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SUBJECT: Western Wake Regional Wastewater Management Facilities
Western Wake Water Reclamation Facility
PER Technical Memorandum No. 32 – Cost Estimate Methodology

INTRODUCTION

This technical memorandum (TM) is one in a series of TMs being prepared for the Preliminary Engineering Report for the Western Wake Regional Wastewater Management Facilities project. This TM provides an overview of the methodology used for estimating the capital and operation and maintenance (O&M) costs of the treatment and conveyance systems. Capital costs were developed for each facility design unit. The design units include each of the pump stations required to convey raw wastewater to the regional water reclamation facility (WRF), each of the process units in the regional WRF, the components required for effluent pumping and conveyance to the Cape Fear River, site development and utilities, and the SCADA systems. Operation and maintenance costs are included where multiple options are presented for a given treatment process or facility.

GENERAL COST ESTIMATE ASSUMPTIONS

The Association for the Advancement of Cost Engineering (AACE) recommends five levels of accuracy for construction cost estimating categories. The five major categories are as follows:

- ❖ Class 5 – Feasibility Estimate Accuracy = +100% to -50%
- ❖ Class 4 – Conceptual Estimate Accuracy = +50% to -30%
- ❖ Class 3 – Budget Estimate Accuracy = +30% to -20%
- ❖ Class 2 – Preliminary Estimate Accuracy = +20% to -15%
- ❖ Class 1 – Detailed Estimate Accuracy = +15% to -10%

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The accuracy of construction cost estimates should increase as the project moves through the process from conceptual to detailed design, and eventually to project bidding and actual construction. It can be expected that preliminary level estimates would have a wider range of accuracy than the actual construction cost because some, but not all, of the design features and details have been addressed. The capital cost estimates prepared for this TM are at the "Preliminary Estimate" level (Class 2). Since the assumptions and methodology for identifying the costs are common to all alternatives, this level of accuracy is appropriate for the comparative evaluations presented in this Preliminary Engineering Report (PER).

Cost estimates prepared for this study were prepared using vendor quotes for equipment, previous cost estimates for similar projects and unit process equipment of similar size and/or complexity, and estimating guides and handbooks. Final project construction costs will depend on actual labor, materials and equipment costs; competitive market conditions; actual site conditions; final project scope; actual level of treatment required; implementation schedule; land acquisition costs; and other factors that cannot be quantified at the current level of detail. Assumptions included in preparing the cost estimates for each specific unit are addressed within the presentation of that unit's cost estimate.

Dewatering costs are based on the assumption of clay-type soils that impede the flow of water. The assumption of clay-type soils is based on the numerous farming ponds located near the site that imply a slowly draining soil. If soil borings reveal a sandy soil that allows a greater flow of water than the clay-type soil, dewatering costs will have to be increased accordingly.

A construction contingency of 15% has been added to all estimated construction costs. The following allowances have been added to the estimated construction cost (including the construction contingency) for the purpose of estimating the fully allocated project capital cost:

- ❖ Engineering Design and Construction Services 10%
- ❖ Legal, Financial, and Administration 5%

The estimated construction costs are in fiscal year (FY) 2005 dollars. O&M costs, where evaluated, are dependent on the type of facility or improvement being evaluated, and the assumptions used to develop the O&M costs are discussed in the TM covering each facility or improvement.

Present worth costs for each option are determined by discounting the future construction and O&M costs back to FY 2005 dollars assuming a rate of return (or financing interest rate) of 5.875 percent. The 5.875 percent rate is the current interest rate used by the U.S. EPA for State Revolving Loan Fund (SRF) projects administered by NCDWQ, Construction Grants and Loans Section. Salvage values are also calculated to determine present worth costs using SRF

criteria. For salvage values, a useful life of 20 years is assumed for equipment, and a useful life of 40 years is assumed for structures. A planning period of 20 years is assumed for present worth cost evaluations. Table 32-1 summarizes base costs common for all facilities. A sample format for the cost tables is presented in Table 32-2. An example of the present worth cost comparison and further description of the methodology is provided in Appendix 32A.

TABLE 32-1
STANDARD COSTS FOR PER FACILITIES

Item	Cost Basis
Soil excavation	\$7/CY
Backfill	\$7/CY
Concrete slab	\$450/CY
Concrete walls	\$550/CY
Concrete elevated slab	\$750/CY
Stone sub-base	\$25/CY
Dewatering (if needed)	\$15,000/structure (for structures requiring 10 feet or less depth of excavation)
	\$50,000/structure (for structures requiring more than 10 foot depth of excavation)
Electrical costs (per facility)	Estimated cost of electrical equipment within the facility
HVAC costs (per facility)	3% of total facility cost (or other value as appropriate)
Instrumentation costs (per facility)	Estimated cost of field instruments
Construction contingency	15% of subtotal
Engineering and construction services	10% of subtotal + construction contingency

TABLE 32-1 (CONTINUED)
STANDARD COSTS FOR PER FACILITIES

Item	Cost Basis
Legal and Financial	5% of subtotal + construction contingency + engineering
For memoranda evaluating multiple options, salvage values and O&M costs are calculated using the following:	
Discount rate for present worth analysis	5.875%
Rate of inflation	2.5%
Planning period	20 years
Service life for equipment (for salvage value)	20 years
Service life for structures (for salvage value)	40 years
Power costs	\$0.07/kw-hr
Annual maintenance costs	4% of mechanical equipment costs
Labor costs	\$20/hr (Labor costs should only be included in evaluations of alternatives when significant differences in labor requirements could impact staffing at the plant.)

ALL COSTS ARE EXPRESSED IN 2005 DOLLARS.

TABLE 32-2
SAMPLE COST FORMAT

Item	Cost (\$)
Sitework	\$110,000
Structural	\$740,000
Architectural	\$25,000
Miscellaneous Metals (Grating, Stairs)	\$30,000
Mechanical Bar Screen with Compactor	\$480,000
Manual Bar Screen	\$7,000
Influent Screw Pumps	\$690,000
Piping	\$30,000
Fittings	\$80,000
Gates	\$185,000
Magnetic Flow Meter	\$25,000
HVAC	\$10,000
Electrical	\$180,000
<i>Subtotal</i>	\$2,592,000
Construction Contingencies @ 15%	\$389,000
Engineering Design and Construction Services @ 10%	\$298,000
Legal, Financial and Administration @ 5%	\$164,000
<i>Total</i>	\$3,443,000

APPENDIX 32A
**Present Worth Comparative Cost
Analysis**

INTRODUCTION

Costs for facilities built in multiple phases were compared on a present worth basis and follow the Present Worth Analysis guidelines outlined in Section E. of the Construction Grants and Loans (CG&L) Guidance for the Preparation of Engineering Reports. Capital costs for the facilities and operation and maintenance costs were estimated in FY 2005 dollars. A financing interest rate of 5.875% (EPA guidelines) was used to calculate the present worth value of annual operations and maintenance costs, salvage value, and the capital cost of facilities constructed in a later phase.

In order to demonstrate the present worth methodology used, the present worth cost comparison of installing the two Beaver Creek force mains in one phase vs. separate phases presented in TM 04 (see Table 4-4), is used as an example. Details of the present worth cost analysis for these force mains are provided in Table 32A-1. Supporting cost data for the force mains is provided in Table 32A-2. The assumptions used in the present worth analysis are listed at the top of Table 32A-1.

CAPITAL COSTS

Capital costs for Phase I of the construction project are assumed to be expended in FY 2010, and Phase II costs are assumed to be expended ten years later in FY 2020. Inflation is not included in the present worth analysis. For example, the capital cost for the 42-inch Phase I force main is \$14,729,000 in FY 2005 dollars as shown in Table 32A-2. Assuming that FY 2005 dollars are equivalent to FY 2010 dollars, our single payment present worth factor (SPPWF) for the Phase I force main is 1.0 (0 years at 5.875%), and the resulting present worth comparative cost is \$14,729,000. For the 36-inch force main installed in Phase II, the capital cost is \$11,527,600 in FY 2005 dollars (see Table 32A-1). The SPPWF for 10 years (from FY 2010 to FY 2020) at an interest rate of 5.875% is approximately 0.565, resulting in a present worth comparative cost for the Phase II 36-inch force main of \$6,513,400.

OPERATION AND MAINTENANCE COSTS

Operation and maintenance (O&M) costs are dependent on the type of facility or improvement being evaluated. The assumptions used to derive O&M costs for the various facilities are outlined in the TM covering each facility or improvement. Following CG&L guidelines, a 20-year planning period is assumed; therefore, annual O&M costs are estimated over a 20-year period (year 2010 to 2030). For pipelines, an O&M cost of \$6,700 per mile has been assumed. For two force mains in the same easement, the O&M cost on the second pipeline is discounted by half, to \$3,350 per mile. The uniform series present worth factor (USPWF) for the force mains installed in Phase I covers a period of 20 years at 5.875% and is approximately 11.587, as shown in Table 32A-1. A pipeline installed in Phase II is only active from 2020 to 2030, or 10

years of the 20-year planning period. The USPWF for 10 years at 5.875% is 7.404. However, this USPWF applies to year 2020 and must be multiplied by the SPPWF for 10 years at 5.875% in the same manner as the Phase II capital costs to determine the present worth O&M cost. The product of the SPPWF (P/F, 5.875%, 10) and the USPWF (P/A, 5.875%, 10 years) is approximately 4.183, as shown in Table 32A-1.

SALVAGE VALUE

For salvage values, a useful life of 20 years is assumed for mechanical equipment, and a useful life of 40 years is assumed for pipelines and structures. Land is always assumed to have a salvage value of 100%. Salvage values are estimated as a percent of the capital cost using the following formula:

$$\% \text{ Salvage Value} = [\text{Useful Life} - \text{Years of Service}] / \text{Useful Life}$$

Given a 20 year planning period, any pipelines installed in Phase I would have a 50% salvage value at the end of the planning period ($[40-20]/40 = 50\%$), while pipelines installed in Phase II would have a salvage value of 75% ($[40-10]/40 = 75\%$). However, the salvage values cannot be applied directly to the total capital cost. As shown on Table 32A-2 for the force mains, the only detailed cost items that have salvage value are the pipe and valves. Line items such as cleaning and testing and mobilization are one-time costs that have no salvageable value. Furthermore, the unit price for the items with salvage value includes installation costs and contractor's overhead and profit; so only a percentage of the total line item has salvage value. For example, refer to the 42" Pipe line item (Item 1) for the Phase I 42-inch force main in Table 32A-2. The total cost for this item is estimated to be \$6,098,200. The salvage value percentage is 50%. Assuming 40% of the cost is installation and profit, the resulting salvage value at the end of the 20-year planning period is:

$$\$6,098,200 * 0.6 * 0.5 = \$1,829,500$$

PIPELINE PHASING

The detailed cost estimates for the Beaver Creek 42-inch and 36-inch force mains are shown in Table 32A-2 and have been used above as an example of how present worth comparative costs were developed for phased construction for the Western Wake Regional Wastewater Management Facilities. A review of Table 32A-2 shows that there are opportunities for capital cost savings for several line items if both force mains are installed in the same phase. These include stream crossing restoration; fertilizing seeding and mulching; sediment and erosion control; clearing and grubbing; traffic control; stream crossing mitigation; and wetlands

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mitigation. Bidding costs, mobilization, and contract administration are based on a percentage of the total project cost; so these costs will also be reduced if both pipes are installed in the same phase. However, as shown on Table 32A-1, the capital cost savings realized by installing both pipes in the same phase does not offset the cost savings realized by deferring installation of the second force main for 10 years. As shown in Table 32A-1, the total comparative cost for phased construction of the two pipelines is approximately \$19,820,000 vs. approximately \$24,740,000 for construction of both pipelines in Phase 1.

Table 32A-1

**Western Wake Regional Wastewater Management Facilities - Beaver Creek Force Mains
Present Worth Cost Analysis Example**

Assumptions:

- 1) 20-year planning period
- 2) Year 1 is FY 2010 - i.e., when Phase 1 facilities go on-line
- 3) 2005 dollars are equivalent to Year 1 (FY 2010) dollars, i.e., no inflation
- 4) Phase 2 facilities go on-line 10 years after Phase 1 (FY 2020)
- 5) O&M - estimate average O&M cost over 20 years for the Phase 1 facilities, 10 years for Phase II facilities
- 6) O&M for pipes is \$6,700/mile/year, plus 50% (\$3,350/mile/year) for two pipelines in the same easement

Salvage Value Assumptions:

- 1) Mechanical Equipment is assumed to have a service life of 20 years
- 2) Piping and Structures are assumed to have a service life of 40 years
- 3) Land has 100% salvage value

Financing Rate = 5.875%

Phase 1 42-inch FM		Phase 1 36-inch FM		Phase 2 36-inch FM	
Capital Cost	* SPPWF (P/F,5.875%,0)	Capital Cost	* SPPWF (P/F,5.875%,0)	Capital Cost	* SPPWF (P/F,5.875%,10)
Cost	\$13,985,000	Cost	\$11,035,300	Cost	\$11,527,600
Land	\$744,000	Land	\$0	Land	\$0
Subtotal =	\$14,729,000	Subtotal =	\$11,035,300	Subtotal =	\$11,527,600
SPPWF	1	SPPWF	1	SPPWF	0.565022532
Total =	\$14,729,000	Total =	\$11,035,300	Total =	\$6,513,400
O&M	* (P/A,5.875%,20)	O&M	* (P/A,5.875%,20)	O&M	* (P/A,5.875%,10)*(P/F,5.875%,10)
Pipe Length (ft.)	23560	Pipe Length (ft.)	23560	Pipe Length (ft.)	23560
Pipe Length (mile)	4.46	Pipe Length (mile)	4.46	Pipe Length (mile)	4.46
Yearly Cost \$/mile	\$6,700	Yearly Cost \$/mile	\$3,350	Yearly Cost \$/mile	\$3,350
Yearly Cost \$	\$29,896	Yearly Cost \$	\$14,948	Yearly Cost \$	\$14,948
USPWF	11.5872	USPWF	11.5872	USPWF*SPPWF	4.183
Total =	\$346,400	Total =	\$173,200	Total =	\$62,500
Salvage Value	* SPPWF (P/F,5.875%,20)	Salvage Value	* SPPWF (P/F,5.875%,20)	Salvage Value	* SPPWF (P/F,5.875%,20)
Salvage Value	(\$2,984,000)	Salvage Value	(\$1,837,000)	Salvage Value	(\$2,755,500)
SPPWF	0.3193	SPPWF	0.3193	SPPWF	0.3193
Total =	(\$952,600)	Total =	(\$586,500)	Total =	(\$879,700)
Capital + O&M + Salvage Value		Capital + O&M + Salvage Value		Capital + O&M + Salvage Value	
Capital & Land Cost	\$14,729,000	Capital & Land Cost	\$11,035,300	Capital & Land Cost	\$6,513,400
O&M Cost	\$346,400	O&M Cost	\$173,200	O&M Cost	\$62,500
Salvage Value	(\$952,600)	Salvage Value	(\$586,500)	Salvage Value	(\$879,700)
Total =	\$14,122,800	Total =	\$10,622,000	Total =	\$5,696,200
Total comparative costs for 42-inch & 36-inch FM both installed in Phase I =		\$24,744,800			
Total comparative costs for the 42-inch & 36-inch FMs installed in separate phases =				\$19,819,000	

Western Wake Regional Wastewater Management Facilities
Raw Wastewater Conveyance - Beaver Creek Pump Station to Western Wake Water Reclamation Facility
Pipeline Costs

Table 32A-2

Phase I - 42-Inch Force Main @ 23,560 LF

Item	Description	Quantity	Unit	Unit Price	Total Price	Salvage Value %	Salvage Value
1	42" Pipe	22,175	LF	\$275	\$6,098,200	50.00%	\$1,829,500 Assume 60% Mat. Costs
2	Trenchless Crossings with 42" Pipe	1,385	LF	\$1,750	\$2,423,800	50.00%	\$114,300 Note only applies to pipe not crossing
3	Stream Crossing Restoration	7	EA	\$5,000	\$35,000		
4	Future interconnections (tee/BF)	4	EA	\$17,200	\$68,800	50.00%	\$20,600 Assume 60% Mat. Costs
5	42" Gate Valves	8	EA	\$67,800	\$542,400	50.00%	\$162,700 Assume 60% Mat. Costs
6	36" Gate Valves	4	EA	\$40,000	\$160,000	50.00%	\$48,000 Assume 60% Mat. Costs
7	Corrosion Protection System	23,560	LF	\$10	\$235,700		
8	Fertilizing, Seeding, and Mulching	135,514	SY	\$0.25	\$33,800		
9	Sediment and Erosion Control	22,175	LF	\$5	\$111,000		
	Overexcavation and backfill with imported material	349	CY	\$30	\$10,500		
11	Cleaning and Testing	23,560	LF	\$1	\$23,600		
12	Pavement Replacement	749	SY	\$30	\$22,500		
13	Anti-seep Collars	6	EA	\$1,000	\$6,000		
14	Manual ARVs	13	EA	\$8,100	\$105,300	50.00%	\$39,300 Assume 70% Mat. Costs
15	ARVs	2	EA	\$37,000	\$74,000	50.00%	\$25,900 Assume 70% Mat. Costs
16	Clearing and Grubbing	22,175	LF	\$9	\$188,500		
17	Traffic Control	15,055	LF	\$5	\$75,400		
18	Mobilization	1	LS	2%	\$204,300		
	Subtotal				\$10,418,800		\$2,240,300
19	Construction Contingencies (15% of Subtotal)				\$1,562,800		
20	Engineering and Construction Services (10% of Subtotal and Contingencies)				\$1,198,200		
21	Legal and Financial (5% of Subtotal, Contingencies, and Engineering Services)				\$658,900		
	Subtotal				\$3,419,900		
	Mitigation						
22	Stream Crossing Mitigations	9	EA	\$13,140	\$118,300		
23	Wetland Mitigation	3.2	AC	\$8,749	\$28,300		
	Subtotal				\$146,600		
	Total Capital Cost with Contingencies				\$13,985,300		\$2,240,300
	Land Costs						
24	0% at \$10,000 per acre	0	AC	\$10,000	\$0	100.00%	\$0
25	0% at \$17,500 per acre	0	AC	\$17,500	\$0	100.00%	\$0
26	100% at \$25,000 per acre	29.75	AC	\$25,000	\$743,700	100.00%	\$743,700
	Total Land Cost				\$743,700		\$743,700
	Total				\$14,729,000		\$2,984,000

Table 32A-2 (continued)

Phase I - 36-Inch Force Main @ 23,560 LF

Item	Description	Quantity	Unit	Unit Price	Total Price	Salvage Value %	Salvage Value
1	36" Pipe	22,175	LF	\$235	\$5,211,200	50.00%	\$1,563,360 Assume 60% Mat. Costs
2	Trenchless Crossings with 36" Pipe	1,385	LF	\$1,500	\$2,077,500	50.00%	\$97,643 Note only applies to pipe not crossing
3	Stream Crossing Restoration	Included in 42-inch Phase 1 FM Cost					
4	Future interconnections (tee/BF)	4	EA	\$16,700	\$66,800	50.00%	\$20,040 Assume 60% Mat. Costs
5	36" Gate Valves	8	EA	\$40,000	\$320,000	50.00%	\$96,000 Assume 60% Mat. Costs
6	Corrosion Protection System	23,560	LF	\$10	\$235,700		
7	Fertilizing, Seeding, and Mulching	Included in 42-inch Phase 1 FM Cost					
8	Sediment and Erosion Control	Included in 42-inch Phase 1 FM Cost					
9	Overexcavation and backfill with imported material	349	CY	\$30	\$10,500		
10	Cleaning and Testing	23,560	LF	\$1	\$23,600		
11	Pavement Replacement	749	SY	\$30	\$22,500		
12	Anti-seep Collars	6	EA	\$1,000	\$6,000		
13	Manual ARVs	13	EA	\$8,100	\$105,300	50.00%	\$36,855 Assume 70% Mat. Costs
14	ARVs	2	EA	\$33,000	\$66,000	50.00%	\$23,100 Assume 70% Mat. Costs
15	Clearing and Grubbing	Included in 42-inch Phase 1 FM Cost					
16	Traffic Control	Included in 42-inch Phase 1 FM Cost					
17	Mobilization	1	LS	2%	\$162,900		
	Subtotal				\$8,308,000		\$1,836,998
18	Construction Contingencies (15% of Subtotal)				\$1,246,300		
19	Engineering and Construction Services (10% of Subtotal and Contingencies)				\$955,500		
20	Legal and Financial (5% of Subtotal, Contingencies, and Engineering Services)				\$525,500		
	Subtotal				\$2,727,300		
	Mitigation						
21	Stream Crossing Mitigations	Included in 42-inch Phase 1 FM Cost					
22	Wetlands Mitigation	Included in 42-inch Phase 1 FM Cost					
	Subtotal				\$0		
	Total Capital Cost with Contingencies				\$11,035,300		\$1,837,000
	Land Costs						
23	0% at \$10,000 per acre	Included in 42-inch Phase 1 FM Cost				100.00%	\$0
24	0% at \$17,500 per acre	Included in 42-inch Phase 1 FM Cost				100.00%	\$0
25	100% at \$25,000 per acre	Included in 42-inch Phase 1 FM Cost				100.00%	\$0
	Total Land Cost				\$0		\$0
	Total				\$11,035,300		\$1,837,000

Table 32A-2 (continued)

Phase II - 36-Inch Force Main @ 23,560 LF

Item	Description	Quantity	Unit	Unit Price	Total Price	Salvage Value %	Salvage Value
1	36" Pipe	22,175	LF	\$235	\$5,211,200	75.00%	\$2,345,000 Assume 60% Mat. Costs
2	Trenchless Crossings with 36" Pipe	1,385	LF	\$1,500	\$2,077,500	75.00%	\$146,464 Note only applies to pipe not crossing
3	Stream Crossing Restoration	7	EA	\$5,000	\$35,000		
4	Future interconnections (tee/BF)	4	EA	\$16,700	\$66,800	75.00%	\$30,060 Assume 60% Mat. Costs
5	36" Gate Valves	8	EA	\$40,000	\$320,000	75.00%	\$144,000 Assume 60% Mat. Costs
6	Corrosion Protection System	23,560	LF	\$10	\$235,700		
7	Fertilizing, Seeding, and Mulching	135,514	SY	\$0.25	\$33,800		
8	Sediment and Erosion Control	22,175	LF	\$5	\$111,000		
9	Overexcavation and backfill with imported material	349	CY	\$30	\$10,500		
10	Cleaning and Testing	23,560	LF	\$1	\$23,600		
11	Pavement Replacement	749	SY	\$30	\$22,500		
12	Anti-seep Collars	6	EA	\$1,000	\$6,000		
13	Manual ARVs	13	EA	\$8,100	\$105,300	75.00%	\$55,283 Assume 70% Mat. Costs
14	ARVs	2	EA	\$33,000	\$66,000	75.00%	\$34,650 Assume 70% Mat. Costs
15	Clearing and Grubbing	Included in 42-inch Phase 1 FM Cost					
16	Traffic Control	15,055	LF	\$5	\$75,400		
17	Mobilization	1	LS	2%	\$168,100		
	Subtotal				\$8,568,400		\$2,755,500
18	Construction Contingencies (15% of Subtotal)				\$1,285,300		
19	Engineering and Construction Services (10% of Subtotal and Contingencies)				\$985,400		
20	Legal and Financial (5% of Subtotal, Contingencies, and Engineering Services)				\$541,900		
	Subtotal				\$2,812,600		
	Mitigation						
21	Stream Crossing Mitigations	9	EA	\$13,140	\$118,300		
22	Wetlands Mitigation	3.24	AC	\$8,749	\$28,300		
	Subtotal				\$146,600		
	Total Capital Cost with Contingencies				\$11,527,600		\$2,755,500
	Land Costs						
23	0% at \$10,000 per acre	Included in 42-inch Phase 1 FM Cost				100.00%	\$0
24	0% at \$17,500 per acre	Included in 42-inch Phase 1 FM Cost				100.00%	\$0
25	100% at \$25,000 per acre	Included in 42-inch Phase 1 FM Cost				100.00%	\$0
	Total Land Cost				\$0		\$0
	Total				\$11,527,600		\$2,755,500