LIFE CYCLE COST ANALYSIS FOR DECISION MAKING IN COLLECTION SYSTEM REHABILITATION

BY

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LIFE CYCLE COST ANALYSIS

- > A Tool for Making Sound Project Decisions Between Alternatives
- > Considers Both Capital and Operating Costs Over a Long Term Period
- Facilitates Supportable Business Case Decisions
- Commonly Applied to Treatment Plant or Pump Station Projects
- Equally Applicable to Collection System Projects
- LCC Analysis Is Required Under Section 602(b)(13) Of The Clean Water Act For Federally Funded and State Revolving Loan Projects



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THE CHALLENGE

- Over 800,000 Miles of Public Sewers and 500,000 Miles of Private Laterals In the US
- All Susceptible to Structural Failure, Blockages and Overflow
- ASCE Grades US Collection System Infrastructure D+
- EPA Estimates That \$51 Billion In Collection System Rehabilitation Is Needed in the Next 25 Years





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WE MUST GET IT RIGHT THE FIRST TIME

- **\$ Budgets for R&R Are Limited**
- \$ We Can't Afford To Get It Wrong. We Can't Afford To Do The Same Projects Over Again
- \$ We Must Choose Projects That Are Sustaina and Cost Less In The Long Run





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WHAT IS LCC?

Standards Worldwide

- STM International Defines LCC In ASTM Standard F1675-13:
- LCC Analysis Measures The Present Value Of All Relevant Costs To Install, Operate and Maintain Project Alternatives Over A Specified Period Of Time
- The Decision Maker Can Then Identify Alternatives With The Lowest Cost Based On Net Present Value
- The Alternatives Must Be Independent and Mutually Exclusive

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COSTS CONSIDERED IN LCC ANALYSIS

- Initial Installed Cost
- Material Service Life
- > Operating Costs
- Maintenance Costs
- Rehabilitation Costs
- Replacement Costs
- Ferminal Value (commonly called salvage value)







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DATA THAT SHOULD BE CONSIDERED IN LCC

- Job Site Reports
- Published Papers and Reports
- Manufacturer Product Data
- Local Experience With Alternatives



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EXAMPLE LCC ANALYSIS

Rehabilitation of a Gravity Sewer Lateral

- Three Independent, Mutually Exclusive Alternatives Analyzed:
 - Do Nothing Alternative
 - CIPP Lined Lateral Using Hydrophilic Adhesive-Based Seals
 - CIPP Lined Lateral Using Pre-Engineered, Hydrophilic, Molded Rubber Gaskets, ASTM F3240 Compliant Seals



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COSTS CONSIDERED IN EXAMPLE



- Initial Installation
- Periodic Replacement (if applicable)
- Conveyance and Treatment of Leakage Flow Volumes
- Periodic Maintenance of Lateral By CCTV Inspection, Cleaning and Grouting (if applicable)
- Costs Estimates Based On Case Studies, Utility Owner Experience and Recent Bids

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DATA USED TO DETERMINE MATERIAL SERVICE LIFE

	NASTT's 2019 Na-Dig Shaw
~	Chirago, Illinois March 17-20, 2019
	MA-T6-03
LIFE CYCL	E COST ANALYSIS FOR DECISION MAKING IN COLLECTION SYSTEM REHABILITATION
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2. INTRO	DUCTION
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	Paper MA-TG-03- 1

- Manufacturers Product Data
 Independent Laboratory Tests
 - **Numerous Case Studies**
 - **Published Papers and Reports**



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10,000 HOUR HYDRATION DE-HYDRATION TEST OF MOLDED RUBBER SEALS



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30-DAY IMMERSION TEST OF ASTM 3240 RUBBER SEALS AND ADHESIVE BASED SEALS



Percent Volume Change with Water

Water Submersion Days

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LONG-TERM CREEP CALCULATIONS

Effects of Creep on CIPP Sealing Mechanisms 8" Pipe 5'of Groundwater

8 Years After Installation

Caulk Sealing Mechanism

Host Pipe

Caulk Maximum

Swelled thickness

(0.12")

Annular Space

Now Present

To Scale

Molded Gasket Sealing Mechanism

Effects of Creep on CIPP Sealing Mechanisms 8" Pipe 5' of Groundwater 95 Years After Installation **Caulk Sealing Mechanism** Molded Gasket Sealing Mechanism Host Pipe Host Pipe Gasket Annular Space Maximum Swelled Thickness .3" Caulk Maximum Swelled thickness (0.012") CIPP .12" (3mm) CIPP .12" (3mm) To Scale

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LCC Calculation Method

Equation [1] is the standard equation for determining inflated costs:

$$InflC = C * (1 + ir)^t$$

where: InfIC = the cost after inflation at time C = initial cost at time t = 0 t = time in years

ir = annual inflation rate





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LCC Calculation Method - Continued

Equation [2] is the equation used for determining NPV:

$$NPV = \sum_{t=0}^{T} \frac{C_t}{(1+dr)^t}$$

where: NPV = the net present value of the stream of costs considered over the analysis period Ct = all relevant costs during year t dr = the discount rate expressed as a % t = the time in years (t=0.....T) (years) T = the selected analysis period

An Annual Inflation Rate of 2.25% and a Discount Rate of 5.00% have been assumed for the example given below, The analysis period has been defined to be 50 years, the generally accepted service life for CIPP mainline lining. Salvage (Terminal) values have been defined based on straight-line depreciation. For instance, if an asset with a useful life of 20 years were only 10 years into its service life at the end of the analysis period, then 50% of its installation cost would be credited at the end of the analysis period

TABLE 1
No Action Alternative

Inflation Rate = 2.25% Di

Discount Rate = 5.00%

rear	Installation Cost	VI Treatment	Inspect/ Grout	Total Annual Cost	Present Va
0	\$0.00	A 100.00			\$0.
1		\$400.00		\$400.00	\$380.
2		\$409.00		\$409.00	\$370.
3		\$418.20		\$418.20	\$361.
4		\$427.61	\$504.00	\$427.61	\$351.
5		\$437.23	\$524.68	\$961.91	\$753.
0		\$55.88		\$55.88	\$41.
1		\$114.28		\$114.28	\$81.
8		\$233.71		\$233.71	\$158.
9		\$358.45	¢5.00 40	\$358.45	\$231.
10		\$488.69	\$586.42	\$1,075.11	\$000.
11		\$02.40		\$02.40	\$30. ¢74
12		\$127.73 \$261.21		\$127.73 \$261.24	\$/1.
13		\$201.21		\$201.21	\$138.
14		\$400.03 \$546.10	CEE 42	\$400.03	\$202
10		\$040.19 \$60.01	\$000.40	\$1,201.03	
17		\$09.01		\$09.01	
10		\$142.70		\$142.70	φυ2. ¢101
10		\$291.95		\$291.95	
20		\$610.47	\$722.56	\$447.70	\$177.
20		\$010.47	\$1.52.50	\$1,343.03	\$300. \$20
21		\$150.56		\$150.56	φ20. \$5.4
22		\$109.00		\$109.00	φJ4. \$106
23		\$500.47		\$500.47	\$100.
24		\$300.47		\$500.47	\$100. \$201
25		\$607.66		\$607.66	\$201
20		\$713.36		\$713.36	\$190.
20		\$713.30		\$715.50	¢191.
20		\$745.92		\$775.92	\$100.
30		\$762.60		\$762.60	\$176
31		\$779.76		\$779.76	\$170
32		\$707.30		\$797.30	\$167
33		\$815.24		\$815.24	\$162
34		\$833.58		\$833.58	\$158
35		\$852.34		\$852.34	\$154
36		\$871.52		\$871.52	\$150
37		\$891.13		\$891.13	\$146
38		\$911.18		\$911.18	\$142
39		\$931.68		\$931.68	\$138
40		\$952.64		\$952.64	\$135
41		\$974.08		\$974.08	\$131
42		\$995.99		\$995.99	\$128
43		\$1,018.40		\$1,018.40	\$124
44		\$1,041.32		\$1,041.32	\$121
45		\$1,064.75		\$1.064.75	\$118
46		\$1,088.70		\$1,088.70	\$115
47		\$1,113.20		\$1,113.20	\$112
48		\$1,138.25		\$1,138.25	\$109
10		\$1 163.86		\$1 163 86	\$106
49		Ψ1,100.001		+ - - - - - - - - - -	÷

TABLE 2

CIPP Lined with Adhesive Seals Alternative

Inflation Rate = 2.25% Discount Rate = 5.00%

Year	Installation Cost	VI Treatment	Inspect/ Grout	Lining Replacement	Total Annual Cost	Present Value
0	\$1 290 00					\$1,290,00
1		\$0.00			\$0.00	\$0.00
2		\$0.00			\$0.00	\$0.00
3		\$0.00			\$0.00	\$0.00
4		\$0.00			\$0.00	\$0.00
5		\$0.00			\$0.00	\$0.00
6		\$55.88			\$55.88	\$41.70
7		\$85.71			\$85.71	\$60.91
8		\$116.85			\$116.85	\$79.09
9		\$179.22			\$179.22	\$115.53
10		\$305.43	\$586.42		\$891.85	\$547.52
11		\$62.46	\$000.42		\$62.46	\$36.52
12		\$95.80			\$95.80	\$53.34
13		\$130.60			\$130.60	\$69.26
14		\$200.32			\$200.32	\$101.17
15		\$273.10			\$273.10	\$131.36
16		\$275.10			\$210.05	\$151.00
17		\$349.00			\$429.00	\$139.90
10		\$420.29			\$420.29	\$100.00
10		\$510.91			\$510.91	\$212.29
19		\$397.03		\$1.069.76	\$397.03	\$230.21
20		\$010.47		\$1,900.70	\$2,579.23	\$972.00
21		\$0.00			\$0.00	\$0.00
22		\$0.00			\$0.00	\$0.00
23		\$0.00			\$0.00	\$0.00
24		\$0.00			\$0.00	\$0.00
25		\$0.00			\$0.00	\$0.00
26		\$87.21			\$87.21	\$24.53
27		\$133.75			\$133.75	\$35.83
28		\$182.35			\$182.35	\$46.52
29		\$279.68			\$279.68	\$67.95
30		\$476.62	\$915.12		\$1,391.74	\$322.02
31		\$97.47			\$97.47	\$21.48
32		\$149.49			\$149.49	\$31.37
33		\$203.81			\$203.81	\$40.74
34		\$312.59			\$312.59	\$59.50
35		\$426.17			\$426.17	\$77.26
36		\$544.70			\$544.70	\$94.05
37		\$668.34			\$668.34	\$109.90
38		\$797.28			\$797.28	\$124.86
39		\$931.68			\$931.68	\$138.96
40		\$952.64		\$3,072.27	\$4,024.91	\$571.72
41		\$0.00			\$0.00	\$0.00
42		\$0.00			\$0.00	\$0.00
43		\$0.00			\$0.00	\$0.00
44		\$0.00			\$0.00	\$0.00
45		\$0.00			\$0.00	\$0.00
46		\$136.09			\$136.09	\$14.42
47		\$208.72			\$208.72	\$21.07
48		\$284.56			\$284.56	\$27.36
49		\$436.45			\$436.45	\$39.96
50		\$743.78	\$1,428.05	(\$1,918.94)	\$252.88	\$22.05
v						\$6,185.37

TABLE 3 CIPP Lined with ASTM 3240 Compliant Seals Inflation Rate = 2.25% Disc

Discount Rate = 5.00%

Year	Installation Cost	VITreatment	Inspect	Lining Replacement	Total Annual Cost	Present Value
0	\$2,440.00					\$2,440.00
1		\$0.00			\$0.00	\$0.00
2		\$0.00			\$0.00	\$0.00
3		\$0.00			\$0.00	\$0.00
4		\$0.00			\$0.00	\$0.00
5		\$0.00			\$0.00	\$0.00
6		\$0.00			\$0.00	\$0.00
7		\$0.00			\$0.00	\$0.00
8		\$0.00			\$0.00	\$0.00
9		\$0.00			\$0.00	\$0.00
10		\$0.00	\$277.94		\$277.94	\$170.63
11		\$9.37			\$9.37	\$5.48
12		\$9.58			\$9.58	\$5.33
13		\$9.80			\$9.80	\$5.19
14		\$10.02			\$10.02	\$5.06
15		\$10.24			\$10.24	\$4.93
16		\$10.47			\$10.47	\$4.80
17		\$10.71			\$10.71	\$4.67
18		\$10.95			\$10.95	\$4.55
19		\$11.19			\$11.19	\$4.43
20		\$11.45	\$347.20		\$358.65	\$135.17
21		\$15.61			\$15.61	\$5.60
22		\$15.96			\$15.96	\$5.45
23		\$16.32			\$16.32	\$5.31
24		\$16.68			\$16.68	\$5.17
25		\$17.06			\$17.06	\$5.04
26		\$17.44			\$17.44	\$4.91
27		\$17.83			\$17.83	\$4.78
28		\$18.24			\$18.24	\$4.65
29		\$18.65			\$18.65	\$4.53
30		\$19.06	\$433.73		\$452.79	\$104.77
31		\$29.24			\$29.24	\$6.44
32		\$29.90			\$29.90	\$6.27
33		\$30.57			\$30.57	\$6.11
34		\$31.26			\$31.26	\$5.95
35		\$31.96			\$31.96	\$5.79
36		\$32.68			\$32.68	\$5.64
37		\$33.42			\$33.42	\$5.49
38		\$34.17			\$34.17	\$5.35
39		\$34.94			\$34.94	\$5.21
40		\$35.72	\$541.81		\$577.54	\$82.04
41		\$48.70			\$48.70	\$6.59
42		\$49.80			\$49.80	\$6.42
43		\$50.92			\$50.92	\$6.25
44		\$52.07			\$52.07	\$6.08
45		\$53.24			\$53.24	\$5.93
46		\$54.44			\$54.44	\$5.77
47		\$55.66			\$55.66	\$5.62
48		\$56.91			\$56.91	\$5.47
49		\$58.19			\$58.19	\$5.33
50		\$59.50	\$676.84		\$736.34	\$64.21
NDV						\$3 100 40
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EXAMPLE LCC ANALYSIS RESULTS

- Do Nothing Alternative: NPV = \$9494.85
- >Adhesive/Paste Based Liner: NPV = \$\$6185.37
- ASTM F3240 Compliant Liner: NPV = \$3192.42



FIGURE 4 Cumulative Annual Costs (Uninflated)

- The ASTM F3240 Compliant Alternative, Although the Most Expensive in Initial Installation Cost, Is the Least Cost Alternative Over the 50-year Period – by a Factor of 2!
 - The LCC Analysis Method Clearly Demonstrates To the Owner the Most Cost Effective Alternative Over the Long-Term
 - LCC Analysis Provides a Clear Cut, Supportable Business Case For Decision Making

QUESTIONS?