Cost and Effectiveness Analysis of Water and Wastewater Projects

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Oklahoma Funding Agency Coordinating Team (FACT)

- Oklahoma Water Resources Board
- Oklahoma Department of Environmental Quality
- Oklahoma Department of Commerce
- Indian Health Services
- Cherokee Nation
- USDA Rural Development

FACT Guidelines and Checklists

- Engineering Reports for Water Projects
- Engineering Reports for Wastewater Projects
- Guide for Preparation of Environmental Information Document (EID)
- EID Checklist for Water & Wastewater Projects
- Guidelines for Request for Proposal for Engineering Services
- Agreement for Engineering and Environmental Services

Interagency Memorandum for Development of Preliminary Engineering Report

January 16, 2013

- US Department of Agriculture, Rural Development, Rural Utilities Service, Water and Environmental Programs
- US Environmental Protection Agency (EPA) Office of Water, Office of Ground Water and Drinking Water and Office of Wastewater Management
- US Department of Housing and Urban Development (HUD), Office of Community Planning and Development
- US Department of Health and Human Services, Indian Health Service (IHS)
- Small Communities Water Infrastructure

Guidelines for ER for Water and Wastewater

- Project Planning Area
- Existing Facilities and Need for Project
- **Alternatives Considered (and Selection of an Alternative)**
- Proposed Project Design and Cost Estimate (Recommended Alternative)
- Financial status
- Conclusions and Recommendations

Alternatives Considered

- Alternatives should be consistent with National Environmental Policy Act (NEPA) environmental review
- Technically feasible
- Other considerations include design criteria, environmental impacts, land requirements, construction problems
- Sustainable considerations including water and energy efficiency, green infrastructure and resiliency
- Cost estimates (construction and non-construction)
- Advantages and disadvantages

Example project

- Headworks with bar screen, grit removal and flow splitter
- Oxidation ditch
- Clarifiers
- Chlorine contact basin
- One stormwater basin
- Sludge holding ponds
- Discharge/outfall

Alternatives Considered

1. No action or Do-nothing
2. Rehabilitate and expand existing facility
3. Construct new wastewater treatment plant
4. Construct new total retention lagoon system
5. Pump wastewater to neighboring community for treatment

Alternatives Considered Example

- ~~No action or Do-nothing~~
- **Rehabilitate and expand existing facility**
- **Construct new wastewater treatment plant**
- ~~Construct new total retention lagoon system~~
- ~~Pump wastewater to neighboring community for treatment~~

Selection of an Alternative

- Cost Analysis
  - Present worth cost analysis
- Non-Monetary Factors
  - Social and environmental
    - Sustainability
    - Water and energy efficiency
    - Operator training
    - Permit issues
    - Community objections
    - Reduction in greenhouse gas emissions
    - Wetland relocation

Cost Effective Present Worth Analysis

- Convert all costs to present day dollars
  - Capital cost
  - O&M cost
  - Salvage value

Present Worth (PW) = [Capital Cost] + [Uniform Series Present Worth]$_{O\&M}$ – [Single Payment Present Worth]$_{Salvage\ Value}$

Cost Effective Present Worth Analysis cont'd

- Determine **Discount Rate Factor (i)**.
  - Use the "real" Federal Discount Rate
    - Appendix C of OMB Circular A-94
  - What is a real rate versus a nominal rate?
    - Nominal includes market inflation
    - Real removes expected inflation
- The rate is based on a calendar year: www.whitehouse.gov/omb/circulars_a094_a94_appx-c/
- *Example: The 20 yr real rate is 3.6% for 2013.*

Cost Effective Present Worth Analysis cont'd

- Determine **Capital Cost.** Capital Cost is the estimated construction plus non-construction costs for the alternative shown in the Engineering Report.

- *Example: Total construction costs for a water treatment plant (WTP) rehabilitation are $1,000,000.00. Total non-construction costs are $156,900 (engineering report = $8500; all other engineering fees = $80,400; legal fees = $26,000; environmental information document = $10,000; land = $20,000; geotechnical testing = $12,000). Total capital costs = $1,156,900.*

Cost Effective Present Worth Analysis cont'd

- Determine **Uniform Series Present Worth $_{O\&M}$.** Uniform Series Present Worth $_{O\&M}$ is the present worth of the operation and maintenance (O&M) costs for the alternative. These costs are assumed to be constant for the life of the project.
  - Determine the annual O&M cost (A)
  - Determine the present worth of the O&M for the life of the project (PW $_{O\&M}$)

Cost Effective Present Worth Analysis cont'd

- $PW_{O\&M} = \frac{A[(1+i)^N - 1]}{i(1+i)^N}$

  $PW_{O\&M}$ = present worth of O&M series

  A = annual O&M value (assumed constant)

  i = discount rate

  N = number of years in evaluation period

- *Example: The WTP has an annual O&M cost of $50,000.*

  N = 20 years (in most cases), i = 0.036, A = $50,000

  *$PW_{O\&M} = A * 14.08 = \$50,000 * 14.08 = \$704,235$*

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Cost Effective Present Worth Analysis cont'd

- Determine **Uniform Series Present Worth $_{SLA}$** for Short Lived Assets.
  - Uniform Series Present Worth $_{SLA}$ is the present worth of the short lived assets for the alternative. Short lived assets should be included in the life cycle cost when deemed appropriate by the consulting engineer and/or the funding agency.

Cost Effective Present Worth Analysis cont'd

- Determine **Salvage Value**. Salvage Value is only needed if the useful life is longer than the planning period, otherwise if the useful life is equal to the planning period, the salvage value is zero
- Start with useful life of facility or infrastructure
- Assume straight line depreciation and 20 year analysis
  - salvage value at 20th year = capital cost * (years of service remaining at end of planning horizon / total useful life)

Cost Effective Present Worth Analysis cont'd

- $PW_{\text{salvage value}} = F(1 + i)^{-N}$

  $PW_{\text{salvage value}}$ = present worth of salvage value

  F = future salvage value

  i = discount rate

  N = number of years in evaluation period

Example: N = 20 years (in most cases), i = 0.036

*If the WTP has a useful life of 30 years (at 20 years, there is 10 years remaining) and a capital cost of $1,156,900, then F = 1/3 * ($1,156,900) = $385,633*

$PW_{\text{salvage value}} = \$385,633\ (1 + 0.036)^{-20} = \$190,100$

Cost Effective Present Worth Analysis cont'd

- **Present Worth (PW) for each alternative = [Capital Cost] + $[\text{Uniform Series Present Worth}]_{O\&M}$ + $[\text{Uniform Series Present Worth}]_{\text{Short Lived Asset}}$ - $[\text{Single Payment Present Worth}]_{\text{Salvage Value}}$**

Example: Therefore, Present Worth (PW) for the alternative = [Capital Cost] + $[\text{Uniform Series Present Worth}]_{O\&M}$ – $[\text{Single Payment Present Worth}]_{SV}$

PW = $1,156,900 + $704,235 – $190,100 = $1,671,035

PW Analysis of Example Project

	Alternative A Rehab and expand existing facility	Alternative B Construct new wastewater treatment plant
Capital cost	$2,484,200.00	$6,000,000.00
PW O&M	$4,133,279.37	$4,133,297.37
PW Salvage value	$0	$0
Net PW (Value)	$6,617,479.37	$10,133,297.37

Water meter replacement project

- **Two alternates considered**
  - *Alternate No. 1 – (Meter Replacement – Non-AMR) Replace the existing meters* with conventional positive displacement water meters that are not equipped with the automated meter reading capability.
  - *Alternate No. 2 – (AMR Meter Replacement) Replace the existing meters with* water meters compatible with automated meter reading and meter interface units (MIU) and install the necessary equipment for a drive-by AMR system.

Cost Comparison

Table 5 – Cost Comparison			
No.	**Description**	**Alternate 1**	**Alternate 2**
1	Materials (PD Meters)	150,000	$380,000
2	Installation	80,000	$87,000
3	AMI Equipment and Installation	0	$15,000
4	Engineering	28,000	$28,000
5	Distribution Repairs & Upgrades	31,000	$31,000
6	Legal	5,000	$5,000
7	Contingency	25,000	$55,000
	Total Project Cost	**$319,000**	**$601,000**

PW Analysis

Table 6 – Present Worth Analysis			
No.	**Description**	**Alternate 1**	**Alternate 2**
1	Capital Cost	$319,000	$601,000
2	Meter Reading (Alt 1 -$30K/YR; Alt 2 - $1.8K/YR)	$407,700	$24,462
3	Service Calls ($5K/YR)	$67,950	0
4	Vehicle Expense ($2K/YR)	$27,180	0
	Total (PW)	**$821,830**	**$625,462**
	Interest of 4% for 20 years (Factor - 13.59)		

Comparison of Alternates

- Alternate No. 1 – This alternate would replace all of the meters in the system with conventional water meters. The replacement program would help determine the water loss in the system and increase revenue. Revenue increase would be as a result of capturing the unmetered water due to the old inaccurate meters in the system. This option does not eliminate the manual reading of meter on a monthly basis. It also does not give the city the ability to monitor individual meter usage on an hourly basis to check for water leakage. None of the advantages and cost savings associated with an automated meter reading system would be realized.
- Alternate No. 2 – This alternate would replace all of the meters in the system with meters designed for an automated meter reading system. Advantages associated with this type of system include:
    - Eliminate the need to manually read meters
    - Increase accuracy in meter reads
    - Leak detection capability for customers
    - Reduction in service calls
    - Increase in revenue due to more accurate meters
    - Better record keeping
    - Help minimize system water loss
    - Increase in customer service
    - Reduction in energy use associated with reading meters

Non-Monetary Factors (Effectiveness)

- Maximizes the potential for
  - Efficient water use
  - Reuse
  - Recapture
  - Conservation
  - Energy conservation
  - Green projects (Checklist as part of Engineering report)
  - Business cases

Minimum Conditions for Fiscal Sustainability Plan (per WRRDA Amendments 2014)

- Each CWSRF program, at a minimum the FSP must cover the following:
  1. An inventory of critical assets that are a part of the treatment works
  2. An evaluation of the condition and performance of inventoried assets or asset groupings
  3. A plan that the borrower has evaluated and will be implementing water and energy conservation efforts
  4. A plan for maintaining, repairing and as necessary replacing the treatment works and a plan for funding such activities

FSP Certification

Two Tracks

	1. AT LOAN CLOSING	2. PRIOR TO FINAL PAY REQUEST
Self-Certify	☑ Borrower certifies that they *have developed* and *implemented* a FSP that contains, at a minimum, the four requirements and *has or will update* its FSP with this loan project.	☑ Borrower certifies that they *have updated* their FSP with this loan project.
Certify	☑ Borrower certifies that they *will develop* a FSP for the infrastructure built with this loan that contains, at a minimum, the four requirements. Borrower further certifies that *implementation will begin prior to the final pay request*	☑ Borrower *has developed* a FSP for the infrastructure built with this loan that contains , at a minimum, the four requirements. OWRB engineers verify that the FSP exists and contains , at a minimum, the four requirements.

Draft Certification At Loan Closing

EXHIBIT H

[Fiscal Sustainability Plan]

The Borrower shall comply with all federal requirements applicable to the Loan (including those imposed by the 2015 Water Resources Reform and Development Acts to the Federal Water Pollution Control Act) which the Borrower understands includes, among other, requirements that a fiscal sustainability plan (FSP) be implemented or a certification that the borrower has previously implemented an FSP. The FSP must meet the following conditions:

- An inventory of critical assets that are a part of the treatment works;
- An evaluation of the condition and performance of inventoried assets or asset groupings:
- A plan that the borrower has evaluated and will be implementing water and energy conservation efforts; and
- A plan for maintaining, repairing and as necessary replacing the treatment works and a plan for funding such activities

Self-Certify

☐ The Borrower certifies that it has already developed and implemented a FSP that contains the four requirements as listed above. A certification that the FSP has been updated to include the infrastructure constructed with this loan will be required prior to the approval of the final disbursement request.

Certify

☐ The Borrower certifies that it will develop a FSP that contains the four requirements as listed above. A certification that the FSP has been developed for the infrastructure constructed with this loan will be required prior to the approval of the final disbursement request.

(internal) FSP Checklist

		Yes	No	N/A
1.	Entity is self-certified[1]	☐	☐	☐

2. If no, entity will have to submit a proposed Fiscal Sustainability Plan (FSP) based on the list below.

	Yes	No	N/A
i. An inventory of critical assets[2] that are part of the treatment works.	☐	☐	☐
ii. An evaluation[3] of condition and performance of inventoried assets.	☐	☐	☐
iii. A certification[4] that the recipient has evaluated and will be implementing water and energy conservation[5] efforts as part of the plan.	☐	☐	☐
iv. A plan for maintaining, repairing and replacing the treatment works and plan for funding such activities.	☐	☐	☐

[1] An entity can self-certify and will not be required to submit an FSP.
[2] Critical assets are developed in Section 4: Asset Management tables of the Wastewater Planning Guide (WWPG).
[3] An evaluation of condition is based on the lifespan of the asset (Evaluations are entered in Section 4 of WWPG).
[4] An FSP certification is a certification by the borrower that the FSP has been developed and is being implemented.
[5] Water and energy conservation resources can be found in Appendix I of CWSRF WWRDA Guidance (Evaluation and Implementation Alternatives are developed in WWPG Section 8: Identifying Conceptual Alternatives. Further resources for water and energy conservation are found in Appendices C and D).

Oklahoma Comprehensive Water Plan

Public Wastewater System Planning Guide

www.owrb.ok.gov/guides

Oklahoma Water Resources Board

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Wastewater Planning Guide (FPS)

- Introduction
- Rules and Regulations
- Gathering Data
- Asset Management
- Wastewater System Administration
- Determining Future Wastewater Needs
- Wastewater System Capital Analysis
- Identifying Conceptual Alternatives
- Evaluating Alternatives
- Preparing an Engineering Report and Project Financing

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Inventory of Critical Assets

System Name			
Date of assessment (mm/dd/yyyy)			
Facility type			
Use numbered columns for each separate unit [1]	Unit 1	Unit 2	Unit 3
PUMPS		Short-lived asset? ☐ Yes ☐ No	
Number of pumps			
Type of pump			
Manufacturer			
Rated capacity of pump (gpm @ feet TDH)			
Specifications — Horsepower			
Specifications — Volts			
Specifications — Speed (rpm)			
Assumed solids concentration?			
Variable or co			
Installation da			
Base effective useful life (years)			
Initial Efficiency Rating			
Estimated remaining effective useful life (years)			
Replacement within next 5 years?	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No
CONTROL		Short-lived asset? ☐ Yes ☐ No	
Number of units			
Description of control strategy			
Installation date (mm/dd/yyyy)			
Estimated remaining effective useful life (years)			
Replacement within next 5 years?	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No
Perceived condition (Poor, Fair, Good, Excellent)			

Evaluation of Condition & Performance

[1] *Use additional forms if necessary.*

Inventory of Short-Lived Assets

Identify the system's short-lived assets and include the expected year of replacement and anticipated cost for each (see Appendix E for examples). Prepare a recommended annual reserve deposit to fund the replacement of these items. Generally, short-lived assets are items not covered under O&M, however, this does not include facilities that are usually funded with long-term capital financing.

Table 4-25: List of Items to be Replaced in 5 Years

System Name		
Name	Date	Means of Replacement[1]

Table 4-28: Routine Operation and Preventative Maintenance Program

System Name	
Attach documentation and/or describe routine operation and preventative maintenance programs. ☐ Documentation is attached.	

Table 4-29: Routine and Preventative Maintenance Data

System Name	
Function	Frequency
List below items to check and/or adjust[1]	Enter function performance interval[2]

[1] *Such as adjusting flow control valves, reading flow meters, checking water or chemical levels, exercising critical valves, lubricating equipment, etc.*

[2] *Daily, weekly, monthly, etc.*

"Normal" Operation

Use the following table to provide a history of process settings during "normal" facility / system operation. For example, in order to achieve a better hydraulic split of flow between two basins, one inlet valve (or gate) may need to be 100 percent open while the valve (or gate) to the other basin needs to be only 75 percent open. If no unique settings are known, the table can be disregarded. This can also include process parameters that achieve successful results, such as "a mixed liquor suspended solids (MLSS) operating range of 2,500 to 3,000 milligrams per liter (mg/L) produces compliant effluent through the entire year" or "keep dissolved oxygen (DO) in the aeration basins at 1 to 3 mg/L, etc."

Table 4-30: Normal Operational Data Tips and Tricks

System Name	
Element	Setting
List below items which require specific settings[1]	Enter setting values or specific instructions including units below[2]

Project Prioritization With Timeline Matrix

	Critical	Funding Sources	Non-Critical	Funding Sources
Within 1 Year				
1 to 3 Years				
3 to 5 Years				
5 to 10 Years				
10 to 25 Years				
Beyond 25 Years				

The second example allows the incorporation of implementation timeline priorities. The projects are listed in critical and noncritical categories similar to the first example
They are placed in time priority order using the general periods listed on the left.

Table 8-3: Evaluation and Implementation of Water and Energy Conservation Efforts

System Name		
Planning Methodology	Yes	No
Project is a comprehensive planning effort that includes other public and/or private sector organizations		
Project alternatives analysis explores the most cost-effective solution at a regional level		
Project incorporates at least one planning methodology[1]		
Rate structures will support ongoing operations and maintenance for this project		
Energy Efficiency	Yes	No
Facility has performed a professional energy audit		
Facility has developed an Energy Conservation Plan		
Equipment is properly maintained, operating as close to nameplate voltage as practicable, and the connection on switches on all major power-driven equipment is checked at least annually		
Facility uses variable frequency drives to improve pump efficiency		
Pump operations are automated		
Facility uses variable and multiple staged single-speed blowers		
Facility uses digester gas to fuel engine-driven blowers		
Facility uses two-speed mechanical aerators where applicable		
Facility implements continuous DO monitoring		
Facility uses digester gas to fuel engine-driven blowers		
Automated aeration control systems are installed		
Facility uses natural light to the greatest extent possible		
Facility uses programmable thermostats		
Facility has assessed building insulation R-values and sealed leaks		
Water Efficiency	Yes	No
Facility has developed a Water Conservation Program		
Facility has taken measures to implement pressure management controls throughout collection system		

Table 8-6: Wastewater Treatment Challenges and Preliminary Alternatives

System Name		
Wastewater Treatment Challenges	Preliminary Alternatives	Implementation Time Frame
Notes		

Table 8-7: Effluent Disposal/Reuse Challenges and Preliminary Alternatives

System Name		
Wastewater Effluent Disposal/Reuse Challenges	Preliminary Alternatives	Implementation Time Frame
Notes		

In Table 8-8, develop alternatives (or combinations of preliminary solutions in the previous subsection) to be considered in Section 9. Because of the interconnected nature of utilities, decisions in one category of preliminary alternatives may have a significant impact on other categories. Do some solutions work better together? Do some potential solutions exclude others? Consider the alternative of doing nothing. What happens if no action is taken and no costs or changes to operation are incurred? The "no action" alternative must always be evaluated by NEPA-driven funding programs.

Table 8-9: Conceptual Alternatives

System Name			
	Conceptual Alternative Name	Conceptual Alternative Description	Will this alternative be given further consideration?
1	No Action	This alternative involves continued operation of the existing wastewater system without modifications to collection, transmission, treatment, effluent disposal, or residuals management.	☐ Will be considered further ☑ Will not be considered further (explain decision below)
2			☐ Will be considered further ☐ Will not be considered further (explain decision below)
3			☐ Will be considered further ☐ Will not be considered further (explain decision below)

Multiple Tools for Project Selection

- Water for 2060
- Planning guides
- OK Advantages Assessment & Scoring for Infrastructure Solutions (OASIS)
- FSP guide
- Green project reserve checklist and EPA Crosswalk for Green projects
- Envision
- Cost Analysis

Questions?

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