Design Review Committee Briefing #19

Subject: Disinfection Technology Approach Recommendation

Date: February 15, 2019

The Issue

The disinfection process is a critical final step in wastewater treatment for the inactivation or destruction of waterborne pathogenic microorganisms. Wastewater utilities implement disinfection treatment for both surface water and recycled water applications. The Nampa Wastewater Treatment Plant (WWTP) currently performs chlorine disinfection prior to Indian Creek discharge. The Preliminary Design Technical Team (Technical Team) performed a business case evaluation (BCE) to evaluate disinfection technologies for application as part of the Phase II Upgrades. The Technical Team is presenting the recommended disinfection technology to the Design Review Committee (DRC) for their concurrence.

Background and Analysis

The design criteria for the disinfection alternatives are determined through the desired discharge location, future flow projections, and regulations from the City's National Pollutant Discharge Elimination System (NPDES) permit and the Recycled Water Rules (Idaho Administrative Procedures Act [IDAPA] 58.01.17). In general, disinfection requirements for recycled water applications are more stringent than those for surface water discharge (i.e. Indian Creek). For the purposes of the evaluation, the disinfection system was designed to accommodate the more stringent recycled water applications. The Disinfection Technology BCE examined eight disinfection alternatives (process figures are attached):

- **Alternative 1 – UV Disinfection.** This is the "base case" alternative from the Facility Plan. This process involves imparting UV radiation to filtered effluent to destroy the cellular DNA and RNA of microorganisms. This approach inactivates viruses and bacteria. These systems can be either closed or open basins with UV bulbs installed. A hypochlorite system is used to dose the effluent with chlorine, which prevents regrowth of microorganisms in distribution lines for the recycled water.
- **Alternative 2 – Combined Chlorine.** This is the current practice at the Nampa WWTP and is one of the most commonly practiced in the industry. Combined chlorine is the application of diluted chlorine to contact chambers for a specified duration. These systems are generally open basins with a chlorine feed system.
- **Alternative 3 – Ozone.** Ozonation is a process involving ozone (O_3) generation from oxygen molecules via electrolysis methods. An inline or sidestream injection system applies the ozone to the wastewater to facilitate disinfection. System components include a vendor-supplied liquid oxygen tank, evaporation system, power supply (to facility the O_2 reaction to O_3) and a thermal destruct unit for the off-gas produced.
- **Alternative 4 – Chlorine Gas.** This process is like Alternative 2; however, it involves injection of chlorine gas to the effluent. This approach requires chemical gas containment facilities or treatment and a dechlorination system to prevent formation of toxic compounds following dispersal to surface water waters. This alternative is fatally flawed due to significant safety concerns with chlorine gas handling and containment.
- **Alternative 5 – Sodium Hypochlorite.** This process is like Alternative 2; however, it involves injection of liquid bleach (NaOCl) to achieve disinfection. This process requires dechlorination, typically via sodium bisulfite, to provide necessary dechlorination. Alternative 5 is fatally flawed because the free chlorine residual would be difficult to maintain and require significant chemical costs for satisfying Class A reuse applications.

- **Alternative 6 – Chlorine Dioxide.** This process involves two reagents, typically chlorine gas and sodium chlorite solution, which are applied to the effluent like other chlorination approaches. This alternative is fatally flawed due to the unstable nature of the chemicals, reliance on external chemical deliveries, and greater safety and handling requirements relative to other options.
- **Alternative 7 – Pasteurization.** Pasteurization is a common technique the food industry for control of pathogenic microorganisms. This process is the heating of water to provide effective disinfection. Two reactors, a preheat reactor and a holding reactor, provide the heating and holding time needed for disinfection. External heat is provided via turbine exhaust, engine exhaust, waste gas burner exhaust, hot water, or other heat sources. Alternative 7 is fatally flawed because it is energy-intensive and would require effluent cooling post-disinfection in order to meet the City's NPDES permit limits for effluent temperature.
- **Alternative 8 – Peracetic Acid.** Peracetic acid is the combination of acetic acid and hydrogen peroxide. This disinfection approach is common to the medical industry for sterilization and disinfection. The wastewater industry, however, has just begun considering applications for wastewater treatment and the efficacy of the approach. Alternative 8 is fatally flawed because it is an uncommon practice and there are limited applications of comparable systems in use for wastewater disinfection.

Alternatives 1, 2 and 3 advanced to the cost estimation stage of preliminary design. The Technical Team prepared Class 4 capital cost estimates (as defined by the Association for the Advancement of Cost Engineering), operations and maintenance costs, repair and replacement costs, and potential risk and benefit costs. Table 1 presents the results of the BCE.

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

Alternative	Capital	O&M	R&R	Risks	Benefits	NPV
Alternative 1	$10,605,000	$3,774,000	$6,863,000	$533,000	$0	($23,498,000)
Alternative 2	$16,187,000	$9,940,000	$7,128,000	$3,030,000	$0	($39,253,000)
Alternative 3	$13,513,000	$5,316,000	$9,929,000	$1,926,000	$0	($33,217,000)

[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

Table 1 indicates Alternative 1 is the lowest lifecycle cost alternative. This is driven by lower capital costs and operations and maintenance costs. The Technical Team performed sensitivity tests that included: high (+50%) capital costs, low (-30% capital costs), power cost increases, and accelerated recycled water program timing from 2031 to 2026. The sensitivity test results never deviated from the original BCE results, suggesting the recommended alternative is a robust technology selection.

Potential Consequences

- **Impacts of Industrial Discharges to UV Transmittance Design Criteria.** UV transmittance (UVT) percentage is a typical design parameter for sizing UV disinfection systems. The design UVT assumption carries implications for system sizing and subsequent costs. The UVT parameter describes the percentage of light that passes through a water sample at a frequency of 254 nanometers. Organics, colloidal solids, and suspended particles scatter UV light and inhibit disinfection performance. This underscores the importance of an effective tertiary filtration system upstream of the disinfection process. The Technical Team based the UVT design assumption on historical Nampa WWTP UVT performance and bleach usage data from 2014 through 2018. This period captures industrial flumewater discharges, which have negatively impacted the disinfection performance at the Nampa WWTP. Phase II Upgrades will install tertiary filters, which are expected to improve the UVT performance of the facility, however the presence of industrial discharges means the City must design its disinfection processes to handle potential industrial impacts. Failure to do so could adversely inhibit the City's ability to meet Class A recycled water requirements. The Technical Team will refine the UVT percentage assumption in the upcoming stages of preliminary design.

- **Tertiary Filtration Impact on UV Dose –** The Class A requirements contained in IDAPA 58.01.17 specify a UV radiation dose based on the upstream tertiary filtration technology. Tertiary sand filtration requires a UV dose of 100 milli-Joules per square centimeter (mJ/cm^2). If the tertiary filtration technology is membranes, the UV dose is lowered to 80 mJ/cm^2 because tertiary membranes can filter out some microorganisms. The reduced dose level carries potential capital and O&M cost savings for the City, which have been accounted for in the Tertiary Filtration Approach BCE (DRC Briefing #15). The disinfection BCE conservatively assumes that sand filtration is the tertiary filtration method, thereby requiring a UV dose of 100 mJ/cm^2. The Technical Team will further define the final UV dose during later stages of preliminary design using site-specific sampling and data analyses.

Recommendation

The Technical Team recommends the selection of Alternative 1 – UV Disinfection. This selection is consistent with the Facility Plan and corroborated through the BCE analysis. The Technical Team requests the DRC's confirmation of this selection.

Attachments

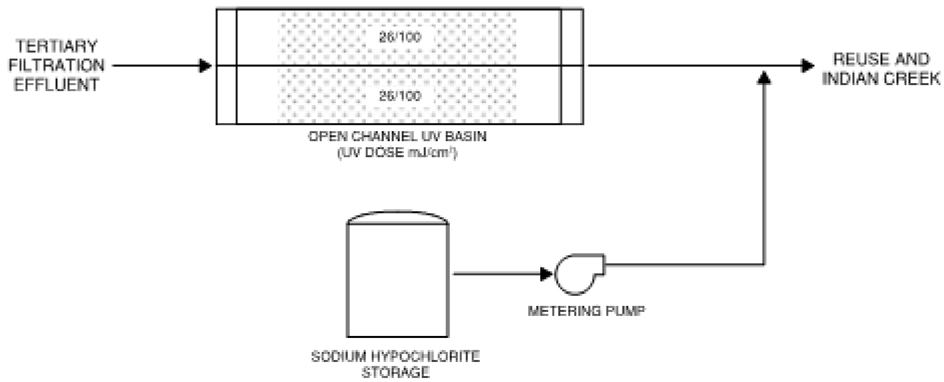

Figure 1. Alternative 1: UV Disinfection Schematic

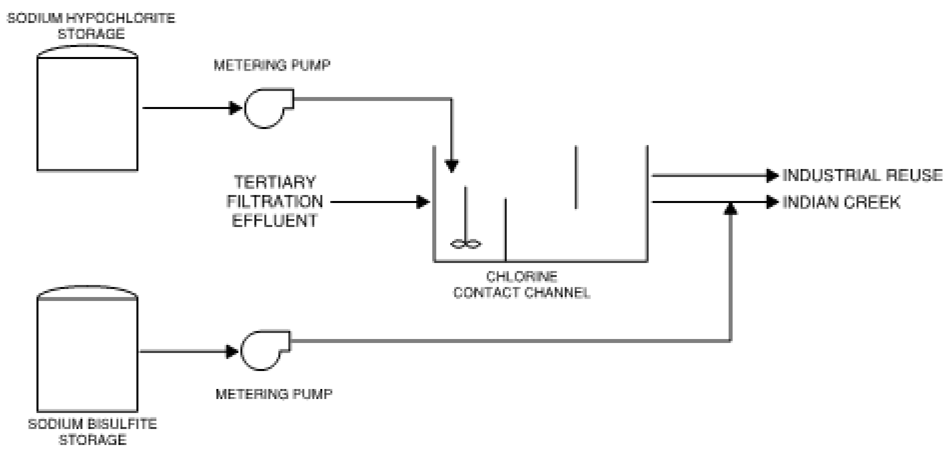

Figure 2. Alternative 2: Chlorination System Schematic

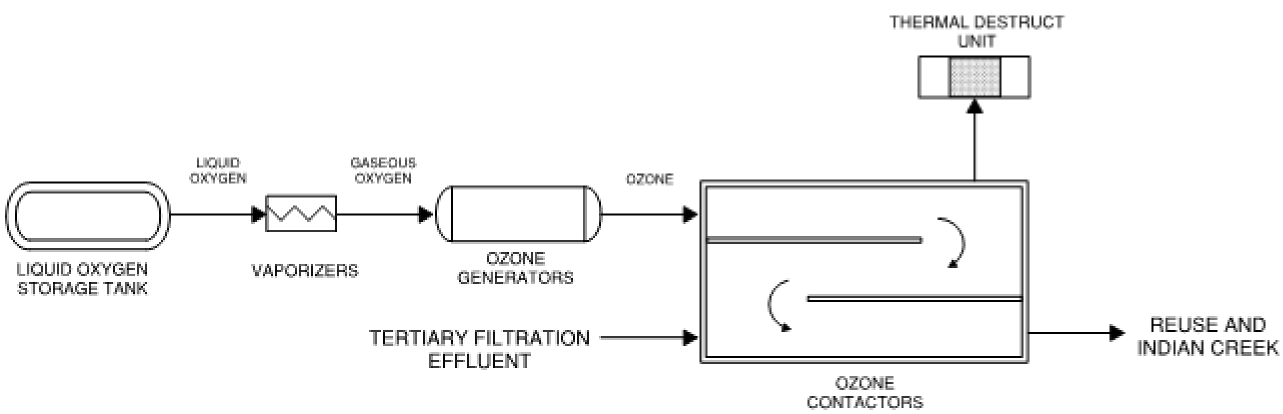

Figure 3. Alternative 3: Ozonation Process Schematic

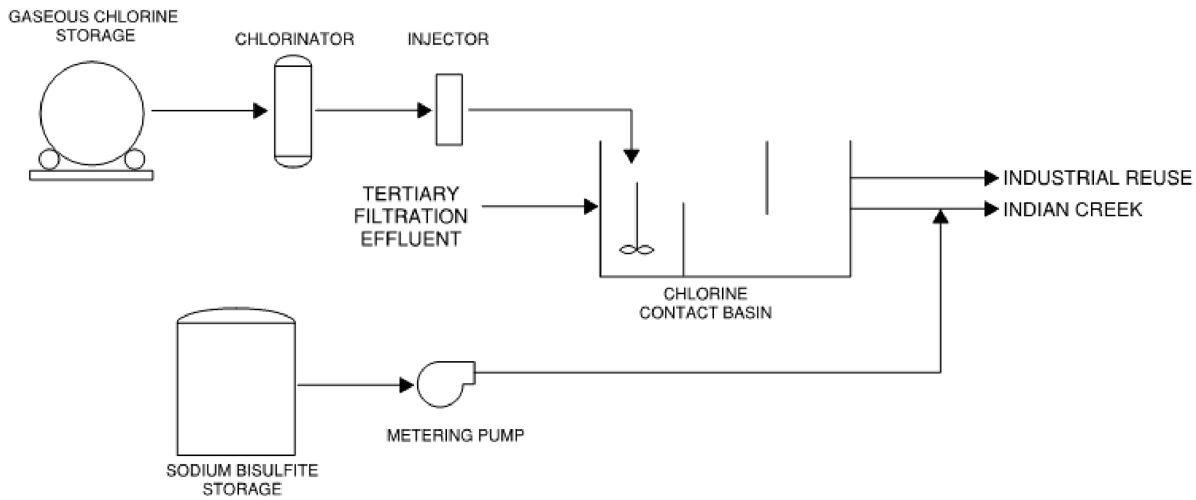

Figure 4. Alternative 4: Chlorine Gas Injection Process Schematic

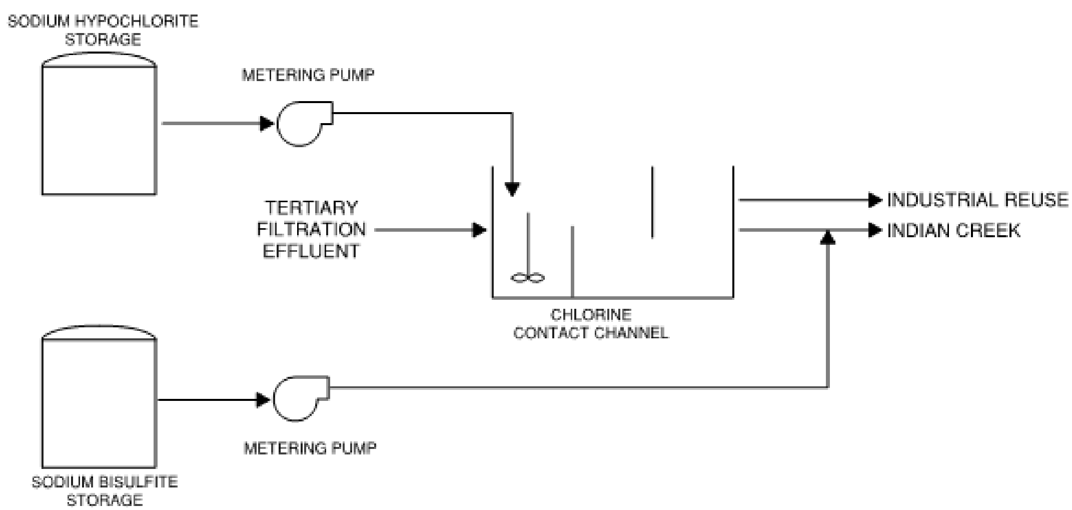

Figure 5. Alternative 5: Sodium Hypochlorite Process Schematic

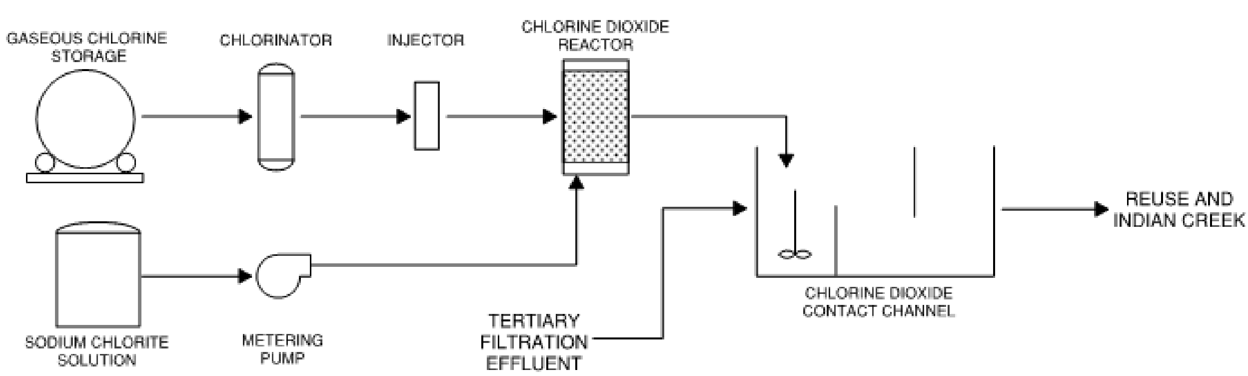

Figure 6. Alternative 6: Chlorine Dioxide Process Schematic

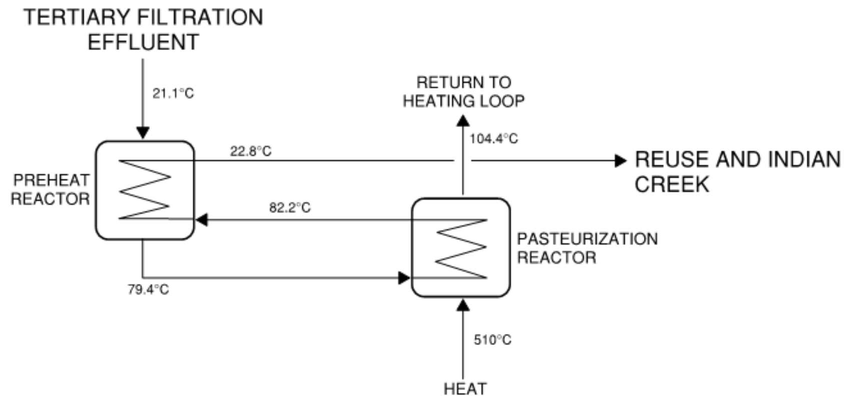

Figure 7. Alternative 7: Pasteurization Schematic

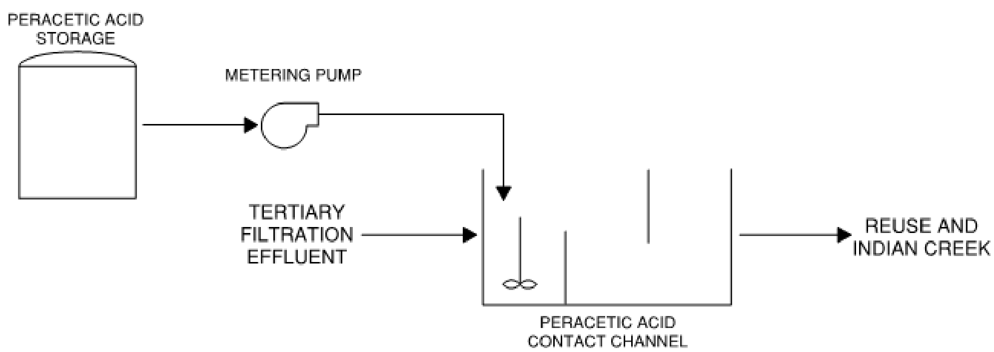

Figure 8. Alternative 8: Peracetic Acid Process Schematic