Fluoridation Implementation
Multi-Objective Decision Analysis

Prepared for
City of Spokane

January 12, 2023

Prepared by
Parametrix
on behalf of
consor

Executive Summary

Parametrix
ENGINEERING . PLANNING . ENVIRONMENTAL SCIENCES
835 NORTH POST, SUITE 201 | SPOKANE, WA 99201 | P 509.328.3371

EXECUTIVE SUMMARY

Fluoridation Implementation Multi-Objective Decision Analysis

A Multi-Objective Decision Analysis (MODA), developed by Parametrix was conducted for the City of Spokane (City). The MODA is composed of an Alternatives Analysis (conducted by Consor), Total Cost of Ownership (TCO), performance evaluation, and alternative value assessment. Performance criteria were developed and weighted in a May 2022 MODA Criteria Workshop, the TCO analysis was prepared by Parametrix in October 2022, and lastly, a MODA Workshop facilitated by Parametrix and Consor occurred in November 2022. This Executive Summary provides an overview of the analysis and key findings as well as a brief description of the preferred fluoridation alternative.

PROJECT DESCRIPTION

The City is conducting a preliminary engineering study to understand all the elements needed to implement fluoridation if the City chooses to move forward. Previously, the design team at Consor and Parametrix provided a Fluoridation System Alternatives report that assessed three alternatives to fluoridate the water system and suggested two preferred chemical alternatives for further evaluation. The first alternative is a Liquid option using fluorosilicic acid (FSA), and the second is a Dry option using sodium fluoride (NaF).

The Parametrix and Consor teams co-facilitated an evaluation of the two final alternatives using the MODA process to select the technically preferred alternative. The preferred alternative was selected based on the City's long-term goals of balancing sustainability, social responsibility, and affordability (City's Triple Bottom Line).

ANALYSIS OBJECTIVES

The MODA is used to assist the City of Spokane in determining a preferred alternative between the Liquid and Dry options, considering several factors for each option, such as impacts to the environment, safety, service reliability, maintenance, and operations. A life cycle cost analysis was also completed, which was also used to inform an analysis of the TCO as presented later in this memorandum. Alternative costs include the initial capital costs and subsequent life cycle costs, including annual maintenance and operations costs, power and chemical costs, and subsequent replacement costs, across a 50-year life cycle. Salvage values were also taken into account. The data were calculated over the 50-year life cycle and discounted to 2022 dollars for evaluation. This type of cost analysis was not intended to understand exact costs but rather to provide information to the City in terms of the relative cost of each option and, more importantly, how they compare with each other.

The MODA takes into consideration a set of weighted performance criteria that were developed as a part of the initial phases of the study during a May 2022 workshop. The six criteria measure different impacts to the environment, neighborhoods, both public and worker safety, service reliability, and ease of maintenance and operations. City water operations personnel were brought together as a technical team to participate in the MODA process to conduct evaluations and score these criteria. The MODA model determines a calculated consensus score, which is performance-based in the application of the ratings from all participants, and an alternative value score, which is a function of performance relative to alternative cost. The alternative cost, performance, and value scores were used to develop and inform the selection of the preferred alternative.

Performance Criteria

The six performance criteria were weighted during the May 2022 workshop as follows:

- Environmental and Sustainability Impacts (*Weighting: 8%)*
- Neighborhood Impacts (*Weighting: 12%*)
- Safety – Public (*Weighting: 25%*)
- Safety – Worker (*Weighting: 25%*)
- Service Reliability (*Weighting: 15%*)
- Ease of Maintenance and Operations (*Weighting: 15%*)

Fluoridation Alternatives Analysis Results

The results from the MODA process identified the Liquid option, FSA, as the preferred alternative. It yielded the better scores for both performance and cost, scoring 5.2 and 5.7, respectively. This resulted in a value index score of 1.2, which is 39% higher when compared with the Dry alternative's score of 0.9. For a deeper explanation of the scoring system, methodology, and general formula used, refer to the Value of Alternatives section at the end of the Fluoridation Implementation Multi-Objective Decision Analysis Technical Memorandum.

Table ES-1 displays a summary of performance; TCO, which includes initial capital costs and subsequent operating costs over a 50-year life cycle; and value scores. Costs in Figure ES-1 below are adjusted to real 2022 dollars (i.e., they are adjusted for inflation and escalation and discounted over the 50-year period to represent 2022 dollars).

Table ES-1. Option Rankings

Option	TCO (USD) *50-Year Life Cycle*	Performance Score	Cost Score	Value Index	% Change
Fluorosilicic Acid – Liquid	$204,289,000	5.2	5.7	1.2	38.5%
Sodium Fluoride – Dry	$264,126,000	4.9	4.3	0.9	

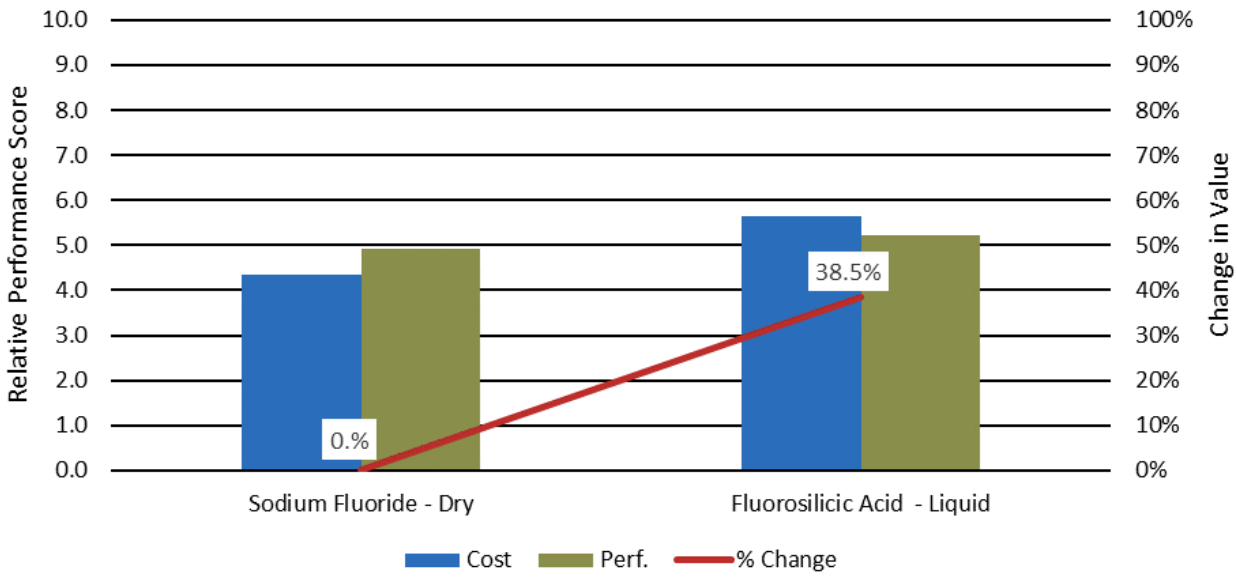


Figure ES-1. Option Ratings

The Liquid alternative is projected to be the lower cost option over a 50-year period, resulting in a better cost score. Annual operating costs were taken into consideration and include maintenance, operation of equipment, power, and chemical costs. Other one-time and periodic costs factored in were initial capital, engineering, capital and equipment replacement, and operating contingency. Salvage value of equipment was also considered.

The Dry alternative's initial capital costs are about $2 million higher. These initial capital costs also drive other costs throughout the life cycle, including engineering, maintenance, and equipment replacement. The price of the chemicals used in the fluoridation process is the most significant source of the life cycle cost differences, with the Dry alternative chemicals costing about $37 million more than Liquid over the 50-year period, which makes up 62% of the cost difference between each alternative. When considering the total cost of ownership of each fluoridation alternative, the Dry alternative costs $60 million more to own and operate over the 50-year life cycle (in real 2022 dollars).

The Liquid alternative also had a higher performance score. Both alternatives scored similarly except for two criteria: Service Reliability (6.4 compared with 5.2) and Ease of Maintenance and Operations (3.6 compared with 2.8). Given its better scores in both performance and cost, the Liquid alternative received a higher value index score, resulting in the recommendation that the Fluorosilicic Acid (Liquid) is the technically preferred alternative for fluoridation implementation if the City chooses to implement fluoridation.

Technical Memorandum

TECHNICAL MEMORANDUM

DATE:	January 12, 2023
TO:	City of Spokane
FROM:	Consor Mike Morse, PE, Project Manager, Parametrix Greg Brink, PMP, PMI-RMP, PMI-PBA, CCEA, CVS, Director of Strategic Advisory Services, Parametrix
SUBJECT:	Fluoridation Implementation Multi-Objective Decision Analysis
CC:	
PROJECT NUMBER:	376 4109 001
PROJECT NAME:	Fluoridation Alternatives Analysis

PROJECT BACKGROUND

The City of Spokane (City) is conducting a preliminary engineering study to understand all the elements needed to implement fluoridation if the City chooses to move forward. A technical team made up of water operators and other Water Department staff was created at the beginning of the study to help in the assessment. Initial work during this study by the design team at Consor and Parametrix, utilizing the technical team, provided a Fluoridation System Alternatives Technical Memorandum, which assessed three different alternatives to fluoridate the water system and suggested two preferred chemical alternatives for further evaluation. The purpose of this technical memorandum is to document the decision process that has resulted in a final recommendation between the two remaining options. The first alternative is a Liquid option using fluorosilicic acid (FSA), and the second is a Dry option using sodium fluoride (NaF). Detailed information and comparisons of the two alternatives can be found in the aforementioned Consor Fluoridation System Alternatives Technical Memorandum.

The Parametrix and Consor teams co-facilitated an evaluation of the two final alternatives using an objective and transparent Multi-Objective Decision Analysis (MODA) process to select the technically preferred alternative. The MODA process included a May 2022 workshop to select performance criteria for the alternatives, which were also weighted; an October 2022 Total Cost of Ownership (TCO) analysis prepared by Parametrix; and finally a November 2022 MODA Workshop with the technical team facilitated by Parametrix and Consor. The MODA Workshop was held to assign performance ratings to each alternative by applying the performance criteria to each of them and then to calculate alternative value scores based on performance ratings and alternative costs. The Parametrix team facilitated a collaborative discussion of each alternative's overall value centered around the calculated scores, which helped select a technically preferred alternative for fluoridating the water system.

This technical memorandum provides an overview of the MODA process and details the steps and considerations taken to arrive at the technically preferred alternative, which include measuring performance using a set of performance criteria applied to both alternatives and then determining the relative value of each alternative compared with each other. The relative value of each alternative was determined using a TCO analysis and modeled over a 50-year life cycle period.

MULTI-OBJECTIVE DECISION ANALYSIS OVERVIEW

MODA is a process for making decisions involving multiple performance criteria and multidisciplinary stakeholders/decision makers. Participants in the process evaluated each proposed alternative of a project by weighting different performance criteria according to the needs and goals of the project and analyzing the tradeoffs each presents in relation to criteria selected. The process also facilitated a thorough discussion among all the technical team members. This allowed individuals to explain and justify their scoring of alternatives to the team based on their perspective, experience, and expertise. The MODA tool determines a calculated consensus that factors in ratings from all participants rather than forcing a group to reach negotiated consensus agreements. This approach allowed for many perspectives to be factored into a quantitative score.

The Parametrix team evaluated each alternative's cost and performance as well as value as a function of performance relative to cost. The Parametrix team evaluated the cost component by performing a TCO and Life Cycle Cost Analysis (LCCA) using data from the concept-level cost estimates provided by Consor. Performance was evaluated by applying weighted criteria to each alternative to calculate a performance score. Measuring performance was a multistep process that started with developing performance criteria and weighting those criteria relative to one another in a May 2022 MODA Criteria Workshop with the project team. In the November 2022 workshop, the project team and the technical team returned for a follow-up to score each alternative based on the criteria. Alternative value was determined during the November 2022 MODA Workshop by using a value formula that is a function of performance relative to cost. The value formula, which is shown below and described in more depth in the Value of Alternatives section of this technical memorandum, uses the performance score and the cost score derived from the TCO. After the value of each alternative was determined, group discussion was facilitated within the technical team regarding the conclusions.

In the following sections of this memorandum, each primary step of the MODA process will be described in further detail along with the process for determining the technically preferred alternative.

COST OF ALTERNATIVES

The cost of each alternative was measured using a TCO model that employs an LCCA. Parametrix prepared the TCO model based on the two remaining options for providing fluoridation of the City's water supply. The analysis of both the Liquid and Dry options included the initial construction costs, subsequent operations and maintenance, energy usage, chemical usage, replacement costs, and salvage benefits of the replaced equipment. The TCO considers costs across a 50-year life cycle and discounts these costs to 2022 dollars for ease of evaluation. All costs are preliminary (i.e., conceptual in nature) and developed for comparison of the alternatives and are reported in real dollars, meaning they are adjusted for inflation and escalation and discounted over the 50-year period to represent 2022 dollars. This means that future costs for both options were normalized to present value (PV) as a part of this process. The Parametrix team utilized the Association for the Advancement of Cost Engineering (AACE) International best practices, using Class 5 estimates with accuracy ranges of -30% on the low side and +50% on the high side.

The summary table and figure in the TCO Analysis Results section includes the initial and subsequent life cycle costs for the two options. These costs are based on P70 values from the uncertainty analysis for the initial and subsequent life cycle costs (i.e., a 30% chance of exceedance). P70 refers to there being a 70% probability that the costs are at or below the projected costs and a 30% probability of exceeding them based on the results of Monte Carlo analysis; it is an industry standard probability level for an LCCA.

Methodology

A TCO model or an LCCA is an economic method of project evaluation in which all costs arising from constructing, owning, operating, and maintaining, as well as subsequent replacement, of project elements are considered. LCCA is well suited to the economic evaluation of design options that satisfy the project requirements but may have differing investment, operating, maintenance, or repair costs, and possibly different life spans. It is particularly relevant to the evaluation of investments where high initial costs are traded for reduced future cost obligations (though that was not found to be the case it this analysis where the Liquid option has lower initial and subsequent costs). LCCA is one method alongside engineering, permitting, and performance criteria in the selection of a technically preferred alternative.

A probabilistic model is used to provide insight into the range of possible life cycle costs over a 50-year service life. The analysis is completed using a Monte Carlo simulation that allows for each uncertain element of the LCCA model to be observed probabilistically as opposed to deterministically. The model was simulated 10,000 times, and the statistics of each iteration were compiled to produce the range of anticipated outcomes. Each variable has been evaluated and the three-point range estimate identified for each variable, including the low, high, and most probable values. Each range identified was utilized to develop a probabilistic triangular distribution.

Basis of Life Cycle Cost Analysis

The TCO model was prepared for the project, with consideration of all initial capital costs, operations and maintenance costs, capital and equipment replacement costs, salvage value, and contingency costs. The model uses these factors to support the selection of a technically preferred alternative through economic evaluation. The TCO was prepared to reflect Parametrix's best understanding of the scope required, as provided by Consor.

Discount and Escalation Rates

The TCO normalizes costs of future periods to the PV to determine the PV of future cash flows. Therefore, the analysis applies a discounted cash flow methodology incorporating two discount rates, as provided by Consor. The base discount rates provided were then ranged based on historic data and forecasted economic analysis and applied in the PV calculations.

Periods	Base Discount Rate
1 through 20	5%
21 through 50	3%

Escalation rates were also provided and utilized in the analysis. These rates were applied on a compounding basis starting in Period 1. The most likely value of the rates varied depending on the period and are as outlined below:

Periods	Base Escalation Rate
1	12.5%
2	12%
3	8%
4 through 20	5%
21 through 50	3%

Basis of TCO Analysis

All conceptual cost estimates, including the initial capital costs, operations and maintenance costs, equipment replacement costs, contingency costs, and salvage value information, were obtained from the *Fluoridation System Alternatives – 2022.09.08* document and associated spreadsheet provided by Consor. This document contained both the data and project context that were utilized in the TCO's assumptions and overall development.

Assumptions

Key assumptions made in the analysis:

- Sites evaluated include Well Electric, Parkwater, Ray, Central Avenue, Grace/Nevada, Hoffman, and Havana.
- The Grace and Nevada sites are in one building.
- For the Dry option, Well Electric and Parkwater, the cheaper building cost of the two was applied. This capital cost is $191,000 (building 635 square feet @ $3,000/square feet).
- Consor's construction cost estimate is in dollars valued at the time of the estimate (September 19, 2022).
- Chemical costs are based on the average operating day from 2019 through 2021.
- Engineering occurs in the year 2023 (Period 1) and is 10% of the initial capital costs (sum of the capital costs in 2023 and 2024).
- Construction will begin in 2024/2025 (Periods 2 and 3). Therefore, initial capital costs are split, with 50% being allocated to 2024 and 50% to 2025. These costs are then escalated to the respective years.
- Annual operating costs begin in 2026 (Period 4).

TCO Analysis Results

Based on the summary analysis of the two options, the Liquid option has lower initial capital and engineering costs as well as lower subsequent life cycle costs than the Dry option over a 50-year life cycle based on the P70 values (see Table CA-1 and Figure 1).

Table CA-1. Total Cost of Ownership

Life Cycle Cost Estimate			
Total Cost of Ownership (P70)		**Option 1**	**Option 2**
Life Cycle Period (Years)	50	Liquid (FSA)	Dry (NaF)
Note: Costs are in real 2022 dollars	Initial Capital	$ 13,050,000	$ 14,903,000
	Engineering	$ 1,412,000	$ 1,608,000
	Maintenance	$ 27,901,000	$ 31,853,000
	Operation of Equipment	$ 48,787,000	$ 50,878,000
	Power	$ 881,000	$ 893,000
	Chemical	$ 52,894,000	$ 89,835,000
	Capital and Equipment Replacement	$ 24,531,000	$ 28,170,000
	Operating Contingency	$ 38,719,000	$ 51,189,000
	Salvage	$ (742,000)	$ (850,000)
Net Present Value in $2022 (NPV)		**$ 204,289,000**	**$ 264,126,000**

Note: Above costs are based on P70 values from Uncertainty Analysis

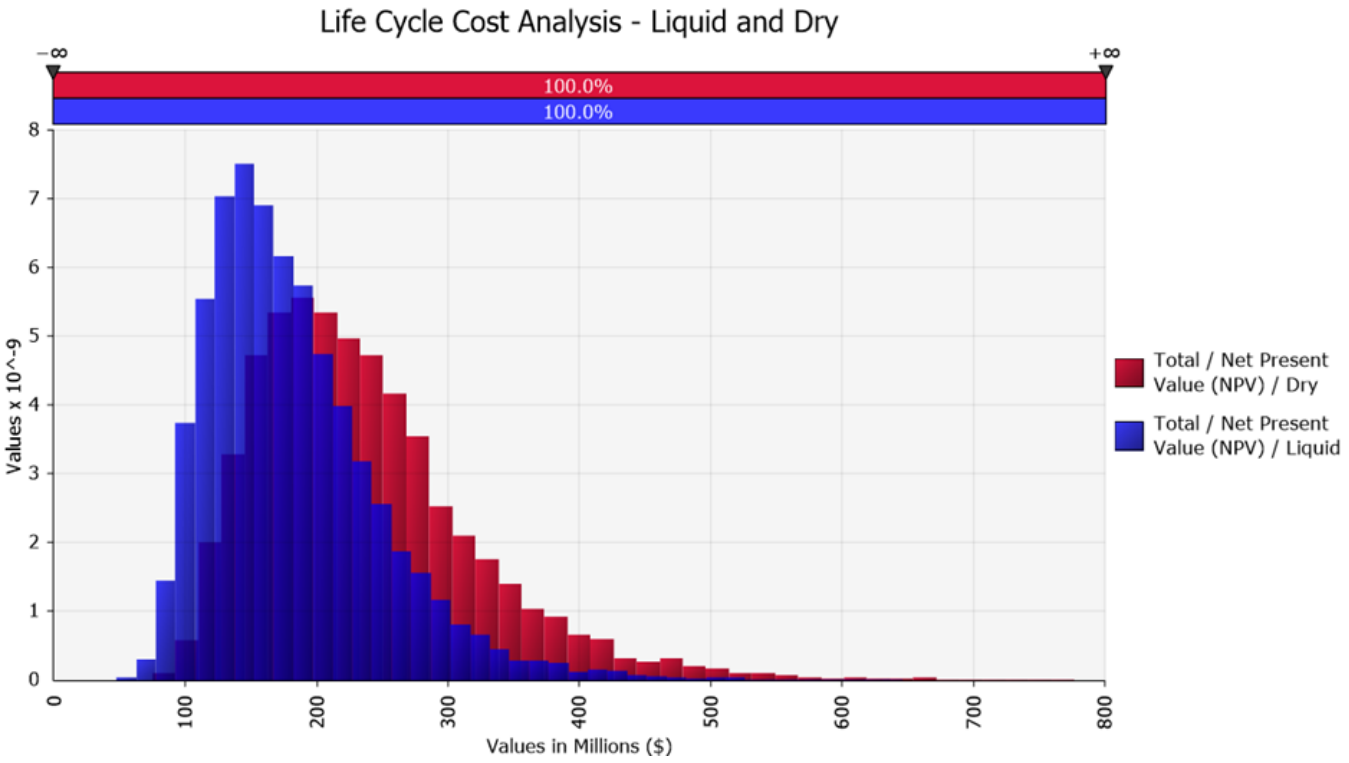


Figure 1. Example Lift Station Asset Type Criticality Formula

Key differences between the Liquid and Dry options are outlined below:

Initial Capital Costs – *Costs for construction of the fluoridation facilities and site improvements*: The Dry option requires additional infrastructure that the Liquid option does not, such as storage warehouse space for the chemicals and water softeners, which drives up the cost.

Liquid Option	Dry Option
$13.05 million	$14.90 million

Engineering Costs – *Costs for design and engineering of the project*: This is a percentage of initial capital costs, so the option with higher capital costs will have higher engineering costs as well. In this case, the Dry option has higher costs.

Liquid Option	Dry Option
$1.41 million	$1.61 million

Subsequent Costs (Total) – *Costs for subsequent operations (labor, utilities, and chemicals), maintenance, and periodic capital and equipment replacement*: The Dry option's chemical costs for NaF are significantly higher than the Liquid's FSA. Additionally, the capital replacement is naturally higher for the Dry option, as its capital and equipment that must be replaced are higher than the Liquid option.

Liquid Option	Dry Option
$192.97 million	$251.97 million

Net Present Value – *Total costs over the 50-year life cycle in 2022 dollars*: The Liquid option has the lowest net costs across all cost categories and thus has a lower net present value (NPV) over its entire life cycle.

Liquid Option	Dry Option
$204.29 million	$264.13 million

The NPV of initial and subsequent costs for the two options are using the 70% confidence interval from the Monte Carlo Analysis (described in the Methodology subsection). Both options share similar assumptions, and the largest sources of uncertainty in both estimates are the escalation and discount rates. The Dry option uniquely sees high levels of uncertainty in the chemical costs of NaF.

Equivalent Annual Cost Analysis Results

Equivalent annual cost (EAC) is the annual cost of owning, operating, and maintaining an asset over its entire life; it excludes the initial capital and engineering costs. EAC is often used by utilities for capital budgeting decisions, as it allows the agency to compare the cost-effectiveness of various assets over their usable lifespans. Essentially, the EAC is derived by taking the NPV of the TCO of the asset divided by the present value of an annuity factor, which takes into account the initial capital investment and associated operating/maintenance costs, the discount rate, and the usable life of the asset to normalize costs into an average annualized amount.

Table CA-2. Equivalent Annual Cost

Equivalent Annual Cost (EAC)			
EAC in $2022 (P70)		**Option 1**	**Option 2**
Life Cycle Period (Years)	50	Liquid (FSA)	Dry (NaF)
Note: Costs are inclusive of price escalation throughout life cycle, and does not include initial costs (Capital and Engineering)	Maintenance	$ 1,327,000	$ 1,515,000
	Operation of Equipment	$ 2,321,000	$ 2,420,000
	Power	$ 42,000	$ 42,000
	Chemical	$ 2,516,000	$ 4,273,000
	Capital and Equipment Replacement	$ 1,167,000	$ 1,340,000
	Operating Contingency	$ 1,842,000	$ 2,435,000
	Salvage	$ (35,000)	$ (40,000)
Net Equivalent Annual Cost in $2022		$ 9,180,000	$ 11,985,000

Note: Above costs are based on P70 values from Uncertainty Analysis

The EAC for the Liquid option is $9.18 million, and $11.99 million for the Dry option. These EACs are inclusive of inflation and expressed in 2022 dollars (see Table CA-2 above). That said, in standard years of operation, the annual operating costs are as low as approximately $3 million and $4 million, respectively. The average EAC is increased by years in which there are major rehabilitative cycles, when costs can be as high as $61 million and $74 million, respectively (in nominal dollars – i.e., not adjusted for inflation). Given these wide disparities in annual operating costs over the entire life of the project, the EAC gives an idea of how much money should be budgeted each year over the project and asset's usable life to account for this.

Key differences in the EAC between the Liquid and Dry options are outlined below:

Maintenance, Capital and Equipment Replacement, and Salvage – These costs represent the annual maintenance of the capital and equipment in each facility, the periodic replacement of capital and equipment as they age, and the salvage value that is recouped after equipment is replaced. These three cost inputs are derived as a percentage of the option's initial capital costs, so the option with the higher initial capital costs will have higher

costs in these categories. In this case the Dry option has higher costs (note that salvage has a higher absolute value, as it is a negative cost).

	Liquid Option	Dry Option
Maintenance	$1.33 million	$1.52 million
Replacements	$1.17 million	$1.34 million
Salvage	$(35,000)	$(40,000)

Chemical – Costs for the chemicals used in the fluoridation process, FSA for Liquid and NaF for Dry. The Dry option's chemical costs for NaF are significantly higher than the Liquid's FSA, which accounts for the most significant annual cost difference between the two options.

Liquid Option	Dry Option
$2.52 million	$4.27 million

Operating Contingency – A reserve of extra funds to cover any unforeseen operating expenses or rise in operating cost inputs. The operating contingency at this stage in the project development is set to 30% of the total of regular annual operating costs, which includes maintenance, operation of equipment, power, and chemical costs. Generally, both options have similar costs for operation of equipment and power, but as described above, both the maintenance and chemical costs are higher for the Dry option. That difference drives the contingency higher for the Dry option as well, given that contingency is derived as a percentage of those costs.

Liquid Option	Dry Option
$1.84 million	$2.44 million

The primary limitations of EAC analysis are the fact that it relies on an estimated discount rate and averages costs over time. As pointed out, there can be wide variances in capital expenditures, considering normal operations relative to periods in which more substantial rehabilitative investments must be made to assets to keep them beneficially in use and operating. As such, it's always important to remember to combine EAC analysis with other capital budgeting tools, such as TCO and MODA, to make sure that the City decision makers understand the full picture regarding the investments being compared.

PERFORMANCE OF ALTERNATIVES

The performance of each alternative is measured by nonfinancial criteria representing the functional performance considerations that were developed during the May 2022 MODA Criteria Workshop. Six criteria were developed and included in the analysis, including Environmental and Sustainability Impacts, Neighborhood Impacts, Safety – Public, Safety – Worker, Service Reliability, and Ease of Maintenance and Operations. These criteria are measured on a 0 to 10 scale, from unacceptable performance to ideal performance, and weighted by relative importance to the project's needs and purpose.

During the November 2022 MODA Workshop, the criteria were applied to both fluoridation alternatives to provide average performance measurement scores. This process will be described further later in this section. Below are the detailed descriptions of each criterion and their measurements.

Environmental and Sustainability Impacts

A relative measure of the impacts to the natural environment, such as those to critical areas or the aquifer, including those attributed to the supply chain (such as carbon emissions from transporting chemicals), in the immediate vicinity of the facilities or the broader region (see Table PA-1). Includes impact on the City of Spokane's sustainability goals.

Weighting: 8%

Table PA-1. Environmental and Sustainability Impacts Scales

Rating	Label	Description
0	Unacceptable Impacts	The environmental impacts are extreme, and the project does not comply with state and/or federal environmental laws.
2	Irreversible Impacts	Significant irreversible adverse impacts, such as destroying a wetland or impact to the aquifer, OR would require a full environmental impact statement.
4	Major Impacts	Major impacts to the natural environment OR significant remediation efforts required.
6	Significant Reversible Impacts	Significant reversible impacts to the natural environment, OR any remediation efforts required, OR significant impacts to the City's sustainability goals.
8	Minor Reversible Impacts	Minor short-term reversible impacts to the natural environment, with no remediation required, OR minor impacts to the City's sustainability goals.
10	Ideal Environmental and Sustainability Impacts	It is anticipated that there will be no negative impacts to the natural environment AND no impact on the City's sustainability goals.

Neighborhood Impacts

A relative measure of the impacts to the built environment in the immediate neighborhood, including cultural, aesthetic, historical preservation, and livability impacts, such as those related to increased traffic, noise, air quality, and odors (see Table PA-2). This includes temporary impacts during construction.

Weighting: 12%

Table PA-2. Neighborhood Impacts Scales

Rating	Label	Description
0	Unacceptable Noticeable/ Lasting Disruption	The degree of noticeable and lasting disruption to the neighborhood is so significant; OR results in considerable persistent increased traffic, noise, air quality, or odors during operations; OR introduces additional environmental inequity in an area with historical inequities beyond any degree of acceptability.
2	High Likelihood of Noticeable/ Lasting Disruption	There is a high likelihood of noticeable and lasting disruption to the neighborhood, such as damage to or destruction of a historic or culturally significant building; OR persistent increased traffic, noise, air quality, or odors during operations; OR would introduce significant additional environmental inequity in an area with historical inequities.

Rating	Label	Description
4	Minor Likelihood of Uncorrectable Disruption	There is a minor likelihood of uncorrectable disruption to the neighborhood, such as damage to a historic or culturally significant building; OR significant short-term traffic, noise, air quality, or odors OR minor but persistent increased traffic, noise, air quality, or odors during operations; OR would introduce minor additional environmental inequity in an area with historical inequities.
6	Moderately Likely Fully Correctable Disruption	There is a moderate likelihood of correctable disruption to the neighborhood, such as damage to a historic or culturally significant building; OR moderate short-term traffic, noise, air quality, or odors; OR periodic (such as monthly) increased traffic, noise, air quality, or odors during facility operations.
8	Highly Likely Fully Correctable Disruption	There is high likelihood of fully correctable disruption to the neighborhood, such as minor damage to a historic or culturally significant building; OR minor short-term livability impacts, such as traffic, noise, air quality, and odors, limited to the construction phase.
10	Ideal Neighborhood Impacts	It is anticipated that there will be no negative impacts to the built environment during construction or long-term operations.

Safety – Public

A relative measure of potential public safety hazards in the immediate neighborhood as well as the broader region, including those related to increased truck traffic. These evaluation criteria do not include health impacts associated with consumption of fluoridated water; however, they do include hazards during construction (see Table PA-3).

Weighting: 25%

Table PA-3. Safety – Public Scales

Rating	Label	Description
0	Unacceptable Safety Impacts to Public	The impacts to public safety, such as a significant fire, major chemical spill, or traffic incident, are beyond acceptable in degree of likelihood; OR semi-sized truck trips in a residential area far exceed one per week on average during facility operations.
2	Incident(s) Impacts Several Members of Public and Truck Trips in Residential Area Exceed One per Week	High likelihood of impacts to public safety, such as a significant fire, major chemical spill, or traffic incident, impacting many members of the community; OR semi-sized truck trips in a residential area exceeding one per week on average during facility operations.
4	Incident Impacts Several Members of Public and Truck Trips in Residential Area Exceed One per Month	Likelihood of a public safety incident, such as a fire, chemical spill, or traffic incident, impacting several members of the community; OR semi-sized truck trips in a residential area exceeding one per month on average during facility operations.

Rating	Label	Description
6	Incident Impacts 1-2 Members of Public	Likelihood of a public safety incident during construction and/or operations, such as a fire, chemical spill, or traffic incident, that would cause impact to one or two members of the public with non-permanent and non-life-threatening injuries.
8	Safety Precautions Required	Safety precautions will need to be put in place during construction and/or operations and there is a likelihood of a near miss or minor public safety incident such as a minor fire, chemical spill, or traffic incident.
10	Ideal Public Safety	It is anticipated that there will be no public safety hazards introduced during construction or long-term operations.

Safety – Worker

A relative measure of potential worker safety hazards, including chemical loading/unloading, exposure to chemicals, and other safety hazards, such as slips, trips, falls, and confined space entry, during facility operations and maintenance (see Table PA-4). Includes hazards during construction.

Weighting: 25%

Table PA-4. Safety – Worker Scales

Rating	Label	Description
0	Unacceptable Safety Impacts to Workers	The degree of workplace safety risk is unacceptably high, with significant possibility of multiple deaths, OR major life-changing injuries.
2	Possible Impacts Resulting in Death or Major Impacts to Workers	There is the possibility of worker safety impacts, including one or more death(s) OR major life-changing injuries.
4	Possible Workplace Injury Incurring Permanent Disability	There is the possibility of a workplace safety incident causing a permanent disability.
6	Possible Significant Workplace Injury	There is the possibility of a significant workplace injury but that can be healed or cured OR any injury requiring up to 30 days off work.
8	Possible Workplace Injury with No Lost Time	There is the possibility of a workplace injury but with no lost time.
10	Ideal Worker Safety	It is anticipated that there will be no worker safety hazards introduced during construction or long-term operations.

Service Reliability

A relative measure of the ability to achieve desired reliability of the fluoridation system, including resiliency in extreme conditions. This includes considerations of overfeeding (which may require public notice due to termination of fluoridation) and the ability of the system to consistently achieve regulatory requirements, both near and long term (see Table PA-5). This measure also considers outcomes at the customer tap.

Weighting: 15%

Table PA-5. Service Reliability Scales

Rating	Label	Description
0	Unacceptable Service Reliability	The degree of extended outages for the customers is frequent and unacceptable in terms of service reliability.
2	Extended Outages (> 1 time per year)	There are extended outages for large groups of customers likely once a year (or more).
4	Likely Service Outages (> 1 time per year) OR Extended Outages to a Small Number of Customers (< 1 time per year)	Service outages likely for a small number of customers more than once a year OR extended outages for small or large groups of customers less than once a year.
6	Likely Service Outages to a Small Number of Customers (< 1 time per year)	Service outages are likely but limited to a small number of customers for short periods of time and less than once per year.
8	Good Service Reliability at Start-Up but Uncertain in Future	Service reliability is easily achieved upon initiation of operations, but future reliability is not certain.
10	Ideal Service Reliability	It is anticipated that reliability of the fluoridation system will be easily achieved with certainty upon initiation of operations as well as into the future.

Ease of Maintenance and Operations

A measure of the relative ease of maintenance and operational activities, including training, certifications, equipment needed, frequency of visits to the sites, and renewal and rehabilitation needs (see Table PA-6).

Note: This measure does not include cost, which will be included in the life cycle cost estimate. In addition, this measure does and not include worker safety, which is considered in the Safety – Worker criterion.

Weighting: 15%

Table PA-6. Ease of Maintenance and Operations Scales

Rating	Label	Description
0	Unacceptable Change in Maintenance and Operations	The relative degree of maintenance and operations will require changes so substantial that they are unacceptable relative to the current maintenance and operations profile.
2	Significant Change in Maintenance and Operations	The relative degree of maintenance and operations will require additional staff with qualifications not currently available among staff, OR will require regular site visits more than once a day, OR major equipment will need renewal within 2 years or less.
4	Considerable Change in Maintenance and Operations	The relative degree of maintenance and operations will require additional staff, OR certifications or annual training for current staff, OR will require regular site visits more than twice a week, OR major equipment will need renewal within about 2 to 5 years.
6	Moderate Change in Maintenance and Operations	The relative degree of maintenance and operations will require new processes or technology tools for which training will be required OR will require regular site visits about once every 2 weeks.

Rating	Label	Description
8	Minor Change in Maintenance and Operations	The relative degree of maintenance and operations will require new processes or technology tools but no new staff or any significant new training OR will require regular site visits about once a month.
10	No Change in Maintenance and Operations	The relative degree of maintenance and operations will not be significantly different from prior to the fluoridation system installation.

Performance Criteria Prioritization

The performance criteria of a project are rarely of equal importance. Therefore, the relative importance of each criterion in meeting the project's need and purpose must be determined. During the May 2022 Criteria Workshop, participants were asked to systematically compare the criteria's importance against each other while considering which would provide the greatest benefit relative to the project's need and purpose. Participants of that workshop were asked to indicate their priorities and the relative intensities of their preferences. Figure 2 below provides the final weightings of the six criteria described in this section.

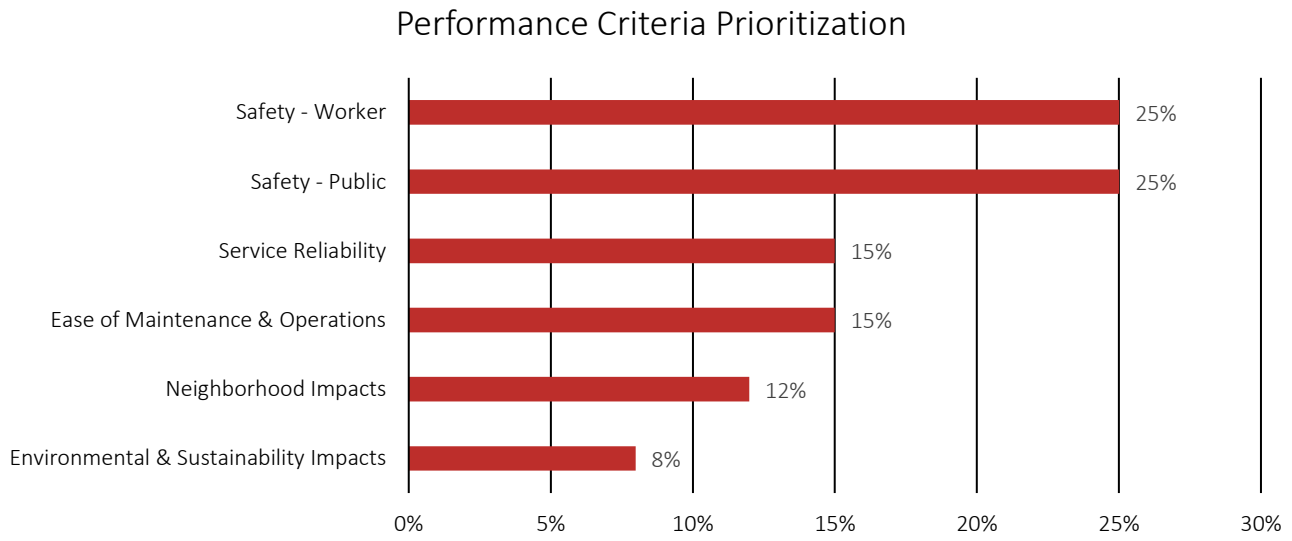


Figure 2. Performance Criteria Prioritization

The weightings heavily favor safety, making up a total of 50% of the total weightings, followed by operating-related criteria and then neighborhood, environmental, and sustainability impacts.

Measuring Performance

The project team worked with the technical team to apply the criteria to both fluoridation alternatives during the November 2022 MODA Workshop. Participants of the workshop were asked to consider each criterion and their measurements and then apply a 0 to 10 score to both the Liquid and Dry fluoridation alternatives based on the criteria definitions and evaluation scales presented in the previous section. Detailed information about each alternative was provided beforehand, and there were opportunities for clarification by the project team during the process. At the end, each participant's rankings were consolidated into an average performance rating for each criterion. Below are final performance ratings for each criterion and alternative as well as a summary of the rationale for the ratings.

Environmental and Sustainability Impacts

Liquid Rating	Dry Rating
5.6	5.7

Rationale – In the event of a spill, there is more impact with the Liquid versus the Dry. In addition, the Liquid could potentially contaminate an aquifer. In the event of a spill of Dry material, there could be a plume of the Dry compound. In terms of sustainability, the material deliveries (either Liquid or Dry) will result in increased greenhouse gases and emissions due to transport from outside the region. There is a relatively higher carbon footprint for the Dry material. The amount of material that is produced, treated, and used by the end user is relatively low for either material in terms of consumptive use.

Neighborhood Impacts

Liquid Rating	Dry Rating
5.3	4.7

Rationale – There is less overall traffic in the neighborhoods for the Liquid material relative to the Dry material. Note that increased traffic also increases the risk of spills of material. Additionally, some locations where the fluoride dosing occurs are recreational areas where the City should be aware of safety considerations and possible odors. Additionally, the Dry alternative requires a taller building to accommodate storage.

Safety – Public

Liquid Rating	Dry Rating
5.6	5.8

Rationale – The two materials are relatively similar. The primary considerations weighing into the safety of the public could consider vehicle traffic (more traffic with Dry versus Liquid). There is a higher potential for spills with the Liquid material versus the Dry material; however, the Dry material could spread in the wind. It is anticipated that any impacts would be non-permanent and non-life-threatening injuries.

Safety – Worker

Liquid Rating	Dry Rating
5.0	5.0

Rationale – The discussion centered around the two alternatives having distinct yet equivalent worker safety components. Both options require some level of personal protective equipment, with Dry requiring a lower level of protection than Liquid. The Dry chemical requires that staff wear a respirator, while Liquid requires splash protection, which is considered more burdensome. The Dry option requires more chemical handling and higher risk of exposure. Dry calls for smaller containment but comes with forklift safety considerations. Both alternatives were scored equally, with a 5.0, when weighing each alternative's unique safety considerations.

Service Reliability

Liquid Rating	Dry Rating
6.4	5.2

Rationale – There are fewer components with Liquid material. With Dry material, there could be caking and plugging of components. In addition, the Dry material requires more product, so there could be logistical/supply chain challenges. The Liquid is also easier to maintain a steadier concentration, primarily because it comes premixed.

Ease of Maintenance and Operations

Liquid Rating	Dry Rating
3.6	2.8

Rationale – There is less overall maintenance required with the Liquid; it requires a daily site visit, but maintenance efforts are easier. The Dry powder has more overall maintenance; it requires fewer visits but more challenging staff efforts during each visit. There is the potential for corrosion to the equipment in the event of a leak of the Liquid material. It is noted that either option results in a significant change for maintenance and operations across the board. However, the additional handling of material for the Dry compound drives a higher maintenance and operational demand than for the Liquid compound.

Weighted Performance Rating

Following the Liquid and Dry alternatives being rated across each criterion, a weighted performance rating can be calculated for each alternative. Each criterion's rating is multiplied by its weight, and all those products are added together to calculate the final weighted performance rating. A higher performance rating indicates better performance based on the criteria. Below are the results.

Liquid Rating	Dry Rating
5.2	4.9

The Liquid alternative performed better than the Dry alternative according to the group ratings. Through further group discussions, this consensus held true, as noted in the above rating rationales. The Service Reliability and Ease of Maintenance and Operations criteria, which had medium weightings, were the largest drivers on the final scoring. Liquid rated higher on both by 1.2 and 0.8, respectively, with a combined weighting of 30% between them both. The two Safety criteria, which accounted for 50% of the weighting, were not large sources of difference between the two alternatives. They rated very closely to each other, with a score difference of 0.2 for Safety – Public in favor of Dry. Safety – Worker received scores of 5.0 for both alternatives.

VALUE OF ALTERNATIVES

Value metrics techniques are utilized to calculate a value index score for each alternative, which is used as a final measurement of relative value of alternatives and determine a *Technically Preferred Alternative.* The relative value of each alternative is derived from the cost and performance scores calculated in the previous sections. The basic value equation used in this analysis is:

$$Value = \frac{Performance}{Cost'}$$

Performance is measured by the weighted performance rating that was calculated out of the MODA Workshop. Cost is measured using the NPV costs from the previously performed TCO analysis. A cost score is calculated adding the two alternatives' costs together, dividing each alternative's cost by that total, multiplying by 10, and then subtracting that total from 10. The value index score is then calculated using the above value equation, with the alternative's performance score divided by the complement of the cost score (for example, the value score for Liquid is equal to its performance score divided by the difference of 10 minus its cost score). A summary of the performance, cost, and value scores is in Table VA-1 below:

Table VA-1. Option Rankings

Option	TCO (USD) *50-Year Life Cycle*	Performance Score	Cost Score	Value Index	% Change
Fluorosilicic Acid – Liquid	$204,289,000	5.2	5.7	1.2	38.5%
Sodium Fluoride – Dry	$264,126,000	4.9	4.3	0.9	

The Liquid option achieved a better score for both performance and cost, with 5.2 and 5.7, respectively. Conversely, the Dry option had a worse score for both performance and cost, with 4.9 and 4.3, respectively. As such, the Liquid option also came out on top with a higher value index of 1.2, compared with 0.9 for Dry. That gives the Liquid option a 38.5% higher value score than the Dry option. Figure 3 below further illustrates the comparison in value between both fluoridation options.

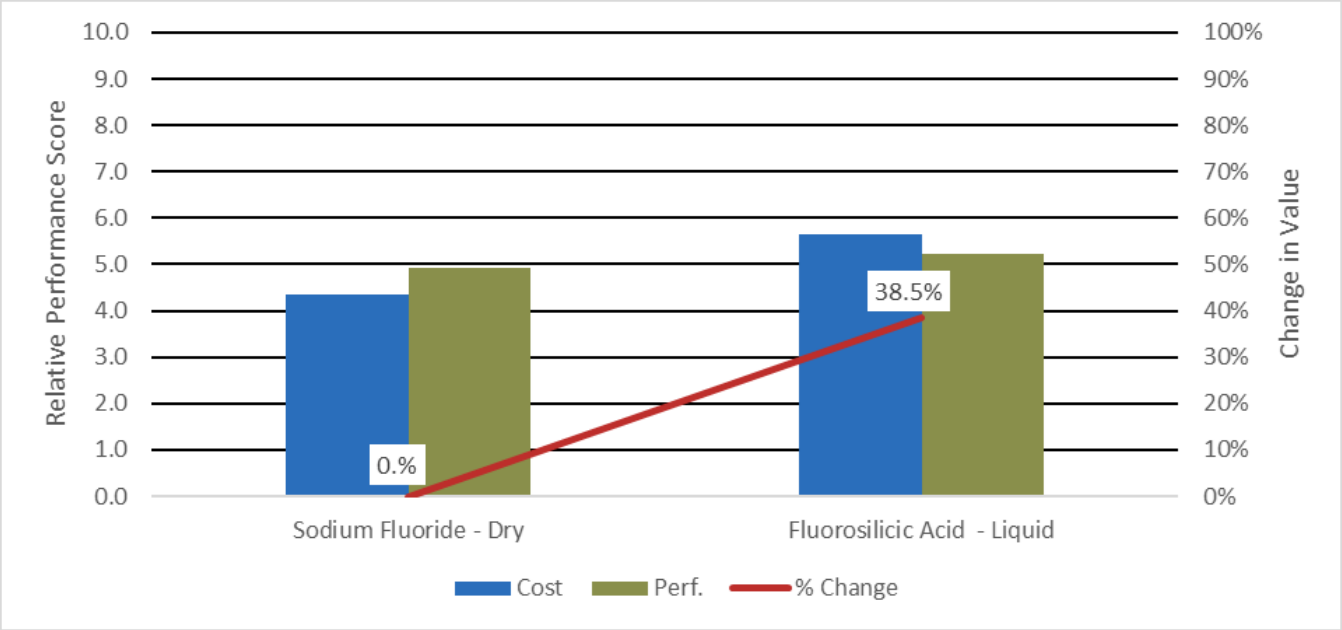


Figure 3. Option Rankings

Technically Preferred Alternative

With the value index score being calculated and compared between alternatives, the technically preferred alternative can be determined.

The Liquid alternative using fluorosilicic acid is projected to be the lower cost option for the City over a 50-year time period, which earns it a better cost score. The differential in the upfront initial capital costs to further develop, engineer, and build the project is close to $2 million higher for the Dry alternative in 2022 dollars, which

is not significant relative to the entire 50-year life cycle of the project and the associated TCO, as the initial costs account for only about 6% of the TCO for each alternative. Several subsequent life cycle costs, including engineering, maintenance, and equipment replacement, are all indexed to the initial project cost. Engineering and maintenance costs are both derived as a percentage of initial capital costs, being 10% and 2%, respectively. Equipment replacement costs are the same as the initial capital costs, escalated to the year in which the replacement occurs. As such, the higher initial capital costs for the Dry alternative will lead to higher subsequent costs for these items, though these items account for only a small share of the overall difference in life cycle costs. The largest driver of the life cycle cost differences is the price of the chemicals used, with Dry NaF costing close to $37 million more than Liquid FSA over the 50-year period of analysis in 2022 dollars, which accounts for 62% of the differential in TCO between the two alternatives.

The Liquid alternative also has a better performance score than the Dry alternative using a set of mutually derived criteria meeting the project's needs and purpose. The two alternatives rate similarly in terms of safety to both workers and the public, which makes up 50% of the weighted performance score. However, Liquid performs significantly better than Dry on Service Reliability (6.4 with to 5.2) and Ease of Maintenance and Operations criteria (3.6 compared with 2.8). Given that the Liquid alternative earned a better cost and performance score, the Liquid alternative also achieved a higher value index score, resulting in the recommendation that the fluorosilicic acid (Liquid) is the technically preferred alternative for fluoridation implementation if the City chooses to move forward.

Total Cost of Ownership

City of Spokane

Fluoridation Total Cost of Ownership Model

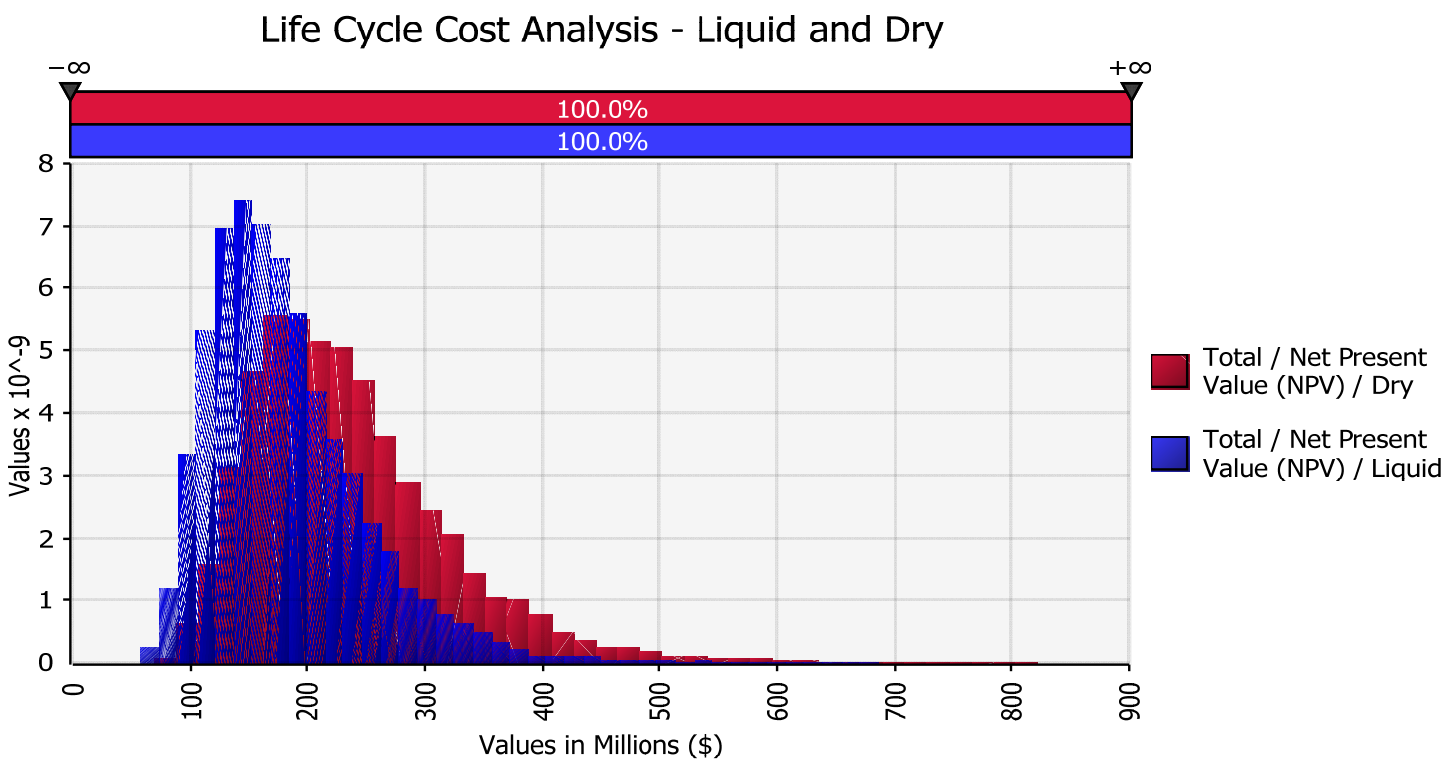
Summary

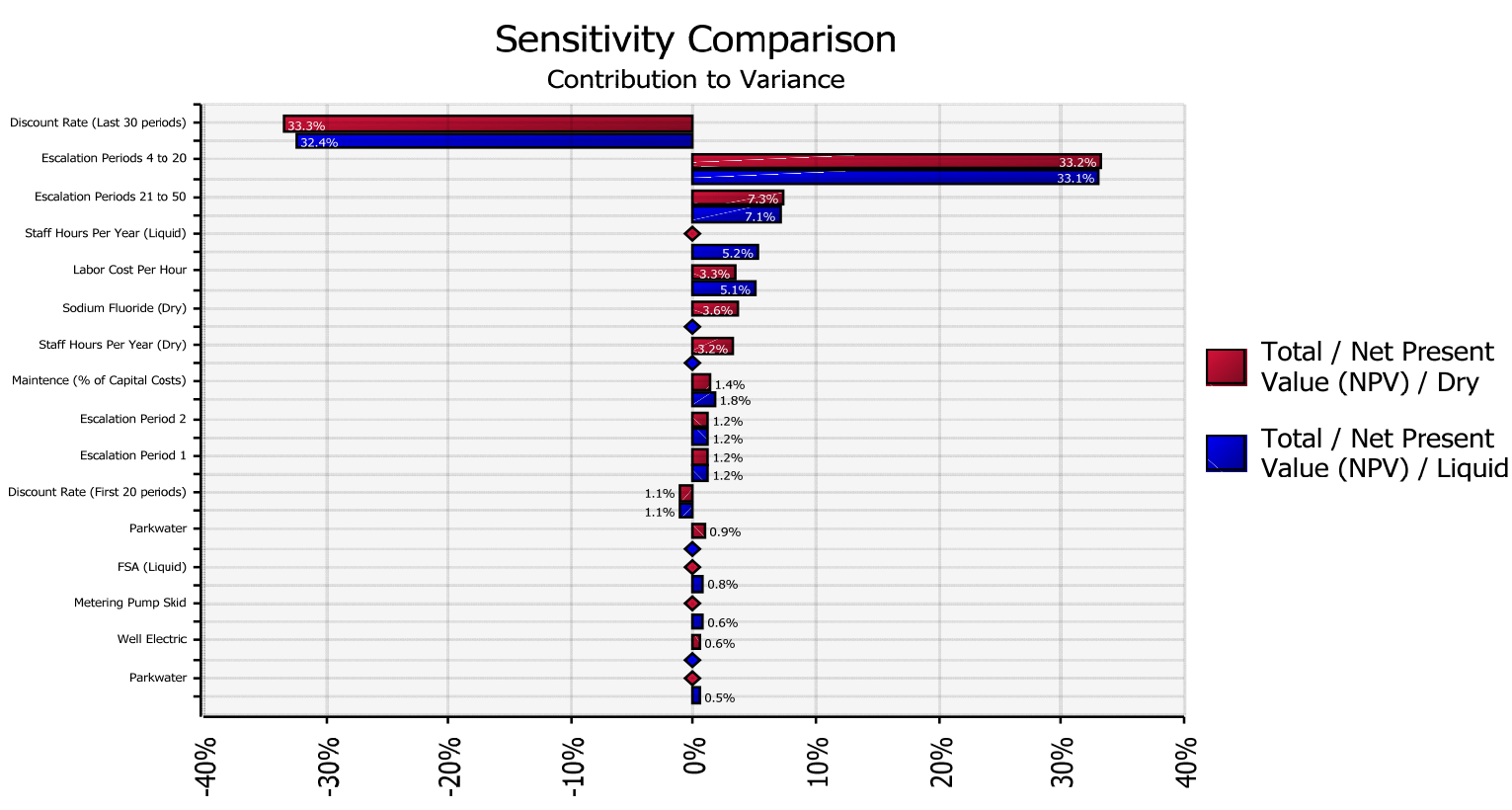
Life Cycle Cost Estimate			
Project Name:	Preliminary Engineering Study for Fluoridation	Date:	11/15/2022
Description:	Options for Fluoridating drinking water supply	Estimators:	Ben Crawley
Location:	Spokane, Washington		Royce Stewart

Total Cost of Ownership (P70)		Option 1	Option 2
Life Cycle Period (Years)	50	Liquid (FSA)	Dry (NaF)
Note: Costs are in nominal dollars	Initial Capital	$ 14,872,000	$ 16,943,000
	Engineering	$ 1,487,000	$ 1,694,000
	Operating and Maintenance	$ 354,981,000	$ 472,364,000
	Capital and Equipment Replacement	$ 71,609,000	$ 81,643,000
	Operating Contingency	$ 106,494,000	$ 141,709,000
	Salvage	$ (2,298,000)	$ (2,641,000)
	Net Costs	$ 543,729,000	$ 707,845,000
Net Present Value in $2022 (NPV)		**$ 202,812,000**	**$ 264,024,000**

Equivalent Annual Cost (EAC) in $2022 (P70)		Option 1	Option 2
Life Cycle Period (Years)	50	Liquid (FSA)	Dry (NaF)
	Operating and Maintenance	$ 6,098,000	$ 8,117,000
	Capital and Equipment Replacement	$ 1,169,000	$ 1,334,000
	Operating Contingency	$ 1,829,000	$ 2,435,000
	Salvage	$ (35,000)	$ (41,000)
Net Equivalent Annual Cost in $2022		$ 9,061,000	$ 11,846,000

Note: Above costs are based on P70 values from Uncertainty Analysis





City of Spokane

Fluoridation Total Cost of Ownership Model

Assumptions

Notes
Cost Data was taken from "Alternatives Estimate_11082022_PostCityReview.xlsx".
General information was taken from "Fluoridation System Alternatives TM-09-08-22.docx".
The Grace/Nevada sites are in one building.
Each site's maintenance costs are 2% of its subtotal capital costs, escalated to the current year's dollars.
For Dry Well Electric and Parkwater, the cheaper building cost of the two was applied. This capital cost is $190,500.00 (building 635 SF @ 300)
Escalation rate is applied to capital, operating, and replacement costs.
For both dry and liquid, Central Ave is the only site that requires demolition of the existing building.
Murray Smith's construction cost estimate is in dollars valued at the time of the estimate (09/19/2022).
This estimate is an opinion of probable cost based on information available at the time of its development.
Chemical costs are based on the average operating day from 2019-2021.
Operating costs start the year after construction is complete.
Residual values are under the assumption that assets will continue to be used after the 50 year LLCA periods.
BBU costs for dry include refill feeder, weigh feeder, model 810 BBU, saturator, volumetric feeder, control panel.
Engineering occurs in the year 2023 (Period 1) and is 10% of the initial capital costs (sum of the capital costs in 2023 and 2024).
Construction will begin in 2024/2025 (Periods 2 and 3). Therefore, initial capital costs are split, with 50% being allocated to 2024, and 50% to 2025. These costs are then escalated to the respective years.
Annual operating costs begin in 2026 (Period 4).

Distributions

Estimate Low	70%
Estimate Medium	100%
Estimate High	150%

Time

Starting Period	0
Start Year	2022
Number of Periods (Years)	50

Life Cycle Cost Estimate Assumptions and Uncertainty Ranges				
Variable	Minimum	Most Likely	Maximum	Probabilistic
Engineering Costs		10%		
Discount Rate (First 20 periods)	3.5%	5.0%	7.5%	5.43%
Discount Rate (Last 30 periods)	2.1%	3.0%	4.5%	3.26%
	Escalation			
Escalation Period 1	8.8%	12.5%	18.8%	13.57%
Escalation Period 2	8.4%	12.0%	18.0%	13.03%
Escalation Period 3	5.6%	8.0%	12.0%	8.69%
Escalation Periods 4 to 20	3.5%	5.0%	7.5%	5.43%
Escalation Periods 21 to 50	2.1%	3.0%	4.5%	3.26%
	Operating Costs			
Maintence (% of Capital Costs)	1%	2%	3%	2.17%
Replacement Schedule (Liquid)		**Years**		
Electrical Equipment	7	10	15	10.86
PLC MicroLogic 1400	7	10	15	10.86
Metering Pump Skid	14	20	30	21.72
Bulk Storage Tank	14	20	30	21.72
Day Storage Tank	14	20	30	21.72
Roll up Door	14	20	30	21.72
Man Door	14	20	30	21.72
Fluoride Analyzer	7	10	15	10.86
Backflow Preventer	14	20	30	21.72
Transfer Pump Skid	14	20	30	21.72
Secondary Containment	0	0	0	0.00
Building 915 sf @ $300	0	0	0	0.00
Site Improvements	14	20	30	21.72
Replacement Schedule (Dry)				
Electrical Panel	7	10	15	10.86
PLC MicroLogic 1400	7	10	15	10.86
Metering Pump Skid	14	20	30	21.72
Backflow Preventer	14	20	30	21.72
Man Door	14	20	30	21.72
Roll up Door	14	20	30	21.72
Fluoride Analyzer	7	10	15	10.86
BBU	14	20	30	21.72
Saturator Basement	0	0	0	0.00
Building 635 sf @ $300	0	0	0	0.00
Site Improvements	14	20	30	21.72
Operations and Maintenance				
Labor Cost Per Hour	$ 49.00	$ 70.00	$ 105.00	$ 76.02
Staff Hours Per Year (Liquid)	4421.2	6316	9474	6858.97
Staff Hours Per Year (Dry)	4634	6620	9930	7189.10
Power Costs				
Cost per kWh	$ 0.07	$ 0.10	$ 0.15	$ 0.11
Total Energy per Year (Liquid)				
Well Electric	7886	11265	16898	12233.42
Parkwater	10141	14487	21731	15732.41
Ray	7414	10591	15887	11501.48
Central Ave	7414	10591	15887	11501.48
Grace	7414	10591	15887	11501.48
Nevada	8071	11530	17295	12521.21
Hoffman	7252	10360	15540	11250.62
Havana	9388	13411	20117	14563.91
Total Energy per Year (Dry)				
Well Electric	8181	11687	17531	12691.70
Parkwater	10514	15020	22530	16311.23
Ray	7493	10704	16056	11624.20
Central Ave	7474	10677	16016	11594.87
Grace	7486	10694	16041	11613.34
Nevada	8152	11645	17468	12646.09
Hoffman	7214	10306	15459	11191.98
Havana	9561	13659	20489	14833.23
Chemical Costs (per lb)				
FSA (Liquid)	$ 0.39	$ 0.45	$ 0.50	$ 0.45
Sodium Fluoride (Dry)	$ 1.54	$ 1.92	$ 2.30	$ 1.92
Usage per Month (Liquid)				
Well Electric	200149	285926	428890	310506.88
Parkwater	251752	359645	539468	390563.19
Ray	71864	102663	153995	111488.79
Central Ave	63249	90356	135534	98124.03
Grace	63243	90347	135520	98113.40
Nevada	78759	112512	168768	122184.61
Hoffman	33322	47603	71405	51695.60
Havana	86924	124177	186266	134852.64
Usage per Month (Dry)				
Well Electric	78162	111660	167490	121259.05
Parkwater	98314	140449	210673	152522.62
Ray	28064	40092	60138	43538.57
Central Ave	24700	35286	52929	38319.37
Grace	24697	35282	52923	38315.21
Nevada	30757	43938	65907	47715.50
Hoffman	13013	18590	27885	20188.15
Havana	33946	48494	72741	52662.61

City of Spokane

Fluoridation Total Cost of Ownership Model

Liquid Data Input

Liquid Capital Costs (Concept Level Costs, 2022 Dollars)

Description	Well Electric	Parkwater	Ray	Central Ave	Grace/Nevada	Hoffman	Havana	Subtotal	Contingency 30%	Total Capital Costs (Most Likely)	Total Capital Costs (Minimum)	Total Capital Costs (Maximum)	Total Capital Costs (Probabilistic)
Electrical Equipment	$ 71,000.00	$ 71,000.00	$ 71,000.00	$ 71,000.00	$ 71,000.00	$ 71,000.00	$ 71,000.00	**$ 497,000.00**	**$ 149,100.00**	**$ 646,100.00**	**$ 452,270.00**	**$ 969,150.00**	**$ 701,644.00**
PLC MicroLogic 1400	$ 45,000.00	$ 45,000.00	$ 45,000.00	$ 45,000.00	$ 45,000.00	$ 45,000.00	$ 45,000.00	**$ 315,000.00**	**$ 94,500.00**	**$ 409,500.00**	**$ 286,650.00**	**$ 614,250.00**	**$ 444,704.00**
Metering Pump Skid	$ 360,000.00	$ 480,000.00	$ 120,000.00	$ 120,000.00	$ 360,000.00	$ 120,000.00	$ 360,000.00	**$ 1,920,000.00**	**$ 576,000.00**	**$ 2,496,000.00**	**$ 1,747,200.00**	**$ 3,744,000.00**	**$ 2,710,575.00**
Bulk Storage Tank	$ 30,000.00	$ 30,000.00	$ 30,000.00	$ 30,000.00	$ 30,000.00	$ 30,000.00	$ 30,000.00	**$ 210,000.00**	**$ 63,000.00**	**$ 273,000.00**	**$ 191,100.00**	**$ 409,500.00**	**$ 296,470.00**
Day Storage Tank	$ 20,000.00	$ 20,000.00	$ 20,000.00	$ 20,000.00	$ 20,000.00	$ 20,000.00	$ 20,000.00	**$ 140,000.00**	**$ 42,000.00**	**$ 182,000.00**	**$ 127,400.00**	**$ 273,000.00**	**$ 197,647.00**
Roll up Door	$ 10,000.00	$ 10,000.00	$ 10,000.00	$ 10,000.00	$ 10,000.00	$ 10,000.00	$ 10,000.00	**$ 70,000.00**	**$ 21,000.00**	**$ 91,000.00**	**$ 63,700.00**	**$ 136,500.00**	**$ 98,824.00**
Man Door	$ 8,000.00	$ 8,000.00	$ 8,000.00	$ 8,000.00	$ 8,000.00	$ 8,000.00	$ 8,000.00	**$ 56,000.00**	**$ 16,800.00**	**$ 72,800.00**	**$ 50,960.00**	**$ 109,200.00**	**$ 79,059.00**
Fluoride Analyzer	$ 20,000.00	$ 20,000.00	$ 20,000.00	$ 20,000.00	$ 20,000.00	$ 20,000.00	$ 20,000.00	**$ 140,000.00**	**$ 42,000.00**	**$ 182,000.00**	**$ 127,400.00**	**$ 273,000.00**	**$ 197,647.00**
Backflow Preventer	$ 6,000.00	$ 6,000.00	$ 6,000.00	$ 6,000.00	$ 6,000.00	$ 6,000.00	$ 6,000.00	**$ 42,000.00**	**$ 12,600.00**	**$ 54,600.00**	**$ 38,220.00**	**$ 81,900.00**	**$ 59,294.00**
Transfer Pump Skid	$ 30,000.00	$ 30,000.00	$ 30,000.00	$ 30,000.00	$ 30,000.00	$ 30,000.00	$ 30,000.00	**$ 210,000.00**	**$ 63,000.00**	**$ 273,000.00**	**$ 191,100.00**	**$ 409,500.00**	**$ 296,470.00**
Secondary Containment	$ 50,000.00	$ 50,000.00	$ 50,000.00	$ 50,000.00	$ 50,000.00	$ 50,000.00	$ 50,000.00	**$ 350,000.00**	**$ 105,000.00**	**$ 455,000.00**	**$ 318,500.00**	**$ 682,500.00**	**$ 494,116.00**
Building SF	$ 194,100.00	$ 274,500.00	$ 291,600.00	$ 440,800.00	$ 194,100.00	$ 291,600.00	$ 366,000.00	**$ 2,052,700.00**	**$ 615,810.00**	**$ 2,668,510.00**	**$ 1,867,957.00**	**$ 4,002,765.00**	**$ 2,897,916.00**
Demo Existing Building	$ -	$ -	$ -	$ 20,000.00	$ -	$ -	$ -	**$ 20,000.00**	**$ 6,000.00**	**$ 26,000.00**	**$ 18,200.00**	**$ 39,000.00**	**$ 28,236.00**
Site Improvements	$ 250,000.00	$ 250,000.00	$ 150,000.00	$ 150,000.00	$ 250,000.00	$ 150,000.00	$ 150,000.00	**$ 1,350,000.00**	**$ 405,000.00**	**$ 1,755,000.00**	**$ 1,228,500.00**	**$ 2,632,500.00**	**$ 1,905,873.00**
Subtotal Capital Cost	$ 1,094,100.00	$ 1,294,500.00	$ 851,600.00	$ 1,020,800.00	$ 1,094,100.00	$ 851,600.00	$ 1,166,000.00	**$ 7,372,700.00**					
Contingency (30%)	$ 328,230.00	$ 388,350.00	$ 255,480.00	$ 306,240.00	$ 328,230.00	$ 255,480.00	$ 349,800.00	**$ 2,211,810.00**					
Total Capital Costs	$ 1,422,330.00	$ 1,682,850.00	$ 1,107,080.00	$ 1,327,040.00	$ 1,422,330.00	$ 1,107,080.00	$ 1,515,800.00	**$ 9,584,510.00**		**$ 9,584,510.00**	**$ 6,709,157.00**	**$ 14,376,765.00**	**$ 10,408,475.00**

Liquid Operating Costs (Concept Level Costs, 2022 Dollars)

Description	Well Electric	Parkwater	Ray	Central Ave	Grace/Nevada	Hoffman	Havana	Total
Operating of Equipment	$74,486.19	$74,486.19	$74,486.19	$74,486.19	$74,486.19	$74,486.19	$74,486.19	**$ 521,403.33**
Energy	$1,328.51	$1,708.49	$1,249.02	$1,249.02	$1,261.17	$1,221.78	$1,581.59	**$ 9,599.59**
Chemical	$138,175.56	$173,800.62	$49,612.51	$43,665.20	$98,032.61	$23,004.54	$60,009.43	**$ 586,300.47**

Replacement Schedule

	Years			
Component	**Minimum**	**Most Likely**	**Maximum**	**Probabilistic**
Electrical Equipment	7	10	15	11
PLC MicroLogic 1400	7	10	15	11
Metering Pump Skid	14	20	30	22
Bulk Storage Tank	14	20	30	22
Day Storage Tank	14	20	30	22
Roll up Door	14	20	30	22
Man Door	14	20	30	22
Fluoride Analyzer	7	10	15	11
Backflow Preventer	14	20	30	22
Transfer Pump Skid	14	20	30	22
Secondary Containment	0	0	0	0
Building 915 sf @ $300	0	0	0	0
Site Improvements	14	20	30	22

Salvage Rate

	Percent			
Minimum	**Most Likely**	**Maximum**	**Probabilistic**
4%	5%	8%	5.43%

City of Spokane | **(Liquid) Fluoridation Total Cost of Ownership Model**

Life Cycle Period	50		Engineering	Initial Capital Costs	Annual Operating Costs				Capital and Equipment Replacement	Contingency	Salvage Values	LCCA Cost (2022 Dollars)		Net Present Value (NPV)			
Period	Year	Escalation (Construction)	Total Engineering	Total Capital	Maintenance	Operation of Equipment	Power	Chemical	Total Replacement	Operating Contingency	Total Salvage	Net Costs	Net Present Value (NPV)	Operating and Maintenance	Capital Replacement	Operating Contingency	Salvage
0	2022	0.00%	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	`	$ -	$ -	$ -	$ -
1	2023	13.57%	$ 1,394,232.32	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 1,394,232.32	$ 1,322,426.70	$ -	$ -	$ -	$ -
2	2024	28.38%	$ -	$ 6,680,949.85	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 6,680,949.85	$ 6,010,507.43	$ -	$ -	$ -	$ -
3	2025	39.53%	$ -	$ 7,261,373.40	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 7,261,373.40	$ 6,196,238.98	$ -	$ -	$ -	$ -
4	2026	47.10%	$ -	$ -	$ 445,458.41	$ 767,006.43	$ 14,121.41	$ 862,472.86	$ -	$ 626,717.73	$ -	$ 2,715,776.83	$ 2,198,061.97	$ 1,690,816.90	$ -	$ 507,245.07	$ -
5	2027	55.09%	$ -	$ -	$ 469,646.08	$ 808,653.63	$ 14,888.17	$ 909,303.73	$ -	$ 660,747.48	$ -	$ 2,863,239.10	$ 2,198,061.97	$ 1,690,816.90	$ -	$ 507,245.07	$ -
6	2028	63.51%	$ -	$ -	$ 495,147.10	$ 852,562.21	$ 15,696.58	$ 958,677.45	$ -	$ 696,625.00	$ -	$ 3,018,708.33	$ 2,198,061.97	$ 1,690,816.90	$ -	$ 507,245.07	$ -
7	2029	72.39%	$ -	$ -	$ 522,032.78	$ 898,854.95	$ 16,548.88	$ 1,010,732.07	$ -	$ 734,450.60	$ -	$ 3,182,619.28	$ 2,198,061.97	$ 1,690,816.90	$ -	$ 507,245.07	$ -
8	2030	81.75%	$ -	$ -	$ 550,378.31	$ 947,661.31	$ 17,447.45	$ 1,065,613.18	$ -	$ 774,330.08	$ -	$ 3,355,430.33	$ 2,198,061.97	$ 1,690,816.90	$ -	$ 507,245.07	$ -
9	2031	91.62%	$ -	$ -	$ 580,262.96	$ 999,117.78	$ 18,394.82	$ 1,123,474.25	$ -	$ 816,374.94	$ -	$ 3,537,624.75	$ 2,198,061.97	$ 1,690,816.90	$ -	$ 507,245.07	$ -
10	2032	102.03%	$ -	$ -	$ 611,770.29	$ 1,053,368.25	$ 19,393.63	$ 1,184,477.07	$ -	$ 860,702.77	$ -	$ 3,729,712.02	$ 2,198,061.97	$ 1,690,816.90	$ -	$ 507,245.07	$ -
11	2033	113.00%	$ -	$ -	$ 644,988.42	$ 1,110,564.43	$ 20,446.67	$ 1,248,792.25	$ -	$ 907,437.53	$ -	$ 3,932,229.32	$ 2,198,061.97	$ 1,690,816.90	$ -	$ 507,245.07	$ -
12	2034	124.56%	$ -	$ -	$ 680,010.25	$ 1,170,866.28	$ 21,556.89	$ 1,316,599.64	$ -	$ 956,709.92	$ -	$ 4,145,742.98	$ 2,198,061.97	$ 1,690,816.90	$ -	$ 507,245.07	$ -
13	2035	136.75%	$ -	$ -	$ 716,933.70	$ 1,234,442.41	$ 22,727.40	$ 1,388,088.86	$ -	$ 1,008,657.71	$ -	$ 4,370,850.08	$ 2,198,061.97	$ 1,690,816.90	$ -	$ 507,245.07	$ -
14	2036	149.61%	$ -	$ -	$ 755,862.03	$ 1,301,470.63	$ 23,961.46	$ 1,463,459.83	$ 2,010,740.00	$ 1,063,426.18	$ (109,179.91)	$ 6,509,740.22	$ 3,105,089.64	$ 1,690,816.90	$ 959,105.55	$ 507,245.07	$ (52,077.87)
15	2037	163.16%	$ -	$ -	$ 796,904.11	$ 1,372,138.37	$ 25,262.53	$ 1,542,923.32	$ -	$ 1,121,168.50	$ -	$ 4,858,396.82	$ 2,198,061.97	$ 1,690,816.90	$ -	$ 507,245.07	$ -
16	2038	177.45%	$ -	$ -	$ 840,174.71	$ 1,446,643.25	$ 26,634.24	$ 1,626,701.54	$ -	$ 1,182,046.12	$ -	$ 5,122,199.87	$ 2,198,061.97	$ 1,690,816.90	$ -	$ 507,245.07	$ -
17	2039	192.52%	$ -	$ -	$ 885,794.83	$ 1,525,193.62	$ 28,080.44	$ 1,715,028.79	$ -	$ 1,246,229.31	$ -	$ 5,400,326.99	$ 2,198,061.97	$ 1,690,816.90	$ -	$ 507,245.07	$ -
18	2040	208.40%	$ -	$ -	$ 933,892.05	$ 1,608,009.16	$ 29,605.16	$ 1,808,152.07	$ -	$ 1,313,897.53	$ -	$ 5,693,555.97	$ 2,198,061.97	$ 1,690,816.90	$ -	$ 507,245.07	$ -
19	2041	225.15%	$ -	$ -	$ 984,600.87	$ 1,695,321.44	$ 31,212.67	$ 1,906,331.79	$ -	$ 1,385,240.03	$ -	$ 6,002,706.80	$ 2,198,061.97	$ 1,690,816.90	$ -	$ 507,245.07	$ -
20	2042	242.80%	$ -	$ -	$ 1,038,063.10	$ 1,787,374.64	$ 32,907.47	$ 2,009,842.50	$ -	$ 1,460,456.31	$ -	$ 6,328,644.02	$ 2,198,061.97	$ 1,690,816.90	$ -	$ 507,245.07	$ -
21	2043	253.97%	$ -	$ -	$ 1,071,882.18	$ 1,845,605.56	$ 33,979.56	$ 2,075,321.21	$ -	$ 1,508,036.55	$ -	$ 6,534,825.07	$ 3,333,071.99	$ 2,563,901.53	$ -	$ 769,170.46	$ -
22	2044	265.50%	$ -	$ -	$ 1,106,803.06	$ 1,905,733.59	$ 35,086.58	$ 2,142,933.15	$ -	$ 1,557,166.91	$ -	$ 6,747,723.30	$ 3,333,071.99	$ 2,563,901.53	$ -	$ 769,170.46	$ -
23	2045	277.41%	$ -	$ -	$ 1,142,861.62	$ 1,967,820.53	$ 36,229.67	$ 2,212,747.82	$ -	$ 1,607,897.89	$ -	$ 6,967,557.54	$ 3,333,071.99	$ 2,563,901.53	$ -	$ 769,170.46	$ -
24	2046	289.70%	$ -	$ -	$ 1,180,094.94	$ 2,031,930.21	$ 37,410.00	$ 2,284,836.99	$ -	$ 1,660,281.64	$ -	$ 7,194,553.77	$ 3,333,071.99	$ 2,563,901.53	$ -	$ 769,170.46	$ -
25	2047	302.40%	$ -	$ -	$ 1,218,541.28	$ 2,098,128.51	$ 38,628.78	$ 2,359,274.75	$ 20,833,516.92	$ 1,714,371.99	$ (1,131,226.10)	$ 27,131,236.13	$ 12,172,705.48	$ 2,563,901.53	$ 9,347,169.60	$ 769,170.46	$ (507,536.11)
26	2048	315.51%	$ -	$ -	$ 1,258,240.16	$ 2,166,483.49	$ 39,887.27	$ 2,436,137.62	$ -	$ 1,770,224.56	$ -	$ 7,670,973.10	$ 3,333,071.99	$ 2,563,901.53	$ -	$ 769,170.46	$ -
27	2049	329.05%	$ -	$ -	$ 1,299,232.40	$ 2,237,065.41	$ 41,186.76	$ 2,515,504.61	$ -	$ 1,827,896.75	$ -	$ 7,920,885.92	$ 3,333,071.99	$ 2,563,901.53	$ -	$ 769,170.46	$ -
28	2050	343.02%	$ -	$ -	$ 1,341,560.12	$ 2,309,946.82	$ 42,528.58	$ 2,597,457.29	$ -	$ 1,887,447.84	$ -	$ 8,178,940.66	$ 3,333,071.99	$ 2,563,901.53	$ -	$ 769,170.46	$ -
29	2051	357.46%	$ -	$ -	$ 1,385,266.84	$ 2,385,202.63	$ 43,914.12	$ 2,682,079.92	$ -	$ 1,948,939.05	$ -	$ 8,445,402.57	$ 3,333,071.99	$ 2,563,901.53	$ -	$ 769,170.46	$ -
30	2052	372.36%	$ -	$ -	$ 1,430,397.49	$ 2,462,910.21	$ 45,344.80	$ 2,769,459.46	$ -	$ 2,012,433.59	$ -	$ 8,720,545.54	$ 3,333,071.99	$ 2,563,901.53	$ -	$ 769,170.46	$ -
31	2053	387.75%	$ -	$ -	$ 1,476,998.44	$ 2,543,149.42	$ 46,822.09	$ 2,859,685.75	$ -	$ 2,077,996.71	$ -	$ 9,004,652.41	$ 3,333,071.99	$ 2,563,901.53	$ -	$ 769,170.46	$ -
32	2054	403.64%	$ -	$ -	$ 1,525,117.61	$ 2,626,002.74	$ 48,347.51	$ 2,952,851.52	$ -	$ 2,145,695.82	$ -	$ 9,298,015.20	$ 3,333,071.99	$ 2,563,901.53	$ -	$ 769,170.46	$ -
33	2055	420.05%	$ -	$ -	$ 1,574,804.45	$ 2,711,555.35	$ 49,922.62	$ 3,049,052.55	$ -	$ 2,215,600.49	$ -	$ 9,600,935.47	$ 3,333,071.99	$ 2,563,901.53	$ -	$ 769,170.46	$ -
34	2056	436.99%	$ -	$ -	$ 1,626,110.05	$ 2,799,895.18	$ 51,549.05	$ 3,148,387.70	$ -	$ 2,287,782.59	$ -	$ 9,913,724.58	$ 3,333,071.99	$ 2,563,901.53	$ -	$ 769,170.46	$ -
35	2057	454.49%	$ -	$ -	$ 1,679,087.13	$ 2,891,113.03	$ 53,228.47	$ 3,250,959.10	$ -	$ 2,362,316.32	$ -	$ 10,236,704.05	$ 3,333,071.99	$ 2,563,901.53	$ -	$ 769,170.46	$ -
36	2058	472.55%	$ -	$ -	$ 1,733,790.15	$ 2,985,302.68	$ 54,962.60	$ 3,356,872.18	$ 6,351,068.70	$ 2,439,278.28	$ (344,852.70)	$ 16,576,421.88	$ 5,226,994.45	$ 2,563,901.53	$ 2,002,663.85	$ 769,170.46	$ (108,741.39)
37	2059	491.20%	$ -	$ -	$ 1,790,275.34	$ 3,082,560.93	$ 56,753.23	$ 3,466,235.80	$ -	$ 2,518,747.59	$ -	$ 10,914,572.88	$ 3,333,071.99	$ 2,563,901.53	$ -	$ 769,170.46	$ -
38	2060	510.47%	$ -	$ -	$ 1,848,600.76	$ 3,182,987.75	$ 58,602.19	$ 3,579,162.38	$ -	$ 2,600,805.93	$ -	$ 11,270,159.02	$ 3,333,071.99	$ 2,563,901.53	$ -	$ 769,170.46	$ -
39	2061	530.35%	$ -	$ -	$ 1,908,826.37	$ 3,286,686.39	$ 60,511.40	$ 3,695,768.00	$ -	$ 2,685,537.65	$ -	$ 11,637,329.81	$ 3,333,071.99	$ 2,563,901.53	$ -	$ 769,170.46	$ -
40	2062	550.89%	$ -	$ -	$ 1,971,014.07	$ 3,393,763.43	$ 62,482.80	$ 3,816,172.52	$ -	$ 2,773,029.84	$ -	$ 12,016,462.66	$ 3,333,071.99	$ 2,563,901.53	$ -	$ 769,170.46	$ -
41	2063	572.10%	$ -	$ -	$ 2,035,227.79	$ 3,504,328.93	$ 64,518.43	$ 3,940,499.69	$ -	$ 2,863,372.45	$ -	$ 12,407,947.29	$ 3,333,071.99	$ 2,563,901.53	$ -	$ 769,170.46	$ -
42	2064	593.99%	$ -	$ -	$ 2,101,533.53	$ 3,618,496.55	$ 66,620.37	$ 4,068,877.33	$ -	$ 2,956,658.33	$ -	$ 12,812,186.11	$ 3,333,071.99	$ 2,563,901.53	$ -	$ 769,170.46	$ -
43	2065	616.60%	$ -	$ -	$ 2,169,999.44	$ 3,736,383.63	$ 68,790.80	$ 4,201,437.39	$ -	$ 3,052,983.38	$ -	$ 13,229,594.63	$ 3,333,071.99	$ 2,563,901.53	$ -	$ 769,170.46	$ -
44	2066	639.95%	$ -	$ -	$ 2,240,695.90	$ 3,858,111.37	$ 71,031.94	$ 4,338,316.12	$ -	$ 3,152,446.60	$ -	$ 13,660,601.92	$ 3,333,071.99	$ 2,563,901.53	$ -	$ 769,170.46	$ -
45	2067	664.05%	$ -	$ -	$ 2,313,695.59	$ 3,983,804.87	$ 73,346.09	$ 4,479,654.22	$ -	$ 3,255,150.23	$ -	$ 14,105,651.01	$ 3,333,071.99	$ 2,563,901.53	$ -	$ 769,170.46	$ -
46	2068	688.95%	$ -	$ -	$ 2,389,073.53	$ 4,113,593.35	$ 75,735.63	$ 4,625,596.99	$ -	$ 3,361,199.85	$ -	$ 14,565,199.36	$ 3,333,071.99	$ 2,563,901.53	$ -	$ 769,170.46	$ -
47	2069	714.65%	$ -	$ -	$ 2,466,907.22	$ 4,247,610.21	$ 78,203.03	$ 4,776,294.43	$ 49,234,955.56	$ 3,470,704.46	$ (2,673,378.04)	$ 61,601,296.87	$ 13,651,954.05	$ 2,563,901.53	$ 10,911,350.65	$ 769,170.46	$ (592,468.60)
48	2070	741.19%	$ -	$ -	$ 2,547,276.65	$ 4,385,993.20	$ 80,750.81	$ 4,931,901.44	$ -	$ 3,583,776.63	$ -	$ 15,529,698.73	$ 3,333,071.99	$ 2,563,901.53	$ -	$ 769,170.46	$ -
49	2071	768.60%	$ -	$ -	$ 2,630,264.44	$ 4,528,884.58	$ 83,381.59	$ 5,092,577.98	$ -	$ 3,700,532.58	$ -	$ 16,035,641.16	$ 3,333,071.99	$ 2,563,901.53	$ -	$ 769,170.46	$ -
50	2072	796.89%	$ -	$ -	$ 2,715,955.89	$ 4,676,431.23	$ 86,098.08	$ 5,258,489.20	$ -	$ 3,821,092.32	$ -	$ 16,558,066.71	$ 3,333,071.99	$ 2,563,901.53	$ -	$ 769,170.46	$ -
Total			**$ 1,394,232.32**	**$ 13,942,323.25**	**$ 65,132,054.44**	**$ 112,146,730.53**	**$ 2,064,740.73**	**$ 126,105,216.31**	**$ 78,430,281.17**	**$ 91,634,622.60**	**$ (4,258,636.75)**	**$ 486,591,564.61**	**$ 172,847,852.06**	**$ 105,660,933.29**	**$ 23,220,289.65**	**$ 31,698,279.99**	**$ (1,260,823.98)**
				Annual Operating Costs	$ 305,448,742.01												

City of Spokane

Fluoridation Total Cost of Ownership Model

Dry Data Input

Dry Capital Costs (Concept Level Costs, 2022 Dollars)												
Description	**Well Electric**	**Parkwater**	**Ray**	**Central Ave**	**Grace/Nevada**	**Hoffman**	**Havana**	**Subtotal**	**Contingency 30%**	**Total Capital Costs (Most Likely)**	**Total Capital Costs (Minimum)**	**Total Capital Costs (Maximum)**	**Total Capital Costs (Probabilistic)**
Electrical Panel	$ 71,000.00	$ 55,000.00	$ 55,000.00	$ 71,000.00	$ 71,000.00	$ 55,000.00	$ 55,000.00	**$ 433,000.00**	**$ 129,900.00**	**$ 562,900.00**	**$ 394,030.00**	**$ 844,350.00**	**$ 611,292.00**
PLC MicroLogic 1400	$ 45,000.00	$ 45,000.00	$ 45,000.00	$ 45,000.00	$ 45,000.00	$ 45,000.00	$ 45,000.00	**$ 315,000.00**	**$ 94,500.00**	**$ 409,500.00**	**$ 286,650.00**	**$ 614,250.00**	**$ 444,704.00**
Metering Pump Skid (2-8 pumps per facility)	$ 360,000.00	$ 480,000.00	$ 120,000.00	$ 120,000.00	$ 360,000.00	$ 120,000.00	$ 360,000.00	**$ 1,920,000.00**	**$ 576,000.00**	**$ 2,496,000.00**	**$ 1,747,200.00**	**$ 3,744,000.00**	**$ 2,710,575.00**
Backflow Preventer	$ 6,000.00	$ 6,000.00	$ 6,000.00	$ 6,000.00	$ 6,000.00	$ 6,000.00	$ 6,000.00	**$ 42,000.00**	**$ 12,600.00**	**$ 54,600.00**	**$ 38,220.00**	**$ 81,900.00**	**$ 59,294.00**
Man Door	$ 8,000.00	$ 8,000.00	$ 8,000.00	$ 8,000.00	$ 8,000.00	$ 8,000.00	$ 8,000.00	**$ 56,000.00**	**$ 16,800.00**	**$ 72,800.00**	**$ 50,960.00**	**$ 109,200.00**	**$ 79,059.00**
Roll up Door	$ 10,000.00	$ 10,000.00	$ 10,000.00	$ 10,000.00	$ 10,000.00	$ 10,000.00	$ 10,000.00	**$ 70,000.00**	**$ 21,000.00**	**$ 91,000.00**	**$ 63,700.00**	**$ 136,500.00**	**$ 98,824.00**
Fluoride Analyzer	$ 20,000.00	$ 20,000.00	$ 20,000.00	$ 20,000.00	$ 20,000.00	$ 20,000.00	$ 20,000.00	**$ 140,000.00**	**$ 42,000.00**	**$ 182,000.00**	**$ 127,400.00**	**$ 273,000.00**	**$ 197,647.00**
Water Softener	$ 2,500.00	$ 2,500.00	$ 2,500.00	$ 2,500.00	$ 2,500.00	$ 2,500.00	$ 2,500.00	**$ 17,500.00**	**$ 5,250.00**	**$ 22,750.00**	**$ 15,925.00**	**$ 34,125.00**	**$ 24,706.00**
BBU	$ 200,000.00	$ 200,000.00	$ 200,000.00	$ 200,000.00	$ 200,000.00	$ 200,000.00	$ 200,000.00	**$ 1,400,000.00**	**$ 420,000.00**	**$ 1,820,000.00**	**$ 1,274,000.00**	**$ 2,730,000.00**	**$ 1,976,461.00**
Saturator Basement	$ 50,000.00	$ 50,000.00	$ 50,000.00	$ 50,000.00	$ 50,000.00	$ 50,000.00	$ 50,000.00	**$ 350,000.00**	**$ 105,000.00**	**$ 455,000.00**	**$ 318,500.00**	**$ 682,500.00**	**$ 494,116.00**
Building SF	$ 142,500.00	$ 190,500.00	$ 254,000.00	$ 440,800.00	$ 142,500.00	$ 254,000.00	$ 254,000.00	**$ 1,678,300.00**	**$ 503,490.00**	**$ 2,181,790.00**	**$ 1,527,253.00**	**$ 3,272,685.00**	**$ 2,369,353.00**
Storage Warehouse Space	$ 78,000.00	$ 117,000.00	$ 104,000.00	$ 104,000.00	$ 78,000.00	$ 104,000.00	$ 84,000.00	**$ 669,000.00**	**$ 200,700.00**	**$ 869,700.00**	**$ 608,790.00**	**$ 1,304,550.00**	**$ 944,466.00**
Demo Existing Building	$ -	$ -	$ -	$ 20,000.00	$ -	$ -	$ -	**$ 20,000.00**	**$ 6,000.00**	**$ 26,000.00**	**$ 18,200.00**	**$ 39,000.00**	**$ 28,236.00**
Site Improvements	$ 250,000.00	$ 250,000.00	$ 150,000.00	$ 150,000.00	$ 250,000.00	$ 150,000.00	$ 150,000.00	**$ 1,350,000.00**	**$ 405,000.00**	**$ 1,755,000.00**	**$ 1,228,500.00**	**$ 2,632,500.00**	**$ 1,905,873.00**
Subtotal Capital Cost	$ 1,243,000.00	$ 1,434,000.00	$ 1,024,500.00	$ 1,247,300.00	$ 1,243,000.00	$ 1,024,500.00	$ 1,244,500.00	**$ 8,460,800.00**					
Contingency (30%)	$ 372,900.00	$ 430,200.00	$ 307,350.00	$ 374,190.00	$ 372,900.00	$ 307,350.00	$ 373,350.00	**$ 2,538,240.00**					
Total Capital Costs	$ 1,615,900.00	$ 1,864,200.00	$ 1,331,850.00	$ 1,621,490.00	$ 1,615,900.00	$ 1,331,850.00	$ 1,617,850.00	**$ 10,999,040.00**		**$ 10,999,040.00**	**$ 7,699,328.00**	**$ 16,498,560.00**	**$ 11,944,606.00**

Liquid Operating Costs (Concept Level Costs, 2022 Dollars)								
Description	**Well Electric**	**Parkwater**	**Ray**	**Central Ave**	**Grace/Nevada**	**Hoffman**	**Havana**	**Total**
Operating of Equipment	$78,071.34	$78,071.34	$78,071.34	$78,071.34	$78,071.34	$78,071.34	$78,071.34	**$546,499.38**
Energy	$1,378.28	$1,771.35	$1,262.35	$ 1,259.17	$ 1,261.17	$ 1,215.41	$ 1,610.84	**$9,758.56**
Chemical	$ 232,817.38	$ 292,843.43	$ 83,594.05	$ 73,573.19	$ 165,178.96	$ 38,761.25	$ 101,112.22	**$987,880.47**

Replacement Schedule					Salvage Rate			
	Years				Percent			
Component	**Minimum**	**Most Likely**	**Maximum**	**Probabilistic**	**Minimum**	**Most Likely**	**Maximum**	**Probabilistic**
Electrical Panel	7	10	15	11	4%	5%	8%	5.43%
PLC MicroLogic 1400	7	10	15	11				
Metering Pump Skid	14	20	30	22				
Backflow Preventer	14	20	30	22				
Man Door	14	20	30	22				
Roll up Door	14	20	30	22				
Fluoride Analyzer	7	10	15	11				
BBU	14	20	30	22				
Saturator Basement	0	0	0	0				
Building 635 sf @ $300	0	0	0	0				
Site Improvements	14	20	30	22				

City of Spokane **(Dry) Fluoridation Total Cost of Ownership Model**

Life Cycle Period	50		Engineering	Initial Capital Costs	Annual Operating Costs				Capital and Equipment Replacement	Contingency	Salvage Values	LCCA Cost (2022 Dollars)		Net Present Value (NPV)			
Period	Year	Escalation (Construction)	Total Engineering	Total Capital	Maintenance	Operation of Equipment	Power	Chemical	Total Replacement	Operating Contingency	Total Salvage	Net Costs	Net Present Value (NPV)	Operating and Maintenance	Capital Replacement	Operating Contingency	Salvage
0	2022	0.00%	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
1	2023	13.57%	$ 1,599,999.60	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 1,599,999.60	$ 1,517,596.57	$ -	$ -	$ -	$ -
2	2024	28.38%	$ -	$ 7,666,955.41	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 7,666,955.41	$ 6,897,565.98	$ -	$ -	$ -	$ -
3	2025	39.53%	$ -	$ 8,333,040.55	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 8,333,040.55	$ 7,110,708.65	$ -	$ -	$ -	$ -
4	2026	47.10%	$ -	$ -	$ 511,201.23	$ 803,923.77	$ 14,355.26	$ 1,453,214.09	$ -	$ 834,808.30	$ -	$ 3,617,502.65	$ 2,927,889.70	$ 2,252,222.84	$ -	$ 675,666.85	$ -
5	2027	55.09%	$ -	$ -	$ 538,958.62	$ 847,575.53	$ 15,134.73	$ 1,532,121.25	$ -	$ 880,137.04	$ -	$ 3,813,927.17	$ 2,927,889.70	$ 2,252,222.84	$ -	$ 675,666.85	$ -
6	2028	63.51%	$ -	$ -	$ 568,223.20	$ 893,597.50	$ 15,956.52	$ 1,615,312.94	$ -	$ 927,927.05	$ -	$ 4,021,017.21	$ 2,927,889.70	$ 2,252,222.84	$ -	$ 675,666.85	$ -
7	2029	72.39%	$ -	$ -	$ 599,076.80	$ 942,118.39	$ 16,822.93	$ 1,703,021.81	$ -	$ 978,311.98	$ -	$ 4,239,351.91	$ 2,927,889.70	$ 2,252,222.84	$ -	$ 675,666.85	$ -
8	2030	81.75%	$ -	$ -	$ 631,605.69	$ 993,273.89	$ 17,736.39	$ 1,795,493.13	$ -	$ 1,031,432.73	$ -	$ 4,469,541.82	$ 2,927,889.70	$ 2,252,222.84	$ -	$ 675,666.85	$ -
9	2031	91.62%	$ -	$ -	$ 665,900.86	$ 1,047,207.04	$ 18,699.45	$ 1,892,985.48	$ -	$ 1,087,437.85	$ -	$ 4,712,230.68	$ 2,927,889.70	$ 2,252,222.84	$ -	$ 675,666.85	$ -
10	2032	102.03%	$ -	$ -	$ 702,058.19	$ 1,104,068.68	$ 19,714.80	$ 1,995,771.52	$ -	$ 1,146,483.96	$ -	$ 4,968,097.14	$ 2,927,889.70	$ 2,252,222.84	$ -	$ 675,666.85	$ -
11	2033	113.00%	$ -	$ -	$ 740,178.81	$ 1,164,017.82	$ 20,785.28	$ 2,104,138.67	$ -	$ 1,208,736.17	$ -	$ 5,237,856.74	$ 2,927,889.70	$ 2,252,222.84	$ -	$ 675,666.85	$ -
12	2034	124.56%	$ -	$ -	$ 780,369.31	$ 1,227,222.09	$ 21,913.89	$ 2,218,389.97	$ -	$ 1,274,368.58	$ -	$ 5,522,263.85	$ 2,927,889.70	$ 2,252,222.84	$ -	$ 675,666.85	$ -
13	2035	136.75%	$ -	$ -	$ 822,742.10	$ 1,293,858.26	$ 23,103.77	$ 2,338,844.94	$ -	$ 1,343,564.72	$ -	$ 5,822,113.79	$ 2,927,889.70	$ 2,252,222.84	$ -	$ 675,666.85	$ -
14	2036	149.61%	$ -	$ -	$ 867,415.66	$ 1,364,112.66	$ 24,358.27	$ 2,465,840.42	$ 1,875,565.11	$ 1,416,518.10	$ (101,840.14)	$ 7,911,970.08	$ 3,773,941.13	$ 2,252,222.84	$ 894,628.29	$ 675,666.85	$ (48,576.86)
15	2037	163.16%	$ -	$ -	$ 914,514.92	$ 1,438,181.76	$ 25,680.89	$ 2,599,731.55	$ -	$ 1,493,432.73	$ -	$ 6,471,541.84	$ 2,927,889.70	$ 2,252,222.84	$ -	$ 675,666.85	$ -
16	2038	177.45%	$ -	$ -	$ 964,171.59	$ 1,516,272.69	$ 27,075.32	$ 2,740,892.74	$ -	$ 1,574,523.70	$ -	$ 6,822,936.04	$ 2,927,889.70	$ 2,252,222.84	$ -	$ 675,666.85	$ -
17	2039	192.52%	$ -	$ -	$ 1,016,524.54	$ 1,598,603.83	$ 28,545.46	$ 2,889,718.76	$ -	$ 1,660,017.78	$ -	$ 7,193,410.37	$ 2,927,889.70	$ 2,252,222.84	$ -	$ 675,666.85	$ -
18	2040	208.40%	$ -	$ -	$ 1,071,720.17	$ 1,685,405.42	$ 30,095.43	$ 3,046,625.79	$ -	$ 1,750,154.04	$ -	$ 7,584,000.86	$ 2,927,889.70	$ 2,252,222.84	$ -	$ 675,666.85	$ -
19	2041	225.15%	$ -	$ -	$ 1,129,912.83	$ 1,776,920.19	$ 31,729.57	$ 3,212,052.62	$ -	$ 1,845,184.56	$ -	$ 7,995,799.78	$ 2,927,889.70	$ 2,252,222.84	$ -	$ 675,666.85	$ -
20	2042	242.80%	$ -	$ -	$ 1,191,265.26	$ 1,873,404.07	$ 33,452.43	$ 3,386,461.85	$ -	$ 1,945,375.09	$ -	$ 8,429,958.70	$ 2,927,889.70	$ 2,252,222.84	$ -	$ 675,666.85	$ -
21	2043	253.97%	$ -	$ -	$ 1,230,075.52	$ 1,934,437.75	$ 34,542.28	$ 3,496,789.48	$ -	$ 2,008,753.51	$ -	$ 8,704,598.53	$ 4,439,759.79	$ 3,415,199.84	$ -	$ 1,024,559.95	$ -
22	2044	265.50%	$ -	$ -	$ 1,270,150.18	$ 1,997,459.84	$ 35,667.63	$ 3,610,711.47	$ -	$ 2,074,196.74	$ -	$ 8,988,185.86	$ 4,439,759.79	$ 3,415,199.84	$ -	$ 1,024,559.95	$ -
23	2045	277.41%	$ -	$ -	$ 1,311,530.44	$ 2,062,535.14	$ 36,829.65	$ 3,728,344.93	$ -	$ 2,141,772.04	$ -	$ 9,281,012.19	$ 4,439,759.79	$ 3,415,199.84	$ -	$ 1,024,559.95	$ -
24	2046	289.70%	$ -	$ -	$ 1,354,258.82	$ 2,129,730.52	$ 38,029.52	$ 3,849,810.77	$ -	$ 2,211,548.89	$ -	$ 9,583,378.51	$ 4,439,759.79	$ 3,415,199.84	$ -	$ 1,024,559.95	$ -
25	2047	302.40%	$ -	$ -	$ 1,398,379.25	$ 2,199,115.06	$ 39,268.49	$ 3,975,233.85	$ 24,445,219.61	$ 2,283,598.99	$ (1,327,335.68)	$ 33,013,479.57	$ 14,811,833.92	$ 3,415,199.84	$ 10,967,596.81	$ 1,024,559.95	$ (595,522.68)
26	2048	315.51%	$ -	$ -	$ 1,443,937.08	$ 2,270,760.09	$ 40,547.82	$ 4,104,743.09	$ -	$ 2,357,996.42	$ -	$ 10,217,984.49	$ 4,439,759.79	$ 3,415,199.84	$ -	$ 1,024,559.95	$ -
27	2049	329.05%	$ -	$ -	$ 1,490,979.14	$ 2,344,739.23	$ 41,868.83	$ 4,238,471.61	$ -	$ 2,434,817.64	$ -	$ 10,550,876.46	$ 4,439,759.79	$ 3,415,199.84	$ -	$ 1,024,559.95	$ -
28	2050	343.02%	$ -	$ -	$ 1,539,553.79	$ 2,421,128.55	$ 43,232.87	$ 4,376,556.88	$ -	$ 2,514,141.63	$ -	$ 10,894,613.72	$ 4,439,759.79	$ 3,415,199.84	$ -	$ 1,024,559.95	$ -
29	2051	357.46%	$ -	$ -	$ 1,589,710.95	$ 2,500,006.56	$ 44,641.36	$ 4,519,140.84	$ -	$ 2,596,049.91	$ -	$ 11,249,549.61	$ 4,439,759.79	$ 3,415,199.84	$ -	$ 1,024,559.95	$ -
30	2052	372.36%	$ -	$ -	$ 1,641,502.18	$ 2,581,454.33	$ 46,095.73	$ 4,666,370.04	$ -	$ 2,680,626.68	$ -	$ 11,616,048.96	$ 4,439,759.79	$ 3,415,199.84	$ -	$ 1,024,559.95	$ -
31	2053	387.75%	$ -	$ -	$ 1,694,980.72	$ 2,665,555.60	$ 47,597.48	$ 4,818,395.82	$ -	$ 2,767,958.89	$ -	$ 11,994,488.50	$ 4,439,759.79	$ 3,415,199.84	$ -	$ 1,024,559.95	$ -
32	2054	403.64%	$ -	$ -	$ 1,750,201.54	$ 2,752,396.80	$ 49,148.16	$ 4,975,374.46	$ -	$ 2,858,136.29	$ -	$ 12,385,257.24	$ 4,439,759.79	$ 3,415,199.84	$ -	$ 1,024,559.95	$ -
33	2055	420.05%	$ -	$ -	$ 1,807,221.40	$ 2,842,067.20	$ 50,749.36	$ 5,137,467.30	$ -	$ 2,951,251.58	$ -	$ 12,788,756.84	$ 4,439,759.79	$ 3,415,199.84	$ -	$ 1,024,559.95	$ -
34	2056	436.99%	$ -	$ -	$ 1,866,098.91	$ 2,934,658.98	$ 52,402.72	$ 5,304,840.97	$ -	$ 3,047,400.48	$ -	$ 13,205,402.06	$ 4,439,759.79	$ 3,415,199.84	$ -	$ 1,024,559.95	$ -
35	2057	454.49%	$ -	$ -	$ 1,926,894.59	$ 3,030,267.30	$ 54,109.95	$ 5,477,667.52	$ -	$ 3,146,681.81	$ -	$ 13,635,621.18	$ 4,439,759.79	$ 3,415,199.84	$ -	$ 1,024,559.95	$ -
36	2058	472.55%	$ -	$ -	$ 1,989,670.94	$ 3,128,990.46	$ 55,872.80	$ 5,656,124.58	$ 5,924,108.95	$ 3,249,197.63	$ (321,669.48)	$ 19,682,295.88	$ 6,206,360.58	$ 3,415,199.84	$ 1,868,031.89	$ 1,024,559.95	$ (101,431.09)
37	2059	491.20%	$ -	$ -	$ 2,054,492.47	$ 3,230,929.91	$ 57,693.09	$ 5,840,395.60	$ -	$ 3,355,053.32	$ -	$ 14,538,564.40	$ 4,439,759.79	$ 3,415,199.84	$ -	$ 1,024,559.95	$ -
38	2060	510.47%	$ -	$ -	$ 2,121,425.83	$ 3,336,190.46	$ 59,572.67	$ 6,030,670.00	$ -	$ 3,464,357.69	$ -	$ 15,012,216.64	$ 4,439,759.79	$ 3,415,199.84	$ -	$ 1,024,559.95	$ -
39	2061	530.35%	$ -	$ -	$ 2,190,539.82	$ 3,444,880.29	$ 61,513.49	$ 6,227,143.34	$ -	$ 3,577,223.08	$ -	$ 15,501,300.02	$ 4,439,759.79	$ 3,415,199.84	$ -	$ 1,024,559.95	$ -
40	2062	550.89%	$ -	$ -	$ 2,261,905.47	$ 3,557,111.13	$ 63,517.54	$ 6,430,017.60	$ -	$ 3,693,765.52	$ -	$ 16,006,317.25	$ 4,439,759.79	$ 3,415,199.84	$ -	$ 1,024,559.95	$ -
41	2063	572.10%	$ -	$ -	$ 2,335,596.14	$ 3,672,998.34	$ 65,586.88	$ 6,639,501.30	$ -	$ 3,814,104.80	$ -	$ 16,527,787.45	$ 4,439,759.79	$ 3,415,199.84	$ -	$ 1,024,559.95	$ -
42	2064	593.99%	$ -	$ -	$ 2,411,687.59	$ 3,792,661.04	$ 67,723.63	$ 6,855,809.77	$ -	$ 3,938,364.61	$ -	$ 17,066,246.65	$ 4,439,759.79	$ 3,415,199.84	$ -	$ 1,024,559.95	$ -
43	2065	616.60%	$ -	$ -	$ 2,490,258.02	$ 3,916,222.24	$ 69,930.00	$ 7,079,165.37	$ -	$ 4,066,672.69	$ -	$ 17,622,248.31	$ 4,439,759.79	$ 3,415,199.84	$ -	$ 1,024,559.95	$ -
44	2066	639.95%	$ -	$ -	$ 2,571,388.19	$ 4,043,808.94	$ 72,208.26	$ 7,309,797.67	$ -	$ 4,199,160.92	$ -	$ 18,196,363.97	$ 4,439,759.79	$ 3,415,199.84	$ -	$ 1,024,559.95	$ -
45	2067	664.05%	$ -	$ -	$ 2,655,161.51	$ 4,175,552.29	$ 74,560.73	$ 7,547,943.75	$ -	$ 4,335,965.48	$ -	$ 18,789,183.76	$ 4,439,759.79	$ 3,415,199.84	$ -	$ 1,024,559.95	$ -
46	2068	688.95%	$ -	$ -	$ 2,741,664.08	$ 4,311,587.71	$ 76,989.85	$ 7,793,848.39	$ -	$ 4,477,227.01	$ -	$ 19,401,317.04	$ 4,439,759.79	$ 3,415,199.84	$ -	$ 1,024,559.95	$ -
47	2069	714.65%	$ -	$ -	$ 2,830,984.83	$ 4,452,055.03	$ 79,498.10	$ 8,047,764.37	$ 57,770,337.39	$ 4,623,090.70	$ (3,136,835.39)	$ 74,666,895.02	$ 16,547,525.32	$ 3,415,199.84	$ 12,802,944.60	$ 1,024,559.95	$ (695,179.08)
48	2070	741.19%	$ -	$ -	$ 2,923,215.55	$ 4,597,098.64	$ 82,088.07	$ 8,309,952.68	$ -	$ 4,773,706.48	$ -	$ 20,686,061.42	$ 4,439,759.79	$ 3,415,199.84	$ -	$ 1,024,559.95	$ -
49	2071	768.60%	$ -	$ -	$ 3,018,451.06	$ 4,746,867.63	$ 84,762.42	$ 8,580,682.83	$ -	$ 4,929,229.18	$ -	$ 21,359,993.12	$ 4,439,759.79	$ 3,415,199.84	$ -	$ 1,024,559.95	$ -
50	2072	796.89%	$ -	$ -	$ 3,116,789.25	$ 4,901,515.95	$ 87,523.90	$ 8,860,233.11	$ -	$ 5,089,818.66	$ -	$ 22,055,880.86	$ 4,439,759.79	$ 3,415,199.84	$ -	$ 1,024,559.95	$ -
Total			**$ 1,599,999.60**	**$ 15,999,995.96**	**$ 74,744,545.02**	**$ 117,544,546.57**	**$ 2,098,933.66**	**$ 212,479,586.89**	**$ 90,015,231.06**	**$ 122,060,283.64**	**$ (4,887,680.70)**	**$ 631,655,441.70**	**$ 223,585,281.67**	**$ 140,743,783.52**	**$ 26,533,201.59**	**$ 42,223,135.06**	**$ (1,440,709.71)**
				Annual Operating Costs	$ 406,867,612.14												

Performance and Value Scoring

Liquid	Criteria	(1) Environmental & Sustainability	(2) Neighborhood Impacts	(3) Safety - Public	(4) Safety - Worker	(5) Service Reliability	(6) Ease of Maintenance & Operations	Total Performance
Weighting		*8%*	*12%*	*25%*	*25%*	*15%*	*15%*	*100%*
Respondant	1	6	5	5	6	7	5	
	2	4	8	4	6	8	4	
	3	5	5	4	4	5	3	
	4	6	8	8	7	9	5	
	5	9	6	8	6	4	4	
	6	6	2	6	4	4	2	
	7	3	3	7	3	6	3	
	8	8	7	6	6	7	4	
	9	1	1	4	2	6	2	
	10	8	8	4	6	8	4	
Average		5.6	5.3	5.6	5.0	6.4	3.6	
Weighted		**0.4**	**0.6**	**1.4**	**1.3**	**1.0**	**0.5**	**5.2**
Liquid TCO (millions)		**$ 202**	**Cost Score:**	**4.3**		**Liquid Value Score:**		**1.2**

Dry	Criteria	(1) Environmental & Sustainability	(2) Neighborhood Impacts	(3) Safety - Public	(4) Safety - Worker	(5) Service Reliability	(6) Ease of Maintenance & Operations	Total Performance
Weighting		*8%*	*12%*	*25%*	*25%*	*15%*	*15%*	*100%*
Respondant	1	7	4	7	5	5	4	
	2	4	8	6	3	4	3	
	3	6	5	5	5	6	3	
	4	5	5	5.5	7	6	4	
	5	9	6	8	6	4	4	
	6	6	0	4	6	4	0	
	7	4	3	6	4	7	3	
	8	7	8	7	4	6	3	
	9	1	2	3	2	4	2	
	10	8	6	6	8	6	2	
Average		5.7	4.7	5.8	5.0	5.2	2.8	
Weighted		**0.5**	**0.6**	**1.4**	**1.3**	**0.8**	**0.4**	**4.9**
Dry TCO (millions)		**$ 264**	**Cost Score:**	**5.7**		**Dry Value Score:**		**0.9**

Score Difference	(1) Environmental & Sustainability	(2) Neighborhood Impacts	(3) Safety - Public	(4) Safety - Worker	(5) Service Reliability	(6) Ease of Maintenance & Operations	Total Performance
	-0.1	**0.6**	**-0.2**	**0.0**	**1.2**	**0.8**	**0.3**