Lifecycle Cost Analysis Primer

Lifecycle cost analysis (LCA) involves estimating the total cost of owning, operating and maintaining equipment or assets over a number of years.[1] Included in LCA are operating and maintenance (O&M) costs, up-front fees, investment and recurring capital costs, depreciation and, in some cases, resale value. LCA is an objective way of blending O&M and capital costs and can be employed in determining the least-cost option, among a list of alternatives.

As an example, a five-Year *Cost of Ownership* calculation in the automotive industry is a form of LCA. Consumer Reports Magazine now evaluates the 5-year cost of owning a vehicle in determining *value to the consumer*. The following quote from the magazine emphasizes the importance of looking at costs over time:

While Hyundai and Kia models have low prices and long warranties, the savings are often offset by poor resale values. Hyundai's Accent and Elantra don't prove any less expensive after five years than Honda's more expensive Fit and Civic.

LCA has been used to estimate the costs of alternate approaches to wastewater treatment in Dawson City, Yukon over a 50-year period of analysis. This is an adequate period of time to evaluate full lifecycle costs. Note to reader: changing the period of analysis to 100 years does not have any impact on the cost ranking of the alternate approaches.

In undertaking LCA, an important consideration is that different elements of a wastewater system maintain different lifespans (i.e., years of effective operation). For example, electronic instrumentation is generally replaced every 10 years, process equipment and mechanical components are replaced every 20 years and buildings and related engineering earth work are re-done on a 50-year replacement cycle. An LCA model takes these different lifespans into account in projecting overall costs.

Another major consideration in undertaking LCA is the treatment of time-value of money. This is perhaps the most challenging LCA-related concept to explain and understand. The basic idea is that the $1 million today is not the same as $1 million in 10 or 20 years. Even if you take out the effects of inflation, this is still the case because we can (a) do something with this money that will either earn us interest or a return or (b) use it to resolve other issues and problems (e.g., investment in a needed school or home for seniors) that also has a value.

When a government is undertaking a project and is issuing a bond to finance the project, the discount rate for the project could simply be set as the rate of return for the bond. While discount rate selection is subjective there are conventions and historical rates that can be used to guide in the selection process. For the Dawson City wastewater treatment facility lifecycle cost assessment, the Yukon Government sought the opinion and expertise of Informetrica, Ltd., an economic consulting company located in Ottawa, in arriving at a discount rate of 4% for this

[1] Life cycle costing is not to be confused with “Life cycle assessment” which refers to the valuation of environmental impacts that are incurred through manufacturing or service procurement. This analysis is strictly focused on economic impacts.

project.[2] Note to reader: based on cost data provided, the mechanical plant proved to be the most economical whether the discount rate was set at 4% or 0% (i.e., no discounting of future expenditures)

The Yukon Government developed an LCA model to analyze the economics of five alternative approaches to wastewater treatment in Dawson City. An external consultant also independently developed an LCA model that confirmed the accuracy of the Yukon Government model.

[2] Informetrica briefing on discount rates can be made available through the Dawson City Wastewater Treatment Project Manager, Catherine Harwood.

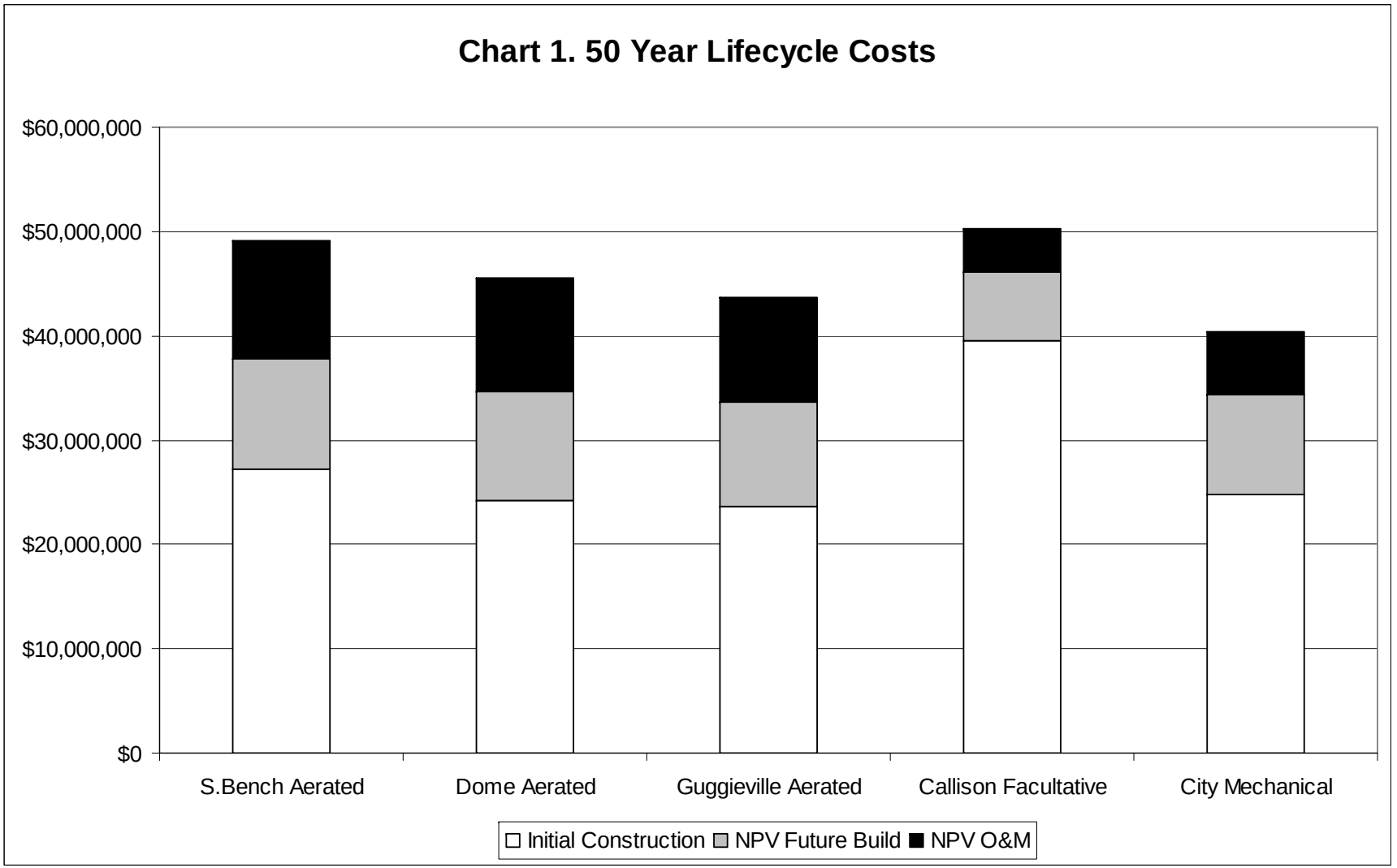
Chart 1. 50 Year Lifecycle Costs
$60,000,000
$50,000,000
$40,000,000
$30,000,000
$20,000,000
$10,000,000
$0
S.Bench Aerated
Dome Aerated
Guggieville Aerated
Callison Facultative
City Mechanical
Initial Construction
NPV Future Build
NPV O&M

Lifecycle Cost Analysis Spreadsheet Calculator

The associated spreadsheet document provides lifecycle costs estimates for different wastewater treatment solutions in a consistent format that is based on all known and existing capital and O&M cost information. Included in this analysis are four lagoon treatment facilities—three aerated- and one facultative-type—and one mechanical treatment plant. Cost estimates for the mechanical plant were derived from a submission to undertake the development of the wastewater treatment as per a Highways and Public Works *Requests for Qualification (RFQ)* and *Requests for Proposals (RFP)* process.

The MS Excel spreadsheet provides input and output values in boxes #1 to #6. These boxes are described as follows:
Box #1: Input requirements are the number of years of analysis or Lifecycle Years (10 to 100 in 10-year increments); Discount Rate (0% to 12%); Unused Depreciation (Included or Excluded); Capital Cost Contingency (0% to 50%); O&M Cost Contingency (not included in model, but option for inclusion in future modeling); and Delay Capital Onset (where capital is included in future years, but not at outset of operations). Unused depreciation—if "Included", this will allow for future years of depreciation in assets to be factored in or deducted from total costs. These will be discounted as per the set discount rate. If "Excluded", then unused depreciation will not be deducted from total net present value costs. Capital cost contingency is set at 40% as a default value as per input from AECOM, Inc. Operating costs contingency has been disabled for this spreadsheet, but can be activated if required (input from AECOM was that O&M estimates should not be inflated with a contingency factor). In the case of the Dawson wastewater treatment plant, some construction is due to commence in year 10 of operations. For this reason, the onset of capital will occur in a manner that complicates the scheduling of recurring capital costs (i.e., at the end of their lifespan of 10, 20 or 50 years). This input cell allows the period of delay to be any value.

Box #2: For the 5 alternative wastewater treatment facilities, this box provides the calculated values for the initial construction costs, the net present value (NPV) of future capital/building requirements, the NPV for operating and maintenance costs as well as the Total NPV. Also included is a calculation of the amount that the treatment plant is above the lowest costs option.

Box #3: Includes cost estimates for 4 lagoon options and RFP submission costs provided by the single qualifying bidder. There are four data sets in this box. The first is the capital costs for all five options; the second data set provided updated capital costs as per input from AECOM, Ltd. The third column of data (Column D) is for the delayed (year 10) construction. Datasets #3 and #4 provide similar inputs from AECOM and the project proponents (i.e., qualifying bidder).

Box #4: Shows the six capital elements: general requirements (various inputs into the planning and development process that are not captured in the other five categories—estimated at 20 years life); civil (facility cost elements with 50 year lifespan); architectural and structural with 50 year lifespan); process equipment (50 year lifespan); mechanical (20 year lifespan); and electrical & instrumentation (10 year lifespan). The box also includes the initial and delayed capital costs.

Box #5: This box includes (for the first alternative) The calculated capital replacement values from year 10 to year 100. The "Asset Category Life" in column K is used along with initial construction costs in column M to determine the replacement periods and costs as noted in columns P through Y.

Box #6: This box demonstrates the impacts of accounting for unused depreciation in the model. To explain this concept, if a 50 year lifecycle period of analysis is selected, then the model would pick up the year 50 capital replacement costs of all facility, construction, architecture and structural cost items incurred in year 50. Even though there would be an additional 50 years to use the equipment, this 50-year "use value" would not be accounted for in the model, significantly over-stating capital costs. If the user has selected (from Box 1) to "Include" unused depreciation, then this will be accounted for. The default setting for this is to include or account for the effects of unused deprecation.

As a note, O&M costs are calculated in rows from 1 to 100 to allow for a total of 100 years of analysis. O&M costs for 10 year periods (i.e., year 1 to 10, year 11 to 20, etc) are discounted and brought to align with 10-year capital cost values. The totals (O&M and capital costs combined) are listed in 2009 dollars with the appropriate discounting applied to the capital cost element.

Risk costs were estimated at approximately $1 million for the lagoon treatment plants and $700 thousand for the mechanical plant. These costs were similar enough to be not included in the cost comparison analysis. If widely disparate "risk costs" were observed, then they would have been included in the model.

Box 1	
Lifecycle Years	**50**
Discount Rate*	**4.0%**
Unused Depreciation	**Included**
Capital Cost Contingency**	**40%**
Delay Capital Onset (Years)***	**10**

Box 2

	Initial Construction	NPV Future Build	NPV O&M	Total NPV	% Above Min Value
S.Bench Aerated	$27,252,400	$10,516,258	$11,396,742	$49,165,400	22%
Dome Aerated	$24,152,800	$10,511,265	$10,827,465	$45,491,530	13%
Guggieville Aerated	$23,673,019	$9,968,729	$10,043,365	$43,685,112	8%
Callison Facultative	$39,467,400	$6,629,710	$4,200,211	$50,297,321	24%
City Mechanical	$24,788,562	$9,535,061	$6,079,458	$40,403,081	0%

*4% target rate (Informetrica, 2009)
**Applied to Lagoons as per AECOM Report: 090304 Sewage Treatment Improvements Report draft.doc
*** Default value: 10 years, as per AECOM (2009)

Box 3

CAPITAL COSTS — **Sour+B19ce: Page 12, "090304 Sewage Treatment Improvements Report draft.doc" Author: Courtney McCracken, AECOM, (March 5, 2009)**

DATA SET #1	S.Bench Aerated	Dome Aerated	Guggieville Aerated	Callison Facultative	City Mechanical	Life of Asset Category
General Req	$1,869,000	$1,884,000	$1,869,000	$3,220,000	$5,984,185	20
Civil	$10,036,000	$8,053,000	$8,038,650	$23,155,000	$2,048,067	50
Arch/Structural	$1,650,000	$1,425,000	$1,350,113	$45,000	$8,563,221	50
Process Equip	$2,577,000	$2,577,000	$2,572,448	$219,000	$5,955,569	20
Mechanical	$751,000	$730,000	$720,788	$30,000	$1,185,360	20
Electric/Inst	$1,833,000	$1,833,000	$1,608,300	$772,000	$1,052,160	10
Totals	$18,716,000	$16,502,000	$16,159,299	$27,441,000	$24,788,562	

***REQUIREMENT: Add 40% Contingency (not included above)**

CAPITAL COSTS — **Source: Ken Johnson, AECOM (Faxed Apr 08, 2009): Supplemental Capital Cost Information for Lagoon Options Only**

DATA SET #2

	1st Year Scr Plant Upgrade	1st Year C4 Lift upgrade	UV/Screening**
General Req	$100,000	$50,000	$100,000
Civil	$20,000	$10,000	$20,000
Arch/Structural	$110,000	$55,000	$110,000
Process Equip	$140,000	$0	$500,000
Mechanical	$75,000	$40,000	$75,000
Electric/Inst	$100,000	$50,000	$100,000
Totals	$545,000	$205,000	$905,000

***REQUIREMENT: Add 40% Contingency (not included above)**

**** Costs effective 10th year of operation forward**

Box 3 (Cont)

O&M COSTS — **Source: Page 13, "090304 Sewage Treatment Improvements Report draft.doc" Author: Courtney McCracken, AECOM, (March 5, 2009)**

DATA SET #3

O&M Annualized

S.Bench Aerated	Dome Aerated	Guggieville Aerated	Callison Facultative	City Mechanical
$411,000	$384,500	$348,000	$76,000	$283,000

***REQUIREMENT: Contingency not included for O&M (over-ride option for contingency has been included)**

O&M COSTS — **Source: Ken Johnson, AECOM (Faxed Apr 08, 2009): Supplemental O&M Cost Information for Lagoon Options Only**

DATA SET #4

O&M	Year 1 Scr Plant Upgrade	Year 1 C4 Lift upgrade	Year 10** UV/Screening
Power	$40,000	$0	$7,500
Heat	$10,000	$5,000	$10,000
O+M	$10,000	$10,000	$10,000
Labour	$10,000	$10,000	$10,000
Total	**$70,000**	**$25,000**	**$37,500**

***REQUIREMENT: Contingency not included for O&M (over-ride option for contingency has been included)**

****** **Costs effective 10th year of operation forward**

Box 4

		Year:	10
		Initial Construction	Timed Construction
Asset Category Life	**S.Bench Aerated**		
20	**General Req.**	**$2,826,600**	**$140,000**
50	**Civil**	**$14,092,400**	**$28,000**
50	**Architect/Struc**	**$2,541,000**	**$154,000**
20	**Process Equip**	**$3,803,800**	**$700,000**
20	**Mechanical**	**$1,212,400**	**$105,000**
10	**Elec & Instrum**	**$2,776,200**	**$140,000**
Check	Sub Totals	$27,252,400	$1,267,000
$ 13,957,019	NPV Subtotals	Total	
	NPV O&M	Annual Values Far Right	

Box 5

Binary->	1	1	1
Year->	10	20	30
	$140,000	**$2,826,600**	**$140,000**
	$28,000	**$0**	**$0**
	$154,000	**$0**	**$0**
	$700,000	**$3,803,800**	**$700,000**
	$105,000	**$1,212,400**	**$105,000**
	$2,916,200	**$2,916,200**	**$2,916,200**
	$4,043,200	$10,759,000	$3,861,200
	$2,731,441	$4,910,267	$1,190,480
	$4,129,447	$2,978,071	$2,011,878

	Box 6						
	Unused Depreciation		Year				
		Years	50			Years	Year 50
	Life Balance	Remain	Deduction		Life Balance	Remain	Deduction
General Req.	**10**	**10**	**$198,869**		**-**	**20**	**$19,700**
Civil	**-**	**50**	**$1,982,978**		**40**	**10**	**$788**
Architect/Struc	**-**	**50**	**$357,551**		**40**	**10**	**$4,334**
Process Equip	**10**	**10**	**$267,621**		**-**	**20**	**$98,499**
Mechanical	**10**	**10**	**$85,300**		**-**	**20**	**$14,775**
Elec & Instrum	**-**	**10**	**$390,646**		**-**	**10**	**$19,700**
$ -	**Total**		**$3,282,966**				$157,795