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CITY OF SUNNYVALE

MASTER PLAN AND PRIMARY TREATMENT DESIGN

TECHNICAL MEMORANDUM

BASIS OF COST EVALUATION: MASTER PLAN

FINAL
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carollo in association with HDR

CITY OF SUNNYVALE

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Technical Memorandum

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1.0 INTRODUCTION

Cost estimates are prepared at various stages during project planning and design and usually become among the most sensitive products prepared for a project. The level of accuracy that can be expected is directly proportional to the level of engineering effort completed. Each cost estimate must be carefully prepared from the conceptual level to the facilities plan level, through the preliminary design and the final engineer's estimate.

This technical memorandum (TM) provides procedures and guidelines for estimating capital, and operation and maintenance (O&M) costs for the Master Plan phase of the Sunnyvale Water Pollution Control Plant (WPCP) Master Plan and Primary Treatment Design Project. These capital and O&M costs are the basis for developing both total annual and life cycle costs. During each major phase of final design for the headworks and primary sedimentation basins, separate more refined cost estimates will be prepared.

2.0 SCOPE AND LEVEL OF ACCURACY

The Association for the Advancement of Cost Engineering International (AACE International, formally known as the American Association of Cost Engineers) has suggested levels of accuracy for five estimate classes. These five estimate classes are presented in the AACE International Recommended Practice No. 18R-97.

Table 1 presents a summary of these five estimate classes and their characteristics, including expected accuracy ranges.

The quantity and quality of the information required to prepare an estimate depends on the end use for that estimate. Typically, as a project progresses from the conceptual phase to the study phase, preliminary design and final design, the quantity and quality of information (or project definition) increases, thereby providing data for development of a progressively more accurate cost estimate. A contingency is often used to compensate for lack of detailed engineering data, oversights, anticipated changes, and imperfection in the estimating methods used. As the quantity and quality of data becomes better, smaller contingency allowances are typically utilized. For the projects developed as a part of the Master Plan phase, cost estimates are typically developed following the AACE International Recommended Practice No. 18R-97 estimate classes 5 and 4. In certain circumstances, a more detailed engineering analysis is completed to allow for the preparation of a Class 3 estimate for critical project elements. A figure excerpted from 18R-97 is presented in Appendix A which illustrates the estimating accuracy for the various estimating classes based on level of project definition.

Table 1 Category of Cost Estimates[1] Master Plan and Primary Treatment Design City of Sunnyvale					
	Primary Characteristic	**Secondary Characteristic**			
Estimate Class	**Level of Project Definition (Expressed as % of complete definition)**	**End Usage**	**Methodology (Typical Estimating Method)**	**Expected Accuracy Range (Typical variation in Low and High Ranges[a])**	**Preparation Effort (Typical degree of Effort Relative to Least Cost Index of 1[b])**
Class 5	0% to 2%	Concept Screening	Capacity Factored, Parametric Models, Judgment, or Analogy	L: -20% to -50% H: +30% - +100%	1
Class 4	1% to 15%	Study or Feasibility	Equipment Factored or parametric Models	L: - 15% to -30% H: +20% - +50%	2 to 4
Class 3	10% to 40%	Budget, Authorization, or Control	Semi-Detailed Unit Costs with Assembly Level Line Items	L: - 10% to -20% H: +10% - +30%	3 to 10
Class 2	30% to 70%	Control or Bid/Tender	Detailed Unit Cost with Forced Detailed Take-Off	L: - 5% to -15% H: +5% - +20%	4 to 20
Class 1	50% to 100%	Check Estimate or Bid/Tender	Detailed Unit Cost with Detailed Take-Off	L: - 3% to -10% H: +3% - +15%	5 to 100

Notes:

(1) Table from the AACE International Recommended Practices and Standards, No. 18R-97:
- (a) The state of process technology and availability of applicable reference cost data affect the range markedly. The +/- value represents typical percentage variation of actual costs from the cost estimate after application of contingency (typically at a 50% level of confidence) for a given scope.
- (b) If the range index value of “1” represents 0.005% of project costs, then an index value of 100 represents 0.5%. Estimate preparation effort is highly dependent upon the size of the project and the quality of estimating data and tools.

Class 5 estimates are prepared for any number of strategic business planning purposes, including, but not limited to project screening, evaluation of resource needs and budgeting, and long-range capital planning. Very limited information is available at the time when a Class 5 estimate is developed. Therefore, Class 5 estimates virtually always use stochastic estimating methods such as cost-to-capacity curves and various scaling factors. Subsequently, estimated costs have wide accuracy ranges. Typical accuracy ranges for Class 5 estimates are –20 percent to –50 percent on the low side, and +30 percent to

+100 percent on the high side, depending on the technological complexity of the project, availability and accuracy of appropriate reference information, and the inclusion of an appropriate contingency determination. Capital costs for the Master Plan improvements that are not needed (and potentially less defined) beyond the first 10± years of planning are typically prepared based on Class 5 estimates.

Class 4 estimates are prepared for any number of strategic business planning purposes including, but not limited to detailed strategic planning, confirmation of economic and/or technical feasibility, and preliminary budget approval or approval to proceed to next stage. Limited information is available at the time when a Class 4 estimate is developed. Therefore, Class 4 estimates virtually always use stochastic estimating methods such as parametric or other modeling techniques, and various factors. Subsequently, estimated costs have fairly wide accuracy ranges. Typical accuracy ranges for Class 4 estimates are –15 percent to –30 percent on the low side, and +20 percent to +50 percent on the high side, depending on the technological complexity of the project, availability and accuracy of appropriate reference information, and the inclusion of an appropriate contingency determination. Capital costs for the Master Plan improvements that are needed within 10± years are typically prepared based on Class 4 estimates.

Class 3 estimates are prepared to support full project funding requests and can become the first of the project phase "control estimates" against which all the actual costs and resources will be monitored for variations to the budget. Therefore, Class 3 estimates involve more deterministic estimating methods than stochastic methods, which involves some use of unit cost line items. Factoring and other stochastic methods may be used to estimate less significant areas of the project. Typical accuracy ranges for Class 3 estimates are –10 percent to –20 percent on the low side, and +10 percent to +30 percent on the high side, depending on the technological complexity of the project, availability and accuracy of engineering detail and the inclusion of an appropriate contingency determination. Capital costs for selected components and/or facilities for the Master Plan improvement are typically prepared based on Class 3 estimates.

3.0 BASIS OF COST EVALUATIONS

The costs presented in the Master Plan phase are based on preliminary layouts, preliminary unit process sizes, and conceptual alternative configurations. Construction costs are estimated from unit costs developed from construction costs of similar facilities and configurations at other locations, estimating guides, preliminary quantity takeoffs, and unit prices.

When cost information for similar sized and configured facilities is not available, the cost curve approach may be utilized (if cost curve information is available). The cost curve approach uses historical project cost data to estimate planning level costs for capital improvement projects. In this approach, historical project cost data are used to develop plots of total cost versus process capacity, or "cost curves," for a given unit process. In the development of the cost curves, the project locations and dates of costs are accounted for with the application of "location factors" (R.S. Means Location Factors), and ENR values (Engineering and News Records). The location factors are based upon the R.S. Means national average construction costs. City-to-City location adjustment factors may be accurately derived by dividing the published factor for one location by the factor for another. By accounting for location factors and ENR values, the cost curves are plots of "locationless" costs in "today's" dollars.

O&M costs will be based on historical operating costs, estimated manpower needs, resource requirements, and equipment replacement and maintenance needs. Where possible, O&M data from the WPCP and other similar facilities will be used.

A summary of the economic criteria to be used for estimating costs is presented in Table 2.

Table 2 Economic Criteria for Master Plan
Master Plan and Primary Treatment Design
City of Sunnyvale

Item	Assumption
Costs in Time and Place	Base estimate costs are based on June 2015 costs in Sunnyvale, California.
Estimating Contingency(1)	Total of 15 percent
Construction Contingency(2)	Total of 15 percent, which includes the following: • Construction costs associated with unknown conditions. • Construction change orders. • Allowance for estimation oversights and slight changes to the project.
Contractor's Overhead & Profit	Total of 10 percent
Escalation in Cost	The cost escalation is 2 percent per annum.
Project Cost Factor(3)	Total of 42 percent, which includes the following: • Engineering design fees. • Construction management fees. • Project management costs. • Program management costs. • Environmental mitigation. • Other legal and administrative costs and fees.
Real Interest Rate(4)	5 percent for amortization purposes
Amortization Period	Up to 30 years (dependent on specific evaluation)

Notes:
(1) Per Carollo Cost Curves Manual, Estimating Contingency of 15-25% is advised. 15% is assumed.
(2) Per Carollo Cost Curves Manual, Construction Contingency of 15-25% is advised. 15% is assumed.
(3) Per Carollo Cost Curves Manual, engineering, legal, and administrative costs are assumed to range between 16-46%. 42% is assumed.
(4) Inflation is estimated at 1-3%; assume 2%. The typical capital borrowing rate is 4-7%; assume 7% on the bond market. Therefore, for amortization calculations, assume the real interest rate is 5% (the difference between 7% and 2%).

3.1 Capital Costs

As noted early, capital costs for the Master Plan improvements are typically based on Class 5 and Class 4 estimates. Under certain circumstances, a Class 3 estimate is prepared for selected elements.

Two types of estimates are generally prepared during a master planning effort:

- Alternative comparison estimates. These are estimates are performed to compare two or more project components on a life cycle cost basis of evaluation. In many cases, elements common to the alternatives being considered are not included in the capital estimate and usually the level of engineering detail is minimal. These comparison estimates are consistent with a Class 5 or 4 estimate level. The contingencies identified in Table 2 are utilized consistently for each alternative cost estimate.

- Preparation of Capital Improvement Plan (CIP) estimates. These estimates are performed to develop a CIP for the projects identified for implementation over the master planning period (typically 20 to 30 years). As expected, projects identified for implementation over the first 10 years or so of the planning period generally are more defined. Because of the near-term impacts of these projects, more effort is made to refine the costs. The use of the contingencies in Table 2 are reviewed and can be modified as necessary to reflect more detailed information. These estimates are consistent with a Class 4 estimate level, with elements refined to a Class 3 level where appropriate.

While the estimated construction costs represent the average bidding conditions for many projects, variations in bidding climate at the time the facilities are constructed can affect actual construction costs. Further, the size of the facilities may be refined during preliminary design based on the most current operational information available. For these reasons, the actual construction costs may be lower or higher than originally estimated. Thus, an estimating contingency of 15 percent will be added to account for the above uncertainties. The construction cost will then be adjusted to include a 15 percent construction contingency to account for unknown site conditions and construction change orders. An additional 10 percent is added for contractor’s overhead and profit.

Construction costs have historically escalated with time. This trend is expected to continue in the future. To record these trends in rising costs, several indices have been established for various fields of construction. The standard indicator of changes in heavy construction prices is the ENR Construction Cost Index (ENRCCI). Where construction costs are developed from construction projects in previous years and/or different locations, the base estimate costs for the Master Plan improvements included in the Master plan CIP will be adjusted to June 2015 costs for Sunnyvale, using the following:

- 20-Cities average ENRCCI of 10,039 (June 2015 – will be adjusted as appropriate).

- An R.S. Means Location Factor for San José, California of 117.4 (2015 – will be adjusted as appropriate).

As part of evaluating the financial impacts of the proposed CIP, the estimated capital costs for each CIP project will be escalated to the projected mid-point of construction based on the proposed implementation date. For the purposes of this master planning effort, the estimated escalation rate is assumed to be 2 percent per annum.

Finally, “soft” costs to the owner, such as engineering, legal, administrative, project contingencies, environmental mitigation, and construction management costs, are added to the construction costs to arrive at total project costs. A 42 percent project cost contingency adjustment is proposed to cover these soft costs.

An example illustrating the process for estimating capital costs, assuming a base construction estimate of $10,000,000, is summarized in Table 3. As is illustrated in this example, the final project cost estimate increases to nearly $36 million dollars (assuming a ten year escalation to mid-point of construction).

Table 3 Example of Process for Estimating Project Costs for Master Plan
Master Plan and Primary Treatment Design
City of Sunnyvale

Item	Percentage	Example of Estimated Cost
	Subtotal	**$10,000,000(1)**
Demolition costs (if applicable)	10%	$1,000,000
Yard piping, sheeting, shoring, coatings, and other miscellaneous costs (if applicable)	15%	$1,500,000
Electrical and instrumentation (if applicable)	20%	$2,000,000
	Subtotal	**$14,500,000**
Estimating contingency	15%	$2,175,000
	Subtotal	**$16,675,000**
Construction contingency	15%	$2,501,000
Contractor’s overhead & profit	10%	$1,668,000
	Construction Cost (today)	**$20,844,000**
Escalation to midpoint of construction (2% per annum to 2023, i.e., 10 years)	21.9%(2)	$4,565,000
Escalated Construction Cost (midpoint of construction)		**$25,409,000**
Project cost factor	42%	$10,672,000
	Total Project Cost	**$36,081,000**

Notes:
(1) This subtotal would be based on quantity take-offs and unit costs associated with the level of design, and vendor quotes for major equipment.
(2) Escalation calculated as $(1.02)^{10}$

3.2 O&M Costs

O&M unit costs are presented in Table 4. The unit costs presented will be used in developing O&M costs for each alternative. These O&M costs will be used to develop annual budgets based on the proposed CIP implementation period.

Table 4 O&M Unit Costs for Master Plan
Master Plan and Primary Treatment Design
City of Sunnyvale

Item	2013 Cost
Labor (average)	$200,000/person-year
Energy	
Electricity	$0.20/kWh
Natural Gas	$0.60/therm
Chemicals	
Ferric Chloride	$1.45/gallon
Caustic Soda	$1.49/gallon
Methanol	$2.00/gallon
Citric Acid	$8.00/gallon (50% solution)
Sodium Hypochlorite (12.5%)	$1.00/gallon(1)
Sodium Bisulfite (25%)	$1.00/gallon
Aqueous Ammonia	$3.50/gallon
Polymer for dewatering	$1.12/pound (active)
Land	$69/sf(2)

Notes:

(1) Estimates will be based on the cost of sodium hypochlorite since the WPCP is currently converting away from gaseous chlorination.

(2) Approximately $3 million/ac.

3.3 Life Cycle Cost Analysis

In addition, O&M costs are utilized to compare project alternatives based on an overall life cycle cost basis. Two approaches can be utilized:

3.3.1 Total Annual Costs

When alternatives are compared based on a combined total annual cost basis, capital costs would be amortized over the selected planning period using an interest rate of 5 percent. Total annual cost is the sum of the amortized capital cost and the annual O&M cost.

3.3.2 Present Worth Costs

Present worth cost represents the value in current dollars of the total cash flow occurring over the life of a project. It includes both capital and O&M costs. As a result, present worth cost represents the life cycle cost of an alternative.

It should be noted that when O&M costs are prepared, the O&M costs that are common among the alternatives are usually not included. Capital, O&M, total annual and present worth cost estimates will be developed for the recommended master planned facilities.

APPENDIX A – EXCERPT FROM AACE PRACTICE NO. 18R-97

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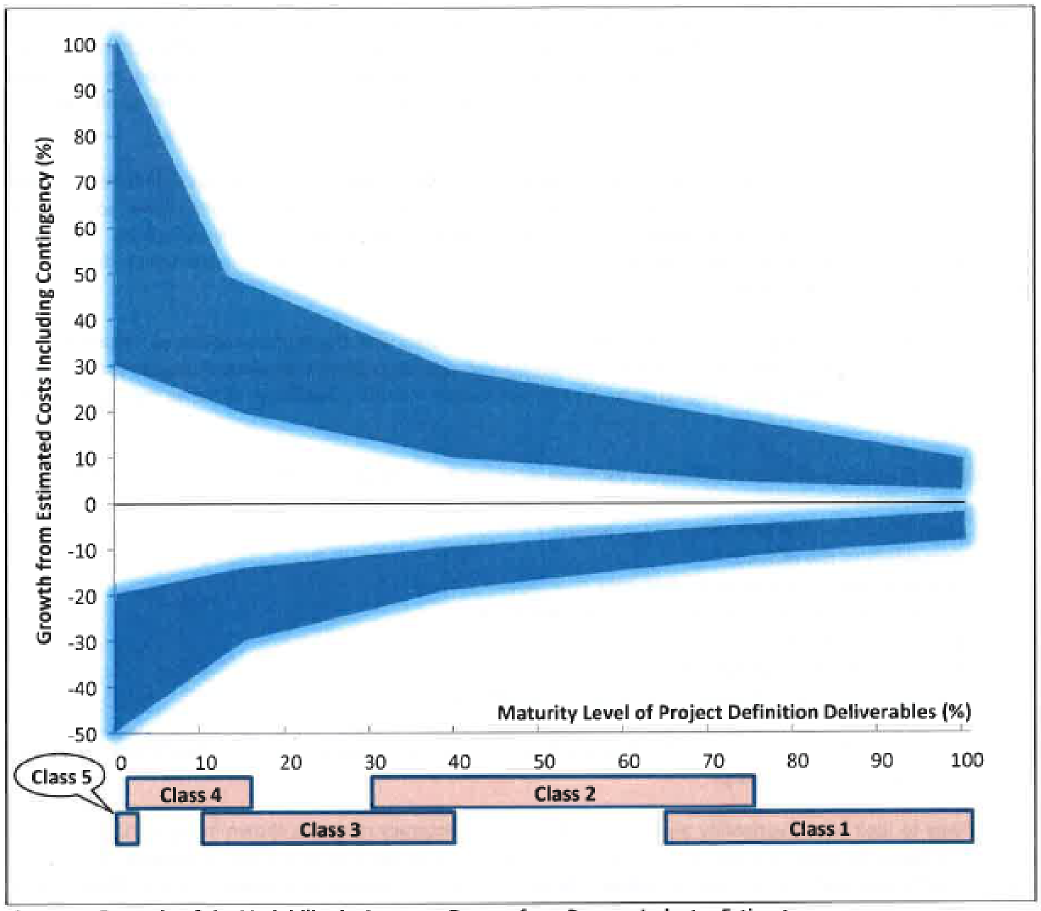

Figure 1 – Example of the Variability in Accuracy Ranges for a Process Industry Estimate