ECONOMIC ANALYSIS OF THE NORTH SEATTLE RECLAIMED WATER PROJECT: A SUMMARY

Seattle Public Utilities
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Introduction

The City of Seattle will soon have an opportunity to provide reclaimed water to large irrigators and other potential users of non-potable water in the northern half of its retail water service area. King County, the regional provider of wastewater treatment, is currently constructing the Brightwater Reclaimed Water Backbone Project which is designed to bring reclaimed water from the new Brightwater Treatment Plant to a portal about one mile from the northeast corner of Seattle's retail water service area. Essentially all wastewater at the plant will be treated to reclaimed water standards whether it is used as reclaimed water or simply discharged into Puget Sound. The County intends to be the wholesale supplier of reclaimed water with water utilities responsible for constructing distribution infrastructure and providing retail service between the Backbone and potential customers. Therefore, Seattle Public Utilities (SPU) has conducted an economic analysis to determine whether it should take advantage of this opportunity to connect to the Backbone. This paper is a summary of that analysis, the overall conclusion of which is that the proposed North Seattle Reclaimed Water Project would not be a sound investment for the region due to high costs, a low level of benefits, and the availability of much lower-cost alternatives for achieving comparable benefits.

The economic analysis utilizes the asset management approach to decision-making that SPU has been refining over the past decade. This approach is consistent with the framework developed by Dr. Robert Raucher and the WateReuse Foundation for applying standard benefit-cost analysis tools to the evaluation of reclaimed water projects.

The Asset Management Approach

The overall goal of asset management can be summarized as making investment decisions that meet agreed-upon customer and environmental service levels while minimizing lifecycle costs. The asset management process features a Business Case which describes a problem or opportunity, identifies a number of alternatives for addressing the problem or opportunity, and then analyzes which alternative, if any, provides the most value in excess of its cost. Standard benefit-cost or cost-effectiveness analysis is used as appropriate. The intent is to account for all benefits and costs of a potential action, regardless of who receives the benefits or bears the costs. This includes financial, environmental and social benefits and costs which together are referred to as the *Triple Bottom Line*.

Applying the concepts of Asset Management and the WateReuse Foundation's Framework for Evaluating Reclaimed Water, the analysis of the North Seattle Reclaimed Water Project (henceforth referred to as the North Seattle Project) is organized as follows:

Step 1: Describe the problem(s) to be solved by the North Seattle Project and define the state of the world if neither the project nor any of its alternatives are pursued. This establishes the base case to which reclaimed water projects and other options are compared. This step also involves an initial high-level assessment of potential benefits from the project.

Step 2: Conduct market analysis. The magnitude of project benefits and costs is a function of the demand for reclaimed water in the study area. For this reason, a market analysis is conducted to identify potential customers and estimate likely demand for reclaimed water.

Step 3: Identify and quantify full life-cycle costs of project. This includes capital and O&M costs as well as customer costs, and possible environmental and social costs and risks. For cost estimating purposes, pipeline and pump size are determined by the demand for reclaimed water as estimated in the previous step.

Step 4: Identify and quantify project benefits. This includes all benefits – financial, social, and environmental – regardless of to whom they may accrue, or where they might be realized. Benefits are then described and quantified, if not in dollars, at least in terms of physical units of measure such as tons of nitrogen kept from being discharged into Puget Sound.

Step 5: Identify and analyze alternatives for achieving project goals. Alternative projects are specified so as to provide benefits the same as or greater than the project. Full life-cycle costs of all options are identified and quantified.

Step 6: Evaluate project and alternatives using cost-effectiveness rather than benefit-cost analysis. This involves specifying a set of benefits or level of service, then comparing the costs of various alternatives that can deliver those benefits. The alternative with the lowest life-cycle costs is the most cost-effective. Cost-effectiveness analysis is appropriate when the benefits of a project are difficult to monetize but all options under consideration provide the same or similar benefits.

Step 7: Perform perspectives analysis to assess the distributional implications of the project and its alternatives (i.e., who gains and who pays).

Step 8: Conduct sensitivity analyses on key assumptions and value estimates in order to explore the robustness of the results with respect to uncertainty.

Step 1 – Problem Statement and Base Case

A business case usually starts with a problem or problems to be solved and then identifies what projects might help solve them. In this analysis, that process is reversed. It begins with the North Seattle Project and then asks what problems the North Seattle Project could help solve. In general, the use of reclaimed water in this region could provide solutions to many types of problems which can be split into two broad categories: water supply and environmental.

Water Supply: Supply benefits can be further divided into three subcategories:

- *Quantity* – In areas where existing supplies are insufficient to meet current and/or anticipated demand, reclaimed water may represent a cost-effective and sustainable source of additional supply.
- *Reliability* – If reliability of supply is an issue, reclaimed water can supplement existing water sources thereby improving their current and future reliability.
- *Cost* – Where existing potable supplies have high operating costs, reclaimed water may be a more cost-effective source of non-potable water.

Environmental: There are also three basic subcategories of potential environmental benefits from reclaimed water:

- *"Upstream" effects* – Substituting reclaimed water for potable water from other sources can improve environmental conditions in the watersheds from which the potable water is extracted. Depending on the source of supply, this can result in less depleted aquifers, reduced salt water intrusion, increased stream flows, expanded wetlands, improved habitat conditions, etc.
- *"Downstream" effects* – By diverting highly treated effluent to land application, the use of reclaimed water can reduce effluent flows and the discharge of pollutants to receiving waters leading to improved water quality and habitat conditions.
- *"Direct" effects* – Reclaimed water can also be used directly to recharge aquifers, augment stream flows, or restore wetlands.

One of these potential benefits, direct environmental effects, was dropped after initial consideration. While direct stream augmentation may benefit a stream by increasing base flows, it would also be expected to degrade water quality in fresh-water streams and lakes due to remaining concentrations of phosphorous and other nutrients – that is, unless additional treatment was done. Because of this and the lack of known sites in the North Seattle area for groundwater recharge or wetlands restoration, no additional analysis of direct environmental effects as a potential benefit was undertaken. The remaining five benefit types were evaluated further as potential drivers for the North Seattle Project:

1. Augmenting the available supply for the Seattle regional water system
2. Contributing to supply reliability for the Seattle regional water system
3. Avoiding some variable costs of providing potable water
4. Providing "upstream" environmental benefits to both regional and local source watersheds by diverting/pumping less water from them
5. Providing "downstream" environmental benefits to Puget Sound by reducing the volume of treated effluent, and therefore the amount of pollutants, discharged into it

The base case for each of these potential benefits is briefly described below:

Augmenting Regional Water Supply

Over the past 20 years, Seattle has gone from a situation of short supply to surplus. Seattle system water demand has plummeted from 170 million gallons per day (mgd) in 1990 to 125 mgd today as the result of conservation programs, state and federal plumbing codes, improved system operations, and a seasonal rate structure designed to encourage conservation. Given the amount of excess capacity now enjoyed by Seattle as well as the half-century it's expected to persist, an additional increment to Seattle's water supply from reclaimed water would provide little immediate benefit. However, reclaimed water could provide a future benefit when demand again reaches existing supply. This is currently forecast to occur sometime after 2060.

Contributing to Regional Supply Reliability

With demand so far below firm yield, Seattle's water system is considered to be reliable with low risk of shortages requiring water use curtailments. Still, there's always a chance that a year will occur with less favorable weather and hydrological conditions than have been experienced in the past. The prospect of climate change and its impact on both water supply and demand also increase the uncertainty around future reliability. Thus, improving the robustness and reliability of Seattle's supply system is a benefit to which reclaimed water could contribute.

Avoiding Variable Costs of Water from Current Sources

Most of the costs of providing municipal water supply are fixed costs that do not vary with the volume of water supplied. Only the variable or marginal costs of providing water are relevant because only they would be reduced by substituting reclaimed water for municipal water. These costs, which increase or decrease with changes in the volume of treated water delivered, are relatively low. They include chemical costs for treatment and energy costs for treatment and pumping (though because the Seattle system operates mostly on gravity, pumping requirements are low). By reducing the use of potable water and avoiding the associated variable costs, the North Seattle Project could provide a benefit.

Providing "Upstream" Environmental Benefits

Most streams in the Central Puget Sound region experience low flow problems during years of low rainfall, in the sense that their flows are lower than normal which can degrade habitat conditions and possibly lead to higher rates of mortality for fish. Natural problems with low flows tend to occur in the summer and early fall, after extended periods with little to no precipitation, when groundwater inflows are at their lowest and snowpacks have already melted. These natural low-flow problems can be aggravated by human impacts, one of which, though not the only, is the withdrawal of water for out-of-stream use.

There are two kinds of potential reclaimed water customers that would be served by the North Seattle Project: those who currently obtain their non-potable water from the Seattle municipal system and those with their own source of non-potable water. It is therefore possible that by providing an alternative source of water, the project could improve environmental conditions in both Seattle's source watersheds and local watersheds.

SPU's primary water management goals for both its Cedar and South Fork Tolt systems focus on the protection of salmonid fishes and the promotion of overall river health while providing an adequate supply of municipal water. SPU's operation of water storage facilities on both systems moderates the severity of both high and low stream flow events. For most of the summer, flows in the South Fork Tolt are increased by reservoir releases to provide flows that are usually higher than under natural conditions. From late September through late October, flows in the Cedar are similarly augmented to provide levels above what would often occur naturally, particularly if fall rains return later than normal. In addition, SPU typically provides operating margins of 3 to 20 cubic feet per second (cfs) over and above guaranteed minimum flow levels, while in most years, "supplemental flows" well above minimum flows are also provided. Nevertheless, reducing customer demand for water in the summer and early fall could provide SPU with additional flexibility in optimizing instream habitat conditions.

Potential reclaimed water customers in the North Seattle area that irrigate using their own wells or surface water diversions might be reducing dry season flows in local streams. Most of the streams in this area flow through urbanized drainage basins with hardened landscapes and dense storm drain networks that combine to increase peak flows from storm events and reduce base flows during the summer irrigation period. One stream in the project area has already been identified as having low-flow problems but other streams could also probably benefit from increased summer baseflows. By providing reclaimed water for irrigation, the project could eliminate the need for surface and groundwater withdrawals by self-supplied irrigators and leave more water available to the local watershed ecosystems.

Providing "Downstream" Environmental Benefits to Puget Sound

An array of contaminants from a variety of sources and transport mechanisms add a mix of pollutants that affects Puget Sound water quality, and one of these sources is treated wastewater. The average daily flow from all wastewater treatment facilities discharging to Puget Sound is estimated to be about 475 mgd. Of this, more than 40% comes from King County's two regional treatment plants. The total average daily discharge from these two plants is about 200 mgd. One of the primary benefits cited for the use of reclaimed water in western Washington is its positive impact on water quality in Puget Sound. By diverting to terrestrial use what would otherwise be advanced secondary-treated effluent discharged to the Sound, the North Seattle Project would reduce the discharge of pollutants to Puget Sound.

Step 2 – Market Analysis

The greater the demand for reclaimed water, the greater the potential benefits. Therefore, the first step in quantifying both the benefits and costs of the North Seattle Project was to assess the demand for reclaimed water in the study area. The area that could be served by the North Seattle Project includes all of the City of Shoreline and north Seattle as far south as the University of Washington. In total, 60 potential reclaimed water customers were identified for further analysis. These were divided into five categories of water use as shown below:

Golf Courses	4
Cemeteries	7
Parks	19
Schools	23
Other	7
TOTAL	60

Again, there are two kinds of potential reclaimed water customers in the study area: those who currently obtain their water from SPU or the Shoreline Water District and those with their own source of non-potable water. All the golf courses and most of the cemeteries have their own source of irrigation water. All the parks and schools plus several of the cemeteries use municipal water for their irrigation needs.

A number of methods were used to estimate non-potable water use including metered consumption data, survey data on application rates and irrigated acreage, "rules of thumb" from local irrigation experts, and an application of the water budget equation to Seattle conditions. Multiple methods were often used for the same customer to check for consistency, resulting in a high level of confidence in the reasonableness of the estimates.

Total potential demand of these customers was estimated at 314 million gallons (MG) per year with almost all of it, 309 MG, occurring in the 6 month irrigation season. Expressed in millions of gallons per day, potential irrigation season demand was estimated at about 1.7 mgd with 1 mgd of that used by the seven self-supplied irrigators. Six of the municipally-supplied customers also have some demand for non-potable water during the off-peak season amounting to 0.03 mgd.

Step 3 – Project Costs

Full life-cycle costs of the North Seattle Project were identified and, to the extent possible, quantified. Included are capital and O&M costs for the City of Seattle and King County, as well as customer costs and environmental/social costs and risks. Not included are capital and O&M costs associated with producing the reclaimed water, and the capital costs of building the Backbone. Because the Brightwater plant and the Backbone pipeline are now under construction, and because wastewater at the plant will be treated to reclaimed water standards whether it is used as reclaimed water or simply discharged into Puget Sound, both are considered sunk costs and are not included in the calculation of project costs. ("Sunk costs" are costs that have already been incurred, cannot be recovered, and therefore should not be considered relevant to subsequent decisions. They should not be included in a benefit-cost analysis nor used to justify continuing a project.)

The largest single cost would be for installation of a reclaimed water distribution system from the Backbone Portal to potential customers scattered throughout North Seattle and Shoreline. This would require about 27 miles of pipeline varying from 4 to 20 inches in diameter, and would cost an estimated $76 million. Pumping facility and customer onsite costs increase the estimate of total capital costs to $87 million. Annual operating costs include those for Seattle's share of disinfection and pressurizing the Backbone, pressurizing the distribution system, and the estimated cost to society of associated CO_2 emissions. These costs total $750,000 per year. Their present value over a 50-year time horizon discounted at 2.5% is $21 million. The estimated total monetized present value cost of the project is $109 million.

Step 4 – Project Benefits

Each of the five benefit types was described in detail and quantified to the extent possible. Three of the benefit types are mutually exclusive and so are considered together.

Augmenting Existing Supply/Enhancing Supply Reliability/Improving Environmental Conditions in Regional Source Watersheds

Based on the market analysis, the North Seattle Project could reduce demand from Seattle's regional supply system by as much as 0.69 mgd over an irrigation season. This reduction in demand could be:

- made available to augment existing supplies and help meet future increases in demand, or
- kept in storage to enhance supply reliability, or
- released from storage to increase flows in Seattle's source rivers, thereby improving instream fish habitat and other environmental conditions.

However, it couldn't provide all these benefits at the same time. If the water freed up by substituting reclaimed water is used to enhance supply reliability, it's not available to increase streamflows or to meet additional demand. Similarly, if the water is left in the source rivers, it can't be used to meet additional demand or improve supply reliability.

Relative to SPU's total water supply, 0.69 mgd is a very small, almost imperceptible quantity. Alone, it would not add to supply or improve reliability in a detectable way. However, as part of a portfolio of measures that together produced a significant reduction in demand, the North Seattle Project could be seen as contributing to an increase in supply or reliability. No attempt is made to put a dollar value on this. Rather, it is quantified in physical terms only, i.e., whatever supply or reliability benefit is associated with a 0.69 mgd reduction in irrigation-season demand.

Relative to dry season flows in the Cedar and Tolt rivers which provide Seattle's water, 0.69 mgd is an even smaller quantity. An assessment of the potential effects of the North Seattle Project on these rivers found that an additional 0.69 mgd might produce increases in minimum stream flows in the range of 0.1% to 1.3%. This translates to even smaller increases in minimum stream depths ranging from 0.01 to 0.07 inches or in percentage terms, 0.04% to 0.24%. The analysis suggests that the North Seattle Project would result in exceedingly small changes in annual mean stream flow, monthly average minimum stream flow, and monthly average minimum water elevation. Therefore, the environmental impacts of the project on the Cedar and South Fork Tolt rivers would be difficult to detect.

Avoiding Variable Cost of Water from Current Sources

By reducing the use of potable water, the North Seattle Project would provide a benefit by reducing the variable costs associated with treating and pumping the water. The variable cost of providing potable water from SPU is about $0.09 per hundred cubic feet (ccf). The variable cost for irrigators with their own sources is estimated at $0.12 per ccf. Both of these estimates include the environmental cost of greenhouse gas emissions associated with the power required for pumping. The total avoided cost from reducing demand from current sources by 314 million gallons a year works out to about $31,000 per year with a present value of about $880,000 (over 50 years with a 2.5% discount rate).

Improving Environmental Conditions in Local Watersheds

A consultant was engaged to assess the potential environmental benefits of providing reclaimed water to the seven potential reclaimed water customers in the North Seattle/Shoreline area that irrigate using their own wells or surface water diversions. The consultant identified three major watersheds that might be affected by the self-supplied irrigators (SSIs) who together withdraw about 1.0 mgd. The impact of eliminating water withdrawals by the SSIs was analyzed to the extent possible given severe data constraints. The consultant concluded that there could be some baseflow-related environmental benefits associated with supplying reclaimed water to SSIs in two of the three watersheds. The largest SSI with 0.3 mgd of irrigation demand was located in the watershed thought to derive no benefit from a reduction in groundwater withdrawals. Therefore, some environmental benefit was assumed to be associated with providing a substitute source of water to 6 of the 7 SSIs with combined demand of about 0.70 mgd. No attempt was made to assign a dollar value to this benefit.

Improving Environmental Conditions in Puget Sound

Total potential demand for the North Seattle Reclaimed Water Project is estimated at about 314 million gallons per year or 0.86 mgd on an annual average basis. Using this volume of reclaimed water would keep about 3.1 metric tons of nitrogen, 26 billion Colony Forming Units (CFU) of fecal coliform, and 2.4 metric tons each of Biochemical Oxygen Demand (BOD) and Total Suspended Solids (TSS) out of the Sound each year. This represents about 0.04% to 0.05% of the total amount of these pollutants currently discharged from King County’s existing treatment plants.

Benefits Summary

The benefits of the North Seattle Project can be summarized as follows:

- An unquantified but minimal benefit to the Seattle regional water supply system associated with reducing irrigation season demand from the system by 0.69 mgd. This benefit could take the form of increased supply, reliability, or streamflows in the source rivers.
- An unquantified but small environmental benefit to several urban watersheds associated with reducing the withdrawals of six of the seven major self-supplied irrigators by a total of 0.70 mgd.
- The avoidance of potable water variable costs with a present value of $880,000
- The withholding of 3.1 metric tons of nitrogen, 26 billion CFU of fecal coliform, and 2.4 metric tons each of BOD and TSS annually from being discharged into Puget Sound

Step 5 – Project Alternatives

A number of alternatives to the North Seattle Project were considered that provide one or more of the four benefits summarized above. These alternatives include:

- installing natural drainage systems in North Seattle
- switching self-supplied irrigators from their own sources to Seattle municipal water
- intensifying existing water conservation programs
- reducing the minimum drawdown level for the Tolt reservoir to increase water supply and/or reliability
- improving the level of treatment at existing wastewater treatment plants

Step 6 – Cost-Effectiveness Analysis

Cost-effectiveness analysis involves specifying a set of benefits or level of service, and then comparing the costs of various alternatives that can deliver those benefits. The alternative with the lowest life-cycle costs is the most cost-effective. This can be a helpful shortcut when the benefits of a project are difficult to quantify in dollar terms, as is the case here, but the options under consideration provide the same or at least similar benefits. The option having the lowest present value cost becomes the preferred option as long as it can be convincingly argued that the benefits, though unquantified, clearly outweigh the cost of the least cost option.

None of the alternatives listed above individually provide all the benefit types that have been ascribed to the North Seattle Project. Therefore, several of them were combined to produce a bundled option that covers all the benefits and is directly comparable to the North Seattle Project. The bundled option consists of three components:

- Providing six of the seven self-supplied irrigators with 0.7 mgd of Seattle municipal water over the irrigation season, eliminating their withdrawals from local watersheds.
- Offsetting the demand of the six new irrigation customers plus all the potential reclaimed water customers that currently use Seattle municipal water by increasing Seattle's investment in water conservation enough to achieve 1.4 mgd in conservation savings over and above what is already planned.
- Installing a 1 mgd Membrane Bioreactor (MBR) facility at the South treatment plant in Renton to reduce pollutant discharge to Puget Sound.

Switching the six self-supplied irrigators to Seattle municipal water would involve new service and meter installations, costing less than $50,000 for all six. This would achieve the identical benefit to local watersheds as the North Seattle Project by providing an alternative source of supply, allowing these irrigators to stop using their own supplies. However, this would increase peak season demand on Seattle's regional supply system by 0.7 mgd. Since the North Seattle Project would reduce peak season demand on the Seattle system by 0.69 mgd, the bundled option must reduce demand or increase supply capacity by at least 1.4

mgd in order to provide the equivalent supply, reliability, or environmental benefit as the North Seattle Project.

Intensifying SPU's existing conservation program could save an additional 1.4 mgd of water demand. Ramping up rebate levels on high efficiency fixtures and appliances enough to achieve 1.4 mgd in conservation savings over and above what's already planned is estimated to cost up to $310,000 per year over a period of 20 years. Assuming average measure lives of 20 years, the program could be run continuously to preserve the savings indefinitely. In present value terms, that would be $8.8 million. This would produce a net reduction in municipal demand of 0.7 mgd, providing the identical supply, reliability, or environmental benefit to the SPU supply system as the North Seattle Project. It would also avoid the same $880,000 in variable water costs from current sources.

An alternative means of achieving the Puget Sound benefit of reducing the discharge of pollutants is to improve the level of treatment at existing King County treatment plants. A facility to produce Class A reclaimed water could be installed at the South treatment plant. This would take a portion of the secondary-treated effluent, treat it to reclaimed water standards using Membrane Bioreactor (MBR) technology, and then return it to the effluent stream being discharged to the Sound. This would significantly reduce the concentration of priority pollutants in the treated effluent, on average by a factor of 11.

The analysis made use of a model for estimating the cost of producing reclaimed water developed by a consultant for King County. The smallest facility for producing Class A water from secondary effluent analyzed by the model has a capacity of 1 mgd. Estimated capital costs would be $14 million with O&M costs of about $360,000 per year. Discounted at 2.5% over 50 years, the present value cost of the facility would be about $18.3 million.

The impact of this higher level of treatment on 1 mgd of effluent would be to remove 43.4 metric tons of nitrogen, 18.0 metric tons of BOD, 20.7 metric tons of TSS, and 304 billion CFU of fecal coliform from the effluent stream. These reductions are 8 to 14 times larger than what would be removed by the North Seattle Project.

Table 1. Comparative Effectiveness for Removing Priority Pollutants from Puget Sound

		Reduction in Discharge to Puget Sound		Factor by which MBR Reduction Exceeds North Seattle Project
	Units	North Seattle Project	1 mgd MBR Treatment	
Total Nitrogen	Metric Tons/yr	3.1	43.4	14
BOD	Metric Tons/yr	2.4	18.0	8
TSS	Metric Tons/yr	2.4	20.7	9
Fecal Coliform	BCFU*/yr	26	304	12

* Billions of Colony Forming Units

As shown in Table 2 below, the North Seattle Project has an estimated present value cost of $109 million. The bundled option would have a total cost of about $27 million: $46,000 to switch self-supplied irrigators to Seattle municipal water, $8.8 million for intensified conservation, and $18.3 million for the MBR treatment facility. This is one-fourth the cost of the North Seattle Project. However as explained above, the MBR facility would remove about 8 to 14 times more pollutants (11 times on average) than the North Seattle Project. To make an apples-to-apples comparison of benefits, the cost of the MBR plant can be divided by 11 to represent that portion of the plant associated with removing an equivalent amount of pollutants from Puget Sound as the North Seattle Project. Adjusting costs in this way, $1.7 million of the MBR plant costs are allocated to the bundled option. This implies a bundled option cost of $10.5 million for providing benefits equivalent to the North Seattle Project.

It can therefore be concluded that the North Seattle Reclaimed Water Project would not be a cost-effective means of achieving the identified benefits. The full bundled option would cost only a quarter as much and be able to generate *equivalent* benefits for 10% of the North Seattle Project's cost.

Table 2. Total and Adjusted Present Value Cost for Components of the Bundled Option

Individual Alternatives		Present Value Cost	Benefits Relative to North Seattle Project	Cost for Equivalent Benefits*
1	Switch SSIs to Seattle Water	$45,900	Same	$45,900
2	Intensify Conservation Program	$8,800,000	Same	$8,800,000
3	1 MGD MBR Facility at South Plant	$18,260,000	8-14 times greater*	$1,660,000
Total PV Cost for Bundled Alternative		$27,105,900	-	$10,505,900
PV Cost for North Seattle Project		$108,562,922	-	$108,562,922
% of North Seattle Project Cost		25%	-	10%

* For ease of exposition, an average of 11 times greater is used to calculate the cost for equivalent benefits.

These results illustrate a general principal for addressing the question of what to do with high quality effluent such as that produced by an MBR facility – discharge it directly into receiving waters or divert it for use on land as reclaimed water. If the primary goal is to reduce pollution to receiving waters, a reclaimed water project is cost-effective only if the cost of *distributing* the reclaimed water is smaller than the cost of *producing* more of it. Otherwise, it's more cost-effective to add another MBR facility and discharge the higher quality effluent into the receiving body. While this does not reduce the *volume* of effluent, it decreases pollutant discharges by lowering the *concentration* of pollutants in the effluent. For example, if MBR treatment removes 90% of the pollutants in secondary-treated wastewater, then adding another 1 mgd MBR plant would keep 10 times more pollutants out of the receiving waters than diverting 1 mgd from the original MBR plant for use as reclaimed water. Therefore, in this example, developing a reclaimed water distribution system would have to cost at least 10 times *less* than a new MBR facility in order to be cost effective. Otherwise, the goal of reducing water pollution is more cost-effectively achieved by adding another MBR facility and discharging the higher quality effluent into the receiving body. In the case of the North Seattle Project, the cost of the distribution system far exceeds this threshold for cost-effectiveness.

Size is another issue. Installing a larger MBR plant than the smallest possible would likely be even more cost-effective in reducing pollutant loadings to Puget Sound than implied by the above. Due to economies of scale, cost-effectiveness in removing pollutants increases as facility size increases.

While the analysis concludes that the bundled option is cost-effective relative to the North Seattle Project, this doesn't mean that the bundled option is the most cost-effective alternative available or that it should be recommended for implementation. Before that decision could be made, a wider range of alternatives would have to be examined and the problem statement would need to be revisited. As discussed at the beginning of Step 1, a business case usually starts with a problem or problems of concern to be solved and then identifies what projects might help solve them. In this analysis, that process was reversed. It began with the North Seattle Project and then asked what problems the North Seattle Project could help solve. These may not be the highest priority problems or the ones that should be tackled first.

A process is now underway through the Puget Sound Partnership to develop a comprehensive problem statement regarding the environmental health of the Puget Sound basin. It may find that reducing nitrogen and other pollutant loadings at the Brightwater outfall site is not the greatest concern. For example, low dissolved oxygen levels are much more of a problem in the South Sound than farther north so the nitrogen content of wastewater discharges is also of greater concern there. Although the expected benefit to Puget Sound of reducing the pollutants discharged from South Plant may be greater than equivalent reductions at the more northern Brighwater outfall, it might make even more sense and provide greater benefits to Puget Sound to invest in improved wastewater treatment at points farther south before doing so in King County.

It could also turn out that there are higher priority actions than upgrading municipal wastewater treatment plants that would more cost-effectively improve the health of Puget Sound. Perhaps the region should first direct its limited resources to addressing the problems of failing septic systems along marine shorelines or storm runoff that washes toxic materials from impervious surfaces into rivers, lakes and the Sound. These questions, however, are beyond the scope of this analysis. While insufficient information has been gathered to conclude that the region should proceed with the bundled option, this analysis does conclude that the bundled option would be a much more cost-effective solution than the North Seattle Project to the problems the North Seattle Project would solve.

Step 7 – Perspectives Analyses

A limitation of benefit-cost analysis is that it doesn't consider the distributional implications of a project. It determines whether total benefits exceed total costs but ignores who wins and who loses. This can be overcome by including a perspectives analysis as part of the project evaluation process. A perspectives analysis links benefits and costs to various groups, identifying who incurs costs and who receives benefits from a particular project. In this perspectives analysis, the world is divided into the following groups:

- reclaimed water customers,
- all other Seattle/Shoreline retail water ratepayers *except for* reclaimed water customers,
- all other sewer ratepayers served by King County *except for* Seattle/Shoreline water ratepayers,
- all other residents of the Puget Sound region *except for* those served by King County, and
- the rest of the world excluding the Puget Sound region.

The analysis found that, since the project's most significant benefits extend well beyond Seattle's retail service area, potential reclaimed water customers and Seattle/Shoreline water ratepayers would most likely end up paying a much larger proportion of project costs than their share of project benefits. Conversely, residents of the Puget Sound region outside of King County would enjoy a significant portion of the benefits while paying none of the costs. Finally, the rest of the world beyond the Puget Sound region would absorb the environmental costs associated with the net increase in greenhouse gas emissions generated by the project without receiving any project benefits.

Step 8 – Sensitivity Analyses

The results of this economic analysis are based on assumptions and estimates around which there is much uncertainty. Costs may be more or less than estimated. There may be more or fewer reclaimed water customers than assumed using more or less non-potable water than estimated. The benefits of using reclaimed water may be higher or lower than estimated and different assumptions about the appropriate discount rates can significantly change the present value calculations. A sensitivity analysis was conducted which found the overall conclusions of the cost-effectiveness analysis to be unaffected by major changes to key estimates and assumptions.

Summary and Conclusions

It was estimated that the full life-cycle cost of building and operating a distribution system to deliver reclaimed water from the Brightwater reclaimed water backbone to potential customers in North Seattle and Shoreline would be about $109 million.

The potential benefits of the North Seattle Project were found to be minimal. The project would be expected to reduce peak season demand from Seattle's regional water supply system by up to 0.7 mgd. By itself, this amount is too small to have a detectable positive impact on regional water supply, reliability, or environmental conditions in the Cedar and Tolt rivers. The project would also be expected to reduce the peak season withdrawals of self-supplied irrigators from their own local supplies by up to 1 mgd. This might provide small improvements in habitat conditions for several streams in the area though it would not be expected to result in significant increases in biological productivity. Finally, the project would be expected to reduce the discharge of pollutants from King County treatment plants into Puget Sound by about 0.04% to 0.05%.

Some alternative means of achieving these benefits were identified although none of them individually could provide all the benefit types ascribed to the North Seattle Project. Therefore, three of them were combined to produce a bundled option that would provide benefits equal to or greater than those expected from the North Seattle Project. The estimated life-cycle cost of the bundled option is $27 million or 25% of North Seattle Project cost. When adjusted to reflect equivalent benefits, the bundled option cost is $10.5 million which amounts to 10% of the North Seattle Project cost.

Given its high cost and the availability of much lower cost alternatives, this analysis concludes that the North Seattle Project would not be a cost-effective means of attaining the project's modest benefits. Before recommending the lower-cost bundled option for implementation, however, a fuller analysis of the environmental problems facing the Puget Sound basin and the available alternatives for addressing them would have to be undertaken. Finally, it is hoped that this analysis will serve as a useful example of how the WateReuse Foundation's Framework and asset management principles can be applied to the evaluation of other potential reclaimed water projects in the region.