EST.08

Controlling Non-Construction Costs

Mr. Peter R. Bredehoeft, Jr.

The success of a capital project starts years prior to the actual design and construction of the project, during the capital improvement budgeting process. The cost estimating process can directly affect the budgeting of capital projects. Poor cost estimating processes or lack of a standard conceptual estimating process may adversely affect capital improvement projects. Owners' expectations revolve around accurate budgets that will not increase throughout the life of the project. Accurate budgets require a cost estimating methodology that is repeatable, defendable, and based on historical information.Owners seek funding through various sources, including working capital, revenue bonds, loans, or grants. Therefore, good estimating practices and methodology applied at the start of the project with the initial capital budget can be the success or failure of a project.

This paper will focus on the budgeting process and methodology for capital improvement projects, primarily for the water, wastewater, and public works market segments. However, the author feels these processes are applicable to all industries. The paper is written from an owner perspective through the eyes of a consultant. Historical costs for construction and non-construction (soft) costs can be a good indicator for future capital projects. In the public bidding process, non-construction costs are virtually the only costs the owner can control. By implementing various estimating validation processes, the owner can control these non-construction costs.

Approximately, 70 percent of the cost of a project is attributable to construction costs and the remaining 30 percent is attributable to non-construction cost for most water treatment processes, wastewater treatment processes, and conveyance type projects. In the late 1970s and early 1980s, the U.S. Environmental Protection Agency studied these types of projects and determined various non-construction percentages from these studies [10] [11]. Other water and wastewater programs have shown these costs to be similar [Table 3]. From a cost estimating perspective, the level of effort should be spent in determination of the construction cost estimate and then by factoring a percentage of construction costs for non-construction costs to determine the overall capital cost of a project. his methodology is an effective and accurate method of budgeting of capital projects.

Jelen's Cost and Optimization Engineering provides the following definition: "capital-cost estimating is essentially an intuitive process which attempts to predict the final outcome of a future capital expenditure program even though not all parameters and conditions concerning a project are known or are not fully defined when the cost estimate is prepared" [12]. The key word is "to predict the final outcome." Using historical factors for budgeting non-construction cost is an effective way to predict the final outcome of these costs. It should be stated that the author is only focusing on the initial capital cost of a project for the purposes of this paper. Included are direct project costs for construction and the indirect project cost, which include non-construction costs for design, engineering, and services during construction, plus other associated costs. However, the project contains other costs that must be considered through the life-cycle of the project, such as: operation and maintenance costs (such as labor, power, chemicals, and consumables), general expenses, and administrative expenses, all of which are a part of the total life-cycle costs [5]. Historical project construction and non-construction costs can be used to budget future capital projects. Use cost estimating best practices to determine a reliable construction cost estimate and then factor non-construction costs by applying historical percentages to determine the total capital cost of a project.

CAPITAL IMPROVEMENT BUDGETING METHODOLOGY

The capital improvement budgeting process involves the following major steps or processes.

Collect Historical Information

Owners and consultants should keep track of construction and non-construction costs for historical purposes. This information is derived from actual construction bids and the associated design or engineering services contracts or associated internal operational costs associated with the total project expenditures. Historical non-construction costs are determined by dividing the actual non-construction component of a project by the total construction cost of that project. Running averages for these non-construction costs should be kept for historical data and analyzed on a yearly basis. See historical cost information for non-construction costs for additional information.

Table 1—Typical Non-construction Cost.

Owner or Agency - External Costs (Services performed by staff other than Owner's staff)

- Planning or Study Services
- Pre-design Services (Schematic)
- Design Services (Design Development and Final)
- Design Oversight (Oversight or PM of Design)
- Geotechnical Testing
- Soil Testing
- Hydraulic Testing
- Permitting Fees
- Bid and Award Services
- Construction Management Services
- Construction Inspection Services
- Engineering Services During Construction
- Modeling Services

Owner or Agency - Internal Costs (Services performed by Owner's staff)

- Planning or Study Services
- Advertising Costs
- Legal Fees
- Accounting Services
- Audit Fees
- Permitting Fees
- Relocation Costs
- Travel Costs
- Bond Fees
- Taxes
- Interest Costs
- Insurance Costs
- Start-up Costs
- Cost of Land & Easements
- Project Management of External Services

Table 2—Typical Non-construction Costs and Percentage of Construction Ranges.

		Percent of Construction $ [A]			
Item	Description or Component	Low Range	High Range	Typical Range [B]	Historical Average from Table 3
	INDIRECT COSTS				
1.	Planning or Studies Services	0.5%	4.1%	1.5%	1.3%
2.	Pre-Design Services (Schematic)	1.5%	3.5%	2.0%	1.7%
3.	Design Services (Design Development and Final)	3.7%	12.3%	8.0%	7.2%
4.	Design Management (Oversight or PM of Design)	0.5%	4.5%	2.0%	0.6%
5.	Land and Easement	0.3%	5.2%	3.0%	1.8%
6.	Material Testing or General Testing	0.5%	1.0%	1.0%	0.1%
7.	Construction Management Services	3.5%	6.3%	4.0%	4.0%
8.	Construction Inspection Services	1.4%	5.0%	5.0%	3.8%
9.	Engineering Services During Construction	1.1%	4.0%	3.0%	2.5%
10.	Other Costs	1.1%	4.0%	0.5%	0.7%
	Subtotal	**14.1%**	**49.9%**	**30.0%**	**23.8%**
	OTHER INDIRECT COSTS				
11.	Program Management	1.5%	9.7%	4.0%	3.2%
	DIRECT COSTS				
12.	Construction Direct Cost	63.1%	90.9%	70.0%	73.0%

A = Typical for the Water, Wastewater and Conveyance industries. Other Industries may vary.
B = Authors interperitation of typical range.

Estimate Construction Cost

The majority of the level of effort in the production of a capital cost estimate should be spent in the determination of the construction amount, since this represents approximately 70 percent of the total capital cost of a project. The cost estimates should be semi-detailed planning level estimates derived from project-specific scopes. The bottoms-up estimating process, standard cost models, or assembly costs can be used to develop a project-specific construction cost estimate. The contingency for the project should be included in the construction costs. See the construction cost estimates section for more information.

Budget for Non-Construction Costs

Once a construction cost is determined, budgets for non-construction cost can be determined by factoring from historical non-construction cost percentages to determine an overall capital budget. See capital improvement budgeting for additional information.

Perform Engineering Labor Fee Estimates

As a capital project is funded and moves forward in the implementation process, independent labor fee estimates can be developed as a comparison to proposed fees for design services, engi-

Table 3—Historical Percentages and Non-construction Costs.

Item	Description or Component	Percent of Construction $ [A] EPA Info WWTP [B]	EPA Info Sewers [C]	Water and Wastewater Program [D]	Wastewater Program [E]	Water and Wastewater Program [F]	Wastewater Program [G]	Water Program [H]	Average
	INDIRECT COSTS								
1.	Planning or Studies Services	4.1%	0.7%	0.5%	2.0%	1.0%	0.0%	1.0%	1.3%
2.	Pre-Design Services (Schematic)	1.5%	0.0%	1.5%	2.0%	1.5%	2.0%	3.5%	1.7%
3.	Design Services (Design Development and Final)	7.6%	3.7%	12.3%	8.0%	4.0%	9.0%	6.0%	7.2%
4.	Design Management (Oversight or PM of Design)	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	4.5%	0.6%
5.	Land and Easement	5.2%	0.3%	4.7%	0.0%	0.0%	0.5%	1.9%	1.8%
6.	Material Testing or General Testing	0.0%	0.0%	0.0%	1.0%	0.0%	0.0%	0.0%	0.1%
7.	Construction Management Services	6.3%	0.0%	0.0%	5.0%	3.5%	9.4%	3.5%	4.0%
8.	Construction Inspection Services	4.6%	1.5%	5.5%	4.0%	4.5%	1.4%	5.0%	3.8%
9.	Engineering Services During Construction	3.0%	1.1%	2.7%	3.0%	2.0%	1.4%	4.0%	2.5%
10.	Other Costs	2.5%	1.9%	0.0%	0.5%	0.0%	0.0%	0.0%	0.7%
	Subtotal	**34.8%**	**9.1%**	**27.2%**	**25.5%**	**16.5%**	**23.8%**	**29.4%**	**23.8%**
	OTHER INDIRECT COSTS								
11.	Program Management	0.0%	0.0%	9.7%	3.0%	1.5%	4.0%	4.5%	**3.2%**
	DIRECT COSTS								
12.	Construction Costs	65.2%	90.9%	63.1%	71.5%	82.0%	72.2%	66.1%	**73.0%**

A = Typical for the Water, Wastewater and Conveyance industries. Other Industries may vary.
B = EPA Doc #430/9-83-004, Table 3.1, June 1983, Construction Costs for Municipal Wastewater Treatment Plants, 1973-1982.
C = EPA Doc #430/9-77-015, Table 6.5, May 1978, Construction Costs for Municipal Wastewater Conveyance Systems, 1973-1977.
D = Large Water and Wastewater Program ($3 billion) in Southeast, December 2004.
E = Large Wastewater Program in Midwest, October 1978
F = Medium Water and Wastewater Program in Southeast, November 2001
G = Medium Wastewater Program in Southwest, November 1997
H = Large Water Program in Puerto Rico, April 2002

neering services, and services during construction. Performing an independent labor fee estimate serves as a benchmark for comparison of scope, level of effort, and man-hour pricing, which helps both the owner and consultant have a better understanding of the project and the labor fee. The labor fee estimate can be compared to the capital budget and the historical non-construction cost for reference in the negotiations process. See the controlling non-construction costs section for additional information.

Review Non-Construction Costs

Periodic review of the actual non-construction costs from previous contract expenditures should be performed as part of the annual capital improvement planning process. These actual percentage of construction costs should be compared with the percentages used in the budgeting process for non-construction budget and adjustments made accordingly. See capital improvement planning process for additional information.

HISTORICAL COST INFORMATION FOR NON-CONSTRUCTION COSTS

Keeping accurate historical costs can be your greatest asset in the determination of capital budgets. Documentation of historical project contract expenditures is critical in the determination of historical percentages of construction costs. There must be a centralized collection system that is consistently the same from project to project. Categories for the types of projects, types of contract expenditures and definitions for these costs must be established and remain the same from year to year so that trends in the historical data can be determined. Only those costs that can be captured from actual contract expenditures can be considered. A simplified approach is the most advantageous. If internal operations costs for a city or government agency for items such as internal construction management or internal construction inspection services cannot be allocated back to the cost of a project from some sort of accounting system or ERP system, then these costs must be excluded from the historical non-construction cost analysis. Note that all owner costs could be included under a single line entry for "estimated owner's costs."

Table 1 illustrates the typical non-construction costs that are external and internal to an owner or agency for most capital projects. Table 2 shows various non-construction cost ranges of percentages. Table 3 illustrates various historical non-construction percentages from EPA documents in the 1970s and 1980s, as well as various program non-construction cost percentages. Although these EPA studies may be old, the percentages have remained approximately the same as construction costs have risen along with costs of labor.

CONSTRUCTION COST ESTIMATES

In the author's opinion, the bottom-up method of cost estimating is the best approach to cost estimating-even as a method for conceptual cost estimating for capital improvement projects. At the conceptual or planning stage of a treatment plant project, scope items are generally known or can be assumed. Therefore, these items can be estimated at some minimum level of detail, including: type of project, size or capacity of the project, existing facilities or process, new or planned process, location of project, and types of facilities. The estimate can be organized by facility type and then by CSI division of work. In the case of a conveyance project, the following information is generally known, or can be assumed, and can be estimated at some level of detail. For

Table 4—Contingency, Based Upon Recommended Practice 18R-97.

					AACE 18R-97 Expected Accuracy		Typical [B] Contingency Range	
	Project Definition							
Estimate Class [A]	Start	End	End Usage	Methodology	Low	High	Low	High
Class 5	0%	2%	Concept Screening	Capacity Factor, Parametric Model, Judgement or Analogy	-50%	+100%	30%	35%
Class 4	1%	15%	Study or Feasibility	Equipment Factored or Parametric Model	-30%	+50%	25%	30%
Class 3	10%	40%	Budget, Authorization, or Control	Semi Detailed Unit Cost with Assembly Level Line Items	-20%	+30%	20%	25%

A = Only Class 2 and Class 1 Estimates are not relevant to Capital Budgeting or Master Planning estimates.
B = For Water Treatment, Wastewater Treatment and Conveyance Type projects. Other industries may be similar.

example, type of fluid, flow, lineal feet of pipe and size of pipe can be calculated and a general route can be assumed. The estimate can be organized by major runs of pipe, trenchless technology, site work items, and general restoration items.

For water and wastewater treatment and conveyance projects, the following items should be estimated using a semi-detailed take-off, bottoms-up cost estimate:

Water and Wastewater Treatment—Cost Estimates:

- Division 2—detailed take-off of major site work components.
- Division 3—detail take-off of all concrete components by facility.
- Division 9—if specialty coatings are required.
- Division 11—equipment quotations for each major piece of process or mechanical equipment, based on the P&IDs.
- Division 15—detailed take-off of mechanical and yard piping greater than 0.1016 meters.
- Historical Percentage of Total—historical percentage of total calculations is used for the remainder of the associated divisions of work, based on the associated scope of work.

Water or Wastewater Conveyance—Cost Estimates:

- linear feet (LF) of pipe by each size of pipe;
- assumed material type of pipe;
- percentages for fittings;
- counts or allowances for valves;
- counts or allowances for manholes or catch basins;
- trenchless technology considerations (per LF);
- pavement restoration;
- landscape restoration;
- water crossings; and
- rock excavation allowance.

Cost Models based on definitive level cost estimates and standard design information can be used for various facility or plant costs at the planning stage, and are often used for conceptual cost estimating. Assemblies or historical unit prices can be used for estimating construction costs for conveyance-type projects early in the conceptual phase of a project.

Other methods for conceptual estimating include an exponent estimating Technique based on the ratio of the known cost with a known capacity to estimate an unknown cost for a given capacity. This is known in the industry as the six-tenths (0.6) factor rule [13]. It can be used to ratio historical construction cost of a given capacity and determine an unknown cost based on a given capacity. It can also be used for unit prices of a known size for determining the cost of an unknown size. For example:

$$C2 = Known\ \$\ (Desired\ Capacity / Known\ Capacity)^{0.6}$$

equation 1

Example: a 10-million-gallon-per-day (mgd) water treatment plant costs $10 million. Estimate the cost of a 15-mgd water treatment plant.

$$15-mgd\ WTP = \$10M \times (15mgd / 10mgd)^{0.6} = \$12.745M\ \ for\ a\ 15-mgd\ plant$$

example 1

When using historical cost for factoring, always remember to adjust the cost of an item from one time period to another, to account for inflation. The author considers the Engineering News-Record (ENR) Construction Cost Index for the 20-City Average [8], which includes components for both labor and mate-

rials, as an industry standard for the water and wastewater industry. If material costs only are being adjusted, then the ENR Material Index [9] should be used.

CONTINGENCY

The contingency of a project can be applied at various levels of a cost estimate. These include, at the bottom line of the estimate, allocated to all costs throughout the estimate or as part of the construction cost. The preferred approach to using contingency in a total capital cost estimate is to apply a separate contingency to the sub-total of the construction cost estimate and include the contingency as a part of the total construction cost, then factor for the non-construction costs to determine a total capital cost. Using this approach ensures that construction costs and non-construction both include contingency. The key in applying contingency is not to apply contingency twice or double counted. Table 4 demonstrates the use of various contingencies on water and wastewater treatment and conveyance projects, base on the AACE International Recommended Practice 18R-97 [7].

CAPITAL IMPROVEMENT BUDGETING

Cities, municipalities, and government agencies all perform some level of yearly capital improvement planning. The forecast for this planning horizon may be one year to three years, five years, 10 years and even 15 years. Some planning horizons go out 25 years for master plans. Capital projects are estimated, prioritized based on various internal factors, and then arranged in yearly categories. Some projects may span multiple years, as in the case of large projects or annual contracts. Funding for design services and land acquisition services may occur in 1 year, and the construction and services during construction may occur in subsequent years. This should be a yearly process with various functional areas, such as engineering and construction departmental reviews, updating, and approving the updated capital budgets at the appropriate levels.

As the project moves forward in time and actual contract values are known for services such as design, bidding and award, and inspection, the actual costs should replace the budgeted non-construction costs and the overall capital budget should be updated in the capital improvement plan on a yearly basis.

USE OF FACTORING FOR NON-CONSTRUCTION COSTS

In addition to capital improvement budgeting, the technique of factoring for non-construction cost can be used in the master planning process for capital project. This technique can also be used for evaluating various alternative analyses, technology, or process selection, and value engineering processes. Construction cost estimates usually are generated for these types of analyses and then factored for non-construction cost to determine a total capital cost for each alternative or analysis. Factoring for non-construction costs is a cost-effective way of determining the overall capital cost of a project early on in the conceptual planning and budgeting phases of a project. See table 2 for percentages of construction cost guidelines.

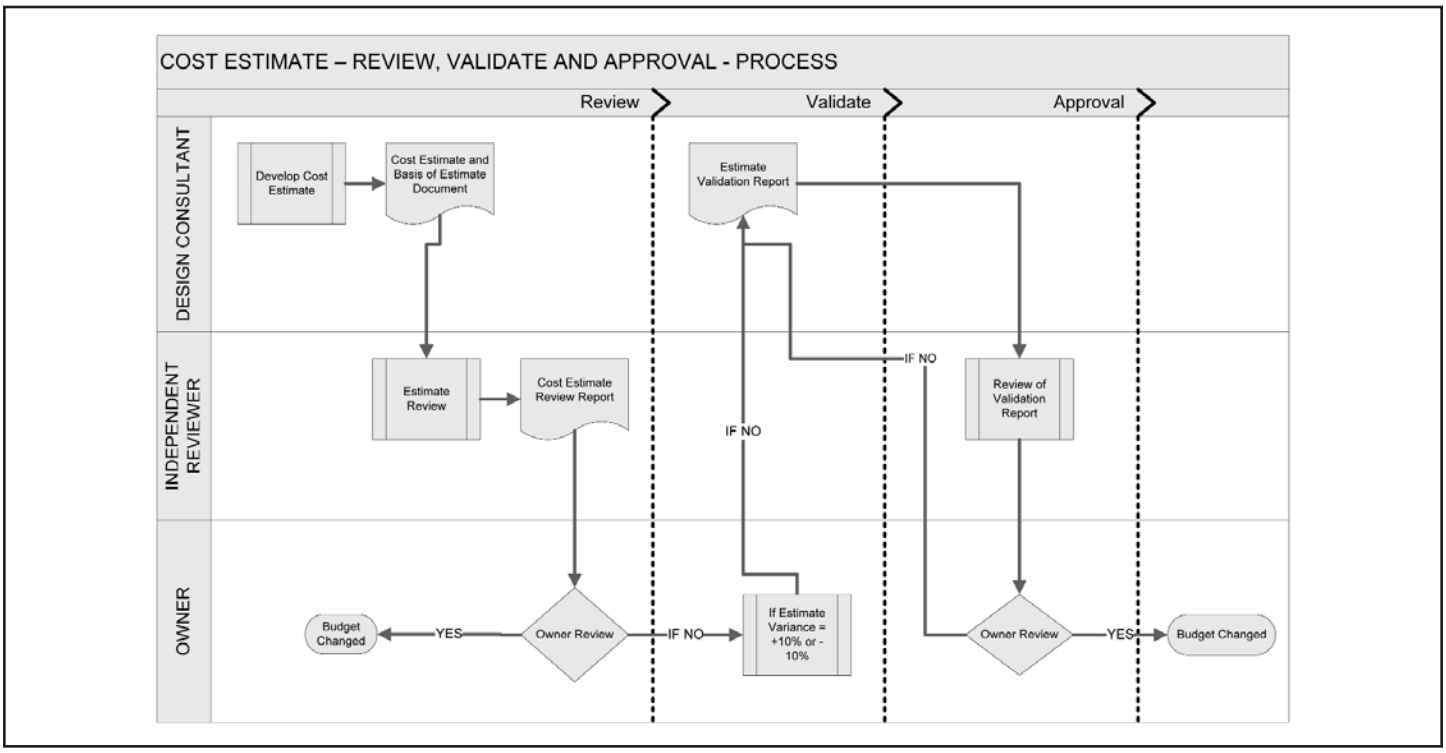

Figure 1—Cost Estimate—Review, Validate and Approval Process.

CONTROLLING NON-CONSTRUCTION COSTS

Various government agencies, cities, and municipalities are required to follow public bidding processes and laws. Construction contracts are awarded to the lowest qualified bidder. A professional consultant's labor fee for design services, engineering services, and services during construction can be negotiated as professional services task orders between the owner and the consultant. These professional services contracts for non-construction costs represent the area that has the highest degree of control by the owner and should be an area of focus for the owners to help control the total project cost.

Independent Engineering Labor Fees

As the capital project gets underway, the owner should start to determine an independent labor fee associated with pending engineering services, rather than directly accepting the design consultant's labor fee proposal. By performing independent labor fee estimates for various design and engineering services, owners can use these labor fee estimates as a benchmark for negotiations with design consultants, in addition to the non-construction budget established at the CIP planning phase. Having an independent labor fee estimate will help identify areas of differences in opinion on scope items, level of effort, and labor rates. As a result, the owner and consultant will better understand the scope and each other's expectations about the project.

Estimate Review, Validation and Approval Process

When the project is in the design phase, an owner or agency can use a cost estimating review, validation, and approval process to control the overall capital cost of the project. This is typically performed at the 30 percent, 60 percent, and 90 percent design stages, because cost estimates are generated at these stages. This process involves an independent estimate review of the consultant's estimate. The owner or agency then either accepts the current estimate or requests additional information about the estimate. f the cost estimate varies by some specific percentage as specified by the owner or agency, typically 10 to 15 percent, a validation report from the design consultant may be required to explain the reasons for the change. The changes between estimates at various design milestones are generally caused by changes in scope or quantities, changes in unit prices, or changes in schedule. The owner or agency then reviews the validation report generated by the design consultant, with assistance from the independent reviewer. The owner or agency either approves or rejects the current cost estimate. If the estimate is approved, the owner should sign a budget change form and the CIP budget should be adjusted in the capital improvement plan. Figure 1 illustrates this process.

For additional information on the cost estimate review and validation of cost estimates, refer to the technical article called "The Estimate Review and Validation Process" [14]. The article is an excellent source and provides a good overview of the validation process of a cost estimate.

DEFINITIONS

For the purpose of this paper, the following definitions are used:

- Construction cost—The sum of all costs, direct and indirect, inherent in converting a design plan for material and equipment into a project ready for startup, but not necessarily in production operation; the sum of field labor, supervision, administration, tools, field office expense, materials, and equipment [1].
- Capital, fixed—The total original value of physical facilities that are not carried as a current expense on the books of account and for which depreciation is allowed by the federal government. It includes plant equipment, building, furniture and fixtures and transportation equipment used directly in the production of a product or service. It includes all costs incident to getting the property in place and in operational condition, including legal costs, purchased patents, and paid-up licenses. Land, which is not depreciable, is often included. Characteristically it cannot be converted readily into cash [2].
- Indirect cost—All costs in construction that do not become a final part of the installation, but that are required for the orderly completion of the installation and may include, but are not limited to, field administration, direct supervision, capital tools, startup costs, contractor's fee, insurance, taxes, etc. [3].
- Non-construction—Often called soft costs, these costs are the indirect cost of a project, which for public works projects typically include planning, design services, material testing, land, right-of-way costs, inspection services, engineering services during construction, bid and award, legal costs, administration costs, and program management services.
- Soft-costs—Indirect costs or non-construction costs.
- Project—An endeavor with a specific objective to be met within the prescribed time and dollar limitations and which has been assigned for definition or execution [4].
- Total project cost—The sum of all costs, direct and indirect, including all construction and non-construction costs, throughout the life of the project for the design and construction phase. The total project cost is equal to the total capital cost of the project.
- Life cycle; project—The stages or phases of project progress during the life of a project. Project life-cycle stages typically include ideation, planning, execution, and closure [5].
- Operating costs—The expenses incurred during the normal operation of a facility or component, including labor, materials, utilities, and other related costs. Includes all fuel, lubricants, and normally scheduled part changes in order to keep a subsystem, system, particular item, or entire project functioning. Operating costs may also include general building maintenance, cleaning services, taxes, and similar items [6].

REFERENCES

1. AACE International, April 2004, Recommended Practice No. 10S-90, Construction Cost, Page 13, Morgantown, WV.
2. AACE International, April 2004, Recommended Practice No. 10S-90, Capital—Fixed, Page 10, Morgantown, WV.
3. AACE International, April 2004, Recommended Practice No. 10S-90, Indirect Cost, Page 34, Morgantown, WV.
4. AACE International, April 2004, Recommended Practice No. 10S-90, Project, Page 52, Morgantown, WV.
5. AACE International, April 2004, Recommended Practice No. 10S-90, Life-Cycle—Project, Page 38, Morgantown, WV.
6. AACE International, April 2004, Recommended Practice No. 10S-90, Operating Costs, Page 45, Morgantown, WV.
7. AACE International, September 12, 2003, Recommended Practice No. 18R-97, Figure 1, Page 2, Morgantown, WV.
8. Engineering News-Record (ENR), Construction Cost Index, 20-City Average, 2005.
9. Engineering News-Record (ENR), Material Price Index, 2005.
10. EPA Document #430/9-83-004, Table 3.1, June 1983, Construction Costs for Municipal Wastewater Treatment Plants, 1973-1982, Washington, D.C.
11. EPA Document #430/9-77-015, Table 6.5, May 1978, Construction Costs for Municipal Wastewater Conveyance Systems, 1973-1977, Washington, D.C.
12. Kenneth K. Humphreys, 1991, Jelen's Cost and Optimization Engineering, Third Edition, New York, McGraw-Hill, Inc., page 367.
13. Kenneth K. Humphreys, 1991, Jelen's Cost and Optimization Engineering, Third Edition, New York, McGraw-Hill, Inc., page 382.
14. Larry Dysert, CCC and Bruce G. Elliott, CCC, January 2002, "The Estimate Review and Validation Process," Cost Engineering, Vol. 44/No. 1, AACE International, Page 17, Morgantown, WV.

Mr. Pete Bredehoeft
CH2M Hill, Inc.
115 Perimeter Center Place, NE
Suite 700
Atlanta, GA 30346-1278

E-mail: pbredeho@ch2m.com