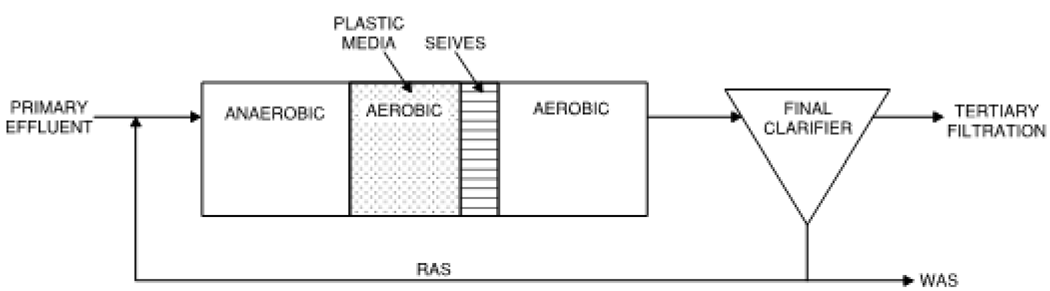

Figure 7. Alternative 7 Process Flow Diagram

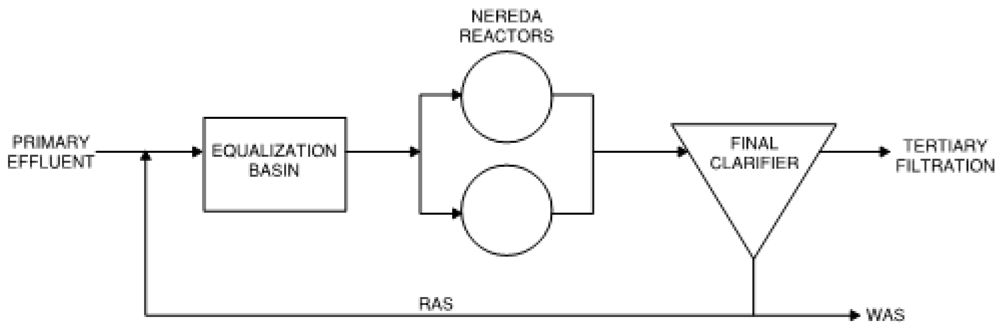

Figure 8. Alternative 8 Process Flow Diagram

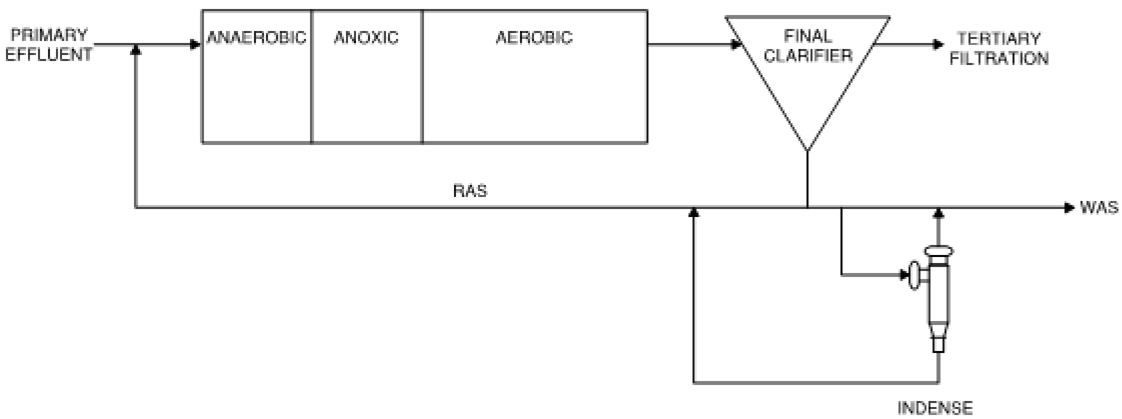

Figure 9. Alternative 9 Process Flow Diagram