

# Johnstown Water Treatment Plant Expansion

## Comparison of Project Costs Between Membrane Filtration/Granular Activated Carbon & Ozone/Biologically Active Filtration

June 4, 2021

Three project fees were included with Burns & McDonnell's proposal of February 5, 2021. Town staff indicated their preference for Option 3, which is a comprehensive site plan based on Membrane Filtration and Granular Activated Carbon (GAC). Subsequent discussions with the Town, as well as a working session with the Town Council on April 12, 2021, lead the project team toward Ozone and Biologically Active Filtration (BAF) as the preferred solution for addressing growing demand, aging infrastructure and on-going taste and odor issues (Option 4).

Option 4 will provide robust treatment for current and future water quality issues and regulations, as well as **effective treatment of high taste and odor issues** related to cyanobacteria in the Town's water supply. However, Ozone/BAF will increase the amount of equipment and complexity of upgrades to the Johnstown WTP. This will increase the construction cost, as well as the related engineering effort. Colorado Department of Public Health and Environment (CDPHE) Water Quality Control Division will require piloting of both Ozone and BAF before approval.

Table 1 compares the anticipated taste and odor removals, construction cost, operating costs and schedules of Option 3 (Membrane Filtration/GAC) and Option 4 (Ozone/BAF). Options 1 and 2 are not discussed because they do not meet all project objectives identified during the Town Council working session of April 12, 2021, in particular, taste and odor control. Costs are based on two phases to build-out capacity, with Phase 1 at a capacity of 12.5 million gallons per day (MGD).

| Table 1: Comparison of Key Considerations |                         |                |
|-------------------------------------------|-------------------------|----------------|
| Approach                                  | Option 3                | Option 4       |
| Process Summary                           | Membrane Filtration/GAC | Ozone/BAF      |
| Taste & Odor Removals                     | 60 to 80%               | 90 to 99%      |
| Annual O&M Costs <sup>1</sup>             | \$391,000               | \$69,000       |
| Capital Costs                             | \$20M to \$35M          | \$45M to \$60M |
| Implementation Timeline                   | 30 months               | 37 months      |

1. O&M cost for taste and odor removal only to compare GAC to Ozone generation. Includes electricity, chemical and carbon replacement costs only.

**Membrane Filtration/GAC (Option 3) offers:**

- Less removal of taste and odor compounds.
- Lower construction cost, due to the simplified nature of the Membrane Building (slab on grade with pre-engineered metal building).
- Higher taste and odor operating costs due to change-outs of the activated carbon multiple times per year.
- Easily scalable for future phases.
- Maintains the use of the existing granular media filters in the short term.
- Relies on existing infrastructure (filter building, storage tanks).
- Integrates the 6 GAC vessels purchased in 2021 into the WTP expansion.

**Ozone/BAF (Option 4) offers:**

- High removals of up to 99% taste and odor compounds.
- Higher construction cost, due to the complex buildings required for ozone system, ozone contact basin, new deep bed filters and new chemical systems.
- Lower taste and odor operating costs for electricity, oxygen and biological filtration chemicals compared to the carbon changeout costs.
- More expensive expansion at the next phase.
- Does not rely on aging infrastructure. Existing filters are abandoned.
- Positions the Town for changes in raw water quality (wildfire, drought, nutrient run off) and future treatment regulations.
- Requires 8-week piloting of ozone and BAF.

Both options will provide effective removal of taste and odor compounds. The GAC option will rely on upstream steps (PAC at Lonetree, ultrasonic buoys at Town Lake, DAF optimization) in a multi-phased approach to extend the life of the activated carbon. Ozone/BAF will be effective on its own across a wide range of water quality. The 2021 demonstration project will prove the effectiveness of GAC, as well as provide data on how often the carbon will need to be changed (\$228,000 each re-bed, up to 2 per year).

***Even if Ozone/BAF is selected at the start of the design phase, the Town will have an option to switch to a Membrane Filtration/GAC solution if the data from this summer shows the GAC working well.***

# Assumed Ozone/BAF Site Layout

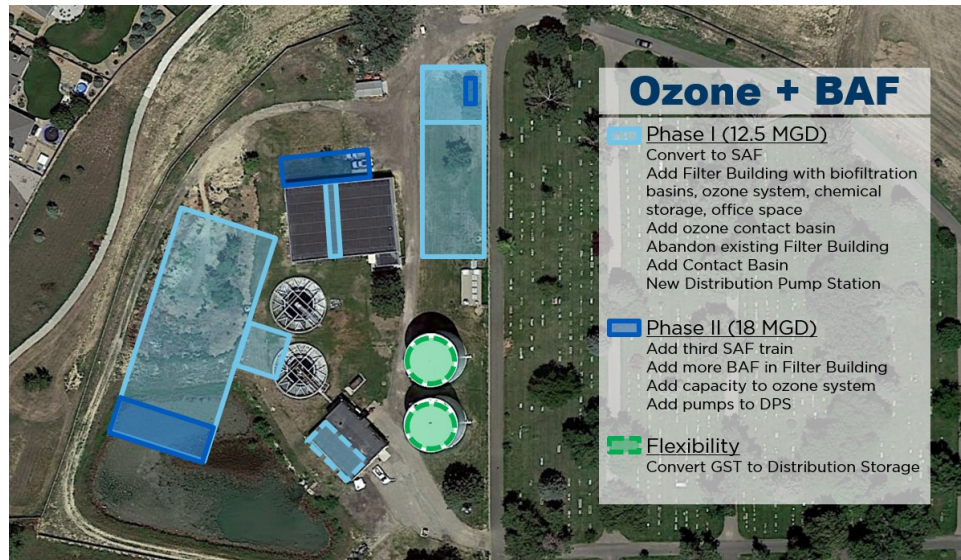


Figure 1 - Ozone/BAF Site Layout

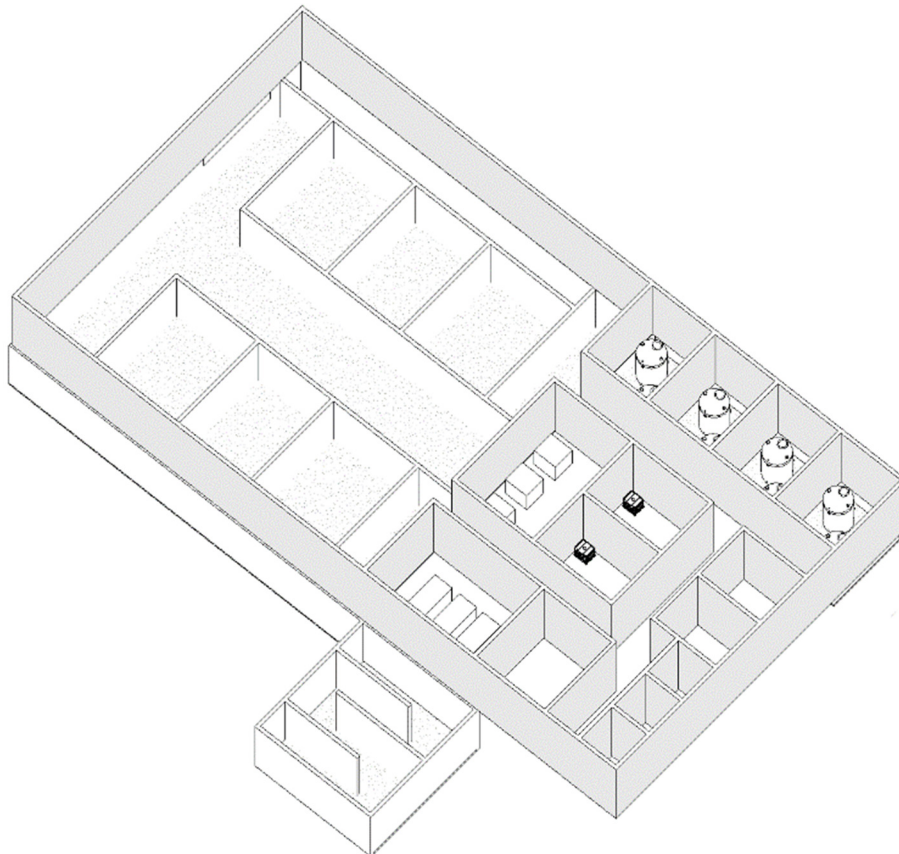


Figure 2 - 3D Model of Ozone/BAF Filter Building

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| Table 2: Project Cost Comparison at 12.5 MGD <sup>1</sup> |                         |                     |
|-----------------------------------------------------------|-------------------------|---------------------|
| Approach                                                  | Option 3                | Option 4            |
| Process Summary                                           | Membrane Filtration/GAC | Ozone/BAF           |
| Div 01 - General Requirements                             | \$-                     | \$-                 |
| Div 02 - Existing Conditions                              | \$236,000               | \$298,000           |
| Div 03 - Concrete                                         | \$1,866,000             | \$5,840,000         |
| Div 04 - Masonry                                          | \$342,000               | \$691,000           |
| Div 05 - Metals                                           | \$1,698,000             | \$2,963,000         |
| Div 06 - Wood, Plastics and Composites                    | \$204,000               | \$275,000           |
| Div 07 - Thermal and Moisture Protection                  | \$47,000                | \$121,000           |
| Div 08 - Openings                                         | \$148,000               | \$213,000           |
| Div 09 - Finishes                                         | \$181,000               | \$287,000           |
| Div 10 - Specialties                                      | \$17,000                | \$30,000            |
| Div 11 - Equipment                                        | \$17,000                | \$20,000            |
| Div 12 - Furnishings                                      | \$43,000                | \$50,000            |
| Div 13 - Special Construction                             | \$17,000                | \$40,000            |
| Div 14 - Conveying Equipment                              | \$51,000                | \$160,000           |
| Div 21 - Fire Suppression                                 | \$170,000               | \$200,000           |
| Div 22 - Plumbing                                         | \$255,000               | \$450,000           |
| Div 23 - HVAC                                             | \$679,000               | \$1,200,000         |
| Div 26 - Electrical                                       | \$1,527,000             | \$3,400,000         |
| Div 27 - Communications                                   | \$-                     | \$-                 |
| Div 28 - Electronic Safety and Security                   | \$26,000                | \$30,000            |
| Div 31 - Earthwork                                        | \$1,301,000             | \$3,465,000         |
| Div 32 - Exterior Improvements                            | \$179,000               | \$250,000           |
| Div 33 - Water Utility                                    | \$1,951,000             | \$3,383,000         |
| Div 40 - Process Integration                              | \$-                     | \$-                 |
| Div 41 - Conveying Systems                                | \$-                     | \$-                 |
| Div 46 - Water Treatment Equipment                        | \$4,286,000             | \$9,158,000         |
| <b>SUBTOTAL</b>                                           | <b>\$15,241,000</b>     | <b>\$32,524,000</b> |
| General Requirements (12%)                                | \$1,829,000             | \$3,903,000         |
| <b>Construction Cost Sub-Total</b>                        | <b>\$17,070,000</b>     | <b>\$36,427,000</b> |
| Contractor Overhead & Profit (15%)                        | \$2,561,000             | \$5,465,000         |
| <b>CONSTRUCTION COST</b>                                  | <b>\$19,631,000</b>     | <b>\$41,892,000</b> |
| Contingency (20%)                                         | \$3,927,000             | \$8,379,000         |
| Design Phase Engineering (6%)                             | \$1,178,000             | \$2,514,000         |
| Construction Phase Engineering (6%)                       | \$1,178,000             | \$2,514,000         |
| <b>TOTAL PROJECT COST<sup>2</sup></b>                     | <b>\$25,914,000</b>     | <b>\$55,299,000</b> |

1. EOPCC in this study were completed in accordance with the Association for the Advancement of Cost Engineering (AACE) Class 5 definition. Class 5 EOPCC are generally developed with limited information (<5% defined) and subsequently vary in their accuracy. They are typically used for project screening, determination of feasibility, concept evaluation, and preliminary budget approval. The expected accuracy range is -20% to -50% below and +30 to +100% above. Vendor quotes were sought and gross unit costs/ratios from past projects were used to develop the estimates in this report. The EOPCC presented in this study are based on 2021 dollars at the time of issue. The use of the costs presented in this study should be escalated if used for future purposes to reflect changes in labor, material, and equipment. Local cost data or published cost indices should be consulted to determine an appropriate cost escalation factor.
2. Excludes land acquisition costs, permitting and legal fees.

| Table 3: Engineering Comparison                       |                         |                     |
|-------------------------------------------------------|-------------------------|---------------------|
| Approach                                              | Option 3                | Option 4            |
| Process Summary                                       | Membrane Filtration/GAC | Ozone/BAF           |
| <b>CONSTRUCTION COST</b>                              | \$19,631,000            | \$41,892,000        |
| Contingency (20%)                                     | \$3,927,000             | \$8,379,000         |
| <b>SUBTOTAL CONSTRUCTION COST</b>                     | <b>\$19,631,000</b>     | <b>\$41,892,000</b> |
| Engineering Task Series <sup>1</sup>                  |                         |                     |
| 100 - Project Initiation & Coordination               | \$41,414                | \$132,603           |
| 200 - Review Existing Data & Basis of Design          | \$177,297               | \$607,074           |
| 200A - Pilot Testing                                  | NA                      | \$194,456           |
| 300 - Preliminary Design 30%                          | \$177,560               | \$402,333           |
| 400 - Detailed Design 60%                             | \$189,499               | \$444,163           |
| 500 - Optimize Operations (Short Term Relief)         | \$50,805                | \$93,939            |
| 600 - Final Design                                    | \$165,556               | \$374,778           |
| 700 - Bid Phase Support <sup>2</sup>                  | \$11,891                | \$11,891            |
| <b>Design Phase Engineering<sup>3</sup></b>           | <b>\$814,022</b>        | <b>\$2,261,237</b>  |
| <b>Estimated Owner Costs for Piloting<sup>4</sup></b> |                         | <b>\$180,000</b>    |

1. Engineering tasks based on a Design-Bid-Build project delivery model. Schedule and cost savings anticipated if the project is completed using a collaborative delivery model, such as Design-Build.
2. Bid Phase Support task series not required with a Design-Build delivery model. Engineering services for bidding and procurement integrated into Phase 2 Construction Services under a Design-Build delivery model.
3. Engineering services during design only. Construction phase engineering support negotiated near completion of design once construction complexity, delivery model, contractor and schedule are better defined.
4. Estimated owner costs for piloting include leasing of piloting equipment (Ozone and BAF trailers), temporary chemical systems, utilities, installation costs, operations and monitoring costs and laboratory analytical costs.



| Table 4: Additional Design Effort for Option 4 |                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                  |                         |
|------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------|-------------------------|
| Approach                                       | Option 3                                                                                                                                                                                                                                                                                                                                            | Option 4                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                  |                         |
| Process Unit                                   | Membrane Filtration/GAC                                                                                                                                                                                                                                                                                                                             | Ozone/BAF                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Design Fee Adder | Additional Design Hours |
| Lonetree Pump Station & Pipeline               | Remain as is                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | \$-              | -                       |
| Town Lake Pump Station                         | Remain as is                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | \$-              | -                       |
| Raw Water Tank                                 | Remain as is                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | \$-              | -                       |
| Chemical Storage                               | Add Storage and Membrane Cleaning Systems to new Membrane Building                                                                                                                                                                                                                                                                                  | Add 4 new chemical systems for advanced oxidation and BAF (hydrogen peroxide, ammonium sulfate, sodium bisulfite, phosphoric acid). Relocate existing chemicals (coagulant, sodium hypochlorite, sodium hydroxide) to the new Filtration Building. Size chemical systems for ultimate capacity of 18 MGD.                                                                                                                                                                                                                                                                                                                            | \$175,000        | 950                     |
| Pretreatment Capacity                          | Convert to SAF at 12.5 MGD capacity                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | \$-              | -                       |
| Filtration                                     | Add Storage and Membrane Cleaning Systems to new Membrane Building. Includes two new systems for membrane cleaning (citric acid and sodium bisulfate) and relocation of two chemical systems (sodium hypochlorite and sodium hydroxide). Sized at capacity of 12.5 MGD. Membrane Building as slab on grade with pre-engineered metal superstructure | Add 4 new deep-bed filters (60-inch, 3.9 MGD each) to replace existing GMF. Includes settled water distribution channel, pipe gallery, new filter boxes with underdrains and backwash troughs, air scour system, and backwash waste collection. Biologically active for taste and odor control. Deep location determined by the hydraulic grade of existing pretreatment. New Filtered Water Tank below filter gallery, including a combination filtered water and backwash supply pump station. Complex concrete basins below grade. Pre-engineered metal superstructure.                                                           | \$225,000        | 1,200                   |
| Taste & Odor Control                           | Implement multi-phase approach. Lease to own GAC contactors in Membrane Building. Optimize T&O removal with SAF conversion. Future flexibility for T&O control.                                                                                                                                                                                     | Multi-phase approach. Improve PAC at Lonetree pump station, install ultrasonic buoys at Town Lake, optimize removals in SAF. Add <b>intermediate ozone</b> (after pretreatment), including liquid oxygen storage, vaporizers, injection skids, generators, concrete Ozone Contact Basin with serpentine baffles, ozone destructor units. Complex stainless steel piping, instrumentation, and controls. Assumed high levels of raw water bromide creating the need for hydrogen peroxide to mitigate bromate formation (disinfection by-product). Use of hydrogen peroxide will also minimize the volume of the Ozone Contact Basin. | \$275,000        | 1,500                   |
| Piloting                                       | No piloting required.                                                                                                                                                                                                                                                                                                                               | CDPHE requirement for approval. Approximately 2 months of piloting required to determine ozone dose, capacity of ozone system, and BAF filter loading rate.                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | \$215,000        | 1,200                   |
| Disinfection Compliance                        | Add new Disinfection Contact Basin (DCB) sized for ultimate flows.                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | \$-              | -                       |
| Treated Water Storage                          | Convert GST to distribution storage                                                                                                                                                                                                                                                                                                                 | Add 1,500,000 gallons of distribution storage in same tank as new DCB. Convert the GST to distribution storage.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | \$75,000         | 400                     |
| Distribution Pump Station                      | New at-grade pump station with vertical turbine pumps above a new DCB.                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | \$-              | -                       |
| Backwash Supply                                | Backwash from distribution system                                                                                                                                                                                                                                                                                                                   | Add Filtered Water Tank below filters. Need non-chlorinated backwash supply water for BAF (not able to take from storage tanks or distribution system). Add combination pump station with filtered water pumps to transfer water to the DCB and backwash supply pumps for the filters.                                                                                                                                                                                                                                                                                                                                               | \$150,000        | 800                     |
| Backwash Waste                                 | No change                                                                                                                                                                                                                                                                                                                                           | Existing backwash pond demolished to create space for the new Filter Building. Add new Backwash Waste Tank with combination pumps station. Recycle pumps to transfer supernatant to the front of the WTP. Backwash waste pumps to send waste to the existing sanitary sewer at a higher elevation than the Backwash Waste Tank.                                                                                                                                                                                                                                                                                                      | \$150,000        | 800                     |
| Electrical System                              | New electrical service for Membrane Building, DCB and DPS. Add second diesel generator. Upgrade site lighting and security                                                                                                                                                                                                                          | Similar to Option 3 but expanded for the additional process systems and equipment.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | \$80,000         | 400                     |
| SCADA System                                   | Add control system nodes for Membrane Building, T&O system, DCB and new DPS.                                                                                                                                                                                                                                                                        | Replace existing SCADA with new network for complex operations and new process units (Ozone, BAF, Filtered Water and Backwash Supply Pump Station, DCB, DPS, Recycle and Backwash Waste Pump Station).                                                                                                                                                                                                                                                                                                                                                                                                                               | \$60,000         | 300                     |

| Approach                | Option 3                                                                                                                                                                                                                                                 | Option 4                                                                                                                                                                                                                                                                                                                                                                                                 |                    |                         |
|-------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------|-------------------------|
| Process Unit            | Membrane Filtration / GAC                                                                                                                                                                                                                                | Ozone / BAF                                                                                                                                                                                                                                                                                                                                                                                              | Design Fee Adder   | Additional Design Hours |
| Project Execution       | As proposed.                                                                                                                                                                                                                                             | Extended management and supervision for longer design schedule.                                                                                                                                                                                                                                                                                                                                          | \$10,000           | 50                      |
| Additional Cost & Hours |                                                                                                                                                                                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                          | <b>\$1,415,000</b> | <b>7,600 hours</b>      |
| Summary                 | <p><b>Best Value Project, Limited T&amp;O Removals</b></p> <p>Option 3 provides comprehensive site plant with future flexibility and operational robustness. Limited taste and odor removals with Membrane Filtration/GAC at higher operating costs.</p> | <p><b>Robust &amp; Effective Operations for Water Quality Concerns</b></p> <p>Address current and future T&amp;O issues at higher certainty with fewer treatment steps, reduced operating costs when compared with Membrane Filtration /GAC, expanded WTP set up for future regulations and water quality events which may impact your watershed, phasing plan with flexibility to meet your budget.</p> |                    |                         |

| ACTIVITY                             | 2021 |     |     |     |     |     |     |     |     |     | 2022 |     |     |     |     |     |     |     |     |     |     |     | 2023 |     |     |     |     |     |     |     |     |     |     |     | 2024 |     |     |     |
|--------------------------------------|------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|-----|-----|-----|
|                                      | MAR  | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | JAN  | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | JAN  | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | JAN  | FEB | MAR | APR |
| OPTION 3 - MEMBRANE FILTRATION / GAC |      |     |     |     |     |     |     |     |     |     |      |     |     |     |     |     |     |     |     |     |     |     |      |     |     |     |     |     |     |     |     |     |     |     |      |     |     |     |
| DESIGN                               |      |     |     |     |     |     |     |     |     |     |      |     |     |     |     |     |     |     |     |     |     |     |      |     |     |     |     |     |     |     |     |     |     |     |      |     |     |     |
| BIDDING                              |      |     |     |     |     |     |     |     |     |     |      |     |     |     |     |     |     |     |     |     |     |     |      |     |     |     |     |     |     |     |     |     |     |     |      |     |     |     |
| CONSTRUCTION                         |      |     |     |     |     |     |     |     |     |     |      |     |     |     |     |     |     |     |     |     |     |     |      |     |     |     |     |     |     |     |     |     |     |     |      |     |     |     |
| OPTION 4 - OZONE / BAF               |      |     |     |     |     |     |     |     |     |     |      |     |     |     |     |     |     |     |     |     |     |     |      |     |     |     |     |     |     |     |     |     |     |     |      |     |     |     |
| DESIGN                               |      |     |     |     |     |     |     |     |     |     |      |     |     |     |     |     |     |     |     |     |     |     |      |     |     |     |     |     |     |     |     |     |     |     |      |     |     |     |
| BIDDING                              |      |     |     |     |     |     |     |     |     |     |      |     |     |     |     |     |     |     |     |     |     |     |      |     |     |     |     |     |     |     |     |     |     |     |      |     |     |     |
| CONSTRUCTION                         |      |     |     |     |     |     |     |     |     |     |      |     |     |     |     |     |     |     |     |     |     |     |      |     |     |     |     |     |     |     |     |     |     |     |      |     |     |     |
|                                      |      |     |     |     |     |     |     |     |     |     |      |     |     |     |     |     |     |     |     |     |     |     |      |     |     |     |     |     |     |     |     |     |     |     |      |     |     |     |

Figure 1 - Schedule Comparison, assuming June 1 start