APPENDIX D
TECHNICAL MEMORANDUM NO. 2

Basis of Costs

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TO: Bruce Moser, Project Manager, City of Corvallis

FROM: Jim Hansen, Project Manager

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PREPARED BY: Dave Felstul, Brown and Caldwell

REVIEWED BY: Walt Meyer, West-Yost

SUBJECT: Basis for Project Costs

PROJECT: Corvallis Stormwater Master Plan

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This technical memorandum briefly documents the assumptions used to prepare the cost estimates for the Corvallis Stormwater Master Plan (SWMP). The watershed projects recommended in the SWMP can be classified as one of two main types, engineered structural solutions and riparian enhancement activities. Examples of engineered structures include culverts, detention ponds, and underground treatment devices. They require engineering analysis for sizing and placement. Examples of riparian enhancement activities include removal of invasive weeds, planting of trees, and placement of geotextile fabric for erosion control.

1.0 BASIS OF COST ESTIMATES

Costs of a project vary depending on the specific conditions of the project site. The accuracy of the cost estimate, therefore, is very dependent on the amount of information available on the site, as discussed below.

Type of Estimate. The costs developed for the SWMP are planning level costs or order-of-magnitude estimates as defined below, and not budget estimates or definitive estimates.

> **Order-of-Magnitude Estimate.** An order-of-magnitude estimate is approximate and is made without detailed engineering data. Techniques such as cost-capacity curves, scale-up or scale-down factors, and ratios are used in developing such an estimate. Typically a cost estimate of this kind is considered accurate within a range of +50 percent or -30 percent. That is, the final cost may be as much as 50 percent more or 30 percent less than the estimated amount.
>
> **Budget Estimate.** In this case, budget applies to the owner's budget and not to the budget as a project control document. This estimate is prepared based on field observations, or using process flow sheets, layouts, and equipment details. An estimate of this type is normally accurate within +30 percent or -15 percent.
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> **Definitive Estimate.** As the name implies, this is an estimate prepared from well-defined engineering data such as construction plans and specifications. As a minimum, the data must include the following: fairly comprehensive plot plans and elevations, piping and instrument diagrams, one-line electrical diagrams, equipment data sheets and quotations, structural drawings, soil data and drawings, and a complete set of specifications. The maximum definitive estimate would be made from approved for construction drawings and specifications. The accuracy of a definitive estimate would fall within +15 percent or – 5 percent.

Cost Index. All costs were updated using the ENR Construction Cost Index of 6300, approximately that for June 2000. The costs for acquisition of land or easements were not included for any of the engineered or riparian enhancement alternatives.

Provisions for Engineering, Administration, and Contingencies. Other project costs have been assumed to be equal to 45 percent of the construction costs of the project. This includes 20 percent for engineering, 5 percent for administration, and 20 percent for contingency. The same percentage was assumed for both engineered and restoration projects because, although the restoration projects typically involve less engineering, they require a lot of permitting effort.

2.0 CONSTRUCTION COSTS FOR ENGINEERED STRUCTURES

Cost estimates for engineered structures are based largely on equations which relate to the volume of stormwater runoff treated, the amount of impervious surface draining to a facility, or the excavated size of the facility. The equations were based on compilations of costs for similar

structures across the United States (EPA, 1999; Center for Watershed Protection, 1997). Where possible, costs were checked against those for projects completed within Oregon and Washington. All costs were adjusted as noted above for June 2000.

Detention Ponds. The equation used to estimate the cost of constructing detention ponds is based on the relationship between pond storage volume and total construction cost (Center for Watershed Protection, 1997). The equation is:

$$CC = 20.80 \times Vs^{0.70} \times 1.08$$

Where CC = construction cost
Vs = storage volume up to the crest of emergency spillway in cubic feet
1.08 = adjustment factor to update costs from 1997 to 2000

The construction cost for stormwater detention ponds includes excavation, grading and control structure costs. It is assumed that detention facilities will be designed with a pond cell where sediment will accumulate, such as a forebay in a wet detention pond.

Constructed Wetland. To estimate the cost of building a constructed wetland, begin with the cost for a detention pond and increase it by 25 percent to account for the extra plant selection and sediment forebay requirements (EPA, 1999).

For comparison, the costs of constructing off-channel wetlands for Portland, Oregon (USA, 1998) and in Washington County, Oregon (USA, 1997), were about $2.50 and $4.00 per square foot, respectively.

Grassed Swales and Filter Strips. The cost of creating a grassed swale is approximately $0.65 per cubic foot of volume (EPA, 1999). The cost of a filter strip is $1.30 per cubic foot of volume. Costs for both types of facilities assume 6 inches of water depth storage in the swale.

Infiltration Trench. Infiltration trench costs range from $2.10 to $4.25 and average $2.65 per cubic foot of treatment value (EPA, 1999). This assumes a porosity of 32 percent in the fill material of the trench.

Sand Filters (Underground Vault). The costs of sand filters range from $2.10 to $6.40 per cubic foot of treatment volume, with a mean cost of $2.65 (Brown and Schueler, 1997). The cost for the underground vault configuration used in the Washington, DC area is approximately $16,000 (EPA, 1999).

Porous Pavement. Average porous pavement costs were reported to be $65,000 per acre (EPA, 1999).

Floodproofing. The cost for elevating a wood frame building on foundation walls was assumed to be $25 per square foot (USACE, 1993).

Culverts. Unit prices for culvert replacement are based on the typical unit prices for new pipe presented in Table TM2-1. They include AC saw cut, AC patch, trench excavation, pipe bedding, trench backfill, and shoring. The table assumes C14 pipe to 15 inches, C76 pipe to 36 inches, corrugated metal pipe to 54 inches, and steel arch pipe larger than 54 inches.

Table TM2-1. Unit Price Per Foot for New Pipe[1]

Pipe diameter, inches	Depth to invert, feet->								
	4	6	8	10	12	14	16	18	20
8	41	50	59	67	76	84	93	103	111
10	45	54	63	72	81	90	99	109	118
12	47	57	66	76	85	95	105	115	125
15	51	61	71	82	92	102	112	123	134
18	64	75	86	97	108	119	130	142	153
21	69	80	92	104	115	127	139	151	163
24	78	91	103	115	128	140	153	166	179
27	86	99	112	125	139	152	165	179	193
30	95	109	123	137	151	165	179	194	208
36	109	135	151	167	182	198	214	230	246
42	104	144	160	176	191	207	223	239	255
48		162	179	196	213	230	247	265	282
54		180	199	217	235	254	272	291	310
60			237	256	276	296	316	336	356
66			279	303	326	350	374	399	422
72			306	331	356	381	406	432	457
84				374	402	430	458	487	515

[1]Updated from Beaverton, 1994 with assistance of Brown and Caldwell cost estimator.

The cost for diverting flow during culvert construction was added to each culvert replacement project. Flow diversion costs were based on the application of a 25 percent factor to the replacement pipe cost, and they include the installation, removal, and maintenance of dams, pumps, and pipes for an average duration of 4 months. Actual flow diversion costs may be less since construction would typically take place during low flow conditions.

Culvert entrance structures protect the embankment from erosion and may improve the hydraulic characteristics of the culvert. Culvert outlet structures protect the downstream slope of the fill from erosion and prevent undercutting of the culvert barrel. Construction costs for new entrance and outlet structures are estimated to be $2,000 for culvert diameters less than or equal to 48 inches and $4,000 for culvert diameters greater than 48 inches for each structure (BES, 1998). Construction costs for retrofitting entrance and outlet structures were based on the application of a 25 percent factor to the new structure cost to account for demolition costs.

Bridges and Box Culverts. If too many parallel culverts are required to route the modeled flow, a bridge, box culvert, or pipe arch was recommended. The structure was sized to pass the 25-year future flows. Cost was estimated based on a simple concrete bridge design with no footing problems. A two-lane bridge was priced at $2,500 per linear foot. A four lane bridge at $6,000 per linear foot. Costs would likely be less if a box culvert or a pipe arch is used. A final decision on the best choice of structure cannot be made prior to predesign work.

3.0 COSTS FOR RIPARIAN ENHANCEMENT

The estimates of costs for riparian restoration are based on costs for materials and labor for similar activities in other locations. Riparian restoration costs are normally calculated by multiplying the square foot of material, per plant, or per volume excavated. To allow for estimation, unit costs were combined into a cost per 100 lineal feet of streambank restoration that was used for most cost estimates. This allowed estimation of project costs without the detailed survey information required for budget or definitive estimates.

Costs for stream and riparian enhancement are site dependent. Site access, soils, existing vegetation, and source of labor (many are volunteer projects) are all examples of factors that influence costs. Unit costs for several typical riparian enhancement projects were developed from detailed project descriptions in the Beaverton Creek Watershed Master Plan, recently completed for the Unified Sewerage Agency (USA, 1998). Costs for individual components of restoration projects are listed in Table TM2-2.

Table TM2-2. Costs for Individual Riparian Restoration Activities[1,2]

Activity	Unit	Cost
Erosion control/site preparation	Linear ft.	$2.00
Dewatering	Day	$120.00
Selective vegetation removal, disposal	sq. ft.	$1.00
Stripping of grass	sq. ft.	$0.50
Sediment removal	cubic yd.	$17.00
Grading	sq. ft.	$1.00
Earthwork (load, haul, place, compact)	cubic yd.	$20.00
Rock and rock placement	cubic yd.	$39.00
Coir/jute fabric and placement	sq. ft.	$2.00
Plant material and revegetation	sq. ft.	$1.00
Log snags/pilings and placement[3]	Each	$2,000.00
Construction administration/inspection	% of cost	2

[1]Table TM2-2 includes construction materials and labor.
[2]Adapted from USA, 1998
[3]Smith, 2000

Cost of trees to be planted along the stream was estimated as $400 per 100 linear feet.

Costs for vegetative establishment of grass and ground cover were estimated as $800 per acre.

Costs for clearing, grading, and revegetation with native species was estimated as $3,000 per 100 lineal feet of stream.

Costs for bank stabilization was estimated as $7,000 per 100 lineal feet of stream.

Costs for streambank excavation and revegetation with native species was estimated to be $20,000 per 100 lineal feet of stream.

Adjustments. Costs were multiplied by a factor of 2 to 3 for riparian enhancement with difficult access, including highly urbanized areas. Project costs were increased by 25 percent if diversion of perennial stream was required. Project costs were increased by 10 percent for work in streams that would require extra permitting because of the Endangered Species Act.

4.0 ANNUAL MAINTENANCE COSTS

Annual maintenance costs were estimated as a percentage of the construction cost for most of the engineered structures, as presented in Table TM2-3. Maintenance of miscellaneous riparian restoration projects was assumed to be 5 percent of the project cost.

Table TM2-3. Costs for Engineered Structures[1]

Type of structure	Annual maintenance as percent of construction cost
Detention pond	1
Constructed wetland	3-6
Grassed swale	5-7
Infiltration trench	5-20
Sand filter	11-13

[1]Table adapted from EPA, 1999.

5.0 PERSONNEL COSTS

Some recommended activities involved mainly personnel costs. The assumed hourly or daily costs for these activities are listed in Table TM2-4.

Table TM2-4. Personnel Costs

Activity	Unit	Cost
Coordination or field inspection	hour	$50
Engineering	hour	$70
Surveying (2 person crew)	hour	$100
Maintenance of channels and pipes (crew and equipment)	day	$1,100

6.0 REFERENCES

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