Appendix C – Stormwater

Technical Memorandum

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Date: April 9, 2008

Subject: Brookman Addition Stormwater Infrastructure Plan

Project No.: 14156

Introduction

This memorandum presents a Stormwater Infrastructure Plan (SWIP) for the Brookman Addition Concept Plan. The purpose of the infrastructure plan is to:

- Describe the recommended stormwater management strategy for Brookman Addition Concept Plan Area.
- Show how the strategy would be applied to the concept plan.
- Provide a cost estimate for the stormwater management infrastructure.
- Document supporting calculations.

An existing conditions analysis was performed by Otak, Inc. in June of 2007, and a technical memorandum was created to document findings. The original analysis provided a basis for developing the draft Brookman Addition SWIP (December, 2007.) Subsequent to the draft SWIP, the concept plan was revised and the draft SWIP was updated to produce this final SWIP. An updated version of the Concept Plan can be seen in Attachment A.

Stormwater Strategy

The Stormwater Management Strategy describes the recommended stormwater management tools to be applied within the Brookman Addition Concept Plan Area to help achieve the City of Sherwood's goals during its expansion. The following goals were incorporated into the stormwater management strategy for this project with respect to parks and green spaces:

- Protection of natural resource areas consistent with the City of Sherwood's Goal 5 program and other priority resource areas identified by the Steering Committee.
- Sustainable, system-based solutions such as regional stormwater management and other low-impact development practices.

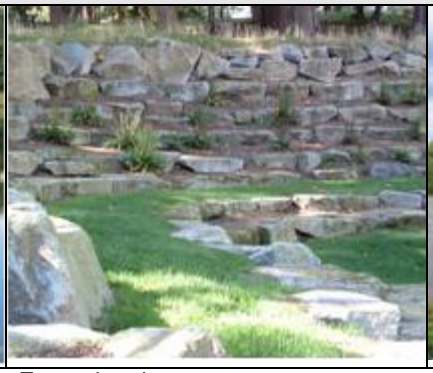
- Stormwater follows the City of Sherwood recommendations.

The recommended Stormwater Management Strategy for Brookman Addition is to collect and convey all runoff from the site primarily within the road right-of-way (R.O.W.), and then route stormwater to regional detention and water quality facilities. After all runoff has been treated and detained, it will be discharged into natural drainage ways adjacent to each facility.

Design of the regional stormwater facilities should be integrated with the urban and natural areas to provide additional habitat value or public open space for recreation. Photograph examples of integrated facilities are shown below.

Examples of Multi-functional Regional Stormwater Facilities

Stormwater Wetland



Terraced outdoor seating

Water Feature along a Trail

While not accounted for in the recommended stormwater infrastructure for this SWIP, Low Impact Development Applications (LIDA) should be encouraged for new development. The integration of LIDA to new development will reduce impervious areas and may also reduce effective runoff that is generated from a particular site. Consequently, regional facility sizes may be reduced per design standards in place at the time the proposed regional facilities are implemented.

Increased interest of LIDA over the past few years has resulted in more literature and design guidance. Clean Water Services is currently developing a LIDA Guidance Manual, which is the suggested reference for design guidance. Pending the release of this document, the following documents are recommended reference materials that include more information about use of LIDA in the Pacific Northwest.

- City of Portland. (September 2004). Stormwater Management Manual. Revision 3. Portland, OR: Bureau of Environmental Services.
- Puget Sound Action Team and Washington State University Extension Pierce County. (January 2005). Low Impact Development Technical Guidance Manual for Puget Sound. (PSAT 05-03). Olympia, WA.

- City of Gresham. (July 2007). Green Development Practices for Sustainable Stormwater Management. Gresham, OR: Department of Environmental Services, Community and Economic Development Department.

Stormwater Concept Plan

The Stormwater Concept Plan Diagram provides a schematic representation of the recommended stormwater system in Brookman Addition. This plan illustrates the application of the recommended stormwater management strategy to the current version of the Brookman Addition Concept Plan, and is used to document assumptions made about the Stormwater Infrastructure Costs. Additional assumptions and calculations performed to determine facility sizes are presented later in the Stormwater Calculations section of this memorandum.

Conveyance of stormwater through the Brookman Addition Concept Plan Area is illustrated in the Stormwater Concept Plan Diagram. Much of the site runoff will need to be conveyed through pipes. All stormwater runoff is conveyed to one of six regional facility sites.

Regional Detention Facilities

Regional detention facilities were sized per *CleanWater Services Design and Construction Standards*. Currently, the standards require that the 2-, 10-, and 25-year post-development runoff rates will not exceed the respective 2-, 10-, and 25-year pre-development runoff rates. Six regional facility sites were identified based upon existing site topography and location of natural systems. Six drainage basins were delineated based on existing drainage patterns as contributing runoff to each regional facility. Locations of recommended regional stormwater facilities and the associated tributary drainage areas are illustrated in the Stormwater Concept Plan Diagram.

Regional Water Quality Facilities

Water quality facilities were also sized per *CleanWater Services Design and Construction Standards (June 2007)* using a water quality flow produced by a design storm of 0.36 inches over four hours applied to 100 percent of new impervious area.

This Storm Water Infrastructure Plan (SWIP) recommends all site runoff to be treated by regional water quality facilities. Vegetated swales are recommended for treating new impervious area within each of the six basins, and were designed to be integrated with the regional stormwater detention facilities. Impervious areas were calculated based on land use assumptions within each basin, as presented in the stormwater calculations section of this memorandum. Proposed locations of facilities are shown in the Stormwater Concept Plan Diagram. Each is next to a detention facility, with the exception of one located in the undetained portion of Basin 1.

Estimated Cost

The Stormwater Infrastructure Cost Estimate includes stormwater infrastructure costs for the following elements:

- Required public conveyance elements that do not follow a road shown in the concept plan.
- Regional facilities.

It is assumed that stormwater conveyance infrastructure shown in within the right of way is part of road cost, and is included in the transportation cost estimate.

The total estimated cost to construct Stormwater Infrastructure for the Brookman Addition Concept Plan Area is $2.6 million. Soft costs for implementation are estimated to cost an additional $1.3 million. Land acquisitions costs for regional facilities are estimated to be $3.3 million.

A detailed breakdown of the Stormwater Infrastructure Cost Estimate is provided in Attachment B.

Costs for Regional Stormwater Facilities were determined according to estimates for facility size (footprint and volume). Assumptions and calculations used to estimate facility sizes are presented later in the Stormwater Calculations section of this memorandum. The following standard assumptions were made about the geometry of the regional stormwater management facilities.

- Facility side slopes were assumed to be 3H:1V.
- Each regional facility site was assumed to require a flow splitter manhole incorporated into the design to route water quality flows to the water quality facility and bypass higher flows directly to the regional detention facility.
- Regional stormwater facilities for detention were assumed to require an excavation volume based upon five to six feet of storage depth, plus an additional one foot for freeboard. Facility footprints were assumed based on depth, bottom area, and side slope.
- Costs for inlet/outlet pipes, manholes, inlets, flow splitters, and flow control devices were based on recent bid tabulations for projects in the area.

Stormwater Calculations

There is a strong correlation between new impervious area and increased stormwater runoff. The first step toward sizing water quality facilities and estimating site runoff is to estimate the amount of impervious area associated with the various types of development planned for the Brookman Addition Concept Plan. Actual imperviousness will vary throughout Brookman Addition and will need to be recalculated as development occurs. Assumptions about impervious area used for the SWIP are documented in this section of the memorandum.

Several calculations were then made as part of developing the SWIP and cost estimate as documented in this section of the memorandum. The calculations include:

- Sizing of regional stormwater facility for water quality.
- Sizing of regional stormwater facility for stormwater detention.

Impervious Area

At the concept planning stage, seven types of residential land uses were mapped for the Brookman Addition community: medium density residential - low, medium density residential - high, high-density residential, employment, mixed use, parks, and streets. Estimated dwelling units per acre for residential lots were estimated to be 8 for Medium Density Residential – Low, 11 for Medium Density Residential – High, and 24 for High Density Residential. Non-residential land uses identified include parks, civic uses, and other open space areas.

Average values for percent impervious area were assumed for each development zone. Table 1 shows the assumed percentages for impervious area associated with each land use that were used in the design of stormwater facilities for the site. These values are based upon a comparison of typical values published in regional stormwater design manuals and local studies of development practices similar to those anticipated to occur in Brookman Addition.

Table 1 – Summary of Impervious Area Reference Calculations

Description	Density (units/acre)	Impervious Area (%)
Employment	N/A	85
High Density Residential	24	65
Medium Density Residential – High	11	60
Medium Density Residential – Low	8	55
Mixed Use	N/A	85
Parks	N/A	10
Streets	N/A	80

Downstream Analysis

City of Sherwood's Stormwater Management Plan requires detention to be provided for all new development within the city, therefore a downstream analysis was not conducted as part of this concept plan.

Regional Stormwater Facility for Stormwater Detention

Regional stormwater pond sizes were estimated for each of the six basins. As part of the draft SWIP analysis, Hydraflow Hydrographs 2004 software was used to estimate peak flows and required pond volumes in accordance with Santa Barbara Urban Hydrograph (SBUH) methodology. Hydrologic curve numbers (CN) of pervious areas with C type soils were assumed to be 86 except for one forested area, where a CN of 79 was assumed. Pervious areas with B type soils were assumed to

have a CN value of 80. For proposed conditions, pervious areas were given the same corresponding CN values, as the land covers were similar. Impervious areas were assigned a CN of 98. Table 2 summarizes area, time of concentration (TOC), and 2-, 10-, and 25-year peak flows for each basin under existing conditions. Basins 4 and 6 would drain to a single regional pond. Table 3 summarizes impervious area, time of concentration, 25-year peak flow and estimated required storage volume for each drainage basin.

Table 2: Summary of Existing Condition Parameters [1]

Basin	Area (ac)	TOC (min)	2-yr Peak (cfs)	10-yr Peak (cfs)	25-yr Peak (cfs)
1	25.3	23.4	4.43	9.45	12.1
2	83.6	30.8	19.49	33.29	40.2
3	12.5	25.9	2.61	4.65	5.7
4 + 6	80.2	24.0	22.79	42.12	51.9
5	22.8	22.0	1.34	3.92	5.4

Table 3: Summary of Proposed Condition Parameters (Preliminary) [1]

Basin	Impervious Area (ac)	Impervious TOC (min)	Pervious Area (ac)	Pervious TOC (min)	25-year peak flow (cfs)	Calculated Storage Volume (cf)
1	19.1	5	6.0	10	9.6	60,489
2	42.6	5	24.9	10	40.1	148,665
3	7.3	5	5.2	10	5.6	19,227
4 + 6	48.7	5	31.4	10	51.9	144,333
5	13.4	5	9.4	10	5.3	91,742

As part of the final SWIP, adjustments were made to pond sizes by calculating new impervious areas based on the latest Brookman Addition concept plan. Modifications including land use areas, and basin connectivity were made to each basin. Ratios were obtained for each basin by comparing total percent impervious areas under the draft SWIP analysis and the final SWIP. Table 4 summarizes results for adjusted detention facility sizing based on these ratios.

Table 4: Summary of Proposed Condition Factors (Adjusted) [2]

Basin	Impervious Area (ac)	Pervious Area (ac)	April 2008 SWIP Impervious Area (%)	Draft SWIP Impervious Area (%)	Updated Pond Sizing Ratio	April 2008 Storage Volume (cf)

[1] Based on calculations from December 2007 analysis

[2] Based on calculations from April 2008 analysis

1	16.3	4.9	77	79	0.98	59,279
2	44.0	20.2	69	67	1.02	151,638
3	8.0	4.8	63	58	1.09	20,957
4	23.7	16.2	59	59	1.0	87,768
5	14.3	8.5	59	63	1.07	98,164
6	26.5	16.7	61	62	0.98	96,642

During the final review process, adjustments were made to the land uses which increased impervious areas in basins 1, 2, and 3. Final runoff volumes for these basins were calculated using methodology described in the preliminary site analysis to produce more refined estimates. Table 5 lists basin parameters and calculated required storage volumes for the final concept.

Table 5: Summary of Proposed Condition Parameters (Final)

Basin	Impervious Area (ac)	Pervious Area (ac)	25-year peak flow (cfs)	Calculated Storage Volume (cf)
1	19.9	4.4	7.87	70,385
2	47.5	19.4	40.1	150,657
3	8.0	4.8	5.66	19,058
4	23.7	16.2	N/A[3]	87,768
5	14.3	8.5	N/A[3]	98,164
6	26.5	16.7	N/A[3]	96,642

Regional Stormwater Facility for Water Quality

Standards indicate a maximum flow depth of six inches, 4:1 side slopes or shallower, one foot of freeboard over the water quality event, minimum longitudinal slope of 0.5 percent, and a minimum length of 100 feet. Table 4 summarizes the calculated water quality flow, and design dimensions for each swale.

During implementation, it may be determined through an alternative analysis that an underground treatment device, or volume based treatment device is a more feasible design solution. Calculated water quality volumes for each basin are also shown in Table 5.

[3] New flows not calculated. Storage volumes are based on April 2008 analysis.

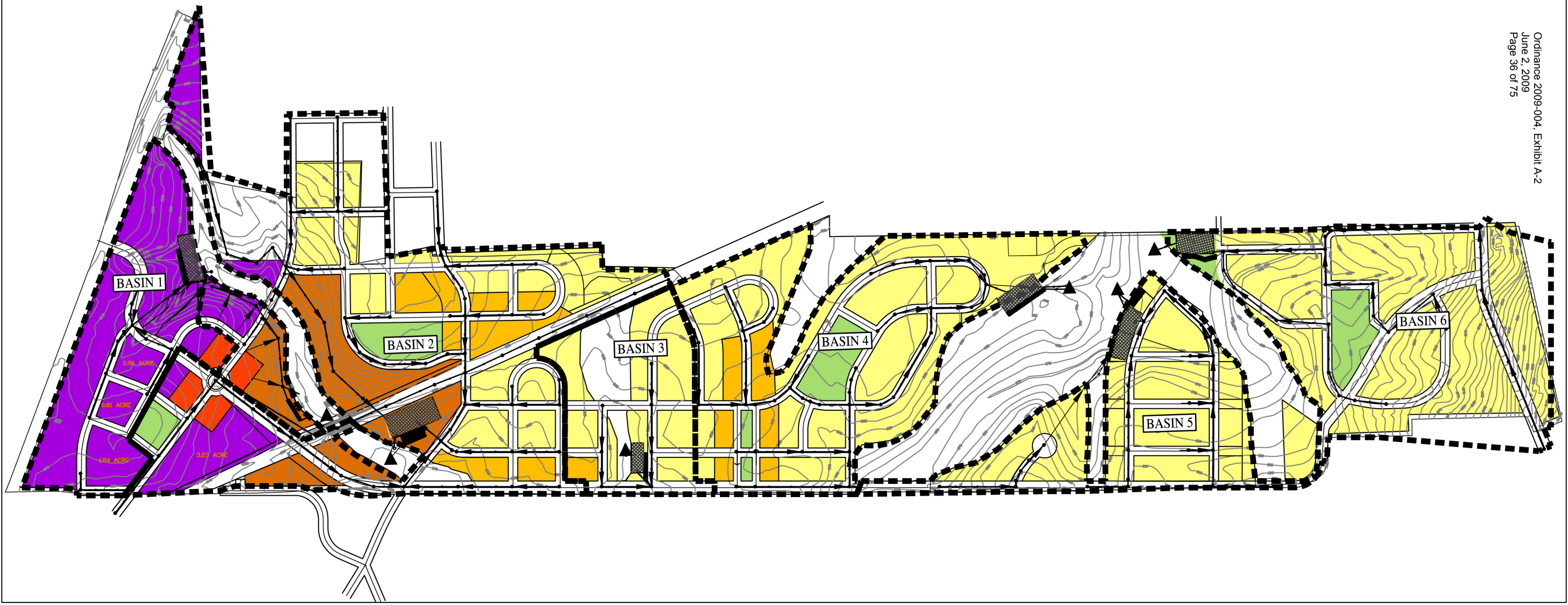
Table 6: Summary of Water Quality Facility Parameters (Final)						
Basin	Water Quality Flow (cfs)	Water Quality Volume (cu. ft.)	Length (ft.)	Width (ft.)	Footprint Area (sq. ft.)	Longitudinal Slope (ft./ft.)
1	1.81	26,031	184	9	4116	0.01
1 (undetained)	0.19	2859	105	4	1872	0.01
2	4.31	57,467	238	18	7500	0.015
3	0.73	10,437	122	4.5	2211	0.005
4	2.15	31,004	226	8.5	4879	0.015
5	1.3	18,662	178	6	3420	0.01
6	2.4	34,624	189	12	4824	0.01

Alternative Analysis

At the City's request, an alternative scenario was analyzed under the condition that Basin 5 would be 50% developed, and the other 50% would remain forested. Under this condition, total impervious area was calculated to be 8.3 ac., which would require a detention pond with a footprint of 184'X93'. A water quality flow of 0.75 cfs was calculated, which would require a regional swale facility with a 4' bottom width, and a length of 160'. These facilities would be located in the same place as proposed in the draft SWIP for Basin 5.

Attachments

Attachment A – Brookman Addition Concept Plan Diagram



Brookman Addition Stormwater Concept Plan Diagram

0’ 250’ 500’ 1000’

- Mixed Use
- Employment
- Medium Density Residential - Low
- Medium Density Residential - High
- High Density Residential
- Park
- Proposed Drainage Pattern
- Proposed Stormwater Detention Facility
- Proposed Stormwater Treatment Facility
- Basin Boundary
- Basin Outflow/Discharge Points

Attachment B – Cost Estimate

CONCEPTUAL PLAN CONSTRUCTION COST ESTIMATE

Brookman Addition Concept Plan Stormwater Infrastructure

CITY: Sherwood, OR

TYPE OF WORK: Stormwater Management Infrastructure | AREA | DATE: 5/14/2009 | Drainage System Designer: Ashley Cantlon

	ITEM DESCRIPTION	UNIT	AMOUNT	UNIT COST	TOTAL
	Base Construction Items (Mobilization, Traffic Control, Erosion Control, etc.)			**20%**	**$526,657**
	Conveyance Infrastructure				
	12 INCH STORM CONDUIT, CP	LF	1,932	$60	$115,920
	15 INCH STORM CONDUIT, CP	LF	692	$68	$47,056
	18 INCH STORM CONDUIT, CP	LF	387	$70	$27,090
	30 INCH STORM CONDUIT, CP	LF	938	$105	$98,490
	36 INCH STORM CONDUIT, CP	LF	322	$175	$56,350
	42 INCH STORM CONDUIT, CP	LF	190	$190	$36,100
	CONC INLET STRUCTURE, CATCH BASIN	EA	36	$1,500	$53,532
	MANHOLE STRUCTURE	EA	15	$3,200	$47,584
	Regional Stormwater Management Facilities				
	EXCAVATION & GRADING	CY	34,700	$12	$416,400
	LANDSCAPING	SY	17,712	$10	$177,120
	PRE-TREATMENT DEVICE	EA	7	$15,000	$105,000
	FLOW SPREADER	EA	16	$1,000	$16,000
	DITCH INLET	EA	13	$2,000	$26,000
	FLOW SPLITTER	EA	4	$1,500	$6,000
	FLOW CONTROL MANHOLE	EA	6	$10,000	$60,000
	RIPRAP OVERFLOW WEIR	EA	6	$2,500	$15,000
	ADDITIONAL STORM PIPE	LF	650	$65	$42,250
	RIPRAP INLET/OUTLET PROTECTION	EA	27	$310	$8,370
SUBTOTAL, Construction					$1,880,919
	CONSTRUCTION CONTINGENCIES			40%	$752,368
SUBTOTAL, Total Construction Cost					$2,633,287
	PRELIMINARY ENGINEERING			25%	$658,322
	PERMITTING			5%	$131,664
	CONSTRUCTION ENGINEERING			20%	$526,657
SUBTOTAL, Implementation					$3,949,931
	LAND ACQUISITION for Regional Stormwater Facilities	SF	159408	$17	$2,709,936
	STAFFING COSTS			17%	$460,689
	APPRAISAL COSTS			5%	$135,497
GRAND TOTAL					**$7,256,053**

Assumptions: 1) Unit Costs are presented in 2007 U.S. Dollars

2) Infrastructure quantities do not include conveyance systems associated with site development beyond the framework illustrated in the SWIP.

3) Costs for conveyance facilities located within road right-of-ways shown in the concept plan are included in the transportation cost estimate.